Ocean and Sea Ice SAF

Product User Manual for the OSI SAF AMSR-2 Global Sea Ice Concentration

Product OSI-408

Version 1.1

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Documentation Change Record

Document version	Software version	Date	Change	Description
V 1.0	V 1.0	26.04.2016		First Version.
V 1.1	V1.0	11.08.2016		Update after ORR

The software version number gives the corresponding version of the OSI SAF AMSR-2 High Latitude software chain, which is used to produce the sea ice concentration product OSI-408.

CONTENTS

1. IntroductionThe EUMETSAT Ocean and Sea Ice SAF

To complement its Central Facilities capability in Darmstadt and to benefit from specialized expertise in Member States, EUMETSAT created Satellite Application Facilities (SAFs). They are based on co-operation between several institutes and hosted by a National Meteorological Service. More on SAFs can be read at www.eumetsat.int.

The Ocean and Sea Ice Satellite Application Facility (OSI SAF) produces, on an operational basis, a range of air-sea interface products, namely: wind, sea ice characteristics, Sea Surface Temperatures (SST), Surface Solar Irradiance (SSI) and Downward Longwave Irradiance (DLI). The OSI SAF consortium is hosted by Météo-France. Sea ice products are produced at the OSI SAF High Latitude processing facility (HL centre), operated jointly by The Norwegian and The Danish Meteorological Institutes. The sea ice products include sea ice concentration, the sea ice emissivity, sea ice edge, sea ice type and sea ice drift and sea ice surface temperature (from mid 2013).

This document gives an overview of the processing sets involved in producing the sea ice concentration products, the specification of the product and the how it may be accessed. Two sea ice products are generated:one using the TUD algorithm and another using with the OSHD algorithm. The OSHD product is the primary product and is recommend for operational systems. The TUD product is experimental and is more susceptible to noise. It has potentially higher resolution that the OSHD, but this is difficult confirm, because of the low resolution of the reference data set used for validation (see RD.3).

The sea ice concentration products are available daily within 6 hours after the last satellite data acquisition. This means before 06:00 UTC each day. The sea ice concentration products are delivered with global coverage on two files, one for the Northern and one for the Southern Hemisphere.

1.1 Ownership and copyright of data

The OSI SAF sea ice concentration data have been produced under the responsibility of the Norwegian Meteorological Institute and the Danish Meteorological Institute.
The ownership and copyrights of the data set belong to EUMETSAT. The data is distributed freely, but EUMETSAT must be acknowledged when using the data. EUMETSAT’s copyright credit must be shown by displaying the words "copyright (year) EUMETSAT" for each of the products used. User feedback to the OSI SAF project team is highly valued. The comments we get from our users are important argumentation when defining development activities and updates. We welcome anyone to use the data and provide feedback.

1.2 Scope

This document is targeted at OSI SAF product users and describes the AMSR-2 sea ice concentration product (OSI-408).

1.3 Sea ice concentration algorithm

This product fulfils the requirement OSI-PRD-PRO-207 “The OSI SAF shall improve the coverage of the existing sea ice concentration, edge and type products by adding interpolation in the coastal zone and the area close to the pole where there is no satellite data coverage.” in the OSI SAF Product Requirement Document [RD.1]. The sea ice concentration algorithm is presented in the algorithm theoretical basis document [RD.2]. This document gives an overview of the processing scheme, a description of the product and how it may be accessed. The validation results of the methodology are presented in the validation report [RD.3].

This product is delivered in HDF5 and NetCDF formats through the MET Norway FTP server and EUMETSAT EUMETCast service.

1.4 Definitions, acronyms and abbreviations

AMSR	Advanced Microwave Scanning Radiometer
ATBD	Algorithm Theoretical Basis Document
CF	Climate and Forecast (Metadata Conventions)
CLW	Cloud liquid water
DLI	Downward Longwave Irradiance
DMI	Danish Meteorological Institute
ECMWF	European Centre for Medium-Range Weather Forecasts
EDC	EUMETSAT Data Center
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
FTP	File Transfer Protocol
GCMD	Global Change Master Directory
GCOM	Global Change Observation Mission
LDAP	Lightweight Directory Access Protocol
MET Norway	Norwegian Meteorological Institute
NASA	National Aeronautics and Space Administration
NetCDF	Network Common Data Form
NH	Northern Hemisphere
NSIDC	National Snow and Ice Data Center
NWP	Numerical Weather Prediction
OSHD	OSI SAF Hybrid Dynamic
OSI SAF	Ocean and Sea Ice Satellite Application Facility
RMDCN	Regional Meteorological Data Communication Network
RTM	Radiative Transfer Model
SAF	Satellite Application Facilities
SD	Standard deviation
SH	Southern Hemisphere
SMMR	Scanning Multichannel Microwave Radiometer
SSI	Surface Solar Irradiance
SSM/I	Special Sensor Microwave/Imager
SSMIS	Special Sensor Microwave Imager/Sounder
SST	Sea Surface Temperatures
Tb	Brightness temperature
TUD	Technical University of Denmark
UCS	User Coordinate System
WMO	World Meteorological Organization

Reference Documents

[RD.1] OSI SAF CDOP2 Product Requirement Document, v3.5.

[RD.2] The EUMETSAT OSI SAF AMSR-2 Sea Ice Concentration Algorithm Theoretical Basis Document, v1.0.

[RD.3] Validation Report for The OSI SAF AMSR-2 Sea Ice Concentration, v1.0.

2 Input data

This chapter describes the AMSR-2 satellite data which is processed using both the OSI SAF Hybrid Dynamic (OSHD) and Technical University of Denmark (TUD) sea ice concentration algorithms. The algorithm is flexible and it can process other types of microwave radiometer data such as SSM/I, SMMR, and SSMIS. Further, the algorithm uses numerical weather prediction (NWP) data from ECMWF for correction of the brightness temperatures prior to calculating the sea ice concentration. The NWP parameter fields are briefly described in Section 2.2.

