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Radiative Effect of Aeolian Dust as a Function of Particle Shape: Implications for Regional and Global Modeling

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Aeolian dust is the most dominant atmospheric aerosol by mass. It influences the weather and climate directly through absorbing and scattering the radiation and thereby it modifies the Earth's energy balance. The magnitude of these effects varies not only with the dust abundance in the atmosphere but also with its optical properties, which are in turn a function of particle size, composition and shape. For simplicity, dust particles are usually assumed to be spherical. But it is known that this assumption can lead to large errors in modeling and remote sensing applications.

This study investigates the impact of dust particle shape on its optical properties using the next-generation atmospheric modeling system ICON-ART (ICOsahedral Nonhydrostatic with Aerosols and Reactive Trace gases). We conduct two sets of numerical experiments by changing the optical shape of the particles: one assuming spherical particles and the other one assuming a physically more accurate mixture of 35 randomly oriented tri-axial ellipsoids. Wavelength-dependent refractive indices of dust are used to calculate the extinction coefficient, single scattering albedo, asymmetry parameter, and backscatter coefficient. These parameters are then implemented in ICON-ART to simulate various dust events over a period of 2 months on a global grid with 40 km horizontal resolution. Results show that the consideration of non-sphericity increases the dust AOD by 10-30%. Regarding the attenuated backscatter, the simulated profiles assuming nonsphericity differ by factors of 2-10 from the experiments assuming spherical dust.