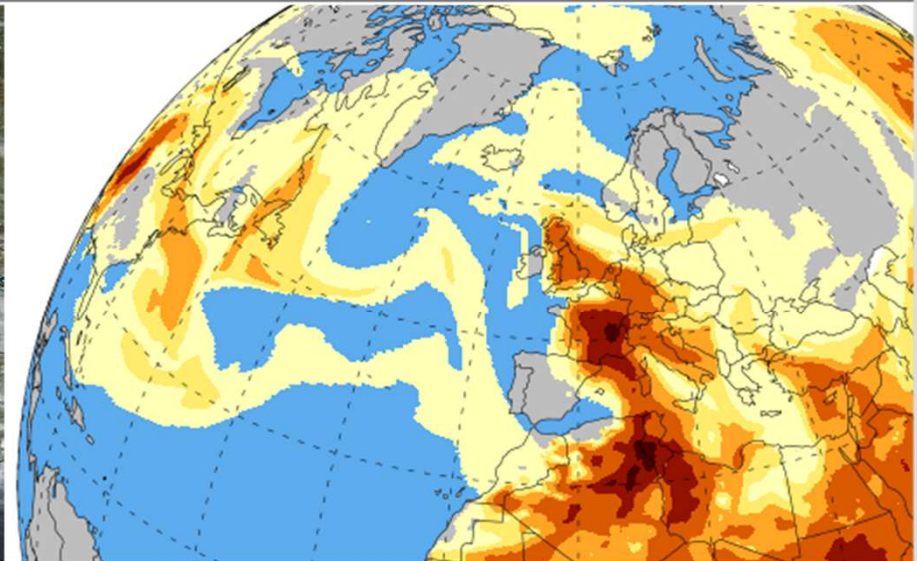
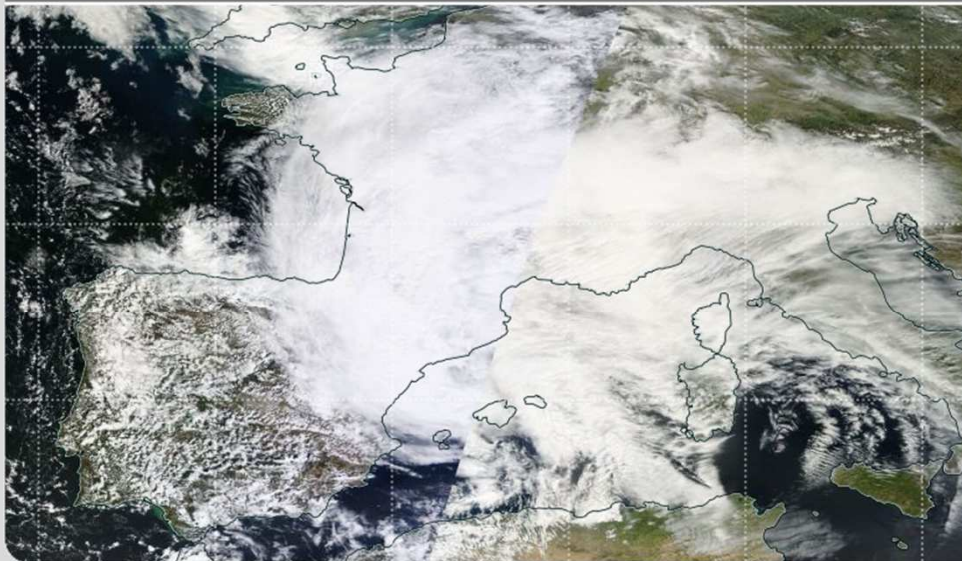


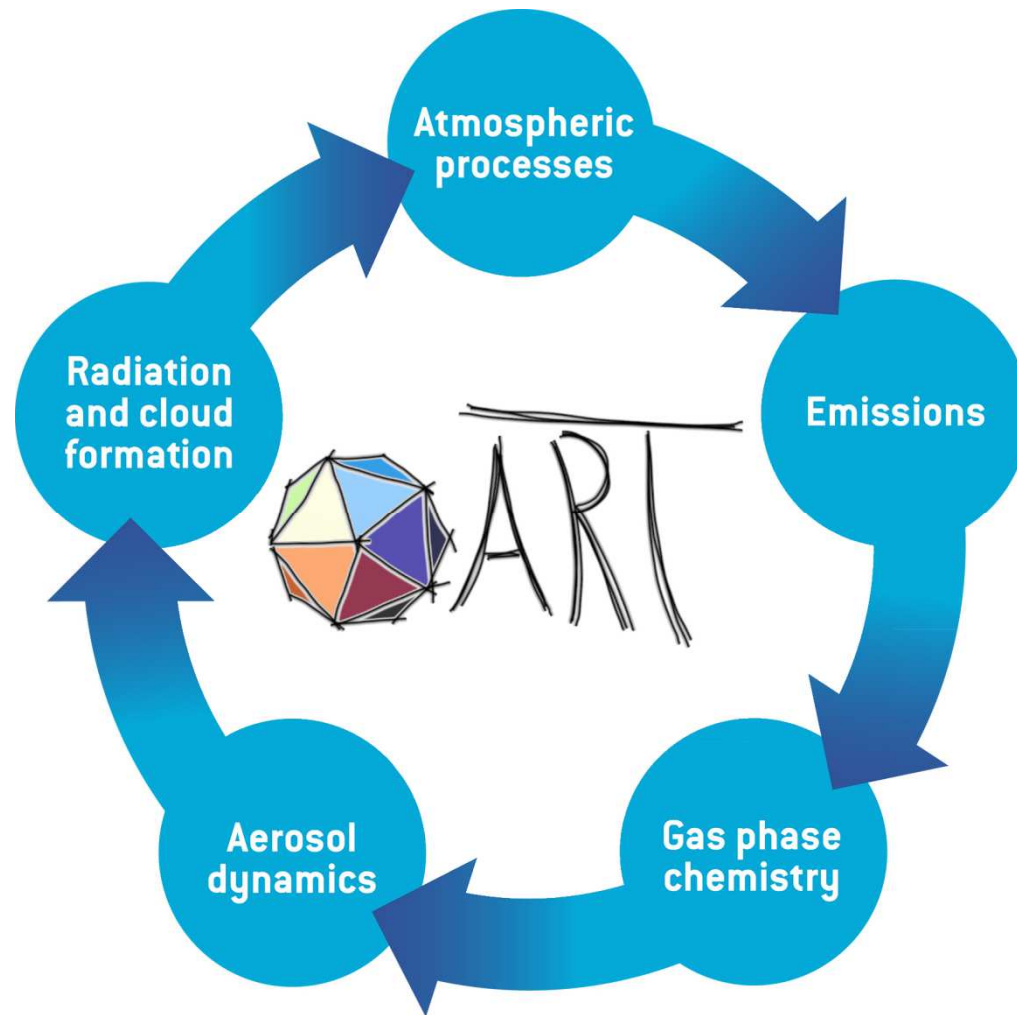
Scale-dependency of cirrus cloud formation in ICON-ART