The AMSR-2 level-1B data is accessed via the GCOM-W1 Data Providing Service (http://gcom-w1.jaxa.jp/). (See Data Users' Manual for the AMSR2: http://suzaku.eorc.jaxa.jp/GCOM_W/data/doc/amsr2_data_user_guide.pdf)

2.1 The AMSR-2 Instrument

The AMSR-2 instrument is a dual-polarized, conically scanning, microwave radiometer. The conically scanning radiometer has a constant incidence angle of approximately 55 degree on the ground and a swath width of approximately 1450 km. The channels used in the computation of the ice concentration fields are given in Table 1.

Nominal Band [Ghz]	Band [GHz]	Polarization	Spatial Resolution [km x km]
19	18.70	V	22 x 14
37	36.50	V,H	12 x 7
89	89.00	V,H	5 x 3

Table 1 : The AMSR-2 instrument channels used for computation of the ice concentration product and their spatial resolution.

2.2 NWP data and radiative transfer model correction

The brightness temperatures (Tb) are corrected explicitly for emission from the geophysical noise sources, including air temperature, wind roughening over open water and water vapour in the atmosphere, prior to the calculation of ice concentration. The correction uses a radiative transfer model function (RTM) and NWP data. Over areas with both ice and water the influence of open water roughness on the Tbs and the ice emissivity is scaled linearly with the ice concentration. The emissivity of ice is given by standard tie-point emissivities (Comiso et al. 1997). The correction procedure is described in the ATBD [RD.2] and in Andersen et al. (2006A). The NWP model grid points are co-located with the satellite swath data in time and space and a correction to the Tbs is applied. The ECMWF High Resolution Atmospheric Model is used, which has a native resolution of 9 km and a time resolution of three hours; the closet 3-hour forecast is used.

The representation of atmospheric liquid water column in the NWP data is not suitable for use with the Tb correction (see Andersen et al., 2006A). The issue has been revisited several times but the conclusion from the reference still holds. The Cloud Liquid Water (CLW) is an important error source in SIC retrieval over open water and in the mixed zone and its representation in the NWP is problematic. Over near 100% ice it is not important. It is highly correlated with other error sources e.g. water vapour in the atmosphere and it is therefore hard to quantify each individual error source. The problem is that the representation of CLW in the NWP model data is not sufficiently quantified or co-located with the satellite observations and the inclusion of CLW adds noise rather than reducing it. The Tbs are therefore not corrected for the influence of CLW. It is constrained to zero in the RTM. The RTM is described in Wentz and Meissner, 2000 and this specific implementation is described in the ATBD [RD.2].

3 Processing scheme

This section describes the steps in the OSI SAF AMSR-2 sea ice concentration processing scheme. The Level 1 swath data is processed to produce a map of ice concentration on a polarsterographic grid, as shown in Figure 1.

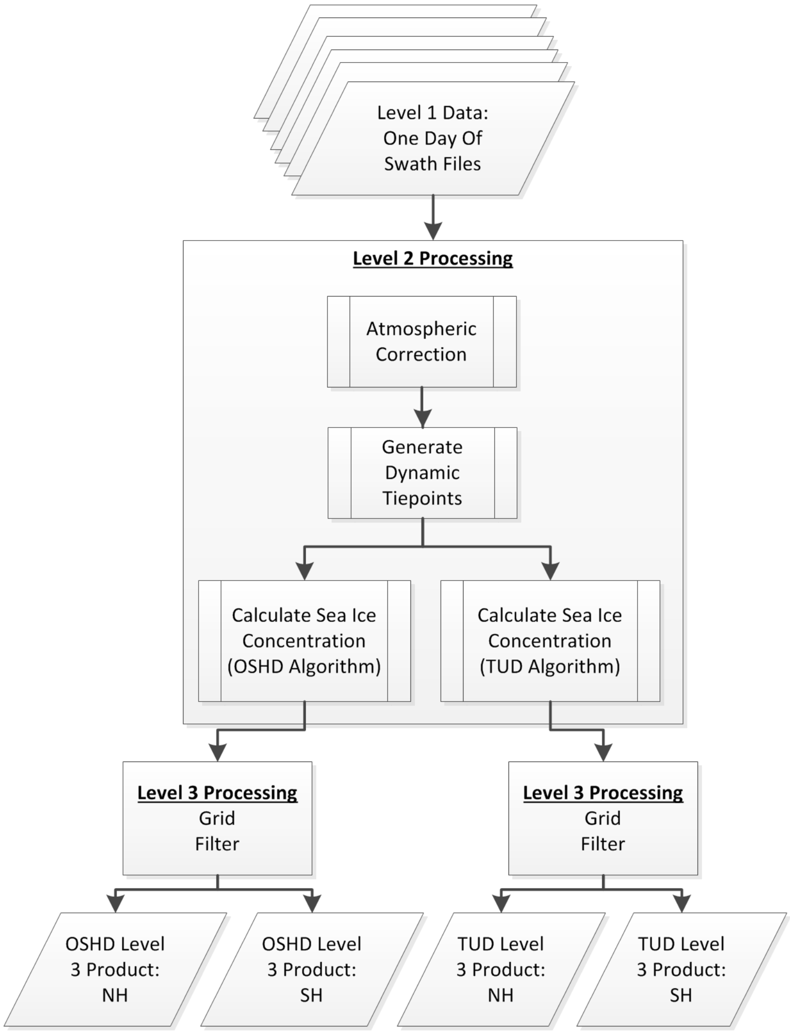


Figure 1: Processing flow chart for the Level 2 and 3 production.

Two ice concentration fields are produced: one computed using the OSHD algorithm and another using the TUD. The OSHD algorithm utilizes the 19 GHz and 37 GHz channels. The TUD utilizes the 89 GHz, 19 GHz and 37 GHz channels , falling back on only the 19 GHz and 37 GHz channels in regions with low ice concentration.

