# Water vapour in the Central Arctic: How well do Satellite Products, Reanalyses and Reference Observations from MOSAiC agree?

B05 #04

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## I: Motivation

- Water vapour is the strongest greenhouse gas and results in a positive climate feedback loop: **Water vapour feedback**[1-2]
- Observations indicate moistening of Arctic for certain regions and seasons, but uncertainties among reanalyses and satellite products are large[3-5]
- Vertical water vapour distribution affects downward thermal-infrared radiation[6]

➢ We need high-quality water vapour observations from field campaigns with high spatial and temporal resolution

➢ **How well do satellite products and reanalyses agree with reference observations from MOSAiC?**

➢ **How well are Arctic humidity profiles represented by reanalyses and satellite products?**

## II: Reference observations from MOSAiC

- Vaisala RS41 radiosondes: Temperature & humidity profiles, Integrated Water Vapour (IWV)
- Microwave radiometers (MWRs) **HATPRO** and **MiRAC-P** (Fig. 1): Measure radiances emitted from atmospheric gases and hydrometeors (see PAMTRA[7] simulations in Fig. 2)
  - Supervised machine learning (Neural Network) algorithm combining both MWRs for improved temperature and humidity profiling, and IWV estimates compared to single-instrument retrievals[8]

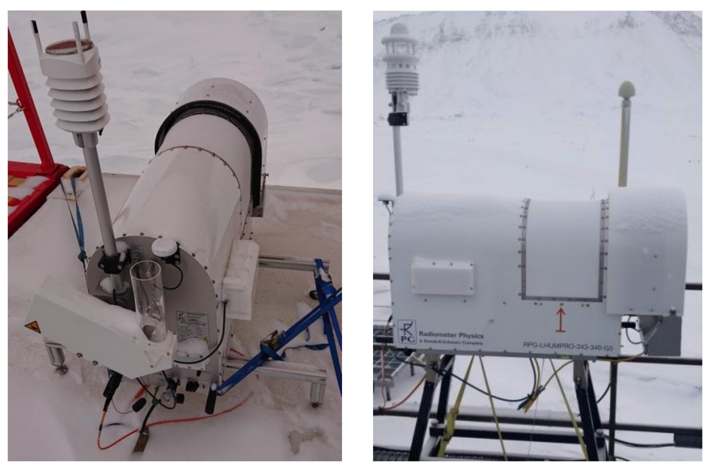


*Fig. 1: Microwave radiometers HATPRO (left) and MiRAC-P (right).*

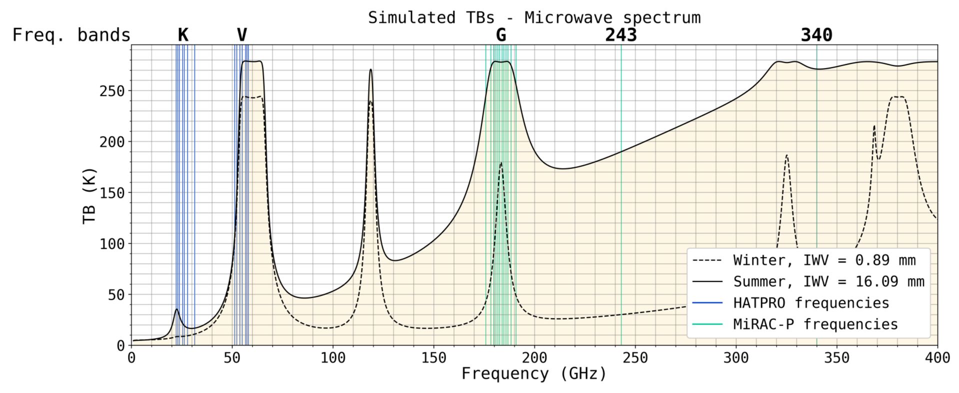


*Fig. 2: Simulated radiances for low and high IWV conditions. Vertical lines indicate the measurement frequencies of HATPRO and MiRAC-P.*

## III: Water vapour error reduction: Synergy vs single radiometer

We evaluate single-instrument and synergetic retrievals with MOSAiC radiosondes for IWV (Fig. 3) and specific humidity profiles (Fig. 4).