D. Rieger, C. Kottmeier, C. Hoose, and B. Vogel

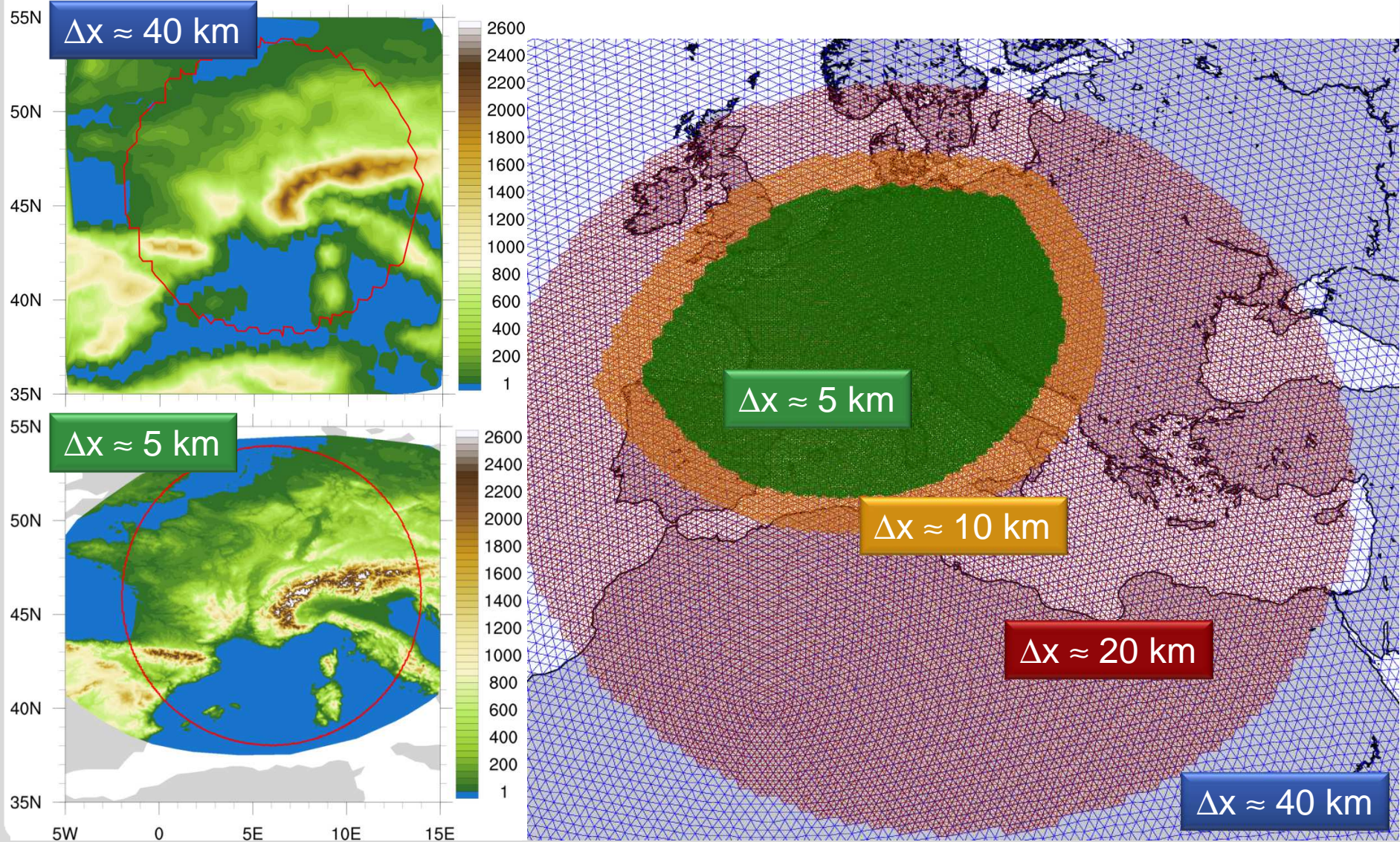
Institut für Meteorologie und Klimaforschung – Forschungsbereich Troposphäre
Fakultät für Physik



