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Modelling of air quality in a changing climate

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Changes in weather patterns associated to climate change may have significant impact on the transport of pollutants and the chemistry of the atmosphere and may thus affect air quality. To study this effect we have coupled the regional climate model RACMO to the chemistry transport model LOTOS-EUROS and performed simulations. As a complication, climate models and air quality models tend to have biases that need to be quantified before a future climate scenario can be interpreted. To this end two LOTOS-EUROS runs, one using RACMO with ERA-interim boundary conditions and one using RACMO with ECHAM5 boundary conditions, were compared to a LOTOS-EUROS run using ECMWF analysis meteorology.

The daily maximum temperature, daily rain and daily average wind speed and direction of the three meteorologies were compared to each other. This revealed that RACMO, when driven by ERA-interim boundary conditions, reproduces the ECMWF analysis meteorology quite well except for rain. For RACMO forced with ECHAM5, no direct correlation with ECMWF analysis meteorology can be expected. Instead, the frequency of occurrence of days with high temperatures, with low wind speed and with rain was investigated, since these parameters have an impact on air quality. For the period investigated (2003-2007) the results from RACMO with ECHAM5 boundary conditions showed considerable biases towards lower daily maximum temperatures, less days with low wind speed and more rain.

Modelled air quality was compared to observations and the relationship of temperature, rain, wind speed and direction with ozone and PM10 components was studied for the ECMWF analysis run and the RACMO-ERA-interim run. The general model performance is good and the observed relationships were reproduced, but the extremes are less well simulated. For ozone, the increase in concentration with temperature is reproduced in the model, but the highest observed concentrations are underestimated. Total PM10 is underestimated by the model since some species and sources are not included. For the secondary inorganic components, LOTOS-EUROS underestimated the values for low temperatures and overestimated the concentrations for the higher temperatures. For the run with RACMO-ECHAM5, the average daily ozone maxima and average PM10 concentrations were lower due to the lower daily maximum temperatures, higher wind speeds and more rain.

The present study indicates that the biases of the climate model and the air quality model can be significant. The comparison was too short for a good bias characterisation of RACMO-ECHAM5, but the period of analysis for bias characterization will be extended to 1989-2009. The combined effect of the biases in the climate model and LOTOS-EUROS on simulated air quality should be taken into account when analysing the results of LOTOS-EUROS coupled to RACMO-ECHAM5 for the period around 2050.