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Synoptic Classification of MODIS Aerosols over Israel

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Reference

Carmona, I. and Alpert, P. 2009. “Synoptic classification of Moderate Resolution Imaging Spectroradiometer aerosols over Israel”.
***J. Geophys. Res.* 114, D07208, doi:10.1029/2008JD010160.**

Average aerosols' Fine Mode Fraction, f (MODIS/Terra)

March2000-Feb2006

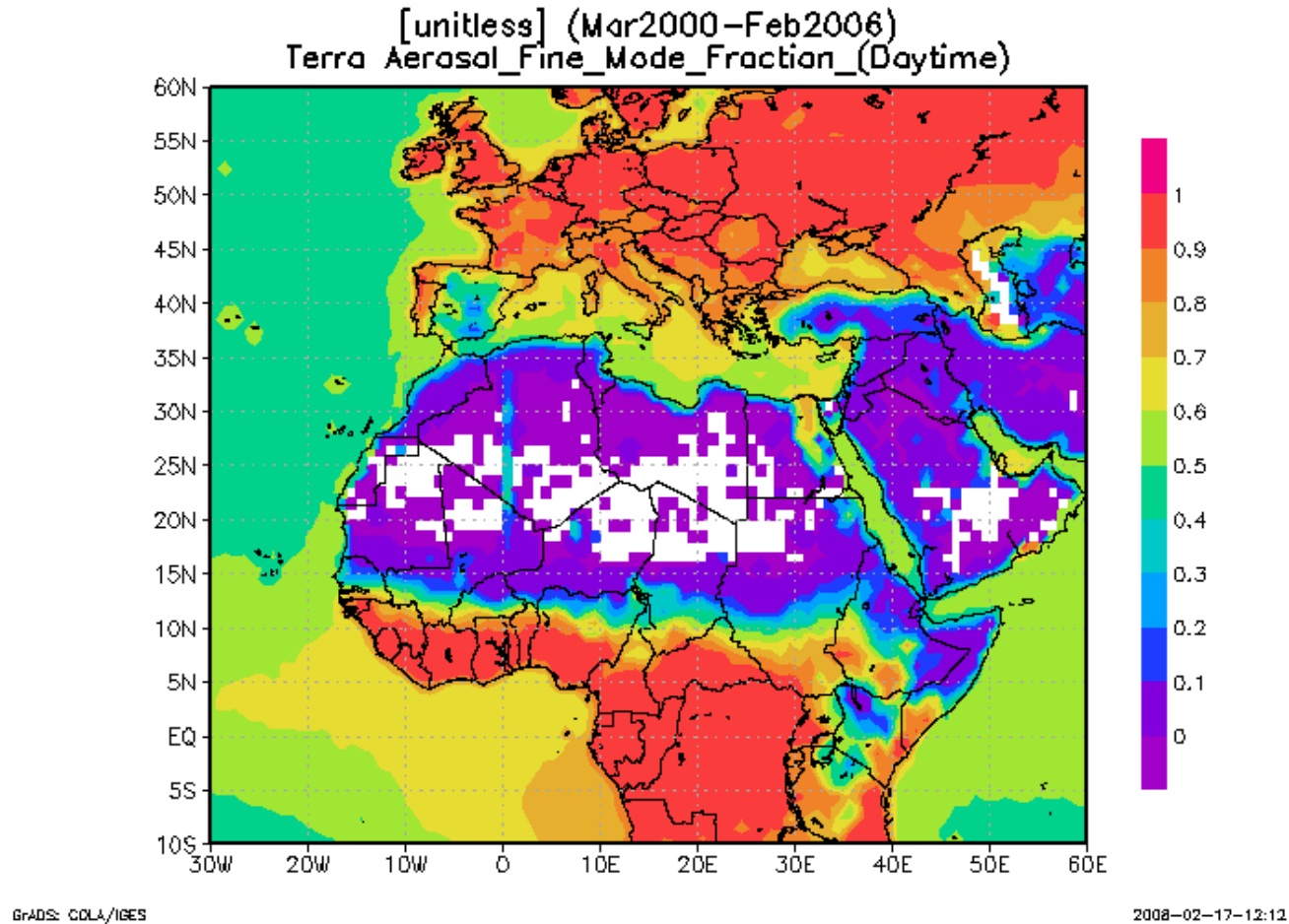


Figure 1: Averages of Terra aerosol fine mode fraction (f) for 6 years (24 February 2000 – 23 February 2006)

Table 2: The distribution (%) of the five frequent synoptic systems
for days with available data (AOT and fine mode fraction (f) during 24/2/00-23/2/06)

Synoptic system/month	Weak Persian Trough (PT/W)	High from the West (H/W)	Red Sea Trough with Eastern Axis (RST/E)	Medium Persian Trough (PT/M)	Red Sea Trough With Central Axis (RST/C)
January	0%	3%	10.7%	0%	9.3%
February	0%	3%	4.5%	0%	10.4%
March	0.6%	10.8%	11.4%	0.8%	12.6%
April	0.6%	12.0%	8.3%	0.4%	1.6%
May	9.3%	17.7%	5.5%	8.2%	3.3%
June	18.1%	9.0%	1.4%	21.8%	0.5%
July	22.1%	7.8%	0%	29.6%	0%
August	27.8%	5.1%	0.3%	22.2%	0%
September	15.6%	12.9%	6.2%	15.2%	1.1%
October	5.9%	9.6%	21.5%	1.6%	14.2%
November	0%	7.8%	13.5%	0%	27.9%
December	0%	1.5%	16.6%	0%	19.1%
total	100.0%	100.0%	100.0%	100.0%	100.0%

