Usability of COSMO-EU Model Liquid Water Output for In-Flight Icing Warnings

Leibniz Universität Hannover
Institute for Meteorology and Climatology

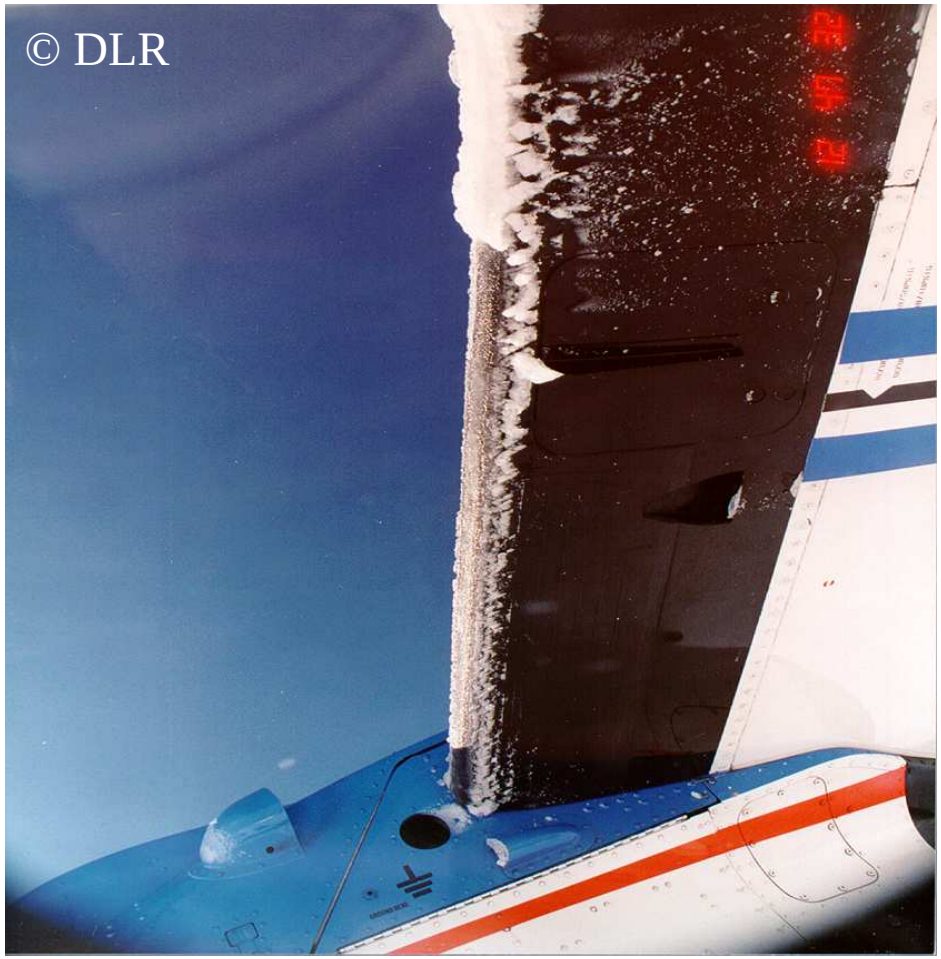
Deutscher Wetterdienst
Research and Development

Katharina Roloff, Thomas Hauf

Felix Rieper

Motivation

- Aircraft icing is one of the most dangerous hazards to aviation.
- Especially smaller aircrafts are more affected.
- Only a reliable diagnosis and forecast can help pilots to avoid hazardous icing conditions.
- ADWICE



