

# Retrieval development and test for HAMP, the HALO microwave package



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## 1. Introduction

New cloud observation techniques are needed to improve our understanding of the impact of clouds on the Earth's water cycle and radiation budget, which still represents one of the largest uncertainties in global and regional climate modelling.



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 radar.

HAMP radiometer					
BAND	K	V	W	F	G
Frequency [GHz]	22.34	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

In this poster the potential of HAMP for the retrieval of hydrometeors and temperature and humidity profiles is assessed.

## 2. Simulations

Based on COSMO-DE cloud resolving model simulations of 3 frontal systems crossing the North Atlantic (2.8 km resolution), forward radiative transfer simulations have been performed to obtain synthetic brightness temperatures at HAMP frequencies.

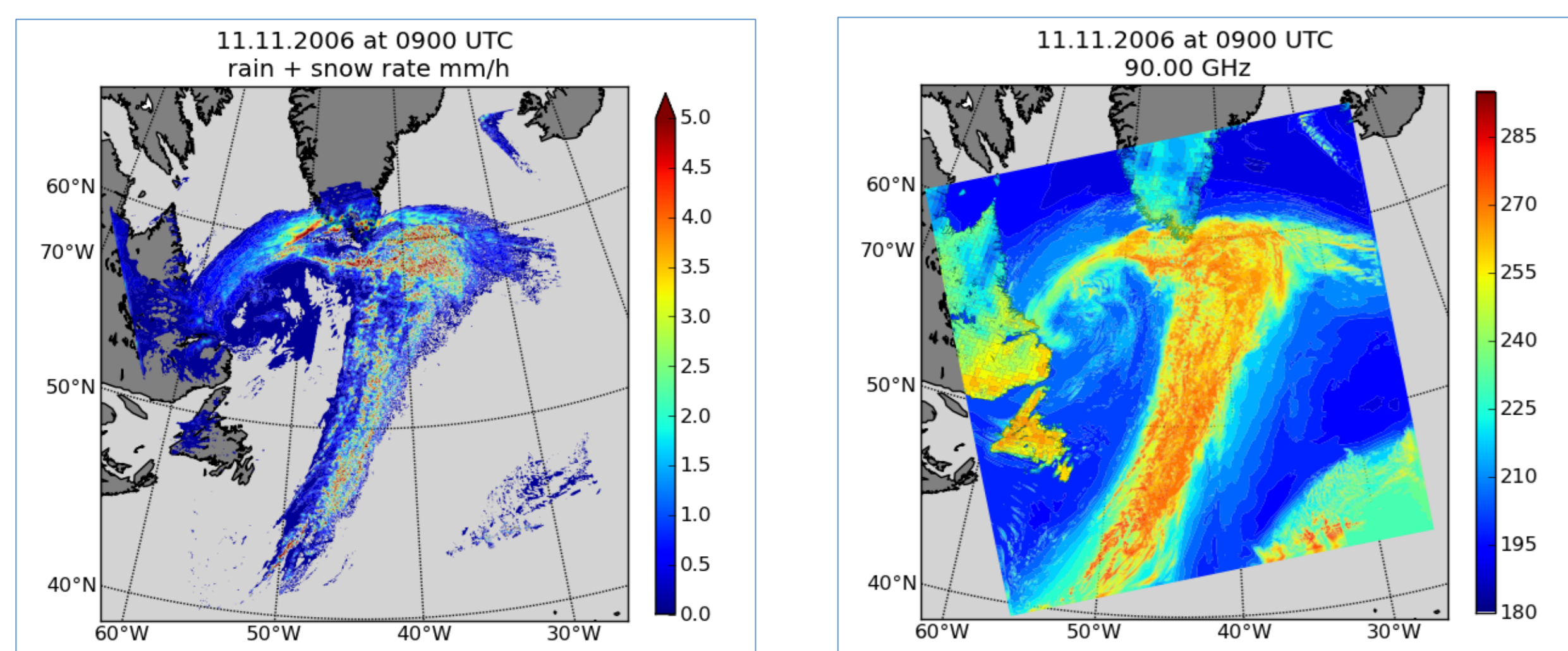


Fig. 1: Rain+snow rate [mm/h] from COSMO simulation on 12-11-2006 (left), corresponding brightness temperature at 90 GHz (right).

## 3. Retrieval

Simulated brightness temperatures in all sky conditions and over ocean have been used to train a **linear regression** algorithm to retrieve path integrated hydrometeors, rain rate, and profiles of temperature and water vapor.

