**Online coupled meteorology-chemistry modelling: Current status and case studies**

R. Forkel 1, A. Baklanov 2,3, A. Balzarini 4, D. Brunner 5, M. Hirtl 6, L. Honzak 7, P. Jiménez-Guerrero 8, O. Jorba 9, J.L. Pérez 10, R. San José10, W. Schröder 11, J. Werhahn 1, R. Wolke 11, R. Žabkar 7

1 Institute for Meteorology and Climate Research IMK-IFU, Karlsruhe Institute of Technology KIT, Kreuzeckbahnstr. 19, 82467 Garmisch-Partenkirchen, renate.forkel@kit.edu

2 World Meteorological Organization, Geneva, Switzerland

2 Danish Meteorological Institute, Danmark

4 Ricerca sul Sistema Energetico RSE SpA, Milano, Italy

5 Laboratory for Air Pollution/Environmental Technology, Empa, Swiss Federal Laboratories for Materials Science and Technology, 8600 Dübendorf, Switzerland

6 Zentralanstalt für Meteorologie und Geodynamik,, ZAMG, Wien, Austria

7 University Ljubljana, SPACE-SI, Slovenia

8 University Murcia, MAR-UMU, Murcia, Spain

9 Earth Sciences Department, Barcelona Supercomputing Center, Barcelona, Spain

10 Technical University of Madrid, ESMG, Madrid, Spain

11 Leibniz-Institute for Tropospheric Research IFT, Leipzig, Germany

It is well accepted that weather strongly influences air quality and atmospheric transport of hazardous materials. It is also recognized that atmospheric composition can influence both weather and climate by directly changing the atmospheric radiation budget or indirectly affecting cloud formation. Until recently, however, because of the scientific complexities and lack of computational power, atmospheric chemistry and weather forecasting have developed as separate disciplines, leading to the development of separate modelling systems that are only loosely coupled.

The increase in computer power during the last decade allowed to couple online regional meteorological models with atmospheric chemical transport models with two-way interactions between different atmospheric processes including chemistry (both gases and aerosols), clouds, radiation, boundary layer, emissions, meteorology and climate. The relative importance of online integration and of the priorities, requirements and level of details necessary for representing different processes and feedbacks can vary stronly for (i) meteorological models and weather prediction, (ii) air quality forecasting and assessments, (iii) climate and earth system modelling.

The current status of European modelling practices towards online coupled modelling of meteorology and atmospheric chemistry including feedback mechanisms had been summarized within the COST Action ES1004 EuMetChem by Baklanov et al. 2014 (Atmos. Chem. Phys., 14, doi:10.5194/acp-14-317-2014, 2014). For example, numerical weather prediction might not depend on detailed chemical processes but considering the cloud and radiative effects of aerosols can be important for fog, visibility and precipitation forecasting. For climate modelling, feedbacks from greenhouse gases and aerosols become extremely important. For chemical weather and prediction of atmospheric composition in a changing climate, the online integration can improve air quality and chemical atmospheric composition projections.

Coupled chemistry and meteorology models may improve numerical weather prediction in particular under highly polluted conditions and may improve regional scale climate simulations in regions affected by high anthropogenic or natural aerosol loads. Such improvements have been demonstrated for single cases such as Saharan dust events but much more extensive evaluations are needed to clarify whether the models are adding sufficient benefit to be used widely for numerical weather prediction and regional climate modeling considering the large additional computational costs. Online coupled, fully integrated models are also expected to improve air quality simulations since atmospheric transport can be simulated more accurately and in a more consistent manner than in offline models. However, demonstrating these benefits through model evaluation is challenging since differences between simulated and observed air pollutant concentrations are often large and not only affected by the quality of transport but also by many other factors that makes it difficult to isolate one effect from the other. With the increasing number and diversity of this type of models, the question is also arising how different models respond to simulated feedback effects, which was also investigated in the COST Action ES1004 EuMetChem.