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Supplement of

Comparison of PMCAMx aerosol optical depth predictions over Europe with AERONET and MODIS measurements

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Supplementary Information

Table S1. PM_{2.5} aerosol concentrations (in $\mu\text{g}/\text{m}^3$) at the boundaries of the domain.

Species	Boundaries ¹			
	North	South	West	East
OA ²	1	1	1	1
Sulfate	1	1	1	1
Ammonium	0.37	0.37	0.37	0.37
Nitrate	0.06	0.015	0.007	0.06
Sodium	0.001	0.003	0.05	0.018
Chloride	0.001	0.006	0.06	0.009

¹ "North", "South", "West", and "East" here represent the top, bottom, left, and right edge, respectively, of our modeling domain.

² organic aerosol

Table S2. Summary of the evaluation of MODIS vs. AERONET AODs at 550nm for land, per satellite and Quality Confidence Flag (QAC).

Satellite	QAC	Collocated Points	Regression equation ¹	Correlation Coefficient	% points in expected error envelope
Aqua and Terra	123	8,331	$y = 1.046 x - 0.0001$	0.81	72.7
	23	7,226	$y = 1.027 x - 0.003$	0.82	74.0
	3	5,544	$y = 0.976 x - 0.004$	0.83	75.5
Aqua	123	3,721	$y = 1.057 x + 0.002$	0.79	71.1
Terra	123	4,592	$y = 1.039 x - 0.002$	0.82	73.9

¹x is AERONET AOD and y is MODIS AOD

Table S3. Expected error values which describe MODIS AOD uncertainties (land and ocean algorithms) with respect to AERONET. The monthly mean value of AERONET AOD is employed for $AOD_{AERONET}$.

Region	$\pm(0.05+0.15AOD_{AERONET})$	$\pm(0.03+0.05AOD_{AERONET})$
	Land	Ocean
UK and Ireland	± 0.09	-
Central Europe	± 0.07	-
North Europe	± 0.06	-
Spain and Portugal	± 0.07	-
East Europe	± 0.07	-
Balkans	± 0.08	-
Russia, Belarus, and Ukraine	± 0.08	-
Turkey and Northern Africa	± 0.08	-
Mediterranean Sea	-	± 0.04
North Atlantic Ocean	-	± 0.04
South Atlantic Ocean	-	± 0.04
Black Sea	-	± 0.04

Table S4. Metrics for the evaluation of PMCAMx against MODIS monthly mean AODs.

Region	Standard Deviation of MODIS AOD	Standard Deviation of PMCAMx AOD	RMSE ¹
UK and Ireland	0.10	0.08	0.08
Central Europe	0.08	0.05	0.08
North Europe	0.05	0.04	0.07
Spain and Portugal	0.06	0.04	0.11
East Europe	0.04	0.03	0.08
Balkans	0.06	0.03	0.12
Russia, Belarus, and Ukraine	0.08	0.02	0.09
Turkey and Northern Africa	0.09	0.06	0.12
Mediterranean Sea	0.07	0.04	0.11
North Atlantic Ocean	0.12	0.08	0.08
South Atlantic Ocean	0.06	0.04	0.12
Black Sea	0.09	0.02	0.10
Domain	0.10	0.07	0.10

$$^1 \text{ RMSE} = \text{Root Mean Square Error} = \sqrt{\frac{1}{N} \sum_{i=1}^N (P_i - O_i)^2}$$

where P_i are predicted values by PMCAMx, O_i the MODIS retrievals and N the number of data values.

Table S5. PMCAMx performance metrics for PM₁ mass concentration in EMEP stations

EMEP station	Average Observed ($\mu\text{g m}^{-3}$)	Average Predicted ($\mu\text{g m}^{-3}$)	Mean Error ($\mu\text{g m}^{-3}$)	Mean Bias ($\mu\text{g m}^{-3}$)	Fractional Error	Fractional Bias
Hyytiala	3.72	4.98	1.56	1.25	0.42	0.37
Illmitz	9.51	8.49	2.24	-1.02	0.25	-0.09
Payerne	6.70	6.42	2.65	-0.27	0.51	-0.23
Rigi	6.11	7.20	2.99	1.09	0.50	0.01
Waldhoff	8.01	10.91	3.62	2.90	0.40	0.33

