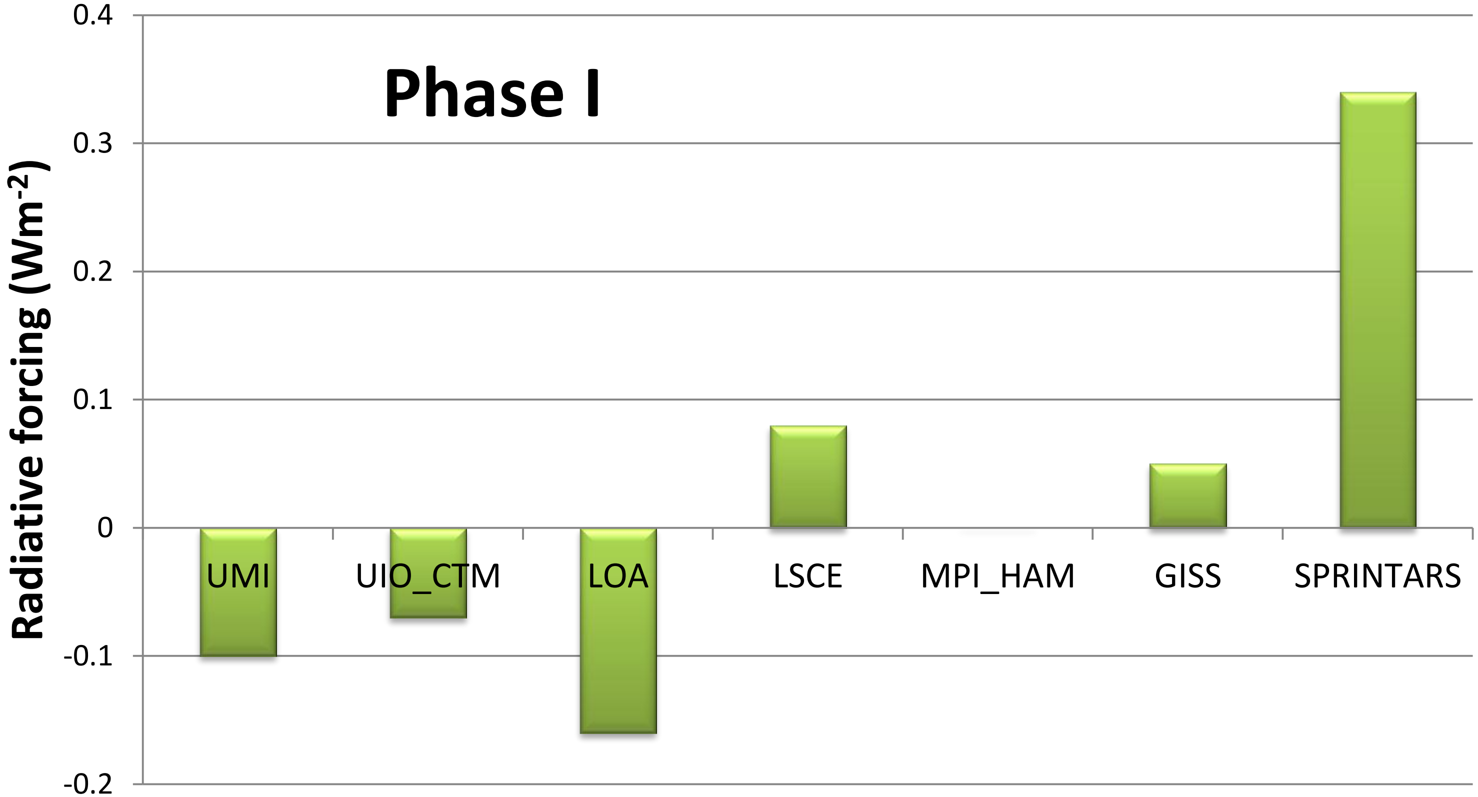



Investigation of direct aerosol effect in cloudy sky regions

Gunnar Myhre, Bjørn Samset, Nick Schutgens,
Philip Stier and AeroCom modellers

What is most important for the sign and magnitude of the cloudy sky forcing? Aerosols or clouds


Radiative forcing in cloudy sky regions



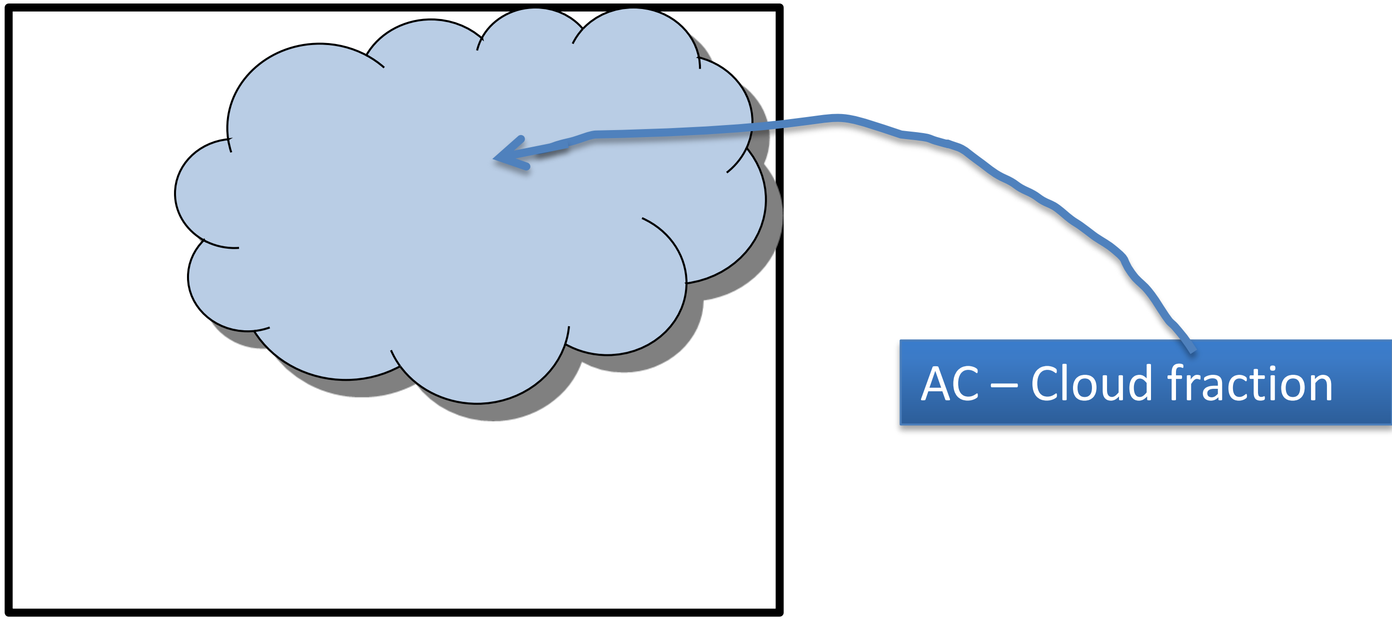
Atmos. Chem. Phys., 6, 5225–5246, 2006

Radiative forcing by aerosols as derived from the AeroCom present-day and pre-industrial simulations

