Evaluation of ice and snow water content in GME with CloudSat data

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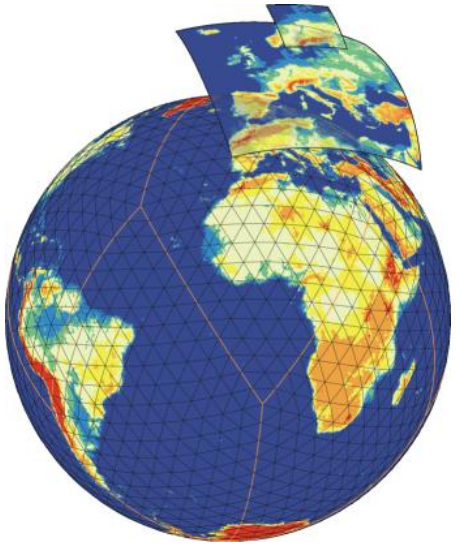
GME

- Global hydrostatic NWP model
- First part of model chain at DWD
- Horizontal: Icosaheder grid with 40 km resolution
- Vertical: 40 hybrid level
- Temporally: Hourly forecasts
- 4 hydrometeor classes: cloud ice, snow, cloud water, rain



model chain at DWD

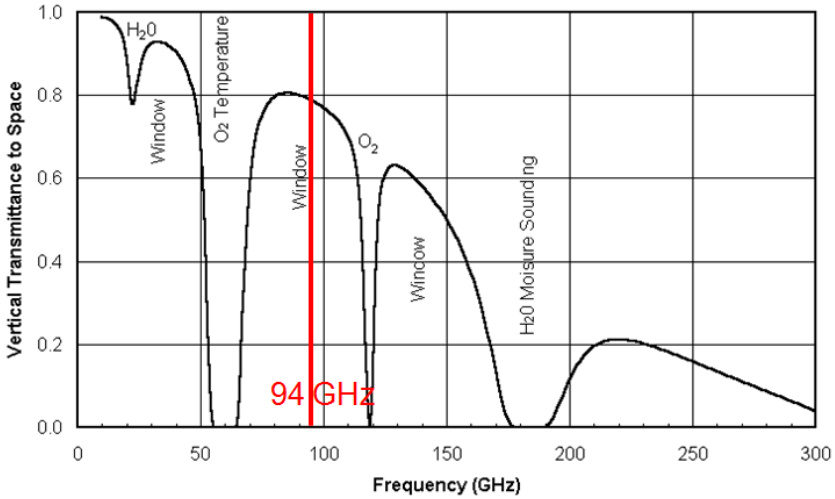
Two versions:
GME → old diagnostic precipitation scheme
GME1007 → prognostic precipitation scheme

Statistical skill scores show improvement in the forecast of accumulated precipitation
→ GME1007 in operational mode since 02/2010

But: Are the ice microphysics really improved?
→ Evaluation period: Juli – Oktober 2009

CloudSat CPR

http://www.nasa.gov/mission_pages/cloudsat/



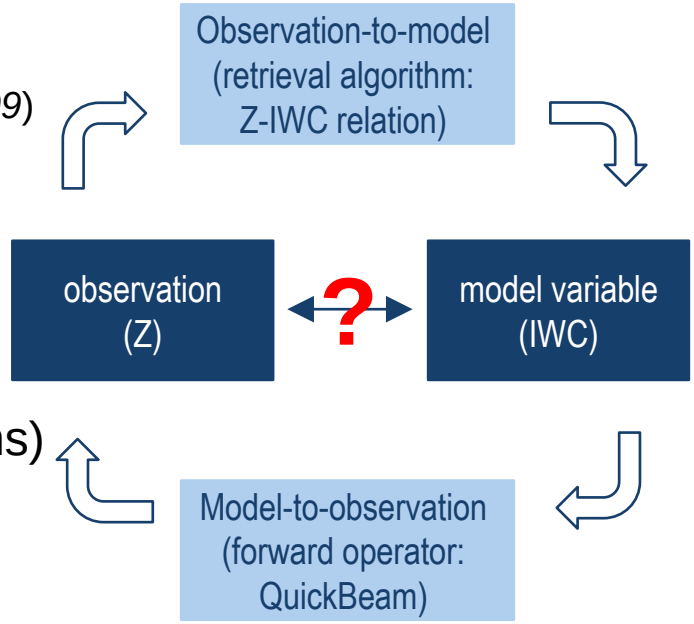
- Operational since 06/2006
- Part of polar-orbiting A-Train
- Orbiting time: 1.5 h
- Cloud Profiling Radar (CPR): 94 GHz nadir-looking radar (1. satellite-based cloud radar)
- Detection range: -27 to +29 dBz
- Footprint: 1.8 x 1.4 km
- Horizontal: averaging interval of 0.16 s results in 1.1 km resolution
- Vertical: 125 bins with 240 m thickness each
- Smallest detectable IWC: ~0.001 g m^{-3}

