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Suspended particulate matter and wet deposition fluxes in regional background stations of the Iberian Peninsula: a detailed study of African dust outbreaks

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APPENDIX

1. Northwestern Iberian Peninsula

The air flow in the NW Iberian Peninsula is clearly dominated by the Atlantic air flux. As shown in Table Ap.1, in the period 1998-2003, 72 % of the days this region was influenced by Atlantic air masses. This resulted in 1568 days, 261 days per year, 22 days per month). In contrast, only in 1% (28 days, 5 days per year, <1 day per month) of the days Mediterranean air masses reached NW Spain. The transport of air masses from the European continent occurred in 10% of the days (227 days, 38 days per year, 3 days per month), and from the African continent in 8% of the days (182 days, 30 days per year, 3 days per month). The episodes without a prevalent advective regime accounted for 8% of the days (186 days, 31 episodes per year, 3 episodes per month).
The above mentioned days were distributed in 223 episodes of Atlantic advection, 67 episodes of European advection, 66 episodes with lack of advection and 16 Mediterranean episodes (Table Ap.1).

Table Ap.1. Number of days, % of days and episodes with Atlantic (ATL), North African (NAF), Mediterranean (MED) and European (EU) advection and without a prevalent advective regime (NOADV) in Northwestern Iberia for the period 1998-2003.

1998-2003	ATL	NAF	MED	EU	NOADV
Number of days	1568	182	28	227	186
% of days	72	8	1	10	9
Number of events	223	67	16	67	66

In the Northwestern region of the Iberian Peninsula daily data from three regional background stations belonging to the EMEP network were utilised to evaluate the impact of different episodes the levels of suspended PM. Noia station (37º 14’ N, -3º 28’ E, 1230 m.a.s.l.) offered data on TSP (1998-June 2000). At Niembro (43º 27’ N, -4º 51’ E, 134 m.a.s.l.), TSP (1999-January 2003) and PM10 and PM2.5 (March 2001-2003) were registered. At O Saviñao (43º 14’ N, -7º 42’ E, 506 m.a.s.l.) data on TSP, PM10 and PM2.5 (March 2001-2003) were available.
The annual levels of TSP in the period 1998-2003 recorded in EMEP stations ranged between 17 $\mu g\ m^{-3}$ in Noia, 20$\mu g\ m^{-3}$ in O Saviñao and 27$\mu g\ m^{-3}$ in Niembro (Table Ap.2). Mean annual PM10 levels recorded at O Saviñao (15 $\mu g\ m^{-3}$) in the study period are slightly lower than those recorded at Niembro with 19 $\mu g\ m^{-3}$ (Table Ap.2). PM2.5 annual mean values are of the same order in O Saviñao and in Niembro (10 $\mu g\ m^{-3}$ and 11 $\mu g\ m^{-3}$ respectively, Table Ap.2). As expected, none of these stations exceeded the annual limits values established for PM10 by the 1999/30/CE Directive neither in the 2005 phase (limit annual value of 40 $\mu g\ m^{-3}$) nor in the 2010 phase (target annual mean of 20 $\mu g PM10\ m^{-3}$). However, in 2001 and 2003 in Niembro annual PM10 means of 20 $\mu g\ m^{-3}$ were registered (Table Ap.2). With respect to the PM2.5 annual mean limit value recommended by the II EC PM Position Paper of 12-20 $\mu g\ m^{-3}$ (EC, 2004), only in 2001 in O Saviñao the annual mean exceeded the lower threshold proposed (Table Ap.2).

Table Ap.2. Mean levels of TSP, PM10 and PM2.5 recorded in EMEP stations in 1998-2003 in Northwestern Iberian Peninsula.

MEAN LEVELS ($\mu g\ m^{-3}$)	Noia	Niembro			O Saviñao		
	TSP	TSP	PM10	PM2.5	TSP	PM10	PM2.5
1998	17	na	na	na	na	na	na
1999	16	29	na	na	na	na	na
2000	*[1]19	28	na	na	na	na	na
2001	na	26	*[2]20	*[2]11	22	*[2]16	*[2]12
2002	na	28	19	10	20	14	9
2003	na	na	20	11	na	15	9
Mean 98-03	17	27	19	11	20	15	10

*[1]Calculated with data of 50% of the months of the year
*[2]Calculated with data of 83% of the months of the year
na: Not available

1.1. Atlantic episodes

The 223 Atlantic episodes (accounting 1568 days) occurred in Northwestern Iberian Peninsula in 1998-2003 resulted in a mean of 37 episodes per year (Table Ap.3) and 3 per month with a mean duration of 7 days per episode.

From the 223 episodes 165 (74% of the Atlantic episodes) occurred under the AZH-NAtD scenario (presence of the Azores high together with a North Atlantic depression) this resulted in 1381 days (88% of the days with Atlantic advection). Thus, a mean of 28 AZH-NAtD episodes occurred per year accounting for a mean of 230 days per year (Table Ap.3) and 19 days per month. The monthly mean frequency of the AZH-NAtD events is 2 per month. The mean duration of these events was 8 days per episode.

The rest of Atlantic events, 58 episodes (26% of the ATL events), were classified as AD (depression over the Atlantic ocean in front of Portugal) type (10 episodes per year, 1 episode per month). These events accounted for a total of 187 days (12% of the days with Atlantic advection) which resulted in averages of 31 days per year (Table Ap.3) and 3 days per month. Atlantic AD episodes have a mean duration of 3 days.

In the study period (1998-2003), the maximum and minimum annual number of days with Atlantic advection occurred in 2000 (295, Table Ap.3) and 2003 (226, Table Ap.3) respectively. As regards AZH-NAtD events, the maximum and the minimum annual number of days were also detected in 2000 (251, Table Ap.3) and 2003 (178, Table Ap.3) respectively. The highest number of days with Atlantic advection of the type AD was detected in 2003 (48, Table Ap.3) and the minimum in 2001 (21, Table Ap.3).

The maximum annual number of Atlantic episodes was reached in 2003 (44, Table Ap.3) and the minimum in 1998 (30, Table Ap.3). The maximum number of AZH-NAtD and AD events occurred in 2001 (31) and in 2000 and 2003 (13) respectively (Table Ap.3). The lowest annual number of episodes was detected in 1998 for AZH-NAtD scenario (23, Table Ap.3) and in 1998 and 1999 for AD scenario (7, Table Ap.3).

Table Ap.3. Annual number of days and episodes with Atlantic advection in the period 1998-2003 over Northwestern Iberian Peninsula. The AZH-NAtD and AD scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total ATL	262	270	295	253	262	226	261	22
AZH-NAtD	237	243	251	232	240	178	230	19
AD	25	27	44	21	22	48	31	3
Episodes								
Total ATL	30	32	38	41	38	44	37	3
AZH-NAtD	23	25	25	32	29	31	28	2
AD	7	7	13	9	9	13	10	1

The seasonal distribution of Atlantic episodes in the period 1998-2003 was characterised by a period of higher number of episodes, December-May, with respect to a period of lower frequency, June-November. The months in which ATL episodes occurred with the highest and lowest frequencies were December (23 episodes in the whole study period, Figure Ap.1) and September (13 in the whole study period episodes, Figure Ap.1). The AZH-NAtD events occurred more often in the period May-August and in the period November-January and with less frequency in February-April and September-October (Figure Ap.1). In January, June and August the maximum number of these events was recorded (16 in 1998-2003, Figure Ap.1) whereas in September only 13 AZH-NAtD episodes were documented. The monthly distribution of number of AD episodes follows the same pattern as the distribution of total ATL events. The maximum is centred in December with a total of 9 episodes in 1998-2003 (Figure Ap.1) and in June no Atlantic AD was recorded.

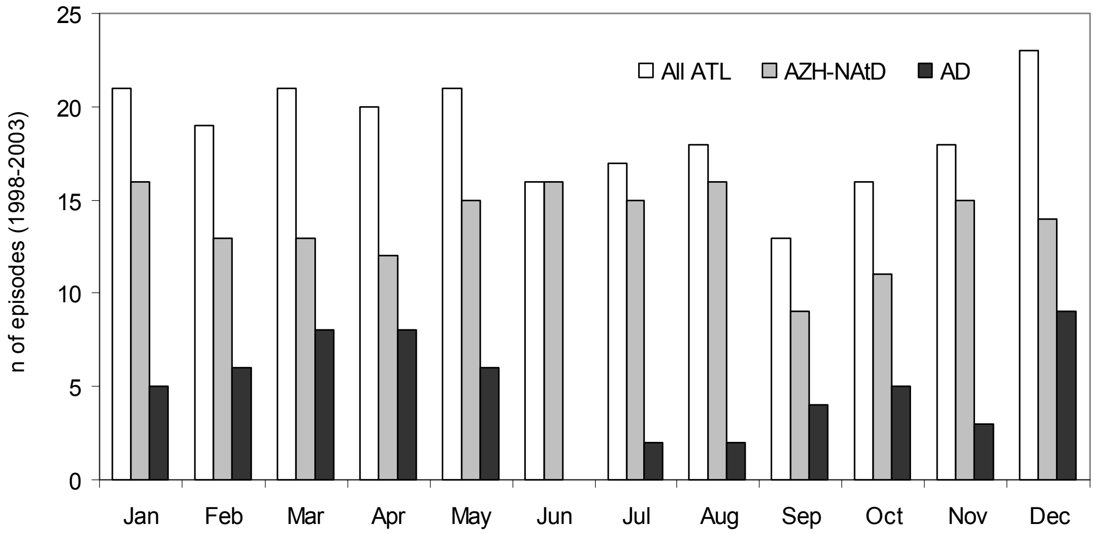

Figure Ap.1. Monthly distribution of the number of Atlantic episodes over Northwestern Iberian Peninsula. The monthly distributions of AZH-NAtD and AD Atlantic events are also shown.

The number of days per month with Atlantic advection recorded in the study period (1998-2003) shows a distribution with three periods of higher frequency April, June-July and October-December (Figures Ap.2 and Ap.3). April and November (26 days as a mean, Figure Ap.3) show the highest frequency of days with Atlantic advection and March (16 days per year, Figure Ap.3) the lowest. This behaviour is also followed by the distribution of Atlantic days of the AZH-NAtD type (Figures Ap.2 and Ap.3). November (a mean of 25 days) and March (12 days on average) were the months in which the number of AZH-NAtD Atlantic days reached the highest and the lowest monthly means respectively. The Atlantic days occurred AD scenarios were more frequent in March-May and December with a secondary peak centred in September. The maximum monthly means were registered in March, April and December (5 days, Figure Ap.3). The lowest frequency of occurrence of Atlantic AD days was recorded in summer and November. In particular, June was devoid of days with Atlantic advection occurred under AD scenario (Figures Ap.2 and Ap.3).

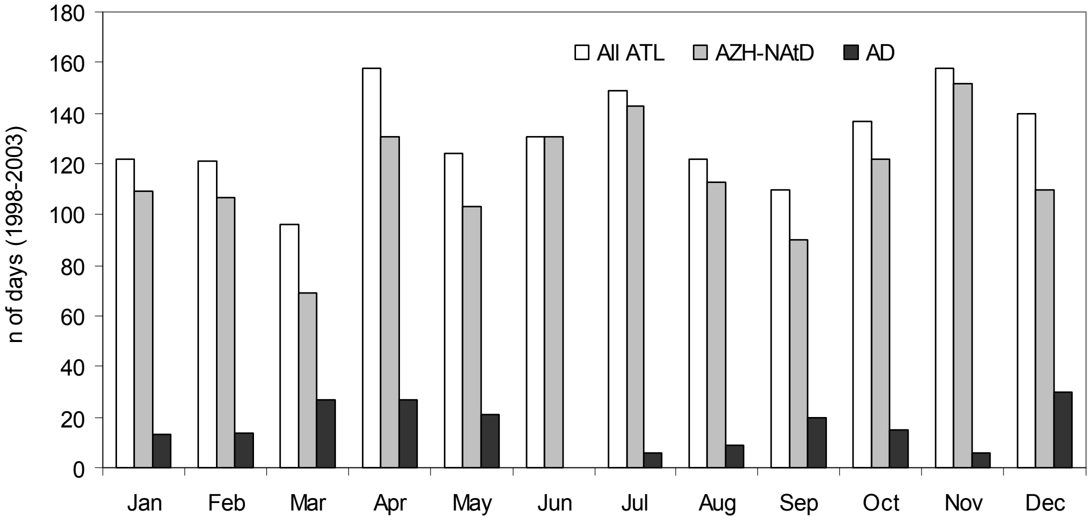

Figure Ap.2. Monthly distribution of the number of days with Atlantic advection over Northwestern Iberian Peninsula. The monthly distributions of days with Atlantic advection occurred under AZH-NAtD and AD scenarios are also shown.

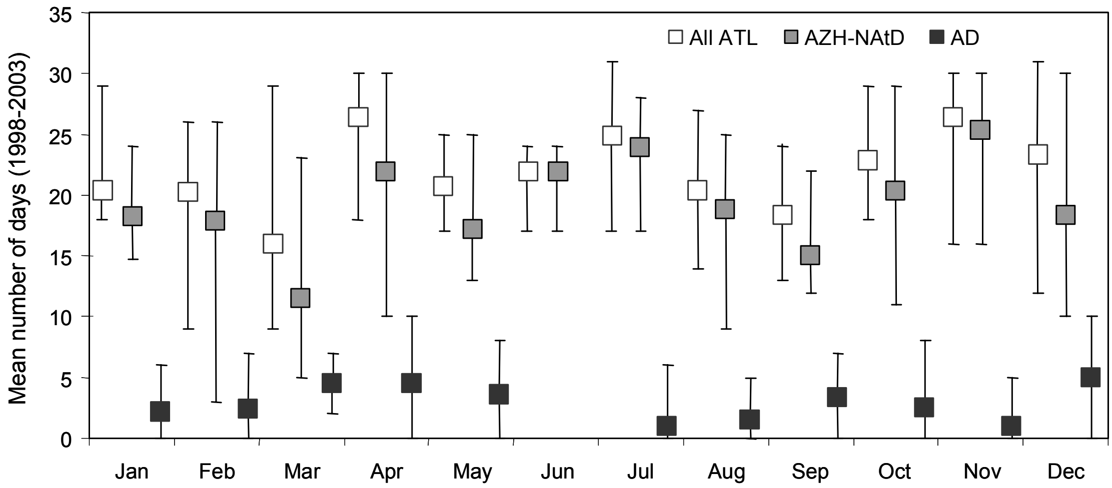

Figure Ap.3. Mean number of days with Atlantic advection over Northwestern Iberian Peninsula per month for 1998-2003. AZH-NAtD and AD episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

A shown in Figure Ap.3, there are months in which the maximum number of days with Atlantic advection is equal to the number of days of such month. Consequently, in one or more years of the study period (1998-2003), during that month, Atlantic advection occurred everyday (April, July, November and December). This happened also in particular for AZH-NAtD episodes for April and November. The only month in which days with Atlantic advection of the type AD were always present was March whereas AZH-NAtD events occurred all the months of the period 1998-2003 in Northwestern Iberian Peninsula.

The duration of Atlantic episodes over Northwestern Iberia in April and June-November (maximum mean duration of Atlantic episodes in July, October and November with 9 days per episode respectively, Figure Ap.4). In March, the mean duration of Atlantic episodes only reached 5 days per episode (Figure Ap.4). AZH-NAtD periods had a higher duration than AD periods. April. July and September-November were the months in which AZH-NAtD episodes lasted the most (mean duration of 11 days per episode in April and in October, Figure Ap.4) whereas for in May and August-September the longest AD events were recorded (average of 5 days per episode in August and in September, Figure Ap.4). Minimum durations of AZH-NAtD events were registered in March (mean duration of 5 days per AZH-NAtD episode, Figure Ap.4).

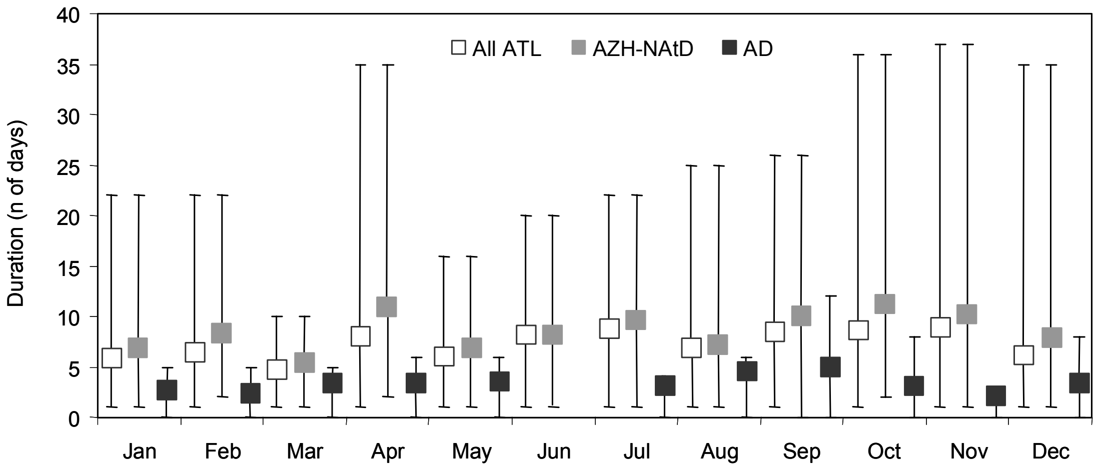

Figure Ap.4. Mean duration of Atlantic episodes per month over Northwestern Iberian Peninsula for 1998-2003. AZH-NAtD and AD episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

Considering only the days with Atlantic influence over Northwestern Spain in the period 1998-2003, mean TSP levels of 14 µg m^{-3} in Noia, 24 µg m^{-3} in Niembro and 16 µg m^{-3} in O Saviñao were recorded. From 2001 to 2003 the mean PM10 and PM2.5 levels registered in O Saviñao were 11 and 7 µg m^{-3} and, in Niembro, 16 and 8 µg m^{-3} (Table Ap.4). Thus, PM levels recorded during Atlantic events were lower than the average. A higher frequency of rain episodes associated with the passage of frontal systems during Atlantic transport and the renewal of air masses can explain the low levels registered during Atlantic episodes.

Table Ap.4. Mean annual levels of TSP, PM10 and PM2.5 registered in Noia, Niembro and O Saviñao during Atlantic advection episodes in 1998-2003.

ATL EPISODES	**Noia**	**Niembro**			**O Saviñao**		
($\mu g\ m^{-3}$)	TSP	TSP	PM10	PM2.5	TSP	PM10	PM2.5
1998	15	na	na	na	na	na	na
1999	13	26	na	na	na	na	na
2000	*[1]14	25	na	na	na	na	na
2001	na	22	*[2]16	*[2]8	17	*[2]12	*[2]9
2002	na	25	16	8	15	10	7
2003	na	na	16	9	na	10	6
Mean 98-03	14	24	16	8	16	11	7

*[1]Calculated with data of 50% of the months of the year
*[2]Calculated with data of 83% of the months of the year
na: Not available

The two transport scenarios considered for Atlantic episodes had different impact on PM levels. PM levels during AZH-NAtD events were superior to the levels recorded during Atlantic AD episodes. This stood for all size ranges. Utilising only data from Noia and O Saviñao, during AZH-NAtD events TSP mean values reached 14 and 16 $\mu g\ m^{-3}$ in Noia and O Saviñao respectively, whereas during AD episodes mean values of 14 and 11 $\mu g\ m^{-3}$ were obtained respectively in these two stations. Mean PM10 levels in O Saviñao were 11 and 8 $\mu g\ m^{-3}$ for AZH-NAtD and AD episodes respectively. Mean annual PM2.5 levels in O Saviñao were 7 $\mu g\ m^{-3}$ for Atlantic episodes of AZH-NAtD type and 5 $\mu g\ m^{-3}$ for AD episodes. Furthermore, if we combine information about the mean number of days and the PM mean levels of into an impact index (II=mean n of days per year influenced by each type of scenario multiplied by the mean PM levels for each scenario in the whole period 1998-2003 and divided by 365 days) we can evaluate the impact of each transport scenario on PM levels in different size ranges. II gives us information about the contribution (in concentration units) of each type of transport scenario and each type of episode on the mean levels of PM recorded at a certain site. For AZH-NAtD episodes in O Saviñao II had values of 10.0, 6.9 and 4.6 $\mu g\ m^{-3}$ in TSP, PM10 and PM2.5 respectively and 9.0 $\mu g\ m^{-3}$ in TSP in Noia. We then must interpret that the contribution of AZH-NAtD episodes to the total PM10 mean, for example, in O Saviñao (14 $\mu g\ m^{-3}$) is 6.9 $\mu g\ m^{-3}$. For AD events, associated with lower PM levels and less frequency of occurrence, II had the following values: 1.2 and 0.9 $\mu g\ m^{-3}$ in TSP in Noia and O Saviñao respectively, 0.6 $\mu g\ m^{-3}$ in PM10 and 0.4 $\mu g\ m^{-3}$ in PM2.5 (these two for O Saviñao, Table Ap.5). In conclusion, the impact of AZH-NAtD events on PM levels in Northwestern Iberia is higher than the impact of AD episodes.

Table Ap.5. Number of days with Atlantic advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 ($\mu g\ m^{-3}$) recorded at Noia and O Saviñao rural sites (NW Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	AZH-NAtD	AD
2003		
O Saviñao TSP ($\mu g\ m^{-3}$)	-	-
O Saviñao PM10 ($\mu g\ m^{-3}$)	10	7
O Saviñao PM2.5 ($\mu g\ m^{-3}$)	7	4
Days	178	48
2002		
O Saviñao TSP ($\mu g\ m^{-3}$)	16	12
O Saviñao PM10 ($\mu g\ m^{-3}$)	10	7
O Saviñao PM2.5 ($\mu g\ m^{-3}$)	7	5
Days	240	22
2001		
O Saviñao TSP ($\mu g\ m^{-3}$)	17	13
O Saviñao PM10 ($\mu g\ m^{-3}$)	12	10
O Saviñao PM2.5 ($\mu g\ m^{-3}$)	9	8
Days	232	21
2000		
Noia TSP* ($\mu g\ m^{-3}$)	14	14
Days*	86	23
1999		
Noia TSP ($\mu g\ m^{-3}$)	13	12
Days	243	27
1998		
Noia TSP ($\mu g\ m^{-3}$)	15	15
Days	237	25
Mean 98-03 ($\mu g\ m^{-3}$)		
Noia TSP	14	14
O Saviñao TSP	16	11
O Saviñao PM10	11	8
O Saviñao PM2.5	7	5
Impact Index (II) ($\mu g\ m^{-3}$)		
Noia TSP	9.0	1.2
O Saviñao TSP	10.0	0.9
O Saviñao PM10	6.9	0.6
O Saviñao PM2.5	4.6	0.4

*Data in Noia only available until 06/2000.

The monthly PM means were higher for the AZH-NAtD than for the AD scenario in all the months. For the case of AZH-NAtD scenario at O saviñao, the mean PM values ranged from 10 to 23 $\mu g\ m^{-3}$ for TSP, from 7 to 14 $\mu g\ m^{-3}$ for PM10 and from 4 to 10 $\mu g\ m^{-3}$ for PM2.5 (Table Ap.6). As AD scenario regards, TSP levels in O Saviñao ranged between 9 and 15 $\mu g\ m^{-3}$, PM10 levels ranged from 5 to 10 $\mu g\ m^{-3}$ and PM2.5 levels ranged between 2 and 6 $\mu g\ m^{-3}$ (Table Ap.6). Levels of PM in all size ranges were generally higher during summer Atlantic episodes (June and September). This occurred for the two types of scenarios distinguished probably due to a lower frequency of rain episodes associated with Atlantic transport. For example, mean PM10 levels in O Saviñao during AZH-NAtD episodes ranged from 13 to 14 μg m^{-3} in summer and from 7 to 10 μg m^{-3} in the period December-March (Table Ap.6). PM10 levels in the same station but during AD events ranged from 8 to 10 μg m^{-3} in June-September and from 6 to 7 μg m^{-3} in the period January-May (Table Ap.6). Mean PM levels during Atlantic episodes in April were found to be generally high and also December registered Atlantic events with higher than the average impact on PM levels (Table Ap.6).

Table Ap.6. Number of days per month with Atlantic advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (μg m^{-3}) recorded at O Saviñao rural site (NW Spain) for those days.

	AZH-NAtD	AD		AZH-NAtD	AD
January			**July**		
Days per month	18.2	2.2	Days per month	23.8	1.0
TSP	10		TSP	17	
PM10	7	7	PM10	14	
PM2.5	4	4	PM2.5	10	
February			**August**		
Days per month	17.8	2.3	Days per month	18.8	1.5
TSP	13		TSP	18	
PM10	9	6	PM10	13	10
PM2.5	5	4	PM2.5	9	5
March			**September**		
Days per month	11.5	4.5	Days per month	15.0	3.3
TSP	12	9	TSP	23	12
PM10	9	6	PM10	14	8
PM2.5	6	4	PM2.5	10	6
April			**October**		
Days per month	21.8	4.5	Days per month	20.3	2.5
TSP	22	14	TSP	13	15
PM10	11	7	PM10	9	8
PM2.5	8	5	PM2.5	5	4
May			**November**		
Days per month	17.2	3.3	Days per month	25.3	1.0
TSP	15	10	TSP	12	
PM10	10	7	PM10	9	5
PM2.5	6	3	PM2.5	5	2
June			**December**		
Days per month	21.8	0.0	Days per month	18.3	5.0
TSP	20		TSP	16	12
PM10	13		PM10	10	9
PM2.5	9		PM2.5	7	6

1.2. African episodes

67 African dust outbreaks occurred from 1998 to 2003 over Northwestern Iberian Peninsula. The averages were 11 events per year and 1 per month. The mean duration of African episodes in Northwestern Iberia was 3 days. These 67 episodes resulted in 182 days with African dust outbreaks (30 days per year, 3 days per month, Table Ap.7).

From the 67 African episodes 17 (25%) occurred under a NAH-S meteorological scenario (transport scenario caused by the placement of an anticyclone over the Iberian Peninsula at surface level). Thus, 3 NAH-S events were recorded per year as annual

mean. The number of days with African advection in which NAH-S scenario was present was 53 (29% of the total days with African advection). 9 days per year and 1 day per month are the annual and monthly mean occurrences of NAH-S days (Table Ap.7). The mean duration of a NAH-S event was 3 days.
19 AD (Atlantic depression in front of Portugal) episodes (28% of the African events) occurred in the study period, that is, a mean of 3 episodes per year (Table Ap.7) with a mean duration of 2 days per episode. These events resulted in 44 days with African transport originated by AD scenario (24% of the days with African advection). The mean annual number of AD days in the study period was 7 days per year (Table Ap.7).
15% of the African episodes (2 episodes per year, Table Ap.7) was caused by the NAD scenario (presence of a depression centred over Northern Africa or over the Western Mediterranean Sea). These events had a mean length of 2 days per episode. The number of days grouped in those episodes was 25 days (14% of the total number of days with African episodes in 1998-2003, 4 days per year, Table Ap.7).
Finally, the remaining 21 African episodes corresponded to NAH-A events (caused by an anticyclone located over Northern Africa but at the upper levels of the atmosphere). This constituted 31% of the African episodes. As an average, 4 NAH-A episodes per year occurred in the study period. These events had a mean extent of 3 days. The number of days with African advection over Northwestern Iberia originated by a NAH-A scenario was 60 (33% of the total number of days with African advection, 10 days per year, 1 day per month, Table Ap.7).
The number of African episodes per year recorded in Northwestern Iberia ranged from 15 (2001 and 2002) to 5 (1999). The years with the highest abundance of episodes were 2000 and 2002 (5 episodes) for the case of NAH-S, 2001 for AD and NAH-A events (5 and 6 episodes respectively) and 2003 for NAD events (4 episodes). The lowest abundance of episodes was 1999 and 2001 for NAH-S episodes (1 event), 1999 for AD episodes (1 event) and 1998, 1999 and 2000 for NAD events (2 episodes). In 1998 no NAD event was recorded (Table Ap.7).
The maximum number of days with African advection was registered in 2003 (44 days) and the minimum was registered in 1999 (10 days). The highest and the lowest number of African days of NAH-S type were 16 (in 2002) and 2 (in 2001) respectively. These extremes for AD episodes were 14 (in 2001) and 2 (in 1999) days respectively. In 2003, 11 NAD African days and 18 NAH-A African days were recorded while in 2000 only 3 NAH-A African days were registered. As exposed above no NAD episode was recorded in 1998.

Table Ap.7. Annual number of days and episodes with African advection in the period 1998-2003 over Northwestern Iberian Peninsula. The NAH-S, AD, NAD and NAH-A scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total NAF	26	10	24	40	38	44	30	3
NAH-S	14	3	14	2	16	4	9	1
AD	5	2	6	14	6	11	7	1
NAD	0	1	1	9	3	11	4	<1
NAH-A	7	4	3	15	13	18	10	1
Episodes								
Total NAF	7	5	12	15	15	13	11	1
NAH-S	3	1	5	1	5	2	3	<1
AD	2	1	4	5	4	3	3	<1
NAD	0	1	1	3	1	4	2	<1
NAH-A	2	2	2	6	5	4	4	<1

Although African events occurred in all the months, dust outbreaks over Northwestern Iberia were registered mostly in two main periods, January-March (25 events out of the 67 events recorded in 1998-2003 over the region, Figure Ap.5) and May-June (18 episodes, Figure Ap.5). April, July (with 1 episode on each month for 1998-2003) and September (with 2 episodes in the study period) registered the lowest frequency. The number of African episodes was also high in October with 7 events in the study period. NAH-S episodes were exclusively registered in the period January-March with the exception of one episode recorded in September. In February the total number of NAH-S events registered reached to 7 episodes (Figure Ap.5). AD events were not present in summer months and there was a clear prevalence of occurrence of such episodes in the period October-March with the maximum numbers in December and January (4 AD episodes, Figure Ap.5). NAD episodes occurred mainly in May (5 events, Figure Ap.5). NAH-A were uniquely restricted to the period May-June. June with 10 NAH-A events and August with 5 were the months with a higher frequency of occurrence of such episodes (Figure Ap.5).

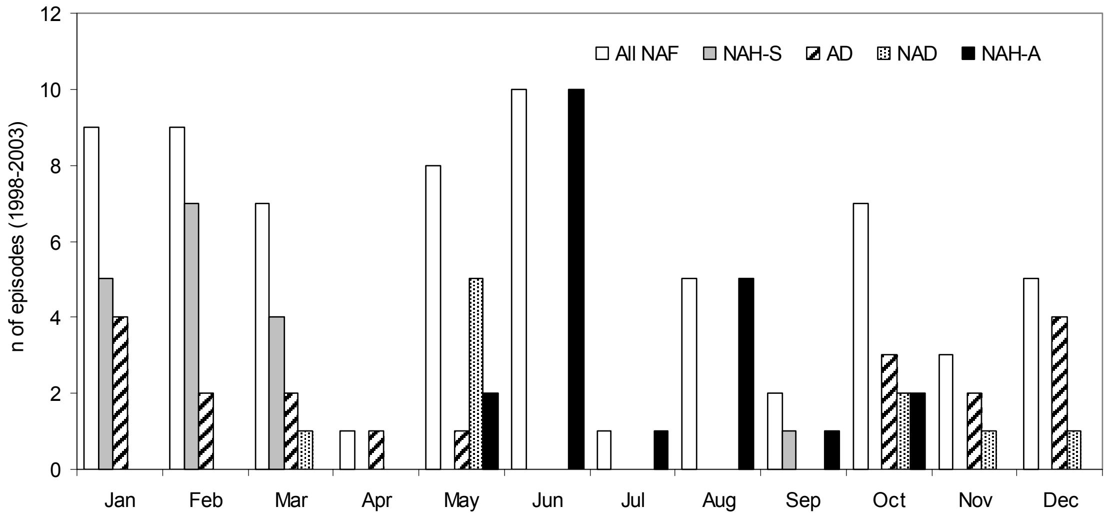

Figure Ap.5. Monthly distribution of the number of African episodes over Northwestern Iberian Peninsula. The monthly distributions of NAH-S, AD, NAD and NAH-A African events are also shown.

As the number of days with African advection regards, the monthly distribution of this variable follows the same patterns as the monthly distribution of the number of African episodes (Figures Ap.6 and Ap.7). Peak frequency was found in January-March (5 days as the mean for March) and in May-June (5 days as average for June). In August and October days with African advection were also frequent. As shown above for the distribution of African episodes, April (only 2 days in the period 1998-2003) and July and September (3 days in 1998-2003 on each of these months) marked the minima in the monthly distribution of days with African advection (Figures Ap.6 and Ap.7). Days with NAH-S situation particularly frequent in February and March (averages of 3 NAH-S days in both months, Figure Ap.7). Days with African advection occurred under AD scenario were more frequent in October- March with maximum frequency in March (2 days as a mean in this month, Figure Ap.7). Days with African advection of NAD type were present mainly in May with 12 days in total and an average of 2 days per year in that month (Figures Ap.6 and Ap.7). Finally, NAH-A African days were frequent in June and August (5 and 3 NAH-A days on average in those months).

It is important to note that although African episodes occurred at least once in all the months of the year, all the months were devoid of African events at least once in the study period (Figure Ap.7).

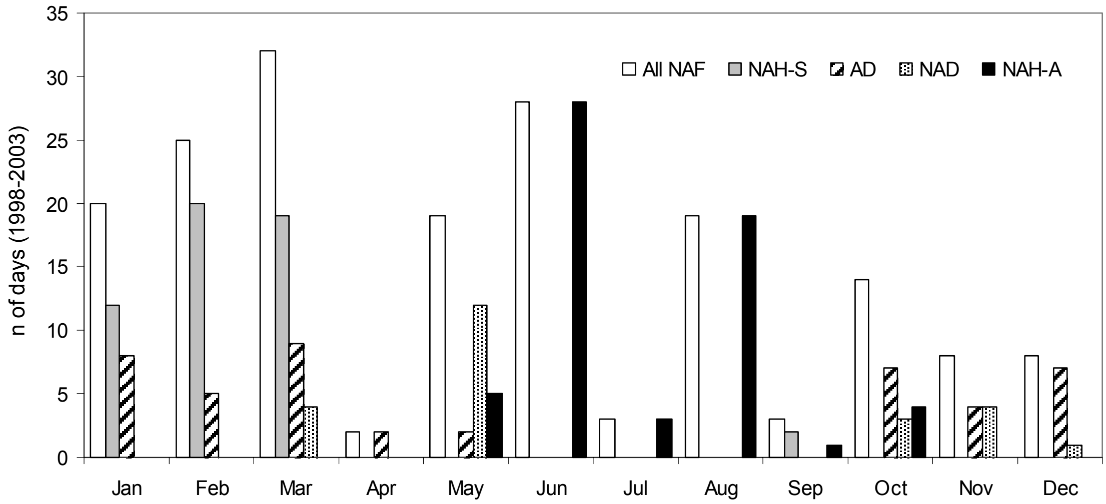

Figure Ap.6. Monthly distribution of the number of days with African advection over Northwestern Iberian Peninsula. The monthly distributions of days with African advection occurred under NAH-S, AD, NAD and NAH-A scenarios are also shown.

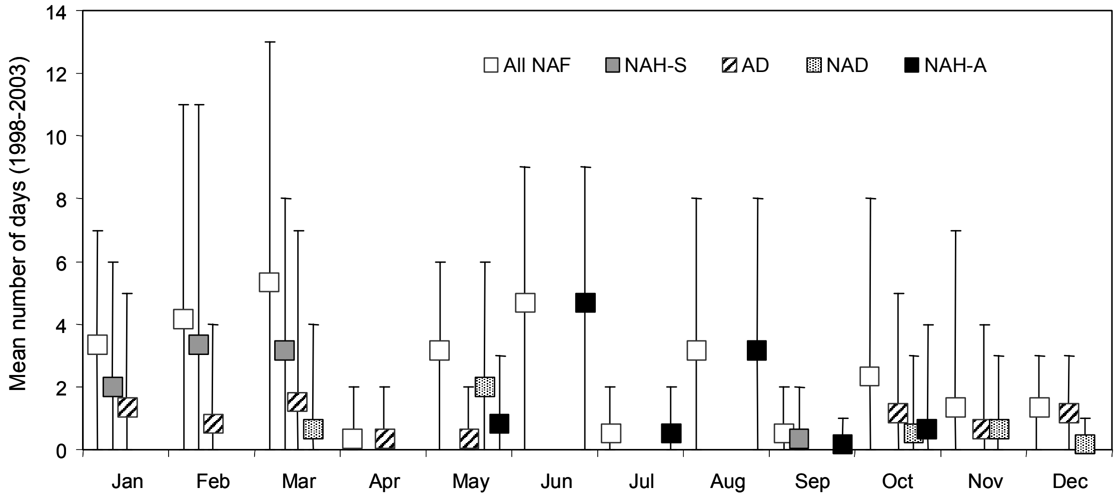

Figure Ap.7. Mean number of days with African advection over Northwestern Iberian Peninsula per month for 1998-2003. NAH-S, AD, NAD and NAH-A episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

The seasonal distribution of the duration of African events showed three-modal behaviour with peaks in March, August and a secondary peak in November. On average, the longest African episodes were recorded in March (5 days per episode). The episodes in March were the longest regardless the type of scenario which caused them, this is, the highest mean duration of NAH-S episodes (5 days per episode), AD episodes (5 days per episode) and NAD episodes (4 days but in a single episode) were recorded in March (Figure Ap.8). In addition NAD events also had a mean duration of 4 days although again in a single episode in November (Figure Ap.8). In August, when only NAH-A events were registered also African episodes (in this case NAH-A episodes) had a long duration (4 days per episode, Figure Ap.8)

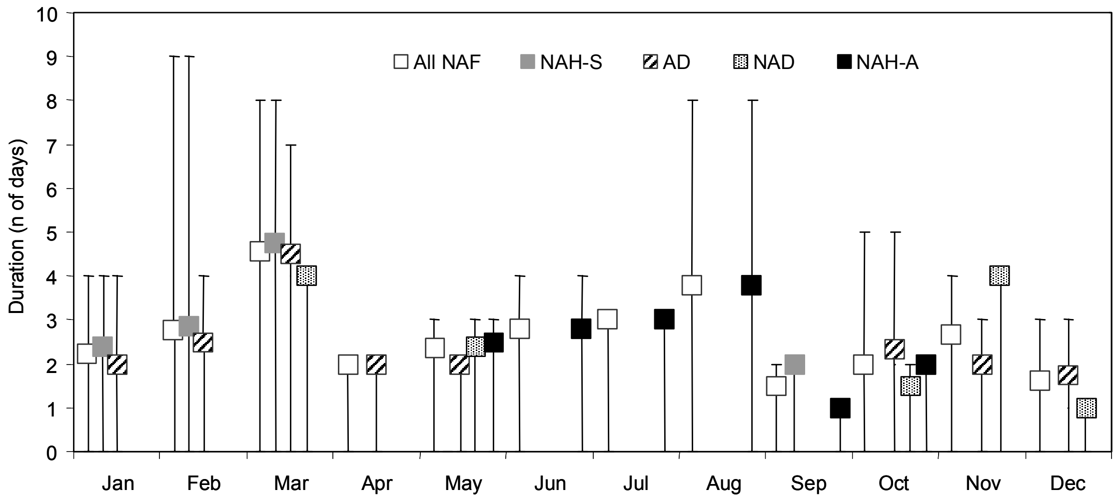

Figure Ap.8. Mean duration of African episodes per month over Northwestern Iberian Peninsula for 1998-2003. NAH-S, AD, NAD and NAH-A episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

If we restrict our attention only to the days with African dust outbreaks we can observe a clear impact on PM levels registered in rural stations of Northwestern Iberia. This can be generalised for all size ranges. Thus, the average PM levels in O Saviñao for the period 1998-2003 reached 37, 28 and 18 µg m^{-3} for TSP, PM10 and PM2.5 respectively (Table Ap.8). In the period 1998-2003, at Noia, the annual mean TSP levels registered during African dust outbreaks reached 30 µg m^{-3} (Table Ap.8). In Niembro, where PM levels recorded were generally higher than in the other two rural stations annual TSP (40 µg m^{-3}), PM10 (31 µg m^{-3}) and PM2.5 (18 µg m^{-3}) mean levels during African events were also elevated (Table Ap.8). These mean values are considerably higher than the mean values considering the complete time series and, obviously, considering only Atlantic episodes (see Tables Ap.8 and Ap.2). This influence is important not only in TSP and PM10 coarse size ranges but also in PM2.5.

Table Ap.8. Mean annual levels of TSP, PM10 and PM2.5 registered in Noia, Niembro and O Saviñao during African advection episodes in 1998-2003.

NAF EPISODES	**Noia**	**Niembro**			**O Saviñao**		
(µg m^{-3})	TSP	TSP	PM10	PM2.5	TSP	PM10	PM2.5
1998	29	na	na	na	na	na	na
1999	18	40	na	na	na	na	na
2000	*[1]34	40	na	na	na	na	na
2001	na	42	*[2]34	*[2]20	38	*[2]29	*[2]21
2002	na	39	27	15	35	24	15
2003	na	na	33	18	na	31	18
Mean 98-03	30	40	31	18	37	28	18

*[1]Calculated with data of 50% of the months of the year
*[2]Calculated with data of 83% of the months of the year
na: Not available

The four transport scenario distinguished for African events had different impact on PM levels. During NAH-A and NAH-S events the mean PM levels were higher than during the other two episodes AD and NAD. The two anticyclonic scenarios had higher mean levels in all size ranges. This reflects the fact of the low occurrence of rain associated with these two scenarios. Furthermore, during NAH-A situations the African plumes travel at high altitudes (>1500 m.a.s.l.) and the dust penetrates in the mixing layer because the vertical development of this layer can reach up to 2500 metres over continental areas in summer (Crespi et al., 1995). Once into the boundary layer the dust is distributed and affects the sampling stations. The formation of secondary particles by the photochemical transformation of gaseous precursors is enhanced during NAH-A situations due to the intense insolation in summer and because, at surface, a low pressure gradient remains causing lack of advective conditions. In these circumstances, superficial air masses are hardly renovated and the aging of contaminated air masses is frequent. Furthermore, during NAH-A episodes, precipitation is reduced and re-suspension of soil material by convection is enhanced. This factors result in a local contribution of PM. Mean TSP levels in Noia reached 34 and 29 $\mu g\ m^{-3}$ for NAH-S and NAH-A events respectively and 17 and 5 $\mu g\ m^{-3}$ for AD and NAD (Table Ap.9). However, this very low mean obtained for NAD scenarios was not representative because only one single value was available to work it out. In O Saviñao, mean TSP levels were superior for NAH-S and NAH-A (40 $\mu g\ m^{-3}$) than those registered during AD and NAD (26 and 34 $\mu g\ m^{-3}$ respectively, Table Ap.9). PM10 and PM2.5 mean levels in O Saviñao were also higher during the anticyclonic transport scenarios. PM10 means reached 33, 29, 25 and 21 $\mu g\ m^{-3}$ for NAH-A, NAH-S, AD and NAD scenarios respectively. As PM2.5 means concerns NAH-A scenario reached an average of 25 $\mu g\ m^{-3}$ while the other three scenarios only reached 16 $\mu g\ m^{-3}$ (NAH-S scenario) and 12 $\mu g\ m^{-3}$ (for both AD and NAD scenarios). The higher PM levels obtained during anticylonic conditions can be explained by the lower frequency of rain episodes associated with these types of episodes than with AD and NAD events. It is important to note that, as the size range decreases, the impact of NAH-A dust outbreaks is higher with respect to the other scenarios included NAH-S. Thus, PM10 and PM2.5 mean levels during NAH-A episodes were higher than during NAH-S but TSP mean levels were alike during these two transport scenarios. This can be explained by the influence of the photochemical processes which generate fine secondary particles and/or favour the growth of secondary particles by heterogeneous reactions of gaseous pollutants with mineral dust (Krueger et al., 2004). NAH-S episodes occur in winter when these processes are greatly reduced compared to summer. The values of II (impact index as defined above) obtained for African episodes of all types were not high due to the relatively low frequency of occurrence of these events although the PM levels registered were high. In general for all size ranges NAH-A scenario had the highest impact but in TSP NAH-S scenario had the same impact index II=0.8 $\mu g\ m^{-3}$ in Noia and in O Saviñao (Table Ap.9). In PM10 and PM2.5 the impact of NAH-A (II of 0.9 and 0.7 $\mu g\ m^{-3}$ respectively) is higher than the impact of NAH-S (II of 0.7 and 0.4 $\mu g\ m^{-3}$ respectively). Finally the impact of the scenarios associated with depressions AD and NAD was reduced in all size ranges (Table Ap.9).

Table Ap.9. Number of days with African dust outbreaks occurred under the 4 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 ($\mu g\ m^{-3}$) recorded at Noia and O Saviñao rural sites (NW Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	NAH-S	**AD**	**NAD**	**NAH-A**
2003				
O Saviñao TSP ($\mu g\ m^{-3}$)	-	-	-	-
O Saviñao PM10 ($\mu g\ m^{-3}$)	30	34	17	39
O Saviñao PM2.5 ($\mu g\ m^{-3}$)	14	14	9	27
Days	4	11	11	18
2002				
O Saviñao TSP ($\mu g\ m^{-3}$)	40	21	22	36
O Saviñao PM10 ($\mu g\ m^{-3}$)	29	11	14	26
O Saviñao PM2.5 ($\mu g\ m^{-3}$)	16	6	10	19
Days	16	6	3	13
2001				
O Saviñao TSP ($\mu g\ m^{-3}$)	-	28	38	45
O Saviñao PM10 ($\mu g\ m^{-3}$)	-	22	28	32
O Saviñao PM2.5 ($\mu g\ m^{-3}$)	-	13	16	28
Days	2	14	9	15
2000				
Noia TSP* ($\mu g\ m^{-3}$)	40	17	-	-
Days*	14	5	0	0
1999				
Noia TSP ($\mu g\ m^{-3}$)	-	-	5	22
Days	3	2	1	4
1998				
Noia TSP ($\mu g\ m^{-3}$)	29	18	-	-
Days	14	5	0	7
Mean 98-03 ($\mu g\ m^{-3}$)				
Noia TSP	34	17	5	29
O Saviñao TSP	40	26	34	40
O Saviñao PM10	29	25	21	33
O Saviñao PM2.5	16	12	12	25
Impact Index(II) ($\mu g\ m^{-3}$)				
Noia TSP	0.8	0.3	0.1	0.8
O Saviñao TSP	1.0	0.5	0.4	1.1
O Saviñao PM10	0.7	0.5	0.2	0.9
O Saviñao PM2.5	0.4	0.2	0.1	0.7

*Data in Noia only available until 06/2000.

The highest monthly means for TSP in O Saviñao during African dust outbreaks were registered in summer (June-September) under the influence of NAH-A episodes ranging from 39 to 82 $\mu g\ m^{-3}$. Very high TSP mean levels were also recorded under NAH-S situations in March (67 $\mu g\ m^{-3}$) and in October caused by NAD events (44 $\mu g\ m^{-3}$). High PM10 means were also found in May-September (from 27 to 70 $\mu g\ m^{-3}$) with NAH-A events but, comparable to those were the mean PM10 levels registered in March and September for NAH-S events (43 and 33 $\mu g\ m^{-3}$), in January, March and November during AD episodes (27, 27 and 41 $\mu g\ m^{-3}$ respectively) and in October with NAD situations (37 $\mu g\ m^{-3}$). PM2.5 mean levels were particularly high during summer (May-September) episodes (NAH-A) with values from 19 to 57 $\mu g\ m^{-3}$ and also in March and September during NAH-S events with 21 and 20 µg m^{-3} of PM2.5 means (Table Ap.10).

Table Ap.10. Number of days per month with Atlantic advection occurred under the 4 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (all units in µg m^{-3}) recorded at O Saviñao rural site (NW Spain) for those days.

	NAH-S	AD	NAD	NAH-A		NAH-S	AD	NAD	NAH-A
January					**July**				
Days per month	0.8	0.7	0.0	0.0	Days per month	0.0	0.0	0.0	0.2
TSP	24	36			TSP				39
PM10	18	27			PM10				27
PM2.5	13	11			PM2.5				19
February					**August**				
Days per month	1.2	0.3	0.0	0.0	Days per month	0.0	0.0	0.0	0.8
TSP	20				TSP				49
PM10	19				PM10				40
PM2.5	10	4			PM2.5				32
March					**September**				
Days per month	0.7	0.3	0.2	0.0	Days per month	0.2	0.0	0.0	0.2
TSP	67	7			TSP				82
PM10	43	27	25		PM10	33			70
PM2.5	21	17	12		PM2.5	20			57
April					**October**				
Days per month	0.0	0.2	0.0	0.0	Days per month	0.0	0.5	0.3	0.3
TSP					TSP		32	44	
PM10					PM10		18	37	
PM2.5					PM2.5		11	10	
May					**November**				
Days per month	0.0	0.2	0.8	0.3	Days per month	0.0	0.3	0.2	0.0
TSP			30	28	TSP				
PM10			19	28	PM10		41	16	
PM2.5			14	21	PM2.5		12	9	
June					**December**				
Days per month	0.0	0.0	0.0	1.7	Days per month	0.0	0.7	0.2	0.0
TSP				37	TSP		25		
PM10				28	PM10		18	9	
PM2.5				21	PM2.5		8	6	

1.3. European episodes

A total of 67 episodes of advection of European air masses were registered in Norwestern Iberian Peninsula in 1998-2003 (11 episodes per year and 1 per month). The average extent of these episodes was 3 days per episode. The number of days with European advection over the Norhwestern region of Iberia was 227 resulting in mean values of 38 days per year and 3 days per month (Table Ap.11).

64% of the 67 European episodes (43 episodes) occurred under a synoptic scenario of EUH type (characterised by the presence of an anticyclone located over the European continent or over the Northern Atlantic). This meant 7 EUH European episodes per year (Table Ap.11). In the period 1998-2003, 68% of the 227 days with European advection (154 days) the EUH synoptic scenario occurred. This resulted in 26 days per year and 2 days per month (Table Ap.11). EUH European events had a mean duration of 4 days per episode.

The remaining 24 European events (36% of the European episodes) and 73 days with European advection (32 % of the days with European advection) occurred under MD synoptic situations (which occur when a depression is located over the Western Mediterranean). Thus, the averages for the period 1998-2003 were: 4 MD European episodes per year, 12 days per year and 1 days per month with European advection caused by MD synoptic situations (Table Ap.11). The mean length of the European MD events was 3 days per episode.

The number of days with European advection recorded in a year was maximum in 1999 and 2003 with 44 days (Table Ap.11). The maximum number of EUH European days was recorded in 1998 (33, Table Ap.11) and the maximum number of days with European advection under MD scenario was recorded in 1999 and 2002 (18, Table Ap.11). As shown in Table Ap.11, in 2000 the number of days with European advection registered was minimum for all events (20), for EUH events (18) and for MD episodes (2).

As for the number of days, the number of European of events registered in 2000 was minimum for all episodes (5 EU episodes, 4 EUH episodes and 1 MD episode, Table Ap.11). The maximum number of EU and MD events was recorded in 2003 (15 EU events and 7 MD events, Table Ap.11). As regards EUH episodes, the highest number of events occurred in 1999 and 2001 (9, Table Ap.11).

Table Ap.11. Annual number of days and episodes with European advection in the period 1998-2003. The EUH and MD scenarios are distinguished.

	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**Annual mean 98-03**	**Monthly mean**
Days								
Total EU	40	44	20	40	39	44	38	3
EUH	33	26	18	32	21	24	26	2
MD	7	18	2	8	18	20	12	1
Episodes								
Total EU	10	14	5	13	10	15	11	1
EUH	7	9	4	9	6	8	7	1
MD	3	5	1	4	4	7	4	<1

The highest frequency of occurrence of European episodes was registered in January-April with other months of secondary maximums such as July, September and November. The maximum number of European events was registered in March (8 episodes in 1998-2003, Figure Ap.9). The lowest frequency of occurrence was found in June (2 European episodes in 1998-2003, Figure Ap.9). EUH episodes showed a higher than average frequency in January-March, July-September and November and low frequency of occurrence in April-June and October. February and March were the months with highest frequency of occurrence of EUH episodes (6 during the study period, Figure Ap.9) and April and October the months with lowest frequency (1 in the whole study period, Figure Ap.9). The MD events occurred principally in April-May but these were also frequent in October-November (maximum number of events, 8, recorded in April for 1998-2003, Figure Ap.9). MD events were not common in winter and summer (no MD episodes were recorded in June in the whole period, Figure Ap.9).

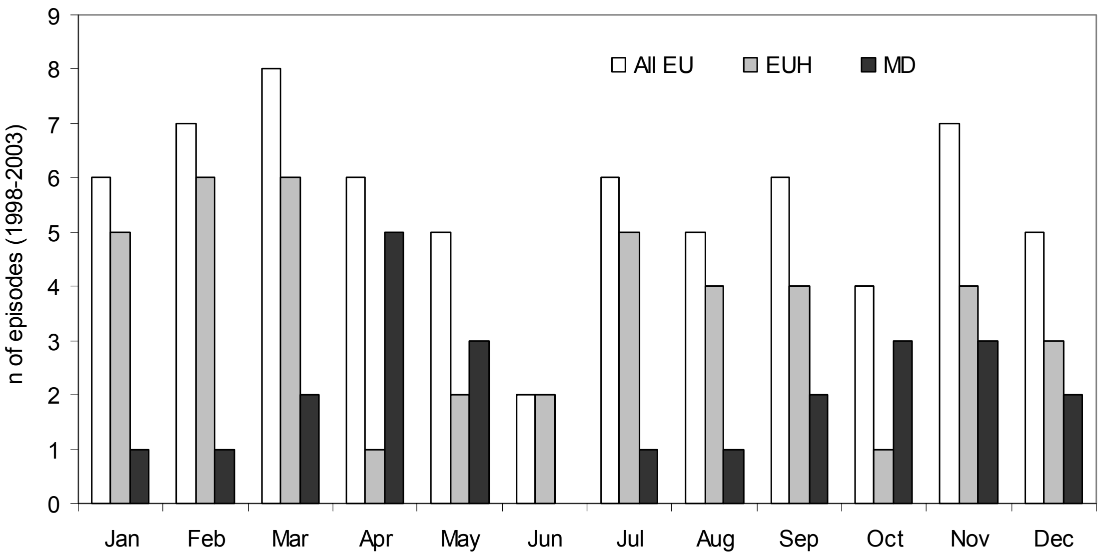

Figure Ap.9. Monthly distribution of the number of European episodes over Northwestern Iberian Peninsula. The monthly distribution of EUH and MD European events is also shown.

The monthly distribution of days with European advection is similar to the monthly distribution of European episodes detailed above. In general, days with European advection occurred principally from November to April and in September. July had a high frequency of European episodes but a low frequency of European advection days (Figures Ap.10 and Ap.11). March with a mean of 5 days is the month with the highest frequency of occurrence of European days (Figure Ap.11). The days with European advection were scarce in June (only 5 days in the whole period, Figure Ap.10), in the rest of the summer and in October (Figures Ap.10 and Ap.11). High frequency of occurrence of European advection days caused by synoptic situations of the type EUH were registered from January to March and in September whereas from April to August and in October the frequency was relatively lower (Figures Ap.10 and Ap.11). March (4 days as a mean, Figure Ap.11) and October (less than 1 day on average, Figure Ap.11) registered the highest and the lowest monthly mean number of days respectively. The highest monthly average of the number of MD April and November-December were the periods when the occurrence of days with European advection of the type MD is greater than the average. The highest mean number of MD European advection days was recorded in April (3 days, Figure Ap.11).

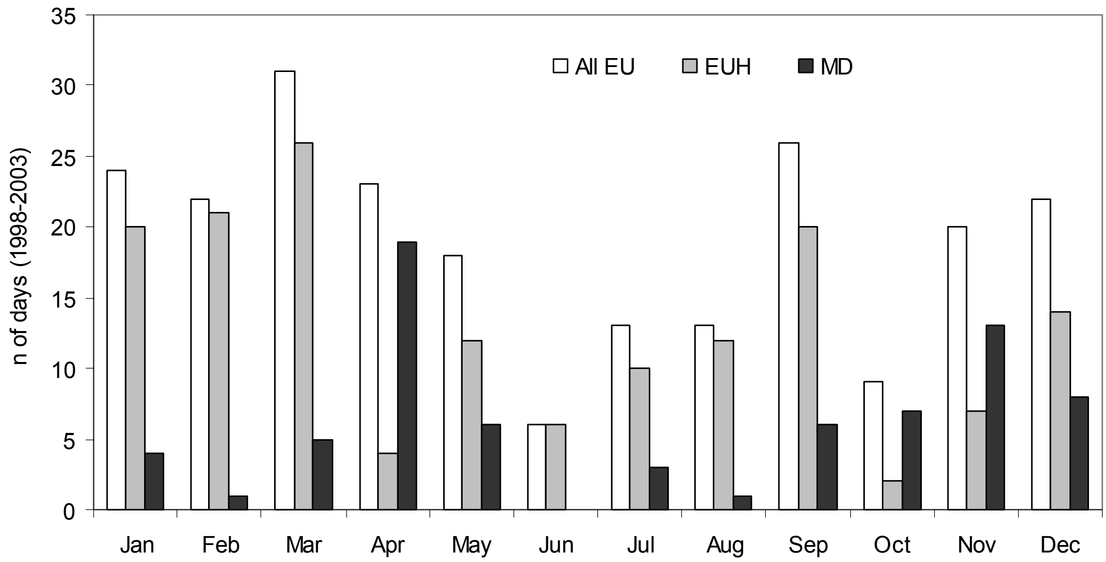

Figure Ap.10. Monthly distribution of the number of days with European advection over Northwestern Iberian Peninsula. The monthly distribution of days with European advection occurred under EUH and MD scenarios is also shown.

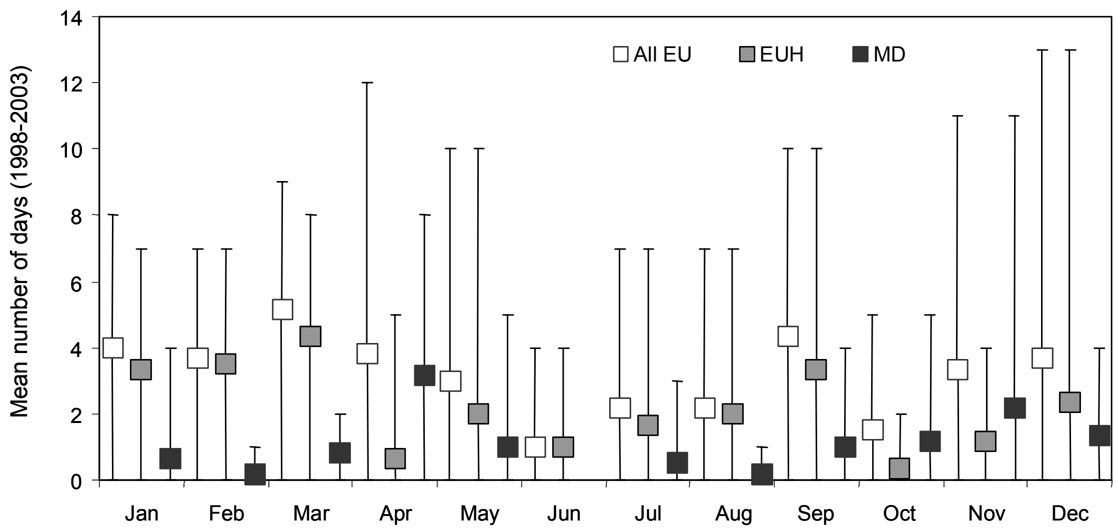

Figure Ap.11. Mean number of days with European advection over Northwestern Iberian Peninsula per month for 1998-2003. EUH and MD episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

The European episodes registered in the study period (1998-2003) reached the highest mean durations in from December to May and in September (Figure Ap.12) this behaviour is the same for EUH European episodes. MD European episodes were longer in November-January and April (Figure Ap.12). The mean duration of European events is low in summer, with the exception of September. The highest mean duration of European events were recorded in December-Enero, March-May and September for all EU episodes (4 days per episode, Figure Ap.12), May for EUH episodes (6 days per episode, Figure Ap.12) and November-January and April for MD episodes (4 days per episode, Figure Ap.12).

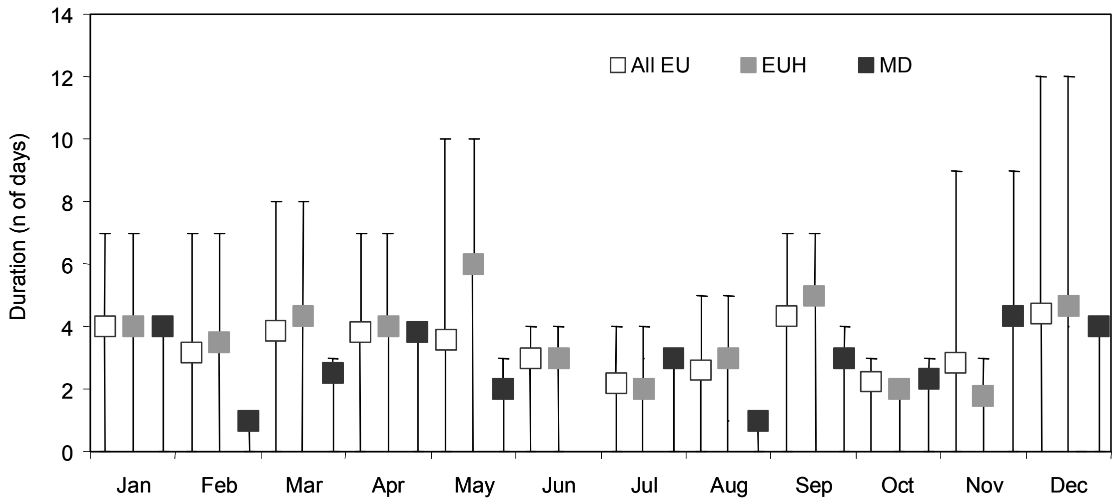

Figure Ap.12. Mean duration of European episodes per month over Northwestern Iberian Peninsula for 1998-2003. EUH and MD episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

As shown in Table Ap.12, mean PM levels recorded during European episodes in regional background stations over Northwestern Iberia in 1998-2003 were moderately high when compared with the annual levels. In Noia, mean TSP reached 24 µg m^{-3}, in Niembro 32 µg m^{-3} and in O Saviñao 29 µg m^{-3}. Mean annual PM10 levels for these sites ranged from 23 µg m^{-3} in Niembro to 20 µg m^{-3} in O Saviñao. As mean PM2.5 levels concern annual mean levels during European events ranged from 15 µg m^{-3} in O Saviñao to 14 µg m^{-3} in Niembro (intermediate between mean levels registered during Atlantic and African events and higher than the annual means shown in Table Ap.2).

Table Ap.12. Mean annual levels of TSP, PM10 and PM2.5 registered in Noia, Niembro and O Saviñao during European advection episodes in 1998-2003.

EU EPISODES	**Noia**	**Niembro**			**O Saviñao**		
(µg m^{-3})	TSP	TSP	PM10	PM2.5	TSP	PM10	PM2.5
1998	22	na	na	na	na	na	na
1999	26	31	na	na	na	na	na
2000	*[1]25	39	na	na	na	na	na
2001	na	29	*[2]22	*[2]15	29	*[2]20	*[2]17
2002	na	34	25	16	31	22	17
2003	na	na	21	13	na	18	13
Mean 98-03	24	32	23	14	29	20	15

*[1]Calculated with data of 50% of the months of the year
*[2]Calculated with data of 83% of the months of the year
na: Not available

Mean PM levels registered during the European episodes associated with the two transport scenarios distinguished are different. On one hand, EUH episodes registered medium-high levels, on the other hand, MD episodes low mean levels were recorded (comparables with the annual mean levels). EUH episodes, associated with an anticyclone, are expected to provide less rainy days than MD events which are associated with a depression Thus, mean TSP levels ranged from 33 and 29 µg m^{-3} in O Saviñao and in Noia respectively for EUH scenario and 23 and 14 µg m^{-3} in O Saviñao and Noia respectively for MD scenario (Table Ap.13). Average PM10 levels in O Saviñao ranged from 23 to 15 µg m^{-3} for EUH and MD situations respectively and, finally, PM2.5 mean levels also followed this trend with 18 and 11 µg m^{-3}

recorded in O Saviñao during EUH and MD episodes respectively (Table Ap.13). II (impact index) values obtained for European events were higher for EUH scenario than for MD scenario for all size ranges and stations. In TSP, II ranged from 2.0 µg m^{-3} (in Noia) or 2.3 µg m^{-3} (in O Saviñao) to 0.5 µg m^{-3} (in Noia) or 0.8 µg m^{-3} (in O saviñao) for EUH and MD scenarios respectively (Table Ap.13). In PM10, the impact index of EUH in O Saviñao reached 1.6 µg m^{-3} and the impact index of MD reached 0.5 µg m^{-3}. In this site, for PM2.5 the impact index of EUH reached 1.3 µg m^{-3} and the impact index of MD 0.4 µg m^{-3} (Table Ap.13).

Table Ap.13. Number of days with European advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (µg m^{-3}) recorded at Noia and O Saviñao rural sites (NW Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	EUH	**MD**
2003		
O Saviñao TSP (µg m^{-3})	-	-
O Saviñao PM10 (µg m^{-3})	22	13
O Saviñao PM2.5 (µg m^{-3})	16	8
Days	24	20
2002		
O Saviñao TSP (µg m^{-3})	36	25
O Saviñao PM10 (µg m^{-3})	26	17
O Saviñao PM2.5 (µg m^{-3})	20	13
Days	21	18
2001		
O Saviñao TSP (µg m^{-3})	32	23
O Saviñao PM10 (µg m^{-3})	21	16
O Saviñao PM2.5 (µg m^{-3})	20	12
Days	32	8
2000		
Noia TSP* (µg m^{-3})	27	13
Days*	18	2
1999		
Noia TSP (µg m^{-3})	37	10
Days	26	18
1998		
Noia TSP (µg m^{-3})	22	22
Days	33	7
Mean 98-03 (µg m^{-3})		
Noia TSP	29	14
O Saviñao TSP	33	23
O Saviñao PM10	23	15
O Saviñao PM2.5	18	11
Impact Index(II) (µg m^{-3})		
Noia TSP	2.0	0.5
O Saviñao TSP	2.3	0.8
O Saviñao PM10	1.6	0.5
O Saviñao PM2.5	1.3	0.4

*Data in Noia only available until 06/2000

During European events the highest TSP monthly means were recorded in September with 62 µg m^{-3} in O Saviñao under EUH scenario and in March-April with mean levels around 40 µg m^{-3} also under EUH situations. The highest TSP levels were measured during December with a mean level of 37 µg m^{-3} for EUH episodes, and July, with TSP mean levels of 34 and 33 µg m^{-3} during EUH and MD events respectively (Table Ap.14). The same periods are also characterised by high PM10 and PM2.5 records associated with the EUH scenario. Thus, in March, July and September PM10 mean levels for the EUH scenario reached 29 µg m^{-3} and 27 and 23 µg m^{-3} in April and September, respectively (Table Ap.14). During EUH events, PM2.5 monthly means of 18, 20, 24, 22 and 22 µg m^{-3} were recorded in March, April, July, September and December, respectively (Table Ap.14).

Table Ap.14. Number of days per month with European advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (µg m^{-3}) recorded at O Saviñao rural site (NW Spain) for those days.

	EUH	MD		EUH	MD
January			**July**		
Days per month	3.3	0.7	Days per month	1.7	0.5
TSP	22	13	TSP	34	33
PM10	15	9	PM10	29	21
PM2.5	14	6	PM2.5	24	15
February			**August**		
Days per month	3.5	0.2	Days per month	2.0	0.2
TSP	22		TSP	24	22
PM10	19		PM10	18	17
PM2.5	14		PM2.5	15	12
March			**September**		
Days per month	4.3	0.8	Days per month	3.3	1.0
TSP	41		TSP	62	23
PM10	29		PM10	29	17
PM2.5	18		PM2.5	22	12
April			**October**		
Days per month	0.7	3.2	Days per month	0.3	1.2
TSP	40	31	TSP		
PM10	27	18	PM10		13
PM2.5	20	14	PM2.5		7
May			**November**		
Days per month	2.0	1.0	Days per month	1.2	2.2
TSP	20		TSP	28	16
PM10	14	17	PM10	17	12
PM2.5	8	10	PM2.5	12	9
June			**December**		
Days per month	1.0	0.0	Days per month	2.3	1.3
TSP			TSP	37	12
PM10			PM10	23	7
PM2.5			PM2.5	22	6

1.4. Mediterranean episodes

16 events of advection of air masses from the Mediterranean Sea occurred over Northwestern Iberia in 1998-2003. This resulted in 3 episodes per year. The mean duration of these episodes was 2 days. The total number of days in which Mediterranean advection was detected over the study region was 28 (5 days per year

and less than 1 day per month, Table Ap.15). Thus, both the number of episodes and days with Mediterranean advection over Northwestern Iberia were scarce.
4 days with Mediterranean advection (14 % of the Mediterranean days) occurred under a synoptic scenario of the NAD-MD type (depression centred over Northern Africa or over the Mediterranean Sea) in the study period, that is, 1 day per year was registered (Table Ap.15). These days were distributed in 4 NAD-MD episodes (25% of the Mediterranean events in the study period and 1 event per year, Table Ap.15). The four NAD-MD episodes had 1 day duration.
75% of the Mediterranean events (12 episodes) occurred under a EUH-MH scenario (when an anticyclone covers the European continent and/or the Mediterranean basin). This resulted in 2 episodes per year (Table Ap.15) with a mean duration of 2 days per event. In 24 days out of the 28 days with Mediterranean advection (86%) in 1998-2003 the meteorological situation was of the EUH-MH type. This resulted in a mean of 4 EUH-MH days per year in the study period (Table Ap.15).
The highest number of Mediterranean episodes was registered in 1999 (5 episodes, Table Ap.15). Also during 1999 the highest number of EUH-MH episodes was recorded (4 episodes, Table Ap.15). As NAD-MD events regard, the maximum number of episodes was recorded in 2000 (2 events, Table Ap.15). In 2003 no Mediterranean episodes were recorded. Furthermore, NAD-MD events neither were recorded in 2001 and 2002 (Table Ap.15).
The maximum number of days with Mediterranean air mass transport was recorded in 1999 (12 days, Table Ap.15). This maximum was caused by a high frequency of Mediterranean advection caused by EUH-MH scenario (11 days, Table Ap.15). Two was the maximum number of days with advection from the Mediterranean Sea with NAD-MD synoptic scenario in a year, this occurred in 2000 (Table Ap.15).

Table Ap.15. Annual number of days and episodes with Mediterranean advection in the period 1998-2003 over Northwestern Iberian Peninsula. The NAD-MD and EUH-MH scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03
Days							
Total MED	2	12	6	4	4	0	5
NAD-MD	1	1	2	0	0	0	1
EUH-MH	1	11	4	4	4	0	4
Episodes							
Total MED	2	5	5	3	1	0	3
NAD-MD	1	1	2	0	0	0	1
EUH-MH	1	4	3	3	1	0	2

As shown in Figure Ap.13, the occurrence of Mediterranean episodes over the Northwestern Iberian Peninsula was almost restricted to the periods October-January (11 episodes from the 16 Mediterranean events occurred in 1998-2003), March (4 episodes) and May (1 episode). Both November and March accumulated 4 Mediterranean episodes in the 6 year period. The rest of the months were devoid of Mediterranean episodes. NAD-MD episodes occurred only in October-November and in March (2 episodes in the study period, Figure Ap.13). EUH-MH events occurred also in October-January, March and May. Maximum number of EUH-MH episodes was recorded in November and in January (3 episodes in the 6-years study period, Figure Ap.13).

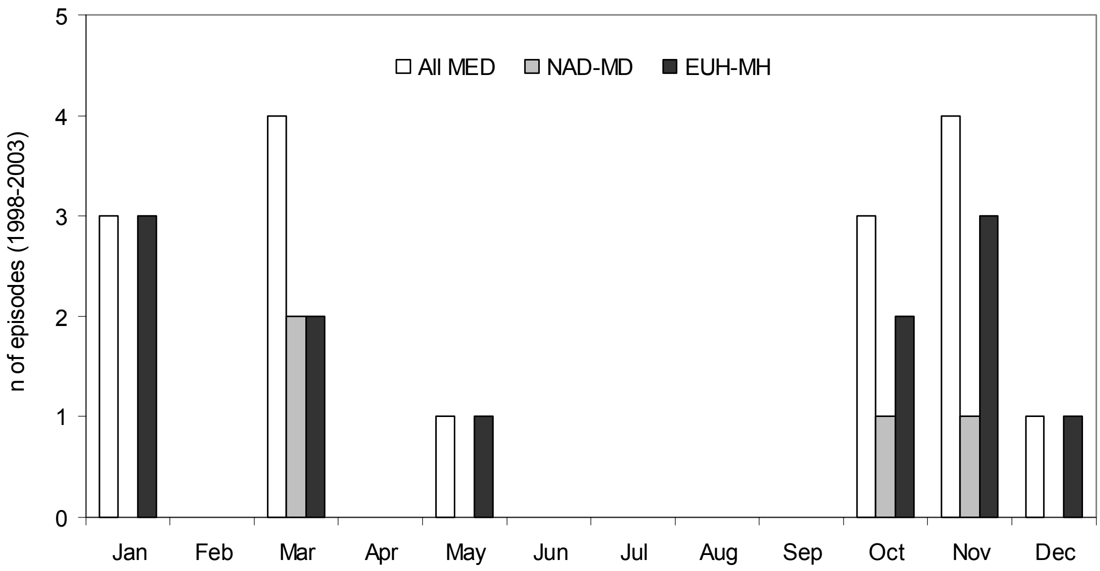

Figure Ap.13. Monthly distribution of the number of Mediterranean episodes over the Northwestern Iberian Peninsula. The monthly distributions of NAD-MD and EUH-MH Mediterranean events are also shown.

The days with Mediterranean advection registered in Norwestern Iberia were almost restricted to four months: January, March, October and November (highest number of days with Mediterranean advection in 1998-2003 with 8 days, Figures Ap.14 and Ap.15). The same occurred with days characterised by Mediterranean advection caused by the EUH-MH scenario (maximum number of days registered in January and November with a total of 7 days in 1998-2003, Figures Ap.14 and Ap.15). Days with Mediterranean advection caused by NAD-MD situations occurred only in March (2 days in the whole study period) and in October-November (Figures Ap.14 and Ap.15).

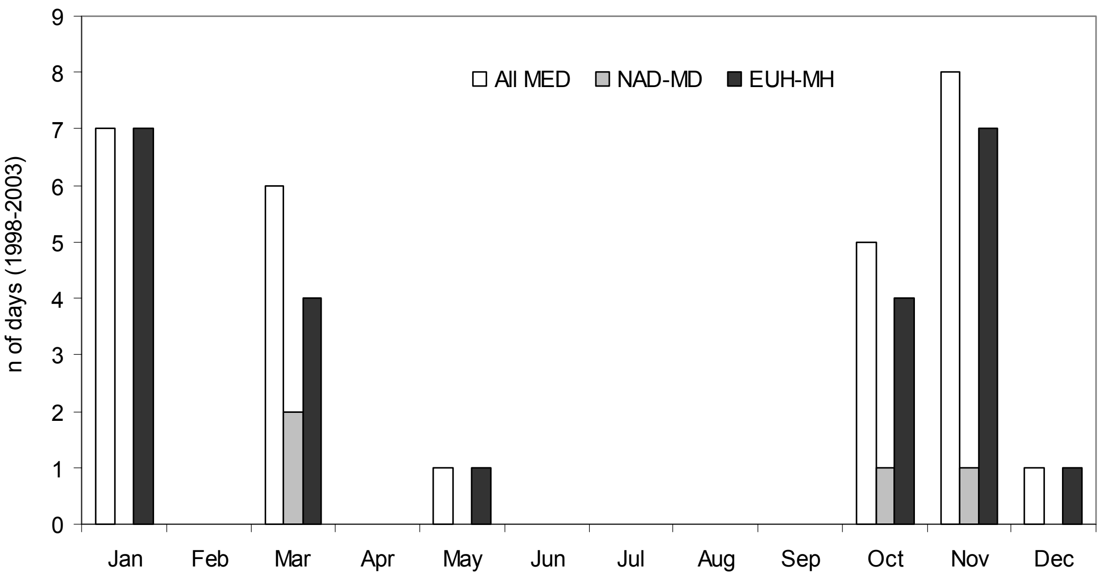

Figure Ap.14. Monthly distribution of the number of days with Mediterranean advection over Northwestern Iberian Peninsula. The monthly distributions of days with Mediterranean advection occurred under NAD-MD and EUH-MH scenarios are also shown.

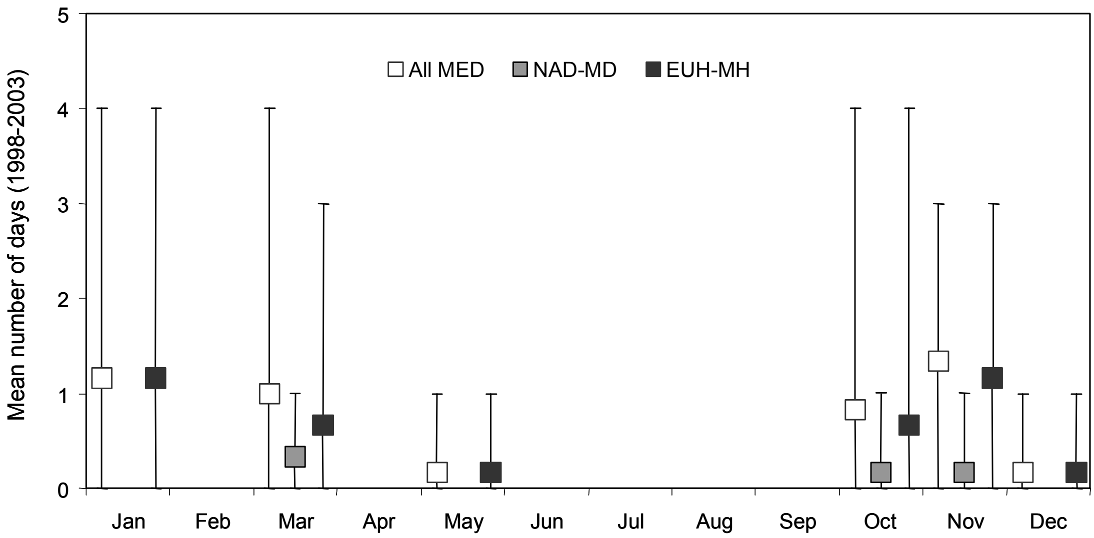

Figure Ap.15. Mean number of days with Mediterranean advection over Northwestern Iberian Peninsula per month for 1998-2003. NAD-MD and EUH-MH episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

Mediterranean events in Northwestern Iberia occurred generally with a short duration. The longest Mediterranean event recorded in the whole study period was 4 days (Figure Ap.16). The average duration of Mediterranean episodes in January and November was the highest (2-3 days per episode for all events and for EUH-MH events, Figure Ap.16). All NAD-MD lasted only one day.

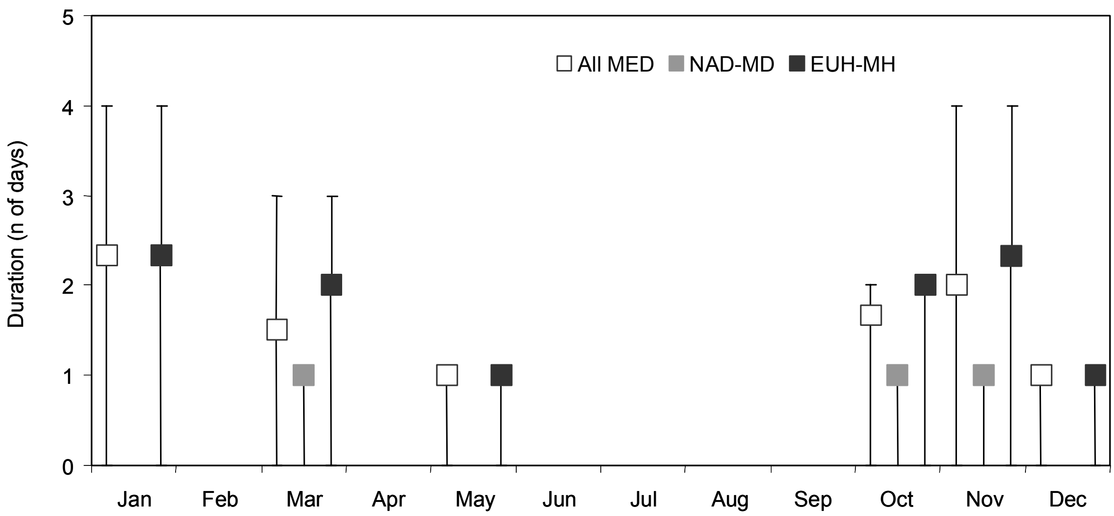

Figure Ap.16. Mean duration of Mediterranean episodes per month over Northwestern Iberian Peninsula for 1998-2003. NAD-MD and EUH-MH episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

PM levels during Mediterranean episodes in Northwestern Iberia in the study period (1998-2003) were very similar to the mean annual levels. TSP mean levels during Mediterranean episodes were 18 µg m^{-3} in Noia, 22 µg m^{-3} in O Saviñao and 26 µg m^{-3} in Niembro. PM10 mean levels ranged from 17 µg m^{-3} in O Saviñao to 16 µg m^{-3} in Niembro. Finally, PM2.5 mean levels during Mediterranean events reached 10 µg m^{-3} and in Niembro and 16 µg m^{-3} in O Saviñao. It is important to point out that the conclusions extracted from these and the following PM data should be analysed with caution owing to the low frequency of occurrence of Mediterranean episodes. For example in one single episodes occurred during 2002, due to the low frequency of occurrence and to the missing data the PM2.5 annual mean resulted to be higher than the PM10 annual mean (Table Ap.16).

Table Ap.16. Mean annual levels of TSP, PM10 and PM2.5 registered in Noia, Niembro and O Saviñao during Mediterranean advection episodes in 1998-2003.

MED EPISODES	**Noia**	**Niembro**			**O Saviñao**		
($\mu g\ m^{-3}$)	TSP	TSP	PM10	PM2.5	TSP	PM10	PM2.5
1998	14	na	na	na	na	na	na
1999	14	25	na	na	na	na	na
2000	*[1]25	30	na	na	na	na	na
2001	na	15	*[2]11	*[2]9	24	*[2]17	*[2]15
2002	na	30	20	12	22	17	18
2003	na	na	na	na	na	na	na
Mean 98-03	18	26	16	10	22	17	16

*[1]Calculated with data of 50% of the months of the year
*[2]Calculated with data of 83% of the months of the year
na: Not available

Owing to the low frequency of occurrence of Mediterranean advection under NAD-MD situations in the study period (4 days), the impact index (II) of these episodes is low, only 0.1 $\mu g\ m^{-3}$ for TSP in Noia. EUH-MH scenarios were more common among Mediterranean advection days (24 days). These episodes drew TSP mean levels of 15 and 22 $\mu g\ m^{-3}$ in Noia and O Saviñao respectively. PM10 and PM2.5 mean levels during EUH-MH episodes in O Saviñao were 17 and 16 $\mu g\ m^{-3}$ respectively (Table Ap.17). The impact of EUH-MH scenario on TSP levels in Noia was low (II=0.2 $\mu g\ m^{-3}$) and in O Saviñao II had the same value (0.2 $\mu g\ m^{-3}$) for all size ranges (Table Ap.17).

Table Ap.17. Number of days with Mediterranean advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (µg m^{-3}) recorded at Noia and O Saviñao rural sites (NW Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	NAD-MD	EUH-MH
2003		
O Saviñao TSP (µg m^{-3})	-	-
O Saviñao PM10 (µg m^{-3})	-	-
O Saviñao PM2.5 (µg m^{-3})	-	-
Days	0	0
2002		
O Saviñao TSP (µg m^{-3})	-	22
O Saviñao PM10 (µg m^{-3})	-	17
O Saviñao PM2.5 (µg m^{-3})	-	18
Days	0	4
2001		
O Saviñao TSP (µg m^{-3})	-	24
O Saviñao PM10 (µg m^{-3})	-	17
O Saviñao PM2.5 (µg m^{-3})	-	15
Days	0	4
2000		
Noia TSP* (µg m^{-3})	59	17
Days*	1	4
1999		
Noia TSP (µg m^{-3})	-	14
Days	1	11
1998		
Noia TSP (µg m^{-3})	18	10
Days	1	1
Mean 98-03 (µg m^{-3})		
Noia TSP	39	15
O Saviñao TSP	-	22
O Saviñao PM10	-	17
O Saviñao PM2.5	-	16
Impact Index(II) (µg m^{-3})		
Noia TSP	0.1	0.2
O Saviñao TSP	-	0.2
O Saviñao PM10	-	0.2
O Saviñao PM2.5	-	0.2

*Data in Noia only available until 06/2000

The occurrence of Mediterranean advection is negligible with the exception of January, March, October and November. During EUH-MH events TSP monthly means in O Saviñao from 30 µg m^{-3} in December to 17 µg m^{-3} in November. PM10 and PM2.5 means were higher in December (23 and 20 µg m^{-3} respectively, Table Ap.18).

Table Ap.18. Number of days per month with Mediterranean advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (μg m^{-3}) recorded at O Saviñao rural site (NW Spain) for those days.

	NAD-MD	EUH-MH		NAD-MD	EUH-MH
January			**July**		
Days per month	0.0	1.2	Days per month	0.0	0.0
TSP		22	TSP		
PM10		17	PM10		
PM2.5		18	PM2.5		
February			**August**		
Days per month	0.0	0.0	Days per month	0.0	0.0
TSP			TSP		
PM10			PM10		
PM2.5			PM2.5		
March			**September**		
Days per month	0.3	0.7	Days per month	0.0	0.0
TSP			TSP		
PM10			PM10		
PM2.5			PM2.5		
April			**October**		
Days per month	0.0	0.0	Days per month	0.2	0.7
TSP			TSP		
PM10			PM10		
PM2.5			PM2.5		
May			**November**		
Days per month	0.0	0.2	Days per month	0.2	1.2
TSP			TSP		17
PM10			PM10		15
PM2.5			PM2.5		12
June			**December**		
Days per month	0.0	0.0	Days per month	0.0	0.2
TSP			TSP		30
PM10			PM10		23
PM2.5			PM2.5		20

1.5. Episodes without dominant advective conditions

66 episodes without dominant advective conditions over Northwestern Iberia occurred in 1998-2003. Frequencies of mean of 11 episodes per year and 1 episode per month were than obtained. The mean duration of these events was 3 days per episode. Those 66 events resulted in 186 days in which definite advection was not noticed (31 days per year, 3 days per month, Table Ap.19).

In 81 days of the 186 days without major advection (44%) the synoptic situation corresponded with the presence of an anticyclone covering partly or completely the Iberian Peninsula during winter (WIA scenario). This resulted in means of 14 days per year and 1 day per month (Table Ap.19). These days were grouped in 25 episodes (38% of the episodes with lack of advection recorded in the study period) which resulted in 4 events per year and less than 1 event per month (Table Ap.19). These episodes had a mean duration of 3 days.

