

Active and passive microwave retrieval algorithm for hydrometeor concentration profiles: application to the HAMP instrument



E. Orlandi¹, M. Mech¹, S. Crewell¹ and A. Lammert²

¹ Institute of Geophysics and Meteorology, University of Cologne, ² Meteorological Institute, University of Hamburg

1. Introduction

New observation and retrieval techniques are needed to improve our understanding of the processes involved in cloud and precipitation formation and their description in global and regional models.



The new German research aircraft HALO will be equipped with the microwave package HAMP (HALO Microwave Package) which consist of a 26 channels microwave radiometer and 35.5 GHz Doppler cloud radar.

The first HALO mission (NARVAL) scheduled for January 2014 aim to validate satellite precipitation retrievals over North Atlantic, a region where strong discrepancies are reported between different algorithms.

HAMP radiometer					
BAND	K	V	W	F	G
Frequency [GHz]	22.29	50.30	90.00	118.75 ± 8.5	183.31 ± 12.5
	23.04	51.76		118.75 ± 4.2	183.31 ± 7.5
	23.84	52.80		118.75 ± 2.3	183.31 ± 4.5
	25.44	53.75		118.75 ± 1.4	183.31 ± 3.5
	26.24	54.94			183.31 ± 2.5
	27.84	56.66			183.31 ± 1.5
	31.40	58.00			183.31 ± 0.6

HAMP RADAR			
Frequency	Sensitivity at 5 km	Range resolution	Parameter measured
35.563 GHz	-44 dBZ	30 m	Z, LDR, Doppler spectrum

2. Simulations

Simulations of frontal systems crossing the North Atlantic have been performed at 2.5 km resolution with COSMO, the operational NWP model of the German weather service. Based on these simulations, synthetic brightness temperatures at HAMP frequencies have been calculated with the PAMTRA radiative transfer model.

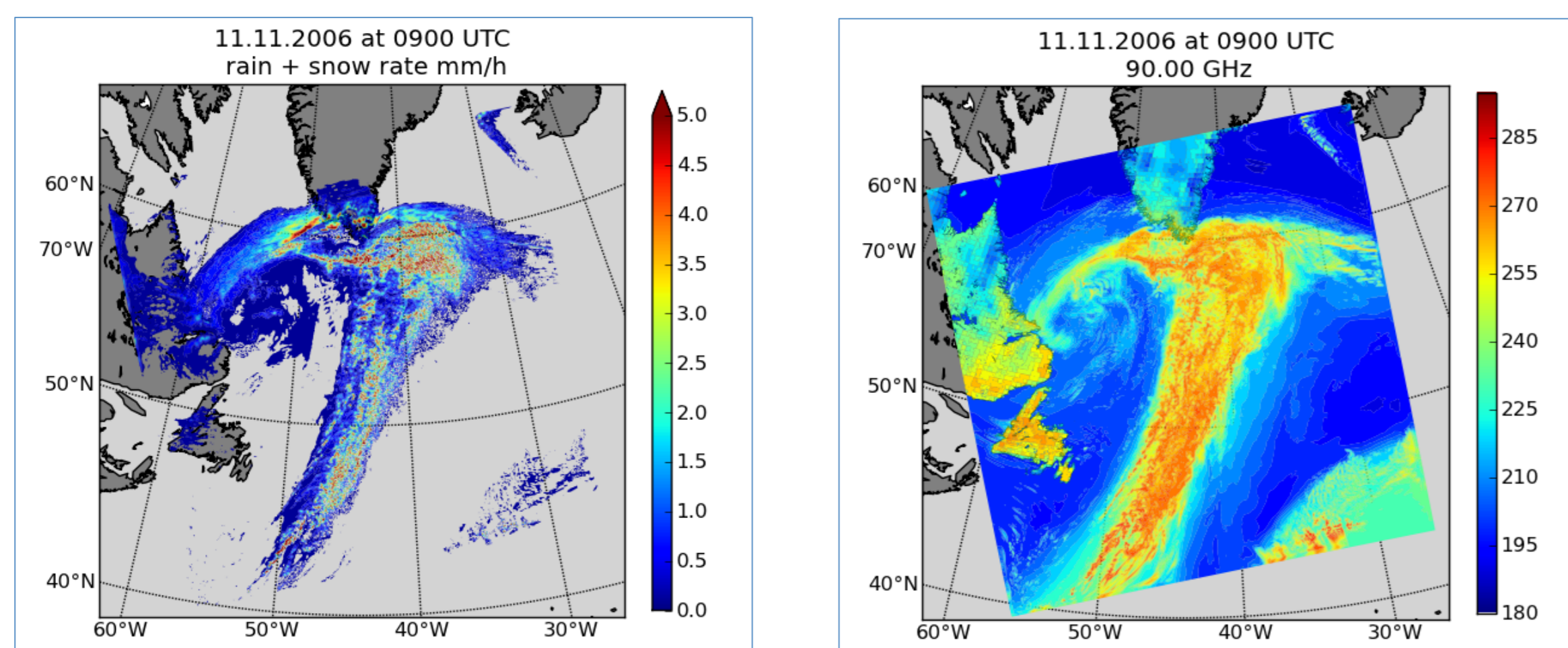


Fig. 1: Precipitation rate (snow+rain) [mm/h] from COSMO simulation on 12-11-2006 (left), corresponding brightness temperature at 90 GHz (right).

