Today's Outline

- Day 2 - Tuesday 09/04 **Atmospheric composision**

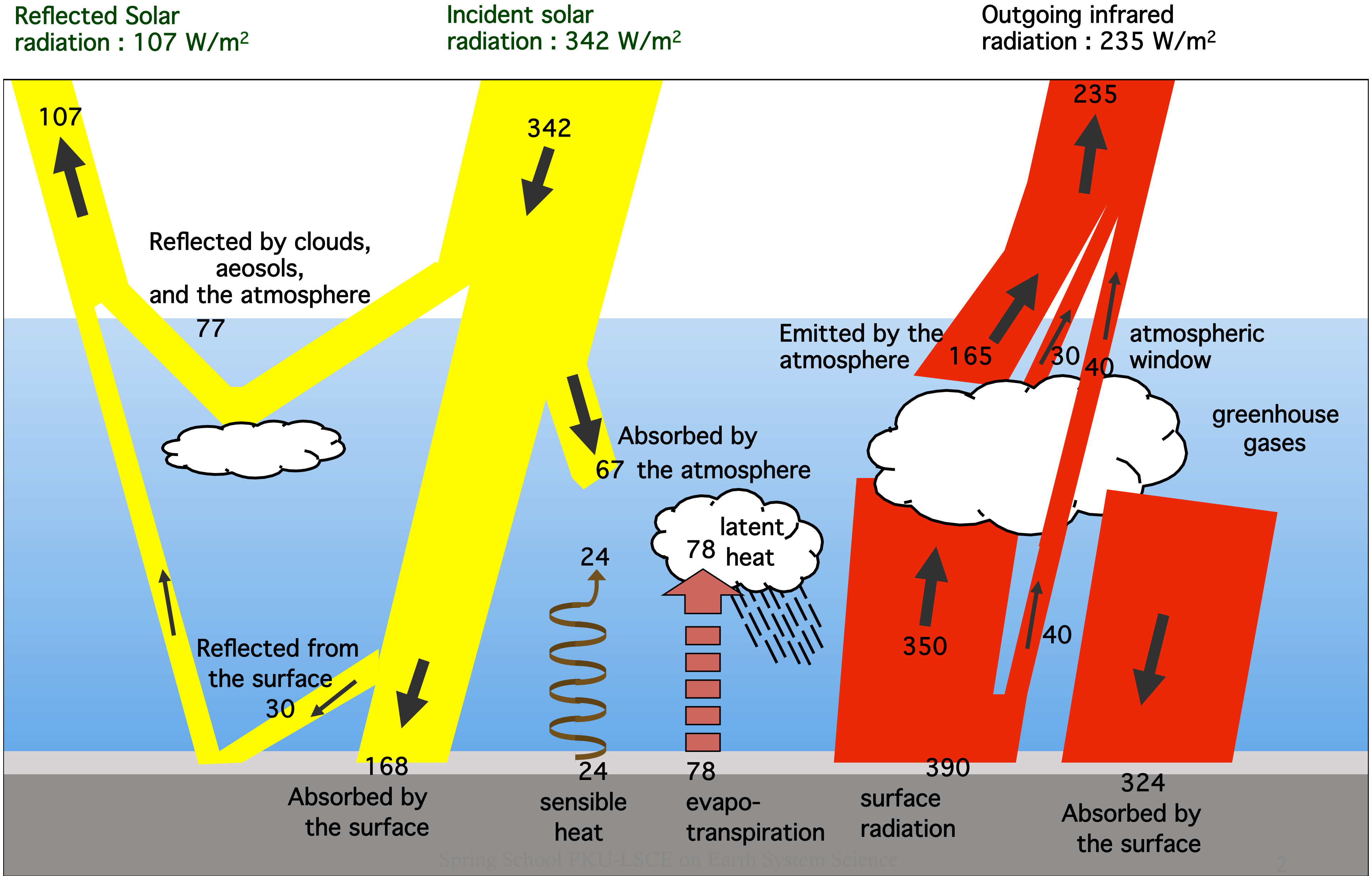
Morning

- Keynote: Y. Balkanski, **Aerosol compositiion, optical properties and their link with climate**
- *Student Presentation*
- Course 1: Yin : The thermal feedback of forest to local and regional climate
- *Student Presentation*

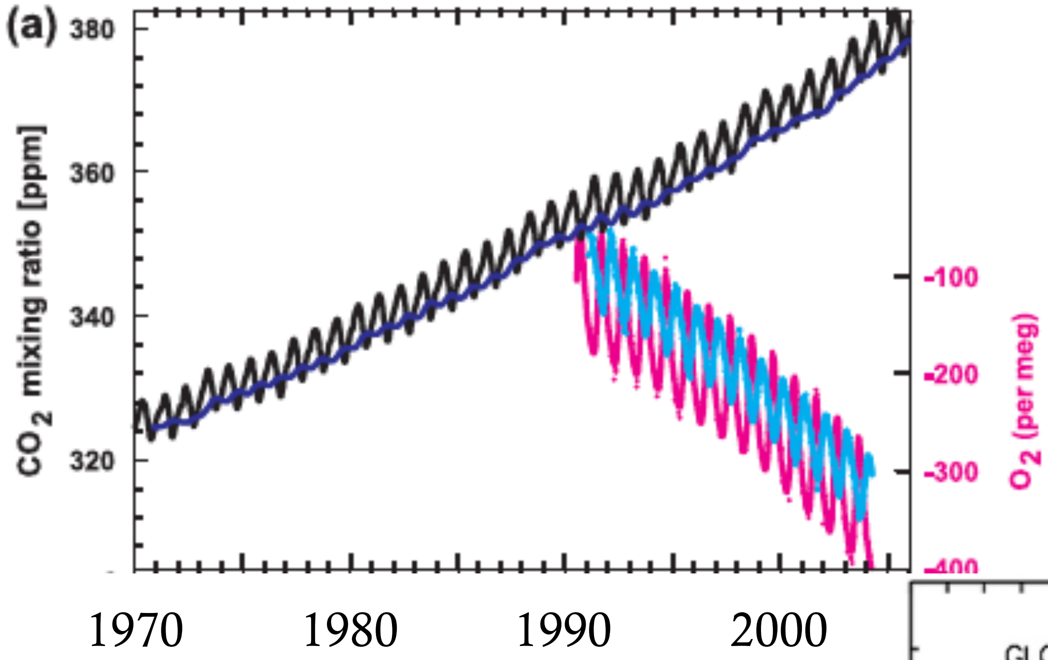
Atfternoon

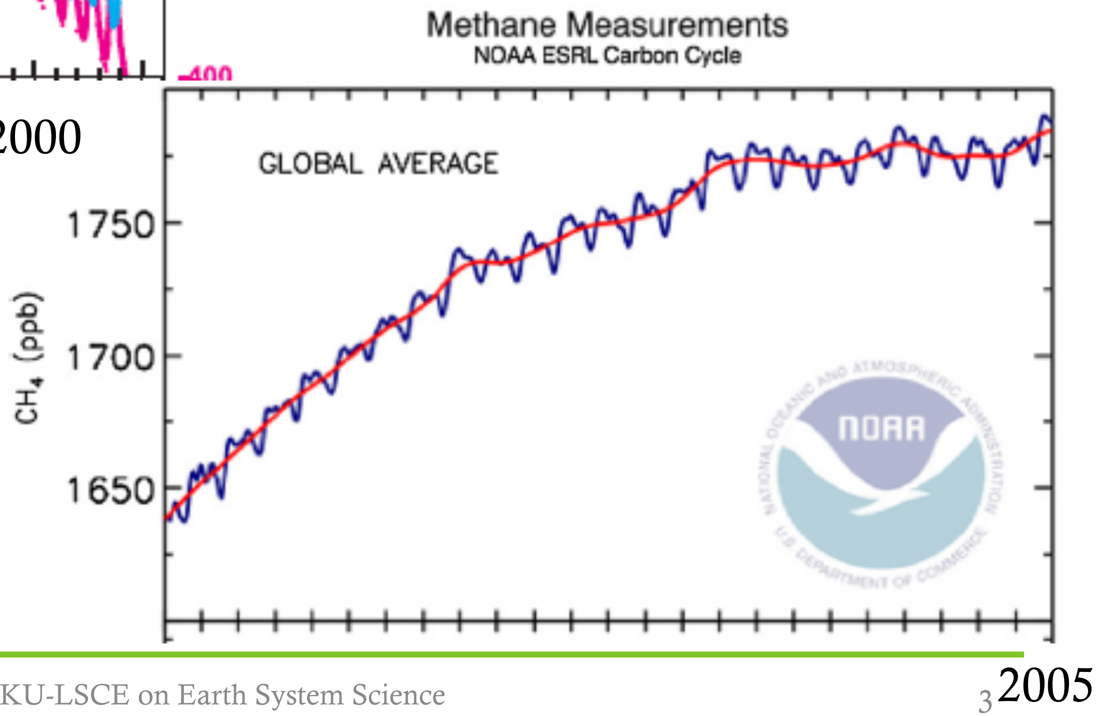
- Course 2: Hauglustaine : Tropospheric chemistry and climate-chemistry interactions
- Student presentation
- Course 3: Bousquet (video) : Atmospheric methane : from global to regional changes over the past 30 years + student presentations
- Course 4: Bréon*:* Remote sensing of vegetation dynamic. Methods, difficulties and results

