



Aerosol Radiative Forcing

The AeroCom Prescribed Experiment: Towards the Quantification of Host Model Errors

AeroCom Meeting, Oxford
29/09/2010

Philip Stier

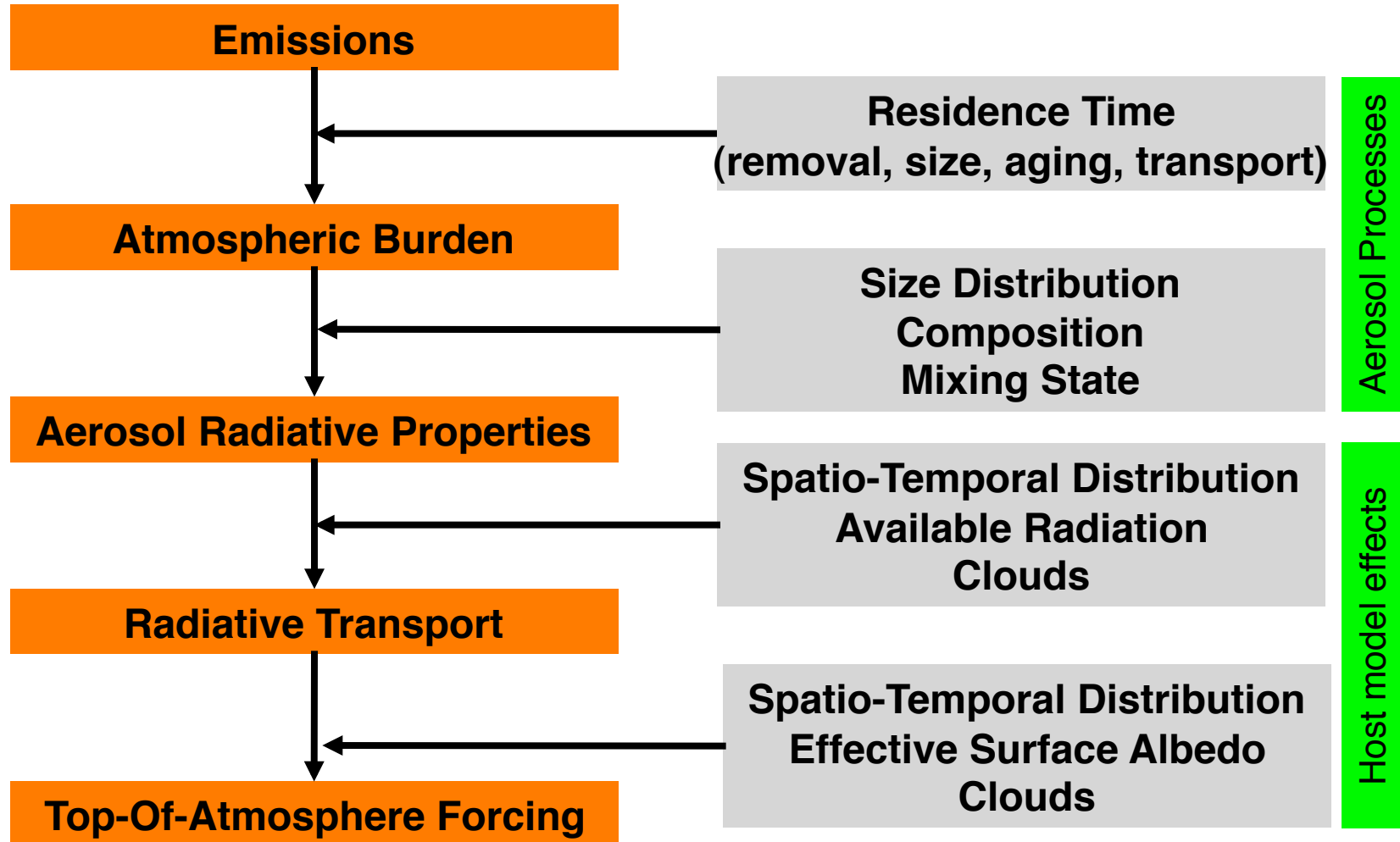
Atmospheric, Oceanic and Planetary Physics / Oriel College
University of Oxford

