

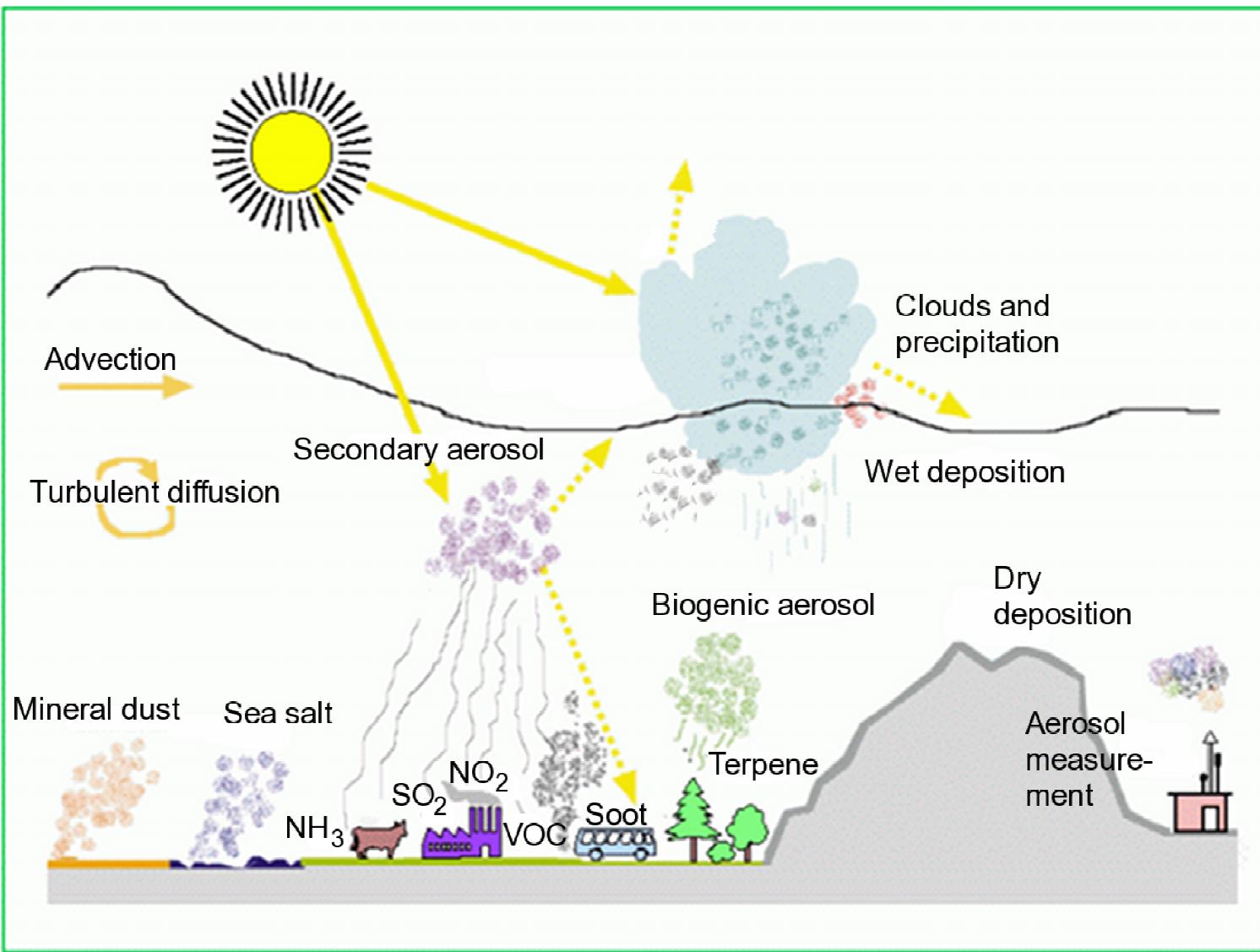
COSMO-ART

Status - Development - Application

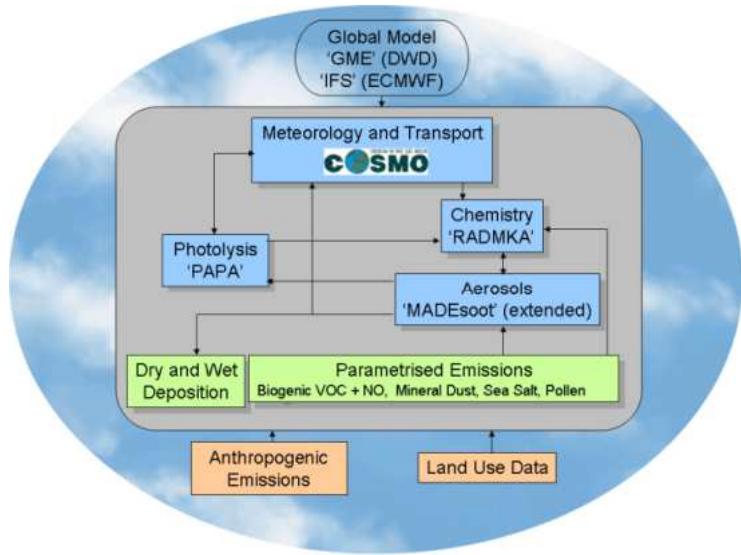
Aerosols and Climate Processes, Institute for Meteorology and Climate Research - Troposphere



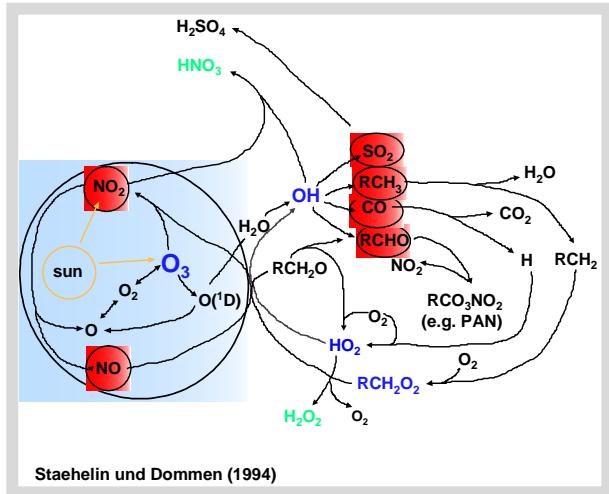
Sources, Sinks and Processes



The Model System COSMO-ART

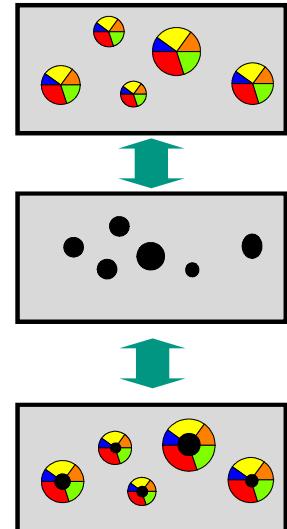


Gas phase chemistry



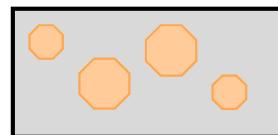
Interactive modes

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



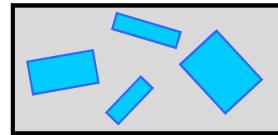
Mineral dust modes

- Three modes



Sea salt modes

- Three modes,
 $\text{Na}^+, \text{Cl}^-, \text{SO}_4^{2-}, \text{H}_2\text{O}$



+ volcanic ash and pollen

Gaseous and particulate compounds

Gas phase chemistry: **~70 transported variables**

including SO_2 , NO_x , O_3 , DMS,

individual organic compounds, halogen species

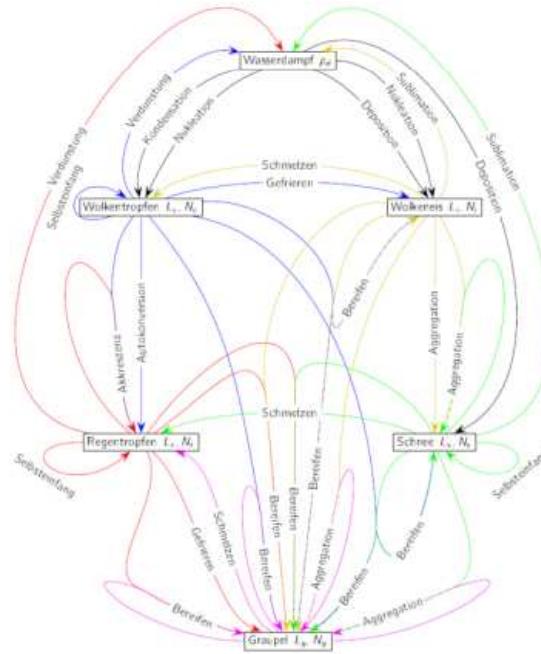
Aerosol: **~80 transported variables**

Two Moment cloud microphysics (Seifert and Beheng, 2006)

