Climate model PArameterizations informed by RAdar (PARA)

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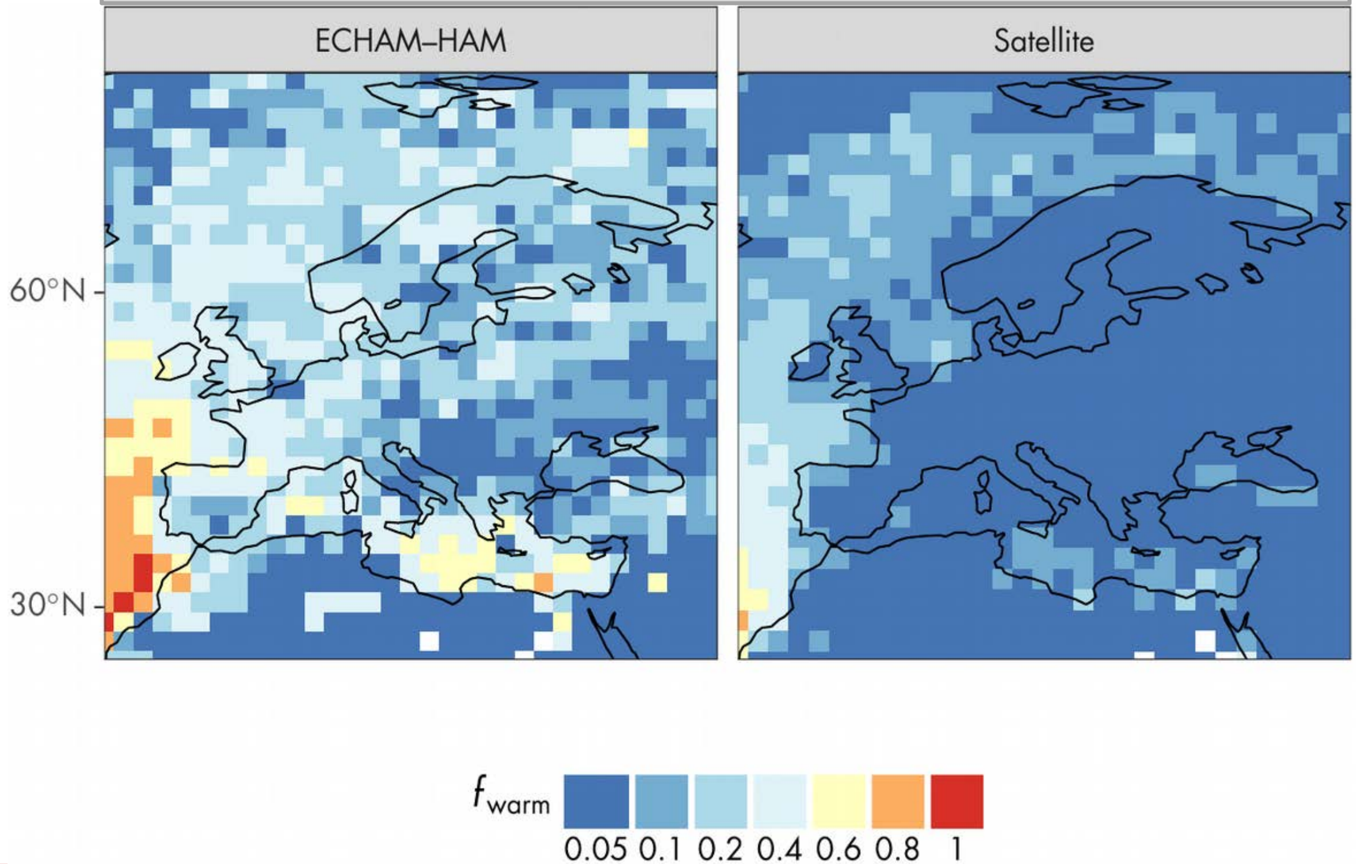
Rain formation over ice phase

