Microphysical sensitivities of wintertime precipitation

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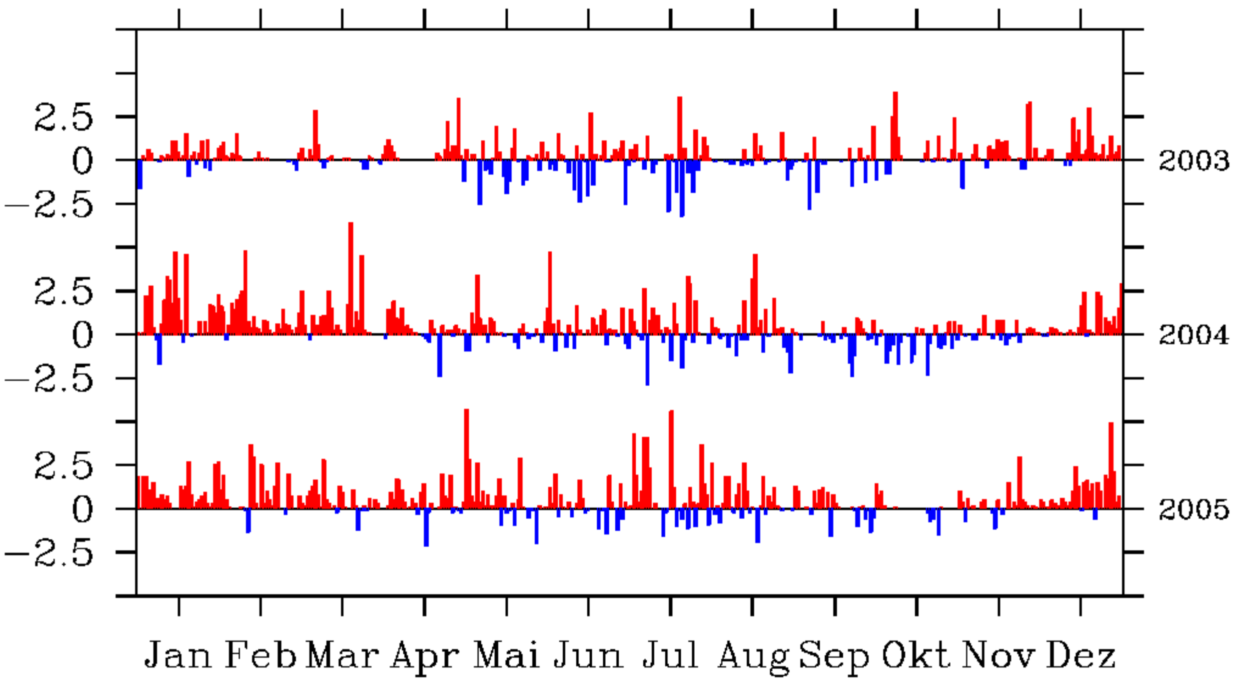
DWD, FE 13

