Combining Data Assimilation and Machine Learning to Estimate Parameters of a Convective-Scale Model

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Abstract

Parametrization of microphysics, as well as parametrization of processes in the surface and boundary layers, typically contain several tunable parameters that are only crudely known, leading to model errors in the representation of clouds in convection-permitting numerical weather prediction models. Traditionally, the numerical values of these model parameters are chosen by manual model tuning. More objectively, they can be estimated from observations by the augmented state approach during the data assimilation.

Alternatively, in this work, we look at the problem of parameter estimation through an AI lens by training two types of artificial neural networks to estimate several parameters of the one-dimensional modified shallow-water model as a function of the observations or analysis of the atmospheric state. We show that Bayesian neural networks and Bayesian approximations of point estimate neural networks are able to estimate model parameters and their relevant statistics. The estimation of parameters combined with data assimilation for the state decrease the initial state errors even when assimilating sparse and noisy observations. The sensitivity to the number of ensemble members, observation coverage, and neural network size is shown. Additionally, we use layer-wise relevance propagation to gain insight into how the neural networks are learning and discover that they naturally select only a few grid points that are subject to strong winds and rain to make their predictions.

Keywords: convective scale data assimilation, parameter estimation, Bayesian neural network, EnKF, layer wise relevance propagation

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