The RMSE of path integrated hydrometeors, rain rate, and temperature and water vapor profiles, retrieved with three combinations of HAMP frequencies, is shown in figure 2 and figure 3:

- K and V band channels are essential to retrieve liquid water content and rain rate -> It will be used to validate controversial SSM/I retrieval (Klepp et al., MetZeit, 2005)
- Higher frequency channels have the largest impact on snow and cloud ice retrieval
- Water vapor retrieval performance is mainly dependent on K band channels, particularly in cloudy and rainy conditions

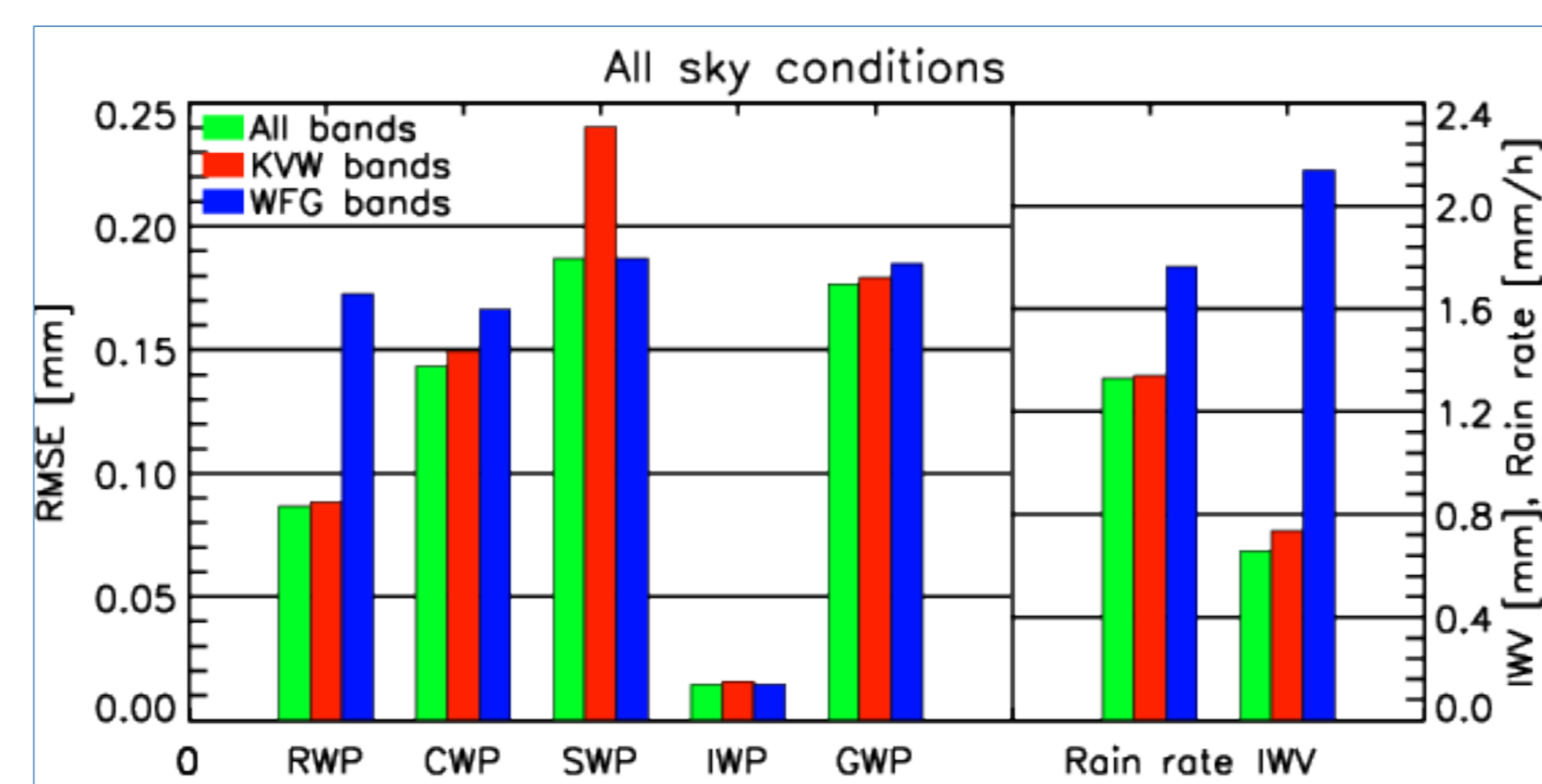


Fig. 2: RMSE for rain, cloud water, snow, cloud ice, graupel and water vapor path integrated content [mm] together with rain rate [mm/h] for three frequency combinations.