M. Schulz[1], C. Textor[1], S. Kinne[2], Y. Balkanski[1], S. Bauer[3], T. Berntsen[4], T. Berglen[4], O. Boucher[5,11], F. Dentener[6], S. Guibert[1], I. S. A. Isaksen[4], T. Iversen[4], D. Koch[3], A. Kirkevåg[4], X. Liu[7,12], V. Montanaro[8], G. Myhre[4], J. E. Penner[7], G. Pitari[8], S. Reddy[9], Ø. Seland[4], P. Stier[2], and T. Takemura[10]

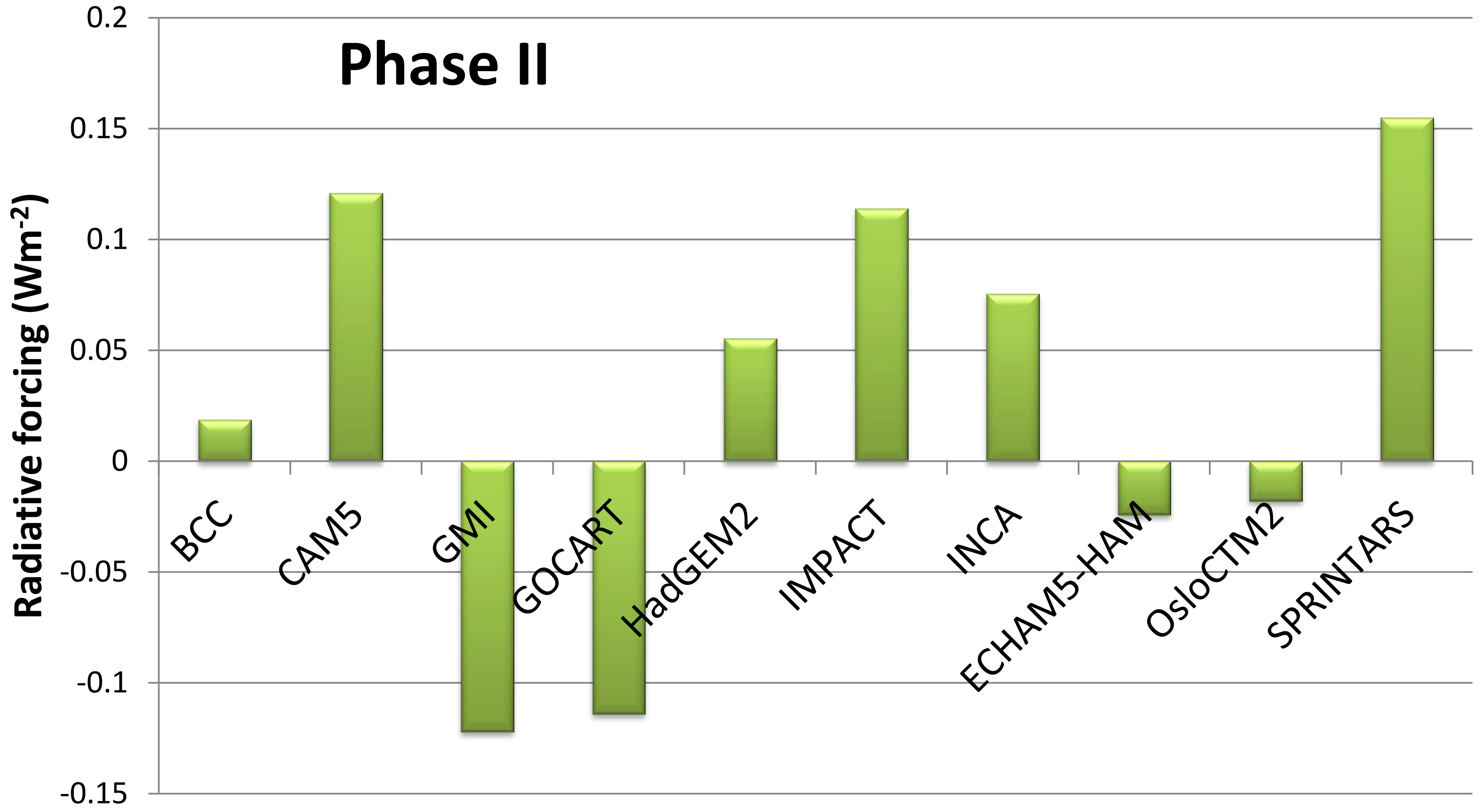
AeroCom

Radiative forcing in cloudy sky regions

