DKRZ – Project 617:

Global and regional atmospheric chemistry modelling

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I) Motivation

Ozone in the troposphere has negative effects on life, other than ozone in the stratosphere, where it absorbs harmful UV radiation. There are two important sources for tropospheric ozone: it can be transported downward from the stratosphere or photochemically produced by precursors within the troposphere. The most important precursors are nitrogen oxides (NOx), carbon monoxide (CO) and non-methane hydrocarbons (NMHCs). However, these precursors do not only have anthropogenic origins but also important natural sources.

Due to the non-linearity of the ozone chemistry it is not possible to directly link the amount of total emissions of precursors from a specific source to the amount of ozone produced by these precursors. Especially for policy related discussions on emission reductions, it is important to understand the contribution of the different emission sectors under present day conditions and changed emission scenarios. Therefore we are using a tagging technique, which is an accounting system following the relevant reaction pathways of emissions from the tagged source categories. Using the MECO(n) model system we investigate the contribution of natural and anthropogenic sources to ground-level ozone over Germany, Europe and the world in the period June – August 2008.

II) MECO(n) Model System

MECO(n) stands for **M**ESSy-fied **E**CHAM and **CO**SMO models nested **n**-times and combines

- the global atmospheric chemistry model EMAC and

- the regional scale climate and atmospheric chemistry model COSMO/MESSy.

MESSy (**M**odular **E**arth **S**ubmodel **Sy**stem) is an interface, which couples processes and diagnostics (as submodels) to different base models;

The same formulation of processes (i.e. submodels) running with different basemodels leads to a highly consistent model chain on different scales.

The coupling between EMAC and COSMO/MESSy is done on-line. Therefore the boundary data must not be stored on disk, but is exchanged directly on-line via the MMD (**M**ulti **M**odel **D**river)-library (Kerkweg & Jöckel, 2012).

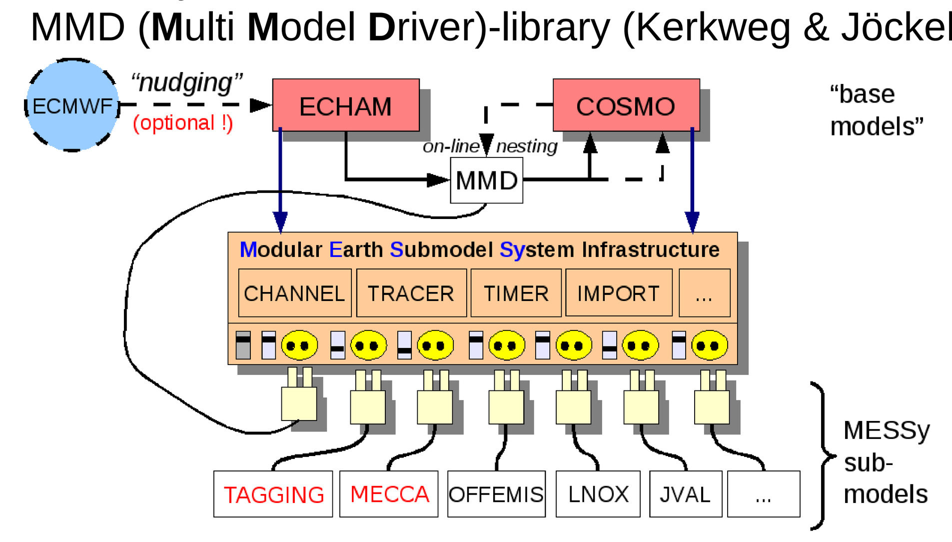

Fig.1: Blockchart of the MECO(n) model system. The individual submodels can be switched on/off in each instance.

III) Emissions

Anthropogenic emissions:

- MACCity (global dataset, 0.5°, Granier et al. 2011) used for "driving" EMAC instance and as COSMO reference run.

- VEU (regional, 0.0625°) for sensitivity studies in COSMO.

Natural emissions:

- on-line calculation of soil/biogenic NO_x and isoprene emission

-lightning NO_x emissions calculated in EMAC and transformed to COSMO

IV) numerical set-up

EMAC → T42L31ECMWF (up to 10 hPa) resolution with dt=720, relaxed towards ERA-Interim reanalysis data.

COSMO(50 km)/MESSy → 0.44° resolution, 40 model levels (up to 20 hPa), dt=240 s, boundary data provided every 720 s from EMAC.