Radiation budget

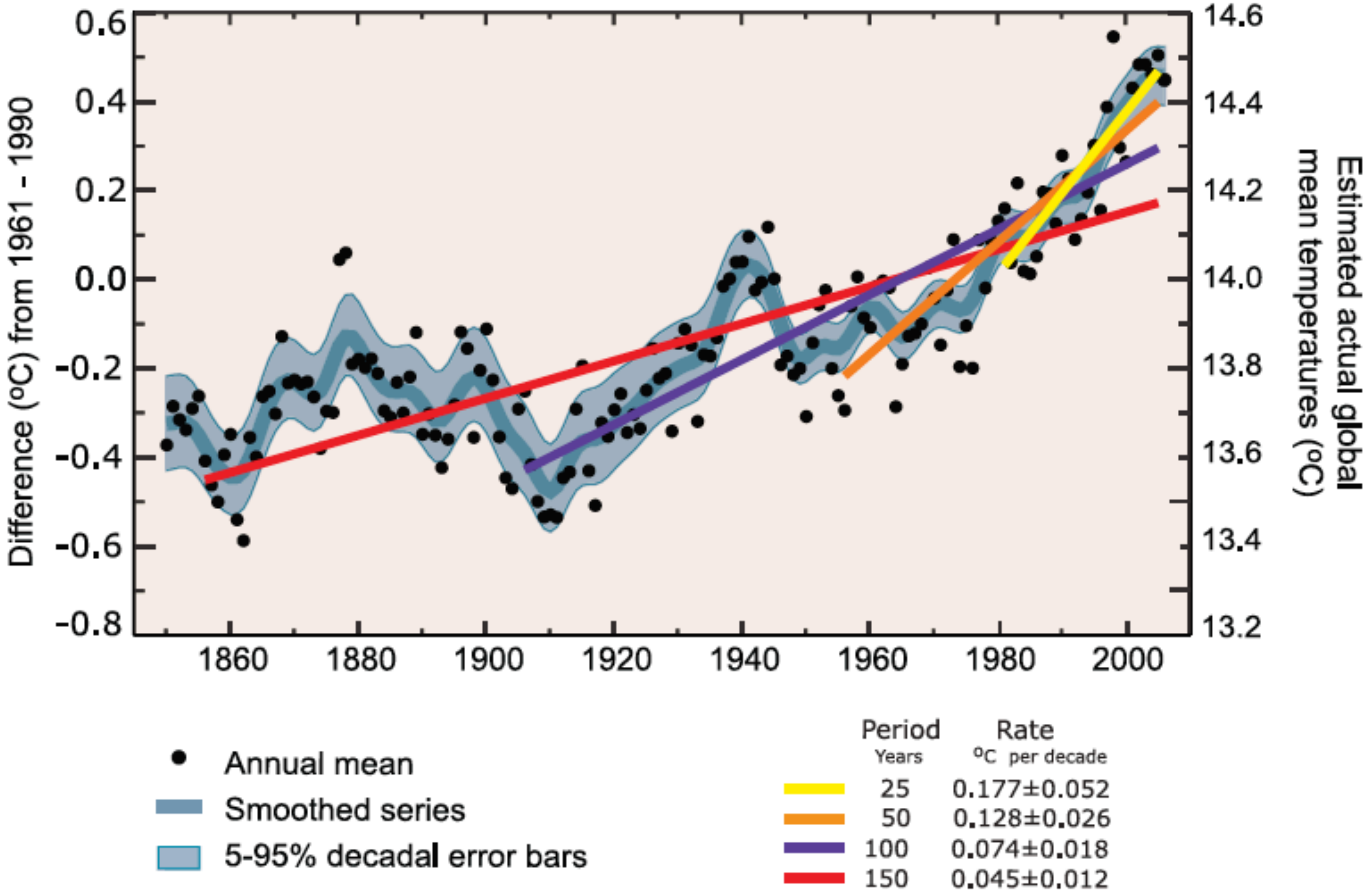


Greenhouse gases increase in the last 35 years

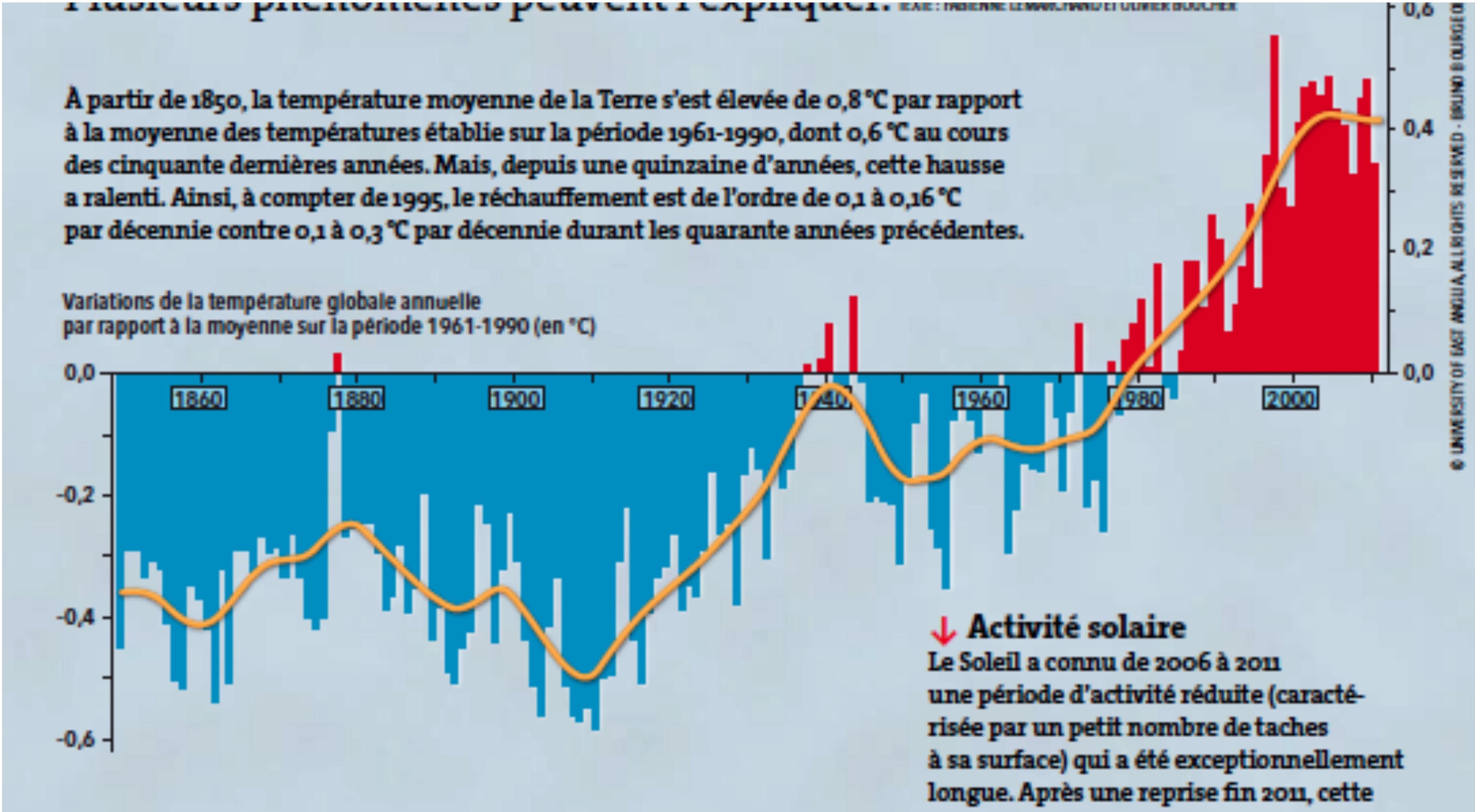




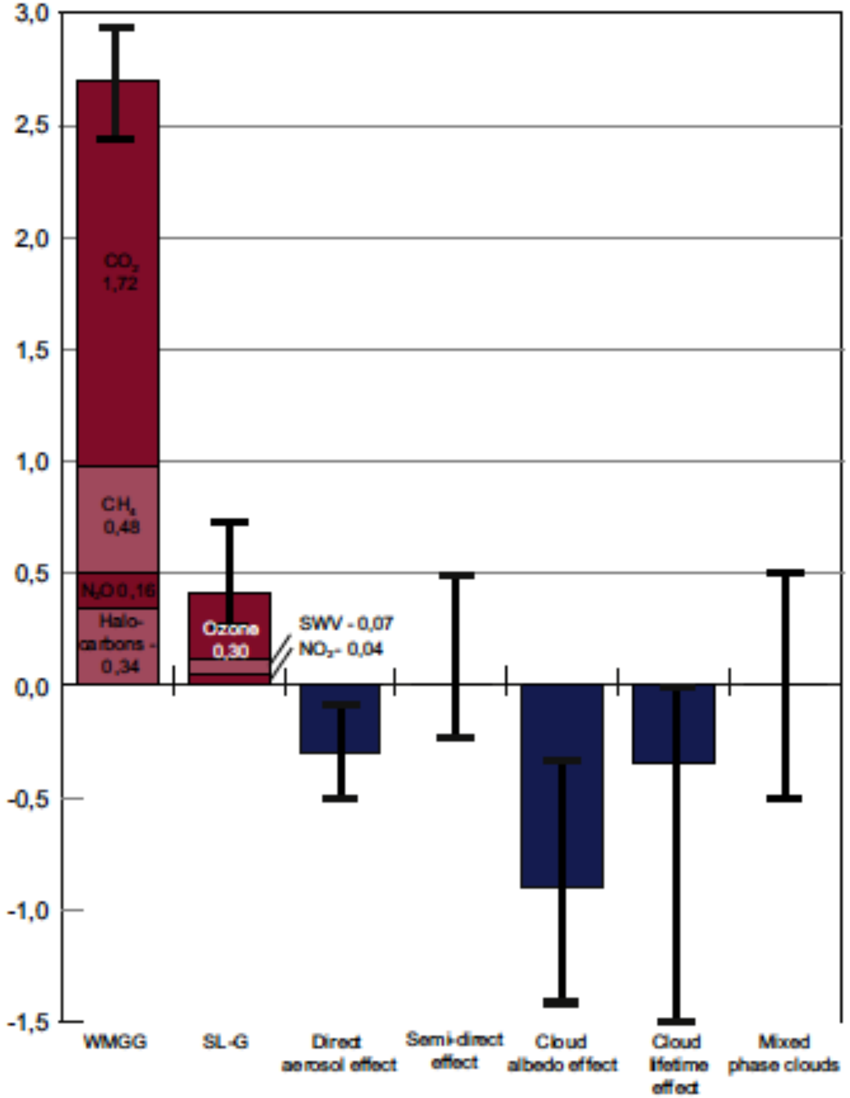
Observed temperature change from 1850



Recent plateau in temperature record (relative to mean 1961-1190)

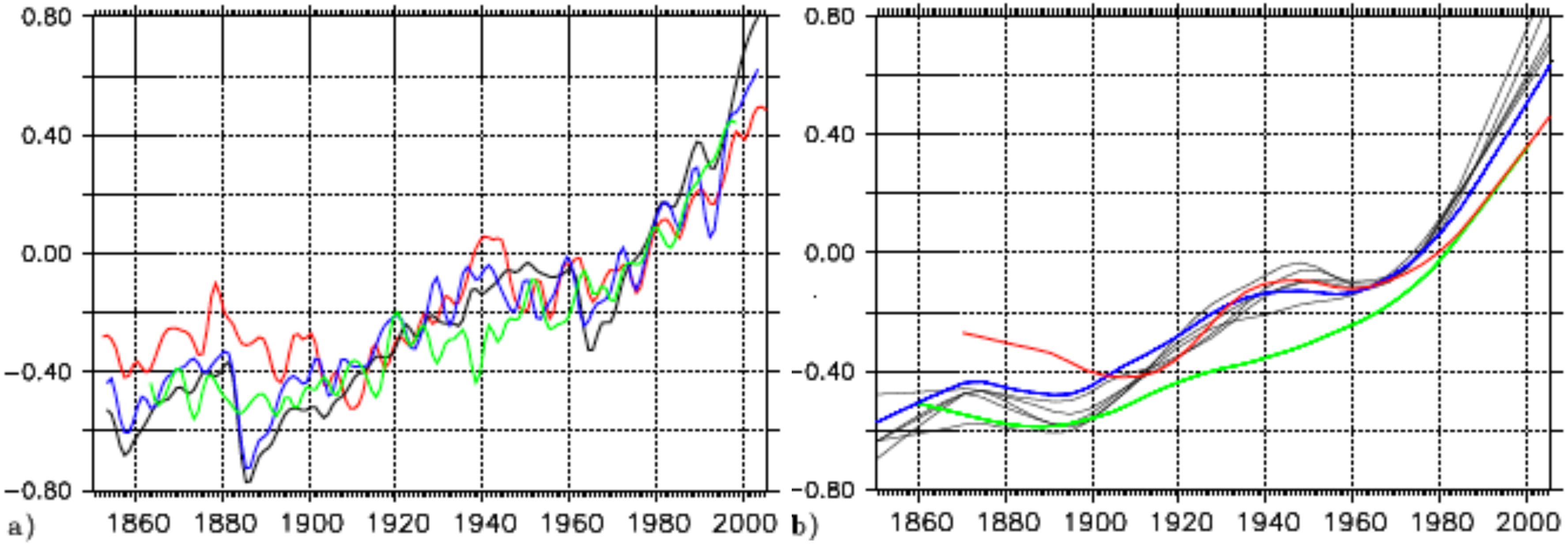


Different climate forcings



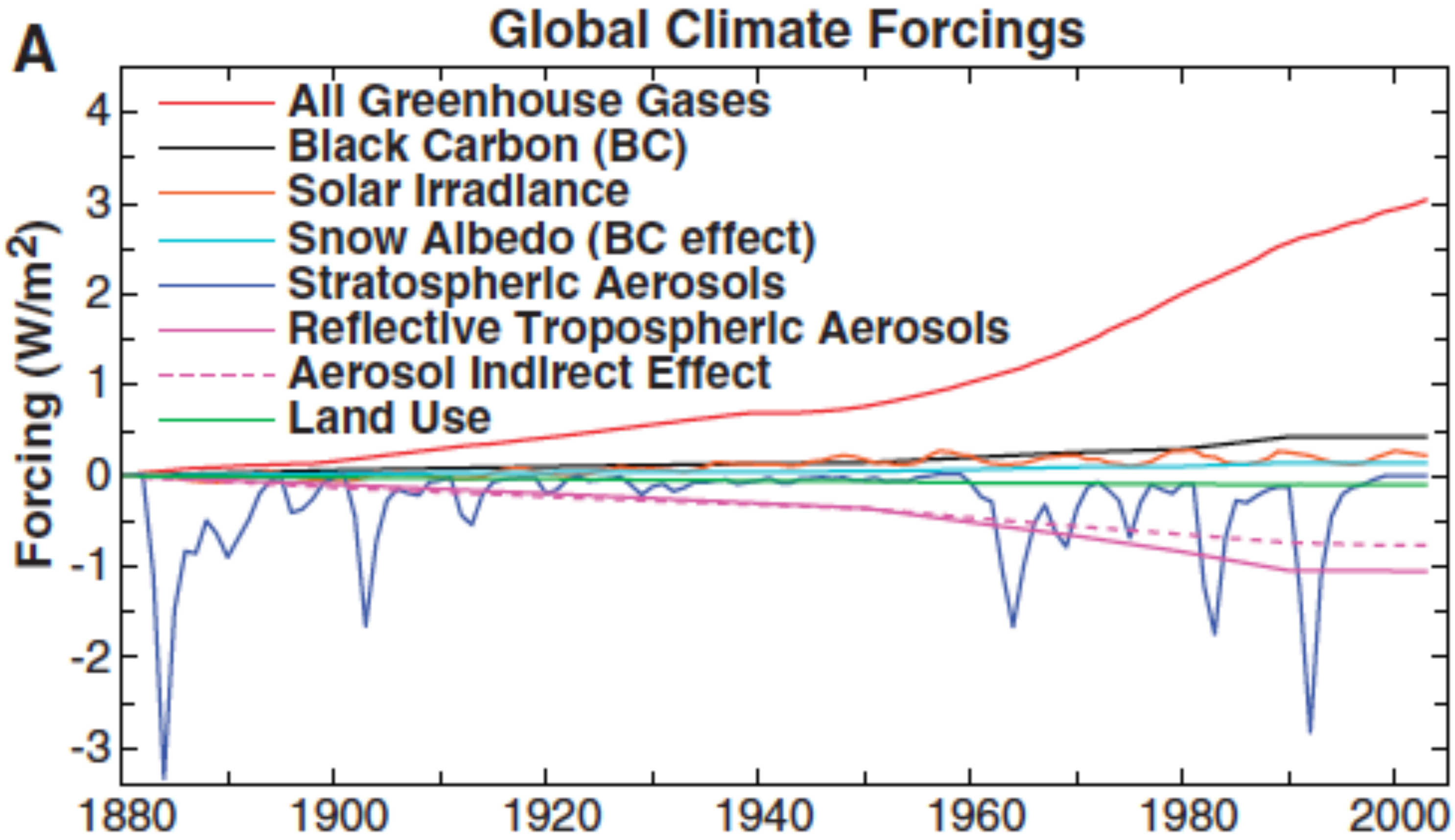
Comparison of observed and simulated temp. changes relative to the 1961-1990 period

Dufresne et al., 2012

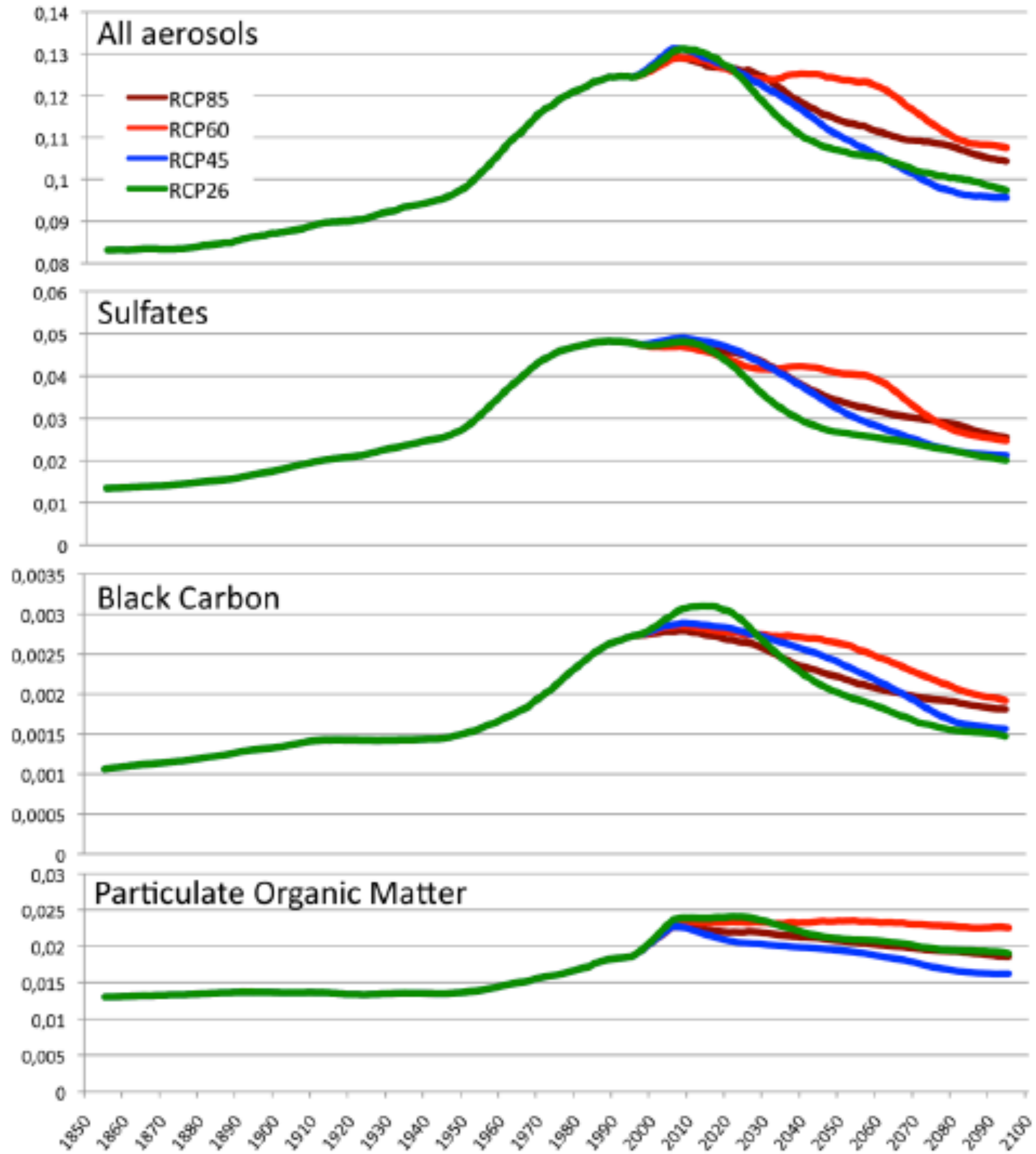


------ Observations Hadcrut3v dataset
------ Low resolution IPSLCM5 (96x95)
------ High resolution IPSLCM5 (144x142)
------ IPSLCM4

Different climate forcings and their relative strength

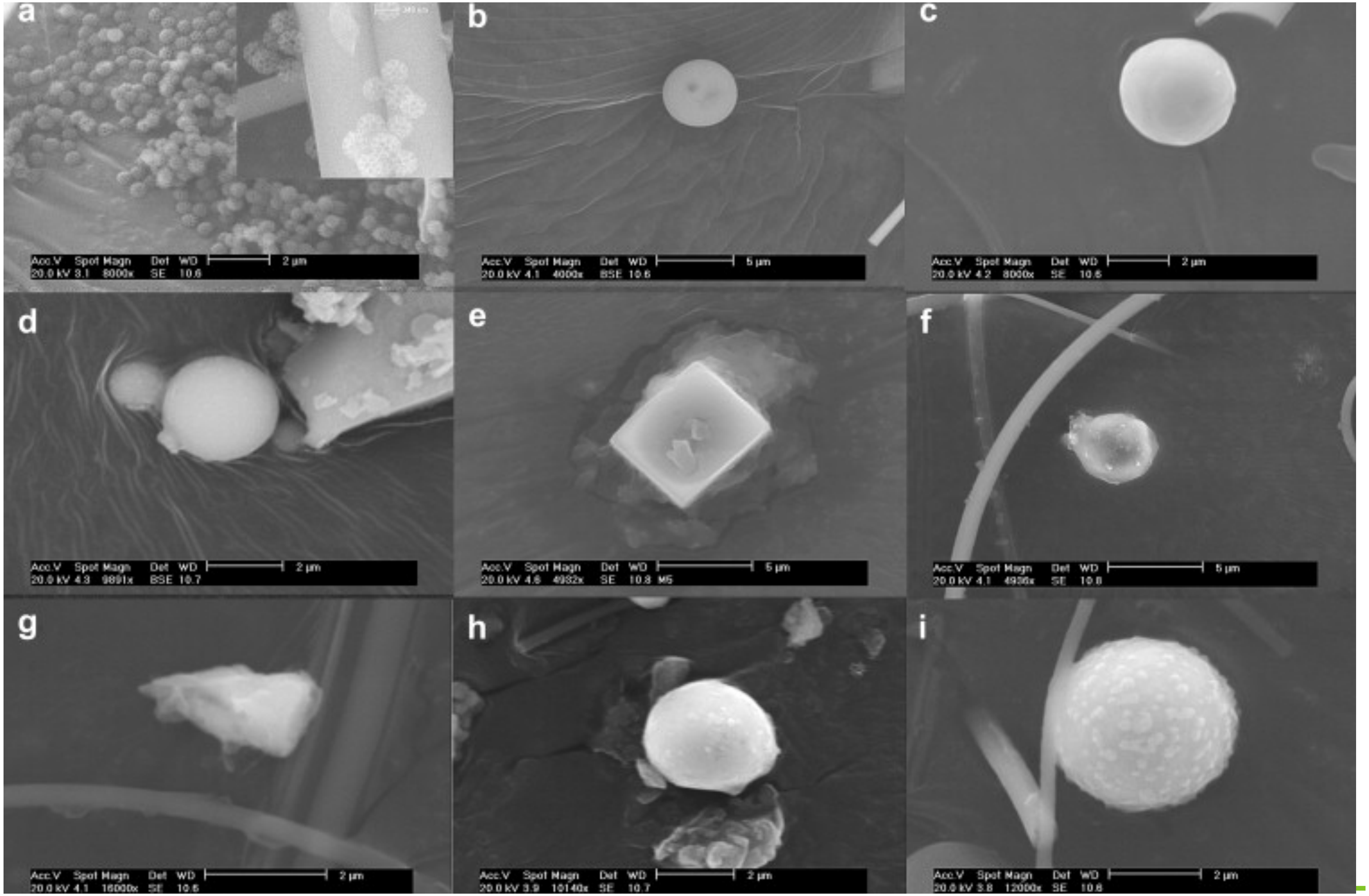


Simulated increase of aerosol optical depth (1850-2100)

