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Gaussian-process emulation for integrating data-driven aerosol-cloud physics from simulation, satellite, and ground-based data

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Data-driven quantification and parameterization of cloud physics in general, and of aerosol-cloud interactions in particular, rely on input data from observations or detailed simulations. These data sources have complementary limitations in terms of their spatial and temporal coverage and resolution; simulation data has the advantage of readily providing causality but cannot represent the full process complexity. In order to base data-driven approaches on comprehensive information, we therefore need ways to integrate different data sources.

We discuss how the classical statistical technique of Gaussian-process emulation can be combined with specifically initialized ensembles of detailed cloud simulations (large-eddy simulations, LES) to provide a framework for evaluating data-driven descriptions of cloud characteristics and processes across different data sources. We specifically illustrate this approach for integrating LES and satellite data of aerosol-cloud interactions in subtropical stratocumulus cloud decks. We furthermore explore the extension of our framework to ground-based observations of Arctic mixed-phase clouds.

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