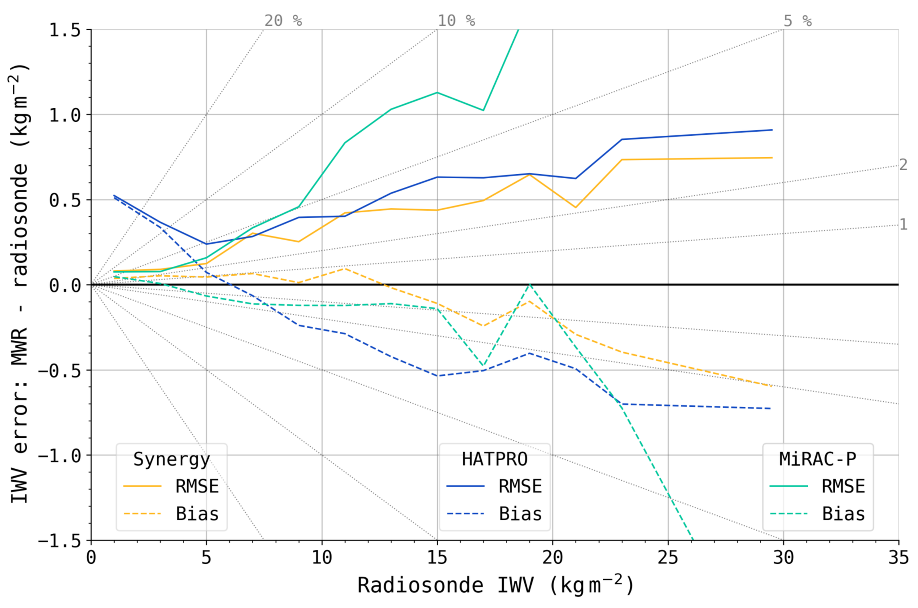


*Fig. 3: IWV root mean squared error (RMSE) and bias with respect to MOSAiC radiosondes for single-instrument and synergetic retrievals.*

The vertical information content (Degrees Of Freedom (DOF)) of retrieved specific humidity profiles with different frequency combinations has been estimated with ERA5 data and simulated TBs (Fig. 5).

