Aerosol forcing fields for CMIP6

Aerosols are a part of the climate system, and need to be incorporated in its description and climate simulation. It has been proven challenging in previous CMIP exercises to model, isolate and understand the effect of aerosol-climate interactions. Dedicated experiments and diagnostics are thus foreseen in CMIP6, in particular in the MIPs AerChemMIP, RFMIP, PDRMIP, ScenarioMIP, DAMIP. A challenge for modelling groups is to decide whether interactive aerosol components are included in the model or whether aerosol forcing fields are read and used. Also consistent DECK and MIP simulations need to be achieved. AerChemMIP has been given the task by the CMIP panel to provide aerosol forcing fields. This document describes several options for modelling groups and invites for feedback by modelling groups, wishing to use such aerosol forcing fields.

Depending on whether ESMs/AOGCMs will run with interactive aerosol scheme or read forcing fields of aerosols the requirements and options for the different MIPs and for the DECK will be different. The choices and the ease to implement the different options are model dependent.

AerChemMIP addresses models interested in aerosol-climate interactions, with several models having an interactive aerosol scheme. However, limited participation in AerChemMIP experiments is also possible using aerosol forcing fields. Note, that this MIP will require also a consistent, traceable link to DECK simulations using the same model version.

If cpu considerations prevent an interactive aerosol scheme for all CMIP simulations, aerosol forcing fields will facilitate participation in other MIPS accounting for aerosol effects (e.g., CMIP6 Historical, DECK-AMIP, Scenario MIP, RFMIP). The AerChemMIP grid-point aerosol forcing fields (either as masses or optical properties) might be easier for models to implement. However, this might be additional work if models want to participate in RFMIP historical, where the MPI aerosol plume climatology is requested. RFMIP historical intends to provide equivalent aerosol forcing to all models.

Emission based grid-point aerosol forcing fields

Purpose: Provide aerosol fields for models without interactive aerosol code or for high resolution AOGCM simulations without aerosol and atmospheric chemistry. (see table 1)

Content: Mass mixing ratio fields for main aerosol components (sulphate, black carbon, organic carbon, nitrate, sea salt, mineral dust), if needed along with effective radius per species. Anthropogenic fraction will be provided for the mass mixing fields for the relevant components. If demand exists for aerosol optical depth, single scattering albedo, and asymmetry factor this will be provided with an interpolation routine for various wavelength bands. Similar anthropogenic CCN can be provided if requested. The aerosol fields will be provided on a 1x1 degree resolution with interpolation schemes for adjustment to vertical resolution in the GCMs.

Time period and frequency: Monthly 3D fields for the historical 1850-2015 period will be provided on a decadal scale between 1850 and 1990, with annual data 1990 to 2015. For various future scenarios decadal data will be provided.

Timeline: Preindustrial by end of 2015, historical by mid 2016, future scenarios autumn 2016.

Details of production: Emissions from CMIP6 (Smith et al.) are underway. Multi-model ensemble (commitment through AerChemMIP) by several global aerosol models used in previous exercises (NCAR, OsloCTM, NorESM, EMEP, INCA, SPRINTARS?, GISS?, HadGEM?, GOCART? +…). Consideration will be made whether aerosol retrievals (satellite and Aeronet) and other aerosol climatology's will be adopted. Averaging of aerosol fields by CICERO/MetNo will be done along what is already established in AeroCom. Format will be harmonized with ozone fields produced by CCMI/AerChemMIP (Heggelin/Lamarque).

Documentation: A research paper will be published on the aerosol fields used for CMIP6 with submission rather soon after data are made available (end of 2016). A further research paper will be published after CMIP6 simulations are completed comparing aerosol fields from CMIP6 models with the AerChemMIP aerosol fields.

Principal contacts: Gunnar Myhre (CICERO, <gunnar.myhre@cicero.oslo.no>)
Michael Schulz (MetNo, <Michael.schulz@met.no>)

Registration for users of the aerosol fields: Modelling groups wishing to use the aerosol fields are asked to write an email to contacts above, as early as possible, for general coordination and specific requests, format, output considerations.

References:

http://aerocom.met.no
Smith et al. (in preparation) An updated pre-industrial and historical emission database, based on Lamarque et al, ACP, 2010.

Simple aerosol plume climatology

Purpose: Provide fields of aerosol optical properties (fine and coarse mode aerosol optical depth (AOD), single scattering albedo (SSA), asymmetry parameter (ASY)) and cloud activity (anthropogenic increment in drop number, dN/N), which are easy to use and to configure (i.e., scale in amplitude for hypothesis testing). As a composite of (ca. 10) individual plumes, strength and properties of individual plumes are allowed to vary for highest flexibility (e.g. easy examinations of different pre-industrial or future scenarios).