This main step contains all processing done on the original swath data, without re-sampling or averaging. Numerical Weather Prediction (NWP) data from ECMWF HRES model were interpolated in time and space to the position of each brightness temperature swath grid point. The NWP model has a spatial resolution of ~9 km and and temporal resolution of 3 hours.

3.1 Dynamical tie-points

Using the channels featured on the AMSR-2 instrument in combination with the radiative characteristics of sea ice, it is possible to distinguish Arctic multiyear and first-year ice concentrations during winter. In order to achieve this it is necessary to provide typical emissivities or brightness temperatures, called tie-points, of ice and open water. Errors and inconsistencies in the estimated ice concentrations may arise when deviations from the tie-point emissivities occur over time due to e.g. melting, flooding, snow cover effects and wind roughening of the ocean surface as well as spatially due to geographical differences in chemical and physical conditions. Nevertheless, tie-point sets, supplied with the various sea ice concentration algorithms, are usually hemispheric and constant in time, although Comiso et al. (1997) have defined sets to cover the summer period for the Bootstrap algorithm. Finally, it is common to define the water tie-point based on minimum observed brightness temperatures, corresponding to a minimum atmospheric influence. However, due to the average atmospheric contribution, this results in a bias over open water and frequent spurious ice concentrations. In order to improve on this, here we use dynamical tie-points based on the actual mean signatures of ice and of open water. The dynamical tie-point method described in the ATBD [RD.2] uses principal component analysis to determine clusters of sea ice and open water.

The swath data for one day is collected and every swath brightness temperature is corrected for atmospheric influence. An initial estimate of the ice concentration is then computed by the NASA Team ice concentration algorithm. The following sea ice parameters are computed:

- The number of near 100% sea ice brightness temperature data points
- The number of open water (near the ice edge) brightness temperature data points
- Using a principal component analysis in the space spanned by the brightness temperatures :
  - the coordinates of the open water tie-point
  - the vector describing the ice line

Dynamic tie-points are used in both the OSHD and TUC algorithms. A weighted hemispheric mean over the last 30 days is computed based on the daily information. The 30 day mean is then used as the tie-point in the sea ice concentration algorithm. The 30 days window is a compromise between capturing the rapid tie-point changes observed at the onset of melt and avoiding the influence of individual weather systems affecting the signatures on shorter time-scales. In addition, the 30 day period is consistent with the OSISAF sea ice climate dataset which uses the same methodology and tie-point selection method.

3.2 Estimation of sea ice concentration

The OSHD and TUC algorithms which are used to compute the sea ice concentration are described in the ATBD.

3.3 Level 3 processing

The ice concentration is calculated using the sea ice concentration algorithm as described in the ATBD with AMSR-2 tie-points. In the second step of this calculation, the multi pass analysis, these results are analysed on the 10 km OSI SAF grid. Several AMSR-2 observation nodes, with estimated concentrations, influence each analysis grid point. The radius of influence, *r*, for each AMSR-2 observation is 36 km for both algorithms; this is twice the FWHM of the beam pattern of the lowest frequency channels used in the algorithms. The weight assigned to each AMSR-2 observation in the analysis is dependent on a Gaussian weighting scaled with the footprint size, as described in the ATBD [RD.2]. Data is missing for the North and South pole because they are not covered by the satellite due to the inclination of the satellite orbit and swath width. The specifications of the sea ice map projection and grid description are given in Table 2 and Table 3.

3.4 Climatology and land mask

Monthly climatology fields of maximum sea ice extent are provided by NSIDC (see http://nsidc.org for details). This dataset is currently based on data from SMMR and SSM/I spanning the period from 1979 through 2002, but will be updated in future.

Measurement which are near land can be affected be land spill-over. Land spill-over is due the contamination of the sea pixel measurements by emissions from the land, due to the instrument's field of view intersecting with the land (Markus, T. et al.). As shown in Figure 1, certain regions are masked out, in particular regions with curved coastlines which contain large amounts of land spill over are masked out. In particular, regions of the Baltic are masked out. This is the same mask as is used in the SSMI product.

