DKRZ – project 853
Earth System Chemistry Integrated Modelling (ESCIMo)
Initiative of the "MESSy Consortium"

Within the

"Earth System Chemistry Integrated Modelling (ESCIMo)"

initiative chemistry-climate-simulations are planned by the "MESSy Consortium" with the ECHAM/MESSy Atmospheric Chemistry (EMAC) model for special topics related to the national project of the DFG-Forschergruppe SHARP (Stratospheric Change and its Role for Climate Prediction) and the international IGAC/SPARC Chemistry-Climate Modelling Initiative (CCMI, see http://www.pa.op.dlr.de/CCMI/).

These simulations will be carried out in support of upcoming WMO/UNEP ozone and IPCC climate assessments and will help to answer emerging science questions as well as to improve process understanding.

To meet these scientific needs, the CCMI community with active support from SHARP scientists jointly defined new reference and sensitivity simulations.

The MESSy Consortium:

Deutsches Zentrum für Luft- und Raumfahrt **(DLR),** Institut für Physik der Atmosphäre

The Max Planck Institute for Chemistry **(MPIC)**

Institute of Meteorology of the Freie Universität Berlin **(FUB),** research group "Physics of the Middle Atmosphere"

Institute for Meteorology and Climate Research **(IMK)** of KIT

Institute for Energy and Climate Research of the Forschungszentrum Jülich GmbH **(FJZ)**

Institute for physics of the atmosphere (IPA) at the Johannes Gutenberg – University Mainz **(UMZ-IPA)**

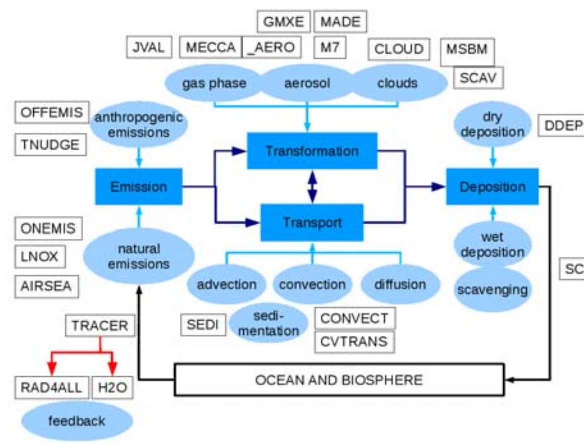
Planned chemistry – climate simulations:

➢ **REF-C1** is a hindcast simulation and covers the time period from 1960 to 2010 to examine the model internal variability and to replicate as closely as possible the atmospheric state in this period for which ozone and other atmospheric constituents have been measured. The primary focus of the proposed hindcast simulation is the evolution and variability of tropospheric and stratospheric ozone over the last 40-50 years. The proposed hindcast will include a number of new aspects not previously examined in multi-model chemical simulations, including detailed evaluations of tropospheric oxidants and chemistry in addition to stratospheric chemistry, interactions between stratospheric and tropospheric chemistry, chemistry-aerosol interactions, and the inclusion of very short-lived species (VSLS).

➢ **REF-C2** is an internally consistent simulation from the past into the future, i.e., spanning the period 1960 to 2100 and thus contains a future projection. The objective of REF-C2 is to produce best estimates of the future ozone-climate change up to 2100 under specific assumptions about the temporal evolution of greenhouse gas (GHG) concentrations as well as tropospheric ozone and aerosol precursors that follow the IPCC scenario RCP 6.0 and a specified scenario of the development of ozone depleting substances (ODSs) following the halogen scenario A1 (WMO, 2007). REF-C2 also considers solar variability in the past and future.

➢ **REF-C1SD** is a another hindcast simulation covering the time period from 1980 to 2012, in which the model dynamics (temperature, vorticity, divergence and (logarithm of) surface pressure) are, however, "nudged" by Newtonian relaxation towards analysed or re-analysed meteorology. The forcings are similar to those of REF-C1. Compared to REF-C1, this simulation can be more directly compared to observations. In "free-running" (in contrast to "nudged") mode CCMs simulate a statistical relationship to the real atmosphere, thus a comparison of model results with measurements must be performed in a statistical manner. To allow a more direct comparison of the model output with observations in CCMs, REF-C1SD complements REF-C1.

The ECHAM/MESSy Atmospheric Chemistry Model (EMAC)



Chemistry – Climate Simulations (general aspects)

The study of *chemistry-climate interactions* represents an important and, at the same time, difficult task of global change research.

The emerging issues of

- climate change,
- ozone depletion,
- and air quality,

which are challenging from both scientific and policy perspectives are represented in Chemistry-Climate Models (CCMs). Understanding how

- the chemistry and composition of the atmosphere may change over the 21st century

is essential in preparing adaptive responses or establishing mitigation strategies. The distribution and development of aerosols and reactive greenhouse gases is controlled by atmospheric chemistry and physics including transport of air masses integrated over global scales.

- Projections of future climate change are coupled with changes in atmospheric composition whose impacts extend from air quality to stratospheric ozone.
- Chemically active species in the troposphere are more amenable to short-term manipulations by changes in emissions and are therefore of major policy relevance to both air quality and climate.
- Provision of high-quality, policy-relevant information on the current state of climate and its possible future states, as well as options for adaptation are strongly dependent on the progress in this area.

Increasingly, the chemistry and dynamics of the middle atmosphere and troposphere are being studied and modeled as a single entity in global models, and EMAC was one of the first community models with this capability.
For the first time, some of the Earth system models (ESMs) with interactive oceans that participated in the fifth round of the Coupled Model Intercomparison Project Phase 5 (CMIP5) had interactive chemistry.
The WMO/UNEP "Scientific Assessment of Ozone Depletion: 2010" (WMO, 2010) also featured several stratospheric models that included tropospheric chemistry, and one model with a coupled ocean.

It was also a main recommendation of the SPARC CCMVal (2010) report, that middle atmosphere - resolving CCMs should continue to evolve towards more comprehensive, self-consistent middle atmosphere - troposphere CCMs.
These developments provide a pathway for including better representation of middle atmosphere - troposphere, chemistry-climate and atmosphere-ocean coupling in CCMs and ESMs used for more robust predictions of future ozone layer and climate changes and mutual influences.
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