Variability and trends of water vapour in the Arctic

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FLUXES TRANSPORT CLOUDS SURFACE ARCTIC AMPLIFICATION (AC)³

B05

1. Summary

Accurate water vapour (WV) observations are key to understand the role of the WV feedback in Arctic amplification.

Research questions:

Q1 Do **improved satellite WV retrievals** allow to quantify the **WV feedback** in the Arctic?

Q2 Can we **explain the strong differences between WV products** exploiting the MOSAiC and HALO-(AC)³ campaigns?

Q3 How well can WV profiles and moisture inversions be derived from satellite and ground-based observations?

Hypothesis

The consideration of temporal and regional variability of water vapour is necessary to establish the role of water vapour for Arctic amplification.

2. Achievements phase I

Satellite retrieval

- Improved integrated water vapour (IWV) retrieval over ocean and ice from merged microwave (MW) satellite observations (Triana Gómez et al., AMTD, 2019)

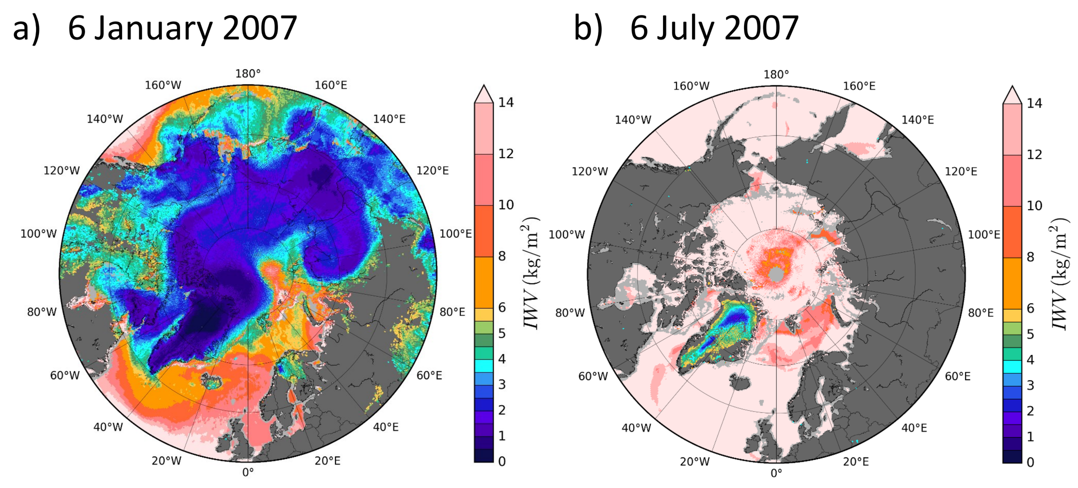


Fig. 1: Merged AMSU-B and AMSR-E IWV for (a) winter and (b) summer.

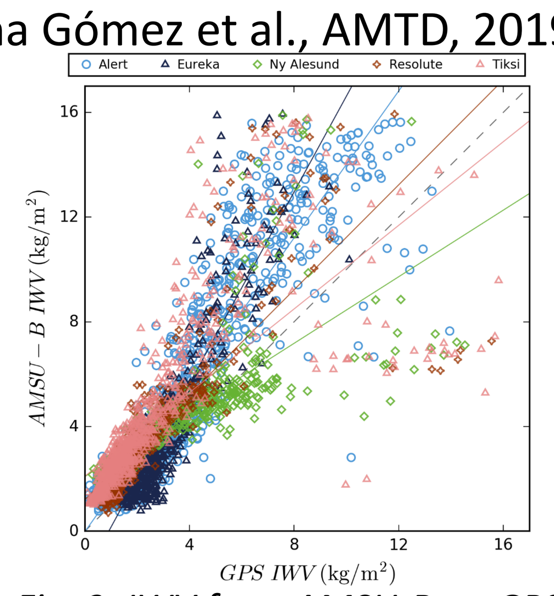


Fig. 2: IWV from AMSU-B vs. GPS.

