

## **Ocean & Sea Ice SAF**

# **Validation Report for Global Sea Ice Concentration Reprocessing**

**Product OSI-409, OSI-409a and OSI-430**

**Version 2.0**

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## Documentation Change Record

Document version	Data set version	Software version	Date	Change description
V 1.0	V 1.0	V 4.0	14.01.2010	First version.
V 1.1	V 1.0	V 4.0	30.03.2010	Updates after DRI review.
V 1.2	V 1.1	V 4.0	23.06.2011	Added 2008 -10.2009.
V 1.3	V 1.1	V 4.0	09/30/2011	Updates after DRI2 review.
V 2.0 draft	V 1.2	V 5.0	02/03/2015	Added validation of OSI-409a and OSI-430
V 2.0	V1.2	V 5.0	29.04.2015	Updates after DRR review

*The software version number gives the corresponding version of the OSI SAF High Latitude software chain which was used to produce the reprocessing data set.*

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# 1 Introduction

## 1.1 Scope of the document

The validation results of the OSI SAF global reprocessed sea ice concentration product OSI-409 version 1.1, covering the period from Oct. 1978 to Oct. 2009, was presented in the first version of this validation report.

The validation results of the continuation of the OSI SAF global reprocessed sea ice concentration product, OSI-409a and OSI-430, is added to the present second version this report. The OSI-409a covers the period from the end of the OSI-409 in Oct. 2009 until April 2015, where the production of the OSI-430 will start. The OSI-430 will serve as continuous updates of the OSI SAF global reprocessed sea ice concentration data set. The OSI-409a aims to be consistent with OSI-409, to ensure homogeneity of the OSI SAF global reprocessed sea ice concentration data set. The OSI-409a uses the same software chain as will be used for the OSI-430. Thus, the validation of the OSI-409a product presented here also serves as a validation of the OSI-430 product.

The validation report describes a comparison between OSI SAF 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.

## 1.2 Reference documents

[RD-1]: OSI SAF Global Sea Ice Concentration Reprocessing Product User Manual, v2.0.

[RD-2]: OSI SAF CDOP-2 Service Specification Document, v2.4.

## 1.3 Definitions, acronyms and abbreviations

AVHRR	Advanced Very High Resolution Radiometer
DMSP	Defence Meteorological Satellite Program
EASE	Equal area grid for the Northern and Southern Hemisphere
ECMWF	European Centre for Medium range Weather Forecast
FTP	File Transfer Protocol
MODIS	Optical and infrared line scanner
NH	Northern Hemisphere
NIC	National Ice Center
NWP	Numerical Weather Prediction
OLS	Optical Line Scanner (on DMSP)
OSI SAF	Ocean and Sea Ice SAF
SAF	Satellite Application Facility
SAR	Synthetic Aperture Radar
SH	Southern Hemisphere
SIGRID	Sea ice chart grid format
SMMR	Scanning Multichannel Microwave Radiometer (on NIMBUS 7)
SSMI	Special Sensor Microwave Imager
SSMIS	Special Sensor Microwave Imager Sounder

## 2 OSI SAF global sea ice concentration availability

The OSI SAF sea ice concentration products are distributed freely through the OSI SAF Sea Ice FTP server. The data are organized in year and month directories. The OSI-409 product is available for the period Oct. 1978 to Oct. 2009 at this address:

<ftp://osisaf.met.no/reprocessing/ice/conc/v1p1/>

The OSI-409a product is available for the period Oct. 2009 to April 2015 at this address:

<ftp://osisaf.met.no/reprocessing/ice/conc/v1p2/>

Some of the daily sea ice concentration products have not been produced as a result of missing satellite data (due to satellite malfunction, planned maintenance or missing archive). The SMMR instrument was operated every second day. More details on this is provided in the PUM [RD-1].

List of sensors on the Nimbus 7 and DMSP satellites. Satellites in grey are not used in these data sets.

Sensor	Launch	End
Nimbus 7 SMMR	October 1978	August 1987
DMSP F8 SSMI	June 1987	December 1991
DMSP F10 SSMI	December 1990	November 1997
DMSP F11 SSMI	November 1991	May 2000
DMSP F13 SSMI	March 1995	November 2009
DMSP F14 SSMI	May 1997	August 2008
DMSP F15 SSMI	December 1999	Present
DMSP F16 SSMIS	October 2003	Present
DMSP F17 SSMIS	December 2006	Present
DMSP F18 SSMIS	October 2009	Present

List of ice chart availability during the reanalysis period. All ice charts are from the National Ice Center (<http://www.natice.noaa.gov/>).

Hemisphere	Period	Frequency
North	1978 – 2014	weekly 1978 - Jun. 2001 twice a month Jun. 2001 – Oct. 2013 twice a week Oct. 2013 – Aug. 2014
South	1978 - Dec. 1994 Jan. 2003 – 2014	weekly 1978 - Dec. 1994 twice a month Jan. 2003 – Oct. 2013 weekly Oct. 2013 – Aug. 2014

## 2.1 Sea Ice product comparison

This validation report describes a comparison between OSI SAF 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.

### 2.1.1 Ice chart data

The OSI SAF global sea ice concentration reprocessed products are compared to the National Ice Center (NIC) ice charts, since they are a relatively independent source of ice information. Ice charts are produced manually on the basis of satellite and reconnaissance data for ship navigation support. They are produced on a regular basis covering all seasons, both Southern and Northern hemispheres. The time series cover the entire reanalysis period (see section 2.0) except for the period 1995 to 2002 in the southern hemisphere where we have been unable to acquire digital ice charts. 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 more recent ice charts are based partly on satellite SAR data e.g. Radarsat 1 since 1995, Envisat since 2000 and Radarsat-2 since 2008, together with visual/infrared line scanners e.g. AVHRR, MODIS, OLS whenever possible for daylight and cloud cover conditions. Also the passive microwave data from SMMR, SMMI and SSMIS used in the reanalysis have been extensively used for making the ice charts in particular before the launch of wide swath SAR instruments in 1995. In addition to the satellite data ice charts are based on information from ships and aircraft reconnaissance. The NIC ice charts are a compilation of the ice conditions over a period (see ice chart frequency in the table on page 6) and it is clear that the estimates of ice concentration in the charts is based on the judgment of the analyst, in most cases with an accuracy of about 20%.

### 2.1.2 Requirements

The OSI SAF product requirement document states about the reprocessed sea ice data that:

**OSI-PRD-PRO-205:** The OSI SAF shall reprocess the time series of SMMR and SSM/I data back to 1978 to expand the time series of global sea ice products.

**OSI-PRD-PRO-206:** The OSI SAF shall test new methods for ensuring a climate consistent data set.

**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.

All of these three requirements have been met at the completion of the OSI SAF global reprocessed sea ice concentration data set.

Further, the specific product requirements listed in the OSI SAF product requirement document table OSI-PRD-PRO-200 are addressed in the conclusions.

A satisfactory match between ice concentrations during the fairly short overlap period (July and August 1987) between SMMR and SSM/I is required. In the Arctic the overlap is during the summer melt near sea ice extent minimum where there is less data and where the surface emissivity may change on an hourly basis. Around Antarctica the overlap period is near sea ice maximum and conditions for comparison are favourable.

### 2.1.3 Representation of ice chart information

The weekly ice chart and the reanalysis product from the same day are gridded onto a common projection and resolution. For the validation of OSI-409 an ease-grid projection was used and a resolution of 12.5 km. For the validation of OSI-409a a polar stereographic projection has been used and a resolution of 10 km. For the comparison of the overlay period between OSI409 and OSI-409a an EASE-grid projection was used for both datasets. Following this a cell by cell comparison is carried out. For each ice chart concentration level the deviation between ice chart concentration and reprocessed ice concentrations is calculated. Afterwards deviations are grouped into categories, i.e.  $\pm 10\%$  and  $\pm 20\%$ . Furthermore the bias and standard deviation is calculated as described in the table below. The bias and standard deviation are reported for *ice* ( $> 0\%$  ice concentration), for *water* ( $0\%$  ice concentration) and for both ice and water as a *total*.

### 2.1.4 Validation parameters

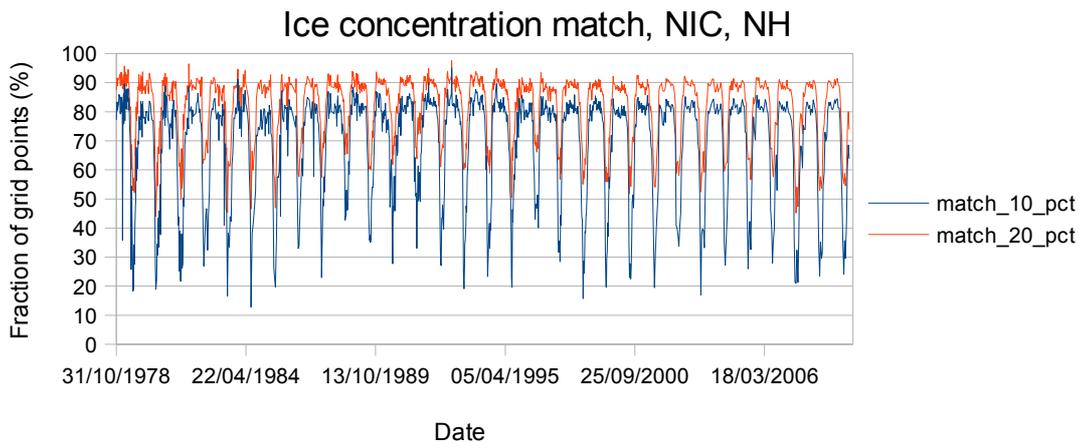
The OSI SAF ice concentration is compared with the SIGRID CT ice concentration code of the ice charts. SIGRID is the WMO standard for describing ice in ice charts. The CT SIGRID variable used for comparison is the total ice concentration given by the ice chart. The CT code defines an ice concentration interval where the average of the interval bounds is used in the comparison with the OSI SAF ice concentration.