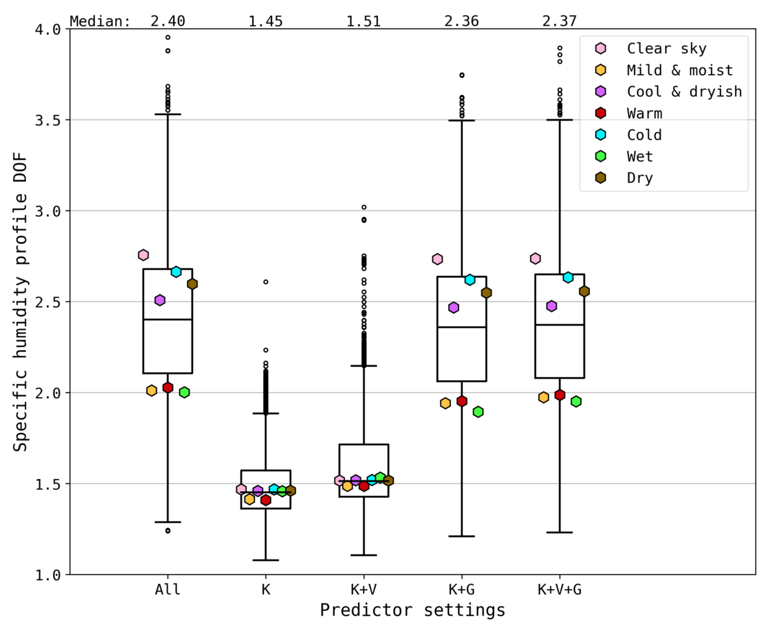
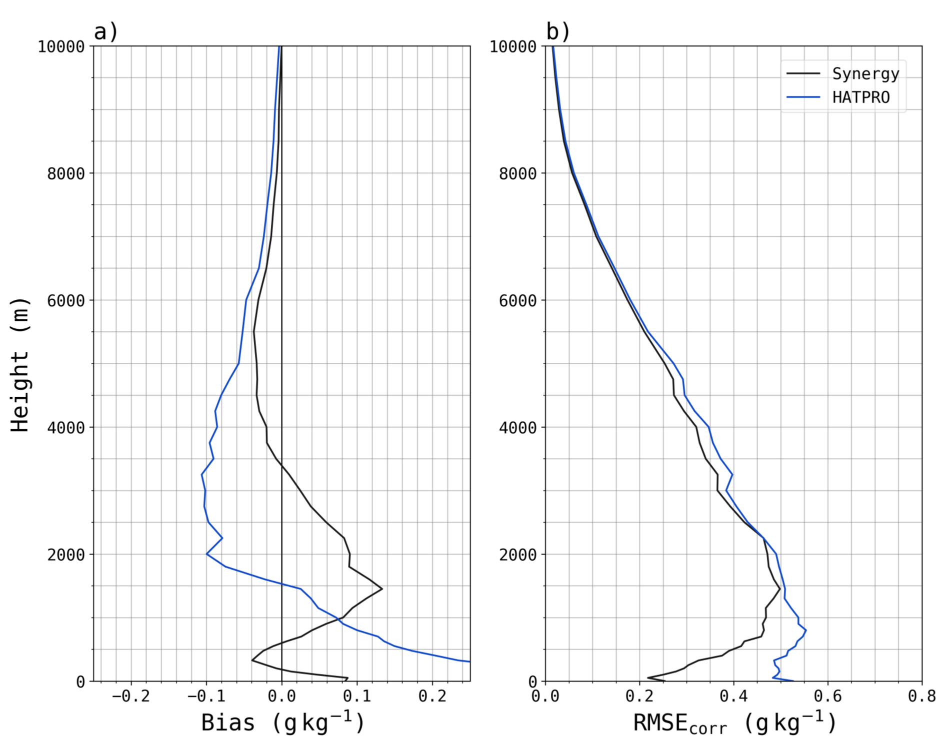


*Fig. 5: Boxplot showing the DOF for various frequency combinations and atmospheric conditions in the Neural Network retrieval.*

**Compared to HATPRO-only:**
- **Error reduction by a factor of 2 close to the surface**
- **Almost doubled DOF**



*← Fig. 4: Specific humidity error profiles showing the bias (a) and bias-corrected-RMSE (b) with respect to MOSAiC radiosondes.*

## IVa: Integrated water vapour comparison

- Reanalyses: ERA5, MERRA2
- Satellite products: IASI Combined Sounding Products – Metop, AMSR-E/2 IWV retrieval[9]

With the IWV from the synergetic retrieval as reference, errors of each dataset are computed.

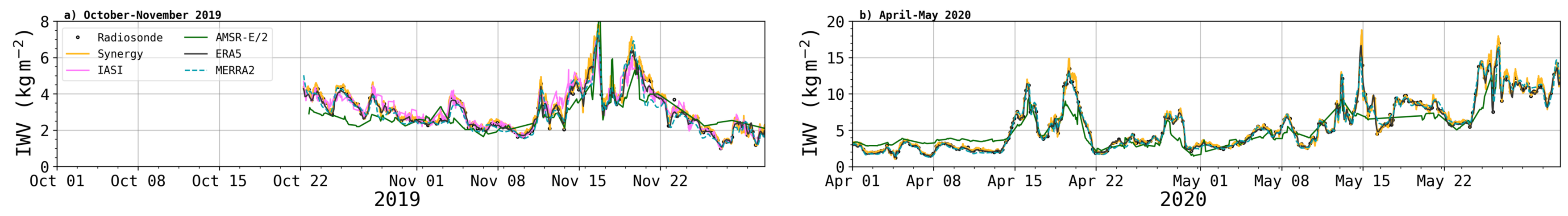


*Fig. 6: IWV time series for parts of MOSAiC from radiosondes, MWR, reanalyses and satellite products.*

