Prolog

KIT
Karlsruhe Institute of Technology

Clouds

Dust optical depth

Forecast

© DWD

© ECMWF

Satellite
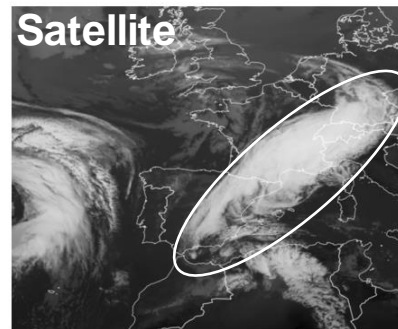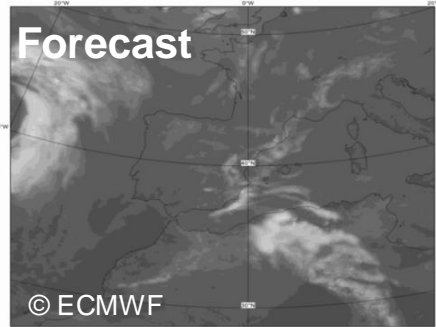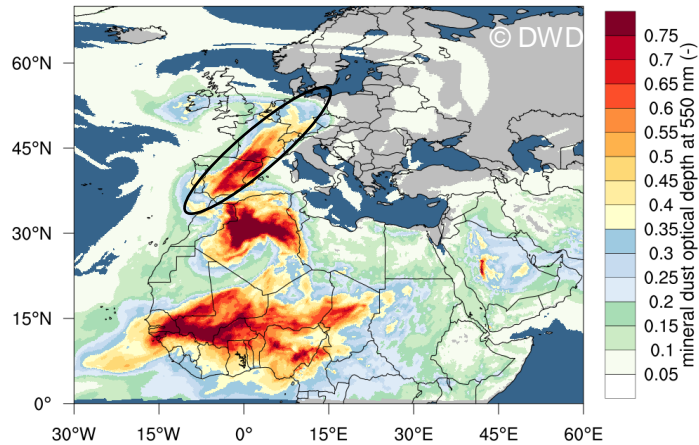
Surface solar radiation forecast – observed

© Kilian Hermes

March 3, 2021

Institute of Meteorology and Climate Research
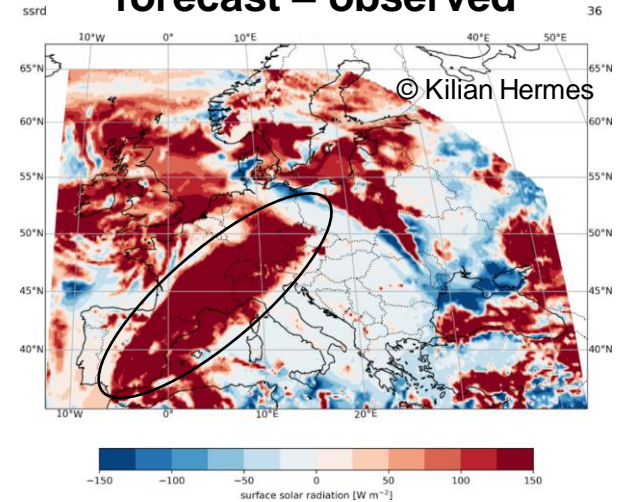
ICON-ART & COSMO-ART

- Operational applications

- New options regarding air quality simulations

- Wild fire emissions

- RRTM → ecRad

- Optical properties

- Multiphase flow

Leonard Parsek

MODIS Terra 26.03.2018

June 21, 2019
NASA earth observatory

https://dailynewsegypt.com/2021/01/08/australian-bushfires-to-be-more-severe/
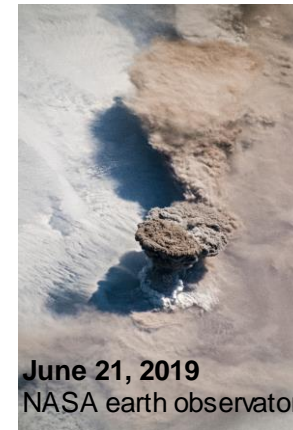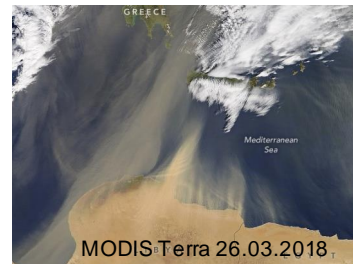
Pollen forecast using COSMO-ART

2011: 6.6 km → 2021: 1.1 km

MeteoSwiss:
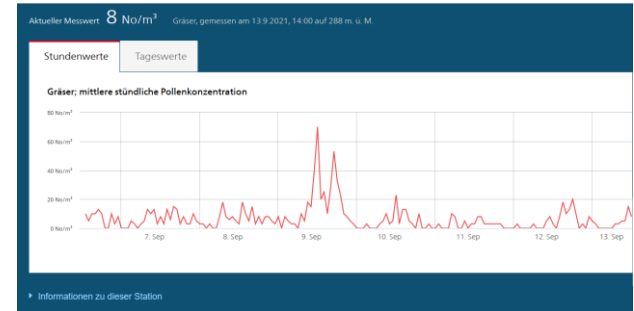
Experimental ensemble forecast

