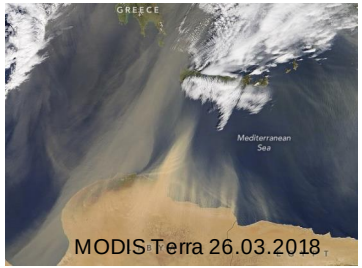
Chemistry, aerosol, clouds, and radiation in ICON-ART – Recent applications

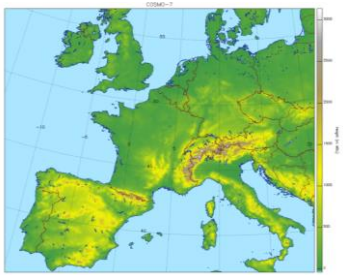
- Operational applications
- New options regarding air quality simulations
- Wild fire emissions
- RRTM → ecRad
- Optical properties
- Multiphase flow




June 21, 2019
NASA earth observatory

Pollen forecast using COSMO-ART

2011: 6.6 km



→

2021: 1.1 km

MeteoSwiss:

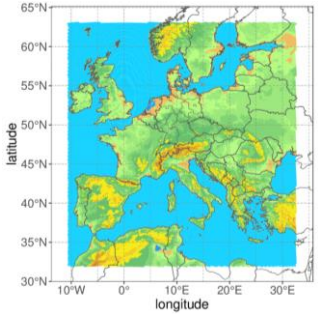
Experimental ensemble forecast

Improvement of strength of pollen season and phenology using real time pollen data
→ implementation in ICON-ART autumn/winter 2021

Implementation of hazel pollen
→ implementation in ICON-ART 2021/2022

Pollen forecast using ICON-ART

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

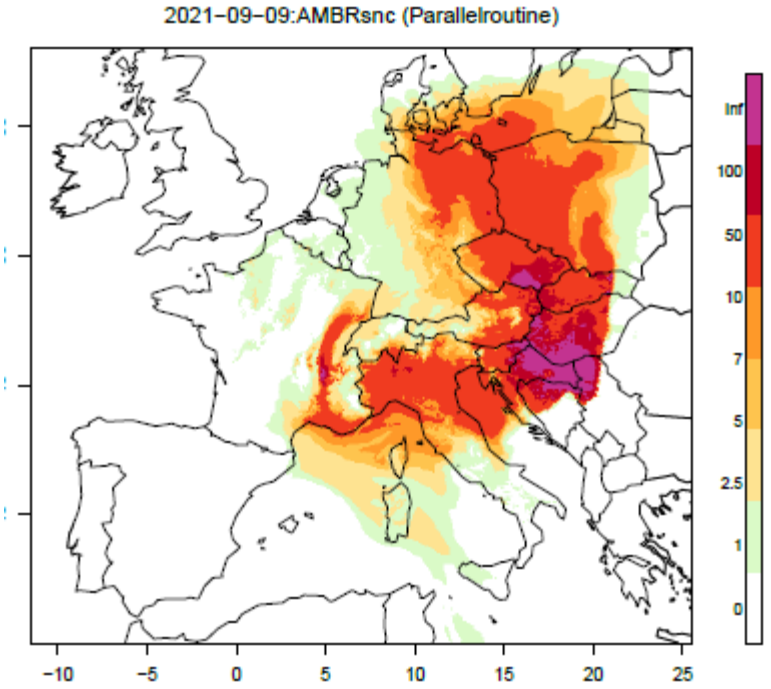


ICON-ART-LAM: 6.5 km

144h-forecast (00 UTC)

4 species: alder, birch, grasses, ragweed

operational in 2021



Jochen Förstner, Christina Endler, Stefan Muthers et al.

Pollen forecast using ICON-ART

Deutscher Wetterdienst
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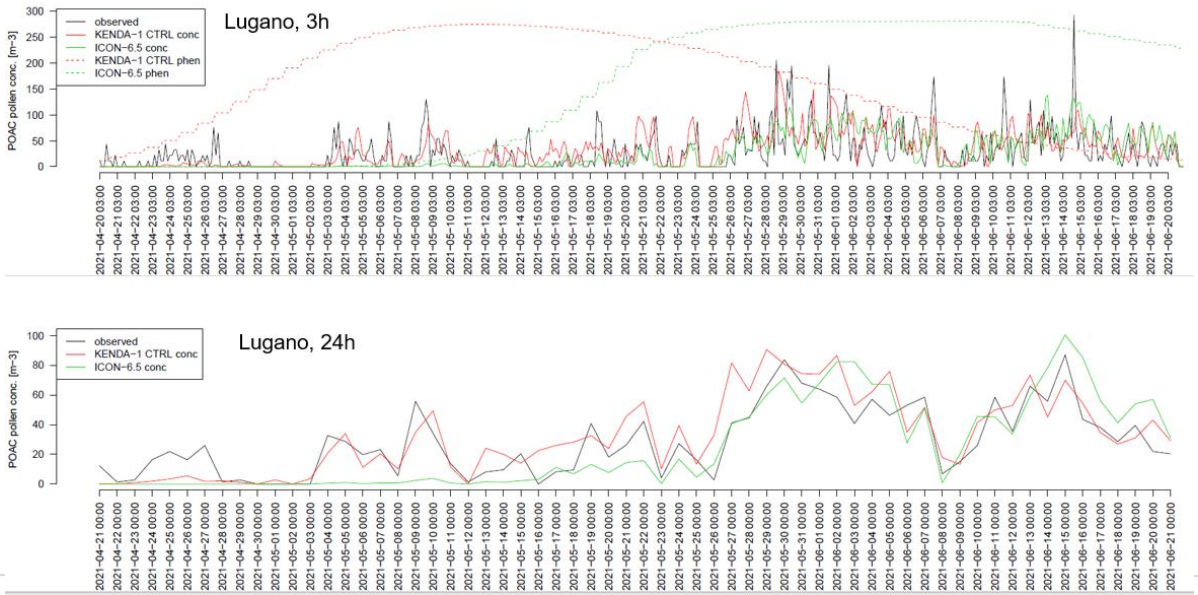
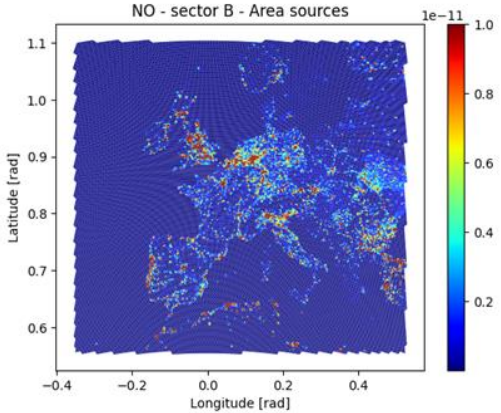
comparison COSMO-ART & ICON-ART

