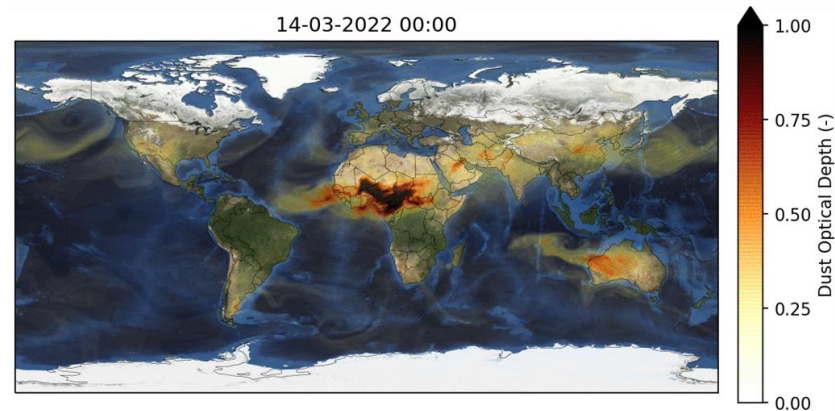


ICON-ART: Status and Plans

Heike Vogel



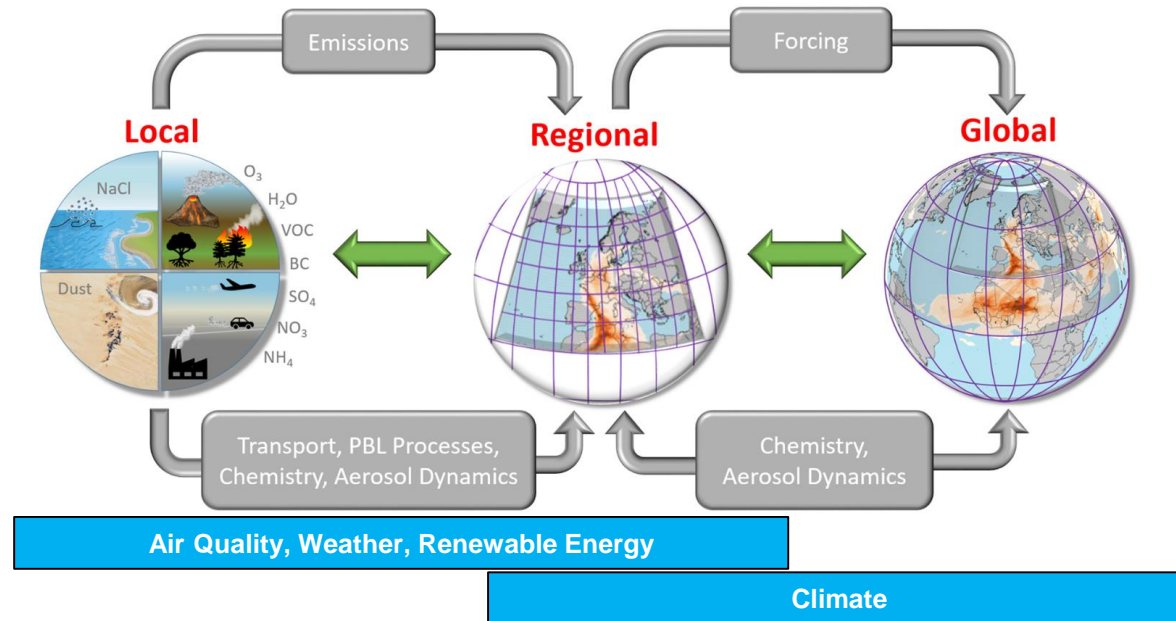
New head of the ICON-ART group at KIT

Ali Hoshyaripour



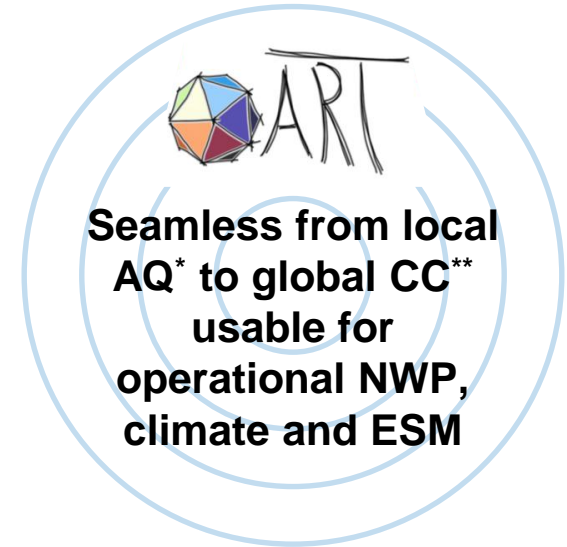
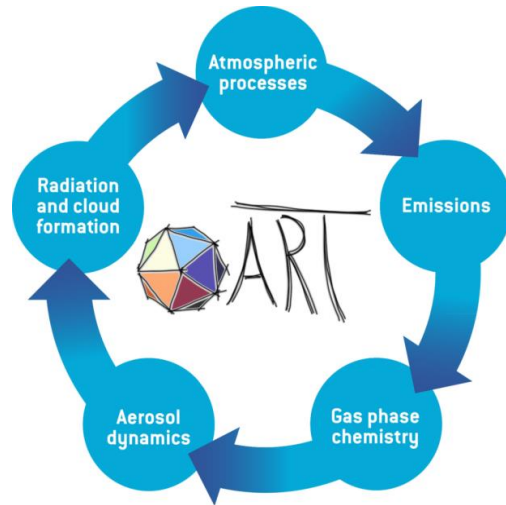
What do we want to do with ICON-ART?

