The CCSM/MICOM based Norwegian earth system model (NorESM): Some results from CAM-Oslo and a first control run.

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Outline

- A first control simulation with fully coupled NorESM
- Early experiments with CAM in NorESM
  - aerosols and interaction with radiation vs. earlier CAM-Oslo version
- Importance of background CDNC for aerosol indirect effects on climate

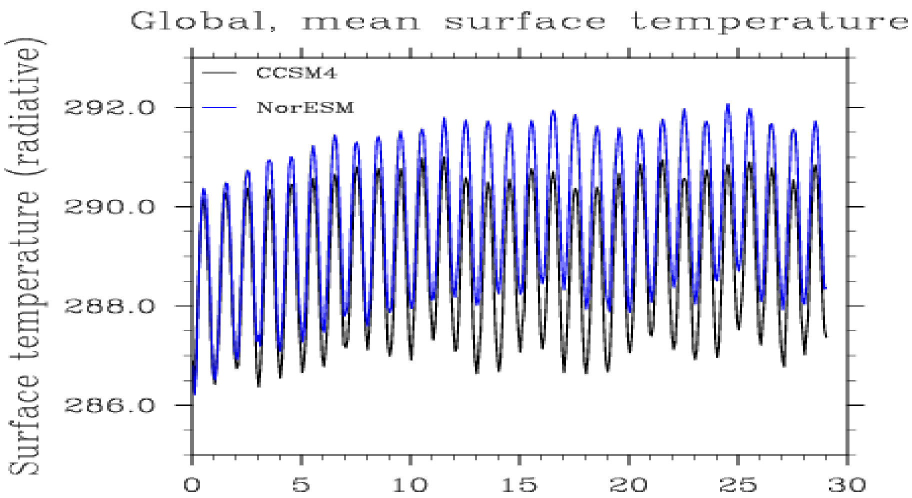
NorESM

based on NCAR CCSM4 alpha 38:

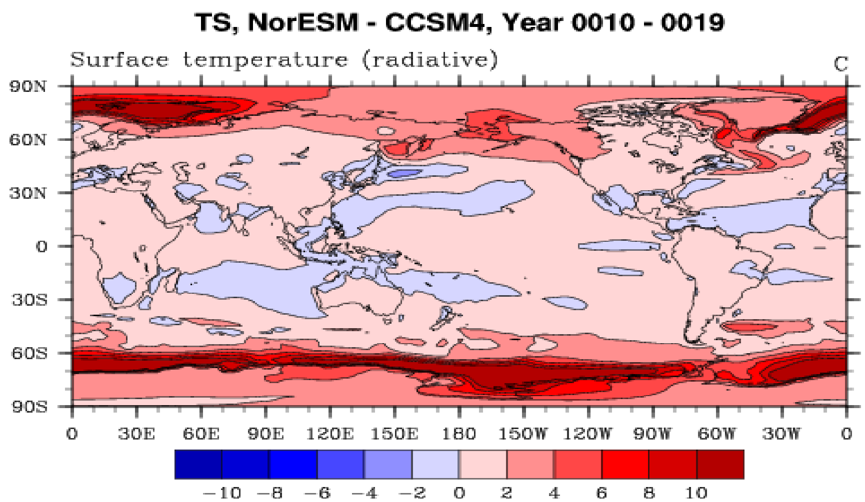
- Atmosphere: CAM-Oslo, based on CCSM4 Atm (CAM4).
  - but using RK instead of MG stratiform cloud microphysics
  - the *published* CAM-Oslo version is based on CAM3
- Ocean: MICOM, version from Bergen Climate Model (BCM)
- Ice: CICE
- Land: CLM
- + near future: interactive carbon cycle with HAMOCC
- + future: coupling with SNICAR for snow albedo effects

First results comparing **CCSM4**_alpha31 and **NorESM** based on alpha31 (with CAM, not CAM-Oslo)

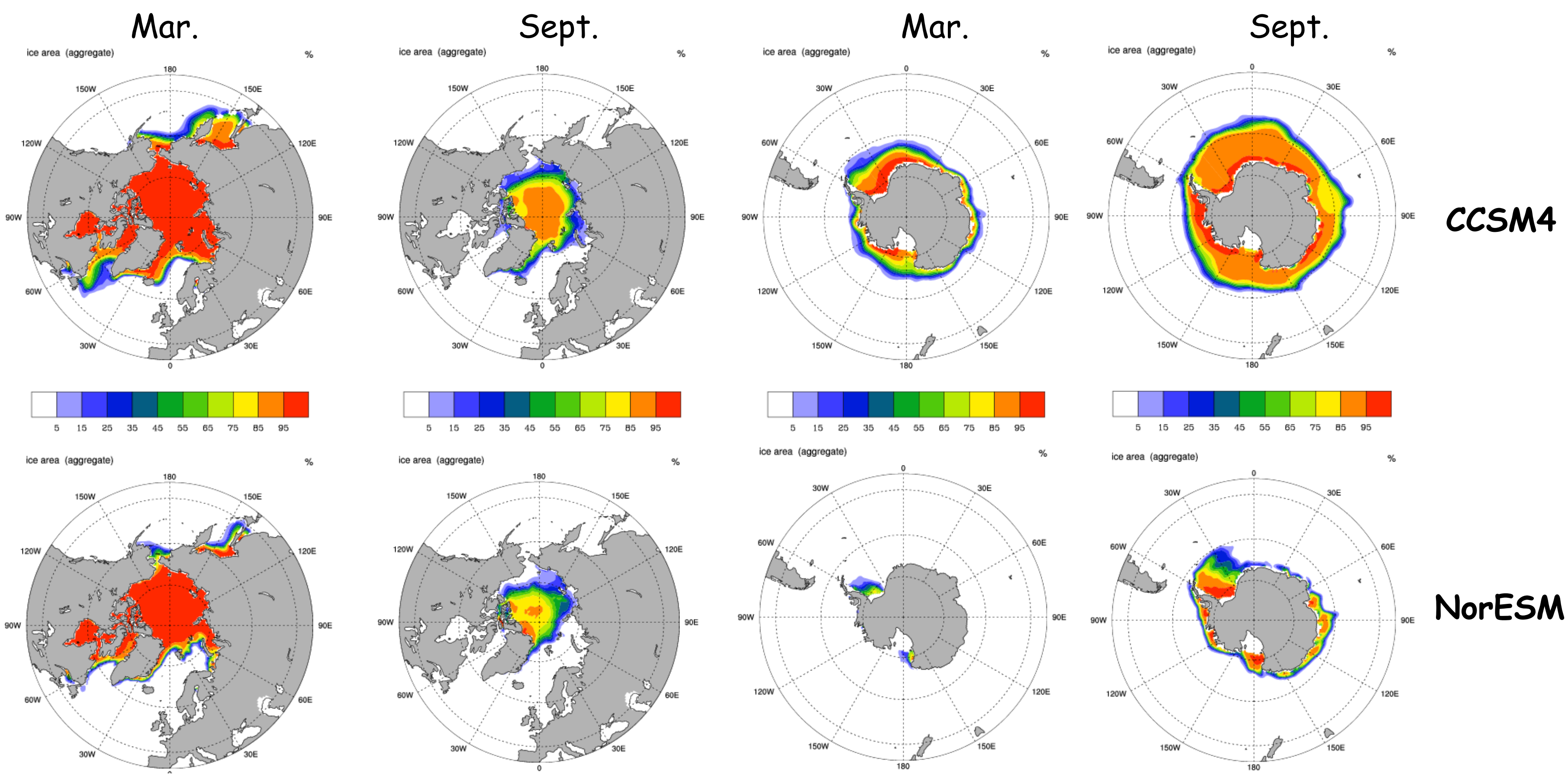
- CAM: FV dycore, 1.9°×2.5° and 26 vertical levels.
- Ocean: gx1v5 default CCSM4 grid, and 35 vertical levels when MICOM is used.
- CICE is configured on the same grid as the ocean.



