



## MyOcean-2

### Quality Information Document - WP14 - OSI TAC

#### Baltic Sea Ice

Reference: MYO-WP14- QUID-V2-OSI

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<b>WP leader:</b> met.no	<b>Issue:</b> 1.0
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## CHANGE RECORD

Issue	Date	Description of Change	Author	Checked By
1.0	28/03/13	new	István Heiler, Juha Karvonen, Ari Seinä, Alexandru Gegiuc	

## **GLOSSARY AND ABBREVIATIONS**

NetCDF	Network Common Data Form
SAR	Synthetic Aperture Radar
SIW	Sea Ice and Wind
OSI	Ocean & Sea Ice
TAC	Thematic Assembly Centre
FMI	Finnish Meteorological Institute
ASI algorithm	ARTIST sea ice algorithm
IBM	Icebreaker measurement

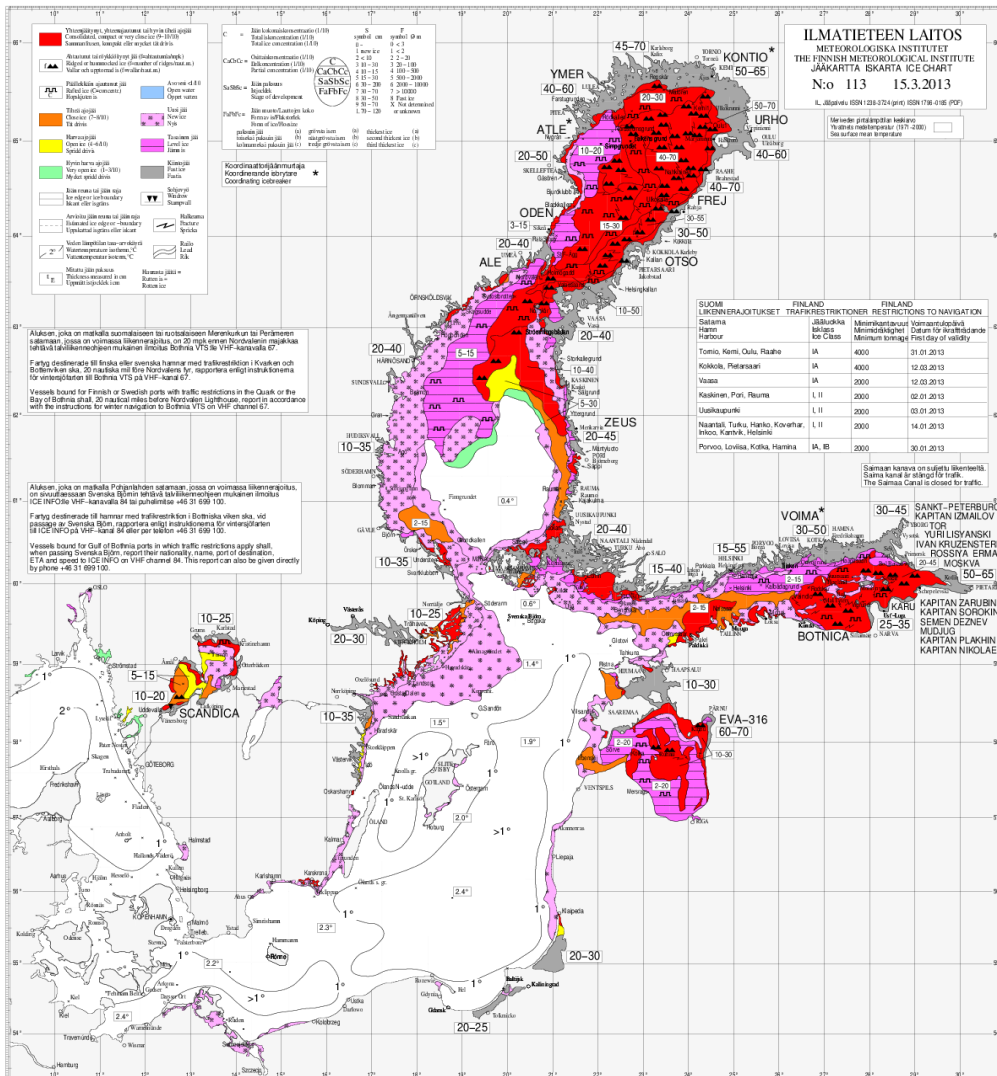
## **I.1 Overall description of validation task**

