Ocean & Sea Ice SAF

Validation Report for The OSI SAF AMSR-2 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	28.04.2016	First version.
V1.1	V1.0	11.08.2016	Update after ORR

The software version number gives the corresponding version of the OSI SAF High Latitude software chain which was used to produce the sea ice concentration product.

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1 Introduction

1.1 Scope of the document

This report presents the validation results of the OSI SAF AMSR-2 Sea Ice Concentration product OSI-408 version 1.0.

The product is derived from the Advanced Microwave Scanning Radiometer - 2 (AMSR-2) satellite measurements. Two ice concentration fields are computed: the primary one, which is computed with the OSHD ice concentration algorithm and utilises the 19 GHz vertical, 37 GHz vertical and 37 GHz horizontal channels and a second which is computed using the TUD algorithm with the 19 GHz vertical, 37 GHz vertical, 89 GHz vertical, and 89 GHz horizontal channels. These algorithms are described in the Algorithm Theoretical Basis Document (ATBD) [RD.3]. The OSHD product uses the same frequency channels and ice concentration alogorthm as the SSMI/S OSI SAF product, whereas the TUD product utiliizes the high frequency channels and therefore is more suseptiable to noise due to water vapour.

This validation method described in this report is similar to the methodology that is used for the ongoing validation of the ice concentration product and documented in the half-year operations report. The validation is a comparison between the OSI SAF AMSR-2 ice concentrations, derived from satellite microwave radiometer data, and ice charts produced manually on the basis of satellite and reconnaissance data for ship navigation support.

1.2Reference documents

[RD-1] : OSI SAF Global Sea Ice Concentration Product User Manual.
[RD-2] : OSI SAF Product Requirement Document.
[RD.3] The EUMETSAT OSI SAF AMSR-2 Sea Ice Concentration Algorithm Theoretical Basis Document, v1.0.

1.3 Definitions, acronyms and abbreviations

AMSR	Advanced Microwave Scanning Radiometer
AOSIC	AMSR-2 OSI SAF ice concentration
AVHRR	Advanced Very High Resolution Radiometer
DMI	Danish Meteorological Institute
FTP	File Transfer Protocol
IAC	Ice chart analysis
MODIS	Moderate Resolution Imaging Spectroradiometer
NH	Northern Hemisphere
NIC	National Ice Center
OSI SAF	Ocean and Sea Ice Satellite Application Facility
SAR	Synthetic Aperture Radar
SH	Southern Hemisphere
SIGRID	Sea ice chart grid format
SSMIS	Special Sensor Microwave Imager Sounder
TUD	Technical University of Denmark
OSHD	OSI SAF Hybrid Dynamic
WMO	World Meteorological Organization

2 Validation dataset

The OSHD sea ice concentration products are distributed freely through the OSI SAF Sea Ice FTP server.

List of sensors on the DMSP satellites, relevant for the ice concentration product:

Sensor	AMSR-2 on JAXA's GCOM-W1 spacecraft
Launch	May 18, 2012
End	Present

Reference ice charts:

Institute	National Ice Center: www.natice.noaa.gov/
Validation Period	January 01 2015 to January 31 2015:
Frequency	Every two weeks

3 Validation methodology

3.1 Ice chart data

The operational sea ice charts from the National Ice Center (NIC), which are used as the reference dataset in the validation, are a relatively independent source of ice information for comparing to the OSHD ice concentration product. The ice charts, intended for aiding navigation, are produced on a regular basis covering all seasons, both Southern and Northern hemispheres and for the entire validation period, from January 01 2015 to December 31 2015.

Ice charts are produced manually, from satellite and reconnaissance data for ship navigation support. The ice charts are a detailed interpretation of primarily satellite imagery and a subsequent mapping procedure is carried out by skilled (experienced and trained) ice analysts. The ice charts are primarily used for strategic and tactical planning within the offshore and shipping community. Requirements are strict with demands for detailed high quality products for several areas.

The ice charts are based on satellite SAR data e.g. Radarsat-2 since 2008, together with visual/infrared line scanners e.g. SSMI, AVHRR, MODIS, whenever daylight and cloud cover conditions allow. The passive microwave data from AMSR-2 used in the EUMETSAT OSI SAF AMSR-2 Sea Ice Concentration products have also possibly been used as background in the manual analysis for making the ice charts. However, the spatial resolution of the microwave radiometer data is too coarse for making navigational ice charts and they are always used together with higher resolution data. In addition to the satellite data, ice charts are based on information from ships and aircraft reconnaissance. The ice charts are a weekly compilation of the ice conditions, and it is clear that the estimates of ice concentration in the charts is based on the judgement of the analyst. The weekly ice chart has a specific date of validity, even though the data from which it was derived can be from various dates within the week.

A comparison between Greenland and Norwegian ice charts and OSI SAF sea ice concentration shows large differences between the different products with 10-25% standard deviation of the difference between Greenland ice charts and the OSI SAF ice concentration, largest at intermediate concentrations. The Ice-charts are systematically higher than the OSI SAF ice concentrations, especially at intermediate concentrations. The comparison between Greenland and Norwegian ice charts shows large differences indicating that the accuracy (standard deviation of the difference) is not better than 10-30%. The analysis is described in:

http://marine.copernicus.eu/documents/QUID/MYOF-OSI-QUID-ARC-SEAICE-INDEX-V1.0.pdf

3.1.1 Representation of ice chart information

The NIC ice chart and the OSI SAF concentration products are gridded onto a common projection and resolution, allowing a cell by cell comparison is carried out. For each ice chart concentration level the deviation between ice chart concentration and OSI SAF AMSR-2 ice concentration is calculated. Afterwards, deviations are grouped into two categories: ±10% and ±20%; which are the percentage of ice concentration measurements within 10 % and of the reference respectively. Furthermore, the the mean difference between the product and the reference and standard deviation is calculated for each concentration level. The the mean difference between the product and the reference and standard deviation are reported for *ice* (> 0% ice concentration), for *water* (0% ice concentration) and for both ice and water as a *total*. The standard deviation is the measure for the target accuracy in [RD-2].

