Evaluation of Atmospheric Chemistry in the Modelling system MECO(n)

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Abstract: We introduce the newly developed global and regional atmospheric chemistry model system ECHAM5/MESSy(→COSMO/MESSy)^n, shortly named MECO(n). The model system couples the regional model COSMO/MESSy to the global model ECHAM5/MESSy on-line using the global data as initial and boundary conditions for the nested regional model.
The system has been evaluated to work technically correct in the reproduction of dynamical development (Ch. Hofmann et al., 2012). Therefore MECO(n) is used in a first application to investigate the effect of model resolution on the representation of dynamics and exchange at the extratropical tropopause. Apart from the transport of chemical tracers, an evaluation of the full chemical system provided by the MECO(n) system is still pending. First evaluation steps indicate a good performance of the system.

Model description:

1. Basemodels
The MECO(n) (**M**ESSy-fied **EC**HAM and **CO**SMO models nested **n**-times) system combines:

• the global model ECHAM5/MESSy for Atmospheric Chemistry (EMAC) and
• the limited-area atmospheric chemistry and climate model COSMO/MESSy

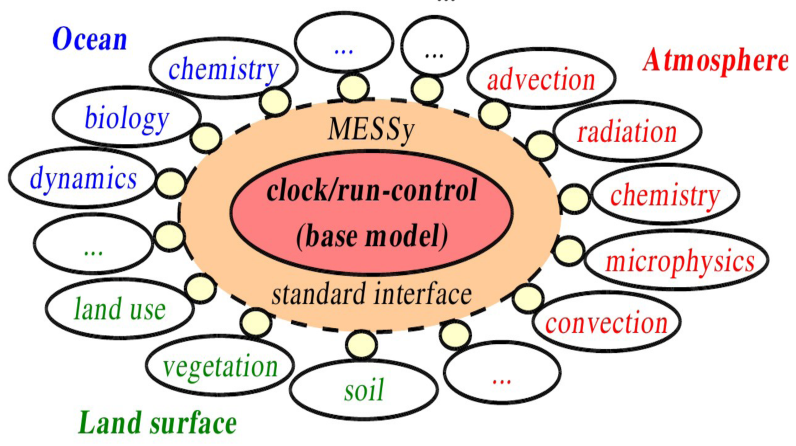

Figure 1: The idea behind MESSy: A modular interface structure couples several submodels to basemodels.

2. Submodels
The Modular Earth Submodel System (MESSy) (Fig. 1) provides:

• a modular interface structure to couple submodels (e.g., coded processes) to basemodels (e.g., ECHAM5, COSMO)
• an extendable set of submodels
• a coding standard

Therefore, the same process formulations are available for all basemodels, leading to the highest degree of achievable consistency.

3. Coupling
COSMO/MESSy has been developed to be driven on-line by the global model EMAC or a coarser COSMO/MESSy model. Therefore,
• no storage of boundary data is necessary
• simultaneous simulation in different regions and
• interlaced nests of one region with increasing resolution are possible.

First steps for the evaluation of the chemical system:

The global model ECHAM5/MESSy is an evaluated chemistry model. Thus a comparison of ECHAM5/MESSy and COSMO/MESSy results gives a first in sight into the performance of the regional chemistry model. The following study uses the model setup illustrated on the rigth of Fig. 3. The full ECHAM5/MESSy evaluation chemistry (Jöckel et al., 2006) is applied in COSMO/MESSy as well. Note: the import to the curvi-linear grid of COSMO/MESSy was not yet available for this test. Hence, the emissions fields are provided by the driving model, using the same way of on-line data transfer as used for the data required for the boundary data calculation.

Figures 5 and 6 show the developments of the O_3, NO_2 and HCHO mixing ratios in nmol/mol for the first 12 days in 2010 in the lowest model layer for six European cities. The black (red) line represent ECHAM5/MESSy (COSMO/MESSy) results, respectively. Most of the time, mixing ratios in COSMO/MESSy follow those of in EMAC.