- Better understand **processes**, **interactions** and **impacts** at different **scales**
- Require seamless fully-coupled modelling systems



ICON-ART: status, mission and vision

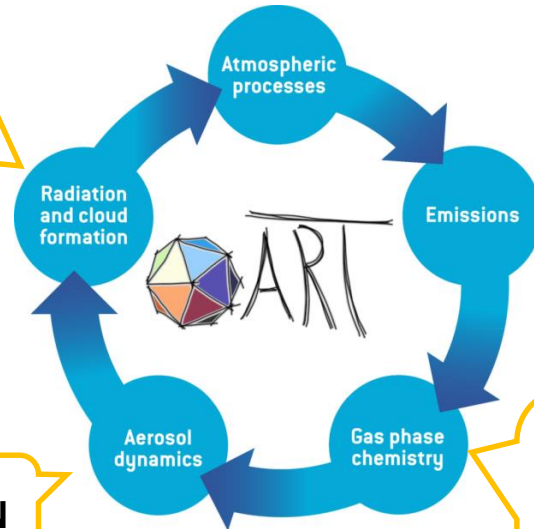
- **(Quasi-)Operational forecast:**
 - Mineral dust (DWD)
 - Pollen (DWD, MeteoSwiss)
 - Emergency: Radionuclides, volcanic ash, accidental release (DWD)



* Air Quality
** Climate-Chemistry

ICON-ART: current features

- Optics of all natural aerosols
- Optics of internally mixed volcanic aerosols
- Coupling with ecRad



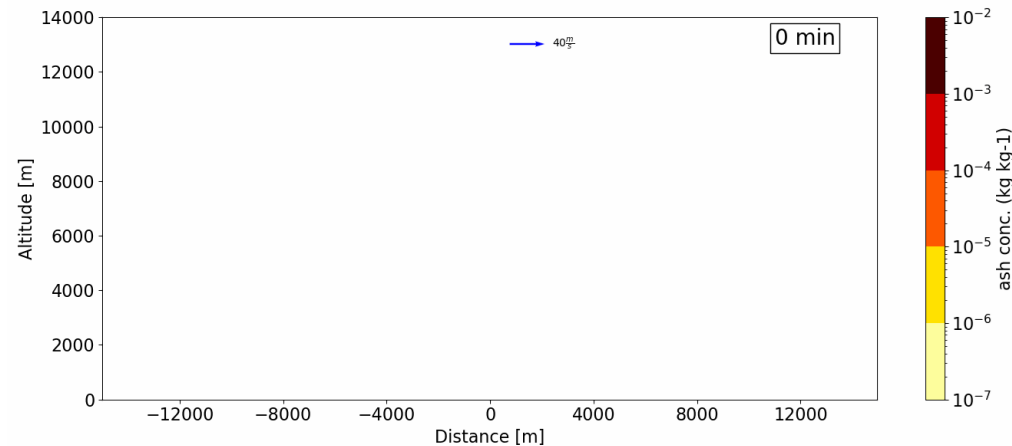
- All source types
- All natural aerosols
- Biomass-burning plumes
- Volcanic plumes
- Online emission module (EMPA)

- Lifetime based
- Linearized schemes (LINOZ, N₂O-NO_y)
- Simplified OH chemistry
- “Complex” chemistry based on MECCA e.g. MOZART

AERODYN

Volcanic eruptions as natural experiments for seamless modeling: LEM

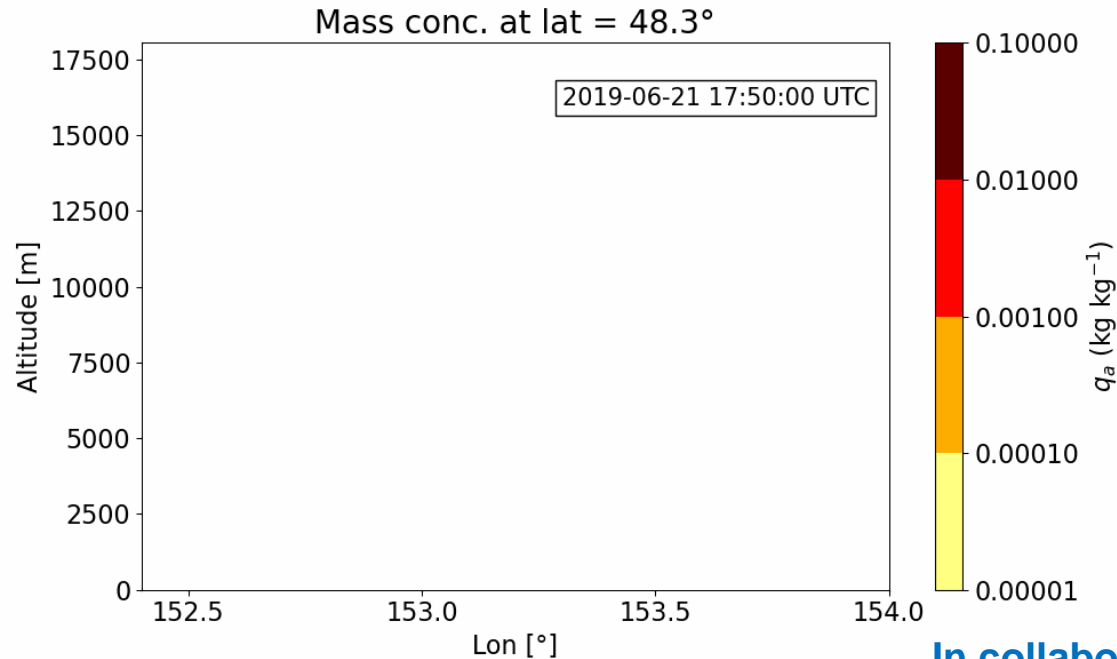
Multi-phase flow in an idealized LES simulation
(2D with 100 m grid)