- Development of an optimal estimation (OE) method from AMSR-E/2 for IWV, liquid water path, sea ice and multiyear ice concentrations, wind speed, sea and ice surface temperatures (Scarlat et al., IEEE J-STARS, 2017)

Polar low and atmospheric river (AR) analysis

- Assessment of environmental conditions for polar low formation using the Arctic System Reanalysis (Radovan et al., Tellus, 2019)
- Process studies of ARs and importance of WV for polar lows

Evaluation of IWV for ACLOUD campaign

- Intercomparison of satellite products and reanalyses (May-June 2017)

Arctic wide evaluation of IWV and trend analysis

- Evaluation of 6 atmospheric reanalyses (Graham et al., JCLIM, 2019)
- IWV trend analysis based on 4 reanalyses (Rinke et al., JCLIM, 2019)
- Long-term assessment of fundamental climate data record of MW brightness temperatures at WV line (Fig. 3)

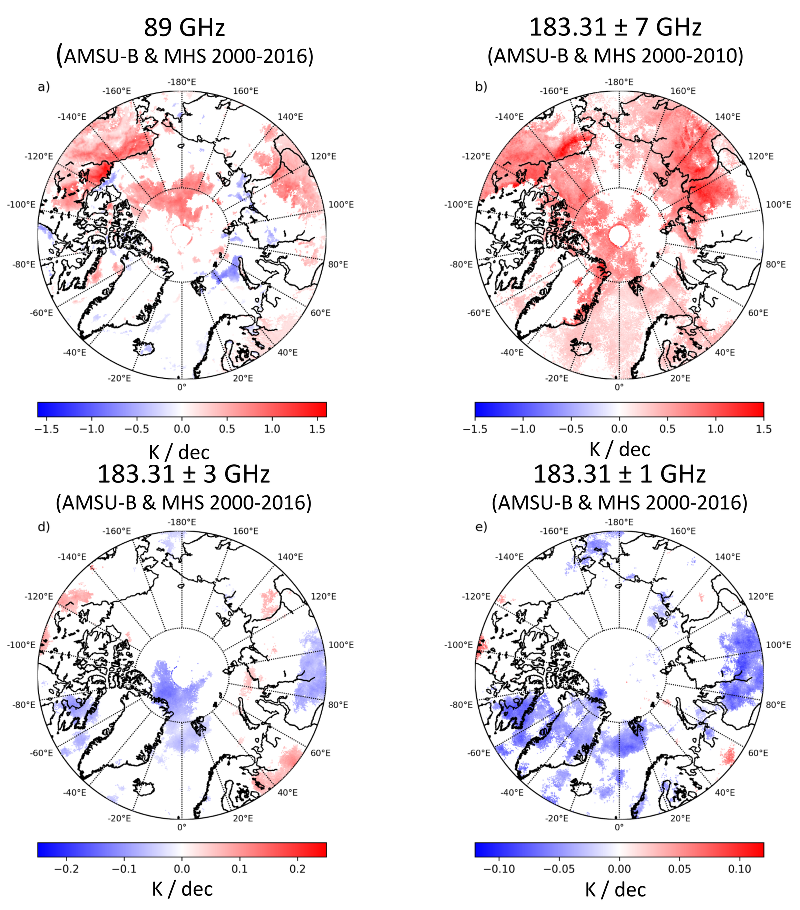


Fig. 3: Trends of AMSU-B/MHS brightness temperatures for the month of May (90% significance).

3. Research plan phase II

application

evaluation

WP1 Improved water vapour retrievals

- Consistent WV and sea ice observations from satellites
  - Arctic IWV and sea ice dataset since 2002 from AMSR-E/2
  - Improvement of OE method by new sea ice emissivity parameterisation
- Improved ground-based MW radiometer WV retrieval using higher frequencies
  - Synergy of standard 22.2-31.4 GHz with 183.31 GHz (243, 340 GHz) channels

WP2 Integrated water vapour in the central Arctic

- Satellite-based IWV and surface parameter retrieval for MOSAiC
  - Evaluation of satellite retrievals of WP1
  - Improvement of forward model by detailed MOSAiC in-situ observations
- Application of ground-based IWV retrieval for MOSAiC
  - Consistent post-processing
  - Evaluation with reference observations

Synthesis of observed and simulated IWV products

Long-term intercomparison

Spatial and long-term variability of WV and trends

Analysis of covariability of WV with sea ice changes

WP3 Vertical structure of water vapour

- Water vapour profiles for MOSAiC
  - Moisture inversions by ground-based MWRs: potential and statistical analysis
- Moisture inversions from satellites
  - IASI capabilities
  - Moisture inversions in ICON-LAM
  - Impact of vertical WV structure on longwave downward radiation
- Anomalous moisture transport/ HALO-(AC)³
  - AR events by HALO-(AC)³ instrumentation
  - ARs in satellite data and reanalyses (example in Fig. 4)

