



Prediction of Ice Supersaturated Regions in the DWD Weather Models

(Subproject within UFO)

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Overview

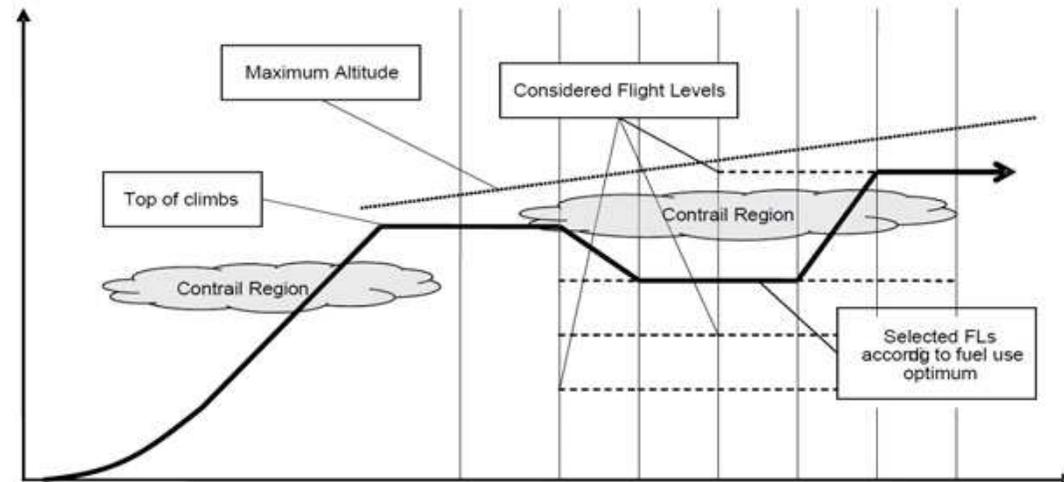
- **Umweltgerechte Flugrouten Optimierung (UFO)**
Environmentally Compatible Flight Route Optimisation :
 - Introduction of the UFO Project
 - Lufthansa Flight Planning Tool
- **Work at the German Weather Service DWD:**
 - Numerical Weather Prediction Models
 - Current status
 - Future Work



UFO Project

→ Basic idea:

- Reduce overall climate impact of air traffic by additionally considering contrails
- Include impact of potential contrail formation into flight planning



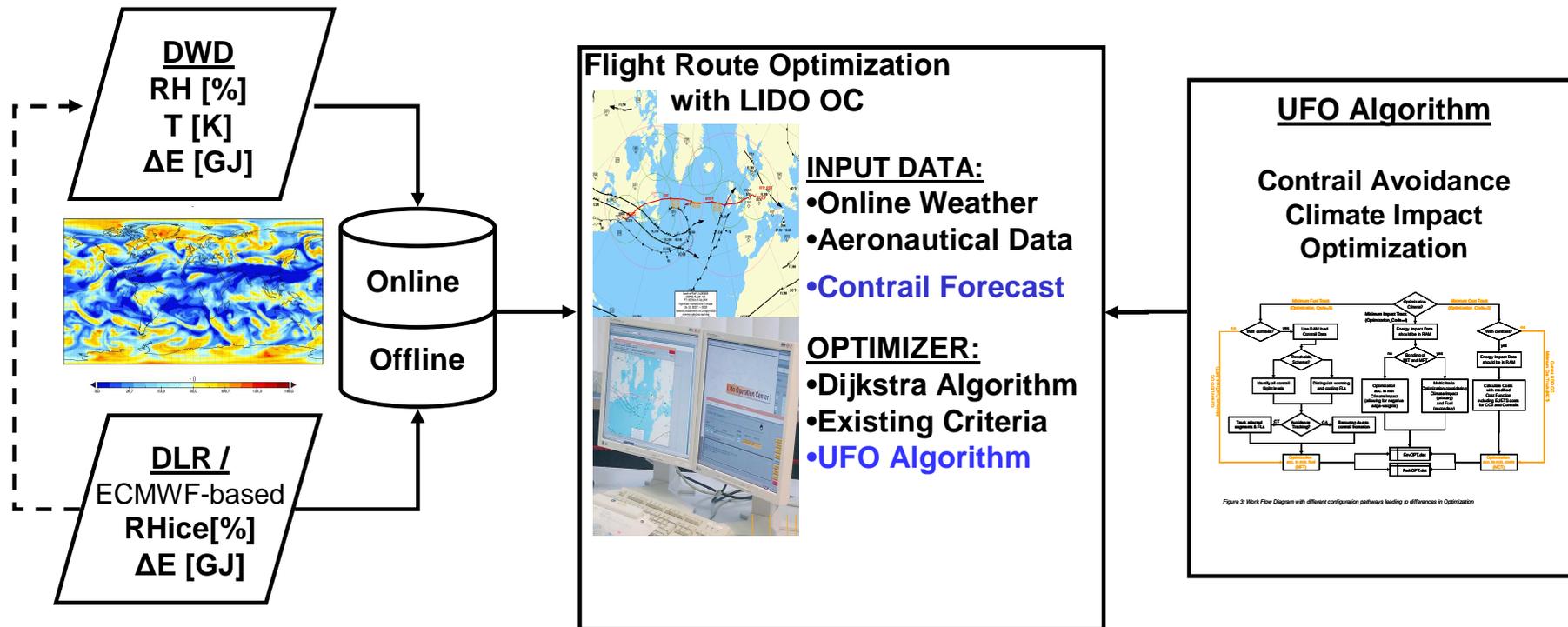
→ Goal:

