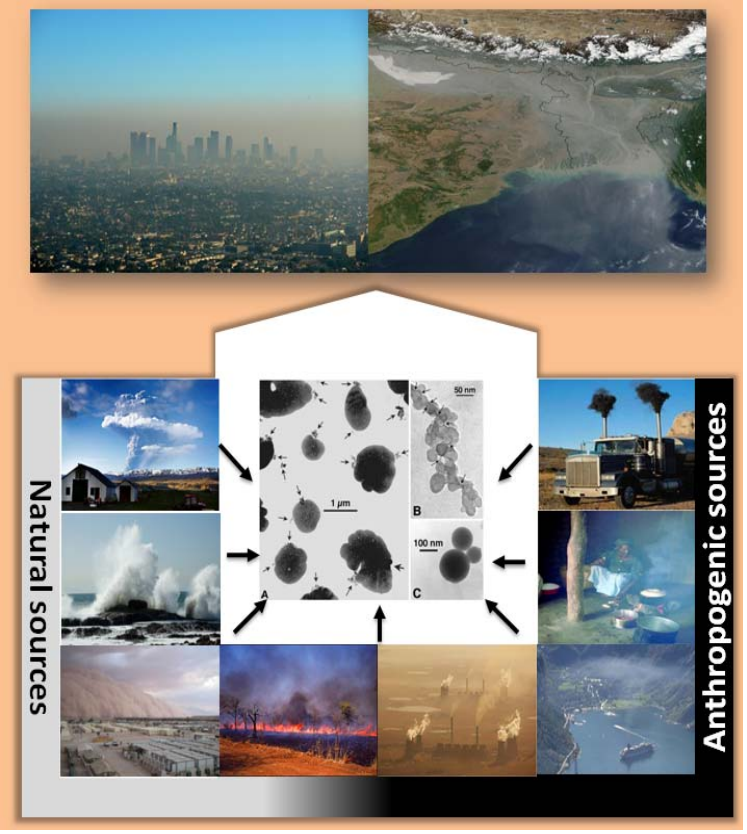
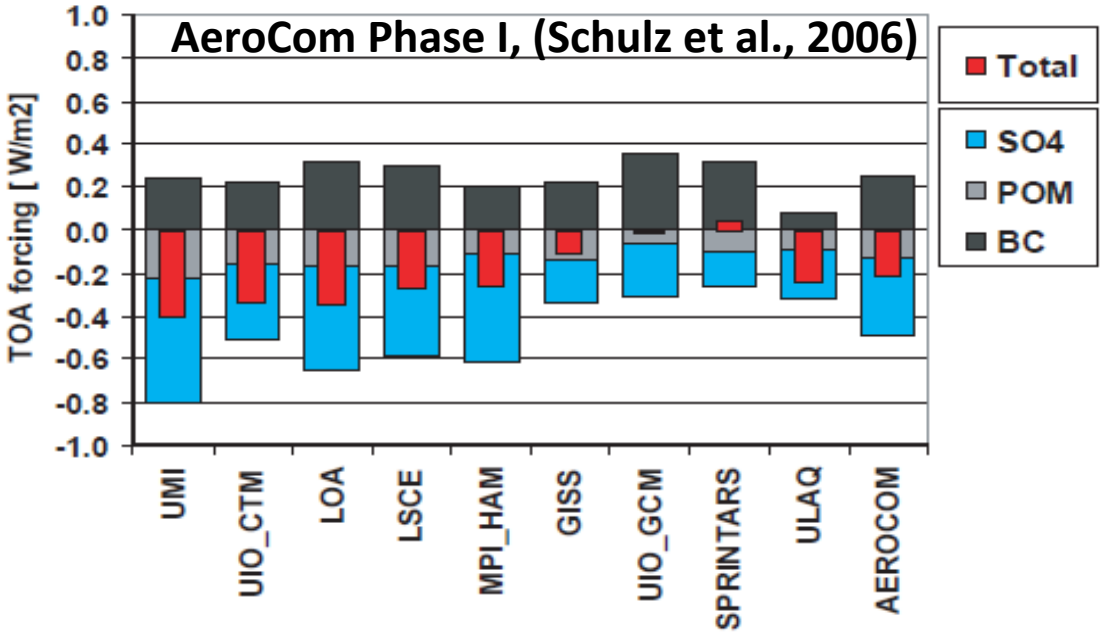
Direct aerosol effect from multi-model simulations in AeroCom Phase II

G. Myhre, B.H. Samset, S. Bauer, N. Bellouin, T. Berntsen, H. Bian, M. Chin, R. Easter, J. Feichter, S. Ghan, T. Iversen, A. Kirkevåg, X. Liu, M. Schulz, Ø. Seland, R. Skeie, P. Stier, T. Takemura, Tsigaridis, Z. Wang, F. Yu, H. Yu, H. Zhang, K. Zhang + +

Two main scientific questions:

- Do the current global aerosol models in AeroCom Phase II show smaller difference in the direct aerosol effect compared to Phase I?
- What is causing the largest uncertainty in the direct aerosol effect, **aerosol burden** or **optical and radiative properties**?



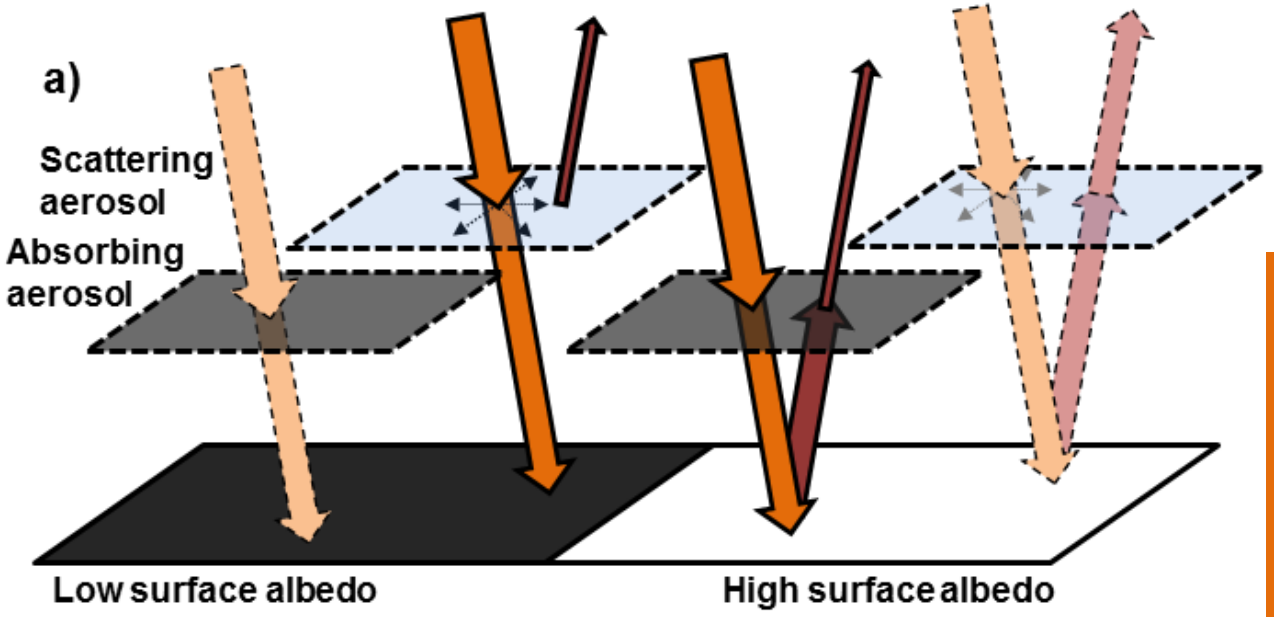


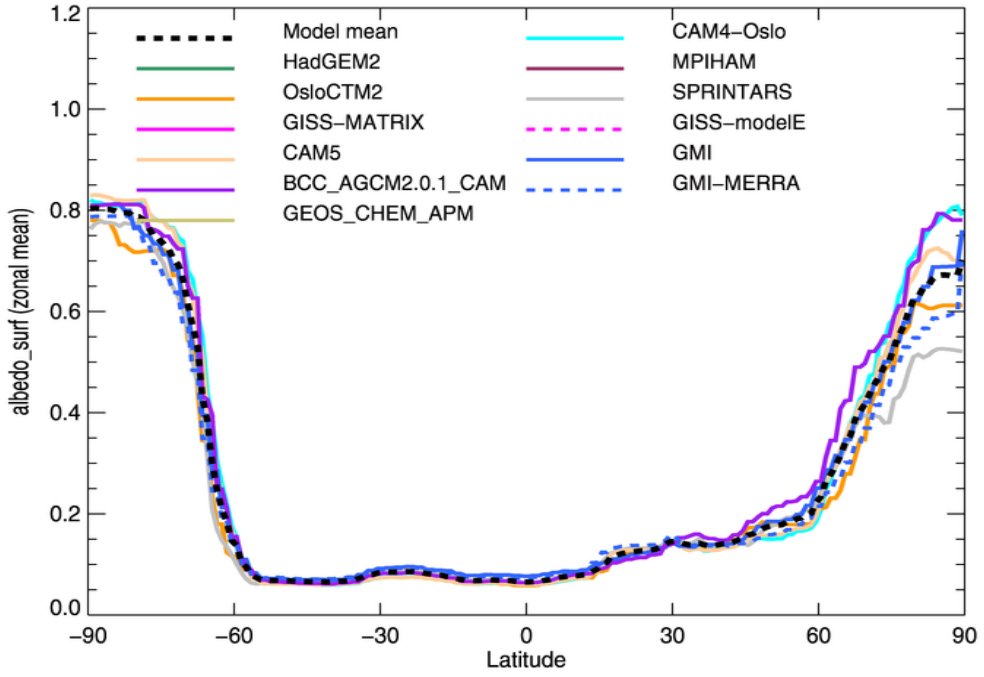
- Have the differences between the models changed from Phase I to Phase II?
- What is causing the largest uncertainty in the direct aerosol effect, **aerosol burden** or **optical and radiative properties**?
- Note that the AeroCom Phase II results are preliminary and updates at a later stage may occur. So far 12models in Phase II

Overview

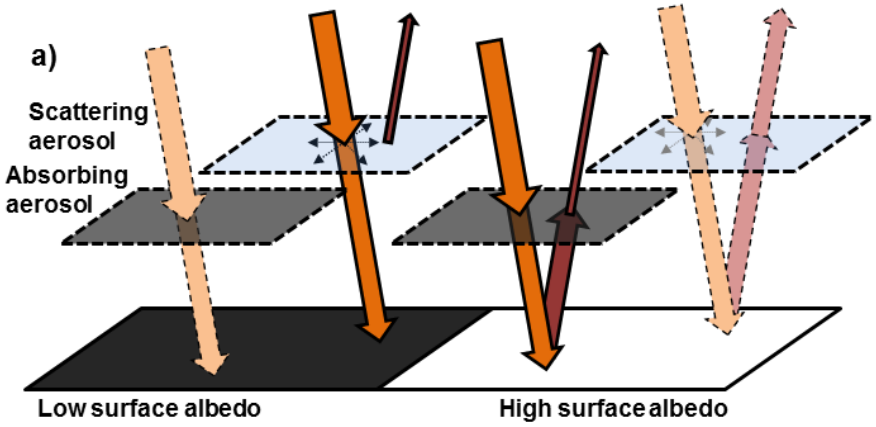
- Some general model performances
- Details on some of the aerosol components
- Main radiative forcing results
- An attempt to understand some of the differences in RF

Models
CAM4-Oslo
HadGEM2-ES
MPIHAM_V2_KZ
OsloCTM2
SPRINTARS-v384
GISS-MATRIX
GISS-modelE
GMI
CAM5
BCC_AGCM2.0.1_CAM
GEOS_CHEM_APM
(GOCART)

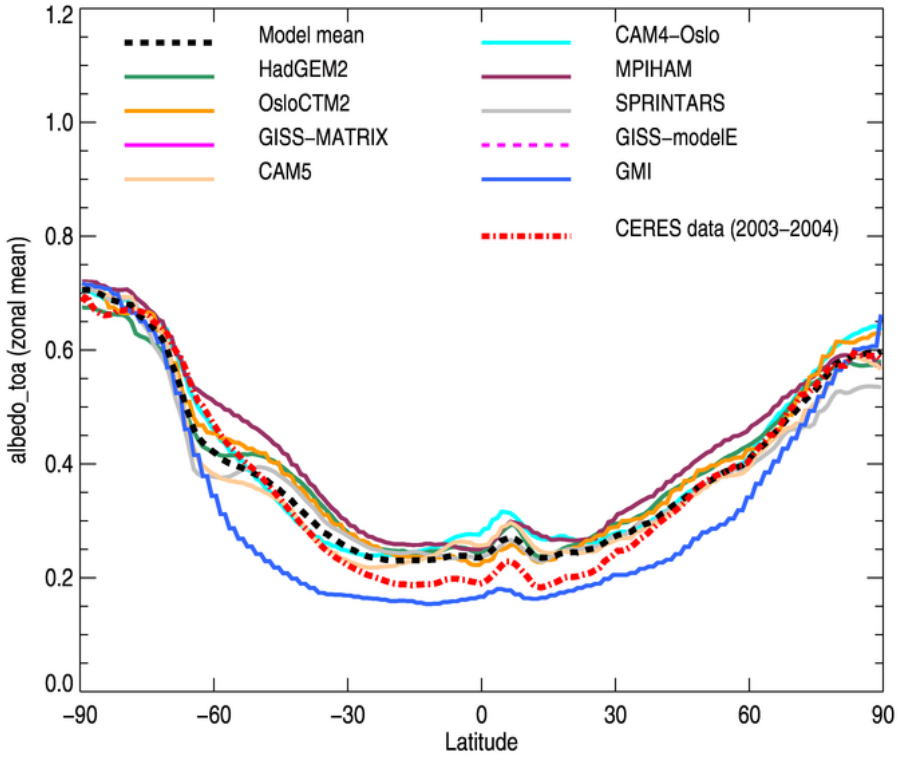




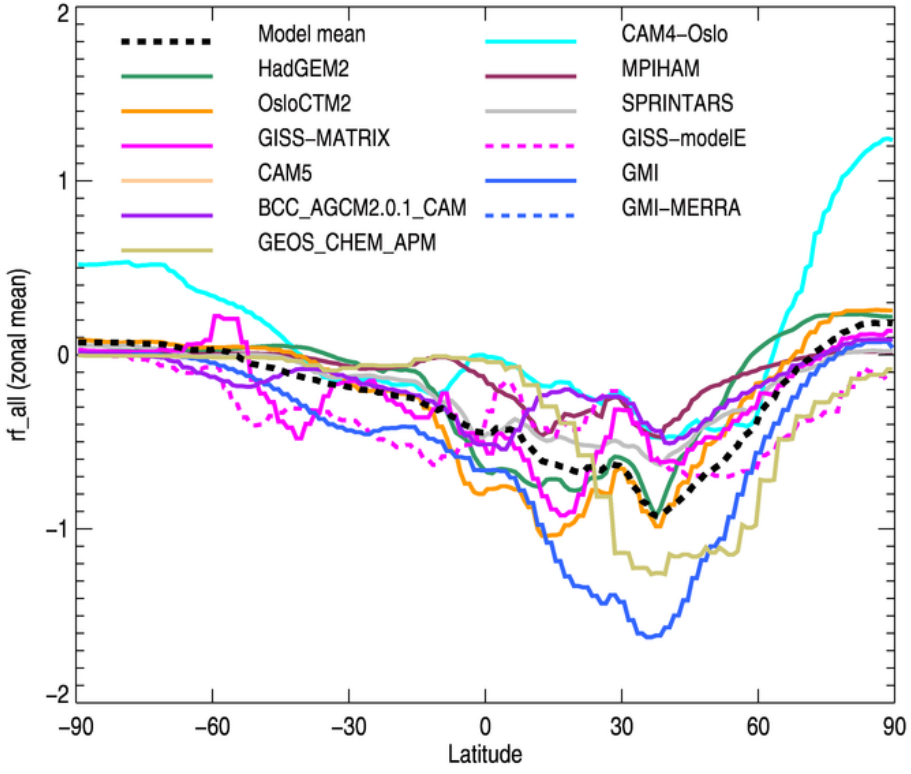
- **Radiative forcing of direct aerosol effect highly dependent on albedo**
- Does albedo differ in the various models?



