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Development the EarthCARE aerosol classification scheme

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The Earth Clouds, Aerosols and Radiation Explorer (EarthCARE) mission is a joint ESA/JAXA mission planned to be launched in 2018. The multi-sensor platform carries a cloud-profiling radar (CPR), a high-spectral-resolution cloud/aerosol lidar (ATLID), a cloud/aerosol multi-spectral imager (MSI), and a three-view broad-band radiometer (BBR). Three out of the four instruments (ATLID, MSI, and BBR) will be able to sense the global aerosol distribution and contribute to the overarching EarthCARE goals of sensor synergy and radiation closure with respect to aerosols. The high-spectral-resolution lidar ATLID obtains profiles of particle extinction and backscatter coefficients, lidar ratio, and linear depolarization ratio as well as the aerosol optical thickness (AOT) at 355 nm. MSI provides AOT at 670 nm (over land and ocean) and 865 nm (over ocean). Next to these primary observables the aerosol type is one of the required products to be derived from both lidar stand-alone and ATLID-MSI synergistic retrievals. ATLID measurements of the aerosol intensive properties (lidar ratio, depolarization ratio) and ATLID-MSI observations of the spectral AOT will provide the basic input for aerosol-type determination.

Aerosol typing is needed for the quantification of anthropogenic versus natural aerosol loadings of the atmosphere, the investigation of aerosol-cloud interaction, assimilation purposes, and the validation of atmospheric transport models which carry components like dust, sea salt, smoke and pollution. Furthermore, aerosol classification is a prerequisite for the estimation of direct aerosol radiative forcing and radiative closure studies. With an appropriate underlying microphysical particle description, the categorization of aerosol observations into predefined aerosol types allows us to infer information needed for the calculation of shortwave radiative effects, such as mean particle size, single-scattering albedo, and spectral conversion factors.

In order to ensure the consistency of EarthCARE retrievals, to support aerosol description in the EarthCARE simulator ECSIM, and to facilitate a uniform specification of broad-band aerosol optical properties, a hybrid end-to-end aerosol classification model (HETEAC) is developed which serves as a baseline for EarthCARE algorithm development and evaluation procedures. The model's theoretical description of aerosol microphysics (bi-modal size distribution, spectral refractive index, and particle shape distribution) is adjusted to experimental data of aerosol optical properties, i.e. lidar ratio, depolarization ratio, Ångström exponents (hybrid approach). The experimental basis is provided by ground-based observations with sophisticated multi-wavelength, polarization lidars applied in the European Aerosol Research Lidar Network (EARLINET) and in dedicated field campaigns in the Sahara (SAMUM-1), Cape Verde (SAMUM-2), Barbados (SALTRACE), Atlantic Ocean (Polarstern and Meteor cruises), and Amazonia. The model is designed such that it covers the entire loop from aerosol microphysics via aerosol classification to optical and radiative properties of the respective types and allows consistency checks of modeled and measured parameters (end-to-end approach). Optical modeling considers scattering properties of spherical and non-spherical particles. A suitable set of aerosol types is defined which includes dust, clean marine, clean continental, pollution, smoke, and stratospheric aerosol. Mixtures of these types are included as well. The definition is consistent with CALIPSO approaches and will thus enable the establishment of a long-term global four-dimensional aerosol dataset.