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Estimation of NO2 and SO2 concentration changes in Europe from meteorological data with Neural Network

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Chemical substances of anthropogenic and natural origin released into the atmosphere affect air quality and, as a consequence, the health of the population. As a result, there is a demand for reliable air quality simulations and future scenarios investigating the effects of emission reduction measures. Due to high computational costs, the prediction of concentrations of chemical substances with discretized atmospheric chemistry transport models (CTM) is still a great challenge. An alternative to the cumbersome numerical estimates is a computationally efficient neural network (NN). The design of the NN is much simpler than a CTM and allows approximating any bounded continuous function (i.e., concentration time series) with the desired accuracy. In particular, the NN trained on a set of CTM estimates can produce similar to CTM estimates up to the approximation error. We test the ability of a NN to produce CTM concentration estimates with the example of daily mean summer NO2 and SO2 concentrations. The measures of success in these tests are the difference in the consumption of computational resources and the difference between NN and CTM concentration estimates. Relying on the fact that after spin-up, CTM estimates are independent of the initial concentrations, we show that recurrent NN can also spin-up and predict atmospheric chemical state without having input concentration data. Moreover, we show that if the emission scenario does not change significantly from year to year, the NN can predict daily mean concentrations from meteorological data only.