In collaboration with D. Reinert, DWD

Volcanic eruptions as natural experiments for seamless modeling: LEM

Multi-phase flow in a real case LES simulation



In collaboration with D. Reinert, DWD

Aerosol dynamics (AERODYN) in ICON-ART

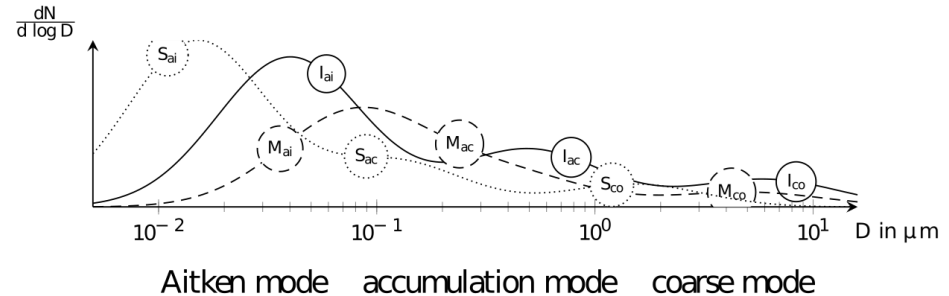
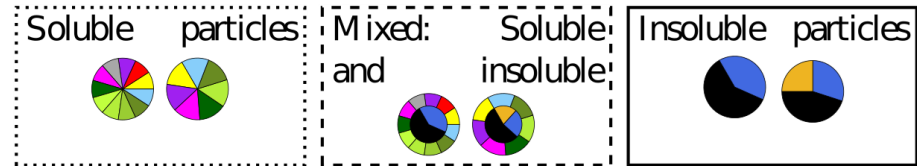
- Enables formation of secondary aerosols and aerosol aging (flexible) log-normal modes

For each mode, prognostic equations for the number density and the mass concentration are solved:

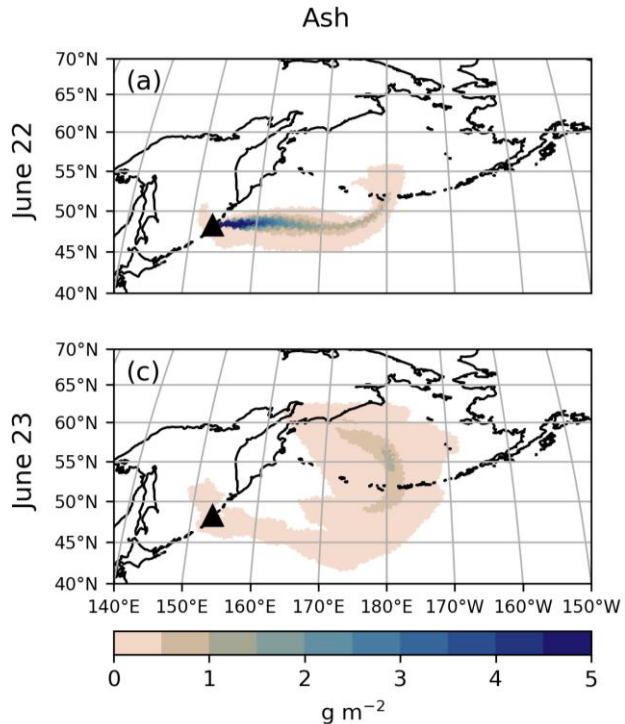
$$\frac{\partial}{\partial t} M_{0,i} = -Ca_{0,ii} - Ca_{0,ij} + Nu_0,$$

$$\frac{\partial}{\partial t} M_{3,i} = -Ca_{3,ij} + Co_{3,i} + Nu_3,$$

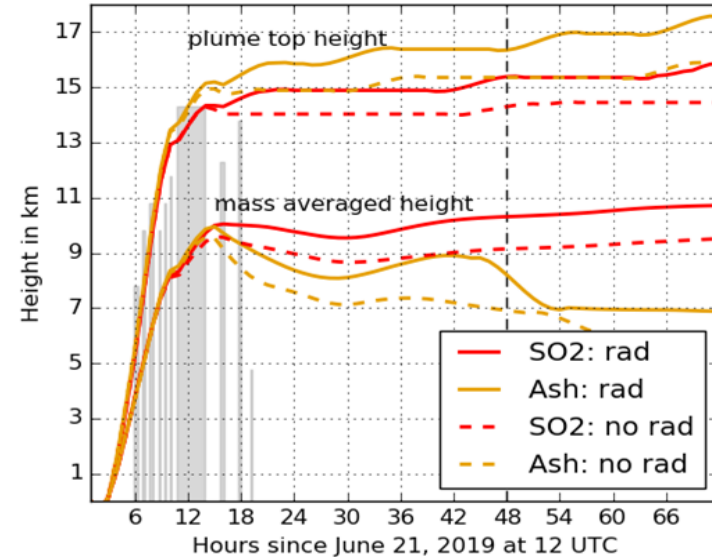
the ISORROPIA II for gas-aerosol partitioning



Volcanic eruptions as natural experiments for seamless modeling: global



The interplay of chemistry, aerosol dynamics, and radiation interaction.

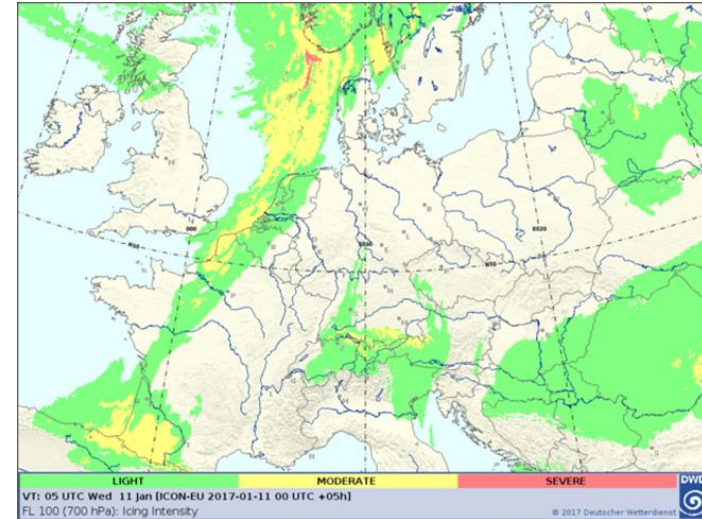




Icing of aircrafts

Current products (e.g. DWD's ADWICE)