Modelling system ICON-ART

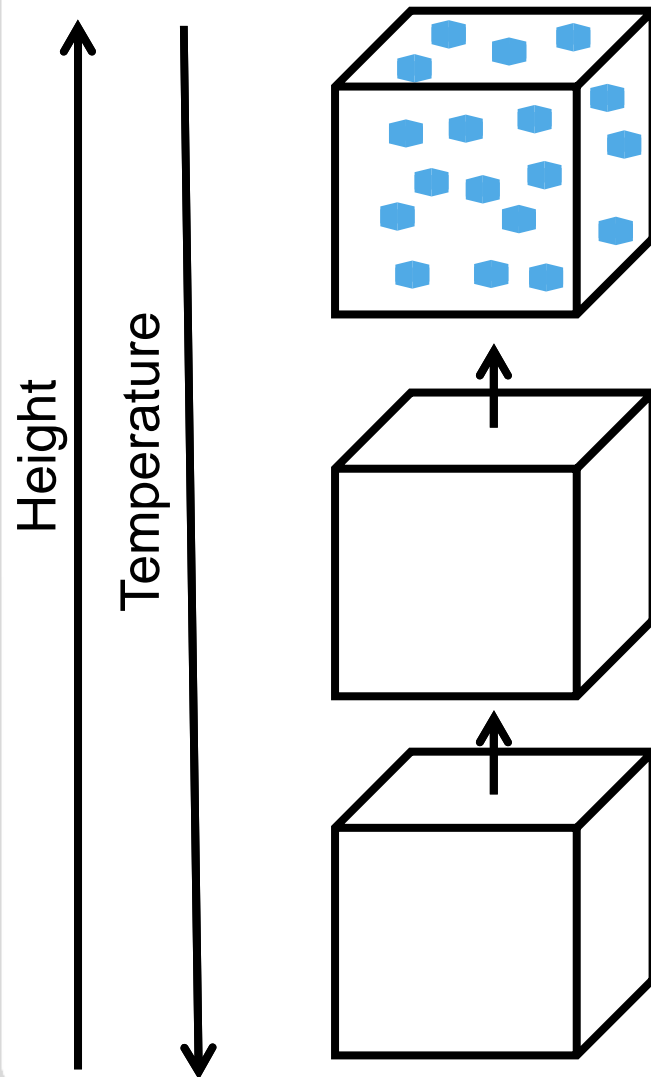


Model setup



IMPACT OF MINERAL DUST ON CLOUD FORMATION

Competition of freezing processes

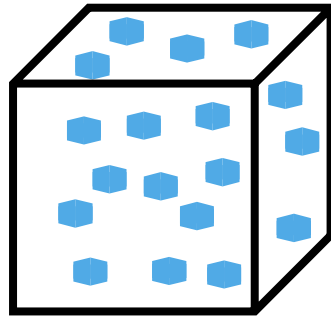
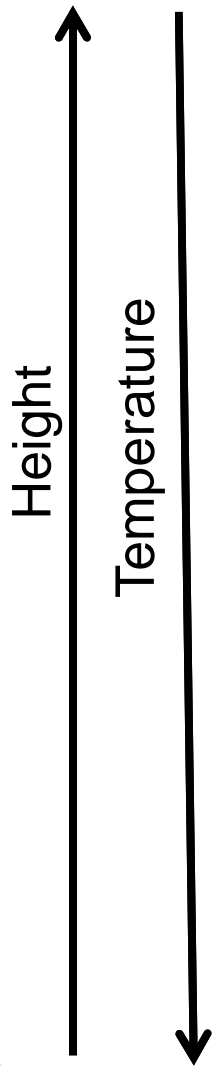


Homogeneous Freezing

- $T < 235 \text{ K}$
- $s_i > 50 \%$

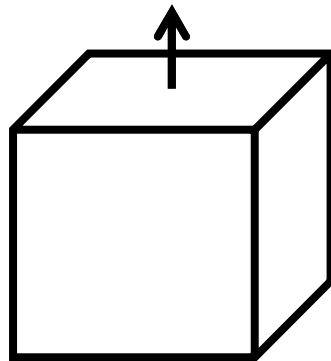
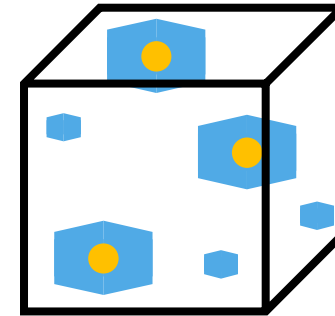
$$\frac{ds_i}{dt} = a(1 + s_i)w + b \frac{dq_v}{dt}$$

Competition of freezing processes



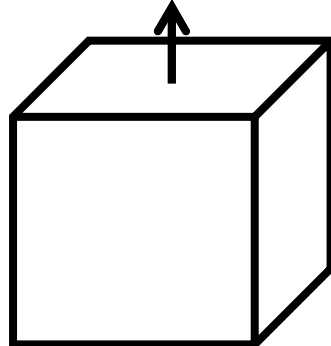
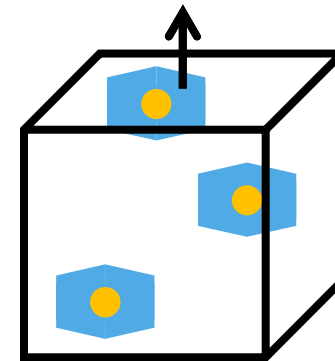
Homogeneous freezing