COSMO(12 km)/MESSy → 0.1° resolution, 40 model levels (up to 20 hPa), dt=120 s, boundary data provided every 240 s from COSMO(50 km)/MESSy.

All instances using the same TAGGING submodel with an algorithm described in Grewe 2013.

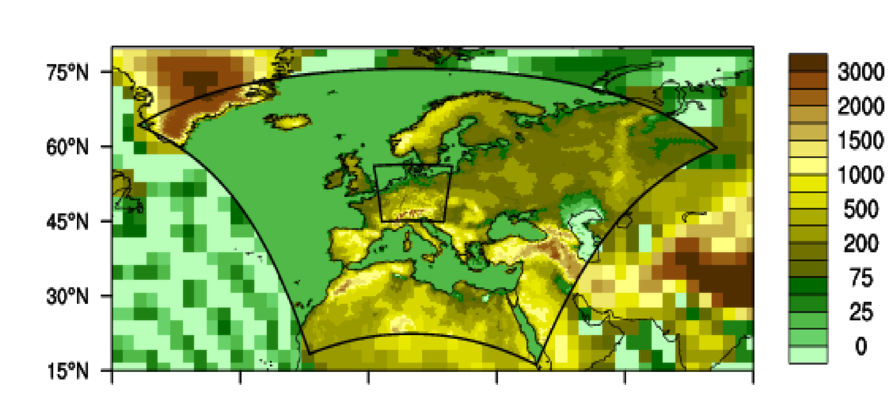

Fig.2: Topography (in m) of the three model instances

VI) Anthropogenic categories

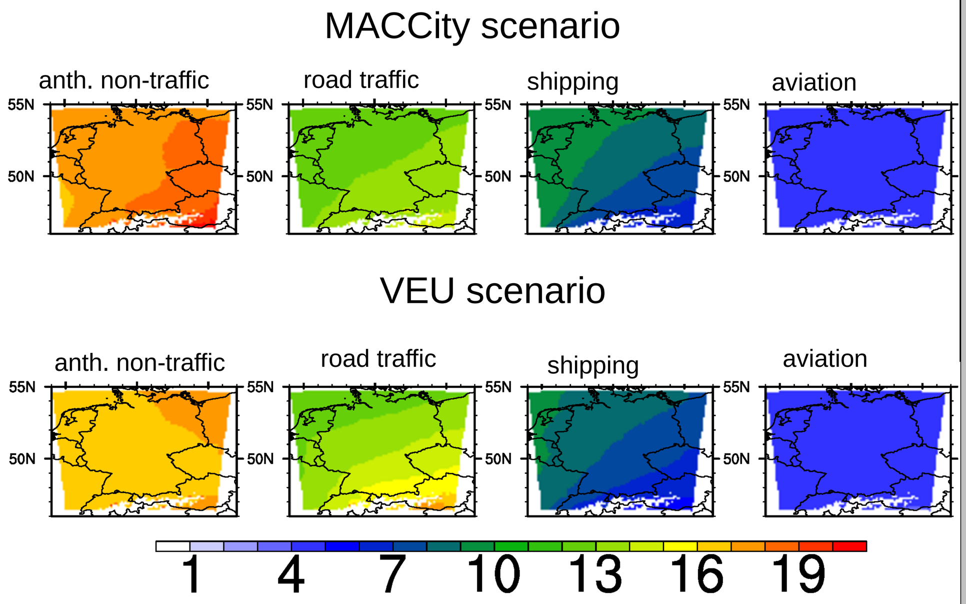

Fig. 5: Contribution (in percent) of different categories to the ozone column up to 850 hPa. Top row MACCity scenario, bottom row VEU scenario.

- Over Germany the VEU scenario features a lower contribution of the anthropogenic non- traffic category.

- The road traffic contribution in Germany is 12.8% for MACCIty and 13.5% for VEU scenario. This is slightly more then for whole Europe (12.7% / 13.2%).

- Compared to global 30°N:70°N average Germany/Europe shows less contribution from anthropogenic non-traffic and shipping categories.

- Contribution from road traffic in Europe/ Germany is higher then for the global 30°N:70°N average.

