Potential of millimeter wavelength observations for remote sensing of precipitation and hydrometeors

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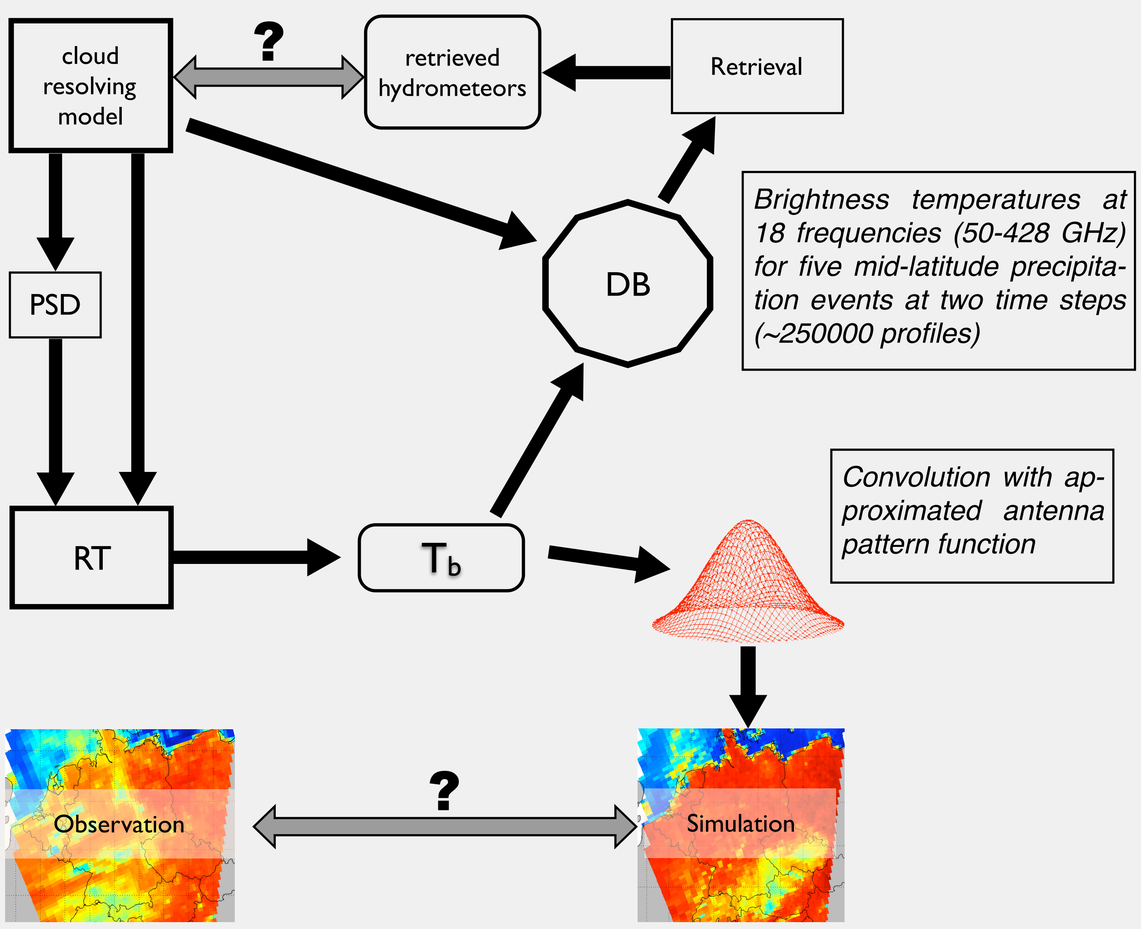
Study objectives and outline

Little is known on the 3D distribution of atmospheric **hydrometeors**. In order to observe the full 3D structure of these quantities only remote sensing in the **higher microwave region** from geostationary orbits can capture most of the desired features. As a trade-off at higher frequencies the observed signal is influenced by the total atmospheric column implicating the scattering at frozen hydrometeors. Therefore the possibility to retrieve the precipitation rate at the ground will depend among others on the vertical distribution of the different hydrometeors and the employed frequencies.

A satellite simulator for the microwave region (**SynSatMic**) was compiled to estimate the potential of the millimeter wavelength range for precipitation or hydrometeor retrieval. This tool was applied to setup a database of hydrometeor profiles and corresponding brightness temperatures and was used to evaluate the microphysical output of **cloud resolving models**.