*AD-1: The objective of the operation is to validate the OSI (Ocean & Sea Ice) TAC (Thematic Assembly Centre) product against high quality reference data to ensure nominal quality.*

Validation is a continuous activity to develop the accuracy and quality of the sea ice product. In OSI TAC ice parameters over the Baltic Sea are provided by the Finnish Meteorological Institute (FMI). These include ice concentration, ice thickness and ice drift. The validation of these parameters is mainly based on operational data but it is also supported by in situ measurements.

## **I.2 Overall description of ice conditions during the ice season 2012-2013**

The ice season 2012-2013 has been an average ice season in the Baltic Sea. A more thorough analysis will be delivered after season is over, in the 2012-2013 Q2 validation report due to June 2013.



**Figure 1.** Ice extent on March 15, 2013. This roughly corresponds to the date of maximum annual extent.

### I.3 Validation metric test

FMI validates ice thickness data, ice concentration data, and ice drift data. Ice thickness is validated with ice thickness measurements made on board Finnish icebreakers. In situ ice thickness measurements are compared to both FMI's ice charts and SAR-based ice thickness values. FMI's ice concentration product is validated against the ASI algorithm (by the University of Bremen). SAR -based drift measurements were validated against drifter buoy data.

### I.3.1 Icebreaker measurements of ice thickness

Icebreakers produce ice thickness drill measurements. Icebreakers produced 47 measurements until 27 March 2013. Measurement locations are illustrated in Figure 3 and 4. Icebreaker measurements were used in the validation of FMI's ice chart thickness values and the SAR -based thickness values. Each ice thickness measurement from an icebreaker was associated to a pixel of the ice thickness map that represents the mean ice thickness by using the map upper left corner coordinates and the pixel x- and y size resolutions:

$$\text{row} = \text{floor}((Y\_origin - \text{msm\_lat}) / \text{fabs}(Y\_incr))$$

$$\text{col} = \text{floor}((\text{msm\_lon} - X\_origin) / \text{fabs}(X\_incr)),$$

where \*\_origin is the map upper left corner location, incr\_\* the map pixel size and msm\_\* location of the measurement. Some icebreaker ice thickness measurements had minimum and maximum ice thickness instead of single value, in that case mean ice thickness was used in the comparison.