- Evaluate the feasibility of route optimization including the climate impact of potential contrail formation

→ Evaluation Criteria:

- Global climate benefits, economic efficiency, safety aspects

Modifications of LIDO OC within the UFO Project

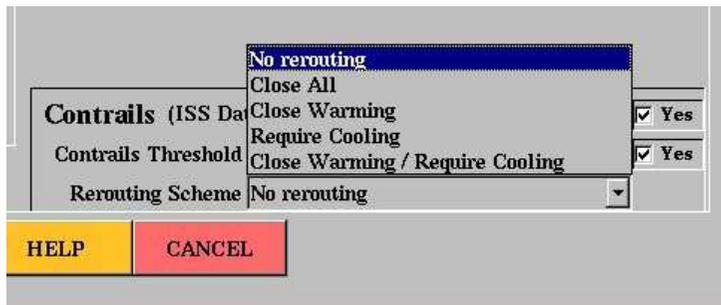
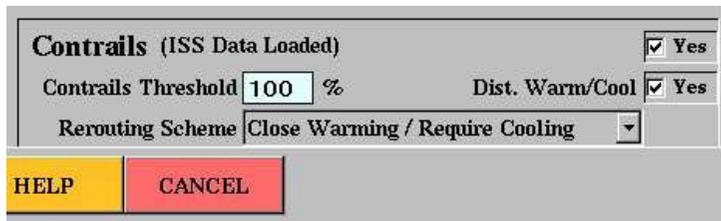


Stefanie Meilinger, Lufthansa Systems

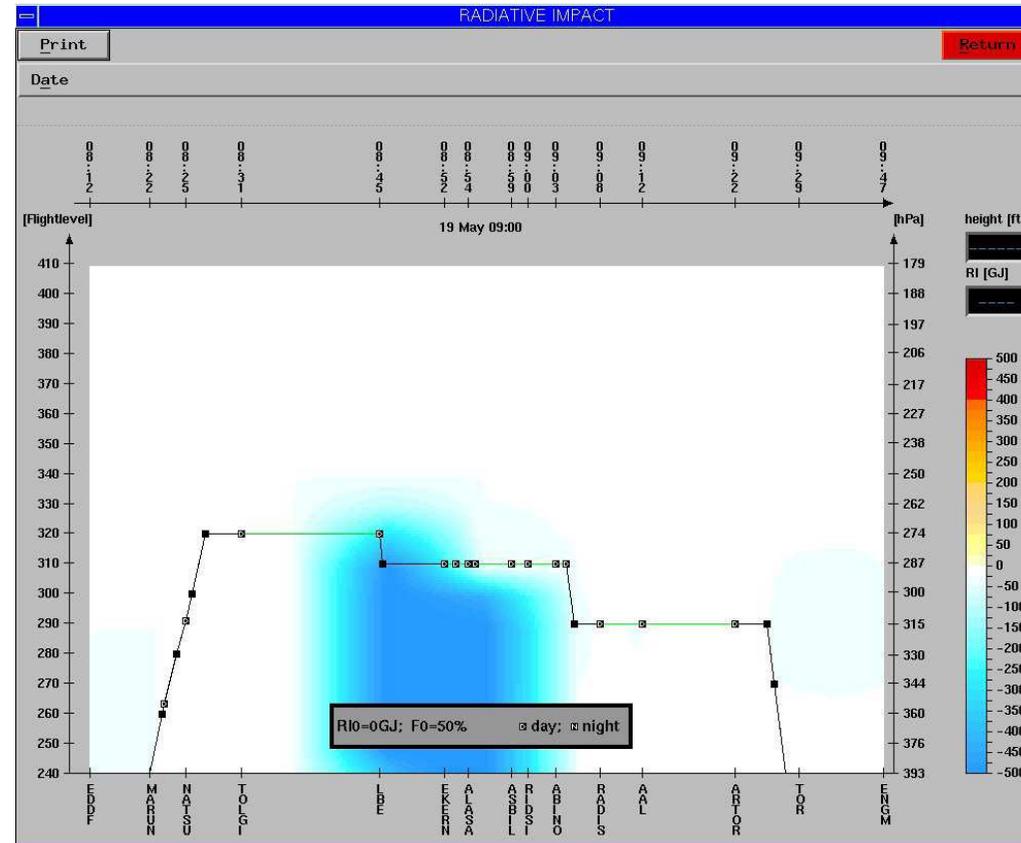
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Contrail Mitigation Option in LIDO OC