Overview

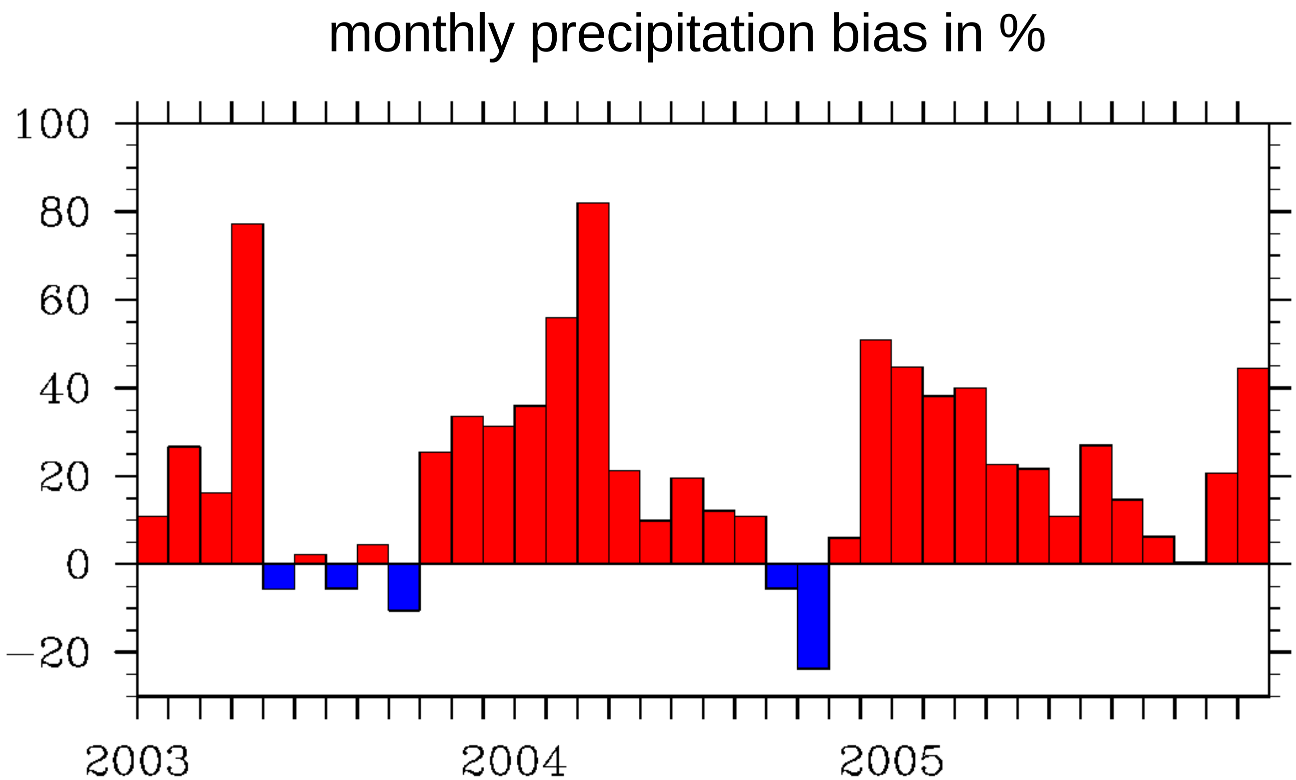
- Verification of LM precipitation and cloud properties
- How can cloud microphysics help to remove the problems?
- Changes in microphysical parameterizations
- A sensitivity study: 7 March 2005
- Conclusions and outlook

Long term verification of mean precipitation over Germany:

daily precipitation bias in mm

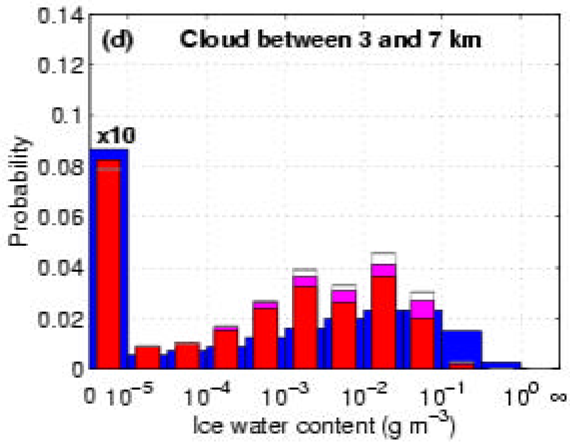


Long term verification of mean precipitation over Germany:

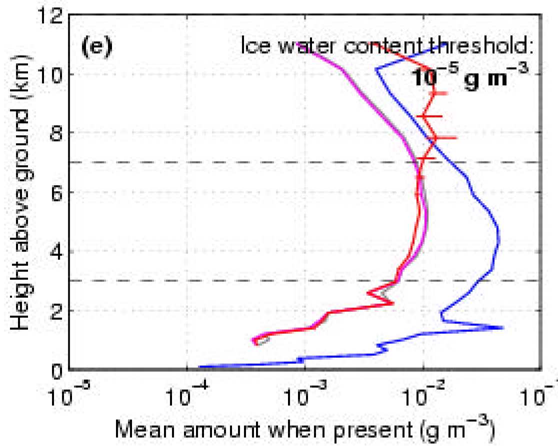


CLOUDNET verification of ice water content at Chilbolton:

PDF of ice content



Vertical profile of IWC



IWC underestimated, IWC > 0.1 g/m^3 observed but hardly simulated

Problems:

- Conditional sampling, since the cloud radar cannot measure in rain
- For LM snow was not included, but only cloud ice

Is there a problem with LM ice microphysics? Facts and excuses

- Systematic overestimation of surface precip compared to measurements. But during winter the measurements might have a positive bias. During summer the model bias might be due to problems in the convection scheme.
- CLOUDNET verification shows a underestimation of IWC at Chilbolton, Palaiseau and Cabauw. But no snow was included in model output and, in addition, Lindenberg data does not show a strong underestimation of IWC.

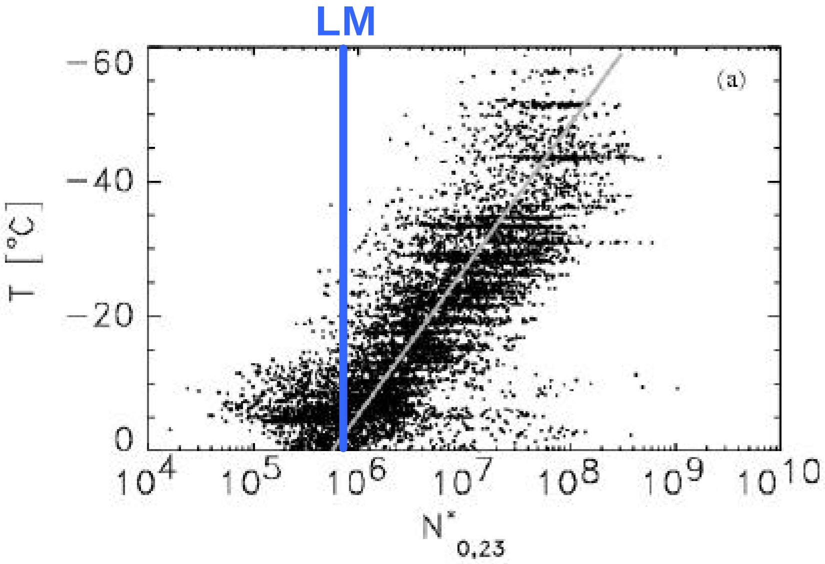
How can cloud microphysics remove the bias?

- Smaller ice particles/snowflakes would fall out slower, and maybe sublimate/evaporate in subsaturated regions, resulting in higher IWC aloft and reduced precipitation at the ground.

Observational evidence that snowflakes are smaller than assumed in LM:

Aircraft measurements of snow size distribution (Field et. al 2005)

Intercept parameter of size distribution



At lower temperature snowflakes are smaller, resulting in $N_{0,s} = N_{0,s}(T)$.