- $T < 235 \text{ K}$
- $s_i > 50 \%$

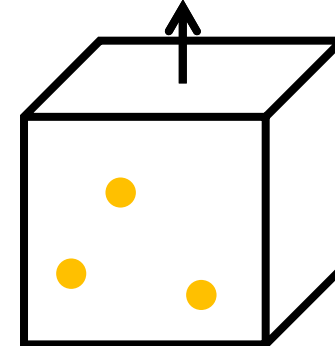


Heterogeneous freezing

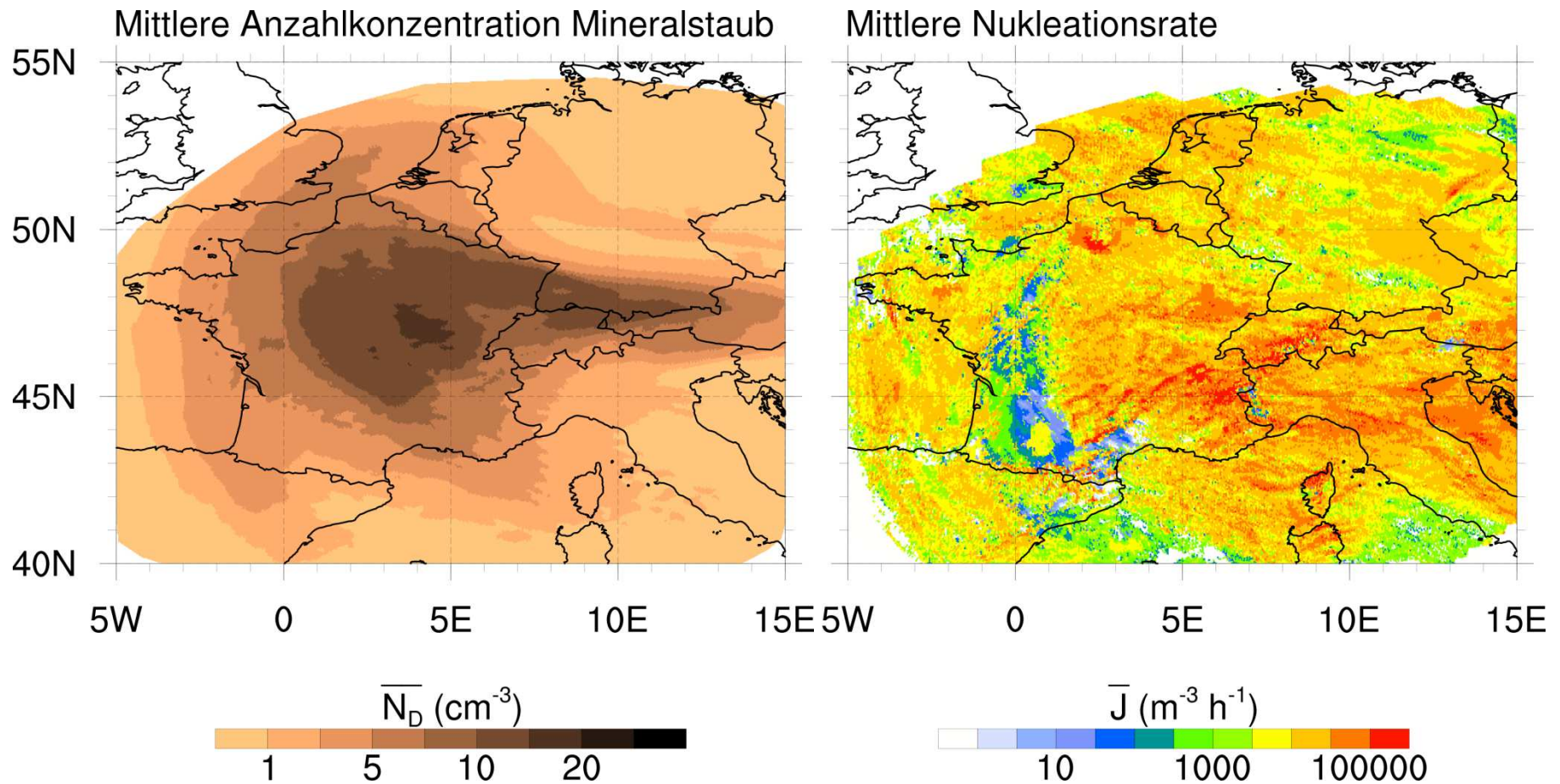
