Comments from Public Consultation on ECV Requirements 13/01 – 13/03 2020 for:

# Sea ice

## ECV Product: Sea Ice Age

### From : Thomas Lavergne thomasl@met.no

**Sea Ice Age** (defined as a number of survived summer melt seasons) and **Sea Ice Type** (defining if a sea-ice location survived at least one summer melt season) are key indicators of climate change. In the latest IPCC SROCC SPM: Arctic sea-ice has undergone “a transition to younger ice: between 1979 and 2018, the areal proportion of multi-year ice at least five years old has declined by approximately 90% (very high confidence)”. Because sea-ice age/type is a proxy for thickness (older sea-ice is generally thicker), this indicator is a proxy for the fate of sea-ice volume.

Example maps of  Sea Ice Age (left) and Type (right) for the Arctic. **NB! not same date.**

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| https://lh6.googleusercontent.com/eLMHQ6f95ma5yHStJN9hvmqQFLlej79GCYUzngNOON2qAimUqx_T4HrC-2lcXctHYMu-hgHKaSmU2H_jopll1fHAZH5SKwAXEV0rapm_HcbBI7QSpoToMxjPQ9EaOioq5z_Vf65p  Source: U.S. NSIDC (<https://nsidc.org/data/nsidc-0611>) | https://lh6.googleusercontent.com/87CPNpnvq24f08R_wB4NG9lw-pamXrFo8SfBLRTHLiJ7YlOOTCwI5AtrU8bkmzvaGdnRCWtVR4fUsICAv4_hWMpuo7ch-LvOb0yIONhZ7Y5KXBDsenaZUoH9gSV5QX8jrs-jI3m-  Source: EUMETSAT OSI SAF ([osisaf.met.no](http://osisaf.met.no/)) |

Sea Ice Age/Type is also a proxy for salinity (old sea-ice is less saline), deformation rate and roughness (old sea-ice is more deformed and rough), snow-depth (more snow piling on old ice), and is generally an integrated measure of general sea-ice circulation (old sea-ice is piled towards Canada and Greenland because of sea-ice drift, and is re-circulated by the Beaufort Gyre). Sea-ice Age/Type is key to characterize the future regional evolution of sea-ice, and the location of the last sea-ice (before an ice free Arctic in summer).

Sea Ice Age and Sea Ice Type are often considered as separate variables because they are retrieved differently. However, their definition overlap and there is scope to consider them together and take stock of the pros/cons of the different EO techniques:

1. sea-ice age is derived from sea-ice drift and sea-ice concentration. sea-ice parcels are tracked forward in time (with sea-ice drift vectors) from their initial freezing (detected with sea-ice concentration) until it melts or is exported from the Arctic Ocean. Each time a sea-ice trajectory survives one summer melt season (typically defined as ending on September 15th), the “age” of the parcel is re-initialized to a cardinal year (2, 3,...).
2. sea-ice type products is typically characterized from daily maps of brightness temperatures (microwave radiometry, like SMMR, SSM/I, SSMIS, AMSR-E, AMSR2) or backscatter from scatterometry (NSCAT, QuikSCAT, ASCAT, etc...). Sea-ice is generally classified as First Year Ice (less than 1 summer melt season) and MultiYear Ice (more than 1 summer melt season), although some investigators also attempt to delineate Second Year Ice from older ice.

The two EO techniques have different strengths and weaknesses, which calls for synergistic methods to observe a combined Sea Ice Age/Type ECV product.

In-situ observations can to some extent inform on the sea-ice age/type when the trajectory of buoys is long enough to survive a summer melt season, in which case it is known that the sea-ice age is 1 more than it was before the melt season. Because most on-ice buoys are installed by research cruise at the end of summer, most in-situ buoys start as multiyear sea-ice. There is thus very little validation available to validate sea-ice Age/Type products on large scales, and they are often compared to each other to assess their credibility (but rarely validated against ground truth). Other EO data (e.g. SAR images) can be used for validation, but they have their weaknesses too.

It is thus not easy task to define requirements for the Sea Ice Age/Type combined ECV product, but they could include:

Spatial : Goal 25km, Breakthrough 50km, Threshold 100km

Frequency: Goal daily, Breakthrough Weekly, Threshold Monthly

NO COMMENT

## ECV Product: General comment on the Sea Ice ECV and its requirements

### From : Thomas Lavergne thomasl@met.no

The Sea Ice Essential Climate Variable encompasses a wide variety of geophysical variables (“products”), requiring a number of different Earth Observation sensors and techniques to observe them. In-situ data are sparse, costly (mostly cost of deployment), and short-lived (due to harsh conditions and a strong seasonal cycle of sea-ice cover).