The parameters shown in the validation plots are defined as follows. The ice chart analysis concentration will be referred as IAC and OSI SAF ice concentration as OSIC:

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

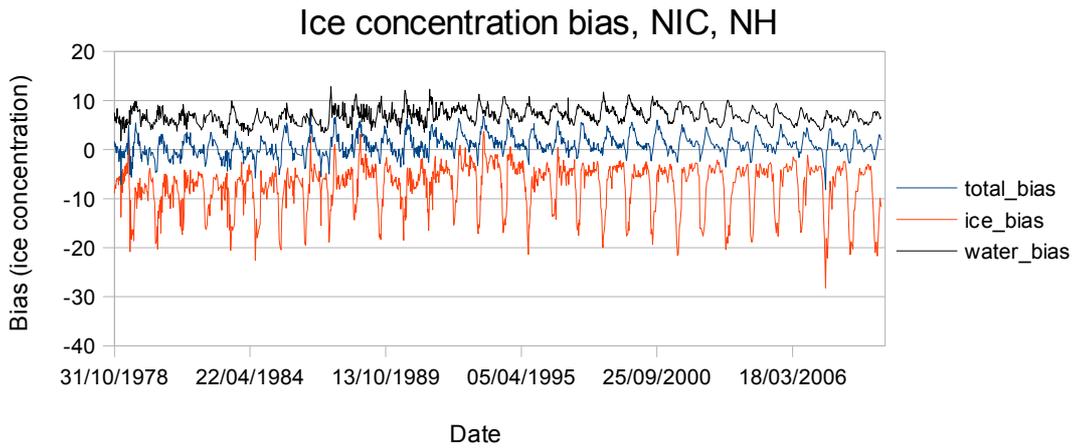
### 2.1.5 Comparison between the OSI-409 product and NIC ice charts for Northern Hemisphere

Comparison between National Ice Center (NIC) ice charts for Northern Hemisphere and the OSI SAF reanalysis in figure 1 shows a clear seasonal cycle with 80% to 90% of cases meeting the criteria during winter and only 20% to 60% during the peak of summer melt.



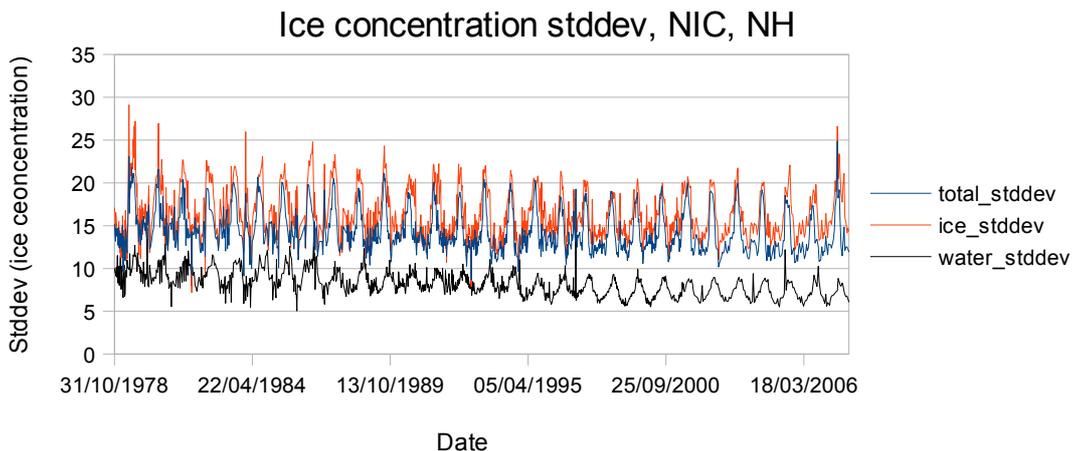
*Figure 1: Comparison between Northern Hemisphere National Ice Center ice charts and OSI SAF reprocessed ice concentrations. The blue and the red curve shows the percentage of cases where the two products deviates by 10% and 20%, respectively.*

The bias in ice concentration between the Northern Hemisphere National Ice Center ice charts and OSI SAF reprocessed ice concentrations is shown in figure 2. The OSI SAF reprocessed ice concentrations is higher than the ice chart over open water, because the radiometer ice concentration is affected by atmospheric noise which increases the ice concentration above zero. The ice charts has a nominal value of zero over open water. The transition between SMMR data and SSM/I data in summer 1987 is faintly visible, perhaps, due to the fact that the SSM/I 19GHz is affected more by water vapor than the 18GHz SMMR. The ice bias has a clear seasonal cycle and a negative winter bias around 5% to 10%.



*Figure 2: Comparison between the Northern Hemisphere National Ice Center ice charts and OSI SAF reprocessed ice concentrations. The total bias between OSI SAF the reanalysis product and the ice chart is shown with the blue curve, the negative bias in ice covered regions with the red curve and the positive bias in water areas with the black curve.*

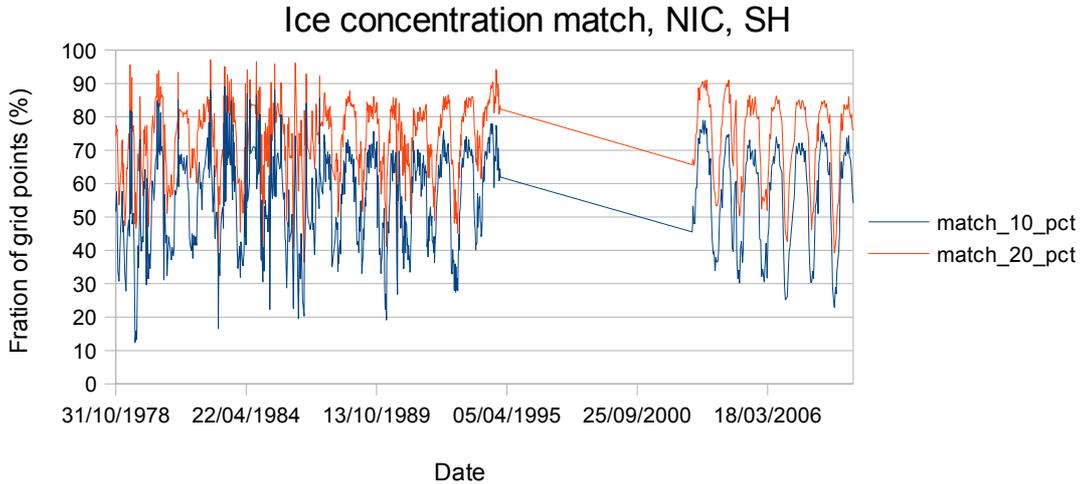
Figure 3 shows the Northern Hemisphere standard deviation of the difference between the OSI SAF reanalysis product and the National Ice Center ice charts. There is a clear seasonal cycle with higher standard deviations during summer than during winter. The standard deviation over open water seems to decrease during the reanalysis period.



*Figure 3: Comparison between Northern Hemisphere National Ice Center ice charts and the OSI SAF reprocessed ice concentrations. The figure shows the standard deviation of the difference between the OSI SAF reanalysis product and the ice charts. The blue curve shows the standard deviation of the difference in ice concentration for both ice and open water regions. The red and the black curve show standard deviation of the difference for ice and water regions respectively.*

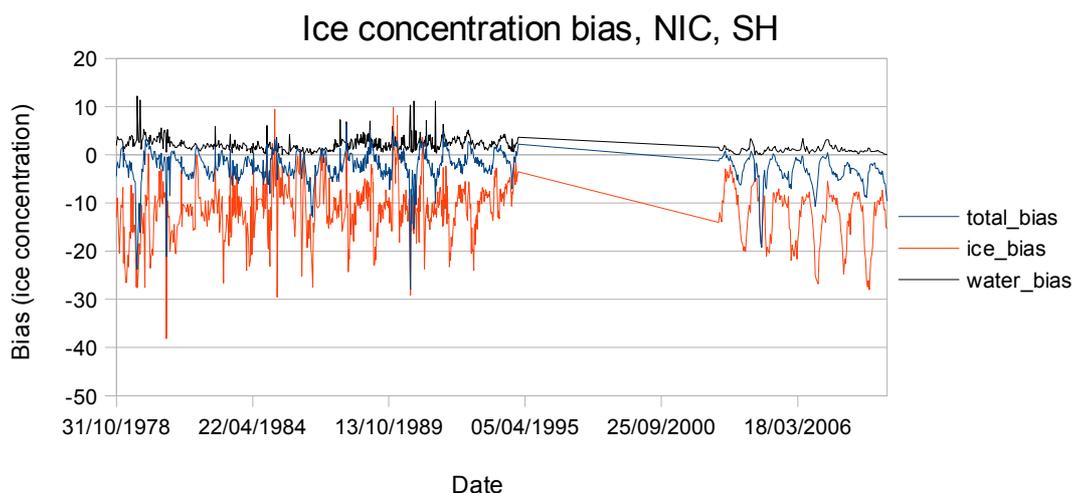
## 2.1.6 Comparison between the OSI-409 product and NIC ice charts for the Southern Hemisphere

Comparison between National Ice Center (NIC) ice charts for Southern Hemisphere and the OSI SAF reanalysis in figure 4 shows a clear seasonal cycle with 50% to 90% of cases meeting the criteria during winter and only 20% to 60% during the peak of summer melt.



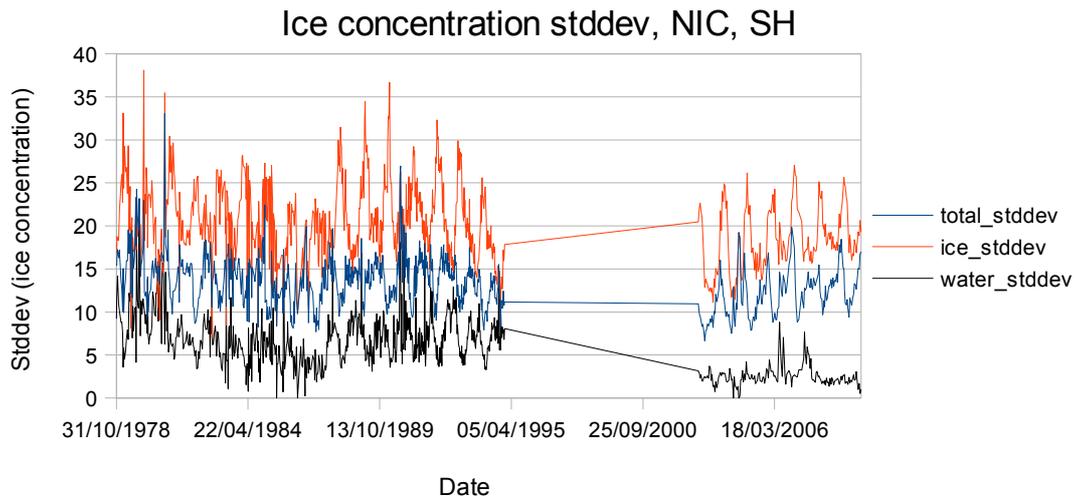
*Figure 4: Comparison between Southern Hemisphere National Ice Center ice charts and OSI SAF reprocessed ice concentrations. The blue and the red curve shows the percentage of cases where the two products deviates by 10% and 20%, respectively. Ice chart data are missing from 1994 to 2003.*

The bias in ice concentration between the Southern Hemisphere National Ice Center ice charts and OSI SAF reprocessed ice concentrations is shown in figure 5. The OSI SAF reprocessed ice concentrations is higher than the ice chart over open water, because the radiometer ice concentration is affected by atmospheric noise which increases the ice concentration above zero. The ice charts has a nominal value of zero over open water. The water bias is smaller than for the Northern Hemisphere which is most likely due to the difference in proportion of coastal zone to ocean waters and atmospheric conditions.