Classification of the five most common synoptic systems in Israel

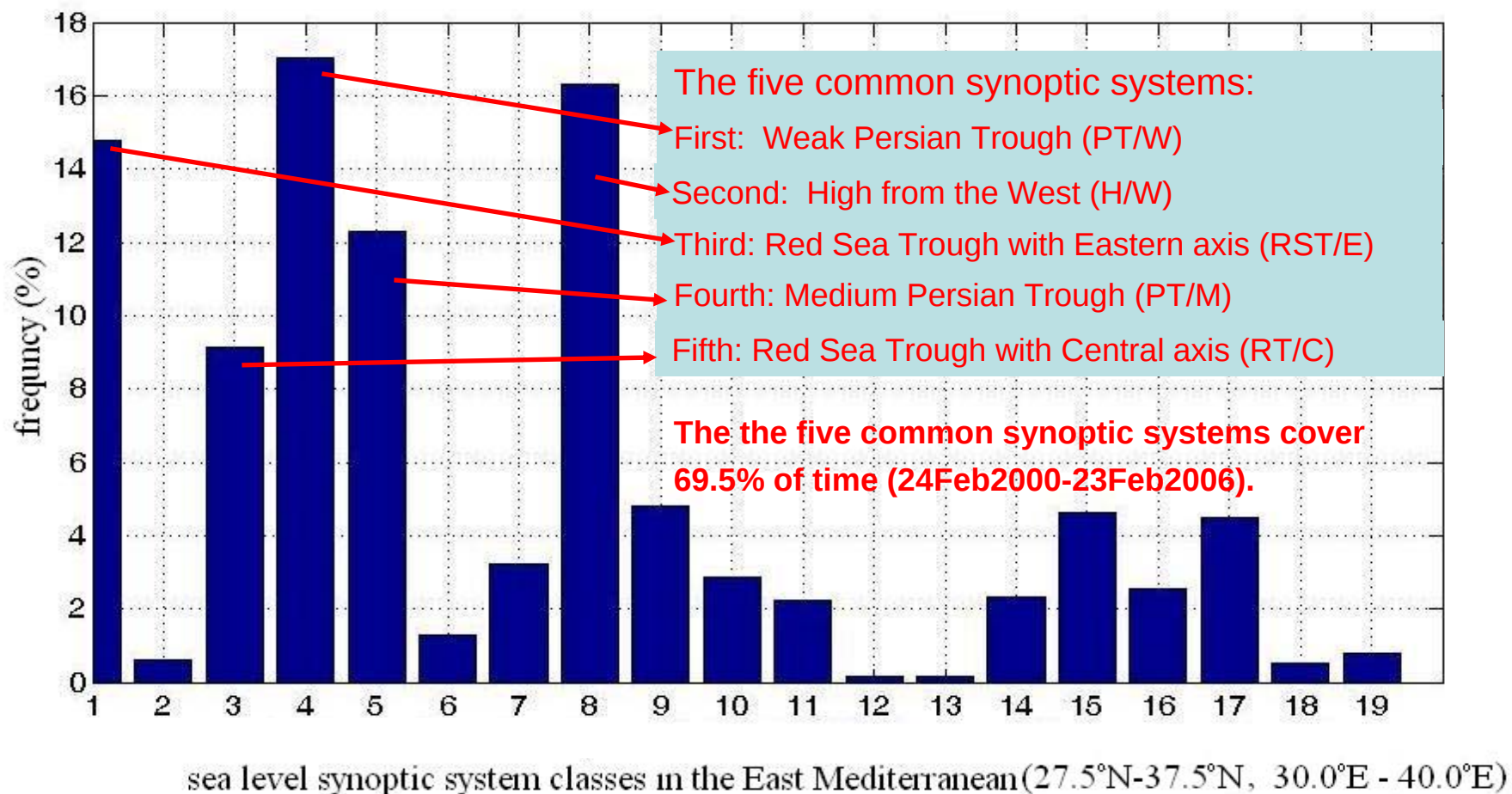


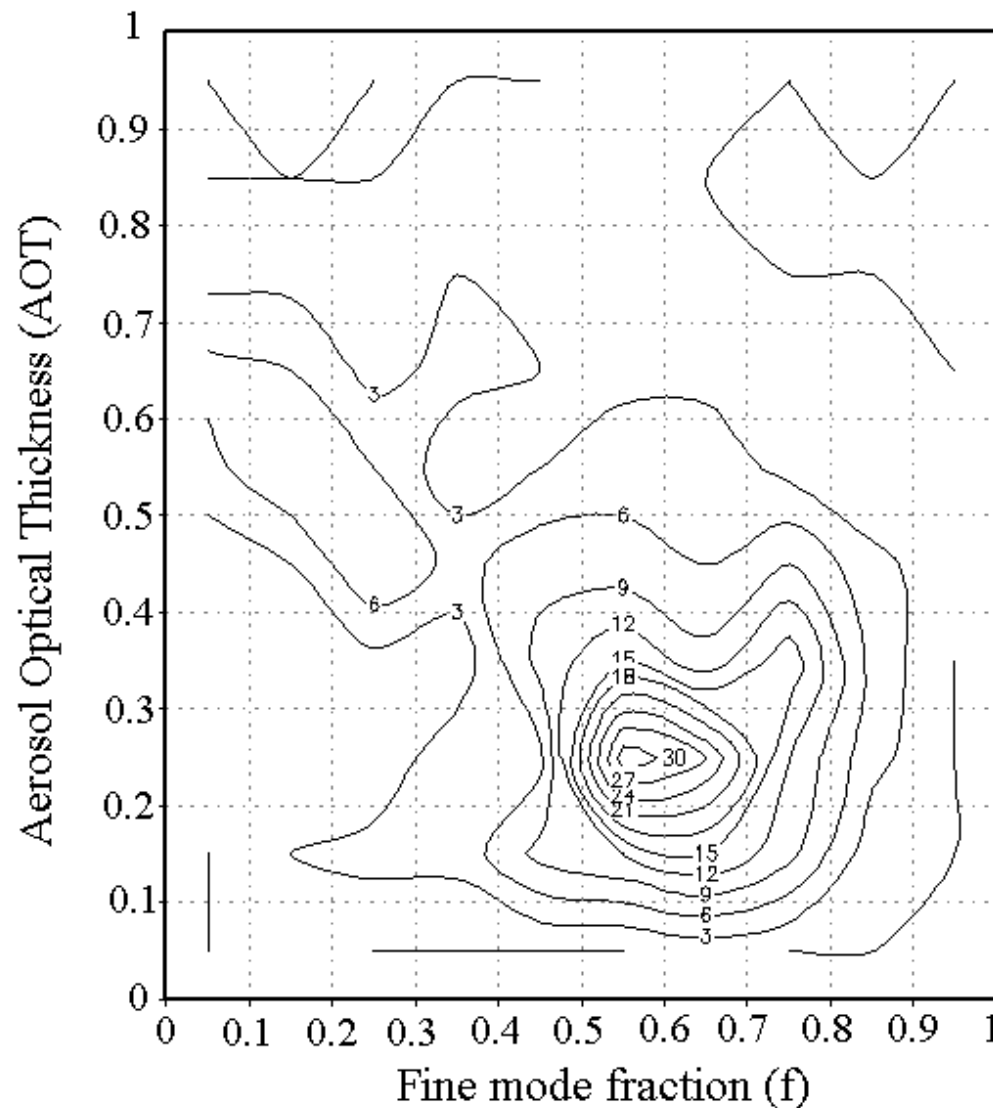
Figure 2: Histogram of frequency of sea level synoptic system classification in the Eastern Mediterranean [27.5°N-37.5°N, 30°E-40°E] based on the period 24 February 2000 - 23 February 2006 (6 years). See section 1.6.2 for the synoptic systems class description. The synoptic systems associated with significant amount of aerosols are number 4 (PT/W), number 8 (H/W), number 1 (RST/E), number 5 (PT/M) and number 3 (RST/C). These 5 systems to be analyzed in this paper are denoted by a star (*).

