Thermodynamic profiles, IWV and LWP from ground-based microwave radiometers during MOSAiC

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HYPOTHESIS

The consideration of temporal and spatial variability of water vapour is necessary to establish the role of water vapour for Arctic Amplification

MOTIVATION

- Arctic shows moistening trend [1] but magnitude and regional distribution are uncertain among reanalyses and satellite products [2, 3]
- Sparse ground observations and difficulties in satellite remote sensing limit estimation of water vapour variability [3]
- ➢ High quality observations gathered during MOSAiC will help to evaluate satellite products and reanalyses

METHODS

We derive integrated water vapour (**IWV**), cloud liquid water path (**LWP**), as well as temperature and humidity profiles from radiances (expressed as **TBs**) from microwave radiometers:

- **HATPRO:** 14 channels along water vapour and oxygen absorption lines (22-31 and 50-58 GHz)
  Regression with quadratic terms, trained with radiosondes from Ny-Ålesund to derive IWV, LWP, temperature and humidity profiles [4]
- **MiRAC-P:** 6 channels along 183 GHz water vapour absorption line, 243 and 340 GHz
  Neural Network approach, trained with ERA-Interim to retrieve IWV [4]
- **ARM:** 2 channels: 23.8 and 31.4 GHz
  MWRRET: Combination of statistical and optimal estimation retrieval to generate a best estimate of LWP and IWV [5]

