The EUMETSAT Network of Satellite Application Facilities

OSI SAF
Ocean and Sea Ice

Ocean & Sea Ice SAF

Global Sea Ice Concentration Reprocessing Validation Report

Product OSI-409

Version 1.3

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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	30.09.2011	Updates after DRI2 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 present report presents the validation results of the OSI SAF global reprocessed sea ice concentration product OSI-409 version 1.1. The report covers the period from Oct. 1978 to Oct. 2009. It describes a comparison between 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 Reprocessing Product User Manual.
[RD-2] : OSI SAF Product Requirement Document.

1.3Definitions, acronyms and abbreviations

AVHRR	Advanced Very High Resolution Radiometer
DMSP	Defense 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
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
SIGRID	Sea ice chart grid format
SMMR	Scanning Multichannel Microwave Radiometer (on NIMBUS 7)
SSMI	Special Sensor Microwave Imager

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, available at this address:

ftp://saf.met.no/reprocessing/ice/conc/v1p1/

The data are organized in year and month directories.

The data are available from Oct. 1978 to Oct. 2009 except for shorter gaps due to satellite malfunction or planned maintenance. The SMMR instrument was operated every second day.

List of sensors on the Nimbus 7 and DMSP satellites.

Sensor	Launch	End
Nimbus 7 SMMR	October 1978	August 1987
DMSP F8	June 1987	December 1991
DMSP F10	December 1990	November 1997
DMSP F11	November 1991	May 2000
DMSP F13	March 1995	November 2009
DMSP F14	May 1997	August 2008
DMSP F15	December 1999	Opr. at the end of 2009

List of ice chart availability during the reanalysis period. All the ice charts are from the National Ice Center.

Hemisphere	Period	Frequency
North	1978 - 2009	weekly 1978 - Jun. 2001 twice a month Jun. 2001 - 2009
South	1978 - Dec. 1994 Jan. 2003 - 2009	weekly 1978 - Dec. 1994 twice a month Jan. 2003 - 2009

2.1 Sea Ice product comparison

It is only actual data-points which are compared. This excludes the missing satellite data around the pole and other areas or individual pixels interpolated during the gap filling procedure.

2.1.1 Ice chart data

The operational sea ice charts from National Ice Center (NIC) are a relatively independent source of ice information for comparing to the reanalysis. The ice charts, intended for aiding navigation are produced on a regular basis covering all seasons, both Southern and Northern hemispheres and the time series cover the entire reanalysis period (see section 2.0) except for the period 1995 to 2002 on the southern hemisphere where we have been unable to acquire digital ice charts.

The OSI SAF global sea ice concentration reanalysis products are therefore compared to the NIC ice charts. Ice charts are produced manually on the basis of 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 more recent ice charts are based partly on satellite SAR data e.g. Radarsat 1 since 1995 and Envisat since 2000, 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 and SMM/I 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 weekly compilation of the ice conditions 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 global sea ice concentration climate dataset. Further the specific requirements listed in the 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 a 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 are gridded onto a common projection and resolution (25 km EASE grid). Following this a cell by cell comparison is carried out. For each ice chart concentration level the deviation between ice chart concentration and reanalysis ice concentration is calculated. Afterwards deviations are grouped into categories, i.e. ±10% and ±20%. Furthermore the bias and standard deviation is calculated for each concentration level. 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 is the WMO standard for describing ice in ice charts. The CT SIGRID variable used for comparison is the total ice concentration lin 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 ice charts are compared with OSI SAF EASE 25 km ice concentration product.

The parameters shown in the validation plots are defined as follows. The ice chart analysis concentration will be refered 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 ±10% of the IAC
match_20_pct	The fraction of points where IAC shows ice and OSIC is within ±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 National Ice Center (NIC) ice charts for Northern Hemisphere and the OSI SAF reanalysis

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.