Table S6. PMCAMx performance metrics for PM_{2.5} mass concentration in EMEP stations

EMEP station	Average Observed ($\mu\text{g m}^{-3}$)	Average Predicted ($\mu\text{g m}^{-3}$)	Mean Error ($\mu\text{g m}^{-3}$)	Mean Bias ($\mu\text{g m}^{-3}$)	Fractional Error	Fractional Bias
Aspvreten	5.79	8.47	3.27	2.68	0.50	0.39
Auchencorth	9.90	15.11	7.36	5.20	0.58	0.33
Barcarotta	7.21	6.58	3.72	-0.63	0.58	-0.14
Cabo de Creus	8.86	11.85	4.81	2.99	0.44	0.27
Campisabalos	4.61	4.04	1.96	-0.58	0.56	-0.15
Els Torms	6.20	10.83	5.66	4.63	0.58	0.33
Hyytiala	4.48	6.02	1.83	1.54	0.40	0.36
Illmitz	12.19	9.70	3.17	-2.48	0.27	-0.20
Iskrba	11.31	8.83	3.56	-2.48	0.38	-0.26
Ispra	9.93	14.34	6.36	4.41	0.52	0.36
Mace Head	12.78	12.79	6.97	0.01	0.57	-0.16
Niembro	8.59	7.72	4.17	-0.87	0.56	-0.27
O Savinao	5.94	5.88	2.71	-0.06	0.44	-0.04
Payerne	8.11	7.25	2.99	-0.85	0.50	-0.28
Penausende	6.56	4.24	3.05	-2.32	0.58	-0.44
Rigi	8.10	8.19	3.76	0.08	0.52	-0.14
Rao	9.56	10.10	4.11	0.53	0.40	0.05
Schaunisland	7.82	9.00	3.44	1.18	0.41	0.09
Vavihill	8.67	10.79	2.74	2.11	0.27	0.17
Viznar	9.64	6.14	4.59	-3.49	0.58	-0.43
Waldhoff	16.13	12.47	6.81	-3.66	0.39	-0.07
Zarra	5.27	6.30	2.89	1.03	0.50	0.11

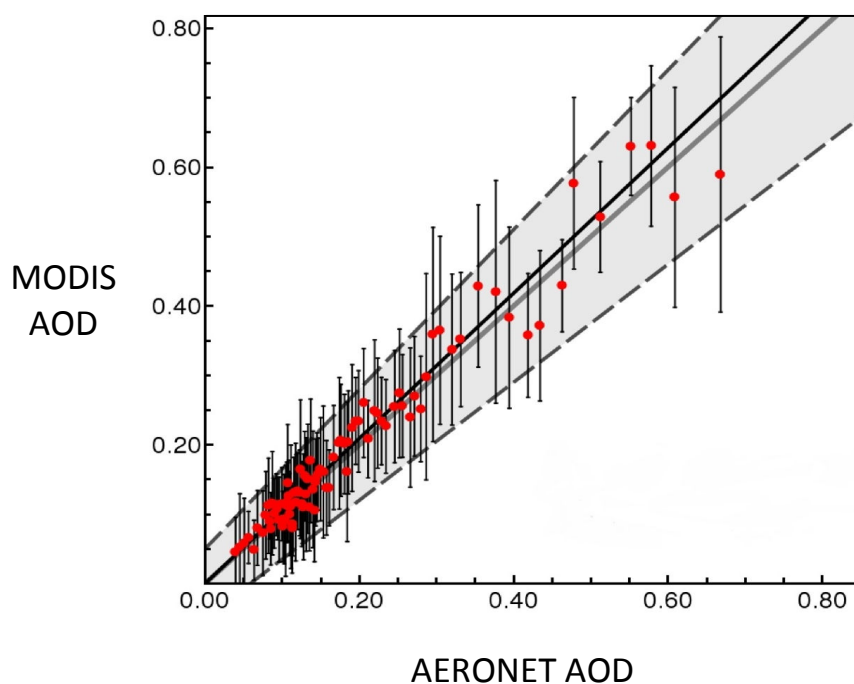


Figure S1 Comparison of MODIS AODs over land at 550 nm from Aqua and Terra ($QAC \geq 1$) with AERONET AODs. The mean AERONET and MODIS values for each bin are denoted by the red dots. The collocated MODIS data standard deviation, for each bin, is illustrated by the vertical error bars. The solid black line is the regression equation $y = -0.0001 + 1.046x$ calculated prior to data partitioning, along with the 1:1 solid gray line. The dashed gray lines denote the land expected error envelope of $\pm(0.05 + 0.15AOD_{AERONET})$.