*Figure 5: Comparison between the Southern Hemisphere National Ice Center ice charts and OSI SAF reprocessed ice concentrations. The total bias between OSI SAF the reanalysis product and the ice chart is shown with the blue curve, the negative bias in ice covered regions with the red curve and the positive bias in water areas with the black curve.*

Figure 6 shows the Southern Hemisphere standard deviation of the difference between the OSI SAF reanalysis product and the National Ice Center ice charts. There is a clear seasonal cycle with higher standard deviations during summer than during winter. The standard deviation over open water seems to decrease during the reanalysis period except when switching from SMMR to SSMI in 1987 where an increase in standard deviation is seen. This increase is due to the stronger impact of water vapour at the 19.35 GHz channel of SSMI relative to the 18 GHz channel of SMMR.

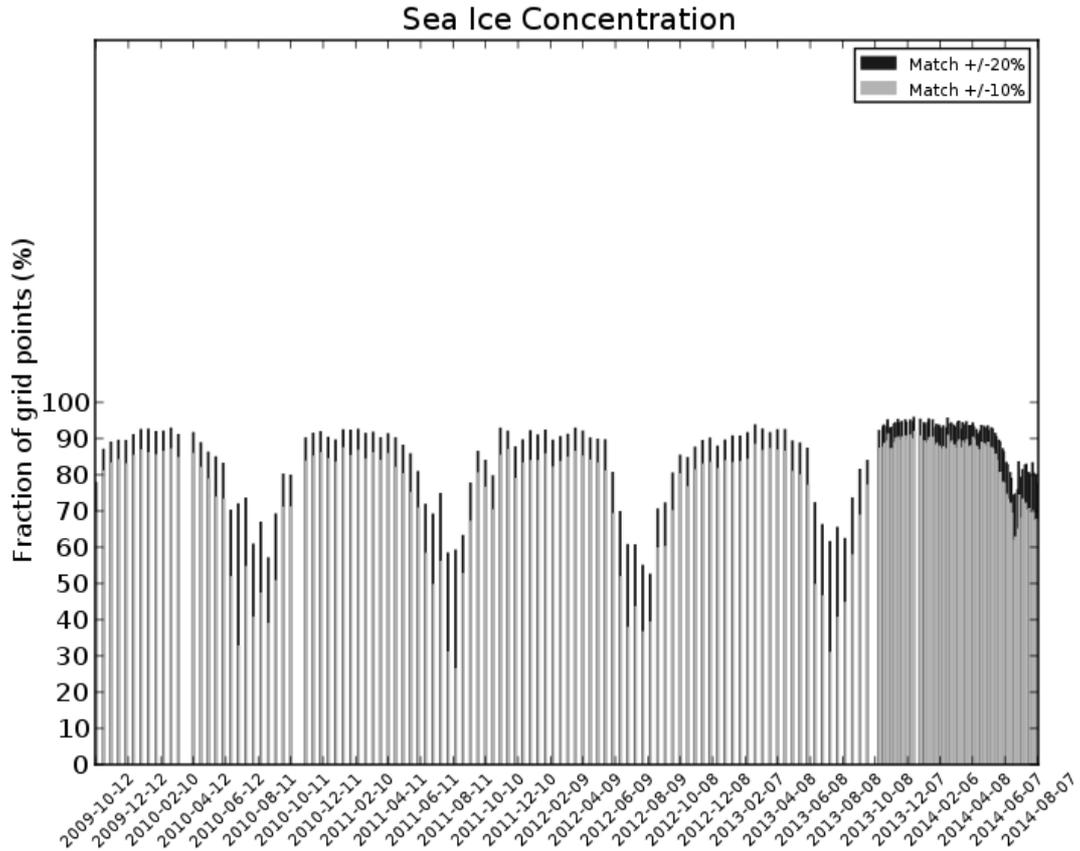


*Figure 6: Comparison between Southern Hemisphere National Ice Center ice charts and the OSI SAF reprocessed ice concentrations. The figure shows the standard deviation of the difference between the OSI SAF reanalysis product and the ice charts. The blue curve shows the standard deviation of the difference for both ice and open water regions. The red and the black curve show standard deviation of the difference for ice and water regions respectively.*

### 2.1.7 Comparison of the OSI-409a and OSI-430 product with NIC ice charts for Northern Hemisphere

Figures below show the comparison between National Ice Center (NIC) ice charts for Northern Hemisphere (SH) and the OSI SAF reanalysis for the period of the OSI-409a product from October 2009 to August 2014 (the full data set OSI-409a covers the period until April 2015). The OSI-409a uses the same software chain as will be used for the OSI-430. Thus, the validation of the OSI-409a product presented here also serves as a validation of the OSI-430 product.

Figure 7, displaying the match between ice chart and reprocessed ice concentrations, show a clear seasonal cycle. 80% to 95% of cases meets the criteria during winter and 30% to 60% during summer. From Oct. 2013, at the same time as the frequency in ice chart production increases, the fraction of cases meeting the criteria increases for both summer and winter. This is discussed in the conclusion.



*Figure 7: Comparison between NH NIC ice charts and OSI-409a reprocessed ice concentrations, for the period Oct. 2009 to Aug. 2014. The grey and the black curve shows the percentage of cases where the two products deviates by 10% and 20%, respectively.*

Figure 8, displaying the bias between the ice chart and reprocessed ice concentrations, shows that the ice bias has a clear seasonal cycle and negative bias around 5% during winter in 2009 to 2013.

From Oct. 2013, at the same time as the frequency in ice chart production increases, the ice bias increases for both summer and winter. This is discussed in the conclusion.

From July 3 2014 and through August the water bias suddenly increases sharply to 6-8%. This is also discussed later in the conclusion.

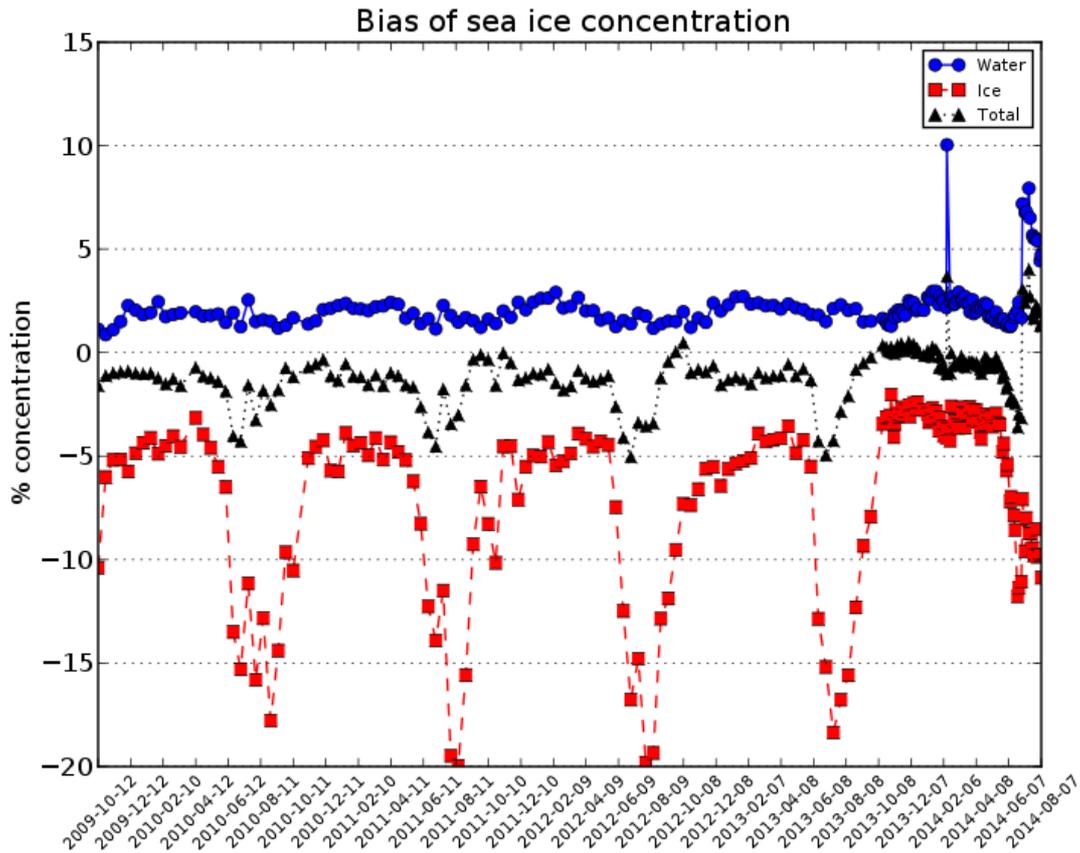


Figure 8: The total bias between NH NIC ice charts and OSI-409a reprocessed ice concentrations, for the period Oct. 2009 to Aug. 2014. The total bias is shown with the black curve, the negative bias in ice covered regions with the red curve and the positive bias in water areas with the blue curve.

Figure 9, displaying the standard deviation of the difference between the ice chart and reprocessed ice concentrations, show that there is a clear seasonal cycle with higher standard deviations during summer than during winter. The standard deviation over open water seems to increase slightly during the reanalysis period.

From Oct. 2013, at the same time as the frequency in ice chart production increases, the ice standard deviation decreases for both summer and winter. This is discussed in the conclusion.