- $T < 270 \text{ K}$
- $s_i > 0 \%$



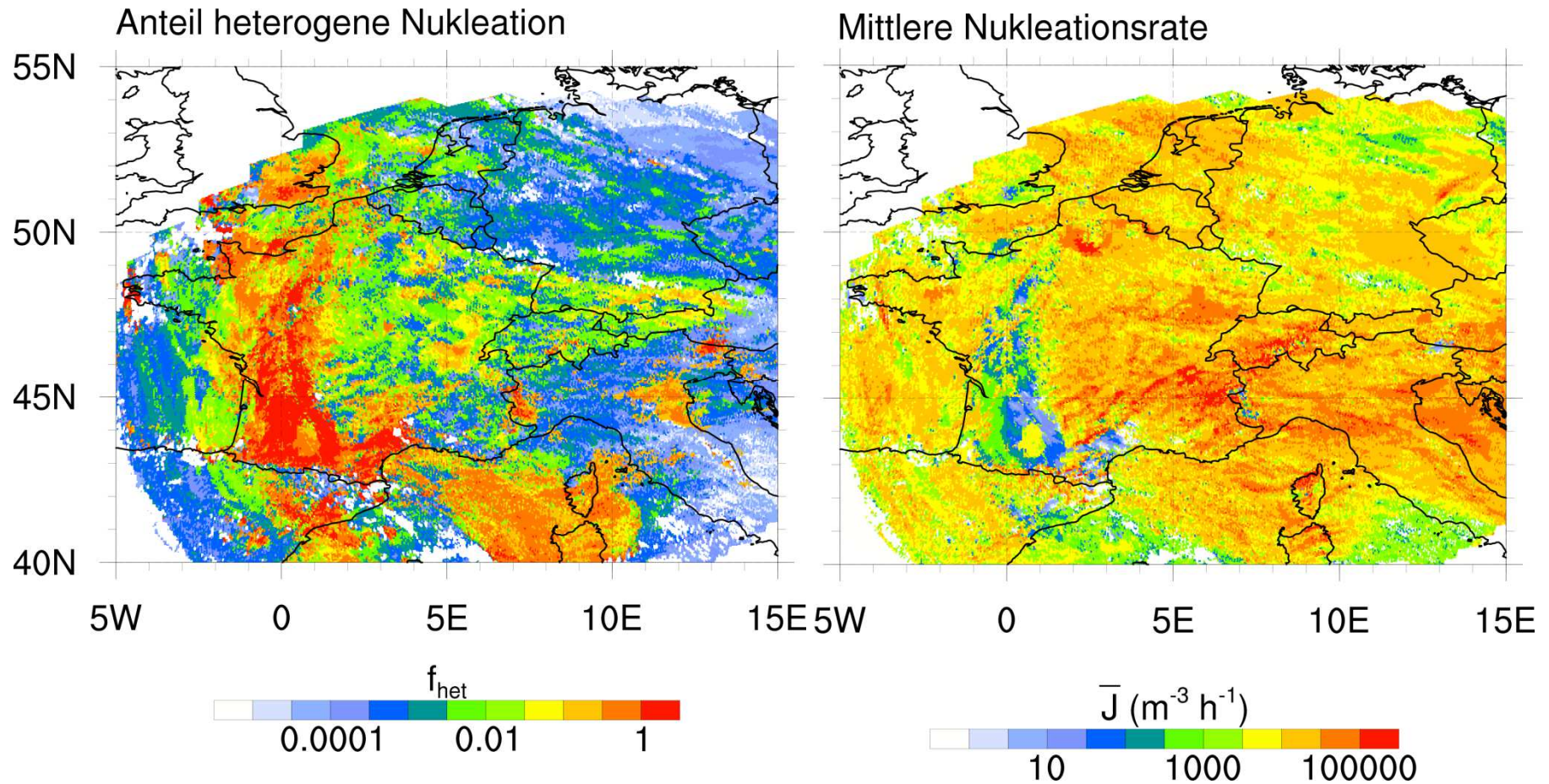
$$\frac{ds_i}{dt} = a(1 + s_i)w + b \frac{dq_v}{dt}$$