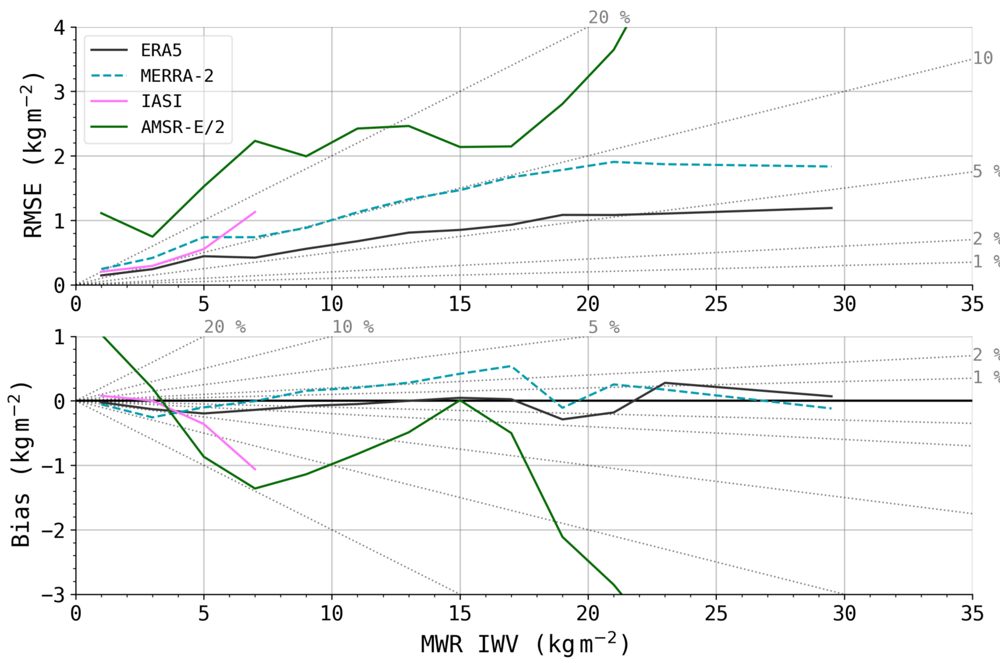


*Fig. 7: RMSE (top) and bias (bottom) of different IWV datasets from reanalyses and satellites.*

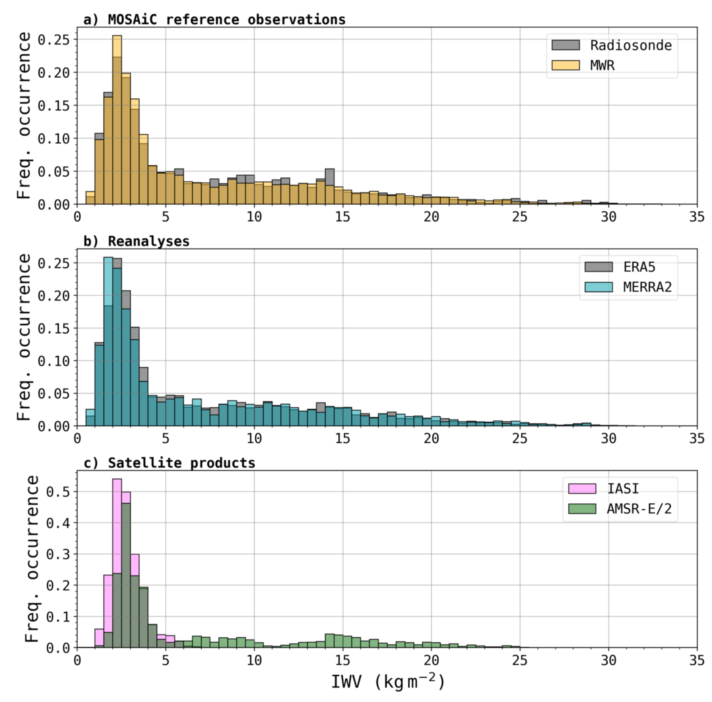


*Fig. 8: IWV histograms from MOSAiC reference observations (a), reanalyses (b) and satellite products (c).*