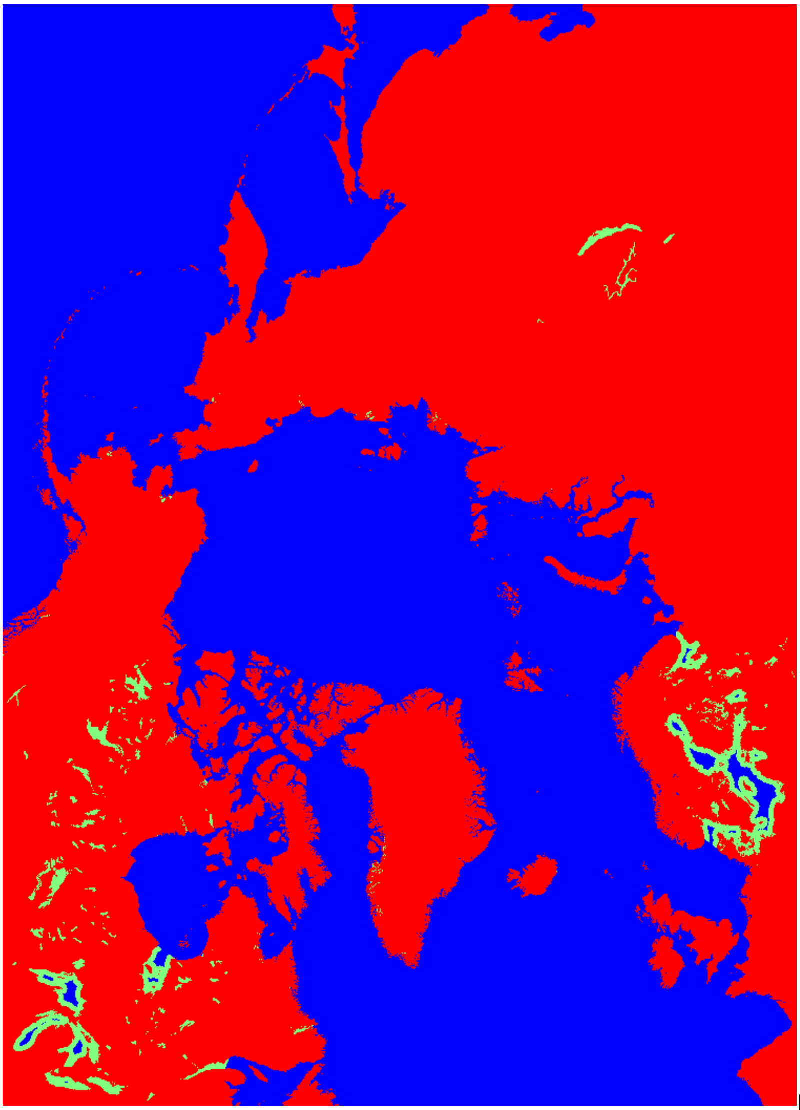


Figure 1: An image showing the lake and coastal zones that are masked out.

Ice is only calculated on the lakes for months 1, 2, 3, 4 and 12, otherwise the ice concentration is set to zero over the regions of the lakes that are not masked out. (See Section 3.6 for more details.)

Measurements near the shore are a mixture of land, coast (mixed ice/water and land pixels) and ice/water emission. The coastline has been derived on the OSI SAF grids from the World Vector Shoreline (http://shoreline.noaa.gov/data/datasheets/wvs.html). In the Southern Hemisphere, information on ice shelf coverage has been added from the NASA AMSR-E land masks and a mask based on inspection of recent VIS-IR imagery developed by S. Kern, University of Hamburg. The mask includes 3 types of pixels: “land”, “coast” and “sea”. Sea ice calculations are done over the “sea” pixels. The “coast” pixels are pixels within a fixed distance from the coastline over sea areas. This fixed distance is chosen in accordance with the size of the footprint of the AMSR-2 data.

Areas near the coast in the Baltic Sea and around Denmark have been masked out. This due to a large amount of land-spillover in that region.

All the lakes have been masked out,with the exception of central regions of Lakes Superior, Michigan and Huron. These lakes have sufficiently large dimensions to have low spill-over. At their centres. Here, the sea ice algorithm has been applied with global tie-points to fresh water and fresh water ice, so these measurements should be used with some caution, and are only indicative of the presence or absence of ice. . They are only included due to demand by users who want a data source for lake ice data, covering the earth.

3.5 Sea ice concentration uncertainties

Uncertainty estimates are needed when the ice concentration data are compared to other data sets or when the ice concentrations are assimilated into numerical models. The mean accuracy of some of the more common algorithms, used to compute ice concentration from SSM/I data, such as NASA Team and Bootstrap are reported to be 1-6 % in winter (Andersen et al., 2006B). In summer the uncertainties are much larger and melt-ponds are included as part of the open water fraction (Kern et al., 2016). This is also achieved with the OSHD algorithm measured as the standard deviation of the difference relative to a reference (open water or 100% ice).

Atmospheric emission and scattering is an error source for retrievals in atmospheric windows. Additionally, tie points are only representative on a hemispheric scale, and deviations from the typical ice and water signatures. Deviations from the typical surface emission signatures result in ice concentration uncertainties.

The AMSR-2 instrument has large footprints on the ground, and the algorithms with the lowest sensitivity to both atmospheric and surface emissivity variability use Tb's at different frequencies with different footprint sizes. Representing these large footprints on a finer, predefined grid results in a representativeness error. This is sometimes called smearing. Additional sources of error are the geo-location error, sensor noise, drift, and sea ice variability over the sampling period.

The representativeness error is computed as a function of ice concentration using a model Tonboe (2016). The tie-point uncertainty (which is the algorithm uncertainty) including residual atmospheric noise, sensor noise and ice surface emissivity variability, is derived from measurements. The total uncertainty is the square root of the sum of the uncertainties squared components:

$$\varepsilon_{total}^2 = \varepsilon_{algorithm}^2 + \varepsilon_{smearing}^2,$$

where the algorithm uncertainty is the inherent uncertainty of the concentration algorithm and the smearing uncertainty is the uncertainty due to re-sampling to a grid where the sensor footprint covers more than one pixel. These are the three uncertainties given in the ice concentration product. The sea ice concentration uncertainty algorithm is described in detail in the ATBD [RD.2].

4 Product description

This chapter gives a description of the product specification, metadata, data formats and product distribution.

4.1 Product specification

The product consists of these major fields:

- sea ice concentration
- uncertainties: total, algorithm and smearing
- confidence level

Sea ice concentration
Sea ice concentration indicates the fraction of a given ocean grid point covered by ice. It is given as a decimal number, with range from 0-100%.

Uncertainties
The algorithm uncertainty, the smearing uncertainty and the resulting total uncertainty of each sea ice concentration grid cell value are given in three separate fields. These, absolute, uncertainties are given in percentages, with a range from 0-100%. The algorithm is described in the ATBD [RD.2].

Confidence level
The confidence level is based on the daily standard deviation within each gridcell, and is defined using the calculated standard deviation (SD) of the sea ice concentration going from L2 to L3. The confidence levels are defined as follows:

- nominal processing, excellent quality: SD 0 – 10
- nominal processing, good quality: SD 10 – 20
- nominal processing, acceptable quality: SD 20 – 30
- processed but to be used with care: SD > 30
- computation failed: Erroneous
- not processed, no input data: No data.

The confidence level is given as a guide only. The user is advised to use the total uncertainty to estimate the quality of the data, rather than the confidence level. The confidence level is subject to elimination in future product versions.

4.2 Grid specification

The product grids are adapted from the 25 km resolution Goddard Space Flight Center projections used to disseminate various SSM/I based products available at the National Snow and Ice Data Center (see [http://nsidc.org] for details). There is one grid for the Northern Hemisphere product (NH) and one grid for the Southern Hemisphere product (SH).