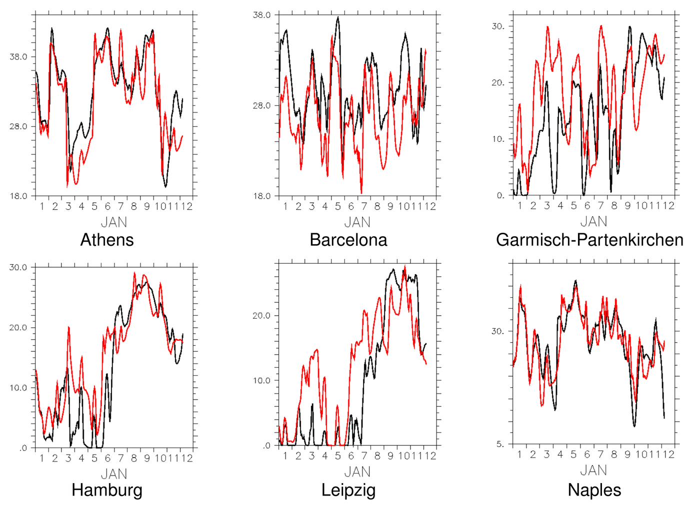

Figure 5: *Ozone mixing ratio [in nmol/mol] in the lowest model layer for the first few days of January 2010. The black line represents EMAC and the red line results of the smaller COSMO/MESSy instance.*

Due to the different resolutions, the dynamics and microphysics differ, which consequently leads to deviations in the tracer mixing ratios. The largest discrepancies occur for HCHO in Leipzig and Hamburg.

Model setup:

For the case studies presented at this poster, the EMAC model was used as global driving model in T106L31 resolution. EMAC provides boundary data at six minute intervals for a COSMO/MESSy instance with 0.36° (≈ 40 km) grid spacing. This intermediate instance operates as driving model for the second COSMO/MESSy instance with a finer grid distance of 0.125° (≈ 14 km, Fig. 3) or 0.0625° (≈ 7 km, Fig. 4) for the transport study and the chemical evaluation, respectively. The boundary data for the smaller COSMO/MESSy instance is provided every two minutes.

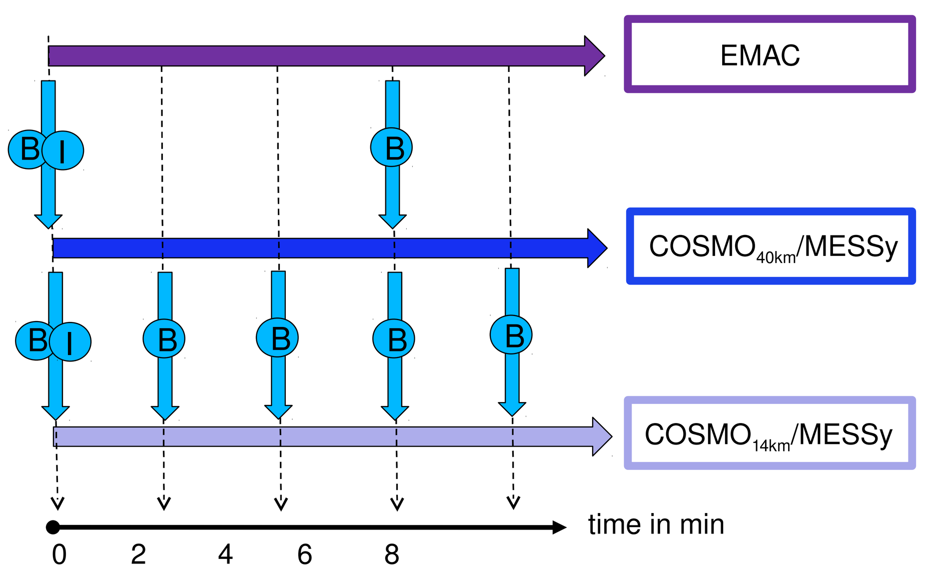

Figure 2: Schematic illustration of the scheduling of the MECO(2) system, used here. B and I represent boundary and initial data calculation, respectively.

