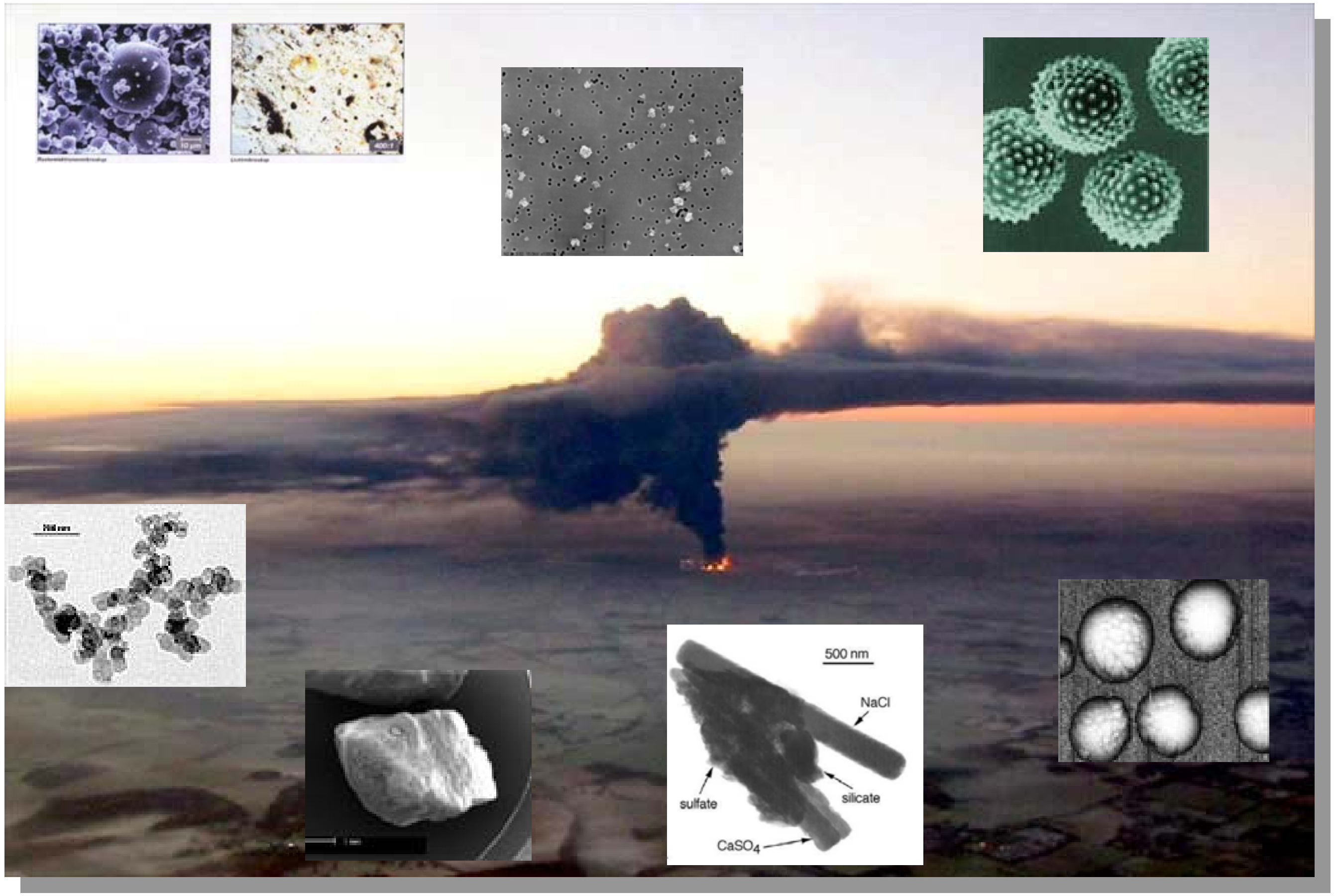
COSMO LM-ART

Aerosols and Reactive Trace Gases within LM



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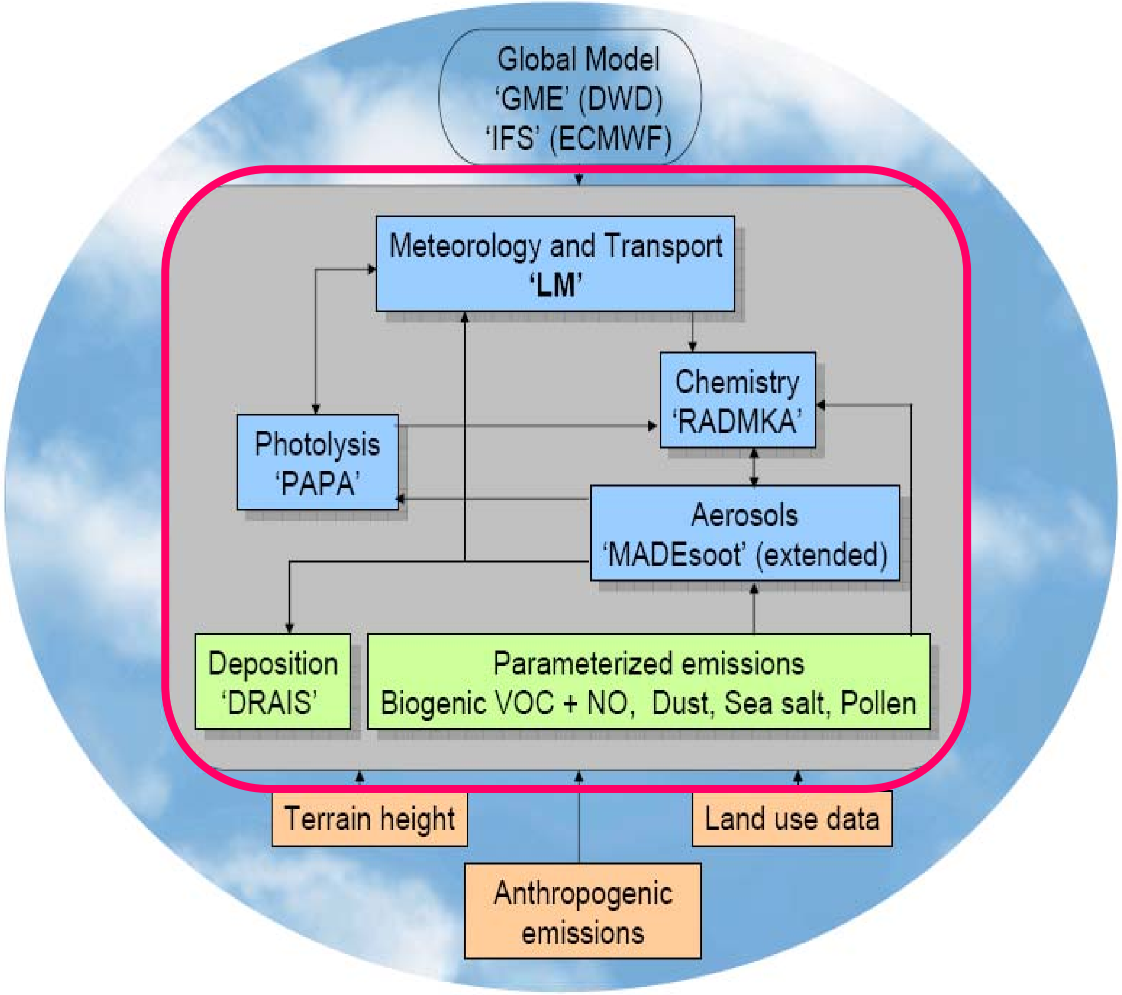
Questions

- **Interaction aerosol and regional climate (e.g. secondary circulations, mineral dust and monsoon)**
- **Interaction aerosol and gas phase**
- **Parameterization of both processes for global scale models**
- **Modelling of the visibility and AOD**
- **Dispersion of pollen**

COSMO LM – ART (ART = Aerosols and Reactive Trace Gases)



Concept:

LM-ART is online coupled.

