Benefit of combining low and high frequency microwave radiometer measurements for Arctic water vapour

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In our research project within the Collaborative Research Centre on Arctic Amplification: Climate Relevant Atmospheric and Surface Processes and Feedback Mechanisms $(AC)^3$, we focus on the influence of water vapour on Arctic Amplification. During the MOSAiC expedition, the low–frequency standard Humidity and Temperature Profiler (HATPRO) and the high-frequency Microwave Radiometer for Arctic Clouds (MiRAC-P) were deployed to measure radiation from atmospheric gases and liquid water. From these observations, given as brightness temperatures, we retrieved a time series with one second resolution of integrated water vapour (IWV) and liquid water path (LWP) for the entire MOSAiC expedition. Additionally, HATPRO observations were used to derive coarse temperature and humidity profiles.

The single–instrument retrievals of IWV revealed a potential for a synergy of HATPRO and MiRAC-P. Compared to radiosondes, HATPRO showed a root mean squared difference of $0.40\,\mathrm{kg\,m^{-2}}$, while MiRAC-P performed even better with merely $0.15\,\mathrm{kg\,m^{-2}}$ for dry conditions with IWV less than $5\,\mathrm{kg\,m^{-2}}$ (Walbröl et al., 2022). During moist conditions, IWV greater than $10\,\mathrm{kg\,m^{-2}}$, the performance is inverted with lower root mean squared differences for HATPRO than for MiRAC-P. The comparison of IWV from satellites with our products will be presented during the conference.

We also aim to improve the vertical resolution of the humidity profiles by including MiRAC-P's additional water vapour sensitive channels. In this study, we present the concept and first results of a new neural network retrieval trained with ERA5 data, which has been forward simulated with the Passive and Active Microwave Radiative Transfer Tool (PAMTRA, Mech et al., 2020) to obtain the corresponding brightness temperatures. We analyze the information benefit of the synergetic over the single–instrument retrieval based on optimal estimation ideas. First tests are performed on a synthetic test data set, also consisting of ERA5 data and respective PAMTRA simulations.

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References

- Walbröl, A., Crewell, S., Engelmann, R. et al., 2022: Atmospheric temperature, water vapour and liquid water path from two microwave radiometers during MOSAiC. *Sci Data* **9**, 534, https://doi.org/10.1038/s41597-022-01504-1.
- Mech, M., Maahn, M., Kneifel, S. et al., 2020: PAMTRA 1.0: the Passive and Active Microwave radiative TRAnsfer tool for simulating radiometer and radar measurements of the cloudy atmosphere. *Geosci Model Dev* **13**, 4229–4251, https://doi.org/10.5194/gmd-13-4229-2020.