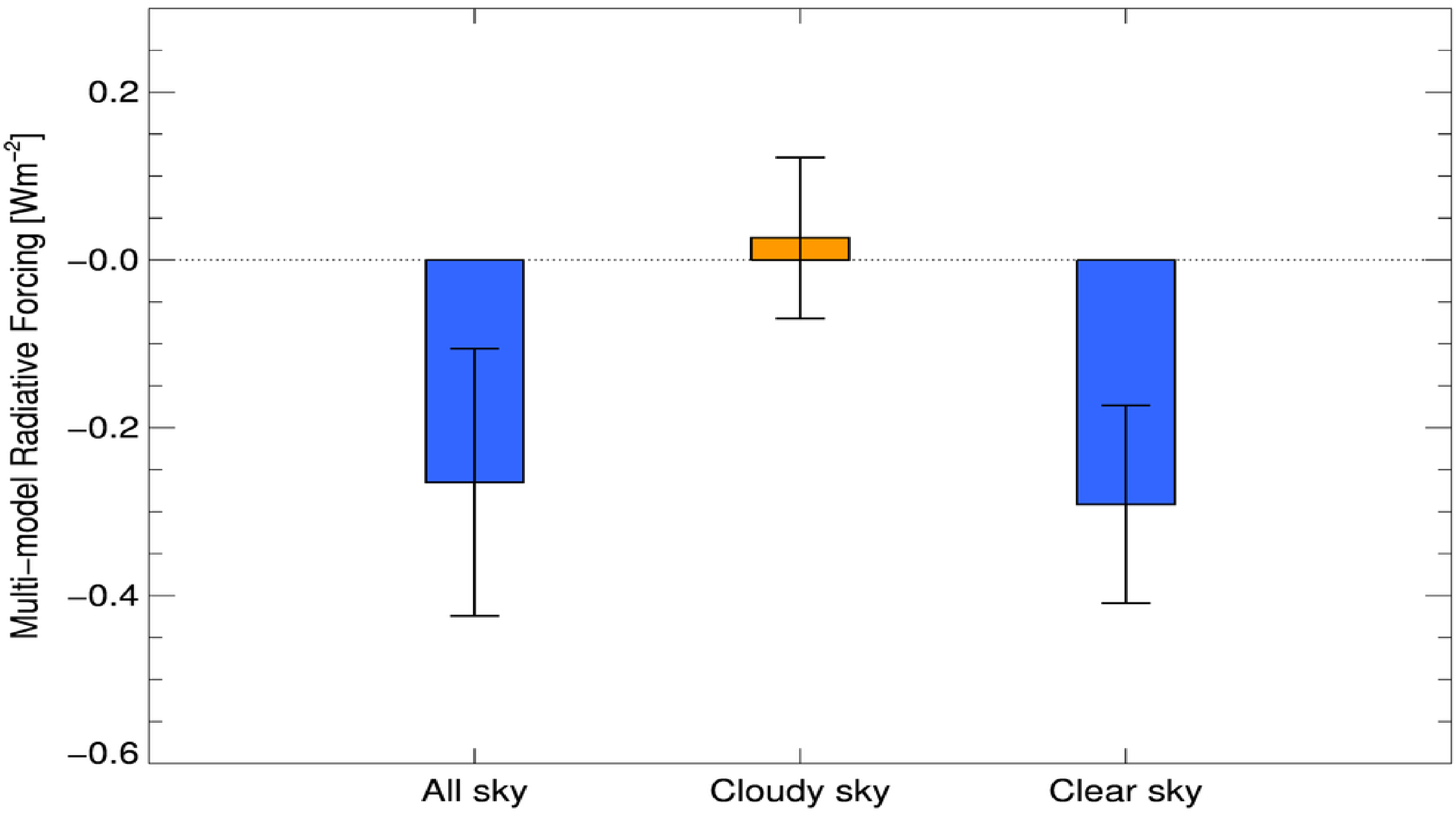


$$\mathbf{RF_{all\ sky} = (1 - AC) * RF_{clear} + AC * RF_{cloud}}$$

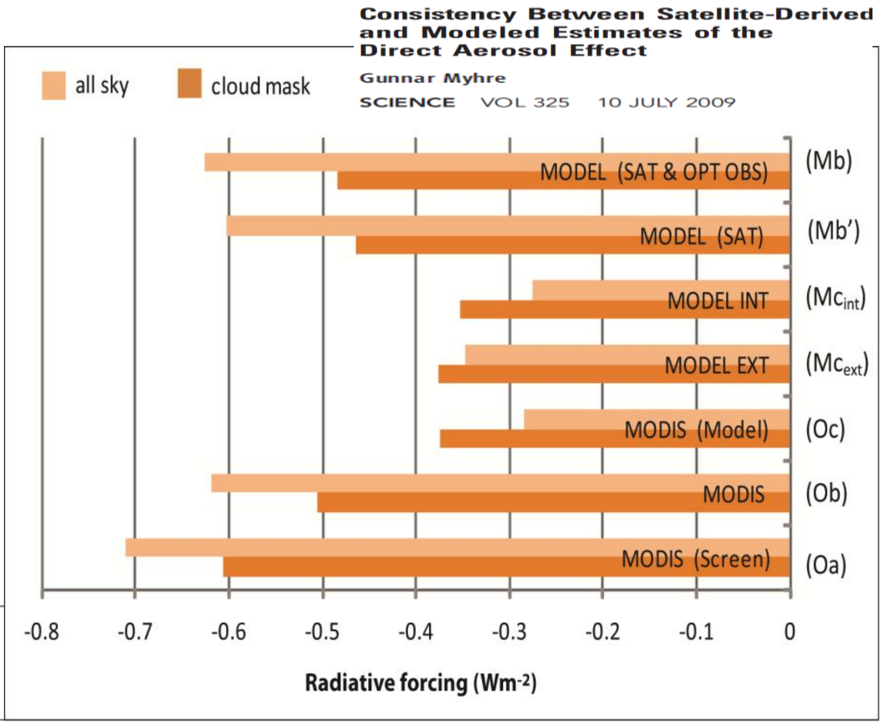
Radiative forcing in cloudy sky regions