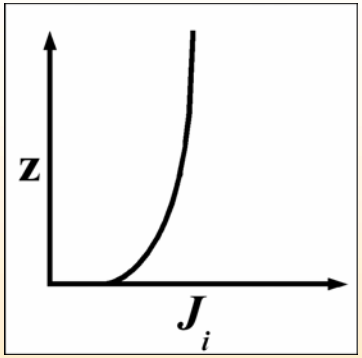
Identical methods are applied for all scalars as temperature, humidity, and concentrations of gases and aerosols to calculate the transport processes.

It has a modular structure.

Therefore LM-ART can easily be used in the forecast mode.

www-imk.fzk.de/tro/ACP/

Parameterizations of the Photolysis Frequencies

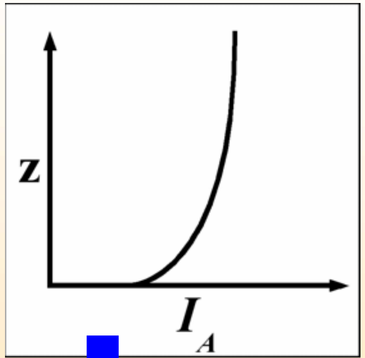


Pre - calculated profiles

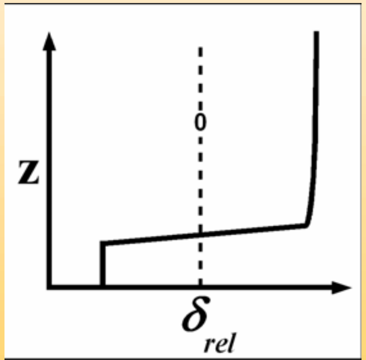
For identical conditions with

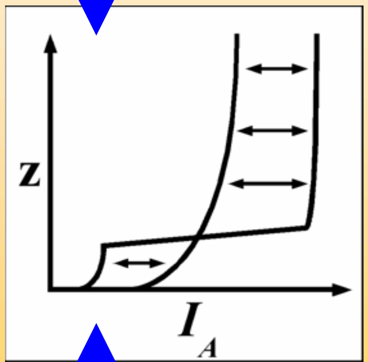
STAR and GRAALS (LM)

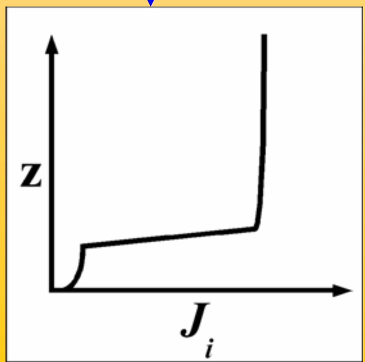
Cloud free, no aerosols, sea level



Wavelength dependent

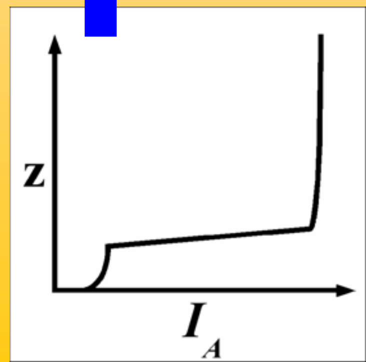






In LM-ART
Online coupled

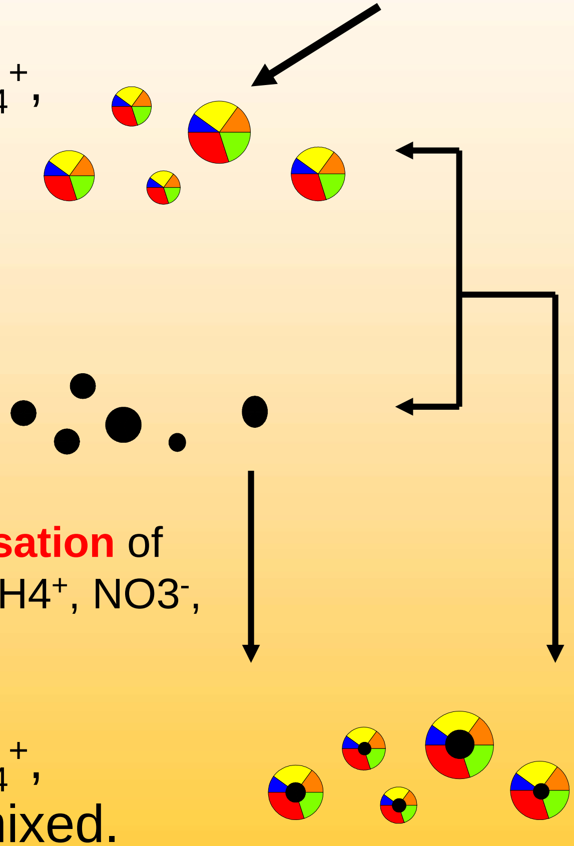
Accounts for
clouds, aerosol,
terrain height, albedo



Treatment of the Aerosol Particles

Interaction of five modes:

- **Two modes** for SO_4^{2-}, NO_3^-, NH_4^+, H_2O, SOA, internally mixed.
- **One mode** for pure soot.
- **Two modes** for SO_4^{2-}, NO_3^-, NH_4^+, H_2O, SOA, and soot internally mixed.



Three modes for **mineral dust** particles + **three** modes for **sea salt** particles **+ pollen**

Optical Properties of the Aerosols

Refractive index of aerosols

Mie Calculations

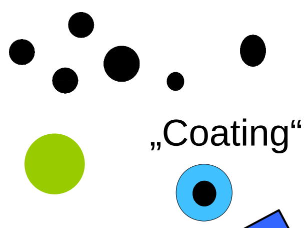
Single scattering albedo (ω), specific extinction coefficient (b), asymmetry parameter (g)

New Routine in LM-ART:

Computation of ω, b, g for prevailing aerosol concentration

Transport, Sedimentation, Deposition

LM-ART



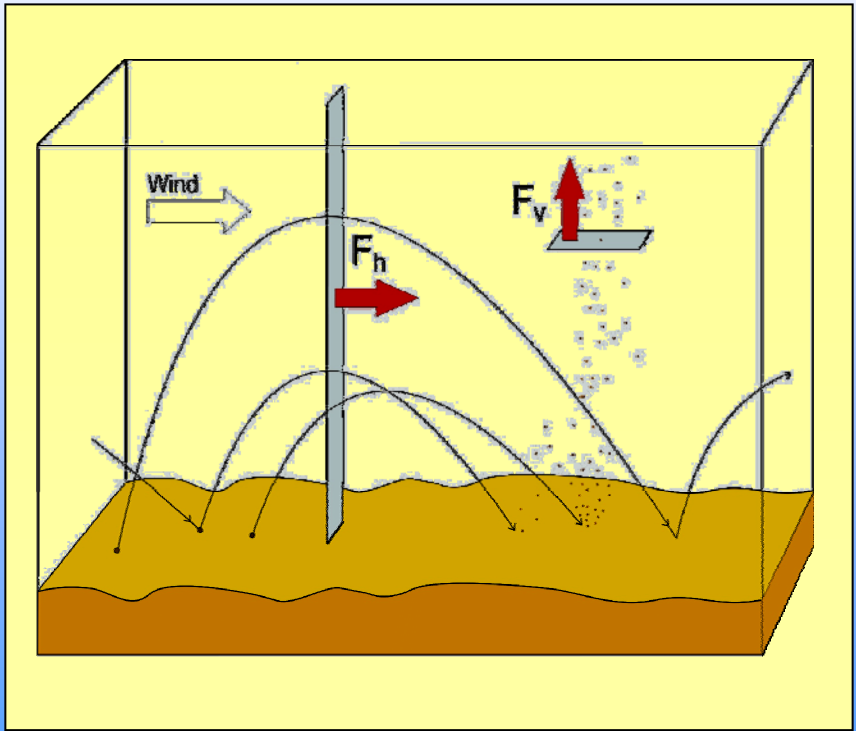
Size distribution, chemical composition of each mode

