Karlsruhe Institute of Technology

COSMO-ART

Status - Development - Application

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

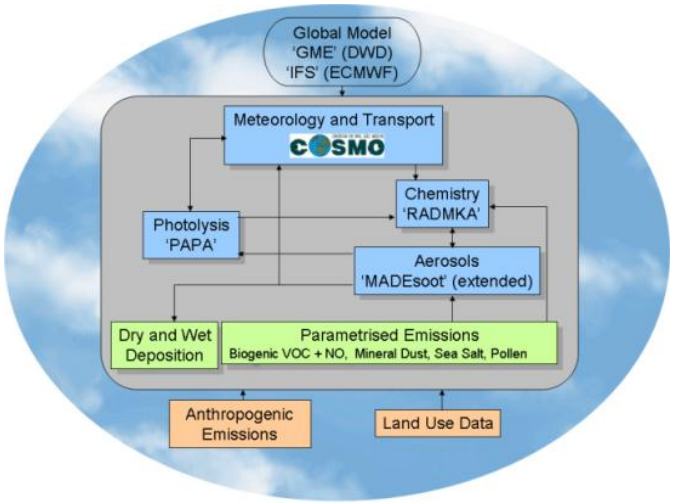
Acknowledgement:

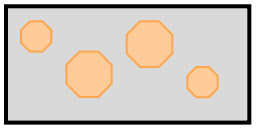
We acknowledge all those who developed and are steadily improving the COSMO model

We appreciate the support by:

U. Schättler, M. Baldauf, J. Förstner, A. Seifert, U. Blahak, M. Raschendorfer

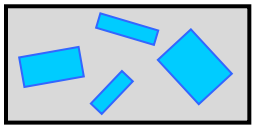
The Model System COSMO-ART





Mineral dust modes

- Three modes



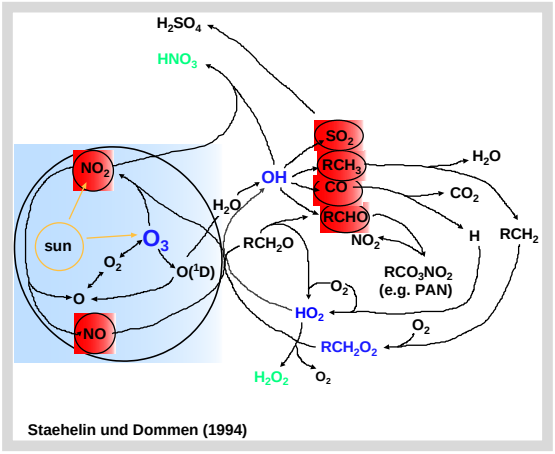
Sea salt modes

- Three modes,

Na^+,Cl^-, SO_4^{2-}, H_2O

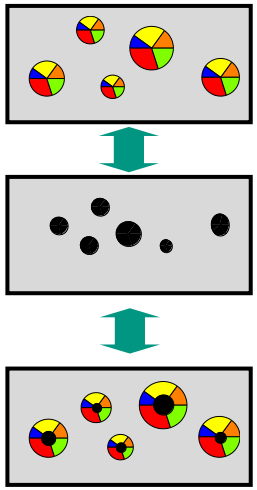
+ volcanic ash and pollen

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.



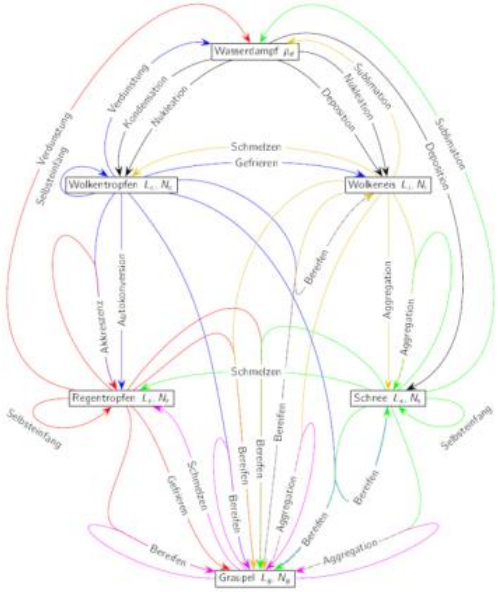
Cloud Microphysics (support by Axel and Uli B.)

Two Moment cloud microphysics (Seifert and Beheng, 2006)

- number and mass concentration of all hydrometeors

Six hydrometeor classes

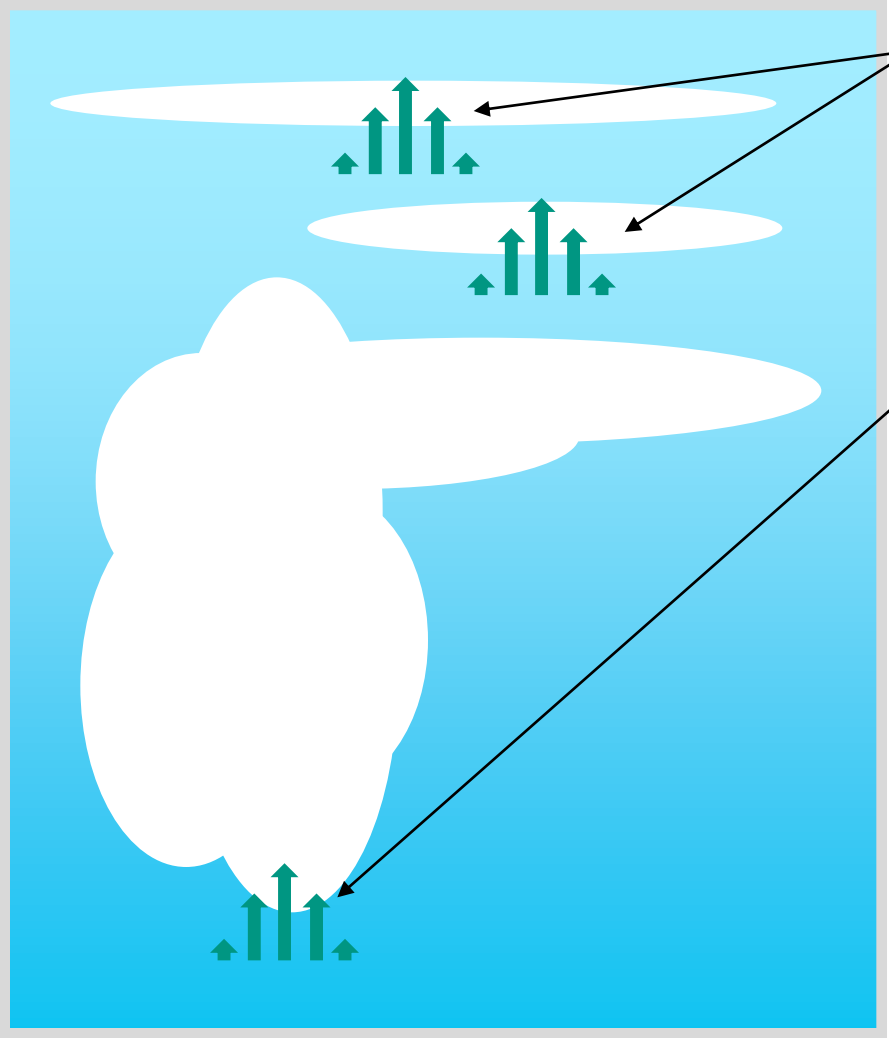
- water droplets
- ice crystals
- rain droplets
- snow flakes
- graupel
- Hail