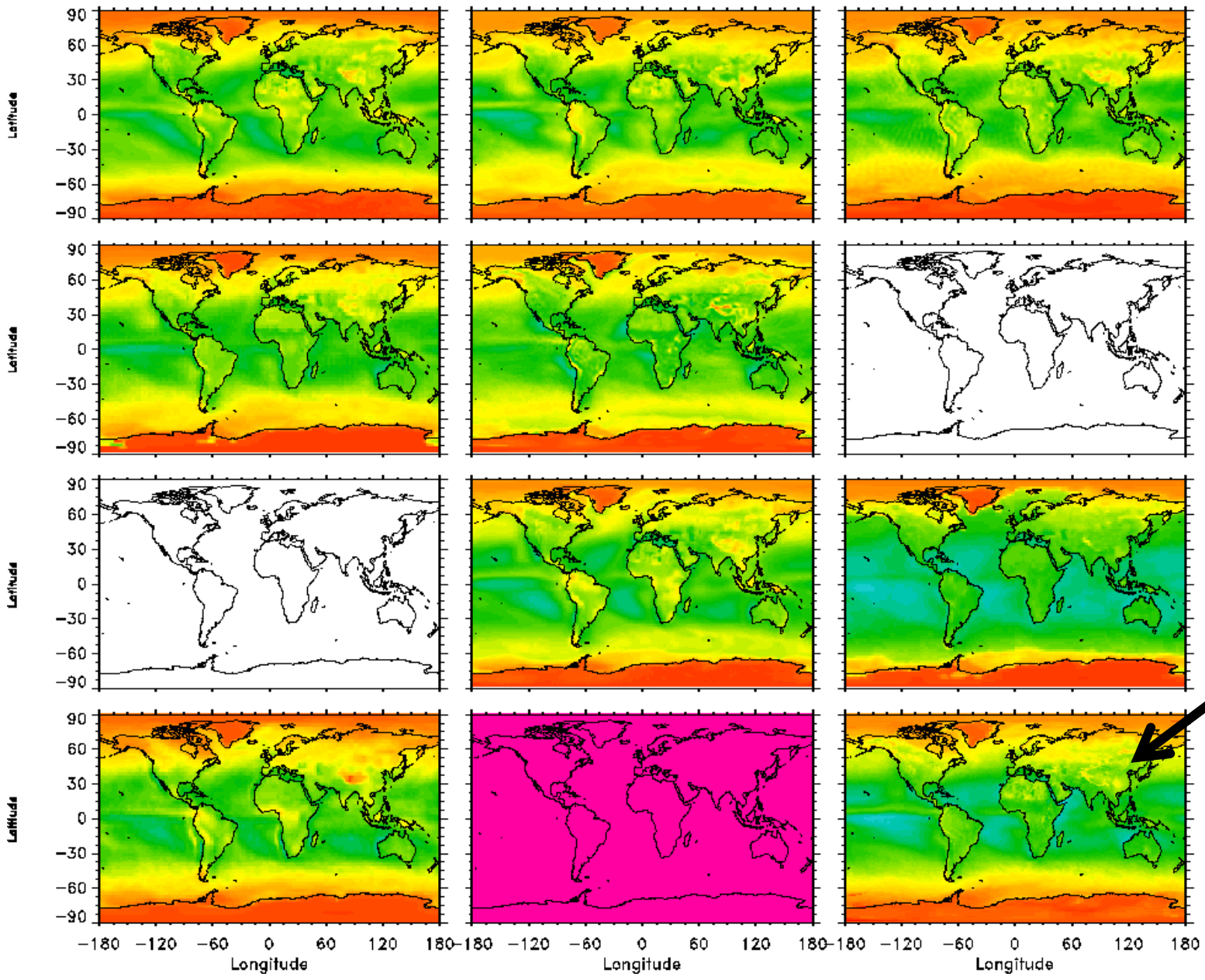
TOA albedo



Radiative forcing (Wm^{-2})



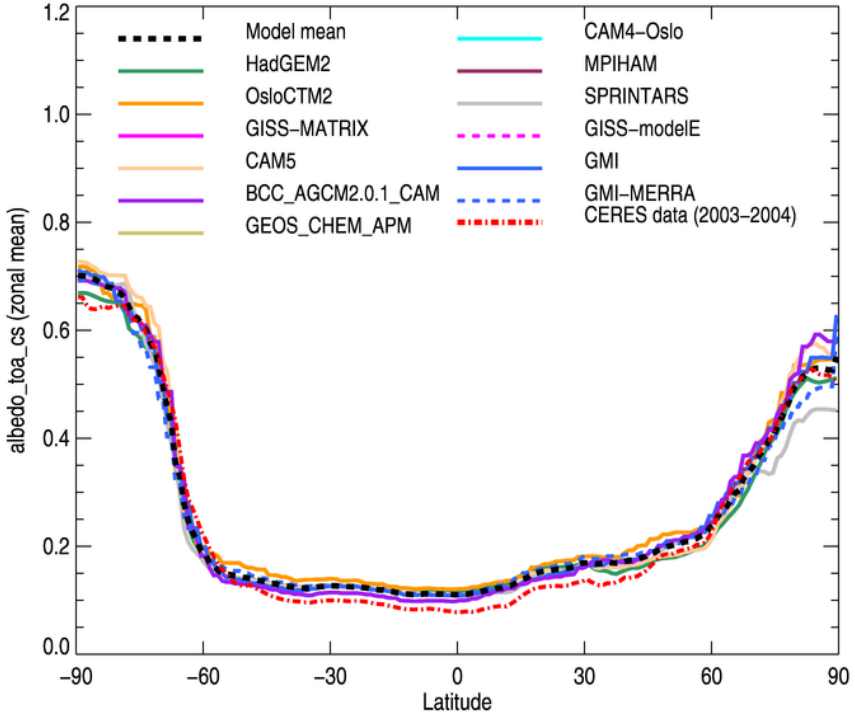
TOA albedo



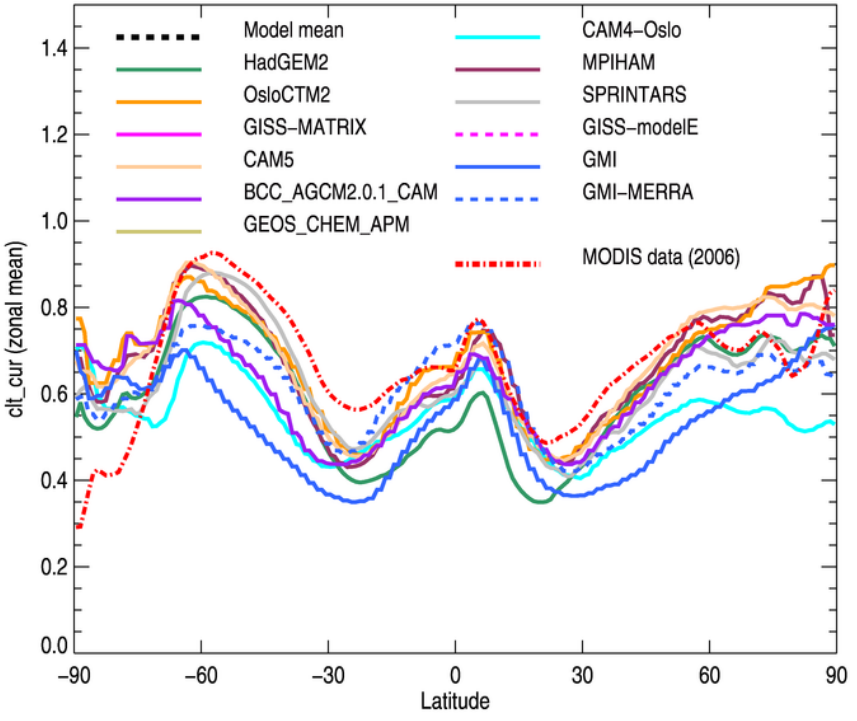
1) CAM4-Oslo
2) HadGEM
3) MPIHAM
4) OsloCMT2
5) SPRINTARS
6) GISS-MATRIX
7) GISS-modelE
8) CAM5
9) GMI
10) BCC
11) GEOS

More on albedo …

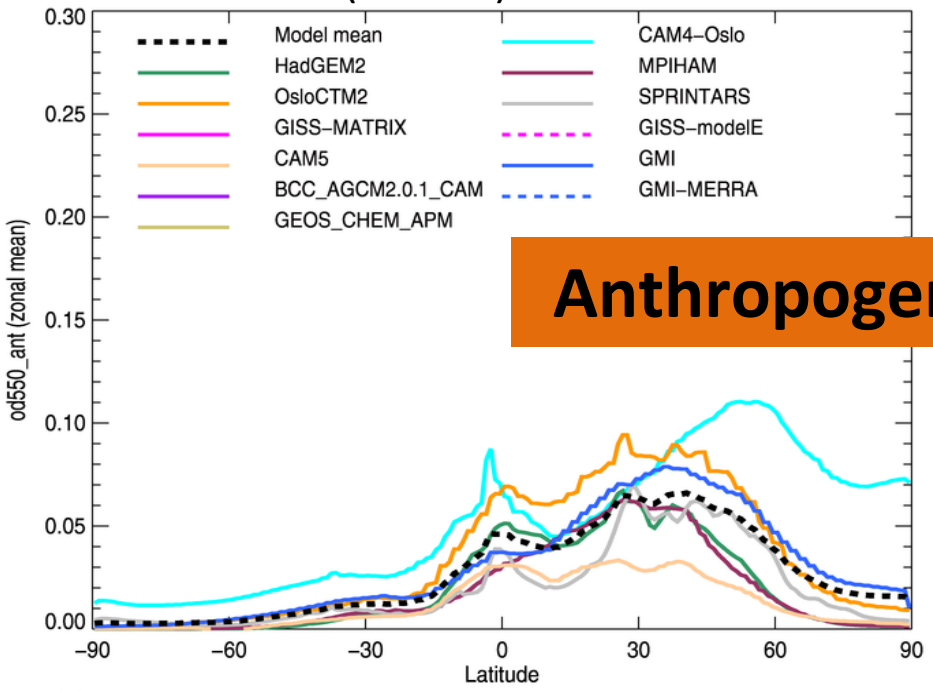
TOA albedo clear sky



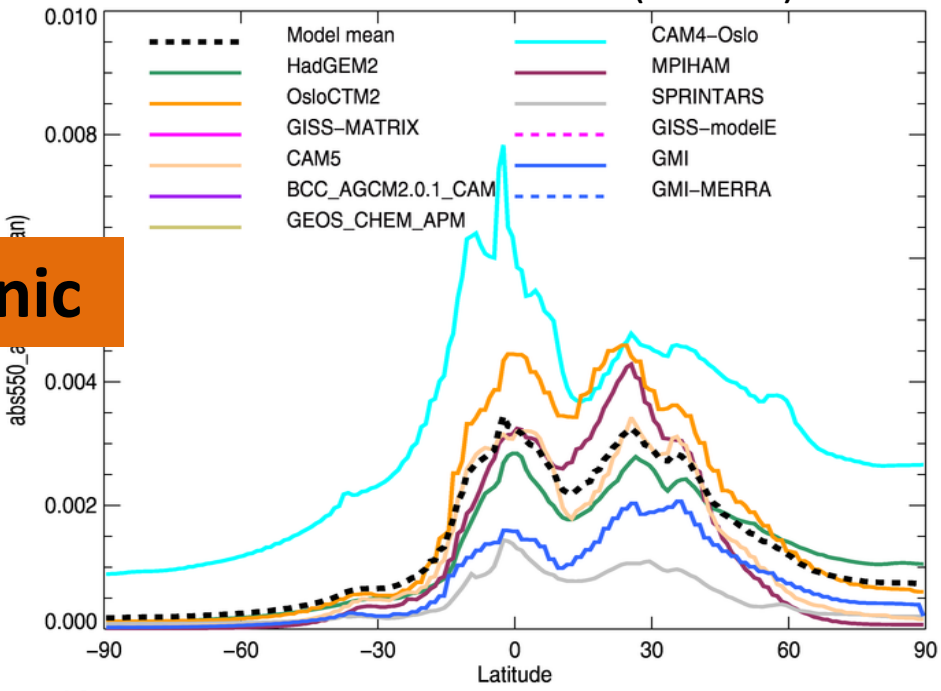
Cloud cover



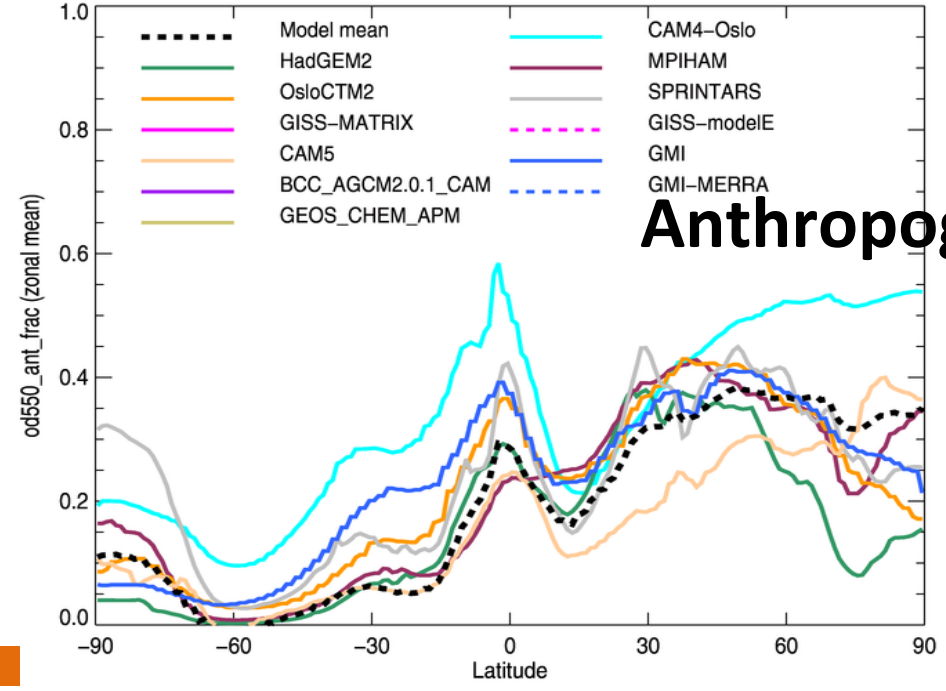
AOD (550nm)



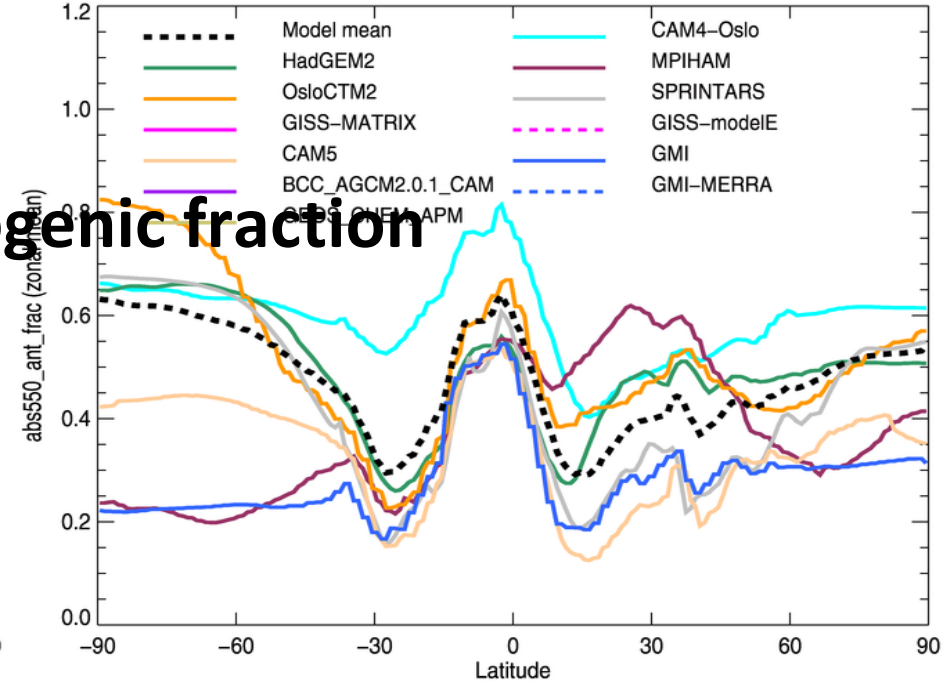
ABSORPTION AOD (550nm)