ω, b, g

Modified radiation in LM:

Substitution of climatological optical properties based on current aerosol concentrations

Parameterization of the Dust Emissions

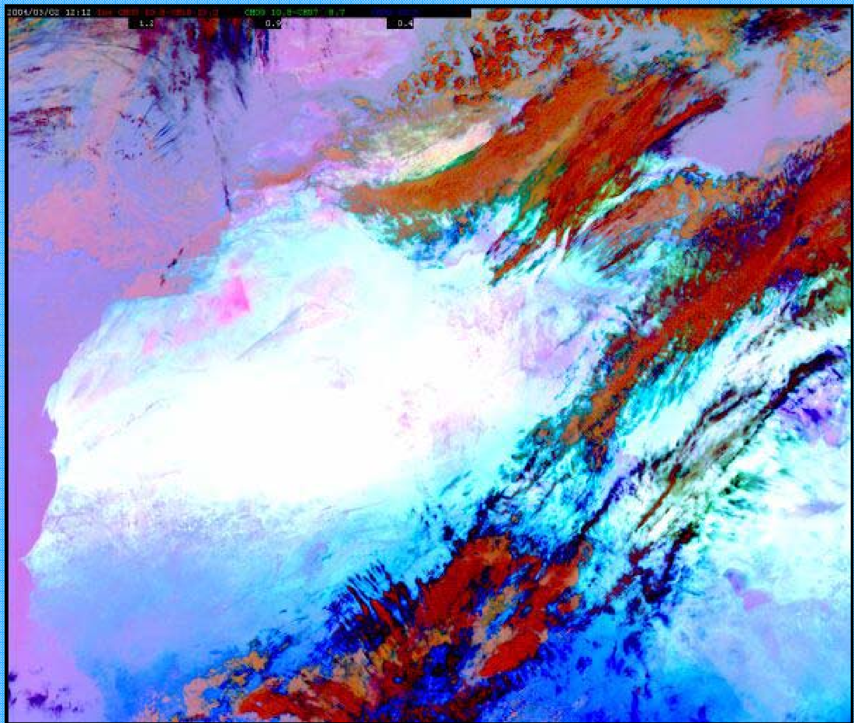


Parameterization of the horizontal and vertical saltation and emission flux (Vogel et al, 2006)

3 different Modes (d = 1.5, 6.7, 14.2 µm)

Log normal distributions

Case Study: Mineral dust over West Africa in March 2004



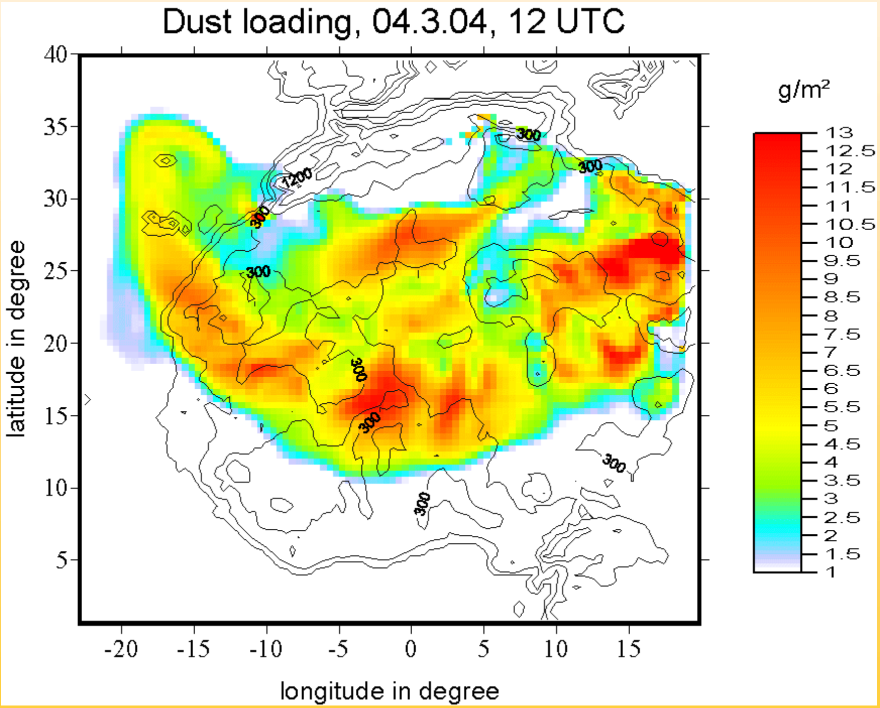
Meteosat-8 Image, 2. – 3. März 2004

Prevailing Situation:

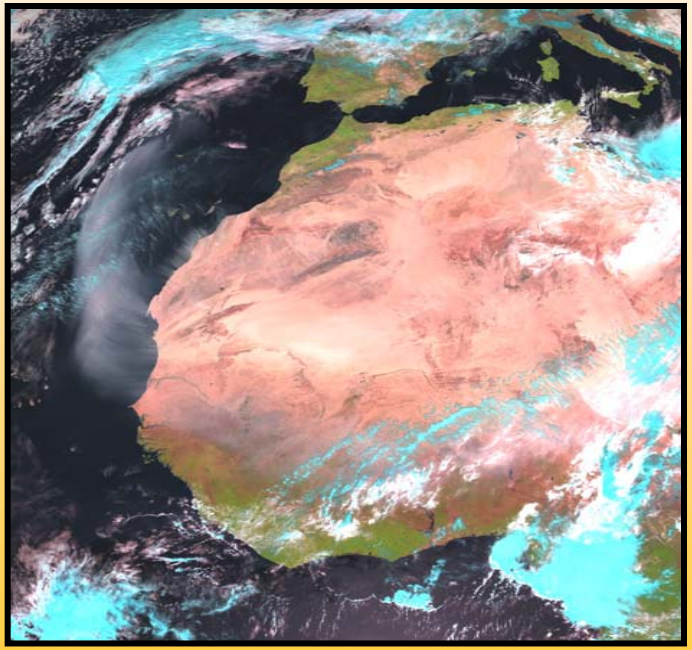
- Unusual
- Low temperatures and high wind speeds in the Sahara
- Heavy Precipitation in Libya
- After the mineral dust event ITC was shifted southwards

(Knippertz and Fink, 2006)

