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Air pollution in the Benelux/Rhine-Ruhr area: Numerical simulations with a multi-scale regional chemistry-transport model

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The Rhine-Ruhr area is a strongly industrialized region with about 10 Million inhabitants. It is one of the regions in Europe, which has the characteristics of a megacity with respect to population density, traffic, industry and environmental issues. The main centre of European steel production and the biggest inland port of the world is located in Duisburg, one of the major cities in the Rhine-Ruhr area. Together with the nearby urban agglomerations in the Benelux area including Brussels, Amsterdam and in particular Rotterdam as one of the most important seaharbours of the world together with Singapore and Shanghai, it forms one of the regions in Europe heavily loaded with air pollutants as ozone, NO2 and particulate matter. Ammonia emissions outside the urban agglomerations but within the domain are also on a quite high level due to intense agricultural usage in Benelux, North-Rhine-Westphalia and lower Saxony. Therefore this area acts also as an important source region for gaseous precursors contributing to the formation of secondary particles in the atmosphere. The Benelux/Rhine-Ruhr area therefore has been selected within the framework of the recently established FP7 research project CityZen as one hot spot for detailed investigations of the past and current status of air pollution and its future development on different spatial and temporal scales. Some examples from numerical simulations with the regional multi-scale chemistry transport model EURAD for Central Europe and the Rhine-Ruhr area will be presented. The model calculates the transport, chemical transformations and deposition of trace constituents in the troposphere from the surface up to about 16 km using MM5 as meteorological driver, the RACM-MIM gas-phase chemistry and MADE-SORGAM for the treatment of particulate matter. Horizontal grid sizes are in the range of 100 km down to 1 km for heavily polluted urbanized areas within Benelux/Rhine-Ruhr. The planetary boundary layer is resolved by 15 layers below 3000 m, 8 layers cover the range from 3 km to 16 km. Emission projections have been used to calculate the future development of air pollution as well as the contribution of different sources to air pollution concentrations. The results are discussed with respect to different characteristic meteorological conditions which control the occurrence of air pollution episodes. Specific examples are heat waves as in summer 2003 leading to high values of photo-oxidants and episodes dominated by high pressure systems over Europe in fall and winter leading to high concentrations of particulate matter or NO2. Interannual variations due to changes of the meteorological conditions from year to year also will be discussed. It turned out that the impact of emission reduction on air pollution could be masked by the interannual variation of weather conditions which influence concentrations of air pollutants. Possible extensions and plans for the further development of the modelling system to include future changes of climate and consequently the coupling to the global scale are discussed with respect to CityZen.