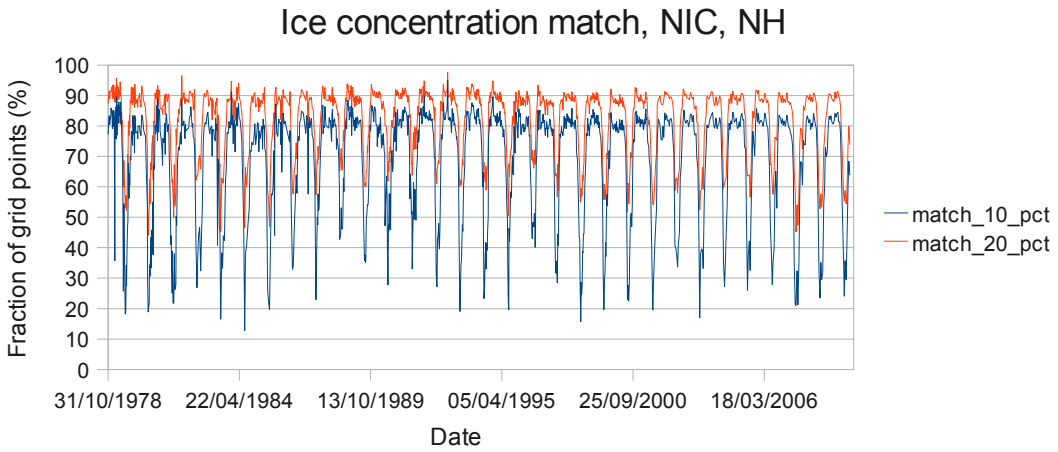

Figure 1: Comparison between Northern Hemisphere National Ice Center ice charts and OSI SAF reanalysis ice concentration. The blue and the red curve shows the percentage of cases where the two products deviates by 10% and 20%, respectively.

The bias in ice concentration between the Northern Hemisphere National Ice Center ice charts and OSI SAF reanalysis ice concentration is shown in figure 2. The OSI SAF reanalysis ice concentration is higher than the ice chart over open water. This is due to the fact that 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 SMMR SSM/I transition 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%.

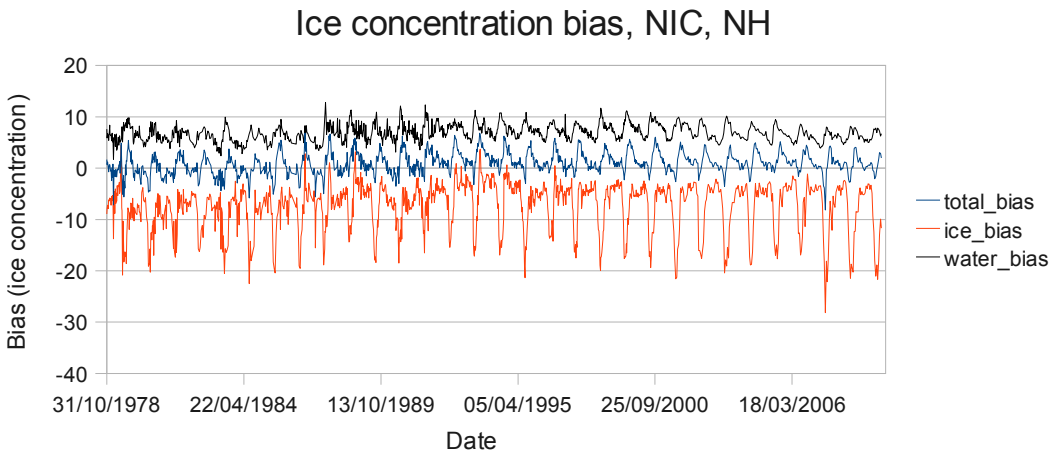

Figure 2: Comparison between the Northern Hemisphere National Ice Center ice charts and OSI SAF reanalysis ice concentration. The total bias between OSI SAF the reanalysis product and the ice chart is shown with the blue curve, the negative bias in ice covered regions with the red curve and the positive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