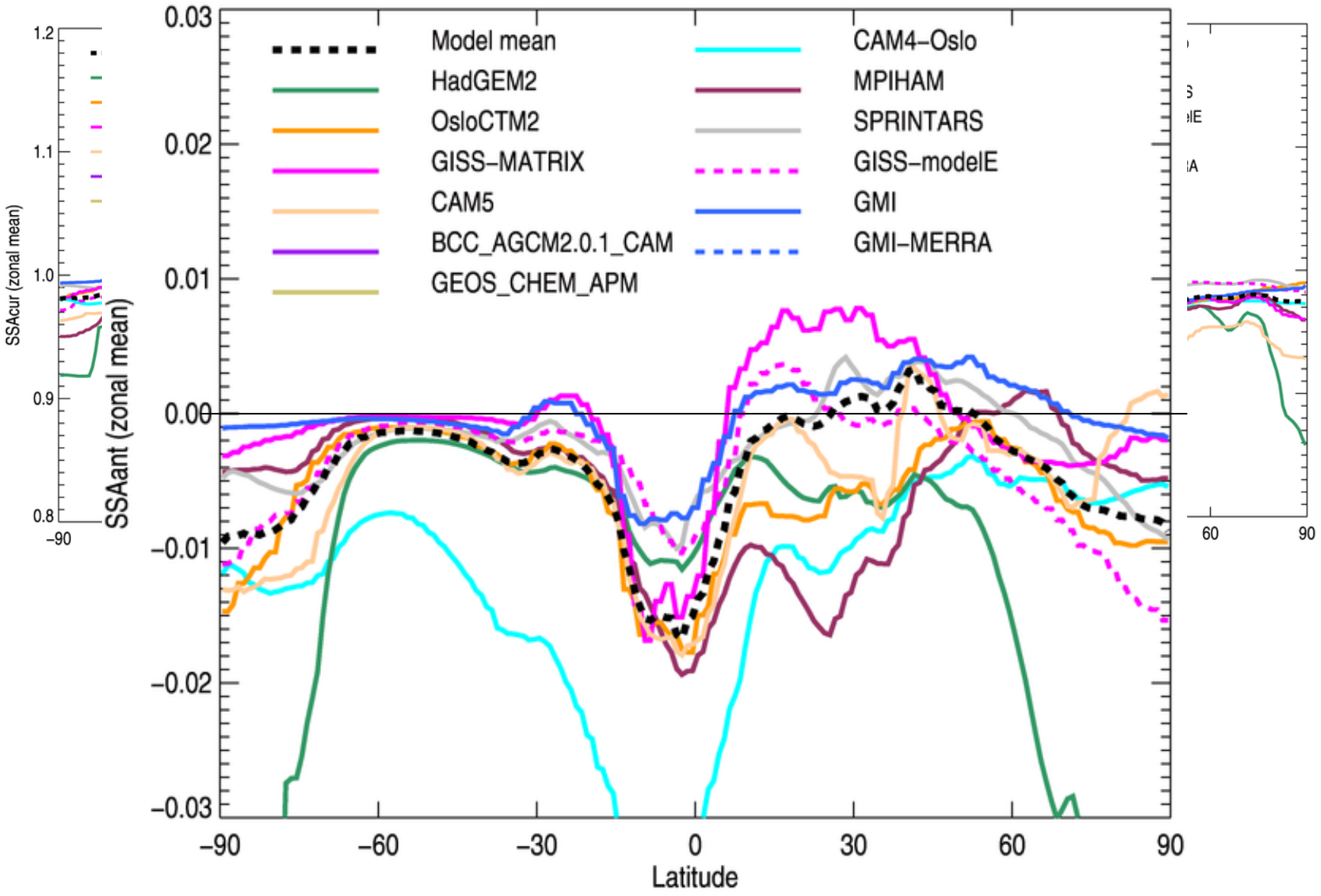
Anthropogenic



Anthropogenic fraction

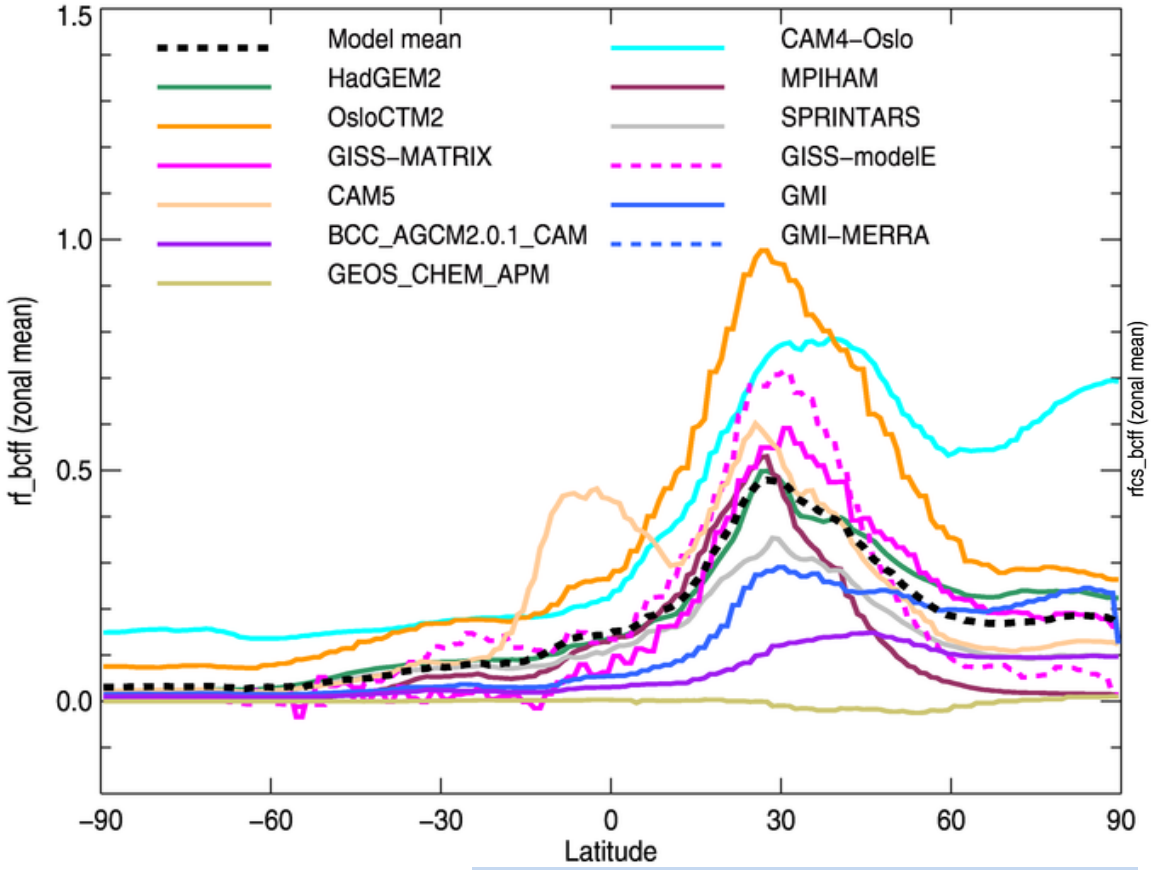


Single scattering albedo

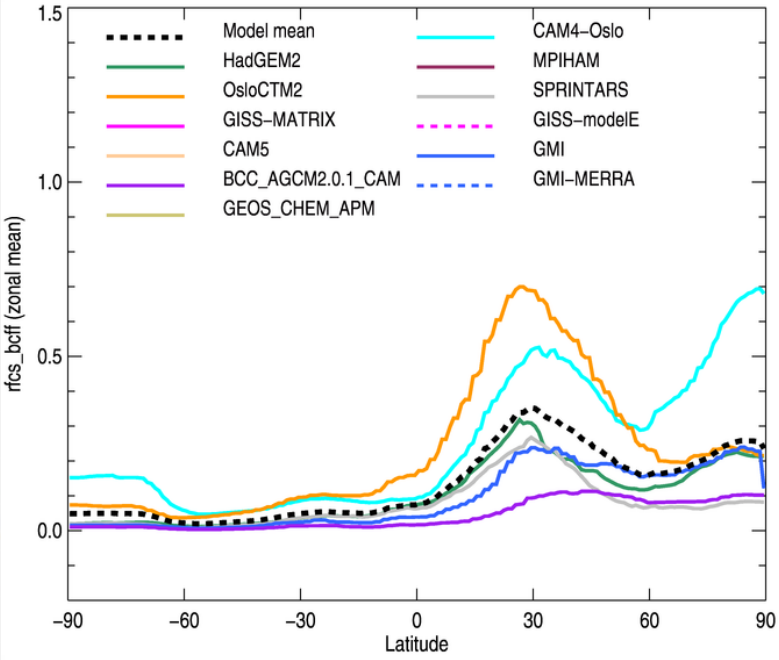


RF [W/m2] for BC from fossil fuel

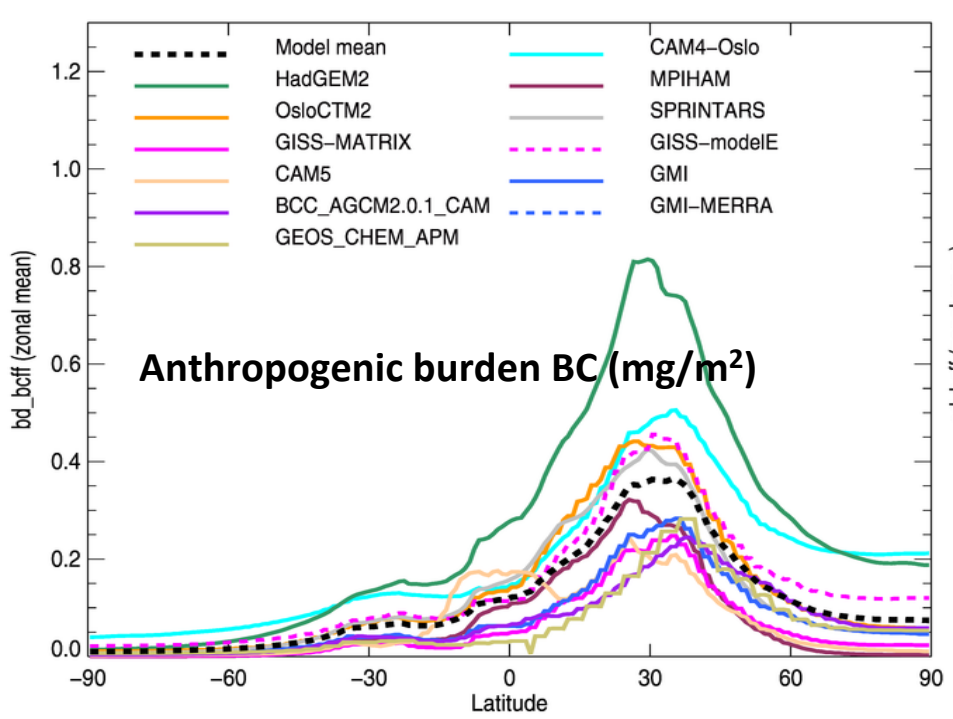
All sky

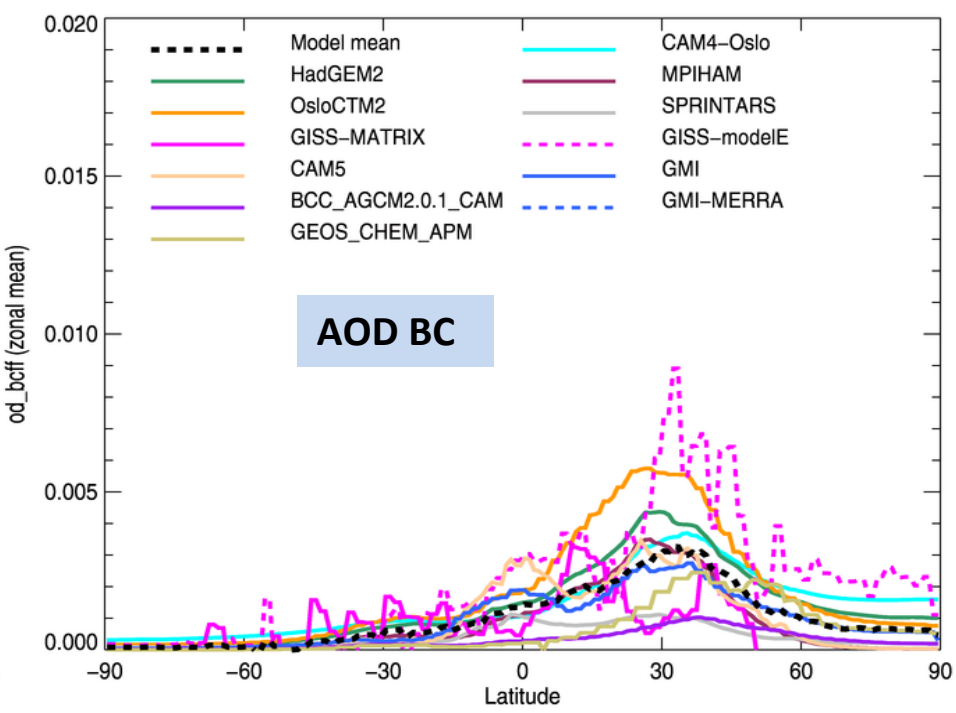


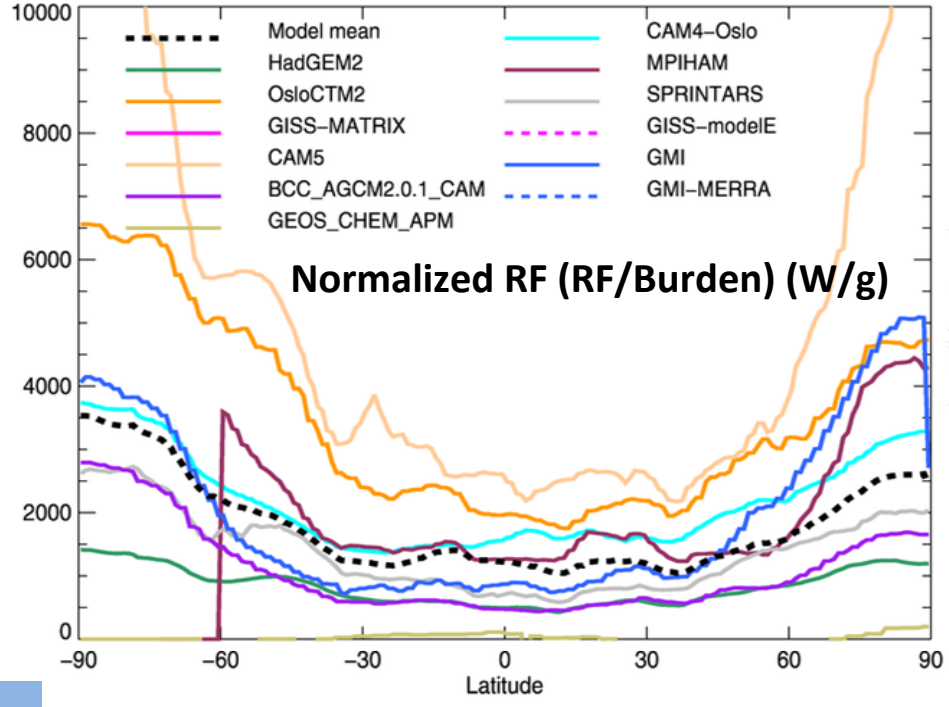
Clear sky

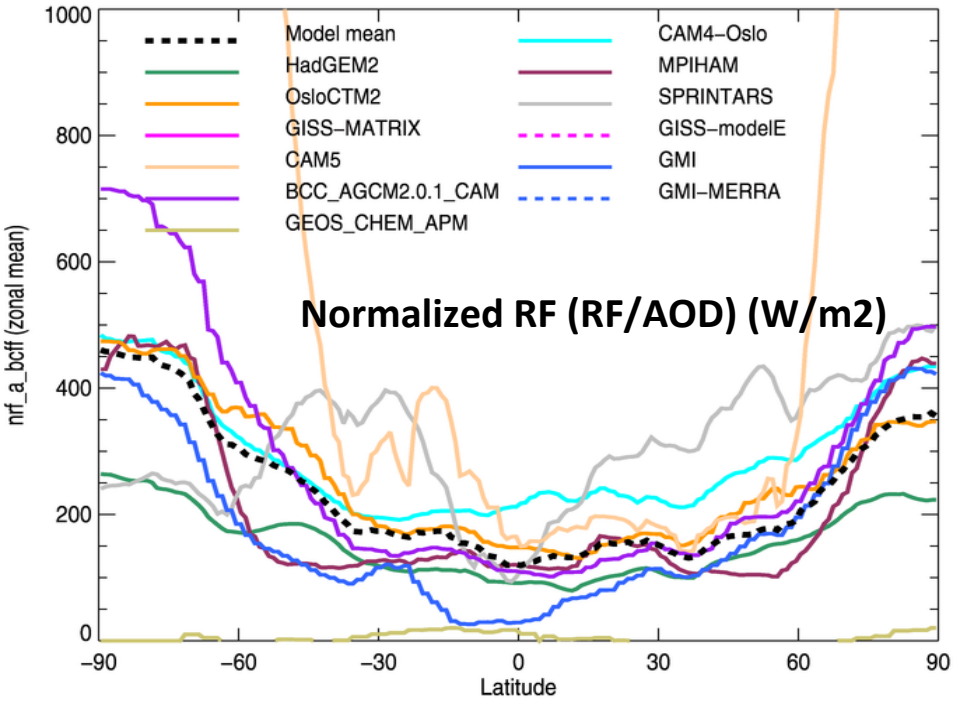


CAM5 includes fossil fuel as well as biomass burning BC

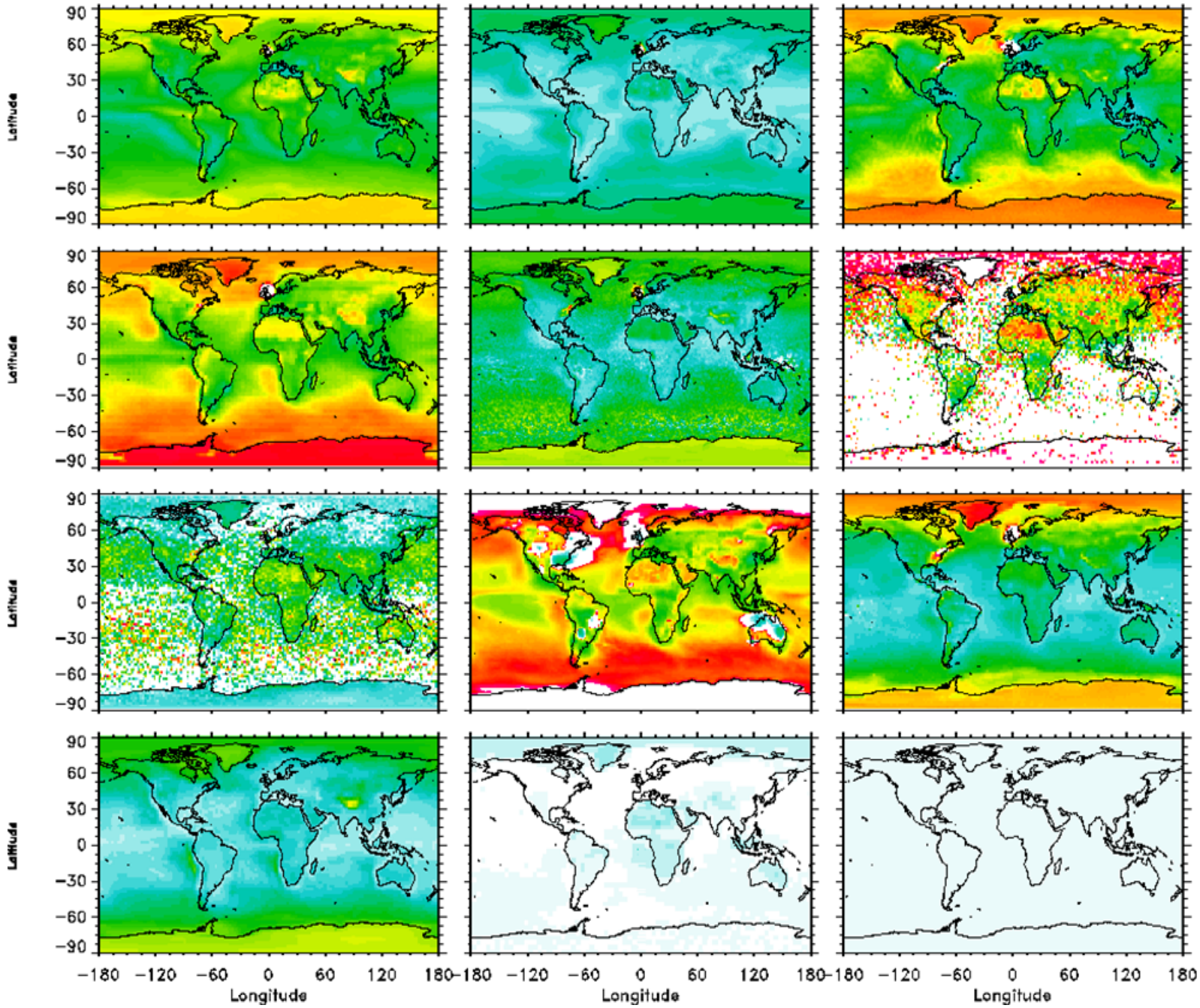

Model mean
HadGEM2
OsloCTM2
GISS–MATRIX
CAM5
BCC_AGCM2.0.1_CAM
GEOS_CHEM_APM
CAM4–Oslo
MPIHAM
SPRINTARS
GISS–modelE
GMI
GMI–MERRA
Anthropogenic burden BC (mg/m²)
bd_bcff (zonal mean)
Latitude


Model mean
HadGEM2
OsloCTM2
GISS–MATRIX
CAM5
BCC_AGCM2.0.1_CAM
GEOS_CHEM_APM
CAM4–Oslo
MPIHAM
SPRINTARS
GISS–modelE
GMI
GMI–MERRA
AOD BC
od_bcff (zonal mean)
Latitude


Model mean
HadGEM2
OsloCTM2
GISS–MATRIX
CAM5
BCC_AGCM2.0.1_CAM
GEOS_CHEM_APM
CAM4–Oslo
MPIHAM
SPRINTARS
GISS–modelE
GMI
GMI–MERRA
Normalized RF (RF/Burden) (W/g)
Latitude