Case Study: Mineral dust over West Africa in March 2004



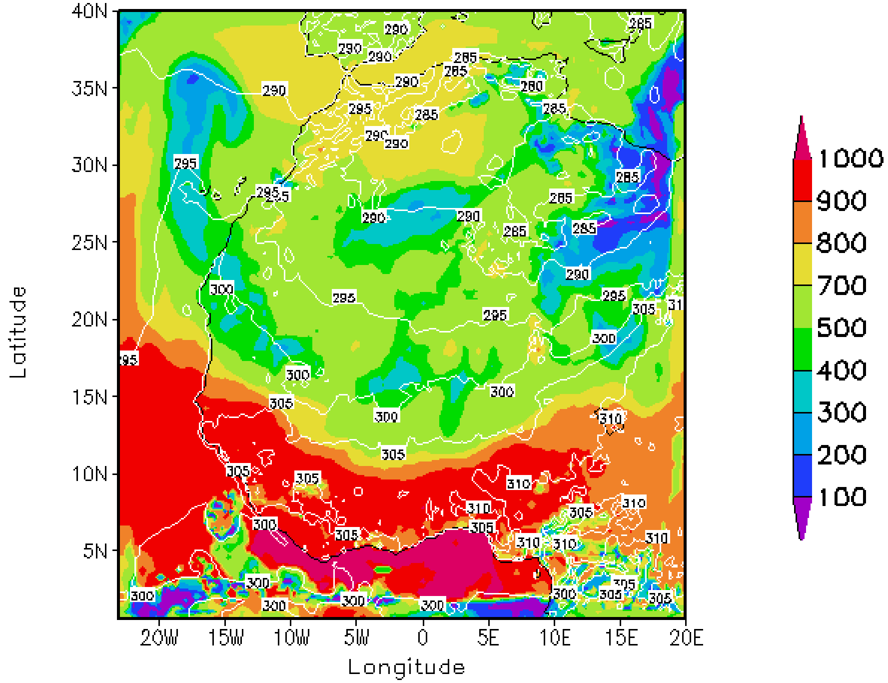
Modis, 04.03.2004, 12 UTC



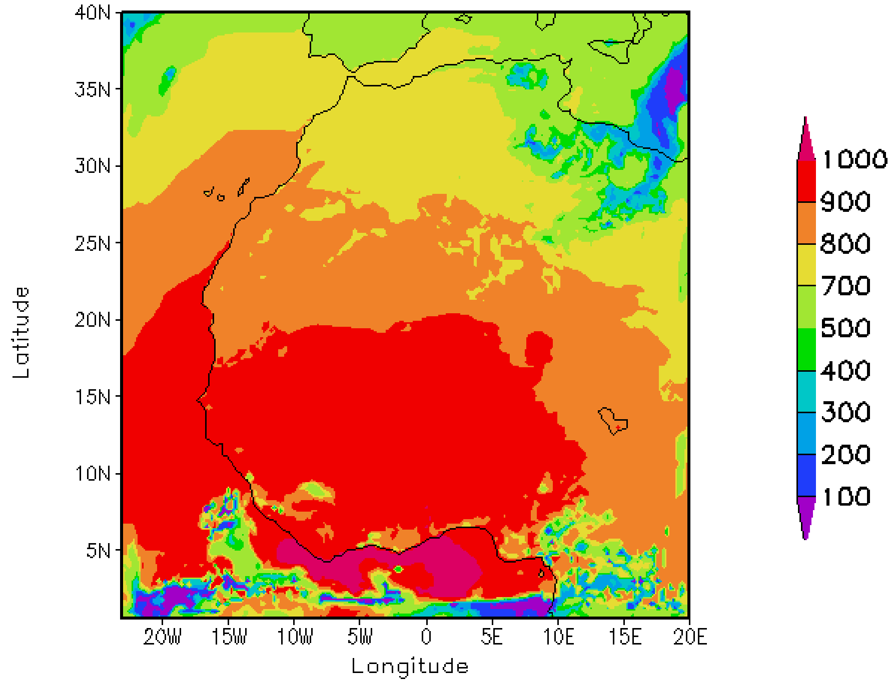
Interaction of Radiation and Mineral Dust

Shortwave radiation balance

with interaction



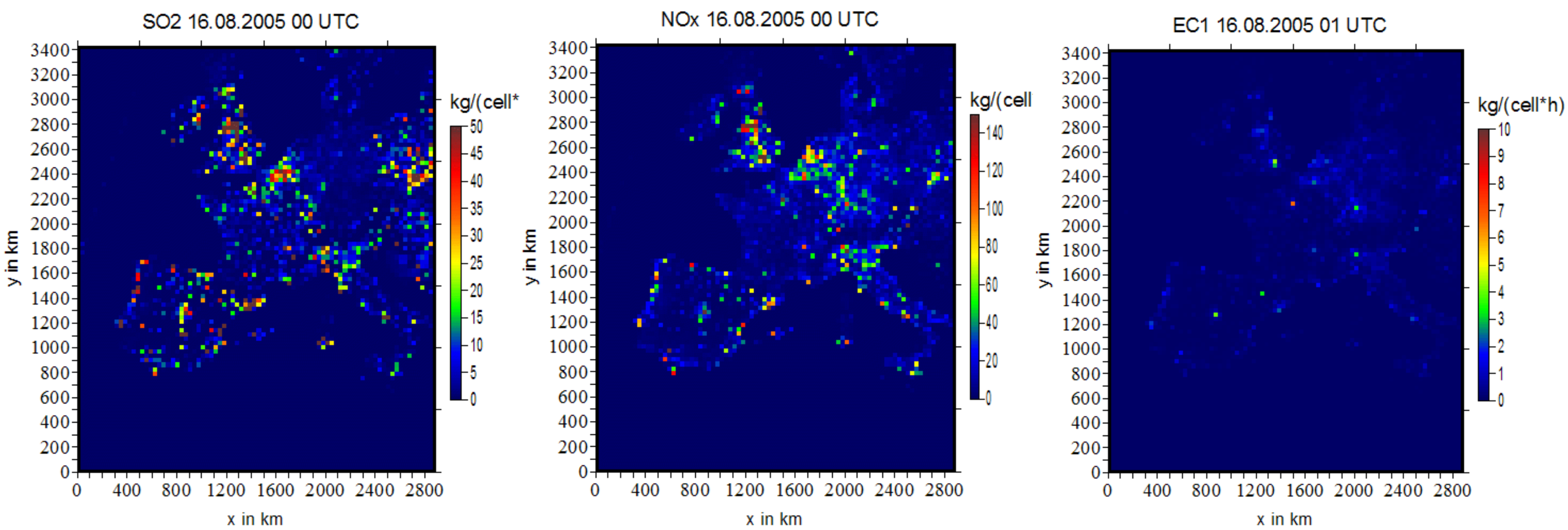
without interaction



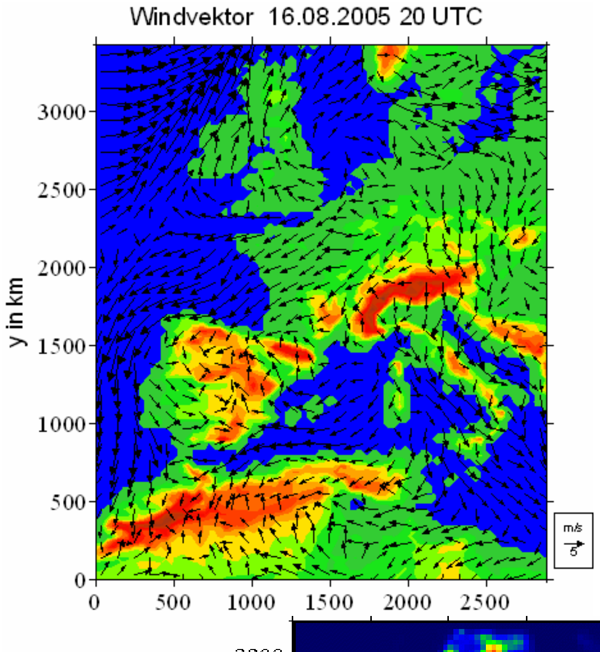
Emissions

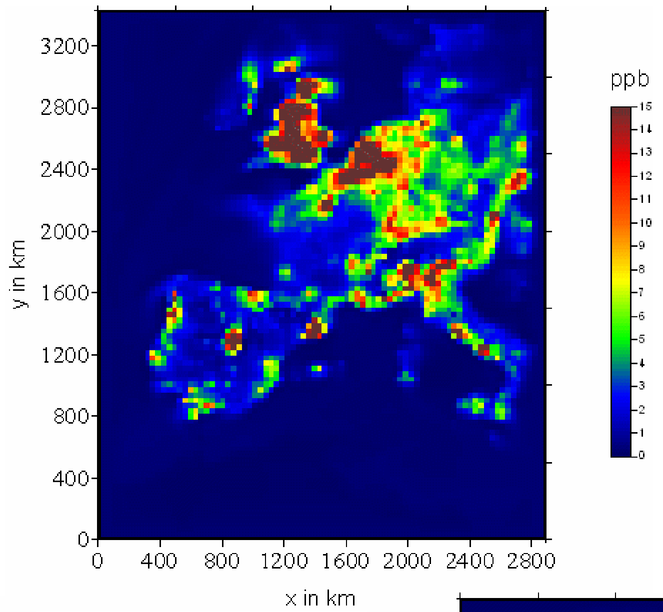
(Pregger et al., IER, Uni Stuttgart)