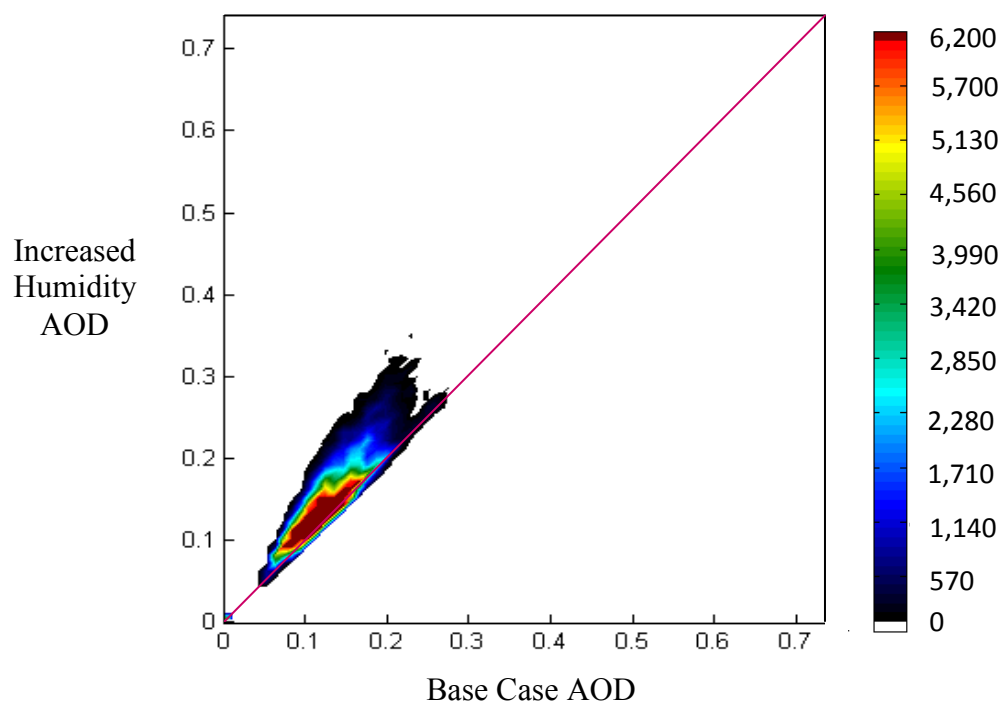


Figure S2 Comparison of the base case PMCAMx with the humidity test PMCAMx monthly mean AODs. The different colors indicate density.

