

Aerosol Radiative Forcing

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

AeroCom Meeting, Kyushu University
2011

Philip Stier

Atmospheric, Oceanic and Planetary Physics

Department of Physics, University of Oxford

Stefan Kinne, Nicolas Bellouin, Gunnar Myhre, Toshi Takemura, Hongbin Yu,...

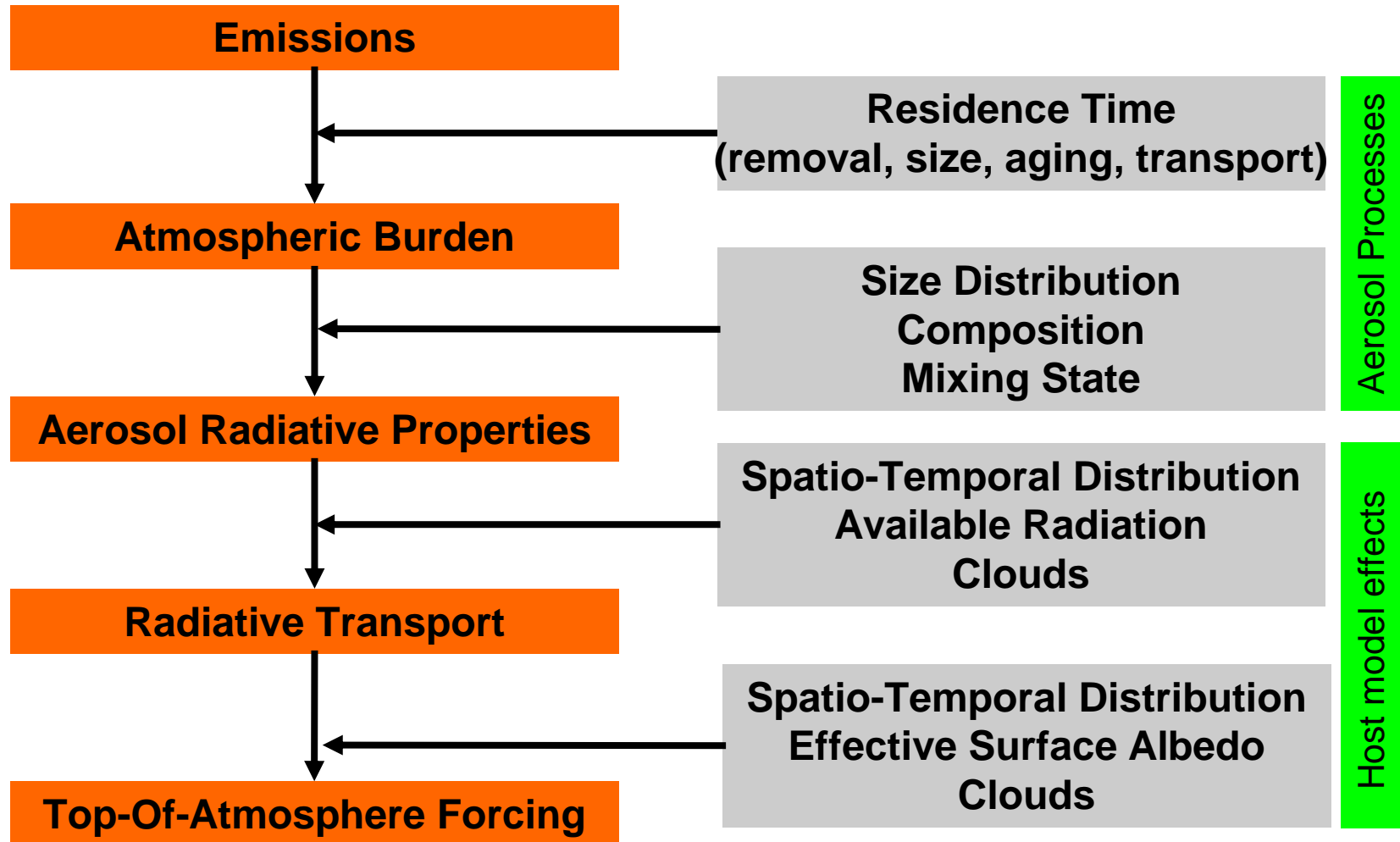


Sorry for not being able to be there – but this guy keeps me busy!



