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Sensitivity Study of Cross-Atlantic Dust Transport to Dust Emissions, Chemical Aging and Removal Processes and Comparison with Ground and Satellite Data

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Representing transatlantic dust transport is one of the challenges in climate modeling and of key importance, because of its large impact on the Earth's radiation budget. Desert dust, emitted from the Sahara, is regularly transported westwards across the Atlantic Ocean towards the Caribbean. The balance between emissions and removal processes, as well as the manifold chemical reactions control the impact of dust on the atmospheric composition and the interaction of dust with climate change. During transatlantic transport, dust undergoes chemical aging, which involves various heterogeneous reactions that strongly depend on the mineral composition of dust (alkalinity), the surface chemistry and the associated aerosol water uptake.

In this study, different parameters affecting the long-range dust transport are studied with the atmospheric chemistry-climate model EMAC. We consider chemical speciation of primary sea salt and dust particles and account for major cations (Na+, K+, Mg2+, Ca2) and anions (Cl-, SO42-, HSO4-), calculated online with meteorology, i.e. feeding back onto precipitation and changing surface wind speed and roughness. We resolve the chemical aging of primary particles through explicit neutralization reactions of the cations and anions with major oxidation products (H2SO4, HNO_3, HCl, NH3) from natural and anthropogenic air pollution sources, which can condense on the particles surface during long-range transport and undergo gas-liquid-solid aerosol partitioning, depending on the concentration level of emissions and the transport processes of the primary and secondary aerosols and their precursor gases. Comprehensive analysis of the different parameters affecting the long-range transport, which include the emission flux and particle size distributions, aging mechanism, convection scheme, wet and dry scavenging, show a strong dependence of the dust concentration and optical properties over the Caribbean mainly on the chemical aging of dust during long-range transport. The comparison of the EMAC results with ground-based observations (AERONET, CASTNET, EMEP), as well as various satellite data (MODIS, MISR and CALIPSO) shows that uncertainties associated with the calculation of the dust transport into the Caribbean reduces by considering the dust aging processes.