# Aerosol climate interactions

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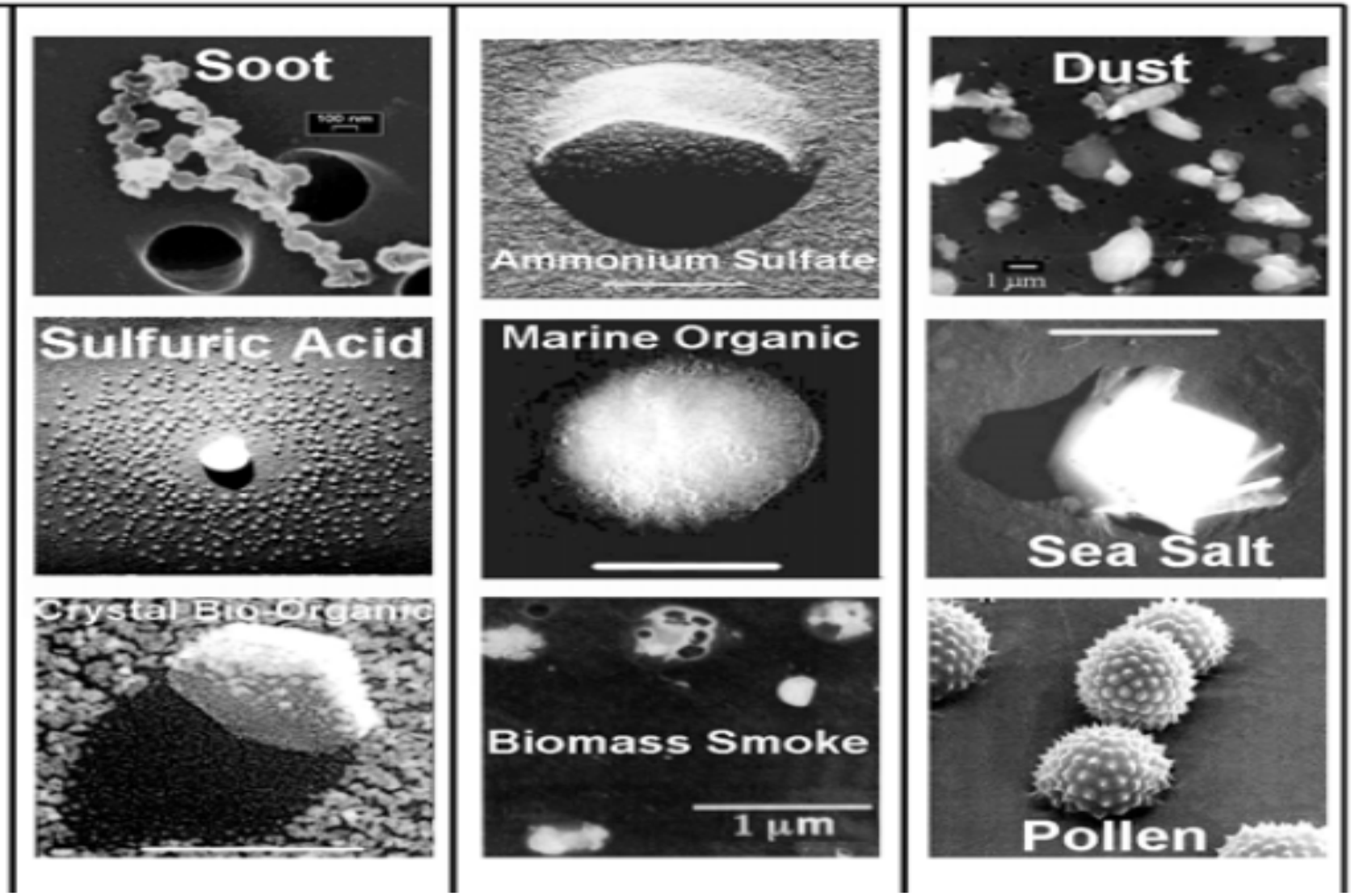
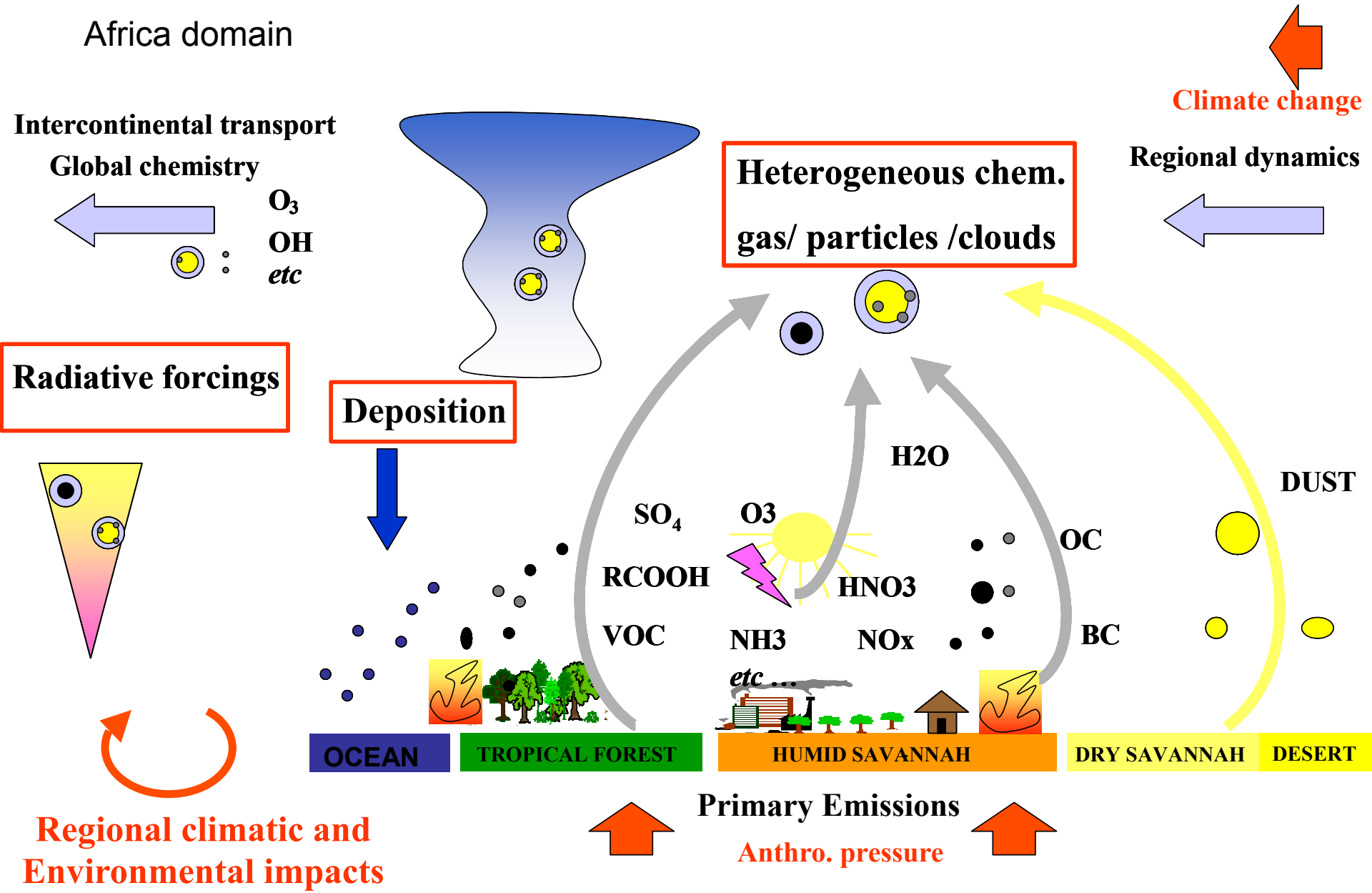
# Aerosol - climate interactions