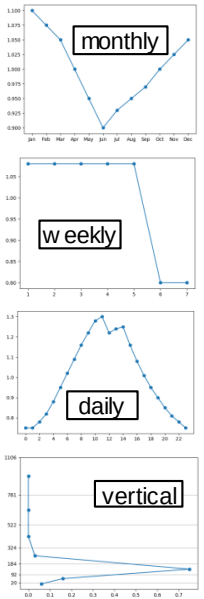


Andreas Pauling

Online emission module



X



- Gridded emissions from TNO inventory
  → remapping to ICON grid
  Species : NH_3, SO_2, NO_X, CO, CH_4, NMVOCs

- Temporal and vertical profiles

- NMVOC split provided by TNO: 23 categories

Air pollution simulations over Europe with ICON-ART

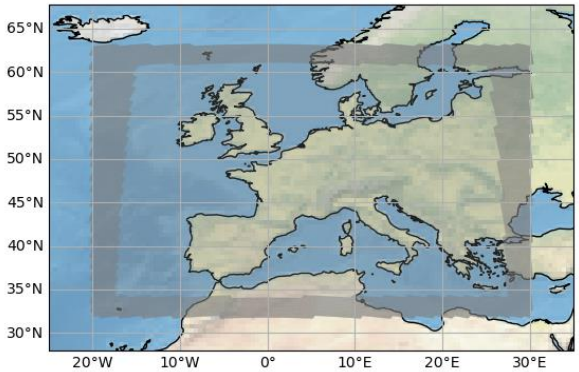
Limited Area Mode (LAM), 01.01. – 20.01.2015

Domain : Western Europe ≈13km resolution

Gas-phase chemistry scheme MOZART-4

Lateral boundary conditions :