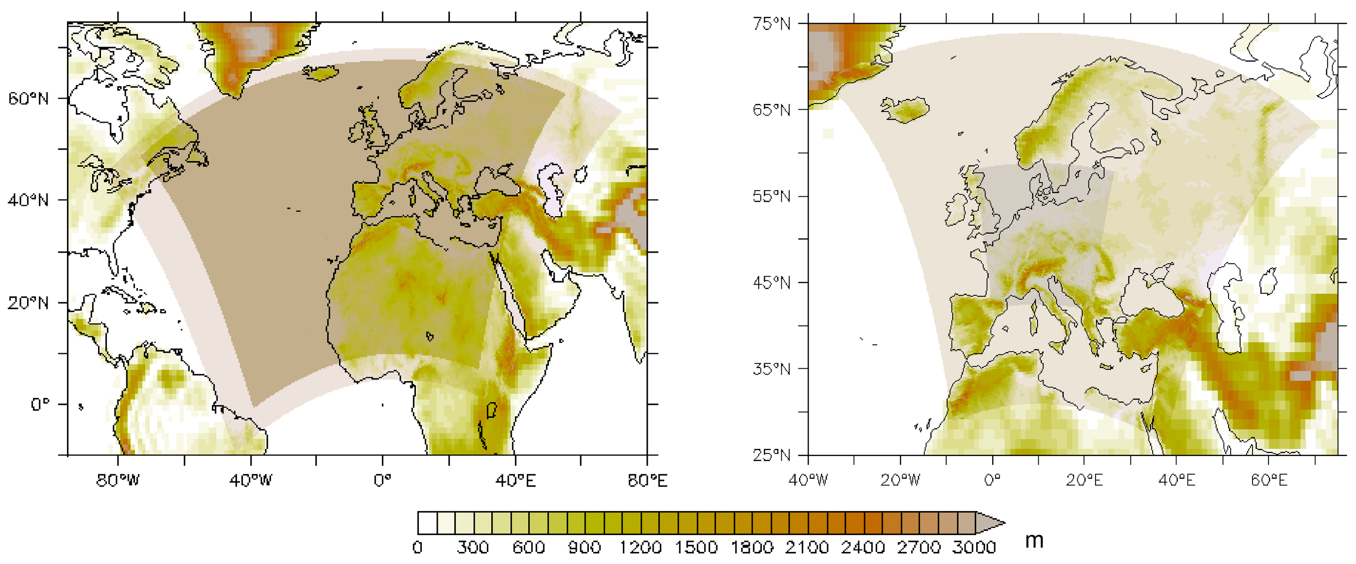

Figure 3: Height of the topography (in m a.s.l.), illustrating the model setup by showing smaller and larger COSMO instances nested into EMAC. Left, for the transport study and, right, for the first chemistry evaluation.

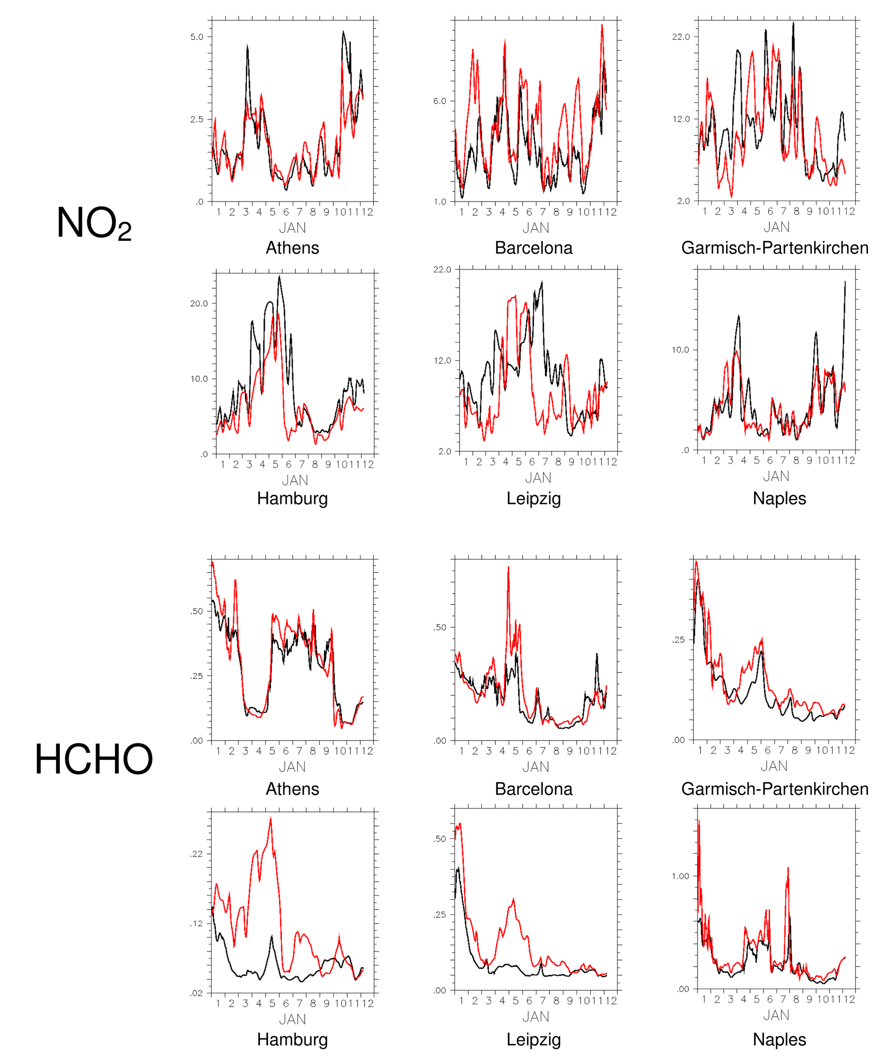

Figure 6: as Figure 5 for NO_2 and HCHO [in nmol/mol]