MODIS grid area (32°N-33°N, 34°E -35° E)

The MODIS grid
box



AOT vs. fine mode fraction (f) scatter plot for the Weak Persian (P/W)

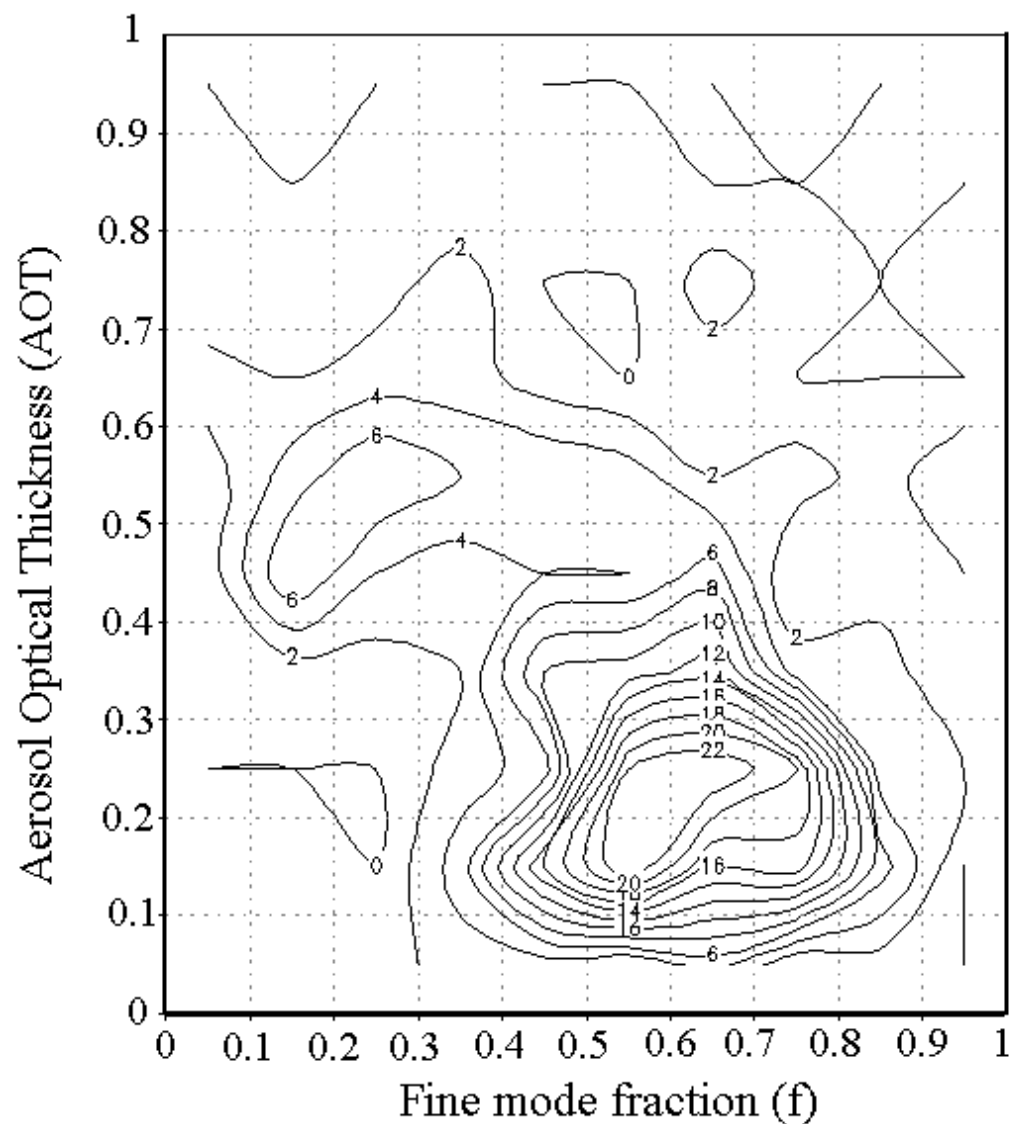


Total number of days: 373

Total number of days with only
available AOT/f: 353

Figure 3a: Contour map of AOT/f density for the Weak Persian (P/W) system. The map shows number of days per interval of $0.1\text{AOT} \times 0.1f$. Data are taken from MODIS Terra AOT sea grid point 32.5°N , 34.5°E (near central Israel) and are based on 353 days during the time period 24 February 2000 – 23 February 2006.

AOT/f scatter plot for High from the west (HW)

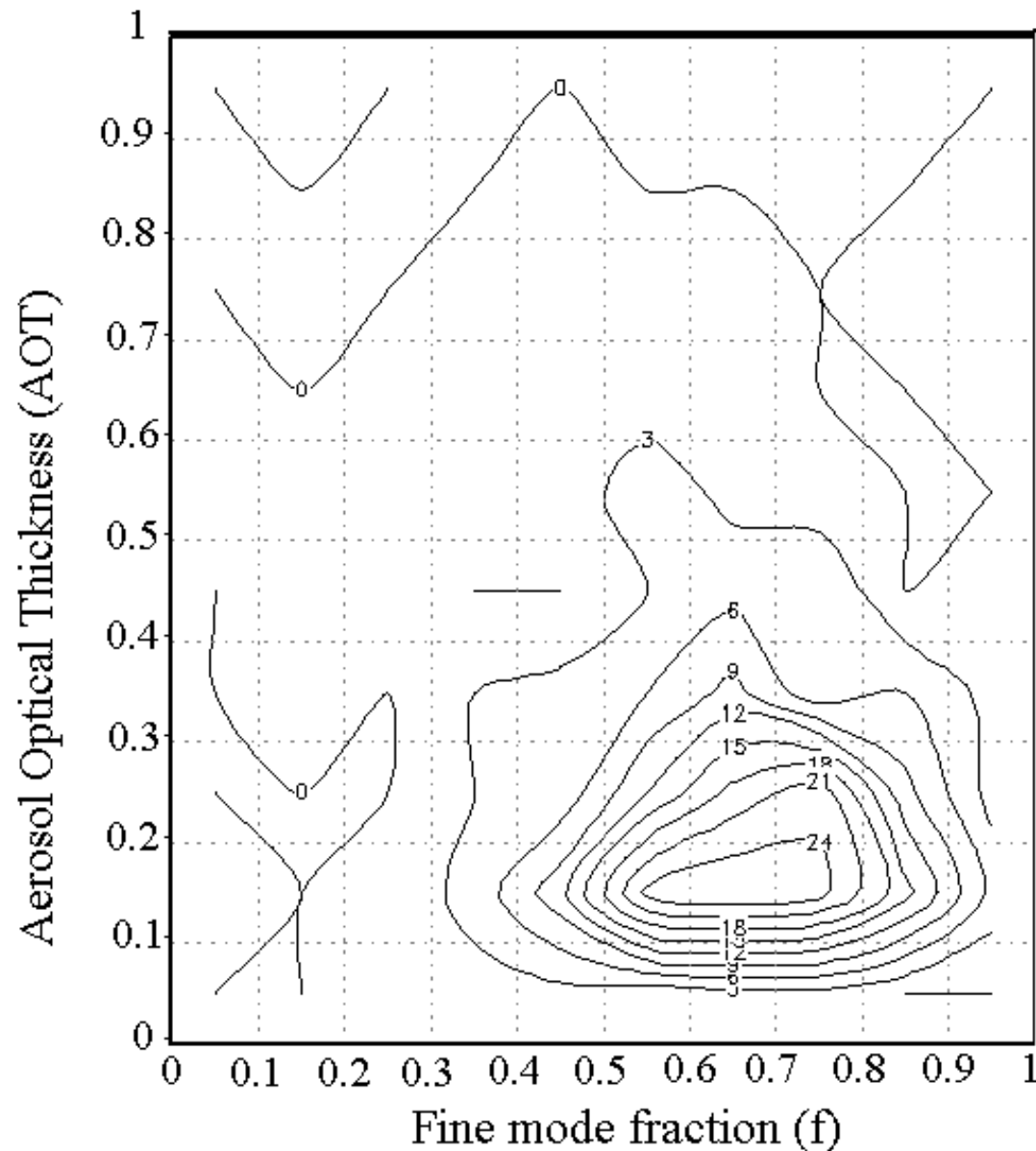


Total number of days: 357

Total number of days with
only available AOT/f: 334

Figure 3b: As in (a) but for the High from the West (HW) system. Analysis is based on 334 days during the time period 24 February 2000 – 23 February 2006.