3.1.2 Validation parameters

The OSI SAF ice concentration is compared with the SIGRID total ice concentration of the ice charts. SIGRID is the WMO standard for describing ice in ice charts. The total ice concentration SIGRID variable used for comparison is the total ice concentration given by the ice chart. The total concentration is an ice concentration interval where the average of the interval bounds is used in the comparison with the OSI SAF ice concentration. The ice charts are compared with the AMSR-2 OSI SAF polar stereographic ice concentration product.

The parameters shown in the validation plots are defined as follows:

Parameter	Description
match_10_pct	The fraction of points where IAC shows ice and AOSIC is within ±10% of the IAC
match_20_pct	The fraction of points where IAC shows ice and AOSIC is within ±20% of the IAC
total_bias	Average of AOSIC – IAC for all valid points
ice_bias	Average of AOSIC – IAC for all points where IAC shows ice
water_bias	Average of AOSIC – IAC for all points where IAC shows water
total_stddev	Standard deviation of AOSIC – IAC for all valid points
ice_stddev	Standard deviation of AOSIC – IAC for all points where IAC shows ice
water_stddev	Standard deviation of AOSIC – IAC for all points where IAC shows water

The acronyms are described in Section 1.3. The ice chart analysis concentration will be refered as IAC and AMSR-2 OSI SAF ice concentration as AOSIC

3.1.3 Masking of data near land

Land spillover affects data near the coast in regions, such as the Baltic, where the water is surrounded, or partly surrouned, by land. These regions are masked out, as shown in Figure 1.

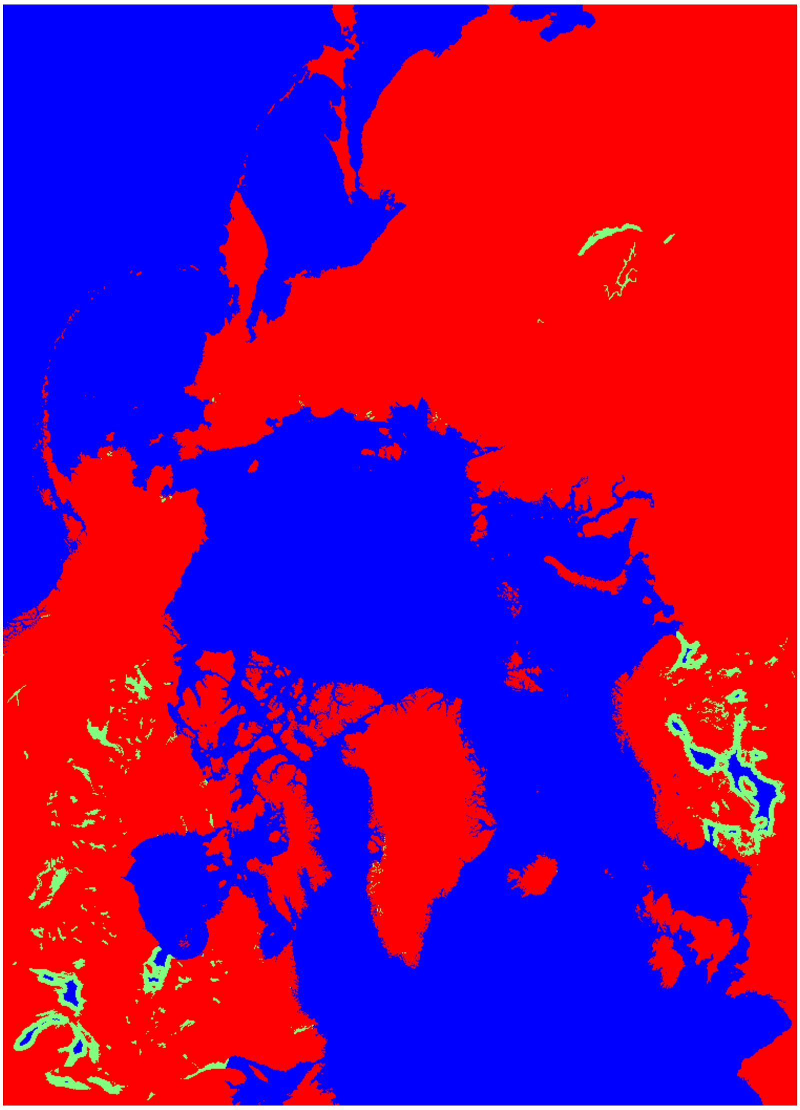

Figure 1: An image showing the lake and coastal zones that are masked out.

Data is provided for the central region of lakes that have sufficiently large dimensions for the central region measurements to have low spillover noise. In Figure 1 , the plots of ice concentration for the 25 February 2015 (with ice on the Lake Superior) and Lake Huron and 05 January 2016 (with the lakes ice free) correspond to measurements given on the U.S. National Ice Centre Naval Ice Center's website. As the sea ice algorithm has been applied to lakes, these measurements should be treated with caution, and only used as indicative of the presence of ice. The lake ice measurements are not used for validation given in this report.

3.2 Product Requirements

The threshold accuracy for the product is 20% for the Northern and Southern Hemispheres; the target accuracies are 10% and 15% for Northern and Southern Hemispheres respectively and the optimal target for both hemispheres is 10%.

