Using neural networks to predict atmospheric optical properties for radiative transfer computations

Menno A. Veerman, Wageningen University, Robert Pincus (University of Colorado), Chiel van Heerwaarden (Wageningen University)

The radiative transfer equations are well-known, but radiation parametrizations in atmospheric models are computationally expensive. A promising tool for accelerating parametrizations is the use of machine learning techniques. In this study, we develop a machine learning-based parametrization for the gaseous optical properties by training neural networks to emulate a modern radiation parameterization (RRTMGP).To minimize computational costs, we reduce the range of atmospheric conditions for which the neural networks are applicable and use machine-specific optimised BLAS functions to accelerate matrix computations. To generate training data, we use a set of randomly perturbed atmospheric profiles and calculate optical properties using RRTMGP. Predicted optical properties are highly accurate and the resulting radiative fluxes have average errors within 0.5 W m-2 compared to RRTMGP. Our neural network-based gas optics parametrization is up to 4 times faster than RRTMGP, depending on the size of the neural networks. We further test the trade-off between speed and accuracy by training neural networks for the narrow range of atmospheric conditions of a single large-eddy simulation, so smaller and therefore faster networks can achieve a desired accuracy. We conclude that our machine learning-based parametrization can speed-up radiative transfer computations whilst retaining high accuracy.