Impact of mineral dust on ice nucleation

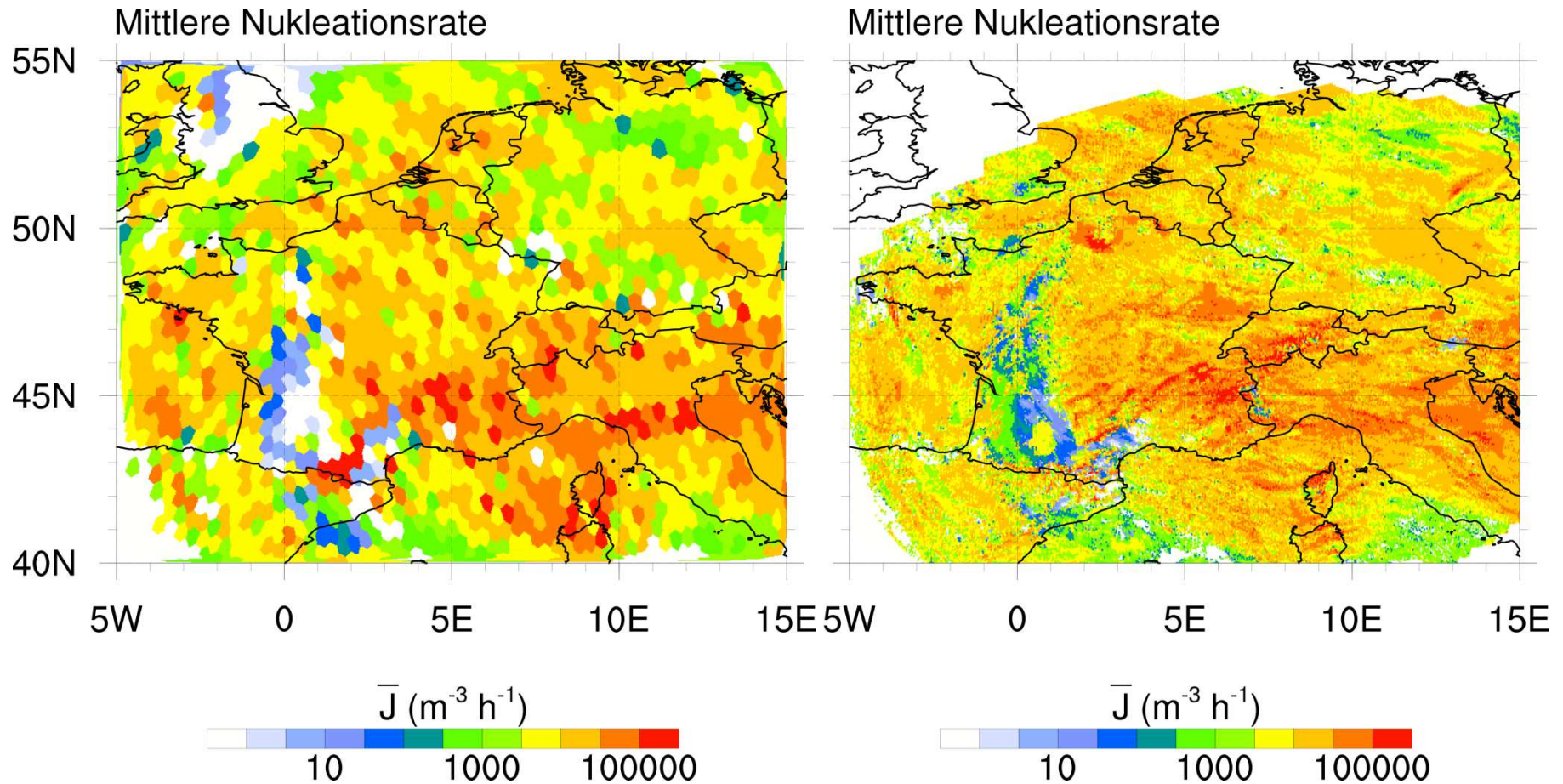


Impact of mineral dust on ice nucleation

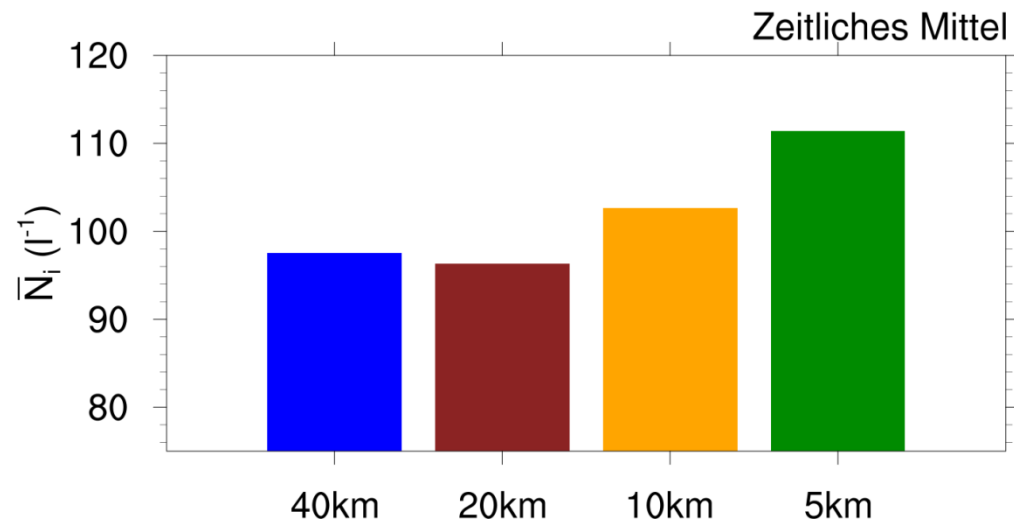
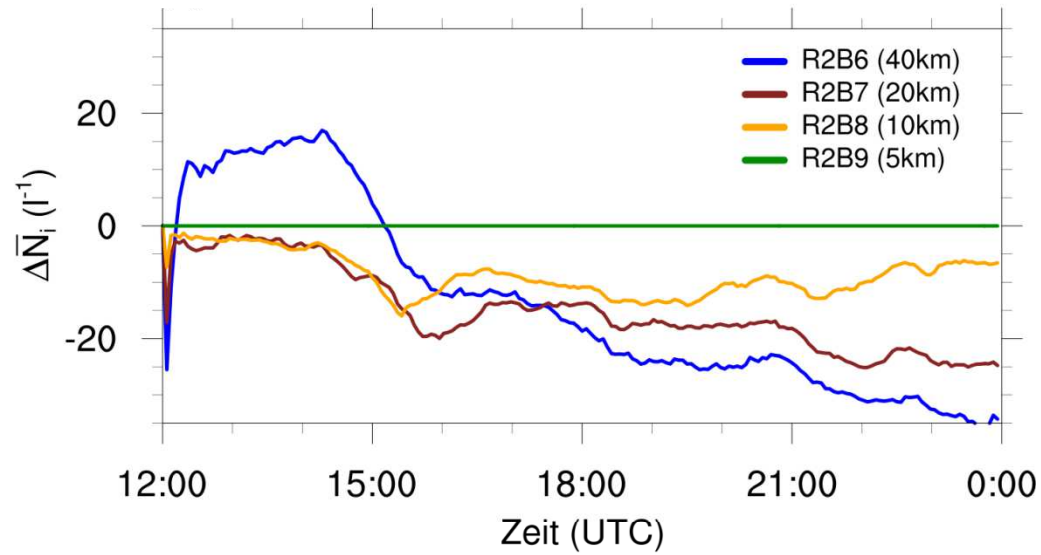