3. Retrieval algorithm

Brightness temperatures (T_b) and equivalent radar reflectivities (Z_e) have been simulated with the PAMTRA radiative transfer model in all sky conditions and over ocean. Simulated T_b s are used to train an algorithm for the retrieval of path integrated hydrometeors, rain rate, and profiles of temperature, water vapor, and hydrometeors.

The algorithm combines regression and Monte Carlo Integration (MCI) methods. MCI is used when the number of cases in the database matching the measured T_b are greater than 20, otherwise the regression algorithm is used.

- Profiles of T, Q, and RH and precipitation rate, LWP, and IWP: retrieval is based on passive measurements only; radar reflectivity profiles are used to discriminate between cloudy and clear sky profiles.
- Profiles of hydrometeors: retrieval is based on radar reflectivity and Doppler velocity together with retrieved temperature and integrated hydrometeor content.

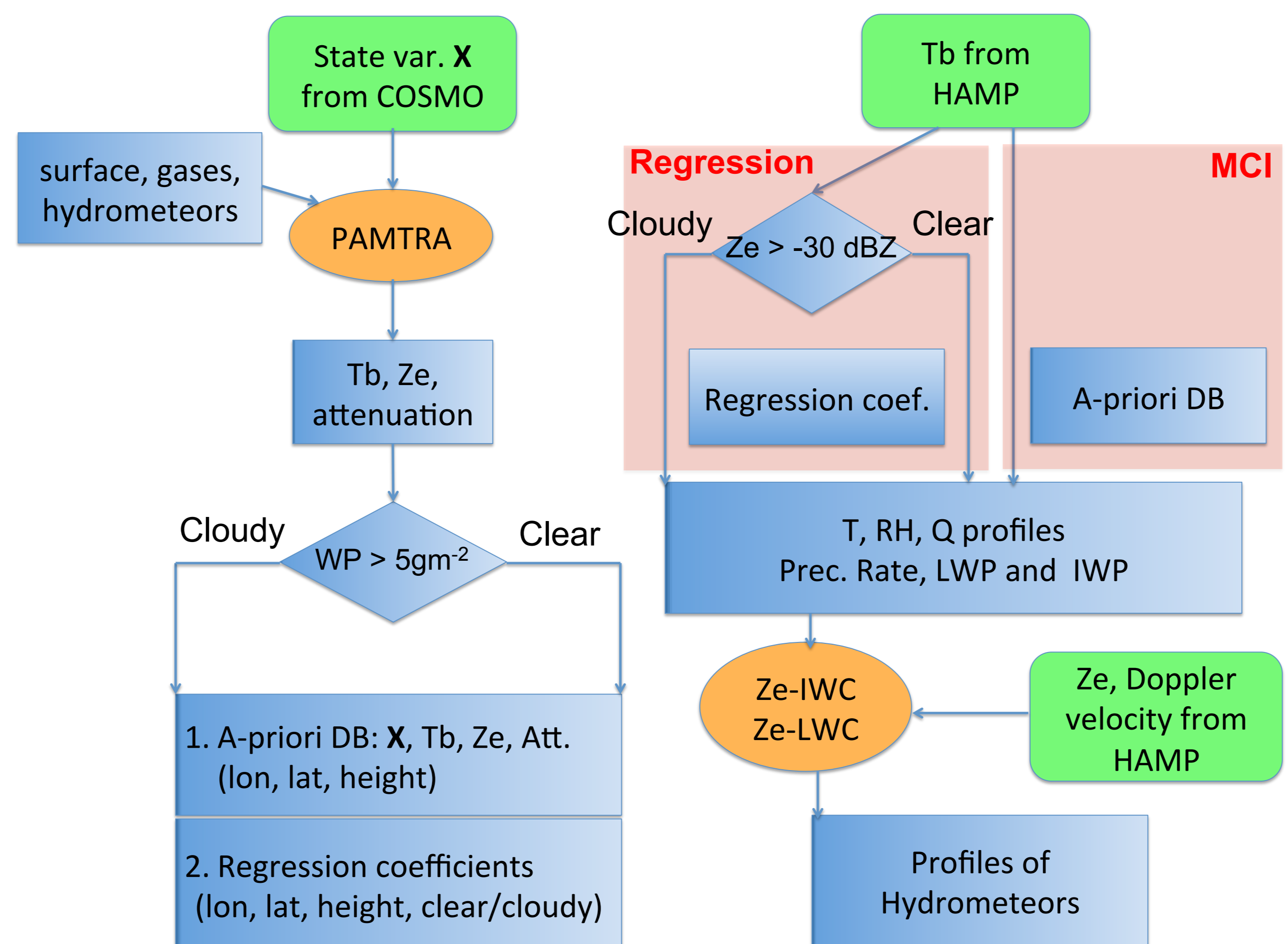


Fig. 2: Generation of the database for the MCI scheme and calculation of the retrieval coefficient (left). Sketch of the retrieval algorithm (right).

4. Retrieval results

The algorithm is tested using simulated T_b and Z_e from independent COSMO fields (test database). Profiles of temperature and humidity rmse and bias are shown in figure 3. The potential of HAMP in retrieving rain rate and liquid water path is assessed in figure 4.

- High retrieval accuracy for T close to the aircraft ceiling height -> high potential for tropopause height retrieval.
- For rain rate greater than 0.5 mm/h, 80% of the retrieved profiles has a rel. error smaller than 50%.

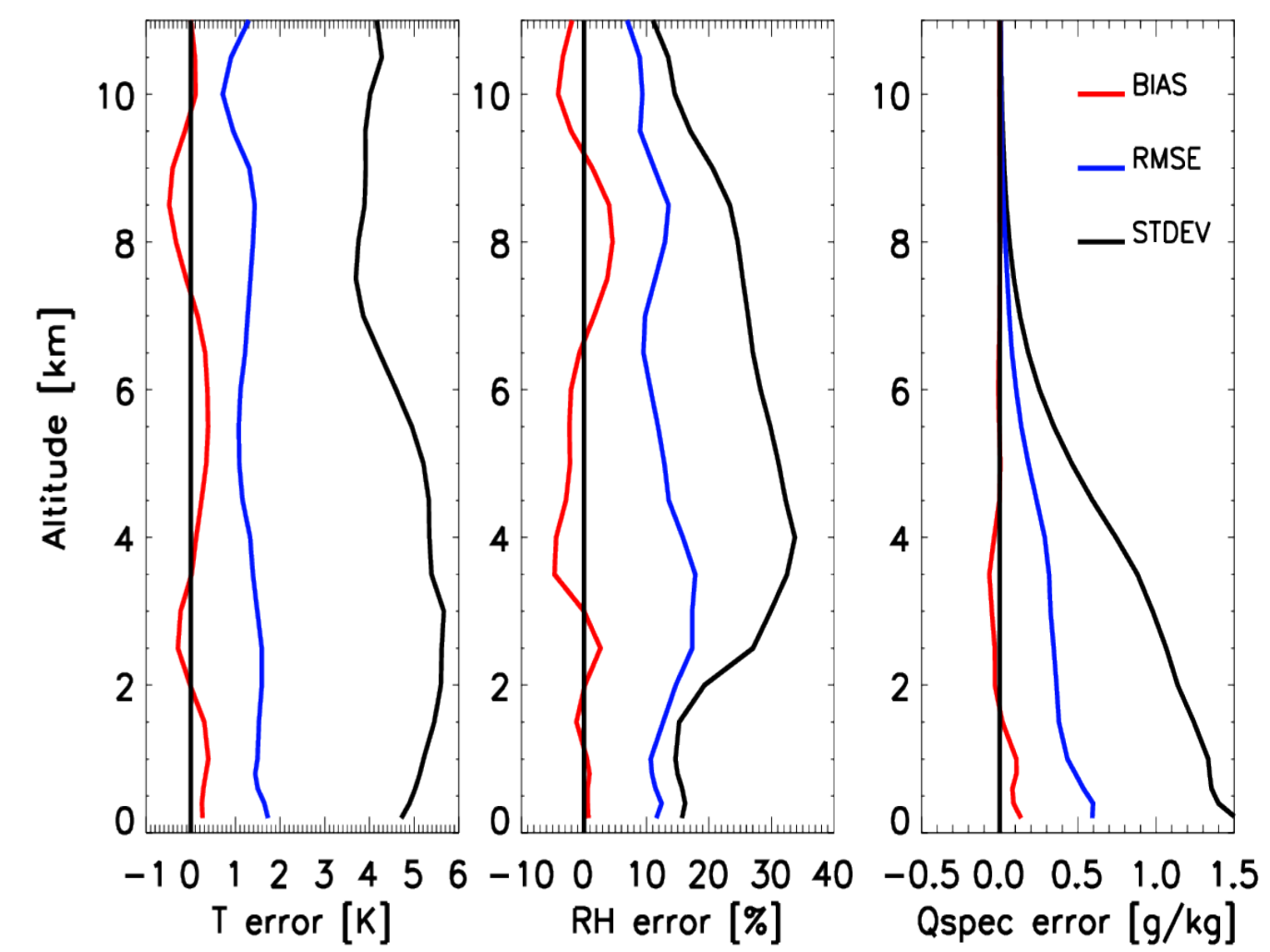


Fig. 3: Temperature, RH and specific humidity bias (red), rmse (blue) together with the standard deviation of the true profiles (black).

