

HAMP - the Microwave Package on the upcoming High Altitude and Long range aircraft (HALO)

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Introduction

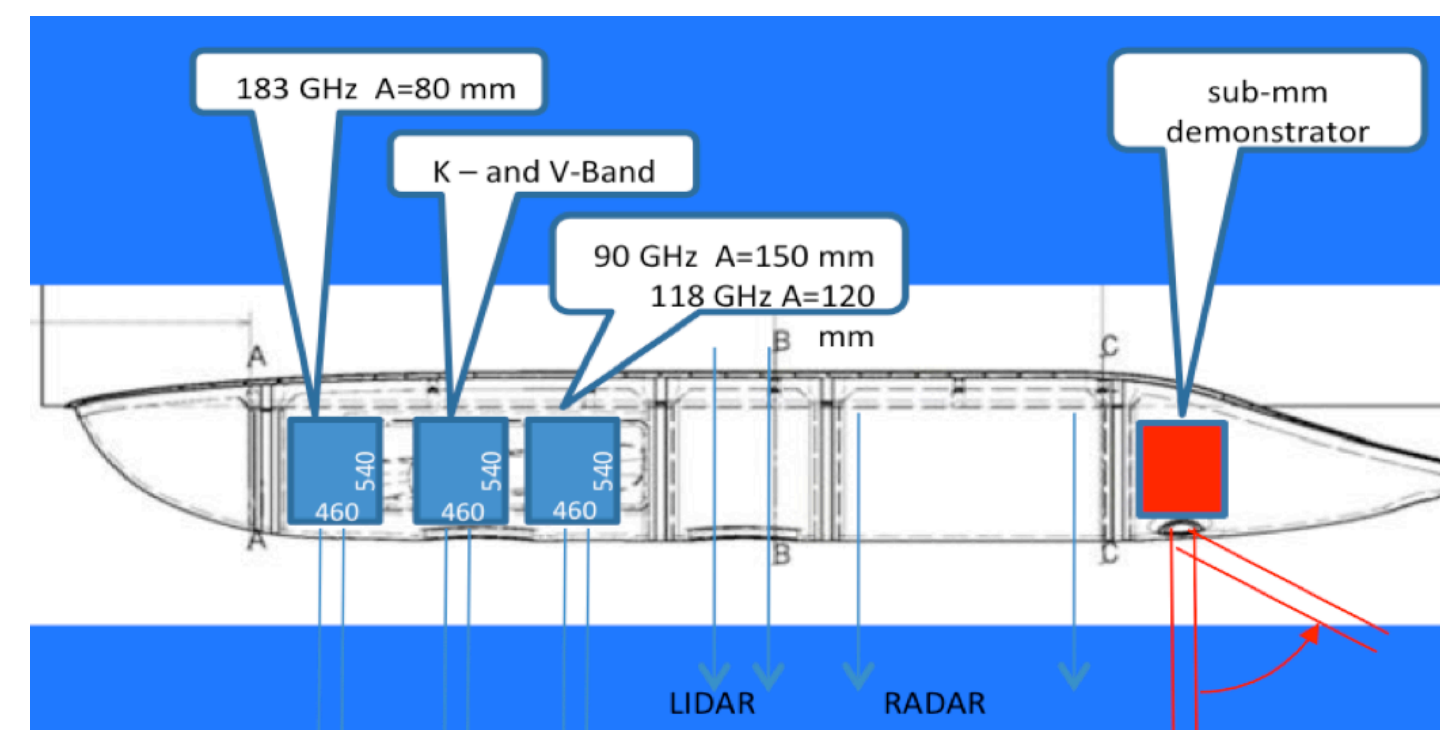
New cloud & precipitation observation techniques are needed to improve our understanding of the earth's radiation budget and water cycle – both presenting major challenges in global and regional climate modeling.

HAMP (High Altitude and Long range-Microwave Package) will provide an advanced set of microwave remote cloud & precipitation sensing instrumentation to be operated on board of the new German research aircraft HALO. It consists of

- 23 channel microwave radiometers from 20-200 GHz
- a 36 GHz polarimetric cloud radar

Here we illustrate HAMP's potential to observe various atmospheric constituents (humidity, temperature and hydrometeors) by generating synthetic observations from a combination of cloud model simulations, appropriate forward operators for the radiative transfer, and simple algorithms.

Instrumentation



Research aircraft HALO and the belly pot underneath it showing the position of the passive microwave sensors (temperature stabilized boxes), the lidar, the cloud radar, and the sensors in the sub-mm wavelength region.