More than **95%** of rain is originated from ice phase processes

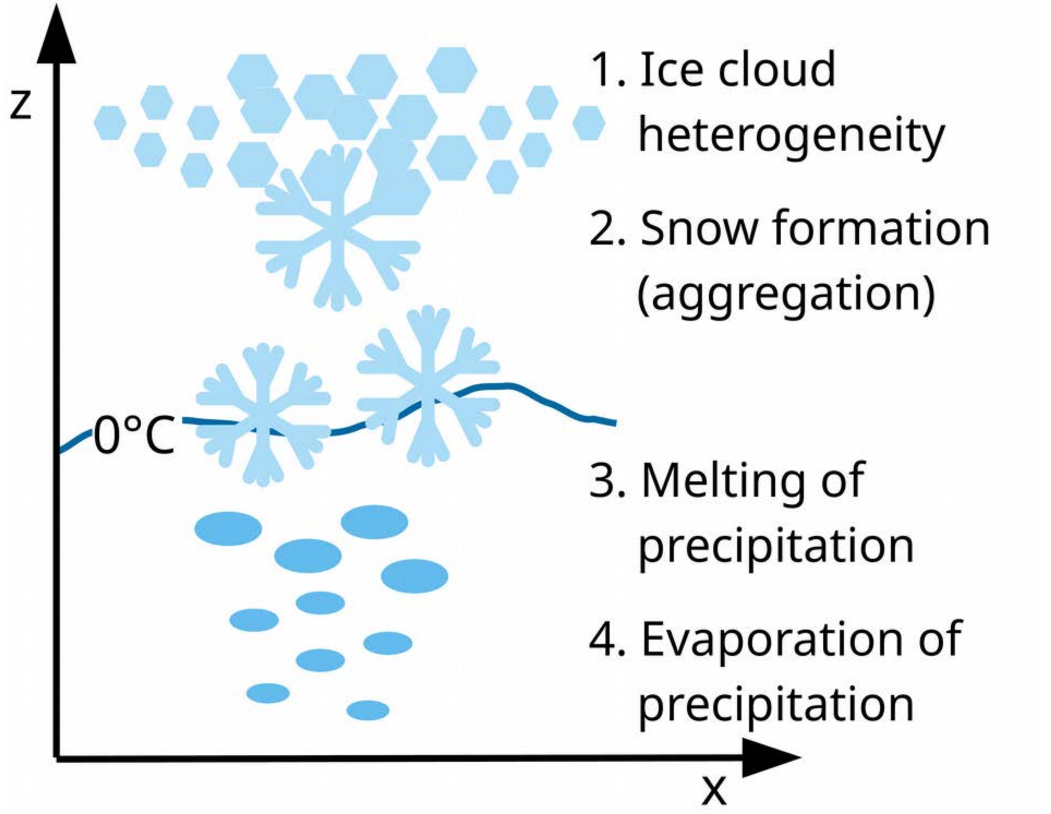
Figure: Fraction of surface rain occurrence originating from liquid phase clouds



Rain formation over ice phase

Cloud processes are unresolved
→ Subgrid – scale parametrizations informed by observations and/or high resolving models

four relevant processes, where mixed phase processes are not relevant

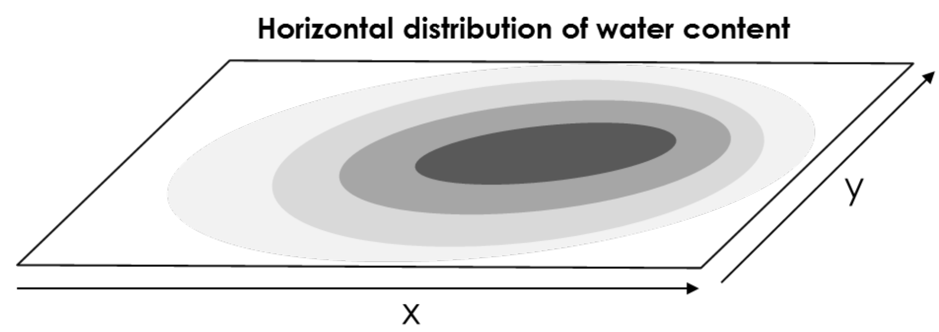


WP1-M: Ice cloud heterogeneity

Usually: mean liquid and ice content is used for calculation of process rates
→ Causes biases for nonlinear processes