The meteorological scenario in 105 days out of the 186 (56%) without advection corresponded to the development of the Iberian Thermal Low due to the strong heating of the central Plateau of the Iberian Peninsula, that is, the ITL situation (17 days per year and 1 day per month during the period 1998-2003, Table Ap.19). The total number of ITL episodes over Northwestern Iberia was 41. This is 62% of the episodes

with lack of advective conditions in the study period. Means of 7 episodes per year and 1 episode per month were then recorded (Table Ap.19). The average duration of these events was 3 days per episode.
The number of days with lack of advection recorded per year varied between 21 days in 2000 and 51 days in 2003 (Table Ap.19). The number of days with lack of advection occurred under WIA scenario were maximum in 2003 with 37 days and minimum in 2001 with 2 days (Table Ap.19). This wide was caused by the unusual high occurrence of WIA days in 1998 and 2003 (>5 times greater than in 1999, 2000, 2001 and 2002). As ITL days concerns the interannual variation is nor so large. 26 ITL days were recorded in 2001 and only 10 in 1998 (Table Ap.19).
As Table Ap.19 shows, the highest number of episodes without advection was registered in 2003 (16) when the highest number of WIA events (10) was also recorded. The year with the highest occurrence of ITL events was 2001 with 11 episodes. The lowest number of events characterised by lack of advective conditions was registered in 2000 (6 episodes), the lowest occurrence of WIA episodes was registered in 2001 and 2002 (1 episode) and, in 2000 and 1998 for ITL events (4 episodes, Table Ap.19).

Table Ap.19. Annual number of days and episodes with lack of advection in the period 1998-2003 over Northwestern Iberian Peninsula. The WIA and ITL scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total NOADV	35	29	21	28	22	51	31	3
WIA	25	5	5	2	7	37	14	1
ITL	10	24	16	26	15	14	17	1
Episodes								
Total NOADV	13	12	6	12	7	16	11	1
WIA	9	2	2	1	1	10	4	<1
ITL	4	10	4	11	6	6	7	1

Most episodes and days without a dominant air mass advection were concentrated in the period May-October caused by a high frequency of occurrence of ITL from June to September but two other secondary maximums were found in December and February caused by the high WIA frequency in these months (Figures Ap.17 to Ap.19). ITL episodes were registered solely from May to October and WIA events were not present in July and August. In August the maximum number of episodes and days without advection (all of them of the ITL type) were registered. 14 ITL episodes and 34 ITL days (6 days as a mean) were recorded in this month during the study period (Figures Ap.17 to Ap.19). Furthermore, ITL episodes always occurred in August in the study period. December was the month in which WIA episodes occurred with the highest frequency with 6 episodes in the period 1998-2003. The monthly number of WIA days is slightly higher in October (18 days in 1998-2003 and 3 days on average, Figures Ap.17 to Ap.19) than in December (17 days in the study period and 3 days on average, Figures Ap.17 to Ap.19).

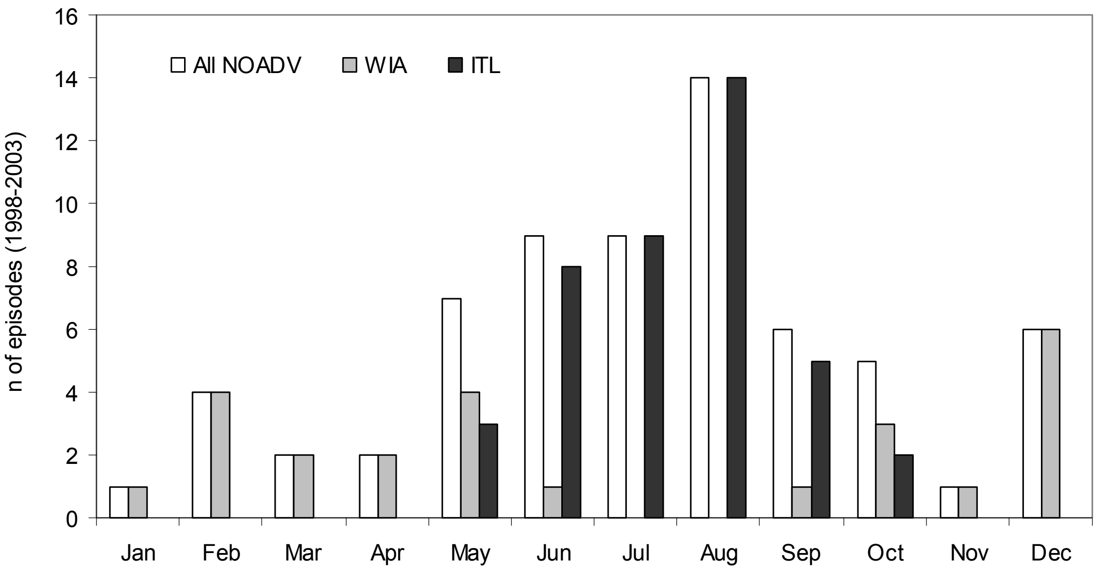

Figure Ap.17. Monthly distribution of the number of episodes without dominant advective conditions over Northwestern Iberian Peninsula. The monthly distribution of WIA and ITL events is also shown.

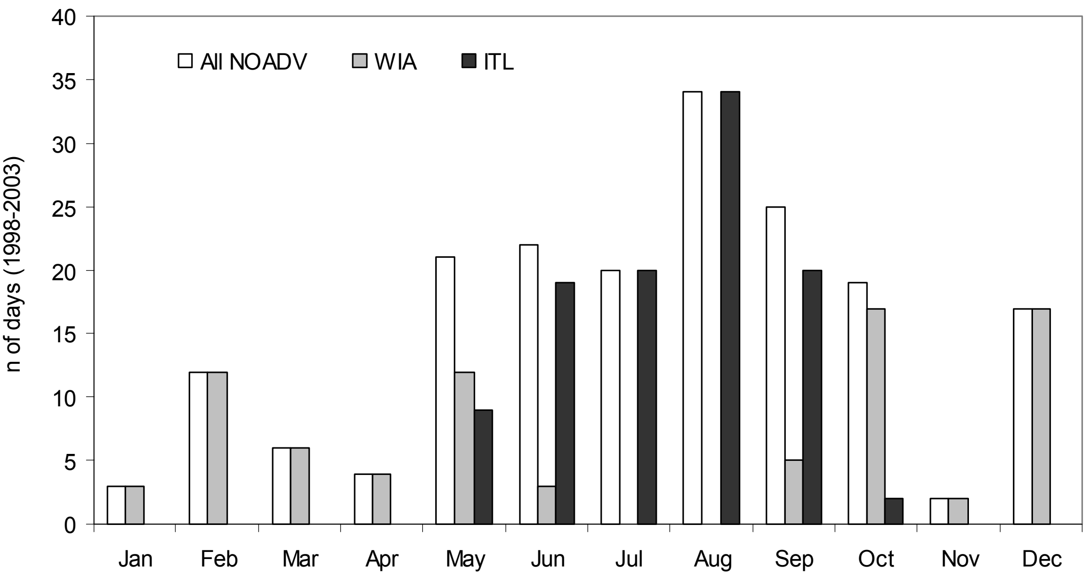

Figure Ap.18. Monthly distribution of the number of days with lack of advective conditions over Northwestern Iberian Peninsula. The monthly distribution of days with lack of advection occurred under WIA and ITL scenarios is also shown.

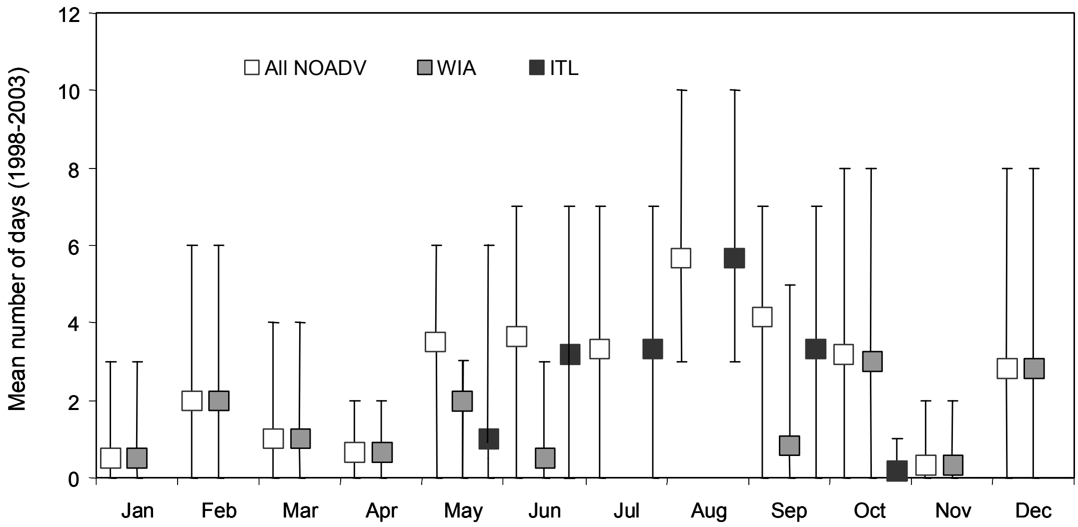

Figure Ap.19. Mean number of days without a dominant air mass advection over Northwestern Iberian Peninsula per month for 1998-2003. WIA and ITL episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

The monthly distribution of mean durations of WIA events recorded over Northwestern Iberia in 1998-2003 showed a maximum on September-October (mean durations of 5-6 days per episode, Figure Ap.20). Summer episodes without a dominant air mass advection (ITL events) were characterised by a similar duration to the WIA events. In September the mean duration of such episodes reached a mean duration of 4 days per episode (Figure Ap.20). Summarising, episodes caused by a lack of advective conditions lasted the longest in September and October (4 days per episode).

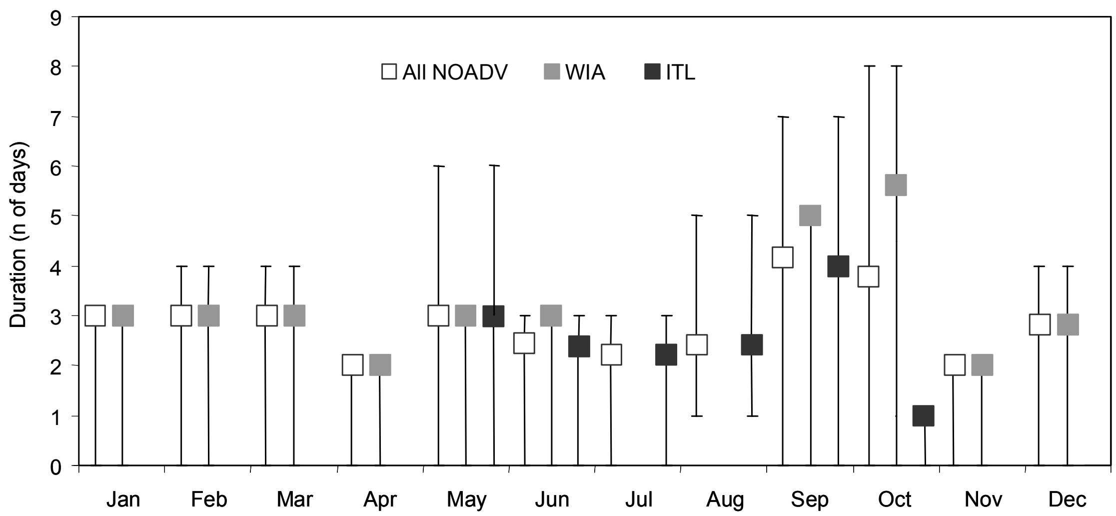

Figure Ap.20. Mean duration of episodes without a dominant air mass advection per month over Northwestern Iberian Peninsula for 1998-2003. WIA and ITL episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

PM episodes caused by a lack of advection of air masses gave rise to PM mean levels clearly higher to the mean annual levels in all the stations and in all the size ranges.

TSP mean levels during such events reached 24 µg m^{-3} in Noia, 32 µg m^{-3} in O Saviñao and 38 µg m^{-3} in Niembro. PM10 mean levels during these episodes ranged from 21 µg m^{-3} in O Saviñao to 25 µg m^{-3} in Niembro whereas PM2.5 mean levels oscillated between 17 µg m^{-3} in O Saviñao to 16 µg m^{-3} in Niembro (Table Ap.20). These levels were not as high as during African dust outbreaks but higher than the rest of episodes evaluated in this study.

Table Ap.20. Mean annual levels of TSP, PM10 and PM2.5 registered in Noia, Niembro and O Saviñao during episodes without a dominant air mass advection in 1998-2003.

NOADV EPISODES	**Noia**	**Niembro**			**O Saviñao**		
(µg m^{-3})	TSP	TSP	PM10	PM2.5	TSP	PM10	PM2.5
1998	20	na	na	na	na	na	na
1999	27	41	na	na	na	na	na
2000	*[1]31	48	na	na	na	na	na
2001	na	34	*[2]28	*[2]19	36	*[2]25	*[2]21
2002	na	31	23	15	30	23	18
2003	na	na	25	15	na	19	13
Mean 98-03	24	38	25	16	32	21	17

*[1]Calculated with data of 50% of the months of the year
*[2]Calculated with data of 83% of the months of the year
na: Not available

Although the two meteorological scenarios considered for the occurrence of these episodes result in lack of advection the impact of WIA and ITL scenario on PM levels differed greatly. Under both scenarios precipitation is reduced so the scavenging potential of the atmosphere is reduced in episodes without lack of advective conditions. In Noia, TSP mean levels for both scenarios resulted to be similar 23 µg m^{-3} for WIA scenario and 25 µg m^{-3} for ITL scenario. The high TSP mean recorded at Noia can be explained by the high levels recorded in two consecutive days with daily means of 97 and 66 µg m^{-3} in March 2000. These two elevated values resulted in a high mean. Punctual local sources may be responsible for those high levels. In O Saviñao, for all size ranges, ITL episodes contributed to PM levels considerably more than WIA events. Thus, in that station, TSP ranged from 24 to 35 µg m^{-3} for WIA and ITL respectively, PM10 varied between 17 µg m^{-3} during WIA events and 25 µg m^{-3} during ITL episodes. PM2.5 mean levels were also greater during ITL episodes (20 µg m^{-3}) than during WIA episodes (12 µg m^{-3}). As a consequence, the impact of each scenario on PM levels, expressed as the impact index (II) may be described as follows: The impact on TSP mean levels in Noia were 0.8 µg m^{-3} for WIA scenario and 1.2 µg m^{-3} for ITL scenario. The impact on TSP levels in O Saviñao were 0.9 µg m^{-3} for WIA events and 1.7 µg m^{-3} for ITL events. The impact of ITL scenario on PM10 and PM2.5 was high with 1.2 and 1.0 µg m^{-3} respectively, clearly more important than the impact of WIA episodes 0.6 and 0.5 µg m^{-3} respectively (Table Ap.21).

Table Ap.21. Number of days without a dominant air mass advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 ($\mu g\ m^{-3}$) recorded at Noia and O Saviñao rural sites (NW Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	WIA	ITL
2003		
O Saviñao TSP ($\mu g\ m^{-3}$)	-	-
O Saviñao PM10 ($\mu g\ m^{-3}$)	16	26
O Saviñao PM2.5 ($\mu g\ m^{-3}$)	11	18
Days	37	14
2002		
O Saviñao TSP ($\mu g\ m^{-3}$)	28	30
O Saviñao PM10 ($\mu g\ m^{-3}$)	23	23
O Saviñao PM2.5 ($\mu g\ m^{-3}$)	19	18
Days	7	15
2001		
O Saviñao TSP ($\mu g\ m^{-3}$)	18	38
O Saviñao PM10 ($\mu g\ m^{-3}$)	13	26
O Saviñao PM2.5 ($\mu g\ m^{-3}$)	12	22
Days	2	26
2000		
Noia TSP* ($\mu g\ m^{-3}$)	39	17
Days*	5	3
1999		
Noia TSP ($\mu g\ m^{-3}$)	-	27
Days	5	23
1998		
Noia TSP ($\mu g\ m^{-3}$)	18	24
Days	25	10
Mean 98-03 ($\mu g\ m^{-3}$)		
Noia TSP	23	25
O Saviñao TSP	24	35
O Saviñao PM10	17	25
O Saviñao PM2.5	12	20
Impact Index(II) ($\mu g\ m^{-3}$)		
Noia TSP	0.8	1.2
O Saviñao TSP	0.9	1.7
O Saviñao PM10	0.6	1.2
O Saviñao PM2.5	0.5	1.0

*Data in Noia only available until 06/2000.

The highest monthly means for PM for low advection episodes in O Saviñao were recorded during summer events (ITL). TSP monthly means were higher under ITL situations (28 to 45 $\mu g\ m^{-3}$) during summer (May-September). The same applies for PM10 and PM2.5 with monthly means ranging from 21 to 30 $\mu g\ m^{-3}$ and from 17 to 24 $\mu g\ m^{-3}$, respectively (Table Ap.22). WIA events did not result in PM monthly mean levels exceeding 28 $\mu g\ m^{-3}$ for TSP, 22 $\mu g\ m^{-3}$ for PM10 and 17 $\mu g\ m^{-3}$ for PM2.5 (Table Ap.22).

Table Ap.22. Number of days per month without dominant air mass advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (µg m^{-3}) recorded at O Saviñao rural site (NW Spain) for those days.

	WIA	ITL		WIA	ITL
January			**July**		
Days per month	0.5	0.0	Days per month	0.0	3.3
TSP	19		TSP		34
PM10	11		PM10		26
PM2.5	8		PM2.5		21
February			**August**		
Days per month	2.0	0.0	Days per month	0.0	5.7
TSP			TSP		32
PM10	11		PM10		25
PM2.5	7		PM2.5		19
March			**September**		
Days per month	1.0	0.0	Days per month	0.8	3.3
TSP			TSP		45
PM10	22		PM10	18	27
PM2.5	16		PM2.5	13	20
April			**October**		
Days per month	0.7	0.0	Days per month	2.8	0.3
TSP			TSP	28	
PM10	13		PM10	21	
PM2.5	9		PM2.5	17	
May			**November**		
Days per month	2.0	1.5	Days per month	0.3	0.0
TSP		41	TSP		
PM10	15	30	PM10		
PM2.5	11	24	PM2.5		
June			**December**		
Days per month	0.5	3.2	Days per month	2.8	0.0
TSP		28	TSP	18	
PM10		21	PM10	12	
PM2.5		17	PM2.5	10	

2. Northern Iberian Peninsula

As shown in Table Ap.23, the arrival of Atlantic air masses was the most common situation. In the study period, 1998-2003, 57% of the days Atlantic air masses reached Northern Iberia. This resulted in a total of 237 episodes summing up 1243 days. That is, means of 207 days per year and 17 days per month. Following Atlantic transport the most common situations are transport of European air masses and situations of lack of advection accounting each with 15% of the days. European air masses arrived to Nothern Iberia in 319 days (53 days per year, 3 days per month) distributed in 90 episodes. The number of days without advection in the study period were 337 (56 days per year and 4 days per month) in a total of 101 episodes. North African advection occurred in 234 days (11% of the days, 39 days per year and 3 days per month) grouped in 92 events. The less frequent air mass transport was Mediterranean advection with 31 episodes resulting in 58 days in the whole study period (3% of the days, 10 days per year and 1 day per month).

Table Ap.23. Number of days, % of days and episodes with Atlantic (ATL), North African (NAF), Mediterranean (MED) and European (EU) advection and without a prevalent advective regime (NOADV) in Northern Iberia for the period 1998-2003.

1998-2003	ATL	NAF	MED	EU	NOADV
Number of days	1243	234	58	319	337
% of days	57	11	3	15	15
Number of events	237	92	31	90	101

In the Northern region of the Iberian Peninsula daily data from three regional background stations were used to evaluate the impact of different transport scenarios on PM levels. Logroño station (42º 27' N, -2º 30' E, 445 m.a.s.l.) belonged to the EMEP network and offered data on TSP from 1998 to January 2001 measured by the gravimetric method. Valderejo (42º 53' N, -3º 14' E, 911 m.a.s.l.) and Izki (42º 39' N, -2º 30' E, 835 m.a.s.l.) stations belonged to the Air Quality monitoring network of the Government of the Basque Country and offered daily TSP data from 1999 to November 1999 in Valderejo, daily PM10 data from November 1999 to 2003 in Valderejo and daily PM10 data from May 2001 to 2003 in Izki. These data were sampled using the β-attenuation method based on monitoring the attenuation of β-radiation during one hour through the filter where the PM is continuously being filtered.

The levels in Logroño were clearly superior to the levels recorded in the other two stations. 30 $\mu g\ m^{-3}$ of TSP was the mean levels in Logroño while in Valderejo only 19 $\mu g\ m^{-3}$ as a mean of TSP were registered in only 11 months (Table Ap.24). In Valderejo and in Izki the PM10 average for the period 1998-2003 was 14 $\mu g\ m^{-3}$ in both cases (Table Ap.24). Again the lowest annual means were registered in 2002 owing to a very wet summer. High annual mean PM levels were recorded in 2000. No exceedances of the annual limit value established by the 1999/30/CE Directive were then registered neither for the limit value established for 2005 (40 $\mu gPM10\ m^{-3}$) nor for the target value established for 2010 (20 $\mu g\ m^{-3}$).

Table Ap.24. Mean levels of TSP, PM10 and PM2.5 recorded in regional background stations in 1998-2003 in Northern Iberian Peninsula.

MEAN LEVELS	Logroño	Valderejo		Izki
(µg m^{-3})	TSP	TSP	PM10	PM10
1998	30	na	na	na
1999	28	*[1]19	na	na
2000	33	na	17	na
2001	na	na	13	*[2]20
2002	na	na	12	11
2003	na	na	13	12
Mean 98-03	30	19	14	14

*[1]Calculated with data of 90% of the months of the year
*[2]Calculated with data of 67% of the months of the year
na: Not available

2.1. Atlantic episodes

237 episodes with advection of Atlantic air masses occurred over Northern Iberia accounting for 1243 days. Averaging, 40 episodes per year and 3 episodes per month with a mean duration of 5 days per episode were recorded. Mean values of 207 days per year and 17 days per month with Atlantic advection were registered (Table Ap.25)
AZH-NAtD (presence of the Azores high and of the Iceland low) meteorological scenario was responsible of the Atlantic episodes in 186 events (78% of the Atlantic events). These episodes grouped 1105 days (89% of the total number of days with Atlantic influence). Averages of 31 events and 184 days per year and 3 episodes and 15 days per month with AZH-NAtD scenario were present in the study period. AZH-NAtD Atlantic episodes had a mean duration of 6 days (Table Ap.25).
A minor percentage of the Atlantic episodes (26%) and of the days with Atlantic advection (11%) occurred under AD (presence of a depression in front of the Portuguese coast) meteorological transport scenario. These resulted in 51 episodes (9 episodes per year, 1 episode per month, Table Ap.25) and 138 days (23 days per year, 2 days per month, Table Ap.25) in the period 1998-2003. The mean AD Atlantic episode lasted 3 days (Table Ap.25).
In 1998-2003, the highest number of days with Atlantic influence over Northern Iberia was registered in 2000 with 236 days and the lowest number in 2003 with 164 days (Table Ap.25). These years corresponded with the years with maximum and minimum number of days with AZH-NAtD situations, 209 days in 2000 and 125 days in 2003. Days with Atlantic advection derived from AD scenario reached maximum number in 2003 with 39 days and minimum number in 1998 with 15 days (Table Ap.25).
The highest number of Atlantic episodes was registered in 2003 for all episodes (46 events) and for AD episodes (14 events) and in 2001 (35 events) for AZH-NAtD episodes (Table Ap.25). The minimum annual number of Atlantic episodes was recorded in 1998 with 35 episodes. For AZH-NAtD events the year with the least occurrence was 2002 (28 episodes) and only 5 AD events were registered during 1998 and during 1999 (Table Ap.25).

Table Ap.25. Annual number of days and episodes with Atlantic advection in the period 1998-2003 over Northern Iberian Peninsula. The AZH-NAtD and AD scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total ATL	197	207	236	225	214	164	207	17
AZH-NAtD	182	188	209	206	195	125	184	15
AD	15	19	27	19	19	39	23	2
Episodes								
Total ATL	35	36	41	43	36	46	40	3
AZH-NAtD	30	31	30	35	28	32	31	3
AD	5	5	11	8	8	14	9	1

Although the occurrence of Atlantic episodes over Northern Spain in 1998-2003 was common all throughout the year two periods of higher frequency of occurrence were observed. In December, as a mean 27 episodes were registered in the study period. From March to July a high number of episodes were also recorded (up to 24 in July, Figure Ap.21). AZH-NAtD events showed a monthly distribution characterised by a maximum in May-July (22 AZH-NAtD episodes occurred in July, Figure Ap.21) and minima in February-April and September (only 12 episodes were registered in February and September in the whole study period, Figure Ap.21). December was the month when the highest number of AD events were registered (12 episodes, Figure Ap.21) but also in the period March-May the frequency of occurrence of these events is relatively high (5 events during 1998-2003 in both March and April, Figure Ap.21). Finally it is important to highlight that as a mean only 6 AD Atlantic episodes were recorded in the period June-September and none of them in June.

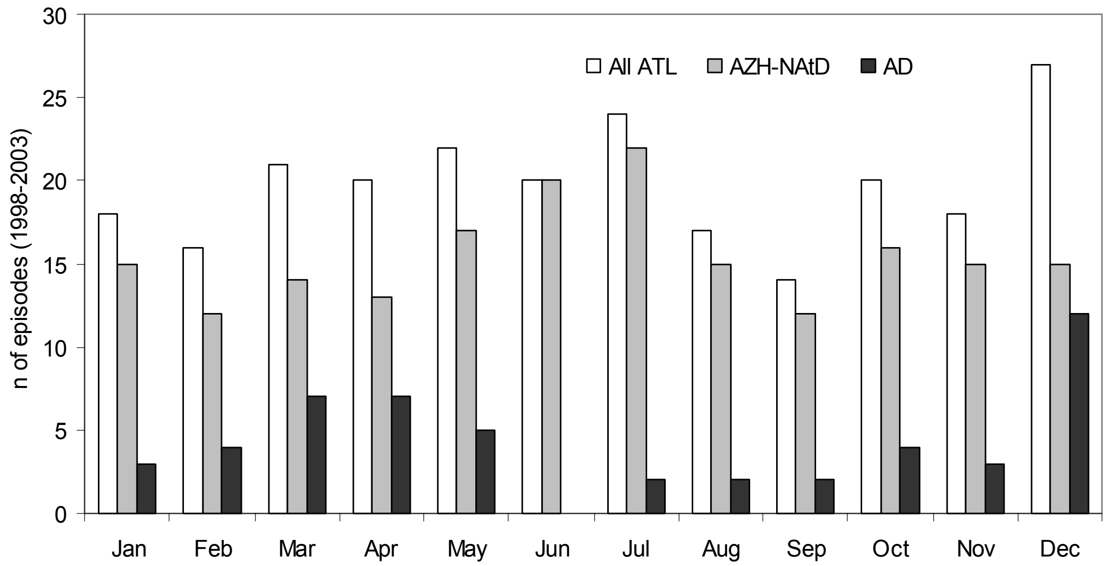

Figure Ap.21. Monthly distribution of the number of Atlantic episodes over Northern Iberian Peninsula. The monthly distributions of AZH-NAtD and AD Atlantic events are also shown.

The monthly distributions of days and episodes with Atlantic advection over Northern Iberia in 1998-2003 did not follow the same patterns of the distribution of Atlantic episodes. The period in which Atlantic advection days were more frequent was autumn-winter (from 18 to 23 days per month from October to January, Figures Ap.22 and Ap.23). Also in April and July high means (22 and 20 days respectively, Figures Ap.22 and Ap.23) were registered. The monthly distribution of days with Atlantic advection occurred under AZH-NAtD transport scenario also showed the same three periods of higher frequency of occurrence. From October to January a range of 17 to 21 days on average was registered. In July and in April a mean of 19 and 18 days with AZH-NAtD scenario was registered (Figures Ap.22 and Ap.23). Days with AD transport scenario were more common in December (Figure Ap.23) and in March-April (3 and 4 days on average) and in December (4 days on average, Figure Ap.23).

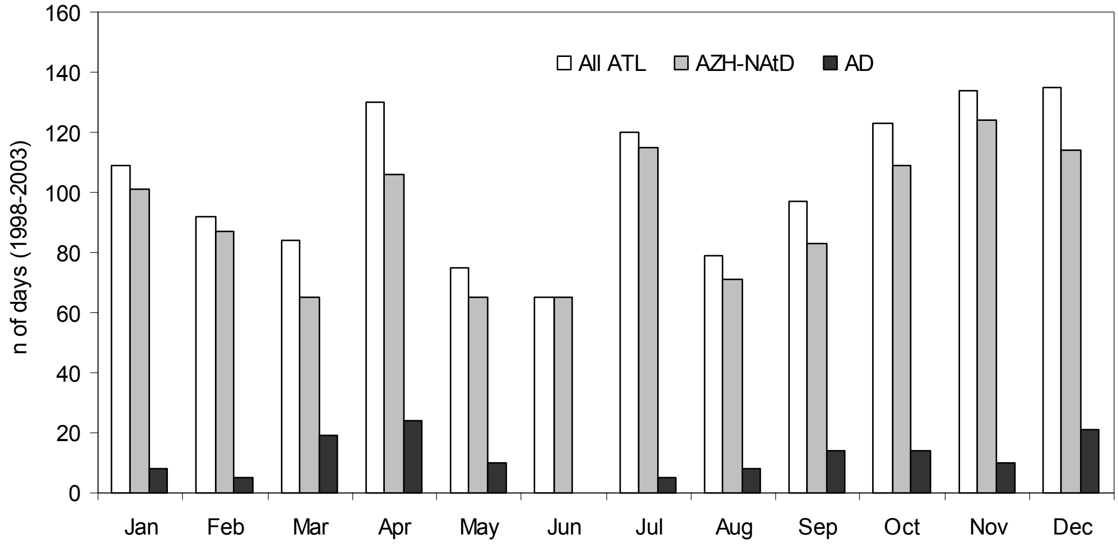

Figure Ap.22. Monthly distribution of the number of days with Atlantic advection over Northern Iberian Peninsula. The monthly distributions of days with Atlantic advection occurred under AZH-NAtD and AD scenarios are also shown.

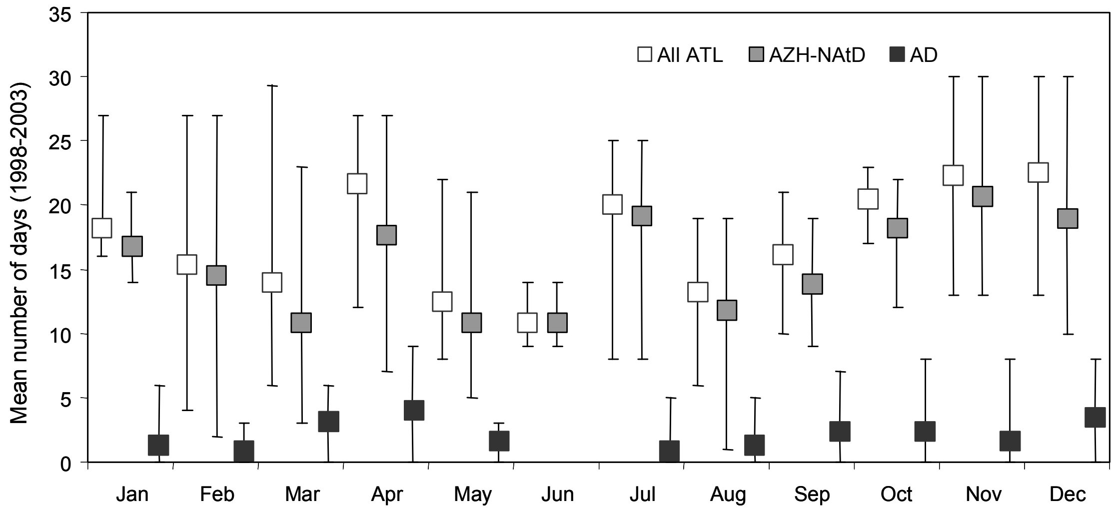

Figure Ap.23. Mean number of days with Atlantic advection over Northern Iberian Peninsula per month for 1998-2003. AZH-NAtD and AD episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

Three periods can be distinguished in the monthly distribution of mean duration of Atlantic episodes over Northern Iberian Peninsula in 1998-2003 (Figure Ap.24). The longest periods were registered in the period September-November with up to mean durations of 7 days in September and November. Atlantic events had a mean duration of 7 days also in April and 6 days in January and February (Figure Ap.24). In summer the length of Atlantic events decreased down to means of 3 days (Figure Ap.24). With respect to AZH-NAtD transport scenario the same periods registered the highest mean duration of these episodes. In September-December, in April and in January-February the mean duration of episodes reached 7-8 days. In June AZH-NAtD events had a mean duration of 3 days. AD episodes had lower duration than AZH-NAtD episodes but in September mean duration of AD episodes reached 7 days and in August and October 4 days (Figure Ap.24).

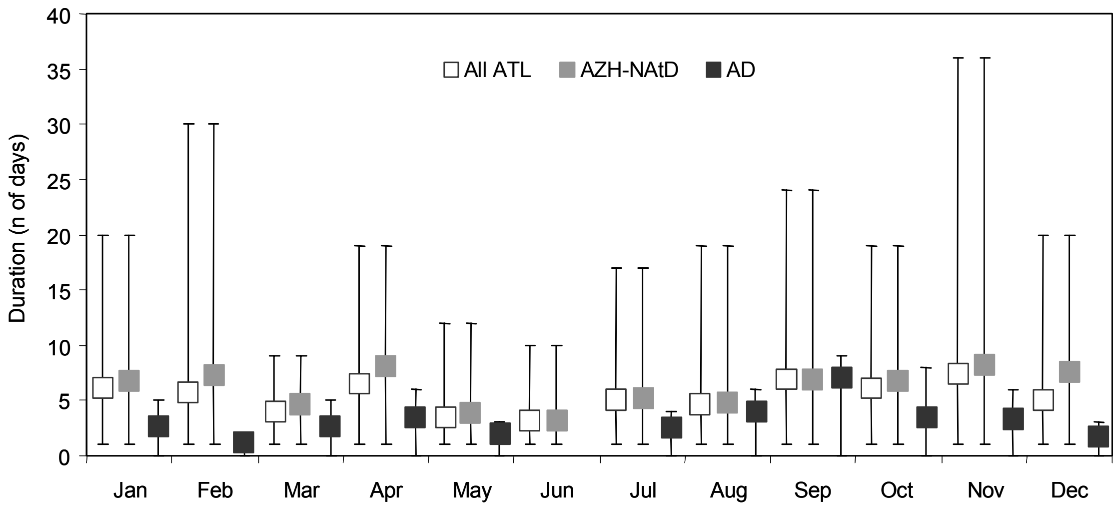

Figure Ap.24. Mean duration of Atlantic episodes per month over Northern Iberian Peninsula for 1998-2003. AZH-NAtD and AD episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

In the period 1998-2003, during Atlantic episodes the PM levels registered in rural stations over Northern Iberia were lower than the mean levels. Thus in Logroño and in Valderejo 24 and 14 µgTSP m^{-3} were registered and 10 µgPM10 m^{-3} mean was recorded as a mean at both sites (Table Ap.26).

Table Ap.26. Mean annual levels of TSP and PM10 registered in Logroño, Valderejo and Izki during Atlantic advection episodes in 1998-2003.

ATL EPISODES	**Logroño**	**Valderejo**		**Izki**
(µg m^{-3})	TSP	TSP	PM10	PM10
1998	22	na	na	na
1999	23	*[1]14	na	na
2000	28	na	13	na
2001	na	na	10	*[2]15
2002	na	na	9	8
2003	na	na	10	8
Mean 98-03	24	14	10	10

*[1]Calculated with data of 90% of the months of the year
*[2]Calculated with data of 67% of the months of the year
na: Not available

Differentiating the two transport scenarios considered for Atlantic events, AZH-NAtD and AD the impact did not vary greatly from one to the other. Mean PM levels registered during AZH-NAtD are comparable with those recorded during AD events. TSP mean levels in Logroño and in Valderejo resulted to be slightly higher during AD episodes (30 and 16 µg m^{-3} respectively) than during AZH-NAtD (24 and 14 µg m^{-3} respectively) events but PM10 mean levels in Valderejo and in Izki were very similar for the two scenarios (10-11 and 9 µg m^{-3} for the AZH-NAtD and AD respectively,

Table Ap.27). However, owing to the greater frequency of occurrence of AZH-NAtD transport scenario, the impact of this scenario is considerably higher than the impact of AD episodes. Thus the II (Impact Index) for TSP had values of 12.0 µg m^{-3} in Logroño and 6.8 µg m^{-3} in Valderejo for AZH-NAtD transport scenario and 1.9 µg m^{-3} in Logroño and 1.0 µg m^{-3} in Valderejo for AD transport scenario. For PM10 the impact of AZH-NAtD events is superior to the impact of AD events, for AZH-NAtD, II had values of 5.4 and 5.1 µg m^{-3} in Valderejo and Izki respectively and for AD, II was 0.6 µg m^{-3} for both stations (Table Ap.27).

Table Ap.27. Number of days with Atlantic advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP and PM10 (µg m^{-3}) recorded at Logroño, Valderejo and Izki rural sites (N Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	AZH-NAtD	AD
2003		
Valderejo PM10 (µg m^{-3})	9	10
Izki PM10 (µg m^{-3})	8	10
Days	125	39
2002		
Valderejo PM10 (µg m^{-3})	9	7
Izki PM10 (µg m^{-3})	8	8
Days	195	19
2001		
Valderejo PM10 (µg m^{-3})	10	7
Days	206	19
2000		
Valderejo PM10 (µg m^{-3})	13	11
Days	209	27
1999		
Valderejo TSP* (µg m^{-3})	14	16
Days*	188	19
1998		
Logroño TSP (µg m^{-3})	22	26
Days	182	15
Mean 98-03 (µg m^{-3})		
LogroñoTSP	24	30
Valderejo TSP	14	16
Valderejo PM10	11	9
Izki PM10	10	9
Impact Index(II) (µg m^{-3})		
LogroñoTSP	12.0	1.9
Valderejo TSP	6.8	1.0
Valderejo PM10	5.4	0.6
Izki PM10	5.1	0.6

*Data in Valderejo only available from 1/1999 until 11/1999.

The highest monthly means during Atlantic episodes in Valderejo were registered in summer and alternatively under AZH-NAtD and AD transport scenarios. Thus, for TSP 39 µg m^{-3} were recorded under AD scenario in May and 21 µg m^{-3} were recorded under AZH-NAtD in June (Table Ap.28). PM10 monthly means were also high during summer (June September) in both transport scenarios ranging from 14 to 17 µg m^{-3} (Table Ap.28). These summer maximums can be attributed to a lower rain frequency in this season and to a possible greater re-suspension.

Table Ap.28. Number of days per month with Atlantic advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP and PM10 (µg m^{-3}) recorded at Valderejo rural site (N Spain) for those days.

	AZH-NAtD	AD		AZH-NAtD	AD
January			**July**		
Days per month	16.8	1.3	Days per month	19.2	0.8
TSP	11		TSP	21	
PM10	8	5	PM10	14	17
February			**August**		
Days per month	14.5	0.8	Days per month	11.8	1.3
TSP	12		TSP	18	
PM10	9	6	PM10	15	13
March			**September**		
Days per month	10.8	3.2	Days per month	13.8	2.3
TSP	12	18	TSP	11	
PM10	8	10	PM10	17	9
April			**October**		
Days per month	17.7	4.0	Days per month	18.2	2.3
TSP	13	12	TSP	12	10
PM10	10	8	PM10	10	11
May			**November**		
Days per month	10.8	1.7	Days per month	20.7	1.7
TSP	11	39	TSP	8	
PM10	10	9	PM10	9	14
June			**December**		
Days per month	10.8	0.0	Days per month	19.0	3.5
TSP	20		TSP		
PM10	14		PM10	8	8

2.2. African episodes

92 episodes of North African dust intrusions occurred over Northern Iberian Peninsula in the study period (1998-2003). In consequence, the mean number of episodes per year was 15 and the number of episodes per month was 1 (Table Ap.29). As a mean, these events lasted an average of 3 days per episode. These dust outbreaks resulted in a total of 234 days in the 6-year period (39 days per year, 3 days per month, Table Ap.29).

16% of the African events (15 events, 3 per year, Table Ap.29) occurred under a meteorological scenario of NAH-S (presence of an anticyclone covering Northern Africa and/or the Iberian Peninsula at the lowest levels of the atmosphere) type. The mean duration of these events was 3 days per episode. The number of days resulting from these 15 episodes was 45 days (19% of the total number of African advection days), that is, 8 days per year and 1 day per month (Table Ap.29).

Approximately one third (32%) of the African episodes corresponded to AD (depression over the Atlantic ocean in front of Portugal) transport scenario. Thus, a total of 29 AD episodes were registered (5 episodes per year, Table Ap.29) with a mean duration of 2 days. 53 days (23% of the number of African days) with this meteorological situation were recorded (9 days per year, 1 day per month, Table Ap.29).

16 episodes out of the 92 African events (17%) occurred under NAD (presence of a depression over Northern Africa or over the Mediterranean) transport scenario. These resulted in 3 days per year (Table Ap.29). The average duration of these episodes was 3 days. From the 234 days with African advection in 46 the synoptic situation was of the NAD type (20%), that is, 8 days per year and 1 day per month (Table Ap.29).
Finally, 35% of the African episodes, that is, 32 episodes corresponded to NAH-A (transport driven by the North African anticyclone at upper levels of the atmosphere) transport scenario. A mean of 5 NAH-A events per year occurred with a mean duration of 3 days (Table Ap.29). These events resulted in 90 days with this scenario (15 days per year, 1 day per month, Table Ap.29). The percentage of days with NAH-A transport scenario from the total number of African days was 38%.
Annually, the number of African events ranged from 9 in 1999 to 18 in 2002 and 2003. No NAH-S episodes were registered in 2001 and 5 in 2002. The maximum number of AD episodes was recorded in 2000 with 8 and the minimum number in 1999 with 1. Five episodes in 2001 and 1 in 2000 and 2002 were the maximum and minimum number of NAD events per year registered in the period 1998-2003. Finally, the number of NAH-A events ranged from 7 in 2002 and 2003 to 4 in 1998 and 1999 (Table Ap.29).
With respect to the number of African days the highest number were recorded in 2003 with 57 and the lowest in 1999 with 15. The highest number of: NAH-S days occurred in 1998 (18 days), AD days in 2000 and 2001 (12 days), NAD days in 2001 (17 days) and NAH-A days in 2003 (27 days). The lowest annual number of days were recorded in 2001 for NAH-S with 0 days, 1999 for AD with 1 day, 2000 for NAD with 2 days and 1999 for NAH-A with 7 days (Table Ap.29).

Table Ap.29. Annual number of days and episodes with African advection in the period 1998-2003 over Northern Iberian Peninsula. The NAH-S, AD, NAD and NAH-A scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total NAF	37	15	30	46	49	57	39	3
NAH-S	18	2	8	0	13	4	8	1
AD	7	1	12	12	11	10	9	1
NAD	3	5	2	17	3	16	8	1
NAH-A	9	7	8	17	22	27	15	1
Episodes								
Total NAF	14	9	17	16	18	18	15	1
NAH-S	4	1	3	0	5	2	3	<1
AD	4	1	8	6	5	5	5	<1
NAD	2	3	1	5	1	4	3	<1
NAH-A	4	4	5	5	7	7	5	<1

The monthly distribution of African events over Northern Iberia showed three periods of higher frequency, December-March (highest number of episodes in March with 12 events, Figure Ap.25), May-August (in June 12 episodes in the study period, Figure Ap.25) and October (with 8 episodes during 1998-2003). Three minima were also registered in April (2 episodes in the study period), September and November (4 episodes on each month for 1998-2003). NAH-S episodes occurred from January to March (6 events of this type in this month, Figure Ap.25). AD episodes practically did not occur in summer and had a period of high frequency, December (6 events in 1998-2003) to March, and two months (May and October) in which these events were also relatively frequent (4 episodes in both months during 1998-2003, Figure Ap.25). As

AD episodes, NAD events practically did not occur during summer but neither in December. May clearly was the month in which NAD episodes showed the highest frequency of occurrence with 5 episodes during 1998-2003 (Figure Ap.25). NAH-A episodes only occurred from May to October and the peak of number of NAH-A episodes was 12 events registered in June (Figure Ap.25).

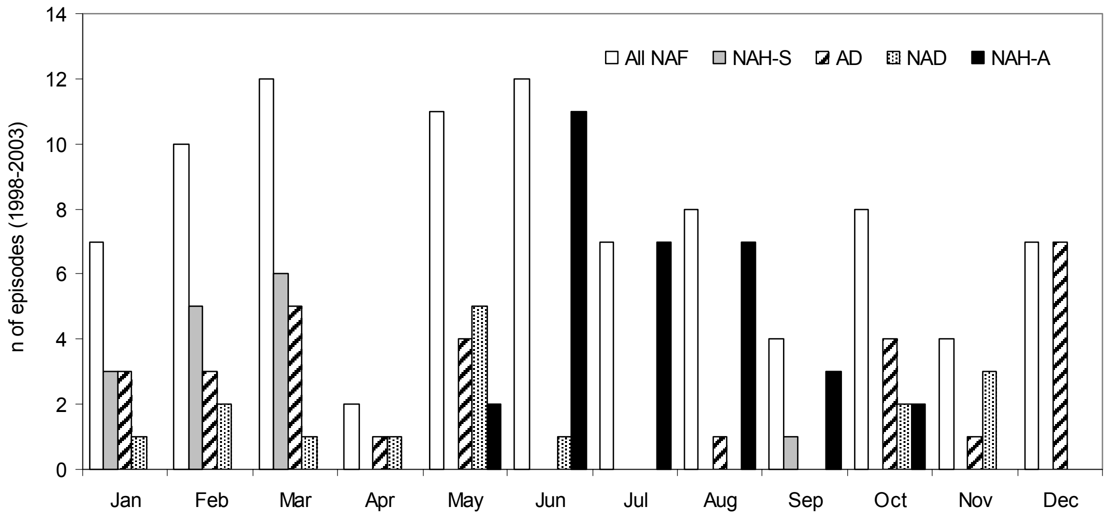

Figure Ap.25. Monthly distribution of the number of African episodes over Northern Iberian Peninsula. The monthly distributions of NAH-S, AD, NAD and NAH-A African events are also shown.

The occurrence of days with African advection over Northern Iberia was high in late spring (May and June), August, late winter (February and March) and October. June registered an average of 7 days followed by February and March with 5 days as a mean (Figure Ap.26 and Ap.27). In February and in May African dust outbreaks were always present. April (6 days in 1998-2003) and September (5 days in 1998-2003) were the months with the lowest frequency of occurrence of African days. February and March accumulated most of the days with African dust outbreak caused by NAH-S scenario, 3 days was the mean in both months (Figure Ap.26 and Ap.27). The days with AD scenario were concentrated in March and December with 3 days on average in each of these months and the days with NAD scenario were basically concentrated in May with 3 days as a mean (Figure Ap.26 and Ap.27). The number of African days with NAH-A scenario was especially important in June (a mean of 7 days, Figure Ap.26 and Ap.27) and in August (4 days on average, Figure Ap.26 and Ap.27).

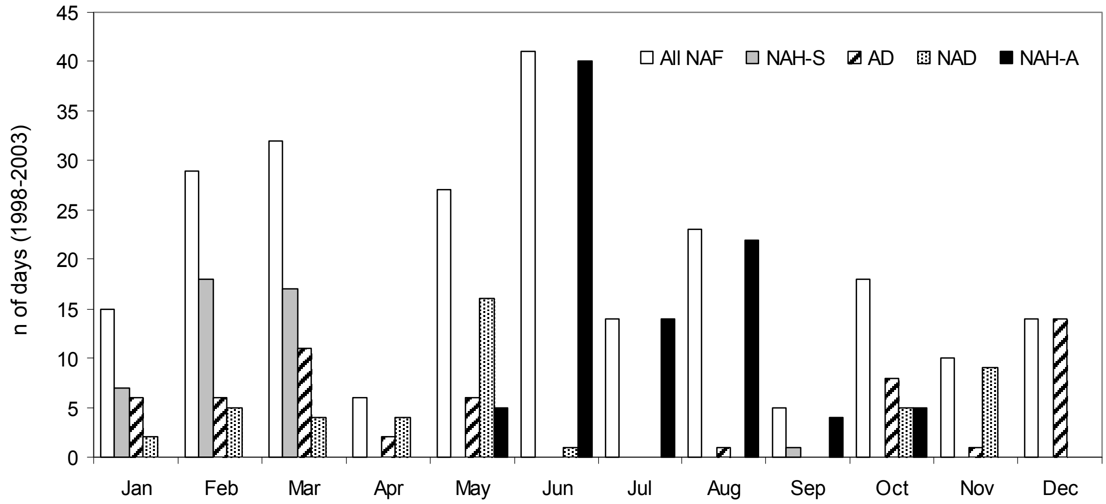

Figure Ap.26. Monthly distribution of the number of days with African advection over Northern Iberian Peninsula. The monthly distributions of days with African advection occurred under NAH-S, AD, NAD and NAH-A scenarios are also shown.

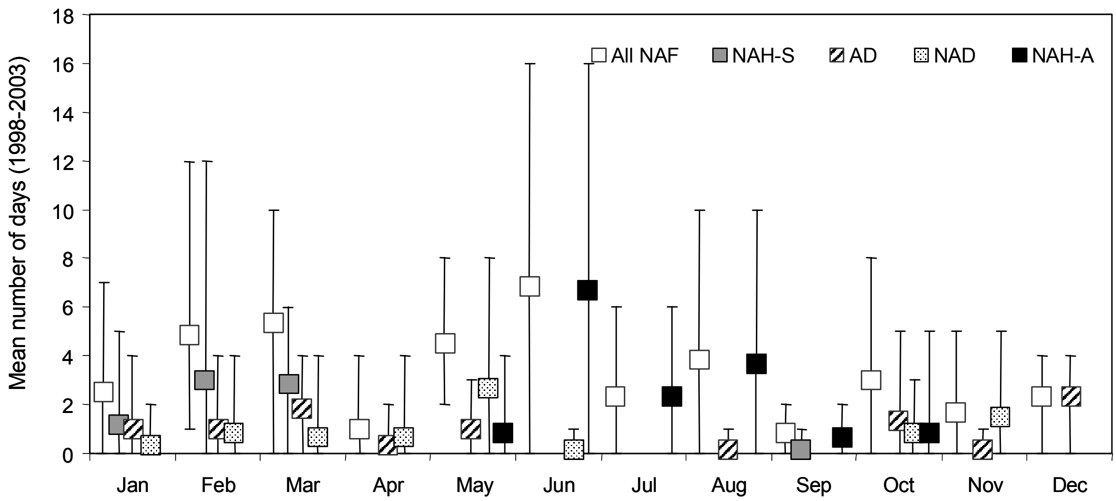

Figure Ap.27. Mean number of days with African advection over Northern Iberian Peninsula per month for 1998-2003. NAH-S, AD, NAD and NAH-A episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

As shown in Figure Ap.28, in all the months the mean duration of African dust outbreaks ranged from 2 to 3 days per episode with the exception of September (when the average duration was 1 day per event) and in June (4 days per episode). The longest NAH-S African events were registered in February with a mean duration of 4 days (Figure Ap.28). The variation on the mean monthly duration of AD episodes is not great. The mean duration of these events is in most months 2 days per event. NAD events lasted 4 days as an average in March and in April and NAH-A showed their highest mean duration in June with 4 days per event (Figure Ap.28).

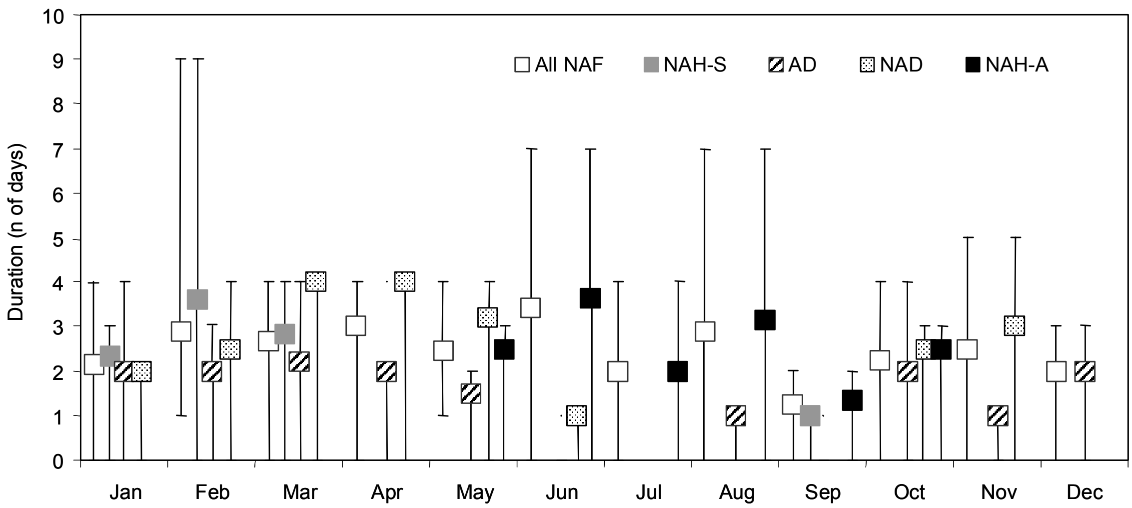

Figure Ap.28. Mean duration of African episodes per month over Northern Iberian Peninsula for 1998-2003. NAH-S, AD, NAD and NAH-A episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

PM levels recorded during African dust outbreaks in rural stations over Northern Spain were considerably higher than the annual average levels (30 µgTSP m^{-3} in Logroño, 19 µgTSP m^{-3} and 14 µgPM10 m^{-3} in Valderejo and 14 µgPM10 m^{-3} in Izki). In the period 1998-2003, Mean TSP levels during African events ranged from 52 µg m^{-3} in Logroño to 35 µg m^{-3} in Valderejo. In the same period, PM10 means during dust outbreaks ranged from 21 µg m^{-3} in Valderejo to 22 µg m^{-3} in Izki (Table Ap.30).

Table Ap.30. Mean annual levels of TSP and PM10 registered in Logroño, Valderejo and Izki during African advection episodes in 1998-2003.

NAF EPISODES	Logroño	Valderejo		Izki
(µg m^{-3})	TSP	TSP	PM10	PM10
1998	54	na	na	na
1999	55	*[1]35	na	na
2000	49	na	27	na
2001	na	na	20	*[2]29
2002	na	na	17	19
2003	na	na	22	20
Mean 98-03	52	35	21	22

*[1]Calculated with data of 90% of the months of the year
*[2]Calculated with data of 67% of the months of the year
na: Not available

As shown in Table Ap.31, NAH-S and NAH-A scenarios had a higher impact on levels of PM registered in regional background stations over Northern Iberia than AD and NAD scenarios. One of the factors may be the low frequency of rain associated with NAH-A and NAH-S compared with AD and NAD. Furthermore, during NAH-A situations the African plumes travel at high altitudes (>1500 m.a.s.l.) and the dust penetrates in the mixing layer because the vertical development of this layer can reach up to 2500 metres over continental areas in summer (Crespi et al., 1995). Once into the boundary layer the dust is distributed and affects the sampling stations. Moreover, the formation of secondary particles is enhanced during NAH-A situations because of the intense insolation and the poor renovation of air masses. Furthermore, during NAH-A episodes, re-suspension of soil material by the intense convection is enhanced. These factors result in a local/regional contribution of PM which may increase PM levels.

TSP mean levels in Logroño during the NAH-A episodes were 60 µg m^{-3}, during NAH-S were 65 µg m^{-3}, during AD events 42 µg m^{-3} and during NAD episodes 36 µg m^{-3}. In Valderejo, TSP mean levels were also high during NAH-S episodes with 40 µg m^{-3}, this mean is comparable with that registered during NAD episodes (43 µg m^{-3}) and higher than the means recorded during NAH-A (33 µg m^{-3}) and AD (22 µg m^{-3}) episodes. In PM10, it can be clearly detected an important impact of NAH-A events (26 µg m^{-3} as PM10 mean in both Valderejo and Izki) and NAH-S (20 µg m^{-3} in Valderejo and 23 µg m^{-3} in Izki). During AD episodes PM10 means of 17 and 18 µg m^{-3} were recorded in Valderejo and Izki respectively and during NAD events 16 µg m^{-3} was the mean PM10 levels registered at these two sites. Thus, during episodes associated with depressions mean PM10 levels were only slightly higher than the annual mean PM10 levels. The impact index (II) of NAH-A scenario is relatively high in all size ranges and stations 2.5 µg m^{-3} for TSP in Logroño, 1.4 µg m^{-3} for TSP in Valderejo, and 1.1 µg m^{-3} for PM10 in both Valderejo and Izki. The impact of NAH-S scenario is lower than the impact of NAH-A scenario with II of 1.3 and 0.8 µg m^{-3} for TSP in Logroño and Valderejo. II in TSP of AD and NAD scenarios were generally lower than II of NAH-S scenario. In PM10 the II of AD and NAD scenarios were comparable with the II of NAH-S scenario (in all cases between 0.5 and 0.3 µg m^{-3}).

Table Ap.31. Number of days with African dust outbreaks occurred under the 4 meteorological scenarios differentiated and mean daily ambient air levels of TSP and PM10 (µg m^{-3}) recorded at Logroño, Valderejo and Izki rural sites (N Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	NAH-S	AD	NAD	NAH-A
2003				
Valderejo PM10 (µg m^{-3})	15	19	19	26
Izki PM10 (µg m^{-3})	17	18	16	23
Days	3	11	16	27
2002				
Valderejo PM10 (µg m^{-3})	18	14	10	19
Izki PM10 (µg m^{-3})	24	15	8	19
Days	13	11	3	22
2001				
Valderejo PM10 (µg m^{-3})	-	17	16	27
Days	0	12	17	17
2000				
Valderejo PM10 (µg m^{-3})	25	20	17	39
Days	8	12	2	8
1999				
Valderejo TSP* (µg m^{-3})	40	22	43	33
Days*	2	1	5	7
1998				
Logroño TSP (µg m^{-3})	70	41	25	58
Days	18	7	3	9
Mean 98-03 (µg m^{-3})				
LogroñoTSP	65	42	36	60
Valderejo TSP	40	22	43	33
Valderejo PM10	20	17	16	26
Izki PM10	23	18	16	26
Impact Index(II) (µg m^{-3})				
LogroñoTSP	1.3	1.0	0.7	2.5
Valderejo TSP	0.8	0.5	0.9	1.4
Valderejo PM10	0.4	0.4	0.3	1.1
Izki PM10	0.5	0.4	0.3	1.1

*Data in Valderejo only available from 1/1999 until 11/1999.

Table Ap.32 shows that the highest monthly TSP means for days with African advection in Valderejo were registered during NAH-A episodes (principally in July with 49 µg m^{-3} and in August with 51 µg m^{-3}). Also under NAH-S situations (with 40 µg m^{-3} as a mean in January) the means were relatively high. As PM10 concerns, the highest monthly means for African episodes were registered also during NAH-A events in summer (June with 25 µg m^{-3}, July with 28 µg m^{-3}, August with 28 µg m^{-3} and September with 34 µg m^{-3}). Also during AD days in August (mean of 50 µg m^{-3}) PM10 means were elevated although a monthly occurrence of 0.2 days with this scenario occurred in August). PM10 mean levels during African days in March were also relatively high (25 µg m^{-3} during AD days, 23 µg m^{-3} during NAH-S days and 22 µg m^{-3} during NAD days as mean levels were registered).

Table Ap.32. Number of days per month with Atlantic advection occurred under the 4 meteorological scenarios differentiated and mean daily ambient air levels of TSP and PM10 (all units in µg m^{-3}) recorded at Valderejo rural site (N Spain) for those days.

	NAH-S	AD	NAD	NAH-A		NAH-S	AD	NAD	NAH-A
January					**July**				
Days per month	1.2	1.0	0.3	0.0	Days per month	0.0	0.0	0.0	2.3
TSP	40	22			TSP				49
PM10	14	11			PM10				28
February					**August**				
Days per month	3.0	1.0	0.8	0.0	Days per month	0.0	0.2	0.0	3.7
TSP			10		TSP				51
PM10	21	11	17		PM10		50		28
March					**September**				
Days per month	2.8	1.8	0.7	0.0	Days per month	0.2	0.0	0.0	0.7
TSP					TSP				
PM10	23	25	22		PM10	20			34
April					**October**				
Days per month	0.0	0.3	0.7	0.0	Days per month	0.0	1.3	0.8	0.8
TSP			59		TSP				26
PM10		11	18		PM10		19	19	
May					**November**				
Days per month	0.0	1.0	2.7	0.8	Days per month	0.0	0.2	1.5	0.0
TSP					TSP				
PM10		22	13	20	PM10		13	15	
June					**December**				
Days per month	0.0	0.0	0.2	6.7	Days per month	0.0	2.3	0.0	0.0
TSP					TSP				
PM10				25	PM10		10		

2.3. European episodes

90 European episodes enclosing 319 days occurred over Northern Iberia in the period 1999-2003. This resulted in means of 15 episodes per year and 1 per month (Table Ap.33) and 53 days per year and 4 per month (Table Ap.33). The mean duration of the European events was 3 days.

A 64% of the 90 episodes (58) occurred under EUH (presence of an anticyclone over the European continent or over the Northern Atlantic Ocean) transport scenario which resulted in 10 episodes per year and 1 per month with a mean length of 4 days. The number of days with European transport caused by EUH situations in the study period were 224 (37 days per year, 3 days per month) which results in 70% of the number of days with European advection (Table Ap.33).

The rest (36%) of European episodes, 32 events, corresponded to MD (presence of a depression over the Mediterranean sea) transport scenario, that is, 5 events per year (Table Ap.33). 30% of the days with European advection occurred during MD situations, this resulted in 95 days (16 days per year, 1 day per month, Table Ap.33). The mean duration of this type of European events was 3 days.

The number of European episodes per year registered over Northern Spain ranged between 12 in 2000 and 21 in 1999. This maximum is due to the maximum number of EUH epuisodes registered in this year while during the rest of the years 8 or 9 EUH events were registered. The number of MD events ranged from 4 in 1998 and in 2000 to 7 in 2003 (Table Ap.33).

As for the number of episodes, the number of days with European advection was maximum in 1999 with 66 days owing to the high number of EUH days (50). The highest number of MD days was registered in 2002 with 26 days. The lowest number

of days with European advection was recorded in 2000 with 40 days, in this year also the lowest number of days with European advection caused by MD scenario was present (7 days). The lowest number of EUH days in the period 1998-2003 was recorded in 2003 with 32 days (Table Ap.33).
The number of days with European advection recorded in a year was maximum in 1999 and 2003 with 44 days (Table Ap.33). The maximum number of EUH European days was recorded in 1998 (33, Table Ap.33) and the maximum number of days with European advection under MD scenario was recorded in 1999 and 2002 (18, Table Ap.33). As shown in Table Ap.33, in 2000 the number of days with European advection registered was minimum for all events (20), for EUH events (18) and for MD episodes (2).

Table Ap.33. Annual number of days and episodes with European advection in the period 1998-2003 over Northern Iberian Peninsula. The EUH and MD scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total EU	60	66	40	49	58	46	53	4
EUH	46	50	33	34	32	29	37	3
MD	14	16	7	15	26	17	16	1
Episodes								
Total EU	13	21	12	14	15	15	15	1
EUH	9	15	8	9	9	8	10	1
MD	4	6	4	5	6	7	5	<1

In Figure Ap.29 three periods of higher frequency of occurrence of European events may be distinguished. The main peak was registered in November (12 episodes) and two secondary maximums were centred in March-May (9 events in each month) and in September (8 episodes). These patterns were similar in the monthly distribution of EUH events with two principal maximums in March and November (7 episodes on each month during 1998-2003) and a secondary maximum in August-September (6 episodes on each month). In the study period the months with lower frequency of occurrence of EUH events were October with 2 events and June and July with 3 events for each month (Figure Ap.29). MD episodes occurred mainly in spring and in autumn. A low frequency of occurrence was registered in winter and summer. In April and May (6 MD episodes on each month during the study period) and November (7 episodes). From July to September only 4 MD episodes were registered in the six-years period 1998-2003 (Figure Ap.29).

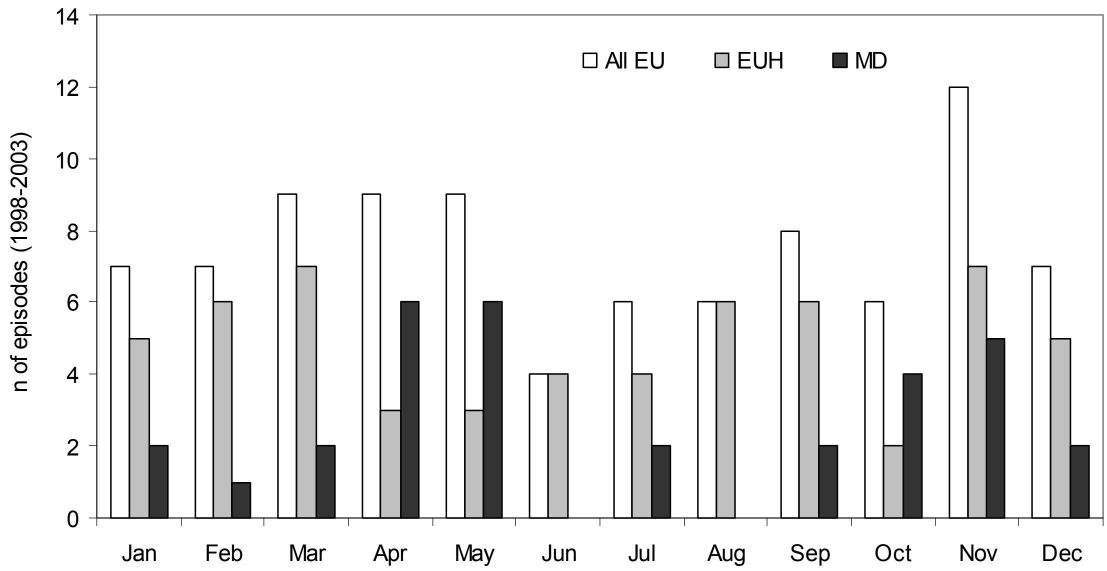

Figure Ap.29. Monthly distribution of the number of European episodes over Northern Iberian Peninsula. The monthly distribution of EUH and MD European events is also shown.

The number of days with European advection over the Northern Iberian Peninsula was particularly important in March (8 days as a mean in this month). From November to April the abundance of days with European advection was higher than from May to October, with the exception of September with a mean of 5 with European advection days (Figures Ap.30 and Ap.31). Moreover, in September, European advection days occurring under the EUH transport scenario were registered every year (a minimum of 2, Figure Ap.31). Days with European advection were frequent in the period January-March (7 EUH days on average in March) and secondly in August (4 days on average). The days with European advection under MD transport scenario were more frequent than the monthly average in April-May, with a mean of 3 days for both months (Figures Ap.30 and Ap.31).

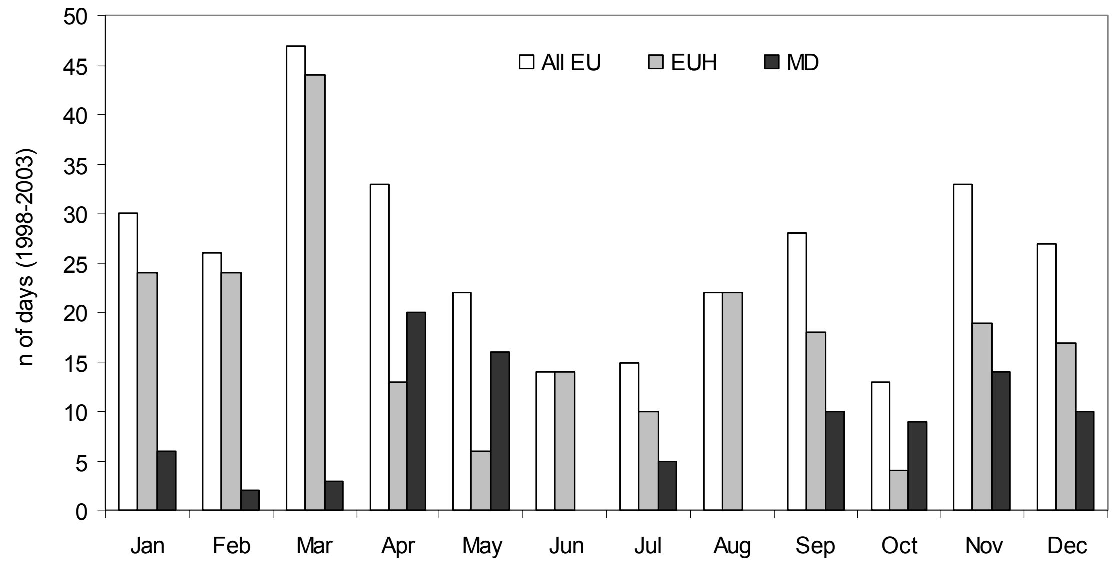

Figure Ap.30. Monthly distribution of the number of days with European advection over Northern Iberian Peninsula. The monthly distributions of days with European advection occurred under EUH and MD scenarios are also shown.

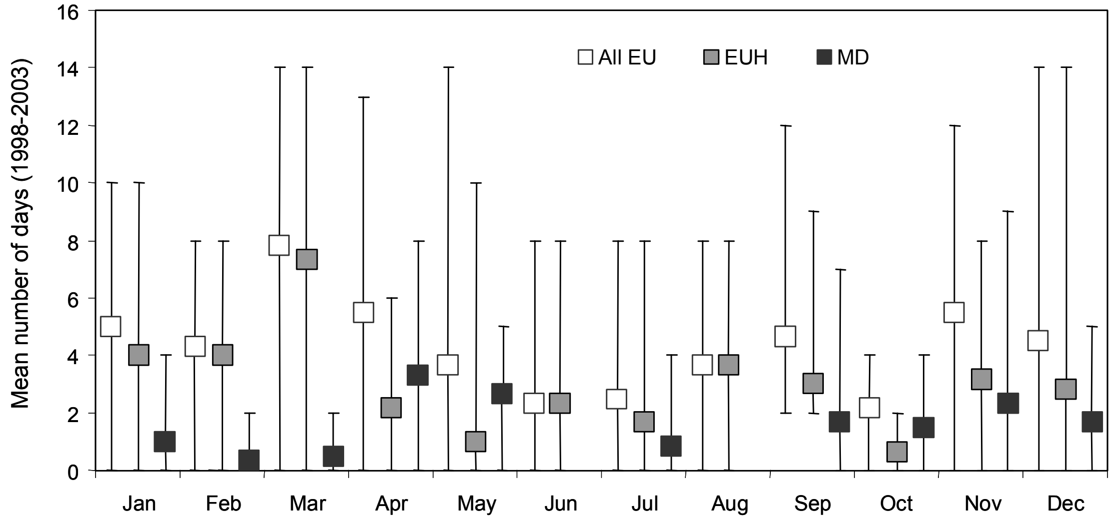

Figure Ap.31. Mean number of days with European advection over Northern Iberian Peninsula per month for 1998-2003. EUH and MD episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

The longest mean durations of European episodes over Northern Iberia in 1998-2003 occurred in March (5 days per episode). Moreover, the mean duration of European events was of 4 days in several months (January, February, April, August, September and December). January-March was the period in which EUH events had a highest duration, in particular in March (EUH episodes lasted 6 days on average in this month) and January (5 days as mean duration of EUH events occurred in this month). MD episodes were clearly longer in two months: September and December with a mean duration per episode of 5 days (Figure Ap.32).

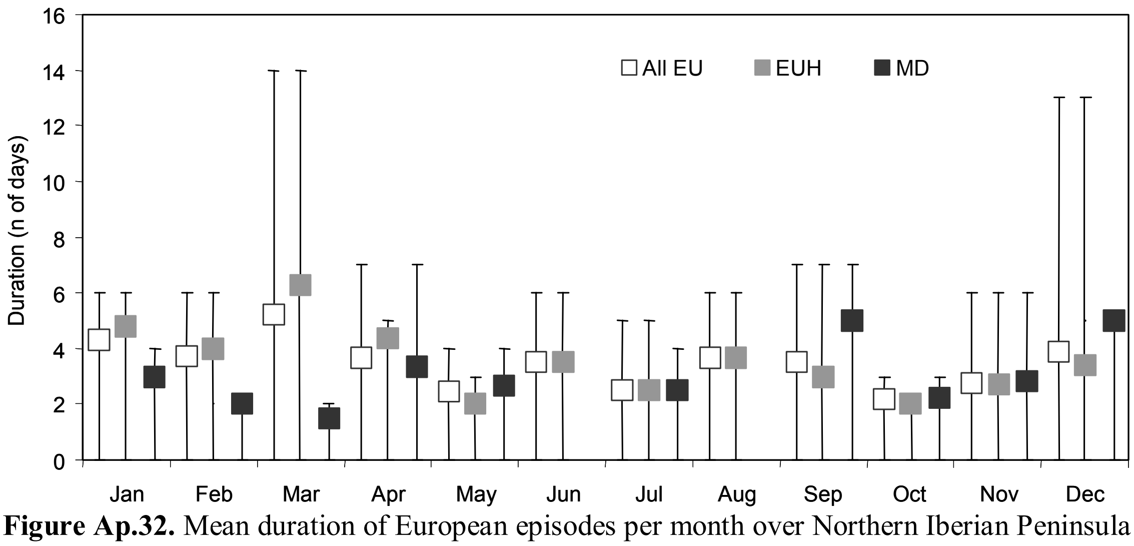

Figure Ap.32. Mean duration of European episodes per month over Northern Iberian Peninsula for 1998-2003. EUH and MD episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

Mean PM levels recorded during European episodes in Northern Iberian Peninsula were only slightly higher than the annual averages (30 µgTSP m^{-3} at Logroño, 19 µgTSP m^{-3} and 14 µgPM10 m^{-3} at Valderejo and 14 µgPM10 m^{-3} at Izki). Mean TSP levels in episodes with European advection were 28 µg m^{-3} in Logroño and 21 µg m^{-3} in Valderejo while mean PM10 levels were 14 µg m^{-3} both in Valderejo and Izki (Table Ap.34).

Table Ap.34. Mean annual levels of TSP and PM10 registered in Logroño, Valderejo and Izki during European advection episodes in 1998-2003.

EU EPISODES	Logroño	Valderejo		Izki
(μg m^{-3})	TSP	TSP	PM10	PM10
1998	28	na	na	na
1999	25	*[1]21	na	na
2000	33	na	18	na
2001	na	na	13	*[2]14
2002	na	na	14	15
2003	na	na	14	13
Mean 98-03	28	21	14	14

*[1]Calculated with data of 90% of the months of the year
*[2]Calculated with data of 67% of the months of the year
na: Not available

Evaluating the two transport scenarios separately it can be concluded that during EUH episodes mean PM levels recorded were higher than during MD events probably due to the rainfall associated with the depressions involved in MD episodes. In the period 1998-2003, TSP mean levels of 32 μg m^{-3} in Logroño and 21 μg m^{-3} in Valderejo were recorded during EUH episodes, while TSP means of 15 μg m^{-3} in Logroño and of 21 μg m^{-3} in Valderejo were measured during MD events. PM10 means during EUH episodes ranged from 16 μg m^{-3} in Valderejo to 15 μg m^{-3} in Izki. During MD events PM10 means were slightly lower, 12 μg m^{-3} for both sites (Table Ap.35). Considering also the frequency of occurrence of these scenarios days, it can be concluded that the impact of EUH transport scenario on annual PM levels is clearly higher than the impact of MD scenario. Thus, as shown by Table Ap.35, impact indexes (II) on TSP of 3.2 μg m^{-3} in Logroño and 2.1 μg m^{-3} in Valderejo were registered for EUH scenario and II's of 0.6 μg m^{-3} in Logroño and 0.9 μg m^{-3} in Valderejo for MD scenario. On PM10, the impact of EUH scenario (II=1.6 μg m^{-3} in Valderejo and II=1.5 μg m^{-3} in Izki) is also important when compared with the impact of MD scenario (II=0.5 μg m^{-3} in both Valderejo and Izki).

Table Ap.35. Number of days with European advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP and PM10 ($\mu g\ m^{-3}$) recorded at Logroño, Valderejo and Izki rural sites (N Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	EUH	**MD**
2003		
Valderejo PM10 ($\mu g\ m^{-3}$)	14	13
Izki PM10 ($\mu g\ m^{-3}$)	14	12
Days	29	17
2002		
Valderejo PM10 ($\mu g\ m^{-3}$)	16	12
Izki PM10 ($\mu g\ m^{-3}$)	15	14
Days	32	26
2001		
Valderejo PM10 ($\mu g\ m^{-3}$)	13	13
Days	34	15
2000		
Valderejo PM10 ($\mu g\ m^{-3}$)	20	9
Days	33	7
1999		
Valderejo TSP* ($\mu g\ m^{-3}$)	21	21
Days*	50	16
1998		
Logroño TSP ($\mu g\ m^{-3}$)	32	15
Days	46	14
Mean 98-03 ($\mu g\ m^{-3}$)		
LogroñoTSP	32	15
Valderejo TSP	21	21
Valderejo PM10	16	12
Izki PM10	15	12
Impact Index(II) ($\mu g\ m^{-3}$)		
LogroñoTSP	3.2	0.6
Valderejo TSP	2.1	0.9
Valderejo PM10	1.6	0.5
Izki PM10	1.5	0.5

*Data in Valderejo only available from 1/1999 until 11/1999.

Concerning the TSP monthly means during days with European advection in Valderejo, the highest mean levels were registered under situations of EUH transport scenario in summer (TSP means ranging from 23 to 38 $\mu g\ m^{-3}$) and in March, with TSP mean of 31 $\mu g\ m^{-3}$. The unique exception was in January during MD events with monthly mean of 48 $\mu g\ m^{-3}$ but with a low monthly occurrence (only 1.0 days per year in this month). PM10 mean levels registered during European days were also elevated during the summer months under EUH transport type (from 16 to 21 $\mu g\ m^{-3}$ in the period June-October) and, also during March with 21 $\mu g\ m^{-3}$ as monthly mean (Table Ap.36).

Table Ap.36. Number of days per month with European advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP and PM10 (µg m^{-3}) recorded at Valderejo rural site (N Spain) for those days.

	EUH	MD		EUH	MD
January			**July**		
Days per month	4.0	1.0	Days per month	1.7	0.8
TSP	11	48	TSP	22	
PM10	12	12	PM10	18	19
February			**August**		
Days per month	4.0	0.3	Days per month	3.7	0.0
TSP	14		TSP	27	
PM10	12		PM10	16	
March			**September**		
Days per month	7.3	0.5	Days per month	3.0	1.7
TSP	31		TSP	38	
PM10	21	10	PM10	18	13
April			**October**		
Days per month	2.2	3.3	Days per month	0.7	1.5
TSP	11		TSP	17	
PM10	15	14	PM10	21	9
May			**November**		
Days per month	1.0	2.7	Days per month	3.2	2.3
TSP	13	11	TSP		
PM10	12	13	PM10	12	9
June			**December**		
Days per month	2.3	0.0	Days per month	2.8	1.7
TSP	23		TSP		
PM10	24		PM10	13	7

2.4. Mediterranean episodes

A total of 31 episodes with advection of Mediterranean air masses were recorded over Northern Iberian Peninsula in the study period (1998-2003), this accounts for 5 events per year with a mean duration of 2 days per event. The number of days with Mediterranean advection was 58, that is, 10 days per year and 1 day per month in 1998-2003 (Table Ap.37). In any case, Mediterranean events are the less frequent transport episodes over Northern Spain.

Nine out of the 31 Mediterranean episodes (29%) occurred when a depression was located over Northern Africa or over the Mediterranean Sea (NAD-MD meteorological scenario). Thus, only 1 event of this type per year was registered as average. These episodes had a mean duration of 1 day per episode. These events comprised a total of 13 days (22% of the total Mediterranean days, 2 days per year) in 1998-2003 (Table Ap.37).

The other 71% of the Mediterranean episodes, that is, 22 episodes (4 episodes per year) and the other 78% of the days with Mediterranean advection, 45 days (8 days per year and 1 day per month) corresponded with EUH-MH transport scenario (caused by the presence of an anticyclone over the European continent or over the Mediterranean). These episodes had a mean duration of 2 days (Table Ap.37).

The number of Mediterranean episodes registered in the six years of the study period ranged from 3 (in 2003) to 8 (in 1999). No NAD-MD episodes were recorded in 2001 and 4 were observed in 1999. Finally, the highest and lowest number of EUH-MH episodes recorded during the study period was 5 events in 1998 and in 2000 and 2 episodes in 2002 and 2003 (Table Ap.37). In 1999, 6 days with NAD-MD scenario were detected. In 1998 and 2002, 10 days with Mediterranean advection occurred under EUH-MH transport scenario, while in 2003, only 3 of those days were detected (Table Ap.37).

Table Ap.37. Annual number of days and episodes with Mediterranean advection in the period 1998-2003 over Northern Iberian Peninsula. The NAD-MD and EUH-MH scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total MED	12	15	11	4	12	4	10	1
NAD-MD	2	6	2	0	2	1	2	<1
EUH-MH	10	9	9	4	10	3	8	1
Episodes								
Total MED	6	8	6	4	4	3	5	<1
NAD-MD	1	4	1	0	2	1	2	<1
EUH-MH	5	4	5	4	2	2	4	<1

January, with 6 Mediterranean episodes in 1998-2003 and May, September, and November with 4 Mediterranean episodes on each month during the study period were the months with the highest frequency of occurrence. EUH-MH episodes occurred in all the months with the exception of April, July and August. January, May and September with 4 EUH-MH events were the months with the highest frequency of occurrence of this scenario. NAD-MD episodes only occurred from January to April (2 episodes on each month for 1998-2003) and on November with a single NAD-MD event during the study period (Figure Ap.33).

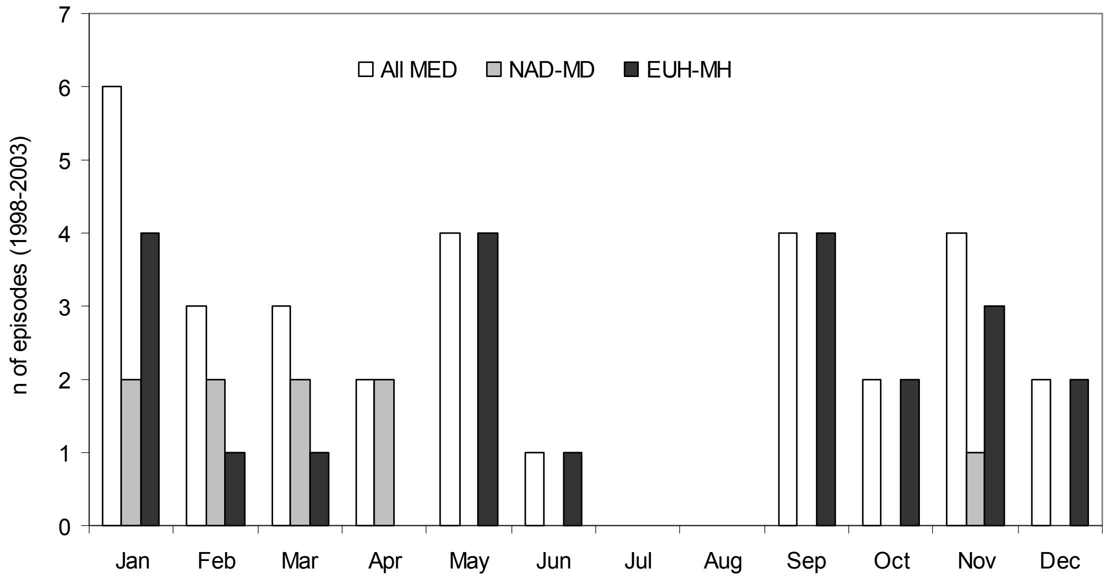

Figure Ap.33. Monthly distribution of the number of Mediterranean episodes over the Northern Iberian Peninsula. The monthly distributions of NAD-MD and EUH-MH Mediterranean events are also shown.

With respect to the number of days with Mediterranean advection, the highest values were registered in January (a mean of 3 days). The highest mean number of NAD-MD events (1 day) and of EUH-MH events (2 days) were registered in this month. In May, the frequency of occurrence of Mediterranean days was also relatively high with a mean of 2 days during this month (Figures Ap.34 and Ap.35).

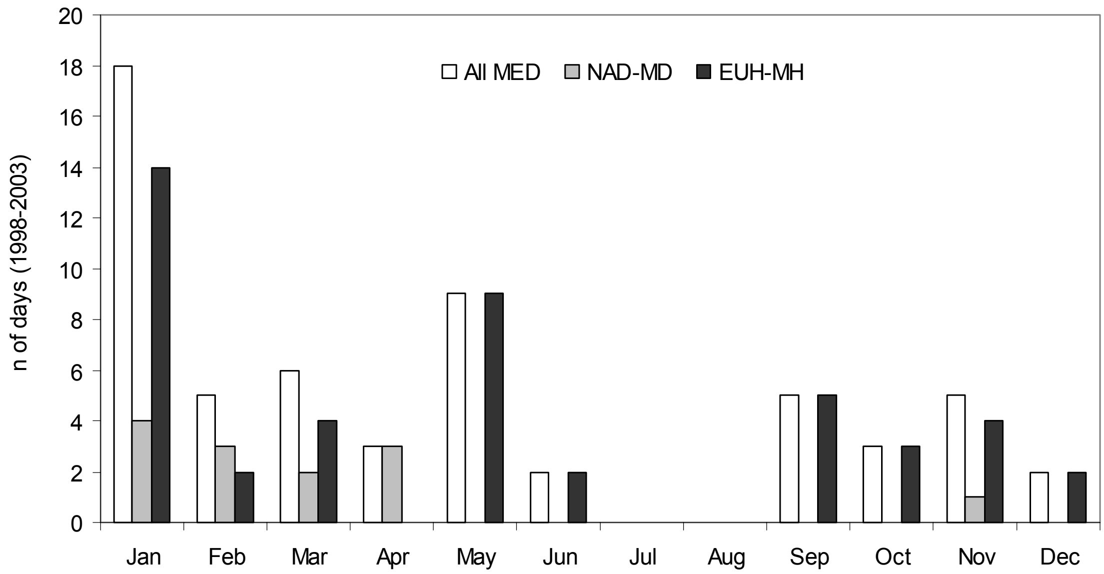

Figure Ap.34. Monthly distribution of the number of days with Mediterranean advection over Northern Iberian Peninsula. The monthly distributions of days with Mediterranean advection occurred under NAD-MD and EUH-MH scenarios are also shown.