Some of these sub-variables identified in the GCOS IP are ice extent and area, ice concentration, ice thickness, ice motion, fast ice, ice type (first year, multi-year) and age, ice salinity, snow cover depth and density, surface freeze-up and melt time, melt pond coverage, ice albedo, surface roughness, lead fractions, sea-ice temperature (surface, and profiles), etc…

Because of the multivariate changes occurring in the polar regions, and the increasing complexity of numerical models (GCMs, re-analysis, …) more and more of these sea-ice variables will be relevant for climate applications and GCOS should provide requirements for more than sea-ice concentration / extent / drift / thickness.

In view of the extent of the Sea Ice ECV (in terms of variables to be covered and EO techniques), I make the following comments:

1. To have the heavily multi-product Sea Ice ECV as a (single) ECV sorted under the GCOS Ocean family limits its visibility, and limits possibilities to attract the funds needed for the maturing of the ECV products (in particularly for moving research-based prototype data to the status of mature CDRs). Could the Sea Ice ECV be split in several sub-themes (sea-ice volume, sea-ice dynamic, sea-ice radiative properties, etc...), each with a smaller number of products?
2. It would be quite relevant to specifically poll the sea-ice EO community on the definitions, validation methodology, and requirements for all the sea-ice ECV products, e.g. through dedicated international workshops. This should probably involve polar-centered WMO groups such as Global Cryosphere Watch (GCW), and Polar Space Task Group (PSTG).

### Comment 1

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| Author: ECMWF | Email: ecresgcosreqs@gmail.com |
| We agree with Thomas Lavergne that the Sea Ice ECV would definitely benefit from being given greater visibility in the GCOS ECV catalogue. | |

## ECV Product: Sea Ice Surface Temperature

### From: Jacob Høyer jlh@dmi.dk

Attached is a document with a rationale for why Sea Ice Surface Temperature (IST) should be regarded as an ECV.

Included is also a requirement table.

**Rationale for Sea Ice Surface Temperature as an ECV**

Surface temperature observations are essential contributions to our understanding of the Earth’s climate and how it is changing. Sea Surface Temperature (SST), which is generally defined as the surface temperature over open ocean with little or no sea ice cover, is recognized as an Essential Climate Variable (ECV) (GCOS, 2016). In addition, Land Surface Temperature (LST) was identified as an ECV in 2016 and includes all surface temperatures over land areas, including land surfaces covered by snow or ice. Finally, Lake Surface Water Temperature (LSWT) was included in the Lakes ECV (GCOS, 2016). One type of surface temperature is missing from a “whole-Earth” perspective as recognized in Merchant et al.(2013) that is: sea ice surface temperature (IST).

Observations of the surface temperature of the sea ice have been performed for many decades from both satellite and in situ observations. Consistent split window infrared (IR) satellite records started in 1981 with the launch of the AVHRR/2 instrument on board NOAA 7 and in situ observations of sea ice surface temperature has existed for many more years. In a user requirement survey conducted by the ESA Sea Ice CCI project (SICCI-URD, 2012 ) the IST was given priority 1 and ranked by the users as the 4th most important parameter out of 22, only exceeded by parameters such as sea ice concentration, sea ice mean thickness and sea ice thickness distribution.

Several recent initiatives have been focusing upon measuring the sea ice surface temperature using in situ and satellite observations. IST can be determined from thermal emission at wavelengths in IR or Microwave atmospheric windows. The infrared instruments observe the radiation from the upper micrometers of the snow or sea ice surface, whereas the MW emission originates from the snow-ice interface temperature (see e.g. Tonboe et al., 2011). The IST from IR and MW can therefore be similar or very different, depending upon the snow cover on top of the sea ice. IST from IR satellites is always the skin surface and is thus used more widely for operational and climate applications.

In situ observations of the skin snow and ice surface is a difficult task using e.g. traditional buoy and air temperature measurements, whereas the temperatures can be estimated with a thermal infrared radiometer. Protocols for IST validation were developed within the ESA project Fiducial Reference Measurements For Satellite Derived Surface Temperature Measurements (FRM4STS). FRM4STS aimed at establishing SI traceability of global Fiducial Reference Measurements (FRM) for satellite derived surface temperature product validation (Theocharous et al., 2016). The focus was on surface temperature for all types of surfaces, including the sea ice, using self-calibrating infrared radiometers (see e.g., Høyer et al., 2017). Among the top recommendations from the project was the establishment of FRM observation sites for IST validation, performing observations traceable to SI units.