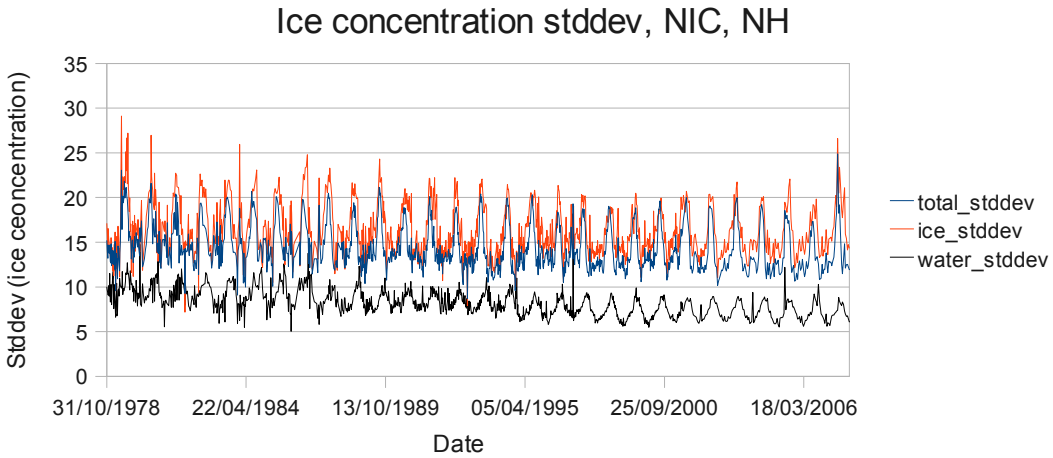

Figure 3: Comparison between Northern Hemisphere National Ice Center ice charts and the OSI SAF reanalysis ice concentration. The figure shows the standard deviation the difference between the OSI SAF reanalysis product and the ice charts. The blue curve shows the standard deviation of the difference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

2.1.6 Comparison between National Ice Center (NIC) ice charts for the Southern Hemisphere and the OSI SAF reanalysis

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.

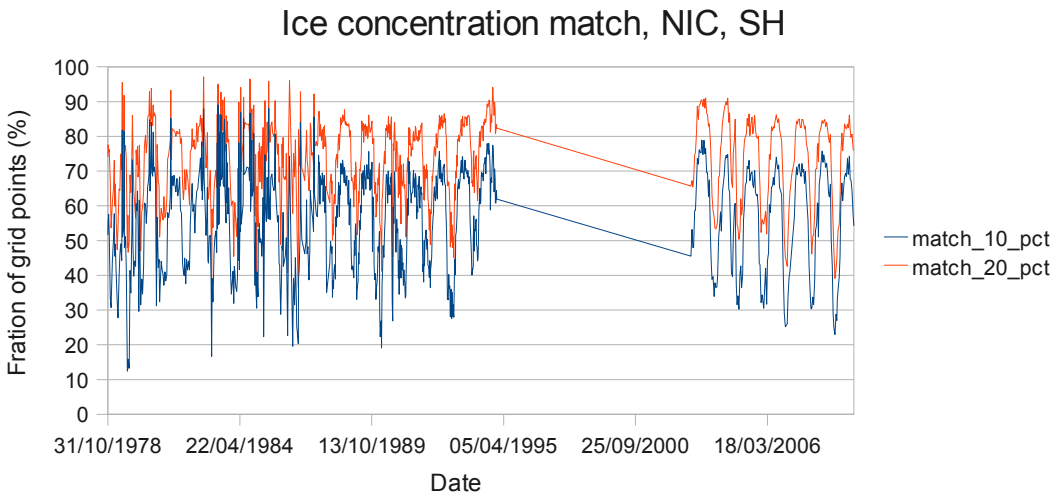

Figure 4: Comparison between Southern Hemisphere National Ice Center ice charts and OSI SAF reanalysis ice concentration. The blue and the red curve shows the percentage of cases where the two products deviates by 10% and 20%, respectively. Ice chart data are missing from 1994 to 2003.

The bias in ice concentration between the Southern Hemisphere National Ice Center ice charts and OSI SAF reanalysis ice concentration is shown in figure 5. The OSI SAF reanalysis ice concentration is higher than the ice chart over open water. This is due to the fact that 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 costal zone to ocean waters and athmospheric conditions.

