CLIVAR-SPAIN CONTRIBUTIONS: Establishing an aerosol climatology for the Mediterranean basin

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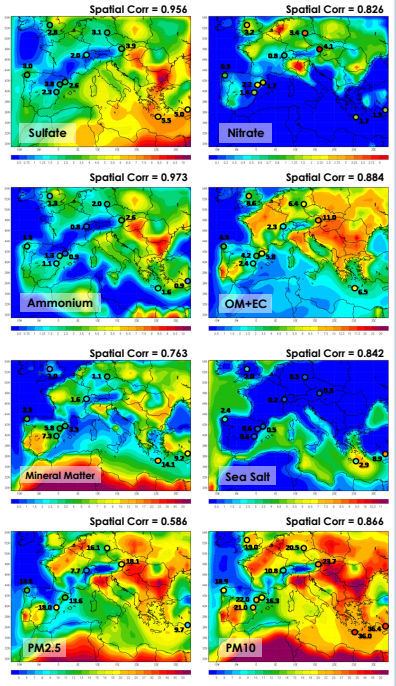
The contribution of the various aerosol sources, the role of long-range transport and the contribution of primary and secondary particulate matter to the ambient aerosol concentrations over Europe are not well known (Kulmala et al., 2009). Focusing on the Mediterranean, Querol et al. (2009) point out that there is a lack of studies on the variability of particulate matter (PM) along the Mediterranean basin, necessary for understanding the special features that differentiate aerosol processes between the western, eastern and central Mediterranean basins. Modelling systems based on state-of-science chemistry transport models (CTMs) are fundamental elements to investigate the transport and chemistry of pollutants behaviour at different scales and to assess the impact of emissions in aerosol levels and composition (Stilbello et al., 2008).

Therefore, this study aims to summarise the results on the levels and chemical composition of aerosols along the Mediterranean basin, highlighting the marked gradient between the western-central-eastern coasts. Special attention is paid to the analysis of the seasonality of PM composition and levels.

The regional modelling system MM5-CHIMERE-EMEP has been implemented for conducting a full transient simulation for the ERA-Interim period (1989-2009) using year-to-year changing EMEP emissions (Vestreng et al., 2007). Physics parameterizations for MM5 include Noah Land Surface Model, MRF PBL scheme, Grell cumulus scheme and Simple Ice for microphysics. CHIMERE chemical mechanism is MELCHIOR2 including aerosols, re-suspension and inert sea-salt. The boundaries for MM5-CHIMERE are provided by the ERA-Interim reanalysis data and LMDz-INCA+GOCART, respectively. The domain of study covers Europe with a horizontal resolution of 25 km and a vertical resolution of 23 layers in the troposphere; however the analysis focuses on the Mediterranean area.

Model validation: observations data taken from Querol et al., 2009.



	Sulphate	Nitrate	Ammonium	OM+EC	Mineral	Sea Salt	PM2.5	PM10
MB (µg m^3)	-0.23	-1.30	0.44	-0.97	-2.38	-0.48	-2.01	-5.30
ME (µg m^3)	0.91	1.30	0.58	1.37	2.44	1.06	2.39	5.40
RMSE (µg m^3)	1.09	1.48	0.71	1.89	4.11	1.84	3.82	7.32
MFB (%)	-19.55	-99.67	24.82	-11.12	-32.37	-19.41	-15.35	-24.34
MFE (%)	31.88	99.67	36.94	28.71	53.45	53.72	27.56	24.85
MNB (%)	-13.24	-41.74	37.12	-5.50	-15.70	-4.22	-9.78	-20.45
MNE (%)	27.38	61.74	47.94	26.94	45.78	48.74	24.52	20.98

The model performance for PM2.5 and PM10 shows a tendency to underestimate the total concentration of aerosols (MB=-2.01 and -5.30 µg m^{-3}, respectively). SO_4 is better than for other species; a large consistency between model and observations was found throughout the year (MFE = 31.9%, ME=0.91 µg m^{-3}; RMSE = 1.01 µg m^{-3}) because SO_4 formation chemistry is well understood and the emissions of precursors are well characterized within emission inventories. Since NH_4 is strongly correlated to the SO_4 cycle in the CHIMERE simulations, the performance of the model is similar for this compound. NO_3 presents a relatively poor performance with strong underestimations (MFB = -99.7%), in the order of magnitude of other CTMs. The model performance of OM+EC shows a slight underprediction through the whole period (MFB=-11.12%; MNB=-5.50%) because of the limitations in the mechanisms for SOA formation. Natural aerosols perform similarly (MFE and MNE around 50%).

Kulmala, M., Asmi, A., Lappalainen, H.K., Carslaw, K.S., Pöschl, U., Baltensperger, U. Hov, O., Brenquier, J.-L., Pandis, S.N., Facchini, M.C., Hanson, H.-C., Wiedensohler, A., O'Dowd, C.D., 2009. Introduction: European Integrated Project on Aerosol Cloud Climate and Air Quality interactions (EUCAARI) – integrating aerosol research from nano to global scales. Atmos. Chem. Phys., 9, 2825-2841.

Querol, X., Alastuey, A., Pey, J., Cusack, M., Pérez, N., Mihalopoulos, N., Theodosi, C., Gerasopoulos, E., Kubilay, N., Koçak, M., 2009. Variability in regional background aerosols within the Mediterranean. Atmos. Chem. Phys., 9, 4575-4591.

Stilbello, C., Calori, G., Brusasca, G., Giudici, A., Angelino, E., Fossati, G., Peroni, E., Buganza, E., 2008. Modelling of PM10 concentrations over Milano urban area using two aerosol modules. Environ. Mod. & Soft., 23, 333-343.

