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High resolution Aerosol Radiative Effects over Europe using detailed optical properties from the Chemical Transport Model PMCAMx

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Natural and anthropogenic aerosol particles are major drivers of the Earth's radiation budget, which they affect directly (through scattering and absorption) and indirectly (through modification of cloud scattering and precipitation properties), while they semi-directly influence atmospheric stability and convection, mainly through modification of solar radiation absorption by the atmosphere. Despite the important climatic role of aerosols, large uncertainties in their radiative effects remain due to limited knowledge of the aerosol spatio-temporal distribution and physico-chemical properties. The interaction of aerosols with radiation is strongly dependent on their optical properties, which in turn are controlled by the particles' size distribution, shape, chemical composition and mixing state. In order to accurately estimate the magnitude of the aerosol direct radiative effect (DRE), detailed knowledge of their optical properties with high spatial and temporal resolution is required.

The European continent is a region of particular interest for studying atmospheric aerosol effects, because of the presence of numerous and varying sources of particles and their precursors, such as industries, large urban centers and biomass burning, especially when combined with high levels of solar insolation during summer. In this study, the aerosol DRE over Europe is examined using the FORTH deterministic spectral radiative transfer model (RTM) and aerosol data from the chemical transport model PMCAMx. Chemically and size resolved aerosol concentrations predicted by PMCAMx are combined with a Mie model to calculate key aerosol optical properties (i.e. vertically resolved aerosol optical depth, single scattering albedo and asymmetry parameter) that are necessary to compute aerosol DRE using the RTM. The Mie model takes into account concentrations of organics, black carbon, sulfate, nitrate, ammonium, chlorine, sodium, water, and crustal material, and calculates aerosol optical properties assuming that the aerosol particles of the same size are internally mixed. The DRE is estimated at the Earth's surface, within the atmospheric column and at the top of the atmosphere (TOA), at high spatial and temporal resolution (36 × 36 km grids, 27 vertical layers, hourly), during June and July 2012.

Initial modelling results reveal that DREs exhibit significant spatio-temporal variability, due to the heterogeneity of source emissions rates, mostly with regard to wildfires, and the varying synoptic conditions. Emphasis is thus given to biomass burning aerosols, which are among the most significant radiative forcing agents in Europe during summer. Their relative forcing is computed by performing model computations with and without biomass burning emissions.