4 Validation results

4.1.1 Comparison of the OSI-408 product with NIC ice charts for Northern Hemisphere

In this section, the OSI SAF AMRS-2 product is compared with the NIC ice charts. Both Northern Hemisphere (NH) and Southern Hemisphere (SH) are compared for the ice concentrations computed using both the OSI SAF and TUD algorithms, for the validation period of the OSI-408-b product from 01 January 2015 to 31 December 2015.

		Points Within		Mean Biases			Mean Std. Dev.		
Hem.	**Algorithm**	**10%**	**20%**	**Ice**	**Water**	***Total***	**Ice**	**Water**	***Total***
NH	OSHD	91.6%	94.3%	-8.1%	0.4%	*-2.8%*	18.8%	3.7%	*13.0%*
SH	OSHD	89.6%	93.9%	-11.5%	0.2%	*-3.4%*	20.8%	1.7%	*13.0%*
NH	**TUD**	92.0%	94.5%	-7.6%	0.4%	*-2.6%*	18.5%	3.9%	*12.8%*
SH	**TUD**	89.4%	93.9%	-11.8%	0.2%	*-3.3%*	20.6%	1.7%	*13.0%*

Table 1 : Metrics summarising the performance of the TUD and OSI SAF algorithms, in the Northern and Southern Hemisphere for the validation period of 2015. As explained in the text, the following metrics are given: the mean grid points within a 10% and 20% match; the mean the mean difference between the product and the reference, split into open water, ice regions and total (both open water and ice); and the mean standard deviation, also by region.

Table 1 contains the mean values of the daily metric values for all the days within the validation period. The performance of the OSI SAF and TUD computed ice concentrations is similar. For both algorithms, the accuracy is greater in the Northern Hemisphere than the Southern.

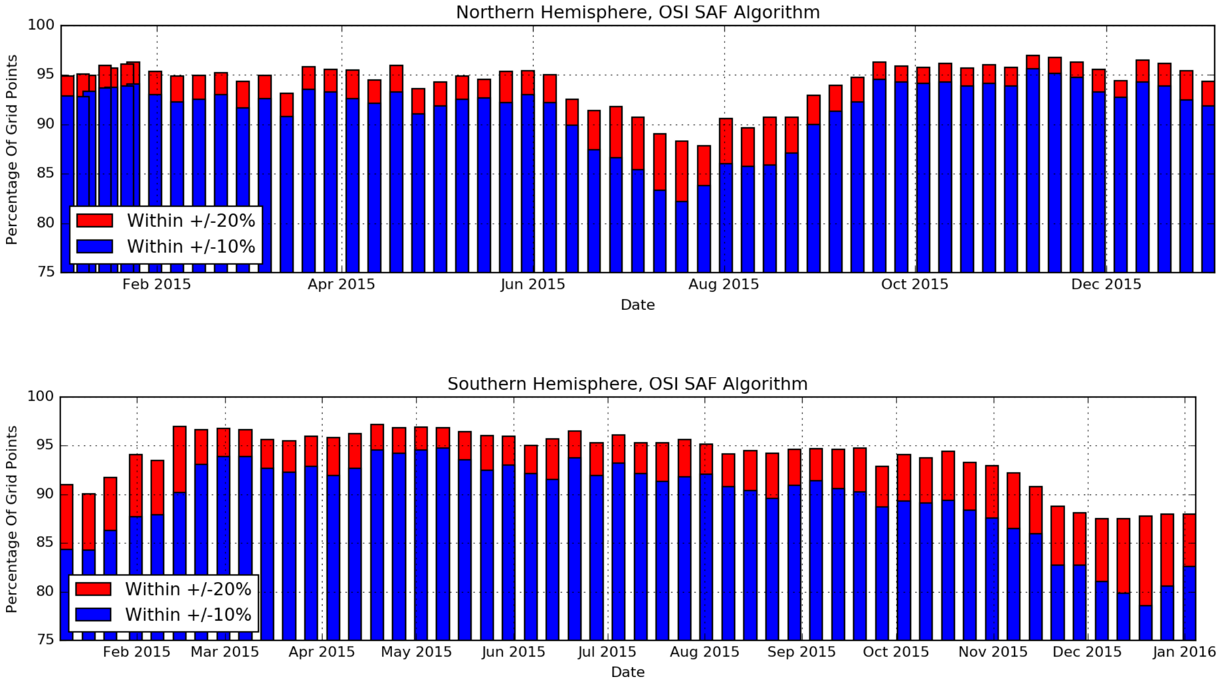

Figure 2: Comparison between NIC ice charts *and the ice concentration computed with the OSI-SAF algorithm, for the validation period, showing where the two products match within 10% and 20%, for the Northern (top) and Southern (bottom) Hemispheres.*

