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Aerosol impacts in the Met Office global NWP model

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An accurate representation of the direct and indirect effect of aerosols is of growing concern for global numerical weather prediction (NWP). Increased scattering and absorption of incoming shortwave (SW) and outgoing longwave radiation (OLR) fields due to the presence of aerosol layers in the atmosphere modifies the atmospheric heating profile and can affect large-scale circulation patterns. The current representation of aerosols in the global NWP configuration of the Met Office Unified Model^{TM} (MetUM) is based on a simple aerosol climatology (Cusack et al., 1998). Profiles of water soluble dust, soot, oceanic and stratospheric sulphate aerosols are described separately for land and ocean surfaces and are distributed over the boundary layer, free troposphere and stratosphere (sulphates only). While this improved the reflected SW radiative bias at the top-of-atmosphere (TOA), there is evidence that the climatology is too absorbing leading to a temperature bias in the lower troposphere of approximately 0.5 K/day. Furthermore, the omission of the scattering and absorption properties of mineral dust and biomass burning aerosol particles in particular, is believed to be the principal cause of significant model biases (in the region of 50-56 W m^{-2}) in both the model OLR at the TOA (Haywood et al., 2005) and the surface SW radiation fields (Milton et al., 2008). One of the objectives of the Global Aerosols (G-AER) component of the MACC (Monitoring Atmospheric Composition and Climate) project is to evaluate the impact of an improved aerosol representation on the performance of global NWP models.

In a stepwise approach of increasing the aerosol complexity in the MetUM, the Cusack climatology is being replaced by the CLASSIC (Coupled Large-scale Aerosol Simulator for Studies in Climate) aerosol scheme, developed for the HadGEM (Hadley Centre Global Environmental Model) climate model. CLASSIC includes representations of external mixtures of sulphate, black carbon, organic carbon, biogenic, sea salt, biomass-burning, mineral dust, and nitrate aerosol particles (Bellouin et al., 2007). As a first step, monthly mean climatologies of these species are implemented in the model. Stage two involves running the CLASSIC scheme in a prognostic mode where the aerosols are fully interactive with the model meteorological and radiation fields. Here we present an evaluation of both stages of the aerosol implementation procedure. An objective verification of the model output fields is carried out against forecast analyses and a wide range of satellite and *in situ* data. The model aerosol optical depth (AOD) is evaluated against ground-based AERONET observations and satellite aerosol retrievals available through the MACC project (e.g., MODIS, SEVIRI). The impacts on model performance, in terms of the general circulation patterns and in addressing the model radiation biases will also be presented.

References:

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