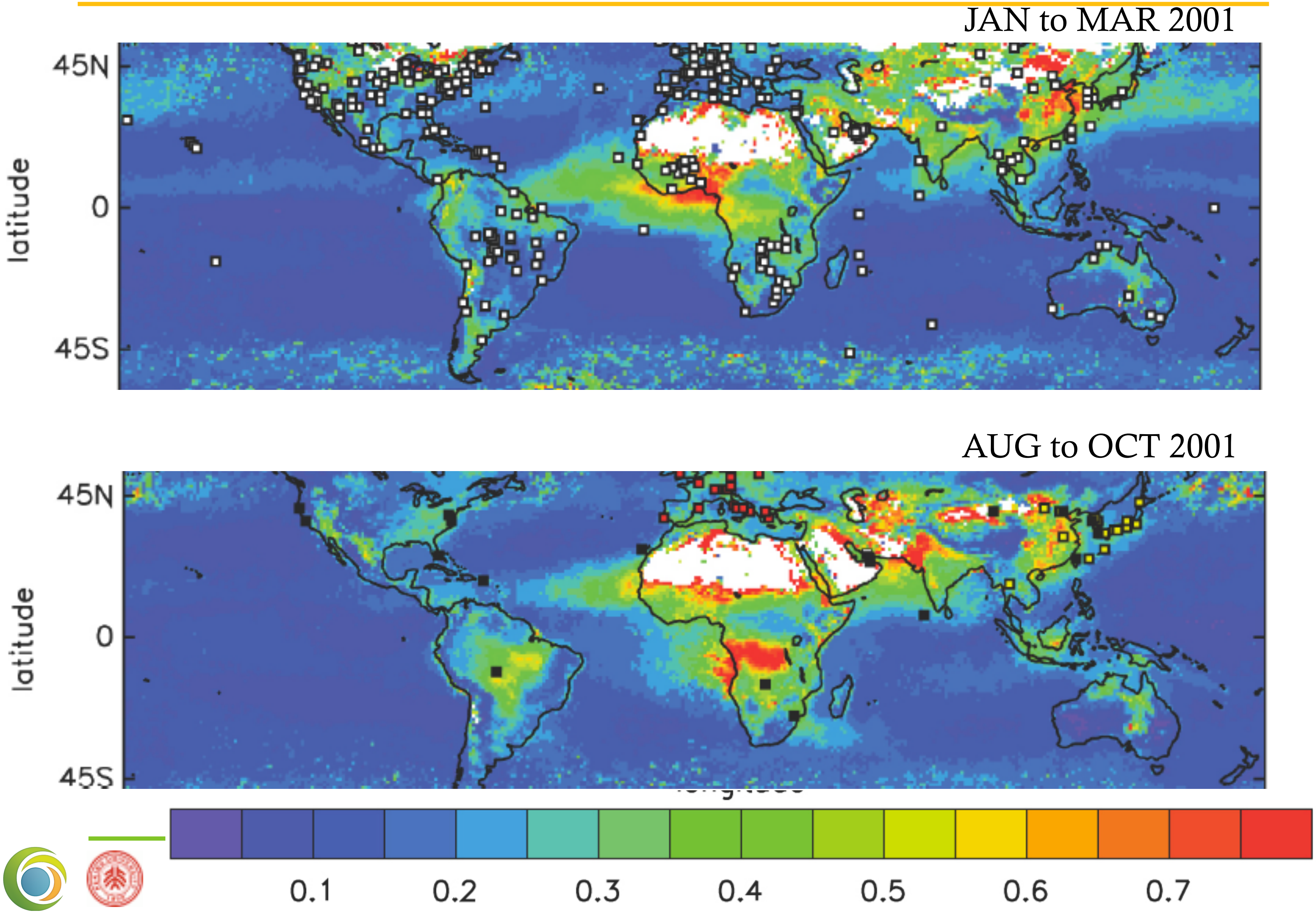


Szopa et al., (2012)

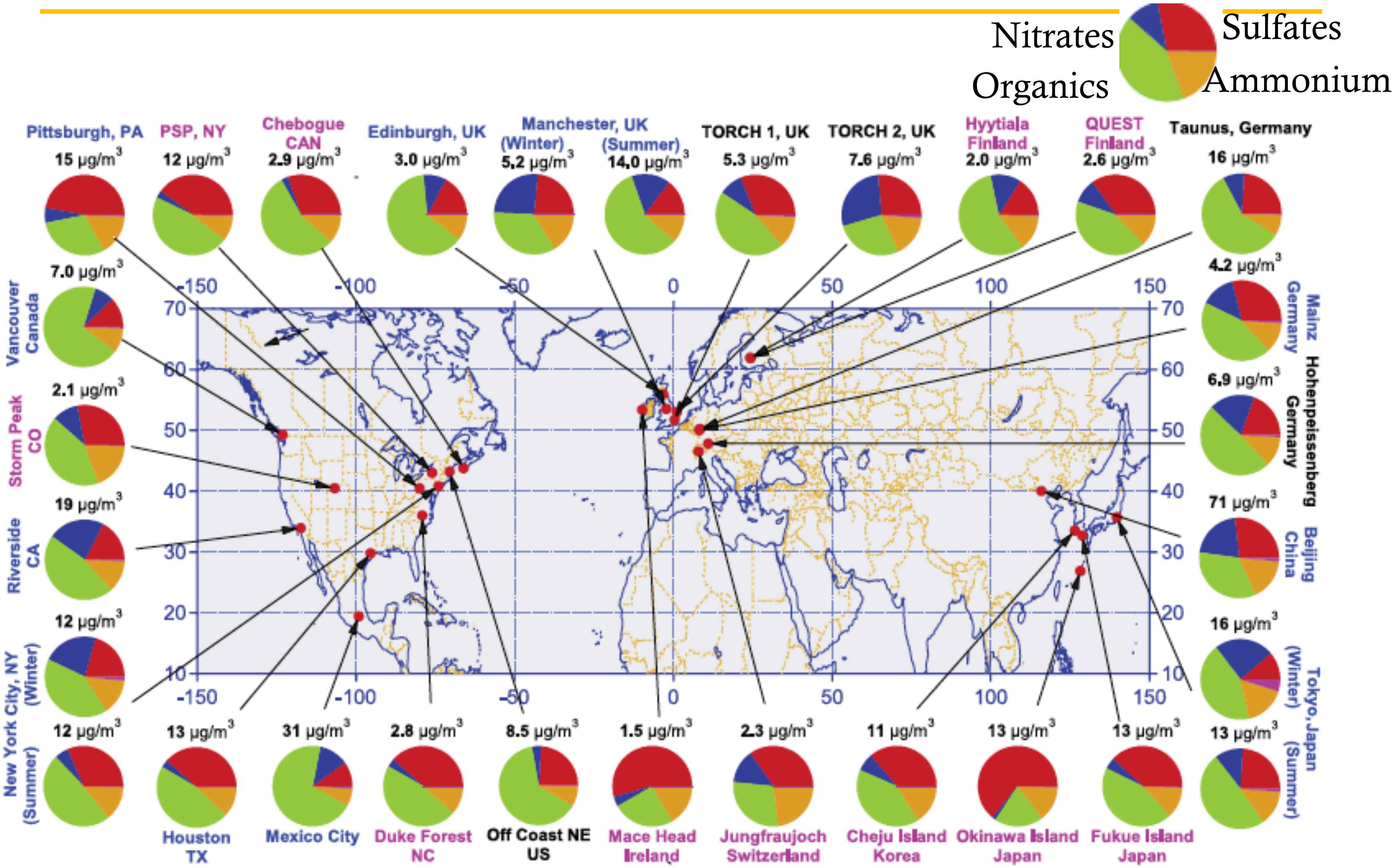
Different aerosol shapes (SEM)



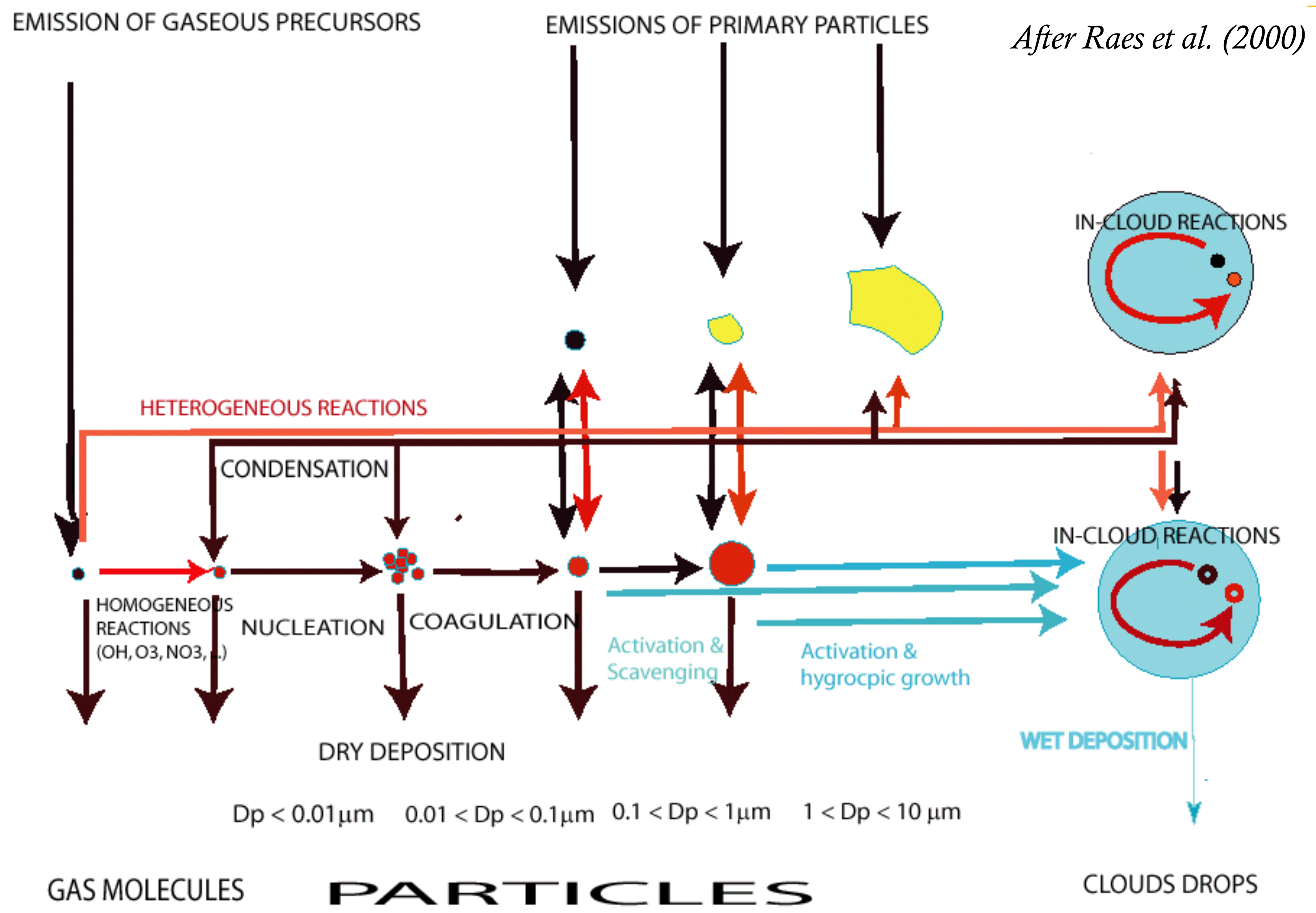
Total aerosol Optical Depth as seen from MODIS retrieval



Importance of organic aerosols (Zhang et al., 2007)



Processes for aerosol formation and loss



Representation of the aerosol in the INCA model

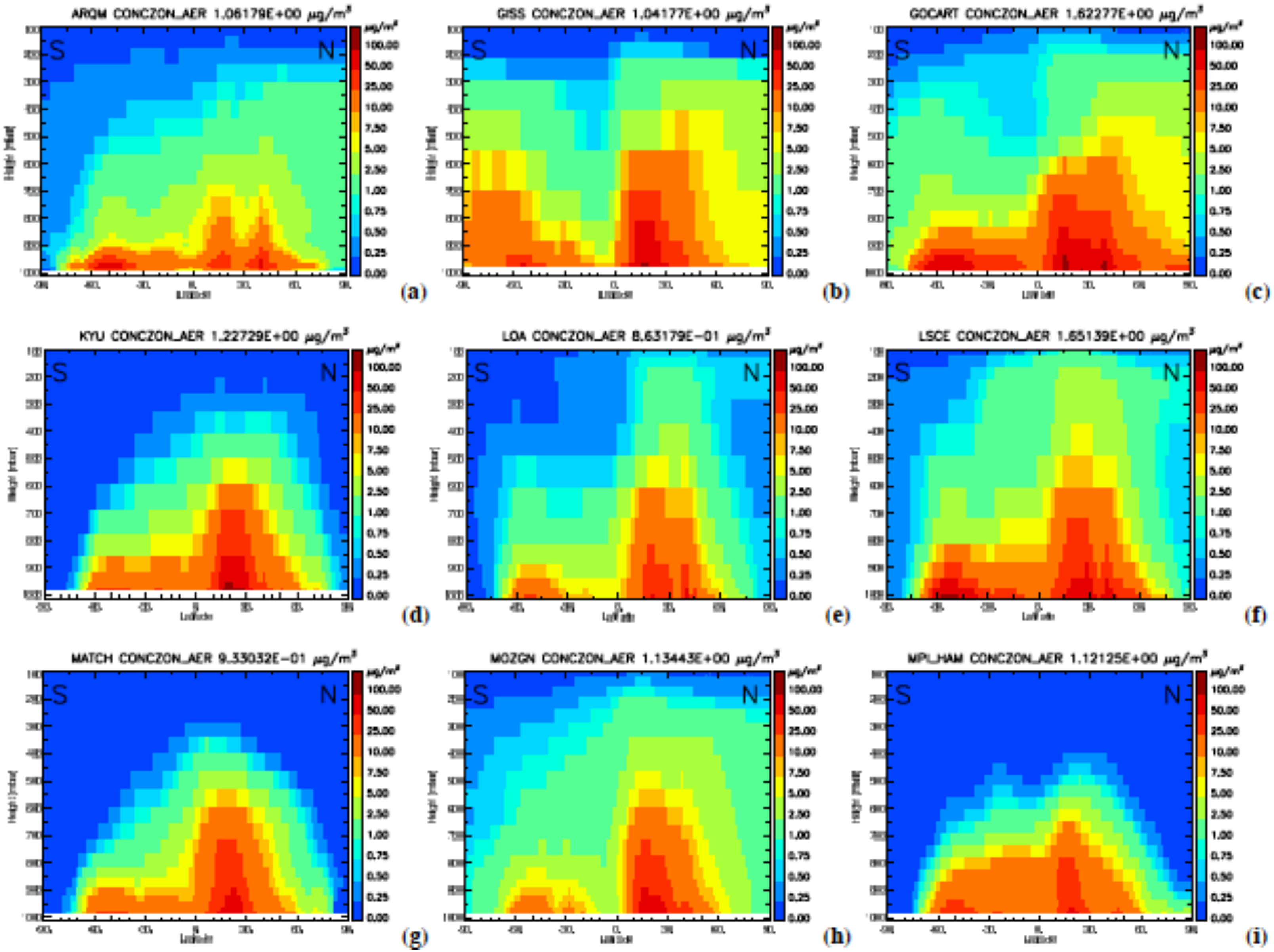
INCA Aerosol Tracer Overview

Dust / Sulphate / Black Carbon / Organic Matter / Sea Salt / Nitrate / Ammonium

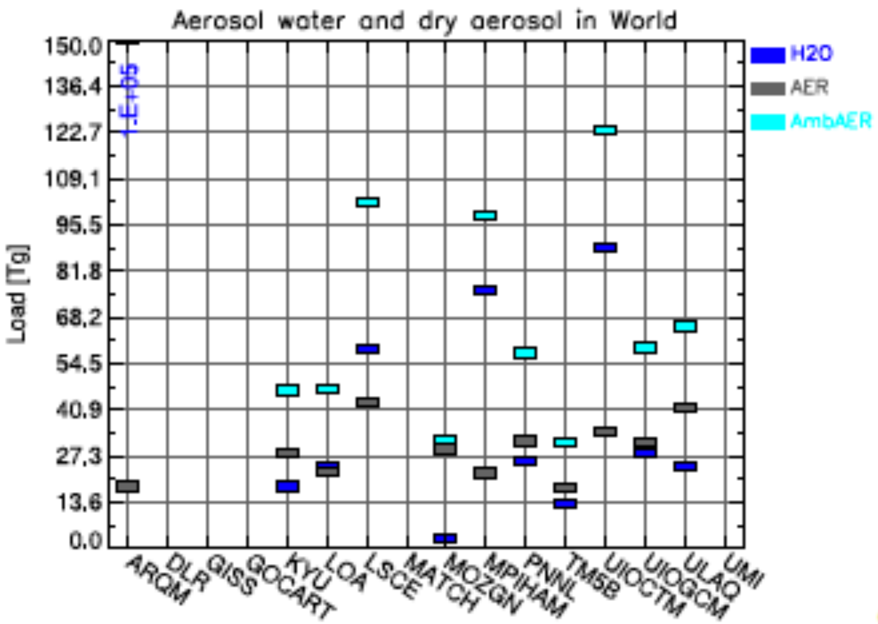
One **N**(umber) and several **M**(ass) tracer per aerosol mode