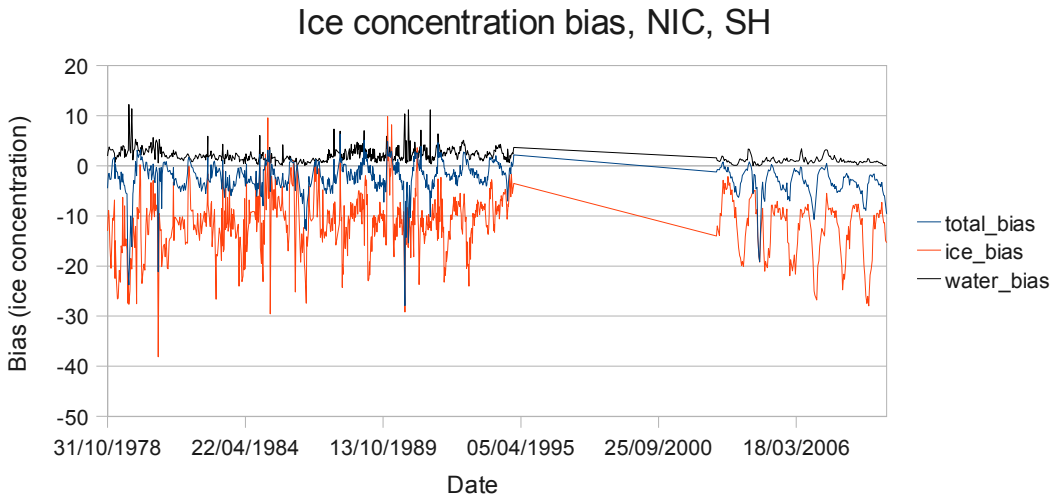

Figure 5: Comparison between the Southern Hemisphere National Ice Center ice charts and OSI SAF reanalysis ice concentration. The total bias between OSI SAF the reanalysis product and the ice chart is shown with the blue curve, the negative bias in ice covered regions with the red curve and the positive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

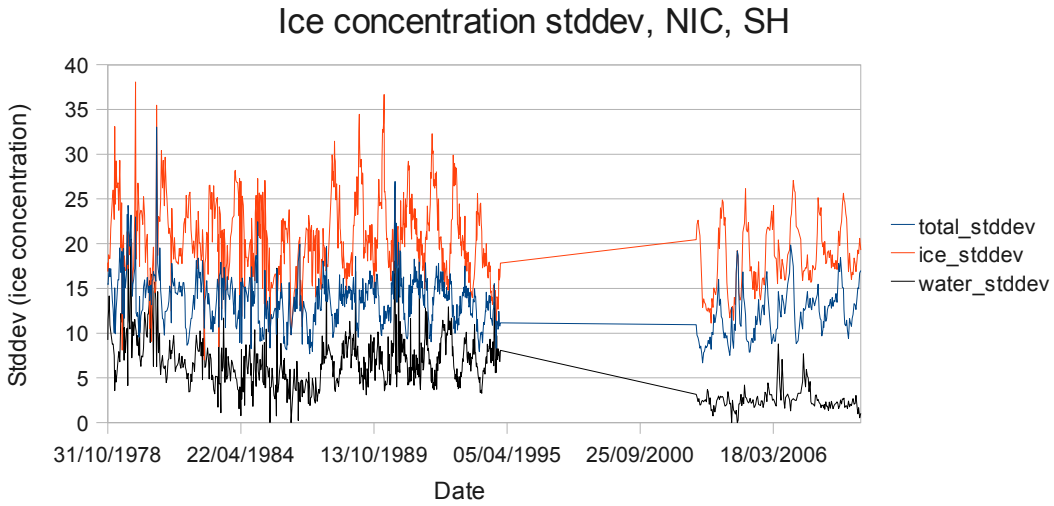

Figure 6: Comparison between Southern Hemisphere National Ice Center ice charts and the OSI SAF reanalysis ice concentration. The figure shows the standard deviation the difference between the OSI SAF reanalysis product and the ice charts. The blue curve shows the standard deviation of the difference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

3 Intercomparision of SMMR and SSMI 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 – SMM/I for all valid points
ice_bias	Average of SMMR – SMM/I for all points where SMMR concentration > 15%
total_stddev	Standard deviation of SMMR – SMM/I for all valid points
ice_stddev	Standard deviation of SMMR – SMM/I for all points where SMMR concentration > 15%

3.1 Intercomparison SMMR/SSMI Northern Hemisphere

The overlap period between SMMR and SSM/I is really short (~2 months). In order to establish the tiepoints 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 tiepoint 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 7. Figure 7 shows the bias overall bias between SMMR and SSM/I including the periods where tie-points are based on less than a months data. Further on the Northern Hemisphere the overlap is during the sea ice minimum which means that there are a limited number of ice data points.