First application (transport study):

To investigate the effect of model resolution on the representation of dynamics and exchange at the extratropical tropopause, we initialise passive, artificial tracers under certain conditions:

Transport of airmasses with stratospheric origin:
Stratospheric tracers are initialised
• for PV > 2 pvu in the tropopause region
• only at the beginning of the simulation (t=00h)
Comparing the vertical cross sections in Figure 4 one finds that
• much more dilution in thin filaments can be observed for the global model
• the tracer is mixed deeper into the troposphere in the COSMO model
• thin PV-folds are not resolved in EMAC ⇨ less tracer transport into lower troposphere

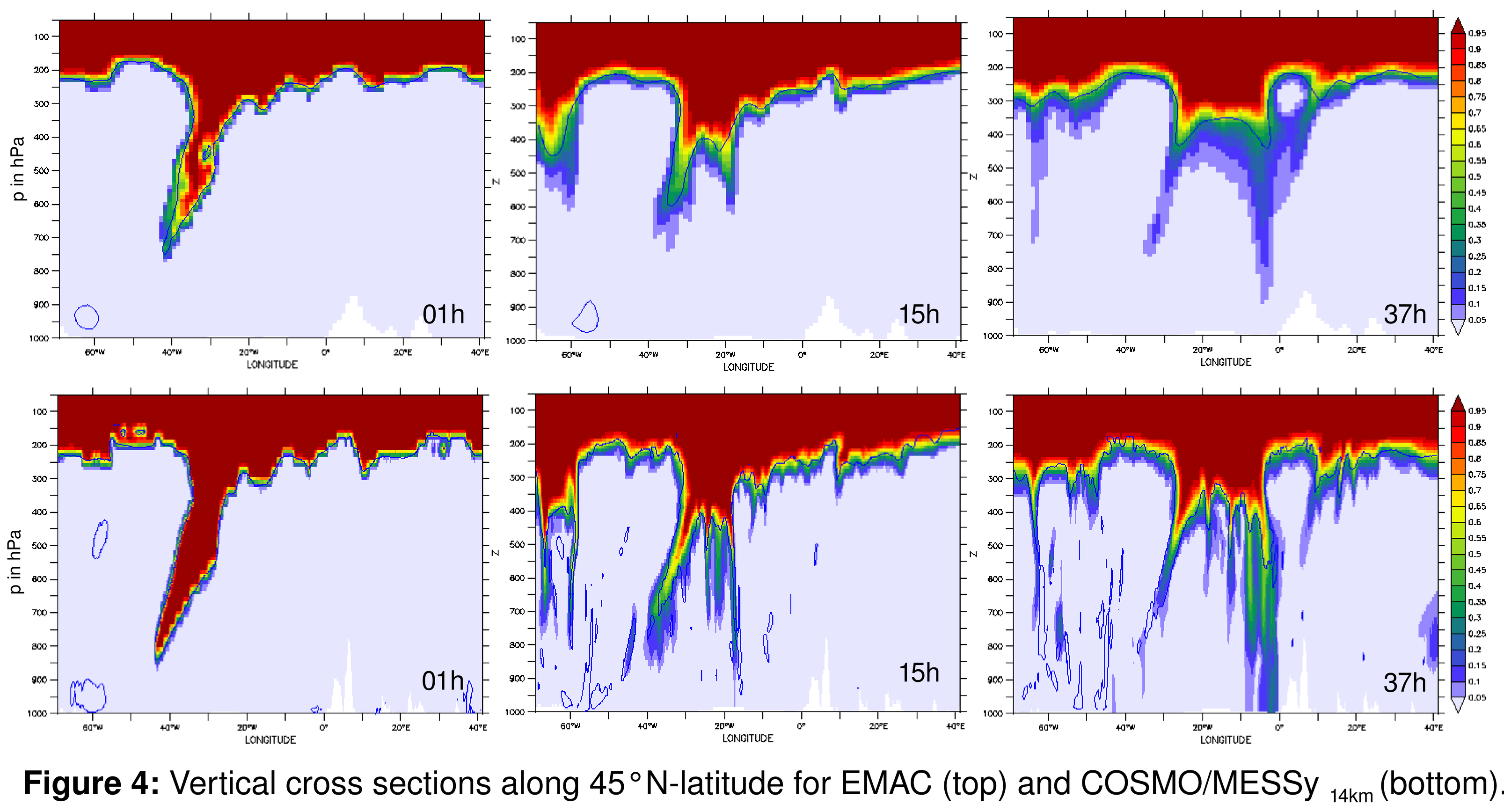

Figure 4: Vertical cross sections along 45°N-latitude for EMAC (top) and COSMO/MESSy $_{14km}$ (bottom). Contour for PV is overlayed (blue, 2pvu).