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

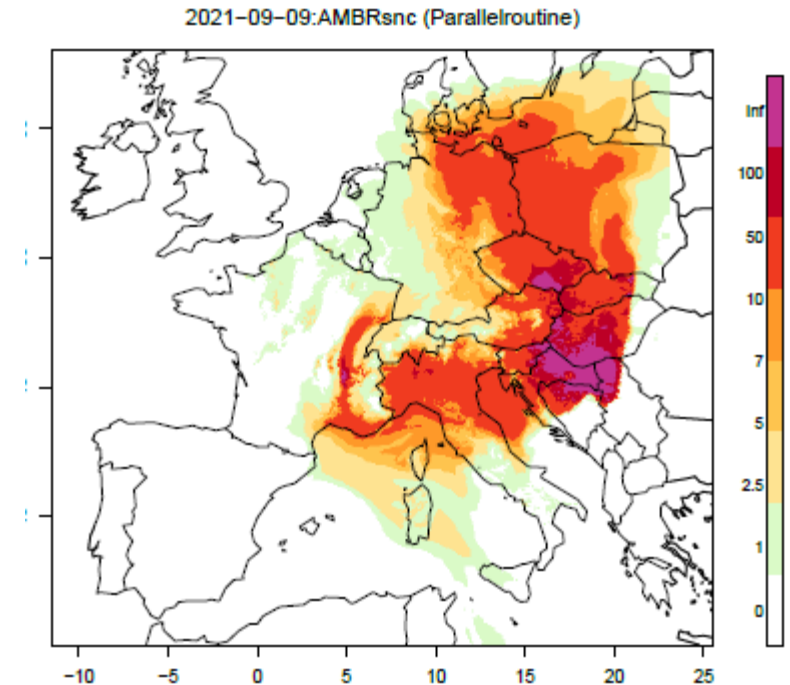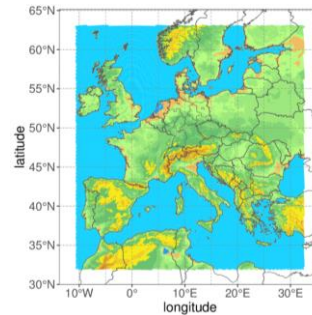Andreas Pauling et al.
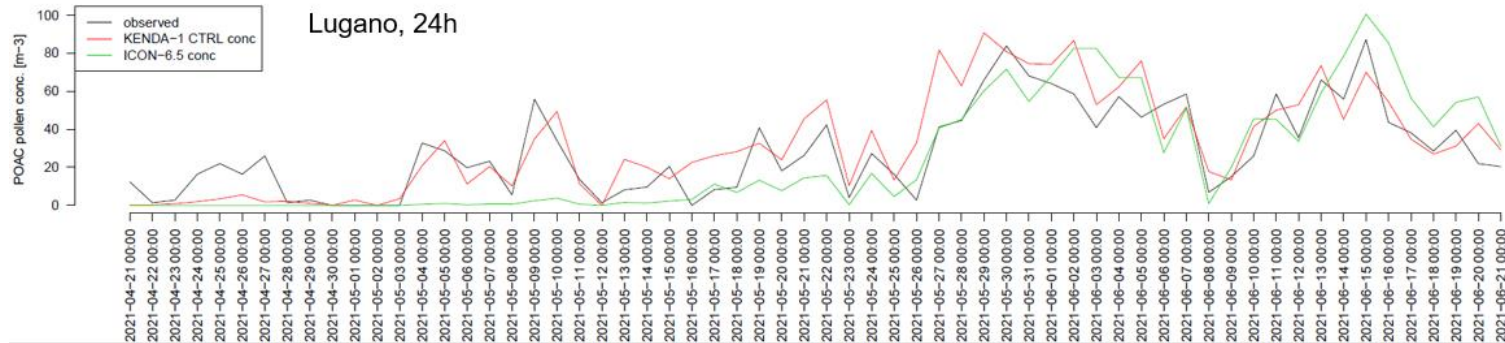
Pollen forecast using ICON-ART

ICON-ART-LAM: 6.5 km

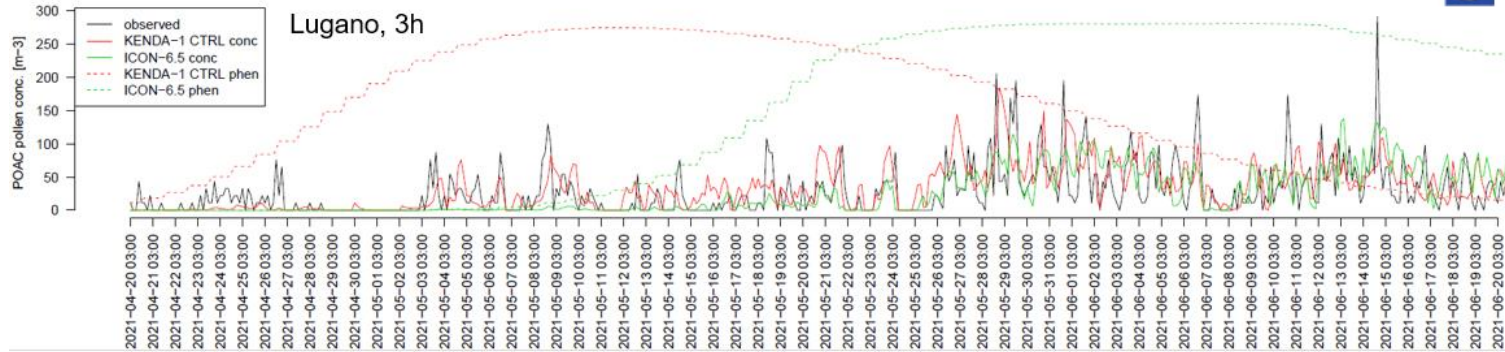144h-forecast (00 UTC)

4 species: alder, birch, grasses, ragweed

operational in 2021

2021-09-09:AMBRsnc (Parallelroutine)

Jochen Förstner, Christina Endler, Stefan Muthers et al.