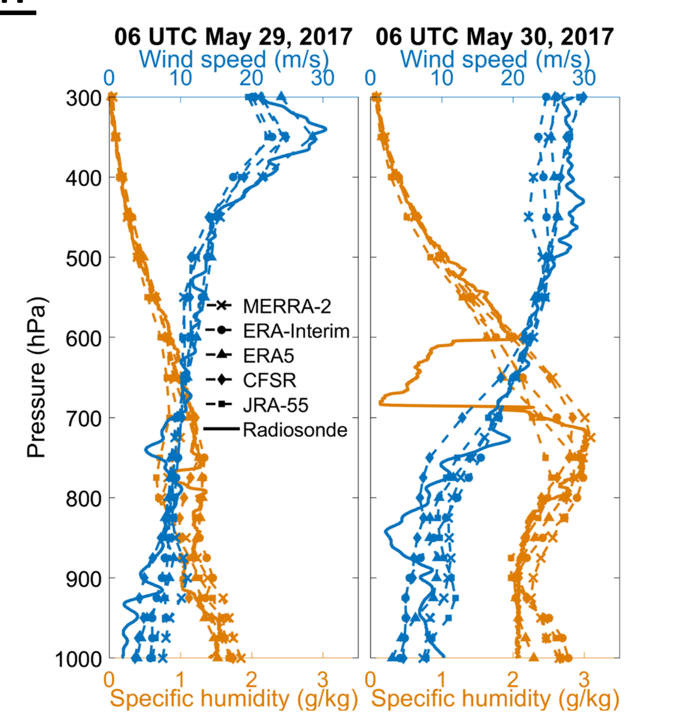


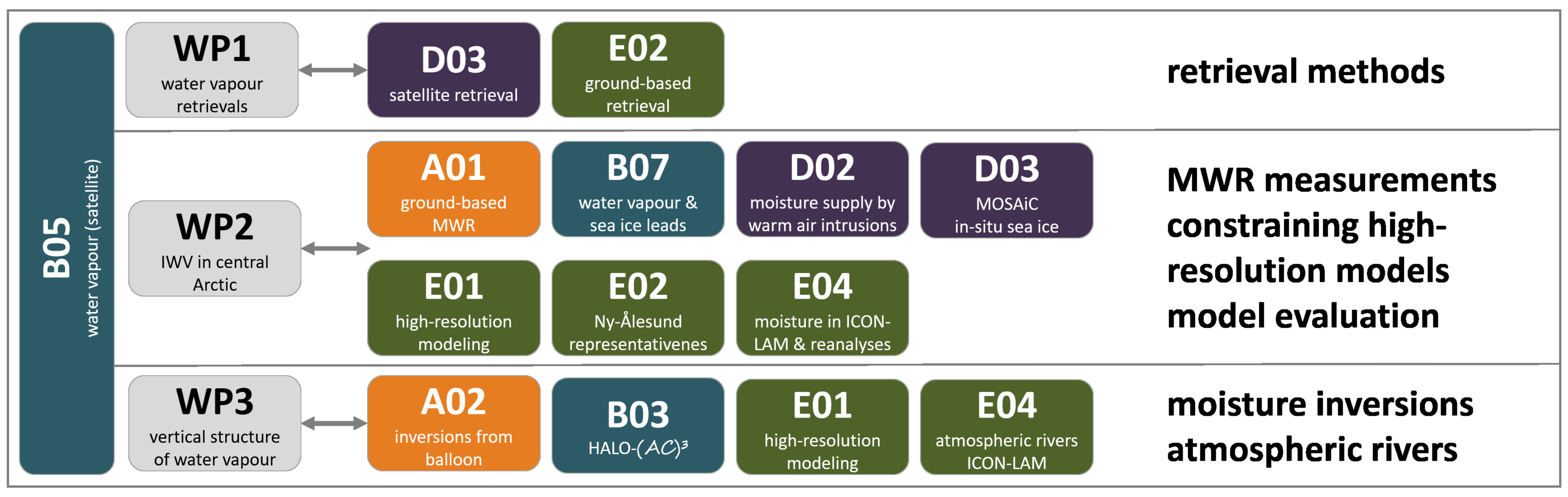
Fig. 4: Atmospheric river event at Ny-Ålesund on May 30, 2017, as seen by radiosonde and different reanalyses.

4. Role within (AC)³ & perspectives

Collaborations within (AC)³

Joint topics of B05 and (AC)³ partners are:

- campaign activities (MOSAiC, HALO-(AC)³) [A01, B03, D03]
- retrieval development [D03, E02]
- model evaluation [E01, E04]
- vertical structure of moisture [A02, B03, B07, E01, E04]
- atmospheric rivers [D02, E04]
- participation in CCA4 "Air mass transport and transformation"



Perspectives

- Exploitation of the new long-term satellite data records for multi-decadal assessment
- Extension of the OE retrieval to humidity sounders at 183 GHz
- Statistical analysis of moisture intrusions, changing patterns and trends
- Exploitation of submillimeter Ice Cloud Imager on MetOp-SG (launch in 2023) for low water vapour conditions and water vapour profiling

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