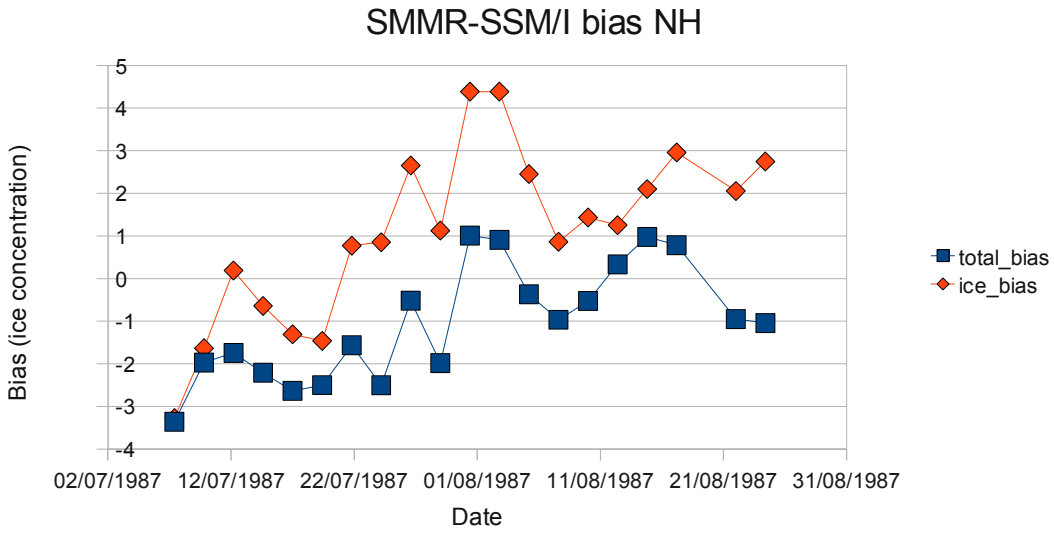

Figure 7: The Northern Hemisphere total bias (blue) and the bias in ice covered regions (red) between SMMR and SSM/I during the overlap period in 1987.

Figure 8 shows the Northern Hemisphere standard deviation of the difference between SMMR and SSMI during the overlap period in 1987.

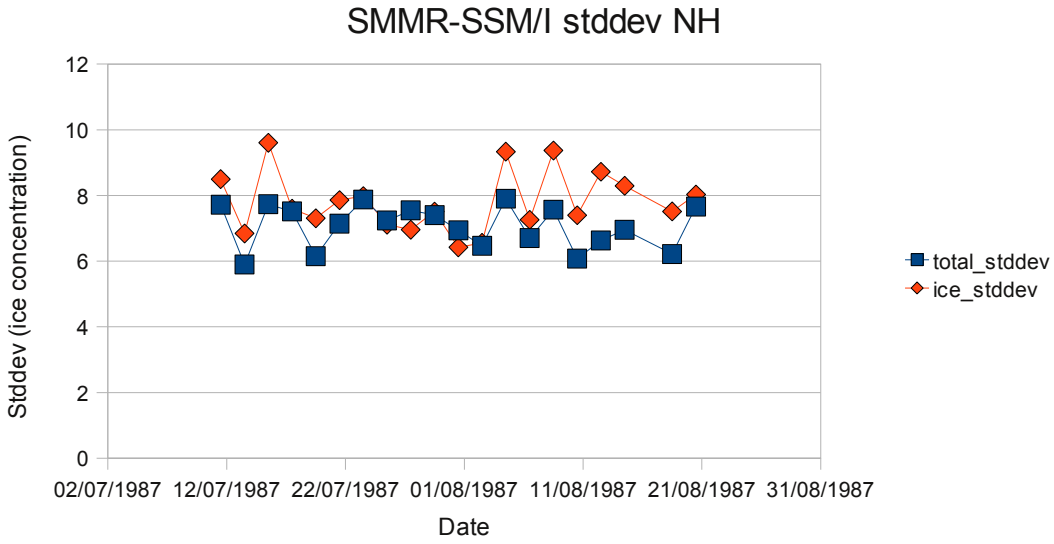

Figure 8: The Northern Hemisphere standard deviation of the difference between SMMR and SSM/I during the overlap period in 1987. Blue is for both ice and water regions and red is for ice covered regions.

Figure 9 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 th 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.