Content: Monthly aerosol optical properties of (<10) plumes are separately defined for fine-mode and coarse mode aerosol. Each plume is defined by an AOD maximum at a particular location a decaying AOD strength in all space (x,y,z) dimensions. Seasonality is considered for AOD maximum, average SSA and average ASY. Decadal variations for local anthropogenic fine-mode AOD fraction and fine-mode SSA will be provided, also for any chosen future scenarios for the different plume regions. 3D local aerosol properties (AOD, SSA and ASY) result from a superposition of the individual plumes (Fortran code will be provided). Estimates of anthropogenic contribution to CCN/IN numbers in terms of dN/N will be derived from fine/coarse mode properties and be informed by analysis of the AEROCOM ensemble. Volcanic plumes covering enhanced aerosol in the stratosphere after major eruptions will also be provided.

Time period and frequency: Monthly 3D fields (from plume combinations) for the period 1850-2010 in decadal time-step. (Data will be provided for different preindustrial base-lines). 2020-2100 decadal data-sets are offered when the regional scenarios are set.

Timeline: Preindustrial and historical by mid 2015 (at least for two different pre-industrial states), future scenarios by autumn 2015 (in coordination with Gunnar and Michael). Volcanoes by end of 2015.

Details of production: The plume scheme is constructed to closely represent the observations based aerosol climatology MAC-v2, which is an update of MAC-v1 (Max-Planck-Institute Aerosol Climatology version 1, Kinne et al. (2013)). The monthly data of MAC-v2 are tied to observational statistics by sun/sky photometry (of AERONET and MAN), which were merged onto a baseline, defined by central values from an ensemble of AeroCom Phase 2 modeling output. Merged aerosol properties are mid-visible properties for AOD, AAOD, fine-AOD and Angstrom parameter. From these optical properties, aerosol single scattering data (AOD, SSA, ASY) as well as microphysical data (dust size, fine-mode size) are derived for estimates for CCN, IN. An illustration of the plume scheme's performance is shown in Figure 1.

Documentation: A research paper will be published on the design of the plume climatology and its performance in GCM simulations compared to using either the full MAC-v2 climatology or a comprehensive aerosol scheme (end 2015).

Principal Contacts: Karsten Peters, Bjorn Stevens, Stefan Kinne. (all MPI-M Hamburg, Germany. firstname.lastname@mpimet.mpg.de)

Registration for users of the aerosol fields: Modelling groups wishing to use the plume climatology are asked to write an email to contacts above, as early as possible, for general coordination.

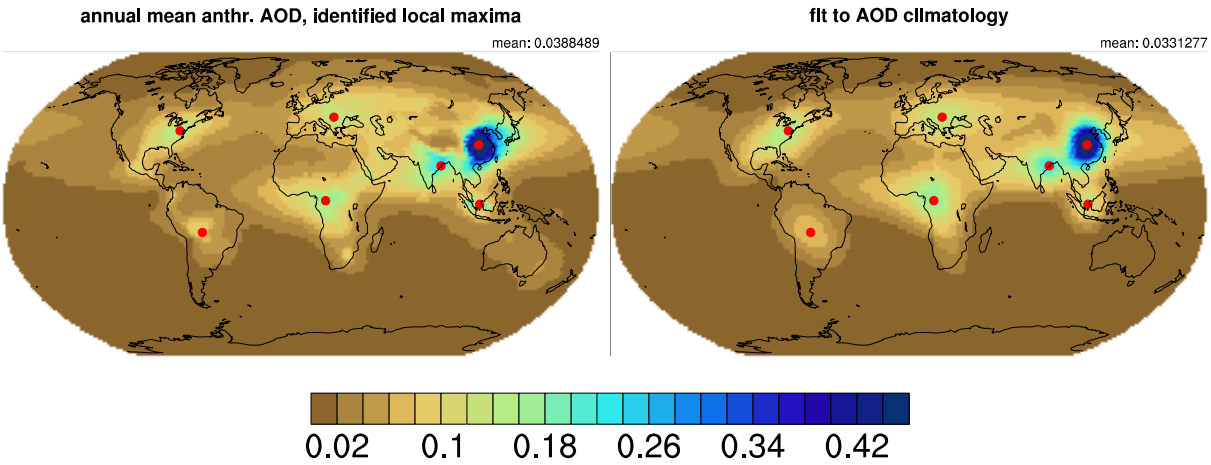

Figure 1: Annual mean anthropogenic AOD, T63 horizontal resolution. Left: MAC-v2. Right: Fit using the modular source scheme. Red markers denote local AOD maxima used to prescribe the AOD plumes in the scheme.

Reference:

Kinne, S., O'Donnel, D., Stier, P., Kloster, S., Zhang, K., Schmidt, H., Rast, S., Giorgetta, M., Eck, T. F., and Stevens, B.: MAC-v1: A new global aerosol climatology for climate studies, J. Adv. Model. Earth Syst., 5, 704–740, doi:10.1002/jame.20035, 2013.