Validating GME, COSMO-EU, and COSMO-DE IWCs with CloudSat CPR data

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- **Last results working contract DWD**
- Ideas for my future investigations in QUEST
- Work by M. Bilstein

Review

Motivation

- Better prediction of precipitation and clouds
- Challenge: ice microphysics
- Problem: sparse good observations of ice water contents (ISCCP, AMSU, MLS, MODIS)
  → passive sensors are not height-resolving
- CloudSat is first satellite-based cloud radar

Aim of the study

- Potential of CloudSat for model evaluation?
  - Survey of literature
  → Good quality of the radar reflectivity factor (*Protat et al., 2009)*
- Comparison of 2 different approaches
  - Observation-to-model (Radar-only retrieval)
  - Model-to-observation (QuickBeam)
- Case studies
- Statistical long-term evaluation

2 GME versions

- Global, hydrostatic NWP model
- Vertical resolution: 40 hybrid level, up to 10 hPa
- Horizontal resolution: ~40 km
- Daily operationat forecasts in hourly resolution
- 4 hydrometeor classes: QC, QI, QR, QS

GMErouti (GME6864)	**GMEexp** (GME6831)
• QC, QI prognostic • QR, QS diagnostic	• All hydrometeor classes prognostic • Improved microphysical parameterizations: ➢ New size parameterizations for snow (after *Field et al., 2005*) ➢ Autoconversion and growth of ice and snow

Last talk

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What's good about the new GME version?

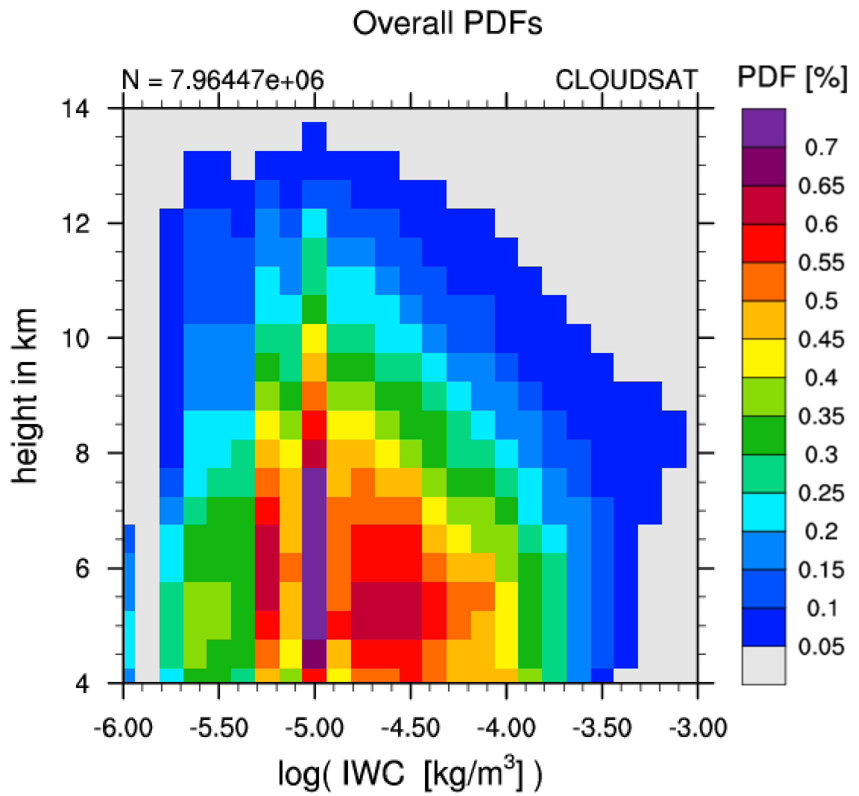
- magnitude of the IWC values fits better to CloudSat
- position and extension of the clouds is recognized better

What needs further improvement?

- frequency distribution of the simulated reflectivities is very narrow and lopsided
- cloud top often too high
- IWCs still too small

To do:

- 11-d statistics!
- search for CloudSat error?



Statistical long-term evaluation

Period:

11 days in August 2008

Criteria:

Temperature	< -10°C	Pure ice	T
Cloud cover	> 50 %	Completely cloudy scenes	C
Convection	no	Stratus, small variability	H
Total column attenuation	< 3 dBZ	No strong attenuation due to snow or liquid water	A

PDF – height-IWC

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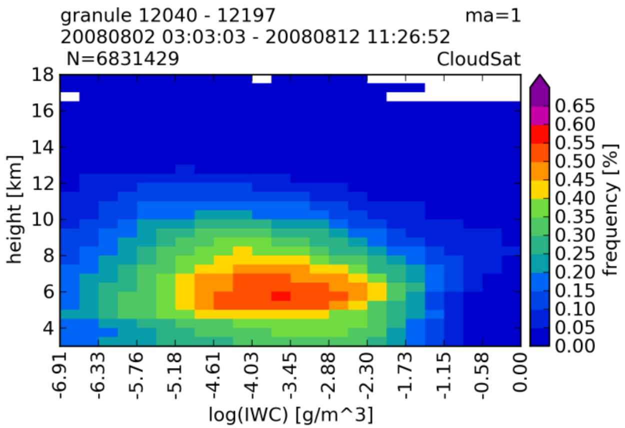
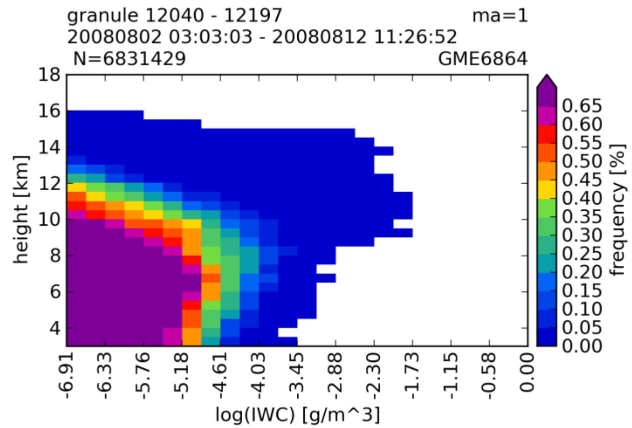
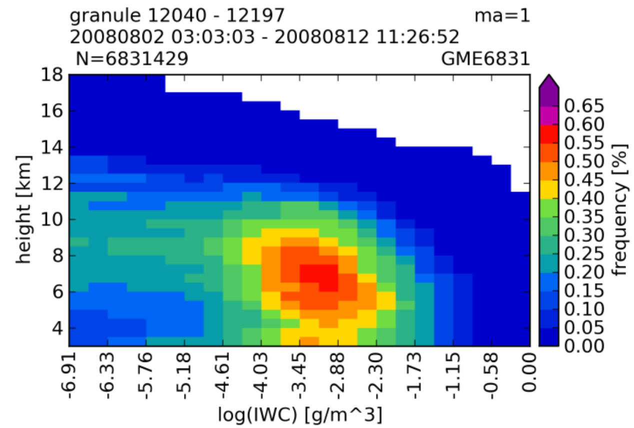
No criteria   N=6 831 429, m=1, all







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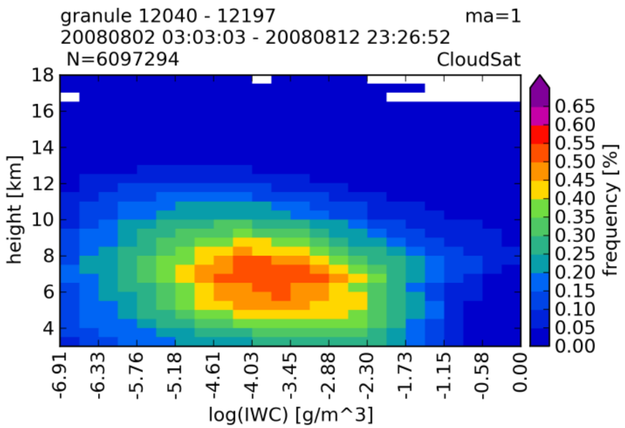