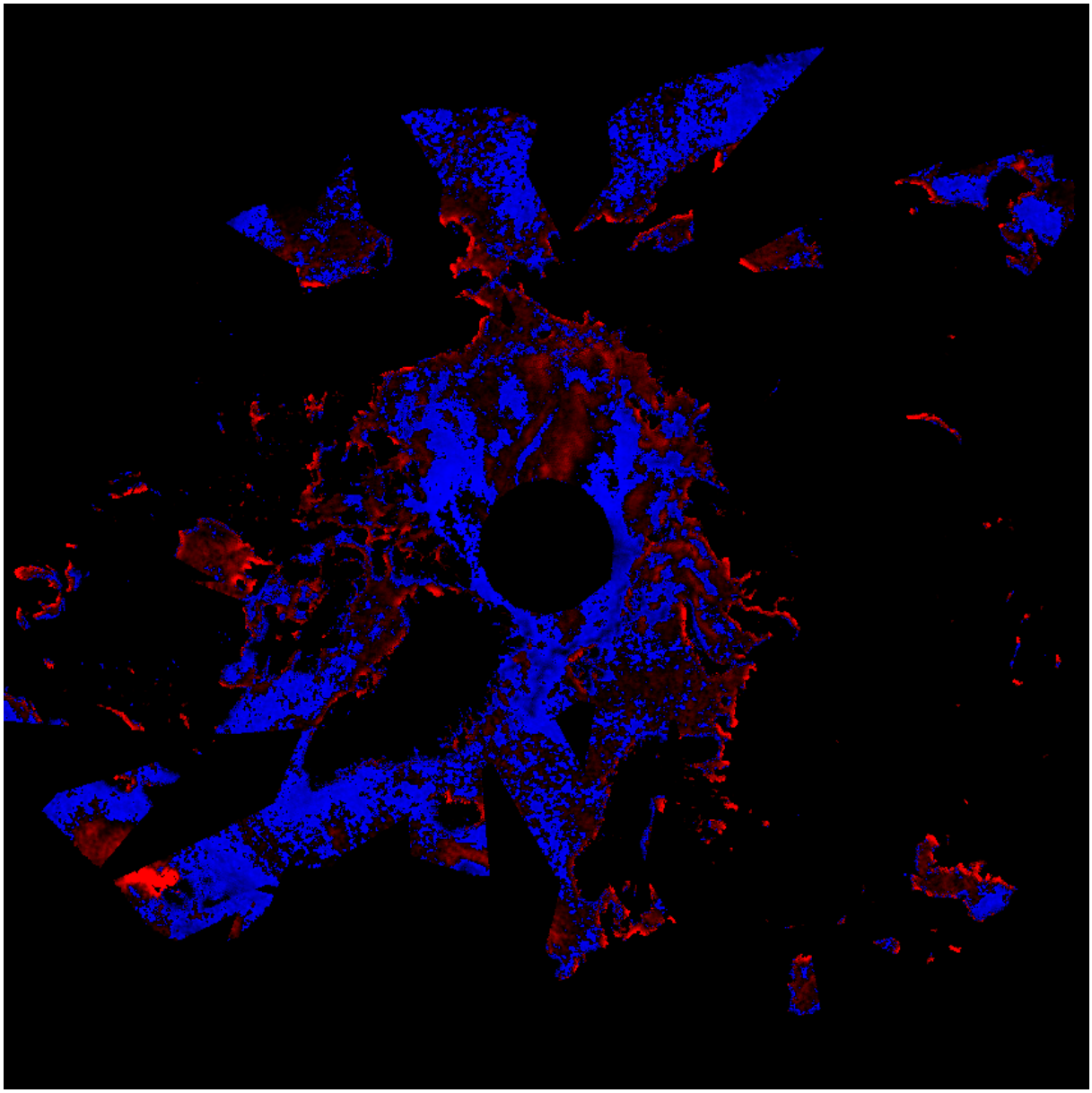

Figure 9: Comparison between SMMR and SSM/I on 12 August 1987. Red shows the regions where SMMR is higher than SSMI and vice versa for blue.

3.2 Intercomparison SMMR/SSMI Southern Hemisphere

The SMMR and SSM/I overlap period coincides with the ice maximum on the Southern Hemisphere which is ideal for camparison. However, the comparison is limited by the very short overlap as on the Northern Hemisphere. Figure 10 and figure 11 shows the bias and standard deviation on the difference respectively.