2 Approaches

Observation-to-model

→ Version 5.1 IWC Retrieval (*Austin et al., 2009*)

- ↗ Easy computation
- ↗ Close to model physics (compares actual model parameters)
- ↘ Retrieval uncertainties (3 parameters from 1 measurement, many assumptions)
- ↘ Linear scaling between liquid and solid phase may lead to false estimation of IWC



Model-to-observation

→ QuickBeam v1.1a (*Haynes et al., 2007)*

- ↗ Avoids retrieval uncertainties
- ↗ Close to actual physics (simulates the reflectivity the radar would have measured in the presence of a certain amount of hydrometeors)
- ↘ Ice crystals are modelled as soft spheres, whereas in GME:
  Snow → Aggregates
  Cloud ice → Hexagonal plates

Sampling and Sensitivity Issues

Sampling

- Model output (starting from 00 UTC run) which is closest to the mean time of a CloudSat orbit
- Horizontal: Nearest neighbour interpolation of GME onto CloudSat track
- Vertical: Linear interpolation onto evenly distributed levels with 500 m height
- Moving average on CloudSat data to account for coarser model resolution

Sensitivity

- Include only (trustworthy) data within the detection limits of CloudSat: $-26 < Z < +29$ dBz and $0.001 < IWC < 1$ gm^{-3}

Criteria

- Temperature ≤ -10°C → avoid liquid and mixed phase
- Cloud cover ≥ 50 % → ensure homogeneous conditions
- HTOPCON ≤ 1 km → avoid convective (sub-grid) effects
- Attenuation ≤ 3 dBz → avoid large particels