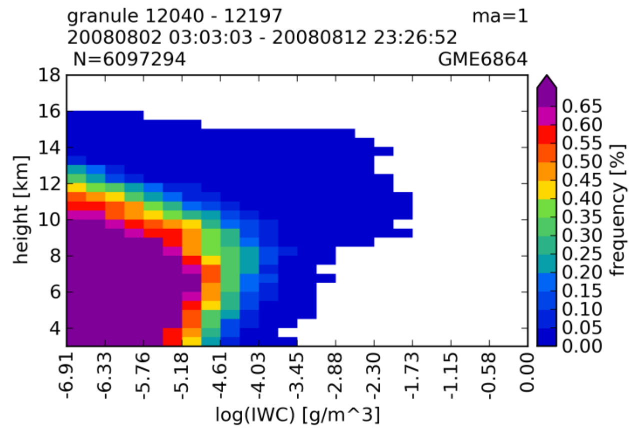

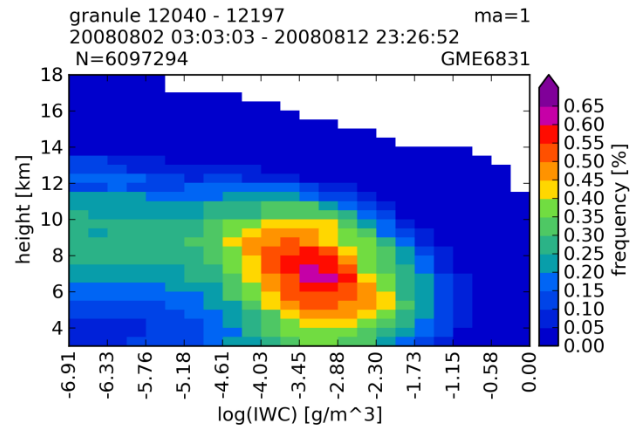

CloudSat   GMErouti   GMEexp

PDF – height-IWC

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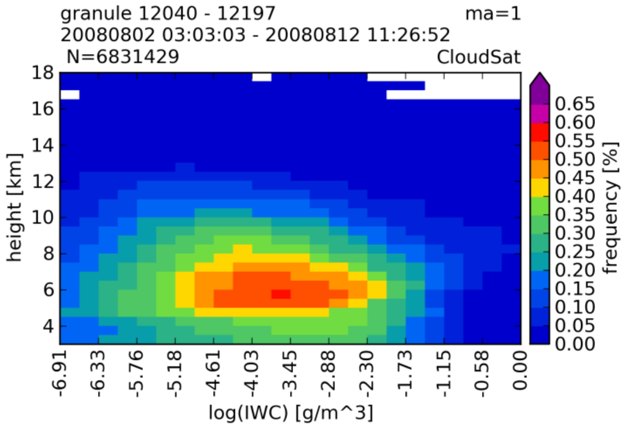
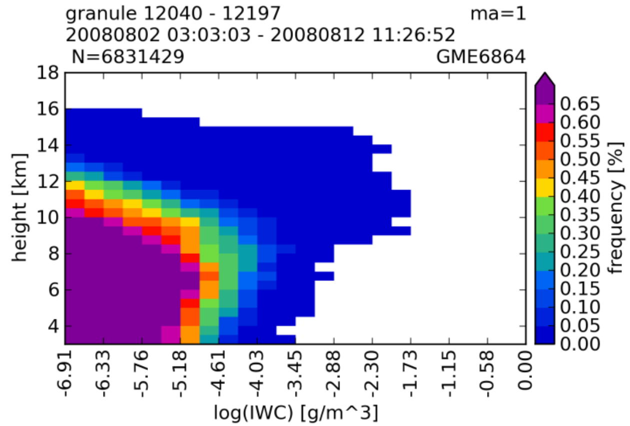
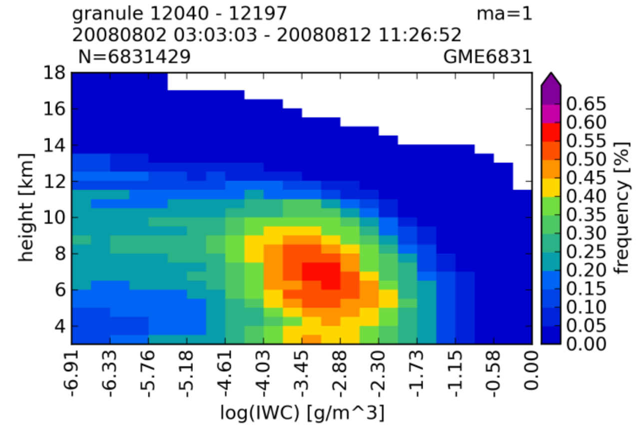
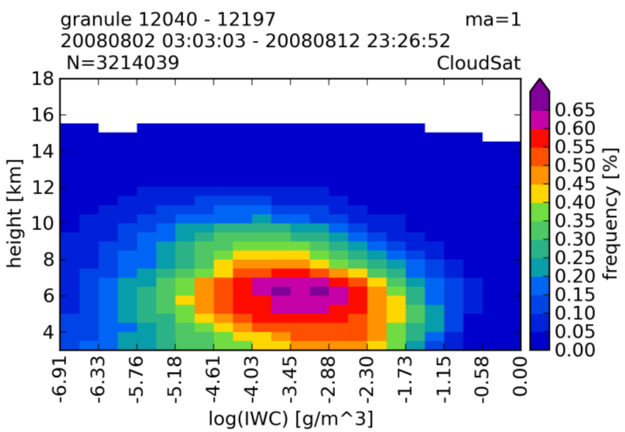
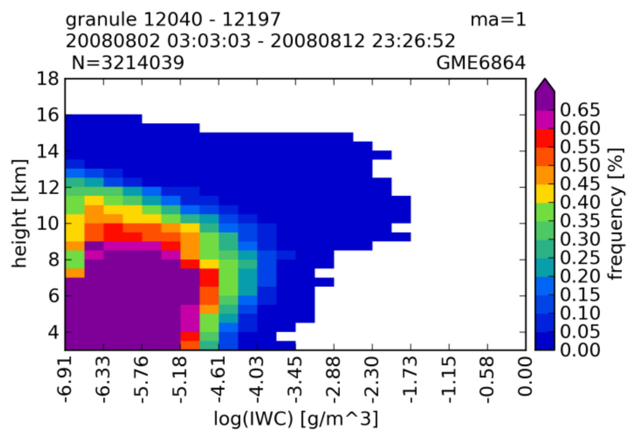


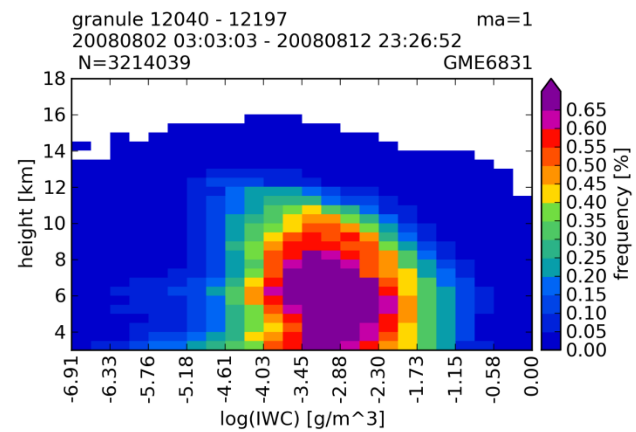




C N=3 214 039, m=1, al







CloudSat GMErouti GMEexp

PDF – height-IWC

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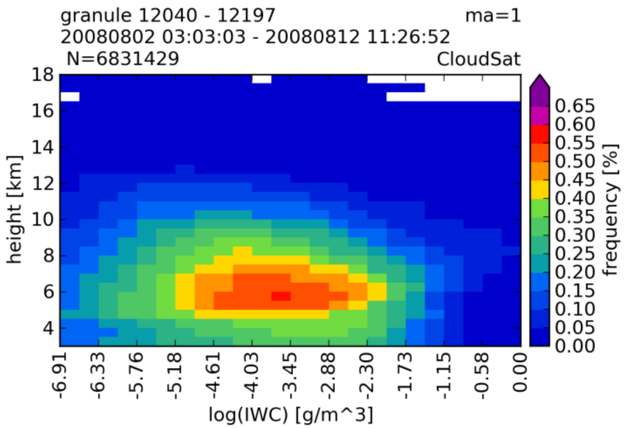