Comparison COSMO-ART & ICON-ART

Andreas Pauling

ICON-ART dust forecast

KIT Dust dashboard:

https://www.imk-tro.kit.edu/english/10581.php

WMO Dust forecast:

https://sds-was.aemet.es
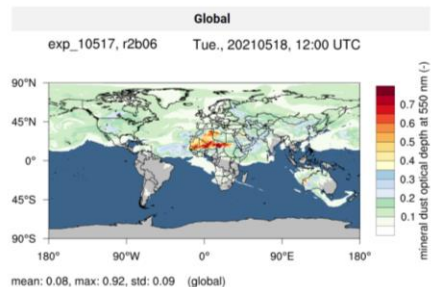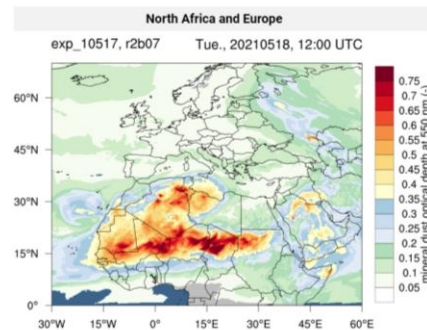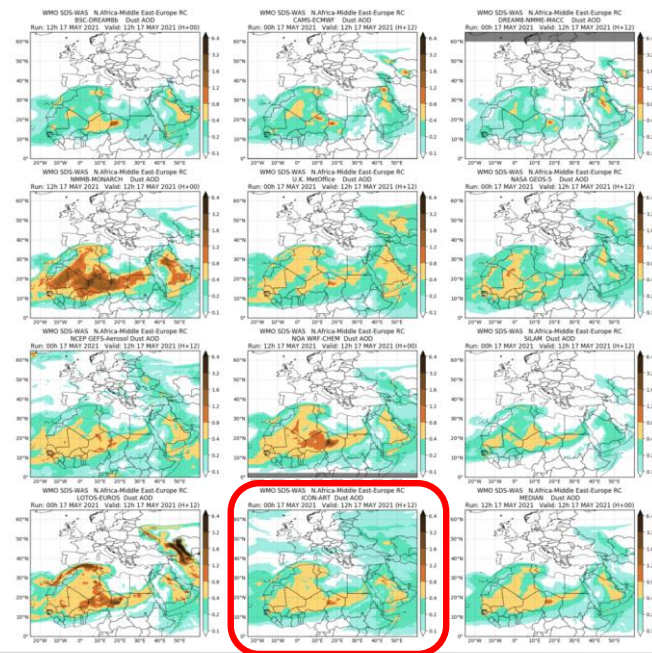
Air pollution simulations over Europe with ICON-ART

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

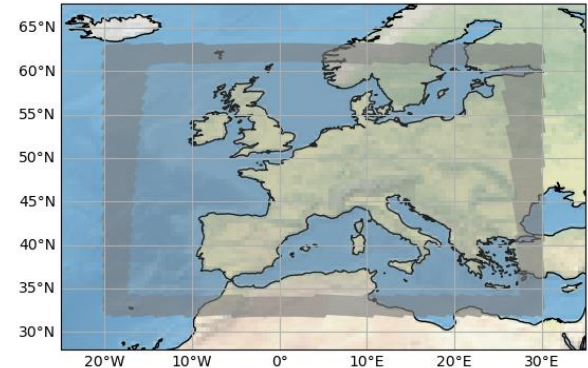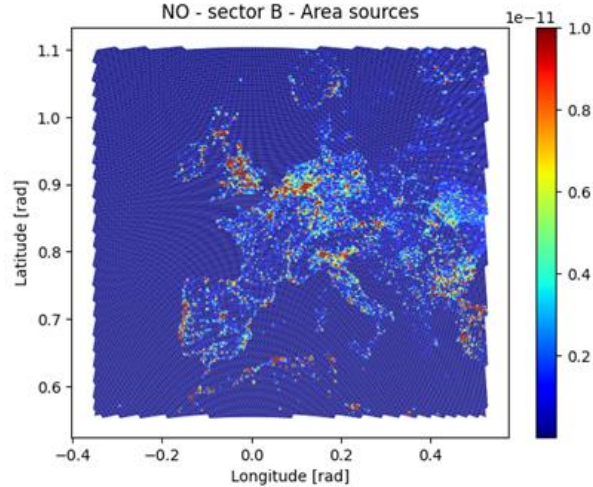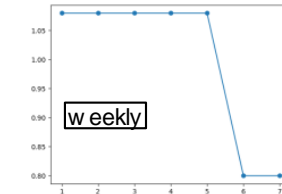# Online emission module

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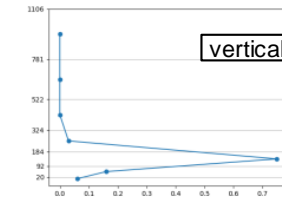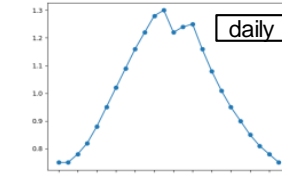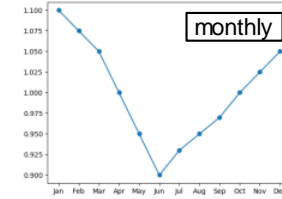
- Gridded emissions from TNO inventory
  → remapping to ICON grid
  Species : NH_3, SO_2, NO_X, CO, CH_4, NMVOCs