Band	K	V	W	F	G
Frequencies [GHz]	22.24	50.30	90.0	118.75±8.5	183.31±12.5
	23.04	51.76		118.75±4.2	183.31±7.5
	23.84	52.8		118.75±2.3	183.31±4.5
	25.44	53.75		118.75±1.4	183.31±3.5
	26.24				183.31±2.5
	27.84				183.31±1.5
	31.40				183.31±0.6
FWHM	4.0°	2.5°	2.5°	2.5°	2.5°

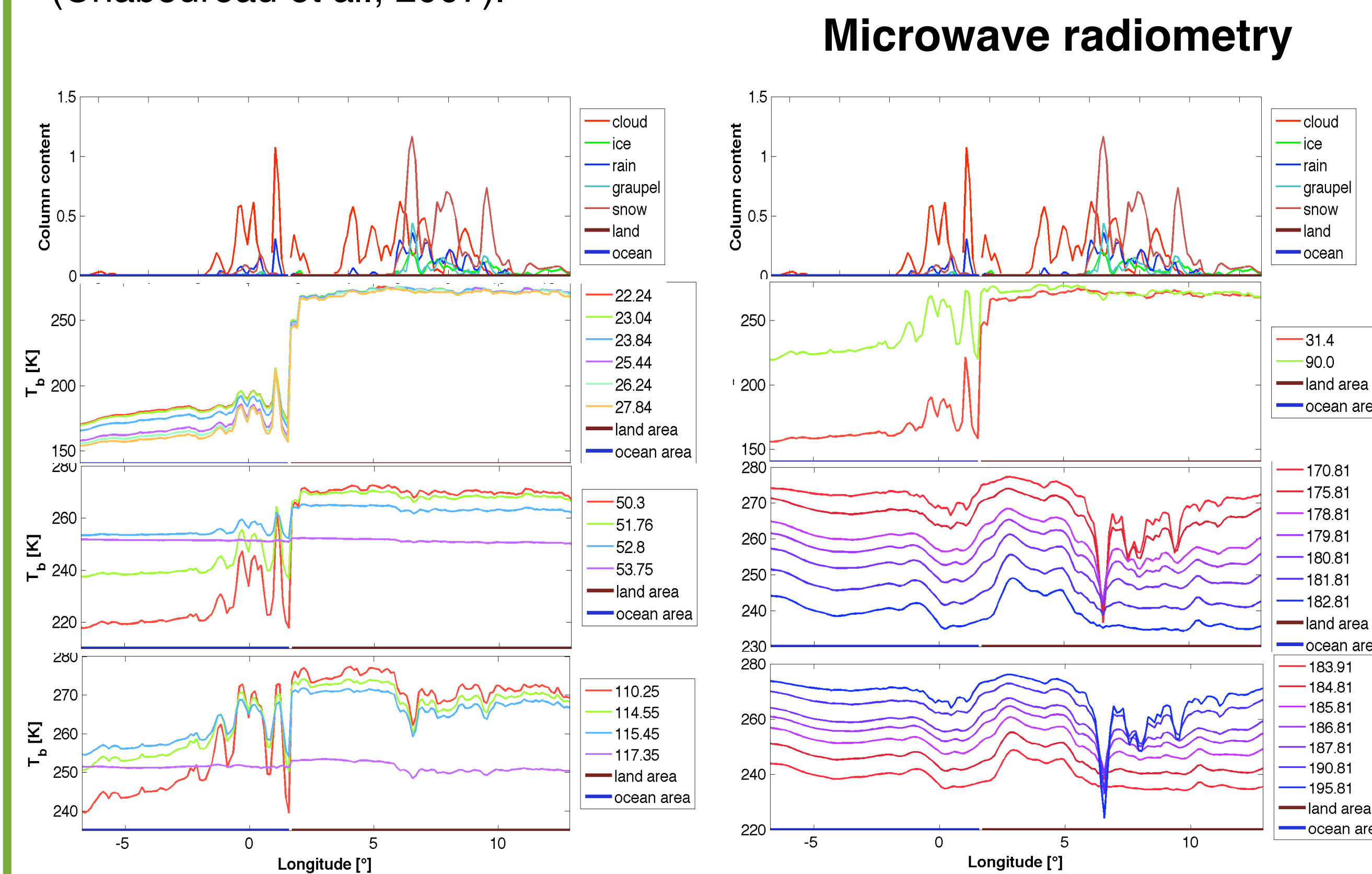
HAMP passive microwave frequencies and their half power beam widths used to observe hydrometeor quantities and profiles of temperature and humidity.