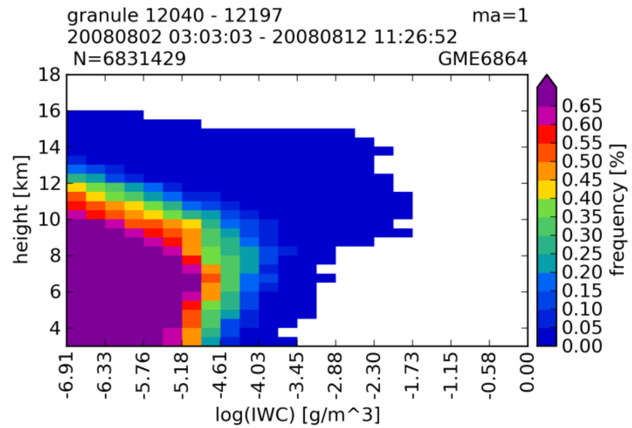

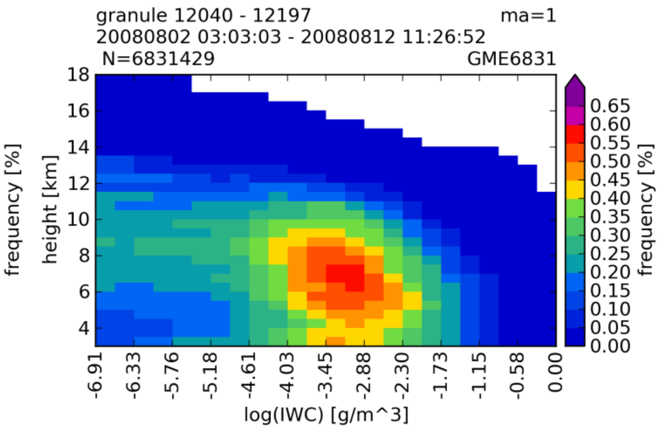

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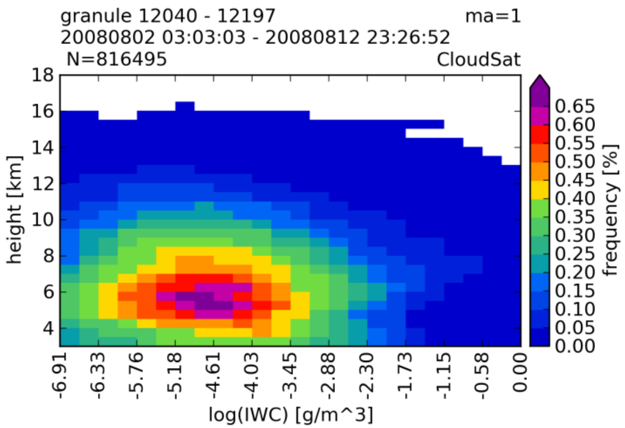

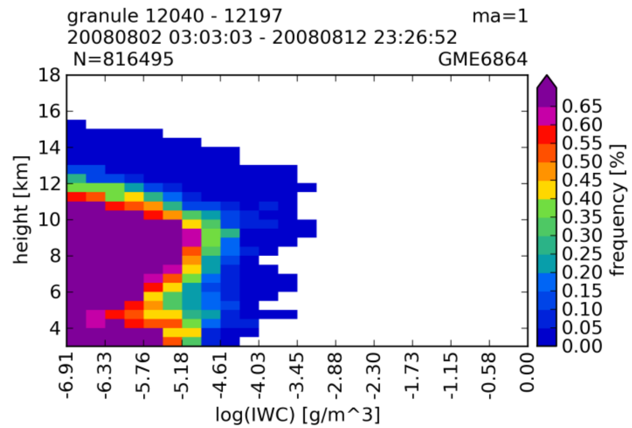

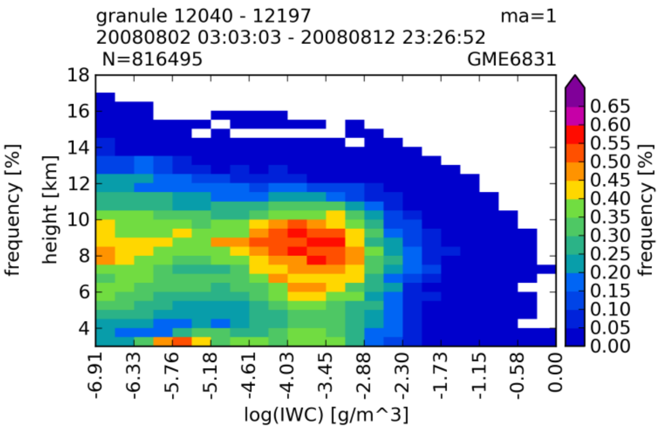

CloudSat GMErouti GMEexp

PDF – height-IWC

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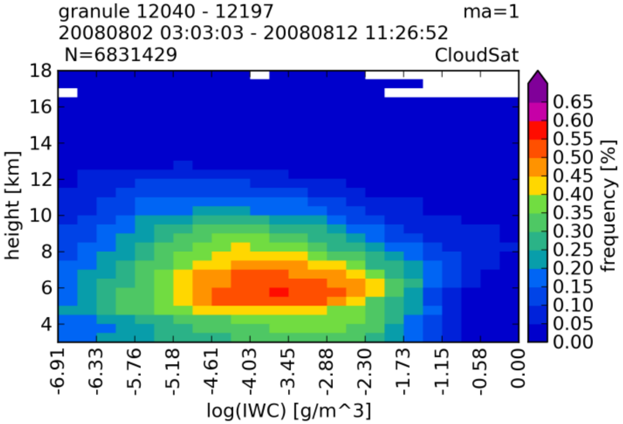
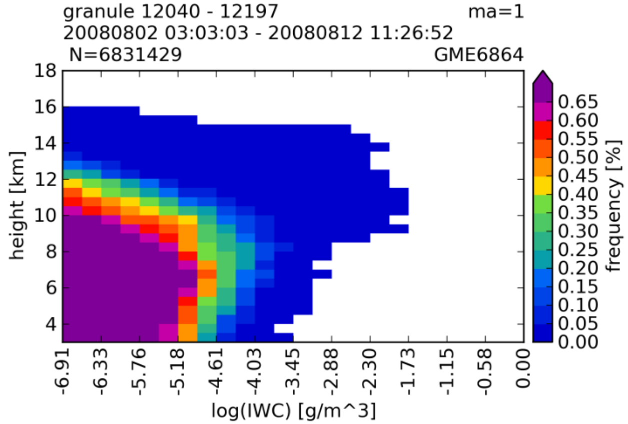
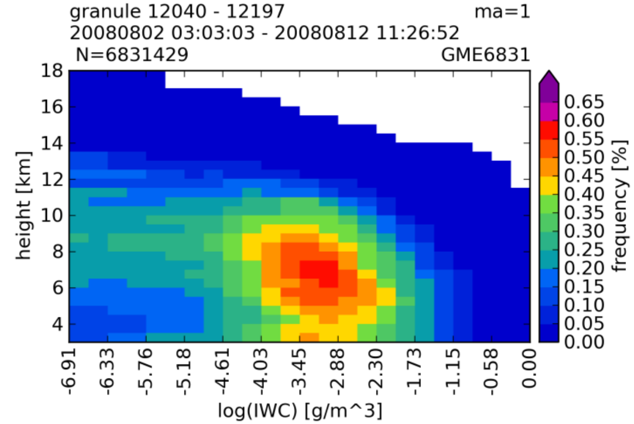
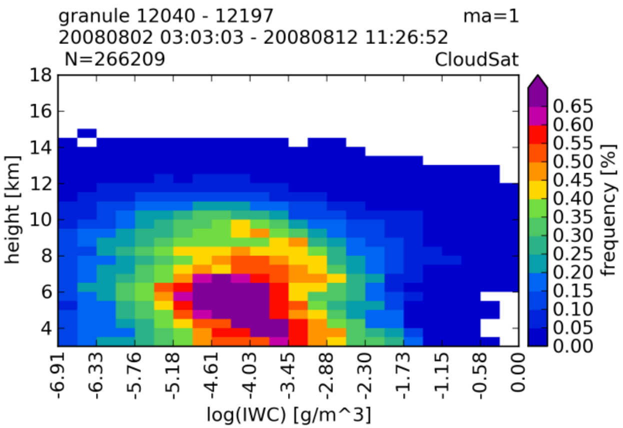
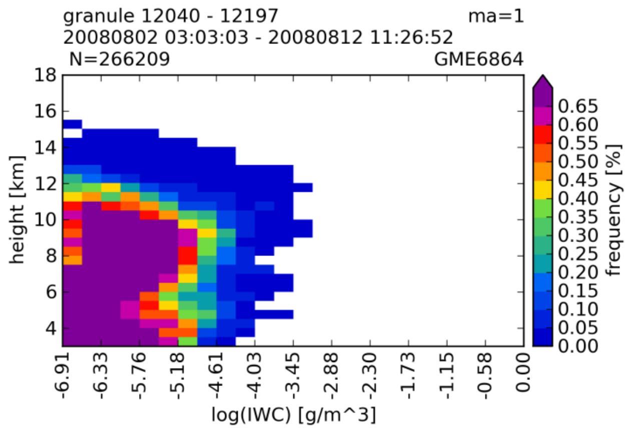