- number and mass concentration of all hydrometeors

Six hydrometeor classes

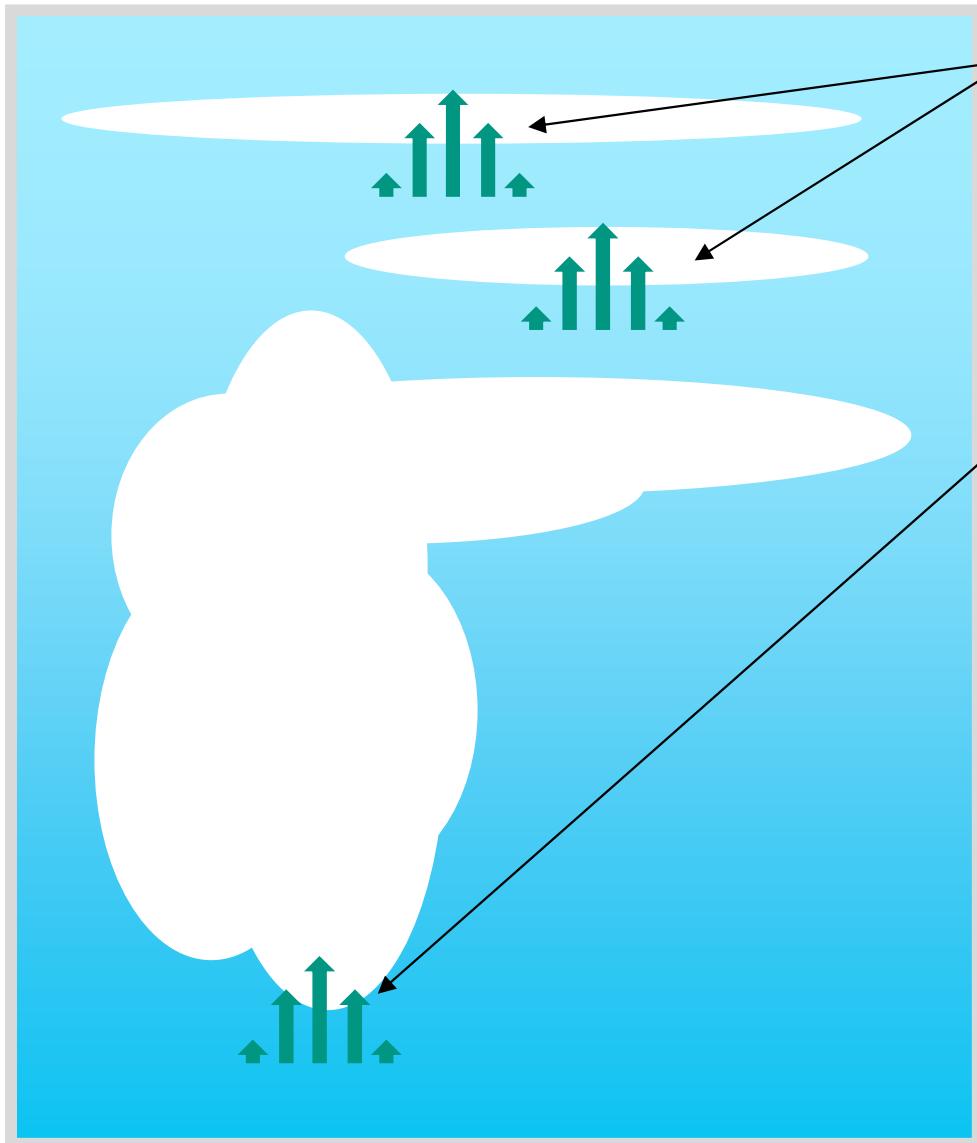
- water droplets
- ice crystals
- rain droplets
- snow flakes
- graupel
- Hail



Parameterization of cloud optical properties

- function of cloud droplet and ice crystal number concentration
- long and short wave (Hu & Stamnes 1993, Edwards et al. 2007)

Aerosol-Cloud-Coupling in COSMO-ART



Ice Nucleation

(Barahona and Nenes 2009)

- competition of heterogeneous freezing involving dust with homogenous freezing of droplets

Aerosol Activation

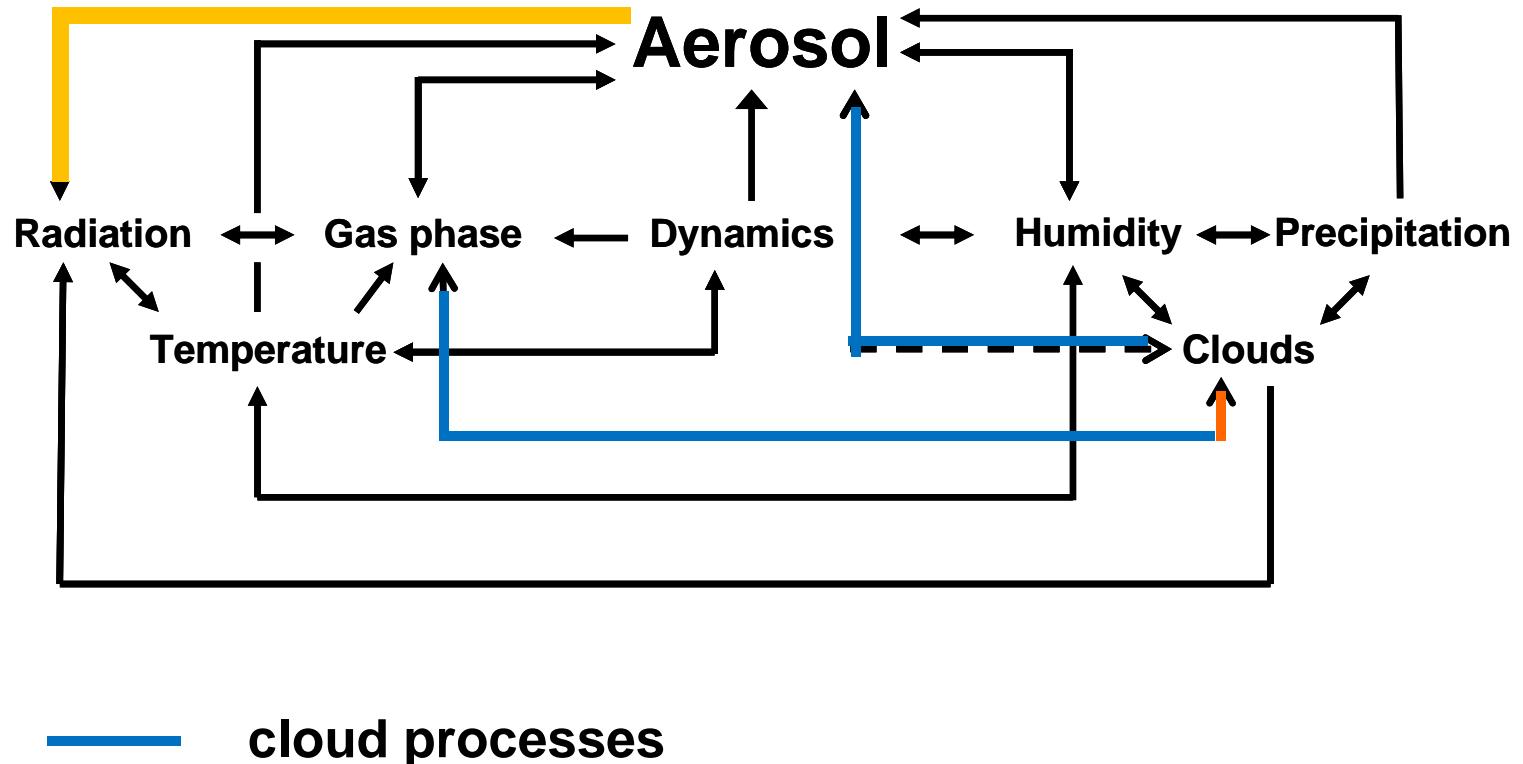
(Kumar et al. 2009, Barahona et al. 2010)

- adsorption activation of dust particles
- competition of the different aerosol particles for water vapor
- considering all simulated aerosol properties

Distribution of subgridscale updrafts

- mean = grid scale updraft
- standard deviation = \sqrt{TKE}

Feedback processes realized in COSMO-ART



Projects:

Eleni Athanasopoulou: Secondary organic aerosol

Andrew Ferrone (REKLIM): **CLM-ART**

Kristina Lundgren: Traffic, air quality and atmospheric processes
Climate engineering

PhD:

Max Bangert: Aerosol cloud interactions

Diploma Thesis:

Isabel Kraut: Halogen chemistry

Alexandra Wintzen: Volcanic ash vs. other aerosol

Seminar Thesis:

Daniel Rieger: Biomass burning aerosol

Tobias Schad: Volcanic ash dispersion

Kristina Stammberger: Mineral dust UAE

Silke Vogelbacher: Pollen dispersion

COSMO-ART outside of IMK-TRO

P. Suppan (IMK-IFU): Simulations for China

C. Hoose (IMK-AAF): Pollen as IN

R. Ruhnke (IMK-ASF): Troposphere-Stratosphere Exchange

Ch. Knote (EMPA): Alternative wet phase chemistry, Validation

Rosshydromet (Russia): Air quality above Moscow

NCMS (UAE): Dust storm forecast

A. Nenes (Georgia Tec): Dust and cloud formation

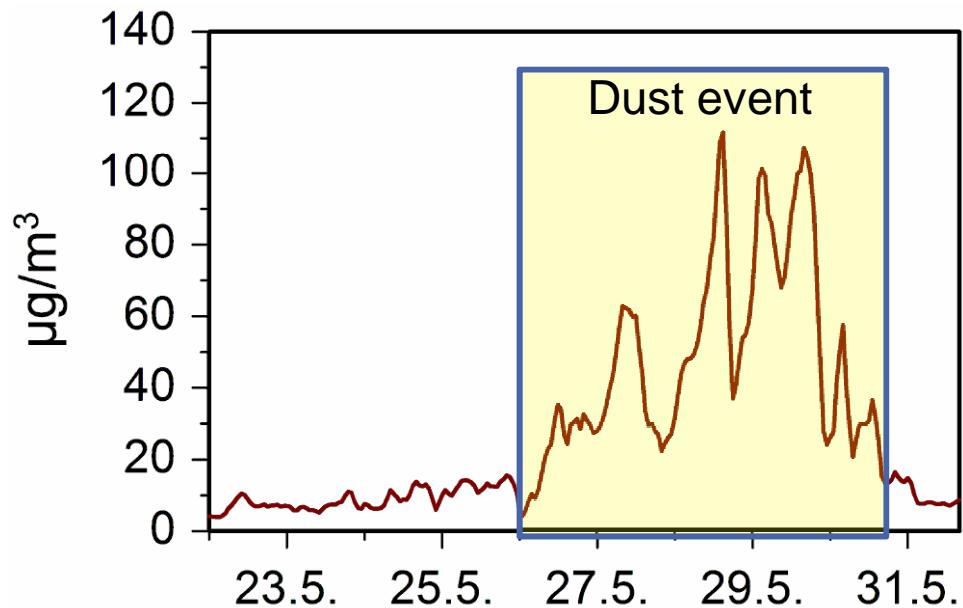
S. Pandis (Carnegie Mellon): Soot impact on regional climate

Meteoswiss: Operational pollen forecast

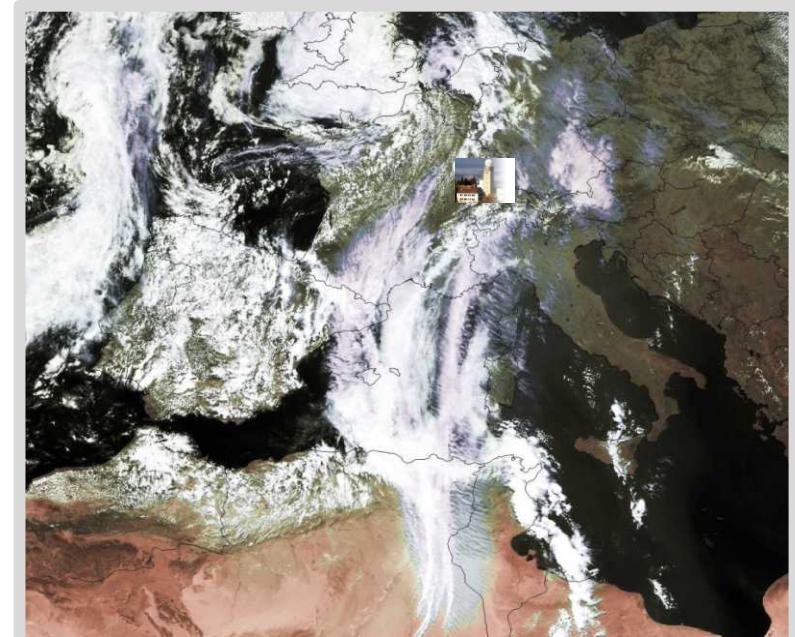
DWD: Operational forecast of pollen, mineral dust and volcanic ash

POMPA: Acceleration of CLM and COSMO-ART on GPUs

New users: Greek weather service; Weather service of Romania



Observed aerosol mass concentration at Hohenpeissenberg
(Data: H. Flentje, DWD)



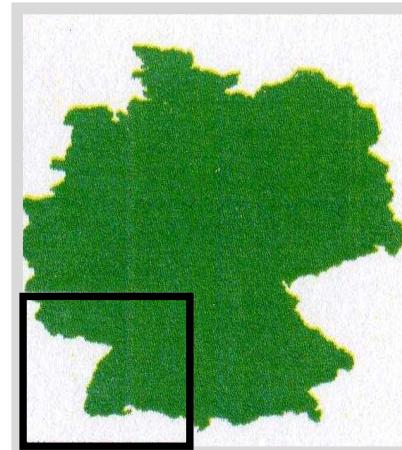
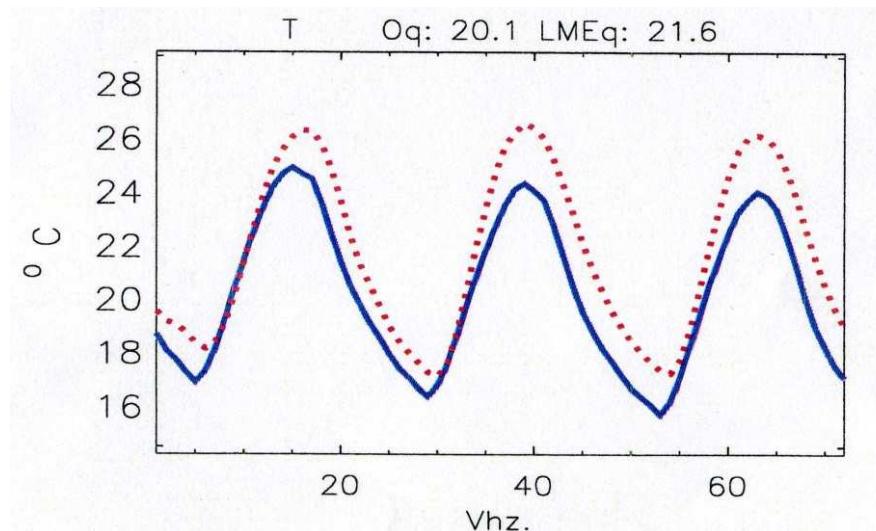
Meteosat picture, 28 May, 2008, 12:00 UTC



May 2008

- A positive temperature bias was detected in the operational weather forecast by the DWD during the dust event.