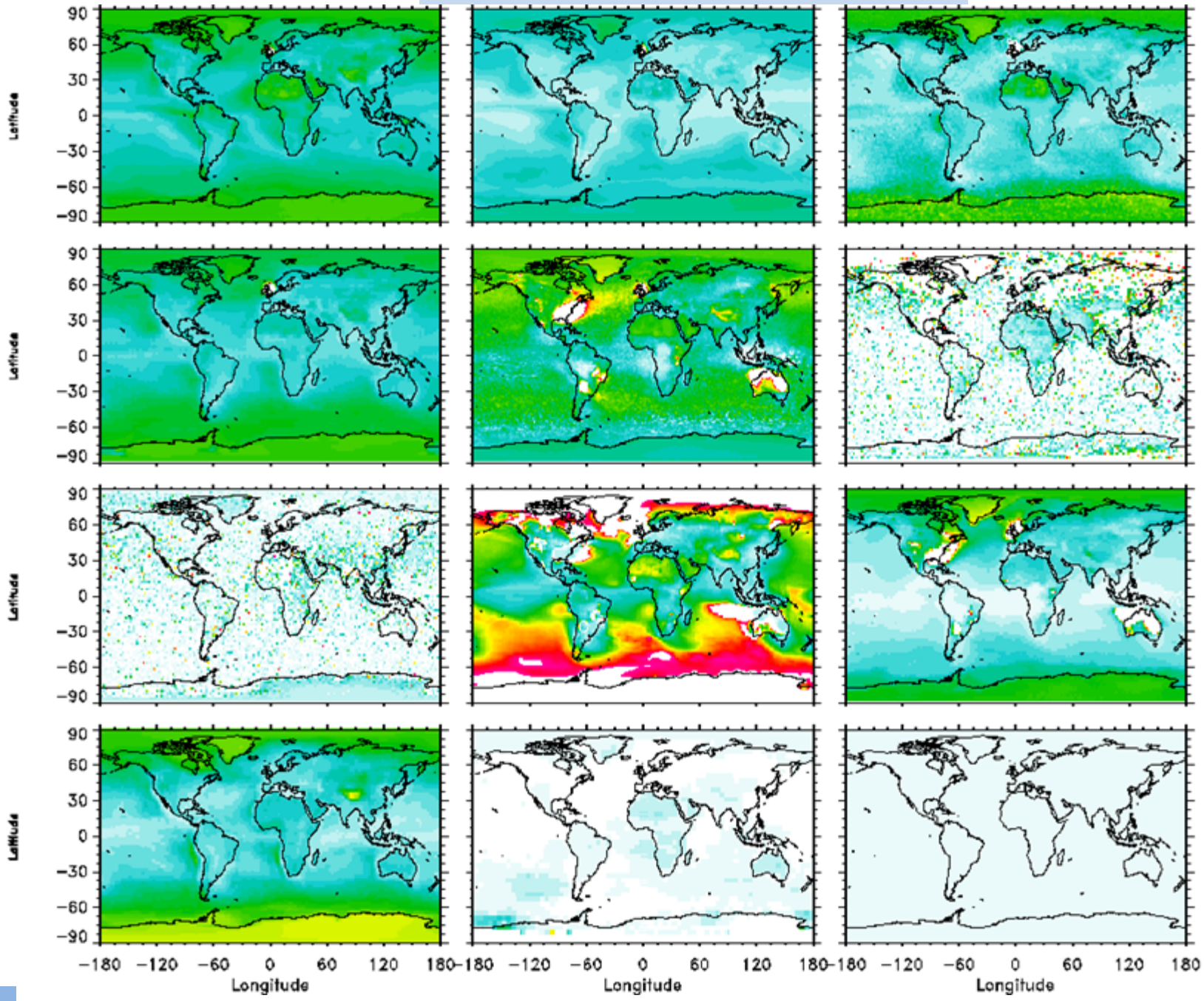

Model mean
HadGEM2
OsloCTM2
GISS–MATRIX
CAM5
BCC_AGCM2.0.1_CAM
GEOS_CHEM_APM
CAM4–Oslo
MPIHAM
SPRINTARS
GISS–modelE
GMI
GMI–MERRA
Normalized RF (RF/AOD) (W/m2)
nrf_a_bcff (zonal mean)
Latitude

Normalized RF (RF/Burden) (W/g)



1) CAM4-Oslo
2) HadGEM
3) MPIHAM
4) OsloCMT2
5) SPRINTARS
6) GISS-MATRIX
7) GISS-modelE
8) CAM5
9) GMI
10) BCC
11) GEOS

Normalized RF (RF/AOD) (W/m2)



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6) GISS-MATRIX
7) GISS-modelE
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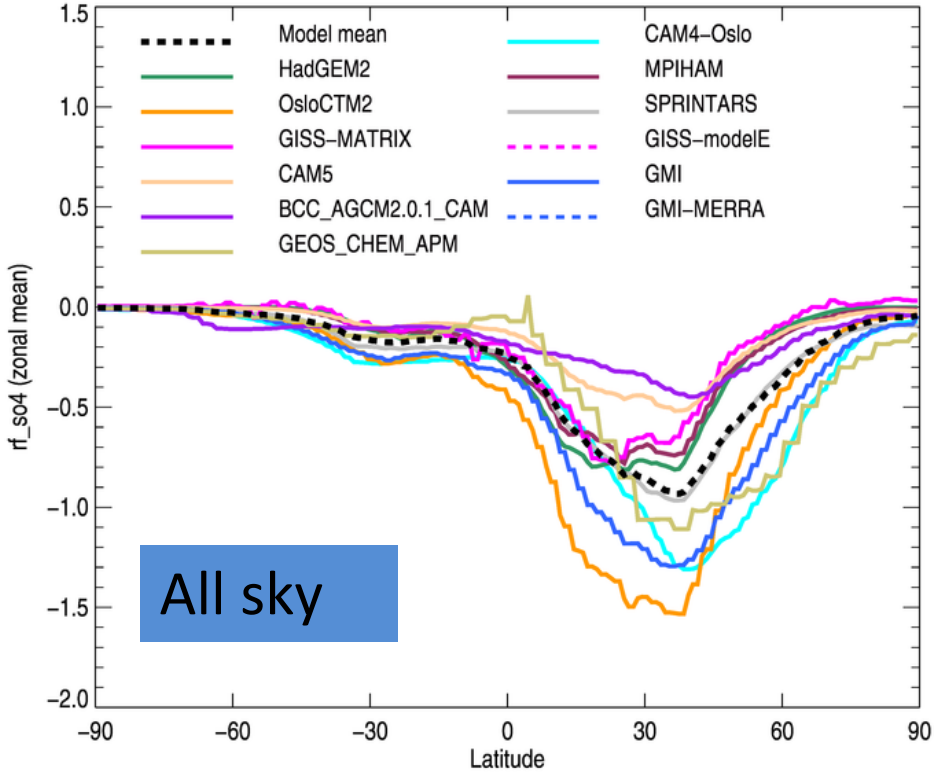
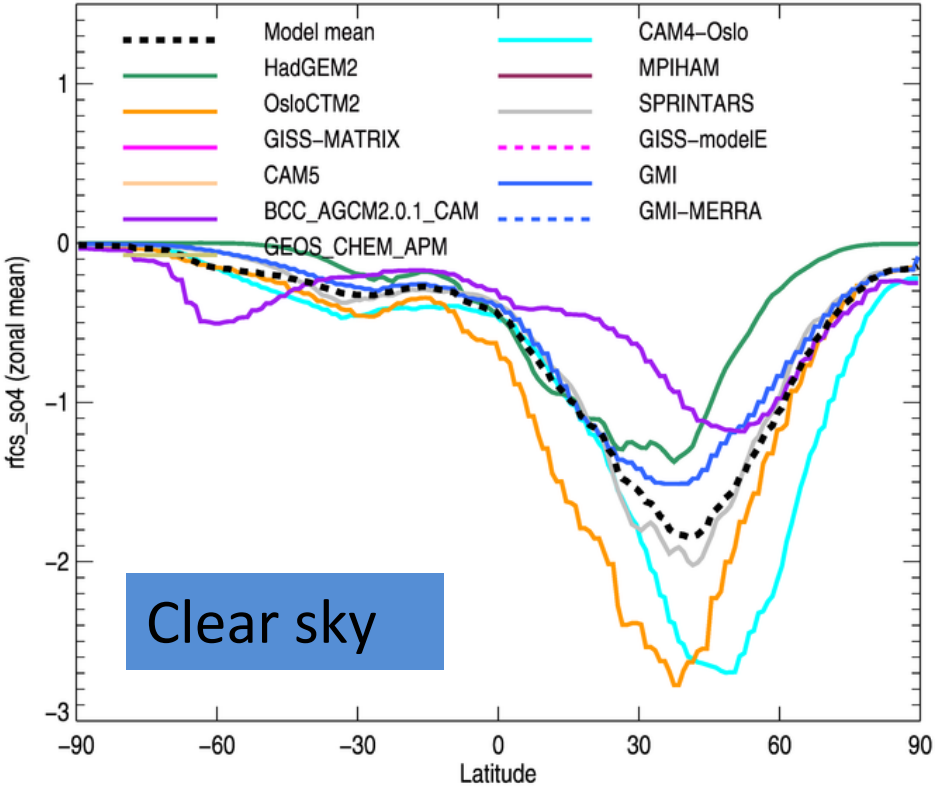
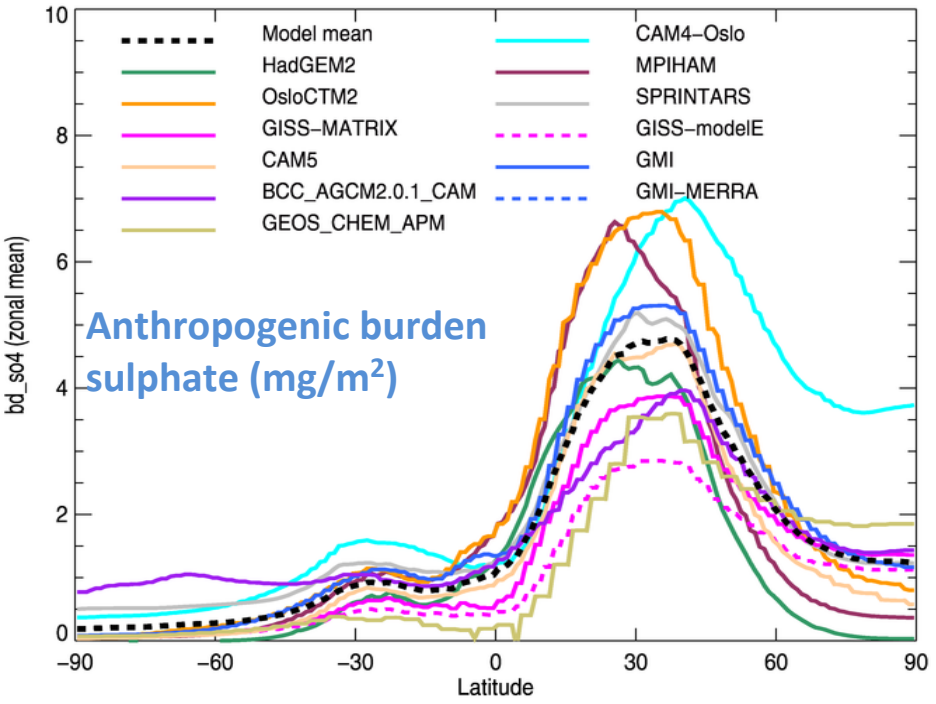
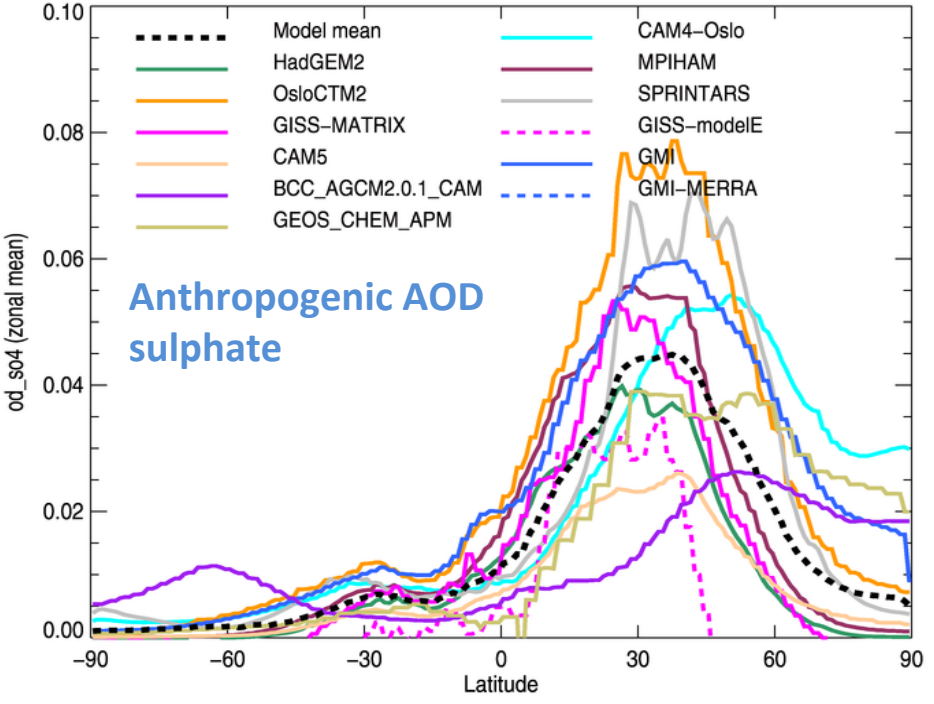
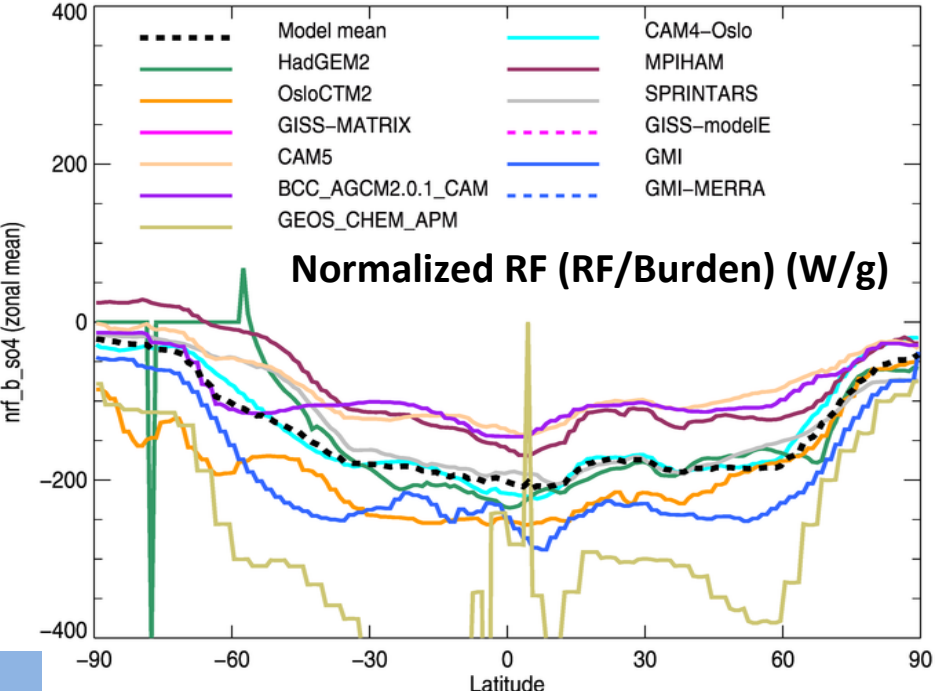
RF sulphate

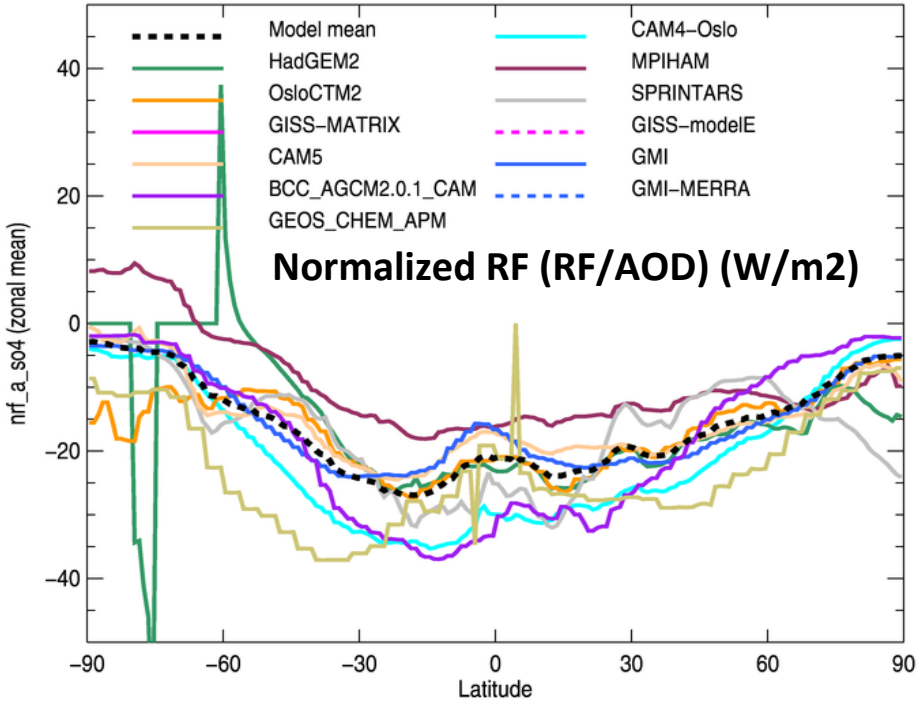

Model mean
HadGEM2
OsloCTM2
GISS–MATRIX
CAM5
BCC_AGCM2.0.1_CAM
GEOS_CHEM_APM
CAM4–Oslo
MPIHAM
SPRINTARS
GISS–modelE
GMI
GMI–MERRA
rf_so4 (zonal mean)
Latitude
All sky


Model mean
HadGEM2
OsloCTM2
GISS–MATRIX
CAM5
BCC_AGCM2.0.1_CAM
GEOS_CHEM_APM
CAM4–Oslo
MPIHAM
SPRINTARS
GISS–modelE
GMI
GMI–MERRA
rfcs_so4 (zonal mean)
Latitude
Clear sky


Model mean
HadGEM2
OsloCTM2
GISS–MATRIX
CAM5
BCC_AGCM2.0.1_CAM
GEOS_CHEM_APM
CAM4–Oslo
MPIHAM
SPRINTARS
GISS–modelE
GMI
GMI–MERRA
Anthropogenic burden sulphate (mg/m²)
bd_so4 (zonal mean)
Latitude