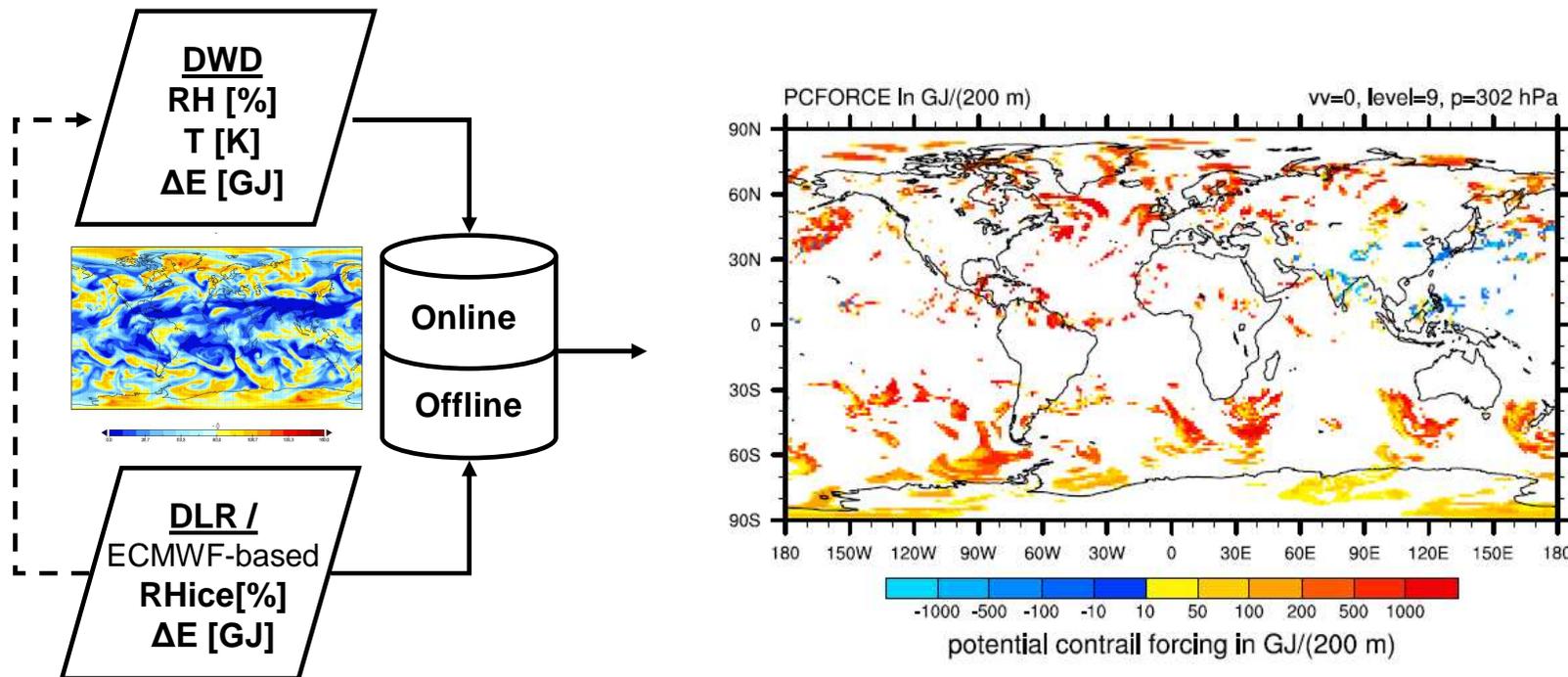


MFT/R Flight FRA-OSL on 19.05.2009 with "Require Cooling", i.e. require flight through region where cooling contrails may potentially form



Stefanie Meilinger, Lufthansa Systems

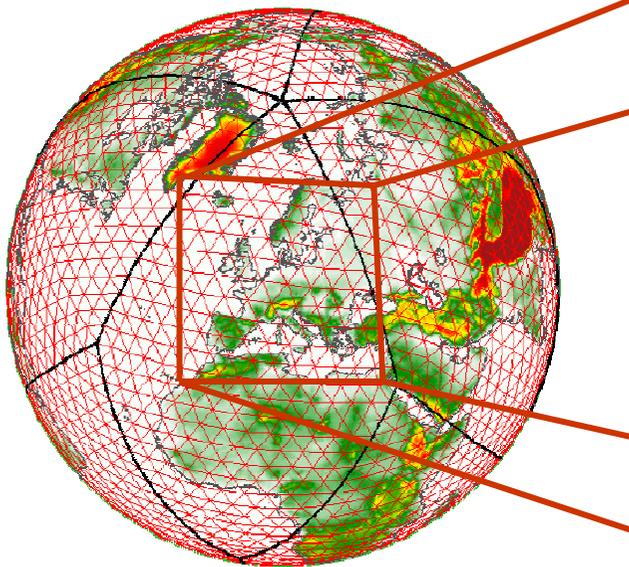
How good is the data for the Ice Supersaturated Regions?



