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A climatology of global aerosol mixtures to support Sentinel-5P and EarthCARE mission applications

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In support of atmospheric composition studies that are planned for Sentinel-5P and EarthCARE, we present a newly-derived global climatology of aerosol mixtures. Constraining aerosol type with satellite remote sensing continues to be a challenge and the global climatology presented here can help inform the choice of components and mixtures in aerosol retrieval algorithms used by instruments such as TROPOMI and ATLID and to test retrieval results. The global climatology was obtained via application of cluster analysis to seven years of 3-hourly, gridded 2.5 x 2 degree aerosol optical depth (AOD) data (for sulfate, biomass burning, mineral dust and marine aerosol) from the Goddard Chemistry Aerosol Radiation and Transport (GOCART) model, led to a spatial partition of the global aerosol distribution into ≈10 aerosol mixtures. Analysis of the percentage contribution of each of the four different aerosol types to mixtures then allowed development of a straightforward naming convention and taxonomy. In addition, assignment of primary colours to the constituent types enabled true colour-mixing and the generation of easy-to-interpret maps. To further help characterize the mixtures, aerosol robotic network (AERONET) Level 2.0 Version 2 inversion products were extracted from within the mean global multiyear and seasonal partition of each cluster. The AERONET data were used to estimate the values of key optical and microphysical parameters. In the context of the observational constraints and uncertainties associated with AERONET retrievals, bivariate analysis of different parameter pairs suggests that mixtures dominated by mineral dust and marine aerosol can be detected with reference to their single scattering albedo and Angstrom exponent at visible wavelengths in conjunction with their fine mode fraction and sphericity. Multivariate approaches at classification in the literature appear to be more ambiguous. The aerosol type climatology represents current knowledge that would be enhanced, possibly corrected, and refined by high temporal and spectral resolution, cloud-free observations produced by Sentinel-5P and EarthCARE instruments. The multiyear mean and seasonal gridded global partitions of AOD and compositional aerosol mixtures comprise a preliminary reference framework that can: i) enable tests of the effect on look-up table derived retrievals of initializing retrieval algorithms used by OMI/TROPOMI or CALIOP/ATLID with aerosol type mixtures, ii) help fine-tune aerosol type selection methods used in existing algorithms by referring to mean and seasonal optical and microphysical properties of aerosol mixtures, iii) allow comparison of retrieved aerosol types with those expected from the climatology and iv) contribute to the assessment of region and season-specific aerosol type assumptions.