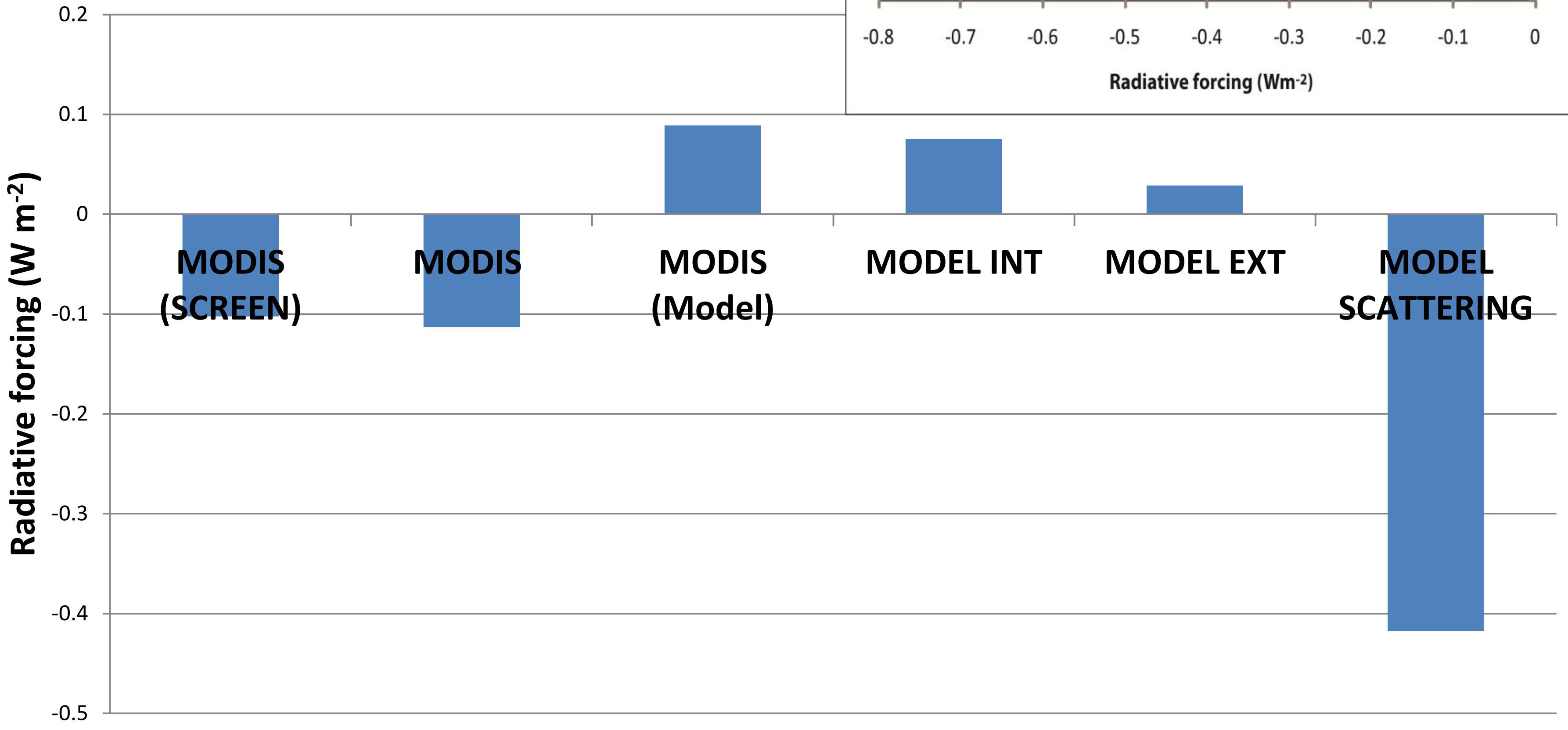


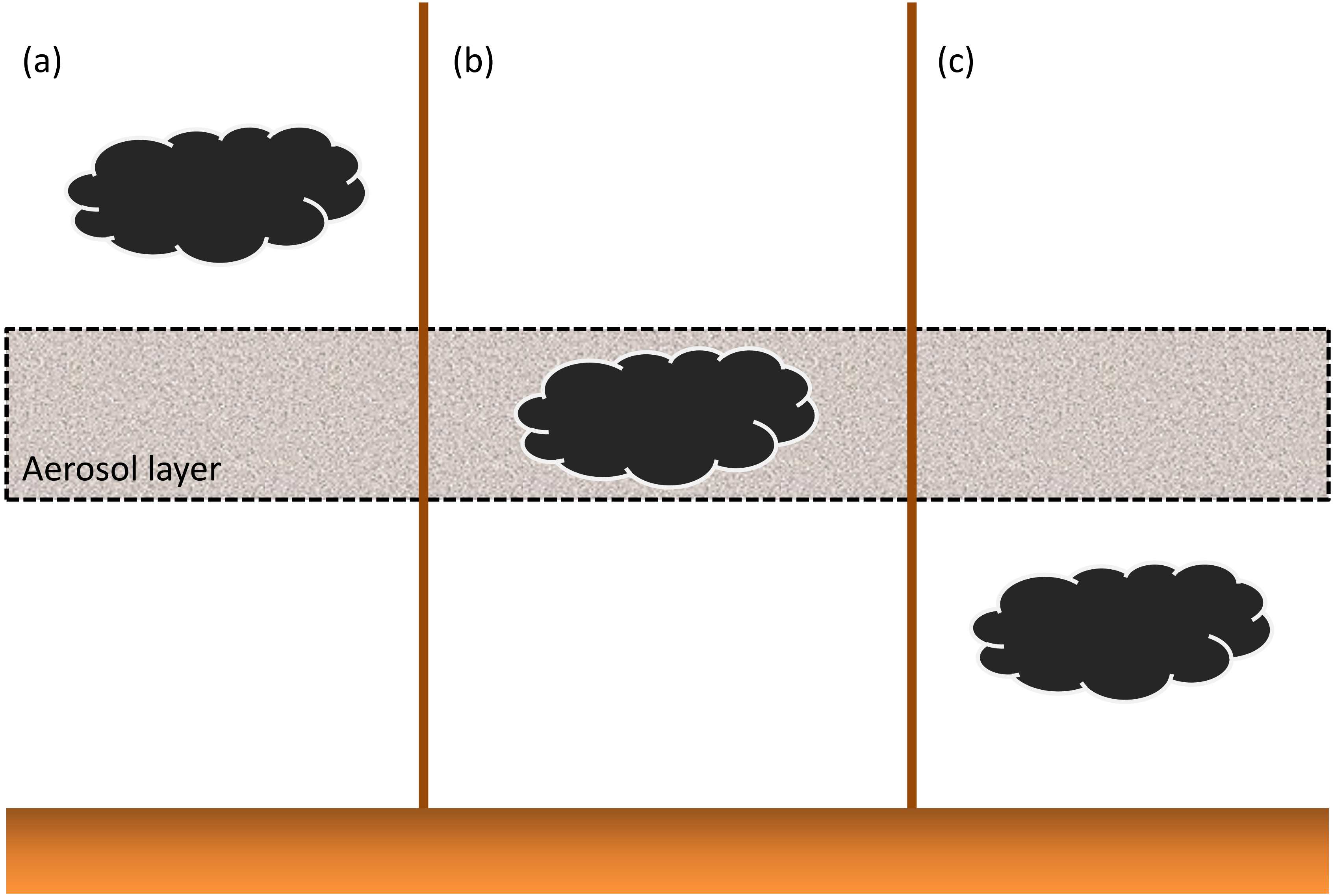
Radiative forcing in cloudy sky regions



RF in cloudy sky regions

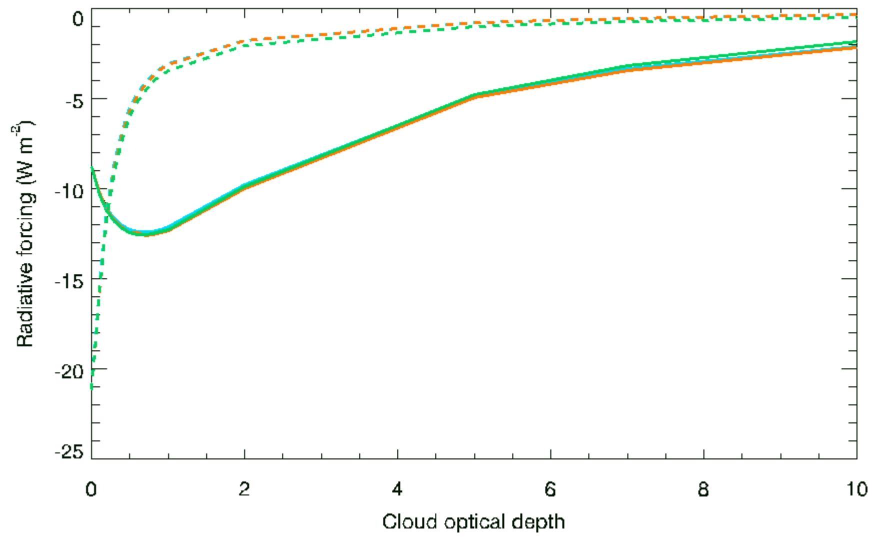


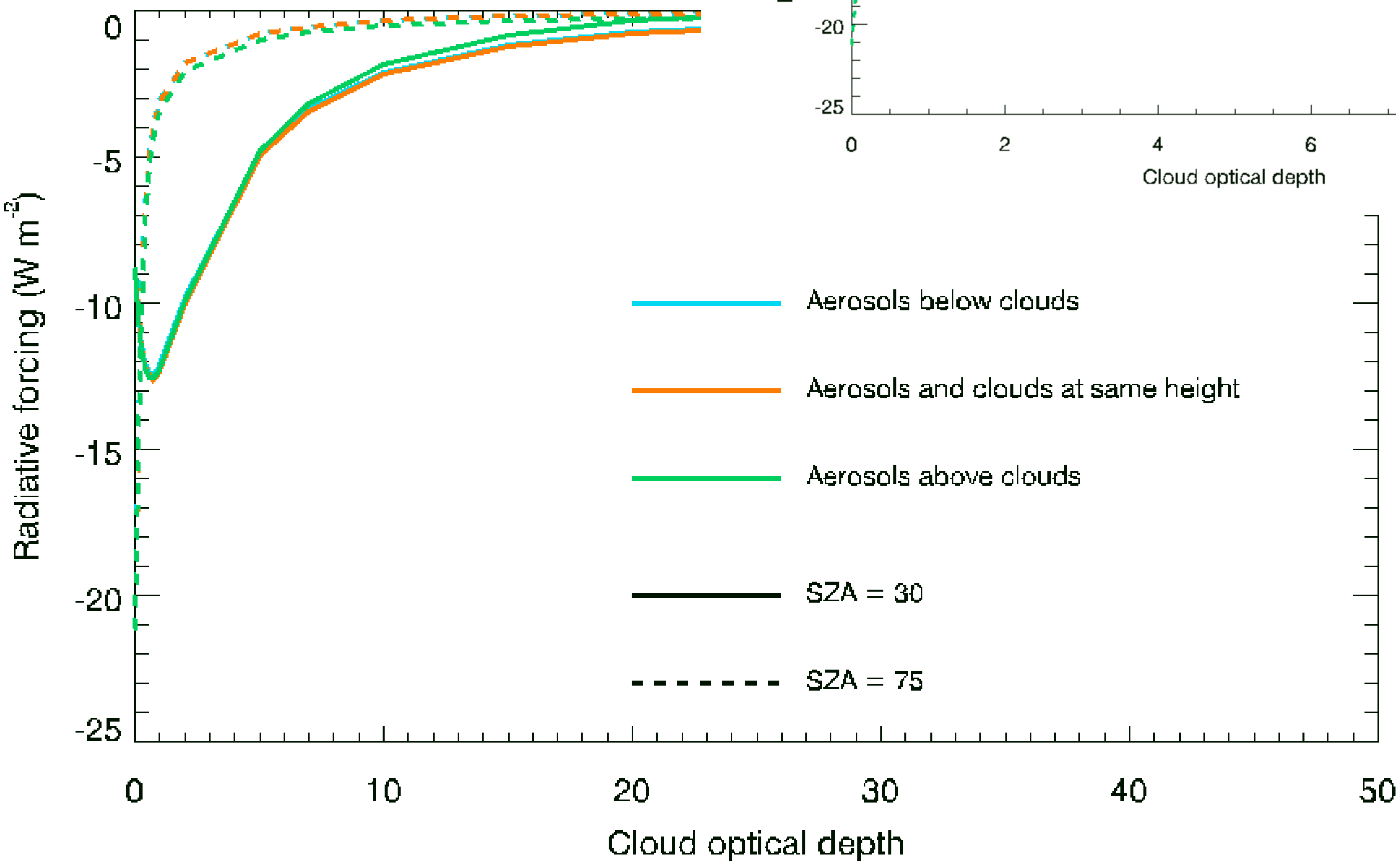