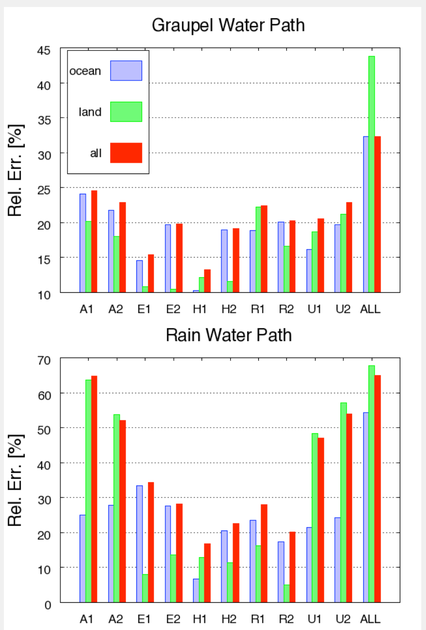
Simulations and database



Brightness temperatures at 18 frequencies (50-428 GHz) for five mid-latitude precipitation events at two time steps (~250000 profiles)

Convolution with approximated antenna pattern function

Retrieval potential

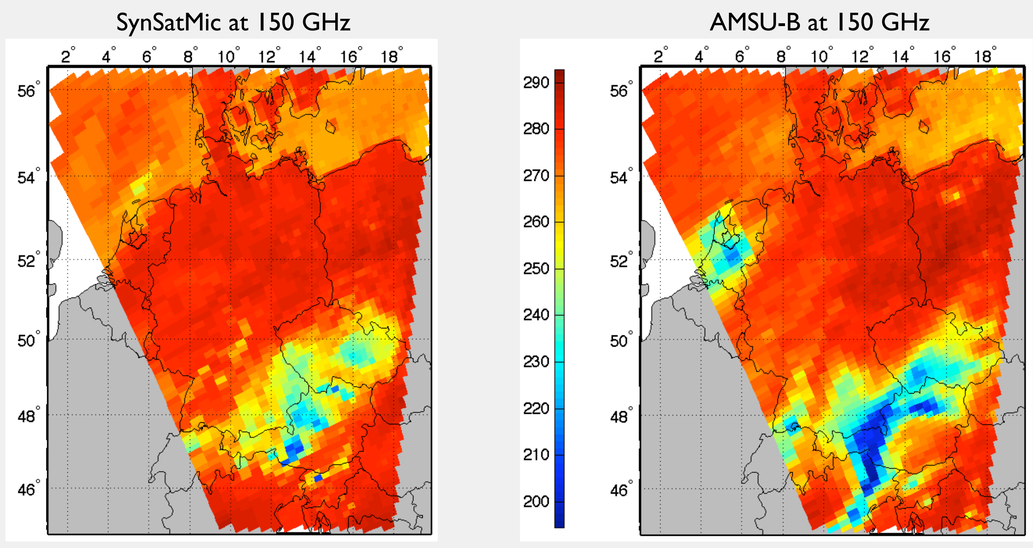


Retrieval performance in terms of relative errors for single cases and all cases and time steps merged together, separated into land, ocean, and all pixels.
A1/2,E1/2 convective
H1/2 stratiform
R1/2 winter
U1/2 frontal

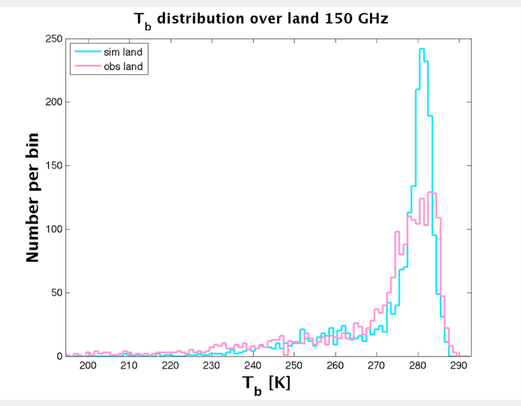
Multiple regression algorithms, developed to evaluate the information content show:

- Different performance for ocean and land pixels and their combination
- Good retrieval results for graupel and snow (especially over land) for stratiform cases (H1/2,R1/2) and over land
- High relative errors for the surface rain rate and convective cases

CRM evaluation



Comparison between simulated brightness temperature based on COSMO-DE and SynSatMic and AMSU-B observations at 150 GHz for a stratiform precipitation case over Central-Europe.
Right: Brightness temperature distribution for land pixels only.



The comparison between simulated brightness temperatures for the microwave region by SynSatMic and observations by AMSU-B for the evaluation of the cloud schemes of CRMs shows:

- General nature of the cloud systems is well captured by the CRM
- Underestimation of frozen hydrometeor contents indicated by weaker brightness temperature depression
- Channels sensitive to water vapor (not shown) show good agreement

Conclusions and outline

- Low contents of graupel and snow can be retrieved quite well even with this simple multiple regression retrieval algorithm
- For higher contents of graupel and especially snow in strong convective regions, the retrieval shows no good performance either by underrepresentation of these amounts in the database or a saturation with respect to the scattering in the radiative transfer model
- The performance for cloud water path (not shown), rain water path, and surface rain rate is not good with this simple algorithms
- Convective cases with high contents of hydrometeors cause problems
- Multiple regression algorithms are a valuable tool to identify relevant channels for future satellite missions
- By SynSatMic evaluation of CRMs with microwave satellite observations is possible
- Calculation of the single-scattering properties for snow and graupel causes the largest uncertainties and are the bottle neck when performing extensive evaluation of CRMs

References:

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