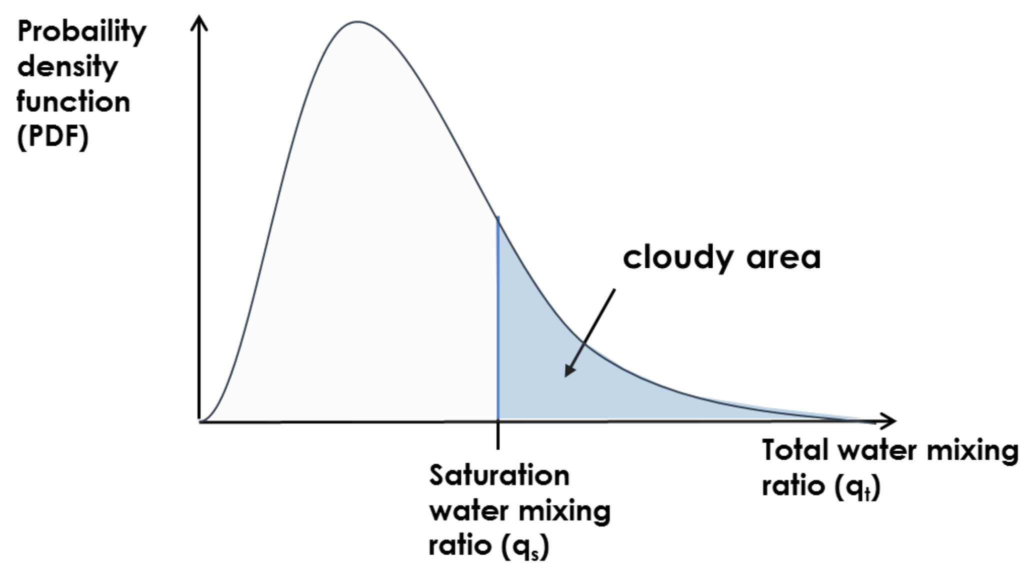
For a realistic representation:

- tuning of process rates
- realistic subgrid-scale cloud variability with help of PDF based approach (currently not considered)



workplan:

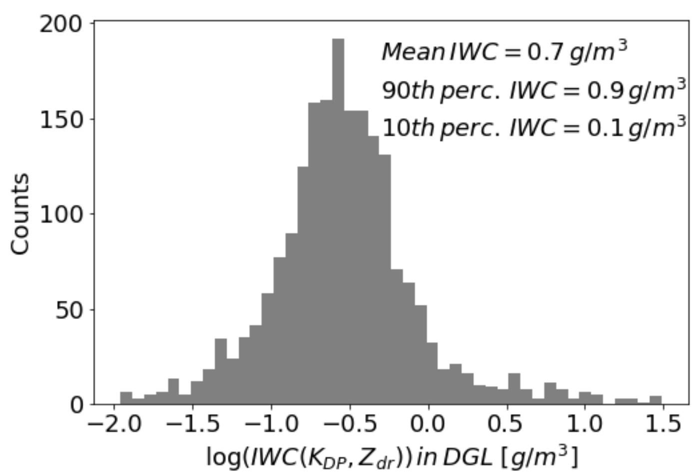
- PDF approach for cloud ice
- Evaluation of cloud ice variability with help of the DARDAR (raDAR/liDAR) retrieval and the detailed radar observations