Outline

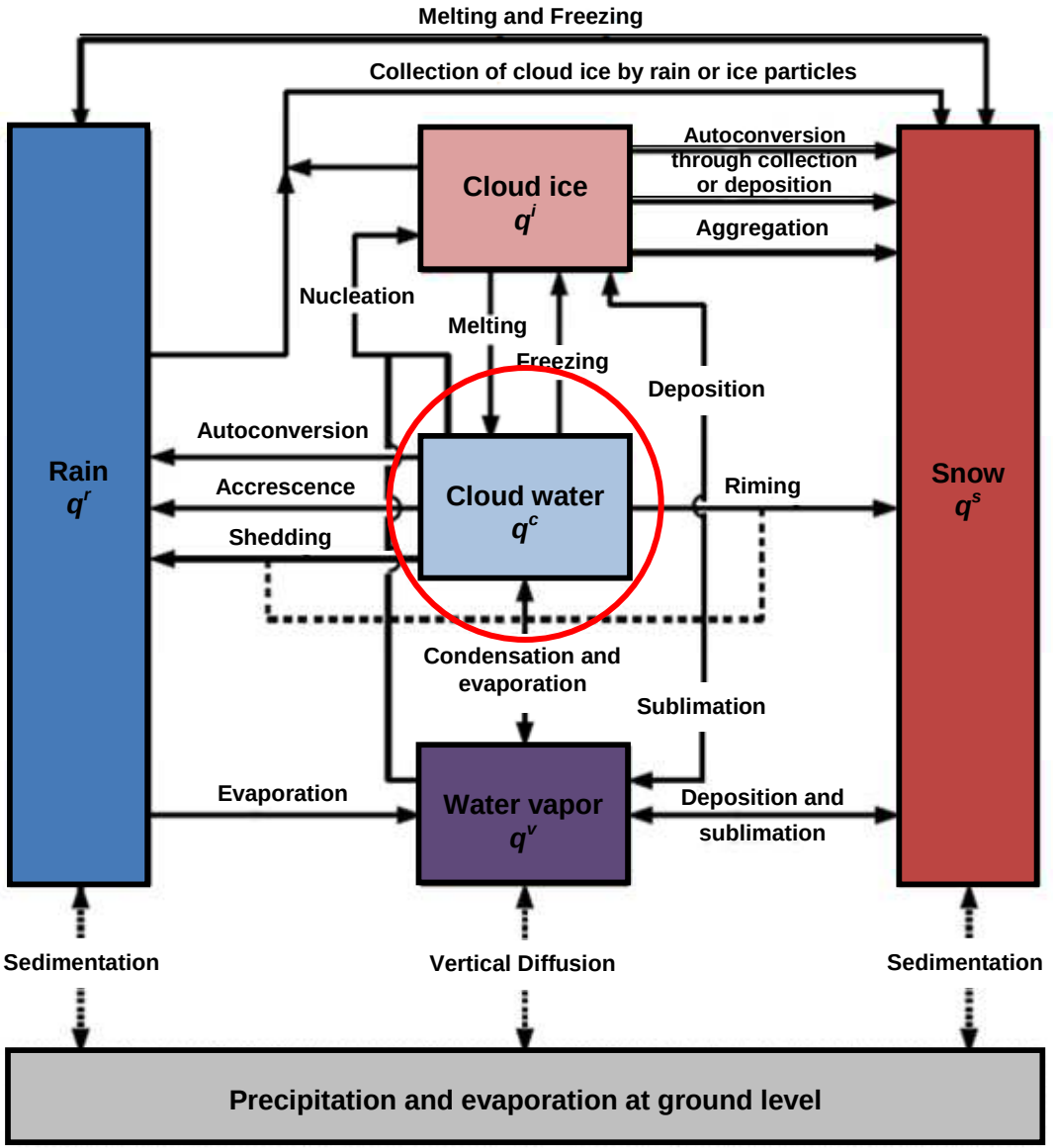
- Meteorological conditions leading to aircraft icing
- COSMO-EU liquid water output
- Weisman and Klemp test case
- Recent experiments

Meteorological conditions

- Flight through super-cooled liquid water
- Temperature range: normally -12°C < T < 0°C
  in updrafts -40°C < T < 0°C
- Super-cooled liquid water occurs: in convective systems
  in stratiform clouds
  in “clean” air with a small number of ice nuclei
- Three influencing factors to icing intensity: temperature
  droplet size
  liquid water content (LWC)