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

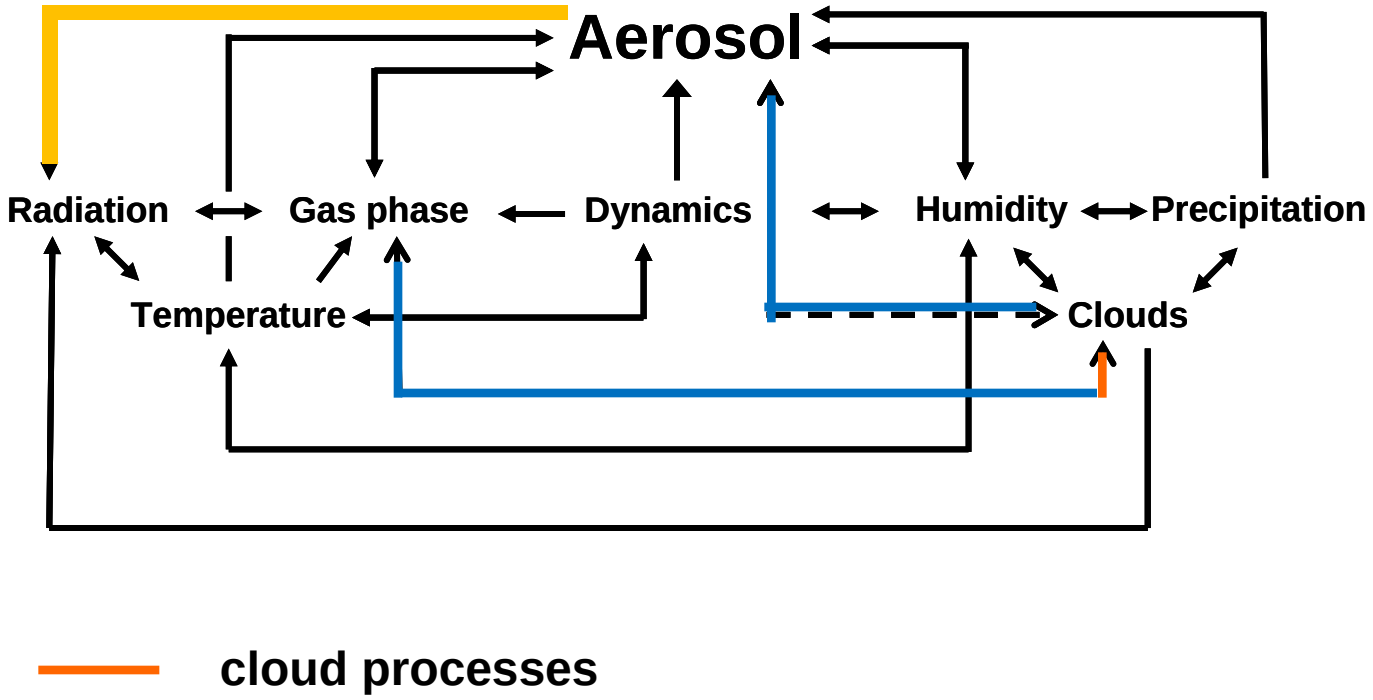
(Kumar et al. 2009, Barahona et al. 2010)

- 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 and COSMO-ART on GPUs New users:

Greek weather service

Weather service of Romania

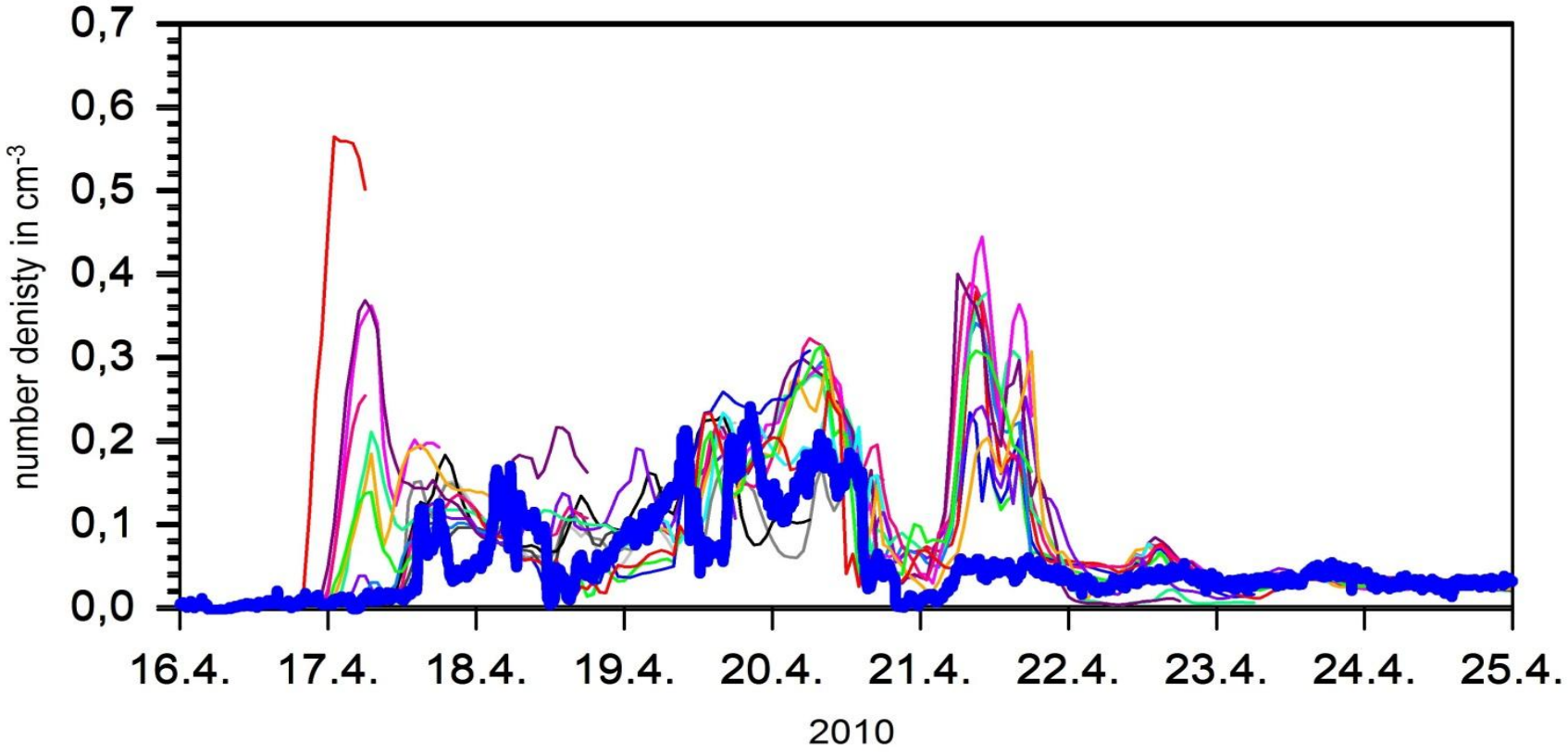
Karlsruhe Institute of Technology

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

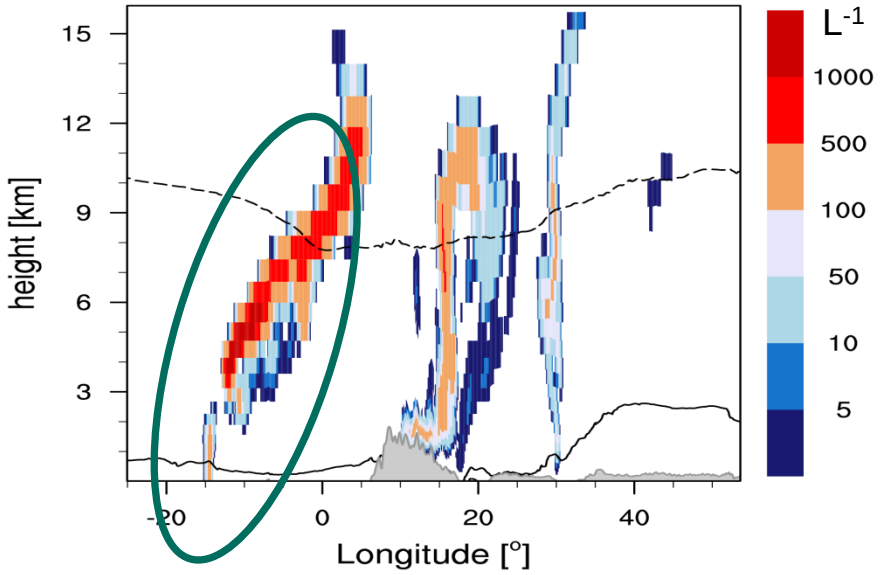
H. Vogel[1], M. Bangert[1], B. Vogel[1], T.L. Lathem[2], A. Nenes[2], J. Förstner[3]

1. Institute for Meteorology and Climate Research, Karlsruhe Institute of Technology, Karlsruhe, Germany.
2. Schools of Earth & Atmospheric Sciences and Chemical & Biomolecular Engineering, Georgia Institute of Technology, Atlanta, GA, United States.
3. Deutscher Wetterdienst, BU Research and Development, Department for Numerical Modeling, Offenbach, Germany.