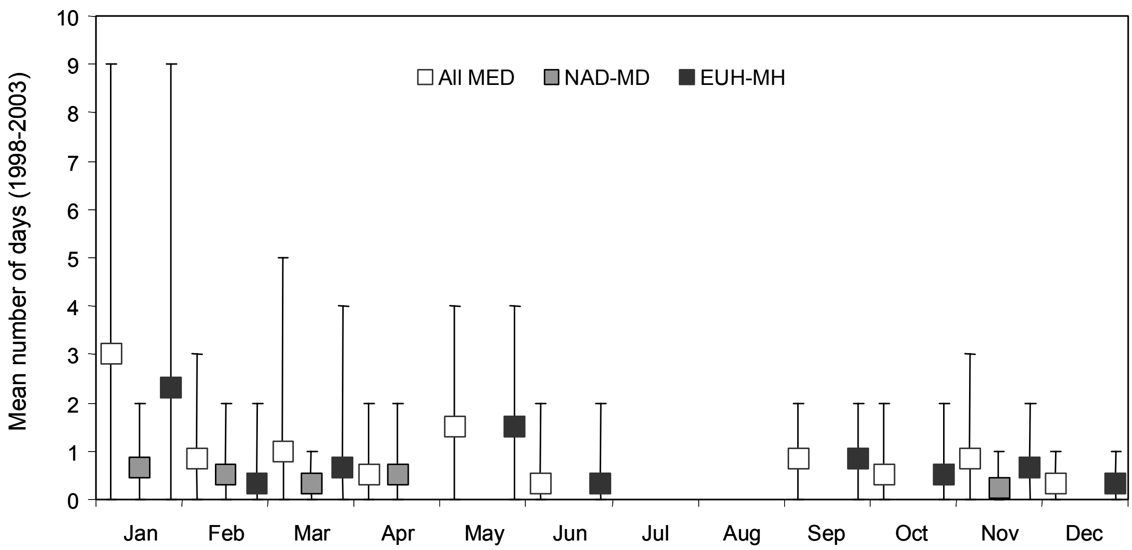

Figure Ap.35. Mean number of days with Mediterranean advection over Northern Iberian Peninsula per month for 1998-2003. NAD-MD and EUH-MH episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

The longest Mediterranean event recorded in the whole study period over Northern Iberia lasted 9 days (Figure Ap.36). In general, Mediterranean events occurring in January-June were longer than those occurring from September to December. The longest mean duration of Mediterranean events was detected in January, with a mean duration of such episodes of 3 days. EUH-MH episodes reached mean durations of 3-4 days in January and March and NAD-MD episodes only reached mean durations of 2 days per episode in January (Figure Ap.36).

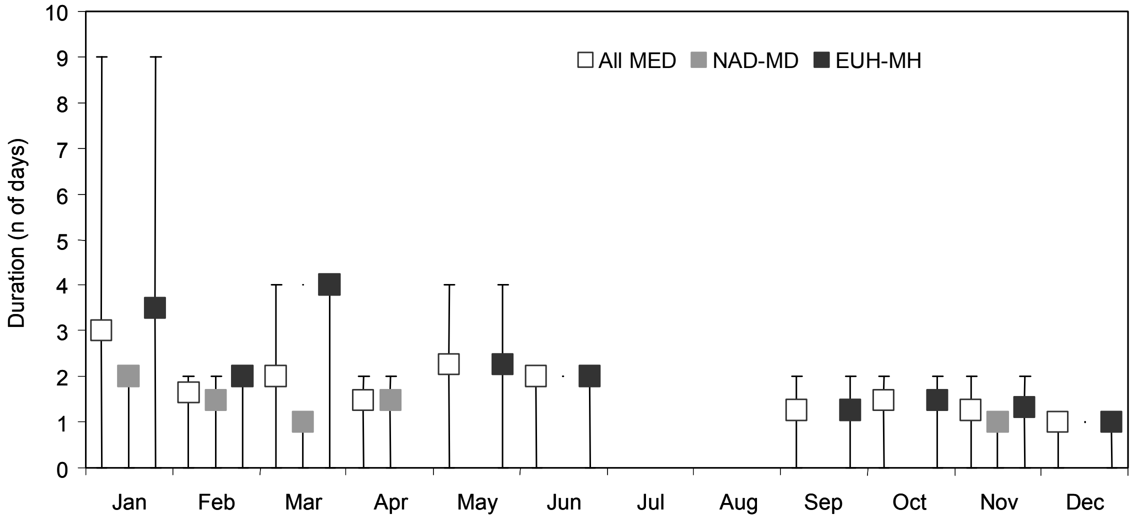

Figure Ap.36. Mean duration of Mediterranean episodes per month over Northern Iberian Peninsula for 1998-2003. NAD-MD and EUH-MH episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

Low mean PM levels were registered in regional background stations over Northern Iberian Peninsula in the period 1998-2003 during Mediterranean advection episodes. The average levels of TSP in Logroño (35 µg m^{-3}) and in Valderejo (16 µg m^{-3}) and the mean PM10 levels in Valderejo (12 µg m^{-3}) and in Izki (11 µg m^{-3}) were below the general mean levels in those stations (30 µgTSP m^{-3} at Logroño, 19 µgTSP m^{-3} and 14 µgPM10 m^{-3} at Valderejo and 14 µgPM10 m^{-3} at Izki) with the exception of Logroño station (Table Ap.38).

Table Ap.38. Mean annual levels of TSP and PM10 registered in Logroño, Valderejo and Izki during Mediterranean advection episodes in 1998-2003.

MED EPISODES	**Logroño**	**Valderejo**		**Izki**
(µg m^{-3})	TSP	TSP	PM10	PM10
1998	37	na	na	na
1999	30	*[1]16	na	na
2000	38	na	14	na
2001	na	na	12	*[2]13
2002	na	na	12	11
2003	na	na	7	6
Mean 98-03	35	16	12	11

*[1]Calculated with data of 90% of the months of the year
*[2]Calculated with data of 67% of the months of the year
na: Not available

The mean PM levels registered during EUH-MH and NAD-MD reached values of the same order of magnitude. Mean TSP levels in regional background stations over Northern Iberia during NAD-MD episodes (27 µg m^{-3} in Logroño and 14 µg m^{-3} in Valderejo) were somewhat lower than during EUH-MH (38 µg m^{-3} in Logroño and 18 µg m^{-3} in Valderejo) while the same PM10 means (12 µg m^{-3} during EUH-MH and 11 µg m^{-3} during NAD-MD) were recorded in Valderejo and Izki (Table Ap.39). However, the higher frequency of occurrence of EUH-MH episodes with respect to NAD-MD episodes resulted, as shown by Table Ap.39, in relatively higher impact indexes of the first scenario in TSP (II=0.8 µg m^{-3} in Logroño and II=0.4 µg m^{-3} in Valderejo) and in PM10 (II=0.2 µg m^{-3} in both Valderejo and Izki) than of the NAD-

MD scenario (II=0.2 µg m^{-3} for TSP in Logroño and II=0.1 µg m^{-3} in Valderejo and Izki for TSP and PM10).

Table Ap.39. Number of days with Mediterranean advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP and PM10 (µg m^{-3}) recorded at Logroño, Valderejo and Izki rural sites (N Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	NAD-MD	EUH-MH
2003		
Valderejo PM10 (µg m^{-3})	5	7
Izki PM10 (µg m^{-3})	7	5
Days	1	3
2002		
Valderejo PM10 (µg m^{-3})	15	12
Izki PM10 (µg m^{-3})	14	11
Days	2	10
2001		
Valderejo PM10 (µg m^{-3})	-	12
Days	0	4
2000		
Valderejo PM10 (µg m^{-3})	15	14
Days	2	9
1999		
Valderejo TSP* (µg m^{-3})	14	18
Days*	6	9
1998		
Logroño TSP (µg m^{-3})	19	42
Days	2	10
Mean 98-03 (µg m^{-3})		
LogroñoTSP	27	38
Valderejo TSP	14	18
Valderejo PM10	12	12
Izki PM10	11	11
Impact Index(II) (µg m^{-3})		
LogroñoTSP	0.2	0.8
Valderejo TSP	0.1	0.4
Valderejo PM10	0.1	0.2
Izki PM10	0.1	0.2

*Data in Valderejo only available from 1/1999 until 11/1999.

Monthly PM means recorded in Valderejo during Mediterranean events were low regardless the transport scenario. As TSP concerns the highest means were registered in March under EUH-MH situations (21 µg m^{-3}) or in January under NAD-MD scenario (19 µg m^{-3}). As PM10 concerns the, April under NAD-MD scenario (18 µg m^{-3}) and May under EUH-MH (16 µg m^{-3}) were the months with the highest monthly mean levels (Table Ap.40).

Table Ap.40. Number of days per month with Mediterranean advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP and PM10 (µg m^{-3}) recorded at Valderejo rural site (N Spain) for those days.

	NAD-MD	EUH-MH		NAD-MD	EUH-MH
January			**July**		
Days per month	0.7	2.3	Days per month	0.0	0.0
TSP	19		TSP		
PM10	15	12	PM10		
February			**August**		
Days per month	0.5	0.3	Days per month	0.0	0.0
TSP			TSP		
PM10	5	7	PM10		
March			**September**		
Days per month	0.3	0.7	Days per month	0.0	0.8
TSP	15	21	TSP		
PM10	12		PM10		15
April			**October**		
Days per month	0.5	0.0	Days per month	0.0	0.5
TSP	9		TSP		11
PM10	18		PM10		11
May			**November**		
Days per month	0.0	1.5	Days per month	0.2	0.7
TSP		14	TSP		
PM10		16	PM10	7	11
June			**December**		
Days per month	0.0	0.3	Days per month	0.0	0.3
TSP			TSP		
PM10			PM10		12

2.5. Episodes without dominant advective conditions

During 1998-2003, 101 episodes (17 episodes per year, 1 episode per month) in which lack of advection of air masses over Northern Iberian Peninsula were registered. On average, these episodes had duration of 3 days. These events collected a total of 337 days, that is, 56 days per year, 5 days per month in 1998-2003 (Table Ap.41).

From the 101 episodes without advection 43% of them (43 events, 7 episodes per year, 1 episode per month) occurred associated with a WIA (caused by an anticyclone covering completely or partly the Iberian Peninsula out of summer time) situation. These episodes had a mean duration of 3 days per episode. Totally, these WIA episodes resulted in 139 days (41% of the 337 Mediterranean days, 23 days per year, 2 days per month) in the period 1998-2003 (Table Ap.41).

The remaining 57% of the episodes with lack of advection, 58 episodes (10 per year and 1 per month in the study period) occurred under ITL (in situations in which the thermal Iberian low was developed) meteorological scenario. The mean duration of such events was also 3 days. With respect to the number of ITL days during 1998-2003, 198 days were registered (59% of the total number of days without advection). Thus, 33 days per year and 3 days per month occurred on average (Table Ap.41).

As shown in Table Ap.41, the maximum and minimum annual number of days and episodes without advection were detected in the same years for all meteorological scenarios. The highest number of days (94) and episodes (28) without advection were registered in 2003. Also in this year the maximum number of WIA days (50) and episodes (17) and ITL events (11 the same as in 1999). The highest number of days without advection under ITL scenario was recorded in 1999 with 46 days. The minimum number of days and episodes without advection occurred in 2002 (32 days and 10 episode). The same happened with the lowest number of ITL days and episodes (20 days and 6 episodes). Finally, the minimum number of WIA episodes and days were recorded in 2001 (11 days and 3 events).

Table Ap.41. Annual number of days and episodes with lack of advective conditions in the period 1998-2003 over Northern Iberian Peninsula. The WIA and ITL scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total NOADV	59	62	49	41	32	94	56	5
WIA	35	16	15	11	12	50	23	2
ITL	24	46	34	30	20	44	33	3
Episodes								
Total NOADV	18	16	16	13	10	28	17	1
WIA	10	5	4	3	4	17	7	1
ITL	8	11	12	10	6	11	10	1

The monthly distribution of the total number of episodes without advection in the study period showed a maximum in summer coinciding with the period of occurrence of ITL episodes. In June (15 episodes, 14 of them of ITL type), July (17 episodes all of them of ITL type) and August (15 episodes all of them of ITL type) were the months with the highest number of episodes without advection and the highest number of ITL episodes. In May and in October two maximums in the distribution of total number of WIA episodes were recorded with 10 episodes on each of those months (Figure Ap.37).

The abundance of days without advection was also maximum in summer associated with the occurrence of ITL days. Thus, averages of 10 (in August) and 9 (both in June and July) days were registered in summer months. Almost all the days with lack of advection in these months corresponded to ITL meteorological scenario. As for the monthly distribution of WIA events, the number of days without advection of the WIA type was higher in May and October, with a mean of 7 and 5 days, respectively (Figures Ap.37 and Ap.38).

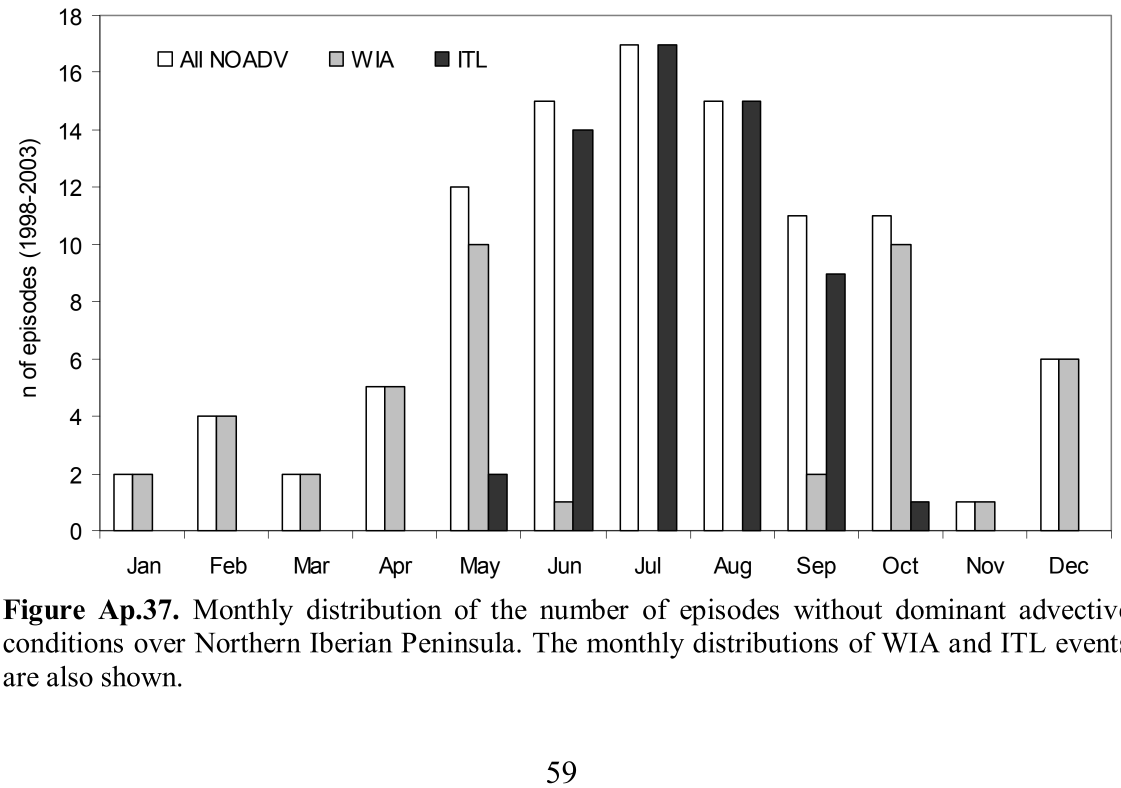

Figure Ap.37. Monthly distribution of the number of episodes without dominant advective conditions over Northern Iberian Peninsula. The monthly distributions of WIA and ITL events are also shown.

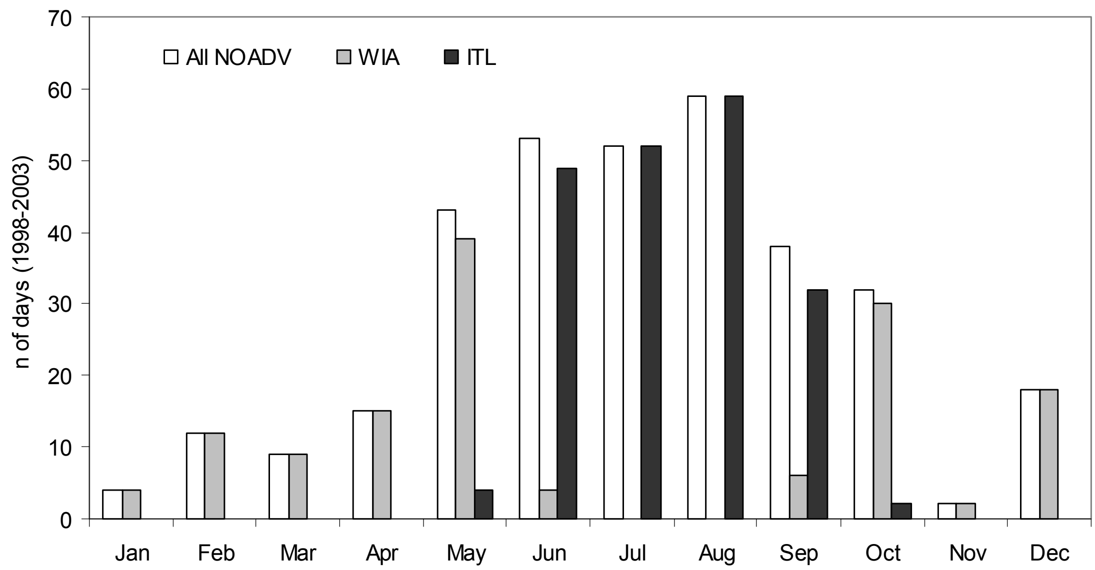

Figure Ap.38. Monthly distribution of the number of days with lack of advective conditions over Northern Iberian Peninsula. The monthly distributions of days with lack of advective conditions occurred under WIA and ITL scenarios are also shown.

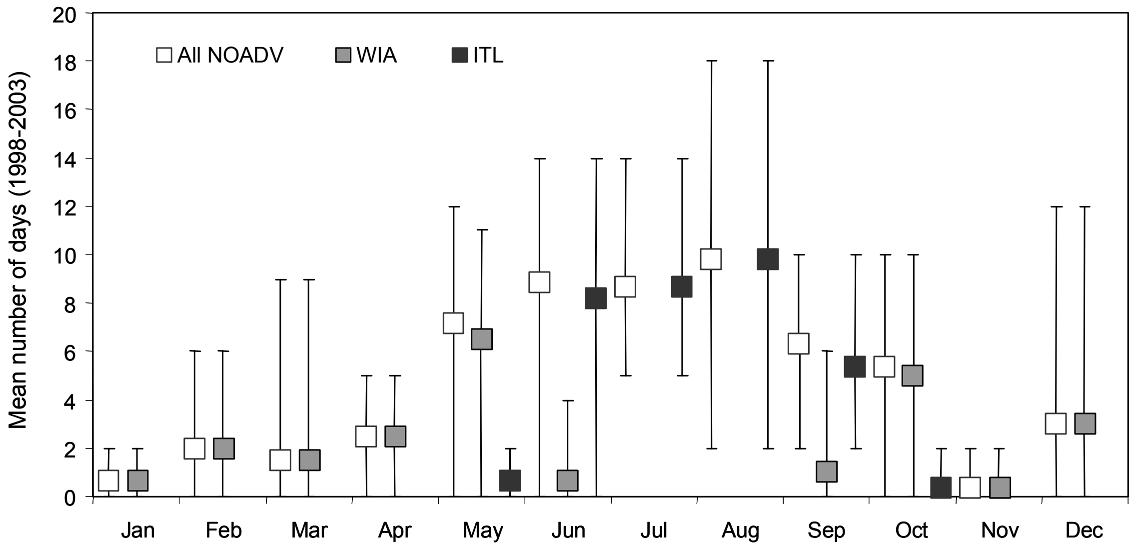

Figure Ap.39. Mean number of days without a dominant air mass advection over Northern Iberian Peninsula per month for 1998-2003. WIA and ITL episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

The mean duration of episodes without dominant advective conditions over Northern Iberia in the period 1998-2003 resulted to be maximum in March with 5 days per episode (this also stands for WIA episodes because in March only episodes of this type occurred). ITL episodes reached to their highest mean duration in June, August and September with 4 days per episode (Figure Ap.40). The longest episode registered in the whole study period occurred in August 2003 (in consequence of an ITL episode) and reached 17 days which was an unusually high duration (Figure Ap.40).

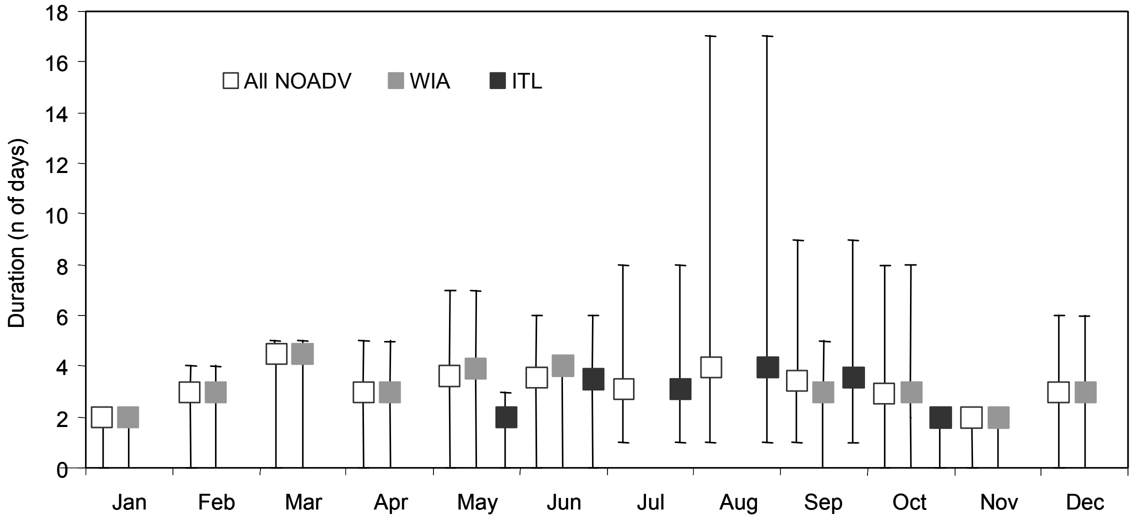

Figure Ap.40. Mean duration of episodes without a dominant air mass advection per month over Northern Iberian Peninsula for 1998-2003. WIA and ITL episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

PM levels registered in regional background stations over Northern Iberia during episodes with lack of advection were superior to the annual mean PM levels in TSP and PM10 (30 µgTSP m^{-3} at Logroño, 19 µgTSP m^{-3} and 14 µgPM10 m^{-3} at Valderejo and 14 µgPM10 m^{-3} at Izki). Precipitation is reduced in situations of lack of prevailing advective conditions so the scavenging potential of the atmosphere is reduced in these episodes. TSP mean levels of 42 and 26 µg m^{-3} were registered during episodes without advection in Logroño and Valderejo respectively and PM10 means of 19 and 18 µg m^{-3} were recorded in Valderejo and Izki respectively during such events (Table Ap.42). The high PM10 mean levels registered in Valderejo during episodes without dominant advective conditions (28 µgPM10 m^{-3}) can be explained in virtue of the high levels registered during summer ITL episodes during that year. At Izki, in 2003, during episodes without a dominant advection, the mean PM10 levels registered were unusually high (30 µgPM10 m^{-3}). This can be explained by a period of unusually high daily means registered in Izki during June-July of that year and the lack of data in the first four months of that year. Episodes without dominant air mass advection in these months (WIA episodes) are generally characterised by low PM levels so the annual mean would be biased toward higher levels.

Table Ap.42. Mean annual levels of TSP and PM10 registered in Logroño, Valderejo and Izki during episodes without dominant air mass advection in 1998-2003.

NOADV EPISODES	Logroño	Valderejo		Izki
(µg m^{-3})	TSP	TSP	PM10	PM10
1998	42	na	na	na
1999	37	*[1]26	na	na
2000	49	na	28	na
2001	na	na	20	*[2]30
2002	na	na	17	15
2003	na	na	15	14
Mean 98-03	42	26	19	18

*[1]Calculated with data of 90% of the months of the year
*[2]Calculated with data of 67% of the months of the year
na: Not available

The impact of the two scenarios causing situations of lack of advection on PM levels in regional background stations over Northern Iberian Peninsula differed greatly. This could be generalised for TSP and PM10. As shown in Table Ap.43, TSP mean levels during ITL episodes in Logroño (44 µg m^{-3}) and in Valderejo (29 µg m^{-3}) reached higher values than during WIA episodes (41 and 18 µg m^{-3} respectively). Logroño station was proved to be influenced by the city of Logroño directly and was retired from the EMEP network in 2001 for not being representative of the regional background. That would explain the narrow margin between the mean levels registered during ITL and WIA events at that site. For PM10, this situation occurred as well. While during WIA episodes PM10 means reached levels of the same order of the annual mean (14 µg m^{-3} in Valderejo and 13 µg m^{-3} in Izki), PM10 means registered during ITL events reached high levels (23 µg m^{-3} in both stations). Together with this different mean PM levels registered during the two scenarios, the higher occurrence of ITL events when compared with WIA episodes resulted in II's well differentiated. II on TSP in Logroño ranged from 2.6 to 3.9 µg m^{-3} for WIA and ITL respectively. Also on TSP but in Valderejo the impact of ITL scenario was more important (II= 2.6 µg m^{-3} for ITL and II=1.1 for WIA). On PM10 the impact of ITL represented by the II was twice as much as the impact of WIA scenario in Valderejo and in Izki (II for ITL went beyond 2.0 µg m^{-3} while for WIA II did not reach 1.0 µg m^{-3}).

Table Ap.43. Number of days without a dominant air mass advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP and PM10 (µg m^{-3}) recorded at Logroño, Valderejo and Izki rural sites (N Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	WIA	ITL
2003		
Valderejo PM10 (µg m^{-3})	13	18
Izki PM10 (µg m^{-3})	11	18
Days	50	44
2002		
Valderejo PM10 (µg m^{-3})	13	20
Izki PM10 (µg m^{-3})	13	16
Days	12	20
2001		
Valderejo PM10 (µg m^{-3})	18	21
Days	11	30
2000		
Valderejo PM10 (µg m^{-3})	18	32
Days	15	34
1999		
Valderejo TSP* (µg m^{-3})	18	29
Days*	16	46
1998		
Logroño TSP (µg m^{-3})	43	41
Days	35	24
Mean 98-03 (µg m^{-3})		
LogroñoTSP	41	44
Valderejo TSP	18	29
Valderejo PM10	14	23
Izki PM10	13	23
Impact Index(II) (µg m^{-3})		
LogroñoTSP	2.6	3.9
Valderejo TSP	1.1	2.6
Valderejo PM10	0.9	2.1
Izki PM10	0.8	2.0

*Data on TSP in Valderejo only available from 1/1999 until 11/1999

The highest PM monthly means during episodes without advection were registered during summer months generally associated with ITL scenario. TSP monthly means in Valderejo in the period May-October ranged from 26 to 34 µg m^{-3} during ITL episodes. PM10 monthly means in the same months during ITL events reached the range 20-29 µg m^{-3}. WIA episodes resulted in PM monthly means clearly lower than those registered during ITL episodes (Table Ap.44).

Table Ap.44. Number of days per month without advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP and PM10 (µg m^{-3}) recorded at Valderejo rural site (N Spain) for those days.

	WIA	ITL		WIA	ITL
January			**July**		
Days per month	0.3	0.0	Days per month	0.0	2.8
TSP	19		TSP		26
PM10	13		PM10		21
February			**August**		
Days per month	0.7	0.0	Days per month	0.0	2.5
TSP			TSP		34
PM10	10		PM10		24
March			**September**		
Days per month	0.3	0.0	Days per month	0.3	1.5
TSP			TSP		29
PM10	10		PM10	20	29
April			**October**		
Days per month	0.8	0.0	Days per month	1.7	0.2
TSP	17		TSP	22	28
PM10	12		PM10	14	
May			**November**		
Days per month	1.7	0.3	Days per month	0.2	0.0
TSP	17	32	TSP		
PM10	16	20	PM10	11	
June			**December**		
Days per month	0.2	2.3	Days per month	1.0	0.0
TSP		30	TSP		
PM10		20	PM10	9	

3. Northeastern Iberian Peninsula

As shown in Table Ap.45, the most common long range air mass transport scenario over Northeastern Iberia was Atlantic advection. 211 Atlantic episodes comprising 926 days occurred over the study area in 1998-2003 (42% of the days). 146 episodes without a prevalent advection accounted for 22% of the days of the study period (492 days). The frequency of occurrence of African and European transport events was similar accounting for 119 and 127 episodes respectively in 1998-2003. These episodes comprised 349 (16% of the days of the study period) and 362 (17% of the days of the study period) days respectively. Mediterranean advection occurred in 35 episodes comprising 3% of the days (62 days).

Table Ap.45. Number of days, % of days and episodes with Atlantic (ATL), North African (NAF), Mediterranean (MED) and European (EU) advection and without a prevalent advective regime (NOADV) in Northeastern Iberia for the period 1998-2003.

1998-2003	ATL	NAF	MED	EU	NOADV
Number of days	926	349	62	362	492
% of days	42	16	3	17	22
Number of events	211	119	35	127	146

For the following study daily data on PM from four regional background stations were used. Three of these stations belonged to the EMEP network: a) Roquetas station (40º 49’ N, 0º 29’ E, 44 m.a.s.l.) offered data on TSP from 1998 to June 2000, b) Cabo de Creus station (42º 19’ N, 3º 19’ E, 23 m.a.s.l.) offered data on TSP from 1998 to January 2003, and data on PM10 and PM2.5 from March 2001 to the end of 2003 and c) Els Torms station (41º 24’ N, 0º 43’ E, 470 m.a.s.l.) with TSP data from November 2001 to January 2003 and data on PM10 and PM2.5 from March 2001 to the end of 2003. These measurements were made using the gravimetric method with high volume samplers. In addition daily PM10 data for the whole period 1998-2003 from Monagrega station (40º 59’ N, -0º 12’ E, 600 m.a.s.l.) were used. This rural station belonged to ENDESA (the largest Spanish power generation company) network and the measurements were performed continuously with TEOM (tapered element oscillating microbalance) instrumentation. These instruments incorporate an inertial balance that directly measures the mass collected on an exchangeable filter cartridge by monitoring the corresponding frequency changes of a tapered element.
Mean annual PM levels in Roquetas and in Cabo de Creus were elevated when compared with those obtained at Els Torms and Monagrega. TSP mean levels for the period 1998-2003 were 39, 38 and 27 µg m^{-3} in Roquetas, Cabo de Creus and Els Torms respectively. Mean PM10 of 21, 18 and 17 µg m^{-3} were registered in Cabo de Creus, Els Torms and Monagrega respectively. Finally, mean PM2.5 levels ranged from 14 µg m^{-3} in Cabo de Creus to 12 µg m^{-3} in Els Torms. No exceedances of the annual limit value established by the 1999/30/CE Directive were registered neither for the limit value of 2005 (40 µgPM10 m^{-3}), but in Cabo de Creus the target value established for 2010 (20 µgPM10 m^{-3}) was surpassed in 2003 with an annual mean of 25 µgPM10 m^{-3}. As reported for the other regions, a general reduction of annual PM means occurred in 2002 owing to a anomalously wet summer in the Iberian Peninsula (Table Ap.46).

Table Ap.46. Mean levels of TSP, PM10 and PM2.5 recorded in regional background stations in 1998-2003 in Northeastern Iberian Peninsula.

MEAN LEVELS	Roquetas	Cabo de Creus			Els Torms			Monagrega
(µg m^{-3})	TSP	TSP	PM10	PM2.5	TSP	PM10	PM2.5	PM10
1998	41	33	na	na	na	na	na	18
1999	35	41	na	na	na	na	na	17
2000	na	37	na	na	na	na	na	17
2001	na	40	*20	*12	32	*19	*12	19
2002	na	35	19	13	23	15	10	13
2003	na	na	25	17	na	20	13	16
Mean 98-03	39	38	21	14	27	18	12	17

*Calculated with data of 83% of the months of the year
na: Not available

3.1. Atlantic episodes

211 episodes with 926 days with Atlantic advection occurred in the study period (1998-2003) over Northeastern Spain (35 episodes and 154 days per year, 3 episodes and 13 days per month, Table Ap.47). The average duration of Atlantic episodes was 4 days per episode.

From the two transport scenarios distinguished for explaining Atlantic advection, AZH-NAtD (presence of the Azores high and the Iceland low on their standard locations) episodes was the one which registered the highest frequency of occurrence (83% and 90% of the Atlantic episodes and days respectively). In particular, 175 Atlantic episodes (29 per year and 2 per month) and 830 days (138 per year and 12 per month) corresponded to this type (Table Ap.47). The mean duration of these episodes was 5 days.

AD (caused by the presence of a depression in front of the Portuguese coast) episodes represented 17% of the total number of Atlantic events and 11% of the days with Atlantic advection. This type of episodes (36 in the study period, 6 per year, 1 per month, Table Ap.47) comprised 96 days (16 per year, 1 per month, Table Ap.47) and had an average duration of 2 days.

In 1998-2003, the highest number of days with Atlantic influence over Northeastern Iberia was registered in 2001 with 173 days and the lowest number in 2003 with 105 days (Table Ap.47). These years corresponded with the years with maximum and minimum number of days with AZH-NAtD situations, 160 days in 2000 and 87 days in 2003. Days with Atlantic advection associated with AD scenario reached its maximum number in 2003 with 18 days and its minimum number in 2001 with 13 days (Table Ap.47).

The highest number of Atlantic episodes was registered in 2001 (39 events). Eight AD episodes occurred in 2003 and 33 AZH-NAtD episodes in 2001 (Table Ap.47). In 1998 the minimum annual number of Atlantic episodes was recorded with 31 episodes (4 AD and 27 AZH-NAtD, Table Ap.47).

Table Ap.47. Annual number of days and episodes with Atlantic advection in the period 1998-2003 over Northeastern Iberian Peninsula. The AZH-NAtD and AD scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total ATL	152	154	170	173	172	105	154	13
AZH-NAtD	138	139	150	160	156	87	138	12
AD	14	15	20	13	16	18	16	1
Episodes								
Total ATL	31	34	34	39	37	36	35	3
AZH-NAtD	27	29	27	33	31	28	29	2
AD	4	5	7	6	6	8	6	1

As shown by Figure Ap.41, Atlantic episodes over Northeastern Iberia occurred during all months. Two primary peaks of frequency were registered in December (24 episodes during this month in 1998-2003) and in February-May (23 episodes occurred during April in 1998-2003) and two second order peaks were registered on July (17 episodes in the study period) and September-October (17 episodes on both months in 1998-2003). The monthly distribution of AZH-NAtD episodes showed approximately the same peaks of frequency of the monthly distribution of all Atlantic episodes. March-May (17 episodes in April and May), December (17 episodes in the study period), July (16 episodes in 1998-2003) and October (15 events in the study period) showed higher frequency of occurrence of AZH-NAtD events. AD episodes occurred mainly in December (7 episodes in 1998-2003), February-April (6 episodes in April in the whole study period) and September (4 episodes in 1998-2003) and rarely from May to August.

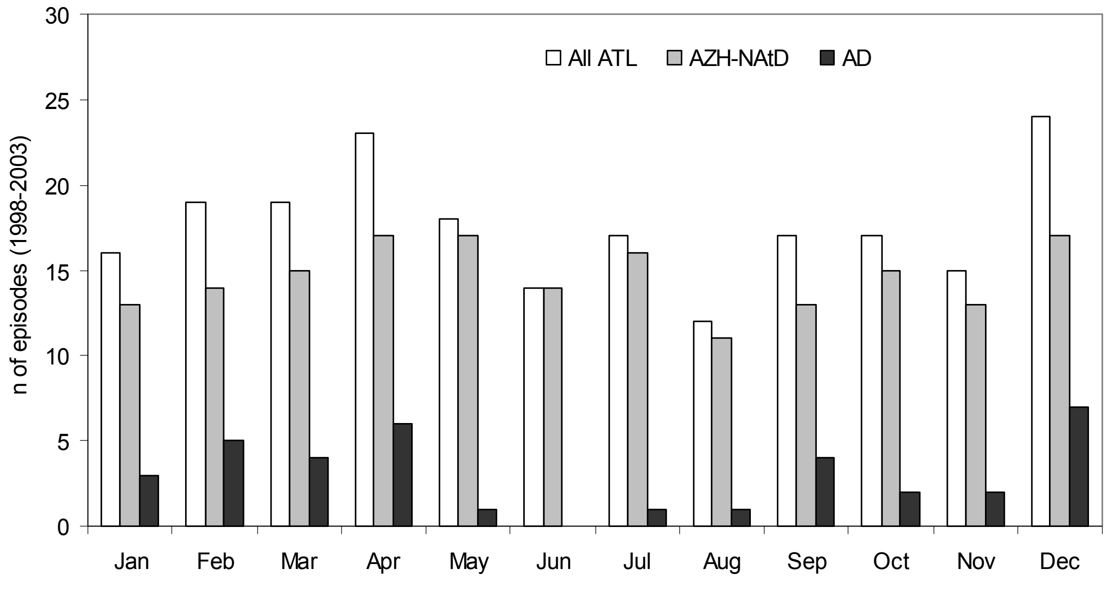

Figure Ap.41. Monthly distribution of the number of Atlantic episodes over Northeastern Iberian Peninsula. The monthly distributions of AZH-NAtD and AD Atlantic events are also shown.

The occurrence of days with Atlantic advection over Northeastern Spain was more frequent from September to April than from May to August. Peaks of occurrence were registered in November-December, February and April with means of 16-17 days in each of those months (Figures Ap.42 and Ap.43). Peaks of frequency of occurrence of AZH-NAtD were registered in these months as well. November-December (with 17 days as a mean in November), February (a mean of 15 days) and April with a mean of 14 days are the periods with important frequency of occurrence of AZH-NAtD transport situations (Figures Ap.42 and Ap.43). Days with Atlantic advection caused by AD situations were more frequent in February-April (with a mean of 3 days in April), September and December (2 days as a mean in both months).

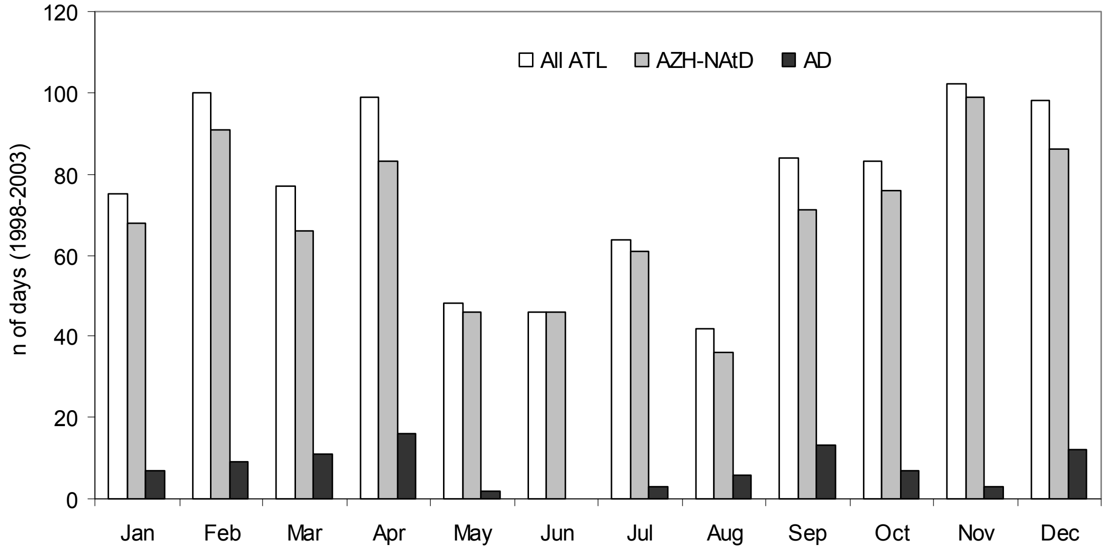

Figure Ap.42. Monthly distribution of the number of days with Atlantic advection over Northeastern Iberian Peninsula. The monthly distributions of days with Atlantic advection occurred under AZH-NAtD and AD scenarios are also shown.

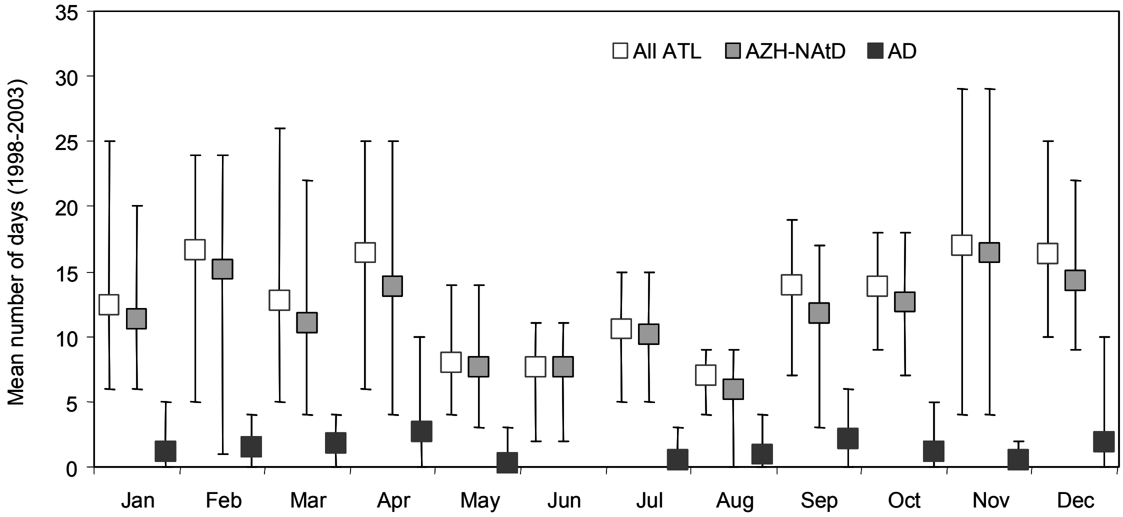

Figure Ap.43. Mean number of days with Atlantic advection over Northeastern Iberian Peninsula per month for 1998-2003. AZH-NAtD and AD episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

As shown in Figure Ap.44, Atlantic episodes in Northeastern Iberia had two periods of longer duration in September-November (with mean duration of 7 days per episode in November) and January-February (mean duration of 5 days per episode in both months). With respect to the duration of AZH-NAtD events, three peaks of higher duration were detected: September-December (in November a mean of 8 days per AZH-NAtD episode), January-February (7 days per episode as a mean in February) and April (5 days per episode). The duration of AD events were lower. In July-October (with a mean duration of 6 days per episode in August but in a unique episode on 2003) and March-April (with 3 days per episode in both months) were the periods in which AD events lasted the longest on average.

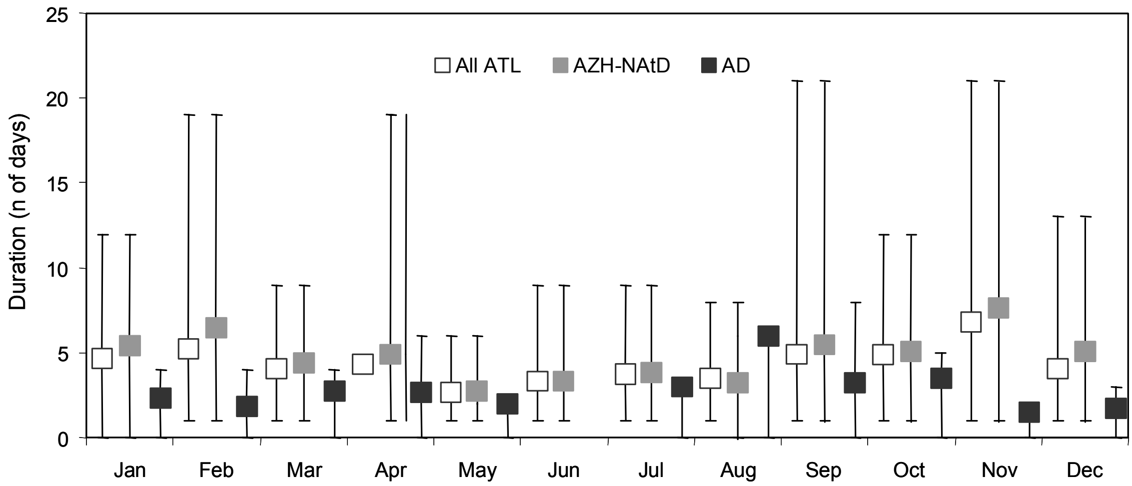

Figure Ap.44. Mean duration of Atlantic episodes per month over Northeastern Iberian Peninsula for 1998-2003. AZH-NAtD and AD episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

During Atlantic episodes the mean PM levels were significantly lower than the annual means (39 µgTSP m^{-3} in Roquetas, 38 µgTSP m^{-3}, 21 µgPM10 m^{-3} and 14 µgPM2.5 m^{-3} in Cabo de Creus, 27 µgTSP m^{-3}, 18 µgPM10 m^{-3} and 12 µgPM2.5 m^{-3} in Els Torms and 17 µgPM10 m^{-3} in Monagrega). In 1998-2003 during Atlantic events TSP mean levels ranged from 34 µg m^{-3} in Roquetas and Cabo de Creus to 23 µg m^{-3} in Els Torms. Mean PM10 levels during Atlantic events were 18, 13 and 12 µg m^{-3} in Cabo de Creus, Els Torms and Monagrega and mean PM2.5 levels ranged from 11 to 9 µg m^{-3} in Cabo de Creus and Els Torms respectively (Table Ap.48).

Table Ap.48. Mean annual levels of TSP and PM10 registered in Roquetas, Cabo de Creus, Els Torms and Monagrega during Atlantic advection episodes in 1998-2003.

ATL EPISODES	**Roquetas**	**Cabo de Creus**			**Els Torms**			**Monagrega**
(µg m^{-3})	TSP	TSP	PM10	PM2.5	TSP	PM10	PM2.5	PM10
1998	35	32	na	na	na	na	na	12
1999	32	38	na	na	na	na	na	11
2000	na	33	na	na	na	na	na	11
2001	na	37	*19	*10	28	*16	*10	14
2002	na	32	17	11	19	12	8	10
2003	na	na	17	11	na	11	8	9
Mean 98-03	34	34	18	11	23	13	9	12

*Calculated with data of 83% of the months of the year
na: Not available

As shown in Table Ap.49, mean PM levels registered in regional background stations during AZH-NAtD episodes were superior to those registered for AD events. This stands for all size ranges and can be explained by a higher frequency of occurrence of rainfall associated with AD episodes. 24, 14 and 9 µg m^{-3} as mean TSP, PM10 and PM2.5 levels respectively in Els Torms during AZH-NAtD events contrasted with 16, 10 and 7 µg m^{-3} as mean PM levels in that site during AD episodes. The same occurred in Monagrega for mean PM10 levels (12 and 9 µg m^{-3} during AZH-NAtD and AD events respectively).

Owing to the difference in the mean PM levels and the higher frequency of occurrence of AZH-NAtD with respect to AD episodes, the impact index (II) also showed great differences (Table Ap.49). Thus, for AZH-NAtD events in Els Torms, II registered values of 9.0, 5.2 and 3.4 µg m^{-3} for TSP, PM10 and PM2.5 respectively and, in Monagrega, 4.5 µg m^{-3} for PM10. These values were 10-13 times the II registered for AD episodes.

Table Ap.49. Number of days with Atlantic advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (µg m^{-3}) recorded at Els Torms and Monagrega rural sites (NE Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	AZH-NAtD	AD
2003		
Els Torms TSP (µg m^{-3})	-	-
Els Torms PM10 (µg m^{-3})	12	10
Els Torms PM2.5 (µg m^{-3})	8	6
Monagrega PM10 (µg m^{-3})	10	8
Days	87	18
2002		
Els Torms TSP (µg m^{-3})	20	13
Els Torms PM10 (µg m^{-3})	12	10
Els Torms PM2.5 (µg m^{-3})	8	6
Monagrega PM10 (µg m^{-3})	10	6
Days	156	16
2001		
Els Torms TSP (µg m^{-3})	28	23
Els Torms PM10 (µg m^{-3})	16	13
Els Torms PM2.5 (µg m^{-3})	10	9
Monagrega PM10 (µg m^{-3})	15	7
Days	160	13
2000		
Monagrega PM10 (µg m^{-3})	11	10
Days	150	20
1999		
Monagrega PM10 (µg m^{-3})	11	11
Days	139	15
1998		
Monagrega PM10 (µg m^{-3})	13	10
Days	138	14
Mean 98-03 (µg m^{-3})		
Els Torms TSP	24	16
Els Torms PM10	14	10
Els Torms PM2.5	9	7
Monagrega PM10	12	9
Impact Index(II) (µg m^{-3})		
Els Torms TSP	9.0	0.7
Els Torms PM10	5.2	0.5
Els Torms PM2.5	3.4	0.3
Monagrega PM10	4.5	0.4

In Monagrega, the highest monthly PM10 means registered for Atlantic episodes occurred in summer when, generally PM levels are superior owing to an intensification of several processes such as resuspension of soil material and formation of secondary aerosols by photochemistry and also due to the low regime of precipitation. The highest monthly PM10 means for Atlantic events were registered under AZH-NAtD situations (15 to 25 µg m^{-3} from June to September with respect to 7 to 13 µg m^{-3} for the other months, Table Ap.50). PM10 levels during AD episodes were lower owing to the greater frequency of rainfall associated with this scenario.

Table Ap.50. Number of days per month with Atlantic advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of PM10 (µg m^{-3}) recorded at Monagrega rural site (NE Spain) for those days.

	AZH-NAtD	AD		AZH-NAtD	AD
January			**July**		
Days per month	11.3	1.2	Days per month	10.2	0.5
PM10	7	7	PM10	17	18
February			**August**		
Days per month	15.2	1.5	Days per month	6.0	1.0
PM10	11	9	PM10	25	14
March			**September**		
Days per month	11.0	1.8	Days per month	11.8	2.2
PM10	9	12	PM10	15	10
April			**October**		
Days per month	13.8	2.7	Days per month	12.7	1.2
PM10	11	8	PM10	12	6
May			**November**		
Days per month	7.7	0.3	Days per month	16.5	0.5
PM10	13	11	PM10	8	10
June			**December**		
Days per month	7.7	0.0	Days per month	14.3	2.0
PM10	22		PM10	8	6

3.2. African episodes

A total of 119 episodes (20 per year and 2 per month) of air mass transport from Northern Africa with a mean duration of 3 days occurred over Northeastern Iberia in 1998-2003. These resulted in 349 days which corresponded with 58 and 5 days per year and month respectively (Table Ap.51).

40% of the African events (48 in total, 8 per year and 1 per month, Table Ap.51) corresponded with NAH-A scenario characterised by the presence of an anticyclone over Northern Africa and the Iberian Peninsula at high atmospheric levels. 43% of the days with African advection corresponded with NAH-A situations (151 in total, 25 per year and 2 per month, Table Ap.51). These episodes had a mean duration of 3 days.

The other anticyclonic scenario, NAH-S (caused by the presence over Northern Africa and the Iberian Peninsula at surface level) occurred in 13% of the African episodes (16 in total, 3 per year, Table Ap.51) and in 10% of the days with African advection (36 in total, 6 per year and 1 per month, Table Ap.51). The duration of these events was of 2 days as mean.

In one fourth of the African days (a total of 88 days for 1998-2003, 15 days per year and 1 day per month, Table Ap.51) and in 27% of the African episodes (32 in total, 5 per year, Table Ap.51), the meteorological situation corresponded with the presence or

development of an Atlantic depression by the Portuguese coast (AD scenario). AD episodes lasted 3 days on average.
23 African episodes (19% of the African episodes) corresponded with meteorological situations associated with the presence of depressions over Northern Africa (NAD), that is, 4 episodes per year (Table Ap.51). These events had a mean duration of 3 days. NAD episodes comprised 74 days (21% of the African days, 12 days per year and 1 day per month, Table Ap.51).
The highest number of African episodes over Northeastern Iberia were registered in 2003 (74 episodes) and the lowest in 1999 (41 episodes). Concerning the different scenarios, the maximum number of events was registered in these years: NAH-S (5) in 2002, AD (8) in 2001 and 2003, NAD (10) in 2001 and NAH-A (12) in 2002. The minimum number of events was registered in the following years: NAH-S (1) in 1999, 2001 and 2003, AD (2) in 1998 and 1999, NAD (1) in 2000 and 2002 and NAH-A (5) in 1999 (Table Ap.51).
As shown in Table Ap.51, the maximum number of days in which African dust outbreaks occurred was registered in 2003 with 74 days and the minimum in 1999 with 41. NAH-S and NAH-A in 2002 (with 12 and 35 days respectively), AD in 2000 (25 days) and NAD in 2001 (28 days) registered their maximum annual frequency of occurrence. The minimum annual number of days was registered in 2001 and 2003 for NAH-S (2), in 1998 for AD (6), in 2002 for NAD (4) and in 1999 for NAH-A (17).

Table Ap.51. Annual number of days and episodes with African advection in the period 1998-2003 over Northeastern Iberian Peninsula. The NAH-S, AD, NAD and NAH-A scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total NAF	43	41	57	71	63	74	58	5
NAH-S	9	3	8	2	12	2	6	1
AD	6	8	25	15	12	22	15	1
NAD	7	13	5	28	4	17	12	1
NAH-A	21	17	19	26	35	33	25	2
Episodes								
Total NAF	14	13	20	25	23	24	20	2
NAH-S	4	1	4	1	5	1	3	<1
AD	2	2	7	8	5	8	5	<1
NAD	2	5	1	10	1	4	4	<1
NAH-A	6	5	8	6	12	11	8	1

The seasonal occurrence of African events is characterised by two periods of higher frequency: February-March (with 14 episodes in March in 1998-2003, Figure Ap.45) and May-August (with 16 episodes in August in the study period, Figure Ap.45). The lowest number of episodes was recorded in April (4 in 1998-2003, Figure Ap.45). NAH-S episodes were present in the first three months of the year (maximum in February with 6 NAH-S episodes in 1998-2003, Figure Ap.45). AD and NAD episodes practically did not occur in summer. AD events were more frequent in February-March (6 episodes accumulated in March), November-December (7 episodes accumulated in December) and secondly in May with 3 episodes during the study period (Figure Ap.45). NAD episodes were particularly frequent in May (7 episodes accumulated in 1998-2003), and March and November with 3 episodes during each month in the study period (Figure Ap.45). NAH-A episodes were present uniquely from May-October with higher frequency in August with 15 episodes registered in 1998-2003 (Figure Ap.45).

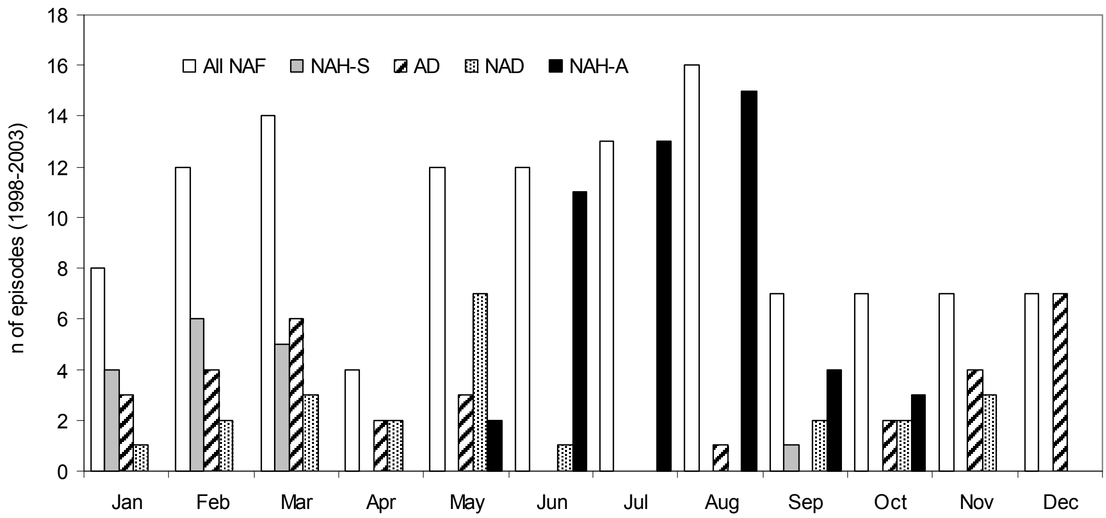

Figure Ap.45. Monthly distribution of the number of African episodes over Northeastern Iberian Peninsula. The monthly distributions of NAH-S, AD, NAD and NAH-A African events are also shown.

As shown in Figures Ap.46 and Ap.47, the seasonal distribution of the number of days with African advection had three periods of higher frequency: May-August with a mean of 9 days in June, March with a mean of 6 days and October with a mean of 4 days. Minima were detected in April (a mean of 2 days) and September, November and December (3 days as a mean). January-March registered practically all the NAH-S days (3 days on average during March) while October-May practically all the AD days (3 days as mean in March, May and December) and the NAD days (mainly in March and November with 4 and 2 days as a mean respectively). Finally, summer African episodes (NAH-A) occurred in a higher number of days in June-August with a mean of 6-9 in those three months.

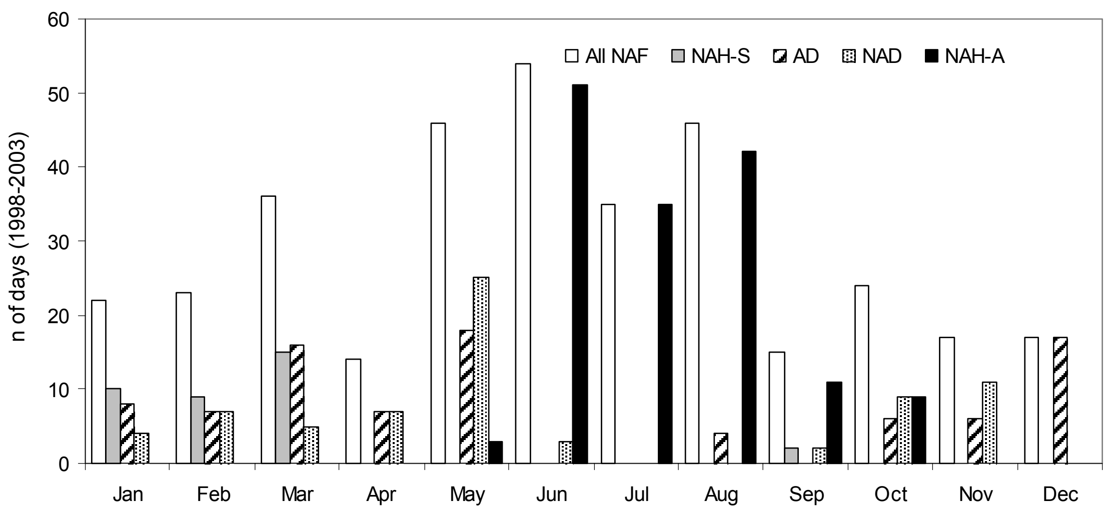

Figure Ap.46. Monthly distribution of the number of days with African advection over Northeastern Iberian Peninsula. The monthly distributions of days with African advection occurred under NAH-S, AD, NAD and NAH-A scenarios are also shown.

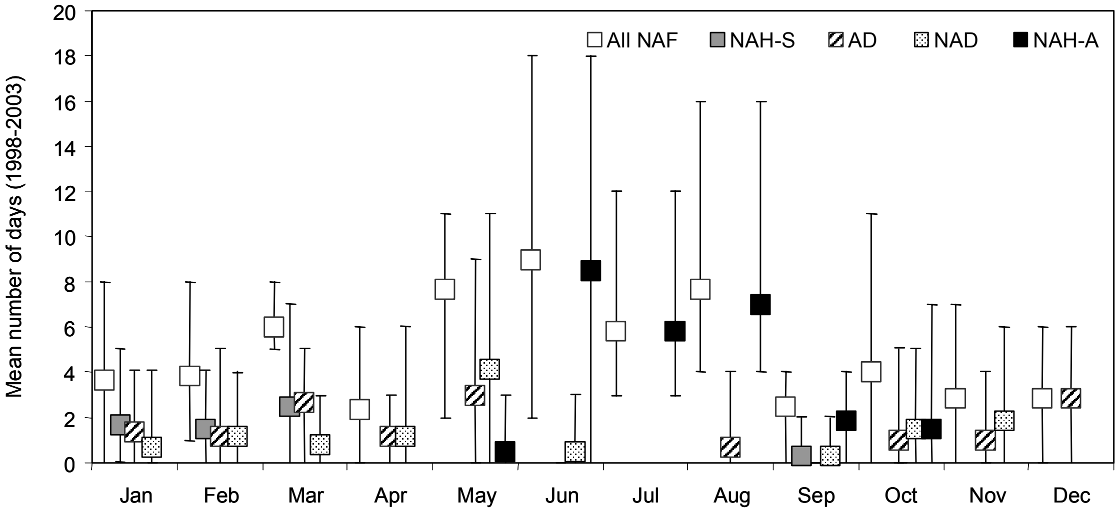

Figure Ap.47. Mean number of days with African advection over Northeastern Iberian Peninsula per month for 1998-2003. NAH-S, AD, NAD and NAH-A episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

The mean duration of African episodes was longer in the period April-June (4-5 days per event in each of those months) followed by October (3 days per episode). NAH-S episodes had a mean duration of 2-3 days in all months. AD events lasted particularly longer as a mean in April and May (6 days per episode on average on this month) and NAD episodes lasted in January-February, April-May and October-November an average of 4 days. NAH-A episodes had a mean duration in July of 5 days and 2-3 days in July-October (Figure Ap.48).

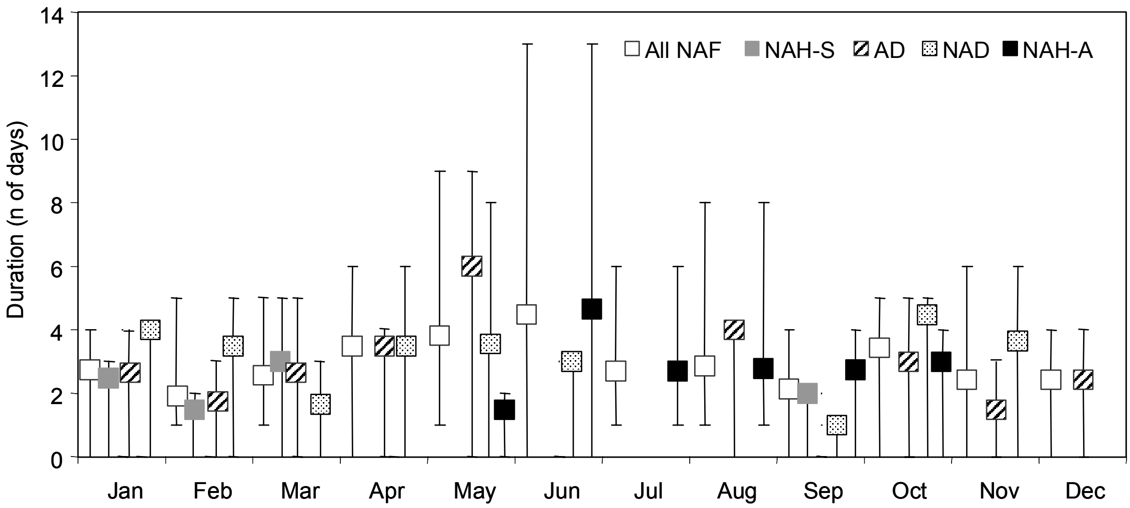

Figure Ap.48. Mean duration of African episodes per month over Northeastern Iberian Peninsula for 1998-2003. NAH-S, AD, NAD and NAH-A episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

Compared with the mean PM levels registered for the study period (39 µgTSP m^{-3} in Roquetas, 38 µgTSP m^{-3}, 21 µgPM10 m^{-3} and 14 µgPM2.5 m^{-3} in Cabo de Creus, 27 µgTSP m^{-3}, 18 µgPM10 m^{-3} and 12 µgPM2.5 m^{-3} in Els Torms and 17 µgPM10 m^{-3} in Monagrega), the mean PM levels recorded during African events (shown in Table Ap.52) resulted considerably higher for all size ranges. Thus, mean TSP levels reached 52, 45 and 35 µg m^{-3} in Roquetas, Cabo de Creus and Els Torms respectively. PM10 mean levels ranged from 27 µg m^{-3} in Monagrega to 24 µg m^{-3} in the stations of Cabo de Creus and Els Torms, and PM2.5 mean levels were 17 and 16 µg m^{-3} in Cabo de Creus and Els Torms respectively (Table Ap.52).

Table Ap.52. Mean annual levels of TSP, PM10 and PM2.5 registered in Roquetas, Cabo de Creus, Els Torms and Monagrega during African advection episodes in 1998-2003.

NAF EPISODES	Roquetas	Cabo de Creus			Els Torms			Monagrega
(µg m^{-3})	TSP	TSP	PM10	PM2.5	TSP	PM10	PM2.5	PM10
1998	53	37	na	na	na	na	na	34
1999	50	48	na	na	na	na	na	29
2000	na	49	na	na	na	na	na	27
2001	na	48	*23	*16	38	*22	*13	27
2002	na	42	22	17	32	19	13	21
2003	na	na	26	18	na	31	20	26
Mean 98-03	52	45	24	17	35	24	16	27

*Calculated with data of 83% of the months of the year
na: Not available

For TSP, mean levels recorded during the different transport scenarios of African events registered similar values in Els Torms (36 µg m^{-3} for NAH-A, 35 µg m^{-3} for both NAH-S and NAD and 32 µg m^{-3} for AD). For finer size ranges, mean PM levels recorded during scenarios associated with anticyclones were clearly higher than those recorded during scenarios associated with depressions. This has to do with the rainfall associated with NAD and AD events. During NAH-A events, the atmospheric conditions of the lowest levels of the atmosphere (weak baric conditions resulting in poor renovation of air masses together with the aging and recirculation of contaminated air masses at Eastern Iberia as explained by Millan et al., 1997) resulted in an significant increase of PM levels especially by generation of secondary species from gaseous precursors. At the same time, During NAH-A situations the African plumes travel at high altitudes (>1500 m.a.s.l.) and the dust penetrates in the mixing layer because the vertical development of this layer can reach up to 2500 metres over continental areas in summer (Crespi et al., 1995). Once into the boundary layer the dust is distributed and affects the sampling stations. These two contributions contribute to increase PM levels during NAH-A events. Thus, while for NAH-A and NAH-S episodes mean PM10 levels reached 26 and 27 µg m^{-3} at Els Torms and 34 and 29 µg m^{-3} at Monagrega, during AD and NAD events PM10 mean levels only reached 21 and 23 µg m^{-3} at Els Torms and 19 and 21 µg m^{-3} at Monagrega. These differences also stood for PM2.5. Mean PM2.5 levels of 20 and 18 µg m^{-3} were recorded during NAH-S and NAH-A respectively and 11 and 14 µg m^{-3} were recorded during AD and NAD respectively (Table Ap.53).

Taking also into account the frequency of occurrence of these episodes in the impact index (II), NAH-A episodes contributed to the annual mean levels significantly in all size ranges: with 2.5 µg m^{-3} in TSP at Els Torms, with 1.8 and 2.3 µg m^{-3} in PM10 at Els Torms and Monagrega respectively and with 1.2 µg m^{-3} in PM2.5 at Els Torms. AD and NAD had a similar impact on annual mean levels in all size ranges (II of 1.3-1.2, 0.8-0.8, and 0.4-0.5 µg m^{-3} at Els Torms for TSP, PM10 and PM2.5 respectively and 0.7-0.7 at Monagrega for PM10). NAH-S events had the lowest impact on PM mean levels: II of 0.6 µgTSP m^{-3}, 0.4 µgPM10 m^{-3} and 0.3 µgPM2.5 m^{-3} at Els Torms and 0.5 µgPM10 m^{-3} at Monagrega (Table Ap.53).

Table Ap.53. Number of days with African dust outbreaks occurred under the 4 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (µg m^{-3}) recorded at Els Torms and Monagrega rural sites (NE Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	NAH-S	AD	NAD	NAH-A
2003				
Els Torms TSP (µg m^{-3})	-	-	-	-
Els Torms PM10 (µg m^{-3})	21	21	31	37
Els Torms PM2.5 (µg m^{-3})	15	12	18	25
Monagrega PM10 (µg m^{-3})	27	17	22	35
Days	2	22	17	33
2002				
Els Torms TSP (µg m^{-3})	37	20	12	35
Els Torms PM10 (µg m^{-3})	28	12	9	20
Els Torms PM2.5 (µg m^{-3})	22	9	5	12
Monagrega PM10 (µg m^{-3})	16	11	6	28
Days	12	12	4	35
2001				
Els Torms TSP (µg m^{-3})	29	43	38	37
Els Torms PM10 (µg m^{-3})	-	30	19	22
Els Torms PM2.5 (µg m^{-3})	-	11	12	15
Monagrega PM10 (µg m^{-3})	14	23	20	37
Days	2	15	28	26
2000				
Monagrega PM10 (µg m^{-3})	30	21	15	37
Days	8	25	5	19
1999				
Monagrega PM10 (µg m^{-3})	55	21	26	31
Days	3	8	13	17
1998				
Monagrega PM10 (µg m^{-3})	43	16	28	39
Days	9	6	7	21
Mean 98-03 (µg m^{-3})				
Els Torms TSP	35	32	35	36
Els Torms PM10	27	21	23	26
Els Torms PM2.5	20	11	14	18
Monagrega PM10	29	19	21	34
Impact Index(II) (µg m^{-3})				
Els Torms TSP	0.6	1.3	1.2	2.5
Els Torms PM10	0.4	0.8	0.8	1.8
Els Torms PM2.5	0.3	0.4	0.5	1.2
Monagrega PM10	0.5	0.7	0.7	2.3

The highest monthly PM10 means for African days at Monagrega were registered in summer under NAH-A scenario (32-38 µg m^{-3} from June to September), also for other occurred in summer but with lower frequency of occurrence PM10 means were high (45 µg m^{-3} for AD in August and 41 µg m^{-3} for NAD in June). Under NAH-S episodes in March high PM10 means (34 µg m^{-3}) were also recorded (Table Ap.54). This is due to the precipitation asoociated with AD and NAD episodes which is not as common during NAH-S and NAH-A.

Table Ap.54. Number of days per month with African advection occurred under the 4 meteorological scenarios differentiated and mean daily ambient air levels of PM10 (all units in µg m^{-3}) recorded at Monagrega rural site (NE Spain) for those days.

	NAH-S	AD	NAD	NAH-A		NAH-S	AD	NAD	NAH-A
January					**July**				
Days per month	1.7	1.3	0.7	0.0	Days per month	0.0	0.0	0.0	5.8
PM10	27	15	14		PM10				34
February					**August**				
Days per month	1.5	1.2	1.2	0.0	Days per month	0.0	0.7	0.0	7.0
PM10	20	12	13		PM10		45		32
March					**September**				
Days per month	2.5	2.7	0.8	0.0	Days per month	0.3	0.0	0.3	1.8
PM10	34	25	20		PM10	27		20	38
April					**October**				
Days per month	0.0	1.2	1.2	0.0	Days per month	0.0	1.0	1.5	1.5
PM10		10	18		PM10		31	21	26
May					**November**				
Days per month	0.0	3.0	4.2	0.5	Days per month	0.0	1.0	1.8	0.0
PM10		17	18	20	PM10		13	27	
June					**December**				
Days per month	0.0	0.0	0.5	8.5	Days per month	0.0	2.8	0.0	0.0
PM10			41	37	PM10		15		

3.3. European episodes

During the study period (1998-2003), transport of European air masses over Northeastern Iberian Peninsula occurred in 362 days (60 and 5 days per year and month respectively, Table Ap.55) grouped in 127 episodes (21 per year and 2 per month, Table Ap.55). European episodes had a mean duration of 3 days.

European events were activated by two meteorological situations: a) EUH situations, characterised by the presence of an anticyclone over the European continent or over the Northern Atlantic Ocean, caused 86 episodes (68% of the European events accounting for 269 days, 74% of the days in which European advection was detected), that is, 14 and 1 episodes per year and month respectively and 45 and 4 days per year and month respectively (Table Ap.55); b) MD situations characterised by the location of a depression over the Mediterranean were present in 32% of the European episodes (41 in the whole study period, 7 per year and 1 per month, Table Ap.55) and in 26% of the European days (93 in the whole study period, 16 per year and 1 per month, Table Ap.55). EUH and MD events had a mean duration of 4 and 3 days respectively.

As shown in Table Ap.55, the accumulated number of European days ranged from 46 in 2000 to 69 in 1999. With respect to the EUH days the range was 57 (in 1998) and 33 (in 2001) and with respect to MD days the range was 29 (in 2002) and 5 (in 2000).

The number of European episodes was maximum in 1999 (21 episodes) and minimum in 2000 and 2001 (14 episodes on each year). The maximum number of episodes of the EUH type was registered also in 1999 (15 episodes) and the minimum in 2001 (8 episodes). Finally the range of annual number of MD episodes was 3 in 2000 to 8 consecutively in 2002 and 2003 (Table Ap.55).

Table Ap.55. Annual number of days and episodes with European advection in the period 1998-2003 over Northeastern Iberian Peninsula. The EUH and MD scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total EU	69	69	46	47	63	68	60	5
EUH	57	56	41	33	34	48	45	4
MD	12	13	5	14	29	20	16	1
Episodes								
Total EU	15	21	14	14	18	20	21	2
EUH	10	15	11	8	10	12	14	1
MD	5	6	3	6	8	8	7	1

Occurrence of European episodes over Northeastern Spain was detected with lower frequency in summer (June with a total of 4 episodes in 1998-2003). The highest frequency were obtained for November-January, with 11 or 12 events accumulated in each month during the study period, March and September with secondary peaks of frequency of 8 episodes accumulated during 1998-2003 (Figure Ap.49). Peaks of occurrence of EUH episodes were registered in: November-January (8 episodes in total in January), March (8 episodes accumulated) and August-September (8 episodes in September in the study period) as maxima (Figure Ap.49). Periods of minimum frequency of occurrence were registered in: April to July (with only 1 episode in May the whole study period) and October (2 EUH events in 1998-2003). MD episodes were roughly not present in summer (only one episode in the whole study period) and maxima were present in autumn (6 MD episodes in October) and spring (7 MD episodes accumulated in May).

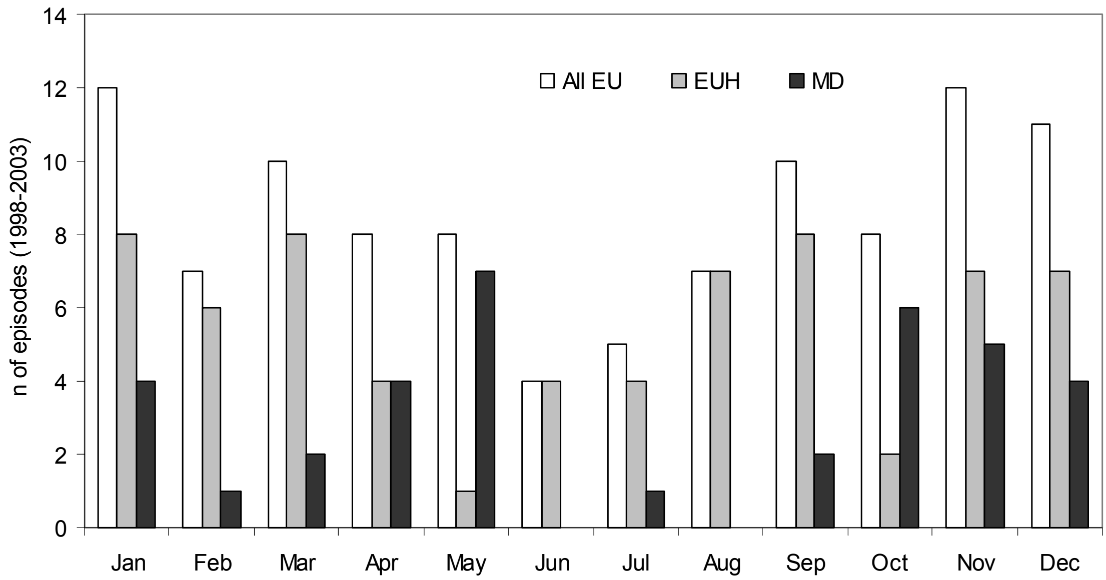

Figure Ap.49. Monthly distribution of the number of European episodes over Northeastern Iberian Peninsula. The monthly distribution of EUH and MD European events is also shown.

Concerning the seasonal distribution of days with European advection over Northeastern Spain showed in Figures Ap.50 and Ap.51 a lower monthly occurrence of European days from May to August is evidenced. Conversely, two peaks of monthly occurrence were found in March (8 European days as average) and December (7 days as mean) and a second order peak was also found in September (5 days as average). A clear frequency peak was found in autumn-winter for EUH days (a mean in March 8 days were registered). Furthermore, although a low relative number of EUH days occurred from April to October two periods of relatively high frequency of occurrence were observed in June (3 days as a mean) and August-September (4 days on average in both months). MD days showed two periods with high frequency of occurrence in spring (April and May with means of 3 days) and autumn (during October a mean of 3 days were registered). Conversely, June-August was practically devoid of MD days.

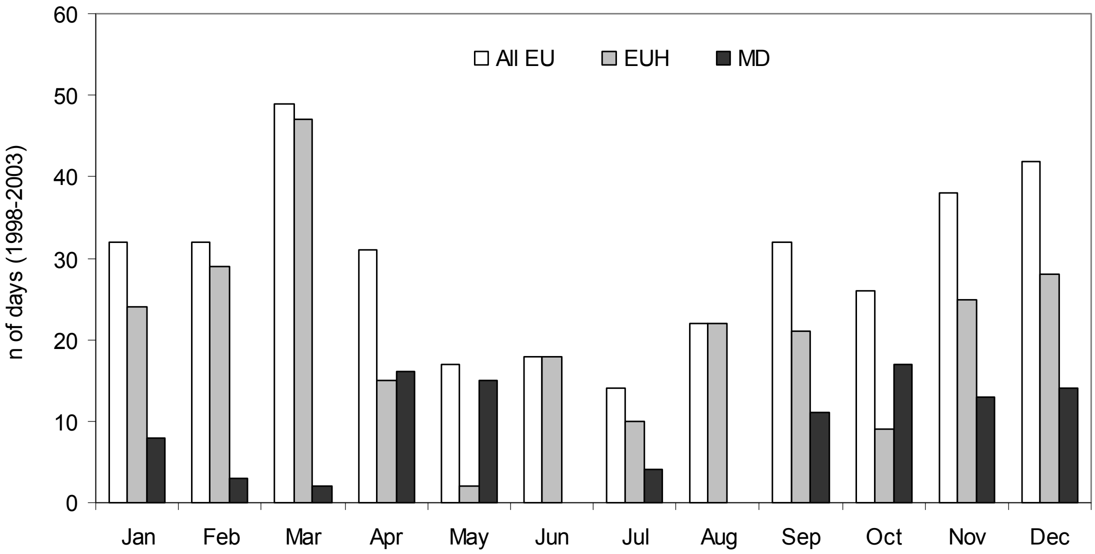

Figure Ap.50. Monthly distribution of the number of days with European advection over Northeastern Iberian Peninsula. The monthly distributions of days with European advection occurred under EUH and MD scenarios are also shown.

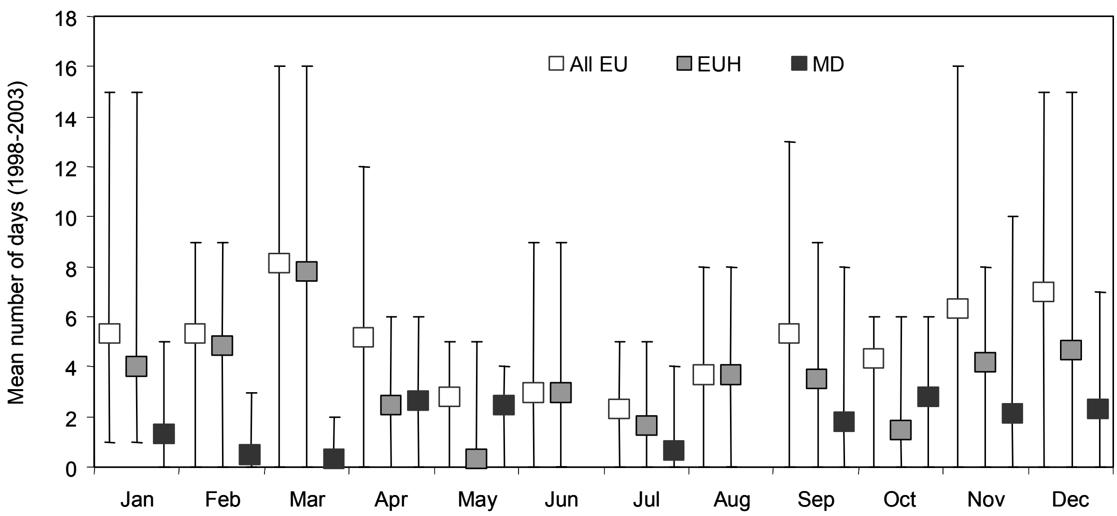

Figure Ap.51. Mean number of days with European advection over Northeastern Iberian Peninsula per month for 1998-2003. EUH and MD episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

The monthly distribution of the mean duration of European episodes (Figure Ap.52) registered over northeastern Iberian Peninsula showed two peaks: in February-March and June, with a mean duration of 5 days. For EUH episodes, during the same three months and October (mean durations of EUH episodes of 5-6 days during these four months). With respect to MD episodes, the mean duration in April, July and December was 4 days and in September was of 6 days (however during this month only two MD episodes occurred in 1998-2003).

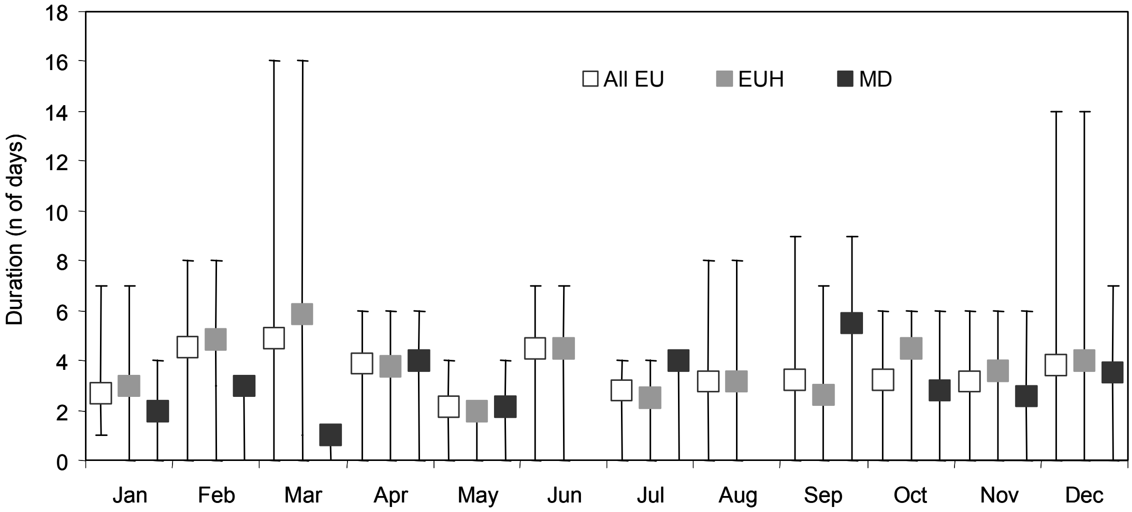

Figure Ap.52. Mean duration of European episodes per month over Northeastern Iberian Peninsula for 1998-2003. EUH and MD episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

Mean PM levels registered during episodes of transport of European air masses were comparable with the global annual means for 1998-2003 (39 µgTSP m^{-3} in Roquetas, 38 µgTSP m^{-3}, 21 µgPM10 m^{-3} and 14 µgPM2.5 m^{-3} in Cabo de Creus, 27 µgTSP m^{-3}, 18 µgPM10 m^{-3} and 12 µgPM2.5 m^{-3} in Els Torms and 17 µgPM10 m^{-3} in Monagrega). During European episodes, at Roquetas (39 µgTSP m^{-3} as mean, Table Ap.56) and Els Torms (26 µgTSP m^{-3}, 18 µgPM10 m^{-3} and 12 µgPM2.5 m^{-3}, Table Ap.56) PM mean levels were comparable to the annual mean PM levels. At Cabo de Creus (38 µgTSP m^{-3}, 21 µgPM10 m^{-3} and 14 µgPM2.5 m^{-3}, Table Ap.56) mean PM levels during European situations were higher than the annual PM means probably owing to the location of this station, on the Northern Spanish Mediterranean coast, occasionally under the direct influence of the transport of European pollutants across the gulf of Lion. At Monagrega, PM10 mean levels during European days (15 µg m^{-3}, Table Ap.56) were lower than the annual mean. The sampling method at Monagrega station was TEOM (oscillating microbalance method) instrumentation while in the other sites PM levels were obtained by gravimetry using high volume samplers. PM10 real time TEOM measurements were validated by means of a comparison with DIGITEL DH-80 gravimetric equipment for 143 measurement days (Rodríguez, 2002). A relation of TEOM = 1.01 x DIGITEL with R^2 = 0.85 was found for spring, summer and autumn whereas for winter the relation was TEOM = 0.68 x DIGITEL with R^2 = 0.57. This results in an underestimation of PM10 mass in winter of 32% due to the loss of species (such as NH_4NO_3 and other semi-volatile organic compounds) due to the difference of temperature between ambient conditions and the heated inlet (50°C to prevent water condensation). As European episodes were especially frequent in winter PM10 mean levels at Monagrega could be partially reduced by around 32% due to this measurement artefact, since data evaluated here is uncorrected by this correction factor. Moreover, the location of this site far from sources of antroppogenic pollution resulting in low local/regional contributions. Owing to the poor dispersive conditions during episodes of development of thermal inversions over urban or industrial sites (very common in winter), local/regional contributions are particularly low in the periods when European episodes are more common. This could also result in a decrease of PM levels in Monagrega during European events.

Table Ap.56. Mean annual levels of TSP, PM10 and PM2.5 registered in Roquetas, Cabo de Creus, Els Torms and Monagrega during European advection episodes in 1998-2003.

EU EPISODES	**Roquetas**	**Cabo de Creus**			**Els Torms**			**Monagrega**
(µg m^{-3})	TSP	TSP	PM10	PM2.5	TSP	PM10	PM2.5	PM10
1998	43	39	na	na	na	na	na	16
1999	33	50	na	na	na	na	na	16
2000	na	42	na	na	na	na	na	16
2001	na	46	*22	*13	35	*19	*13	15
2002	na	39	20	13	22	15	11	13
2003	na	na	35	24	na	19	13	13
Mean 98-03	39	43	25	16	26	18	12	15

*Calculated with data of 83% of the months of the year
na: Not available

In Table Ap.57, the considerable difference between the PM levels registered during the two types of European episodes considered can be observed. PM mean levels during EUH episodes (29 µgTSP m^{-3}, 20 µgPM10 m^{-3} and 14 µgPM2.5 m^{-3} in Els Torms and 15 µgPM10 m^{-3} in Monagrega) were higher than PM mean levels during MD events (21 µgTSP m^{-3}, 14 µgPM10 m^{-3} and 9 µgPM2.5 m^{-3} in Els Torms and 13 µgPM10 m^{-3} in Monagrega) regardless the sampling station and the size range. This difference can be explained in virtue of the common presence of rain episodes associated with MD episodes. These rain events would affect Northeastern Iberian in most cases while, in occasions, the precipitation during these episodes would not affect Western Iberia. This could also explain in part the lower mean PM levels recorded during European episodes over Northeastern Spain when compared with Northwestern and Northern Iberia.