AOT/f scatter plot for Red Sea Trough with Eastern axis (RST/E)

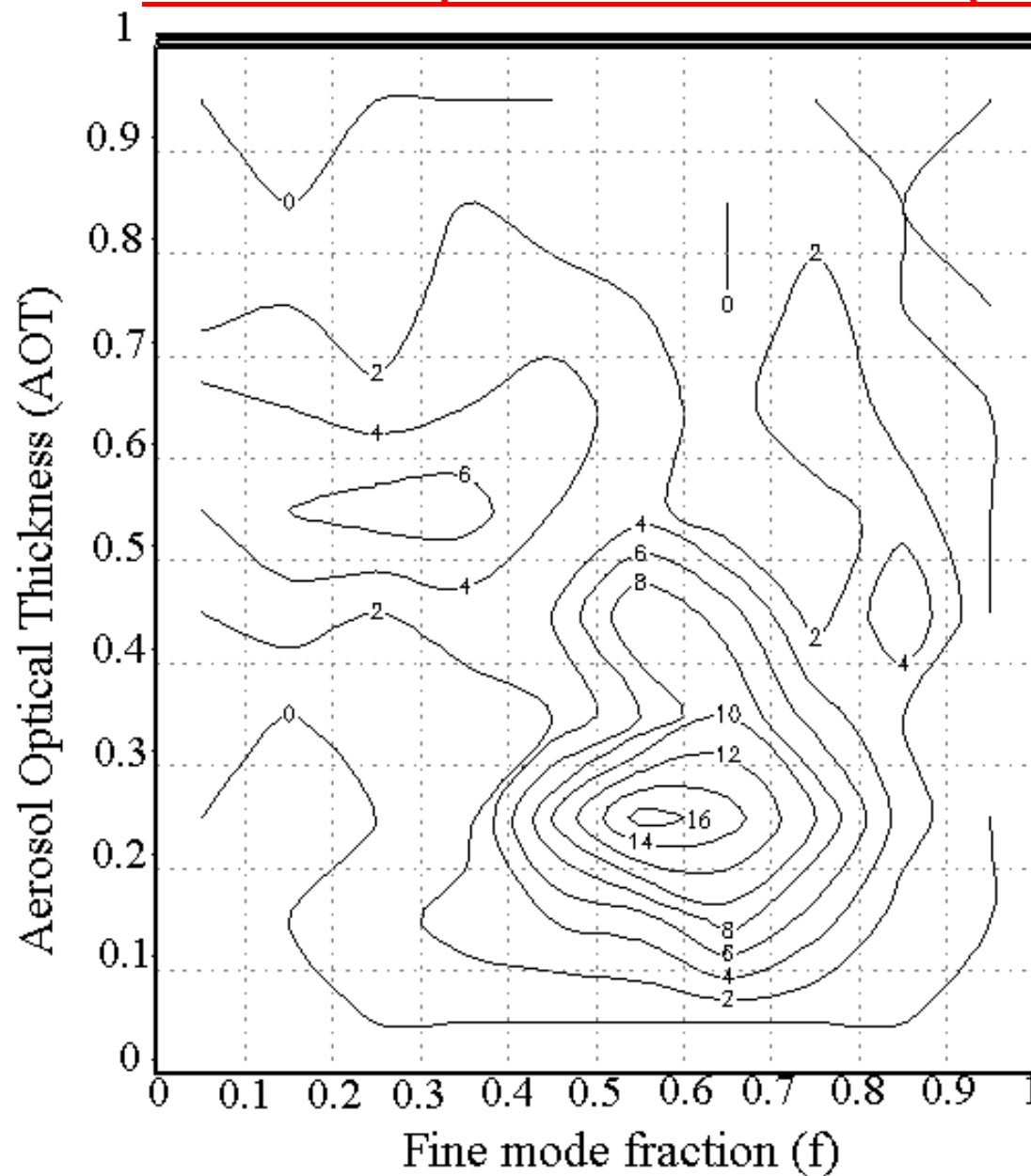


Total number of days: 324

Total number of days with
only available AOT/f: 289

Figure 3c: As in (a) but for the Red Sea Trough with Eastern axis (RST/E) system. Analysis is based on 289 days during the time period 24 February 2000 – 23 February 2006.

AOT/f scatter plot for Medium Persian (PT/M)

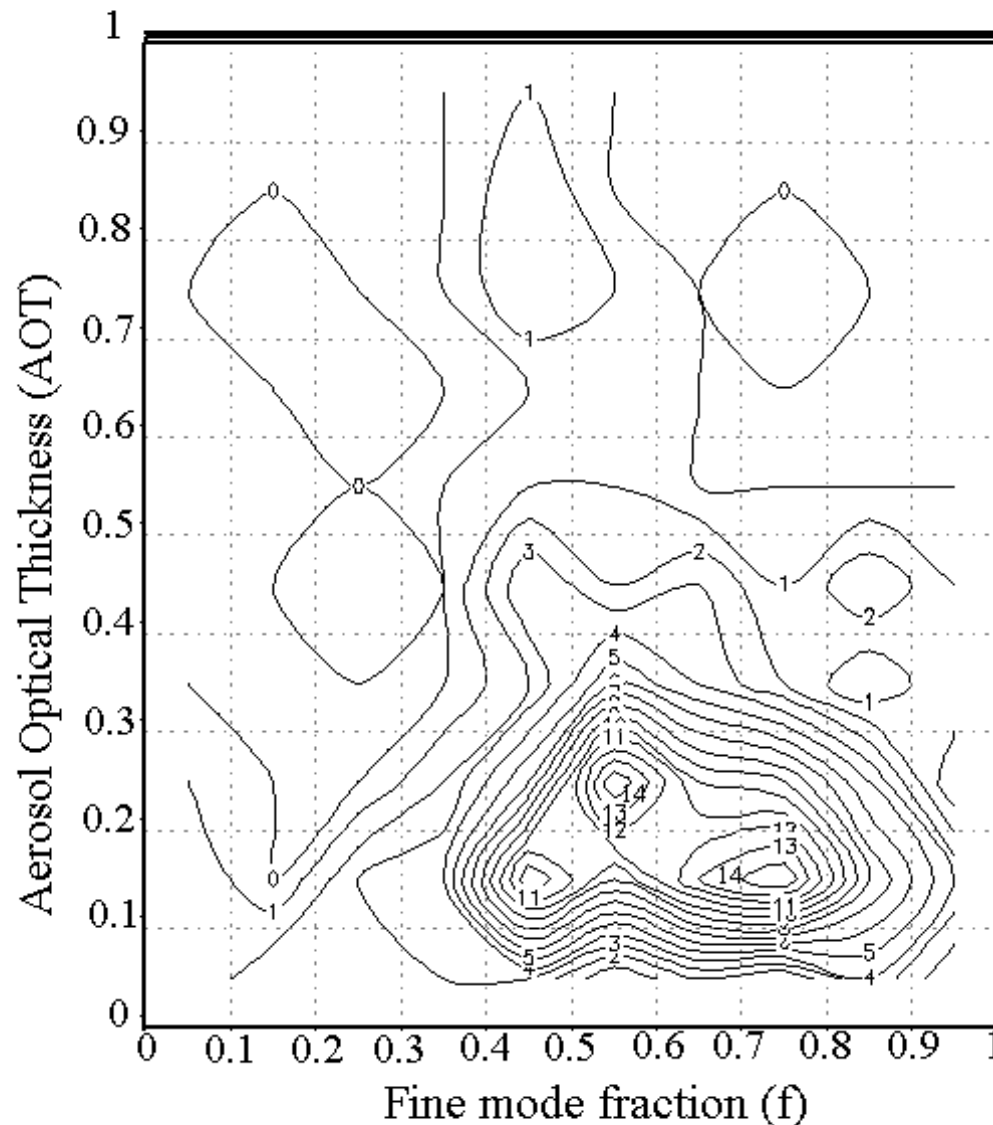


Total number of days: 269

Total number of days with
only available AOT/f: 243

Figure 3d: As in (a) but for the Medium Persian (PT/M) system. Analysis is based on 243 days during the time period 24 February 2000 – 23 February 2006.

