The MACC Reanalysis: An 8-year Data Set on Atmospheric Composition

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The Monitoring Atmospheric Composition and Climate (MACC) project is the current pre-operational atmospheric service of the European GMES (Global Monitoring for Environment and Security) programme funded by the European Union. MACC provides data records on atmospheric composition for recent years, data for monitoring present conditions, and forecasts of the distribution of key constituents for a few days ahead. MACC combines atmospheric modelling and observational data to provide information services covering European air quality, global atmospheric composition, climate, and UV and solar energy. MACC formally ended on 31 December 2011, but is being continued by the MACC-II project, which will run until July 2014.

The global model and data assimilation system that is being used in MACC was developed in the pre-cursor project GEMS (Global and regional Earth-system (Atmosphere) Monitoring using Satellite and in-situ data), and is based on ECMWF's Integrated Forecast System (IFS). In GEMS the IFS was extended to include aerosols, chemically reactive gases and greenhouse gases, so that ECMWF's 4D-Var data assimilation system could be used to assimilate satellite observations of atmospheric composition at a global scale. An aerosol model was implemented in the IFS and chemical transport models (CTMs) were coupled to the IFS using the OASIS-4 coupler to provide initial fields and chemical production and loss rates for the reactive gases.

An important part of MACC was the production of an eight-year long reanalysis of atmospheric composition. This reanalysis covers the period 2003-2010 and assimilates satellite data on atmospheric composition in addition to all the standard meteorological observations. The period 2003-2010 was chosen because significantly more satellite data on atmospheric composition are available from 2003 than before this period. The new IFS variables that could be constrained by satellite observations were ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), carbon dioxide (CO_2), methane (CH_4) and aerosol optical depth (AOD). Many other species that take part in the atmospheric chemical processes were not directly constrained by observations, but modelled through the coupled MOZART CTM. Emissions and natural sinks and sources at the surface form an important component of any atmospheric composition model. For most species these fluxes were prescribed using various flux data sets, such as MACCity for the chemical tracers, CASA natural biosphere fluxes for CO_2, GFED and GFAS fire emissions for all relevant species, and EDGAR for CH_4 and some of the aerosol species. Sources of sea-salt and desert-dust aerosol were directly modelled using other model variables, such as wind and soil moisture.

Various independent data sets have been used to validate the output from the reanalysis. This validation provided not only a quality check on the reanalysis fields, but also important insights into the effects of data usage, bias correction, and forecast error assumptions. A reanalysis results from a complicated interplay between many factors and validation is crucial to find the proper balance in the assumptions that have to be made.

This presentation will provide an overview of the MACC reanalysis, illustrated with examples showing the interannual variability of various species. We will also illustrate the impact of a changing observing system on the quality of the reanalysis output, which is important information for future satellite mission planning. We will conclude with some lessons learnt and an outlook on future reanalyses of atmospheric composition.

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