Aerosols in climate change - small particles with large effects

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Aerosols are small airborne particles that are surrounding us but are mostly invisible to our eyes. Multiple natural and anthropogenic emission sources lead to various chemical compositions of aerosols in the Earth's atmosphere. Influences of aerosols on radiative transfer and cloud microphysical processes are qualitatively understood, but the magnitudes of these effects are under debate with important implication for understanding past and future climate change. In this colloquium, I will give a glimpse on aerosol effects on climate, explain some reasons for uncertainties in our understanding of their effects on climate, and outline how we can make progress despite persistent model uncertainty.

Based on own research activities, I will share first results from our ocean expeditions in 2025 to measure aerosol and meteorological states over the tropical Atlantic, examples of kilometre-scale modelling for dust from the Sahara Desert, and first completed steps towards advancing forecast capabilities for dust outbreaks using machine learning methods and satellite images. We will also see model-to-model differences for anthropogenic aerosol effects from global climate model simulations, and recently accepted results obtained with the new German weather and climate model ICON-XPP paired with newly generated anthropogenic aerosol data for use in climate model simulations for the next climate change assessments. Looking ahead, I will present some of the plans for advancing the research field, e.g., through leading the new experiment protocol of the Aerosol and Chemistry Model Intercomparison Project, to which the most complex Earth system models currently available worldwide will contribute simulations.