V) Contribution of different categories to near surface ozone over Germany

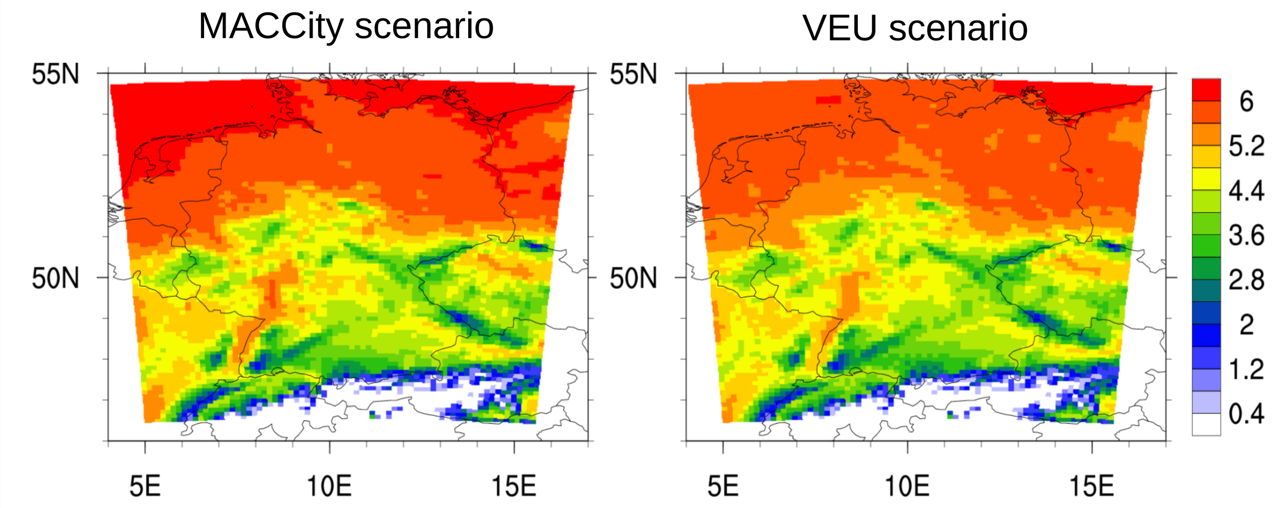

Fig 2: Average ozone column (in DU) from ground up to 850 hPa (850 hPa ozone column) over Germany for June – August 2008.

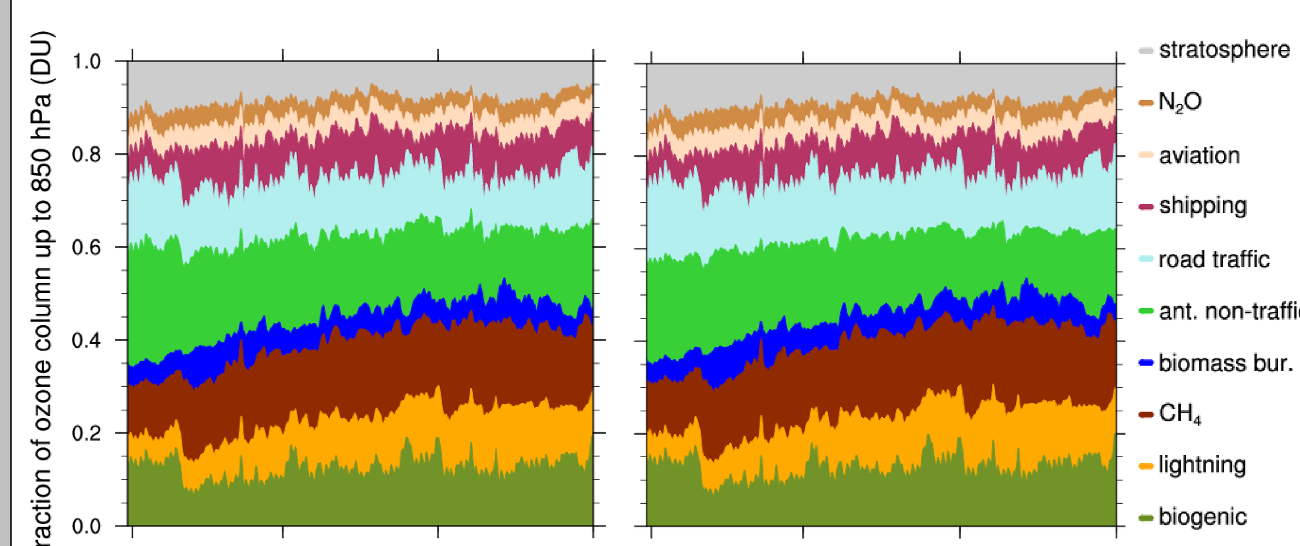

Fig 3: Contribution of tagged categories to the area averaged 850 hPa ozone column over Germany for June - August 2008.