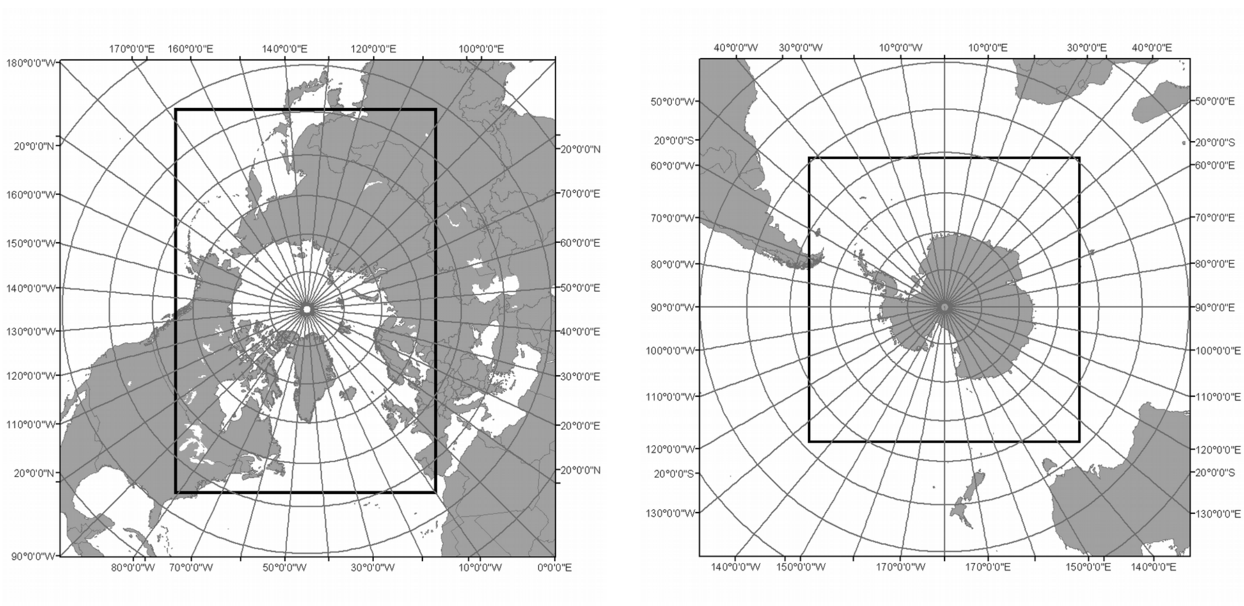
Below are given the grid definitions and approximate maps of the grid extents. Corner coordinates are the coordinates of center of corner the pixels. s. Projection definitions in the form of PROJ-4 initialization strings are also given (see [http://www.remotesensing.org/proj] for details).

Projection:	Polar stereographic projection true at 70°N
Resolution:	10 km
Size:	760 columns, 1120 lines
Central Meridian:	45°W
Radius of Earth:	6378273 x 6356889.44891 m
PROJ-4 string:	+proj=stere +a=6378273 +b=6356889.44891 +lat_0=90 +lat_ts=70 +lon_0=45

Table 2: Geographical definition for the Northern Hemisphere (NH) Grid.

Projection:	Polar stereographic projection true at 70°S
Resolution:	10 km
Size:	790 columns, 830 lines
Central Meridian:	0°
Radius of Earth:	6378273 x 6356889.44891 m
PROJ-4 string:	+proj=stere +a=6378273 +b=6356889.44891 +lat_0=-90 +lat_ts=-70 +lon_0=0

Table 3: Geographical definition for Southern Hemisphere (SH) Grid.



Northern Hemisphere **Southern Hemisphere**

Figure 2: Coverage of the Northern and Southern grids are shown by the black, thick boxes (from NSIDC).

4.3 Product sample

Figures 3 and 4 show examples of OSHD and TUD sea ice concentration products, respectively, for the Northern and Southern hemispheres.

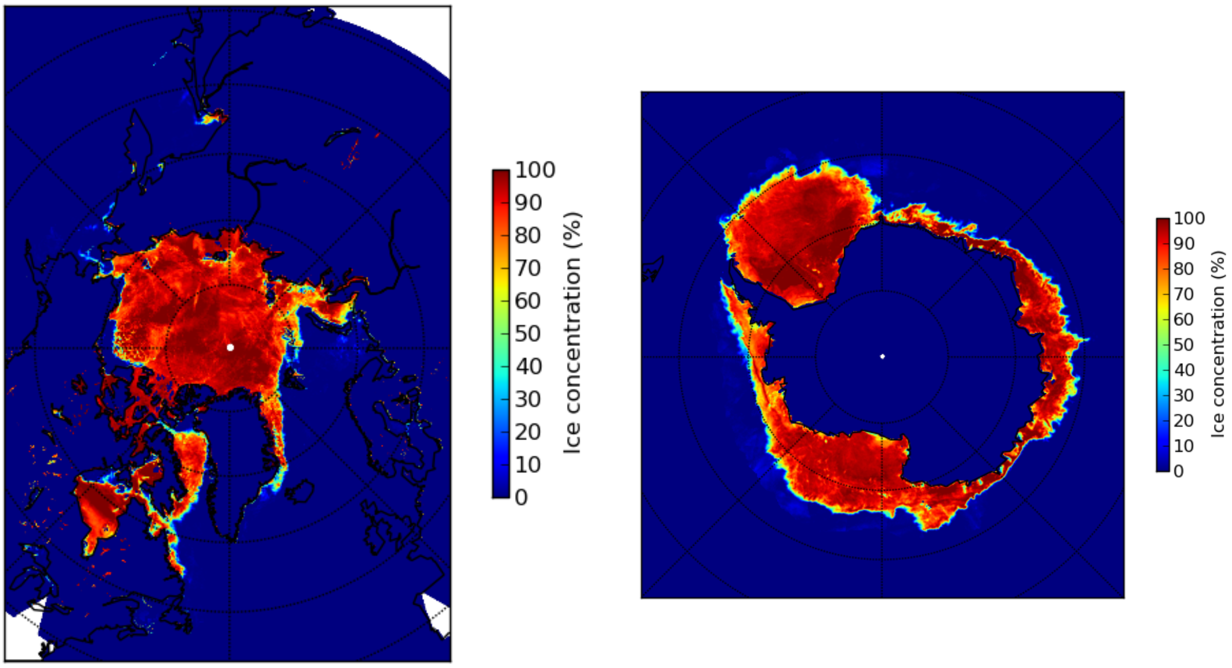


Figure 3: The ice concentration for 23 May 2016 at the Northern (left) and Southern (right) Hemispheres, computed using the OSHD .