	Insoluble Modes		**Soluble Modes**
Super coarse			N_{SS} M_{SS}
Coarse	N_{CI} M_D M_{NO3}	⇒	N_{CS} M_{SO4} M_{MSA} M_{SS} M_{NO3} M_{NH4}
			⇑
Accumulation	N_{AI} M_{BC} M_{POM}	⇒	N_{AS}, M_{SO4} M_{MSA} M_{BC}, M_{POM}, M_{SS} M_{NO3} M_{NH4}

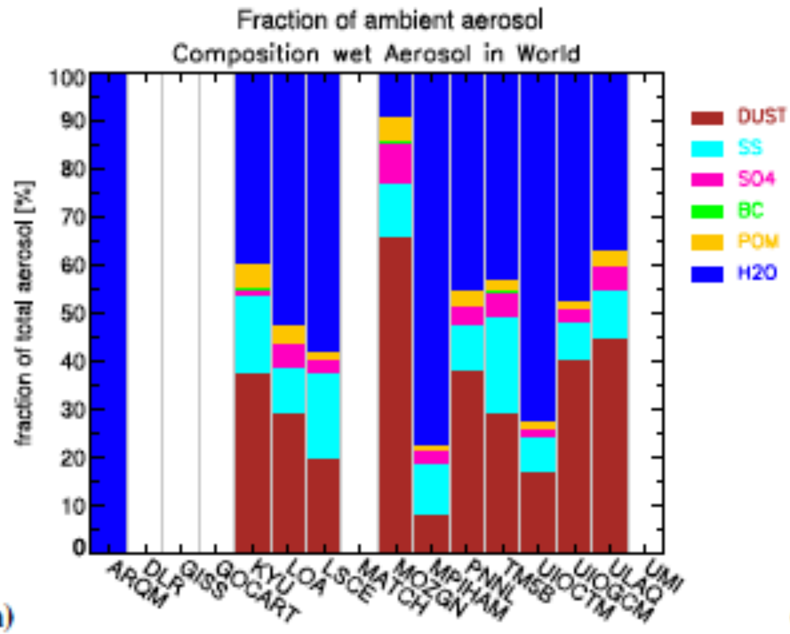
Differences in simulated zonal aerosol distributions



Uncertainty in the water associated with the aerosol



(a)



(b)

Steps to compute aerosol direct radiative forcing

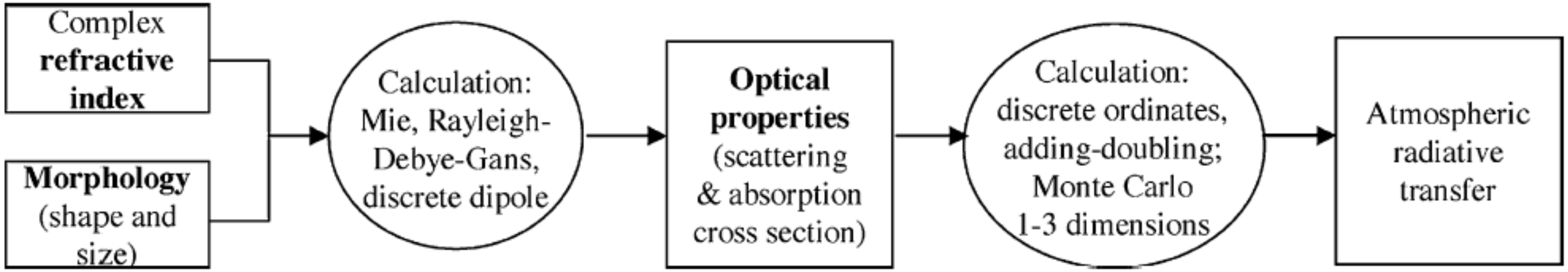


FIG. 1. Calculating radiative transfer

What are optical parameters?

Optical Parameters to Compute the Aerosol Direct Forcing

✓ Light can be either scattered or absorbed. Both processes lead to extinction.

We define 3 parameters in order to compute the Aerosol Direct Forcing:

1/ Aerosol Optical Depth (*AOD*) often noted τ

2/ The *asymmetry parameter* (or the phase function) β

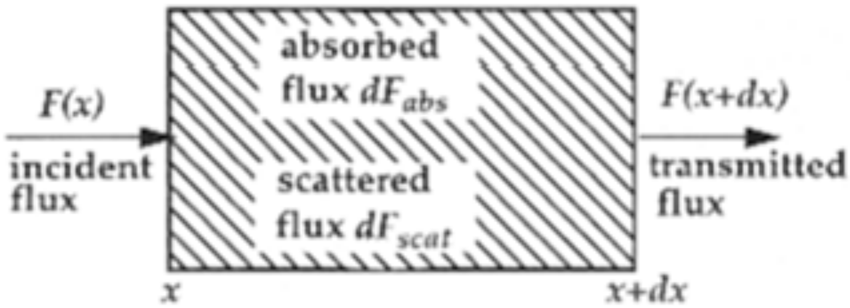
3/ The *single scattering albedo* often noted ω_0

AOD is a measure of the integrated vertical column of aerosol present,

Asymmetry parameter gives information on the ratio of backward to forward light scattering,

The single scattering albedo measures how absorbing a particle is.

Definition of the Scattering coefficient



$$F(x+dx) = F(x) - dF_{abs} - dF_{scat}$$

$$dF_{abs} = n\,\sigma_{abs}\,F(x)\,dx$$

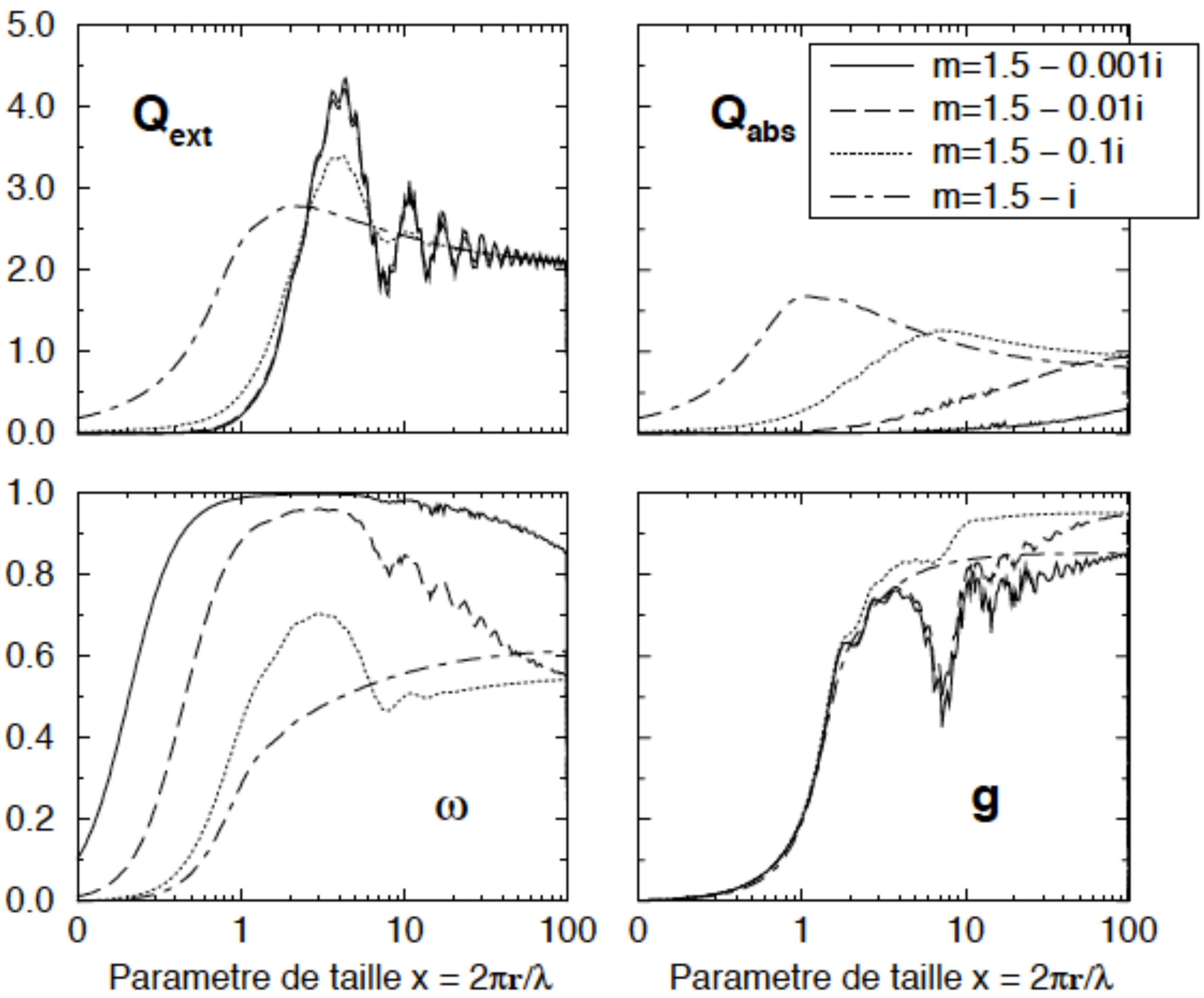
$$dF_{scat} = n\,\sigma_{scat}\,F(x)\,dx$$

$\sigma_{abs} = Q_{abst}\,\sigma$

and, $\sigma_{scat} = Q_{scat}\,\sigma$

Q_{scat} is the scattering coefficient

Where σ is the cross-section of the particle, $\sigma = \Pi . r_{eff}^{2}$



Q_ext
Q_abs
m=1.5 – 0.001i
m=1.5 – 0.01i
m=1.5 – 0.1i
m=1.5 – i
ω
g
5.0
4.0
3.0
2.0
1.0
0.0
1.0
0.8
0.6
0.4
0.2
0.0
0
1
10
100
0
1
10
100
Parametre de taille x = 2πr/λ
Parametre de taille x = 2πr/λ

Which strategy to reduce uncertainty in aerosol radiative forcing?

Change in albedo due to aerosols

$$\Delta \alpha_p = [T_a^2(1-A_c)][2(1-R_s)^2 \overline{\beta} f_b M \alpha_s f(RH) - 4 R_s M \alpha_s f(RH)((1-\omega_0)/\omega_0)]$$

cloud fraction

surface albedo

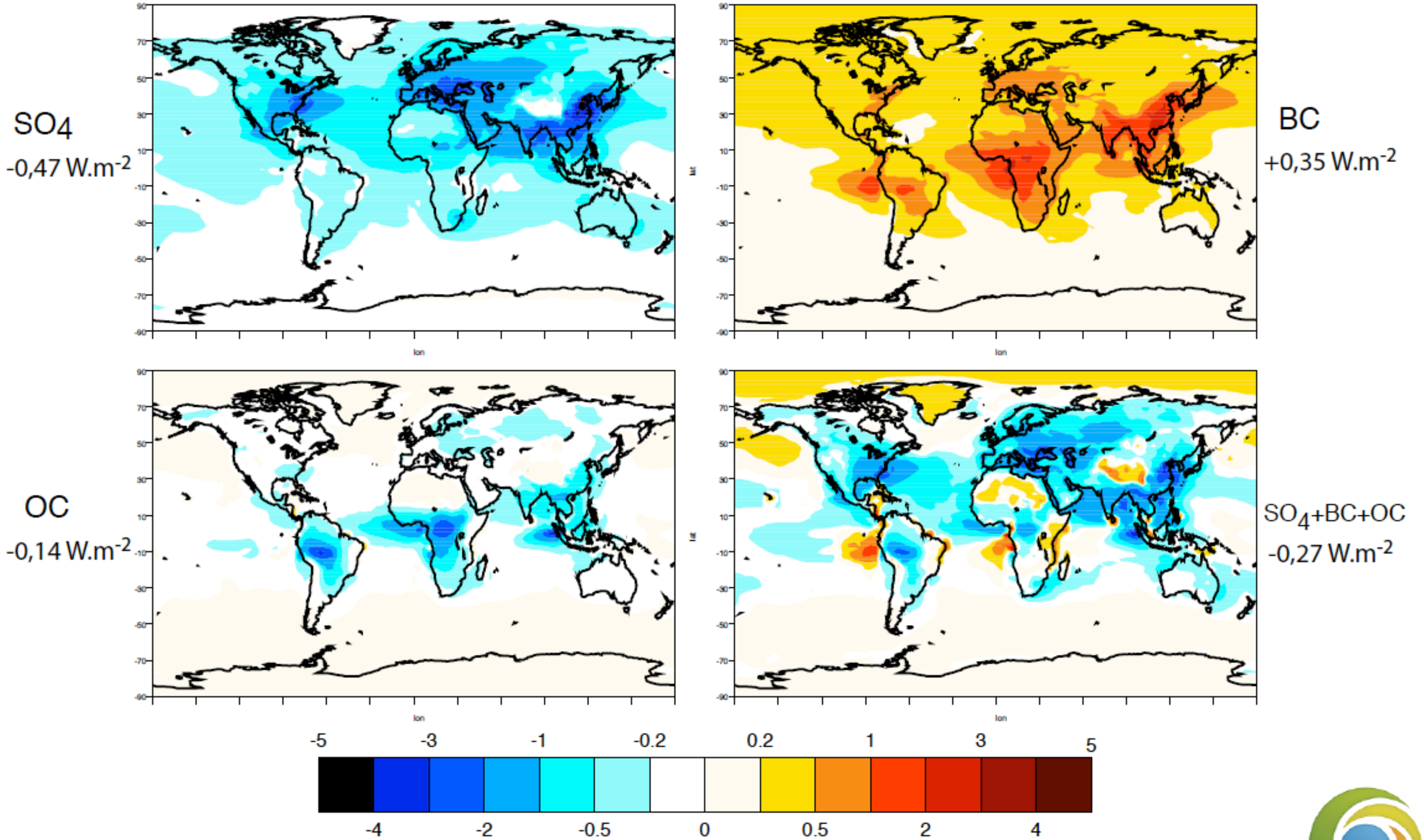
upscatter fraction
+f(RH) for upscatter

burden

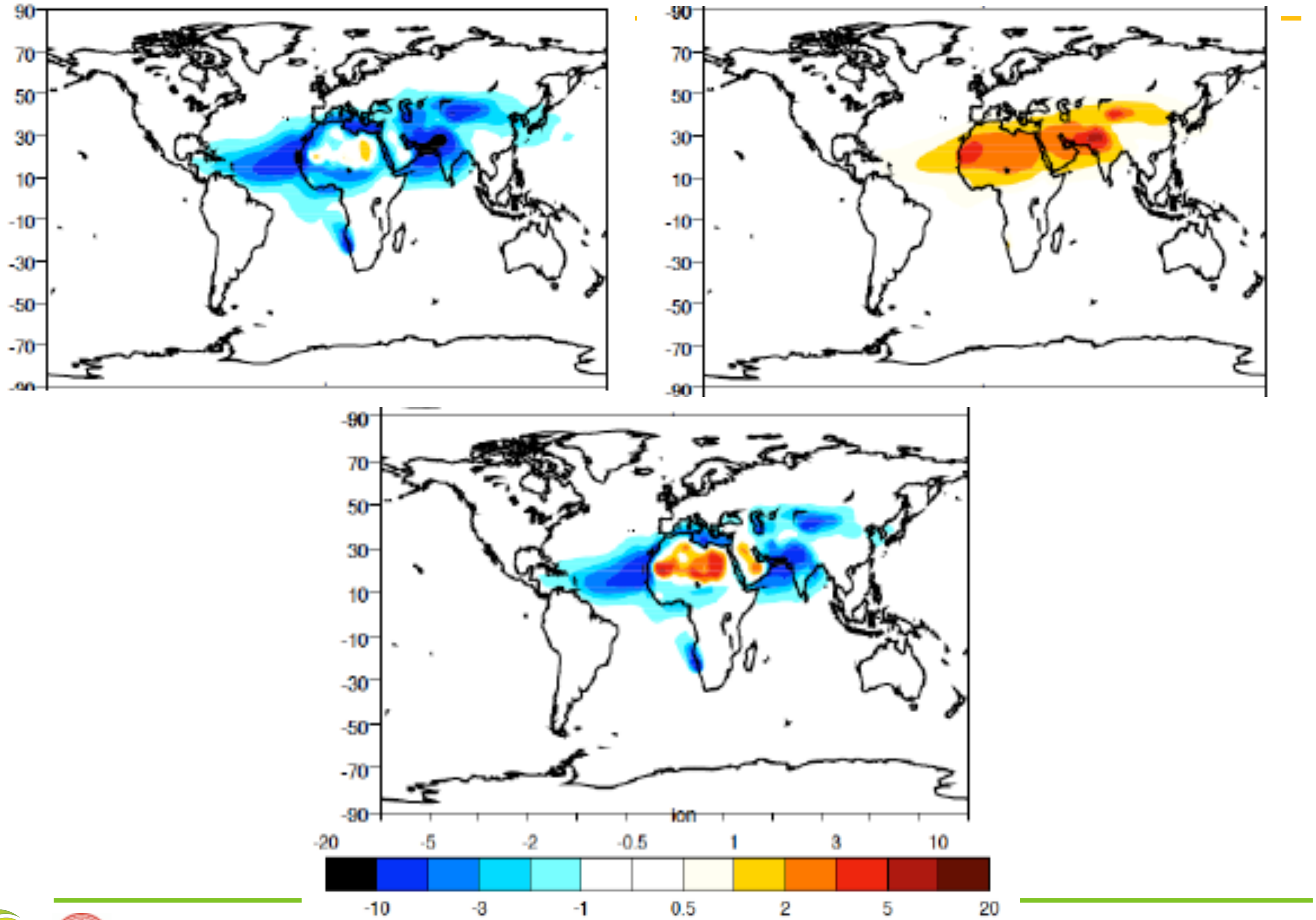
mass extinction coefficient
hygroscopic growth factor mec

