Information content of millimeter- and submillimeter-wave observations for hydrometeor properties in mid-latitudes

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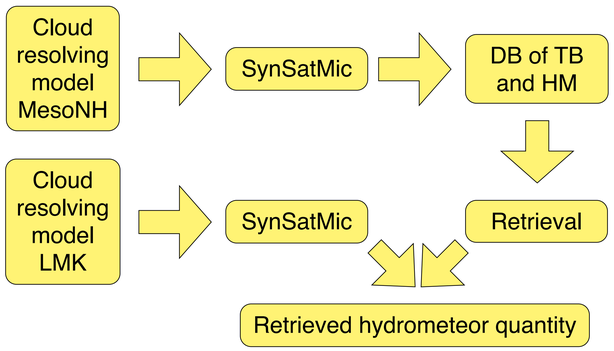
Study objectives and outline

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.

To estimate the potential of the millimeter wavelength range for precipitation or hydrometeor retrieval the study was structured in the following way:

• Build a database consisting of hydrometeor profiles with corresponding simulated brightness temperatures for the mid-latitudes
• Investigate the linkage between mw-signal and hydrometeor contents
• Investigate the potential of the frequency range by developing simple retrieval algorithms and apply these to simulated observations



Simulated database

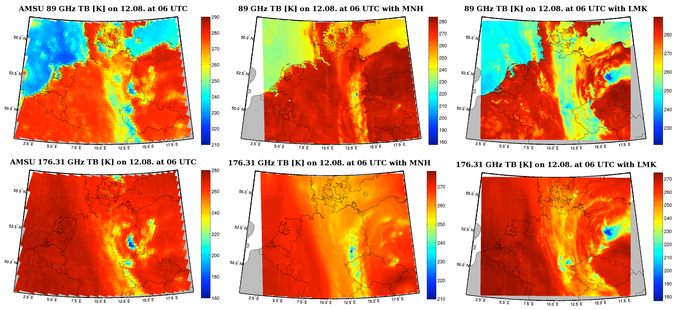
Simulations of the 3D evolution of the atmospheric state are performed with the mesoscale, cloud resolving model MesoNH with 10 km spatial resolution (http://www.aero.obs-mip.fr/mesonh/).

• 5 mid-latitude cases at 2 timesteps (~250000 profiles of standard variables and 5 hydrometeor categories: cloud, ice, graupel, snow, and rain)
• Different precipitation regimes (convective, frontal, stratiform)

Based on the detailed microphysics of the CRM brightness temperatures are calculated with the radiative transfer model MWMOD.

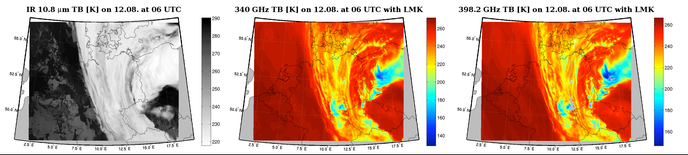
• 18 frequencies between 50 and 428 GHz at 9 observation angles
• Generation of unique database of brightness temperatures and corresponding hydrometeor contents

SynSatMic - Model vs. observation



Comparison between AMSU-B and MesoNH/SynSatMic respectively LMK/SynSatMic

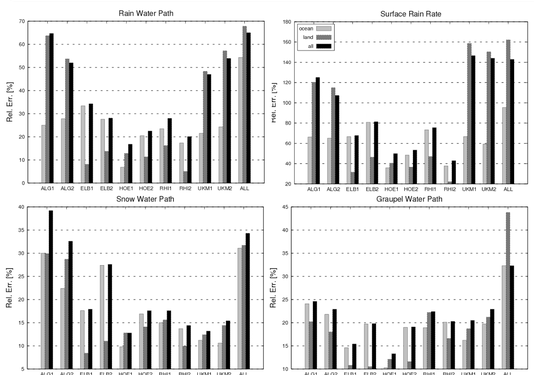
Simulated brightness temperatures areextensively compared for MesoNH and AMSU observations (*details: Meirold-Mautner et al. 2007*):
• Generell good agreement in terms of large scale structure
• To few scattering in regions of high snow and graupel contents



Comparison between simulated IR and higher microwave frequencies showing finer structures in regions conteining frozen hydrometeors and therefore provide more information

Retrieval potential

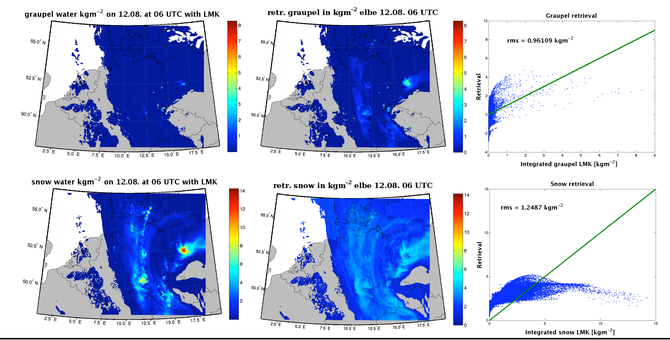
$$q = a_0 + \sum_{i=1}^{nf}(b_i * T_{B_i}) + \sum_{i=1}^{nf}(c_i * T_{B_i}^2)$$



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.

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 (HOEK,RHINE) and over land
• High relative errors for the surface rain rate and convective cases (ALG)

Application and results



Retrieval developed with MesoNH/SynSatMic database for graupel and snow separated into land and ocean applied to simulated satellite observations based on LMK/SynSatMic.

• 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, rain water path and surface rain rate (not shown) is not good with this simple algorithms
• Convective cases with high contents of hydrometeors cause problems
• Multiple regresssion algorithms are a valuable tool to identify relevant channels for future satellite missions

Future work and references

We have presented a work with encouraging results, but more to do is on:
•Investigate effect of higher horizontal resolution of CRM on their cloud microphysics and on simulated brightness temperatures
• Perform sensitivity study on scattering at frozen hydrometeors
• Influence of particle shape by applying different scattering approximations (Discrete Dipole Approximation)
• Contineously increase database to make the retrieval more robust
• Development of more complexe retrieval algorithms

References:

Chaboureau, J.-P., N. Soehne, I. Meirold-Mautner, E. Defer, C. Prigent, M. Mech, and S. Crewell, 2007: A mid-latitude precipitating cloud database validated with observations. J. Atmos. Sci, in revision.

Meirold-Mautner, I., C. Prigent, E. Defer, J.R. Pardo, J.-P. Chaboureau, J.-P. Pinty, M. Mech, and S. Crewell, 2007: Radiative transfer simulations using mesoscale cloud model outputs: comparisons with passive microwave and infrared satellite observations for mid-latitudes. J. Atmos. Sci., 64, 1550-1568.

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