Brightness temperatures from passive microwave satellites as a proxy for spatiotemporal trends of water vapour in the Arctic

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Water in the vapour phase is the most important component of the hydrological cycle. In the light of global climate change, it is of great importance to identify trends of water vapour amounts in the atmosphere and its variability. Climate change in terms of the near-surface temperature is most pronounced in the Arctic, known as Arctic Amplification. Since most of the Arctic are either open ocean or sea-ice covered surfaces, only sparse ground-based observations, mostly confined to land area are available. Therefore, one must resort to usage of the satellite based observations which offer a great advantage by their large spatial coverage. For water vapour assessment, passive microwave satellites are well suited due to their ability to sense water vapour under clear and cloudy sky conditions independent of sun light.

Although, a number of products of integrated water vapour (IWV) from various satellites are available, these are often inconsistent and prone to have biases due to various assumptions and uncertainties of a priori data included in the retrieval algorithms. According to the Clausius-Clapeyron relation, water vapour is constrained by the saturation vapour pressure which is constrained only by the temperature. Therefore, this study investigates the hypothesis that brightness temperatures (Tbs) from space borne passive microwave instruments can be used as a proxy for water vapour trends.

To test the mentioned hypothesis, satellites based Tbs are compared to synthetic Tbs derived from the Arctic System Reanalysis (ASR). To enable the comparison, the ASR has been evaluated in Tb space by employing the forward operator Passive and Active Microwave TRAnsfer model (PAMTRA) (*Mech et al., 2020*). Moreover, Tbs from sounding channels were correlated with corresponding IWV based on the weighted absolute humidity profiles peaks. The hypothesis is tested for January and May.

The results show that Tbs from frequency channels which are dominated by the signal from the lower troposphere can explain trends in the corresponding IWV columns derived from ASR for regions with significant positive trends for both, Tb and IWV since high correlation coefficient, reaching 0.98, has been found. For May, however, frequency channel dominated by the signal from the upper troposphere lower stratosphere (UTLS), shows weaker and negative correlation between Tbs and IWV. This is consistent with theoretical calculations and observational studies which report a cooling in the UTLS region for increasing IWV. However, Tbs from the corresponding channel seem less reliable in explaining trends of the corresponding IWV derived from the ASR. This indicates the importance of other processes relevant in the UTLS region during spring.

References:

[1] Mech et al., 2020: PAMTRA 1.0: A Passive and Active Microwave radiative TRAnsfer tool for simulating radiometer and radar measurements of the cloudy atmosphere.