The CCM-Oslo model

An AGCM operated at University of Oslo (UiO) Norway
by
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Basic: NCAR-CCM3.2

(Kiehl,et al., 1998; *J. Climate*, **11**, p1131):

- **T42L16, semi-Lagrangian,**
- **Mass-flux deep-convection** (Zhang and McFarlane, 1995)
- **SW-radiation: 2-stream delta-Eddington**
- **18 spectral intervals, 11 bands for aerosol optics,**
- **LW-absorption by O3, H20, CO2, O2, cloud droplets, aerosols**
- **Readilly coupled to ocean and sea-ice models**
- **Option for nudging** (not used at UiO yet)

Extensions

to NCAR CCM3.2

- **Prognostic cloud water** (Rasch and Kristjansson, 1998, *J. Climate,* **11**, 1587);
- **Life-cycle module for Sulphate and BC and OC aerosols**
  (Iversen and Seland, 2002. *J. Geophys. Res*., **107** D24, 4751)
  Dry deposition module from Barth et al.,2000, *J. Geophys. Res*. **105**D1,1387
  Thanks to P. J. Rasch, NCAR.
- **Parameterisation of aerorol size-distribution, composition, optical, and hygroscopic properties; Direct effects**
  Kirkevåg and Iversen, 2002, *J. Geophys. Res*., **107** D20, 4433.
- **Parameterisation of aerosol-cloud-precipitation interactions; Indirect effects**
  Kristjánsson, 2002. *J. Geophys. Res*., **107** D15, 4246.

The aerosol module

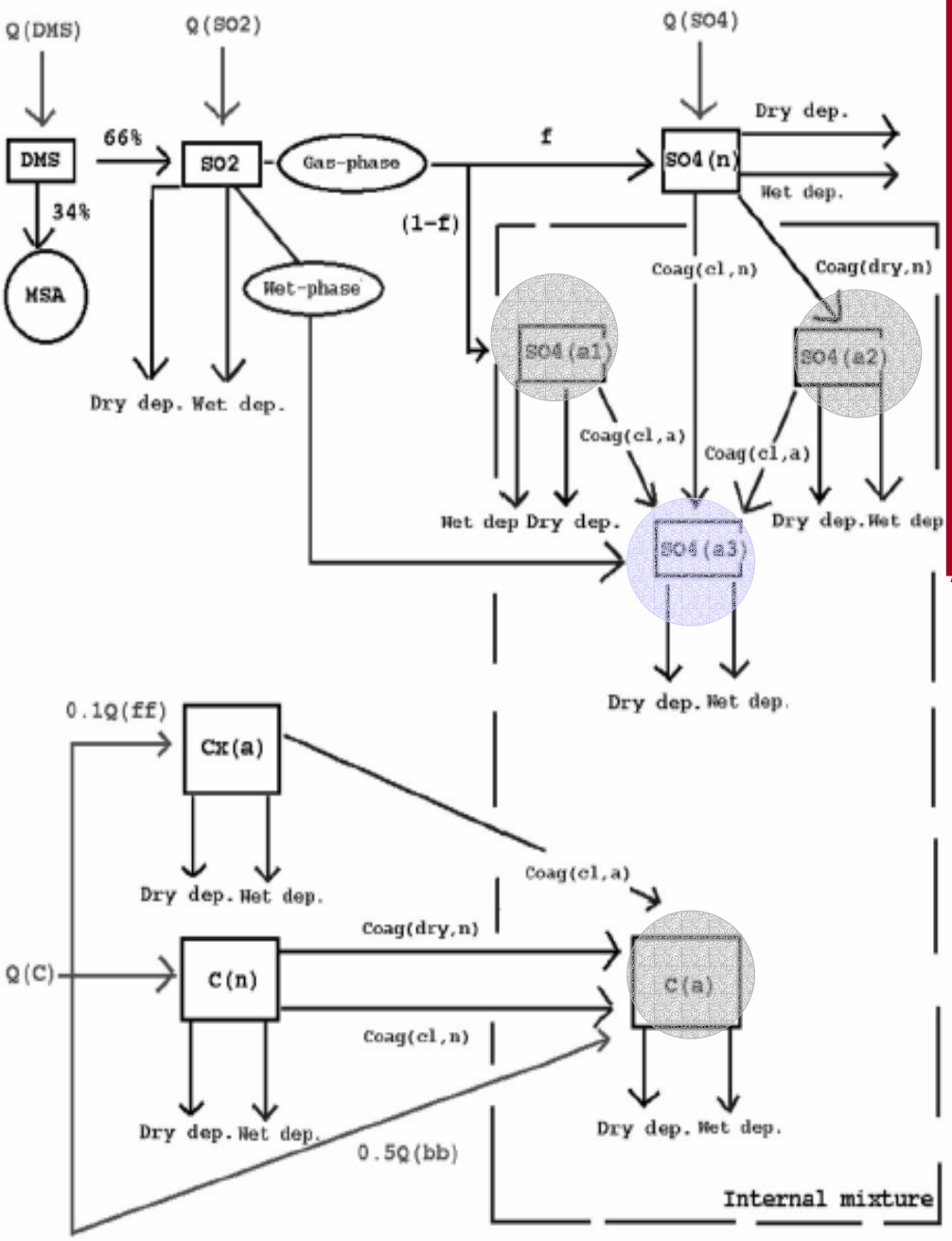
- **Components: DMS, SO_2, SO_4 , BC and OC** (new)
- **Emissions from IPCC-TAR**; years 2000 and 2100
- **Clear and cloudy air chemistry,** prescribed oxidants
- **SO_4, BC and OC - mass allocated by production pathways**:
  - Primary emissions
  - Aqueous phase production
  - Gas-phase production followed by
    - Condensation
    - Nucleation
  - Coagulation
- **Background aerosols prescribed** (mainly primary)
  - Continental, Marine, Desert/semi-Desert (new), Arctic, Antarctic (new):
    - number-conc. with vertical variation, composition, size-dirstribution,
  - Stratospheric (Sulphuric Acid) (new)

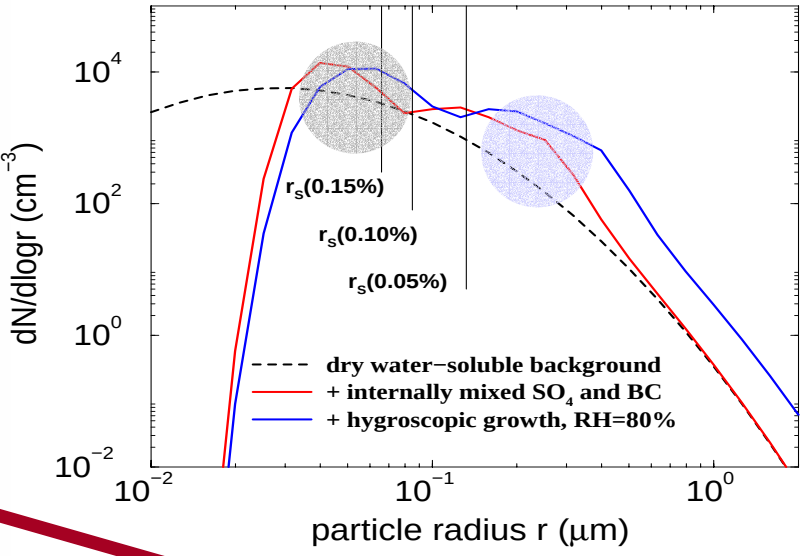
Data: ”GADS” (Kopke et al. 1997); Ghan etal (2001); ”AERONET” Smirnov et al. (2003); Dubovik et al. (2002); Hoppel and Frick (1990)