COSMO-EU Microphysics

- Five microphysical classes
- Class is defined by its mass concentration q^{ψ}
- Bulk parameterization to describe the conversion terms
- Most interesting: cloud water



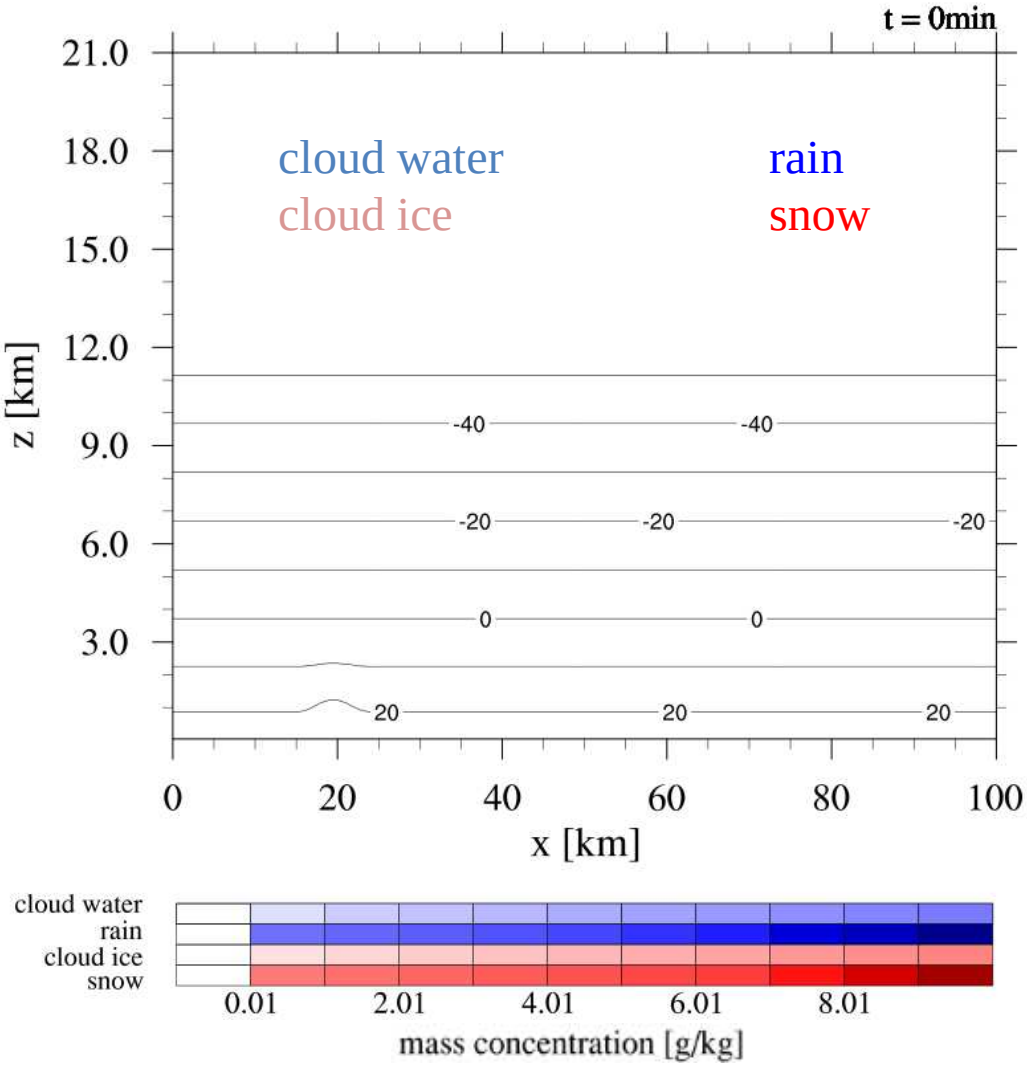
Forecast quality of COSMO LWC

- COSMO-US Experiment: COSMO-EU over the Eastern US in winter 2009/2010
- Comparison of COSMO-US cloud water forecasts to pilot reports concerning aircraft icing
- Results:
  1. COSMO-EU forecasts too small amounts of LWC in the vicinity of icing PIREP observations.
  2. The predicted spatial distribution of LWC shows unacceptable deficiencies in comparison to icing PIREPs.