Global Frequency Distributions T versus IWC / Z

CloudSat IWC

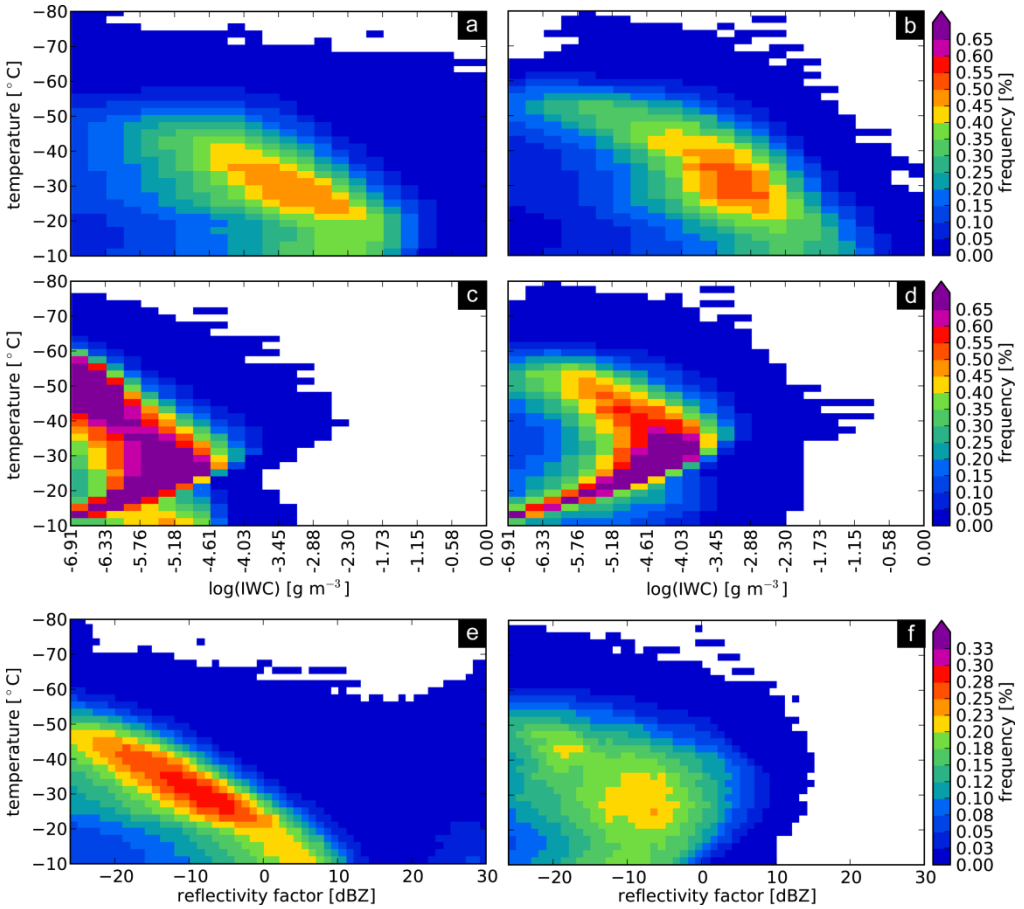
GME1007 IWC

GME IWC

GME1007 ice-only IWC

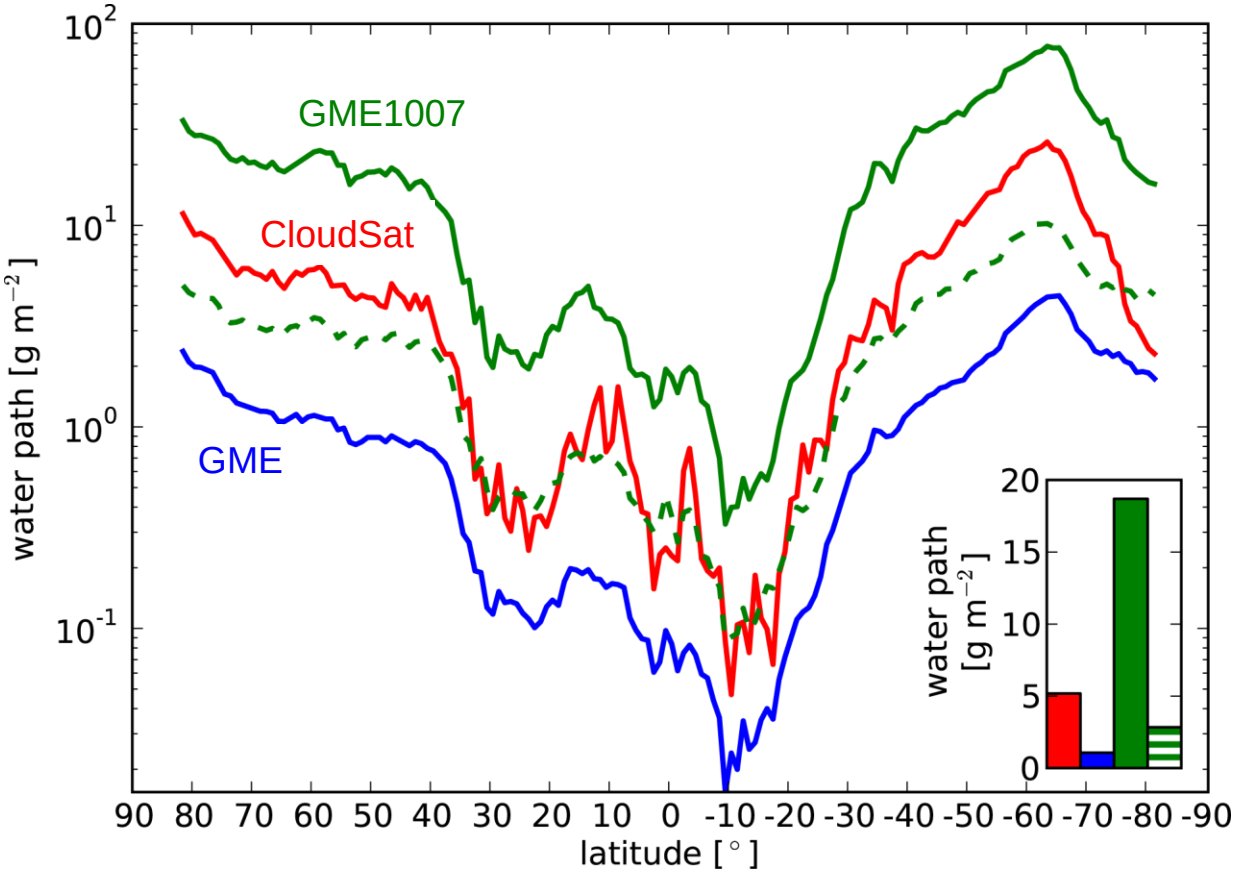
CloudSat Z

GME1007 Z



- ↗ GME1007 reproduces large IWC / Z values
- ➔ Even ice-only IWC larger in GME1007 than in GME
