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The Arctic Ocean Observation Operator for 6.9 GHz (ARC3O)

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The diversity in sea-ice concentration observational estimates retrieved from brightness temperatures measured from space is a challenge for our understanding of past and future sea-ice evolution as it inhibits reliable climate model evaluation and initialisation. To address this challenge, we introduce a new tool: the Arctic Ocean Observation Operator (ARC3O).

ARC3O allows us to simulate brightness temperatures at 6.9 GHz at vertical polarisation from standard output of an Earth System Model to be compared to observations from space at this frequency. We use simple temperature and salinity profiles inside the snow and ice column based on the output of the Earth System Model to compute these brightness temperatures.

In this study, we evaluate ARC3O by simulating brightness temperatures based on three assimilation runs of the MPI Earth System Model (MPI-ESM) assimilated with three different sea-ice concentration products. We then compare these three sets of simulated brightness temperatures to brightness temperatures measured by the Advanced Microwave Scanning Radiometer Earth Observing System (AMSR-E) from space. We find that they differ up to 10 K in the period between October and June, depending on the region and the assimilation run. However, we show that these discrepancies between simulated and observed brightness temperature can be mainly attributed to the underlying observational uncertainty in sea-ice concentration and, to a lesser extent, to the data assimilation process, rather than to biases in ARC3O itself. In summer, the discrepancies between simulated and observed brightness temperatures are larger than in winter and locally reach up to 20 K. This is caused by the very large observational uncertainty in summer sea-ice concentration but also by the melt-pond parametrisation in MPI-ESM, which is not necessarily realistic.

ARC3O is therefore capable to realistically translate the simulated Arctic Ocean climate state into one observable quantity for a more comprehensive climate model evaluation and initialisation, an exciting perspective for further developing this and similar methods.