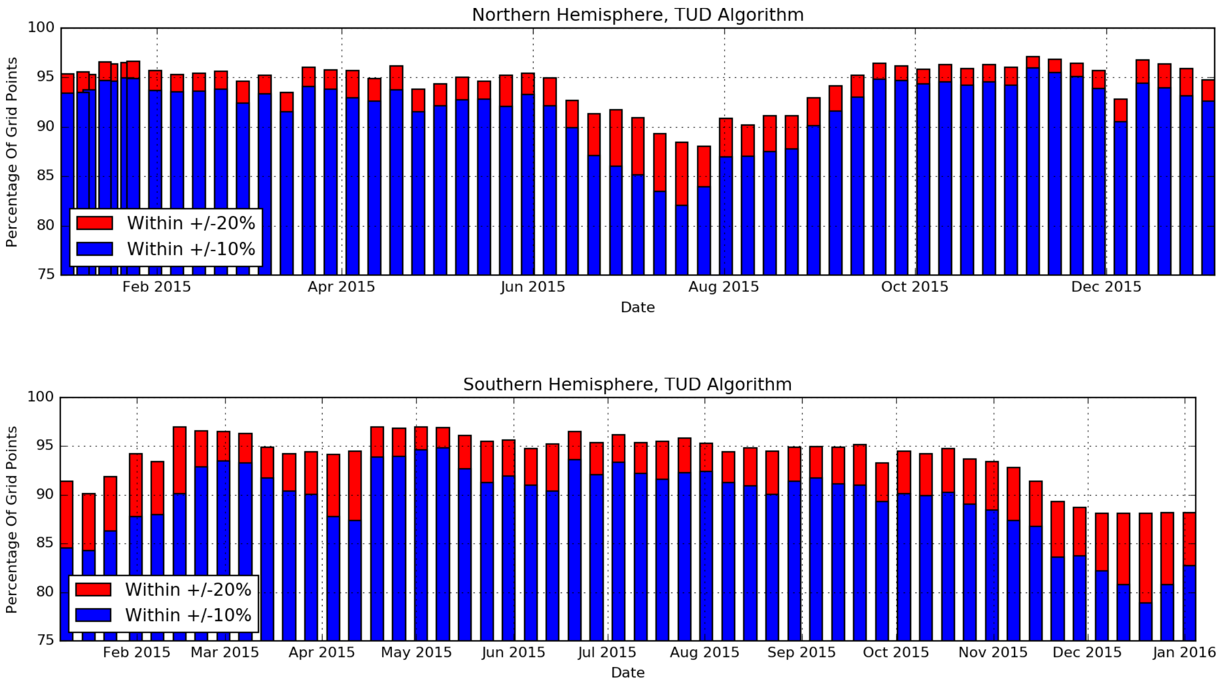

Figure 3: Comparison between NIC ice charts and the ice concentration computed with the TUD algorithm, for the validation period, showing where the two products match within 10% and 20%, for the Northern (top) and Southern (bottom) Hemispheres.

Figures 2 and 3 show the match between ice chart and product ice concentrations for the OSHD algorithm and TUD algorithm respectively. The accuracy of the products follows a seasonal cycle; in the Northern Hemisphere and for both the OSI SAF and TUD, the 10% match varies between ~82% and ~96%, with a poorer performance during June to September. In the Southern Hemisphere the accuracy of the products also shows a seasonal dependency, with the accuracy varying between ~78% and ~95% for both algorithms, with the lowest accuracy in December and January.

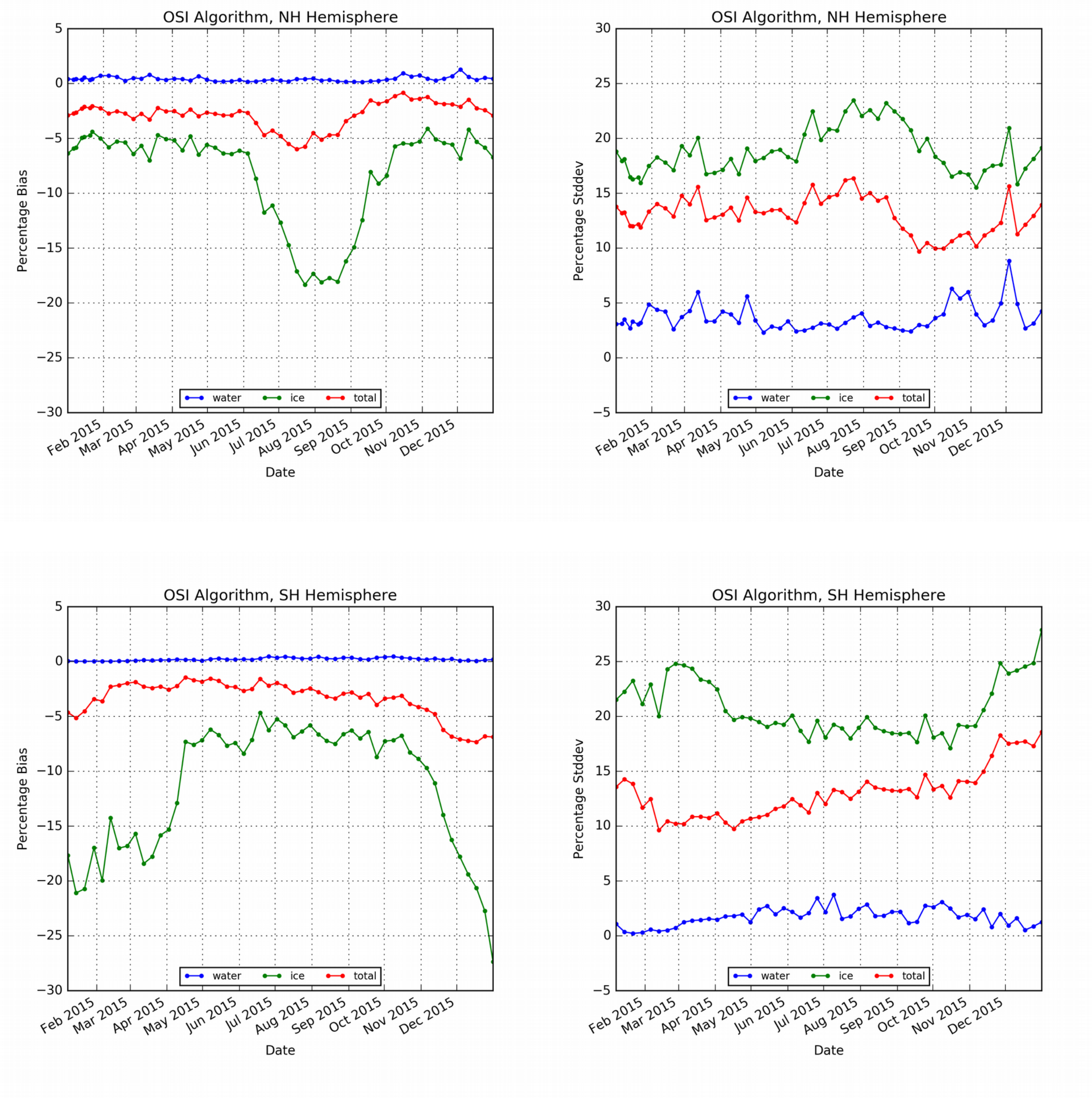

Figure 4: The percentage biases (more accuratly the mean difference between the product and the reference) and standard deviations for the OSHD Algorithm, for the Northern (top) and Southern (bottom) hemispheres. The biases are given separately for the open water-, ice-regions and both together.