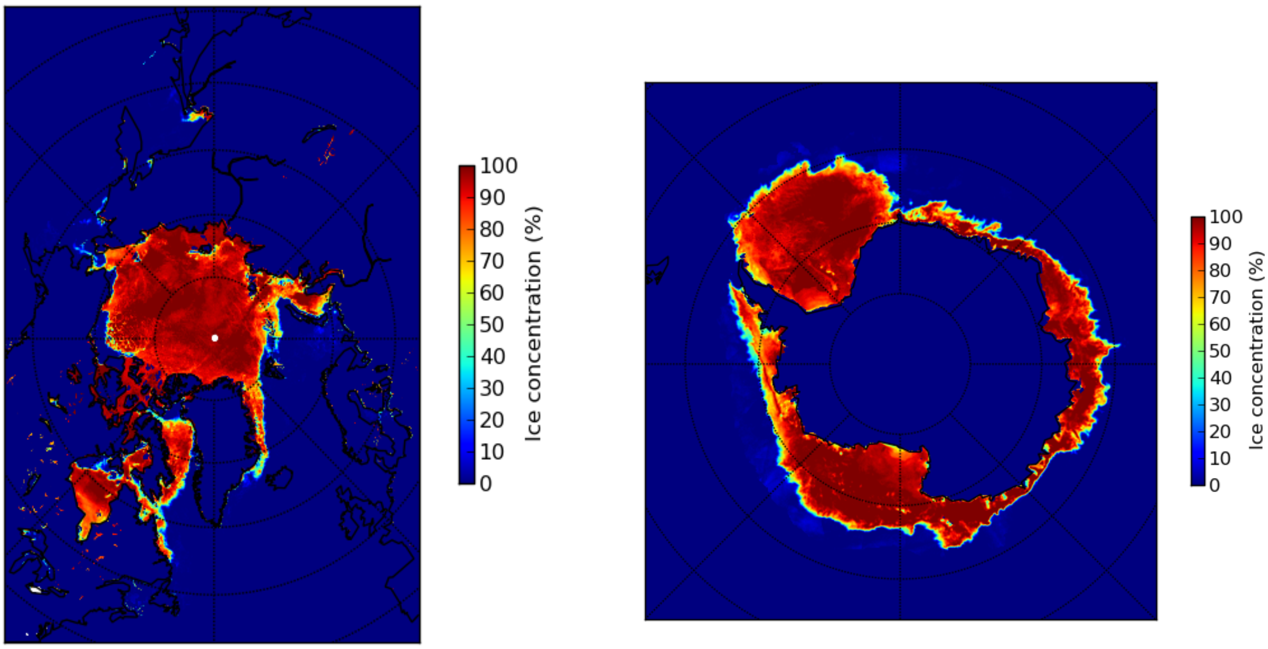


Figure 4: The ice concentration for 23 May 2016 at the Northern (left) and Southern (right) Hemispheres, computed using the TUD algorithm.

In general the TUD is giving higher concentrations in regions with near 100% ice. However there are some regional differences. A good reference describing the differences between algorithms (including the TUD and OSHD) is Ivanova N. et al..

4.4 File formats

The products are available in NCSA HDF5 format and Unidata NetCDF format. More information about the OSI SAF sea ice data formats can be found at http://osisaf.met.no/p/ice/.

HDF5 format

The HDF5 format is a public format. Documentation is found at: http://www.hdfgroup.org/HDF5/doc

The metadata are stored in HDF5 attributes. Appendix B describes the HDF5 attributes defined for the sea ice concentration data products.

NetCDF3 format

The NetCDF3 format is a public format, with documentation available at: http://www.digitalpreservation.gov/formats/fdd/fdd000330.shtml

The OSI SAF sea ice products use the CF 1.0 standard for metadata in the NetCDF3 files. The metadata in the NetCDF3 files are described in Appendix C. More metadata have been added to the NetCDF files than the HDF5 files.

4.5 Data distribution

There are two main sources for obtaining the OSI SAF Sea Ice products in near-real time; by FTP or through EUMETCast. In addition the products can be delivered through the Regional Meteorological Data Communication Network (RMDCN) on request.

At the OSI SAF Sea Ice FTP server [ftp://saf.met.no/prod/ice] the products are available in HDF5 format and NetCDF format.. Here products from the last month are available. In addition, there is a separate directory with an archive of all previously produced sea ice products (up to the last available product) at [ftp://saf.met.no/archive/ice]. The file name convention for these products is given in the table Section 5.6.

The distributed files have been compressed with gzip. Different file name conventions have been chosen for the Sea Ice products at EUMETCast since many different products are disseminated through EUMETCast. More information about the EUMETCast service can be found at [http://www.eumetsat.int].

4.6 Filename convention

Four files are produced each day: one pair for each hemisphere for the ice concentration field computed using the OSHD algorithm and another pair for the ice concentration field computed using the TUD algorithm. The following table gives the file name convention used on the OSI SAF FTP server:

File name convention for NH and SH NetCDF3 files on OSI SAF FTP and LDAP server	
Ice concentration OSHD	ice_conc_XX_polstere-100_amsr2_<date12>.nc
Ice concentration TUD	ice_conc_XX_polstere-100_amsr2-tud_<date12>.nc

XX: NH for Northern Hemisphere products, SH for Southern Hemisphere.
<date12>: Date and time of the product on format YYYYMMDDhhmm, e.g. 201501011200.