K.Roloff, 2012: Untersuchung zur Eignung wolkenmikrophysikalischer Parameter des numerischen Wettervorhersagemodells COSMO-EU zur Vereisungsprognose in ADWICE. Master thesis. Leibniz Universität Hannover. 141pp.

Weisman and Klemp Test Case I

- Model domain: 100 x 100 x 20 km^3 without orology
- Horizontal resolution: 1 km
- Vertical resolution: 64 layers
- Horizontal homogenous, vertical profiles for *T*, *rH*, *u*, *v*
- Constant inflow in *x*-direction
- Initialization of a warm bubble



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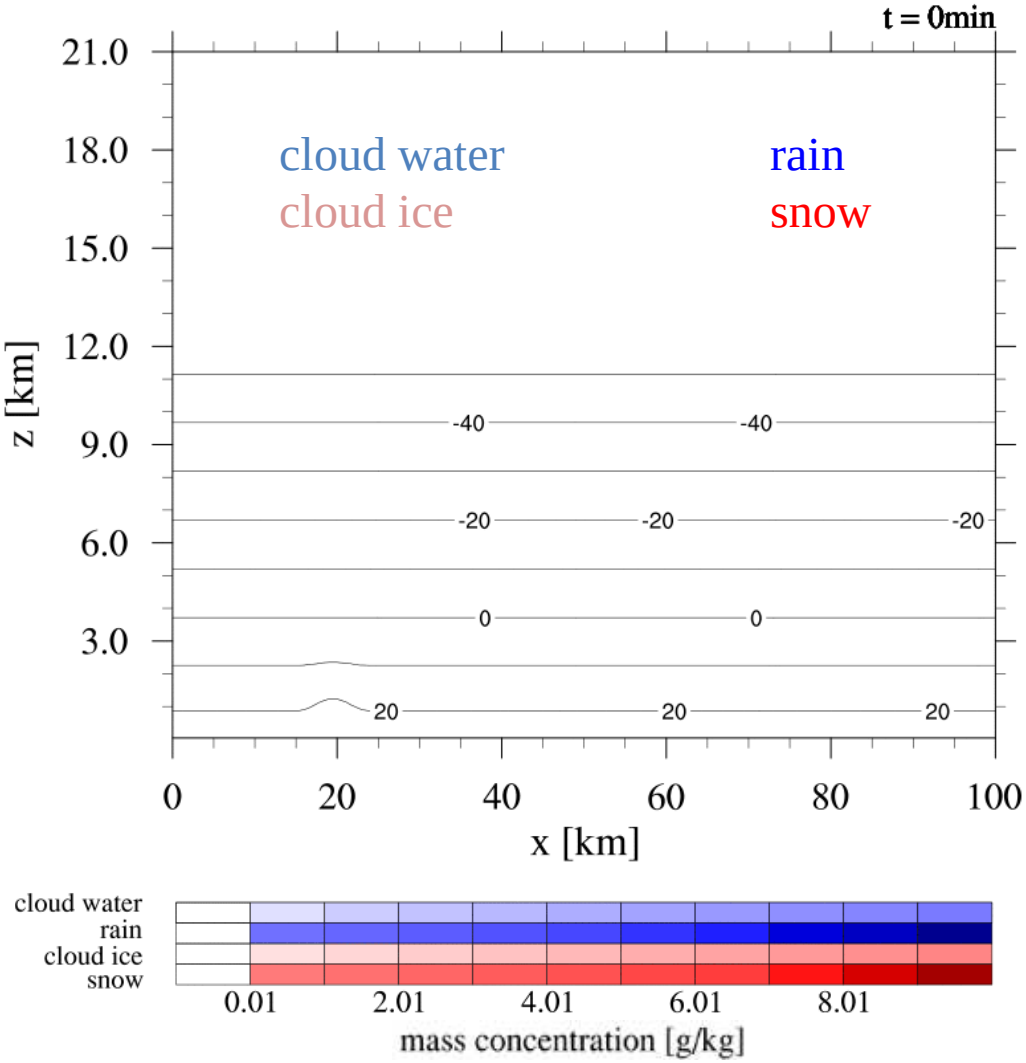
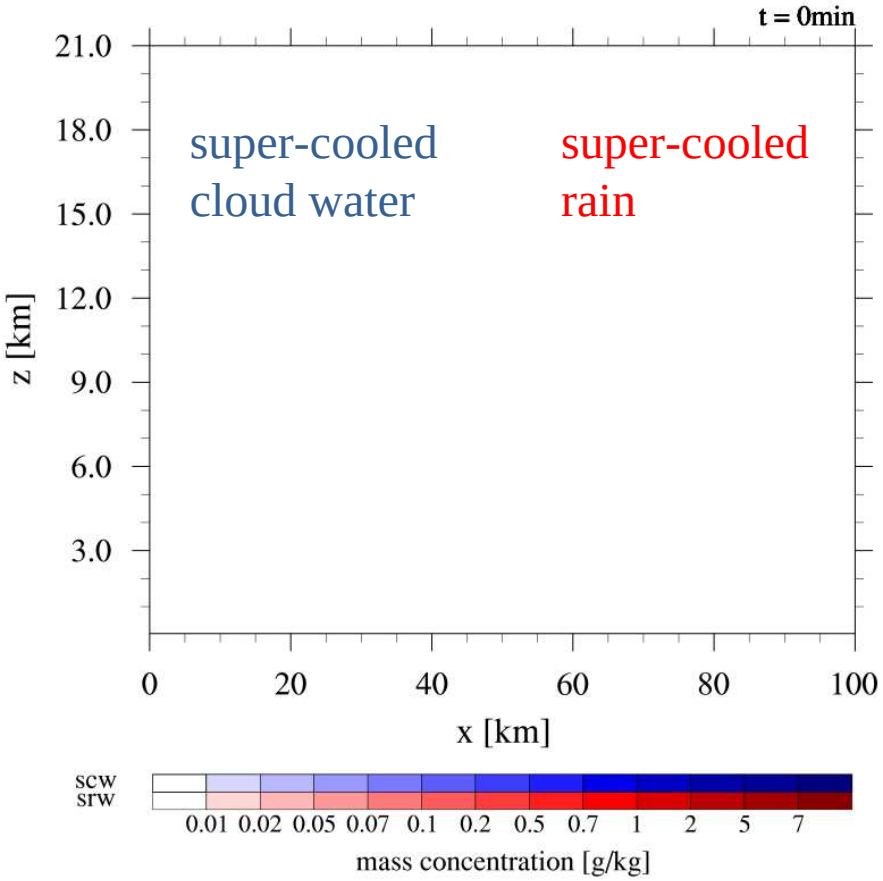
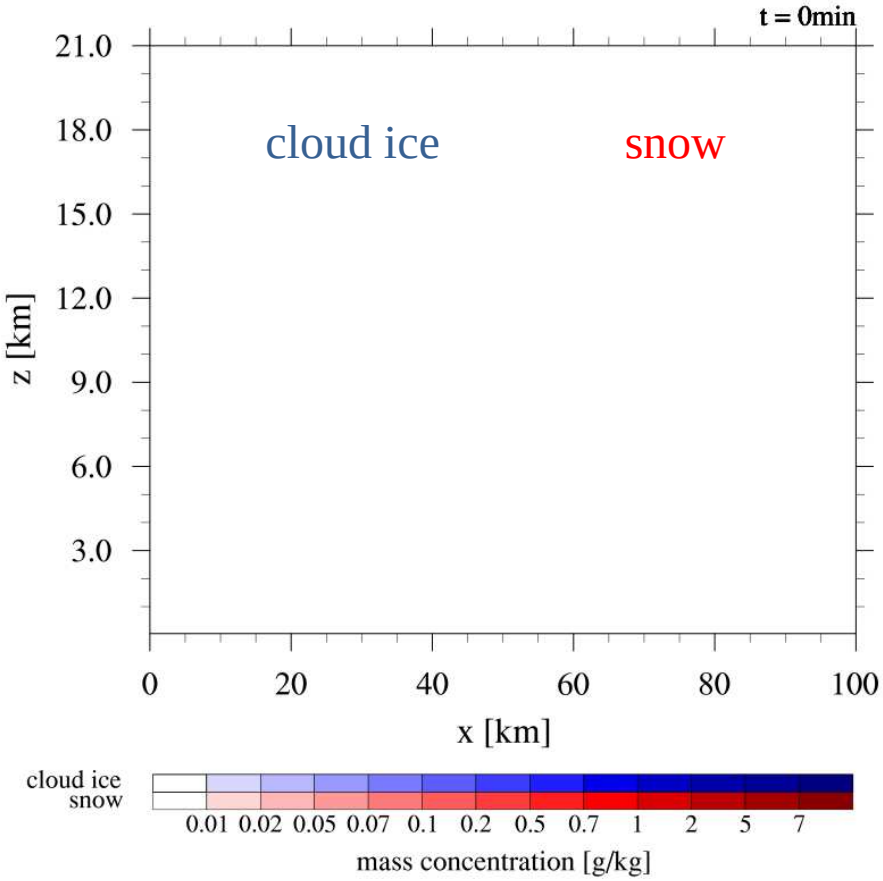