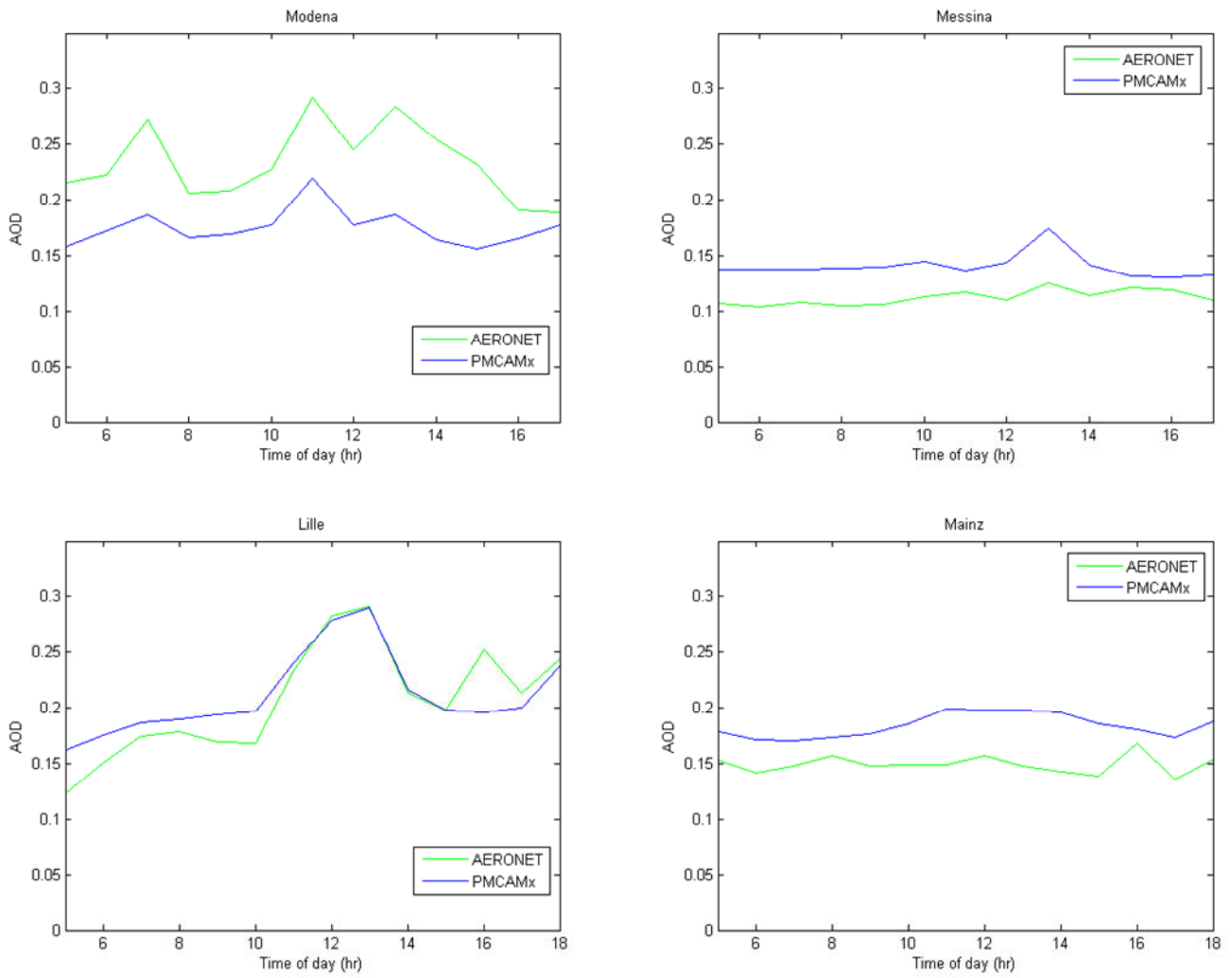


Figure S3. Comparison of the PMCAMx predictions (blue lines) with the average temporal profiles of AODs measured in the AERONET stations of Modena, Messina, Lille, and Mainz (green lines).