Only the OSHD-algorithm product (in NetCDF format) will be distbributed through EUMETCast, not the TUD product. The following table gives the file name convention used for the product disseminated through EUMETCast.

File name convention for NH and SH files through EUMETCast	
Sea Ice Product: NetCDF	
Ice concentration	S-OSI_-DMI_-MULT-GL_XX_CONC__-<date12>.nc.gz
Ice concentration quality index	S-OSI_-DMI_-MULT-GL_XX_CONC_Q-<date12>.nc.gz

5 References

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Wentz, F. J. A well-calibrated ocean algorithm for SSM/I. *Journal of Geophysical Research* 102(C4), 8703-8718, 1997.

Appendix B: The OSIHDF5 format

The sea ice products are stored in a local implementation of the HDF5 format, which is called the OSIHDF5 format. More details about this format are presented at the OSI SAF Sea Ice web portal [http://saf.met.no], under Documents. The information presented here describes all the metadata in the product files.

The tables in this appendix give the description of the parameters and the content of the fixed parameters for each sea ice product.

OSI SAF Sea Ice products HDF5 format		
Object	Element	Contents
Header	source	Source of product, "OSI_SAF_HL" for all products.
	product	Type of product.
	area	Name of product grid area.
	projstr	PROJ-4 string for product projection.
	iw	Image width.
	ih	Image height.
	z	Number of fields in file, "1" for all products.
	Ax	Pixel size in x and y-direction.
	Ay	
	Bx	x and y-position of upper left corner of upper left pixel in UCS coordinates.
	By	
	year	Date and time of product.
	month	
	day	
	hour	
	minute	
data[00]	description	Description of data field.
	osi_dtype	Data value type.

Values for fixed Header parameters for the hree product grids			
Parameter	NH grid	SH grid	
area	"OSISAF_NH"	"OSISAF_SH"	
projstr	(see tables under 'Grid Specification' for values)		
iw	760	790	
ih	1120	830	
Ax	10.0	10.0	
Ay	10.0	10.0	
Bx	-3850.0	-3950.0	
By	5850.0	4350.0	

Values for fixed parameters for each Sea Ice product			
Sea Ice Product	Header/"product"	data/"description"	data/"osi_dtype"
Ice concentration	"Ice Conc"	"Ice Conc"	OSI_FLOAT
Ice concentration quality index	"Ice Conc QF"	"Ice Conc QF"	OSI_UINT