- **Apart from slight biases (5 %), ERA5 agrees very well with MOSAiC observations for IWV and humidity profiles (but radiosondes have been assimilated)**
- **MERRA2 shows negative biases for low IWV, positive bias for high IWV**
- **The satellite products IASI & AMSR-E/2 have biases > 10 % in low IWV conditions**

## IVb: Humidity profile comparison

Case study of a developing humidity inversion on 20 November 2019 (Fig. 9 and 10). Here, the AMSR-E/2 is excluded because it contains IWV only. ERA5 captures the inversion best compared to the reference observations.

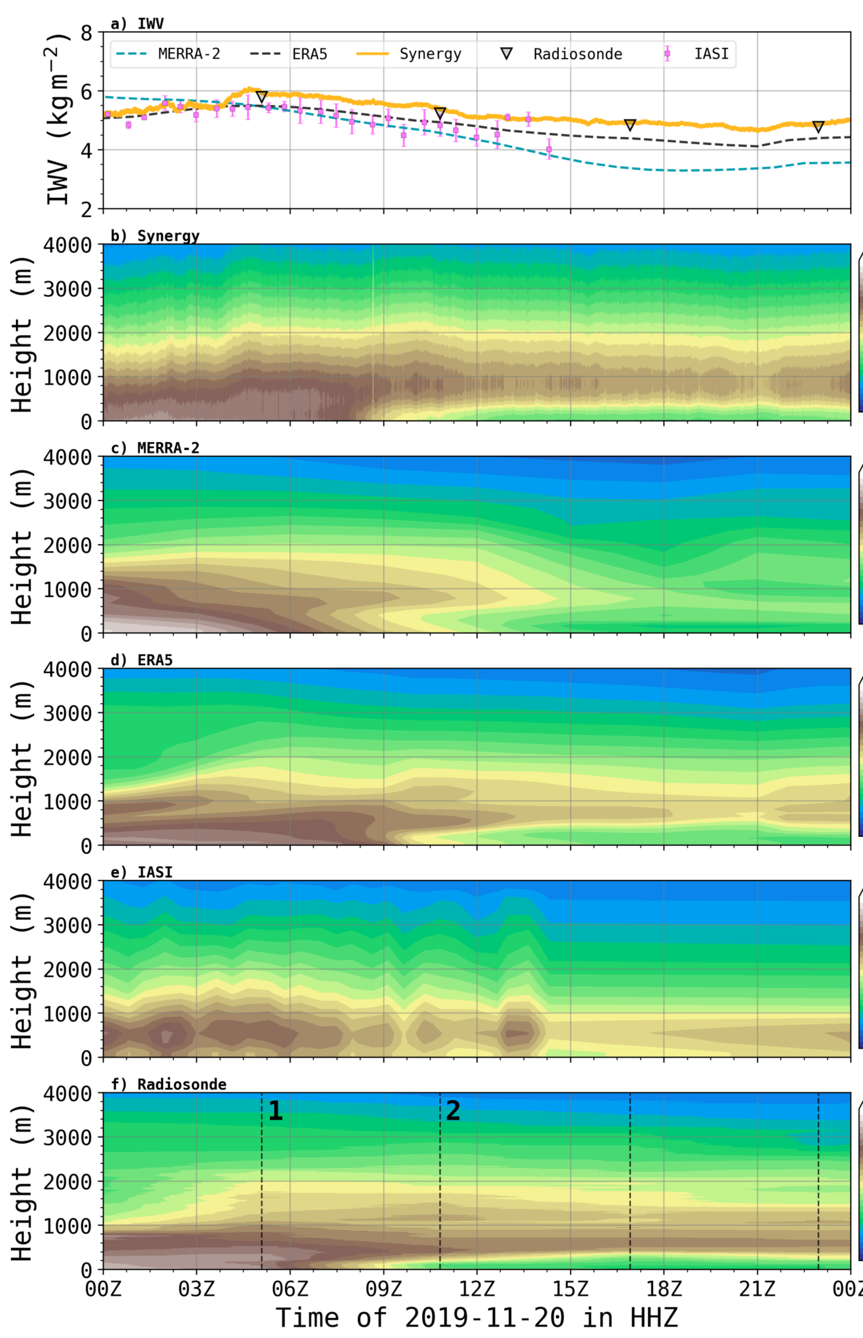


*Fig. 9: (a) IWV and (b) – (f) specific humidity time-height cross sections from reanalyses, satellite products and MOSAiC reference observations.*

