Sea Ice Climate Change Initiative: Phase 2

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1 Introduction

1.1 Purpose

A general user requirement study of sea ice data from satellites was presented in the *User Requirements Document* from Phase 1 (May 2012*).* The purpose of the Phase 2 *User Requirements Document* is to review and update the user requirements for sea ice ECV data sets with focus on user comments to the SIC and SIT data sets provided in Phase 1. The Phase 2 *User Requirements Document* is updated in July 2018 to include new requirements that have evolved in the last three years.

1.2 Scope

The scope of the work is to

(1) conduct on-line survey asking users of the sea ice ECV data sets from Phase 1 (SIC and SIT) how the data were used with focus on climate research activities. These include climate modelling, model development, model validation, model initialisation, boundary layer definition and data assimilation, and other sea ice monitoring and research activities.

(2) Investigate requirements for sea ice drift as a third ECV

(3) Obtain assessment of sea ice ECVs from the climate modelling community, represented by Dirk Notz from Max Planck Institute for Meterology

1.3 Document Status

This is a draft issue for the KO+36 milestone of phase 2 of the SICCI project.

1.4 Applicable Documents

The following table lists the Applicable Documents that have a direct impact on the contents of this document.

Acronym	Title	Reference	Issue
URD Phase 1	User Requirement Document	SICCI-URD-02-122 May 2012	

Table 1-1: Applicable Documents

1.5 Acronyms and Abbreviations

Acronym	Meaning
AMW	Active Microwave
APP	Alternative Polarization Mode Precision Image
ASAR	Advanced Synthetic Aperture Radar
CCI	Climate Change Initiative
CCSDS	Consultative Committee for Space Systems

Acronym	Meaning
CFI	Customer Furnished Item
DSWG	CCI Data Standard Working Group
ECV	Essential Climate Variable
ENVISAT	Environmental Satellite
ERS	European Remote Sensing Satellite
ESA	European Space Agency
ESOC	European Space Operations Centre
ECSS	European Cooperation for Space Standardization
FMI	Finnish MeteoroCGIl Institute
GCOS	Global Climate Observing System
GECA	Generic Environment for Calibration/Validation Analysis
GMES	Global Monitoring for Environment and Security
IEEE	Institute of Electrical and Electronics Engineers
INSPIRE	The Infrastructure for Spatial Information in Europe
MMFI	Multi-Mission Facility Infrastructure
MODIS	Moderate Resolution Imaging Spectroradiometer
MTG	Meteosat Third Generation
NSIDC	US National Snow and Ice Data Centre
OGC	Open Geospatial Consortium
OSI SAF	EUMETSAT Ocean and Sea Ice Satellite Application Facillity
PALSAR	Phased Array type L-band Synthetic Aperture Radar
PDGS	Payload Data Ground Segment
PMR	Passive Microwave Radiometer
PMW	Passive Microwave
RA	Radar Altimeter
RID	Review Item Discrepancy
SIC	Sea Ice Concentration
SIT	Sea Ice Thickness
SEWG	CCI System Engineering Working Group

Table 1-2: Acronyms

2 Summary of Phase 1 user requirement survey

The user requirement survey in Phase 1 was carried out with a broad scope, asking for general questions about relevant sea ice parameters derivable from satellite data. The requirement survey is summarized as follows:

- The requirement analysis was focussed on climate users and their need for sea ice concentration and sea ice thickness data in various activities such as sea ice model development, data assimilation and climate model evaluation. This is a follow-up of the more general user requirements for climate research defined by GCOS, WMO and other, where quantitative requirements for data coverage, measurement accuracy and long-term stability of the observing systems are addressed.

- The web-based user survey was conducted using an on-line questionnaire. A total of 91 respondents participated in the survey, where requirements in different application areas were identified. These comprised climate and sea ice modelling, validation of models, data assimilation, ice charting and forecasting, marine biology, fisheries and ecosystem research, marine transportation and offshore operations in ice-covered seas.