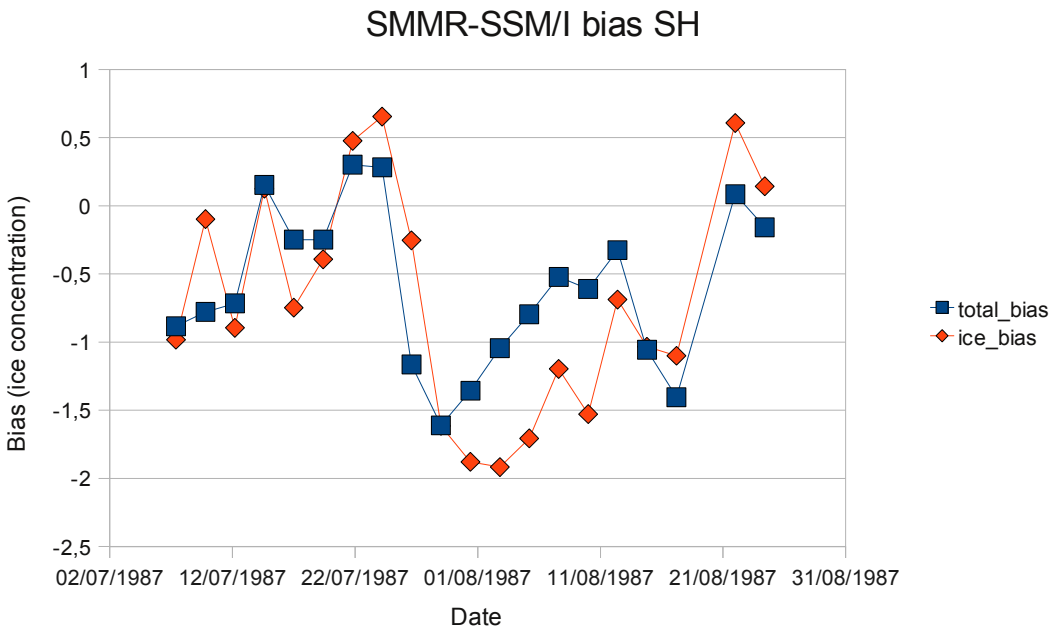

Figure 10: The Southern Hemisphere total bias (blue) and the bias in ice covered regions (red) between SMMR and SSM/I during the overlap period in 1987.

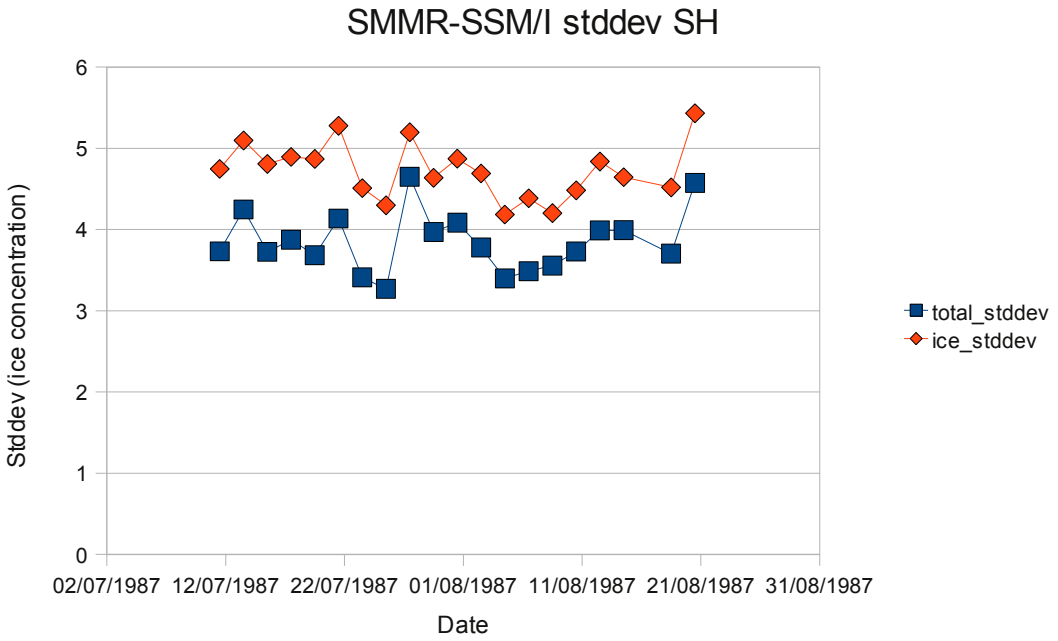

Figure 11: The Southern Hemisphere standard deviation of the difference between SMMR and SSM/I during the overlap period in 1987. Blue is for both ice and water regions and red is for ice covered regions.

Figure 12 shows the difference between SMMR and SSM/I on 27 July 1987 as a typical example (no recurring features in spatial distribution of the difference was observed by visual inspection in the verlap period) during the overlap period. Over

ice and open water the differences between the sensors are probably due to acquisition time and the changing environmental conditions.