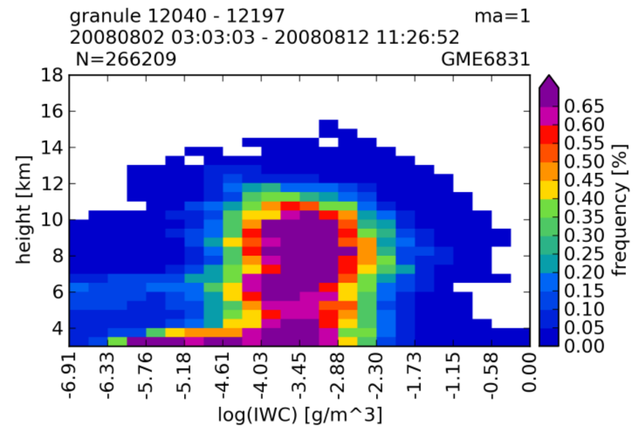




TCH   N=2 008 082, m=1, all







CloudSat   GMErouti   GMEexp

PDF – height-IWC

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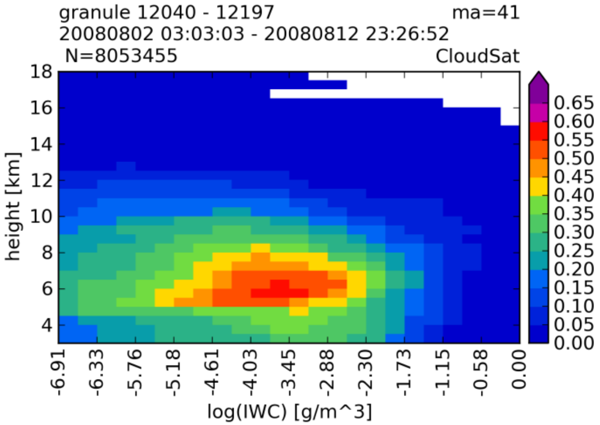
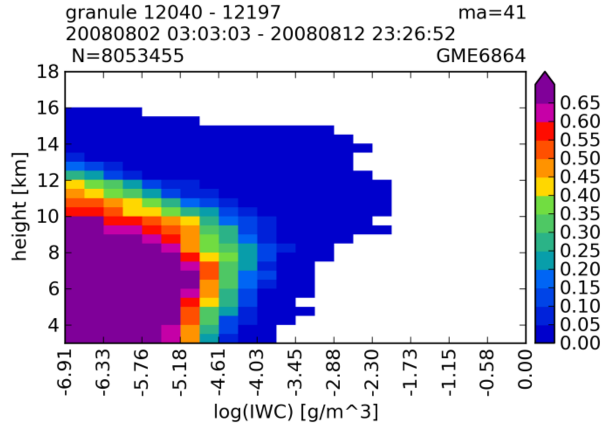
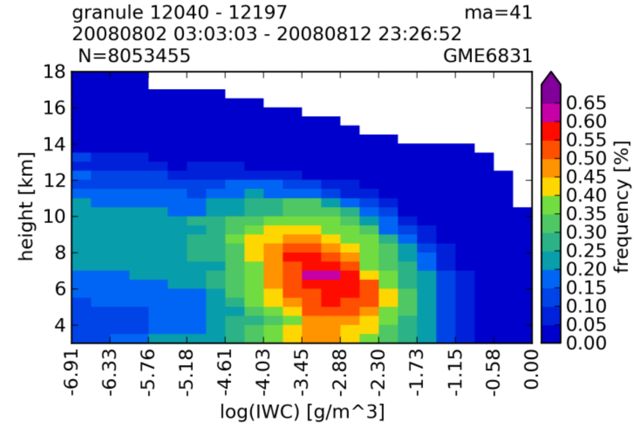
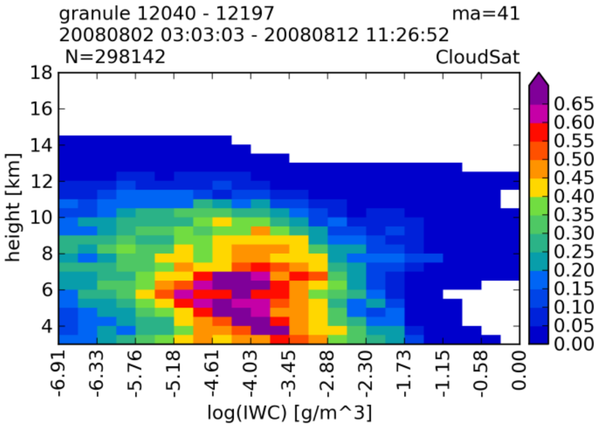
No criteria N=8 053 450, m=41, all