Global average surface temperature.
NorESM/MICOM vs. CCSM4/POP2.



Surface temperature difference for yr 10-19.

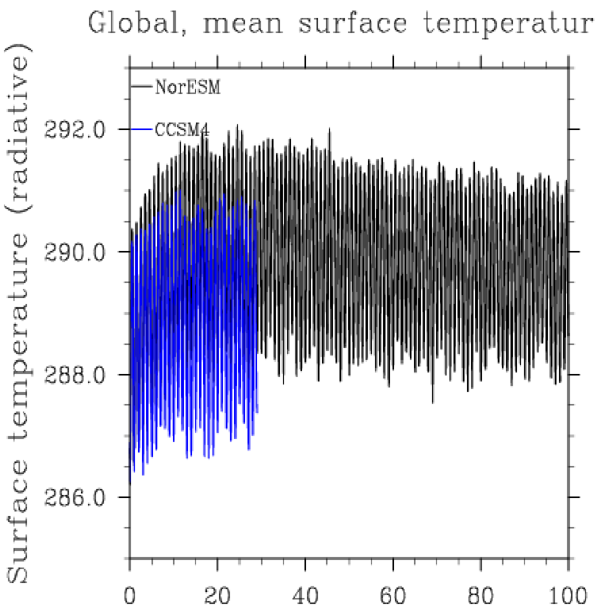


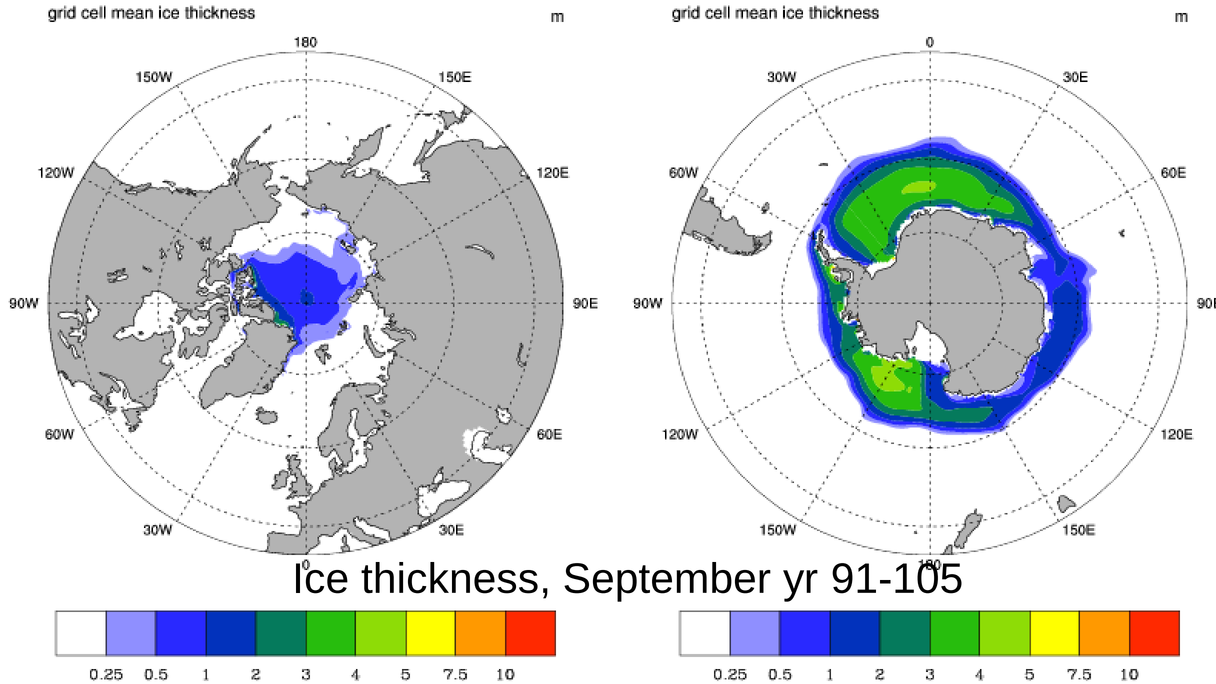
Sea ice concentration for <u>years 10-19</u>.

Although promising, the results indicates a too warm Southern Ocean in NorESM.

Likely cause: the thin, fresh, and cold surface layer is not properly maintained.

Extending the simulation to 108 years ...





Ice thickness, September yr 91-105

- Too much ice around Antarctica, and too little in the Arctic.
- Consistent with vertical mixing problems in MICOM: the mixed layer is too deep and cold.
- Preliminary tests with the alpha 38 version and revised mixed layer representation show great improvements, using
  - turbulent kinetic energy model of Oberhuber (1993) for estimating mixed layer depth
  - new param. of mixed layer restratification by eddies by Fox-Kemper et al. (2008)