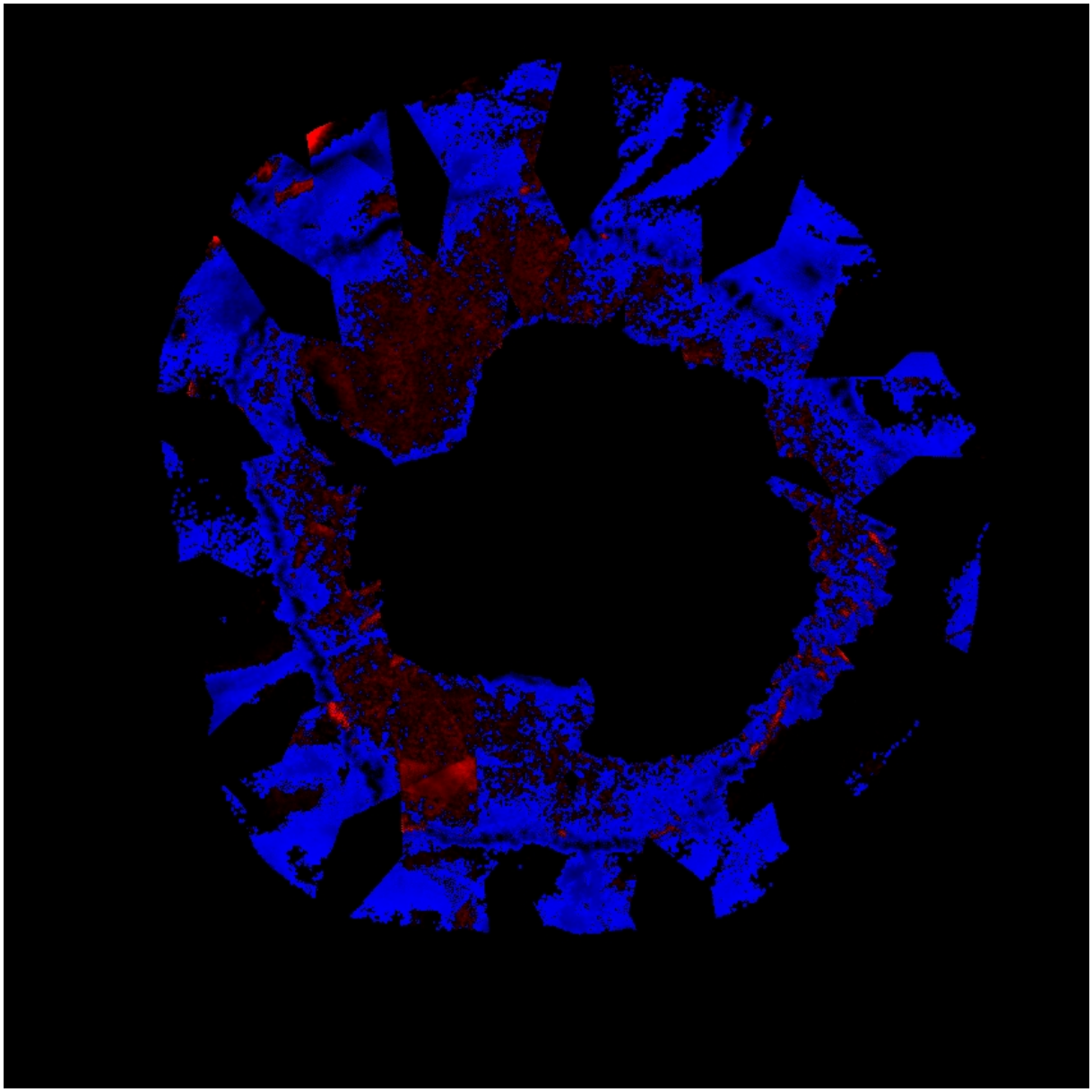

Figure 12: Comparison between SMMR and SSM/I on 27 July 1987. Red shows the regions where SMMR is higher than SSMI and vice versa for blue.

4 Conclusions

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

Spatial resolution: 10km. This requirement is not directly met. Even though the ice concentrations are provided on 10, 12.5 and 25km grids the sensor resolution of the 19GHz channels is much coarser (about 50km) and the oversampling means that the corresponding uncertainty on each estimate is larger than it would be if grid and actual spatial resolution were comparable. The penalty for the oversampling is quantified in the corresponding uncertainty estimate. This requirement can not be fulfilled with this microwave radiometer data set.

There are three requirements on accuracy: 1) threshold accuracy 20 % (yearly average), 2) target accuracy 10% for the NH-product and 15% for SH-product (yearly average), and 3) optimal accuracy: 10% (yearly average). 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%. It is clear that the ice charts does not necessarily represent the truth rather a fairly independent dataset for comparison.