Stefan Kinne, Nicolas Bellouin, Michael Schulz, Gunnar Myhre, John Seinfeld



Assessment of aerosol direct radiative forcing

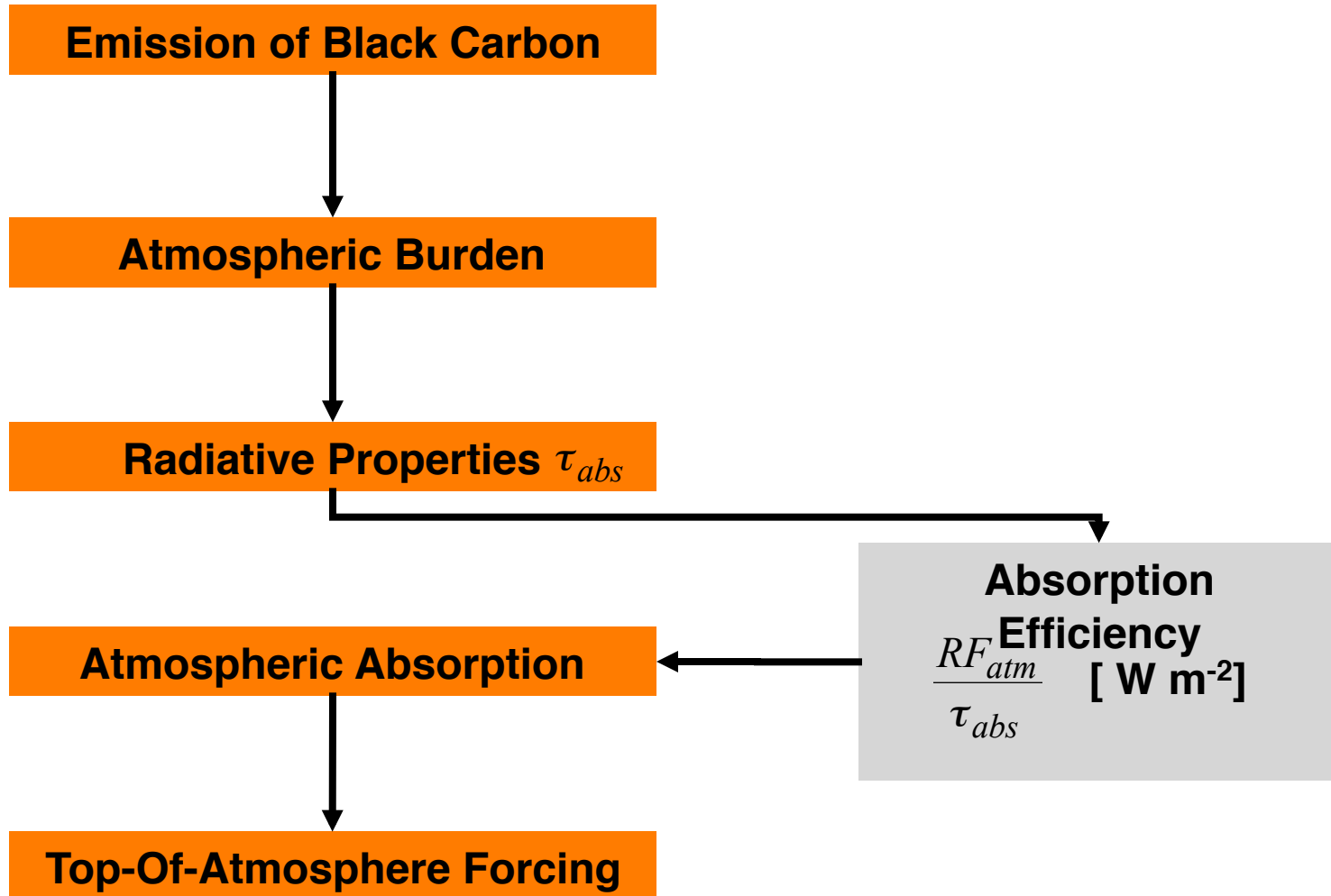
AeroCom: Intercomparison and assessment of the underlying process representations



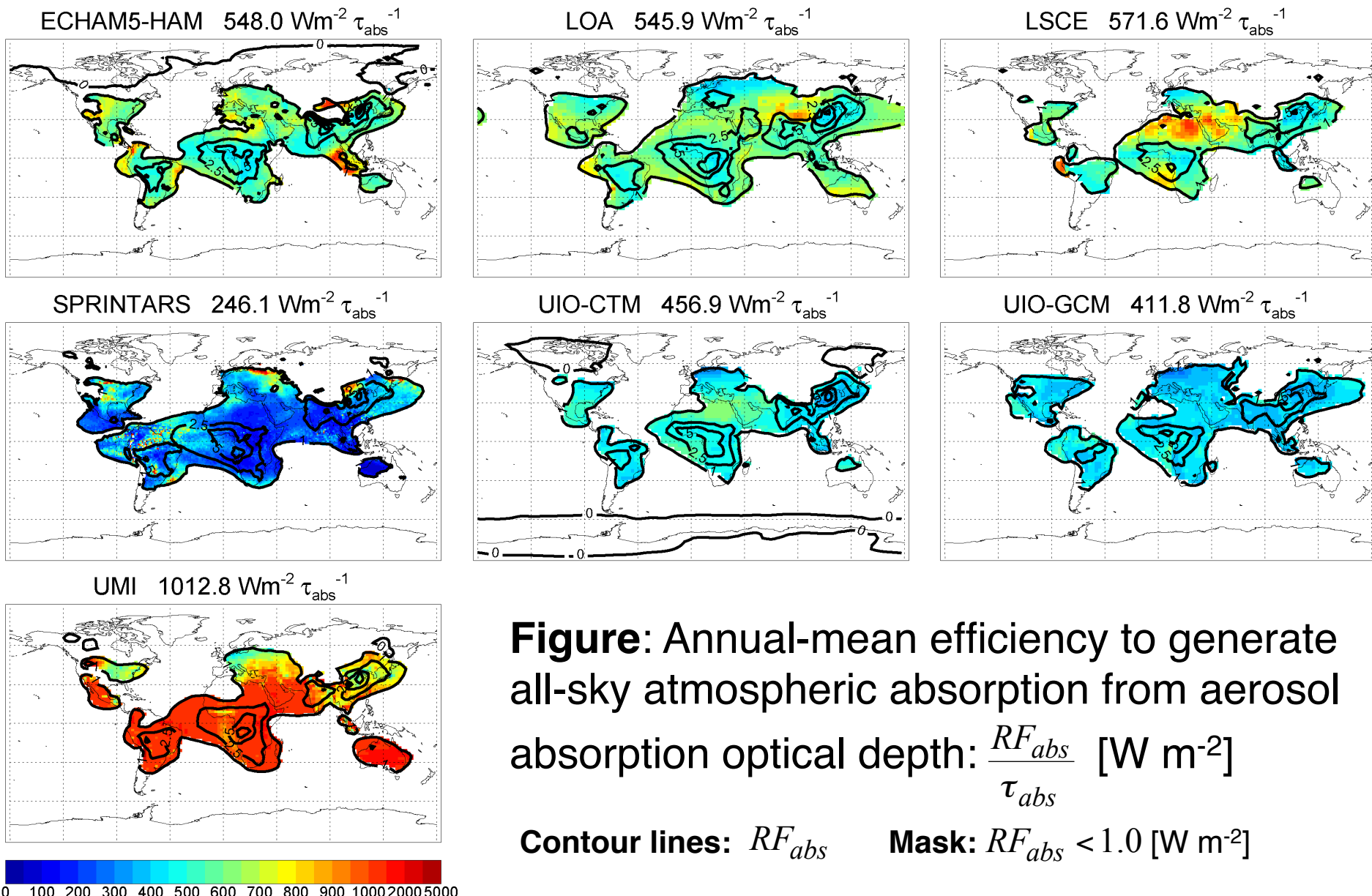
Assessment of aerosol direct radiative forcing