From July 3<sup>rd</sup> 2014 and through August the water standard deviation suddenly increases sharply (from 7% on July 1<sup>st</sup> to 20% on July 3<sup>rd</sup>). This causes also the total standard deviation to increase sharply and thus the total standard deviation yearly average to be around 11%. This is discussed in the conclusion.

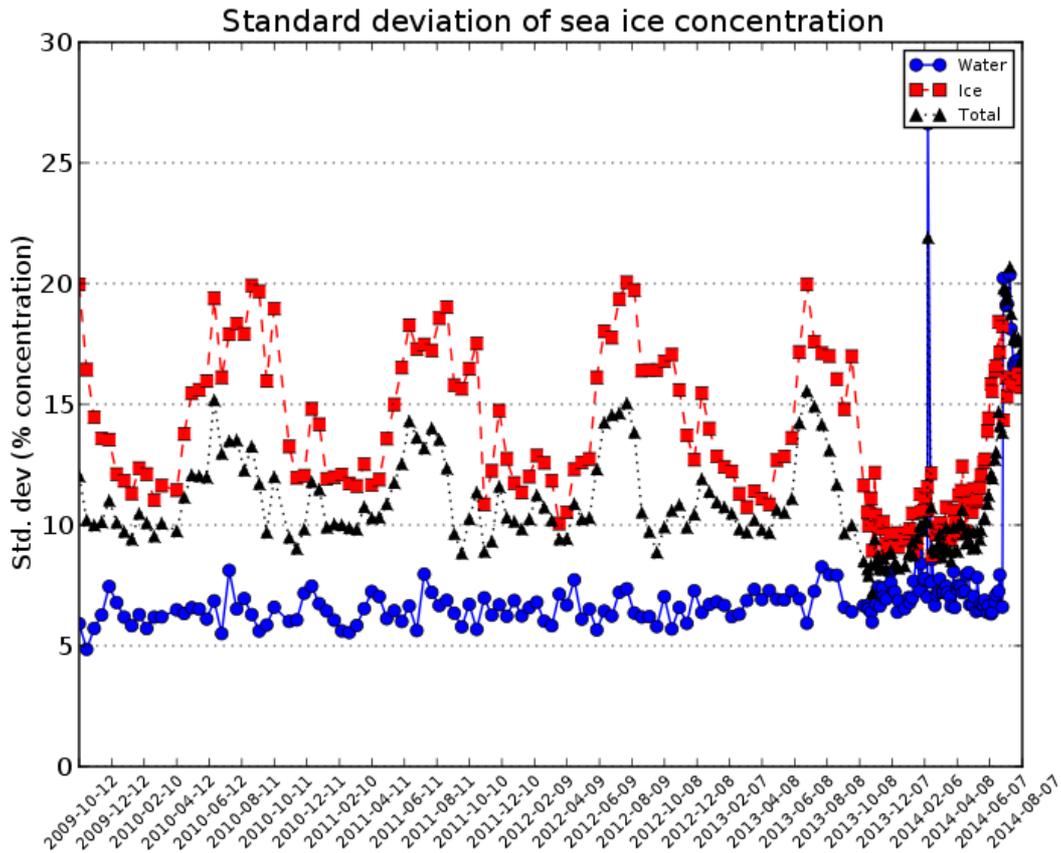


Figure 9: The standard deviation on the difference between the NH NIC ice charts and OSI-409a reprocessed ice concentrations, for the period Oct. 2009 to Aug. 2014. The black curve shows the standard deviation of the difference in ice concentration for both ice and open water regions. The red and the blue curve show standard deviation of the difference for ice and water regions, respectively.

### 2.1.8 Comparison of the OSI-409a and OSI-430 product with NIC ice charts for Southern Hemisphere

Figures below show the comparison between National Ice Center (NIC) ice charts for Southern Hemisphere (SH) and the OSI SAF reanalysis for the period of the OSI-409a product from October 2009 to August 2014.

The OSI-409a uses the same software chain as will be used for the OSI-430. Thus, the validation of the OSI-409a product presented here also serves as a validation of the OSI-430 product.

Figure 10, displaying the match between ice chart and reprocessed ice concentrations, show a clear seasonal cycle. 50% to 90% of cases meets the criteria during Antarctic winter and 40% to 60% during summer. From Oct. 2013, at the same time as the frequency in ice chart production increases, the fraction of cases meeting the criteria increases for both summer and winter. This is discussed in the conclusion.

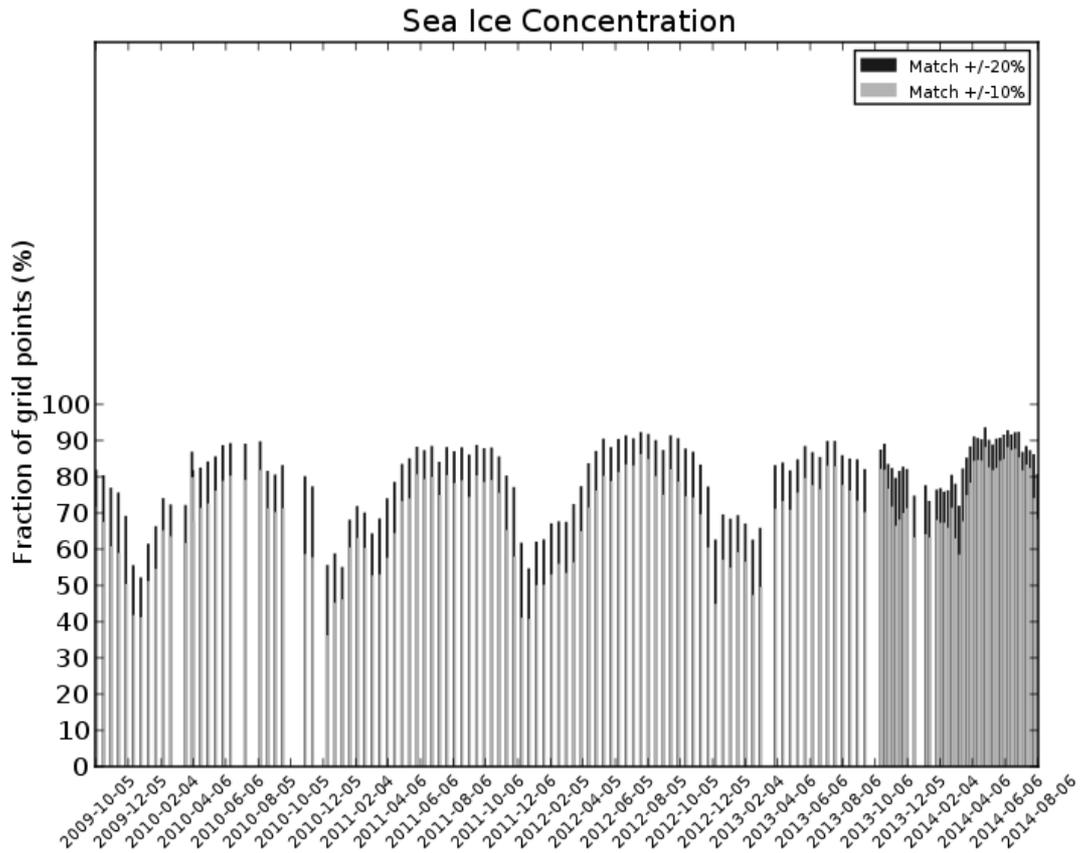


Figure 10: Comparison between SH NIC ice charts and OSI-409a reprocessed ice concentrations, for the period Oct. 2009 to Aug. 2014. The grey and the black curve shows the percentage of cases where the two products deviates by 10% and 20%, respectively.

Figure 11, displaying the bias between the ice chart and reprocessed ice concentrations, shows that the water bias is smaller than for the Northern Hemisphere comparison which is most likely due to the difference in proportion of coastal zone to ocean waters and atmospheric conditions.

From Oct. 2013, at the same time as the frequency in ice chart production increases, the ice bias increases for both summer and winter. This is discussed in the conclusion.

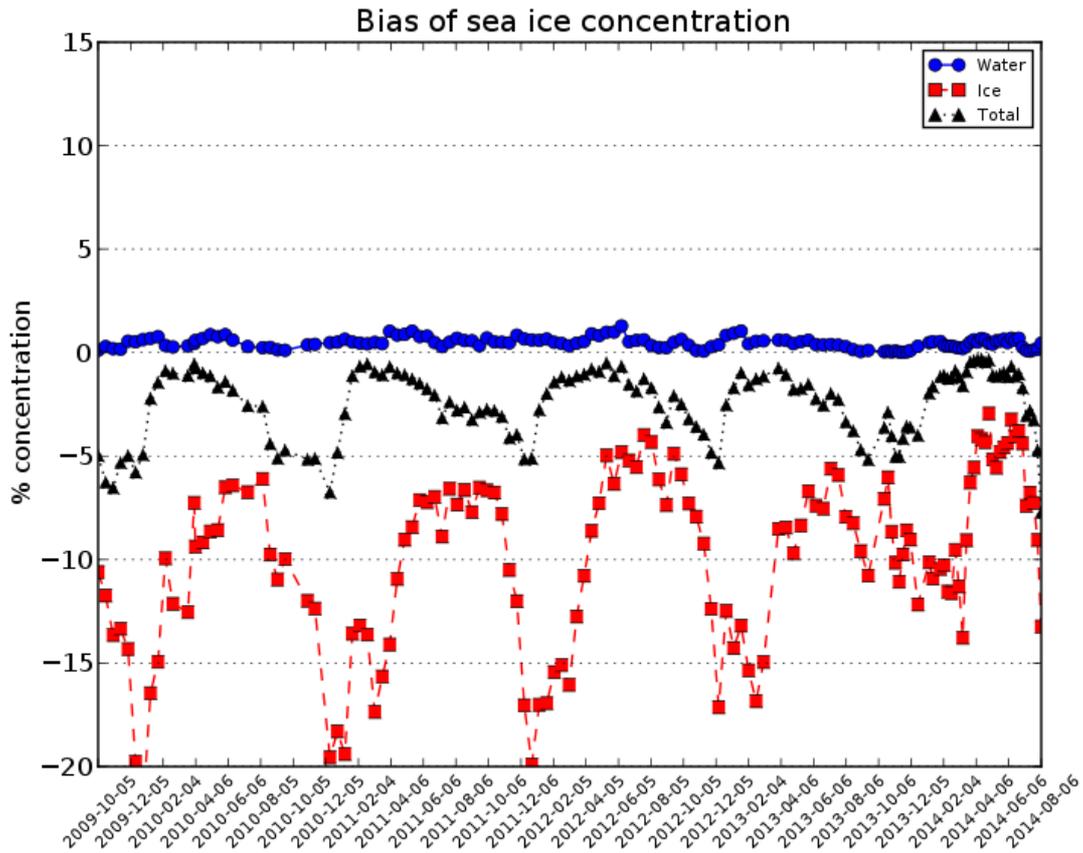


Figure 11: The total bias between SH NIC ice charts and OSI-409a reprocessed ice concentrations, for the period Oct. 2009 to Aug. 2014. The total bias is shown with the black curve, the negative bias in ice covered regions with the red curve and the positive bias in water areas with the blue curve.