SCALE-DEPENDENCY OF CLOUD FORMATION

Scale-dependency of ice nucleation



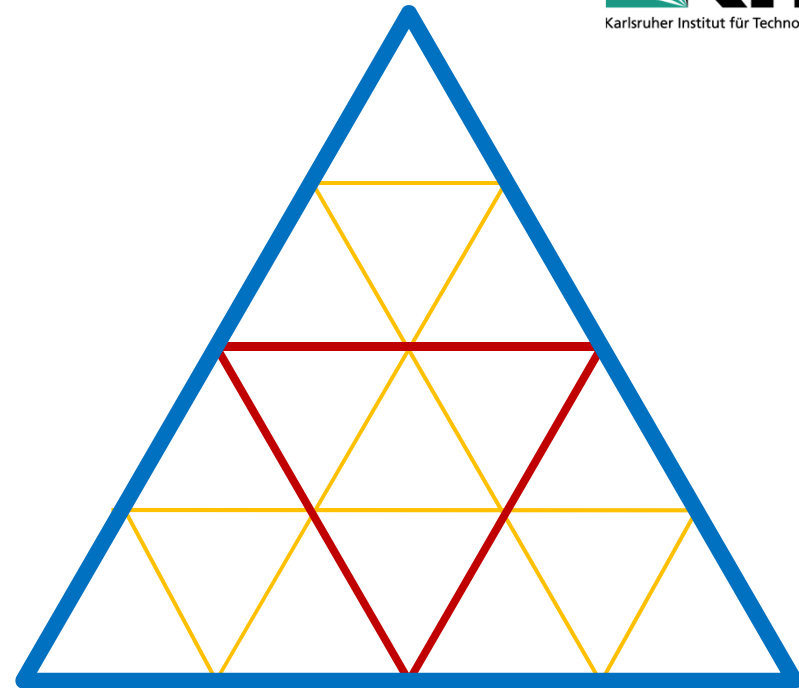
Scale-dependency of ice nucleation



Causes of scale-dependency

$$\frac{ds_i}{dt} = a(1 + s_i)w - b \frac{dq_v}{dt}$$

$$\overline{N_i(w)} \neq N_i(\overline{w})$$



- Consideration of vertical velocity subgrid-scale variance with a normal distribution with $\sigma_w = 0,3 \cdot \sqrt{TKE}$.

Parameterization of the scale-dependency

Ideal case:

Specific energy of vertical motion in a grid element in domain 1 and 4:

$$E^1 = \overline{E^4}$$

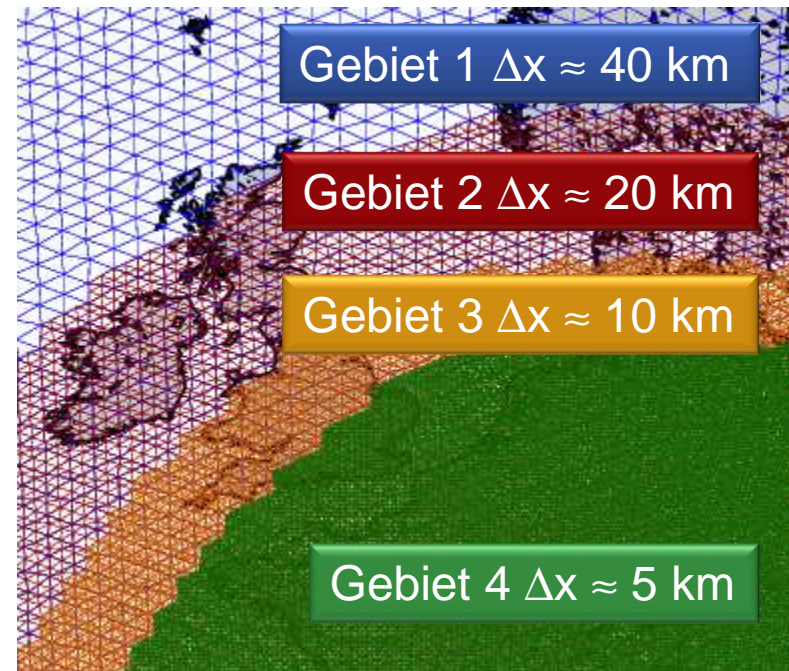
Real case:

$$E^1 + R^{1,4} = \overline{E^4}$$

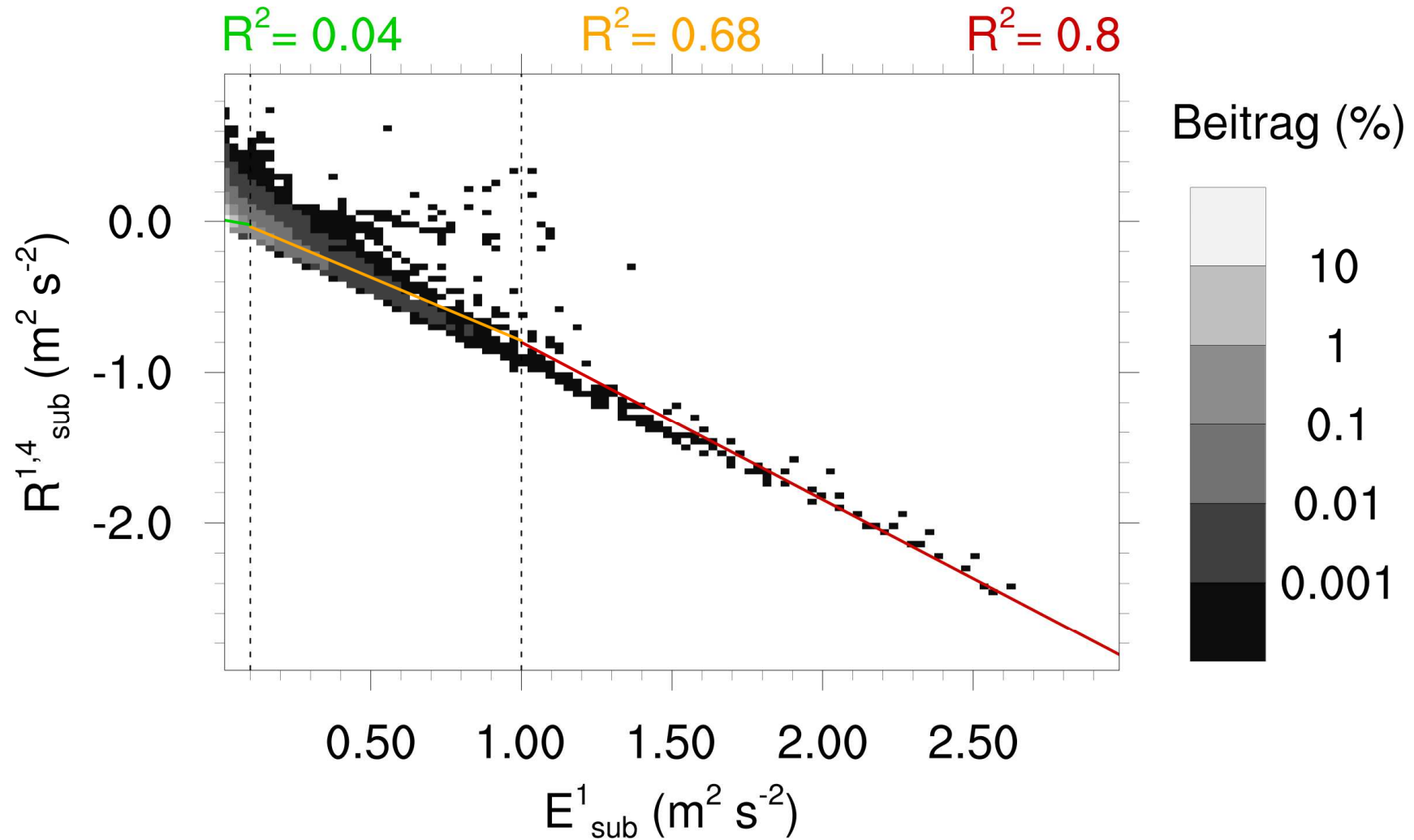
Parameterization:

Usage of the residuum as additional variance:

$$\sigma_P = \sqrt{\sigma_w \cdot \sigma_w + R^{1,4}_{sub,P}} = \sqrt{E^1_{sub} + R^{1,4}_{sub,P}}$$

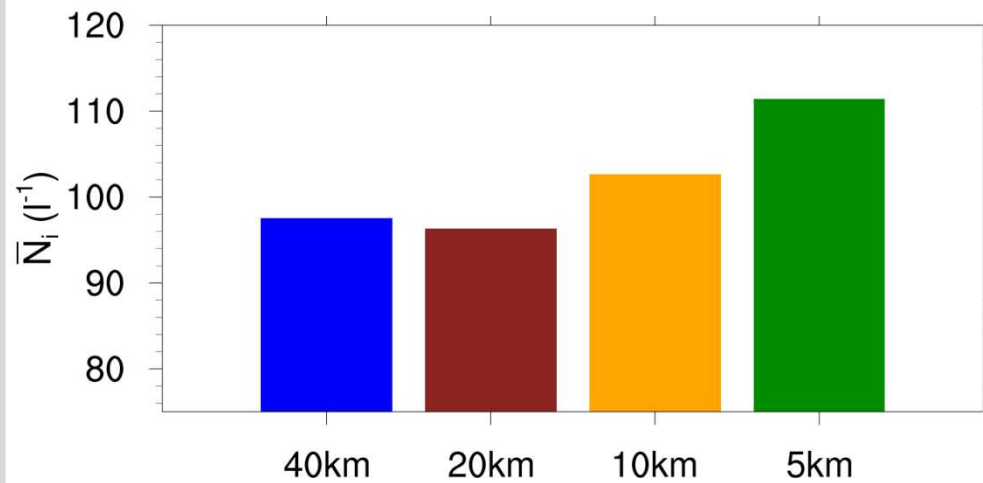


Determination of the parameterization

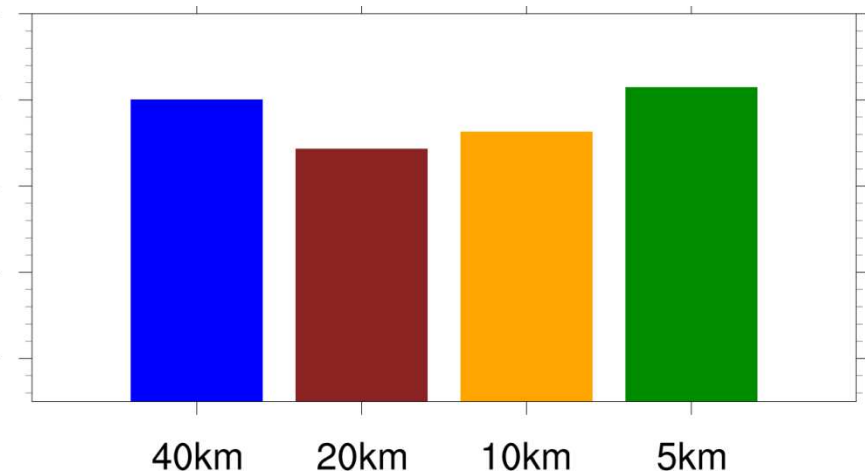


Resulting simulation

Without parameterization



With parameterization



Summary

- Locally reduced ice nucleation caused by mineral dust leads to increased solar radiation in France and Southern Germany
- Parameterization based on the energy of vertical motion
- Parameterizing the scale-dependency of cirrus cloud formation reduces the differences between 40 km and 5 km grid spacing from 12% to 2%