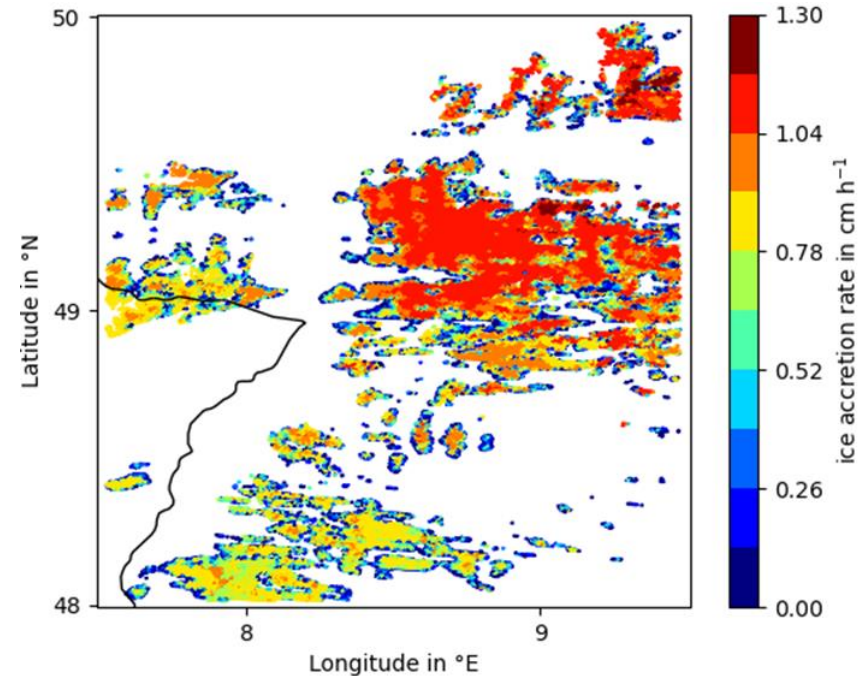
- Provide icing intensity levels
- Based on profiles of temperature and humidity
- Postprocessing
- Empirical
- **No** consideration of droplet sizes and spectrum





New aircraft icing parameterization

- Simulation of expected **accretion**
 - Rates and thickness
 - Rime ice, glaze ice, and liquid water
- Representing main physical processes
 - Droplet impingement
 - Freezing behaviour of impinged water
- Online computation
- Explicit consideration of droplet spectrum



Pollen forecast and data assimilation

Operational at DWD since Sep. 2021

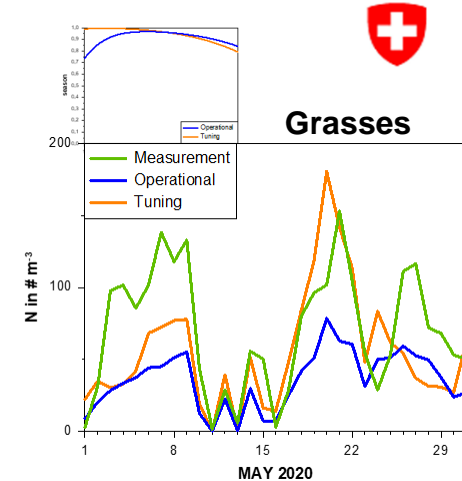
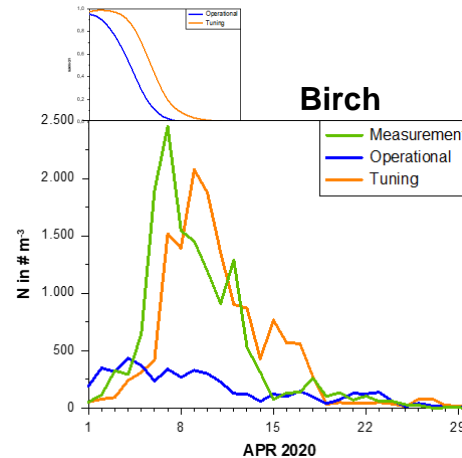
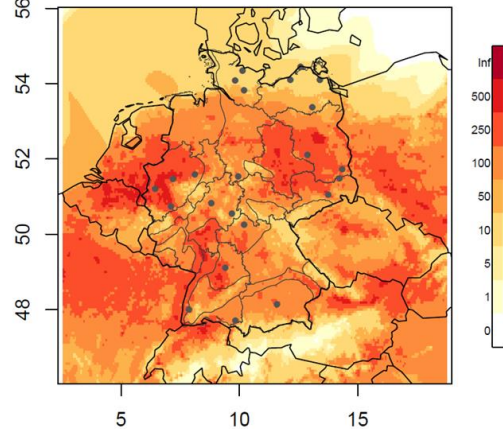
- ICON-ART-LAM: 6.5 km
- 144h-forecast (00 UTC)
- alder, birch, grasses, ragweed, hazel

MeteoSwiss

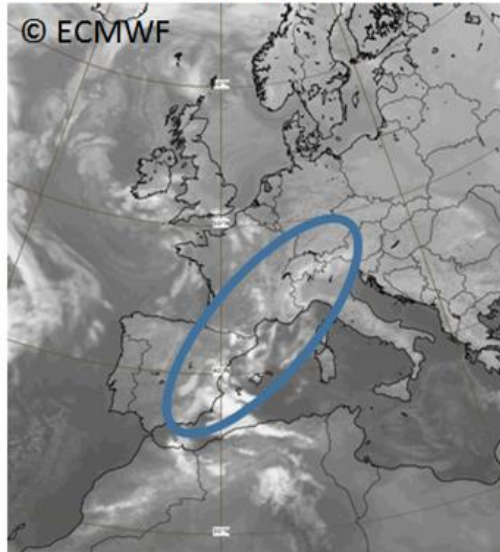
First steps for data assimilation

based on CHAPo - Automatic Pollen Network in Switzerland (~20 stations)