Chem./Phys. Production

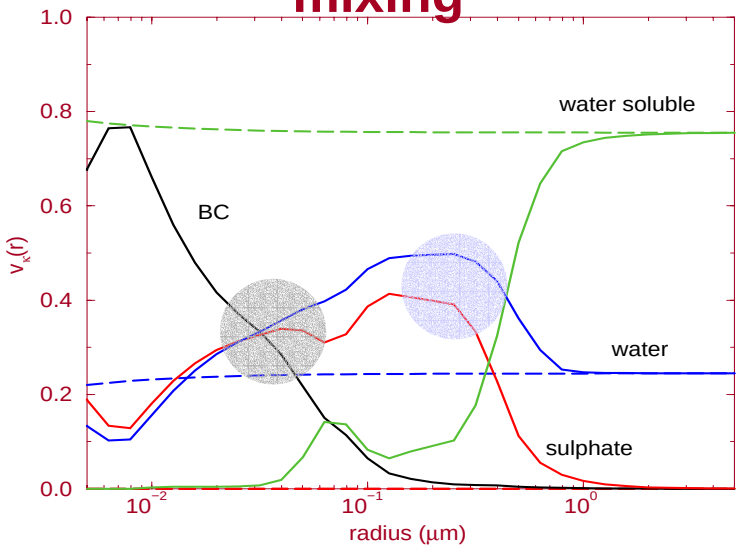
The CCM-Oslo model

Size distrib, CCN,

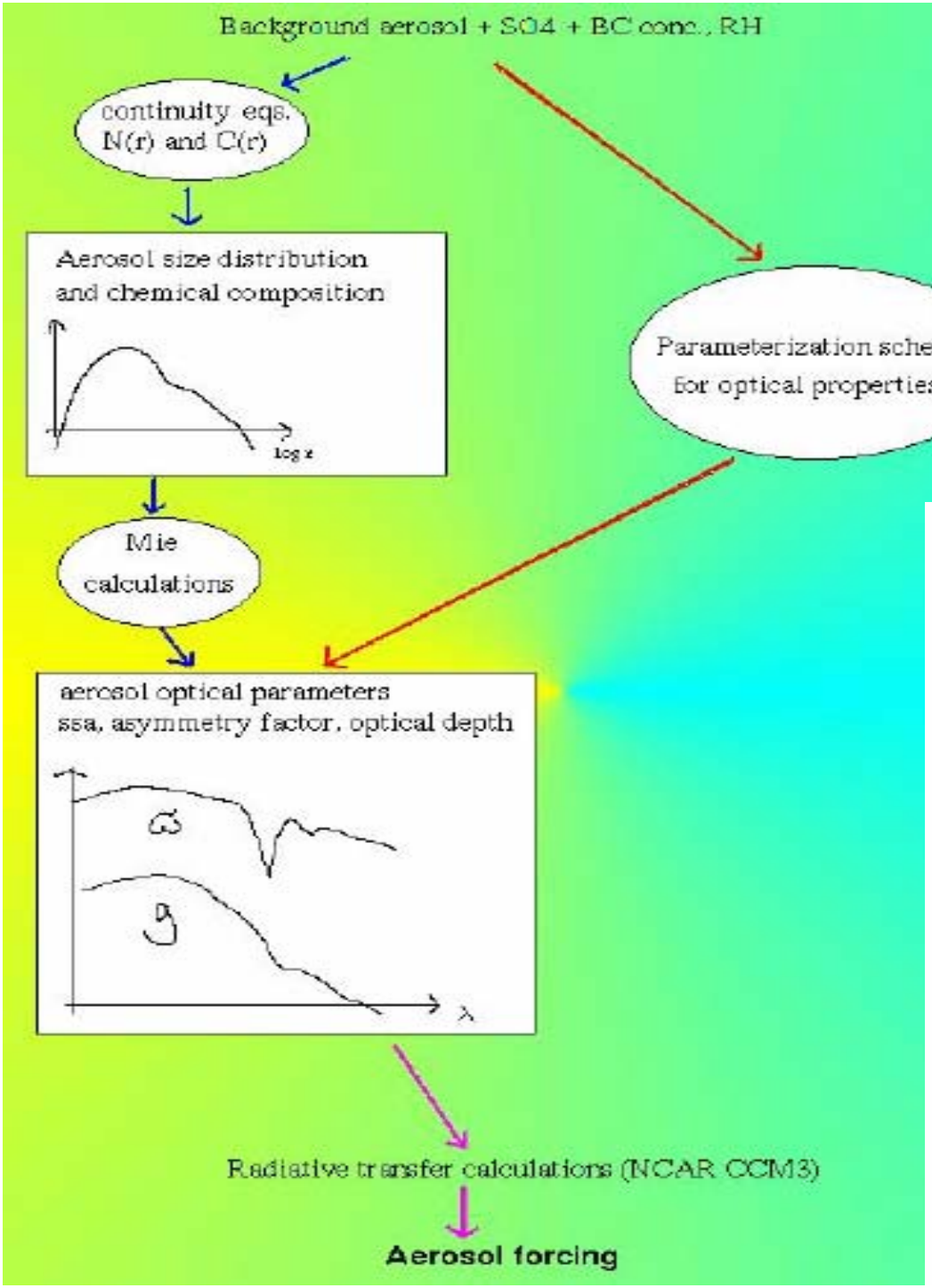




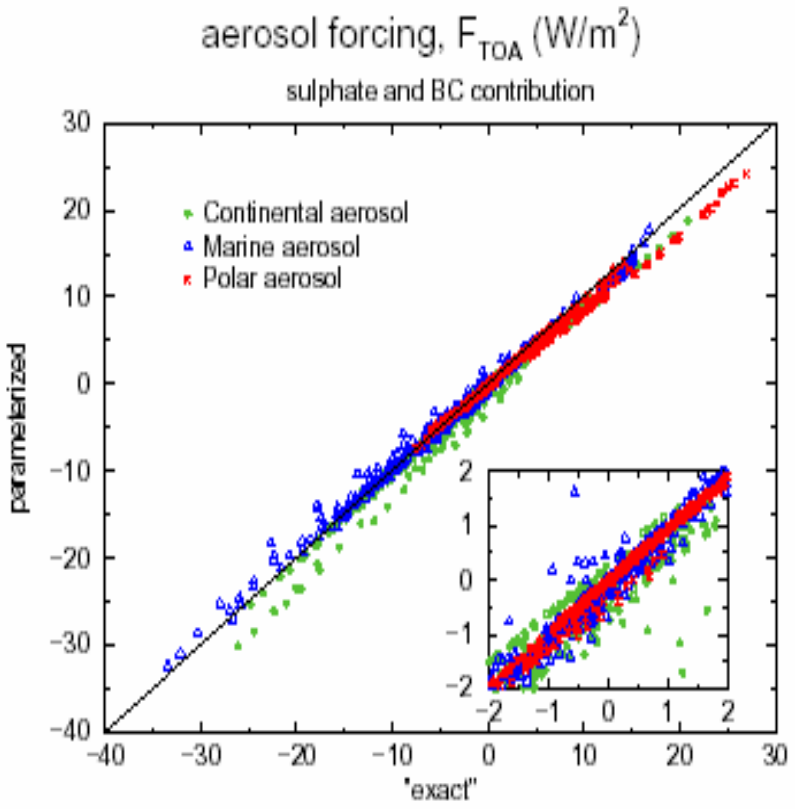
mixing



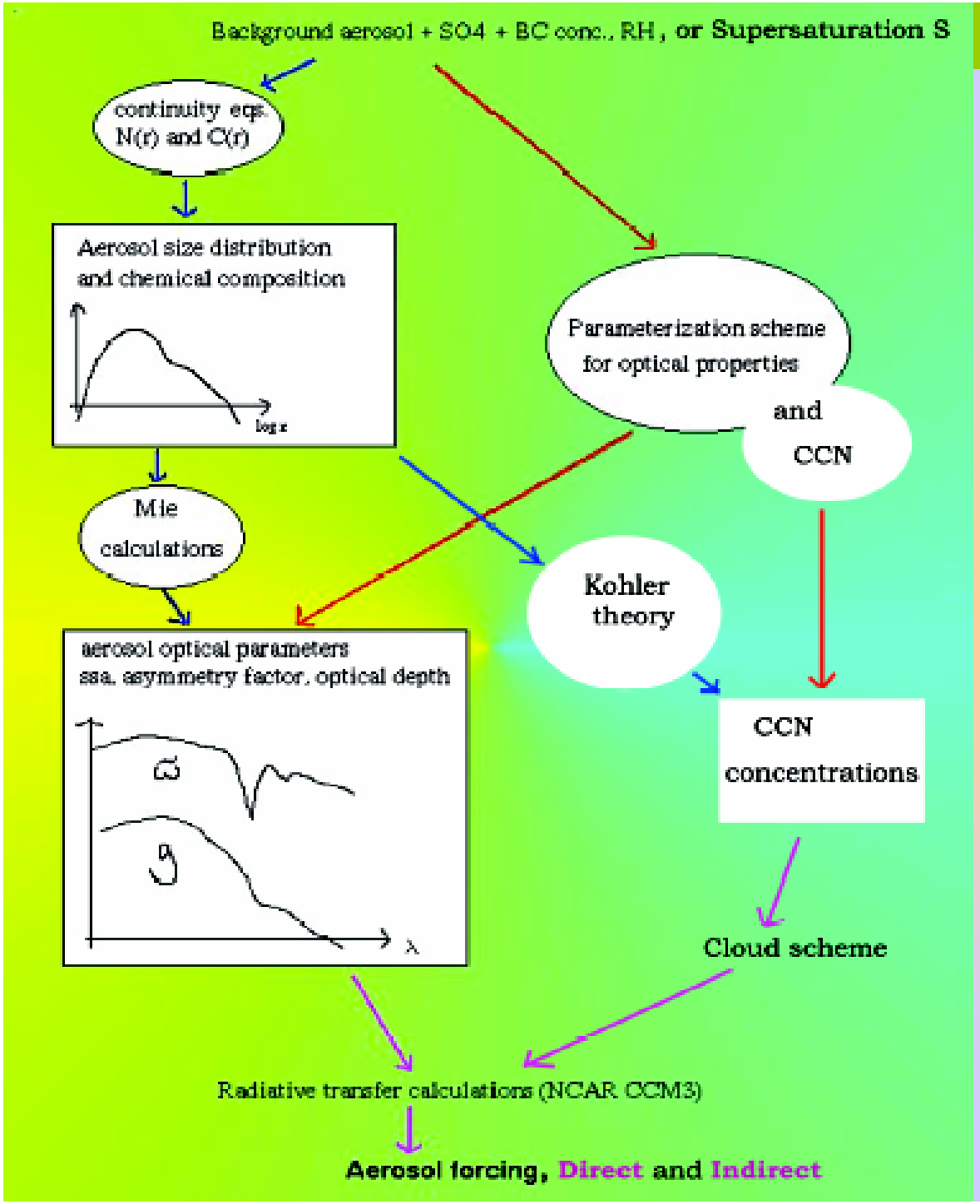
The CCM-Oslo model



Scheme for parameterized Optical parameters

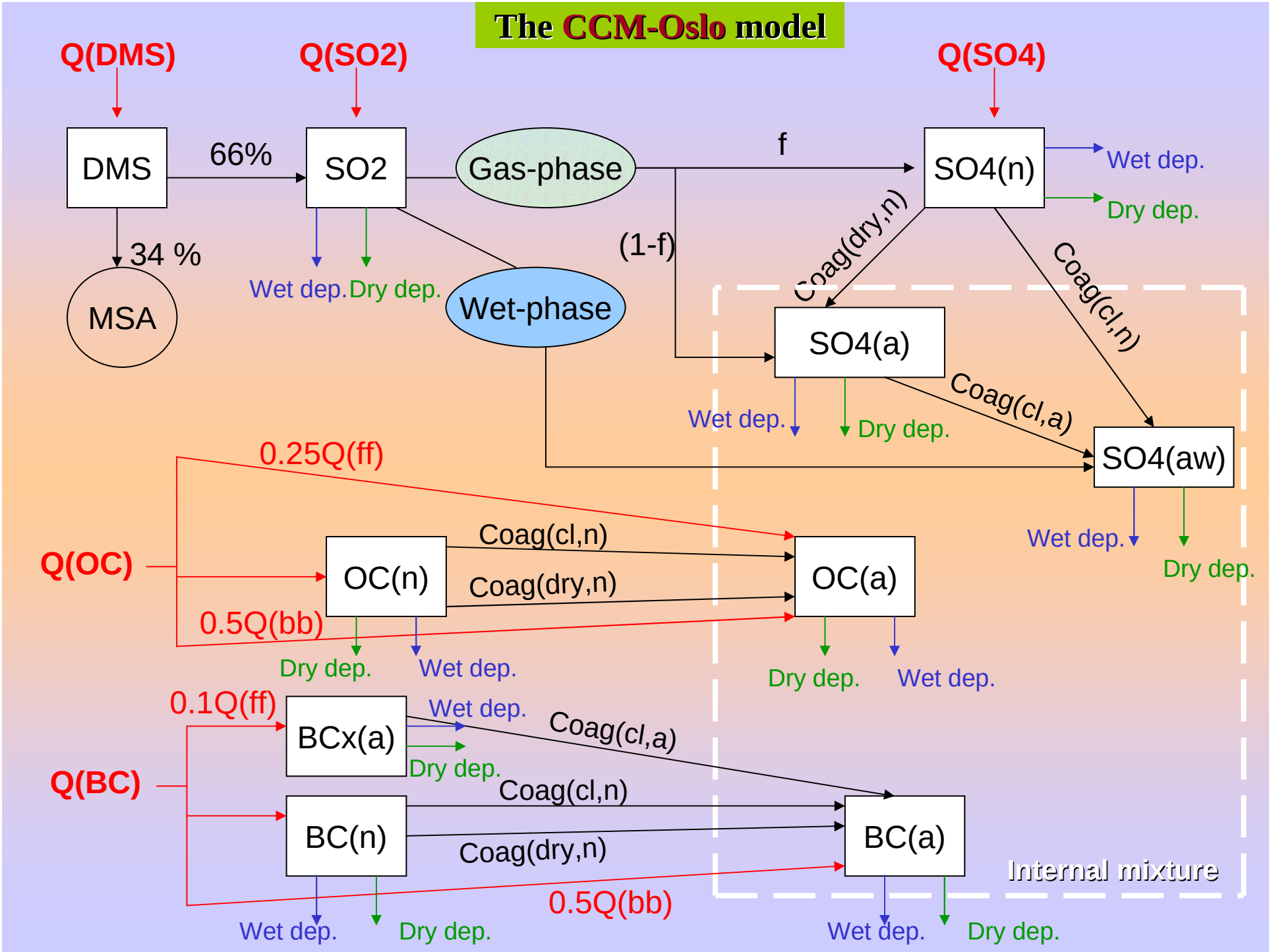


The CCM-Oslo model



… and concentrations of

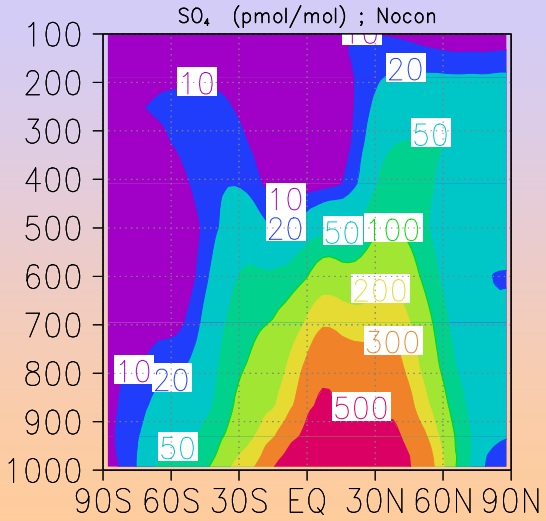
Cloud Condensation Nuclei