Vestreng, V., Mareckova, K., Kakareka, S., Malchykhina, A., Kukharchyk, T., 2007. Inventory Review 2007: Emission Data reported to LRTAP Convention and NEC Directive, MSC-W Technical Report 1/07, The Norwegian Meteorological Institute, Oslo, Norway.

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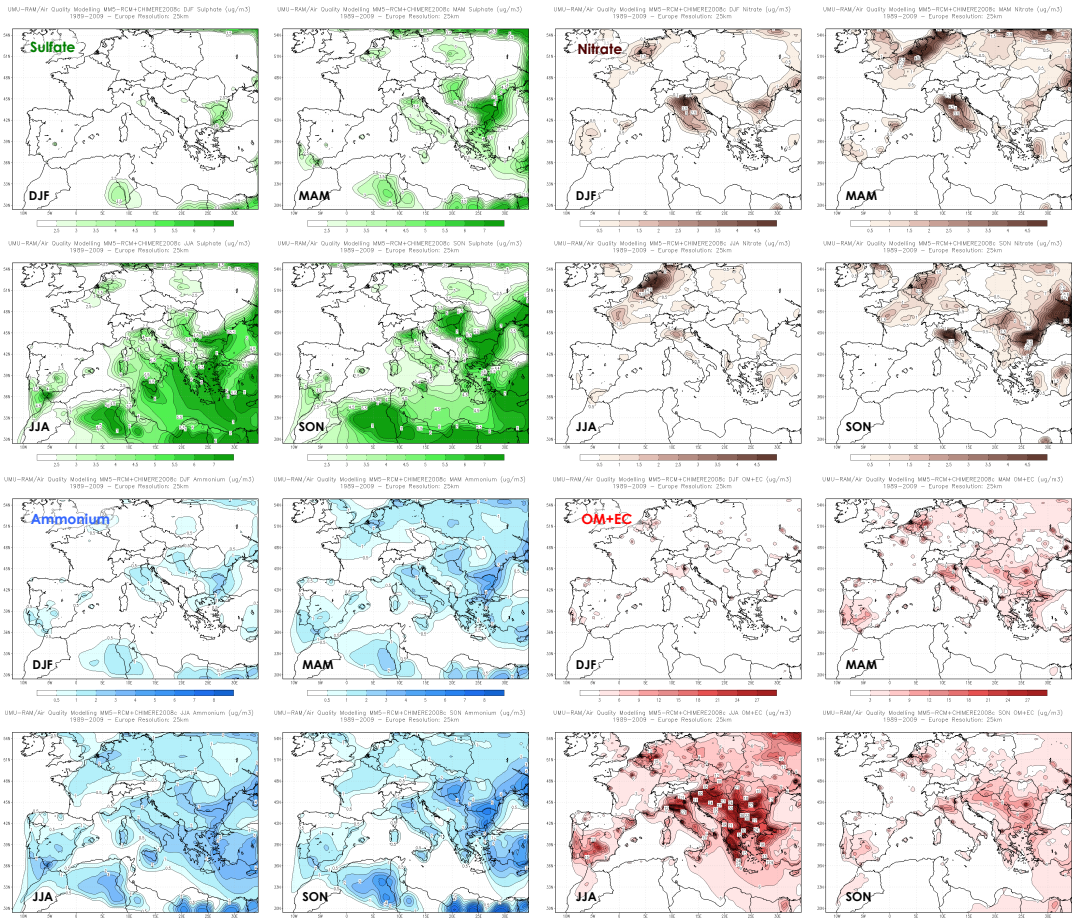
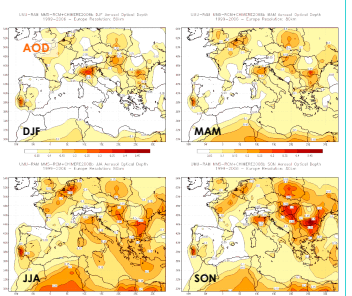
The modelling results for the Mediterranean basin indicate that the aerosol levels follow a seasonal pattern with summer maximum concentrations caused by an increased secondary activity and the lower precipitation in the area, together with the contribution of Saharan dust outbreaks. The high spatial correlation indicates an accurate reproducibility of the patterns of spatial variation within the basin.



Sulphate levels at both parts of the basin increase progressively from April–May to reach maximum levels in mid-summer, due to enhanced photochemistry, low air mass renovation at regional scale, the increment of the summer mixing layer depth favouring the regional mixing of polluted air masses, and the possible higher summer contribution of marine secondary sulphate from DMS oxidation. Nitrate presents much differentiated levels between winter (DJF) and summer (JJA) periods, with maxima during colder months in northern Italy and the Netherlands and lower levels in the warm season. This can be related to the thermal instability of the ammonium nitrate in summer ambient conditions, favouring the gas phase prevalence of nitrate. The levels of ammonium are higher in the eastern Mediterranean and are highly correlated to sulphate levels. OM+EC concentrations are maximum in JJA in the whole basin, because of the higher formation of secondary organic aerosols (SOA) from different natural and anthropogenic sources. Secondary peaks are usually observed in spring (MAM) and autumn (SON) and are associated with winter anticyclonic pollution episodes.



The largest modeled AOD exceeds 0.25 in Eastern Europe during summer and autumn. Over the northwestern Europe the AOD ranges between 0.15 and 0.25 as an annual average. The AOD decreases towards the south-west and becomes lower than 0.1 for all seasons in the Iberian Peninsula. The seasonal variation of nitrate and sulfate and their impact on AOD is strongly visible in the modelled AOD. Only in northwestern Europe modeled nitrate contributed significantly to AOD.