

Variability and trends of water vapour in the Arctic and related feedback processes

B05

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1 Summary

Combining long-term satellite data, regional climate model (RCM) simulations and high resolution field campaign data to address the central questions:

- How does the water vapour feedback influence the Arctic Amplification?
- What are the relative effects on radiation, clouds and temperature?
- How did the water vapour and related feedback processes change temporally and regionally over the last decades and how will they change in the future?

Hypothesis

Long-term, temporally and spatially different changes of water vapour influence Arctic Amplification via their effects on radiation, clouds, and temperature.

2 Research rationale

Motivation

- Water vapour (WV) is a crucial component in several feedback mechanisms leading to Arctic Amplification, e.g. sea-ice loss via enhanced longwave downward radiation (LWD), and cloud cover feedback
- Relative strength & future development of WV feedback are uncertain as observational basis and representation in models are limited
- Different reanalyses: large differences in precipitable WV (PWV) trends (Fig. 1)

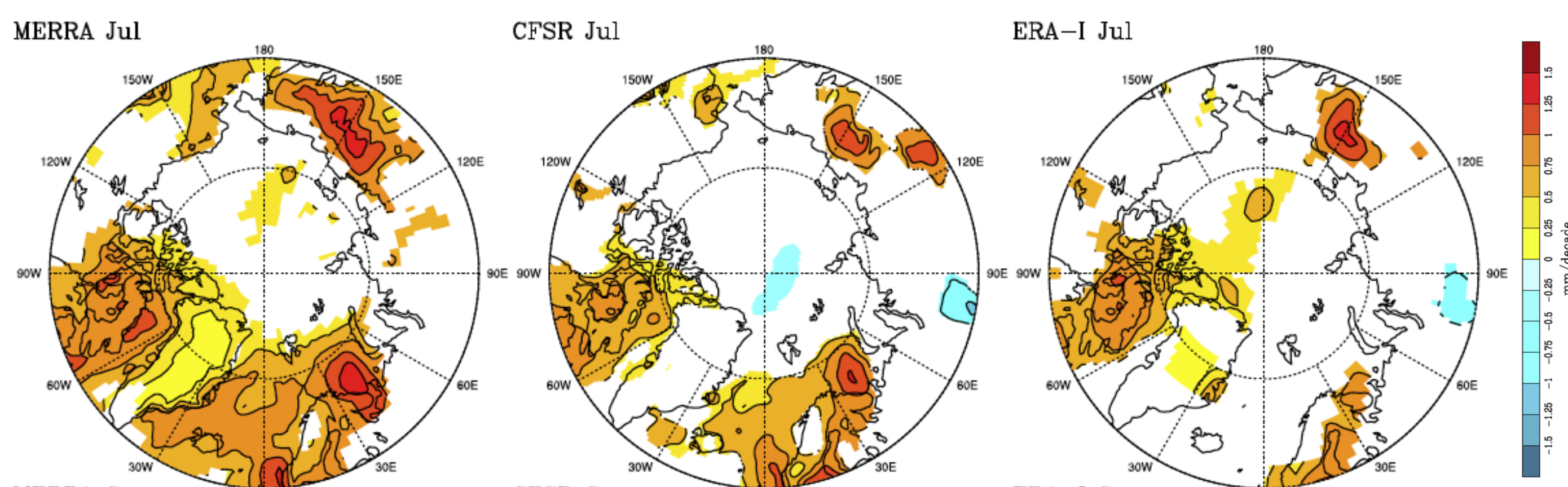


Fig. 1: Spatial pattern of linear trends in surface to 500 hPa PWV (mm/decade) in July for 1979-2010. Colours show statistically significant (> 90%) trends (Serreze et al., 2012).

Challenges

- High spatiotemporal WV variability over different sfc types hinders obs. evaluation
- Different PWV data sets (GEWEX water vapour assessment; GVAP) show largest relative standard deviations in the Arctic
- Humidity inversions: important for cloud-rad. processes but difficult to capture