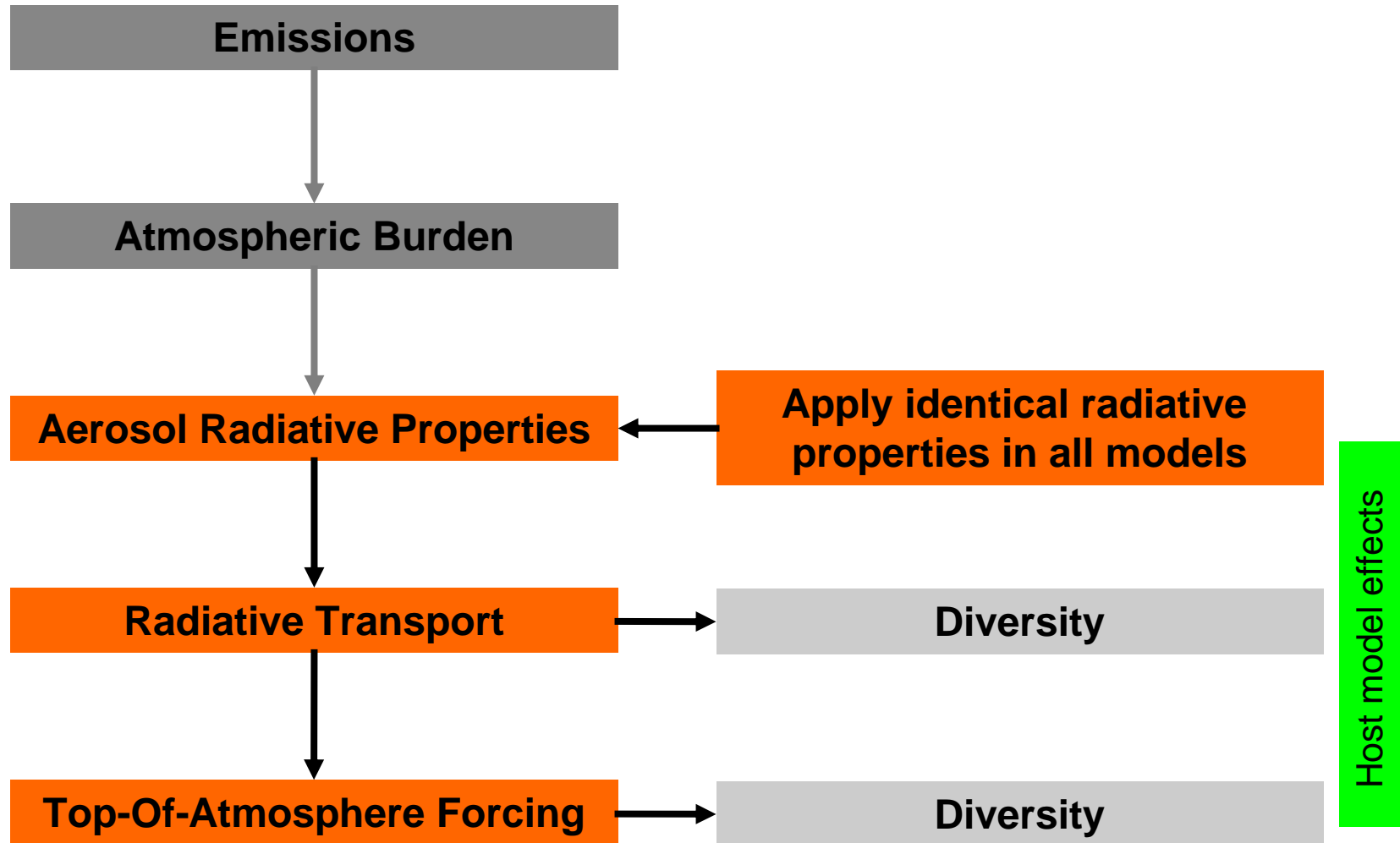
Assessment of aerosol direct radiative forcing

AeroCom: Intercomparison and assessment of the underlying process representations