Frequency [GHz]	36.5
Sensitivity	-48
Range resolution in m	30
Along track resolution in m	250, 50
Cross track resolution in m	50
Parameters	Z, V _{Doppler} , LDR

Specifications of the MIRA36 cloud radar as a component of the HAMP on the research aircraft HALO.

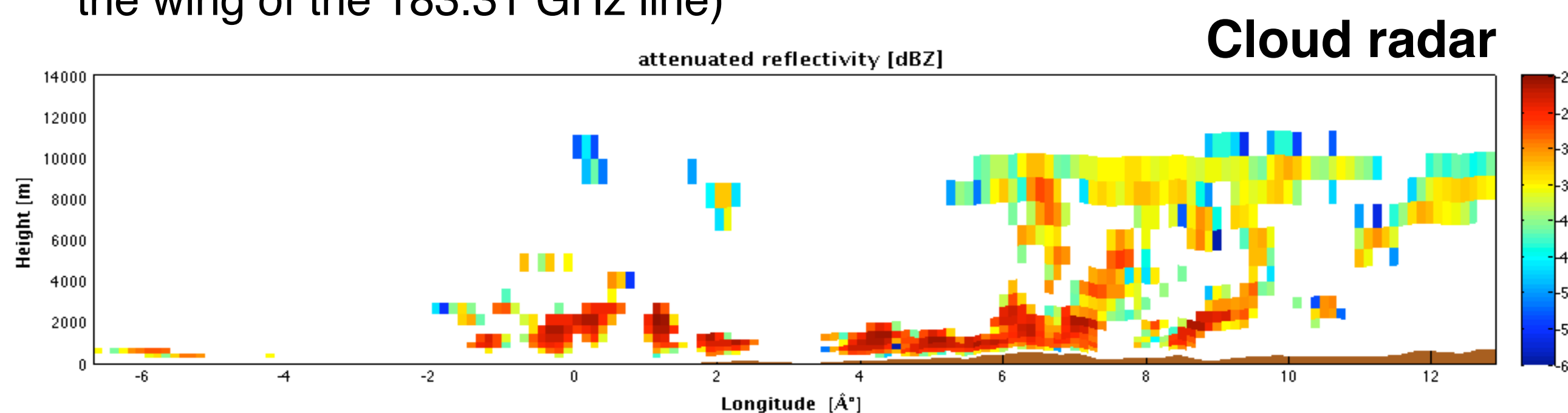
Simulations

A typical flight by HALO across a frontal precipitation event is simulated along the 53 deg latitude circle for the Hoek van Holland event. Meso-NH was used for the cloud model simulations covering ocean and land areas (Chaboureaud et al., 2007).



Top: Simulated hydrometeor contents for a flight from 7 W to 13 E along 53 N. Lower three panels: Corresponding brightness temperatures at HAMP' 23 channels simulated by the approach of Mech et al. (2007).