« absorption coefficient »

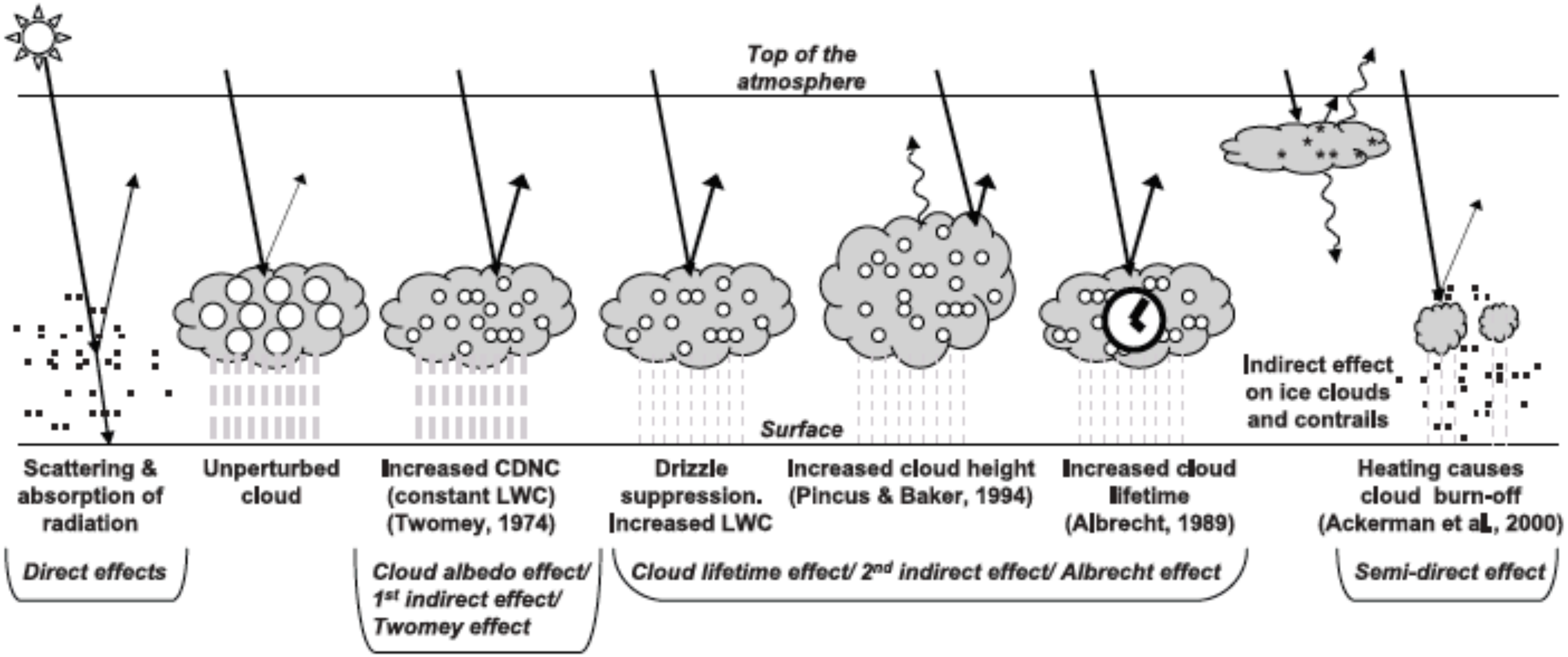
Radiative Forcings from the ESM IPSLCM5a



Radiative pertubation from mineral dust



Aerosol effects on radiation and clouds

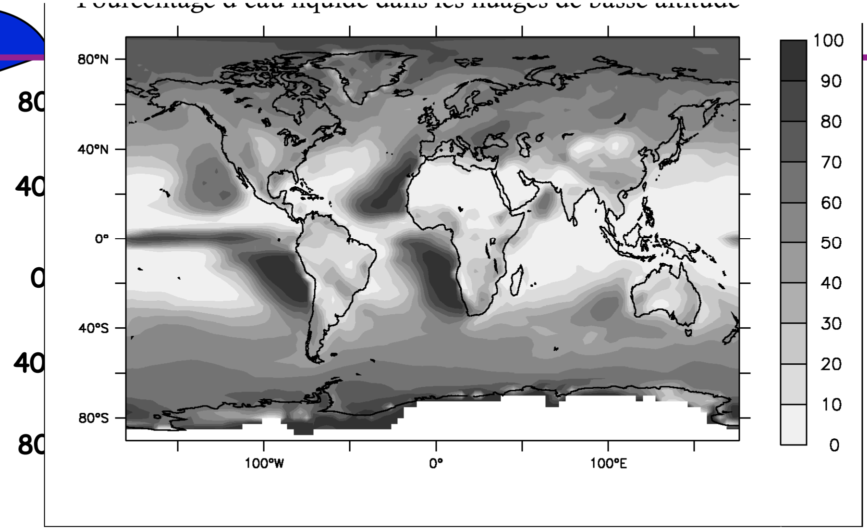


Ship Tracks seen from space (from Durkee et al., 2000)

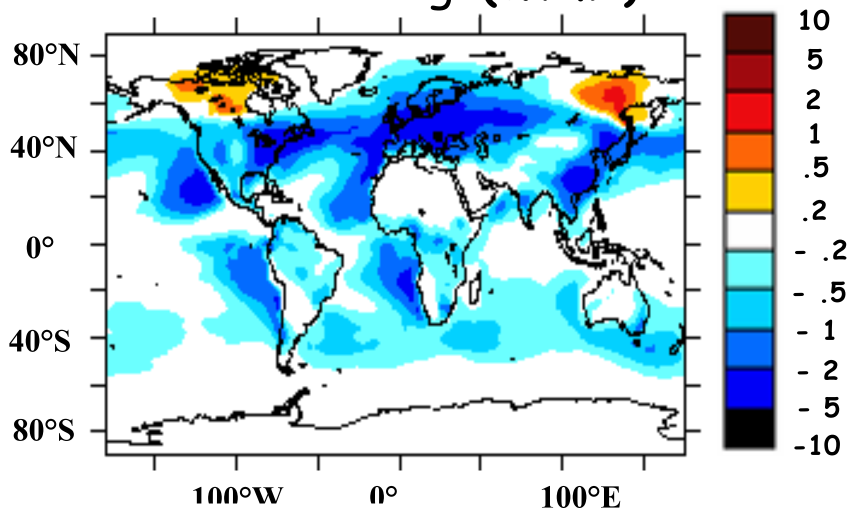
Aerosol first indirect effect

Deandreis et al., (2012)

Pourcentage of liquid water in low-level clouds

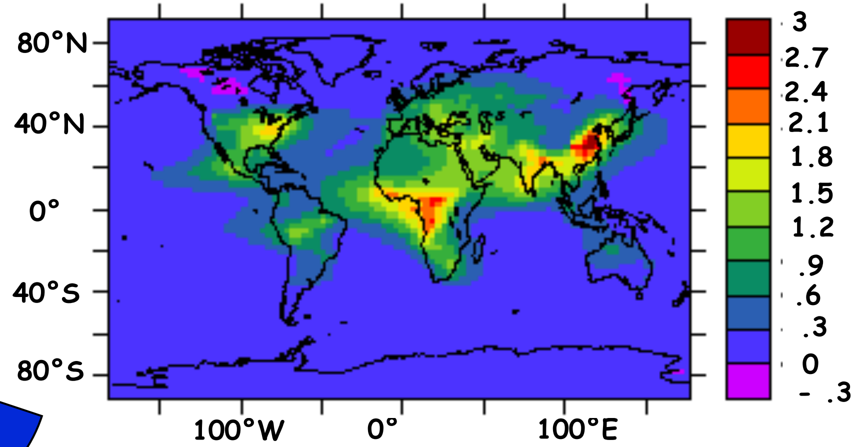


Radiative Forcing (W/m²)



Global Mean = - 0.46 W/m²

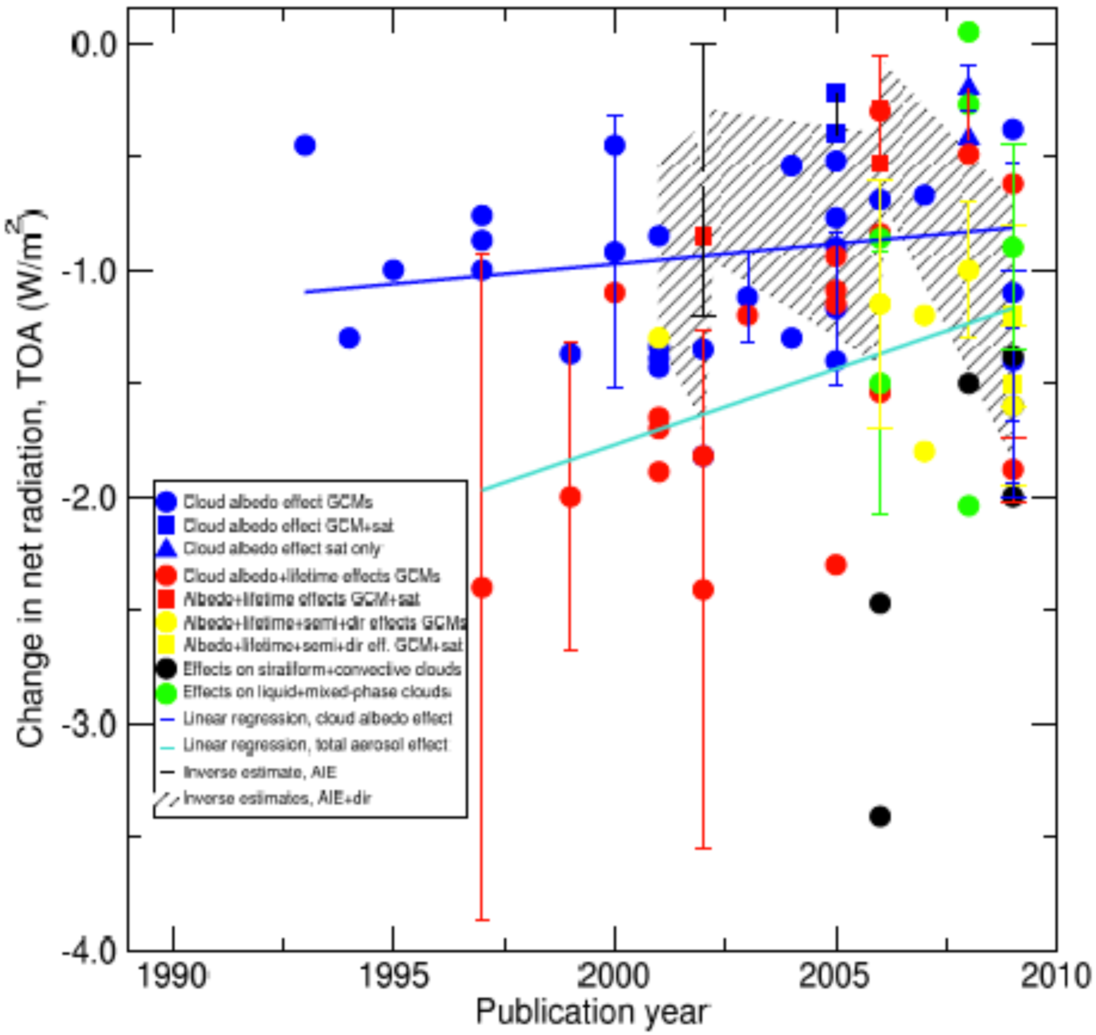
IPCC AR4: - 0.7 [-1.8 to -0.3] W/m²



Difference in aerosol concentrations 2000 -1750 (µg/m³)

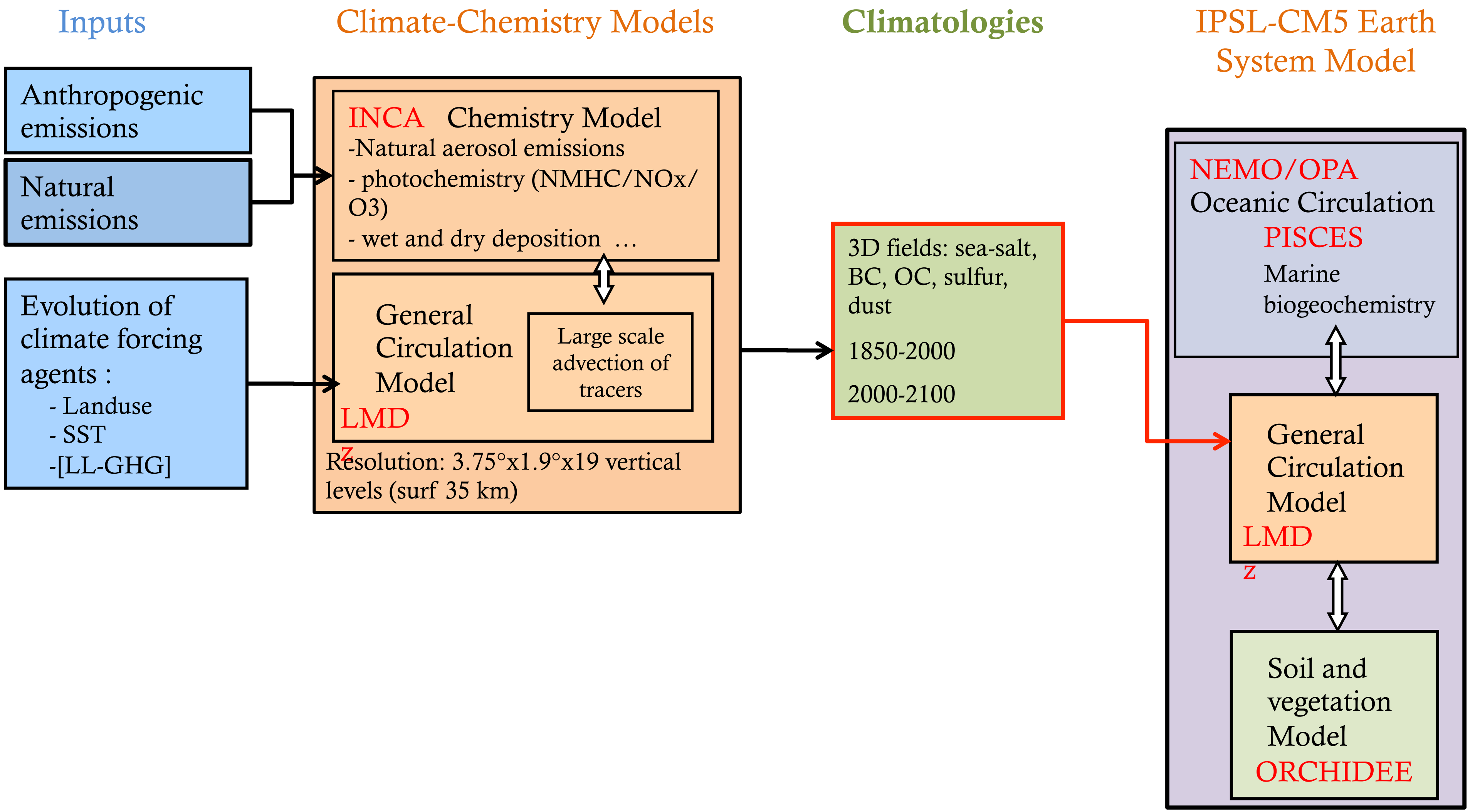
Published estimates of the aerosol indirect effect