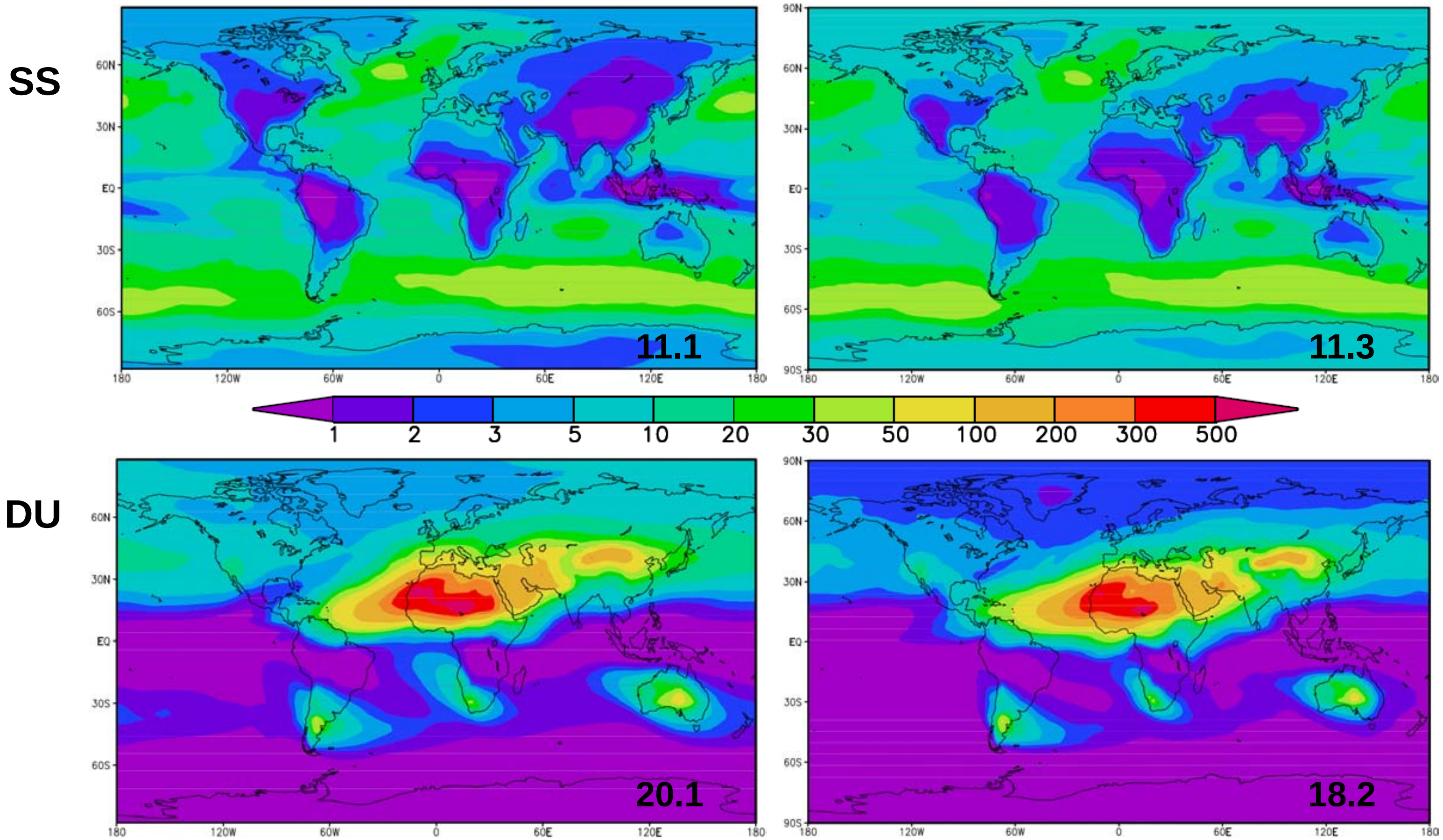
Aerosol-climate interactions in CAM-Oslo / NorESM,
using the Rasch-Kristjánsson stratiform cloud microphysics scheme (RK)

Major changes from NCAR CAM3:

- Aerosol life cycling, physical properties and interaction with clouds and radiation:
  - Seland et al., Tellus (2008), **60A**, 459-491
  - Kirkevåg et al., Tellus (2008), **60A**, 492-512
- Aerosol interaction with clouds is under major revisions:
  - Tellus (2008) version:
    CDNC = CCN(S) with prescribed super-saturations, S } used in this talk
  - Based on Storelvmo et al., Env. Res. Lett. (2008), **3**:
    Under implementation:
    prognostic CDNC scheme using realised supersaturations
    Future work:
    include prognostic IN scheme for cold and mixed phase clouds

(This is the background for chosing RK instead of MG cloud microphysics…)

Aerosol column burdens (mg m^{-2})