AOT/f scatter plot for Red Sea Trough with Central axis (RST/C)

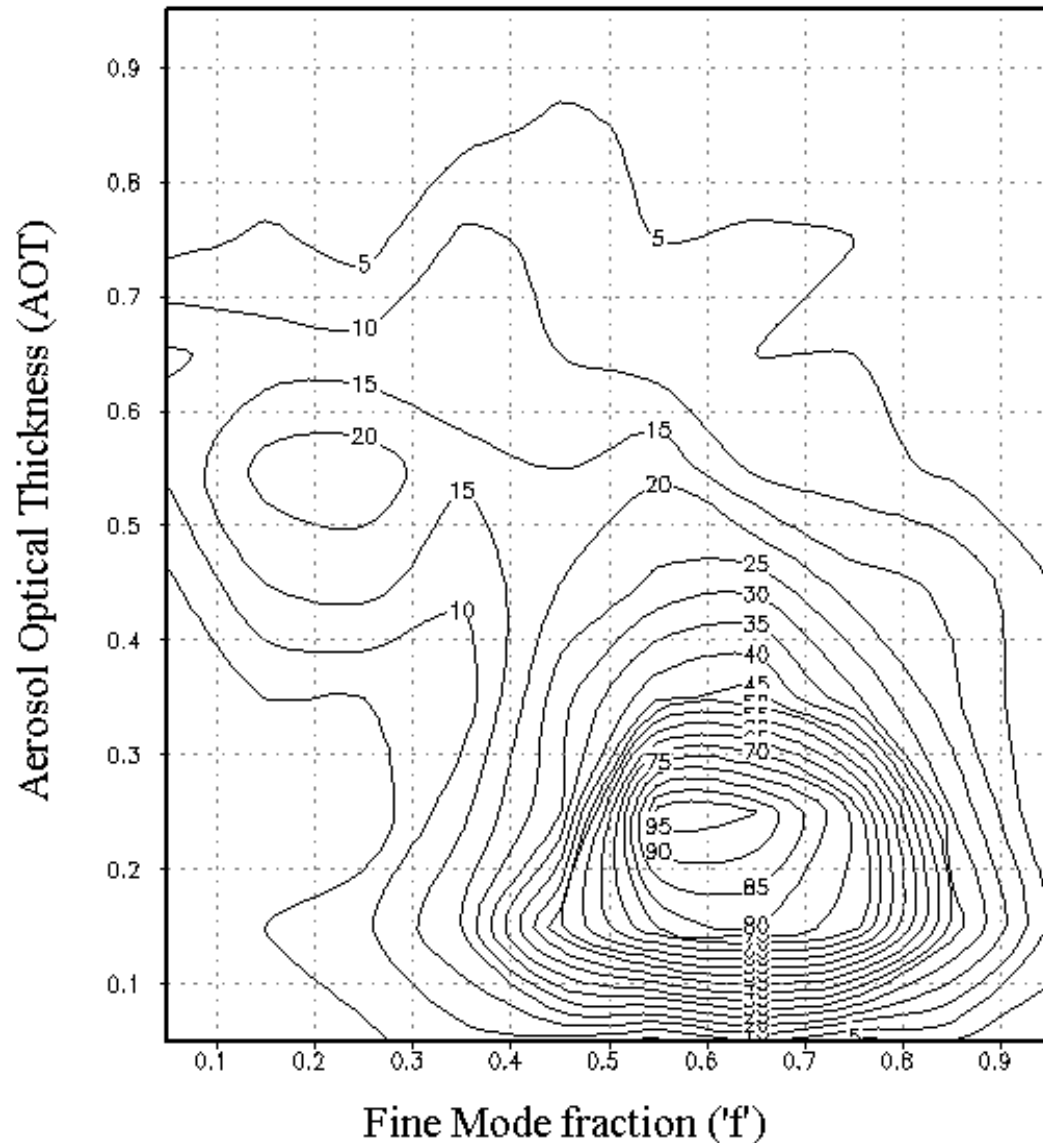


Total number of days: 200

Total number of days with
only available AOT/f: 183

Figure 3e: As in (a) but for the Red Sea Trough with Central axis (RST/C) system. Analysis and based on 183 days during the time period 24 February 2000 – 23 February 2006.