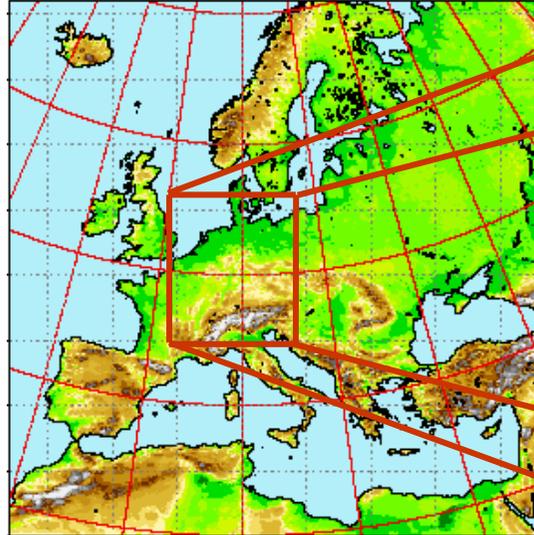
- DWD data of humidity fields used in order to calculate potential contrail forcing ΔE dependent on ice water content and contrail life-time
- Forcing dependent on ice crystal size and number densities

Operational Prediction Systems

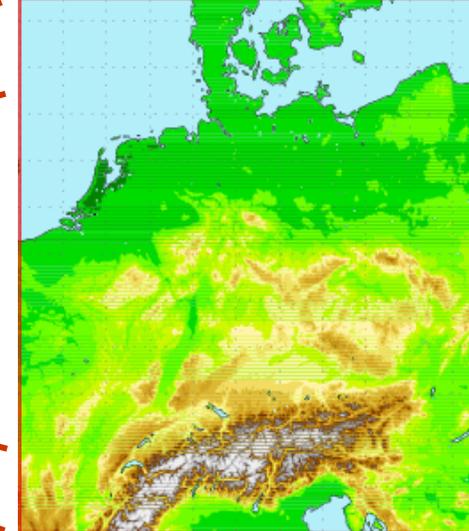
GME 30 km



COSMO-EU 7 km



COSMO-DE 2.8 km



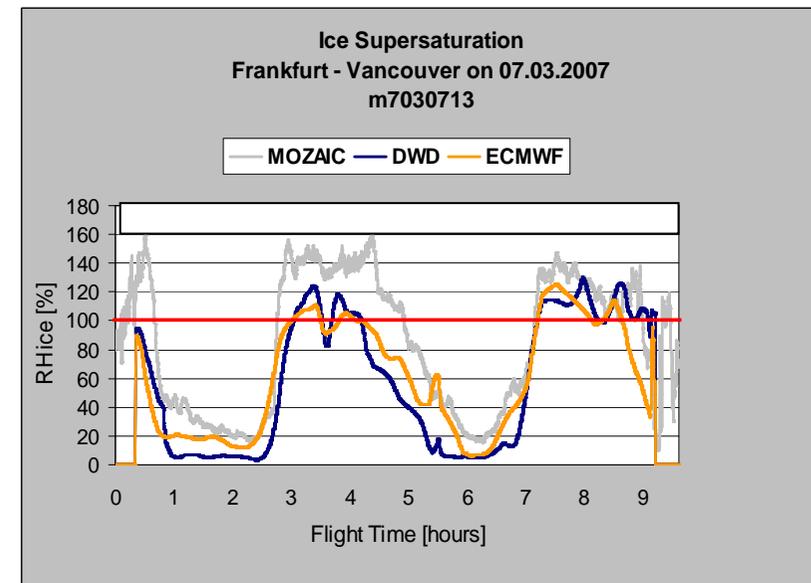
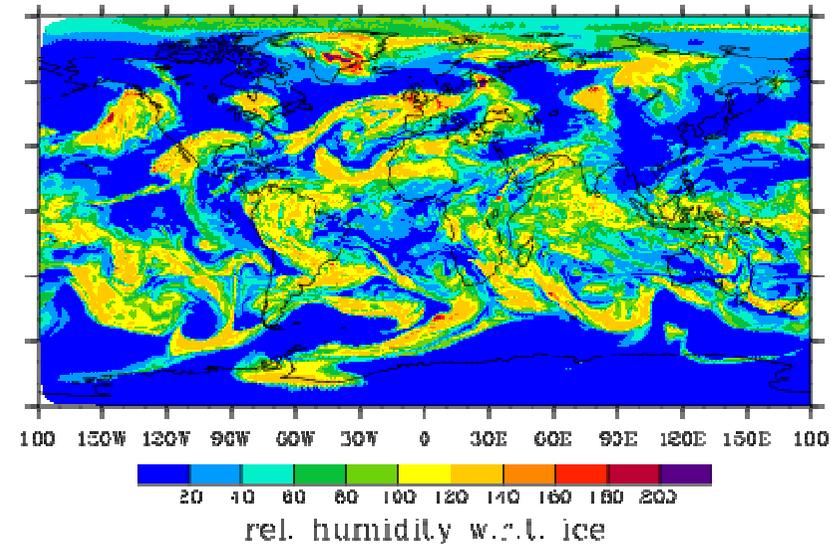
Within the UFO Project the GME is of primary interest. The COSMO models are used for further analysis of ice supersaturated regions.