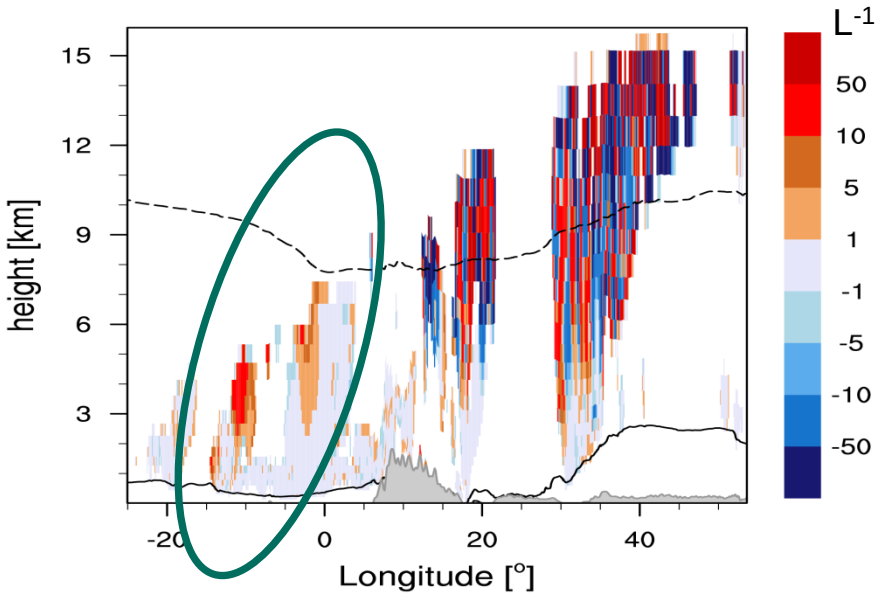
Comparison of scaled simulated number concentrations with observations at MO Hohenpeißenberg (Flentje et al. 2010)

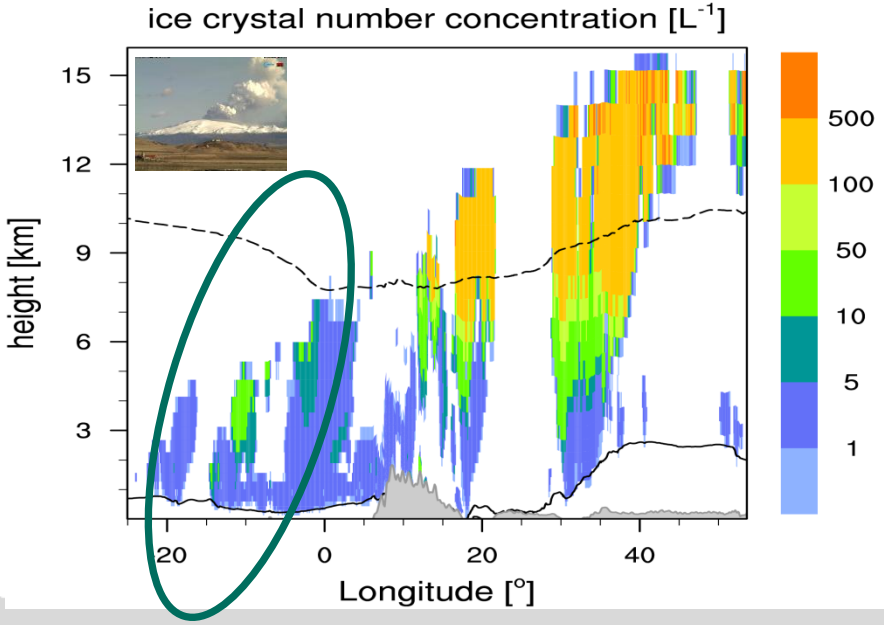


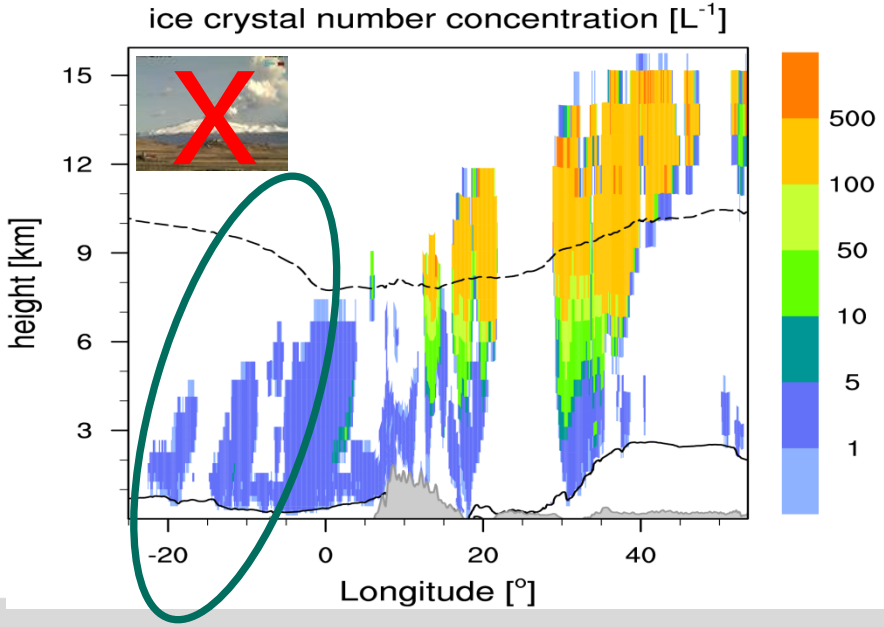
number densitiy of ash particles

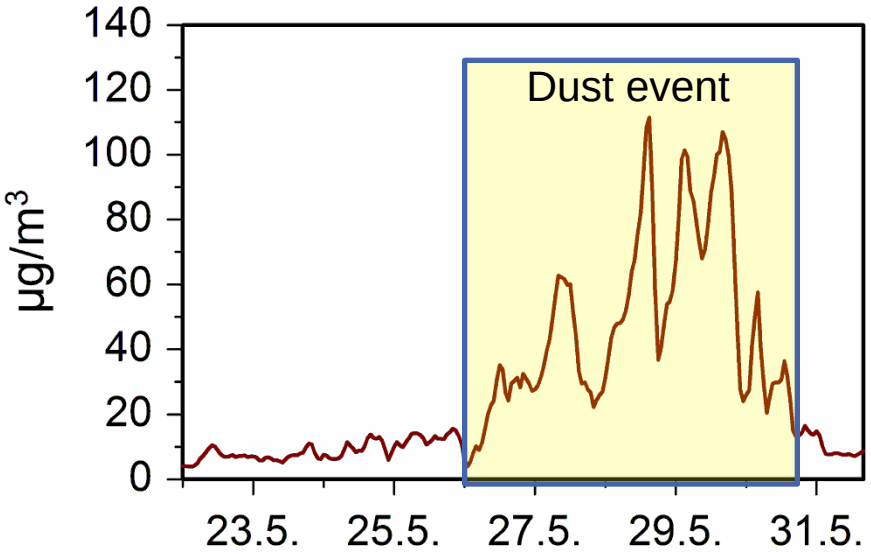


difference of ice crystals

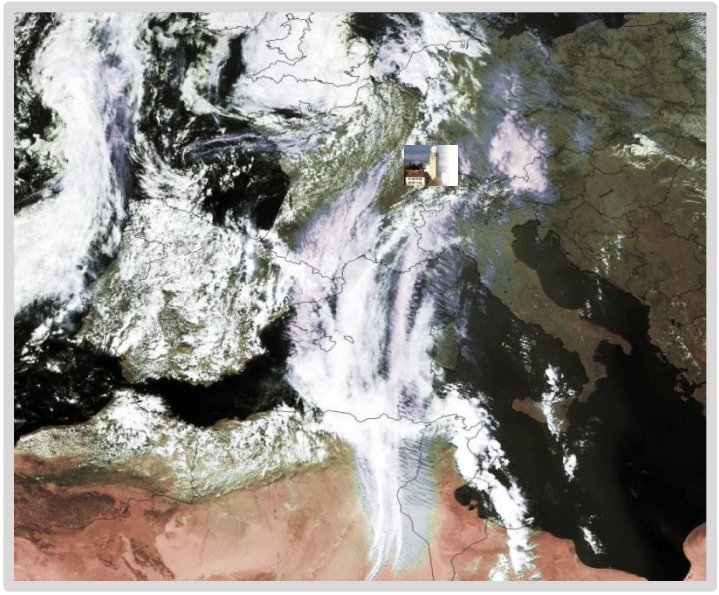




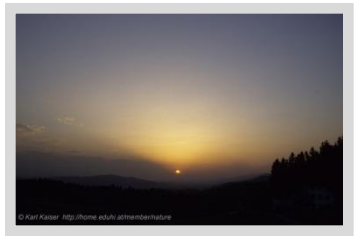




Observed aerosol mass concentration at Hohenpeissenberg
(Data: H. Flentje, DWD)