- Temporal and vertical profiles

Michael Steiner

Results

Louise Aubert
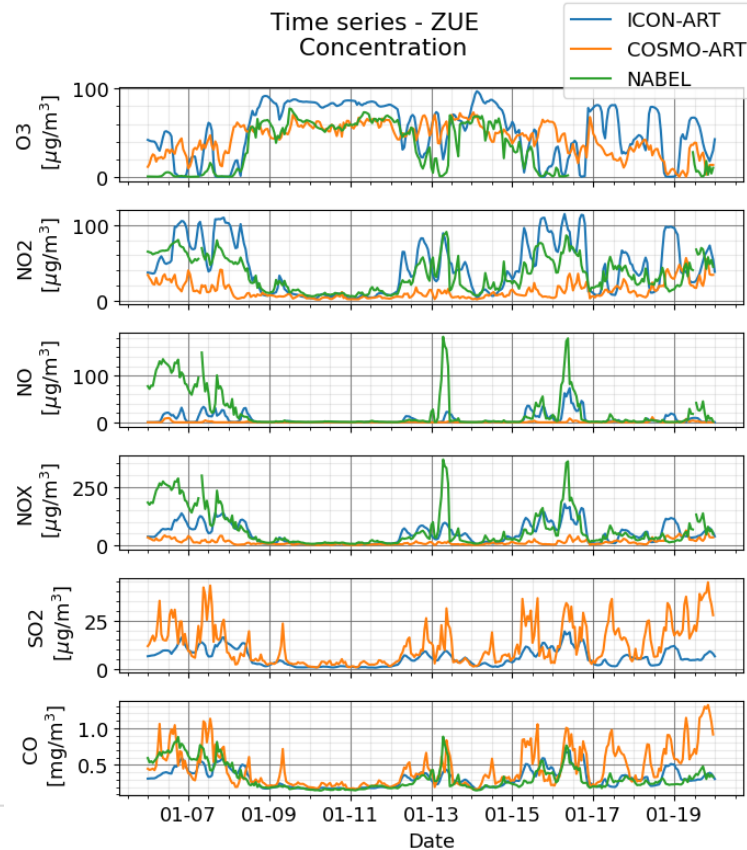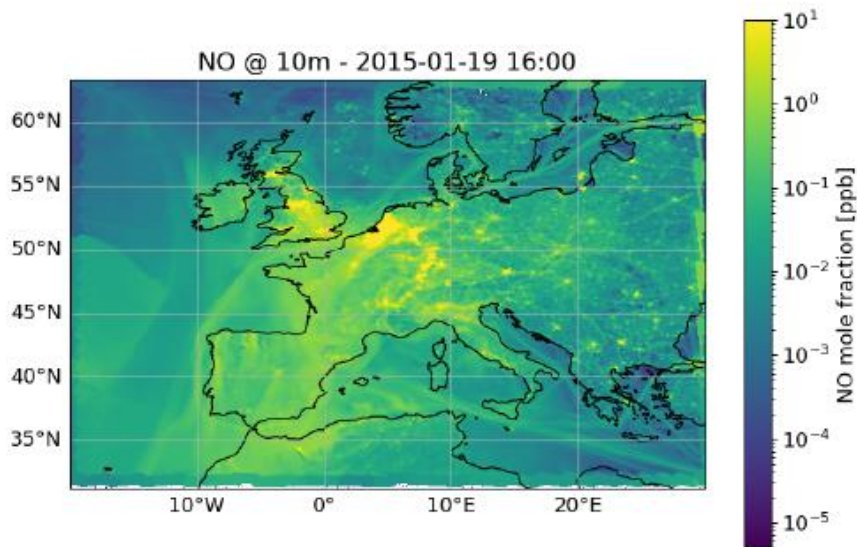
Biomass burning aerosols in ICON-ART

**Time
Location
Emission flux**

**Atmospheric conditions:
T, p, u, v, q$_v$**

Plume rise model

**Heat flux
Vegetation type:
grass, savanna, forest**
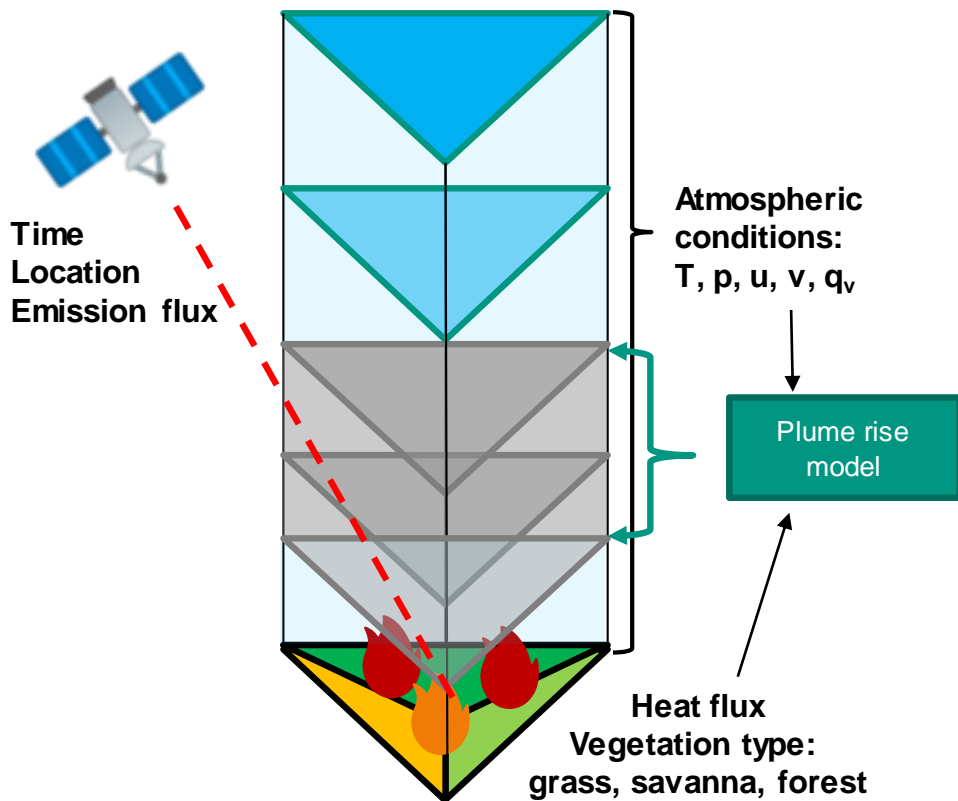
$$E_{bc}(z) = F_{bc} \cdot W_{emiss}(z) \cdot c_{emiss} \cdot \frac{1}{\Delta z}$$

daily mean flux soot

vertical distribution

diurnal cycle

layer size

Freitas et al, 2006, Walter et al., 2015

Lisa Muth

AOD MODIS & ICON-ART 4.12.2019 00:00 UTC
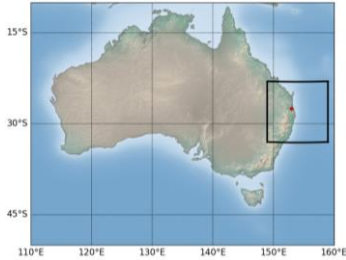
LAM Simulation
Resolution: ~ 6.5km