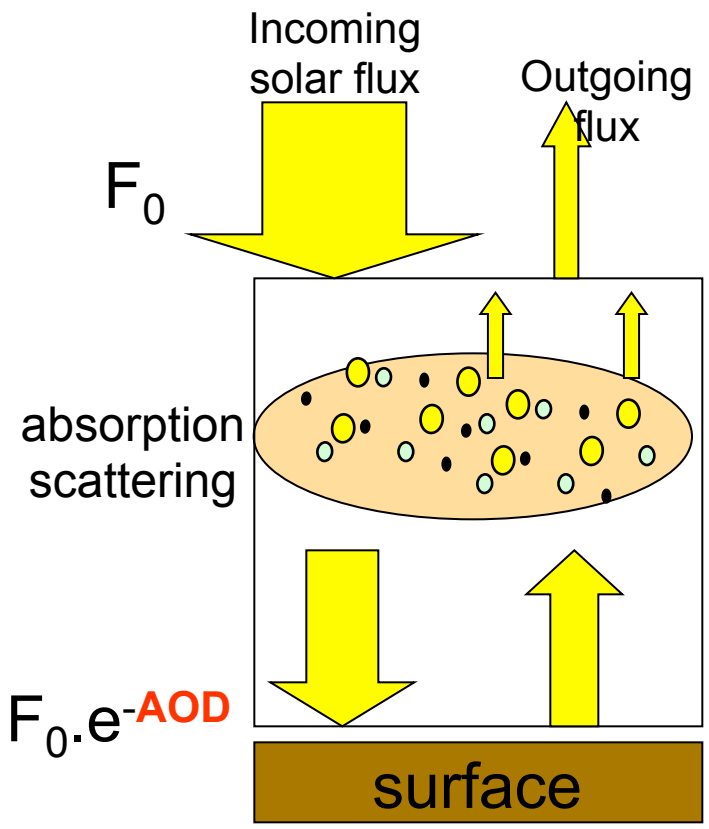


Interaction between atmospheric chemistry, climate, and biogeochemical cylces in a changing environment.



Direct effect

# Dust Short Wave radiative forcing




Aerosol optical depth AOD describes the aerosol extinction due to the sum of absorption and scattering effects.

⇨ **TOA SW Radiative forcing** : difference of outgoing fluxes without and with aerosol

All other atmospheric and surface variables being fixed.

> 0. = warming of the system

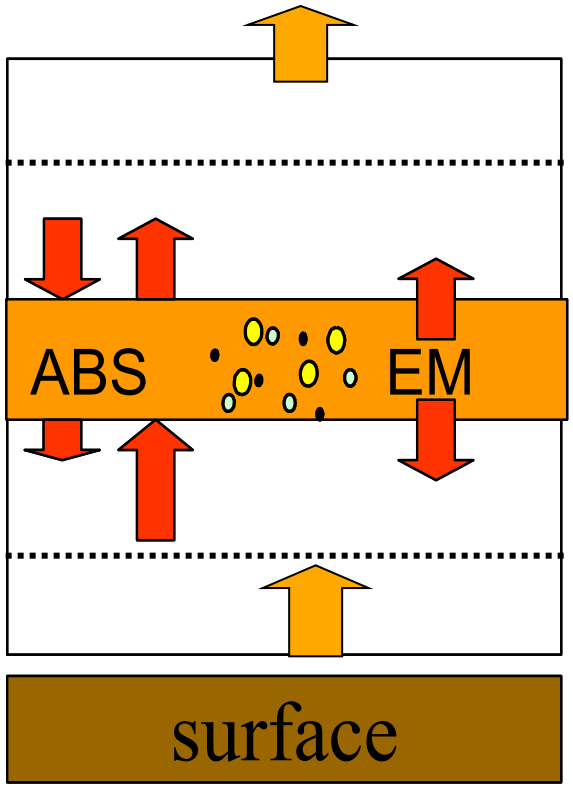
< 0. = cooling of the system

⇨ **SRF SW Radiative forcing :** difference of net flux at the surface

Always < 0. = cooling of the surface

# Dust Long Wave radiative forcing

Atmospheric layers absorb and emit (grey body) in thermal radiation range.
Radiative equilibrium between layers




