Workshop on “Improved satellite retrievals of sea-ice concentration and sea-ice thickness for climate applications”

October 9-11, 2017
University of Hamburg, Hamburg, Germany

Group picture

Workshop Sponsors:

CliSAP
WRCP-CliC
ESA Climate Change Initiative

Executive Summary

The "Workshop on improved satellite retrievals of sea-ice concentration and sea-ice thickness for climate applications" was held in Hamburg, Germany, from 9 to 11 October 2017.

The main purpose of this workshop was to bring together scientists from the sea-ice remote sensing community with scientists from the sea-ice modelling community to examine how observations and models can best be combined to understand the evolution of sea-ice concentration and thickness. The workshop was designed as a discussion forum with a few keynote presentations to set the scene for discussion. We also had two long poster sessions that allowed for additional in-depth discussion of the workshop themes.

It became obvious throughout the workshop that neither satellite observations nor large-scale model activities can ever describe the "true" sea-ice concentration or sea-ice thickness. Nevertheless, both sources of information can provide useful information on this true state. We also found that in comparing models and observations, it might be useful to examine in both communities which observable bears the best compromise of observational uncertainty and availability from model simulations. For sea-ice thickness, for example, it might be more useful to evaluate modeled sea-ice freeboard rather than satellite derived sea-ice thickness, as the latter can only be estimated with much larger uncertainty.

The workshop with its about 80 participants was sponsored by CliSAP [http://www.clisap.de], the ESA Climate Change Initiative [http://esa-cci.nersc.no/] and CliC, partially through its "Sea ice and climate modeling forum" [http://www.climate-cryosphere.org/activities/groups/seaicemodeling].

Background

The growing fleet of satellite sensors allows us to retrieve more and more geophysical parameters that help us to understand the Earth’s Climate System. Two of these parameters are sea-ice concentration and sea-ice thickness. Even though sea-ice concentration data sets have been available for more than three decades there is still a debate about its seasonally varying accuracy and retrieval limitations. Sea-ice thickness products are still sparse and often too short in time to be useful for climate applications. The lack of proper evaluation data as well as challenges in the sea-ice thickness retrieval make this parameter even more prone to yet unquantified uncertainty sources and biases than sea-ice concentration.
One of the main user groups of such data sets is the climate modeling community. The available satellite data is used both for model initialization in seasonal or decadal

forecast studies and for the evaluation of long-term climate simulations. For both purposes, a good understanding of the terminology used in both communities is necessary to not misinterpret results and/or requirements.
The main rationale of the workshop was to establish a better understanding between the sea-ice modeling and the sea-ice remote sensing communities regarding their use, interpretation and analysis of the two climate-relevant parameters sea-ice concentration and sea-ice thickness.

The workshop was jointly organized by the University of Hamburg, Integrated Climate Data Center, and the Max-Planck Institute for Meteorology, Hamburg. Both Institutions have been cooperating closely within the ESA Climate Change Initiative (CCI) sea ice ECV project on satellite-data evaluation and assimilation.

Objectives

The overarching aim of the workshop was to provide a discussion forum between the observational and the modeling community with focus on sea-ice concentration and sea-ice thickness.

Three cardinal questions were formulated, acting as the red threat that we followed throughout the workshop:

1) What do we mean with the term uncertainty?
2) What is the relationship between reality and a validated observational product?
3) How can we best combine model and measurement to understand reality?

The main objective behind these questions was not necessarily to obtain answers during the workshop but to start a thought process that would last well beyond the duration of the workshop.

Description/Details

The workshop began on time every day. Organization of presentations and discussions was kept flexible to allow for sufficient breaks in between. The workshop was opened by introducing the three cardinal questions upfront to give the audience a red threat to follow during the three days.

The first half day was dedicated to presentations which gave an overview about the current state-of-the-art in the respective fields. Presenters were specifically asked to lay out their presentations for the “other community”, so that the observational community takes home a better understanding of what the modeling community does (any why) and vice versa. Three key messages could be taken from these three introduction presentations:

1) The observational community is far closer to the modeling community than thought because many parts of the retrieval of sea-ice parameters involve application of models to convert a satellite measurement into a geophysical parameter like sea-ice concentration or thickness.