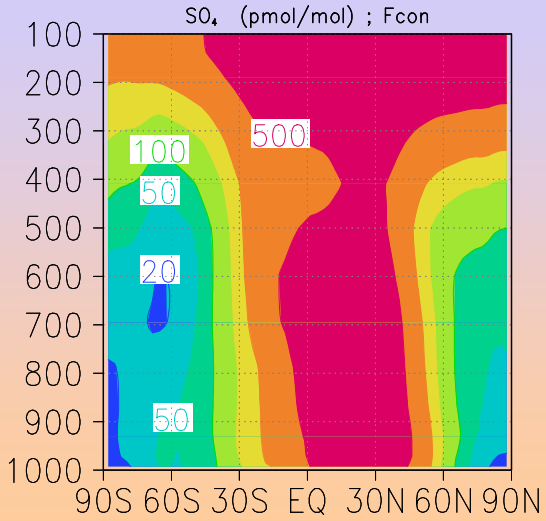

The CCM-Oslo model
Q(DMS)
Q(SO2)
Q(SO4)
DMS
66%
SO2
Gas-phase
f
SO4(n)
Wet dep.
Dry dep.
34 %
MSA
Wet dep.
Dry dep.
Wet-phase
(1-f)
Coag(dry,n)
Coag(cl,n)
SO4(a)
Wet dep.
Dry dep.
Coag(cl,a)
SO4(aw)
Wet dep.
Dry dep.
0.25Q(ff)
Q(OC)
OC(n)
Coag(cl,n)
Coag(dry,n)
OC(a)
0.5Q(bb)
Dry dep.
Wet dep.
Dry dep.
Wet dep.
0.1Q(ff)
BCx(a)
Wet dep.
Coag(cl,a)
Dry dep.
Q(BC)
Coag(cl,n)
BC(n)
BC(a)
Coag(dry,n)
Internal mixture
0.5Q(bb)
Wet dep.
Dry dep.
Wet dep.
Dry dep.