Status:

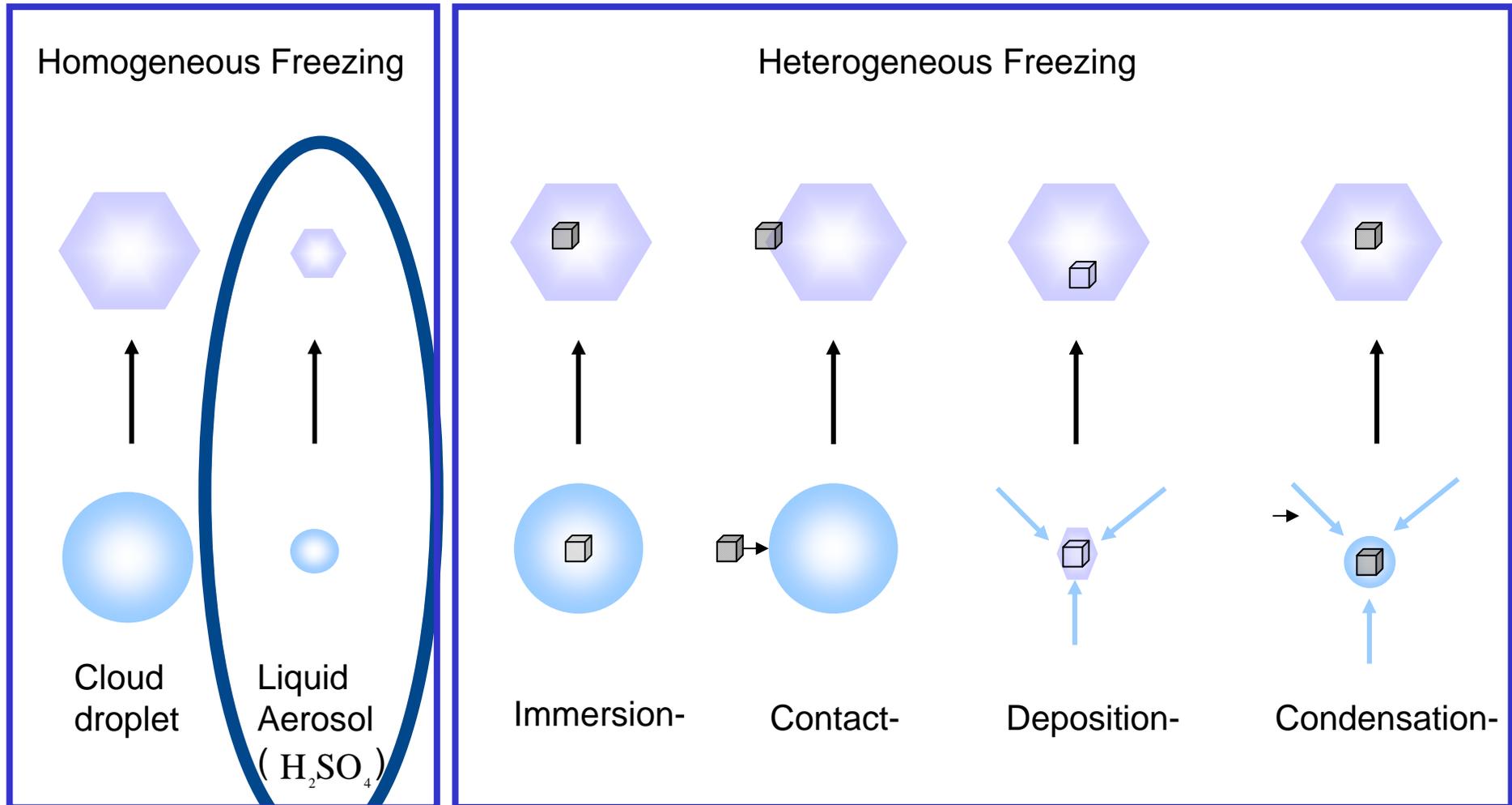
- ❄ Ice supersaturation in GME and COSMO possible but often too low
- ❄ Reason may lie in overestimation of ice nucleation

Goal:

- ❄ Analysis of current nucleation scheme
- ❄ Develop a new parameterisation for ice nucleation in numerical weather prediction models
- ❄ Evaluation and verification of results



Processes of Ice Nucleation



Thomas Leisner, Institut für Meteorologie und Klimaforschung FZ Karlsruhe und Institut für Umweltphysik, Uni Heidelberg (modified)

Number Densities of Ice Nucleation Schemes

	New Parameterisation	Current Parameterisation used in COSMO/GME
Homogeneous Nucleation	$S_{cr} = 2.349 - T / 259$ $n_i = \frac{a_1 S_{cr}}{a_2 + a_3 S_{cr}} (w - w_p) R_{im}^{-1}$ (Kärcher et al. 2006)	-----
Heterogeneous Nucleation	$\Delta n_i = \sum_X \max(n_{IN,X} - n_{X,a}, 0)$ $X = DM, BC \text{ and } O$ (Phillips et al. 2008)	$n_i(T) = e^{(0.2(273.15-T))}$ (modified Fletcher 1962)

Validation with Parcel Model

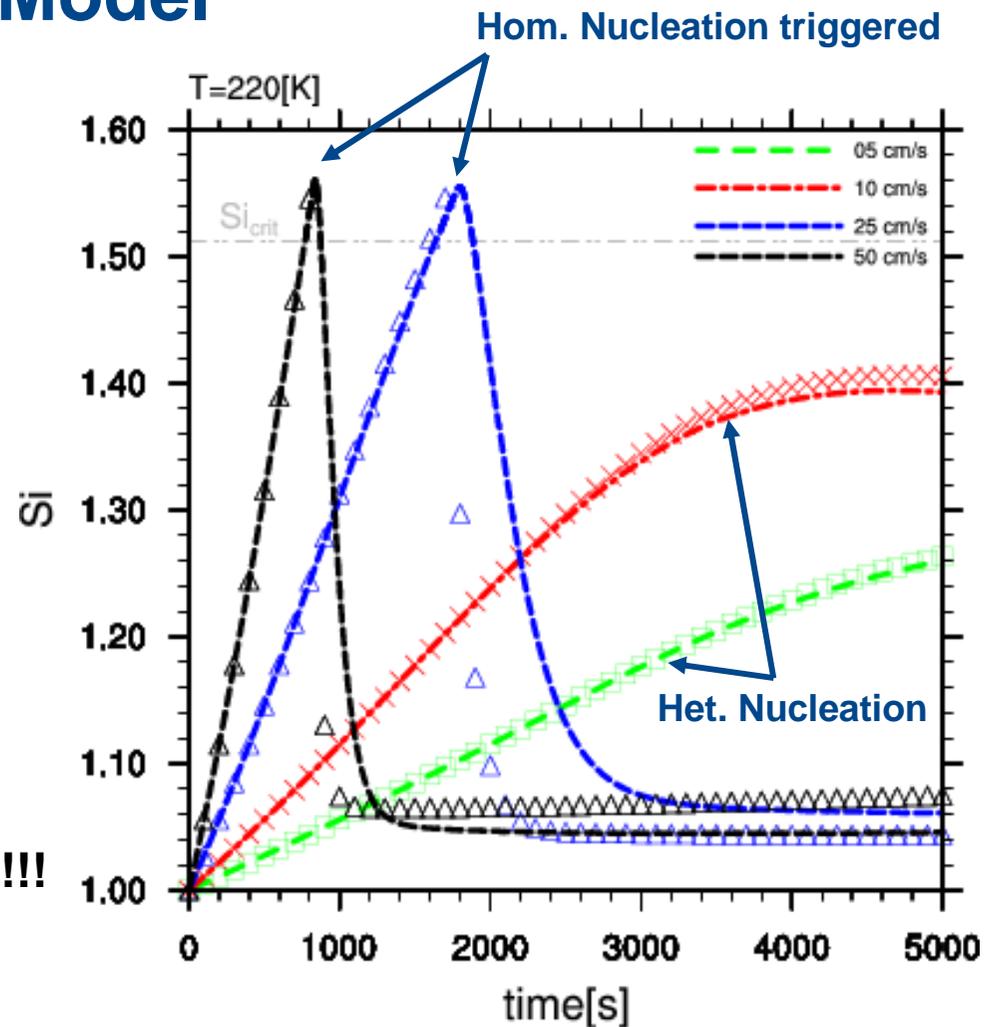
- explicit Model dt = 1s
- △△△ Parameterisation dt = 100s

Parameterisation verified against model with explicit calculation of number density and nucleation rate

$$\dot{n}_i = nJV_0$$

(Koop et al. 2000)

Test in Model Environment !!!