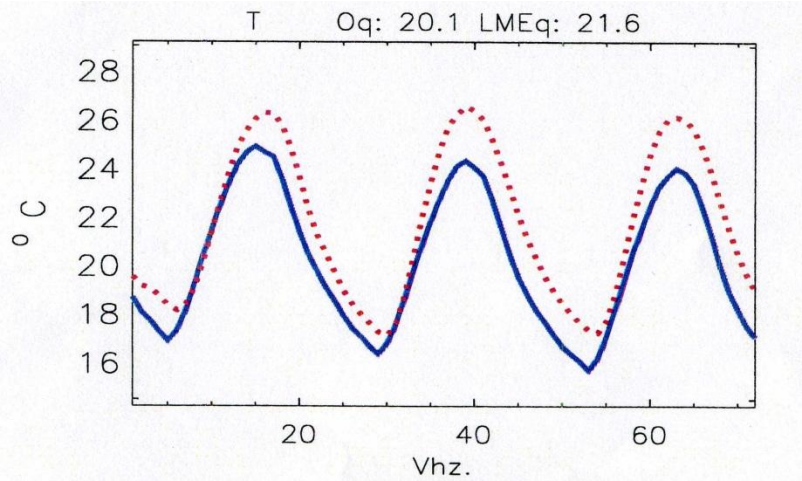
Meteosat picture, 28 May, 2008, 12:00 UTC

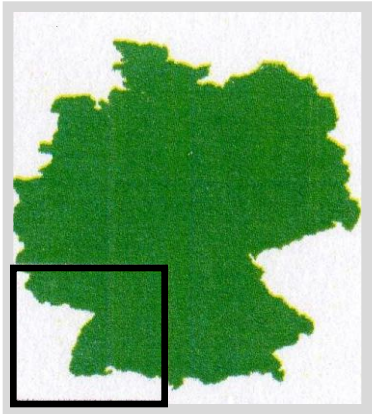


May 2008

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

26.05.2008 – 30.05.2008



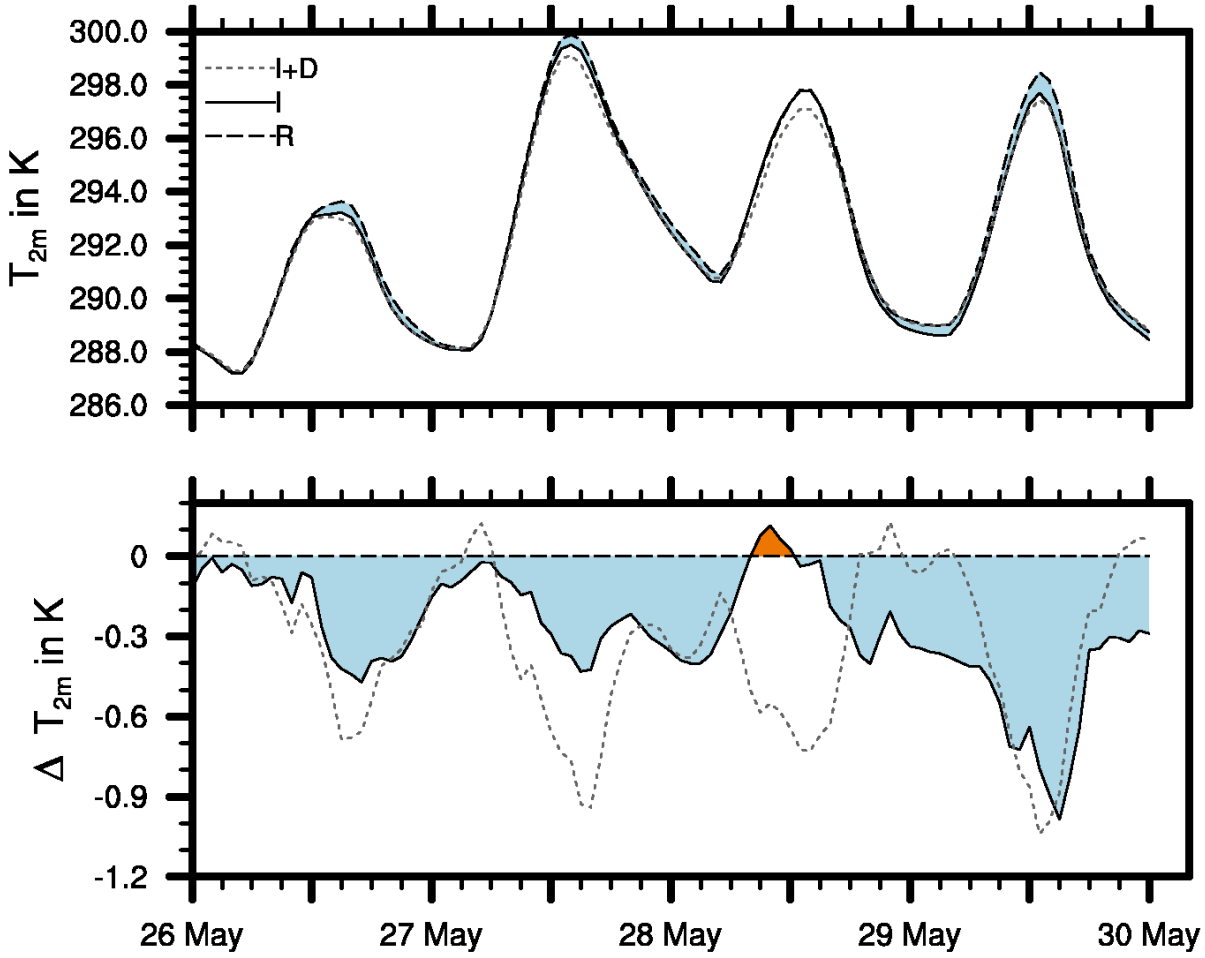


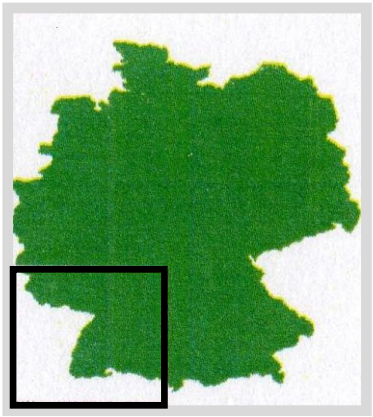
Observed (blue line) and predicted (doted red line)
2m-temperatures for SW-Germany (Data: U. Damrath, DWD)