Start: 3.12.2019
End : 7.12.2019

soot as passive tracer

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

Lisa Muth
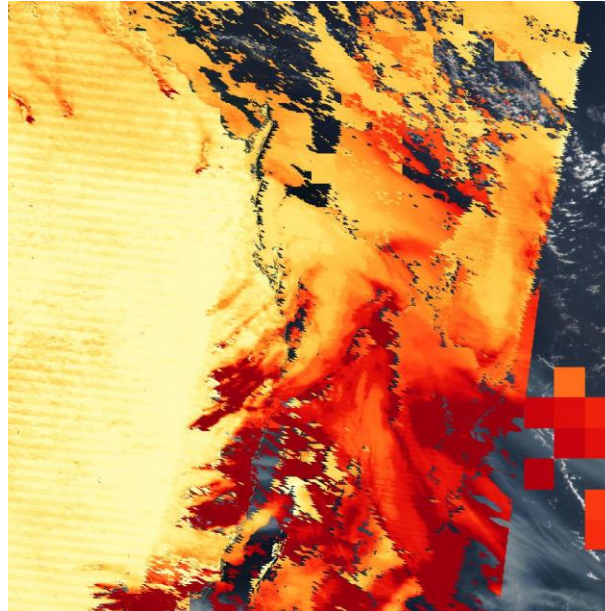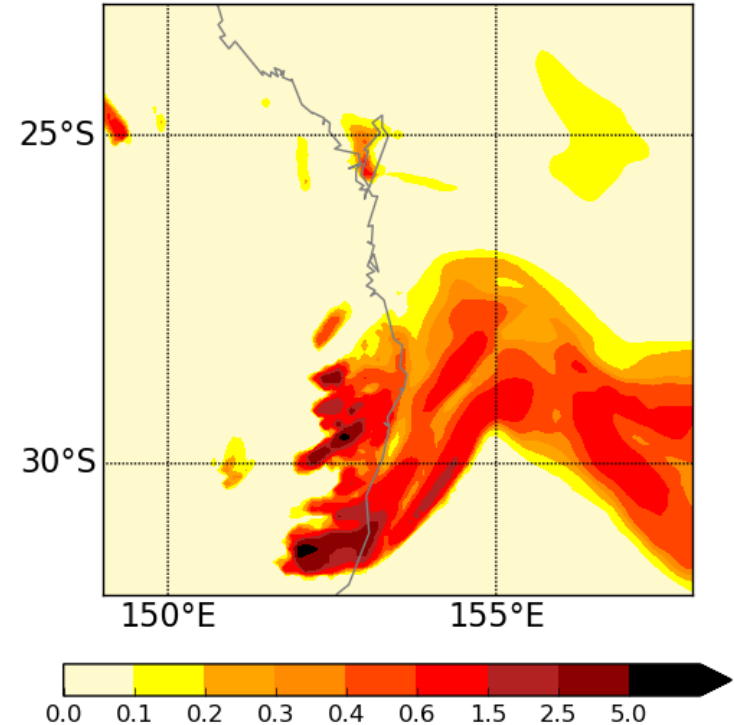
PM2.5 comparison and impact on wind field

Lisa Muth
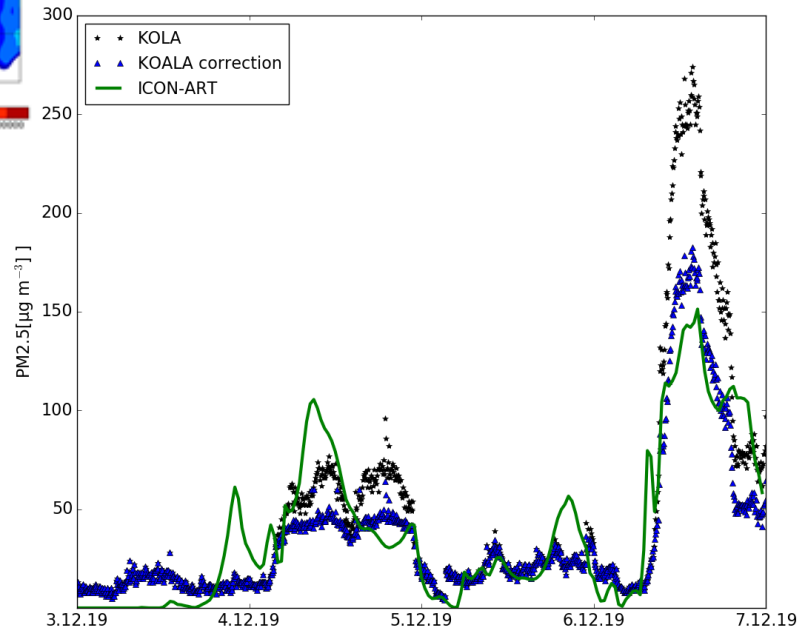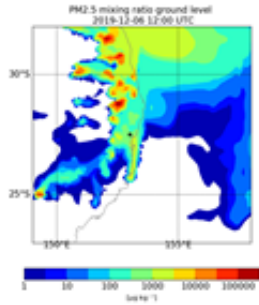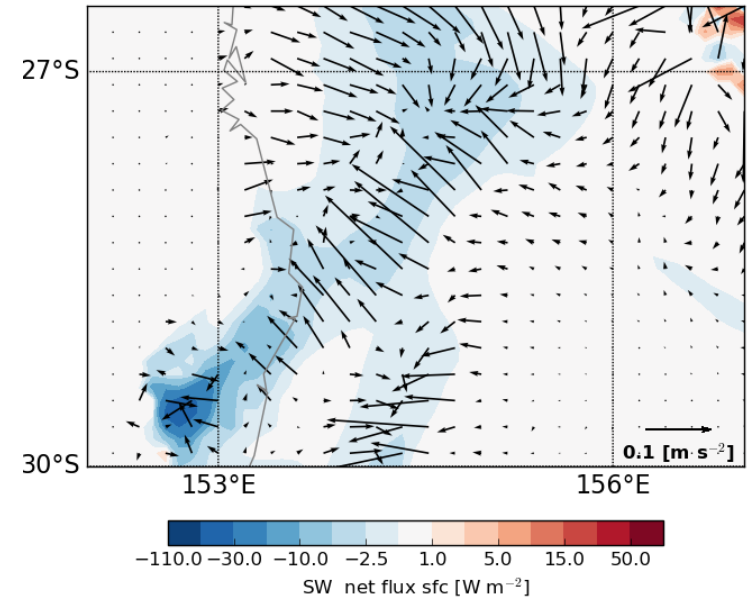
Coupling of ICON-ART and ecRad