2) A single model result, e.g. a single sea-ice extent time series is not sufficient to describe or assess a geophysical process. Internal variability that is inherent to the Earth's climate system and to any reasonable climate model describing the Earth's climate usually yields a suite of sometimes substantially different solutions. Hence, ensemble simulations are necessary to span the full range of possible climate states permitted by a given forcing. This has to be taken into account when evaluating a model with observational data or when performing assimilation experiments.
3) Satellite observations are not the truth. Neither sea-ice concentration nor sea-ice thickness is directly measured by a satellite. For conversion of the respective satellite measurement in one of these parameters certain assumptions have to be made. Naturally, the quality of the retrieved product has limitations which may change over space and time and which need to be clearly understood and communicated. Provision of retrieval uncertainties should be considered as a mandatory thing to do, but these do typically not reflect the retrieval limitations.

The workshop went on with the first of two poster session where ~ 20 posters were on display. A lively discussion went on in front of the posters for about 1.5 to 2 hours. The posters stayed on display until lunch-time of the 2nd day of the workshop.

The 2nd day of the workshop could be considered as "the science day". Very detailed and interesting presentations were given throughout the day. Every keynote triggered a lively, deep and broad discussion in the auditorium. The keynotes given on the 2nd day fostered a deeper understanding of the differences between both communities when using terms such as uncertainty, accuracy, evaluation, error, etc. The keynotes and discussions also led to a better understanding of the limitations by both satellite observations and climate models in representing the truth. These discussions were continued during the second poster sessions with poster being displayed from 2nd day lunchtime to 3rd day coffee break. Posters covered a wide mixture of different novel retrieval methods to obtain sea-ice concentration or sea-ice thickness from well-known and new satellite sensors as well as results from evaluation studies.

On the 3rd day of the workshop we tried to summarize the main outcomes of the discussion on the previous days. However, before doing so, we first learned in an impressive way how difficult it is to obtain a representative picture of sea ice given its often immense horizontal and vertical heterogeneity. Together with the keynotes of the other two days this presentation again stressed the point that neither large-scale satellite observations nor large-scale climate model simulations will ever be able to present a detailed, true picture of reality. The question then only remains if both sources of information can at least provide a useful approximation to reality.

It is time to re-think strategies of how the observational and the modelling community could work together – which is one of the main outcomes of the workshop. Instead of each community developing their own product and subsequently being in danger to compare apples and oranges when evaluating their products, it might make sense to understand where the benefits and limitations in each community are and combine the

best out of it. And if this is not possible then communication between both communities should at least go into the direction that one community, e.g. the observational community, produces tailored products for the other community, e.g. the modelling community, in order to optimize usage of these products. One example of such products clearly would be sea-ice freeboard. The conversion of observed sea-ice freeboard into observed sea-ice thickness includes several error sources, actually so many error sources that a user might go better with just the sea-ice freeboard and apply its own data or estimates (e.g. from a numerical model) to obtain sea-ice thickness. While this is a straightforward thing to do it has one caveat. It is possibly more difficult to evaluate the sea-ice freeboard obtained from satellite observations with independent observations than it is to evaluate the sea-ice thickness.

Repeatedly the role of using ensembles of numerical model results to better represent the variability inherent in the climate system was discussed as a mandatory step to not being trapped in a wrong interpretation of inter-comparison results involving observational data sets. In this context the discussion came up whether it wouldn't make sense to treat estimates of the same sea-ice parameter, e.g. the sea-ice area fraction, obtained with different algorithms applied to the same satellite data set in the same way, i.e. also use an ensemble of observational data. This was discussed controversially but the tentative conclusion to that discussion was that algorithms that have been selected within the GCOS-requirements driven EUMETSAT OSISAF – ESA-CCI activities were selected for good reason, for instance minimum sensitivity to atmospheric influence. Therefore our feeling is that using ensembles of results from numerical models is mandatory while using ensembles of results from observations is possibly misleading.