Analysis of AeroCom forcing experiment:

Large diversity in absorption efficiency from aerosol radiative properties:

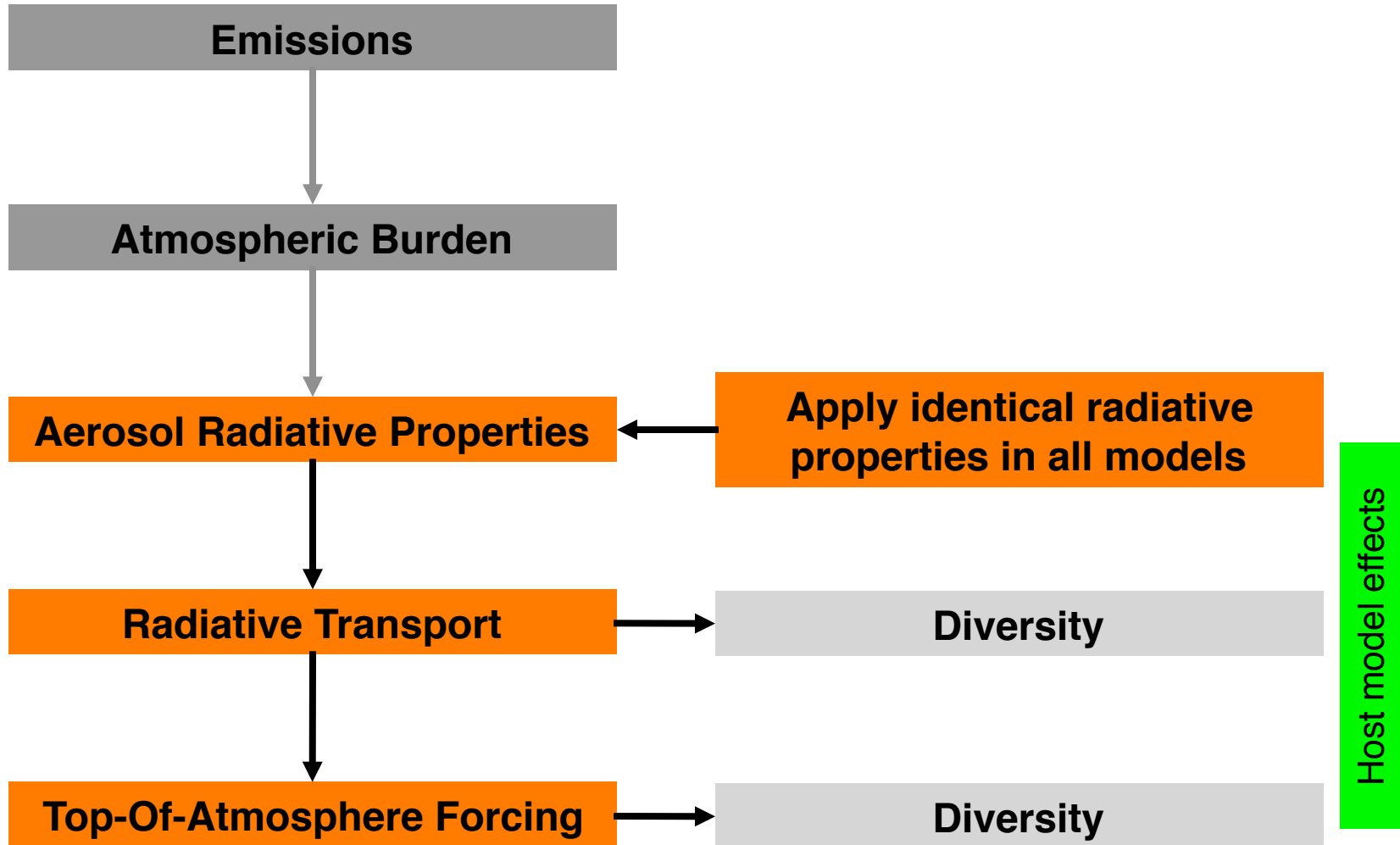


Analysis of AeroCom Forcing Experiment



The AeroCom Prescribed Experiment

Facilitate inter-comparability through fixing 3D aerosol radiative properties



AeroCom Prescribed - Set-up

Prescribe **aerosol radiative properties** identically in all “**models**”:

- Extinction, Single Scattering Albedo, Asymmetry Factor:
 - 3D distributions
 - 24 SW wavelengths
 - “fool proof” offline mapping tools to model resolution and radiation bands

Anthropogenic AOD (545nm): 0.042

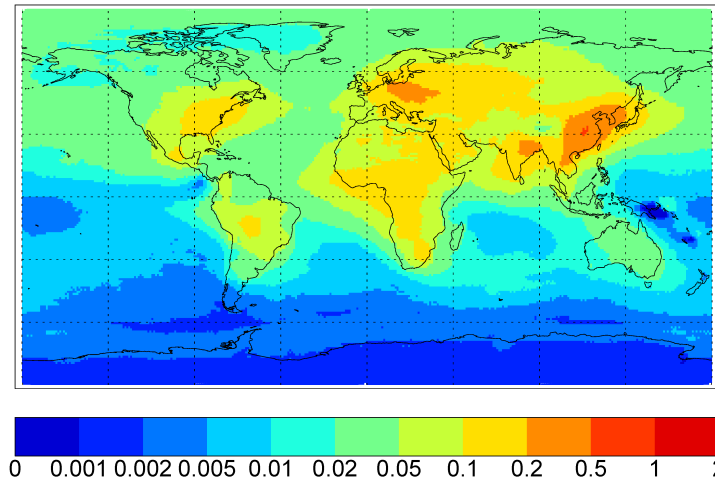


Figure: Annual-mean anthropogenic and total aerosol optical depth at 550 nm derived from AeroCom median model and AERONET.