- 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
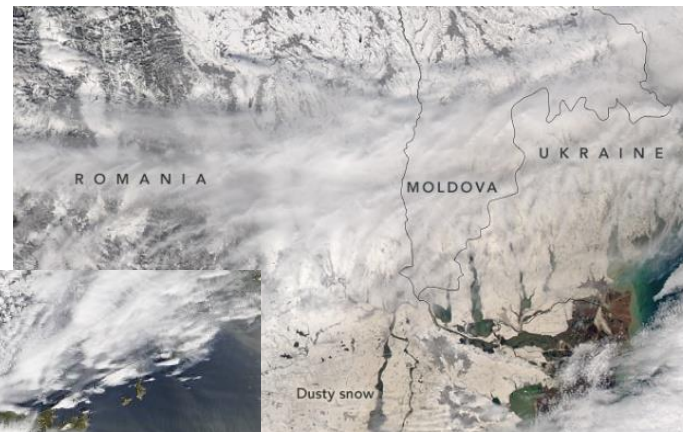
MODIS Aqua 24.03.2018

MODIS Terra 26.03.2018

Anika Rohde

Coupling of ICON-ART and ecRad

ecRad

RRTM

atmospheric shortwave radiation absorption (asob_t - asob_s)

ecRad - RRTM
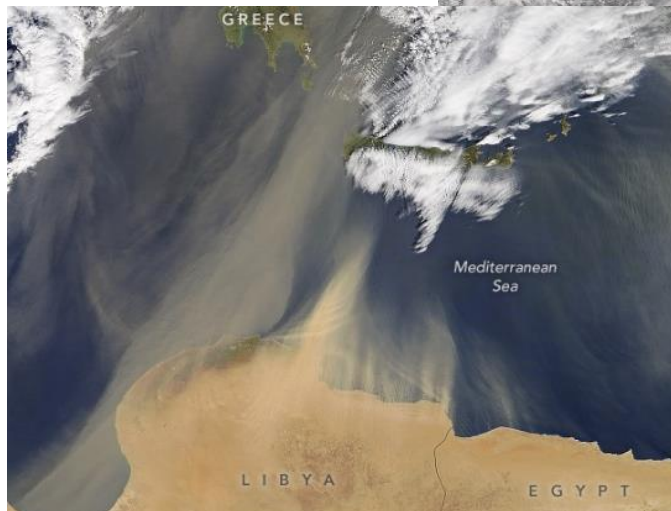
atmospheric shortwave radiation absorption (asob_t - asob_s)
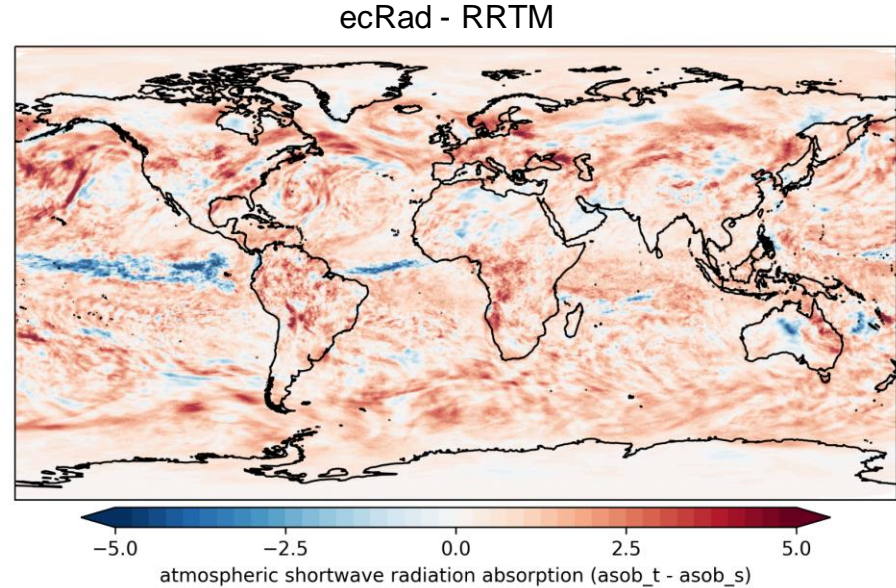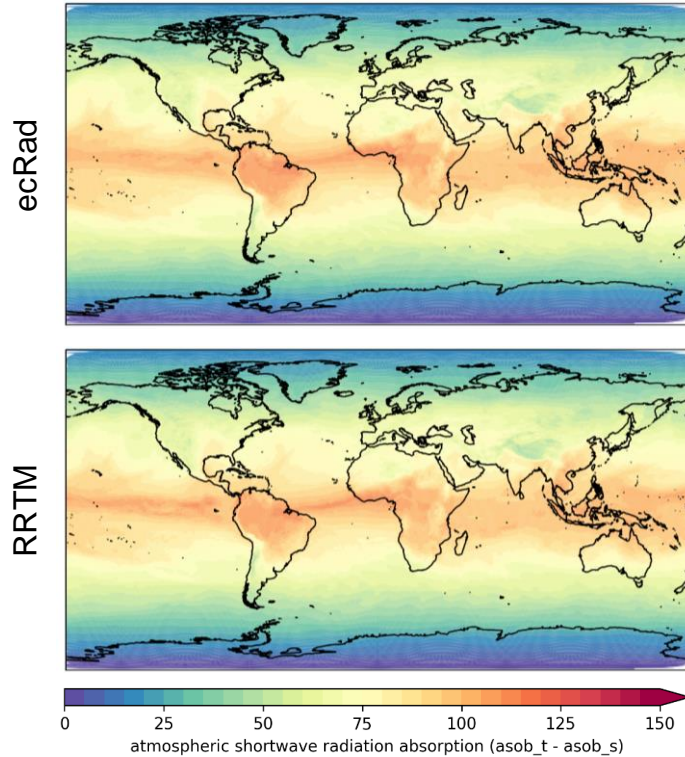
Atmospheric shortwave absorption:

Mean difference over 10 days: 1.6 %

Anika Rohde

ICON-ART dust assimilation – first results

MODIS AQUA AOD

2019.02.01;10:10

DA region

File: modis_aqua_20190201101000-20190201101000

FG DOD

2019.02.01;10:30

File: fc_ART_R02B06.20190201103000.orig.AOD_DUST

ANA DOD

2019.02.01;10:30

File: fc_ART_R02B06.20190201103000.mod
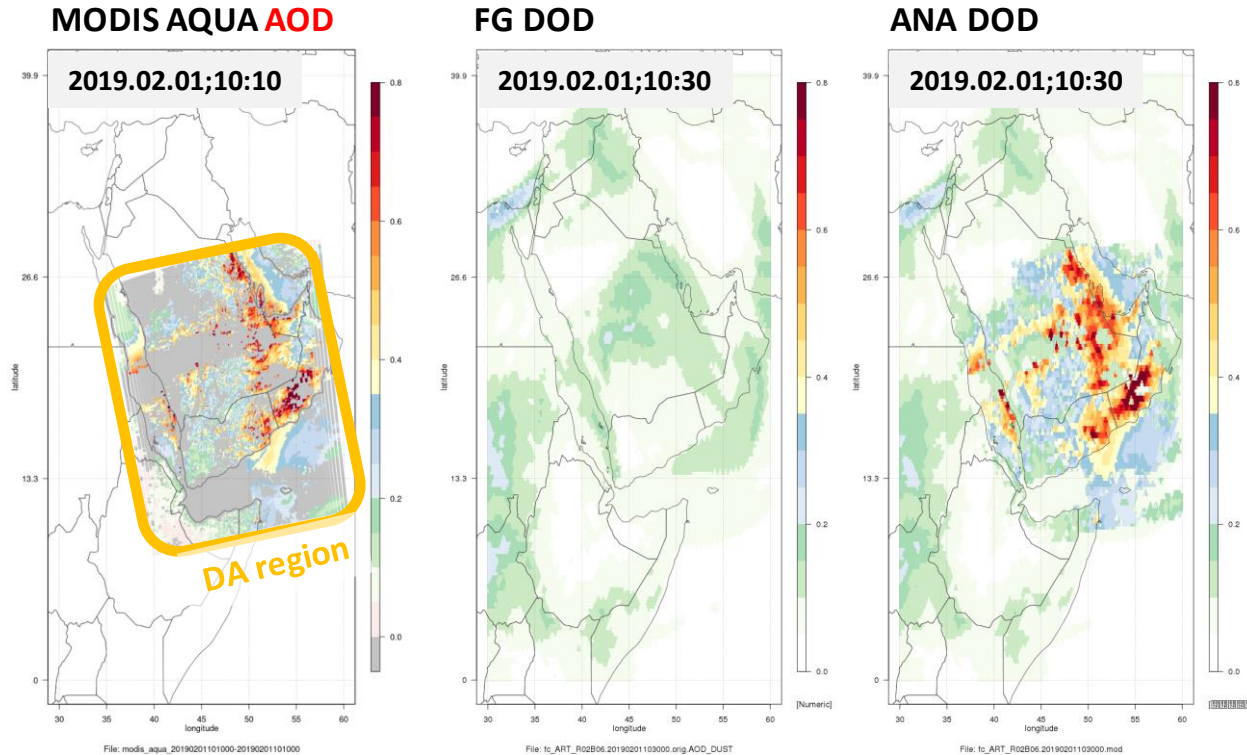
First test:
no observation error,
ass. of AOD