- **Discrimination of point and area sources.**
- **Temporal resolution 1h, spatial resolution 7km x 7km**
- **20 gas phase species (5 inorganic species, 15 VOC‘s)**
- **Primary particle emissions as EC and PM (1, 2.5, 10 μm)**
- **Biogenic emissions calculated online**



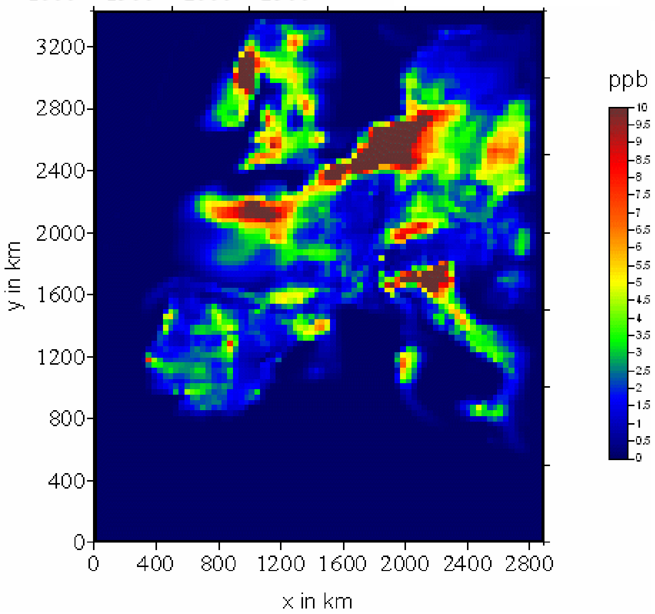
Trace Gases and Aerosols over Europe



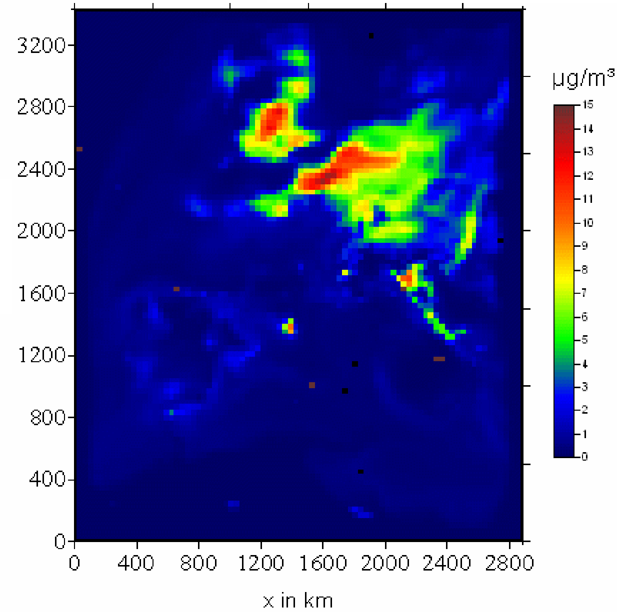


NO_2

NH_3



Dry aerosol mass



Anthropogenic Aerosol Radiation Interaction

Simulation period:

16.08.05 - 22.08.05

Simulation domain:

Southwest Germany + adjacent areas

Horizontal Resolution 7km x 7km

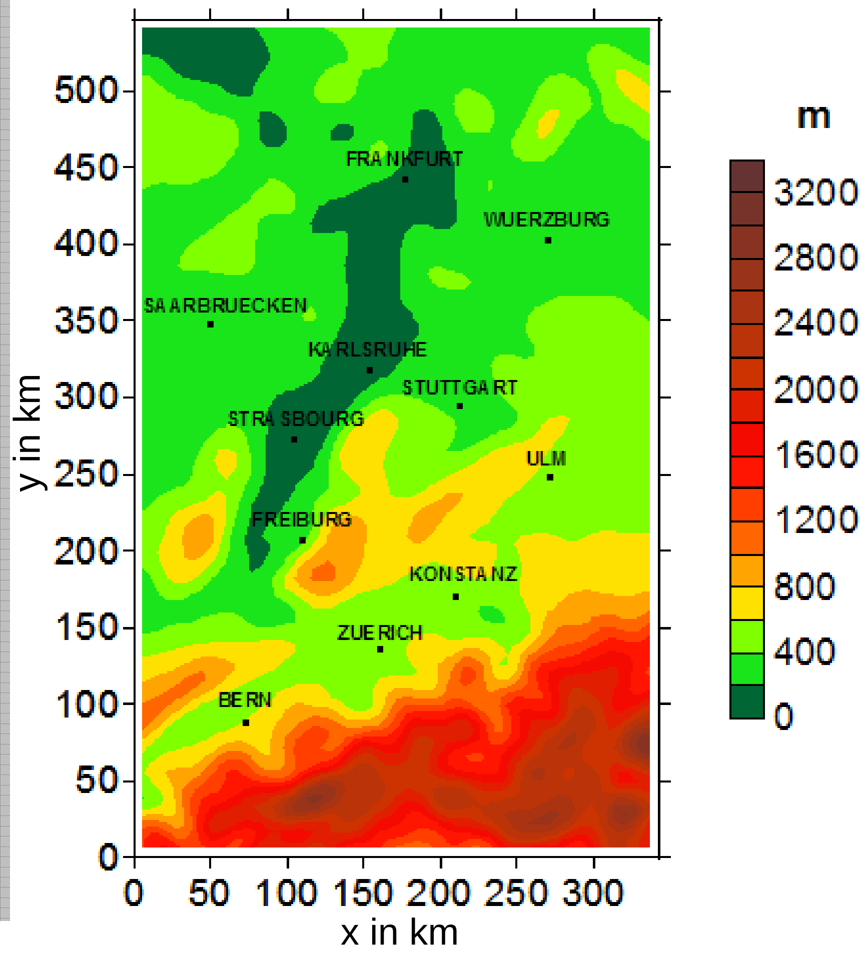
Input data:

- Meteorology: GME Reanalysis (DWD)
- Emission data (IER,Stuttgart)
- Land use (JRC-IES,Ispra)