26.05.2008 – 30.05.2008

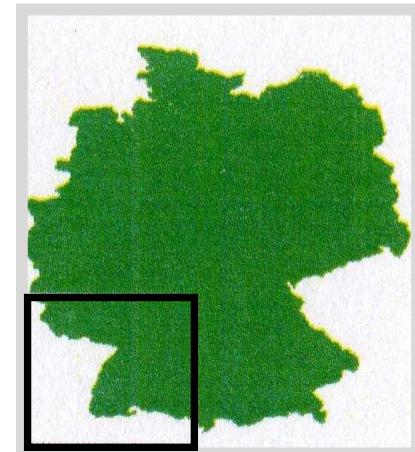
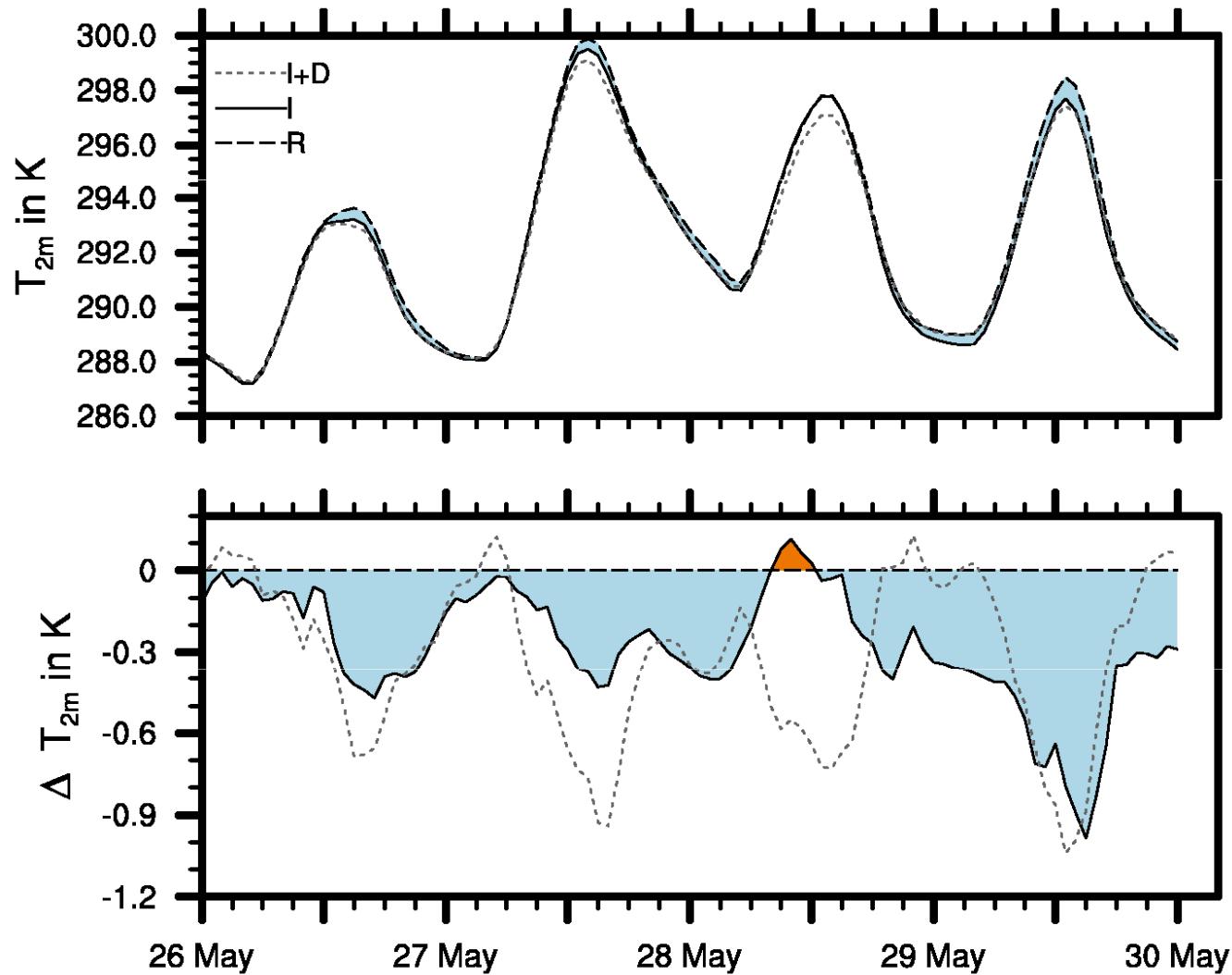


Observed (blue line) and predicted (dotted red line)
 2m-temperatures for SW-Germany (Data: U. Damrath, DWD)

Can the bias be explained by the interaction of dust with the atmosphere?

2-m Temperatures

Average over SW-Germany





Courtesy to modelling group at MeteoSwiss

COSMO-7 Analysis for: Sun 3 Apr 2011 00 UTC

Version: opr 7km (897)

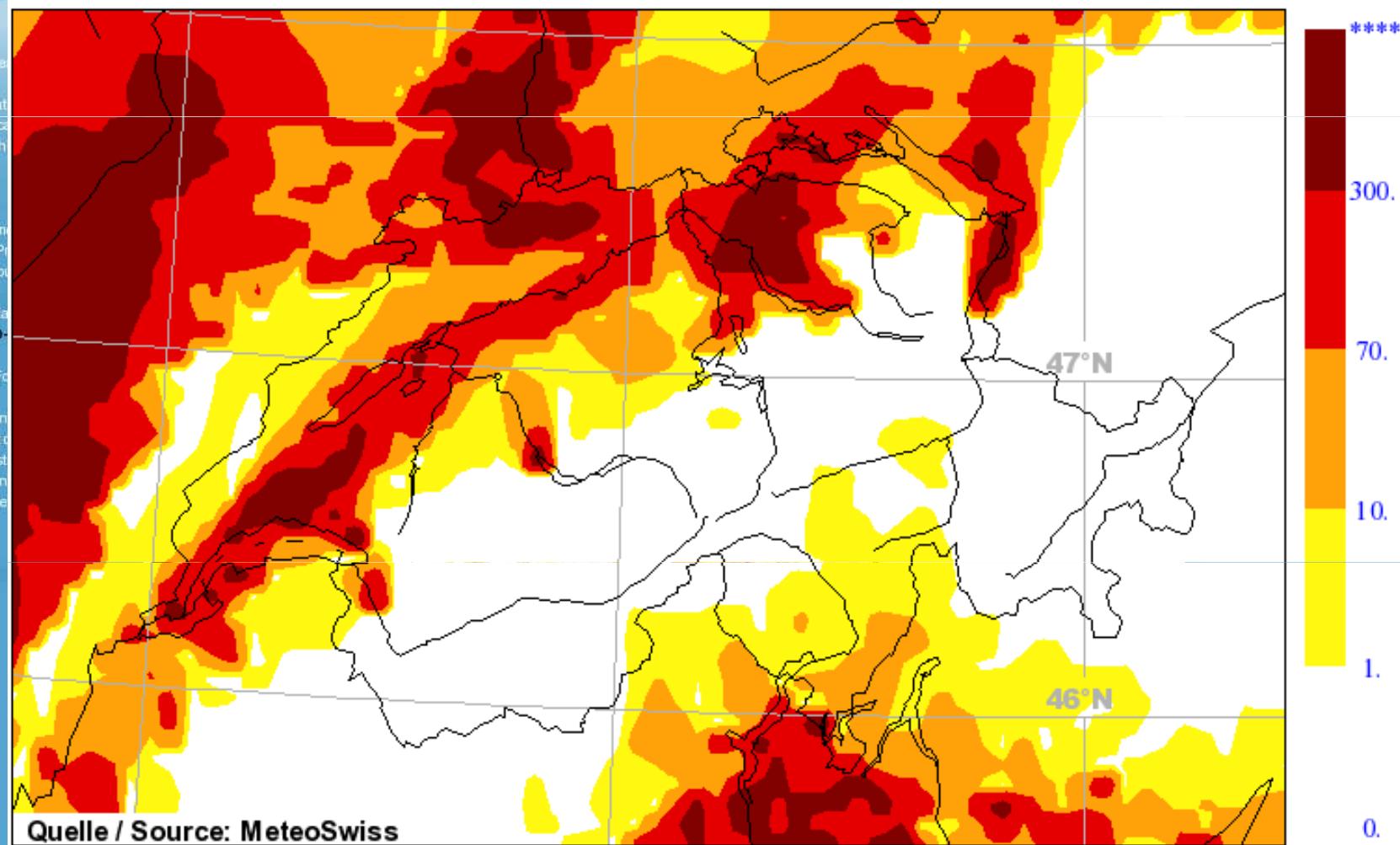
Birch Pollen Concentration

Maximum: 1534.3m-3

Run: 03.04.2011 00UTC+0h

... Weather

- Overview: Weather
- General situation
- Detailed forecast
- Current weather
- Ozone layer
- ↓ Health
 - ↓ Pollen
 - Pollen map
 - Pollen-Profile
 - Background
 - Links
 - Ambrosia
 - ... COSMO-ART
- Heat
- UV Index Forecast
- Ozone
- Meteoroswiss
- Developments
- Model forecast
- Weather events
- Weather review