(a)
(b)
(c)
Aerosol layer

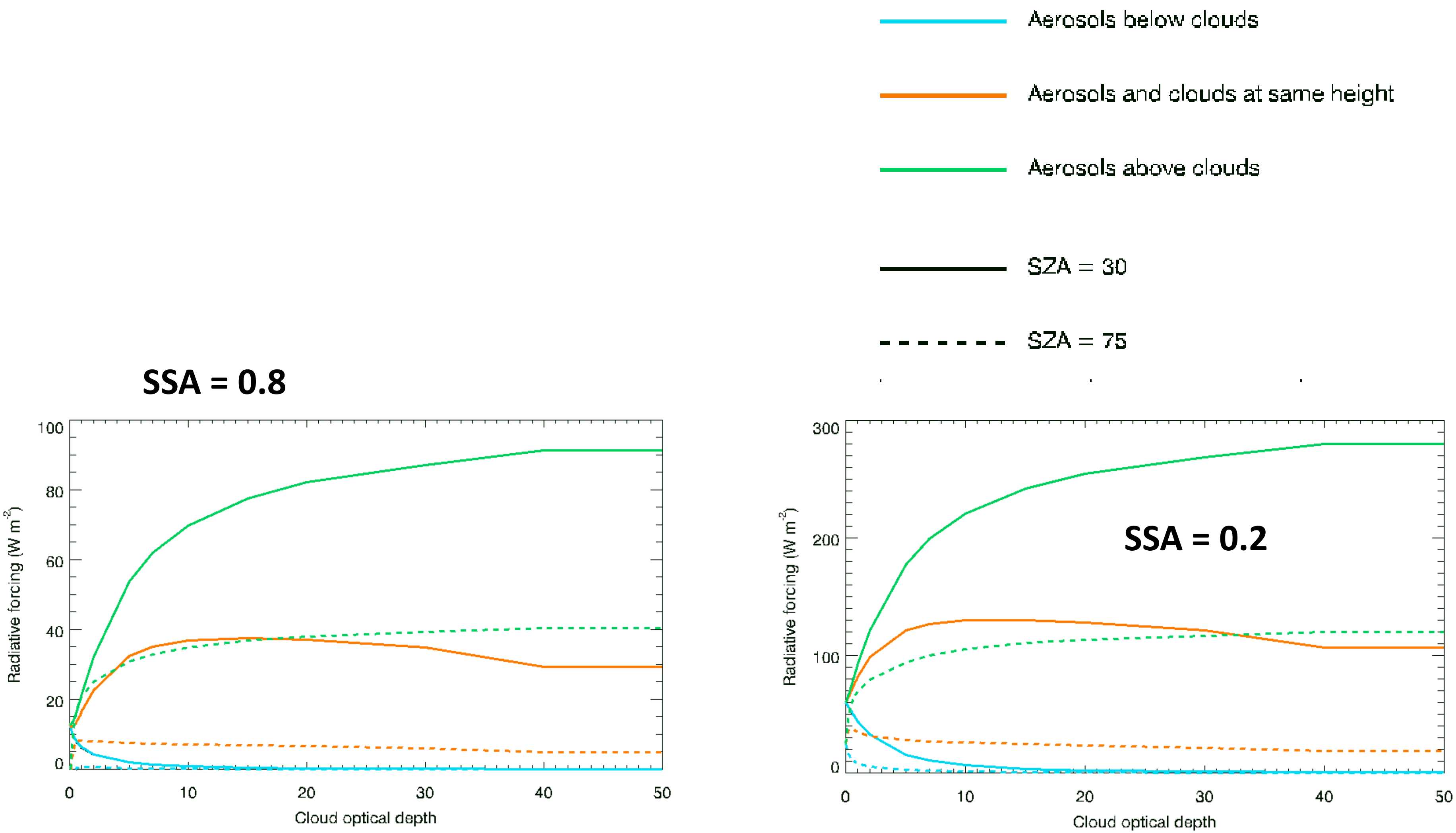
Pure scattering aerosols

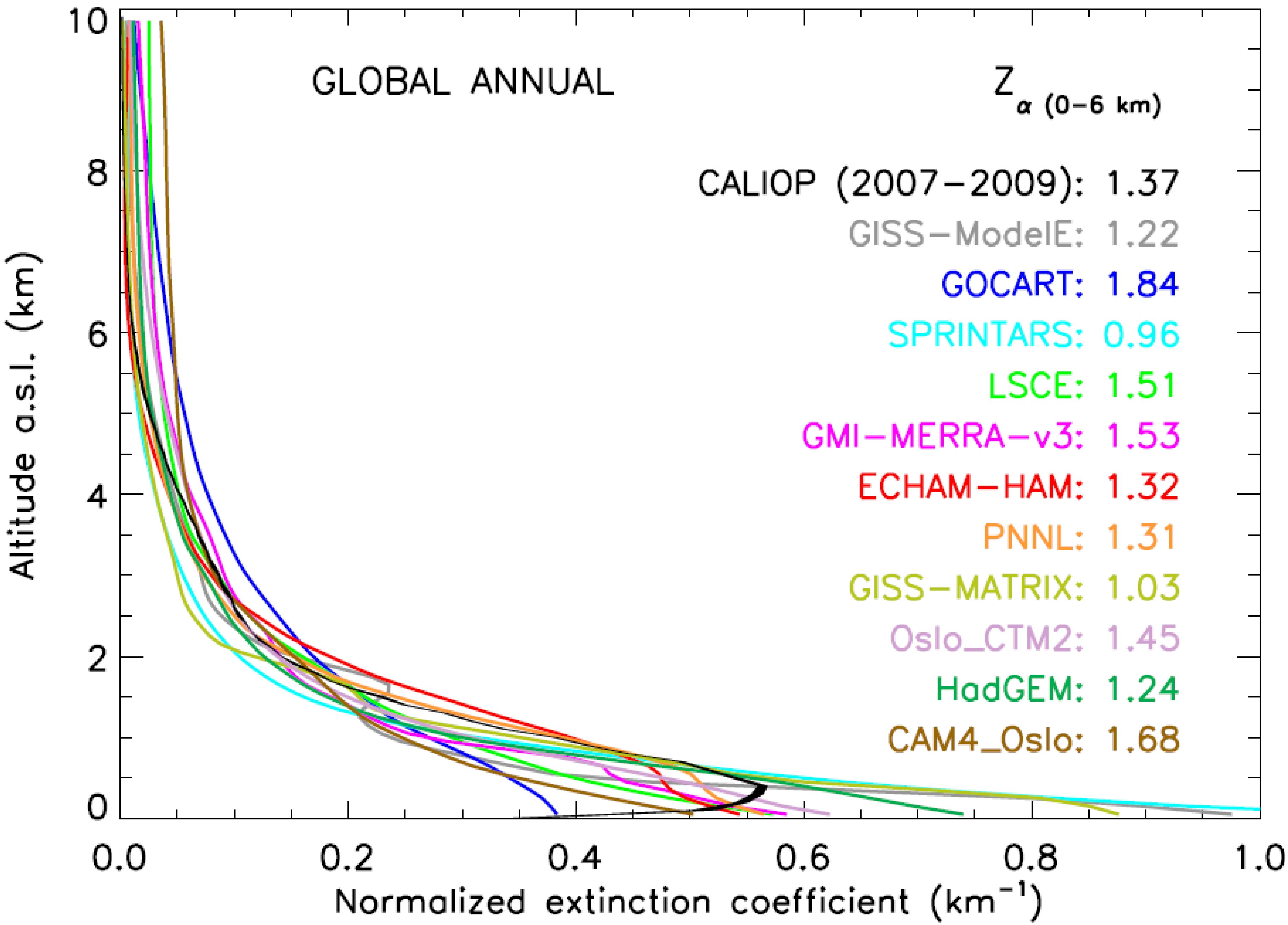
Aerosol optical properties as in prescribed and single profile experiments