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

2-m Temperatures

Average over SW-Germany



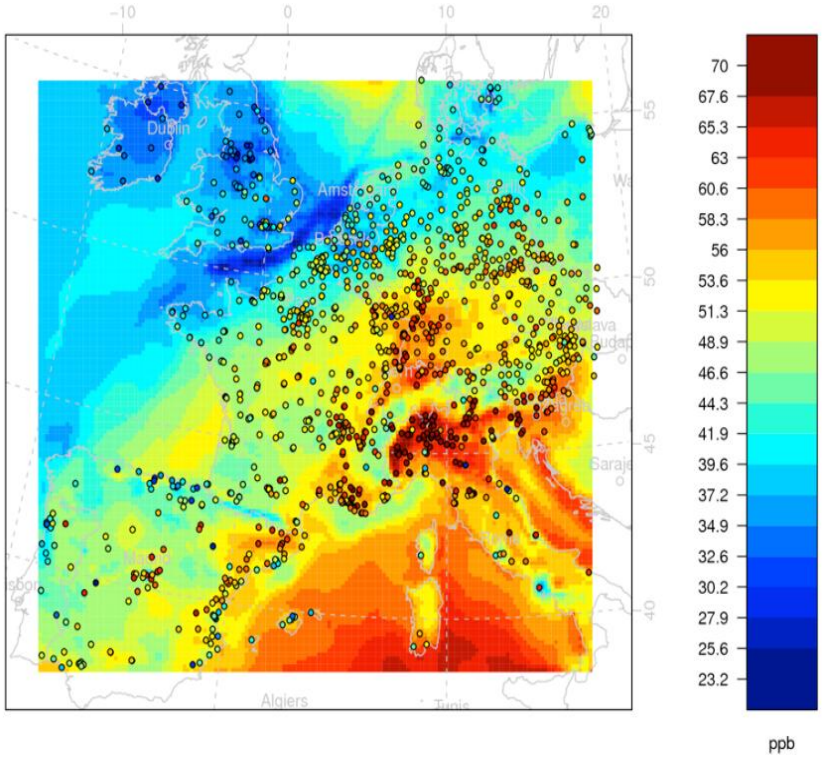


Comparison of COSMO-ART with observations

Christoph Knote*°, Dominik Brunner*, Ulrike Lohmann°

*Empa Duebendorf, °IAC ETH Zurich

Ozone concentrations compared to AIRBASE stations



Ch. Knote et al., 2011

C2SM Center for Climate Systems Modeling

EMPA Materials Science & Technology

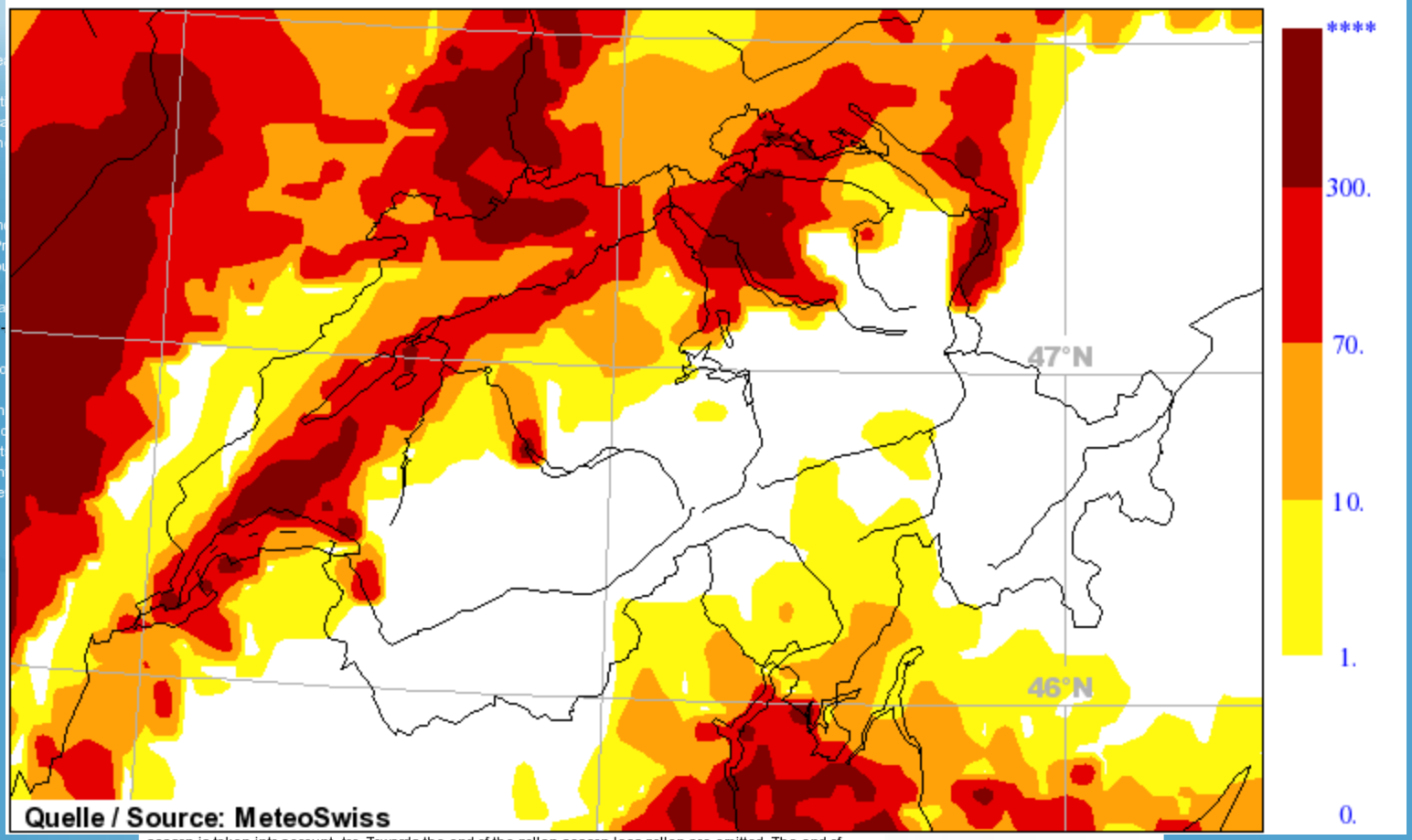
MeteoSwiss - Model forecast COSMO-ART outside pollen season - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.meteoschweiz.admin.ch/web/en/weather/health/pollen/pollen_forecast_cosmo_art.html

Most Visited Top NZZ Intranet Startseite BU

Courtesy to modelling group at MeteoSwiss



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.

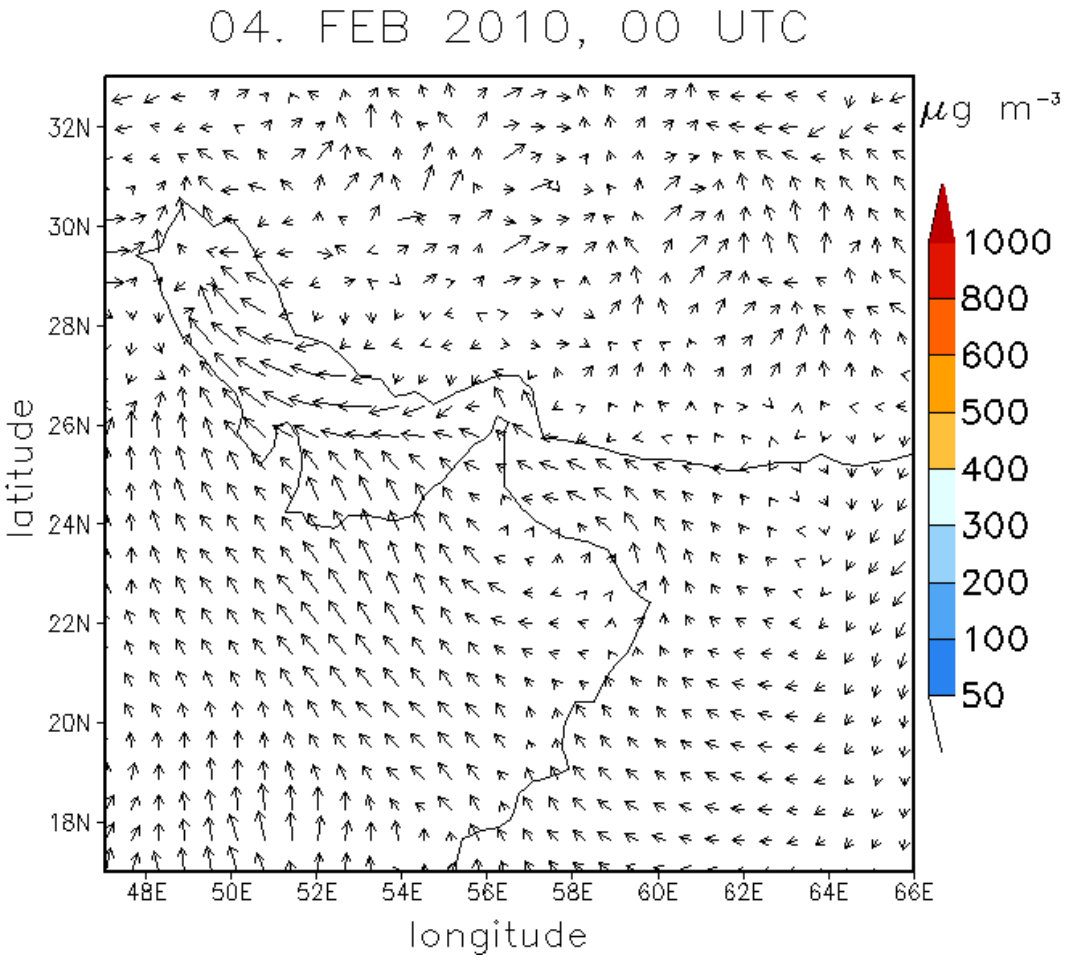
The important advantage of the new birch pollen forecasts is the complete spatial coverage of Switzerland

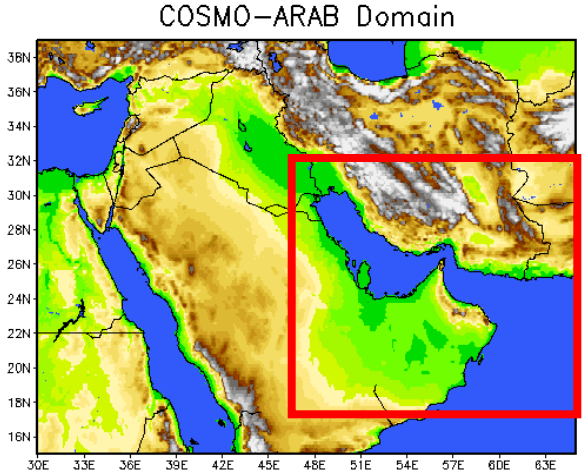
Connecting to meteoch.wemfbox.ch...