The impact of EUH episodes (II of 3.6 µgTSP m^{-3}, 2.5 µgPM10 m^{-3} and 1.7 µgPM2.5 m^{-3} at Els Torms and 1.9 µgPM10 m^{-3} at Monagrega, Table Ap.57) on annual mean PM levels was higher to the impact of MD events (II of 0.9 µgTSP m^{-3}, 0.6 µgPM10 m^{-3} and 0.4 µgPM2.5 m^{-3} at Els Torms and 0.5 µgPM10 m^{-3} at Monagrega, Table Ap.57). This was explained by two factors: the higher mean TSP levels recorded during EUH events and the higher frequency of occurrence of EUH episodes.

Table Ap.57. Number of days with European advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 ($\mu g\ m^{-3}$) recorded at Els Torms and Monagrega rural sites (NE Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	EUH	MD
2003		
Els Torms TSP ($\mu g\ m^{-3}$)	-	-
Els Torms PM10 ($\mu g\ m^{-3}$)	22	14
Els Torms PM2.5 ($\mu g\ m^{-3}$)	15	8
Monagrega PM10 ($\mu g\ m^{-3}$)	13	12
Days	48	20
2002		
Els Torms TSP ($\mu g\ m^{-3}$)	24	20
Els Torms PM10 ($\mu g\ m^{-3}$)	17	14
Els Torms PM2.5 ($\mu g\ m^{-3}$)	12	10
Monagrega PM10 ($\mu g\ m^{-3}$)	14	13
Days	34	29
2001		
Els Torms TSP ($\mu g\ m^{-3}$)	40	25
Els Torms PM10 ($\mu g\ m^{-3}$)	23	14
Els Torms PM2.5 ($\mu g\ m^{-3}$)	15	10
Monagrega PM10 ($\mu g\ m^{-3}$)	16	12
Days	33	14
2000		
Monagrega PM10 ($\mu g\ m^{-3}$)	17	9
Days	41	5
1999		
Monagrega PM10 ($\mu g\ m^{-3}$)	15	18
Days	56	13
1998		
Monagrega PM10 ($\mu g\ m^{-3}$)	17	11
Days	57	12
Mean 98-03 ($\mu g\ m^{-3}$)		
Els Torms TSP	29	21
Els Torms PM10	20	14
Els Torms PM2.5	14	9
Monagrega PM10	15	13
Impact Index(II) ($\mu g\ m^{-3}$)		
Els Torms TSP	3.6	0.9
Els Torms PM10	2.5	0.6
Els Torms PM2.5	1.7	0.4
Monagrega PM10	1.9	0.5

Considering the monthly mean PM10 levels only for the European days, the highest mean levels were registered under EUH scenario in March (21 $\mu g\ m^{-3}$, Table Ap.58) and in the period June-July (19 $\mu g\ m^{-3}$ on both months Table Ap.58) but also under MD situations in November (18 $\mu g\ m^{-3}$, Table Ap.58).

Table Ap.58. Number of days per month with European advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of PM10 (µg m^{-3}) recorded at Monagrega rural site (NE Spain) for those days.

	EUH	MD		EUH	MD
January			**July**		
Days per month	4.0	1.3	Days per month	1.7	0.7
PM10	10	7	PM10	19	17
February			**August**		
Days per month	4.8	0.5	Days per month	3.7	0.0
PM10	13	14	PM10	16	
March			**September**		
Days per month	7.8	0.3	Days per month	3.5	1.8
PM10	21	13	PM10	15	16
April			**October**		
Days per month	2.5	2.7	Days per month	1.5	2.8
PM10	16	15	PM10	13	9
May			**November**		
Days per month	0.3	2.5	Days per month	4.2	2.2
PM10	16	11	PM10	15	18
June			**December**		
Days per month	3.0	0.0	Days per month	4.7	2.3
PM10	19		PM10	13	9

3.4. Mediterranean episodes

The less frequent long range atmospheric transport scenario in Northeastern Iberian Peninsula was the Mediterranean advection. Mediterranean advection was detected in only 35 episodes, with a mean duration of 2 days per episode, and a total of 62 days in 1998-2003. These resulted in means of 6 and 1 episode per year and month respectively, and 10 and 1 day per year and month respectively (Table Ap.59).

The 35 Mediterranean episodes were classified in 18 episodes (51%, 3 episodes per year, Table Ap.59) caused by the presence of a depression over Northern Africa and/or the Mediterranean (NAD-MD scenario), and 17 episodes (49%, 3 episodes per year, Table Ap.59) by the presence of an anticyclone over the European continent and/or the Mediterranean Sea (EUH-MH scenario). NAD-MD and EUH-MH episodes had the same mean duration over Northeastern Spain, 2 days per episode.

From the 62 days with Mediterranean advection, 48% (30 days, 5 per year, Table Ap.59) occurred under NAD-MD situations and 52% (32 days, 5 per year, Table Ap.59) under EUH-MH situations.

The interannual variation of the total number of Mediterranean episodes and days is high (Table Ap.59). In 1999 11 episodes (20 days) contrasted with 2000, with 2 episodes (3 days) or with 1998 with 3 episodes (3 days). Very low number of NAD-MD episodes was observed in 2000 (1 episode of 1 day) and 2001 (1 episode, 2 days). In contrast, in 1999 11 NAD-MD episodes (7 days) were observed. The lowest number of EUH-MH episodes was registered in 1998 and 2000 with only 1 episode during each year (in 1998 only 1 day was registered) and the highest number was registered in 2003 with 5 EUH-MH episodes. The highest number of days with EUH-MH situation was registered in 1999 and 2002 (9 days during each of these years).

Table Ap.59. Annual number of days and episodes with Mediterranean advection in the period 1998-2003 over Northeastern Iberian Peninsula. The NAD-MD and EUH-MH scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total MED	3	20	3	8	15	13	10	1
NAD-MD	2	11	1	2	6	8	5	<1
EUH-MH	1	9	2	6	9	5	5	<1
Episodes								
Total MED	3	11	2	4	6	9	6	1
NAD-MD	2	7	1	1	3	4	3	<1
EUH-MH	1	4	1	3	3	5	3	<1

Concerning the seasonal distribution, in January (7 Mediterranean episodes in 1998-2003), April-May (April with 6 Mediterranean events during the study period) and November (5 episodes in 1998-2003) a higher frequency of occurrence of Mediterranean events in Northeastern Spain was observed. In these periods, a relatively high frequency of occurrence of NAD-MD episodes and EUH-MH episodes was observed. January registered 4 NAD-MD and 3 EUH-MH episodes, April registered 4 and 2 NAD-MD and EUH-MH episodes respectively, and November 2 and 3 NAD-MD and EUH-MH episodes respectively (Figure Ap.53). Mediterranean episodes of both types were very rare from June to September (Figure Ap.53).

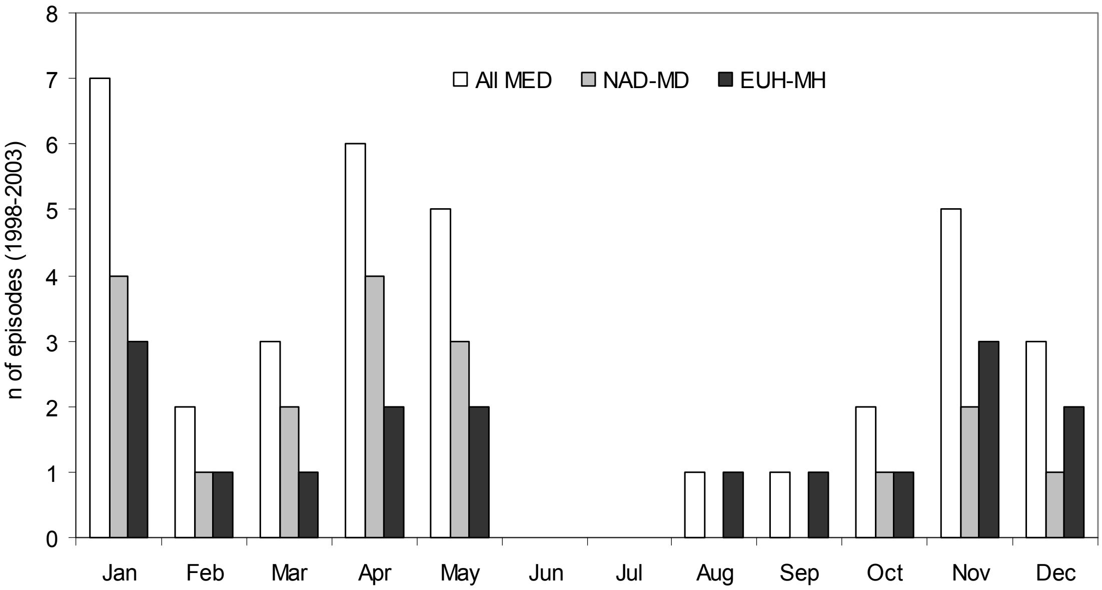

Figure Ap.53. Monthly distribution of the number of Mediterranean episodes over Northeastern Iberian Peninsula. The monthly distributions of NAD-MD and EUH-MH Mediterranean events are also shown.

Concerning the number of days with atmospheric Mediterranean transport over Northeastern Iberia, two periods of high occurrence were observed: October-January (in which January with a mean of 3 days was the month with the highest frequency of occurrence of Mediterranean days, Figures Ap.54 and Ap.55) and spring (centred in April with a mean of 2 days, Figures Ap.54 and Ap.55). The peak frequency in spring was present for the two scenarios distinguished (6 and 4 NAD-MD and EUH-MH days in 1998-2003 respectively, Figures Ap.54 and Ap.55). Concerning days with Mediterranean advection caused by EUH-MH scenario, the peak frequency was observed from November to January (9 days during 1998-2003 in January). With respect to the occurrence of NAD-MD days, two frequency peaks were registered in January (6 days in 1998-2003) and October-November (5 days in November in 1998-2003).

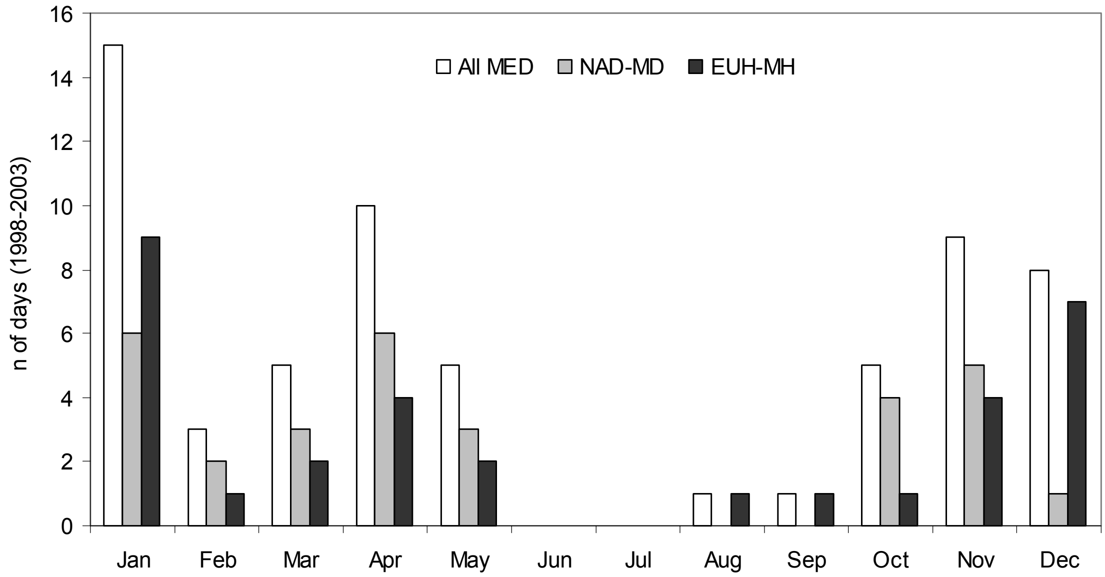

Figure Ap.54. Monthly distribution of the number of days with Mediterranean advection over Northeastern Iberian Peninsula. The monthly distributions of days with Mediterranean advection occurred under NAD-MD and EUH-MH scenarios are also shown.

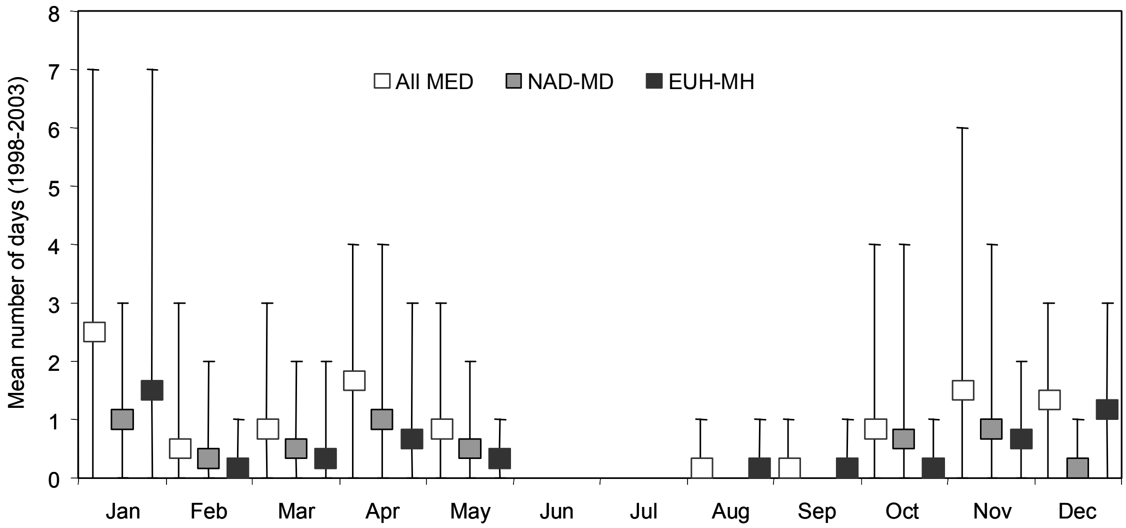

Figure Ap.55. Mean number of days with Mediterranean advection over Northeastern Iberian Peninsula per month for 1998-2003. NAD-MD and EUH-MH episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

On average Mediterranean episodes lasted longer in the period October-January (3 days per event as mean in both October and November, Figure Ap.56) than in the rest of the year. NAD-MD events had a higher duration in October-November (4 and 3 days per event as a mean) and in February (2 days per episode as mean). EUH-MH episodes presented their highest mean duration in December-January (3 and 4 days per episode on average, Figure Ap.56).

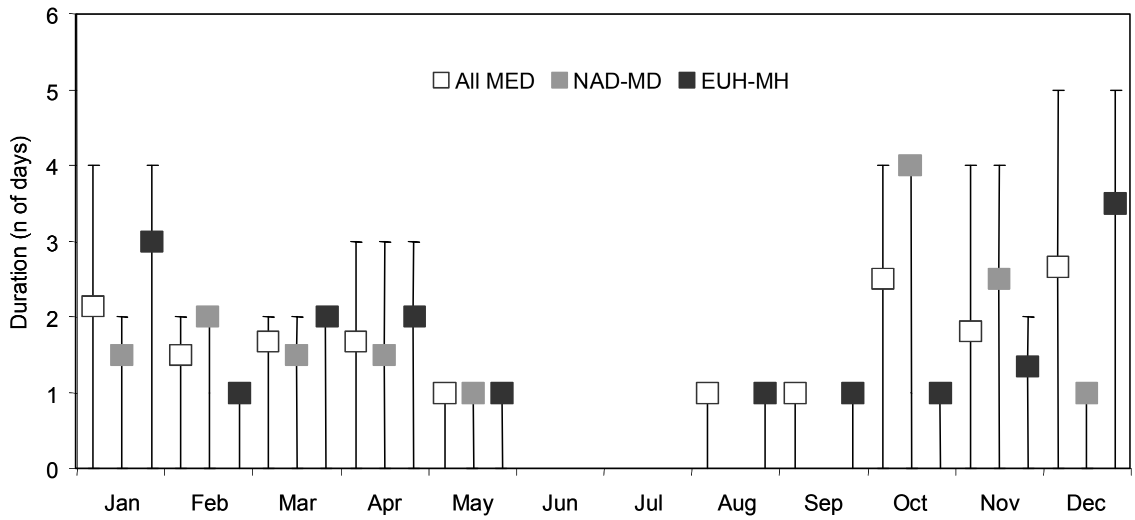

Figure Ap.56. Mean duration of Mediterranean episodes per month over Northeastern Iberian Peninsula for 1998-2003. NAD-MD and EUH-MH episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

Relatively low mean PM levels were registered in regional background stations over Northeastern Iberian Peninsula in the period 1998-2003 during Mediterranean advection episodes when compared with annual PM means in the same period (39 µgTSP m^{-3} in Roquetas, 38 µgTSP m^{-3}, 21 µgPM10 m^{-3} and 14 µgPM2.5 m^{-3} in Cabo de Creus, 27 µgTSP m^{-3}, 18 µgPM10 m^{-3} and 12 µgPM2.5 m^{-3} in Els Torms and 17 µgPM10 m^{-3} in Monagrega). With the exception of mean TSP and PM10 levels in Cabo de Creus (39 µgTSP m^{-3} and 24 µgPM10 m^{-3}, Table Ap.60), the rest of the mean PM levels during Mediterranean event were lower than the annual mean levels respectively (27 µgTSP m^{-3} in Roquetas, 12 µgPM2.5 m^{-3} in Cabo de Creus, 22 µgTSP m^{-3}, 15 µgPM10 m^{-3} and 10 µgPM2.5 m^{-3} in Els Torms and 11 µgPM10 m^{-3} in Monagrega, Table Ap.60).

Table Ap.60. Mean annual levels of TSP, PM10 and PM2.5 registered in Roquetas, Cabo de Creus, Els Torms and Monagrega during Mediterranean advection episodes in 1998-2003.

MED EPISODES	Roquetas	Cabo de Creus			Els Torms			Monagrega
(µg m^{-3})	TSP	TSP	PM10	PM2.5	TSP	PM10	PM2.5	PM10
1998	30	50	na	na	na	na	na	11
1999	26	36	na	na	na	na	na	11
2000	na	40	na	na	na	na	na	10
2001	na	39	*18	*11	26	*17	*11	13
2002	na	40	20	11	19	13	9	11
2003	na	na	33	13	na	17	11	11
Mean 98-03	27	39	24	12	22	15	10	11

*Calculated with data of 83% of the months of the year
na: Not available

Concerning the two transport scenarios defined for Mediterranean episodes, mean PM levels measured during EUH-MH events (22 µgTSP m^{-3}, 17 µgPM10 m^{-3} and 12 µgPM2.5 m^{-3} in Els Torms and 13 µgPM10 m^{-3} in Monagrega, Table Ap.61) were slightly higher than during NAD-MD events (21 µgTSP m^{-3}, 13 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3} in Els Torms and 9 µgPM10 m^{-3} in Monagrega, Table Ap.61). This is probably caused by the high rainfall during the latter scenario. The relatively low PM levels combined with the low annual frequency of occurrence of Mediterranean events resulted in low impact indexes (II) for both scenarios (II of 0.3 µgTSP m^{-3}, 0.2 µgPM10 m^{-3} and 0.1 µgPM2.5 m^{-3} at Els Torms and 0.1 µgPM10 m^{-3} at Monagrega for NAD-MD and II of 0.3 µgTSP m^{-3}, 0.2 µgPM10 m^{-3} and 0.2 µgPM2.5 m^{-3} at Els Torms and 0.2 µgPM10 m^{-3} at Monagrega for EUH-MH, Table Ap.61).

Table Ap.61. Number of days with Mediterranean advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (µg m^{-3}) recorded at Els Torms and Monagrega rural sites (NE Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	NAD-MD	EUH-MH
2003		
Els Torms TSP (µg m^{-3})	-	-
Els Torms PM10 (µg m^{-3})	12	25
Els Torms PM2.5 (µg m^{-3})	7	17
Monagrega PM10 (µg m^{-3})	10	14
Days	8	5
2002		
Els Torms TSP (µg m^{-3})	23	17
Els Torms PM10 (µg m^{-3})	14	12
Els Torms PM2.5 (µg m^{-3})	9	10
Monagrega PM10 (µg m^{-3})	11	11
Days	6	9
2001		
Els Torms TSP (µg m^{-3})	18	29
Els Torms PM10 (µg m^{-3})	-	17
Els Torms PM2.5 (µg m^{-3})	-	11
Monagrega PM10 (µg m^{-3})	7	15
Days	2	6
2000		
Monagrega PM10 (µg m^{-3})	2	13
Days	1	2
1999		
Monagrega PM10 (µg m^{-3})	8	16
Days	11	9
1998		
Monagrega PM10 (µg m^{-3})	17	6
Days	2	1
Mean 98-03 (µg m^{-3})		
Els Torms TSP	21	22
Els Torms PM10	13	17
Els Torms PM2.5	8	12
Monagrega PM10	9	13
Impact Index(II) (µg m^{-3})		
Els Torms TSP	0.3	0.3
Els Torms PM10	0.2	0.2
Els Torms PM2.5	0.1	0.2
Monagrega PM10	0.1	0.2

As shown by Table Ap.62, the monthly PM means obtained only for Mediterranean days, only in March and August for EUH-MH events recorded relatively high PM levels (21 and 21 µgPM10 m^{-3} at Monagrega) but in any case, similar to the mean annual values. For other scenario and/or month, PM levels were significantly lower than the annual means.

Table Ap.62. Number of days per month with Mediterranean advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of PM10 (µg m^{-3}) recorded at Monagrega rural site (NE Spain) for those days.

	NAD-MD	EUH-MH		NAD-MD	EUH-MH
January			**July**		
Days per month	1.0	1.5	Days per month	0.0	0.0
PM10	6	12	PM10		
February			**August**		
Days per month	0.3	0.2	Days per month	0.0	0.2
PM10	6	10	PM10		20
March			**September**		
Days per month	0.5	0.3	Days per month	0.0	0.2
PM10	13	21	PM10		12
April			**October**		
Days per month	1.0	0.7	Days per month	0.7	0.2
PM10	11	14	PM10	13	15
May			**November**		
Days per month	0.5	0.3	Days per month	0.8	0.7
PM10	13		PM10	6	14
June			**December**		
Days per month	0.0	0.0	Days per month	0.2	1.2
PM10		10	PM10	7	11

3.5. Episodes without dominant advective conditions

In the study period (1998-2003) a total of 492 days (82 per year, 7 per month, Table Ap.63) in which no advective conditions were present. These were grouped in 146 episodes (24 per year, 2 per month, Table Ap.63) with a mean duration of 3 days.

The 492 days were distributed in, approximately, equal parts in WIA (46% of the days, caused by an anticyclone covering completely or partly the Iberian Peninsula out of summer) and ITL scenarios (54% of the days, situations in which the thermal Iberian low developed over the Iberian plateau during summer owing to the great heating of the surface). This resulted in 225 days (38 per year, 3 per month, Table Ap.63) with WIA scenario grouped in 72 events (49% of the episodes without advective conditions, 12 per year, 1 per month, Table Ap.63) with a mean duration of 3 days. In the other 267 days (45 per year, 4 per month, Table Ap.63) ITL conditions occurred which resulted in 74 episodes (51% of the episodes without advective conditions, 12 per year, 1 per month, Table Ap.63) with a mean extent of 3 days.

The annual number of episodes without dominant advection ranged from 19 (in 2002) to 30 (in 1998 and 2003). For WIA episodes this range was 7 (in 2001) to 18 (in 1998 and 2003) and for ITL 10 (in 1999) to 14 (in 2000 and 2001).

With respect to days without prevalent advection 2002 registered the lowest total number (52) and both the lowest number of both WIA (20) and ITL (32). The maximum number of days without advective conditions was registered in 2003 (105) but the two types of episodes defined reached their maximum annual number of days in 1998 (59 WIA days) and in 1999 (55 ITL days).

Table Ap.63. Annual number of days and episodes with lack of advective conditions in the period 1998-2003 over Northeastern Iberian Peninsula. The WIA and ITL scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total NOADV	98	81	90	66	52	105	82	7
WIA	59	26	39	25	20	56	38	3
ITL	39	55	51	41	32	49	45	4
Episodes								
Total NOADV	30	19	26	21	20	30	24	2
WIA	18	9	12	7	8	18	12	1
ITL	12	10	14	14	12	12	12	1

The episodes without dominant advective conditions were particularly frequent from late spring to early autumn (Figure Ap.57). During summer months and in particular in July (24 episodes accumulated during 1998-2003 all of them of ITL type) ITL was the only scenario present in episodes without dominant advection. WIA events, not present during summer, were particularly high in April-May (15 episodes accumulated in May) and October (13 episodes during this month in the study period).

As for the monthly distribution of episodes without advective conditions, the maximum concentration of days without prevalent advection occurred in late spring-early autumn. In June-August, averages of 10-11 days without advective conditions, almost all of them of ITL type, were recorded. WIA days had their principal maxima in April-May (8 days as a mean in May) and October (a mean of 7 days) although in February (4 days as a mean) a secondary maximum was registered (Figures Ap.58 and Ap.59).

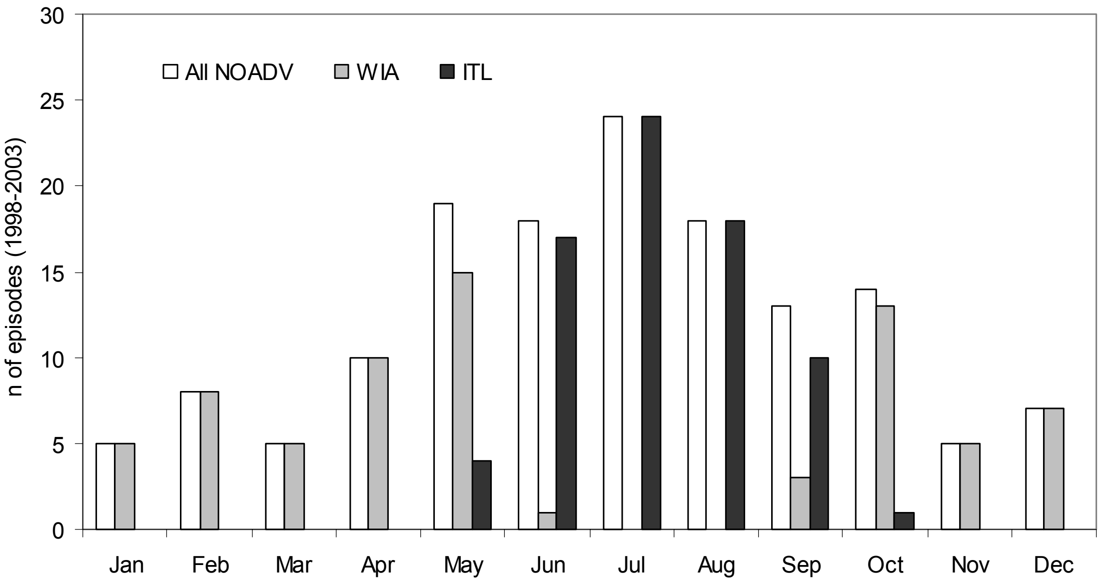

Figure Ap.57. Monthly distribution of the number of episodes without dominant advective conditions over Northeastern Iberian Peninsula. The monthly distributions of WIA and ITL events are also shown.

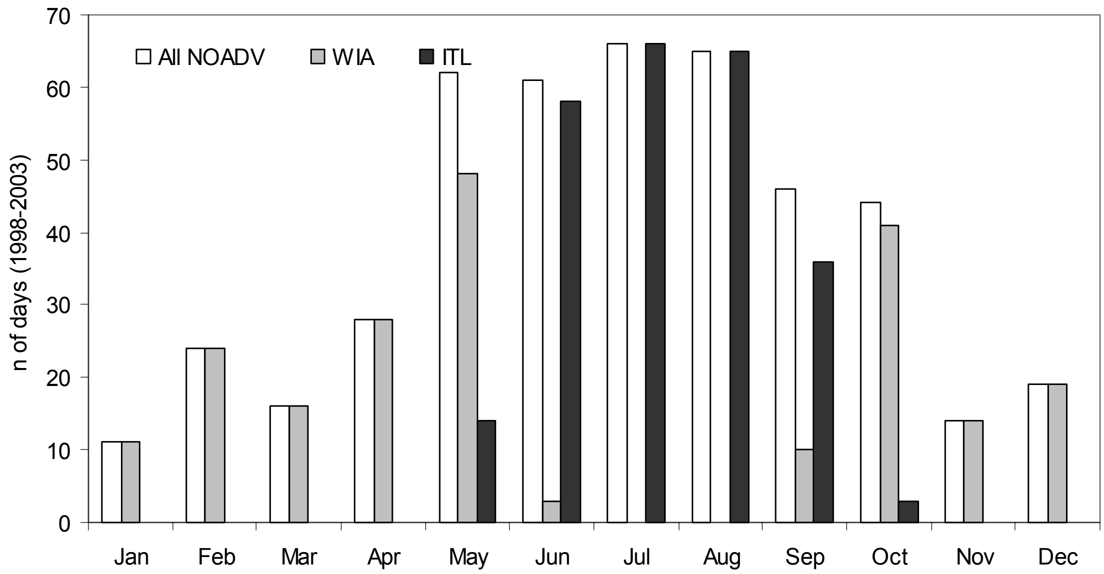

Figure Ap.58. Monthly distribution of the number of days with lack of advective conditions over Northeastern Iberian Peninsula. The monthly distributions of days with lack of advective conditions occurred under WIA and ITL scenarios are also shown.

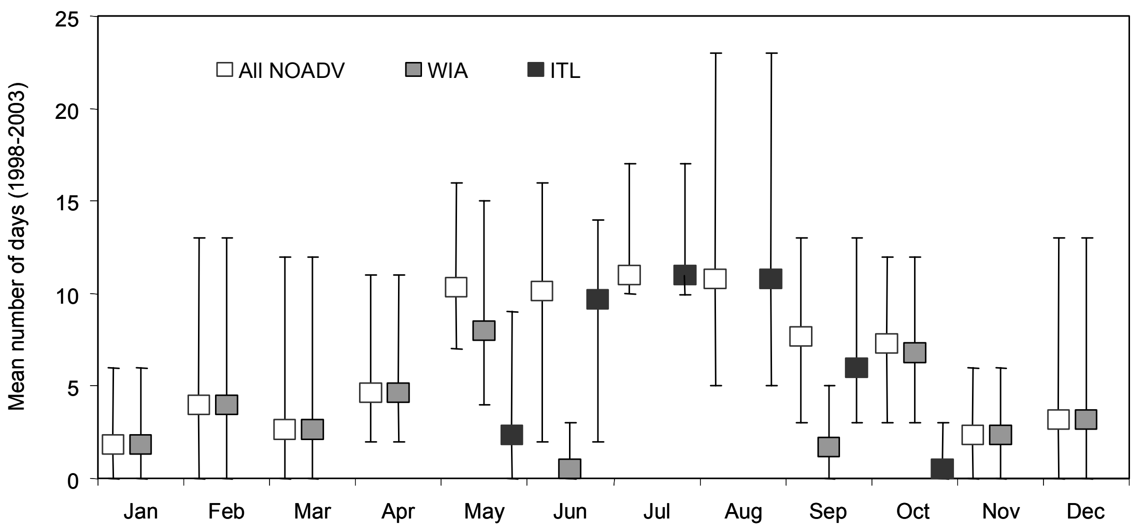

Figure Ap.59. Mean number of days without a dominant air mass advection over Northeastern Iberian Peninsula per month for 1998-2003. WIA and ITL episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

The monthly distribution of the mean duration of episodes without dominant advective conditions was constant, with 3 days per episode during all the months with the exception of January (2 days per episode) when only WIA episodes occurred, and August-September (4 days per episode on average in these two months), when mainly ITL events occurred (Figure Ap.60). Nevertheless, sporadically, occasionally long ITL episodes occurred, such as in September 1999 when 14 consecutive days were registered.

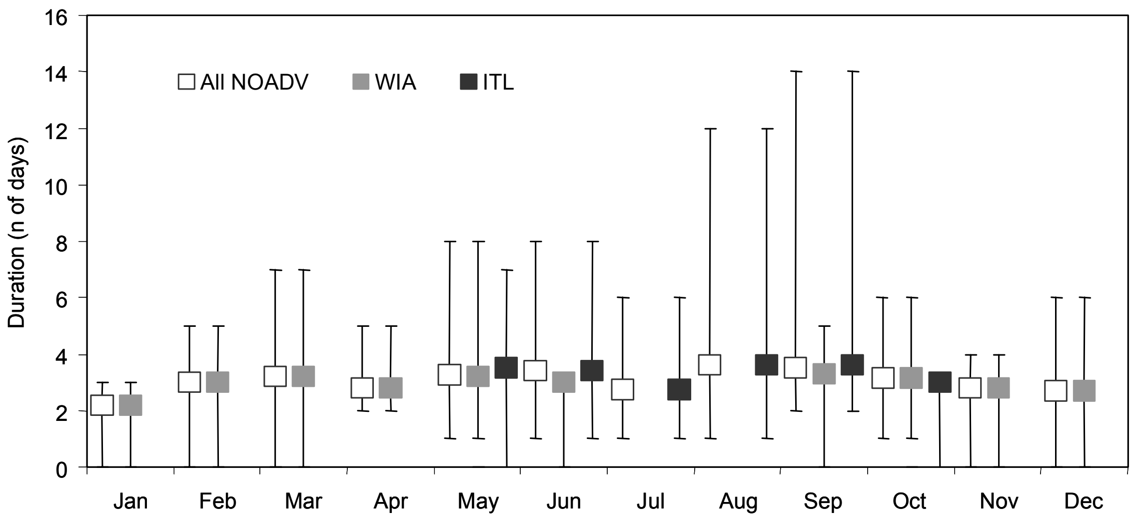

Figure Ap.60. Mean duration of episodes without a dominant air mass advection per month over Northeastern Iberian Peninsula for 1998-2003. WIA and ITL episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

The mean PM levels recorded for the days without dominant advection are generally higher than the annual mean PM levels (39 µgTSP m^{-3} in Roquetas, 38 µgTSP m^{-3}, 21 µgPM10 m^{-3} and 14 µgPM2.5 m^{-3} in Cabo de Creus, 27 µgTSP m^{-3}, 18 µgPM10 m^{-3} and 12 µgPM2.5 m^{-3} in Els Torms and 17 µgPM10 m^{-3} in Monagrega). This stands for all the stations and size ranges with the exception of TSP at Cabo de Creus (35 µgTSP m^{-3}, Table Ap.64). In the rest of the cases, the impact of episodes without advective conditions on PM levels is clear (42 µgTSP m^{-3} in Roquetas, 23 µgPM10 m^{-3} and 16 µgPM2.5 m^{-3} in Cabo de Creus, 30 µgTSP m^{-3}, 20 µgPM10 m^{-3} and 14 µgPM2.5 m^{-3} in Els Torms and 22 µgPM10 m^{-3} in Monagrega). Under both scenarios causing lack of advective conditions (WIA and ITL) precipitation is reduced so the scavenging potential of the atmosphere is reduced.

Table Ap.64. Mean annual levels of TSP, PM10 and PM2.5 registered in Roquetas, Cabo de Creus, Els Torms and Monagrega during episodes without dominant air mass advection in 1998-2003.

NOADV EPISODES	**Roquetas**	**Cabo de Creus**			**Els Torms**			**Monagrega**
(µg m^{-3})	TSP	TSP	PM10	PM2.5	TSP	PM10	PM2.5	PM10
1998	44	27	na	na	na	na	na	21
1999	39	37	na	na	na	na	na	24
2000	na	37	na	na	na	na	na	23
2001	na	38	*21	*13	35	*23	*16	27
2002	na	33	19	14	25	17	12	17
2003	na	na	26	19	na	20	15	19
Mean 98-03	42	35	23	16	30	20	14	22

*Calculated with data of 83% of the months of the year
na: Not available

ITL episodes resulted in higher PM mean levels than WIA episodes. This difference is very important in Monagrega where, during WIA episodes, a mean of 16 µgPM10 m^{-3} was recorded and during ITL events a mean of 26 µgPM10 m^{-3} was registered (Table Ap.65). In Els Torms, probably owing to its location, closer to urban or industrial nuclei, might be affected occasionally by regional pollution during WIA events (29 µgTSP m^{-3}, 19 µgPM10 m^{-3} and 14 µgPM2.5 m^{-3}). Thus, at Els Torms the mean levels

during these episodes are close to the mean levels recorded during ITL episodes (31 µgTSP m^{-3}, 22 µgPM10 m^{-3} and 15 µgPM2.5 m^{-3}, Table Ap.65).
As the frequency of occurrence of both scenarios is very similar and, at Els Torms, mean PM levels during ITL and WIA were close, the impact indexes (II) both scenarios at this station did not differ greatly (II of 3.0 µgTSP m^{-3}, 1.9 µgPM10 m^{-3} and 1.4 µgPM2.5 m^{-3} for WIA and II of 3.8 µgTSP m^{-3}, 2.6 µgPM10 m^{-3} and 1.8 µgPM2.5 m^{-3}, Table Ap.65). In the annual mean PM10 level at Monagrega the II of ITL scenario is almost twice as high as the II of WIA (II of 3.2 and 1.7 µg m^{-3} for ITL and WIA respectively, Table Ap.65).

Table Ap.65. Number of days without a dominant air mass advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (µg m^{-3}) recorded at Els Torms and Monagrega rural sites (NE Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	WIA	ITL
2003		
Els Torms TSP (µg m^{-3})	-	-
Els Torms PM10 (µg m^{-3})	19	22
Els Torms PM2.5 (µg m^{-3})	14	16
Monagrega PM10 (µg m^{-3})	14	24
Days	56	49
2002		
Els Torms TSP (µg m^{-3})	21	27
Els Torms PM10 (µg m^{-3})	14	19
Els Torms PM2.5 (µg m^{-3})	11	14
Monagrega PM10 (µg m^{-3})	13	19
Days	20	32
2001		
Els Torms TSP (µg m^{-3})	36	34
Els Torms PM10 (µg m^{-3})	24	23
Els Torms PM2.5 (µg m^{-3})	17	15
Monagrega PM10 (µg m^{-3})	20	31
Days	25	41
2000		
Monagrega PM10 (µg m^{-3})	16	28
Days	39	51
1999		
Monagrega PM10 (µg m^{-3})	17	27
Days	26	55
1998		
Monagrega PM10 (µg m^{-3})	17	26
Days	59	39
Mean 98-03 (µg m^{-3})		
Els Torms TSP	29	31
Els Torms PM10	19	22
Els Torms PM2.5	14	15
Monagrega PM10	16	26
Impact Index(II) (µg m^{-3})		
Els Torms TSP	3.0	3.8
Els Torms PM10	1.9	2.6
Els Torms PM2.5	1.4	1.8
Monagrega PM10	1.7	3.2

There is a considerable difference between the mean monthly PM10 levels worked out for WIA and ITL days at Monagrega (Table Ap.66). While during summer events (ITL) PM10 mean levels went beyond 20 µg m^{-3} in all the months from May to October, WIA episodes only resulted in high PM10 means in the small number of events (a mean of 0.5 days per year in this month) occurred in June (24 µg m^{-3}).

Table Ap.66. Number of days per month without advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of PM10 (µg m^{-3}) recorded at Monagrega rural site (NE Spain) for those days.

	WIA	ITL		WIA	ITL
January			**July**		
Days per month	1.8	0.0	Days per month	0.0	11.0
PM10	12		PM10		26
February			**August**		
Days per month	4.0	0.0	Days per month	0.0	10.8
PM10	17		PM10		29
March			**September**		
Days per month	2.7	0.0	Days per month	1.7	6.0
PM10	19		PM10	19	24
April			**October**		
Days per month	4.7	0.0	Days per month	6.8	0.5
PM10	13		PM10	16	21
May			**November**		
Days per month	8.0	2.3	Days per month	2.3	0.0
PM10	18	20	PM10	16	
June			**December**		
Days per month	0.5	9.7	Days per month	3.2	0.0
PM10	24	26	PM10	11	

4. Central Iberian Peninsula

The Atlantic advection is the most frequent air mass transport situation over Central Spain with 48% of the days in 1998-2003 (237 episodes and 1060 days). Situations with lack of dominant advection occurred in 24% of the days in 528 days grouped in 153 episodes and the arrival of African air masses in 14% of the days in 311 days grouped in 110 episodes. With less frequency, 8 and 6 % of the days in 1998-2003 respectively transport of European (168 days in 48 episodes) and Mediterranean (124 days in 54 episodes) air masses also occurred over the study area (Table Ap.67).

Table Ap.67. Number of days, % of days and episodes with Atlantic (ATL), North African (NAF), Mediterranean (MED) and European (EU) advection and without a prevalent advective regime (NOADV) in Central Iberia for the period 1998-2003.

1998-2003	ATL	NAF	MED	EU	NOADV
Number of days	1060	311	124	168	528
% of days	48	14	6	8	24
Number of events	237	110	54	48	153

In the study region four EMEP stations were operative during 1998-2003. As specified several times during this work, EMEP stations offered daily mean PM data based on gravimetric sampling. From San Pablo de los Montes station (39º 23’ N, -4º 20’ E, 917 m.a.s.l.) daily mean TSP data were available from 1998 to June 2000. Months after this date, this station was moved to very close location (39º 31’ N, -4º 21’ E, 1241 m.a.s.l.) at Risco Llano. This station was operative from November 2000 to present time offering mean daily data on TSP (from November 2000 to January 2003) and PM10 and PM2.5 (from March 2001 beyond the end of the study period 1998-2003). Daily mean PM data from Campisábalos site (41º 17’ N, -3º 09’ E, 1360 m.a.s.l.) were also available. There, TSP measurements were performed from March 1998 to January 2003 and PM10 and PM2.5 data were available from March 2001 to the end of the study period. Peñausende station (41º 17’ N, -5º 52’ E, 985 m.a.s.l.) began to be operative from July 2000 offering data on TSP from that date up to January 2003 and on PM10 and PM2.5 from March 2001 to present time.

Mean daily PM data recorded at all these sites were considerably low and similar for all size ranges (Table Ap.68). Mean TSP levels ranged from 22 $\mu g\ m^{-3}$ (at both San Pablo de los Montes and Risco Llano) to 18 $\mu g\ m^{-3}$ (at both Campisábalos and Peñausende). PM10 mean levels for 1998-2003 were 12 $\mu g\ m^{-3}$ at Campisábalos, 13 $\mu g\ m^{-3}$ at Peñausende and 14 $\mu g\ m^{-3}$ at Risco Llano. Also mean PM2.5 mean levels for the study period were close in all stations (7 $\mu g\ m^{-3}$ at Risco Llano and 8 $\mu g\ m^{-3}$ at both Campisábalos and Peñausende). These mean PM levels did not show a great interannual variation and in any case surpassed the annual limit values of the 1999/30/CE Directive for 2005 (40 $\mu g PM10\ m^{-3}$) or for 2010 (20 $\mu g PM10\ m^{-3}$) were exceeded. With respect to the mean PM2.5 levels, in any station the annual limit value proposed by the II PM position paper (not fixed yet but between 12 and 20 $\mu g PM2.5\ m^{-3}$) was exceeded.

Table Ap.68. Mean levels of TSP, PM10 and PM2.5 recorded in EMEP stations in 1998-2003 in Central Iberian Peninsula.

MEAN LEVELS ($\mu g\ m^{-3}$)	San Pablo de los Montes	Risco Llano			Campisábalos			Peñausende		
	TSP	TSP	PM10	PM2.5	TSP	PM10	PM2.5	TSP	PM10	PM2.5
1998	24	na	na	na	*[2]18	na	na	na	na	na
1999	20	na	na	na	15	na	na	na	na	na
2000	*[1]20	na	na	na	20	na	na	na	na	na
2001	na	23	*[3]15	*[3]9	22	*[3]14	*[3]9	19	*[3]15	*[3]10
2002	na	23	12	7	17	11	7	18	12	8
2003	na	na	14	7	na	12	7	na	13	8
Mean 98-03	22	22	14	7	18	12	8	18	13	8

*[1]Calculated with data of 50% of the months of the year
*[2]Calculated with data of 83% of the months of the year
*[3]Calculated with data of 83% of the months of the year
na: Not available

4.1. Atlantic episodes

The most abundant transport situation over Central Iberia was advection of Atlantic air masses. In 1998-2003, this occurred in 1060 days (177 per year and 15 per month, Table Ap.69) grouped in 237 episodes (40 per year and 3 per month, Table Ap.69) with a mean duration of 4 days per event.

Distinguishing between synoptic scenarios, AZH-NAtD (characterised by the presence of the Azores high and the Iceland low at their standard positions) was the dominant situation. In 79% of the events, 188 out of the 237 Atlantic episodes (31 per year and 3 per month) this scenario occurred. These episodes resulted in 937 days (88% of the total number of days with Atlantic advection in 1998-2003), that is, 156 and 13 days per year and month respectively (Table Ap.69). The mean extent of the AZH-NAtD episodes over Central Iberia was 5 days.

AD episodes (caused by the presence of a depression in front of the Portuguese coast) had a lower frequency of occurrence and a lower mean duration than AZH-NAtD events (only 2 days per episode on average). This scenario explained the occurrence of Atlantic transport in 123 days (21 per year and 2 per month), that is, 12% of the total number of days with Atlantic advection in 1998-2003. These days were distributed in 49 events (8 per year, 1 per month) which resulted in 21% of the Atlantic episodes over the study area (Table Ap.69).

There was not a great interannual variability in the number of Atlantic episodes over Central Spain in 1998-2003. Thus, the minimum number of Atlantic episodes was registered in 2001 and 2002 with 38 events and the maximum in 2000 with 43. This variability was higher for the two transport scenarios distinguished. 2003 registered the maximum and the minimum number of AD and AZH-NAtD episodes respectively. 16 AD events and 23 AZH-NAtD events were registered that year. By contrast 1998, 1999 and 2001 registered the lowest number of AD episodes (6) and 2000 the highest number of AZH-NAtD events with 35 (Table Ap.69).

The range of the number of days with Atlantic advection over Central Spain in 1998-2003 varied between 137 (in 2003) and 198 (in 2002). As for Atlantic episodes, when distinguishing between transport scenarios, 2003 had an anomalous behaviour. In that year, the lowest number of days with AZH-NAtD situation occurred (102) coinciding with the highest number of days with AD situation (35). The maximum number of AZH-NAtD days occurred in 2002 with 179 days and the minimum number of days with AD scenario was registered in 2001 with 14 days (Table Ap.69).

Table Ap.69. Annual number of days and episodes with Atlantic advection in the period 1998-2003 over Central Iberian Peninsula. The AZH-NAtD and AD scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total ATL	170	193	180	182	198	137	177	15
AZH-NAtD	150	177	161	168	179	102	156	13
AD	20	16	19	14	19	35	21	2
Episodes								
Total ATL	39	40	43	38	38	39	40	3
AZH-NAtD	33	34	35	32	31	23	31	3
AD	6	6	8	6	7	16	8	1

The Atlantic episodes occurred over Central Iberia all throughout the year but several periods of relatively higher frequency were registered in spring (27 episodes in April during 1998-2003), July (25 episodes during 1998-2003), October (21 during 1998-2003) and December (23 during 1998-2003). However, the frequency of occurrence of the two types of episodes distinguished differed. AZH-NAtD episodes showed a principal peak of occurrence in summer (23 episodes in July during 1998-2003) and a secondary peak around April-May (18 events accumulated in May during the study period). AD occurred principally in spring (April registered 10 of these episodes in 1998-2003) and in autumn-early winter with 8 episodes accumulated in particular in December during the study period (Figure Ap.61).

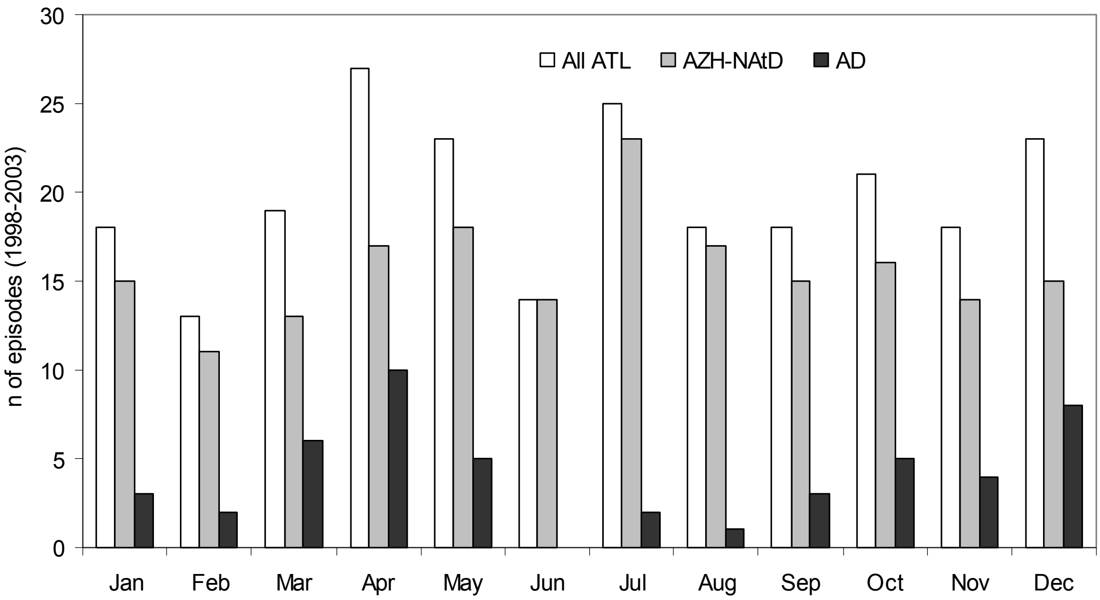

Figure Ap.61. Monthly distribution of the number of Atlantic episodes over Central Iberian Peninsula. The monthly distributions of AZH-NAtD and AD Atlantic events are also shown.

The days with Atlantic advection had two main periods of higher frequency of occurrence (Figures Ap.62 and Ap.63), autumn (November with a mean of 21 days) and spring (April with a mean of 21 days) and a secondary period of high frequency in January (19 days as a mean). In summer, the number of days with Atlantic advection was lower in summer with the minimum in June (only 8 days as a mean). Concerning the frequency of occurrence of the number of days with Atlantic advection caused by AZH-NAtD synoptic scenario in three months can be highlighted: November (with a mean of 20 days), January (18 days as a mean) and April (a mean of 16 days). A second order frequency peak was observed in August (13 days as a mean) in the middle of the period in which the lowest frequency of occurrence of AZH-NAtD situations occurred (May-September). The number of days with Atlantic advection occurred under AD scenario were more frequent in spring (a mean of 4 days in April), late summer-early autumn (3 days as a mean in September) and December (3 days as a mean). AD episodes occurred in late spring-summer (May to August) resulted only in a total of 15 days in the whole study period (1998-2003).

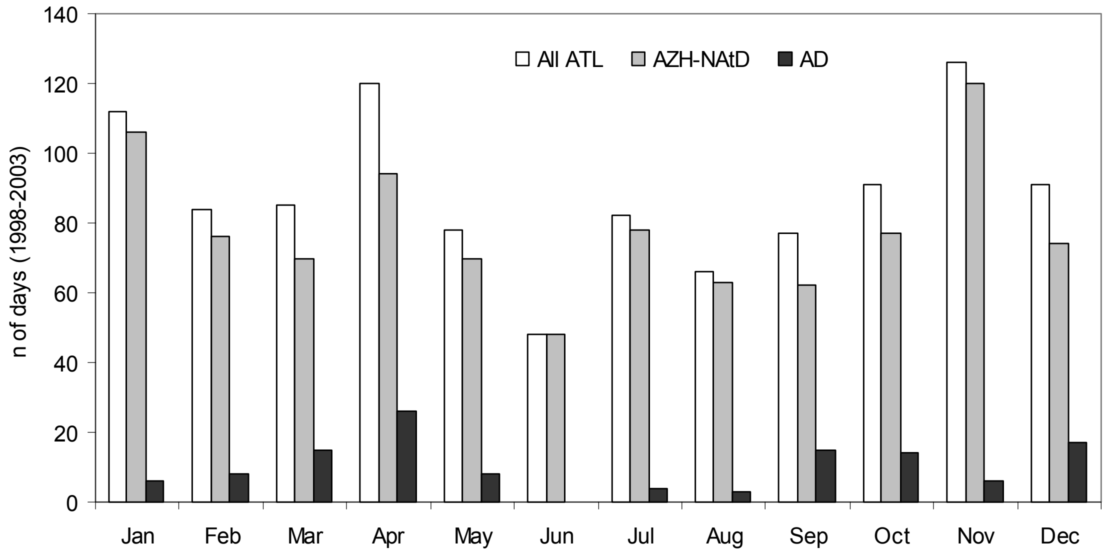

Figure Ap.62. Monthly distribution of the number of days with Atlantic advection over Central Iberian Peninsula. The monthly distributions of days with Atlantic advection occurred under AZH-NAtD and AD scenarios are also shown.

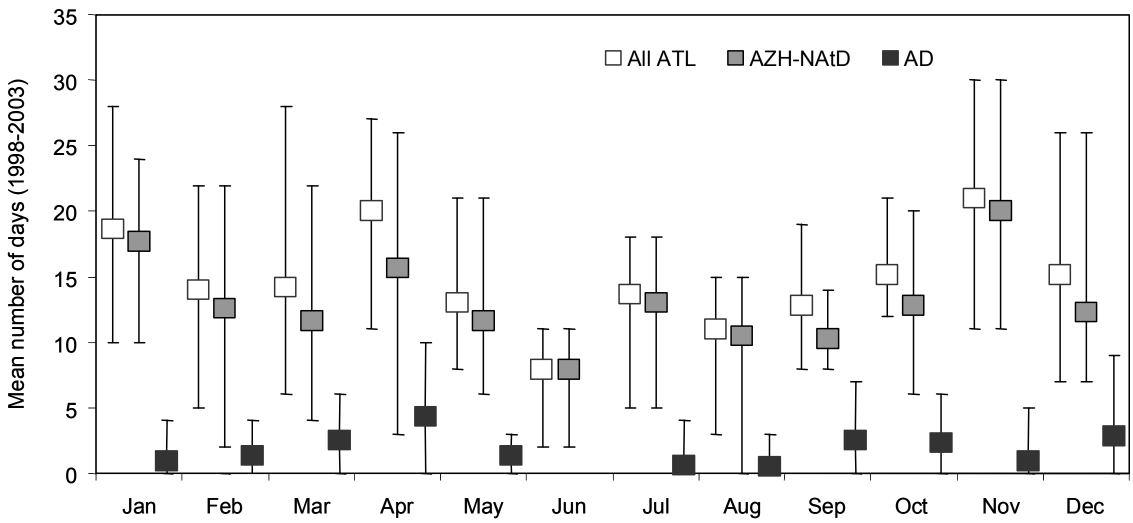

Figure Ap.63. Mean number of days with Atlantic advection over Central Iberian Peninsula per month for 1998-2003. AZH-NAtD and AD episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

As shown in Figure Ap.64, Atlantic episodes over Central Iberia had a higher duration in November (mean duration of 7 days per episode) and winter (6 days as mean duration in both January and February) while in summer the mean duration of Atlantic episodes did not surpass 4 days. The seasonal distribution of the mean duration of AZH-NAtD events also points to November (with a mean duration of 9 days) and

January-February (a mean duration of 7 days in both months) as the periods with the longest episodes on average. AD episodes showed higher mean durations in February-April (4 days as mean duration in February) and August-October (5 days as mean duration in September). Relatively low mean duration of episodes in summer is a common feature applicable to AZH-NAtD and AD scenarios

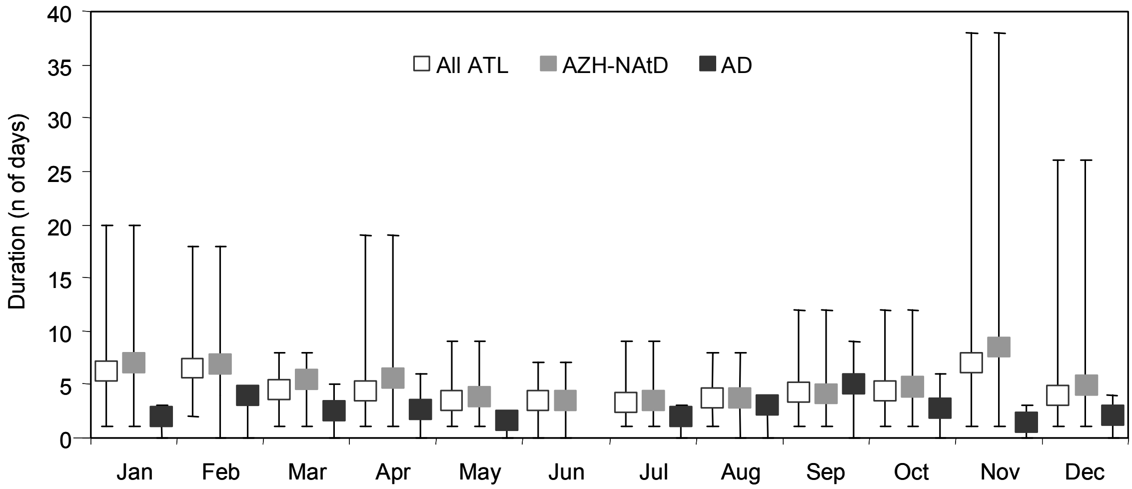

Figure Ap.64. Mean duration of Atlantic episodes per month over Central Iberian Peninsula for 1998-2003. AZH-NAtD and AD episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

Atlantic episodes yielded lower mean PM levels in background stations over Central Iberia than the annual means (22 µgTSP m^{-3} in San Pablo de los Montes, 22 µgTSP m^{-3}, 14 µgPM10 m^{-3} and 7 µgPM2.5 m^{-3} in Risco Llano, 18 µgTSP m^{-3}, 12 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3} in Campisábalos and 18 µgTSP m^{-3}, 13 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3} in Peñausende). TSP mean annual levels ranged from 15 µg m^{-3} in both San Pablo de los Montes and Risco Llano, to 11 µg m^{-3} in both Campisábalos and Peñausende (Table Ap.70). PM10 mean levels in the study period ranged from 7 µg m^{-3}, at Campisábalos to 8 µg m^{-3} at both Risco Llano and Peñausende (Table Ap.70). Finally, PM2.5 mean levels were 5 µg m^{-3} in the three stations where PM2.5 was measured: Risco Llano, Campisábalos and Peñausende (Table Ap.70). The relatively unpolluted air masses transported from the Atlantic Ocean resulted in these low PM levels which, basically, corresponded to local/regional contributions.

Table Ap.70. Mean annual levels of TSP, PM10 and PM2.5 registered in San Pablo de los Montes, Risco Llano, Campisábalos and Peñausende during Atlantic advection episodes in 1998-2003.

ATL EPISODES ($\mu g\ m^{-3}$)	**San Pablo de los Montes**	**Risco Llano**			**Campisábalos**			**Peñausende**		
	TSP	TSP	PM10	PM2.5	TSP	PM10	PM2.5	TSP	PM10	PM2.5
1998	17	na	na	na	*[2]11	na	na	na	na	na
1999	15	na	na	na	10	na	na	na	na	na
2000	*[1]13	na	na	na	12	na	na	na	na	na
2001	na	16	*[3]10	*[3]6	13	*[3]9	*[3]6	12	*[3]10	*[3]7
2002	na	15	8	4	10	7	5	11	8	5
2003	na	na	6	3	na	5	4	na	7	4
Mean 98-03	15	15	8	5	11	7	5	11	8	5

*[1]Calculated with data of 50% of the months of the year
*[2]Calculated with data of 83% of the months of the year
*[3]Calculated with data of 83% of the months of the year
na: Not available

Table Ap.71, shows the mean PM levels registered in regional background stations during AZH-NAtD and AD episodes at San Pablo de los Montes and Campisábalos. Mean annual PM levels recorded during the anticyclonic scenario (AZH-NAtD) were higher than those recorded during AD (associated with depressions). This can be explained by a higher frequency of occurrence of rainfall associated with the latter scenario. In particular, during AZH-NAtD events the annual means for TSP, PM10 and PM2.5 were: 16 μgTSP m^{-3} in San Pablo de los Montes and 11 μgTSP m^{-3}, 7 μgPM10 m^{-3} and 5 μgPM2.5 m^{-3} in Campisábalos. As AD episodes concern, the mean PM levels were: 11 μgTSP m^{-3} in San Pablo de los Montes and 9 μgTSP m^{-3}, 6 μgPM10 m^{-3} and 4 μgPM2.5 m^{-3} in Campisábalos.
The great difference existing in the occurrence of both scenarios resulted in important differences in the impact index (II). AZH-NAtD, with high frequency of occurrence, had II of 6.6 μgTSP m^{-3} at San Pablo de los Montes and 4.8 μgTSP m^{-3}, 3.1 μgPM10 m^{-3} and 2.2 μgPM2.5 m^{-3} at Campisábalos. AD events, considerably less frequent, registered II 10-11 times lower than AZH-NAtD (0.6 μgTSP m^{-3} at San Pablo de los Montes and 0.5 μgTSP m^{-3}, 0.3 μgPM10 m^{-3} and 0.2 μgPM2.5 m^{-3} at Campisábalos, Table Ap.71).

Table Ap.71. Number of days with Atlantic advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (µg m^{-3}) recorded at San Pablo de los Montes and Campisábalos rural sites (C Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	AZH-NAtD	**AD**
2003		
Campisábalos TSP (µg m^{-3})	-	-
Campisábalos PM10 (µg m^{-3})	5	6
Campisábalos PM2.5 (µg m^{-3})	4	4
Days	102	35
2002		
Campisábalos TSP (µg m^{-3})	10	5
Campisábalos PM10 (µg m^{-3})	7	5
Campisábalos PM2.5 (µg m^{-3})	5	4
Days	179	19
2001		
Campisábalos TSP (µg m^{-3})	13	6
Campisábalos PM10 (µg m^{-3})	9	6
Campisábalos PM2.5 (µg m^{-3})	6	4
Days	168	14
2000		
San Pablo de los Montes TSP*[1] (µg m^{-3})	13	9
Campisábalos TSP (µg m^{-3})	12	10
Days	161	19
1999		
San Pablo de los Montes TSP (µg m^{-3})	15	12
Campisábalos TSP (µg m^{-3})	10	14
Days	177	16
1998		
San Pablo de los Montes TSP (µg m^{-3})	18	11
Campisábalos TSP*[2] (µg m^{-3})	11	9
Days	150	20
Mean 98-03 (µg m^{-3})		
San Pablo de los Montes TSP	16	11
Campisábalos TSP	11	9
Campisábalos PM10	7	6
Campisábalos PM2.5	5	4
Impact Index(II) (µg m^{-3})		
San Pablo de los Montes TSP	6.6	0.6
Campisábalos TSP	4.8	0.5
Campisábalos PM10	3.1	0.3
Campisábalos PM2.5	2.2	0.2

*[1]Calculated with data of 50% of the months of the year
*[2]Calculated with data of 83% of the months of the year

During Atlantic events, highest monthly PM means at Campisábalos were recorded in summer when PM levels are high owing to processes such as resuspension of soil material, formation of secondary aerosols by photochemistry and low rainfall. These processes exert an important influence in the local/regional contribution. Concerning transport scenarios monthly PM means during AD episodes are generally lower owing to the higher frequency of rainfall associated with this scenario. Thus, the highest monthly PM means were recorded under AZH-NAtD situations in summer (14-23 µgTSP m^{-3}, 9-13 µgPM10 m^{-3} and 6-9 µgPM2.5 m^{-3} from June to September with respect to 6-12 µgTSP m^{-3}, 4-9 µgPM10 m^{-3} and 3-6 µgPM2.5 m^{-3} in the rest of the months, Table Ap.72).

Table Ap.72. Number of days per month with Atlantic advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (µg m^{-3}) recorded at Campisábalos rural site (C Spain) for those days.

	AZH-NAtD	AD		AZH-NAtD	AD
January			**July**		
Days per month	17.7	1.0	Days per month	13.0	0.7
TSP	6	4	TSP	19	18
PM10	4	4	PM10	11	
PM2.5	3	3	PM2.5	7	
February			**August**		
Days per month	12.7	1.3	Days per month	10.5	0.5
TSP	9		TSP	23	
PM10	7	4	PM10	13	10
PM2.5	4	3	PM2.5	9	6
March			**September**		
Days per month	11.7	2.5	Days per month	10.3	2.5
TSP	8	11	TSP	14	8
PM10	5	4	PM10	9	7
PM2.5	4	4	PM2.5	6	4
April			**October**		
Days per month	15.7	4.3	Days per month	12.8	2.3
TSP	10	7	TSP	11	6
PM10	9	5	PM10	6	5
PM2.5	6	3	PM2.5	5	4
May			**November**		
Days per month	11.7	1.3	Days per month	20.0	1.0
TSP	12	24	TSP	7	
PM10	7	7	PM10	5	15
PM2.5	5	4	PM2.5	4	7
June			**December**		
Days per month	8.0		Days per month	12.3	2.8
TSP	20		TSP	6	4
PM10	11		PM10	5	5
PM2.5	7		PM2.5	4	3

4.2. African episodes

110 episodes (18 per year and 2 per month, Table Ap.73) of air mass transport from Northern Africa occurred over Central Iberian Peninsula in 1998-2003. These episodes had a mean duration of 3 days and resulted in 311 days (52 per year and 4 per month, Table Ap.73).

13% of these 110 episodes (14 in total and 2 per year, Table Ap.73) occurred driven by a NAH-S transport scenario (characterised by the presence of an anticyclone over Northern Africa and the Iberian Peninsula at surface atmospheric levels). 15% of the 311 days with African advection (47 in 1998-2003, 8 per year and 2 per month, Table Ap.73) were detected. These episodes had a mean duration of 3 days.

In 35% of the African episodes (38 in the whole study period, 6 per year and 1 per month, Table Ap.73) and in 23% of the days with African advection (73 in total, 12 per year and 1 per month, Table Ap.73) the synoptic scenario responsible of the transport was AD (which corresponded with the presence or development of an Atlantic depression by the Portuguese coast). AD events had a mean duration of 2 days in Central Iberia.

NAD situations (associated with the development of depressions over Northern Africa) occurred in 15% of the 110 episodes (16 in 1998-2003 and 3 per year, Table Ap.73) and, also, in 15% of the 311 days with African advection (47 in 1998-2003, 8 per year and 2 per month, Table Ap.73). The mean duration of NAD episodes was of 3 days.

NAH-A scenario (characterised by the presence of an anticyclone over Northern Africa and the Iberian Peninsula at upper atmospheric levels) was observed in 38% of the African episodes (42 in total, 7 per year and 1 per month, Table Ap.73) and in 46% of the days in which African air masses reached Central Spain (144 in 1998-2003, 24 per year and 2 per month, Table Ap.73). These episodes had a mean duration of 4 days.

As shown in Table Ap.73, the maximum number of African episodes in a year was reached in 2003 (22 episodes) and the minimum was registered in 1999 (12 episodes). With respect to the different transport scenarios, the highest amount of episodes was observed in: 2002 for NAH-S (5 episodes), 2003 for AD (9 episodes), 2001 for NAD (5 episodes) and both 2002 and 2003 for NAH-A (8 episodes). The lowest number of episodes was registered in: 1999 and 2001 for NAH-S (1 episode in each year), 1999 for AD (2 episodes), both 2000 and 2002 for NAD (1 episode in each year) and 1999 for NAH-A (5 episodes).

Table Ap.73 also shows the total number of days with African advection observed over Central Iberia for all the years of the study period. The range of the annual occurrence of days with African advection associated with the different scenarios was: 2 (in both 1999 and 2003) to 14 days (in both 1998 and 2002) for NAH-S; 4 (in 1999) to 17 days (in 2003) for AD; 4 (in 1998) to 15 days (in 2001) for NAD; 13 (in 1998) to 40 days (in 2003) for NAH-A.

Table Ap.73. Annual number of days and episodes with African advection in the period 1998-2003 over Central Iberian Peninsula. The NAH-S, AD, NAD and NAH-A scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total NAF	48	29	47	57	61	69	52	4
NAH-S	14	2	12	3	14	2	8	1
AD	11	4	15	15	11	17	12	1
NAD	4	10	5	15	3	10	8	1
NAH-A	19	13	15	24	33	40	24	2
Episodes								
Total NAF	18	12	18	19	20	22	18	2
NAH-S	3	1	2	1	5	2	2	<1
AD	6	2	8	6	6	9	6	1
NAD	2	4	1	5	1	3	3	<1
NAH-A	7	5	7	7	8	8	7	1

Four periods of higher frequency in the monthly distribution of African episodes may be differentiated in Figure Ap.65: May-August (15 episodes in July) and February-March (14 episodes in March) as first order peaks and October (8 events) and December (10 events) as second order peaks. Minima of occurrence were observed in April, September and November (with less than 4 episodes in all of those months). NAH-S episodes occurred only from January-March (5 episodes in February) and in September (only 1 event in 1998-2003). Summer was practically devoid of AD and

NAD episodes. December (10 episodes), March (8 episodes) and May (5 episodes) were the months with the highest frequency of occurrence of AD episodes and May (5 episodes) registered the highest number of NAD episodes. In the rest of the months the number of NAD events was less than 2 in the whole study period. NAH-A episodes were confined from late spring to early autumn but, more precisely, from June to August a high frequency of occurrence of these events was observed (up to 15 episodes in July).

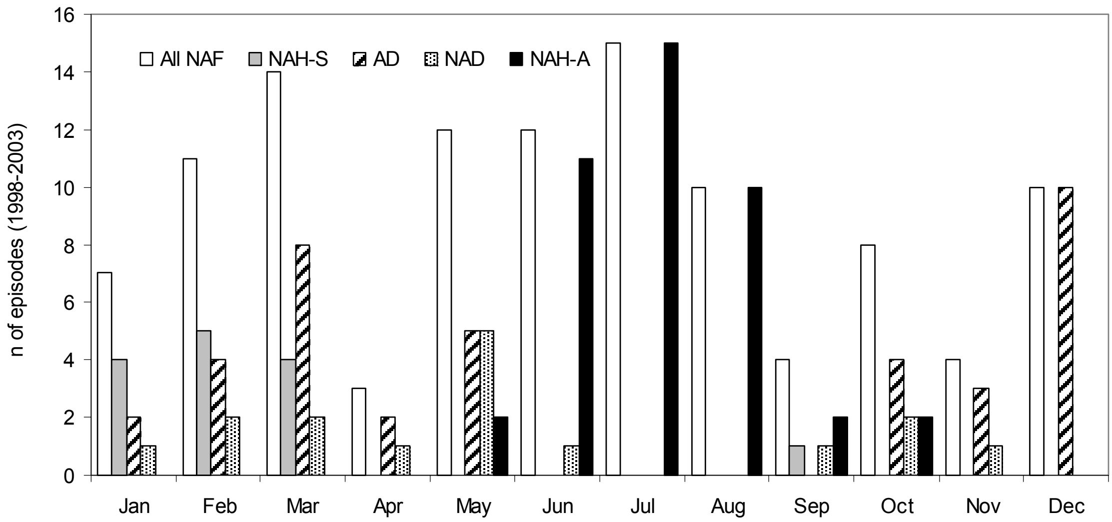

Figure Ap.65. Monthly distribution of the number of African episodes over Central Iberian Peninsula. The monthly distributions of NAH-S, AD, NAD and NAH-A African events are also shown.

The seasonal distribution of days with African advection over Central Iberian Peninsula evidenced three frequency peaks (Figures Ap.66 and Ap.67). Two first order peaks in May-August (9 days as a mean in June) and January-March (7 days as a mean in March) and a second order peak in October (4 days on average). Days with African advection occurred under NAH-S scenario were, practically, all registered from January to March (3 days as a mean in both February and March). As mentioned above, AD and NAD episodes did not occur during summer. The periods of maximum occurrence of days with African advection associated with AD situations were February-March (3 days as a mean in March) and December (3 days as a mean). Concerning the NAD scenario a frequency peak period was registered in May (2 days as a mean). The abundance of NAH-A episodes in June-August resulted in the highest frequency of occurrence of days in those months (8 days as a mean in June).

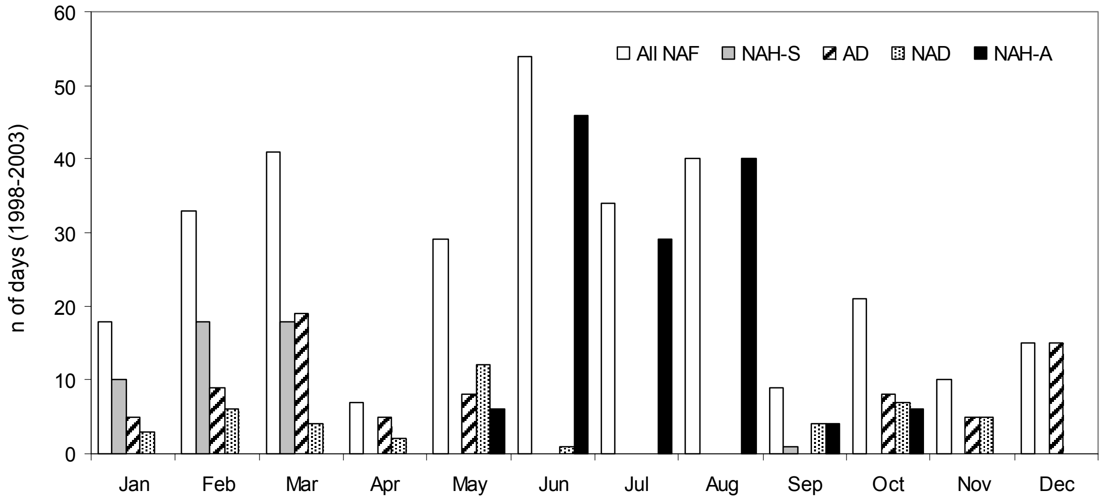

Figure Ap.66. Monthly distribution of the number of days with African advection over Central Iberian Peninsula. The monthly distributions of days with African advection occurred under NAH-S, AD, NAD and NAH-A scenarios are also shown.

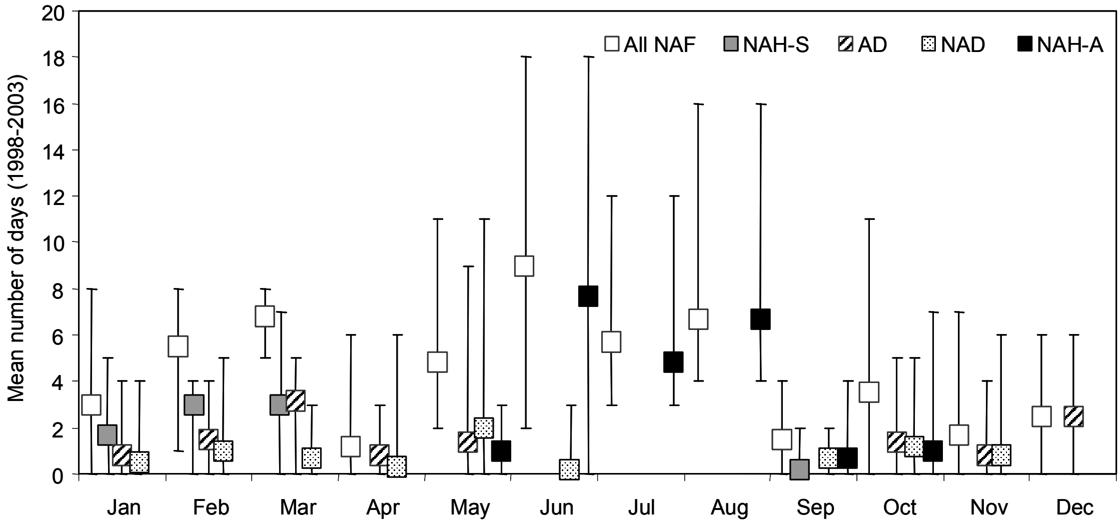

Figure Ap.67. Mean number of days with African advection over Central Iberian Peninsula per month for 1998-2003. NAH-S, AD, NAD and NAH-A episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

Figure Ap.68 shows that the mean duration of African episodes was higher in June (5 days) and August (4 days) compared with the rest of the months (2-3 days as mean duration in all the months). NAH-S lasted, on average, up to 5 days in March. The mean duration of AD episodes ranged from 2 to 3 days in all the months. NAD lasted more, on average, in September-November (4-5 days) than in the rest of the months (2-3 days with the exception of June with a mean duration of 1 day). Finally, summer episodes (NAH-A) were the longest African episodes on average. The mean duration of these episodes reached 6 days in June.

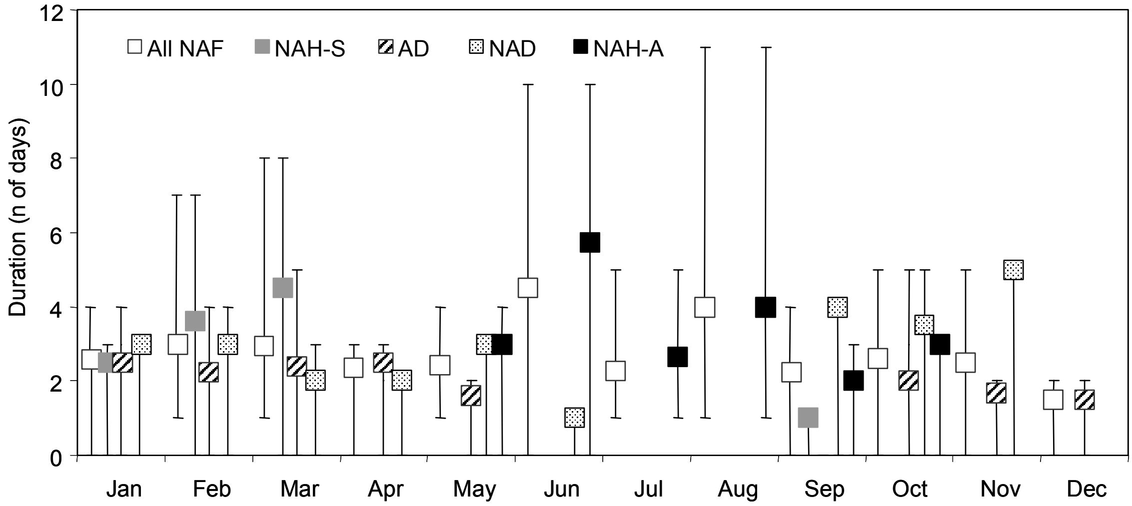

Figure Ap.68. Mean duration of African episodes per month over Central Iberian Peninsula for 1998-2003. NAH-S, AD, NAD and NAH-A episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

The mean PM annual means registered at regional background stations in Central Iberia only for the days with African advection were very high compared with the annual PM means in 1998-2003 (22 µgTSP m^{-3} in San Pablo de los Montes, 22 µgTSP m^{-3}, 14 µgPM10 m^{-3} and 7 µgPM2.5 m^{-3} in Risco Llano, 18 µgTSP m^{-3}, 12 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3} in Campisábalos and 18 µgTSP m^{-3}, 13 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3} in Peñausende). TSP mean levels during African dust outbreaks reached 45, 41, 40 and 29 µg m^{-3} at San Pablo de los Montes, Risco Llano, Campisábalos and Peñausende respectively. In 1998 mean TSP levels at EMEP stations were considerably high owing to an African dust episode occurred from 30/8 to 2/9 during which daily means of TSP reached 342 and 324 µg m^{-3} at San Pablo de los Montes and Campisábalos respectively. During African events, mean PM10 levels were 25, 23 and 22 µg m^{-3} at Risco Llano, Campisábalos and Peñausende respectively while mean PM2.5 levels were 12 µg m^{-3} at these three stations (Table Ap.74).

Table Ap.74. Mean annual levels of TSP, PM10 and PM2.5 registered in San Pablo de los Montes, Risco Llano, Campisábalos and Peñausende during African advection episodes in 1998-2003.

NAF EPISODES (µg m^{-3})	San Pablo de los Montes	Risco Llano			Campisábalos			Peñausende		
	TSP	TSP	PM10	PM2.5	TSP	PM10	PM2.5	TSP	PM10	PM2.5
1998	50	na	na	na	*[2]83	na	na	na	na	na
1999	42	na	na	na	38	na	na	na	na	na
2000	*[1]38	na	na	na	33	na	na	na	na	na
2001	na	40	*[3]28	*[3]14	41	*[3]27	*[3]15	32	*[3]24	*[3]13
2002	na	45	23	11	37	21	11	29	19	11
2003	na	na	26	12	na	21	11	na	23	12
Mean 98-03	45	41	25	12	40	23	12	29	22	12

*[1]Calculated with data of 50% of the months of the year
*[2]Calculated with data of 83% of the months of the year
*[3]Calculated with data of 83% of the months of the year
na: Not available

Among the transport scenarios of African episodes NAH-A was the one which exerted the greatest impact on mean PM levels of San Pablo de los Montes and Campisábalos

(Table Ap.75). During these episodes, means of 71 µgTSP m^{-3} at San Pablo de los Montes and 56 µgTSP m^{-3}, 27 µgPM10 m^{-3} and 14 µgPM2.5 m^{-3} at Campisábalos were recorded. These PM levels were considerably higher than the mean PM levels recorded during African episodes associated with depressions (AD and NAD). These may be attributted to several factors, such as a lower frequency of washing out by precipitation, higher proportion of resuspended material and higher degree of formation of secondary aerosols from gaseous precursors derived from the strong insolation in summer, when NAH-A episodes are more frequent. Moreover, during NAH-A events, the African plumes travel at high altitudes (>1500 m.a.s.l.) and the dust penetrates in the mixing layer because the vertical development of this layer can reach up to 2500 metres over continental areas in summer (Crespi et al., 1995). Once into the boundary layer the dust is distributed and affects the sampling stations. These two contributions contribute to increase PM levels during NAH-A events. During AD episodes means of 22 µgTSP m^{-3} at San Pablo de los Montes and 21 µgTSP m^{-3}, 16 µgPM10 m^{-3} and 9 µgPM2.5 m^{-3} at Campisábalos were recorded and during NAD events the mean levels were 30 µgTSP m^{-3} at San Pablo de los Montes and 28 µgTSP m^{-3}, 21 µgPM10 m^{-3} and 9 µgPM2.5 m^{-3} at Campisábalos. Finally, NAH-S episodes mean PM levels of 41 µgTSP m^{-3} at San Pablo de los Montes and 27 µgTSP m^{-3}, 16 µgPM10 m^{-3} and 9 µgPM2.5 m^{-3} at Campisábalos. These levels were considerably high in San Pablo de los Montes but in the same order of those recorded during AD and NAD episodes in Campisábalos. Therefore, in a number of years, mean PM levels during "Atlantic arch" episodes were high at Campisábalos (1999, 2000 and 2003) and, in some other, were relatively low (2001 and 2002). On the other hand, at San Pablo de los Montes, during NAH-S mean PM levels were relatively high in all the years (Table Ap.75).

Combining information on the frequency of occurrence of African episodes and on PM levels in the impact index (II), NAH-A appeared as the scenario which exerted the highest influence on annual PM means at San Pablo de los Montes and Campisábalos. II of 4.7 µgTSP m^{-3} at San Pablo de los Montes and 3.7 µgTSP m^{-3}, 1.7 µgPM10 m^{-3} and 0.9 µgPM2.5 m^{-3} at Campisábalos were recorded for typical summer African episodes. The other three types of events exerted a lower impact on annual PM means. The following II were recorded: (a) 0.9 µgTSP m^{-3} at San Pablo de los Montes and 0.6 µgTSP m^{-3}, 0.3 µgPM10 m^{-3} and 0.2 µgPM2.5 m^{-3} at Campisábalos for NAH-S episodes; (b) 0.7 µgTSP m^{-3} at San Pablo de los Montes and 0.7 µgTSP m^{-3}, 0.5 µgPM10 m^{-3} and 0.3 µgPM2.5 m^{-3} at Campisábalos for AD episodes; (c) 0.6 µgTSP m^{-3} at San Pablo de los Montes and 0.6 µgTSP m^{-3}, 0.5 µgPM10 m^{-3} and 0.2 µgPM2.5 m^{-3} at Campisábalos for NAD events.

Table Ap.75. Number of days with African dust outbreaks occurred under the 4 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (µg m^{-3}) recorded at San Pablo de los Montes and Campisábalos rural sites (C Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	NAH-S	AD	NAD	NAH-A
2003				
Campisábalos TSP (µg m^{-3})	-	-	-	-
Campisábalos PM10 (µg m^{-3})	23	15	24	23
Campisábalos PM2.5 (µg m^{-3})	14	7	9	12
Days	2	17	10	40
2002				
Campisábalos TSP (µg m^{-3})	19	19	7	52
Campisábalos PM10 (µg m^{-3})	15	12	-	28
Campisábalos PM2.5 (µg m^{-3})	9	7	5	13
Days	14	11	3	33
2001				
Campisábalos TSP (µg m^{-3})	6	31	28	58
Campisábalos PM10 (µg m^{-3})	-	23	19	31
Campisábalos PM2.5 (µg m^{-3})	-	13	10	17
Days	3	15	15	24
2000				
San Pablo de los Montes TSP*[1] (µg m^{-3})	45	18	-	55
Campisábalos TSP (µg m^{-3})	35	18	18	49
Days	12	15	5	15
1999				
San Pablo de los Montes TSP (µg m^{-3})	66	15	37	52
Campisábalos TSP (µg m^{-3})	62	7	36	43
Days	2	4	10	13
1998				
San Pablo de los Montes TSP (µg m^{-3})	34	27	12	85
Campisábalos TSP*[2] (µg m^{-3})	-	17	-	102
Days	14	11	4	19
Mean 98-03 (µg m^{-3})				
San Pablo de los Montes TSP	41	22	30	71
Campisábalos TSP	27	21	28	56
Campisábalos PM10	16	16	21	27
Campisábalos PM2.5	9	9	9	14
Impact Index(II) (µg m^{-3})				
San Pablo de los Montes TSP	0.9	0.7	0.6	4.7
Campisábalos TSP	0.6	0.7	0.6	3.7
Campisábalos PM10	0.3	0.5	0.5	1.7
Campisábalos PM2.5	0.2	0.3	0.2	0.9

*[1]Calculated with data of 50% of the months of the year
*[2]Calculated with data of 83% of the months of the year

At Campisábalos, the highest monthly PM means only for African days were recorded during summer under NAH-A scenario (ranges of 37-90 µgTSP m^{-3}, 19-30 µgPM10 m^{-3} and 10-16 µgPM2.5 m^{-3} from May-October, Table Ap.76). High monthly PM means were registered for NAH-S in March (39 µgTSP m^{-3}, 24 µgPM10 m^{-3} and 12 µgPM2.5 m^{-3}) and in September (32 µgPM10 m^{-3} and 14 µgPM2.5 m^{-3}) and for NAD in October-November (38-32 µgTSP m^{-3}, 34-28 µgPM10 m^{-3} and 14-9 µgPM2.5 m^{-3}).

Table Ap.76. Number of days per month with Atlantic advection occurred under the 4 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (all units in µg m^{-3}) recorded at Campisábalos rural site (C Spain) for those days.