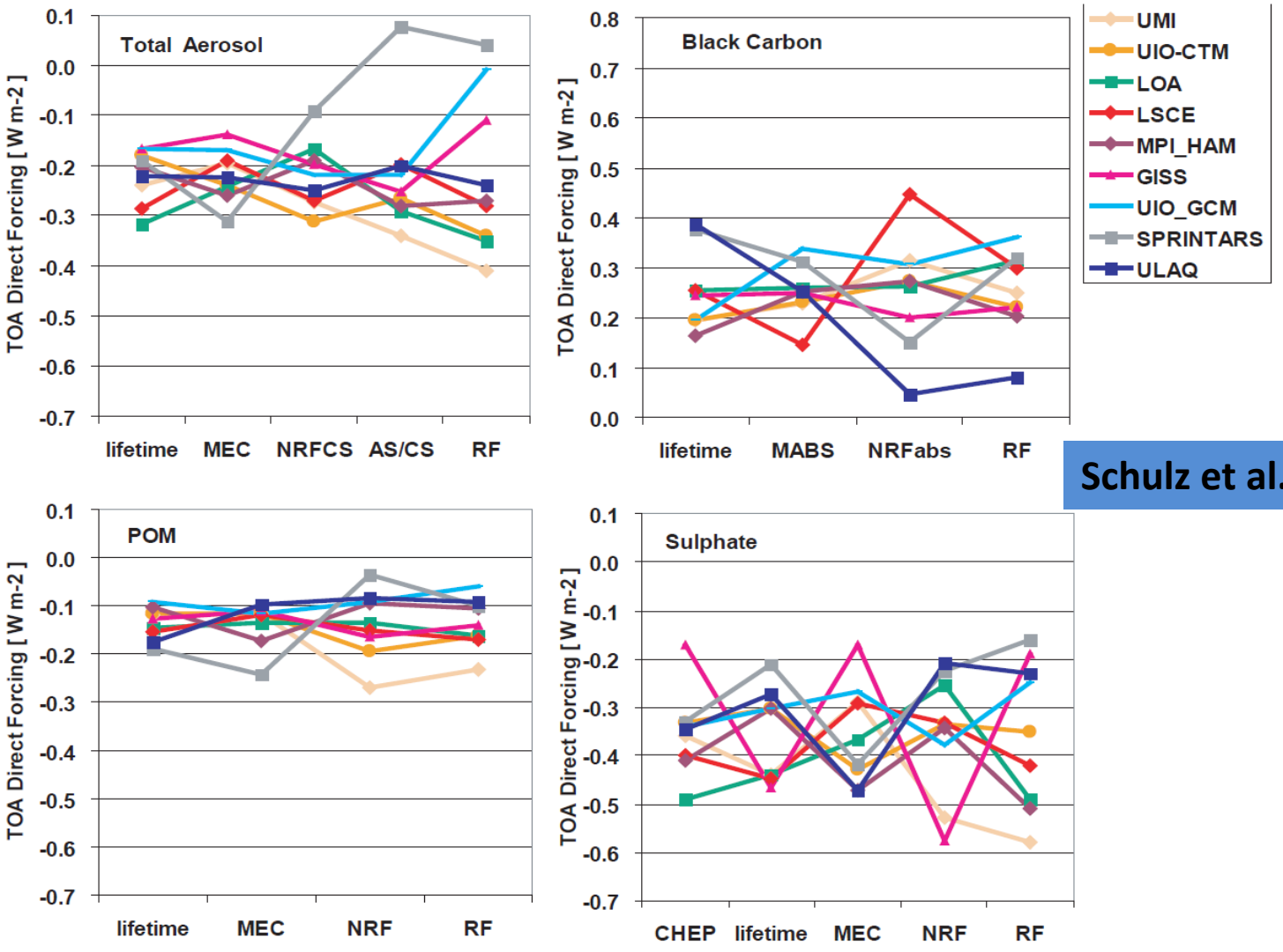

Model mean
HadGEM2
OsloCTM2
GISS–MATRIX
CAM5
BCC_AGCM2.0.1_CAM
GEOS_CHEM_APM
CAM4–Oslo
MPIHAM
SPRINTARS
GISS–modelE
GMI
GMI–MERRA
Anthropogenic AOD sulphate
od_so4 (zonal mean)
Latitude


Model mean
HadGEM2
OsloCTM2
GISS–MATRIX
CAM5
BCC_AGCM2.0.1_CAM
GEOS_CHEM_APM
CAM4–Oslo
MPIHAM
SPRINTARS
GISS–modelE
GMI
GMI–MERRA
Normalized RF (RF/Burden) (W/g)
nrf_b_so4 (zonal mean)
Latitude

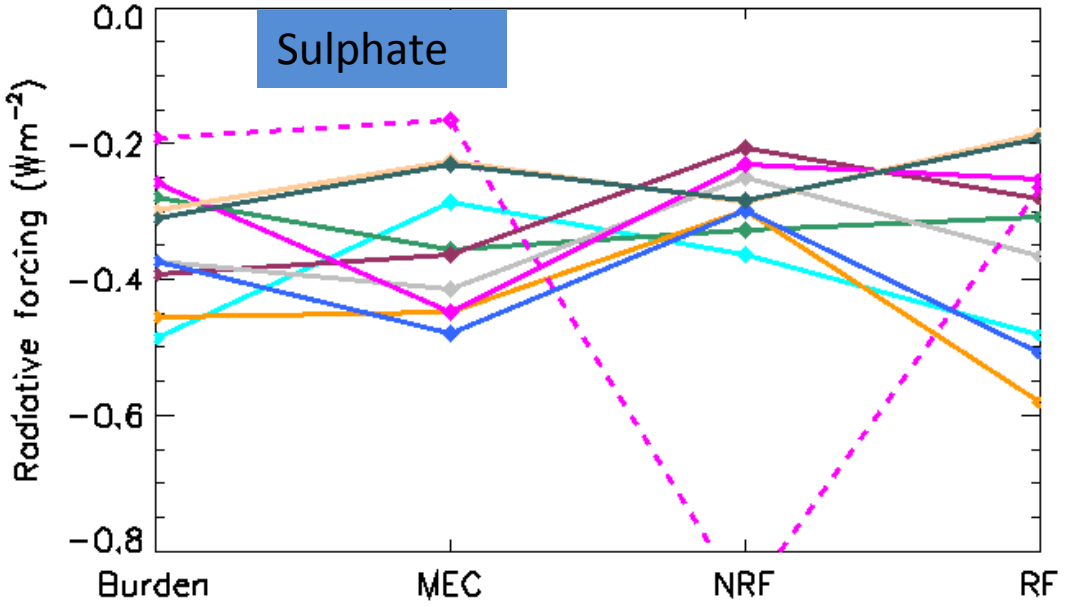

Model mean
HadGEM2
OsloCTM2
GISS–MATRIX
CAM5
BCC_AGCM2.0.1_CAM
GEOS_CHEM_APM
CAM4–Oslo
MPIHAM
SPRINTARS
GISS–modelE
GMI
GMI–MERRA
Normalized RF (RF/AOD) (W/m2)
nrf_a_so4 (zonal mean)
Latitude

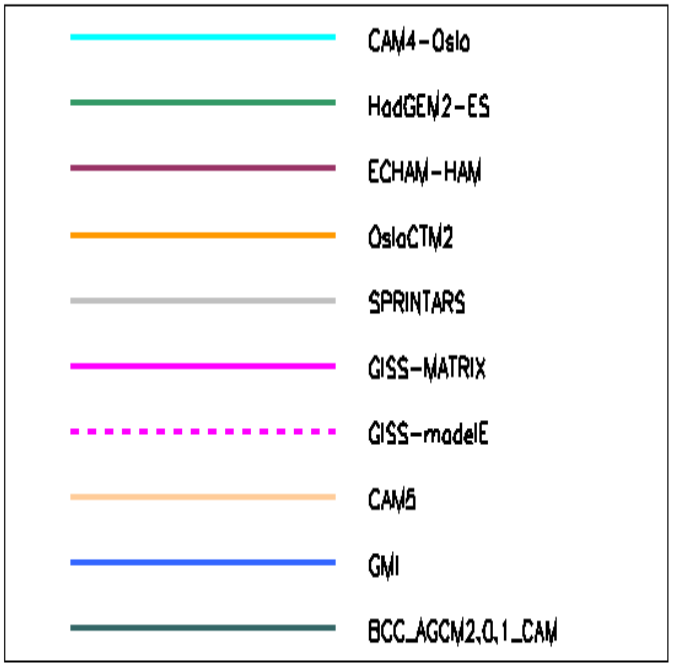
$$F_{x,n} = x_n / \langle x \rangle * \langle RF \rangle$$

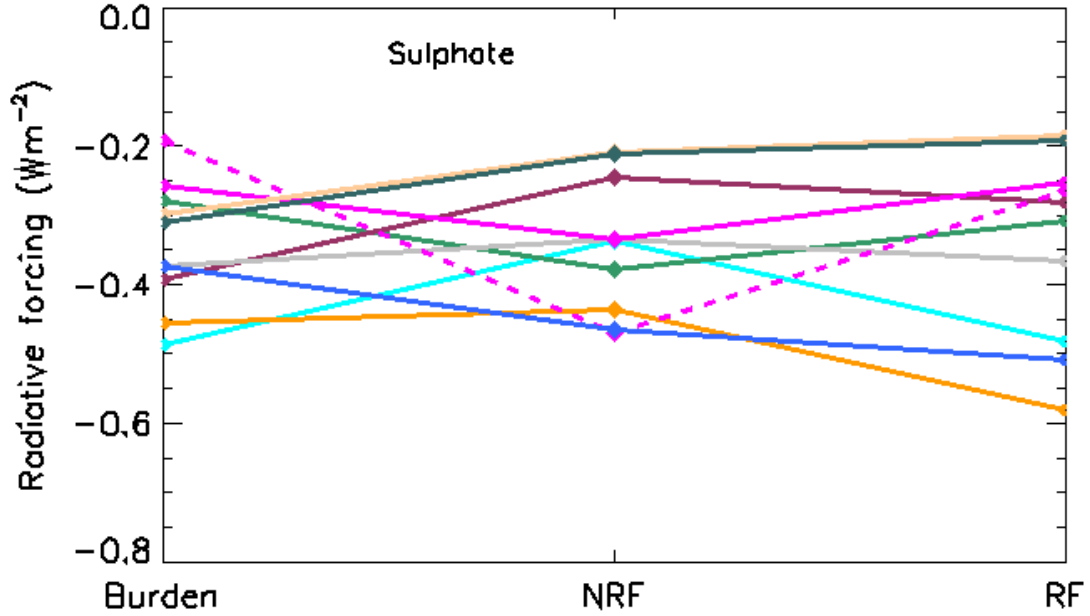
AeroCom mean $\langle x \rangle$



Schulz et al., ACP, 2006

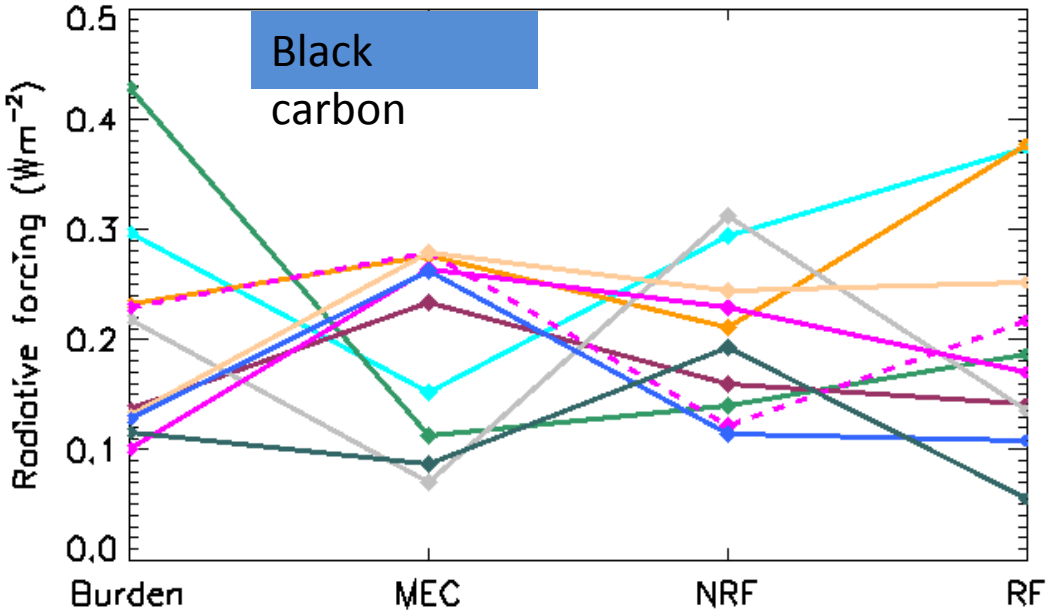


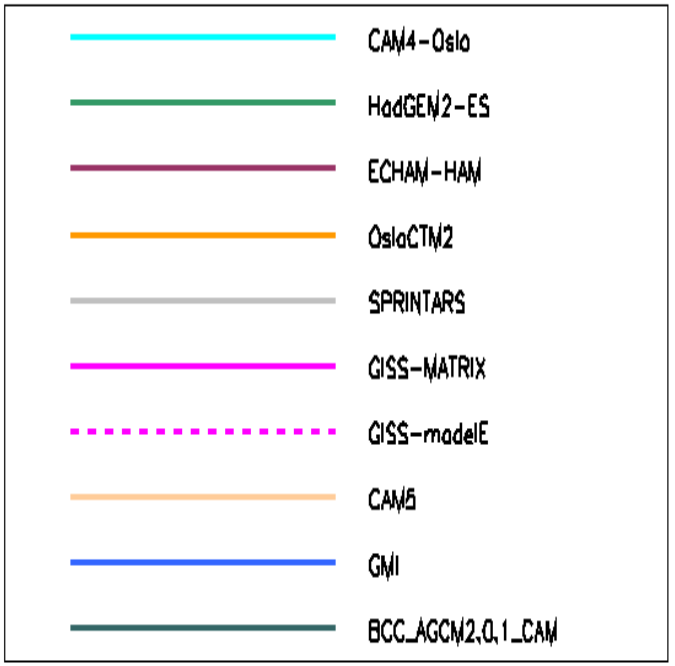


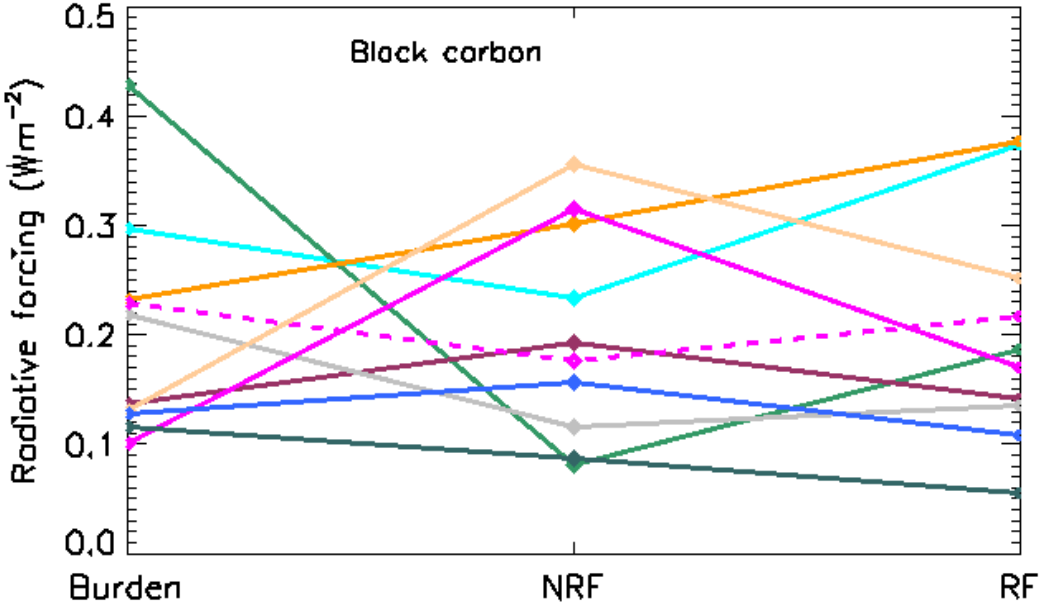


MEC – Mass extinction coefficient

NRF – Normalized radiative forcing (upper panel with respect to AOD and lower with respect to burden)