AeroCom Prescribed - Set-up

Prescribe **aerosol radiative properties** identically in all “**models**”:

- Extinction, Single Scattering Albedo, Asymmetry Factor:
 - 3D distributions
 - 24 SW wavelengths
 - “fool proof” offline mapping tools to model resolution and radiation bands

To make this very clear:

- **You do not need to run your aerosol model for this experiment**
- **You may want to run parts of it anyway to keep your AeroCom diagnostics routines**

Input Data Set-up - Step 1 out of 3

```
Emacs@cloud-2.local
#!/bin/tcsh -xv
#
#####
#
# AeroComPrescribed_Step_1_SpectralMapping.sh
#
# Purpose:
# =====
# Performs spectral mapping from 24 streamer short-wave bands to
# respective model bands.
#
# Usage:
# =====
# Example set-up for 6 SW bands of ECHAM5. Simply adjust the weighting
# below to the respective model bands. Please include the 545nm band as
# below for quality control. Warning: ensure proper usage of brackets as
# errors give incorrect results but no warning using the nco tools.
#
# Input:
# =====
# - AeroComPrescribed_RadiativeProperties_${TYPE}_SW.nc
#   for each TYPE ( Fine_PresentDay Fine_PreIndustrial Coarse)
#
# Output:
# =====
# - AeroComPrescribed_RadiativeProperties_${TYPE}_SW_mapped.nc
#   for each TYPE ( Fine_PresentDay Fine_PreIndustrial Coarse)
#
# Authors:
# =====
# Philip Stier, University of Oxford (philip.stier@atm.ox.ac.uk), 2009
#
# Required tools:
# =====
# NetCDF Operators (nco-tools) available from http://nco.sourceforge.net
#
#####
foreach TYPE ( Fine_PresentDay_SW Fine_PreIndustrial_SW Coarse_SW )
#
set IFILE=AeroComPrescribed_RadiativeProperties_${TYPE}.nc
#
set OFILE=${IFILE:r}_mapped.nc
--:-- AeroComPrescribed_Step_1_SpectralMapping.sh Top L1 (Shell-script[tcsh])-----
No indentation for this shell type.
```

Input data on 2D 1x1 degree with 24 spectral bands

Step 1:
Mapping to model specific spectral bands.

Required:
NetCDF operators
(nco tools)



Input Data Set-up - Step 2 out of 3

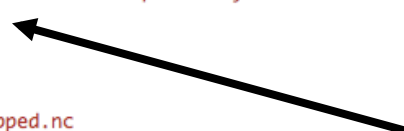
```
Emacs@cloud-2.local
#!/bin/tcsh -xv
#
#####
#
# AeroComPrescribed_Step_2_Regridding.sh
#
# Purpose:
# =====
# Regridding of created spectrally weighed aerosol radiative properties to
# horizontal resolution and regridding of 3D Aerosol Optical Depths for
# vertical distribution from 1x1 degree with 31 levels to the respective
# 3D model resolution.
#
# Usage:
# =====
# Example set-up for 6 SW bands of ECHAM5. Simply adjust the number of
# model bands as processed in Step 1. Please include the 545nm band as
# below for quality control.
#
# Warning:
# =====
# This step should work well for models with hybrid p-sigma coordinates in CF
# compliant standard format. For other models it might need to be replaced by
# a model specific regridding scheme.
#
# Input:
# =====
# - AeroComPrescribed_RadiativeProperties_${TYPE}_SW_mapped.nc
#   for each TYPE ( Fine_PresentDay Fine_PreIndustrial Coarse)
#   (from Step 1)
# - Provided 3D Aerosol Optical Depths (AeroComPrescribed_AODs_3D.nc)
# - Model specific output grid definitions as input for CDO regridding
#   tools. These can be automatically created by CDO using the following
#   commands (echam5 example):
#   cdo vct ECHAM5-FILE.nc > echam5_levels_L19.txt (creates vertical coordinate table)
#   cdo griddes ECHAM5-FILE.nc > echam5_grid_T21.txt (creates grid description)
#
# Output:
# =====
# - Horizontally regridded spectrally mapped aerosol radiative properties
#   AeroComPrescribed_RadiativeProperties_${TYPE}_mapped_${HRES}.nc
#   for each TYPE ( Fine_PresentDay Fine_PreIndustrial Coarse) and the
#   horizontal resolution HRES
--:-- AeroComPrescribed_Step_2_Regridding.sh Top L14 (Shell-script[tcsh])
```

Input data on 2D 1x1 degree with 24 spectral bands

Step 2:
Regridding to respective spatial model resolution.

Warning:
Works with hybrid p-sigma but not all grids

Required:
cdo climate data operators



Input Data Set-up - Step 3 out of 3

```
Emacs@cloud-2.local
#####
#
# AeroComPrescribed_Step_3_2D_To_3D.sh
#
# Purpose:
# =====
# Creates 3D fields of aerosol radiative properties from spectrally
# mapped 2D input data (Step 1) and an input file of 3D fractional AODs
# for fine and coarse mode AODs regridded to the respective model resolution
# (Step 2).
#
# Usage:
# =====
# Example set-up for ECHAM5. Simply adjust the model resolution
# according to Step 2.
#
# Input (from Step 2):
# =====
# - AeroComPrescribed_RadiativeProperties_${TYPE}_SW_mapped_${HRES}.nc
#   for each TYPE ( Fine_PresentDay Fine_PreIndustrial Coarse) and the
#   horizontal resolution HRES
# - 3D Aerosol Optical Depths regridded to the model resolution
#   AeroComPrescribed_AODs_3D_${HRES}_${VRES}.nc with horizontal and
#   vertical resolutions HRES and VRES
#
# Output:
# =====
# - AeroComPrescribed_RadiativeProperties_${PERIOD}_3D_${HRES}_${VRES}_mapped_${BAND}.nc
#   for each PERIOD (PreIndustrial and PresentDay), BAND (sw_01,...sw_01), HRES and VRES
#
# Authors:
# =====
# Philip Stier, University of Oxford (philip.stier@atm.ox.ac.uk), 2009
#
# Required tools:
# =====
# NetCDF Operators (nco-tools) available from http://nco.sourceforge.net
# Climate Data Operators (CDO) available from http://www.mpimet.mpg.de/cdo
#
### Change your resolution here: #####
#
--:-- AeroComPrescribed_Step_3_2D_To_3D.sh Top L1 (Shell-script[tcsh])-----
No indentation for this shell type.
```