The AeroCom Prescribed Experiment

Facilitate inter-comparability through fixing 3D aerosol radiative properties



AeroCom Prescribed I

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

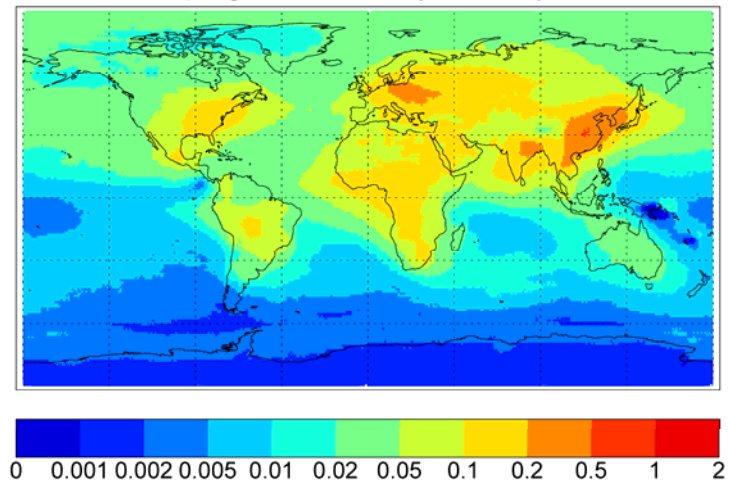


Figure: Annual-mean anthropogenic at 550 nm derived from AeroCom median model and AERONET.

AeroCom Prescribed I

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**

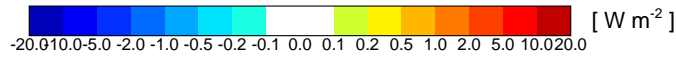
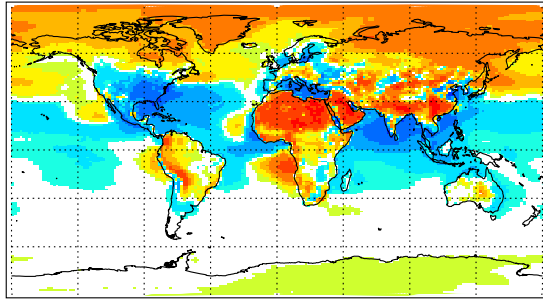
AeroCom Prescribed I - Results

Model submissions:

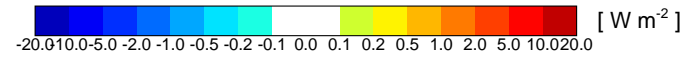
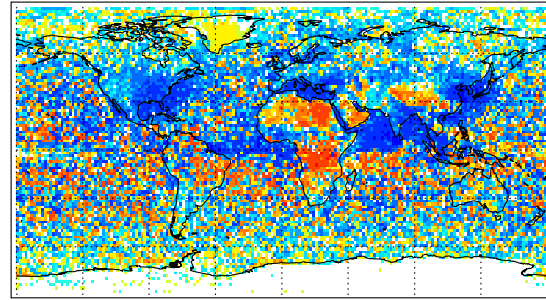
- HadGEM2 (Nicolas Belloin)
- ECHAM5.5 (Philip Stier)
- SPRINTARS (Toshi Takemura)
- GOCART-MERRA (Hongbin Yu)
- GOCART-GEOS4 (Hongbin Yu)
- OSLO-CTM2 (Gunnar Myhre)

AeroCom Prescribed I – All-Sky Forcing

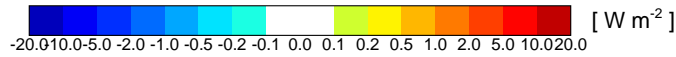
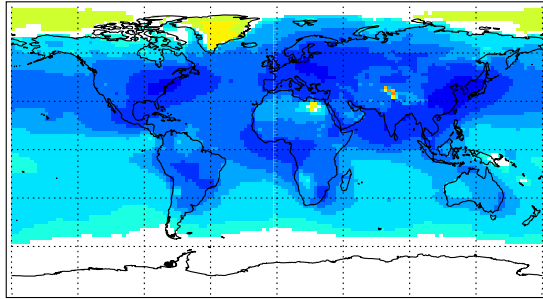
HadGEM2-ES Forcing All-Sky [W m^{-2}]: 0.15