Figure 12, displaying the standard deviation of the difference between the ice chart and reprocessed ice concentrations, show that there is a clear seasonal cycle with higher standard deviations during Antarctic summer than during winter. The standard deviation over open water seems to decrease during the reanalysis period.

From Oct. 2013, at the same time as the frequency in ice chart production increases, the ice standard deviation decreases for both summer and winter. This is discussed in the conclusion.

The total standard deviation yearly average is a little below 10%.

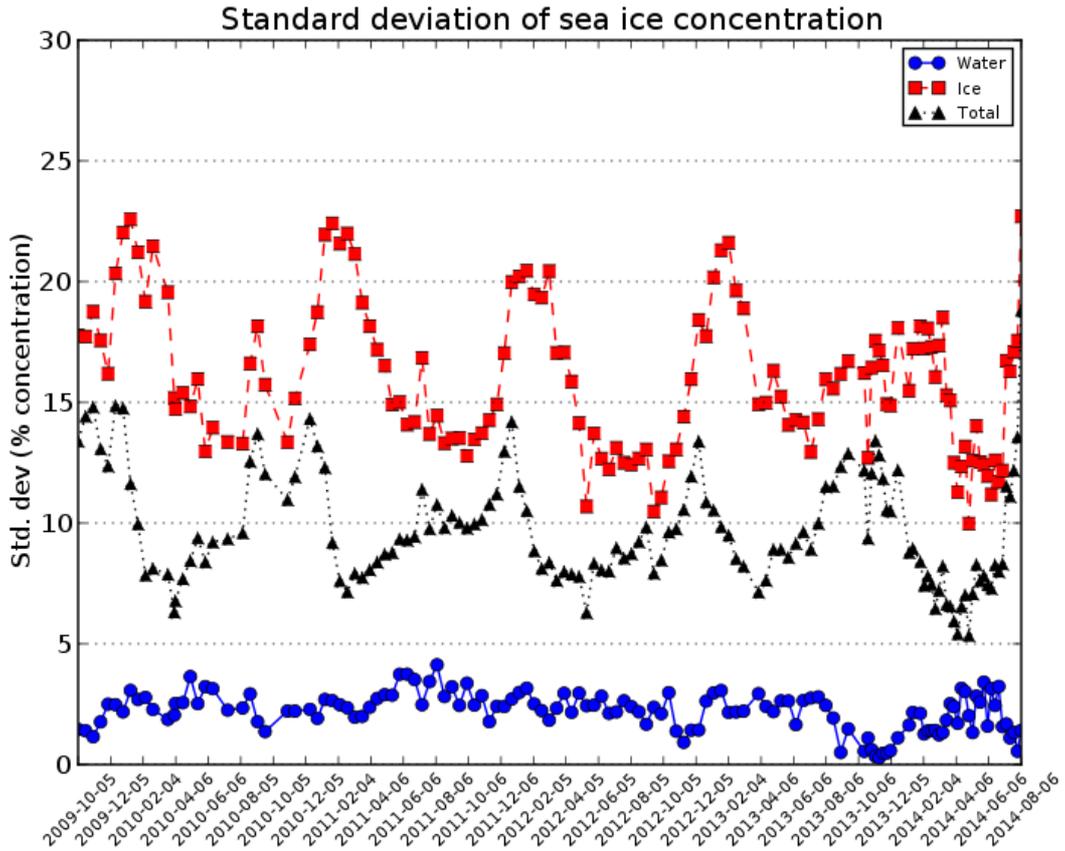


Figure 12: The standard deviation on the difference between the SH NIC ice charts and OSI-409a reprocessed ice concentrations, for the period Oct. 2009 to Aug. 2014. The black curve shows the standard deviation of the difference in ice concentration for both ice and open water regions. The red and the blue curve show standard deviation of the difference for ice and water regions, respectively.

### 3 Intercomparison of SMMR and SSM/I ice concentration during the overlap period

An intercomparison of OSI SAF ice concentration products generated from SMMR sensor data and SSM/I sensor data in the overlap period in July and August 1987 has been carried out. The OSI SAF EASE 12.5 km ice concentration product has been used in the intercomparison.

The parameters shown in the intercomparison plots are:

Parameter	Description
total_bias	Average of SMMR – SSM/I for all valid points
ice_bias	Average of SMMR – SSM/I for all points where SMMR concentration > 15%
total_stddev	Standard deviation of SMMR – SSM/I for all valid points
ice_stddev	Standard deviation of SMMR – SSM/I for all points where SMMR concentration > 15%

#### 3.1 Intercomparison SMMR/SSM/I Northern Hemisphere

The overlap period between SMMR and SSM/I is really short (~2 months). In order to establish the tie-points 15 days prior and after the actual date is needed. Subtracting 15 days in each end of the overlap period leaves only a few days. It takes two weeks after the beginning of SSM/I to establish a tie-point period which is identical to SMMR and vice versa for SMMR. One month is subtracted in total from the total overlap shown in the figure 13. Figure 13 shows the overall bias between SMMR and SSM/I including the periods where tie-points are based on less than one month's data. On the Northern Hemisphere there are a limited number of ice data points because the overlap is during the sea ice minimum.

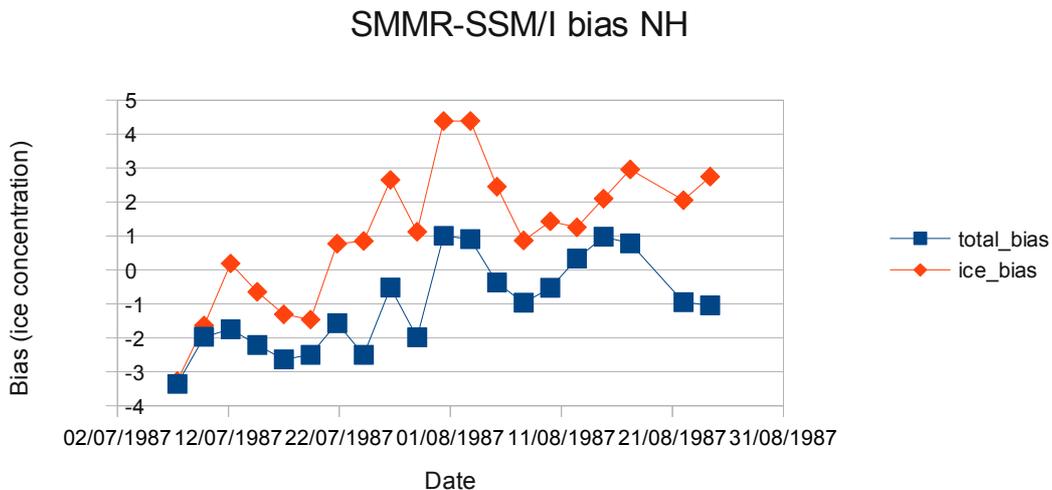
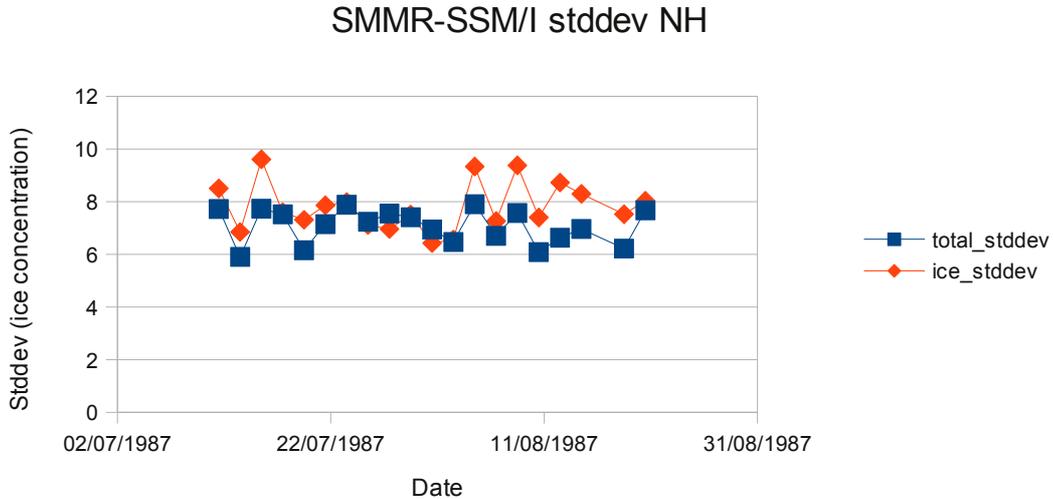