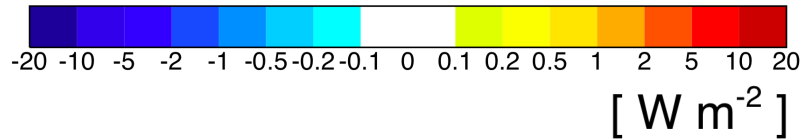
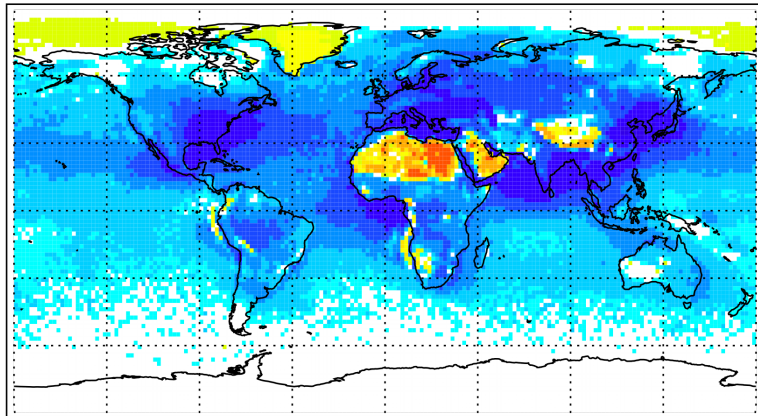
Input data on 2D 1x1 degree with 24 spectral bands

Step 3:
Creation of 3D files from 2D fields using 3D fractional optical depth input file.

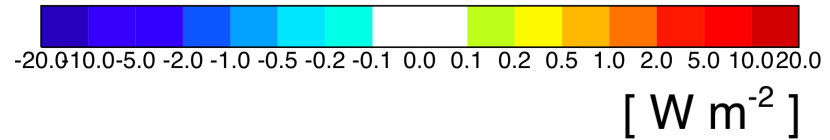
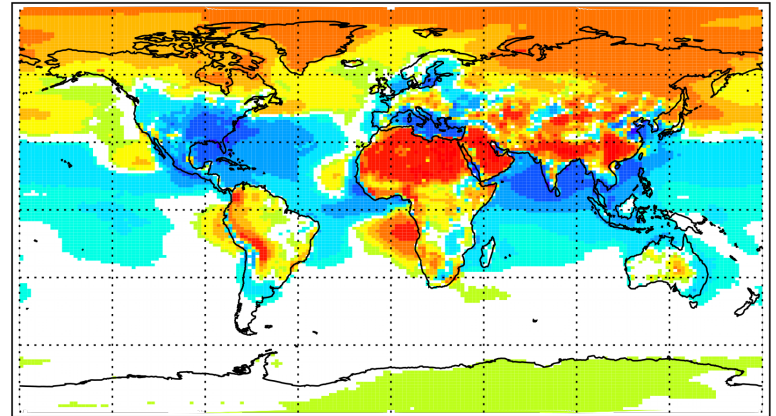
First results - Forcing

Present-Day – Pre-Industrial Aerosol Radiative Forcing:

TOA All-Sky: -0.59 W m^{-2}



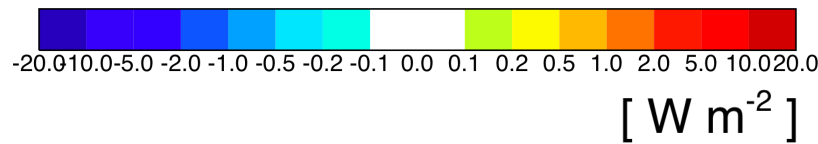
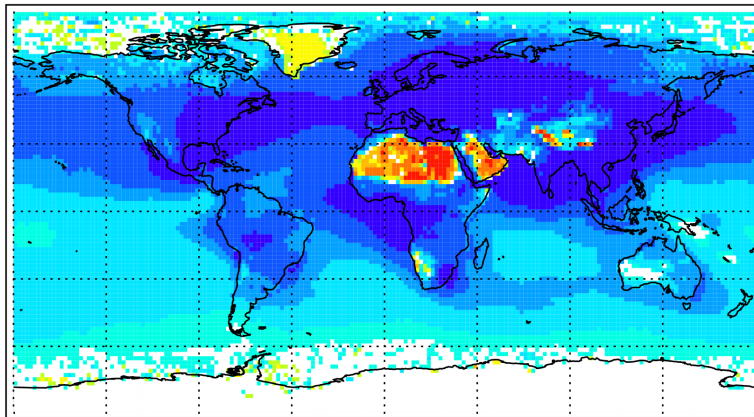
HadGEM2-ES Forcing: 0.15