Figures 4 shows the the mean difference between the product and the reference and standard deviation of the product computed by the OSHD algorithm. The OSHD algorithm ice concentrations are higher than ice chart ice concentrations over open water. For both the Northern and Southern Hemispheres, the mean difference between the product and the reference for the water water is close to zero. For the ice, a minimum mean difference between the product and the reference of -18.3% occurs in July in the Northern Hemisphere and a minimum mean difference between the product and the reference of -26.8% occurs on in December for the Southern. The standard deviation tends to be greater during the summer at both hemispheres, and the standard deviation tends to be lower in the Northern Hemisphere, with means of 20.8% and 18.8% for the Southern and Northern Hemispheres respectively (see Table 1). The mean the mean difference between the product and the reference and standard deviation for open water are relatively small, compared to the ice.

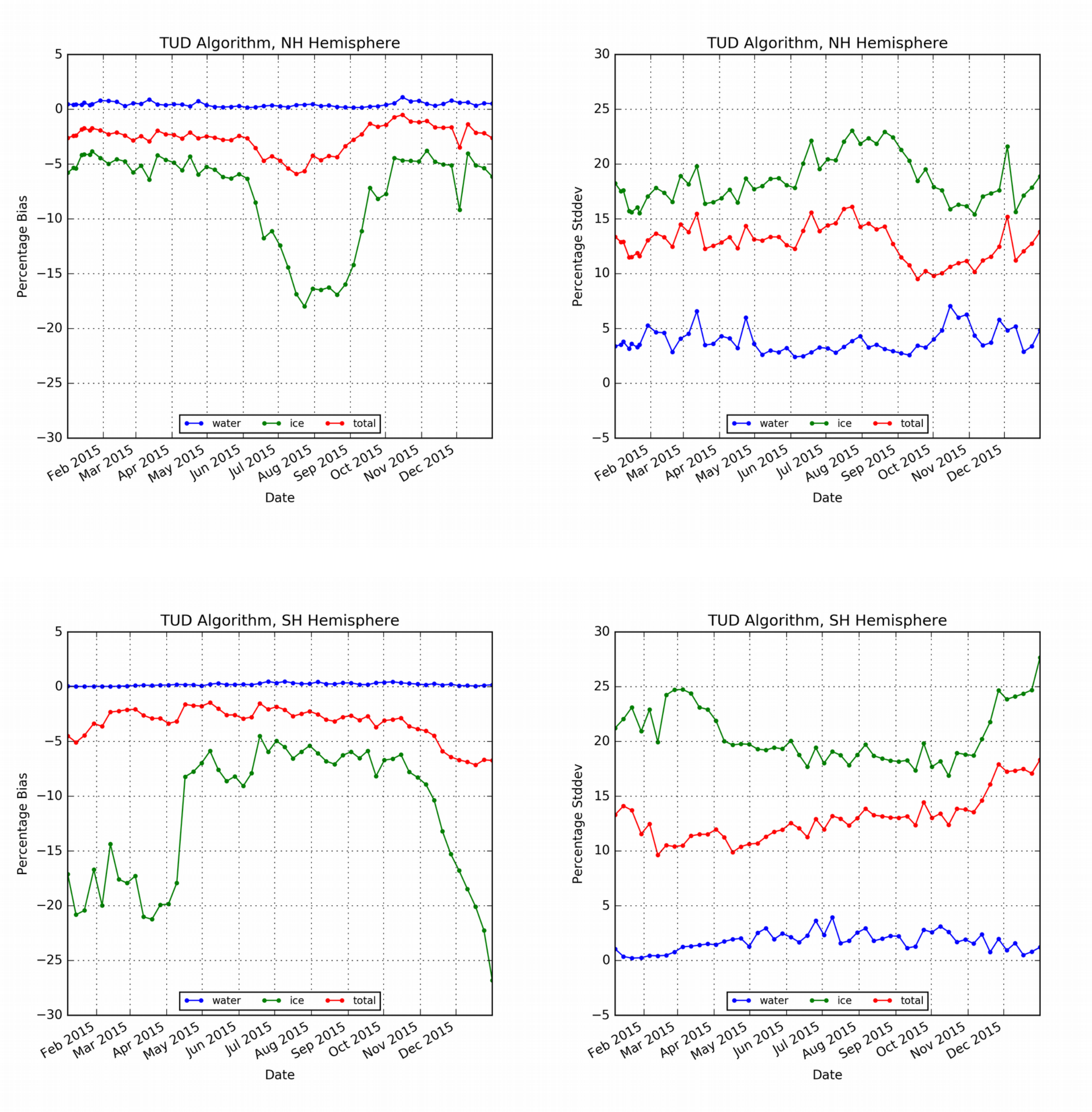

Figure 5: The percentage biases (more accurately the mean difference between the product and the reference) and standard deviations for the TUD Algorithm, for he Northern (top) and Southern (bottom) hemispheres. The biases are given separately for the open water regions , ice regions and both together.