MEC – Mass extinction coefficient

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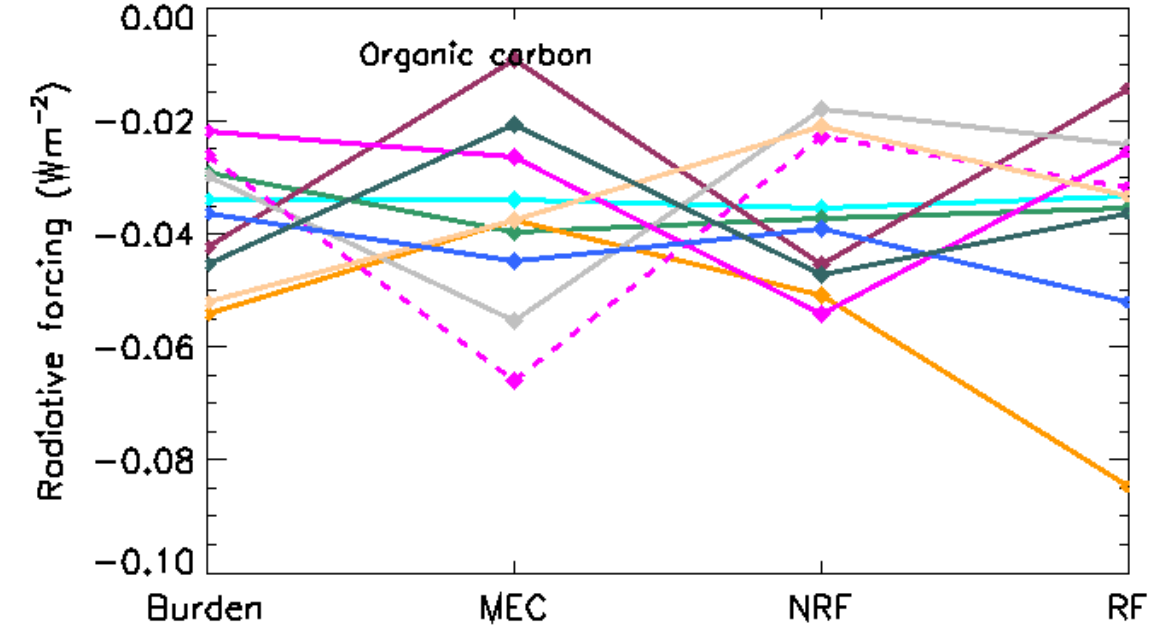
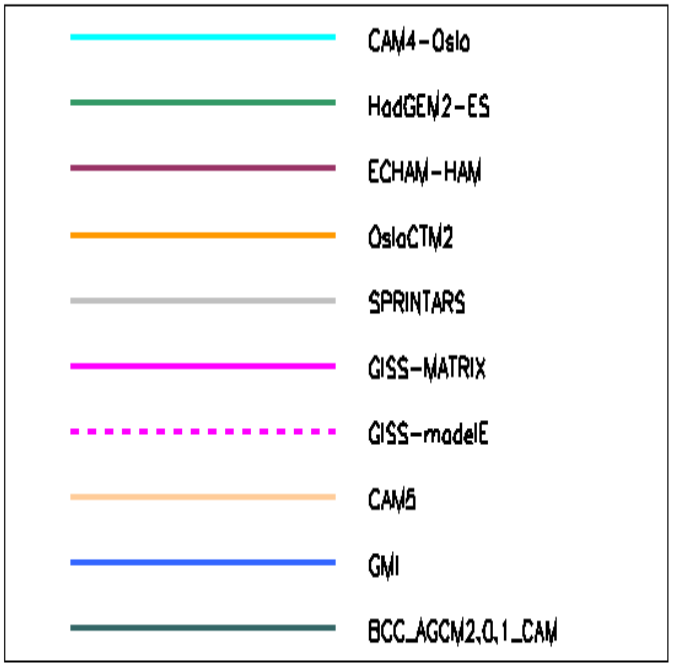
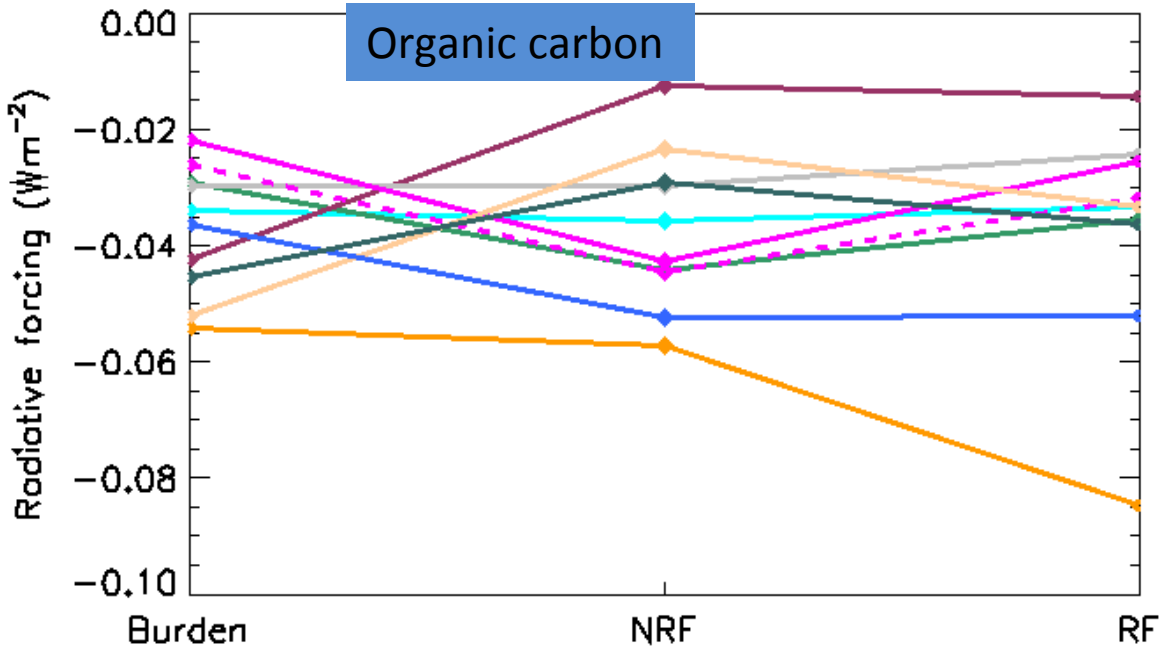
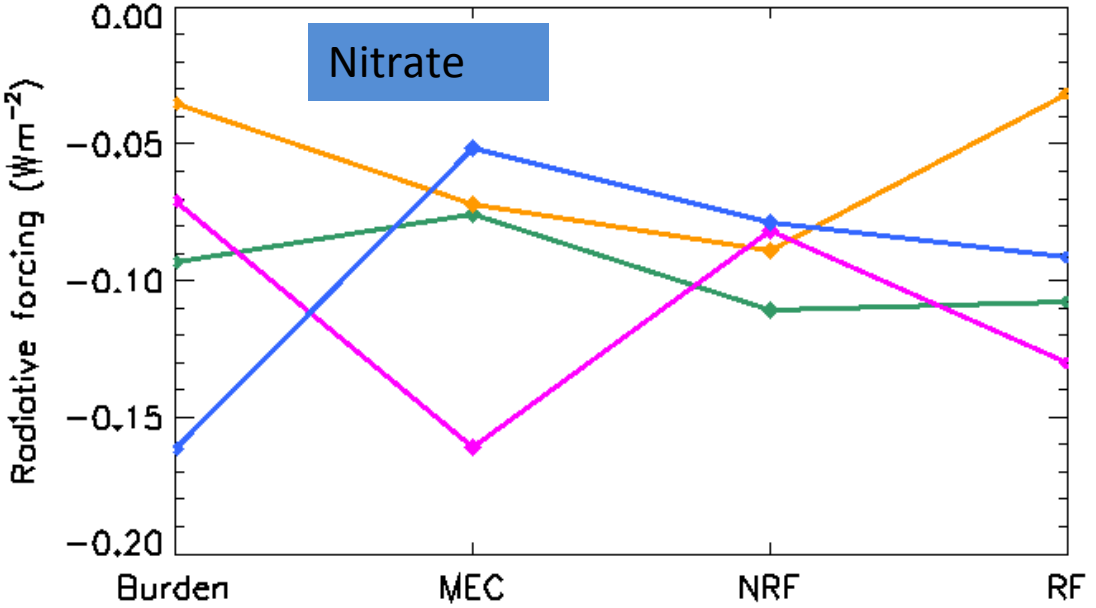


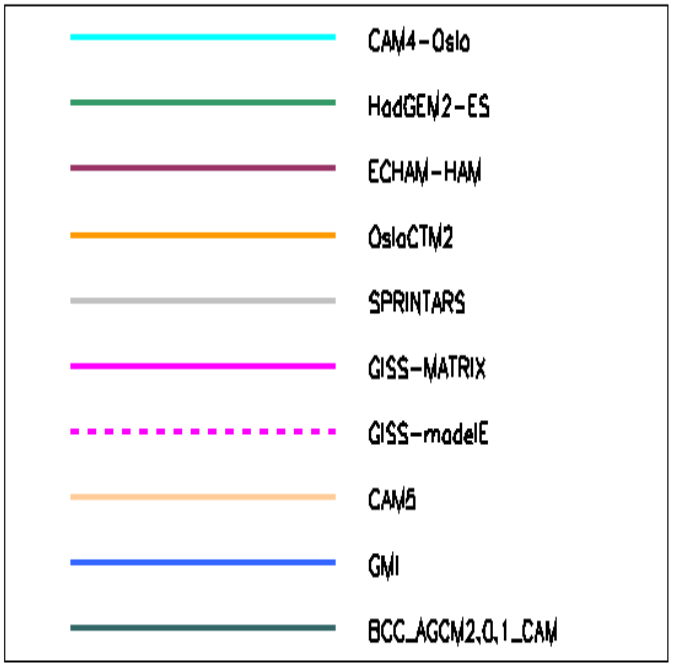


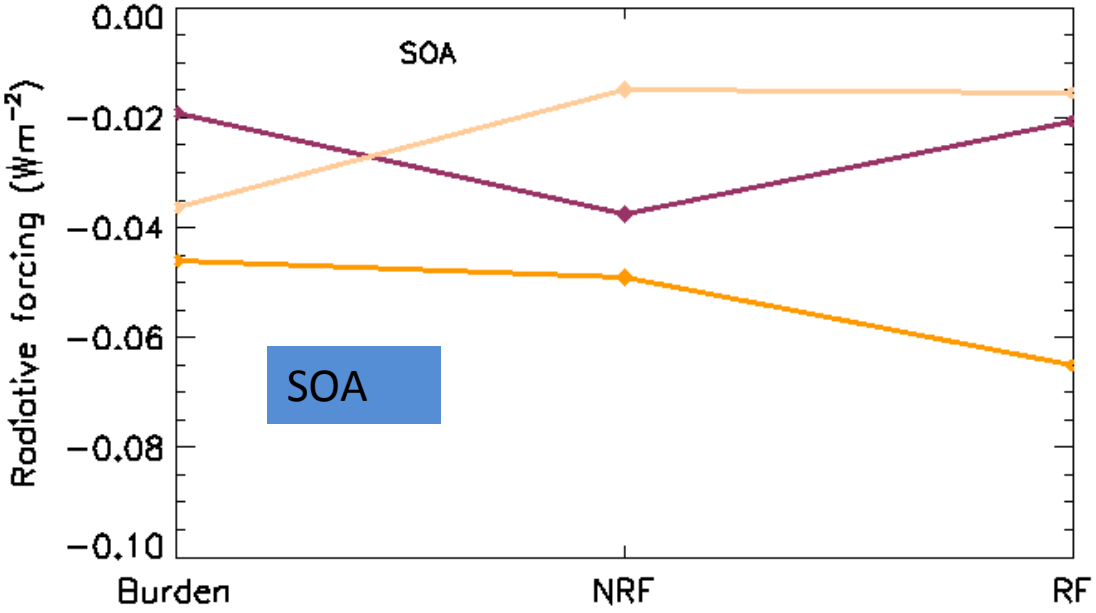


MEC – Mass extinction coefficient

NRF – Normalized radiative forcing (upper panel with respect to AOD and lower with respect to burden)



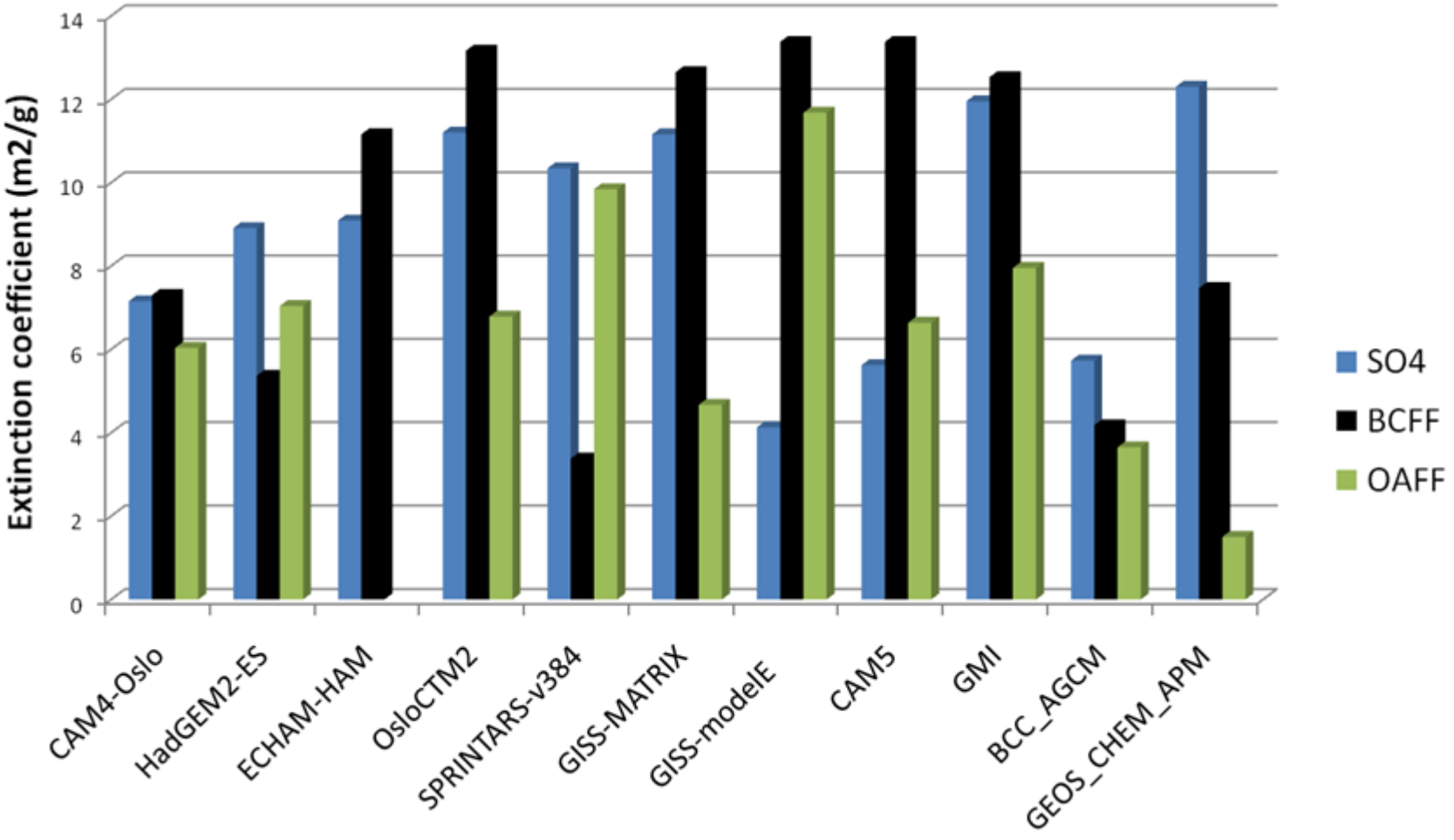




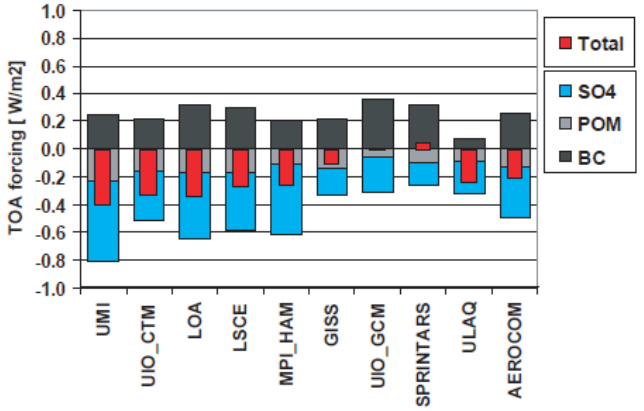
MEC – Mass extinction coefficient

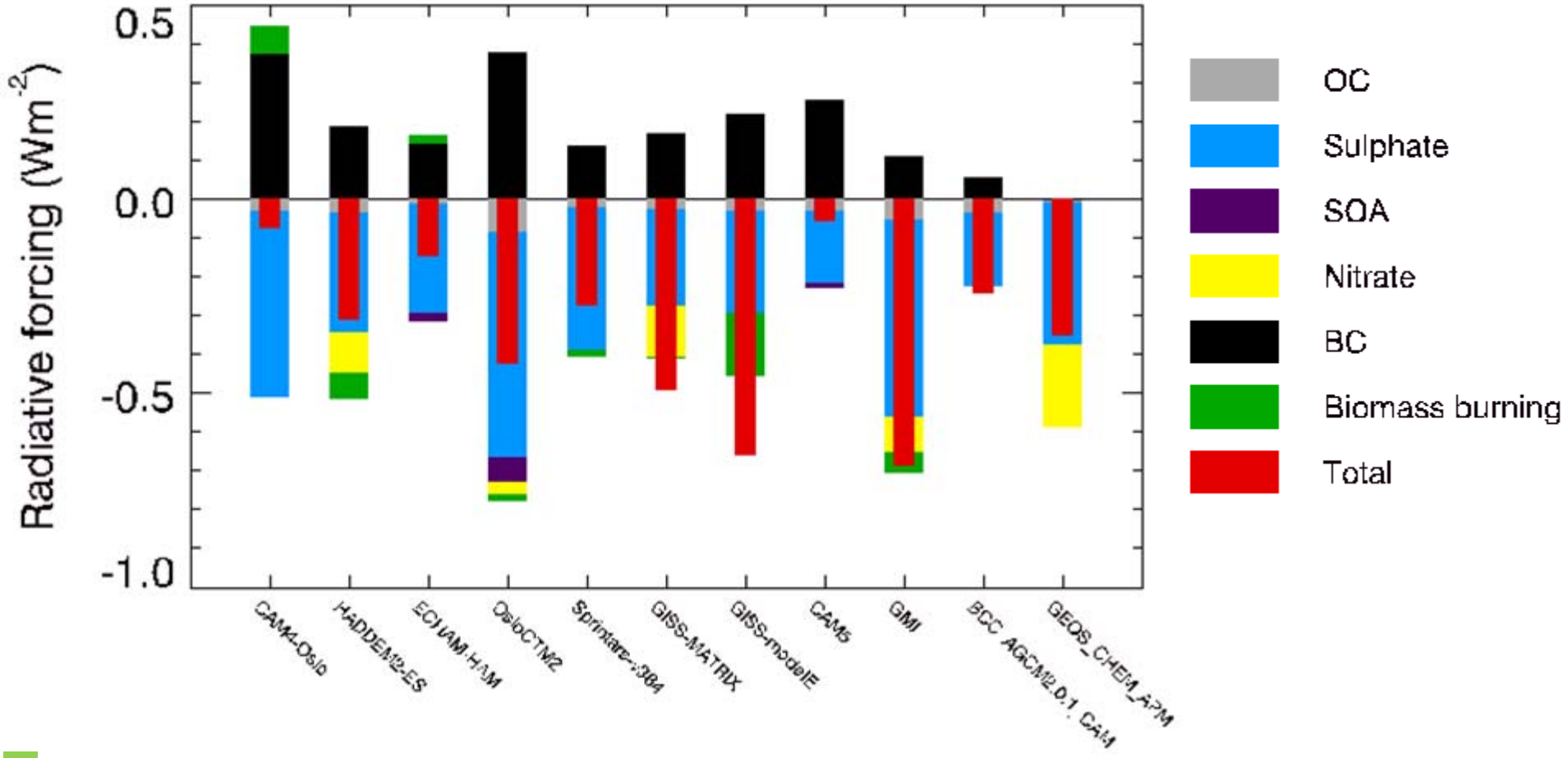
NRF – Normalized radiative forcing

Extinction coefficient (m^2/g)