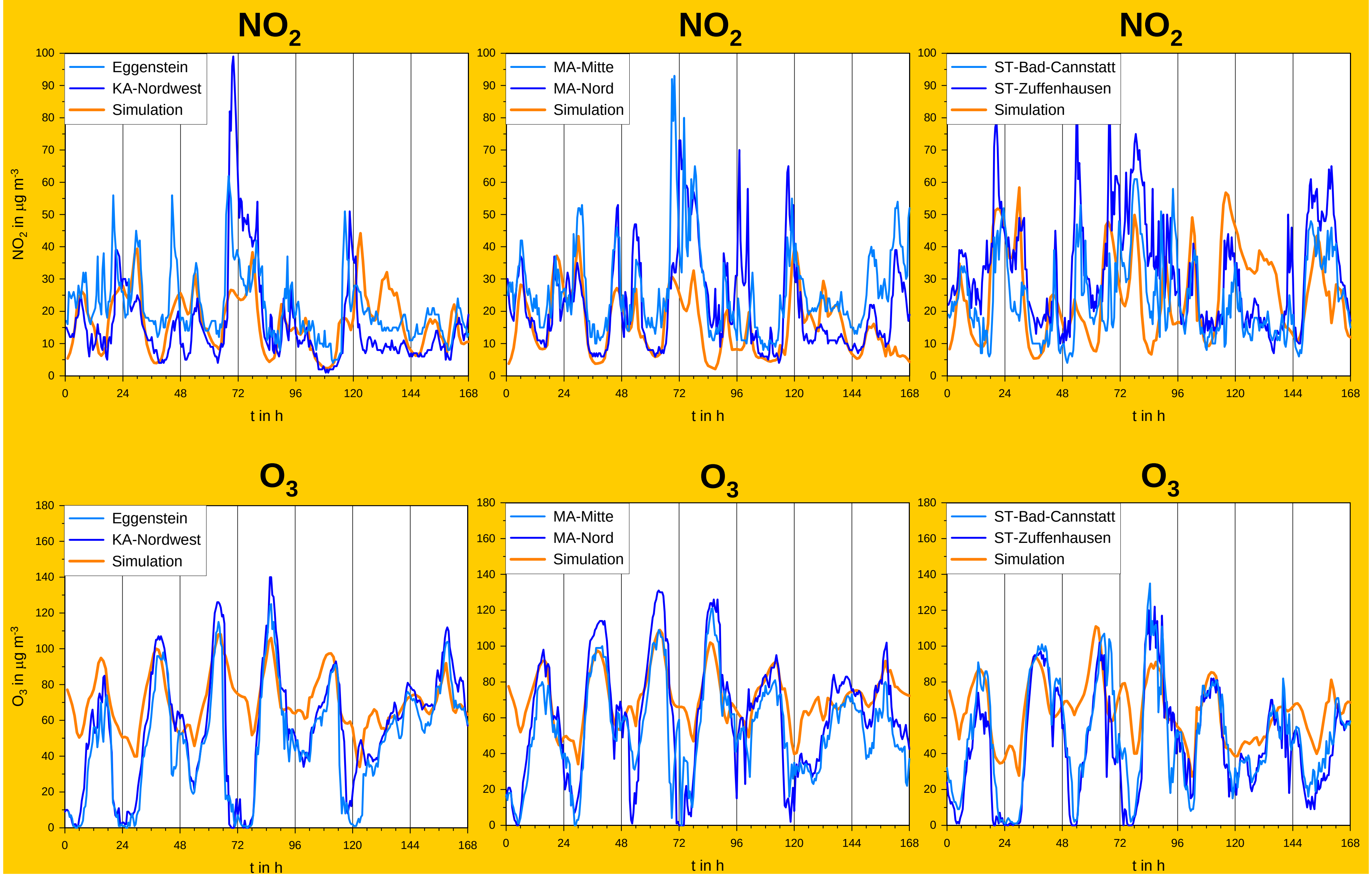
Run A: with aerosol radiation interaction.

Run B: without aerosol radiation interaction

Model domain

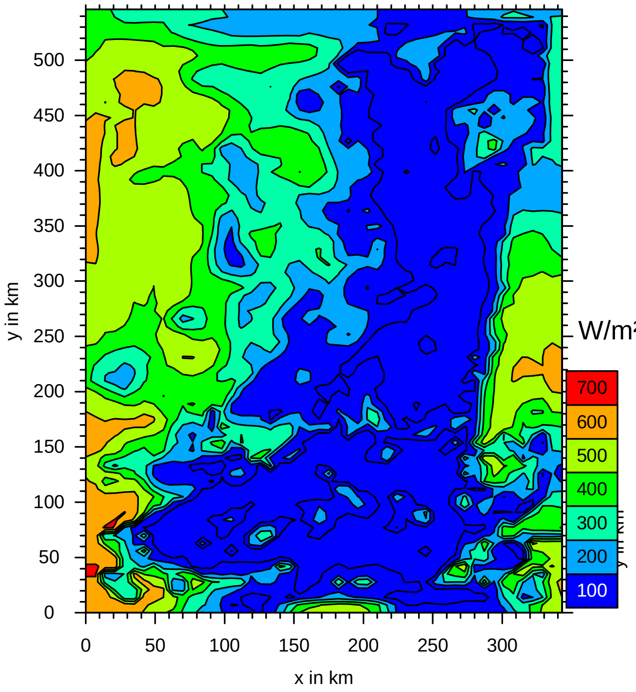


Comparison with Measurements (16.08. – 22.08.2005)



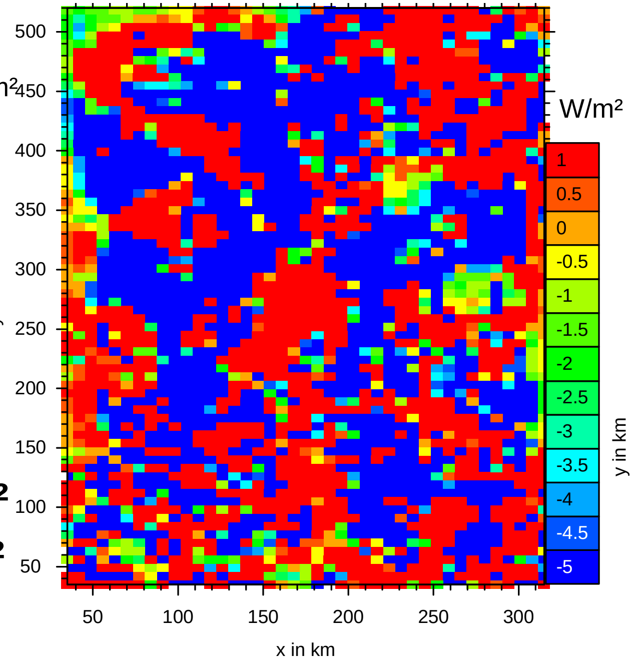
Direct Aerosol Effect on Radiation and Temperature (20.08.2005 12 UTC)

Shortwave radiation balance



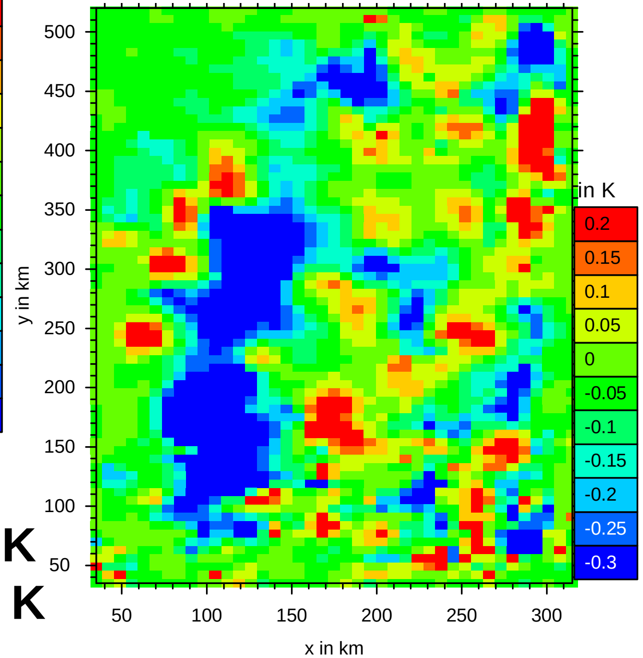
Min: -342.6 Wm^{-2}
Max: +349.5 Wm^{-2}

Difference of the shortwave radiation balance (Run A – Run B)



Min: -1.23 K
Max: +0.85 K

ΔT (Run A – Run B)



Parameterization of the Source Function of Pollen Emission

$$F_p = c_p \cdot \frac{q_p}{LAI \cdot h} \cdot u_* \cdot K_e$$

F_p:	**flux of pollen grains**
c_p:	**plant specific factor**
q_p:	**total pollen number of a season per m^{-2}**
LAI:	**leaf area index**
h:	**canopy height**
u_*:	**friction velocity**
K_e:	**meteorological correction factor**

