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SHORT ABSTRACT

Abstract title: Enhancing air quality simulations with neural network-based resolution downscaling

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Abstract text *(maximum 350 words.)*

To support policymakers in the design of effective air quality plans, high-resolution air quality simulations are frequently used. Using a wide range of variables to predict the state of the atmosphere, they allow capturing the fine-scale structure of atmospheric composition and variability. However, their computational costs limit their use in air quality planning and often prevent the exploration of different emission reduction scenarios aiming to improve air quality levels. This motivates the use of alternative methods to establish relationships between various atmospheric parameters and surface concentrations of air pollutants. This study presents a neural network-based approach to spatially downscale coarse-resolution chemical transport model outputs, enabling finer-scale surface concentration estimates of fine particles (PM2.5) and nitrogen dioxide (NO2) in Europe. The model is trained on a set of 20 meteorological and chemical variables from paired high- and low-resolution simulations obtained with the chemistry-transport model EMEP at hourly temporal resolution and for different scenarios of emission reductions. Using various metrics (RMSE and MAE), the performance of the network is evaluated. The model effectively reconstructs high-resolution concentration fields from low-resolution inputs, with estimates comparable to the high-resolution simulations, and better than the low-resolution ones. While averages on time scales lower than the day reveal some performance degradation, daily and weekly-averaged evaluations show strong agreement with reference high-resolution outputs. This approach demonstrates potential for improving source apportionment tools, where fine spatial information is critical.