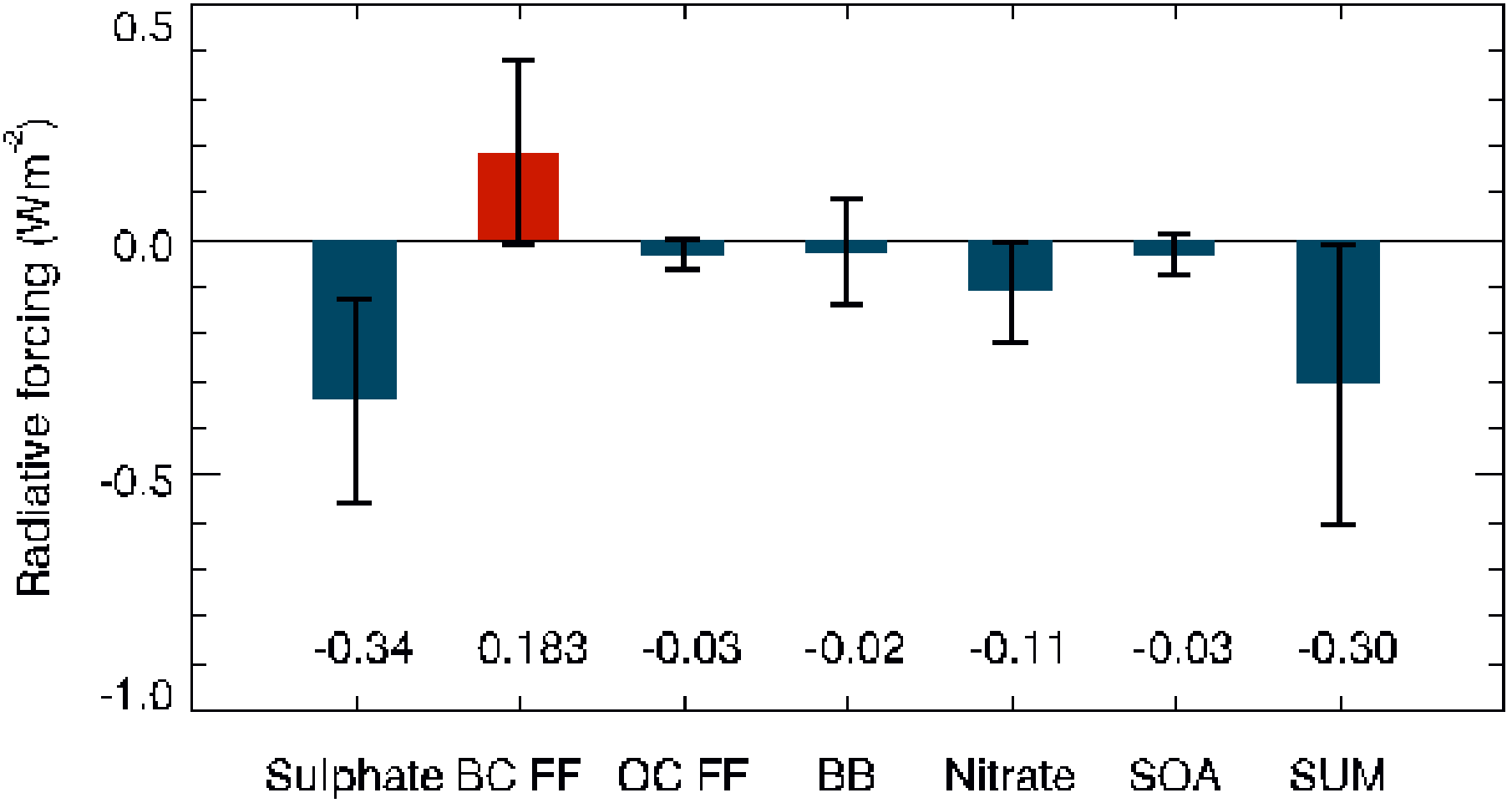


Preliminary main results

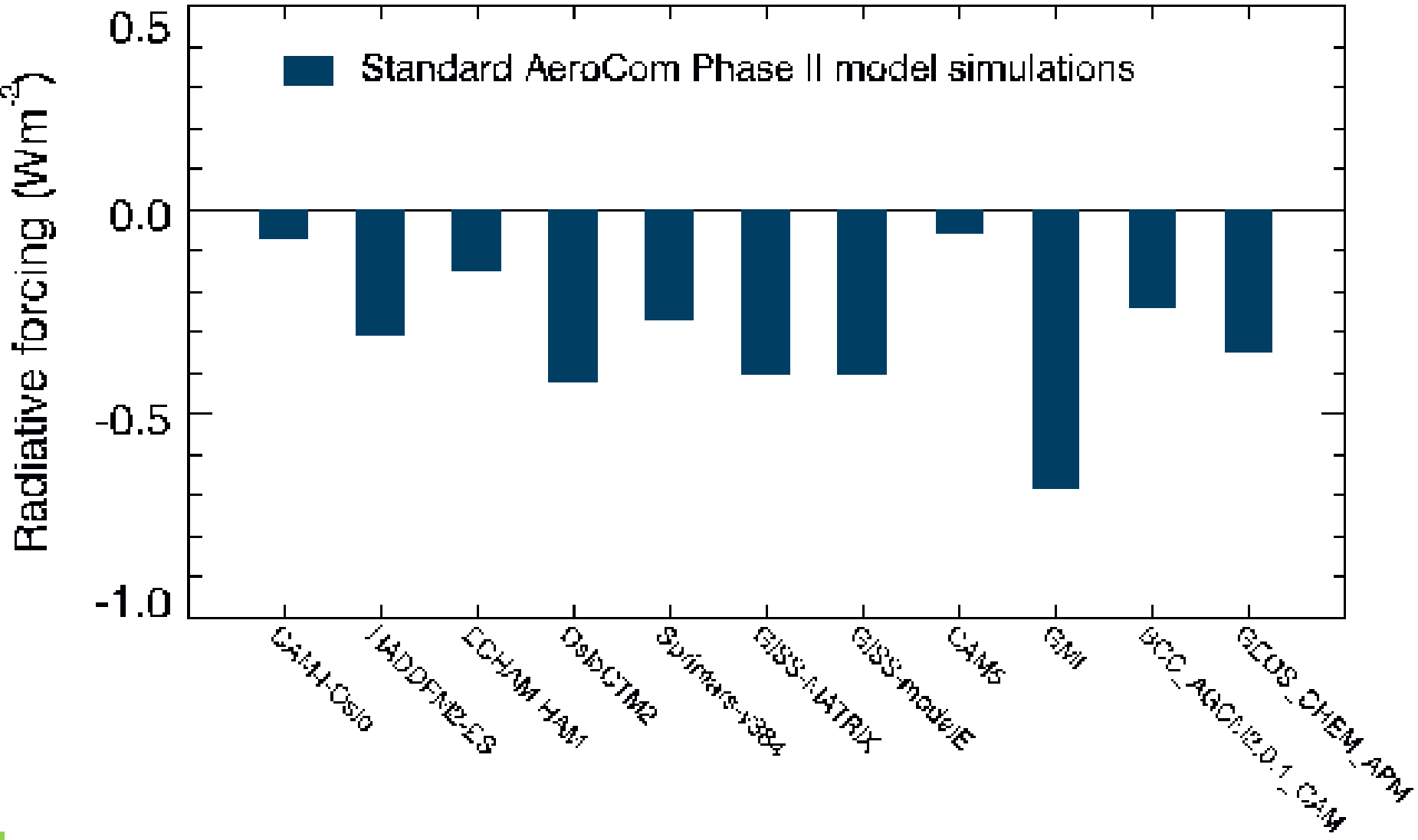




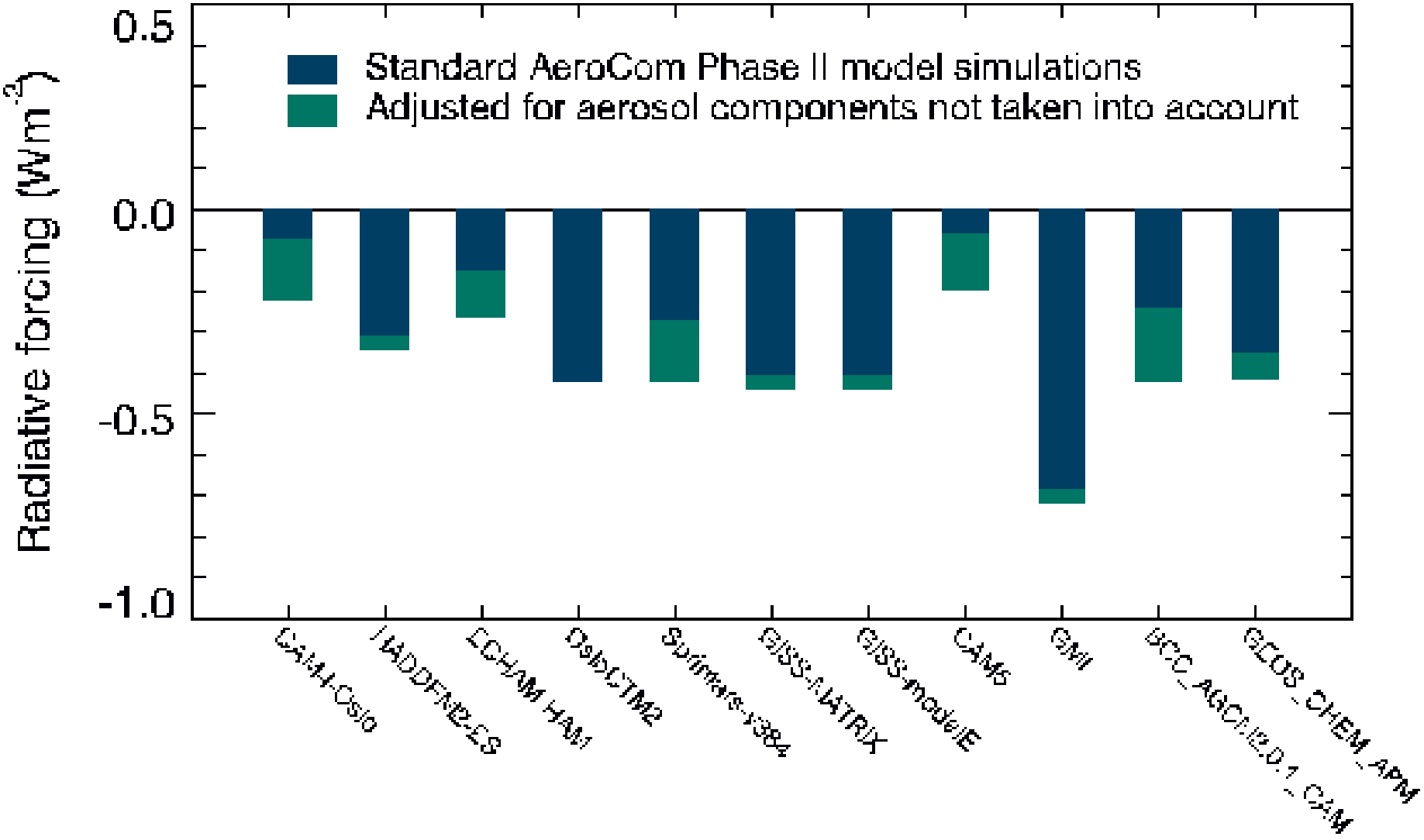
Preliminary main results



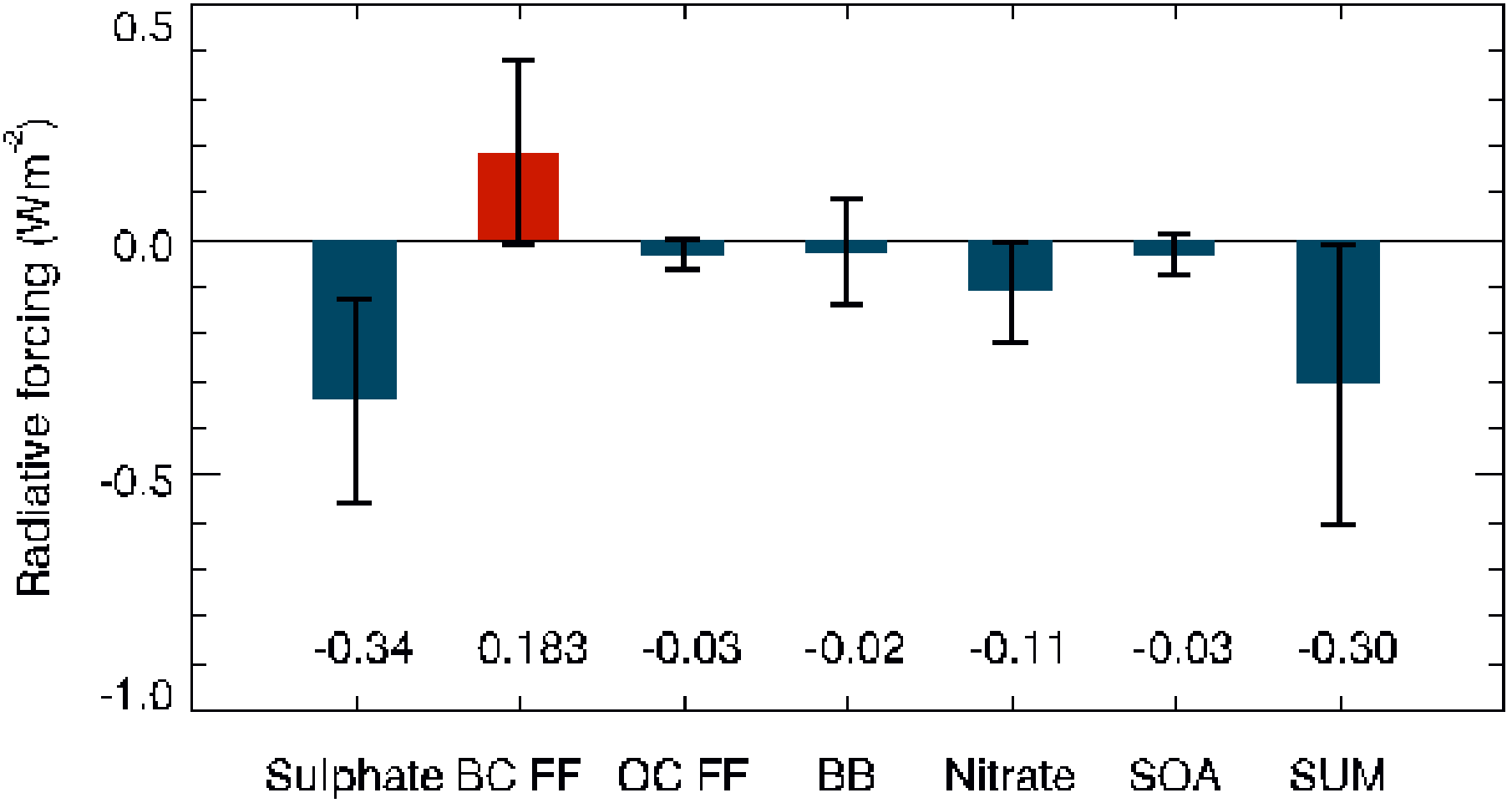
Total direct aerosol effect for 11 AeroCom models



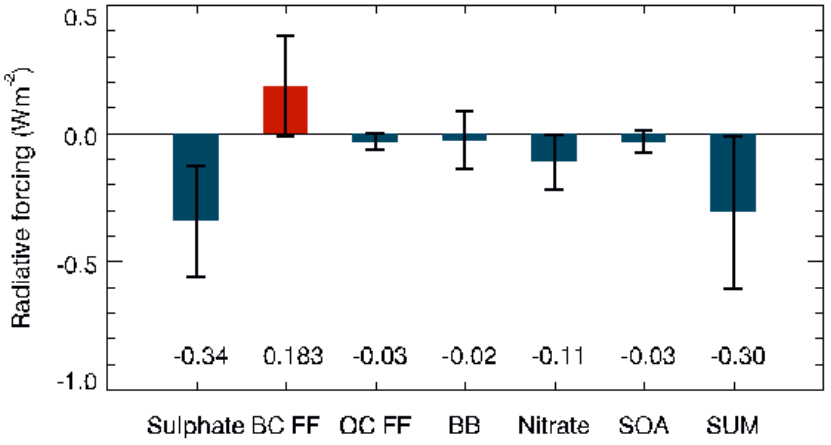
Total direct aerosol effect for 11 AeroCom models