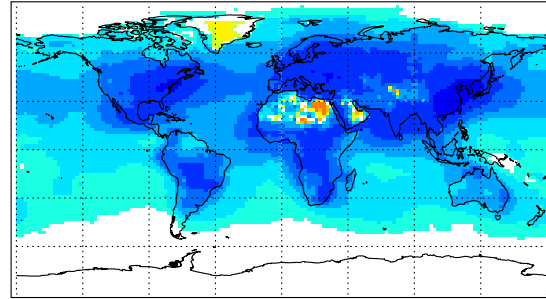
MPIHAM_V2 Forcing All-Sky [W m^{-2}]: -0.40



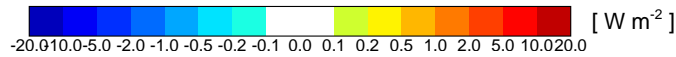
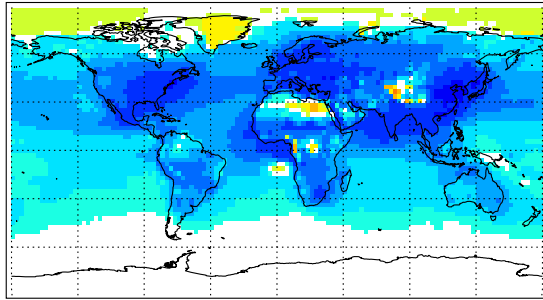
GOCART-GEOS4 Forcing All-Sky [W m^{-2}]: -1.09



GOCART-MERRA Forcing All-Sky [W m^{-2}]: -0.91



OsloCTM2 Forcing All-Sky [W m^{-2}]: -0.78

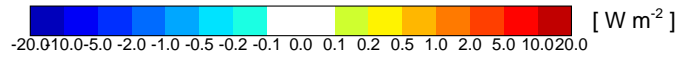
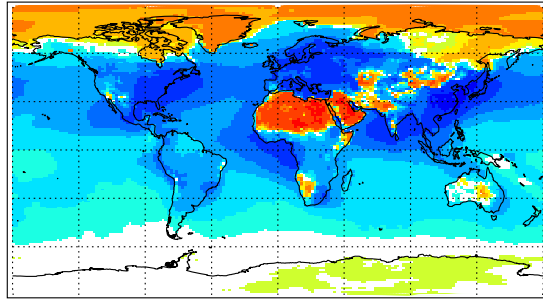


Meteorology
not bit-
identical!

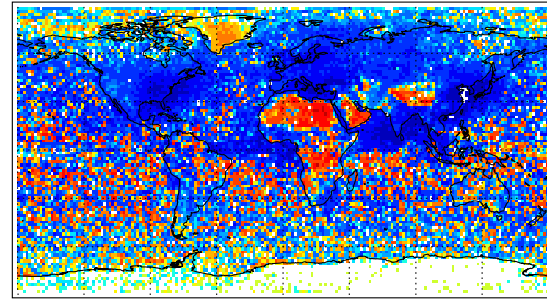
Will be
rerun...

AeroCom Prescribed I – Clear-Sky Forcing

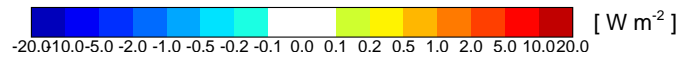
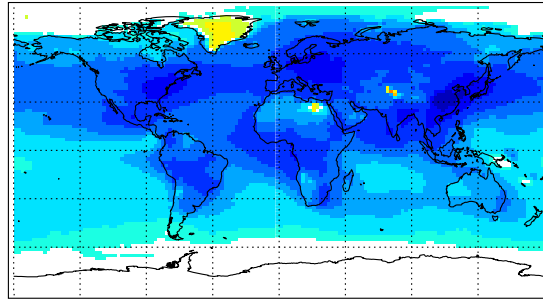
HadGEM2-ES Forcing Clear-Sky [W m^{-2}]: -0.53



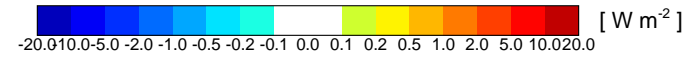
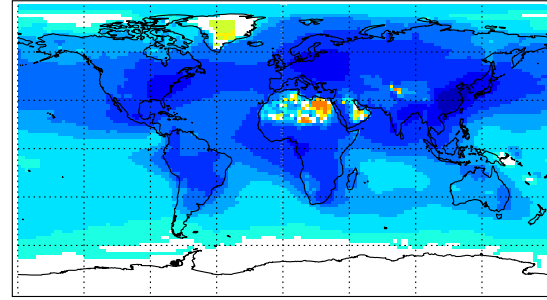
MPIHAM_V2 Forcing Clear-Sky [W m^{-2}]: -1.93