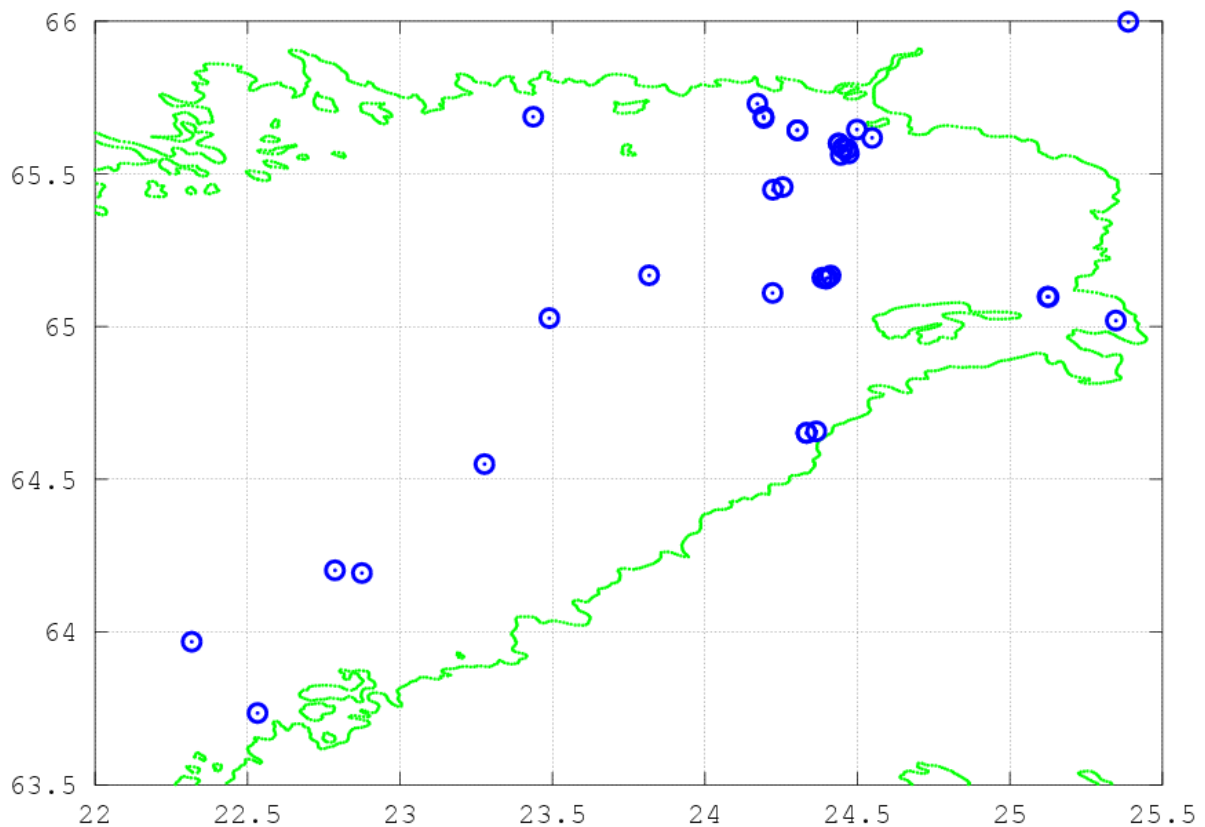


Figure 2. Bay of Botnia, locations of the icebreaker measurements (IBM) in winter 2013. Some locations are partially overlapping. The location near the upper right corner is due typing error in the original data.

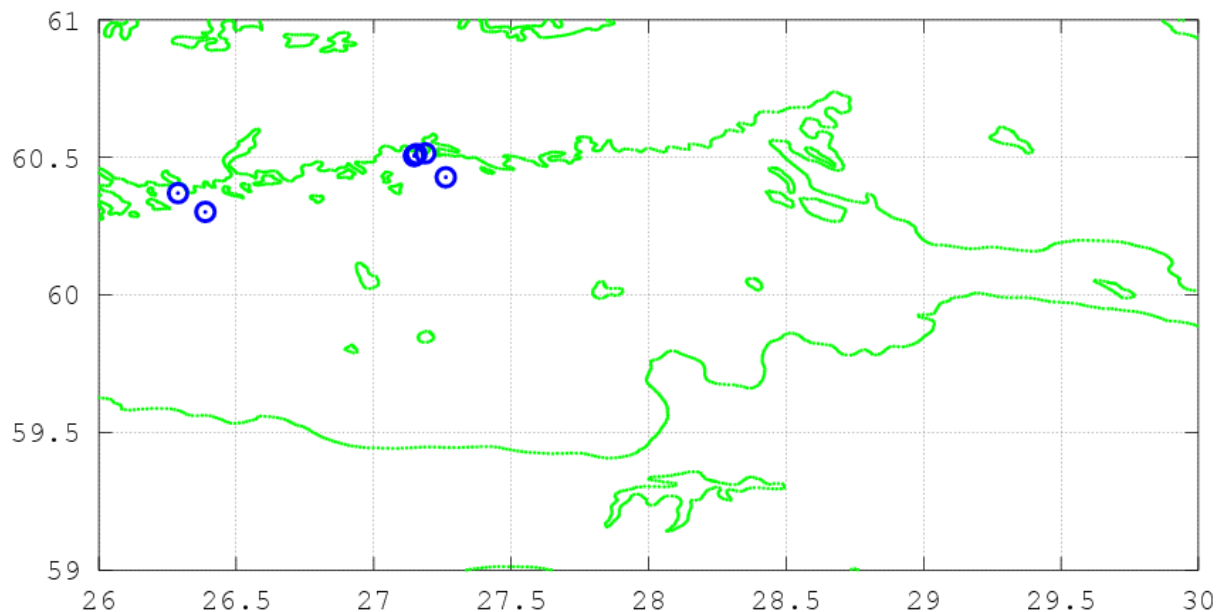


Figure 3. Gulf of Finland, locations of the icebreaker measurements (IBM) in winter 2013. Some locations are partially overlapping.