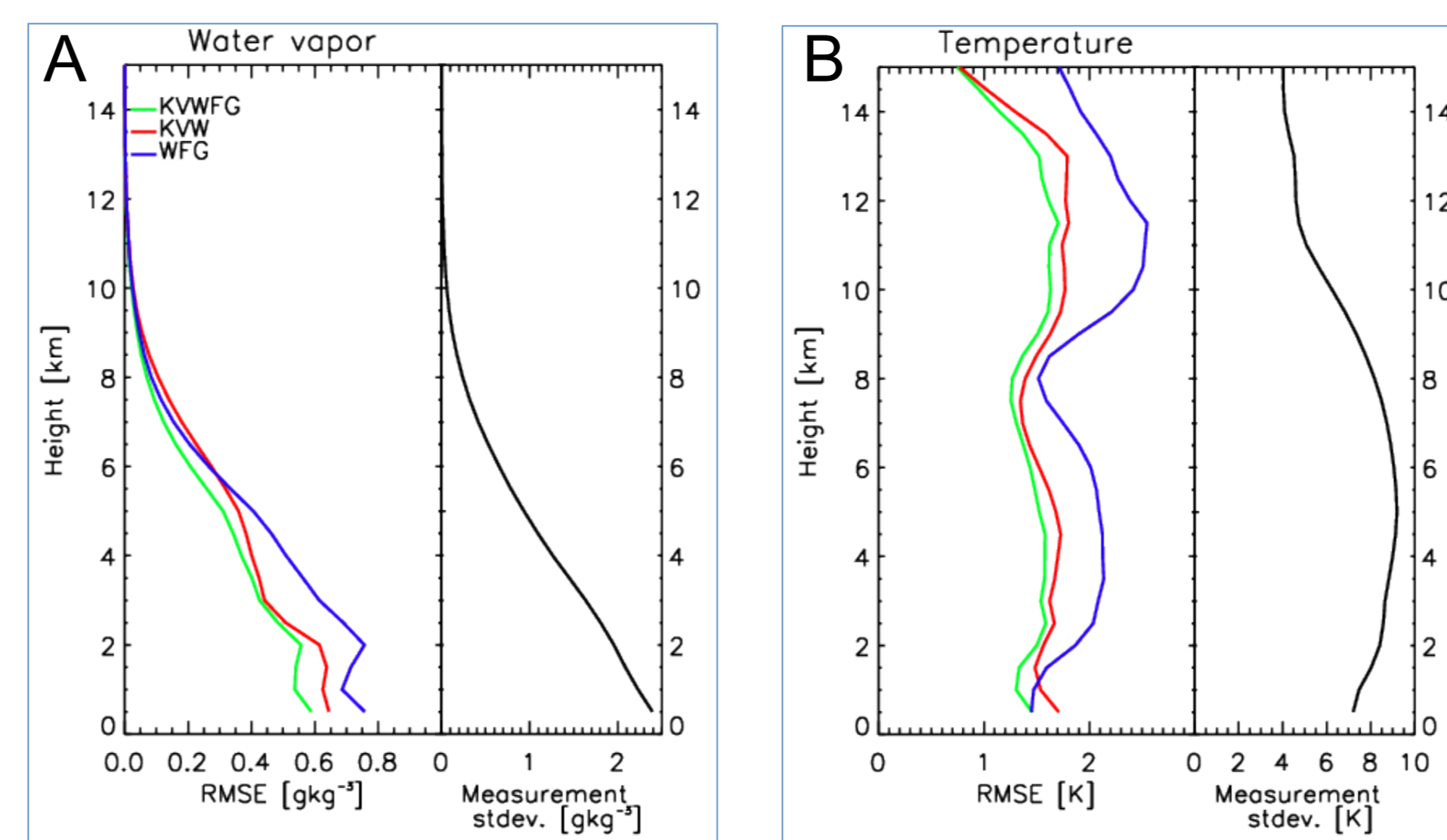


Fig. 3-A: Specific humidity RMSE for different set of frequency bands [gkg<sup>-3</sup>] (left) standard deviation profiles (right). Fig. 3-B: As in figure 3-A for temperature [K].

- Over ocean and in all sky condition both V and F bands lead to a decrease the temperature retrieval error

## 4. Variational approach

Information content (IC) analysis for HAMP have also been performed using a 1-D variational retrieval. The advantage of this approach is that a priori information, together with their error statistic, can be taken into account in the retrieval.

An 8 years database of clear sky Lindenberg radiosondes have been used to estimate the retrieval error and the IC of HAMP measurements at 12 km ceiling height.