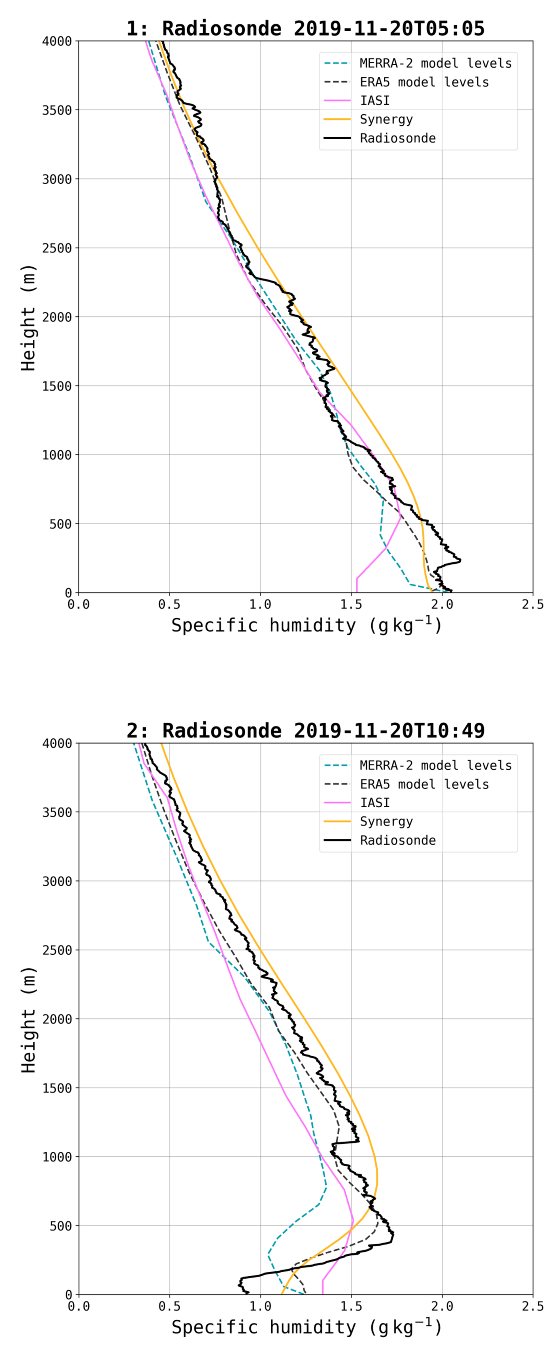


*Fig. 10: Specific humidity profile snapshots at 05:05 (top) and 10:49 UTC (bottom) on 2019-11-20.*

- **The synergetic MWR humidity profile retrieval is able to resolve the inversion and capture its development**
- **ERA5 agrees well with radiosonde observations, which is expected because they have been assimilated**
- **IASI and MERRA2 cannot capture the strength and development of the humidity inversion**

## V: OUTLOOK

- Perform statistical analysis of humidity inversion characteristics
- Investigate influence of humidity profile errors on downward thermal-infrared radiation errors

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