### I.3.2 Ice concentration

Two ice concentration products were compared to each other. The first one was the FMI's routine ice chart-based concentration grid. The ice chart is based on ground truth and satellite data, where main input data are SAR images. The second product was calculated based on SSMIS data and produced by University of Bremen (BR). The comparison was performed by inspecting the distributions of the classified concentration subtractions and by confusion matrices of the classified concentrations. In both cases 3x3 homogeneous windows were used to eliminate the possible errors due to the re-rectification of the BR-maps.

### I.3.3 Ice motion measured by GPS buoys

The SAR based short and long ice drift vectors were combined with the motion of the GPS buoys deployed on the ice in the Gulf of Bothnia and Gulf of Finland. Buoys collected location data from January 1 to March 17, 2013. The buoys indicate their location based on their GPS coordinates once an hour.

## I.4 Validation results

### I.4.1 Ice chart ice concentration

As the ice charts use 10% classes for the ice concentrations, the ice concentration subtractions between Finnish (FI) and Bremen (BR) ice concentration data were also classified in to 10% classes from  $[-100, -90[$  to  $[90, 100]$ . Figure 6 shows the ice concentration distribution

of the subtractions at individual dates and the mean distribution. Positive values mean that FI-product has provided higher concentrations than BR-product and vice versa. Therefore the fatter right tail indicates that the BR-product gives lower concentration values as the FI-product. However, the majority of the subtractions are between -10% and 10%. Hence, FI-product and BR-product results provide rather similar results.

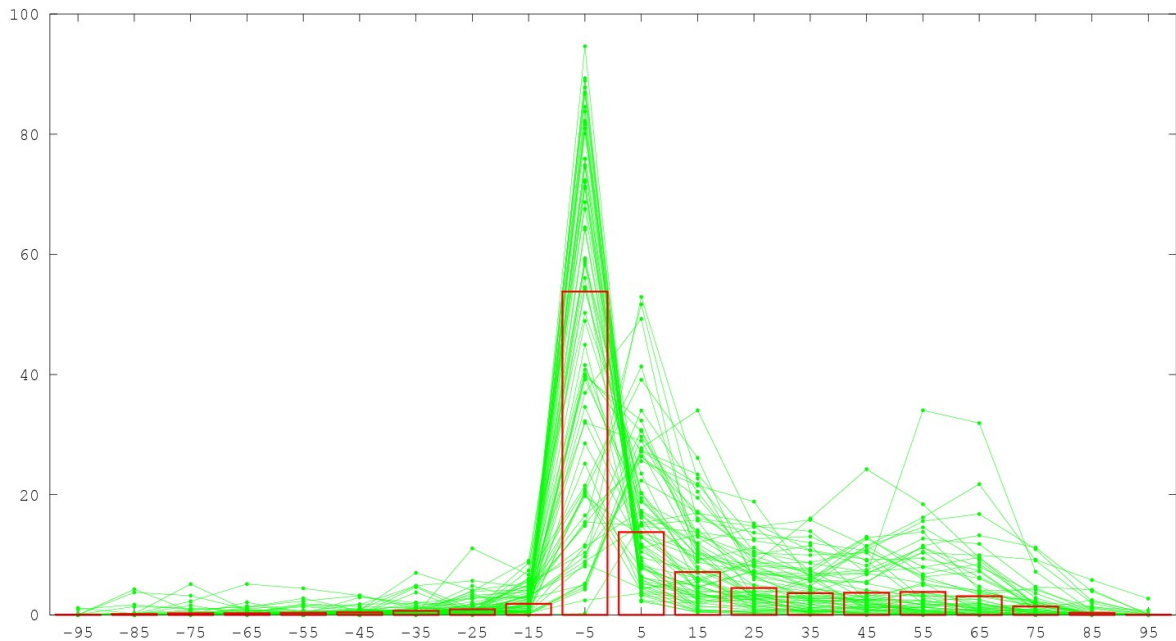


Figure 4. Distributions of the ice concentration subtractions between FMI- product and BR-product. Positive values indicate that FI-product is providing higher concentrations than BR-product and vice versa. At x-axis are the class centres of the 10% wide classes and y-axis values are in percentages.