Sensitivity to deep convection treatment

The CCM-Oslo model

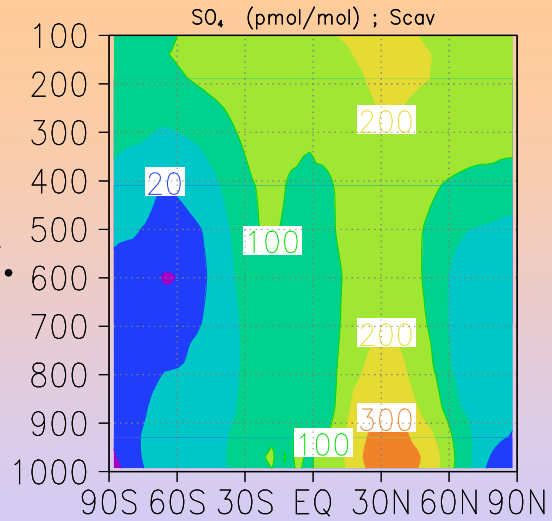
No conv. Transport
B=0.60 TgS
T=4.1 d

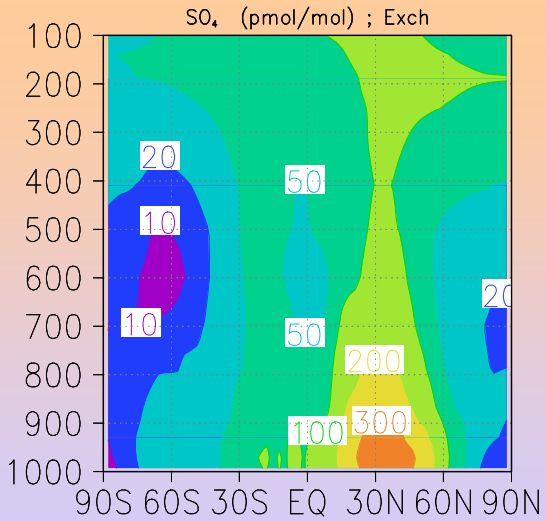




Full conv. Transport
B=2.40 TgS
T=14.6 d

Full conv. transport & Incr. Low-lev. Scavenging
B=0.63 TgS
T=4.4 d





Full conv. transport & incr. scav. & updraft-downdraft Exchange
B=0.44 TgS
T=3.1 d

The CCM-Oslo model

Strengths

- **Aerosols fully time-resolved**
- **Mixing-state calculated according to condensation and coagulation processes** (not prescribed)
- **Anthropogenic aerosols add to a background, size-distribution and mixing is process-dependant**
- **Calculations of optical parameters and cloud-activity tabulated efficiently: enables climate runs.**

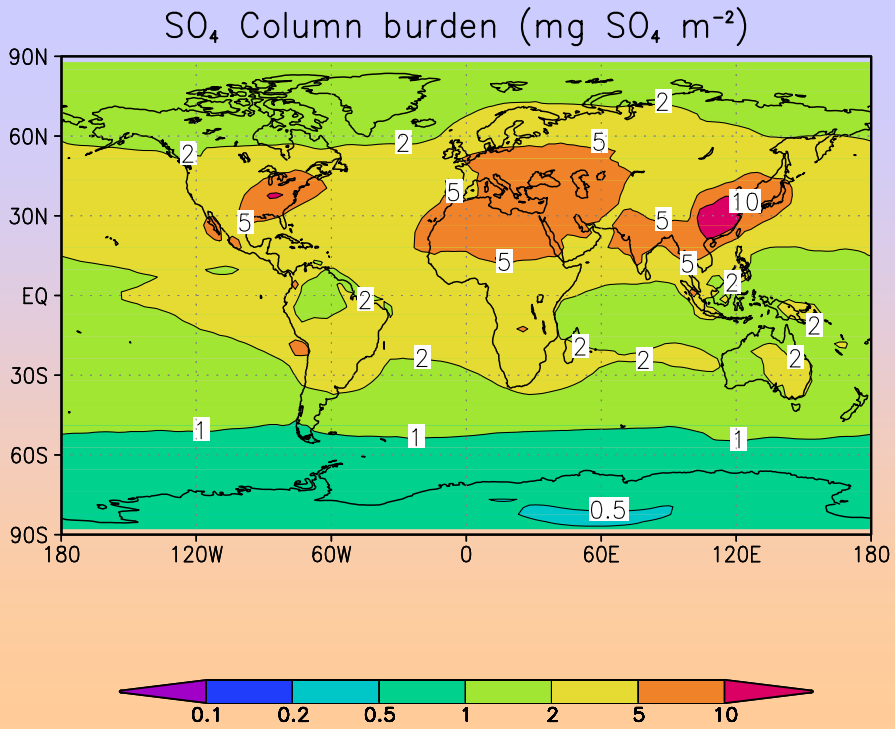
Weaknesses (incl. work to be addressed shortly)

- **Background aerosols prescribed**
- **Processing by deep convection not fully solved**
- **Bulk OC-properties are very uncertain / unknown**
- **OC not validated yet**
- **Need better estimates of cloud-droplet size development, incl. production of CCNs by realized super-saturation**
- **Cleansing mechanism through giant sea-salt particles(?)**
- **Nudging not tested yet – will switch to NCAR CAM2**

Status Aerocom

- 5 year model runs using the last 3 years for statistics
- Aerosol components given in wanted format
- Size distributions and radiative effects calculated, but not in the wanted format