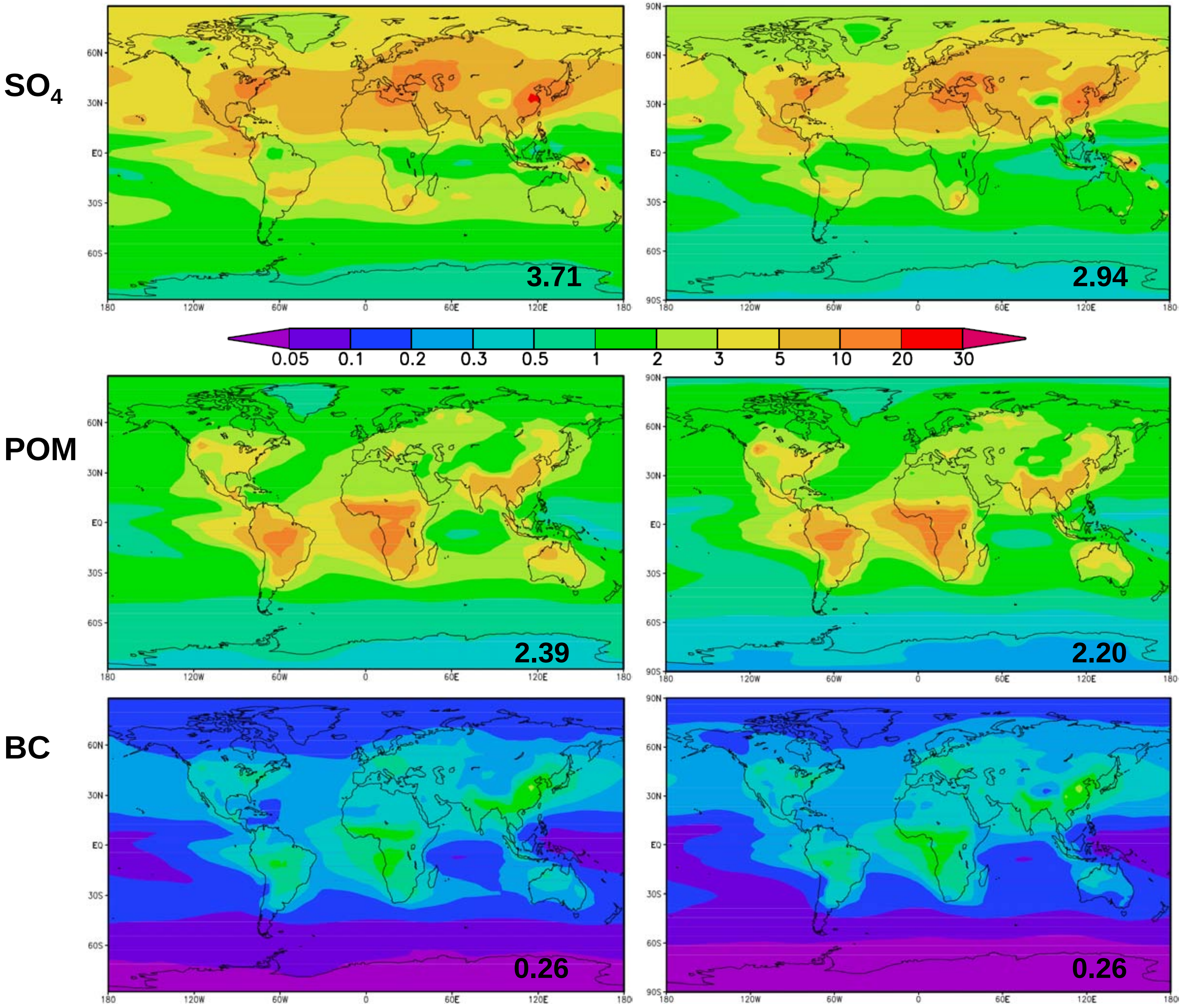
CAM-Oslo

CAM-Oslo/NorESM

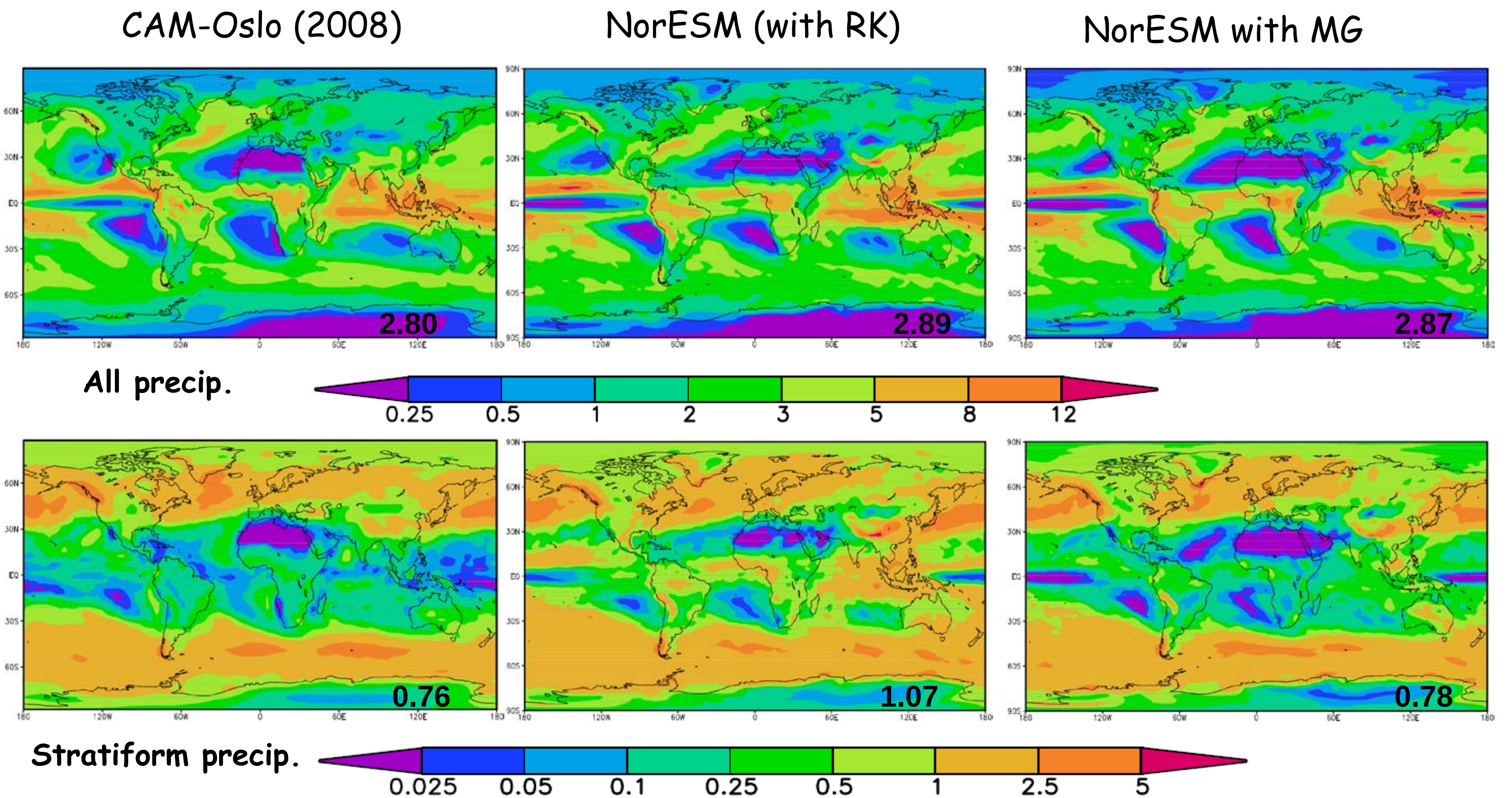
(Seland et al., 2008)

Version under development, with meteorology forced by standard CCSM4 aerosol and clouds (1 yr simulation with 3 months spin-up)

Aerosol column burdens (mg m^{-2})



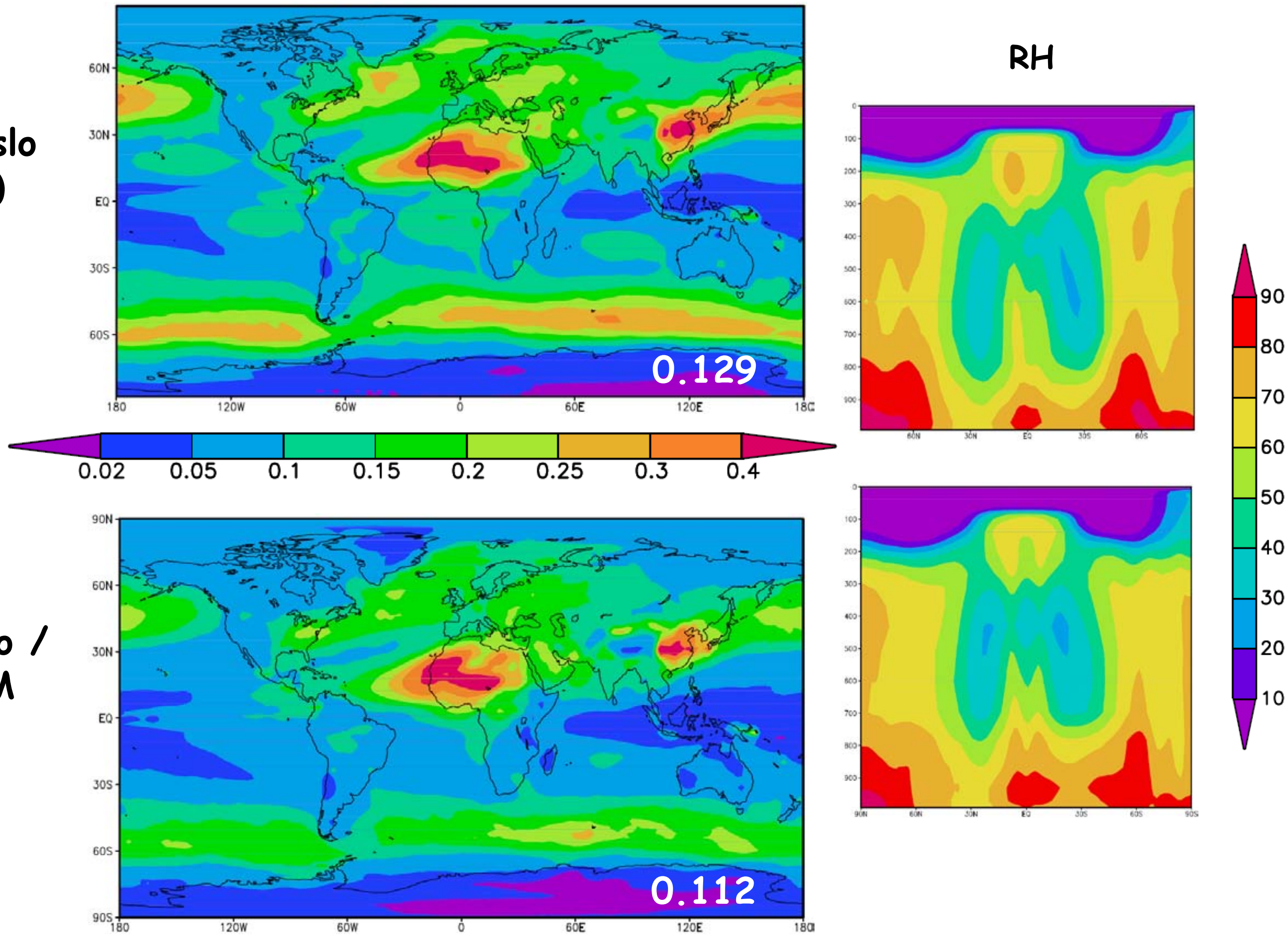
Precipitation (mm/day)