Operational level 2 satellite products from IR and MW observations are currently being produced for the polar regions by EUMETSAT, NASA and NOAA from the Metop and NOAA AVHRRs, (A)ATSR, VIIRS, MODIS, Sentinel3 SLSTR (in progress) and IASI instruments with a spatial resolutions from 1-12 km. In addition, downstream level 4 products are delivered within the Copernicus Marine Environment Monitoring System (CMEMS) for the Arctic SST and IST. Long term IST data records combining data from sensors in series have also been produced, such as for the AVHRRs and ATSRs (Dodd et al., 2019; ESA DUE GlobTemperature; Høyer et al., 2019) and the 34 year AASTI (version 2) IST data record based on the CLARA version 2 climate data record (Karlsson et al., 2017) using the OSISAF IST algorithm (Dybkjær et al., 2018).

User requirements surveys for IST have been carried out in several projects, such as: ESA SI CCI project, EUMETSAT Position Paper (Stammer et al., 2007; GCOS, 2016; CLiC , 2012; CMEMS 2016, 2017 & 2020; Copernicus 2018a, 2018b). However, the IST requirements are for some cases more than 10 years old, they differ in their nature and in the numbers. In addition, due to the lack of traceable IST FRM in situ observations it is difficult to test if a satellite product meets the user requirements in terms of accuracy, precision and stability.

There is thus a need for a community consensus on the IST requirements for climate applications to facilitate a common validation and uncertainty characterization within different satellite and in situ providers covering the Polar Seas ice surface temperature. Including IST as an ECV within the GCOS and WMO framework could ensure a consistent approach on the “whole Earth” perspective for surface temperatures and facilitate a wider user uptake of IST observations.

**Summary points**

* Operational and climate data records of satellite based IST are currently available from Infrared and Passive Microwave observations from several space agencies and services.
* Existing initiatives have been working with IST FRMs and establishing protocols for validating and characterizing sea ice surface temperatures.
* Measurements of IST play a key role in describing the physics of sea ice processes in the Polar regions.
* IST from Infrared observations provides a globally consistent satellite record of clear-sky, radiative temperatures of the Earth’s sea ice surface Observations from microwave instruments provide additional information through an all-sky global coverage of the snow and sea ice interface temperature. These records complement the satellite based SST, LST and LSWT records.
* IST plays a key role in surface energy balances in the Polar regions.
* IST can be used to derive the near surface air temperature in the Polar regions, which are sparse with in situ observations.
* There is a need for a community consensus on the user requirements for IST. The existing user requirements for IST are old and there is a spread of the user requirements within the different surveys.