- Error characterisation for the sea ice ECVs is an important part of the study, and users were therefore asked about their requirements for three different error parameters: BIAS: defined as the offset of the mean satellite observations from the "true" values; PRECISION: defined as scatter of multiple measurements of a constant target, and STABILITY: defined as drift in observed mean value of a constant target over a decade. Many respondents replied that they did not have clear view on requirements on error characterization and therefore their replies were based on intuition. Some respondents replied that error characterization was "not relevant" or they had no idea how to respond to this question.

- The survey primarily addressed the requirements for data on sea ice concentration and sea ice thickness, which are the main constituents of the sea ice ECV. For ice concentration the majority of the respondents required daily sampling, 10-20 km spatial resolution and measurement precision better than 10 %. For ice thickness, the majority of the respondents required spatial resolution better than 50 km and measurement precision better than 20 cm. Temporal resolution of ice thickness data is envisaged to be about a month for satellite altimeter retrievals. The requirement for long-term stability is 2 % per decade for ice concentration and 5 cm per decade for ice thickness.

- Also requirements for other sea ice parameters such as ice drift, ice volume, snow cover, meltpond fraction, albedo, surface temperature, sea ice salinity and others were investigated. All these parameters were required by between 16 and 38 out of the 91 respondents. Most of the respondents required daily or weekly temporal sampling and spatial resolution of 20 km or better. The ongoing project will not provide data sets on these parameters, but recommendation is made to extend sea ice data sets with more parameters in future studies of sea ice data in climate research.

- The survey addressed some practical aspects of the sea ice data sets such as gridded versus swath-based data sets, map projection and formats. Users were also asked to choose between long-term stability of timeseries and higher accuracy of newer data for shorter timeseries, which is normally the case for satellite retrievals. The replies were distributed 50 – 50 % between the two choices. The results of the user survey will be used to define the sea ECV time series to be provided by the project.

3 User survey in Phase 2

The objective of the user survey in Phase 2 was to ask those users who had downloaded the SIC and SIT data sets produced in Phase 1 a set of specific questions about these data sets. About 90 users had registered for downloading one or more of the following data sets:

- Sea ice concentration based on passive microwave data from SSM/I (F10, F11, F13, F14, F15) (1992-2008) and AMSR-E (2002-2011), covering both Arctic and Antarctic. The ice concentration data are presented in a 25 km grid with uncertainty estimate and quality control flags for each grid cell. The ice concentration products are developed in collaboration with Eumetsat OSI SAF.

- Sea ice thickness and freeboard in the Arctic based on radar altimeter data from Envisat RA-2 for the winter months (2002-2012)

The data were downloaded from http://icdc.zmaw.de/projekte/esa-cci-sea-ice-ecv0.html

4 Assessment of Sea Ice Concentration

4.1 Response to the survey in Phase 2

Of the 29 respondent 24 answered questions about ice concentration and 17 said that they had downloaded the data and 7 had not. The data have been used for the following purposes:

1) comparison with output from climate models and OGCMs

2) comparison with other established data sets, including use as a reference data set for SIC

3) algorithm studies where comparison with other existing algorithms can be done.

4) Test atmospheric correction in ice concentration algorithms

5) Research on sea ice transfer function for passive microwave data

6) Research on sea ice - ocean model development, including model validation

7) Research on sea ice data assimilation, where the uncertainty estimates per grid cell are very relevant

8) To get uncertainty estimates for SIC (but only 2 users actually used it)

9) comparison with ice charting data as part of assimilation in re-analysis studies

10) Support analysis of in situ sea ice data

11) Studies of sea ice conditions in the Arctic, both temporal and spatial variability, as well as trends

12) Study the driving forces for ice edge variability and ice motion

13) Analysis of sea ice area and extent time series in different Arctic regions

14) Studies of climate signals between Arctic and central Pacific, in particular lag times between sea ice extent and ENSO signals

15) Use of monthly data do analysis sea ice navigation conditions in the Arctic

4.2 Why some users did not use the SIC ECV data sets

1) Use of other established SIC data sets (from OSISAF, NSIDC, University of Bremen) which cover a longer period, so there is no need to use the ECV data sets.

2) Monthly data sets obtained from other sources are more relevant than daily data sets from ECV.