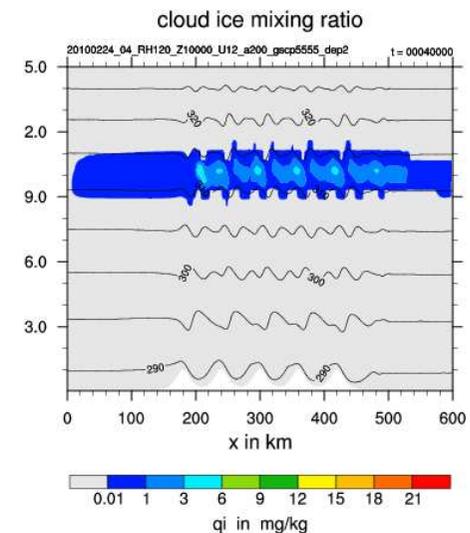
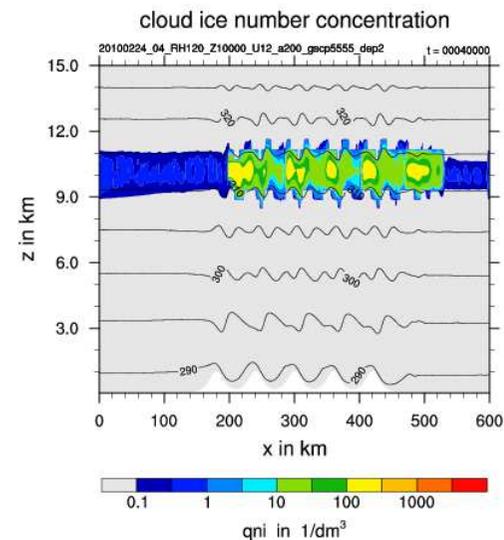
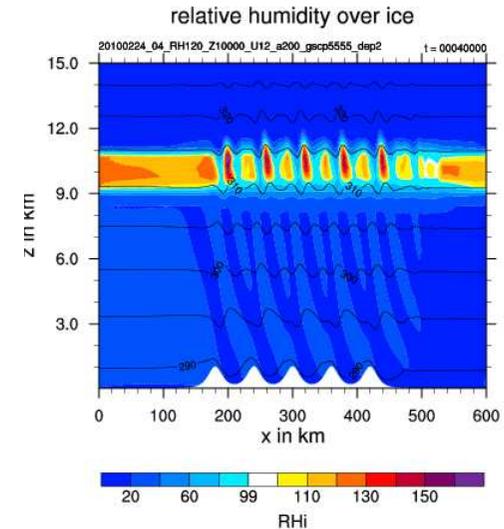
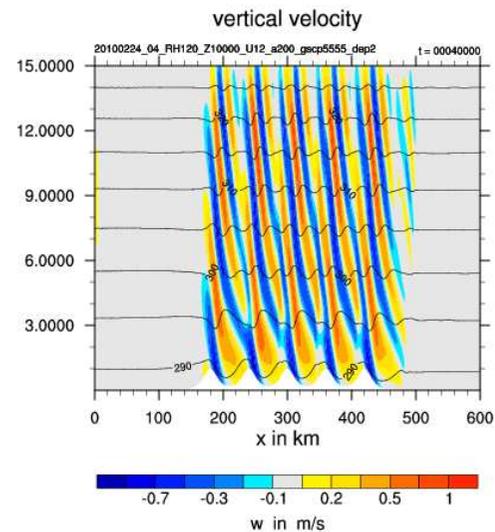


Idealised Case

Flow over hills used as idealised case in COSMO environment resulting in gravity wave patterns

Initial Conditions given for humidity field, e.g. for this case $RH_i = 120\%$

Homogeneous freezing is triggered as it results in number concentrations of $0.1-10 \text{ per cm}^3$ (Kärcher & Burkhardt 2008)