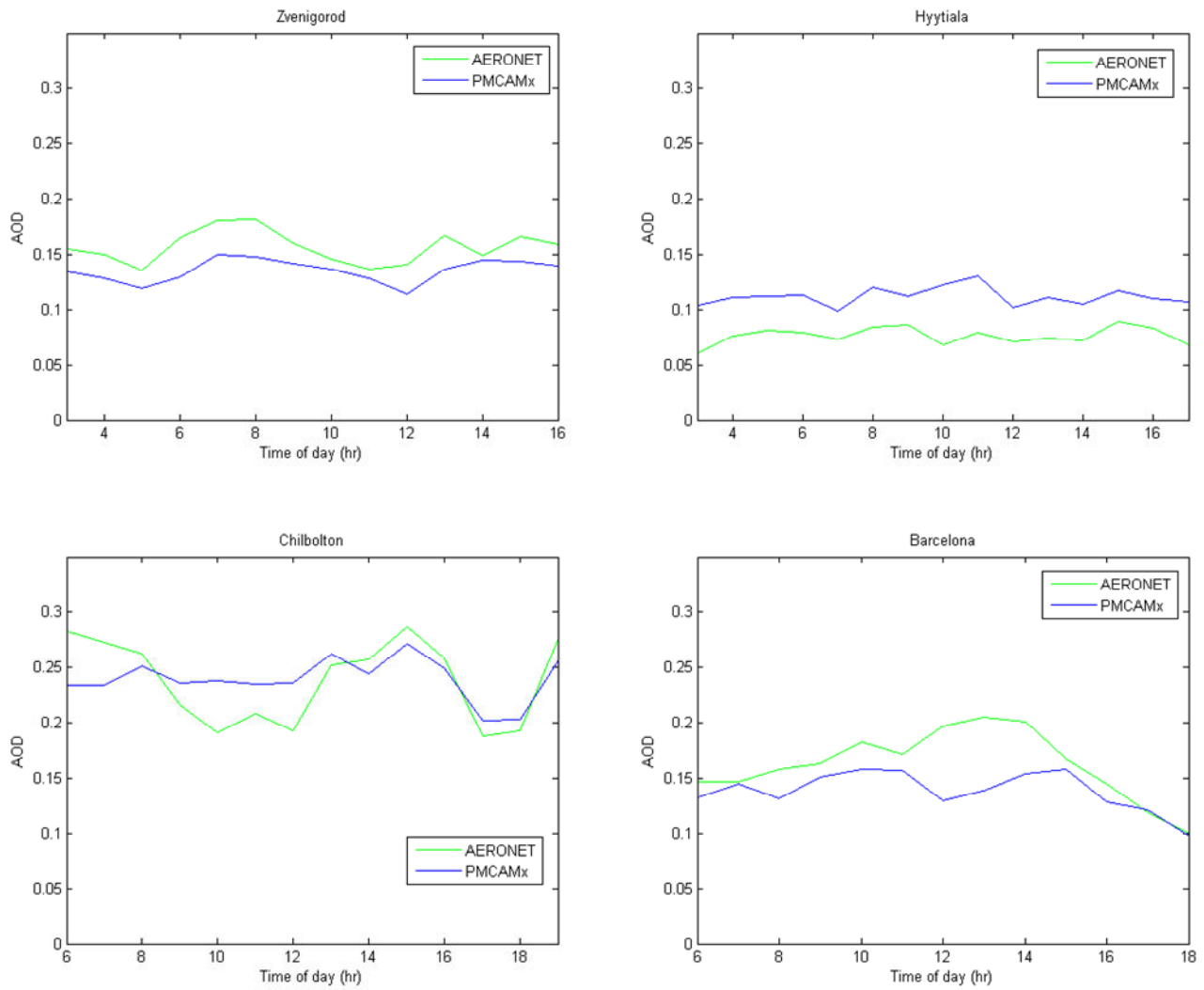


Figure S4. Comparison of the PMCAMx predictions (blue lines) with the average temporal profiles of AODs measured in the AERONET stations of Zvenigorod, Hyttiala, Chibolton, and Barcelona (green lines) during May 2008.

