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Four dimensional variational data assimilation of species-resolved satellite-retrieved aerosol optical thickness

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Aerosols play an increasingly important role in atmospheric modelling. They have a strong influence on the radiative transfer balance and a significant impact on human health. Their origin is various and so are its effects. Most of the measurement sites in Europe only account for an integrated aerosol load PM_x (Particulate Matter of less than x μm in diameter) which does not give any qualitative information on the composition of the aerosol. Since very different constituents like mineral dust derived from desert storms and sea salt contribute to PM_x it is necessary to make aerosol forcasts not only of load, but also type resolved.

The source of information chosen for this study is the aerosol retrieval system SYNAER (SYNergetic AErosol Retrieval) from DLR-DFD that retrieves BLAOT (Boundary Layer Aerosol Optical Thickness) making use of both AATSR/SCIAMACHY and AVHRR/GOME-2 data respectively. Its strengths are a large spatial coverage, near real-time availability, and the classification of five intrinsic aerosol species, namely water-solubles, water-insolubles, soot, sea salt, and mineral dust which are furthermore size resolved in terms of modes.

A widely known technique to enhance forecast skills of CTMs (Chemistry-Transport-Models) by ingesting in-situ and, especially, remote-sensing measurements is the method of four dimensional variational data assimilation (4Dvar). The EURAD-IM (EURopean Air pollution Dispersion - Inverse Model), containing a full adjoint gas-phase model, has been expanded with an adjoint of the MADE (Modal Aerosol Dynamics model for Europe) to optimise initial and boundary values for aerosols using 4Dvar. A forward and an adjoint radiative transfer model is driven by the EURAD-IM as mapping between BLAOT and internal aerosol species. Furthermore, its condensation scheme has been bypassed by an HDMR (High-Dimensional-Model-Representation) to ensure differentiability, and a time saving online NMC-module for the generation of the background error covariance matrix has been developped.

The skill of the aerosol 4Dvar system was tested in two episodes: July through August 2003, a dry period with strong wildfire activity in Europe, and June 2006, when a saharan desert dust outbreak could be observed.