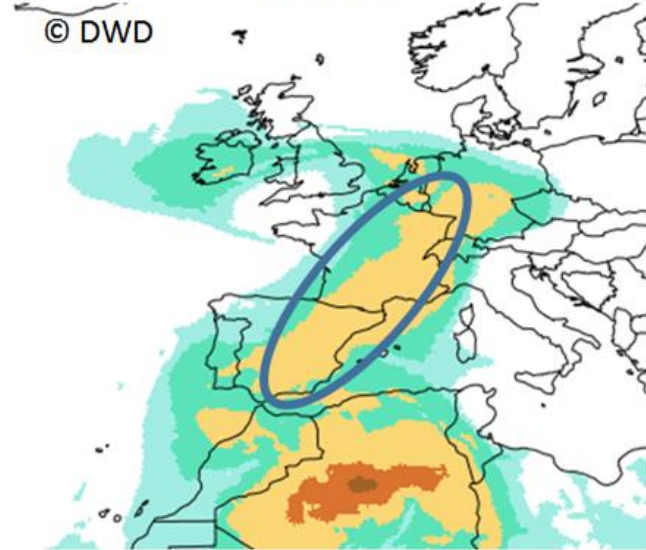
2020-04-08:BETUsnc (exp_11087)



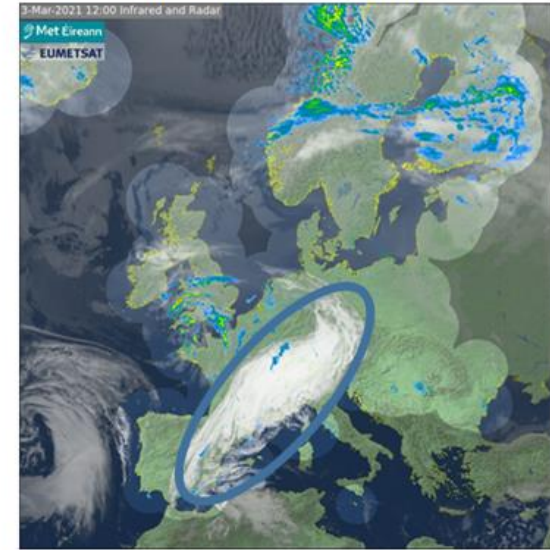
Simulated images - Infrared



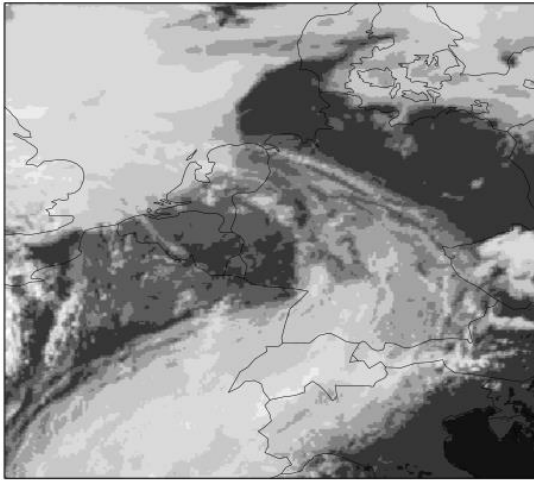
Dust AOD



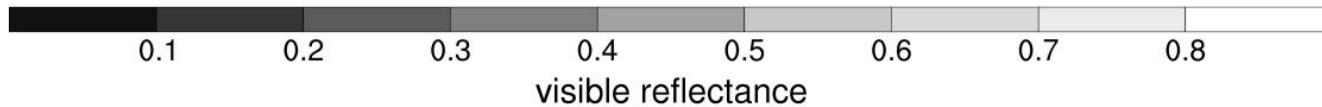
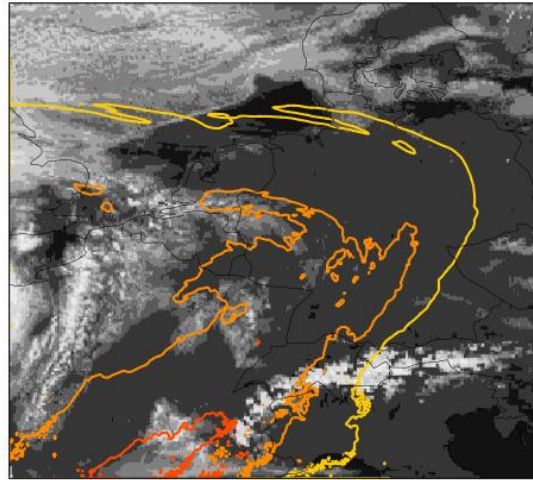
Satellite images - Infrared