Weisman and Klemp Test Case II





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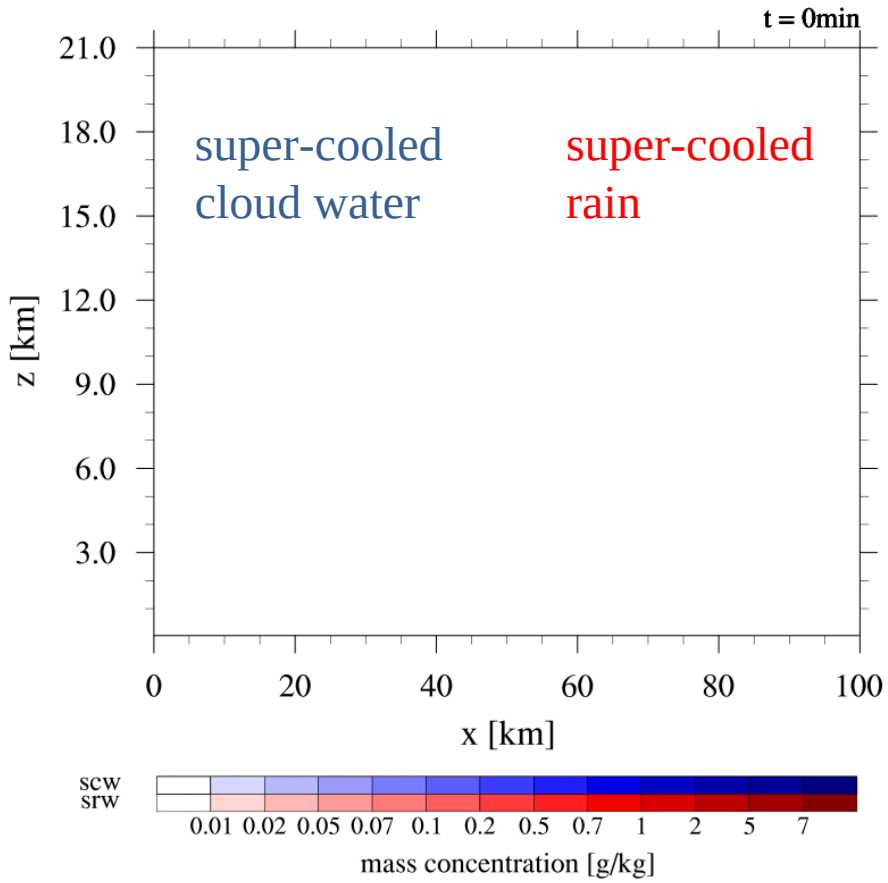
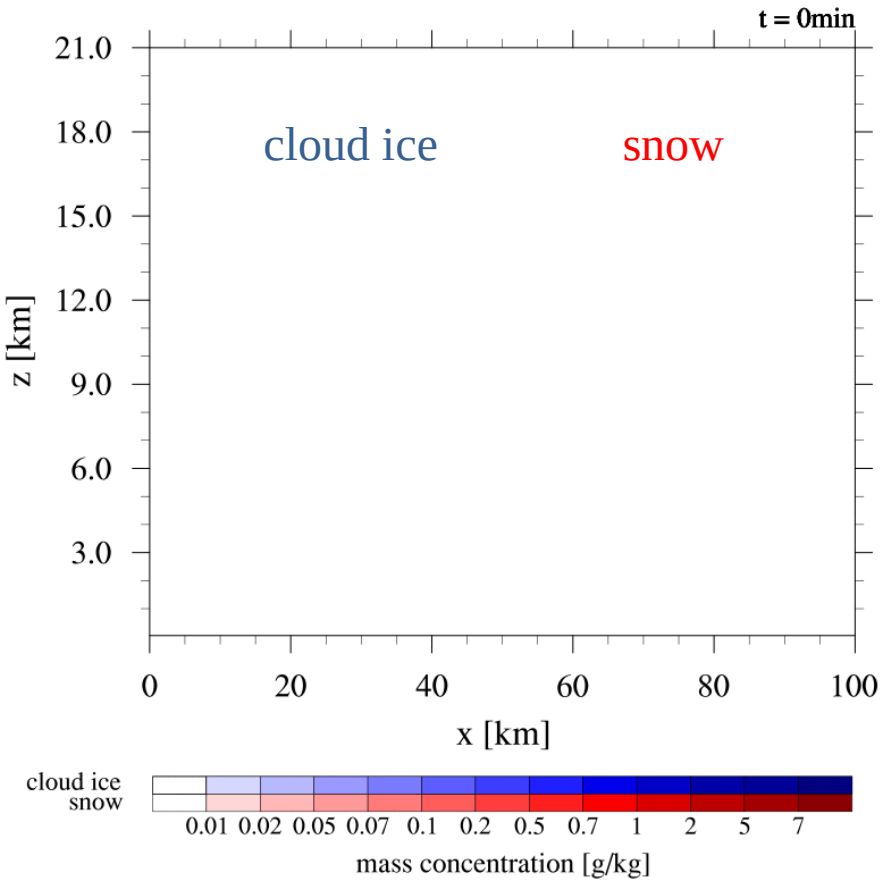
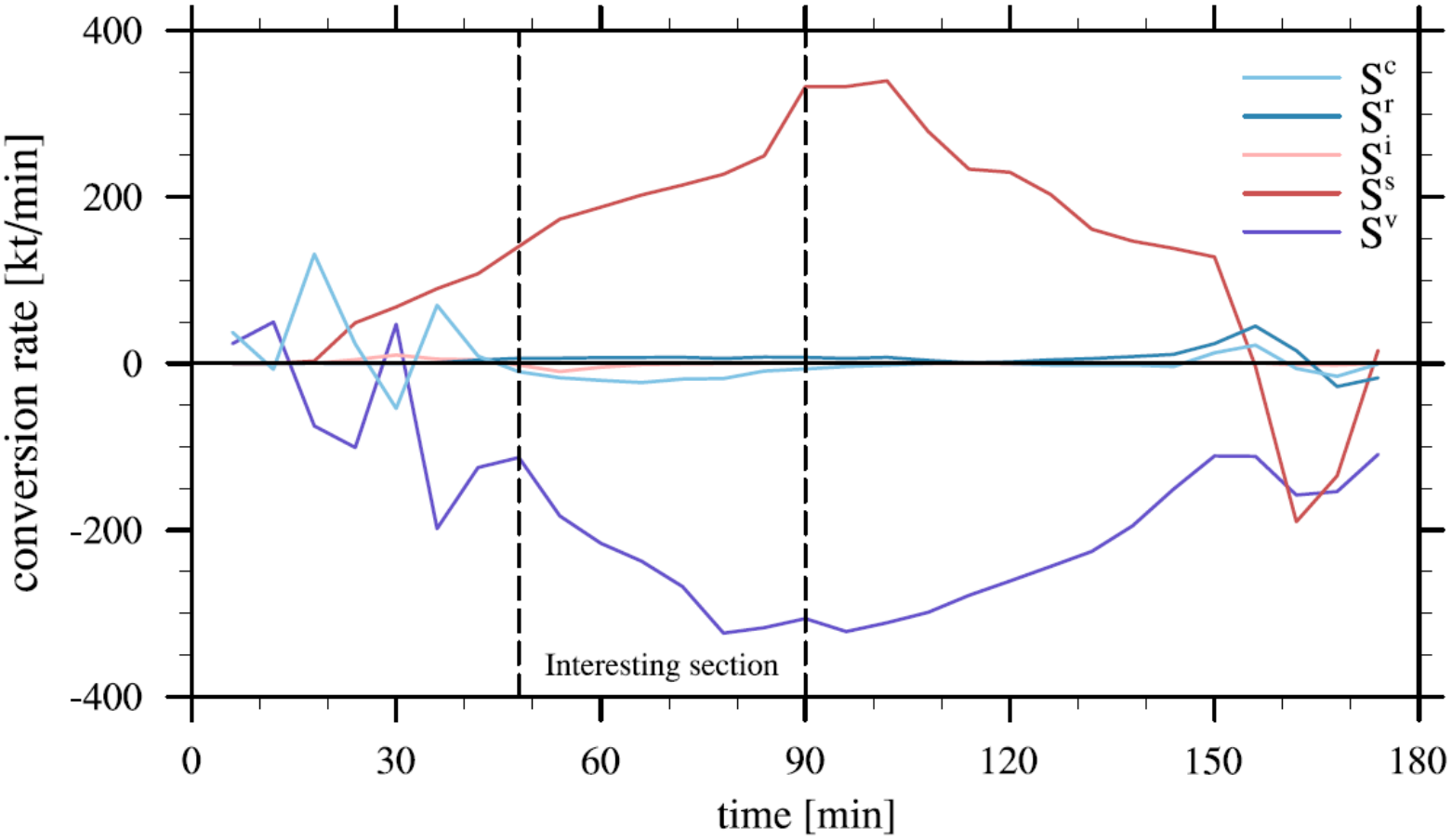




Weisman and Klemp Test Case III



Time series of the conversion terms S^{ψ}.

Recent experiments

- One week stay at the NCAR, Boulder (CO) in the working group of Greg Thompson
- Greg Thompson microphysical scheme is more “water friendly”
- Possible reasons for low LWC: High ice crystal number concentration
  High freezing rate of rain
- Several case studies to improve the forecast quality of the model field “specific cloud water content”
- Summer and winter month experiments

Conclusion

- COSMO-EU predicts too small amounts of LWC in a wrong spatial distribution.
- Freezing processes are simulated too fast in its microphysical scheme.
- Potential reasons are identified and improvements are planned.
- For now, it is not advisable to use this field for aircraft icing forecasts additionally.

Thank you for your kind attention!

Contact: Mail to roloff@muk.uni-hannover.de or call 0049 511 762 4101.

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The ADWICE System

- *Advanced **D**iagnosis and **W**arning System for Aircraft **Ic**ing **E**nvironments*
- Developed in 1998 in cooperation with DWD, DLR and IMuK
- Two-part post processing warning system to **forecast** and **diagnose** icing conditions
- Several COSMO-EU model fields used to **identify icing conditions**
- O-EU m d to **calc ensity**