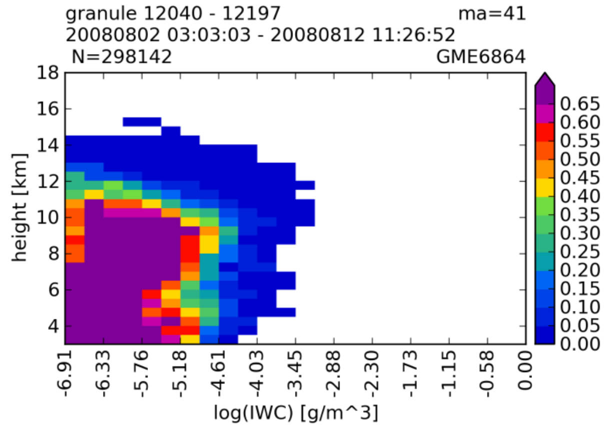


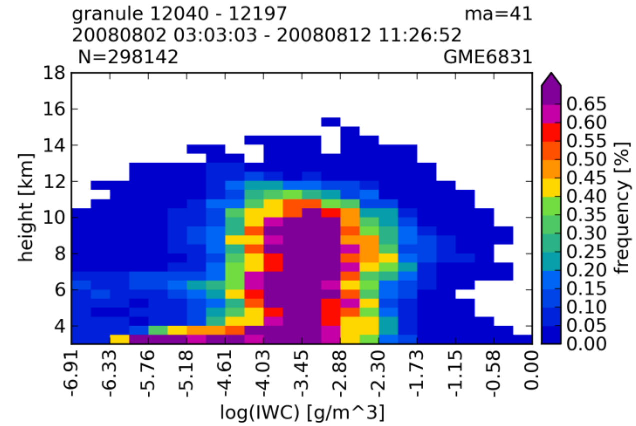




TCH N=298 142, m=41, all







CloudSat GMErouti GMEexp

PDF – height-dBZ

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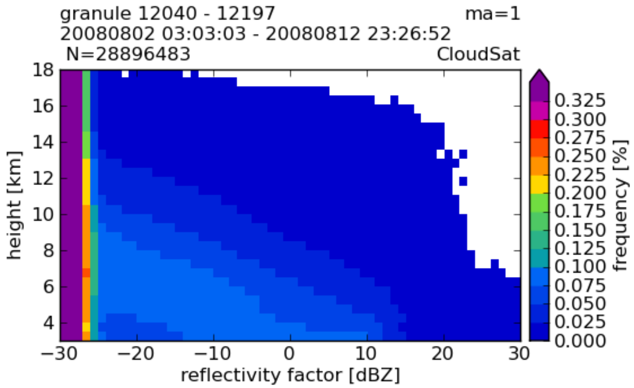
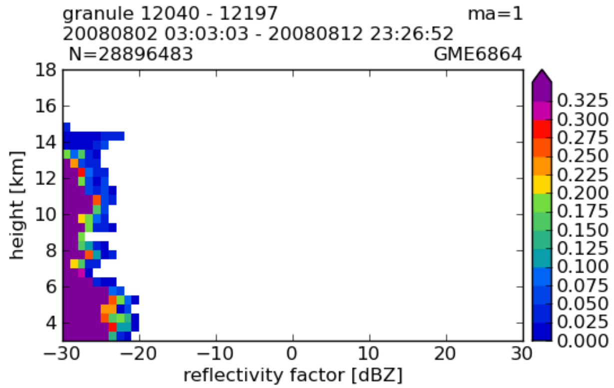
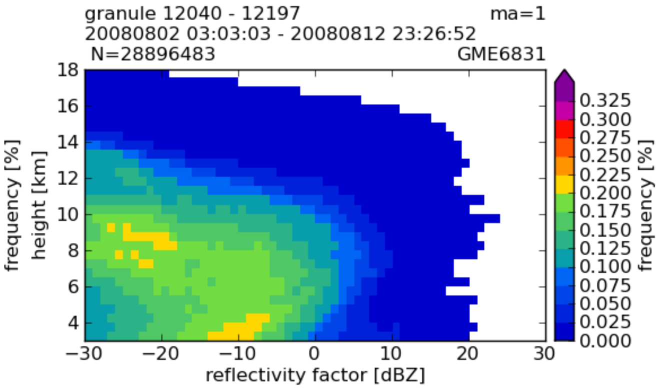
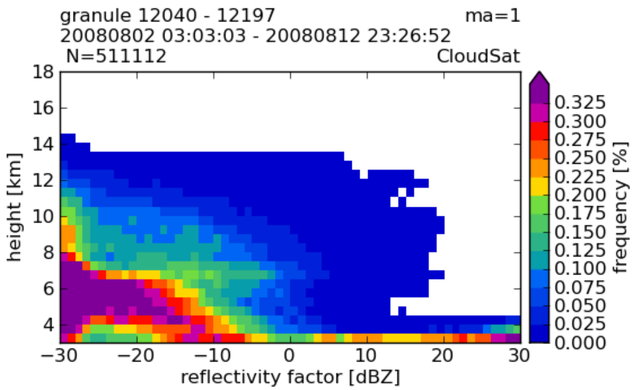
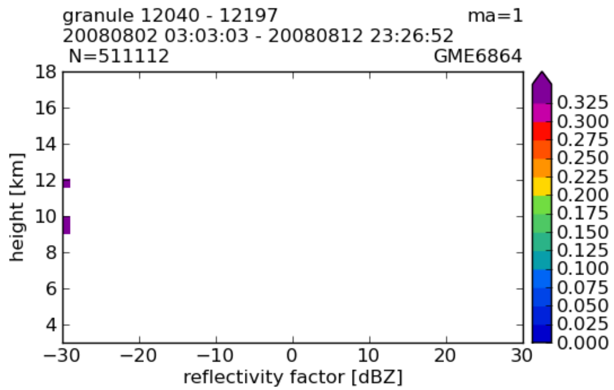


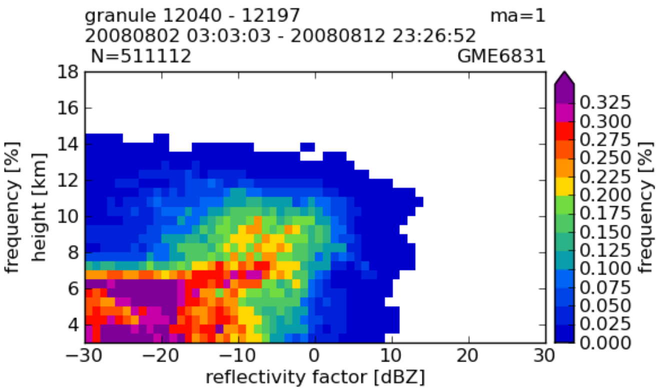




TCHA N=511 112, m=1







CloudSat GMErouti GMEexp

Summary & Outlook

Summary

\+ Extent and position of clouds is determined better in new GME version
\+ Magnitude of IWCs is better represented in new GME version
\- Cloud top sometimes too high in GME
\- IWC in GME still smaller than in observations

Conclusions

Model-to-observation approach is to be preferred
\+ Better control, e.g. profiles with much attenuation can be filtered out
\- Unknown particle size: all hydrometeors are modeled as soft spheres in QuickBeam

ToDo

- Extend analysis to longer period
- Paper

- Last results working contract DWD
- **Ideas for my future investigations in QUEST**
- Work by Maike Bilstein

1 - Extend Study

Reconsider criteria.

11-days is too short a period for sound statistical conclusions

→ Extend evaluation of GME to 4 month period: July-Oktober 2009

For precipitation regional-scale models are more interesting

→ Extend analysis to COSMO-EU & -DE

→ Include gamma distribution in QuickBeam for rain in COSMO-DE!

2 - Improve QuickBeam

	QuickBeam	COSMO
Cloud ice	all modeled as soft spheres	hexagonal plates
Snow		rimmed aggregates
Cloud water		spheres
Rain		spheres
Graupel		spheres

How much change/improvement is obtained by simulating the reflectivity factors with the exact hydrometeor shapes of the model?

→ Rayleigh- and Mie scattering on new particle shapes has to be implemented.

3 - Additional Satellite Data

How large is the underestimation of cloud top height by CloudSat?

How much ice water content is overseen by CloudSat at cloud top level due to its low sensitivity with respect to small particles?

→ Utilize MSG SEVIRI or CALIPSO CALIOP!

4 - Subgrid IWC

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Ebell et al., 2010, QJRMS

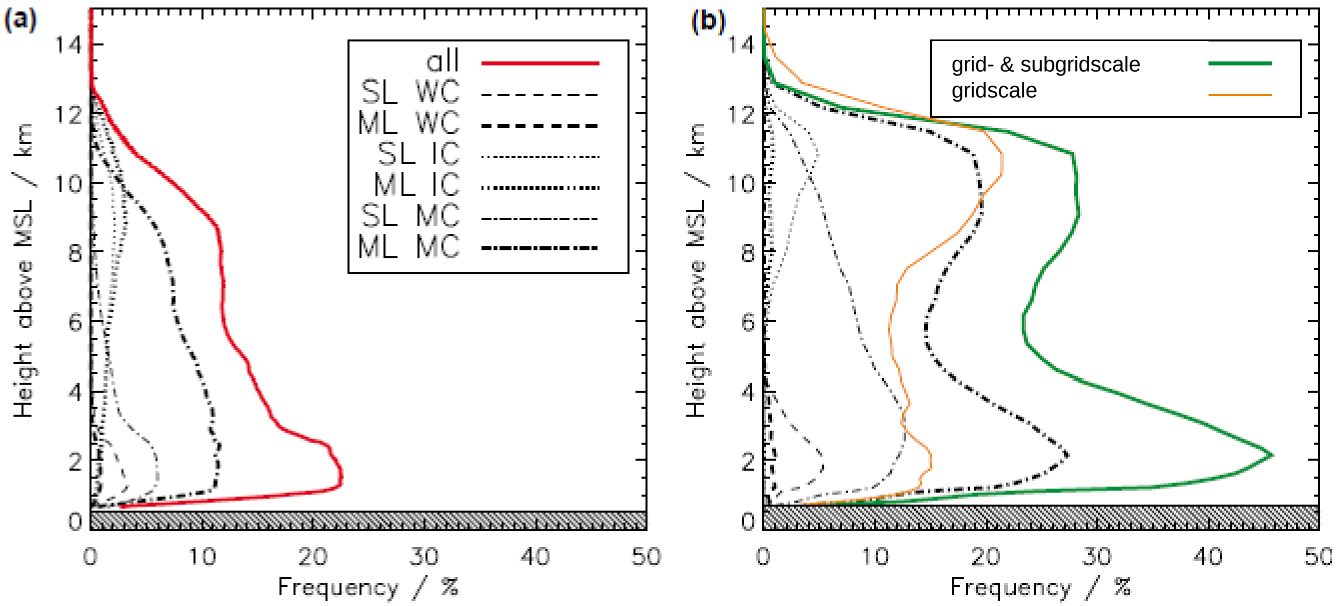


Figure 4. Frequency distributions of different cloud types in the atmospheric column. Frequency is normalized by level. Cloud types are single-layer (sl) and multi-layer (ml) water (wc), ice (ic) and mixed clouds (mc). (a) Cloudnet categorization data; (b) COSMO-DE model; (c) and (d) show an image detail of (a) and (b), respectively. The height of the AMF site (511 m above MSL) and the COSMO-DE model surface height (683 m above MSL) are indicated by the shaded area.

Does CloudSat - not beeing affected by attenuation - observe this peak?

→ Investigate for COMSO-DE for whole model area!

5 - Snow - Radiation

Radiation scheme of COSMO does not take snow into account.

Which and how large are the changes that occur if you do take it into account?