One of the largest challenges in the application of COSMO/MESSy potentially rotated rectangular grid of the regional model. For the EMAC grid, so far, NCREGRID (Jöckel, ACP, 2006) is used. But, NCREGRID can not be applied to non-geographical rectangular grids. Therefore, the SCRIP soft-ware[1] is being implemented into the MESSy submodel IMPORT dealing with the import of gridded data provided in netCDF format. Figure 7 illustrates this.

[1] http://climate.lanl.gov/Software/SCRIP

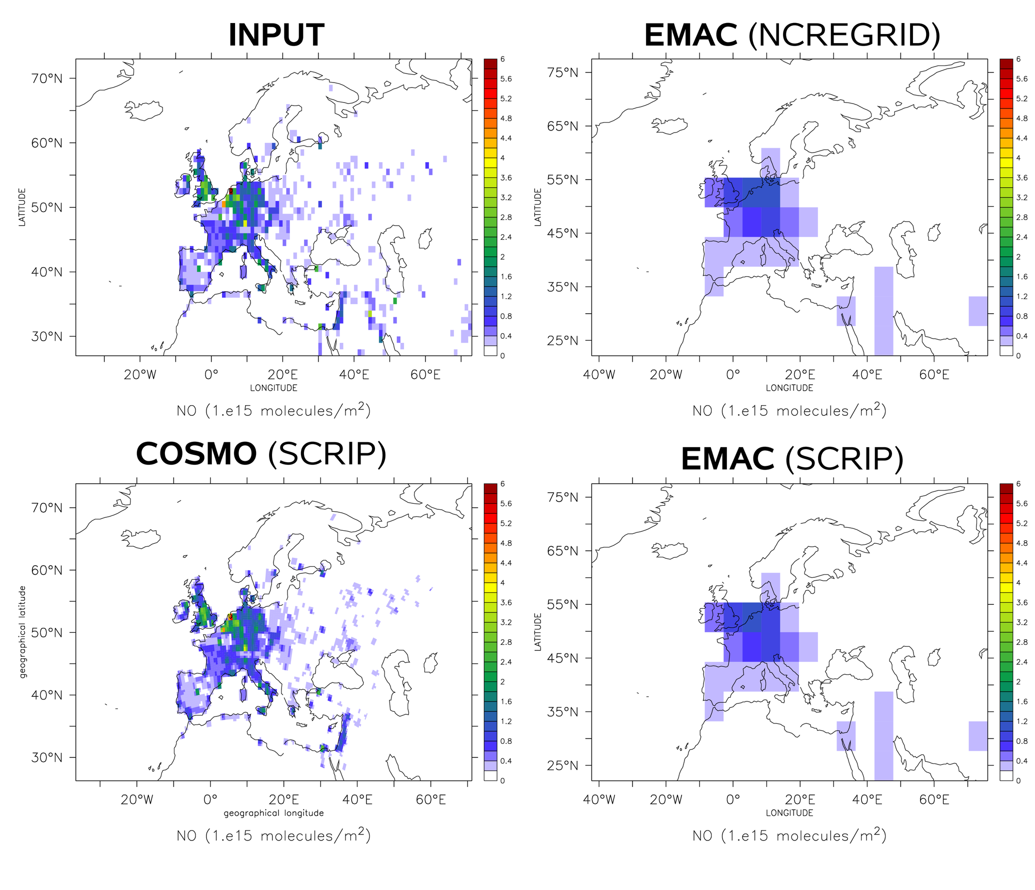

Figure 7: Example for an imported NO land emission field. Shown are this original field, the SCRIP-interpolated COSMO field and, ffor cmparison, the NCREGRID and the SCRIP interpolated EMAC fields.

Documentation of the MECO(n) system:

* COSMO/MESSy:
Kerkweg A. and P. Jöckel: The 1-way on-line coupled model system MECO(n): Part 1: COSMO/MESSy; Geosci. Model Dev., 5, 87-110, 2012
* On-line Coupling:
Kerkweg A. and P. Jöckel: The 1-way on-line coupled model system MECO(n): Part 2: On-line Coupling; Geosci. Model Dev., 5, 111-128, 2012
* Meteorological Evaluation:
Hofmann, Ch., A. Kerkweg, H. Wernli and P. Jöckel: The 1-way on-line coupled model system MECO(n): Part 3: Meteorological Evaluation Geosci. Model Dev., 5, 129-147, 2012