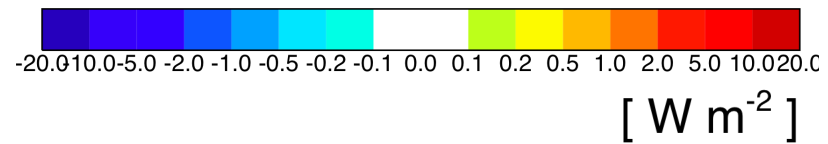
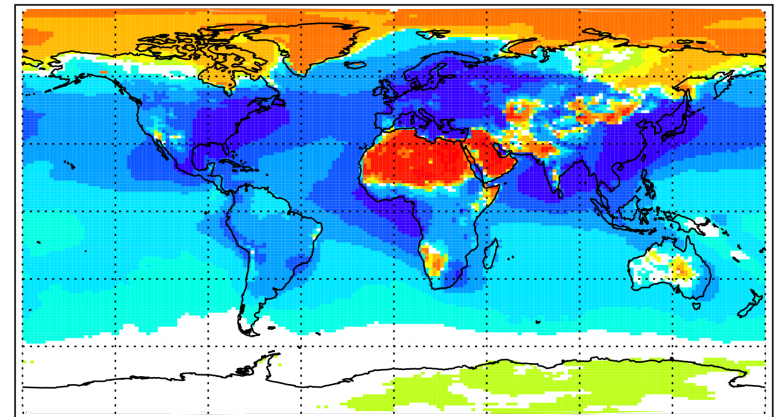
First results - Forcing

Present-Day – Pre-Industrial Aerosol Radiative Forcing Clear-Sky:

MPIHAM_V2 Forcing Clear-Sky: -1.12



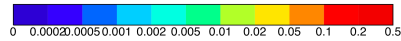
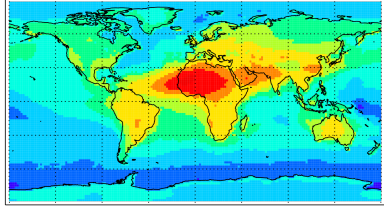
HadGEM2-ES Forcing Clear-Sky: -0.53



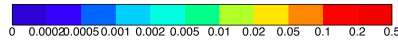
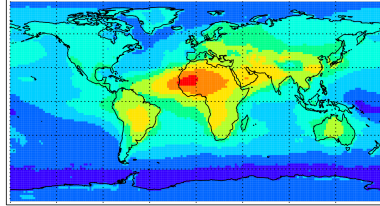
First results - Input Data

Present-Day Aerosol Absorption Optical Depth:

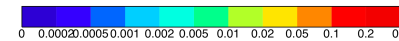
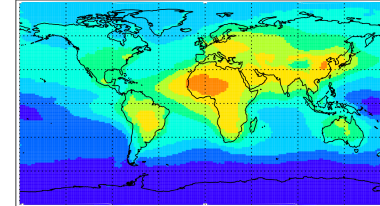
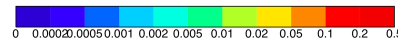
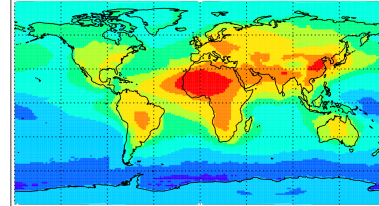
MPIHAM_V2 2000 AOD (Band sw1): 0.0139



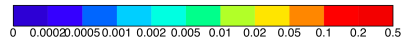
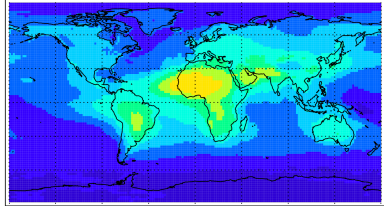
MPIHAM_V2 2000 AOD (Band sw2): 0.0070



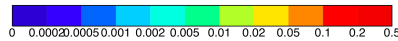
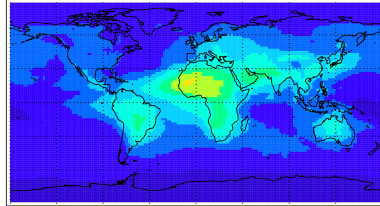
HadGEM2-ES 2006 AOD (Band sw1): 0.0167 HadGEM2-ES 2006 AOD (Band sw2): 0.0072



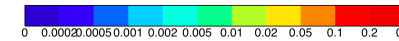
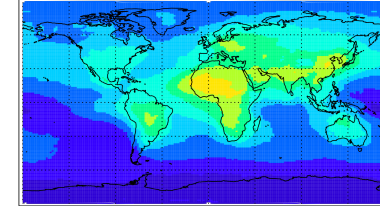
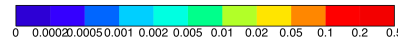
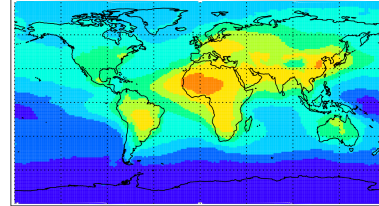
MPIHAM_V2 2000 AOD (Band sw3): 0.0025



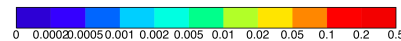
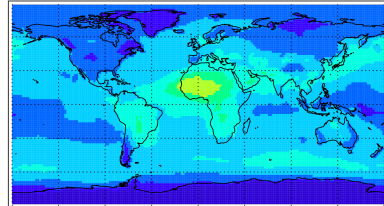
MPIHAM_V2 2000 AOD (Band sw4): 0.0013



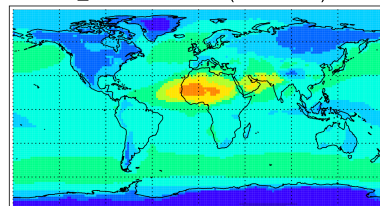
HadGEM2-ES 2006 AOD (Band sw3): 0.0072 HadGEM2-ES 2006 AOD (Band sw4): 0.0031



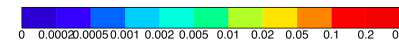
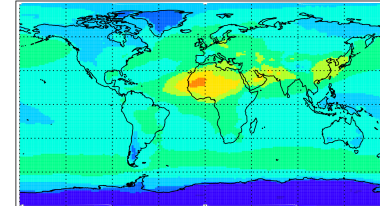
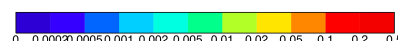
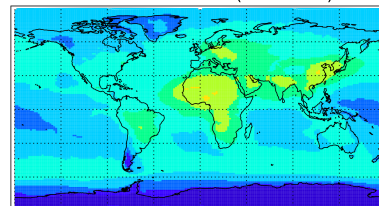
MPIHAM_V2 2000 AOD (Band sw5): 0.0017