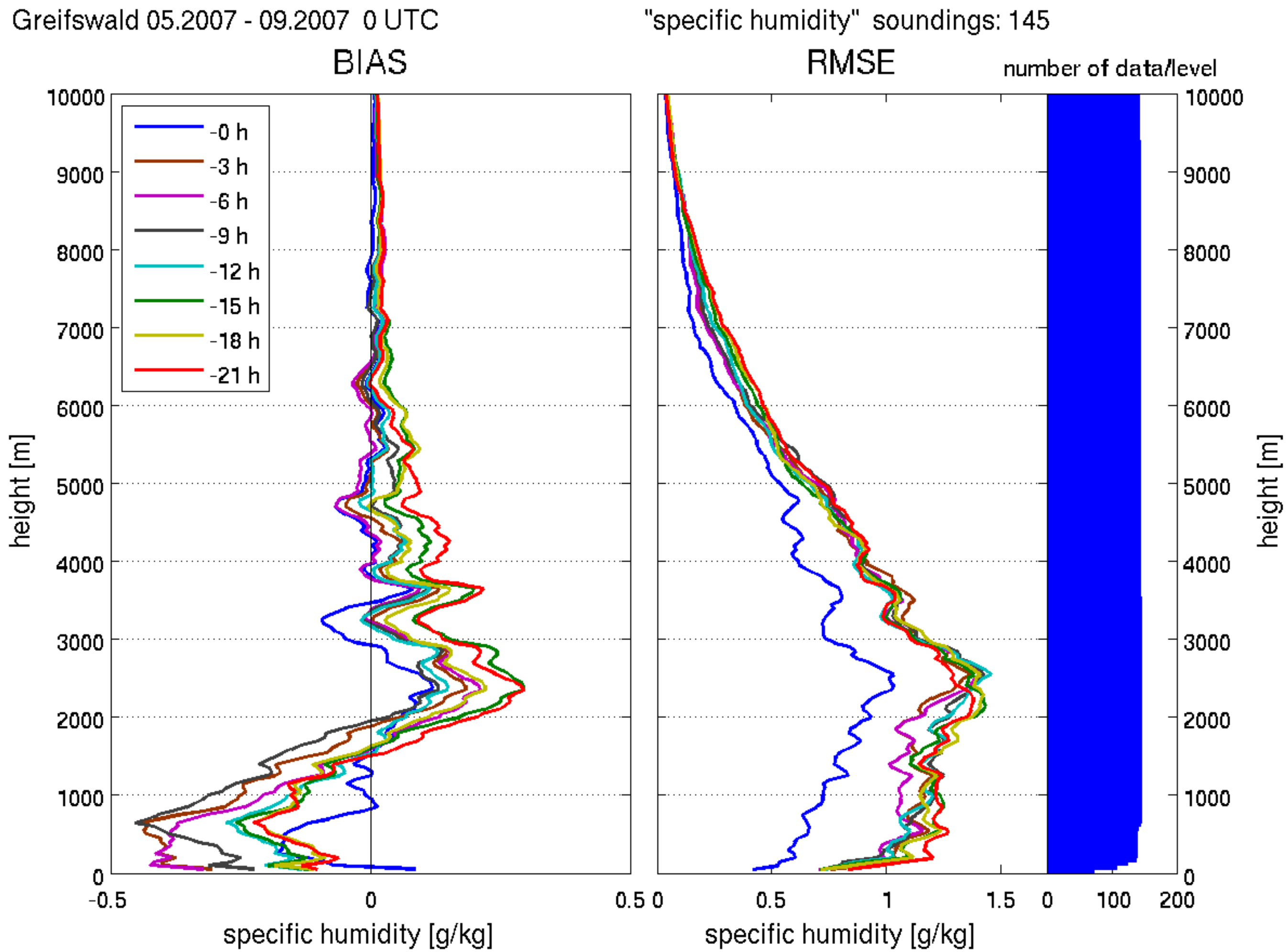
→ Test with offline radiation scheme!

- Last results working contract DWD
- Ideas for my future investigations in QUEST
- **Work by M. Bilstein**

COSMO-DE/EU versus Radiosoundings

Working Contract – Future Investigations – **Work by M. Bilstein**

GOP website → Data Quicklooks → GOP9 Comparison of COSMO-DW and COSMO-EU to radiosonde measurements

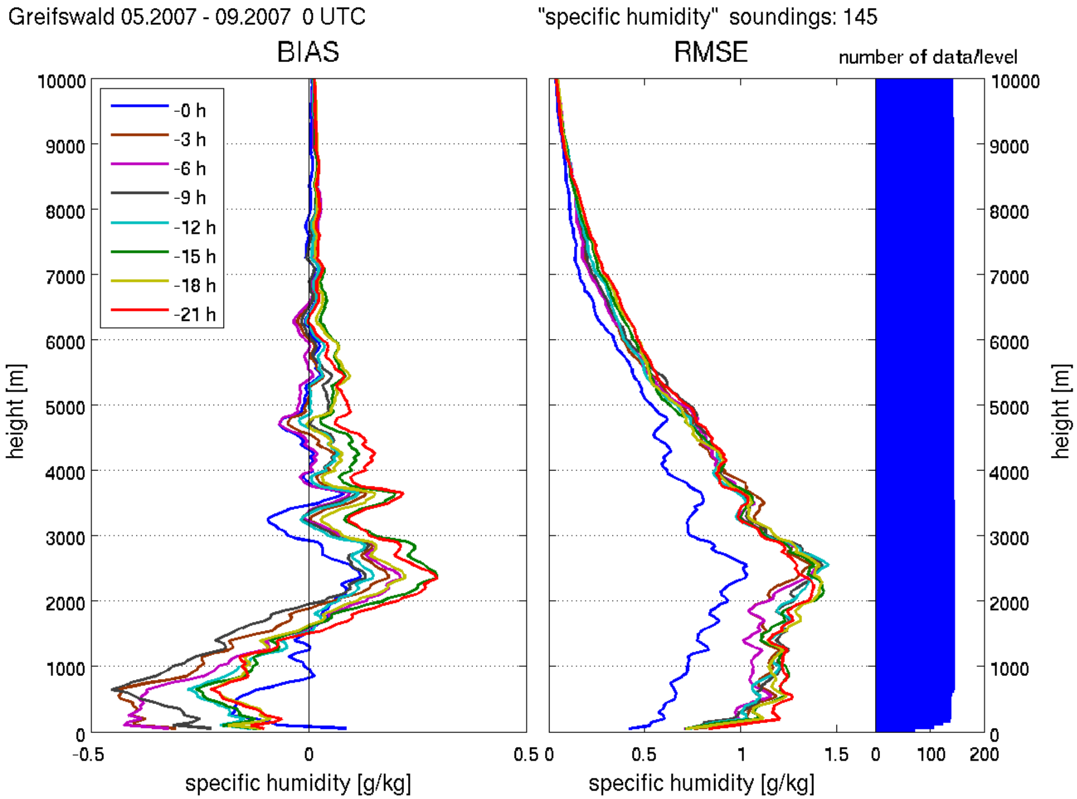


Available plot types

Comparisons of profiles of temperature, humidity, wind speed, and wind direction are available for

- Each station, time steps separately
- Each station, monthly averages over all time steps
- Each station, monthly averages, time steps separately
- Each station, summer/winter averages, time steps separately
- All stations, monthly averages over all time steps
- All stations, monthly averages, time steps separately
- All stations, monthly averages, time steps separately
- All stations, monthly averages, time steps separately , different weather types
- All stations, annual average, time steps separately
- All stations, annual average, time steps separately, different weather types

PBL/free troposphere



Question

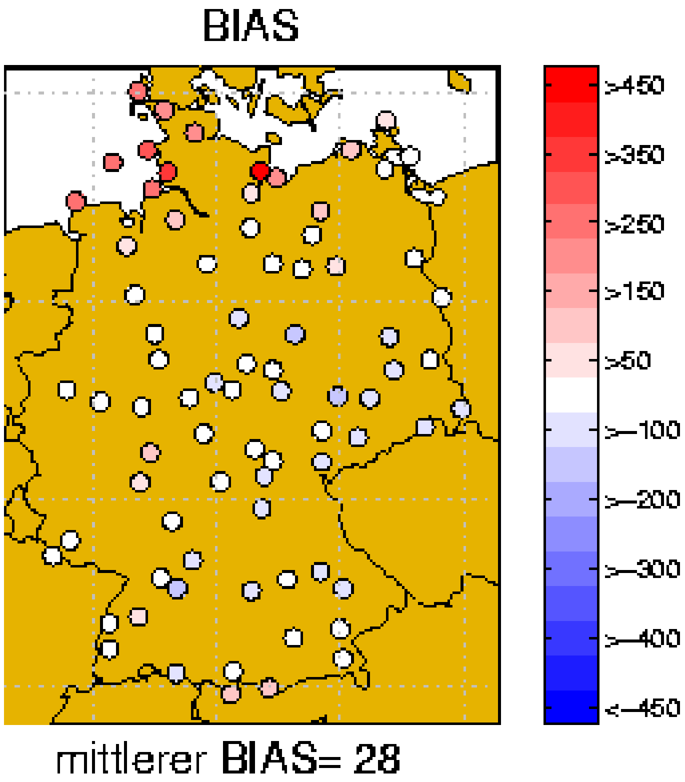
Model is too dry in lower layers and too wet in upper layers.