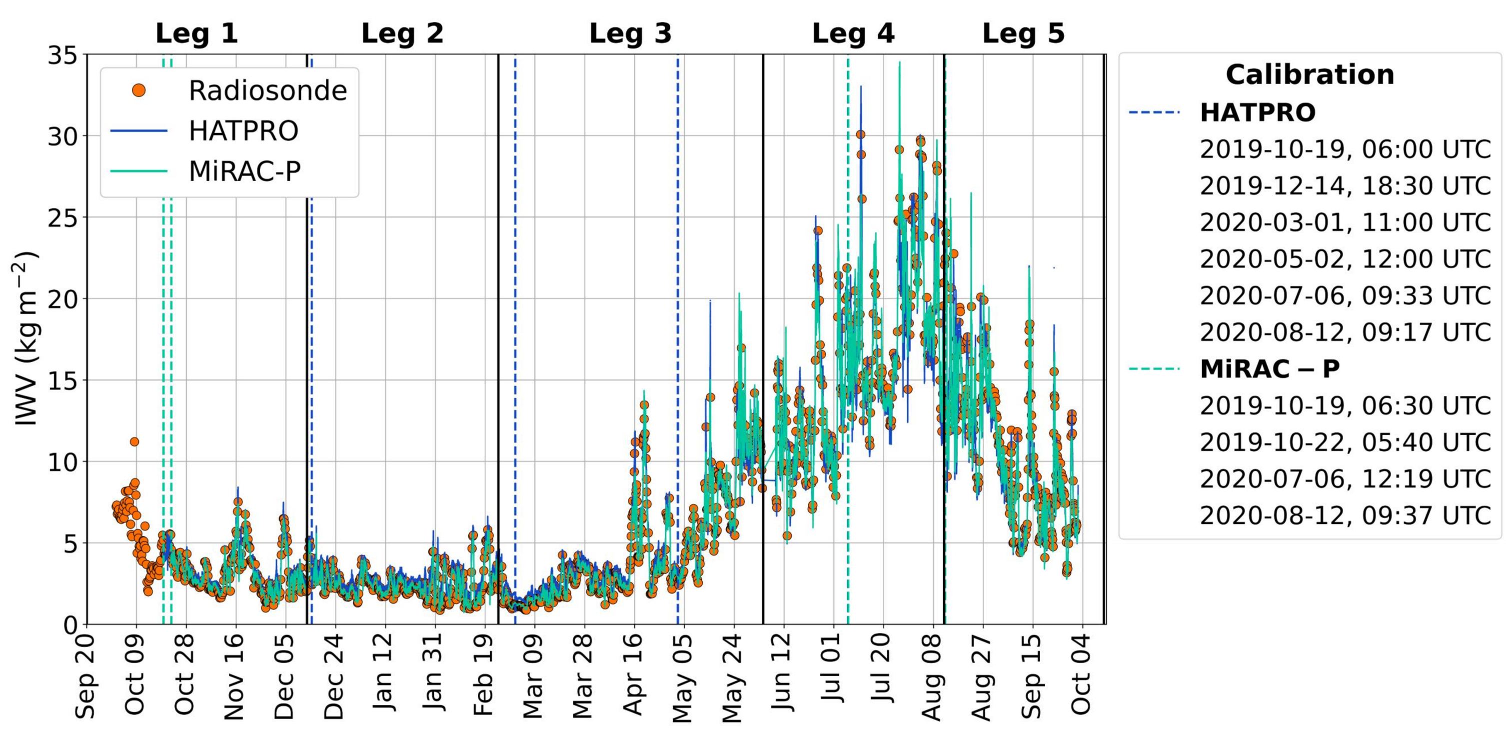

Fig. 1: IWV time series from **HATPRO**, **MiRAC-P** and radiosondes.

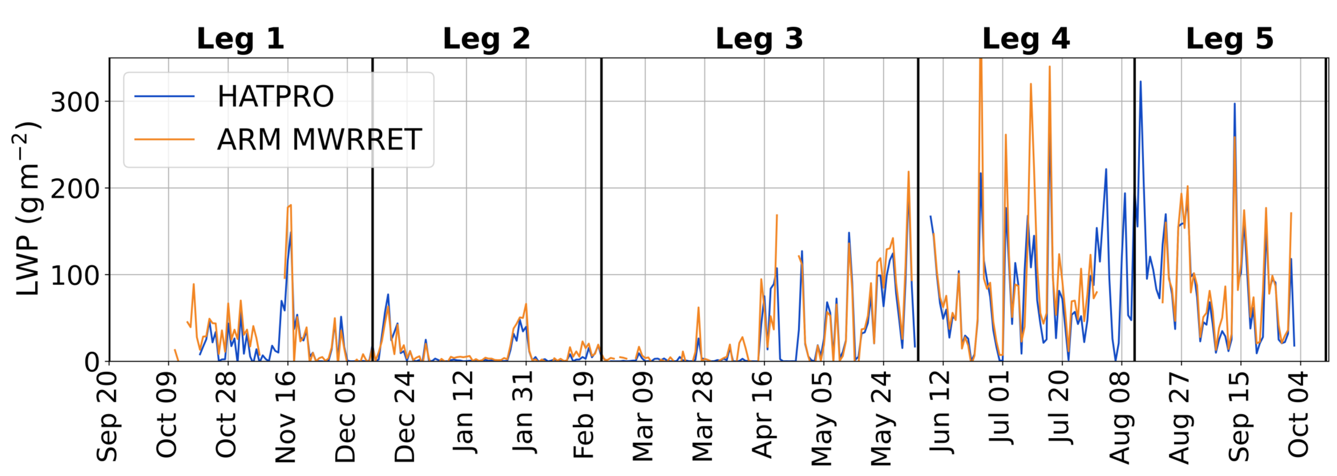

Fig. 2: Daily average of LWP from **HATPRO** and **ARM MWRRET**.