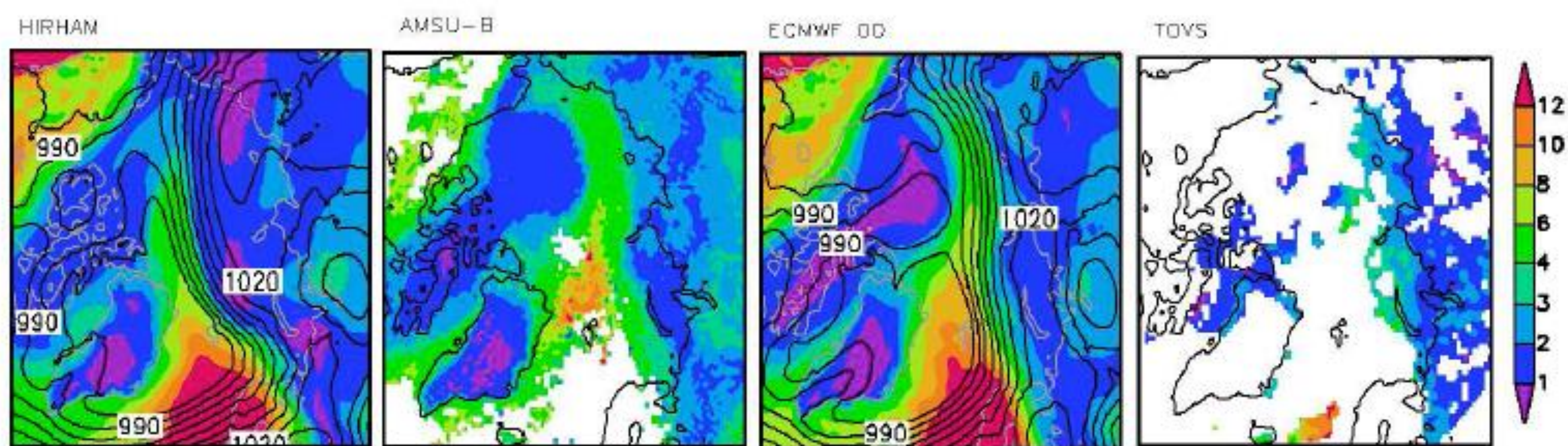
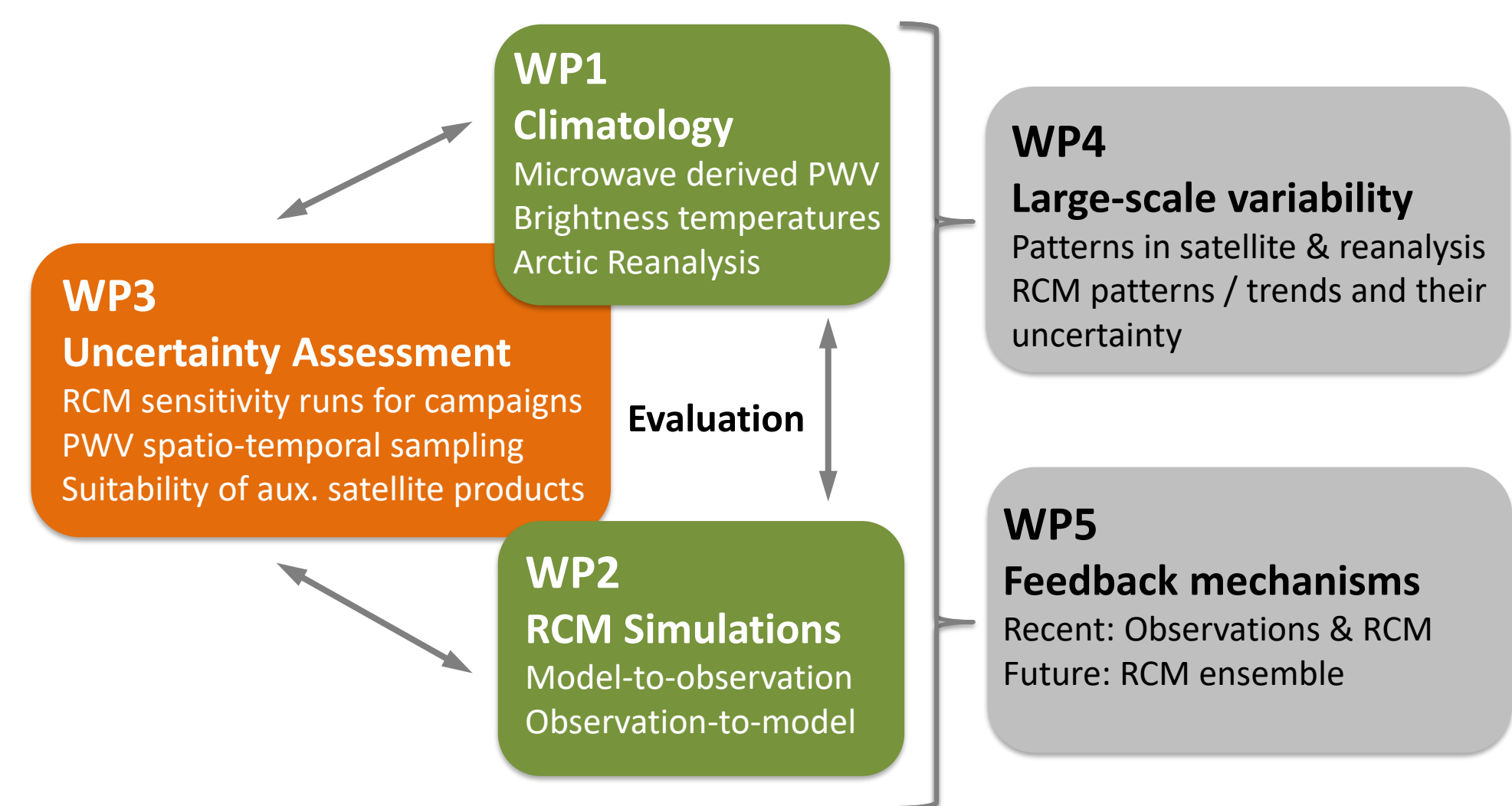