#### I.4.2 Ice Chart Based Ice Thickness

The ice chart based ice thickness results were compared with ice thickness results measured on icebreakers.



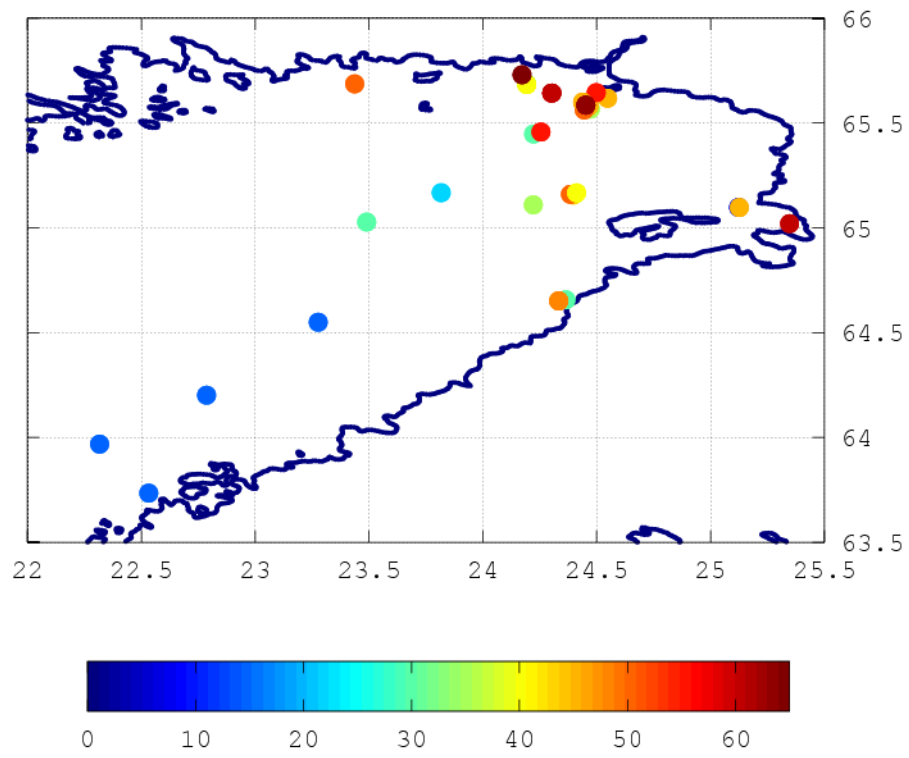


Figure 5. Locations of the used icebreaker measurements and measured ice thicknesses in centimetres.