- Chemistry data: global model MOZART-4
- Meteorological data: IFS model

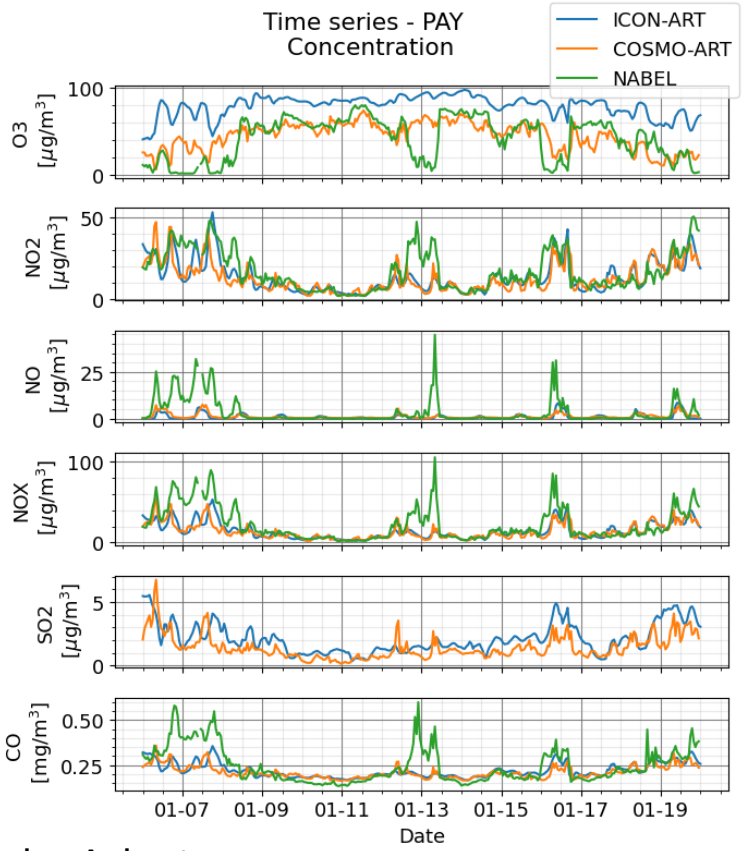


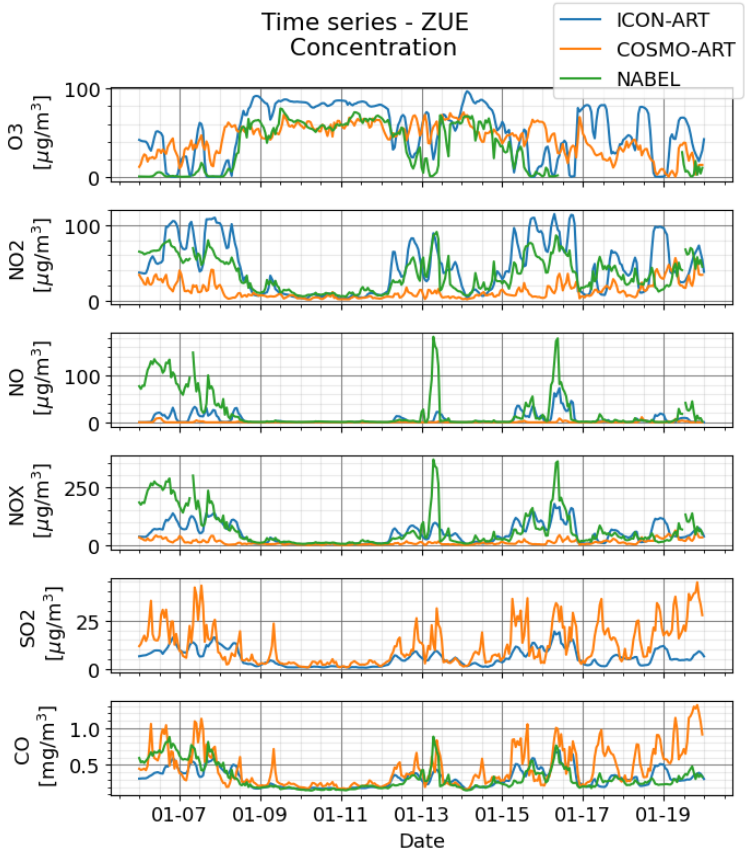
Louise Aubert

Results

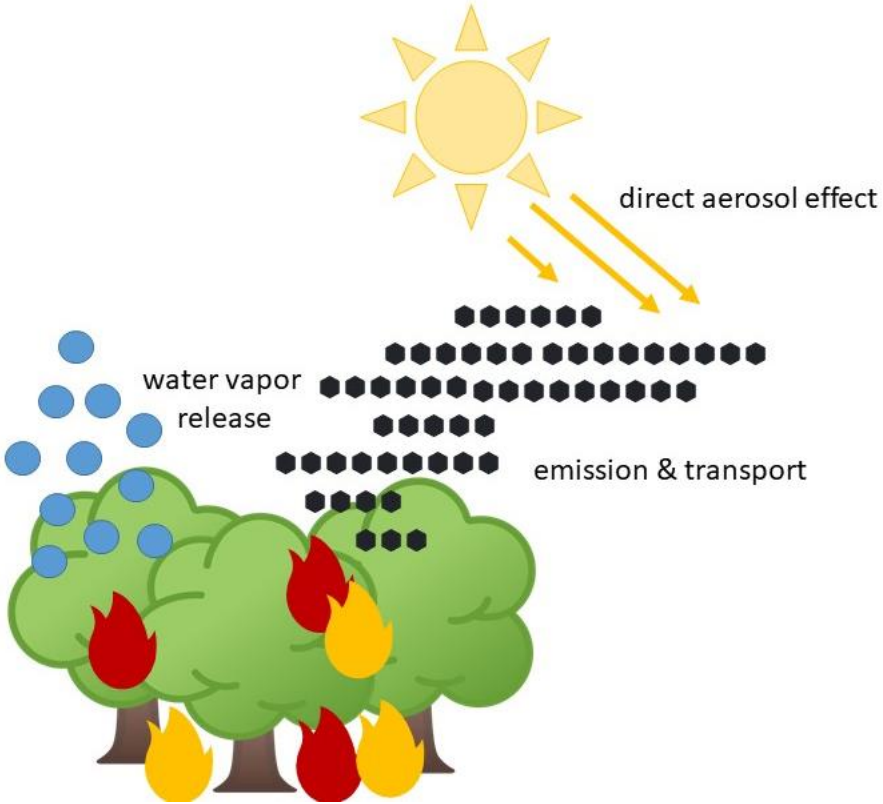
Empa
Materials Science and Technology

KIT
Karlsruhe Institute of Technology

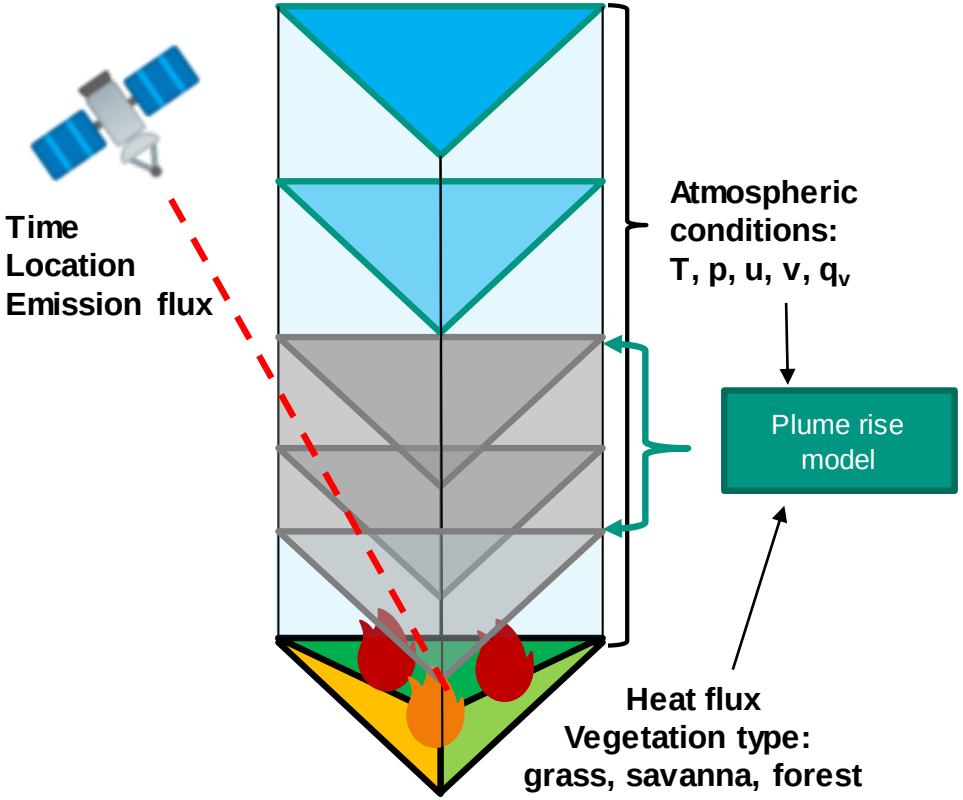




Biomass burning aerosols in ICON-ART



Parameterisation (Freitas et al, 2006, Walter et al., 2015)



$$E_{bc}(z) = F_{bc} \cdot W_{emiss}(z) \cdot c_{emiss} \cdot \frac{1}{\Delta z}$$