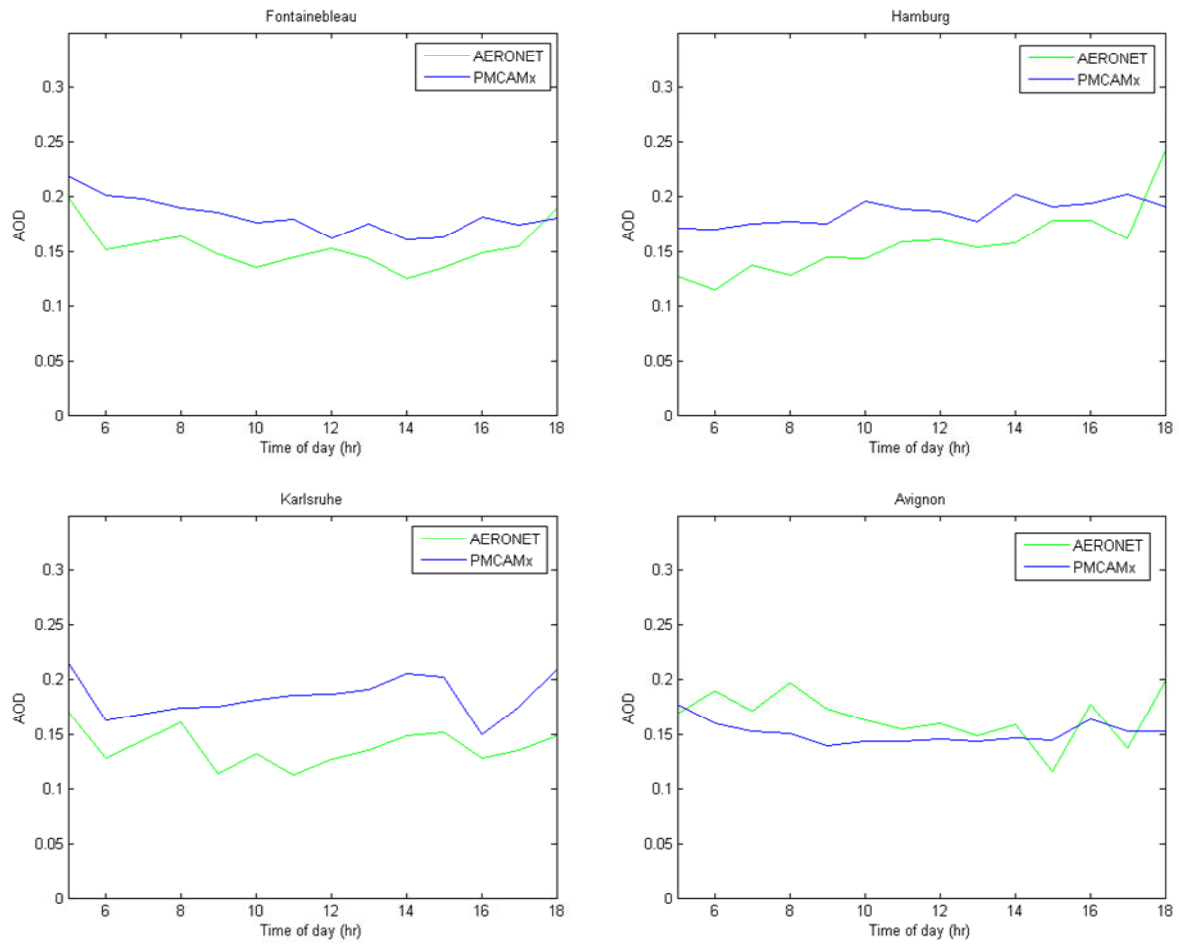


Figure S5. Comparison of the PMCAMx predictions (blue lines) with the average temporal profiles of AODs measured in the AERONET stations of Fonteneblau, Hamburg, Karlsruhe, and Avignon (green lines) during May 2008.