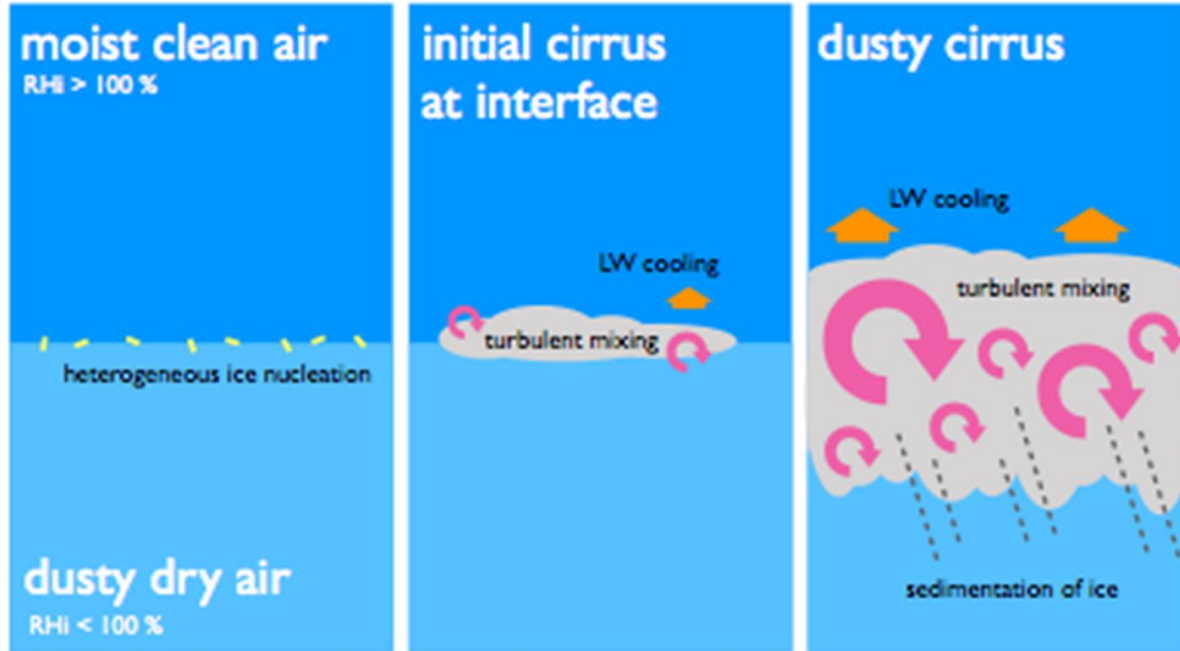
MSG-SEVIRI



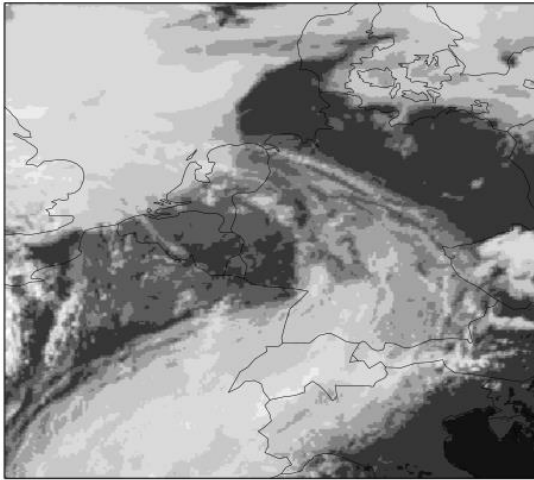
ICON-ART



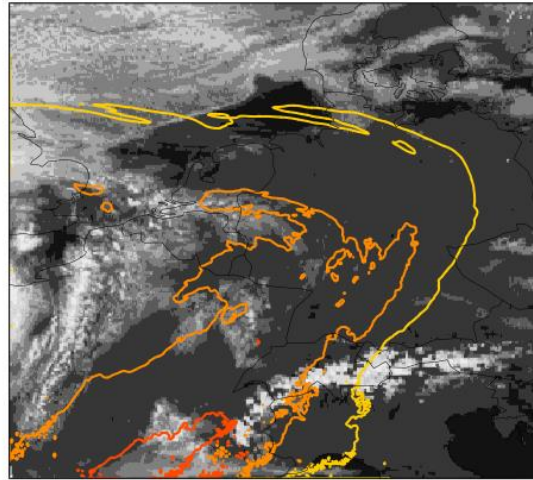
Dusty cirrus: conceptual model



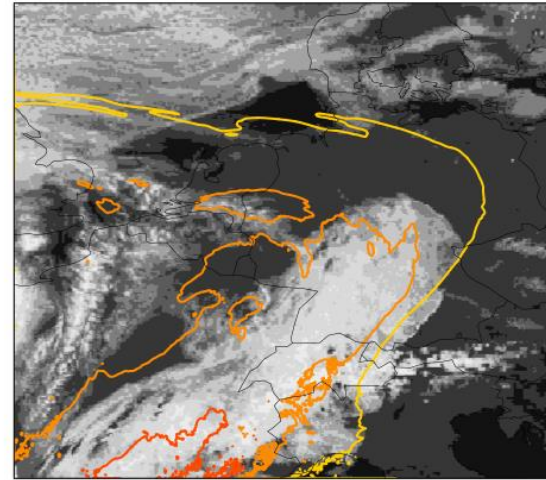
MSG-SEVIRI



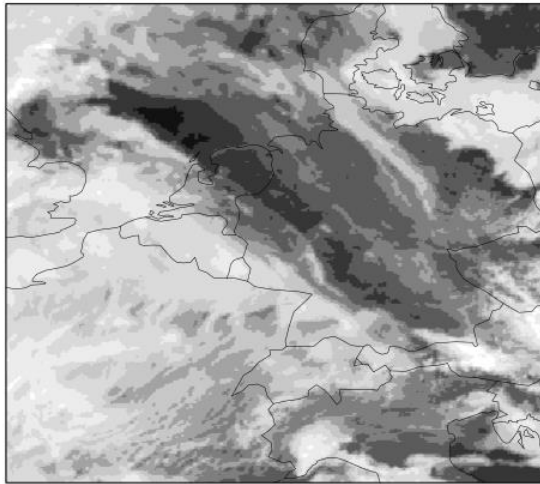
ICON-ART



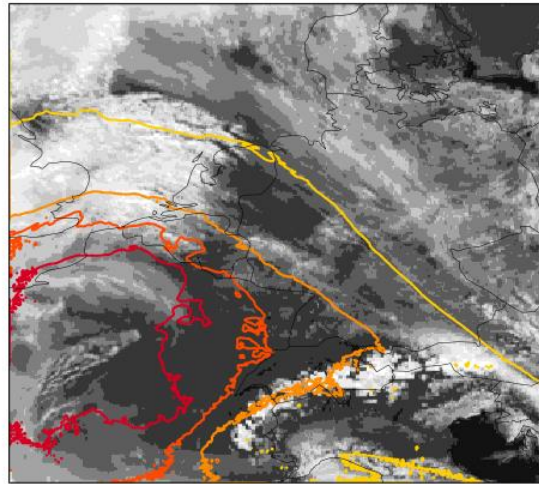
ICON-ART & „dusty cirrus“



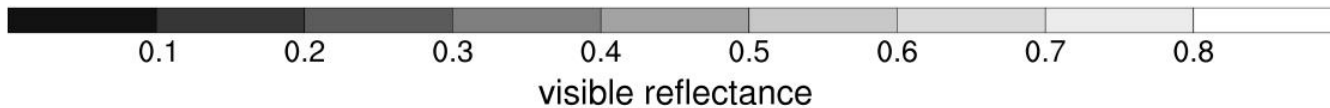
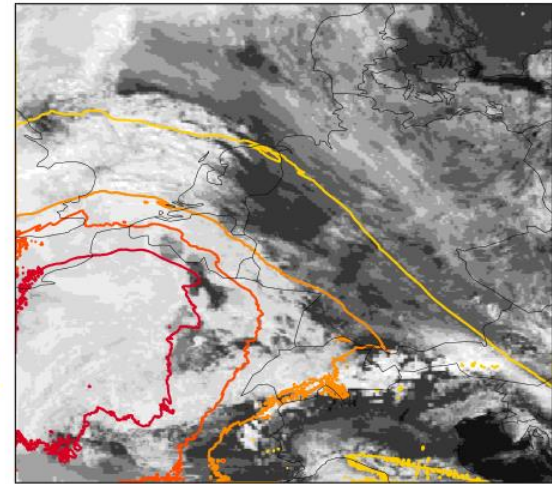
MSG-SEVIRI