	NAH-S	AD	NAD	NAH-A		NAH-S	AD	NAD	NAH-A
January					**July**				
Days per month	1.7	0.8	0.5	0.0	Days per month	0.0	0.0	0.0	4.8
TSP	23	12			TSP				49
PM10	10				PM10				25
PM2.5	6				PM2.5				14
February					**August**				
Days per month	3.0	1.5	1.0	0.0	Days per month	0.0	0.0	0.0	6.7
TSP	16	32	20		TSP				58
PM10	12	6			PM10				26
PM2.5	8	3			PM2.5				14
March					**September**				
Days per month	3.0	3.2	0.7	0.0	Days per month	0.2	0.0	0.7	0.7
TSP	39	26			TSP				90
PM10	24	22	21		PM10	32		21	20
PM2.5	12	13	10		PM2.5	14		11	16
April					**October**				
Days per month	0.0	0.8	0.3	0.0	Days per month	0.0	1.3	1.2	1.0
TSP		5			TSP		30	38	37
PM10		5	17		PM10		19	34	
PM2.5		4	10		PM2.5		10	14	
May					**November**				
Days per month	0.0	1.3	2.0	1.0	Days per month	0.0	0.8	0.8	0.0
TSP		37	25	39	TSP		18	32	
PM10		2	10	19	PM10		13	28	
PM2.5			7	10	PM2.5		6	9	
June					**December**				
Days per month	0.0	0.0	0.2	7.7	Days per month	0.0	2.5	0.0	0.0
TSP			55	60	TSP		14		
PM10				30	PM10		16		
PM2.5				14	PM2.5		8		

4.3. European episodes

In the period 1998-2003, European air masses reached the Central Plateau of the Iberian Peninsula in 168 days (28 days per year and 2 days per month, Table Ap.77) which were grouped in 48 episodes (8 per year and 1 per month, Table Ap.77) with a mean duration of 4 days per episode.

The air mass transport scenario consisting in the presence of an anticyclone over the European continent (EUH) occurred in 114 days (68% of the days with European advection, 19 days per year and 2 days per month, Table Ap.77) during the study period. These days resulted in 32 events (67% of the European episodes, 5 per year, Table Ap.77) with a mean duration of 4 days.

On the other hand, the remaining 32% of the days (54 days in 1998-2003, 9 per year and 1 per month, Table Ap.77) with European air mass transport caused by the presence of a depression over the Mediterranean (MD scenario). These days were grouped in 16 episodes (33% of the total number of European episodes in 1998-2003, 3 events per year, Table Ap.77) whith an average duration of 3 days.

As shown in Table Ap.77, the annual number of European episodes over Central Iberia ranged from 21 in 2000 to 33 in 1998, while the annual number of European days ranged from 6 in 1999 to 10 in 1998. The number of EUH episodes recorded over the study area ranged from 4 in 1999 to 7 in 1998 and, with respect to the number of days with EUH scenario, the range went from 13 in 1999 and 2002 to 24 in 1998 and 2003. Finally, the annual occurrence of MD episodes ranged from 1 in 2000 to 4 in 2002 while the annual occurrence of days with MD scenario ranged from 2 in 2000 to 13 in 2002.

Table Ap.77. Annual number of days and episodes with European advection in the period 1998-2003 over Central Iberian Peninsula. The EUH and MD scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total EU	33	24	21	32	26	32	28	2
EUH	24	13	19	21	13	24	19	2
MD	9	11	2	11	13	8	9	1
Episodes								
Total EU	10	6	7	9	8	8	8	1
EUH	7	4	6	5	5	5	5	<1
MD	3	2	1	4	3	3	3	<1

European episodes over Central Iberian Peninsula were clearly more frequent during winter than during summer. January (7 episodes in 1998-2003) and July (devoid events in 1998-2003) were the months with the highest and the lowest frequency of occurrence of European episodes (Figure Ap.69). EUH episodes were especially frequent from January to March (6 episodes accumulated in February during the study period, Figure Ap.69) and peaks of frequency of MD events were registered in autumn (in 1998-2003, 3 episodes were recorded in October, November and December, Figure Ap.69) and in spring (3 episodes in April during the study period, Figure Ap.69).

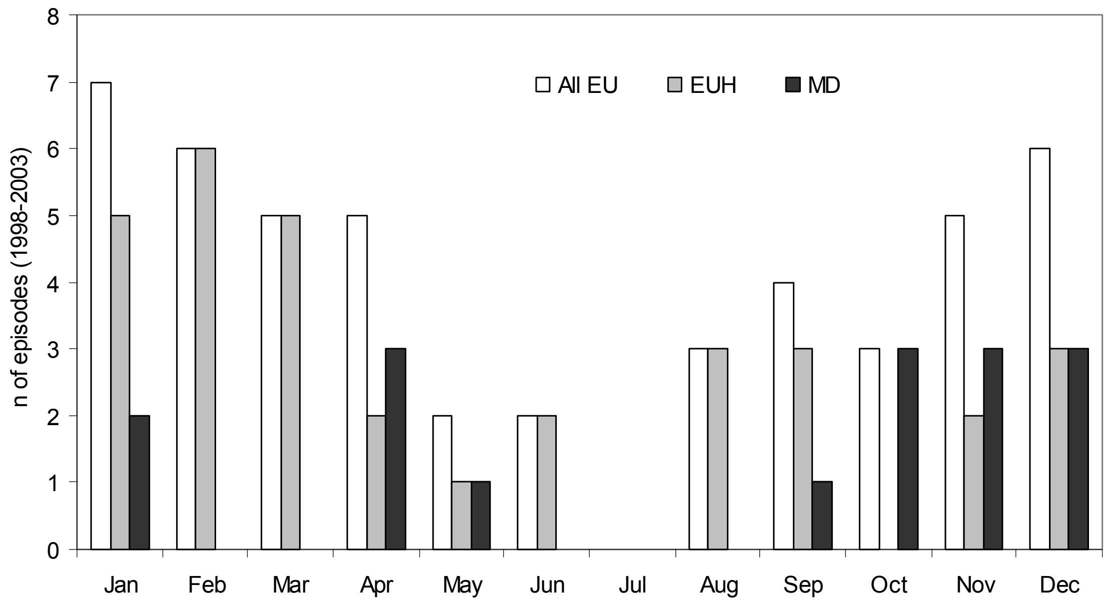

Figure Ap.69. Monthly distribution of the number of European episodes over Central Iberian Peninsula. The monthly distribution of EUH and MD European events is also shown.

As shown in Figures Ap.70 and Ap.71, in the seasonal distribution of the number of days with advection from the European continent two frequency peaks were registered. From November to March monthly means of 4 days were recorded in all the months. A secondary peak of frequency occurred in September with a mean of 3 days. Days with

EUH transport type were particularly frequent in winter (monthly means of 3 days in both February and March) and days associated with MD transport scenario registered frequency peaks in November-December (3 days as mean in November) and in April (2 days on average).

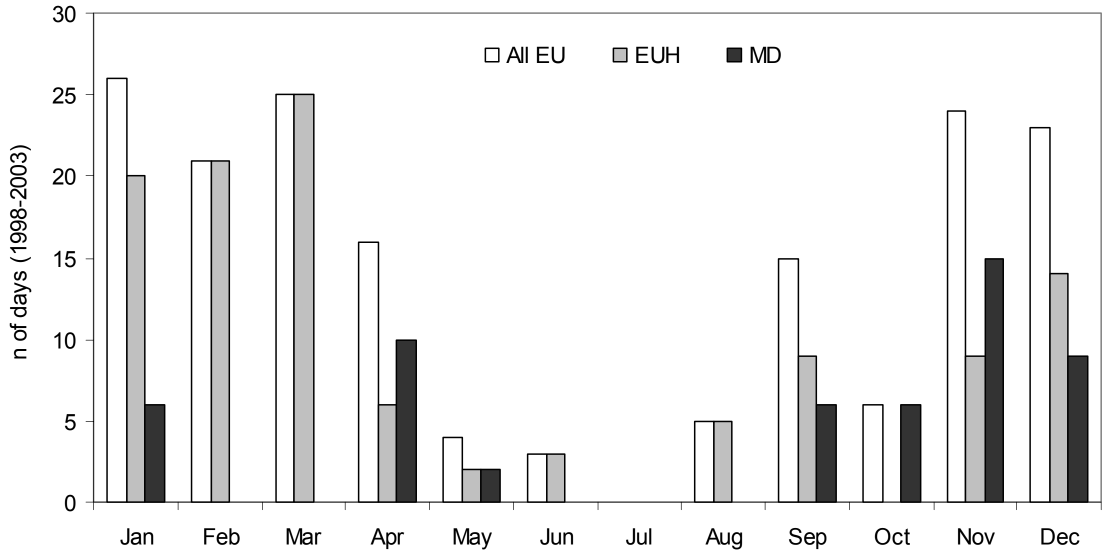

Figure Ap.70. Monthly distribution of the number of days with European advection over Central Iberian Peninsula. The monthly distributions of days with European advection occurred under EUH and MD scenarios are also shown.

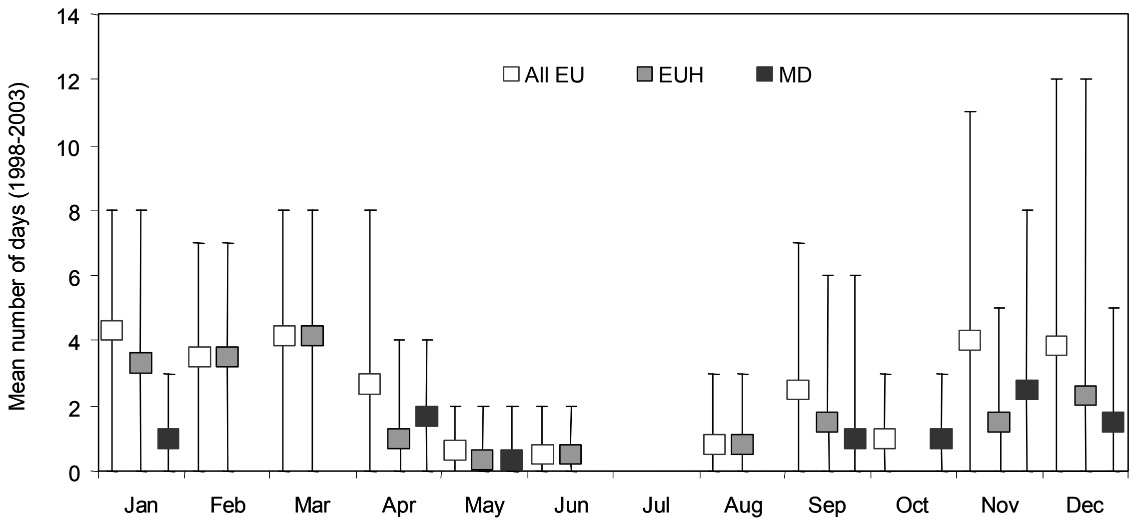

Figure Ap.71. Mean number of days with European advection over Central Iberian Peninsula per month for 1998-2003. EUH and MD episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

The mean duration of European episodes was long from November to March with the highest mean durations in November and March with 5 days. The duration of EUH episodes was long in November, December and March with a mean duration of 5 days and, concerning MD episodes, in September (6 days) and in November (5 days) the highest mean durations were registered (Figure Ap.72).

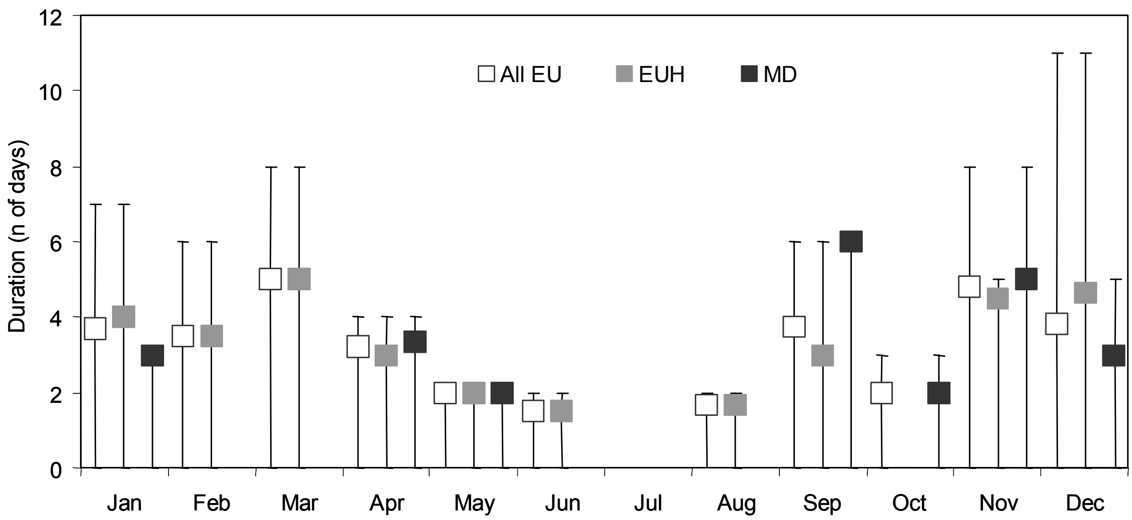

Figure Ap.72. Mean duration of European episodes per month over Central Iberian Peninsula for 1998-2003. EUH and MD episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

Over the Central plateau of the Iberian Peninsula the mean PM recorded during European episodes were, in general, slightly lower than the annual means for 1998-2003 (22 µgTSP m^{-3} in San Pablo de los Montes, 22 µgTSP m^{-3}, 14 µgPM10 m^{-3} and 7 µgPM2.5 m^{-3} in Risco Llano, 18 µgTSP m^{-3}, 12 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3} in Campisábalos and 18 µgTSP m^{-3}, 13 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3} in Peñausende). Thus, European episodes over Central Iberia did not increase PM levels significantly. This stood for San Pablo de los Montes (19 µgTSP m^{-3}, Table Ap.78), Risco Llano (19 µgTSP m^{-3}, 13 µgPM10 m^{-3} and 7 µgPM2.5 m^{-3}, Table Ap.78) and Campisábalos (13 µgTSP m^{-3}, 10 µgPM10 m^{-3} and 7 µgPM2.5 m^{-3}, Table Ap.78). By contrast, at Peñausende (20 µgTSP m^{-3}, 14 µgPM10 m^{-3} and 10 µgPM2.5 m^{-3}, Table Ap.78), PM levels were higher than the annual means in 1998-2003. A National road (N-630), 11 kms to the east of Peñausende sampling station, may be a local source of pollutants during episodes of eastern advection at this site (as European events are). The distance of the Iberian Central Plateau to the European continent is higher than in the case of the regions previously presented in this study, in consequence the PM concentration in European plumes can be reduced by processes such as gravitational settling, washing out or dilution. Moreover, these episodes are characteristics of winter time when poor dispersive conditions are common especially during episodes of development of thermal inversions over urban or industrial areas. Under these circumstances, the local or regional contributions to regional background stations are reduced resulting in low PM levels.

Table Ap.78. Mean annual levels of TSP, PM10 and PM2.5 registered in San Pablo de los Montes, Risco Llano, Campisábalos and Peñausende during European advection episodes in 1998-2003.

EU EPISODES ($\mu g\ m^{-3}$)	San Pablo de los Montes	Risco Llano			Campisábalos			Peñausende		
	TSP	TSP	PM10	PM2.5	TSP	PM10	PM2.5	TSP	PM10	PM2.5
1998	17	na	na	na	*[2]12	na	na	na	na	na
1999	16	na	na	na	9	na	na	na	na	na
2000	*[1]27	na	na	na	19	na	na	na	na	na
2001	na	16	*[3]10	*[3]6	10	*[3]8	*[3]6	20	*[3]13	*[3]9
2002	na	24	16	9	16	11	8	24	16	11
2003	na	na	12	6	na	9	7	na	14	10
Mean 98-03	19	19	13	7	13	10	7	20	14	10

*[1]Calculated with data of 50% of the months of the year
*[2]Calculated with data of 83% of the months of the year
*[3]Calculated with data of 83% of the months of the year
na: Not available

As shown in Table Ap.79, mean PM levels recorded during EUH episodes at San Pablo de los Montes (21 µgTSP m^{-3}) and Campisábalos (14 µgTSP m^{-3}, 11 µgPM10 m^{-3} and 7 µgPM2.5 m^{-3}) were superior to those recorded during MD episodes (29 µgTSP m^{-3} at San Pablo de los Montes and 29 µgTSP m^{-3}, 20 µgPM10 m^{-3} and 14 µgPM2.5 m^{-3} at Campisábalos). Rains, often associated with MD events, could explain the reduced levels recorded during this scenario.
This difference in the mean PM levels recorded under the two transport scenario and the higher frequency of occurrence of EUH situations when compared with MD situations, resulted in a higher impact of EUH events (II of 1.1 µgTSP m^{-3} at San Pablo de los Montes and II of 0.7 µgTSP m^{-3}, 0.5 µgPM10 m^{-3} and 0.4 µgPM2.5 m^{-3} at Campisábalos, Table Ap.79) when compared with MD episodes (II of 0.3 µgTSP m^{-3} at San Pablo de los Montes and II of 0.2 µgTSP m^{-3}, 0.2 µgPM10 m^{-3} and 0.1 µgPM2.5 m^{-3} at Campisábalos, Table Ap.79).

Table Ap.79. Number of days with European advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (µg m^{-3}) recorded at San Pablo de los Montes and Campisábalos rural sites (C Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	EUH	MD
2003		
Campisábalos TSP (µg m^{-3})	-	-
Campisábalos PM10 (µg m^{-3})	10	7
Campisábalos PM2.5 (µg m^{-3})	7	5
Days	24	8
2002		
Campisábalos TSP (µg m^{-3})	20	11
Campisábalos PM10 (µg m^{-3})	14	9
Campisábalos PM2.5 (µg m^{-3})	9	7
Days	13	13
2001		
Campisábalos TSP (µg m^{-3})	11	8
Campisábalos PM10 (µg m^{-3})	9	6
Campisábalos PM2.5 (µg m^{-3})	7	5
Days	21	11
2000		
San Pablo de los Montes TSP*[1] (µg m^{-3})	27	-
Campisábalos TSP (µg m^{-3})	18	22
Days	19	2
1999		
San Pablo de los Montes TSP (µg m^{-3})	20	12
Campisábalos TSP (µg m^{-3})	10	6
Days	13	11
1998		
San Pablo de los Montes TSP (µg m^{-3})	17	15
Campisábalos TSP*[2] (µg m^{-3})	15	8
Days	24	9
Mean 98-03 (µg m^{-3})		
San Pablo de los Montes TSP	21	13
Campisábalos TSP	14	9
Campisábalos PM10	11	8
Campisábalos PM2.5	7	6
Impact Index(II) (µg m^{-3})		
San Pablo de los Montes TSP	1.1	0.3
Campisábalos TSP	0.7	0.2
Campisábalos PM10	0.5	0.2
Campisábalos PM2.5	0.4	0.1

*[1]Calculated with data of 50% of the months of the year
*[2]Calculated with data of 83% of the months of the year

Monthly PM means for the European episodes were higher in spring and under the EUH scenario (Table Ap.80). From March to May monthly TSP means ranged from 22 to 25 µg m^{-3} but also in October under MD scenarios (22 µg m^{-3}). In March and April (14 and 16 µgPM10 m^{-3} as monthly means, respectively) high levels were recorded during EUH epìsodes. Also under EUH scenario the highest PM2.5 monthly means were recorded in March-April and August (10 or 9 µgPM2.5 m^{-3}).

Table Ap.80. Number of days per month with European advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (all units in µg m^{-3}) recorded at Campisábalos rural site (C Spain) for those days.

	EUH	MD		EUH	MD
January			**July**		
Days per month	3.3	1.0	Days per month	0.0	0.0
TSP	7	5	TSP		
PM10	7	5	PM10		
PM2.5	6	5	PM2.5		
February			**August**		
Days per month	3.5	0.0	Days per month	0.8	0.0
TSP	9		TSP	19	
PM10	8		PM10	13	
PM2.5	7		PM2.5	9	
March			**September**		
Days per month	4.2	0.0	Days per month	1.5	1.0
TSP	25		TSP	15	13
PM10	14		PM10	12	10
PM2.5	9		PM2.5	8	8
April			**October**		
Days per month	1.0	1.7	Days per month	0.0	1.0
TSP	22	15	TSP		22
PM10	16	10	PM10		5
PM2.5	10	8	PM2.5		
May			**November**		
Days per month	0.3	0.3	Days per month	1.5	2.5
TSP	24	6	TSP	9	6
PM10		6	PM10	7	6
PM2.5		5	PM2.5	5	4
June			**December**		
Days per month	0.5	0.0	Days per month	2.3	1.5
TSP	16		TSP	11	7
PM10			PM10	9	3
PM2.5			PM2.5	7	3

4.4. Mediterranean episodes

The transport of Mediterranean air masses over Central Iberian Peninsula occurred in 124 days (21 per year and 2 per month, Table Ap.81) in 1998-2003. These days were grouped in 54 episodes (9 per year and 1 per month, Table Ap.81) with a mean duration of 2 days per event.

From the 54 episodes a proportion of 22% (12 in 1998-2003, 2 per year, Table Ap.81) occurred under a meteorological situation characterised by the presence of a depression over Northern Africa or over the Mediterranean (NAD-MD scenario). These episodes resulted in 20 days (16 % of the days with Mediterranean advection, 2 per year, Table Ap.81). NAD-MD episodes had a mean duration of 2 days.

The rest of the episodes, 78% (42 in 1998-2003, 7 per year, 1 per month, Table Ap.81) occurred with the presence of an anticyclone over the European continent and/or the Mediterranean Sea (EUH-MH scenario). These episodes had a mean duration of 2 days and resulted in the 84% of the days (104 days from 1998 to 2003, 17 per year, 1 per month, Table Ap.81) with Mediterranean advection over Central Iberia during the study period.

The annual number of days with Mediterranean advection ranged from 8 in 2003 to 30 in 1999. These two years registered the minimum and maximum number of days with EUH-MH situations (5 in 2003 and 25 in 1999). The number of days with Mediterranean advection associated with NAD-MD scenario reached 7 (in 2002) while 2000 was devoid of them (Table Ap.81).

With respect to Mediterranean episodes, the highest annual number was 12 (in both 1999 and 2000) while the lowest was 6 (in both 2001 and 2003). The number of EUH-MH episodes reached 9 in three consecutive years (1998 to 2000) while only 4 were registered in 2003. As stated above in 2001 no NAD-MD episode occurred while the highest number of these episodes occurred in 1999 and 2000 with 3 events in each year (Table Ap.81).

Table Ap.81. Annual number of days and episodes with Mediterranean advection in the period 1998-2003 over Central Iberian Peninsula. The NAD-MD and EUH-MH scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total MED	22	30	26	17	21	8	21	2
NAD-MD	2	5	3	0	7	3	3	<1
EUH-MH	20	25	23	17	14	5	17	1
Episodes								
Total MED	11	12	12	6	7	6	9	1
NAD-MD	2	3	3	0	2	2	2	<1
EUH-MH	9	9	9	6	5	4	7	1

In 1998-2003 Mediterranean events were found to be especially frequent in March (10 episodes in 1998-2003) and in January (7 episodes in 1998-2003). Other frequency peaks were registered in June, July, October and November (5 episodes in 1998-2003 in each month). NAD-MD episodes occurred mainly in March-May (9 out of the 12 episodes occurred in 1998-2003 were registered in these three months). The seasonal distribution of the number of EUH-MH events showed four frequency peaks of 5 episodes in the months of January, March, June-July, and October (Figure Ap.73).

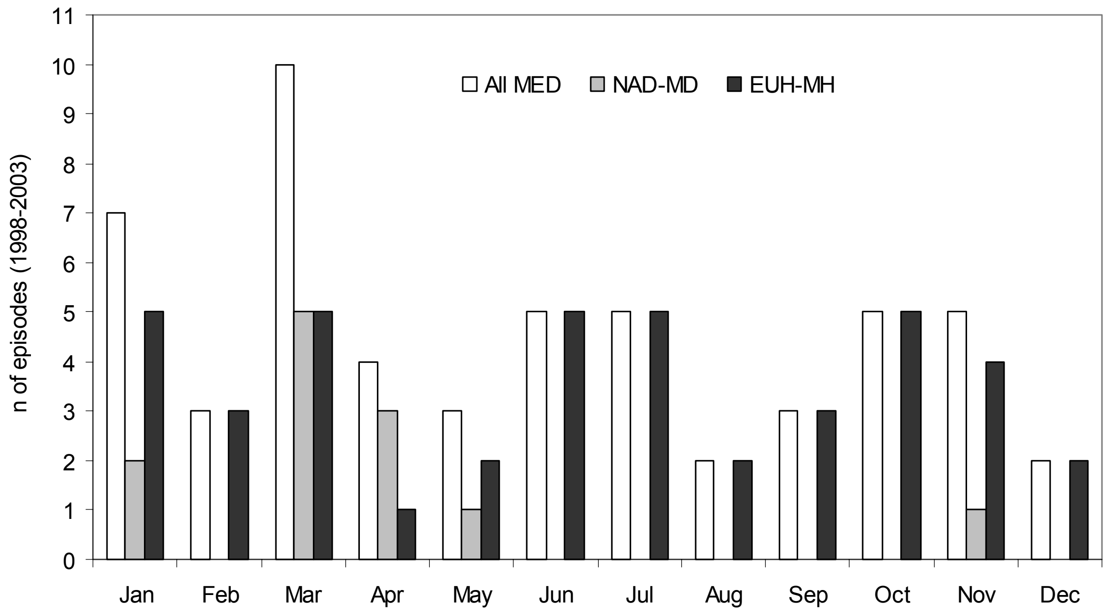

Figure Ap.73. Monthly distribution of the number of Mediterranean episodes over Central Iberian Peninsula. The monthly distributions of NAD-MD and EUH-MH Mediterranean events are also shown.

As shown in Figures Ap.74 and Ap.75, the number of days with Mediterranean advection over Central Iberian Peninsula were especially frequent in January (4 days on average), March (3 days as a mean) and November (3 days as a mean). Also in June a secondary maximum was recorded (2 days as monthly mean). Most of the days with Mediterranean advection occurred under NAD-MD situations were registered in March (2 days as a mean) and April (1 day on average). The Mediterranean days with EUH-MH scenario had peaks of frequency of occurrence in January (4 days as monthly mean), November (3 days as mean) and, a secondary peak, in June (2 days on average).

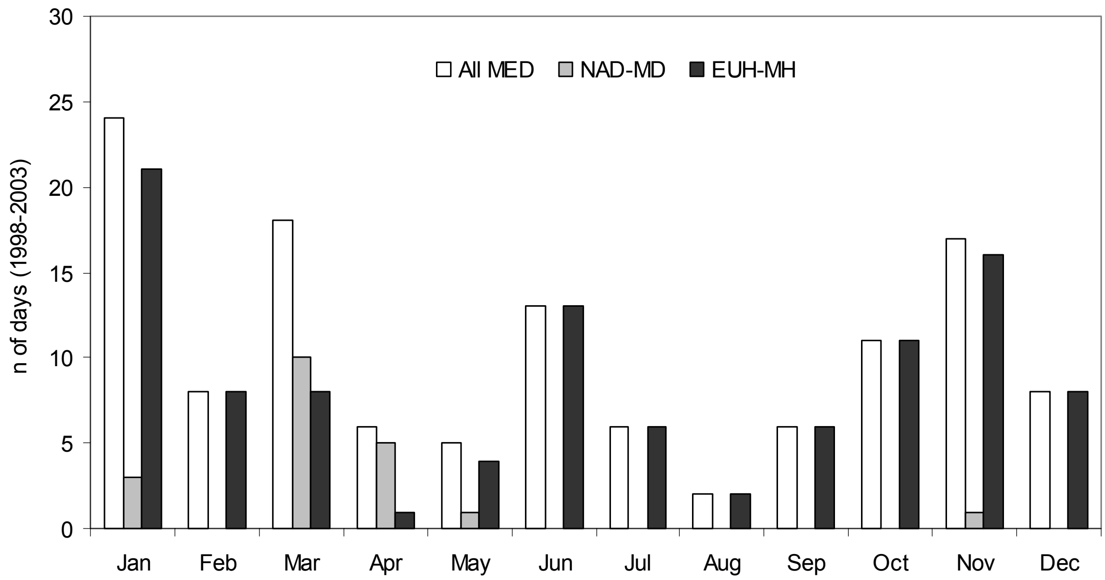

Figure Ap.74. Monthly distribution of the number of days with Mediterranean advection over Central Iberian Peninsula. The monthly distributions of days with Mediterranean advection occurred under NAD-MD and EUH-MH scenarios are also shown.

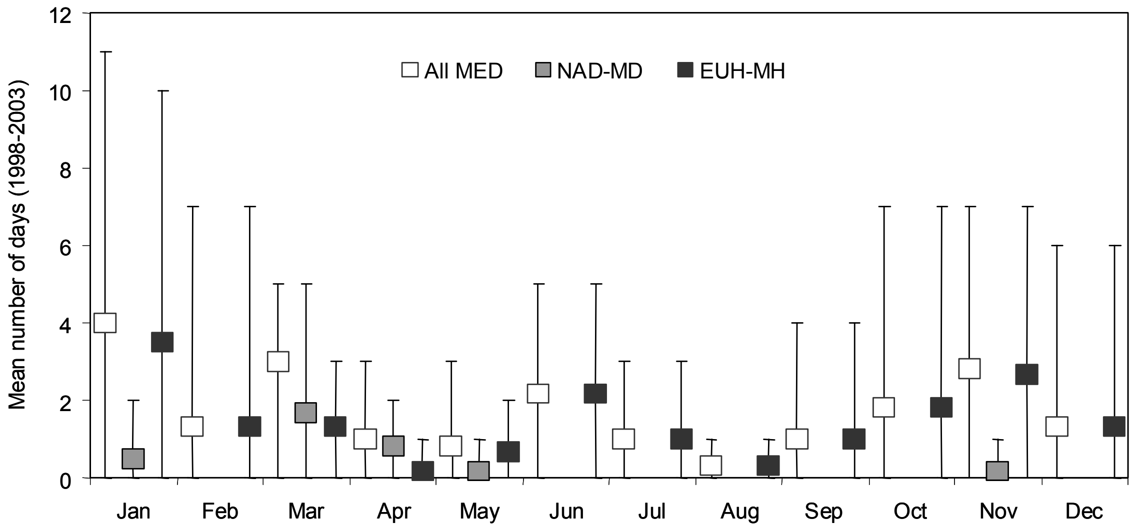

Figure Ap.75. Mean number of days with Mediterranean advection over Central Iberian Peninsula per month for 1998-2003. NAD-MD and EUH-MH episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

As shown in Figure Ap.76, Mediterranean episodes had a higher mean duration from November to February (3-4 days per episode as monthly means) than in the rest of the year (1-2 days episode as monthly means). Only in June (3 days per episode) the mean duration of Mediterranean was comparable with the mean durations registered during winter. NAD-MD episodes registered their highest mean durations in January, March and April with 2 days per episode. EUH-MH events were longer as a mean in winter (4 days per event in November, December and January) and in June (3 days per episode).

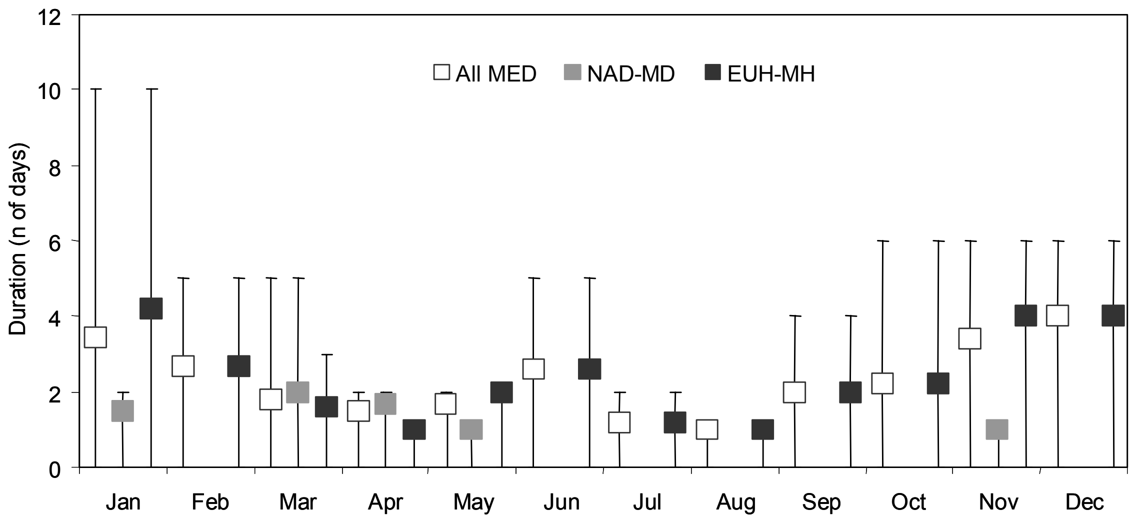

Figure Ap.76. Mean duration of Mediterranean episodes per month over Central Iberian Peninsula for 1998-2003. NAD-MD and EUH-MH episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

With respect to the annual mean levels for 1998-2003 (22 µgTSP m^{-3} in San Pablo de los Montes, 22 µgTSP m^{-3}, 14 µgPM10 m^{-3} and 7 µgPM2.5 m^{-3} in Risco Llano, 18 µgTSP m^{-3}, 12 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3} in Campisábalos and 18 µgTSP m^{-3}, 13 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3} in Peñausende), mean PM levels recorded during Mediterranean episodes at regional background stations over Central Iberia were low.

These mean levels are shown in Table Ap.82: 21 µgTSP m^{-3} at San Pablo de los Montes; 13 µgTSP m^{-3}, 10 µgPM10 m^{-3} and 6 µgPM2.5 m^{-3} at Risco Llano, 14 µgTSP m^{-3}, 9 µgPM10 m^{-3} and 7 µgPM2.5 m^{-3} at Campisábalos and 17 µgTSP m^{-3}, 13 µgPM10 m^{-3} and 9 µgPM2.5 m^{-3} at Peñausende.

Table Ap.82. Mean annual levels of TSP, PM10 and PM2.5 registered in San Pablo de los Montes, Risco Llano, Campisábalos and Peñausende during Mediterranean advection episodes in 1998-2003.

MED EPISODES ($\mu g\ m^{-3}$)	San Pablo de los Montes	Risco Llano			Campisábalos			Peñausende		
	TSP	TSP	PM10	PM2.5	TSP	PM10	PM2.5	TSP	PM10	PM2.5
1998	20	na	na	na	*[2]17	na	na	na	na	na
1999	21	na	na	na	14	na	na	na	na	na
2000	*[1]20	na	na	na	20	na	na	na	na	na
2001	na	13	*[3]8	*[3]6	11	*[3]9	*[3]7	18	*[3]15	*[3]11
2002	na	13	9	5	10	7	6	16	11	9
2003	na	na	19	11	na	13	8	na	11	7
Mean 98-03	21	13	10	6	14	9	7	17	13	9

*[1]Calculated with data of 50% of the months of the year
*[2]Calculated with data of 83% of the months of the year
*[3]Calculated with data of 83% of the months of the year
na: Not available

The mean PM levels recorded during the two transport scenarios considered in this study were similar. During NAD-MD, 17 µgTSP m^{-3} at San Pablo de los Montes and 14 µgTSP m^{-3}, 11 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3} at Campisábalos were recorded. The mean PM levels recorded during EUH-MH episodes were: 21 µgTSP m^{-3} at San Pablo de los Montes and 14 µgTSP m^{-3}, 8 µgPM10 m^{-3} and 6 µgPM2.5 m^{-3} at Campisábalos (Table Ap.83). Although rain was more frequent during NAD-MD events, mean PM10 and PM2.5 levels at Campisábalos were higher during these episodes than during EUH-MH events. This was the reflection of an EUH-MH episode in January 2002 during which very low PM levels were recorded.

Although the mean PM levels were comparable for both scenarios, the higher frequency of occurrence of EUH-MH episodes with respect to NAD-MD events resulted in a higher impact index (II) of the scenario involving an anticyclone over the European continent or the Mediterranean. II of 1.0 µgTSP m^{-3} at San Pablo de los Montes and 0.7 µgTSP m^{-3}, 0.4 µgPM10 m^{-3} and 0.3 µgPM2.5 m^{-3} at Campisábalos were obtained for EUH-MH scenario, while II of 0.2 µgTSP m^{-3} at San Pablo de los Montes and 0.1 µgTSP m^{-3}, 0.1 µgPM10 m^{-3} and 0.1 µgPM2.5 m^{-3} at Campisábalos were obtained for NAD-MD scenario (Table Ap.83). However, these II were low when compared with other transport episodes.

Table Ap.83. Number of days with Mediterranean advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 ($\mu g\ m^{-3}$) recorded at San Pablo de los Montes and Campisábalos rural sites (C Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	NAD-MD	EUH-MH
2003		
Campisábalos TSP ($\mu g\ m^{-3}$)	-	-
Campisábalos PM10 ($\mu g\ m^{-3}$)	9	14
Campisábalos PM2.5 ($\mu g\ m^{-3}$)	8	9
Days	3	5
2002		
Campisábalos TSP ($\mu g\ m^{-3}$)	14	8
Campisábalos PM10 ($\mu g\ m^{-3}$)	11	5
Campisábalos PM2.5 ($\mu g\ m^{-3}$)	9	4
Days	7	14
2001		
Campisábalos TSP ($\mu g\ m^{-3}$)	-	11
Campisábalos PM10 ($\mu g\ m^{-3}$)	-	9
Campisábalos PM2.5 ($\mu g\ m^{-3}$)	-	7
Days	0	17
2000		
San Pablo de los Montes TSP*[1] ($\mu g\ m^{-3}$)	24	20
Campisábalos TSP ($\mu g\ m^{-3}$)	23	20
Days	3	23
1999		
San Pablo de los Montes TSP ($\mu g\ m^{-3}$)	12	23
Campisábalos TSP ($\mu g\ m^{-3}$)	9	15
Days	5	25
1998		
San Pablo de los Montes TSP ($\mu g\ m^{-3}$)	19	20
Campisábalos TSP*[2] ($\mu g\ m^{-3}$)	14	18
Days	2	20
Mean 98-03 ($\mu g\ m^{-3}$)		
San Pablo de los Montes TSP	17	21
Campisábalos TSP	14	14
Campisábalos PM10	11	8
Campisábalos PM2.5	8	6
Impact Index(II) ($\mu g\ m^{-3}$)		
San Pablo de los Montes TSP	0.2	1.0
Campisábalos TSP	0.1	0.7
Campisábalos PM10	0.1	0.4
Campisábalos PM2.5	0.1	0.3

*[1]Calculated with data of 50% of the months of the year
*[2]Calculated with data of 83% of the months of the year

As shown in Table Ap.84, the highest monthly PM means during Mediterranean episodes over Central Iberian Peninsula were recorded under EUH-MH situations. The highest monthly TSP means were recorded during this scenario from May to August (a range of 21-32 μgTSP m^{-3}) influenced by local or regional contributions which are superior in summer time. With respect to PM10, only in March during EUH-MH (17 μgPM10 m^{-3}) surpassed the mean levels recorded in June and July (14 and 12 μgPM10 m^{-3}, respectively) also during EUH-MH scenario. Finally, PM2.5 monthly means for NAD-MD or EUH-MH episodes did not surpass 9 µgPM2.5 m^{-3} in any month.

Table Ap.84. Number of days per month with Mediterranean advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (all units in µg m^{-3}) recorded at Campisábalos rural site (C Spain) for those days.

	NAD-MD	EUH-MH		NAD-MD	EUH-MH
January			**July**		
Days per month	0.5	3.5	Days per month	0.0	1.0
TSP	10	5	TSP		21
PM10		4	PM10		12
PM2.5		3	PM2.5		8
February			**August**		
Days per month	0.0	1.3	Days per month	0.0	0.3
TSP		7	TSP		31
PM10			PM10		
PM2.5			PM2.5		
March			**September**		
Days per month	1.7	1.3	Days per month	0.0	1.0
TSP	17	19	TSP		16
PM10	11	17	PM10		7
PM2.5	9	9	PM2.5		4
April			**October**		
Days per month	0.8	0.2	Days per month	0.0	1.8
TSP	12	16	TSP		14
PM10	12	10	PM10		11
PM2.5	10	8	PM2.5		8
May			**November**		
Days per month	0.2	0.7	Days per month	0.2	2.7
TSP	14	31	TSP		11
PM10			PM10	2	10
PM2.5			PM2.5	2	7
June			**December**		
Days per month	0.0	2.2	Days per month	0.0	1.3
TSP		32	TSP		9
PM10		14	PM10		8
PM2.5		9	PM2.5		6

4.5. Episodes without dominant advective conditions

A total of 153 episodes (26 per year, 2 per month, Table Ap.85) without prevalent advective conditions occurred in 1998-2003 over Central Iberia. These events had a mean duration of 3 days. These episodes resulted in 528 days (88 per year, 8 per month, Table Ap.85).

Approximately, half of the days (263 days in 1998-2003, 44 per year, 4 per month, Table Ap.85) and the episodes (75 episodes in 1998-2003, 13 per year, 1 per month, Table Ap.85) without prevalent advective conditions occurred accompanied with a meteorological situation characterised by an anticyclone covering completely or partly the Iberian Peninsula out of summer (WIA).

The other 50% of the days (265 days in 1998-2003, 44 per year, 4 per month, Table Ap.85) and episodes (78 episodes in 1998-2003, 13 per year, 1 per month, Table Ap.85) occurred in summer when the development of the Iberian thermal low over the Iberian plateau, caused by the great heating of the surface, occurred (ITL scenario).

As shown in Table Ap.85, the annual number of days without dominant advective conditions over Central Iberia ranged from 77 (in 2001) and 119 (in 2003). The annual number of days with WIA situations ranged from 23 (in 2002) and 69 (in 2003) and the annual number of ITL events ranged from 36 (in 2002) and 52 (in both 1999 and 2000).

With respect to the annual number of events without prevalent advective conditions, as shown in Table Ap.85, the maximum amount was registered in 1998 (31) and the minimum in 2002 (21). The maximum annual number of WIA episodes was recorded in 2003 (18) and the minimum in 2002 (8). Concerning ITL episodes, the maximum annual number was registered in 2000 (17) and the minimum in 1999 (10).

Table Ap.85. Annual number of days and episodes with lack of advective conditions in the period 1998-2003 over Central Iberian Peninsula. The WIA and ITL scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total NOADV	92	89	92	77	59	119	88	7
WIA	54	37	40	40	23	69	44	4
ITL	38	52	52	37	36	50	44	4
Episodes								
Total NOADV	31	22	27	22	21	30	26	2
WIA	17	12	10	10	8	18	13	1
ITL	14	10	17	12	13	12	13	1

The seasonal variability of the number of episodes without prevalent advective conditions (Figure Ap.77) was characterised by a main maximum from late spring to early autumn (maximum in July with 25 episodes in 1998-2003) and two secondary maxima in December (11 episodes in 1998-2003) and in February (8 episodes from 1998-2003). The 25 episodes of July were of the ITL type. ITL episodes only occurred in summer. WIA episodes were scarce from June to September. The frequency of occurrence maxima of these events were registered in April-May (12 and 14 episodes in 1998-2003, respectively), October (13 episodes in 1998-2003) and two secondary peaks in December (11 episodes in 1998-2003) and February (8 episodes in 1998-2003).

As shown in Figures Ap.78 and Ap.79, the highest number of days without prevalent advective conditions was registered also in summer (9 to 13 days as monthly mean from May to October) with two other secondary maxima in December (7 days on average) and February (4 days as monthly mean). The days without prevalent advective conditions occurred under ITL meteorological situations were frequent in summer (10-12 days on average from June to September). WIA days were frequent in May (10 days on average), October (8 days as a mean) and December (7 days as monthly mean).

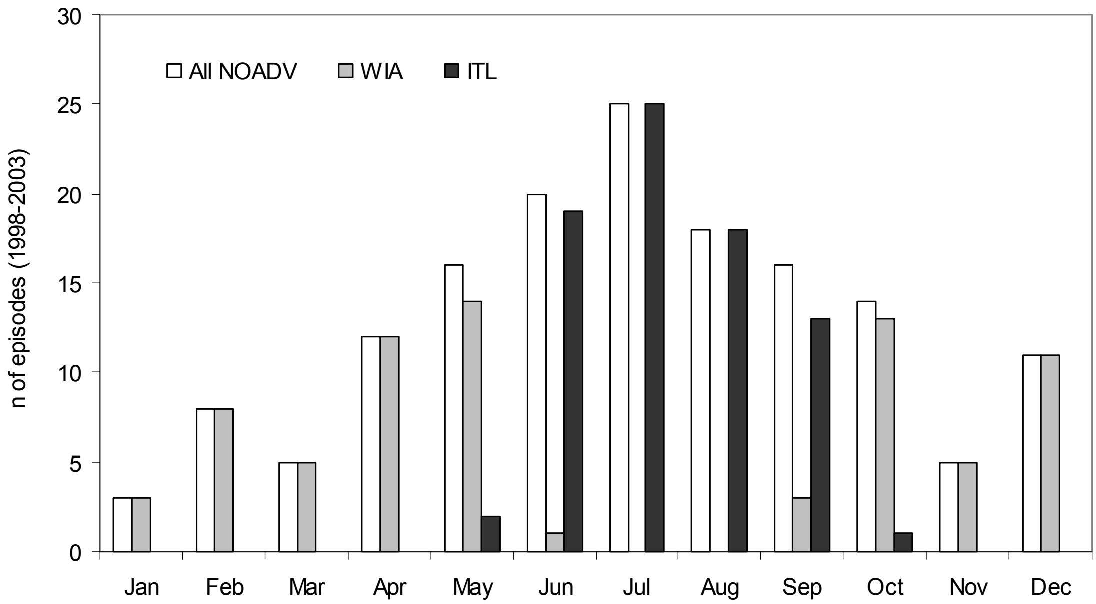

Figure Ap.77. Monthly distribution of the number of episodes without dominant advective conditions over Central Iberian Peninsula. The monthly distributions of WIA and ITL events are also shown.

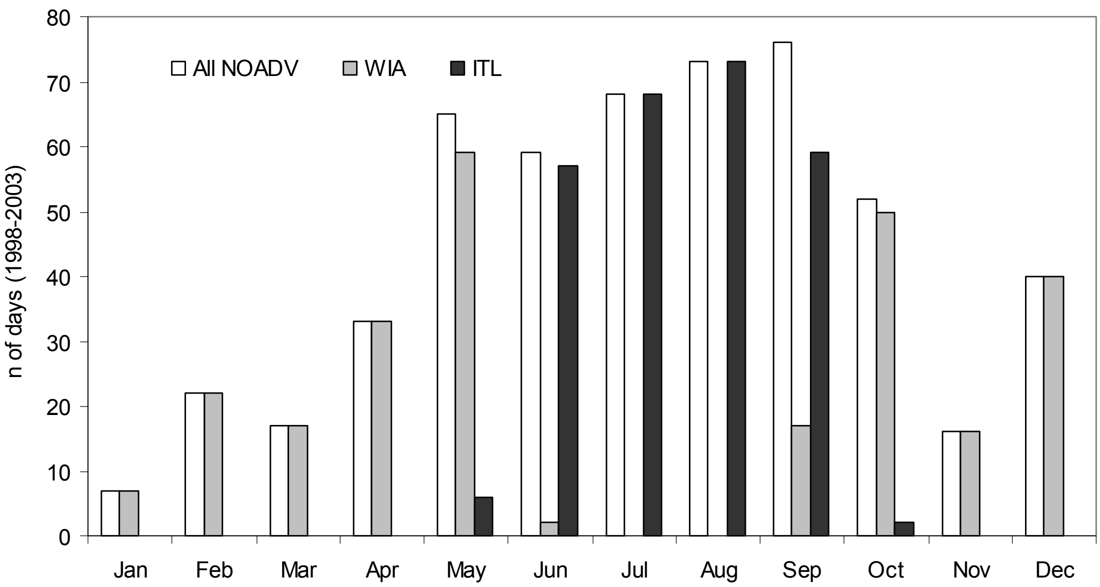

Figure Ap.78. Monthly distribution of the number of days with lack of advective conditions over Central Iberian Peninsula. The monthly distributions of days with lack of advective conditions occurred under WIA and ITL scenarios are also shown.

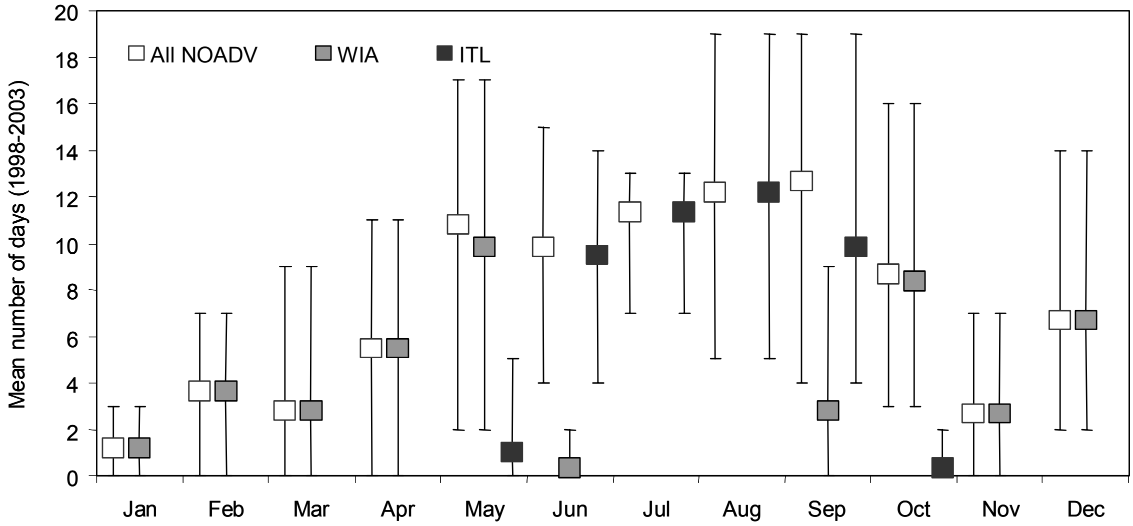

Figure Ap.79. Mean number of days without a dominant air mass advection over Central Iberian Peninsula per month for 1998-2003. WIA and ITL episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

The longest episodes without dominant advective conditions were registered in May, August-October and December. In these 5 months the mean duration of such events was 4 or 5 days (only in September). With respect to WIA episodes, the longest mean durations were recorded in September (6 days per episode) and in May, October and December when these episodes had a mean duration of 4 days. August (4 days on average) and September (5 days as a mean) were the months in which ITL episodes had the longest duration (Figure Ap.80). Sporadically WIA and ITL episodes reached high durations, such as in May 2001 when a WIA event lasted for 14 days. The same duration for an ITL event was registered in August 2003 and September 1999.

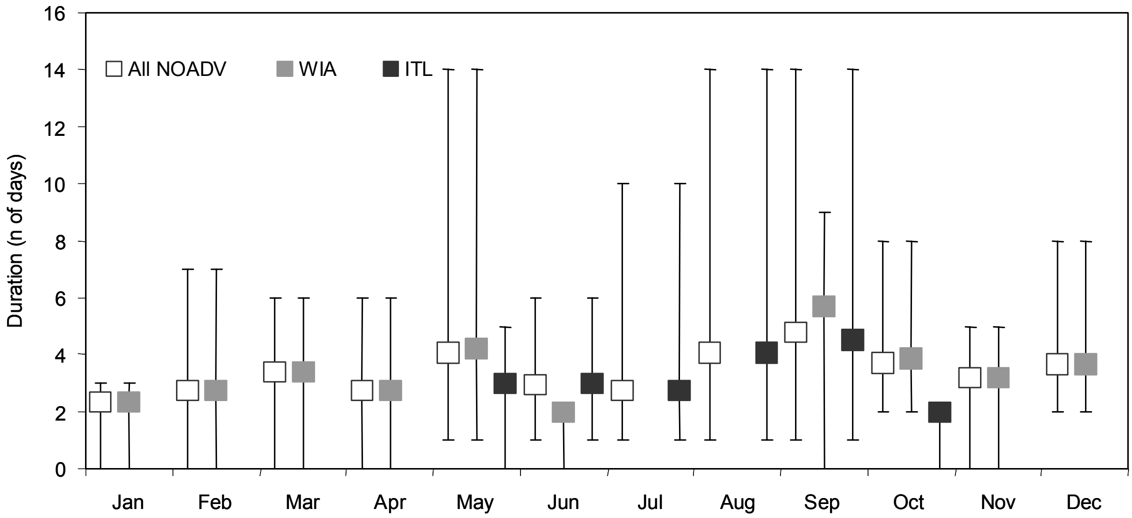

Figure Ap.80. Mean duration of episodes without a dominant air mass advection per month over Central Iberian Peninsula for 1998-2003. WIA and ITL episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

Compared with the annual mean PM levels recorded at regional background stations over Central Iberia during 1998-2003 (22 µgTSP m^{-3} in San Pablo de los Montes, 22 µgTSP m^{-3}, 14 µgPM10 m^{-3} and 7 µgPM2.5 m^{-3} in Risco Llano, 18 µgTSP m^{-3}, 12 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3} in Campisábalos and 18 µgTSP m^{-3}, 13 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3} in Peñausende), the mean PM levels during episodes without prevalent advective conditions were moderately high. During these episodes, mean levels of 26 µgTSP m^{-3} in San Pablo de los Montes; 25 µgTSP m^{-3}, 16 µgPM10 m^{-3} and 9 µgPM2.5 m^{-3} in Risco llano; 26 µgTSP m^{-3}, 15 µgPM10 m^{-3} and 10 µgPM2.5 m^{-3} in Campisábalos and 25 µgTSP m^{-3}, 15 µgPM10 m^{-3} and 11 µgPM2.5 m^{-3} in Peñausende were registered (Table Ap.86). During these episodes, precipitation is reduced so the scavenging potential of the atmosphere is reduced.

Table Ap.86. Mean annual levels of TSP, PM10 and PM2.5 registered in San Pablo de los Montes, Risco Llano, Campisábalos and Peñausende during episodes without dominant air mass advection in 1998-2003.

NOADV EPISODES (µg m^{-3})	**San Pablo de los Montes**	**Risco Llano**			**Campisábalos**			**Peñausende**		
	TSP	TSP	PM10	PM2.5	TSP	PM10	PM2.5	TSP	PM10	PM2.5
1998	27	na	na	na	*[2]20	na	na	na	na	na
1999	26	na	na	na	20	na	na	na	na	na
2000	*[1]23	na	na	na	31	na	na	na	na	na
2001	na	28	*[3]17	*[3]10	34	*[3]20	*[3]12	27	*[3]18	*[3]13
2002	na	23	14	9	21	13	9	24	16	11
2003	na	na	16	8	na	13	9	na	13	9
Mean 98-03	26	25	16	9	26	15	10	25	15	11

*[1]Calculated with data of 50% of the months of the year
*[2]Calculated with data of 83% of the months of the year
*[3]Calculated with data of 83% of the months of the year
na: Not available

The PM mean levels recorded during ITL events were clearly higher than those recorded during WIA episodes. During the summer episodes, pollution generated in industrial or urban sites reached the rural areas where EMEP stations are located. This was caused by the great vertical development of the boundary layer. During WIA episodes, the boundary layer does not reach high altitudes and rural locations are not affected by the pollution originated in urban or industrial sites. Moreover, during ITL conditions, the strong insolation and the consequent development of vertical convective movements often result in generation of secondary aerosols from gaseous precursors and in the resuspension of crustal aerosols. In consequence, 34 µgTSP m^{-3} at San Pablo de los Montes, 35 µgTSP m^{-3}, 20 µgPM10 m^{-3} and 12 µgPM2.5 m^{-3} at Campisábalos were recorded as PM means during ITL episodes, while, only 19 µgTSP m^{-3} in San Pablo de los Montes, 15 µgTSP m^{-3}, 10 µgPM10 m^{-3} and 7 µgPM2.5 m^{-3} in Campisábalos during WIA events (Table Ap.87).

The frequency of occurrence of WIA and ITL events over Central Iberian Peninsula was comparable but the PM levels recorded during these two types of episode differed greatly as just stated. This resulted in a remarkable difference in the impact index (II) of both scenarios. II during ITL events reached 4.1 µgTSP m^{-3} at San Pablo de los Montes, 4.2 µgTSP m^{-3}, 2.4 µgPM10 m^{-3} and 1.5 µgPM2.5 m^{-3} at Campisábalos. II for WIA episodes reached 2.3 µgTSP m^{-3} at San Pablo de los Montes, 1.8 µgTSP m^{-3}, 1.2 µgPM10 m^{-3} and 0.9 µgPM2.5 m^{-3} at Campisábalos (Table Ap.87).

Table Ap.87. Number of days without a dominant air mass advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (µg m^{-3}) recorded at San Pablo de los Montes and Campisábalos rural sites (C Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	WIA	ITL
2003		
Campisábalos TSP (µg m^{-3})	-	-
Campisábalos PM10 (µg m^{-3})	9	18
Campisábalos PM2.5 (µg m^{-3})	6	12
Days	69	50
2002		
Campisábalos TSP (µg m^{-3})	10	28
Campisábalos PM10 (µg m^{-3})	8	17
Campisábalos PM2.5 (µg m^{-3})	6	11
Days	23	36
2001		
Campisábalos TSP (µg m^{-3})	22	46
Campisábalos PM10 (µg m^{-3})	14	25
Campisábalos PM2.5 (µg m^{-3})	10	14
Days	40	37
2000		
San Pablo de los Montes TSP*[1] (µg m^{-3})	20	35
Campisábalos TSP (µg m^{-3})	16	42
Days	40	52
1999		
San Pablo de los Montes TSP (µg m^{-3})	14	35
Campisábalos TSP (µg m^{-3})	13	26
Days	37	52
1998		
San Pablo de los Montes TSP (µg m^{-3})	22	33
Campisábalos TSP*[2] (µg m^{-3})	12	28
Days	54	38
Mean 98-03 (µg m^{-3})		
San Pablo de los Montes TSP	19	34
Campisábalos TSP	15	35
Campisábalos PM10	10	20
Campisábalos PM2.5	7	12
Impact Index(II) (µg m^{-3})		
San Pablo de los Montes TSP	2.3	4.1
Campisábalos TSP	1.8	4.2
Campisábalos PM10	1.2	2.4
Campisábalos PM2.5	0.9	1.5

*[1]Calculated with data of 50% of the months of the year
*[2]Calculated with data of 83% of the months of the year

Considering only the days without prevailing advective conditions, the highest monthly PM means at Campisábalos were registered under ITL scenario from June to September (33 to 38 µgTSP m^{-3}, 19 to 22 µgPM10 m^{-3} and 12 to 13 µgPM2.5 m^{-3}). Also for WIA scenario high PM levels were recorded for June (52 µgTSP m^{-3}, 22 µgPM10 m^{-3} and 17 µgPM2.5 m^{-3}), although the monthly occurrence of this scenario in June is very low (Table Ap.88).

Table Ap.88. Number of days per month without advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (all units µg m^{-3}) recorded at Campisábalos rural site (C Spain) for those days.

	WIA	ITL		WIA	ITL
January			**July**		
Days per month	1.2	0.0	Days per month	0.0	11.3
TSP	8		TSP		33
PM10	5		PM10		22
PM2.5	4		PM2.5		13
February			**August**		
Days per month	3.7	0.0	Days per month	0.0	12.2
TSP	9		TSP		35
PM10	8		PM10		20
PM2.5	6		PM2.5		13
March			**September**		
Days per month	2.8	0.0	Days per month	2.8	9.8
TSP	13		TSP	17	38
PM10	9		PM10	16	20
PM2.5	7		PM2.5	11	12
April			**October**		
Days per month	5.5	0.0	Days per month	8.3	0.3
TSP	15		TSP	18	
PM10	10		PM10	9	
PM2.5	7		PM2.5	7	
May			**November**		
Days per month	9.8	1.0	Days per month	2.7	0.0
TSP	20	18	TSP	10	
PM10	12	13	PM10	6	
PM2.5	9	9	PM2.5	3	
June			**December**		
Days per month	0.3	9.5	Days per month	6.7	0.0
TSP	52	34	TSP	8	
PM10	22	19	PM10	7	
PM2.5	17	12	PM2.5	4	

5. Eastern Iberian Peninsula

As in the other regions previously presented, the most frequent long range air mass transport scenario over Eastern Iberian Peninsula is the Atlantic advection. 204 Atlantic episodes comprising 825 days (38% of the days in the study period) were registered from 1998-2003. Also episodes without prevailing advective conditions were frequent. This scenario occurred in 176 episodes resulting in 587 days (27% of the days from 1998-2003). The number of North African dust outbreaks over Eastern Iberia was 141 comprising 465 days (21% of the days from 1998 to 2003). Considerably less frequent scenarios were Mediterranean and European episodes. Only 72 episodes with Mediterranean advection which resulted in 215 days (10% of the total number of days) and 50 European events comprising 99 days (5% of the days) occurred in 1998-2003 (Table Ap.89).

TableAp.89. Number of days, % of days and episodes with Atlantic (ATL), North African (NAF), Mediterranean (MED) and European (EU) advection and without a prevalent advective regime (NOADV) in Eastern Iberia for the period 1998-2003.

1998-2003	ATL	NAF	MED	EU	NOADV
Number of days	825	465	99	215	587
% of days	38	21	5	10	27
Number of events	204	141	50	72	176

Daily data on PM from a regional background air quality station belonging to the EMEP network were available in this area. This station is located at Zarra (39º 05' N, -1º 06' W, 885 m.a.s.l.) and offered data on TSP from January 1999 to January 2003 and data on PM10 and PM2.5 from March 2001 to the end of 2003. These measurements were made using the gravimetric method with high volume samplers.
As expected for a regional background station, the mean PM levels recorded at Zarra for the study period (1998-2003) were low (23 µgTSP m^{-3}, 16 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3}). As shown in Table Ap.90, no exceedance of the annual limit value established by the 1999/30/CE Directive was registered neither considering the limit value for 2005 (40 µgPM10 m^{-3}) nor considering the limit value for 2010 (20 µgPM10 m^{-3}).

Table Ap.90. Mean levels of TSP, PM10 and PM2.5 recorded in Zarra in 1998-2003.

MEAN LEVELS	Zarra		
(µg m^{-3})	TSP	PM10	PM2.5
1998	na	na	na
1999	24	na	na
2000	26	na	na
2001	22	*16	*9
2002	21	15	8
2003	na	16	8
Mean 98-03	23	16	8

*Calculated with data of 83% of the months of the year
na: Not available

5.1. Atlantic episodes

In 1998-2003 in 204 episodes (34 per year and 3 per month, Table Ap.91), Atlantic air masses affected the Eastern Iberian Peninsula. These episodes had a mean duration of 4 days. This number of events resulted in 825 days (138 per year and 11 per month, Table Ap.91).

The most frequent transport scenario among Atlantic episodes is the one characterised by the presence of the Azores high and the Iceland low on their standard locations (AZH-NAtD scenario). 82% of the 204 events (167 events, 28 per year and 2 per month, Table Ap.91) and 89% of the 825 days (734 days, 122 per year and 10 per month, Table Ap.91) corresponded with this scenario. The mean duration of these events was 4 days.
The transport scenario associated with the development of depressions in front of the Portuguese coast (AD scenario) was less frequent. Only in 18% of the 204 episodes (37 events, 6 per year and 1 per month, Table Ap.91) and 11% of the 825 days (91 days, 15 per year and 1 per month, Table Ap.91) this was the synoptic situation causing the transport. The average extent of AD events was 2 days.
As shown in Table Ap.91, the annual number of Atlantic episodes registered over Eastern Iberian Peninsula from 1998 to 2003 ranged from 33 (in 1998, 2000, 2001 and 2003) to 37 (in 1999). The number of AZH-NAtD events ranged from 21 (in 2003) to 33 (in 1999) and the number of AD episodes ranged from 4 (in 1998, 1999 and 2001) to 12 (in 2003).
With respect to the number of days with Atlantic advection (Table Ap.91), in 1998-2003 they ranged from 102 (in 2003) and 165 (in 2002). The number of days associated with the AZH-NAtD scenario ranged from 83 (in 2003) to 152 (in 2002) and the number of days associated with AD scenario ranged from 10 (in 2001) to 21 (in 2000).

Table Ap.91. Annual number of days and episodes with Atlantic advection in the period 1998-2003 over Eastern Iberian Peninsula. The AZH-NAtD and AD scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total ATL	141	147	143	127	165	102	138	11
AZH-NAtD	124	136	122	117	152	83	122	10
AD	17	11	21	10	13	19	15	1
Episodes								
Total ATL	33	37	33	33	35	33	34	3
AZH-NAtD	29	33	27	29	28	21	28	2
AD	4	4	6	4	7	12	6	1

The occurrence of Atlantic episodes over Eastern Iberian Peninsula was more important from autumn to early spring than in the rest of the year (Figure Ap.81). In particular, monthly occurrence peaks were registered in April (26 events from 1998 to 2003) and in December (25 episodes in 1998-2003). Also a second order peak was registered in July (17 events in the study period). In June and August the frequency of occurrence of Atlantic events was the lowest (9 and 10 episodes in the 6-years period respectively). AZH-NAtD episodes showed the same occurrence peaks just detailed. In both April and December, 18 of these episodes were observed to occur in 1998-2003 and also a second order frequency peak was observed in the middle of the summer (July with 16 AZH-NAtD events in the study period). With respect to AD events, their occurrence was maximum in April (8 episodes from 1998 to 2003), December (7 events in the study period) and, in a lesser extent, in October (5 episodes in 1998-2003).

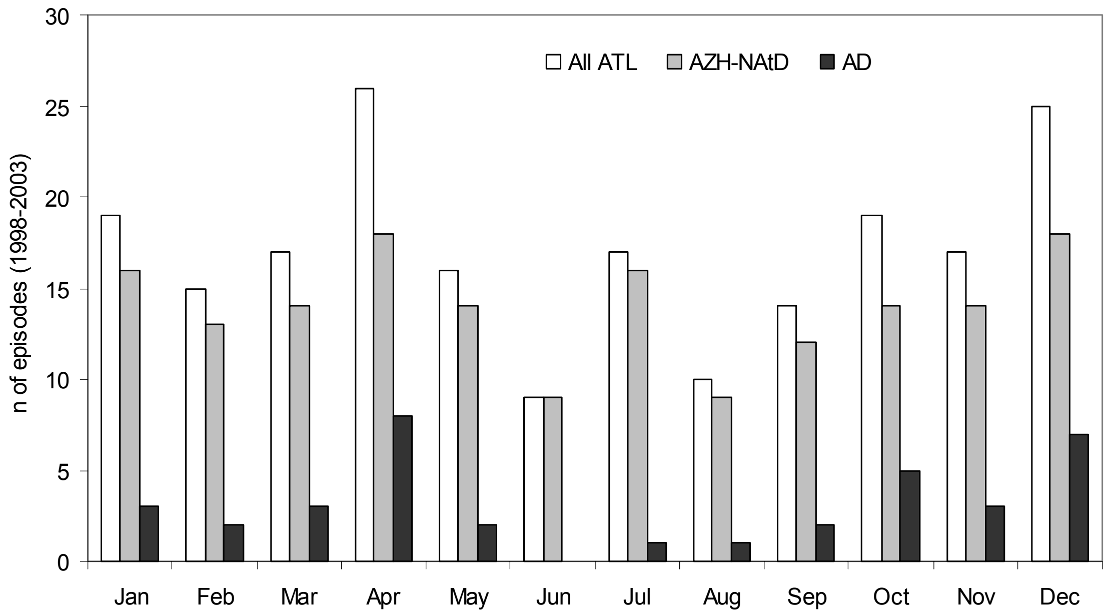

Figure Ap.81. Monthly distribution of the number of Atlantic episodes over Eastern Iberian Peninsula. The monthly distributions of AZH-NAtD and AD Atlantic events are also shown.

As shown in Figures Ap.82 and Ap.83, the frequency of occurrence of the days with Atlantic advection over Eastern Iberia in 1998-2003 was clearly higher from November to April than in the rest of the year. In November-February (17 days as monthly mean in November), April (12 days on average) and, secondarily, in July (8 days as monthly average) the number of days was important. June and August were months in which the occurrence of days with Atlantic advection was the lowest (monthly average of 5 days on both months). Concerning AZH-NAtD scenario, the number of Atlantic days responding to this situation were especially important from November to February (17 days as monthly average in November and in none of these months less than 13 days of monthly mean) and April (12 days as monthly mean). Moreover, although the frequency of occurrence of these days was low in summer a second order frequency peak was registered in July (a monthly average of 8 days).

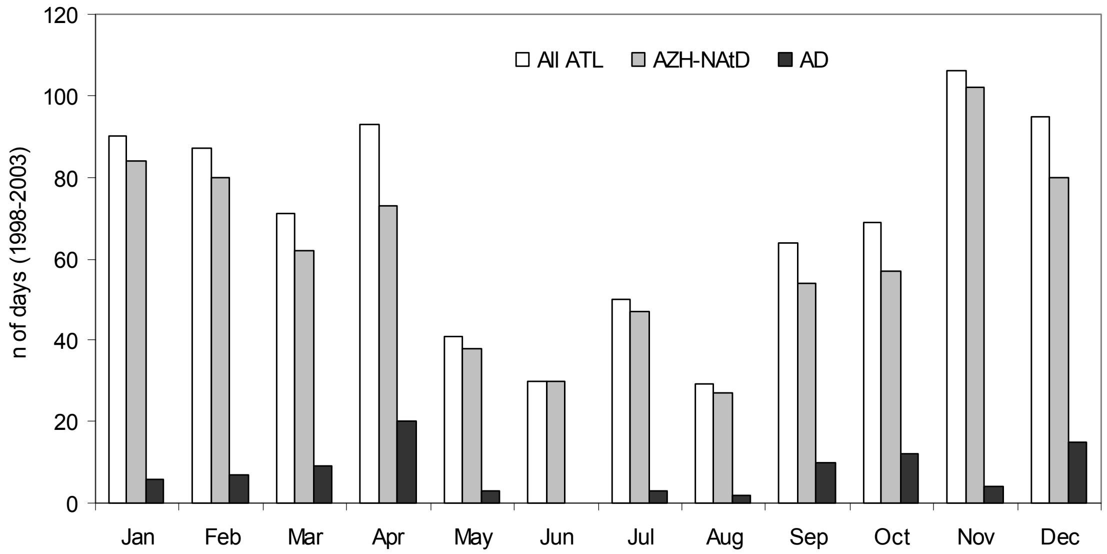

Figure Ap.82. Monthly distribution of the number of days with Atlantic advection over Eastern Iberian Peninsula. The monthly distributions of days with Atlantic advection occurred under AZH-NAtD and AD scenarios are also shown.

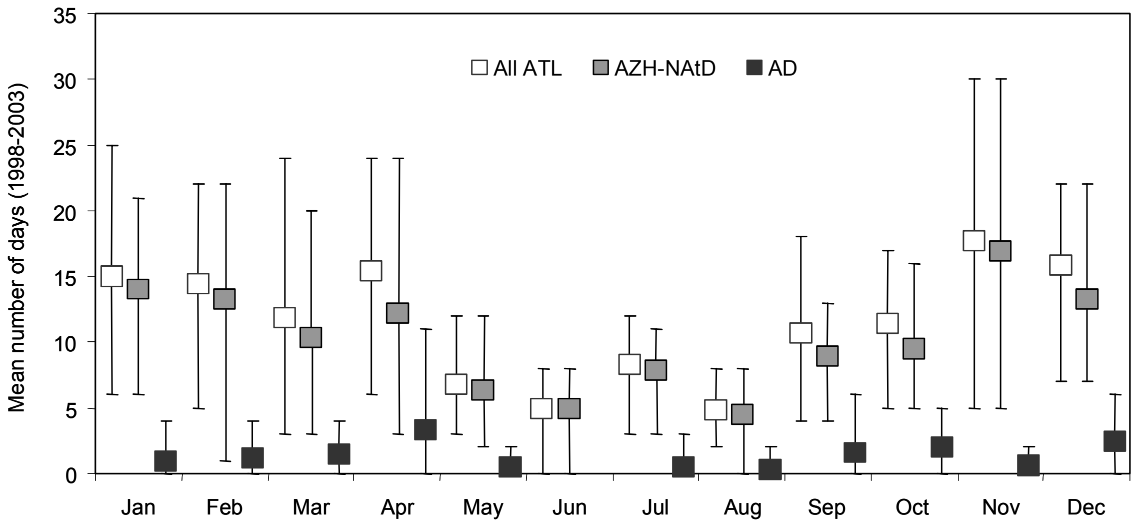

Figure Ap.83. Mean number of days with Atlantic advection over Eastern Iberian Peninsula per month for 1998-2003. AZH-NAtD and AD episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

The Atlantic episodes had a lower mean duration in summer than in the rest of the year. The mean duration of the episodes in January-February (5-6 days respectively), November (6 days) and September (5 days) was especially high. The mean duration of the AZH-NAtD episodes was important in November (7 days as a mean), January-February (6 days in February as a mean) and September (5 days on average) while the months in which AD episodes had a long duration were September (5 days on average) and February (4 days as a mean).

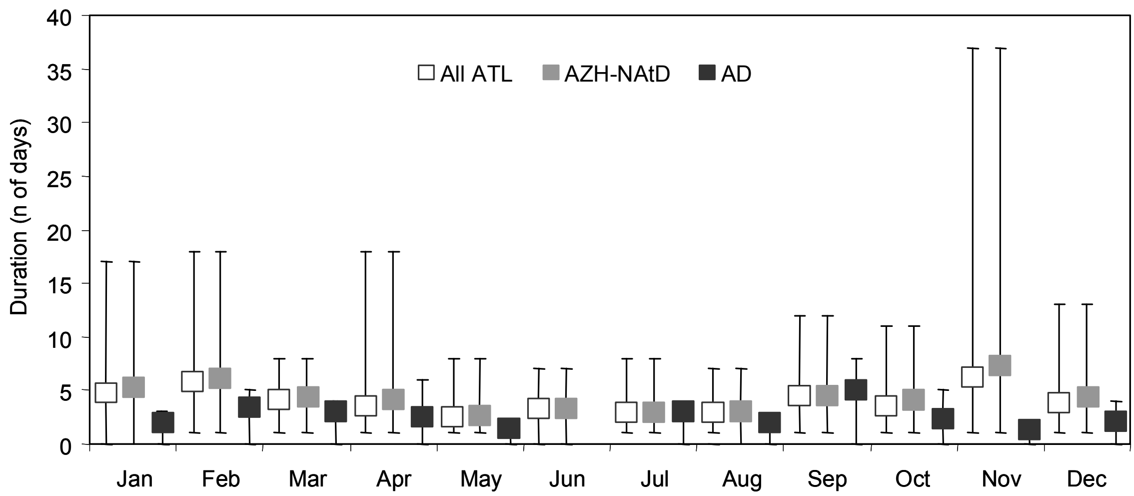

Figure Ap.84. Mean duration of Atlantic episodes per month over Eastern Iberian Peninsula for 1998-2003. AZH-NAtD and AD episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

As shown in Table Ap.92, during Atlantic episodes the mean PM levels at Zarra were significantly low compared with the annual means (23 µgTSP m^{-3}, 16 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3}). Mean levels of 16 µgTSP m^{-3}, 11 µgPM10 m^{-3} and 6 µgPM2.5 m^{-3} were recorded in Zarra during Atlantic events. These levels would have local or regional origin assuming the low concentration of particles in Atlantic air masses. Moreover, the rainfall associated with the passage of frontal systems common during the Atlantic episodes reduced significantly the PM levels.

Table Ap.92. Mean annual levels of TSP and PM10 registered in Zarra during Atlantic advection episodes in 1998-2003.

ATL EPISODES	**Zarra**		
(µg m^{-3})	TSP	PM10	PM2.5
1998	na	na	na
1999	17	na	na
2000	18	na	na
2001	15	*12	*7
2002	16	11	6
2003	na	9	4
Mean 98-03	16	11	6

*Calculated with data of 83% of the months of the year
na: Not available

The mean PM levels recorded at Zarra during AZH-NAtD events were considerably higher than during AD episodes although both Atlantic scenarios resulted in low PM levels. This can be explained by a higher frequency of occurrence of rainfall associated with AD episodes. Mean levels of 16 µgTSP m^{-3}, 11 µgPM10 m^{-3} and 6 µgPM2.5 m^{-3} were recorded during AZH-NAtD episodes and 13 µgTSP m^{-3}, 9 µgPM10 m^{-3} and 4 µgPM2.5 m^{-3} during AD events.

Providing the higher frequency of occurrence and the higher PM levels associated with AZH-NAtD events when compared with AD episodes, the impact index (II) of the AZH-NAtD scenario is higher at Zarra. II of 5.5 µgTSP m^{-3}, 3.6 µgPM10 m^{-3} and 2.0 µgPM2.5 m^{-3} were found for AZH-NAtD scenario while 0.5 µgTSP m^{-3}, 0.4 µgPM10 m^{-3} and 0.2 µgPM2.5 m^{-3} were the II of AD scenario.

Table Ap.93. Number of days with Atlantic advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (µg m^{-3}) recorded at Zarra rural site (E Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	AZH-NAtD	AD
2003		
Zarra TSP (µg m^{-3})	-	-
Zarra PM10 (µg m^{-3})	8	11
Zarra PM2.5 (µg m^{-3})	4	5
Days	83	19
2002		
Zarra TSP (µg m^{-3})	16	10
Zarra PM10 (µg m^{-3})	12	7
Zarra PM2.5 (µg m^{-3})	6	4
Days	152	13
2001		
Zarra TSP (µg m^{-3})	15	8
Zarra PM10 (µg m^{-3})	12	7
Zarra PM2.5 (µg m^{-3})	7	4
Days	117	10
2000		
Zarra TSP (µg m^{-3})	17	18
Days	122	21
1999		
Zarra TSP (µg m^{-3})	18	12
Days	136	11
1998		
Zarra TSP (µg m^{-3})	-	-
Days	124	17
Mean 98-03 (µg m^{-3})		
Zarra TSP	16	13
Zarra PM10	11	9
Zarra PM2.5	6	4
Impact Index(II) (µg m^{-3})		
Zarra TSP	5.5	0.5
Zarra PM10	3.6	0.4
Zarra PM2.5	2.0	0.2

As shown in Table Ap.94, the highest monthly PM means registered for Atlantic episodes occurred in summer when, generally PM levels are superior owing to an intensification of several processes such as re-suspension of soil material and formation of secondary aerosols by photochemistry and also due to the low regime of precipitation. In particular the highest monthly means were recorded during AZH-NAtD events (23-30 µgTSP m^{-3}, 12-17 µgPM10 m^{-3} and 7-9 µgPM2.5 m^{-3} from June to September and 10-19 µgTSP m^{-3}, 7-11 µgPM10 m^{-3} and 4-7 µgPM2.5 m^{-3} in the rest of the year). Monthly PM levels during AD episodes were low with the exception of TSP in July (39 µg m^{-3}), PM10 in August (19 µg m^{-3}) and November (24 µg m^{-3}) and PM2.5 in August (7 µg m^{-3}) and November (10 µg m^{-3}). Nevertheless, the occurrence of AD situations in those months was very low.

Table Ap.94. Number of days per month with Atlantic advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 ($\mu g\ m^{-3}$) recorded at Zarra rural site (E Spain) for those days.

	AZH-NAtD	**AD**		**AZH-NAtD**	**AD**
January			**July**		
Days per month	14.0	1.0	Days per month	7.8	0.5
TSP	10	8	TSP	30	39
PM10	8		PM10	17	
PM2.5	6	4	PM2.5	9	
February			**August**		
Days per month	13.3	1.2	Days per month	4.5	0.3
TSP	16		TSP	29	
PM10	11	7	PM10	16	19
PM2.5	6	3	PM2.5	9	7
March			**September**		
Days per month	10.3	1.5	Days per month	9.0	1.7
TSP	16	13	TSP	25	11
PM10	10	4	PM10	17	8
PM2.5	6		PM2.5	9	5
April			**October**		
Days per month	12.2	3.3	Days per month	9.5	2.0
TSP	19	15	TSP	15	8
PM10	11	7	PM10	9	7
PM2.5	7	4	PM2.5	4	3
May			**November**		
Days per month	6.3	0.5	Days per month	17.0	0.7
TSP	18	12	TSP	10	
PM10	11	7	PM10	7	24
PM2.5	6	4	PM2.5	4	10
June			**December**		
Days per month	5.0	0.0	Days per month	13.3	2.5
TSP	23		TSP	10	8
PM10	12		PM10	8	8
PM2.5	7		PM2.5	6	4

5.2. African episodes

In 465 days (78 per year and 6 per month, Table Ap.95) of the period 1998-2003, long range transport of North African air masses affected the Eastern flank of the Iberian Peninsula. These days were grouped in 141 episodes (24 per year and 2 per month, Table Ap.95) with a mean duration of 3 days.

In 51 of those 465 days (11% of the days with African advection, 9 per year and 1 per month, Table Ap.95) the meteorological scenario present was characterised by the presence of presence of an anticyclone over Northern Africa and the Iberian Peninsula at surface level (NAH-S scenario). These days resulted in 16 episodes (11% of the African episodes and 3 per year, Table Ap.95) with an average duration of 3 days.

In 89 days of the 465 (19% of the days with African advection, 15 per year and 1 per month, Table Ap.95) the synoptic scenario causing the transport was AD, this was associated with the development an Atlantic depression by the Portuguese coast. These days resulted in 37 episodes (26% of the African events, 6 per year and 1 per month, Table Ap.95) with 2 days as average duration.

NAD situations in which the presence of depressions over Northern Africa is the main feature accounted for 84 days of the 465 days (18% of the days with African advection, 14 per year and 1 per month, Table Ap.95). These days were distributed in

27 events (19% of the episodes of African advection and 5 per year, Table Ap.95) with an average duration of 3 days.
The most frequent transport scenario was NAH-A in which the presence of an anticyclone shifted at high atmospheric levels over North Africa or the Iberian Peninsula. In 241 days of the 465 (52% of the days with African advection, 40 per year and 3 per month, Table Ap.95) grouped in 61 events (43% of the episodes of African advection, 10 per year and 1 per month, Table Ap.95) this was the corresponding transport scenario. NAH-A events had a mean duration of 4 days.
As shown in Table Ap.95, the number of African events ranged from 16 (in 1999) to 29 (in 2001). Distinguishing among transport scenarios the following ranges of occurrence of African episodes were observed: 1 (in 1999, 2001 and 2003) to 5 (in 2002) for NAH-S events, 2 (in 1999) to 9 (in 2000 and 2003) for AD episodes, 1 (in 2000) to 10 (in 2001) for NAD events, and 8 (in 1999) to 12 (in 2002) for NAH-A.
Focusing our attention in the frequency of occurrence of days with African advection over Eastern Iberia, a range of 58 (in 1998 and 1999) to 92 (in 2003) was observed (Table Ap.95). The number of days associated with the different synoptic scenarios distinguished in this study ranged between the following values: 2 (in 1999 and 2001) to 20 (in 2002) for NAH-S, 9 (in 1998 and 1999) to 23 (in 2000) for AD, 5 (in 2000) to 30 (in 2001) for NAD, and 26 (in 1998) to 52 (in 2003).

Table Ap.95. Annual number of days and episodes with African advection in the period 1998-2003 over Eastern Iberian Peninsula. The NAH-S, AD, NAD and NAH-A scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total NAF	58	58	82	86	89	92	78	6
NAH-S	15	2	10	2	20	2	9	1
AD	9	9	23	16	12	20	15	1
NAD	8	17	5	30	6	18	14	1
NAH-A	26	30	44	38	51	52	40	3
Episodes								
Total NAF	20	16	25	29	25	25	24	2
NAH-S	4	1	4	1	5	1	3	<1
AD	4	2	9	7	5	9	6	1
NAD	3	5	1	10	3	5	5	<1
NAH-A	9	8	11	11	12	10	10	1

Three main frequency peaks were found in the monthly distribution of the number of African episodes over Eastern Iberian Peninsula from 1998-2003 (Figure Ap.85). In March (18 episodes from 1998 to 2003) and May-August (with two relative frequency peaks in May and August with 17 and 19 in 1998-2003 respectively) resulted as the periods with the highest frequency of occurrence of North African dust outbreaks. The months with low occurrence of African events were April and November (5 and 6 episodes in the study period respectively). NAH-S episodes practically did not occur out of the period January-March (maximum frequency in February with 6 events in 1998-2003). The monthly distribution of AD episodes showed three peaks in March (9 episodes from 1998-2003), May (6 events in the study period) and December (7 episodes from 1998 and 2003). These episodes only occurred from October to May. The summer months were also practically devoid of NAD events and the seasonal distribution of these episodes revealed May as the month in which these situations developed more often. Also in March and October (4 episodes in 1998-2003 in both months) two second order peaks were observed. NAH-A episodes only occurred from

May to October but with especial frequency from June to September (frequency peak in July with 19 episodes in 1998-2003).

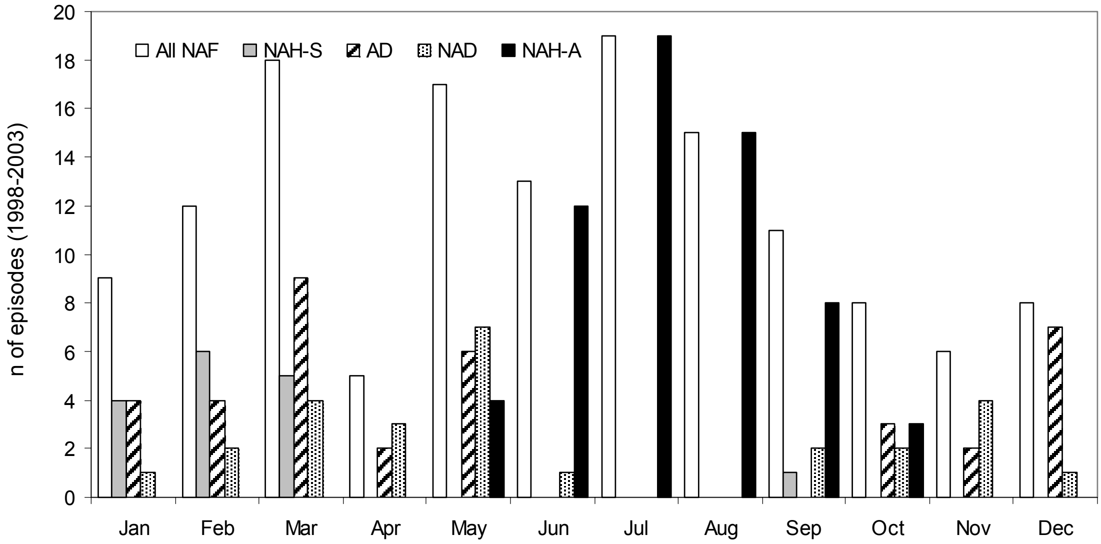

Figure Ap.85. Monthly distribution of the number of African episodes over Eastern Iberian Peninsula. The monthly distributions of NAH-S, AD, NAD and NAH-A African events are also shown.

Concerning the number of days with African advection over Eastern Iberia most of them were in two periods (Figures Ap.86 and Ap.87). Principally from May to August (with frequency peaks in June and August with monthly means of 12 days in both months) and, secondarily, in March (9 days as monthly mean). The minima were registered in April and December (2 days as monthly mean in both cases). NAH-S episodes resulted in relatively important number of days in February and March (3 days as monthly means in both months). The number of days associated with AD scenario was high in March (4 days as monthly average) and May (3 days as monthly mean) together with November (in which a second order peak was registered in December with 2 days as a monthly mean). NAD episodes resulted in high number of days in May (4 days as monthly mean) and, secondarily, in November (3 days as monthly mean) and March (monthly average of 2 days). NAH-A episodes, only registered in summer, resulted in very high number of days in June-August (10-12 days as monthly means).