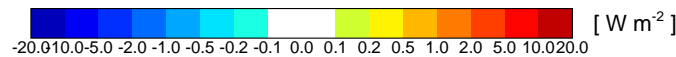
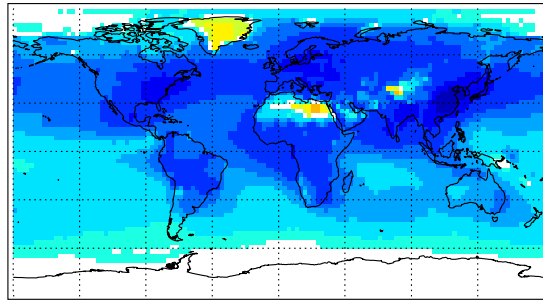
GOCART-GEOS4 Forcing Clear-Sky [W m^{-2}]: -1.38



GOCART-MERRA Forcing Clear-Sky [W m^{-2}]: -1.46



OsloCTM2 Forcing Clear-Sky [W m^{-2}]: -1.47

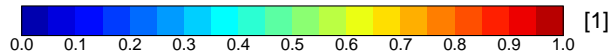
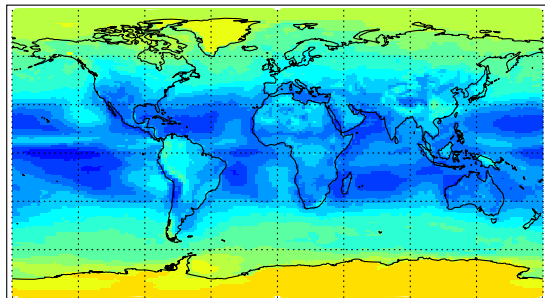


Meteorology
not bit-
identical!

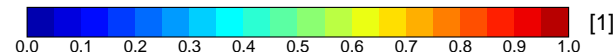
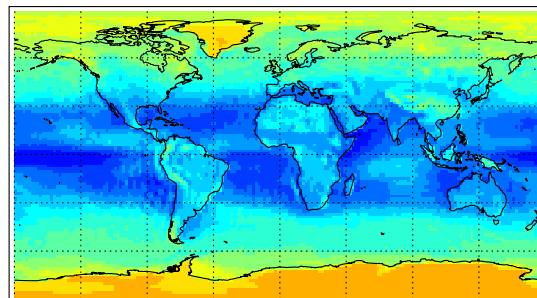
Will be
rerun...

AeroCom Prescribed I – TOA Albedo

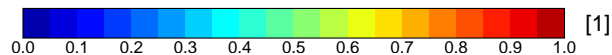
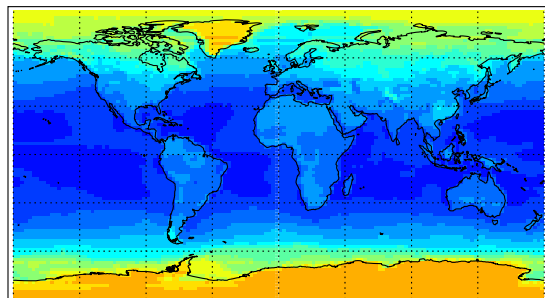
HadGEM2-ES TOA Albedo: 0.34



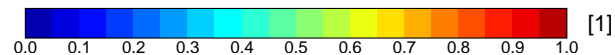
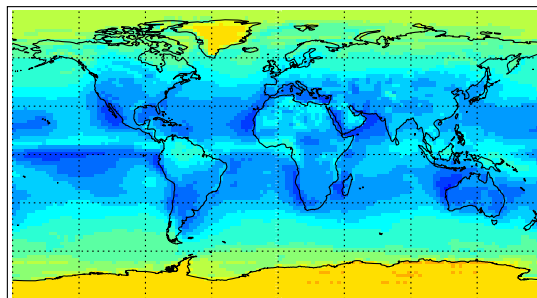
MPIHAM_V2 TOA Albedo: 0.34



