Monitoring dust orientation

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Triboelectricity (Harper, 1967), also referred to as contact electrification, is a potential key player in the transport of desert dust and in its effect on climate, health and ecosystems. Depending on its strength, the total electric field within a dust cloud counteracts the gravitational settling of large particles and causes a preferential orientation of dust along the vertical direction (Ulanowski et al., 2007). The ERC Consolidator Grant «D-TECT» investigates these processes with the aim of assessing the impact of dust triboelectrification on climate.

Dust orientation due to triboelectric charging cannot be easily monitored with traditional remote sensing techniques, mainly due to the challenges in calculating the scattering properties of realistic-shaped large dust particles. The Scattering simulations of Oriented large Dust particles (SODust) project quantifies the scattering properties of large, irregularly-shaped desert dust particles, oriented due to triboelectrification processes within the dust cloud.

SODust project currently develops for the first time a scattering database for large oriented non-spherical dust particles, a task that requires considerable computer resources of the order of tens of millions of CPU core hours. These extensive resources can only be accommodated by HPC systems.

Within the ERC project we currently use the SODust scattering database for the design and construction of a novel polarization lidar that will measure the properties of the oriented dust particles in the atmosphere. The system is designed in collaboration with the industry (RAYMETRICS S.A.). Currently, the only signature of particle orientation comes from astronomical polarimetry measurements of dichroic extinction (Ulanowski et al., 2007), however these measurements provide only an indication of the alignment and refer to column-integrated values, not being capable for vertically-resolved retrievals. The novel polarization lidar will provide vertically-resolved measurements of dust orientation. The system design targets the off-diagonal elements of the backscattering matrix which are non-zero only when the particles are oriented (Geier and Arienti, 2014).

The scattering database for the oriented particles is of high importance for optimizing a wider range of applications including radiative transfer models and inversion algorithms. It will have a large impact that will be a paradigm shift for satellite remote sensing applications, especially if the orientation of the dust particles proves to be largely extended. SODust will unlock our ability for realistic simulations of the desert dust climatic impact. In front of today's challenges posed by climate change, SODust will be timely to provide answers regarding the impact of the natural component to our climate, on top of the anthropogenic forcing. The applications do not limit only on Earth's environment but are anticipated to open new horizons for atmospheric dust research on Mars, Moon and asteroids.

References

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