→ Problem with vertical moisture transport?

No conclusion.

North/South gradient

Dipl. Selbach, 2008
CBH 20080401-20080731 lmk-obs



Question

Comparisons of model cloud base height with ceilometer data exhibit North/South gradient.

→ North/South differences to be detected in q?

Conclusion:
In general, q is underestimated in northern, overestimated in southern Germany

Emden

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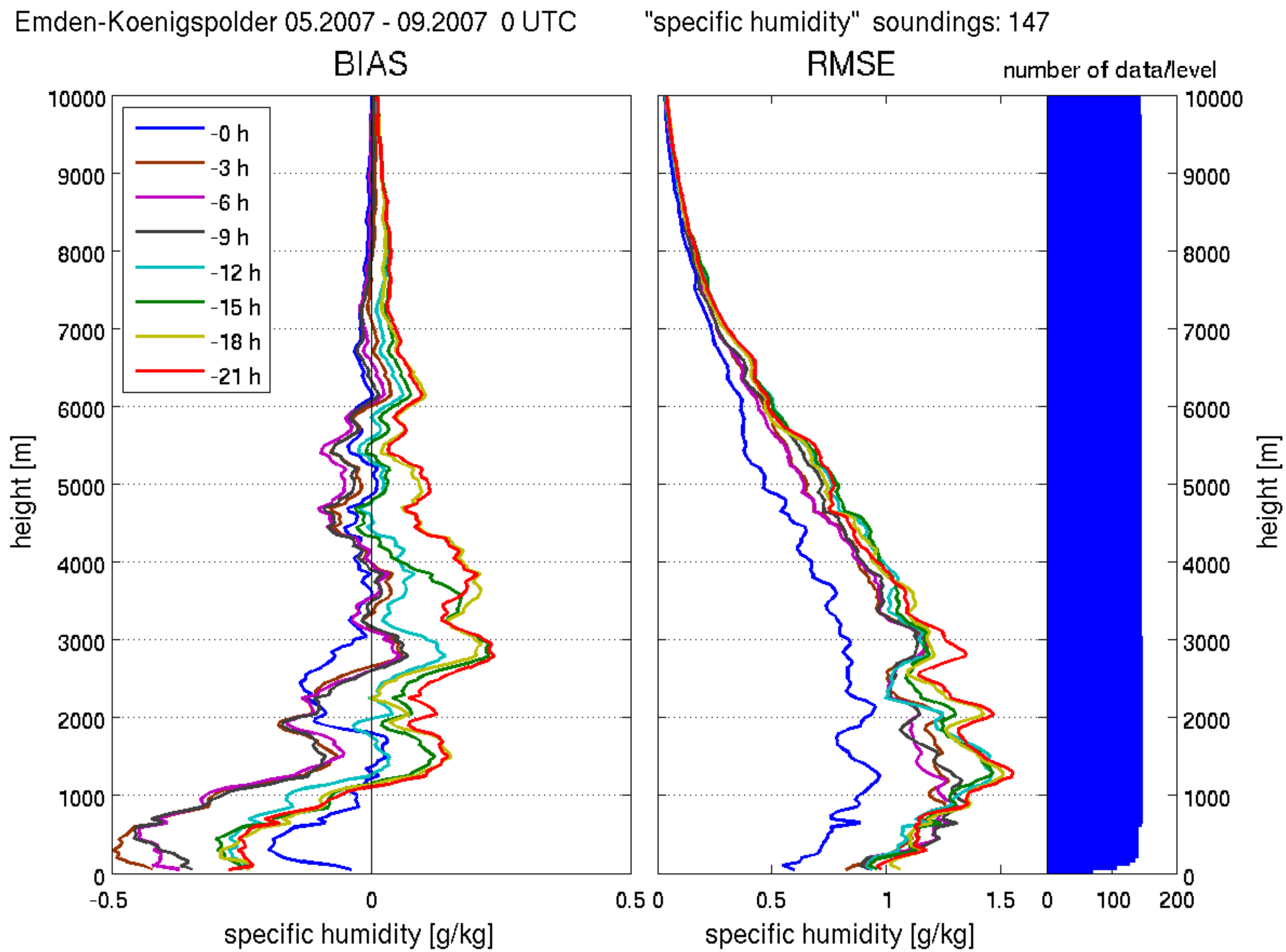

Emden

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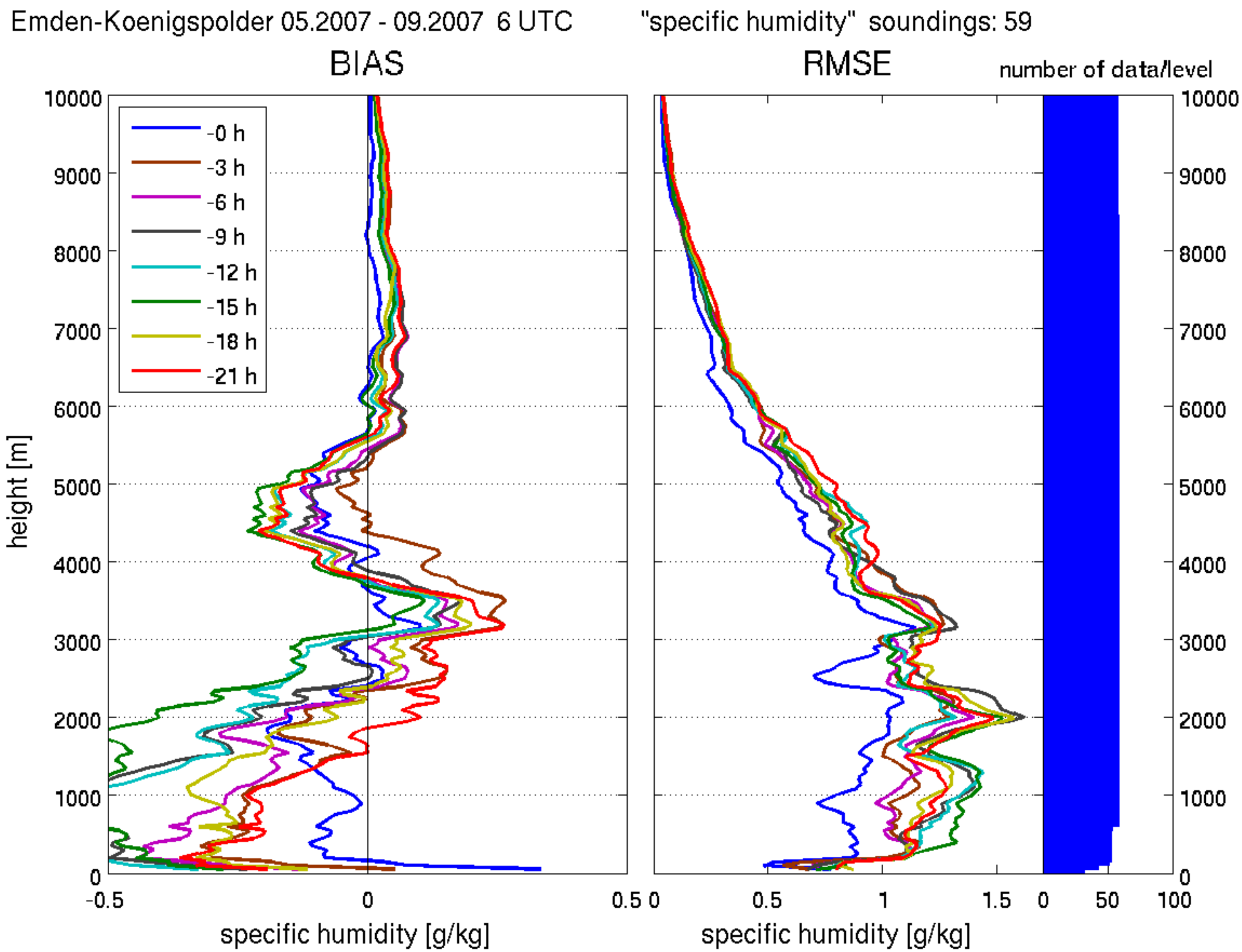