Anthropogenic changes in net radiation at the TOA

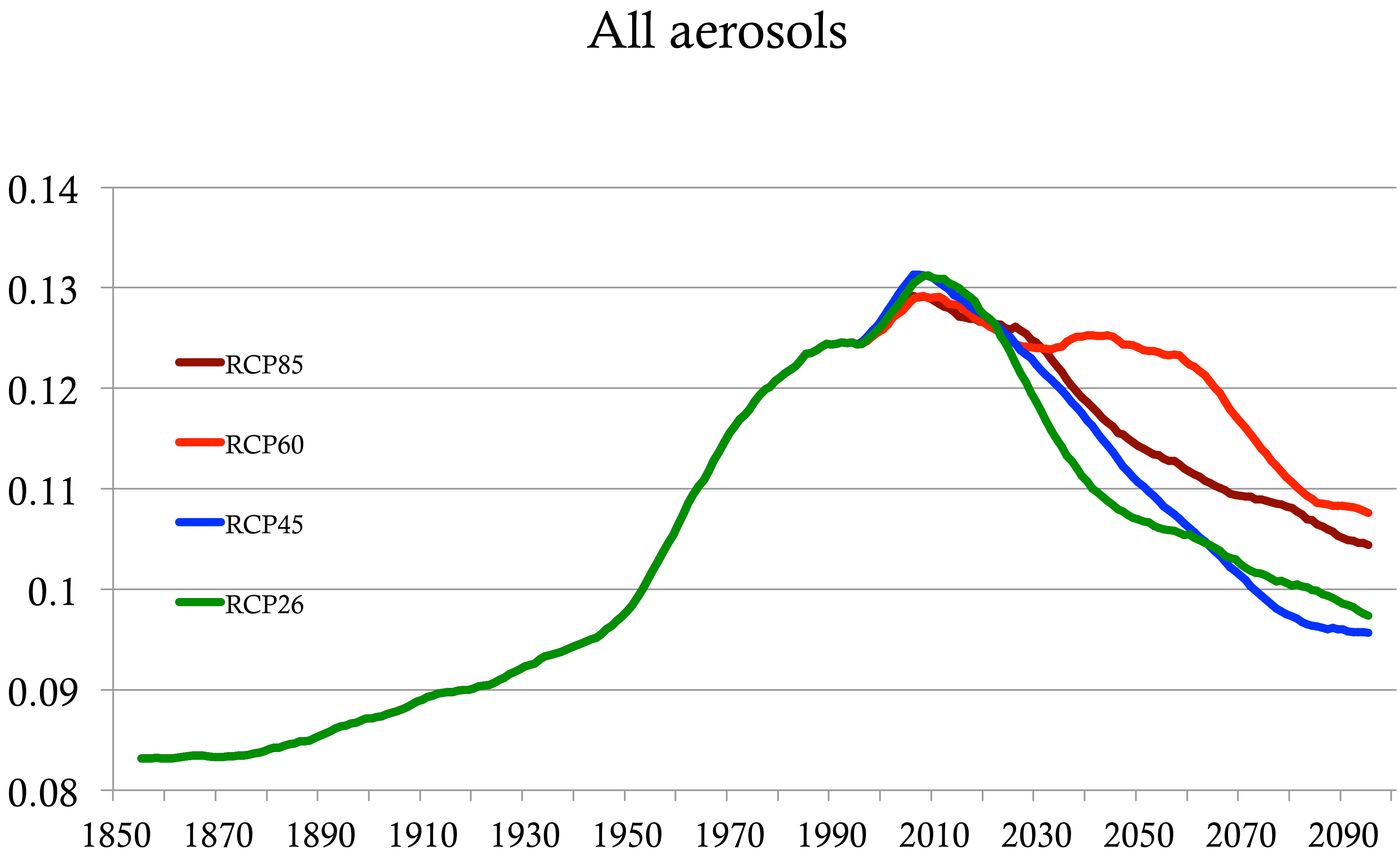


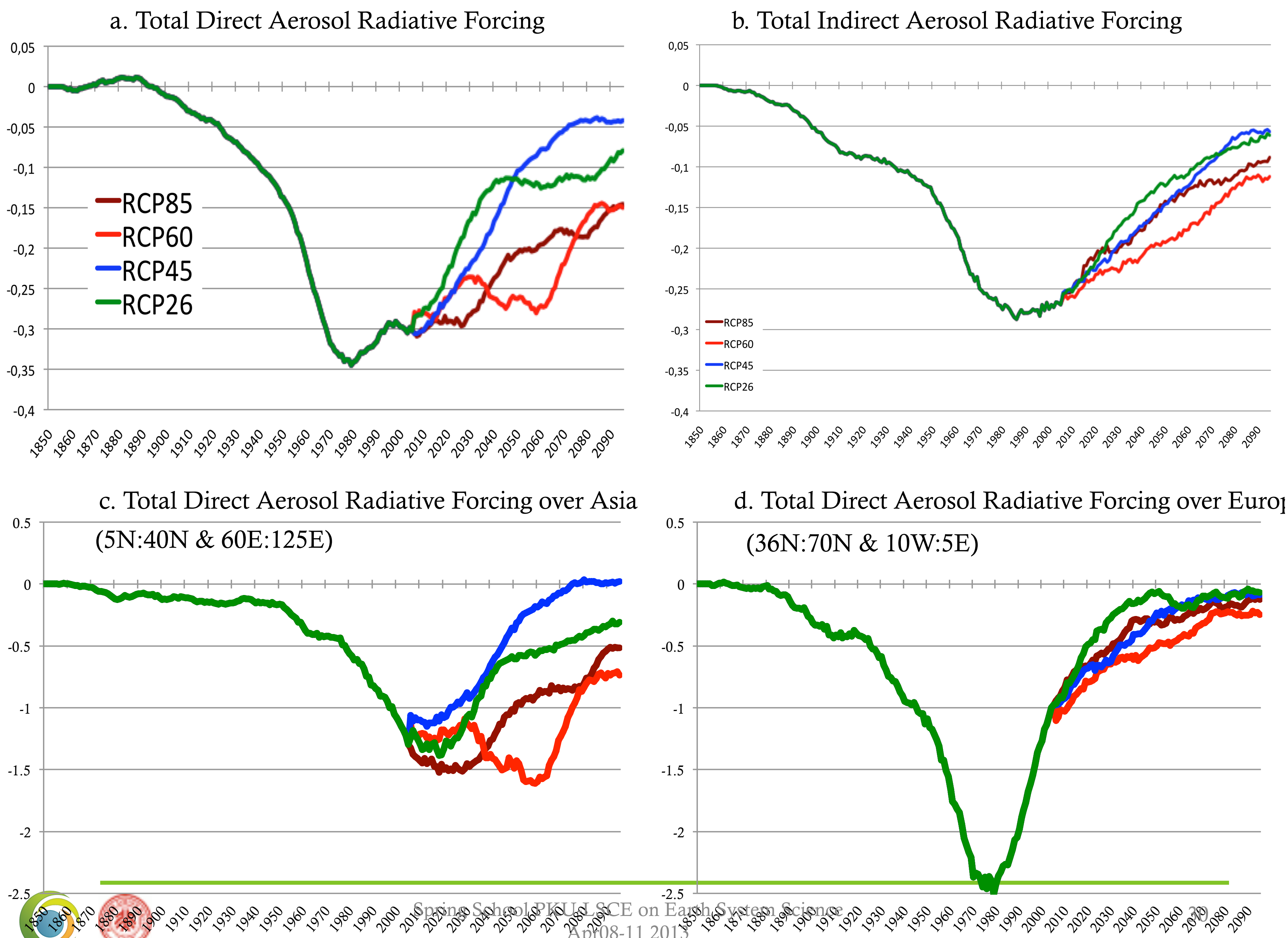
Modelling aerosol-chemistry/ climate interactions in an Earth System Model

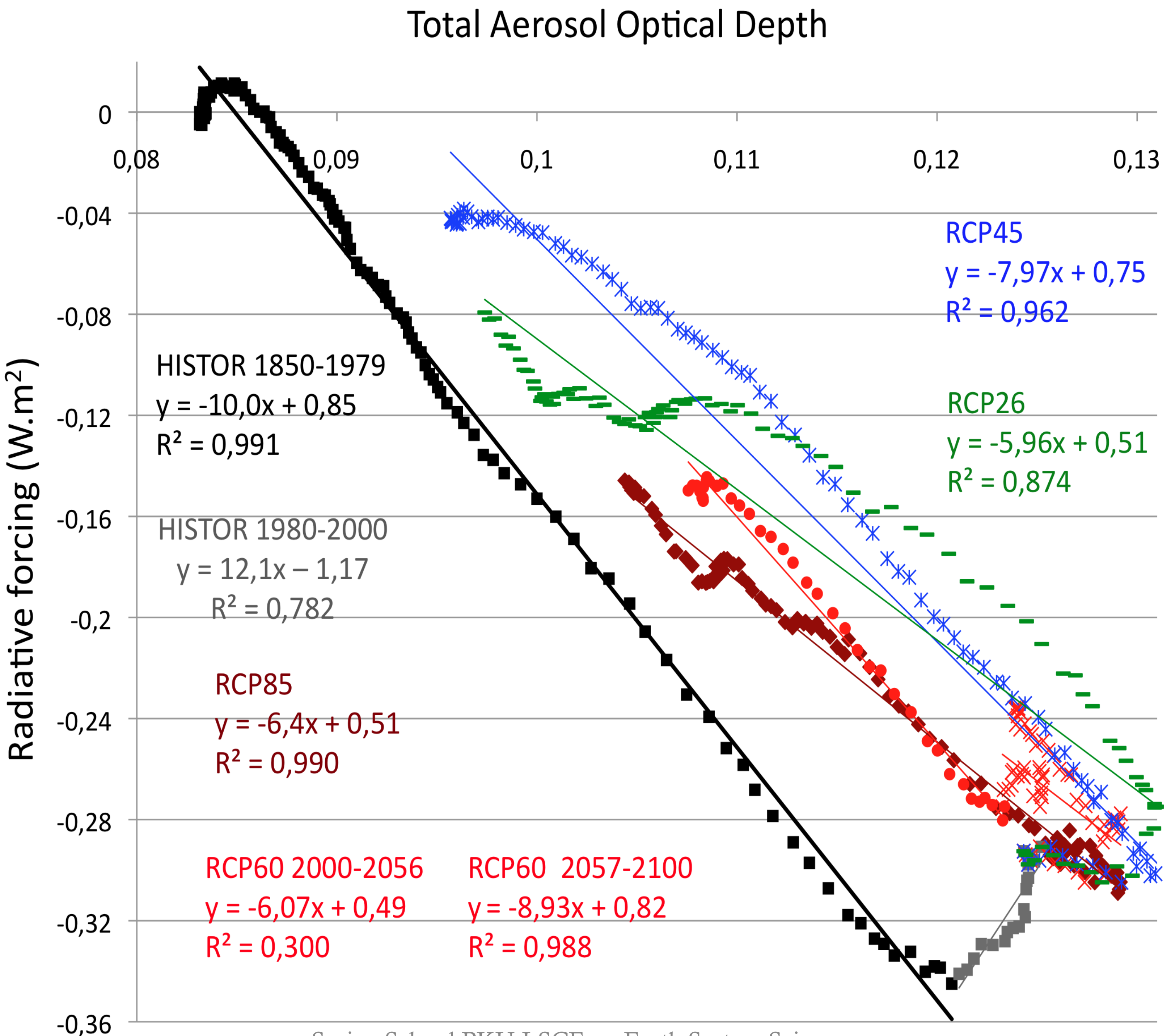
AR5



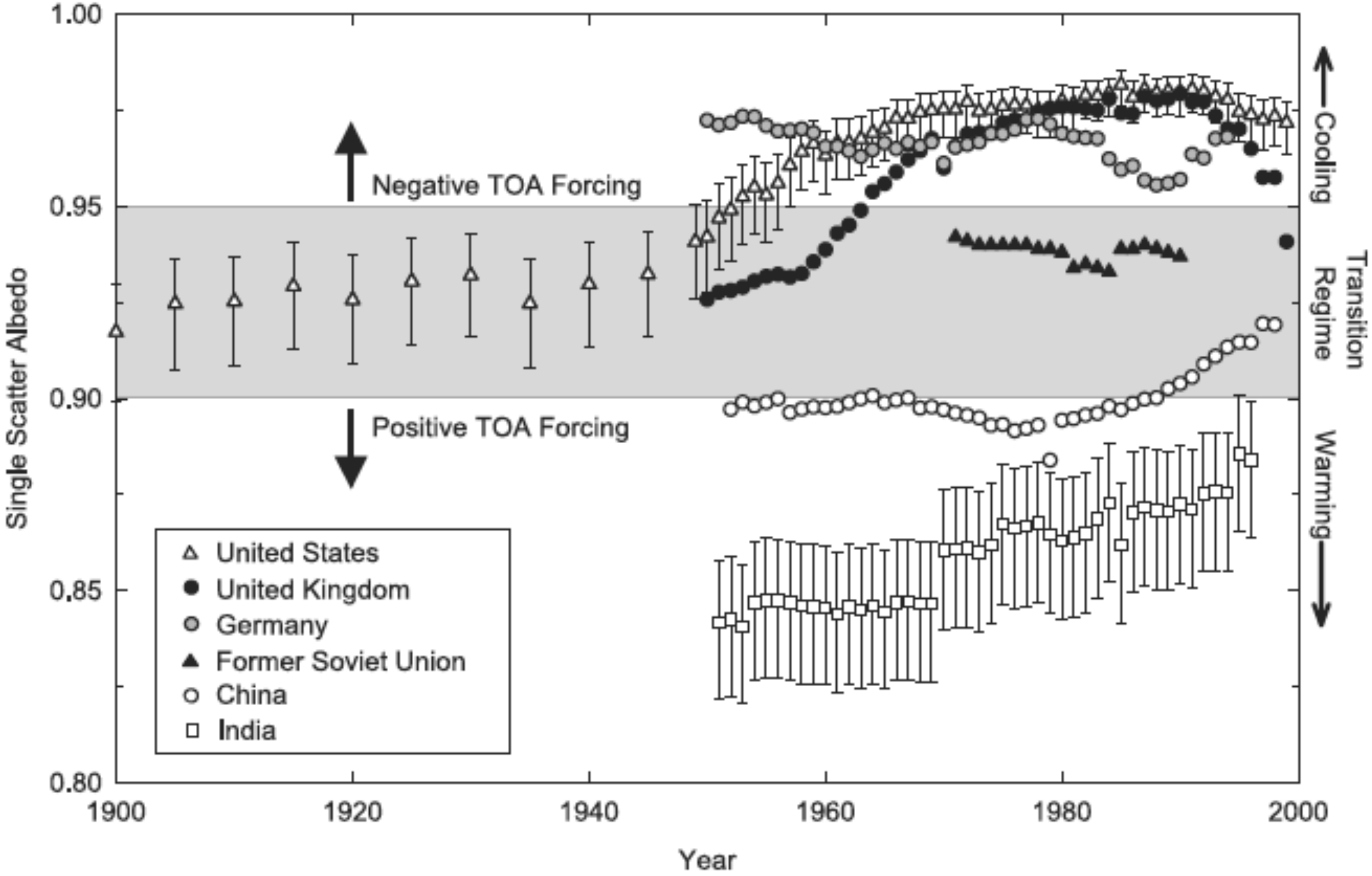
Aerosol Optical Depth at 550 nm (11 years running-mean)