Almost in every keynote and within almost every discussion the impact of varying snow properties on both retrieval and evaluation of observational products was mentioned as particularly problematic and as particularly difficult to assess and mitigate. Snow is not only among the largest error sources for sea-ice thickness retrieval but also for sea-ice concentration retrieval, which has been in place now for > 35 years. During winter spatiotemporal variation of snow properties – together with sea-ice type signature variations – inhibit a desired sea-ice concentration accuracy and precision of < 1%. During summer, the melt-induced variations in snow and sea-ice properties and formation of melt ponds render the sea-ice concentration accuracy and precision as basically being unknown. In addition to that, both communities might need to re-think the definition of what sea-ice concentration really is: surface sea-ice area fraction with the supplement "surface" underlining that sea-ice concentration retrieval over any water surface (lead or melt ponds) should give 0% surface sea-ice area fraction.

Outcomes / Products

- Enhanced understanding of possibilities and limitations on both the observational and the modelling side for both communities with a clear need to continue open-minded discussions as was allowed during this workshop.

- Recommendation about where to find appropriate information about terminology describing results and products from the evaluation of satellite-based Earth observation data (Loew, A. , et al., Rev. in Geophysics, doi:10.1002/2017RG000562)
- The term “validation” should be replaced by the term “evaluation”.
- There is definitely the need for more discussion about this topic.
- Compilation of keynote and poster presentations
- See recommendations (below)

Recommendations

- See outcomes / products (above)
- Observational products are already using some form of a geophysical model to translate satellite measurements to a geophysical variable. Satellite simulators were mentioned repeatedly - together with assimilation – and should be developed further.
- General feedback from the workshop participants was that this was an excellent forum to discuss issues in an open-minded way with enough time available both to go into details and to allow multiple opinions to be expressed and understood. Such workshops should therefore be repeated.
- Neither satellite observations nor large-scale model activities can ever describe the "true" sea-ice concentration or sea-ice thickness. Nevertheless, both sources of information can provide useful information on this true state. We also found that in comparing models and observations, it might be useful to examine in both communities which observable bears the best compromise of observational uncertainty and availability from model simulations. For sea-ice thickness, for example, it might be more useful to evaluate modeled sea-ice freeboard rather than satellite derived sea-ice thickness, as the latter can only be estimated with much larger uncertainty.

Participant List Table

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Pierre Rampal	NERSC, Bergen, Norway
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Xi Zhao	Chinese Antarctic Center of Surveying and Mapping, Wuhan University, China
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Zhijun Li	State Key Laboratory of Coastal & Offshore Engineering, Dalian Univ. of Technology, China

Final Agenda

Monday, October 9:

Session 1: Understanding each other

from 12:00	Arrival and Registration	
13:00	Welcome of participants, Outline of the workshop, introduction of the sessions	
13:30	Talks and Discussion	
	L. T. Pedersen + G. Spreen:	Keynote: An introduction to sea-ice remote sensing
	M. Vancoppennolle:	Keynote: An introduction to sea-ice modeling
	(coffee break in between)	
16:30 – open end	Posters and Discussion	

Tuesday, October 10

Session 2: Understanding and reducing errors

9:00	Talks and Discussion	
	C. Burgard	Modeling – Keynote on long term, global simulations
	A. Jahn	Modeling – Keynote on long-term projections
	W. Maslowski	Modeling – Keynote on regional predictions
	T. Lavergne	Remote sensing – Keynote on sea-ice concentration
	H. Skourup	Remote sensing – Keynote on sea-ice thickness
	(coffee break in between)	
12:00	Lunch break (provided)	

Session 3: Quantification of uncertainties and product evaluation

13:00	Talks and Discussions	
	W. Meier	Remote sensing – Keynote on sea-ice concentration
	P. Heil	Remote sensing – Keynote on sea-ice thickness
	S. Tietsche	Modeling – Keynote on global predictions
	E. Olason	Modeling – Keynote on short term, regional simulations
	(coffee break in between)	
16:00	Posters and Discussion	
19:00	No-host dinner	

Wednesday, October 11

Session 4: Harvesting the fruit: The scope of final products

9:00	Talks and Discussions	
	R. Tonboe	The remote sensing view
	F. Massonnet	The modeling view
	(coffee break in between)	
12:00-12:30	Workshop conclusions	
12:30	End of Workshop	