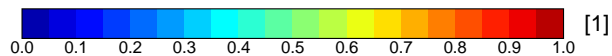
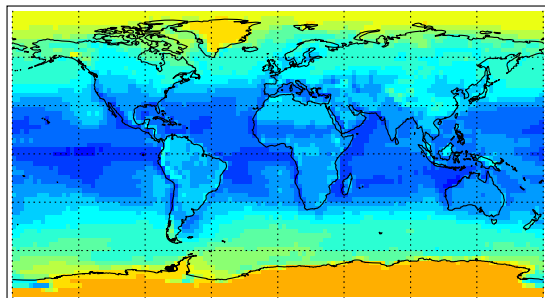
GOCART-GEOS4 TOA Albedo: 0.25



GOCART-MERRA TOA Albedo: 0.35

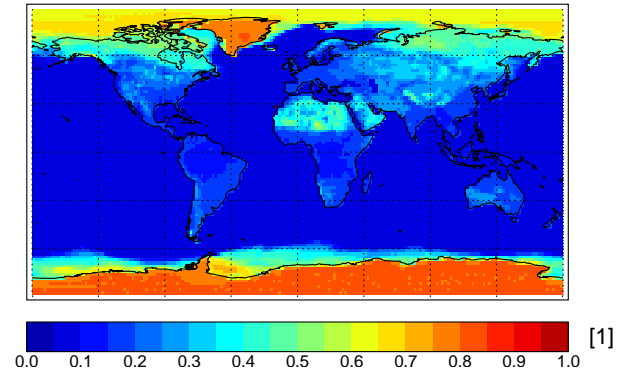


OsloCTM2 TOA Albedo: 0.33

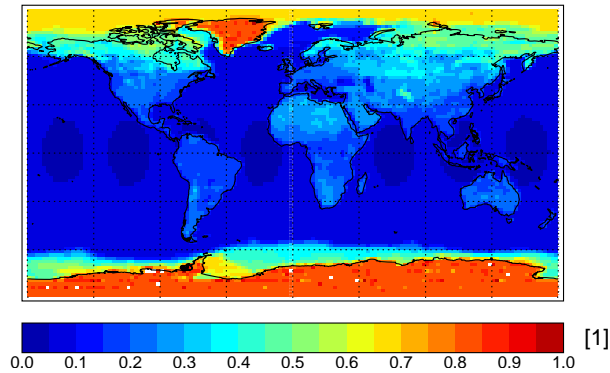


AeroCom Prescribed I – Surface Albedo

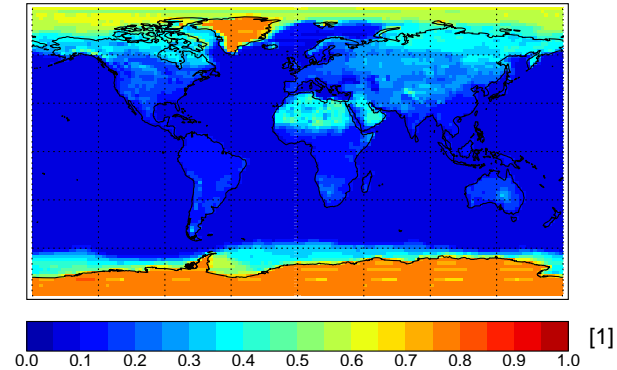
MPIHAM_V2 Surface Albedo: 0.16



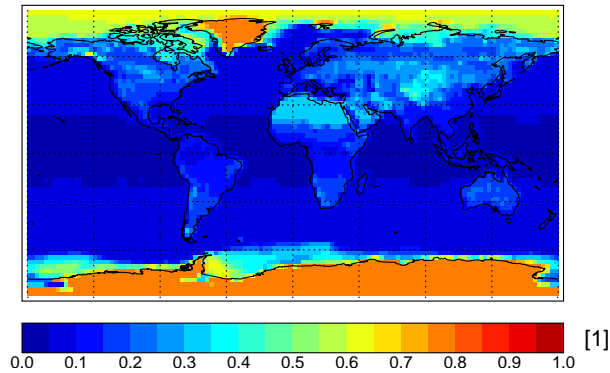
GOCART-GEOS4 Surface Albedo: 0.16



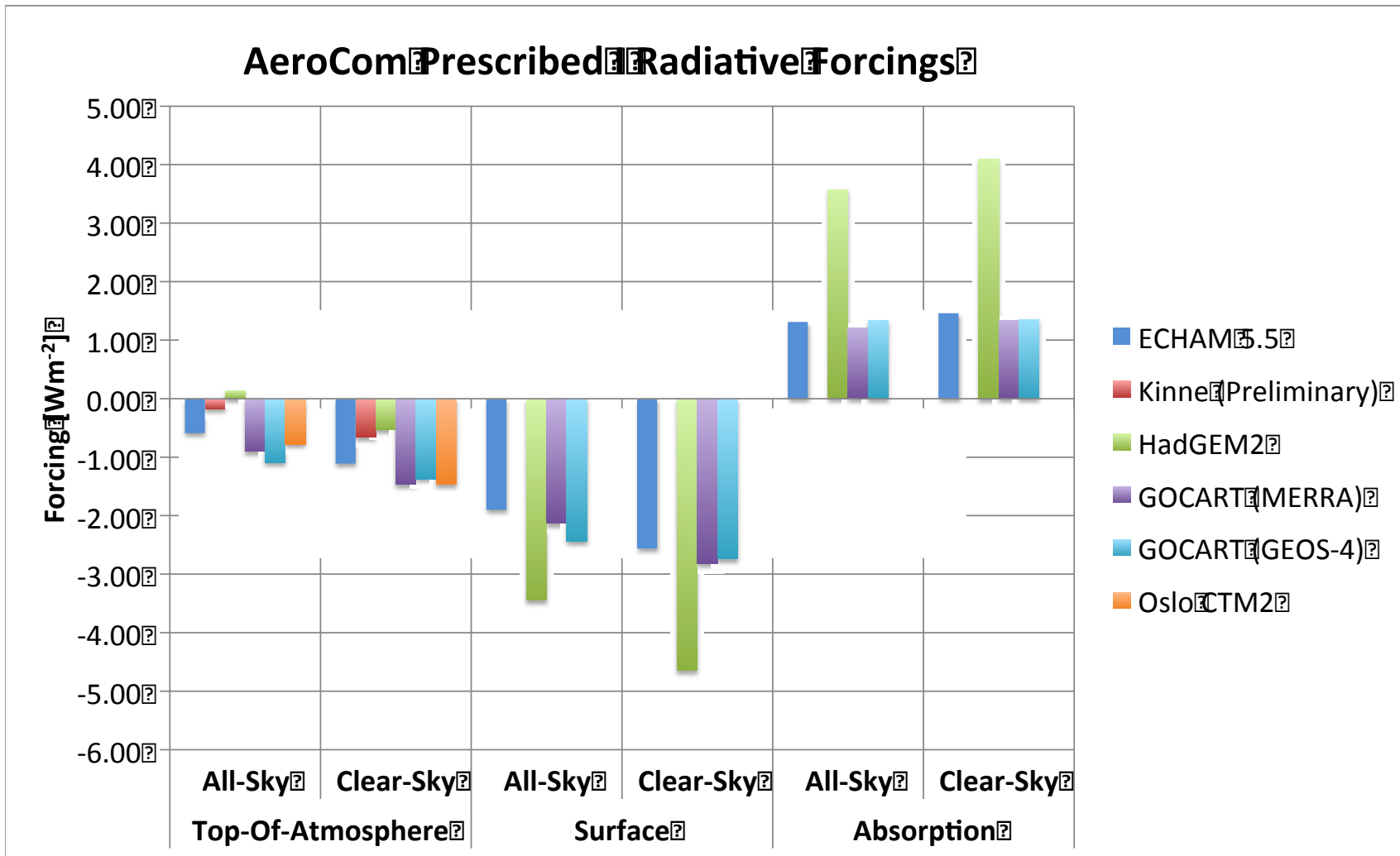
GOCART-MERRA Surface Albedo: 0.15



OsloCTM2 Surface Albedo: 0.14



AeroCom Prescribed I - Forcings



Conclusions – I

Conclusions from Prescribed I:

- Despite prescription of “identical” aerosol radiative properties, forcing diversity is with 1.24 Wm^{-2} unacceptably large
 - Contribution of implementation errors likely (but sources hard to attribute)
 - Even models (GOCART) with identical implementation of radiative properties but different meteorological fields show significant differences in all-sky forcings (though TOA albedo needs investigation)
- ➔ **Setup of Prescribed was not fool-proof enough (sorry)**

AeroCom Prescribed 0

We propose to take a step back and make this even simpler

Following the Radiative Transfer experiment prescribe globally uniform fields:

- AOD of 0.2 at 550nm distributed linearly over lowest 2km in the model (ideally linearly in height, not in levels)

I propose to keep AOD spectrally flat to avoid differences in interpretation of Ångström exponent (mid-Wavelength, mid-Wavenumber,...) – please discuss!

