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An evaluation of uncertainty in the aerosol optical properties as represented by satellites and an ensemble of chemistry-climate coupled models over Europe

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The changes in Earth's climate are produced by forcing agents such as greenhouse gases, clouds and atmospheric aerosols. The latter modify the Earth's radiative budget due to their optical, microphysical and chemical properties, and are considered to be the most uncertain forcing agent. There are two main approaches to the study of aerosols: (1) ground-based and remote sensing observations and (2) atmospheric modelling. With the aim of characterizing the uncertainties associated with these approaches, and estimating the radiative forcing caused by aerosols, the main objective of this work is to assess the representation of aerosol optical properties by different remote sensing sensors and online-coupled chemistry-climate models and to determine whether the inclusion of aerosol radiative feedbacks in this type of models improves the modelling outputs over Europe.

Two case studies have been selected under the framework of the EuMetChem COST Action ES1004, when important aerosol episodes during 2010 over Europe took place: a Russian wildfires episode and a Saharan desert dust outbreak covering most of Europe. Model data comes from an ensemble of regional air quality-climate simulations performed by the working group 2 of EuMetChem, that investigates the importance of different processes and feedbacks in on-line coupled chemistry-climate models. These simulations are run for three different configurations for each model, differing in the inclusion (or not) of aerosol-radiation and aerosol-cloud interactions. The remote sensing data comes from three different sensors, MODIS (Moderate Resolution Imaging Spectroradiometer), OMI (Ozone Monitoring Instrument) and SeaWIFS (Sea-viewing Wide Field-of-view Sensor). The evaluation has been performed by using classical statistical metrics, comparing modelled and remotely sensed data versus a ground-based instrument network (AERONET). The evaluated variables are aerosol optical depth (AOD) and the Angström exponent (AE) at different wavelengths.

Regarding the uncertainty in satellite representation of AOD, MODIS appears to have the best agreement with AERONET observations when compared to other satellite AOD observations. Focusing on the comparison between model output and MODIS and AERONET, results indicate a general slight improvement of AOD in the case of including the aerosol radiative effects in the model and a slight worsening for the Angström exponent for some stations and regions. Regarding the correlation coefficient, both episodes show similar values of this metric, which are higher for AOD. Generally, for the Angström exponent, models tend to underestimate the variability of this variable. Despite this , the improvement in the representation by on-line coupled chemistry-climate models of AOD reflected here may be of essential importance for a better description of aerosol-radiation-cloud interactions in regional climate models. On the other hand, the differences found between remote sensing sensors (which is of the same order of magnitude as the differences between the different members of the model ensemble) point out the uncertainty in the measurements and observations that have to be taken into account when the models are evaluated.

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