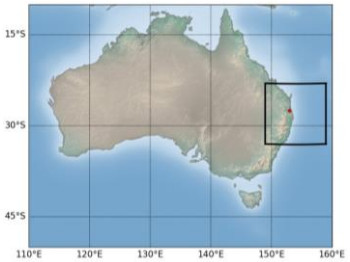
daily mean flux soot

vertical distribution

diurnal cycle

layer size

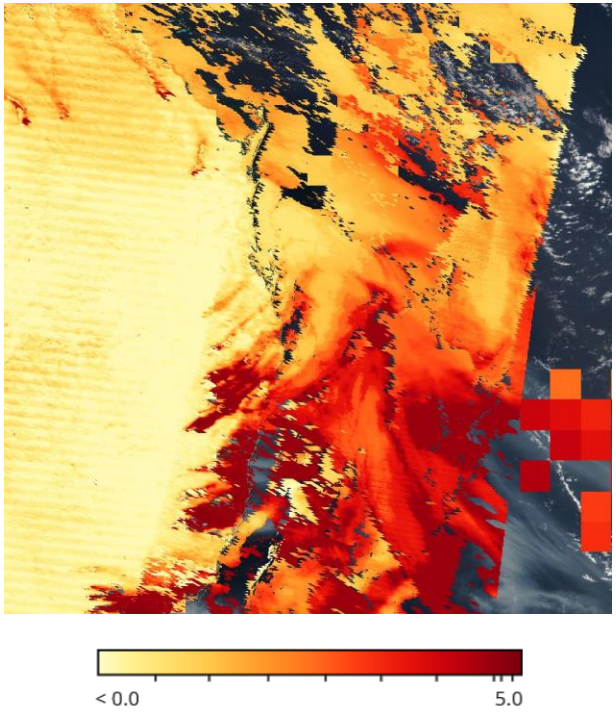
AOD MODIS & ICON-ART 4.12.2019 00:00 UTC