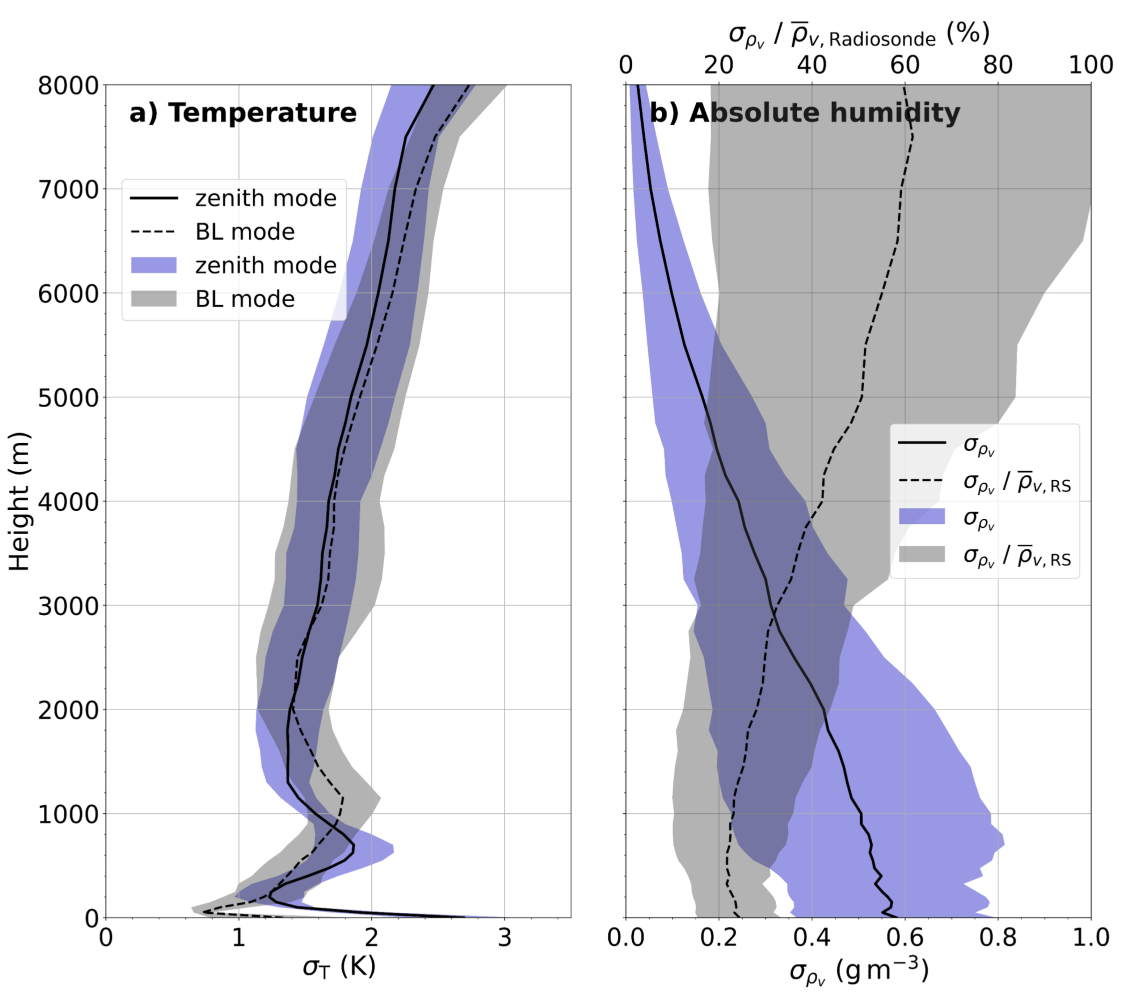

Fig. 3: Standard deviation of temperature and humidity profiles between radiosondes and those from **HATPRO**. Shading indicates the spread over the MOSAiC legs.

RESULTS [4]

MOSAiC observations show a large variability in IWV and LWP (Fig. 1, Fig. 2). In dry conditions, **MiRAC-P** agrees extremely well with radiosondes, while **HATPRO** and **ARM** slightly deviate (Tab. 1). This is the opposite for moister conditions, where **MiRAC-P** shows higher deviations than the other radiometers. Regarding LWP, both **HATPRO** and **ARM** agree well on most days. Absolute calibrations of **HATPRO** and **MiRAC-P** ensure high quality measurements (Fig. 1).

Retrieved temperature and humidity profiles from **HATPRO** are able to resolve coarse inversions but cannot detect any small variations (Fig. 3, Fig. 4). Especially the boundary layer mode of **HATPRO** is able to capture lower tropospheric inversions.

Fig. 4 shows the record breaking moist air intrusion captured in April 2020. Coarse temperature inversions are resolved but the humidity inversions are smoothed out.

Tab. 1: Standard deviation, root mean squared error (RMSE), and bias (all in kg m^{-2}) between the radiometer and radiosonde IWV for IWV ≤ 5 and IWV > 5 kg m^{-2}.