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| Name | Sea Ice Surface Temperature (IST) | | | | | |
| Definition | Snow and Ice skin temperature | | | | | |
| Unit | Kelvin | | | | | |
| Note | The IST requirements below are based on several requirement/recommendation documents from relevant communities and institutions, e.g. WMO, GCOS, GMES, Copernicus/CMEMS, ESA CCI, and other. Requirements for IST range widely in both in values and metric and the given values are based on these documents and expert judgments from the OSISAF High Latitude team. The main requirements cover infrared satellite IST. Specific Microwave derived IST (snow-ice interface temperature) requirements are stated in parenthesis. | | | | | |
| Requirements | | | | | | |
| Item needed | **Unit** | **Metric** | **[[1]](#footnote-1)** | | **Value** | **Derivation and References and Standards** |
| Horizontal Resolution | km | Km | G | | 1 (5) | GCOS, GMES, Copernicus/CMEMS |
| B | | 5 (15) | GCOS, GMES, Copernicus/CMEMS |
| T | | 25 (50) | WMO |
| Vertical Resolution |  |  | G | | Skin (snow-sea ice int.) | Determined by sensor – i.e. Thermal Infrared is skin, Microwave is snow-sea ice interface temperature |
| B | | Skin (snow-sea ice int.) |  |
| T | | Skin (snow-sea ice int.) |  |
| Temporal Resolution | Hour | Hour | G | | 1 | GCOS, Copernicus/CMEMS, enable diurnal analysis |
| B | | 3 | GCOS, Copernicus/CMEMS, enable diurnal analysis |
| T | | 24 | GCOS, Copernicus/CMEMS, enable seasonal and long term trend analysis |
| Timeliness | Hour | Hour | G | | 1 | GMES, For use in sea ice services |
| B | | 3 | For operational use |
| T | | N/A | For climate analysis – Non Time Critical |
| Required Measurement Uncertainty | K | STD | G | | 0.5 | Copernicus/CMEMS, GMES, EUMETSAT/OSISAF, Dybkjær et al., 2019 |
| B | | 1.5 | Copernicus/CMEMS, GMES, EUMETSAT/OSISAF, Dybkjær et al., 2019 |
| T | | 3.0 | Copernicus/CMEMS, GMES, EUMETSAT/OSISAF, Dybkjær et al., 2019 |
| Stability | K/decade |  | G | | 0.1 | As defined in the GCOS LST ECV requirements |
| B | | 0.2 |  |
| T | | 0.3 | As defined in the GCOS LST ECV requirements |
| Standards and References | CLiC (2012) Observational needs for sea ice models - Short note. Discussion note from CLiC Arctic Sea Ice Working Group, http://www.climate-cryosphere.org/about, 2012.  *CMEMS (2016) Bertino, L., L.A. Breivik, F. Dinesen, Y. Faugere, G. Garric, B. Hackett, J. A. Johannesen, T. Lavergne, P.-Y. LeTraon, L.T. Pedersen, P. Rampal, S. Sandven & H. Shyberg. Position paper Polar and snow cover applications User Requirements Workshop Brussels, Copernicus Marine Environment Monitoring Service, Mercator Ocean.*  *CMEMS (2017) CMEMS requirements for the evolution of the Copernicus Satellite Component. Copernicus Marine Environment Monitoring Service, Mercator Ocean and CMEMS partners.*  *CMEMS (2020) CMEMS Dashboard Upstream Satellite Data Requirements, V10.0 March 2020 (spreadsheet)*  *Copernicus (2018a) Duchossois, G., P. Strobl, V. Toumazou (Eds.) User Requirements for a Copernicus Polar Mission Phase 1 Report - User Requirements and Priorities. JRC Technical Report, doi:10.2760/22832, 2018.*  *Copernicus. (2018b) Duchossois, G., P. Strobl, V. Toumazou (Eds.) User Requirements for a Copernicus Polar Mission Phase 2 Report - High-level mission requirements. JRC Technical Report, doi:10.2760/44170, 2018.*  Dybkjær, G., R. Tonboe, M. Winstrup and J. L. Høyer (2019) Review of state-of-the-art methods and algorithms for Ice Surface Temperature retrieval algorithms - Including consolidate and refine output product requirements and software specification, Product requirement and baseline document, version 2.3. EUMETSAT document Reference Number: EUM/OPS-COPER/19/1065840.  GCOS (2016) The Global Observing System for Climate: Implementation Needs (World Meteorological Organization, GCOS-200).  OSI SAF CDOP 3 (2018) Product Requirement Document, http://www.osi-saf.org/sites/default/files/dynamic/public\_doc/osisaf\_cdop3\_gen\_prd\_1.4.pdf, Version: 1.4, 2018  SICCI-URD (2012) Sea Ice Climate Change Initiative: Phase 1 User Requirement Document (URD) SICCI-URD-03-12 Version 1.3.  Stammer, D., Johanessen, J., LeTraon, P.-Y., Minnett, P., Roquet, H., and Srokosz, M. (2007) Requirements for Ocean Observations Relevant to post-EPS, EUMETSAT Position Paper: AEG Ocean Topography and Ocean Imaging, 10 January 2007, version 3. | | | | | |
| Adaptation and Extremes | | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | | Explanation | | |
| Adaptation[[2]](#footnote-2) | ? | ? | |  | | |
| Extremes[[3]](#footnote-3) | Yes | Yes | |  | | |

NO COMMENT

## ECV Product: Sea Ice Edge

See discussion under ECV Product "Sea Ice Extent".

