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First global assessment of modelled aerosol hygroscopicity in the context of other aerosol optical properties

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The particle hygroscopic growth impacts the optical properties of aerosols and, in turn, affects the aerosol-radiation interaction and calculation of the Earth's radiative balance. The dependence of particle light scattering on relative humidity (RH) can be described by the scattering enhancement factor f(RH), defined as the ratio between the particle light scattering coefficient at a given RH divided by its dry value.

The first effort of the AeroCom Phase III – INSITU experiment was to develop an observational dataset of scattering enhancement values at 26 sites to study the uptake of water by atmospheric aerosols, and evaluate f(RH) globally (Burgos et al., 2019). Model outputs from 10 Earth System Models (CAM, CAM-ATRAS, CAM-Oslo, GEOS-Chem, GEOS-GOCART, MERRAero, TM5, OsloCTM3, IFS-AER, and ECMWF) were then evaluated against this in-situ dataset. Building on these results, we investigate f(RH) in the context of other aerosol optical and chemical properties, making use of the

same 10 Earth System Models (ESMs) and in-situ measurements as in Burgos et al. (2020) and Titos et al. (2021).

Given the difficulties of deploying and maintaining instrumentation for long-term, accurate and comprehensive f(RH) observations, it is desirable to find an observational proxy for f(RH). This observation-based proxy would also need to be reproduced in modelling space. Our aim here is to evaluate how ESMs currently represent the relationship between f(RH), scattering Ångström exponent (SAE), and single scattering albedo (SSA). This work helps to identify current challenges in modelling water-uptake by aerosols and their impact on aerosol optical properties within Earth system models.

We start by analyzing the behavior of SSA with RH, finding the expected increase with RH for all site types and models. Then, we analyze the three variables together (f(RH)-SSA-SAE relationship). Results show that hygroscopic particles tend to be bigger and scatter more than non-hygroscopic small particles, though variability within models is noticeable. This relationship can be further studied by relating SAE to model chemistry, by selecting those grid points dominated by a single chemical component (mass mixing ratios > 90%). Finally, we analyze model performance at three specific sites representing different aerosol types: Arctic, marine and rural. At these sites, the model data can be exactly temporally and spatially collocated with the observations, which should help to identify the models which exhibit better agreement with measurements and for which aerosol type.

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