2019.02.01;10:30 UTC

Vanessa Bachmann

ICON-ART dust assimilation – first results

MODIS AQUA DOD land

2019.02.02;09:15-
2019.02.02;11:00

DA region

FCS DOD w/o DA dust

2019.02.02;10:00

FCS DOD w DA dust

2019.02.02;10:00

Deutscher Wetterdienst
Wetter und Klima aus einer Hand
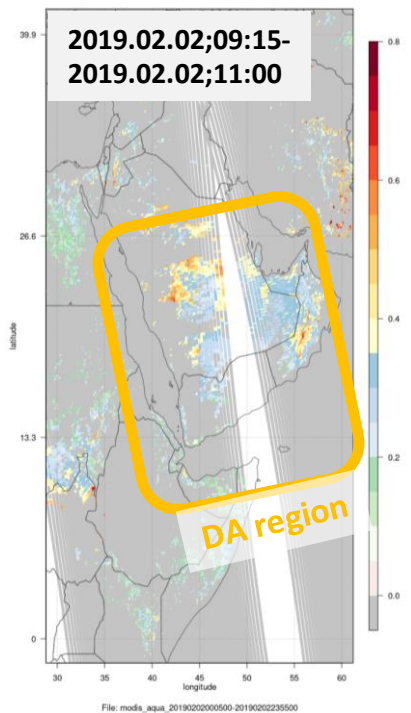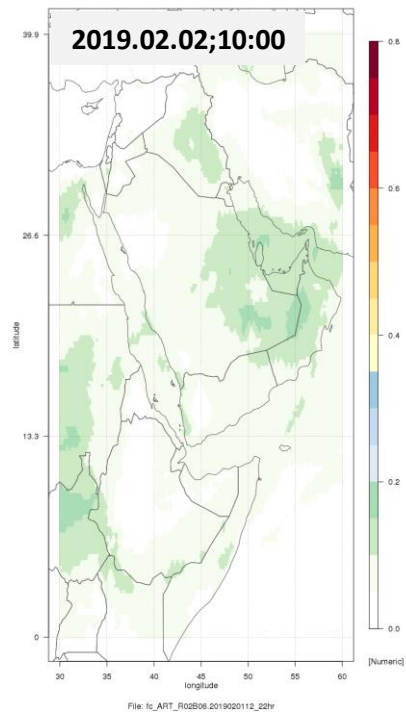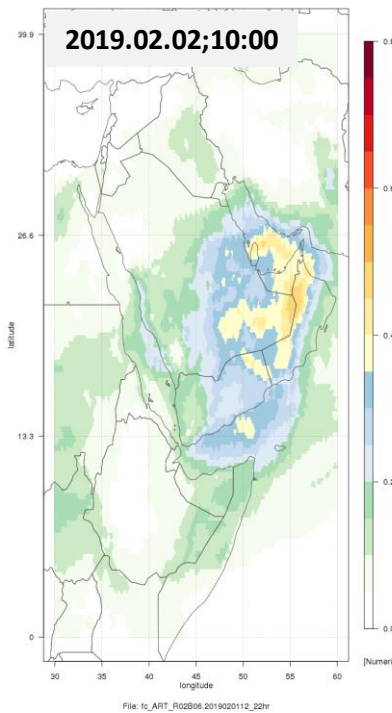
First test:
no observation error,
ass. of AOD

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)**

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

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

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

at the surface: $\qquad \widehat{\boldsymbol{w}}_s = \dfrac{\bar{\rho}_a \widehat{\boldsymbol{w}}_a}{\bar{\rho}_d}$

Sascha Bierbauer

Multiphase flow (first results)

Eruption

Δx = 100 m

Sascha Bierbauer
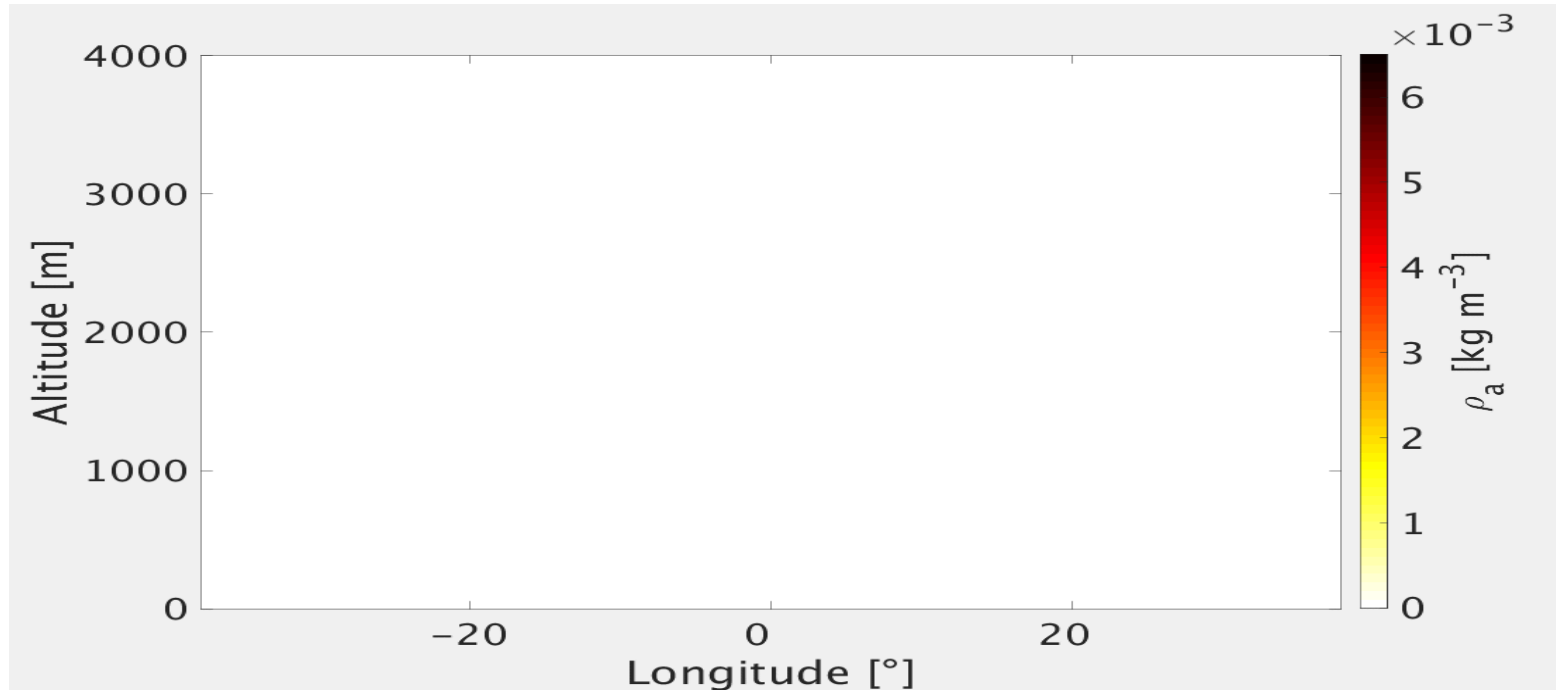
Summary

- **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

- **Assimilation:** first steps, dust & volcanic ash

- **Multiphase flow:** implemented (plume simulation in LES)

- **AERODYN:** implemented in the next release version

Where we are going with ICON-ART

- Seamless fully-coupled modelling system
- Deal with **processes**, **interactions** and **impacts** at different **scales**