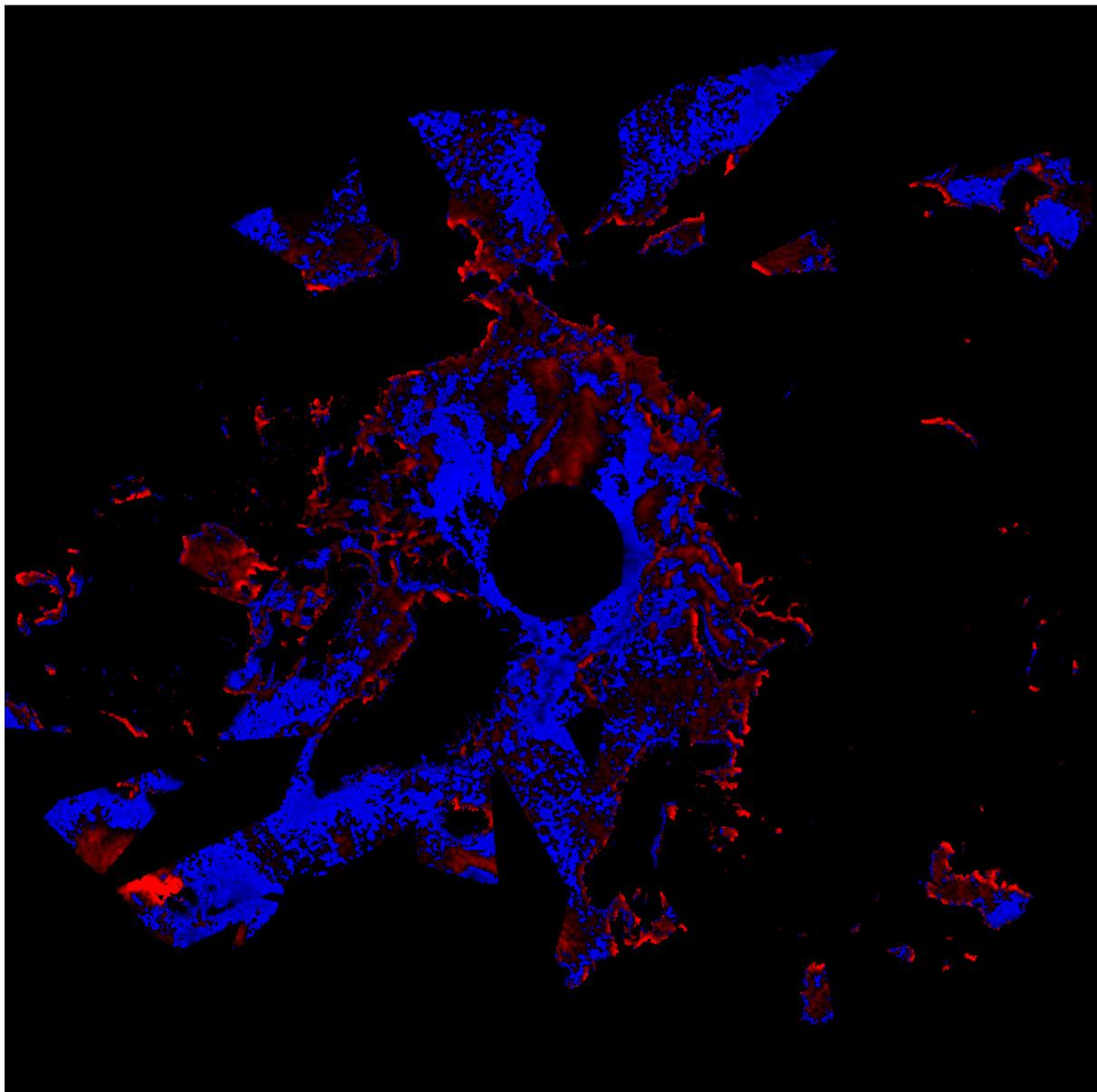
Figure 13: The Northern Hemisphere total bias (blue) and the bias in ice covered regions (red) between SMMR and SSM/I during the overlap period in 1987.

Figure 14 shows the Northern Hemisphere standard deviation of the difference between SMMR and SSM/I during the overlap period in 1987.



*Figure 14: The Northern Hemisphere standard deviation of the difference between SMMR and SSM/I during the overlap period in 1987. Blue is for both ice and water regions and red is for ice covered regions.*

Figure 15 shows the difference between SMMR and SSM/I on 12 August 1987 as a typical example (the difference in the coastal region is a constant feature in the NH region) during the overlap period. It is clear that the SMMR estimates are higher than SSM/I along the coast lines. Over ice and open water the differences between the sensors are probably due to acquisition time and the changing environmental conditions.



*Figure 15: Comparison between SMMR and SSM/I on 12 August 1987. Red shows the regions where SMMR is higher than SSM/I and vice versa for blue.*

### **3.2 Intercomparison SMMR/SSM/I Southern Hemisphere**

The SMMR and SSM/I overlap period coincides with the ice maximum in the Southern Hemisphere which is ideal for comparison. However, the comparison is limited by the very short overlap as on the Northern Hemisphere. Figure 16 and figure 17 shows the average bias and standard deviation on the differences respectively.

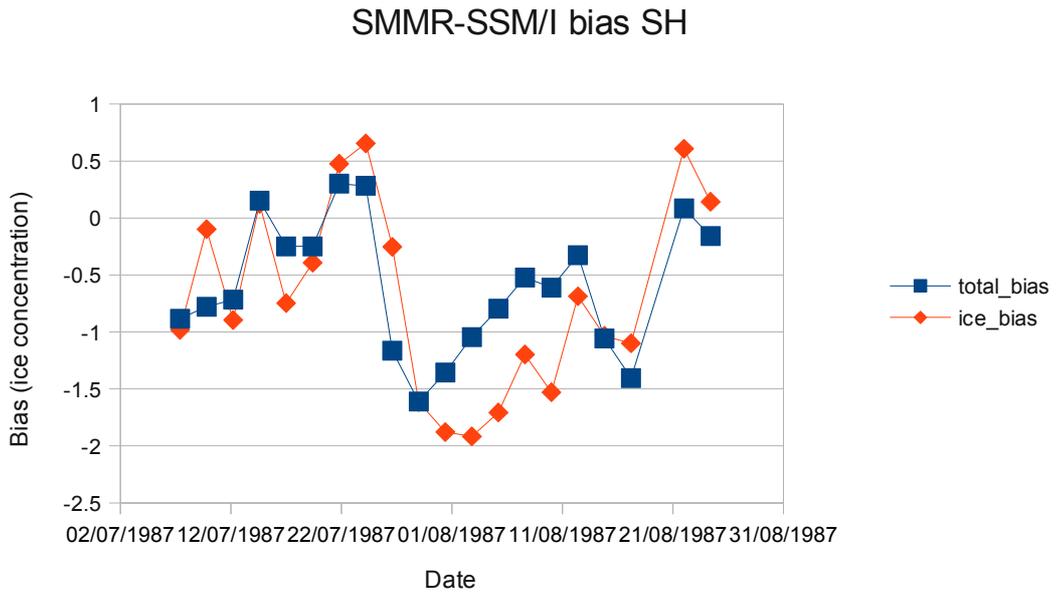


Figure 16: The Southern Hemisphere total bias (blue) and the bias in ice covered regions (red) between SMMR and SSM/I during the overlap period in 1987.

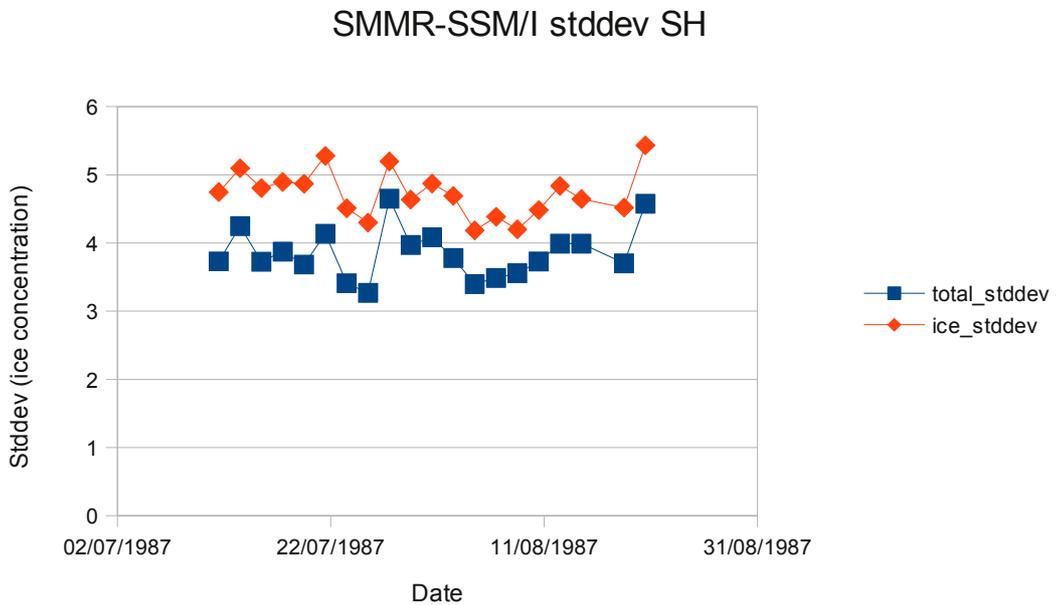
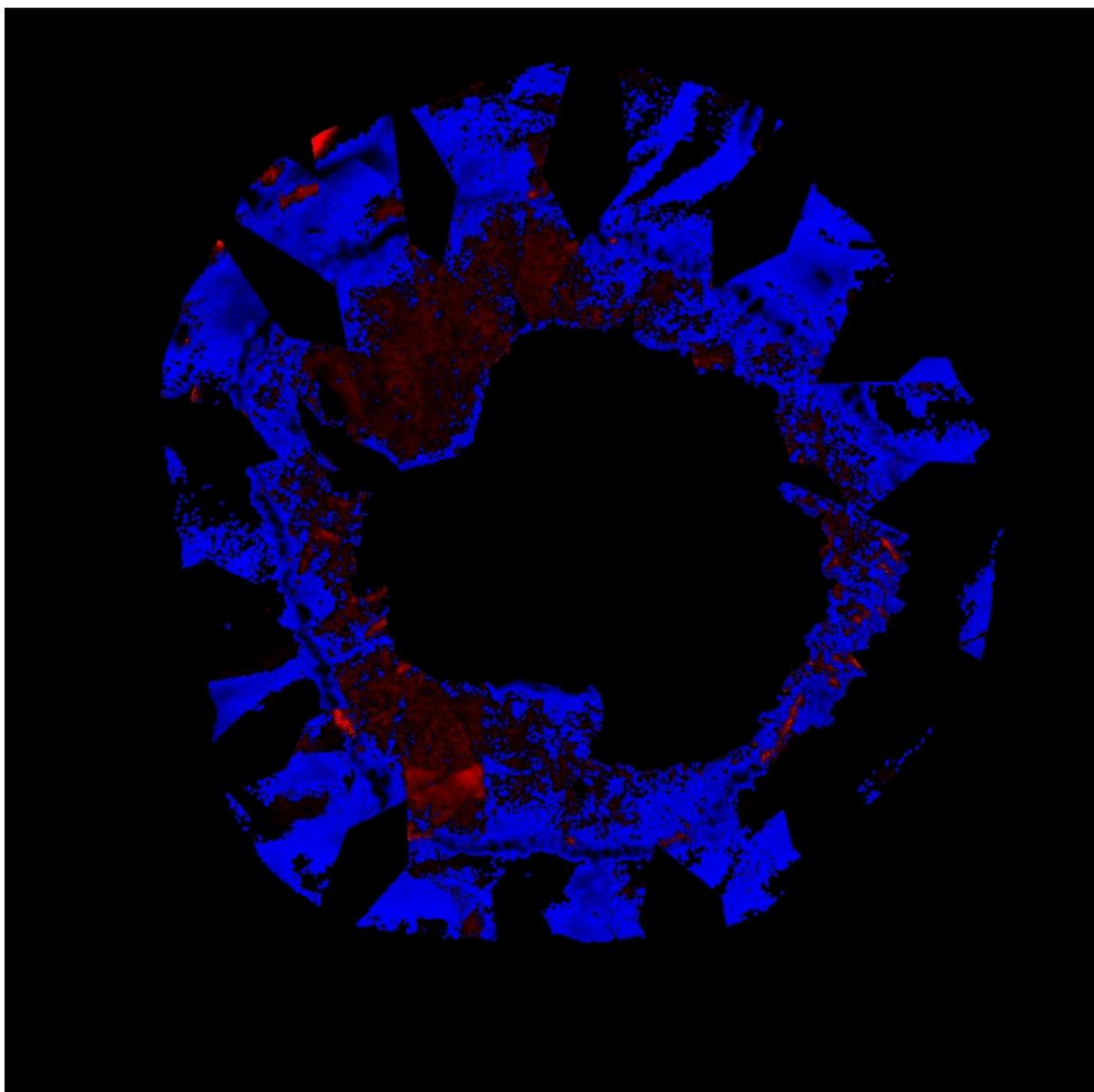