- ↘ Maximum in GME1007 distribution extends to colder temperatures (underestimated by CloudSat?)
- ↘ GME1007 underestimates large Z at higher temperatures

Zonally averaged IWP

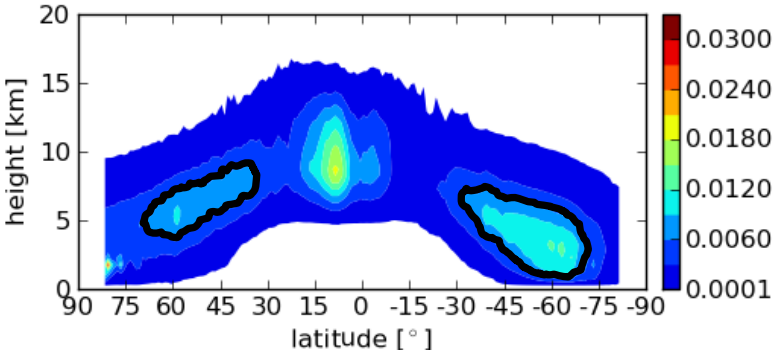


- ↗ Zonal IWP reproduced by GME1007
- ➔ Contribution of SWP to total IWP is major
- ↘ GME1007 highly overestimates IWP, especially in mid-latitudes

