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| Meeting Date | 22. & 23.05.2017 |  | Ref |  |
| Meeting Place | ISSI, Bern |  | Chairman |  |
| Minute’s Date | 42884.92 |  | Participants | Nina Maaß, Lars Kaleschke, Melody Sandells, Rasmus Tonboe, Giovanni Macelloni, Julienne Stroeve, Nander Wever, Carolina Gabarro, Mike Schwank, Christian Mätzler, Steffen Tietsche, Nicolas Champollion, Ghislain Picard, Marion Leduc-Leballeur, Susanne Mecklenburg, Matthias Drusch, Laurent Bertino (via webex), Ludovic Brucker (via webex) |
| Subject | Virtual Sea Ice Mission WG |  | Copy |  |

| **Description** | **Action** | **Due Date** |
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| Draft MOSAIC Campaign Plan (Science Objectives and Instrumentation) | L. Kaleschke | 23 June |
| Set up a doodle defining date of the next meeting in the December to February period | M. Drusch | 23 June |

| **Recommendation** |
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| The WG recommends to extent SMRT with a sea ice module. |

S. Mecklenburg and M. Drusch welcomed the participants to the second meeting of the Working Group.

**1. Working Group Objectives**

Since a number of new participants joined the group the objectives of the WG were outlined:

* In order to retrieve sea ice parameters or to assimilate brightness temperatures directly, it is necessary to establish a microwave emissivity model linking the various geophysical quantities with the measurements. So far, a range of models has been introduced but concepts are diverse and each one has been used for a different purpose.
* The objective of the ISSI WG is to provide an overview of the existing models and define a strategy towards a community sea-ice emission model that can facilitate an improved and consistent exploitation of existing capabilities and support the definition of future EO missions.
* A second objective is to outline a model verification strategy including laboratory measurements and campaigns.

**2. Outcome of the 1st Meeting**

The existing models were presented and discussed to deepen the understanding of their individual characteristics and limitations. The requirements for a unified emissivity model will be defined, focussing on sea ice parameter retrievals and the use as observational operator for predictive models. In addition, needs and requirements for emissivity model verification and data future data assimilation applications will be established.

The outcome of the first meeting was summarised:

1. It was agreed that – as an overarching goal for the Working Group – a community sea-ice emission model would be defined and as part of this a better understanding of the measured signal at low frequency microwave frequencies over sea ice, in particular L-Band, should be established.
2. Complementing the development of the sea ice model, the outcome of the working group’s work shall include:
   * A strategy for a common validation of the community sea-ice model and input going into this model;
   * A dedicated campaign plan for model and parameter validation
   * A coherent sea ice parameter retrieval algorithm development
   * A consistent integration of auxiliary data sets
3. It was decided to make use of existing capabilities. The SMRT model, currently developed by a consortium led by the University of Grenoble under contract from ESA, was defined as a suitable starting point.
4. An opportunity for in-situ measurements is the MOSAIC campaign, which will take place 01.10.2019 – 31.10.2020, organized by AWI.

**3. Objectives for the 2nd Meeting**

For the second meeting of the WG the following objectives were defined:

1. Define the work on the SMRT extension including a sea ice layer.
2. Provide first inputs on MOSAIC campaign objectives and instrumentation relevant for emissivity model evaluation.

**4. Findings for SMRT model extension**

As follow-up action from the first meeting, N. Maaß presented a comparison of sea ice permittivity measurements and models and L. Brucker showed an overview of three dielectric mixing models describing snow on sea ice.

Dielectric properties for sea ice were found to be very sensitive to changes in size, shape and distribution of brine inclusions. For the radiative transfer simulations scattering could be neglected for frequencies below 24 GHz (for first year ice) and 1.5 GHz (for multi-year ice). The models provided reasonable results when compared against measurements. For the dielectric mixing models describing snow on ice the choice of the parameterization resulted in differences of 2 – 9 cm difference in snow depth.

R. Tonboe complemented the two presentations by showing snow depth retrievals obtained from (simple) empirical models and (more complex) physical models.

M. Sandells presented SMRT. The background for this ESA led study has been the consolidation of the science for the next dedicated snow mission following CoReH2O activities. In SMRT, sea ice can be integrated technically by adding an additional layer. The parameterization of sea ice permittivity, including the treatment of brine and bubbles for scattering may pose challenges. Currently, the auxiliary snow data forcing SMRT are being generated with CROCUS.

N. Wever gave on overview of the latest developments on the SNOWPACK model, which was originally developed for alpine snowpack to support avalanche-warning systems. SNOWPACK is a 1-dimensional, multi-layer, detailed physics based snow cover model that has been recently extended with a sea ice module. The revised SNOWPACK version could be used in the future to generate a consistent sea ice and snowpack data set to drive SMRT.