Aerosol optical depth (0.35-0.64 μm)

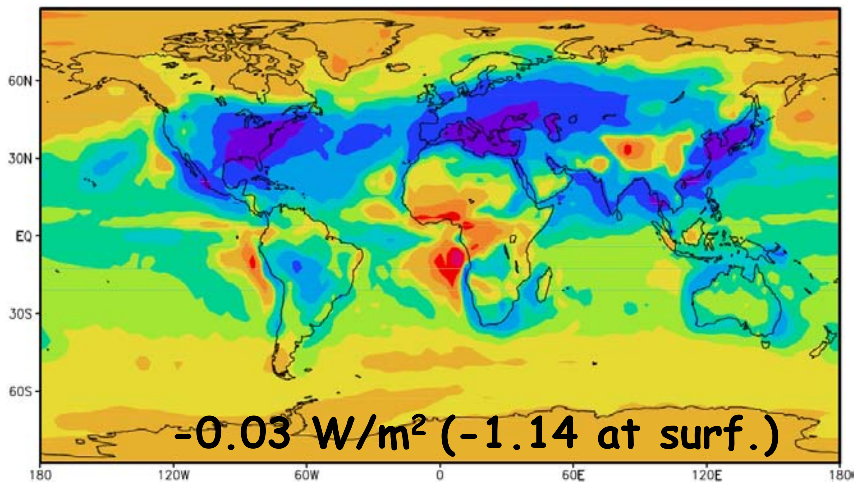
CAM-Oslo (2008)

CAM-Oslo / NorESM

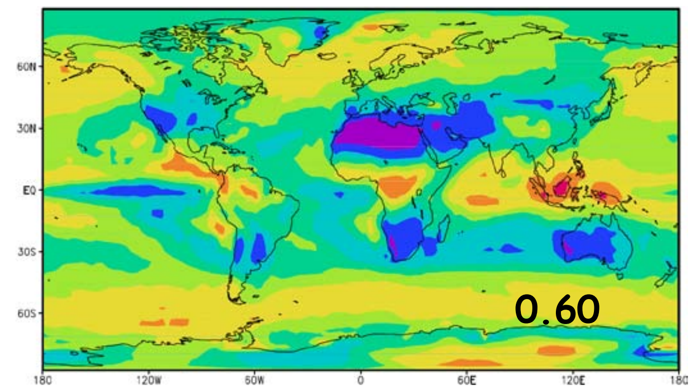


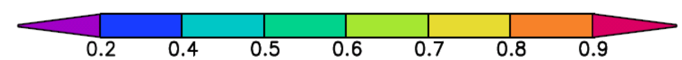
TOA Direct radiative forcing (PD-PI)

CAM-Oslo (2008)