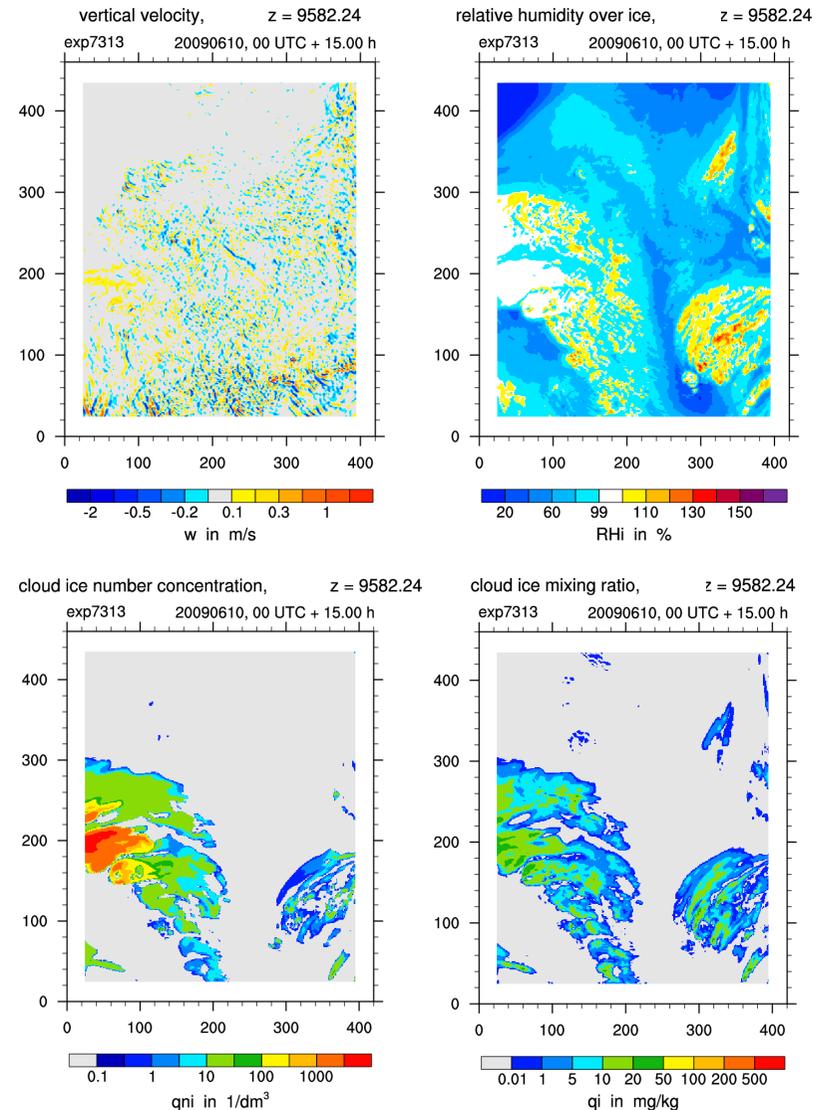


Test- and Reference Calculations with the COSMO-DE

The relevant processes for cirrus cloud formations such as orographic and convective effects are captured due to the resolution of 2.8 km.

Calculation serves as test for the parameterisation and the high resolution data set can then be used in further investigations concerning the coarser gridded GME.

Calculations for the Juni/Juli 2009, shown is the 10 Juni 2009.



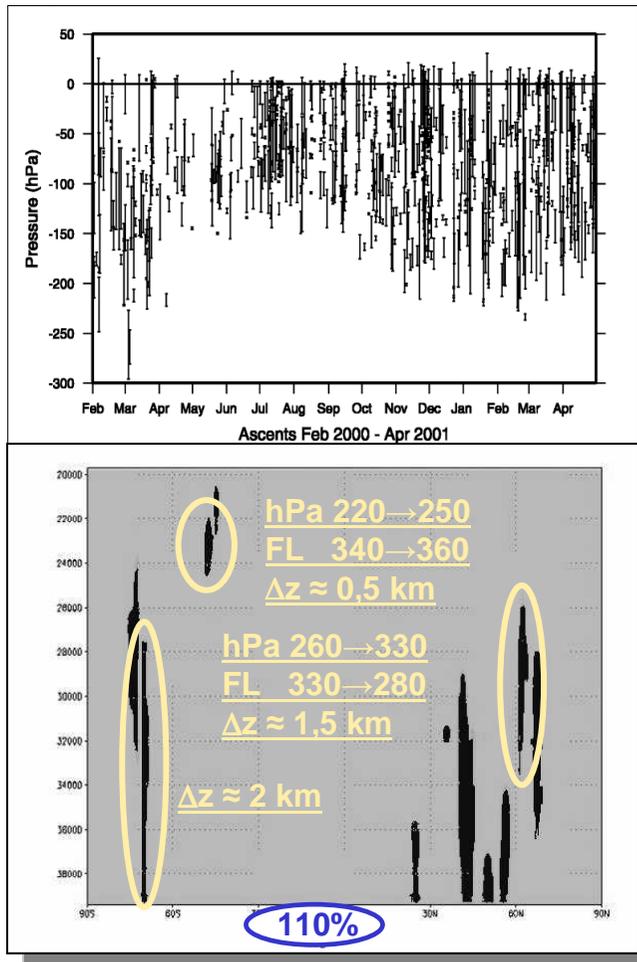
Summary and Outlook

- Flight Planning Tool is ready for operational use
- Verification of the Potential Contrail Forcing
- ❄ Implementation of the new parameterisation into the GME
- ❄ Validation with satellite data (CloudSat) due to strong sensitivity in cloud ice mixing ratio QI

Witelaes.org

Thank You !





- **In-situ measurements:**
 - $\Delta z < 560 \pm 610$ m
Spichtinger et al., 2003 (shown)
 - $\Delta z < 1-2$ km
Volz-Thomas (via A. Waibel)
- **Model?**
 - Top: measurements by Spichtinger et al. 2003
 - Bottom: Vertical cut of DWD model data (40°E, 3. March 2008, midnight, 340-260 hPa=FL 280-330=8,5-10,1 km)

How good is our Contrail Forecasts?