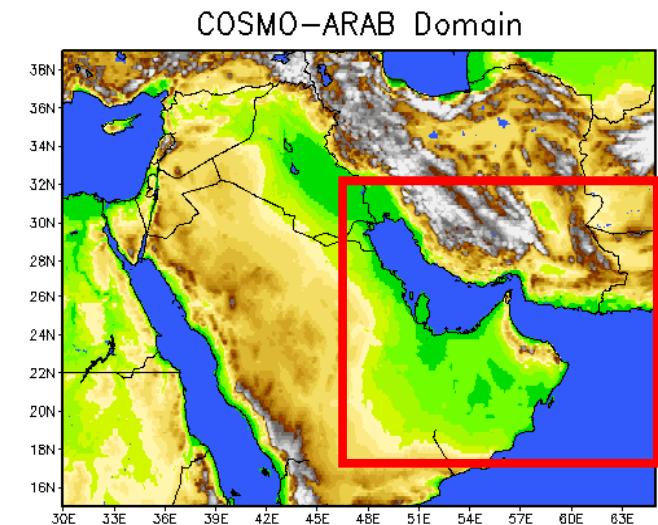
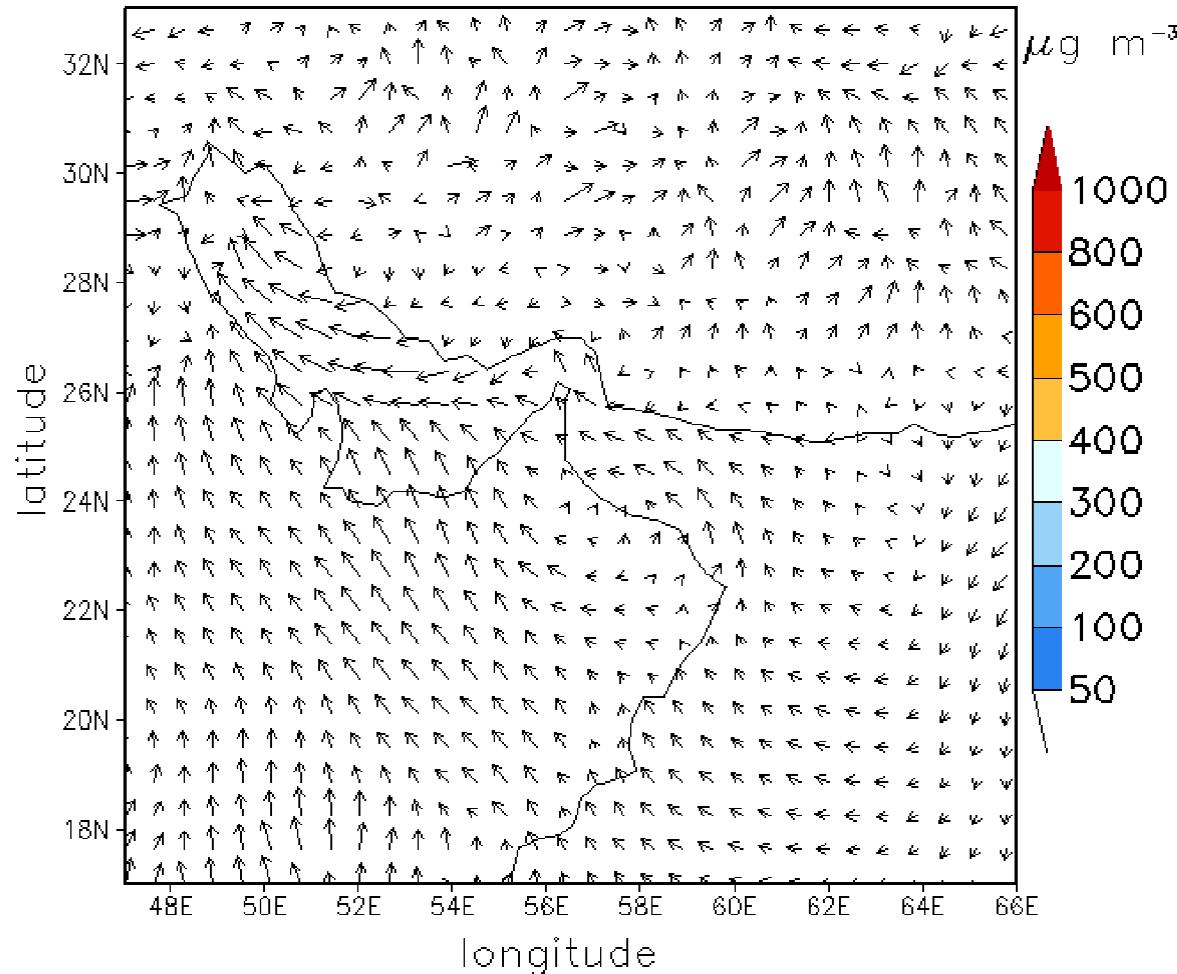
season is taken into account, too. Towards the end of the pollen season less pollen are emitted. The end of flowering is calculated using a temperature model as well.

The important advantage of the new birch pollen forecasts is the complete spatial coverage of Switzerland

Operational use of COSMO-ART for UAE

Simulated mass concentration, 4-6 February 2010

04. FEB 2010, 00 UTC



COSMO(-ART) meets stratosphere

Roland Ruhnke, Sarah Schmitz, Inge Bischoff-Gauß, Andrew Ferrone, Hans-Jürgen Panitz, Heike Vogel, and Bernhard Vogel

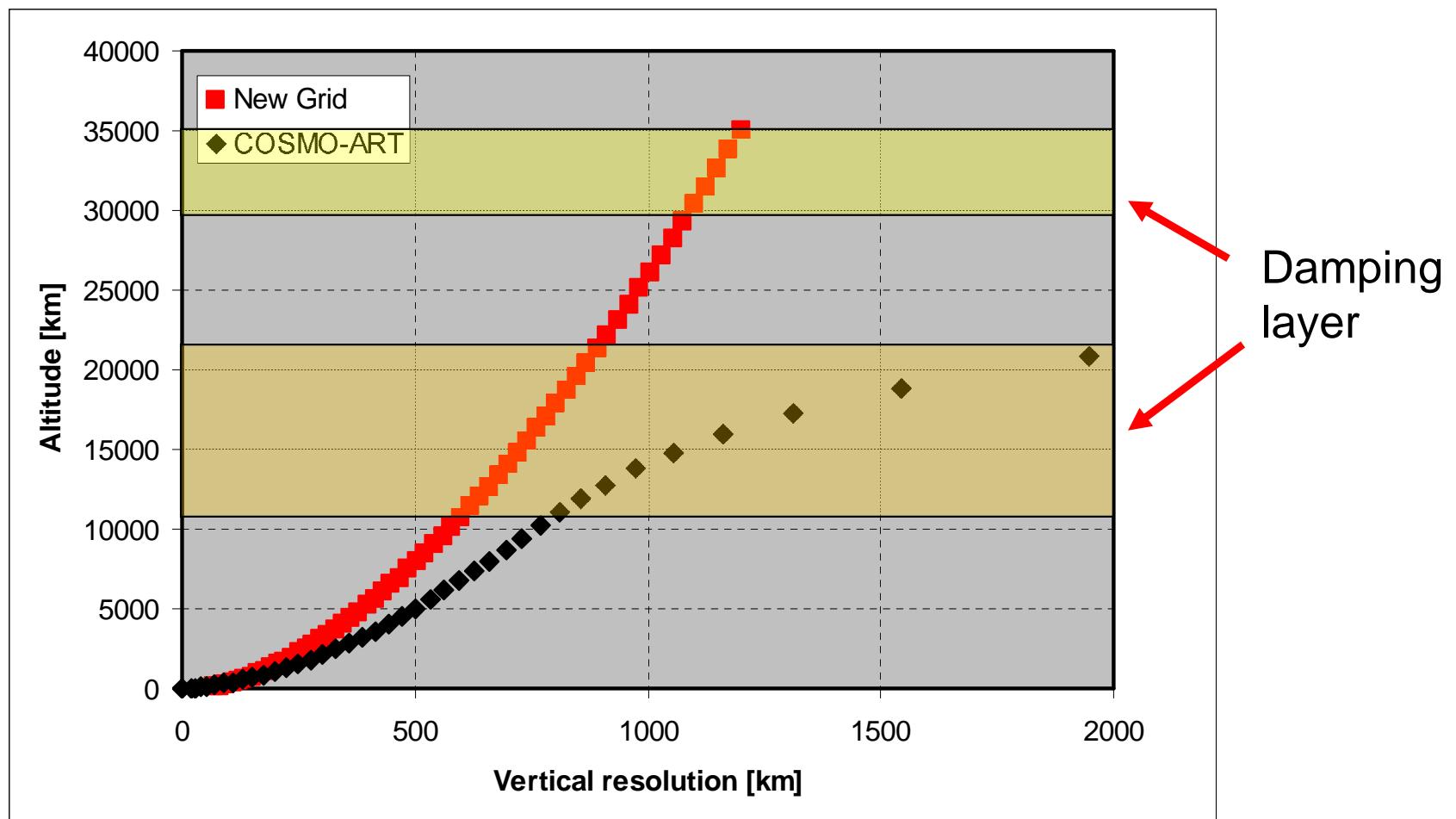
Institut für Meteorologie und Klimaforschung