## ECV Product: Sea ice drift

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| **Name** | Sea ice drift | | | | |
| **Definition** | Rate of movement of Sea Ice due to winds, currents or other forces. | | | | |
| **Unit** | Km/day | | | | |
| **Note** |  | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** |  | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | km |  | G | 5 |  |
| B |  |  |
| T |  |  |
| **Vertical Resolution** |  |  | G |  |  |
| B |  |  |
| T |  |  |
| **Temporal Resolution** |  |  | G | Monthly |  |
| B |  |  |
| T |  |  |
| **Timeliness** | Month |  | G |  |  |
| B |  |  |
| T |  |  |
| **Required Measurement Uncertainty** | Km/day |  | G | 1 |  |
| B |  |  |
| T |  |  |
| **Stability** |  |  | G |  |  |
| B |  |  |
| T |  |  |
| **Standards and References** |  | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[1]** |  |  |  | | |
| **Extremes[2]** |  |  |  | | |

[1] Is the ECV Product directly relevant to support Climate Adaptation?

[2] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

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| **A note on the Sea Ice Drift ECV product:**  It has (at least) two very different usage area, and this should be reflected in different requirements.  **Application 1: large scale circulation.** The Sea Ice Drift ECV product is relevant when studying trends of the general circulation of sea-ice, informing us on changes in wind patterns over the polar regions, general thinning of sea-ice, changes in under-ice currents, dynamic thickening/thinning along the coasts, sea ice age, transport of tracers (sediments and pollutants) across the Arctic ocean, sea-ice area/volume fluxes through Fram Strait, etc. etc. These large scale circulation patterns are far from being understood, and require good ECV products at appropriate scales, e.g. Goal 25km, Breakthrough 50km, Threshold 100km / Goal Weekly, Breakthrough Monthly, Threshold Monthly / Goal 2 km/day, Breakthrough 10 km/day, Threshold 20 km/day (remember: these numbers er 2-stddev). This type of application can be (and partly is already) well supported by time-series of medium- to coarse- resolution microwave radiometry missions, as well as scatteromoters, complemented by buoy trajectory data. The accuracy is better in more recent years thanks to technology improvements (satellites have better resolution, availability of GPS positioning system...)  **Applic**ation 2: monitoring of sea-ice deformation. The Sea Ice Drift ECV product is also relevant for studying the sea-ice rheology and its changes via deformation metrics (mainly convergence/divergence, curl, shear). Here, the Sea Ice Drift ECV product is an intermediate step, and we need to setup requirements that allow for the sea-ice deformation metrics to be relevant for climate studies. It is a complex task but we can probably aim at ambitious targets in terms of spatio-temporal resolution (because the deformation events are localized in space and time) and accuracy (because noise will propagate and probably increase from drift vectors to deformation metrics). Goal 1km, Breakthrough 5km, Threshold 10km / Goal daily, Breakthrough Weekly, Threshold Monthly / Goal 300m/day, Breakthrough 1km/day, Threshold 2km/day (again: 2-stddev values). This type of application is supported by EO data (Synthetic Aperture Radar) and buoy data (buoy arrays). The available time series are much shorter (than App1), and biased towards Arctic (fewer EO and buoy data in Southern Hemisphere).  I am not sure how GCOS could best handle these two very different applications of the Sea Ice ECV product. The requirements today seem to be a mix of these applications (5km spatial resolution but monthly frequency). Maybe create two ECV products: Sea Ice Drift (circulation) and Sea Ice Drift (Deformation). Or even better, keep the Sea Ice Drift product for the circulation application, and create a Sea Ice Deformation ECV product (where the target quantities would be the deformation metrics and sea-ice drift vectors would only be an intermediate product.  In anycase, the community should try and clear the confusion on the current GCOS requirements, as they are not helpful to guide EO data products (and funding agencies) towards new / improved sea-ice drift ECV products. | |

## ECV Product: Sea ice thickness

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| **Name** | Sea ice thickness | | | | |
| **Definition** | Average thickness from sea ice surface-to-underside in the ice-covered fraction of an area. | | | | |
| **Unit** | m | | | | |
| **Note** |  | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** |  | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | km |  | G | 25 |  |
| B |  |  |
| T |  |  |
| **Vertical Resolution** |  |  | G |  |  |
| B |  |  |
| T |  |  |
| **Temporal Resolution** |  |  | G | Monthly |  |
| B |  |  |
| T |  |  |
| **Timeliness** | Month |  | G |  |  |
| B |  |  |
| T |  |  |
| **Required Measurement Uncertainty** | km |  | G | 5 |  |
| B |  |  |
| T |  |  |
| **Stability** |  |  | G |  |  |
| B |  |  |
| T |  |  |
| **Standards and References** |  | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[1]** |  |  |  | | |
| **Extremes[2]** |  |  |  | | |

[1] Is the ECV Product directly relevant to support Climate Adaptation?