Figure 5 shows the the mean difference between the product and the reference and standard deviation of the product computed by the TUD algorithm compared to ice charts. The OSHD ice concentrations are higher than ice chart ice concentrations over open water. For both the Northern and Southern Hemispheres, the mean difference between the product and the reference for water is close to zero. For the ice, a maximum mean difference between the product and the reference of -18% occurs in July in the Northern Hemisphere and a minimum mean difference between the product and the reference of -26.8% occurs in December for the Southern. The standard deviation tends to be greater during the summer at both hemispheres. The standard deviation tends to be lower in the Northern than the Southern Hemisphere, with means for the whole validation period of 20.6% and 18.5% for the Southern and Northern Hemispheres respectively (see Table 1). The mean difference between the product and the reference and standard deviation for open water are relatively small, compared to the ice.

Southern Hemisphere, OSHD Algorithm

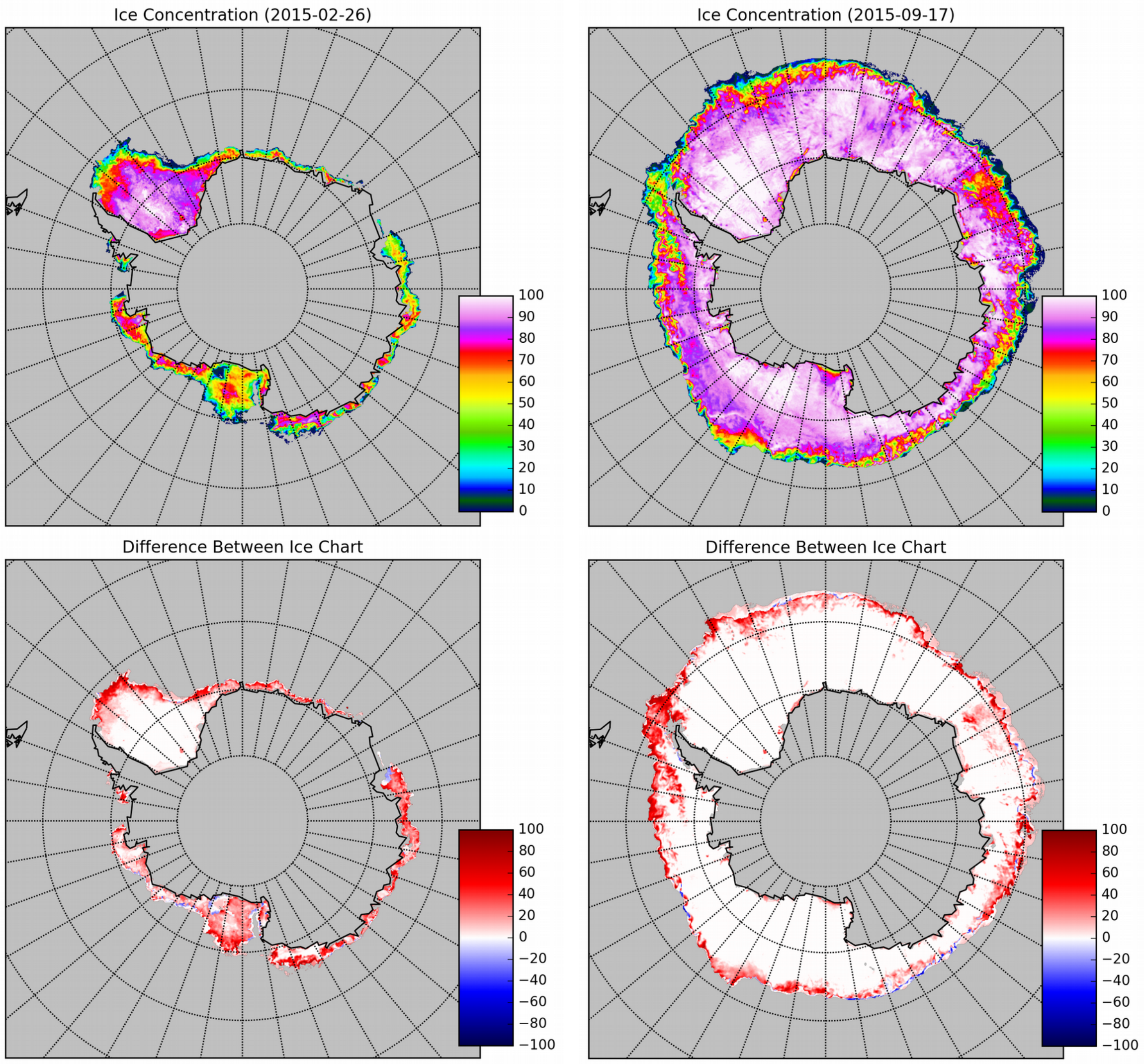

Figure 7: The percentage ice concentration in the Southern Hemisphere (the top plots) and the difference in ice concentration from the reference data (the bottom plots). The left plots are for the 26th February 2015 and the right the 17th September 2015. The ice concentration is computed using the OSI SAF algorithm. Regions with zero ice concentration are masked in the reference data and masked regions in the either map are coloured grey (only non-masked regions are compared).

Figure 6: The percentage ice concentration in the Northern Hemisphere (the top plots) and the difference in ice concentration from the reference data (the bottom plots). The left plots are for the 26th February 2015 and the right the 17th September 2015. The ice concentration is computed using the OSHD algorithm. Regions with zero ice concentration are masked in the reference data and masked regions in the either map are coloured grey (only non-masked regions are compared).