Definition of a new vertical grid in COSMO

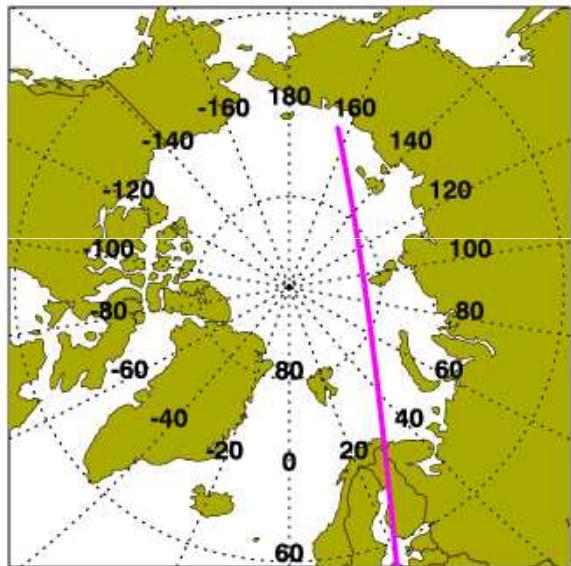
Vertical Grid

- 62 layers
- upper boundary at 35 km

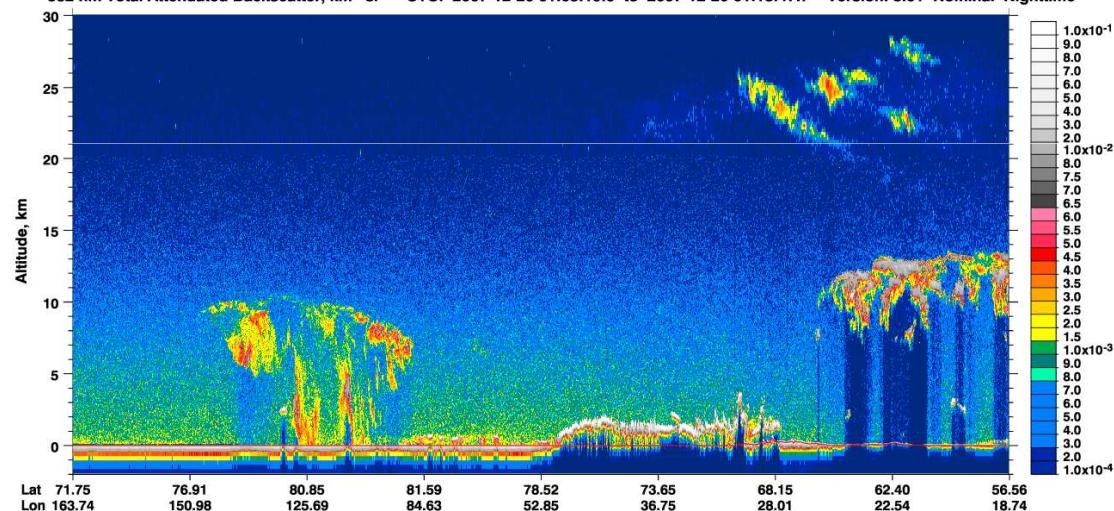


COSMO vs CALIPSO

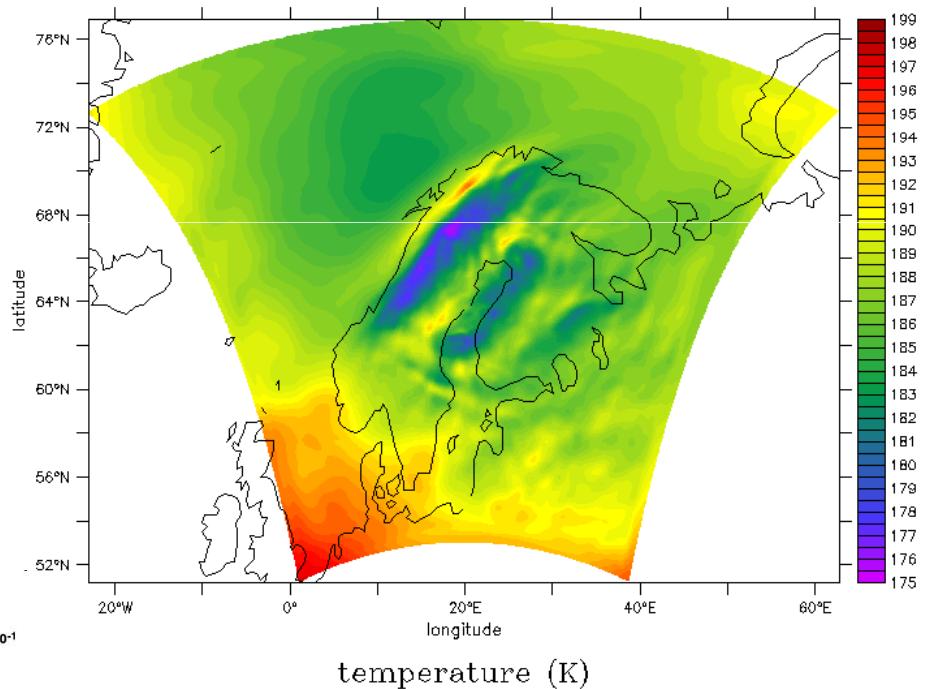
UTC: 2007-12-20 01-05-20 Version: 3.01 Nominal Nighttime



532 nm Total Attenuated Backscatter, $\text{km}^{-1} \text{sr}^{-1}$ UTC: 2007-12-20 01:05:19.0 to 2007-12-20 01:18:47.7 Version: 3.01 Nominal Nighttime



Z : 10
TIME : 20-DEC-2007 00:00
DATA SET: Scandinavia_chain.mc
Winter 2007/2008 Scandinavia 0.1 degree ERA-Interim