Figure 17: The Southern Hemisphere standard deviation of the difference between SMMR and SSM/I during the overlap period in 1987. Blue is for both ice and water regions and red is for ice covered regions.

Figure 18 shows the difference between SMMR and SSM/I on 27 July 1987 as a typical example (no recurring features in spatial distribution of the differences was observed by visual inspection in the overlap period). Over ice and open water the differences between the sensors are probably due to acquisition time and the changing environmental conditions. The snapshot in figure 18 and 19 also reflects the Antarctic winter and the Arctic summer. The contrast in brightness temperature is large between land and open water and small between land and sea ice. These differences in contrast is seen as red artifacts along the coast on the northern hemisphere in figure 19.



*Figure 18: Comparison between SMMR and SSM/I on 27 July 1987. Red shows the regions where SMMR is higher than SSM/I and vice versa for blue.*

## 4 Extension of the dataset beyond 2009: comparison of the overlap

In 2015 the climate record was extended from 2009 to 2015. Selected months during a two year overlap period (Jan. 2008 - Oct. 2009) between the initial climate record (OSI-409) and the extension (OSI-409a) were compared to monitor the continuity. The difference between the initial data set and the extension is the input data source. The initial data set is based on re-calibrated SSM/I data from Remote Sensing System and the extension is based on non re-calibrated operational data received from NOAA. This difference is further described in the section 2.2 and 2.3 of the PUM [RD-1].

Only small differences between the two data sets in the overlapping period are expected as they are both based on SSM/I data, the dynamical tie-point method will take care of most calibration differences and they are independent. It should be noted that the standard deviations that were calculated in Section 2.1 in the comparison to ice charts were lower for the extension (OSI-409a) than for the initial data set (OSI-409). It is yet unclear why. Eight panels are shown below as an example. Four show the comparison on the Northern Hemisphere (Figure 19-22) and four show the comparison on the Southern Hemisphere (Figure 23-26). Figure 19 shows the mean 2009 January NH sea ice concentration from the initial climate record. Figure 20 shows the mean 2009 January NH sea ice concentration from the extension. Figure 21 shows the difference of the mean between Figure 20 and 19. This figure shows that the differences between the extension and the initial ice concentration are small. Figure 22 shows the scatter-plot of ice concentrations between the extension and the initial ice concentration. The differences in Figure 21 and the scatter in Figure 22 are typical for the NH fields looked at during the overlap period. Figure 23 shows the mean 2009 January SH sea ice concentration from the initial climate record. Figure 24 shows the mean 2009 January SH sea ice concentration from the extension. Figure 25 shows the difference of the mean between Figure 24 and 23. It is shown that the differences between the extension and the initial ice concentration are small. The climatological maximum extent mask in OSI-409a is larger than for OSI-409 (see section 3.2.3 of the PUM), which has resulted in a zone of systematic differences. Figure 26 shows the scatter-plot of ice concentrations between the extension and the initial ice concentration. The differences in Figure 25 and the scatter in Figure 26 are typical for the SH fields looked at during the overlap period.

The overall results shows that the differences between the OSI-409 and OSI-409a in the overlapping period are small and there is consistency between the two datasets.

It should be noted that the climatological maximum ice extent mask in the Northern Hemisphere has not been extended as in the Southern Hemisphere, as it mainly works as intended. The only known area where the NH climatological mask is not extensive enough is in the Cook Inlet by the Gulf of Alaska, where some seasonal ice is removed from the product. This will be fixed in the next reprocessing, planned for 2016.

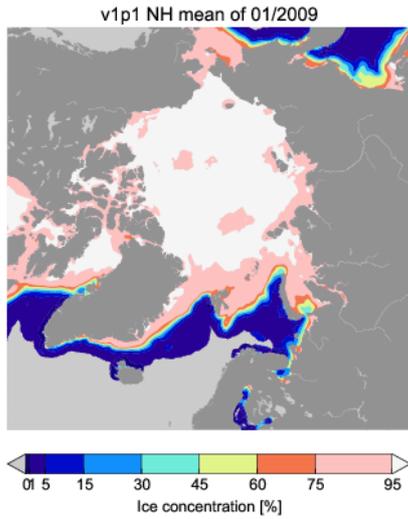


Figure 19: Mean Jan. 2009 NH sea ice concentration initial climate record (OSI-409).

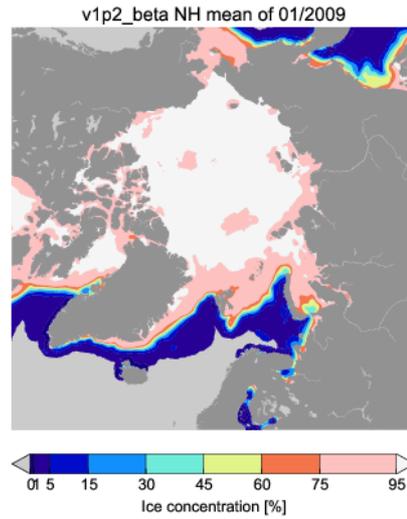


Figure 20: Mean Jan. 2009 NH sea ice concentration extension climate record (OSI-409a).



Figure 21: Difference of the mean of extension versus initial (extension - initial).

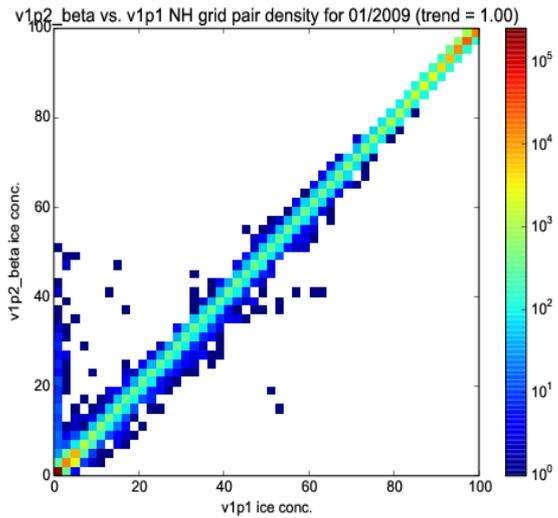


Figure 22: Extension versus initial.

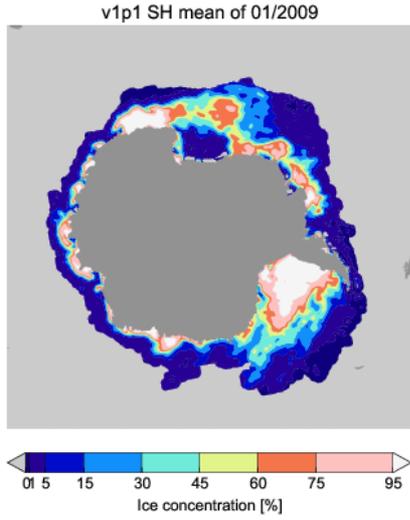


Figure 23: Mean Jan. 2009 SH sea ice concentration initial climate record (OSI-409).

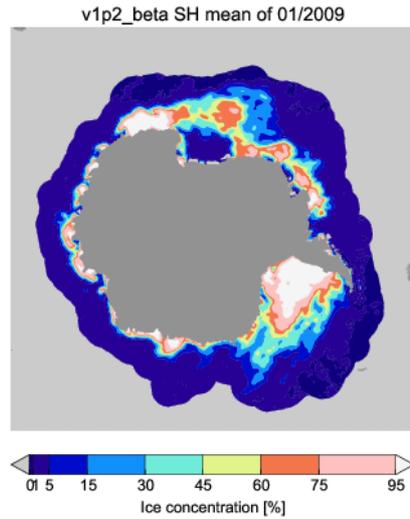


Figure 24: Mean Jan. 2009 SH sea ice concentration extension (OSI-409a).

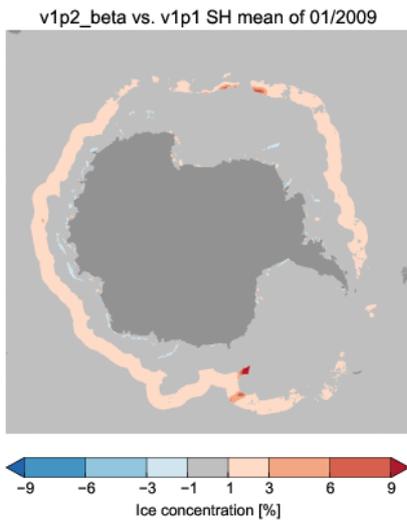


Figure 25: Difference of the mean of extension versus initial (extension – initial).