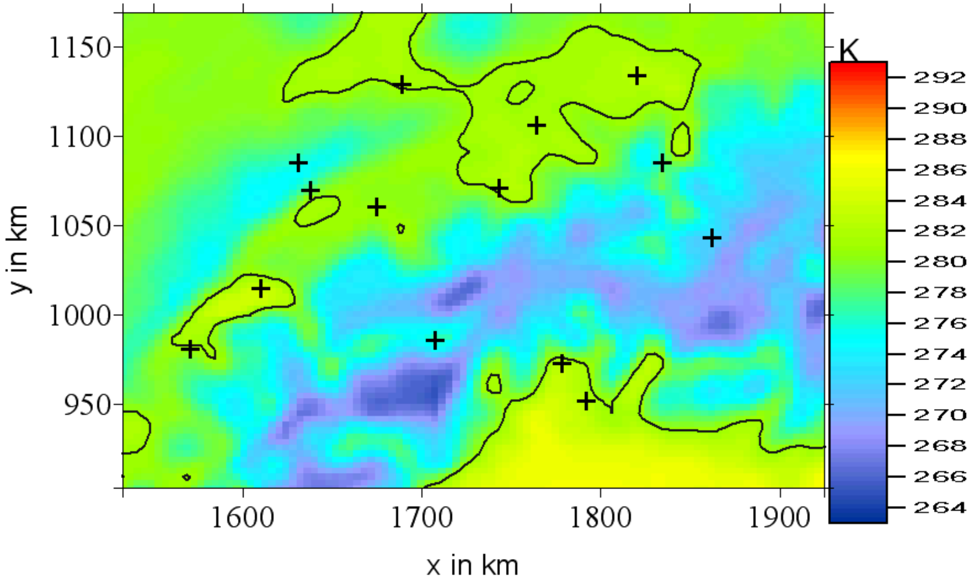
Helbig et al., 2004

Birch Pollen Episode in Switzerland

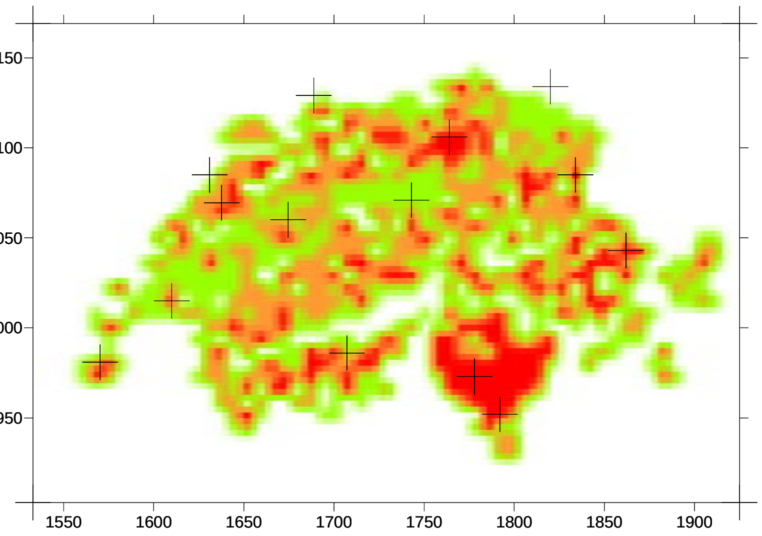
In collaboration with A. Pauling, Meteoswiss