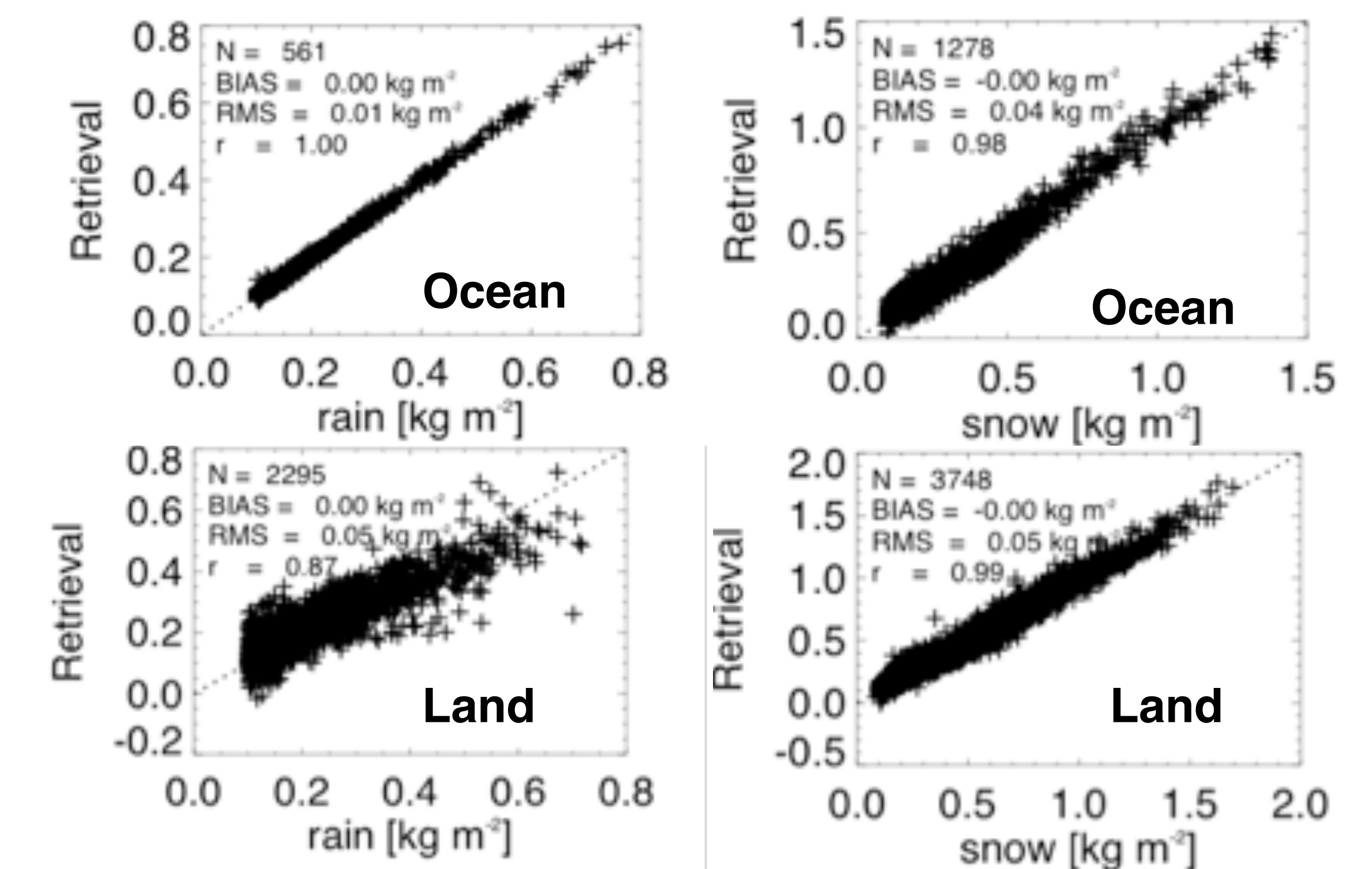
- over ocean emission by liquid water (cloud and rain) is clearly seen as peaks of higher brightness temperatures at relatively transparent (22-53 GHz) frequencies
- over land hydrometeor emission is obscured by the high emissivity of the land surfaces
- along absorption bands channels closer to the line center successively observe information from higher atmospheric layers
 → because hydrometeor effects increase with frequency the differential response of the 60 GHz and 118 GHz bands is suggested for precipitation profile retrieval (Bauer and Mugnai, 2003)
- scattering by frozen hydrometeors is visible at higher frequencies (along the wing of the 183.31 GHz line)



The synthetic radar signal for the same scene was calculated by the radar simulator Quickbeam (Haynes et al., 2007). It has to be kept in mind that the vertical resolution in the figure corresponds to the cloud resolving model resolution and not to the range gates of the cloud radar:

- due to its high dynamic range HAMP will be able to detect a wide variety of hydrometeors from water and ice clouds to medium precipitation
- additional observations of Doppler velocity and linear depolarization will allow to classify the hydrometeor type

Retrieval potential



Simple retrieval algorithms based on the simulated brightness temperatures to estimate the potential of the selected microwave frequency bands for hydrometeor observations show:

- good results for rain water and snow with root mean square errors of 0.01 and 0.04 kgm⁻² respectively
- over land the scattering between retrieved and modeled contents is larger due to the indirect information via ice scattering indicating the importance of separate retrieval and observation methods as well as the challenge to derive hydrometeor observations over land

Conclusions and Outlook

The combination of active (cloud radar) and passive microwave radiometry offers unique potential to observe atmospheric hydrometeors simultaneously with information on the environmental conditions – the retrieval of humidity (22 and 183 GHz water vapor line) and temperature (60 and 110 GHz oxygen bands) is well established.

Missions on board of HALO (with additional observations by lidar, drop sondes etc) will open up new possibilities for process studies and satellite validation

To fully exploit the information content of HAMP more complex (semi-statistical/physical) algorithms will be developed for hydrometeor profile retrieval. First flights with HAMP over the North Atlantic are scheduled for 2011.

References:
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