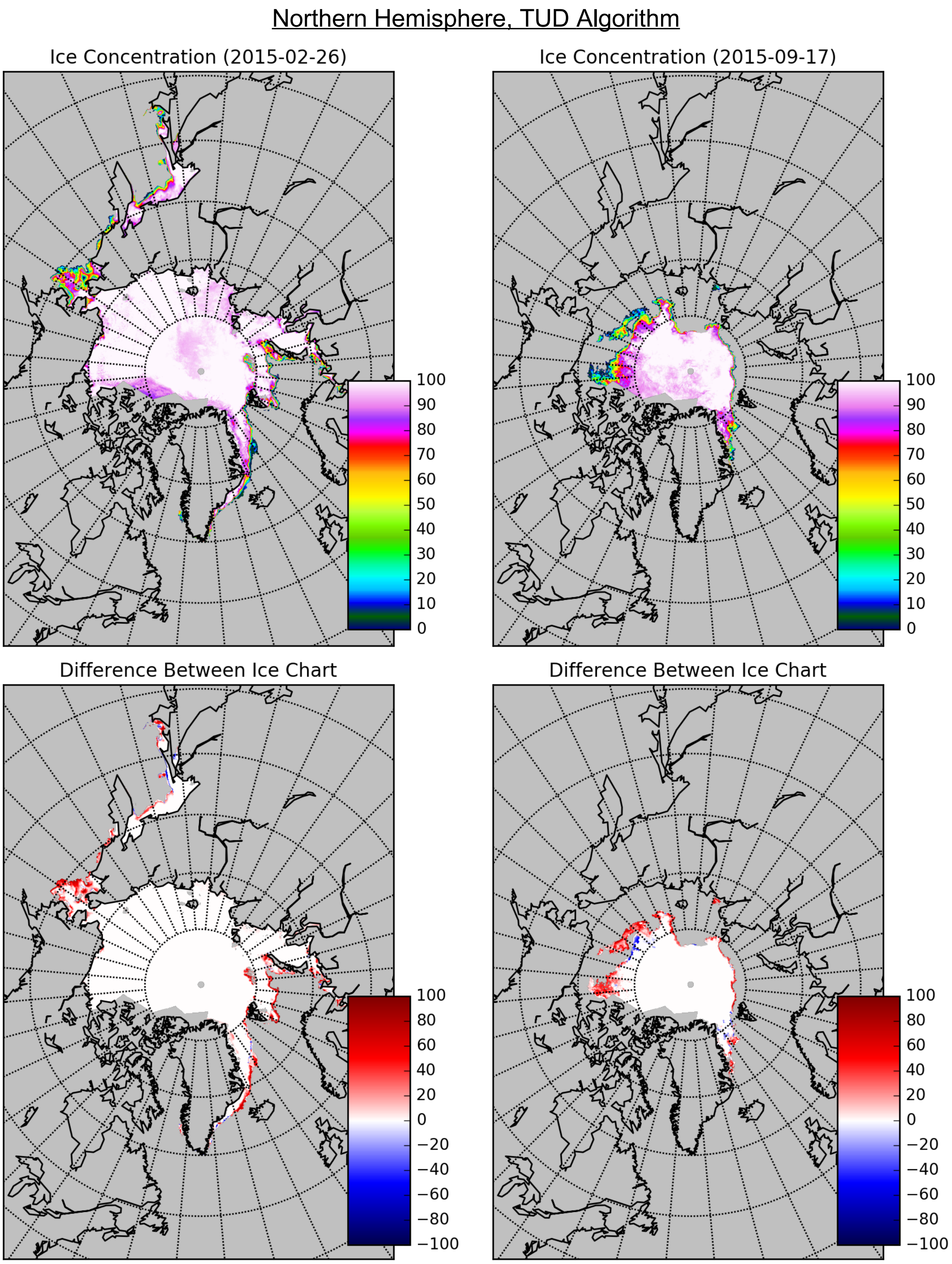

Figure 8: The percentage ice concentration in the Northern Hemisphere (the top plots) and the difference in ice concentration from the reference data (the bottom plots). The left plots are for the 26th February 2015 and the right the 17th September 2015. The ice concentration is computed using the TUD algorithm. Regions with zero ice concentration are masked in the reference data and masked regions in the either map are coloured grey (only non-masked regions are compared).