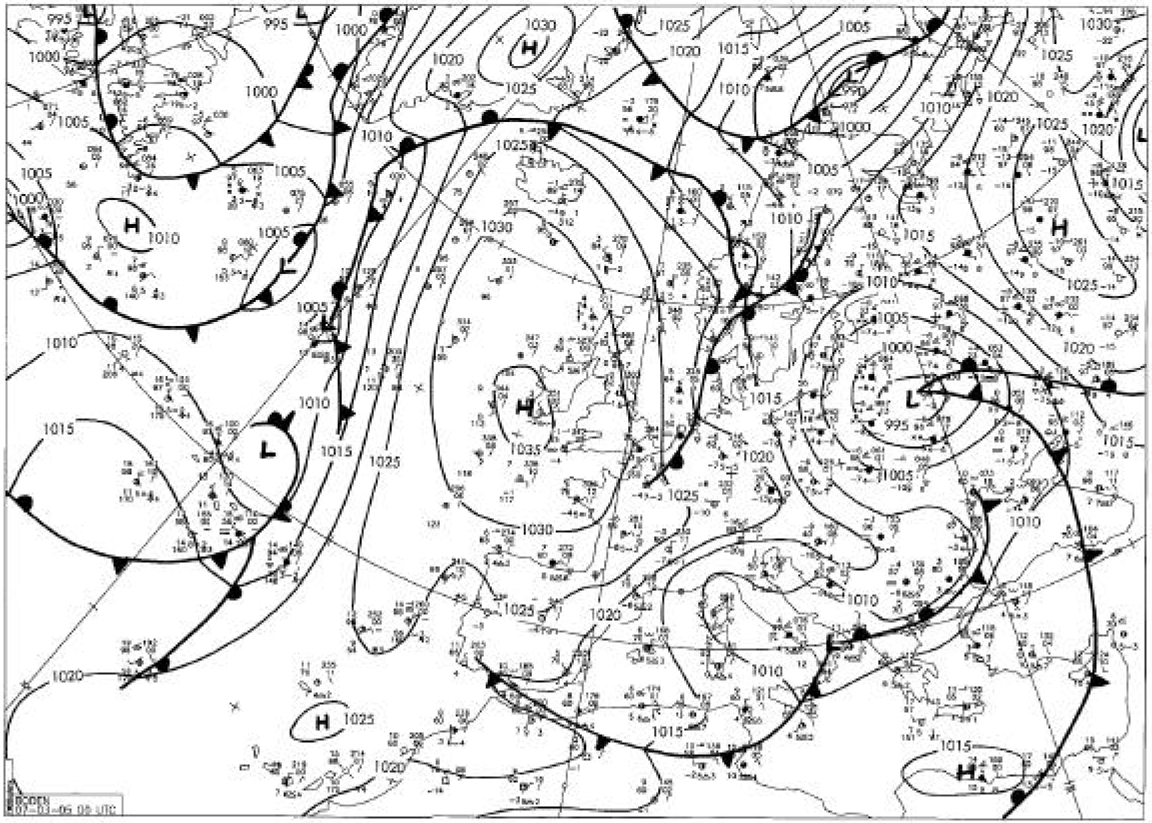
The value of $N_{0,s}$ assumed in LM is typical for ~0 °C

Changes to LM microphysics for this sensitivity study:

- Following Field et al. (2005), $N_{0,s}$ is parameterized as a function of temperature T and the snow mixing ratio q_s using a scaling approach.
- A threshold value for ice autoconversion (production of snow) of $qi0 = 0.1$ g/kg is applied.
- Mass-size-relation for snow is changed from $m = 0.038\ D^2$ to $m = 0.069\ D^2$ and fall speed is reduced using $v = 12\ D^{1/2}$.
- Collision efficiency of snow collecting cloud ice is reduced from $e_{is} = 0.5$ to $e_{is} = 0.1$
- Depositional growth of ice and snow now includes the pressure and temperature dependency in H_i and D_v
- SB2001 autoconversion scheme is used with a constant cloud droplet concentration $N_c = 500\ cm^{-3}$

A sensitivity study: 7 March 2005

Surface analysis 07.03.2005 00 UTC



Sensitivity of accumulated surface precipitation 00 UTC + 24 h:

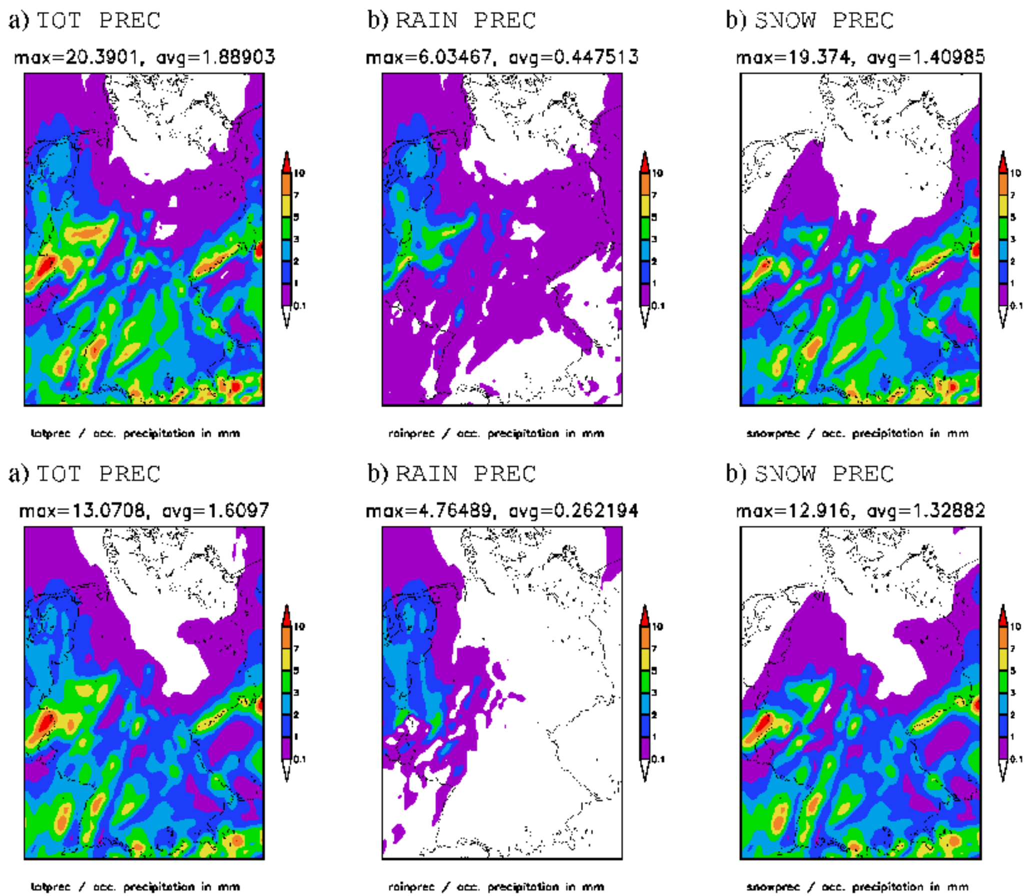
CONTROL

EXPERIMENT

Mean precip reduced by ~15 %

Maximum precip reduced from 20 mm to 13 mm

Some drizzle removed

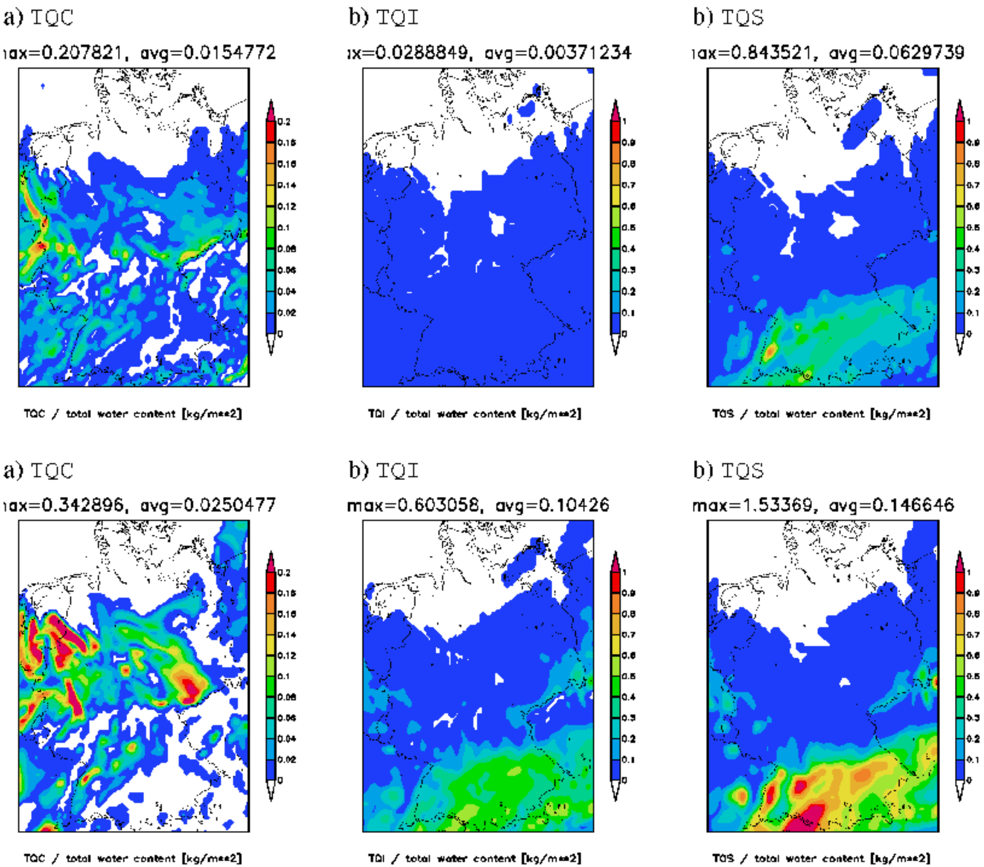


Sensitivity of column integrated water content (00 UTC + 24 h):