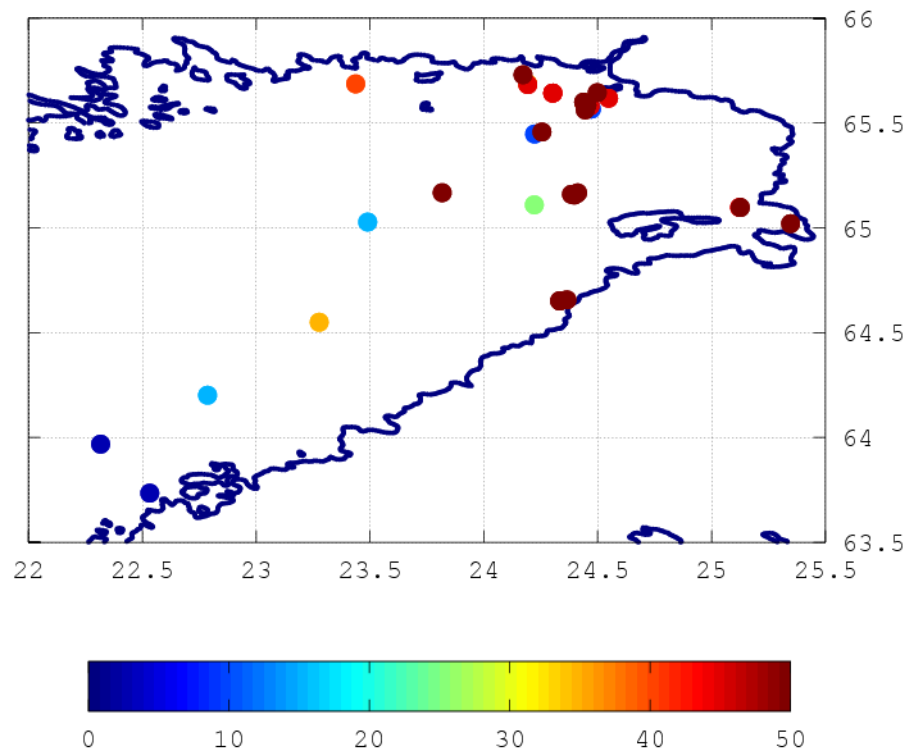


Figure 6. At the ice breaker measurement locations the ice chart thicknesses in cm. All red dots (30 cm) are located in the fast ice area and majority of the brown dots (50 cm) also.

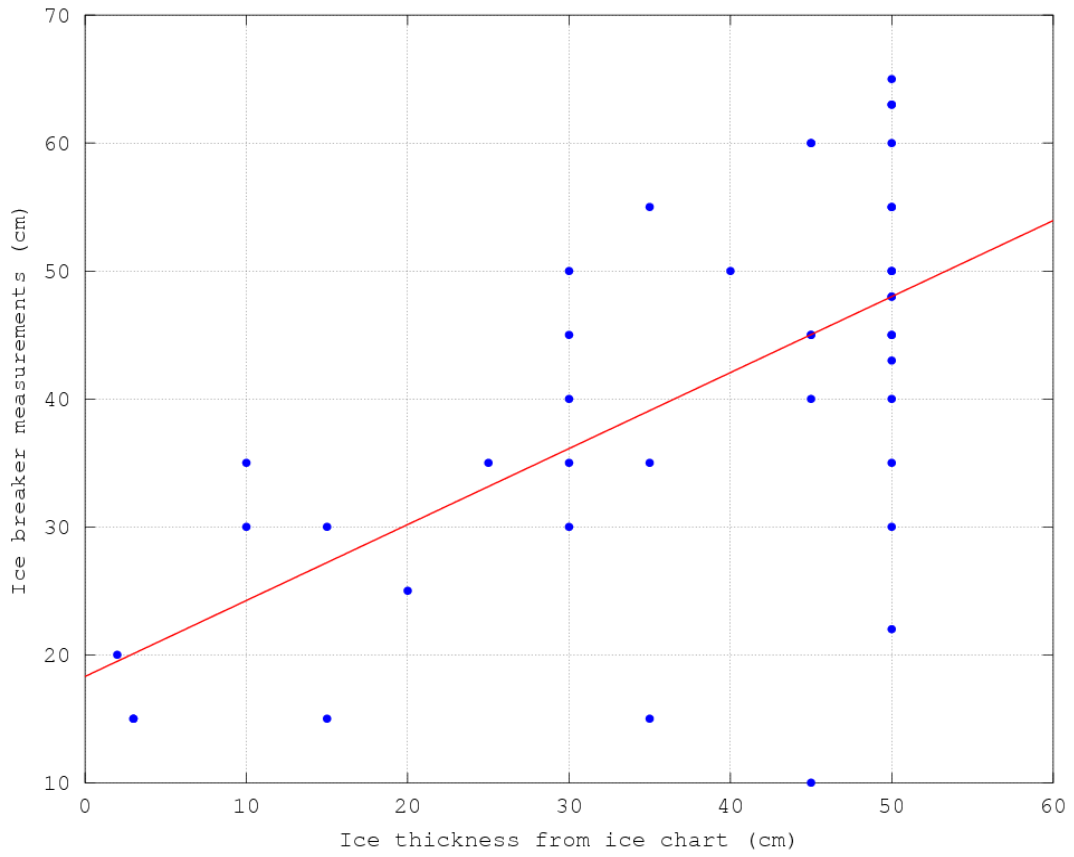


Figure 7. Ice thickness values from ice charts and ice breaker measurements in centimetres. Solid line is the fitted regression line by the least squares method.