	IWV ≤ 5	IWV > 5
HATPRO		
Std. dev.	0.19	0.37
RMSE	0.41	0.46
Bias	0.37	-0.27
MiRAC-P		
Std. dev.	0.08	0.99
RMSE	0.12	0.99
Bias	0.09	-0.07
ARM		
Std. dev.	0.40	0.45
RMSE	0.42	0.46
Bias	0.12	-0.09

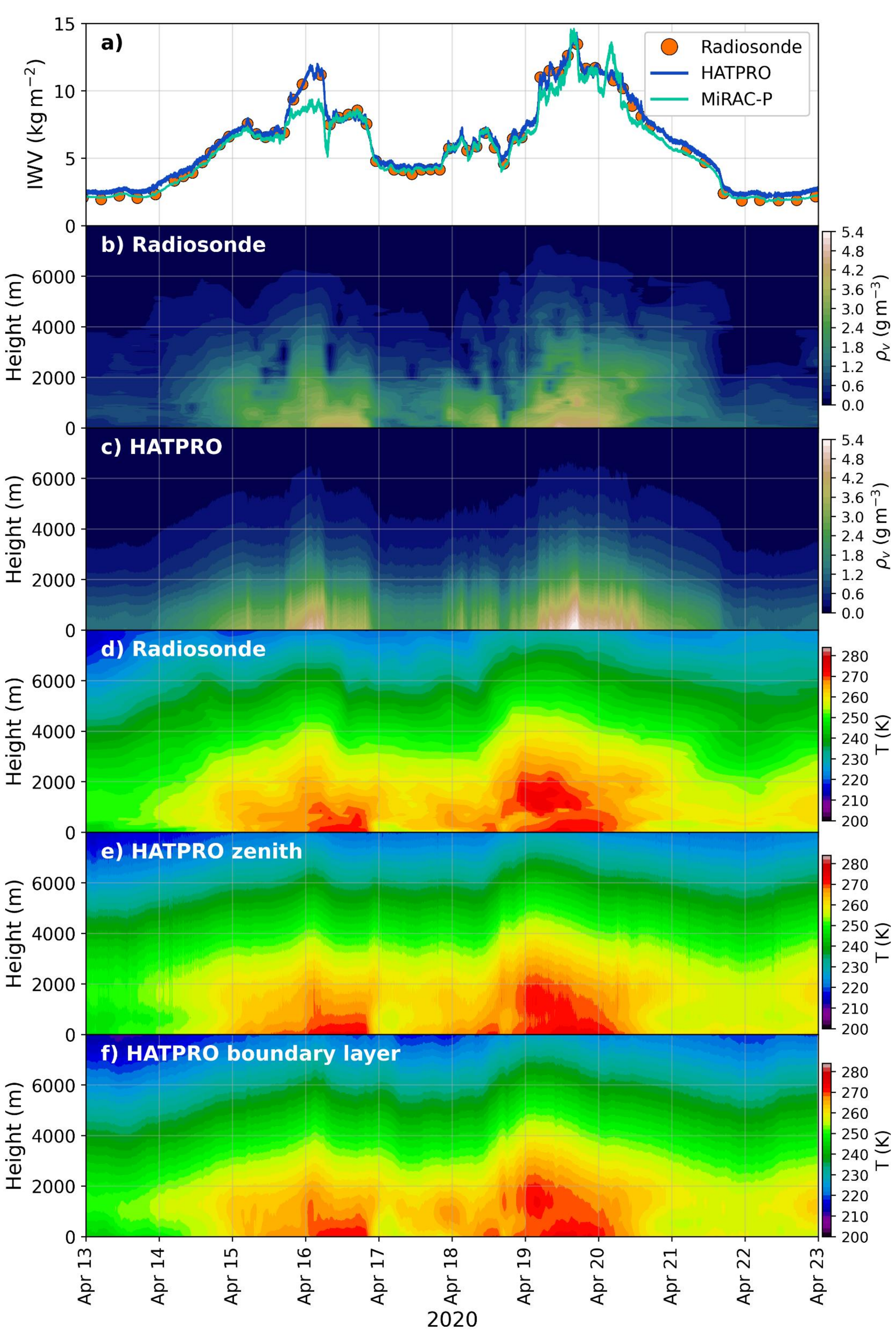

Fig. 4: Overview of moist air intrusion case from 13th to 23rd April 2020, showing IWV, absolute humidity and temperature profiles from **HATPRO**, **MiRAC-P** and radiosondes.

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CONCLUSION & OUTLOOK

- Continuous data sets with high temporal resolution (≈1 s) available on **PANGAEA** [4]
- Excellent agreement of derived IWV with radiosonde obs (Fig. 1, Fig. 4, Tab. 1)
- Profiles show coarser vertical resolution but surface temperature inversions are resolved (Fig. 3, Fig. 4)
- ➢ Humidity profiles and IWV may benefit from synergy of **HATPRO** and **MiRAC-P**