[2] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

|  |  |
| --- | --- |
| Author: Stefan Hendricks | Email: stefan.hendricks@gmail.com |
| * Unit for "Required Measurement Uncertainty" needs to be "m" not "km" * Values for "required Measurement Uncertainty" could be   + Goal: 0.1m   + Breakthrough: 0.25m   + Target: 0.5m   Also, do the requirements specifically included gapless coverage of sea ice in the northern and southern hemisphere? This is important for the timeliness of the data.  Best Regards, Stefan | |

### Comment 2

|  |  |
| --- | --- |
| Author: Petra Heil | Email: petraheil1@gmail.com |
| Would suggest to redefine as "Mean distance from upper to lower sea ice surface of the ice-covered fraction of an area."  Agree with Stefan's corrections for units and accuracy requirements... but make the Target "0.1m". | |

## ECV Product: Sea ice extent

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name** | Sea ice extent | | | | |
| **Definition** | Sea ice extent is the area of sea with a specified minimum fraction of ice-cover, usually 15%. | | | | |
| **Unit** | Km2 | | | | |
| **Note** |  | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** |  | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | km |  | G | 1 |  |
| B |  |  |
| T | 5 |  |
| **Vertical Resolution** |  |  | G |  |  |
| B |  |  |
| T |  |  |
| **Temporal Resolution** |  |  | G | weekly |  |
| B |  |  |
| T |  |  |
| **Timeliness** | Month |  | G |  |  |
| B |  |  |
| T |  |  |
| **Required Measurement Uncertainty** | km |  | G | 5 |  |
| B |  |  |
| T |  |  |
| **Stability** |  |  | G |  |  |
| B |  |  |
| T |  |  |
| **Standards and References** |  | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[1]** |  |  |  | | |
| **Extremes[2]** |  |  |  | | |

[1] Is the ECV Product directly relevant to support Climate Adaptation?

[2] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

|  |  |
| --- | --- |
| Author: Thomas Lavergne | Email: thomasl@met.no |
| Good morning,    Can we confirm what geo-physical variable this is? Is it Sea Ice Extent (an integrated quantity frequently used to illustrate the development of sea ice along the decades) or Sea Ice Edge (maps of ice/no-ice).    Sea Ice Extent is most of the time derived from SIConcentration (using a threshold, often 15%). It has no spatial resolution (it is a sum of area over a domain). It has unit km^2. It is often split by hemisphere (NH SIExtent, SH SIExtent) but can also be a global SIExtent, or regional SIExtents (e.g. Beaufort Sea SIExtent, Ross Sea SIExtent). It is hard to discuss uncertainties (or at least to assess these) because there generally is no ground truth. An example SIExtent graph from the (provisional) WMO State of Climate 2019:  https://lh6.googleusercontent.com/8cErhaooaqMLPtPK7moB-9u4kv59a9cC0ck2mw1jJMMb--btKYJSgC2yCJQ17VUtA7fInhCNqz3cPE-sqbat0fvALWouuvA8rUnFMPTSWd6Pm_oMC0urxUAPLLvzrM32UOPTGTjn    Sea Ice Area (another integrated quantity derived from SIConcentration) is sometimes used rather than SIExtent for validating climate simulations and commenting trends.    Sea Ice Edge is often an ice/no-ice map. It has a spatial resolution expressed in km. The unit is probably N/A (this is a binary product). SIEdge is sometimes derived from SIConcentration (also using a threshold) but can also be derived from other means (e.g. semi-manual delineation of ice area, ingestion of additional higher resolution satellite information, etc). The definition of the classes “ice” and “no ice” is not fixed. Often 15% concentration is used to separate the classes as for SIExtent, sometime 30% is used. This should be taken into account for each SIEdge ECV and how accuracy is evaluated. The accuracy would probably have to be expressed as a contingency table (HitRate + FalseAlarm ratio). Alternatively, Sea Ice Edge retrieved as a ice/no-ice map can be validated in terms of distance of the edge to a reference (higher-resolution) SIEdge dataset (as is done at the OSI SAF / C3S). See also integrated ice edge metrics (e.g. Melsom et al. 2019). Here an example of sea-ice edge map from the C3S:  https://lh3.googleusercontent.com/Z3vHkjVy3ec2V-92ogpyu-nyXmHEkV3I89Z1Q775Fdw42VvmS6Cmvc3oYl41ATefu4vspXmONz6y5Id5kt55hkfOQ-1GJwmkjfloH4cxdAmB_rQRijsNoTDMqy1dtmIg3siRmkZB  In the current IP (GCOS-200), the product is referred to as "Sea-ice extent/edge" with frequency "Weekly", spatial resolution  "1–5 km" and accuracy "5 km".    For clarity, and for backward compatibility with GCOS-200, **we suggest this ECV product is named "sea ice edge"**, is defined as a "**classification of ocean surfaces into ice/no-ice (possibly additional classes such as open ice, closed ice, etc...)**", has units **N/A**, and its uncertainty expressed as **“distance of the ice/no-ice boundary contour to true ice edge (unit km)”**.    **We further suggest** that Sea Ice Extent/Area are not made an ECV products, but are rather referred to in the Sea Ice Concentration entry as indicators derived from SIC.  Once this clarification is made, we can work on the numbered requirements.  All the best,  Thomas Lavergne and Signe Aaboe (both at the Norwegian Meteorological Institute)    Melsom, A., Palerme, C., and Müller, M.: Validation metrics for ice edge position forecasts, Ocean Sci., 15, 615–630, <https://doi.org/10.5194/os-15-615-2019>, 2019. | |

