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The impact of uncertainties in climate models on future air quality modelling

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Meteorology has a strong impact on air quality, therefore air quality is expected to change under future climate conditions. In particular ozone concentrations would increase due to rising temperatures. For particulate matter (PM), concentrations depend also strongly on wind and precipitation, which makes it more difficult to find clear trends. A common strategy to study these changes is to couple meteorology from a climate model to a chemistry transport model (CTM) and study concentration changes. However, all climate models have biases. To investigate the impact of these biases on ozone and PM concentrations, several simulations were performed with the KNMI regional climate model $RACMO_2$ coupled to the CTM LOTOS-EUROS. Meteorology was calculated by $RACMO_2$ using lateral and sea surface boundary conditions from ERA-Interim as a baseline, and from the global climate models ECHAM5/MPI-OM and MIROC3.2-hires forced with the A1B SRES emission scenario as climate simulations (1970-2060). Results for concentrations from LOTOS-EUROS and meteorological parameters from $RACMO_2$ were compared for the periods 1989-2009 and 2041-2060.

The simulations forced with ECHAM5 and MIROC boundary conditions showed considerable biases with respect to the ERA-Interim forced integration(1989-2009), resulting in differences up to 3 μg/m3 for annual average PM10 and up to 12 μg/m3 for summer average ozone maximum concentrations. These were related to biases in temperature, wind speed and precipitation. The $RACMO_2$-ECHAM5 simulation was too cold, wet and windy in summer whereas the $RACMO_2$-MIROC simulation gave too high temperatures for Northwestern Europe.

When comparing 2041-2060 to 1989-2009, modelled changes in concentration were smaller than the bias in the present-day climate for ECHAM5 boundary forcing and of the same order of magnitude for MIROC boundary forcing. The simulations did partly agree on the concentration changes for ozone and PM10. But on many locations the magnitude (ozone) or even the sign of the change (PM10) was different for the two simulations. The present approach thus illustrates the impact of uncertainties in the climate models on modeled air quality. A broad ensemble of climate and air quality models would be needed in order to come to more quantitative results.