**TOA LW Radiative forcing** : difference of outgoing fluxes without and with aerosol

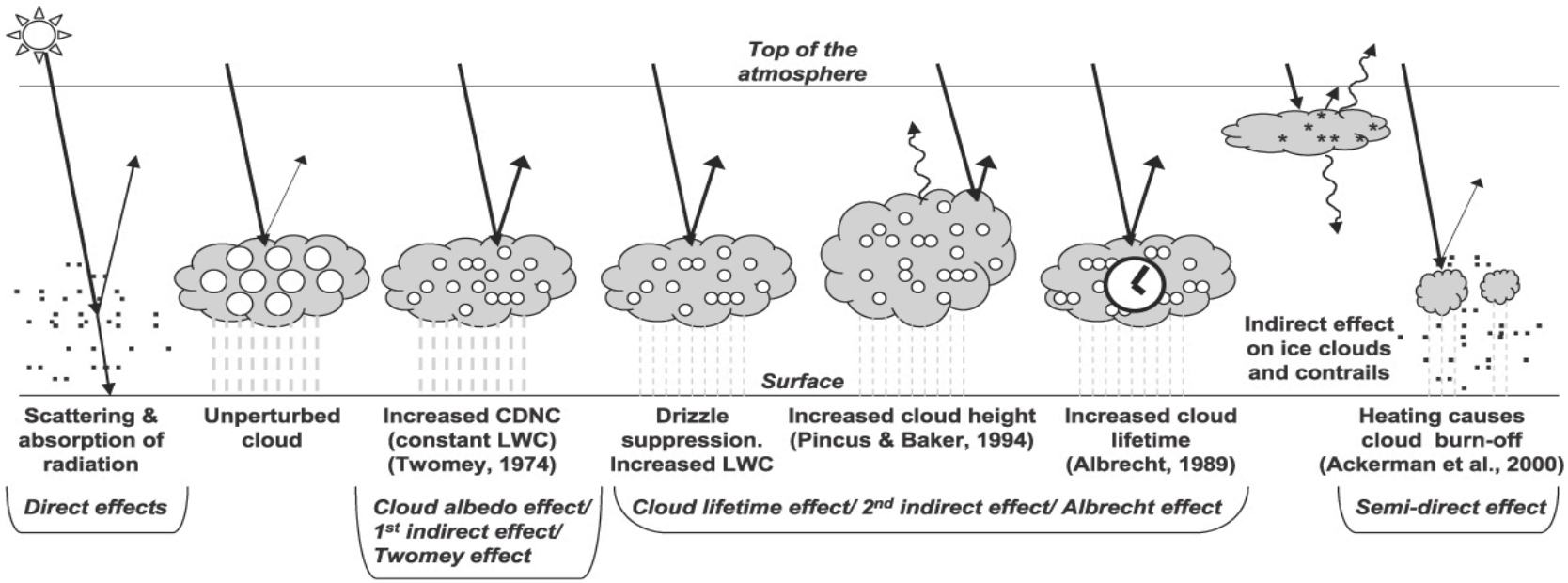
All other atmospheric and surface variables being fixed

