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Abstract:

Fully Connected Neural Networks (FCNNs) have had much recent success in science applications due to their ability to regress very nonlinear relationships in high-dimensional space. We have applied this technique to two problems: 1) The computational expense required for explicit radiative transfer calculations and 2) Detecting non-geophysical anomalies in passive microwave sensor observations. The first case presents a method for creating a general emulator that is able to estimate brightness temperatures (Tbs) at all frequencies from 1 to 300 GHz over ocean, sea ice, and land surfaces. This emulator was trained against an Eddington two-stream approximation radiative transfer code, using global ERA5 reanalysis fields and randomly assigned particle size distribution parameters for cloud water and ice, rain, and snow. It is able to simulate Tbs in a small fraction of the time required for the explicit calculations with a root mean squared error on the order of 0.05 K. The second case presents a method based on exploiting the well-known out-of-sample prediction failure of FCNNs for microwave radiometer quality control. In this scheme, a suite of FCNNs is trained to predict the nth channel from n-1 channels, and the prediction error compared to the true observation is assessed. When prediction performance is poor, non-geophysical anomalies can most often be found to be responsible. We find that this method is effective for identifying various types of observational problems and present case studies to this effect that demonstrate radio frequency interference, sensor electronic and physical anomalies, sun glint, and channel performance degradation. We also find that its sensitivity is ideal for quality control, even when the observational data has previously passed operational quality checks, and that this tool can be used to effectively prescreen problematic observations that may not be initially identifiable in the data application.