Lothar-Collatz-Kolloquium für Angewandte Mathematik

Donnerstag, den 14. Januar 2021, um 17:15 Uhr, - ONLINE -

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Deep Emulators for Differentiation, Forecasting and Parametrization in Earth Science Simulators

Zusammenfassung/Abstract:

To understand and predict the behavior of large, complex and chaotic systems, Earth scientists construct sophisticated simulators from physical laws. These simulators generalize better to new scenarios, require fewer tunable parameters and are more interpretable than non-physical deep learning, but procedures for differentiation through the simulator are typically unavailable. These missing gradients limit the application of many important tools for forecasting, model tuning, sensitivity analysis or sub-grid-scale parametrization. We address this limitation by applying deep learning to simulation data, translating the simulator into a differentiable emulator to provide the missing gradients. Emulator training does not require analyzing simulator code or equations, so modified simulators do not require new gradient calculation routines. We demonstrate that emulator-derived gradients enable accurate optimization-based sensitivity analysis, 4D-Var data assimilation and closed-loop training of parametrizations without access to the simulator's source code or internal states. These results provide a basis for further combining the unique inductive biases of physical models with the power and flexibility of machine learning.

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