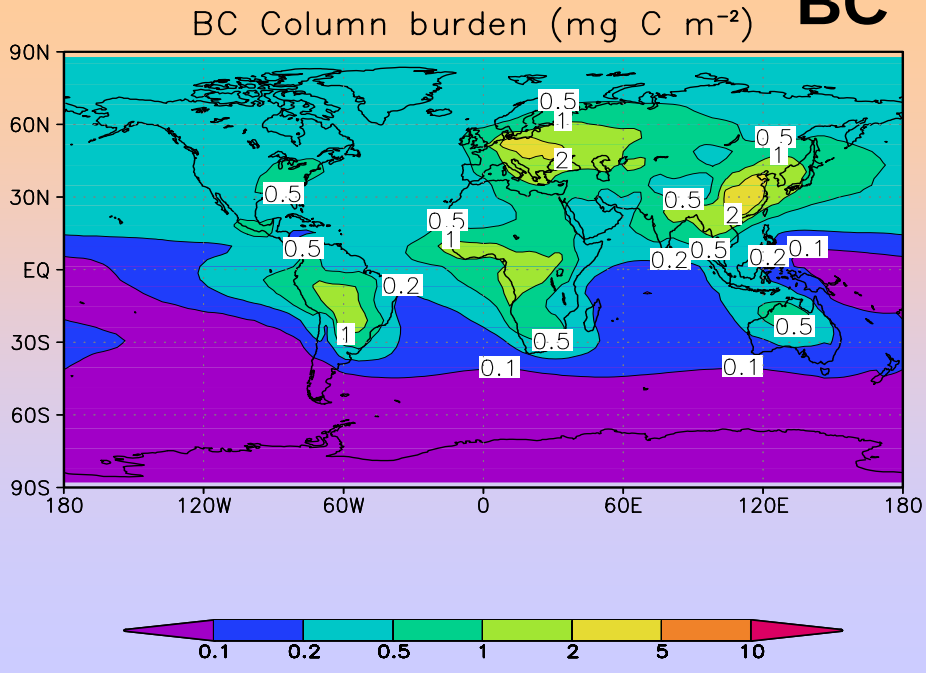
The CCM-Oslo model



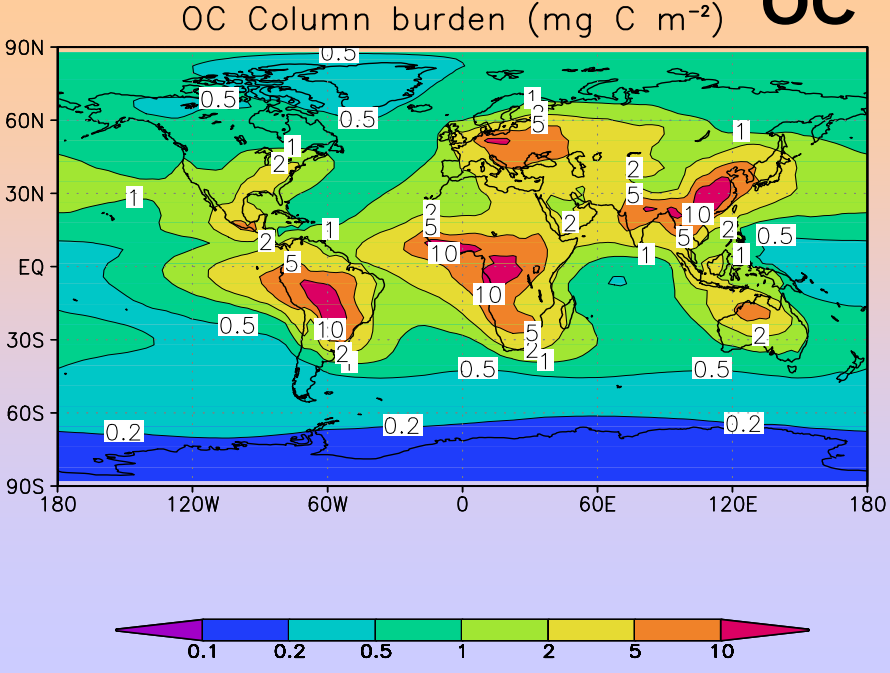
SO4

Annual Burdens mg/m²

BC



OC



Global Budget numbers

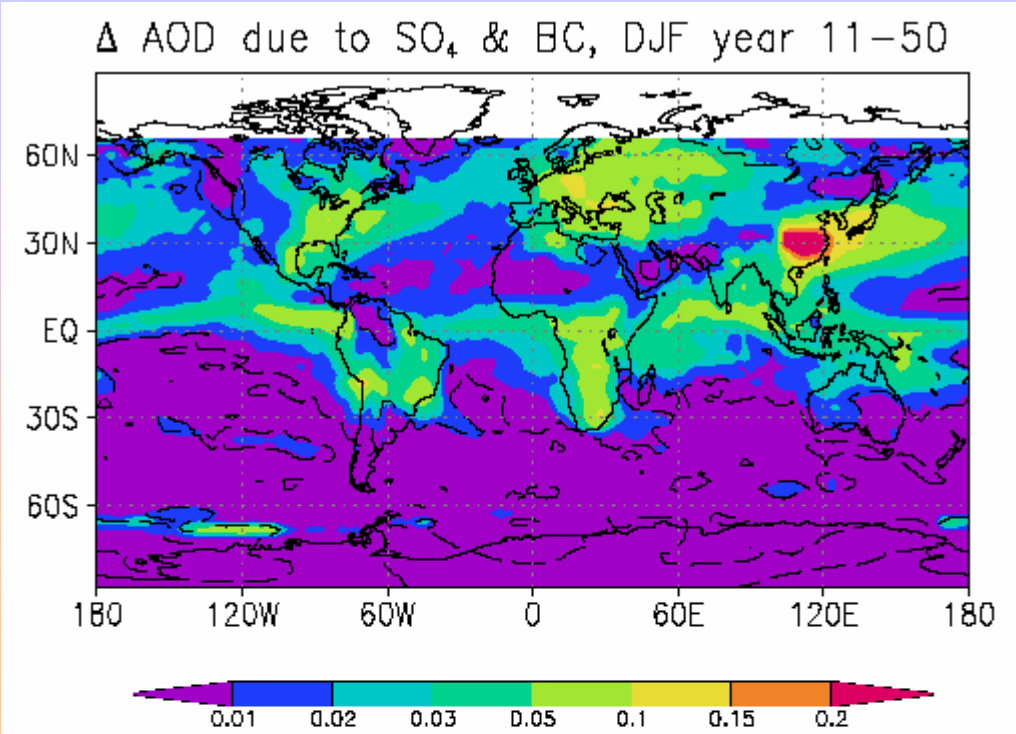
	Source (Tg S/C)	Burden (Tg S/C)	Lifetime (days)	Wet dep. (%)
SO2	90.4	0.39	1.6	19
SO4	51.0	0.44	3.1	92
BC	12.4	0.18	5.3	76
OC	81.4	0.90	4.0	79