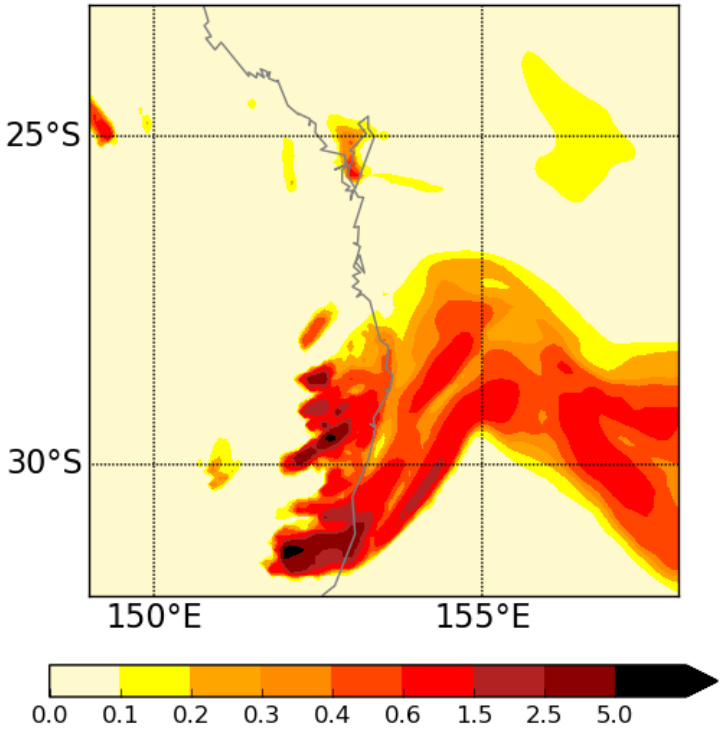
LAM Simulation
Resolution: ~ 6.5km

Start: 3.12.2019
End : 7.12.2019

soot as passive tracer

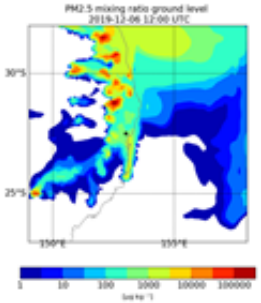


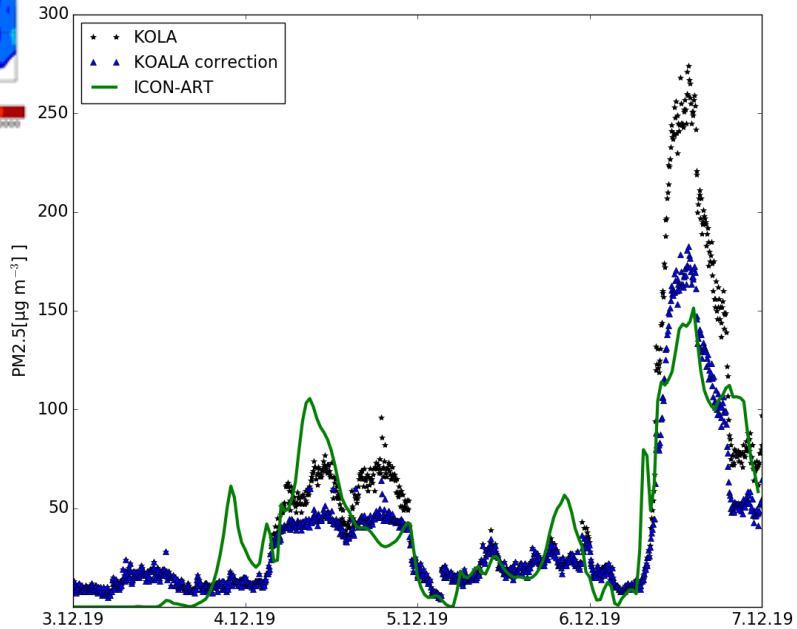
https://worldview.earthdata.nasa.gov/



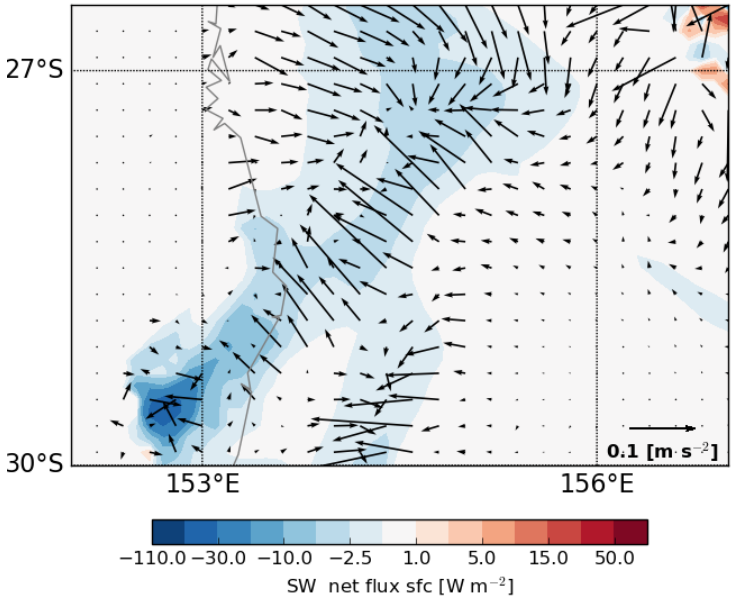
Lisa Muth

PM2.5 comparison and impact on wind field





Difference v_h 04.12.2019, 02:00 UTC
rad – no rad



Lisa Muth

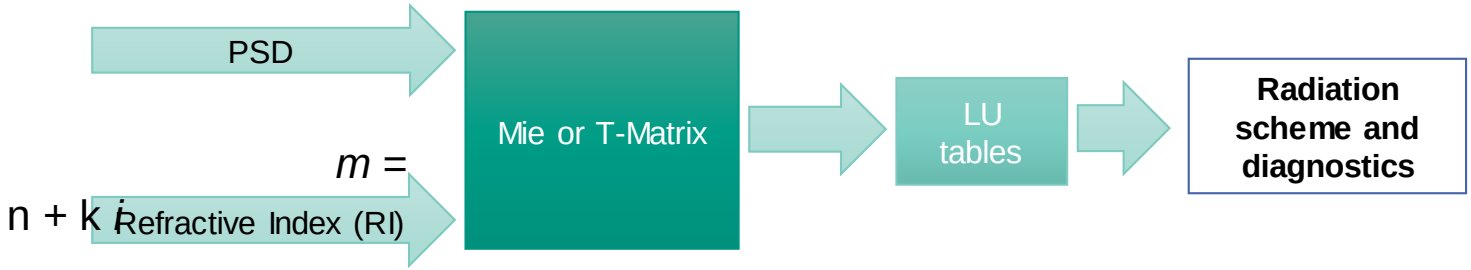
Aerosol optical properties in ICON-ART

- Natural aerosols as externally mixed:

Saharan Dust,	*3 modes,*	*Shape*
Volcanic Ash	*3 modes,*	*Shape, composition*
Sea Salt	*3 modes,*	*RH = 70%*
Biomass Burning	*1 mode*	*Composition (OC/BC = 30), shape: sphere*

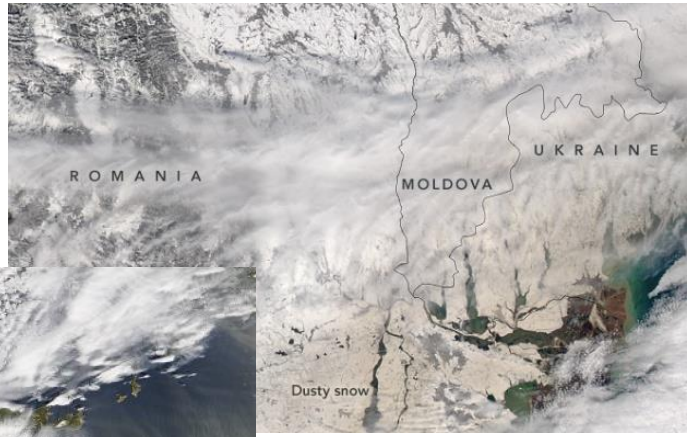
- Natural aerosols as internally mixed:

Volcanic Aerosols	*Aerodyn,*	*Core-Shell*

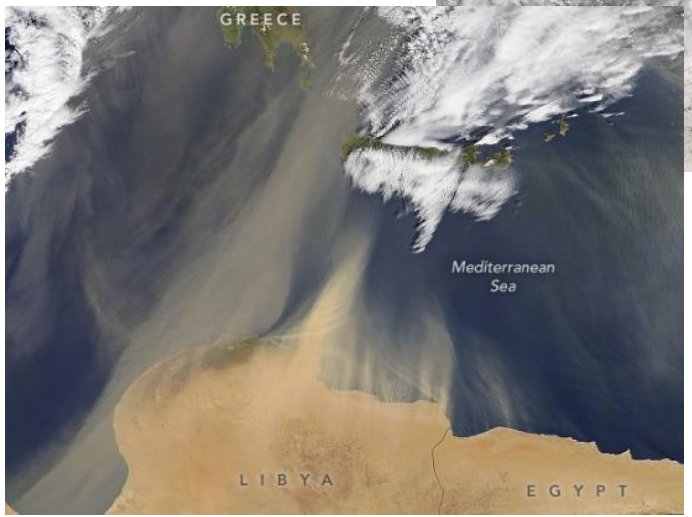


Coupling of ICON-ART and ecRad

- Restructuring and transfer of optical properties implemented
- Test case: Saharan dust transport event 2018
- model configuration:
  - R2B06 (~ 40 km)
  - 10 days
  - ICON-ART + ecRad
  - ICON-ART + RRTM