MPIHAM_V2 2000 AOD (Band sw6): 0.0048



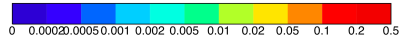
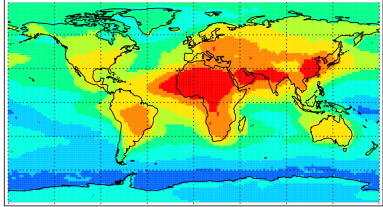
HadGEM2-ES 2006 AOD (Band sw5): 0.0035 HadGEM2-ES 2006 AOD (Band sw6): 0.0052



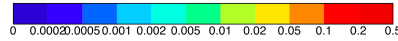
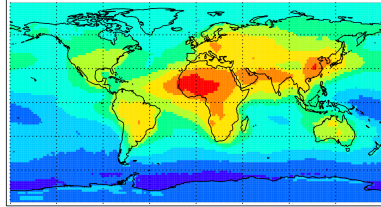
First results - Input Data

Pre-Industrial Aerosol Absorption Optical Depth:

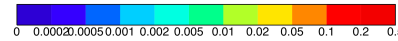
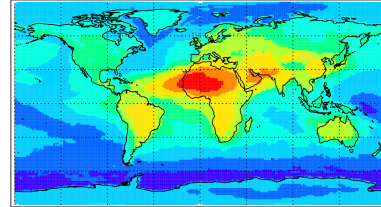
MPIHAM_V2 1850 AAOD (Band sw1): 0.0244



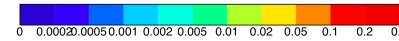
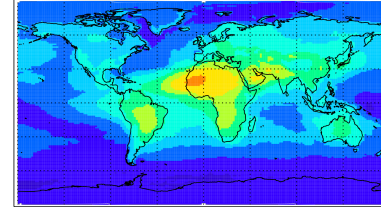
MPIHAM_V2 1850 AAOD (Band sw2): 0.0133



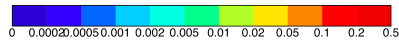
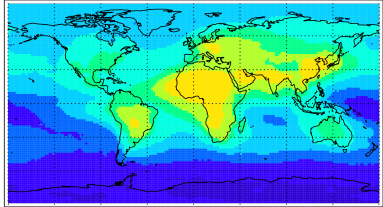
HadGEM2-ES 1850 AAOD (Band sw1): 0.0093



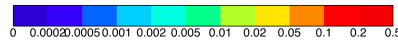
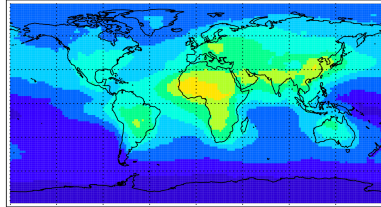
HadGEM2-ES 1850 AAOD (Band sw2): 0.0035



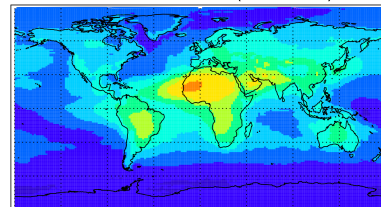
MPIHAM_V2 1850 AAOD (Band sw3): 0.0055



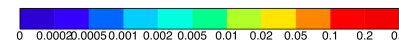
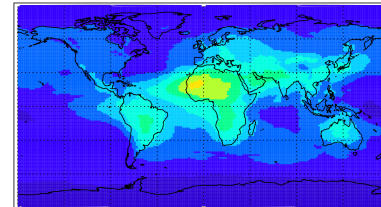
MPIHAM_V2 1850 AAOD (Band sw4): 0.0029



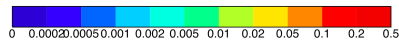
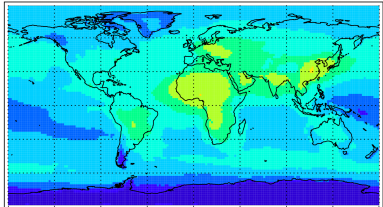
HadGEM2-ES 1850 AAOD (Band sw3): 0.0035



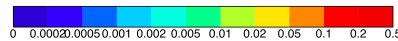
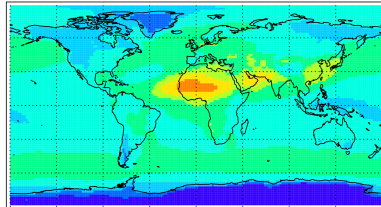
HadGEM2-ES 1850 AAOD (Band sw4): 0.0014



