Instrument synergy for Arctic monitoring

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Research on improving the prediction skill of climate models requires refining the quality of observational data used for initializing and tuning the models. This is especially true in the Polar Regions where uncertainties about the interactions between sea ice, ocean and atmosphere are driving ongoing monitoring efforts. A special characteristic of the Arctic sea ice covered regions at microwave frequencies is the high emissivity of sea ice, with and without snow, which contribute more to the microwave signal observed by satellites than the often dry atmosphere.

To assess the potential impact of the future Copernicus Imaging Microwave Radiometer (CIMR) for sea ice parameter retrieval a surrogate instrumental configuration was constructed by combining observations from AMSR2 and SMOS satellite radiometers, which together cover all CIMR channel frequencies.

A series of tests are carried out over a data set of validated sea ice concentration values for determining the channel combination that offers the best retrieval accuracy and product resolution. To ensure consistency all retrievals are performed with an optimal estimation method (OEM) which can output seven geophysical parameters (sea ice concentration, multi-year ice fraction, air temperature over sea ice, integrated water vapor, liquid water path, over ocean wind speed and sea surface temperature) from any combination of input passive microwave channels.

Individual radiometer channels or channel combinations can be used as input for the optimal estimation retrieval which allows for flexibility in selecting frequency specific parameter sensitivities. While sea ice concentration is the most relevant parameter for the future CIMR instrument, an information content study expands the analysis to all OEM retrievable surface and atmospheric parameters. This study quantifies the parameter contributions to the observed signal and highlights the difference in retrieval performance between different input channel combinations. A composite input based on the 18.7 and 36.5~GHz channels can provide increased accuracy for OEM sea ice concentration retrieval while also maintaining sensitivity for atmospheric water vapor retrieval.

As the future CIMR instrument will include two 1.4 GHz channels, the OEM forward model is extended to also include this frequency. Using a dataset of collocated SMOS and AMSR2 measurements, the dependence of brightness temperatures on sea ice thickness is parameterized for all channels between 1.4 and 36.5 GHz. This allows sea ice thickness to be added as an eighth retrieval parameter when input from both instruments is used. The resulting OEM sea ice thickness retrieval shows good agreement with existing operational products.

While these tests are meant to predict the future performance of CIMR, they also provide insight into the potential of combining existing measurements for creating a new retrieval product. Using collocated AMSR2 or AMSR-E and SMOS observations as input for the OEM would allow for retrieving eight Arctic surface and atmospheric parameters with one physically consistent method.