3) Longer time series of gridded ice charting data are more useful

4.3 Identification of specific requirements and other issues

One user asked for a combined SSM/I and AMSR-E algorithm, but it was not clear what the purpose of such algorithm would be.

Use of the data for navigation analysis by engineering teams is not easy. Products that are better suited for navigation should be developed, i.e. combine SIC and SIT data.

Comparison between different SIC data sets shows that there are discontinuities and/or discrepancies between near realtime of re-analysis products. This issue should be discussed in the PUG document.

Methods for coastal correction is an issue of major concern. These methods have impact on the total ice area/extent calculations, especially in the Arctic.

The products should be accompanied by regional masks, or scripts to facilitate extraction and analysis of data from specific regions

There is expectation that the SICCI data sets is of the best quality and that the production can be implemented in near realtime as well as for reanalysis.

Information on temporal and spatial correlation of errors

Can the uncertainty estimates in summer be improved ? It seems that the error in the central Arctic is too small in summer.

4.4 Overall assessment

The quality is comparable to other similar products, such as OSISAF. The advantage of the SICCI products is the uncertainty estimate per grid cell and more complete metadata

Time series is too short (i.e. ony from 1992 to 2008), but this will improve in Phase 2

Most of the users expressed that there were no technical problems to obtain and use the SIC data.

The metadata and documentation accompanying the products is generally good, but the Product User Guide (PUG) format could be improved. See the format of the NSIDC user guide.

14 users (of 17 who downloaded the data) answered that they would use the SIC data again when there is an updated version covering the whole period from 1978 to present.

5 Assessment of Sea Ice Thickness

5.1 Response to the survey in Phase 2

Of the 29 respondent 10 answered questions about ice thickness and 6 said that they had downloaded the data. The data have been used for the following purposes:

1) Compare ice thickness data with sea ice analysis and other ice thickness data
2) Compare ice thickness data with climate model output
3) Comparison with other EO-derived ice thickness products
4) Validation of ice-ocean models
5) Check ice thickness in a specific region (i.e. New Siberian islands)
6) Collecting all available sea ice thickness data for climate research
7) Calculate timeseries of thickness and combine with ice extent to estimate ice volume
8) Study of climate signals between ENSO and Arctic sea ice
9) General sea ice research
10) Student exercises

5.2 Why some users did not use the SIT ECV data sets

1) Discrepancies between SIT and own estimates of thickness
2) Too poor spatial resolution for meaningful comparison
3) Too little thin ice in the data, which is to be expected from RA data. (The user is apparently familiar with SMOS-derived thickness)

5.3 Identification of specific requirements and other issues

Correction of the too thick bias is the most urgent requirement

Limited data coverage in the Arctic north of 81.5 N excludes large ice-covered areas. This makes the SIT product less useful.

Information about uncertainty is lacking

Gridding problem: one user had to interpolate data to another grid. Would be useful to have data also in GeoTIFF format

5.4 Overall assessment

1) All the users who responded have experience with other similar data sets (IceSat, CryoSat-2) and have therefore questions about the quality of the SIT data. There are significant discrepancies compared with other data sets. It is clear that this first version of the SIT needs to be improved before it makes sense to carry out a rigorous comparison with other data.

2) The present SIT data set has a too thick bias, which was already known when the data were published. This will be improved when we decide which snow climatology should be used in the algorithm.

3) The decadal timeseries of the SIT data can be very valuable, but the timeseries cannot be used for any scientific analysis before the bias is reduced.

4) An explanation of the elements contribution to the overall uncertainty in the data products is needed.

5) Most of the users would download an updated version of the products, although the resolution and coverage is limited and the usefulness of the data is not clear.

6 Sea ice Drift requirements

5 users responded to the questions about sea ice drift. This part of the survey is less interesting than the SIC and SIT surveys because it is very general without presenting any data products. The survey is still important because it will some guidelines to the algorithm intercomparison work in Phase 2.