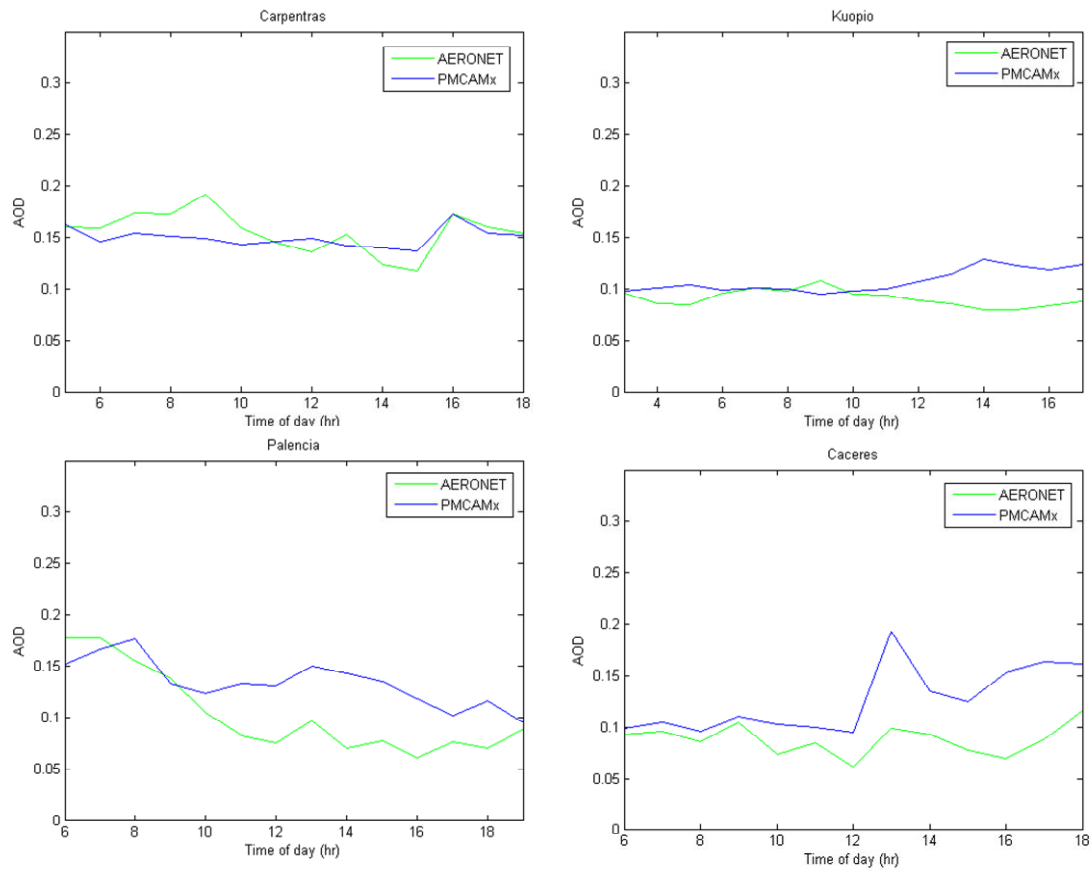


Figure S6. Comparison of the PMCAMx predictions (blue lines) with the average temporal profiles of AODs measured in the AERONET stations of Carpentras, Kuopio, Palencia, and Caceres (green lines) during May 2008.

