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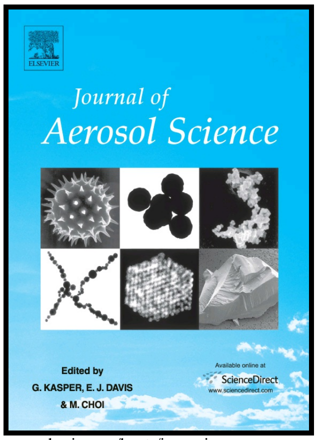

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Impact of aerosol microphysical properties on mass scattering cross sections

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Abstract

We assessed the sensitivity of simulated mass scattering cross sections (α_λ^{sca}) of three aerosol species to perturbed particle microphysical properties and derived constraints on these microphysical properties, suitable for the north-western Mediterranean basin, from a comparison between code calculations and observations. In detail, we calculated α_λ^{sca} of mineral dust, organic carbon and sulfate at three wavelengths in the visible range ($\lambda_1 = 0,450\mu m; \lambda_2 = 0,525\mu m; \lambda_3 = 0,635\mu m$) with a T-matrix optical code, considering ±20% perturbations on size distribution, refractive index and mass density (respect to reference values mainly taken from the OPAC database), and spheroids with two different axial ratios as shape perturbations (reference shape: sphere). Then, we compared the simulation results with a set of observed α_λ^{sca} of mineral dust, aged organics and ammonium sulfate sources, available at the same three wavelengths of the code calculations. These observations, provided by the Institute of Environmental Assessment and Water Research (IDAEA-CSIC), have been derived through Multilinear Regression (MLR) analysis from measurements of aerosol mass concentrations and optical properties, collected during a 4-year campaign at the Montseny regional background station (Spain) and representative of the north-western Mediterranean basin. We observed quite different impacts of the microphysical perturbations on α_λ^{sca} values and spectral dependence for different aerosol species, due mainly to the different size of the particles respect to the visible wavelengths. Moreover, by means of a compatibility test on best fit parameters, we constrained the mineral dust log-normal size distribution to a geometric radius and a standard deviation of $r_g = 3,583 \cdot 10^{-1}\mu m$ and $\sigma_g = 1,600$ respectively (effective radius: $r_{eff} = 6,221 \cdot 10^{-1}\mu m$), the organic carbon log-normal size distribution parameters to $r_g = 2,544 \cdot 10^{-2}\mu m$ and $\sigma_g = 1,760$ ($r_{eff} = 5,656 \cdot 10^{-2}\mu m$), the organic carbon real refractive index to $n_R = (1,576; 1,576; 1,576)$ at $(\lambda_1; \lambda_2; \lambda_3)$, the sulfate log-normal size distribution parameters to $r_g = 8,340 \cdot 10^{-2}\mu m$ and $\sigma_g = 1,624$ ($r_{eff} = 1,501 \cdot 10^{-1}\mu m$) and the sulfate real refractive index to $n_R = (1,547; 1,545; 1,543)$ at $(\lambda_1; \lambda_2; \lambda_3)$, in the north-western Mediterranean basin. Regarding the other perturbed microphysical properties, we found the reference prescriptions to be suitable for this geographical region, according to the same analysis procedure.

Keywords

1. Aerosol microphysical properties
2. Aerosol optical properties
3. Aerosol scattering spectral analysis
4. Aerosol source scattering observations
5. Constraints on particle microphysical properties

1. Introduction

Atmospheric aerosols can scatter and absorb electromagnetic radiation, causing a redistribution of the radiative energy in the atmosphere [Boucher et al., 2013]. Even if the model parameterization of this Aerosol-Radiation Interaction (ARI) have extremely improved over the last two decades [Myhre et al., 2013a], the ARI radiative forcing still contributes to dominate the uncertainty associated with the anthropogenic contribution to the climate change [Myhre et al., 2013b]. Also the role of the natural aerosols in affecting the Earth's radiative balance through ARI is poorly constrained [Rap et al., 2013]. The ARI parameterization mainly consists in the characterization of the aerosol optical properties. Yu et al. [2006] and Zhang et al. [2016] pointed out that large uncertainties in the estimates of the ARI radiative effects still exist and that they are mainly caused (among other factors) by errors in the estimation of the aerosol optical properties. The optical properties in turn depend, in addition to radiation wavelength and aerosol mass concentration, on the microphysical properties of the particles, such as size distribution, refractive index, mixing state, shape, hygroscopicity and mass density [Boucher et al., 2013; Hand and Malm, 2007]. The uncertainty affecting the optical properties, indeed, is caused above all by an incomplete knowledge concerning the microphysical properties of the particles [Yu et al., 2006]. Hence, different assumptions on the microphysical properties can affect the calculation of the optical properties and so the assessments of the ARI radiative effects. For this reason, we consider a study on the relationship between microphysical and optical properties a recommendable first step to better parameterize the ARI in the atmospheric models.

In this paper we present a numerical experiment carried out in

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