20.12.2007 / 0 UT
~ 25 km altitude

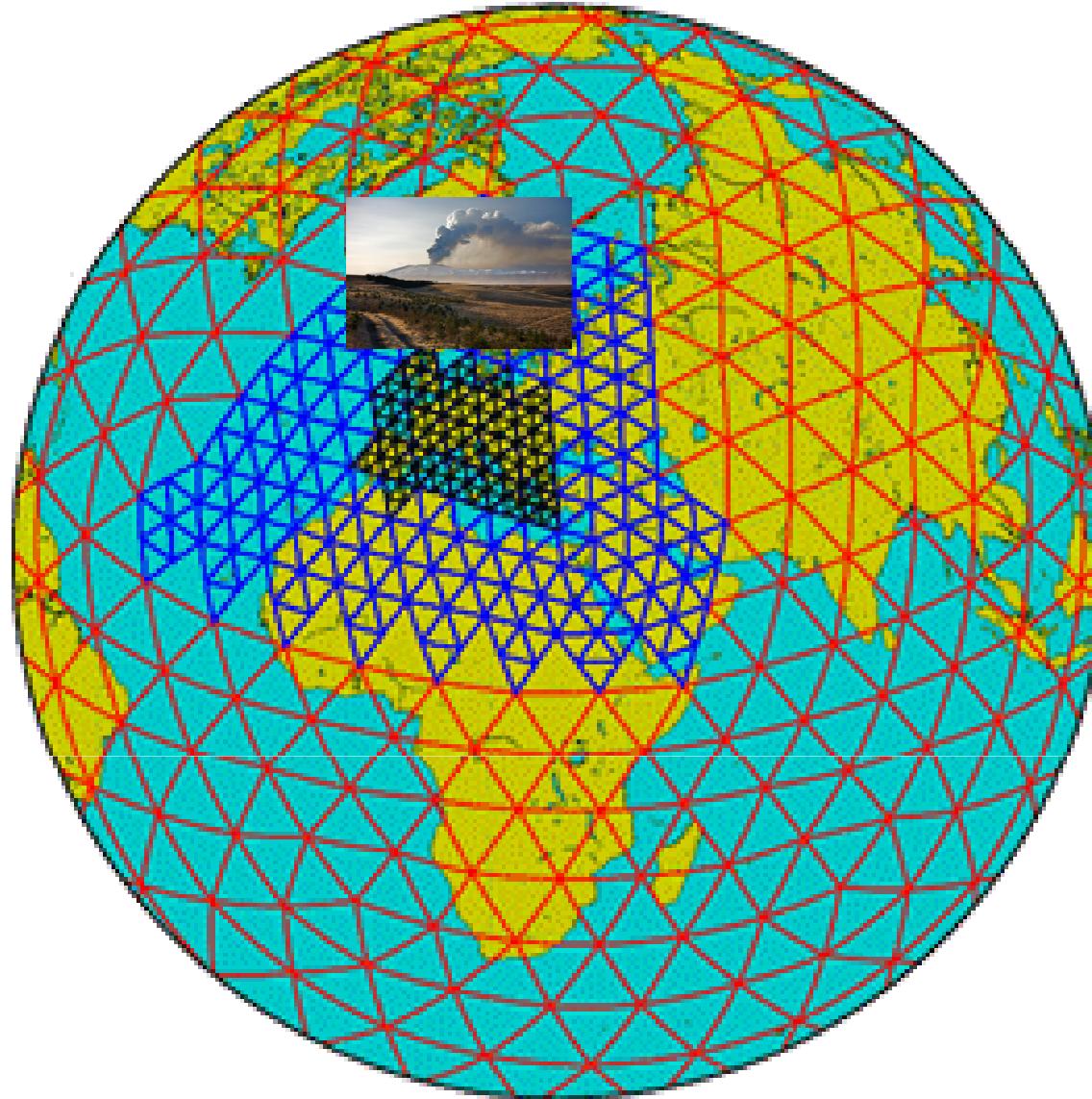
Conclusions

COSMO-ART is a fully online coupled model system that includes detailed photochemistry and size and chemical resolved aerosol processes.

It treats feedback processes between aerosols, clouds, and radiation.

It is already used operationally for pollen, volcanic ash and mineral dust.

Coming up soon: ICON-ART



Simulation of the impact of Eyjafjallajökull plume on cloud formation and precipitation over Europe with COSMO-ART

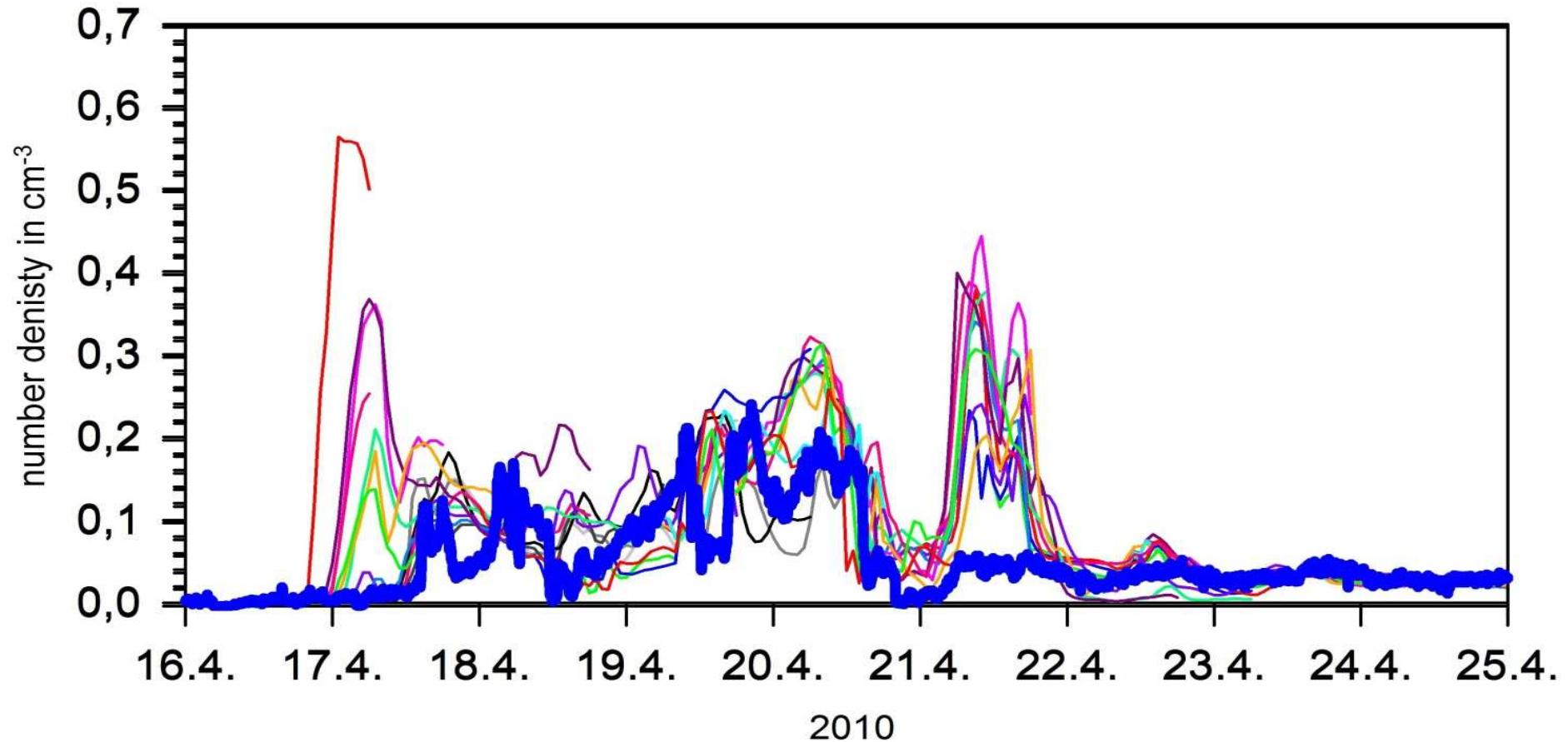
H. Vogel¹, M. Bangert¹, B. Vogel¹, T.L. Lathem², A. Nenes², J. Förstner³

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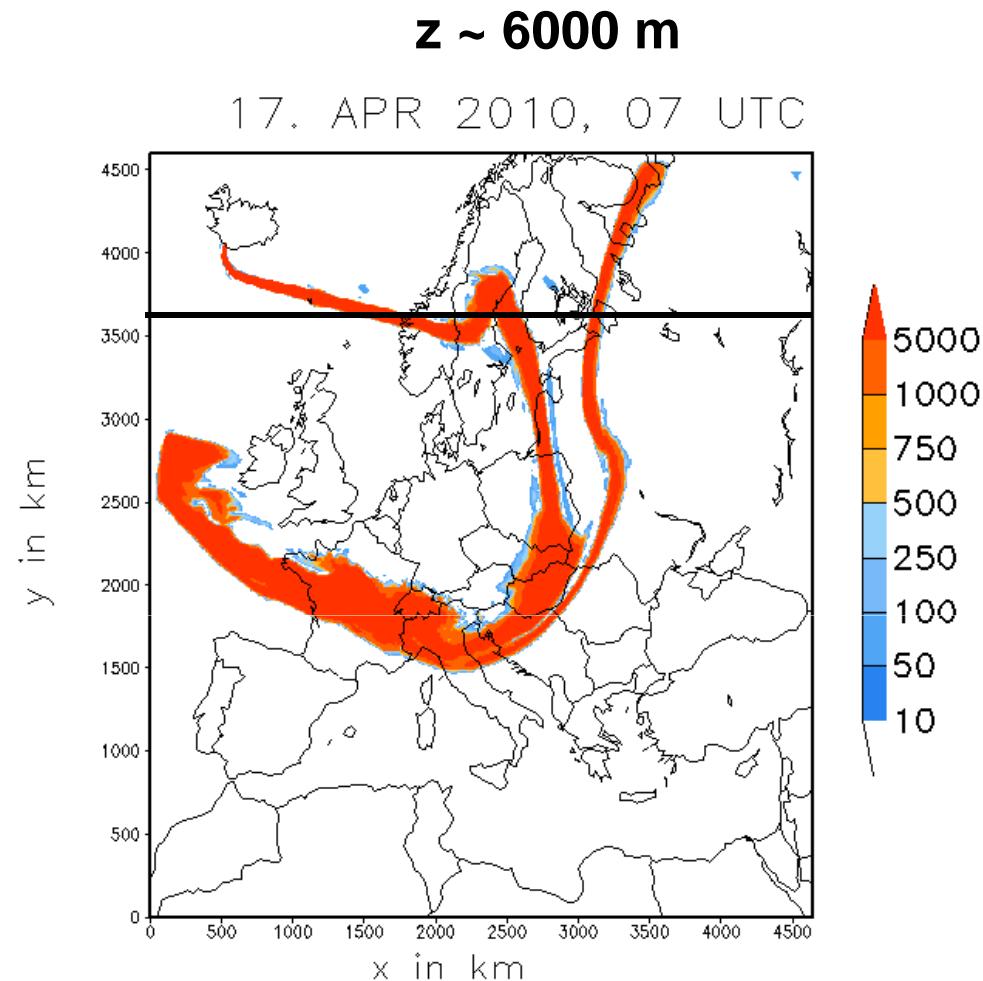