<u>Southern Hemisphere, TUD Algorithm</u>

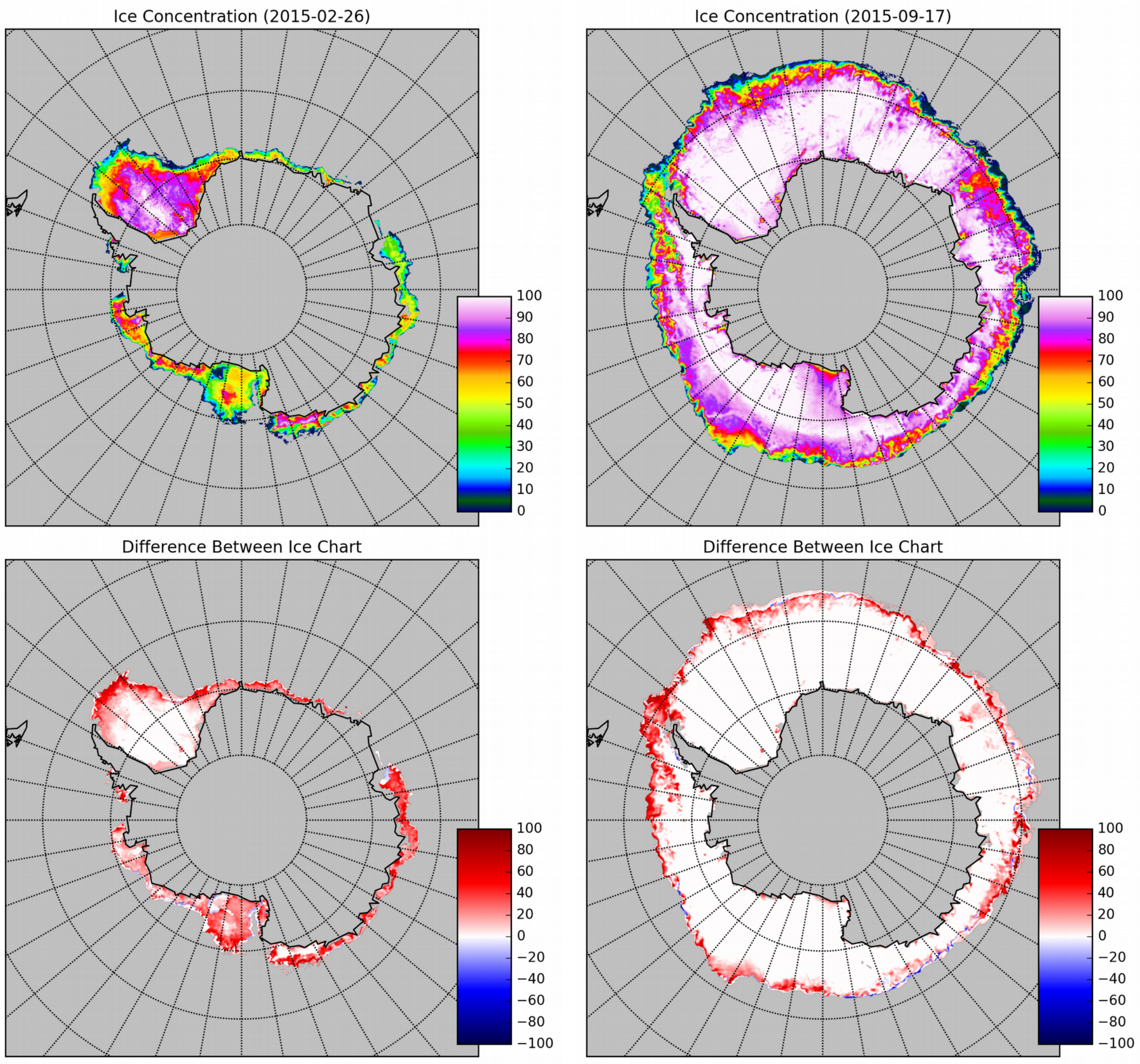

Figure 9: The percentage ice concentration in the Northern Hemisphere (the top plots) and the difference in ice concentration from the reference data (the bottom plots). The left plots are for the 26th February 2015 and the right the 17th September 2015. The ice concentration is computed using the TUD algorithm.<u>Regions with zero ice concentration are masked in the reference data and masked regions in the either map are coloured grey (only non-masked regions are compared).</u>

Figures 6 to 9 show examples of the ice concentration for days in the winter and summer and for both the OSHD and TUD algorithms. The anomaly plots (the difference between the product and the reference), show a larger discrepancy during the summer than the winter.

	SSMI/S		AMSR-2 (OSHD)	
Means	**NH %**	**SH %**	**NH %**	**SH %**
ice_bias	-5,6	-9,2	-8,1	-11,5
water_bias	1,1	0,6	0,4	0,2
total_bias	-3,3	-6,2	-2,8	-3,4
ice_stddev	13,3	16,6	18,8	20,8
water_stddev	4,5	3,1	3,7	1,7
total_stddev	11,7	14,9	13,0	13,0
within 10%	88,5	78,7	91,6	89,6
within 20%	92,2	88,0	94,3	93,9

Table 2: The mean metric values for the validation period (of 2015).

Table 2 show the performance metrics for the SSMI/S and AMSR-2 (OSHD algorithm) products. The same ice charts were used as in the rest of the document. Based on the total standard deviation metric, AMRS-2 performs better in the Southern Hemisphere, but worse in the Northern, in comparison to SSMI. The AMSR-2 products outperform SSMI in both hemispheres according the “within-10 %” and “ -20%” metrics.

5 Conclusions

The OSHD and TUD products perform similarly according to the validation parameters given here. They both have a lower mean difference between the product and the reference and lower standard deviation relative to the NIC ice chart reference data set in the winter than the summer. The main sources of error in the ice concentration measurements are atmospheric noise and melt ponds on the ice (which have a similar signal to open water). Melt ponds (which occur most frequently during the summer) are the main reason for the worse performance during the summer.

The target accuracy requirement for the OSI-408 product is 10% for the NH-product and 15% for SH-product (yearly average – for both the TUD and OSI SAF algorithm computed ice fields). The tolerance is larger for the SH-product, since there in typically are more intermediate concentrations in the Southern Hemisphere, which is more difficult to estimate in the ice chart.

For the Northern Hemisphere, the target requirement on accuracy of 10% is not met in the comparison with NIC ice charts, but the threshold accuracy of 20% is met for both algorithms. The yearly average of the total standard deviation is ~13% for fields computed for both the OSI SAF and TUD algorithms. For the SH the target requirement on accuracy of 15% is met in the comparison with NIC ice charts. The yearly average of the total standard deviation is ~13% for both algorithms.

For both the OSI SAF and TUD products the standard deviations between the AMSR-2 and the ice charts are large over ice covered areas during summer melt: up to ~17% in both hemispheres, while during the winter the ice standard deviation is 10-15%. Over open water areas the standard deviation of the differences is 0-4% for SH and somewhat higher for the NH; around 5%.

It is clear that the ice charts over ice covered areas do not necessarily represent the truth; rather a fairly independent dataset for comparison. Therefore the change of methodology does not necessarily result in improved validation results.