Launch Mon Sep 5, 09:39 MeteoSwiss - Model forecast COSMO-ART outside pollen season - M

Operational use of COSMO-ART for UAE

Simulated mass concentration, 4-6 February 2010





Mineral dust and anthropogenic aerosol over China

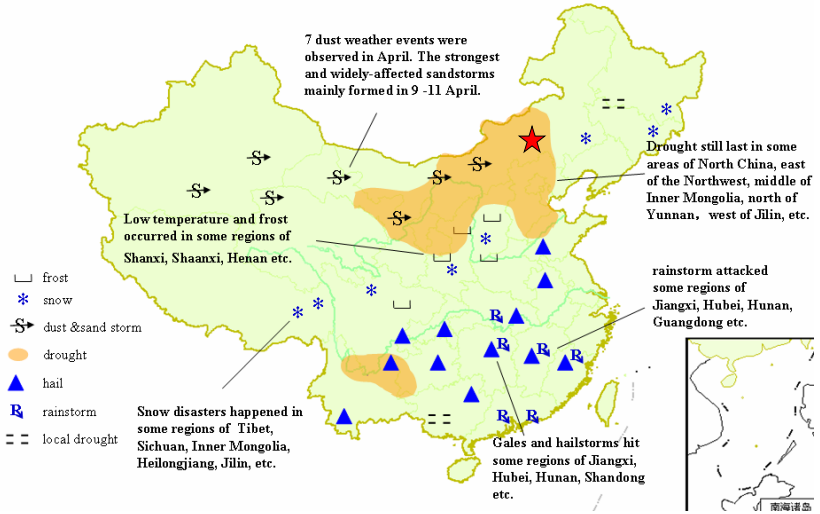
P. Suppan, H. Vogel, B. Vogel, S. Norra, Y. Wang4, G. Tang4

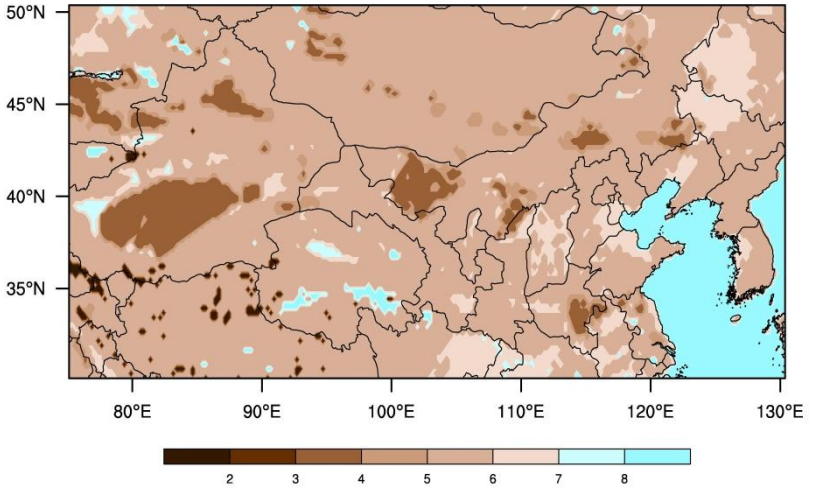
Karlsruher Institut für Technologie

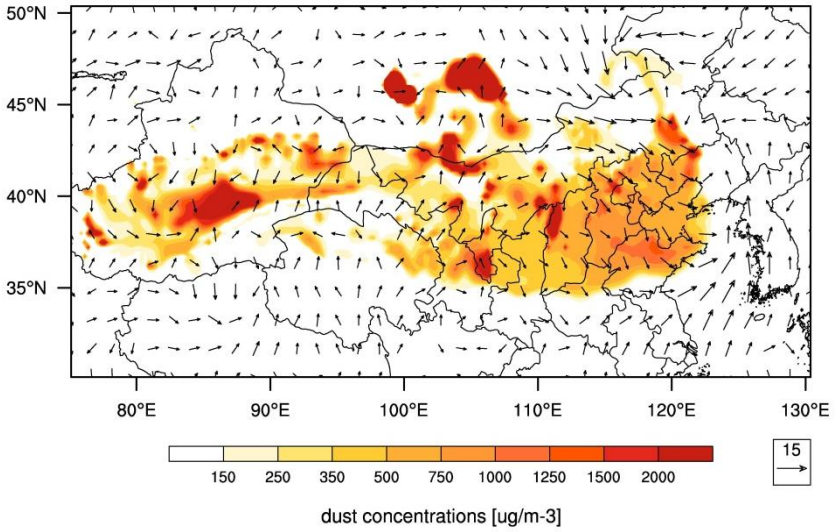
institut für geographie & geoökologie

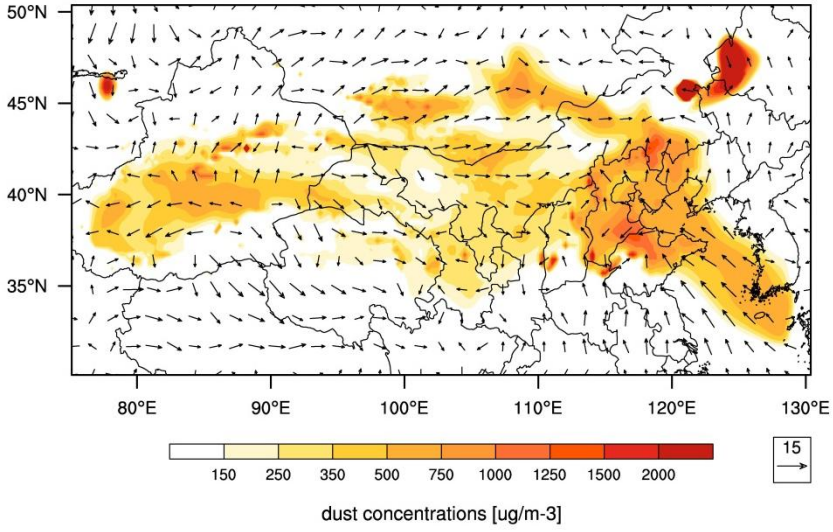
CHINESE ACADEMY OF SCIENCES

Weather events in China in April 2006



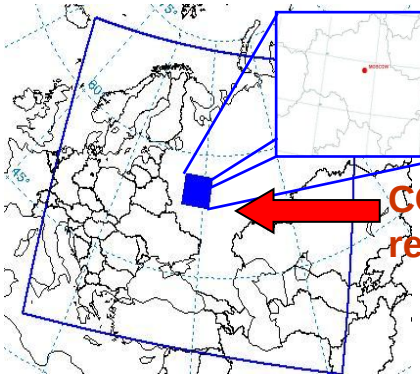






COSMO-ART in Russian Hydrometcentre

Domain



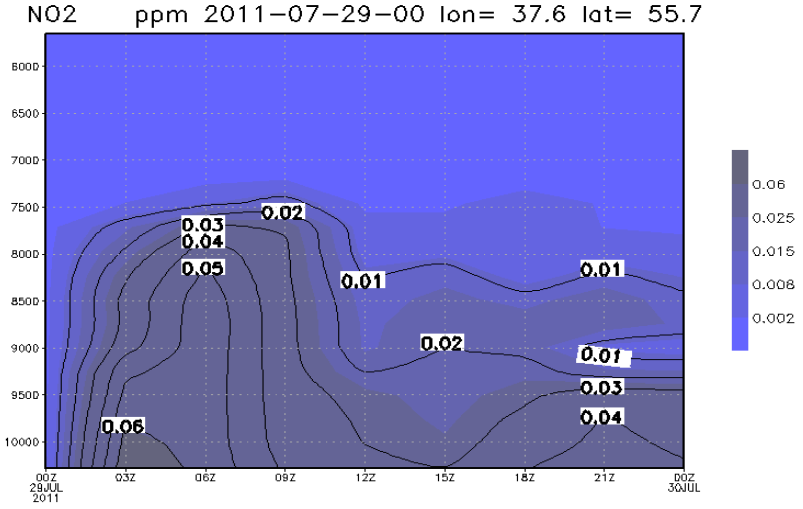
COSMO-ART, Moscow region
resolution 7x7 km (64x64 grid cells)

COSMO (RU) – European part of Russia
resolution 7x7 km (700x620 grid cells)

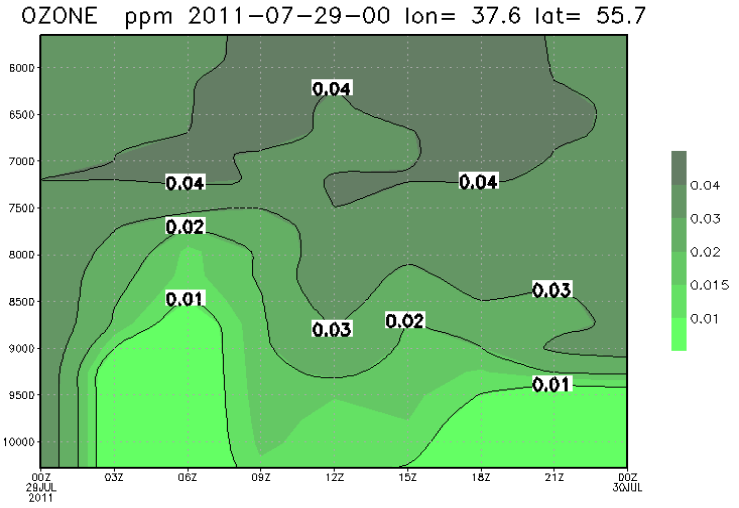
2 current versions:

- COSMO_ART_4.11
- COSMO_ART_4.17

Emissions database: **TNO**
Global Meteorological data: **GME**
Land use data**: GLC2000**



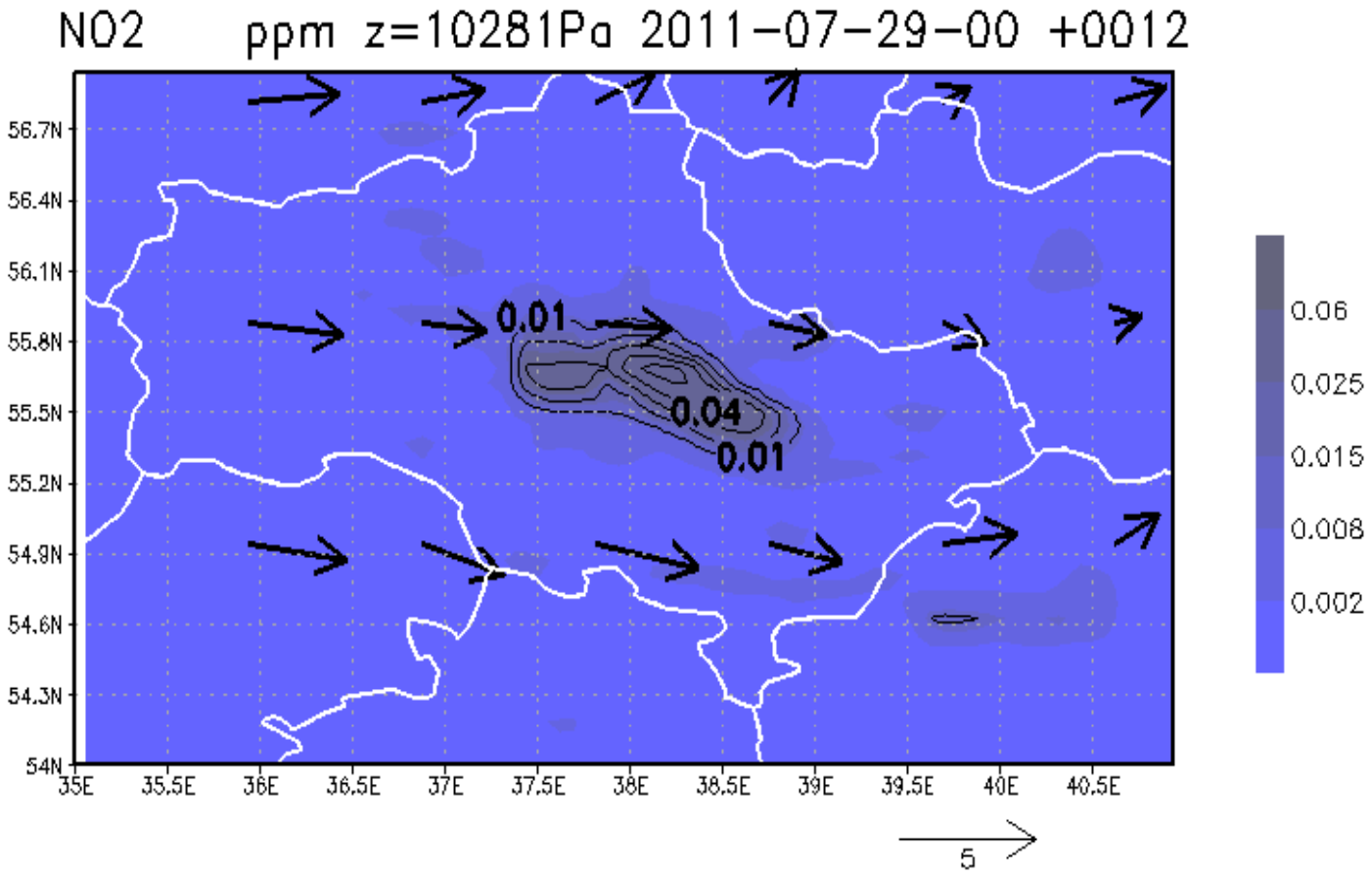
(1)



(2)

2-days forecast of NO_2 (1) and ozone (2) temporal-vertical distribution over Moscow centre

24 hours forecast of spatial-temporal distribution of NO_2 in Moscow region



- **<u>Future development of COSMO_ART in Russia:</u>**
- Preparing of detailed emissions for Moscow region
- Increasing of model resolution to 2.2x2.2 km
- Fires forecast
- COSMO_ART as operative system of air quality forecast

Karlsruher Institut für Technologie

COSMO(-ART) meets stratosphere

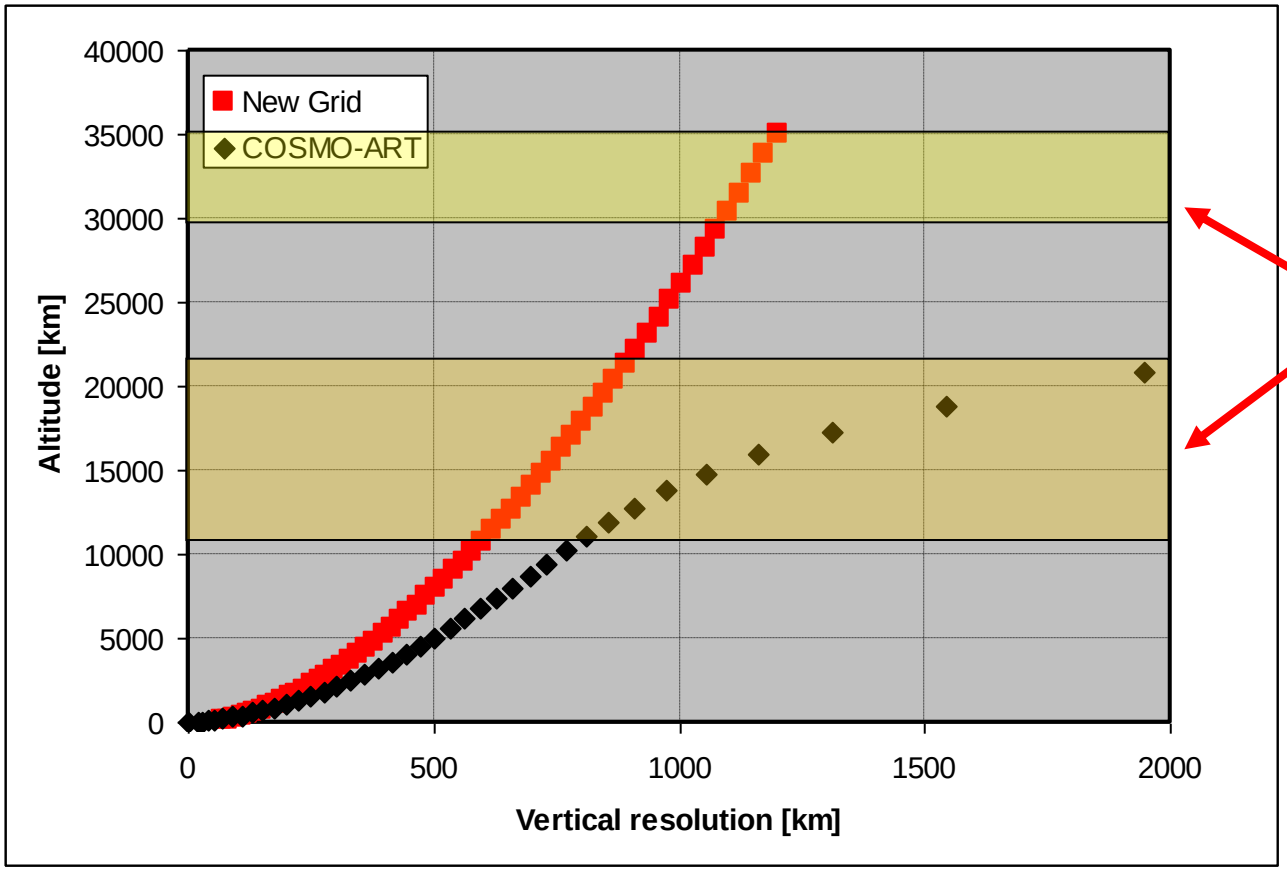
Roland Ruhnke, Sarah Schmitz, Inge Bischoff-Gauß, Andrew Ferrone, Hans-Jürgen Panitz, Heike Vogel, and Bernhard Vogel