CONTROL

EXPERIMENT

Ice and liquid water content is considerably increased. Most dramatic for cloud ice.



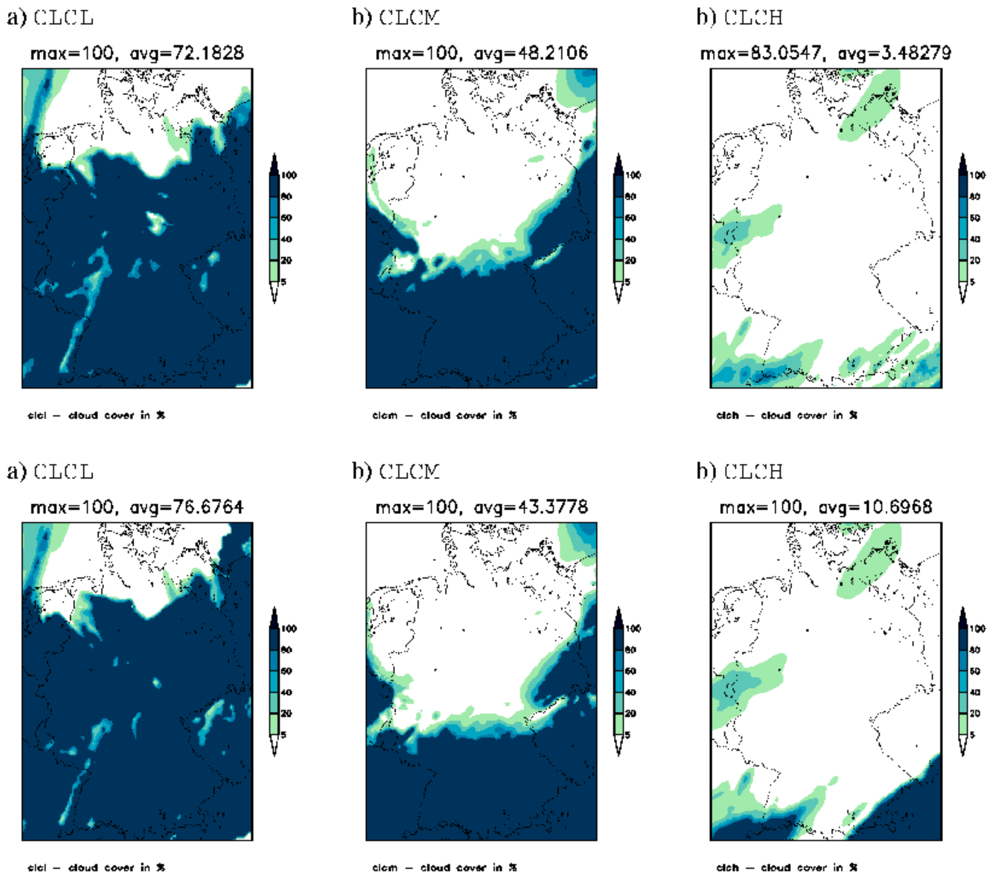
Sensitivity of column integrated water content (00 UTC + 24 h):