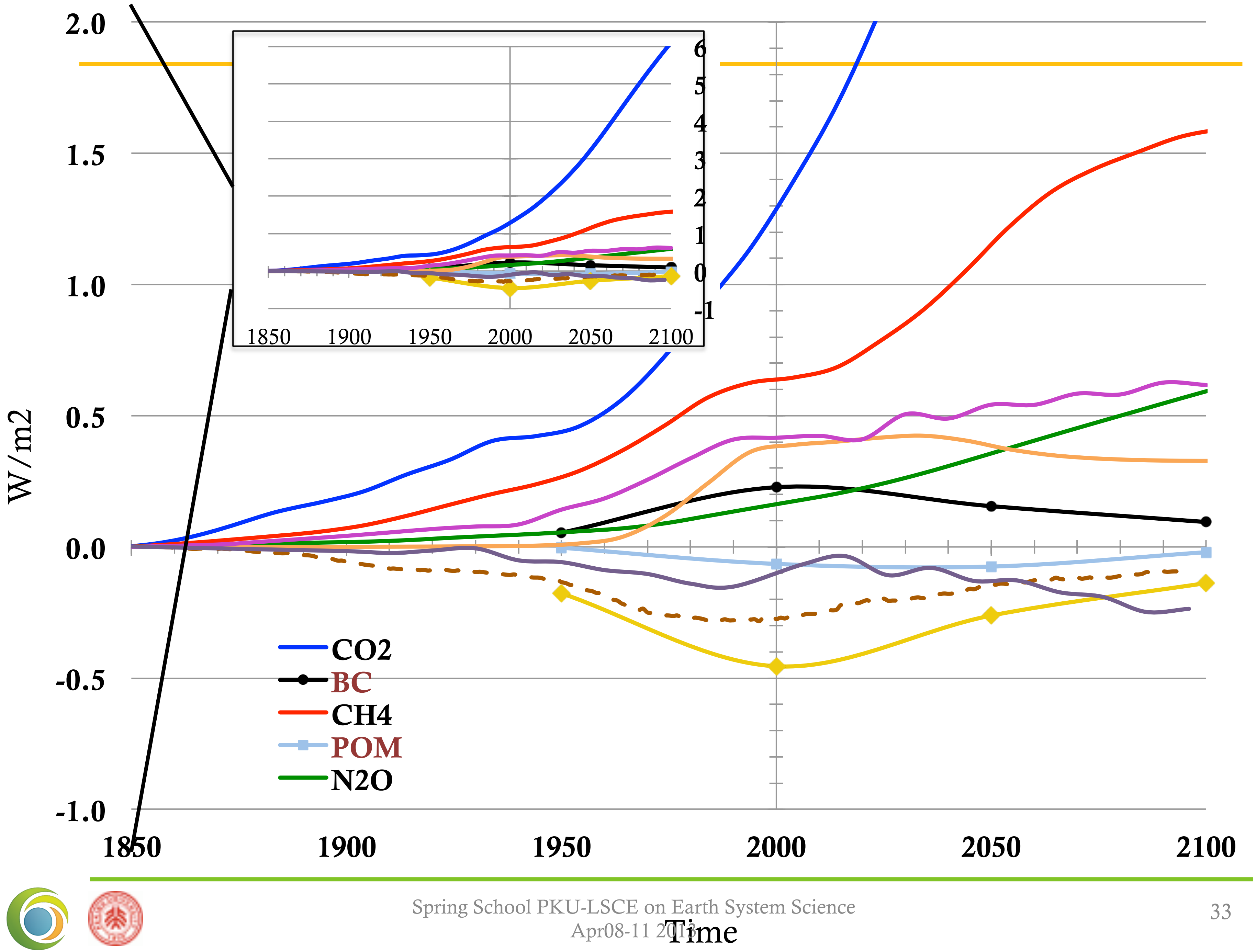



a. Total Direct Aerosol Radiative Forcing
b. Total Indirect Aerosol Radiative Forcing
c. Total Direct Aerosol Radiative Forcing over Asia
(5N:40N & 60E:125E)
d. Total Direct Aerosol Radiative Forcing over Europ
(36N:70N & 10W:5E)
RCP85
RCP60
RCP45
RCP26

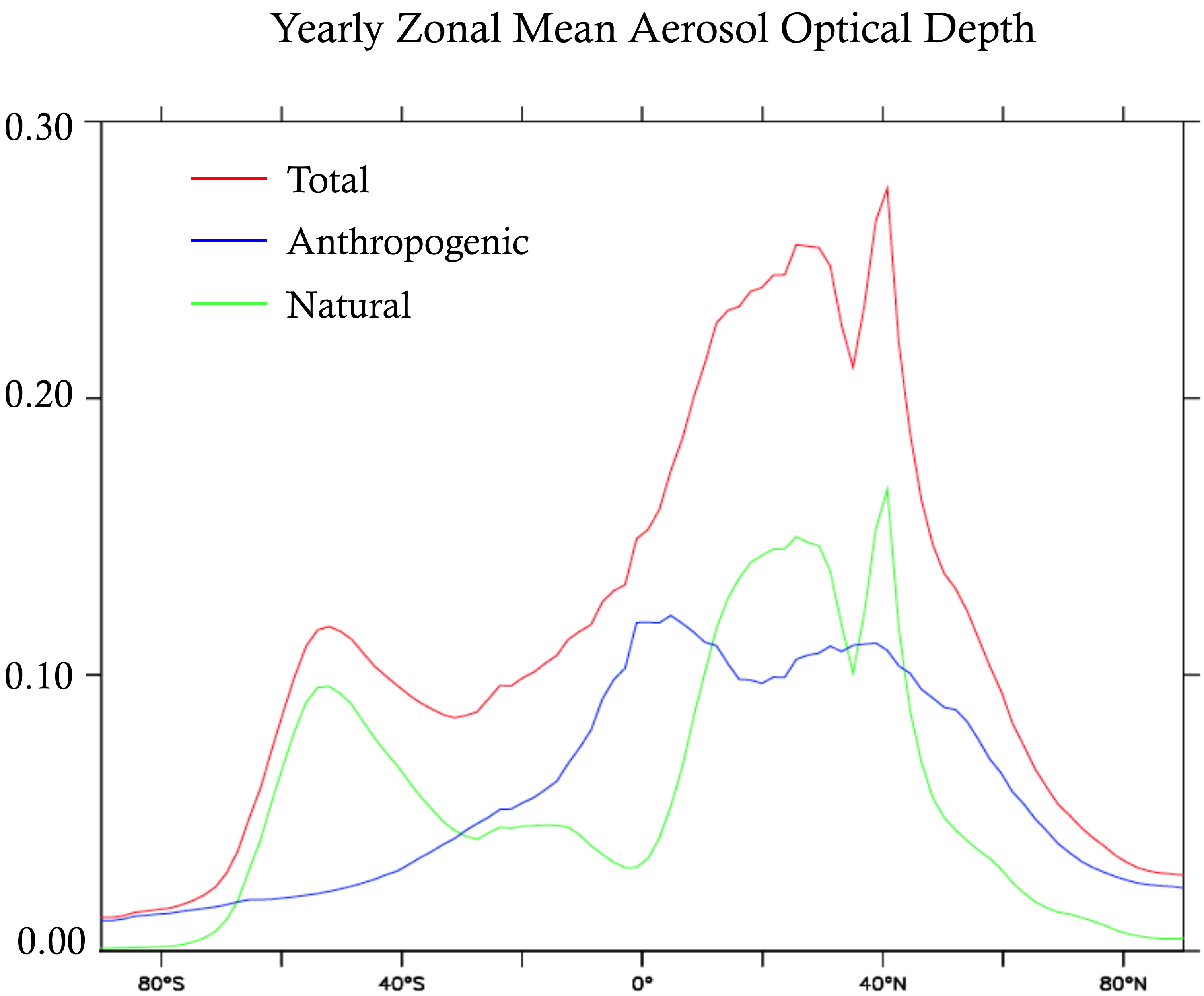

Total Aerosol Optical Depth
Radiative forcing (W.m²)
0
-0,04
-0,08
-0,12
-0,16
-0,2
-0,24
-0,28
-0,32
-0,36
0,08
0,09
0,1
0,11
0,12
0,13
RCP45
y = -7,97x + 0,75
R² = 0,962
RCP26
y = -5,96x + 0,51
R² = 0,874
HISTOR 1850-1979
y = -10,0x + 0,85
R² = 0,991
HISTOR 1980-2000
y = 12,1x – 1,17
R² = 0,782
RCP85
y = -6,4x + 0,51
R² = 0,990
RCP60 2000-2056
y = -6,07x + 0,49
R² = 0,300
RCP60 2057-2100
y = -8,93x + 0,82
R² = 0,988

The role of aerosol absorption



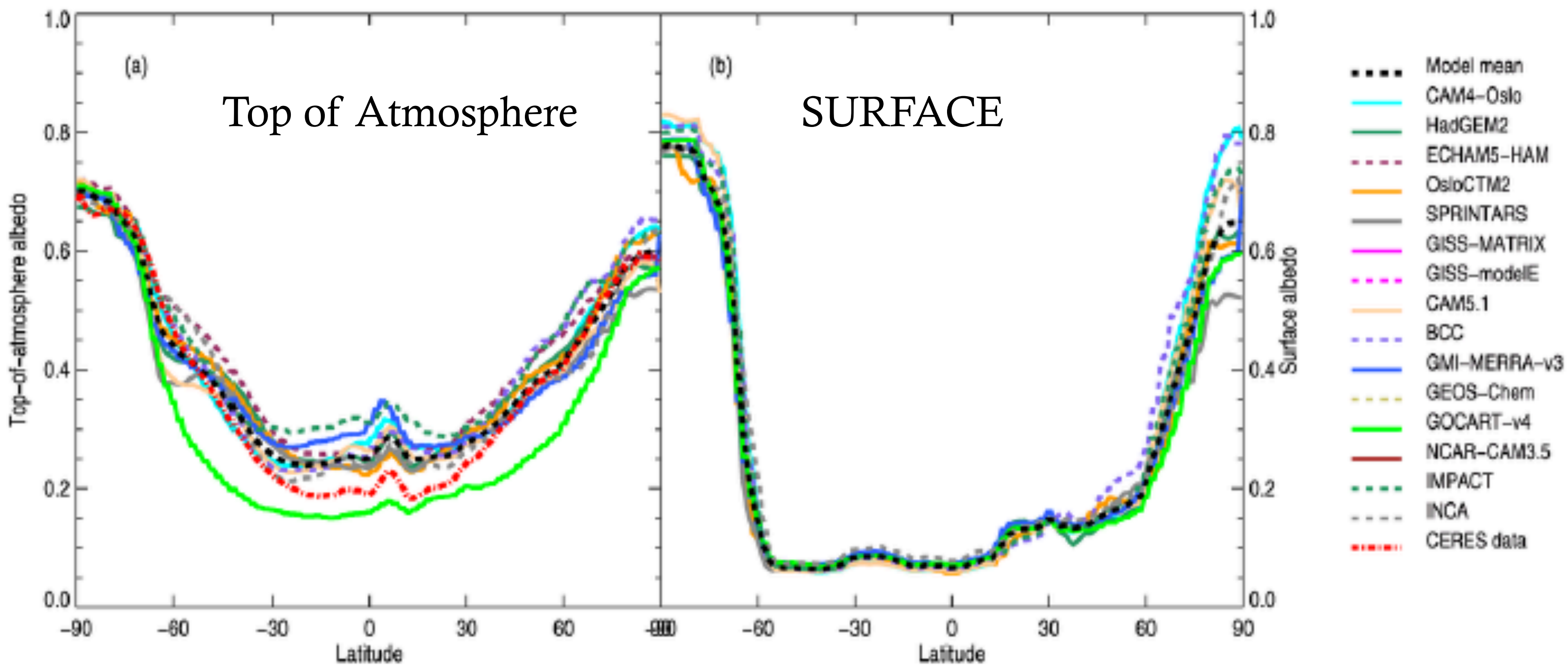

2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
W / m2
1850
1900
1950
2000
2050
2100
Time
CO2
BC
CH4
POM
N2O
6
5
4
3
2
1
0
-1
1850
1900
1950
2000
2050
2100

Vers une approche simplifiée?