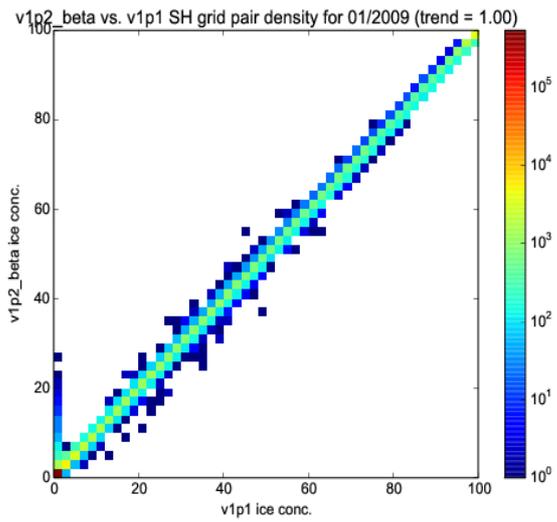


Figure 26: Extension versus initial.

## 5 Conclusions

There are two scientific requirements listed in the Product requirement document table OSI-PRD-PRO-200: (i) the requirement on spatial resolution and (ii) the accuracy of the product on a yearly basis. Here the accuracy of the OSI SAF ice concentration products are evaluated using ice chart information for comparison.

(i) The requirement on spatial sampling is 10km. That applies to both the OSI-409 and the OSI-409a/OSI-430 product. This requirement is met.

(ii) The requirement on target accuracy, that applies to both the OSI-409, OSI-409a and the OSI-430 product, is standard deviation yearly average of 10% for the NH-product and 15% for SH-product.

For the OSI-409 product, all requirements on accuracy are met in the comparison with ice charts. The deviations between the ice product and the ice charts are large during summer melt: up to 20% on both hemispheres, while during the winter the deviations are 5-10%.

For the OSI-409a/OSI-430 product, the requirements on target accuracy are met for the SH comparison, with a total standard deviation yearly average of 10%. For the NH comparison the total standard deviation yearly average is also 10%, and the requirement met, if not including the increase in water standard deviation from July 3 2014 and through August, see figure 9. An explanation to this abrupt change in water standard deviation is *not* found when looking at plots of the OSI SAF ice concentration product before and after the change in water standard deviation on July 3 2014, cf. the plots of the products from July 1<sup>st</sup> 2014 and July 3<sup>rd</sup> 2014 in Figure 27 and 28 in the appendix. We have analysed the ice charts and the OSI SAF ice concentration product but have not been able to find the explanation for the spikes in standard deviation in Figure 9. There are also spikes if we compare to DMI ice charts instead of NIC ice charts see Figure 29 in the appendix.

It is clear that the ice charts does not necessarily represent the truth rather a fairly independent dataset for comparison. The increased frequency in ice chart production for both hemispheres from Oct. 2013 (until July 2014), however has a positive effect on the comparison with the OSI SAF product. This may be because of an increase in the quality of the ice chart product, which makes the comparison more representative.

The transition between the initial climate record and the extension is investigated in chapter 4. The analysis indicates that continuity is ensured.

## Appendix: OSI-409a/OSI-430 product samples

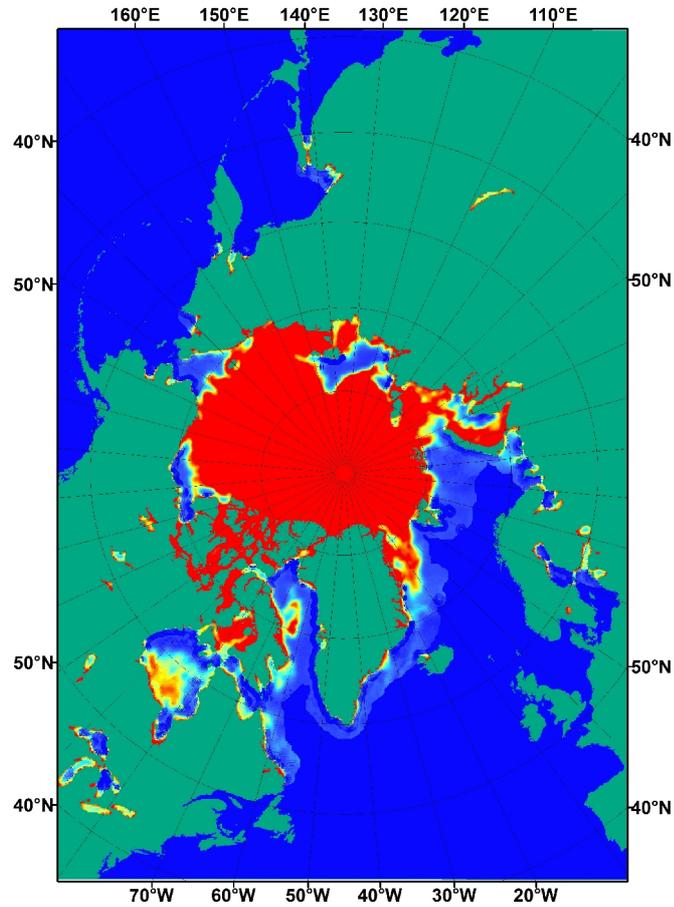
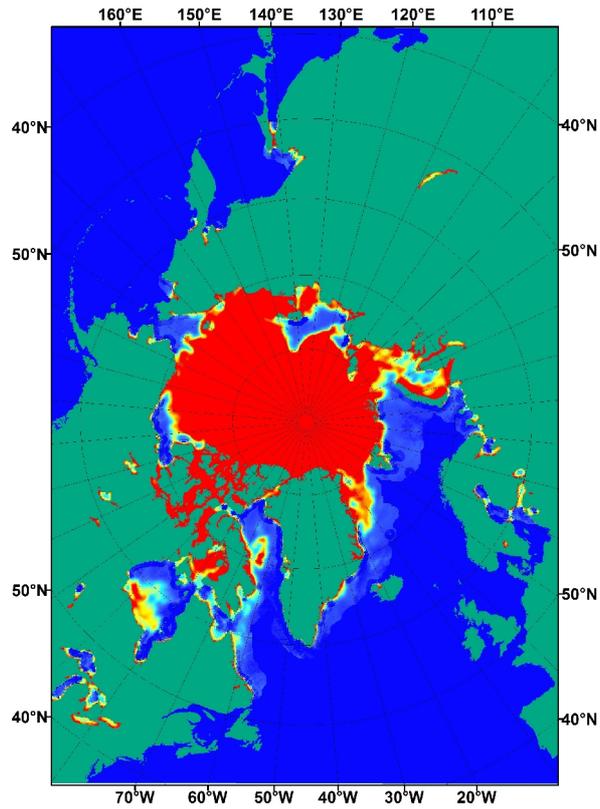


Figure 27: Plot of OSI-409a ice concentration reprocessing product from July 1<sup>st</sup> 2014, showing ice concentration values from 0% (dark blue) to 100% (red). Green is land.



*Figure 28: Plot of OSI-409a ice concentration reprocessing product from July 3<sup>rd</sup> 2014, showing ice concentration values from 0% (dark blue) to 100% (red). Green is land.*

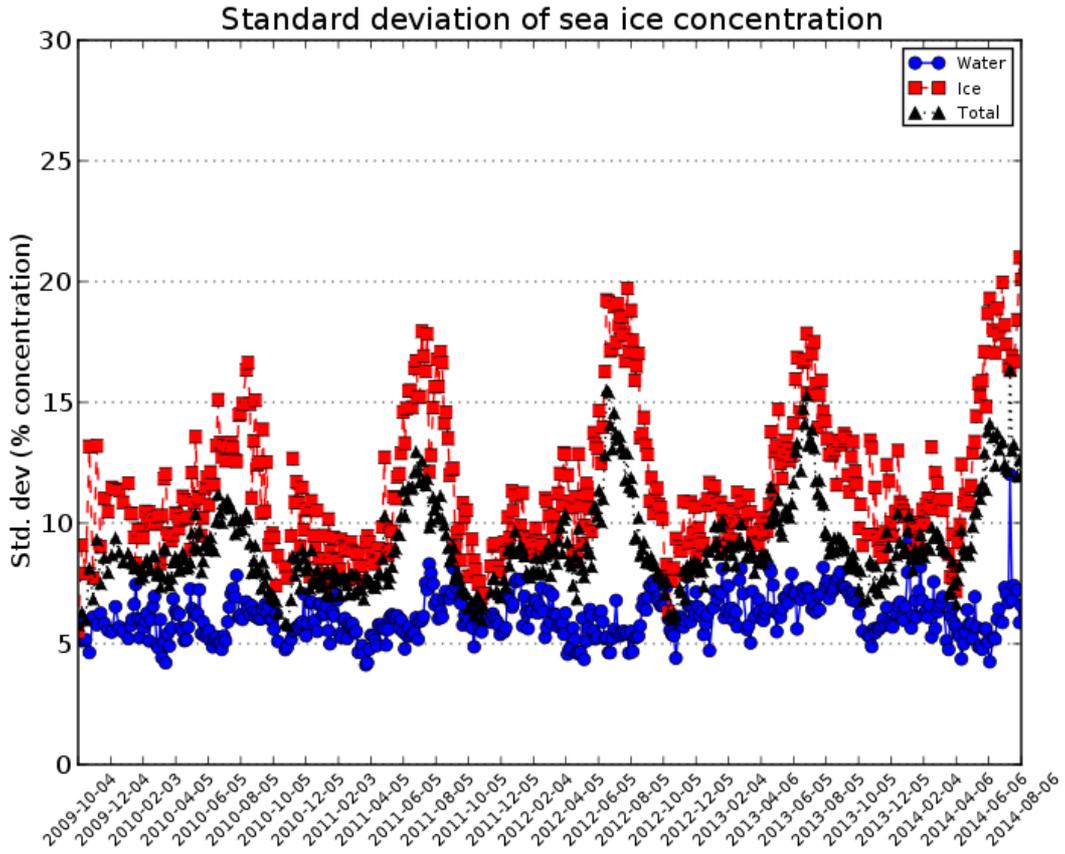


Figure 29: The standard deviation on the difference between the NH DMI ice charts and OSI-409a reprocessed ice concentrations, for the period Oct. 2009 to Aug. 2014. The black curve shows the standard deviation of the difference in ice concentration for both ice and open water regions. The red and the blue curve show standard deviation of the difference for ice and water regions, respectively.