CONTROL

EXPERIMENT

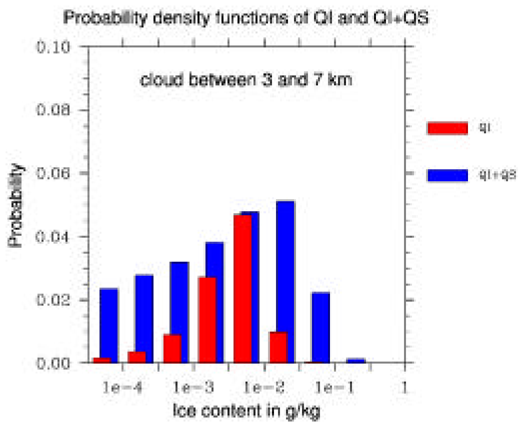
Only high level cloud cover is increased in this case.

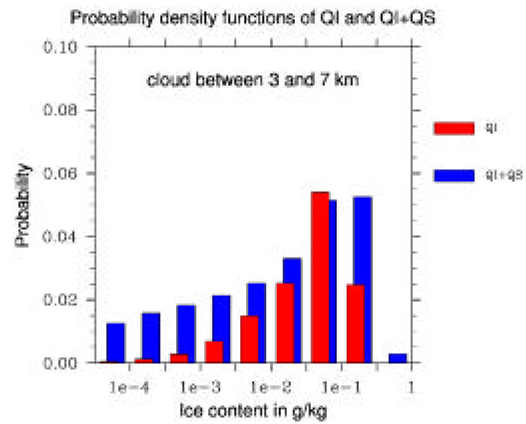
Low and mid level clouds are optically thick in both runs.