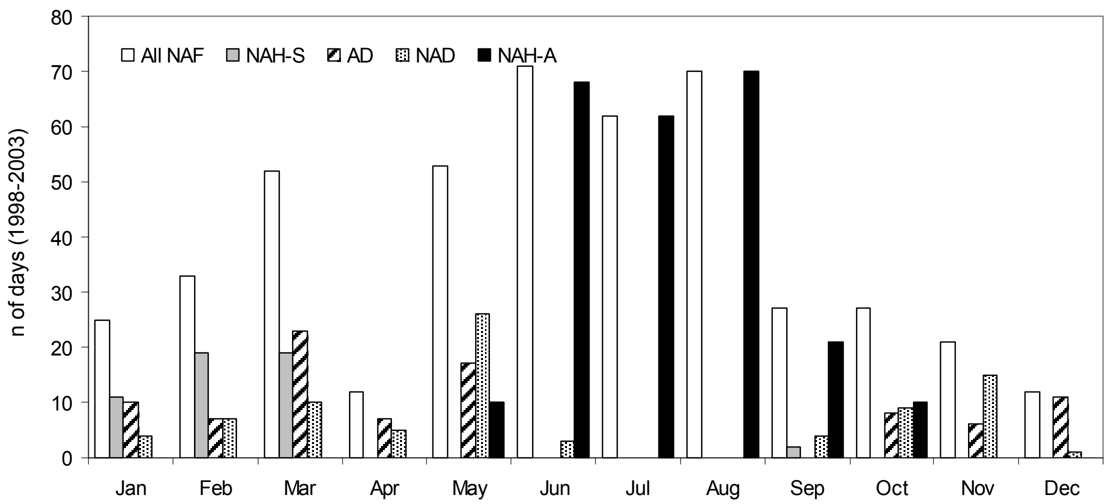

Figure Ap.86. Monthly distribution of the number of days with African advection over Eastern Iberian Peninsula. The monthly distributions of days with African advection occurred under NAH-S, AD, NAD and NAH-A scenarios are also shown.

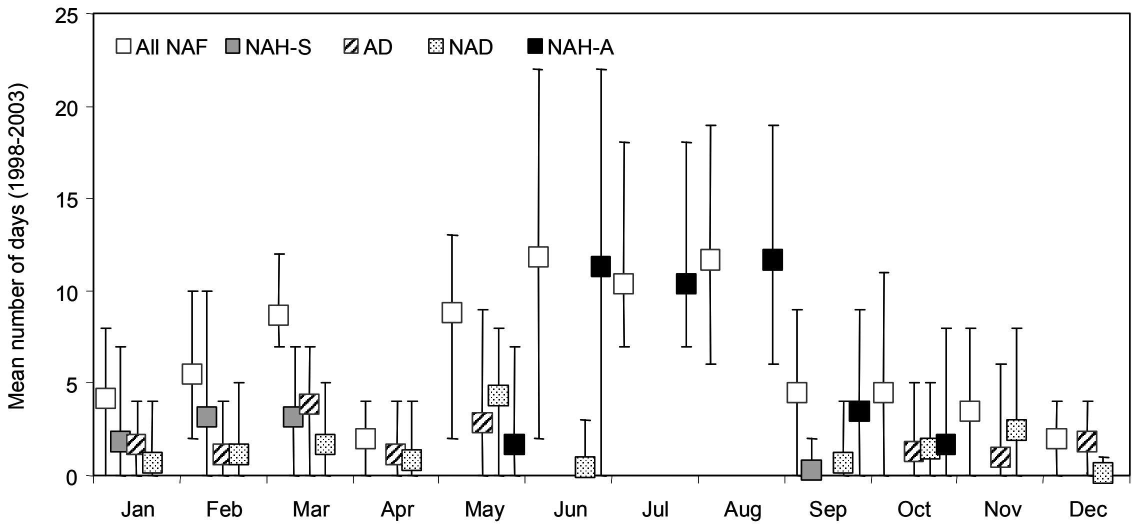

Figure Ap.87. Mean number of days with African advection over Eastern Iberian Peninsula per month for 1998-2003. NAH-S, AD, NAD and NAH-A episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

The African episodes, on average, had a high duration in June (5 days), August (5 days) and November (4 days). NAH-S events reached mean durations of 4 days in March, AD events also reached average durations of 4 days in March and NAD episodes reached important mean durations in October (5 days), January (4 days), February (4 days) and March (4 days). In June and August, NAH-A episodes reached average durations of 6 and 5 days respectively (Figure Ap.88).

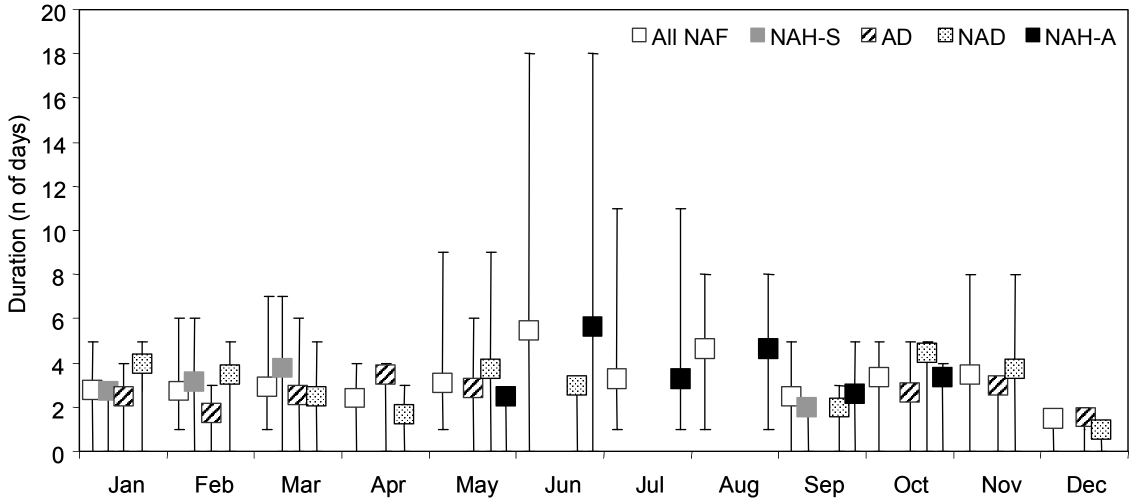

Figure Ap.88. Mean duration of African episodes per month over Eastern Iberian Peninsula for 1998-2003. NAH-S, AD, NAD and NAH-A episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

As shown in Table Ap.96, the mean PM levels recorded at Zarra during African episodes were 36 µgTSP m^{-3}, 23 µgPM10 m^{-3} and 11 µgPM2.5 m^{-3}. These levels were considerably high than the mean annual PM levels (23 µgTSP m^{-3}, 16 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3}). The important load of dust in the African air masses explain these levels.

Table Ap.96. Mean annual levels of TSP, PM10 and PM2.5 registered in Zarra during African advection episodes in 1998-2003.

NAF EPISODES	**Zarra**		
(µg m^{-3})	TSP	PM10	PM2.5
1998	na	na	na
1999	38	na	na
2000	40	na	na
2001	34	*21	*10
2002	33	21	11
2003	na	25	11
Mean 98-03	36	23	11

*Calculated with data of 83% of the months of the year
na: Not available

The different transport scenarios associated with African episodes had different impact on PM levels at Zarra (Table Ap.97). The scenarios characterised by the presence of anticyclones (NAH-S and NAH-A) gave rise to high PM levels (means in 1998-2003 of 33 µgTSP m^{-3}, 21 µgPM10 m^{-3} and 11 µgPM2.5 m^{-3} during NAH-S and 45 µgTSP m^{-3}, 26 µgPM10 m^{-3} and 12 µgPM2.5 m^{-3} during NAH-A). The scenarios characterised by the development of depressions near the Iberian Peninsula (AD and NAD), with a higher frequency of rainfall, resulted in moderate PM levels (means in 1998-2003 of 23 µgTSP m^{-3}, 19 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3} during AD and 28 µgTSP m^{-3}, 17 µgPM10 m^{-3} and 9 µgPM2.5 m^{-3} during NAD). In order to explain the high PM levels recorded during NAH-A events it should be considered the influence of situations of weak baric conditions occurring during these episodes at surface levels (the transport of dust occurs at high altitudes). Under these circumstances poor renovation of air masses occurs together with the aging and recirculation of contaminated air masses at Eastern Iberia (Millan et al., 1997). These processes,

together with the intense insolation in summer result in an increase of PM levels especially through the photochemical generation of secondary species from gaseous precursors.
Combining the information on the frequency of occurrence and on the PM levels characterising each of the transport scenario allowed defining the impact index (II) which could be understood as the weight a certain scenario on the annual mean PM levels at Zarra. Regardless the high PM levels recorded during NAH-S the low frequency occurrence of these events resulted in comparable values of II to those obtained for AD and NAD. During these scenarios, PM levels were significantly lower than during NAH-S. Thus, II reached values of 0.8 μgTSP m^{-3}, 0.5 μgPM10 m^{-3} and 0.3 μgPM2.5 m^{-3} for NAH-S, 0.9 μgTSP m^{-3}, 0.8 μgPM10 m^{-3} and 0.3 μgPM2.5 m^{-3} for AD and 1.0 μgTSP m^{-3}, 0.6 μgPM10 m^{-3} and 0.3 μgPM2.5 m^{-3} for NAD (Table Ap.97). In virtue of the high PM levels recorded at Zarra during NAH-A episodes together with their relatively high frequency of occurrence, II associated with this scenario were elevated (5.0 μgTSP m^{-3}, 2.9 μgPM10 m^{-3} and 1.3 μgPM2.5 m^{-3}, Table Ap.97).

Table Ap.97. Number of days with African dust outbreaks occurred under the 4 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (µg m^{-3}) recorded at Zarra rural site (E Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	NAH-S	AD	NAD	NAH-A
2003				
Zarra TSP (µg m^{-3})	-	-	-	-
Zarra PM10 (µg m^{-3})	25	20	20	29
Zarra PM2.5 (µg m^{-3})	13	8	10	12
Days	2	20	18	52
2002				
Zarra TSP (µg m^{-3})	27	18	17	42
Zarra PM10 (µg m^{-3})	20	13	12	25
Zarra PM2.5 (µg m^{-3})	11	6	7	12
Days	20	12	6	51
2001				
Zarra TSP (µg m^{-3})	14	31	26	43
Zarra PM10 (µg m^{-3})	-	23	16	24
Zarra PM2.5 (µg m^{-3})	-	11	8	12
Days	2	16	30	38
2000				
Zarra TSP (µg m^{-3})	41	20	31	52
Days	10	23	5	44
1999				
Zarra TSP (µg m^{-3})	69	26	36	43
Days	2	9	17	30
1998				
Zarra TSP (µg m^{-3})	-	-	-	-
Days	15	9	8	26
Mean 98-03 (µg m^{-3})				
Zarra TSP	33	23	28	45
Zarra PM10	21	19	17	26
Zarra PM2.5	11	8	9	12
Impact Index(II) (µg m^{-3})				
Zarra TSP	0.8	0.9	1.0	5.0
Zarra PM10	0.5	0.8	0.6	2.9
Zarra PM2.5	0.3	0.3	0.3	1.3

Considering only African days, the highest mean monthly PM levels (Table Ap.98) were recorded from May to October under NAH-A situations (means of 31-51 µgTSP m^{-3}, 16-30 µgPM10 m^{-3} and 9-13 µgPM2.5 m^{-3}). In a second level, monthly means were high during AD and NAD in March (30 µgTSP m^{-3}, 24 µgPM10 m^{-3} and 11 µgPM2.5 m^{-3} for AD and 28 µgTSP m^{-3}, 20 µgPM10 m^{-3} and 11 µgPM2.5 m^{-3} for NAD) and in September-October (29 µgTSP m^{-3}, 23 µgPM10 m^{-3} and 9 µgPM2.5 m^{-3}, only in October, for AD and 29-31 µgTSP m^{-3}, 18-20 µgPM10 m^{-3} and 7-9 µgPM2.5 m^{-3} for NAD). Moreover, during NAD episodes also relatively high PM levels were recorded in May (31 µgTSP m^{-3}, 13 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3} in January-March and September). Finally, PM means for NAH-S episodes were considerably high for all the months in which these events occurred (27-39 µgTSP m^{-3}, 15-25 µgPM10 m^{-3} and 8-13 µgPM2.5 m^{-3} in January-March and September).

Table Ap.98. Number of days per month with African advection occurred under the 4 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (all units in µg m^{-3}) recorded at Zarra rural site (E Spain) for those days.

	NAH-S	AD	NAD	NAH-A		NAH-S	AD	NAD	NAH-A
January					**July**				
Days per month	1.8	1.7	0.7	0.0	Days per month	0.0	0.0	0.0	10.3
TSP	27	17			TSP				51
PM10	15	6			PM10				30
PM2.5	8	4			PM2.5				13
February					**August**				
Days per month	3.2	1.2	1.2	0.0	Days per month	0.0	0.0	0.0	11.7
TSP	31	32	18		TSP				49
PM10	21	6			PM10				24
PM2.5	12	4			PM2.5				12
March					**September**				
Days per month	3.2	3.8	1.7	0.0	Days per month	0.3	0.0	0.7	3.5
TSP	39	30	28		TSP			29	45
PM10	25	24	20		PM10	25		18	21
PM2.5	13	11	11		PM2.5	13		9	10
April					**October**				
Days per month	0.0	1.2	0.8	0.0	Days per month	0.0	1.3	1.5	1.7
TSP		12			TSP		29	31	32
PM10		5	28		PM10		23	20	24
PM2.5		4	15		PM2.5		9	7	13
May					**November**				
Days per month	0.0	2.8	4.3	1.7	Days per month	0.0	1.0	2.5	0.0
TSP		25	31	31	TSP		19	24	
PM10		15	13	16	PM10			16	
PM2.5		8	8	9	PM2.5			6	
June					**December**				
Days per month	0.0	0.0	0.5	11.3	Days per month	0.0	1.8	0.2	0.0
TSP			44	42	TSP		18		
PM10				27	PM10		21		
PM2.5				13	PM2.5		6		

5.3. European episodes

A total of 215 days (36 per year and 3 per month, Table Ap.99) with European advection over Eastern Iberian Peninsula were registered in the study period (1998-2003). These days were distributed in 72 events (12 per year and 1 per month, Table Ap.99) with a mean duration of 3 days.

A major proportion of those 215 days (69%, 149 days from 1998 to 2003, 25 per year and 2 per month, Table Ap.99) occurred when an anticyclone was located over the European continent or over the Northern Atlantic Ocean (EUH scenario). These days resulted in 47 episodes (65% of the number of European episodes from 1998 to 2003, 8 per year and 1 per month, Table Ap.99) characterised by an average duration of 3 days

Less frequently, in 31% of those 215 occasions (149 days from 1998 to 2003, 25 per year and 2 per month, Table Ap.99), the meteorological scenario involved was characterised by the development of a depression over the Mediterranean (MD scenario). The number of MD episodes from 1998-2003 was 25 (65% of the number of European episodes from 1998 to 2003, 8 per year and 1 per month, Table Ap.99) and had a mean duration of 3 days.

As shown in Table Ap.99, the annual number of days with European advection ranged from 32 (in 1998 and 2002) to 49 (in 2003). Considering only the days associated with EUH scenario this range varied from 22 (in 1998 and 1999) to 36 (in 2003) and, focusing on the days characterised by MD scenario, the range was 4 (in 2000) to 18 (in 2002).
As presented in Table Ap.99, the annual number of European episodes over Eastern Iberian Peninsula in 1998-2003 varied from 9 (in 2002) to 16 (in 2003). The number of EUH episodes ranged from 4 (in 2002) to 11 (in 2003) while the number of MD events went from 3 (in 1999 and 2000) to 5 (in 1998, 2002 and 2003).

Table Ap.99. Annual number of days and episodes with European advection in the period 1998-2003 over Eastern Iberian Peninsula. The EUH and MD scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total EU	32	35	33	34	32	49	36	3
EUH	22	22	29	26	14	36	25	2
MD	10	13	4	8	18	13	11	1
Episodes								
Total EU	12	11	13	11	9	16	12	1
EUH	7	8	10	7	4	11	8	1
MD	5	3	3	4	5	5	4	<1

As Figure Ap.89 shows, the European events were more frequent during the winter than during the summer. A great part of the European events occurred from November to April (with a frequency peak of 11 episodes in January from 1998 to 2003). However, two second order frequency peaks occurred in summer (5 and 6 episodes in June and September respectively in 1998-2003). The seasonal distribution of the number of EUH episodes was characterised also by a maximum in winter (a peak of 8 events in January in 1998-2003) and two second order maxima in June (5 episodes in 1998-2003) and September (5 episodes in the study period). MD episodes showed two periods of occurrence in September-January (a peak of frequency of 5 events in the study period in November) and March-May (3 episodes in 1998-2003 in both April and May).

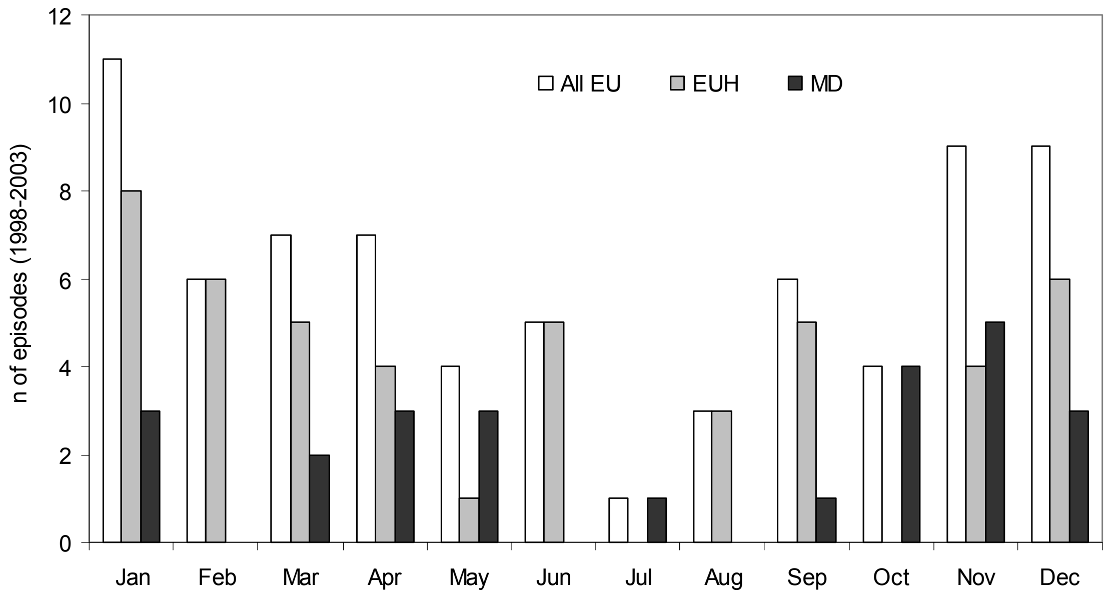

Figure Ap.89. Monthly distribution of the number of European episodes over Eastern Iberian Peninsula. The monthly distribution of EUH and MD European events is also shown.

As shown in Figures Ap.90 and Ap.91, the predominance of days with European advection over Eastern Iberia in 1998-2003 is clear from November to April (with monthly means above 3 days in all the months and up to 6 days in January) with respect to the rest of the year (1 or 2 days of monthly averages with the exception of September with 3 days). The days with European advection characterised by EUH scenario were especially frequent from November to April (with monthly means of 4 days in December, January and February) and, secondarily, in September (3 days as monthly average). Most of the days with European advection associated with MD scenario were registered in autumn or early winter (frequency peak in November with 3 days as monthly mean) and in spring (clear peak in April with a monthly average of 2 days).

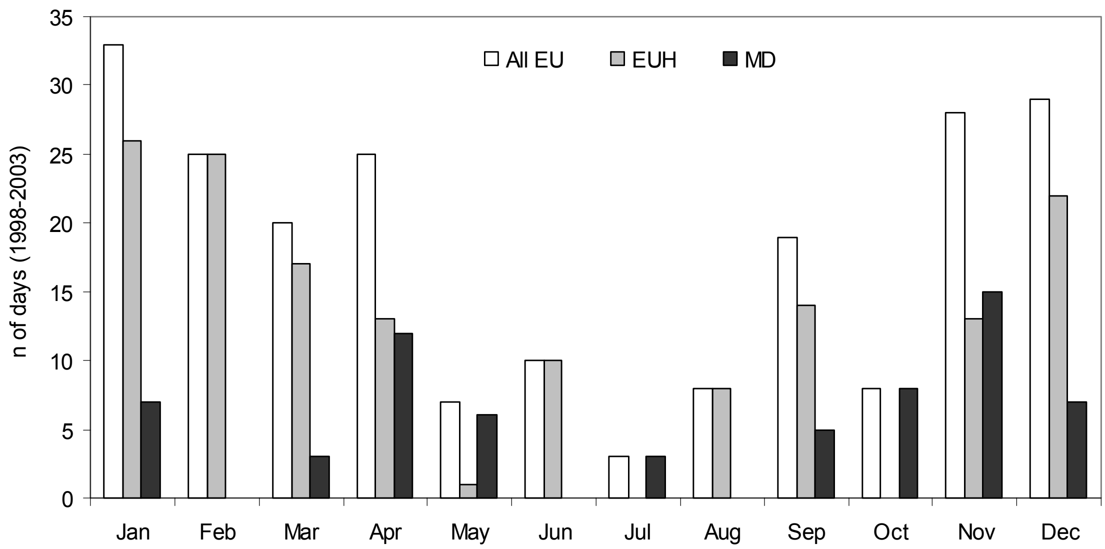

Figure Ap.90. Monthly distribution of the number of days with European advection over Eastern Iberian Peninsula. The monthly distributions of days with European advection occurred under EUH and MD scenarios are also shown.

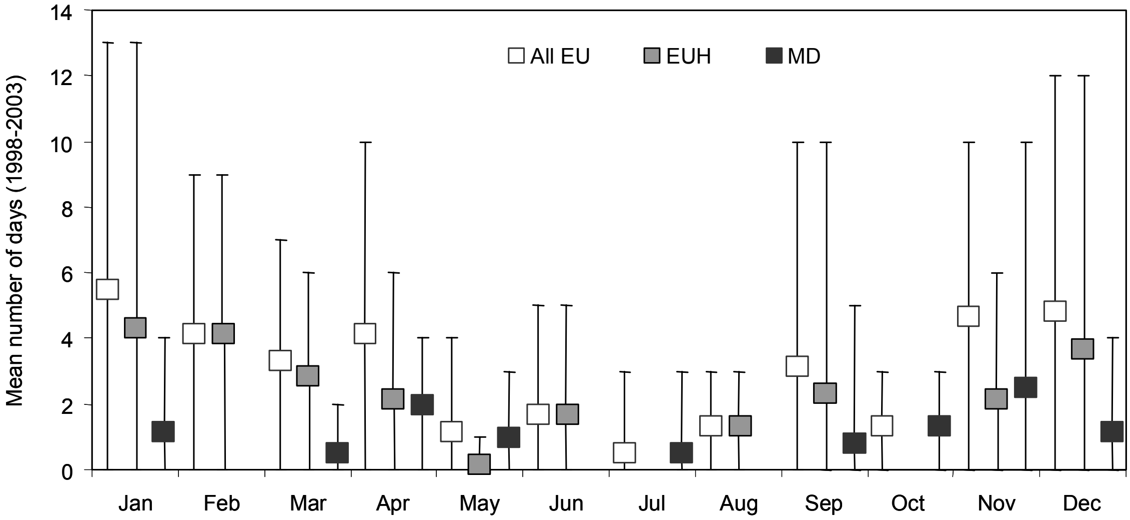

Figure Ap.91. Mean number of days with European advection over Eastern Iberian Peninsula per month for 1998-2003. EUH and MD episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

As shown in Figure Ap.92, the mean duration of European events reached only 4 days in February and April. In the rest of the year the mean extent of European episodes was 3-2 days in all the months. The EUH episodes had a mean duration of 2-3 days in all the months with the exception of May (1 day), December (4 days) and February (4 days). MD episodes also reached 2-3 days as mean duration with two exceptions: April (4 days) and September (5 days).

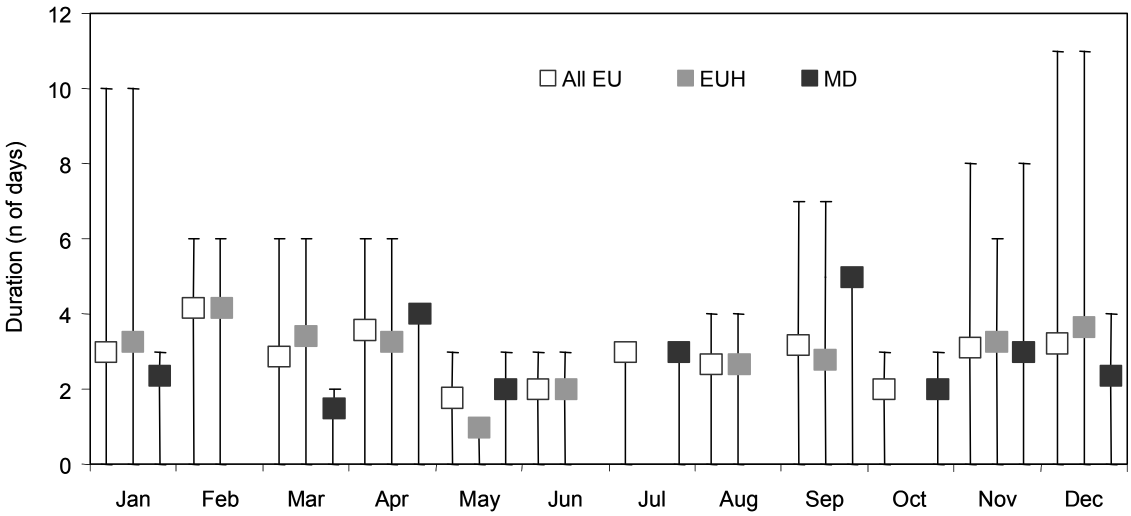

Figure Ap.92. Mean duration of European episodes per month over Eastern Iberian Peninsula for 1998-2003. EUH and MD episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

The mean PM levels recorded at Zarra during European episodes (18 µgTSP m^{-3}, 13 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3}, Table Ap.100) were low when compared with the annual mean PM levels at this site (23 µgTSP m^{-3}, 16 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3}). This can be attributed to the dilution and the dispersion of pollutants in the air masses from the European continent as a consequence of the long distance travelled to reach the Eastern Iberian Peninsula.

Table Ap.100. Mean annual levels of TSP, PM10 and PM2.5 registered in Zarra during European advection episodes in 1998-2003.

EU EPISODES ($\mu g\ m^{-3}$)	Zarra		
	TSP	PM10	PM2.5
1998	na	na	na
1999	18	na	na
2000	22	na	na
2001	15	*11	*7
2002	22	16	10
2003	na	11	6
Mean 98-03	18	13	8

*Calculated with data of 83% of the months of the year
na: Not available

The mean PM levels recorded during the two transport scenarios considered in this study (EUH and MD) were different (19 µgTSP m^{-3}, 14 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3} during EUH events and 16 µgTSP m^{-3}, 11 µgPM10 m^{-3} and 7 µgPM2.5 m^{-3} during MD episodes, Table Ap.101). For both scenarios the mean PM levels at Zarra were low but, a higher frequency of rainfall associated with MD episodes with respect to EUH events probably accounts for the lower PM levels measured during the first scenario.
The frequency of occurrence of EUH situations was higher than MD situations. This, together with the difference in PM levels recorded at Zarra during the two transport scenarios, resulted in a higher impact index (II) of EUH (II of 1.3 µgTSP m^{-3}, 0.9 µgPM10 m^{-3} and 0.3 µgPM2.5 m^{-3} for EUH and II of 0.5 µgTSP m^{-3}, 0.3 µgPM10 m^{-3} and 0.2 µgPM2.5 m^{-3} for MD, Table Ap.101).

Table Ap.101. Number of days with European advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 ($\mu g\ m^{-3}$) recorded at Zarra rural site (E Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	EUH	MD
2003		
Zarra TSP ($\mu g\ m^{-3}$)	-	-
Zarra PM10 ($\mu g\ m^{-3}$)	14	9
Zarra PM2.5 ($\mu g\ m^{-3}$)	7	4
Days	36	13
2002		
Zarra TSP ($\mu g\ m^{-3}$)	27	18
Zarra PM10 ($\mu g\ m^{-3}$)	20	13
Zarra PM2.5 ($\mu g\ m^{-3}$)	13	8
Days	14	18
2001		
Zarra TSP ($\mu g\ m^{-3}$)	14	17
Zarra PM10 ($\mu g\ m^{-3}$)	11	10
Zarra PM2.5 ($\mu g\ m^{-3}$)	7	6
Days	26	8
2000		
Zarra TSP ($\mu g\ m^{-3}$)	22	18
Days	29	4
1999		
Zarra TSP ($\mu g\ m^{-3}$)	19	15
Days	22	13
1998		
Zarra TSP ($\mu g\ m^{-3}$)	-	-
Days	22	10
Mean 98-03 ($\mu g\ m^{-3}$)		
Zarra TSP	19	16
Zarra PM10	14	11
Zarra PM2.5	8	7
Impact Index(II) ($\mu g\ m^{-3}$)		
Zarra TSP	1.3	0.5
Zarra PM10	0.9	0.3
Zarra PM2.5	0.6	0.2

The monthly means of PM levels for the days with European advection over Eastern Iberian Peninsula were calculated Table Ap.102. The highest PM levels were reached under EUH situations, in March-April (25-31 $\mu gTSP\ m^{-3}$, 13-17 $\mu gPM10\ m^{-3}$ and 7-10 $\mu gPM2.5\ m^{-3}$), June (23 $\mu gTSP\ m^{-3}$ and 13 $\mu gPM2.5\ m^{-3}$) and August-September (18-24 $\mu gTSP\ m^{-3}$, 15-16 $\mu gPM10\ m^{-3}$ and 18-10 $\mu gPM2.5\ m^{-3}$). Under MD situations, the highest monthly means were recorded in July (32 $\mu gTSP\ m^{-3}$, 19 $\mu gPM10\ m^{-3}$ and 11 $\mu gPM2.5\ m^{-3}$) and in March-April (18-21 $\mu gTSP\ m^{-3}$, 14-14 $\mu gPM10\ m^{-3}$ and 9-9 $\mu gPM2.5\ m^{-3}$).

Table Ap.102. Number of days per month with European advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 ($\mu g\ m^{-3}$) recorded at Zarra rural site (E Spain) for those days.

	EUH	MD		EUH	MD
January			**July**		
Days per month	4.3	1.2	Days per month	0.0	0.5
TSP	13	16	TSP		32
PM10	8	5	PM10		19
PM2.5	5	4	PM2.5		11
February			**August**		
Days per month	4.2	0.0	Days per month	1.3	0.0
TSP	19		TSP	18	
PM10	16		PM10	16	
PM2.5	10		PM2.5	10	
March			**September**		
Days per month	2.8	0.5	Days per month	2.3	0.8
TSP	31	18	TSP	24	16
PM10	13	14	PM10	15	12
PM2.5	7	9	PM2.5	8	8
April			**October**		
Days per month	2.2	2.0	Days per month	0.0	1.3
TSP	25	21	TSP		17
PM10	17	14	PM10		6
PM2.5	10	9	PM2.5		3
May			**November**		
Days per month	0.2	1.0	Days per month	2.2	2.5
TSP			TSP	12	11
PM10		8	PM10	12	5
PM2.5		4	PM2.5	8	3
June			**December**		
Days per month	1.7	0.0	Days per month	3.7	1.2
TSP	23		TSP	14	8
PM10			PM10	11	7
PM2.5	13		PM2.5	7	5

5.4. Mediterranean episodes

The transport of air masses from the Mediterranean Sea occurred in 99 days (17 per year and 1 per month, Table Ap.103) over Eastern Iberian Peninsula in 1998-2003. These 99 days resulted in 50 episodes (8 per year and 1 per month, Table Ap.103) with a mean duration of 2 days.

Only 32% of the 99 days (32 days in 1998-2003 and 5 per year, Table Ap.103) occurred under the NAD-MD meteorological scenario (characterised by the presence of a depression over Northern Africa and/or the Mediterranean). These days were grouped in 16 events (32% of the 50 episodes and 3 per year) with a mean extent of 2 days.

The situations associated with EUH-MH scenario (when an anticyclone was present over the European continent and/or over the Mediterranean) occurred in 68% of the 99 days (67 days in 1998-2003, 11 per year and 1 per month, Table Ap.103). These 67 days were distributed in 34 episodes (68% of the 50 Mediterranean episodes occurred in 1998-2003 and 6 per year, Table Ap.103). These episodes had a mean duration of 2 days.

The number of days with advection of Mediterranean air masses over Eastern Iberia ranged from 10 (in 2000) to 26 (in 1999). Distinguishing between transport scenarios, the annual number of days associated with NAD-MD scenario ranged from 2 (in 2000) to 9 (in 2002 and 2003) and the annual number of days associated with EUH-MH scenario ranged from 8 (in 1998 and 2000) to 22 (in 1999).

Focusing now on the number of Mediterranean episodes, the range of occurrence from 1998 to 2003 varied from 6 (in 2001) to 11 (in 1999). The number of NAD-MD episodes ranged from 1 (in 2001) to 4 (in 1998) and the number of EUH-MH episodes varied from 4 (in 1998) to 8 (in 1999).

Table Ap.103. Annual number of days and episodes with Mediterranean advection in the period 1998-2003 over Eastern Iberian Peninsula. The NAD-MD and EUH-MH scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total MED	13	26	10	15	20	15	17	1
NAD-MD	5	4	2	3	9	9	5	<1
EUH-MH	8	22	8	12	11	6	11	1
Episodes								
Total MED	8	11	8	6	9	8	8	1
NAD-MD	4	3	2	1	3	3	3	<1
EUH-MH	4	8	6	5	6	5	6	<1

The Mediterranean episodes occurred less frequently over Eastern Iberia during summer and in February (Figure Ap.93). In January (8 events in 1998-2003), March-May (7 episodes in April in 1998-2003), September (6 events from 1998-2003) and November (5 episodes in the study period) the frequency of occurrence of Mediterranean episodes was relatively high (Figure Ap.93). NAD-MD episodes occurred practically in two periods: January (4 episodes in 1998-2003, Figure Ap.93) and March-May (frequency peak in April with 5 days in 1998-2003, Figure Ap.93). EUH-MH events occurred in all the months along the year but only reached relatively important frequencies in September (6 events in the study period, Figure Ap.93), November (5 episodes from 1998 to 2003, Figure Ap.93) and January (4 events in 1998-2003, Figure Ap.93).

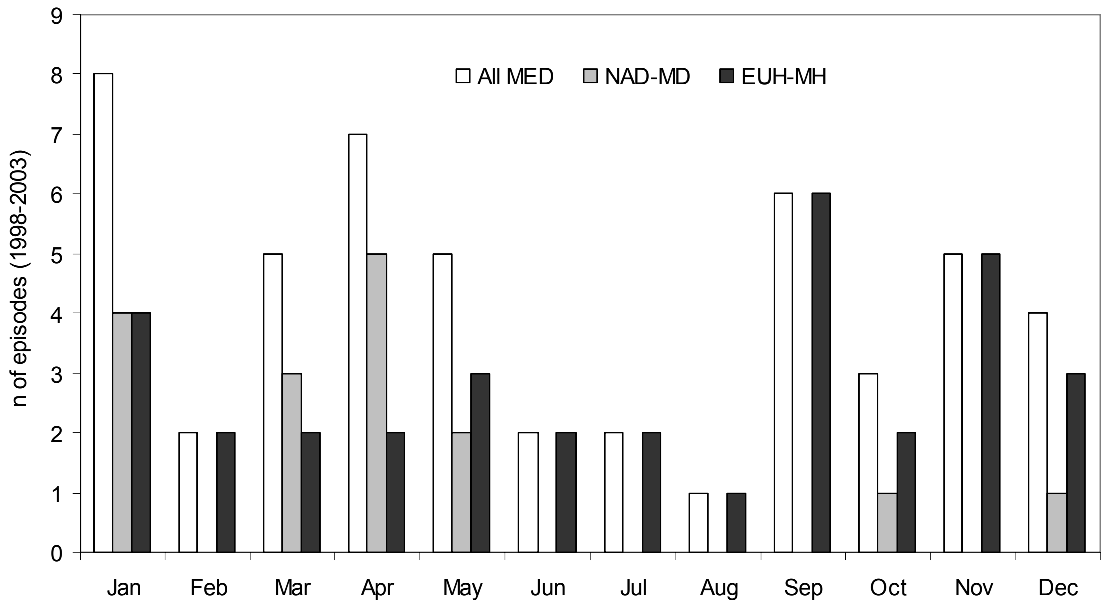

Figure Ap.93. Monthly distribution of the number of Mediterranean episodes over Eastern Iberian Peninsula. The monthly distributions of NAD-MD and EUH-MH Mediterranean events are also shown.

As shown in Figures Ap.94 and Ap.95, the seasonal distribution of the days with Mediterranean advection is characterised by two main maximum frequency periods in January (monthly mean of 3 days) and September-November (with the frequency peak in November with 3 days as monthly mean). A secondary maximum was registered from March to May (with 2 day as monthly mean in March). Focusing on days associated with NAD-MD transport scenario, these were only registered in January (monthly average of 1 day), March-May (1 day as monthly average in all the months of this period) and October (1 day as monthly mean). In November (3 days as monthly average), January (2 days as monthly mean) and September (a monthly mean of 2 days) the frequency of occurrence of days characterised by EUH-MH scenario was high. Although from February to August the number of days associated with EUH-MH situations was low a second order frequency peak was registered in June-July (a total of 5 days in 1998-2003 registered in both months).

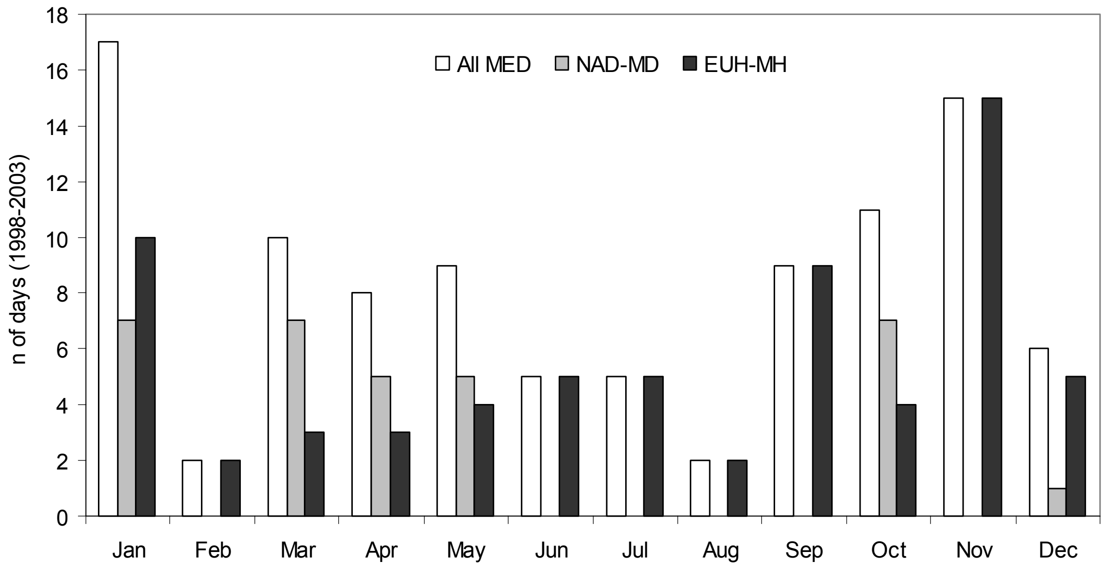

Figure Ap.94. Monthly distribution of the number of days with Mediterranean advection over Eastern Iberian Peninsula. The monthly distributions of days with Mediterranean advection occurred under NAD-MD and EUH-MH scenarios are also shown.

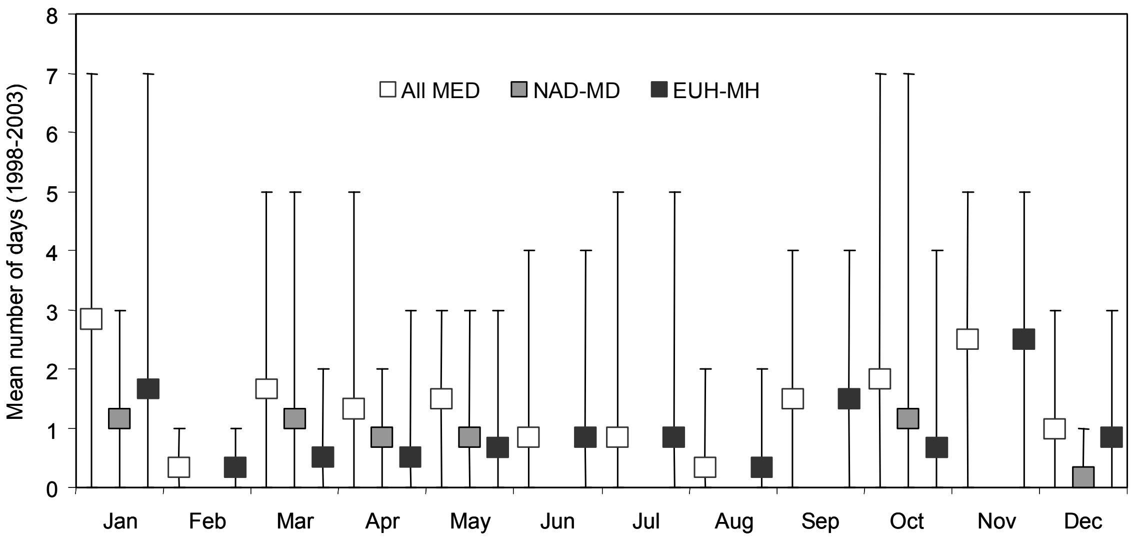

Figure Ap.95. Mean number of days with Mediterranean advection over Eastern Iberian Peninsula per month for 1998-2003. NAD-MD and EUH-MH episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

As shown in Figure Ap.96, the average duration of Mediterranean episodes over Eastern Iberian Peninsula was relatively higher in October-November (4-3 days) and in June-July (3 days). However, the frequency of occurrence of Mediterranean episodes in summer is low. NAD-MD episodes had, on average, the highest duration in October (7 days but in a unique event in 1998-2003). Moreover, in May (3 days), January (2 days) and March (2 days) the mean duration of NAD-MD episodes was relatively high. EUH-MH events had the highest mean duration with 3 days in November, January, June and July.

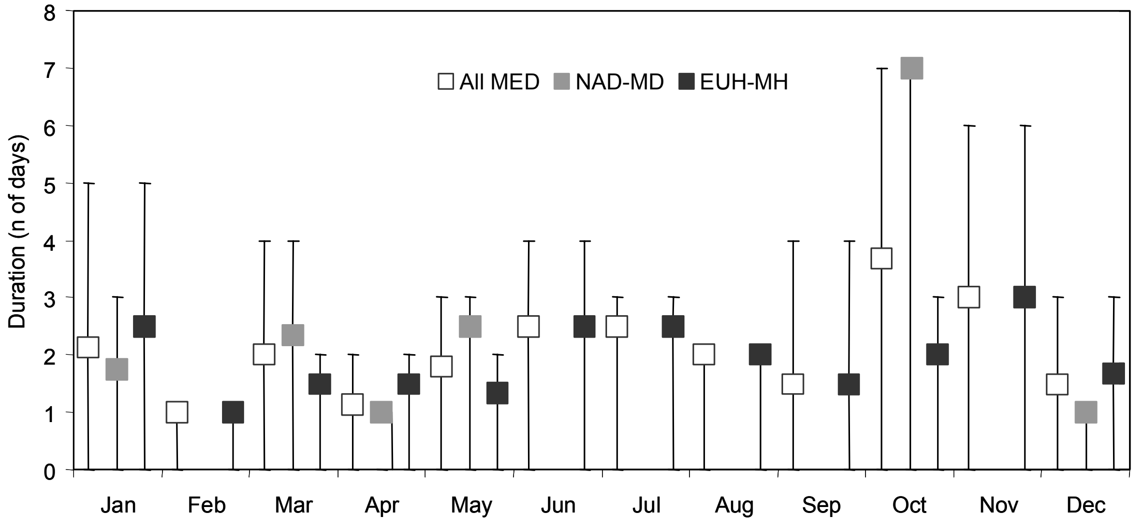

Figure Ap.96. Mean duration of Mediterranean episodes per month over Eastern Iberian Peninsula for 1998-2003. NAD-MD and EUH-MH episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

Low mean PM levels were recorded at Zarra from 1998 to 2003 under situations of transport of Mediterranean air masses over Eastern Iberian Peninsula (18 µgTSP m^{-3}, 10 µgPM10 m^{-3} and 6 µgPM2.5 m^{-3}, Table Ap.104). Compared with the annual mean PM levels at Zarra (23 µgTSP m^{-3}, 16 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3}, Table Ap.104), the mean PM levels measured for Mediterranean events were low probably owing to the important occurrence of rainfall associated with Mediterranean episodes.

Table Ap.104. Mean annual levels of TSP, PM10 and PM2.5 registered in Zarra during Mediterranean advection episodes in 1998-2003.

MED EPISODES	**Zarra**		
(µg m^{-3})	TSP	PM10	PM2.5
1998	na	na	na
1999	21	na	na
2000	23	na	na
2001	16	*12	*7
2002	12	9	6
2003	na	12	5
Mean 98-03	18	10	6

*Calculated with data of 83% of the months of the year
na: Not available

The comparison between the mean PM levels recorded at Zarra during the two transport scenarios differentiated for Mediterranean advection situations is shown in Table Ap.105. These levels are comparable but slightly higher during EUH-MH episodes probably in virtue of a lower occurrence of rainfall associated with this scenario. Means of 12 µgTSP m^{-3}, 10 µgPM10 m^{-3} and 5 µgPM2.5 m^{-3} were recorded during NAD-MD episodes and 20 µgTSP m^{-3}, 11 µgPM10 m^{-3} and 6 µgPM2.5 m^{-3} during EUH-MH.

The impact index (II) of both scenarios was clearly different principally because EUH-MH situations occurred more frequently than NAD-MD situations. II of 0.2 µgTSP m^{-3}, 0.1 µgPM10 m^{-3} and 0.1 µgPM2.5 m^{-3} for NAD-MD scenario and 0.6 µgTSP m^{-3}, 0.3 µgPM10 m^{-3} and 0.2 µgPM2.5 m^{-3} for EUH-MH scenario were registered (Table Ap.105). Nevertheless, these II were considerably low for both scenarios.

Table Ap.105. Number of days with Mediterranean advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 ($\mu g\ m^{-3}$) recorded at Zarra rural site (E Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	NAD-MD	EUH-MH
2003		
Zarra TSP ($\mu g\ m^{-3}$)	-	-
Zarra PM10 ($\mu g\ m^{-3}$)	10	14
Zarra PM2.5 ($\mu g\ m^{-3}$)	5	6
Days	9	6
2002		
Zarra TSP ($\mu g\ m^{-3}$)	13	12
Zarra PM10 ($\mu g\ m^{-3}$)	10	8
Zarra PM2.5 ($\mu g\ m^{-3}$)	6	5
Days	9	11
2001		
Zarra TSP ($\mu g\ m^{-3}$)	10	17
Zarra PM10 ($\mu g\ m^{-3}$)	-	12
Zarra PM2.5 ($\mu g\ m^{-3}$)	-	7
Days	3	12
2000		
Zarra TSP ($\mu g\ m^{-3}$)	9	26
Days	2	8
1999		
Zarra TSP ($\mu g\ m^{-3}$)	13	23
Days	4	22
1998		
Zarra TSP ($\mu g\ m^{-3}$)	-	-
Days	5	8
Mean 98-03 ($\mu g\ m^{-3}$)		
Zarra TSP	12	20
Zarra PM10	10	11
Zarra PM2.5	5	6
Impact Index(II) ($\mu g\ m^{-3}$)		
Zarra TSP	0.2	0.6
Zarra PM10	0.1	0.3
Zarra PM2.5	0.1	0.2

As shown by Table Ap.106, the monthly PM means obtained only for Mediterranean days were high in summer under EUH-MH situations. TSP ranged from 33 to 41 $\mu g\ m^{-3}$ in May-August and, in August, PM10 and PM2.5 levels were 22 and 10 $\mu g\ m^{-3}$ respectively. Moreover, also during EUH-MH events in March the TSP mean levels reached 31 $\mu g\ m^{-3}$.

Table Ap.106. Number of days per month with Mediterranean advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (µg m^{-3}) recorded at Zarra rural site (E Spain) for those days.

	NAD-MD	EUH-MH		NAD-MD	EUH-MH
January			**July**		
Days per month	1.2	1.7	Days per month	0.0	0.8
TSP	9	10	TSP		41
PM10		5	PM10		
PM2.5		4	PM2.5		
February			**August**		
Days per month	0.0	0.3	Days per month	0.0	0.3
TSP		16	TSP		33
PM10		4	PM10		22
PM2.5		3	PM2.5		12
March			**September**		
Days per month	1.2	0.5	Days per month	0.0	1.5
TSP	11	31	TSP		14
PM10	9		PM10		10
PM2.5	6		PM2.5		7
April			**October**		
Days per month	0.8	0.5	Days per month	1.2	0.7
TSP	19		TSP		17
PM10	12	14	PM10	9	
PM2.5	7	6	PM2.5	4	
May			**November**		
Days per month	0.8	0.7	Days per month	0.0	2.5
TSP	12	37	TSP		18
PM10	9		PM10		15
PM2.5	7		PM2.5		7
June			**December**		
Days per month	0.0	0.8	Days per month	0.2	0.8
TSP		33	TSP		11
PM10			PM10		7
PM2.5			PM2.5		4

5.5. Episodes without dominant advective conditions

In 587 days of the period 1998-2003 (98 per year and 8 per month, Table Ap.107) a lack of dominant advective conditions was observed over Eastern Iberia. These days occurred in 176 episodes (29 per year and 2 per month, Table Ap.107) which had a mean duration of 3 days.

In 56% of the 587 days (329 in 1998-2003, 55 per year and 5 per month, Table Ap.107) the lack of advective conditions was caused by the presence of an anticyclone covering completely or partly the Iberian Peninsula out of summer (WIA scenario). The number of WIA events reached 98 (56% of the 176 episodes registered from 1998 to 2003, 16 per year and 1 per month, Table Ap.107). The mean duration of WIA events was 3 days.

In 44% of the 587 days (258 days in 1998-2003, 43 per year and 4 per month, Table Ap.107) the meteorological scenario present was characterised by the development of thermal Iberian low over the Iberian plateau during summer owing to the great heating of the surface (ITL scenario). These days were distributed in 78 episodes (44% of the 176 events recorded in 1998-2003, 13 per year and 1 per month, Table Ap.107). The ITL episodes had a mean extent of 3 days.

As shown in Table Ap.107, the number of episodes without prevailing advective conditions ranged from 22 (in 2002) to 36 (in 1998). Focusing on the two transport scenarios considered in this study, the number of WIA episodes ranged from 12 (in 2002) to 21 (in 1998) and the number of ITL events ranged from 10 (in 2002) to 15 (in both 1998 and 2000).
The number of days in which no advective conditions were detected (Table Ap.107) varied between 59 (in 2002) and 121 (in 1998). The number of days associated with WIA scenario ranged from 33 (in 2002) to 74 (in 1998) and the number of days associated with ITL scenario ranged from 26 (in 2002) to 55 (in 1999).

Table Ap.107. Annual number of days and episodes with lack of advective conditions in the period 1998-2003 over Eastern Iberian Peninsula. The WIA and ITL scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total NOADV	121	99	98	103	59	107	98	8
WIA	74	44	52	60	33	66	55	5
ITL	47	55	46	43	26	41	43	4
Episodes								
Total NOADV	36	27	32	31	22	28	29	2
WIA	21	16	17	17	12	15	16	1
ITL	15	11	15	14	10	13	13	1

The episodes without dominant advective conditions were particularly frequent from late spring to early autumn (Figure Ap.97). During summer months and in particular in July (24 episodes accumulated during 1998-2003 all of them of ITL type) ITL was the only scenario causing such kind of episodes. WIA events, not occurring during summer, were particularly frequent in April-May (15 episodes in May in the study period) and October (13 episodes during this month in the study period).
As for the monthly distribution of episodes without advective conditions, the maximum number of days without prevalent advection occurred in late spring-early autumn. In June-August, averages of 10-11 days without advective conditions, almost all of them of ITL type, occurred. WIA days had their principal maxima in April-May (8 days as a mean in May) and October (a mean of 7 days) although in February (4 days as a mean) a secondary maximum was registered (Figures Ap.98 and Ap.99).
As shown in Figure Ap.97, the frequency of occurrence of episodes without dominant advective conditions was considerably higher from May to October (with very high number of episodes in May and July with 24 and 25 events in 1998-2003) although second order frequency maxima were registered in December (12 episodes in 1998-2003) and February (11 events from 1998 to 2003). Four maxima were registered in the seasonal distribution of the number of WIA episodes registered over Eastern Iberia. In May (20 episodes in the study period) and October (16 events in 1998-2003) first order maxima were registered and in December (12 events in 1998-2003) and February (11 episodes in the study period) second order maxima were registered. With respect to ITL episodes, only registered from May to October, reached the highest frequency of occurrence in July (25 episodes from 1998 to 2003).
As shown in Figures Ap.98 and Ap.99, the number of days in which no advection was observed was considerably higher in May-October (11-13 days as monthly mean in all the months of this period) with a second order maximum in December (6 days as monthly average). The days associated with WIA scenario were very frequent in May and October (11 days as monthly average in both months) and, secondarily, in December (a monthly mean of 6 days). The days characterised by the ITL scenario

were registered mainly from June to September (with monthly averages in this period ranging from 8 to 12 days).

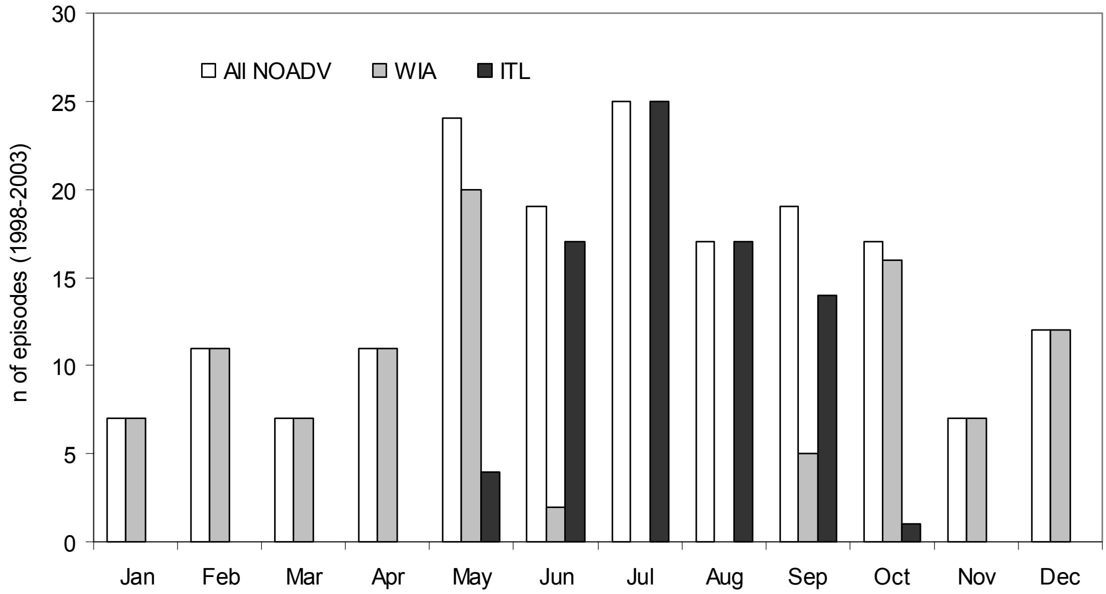

Figure Ap.97. Monthly distribution of the number of episodes without dominant advective conditions over Eastern Iberian Peninsula. The monthly distributions of WIA and ITL events are also shown.

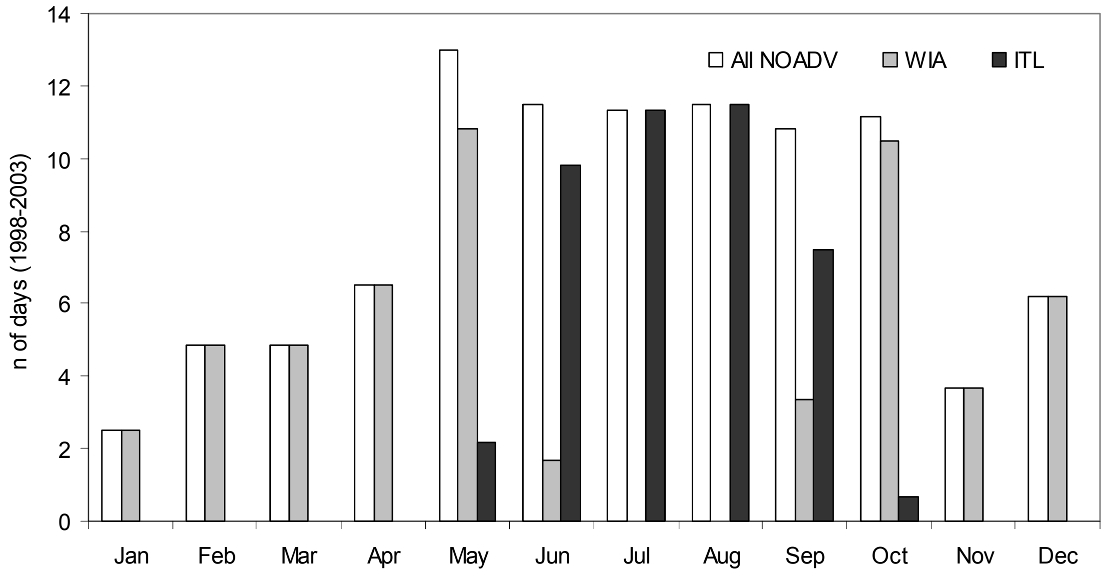

Figure Ap.98. Monthly distribution of the number of days with lack of advective conditions over Eastern Iberian Peninsula. The monthly distributions of days with lack of advective conditions occurred under WIA and ITL scenarios are also shown.

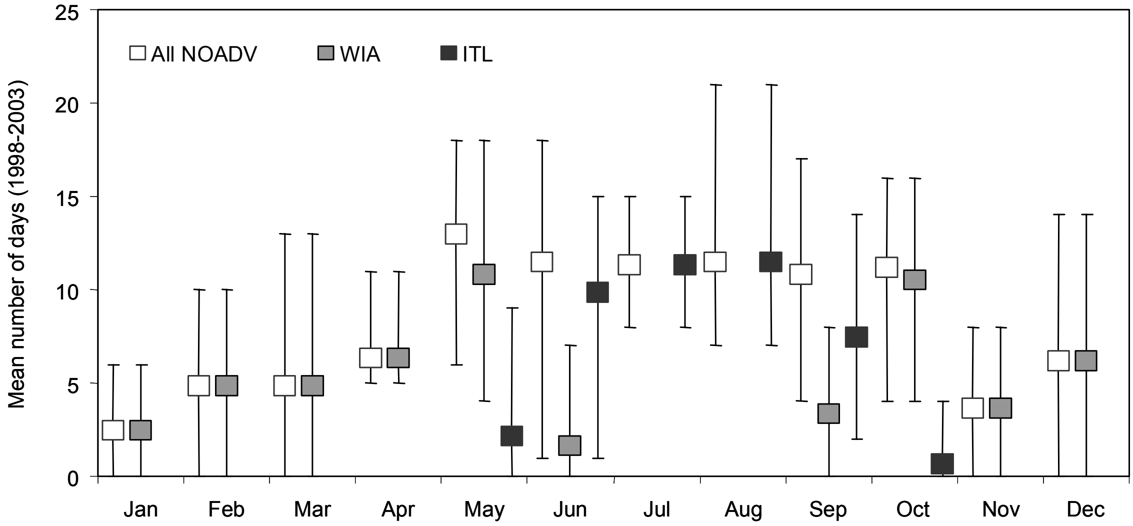

Figure Ap.99. Mean number of days without a dominant air mass advection over Eastern Iberian Peninsula per month for 1998-2003. WIA and ITL episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

As shown in Figure Ap.100, the episodes without dominant advective conditions had a mean duration of 3-4 days in all the months with the exception of January when the mean extent of these events was 2 days. The mean duration of WIA events was also 3-4 in all the months again with the exception of January (2 days) and June (5 days although this could not be generalised as only 2 episodes were recorded in the 6-year study period). With respect to the mean duration of ITL episodes it ranged from 3 to 4 days.

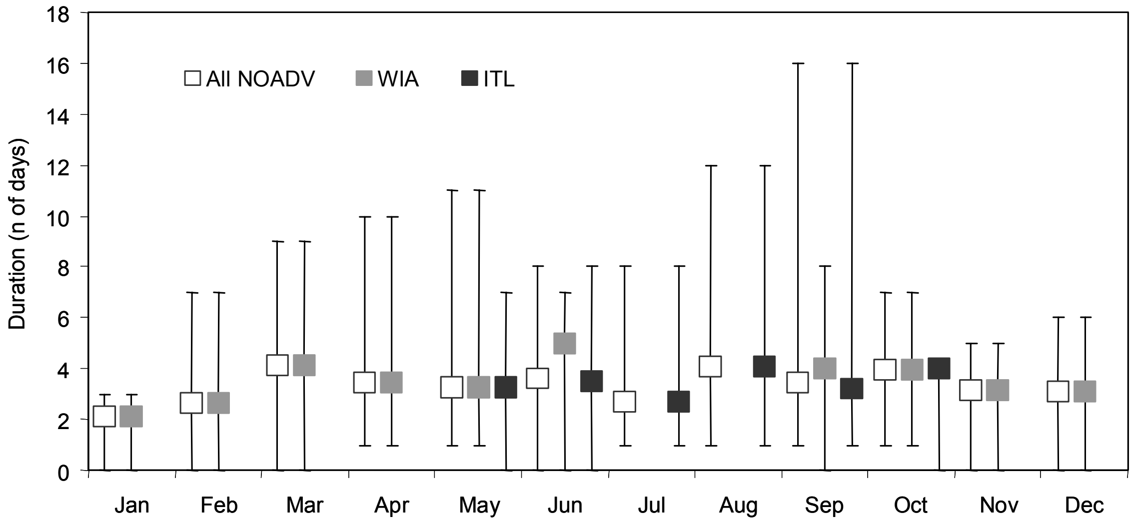

Figure Ap.100. Mean duration of episodes without a dominant air mass advection per month over Eastern Iberian Peninsula for 1998-2003. WIA and ITL episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

As shown in Table Ap.108, the mean PM levels recorded at Zarra during episodes without dominant advective conditions (27 µgTSP m^{-3}, 18 µgPM10 m^{-3} and 10 µgPM2.5 m^{-3}) were somewhat higher than the mean annual PM levels (23 µgTSP m^{-3}, 16 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3}). This can be due to the low rainfall associated with these episodes and to the high mean PM levels recorded in summer during these episodes (especially during ITL events).

Table Ap.108. Mean annual levels of TSP, PM10 and PM2.5 registered in Zarra during episodes without dominant air mass advection in 1998-2003.

NOADV EPISODES ($\mu g\ m^{-3}$)	Zarra		
	TSP	PM10	PM2.5
1998	na	na	na
1999	29	na	na
2000	29	na	na
2001	26	*18	*10
2002	22	16	10
2003	na	18	9
Mean 98-03	27	18	10

*Calculated with data of 83% of the months of the year
na: Not available

The two different transport scenarios resulting in situations of lack of advection were associated with different mean PM levels at Zarra. While WIA episodes gave rise to relatively low mean PM levels (20 µgTSP m^{-3}, 15 µgPM10 m^{-3} and 9 µgPM2.5 m^{-3}, Table Ap.109), ITL events had a very important impact on PM levels (35 µgTSP m^{-3}, 21 µgPM10 m^{-3} and 11 µgPM2.5 m^{-3}, Table Ap.109). These differences can be explained by the low rainfall (although this stands as well for WIA episodes), the aging of air masses, the high rate of re-suspension or the enhancement of transformation of gaseous precursors into secondary aerosols in virtue of the increased photochemistry associated with ITL scenario, together with the recirculation of contaminated air masses typical from the Eastern flank of the Iberian Peninsula in summer, late spring and early autumn (Millan et al., 1997). In the cold part of the year, when WIA events occurred, the dispersive conditions were reduced and the vertical development of the boundary layer was reduced; this is especially intense over urban and/or industrial sites when thermal inversions developed. As Zarra station over Central Iberia is placed at a high location, 885 m.a.s.l., and far from sources of anthropogenic pollutants, the PM levels recorded there during WIA episodes were low. Both scenarios resulted to have considerably high impact index (II) on the annual mean PM levels recorded at Zarra. On one hand, the high mean PM levels associated with ITL scenario explain the relatively high II found for this scenario (4.1 µgTSP m^{-3}, 2.4 µgPM10 m^{-3} and 1.3 µgPM2.5 m^{-3}, Table Ap.109). On the other hand, although the mean PM levels recorded during WIA events were low the high frequency of occurrence of these situations resulted in moderately high II (3.0 µgTSP m^{-3}, 2.3 µgPM10 m^{-3} and 1.3 µgPM2.5 m^{-3}, Table Ap.109).

Table Ap.109. Number of days without a dominant air mass advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 ($\mu g\ m^{-3}$) recorded at Zarra rural site (E Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	WIA	**ITL**
2003		
Zarra TSP ($\mu g\ m^{-3}$)	-	-
Zarra PM10 ($\mu g\ m^{-3}$)	17	20
Zarra PM2.5 ($\mu g\ m^{-3}$)	9	10
Days	66	41
2002		
Zarra TSP ($\mu g\ m^{-3}$)	19	26
Zarra PM10 ($\mu g\ m^{-3}$)	14	19
Zarra PM2.5 ($\mu g\ m^{-3}$)	9	11
Days	33	26
2001		
Zarra TSP ($\mu g\ m^{-3}$)	18	37
Zarra PM10 ($\mu g\ m^{-3}$)	14	22
Zarra PM2.5 ($\mu g\ m^{-3}$)	9	12
Days	60	43
2000		
Zarra TSP ($\mu g\ m^{-3}$)	20	38
Days	52	46
1999		
Zarra TSP ($\mu g\ m^{-3}$)	22	34
Days	44	55
1998		
Zarra TSP ($\mu g\ m^{-3}$)	-	-
Days	74	47
Mean 98-03 ($\mu g\ m^{-3}$)		
Zarra TSP	20	35
Zarra PM10	15	21
Zarra PM2.5	9	11
Impact Index(II) ($\mu g\ m^{-3}$)		
Zarra TSP	3.0	4.1
Zarra PM10	2.3	2.4
Zarra PM2.5	1.3	1.3

Considering only days with lack of dominant advective conditions over Eastern Iberian Peninsula, the highest monthly PM means were recorded at Zarra in summer under ITL situations (the ranges of monthly PM means were 30-37 µgTSP m^{-3}, 18-21 µgPM10 m^{-3} and 9-11 µgPM2.5 m^{-3}, from May to October, Table Ap.110). For WIA situations, with the exception of June (32 µgTSP m^{-3}, 23 µgPM10 m^{-3} and 17 µgPM2.5 m^{-3} although these episodes were not common in this month, Table Ap.110), low monthly PM means were recorded (ranges of 10-29 µgTSP m^{-3}, 10-19 µgPM10 m^{-3} and 8-11 µgPM2.5 m^{-3}, Table Ap.110).

Table Ap.110. Number of days per month without advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 ($\mu g\ m^{-3}$) recorded at Zarra rural site (E Spain) for those days.

	WIA	ITL		WIA	ITL
January			**July**		
Days per month	2.5	0.0	Days per month	0.0	11.3
TSP	19		TSP		37
PM10			PM10		21
PM2.5			PM2.5		11
February			**August**		
Days per month	4.8	0.0	Days per month	0.0	11.5
TSP	19		TSP		35
PM10	16		PM10		21
PM2.5	9		PM2.5		11
March			**September**		
Days per month	4.8	0.0	Days per month	3.3	7.5
TSP	29		TSP	20	30
PM10	19		PM10	19	20
PM2.5	9		PM2.5	11	11
April			**October**		
Days per month	6.5	0.0	Days per month	10.5	0.7
TSP	23		TSP	20	32
PM10	15		PM10	14	
PM2.5	9		PM2.5	8	
May			**November**		
Days per month	10.8	2.2	Days per month	3.7	0.0
TSP	20	36	TSP	17	
PM10	15	18	PM10	15	
PM2.5	8	9	PM2.5	10	
June			**December**		
Days per month	1.7	9.8	Days per month	6.2	0.0
TSP	32	37	TSP	10	
PM10	23	21	PM10	10	
PM2.5	17	11	PM2.5	8	

6. Southwestern Iberian Peninsula

As shown in Table Ap.111, the most common type of air mass long range transport over Southwestern Iberian Peninsula in 1998-2003 was the advection of Atlantic air masses. This situation occurred in 1254 days (57% of the total number of days in the study period) grouped in 245 events. In 418 days (19% of the total number of days in 1998-2003) of the study period the transport of African air masses were observed over Southwestern Iberia. These days were distributed in 139 African dust outbreaks. The number of episodes without prevailing advective conditions reached 110 in 1998-2003. These resulted in 344 days (16% of the days in the study period). Less frequent were the Mediterranean events with a total of 51 episodes in 1998-2003 which resulted in 103 days (5% of the days in 1998-2003). In 72 days of the study period (3% of the days from 1998 to 2003) the long range transport of European air masses reached Southwestern Iberia. These days were grouped in 29 episodes.

Table Ap.111. Number of days, % of days and episodes with Atlantic (ATL), North African (NAF), Mediterranean (MED) and European (EU) advection and without a prevalent advective regime (NOADV) in Southwestern Iberia for the period 1998-2003.

1998-2003	ATL	NAF	MED	EU	NOADV
Number of days	1254	418	103	72	344
% of days	57	19	5	3	16
Number of events	245	139	51	29	110

Daily data on PM levels from one air quality station belonging to the EMEP network were used for this study. This station is located at Barcarrota (38º 29' N, 6º 55' W, 393 m.a.s.l.). TSP data from this station were available from March 1999 to January 2003 while PM10 and PM2.5 daily data were available from March 2001 to the end of 2003. The sampling was performed using the gravimetric method with high volume samplers.
As shown in Table Ap.112, the mean PM levels recorded at Barcarrota during 1998-2003 were low (23 µgTSP m^{-3}, 16 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3}). The 1999/30/CE Directive established limit values for 2005 (40 µgPM10 m^{-3}) and 2010 (20 µgPM10 m^{-3}). AS expected, the annual means in the period 1998-2003 in Barcarrota did not exceed any of those two limit values.

Table Ap.112. Mean levels of TSP, PM10 and PM2.5 recorded in Barcarrota in 1998-2003.

MEAN LEVELS	Barcarrota		
(µg m^{-3})	TSP	PM10	PM2.5
1998	na	na	na
1999	*[1]30	na	na
2000	29	na	na
2001	28	*[2]19	*[2]11
2002	25	16	12
2003	na	17	8
Mean 98-03	27	17	11

*[1]Calculated with data of 83% of the months of the year
*[2]Calculated with data of 83% of the months of the year
na: Not available

6.1. Atlantic episodes

In the study period (1998-2003), the number of days in which Atlantic air masses affecting Southwestern Iberia reached 1254 (209 days per year and 17 per month,

Table Ap.113). These days were grouped in 245 episodes (41 per year and 3 per month, Table Ap.113) with a mean duration of 5 days.
In 1088 days of the 1254 in the study period (87% of the days with Atlantic advection in 1998-2003, 181 per year and 15 per month, Table Ap.113), the meteorological situation driving the atmospheric transport was characterised by the presence of the Azores high and the Iceland low on their standard locations (AZH-NAtD scenario). These days were distributed in 187 events (76% of the total number of Atlantic episodes in 1998-2003, 31 per year and 3 per month, Table Ap.113). The mean duration of AZH-NAtD episodes reached 6 days.
In the remaining 166 of the 1254 days (13% of the days with Atlantic advection in 1998-2003, 28 per year and 2 per month, Table Ap.113) the meteorological scenario was characterised by the development of depressions in front of the Portuguese coast (AD scenario). Concerning the number of AD events these reached 58 (resulting in 24% of the 245 Atlantic episodes occurred in the study period, 10 per year and 1 per month, Table Ap.113). These episodes had a mean duration of 3 days.
As shown in Table Ap.113, the annual number of days in which Atlantic air masses affected Southwestern Iberian Peninsula ranged from 188 (in 2003) to 227 (in 1999). The number of days associated with AZH-NAtD situations ranged from 145 (in 2003) to 204 (in 1999) while the number of days associated with AD scenario ranged from 18 (2001) to 43 (2003).
The number of Atlantic episodes from 1998-2003 occurring over Southwestern Iberia ranged from 36 (in 1998) to 46 (in 2000). The range of occurrence of AZH-NAtD episodes varied between 29 (in 2002) and 35 (in 2000) while this range varied from 5 (in 1998) to 15 (in 2003) for the case of AD episodes (Table Ap.113).

Table Ap.113. Annual number of days and episodes with Atlantic advection in the period 1998-2003 over Southwestern Iberian Peninsula. The AZH-NAtD and AD scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total ATL	203	227	212	202	222	188	209	17
AZH-NAtD	178	204	177	184	200	145	181	15
AD	25	23	35	18	22	43	28	2
Episodes								
Total ATL	36	41	46	37	40	45	41	3
AZH-NAtD	31	32	35	30	29	30	31	3
AD	5	9	11	7	11	15	10	1

As shown in Figure Ap.101, the occurrence of Atlantic episodes over Southwestern Iberia during 1998-2003 showed a seasonal distribution characterised by three maxima. These occurred in July (26 events in 1998-2003), January (25 episodes from 1998 to 2003) and October (23 events in the study period). However, Atlantic episodes were registered during all the months with relatively high frequency (September marked the minimum frequency with 16 events in 1998-2003). As AZH-NAtD episodes concern, a clear summer frequency peak was observed (24 episodes in July from 1998 to 2003) together with two second order maxima in January and October (18 events during the study period in both months). AD episodes practically did not occur over the study area in summer and reached their maximum frequency of occurrence in December (9 events in 1998-2003). Other two relative maxima in the seasonal distribution of AD episodes were registered in April (8 episodes from 1998 to 2003) and October (5 episodes in the study period).

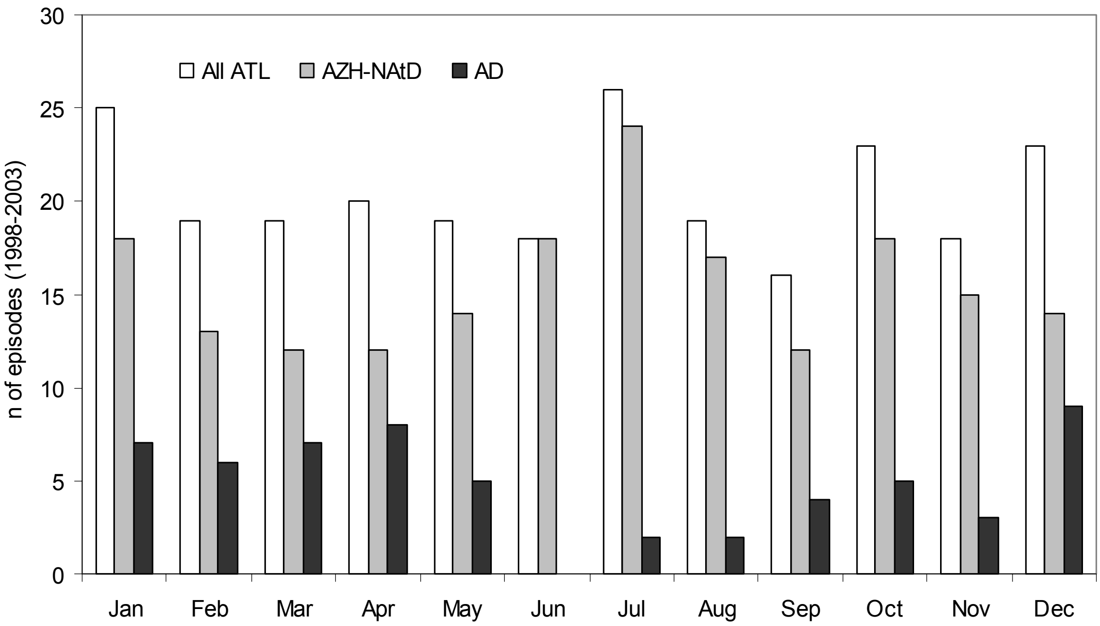

Figure Ap.101. Monthly distribution of the number of Atlantic episodes over Southwestern Iberian Peninsula. The monthly distributions of AZH-NAtD and AD Atlantic events are also shown.

As shown by Figures Ap.102 and Ap.103, April (27 days as monthly mean), January (with a monthly average of 22 days), November (a monthly mean of 21 days) and, secondarily, July-August (18 days as monthly mean in July) were the periods in which advection of Atlantic air masses most commonly occurred over Southwestern Iberia in 1998-2003. By contrast, May-June (12 days as monthly average in June), February-March (14 days as monthly mean in March) and September (monthly mean of 14 days) were periods characterised by a low frequency of occurrence of days with Atlantic advection. In the same periods in which the occurrence of days with Atlantic advection was frequent, the days associated with AZH-NAtD scenario reached also a high frequency of occurrence (22, 20, 19 and 17 days as monthly means in April, November, January and July respectively). The days characterised by the presence of an AD meteorological scenario were especially frequent in April (5 days as monthly mean), September (4 days as monthly average) and December (a monthly average of 4 days).

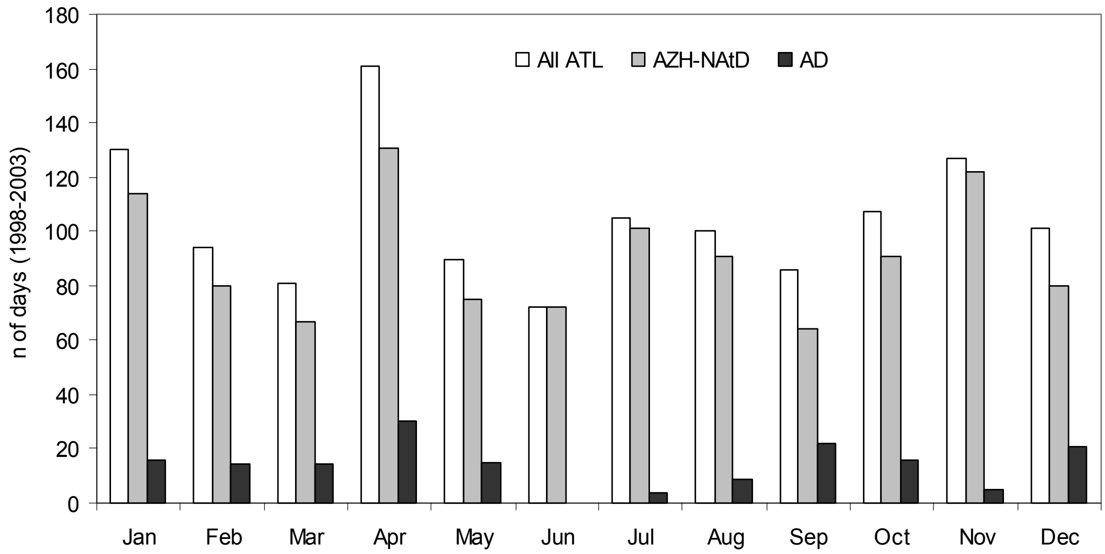

Figure Ap.102. Monthly distribution of the number of days with Atlantic advection over Southwestern Iberian Peninsula. The monthly distributions of days with Atlantic advection occurred under AZH-NAtD and AD scenarios are also shown.

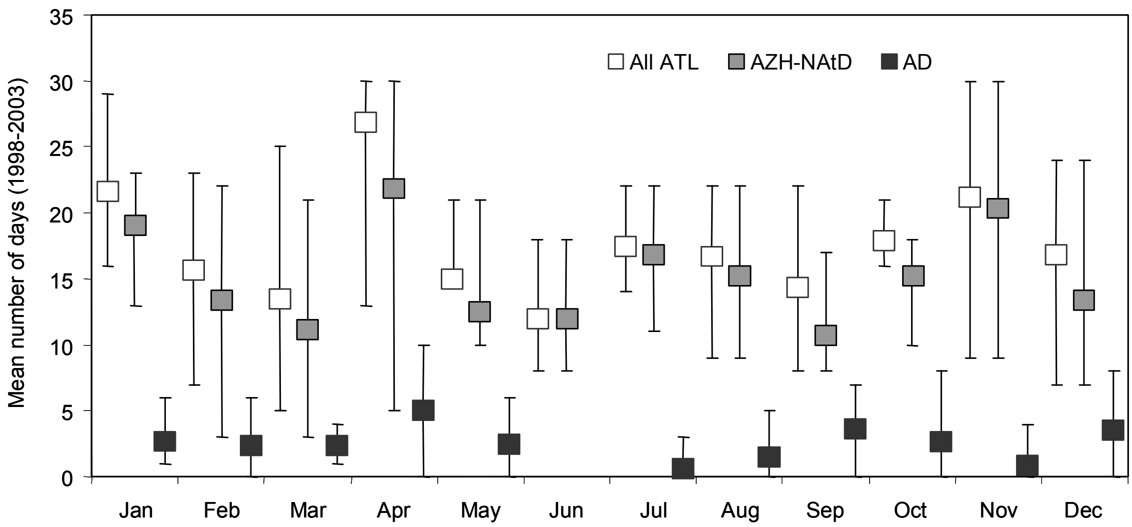

Figure Ap.103. Mean number of days with Atlantic advection over Southwestern Iberian Peninsula per month for 1998-2003. AZH-NAtD and AD episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

As shown in Figure Ap.104, the mean duration of Atlantic episodes was the longest in April (8 days as a mean) and November (7 days on average). In the rest of the months the mean duration of Atlantic events ranged from 4 to 5 days. With respect to the mean duration of AZH-NAtD episodes, these reached to 11 days in April and 8 days in September. AD events were, in general, shorter with the longest durations occurring in August-September (5 and 6 days as mean durations respectively).

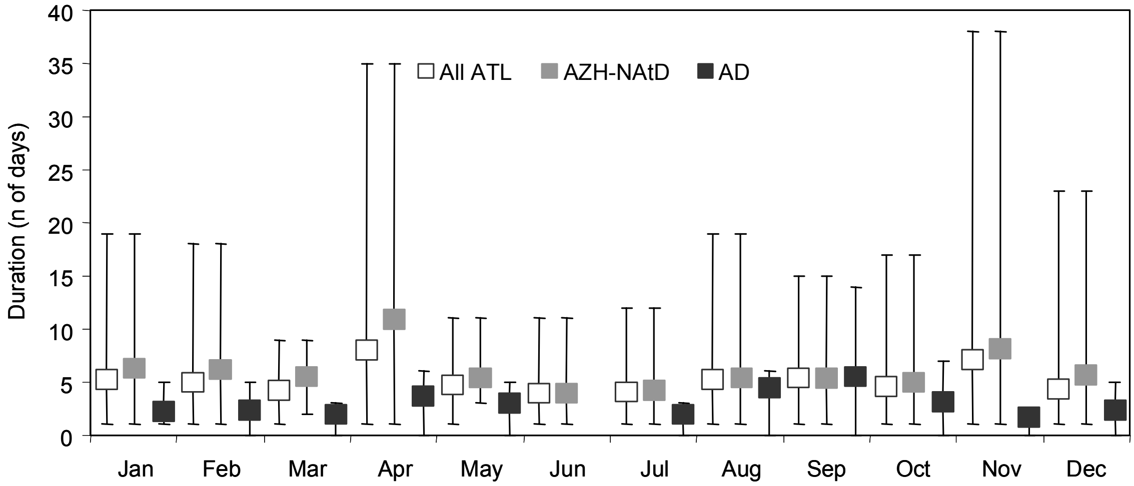

Figure Ap.104. Mean duration of Atlantic episodes per month over Southwestern Iberian Peninsula for 1998-2003. AZH-NAtD and AD episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

Table Ap.114 shows the mean PM levels recorded at Barcarrota during episodes of Atlantic advection over Southwestern Iberian Peninsula. These reached 21 µgTSP m^{-3}, 13 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3}, values below the annual mean PM levels at this station (27 µgTSP m^{-3}, 17 µgPM10 m^{-3} and 11 µgPM2.5 m^{-3}). The relative low concentration of pollutants in Atlantic air masses and the washing out produced by the rain associated with the passage of frontal systems during Atlantic episodes resulted in those low PM levels. Under these circumstances most of the PM load could be attributed to local/regional contributions.

Table Ap.114. Mean annual levels of TSP, PM10 and PM2.5 registered in Barcarrota during Atlantic advection episodes in 1998-2003.

ATL EPISODES	**Barcarrota**		
(µg m^{-3})	TSP	PM10	PM2.5
1998	na	na	na
1999	*[1]26	na	na
2000	21	na	na
2001	20	*[2]14	*[2]8
2002	19	12	9
2003	na	12	6
Mean 98-03	21	13	8

*[1]Calculated with data of 83% of the months of the year
*[2]Calculated with data of 83% of the months of the year
na: Not available

During the two types of Atlantic episodes distinguished in this study different mean PM levels were recorded at Barcarrota. AZH-NAtD events (22 µgTSP m^{-3}, 13 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3}, Table Ap.115) were associated with higher PM levels than AD episodes (14 µgTSP m^{-3}, 9 µgPM10 m^{-3} and 4 µgPM2.5 m^{-3}, Table Ap.115) in virtue of the higher degree of occurrence of rain during AD events.
The impact index (II) for AZH-NAtD scenario reached 10.8 µgTSP m^{-3}, 6.5 µgPM10 m^{-3} and 4.1 µgPM2.5 m^{-3} while, for AD scenario only reached 1.1 µgTSP m^{-3}, 0.7 µgPM10 m^{-3} and 0.3 µgPM2.5 m^{-3} (Table Ap.115). These differences on II are explained by the different frequency of occurrence and the mean PM levels recorded for the two Atlantic scenarios.

Table Ap.115. Number of days with Atlantic advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (µg m^{-3}) recorded at Barcarrota rural site (SW Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	AZH-NAtD	**AD**
2003		
Barcarrota TSP (µg m^{-3})	-	-
Barcarrota PM10 (µg m^{-3})	13	8
Barcarrota PM2.5 (µg m^{-3})	6	3
Days	145	43
2002		
Barcarrota TSP (µg m^{-3})	20	12
Barcarrota PM10 (µg m^{-3})	13	8
Barcarrota PM2.5 (µg m^{-3})	10	5
Days	200	22
2001		
Barcarrota TSP (µg m^{-3})	21	13
Barcarrota PM10 (µg m^{-3})	14	13
Barcarrota PM2.5 (µg m^{-3})	8	7
Days	184	18
2000		
Barcarrota TSP (µg m^{-3})	21	16
Days	177	35
1999		
Barcarrota TSP (µg m^{-3})	27	17
Days	204	23
1998		
Barcarrota TSP (µg m^{-3})	-	-
Days	178	25
Mean 98-03 (µg m^{-3})		
Barcarrota TSP	22	14
Barcarrota PM10	13	9
Barcarrota PM2.5	8	4
Impact Index(II) (µg m^{-3})		
Barcarrota TSP	10.8	1.1
Barcarrota PM10	6.5	0.7
Barcarrota PM2.5	4.1	0.3

The highest monthly PM means for Atlantic episodes were recorded in summer and, especially, under AZH-NAtD scenario (24-40 µgTSP m^{-3}, 14-21 µgPM10 m^{-3} and 8-14 µgPM2.5 m^{-3} from June to September and 10-27 µgTSP m^{-3}, 8-13 µgPM10 m^{-3} and 5-9 µgPM2.5 m^{-3} in the rest of the year, Table Ap.116). The levels recorded during AD in summer (24-40 µgTSP m^{-3}, 14-21 µgPM10 m^{-3} and 8-14 µgPM2.5 m^{-3}, Table Ap.116) were also higher than in winter (10-27 µgTSP m^{-3}, 8-13 µgPM10 m^{-3} and 5-9 µgPM2.5 m^{-3}, Table Ap.116). Summer PM levels are relative higher in virtue of the intensification of re-suspension of soil material, the formation of secondary aerosols by photochemistry and also due to the scarce precipitation.