**SRF LW Radiative forcing :** difference of net flux at the surface

Always > 0. = relative warming of the surface …

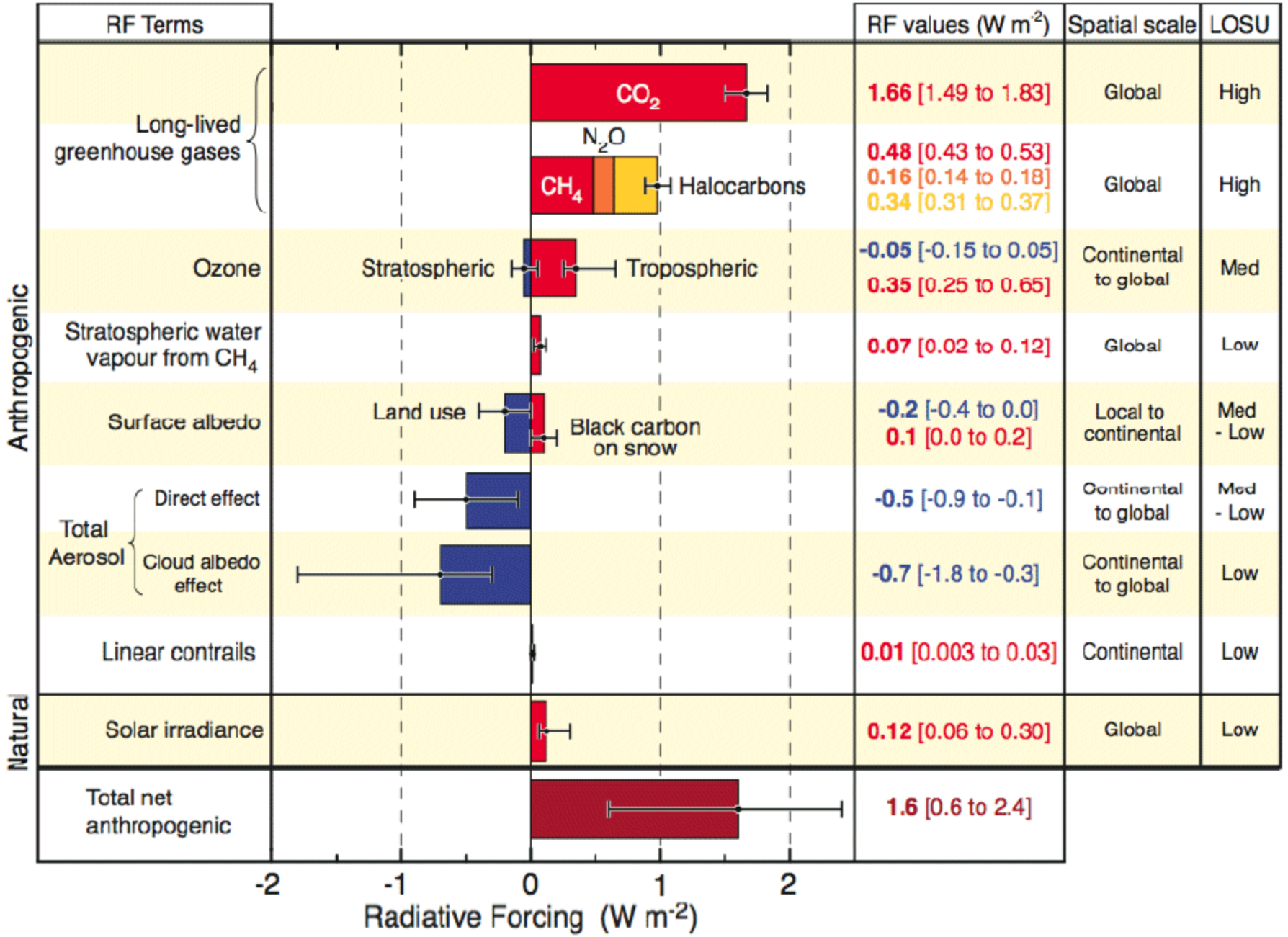
Indirect effects …not yet in regcm (or very simplified)

Aerosol /cloud interactions




Aerosol deposition on snow

Impact on climate via biogeochemical effects


RF Terms
RF values (W m-2)
Spatial scale
LOSU
Anthropogenic
Natural
Long-lived greenhouse gases
CO2
N2O
CH4
Halocarbons
1.66 [1.49 to 1.83]
0.48 [0.43 to 0.53]
0.16 [0.14 to 0.18]
0.34 [0.31 to 0.37]
Global
High
Ozone
Stratospheric
Tropospheric
-0.05 [-0.15 to 0.05]
0.35 [0.25 to 0.65]
Continental to global
Med
Stratospheric water vapour from CH4
0.07 [0.02 to 0.12]
Global
Low
Surface albedo
Land use
Black carbon on snow
-0.2 [-0.4 to 0.0]
0.1 [0.0 to 0.2]
Local to continental
Med - Low
Total Aerosol
Direct effect
Cloud albedo effect
-0.5 [-0.9 to -0.1]
-0.7 [-1.8 to -0.3]
Continental to global
Med - Low
Low
Linear contrails
0.01 [0.003 to 0.03]
Continental
Low
Solar irradiance
0.12 [0.06 to 0.30]
Global
Low
Total net anthropogenic
1.6 [0.6 to 2.4]
-2
-1
0
1
2
Radiative Forcing (W m-2)
©IPCC 2007: WG1-AR4

# Aerosols in RegCM3-4.1

- **Tracer model / RegCM4.1**

$$\frac{\partial \chi}{\partial t} = -\overline{V} \cdot \nabla \chi + F_H + F_V + T_{CUM} + S_\chi - R_{w,ls} - R_{w,cum} - D_{dep} + \sum Q_p - Q_l$$

Transport | Primary Emissions | Removal terms | Physico – chemical transformations