Institut für Meteorologie und Klimaforschung

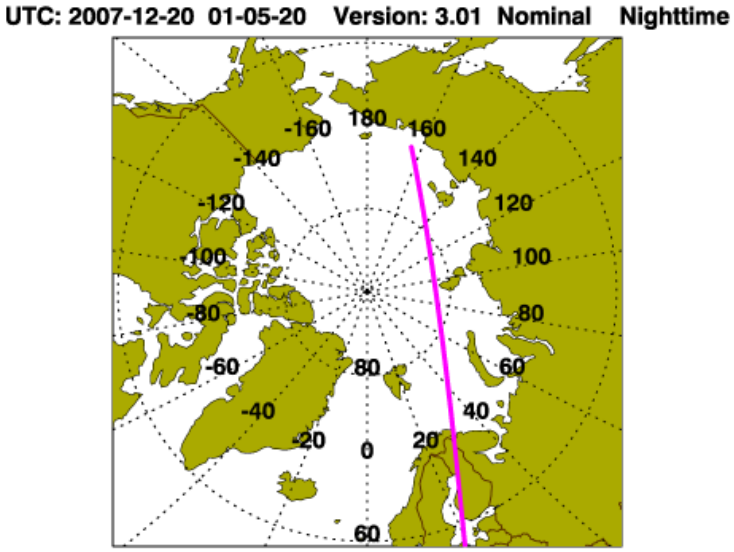
Definition of a new vertical grid in COSMO

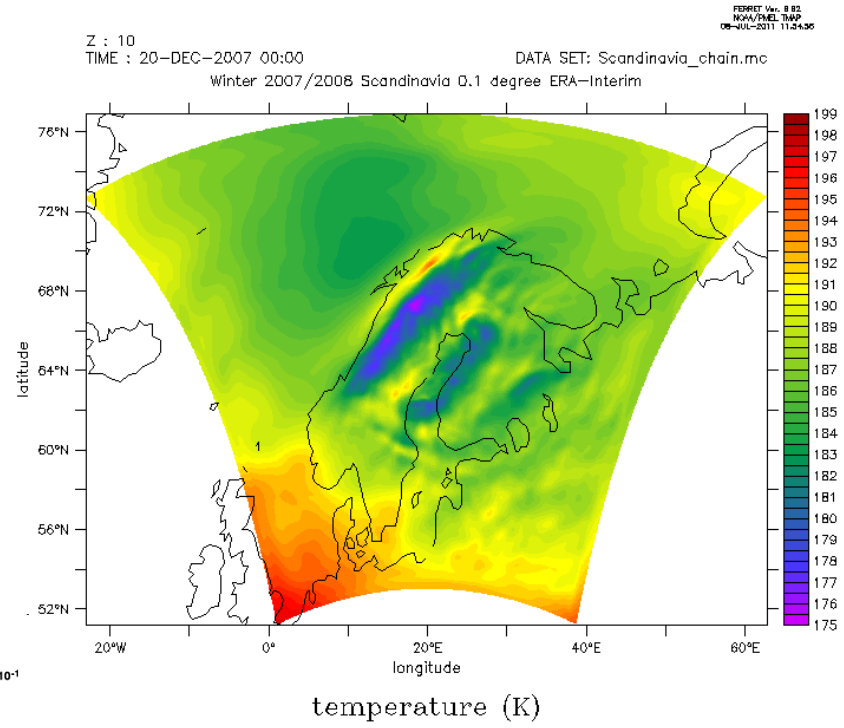
Vertical Grid

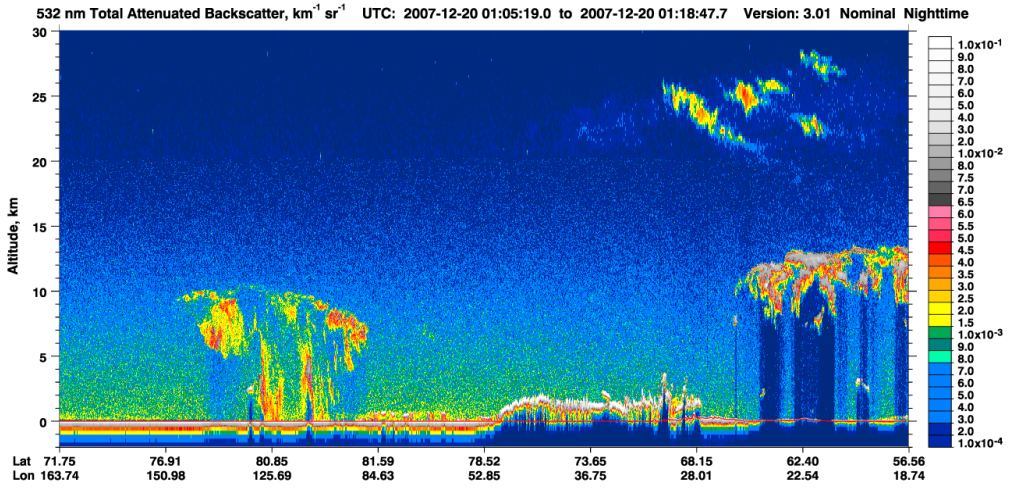
- 62 layers
- upper boundary at 35 km

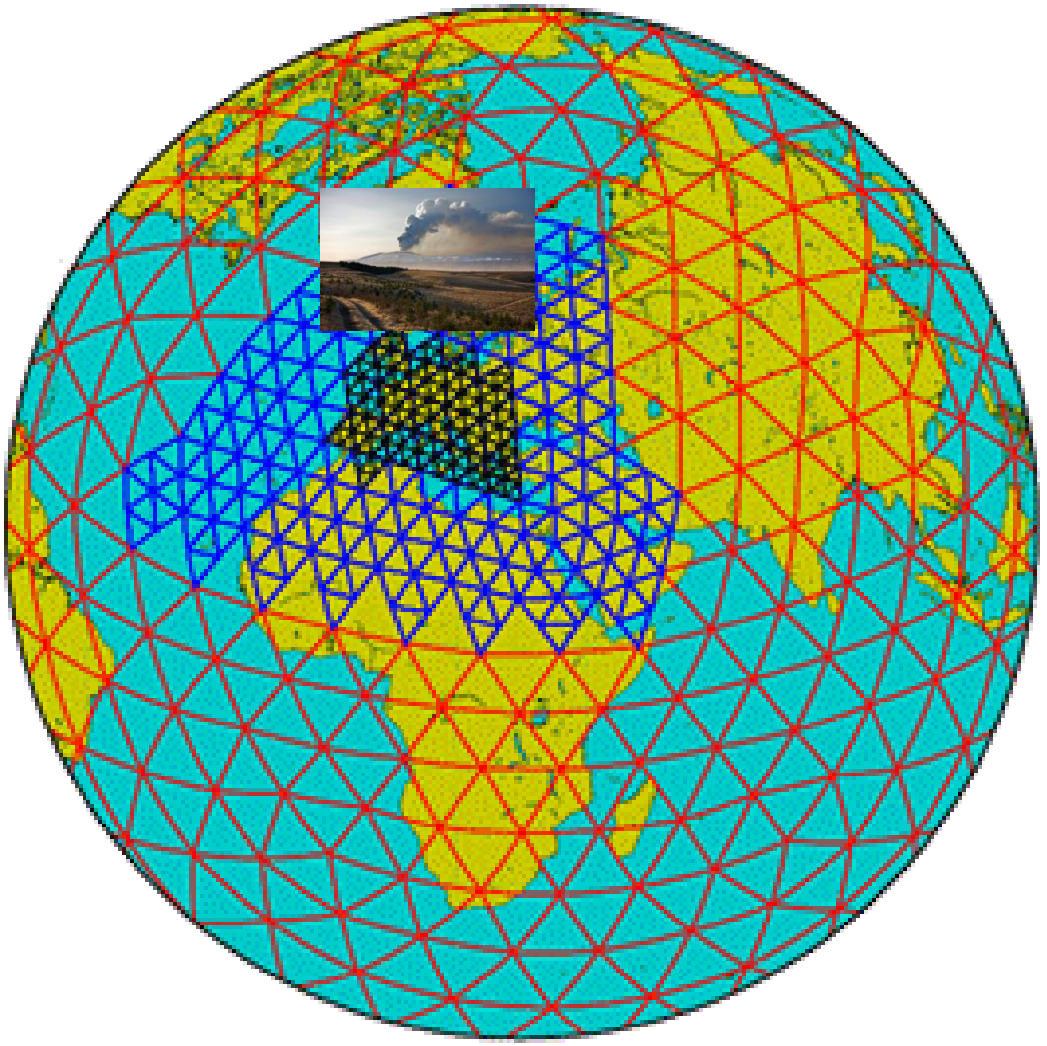


COSMO vs CALIPSO







20.12.2007 / 0 UT
~ 25 km altitude

Coming up soon: ICON-ART