Table Ap.116. Number of days per month with Atlantic advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 ($\mu g\ m^{-3}$) recorded at Barcarrota rural site (SW Spain) for those days.

	AZH-NAtD	AD		AZH-NAtD	AD
January			**July**		
Days per month	19.0	2.7	Days per month	16.8	0.7
TSP	12	9	TSP	40	27
PM10	8		PM10	19	
PM2.5	5		PM2.5	14	
February			**August**		
Days per month	13.3	2.3	Days per month	15.2	1.5
TSP	14	17	TSP	35	18
PM10	10	5	PM10	21	14
PM2.5	6	3	PM2.5	13	6
March			**September**		
Days per month	11.2	2.3	Days per month	10.7	3.7
TSP	16	13	TSP	24	13
PM10	10	8	PM10	17	11
PM2.5	6	3	PM2.5	11	6
April			**October**		
Days per month	21.8	5.0	Days per month	15.2	2.7
TSP	27	14	TSP	15	14
PM10	13	6	PM10	11	9
PM2.5	8	4	PM2.5	5	3
May			**November**		
Days per month	12.5	2.5	Days per month	20.3	0.8
TSP	26	16	TSP	13	9
PM10	13	13	PM10	9	7
PM2.5	9	8	PM2.5	5	2
June			**December**		
Days per month	12.0	0.0	Days per month	13.3	3.5
TSP	30		TSP	10	16
PM10	14		PM10	8	7
PM2.5	8		PM2.5	5	3

6.2. African episodes

In 418 days (70 per year and 6 per month, Table Ap.117) of the period 1998-2003 African air masses reached Southwestern Iberian Peninsula. These days were grouped in 139 episodes (23 per year and 2 per month, Table Ap.117) with a mean duration of 3 days.

The synoptic scenario associated with the transport of African air masses over the study area in 65 days (16% of the 418 days, 11 per year and 1 per month, Table Ap.117) grouped in 16 episodes (12% of the 139 events, 3 per year, Table Ap.117) was characterised by the presence of an anticyclone over Northern Africa and the Iberian Peninsula at surface level (NAH-S scenario). These episodes had a mean duration of 5 days.

A total of 41 African dust outbreaks (29% of the 139 episodes, 7 per year and 1 per month, Table Ap.117) resulting in 111 days (27% of the 418 days, 19 per year and 2 per month, Table Ap.117) occurred when a depression developed over the Atlantic by the Portuguese coast (AD scenario). These episodes reached an average duration of 3 days.

In 47 days of the 418 registered in 1998-2003 (11% of the 418 days, 8 per year and 1 per month, Table Ap.117) the meteorological scenario responsible for the transport

was characterised by the presence of depressions over Northern Africa (NAD scenario). These days were grouped in 21 episodes (15% of the 139 episodes, 4 per year, Table Ap.117) with a mean duration of 2 days.
The most common type of African event over Southwestern Iberian Peninsula was characterised by the presence of an anticyclone shifted at high atmospheric levels over North Africa or the Iberian Peninsula (NAH-A scenario). These situations resulted in 61 episodes (44% of the 139 episodes, 10 per year and 1 per month, Table Ap.117) and 195 days (47% of the 418 days, 33 per year and 3 per month, Table Ap.117) in the study period. NAH-A events had an average duration of 3 days.
As shown in Table Ap.117, the number of days with African advection over the study area in 1998-2003 ranged from 48 (in 1999) to 78 (in 2002). The number of days associated with the different transport scenarios varied in the following ranges: 0 (in 2001) to 22 (in 2002) for NAH-S, 10 (in 1999) to 28 (in 2001) for AD, 5 (in 1998, 2000 and 2002) to 13 (in 2003) for NAD, and 21 (in 1999) to 42 (in 2003) for NAH-A.
As the number of African episodes concern, their occurrence ranged from 18 (in 1998) to 26 (in 2000, 2001 and 2002). The following ranges of occurrence were observed for the different scenarios of African air mass transport: 0 (in 2001) to 5 (in 2002) for NAH-S events, 4 (in 1998) to 9 (in 2001) for AD episodes, 1 (in 2000) to 7 (in 2001) for NAD events, and 8 (in 1998 and 1999) to 14 (in 2000) for NAH-A (Table Ap.117).

Table Ap.117. Annual number of days and episodes with African advection in the period 1998-2003 over Southwestern Iberian Peninsula. The NAH-S, AD, NAD and NAH-A scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total NAF	64	48	79	72	78	77	70	6
NAH-S	17	9	14	0	22	3	11	1
AD	19	10	24	28	11	19	19	2
NAD	5	8	5	11	5	13	8	1
NAH-A	23	21	36	33	40	42	33	3
Episodes								
Total NAF	18	20	26	26	26	21	23	2
NAH-S	4	2	3	0	5	2	3	<1
AD	4	5	8	9	7	6	7	1
NAD	2	5	1	7	2	4	4	<1
NAH-A	8	8	14	10	12	9	10	1

Two periods of maximum frequency of occurrence of African events over Southwestern Iberian Peninsula might be distinguished in Figure Ap.105. During May-August (20 episodes in July in 1998-2003) and March (16 episodes from 1998-2003) peaks of frequency were evident while the minimum frequency was obtained for April (5 events in the whole study period). The occurrence of different transport scenarios had a marked seasonal trend. Most of the NAH-S events were registered from January to March (reaching up to 4 in both February and March from 1998 to 2003) although a number of events (a total of 5 in the study period) were also observed from September to December. March and December (9 events in both months) were the months with the highest number of AD events in 1998-2003. Also in May (5 episodes from 1998 to 2003), the number of AD episodes was relatively high. NAD episodes were mainly registered in the study area in spring (reaching up to 4 episodes in May in the 6-years period) and in October-November (4 episodes in October from 1998 to 2003). Summer months were practically devoid of AD and NAD events. Finally, NAH-A episodes were only registered from late spring to early autumn (with especial intensity in the period June-August with a range of 14-20 episodes during 1998-2003).

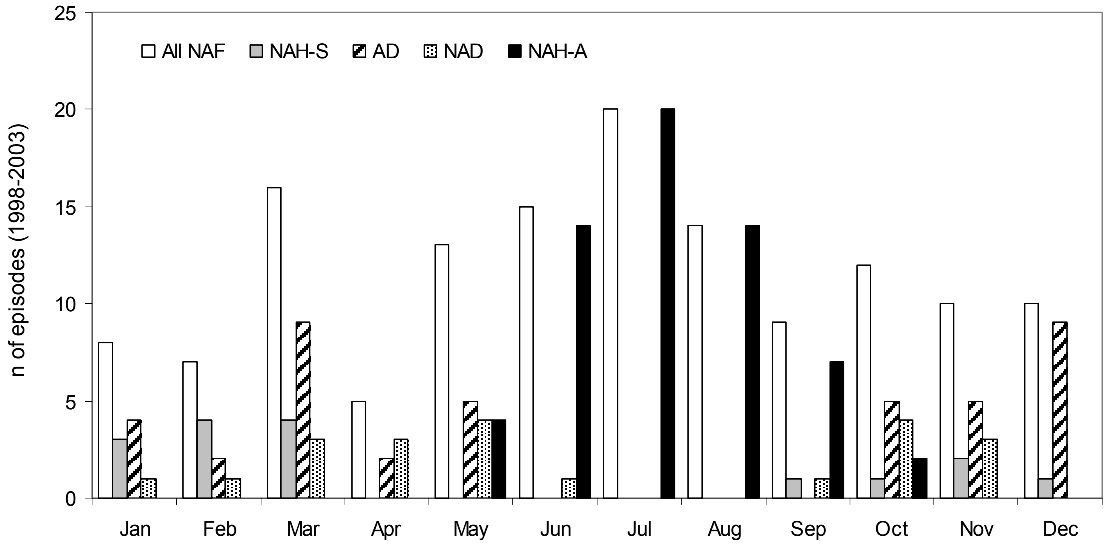

Figure Ap.105. Monthly distribution of the number of African episodes over Southwestern Iberian Peninsula. The monthly distributions of NAH-S, AD, NAD and NAH-A African events are also shown.

The frequency of occurrence of days with African advection over Southwestern Iberian Peninsula (Figures Ap.106 and Ap.107) was the maximum in two periods. These were June to August (with the peak in June with 11 days as monthly mean) and March (9 days as monthly mean). In April the number of days with African advection was the lowest with only 2 days as monthly mean. Distinguishing the different transport scenarios, NAH-S situations occurred mainly from January to March (4 days as monthly mean in both February and March) although a few days associated with this scenario were registered in September-December (reaching up to 1 day as monthly average in November). The days characterised by African transport of AD type occurred solely from October to May with frequency maxima in March and December with 4 days as monthly mean in both cases. The monthly mean number of days associated with NAD scenario only reached values above 1 in October-November (reaching up to 2 days in October as the annual absolute maximum), March and May. NAH-A situations were only observed to develop from late spring to early autumn but with higher relative frequency in June-August (reaching up to 11 days as monthly average in June).

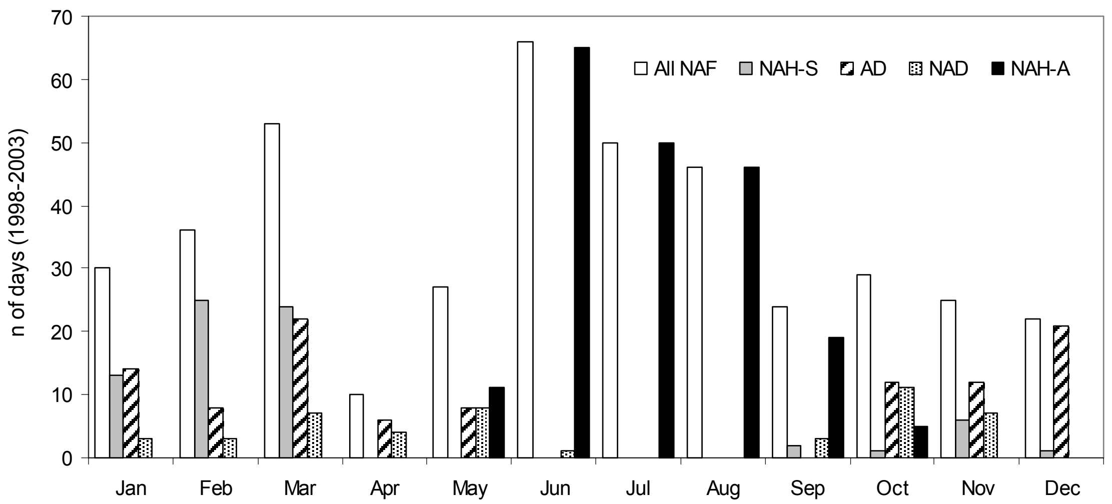

Figure Ap.106. Monthly distribution of the number of days with African advection over Southwestern Iberian Peninsula. The monthly distributions of days with African advection occurred under NAH-S, AD, NAD and NAH-A scenarios are also shown.

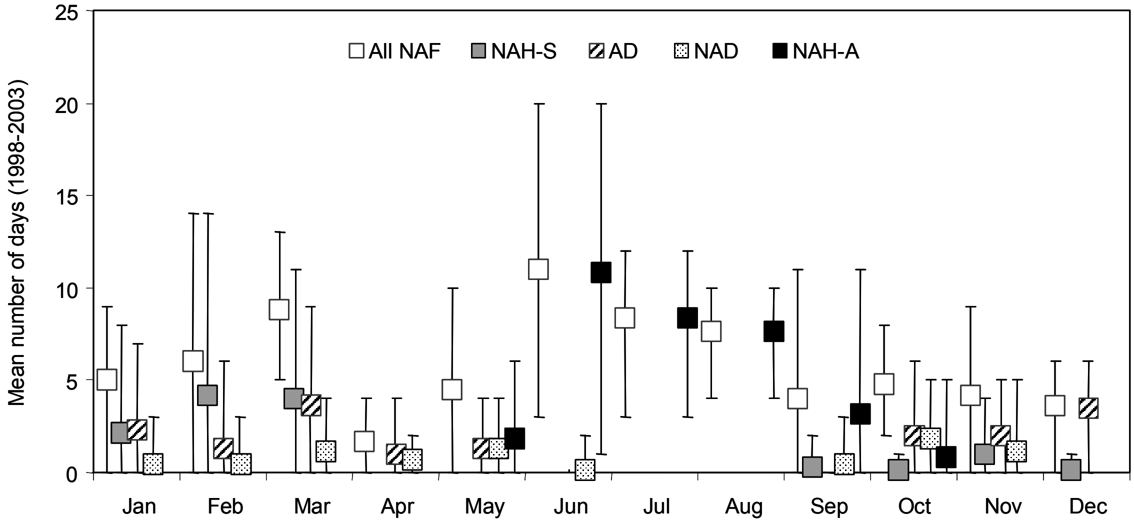

Figure Ap.107. Mean number of days with African advection over Southwestern Iberian Peninsula per month for 1998-2003. NAH-S, AD, NAD and NAH-A episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

The mean duration of the African events occurred over Southwestern Iberia was relatively longer in January-March (up to 5 days in February) and in June (4 days). The mean duration of NAH-S episodes reached 6 days in both February and March; the mean duration of AD episodes reached to its maximum duration in January and February (4 days as mean duration on both months); NAD events were, on average, longer in January-February and September-October (with mean durations of 3 days in these four months); finally, the mean duration of NAH-A events reached up to 5 days in June (Figure Ap.108).

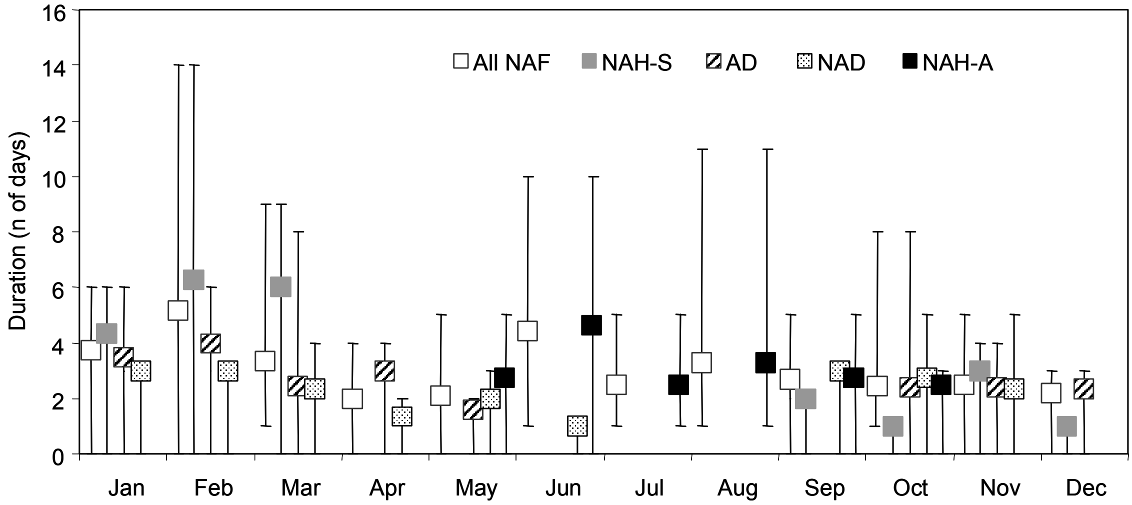

Figure Ap.108. Mean duration of African episodes per month over Southwestern Iberian Peninsula for 1998-2003. NAH-S, AD, NAD and NAH-A episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

Owing to the important dust loads in African air masses, the mean PM levels recorded at Barcarrota during African dust outbreaks were very high (41 µgTSP m^{-3}, 27 µgPM10 m^{-3} and 16 µgPM2.5 m^{-3}, Table Ap.118) when compared with the mean annual PM levels at this station for 1998-2003 (27 µgTSP m^{-3}, 17 µgPM10 m^{-3} and 11 µgPM2.5 m^{-3}).

Table Ap.118. Mean annual levels of TSP, PM10 and PM2.5 registered in Barcarrota during African advection episodes in 1998-2003.

NAF EPISODES	**Barcarrota**		
(µg m^{-3})	TSP	PM10	PM2.5
1998	na	na	na
1999	*[1]41	na	na
2000	42	na	na
2001	45	*[2]30	*[2]16
2002	37	24	19
2003	na	27	12
Mean 98-03	41	27	16

*[1]Calculated with data of 83% of the months of the year
*[2]Calculated with data of 83% of the months of the year
na: Not available

As shown in Table Ap.119, during the different transport scenarios the mean PM levels recorded at Barcarrota differed greatly. The highest mean PM levels were recorded during NAH-A episodes (50 µgTSP m^{-3}, 30 µgPM10 m^{-3} and 20 µgPM2.5 m^{-3}). These events occurred mainly in summer when precipitation is reduced and re-suspension is enhanced. These two factors contributed to increase PM levels. Moreover, during NAH-A episodes the transport of African air masses occurred at high altitudes (>1500 m.a.s.l.) and the dust penetrates in the mixing layer because the vertical development of this layer can reach up to 2500 metres over continental areas in summer (Crespi et al., 1995). Once into the boundary layer the dust is distributed and affects the sampling stations. Simultanously, at surface, a low baric gradient occurred across the Iberian Peninsula. In consequence, the renovation of superficial air masses is poor and, owing to the important insolation, the photochemical generation of secondary species from gaseous precursors contributed also to regionally increase PM levels. The lowest mean PM levels were recorded during AD episodes (27 µgTSP m^{-3}, 22 µgPM10 m^{-3} and 9 µgPM2.5 m^{-3}) in virtue of the frequent rainfall. During NAH-S and NAD the mean PM levels at Barcarrota were similar and considerably high (36 µgTSP m^{-3}, 24 µgPM10 m^{-3}, 13 µgPM2.5 m^{-3} during NAH-S episodes and 40 µgTSP m^{-3}, 23 µgPM10 m^{-3}, 12 µgPM2.5 m^{-3} during NAD events). During NAH-S episodes the anticyclonic conditions occurring over the Iberian Peninsula resulted in high PM levels. With respect to NAD episodes, the vicinity of the study area to the source areas of the desert dust is a factor that could explain those high PM levels because the dilution and dispersion of the crustal aerosols was reduced with respect to other regions over the Iberian Peninsula. However, these episodes were associated with depressions and, consequently, precipitation. This factor could reduce PM levels but probably the rainfall associated with these depressions affected the western side of Iberia in lesser extent and that is the reason for the high PM mean levels recorded at Barcarrota.

By combining the information just presented with information on the frequency of occurrence of the transport scenarios the impact index (II) was defined. This could be understood as the weight of a certain scenario on the annual mean PM levels at Barcarrota. NAH-A scenario, which combined high PM levels and high frequency of occurrence, reached high II (4.5 µgTSP m^{-3}, 2.7 µgPM10 m^{-3}, 1.8 µgPM2.5 m^{-3}, Table Ap.119). All the rest scenarios had clearly lower II than NAH-A. AD, despite being the scenario associated with the lowest mean PM levels at Barcarrota, reached higher II than NAH-S and NAD scenarios owing to a higher frequency of occurrence (1.4 µgTSP m^{-3}, 1.1 µgPM10 m^{-3}, 0.5 µgPM2.5 m^{-3} for AD; 1.1 µgTSP m^{-3}, 0.7 µgPM10 m^{-3}, 0.4 µgPM2.5 m^{-3} for NAH-S and 0.9 µgTSP m^{-3}, 0.5 µgPM10 m^{-3}, 0.2 µgPM2.5 m^{-3} for NAD, Table Ap.119)

Table Ap.119. Number of days with African dust outbreaks occurred under the 4 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 ($\mu g\ m^{-3}$) recorded at Barcarrota rural site (SW Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	NAH-S	AD	NAD	NAH-A
2003				
Barcarrota TSP ($\mu g\ m^{-3}$)	-	-	-	-
Barcarrota PM10 ($\mu g\ m^{-3}$)	30	21	26	31
Barcarrota PM2.5 ($\mu g\ m^{-3}$)	11	7	8	15
Days	3	19	13	42
2002				
Barcarrota TSP ($\mu g\ m^{-3}$)	30	20	25	48
Barcarrota PM10 ($\mu g\ m^{-3}$)	23	14	15	29
Barcarrota PM2.5 ($\mu g\ m^{-3}$)	13	8	13	26
Days	22	11	5	40
2001				
Barcarrota TSP ($\mu g\ m^{-3}$)	-	33	47	54
Barcarrota PM10 ($\mu g\ m^{-3}$)	-	28	24	33
Barcarrota PM2.5 ($\mu g\ m^{-3}$)	-	12	17	19
Days	0	28	11	33
2000				
Barcarrota TSP ($\mu g\ m^{-3}$)	47	27	32	51
Days	14	24	5	36
1999				
Barcarrota TSP ($\mu g\ m^{-3}$)	28	17	49	46
Days	9	10	8	21
1998				
Barcarrota TSP ($\mu g\ m^{-3}$)	-	-	-	-
Days	17	19	5	23
Mean 98-03 ($\mu g\ m^{-3}$)				
Barcarrota TSP	36	27	40	50
Barcarrota PM10	24	22	23	30
Barcarrota PM2.5	13	9	12	20
Impact Index(II) ($\mu g\ m^{-3}$)				
Barcarrota TSP	1.1	1.4	0.9	4.5
Barcarrota PM10	0.7	1.1	0.5	2.7
Barcarrota PM2.5	0.4	0.5	0.2	1.8

Taking into consideration only the days with African advection, the highest monthly PM means were recorded under NAH-A scenario from May to September (ranges of 47-56 $\mu gTSP\ m^{-3}$, 24-40 $\mu gPM10\ m^{-3}$ and 18-33 $\mu gPM2.5\ m^{-3}$, Table Ap.120). In September high PM means were also recoded for NAD events (61 $\mu gTSP\ m^{-3}$, 37 $\mu gPM10\ m^{-3}$ and 19 $\mu gPM2.5\ m^{-3}$, Table Ap.120). However, only one NAD event occurred in September so these high PM means should not be taken as a general behaviour. Other scenarios also gave rise to high monthly TSP levels sporadically such as AD in May (65 $\mu g\ m^{-3}$, Table Ap.120) or NAH-S in March (48 $\mu g\ m^{-3}$, Table Ap.120).

Table Ap.120. Number of days per month with African advection occurred under the 4 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (all units in µg m^{-3}) recorded at Barcarrota rural site (SW Spain) for those days.

	NAH-S	AD	NAD	NAH-A		NAH-S	AD	NAD	NAH-A
January					**July**				
Days per month	2.2	2.3	0.5	0.0	Days per month	0.0	0.0	0.0	8.3
TSP	32	18			TSP				56
PM10	27				PM10				31
PM2.5	11				PM2.5				19
February					**August**				
Days per month	4.2	1.3	0.5	0.0	Days per month	0.0	0.0	0.0	7.7
TSP	25	23	32		TSP				54
PM10	21	8			PM10				36
PM2.5	10	6			PM2.5				21
March					**September**				
Days per month	4.0	3.7	1.2	0.0	Days per month	0.3	0.0	0.5	3.2
TSP	48	27	24		TSP			61	47
PM10	21	20	33		PM10	35		37	40
PM2.5	16	8	10		PM2.5	13		19	33
April					**October**				
Days per month	0.0	1.0	0.7	0.0	Days per month	0.2	2.0	1.8	0.8
TSP		26	44		TSP		34	44	28
PM10		9	27		PM10		25	15	
PM2.5		9	14		PM2.5		12	15	
May					**November**				
Days per month	0.0	1.3	1.3	1.8	Days per month	1.0	2.0	1.2	0.0
TSP		65	40	47	TSP	28	27	15	
PM10		13	12	24	PM10		29	14	
PM2.5		8	11	18	PM2.5		11	6	
June					**December**				
Days per month	0.0	0.0	0.2	10.8	Days per month	0.2	3.5	0.0	0.0
TSP			26	47	TSP	11	21		
PM10				28	PM10		25		
PM2.5				18	PM2.5		9		

6.3. European episodes

In a total of 72 days (12 per year and 1 per month, Table Ap.121) of the 1998-2003 period European air masses reached Southwestern Iberia. These days were grouped in 29 episodes (5 per year, Table Ap.121) with a mean duration of 2 days.

The majority, 69%, of these 29 episodes (20 episodes in total and 3 per year, Table Ap.121) occurred when an anticyclone was located over the European continent or over the Northern Atlantic Ocean (EUH scenario). The mean duration of these events was 2 days. These events resulted in 47 days (65% of the 72 days registered in 1998-2003, 8 per year and 1 per month, Table Ap.121).

The remaining 31% of the 29 episodes (9 episodes in 1998-2003 and 1 per year, Table Ap.121) were associated with the development of depressions over the western Mediterranean (MD scenario). These episodes had an average duration of 3 days and resulted in 25 days (35% of the 72 days in 1998-2003 and 4 per year, Table Ap.121) in 1998-2003.

As shown in Table Ap.121, the annual number of days and episodes with European advection in the study region were low. The number of days ranged from 7 (in 1998 and 2000) to 20 (in 20003) and the number of episodes ranged from 4 (in 1999 and 2000) to 6 (in 2003). Distinguishing in transport scenarios, the number of days with

European advection over the study area characterised by EUH scenario ranged from 4 (in 1998) to 13 (in 2003) and the number of events associated with that scenario were either 3 (in 1998, 1999, 2001 and 2002) or 4 (in 2000 and 2003). With respect to MD scenario, the number of days associated with those synoptic situations ranged from 0 (in 2000) to 7 (in 2003) while the number of MD events reached 2 as the maximum number of annual occurrences (in 1998, 2001, 2002 and 2003).

Table Ap.121. Annual number of days and episodes with European advection in the period 1998-2003 over Southwestern Iberian Peninsula. The EUH and MD scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total EU	7	12	7	12	14	20	12	1
EUH	4	8	7	7	8	13	8	1
MD	3	4	0	5	6	7	4	<1
Episodes								
Total EU	5	4	4	5	5	6	5	<1
EUH	3	3	4	3	3	4	3	<1
MD	2	1	0	2	2	2	2	<1

The occurrence of European episodes over Southwestern Iberian Peninsula in 1998-2003 (Figure Ap.109) was almost restricted to November-April because only 5 episodes were registered from May to October in the 6-years period. In particular November and February (6 episodes in both months from 1998 to 2003) the highest number of European events were registered. The majority of the EUH episodes occurred from November to March (15 out of 20 EUH episodes occurred in this period with the maximum in February with 6 events). The MD episodes occurred only in October-January (with a maximum in November with 4 episodes in 1998-2003) and April (2 episodes in 1998-2003).

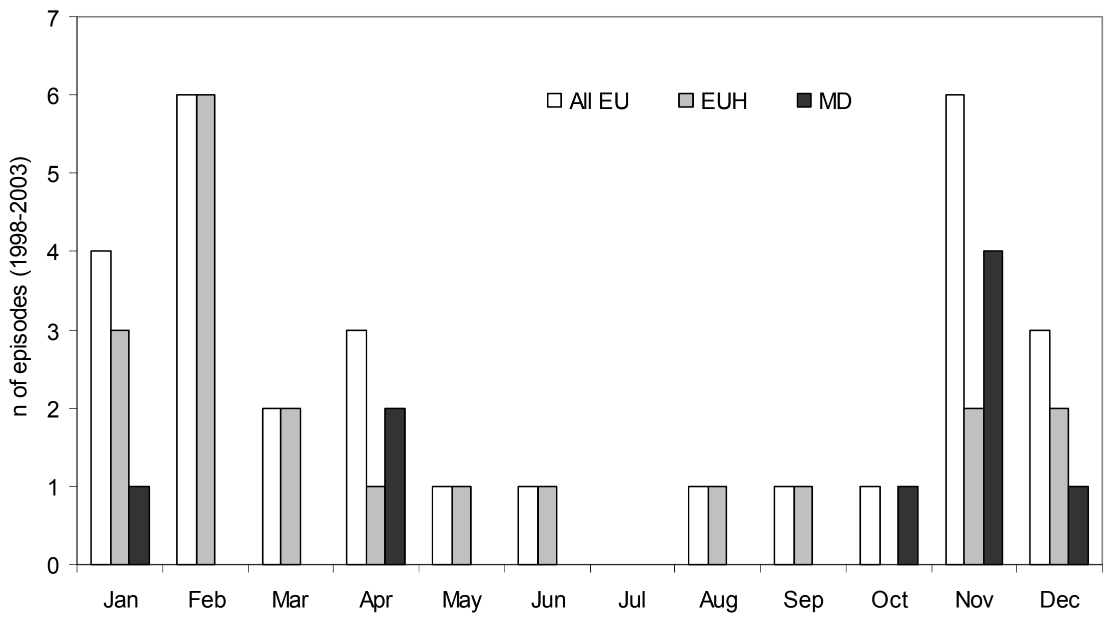

Figure Ap.109. Monthly distribution of the number of European episodes over Southwestern Iberian Peninsula. The monthly distribution of EUH and MD European events is also shown.

The seasonal distribution of the days with European advection over Southwestern Iberian Peninsula (Figures Ap.110 and Ap.111) showed the predominance of these days from November to April with three maxima in February (a monthly mean of 3 days), November (2 days as monthly mean) and April (2 days as monthly average). The days associated with EUH scenario occurred mainly around February (a monthly average of 3 days) and the days associated with MD scenario occurred principally in November (a monthly mean of 2 days) and April (above 1 day of monthly mean).

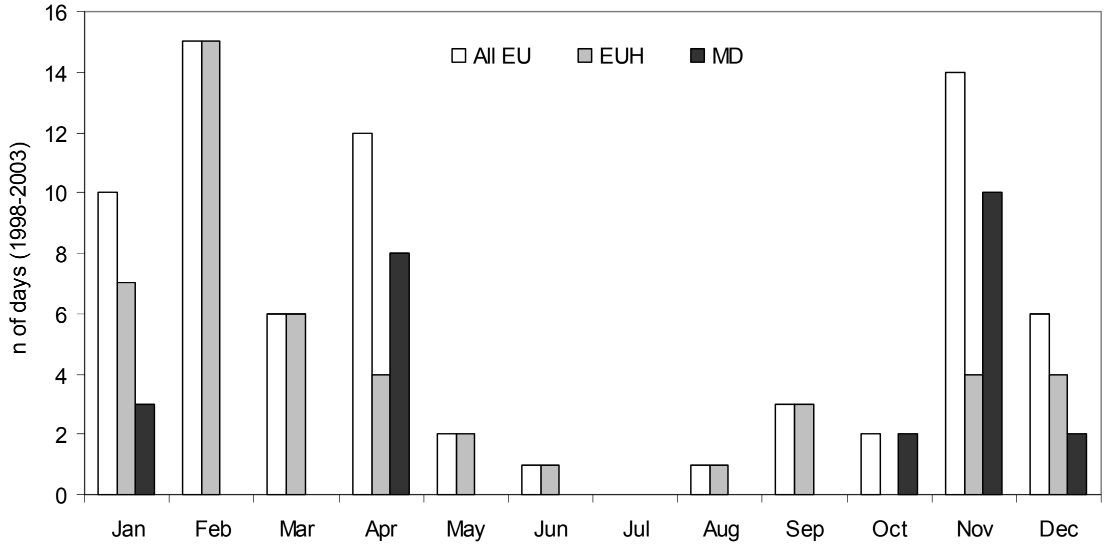

Figure Ap.110. Monthly distribution of the number of days with European advection over Southwestern Iberian Peninsula. The monthly distributions of days with European advection occurred under EUH and MD scenarios are also shown.

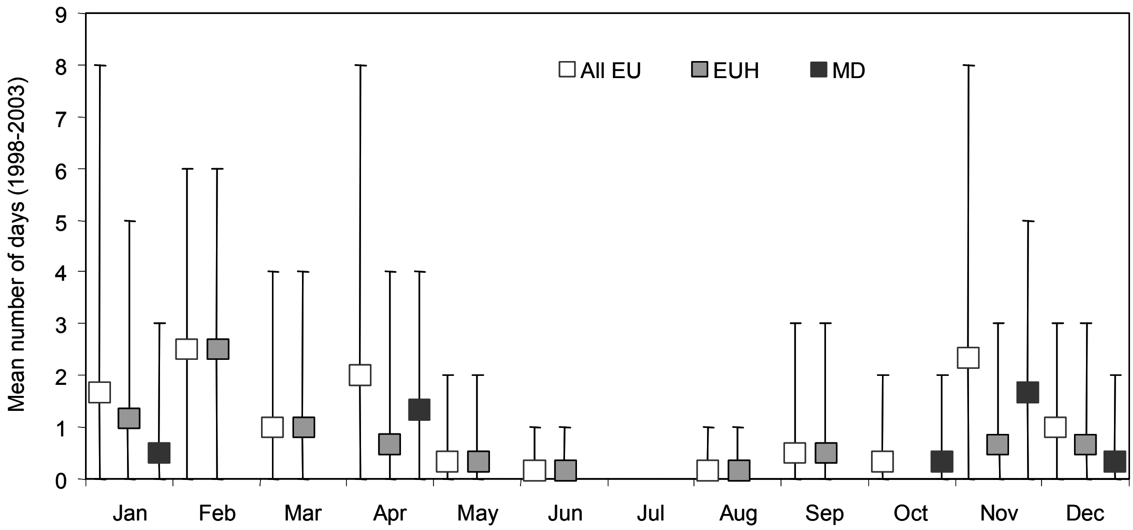

Figure Ap.111. Mean number of days with European advection over Southwestern Iberian Peninsula per month for 1998-2003. EUH and MD episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

As shown in Figure Ap.112, the mean duration of European events over Southwestern Iberia was longer in September-April reaching up to 4 days of mean duration in April (in fact the 3 episodes registered in this month lasted 4 days). EUH and MD events also showed the maximum duration in April, with 4 days.

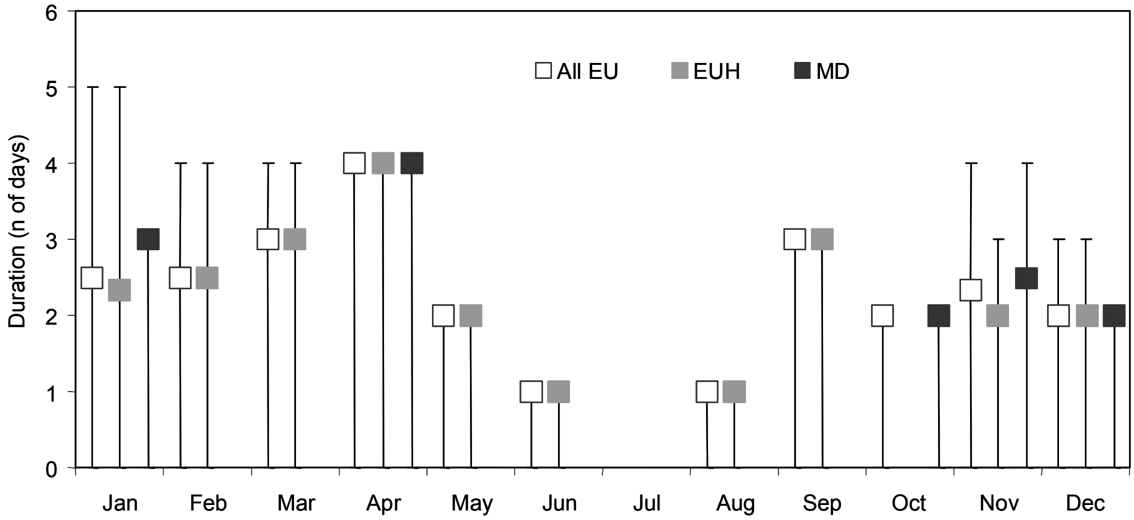

Figure Ap.112. Mean duration of European episodes per month over Southwestern Iberian Peninsula for 1998-2003. EUH and MD episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

As shown in Table Ap.122, the mean PM levels recorded at Barcarrota when European air masses reached Southwestern Iberian Peninsula were 23 µgTSP m^{-3}, 15 µgPM10 m^{-3} and 10 µgPM2.5 m^{-3}, lower than the annual PM mean levels at that station (27 µgTSP m^{-3}, 17 µgPM10 m^{-3} and 11 µgPM2.5 m^{-3}). Pollutants in European air masses suffer very important dilution and dispersion before reaching Southwestern Iberia and this may explain the low levels recorded at Barcarrota. However, a great interannual variability in the PM levels recorded during European events was observed, with very low levels in 1999, 2001 and 2003 and higher levels in 2000 and 2002. This could be attributed to the occurrence of intense European events in those years, although local/regional contributions can not be discarded. These conclusions should be taken with caution according to the small number of European episodes over the area.

Table Ap.122. Mean annual levels of TSP, PM10 and PM2.5 registered in Barcarrota during European advection episodes in 1998-2003.

EU EPISODES	Barcarrota		
(µg m^{-3})	TSP	PM10	PM2.5
1998	na	na	na
1999	*[1]14	na	na
2000	41	na	na
2001	14	*[2]11	*[2]7
2002	30	20	15
2003	na	14	8
Mean 98-03	23	15	10

*[1]Calculated with data of 83% of the months of the year
*[2]Calculated with data of 83% of the months of the year
na: Not available

During EUH episodes, characterised by the presence of an anticyclone, rain occurred less frequently than during MD events (under the effect of depressions). This resulted in higher mean PM levels during EUH episodes (27 µgTSP m^{-3}, 17 µgPM10 m^{-3} and 12 µgPM2.5 m^{-3}, Table Ap.123) than during MD (17 µgTSP m^{-3}, 12 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3}, Table Ap.123).

Since the frequency of occurrence of European episodes and the mean PM levels recorded during these events at Barcarrota were low, the Impact Index (II) of both scenarios were low. However, the impact of EUH (II of 0.6 µgTSP m^{-3}, 0.4 µgPM10 m^{-3} and 0.3 µgPM2.5 m^{-3}, Table Ap.123) was higher than the impact of MD (II of 0.2 µgTSP m^{-3}, 0.1 µgPM10 m^{-3} and 0.1 µgPM2.5 m^{-3}, Table Ap.123) because the first scenario occurred more frequently and gave rise to higher PM levels at Barcarrota.

Table Ap.123. Number of days with European advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (µg m^{-3}) recorded at Barcarrota rural site (SW Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	EUH	MD
2003		
Barcarrota TSP (µg m^{-3})	-	-
Barcarrota PM10 (µg m^{-3})	17	10
Barcarrota PM2.5 (µg m^{-3})	9	6
Days	13	7
2002		
Barcarrota TSP (µg m^{-3})	35	23
Barcarrota PM10 (µg m^{-3})	23	16
Barcarrota PM2.5 (µg m^{-3})	18	12
Days	8	6
2001		
Barcarrota TSP (µg m^{-3})	13	16
Barcarrota PM10 (µg m^{-3})	11	10
Barcarrota PM2.5 (µg m^{-3})	8	6
Days	7	5
2000		
Barcarrota TSP (µg m^{-3})	41	-
Days	7	0
1999		
Barcarrota TSP (µg m^{-3})	-	14
Days	8	4
1998		
Barcarrota TSP (µg m^{-3})	-	-
Days	4	3
Mean 98-03 (µg m^{-3})		
Barcarrota TSP	27	17
Barcarrota PM10	17	12
Barcarrota PM2.5	12	8
Impact Index(II) (µg m^{-3})		
Barcarrota TSP	0.6	0.2
Barcarrota PM10	0.4	0.1
Barcarrota PM2.5	0.3	0.1

The monthly PM means calculated only for days with European advection are shown in Table Ap.124. The highest monthly means were always recorded under the EUH scenario. From March to June TSP mean levels ranging from 41 to 54 µgTSP m^{-3} were recorded. For PM10 and PM2.5, April (22 µgPM10 m^{-3} and 21 µgPM2.5) and August-September (24-32 µgPM10 m^{-3} and 21-12 µgPM2.5) were also periods in which high levels were recoded under EUH situations. However, according to the small number of European episodes over the area these conclusions should be taken with caution.

Table Ap.124. Number of days per month with European advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 ($\mu g\ m^{-3}$) recorded at Barcarrota rural site (SW Spain) for those days.

	EUH	MD		EUH	MD
January			**July**		
Days per month	1.2	0.5	Days per month	0.0	0.0
TSP	14	10	TSP		
PM10	12	9	PM10		
PM2.5	9	6	PM2.5		
February			**August**		
Days per month	2.5	0.0	Days per month	0.2	0.0
TSP	24		TSP	28	
PM10	17		PM10	24	
PM2.5	10		PM2.5	21	
March			**September**		
Days per month	1.0	0.0	Days per month	0.5	0.0
TSP	54		TSP		
PM10			PM10	32	
PM2.5			PM2.5	12	
April			**October**		
Days per month	0.7	1.3	Days per month	0.0	0.3
TSP	41	29	TSP		
PM10	22	15	PM10		
PM2.5	21	11	PM2.5		
May			**November**		
Days per month	0.3	0.0	Days per month	0.7	1.7
TSP			TSP	13	15
PM10			PM10	12	10
PM2.5			PM2.5	9	6
June			**December**		
Days per month	0.2	0.0	Days per month	0.7	0.3
TSP	42		TSP	13	11
PM10			PM10	10	9
PM2.5			PM2.5	7	5

6.4. Mediterranean episodes

A total of 103 days (17 per year and 1 per month, Table Ap.125) with advection of Mediterranean air masses over Southwestern Iberian Peninsula were registered in 1998-2003. These days were grouped in 51 episodes (9 per year and 1 per month, Table Ap.125) with a mean duration of 2 days.

Only 16% of the 51 episodes (8 events in 1998-2003 and 1 per year, Table Ap.125) were caused by the presence of a depression over Northern Africa and/or the Mediterranean (NAD-MD scenario). These episodes resulted in 20 days (19% of the 103 days registered in 1998-2003 and 3 per year, Table Ap.125). NAD-MD events had a mean duration of 3 days.

The remaining 84% of the 51 Mediterranean episodes (43 episodes in 1998-2003, 7 per year and 1 per month, Table Ap.125) occurred when an anticyclone was located over the European continent and/or over the Mediterranean (EUH-MH scenario). These episodes reached an average duration of 2 days and resulted in a total of 83 days in the study period (81% of the 103 days, 14 per year and 1 per month, Table Ap.125).

As shown in Table Ap.125, the number of days with advection of Mediterranean air masses over Eastern Iberia ranged from 9 (in 2002) to 28 (in 1999). The number of days associated with NAD-MD scenario varied in the range 0 (in 2001) to 8 (in 1998)

while the number of days characterised by EUH-MH scenario ranged from 4 (in 2002) to 25 (in 1999).
The annual occurrence of Mediterranean events ranged from 3 (in 2002) to 13 (in 1999). The number of NAD-MD episodes ranged from 0 (in 2001) to 3 (in 1998) and the number of EUH-MH events ranged from 2 (in 2002) to 12 (in 1999).

Table Ap.125. Annual number of days and episodes with Mediterranean advection in the period 1998-2003 over Southwestern Iberian Peninsula. The NAD-MD and EUH-MH scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total MED	21	28	12	18	9	15	17	1
NAD-MD	8	3	1	0	5	3	3	<1
EUH-MH	13	25	11	18	4	12	14	1
Episodes								
Total MED	10	13	9	7	3	9	9	1
NAD-MD	3	1	1	0	1	2	1	<1
EUH-MH	7	12	8	7	2	7	7	1

Concerning the seasonal distribution of Mediterranean events over Southwestern Iberian Peninsula from 1998 to 2003 (Figure Ap.113) it is observed that three periods with high frequency of occurrence were registered in March (8 events in 1998-2003), autumn (with the relative frequency peak in November with 7 episodes in 1998-2003) and January (6 episodes in the study period). A second order frequency peak was observed in the early summer (4 and 5 events in 1998-2003 in June and July respectively). The minimum frequency of occurrence was observed in August-September (1 episode in the study period in September) and April (only 2 events in 1998-2003). NAD-MD events only occurred in spring (with 2 events in the study period) and autumn (2 episodes in both November and December from 1998 to 2003). EUH-MH episodes were especially frequent in March (7 episodes in 1998-2003) and January (6 events from 1998 to 2003) and, in a lesser extent, in autumn (5 episodes in November in 1998-2003) and early summer (5 events in July in the study period).

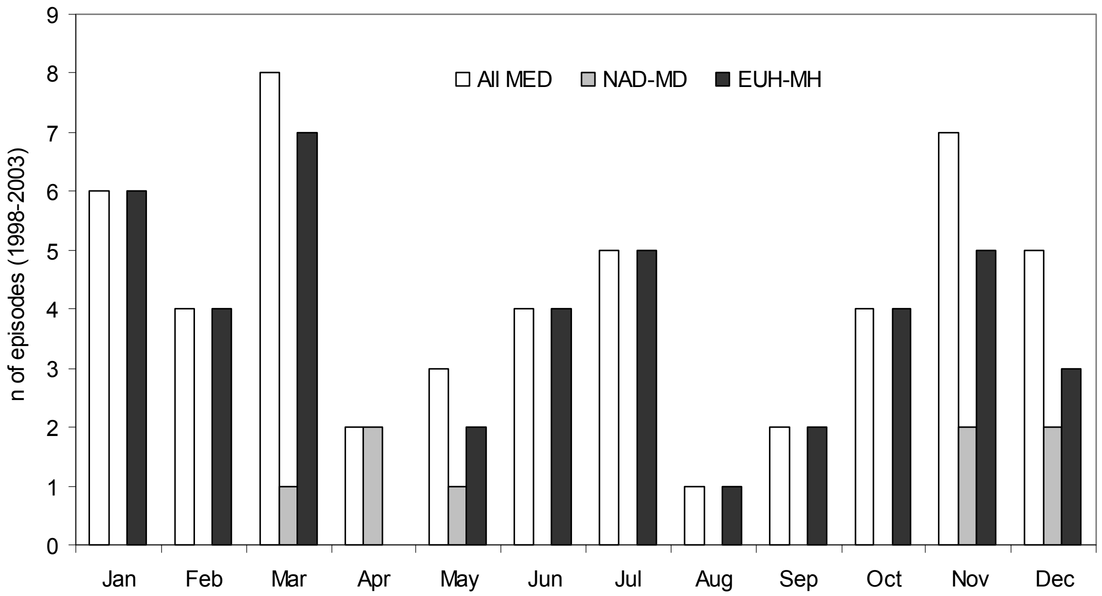

Figure Ap.113. Monthly distribution of the number of Mediterranean episodes over Southwestern Iberian Peninsula. The monthly distributions of NAD-MD and EUH-MH Mediterranean events are also shown.

As shown in Figures Ap.114 and Ap.115, the maximum number of days with Mediterranean advection over Southwestern Iberian Peninsula in 1998-2003 was registered in March, November and December (3 days as monthly mean in these three months). Also in June a good number of days with Mediterranean advection were observed (a mean of 2 days). The occurrence of days associated with NAD-MD scenario was only relevant in March, November and December (with monthly means near 1 day in these three months). The days with Mediterranean advection of EUH-MH type were especially frequent in March, November, December and June, with 2 days as monthly average these four months.

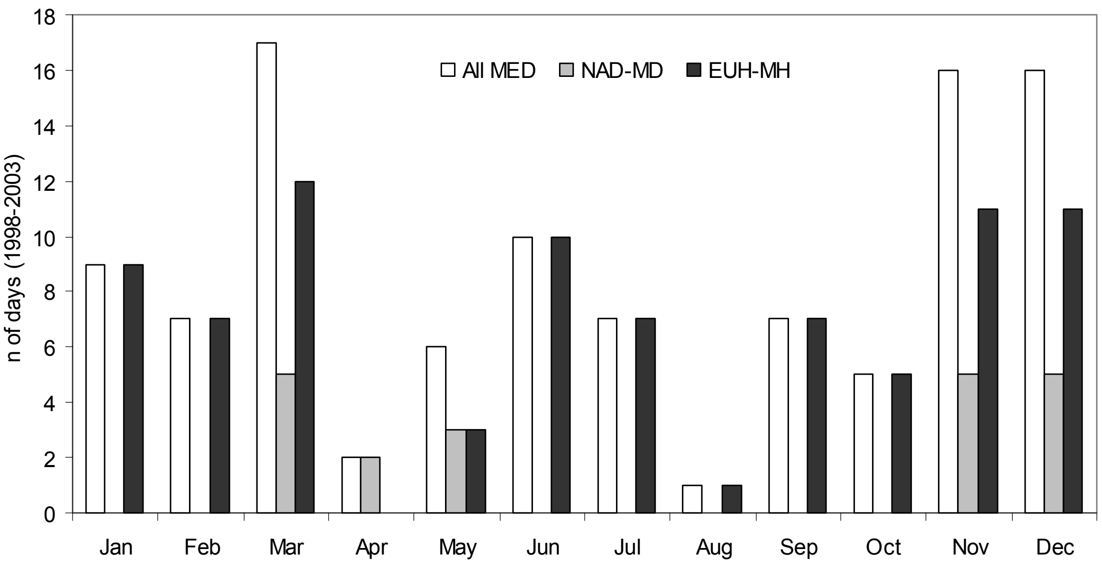

Figure Ap.114. Monthly distribution of the number of days with Mediterranean advection over Southwestern Iberian Peninsula. The monthly distributions of days with Mediterranean advection occurred under NAD-MD and EUH-MH scenarios are also shown.

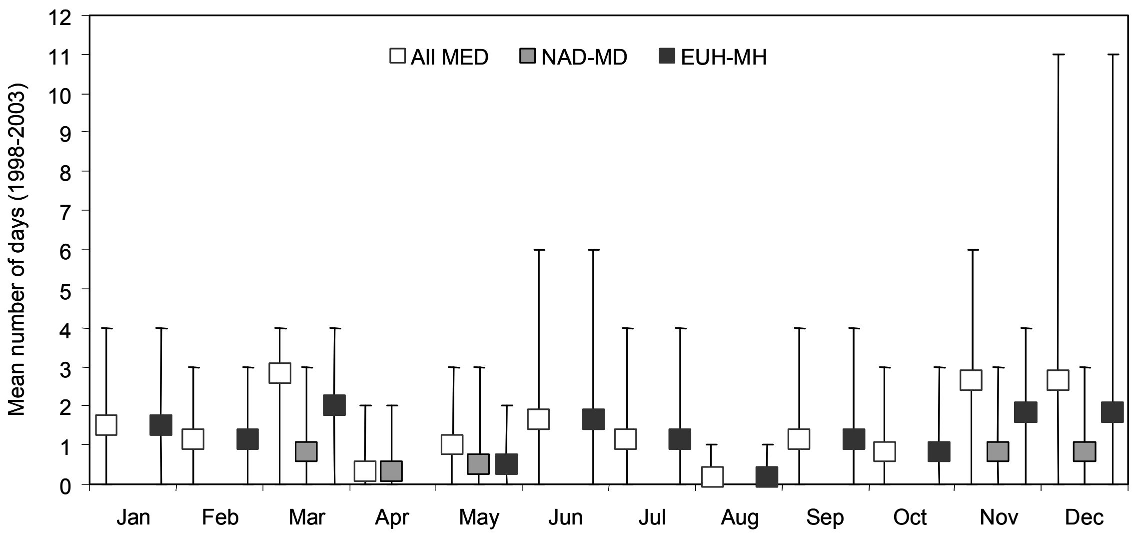

Figure Ap.115. Mean number of days with Mediterranean advection over Southwestern Iberian Peninsula per month for 1998-2003. NAD-MD and EUH-MH episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

The mean duration of Mediterranean events in all the months (Figure Ap.116) ranged from 1 to 2 days with the exception of September (4 days), December (3 days) and June (3 days). With respect to NAD-MD episodes, the small number of these events occurred in 1998-2003 does not allow extracting conclusions about the monthly average duration. For example, the maximum and minimum mean duration of NAD-MD events were registered in March (5 days in a single episode) and in April (1 day in two episodes of that duration). EUH-MH events only lasted, on average, more than 2 days in December (4 days), September (4 days) and June (3 days).

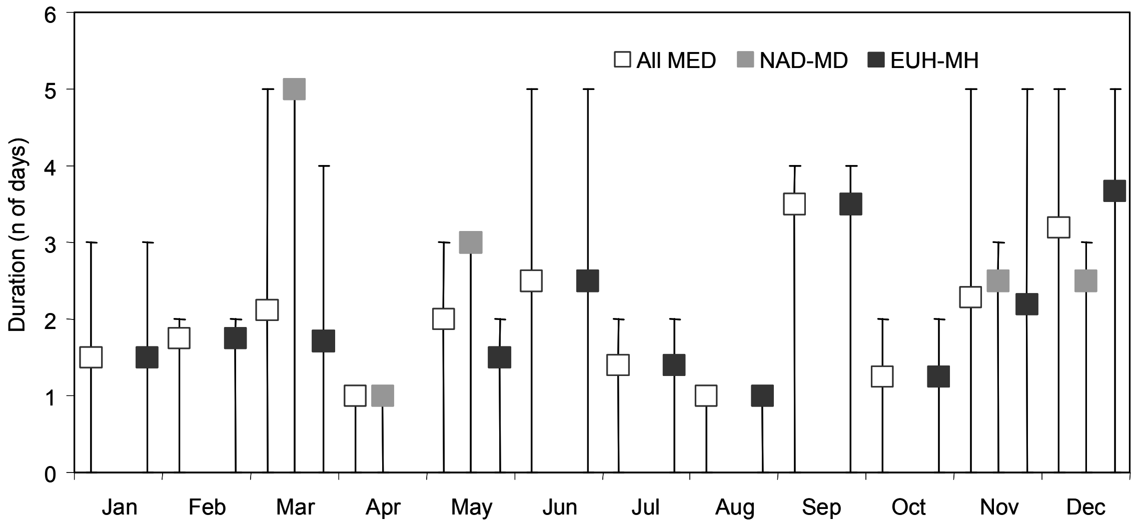

Figure Ap.116. Mean duration of Mediterranean episodes per month over Southwestern Iberian Peninsula for 1998-2003. NAD-MD and EUH-MH episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

As shown in Table Ap.126, the mean annual levels of PM at Barcarrota for episodes of transport of Mediterranean air masses over Southwestern Iberian Peninsula (27 µgTSP m^{-3}, 15 µgPM10 m^{-3} and 9 µgPM2.5 m^{-3}) were slightly lower than the annual mean

PM levels at this sampling site (27 µgTSP m^{-3}, 17 µgPM10 m^{-3} and 11 µgPM2.5 m^{-3}). The occurrence of rainfall associated with these events is common although, generally, the precipitation is more likely to affect the Eastern flank of the Iberian Peninsula. Moreover the Mediterranean air masses are relatively clean owing to their marine origin. In 2001, the mean PM levels at Barcarrota during Mediterranean episodes were considerably lower than during the rest of the years because summer events (when local/regional contributions are higher at regional background stations) did not occur in this year.

Table Ap.126. Mean annual levels of TSP, PM10 and PM2.5 registered in Barcarrota during Mediterranean advection episodes in 1998-2003.

MED EPISODES	Barcarrota		
(µg m^{-3})	TSP	PM10	PM2.5
1998	na	na	na
1999	*[1]33	na	na
2000	36	na	na
2001	15	*[2]10	*[2]6
2002	27	14	11
2003	na	20	10
Mean 98-03	27	15	9

*[1]Calculated with data of 83% of the months of the year
*[2]Calculated with data of 83% of the months of the year
na: Not available

The mean PM levels recorded at Barcarrota during NAD-MD episodes were slightly higher than during EUH-MH events (31 µgTSP m^{-3}, 15 µgPM10 m^{-3} and 11 µgPM2.5 m^{-3} during NAD-MD episodes and 26 µgTSP m^{-3}, 15 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3} during EUH-MH episodes, Table Ap.127). The occurrence of NAD-MD episodes is very low and any conclusion drawn with PM means calculated with such low number of days should be taken with caution. In fact, the mean PM levels during NAD-MD events was higher than during EUH-MH events owing to an episode with high PM levels occurred in at the end of March 2002. In this episode, local/regional contributions could have contributed greatly to increase the PM levels.

The impact index (II) gives the weight of each transport scenario on the annual mean PM levels at a sampling station. The weight of both Mediterranean transport scenarios was low although NAD-MD scenario, owing to its low frequency of occurrence, had negligible II (0.3 µgTSP m^{-3}, 0.1 µgPM10 m^{-3} and 0.1 µgPM2.5 m^{-3}, Table Ap.127) compared with the II of EUH-MH (1.0 µgTSP m^{-3}, 0.6 µgPM10 m^{-3} and 0.3 µgPM2.5 m^{-3}, Table Ap.127).

Table Ap.127. Number of days with Mediterranean advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (µg m^{-3}) recorded at Barcarrota rural site (SW Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	NAD-MD	EUH-MH
2003		
Barcarrota TSP (µg m^{-3})	-	-
Barcarrota PM10 (µg m^{-3})	6	22
Barcarrota PM2.5 (µg m^{-3})	4	11
Days	3	12
2002		
Barcarrota TSP (µg m^{-3})	41	11
Barcarrota PM10 (µg m^{-3})	18	9
Barcarrota PM2.5 (µg m^{-3})	15	4
Days	5	4
2001		
Barcarrota TSP (µg m^{-3})	-	15
Barcarrota PM10 (µg m^{-3})	-	10
Barcarrota PM2.5 (µg m^{-3})	-	6
Days	0	18
2000		
Barcarrota TSP (µg m^{-3})	28	37
Days	1	11
1999		
Barcarrota TSP (µg m^{-3})	17	37
Days	3	25
1998		
Barcarrota TSP (µg m^{-3})	-	-
Days	8	13
Mean 98-03 (µg m^{-3})		
Barcarrota TSP	31	26
Barcarrota PM10	15	15
Barcarrota PM2.5	11	8
Impact Index(II) (µg m^{-3})		
Barcarrota TSP	0.3	1.0
Barcarrota PM10	0.1	0.6
Barcarrota PM2.5	0.1	0.3

As shown by Table Ap.128, the highest monthly PM means obtained for the days with Mediterranean advection were recorded in summer under EUH-MH situations (48-54 µgTSP m^{-3}, 21-37 µgPM10 m^{-3} and 15-18 µgPM2.5 m^{-3} were recorded from June to September for this scenario). In this season the local and regional contributions are elevated owing to the low precipitation regime, re-suspension of soil material owing to the intense convective dynamics and the high photochemical conversion rate from gaseous precursors to secondary aerosols in virtue of the high insolation.

Table Ap.128. Number of days per month with Mediterranean advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 ($\mu g\ m^{-3}$) recorded at Barcarrota rural site (SW Spain) for those days.

	NAD-MD	EUH-MH		NAD-MD	EUH-MH
January			**July**		
Days per month	0.0	1.5	Days per month	0.0	1.2
TSP		14	TSP		68
PM10		9	PM10		21
PM2.5		4	PM2.5		
February			**August**		
Days per month	0.0	1.2	Days per month	0.0	0.2
TSP		20	TSP		54
PM10			PM10		
PM2.5			PM2.5		
March			**September**		
Days per month	0.8	2.0	Days per month	0.0	1.2
TSP	38	38	TSP		
PM10	21	14	PM10		33
PM2.5	15	7	PM2.5		15
April			**October**		
Days per month	0.3	0.0	Days per month	0.0	0.8
TSP	39		TSP		22
PM10	12		PM10		14
PM2.5	11		PM2.5		9
May			**November**		
Days per month	0.5	0.5	Days per month	0.8	1.8
TSP		37	TSP	17	16
PM10		20	PM10		14
PM2.5		11	PM2.5		9
June			**December**		
Days per month	0.0	1.7	Days per month	0.8	1.8
TSP		48	TSP		13
PM10		37	PM10	4	9
PM2.5		18	PM2.5	3	6

6.5. Episodes without dominant advective conditions

A total of 344 days (57 per year and 5 per month, Table Ap.129) with lack of prevailing advective conditions occurred over Southwestern Iberia in 1998-2003. These days were grouped in 110 episodes (18 per year and 2 per month, Table Ap.129) with a mean duration of 3 days.

In 58% of these 344 days (198 days in total, 33 per year and 3 per month, Table Ap.129) the meteorological scenario causing the lack of advection was characterised by the presence of an anticyclone covering completely or partly the Iberian Peninsula in the cold part of the year (WIA scenario). The total number of WIA episodes in 1998-2003 over the study area was 58 (53% of the 110 events, 10 per year and 1 per month, Table Ap.129) and had a mean duration of 3 days.

The remaining 42% of the 344 days (146 days in total, 24 per year and 2 per month, Table Ap.129) occurred from late spring to early autumn in summer when the thermal Iberian low developed over the Iberian plateau owing to the great heating of the surface (ITL scenario). These days resulted in 52 ITL episodes (47% of the 110 events, 9 per year and 1 per month, Table Ap.129) with an average duration of 3 days.

As shown in Table Ap.129, the annual number of days with lack of dominant advective conditions ranged from 42 (in 2002) to 70 (in 1998). The number of days associated with WIA scenario ranged from 21 (in 2002) to 55 (in 2003) while the number of days associated with ITL situations varied between 10 (in 2003) and 33 (in 2000).

With respect to the number of episodes without prevailing advective conditions these ranged from 10 (in 2002) to 24 (in 1998). The number of WIA episodes ranged between 4 (in 2002) and 15 (in 2003) and the number of ITL from 5 (in 2003) to 14 (in 2000).

Table Ap.129. Annual number of days and episodes with lack of advective conditions in the period 1998-2003 over Southwestern Iberian Peninsula. The WIA and ITL scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total NOADV	70	50	56	61	42	65	57	5
WIA	41	27	23	31	21	55	33	3
ITL	29	23	33	30	21	10	24	2
Episodes								
Total NOADV	24	15	21	18	10	18	18	2
WIA	13	9	7	8	4	15	10	1
ITL	11	6	14	10	6	5	9	1

As shown in Figure Ap.117, the episodes with lack of dominant advective conditions occurred with high frequency from May to October (up to 14 episodes from 1998 to 2003 in both July and September) and in December (11 episodes in 1998-2003). The minima of the frequency of occurrence of these events were registered in January and November (4 events in both months in the 6-years period). WIA events did not occur from June to August and were especially common in October (11 events in 1998-2003), December (11 episodes in the study period), and May (9 events from 1998 to 2003). ITL episodes, by definition, occurred exclusively from May to October but with especial frequency from June to September (a range of 11-14 episodes accumulated in 1998-2003).

The seasonal distribution of the number of days without dominant advective conditions over Southwestern Iberia from 1998 to 2003 (Figures Ap.118 and Ap.119) was similar to described for the episodes. However, a summer maximum is also observed and a relative minimum was registered in July (4 days as monthly mean). Thus, the main frequency peak was registered in August-October (7-8 days as the range of monthly means) and two second order peaks were observed in May (with a monthly average of 7 days) and December (6 days as monthly mean). The days characterised by ITL scenario occurred mainly from June to September (7 days as monthly mean in both August and September) and the days associated with WIA scenario were particularly frequent in October (8 days as monthly average), December (6 days as monthly mean) and May (a monthly mean of 6 days).

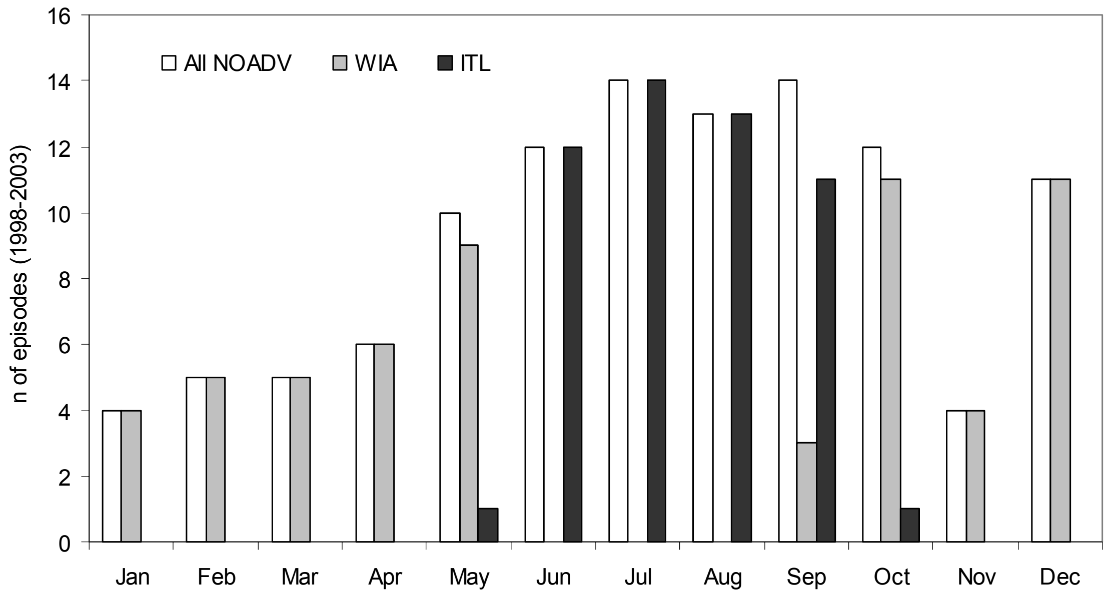

Figure Ap.117. Monthly distribution of the number of episodes without dominant advective conditions over Southwestern Iberian Peninsula. The monthly distributions of WIA and ITL events are also shown.

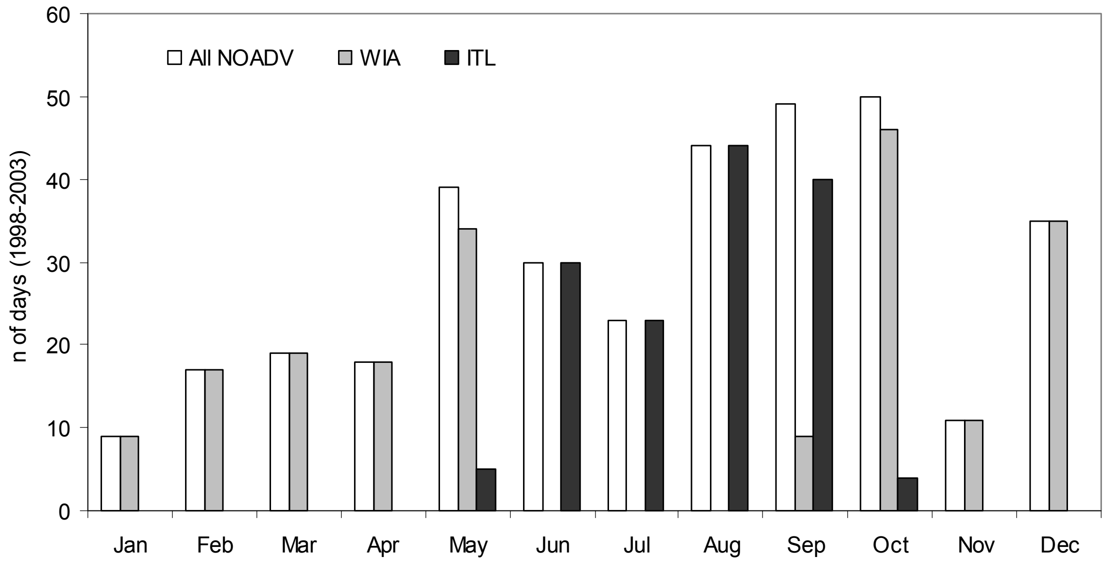

Figure Ap.118. Monthly distribution of the number of days with lack of advective conditions over Southwestern Iberian Peninsula. The monthly distributions of days with lack of advective conditions occurred under WIA and ITL scenarios are also shown.

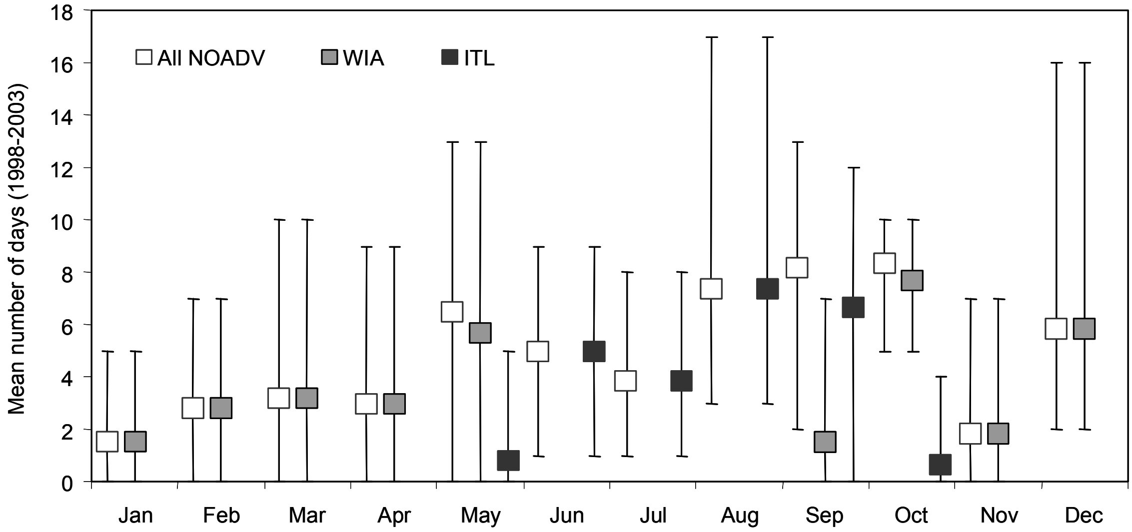

Figure Ap.119. Mean number of days without a dominant air mass advection over Southwestern Iberian Peninsula per month for 1998-2003. WIA and ITL episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

As shown in Figure Ap.120, the mean duration of episodes without dominant advective conditions ranged from 3 to 4 days (with the longest mean duration in March, May and October) in all the months with the exception of January and July with 2 days. The mean duration of WIA events was minimum in January (2 days). In the rest of the months the average extent of WIA episodes was either 3 or 4 days. The longest ITL episodes occurred in May (5 days) and the shortest in July (2 days). In the remaining months ITL events lasted, as a mean, 3 or 4 days.

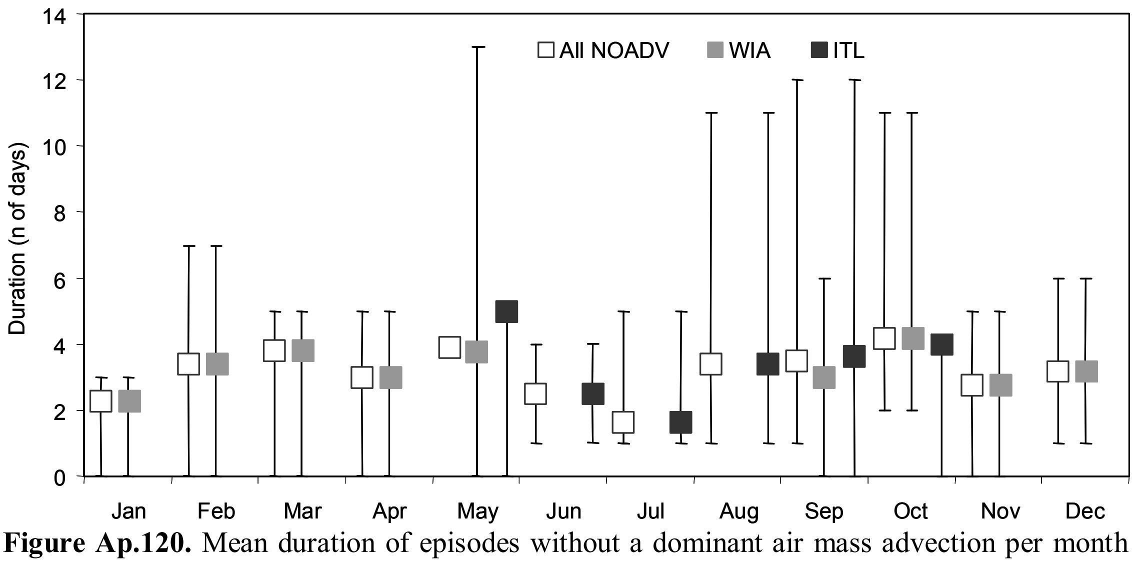

Figure Ap.120. Mean duration of episodes without a dominant air mass advection per month over Southwestern Iberian Peninsula for 1998-2003. WIA and ITL episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

As occurred in most of the regional background stations used in this study, the mean PM levels recorded at Barcarrota during episodes with lack of dominant advective conditions (27 µgTSP m^{-3}, 15 µgPM10 m^{-3} and 9 µgPM2.5 m^{-3}, Table Ap.130) were higher than the annual mean PM levels at that site (27 µgTSP m^{-3}, 17 µgPM10 m^{-3} and

11 µgPM2.5 m^{-3}). It is important to notice that precipitation is low during these events so the PM scavenging potential of the atmosphere is reduced.

Table Ap.130. Mean annual levels of TSP, PM10 and PM2.5 registered in Barcarrota during episodes without dominant air mass advection in 1998-2003.

NOADV EPISODES (µg m^{-3})	**Barcarrota**		
	TSP	PM10	PM2.5
1998	na	na	na
1999	*[1]34	na	na
2000	38	na	na
2001	38	*[2]26	*[2]17
2002	30	19	16
2003	na	16	9
Mean 98-03	36	20	13

*[1]Calculated with data of 83% of the months of the year
*[2]Calculated with data of 83% of the months of the year
na: Not available

As shown in Table Ap.131, the mean PM levels recorded at Barcarrota during the two types of episode with of lack of dominant advective conditions differed greatly. During ITL episodes (PM means of 46 µgTSP m^{-3}, 30 µgPM10 m^{-3} and 21 µgPM2.5 m^{-3}), factors such as the low rainfall regime, the aging of pollutants in air masses, the high rate of re-suspension or the enhancement of transformation of gaseous precursors into secondary aerosols by the increased photochemistry, tend to increase PM levels in regional background stations. During WIA episodes (24 µgTSP m^{-3}, 15 µgPM10 m^{-3} and 9 µgPM2.5 m^{-3}), the reduced vertical growth of the boundary layer and the common development of thermal inversions result in a very low dispersion of pollutants. This is the reason for the low PM levels recorded at Barcarrota during WIA events.

As stated above, WIA situations were somewhat more frequent than ITL but the mean PM levels reached during ITL episodes were clearly higher than those recorded during WIA events. As a result, there was a considerable difference in the impact index (II) of these two scenarios reaching ITL to II of 3.1 µgTSP m^{-3}, 2.0 µgPM10 m^{-3} and 1.4 µgPM2.5 m^{-3} and WIA only to II of 2.2 µgTSP m^{-3}, 1.3 µgPM10 m^{-3} and 0.8 µgPM2.5 m^{-3} (Table Ap.131).

Table Ap.131. Number of days without a dominant air mass advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 ($\mu g\ m^{-3}$) recorded at Barcarrota rural site (SW Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	WIA	ITL
2003		
Barcarrota TSP ($\mu g\ m^{-3}$)	-	-
Barcarrota PM10 ($\mu g\ m^{-3}$)	12	37
Barcarrota PM2.5 ($\mu g\ m^{-3}$)	7	21
Days	55	10
2002		
Barcarrota TSP ($\mu g\ m^{-3}$)	22	38
Barcarrota PM10 ($\mu g\ m^{-3}$)	14	24
Barcarrota PM2.5 ($\mu g\ m^{-3}$)	10	22
Days	21	21
2001		
Barcarrota TSP ($\mu g\ m^{-3}$)	28	48
Barcarrota PM10 ($\mu g\ m^{-3}$)	19	32
Barcarrota PM2.5 ($\mu g\ m^{-3}$)	11	21
Days	31	30
2000		
Barcarrota TSP ($\mu g\ m^{-3}$)	20	50
Days	23	33
1999		
Barcarrota TSP ($\mu g\ m^{-3}$)	24	45
Days	27	23
1998		
Barcarrota TSP ($\mu g\ m^{-3}$)	-	-
Days	41	29
Mean 98-03 ($\mu g\ m^{-3}$)		
Barcarrota TSP	24	46
Barcarrota PM10	15	30
Barcarrota PM2.5	9	21
Impact Index(II) ($\mu g\ m^{-3}$)		
Barcarrota TSP	2.2	3.1
Barcarrota PM10	1.3	2.0
Barcarrota PM2.5	0.8	1.4

The monthly PM means obtained only from the levels recorded at Barcarrota in the days with lack of advective conditions over the study area (Table Ap.132) reached the highest values from May to October during ITL episodes (in the ranges 39-78 $\mu gTSP\ m^{-3}$, 25-37 $\mu gPM10\ m^{-3}$ and 17-25 $\mu gPM2.5\ m^{-3}$). By contrast, during WIA, monthly PM means in the ranges 10-31 $\mu gTSP\ m^{-3}$, 9-22 $\mu gPM10\ m^{-3}$ and 4-11 $\mu gPM2.5\ m^{-3}$ were recorded. In September, PM10 mean is higher than TSP mean. This is due to the levels registered during an episode with relative high PM levels in September 2003 when TSP was not measured. This episode biased PM10 and PM2.5 mean levels towards high values while TSP mean levels were not affected.

Table Ap.132. Number of days per month without advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 ($\mu g\ m^{-3}$) recorded at Barcarrota rural site (SW Spain) for those days.

	WIA	ITL		WIA	ITL
January			**July**		
Days per month	1.5	0.0	Days per month	0.0	3.8
TSP	15		TSP		44
PM10			PM10		25
PM2.5			PM2.5		17
February			**August**		
Days per month	2.8	0.0	Days per month	0.0	7.3
TSP	16		TSP		39
PM10	10		PM10		29
PM2.5	7		PM2.5		22
March			**September**		
Days per month	3.2	0.0	Days per month	1.5	6.7
TSP			TSP	16	50
PM10	12		PM10	21	37
PM2.5	7		PM2.5	11	25
April			**October**		
Days per month	3.0	0.0	Days per month	7.7	0.7
TSP	31		TSP	22	39
PM10	13		PM10	14	
PM2.5	10		PM2.5	9	
May			**November**		
Days per month	5.7	0.8	Days per month	1.8	0.0
TSP	30	78	TSP	10	
PM10	22		PM10	9	
PM2.5	11		PM2.5	4	
June			**December**		
Days per month	0.0	5.0	Days per month	5.8	0.0
TSP		49	TSP	16	
PM10		28	PM10	13	
PM2.5		19	PM2.5	9	

7. Southwestern Iberian Peninsula

As Table Ap.133 shows, the most frequent type of air mass long range transport over Southeastern Iberian Peninsula in the study period (1998-2003) was the advection of Atlantic air masses which occurred in 782 days (36% of the 2191 days of the period 1998-2003) resulting in 211 episodes. The situations in which no prevailing advective conditions prevail were also considerably frequent. These conditions were observed in 626 days (29% of the total number of days in 1998-2003) grouped in 191 events. Similar frequencies of occurrence were observed for North African dust outbreaks over the area. 160 of these events occurred resulting in 578 days (26% of the 2191 days of the period 1998-2003). Much less frequent was the transport of European and Mediterranean air masses over Southeastern Iberia. A total of 54 Mediterranean episodes and 40 European episodes occurred resulting in 100 and 105 days respectively (5% of the days in the study period in both cases).

Table Ap.133. Number of days, % of days and episodes with Atlantic (ATL), North African (NAF), Mediterranean (MED) and European (EU) advection and without a prevalent advective regime (NOADV) in Southeastern Iberia for the period 1998-2003.

1998-2003	ATL	NAF	MED	EU	NOADV
Number of days	782	578	100	105	626
% of days	36	26	5	5	29
Number of events	211	160	54	40	191

Daily data on PM levels recorded at Víznar air quality monitoring station (37º 14' N, 3º 28' W, 1230 m.a.s.l.) was used in this study as representative regional background site of Southeastern Iberia. This station belongs to the EMEP network and the sampling was performed using the gravimetric method using high volume samplers. In the study period (1998-2003), Víznar station offered data on TSP from the beginning of 1998 until January 2003 and data on PM10 and PM2.5 since March 2001.
The mean PM levels recorded at Víznar in the study period were low (40 µgTSP m^{-3}, 22 µgPM10 m^{-3} and 11 µgPM2.5 m^{-3}, Table Ap.134), although considerably high if compared with those obtained at other regional background of the Iberian Peninsula. As expected, the annual limit value established by the 1999/30/CE for 2005 (40 µgPM10 m^{-3}) is not exceeded in any of the years. On the contrary, the annual limit value proposed in the European Directive for 2010 (20 µgPM10 m^{-3}) was exceeded in 2001, 2002 and 2003.

Table Ap.134. Mean levels of TSP, PM10 and PM2.5 recorded in Víznar in 1998-2003.

MEAN LEVELS	**Víznar**		
(µg m^{-3})	TSP	PM10	PM2.5
1998	36	na	na
1999	42	na	na
2000	44	na	na
2001	41	*24	*12
2002	39	21	10
2003	na	21	9
Mean 98-03	40	22	11

*Calculated with data of 83% of the months of the year
na: Not available

7.1. Atlantic episodes

As shown in Table Ap.135, in a total of 782 days (130 per year and 11 per month) Southeastern Iberian Peninsula was under the influence of the advection of Atlantic air masses. These days were grouped in 211 events (35 per year and 3 per month) with a mean duration of 4 days.
The majority of the Atlantic advection situations were caused by the presence of the Azores high and the Iceland low on their standard locations (AZH-NAtD scenario). A total of 687 days (88% of the 782 days, 115 per year and 10 per month, Table Ap.135) grouped in 169 episodes (80% of the 211 episodes, 28 per year and 2 per month, Table Ap.135) were associated with this transport scenario. AZH-NAtD episodes had a mean duration of 4 days.
The remaining 95 days of the 782 (12% of the days, 16 per year and 1 per month, Table Ap.135) occurred when depressions developed in front of the Portuguese coast (AD scenario). These 95 days resulted in 42 AD episodes (20% of the 211 episodes, 7 per year and 1 per month, Table Ap.135) with an average duration of 2 days.
The annual number of days with Atlantic advection over Southeastern Iberian Peninsula ranged from 90 (in 2003) to 151 (in 2002). The number of days associated with AZH-NAtD scenario ranged from 74 (in 2003) to 136 (in 2002) while the number if days associated with AD scenario varied in the range 9 (in 1999) to 24 (in 2000).
The number of Atlantic events ranged from 26 (in 2003) to 39 (in 2001 and 2002). Focusing on the transport scenarios, the number of AZH-NAtD episodes ranged from 16 (in 2003) to 33 (in 1999) and the number of AD events ranged from 4 (in 1998 and 1999) to 10 (in 2003).

Table Ap.135. Annual number of days and episodes with Atlantic advection in the period 1998-2003 over Southeastern Iberian Peninsula. The AZH-NAtD and AD scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total ATL	130	143	138	130	151	90	130	11
AZH-NAtD	112	134	114	117	136	74	115	10
AD	18	9	24	13	15	16	16	1
Episodes								
Total ATL	34	37	36	39	39	26	35	3
AZH-NAtD	30	33	28	32	30	16	28	2
AD	4	4	8	7	9	10	7	1

As Figure Ap.121 shows, the occurrence of Atlantic episodes over Southeastern Iberia in 1998-2003 was superior in April (a total of 27 episodes in 1998-2003) and in December-January (23 events from 1998-2003 in January). Atlantic events were also common in September (20 episodes in 1998-2003) and, secondarily, in July (15 events in the study period) although in June and August the lowest frequencies of occurrence in the year were registered (9 episodes in both months in 1998-2003). AZH-NAtD episodes were also common in the same periods as the general Atlantic events. Thus, April (18 episodes in the study period), December-January (17 episodes in 1998-2003 in January), September (16 events from 1998 to 2003) and July (15 events in the 6-years period) were periods of frequency maxima for these episodes. AD episodes were frequent in spring (9 events in April during 1998-2003) and in December-January (6 episodes in both month in the study period). Moreover a second order frequency peak was registered in late summer (the peak in September with 4 days in 1998-2003).

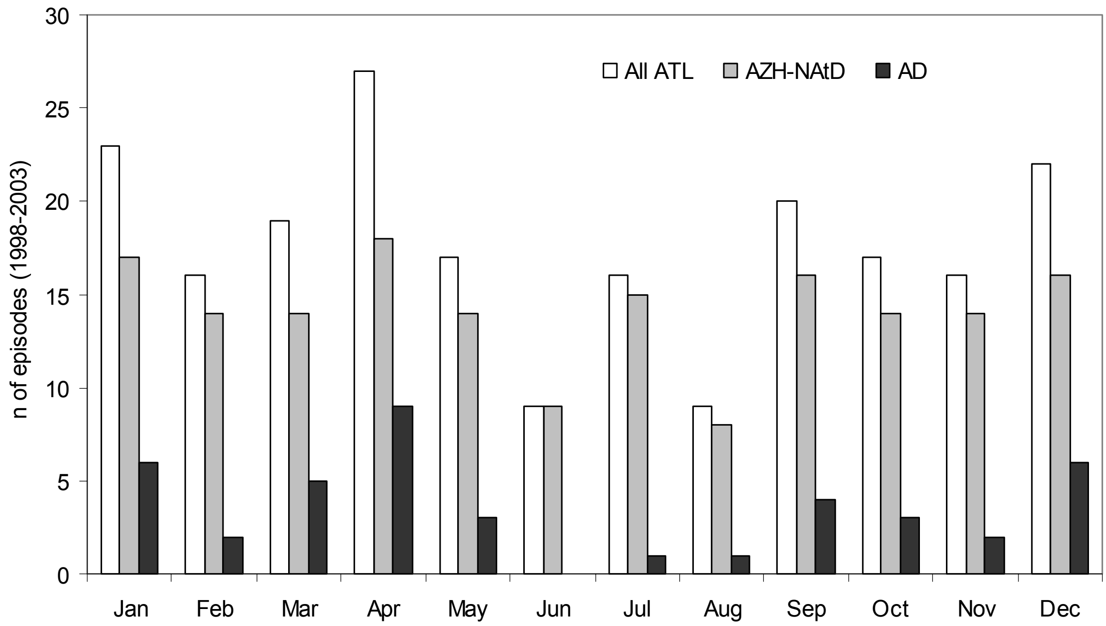

Figure Ap.121. Monthly distribution of the number of Atlantic episodes over Southeastern Iberian Peninsula. The monthly distributions of AZH-NAtD and AD Atlantic events are also shown.

As shown by Figures Ap.122 and Ap.123, the frequency peaks in the seasonal distribution of the days with Atlantic advection were registered in autumn (frequency peak in November with 18 days), January and April (17 days as monthly mean in these two months). The daily occurrence of these scenarios in summer was scarce. The days with Atlantic advection associated with AZH-NAtD scenario were also frequent in autumn (with a monthly mean of 18 days in November), January (monthly average of 15 days) and April (13 days as monthly mean) while the days associated with AD scenario were particularly frequent in April (monthly average of 4 days) and, in a second extent, in September-October and December-January (a monthly mean of 2 days in these 4 months).