Comparison of scaled simulated number concentrations

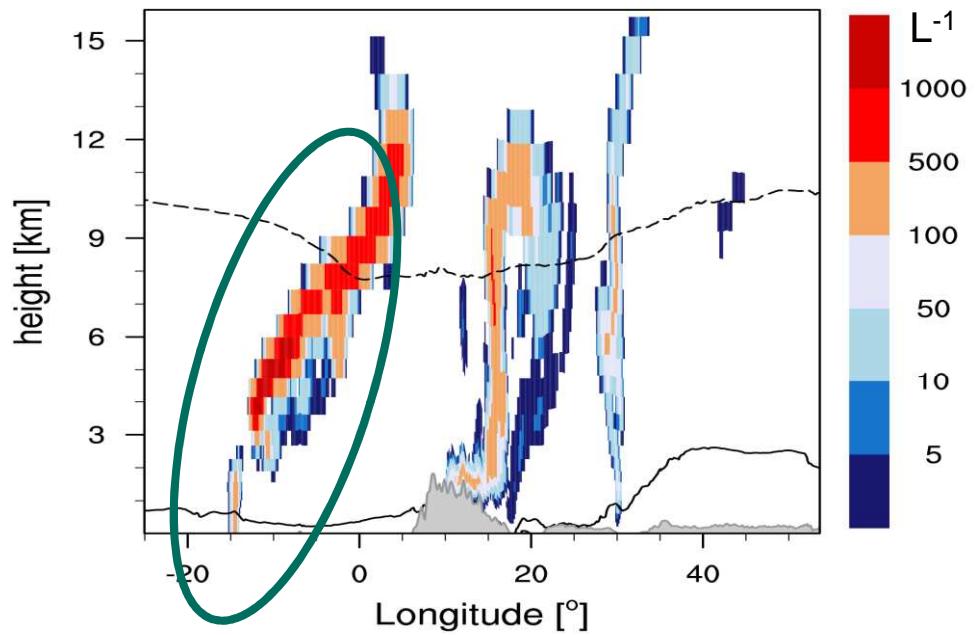
with observations at MO Hohenpeißenberg (Flentje et al. 2010)



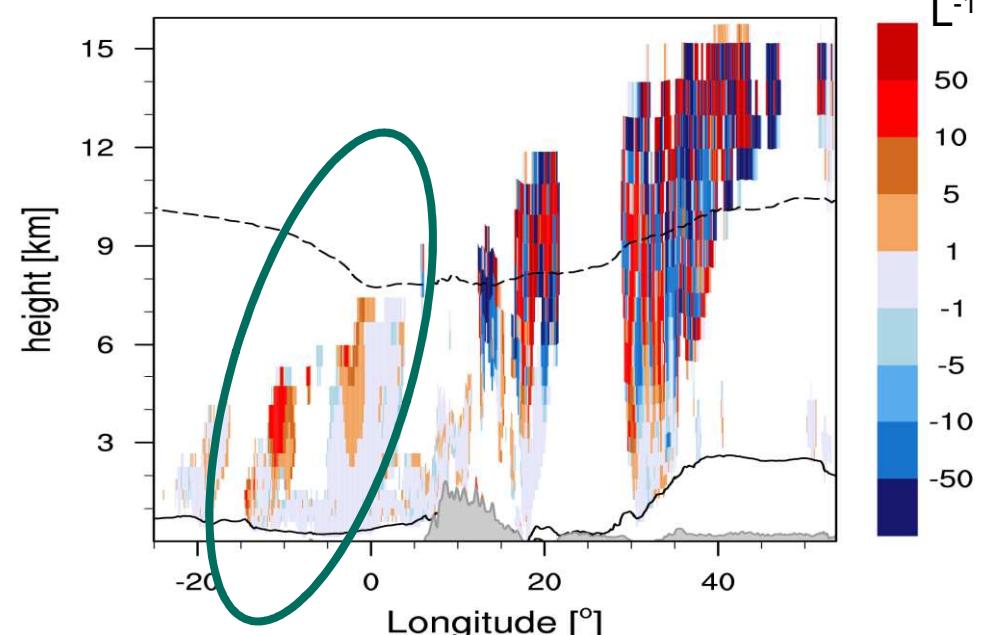
Die nächsten Folien zeigen den Einfluss von Vulkanasche auf die Bewölkung im Vertikalschnitt entlang der schwarzen Linie



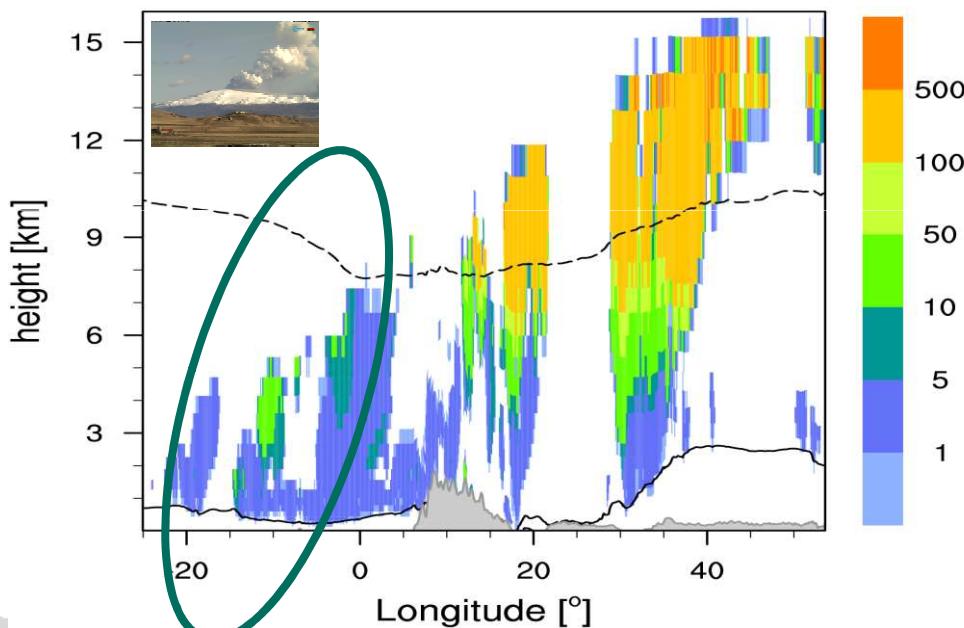
number density of ash particles



difference of ice crystals

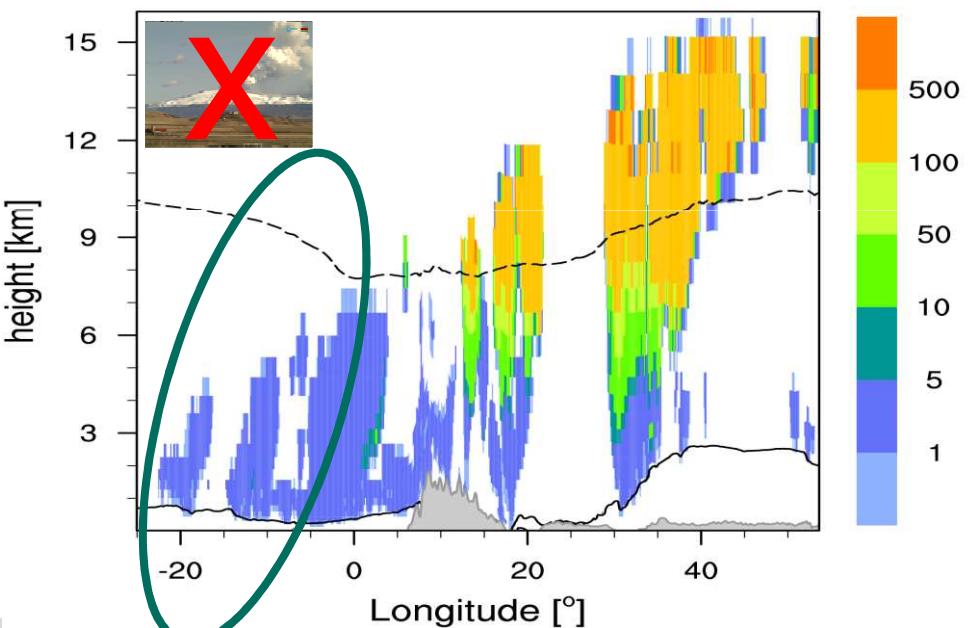


ice crystal number concentration [L^{-1}]



COSMO-ART

ice crystal number concentration [L^{-1}]



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