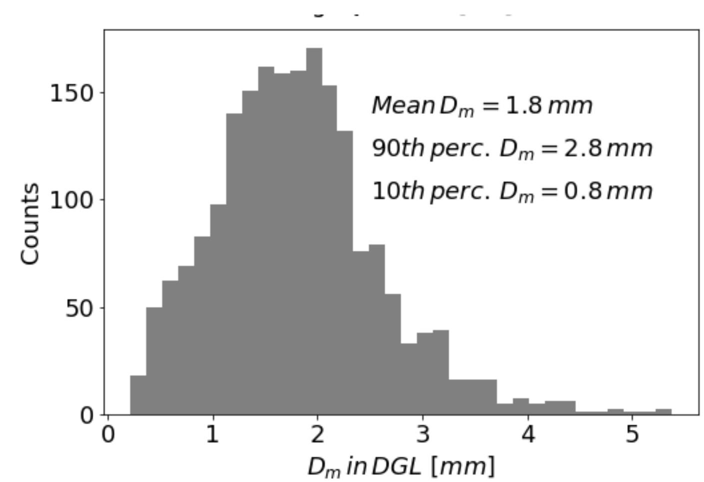


WP1-R: Ice cloud heterogeneity

Workplan:

- Polarimetric retrievals of IWC, number concentration N_t, and mean volume diameter D_m are applied to QVPs
  - → evaluated in **POLICE**
  - → PPIs for GCM subgrid-scale variability
  - → QVPs for best estimate
- Provision of mean value and variance of IWC(D_m<D_{aggr}), N_t(D_m<D_{aggr}), D_m(D_m<D_{aggr}) for each radar site as a function of height, where D_{aggr}=100µm





WP2-M: Snow formation via aggregation

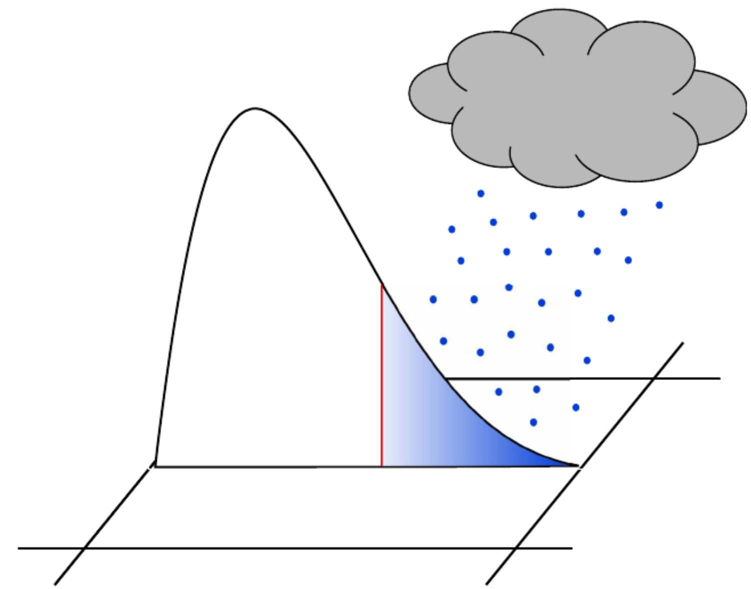
Snow formation in the dense part of ice clouds via aggregation

workplan:

- PDF of cloud ice variability
  → cumulative PDF
  → specific cloud ice

➡ Evaluation with the aggregation parametrization and radar observations

- Revising the size threshold between cloud ice and snow might lead to a better model-observation match



Torsten Weber, PhD Thesis, MPI for Meteorology, 2010

WP2-R: Snow formation via aggregation

workplan:

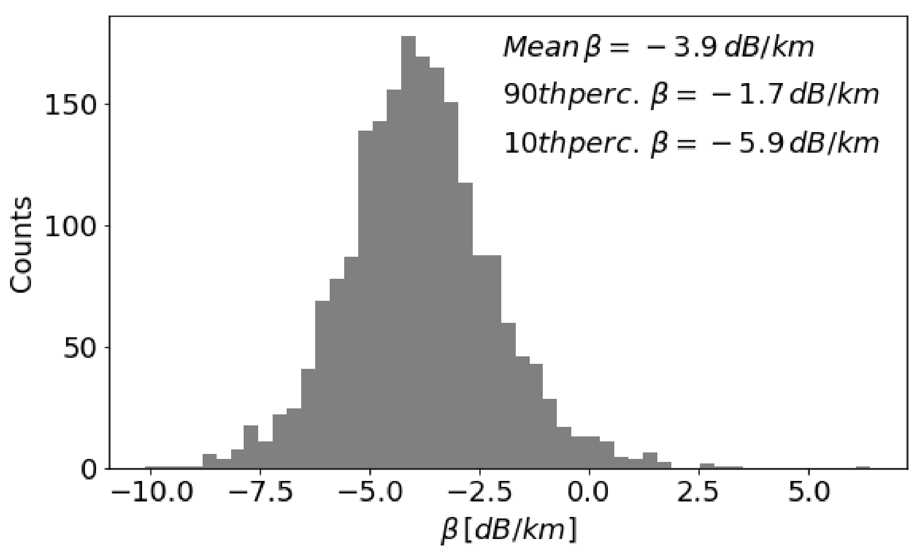
Different radar-based parameters for the onset of aggregtion are investigated.

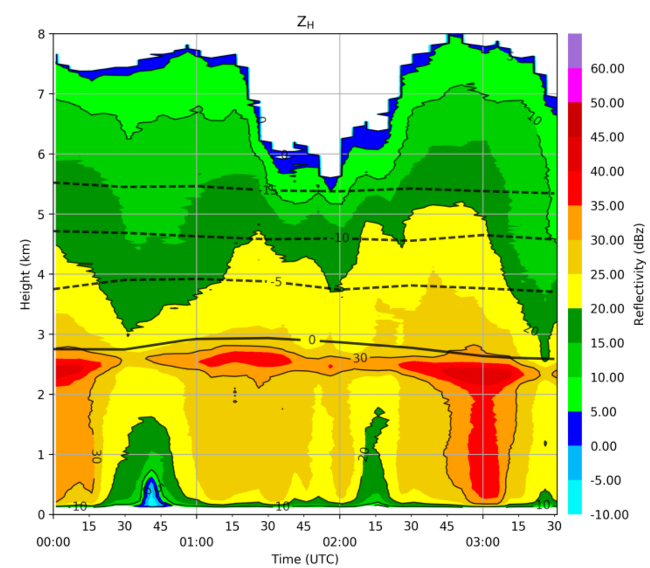
I. IWC(D_m>=D_{aggr})

II. POLICE provides in-situ measurements of IWC_{aggr} and D_{aggr} for comparison

III. POLICE will help to specify the gradient in Z_H, i.e. β.

→ Comparison with respective synthetic β.





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➡ Provision of first-guess estimateor IWC_{aggr} based on model-defined D_{aggr} and verified radar-observed thresholds based on in-situ measurements.

