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The third phase of AQMEII: evaluation strategy and multi-model performance analysis

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AQMEII (Air Quality Model Evaluation International Initiative) is an extraordinary effort promoting policy-relevant research on regional air quality model evaluation across the European and North American atmospheric modelling communities, providing the ideal platform for advancing the evaluation of air quality models at the regional scale.

This study presents a comprehensive overview of the multi-model evaluation results achieved in the ongoing third phase of AQMEII. Sixteen regional-scale chemistry transport modelling systems have simulated the air quality for the year 2010 over the two continental areas of Europe and North America, providing pollutant concentration values at the surface as well as vertical profiles. The performance of the modelling systems have been evaluated against observational data for ozone, CO, NO_2, PM10, PM2.5, wind speed and temperature, offering a valuable opportunity to learn about the models' behaviour by performing model-to-model and model-to-measurement comparisons.

We make use of the error apportionment strategy, a novel approach to model evaluation developed within AQMEII that combines elements of operational and diagnostic evaluation. This method apportions the model error to its spectral components, thereby identifying the space/timescale at which it is most relevant and, when possible, to infer which process/es could have generated it. We investigate the deviation between modelled and observed time series of pollutants through a revised formulation for breaking down the mean square error into bias, variance, and the minimum achievable MSE (mMSE). Each of the error components is analysed independently and apportioned to specific processes based on the corresponding timescale (long scale, synoptic, diurnal, and intra-day). Compared to a conventional operational evaluation approach, the new method allows for a more precise identification of where each portion of the model error predominantly occurs. Information about the nature of the error and the class of process can significantly help modellers and developers to improve model performance.

The application of the error apportionment method to the AQMEII runs has generated a wealth of results and insights. In addition to reaffirming the strong impacts of model inputs (emissions and boundary conditions) and poor representation of the stable boundary layer on model bias, results also highlighted the high interdependencies among meteorological and chemical variables, as well as among their errors. This indicates that the evaluation of air quality model performance for individual pollutants needs to be supported by complementary analysis of meteorological fields and chemical precursors to provide results that are more insightful from a model development perspective.