ECHAM-HAMMOZ echam6.0.1-ham2.1-moz0.8: Description and reference publications

General overview of the model

- The ECHAM-HAMMOZ model version *echam6.1.0-ham2.1-moz0.8* is based on the ECHAM6 global climate model (Stevens et al., submitted) and the sub-model for tropospheric aerosols HAM (Stier et al., 2005; Zhang et al., 2012) and the sub-model for trace gas chemistry MOZ (Kinnison et al., 2007).
- The HAM sub-model predicts the evolution of sulfate (SU), black carbon (BC), particulate organic matter (POM), sea salt (SS), and mineral dust (DU) with the size distribution of this aerosol population being described by seven log-normal modes with prescribed variance as in the M7 aerosol module (Vignati et al., 2004; Stier at al., 2005; Zhang et al., 2012). The prognostic variables are the particle number concentration of each mode, as well as the mass concentration of each compound present in that mode.
- The MOZ sub-model describes the trace-gas chemistry for the middle atmosphere (including troposphere through the lower thermosphere). The species included within the chemical mechanism are contained within the OX, NOX, HOX, ClOX, and BrOX chemical families, along with CH4 and its degradation products. Several primary non-methane hydrocarbons (NMHCs) and related oxygenated organic compounds are also included. This mechanism contains 108 species, 218 gas-phase reactions, 71 photolytic processes, and 18 heterogeneous reactions on aerosol (Kinnison et al., 2007). Note that the MOZ sub-model as provided in this release is not fit for scientific use yet. Further detailed for the sub-model will be provided in up-coming releases.

Emissions

- Anthropogenic and biomass burning emissions of SO2, BC, and OC follow the latest recommendations of AEROCOM_II ACCMIP ((http://aerocom.met.no/emissions.html) are available from 1980-2010 and 1850 (Pre-industrial)
  - anthropogenic emissions are based on Lamarque et al., (2010)
  - biomass burning emissions are based on:
    - GICC inventory over the period 1850-1950 (Mieville et al., 2010)
    - RETRO inventory over the period 1960-1990 (Schultz et al., 2008)
    - GFED v2 for the end of the period (1997-2008) (van der Werf et al., 2006 and http://www.falw.vu/~gwerf/GFED/GFED2/) followed by time interpolation for 2009-2010.
    - Vertical profile, see Annex 1
- SOA emissions are prescribed according to AEROCOM as described in Dentener et al. (2006) (http://themasites.pbl.nl/en/themasites/edgar/index.html)
- Emissions of sea salt are computed interactively following Guelle et al. (2001) and Stier et al. (2005)
- Dust emissions are computed interactivity following Stier et al. (2004) based on Tegen et al. 2002) with updated Asian soil properties as described in Cheng et al. (2008).
- Natural emissions of dimethyl sulfide (DMS) from the marine biosphere are calculated online following Kloster et al. (2006).

- Terrestial DMS emissions are prescribed according to Pham et al. (1995).
- Aerosol emission size ranges (see annex 2)

Oxidant fields

- Oxidant fields (OH, O_3, NO_3, NO_2, H_2O_2) are a multi-year average taken from the MACC system (Flemming et al., 2009) as described in Inness et al. (in preparation).

Aerosol- and cloud-related schemes

- The sulfur chemistry module is based on sulfur cycle model described in Feichter et al. (1996).
- Below-cloud scavenging by rain and snow follows Croft et al. (2009).
- In-cloud scavenging follows Stier et al. (2005).
- Aerosol water uptake scheme follows the Kappa-Koehler theory based approach following Petters and Kreidenweis (2007) as described in Zhang et al. (2012).
- The nucleation scheme follows Kazil and Lovejoy (2007) as described in Kazil et al. (2010)
- Organic nucleation scheme based on Kulmala et al. (2006) is included.
- Cloud microphysics are described with a 2-moment scheme described in Lohmann et al., (2007) and Lohmann and Hoose (2009).
- The stratiform cloud scheme consists of prognostic equations for the water phases (vapor, liquid, solid), bulk cloud microphysics (Lohmann and Roeckner, 1996), and an empirical cloud cover scheme (Sundqvist et al., 1989).
- Aerosol activation in warm clouds follows Lin and Leaitch (1997).
- Ice crystal cirrus scheme is described in Lohmann et al. (2008).
- Autoconversion of cloud droplets to rain follows Khairoutdinov and Kogan (2000).
- Immersion and contact freezing follows Lohmann and Diehl (2006).

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Annex 1: Biomass burning vertical resolution

2D fire emissions are injected both within and above the PBL with the following percentages:

- 75 % within the PBL (equally distributed in all levels within the PBL)
- 17 % in the first level above the PBL
- 8 % in the second level above the PBL

In case the PBL depth is higher than 4km, then the 2D fire emissions are only injected within the PBL (equally distributed in all levels within the PBL).

The reference paper for this parameterization is the following:

Title: Smoke injection heights from fires in North America: analysis of 5 years of satellite observations
Author(s): Martin M. Val; Logan J. A.; Kahn R. A.; et al.
Source: ATMOSPHERIC CHEMISTRY AND PHYSICS Volume: 10 Issue: 4 Pages: 1491-1510 Published: 2010

Annex 2: Aerosol emission size ranges

Modes:
Nucleation Mode ($r < 0.005$ µm), soluble (NS)
Aitken Mode (0.005 µm $< r < 0.05$ µm), soluble (KS) and insoluble (KI)
Accumulation Mode (0.05 µm $< r < 0.5$ µm), soluble (AS) and insoluble (AI)
Coarse Mode ($r > 0.5$ µm), soluble (CS) and insoluble (CI)

AGRICULTURAL WASTE BURNING, DOMESTIC, FOREST FIRE, GRASS FIRE,
BC --> KI
OC --> 0.35*KI, 0.65*KS
SO4 --> 0.5*KS, 0.5*AS

AIRCRAFT
BC --> KI

BIOGENIC (when prescribed SOA are used)
OC --> 0.35*KI, 0.65*KS

ENERGY, SHIPS
BC --> KI
OC --> KI
SO4 --> 0.5*AS, 0.5*CS

INDUSTRIAL, TRANSPORT, WASTE
BC --> KI
OC --> KI
SO4 (2.5% SO2) --> 0.5*KS, 0.5*AS

VOLCANIC
SO4 (2.5% SO2) --> 0.5*KS, 0.5*AS

DUST
DU --> AI, CI (distributed accordingly to the dust scheme)

SEASALT
SS --> AS, CS (distributed accordingly to the seasalt scheme)