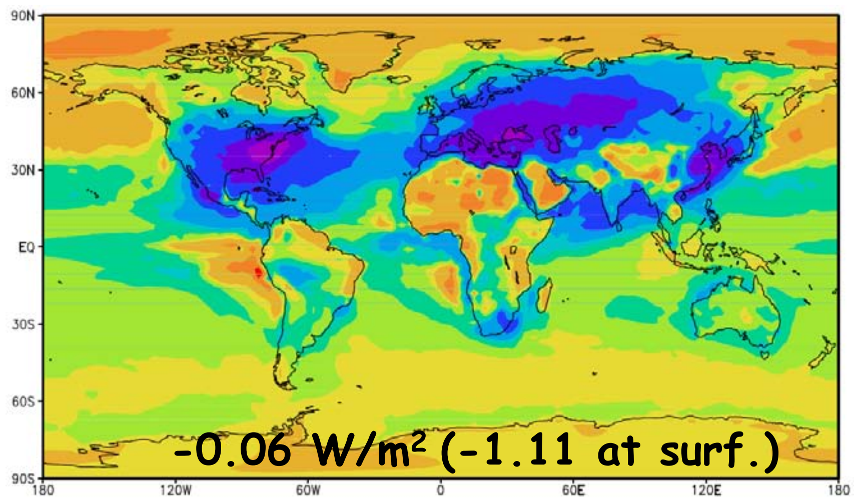


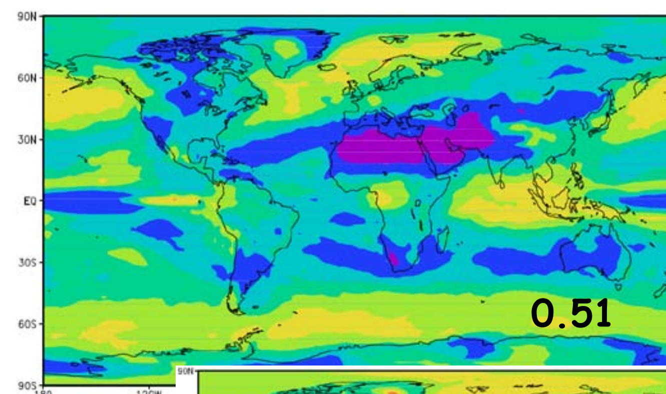
Total cloud cover



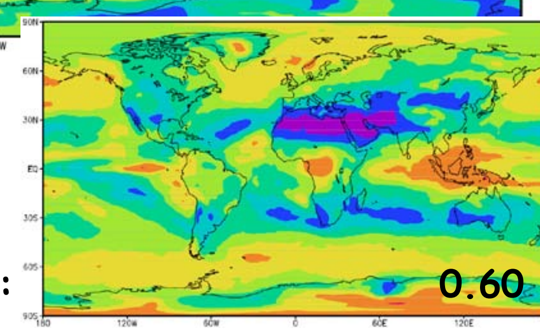


CAM-Oslo / NorESM





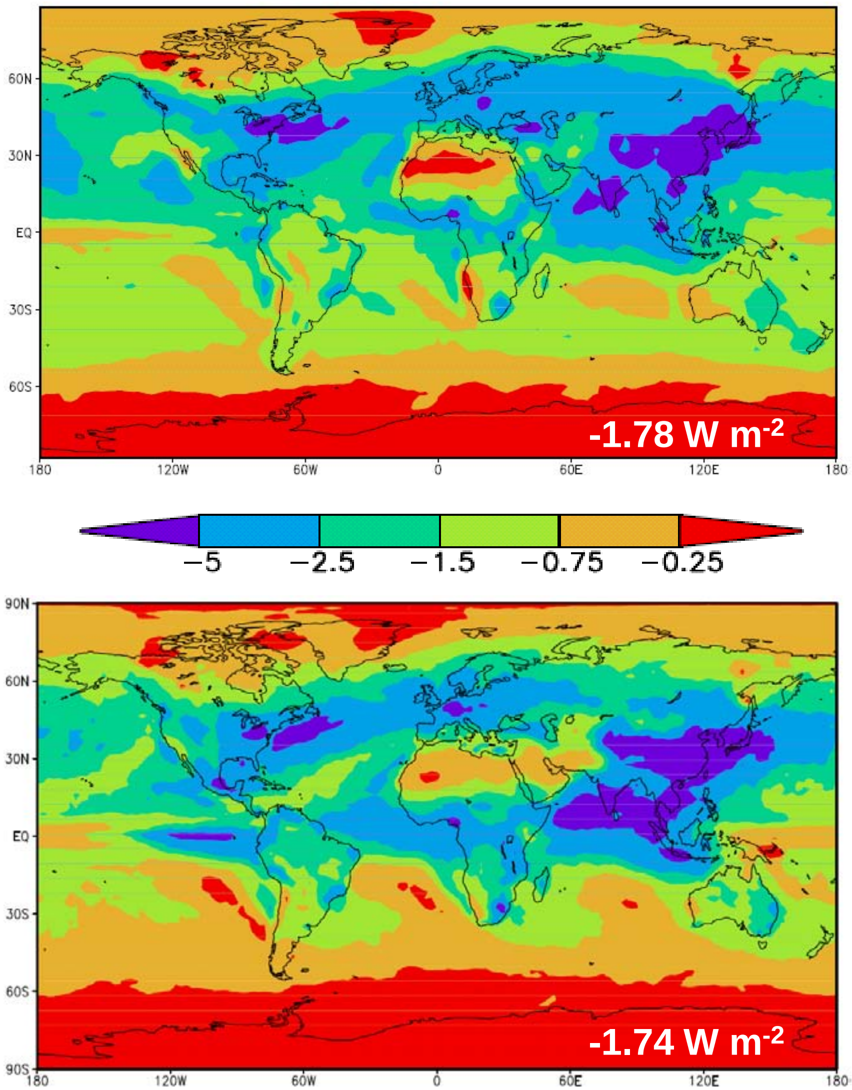
with MG:



1. indirect radiative forcing (PD-PI)

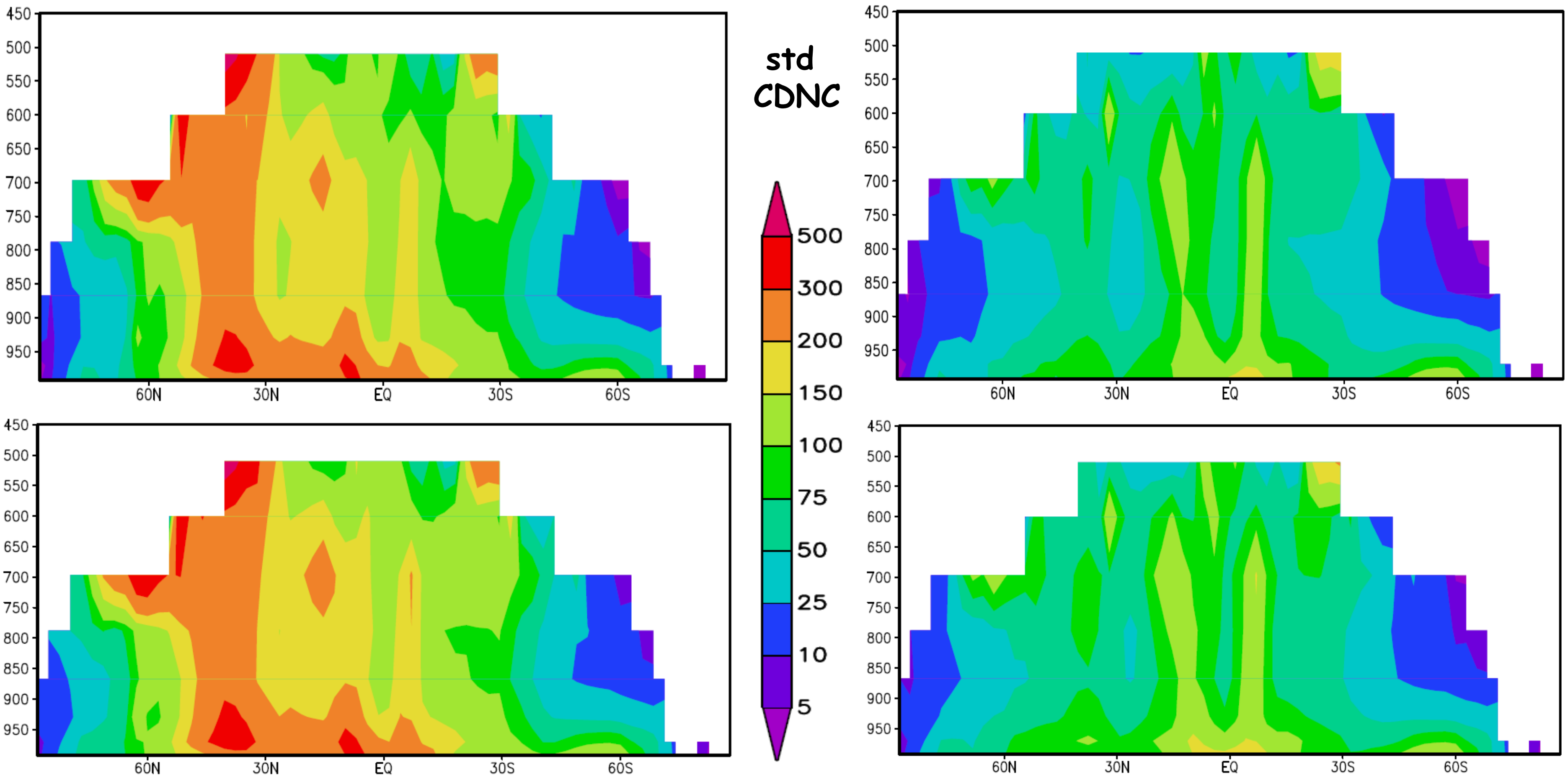
CAM-Oslo (2008)

CAM-Oslo / NorESM



Sensitivity of aerosol indirect effects to background CDNC
in CAM-Oslo (2008)

Present day (PD) | Pre-industrial (PI)