PDFs of control run and modified microphysics experiment

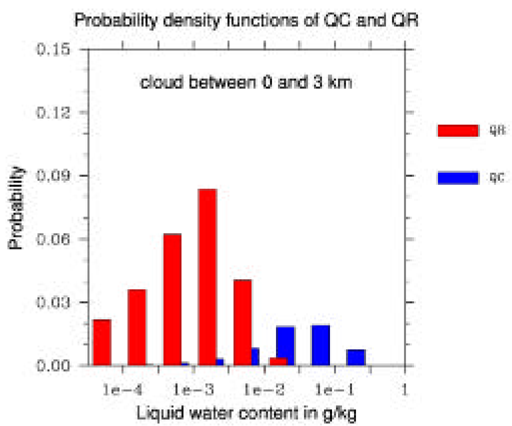
CONTROL

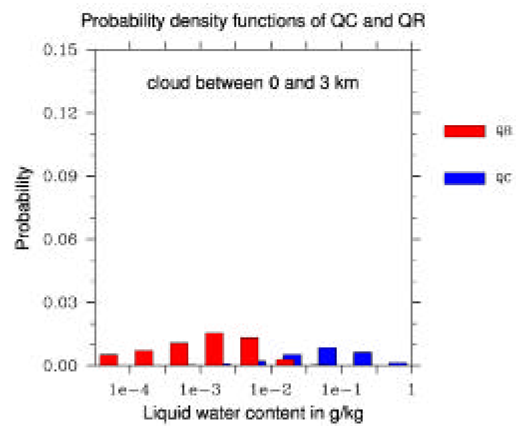




EXPERIMENT

PDF of ice content is shifted to higher mixing ratios





Less rain/drizzle, cloud water shifted to higher mixing ratios

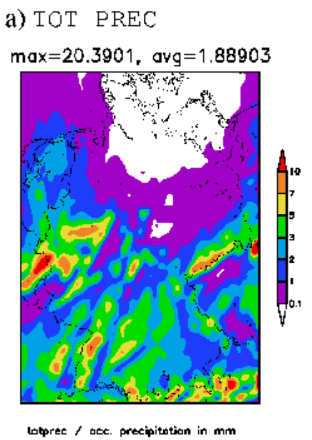
Conclusions and outlook

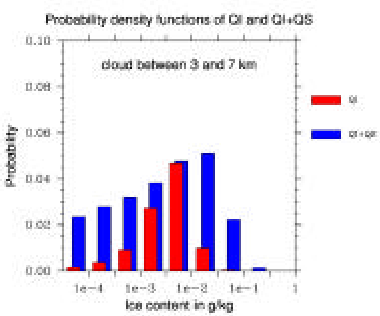
- LM seems to have a positive bias in wintertime precipitation
- Changing the grid-scale microphysics could remove some of the problems, but would increase the IWC by a factor of 10.
- The long-term effects of optically thicker clouds on radiation and surface temperature have to be investigated.
  An LM-Q experiment for Dec 2005 is planned.
- A reliable verification of CWC and IWC would be necessary, but seems to be almost impossible.
- Results need prognostic precipitation
  (and cannot be easily transferred to GME)
- The modified microphysics could be applied in an ensemble system

The End

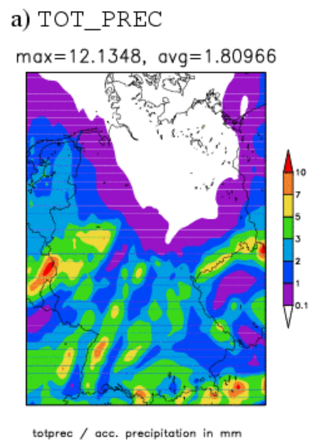
Sensitivity to ice autoconversion threshold:

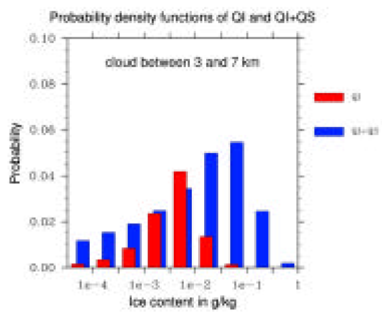
CONTROL



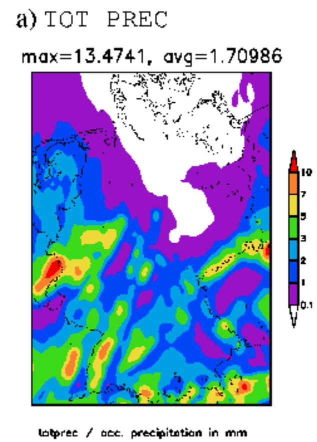


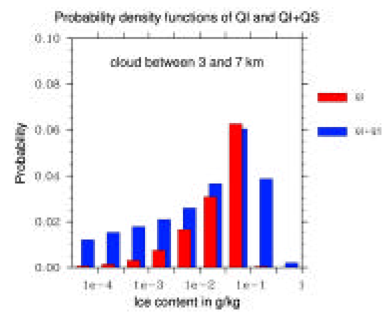
qi0 = 0.00 g/kg





qi0 = 0.05 g/kg





qi0 = 0.10 g/kg