WP3-M: Melting of precipitation

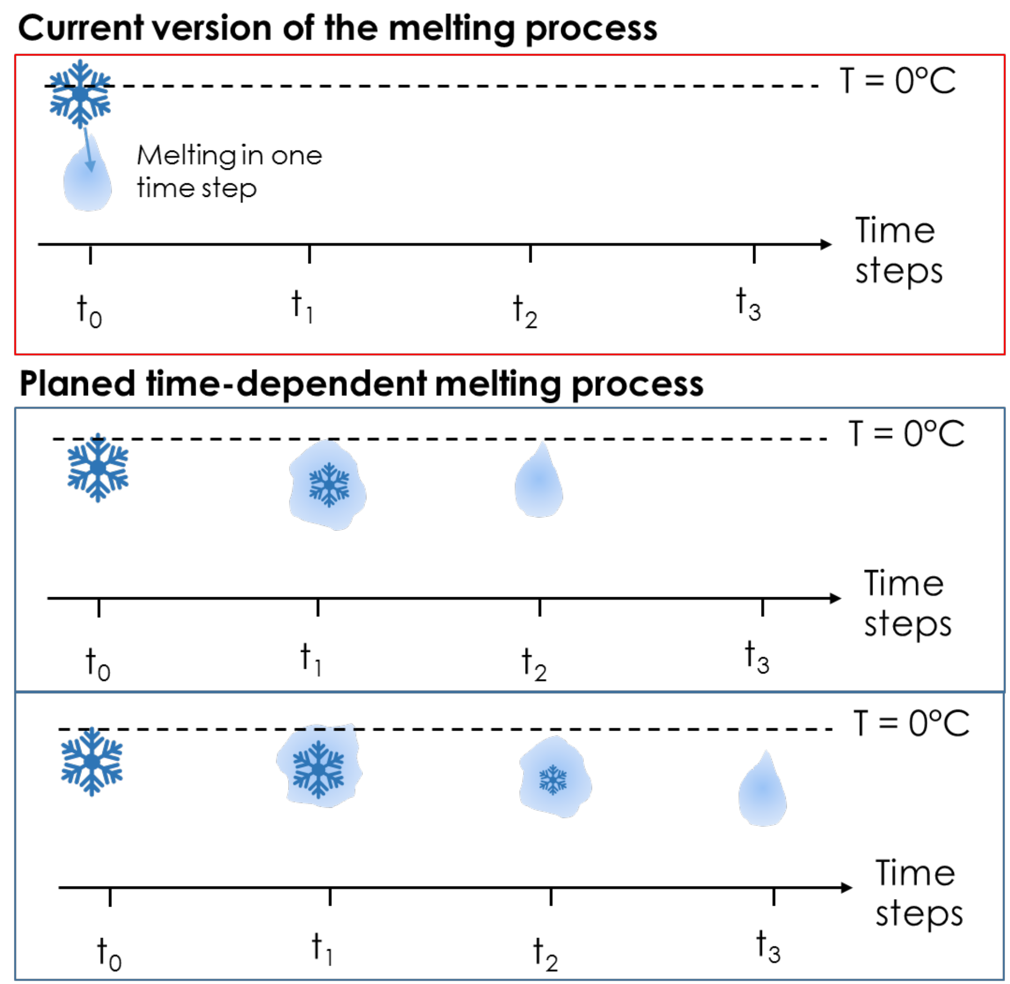
Current version: heat transfer from the excess temperature in the environment compared to the melting temperature T_0 = 0°C
→ occurs in one time step

Dependence of time may be more realistic

Plan of work:

→ Evaluation of various time scales longer than the model time step with the radar observations (melting layer depth)

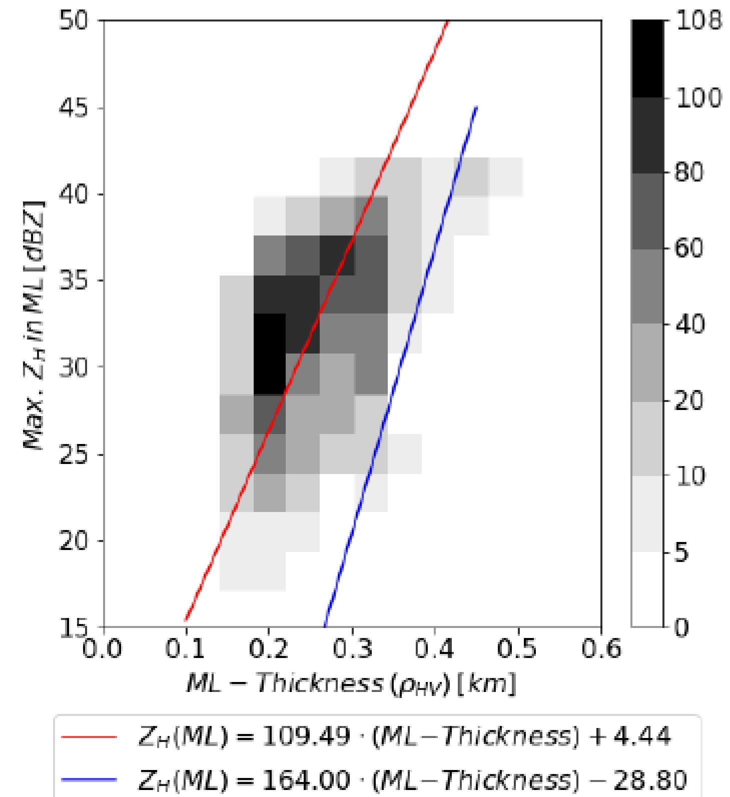
➡ to identify the time scale that is most consistent with the observations