6.1 Why is ice drift data needed ?

1) For validation of ice drift in sea ice models

2) For validation of climate models

3) Comparison with other ice drift data (in particular buoy data)

4) Studies of sea ice circulation in Arctic and Antarctic: variability, trends and tracking of ice age

5) Ice drift data should have uncertainty estimates in order to be useful in scientific work

6.2 What ice drift data sets do you use ?

1) NSIDC Pathfinder sea ice motion data

2) CERSAT and OSISAT ice motion data

6.3 What resolution do you need ?

Temporal resolution: Most of the respondents need several resolutions, from daily to monthly averaged data

Spatial resolution: Many users working with climate research can do with resolution from 10 km and upwards. Some users need as high resolution as possible from the given input data, and will interpolate to a grid as needed.

7 On the relationship between observations and models

Most users apply the data provided by the SI-CCI project in a large-scale modeling context, usually either to evaluate their models or to initialize model simulations for seasonal or decadal prediction studies. In this context, a number of fundamental difficulties arise that not only relates to sea ice but is generally valid for any study that combines model simulations and observational data (see *Notz*, 2015). These difficulties stem from various sources of uncertainty that render any one-to-one transfer between observational data and models impossible. These difficulties emerge on the one hand from the fact that neither models nor observational data can ever fully reflect the true state of any geophysical system, and on the other hand arise from the strong internal variability of the climate system that allows for an infinite number of possible climate trajectories for any given external forcing. In this section, we briefly summarize these points and discuss how the SICCI project aims at addressing them. We start with internal variability and then afterwards discuss the impact of biases.

7.1 Internal variabiliaty

Since the climate system of our planet is a chaotic, dynamic system, its response to any given external forcing cannot uniquely be determined, but instead will be drawn from an infinite number of possible trajectories. This, per se, renders any model evaluation largely meaningless that simply evaluates whether a model simulation precisely matches the observed evolution of any observable or not. A useful example for this fact is a model that simulates the casting of a standard six-faced die. Let's assume that this model produces in three simulations a 3, a 1 and another 3, while casting a real die gives a 6. This does not allow us to draw firm conclusions about the quality of the model, and a comparison of the mean of all simulations (2.3) to the casting of the die (6) does not provide very useful insight.

However, precisely this method is often applied to determine whether a simulation of, say, the loss of Arctic sea ice is realistic. If a model does not produce the same trend as the observations, the model is often assumed to be of limited quality. However, as discussed by *Notz* (2015), in addition to the actually observed trend, the climate forcing of the past decades could have resulted in an increase in Arctic sea ice or an even stronger decrease then has been observed. This conclusion was reached by analyzing simulations of those CMIP5 climate simulations that contain the observed spread with their range of sea-ice simulations. Hence, the sea-ice trend is one of the many metrics that are not a very helpful to determine model quality. For such metrics, any useful model evaluation must consider the internal variability of the climate system which is provided by the range of possible trajectories, one example of which is the actually observed one.

This fundamental problem cannot be overcome. The SICCI project team therefor focuses on providing this information to the users, making them aware of the impact of internal variability on any model evaluation. In addition, the work of SICCI also opens new ways of model evaluation that no longer are based on the simple comparison of largely varying quantities between model and satellite retrievals. Instead, the SICCI data allows users to determine robust physical relationships between individual sea-ice related parameters, for example between ice concentration and drift speed etc., which then allow for a physically based, consistent evaluation of large scale models. This then allows users to circumnavigate the issues caused by internal variability.

7.2 Biases

In addition to internal variability just discussed, also observational biases hinder a robust assessment of model quality in many cases. A standard example for the impact of such biases in the sea-ice context is the occurrence of melt ponds on the sea-ice surface during summer. The standard passive-microwave sensors used for the determination of sea-ice concentration in most satellite-retrieval algorithms are not able to distinguish such melt ponds from open water. Hence, the satellites are only able to determine the concentration of melt-pond free sea ice. This then, obviously, causes biases in any product that aims at reporting total sea-ice concentration.

A standard method to overcome this specific lies in the synthetic ad-hoc increase of reported sea-ice concentration by some algorithms, which then causes sea-ice area reported by these algorithms to be substantially (order million km^2 above) the estimates of other algorithms. This then, again, limits the usefulness of the reported sea-ice concentration for both a model evaluation and a model initialization context. Regarding the latter, a recent study by *Bunzel et al*. (submitted) has found that the differences in seasonal predictions of Arctic temperature exceed regionally 3 °C if one changes from an algorithm without a strong bias correction during summer to an algorithm with such bias correction.