AOT/f scatter plot for all the five common synoptic systems in Israel

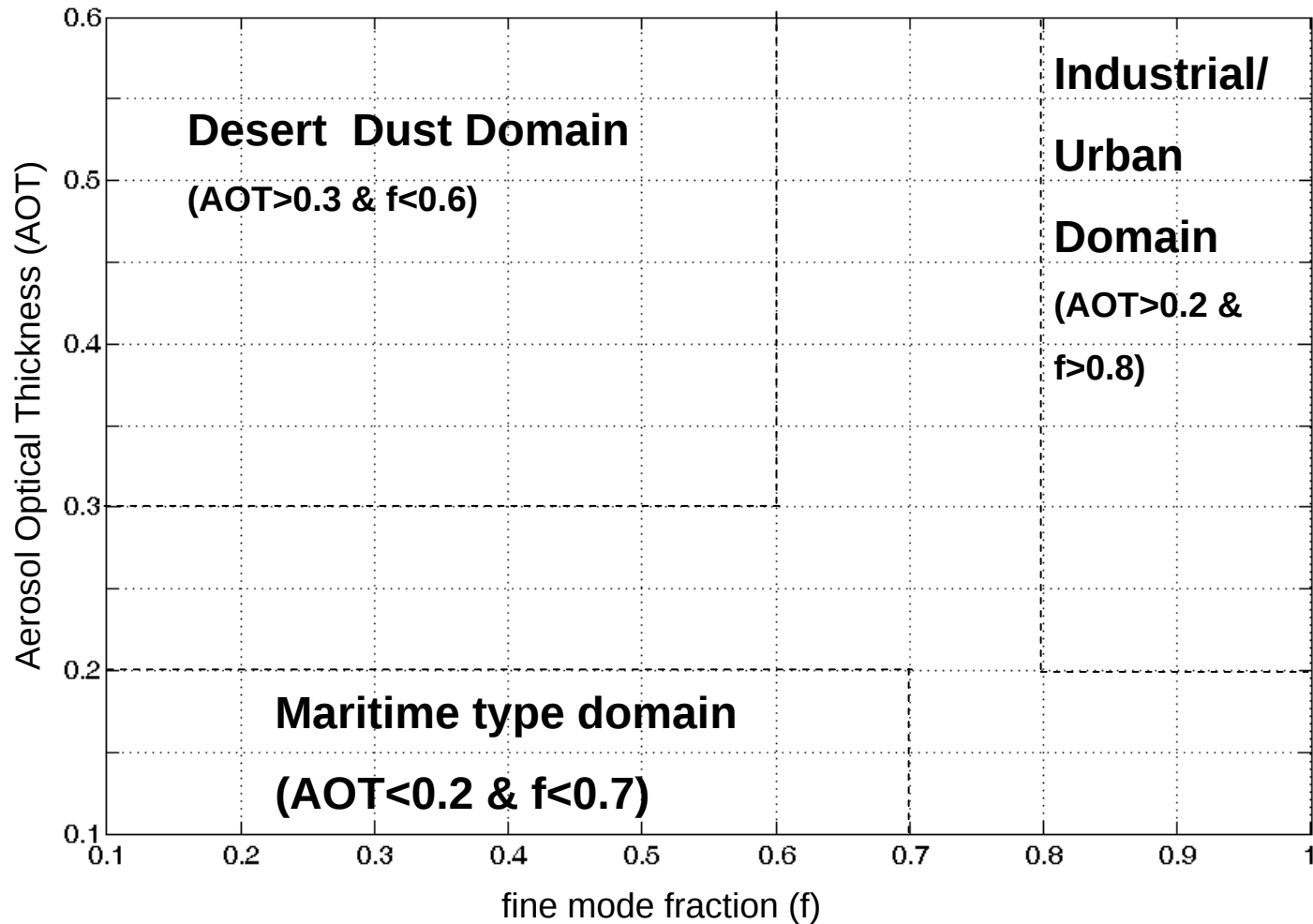


Total number of days:
1523

Total number of days with
only available AOT/f:
1402

Figure 3f: as in (a) but for the total 5 synoptic systems: Weak Persian (WP) system, High from the West (HW), Red Sea Trough with Eastern axis (RST/E), the Medium Persian (PT/M) and Red Sea Trough with Central axis (RST/C) system. The map shows number of days per interval of $0.1 \text{ AOT} \times 0.1 f$. Analysis and based on 1402 days during the time period 24 February 2000 – 23 February 2006.

Aerosols group definitions



Kosmopoulos, P. G., Kaskaoutis, D. G., Nastos, P. T. and Kambezidis, H. D., 2008. Seasonal variation of columnar aerosol optical properties over Athens, Greece, based on MODIS data. *Remote Sensing of Environ.* **112**, 2354-2366.

Aerosols group definitions

Following Kosmopoulos et al., (2008) the definition of the aerosols groups is:

- 1. Desert dust group – for $AOT > 0.3$ and $f < 0.6$.a**
- 2. Urban/Industrial group – for $AOT > 0.2$ and $f > 0.8$**
- 3. Marmite group – for $AOT < 0.2$ and $f < 0.7$**
- 4. Undetermined group – all other domains**

The 5 types of aerosols that were found in the classification of aerosols by synoptic systems

Aerosols type	AOT	f	Synoptic systems and group of aerosols (the number in the parenthesis are the maxima density per $0.1AOT \cdot 0.1f$)	Description of the aerosol type.
I	0.2-0.3	0.5-0.6	PT/W (32) group I H/W (24) group I RST/C (15) group II PT/M (17) group I	Mixed aerosols of dust aerosols and maritime aerosols.
II	0.1-0.2	0.6-0.7	RST/E (27) group I	Fine aerosols that belong to the maritime group.
III	0.4-0.6	0.1-0.3	PT/W (6) group II H/W (5) group II PT/M (7) group II	Very coarse aerosols of mineral dust particles.
IV	0.1-0.2	0.7-0.8	RST/C (17) group I	Fine-mixed aerosol of urban/industrial and maritime particles.
V	0.1-0.2	0.4-0.5	RST/C (13) group III	Maritime coarse aerosol .

The aerosols groups for each of the five common synoptic systems

Table 3. Synoptic Classification the Five Common Synoptic Systems in Decreasing Order^a

Synoptic System	Aerosol Group Number				Range of AOT and 'f'		Estimated Aerosol Type (Achieved by Using the Optical Properties)
		AOT	'f'	Number of Cases	AOT	'f'	
PT/W	I	$0.254 \pm 0.030^*$	$0.553 \pm 0.060^*$	32	0.2–0.3	0.5–0.6	undetermined aerosols
	II	0.507 ± 0.060	0.205 ± 0.056	27	0.4–0.6	0.1–0.3	desert dust
H/W	I	0.202 ± 0.056	0.596 ± 0.053	85	0.1–0.3	0.5–0.7	maritime aerosols and undetermined aerosols
	II	0.503 ± 0.052	0.197 ± 0.052	25	0.4–0.6	0.1–0.3	desert dust
RST/E	I	0.151 ± 0.028	0.651 ± 0.086	77	0.1–0.2	0.5–0.8	maritime aerosols and undetermined aerosols
	II	$0.239 \pm 0.031^*$	$0.558 \pm 0.027^*$	17	0.2–0.3	0.5–0.6	undetermined aerosols
PT/M	I	0.546 ± 0.031	0.264 ± 0.089	20	0.5–0.6	0.1–0.4	desert aerosols
	II	0.149 ± 0.034	0.740 ± 0.030	17	0.1–0.2	0.7–0.8	undetermined aerosols
RST/C	I	$0.253 \pm 0.024^*$	$0.548 \pm 0.028^*$	15	0.2–0.3	0.5–0.6	undetermined aerosols
	II	0.141 ± 0.031	0.437 ± 0.032	13	0.1–0.2	0.4–0.5	maritime aerosols

^aThe values following the plus/minus sign represent the standard deviation. The numbers that are marked with the asterisks are probably a mixture of desert aerosols and maritime aerosols with small AOT dust because AOT is in the middle between 0.2–0.3 and close to 0.3 and 'f' value is <0.6.

Mean AOT and 'f' and its standard deviation ($\pm$) for each of the 5 synoptic systems

	Weak Persian Trough (PT/W)	High from the West (H/W)	Red Sea Trough with Eastern Axis (RST/E)	Medium Persian Trough (PT/M)	Red Sea Trough with central Axis (RST/E)
Averaged AOT	0.38 $\pm$ 0.19	0.33 $\pm$ 0.20	0.28 $\pm$ 0.18	0.43 $\pm$ 0.20	0.25 $\pm$ 0.17
Averaged f	0.51 $\pm$ 0.21	0.54 $\pm$ 0.21	0.63 $\pm$ 0.18	0.51 $\pm$ 0.22	0.59 $\pm$ 0.20
number of days for each synoptic system	353	334	289	243	183

On the average, the aerosols in Weak and Medium Persian Trough contain larger particles than in Red Sea Trough (with Central and Eastern axis) (T-test significant <5%).