Appendix A: Sea Ice products in NetCDF format

The OSI SAF Sea Ice products have been made available in NetCDF format.
Below is an example of the NetCDF header of a sea ice concentration file computed using the OSHD algorithm.

```
$ ncdump -h ice_conc_nh_polstere-100_amsr2_201605171200.nc
netcdf ice_conc_nh_polstere-100_amsr2_201605171200 {
dimensions:
        time = 1 ;
        nv = 2 ;
        xc = 760 ;
        yc = 1120 ;
variables:
        int Polar_Stereographic_Grid ;
                Polar_Stereographic_Grid:grid_mapping_name = "polar_stereographic" ;
                Polar_Stereographic_Grid:false_easting = 0. ;
                Polar_Stereographic_Grid:false_northing = 0. ;
                Polar_Stereographic_Grid:semi_major_axis = 6378273. ;
                Polar_Stereographic_Grid:semi_minor_axis = 6356889.44891 ;
                Polar_Stereographic_Grid:straight_vertical_longitude_from_pole = -45. ;
                Polar_Stereographic_Grid:latitude_of_projection_origin = 90. ;
                Polar_Stereographic_Grid:standard_parallel = 70. ;
                Polar_Stereographic_Grid:proj4_string = "+proj=stere +a=6378273
+b=6356889.44891 +lat_0=90 +lat_ts=70 +lon_0=-45" ;
        double time(time) ;
                time:axis = "T" ;
                time:long_name = "reference time of product" ;
                time:standard_name = "time" ;
                time:units = "seconds since 1978-01-01 00:00:00" ;
                time:calendar = "standard" ;
                time:bounds = "time_bnds" ;
        double time_bnds(time, nv) ;
                time_bnds:units = "seconds since 1978-01-01 00:00:00" ;
        double xc(xc) ;
                xc:axis = "X" ;
                xc:units = "km" ;
                xc:long_name = "x coordinate in Cartesian system" ;
                xc:standard_name = "projection_x_coordinate" ;
        double yc(yc) ;
                yc:axis = "Y" ;
                yc:units = "km" ;
                yc:long_name = "y coordinate in Cartesian system" ;
                yc:standard_name = "projection_y_coordinate" ;
        float lat(yc, xc) ;
                lat:long_name = "latitude coordinate" ;
                lat:standard_name = "latitude" ;
                lat:units = "degrees_north" ;
        float lon(yc, xc) ;
                lon:long_name = "longitude coordinate" ;
                lon:standard_name = "longitude" ;
                lon:units = "degrees_east" ;
        short ice_conc(time, yc, xc) ;
                ice_conc:_FillValue = -999s ;
                ice_conc:long_name = "The sea ice concentration on the northern
hemisphere" ;
                ice_conc:standard_name = "sea_ice_area_fraction" ;
                ice_conc:units = "%" ;
                ice_conc:valid_min = 0s ;
                ice_conc:valid_max = 10000s ;
                ice_conc:grid_mapping = "Polar_Stereographic_Grid" ;
                ice_conc:coordinates = "lat lon" ;
                ice_conc:scale_factor = 0.01f ;
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                ice_conc:add_offset = 0.f ;
        byte confidence_level(time, yc, xc) ;
                confidence_level:long_name = "confidence level" ;
                confidence_level:valid_min = 0b ;
                confidence_level:valid_max = 5b ;
                confidence_level:grid_mapping = "Polar_Stereographic_Grid" ;
                confidence_level:coordinates = "lat lon" ;
                confidence_level:flag_values = 0b, 1b, 2b, 3b, 4b, 5b ;
                confidence_level:flag_meanings = "unprocessed, erroneous, unreliable,
acceptable, good, excellent" ;
                confidence_level:flag_descriptions = "\n",
                        "0 -> not processed, no input data\n",
                        "1 -> computation failed\n",
                        "2 -> processed but to be used with care\n",
                        "3 -> nominal processing, acceptable quality\n",
                        "4 -> nominal processing, good quality\n",
                        "5 -> nominal processing, excellent quality" ;
        byte status_flag(time, yc, xc) ;
                status_flag:_FillValue = -1b ;
                status_flag:units = "1" ;
                status_flag:long_name = "status flag for concentration of sea ice
retrieval" ;
                status_flag:standard_name = "sea_ice_area_fraction status_flag" ;
                status_flag:valid_min = 0b ;
                status_flag:valid_max = 102b ;
                status_flag:grid_mapping = "Polar_Stereographic_Grid" ;
                status_flag:coordinates = "lat lon" ;
                status_flag:flag_values = 0b, 2b, 10b, 14b, 100b, 101b, 102b ;
                status_flag:flag_meanings = "nominal lake background type_mask land
missing unclassified" ;
                status_flag:flag_descriptions = "\n",
                        "  0 -> nominal value from algorithm used\n",
                        "  2 -> sea ice algorithm applied over lake\n",
                        " 10 -> background data was used for setting the value\n",
                        " 14 -> value set using an ice type mask\n",
                        "100 -> missing value due to over land\n",
                        "101 -> missing value due to missing data\n",
                        "102 -> unclassified pixel" ;
        float total_uncertainty(time, yc, xc) ;
                total_uncertainty:_FillValue = -1.e+10f ;
                total_uncertainty:least_significant_digit = 3 ;
                total_uncertainty:units = "1" ;
                total_uncertainty:long_name = "The sea ice concentration uncertainty on
the northern hemisphere" ;
                total_uncertainty:coordinates = "lat lon" ;
                total_uncertainty:grid_mapping = "Polar_Stereographic_Grid" ;
        float smearing_uncertainty(time, yc, xc) ;
                smearing_uncertainty:_FillValue = -1.e+10f ;
                smearing_uncertainty:least_significant_digit = 3 ;
                smearing_uncertainty:units = "1" ;
                smearing_uncertainty:long_name = "The sea ice concentration smearing
uncertainty on the northern hemisphere" ;
                smearing_uncertainty:coordinates = "lat lon" ;
                smearing_uncertainty:grid_mapping = "Polar_Stereographic_Grid" ;
        float algorithm_uncertainty(time, yc, xc) ;
                algorithm_uncertainty:_FillValue = -1.e+10f ;
                algorithm_uncertainty:least_significant_digit = 3 ;
                algorithm_uncertainty:units = "1" ;
                algorithm_uncertainty:long_name = "The sea ice concentration algorithm
and tie-point uncertainty on the northern hemisphere" ;
                algorithm_uncertainty:coordinates = "lat lon" ;
                algorithm_uncertainty:grid_mapping = "Polar_Stereographic_Grid" ;

// global attributes:
                :title = "Daily Sea Ice Concentration Analysis from OSI SAF EUMETSAT,
```

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using the OSI SAF Ice Concentration Algorithm" ;
                :product_id = "OSI-408" ;
                :product_name = "osi_saf_amsr2ice_conc" ;
                :product_status = "pre-operational" ;
                :abstract = "The daily analysis of sea ice concentration is obtained from
operation satellite images of the polar regions. It is ased on atmospherically corrected
signal and a carefully selected sea ice concentration algorithm. This product is freely
available from the EUMETSAT Oean and Sea Ice Satellite Application Facility (OSI SAF)." ;
                :topiccategory = "Oceans Climatology Meteorology Atmosphere" ;
                :keywords = "Sea Ice Concentration, Sea Ice, Oceanography, Meteorology,
Climate, Remote Sensing" ;
                :gcmd_keywords = "Cryosphere > Sea Ice > Sea Ice Concentration\n",
                        "Oceans > Sea Ice > Sea Ice Concentration\n",
                        "Geographic Region > Northern Hemisphere\n",
                        "Vertical Location > Sea Surface\n",
                        "EUMETSAT/OSISAF > Satellite Application Facility on Ocean and
Sea Ice, European Organisation for the Exploitation of Meteorological Satellites" ;
                :activity_type = "Space borne instrument" ;
                :easternmost_longitude = 180. ;
                :westernmost_longitude = -180. ;
                :northernmost_latitude = 90. ;
                :southernmost_latitude = 30.98056 ;
                :area = "Northern Hemisphere" ;
                :instrument_type = "AMSR2" ;
                :platform_name = "GCOM-W " ;
                :start_date = "2016-05-17 00:00:00" ;
                :stop_date = "2016-05-18 00:00:00" ;
                :project_name = "EUMETSAT OSI SAF" ;
                :institution = "EUMETSAT OSI SAF" ;
                :PI_name = "Rasmus Tonboe" ;
                :contact = "osisaf-manager@met.no" ;
                :distribution_statement = "Free" ;
                :copyright_statement = "Copyright 2016 EUMETSAT" ;
                :references = "OSI SAF Sea Ice Product Manual, Eastwood S. (editor)\n",
                        "v1.0, April 2016\n",
                        "http://osisaf.met.no\n",
                        "http://www.osi-saf.org" ;
                :history = "2016-05-18 creation" ;
                :product_version = "1.0" ;
                :software_version = "1.0" ;
                :netcdf_version = "3.6.3" ;
                :Conventions = "CF-1.4" ;
}
```