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Bridging Scales in Atmospheric Aerosol Modeling

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Atmospheric aerosols play a crucial role in Earth's energy balance by interacting with radiation and clouds, thereby influencing both weather and climate. Beyond their direct atmospheric effects, aerosols act as dynamic connectors across multiple Earth system components including the atmosphere, hydrosphere, cryosphere, and geosphere through processes such as emission, transport, deposition, chemical interactions, and radiative forcing. For instance, aerosol perturbations manifest differently at regional and global scales, affecting weather patterns and renewable energy generation in the short term while shaping the climate system over longer periods. Another example is the fertilization of oceans through the deposition of volcanic ash and other mineral dusts which stimulates marine ecosystems and biogeochemical cycles. Despite their importance, significant uncertainties in model predictions remain largely due to the complex and diverse properties of aerosol particles, particularly at micro-scales.

In this seminar, I address this challenge by integrating recent advancements in aerosol property and process understanding into the atmospheric modeling framework ICON-ART (ICOsahedral Nonhydrostatic model with Aerosols and Reactive Trace gases). This integration facilitates a comprehensive and consistent treatment of aerosol processes and interactions across scales. Leveraging natural experiments such as desert dust outbreaks and volcanic eruptions, I will discuss how precisely can we quantify the influence of different aerosol properties and processes on their evolution and impacts.