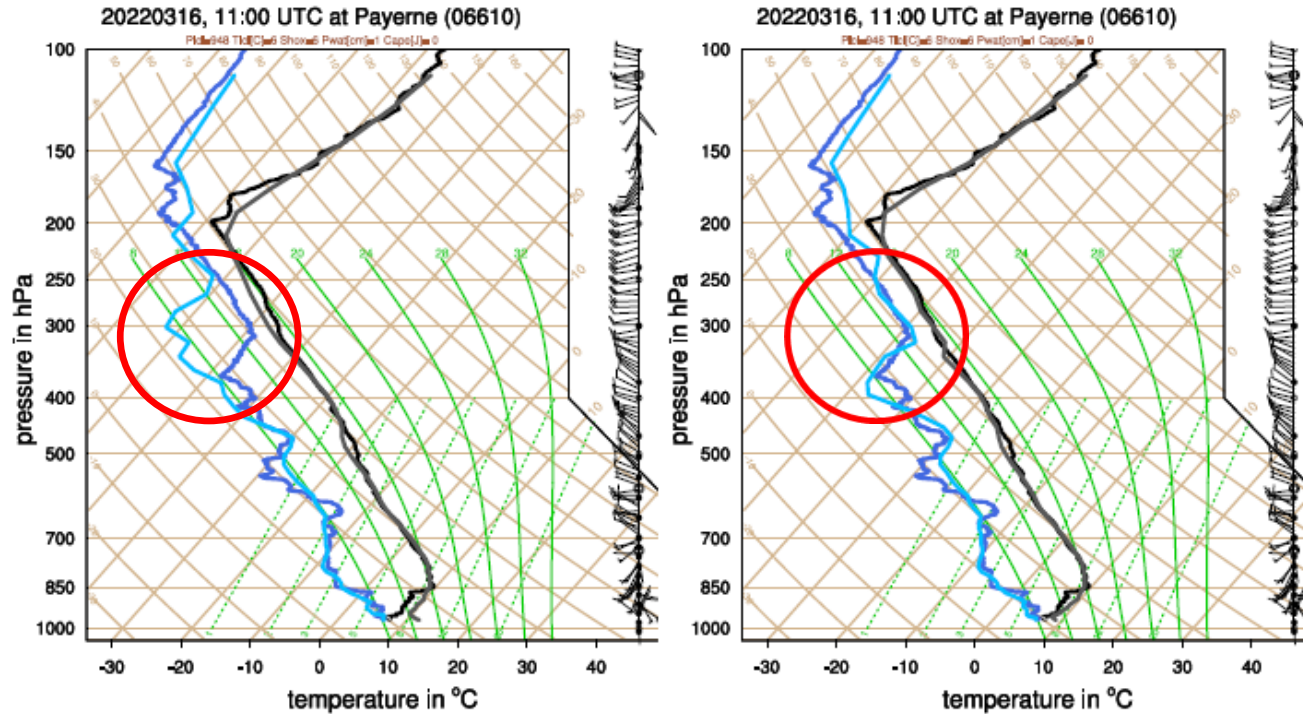
ICON-ART

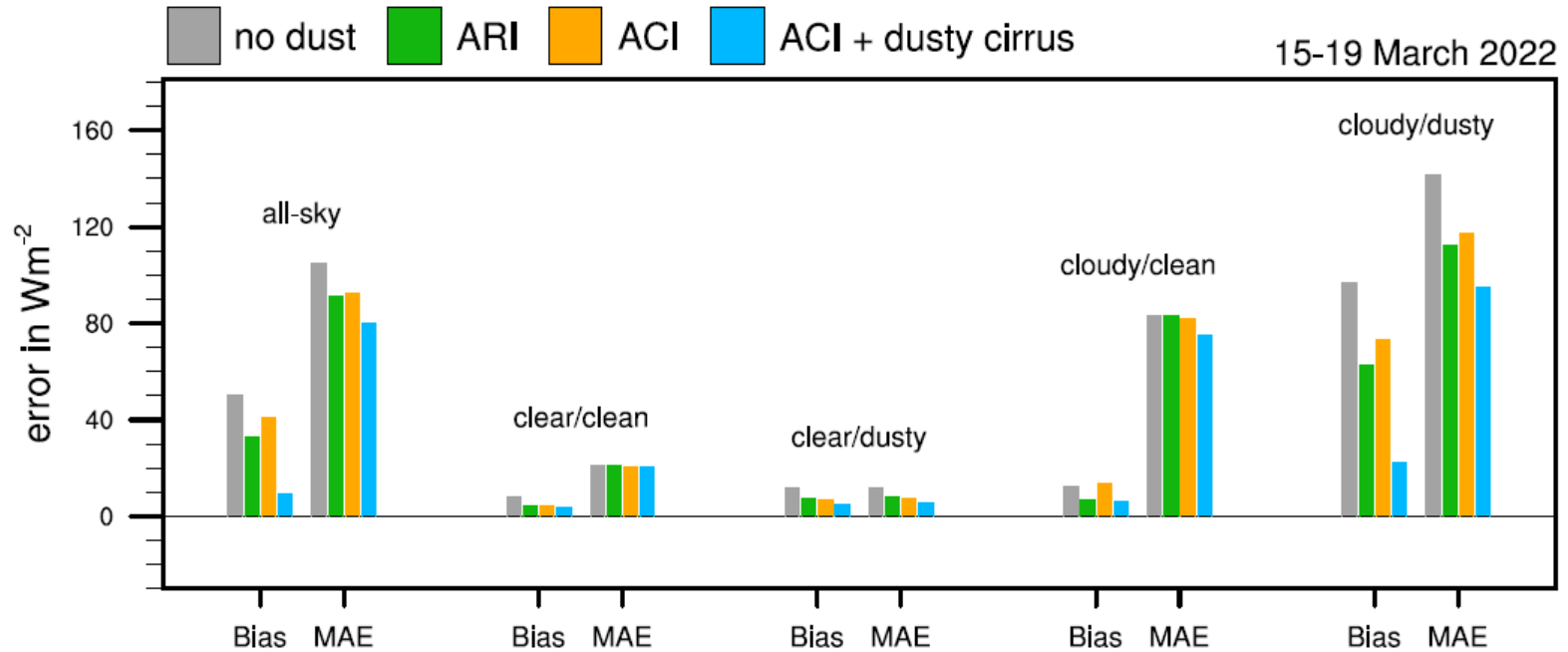


ICON-ART & „dusty cirrus“



Vertical profiles at Payerne



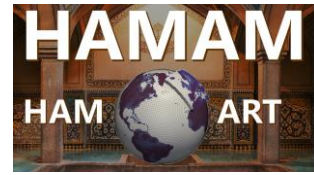


Further activities

- Porting of ICON-ART components to **GPUs starting** with online emissions module (project HAMAM)
- Development of inverse emission estimation system by coupling ICON-ART with CarbonTracker Data Assimilation Shell
- Design of a global tracer release experiment to benchmark inverse emission estimation models
- Online integration of Vegetation Photosynthesis and Respiration Model (VPRM) into ICON-ART

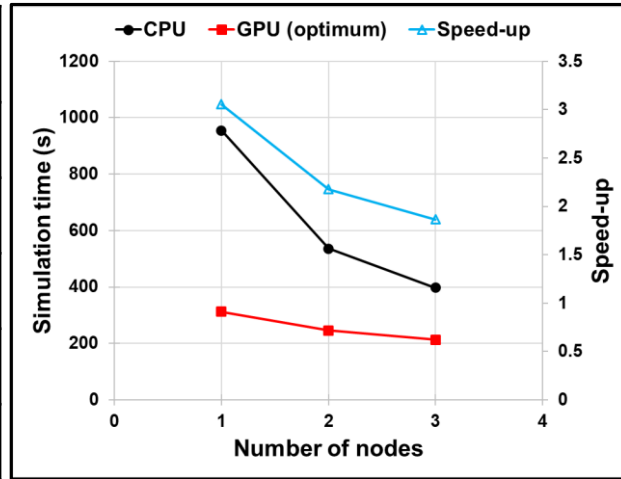


GPU porting of ICON-ART components

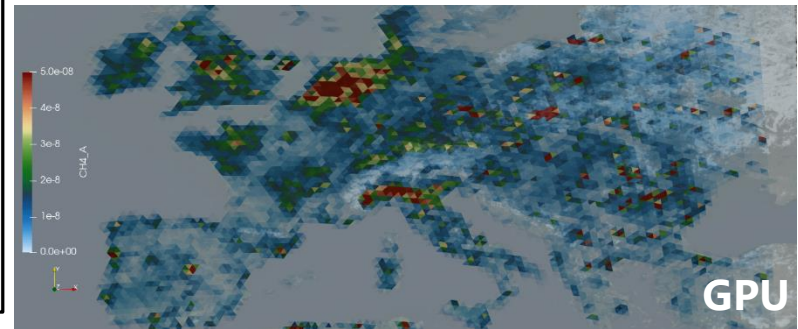