From a user perspective, the ad-hoc bias correction has a number of drawbacks. Since based on passive-microwave products alone there is now way to correct in a physically consistent manner for the melt-pond related bias, any such bias correction will always be ad hoc and cannot account for, say, changes in melt-pond coverage from one year to the next or for regional differences in melt-pond coverage. Aiming for the most consistent record, and aiming at maximum transparency on any of its products, the SI-CCI project team has consciously decided on a different approach. Rather than including any ad-hoc bias correction into its product, the sea-ice concentration record is simply reported as covering melt-pond free sea ice. Based on such physically consistent product, the users can then decide whether they would like to apply a bias correction themselves, for example based on additional observational information, or whether they for example use a melt-pond scheme in their individual models to simulate just such reported area of melt-pond free sea ice. This then gives users the greatest possible control and freedom over using our data.

Along similar thinking, the SI-CCI products contain very detailed estimates of uncertainty, which allow the users to judge themselves whether they trust a certain data set on a certain day in a certain area or not. Along these lines, the data provided is only very lightly filtered, since the SI-CCI project team believes, consistent with information gained from the users, that it is better for the users to disregard certain data points themselves, rather than having points removed beforehand which might have contained valuable, geophysical information to some users.

In summary, the SI-CCI team very openly acknowledges that any observational product has biases, and very opens communicates these biases rather than trying to hide them from the user by ad-hoc corrections.

We believe that this approach of largest possible transparency allows users for more consistent use of our data, which will then allow for more robust insights into the functioning of the climate system of our planet.

7.3 References

Notz D.Ö How well must climate models agree with observations? *Phil. Trans. R. Soc*. A 373: 20140164. http://dx.doi.org/10.1098/rsta.2014.0164, 2015.

Bunzel F., D. Notz, J. Baehr, W. Müller and K. Fröhlich: Impact of biases in assimilated sea-ice concentration retrievals on seasonal climate prediction with MPI-ESM, *Geophys. Res. Lett*., submitted.

8 Updated information on requirements 2015-2018

In the last three years new information on requirements for sea ice climate data has arisen from initiatives mainly by Copernicus and ESA, which have produced a number of requirement documents relate to sea ice. These are summarized below.

- Copernicus Climate Change Services (C3S), where the sea ice climate data sets from the CCI project have been included in the portfolio of climate data sets (https://climate.copernicus.eu/). The C3S has provided a requirement document for the sea ice concentration and sea ice thickness products developed in the CCI project. This document provides a review of user requirements for sea ice data obtained from a number of studies and surveys conducted in the last decade. Several studies have been focused on the requirements from space agencies to develop and launch satellites that can observe many atmospheric and ocean/sea ice variables to support modelling and forecasting. The requirements are defined in terms of spatial and temporal resolution and sampling, measurement range and accuracy, delay time and performance limits for each variable. The requirements are also divided into (1) operational requirements, implying that data are needed daily in near-real time in order to be used in monitoring and short-term forecasting, and (2) seasonal and long-term observations for climate research requirements, which require long time series with high accuracy based on merging of data from several satellites. The climate research requirements for sea ice variables were reiterated in the CGOS report no 154 from 2011 (GCOS, 2011) and the GCOS Implementation document (GCOS, 2016), where specifications were given for sea ice concentration, extent/edge, thickness and drift. These are summarized as follows:

    - *SI concentration (SIC):* Target requirements are 10 – 15 km horizontal resolution, weekly temporal resolution, and measurement accuracy: 5 %.
    - *SI extent/edge:* Target requirements are 1 – 5 km horizontal resolution, weekly temporal resolution, and measurement accuracy: 5 km
    - *SI thickness (SIT):* Target requirements are 25 km in horizontal resolution, > 0.05 m in vertical resolution, monthly temporal resolution, and measurement accuracy: 0.10 m.
    - *SI drift:* Target requirements are 1 km in horizontal resolution, weekly temporal resolution, and measurement accuracy: 1 km per day. SI drift is not included in the portfolio of sea ice climate data sets.

