MACC D-G_RG_2.4: Updated stratospheric chemistry model

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Previous analyses in GEMS and MACC demonstrated a weakness of the IFS-MOZART model to accurately simulate the Antarctic ozone depletion. Several diagnostics and sensitivity runs were performed to diagnose the problem, but the results showed only marginal improvements until recently. This was particularly disturbing, because simulations done at NCAR yielded reasonable ozone loss rates.

On September 27, 2010 an updated MOZART3 version (MOZART3.5.02) was released by NCAR. This MOZART version supersedes MOZART3.1 (as described in Kinnison et al. 2007) which is currently employed in the MACC global chemistry simulations. MOZART3.5.02 shows several improvements over previous versions which enhance it's capability to adequately simulate Antarctic ozone depletion:

- Updates in the photolysis look-up-table approach
- Local conservation of inorganic chlorine and bromine has been added
- Update of chemical rate constants
- Photolysis extended to solar zenith angles up to 97 degrees
- New sulphate surface area density input files provided from the CCMVal-2 project
- New approach to derive NAT surface area density (variable radius)
- Increased particle numbers from NAT and ice PSCs

A first MOZART3.5 offline simulation for the year 2003 (resolution T63L60) has been performed at FZJ using the NCAR settings for chemistry and emissions but with initial tracer conditions from the MACC reanalysis and meteorological input files from ERA INTERIM. It could be shown from this run that MOZART3.5.02 driven by meteorology from recent IFS versions is able to simulate reasonable stratospheric tracer concentrations and is producing an ozone hole comparable to observations (Figure 1).

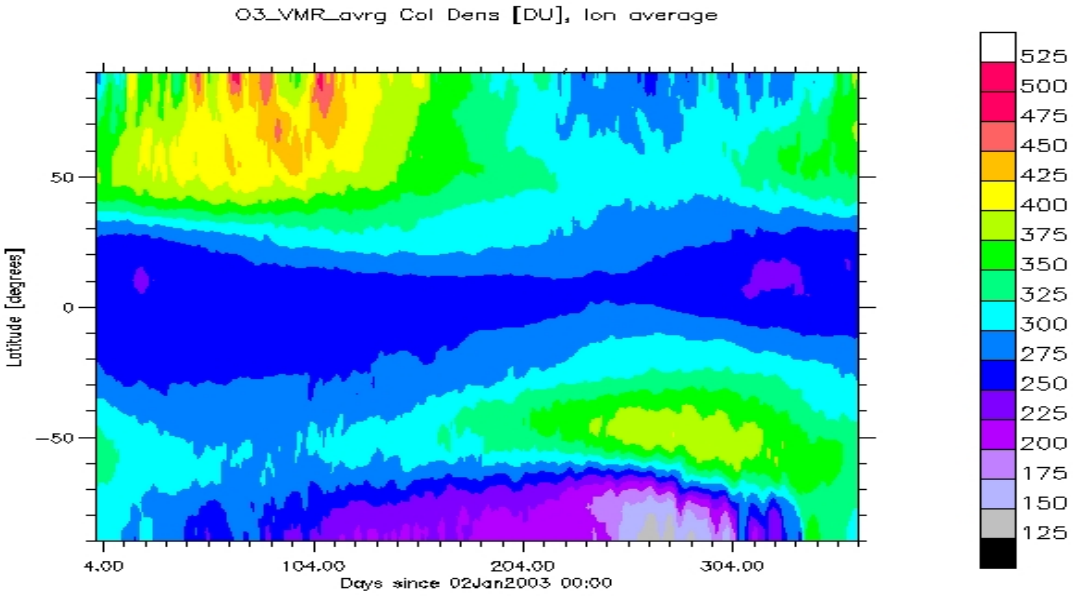

Figure 1: Timeseries of 2003 zonal mean Ozone total column density in Dobson Units as simulated by MOZART3.5.02 with meteorology from ERA-INTERIM and tracer initial conditions from the MACC reanalysis. Minimal total columns are ~136 DU. Note that previous simulations with MOZART 3.1 did not reach values below 200 DU.

After successful initial testing, the code modifications and extensions which had been developed in GEMS (Stein, 2009) and MACC were re-introduced into the MOZART3.5.02 code. This updated MACC MOZART offline model was delivered to ECMWF on October 06, 2010 and constitutes the essential part of this deliverable. Major code modifications include:

- Use of MACC fire emission inventory in daily resolution
- Use of MACC anthropogenic and natural emission inventories
- Integration of SOx and NH3 chemistry routines from MOZART4 (Emmons et al. 2010)

A first offline simulation with the complete MACC settings yields results that are fairly similar to the run with NCAR settings (Figures 2 and 3).