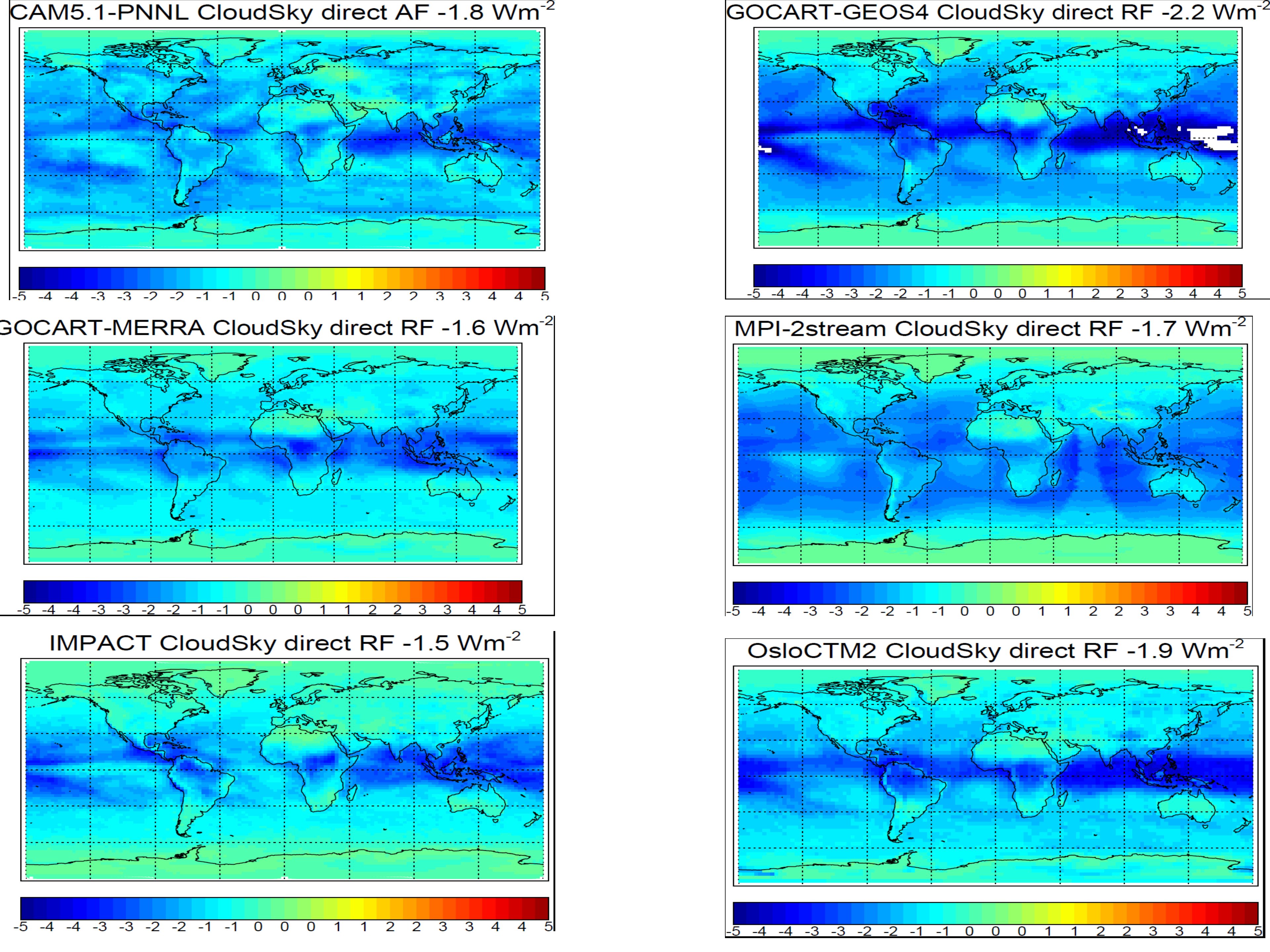


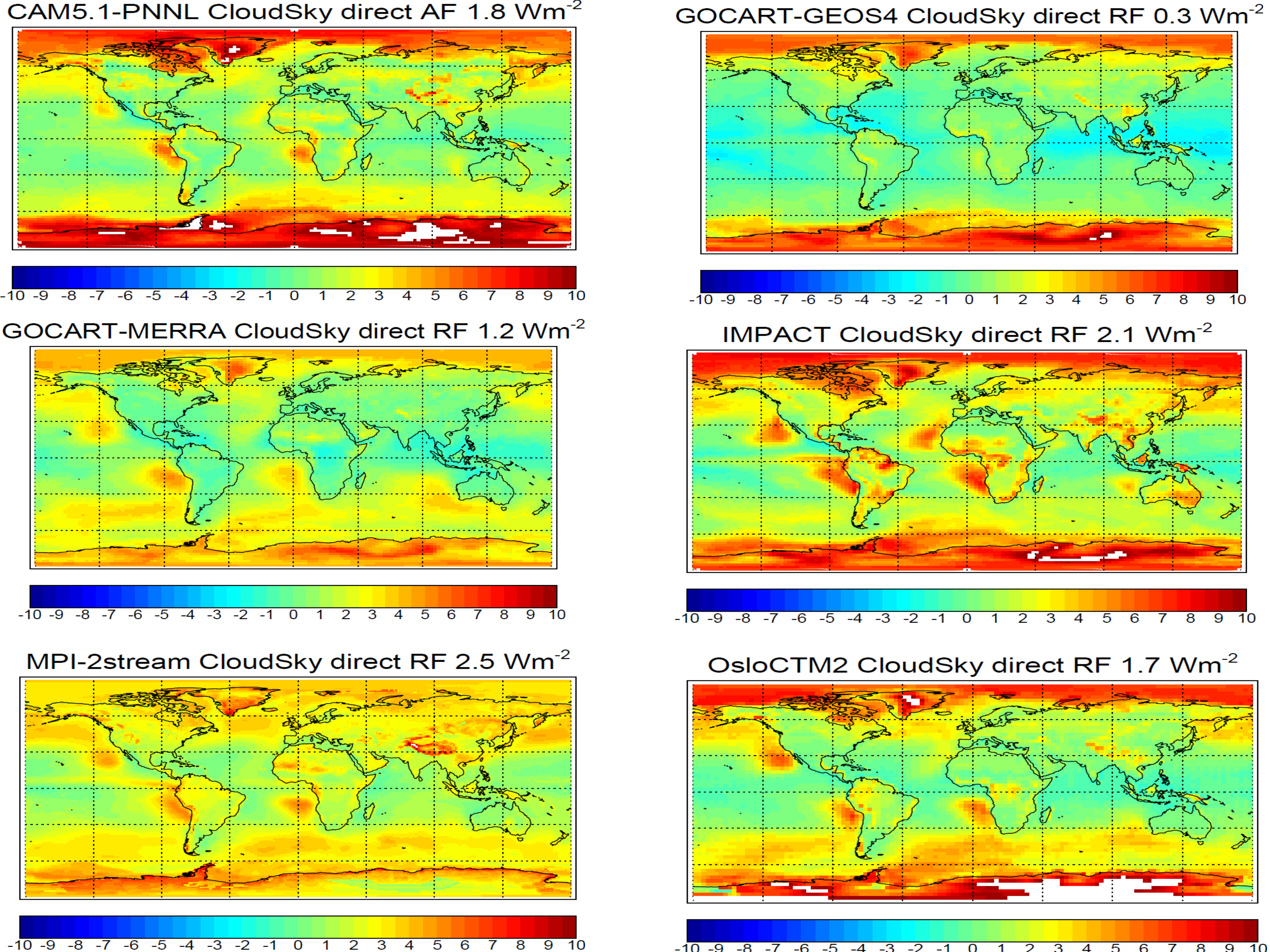


Medium and strongly absorbing aerosols




GLOBAL ANNUAL
$Z_{\alpha\ (0-6\ km)}$
CALIOP (2007–2009): 1.37
GISS–ModelE: 1.22
GOCART: 1.84
SPRINTARS: 0.96
LSCE: 1.51
GMI–MERRA–v3: 1.53
ECHAM–HAM: 1.32
PNNL: 1.31
GISS–MATRIX: 1.03
Oslo_CTM2: 1.45
HadGEM: 1.24
CAM4_Oslo: 1.68
Altitude a.s.l. (km)
0
2
4
6
8
10
0.0
0.2
0.4
0.6
0.8
1.0
Normalized extinction coefficient (km^{-1})


CAM5.1-PNNL CloudSky direct AF -1.8 Wm-2
GOCART-GEOS4 CloudSky direct RF -2.2 Wm-2
GOCART-MERRA CloudSky direct RF -1.6 Wm-2
MPI-2stream CloudSky direct RF -1.7 Wm-2
IMPACT CloudSky direct RF -1.5 Wm-2
OsloCTM2 CloudSky direct RF -1.9 Wm-2
-5 -4 -4 -3 -3 -2 -2 -1 -1 0 0 0 1 1 2 2 3 3 4 4 5


CAM5.1-PNNL CloudSky direct AF 1.8 Wm^{-2}
GOCART-GEOS4 CloudSky direct RF 0.3 Wm^{-2}
GOCART-MERRA CloudSky direct RF 1.2 Wm^{-2}
IMPACT CloudSky direct RF 2.1 Wm^{-2}
MPI-2stream CloudSky direct RF 2.5 Wm^{-2}
OsloCTM2 CloudSky direct RF 1.7 Wm^{-2}
-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10

Model	Scattering	Absorbing	Difference
CAM5.1-PNNL	-1.8	1.8	3.6
GOCART-GEOS4	-2.2	0.3	2.5
GOCART-MERRA	-1.6	1.2	2.8
MPI-2stream	-1.7	2.1	3.8
IMPACT	-1.5	2.5	4.0
OsloCTM2	-1.9	1.7	3.6

MODELS	RF	SSA	Z_*	Clouds Scat	Clouds Abs
CAM5.1-MAM3-PNNL	**0.12**				
GOCART-v4	**-0.11**				