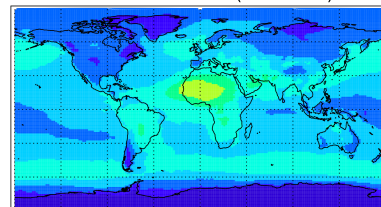
MPIHAM_V2 1850 AAOD (Band sw5): 0.0033



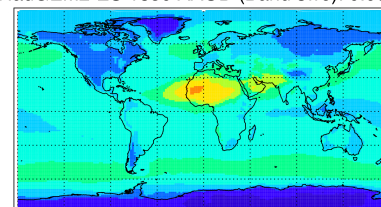
MPIHAM_V2 1850 AAOD (Band sw6): 0.0058



HadGEM2-ES 1850 AAOD (Band sw5): 0.0019



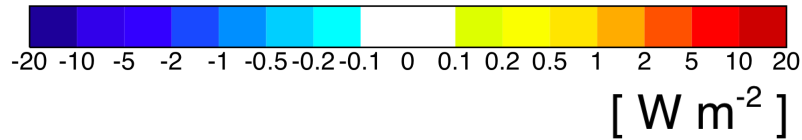
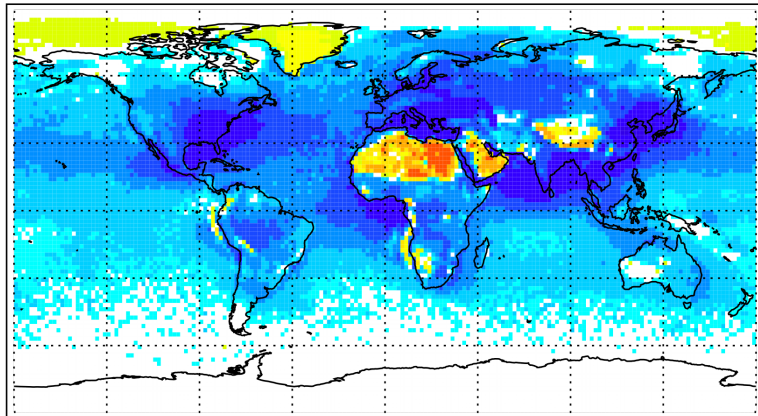
HadGEM2-ES 1850 AAOD (Band sw6): 0.0040



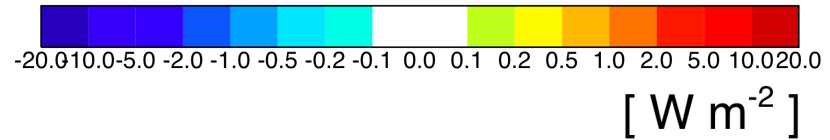
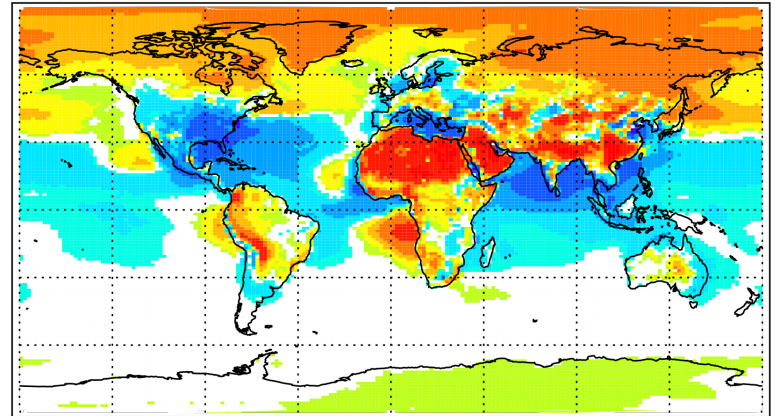
First results - Forcing

Present-Day – Pre-Industrial Aerosol Radiative Forcing:

TOA All-Sky: -0.59 W m^{-2}



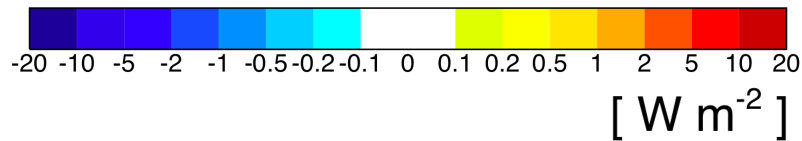
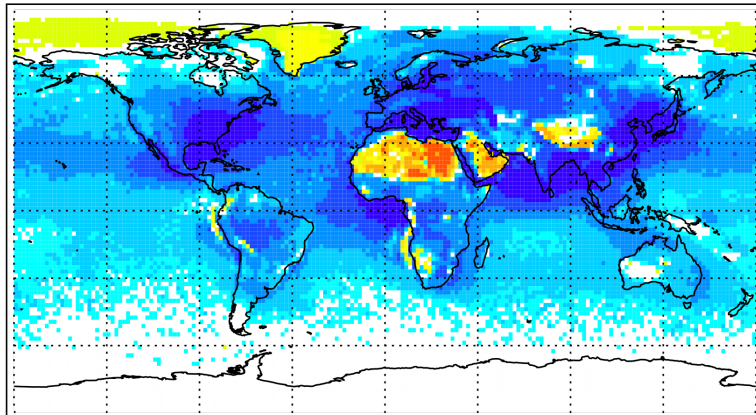
HadGEM2-ES Forcing: 0.15



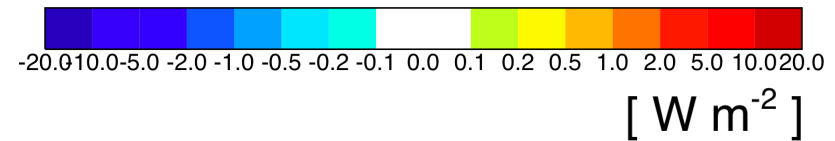
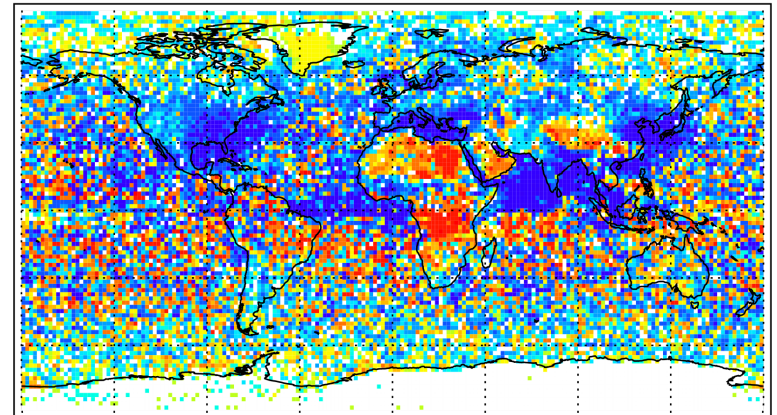
First results - “Forcing”?

ECHAM instantaneous forcing versus radiative flux perturbation:
(Nudged, aerosols online and coupled to radiation)

Instantaneous: -0.59 W m^{-2}



Flux Perturbation: -0.40



We requested flux perturbations in the AeroCom protocol but not total aerosol instantaneous forcing (just by component).

Participation

Interested? Speak to me.