The new model serves as a basis for the integrated MACC chemistry model MOZART-IFS as well as for the C-IFS developments and it will be used for offline CTM comparisons. Work has started at ECMWF to re-introduce the technical modifications needed for the coupled setup in the quasi-operational MACC system. It is not expected that these modifications will lead to major changes in the MOZART stratospheric performance.

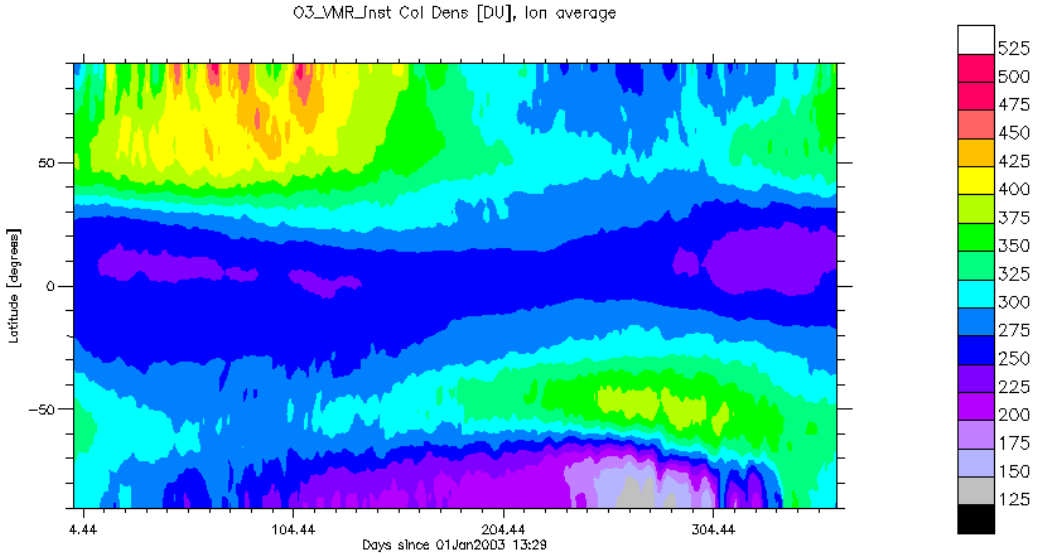

Figure 2: As Figure 1, but using MACC initial fields and boundary conditions

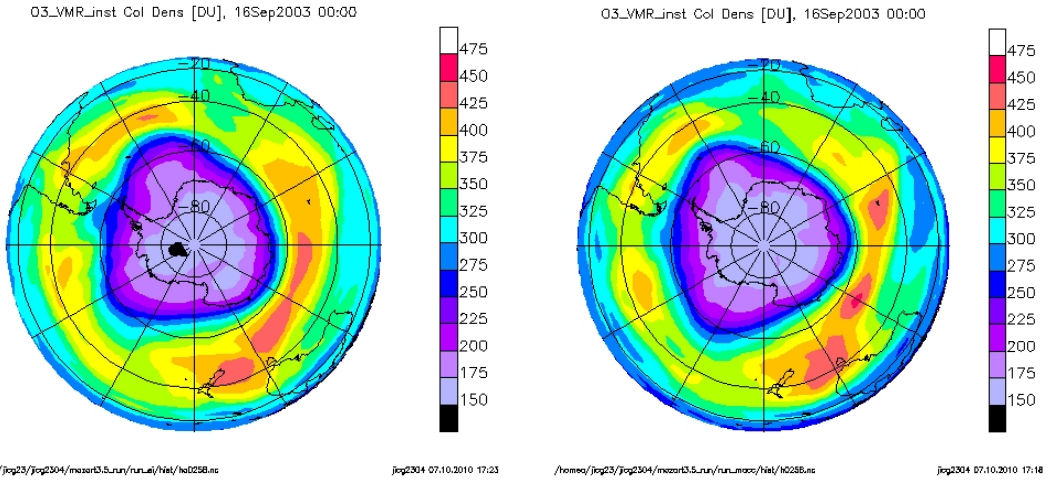

Figure 3: Comparison between a MOZART 3.5 simulation with NCAR settings (left) and MACC settings (right) for 16 September 2003. The small differences are most likely due to the different initial conditions used

References:

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