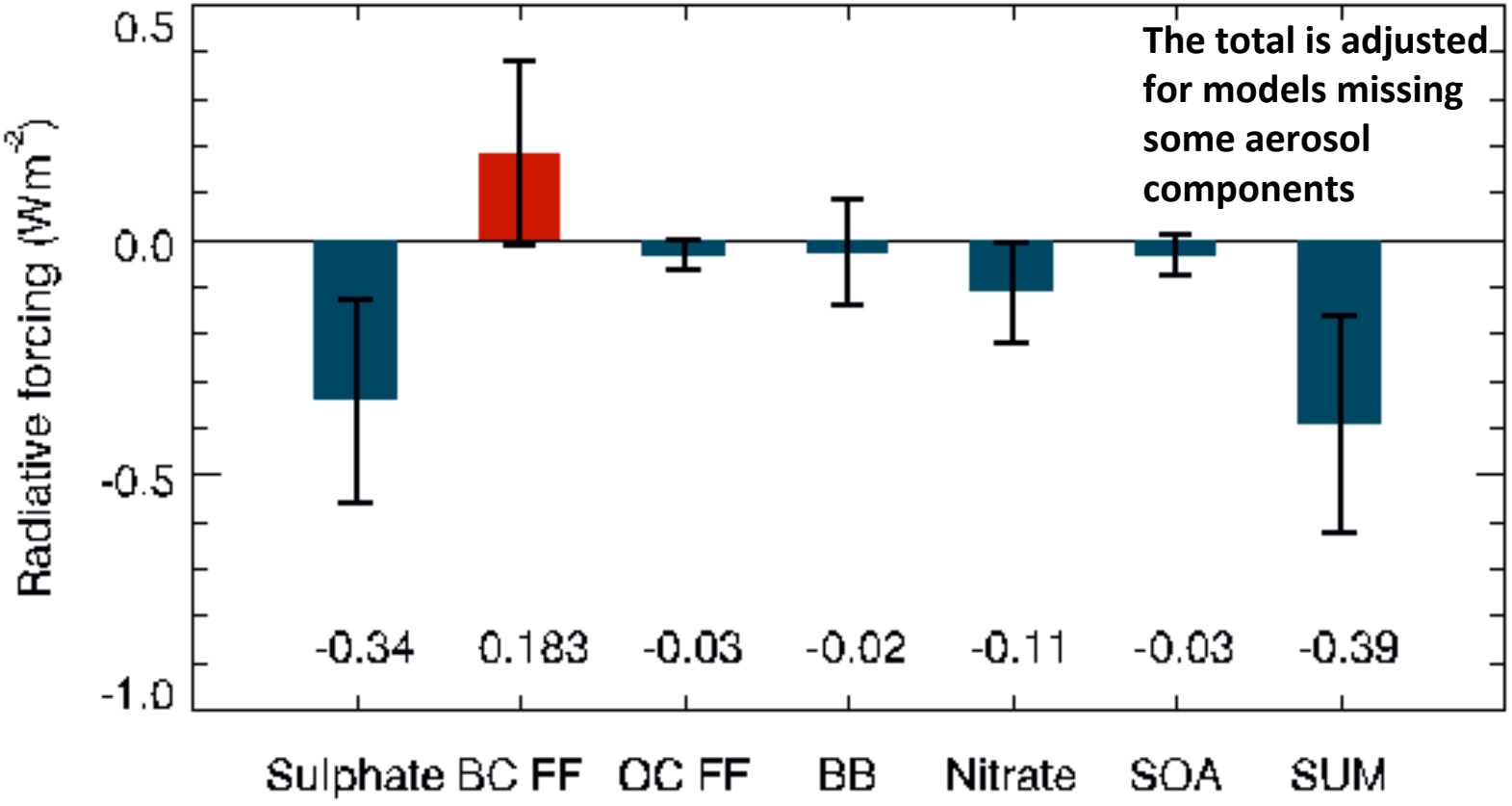


Preliminary main results



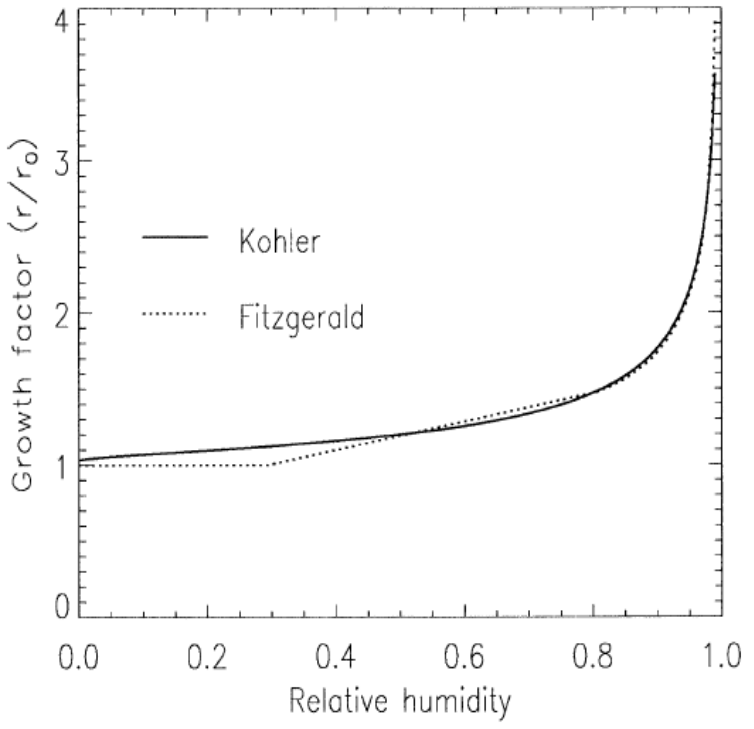
Preliminary main results

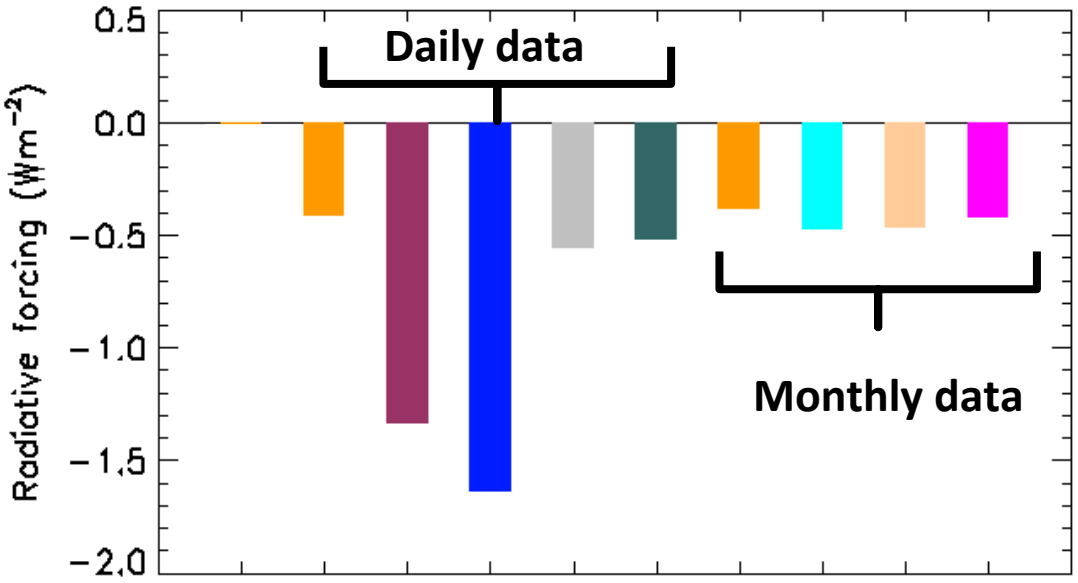




Importance of relative humidity (RH)

- Very preliminary results, the calculated RH fields have not been checked with the modelling groups.
- Validation of RH difficult
- Several studies have shown strong impact on the RF from differences in RH

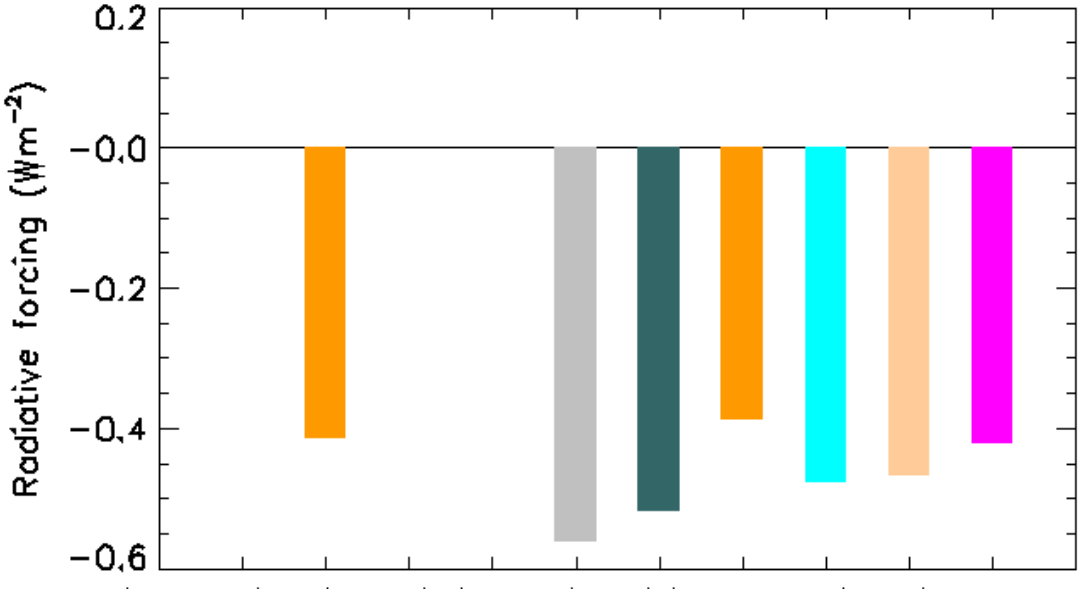


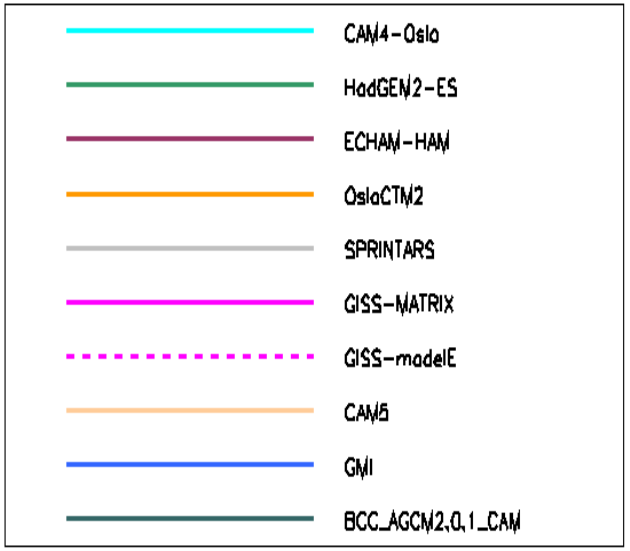


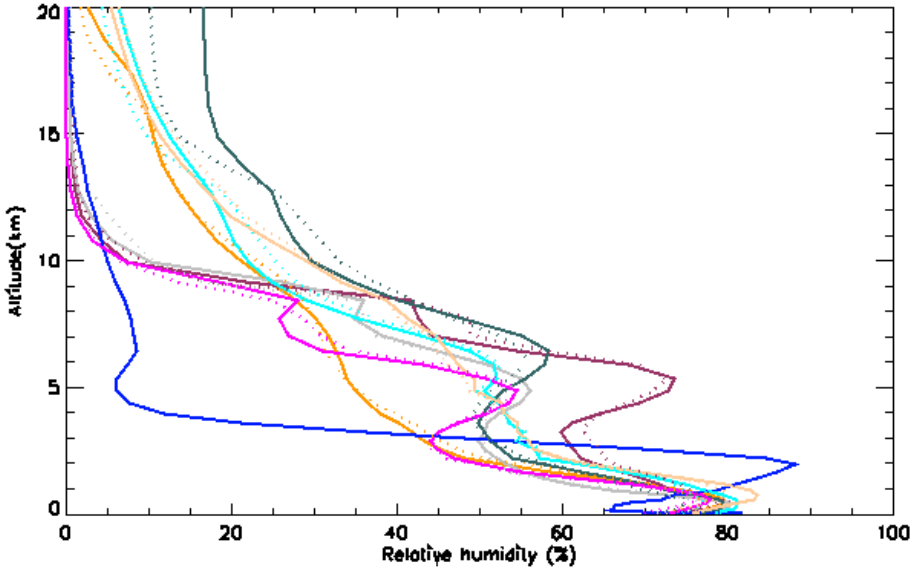
RH from individual models included in OsloCTM2

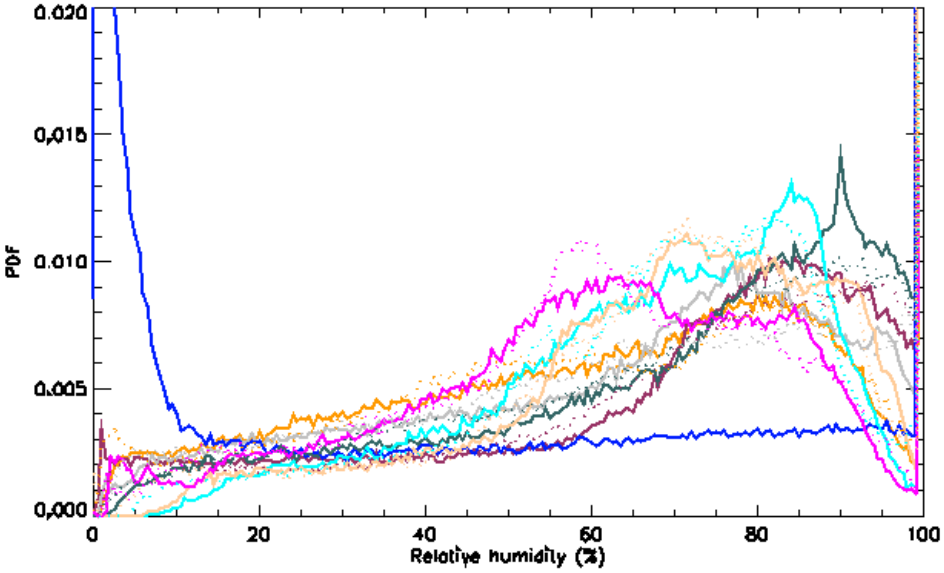
Warning: A careful check of the RH is needed

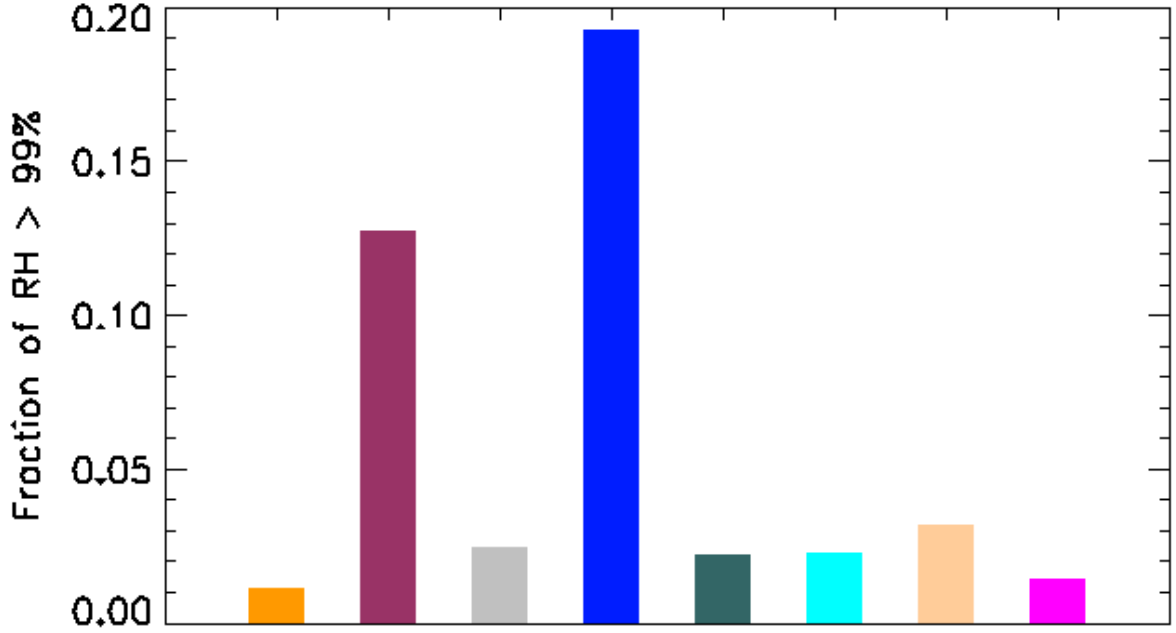
Assumptions regarding threshold of RH need to be discussed with all groups

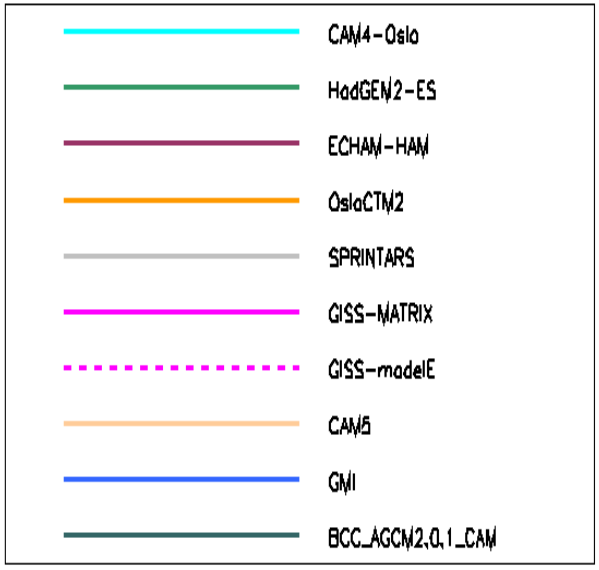





Altitude(km)
Relative humidity (%)

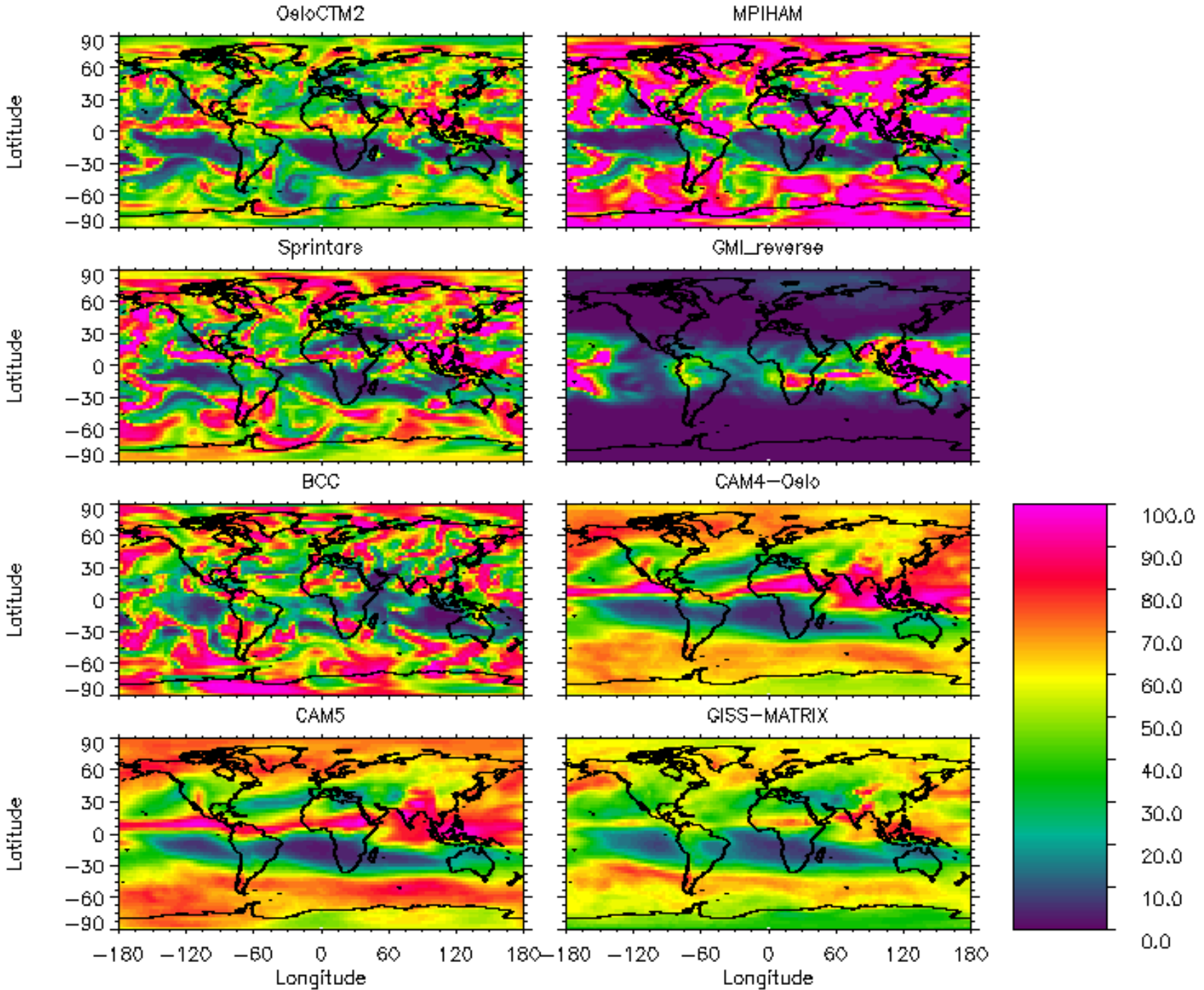

PDF
Relative humidity (%)


Fraction of RH > 99%


CAM4-Oslo
HadGEM2-ES
ECHAM-HAM
OsloCTM2
SPRINTARS
GISS-MATRIX
GISS-modelE
CAM5
GMI
BCC_AGCM2.0.1_CAM

Next step

- More work needs to be done to understand all the submitted fields, we would like to talk to all the groups present at the meeting to discuss further details.
- 12 models have now submitted data to the direct aerosol effect experiment. We expect submissions from 1-2 additional groups.
- We encourage more groups to participate, but a final deadline for submission will be end of this month.
- A paper needs to be submitted before next summer
- Main results and figures can be found here: http://folk.uio.no/bjornhs/cicero/aerocom/A2/gallery/


OsloCTM2
MPIHAM
Sprintars
GMI_reverse
BCC
CAM4−Oslo
CAM5
GISS−MATRIX
Latitude
Longitude
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30
0
−30
−60
−90
−180
−120
−60
0
60
120
180
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90.0
80.0
70.0
60.0
50.0
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30.0
20.0
10.0
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