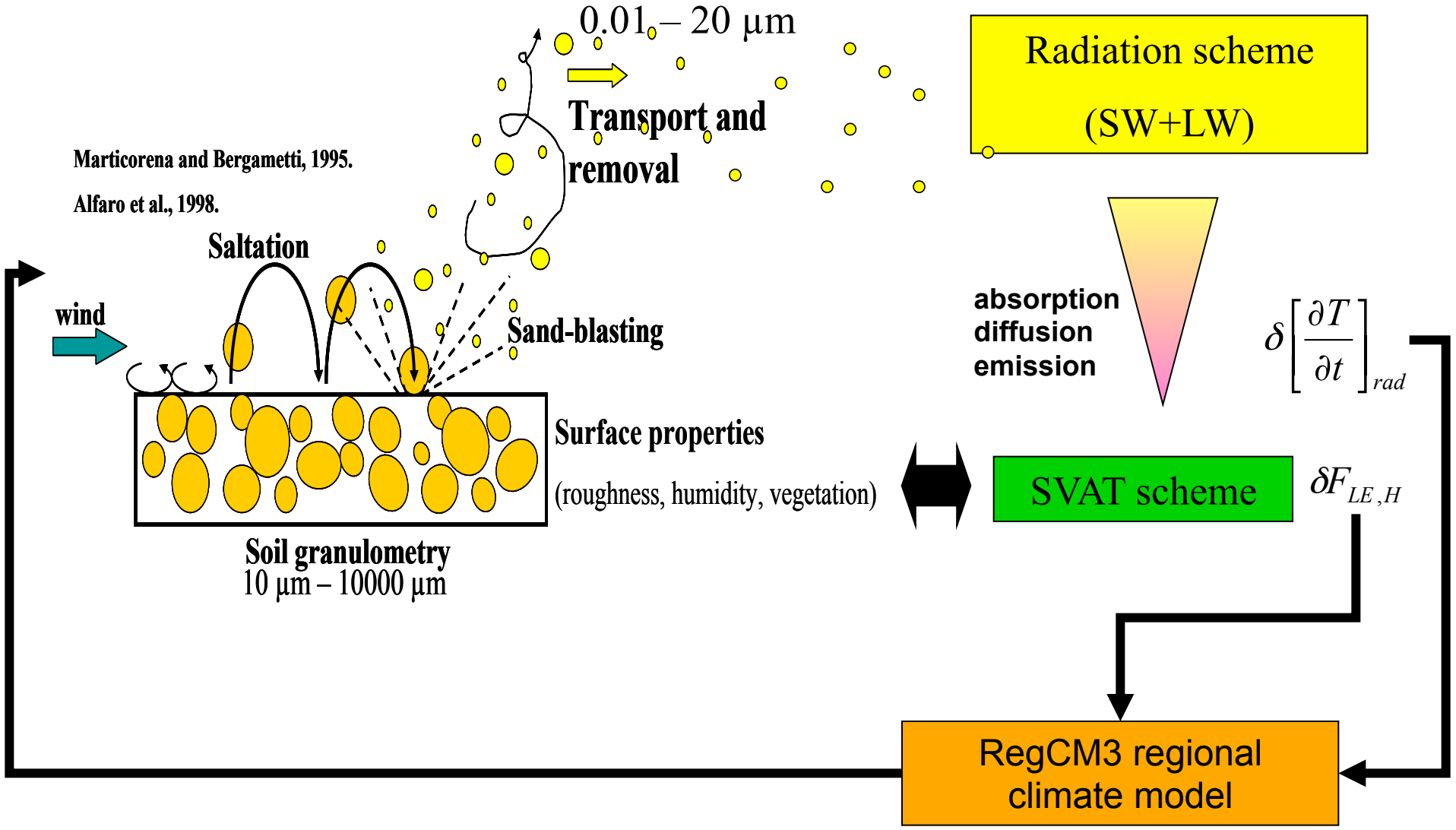
- **Particles and chemical species considered**

| $SO_2$ | $SO_4^{--}$ | BC (soot) | | OC (total organic carbon) | | DUST (4 bins) | | | |
|---|---|---|---|---|---|---|---|---|---|
| Aqueous and gazeous conversion (Qian et al., 2001) | | *Hydrophilic (20% at emission)* → | Hydrophobic (80%at emission) | *Hydrophilic (50%at emission)* → | *Hydrophobic(50%at emission)* | 0.01-1 µm | 1-2.5 µm | 2.5-5 µm | 5-20 µm |

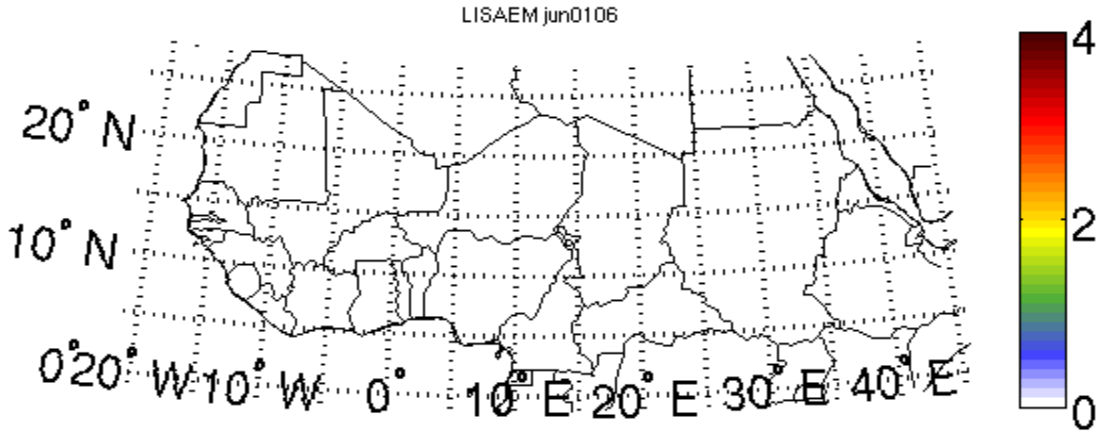
**RegCM4.2 : Sea-Salt, Gas phase chemistry**

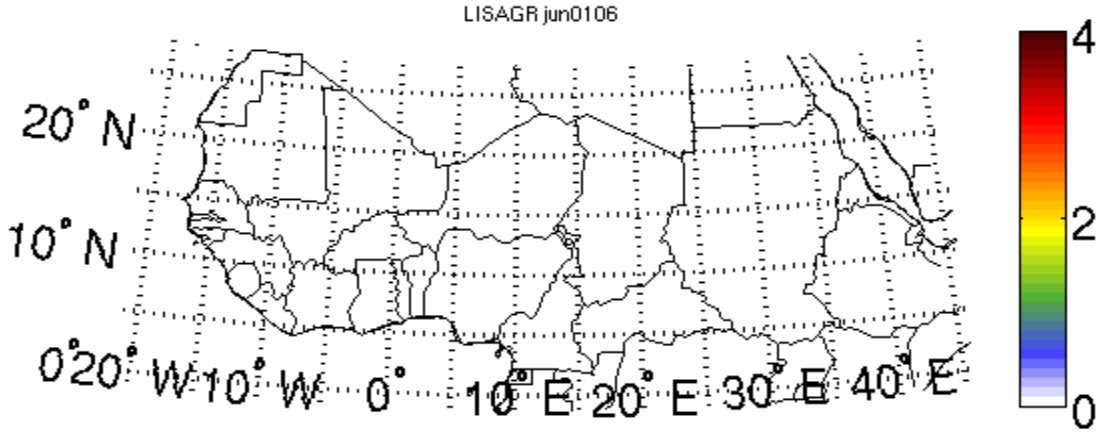
# Dust aerosol on-line module in the ICTP RegCM model

No cloud microphysics interaction !