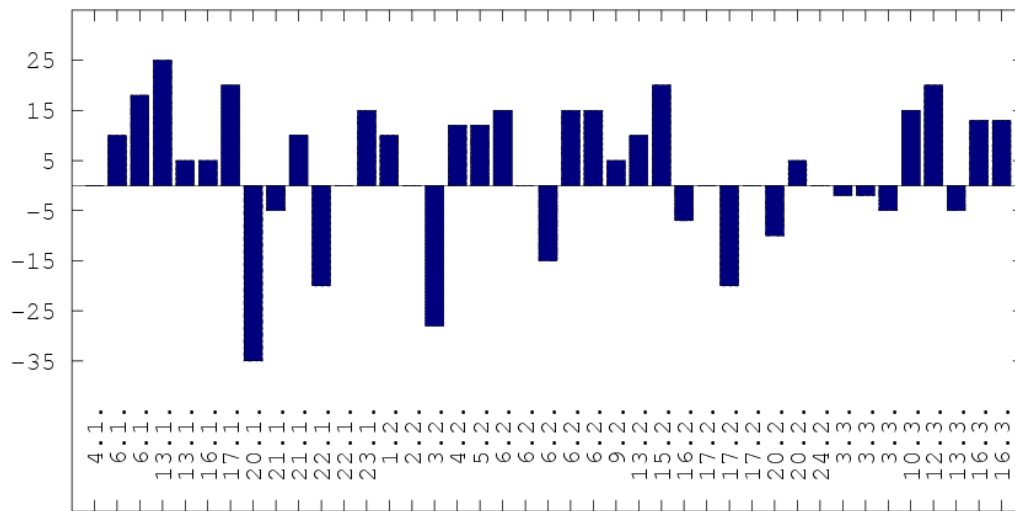


Figure 8. Differences between ice thickness from icebreaker measurements and FMI's ice chart values in centimetres.

**I.4.3 SAR Based Ice Thickness**

The SAR- based ice thickness results were compared with ice thickness results measured on icebreakers. Several icebreaker measurements were excluded, because no matching SAR image was available.

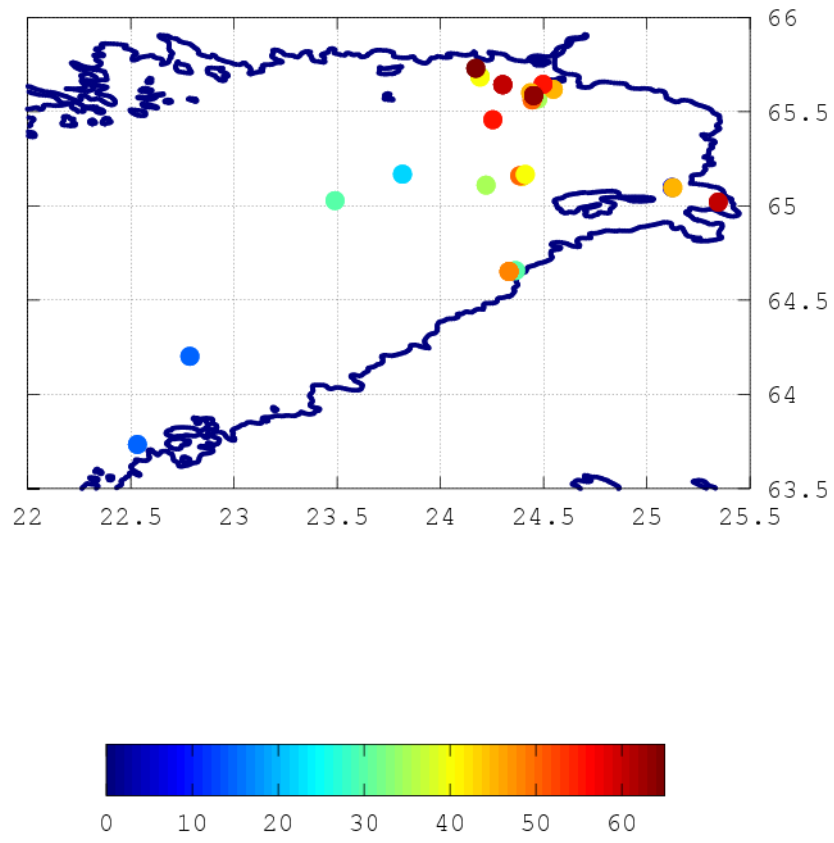


Figure 9. Locations of the used icebreaker measurements and measured ice thicknesses in centimetres.