### Comment 2

|  |  |
| --- | --- |
| Author: Valentin Aich | Email: vaich@wmo.int |
| Thank you very much for your contribution. In this case, I will open a new topic with the suggested ECV product "Sea Ice Edge" and I would invite you, to suggest appropriate requirements. I understand that this product would replace "Sea-ice extent/edge" and the "extent" part would be rather part of "Sea Ice Concentration ".  Best regards,  Valentin | |

### Comment 3

|  |  |
| --- | --- |
| Author: ECMWF | Email: ecresgcosreqs@gmail.com |
| We agree with Thomas Lavergne that sea ice extent is should be defined as a spatially integrated quantity and would be better considered as an indicator derived from sea ice concentration than as a measurable product under the Sea Ice ECV.  One comment about terminology: defining "sea ice edge" as a **gridded** classification of ocean surface depending on various amounts of sea ice concentration is somewhat confusing. From the word "edge", one would expect the product to be a **line** or (in data terms) a **shapefile**, not a 2D gridded product. Wouldn't it be less confusing to do the following?   1. call the gridded product "**sea ice class**" (or something equivalent) instead of "sea ice edge"; 2. define "**sea ice edge**" as the **boundary (i.e., a line defined by a series of lat-lon points) between ice-covered and open ocean** with different sea ice edges defined for different amounts of sea ice concentration; 3. consider "sea ice edge" a product **derived** from "sea ice class" or from "sea ice concentration." | |

### Comment 4

|  |  |
| --- | --- |
| Author: Thomas Lavergne | Email: thomasl@met.no |
| Dear "ECMWF",  Thank you for your comment/support on that matter.  When it comes to the naming "sea-ice edge", I would not modify it, because:  it is already in use by several data producers;  "sea-ice class" is still an ambiguous naming (the sea-ice type products discriminating FYI from MYI are also "classes");  I do not agree sea-ice "edge" necessarily calls for a "contour line" representation. I view this as a formatting/implementation choice. One can store the ice/no-ice information as 2D maps or their contour lines. Contour lines have the downside that one needs to indicate which "side of the line" is ice free.  It is however correct that sea-ice edge products can (and are) be validated/evaluated both as binary maps (through a confusion matrix) or as a line (via distance metrics).  Have a nice week-end,  Thomas | |

## ECV Product: Sea ice concentration

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name** | Sea ice concentration | | | | |
| **Definition** | Fraction of area covered with sea ice. | | | | |
| **Unit** | % | | | | |
| **Note** |  | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | km |  | G | 10 |  |
| B |  |  |
| T | 15 |  |
| **Vertical Resolution** |  |  | G |  |  |
| B |  |  |
| T |  |  |
| **Temporal Resolution** |  |  | G | weekly |  |
| B |  |  |
| T |  |  |
| **Timeliness** | Month |  | G |  |  |
| B |  |  |
| T |  |  |
| **Required Measurement Uncertainty** | % ice area fraction |  | G | 5 |  |
| B |  |  |
| T |  |  |
| **Stability** | % |  | G | 5 |  |
| B |  |  |
| T |  |  |
| **Standards and References** |  | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** |  |  |  | | |
| **Extremes[3]** |  |  |  | | |