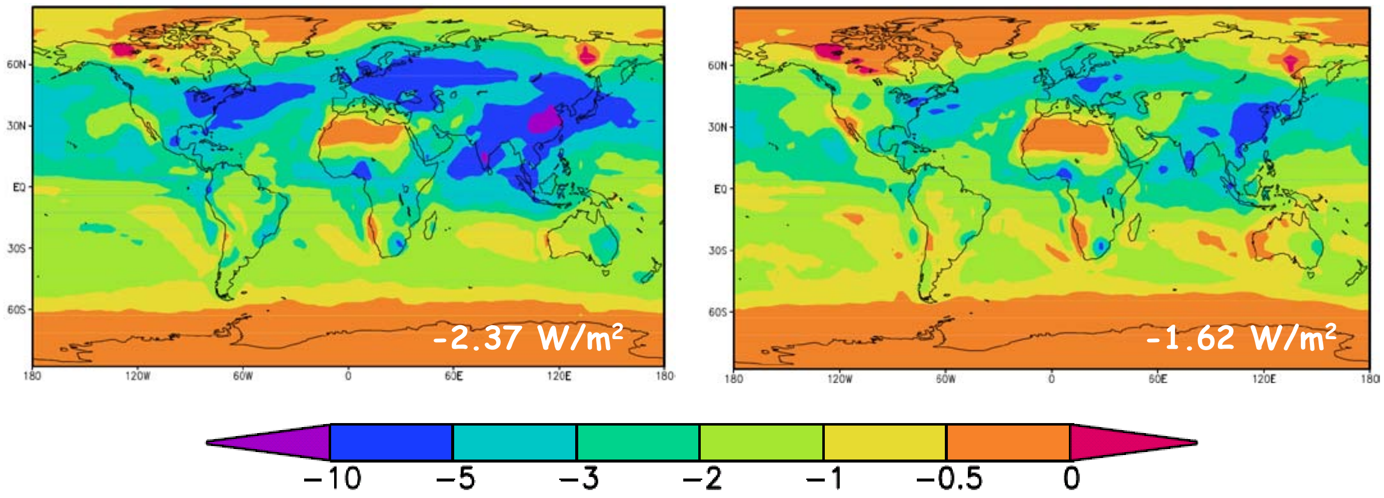


Adding natural CDNC: **std CDNC +** { **17 cm^{-3}** over continents except Antarctica; **3 cm^{-3}** over oceans and Antarctica }

1+2. indirect SW radiative forcing in CAM-Oslo

std CDNC (Tellus, 2008)

std CDNC + **17 cm^{-3}** (cont.)
3 cm^{-3} (ocean)



Δ LWP (g m^{-2}) =	9.30	5.79
Δ Reff (μm) =	-1.43	-1.09

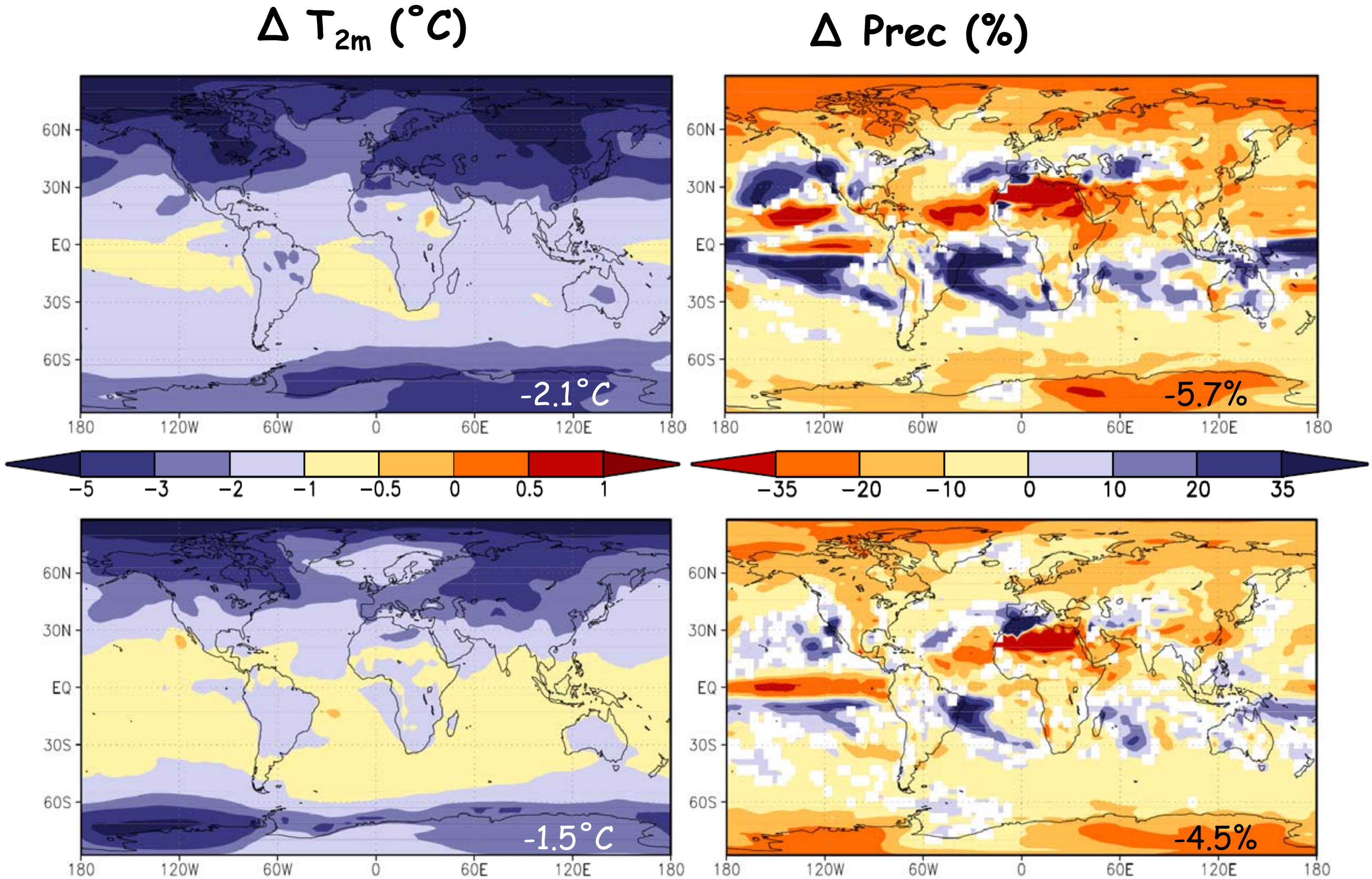
Decrease in indirect SW radiative forcing: 32%

Equilibrium climate response to aerosols:

results from the year 16 - 30 from online simulations (PD-PI) with **CAM-Oslo + slab ocean**

std CDNC

Kirkevåg et al. (2008)



std CDNC
+ { **17 cm^{-3}** (cont.)
3 cm^{-3} (ocean)

~ 28% weaker temperature response

Summary

- Early control simulations with NorESM
  - the first results indicates a too warm Southern Ocean, but
  - tests with revised mixed layer representation show great improvements
- Aerosol radiative forcing is similar to previous CAM-Oslo results, although
- Sulfate column burdens are much lower
  - Production and deposition are sensitive to cloud volume and precipitation
  - Use of MG microphysics gives increased sulfate burdens
  - More tuning is needed with our RK version: input is appreciated!
- Sensitivity to natural background aerosols / CDNC
  - is large for aerosol indirect effects (AIE) of warm clouds
    - natural aerosols are also important to get right !
    - constraining AIE with imposed thresholds on CDNC is problematic
- Scheme for prognostic CDNC and realized supersaturations almost finalized for use in CAM-Oslo / NorESM (→ smaller AIE)
- Finally: should we use the new RRTMG radiation scheme?