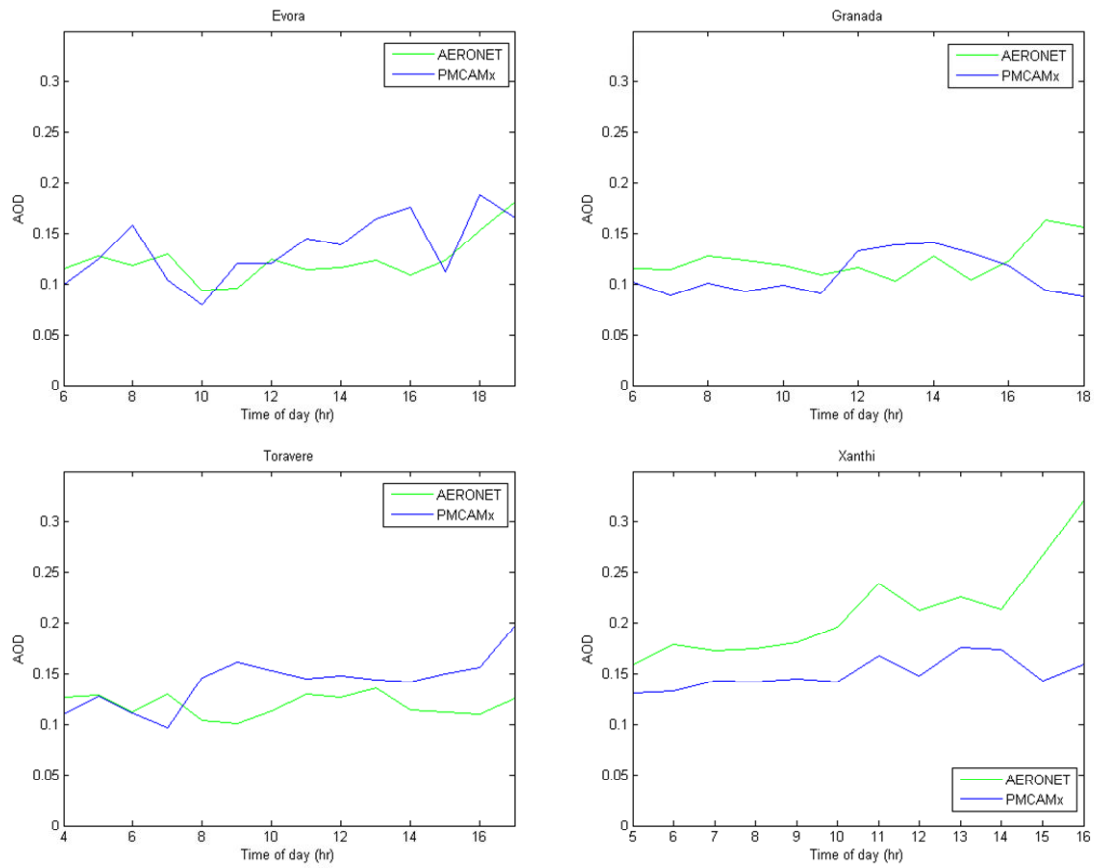


Figure S7. Comparison of the PMCAMx predictions (blue lines) with the average temporal profiles of AODs measured in the AERONET stations of Evora, Granada, Toravere, and Xanthi (green lines) during May 2008.

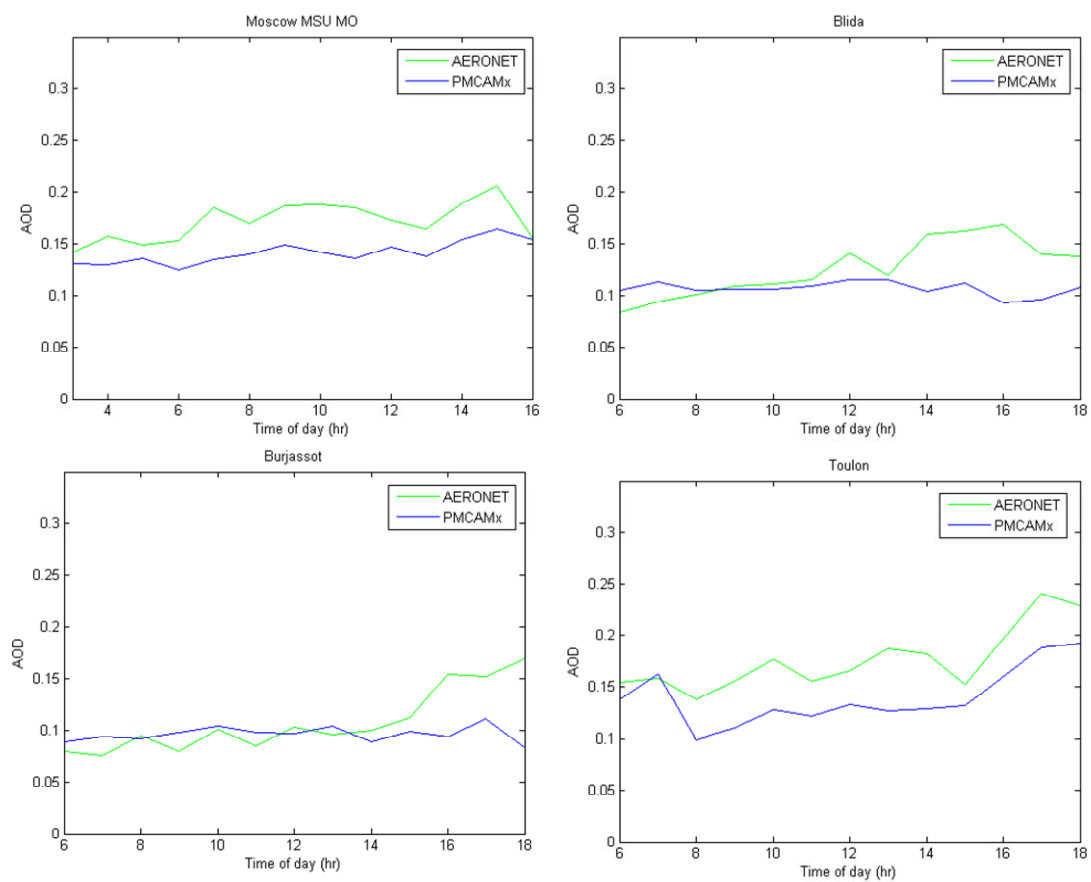


Figure S8. Comparison of the PMCAMx predictions (blue lines) with the average temporal profiles of AODs measured in the AERONET stations of Moscow, Blida, Burjassot, and Toulon (green lines) during May 2008.