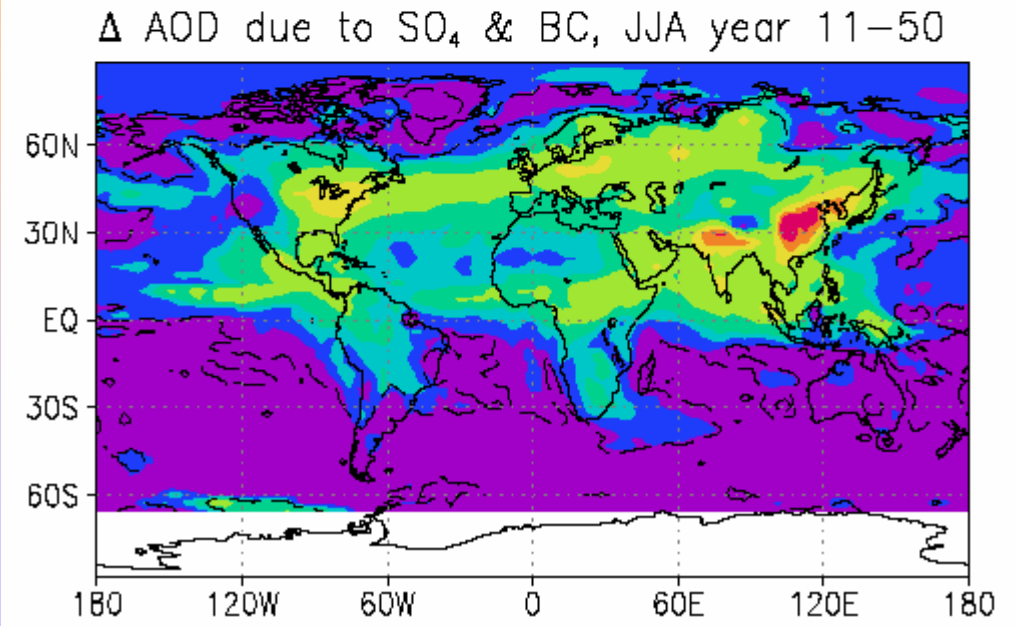
The CCM-Oslo model

Change in optical depth

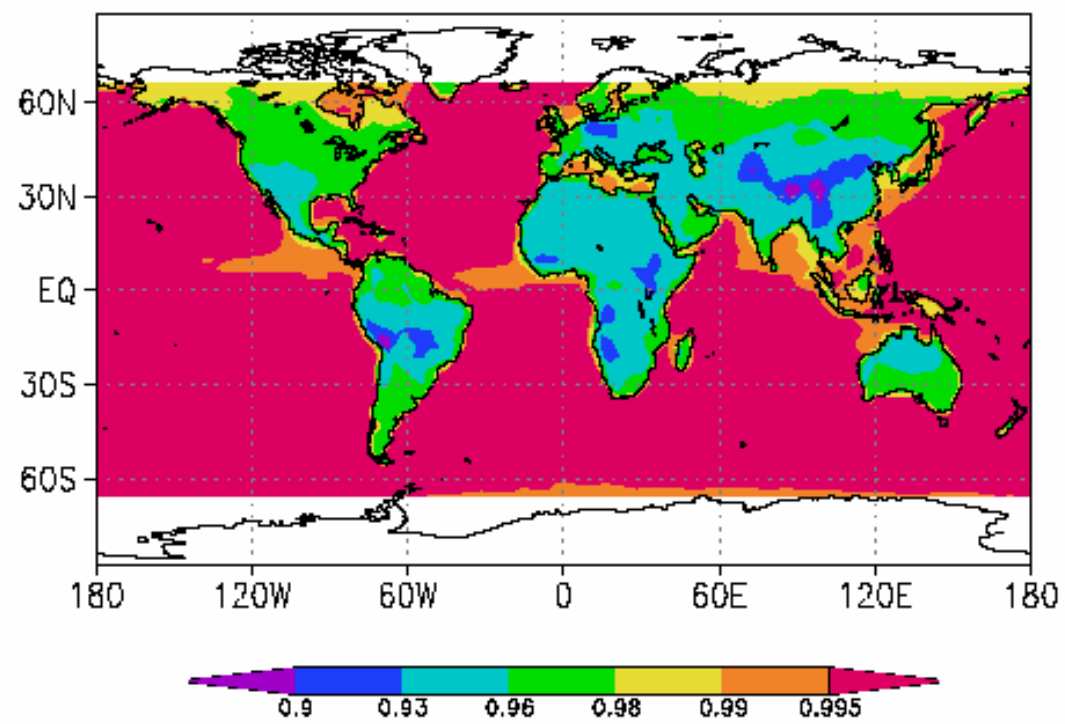
due to anthropogenic

Sulphate and Black Carbon





The CCM-Oslo model

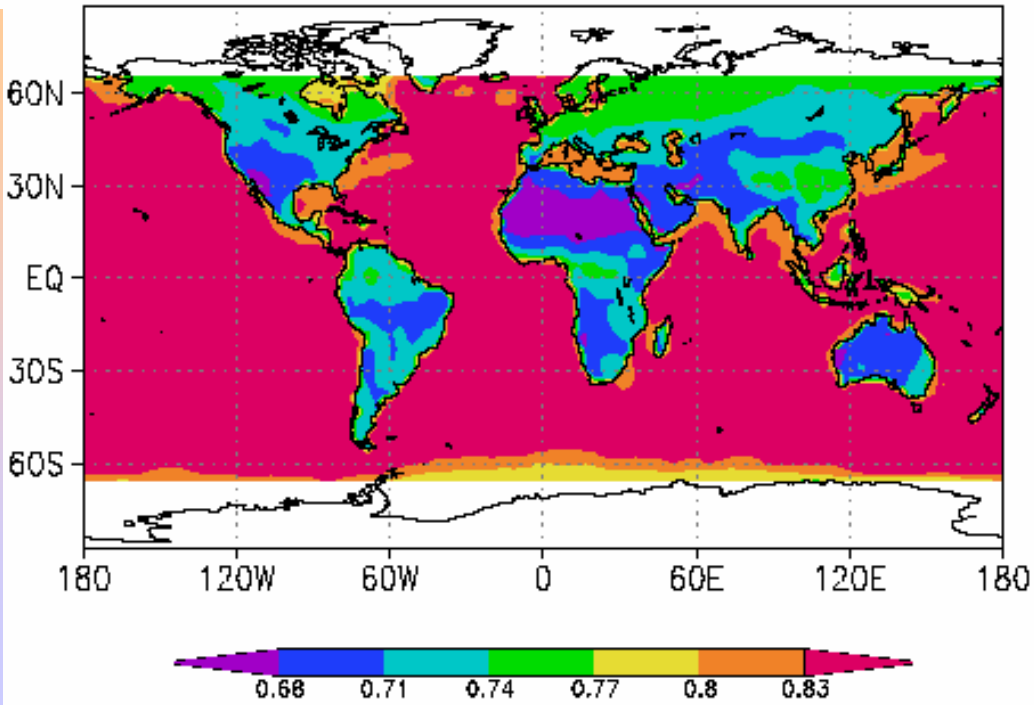


Aerosol optical parameters

near the surface (993 hPa)

Single scattering albedo

Asymmetry factor



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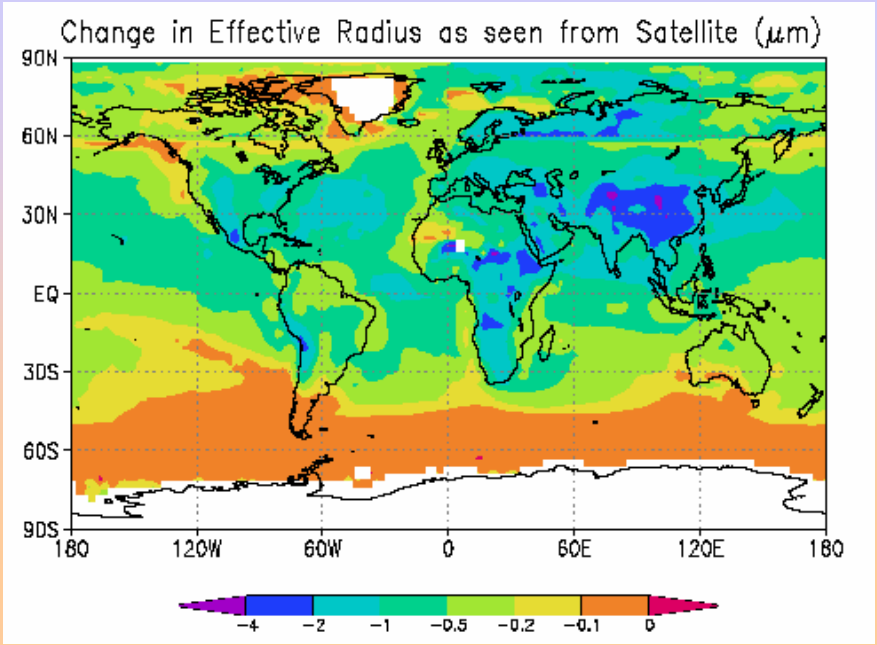
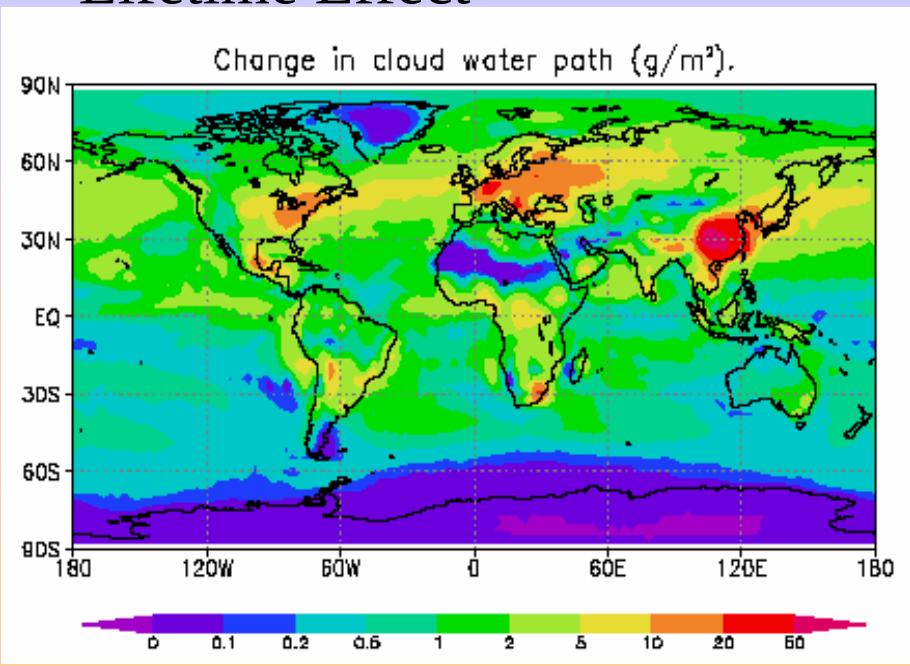
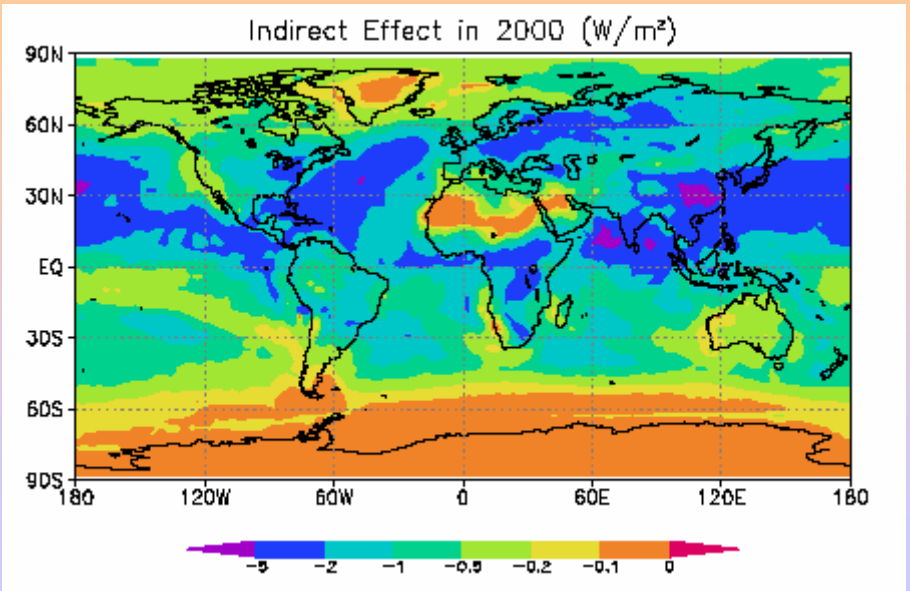
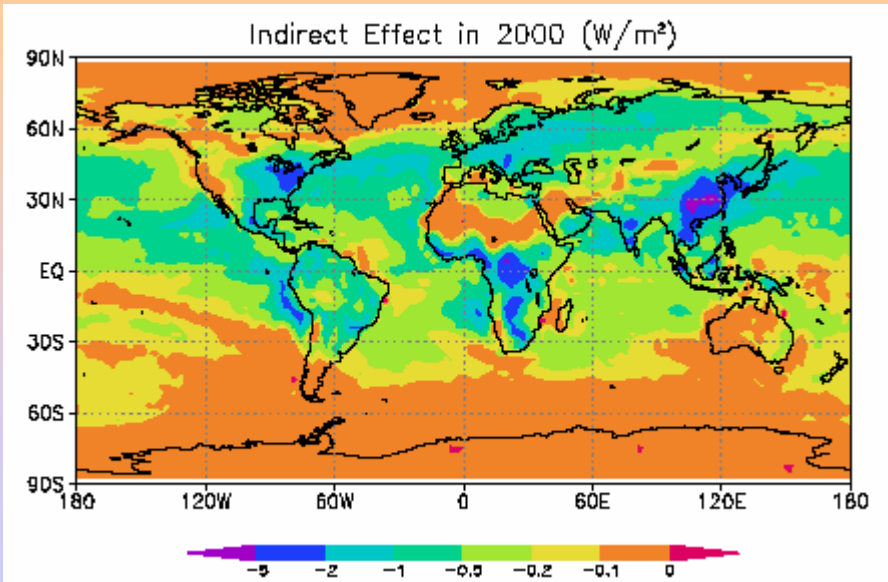
Radius Effect