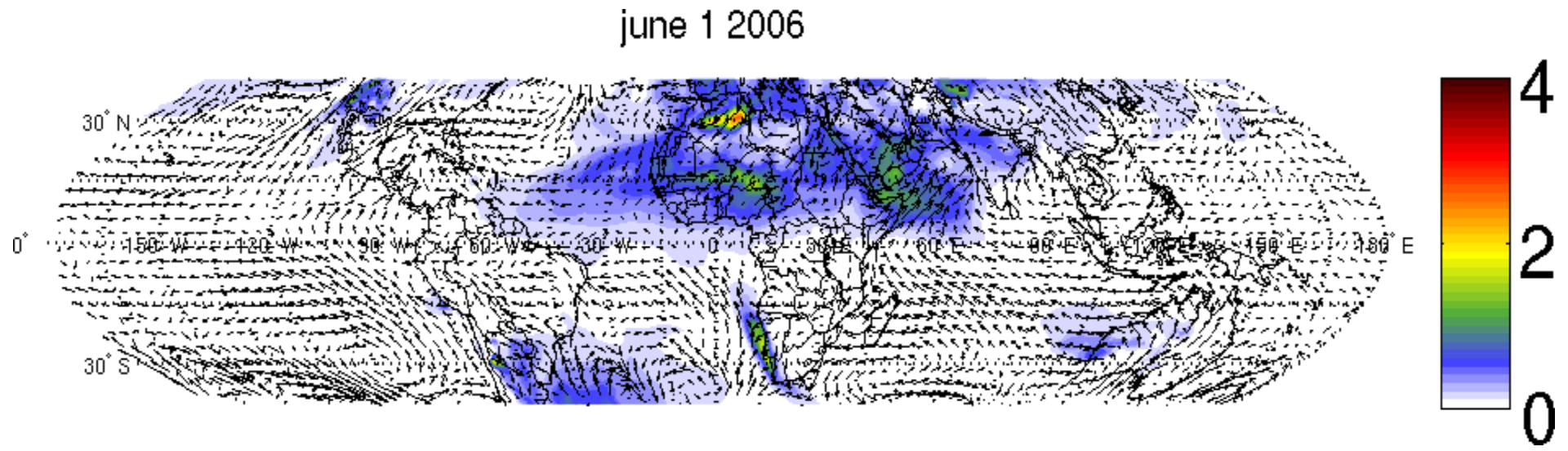


AOD



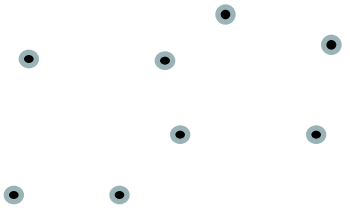

In this study : Grell + FC, Resolution of 60 km !


june 1 2006
30° N
0°
30° S
150° W
120° W
90° W
60° W
30° W
0°
30° E
60° E
90° E
120° E
150° E
180° E
4
2
0

BB aerosol module

BB emissions
LA + JRC(ISPRA)
From burnt area products
Inventory
0.5 deg
10 days

Transport and removal



Radiation scheme (SW+LW)

absorption
diffusion
emission

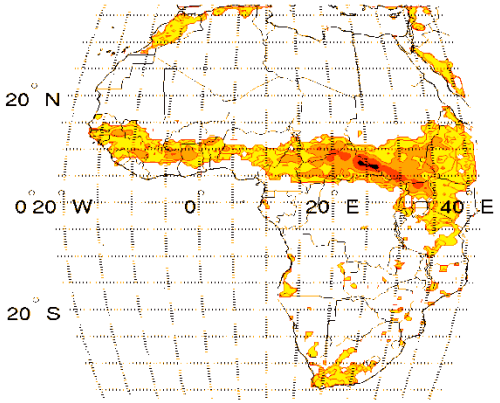
$$\delta\left[\frac{\partial T}{\partial t}\right]_{rad}$$