- With the VEU scenario a slightly lower ozone column is simulated (4.81 DU for MACCity, 4.70 DU for VEU).

- Difference is due to anthropogenic categories (2.10 DU MACCity, 2.01 DU VEU). The contribution of natural categories (2.71 DU MACCity, 2.69 DU VEU) is similar as sources are identical.

- In general the ozone column decreases from June – August with strongly decreasing contributions from the stratosphere and the anthropogenic non-traffic categories.

VII) Natural categories

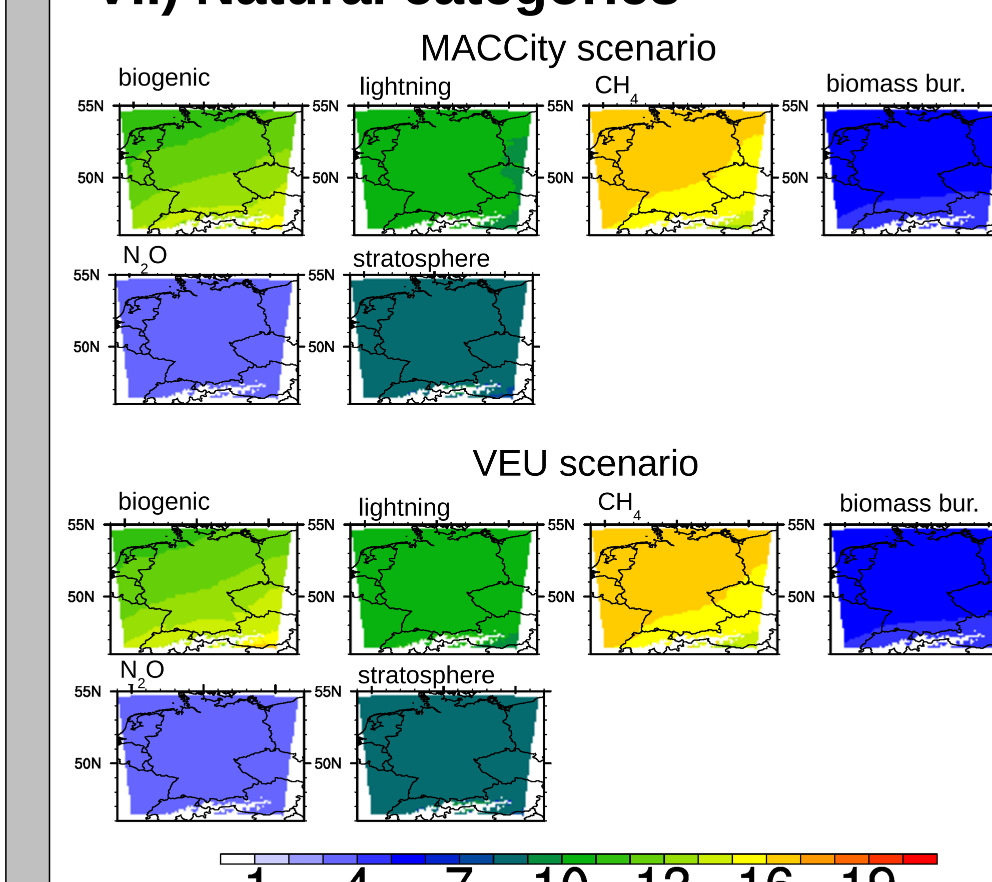

Fig. 6: Contribution (in percent) of different categories to the ozone column up to 850 hPa. Top row MACCity Scenario, bottom row VEU scenario.

- Global 30°N:70°N average shows lower biogenic contribution → smaller on-line source → uncertainties due to parametrisation.
- Compared to global average lower contribution of biomass burning category over Europe as biggest sources not located in Europe.

VIII) First conclusions

In the summer 2008 anthropogenic categories had a contribution of ~ 43.0 % to the ground level ozone over Germany. This is slightly higher as for whole Europe (42.3 %), which is due to a higher contribution of traffic sectors (road traffic and shipping).

IX) References

Granier, C. et a.l, Evolution of anthropogenic and biomass burning emissions of air pollutants at global and regional scales during the 1980-2010 period, Climatic Change 109, 1-2, 2011

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Kerkweg, A. and Jöckel, P.: The 1-way on-line coupled atmospheric chemistry model system MECO(n) – Part 1: Description of the limited-area atmospheric chemistry model COSMO/MESSy, Geosci. Model Dev., 5, 87-110, 2012.

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