The aerosol group centers for the five common synoptic systems in Israel

(The numbers in the parentheses are the maxima density of observations per $0.1\text{AOT} \times 0.1f$ and not the total number of

observations for all the group range)

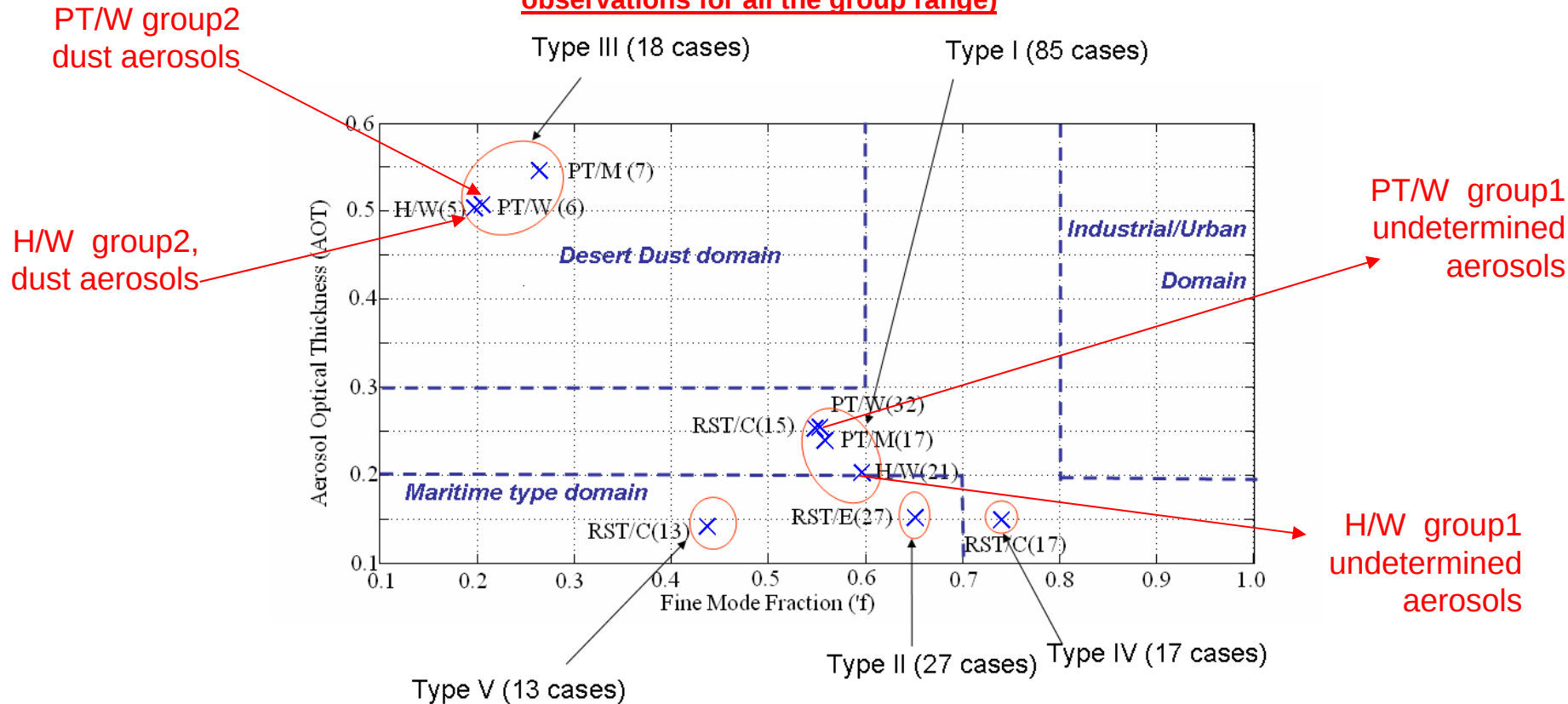


Figure 4: Scatter plot of aerosol group centers as detailed in table 3. Each point (marked as "X") indicates an aerosol group for a specific synoptic system. The number (in parentheses) that follows each point indicates the number of cases in the vicinity of $0.1\text{AOT} \times 0.1f$. Each type of aerosol gathered inside a few aerosol groups, which related to synoptic systems. In the dashed lines the approximate domains for the three aerosol types, i.e., Desert Dust, Maritime and Urban/Industrial are drawn, following Kosmopoluos et al. (2008) definition. The numbers of days for each aerosol type are only for the systems drawn on the figure. If all 5 systems are counted the numbers are larger as follows: type I (97 instead of 85), Type II (79 instead of 27).