Fig. 2: Example of daily patterns of PWV (mm) for 7 Jan 2002. The daily sea level pressure (hPa) patterns from HIRHAM and ECMWF are included as isolines (from Rinke et al., 2009).

Opportunities

- Comprehensive high frequency microwave (>150 GHz) satellite observations suitable for all weather, low PWV conditions, are available for nearly two decades
- Availability of new high resolution (15 km) Arctic system reanalysis (ASR) and multi-model ensemble of high-resolution Arctic RCM simulations
- Improved techniques for model evaluation and feedback attribution

3 Research plan



WP1 & 2: Data compilation

- Merged microwave (MW) satellite PWV climatology over ocean and land (UNI-B)
- RCM simulations with and without ocean coupling (AWI-P)
- Multi-frequency synthetic MW brightness temperatures (BT) from RCM and CM-SAF intercalibrated measurements (UNI-K)

WP3: Uncertainty assessment – focus on water vapour variability

- High resolution nudged RCM runs for (AC)³ intensive observation periods and sensitivity studies (horizontal & vertical resolution, boundary layer & cloud parameterizations, longwave downward radiation)
- Evaluate RCM, satellites and reanalysis with time series from atmospheric observatories, airborne and ship measurements and assess uncertainty
- Test information content with respect to WV vertical structure in BT space and explore potential of auxiliary data sets, e.g. IASI, GOME

WP4: Large-scale spatio-temporal variability of water vapour

- Monthly and seasonal regional PWV patterns and their interannual variability & trends
- Use WP1 & 2 climatologies and ATOVS climatology from CM-SAF to quantify uncertainty of WV patterns
- Characterize model PWV biases, influence of atm. stability, circulation, cyclone activity (Figs. 2, 3)