WP3-R: Melting of precipitation

Workplan:

- Extend statistics on ML-(thickness) to cover a broader range of rain rates
- Use SBM of the ML to investigate further improvements in GCM parameterizations of melting
  - convert radar-derived snow DSDs into rain DSDs using the GCM-modeled profiles of T and RH.
  - Compare N_{rain}, D_{rain}, LWC-profiles from SBM, radar and GCM
  - Process refinement s in SBM



➡ Provision of observed distribution of ML-thickness and identified processes to be included in GCM parameterizations.

WP4-M: Evaporation of precipiation

Rain evaporates in sub-saturated air below the cloud

Current parametrization in ICON-GCM:

- Evaporative flux of water vapor from rain drops to sub-saturated environment
  → Using grid-box mean of relative humidity

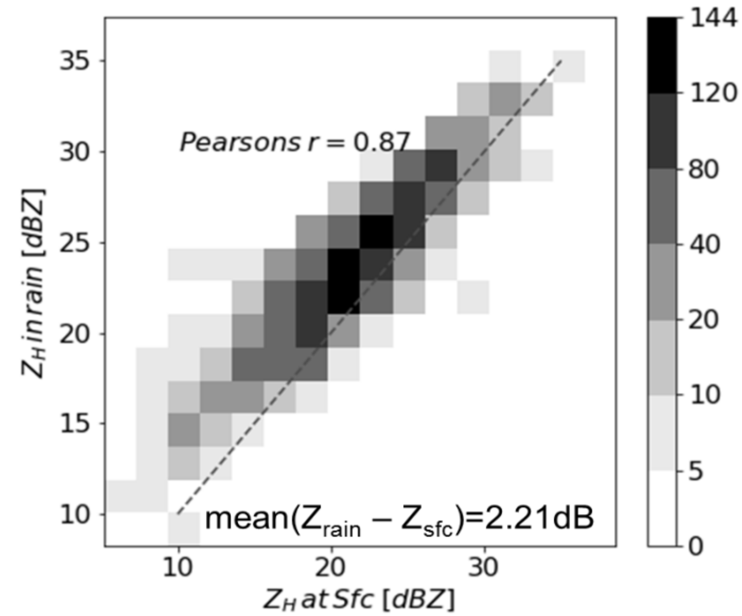
Workplan:

With use of the subgrid scale variability of relative humidity

➡ Evaluation of the new and the old version against the height-resolved rain flux observed by radar

Investigation of the empirical parameters of the evaporation parametrization

WP4-R: Evaporation of precipiation



Workplan:

The usability of LWC(A) retrievals compared to LWC(K_{DP}) retrievals will be investigated. For rain retrievals the combined R(A, Z_H)-relations will be applied.

➡ Provision of LWC(h) and R(h) as a function of height h using most accurate retrievals.

Employ SBM to further refine evaporation parameterizations. Compare vertical profiles from SBM, radar, and GCM below ML.

➡ Evaluate the assumption of the simple Marshall-Palmer DSD.

Thank you

Sabine Hörnig
Silke Trömel | https://www2.meteo.uni-bonn.de/staff/stroemel/doku.php/radar:radargroup
Johannes Quaas | http://research.uni-leipzig.de/climate
Clemens Simmer | http://www2.meteo.uni-bonn.de/staff/femmag/wiki/doku.php