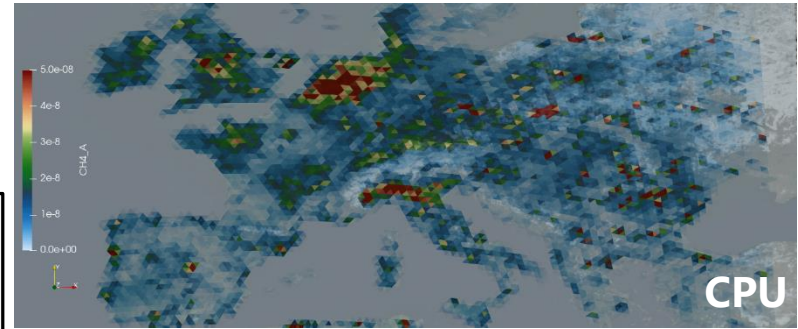


- Online emission module (OEM) ported.
- Near 3X benchmark speed-up on 1 GPU.
- Host-device data exchange is being further optimised.

Setup	ICON + OEM
Tracer	Methane
Ver. level	60
nprma	8000
Time step	15 s
Iterations	720



One node = 12 CPUs + 1 P100 GPU



CPU vs. GPU at level 1 after 720 iterations

- 🌐 **Multiphase flow:** first LES simulations of real case
- 🌐 **Interaction I:** impact on plume height of strong eruptions
- 🌐 **Aircraft icing:** development of new parameterization
- 🌐 **Pollen forecast:** operational at DWD and data assimilation at MeteoSwiss
- 🌐 **Interaction II:** SGS parametrization shows strong improvement
- 🌐 **GPU porting:** first steps successful