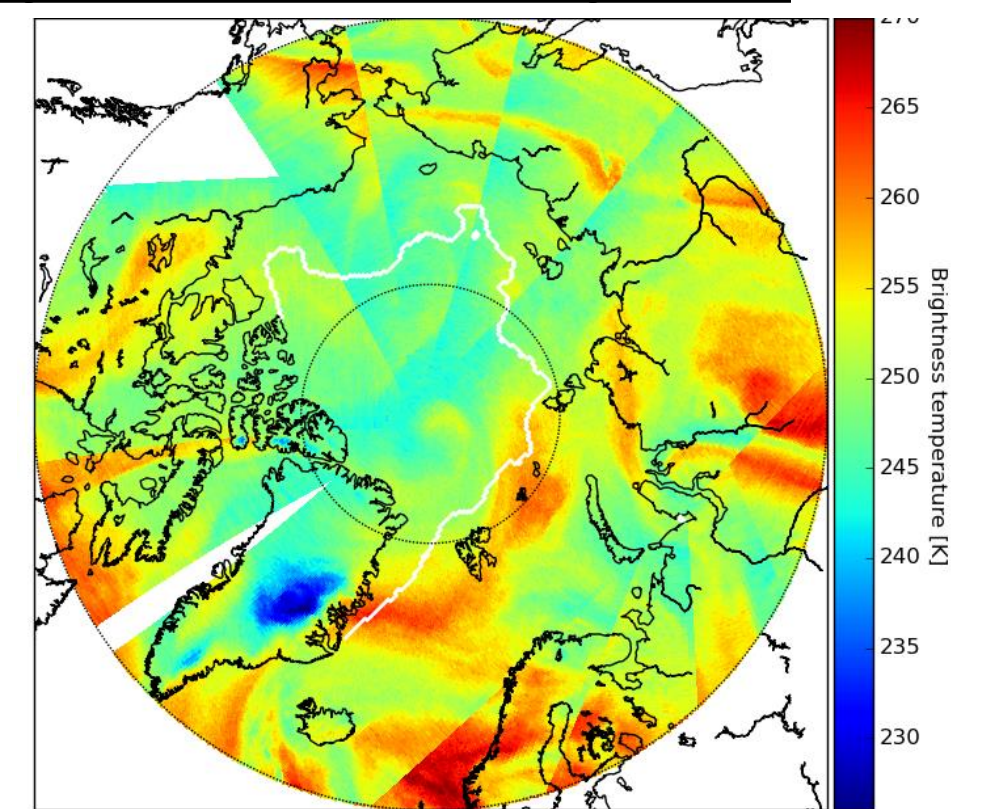
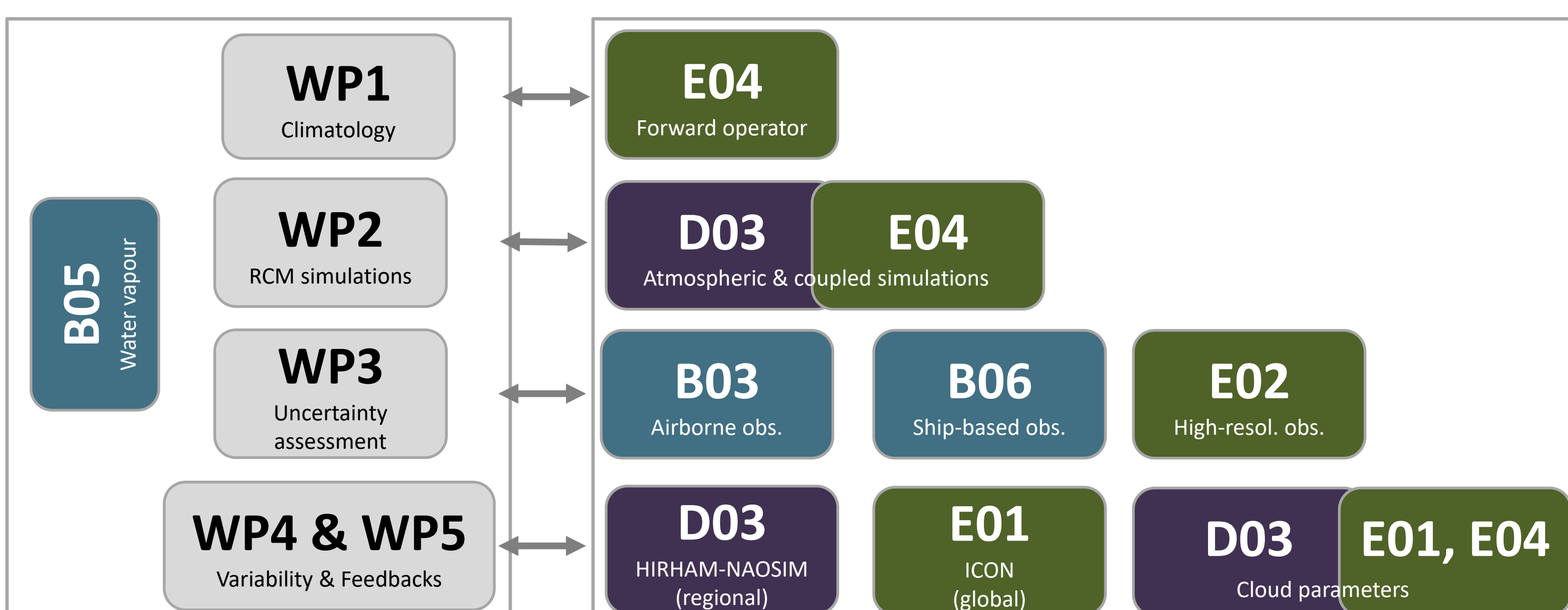


Fig. 3: BT at 183±3 GHz from various satellites during 0-6 UTC on 30 Sep 2011.

WP5: Related feedback processes

- PWV-LWD relationship & impact of vertical WV structure
- Identify spatial variability & strength of PWV-LWD relation
- Fingerprints due to interactive coupling with sea ice-ocean
- Potential impacts by clouds & changes in cyclone activity

4 Role within (AC)³ & perspectives



Collaboration within (AC)³

- Regional climate simulations, derivation of synthetic satellite observations, and feedback assessment (D03, E01, E04)
- Evaluation of high-resolution WV products at super sites (B03, B06, E02)

Perspectives

- Extend satellite time series to longer time spans (2002+) and enhanced products; use HALO and MOSAiC; assess vertical resolution
- Investigate interplay between the different WV-related feedback processes in particular with respect to clouds potentially using higher resolution non-hydrostatic RCM with interactive aerosol