  The Target requirements are set by GCOS in order to resolve interannual variations and trends in each of the variables. The CGOS documents are available at https://public.wmo.int/en/programmes/global-climate-observing-system

Not all the GCOS requirements are realistic, such as the SIT measurements accuracy of 0.10m. A realistic accuracy is about 0.50 m. (Ref. C3S_D312a_Lot1.1.1.1-2017_201712_Target_Requirement_v4). The major source of this uncertainty is lack of data on snow properties on top of the sea ice. A main recommendation from the CCI and the C3S sea ice project is therefore to improve snow measurements on sea ice. A possibility to do this from satellites is to use a dual frequency (Ku- and Ka-band) radar altimeter, as shown by the Altika mission. (Guerreiro et al., 2016, https://www.sciencedirect.com/science/article/pii/S0034425716302711)

Regarding sea ice, the GCOS Implementation plan has focus on the need to establish and sustain systematic in situ observations from sea ice, buoys, visual surveys (SOOP and aircraft) and in-water upward-looking Sonar (ULS). This is action O15 in the document, available at https://public.wmo.int/en/programmes/global-climate-observing-system

The sea ice climate data sets are included in the Climate Data Store under C3S (https://cds.climate.copernicus.eu/#!/home), where sea ice and other data sets are used in connection with reanalysis. Sea ice provides one of the most important data sets in the Polar regions.

- Copernicus organised a Polar and Snow Cover Application and User Requirement Workshop in Brussels on 23 June 2016. The purpose was to collect user requirements for the next generation of the Copernicus Space Component. The presentations and document from the workshop are available at http://www.copernicus.eu/polar-snow-workshop

- A further evolution of the Copernicus process is the Mission Requirements Document provided by ESA on Copernicus Imaging Microwave Radiometer (CIMR). This document outlines among other things, the instrument, the platform, the orbit and the Level 1 and Level 2 products. The document is available at https://cimr.eu/documents

- In early 2017, EU DG-GROW appointed a group of European experts with the mandate to update and/or complete the review and analysis of the users' needs for a mission dedicated to Polar Ice and Snow monitoring. The Polar Expert Group (PEG) have generated two reports. The **first report** contains the user requirements in terms of observations, parameters and/or products. The **second report** defines high-level mission requirements of the dedicated Polar and Snow Missions. Both are available at https://cimr.eu/documents

- ESA organised the CryoSat Scientific Expert Meeting at ESRIN on 7-8 November 2017, where a number of recommendations for further development of sea ice, land ice and other polar data from future Polar Earth observation satellite, in particular a follow-up of CryoSat.
  Here are some excerpts from the conclusion of the workshop report:

The development of a highly elliptical orbit (HEO) mission in complement to the meteorological programmes would provide unique benefits to the users. Interesting and useful products are already delivered, in a quasi-operational form, by the Copernicus marine service and by EUMETSAT Satellite Applications Facilities (SAFs), but those are by far not satisfactory. It is therefore not surprising that most of the requirements are well consolidated and did not evolve in the nearest past, backed up by scientists and by operational organisations. It is clear that an operational enhanced continuity should be provided after CryoSat, but also to several measurements performed by SMOS. Multi-band radar measurements would improve operational services. A better coverage should be achieved, possibly with dedicated orbits such as the HEO concept developed for polar communications. Spatial resolution should be improved in several domains and temporal resolution in nearly all of *them. Freezing and thawing should be monitored better than they are today, for climate monitoring and for industry operations. Ice mass changes over land should be better estimated.*

The user community also still has to rely on sufficiently frequent observations which have to be available on a daily basis (e.g. for automatic sea ice chart production or production of other similarly useful products for the safety of navigation, including high resolution near real time sea ice thickness, sea ice drift and iceberg detection). In addition, timeliness of the delivery of products for operational use as well as their adequacy to the objectives should be improved: delays are often unacceptable (ice breakers, navigation, infrastructure building, search-and-rescue support, etc.).