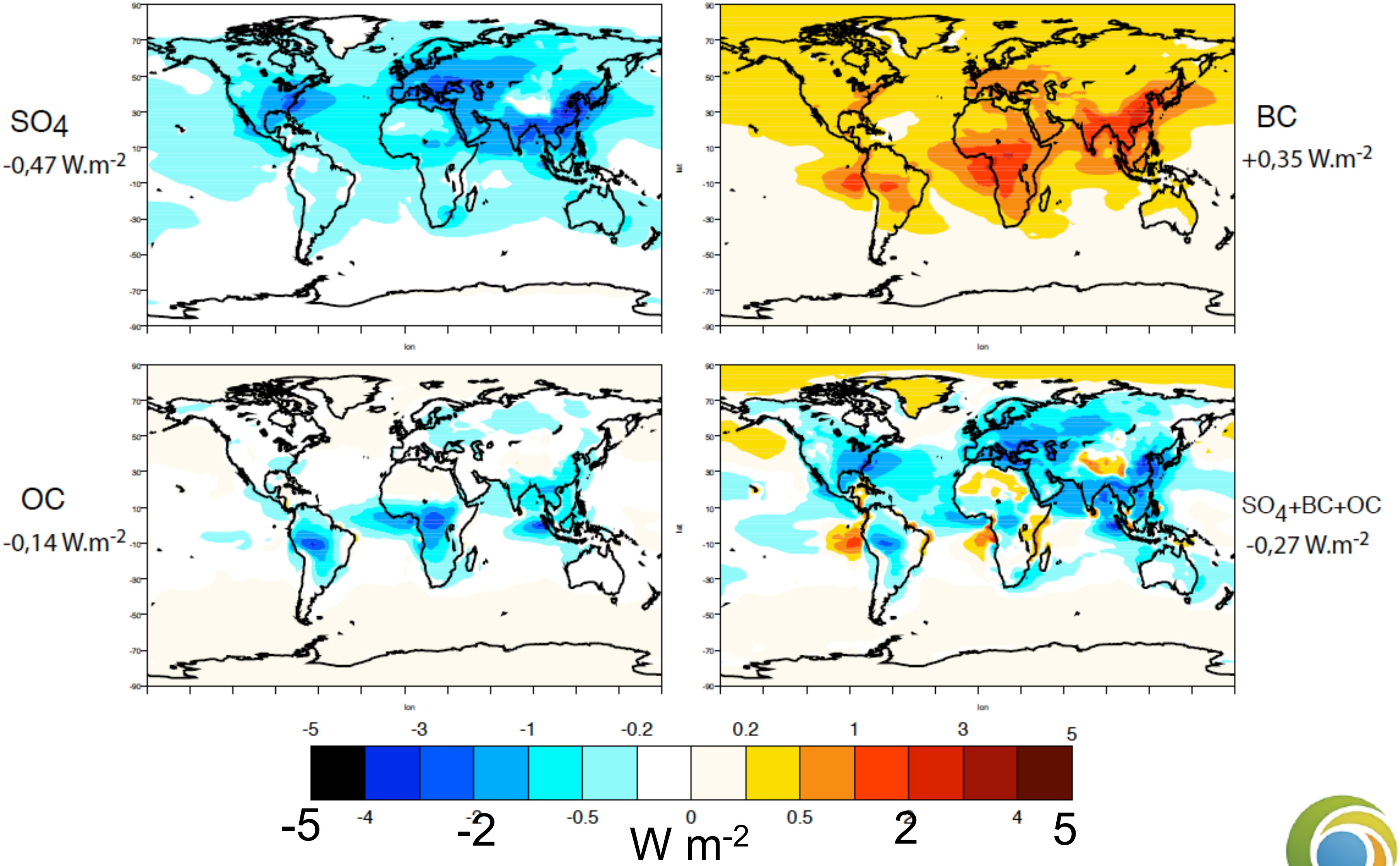


Zonal mean albedo from global models

Myhre et al., 2012

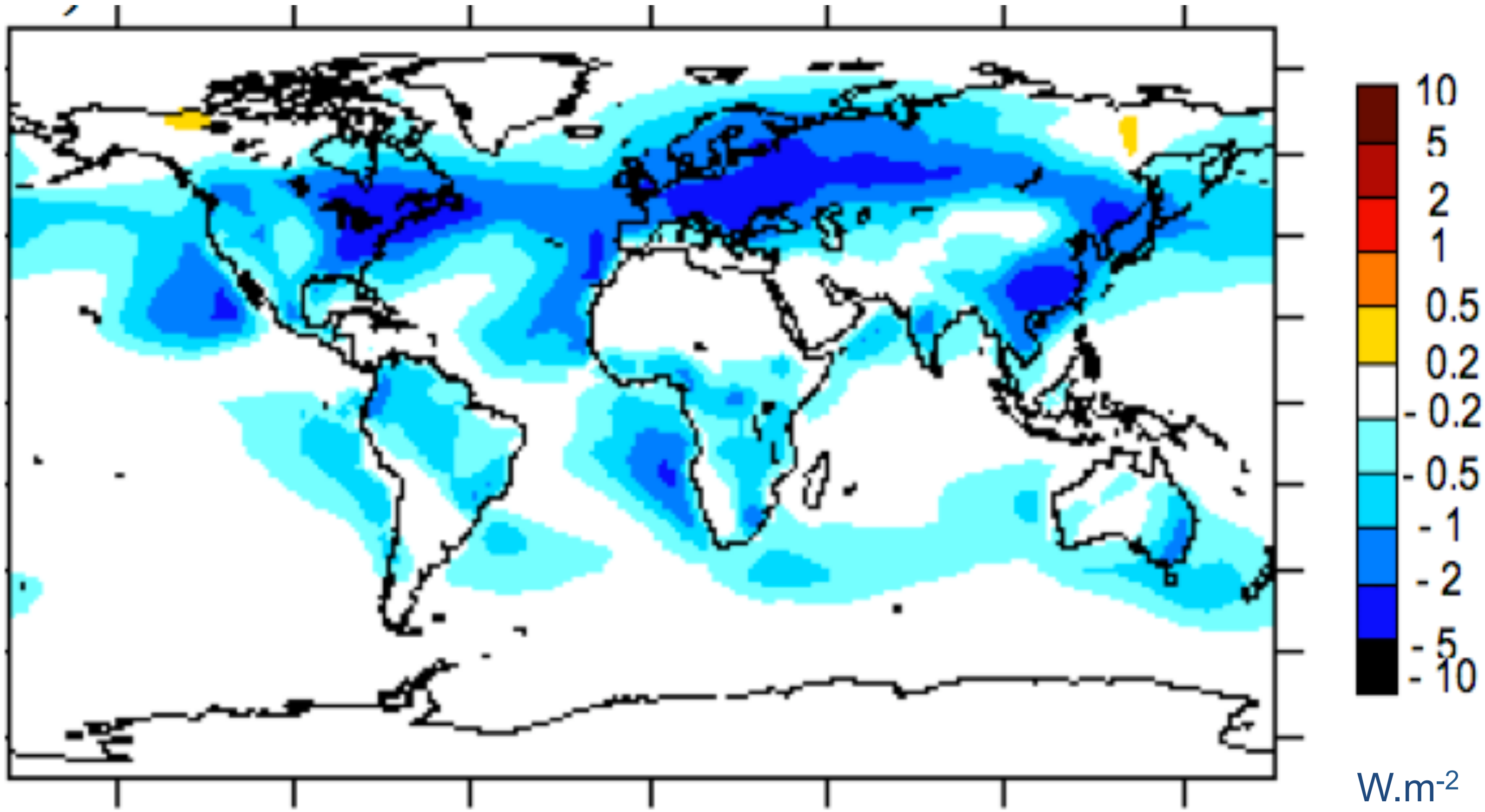


Radiative Forcings from the ESM IPSLCM5a

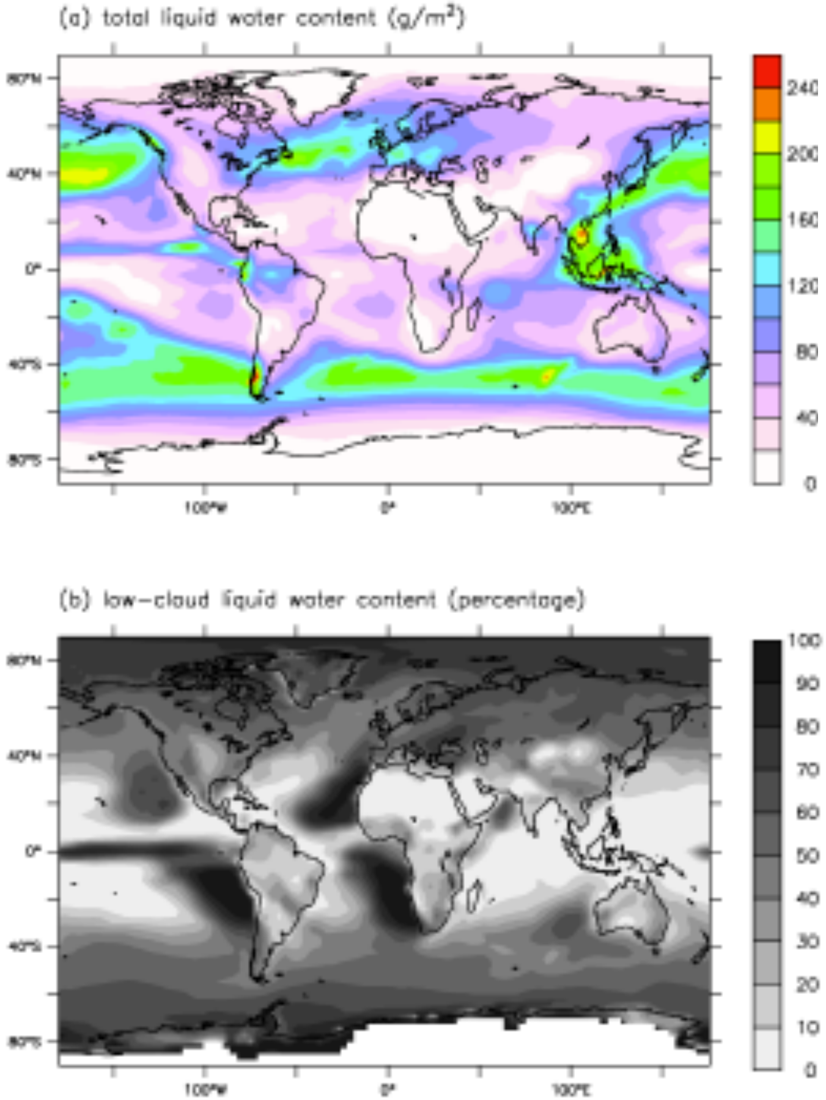


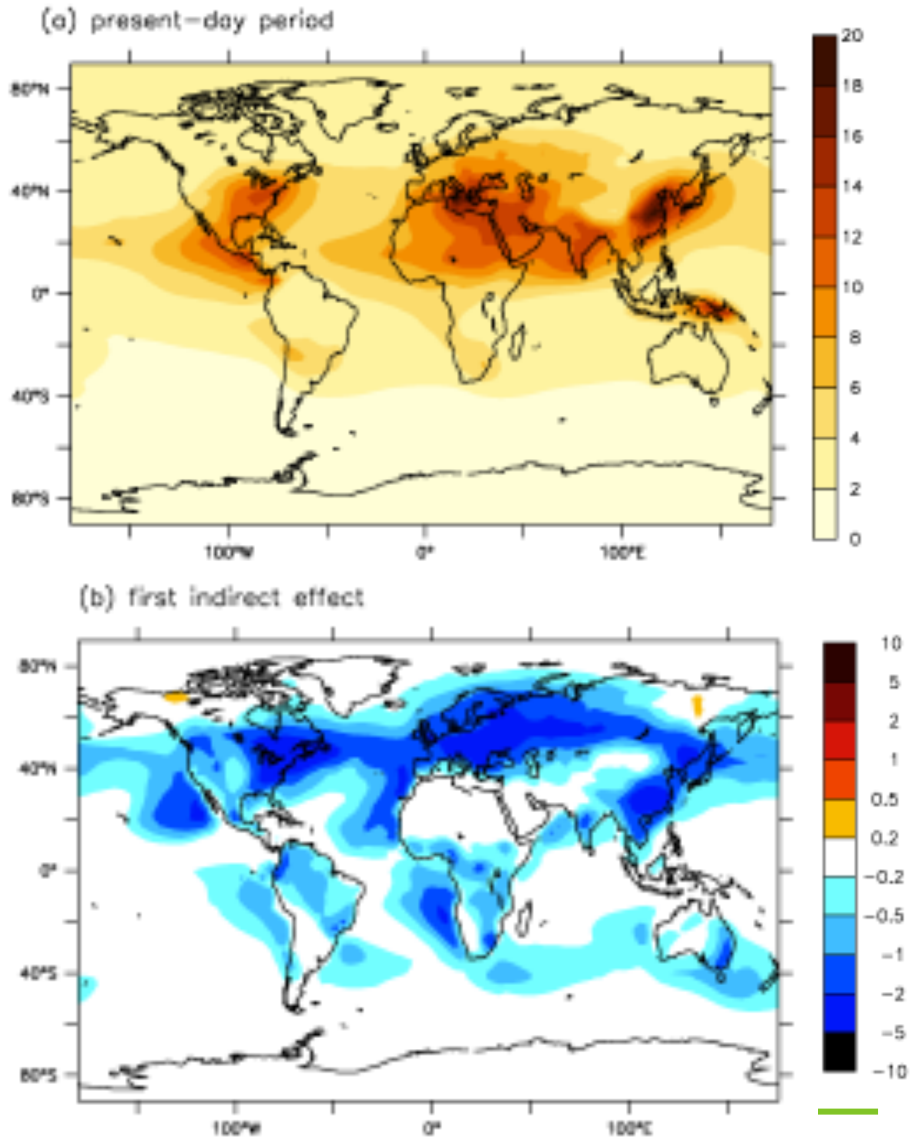
LSCE

Aerosol indirect effect



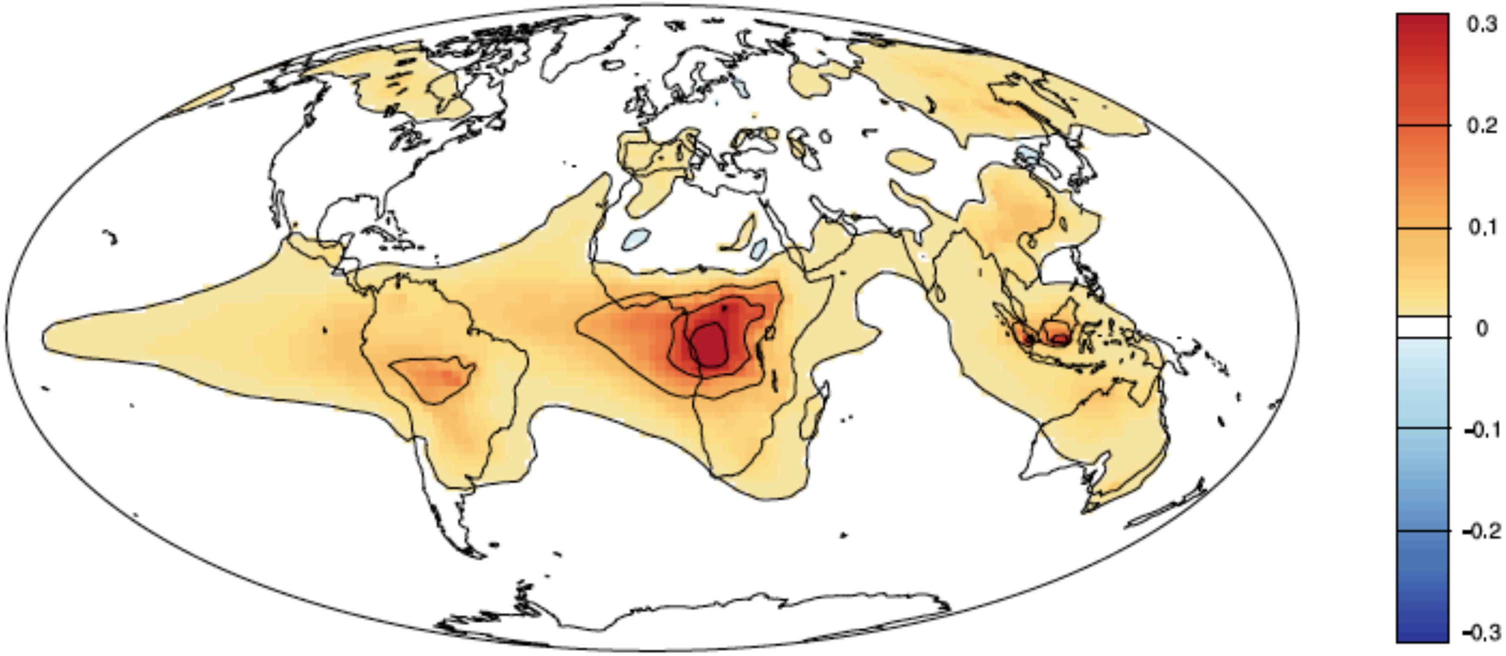
Low-level clouds



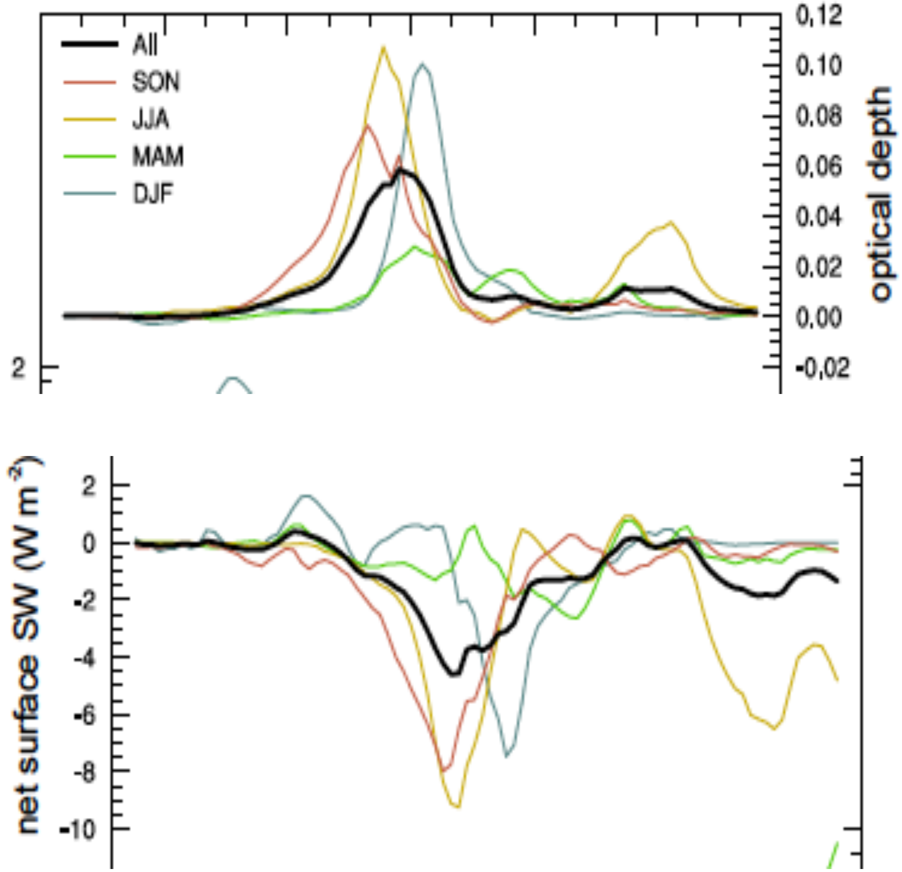


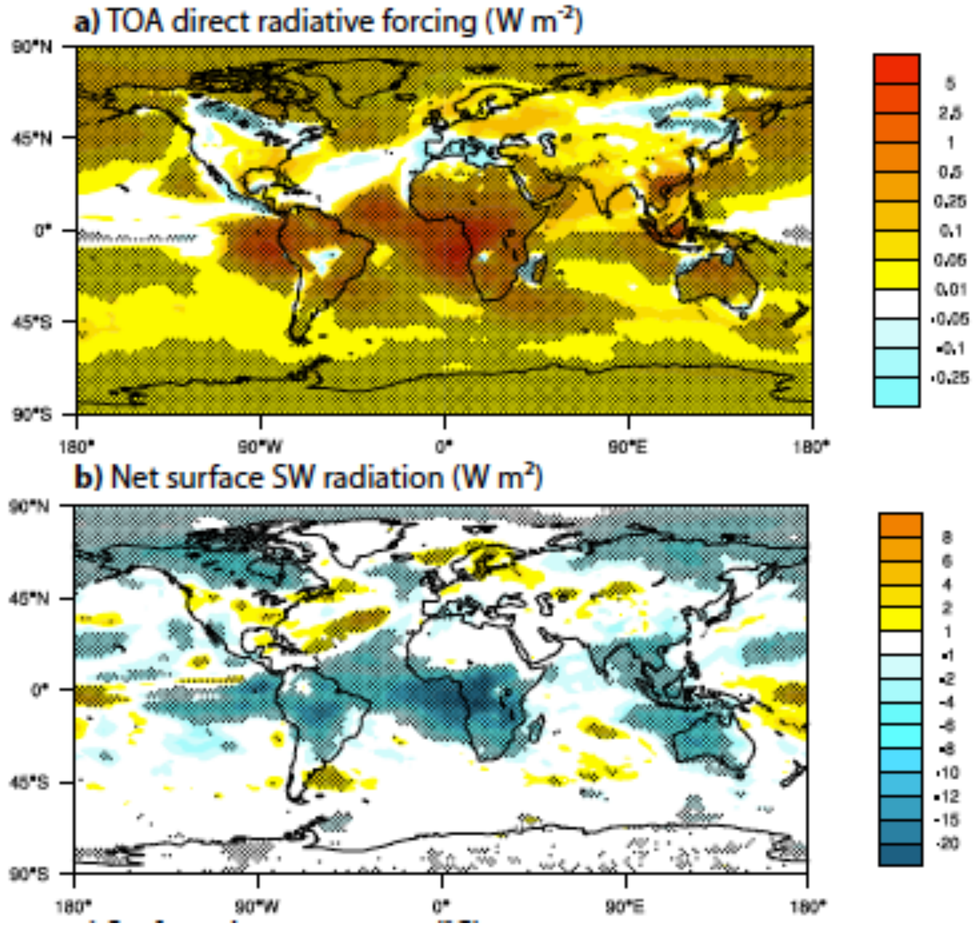
Optical depth from aerosols produced by fires

Tosca et al. (2012)



Radiative forcings due to aerosol from fires





Effects on temperature and precipitation