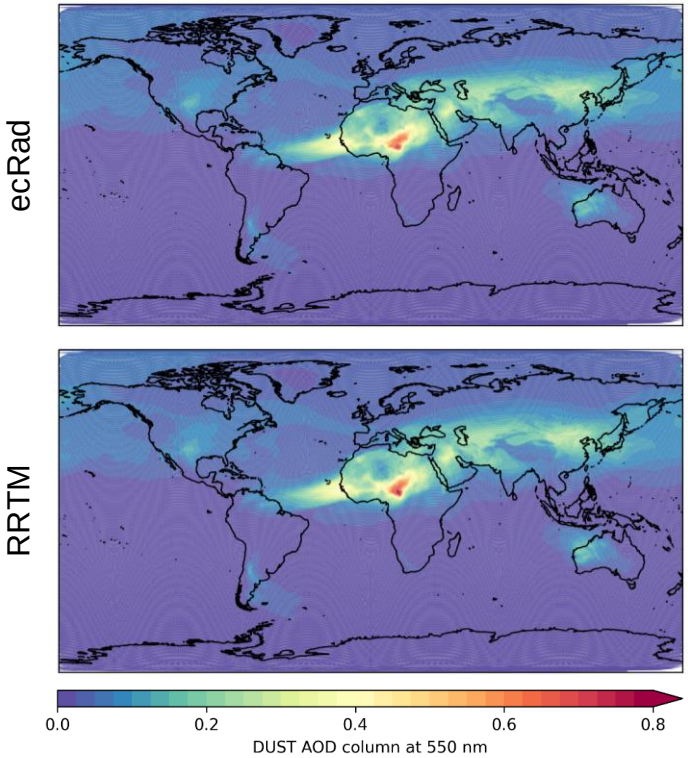


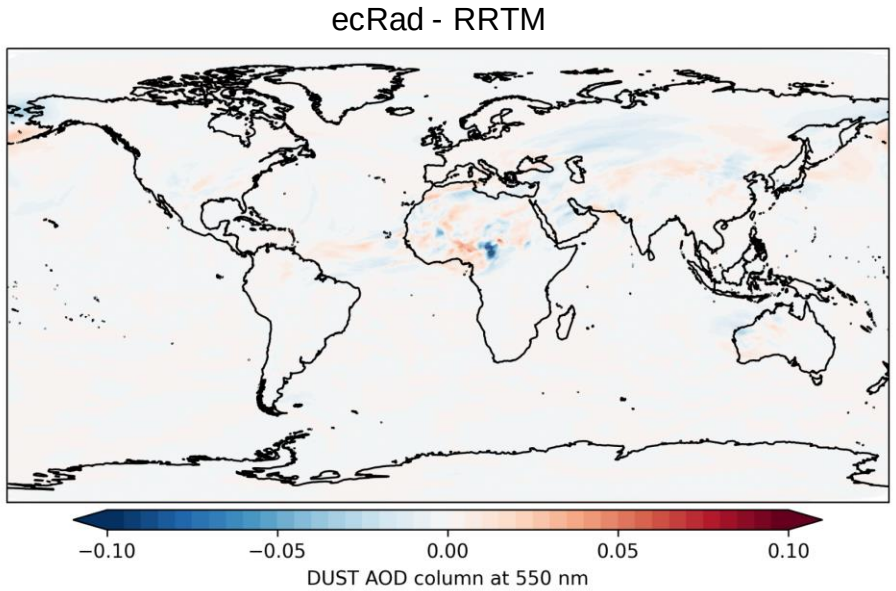
MODIS Aqua 24.03.2018



MODIS Terra 26.03.2018

Coupling of ICON-ART and ecRad

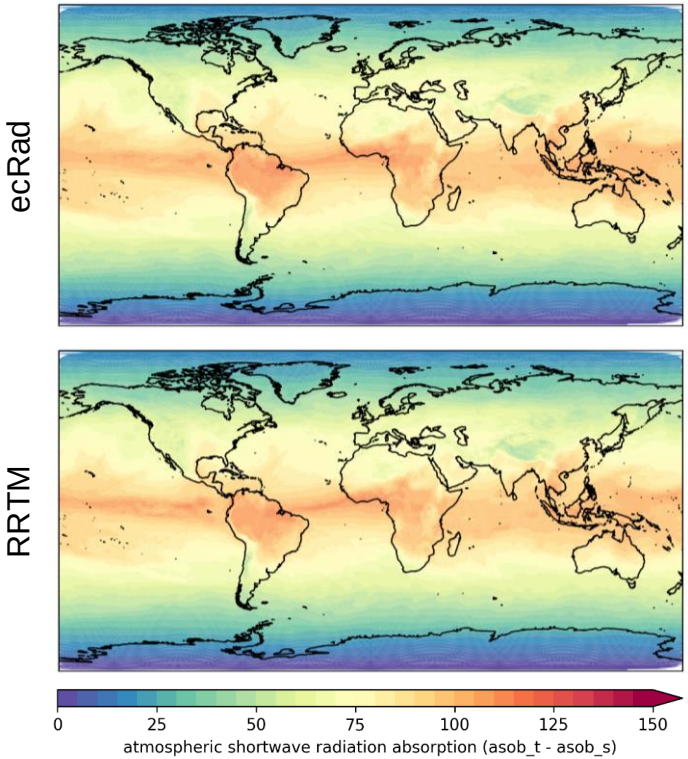


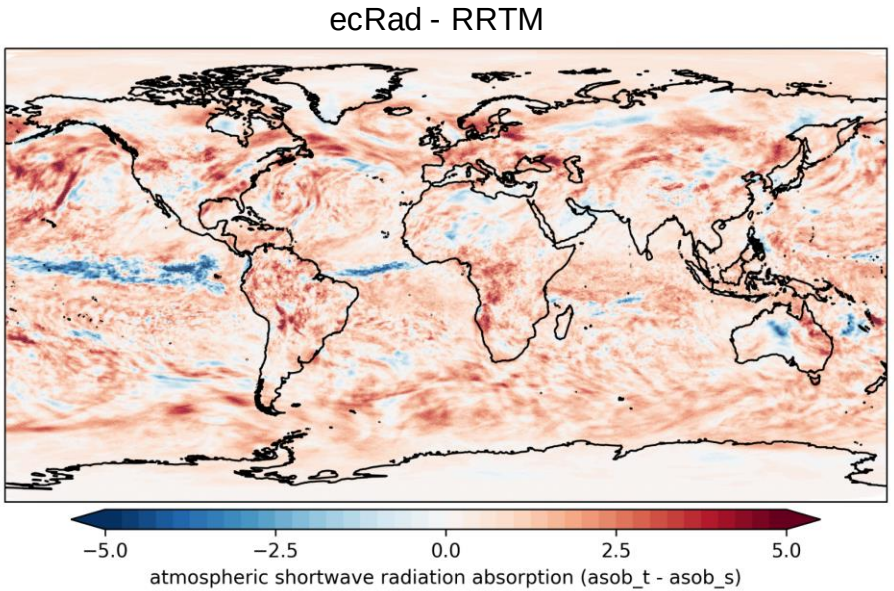


Aerosol Optical Depth:

Mean difference over 10 days: 4 %

Coupling of ICON-ART and ecRad

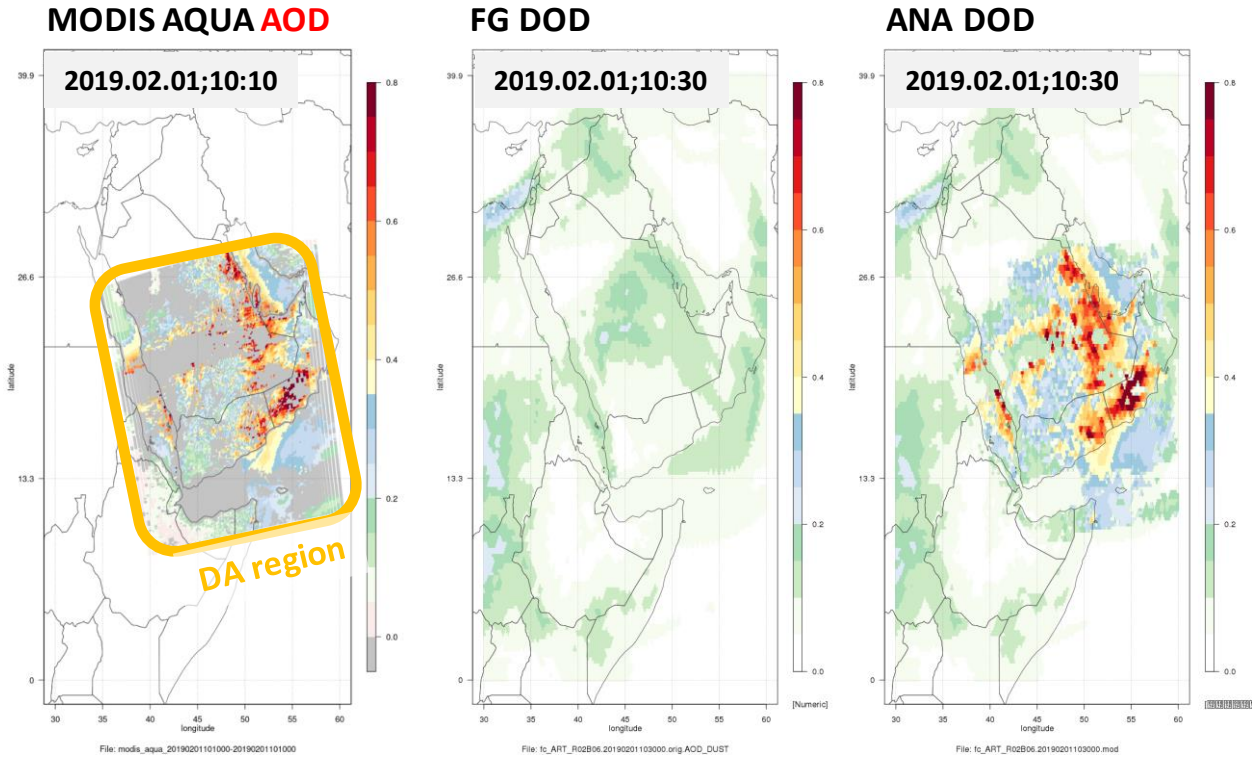




Atmospheric shortwave absorption:

Mean difference over 10 days: 1.6 %

ICON-ART dust assimilation – first results

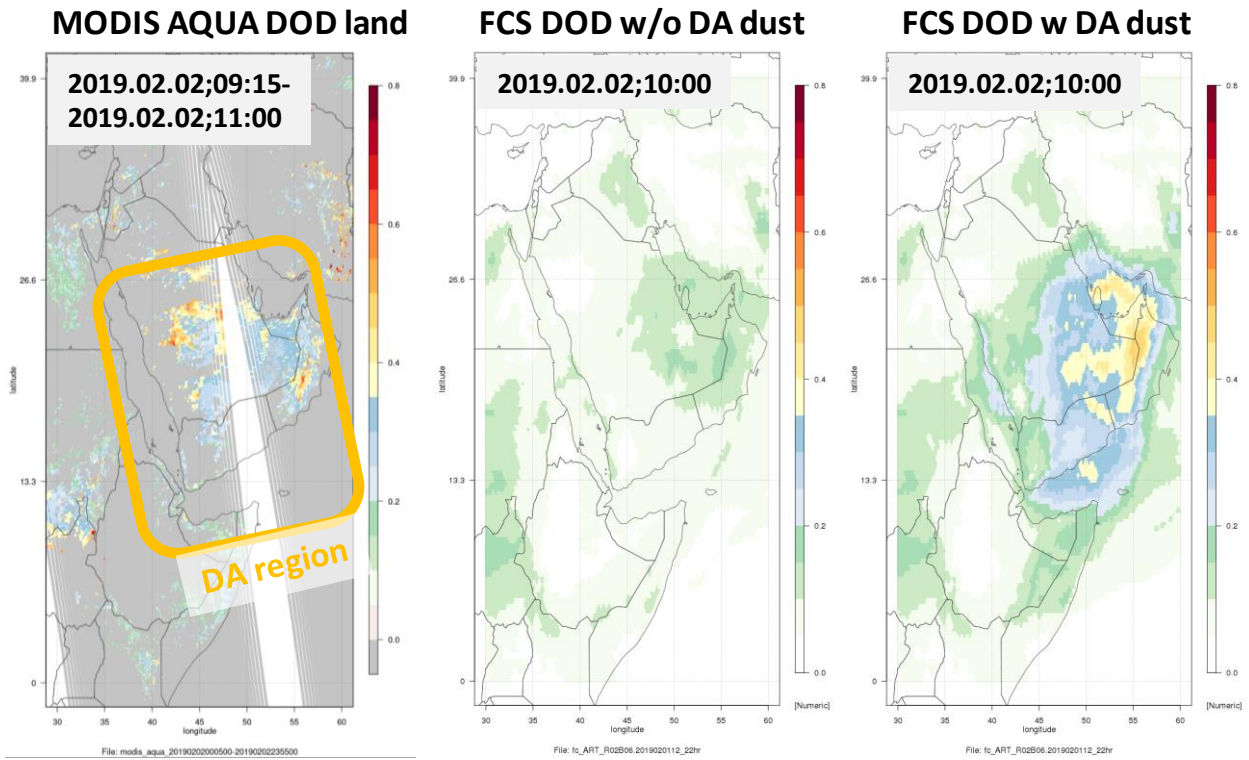


First test:
no observation error,
ass. of AOD

2019.02.01;10:30 UTC

Vanessa Bachmann

ICON-ART dust assimilation – first results



Deutscher Wetterdienst
Wetter und Klima aus einer Hand

First test:
no observation error,
ass. of AOD

2019.02.02;10:00
(22 h fcs)

Vanessa Bachmann

Multiphase flow

Density of tracer modifies the flow

Modification of the ICON equations **(Daniel Reinert)**

$$\frac{\partial \bar{\rho}}{\partial t} + \nabla \cdot (\bar{\rho}\hat{\boldsymbol{v}}) = 0 \qquad \bar{\rho} = \bar{\rho}_d + \bar{\rho}_a$$

$$\frac{\partial \bar{\rho}\hat{q}_a}{\partial t} + \nabla \cdot (\bar{\rho}\hat{q}_a\hat{\boldsymbol{v}}) = -\nabla \cdot \left(\bar{\boldsymbol{S}}_a + \overline{\rho q_a'' \boldsymbol{v}''}\right)$$

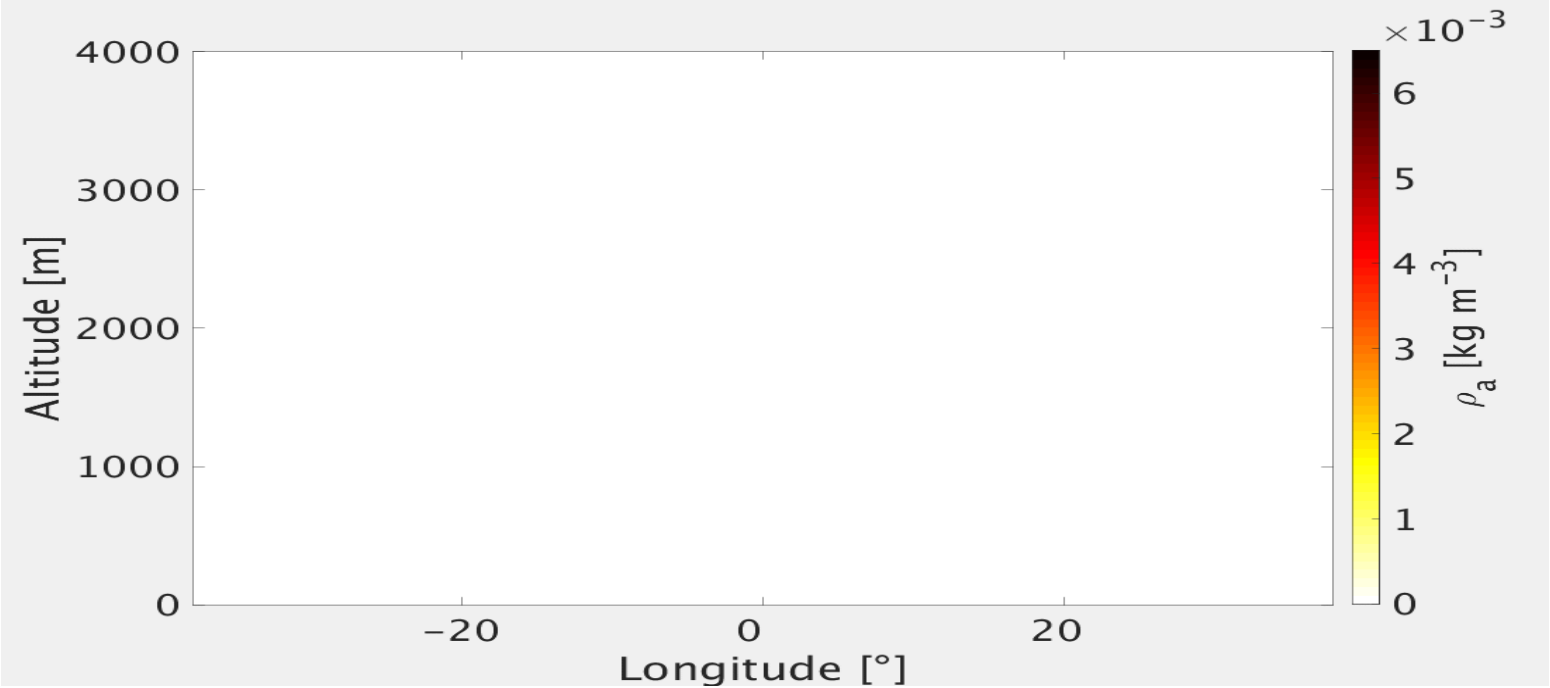
$$\hat{\boldsymbol{v}} = \frac{\bar{\rho}_d\hat{\boldsymbol{v}}_d + \bar{\rho}_a\hat{\boldsymbol{v}}_a}{\bar{\rho}}$$

at the surface: $\hat{\boldsymbol{w}}_s = \frac{\bar{\rho}_a\hat{\boldsymbol{w}}_a}{\bar{\rho}_d}$

Multiphase flow (first results)

Eruption

Δx = 100 m



Summary

- **Pollen forecast:** operational with ICON-ART at DWD
- **Air quality:** online emission module, options for gas phase chemistry
- **Aerosol:** additional emission modules
- **Interaction:** ecRad implemented, improvement optical properities
- **Assimilation:** first steps, dust & volcanic ash
- **Multiphase flow:** implemented (plume simulation in LES)
- **AERODYN:** implemented in the next release version