

Bridging Scales in Cloud Microphysics from Observation to Simulation

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Abstract:

Cloud microphysics—the processes governing droplets, ice, and aerosols at microscopic scales—remains a leading source of uncertainty in weather and climate predictions. These processes shape cloud structure, precipitation, and radiative feedbacks, yet they are neither resolvable in large-scale models nor directly constrained by most observing systems. Bridging the scale gap between observations, microphysical processes, and predictive models is a central challenge in atmospheric science.

This talk presents a data-driven approach to integrating satellite observations, high-fidelity simulations, and subgrid-scale modeling to better constrain and represent cloud microphysics across scales. First, I will present recent work that applies machine learning to infer vertically resolved cloud properties from passive satellite observations, combining multi-modal data sources to reconstruct properties and structure that are not directly observed. This approach provides new observation-informed constraints across regimes and helps bridge the gap between sparse microphysical measurements and global passive observations. Next, I will introduce a complementary framework for learning reduced-order representations of cloud microphysics from high-fidelity particle-based simulations. This surrogate model discovers compact, physically-consistent, and performant representations of cloud droplet dynamics, enabling efficient and interpretable representations of warm cloud processes in weather and climate models. Together, these approaches illustrate a pathway for integrating observations and simulations within a unified data-driven framework. By linking space-based observation to vertically-resolved cloud properties and reduced-order parameterization to droplet-scale details, this work aims to improve the physical realism and predictive capability of atmosphere prediction systems.

Speaker biography:

Emily de Jong is a Lawrence Postdoctoral Fellow in the climate program at Lawrence Livermore National Lab. After receiving her B.S. in Chemical Engineering from Princeton University in 2019, Emily pursued her Ph.D. in Mechanical Engineering from Caltech as a Department of Energy Computational Sciences Fellow, contributing to the Climate

Modeling Alliance project. With a broad background in multiscale modeling, Emily specializes in developing computational techniques and data-driven approaches for cloud microphysics in the context of atmospheric simulations.