- Water vapor: K band brightness temp. add information in low levels while G band to the middle and high troposphere
- Temperature: high retrieval accuracy close to the aircraft ceiling height

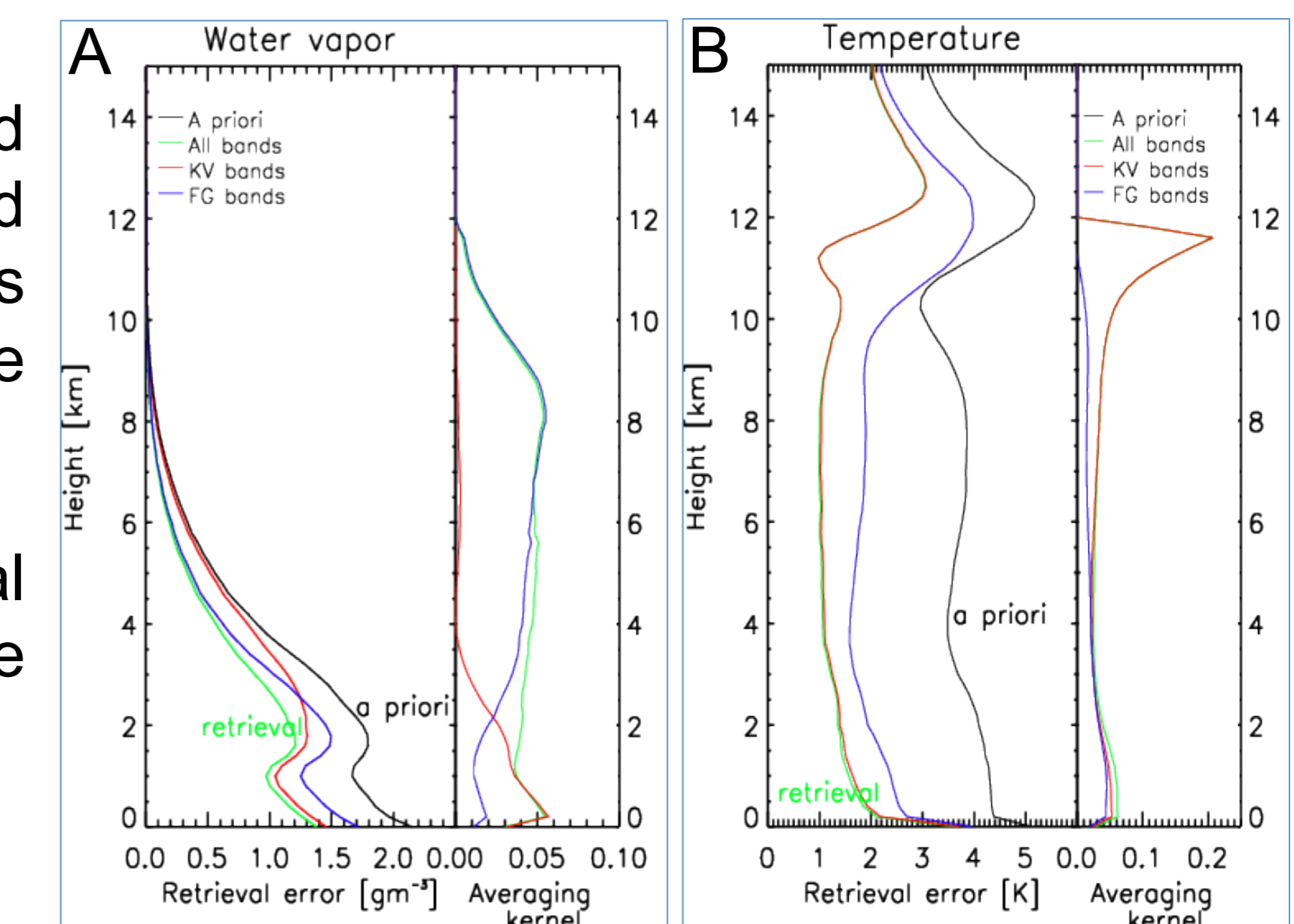


Fig. 4-A: Absolute humidity a priori and retrieval errors [g m<sup>-3</sup>] for three frequency combinations (left) and averaging kernel profiles (right). Fig. 4-B: As in figure 4-A for temperature [K]

## 5. Conclusion and outlook

- The HAMP radiometer has a unique combination of frequencies suitable for retrieving liquid and frozen hydrometeors
- IC analysis shows high accuracy for temperature retrieval close to the aircraft ceiling height -> high potential for tropopause height retrieval
- Retrieval algorithm fully exploiting the synergy between active and passive HAMP measurements are under development
- HAMP will be operated on HALO during **NARVAL/ACPC** measurement campaign (North Atlantic and Caribbean area) which will take place in **January and February 2012**

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