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera

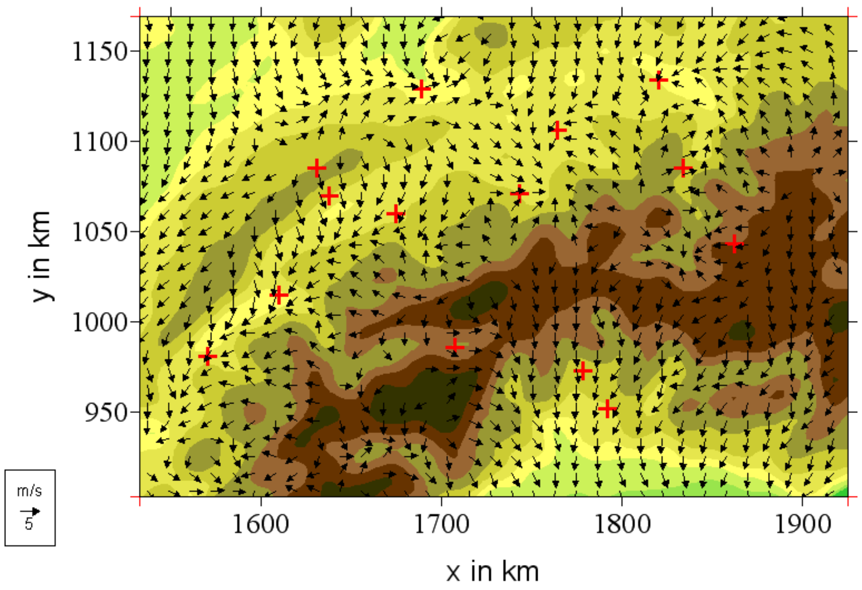
Temperature, 19.04.2006, 01 UTC



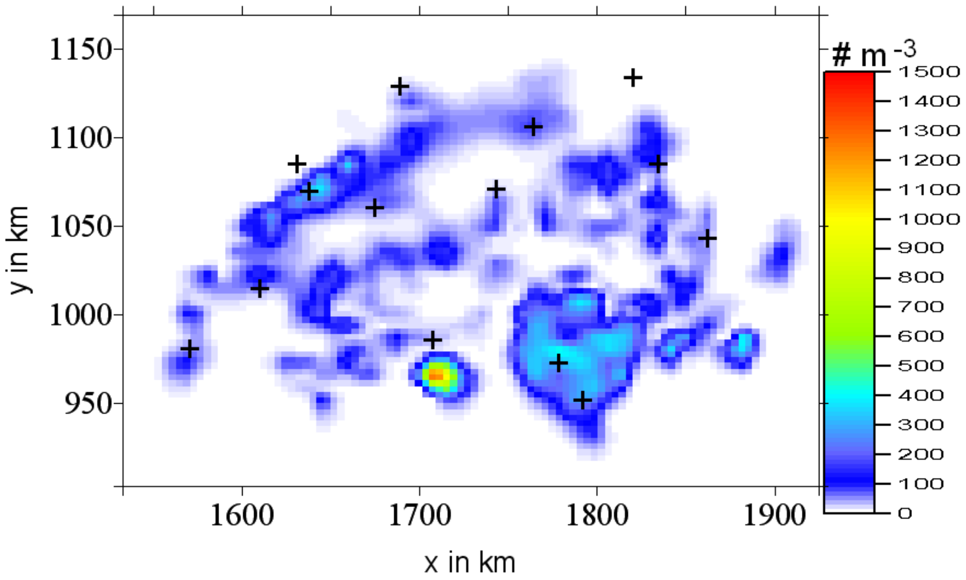
Birches



Wind , 19.04.2006, 01 UTC

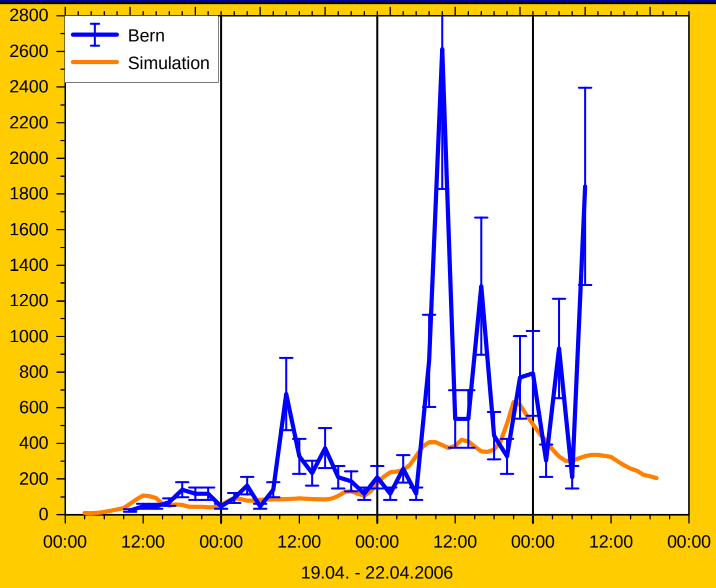


Pollen, 19.04.2006, 01 UTC

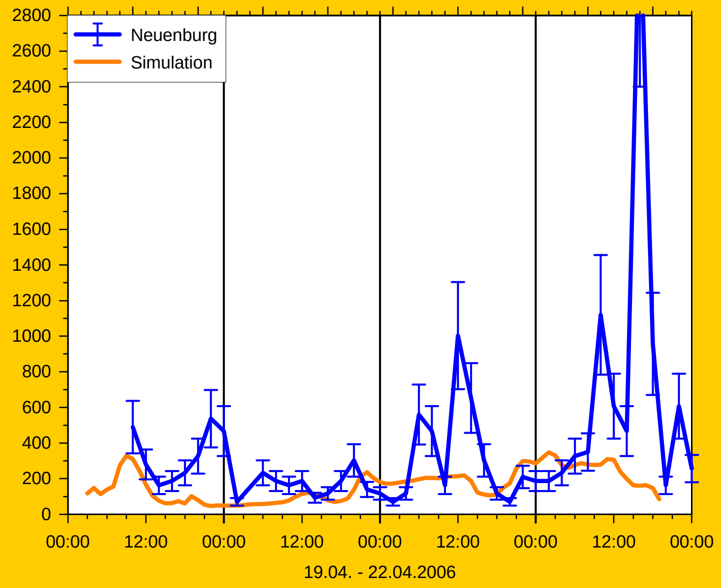


Comparison with Measurements

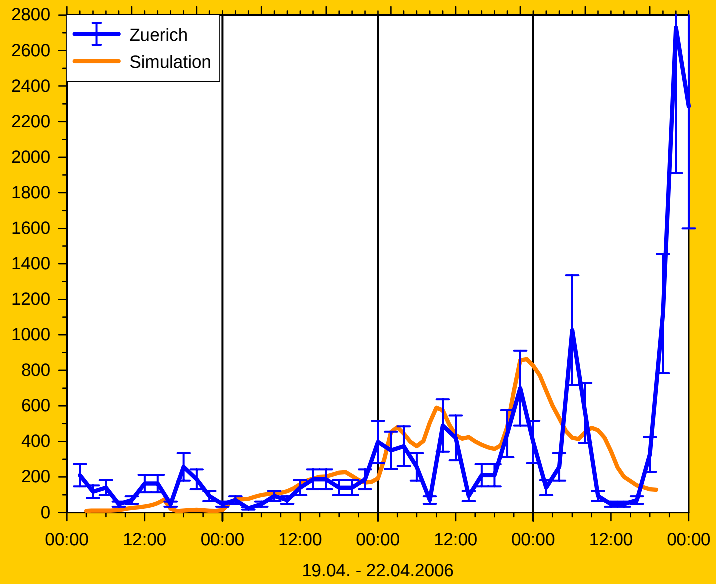
Bern



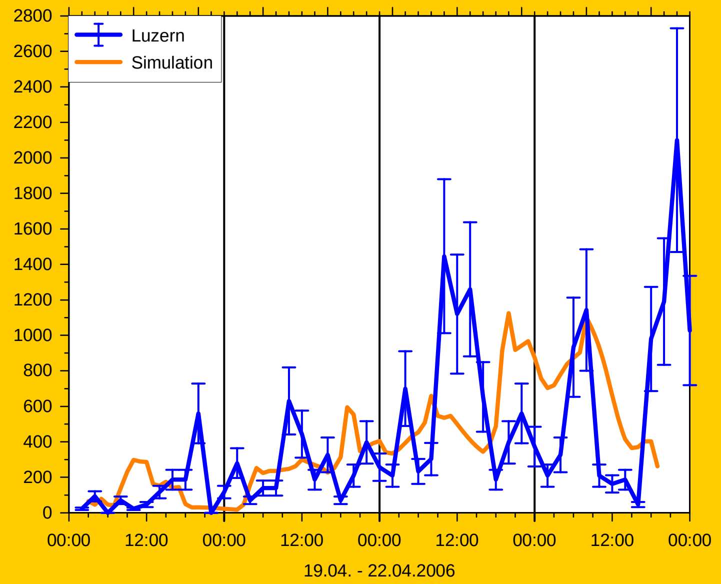
Neuen-burg



Zürich



Luzern



Summary

- **LM-ART contains a variety of natural and anthropogenic aerosol particles.**
  This includes an explicit treatment of the soot ageing. The treatment of their impact on the atmospheric radiation allows the quantification of feedback mechanisms.

- **Dust-radiation-interaction in LM-ART:**
  Strong influence on radiation balance and consequently on the dynamics

- **Anthropogenic aerosol-radiation-interaction in LM-ART:**
  Very low aerosol loads cause changes in shortwave radiation balance at the ground of reasonable sign and order.
  Surprisingly strong effect on cloud pattern (semi-indirect effect) was found.

- Pollen dispersion is also included. This allows an operational pollen forecast with **LM-ART** in the near future.

COSMO LM – ART (ART=Aerosols and Reactive Trace Gases)

Gas phase chemistry: 58 transported variables,
Aerosol: 77 transported variables

Nesting option is currently realized in collaboration with U. Schättler

Future Developents:

Interaction of aerosols and clouds

Wet phase chemistry

Aerosols and Climate Processes

Aerosols have an impact on human health,

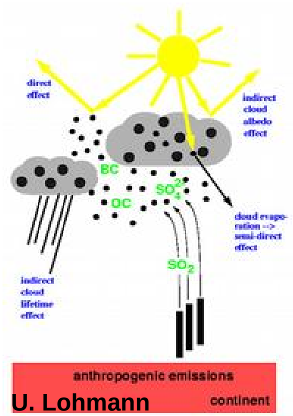
BUT they have also an impact on climate (and weather).

by:

modifying the atmospheric radiation (direct effect),

modifying cloud formation (indirect effect),

and mixtures of both.



AND:

They are changing the chemical composition of the atmosphere.

Emissions of Sea Salt Particles

- **Mårtensson *et al.* [2003]:** $$\frac{dF_0}{d\log D_p} = \Phi \cdot 3.84 \cdot 10^{-6} \cdot \underline{U_{10}^{3.41}} \quad , \Phi = \Phi(\underline{T_w}, D_p)$$

- **Monahan *et al.* [1986]:** $$\frac{dF_0}{dr_{80}} = 1.373\ \underline{U_{10}^{3.41}}\ r_{80}^{-3} \left(1 + 0.057\, r_{80}^{1.05}\right) \cdot 10^{1.19 e^{-B^2}}$$

- **Smith *et al.* [1993]:** $$\frac{dF_0}{dr_{80}} = \sum_{i=1,2} A_i \exp\left(-f_i \left(\ln \frac{r_{80}}{r_{0i}}\right)^2\right), \qquad A_i = A_i(\underline{U_{10}})$$

Lewis and Schwartz [2005]: $$r_{RH} = (r_d)\left(\frac{4.0}{3.7}\right)\left(\frac{2.0 - RH}{1 - RH}\right)^{\frac{1}{3}}$$

Wind and Number Density