**The WG recommends to extent SMRT with a sea ice module.** The work that could be covered through a Contract Change Note to the existing snow contract shall comprise:

* A technical task to implement two additional layers representing sea ice and ocean in SMRT. The first set of parameterizations used to describe these layers shall allow the validation of the software and shall enable the community to perform sensitivity studies under varying sea ice parameters.
* A task on defining and validating the sea ice module prior and after the integration in SMRT, respectively. The frequency range shall eventually comprise 0.5 GHz to 100 GHz.
* A task on generating auxiliary data sets for the coupled sea ice and snow system that can be used to drive the revised version of the SMRT model.

**5. Findings for MOSAIC campaign element**

L. Kaleschke presented an update on the MOSAIC campaign. The campaign will start in fall 2019 and end in fall 2020. German funding for RV ‘Polarstern’ was confirmed and a first campaign implementation plan will be consolidated during the next meeting 14 - 16 November 2017 in St Petersburg. A campaign element supporting radiative transfer model developments, validation, and subsequent parameter retrievals could comprise the operation of one or more radiometers on board RV ‘Polarstern’ complementing collocated in-situ measurements of sea ice properties.

M. Schwank and C. Gabarro presented two types of radiometers and applications in field experiments. M. Schwank demonstrated the use of the ELBARA system in the Swiss Alpine Snow and Climate Observation Site providing a set of recommendations relevant for continuous operations under harsh environmental conditions. For use on-board RV ‘Polarstern’ the ELBARA system would have to be mounted allowing vertical scans. M. Gabarro showed the newly developed radiometers from Balamis. These radiometers feature a flat antenna array and have been operated from small vehicles including drones. It was questioned whether this type of instrument could be operated from the deck of the vessel. However, for the MOSAIC campaign it could complement the ELBARA system performing measurements from a sledge.

The overarching science objectives for a MOSAIC campaign element could be to quantify the impact of salinity and other snow / sea ice parameter on brightness temperatures (across the spectral domain). In more detail, three objectives can be formulated:

1. Measure the brightness temperature signal from multiple frequencies for snow covered ice across a long period of time under varying environmental conditions;
2. Characterize the spatial variability of L-band temperatures by combining measurements from two radiometers (and compare against satellite measurements);
3. Validate the SMRT model across frequencies and active / passive including snow and ice microstructures using collocated measurements from remote sensing and in-situ.

An action was given to L. Kalescke to prepare a three page summary on science objectives and high level requirements (including traceability between objectives and requirements) to further stimulate the discussion between the MOSAIC Team, National funding Agencies, and ESA. One particular point for discussion is the selection of frequencies.

**5. Complementing presentations**

G. Macelloni presented results from the CryoRad project (funded by ASI) focussing on the development of a space mission concept for a multi-channel microwave radiometer observing in the range of 500 MHz to 2 GHz. First results from the UWBRAD project with an airborne demonstrator over Antarctica indicate that the information obtained cannot be achieved from any other system that is currently in space. For sea ice, the brightness temperature measurements are highly sensitive to thickness, temperature, and salinity. It was recommended to extend the frequency range of the emissivity model to 0.5 GHz. In addition, the opportunity to include 0.5 GHz measurements in the MOSAIC campaign element shall be exploited.

J. Stroeve covered altimeter measurements in her presentation. Snow and ice thickness retrievals were based on collocated CryoSat2 and AltiKa measurements during the Observation Ice Bridge campaign in 2013 and 2014. One of the major uncertainties in the retrievals is the temporal evolution of the penetration factors for Ka and Ku band. It would be ideal to have a system where the snowpack evolution can be modeled with an accurate description of snow grain size. Using these results radiative transfer simulations could yield the radar penetration depths and radar backscatter as a function of time (i.e. capture the seasonal evolution). It was recommended to extend the SNRT modules so that active and passive microwave radiation can be simulated.

Two presentations focused on the assimilation of sea ice observations into operational forecasting models. L. Bertino summarized the findings at NERSC where the merged SMOS / CryoSat2 data product is assimilated together with measurements from other observation systems. It was found that the ice thickness observations had a positive impact, especially at the Marginal Ice Zone. Operational implementation is foreseen for October 2017. At ECMWF, sea ice concentration has been assimilated using 3D-VAR FGAT. SMOS data are being used operationally for quality control and consistency checks. It was pointed out that an observation operator would be needed in the future for the assimilation of passive microwave measurements. Based on the SMRT developments and findings a robust and fast tool for data assimilation applications could be developed.