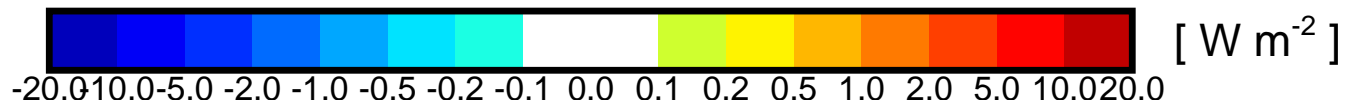
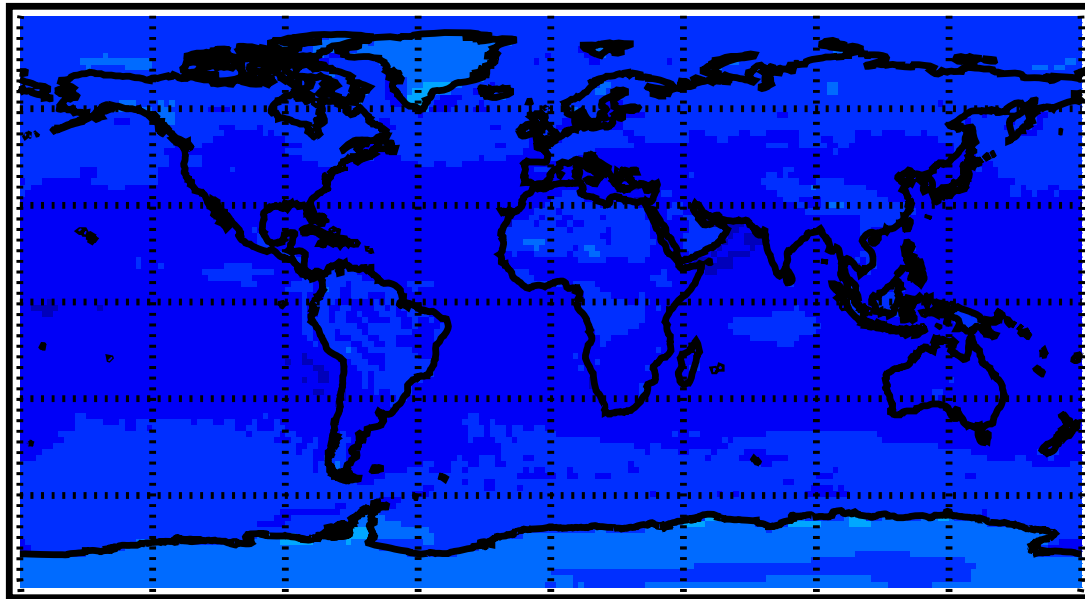
- Asymmetry factor of 0.7 (spectrally flat)
- Single scattering albedos of 1.0 and 0.8 (spectrally flat)
- Forcing calculated from as difference between this setup and zero aerosol case

AeroCom Prescribed 0

Example from ECHAM5.5:

All-sky forcing using AOD=0.2 over lowest 2km, SSA=1.0, g=0.7:

MPIHAM_V2 Forcing All-Sky [W m^{-2}]: -5.79



This corresponds to a normalised radiative forcing (NRF) of 28.95 Wm^{-2} .

Conclusions

- Diversity of Prescribed I results unacceptably large –
Serious concern for general aerosol forcing estimates
- **It seems mandatory to aim for a simpler experiment with wider participation before AR5 deadlines.**

- Proposed deadlines:

30/11/2011: Submissions for Prescribed 0 (this is very easy!)

15/01/2012: Completion of Prescribed 0 analysis and continued analysis
of Prescribed 1 differences

01/03/2012: First draft of publication

01/05/2012: Submission of publication