SVAT scheme

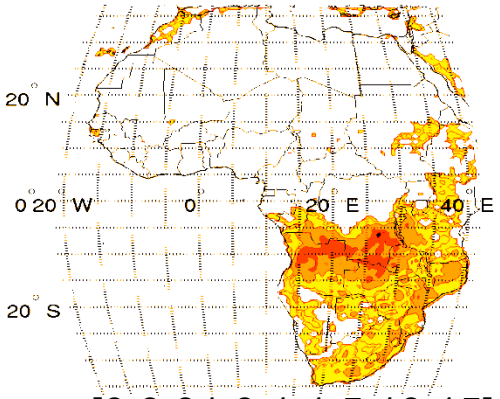
$$\delta F_{LE,H}$$

RegCM3 regional climate model

DJF

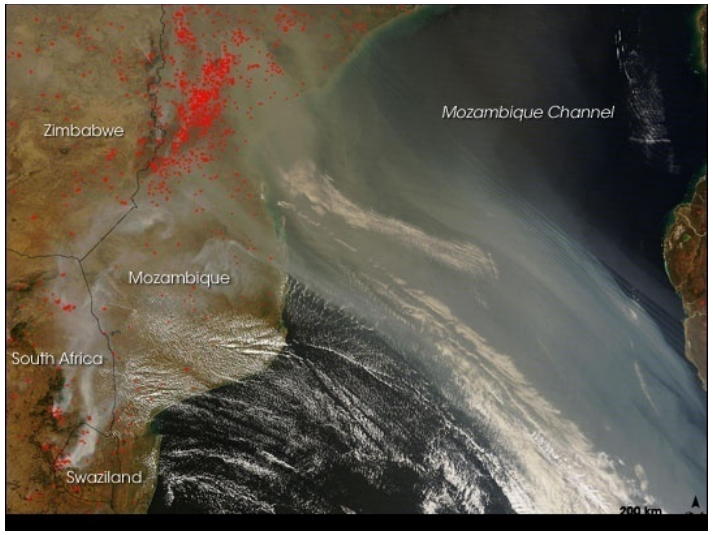



JJAS

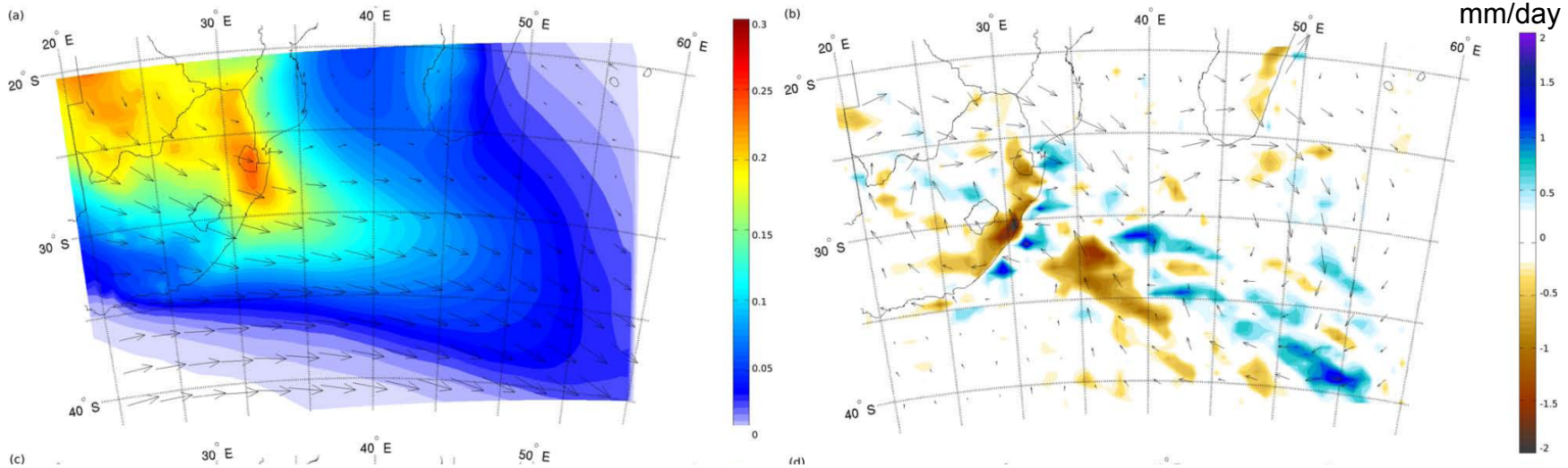



contour =[0 0.01 0.1 1 5 10 15] mg.m-2.day

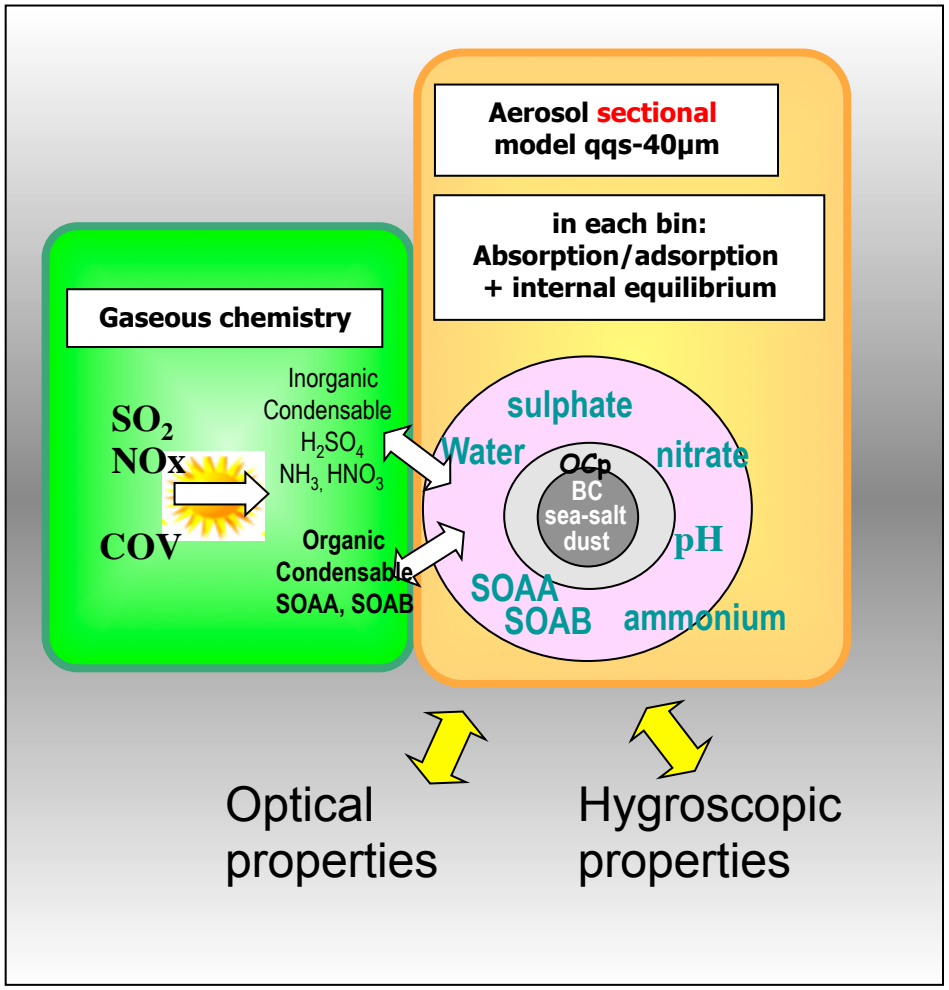
Impact during intense outflow conditions ?