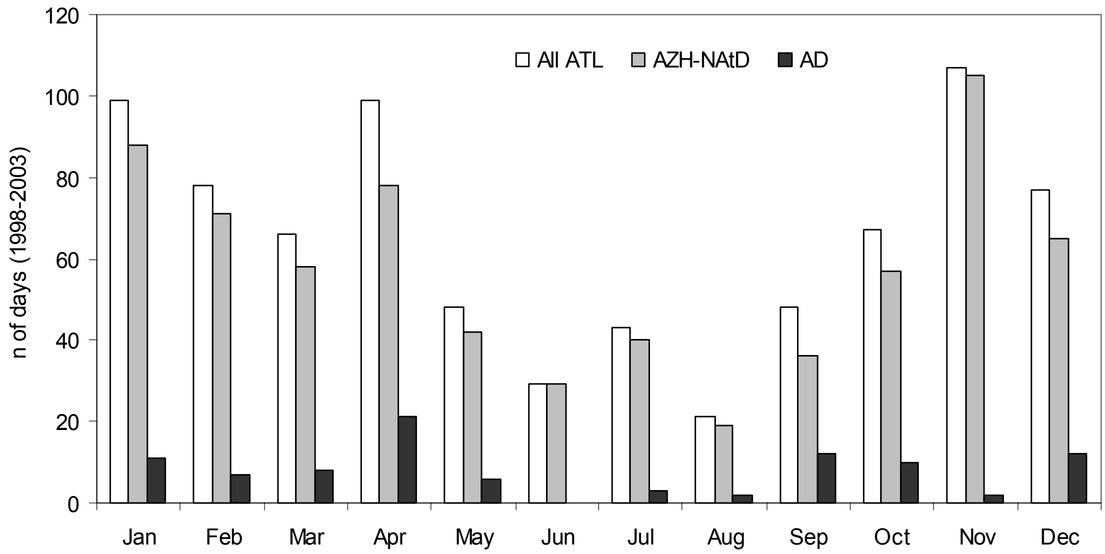

Figure Ap.122. Monthly distribution of the number of days with Atlantic advection over Southeastern Iberian Peninsula. The monthly distributions of days with Atlantic advection occurred under AZH-NAtD and AD scenarios are also shown.

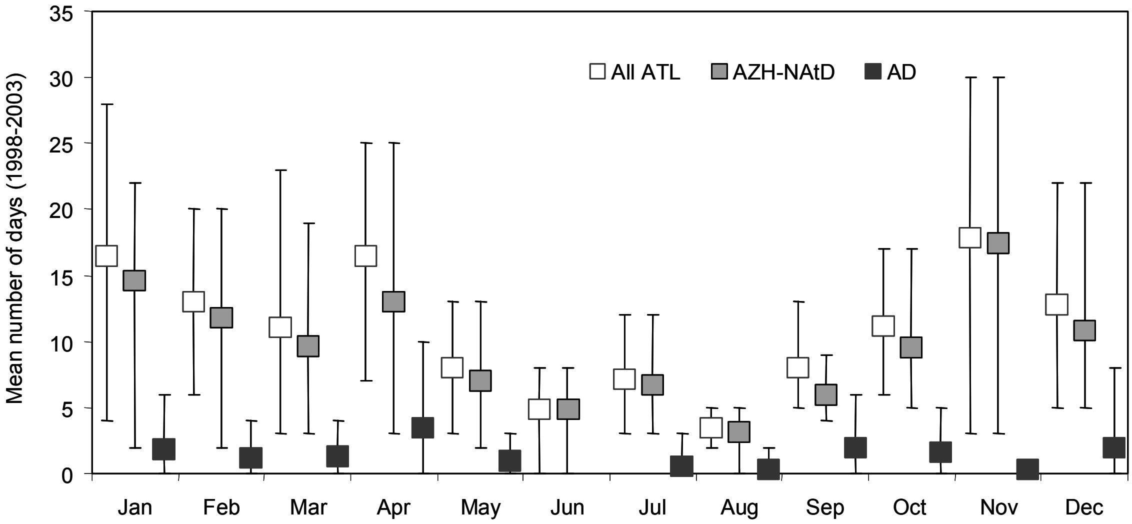

Figure Ap.123. Mean number of days with Atlantic advection over Southeastern Iberian Peninsula per month for 1998-2003. AZH-NAtD and AD episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

The mean duration of the Atlantic episodes (Figure Ap.124) was shorter in from May to September (2 -3 days) than in the rest of the year (in the range 3 to 7 days with the longest episodes in November). The mean duration of AZH-NAtD episodes was longer from October to April (4-8 days with the maximum mean duration of 8 days in November), in the rest of the year the average duration reached 2-3 days. AD events lasted on average 1-3 days in all the months with the exception of February with 4 days.

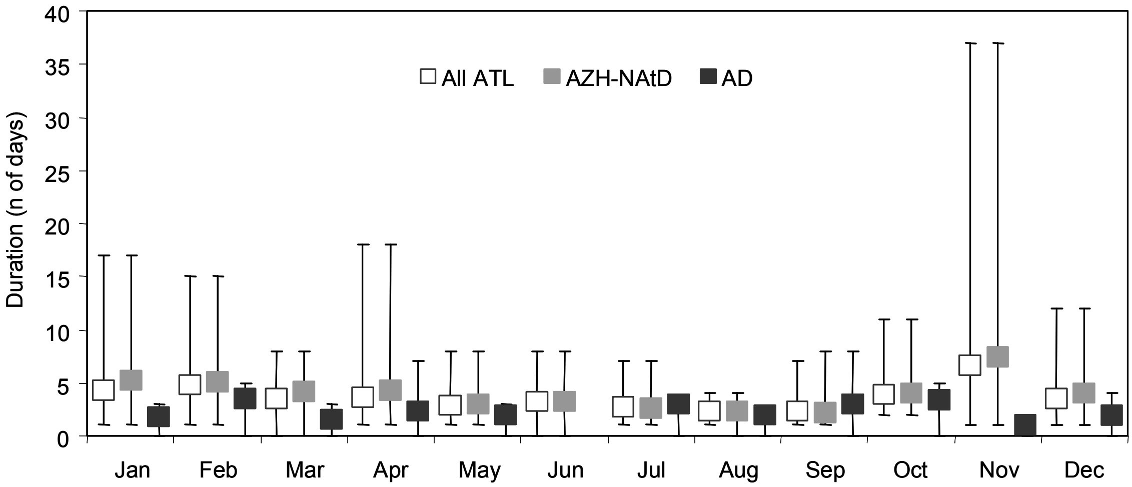

Figure Ap.124. Mean duration of Atlantic episodes per month over Southeastern Iberian Peninsula for 1998-2003. AZH-NAtD and AD episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

The mean PM levels recorded at Víznar during episodes of Atlantic advection (26 µgTSP m^{-3}, 13 µgPM10 m^{-3} and 7 µgPM2.5 m^{-3}, Table Ap.136) were considerably lower than the annual mean PM levels (40 µgTSP m^{-3}, 22 µgPM10 m^{-3} and 11 µgPM2.5 m^{-3}). The relatively low concentration of pollutants in Atlantic air masses and the relatively high frequency of occurrence of rain associated with the frontal systems crossing the Iberian Peninsula during Atlantic episodes could explain this fact. Thus, most of the mean PM load of Atlantic events could be attributed to local or regional contributions.

Table Ap.136. Mean annual levels of TSP, PM10 and PM2.5 registered in Víznar during Atlantic advection episodes in 1998-2003.

ATL EPISODES	**Víznar**		
($\mu g\ m^{-3}$)	TSP	PM10	PM2.5
1998	24	na	na
1999	29	na	na
2000	30	na	na
2001	25	*16	*9
2002	23	13	7
2003	na	10	5
Mean 98-03	26	13	7

*Calculated with data of 83% of the months of the year
na: Not available

The different mean PM levels recorded at Víznar during the two types of Atlantic transport scenarios (26 µgTSP m^{-3}, 13 µgPM10 m^{-3} and 7 µgPM2.5 m^{-3} during AZH-NAtD events and 20 µgTSP m^{-3}, 9 µgPM10 m^{-3} and 4 µgPM2.5 m^{-3} during AD episodes, Table Ap.137) is a consequence of the higher frequency of rain associated with the Atlantic depressions during AD episodes.
Due to the higher frequency of occurrence of AZH-NAtD episodes with respect to AD events the impact index (II) of these two transport scenarios on the annual mean PM levels at Víznar differed greatly (II of 8.2 µgTSP m^{-3}, 4.2 µgPM10 m^{-3} and 2.3 µgPM2.5 m^{-3} for AZH-NAtD events and of 0.9 µgTSP m^{-3}, 0.4 µgPM10 m^{-3} and 0.2 µgPM2.5 m^{-3} for AD episodes, Table Ap.137).

Table Ap.137. Number of days with Atlantic advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 ($\mu g\ m^{-3}$) recorded at Víznar rural site (SE Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	AZH-NAtD	AD
2003		
Víznar TSP ($\mu g\ m^{-3}$)	-	-
Víznar PM10 ($\mu g\ m^{-3}$)	10	9
Víznar PM2.5 ($\mu g\ m^{-3}$)	5	4
Days	74	16
2002		
Víznar TSP ($\mu g\ m^{-3}$)	24	11
Víznar PM10 ($\mu g\ m^{-3}$)	13	7
Víznar PM2.5 ($\mu g\ m^{-3}$)	7	3
Days	136	15
2001		
Víznar TSP ($\mu g\ m^{-3}$)	25	19
Víznar PM10 ($\mu g\ m^{-3}$)	16	10
Víznar PM2.5 ($\mu g\ m^{-3}$)	9	6
Days	117	13
2000		
Víznar TSP ($\mu g\ m^{-3}$)	29	30
Days	114	24
1999		
Víznar TSP ($\mu g\ m^{-3}$)	29	21
Days	134	9
1998		
Víznar TSP ($\mu g\ m^{-3}$)	25	12
Days	112	18
Mean 98-03 ($\mu g\ m^{-3}$)		
Víznar TSP	26	20
Víznar PM10	13	9
Víznar PM2.5	7	4
Impact Index(II) ($\mu g\ m^{-3}$)		
Víznar TSP	8.2	0.9
Víznar PM10	4.2	0.4
Víznar PM2.5	2.3	0.2

The monthly PM means at Víznar for the days with Atlantic advection over Southeastern Iberia were calculated and are presented in Table Ap.138. The highest levels were recorded for AZH-NAtD events from June to September (when PM levels are higher owing to the intensification of re-suspension of soil material, the formation of secondary aerosols by photochemistry and to the low precipitation). Ranges of 33-51 µgTSP m^{-3}, 12-24 µgPM10 m^{-3} and 6-12 µgPM2.5 m^{-3} were recorded in this period during AZH-NAtD events. Also during AZH-NAtD events the monthly PM means were relatively high in February-May (25-31 µgTSP m^{-3}, 12-19 µgPM10 m^{-3} and 7-11 µgPM2.5 m^{-3}). The monthly TSP means during AD episodes were relatively high in March-May (21-34 µgTSP m^{-3}) but, in general, AD events did not give rise to high monthly PM levels.

Table Ap.138. Number of days per month with Atlantic advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 ($\mu g\ m^{-3}$) recorded at Víznar rural site (SE Spain) for those days.

	AZH-NAtD	AD		AZH-NAtD	AD
January			**July**		
Days per month	14.7	1.8	Days per month	6.7	0.5
TSP	16	15	TSP	51	55
PM10	11	9	PM10	24	
PM2.5	6	4	PM2.5	12	
February			**August**		
Days per month	11.8	1.2	Days per month	3.2	0.3
TSP	31	8	TSP	41	
PM10	15	5	PM10	18	21
PM2.5	9	2	PM2.5	9	8
March			**September**		
Days per month	9.7	1.3	Days per month	6.0	2.0
TSP	25	21	TSP	39	16
PM10	12	9	PM10	18	9
PM2.5	8	5	PM2.5	9	5
April			**October**		
Days per month	13.0	3.5	Days per month	9.5	1.7
TSP	30	34	TSP	20	14
PM10	19	7	PM10	10	10
PM2.5	11	4	PM2.5	5	4
May			**November**		
Days per month	7.0	1.0	Days per month	17.5	0.3
TSP	29	25	TSP	17	7
PM10	13	11	PM10	9	
PM2.5	7	6	PM2.5	5	
June			**December**		
Days per month	4.8	0.0	Days per month	10.8	2.0
TSP	33		TSP	15	8
PM10	12		PM10	8	6
PM2.5	6		PM2.5	5	3

7.2. African episodes

A total of 160 African dust outbreaks (27 per year and 2 per month, Table Ap.139) were registered over the Southeastern Iberian Peninsula in 1998-2003. These events resulted in 578 days (96 per year and 8 per month, Table Ap.139). The African episodes had a mean duration of 4 days.

A total of 61 days (11% of the 578 days, 10 per year and 1 per month, Table Ap.139) occurred when an anticyclone was present at surface level over Northern Africa and the Iberian Peninsula (NAH-S scenario). These days were grouped in 16 NAH-S episodes (10% of the African events in 1998-2003 and 3 per year, Table Ap.139) with a mean duration of 4 days.

Other 122 days of the 578 (21% of the days, 20 per year and 2 per month, Table Ap.139) occurred under meteorological conditions characterised by the presence of an Atlantic depression by the Portuguese coast (AD scenario). These 122 days gave rise to 45 episodes (28% of the African events in 1998-2003, 8 per year and 1 per month, Table Ap.139) with an average extent of 3 days.

From the 160 African events, in 28 (18% of the African events in 1998-2003 and 5 per year, Table Ap.139) the meteorological situation was associated with the development of depressions over Northern Africa (NAD scenario). These 28 episodes had a mean

duration of 3 days and resulted in 87 days (15% of the 578 days, 15 per year and 1 per month, Table Ap.139).
The most common synoptic scenario which resulted in African dust outbreaks over the study area was characterised by the presence of an anticyclone shifted at high atmospheric levels over North Africa or the Iberian Peninsula in the warm season (NAH-A scenario). These situations occurred in 71 events (44% of the African events in 1998-2003, 12 per year and 1 per month, Table Ap.139) which resulted in 308 days (53% of the 578 days, 51 per year and 4 per month, Table Ap.139) and had a mean duration of 4 days.
The annual number of days in which African air masses reached Southeastern Iberia (Table Ap.139) ranged from 69 (in 1998) to 115 (in 2003). The ranges of the annual number of days associated with the different transport scenarios were: 2 (in 1999 and 2001) to 20 (in 1998 and 2002) for NAH-S, 12 (in 1998) to 28 (in 2001) for AD, 6 (in 2000) to 26 (in 2001) for NAD, and 29 (in 1998) to 63 (in 2003) for NAH-A.
With respect to the annual number of African events (Table Ap.139), these ranged from 19 (in 1998) to 2001 (in 2001). The ranges of variation of the number of the African episodes associated with the different transport scenarios in 1998-2003 were: 1 (in 1999 and 2003) to 5 (in 2000 and 2002) for NAH-S, 4 (in 1998 and 1999) to 11 (in 2003) for AD, 1 (in 2000) to 11 (in 2001) for NAD, and 10 (in 1998) to 15 (in 2003) for NAH-A.

Table Ap.139. Annual number of days and episodes with African advection in the period 1998-2003 over Southeastern Iberian Peninsula. The NAH-S, AD, NAD and NAH-A scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total NAF	69	84	106	103	101	115	96	8
NAH-S	20	2	13	2	20	4	10	1
AD	12	14	26	27	15	28	20	2
NAD	8	20	6	26	7	20	15	1
NAH-A	29	48	61	48	59	63	51	4
Episodes								
Total NAF	19	21	25	35	29	28	27	2
NAH-S	2	1	5	2	5	1	3	<1
AD	4	4	8	9	6	11	8	1
NAD	3	5	1	11	3	5	5	<1
NAH-A	10	11	11	13	15	11	12	1

The seasonal distribution of the number of African episodes occurred over Southeastern Iberian Peninsula in 1998-2003 (Figure Ap.125) is characterised by two main maxima, in summer (especially in July with 23 events in 1998-2003) and in March (20 episodes in the whole study period), and a second order maximum in December-January (12 events from 1998 to 2003 in January). The lowest occurrence of African episodes was registered in April and November with 8 events in the whole study period in these two months. NAH-S episodes practically did not occur out of the period December-March (with the highest frequency of occurrence in January-March reaching 5 events in the 6-years period in both January and March). AD episodes did not occur in summer and were especially frequent in March (11 events in the 6-years period), December (9 events in 1998-2003) and, in a lesser extent, in October (6 episodes in the study period). NAD episodes occurred only from January to May (with the frequency peak in May with 6 events in 1998-2003) and from September to November (with 4 episodes in the study period in November). The period of occurrence of NAH-A episodes run from May to October but these events were very frequent from June to September (up to 23 episodes in July from 1998 to 2003).

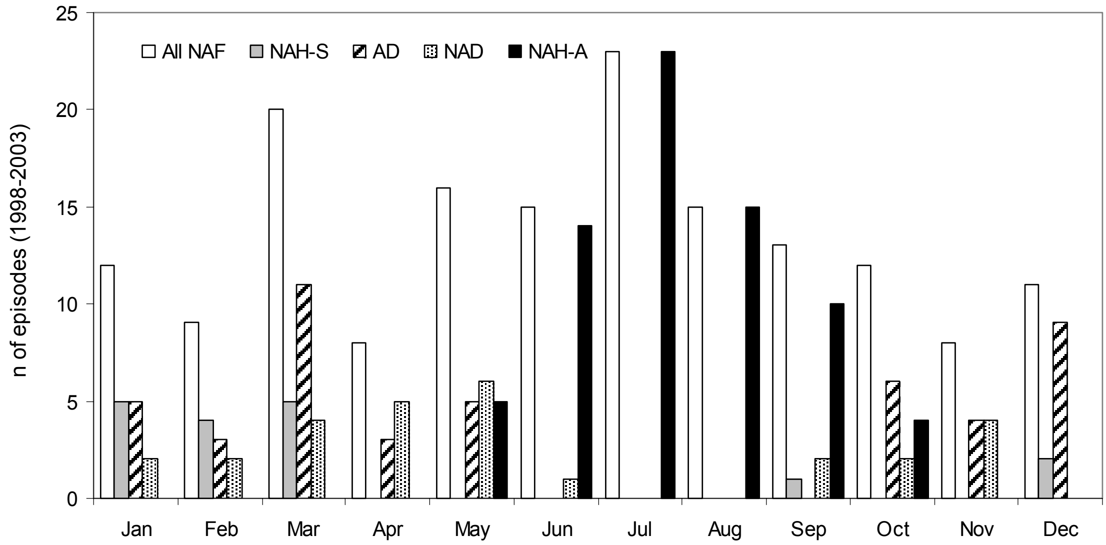

Figure Ap.125. Monthly distribution of the number of African episodes over Southeastern Iberian Peninsula. The monthly distributions of NAH-S, AD, NAD and NAH-A African events are also shown.

Concerning the seasonal distribution of the days with African advection over Southeastern Iberia in 1998-2003 (Figures Ap.126 and Ap.127) a clear summer maximum can be observed (up to 15 days as monthly mean in July). In January-March (with 9 days as monthly mean in March) and in October (7 days as monthly average), second order peaks can be also observed. The occurrence of days associated with NAH-S scenario only was relatively important from January to March (up to 4 days as monthly mean in February). The days associated with the AD scenario reached up to 5 days as monthly mean frequency in March and 3 days as monthly mean frequencies in October, December and May. The frequency of occurrence of NAD situations was especially high in May (4 days as monthly average) although second order maxima were registered in November (3 days as monthly mean) and March (monthly mean of 2 days). The occurrence of NAH-A situations was centred in summer (13-15 days as monthly means in June-August with the frequency peak in July).

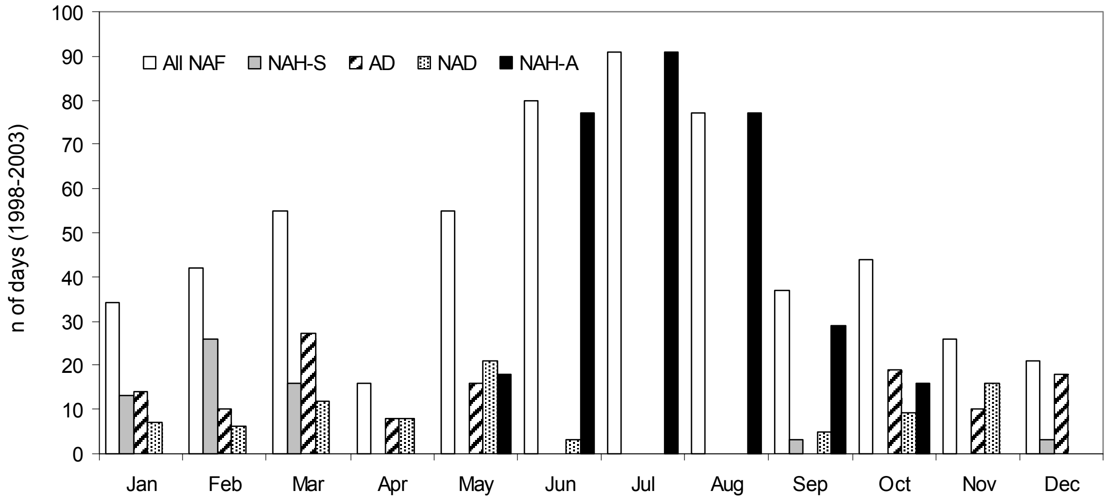

Figure Ap.126. Monthly distribution of the number of days with African advection over Southeastern Iberian Peninsula. The monthly distributions of days with African advection occurred under NAH-S, AD, NAD and NAH-A scenarios are also shown.

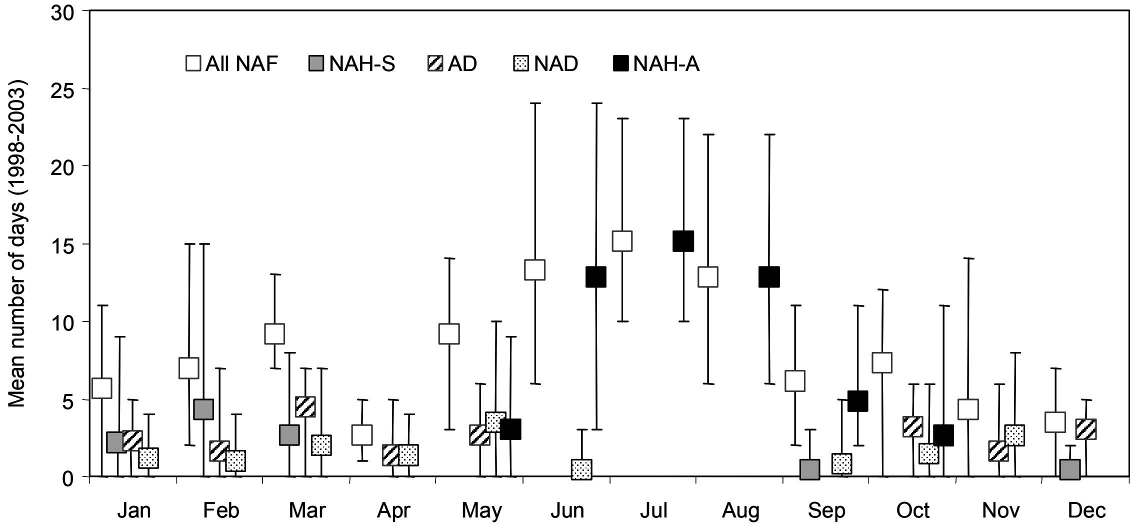

Figure Ap.127. Mean number of days with African advection over Southeastern Iberian Peninsula per month for 1998-2003. NAH-S, AD, NAD and NAH-A episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

As shown in Figure Ap.128, the African episodes were longer in February (5 days on average) and in summer (5 days as a mean in June and August). NAH-S episodes reached up to a mean duration of 7 days in February and AD events had a mean duration of 2-3 days in all the months. NAD episodes had a mean duration of 2-3 days in all the months with the exception of October (5 days) and November, January and May (4 days). NAH-A events lasted on average 3-4 days in all the months with the exception of June (6 days) and August (5 days).

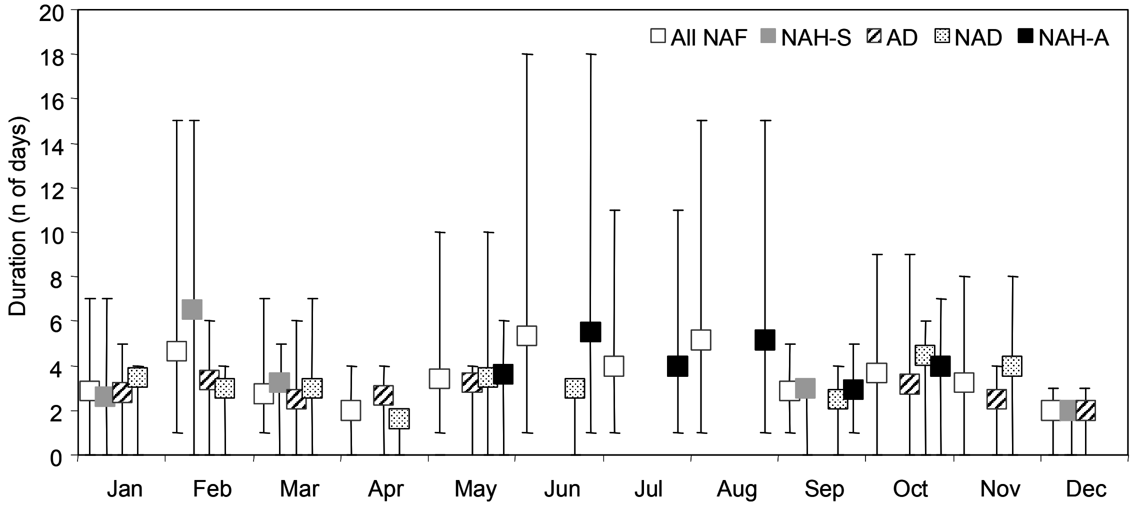

Figure Ap.128. Mean duration of African episodes per month over Southeastern Iberian Peninsula for 1998-2003. NAH-S, AD, NAD and NAH-A episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

As the African air masses are generally heavy loaded with crustal material the mean PM levels recorded at Víznar during African dust outbreaks (62 µgTSP m^{-3}, 35 µgPM10 m^{-3} and 14 µgPM2.5 m^{-3}, Table Ap.140) were much higher than the annual mean PM levels from 1998 to 2003 (40 µgTSP m^{-3}, 22 µgPM10 m^{-3} and 11 µgPM2.5 m^{-3}).

Table Ap.140. Mean annual levels of TSP, PM10 and PM2.5 registered in Víznar during African advection episodes in 1998-2003.

NAF EPISODES	Víznar		
(µg m^{-3})	TSP	PM10	PM2.5
1998	50	na	na
1999	66	na	na
2000	65	na	na
2001	62	*36	*15
2002	64	36	14
2003	na	33	12
Mean 98-03	62	35	14

*Calculated with data of 83% of the months of the year
na: Not available

As shown in Table Ap.141, the mean PM levels recorded at Víznar during the four different African episodes distinguished in this study were different. Very high mean PM levels were recorded at Víznar during NAH-A episodes (81 µgTSP m^{-3}, 42 µgPM10 m^{-3} and 16 µgPM2.5 m^{-3}). Apart from the high loads of mineral aerosols in the African air masses, these high mean PM levels were reached owing to the regional contribution consisting in secondary aerosols arising from the photochemical transformation of gaseous precursors. During NAH-A situations the African plumes travel at high altitudes (>1500 m.a.s.l.) and the dust penetrates in the mixing layer because the vertical development of this layer can reach up to 2500 metres over continental areas in summer (Crespi et al., 1995). Once into the boundary layer the dust is distributed and affects the sampling stations. The formation of these secondary particles is enhanced during NAH-A situations because, at surface, a low pressure gradient remains causing lack of advective conditions. In these circumstances, superficial air masses are hardly renovated and the aging and recirculation of contaminated air masses aided by the orographic conditions of Eastern Iberian Peninsula commonly occur (Millán et al., 1997). Furthermore, during NAH-A episodes, precipitation is reduced and re-suspension of soil material by convection is enhanced. This factors result in a local contribution of PM. Thus, owing to these complex convective dynamics there is mixing of aerosols in the troposphere during NAH-A events. Other African events also had an important impact on mean PM levels at Víznar such as NAH-S episodes, with low frequency of rain associated, (48 µgTSP m^{-3}, 35 µgPM10 m^{-3} and 15 µgPM2.5 m^{-3}) and NAD events because of the vicinity of the active desert source areas during this type of transport (Northern Algeria and Tunisia) to Southeastern Iberia (45 µgTSP m^{-3}, 25 µgPM10 m^{-3} and 12 µgPM2.5 m^{-3}). The lowest mean PM levels at Víznar among African events were recorded during AD episodes (36 µgTSP m^{-3}, 21 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3}).

These different PM levels and the difference in frequency of occurrence of the four types of African episodes result in strong differences in the impact index (II) on the annual mean PM levels at Víznar (Table Ap.141). NAH-A reached a very important II (11.3 µgTSP m^{-3}, 5.9 µgPM10 m^{-3} and 2.3 µgPM2.5 m^{-3}) because the occurrence of these events is abundant and the PM levels recorded during these events were very high. AD and NAD episodes reached similar II (2.0 µgTSP m^{-3}, 1.2 µgPM10 m^{-3} and 0.5 µgPM2.5 m^{-3} for AD and 1.8 µgTSP m^{-3}, 1.0 µgPM10 m^{-3} and 0.5 µgPM2.5 m^{-3} for NAD). AD situations were more frequent than NAD but these are relatively more frequent than AD events. The low frequency of occurrence of NAH-S events cause the II for this scenario to be the lowest among African situations (1.3 µgTSP m^{-3}, 1.0 µgPM10 m^{-3} and 0.4 µgPM2.5 m^{-3}).

Table Ap.141. Number of days with African dust outbreaks occurred under the 4 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 ($\mu g\ m^{-3}$) recorded at Víznar rural site (SE Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	NAH-S	AD	NAD	NAH-A
2003				
Víznar TSP ($\mu g\ m^{-3}$)	-	-	-	-
Víznar PM10 ($\mu g\ m^{-3}$)	33	20	24	41
Víznar PM2.5 ($\mu g\ m^{-3}$)	11	8	9	15
Days	4	28	20	63
2002				
Víznar TSP ($\mu g\ m^{-3}$)	54	26	32	80
Víznar PM10 ($\mu g\ m^{-3}$)	35	14	21	41
Víznar PM2.5 ($\mu g\ m^{-3}$)	15	6	13	15
Days	20	15	7	59
2001				
Víznar TSP ($\mu g\ m^{-3}$)	-	45	44	82
Víznar PM10 ($\mu g\ m^{-3}$)	-	27	27	43
Víznar PM2.5 ($\mu g\ m^{-3}$)	-	11	14	18
Days	2	27	26	48
2000				
Víznar TSP ($\mu g\ m^{-3}$)	72	38	37	77
Days	13	26	6	61
1999				
Víznar TSP ($\mu g\ m^{-3}$)	62	23	61	82
Days	2	14	20	48
1998				
Víznar TSP ($\mu g\ m^{-3}$)	28	40	26	86
Days	20	12	8	29
Mean 98-03 ($\mu g\ m^{-3}$)				
Víznar TSP	48	36	45	81
Víznar PM10	35	21	25	42
Víznar PM2.5	15	8	12	16
Impact Index(II) ($\mu g\ m^{-3}$)				
Víznar TSP	1.3	2.0	1.8	11.3
Víznar PM10	1.0	1.2	1.0	5.9
Víznar PM2.5	0.4	0.5	0.5	2.3

The highest monthly means for African episodes were recorded in summer during NAH-A episodes (with means in the ranges 63-87 µgTSP m^{-3}, 30-46 µgPM10 m^{-3} and 12-17 µgPM2.5 m^{-3}, Table Ap.142) although during other types of African episodes PM means also reached high levels, such as in January-March for NAH-S events (with means in the ranges 34-77 µgTSP m^{-3}, 29-52 µgPM10 m^{-3} and 13-18 µgPM2.5 m^{-3}, Table Ap.142) and for NAD episodes in September-October (37-78 µgTSP m^{-3}, 28-40 µgPM10 m^{-3} and 17-20 µgPM2.5 m^{-3}, Table Ap.142).

Table Ap.142. Number of days per month with African advection occurred under the 4 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (all units in µg m^{-3}) recorded at Víznar rural site (SE Spain) for those days.

	NAH-S	AD	NAD	NAH-A		NAH-S	AD	NAD	NAH-A
January					**July**				
Days per month	2.2	2.3	1.2	0.0	Days per month	0.0	0.0	0.0	15.2
TSP	40	28	27		TSP				82
PM10	29	18			PM10				45
PM2.5	13	8			PM2.5				17
February					**August**				
Days per month	4.3	1.7	1.0	0.0	Days per month	0.0	0.0	0.0	12.8
TSP	34	56	21		TSP				82
PM10	36	14			PM10				38
PM2.5	18	6			PM2.5				16
March					**September**				
Days per month	2.7	4.5	2.0	0.0	Days per month	0.5	0.0	0.8	4.8
TSP	77	37	50		TSP			78	75
PM10	52	29	35		PM10	33		40	35
PM2.5	18	10	15		PM2.5	12		17	16
April					**October**				
Days per month	0.0	1.3	1.3	0.0	Days per month	0.0	3.2	1.5	2.7
TSP		27	47		TSP		37	37	63
PM10		8	29		PM10		18	28	30
PM2.5		4	14		PM2.5		7	20	13
May					**November**				
Days per month	0.0	2.7	3.5	3.0	Days per month	0.0	1.7	2.7	0.0
TSP		62	57	72	TSP		34	32	
PM10		20	15	36	PM10		32	18	
PM2.5		9	8	12	PM2.5		12	8	
June					**December**				
Days per month	0.0	0.0	0.5	12.8	Days per month	0.5	3.0	0.0	0.0
TSP			51	87	TSP	23	23		
PM10				46	PM10	33	14		
PM2.5				16	PM2.5	9	5		

7.3. European episodes

In 105 days of the period 1998-2003 (18 per year and 1 per month, Table Ap.143) the long range transport of European air masses affected occurred over the Southeastern Iberian Peninsula. These days were grouped in 40 episodes (7 per year and 1 per month, Table Ap.143) with a mean duration of 3 days.

A large proportion, 65%, of those 40 episodes (26 episodes in total and 4 per year, Table Ap.143) occurred when an anticyclone was located over the European continent or over the North Atlantic Ocean (EUH scenario). These episodes, with a mean duration of 3 days, resulted in 70 days of the study period (67% of the days with European advection, 12 per year and 1 per month, Table Ap.143).

The remaining 35% of the events (14 episodes in total and 2 per year, Table xxx126) were caused by the presence of depressions over the western Mediterranean (MD scenario). These episodes resulted in 35 days (33% of the days with European advection and 6 per year, Table Ap.143) and reached an average duration of 3 days.

The annual frequency of occurrence of days with European advection over Southeastern Iberia ranged from 10 (in 2001) to 23 (in 2003). Differentiating the transport scenarios, the number of days associated with EUH scenario ranged from 8

(in 2001 and 2002) to 17 (in 2003) while the number of days associated with MD scenario varied in the range 0 (in 2000) to 14 (in 2002).
The annual number of European events over Southeastern Iberian Peninsula ranged from 5 (in 2000 and 2001) to 11 (in 1998) in 1998-2003. While the number of EUH events ranged from 2 (in 2002) to 6 (in 1998), the number of MD episodes run from 0 (in 2000) to 5 (in 1998).

Table Ap.143. Annual number of days and episodes with European advection in the period 1998-2003 over Southeastern Iberian Peninsula. The EUH and MD scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total EU	21	14	15	10	22	23	18	1
EUH	13	9	15	8	8	17	12	1
MD	8	5	0	2	14	6	6	<1
Episodes								
Total EU	11	6	5	5	6	7	7	1
EUH	6	4	5	4	2	5	4	<1
MD	5	2	0	1	4	2	2	<1

The occurrence of European events over Southeastern Iberian Peninsula (Figure Ap.129) is practically restricted to the period November-March (30 of the 40 European episodes of the period 1998-2003 occurred in these 5 months) reaching up to 8 episodes in January in the whole study period. In fact, July and August were devoid of this type of episodes. The seasonal distribution of the number of EUH episodes followed the same trend with a peak of 7 events in January during the study period. MD episodes occurred mainly in November and December (50% of the 14 MD episodes registered in the period 1998-2003 occurred in these two months).

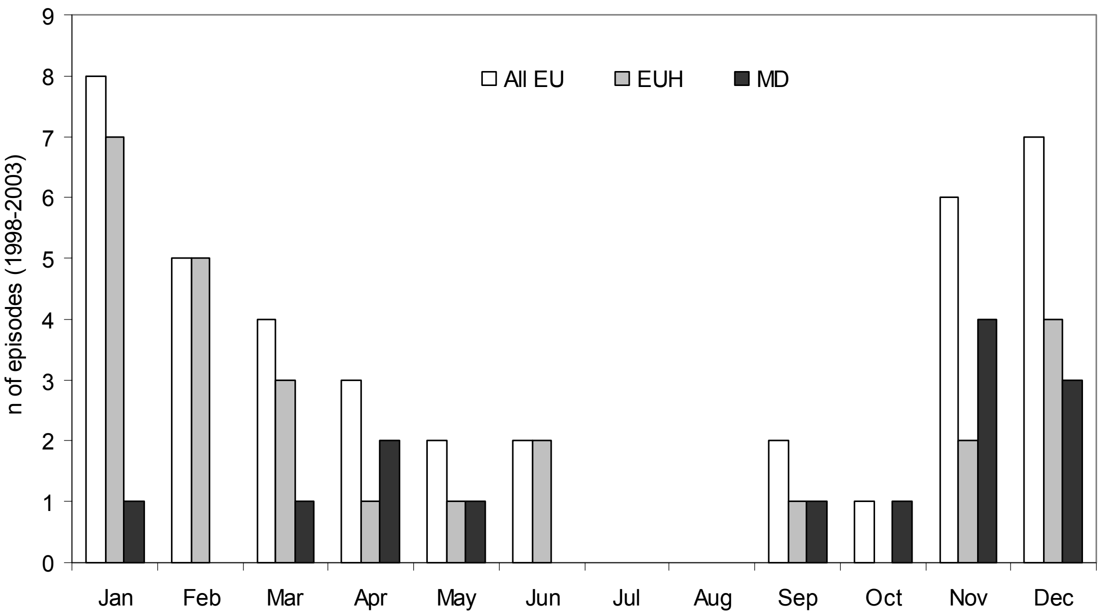

Figure Ap.129. Monthly distribution of the number of European episodes over Southeastern Iberian Peninsula. The monthly distribution of EUH and MD European events is also shown.

The seasonal distribution of days with European advection over Southeastern Iberian Peninsula (Figures Ap.130 and Ap.131) is characterised by a higher frequency of occurrence in the cold season of the year (the monthly means from November to April reached 2 or 3 days with the frequency peak in January). Very few days with European transport occurred in the rest of the year only with the exception of September (1 day as monthly mean). This seasonal pattern is governed by the occurrence of EUH scenario. This mainly occurred from December to March (with monthly means reaching up to 3 days in January). The MD scenario commonly occurred in three periods: April, November-December and September (with monthly means of 1 day in these four months).

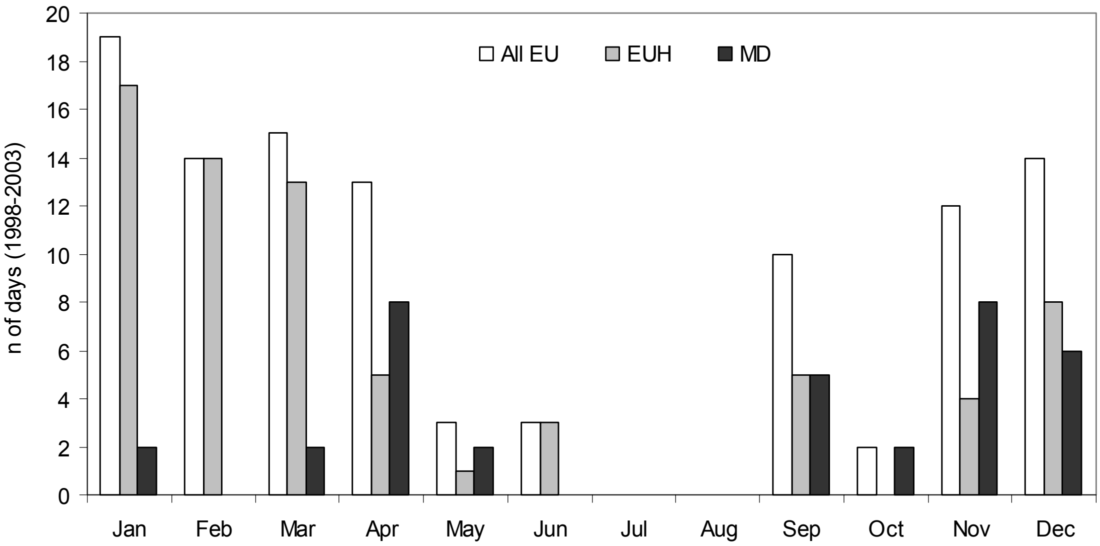

Figure Ap.130. Monthly distribution of the number of days with European advection over Southeastern Iberian Peninsula. The monthly distributions of days with European advection occurred under EUH and MD scenarios are also shown.

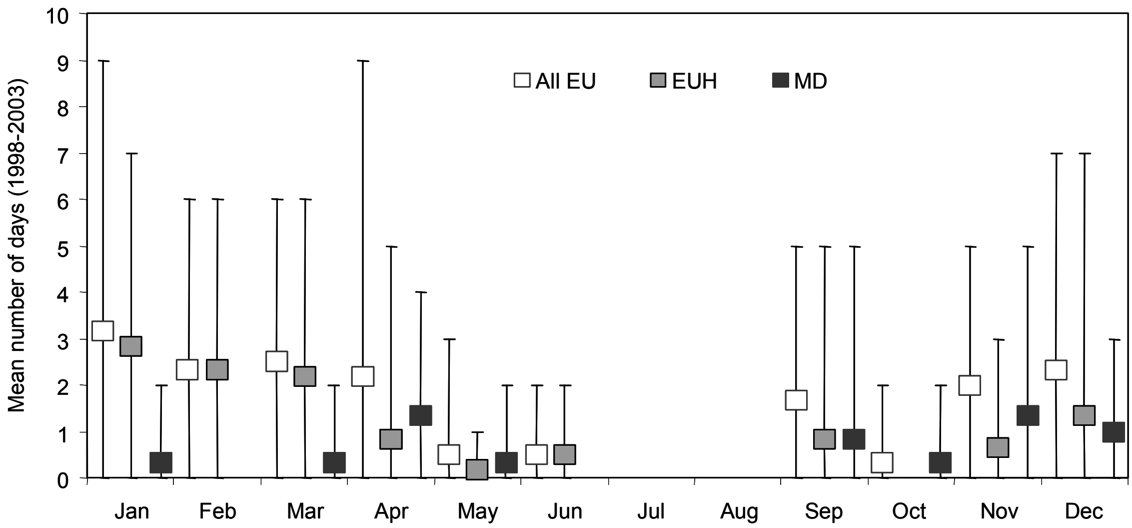

Figure Ap.131. Mean number of days with European advection over Southeastern Iberian Peninsula per month for 1998-2003. EUH and MD episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

As shown in Figure Ap.132, the longest European events on average occurred in September (5 days) and in March-April (4 days in both months). EUH episodes also reached the longest mean durations in these two periods (5 days in September and 4-5 days in March-April) and MD episodes lasted on average up to 5 days in September and 4 days in April. However, the number of episodes in September, March and April were low so these conclusions should be taken with caution

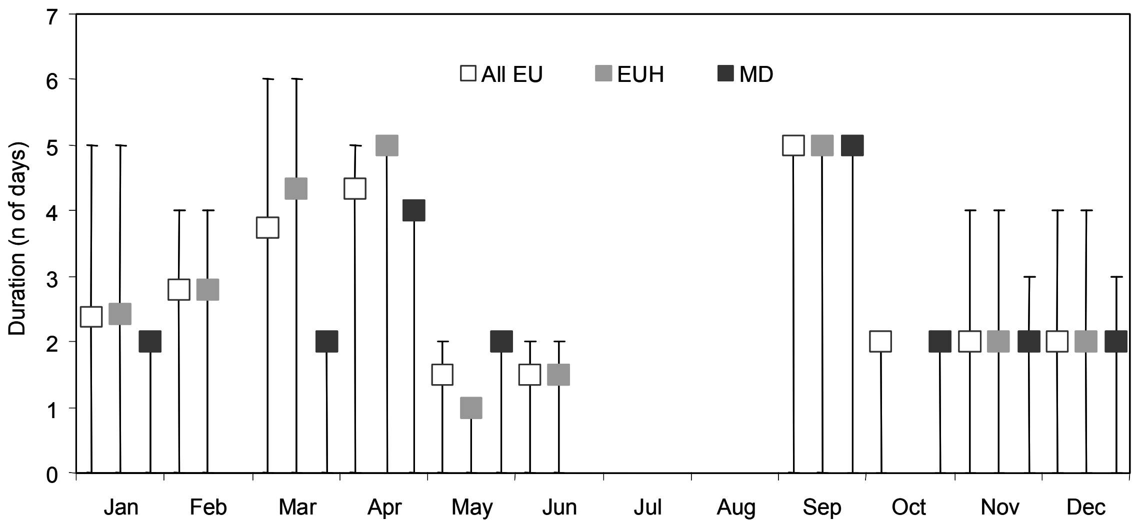

Figure Ap.132. Mean duration of European episodes per month over Southeastern Iberian Peninsula for 1998-2003. EUH and MD episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

The mean PM levels recorded at Víznar during episodes of advection of European air masses (28 µgTSP m^{-3}, 15 µgPM10 m^{-3} and 9 µgPM2.5 m^{-3}, Table Ap.144) were low compared with the annual mean PM levels at that site (40 µgTSP m^{-3}, 22 µgPM10 m^{-3} and 11 µgPM2.5 m^{-3}). This can respond to the dispersion/dilution of pollutants in the European air masses in the long transport down to Southeastern Iberia. Moreover, the effect of the common rainfall which affects the study area associated with some the European episodes (especially MD episodes) may be also of relevance.

Table Ap.144. Mean annual levels of TSP, PM10 and PM2.5 registered in Víznar during European advection episodes in 1998-2003.

EU EPISODES	**Víznar**		
(µg m^{-3})	TSP	PM10	PM2.5
1998	22	na	na
1999	28	na	na
2000	47	na	na
2001	18	*11	*10
2002	26	16	10
2003	na	15	9
Mean 98-03	28	15	9

*Calculated with data of 83% of the months of the year
na: Not available

The mean PM levels recorded at Víznar during EUH events (34 µgTSP m^{-3}, 17 µgPM10 m^{-3} and 11 µgPM2.5 m^{-3}, Table Ap.145) were superior to those recorded during MD episodes (14 µgTSP m^{-3}, 12 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3}, Table Ap.145). Under MD situations rainfall commonly occur in the study area and this may diminish of PM levels by washing out of the atmosphere.

The impact index (II) of these scenarios reflect the low weight of European episodes on the annual mean PM levels in Víznar and the differences in PM levels and in frequency of occurrence between EUH and MD events. II of 1.1 µgTSP m^{-3}, 0.5

μgPM10 m^{-3} and 0.3 μgPM2.5 m^{-3} and 0.2 μgTSP m^{-3}, 0.2 μgPM10 m^{-3} and 0.1 μgPM2.5 m^{-3} were recorded for EUH and MD respectively (Table Ap.145).

Table Ap.145. Number of days with European advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (μg m^{-3}) recorded at Víznar rural site (SE Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	EUH	MD
2003		
Víznar TSP (μg m^{-3})	-	-
Víznar PM10 (μg m^{-3})	16	14
Víznar PM2.5 (μg m^{-3})	9	8
Days	17	6
2002		
Víznar TSP (μg m^{-3})	44	16
Víznar PM10 (μg m^{-3})	24	12
Víznar PM2.5 (μg m^{-3})	15	8
Days	8	14
2001		
Víznar TSP (μg m^{-3})	18	19
Víznar PM10 (μg m^{-3})	11	10
Víznar PM2.5 (μg m^{-3})	10	10
Days	8	2
2000		
Víznar TSP (μg m^{-3})	36	-
Days	15	0
1999		
Víznar TSP (μg m^{-3})	47	14
Days	9	5
1998		
Víznar TSP (μg m^{-3})	27	10
Days	13	8
Mean 98-03 (μg m^{-3})		
Víznar TSP	34	14
Víznar PM10	17	12
Víznar PM2.5	11	8
Impact Index(II) (μg m^{-3})		
Víznar TSP	1.1	0.2
Víznar PM10	0.5	0.2
Víznar PM2.5	0.3	0.1

The monthly PM levels for the days with European advection were relatively high only under EUH scenario and in February-April (31-49 μgPM10 m^{-3}, 17-23 μgPM10 m^{-3} and 11-13 μgPM2.5, Table Ap.146) and September (only PM10 and PM2.5 means available 24 μgPM10 m^{-3} and 11 μgPM2.5, Table Ap.146). Also a high TSP monthly mean was recorded in June under EUH situations (71 μgTSP m^{-3}, Table Ap.146), although these events were rare in this month.

Table Ap.146. Number of days per month with European advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (µg m^{-3}) recorded at Víznar rural site (SE Spain) for those days.

	EUH	MD		EUH	MD
January			**July**		
Days per month	2.8	0.3	Days per month	0.0	0.0
TSP	24	5	TSP		
PM10	14	4	PM10		
PM2.5	9	3	PM2.5		
February			**August**		
Days per month	2.3	0.0	Days per month	0.0	0.0
TSP	31		TSP		
PM10	17		PM10		
PM2.5	11		PM2.5		
March			**September**		
Days per month	2.2	0.3	Days per month	0.8	0.8
TSP	45	13	TSP		20
PM10		12	PM10	24	14
PM2.5		8	PM2.5	11	9
April			**October**		
Days per month	0.8	1.3	Days per month	0.0	0.3
TSP	49	17	TSP		11
PM10	23	14	PM10		
PM2.5	13	8	PM2.5		
May			**November**		
Days per month	0.2	0.3	Days per month	0.7	1.3
TSP	28	9	TSP	11	15
PM10			PM10	5	10
PM2.5			PM2.5	3	10
June			**December**		
Days per month	0.5	0.0	Days per month	1.3	1.0
TSP	71		TSP	19	10
PM10			PM10	12	8
PM2.5			PM2.5	10	5

7.4. Mediterranean episodes

Air masses with Mediterranean origin reached Southeastern Iberia in 100 days of the study period 1998-2003 (17 per year and 1 per month, Table Ap.147). These days resulted in 54 Mediterranean events (9 per year and 1 per month, Table Ap.147) with a mean duration of 2 days.

A minor part, 22%, of these 100 days (22 days in total and 4 per year, Table Ap.147) occurred under a meteorological situation characterised by the development of depressions over Northern Africa and/or the Mediterranean (NAD-MD scenario). These 22 days were grouped in 14 episodes (% of the total number of episodes and 2 per year, Table Ap.147) with an average duration of 2 days.

The rest, 78% of the 100 days (78 days in total, 13 per year and 1 per month, Table Ap.147) were associated with the presence of an anticyclone over the European continent and/or over the Mediterranean (EUH-MH scenario). Grouping these days, a total of 40 EUH-MH episodes (% of the total number of episodes and 2 per year, Table Ap.147) with a mean duration of 2 days were registered in the study period.

With respect to the annual occurrence of days with Mediterranean advection over Southeastern Iberia, these ranged from 11 (in 2000 and 2002) to 28 (in 1999). The number of days associated with the two transport scenarios ranged from 2 (in 2000 and 2001) to 6 (in 1998) for NAD-MD and from 7 (in 2002) to 23 (in 1999) for EUH-MH. The annual number of Mediterranean episodes ranged from 7 (in 2000 and 2002) to 14 (in 1999). The number of NAD-MD events varied from 1 (in 2002) to 3 (in 1198, 1999 and 2003) and the number of EUH-MH episodes from 5 (in 2000) to 11 (in 1999).

Table Ap.147. Annual number of days and episodes with Mediterranean advection in the period 1998-2003 over Southeastern Iberian Peninsula. The NAD-MD and EUH-MH scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total MED	19	28	11	17	11	14	17	1
NAD-MD	6	5	2	2	4	3	4	<1
EUH-MH	13	23	9	15	7	11	13	1
Episodes								
Total MED	9	14	7	8	7	9	9	1
NAD-MD	3	3	2	2	1	3	2	<1
EUH-MH	6	11	5	6	6	6	7	1

The seasonal distribution of Mediterranean episodes in 1998-2003 over Southeastern Iberian Peninsula (Figure Ap.133) is characterised by a maximum frequency in December-January was clearly the period with the highest frequency of occurrence of these episodes (9 in the study period in January). In each of the remaining months 3-5 episodes occurred in the whole study period with the exception of August with 2 episodes. NAD-MD episodes occurred in two periods: November-January (4 events in January from 1998 to 2003) and March-May (3 episodes in the study period in April). EUH-MH events occurred more frequently from September to January (up to 5 episodes in January in 1998-2003), although 4 EUH-MH episodes also occurred in June during the study period.

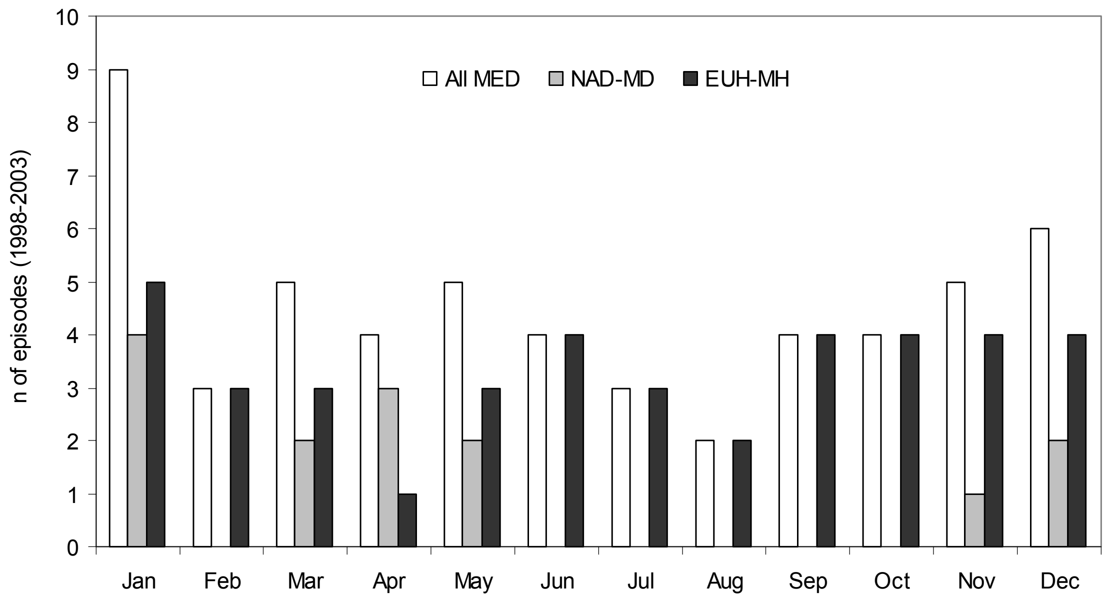

Figure Ap.133. Monthly distribution of the number of Mediterranean episodes over Southeastern Iberian Peninsula. The monthly distributions of NAD-MD and EUH-MH Mediterranean events are also shown.

As shown in Figures Ap.134 and Ap.135, the days with Mediterranean advection over Southeastern Iberia were especially frequent from November to January (3 days as monthly mean in December). However, in other months such as March, June and September (all these months with means of 2 days) the number of days was also important. The period with the lowest occurrence of Mediterranean transport situations was July-August. With respect to the days associated with NAD-MD scenario, December-January (almost 1 day as monthly mean in these two months) and March-April (also near 1 day as monthly mean in these two months) were the periods when these occurred most commonly. The days associated with EUH-MH were more frequent in November-January (with 2 days as monthly mean in both November and December), June and September (both months with 2 days as a mean).

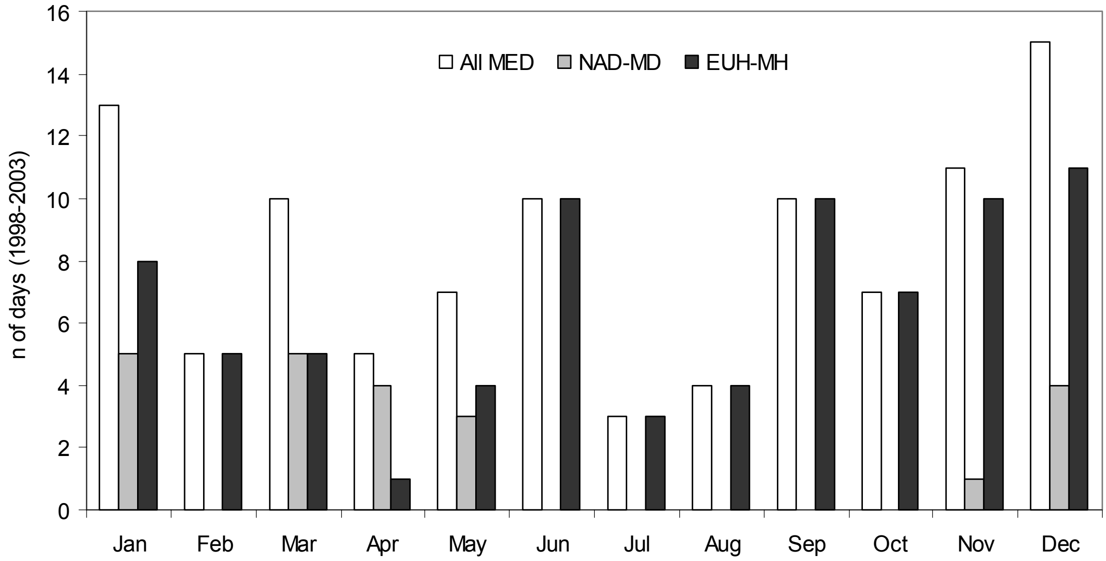

Figure Ap.134. Monthly distribution of the number of days with Mediterranean advection over Southeastern Iberian Peninsula. The monthly distributions of days with Mediterranean advection occurred under NAD-MD and EUH-MH scenarios are also shown.

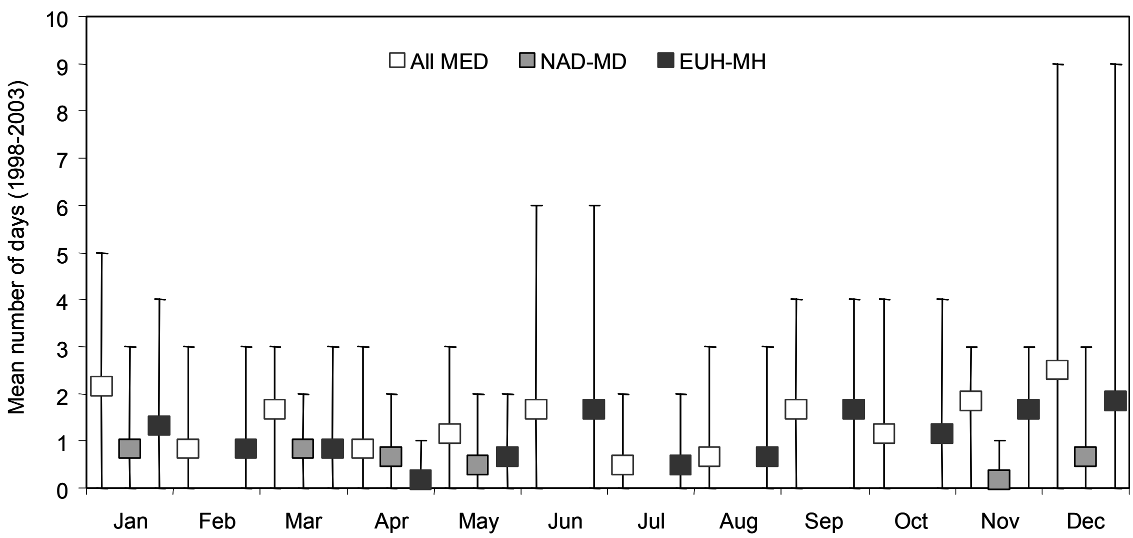

Figure Ap.135. Mean number of days with Mediterranean advection over Southeastern Iberian Peninsula per month for 1998-2003. NAD-MD and EUH-MH episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

The Mediterranean episodes had mean durations of 1-2 days in all the months with the exception of June, September and December with 3 days. The same occurred with NAD-MD episodes which only reached 3 days as monthly mean in March. EUH-MH episodes also had average durations ranging 1-2 days in all the months with the exception of June, September and November-December with average durations of 3 days (Figure Ap.136).

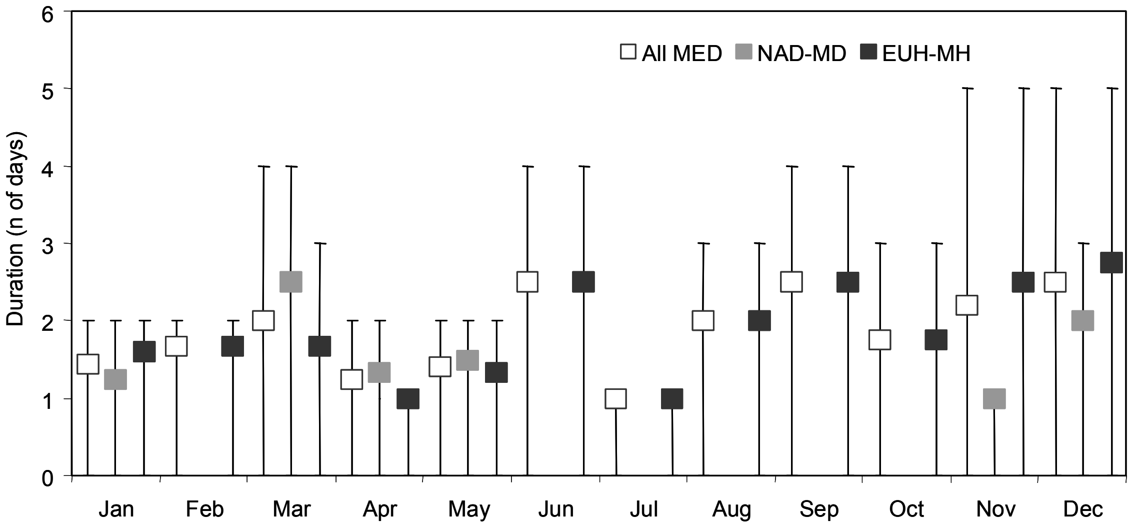

Figure Ap.136. Mean duration of Mediterranean episodes per month over Southeastern Iberian Peninsula for 1998-2003. NAD-MD and EUH-MH episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

The mean PM levels recorded at Víznar during episodes of advection of Mediterranean air masses (30 µgTSP m^{-3}, 16 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3}, Table Ap.148) was lower than the annual mean PM levels in that station (40 µgTSP m^{-3}, 22 µgPM10 m^{-3} and 11 µgPM2.5 m^{-3}). The occurrence of rainfall over the Eastern flank of the Iberian Peninsula is common during Mediterranean events which results in the washing out of the atmosphere. Moreover, the relative clean marine air masses involved in this type of transport also contributed to keep the mean PM levels low.

Table Ap.148. Mean annual levels of TSP, PM10 and PM2.5 registered in Víznar during Mediterranean advection episodes in 1998-2003.

MED EPISODES	**Víznar**		
(µg m^{-3})	TSP	PM10	PM2.5
1998	37	na	na
1999	34	na	na
2000	26	na	na
2001	25	*14	*8
2002	27	17	8
2003	na	17	8
Mean 98-03	30	16	8

*Calculated with data of 83% of the months of the year
na: Not available

The mean PM levels obtained for Mediterranean episodes of EUH-MH type (32 µgTSP m^{-3}, 16 µgPM10 m^{-3} and 8 µgPM2.5 m^{-3}, Table Ap.149) were slightly higher than those recorded during NAD-MD events (24 µgTSP m^{-3}, 15 µgPM10 m^{-3} and 8

μgPM2.5 m^{-3}, Table Ap.149). This can be attributed to the higher frequency of rain associated with NAD-MD episodes than with EUH-MH events.
Owing to the low frequency of occurrence of the NAD-MD episodes the impact index (II) of this scenario (0.2 μgTSP m^{-3}, 0.2 μgPM10 m^{-3} and 0.1 μgPM2.5 m^{-3}, Table Ap.149) was lower than the II of EUH-MH (1.1 μgTSP m^{-3}, 0.6 μgPM10 m^{-3} and 0.3 μgPM2.5 m^{-3}, Table Ap.149). However, both scenarios had considerably low weights in the annual mean PM levels.

Table Ap.149. Number of days with Mediterranean advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (μg m^{-3}) recorded at Víznar rural site (SE Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	NAD-MD	EUH-MH
2003		
Víznar TSP (μg m^{-3})	-	-
Víznar PM10 (μg m^{-3})	13	15
Víznar PM2.5 (μg m^{-3})	6	7
Days	3	11
2002		
Víznar TSP (μg m^{-3})	31	25
Víznar PM10 (μg m^{-3})	22	18
Víznar PM2.5 (μg m^{-3})	11	9
Days	4	7
2001		
Víznar TSP (μg m^{-3})	15	26
Víznar PM10 (μg m^{-3})	4	15
Víznar PM2.5 (μg m^{-3})	3	9
Days	2	15
2000		
Víznar TSP (μg m^{-3})	-	29
Days	2	9
1999		
Víznar TSP (μg m^{-3})	20	37
Days	5	23
1998		
Víznar TSP (μg m^{-3})	38	37
Days	6	13
Mean 98-03 (μg m^{-3})		
Víznar TSP	24	32
Víznar PM10	15	16
Víznar PM2.5	8	8
Impact Index(II) (μg m^{-3})		
Víznar TSP	0.2	1.1
Víznar PM10	0.2	0.6
Víznar PM2.5	0.1	0.3

The highest monthly PM means for Mediterranean episodes were recorded in Víznar during EUH-MH situations in June-September (43-77 μgTSP m^{-3}, 23-29 μgPM10 m^{-3} and 10-17 μgPM2.5 m^{-3}, Table Ap.150). In summer several factors may contribute to increase PM levels these are the low precipitation regime, the re-suspension of soil material owing to the high convection, and the high photochemical conversion rate between gaseous precursors and secondary aerosols in virtue of the high insolation. Also during EUH-MH episodes in the period April-May mean PM levels were relatively high (34-55 µgTSP m^{-3}, 28 µgPM10 m^{-3} and 13-14 µgPM2.5 m^{-3}, Table Ap.150). Moreover, in March MD episodes gave rise to relatively high PM levels (49 µgTSP m^{-3}, 25 µgPM10 m^{-3} and 13 µgPM2.5 m^{-3}, Table Ap.150).

Table Ap.150. Number of days per month with Mediterranean advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (µg m^{-3}) recorded at Víznar rural site (SE Spain) for those days.

	NAD-MD	EUH-MH		NAD-MD	EUH-MH
January			**July**		
Days per month	0.8	1.3	Days per month	0.0	0.5
TSP	12	11	TSP		77
PM10		7	PM10		24
PM2.5		3	PM2.5		10
February			**August**		
Days per month	0.0	0.8	Days per month	0.0	0.7
TSP		27	TSP		51
PM10			PM10		29
PM2.5			PM2.5		17
March			**September**		
Days per month	0.8	0.8	Days per month	0.0	1.7
TSP	49	34	TSP		43
PM10	25	13	PM10		24
PM2.5	13	7	PM2.5		13
April			**October**		
Days per month	0.7	0.2	Days per month	0.0	1.2
TSP	26	55	TSP		34
PM10	14	28	PM10		9
PM2.5	7	13	PM2.5		4
May			**November**		
Days per month	0.5	0.7	Days per month	0.2	1.7
TSP	23	34	TSP	8	18
PM10	23	28	PM10	4	25
PM2.5	10	14	PM2.5	3	10
June			**December**		
Days per month	0.0	1.7	Days per month	0.7	1.8
TSP		52	TSP		12
PM10		23	PM10	3	7
PM2.5		11	PM2.5	2	4

7.5. Episodes without dominant advective conditions

A total of 191 episodes with lack of dominant advective conditions (32 per year and 3 per month, Table Ap.151) occurred over Southeastern Iberia in 1998-2003. These episodes had an average duration of 3 days and resulted in 626 days (104 per year and 9 per month, Table Ap.151).

From these 191 events, 114 (60% of the total number of episodes in 1998-2003, 19 per year and 2 per month, Table Ap.151) were caused in the cold part of the year by the presence of an anticyclone covering completely or partly the Iberian Peninsula (WIA scenario). These episodes resulted in 376 days (60% of the 626 days occurred in 1998-2003, 63 per year and 5 per month, Table Ap.151). WIA episodes had a mean duration of 3 days.

The remaining 77 episodes (40% of the total number of episodes in 1998-2003, 13 per year and 1 per month, Table Ap.151) occurred in the warm part of the year when the thermal Iberian low developed over the Iberian plateau owing to the intense heating of the surface (ITL scenario) concerning the Iberian thermal low (Millán et al., 1992). ITL events lasted, on average, 3 days. Moreover, these resulted in 250 days (40% of the total number of episodes in 1998-2003, 42 per year and 3 per month, Table Ap.151).
The number of days with lack of prevailing advective conditions ranged from 80 (in 2002) to 126 (in 1998). The number of days associated with WIA scenario runs from 42 (in 2002) to 88 (in 2003) while the number of days related to ITL scenario ranged from 35 (in 2003) to 57 (in 1998).
With respect to the annual number of episodes without dominant advective conditions this ranged from 29 (in 2000) to 36 (in 1998). The annual number of WIA events ranged from 15 (in 2002) to 21 (in 2003), and the number of ITL events runs from 10 (in 2000) to 16 (in 1998 and 2002).

Table Ap.151. Annual number of days and episodes with lack of advective conditions in the period 1998-2003 over Southeastern Iberian Peninsula. The WIA and ITL scenarios are distinguished.

	1998	1999	2000	2001	2002	2003	Annual mean 98-03	Monthly mean
Days								
Total NOADV	126	96	96	105	80	123	104	9
WIA	69	50	59	68	42	88	63	5
ITL	57	46	37	37	38	35	42	3
Episodes								
Total NOADV	36	30	29	31	31	34	32	3
WIA	20	19	19	20	15	21	19	2
ITL	16	11	10	11	16	13	13	1

As shown in Figure Ap.137, The occurrence of episodes with lack of advective conditions over Southeastern Iberian Peninsula was characteristic of the period May-October (in the range 16-23 episodes in 1998-2003) with a second order frequency maximum in December (16 events in the study period). While ITL events occurred mainly from June to September (reaching up to 21 episodes in July during 1998-2003), three periods in which the occurrence of WIA events were relatively frequent were observed: April-May (18 episodes in May from 1998 to 2003), December (16 episodes in the study period) and October (15 events in 1998-2003).
With respect to the seasonal variability of the number of days with lack of dominant advective conditions over the study area (Figures Ap.138 and Ap.139), two main periods of maximum frequency of occurrence were registered in May (monthly mean of 14 days) and July-October (reaching up to a monthly means of 13 days in both August and September), but also a second order maximum was observed in December (9 days as monthly mean). It is also observed that the relatively high number of episodes occurring in June (18 in 1998-2003) did not result in a very high number of days with non advective conditions in this month (48 in 1998-2003, 8 as monthly mean). The frequency peaks of the occurrence of days related to WIA scenario were observed in April-May (with a monthly mean of 11 days in May), October (10 days as monthly average) and, with less slightly frequency, in December (9 days as monthly mean). ITL situations occurred mainly from June to September (in August 13 days of monthly average were registered).

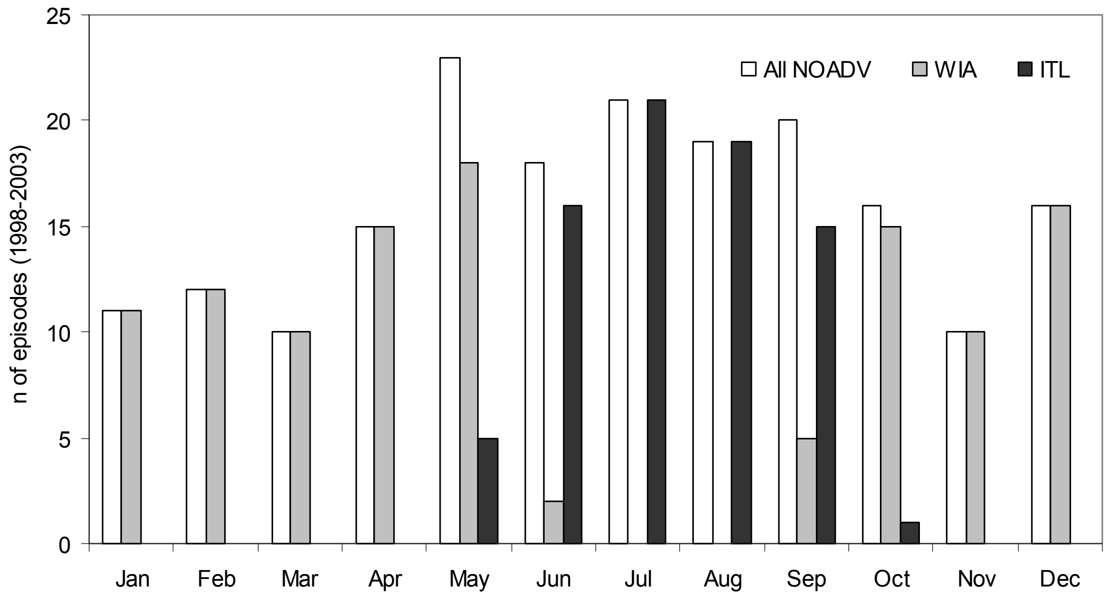

Figure Ap.137. Monthly distribution of the number of episodes without dominant advective conditions over Southeastern Iberian Peninsula. The monthly distributions of WIA and ITL events are also shown.

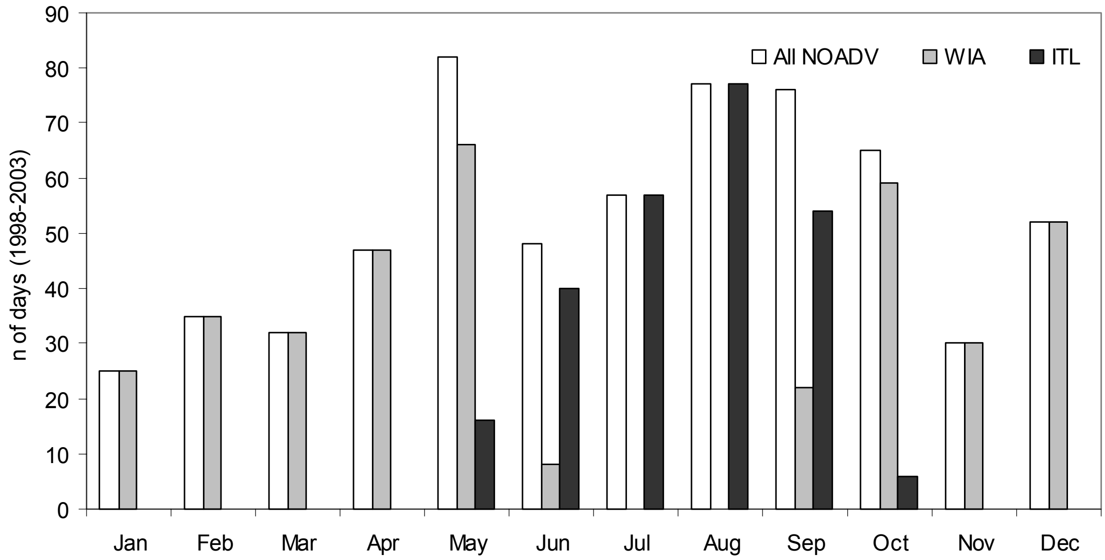

Figure Ap.138. Monthly distribution of the number of days with lack of advective conditions over Southeastern Iberian Peninsula. The monthly distributions of days with lack of advective conditions occurred under WIA and ITL scenarios are also shown.

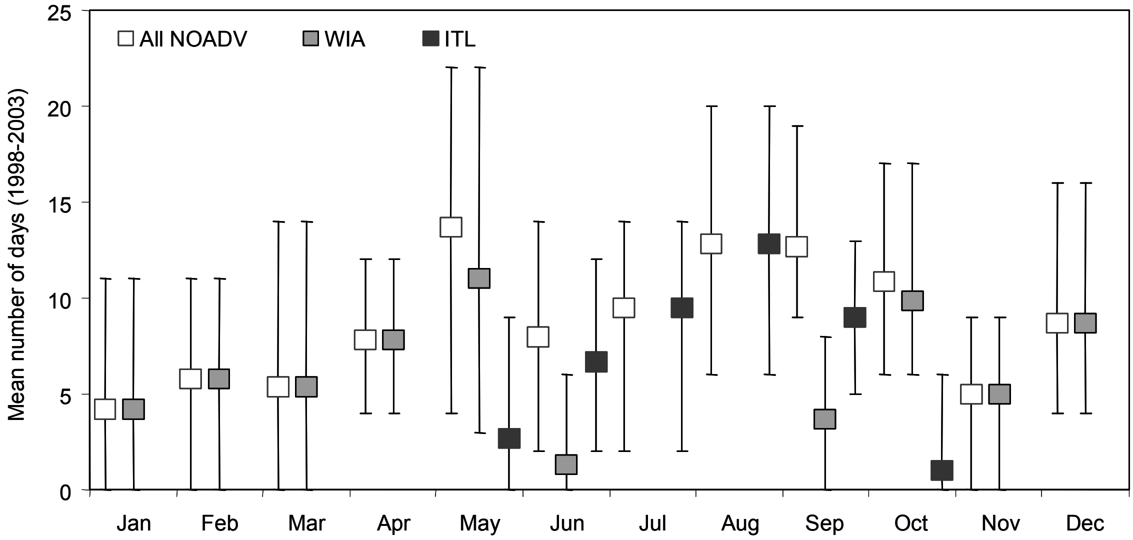

Figure Ap.139. Mean number of days without a dominant air mass advection over Southeastern Iberian Peninsula per month for 1998-2003. WIA and ITL episodes are shown separately. Bars indicate the maximum and the minimum number of days for a single month recorded in the study period.

As shown in Figure Ap.140, the mean duration of episodes without dominant advective conditions reached up to 4 days from August to October and in May although in most of the months 3 days is the average durations of these events. WIA events also lasted 3 days on average in all the months with the exception of May, June, September and October (with 4 days as a mean). ITL episodes lasted 3 or 4 days on average in all the months with the exception of October with 6 days.

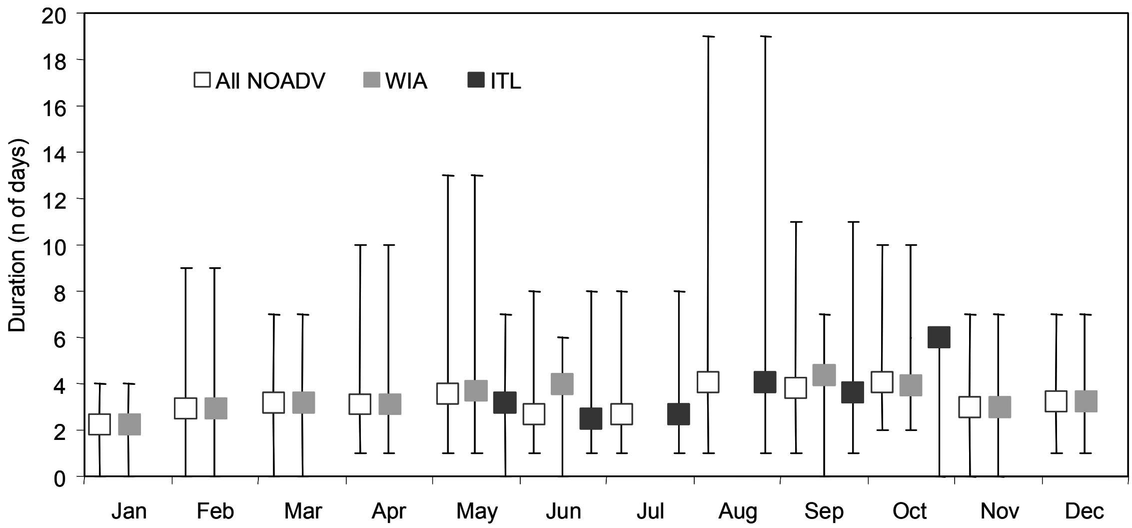

Figure Ap.140. Mean duration of episodes without a dominant air mass advection per month over Southeastern Iberian Peninsula for 1998-2003. WIA and ITL episodes are shown separately. Bars indicate the longest and the shortest episode recorded in a single month of the study period.

During events in which no prevalent advective conditions were observed over Southeastern Iberia the mean PM levels reached at Víznar (42 µgTSP m^{-3}, 22 µgPM10 m^{-3} and 12 µgPM2.5 m^{-3}, Table Ap.152) were similar to the annual mean PM levels at this station (40 µgTSP m^{-3}, 22 µgPM10 m^{-3} and 11 µgPM2.5 m^{-3}). The low occurrence of rain during these episodes contribute to increase PM levels because the rain scavenging of aerosols is reduced.

Table Ap.152. Mean annual levels of TSP, PM10 and PM2.5 registered in Víznar during episodes without dominant air mass advection in 1998-2003.

NOADV EPISODES ($\mu g\ m^{-3}$)	Víznar		
	TSP	PM10	PM2.5
1998	40	na	na
1999	45	na	na
2000	40	na	na
2001	44	*23	*14
2002	42	23	13
2003	na	20	10
Mean 98-03	42	22	12

*Calculated with data of 83% of the months of the year
na: Not available

The differences between the mean PM levels obtained at Víznar for WIA and ITL episodes were important (means of 54 µgTSP m^{-3}, 28 µgPM10 m^{-3} and 14 µgPM2.5 m^{-3} for ITL events and 24 µgTSP m^{-3}, 15 µgPM10 m^{-3} and 9 µgPM2.5 m^{-3} for WIA, Table Ap.153). Major characteristics of the ITL situations, such as the low rainfall regime, the aging and re-circulation of polluted in air masses (Millán et al., 1997), the high rate of re-suspension or the enhancement of transformation of gaseous precursors into secondary aerosols by the increased photochemistry, tend to increase PM levels in regional background stations over the Eastern flank of the Iberian Peninsula (Rodríguez et al, 2003). During WIA episodes, the low vertical growth of the boundary layer, especially during the typical development of thermal inversions over industrial/urban sites, reduces the anthropogenic contribution of PM in regional background stations.

Although the mean PM levels recorded at Víznar during ITL events were considerably higher than during WIA episodes, as the frequency of occurrence of the latter events was higher, the difference between the impact index (II) of these two scenarios was not important (ITL reached to II of 6.2 µgTSP m^{-3}, 3.3 µgPM10 m^{-3} and 1.7 µgPM2.5 m^{-3} and WIA to II of 5.6 µgTSP m^{-3}, 3.1 µgPM10 m^{-3} and 1.8 µgPM2.5 m^{-3}, Table Ap.153).

Table Ap.153. Number of days without a dominant air mass advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 ($\mu g\ m^{-3}$) recorded at Víznar rural site (SE Spain) for those days. The impact index (II) of each type of scenario is defined as the mean number of days per year with that scenario multiplied by the mean PM levels recorded with that scenario and divided by 365 days.

	WIA	ITL
2003		
Víznar TSP ($\mu g\ m^{-3}$)	-	-
Víznar PM10 ($\mu g\ m^{-3}$)	17	28
Víznar PM2.5 ($\mu g\ m^{-3}$)	9	13
Days	88	35
2002		
Víznar TSP ($\mu g\ m^{-3}$)	33	52
Víznar PM10 ($\mu g\ m^{-3}$)	19	28
Víznar PM2.5 ($\mu g\ m^{-3}$)	11	14
Days	42	38
2001		
Víznar TSP ($\mu g\ m^{-3}$)	34	61
Víznar PM10 ($\mu g\ m^{-3}$)	19	30
Víznar PM2.5 ($\mu g\ m^{-3}$)	12	17
Days	68	37
2000		
Víznar TSP ($\mu g\ m^{-3}$)	31	55
Days	59	37
1999		
Víznar TSP ($\mu g\ m^{-3}$)	35	56
Days	50	46
1998		
Víznar TSP ($\mu g\ m^{-3}$)	31	49
Days	69	57
Mean 98-03 ($\mu g\ m^{-3}$)		
Víznar TSP	32	54
Víznar PM10	18	28
Víznar PM2.5	10	14
Impact Index(II) ($\mu g\ m^{-3}$)		
Víznar TSP	5.6	6.2
Víznar PM10	3.1	3.3
Víznar PM2.5	1.8	1.7

High monthly PM means for episodes with lack of advective conditions were recorded under ITL scenario in May-October (with means in the ranges 34-58 $\mu gTSP\ m^{-3}$, 23-29 $\mu gPM10\ m^{-3}$ and 11-15 $\mu gPM2.5\ m^{-3}$, Table Ap.154). However, also during WIA events monthly PM means reached high levels such as in June (54 $\mu gTSP\ m^{-3}$, 39 $\mu gPM10\ m^{-3}$ and 22 $\mu gPM2.5\ m^{-3}$, Table Ap.154) or March (51 $\mu gTSP\ m^{-3}$, 24 $\mu gPM10\ m^{-3}$ and 13 $\mu gPM2.5\ m^{-3}$, Table Ap.154). This may reflect local contributions although the low rainfall regime of WIA episodes may also be another factor explaining these high mean PM levels.

Table Ap.154. Number of days per month without advection occurred under the 2 meteorological scenarios differentiated and mean daily ambient air levels of TSP, PM10 and PM2.5 (µg m^{-3}) recorded at Víznar rural site (SE Spain) for those days.

	WIA	ITL		WIA	ITL
January			**July**		
Days per month	4.2	0.0	Days per month	0.0	9.5
TSP	24		TSP		58
PM10	16		PM10		29
PM2.5	10		PM2.5		15
February			**August**		
Days per month	5.8	0.0	Days per month	0.0	12.8
TSP	28		TSP		56
PM10	18		PM10		29
PM2.5	11		PM2.5		15
March			**September**		
Days per month	5.3	0.0	Days per month	3.7	9.0
TSP	51		TSP	33	54
PM10	24		PM10	21	28
PM2.5	13		PM2.5	12	15
April			**October**		
Days per month	7.8	0.0	Days per month	9.8	1.0
TSP	39		TSP	30	43
PM10	19		PM10	18	
PM2.5	10		PM2.5	9	
May			**November**		
Days per month	11.0	2.7	Days per month	5.0	0.0
TSP	35	34	TSP	26	
PM10	20	23	PM10	17	
PM2.5	11	11	PM2.5	10	
June			**December**		
Days per month	1.3	6.7	Days per month	8.7	0.0
TSP	54	56	TSP	23	
PM10	39	28	PM10	12	
PM2.5	22	14	PM2.5	7	