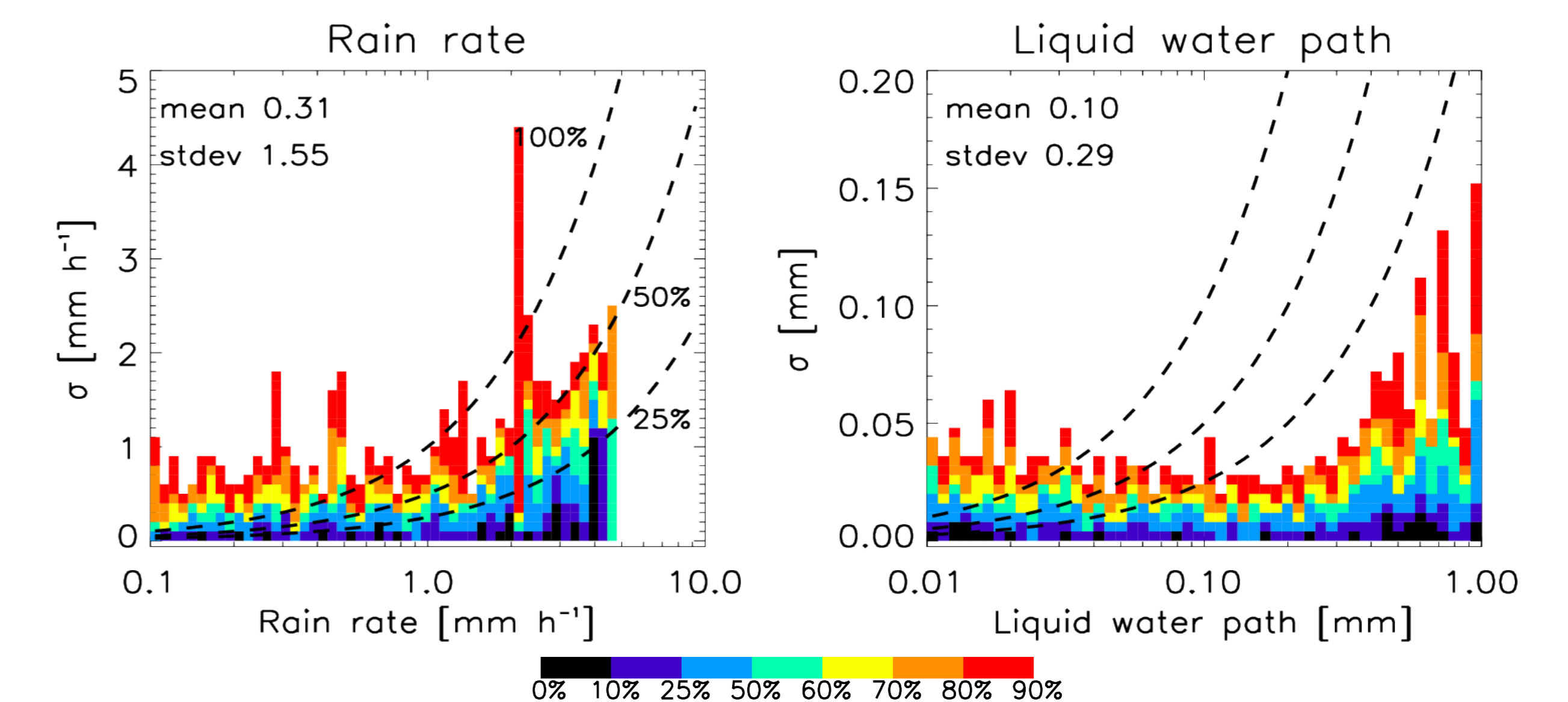


Fig. 4: Histogram of departure (retrieved - true) accumulated occurrence for rain rate and liquid (rain + cloud) water path. Dashed lines represent relative error of ±25%, ±50% and ±100%. Mean and standard deviation of the test database are also reported.

5. Conclusion and outlook

- High accuracy for precipitation retrieval, including low precipitation rates.
- Combined Monte Carlo Integration and regression algorithm improve precipitation retrieval by around 10% with respect to regression alone.
- Target classification algorithm to retrieve hydrometeor profiles from Z_e and Doppler velocity is under development.
- First HALO flight with HAMP in May 2013. Narval campaign in January 2014.