Emden

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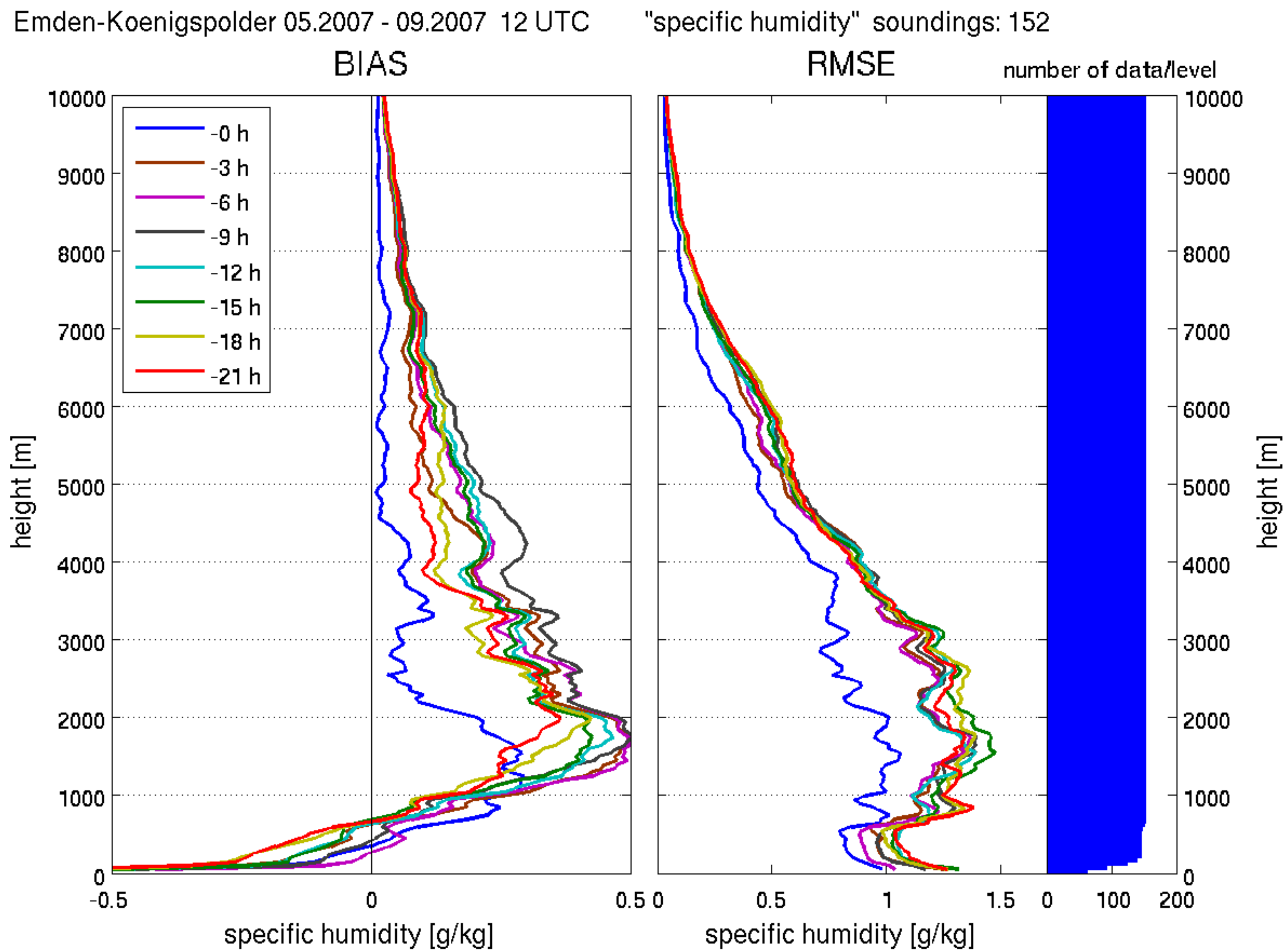
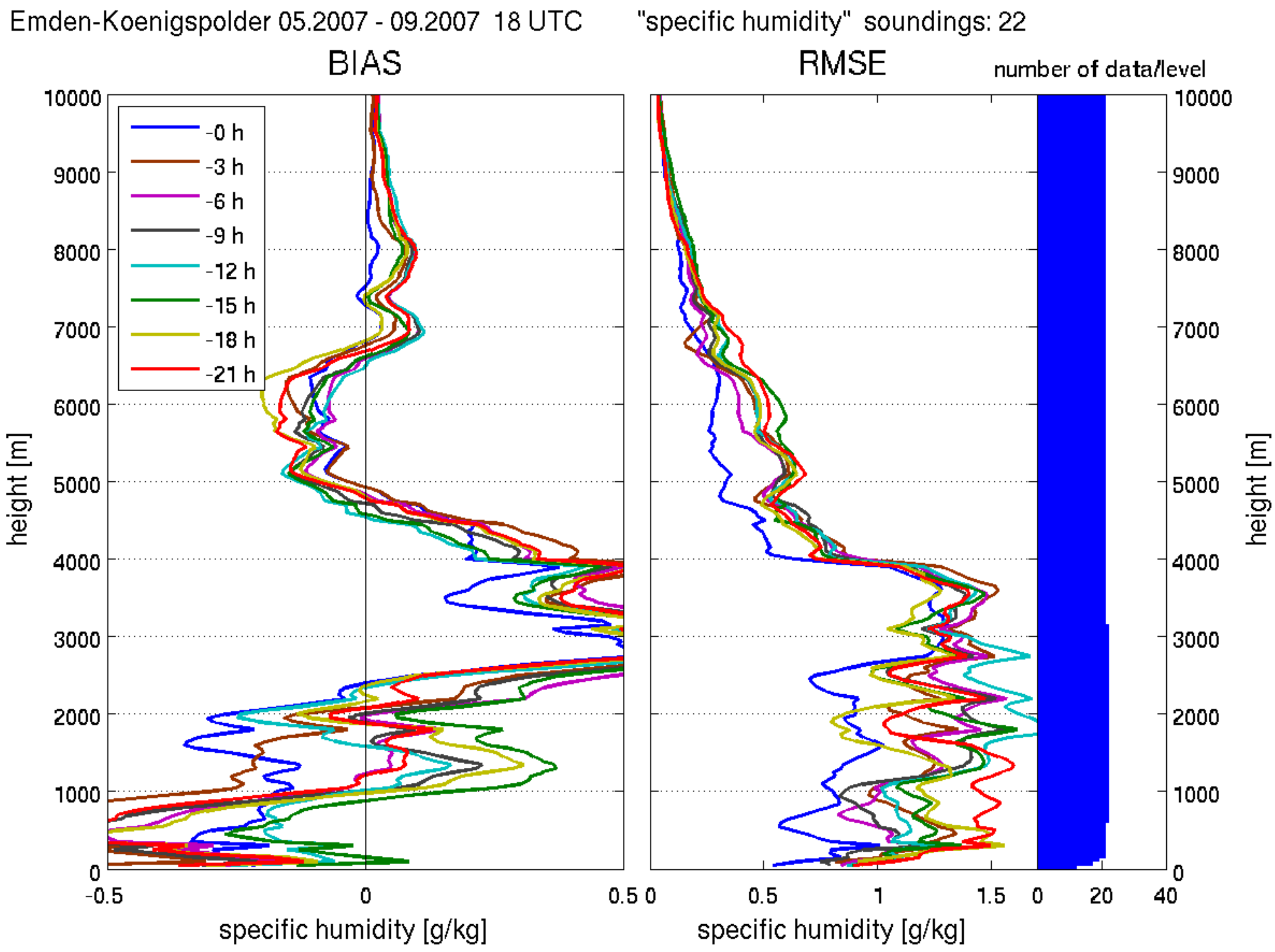


Emden

Working Contract – Future Investigations – **Work by M. Bilstein**



COSMO-DE/EU versus Radiosoundings

Summary

- High accuracy of model data (even higher in winter months)
- No coherent conclusion concerning difference PBL-free troposphere
- North Germany: underestimation of q
- South Germany: overestimation of q

Thank you for your attention!