Moreover, Copernicus has to rely on a strong in situ observation capability which has to be used for operational modelling. In this context, the reduced availability of critical in situ networks is another source of concern: polar zones require an integrated view and the question of an integrated polar service has been raised.
The report and presentations from the workshop is available at https://earth.esa.int/web/guest/content/-/article/cryosat-scientific-expert-meeting-presentations-and-summary-report

- A new satellite under Copernicus Extension, addressing critical parameters affecting the polar regions. Copernicus is the most ambitious space Earth Observation programme to date. User requirements collected under Copernicus have strong impact on further evolution of the satellite earth observation programme. After performing a mature assessment of user requirements (see workshops and documents mentioned above), the European Commission has prioritized a new mission to collect data on critical parameters affecting the polar regions. ESA has issued an ITT to assess and consolidate the requirements for a Polar Monitoring Mission. Building on CryoSat-2 experience, this mission shall provide enhanced land ice elevation and sea ice thickness measurements implementing higher spatial resolution for improved lead detection and additional capability to determine snow loading on sea ice.

In conclusion, there is an ongoing development to plan and implement observing systems for sea ice and other polar variables. As shown above, there are also a number of new requirement documents and planning documents with focus on satellite observations. For in situ observations of sea ice, there is no systematic observing system in place yet, but such systems are highly recommended and it is expected that more resources will be allocated to collection of in situ sea ice data.

Appendix A List of users

A.1 List of users who downloaded SIC and SIT data sets from Phase 1

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A.2 List of users who responded the survey in Phase 2

#	Responses	Date
1	Andrew Peterson, Met Office, Exeter, UK	5/22/2015 8:17 PM
2	Yuanyuan Zhang,graduate stuedet form Beijing Normal Unversity	5/11/2015 4:40 AM
3	D. Ram Rajak, Space Applications Centre (ISRO), Ahmedabad, India.	5/9/2015 7:27 PM
4	Arto Miettinen, Norwegian Polar Institute, Tromsø, Norway	5/6/2015 5:04 PM
5	Stefan Muckenhuber, NERSC	5/6/2015 11:48 AM
6	Jens Boldingh Debernard, Norwegian Meteorological Institute	5/6/2015 10:53 AM
7	Xiangshan Tian-Kunze University of Hamburg	5/6/2015 10:45 AM
8	Sascha Willmes University Trier	5/6/2015 10:30 AM
9	Qinghua Yang; AWI, Germany	4/20/2015 4:43 PM
10	Julienne Stroeve NSIDC, CU	4/13/2015 8:42 PM
11	Petra Heil, AAD	4/11/2015 2:37 PM
12	Walt Meier NASA Goddard Space Flight Center Cryospheric Sciences Lab	4/10/2015 9:37 PM
13	Xianmin Hu University of Alberta	4/9/2015 10:20 PM
14	Annette Samuelsen, NERSC	4/9/2015 12:43 PM
15	Mengxi Zhai Beijing Normal University, University of Helsinki	4/8/2015 8:26 AM
16	Zhijun LI State Key Laboratory of Coastal and Offshore Engineering, Dalian University of Technology, China	4/8/2015 1:33 AM
17	Junshen Lu, University of Bremen	4/7/2015 1:07 PM
18	Julian Zimmermann Master Student at GeoForschungsZentrum Potsdam	4/7/2015 10:36 AM
19	Øystein Rudjord, Norwegian Computing Center	3/23/2015 4:50 PM
20	Anne Stefaniak, ESA Climate Office YGT	3/23/2015 11:14 AM
21	Dr. Burcu Ozsoy-Cicek Istanbul Technical University, Maritime Faculty	3/19/2015 10:46 PM
22	Sean Helfrich NOAA	3/19/2015 10:00 PM
23	Frank Kauker Alfred Wegener Institut	3/18/2015 11:09 AM
24	Scott Stewart, working with National Snow and Ice Data Center in Boulder, Colorado, USA.	3/17/2015 7:10 PM
25	Vasily Smolyanitsky, AARI	3/17/2015 6:44 AM
26	Junshen Lu, IUP Uni Bremen	3/16/2015 7:11 PM
27	Xianmin Hu University of Alberta	3/16/2015 5:39 PM
28	Bretonnière, IC3	3/16/2015 5:06 PM