Lifetime Effect







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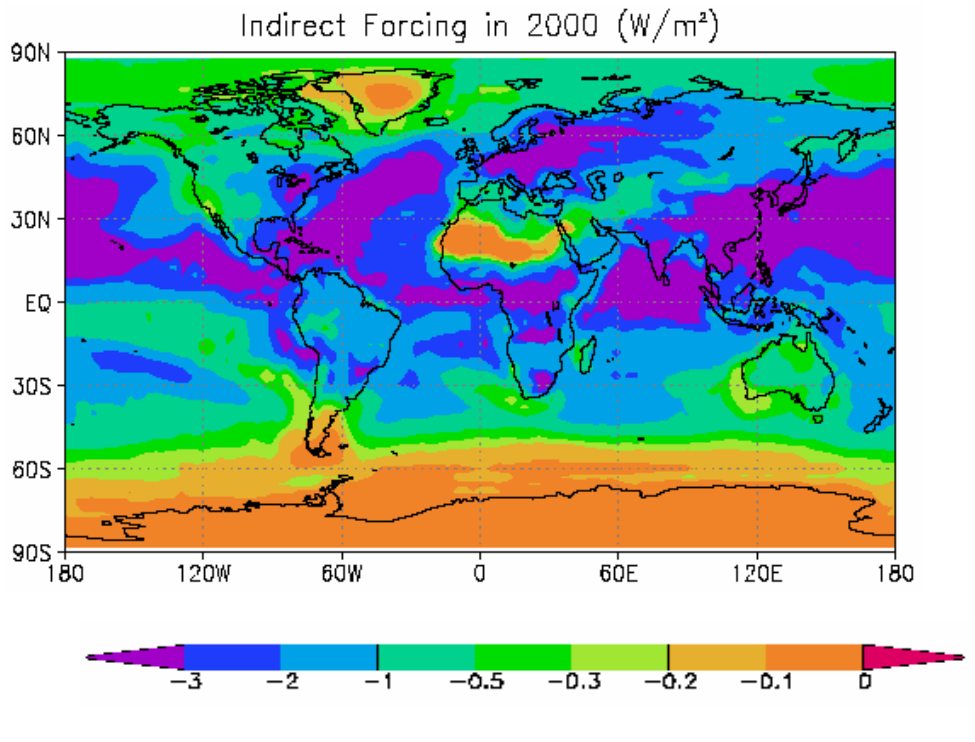
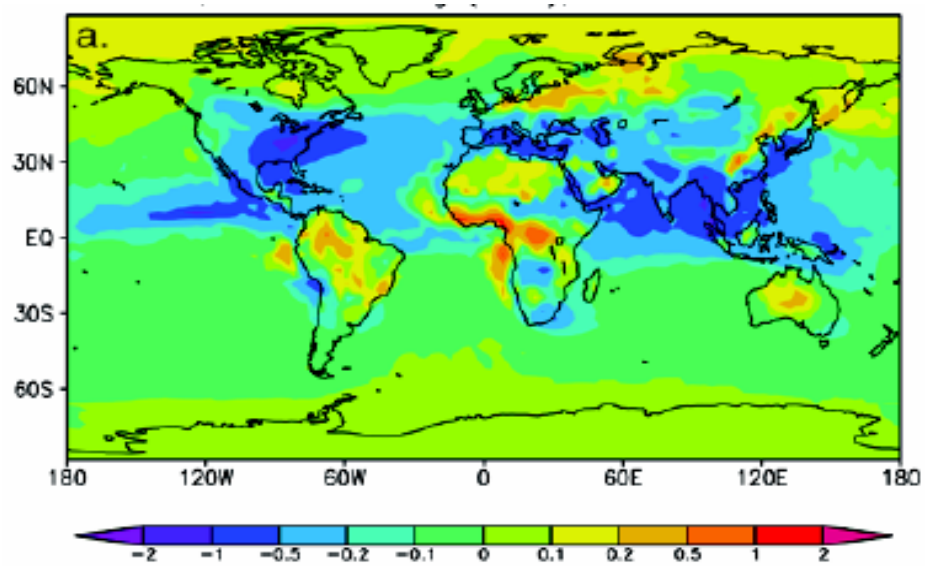




Forcing

Indirect:

-1.76 W/m^2

Direct:

-0.11 W/m^2

-at the surface

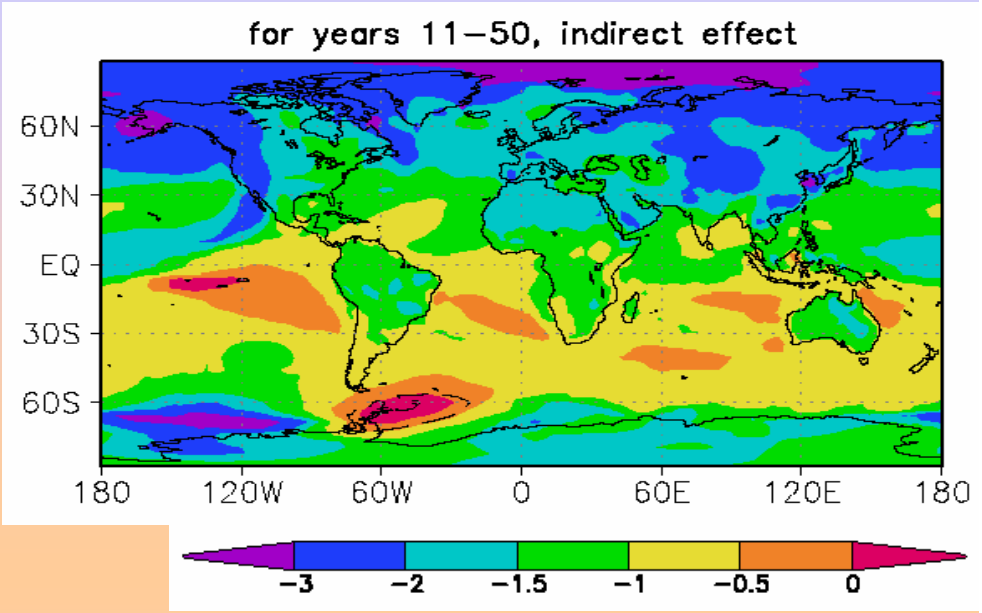
Temperature Change

(equilibrium calculations

The CCM-Oslo model

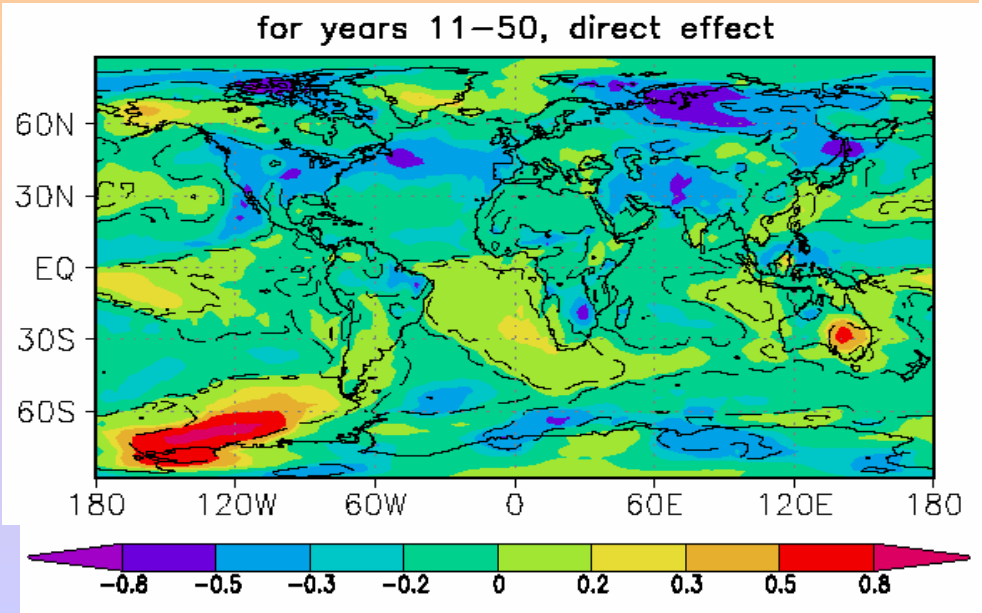
Indirect effect:

Global Average: -1.28 K



Direct effect:

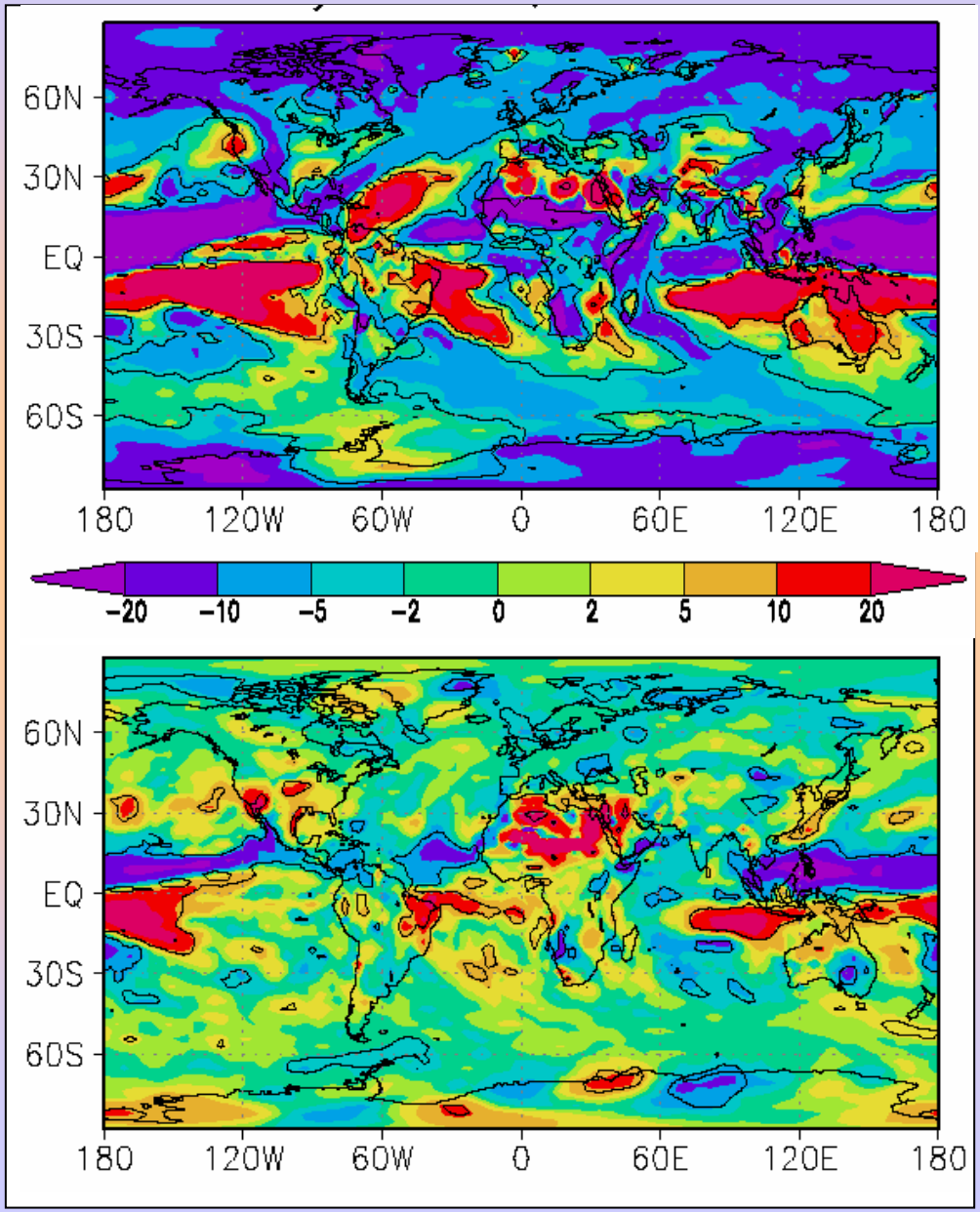
Global Average: - 0.10 K



Percentwise change in precipitation

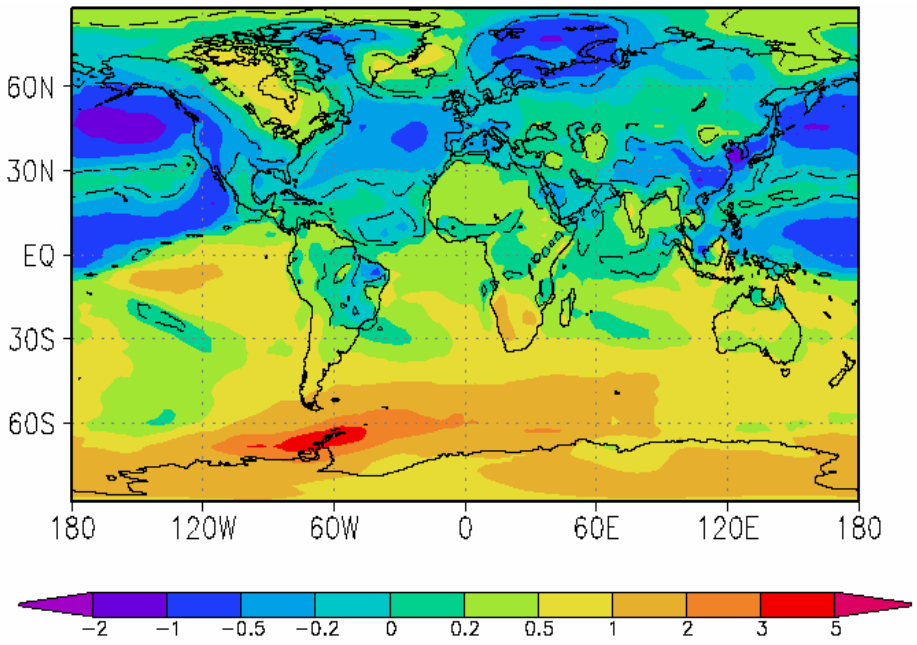
INDIRECT

DIRECT



Greenhouse Gases + Indirect Effect

Temperature change



Precipitation change