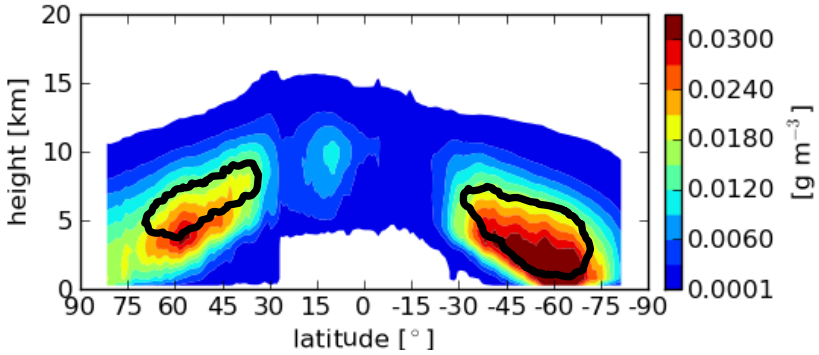
Zonally averaged IWC

1. GME
2. CloudSat
3. Methodology
4. Results
5. Summary & Outlook

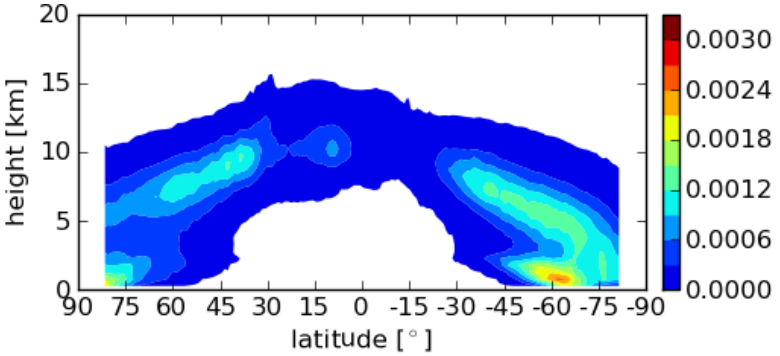
CloudSat IWC



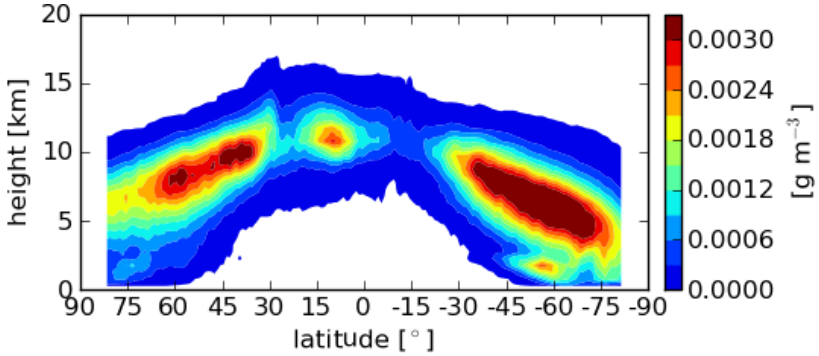
GME1007 IWC



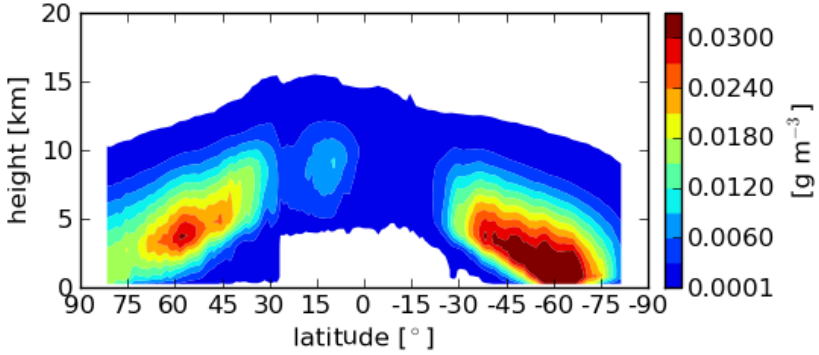
GME IWC



GME1007 ice-only IWC

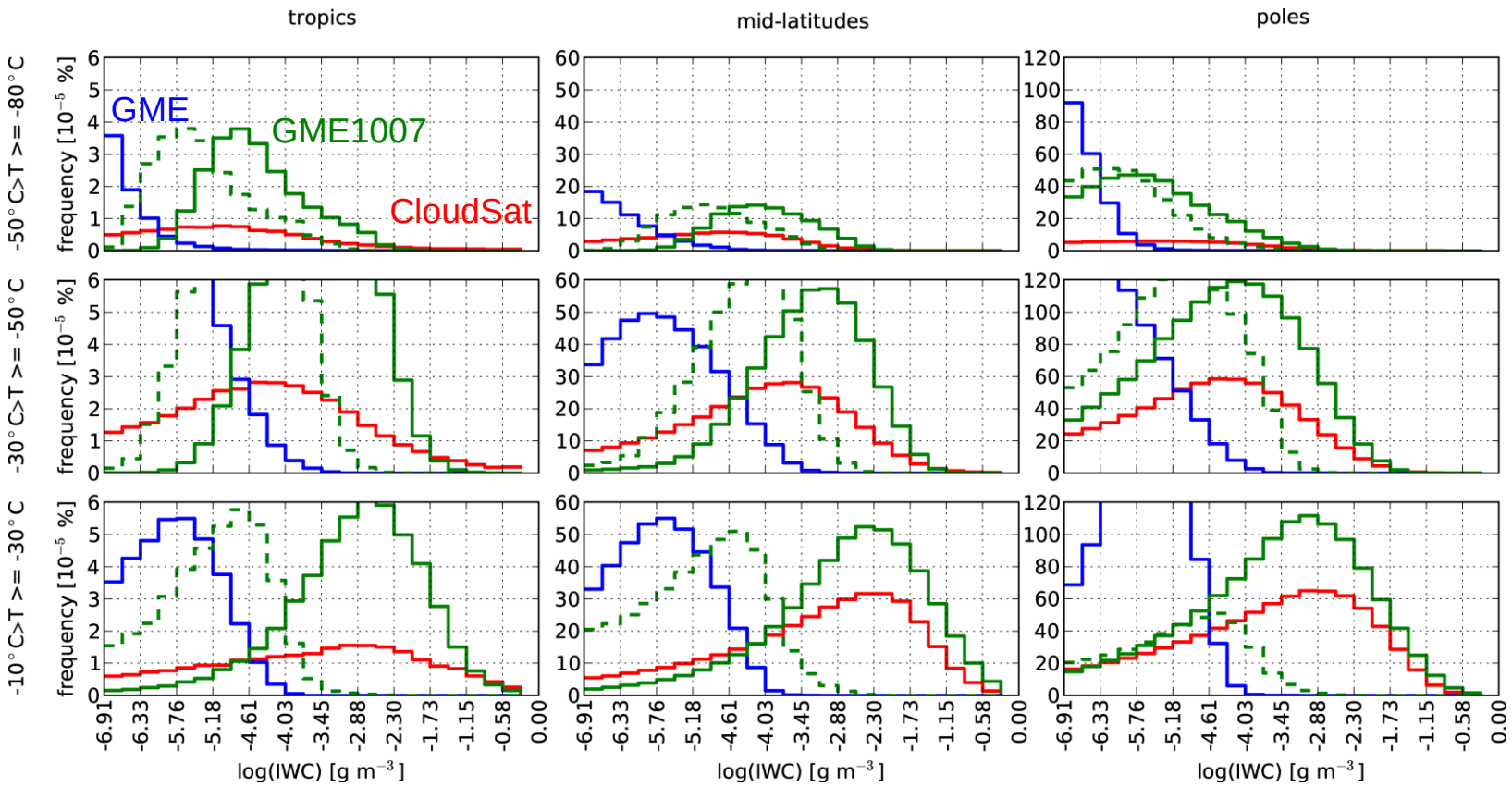


GME1007 SWC



- Position of IWC maxima reproduced well by GME1007

Histograms Temperature versus IWC



- Shape of frequency distributions captured well by GME1007
- Peak positioned at same IWC range
- Overestimation of peak, increasingly with decreasing temperature
  → fall speed of snow too small?
- Underestimation of large IWCs in the tropics
  → partly compensates ovestimation of IWP

Summary & Outlook

Summary

- ↗ IWC / Z magnitude better in GME1007
- ↗ Shape of IWC / Z frequency distributions captured well by GME1007
- ↗ Zonal IWP generally captured by GME1007
- ➔ Snow dominates total IWP
- ➔ Multi-parameter approach promising
- ↘ General overestimation of zonally averaged IWP

Outlook

- Further experiments already in progress
- Improve comparability between model and observations
- Different model output sampling, e. g., differ between age of forecast runs
- Implementation of model particle shape into QuickBeam
- Include sub-grid IWC
- Use CALIPSO or MSG data for small IWCs and cloud tops
- Extend investigations onto COSMO-EU

Thank you for your attention!