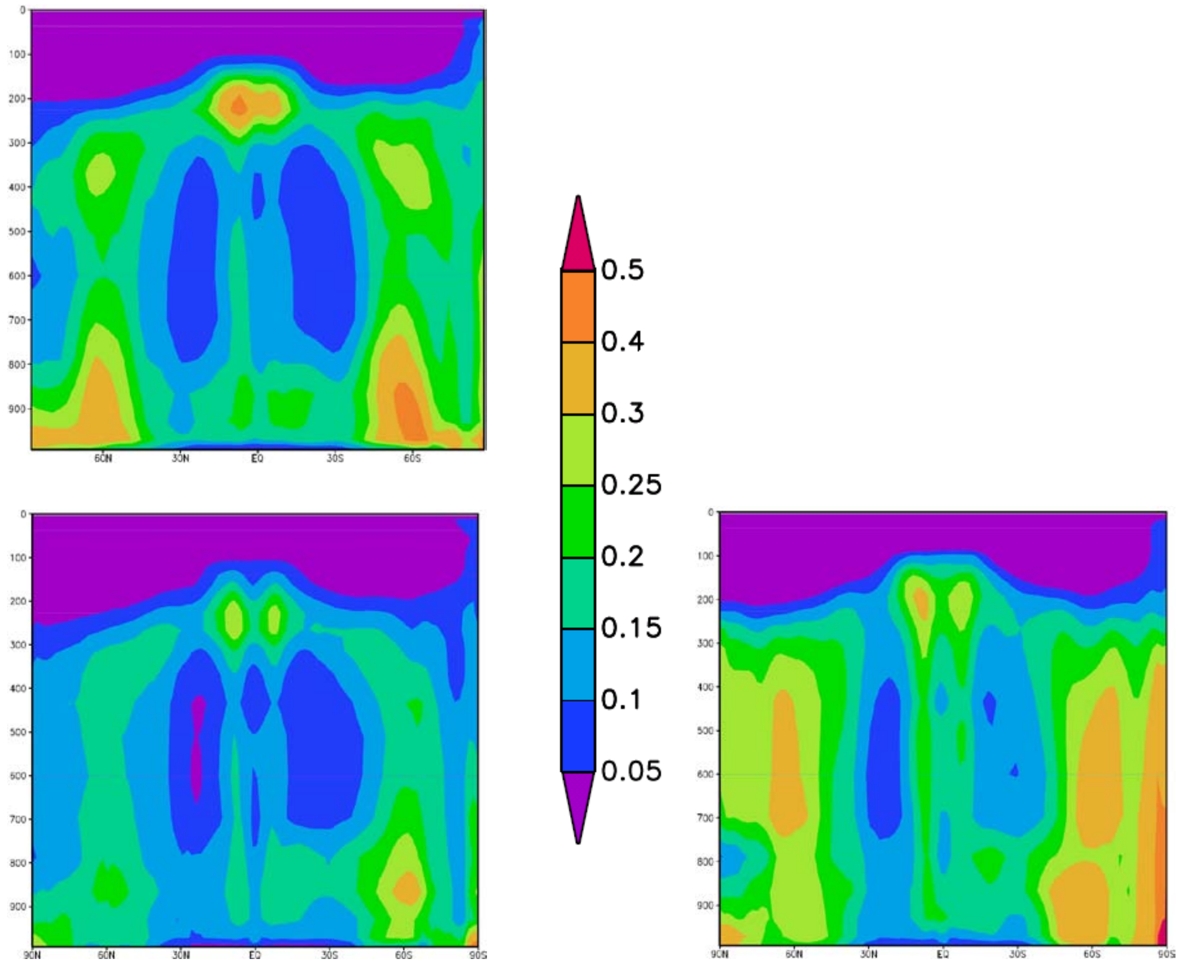
Extra slides

Cloud fraction (cloud)

with RK — **with MG**

CAM-Oslo (2008)

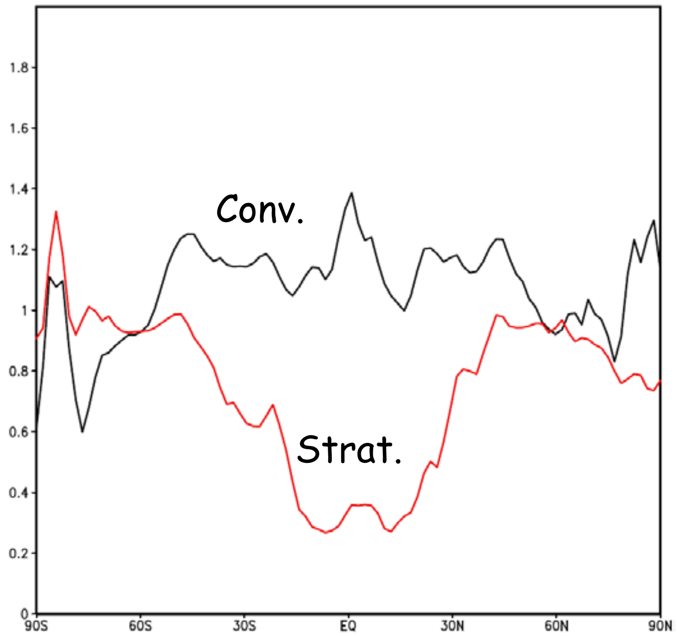
CAM-Oslo / NorESM



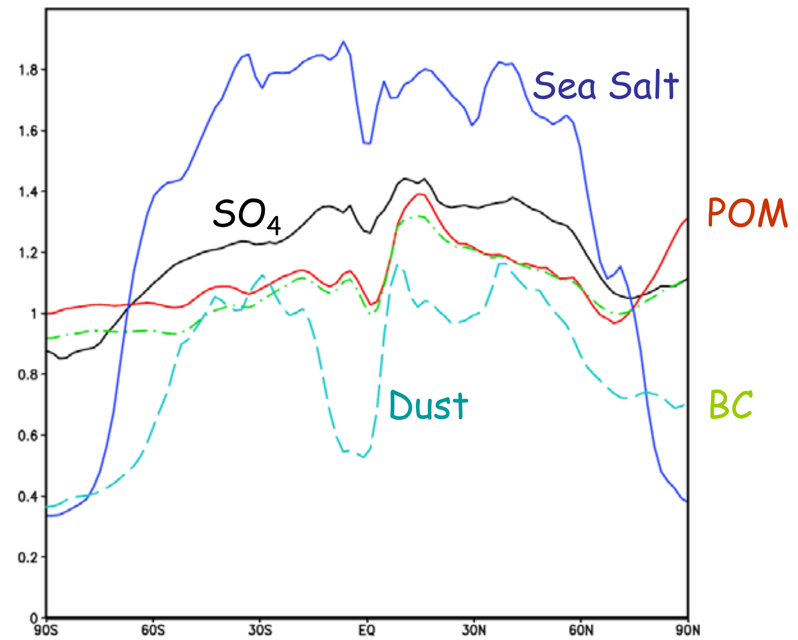
So far no tuning of RH_c has been performed after replacing MG with RK...

(NorESM with MG) / (NorESM with RK) ratio:

Precipitation (mm/day)



Column burdens



Note: These ratios include an update in the treatment of dry-deposition from the RK to the MG model versions.

Present day (PD) Cloud Droplet Number Concentrations (CDNC)