selected using a SOM
( applied to AOD )



# chemistry/aerosol scheme in RegCM




RegCM3

RegCM3/chem

'Simple' aerosol module

**( < 1 year)**
**sea salt / DMS scheme**
**gas phase chemistry**

**(longer term 2-3 years)**
**inorganic aerosol**
**full aerosol**

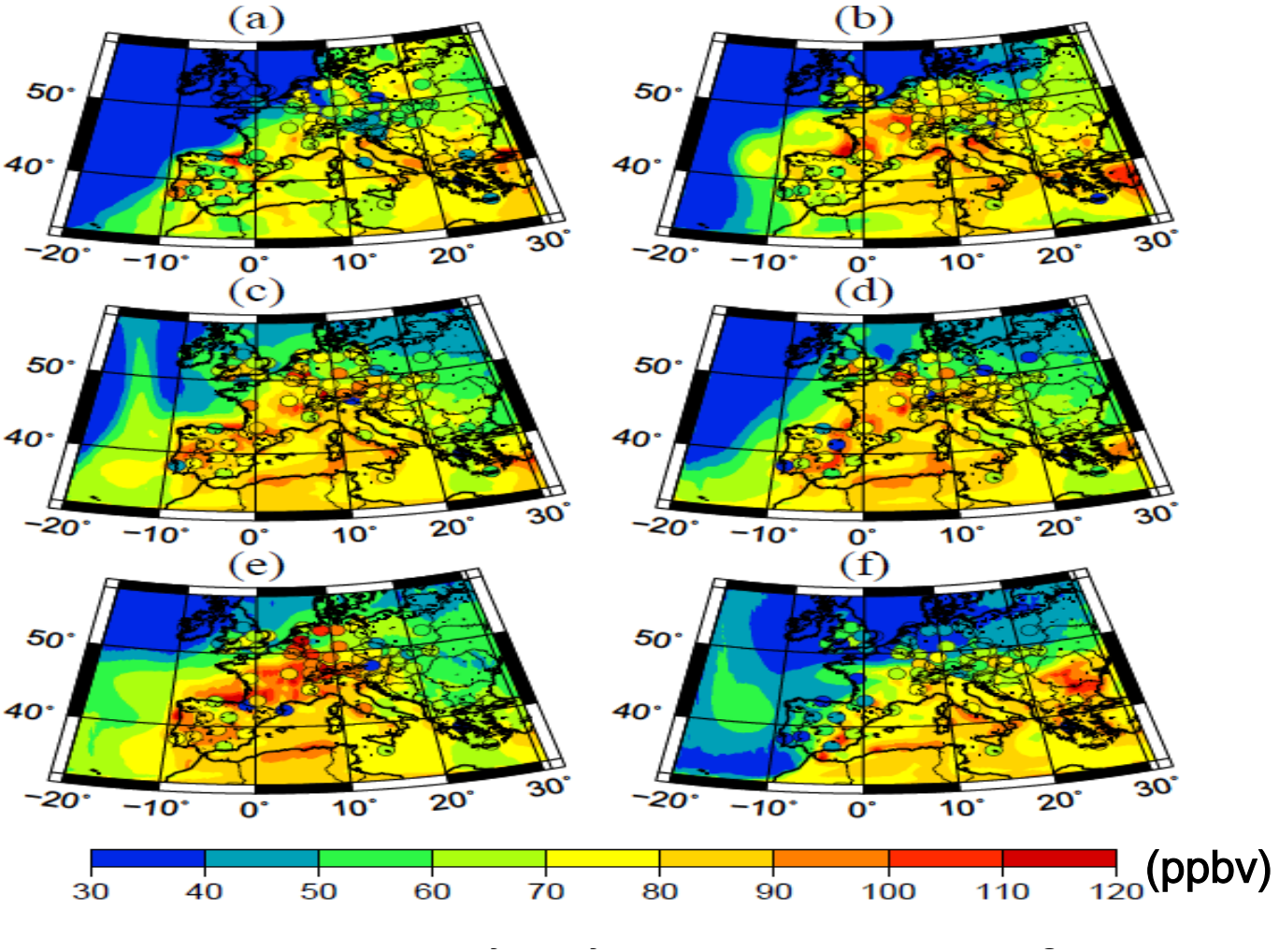
RegCM4

# On going developments in RegCM (relevant to charmex, hymex, medcordex)

- **On line Gas phase chemistry / ozone / improved inorganic aerosol / secondary organic aerosol**

**Simulation of the evolution of ozone concentration during Aug 2003 heat wave**

Each panel displays a concentration field in (ppbv) at 14 h UT.
(a) 1-August,
(b) 4-August,
(c) 8-August,
(d) 10-August,
(e) 12-August,
(f) 16-August.




- **Indirect effects**