Passive and active microwave forward simulations for Arctic applications

The German DFG project - TRR 172, "ArctiC Amplification: Climate Relevant Atmospheric and SurfaCe Processes, and Feedback Mechanisms $(AC)^3$"[1] is investigating the process and feedback mechanisms related to Arctic amplification by model studies and observations. Within the framework of $(AC)^3$, several airborne campaigns over the Arctic ocean have been carried out with the research aircraft Polar5 and Polar6 operated by Alfred-Wegener-Institute for Polar and Marine research (AWI) focusing on the observation of Arctic mixed-phase clouds and boundary layer (ACLOUD, AFLUX, and MOSAiC-ACA)[2]. In March/April 2022, HALO-$(AC)^3$ has been added to the series of airborne campaigns, where the polar aircraft have been operated out of Svalbard and the High Altitude and LOng research aircraft (HALO) used Kiruna (Sweden) as base. By HALO-$(AC)^3$, and thereby including HALO, the focus has been extended to include large scale atmospheric processes in the Arctic atmosphere by investigating cold air outbreaks (CAO) and warm air intrusions (WAI) with a more small scale view by the polar research aircraft West of Svalbard. Polar 5 and HALO have been equipped with remote sensing instrumentation and dropsondes, whereas Polar 6 has been set up as in-situ platform. With in total 350 flight hours and a large amount of in-situ and remote sensing data, the campaign has been very successful in sampling the Arctic atmosphere.

Several research interests and topics are related to the airborne observations and the data collected therein. Many of the projects make use of retrieval algorithms that relate measured (brightness temperature or radar reflectivities) to physical quantities (water vapour, hydrometeor content, or temperature and humidity profiles). These retrieval algorithms need to be developed and tested, requiring a large and realistic database of (modeled) atmospheric quantities and forward simulated measurements. Once the retrieval has been developed and tested, it can be applied to the measurement and the derived physical quantities can be used for process understanding or evaluation of atmospheric models. The counterpart of this so called obs-to-model approach where observations are transformed into model variables, is model-to-obs. Thereby, atmospheric profiles are used to forward simulate artificial measurements, meaning the atmospheric model is brought in the observational space. The second approach requires less assumptions and is therefore often the preferred method when performing atmospheric model evaluations. In addition to model evaluation, the creation of artificial observations by forward models is a valuable tool in developing future instruments and estimating their performance in the virtual world.

Within the proposed project, the backbone for the described research topics will be set. This backbone is a database formed out of forward simulated measurements with a state-of-the-art forward simulator and the corresponding atmospheric profiles. The simulations have to be performed on a set of atmospheric profiles as large as possible in space and time for a set of up to 100 frequencies for passive simulations and up to 10 for the active part. To accomplish this in terms of computation time expensive task, the

[1] https://www.ac3-tr.de/

[2] https://igmk.github.io/how_to_ac3airborne/

passive and active microwave transfer model (PAMTRA) will be applied, that is able to perform simulations for passive and active applications throughout the microwave frequency range for atmospheres with hydrometeors. As atmospheric input, the ERA5 reanalyses for the full period as well simulations with the ICON-LEM performed for the specific campaign periods will be used.