[1]Goal (G); Breakthrough (B)(not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

|  |  |
| --- | --- |
| Author:Petra Heil | Email: petraheil1@gmail.com |
| Wondering if weekly data are sufficient... as one would be able to use daily CICE and other sea-ice parameters to explore, for example, the dynamic contributions to ice thickness etc if high-freq (at least daily) info are available.  Also: Spatial resolution requirements are quite coarse. | |

### Comment 2

|  |  |
| --- | --- |
| Author: Thomas Lavergne | Email: thomasl@met.no |
| Some elements below:  Spatial Resolution: today most existing climate data records of sea-ice concentration that span the 40+ years of available satellite data are at a resolution of 25 - 50 km (gridded at 25 km, but representative of a larger area). They are however what we have and have always had to describe the changing sea-ice. It is not intuitive to read 15 km as "Threshold" (The minimum requirement: the value that has to be met to ensure that data are useful). (Note: of course higher resolution <15km can be achieved for part of the time-series, e.g. post 2002, but then the length is limited). A solution could be to bring 15km to breakthrough, and have 25km as threshold.  Vertical resolution is n/a not applicable  Temporal resolution: the satellite observations open for daily and even sub-daily. A user requirement of "weekly" is thus met.  Timeliness: sea-ice extent/area (derived from sea-ice concentration) are one of the iconic indicators of climate change. monthly trends are often discussed reported and updated on a monthly basis, as well as daily min/max values. So a goal of "daily" (at least "monthly") timeliness does make sense (and is achievable). | |

### Comment 3

|  |  |
| --- | --- |
| Author: Shinya Kobayashi | Email: shn.kobayashi@gmail.com |
|  |  |
| \* Temporal Resolution  The sea ice concentration is an imporant variable for computing the sensible and latent heat fluxes in the polar regions performed by physical parameterizations in models. Therefore, I think that higher temporal resolution is needed (say, 12 hourly for Goal and daily for Threshold).  \* Timeliness  Sea ice concentration data are used as a boundary condition for reanalysis, and in order to use them for near-real-time continuation of reanalysis as well, the data need to be made available within a one-day delay or so from the real time. If the data are made available within this time frame, that would enable a consistent use of sea ice concentration data between the past and near-real-time periods in reanalysis. | |

### Comment 4

|  |  |
| --- | --- |
| Author: Shinya Kobayashi | Email: shn.kobayashi@gmail.com |
| Let me correct my previous comment regarding the Temporal Resolution, "... (say, 12 hourly for Goal and daily for Threshold)", which should be "... (say, 12 hourly for Goal and daily for Breakthrough)". I am sorry about the mistake. | |

### Comment 5

|  |  |
| --- | --- |
| Author: ECMWF | Email: ecresgcosreqs@gmail.com |
| Temporal resolution:  Further to the previous comments, the timings of sea ice retreat and sea ice advance during the year and their temporal changes/trends are important climate indicators for the polar regions (see, e.g., the work done by the SIMIP - Sea Ice Advance and Retreat Working group). These indicators require daily sea ice data. Therefore, a goal of weekly temporal resolution is clearly insufficient. In agreement with the previous comments, the requirements for temporal resolution could be changed to G: 12-hourly, B: daily, and T: weekly.  Adaptation/Extremes:  Sea ice concentration is clearly relevant for monitoring and supporting adaptation of societies, economies, and ecosystems to climate change in northern high latitudes.This ECV product is also relevant for monitoring extremes, which would typically refer to sudden, rapid, and substantial sea ice loss (also called "drastic ice reduction events" by Ono et al., 2019) over the course of a single melt season.  Ono, J., H. Tatebe, and Y. Komuro, 2019: Mechanisms for and Predictability of a Drastic Reduction in the Arctic Sea Ice: APPOSITE Data with Climate Model MIROC. J. Climate, 32, 1361–1380, https://doi.org/10.1175/JCLI-D-18-0195.1. | |

1. Goal (G); Breakthrough (B) (not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review) [↑](#footnote-ref-1)
2. Is the ECV Product directly relevant to support Climate Adaptation? [↑](#footnote-ref-2)
3. Can the ECV Product be used to monitor climate extremes or aspects of extremes? [↑](#footnote-ref-3)