The averaged back trajectories for Weak Persian Trough (PT/W) at height 3000m

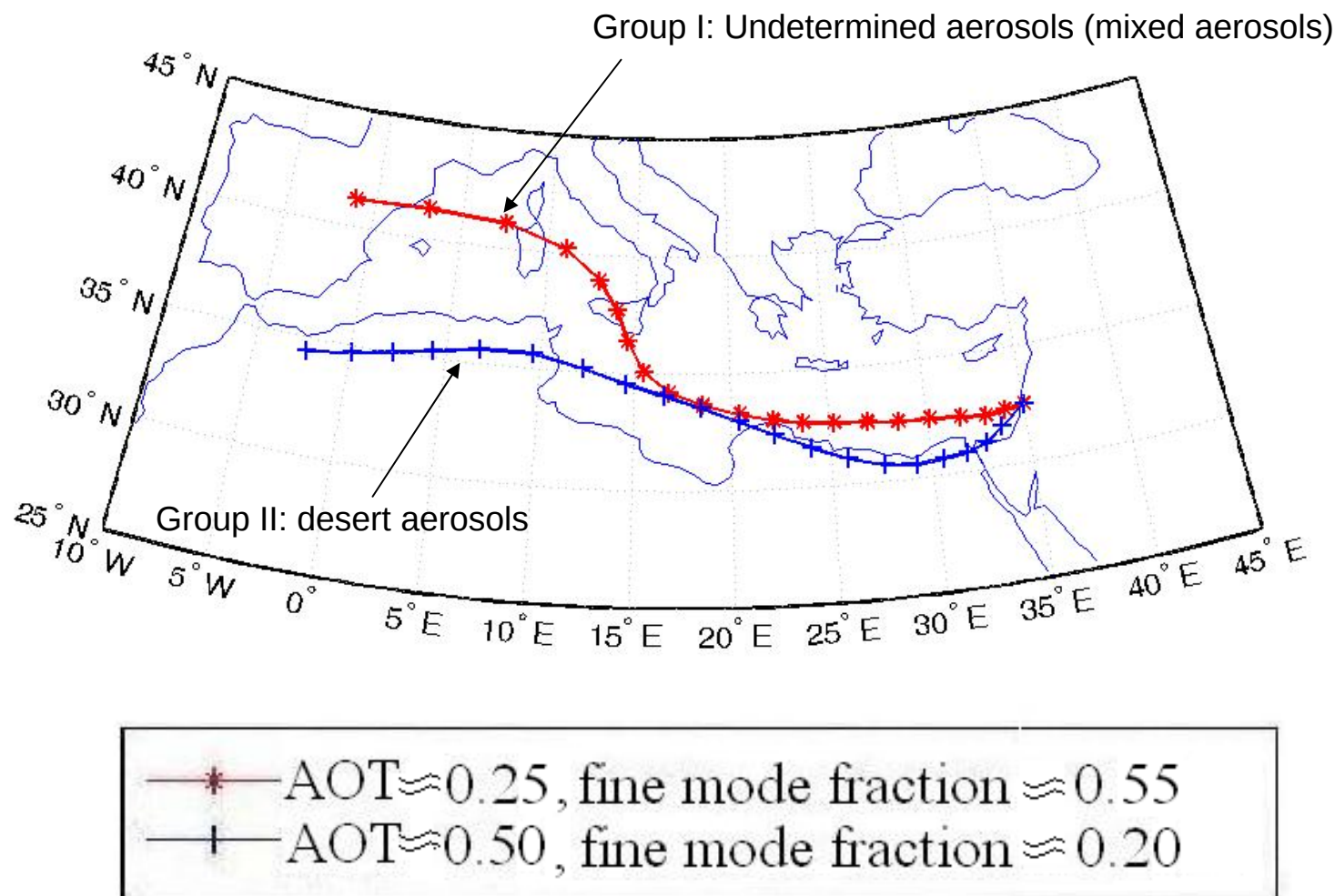


Figure 5: The averaged back trajectories for Weak Persian Trough (PT/W) system in the Eastern Mediterranean are for 10 random days within every group of aerosol. Line marked with "*" presents group I, i.e., AOT $\approx$ 0.25 & f $\approx$ 0.55 and line marked with "+" presents group II, i.e., AOT $\approx$ 0.50 & f $\approx$ 0.20. The groups of aerosols are detailed in table 3. The end point of the back trajectories is located at latitude 32.5°N, longitude 35.0°E (vicinity of Tel Aviv) and at the height of 3000m above ground level (AGL). Back trajectories are for 120 hours and the time interval between two close points is 6 hours.

The averaged back trajectories for High from the west (H/W) at height 3000m

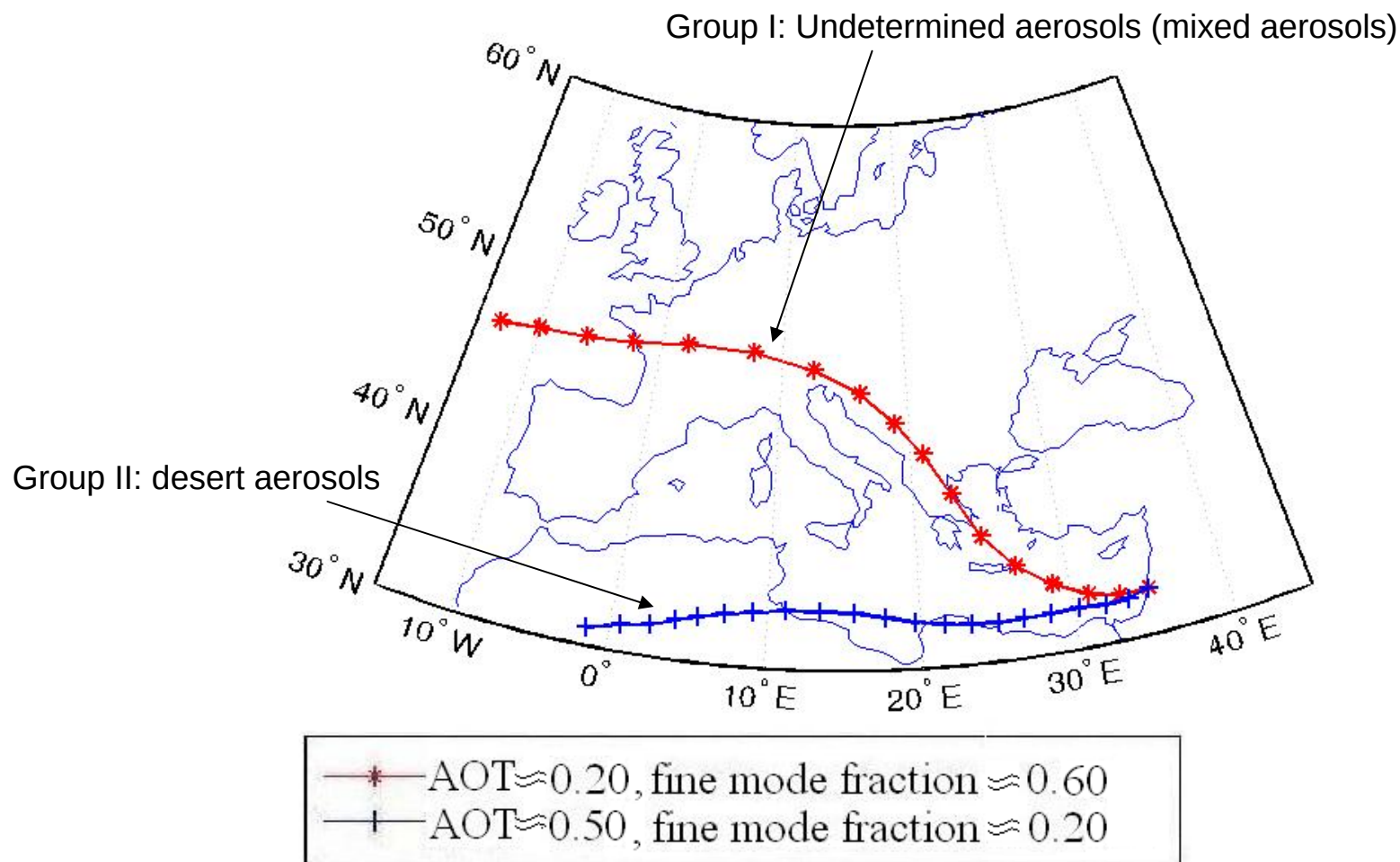


Figure 6: The averaged back trajectories for High from the west (H/W) system in the Eastern Mediterranean are for 10 random days within every group of aerosol. Line marked with "*" presents group I, i.e., AOT $\approx$ 0.20 & $f' \approx$ 0.60 and line marked with "+" presents group II, i.e., AOT $\approx$ 0.50 & $f' \approx$ 0.20. The groups of aerosols are detailed in table 3. The end point of the back trajectories is located at latitude 32.5°N, longitude 35.0°E (vicinity of Tel Aviv) and at the height of 3000m above ground level (AGL). Back trajectories of group II ($f' \approx$ 0.2') is for 120 hours but Back trajectories of group I ($f' \approx$ 0.6') is only for 96 hours because above 96 hours it is out of the map boundaries. The time interval between two close points is 6 hours.

summary

- This is the first extensive study that employs the MODIS satellite data in order to define the relationship between aerosol types and synoptic conditions over the EM.
- The averaged AOT fine mode fractions in the Weak Persian Trough (PT/W) and Medium Persian Trough (PT/M) are lower compared to the Red Sea Troughs. In Persian Trough the averaged f is 0.5 ± 0.2 while in Red Sea trough it is 0.6 ± 0.2 .
- The AOT/ f distributions analysis suggests five ranges of AOT/ f where the number of occurrences is maximum.
0.2-0.3/0.5-0.6, 0.1-0.2/0.6-0.7, 0.4-0.6/0.1-0.3,
0.1-0.2/0.7-0.8 & 0.1-0.2/0.4-0.5.
- The thresholds optical conditions for desert aerosols group ($AOT > 0.3$ and ' f ' < 0.6) agree with our back trajectories study.
- The undetermined aerosol group in the zone $0.2 < AOT < 0.3$ & ' f ' < 0.8 is not a clear desert aerosol but probably mixed with Urban/Industrial and Maritime ingredients.