GMI-MERRA-v3	**-0.12**				
IMPACT-Umich	**0.11**				
OsloCTM2	**-0.02**				

Warming effect

Weak warming effect

Neutral

Weak cooling effect

Cooling effect

SSA	Single scattering albedo
Z_*	Normalized extinction coefficient
Clouds Scat	Efficiency of clouds on scattering aerosols
Clouds Abs	Efficiency of clouds on absorbing aerosols

MODELS	RF	SSA	Z_*	Clouds Scat	Clouds Abs
CAM5.1-MAM3-PNNL	**0.12**	0.90	1.31	-1.8	3.6
GOCART-v4	**-0.11**	0.94	1.84	-2.2	2.5
GMI-MERRA-v3	**-0.12**	0.97	1.53	-1.6	2.8
IMPACT-Umich	**0.11**	0.97	NA	-1.5	4.0
OsloCTM2	**-0.02**	0.95	1.45	-1.9	3.6

- Warming effect
- Weak warming effect
- Neutral
- Weak cooling effect
- Cooling effect

SSA	Single scattering albedo
Z_*	Normalized extinction coefficient
Clouds Scat	Efficiency of clouds on scattering aerosols
Clouds Abs	Efficiency of clouds on absoring aerosols

MODELS	RF	SSA	Z_*	Clouds Scat	Clouds Abs
CAM5.1-MAM3-PNNL	**0.12**	0.90	1.31	-1.8	3.6
GOCART-v4	**-0.11**	0.94	1.84	-2.2	2.5
GMI-MERRA-v3	**-0.12**	0.97	1.53	-1.6	2.8
IMPACT-Umich	**0.11**	0.97	NA	-1.5	4.0
OsloCTM2	**-0.02**	0.95	1.45	-1.9	3.6

Warming effect

Weak warming effect

Neutral

Weak cooling effect

Cooling effect

Additional models:

Prescribed – **BCC**, **ECHAM5-HAM** (should be available?), **HadGEM2** (have completed the runs), **INCA** (problems with cloud fields), **SPRINTARS**