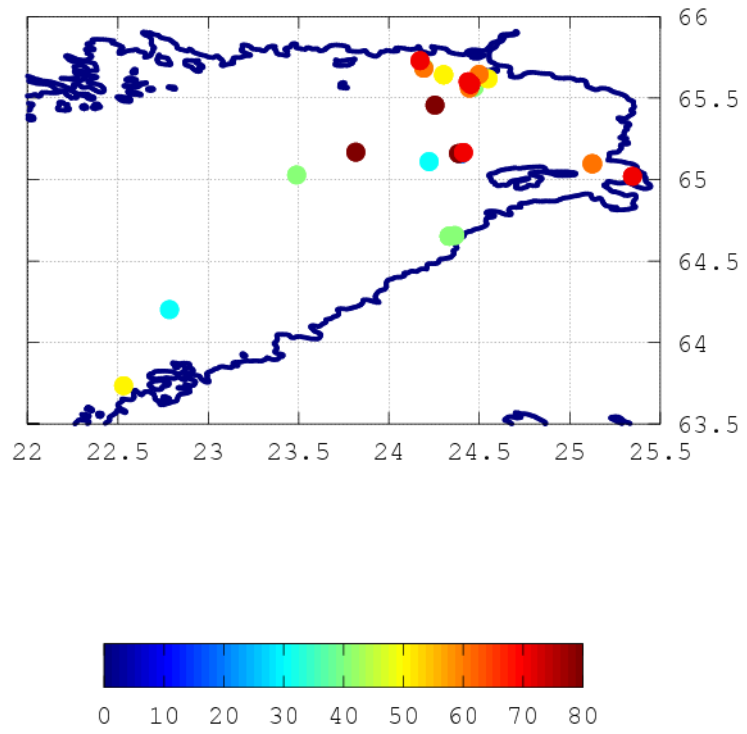


Figure 10. At the ice breaker measurement locations the SAR based ice thickness in cm.

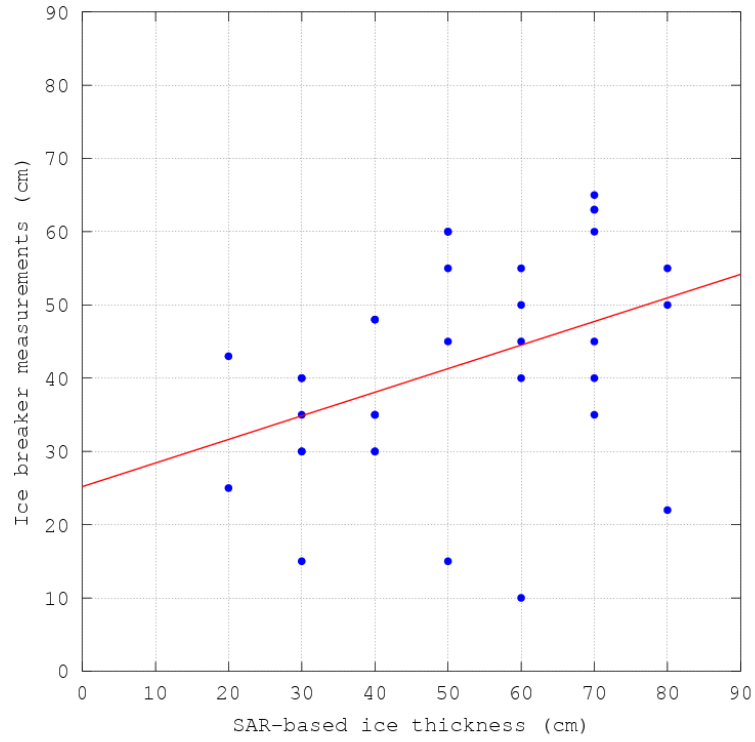


Figure 11. SAR based ice thicknesses and ice breaker measurements in centimetres. Solid line is the fitted regression line by the least squares method.

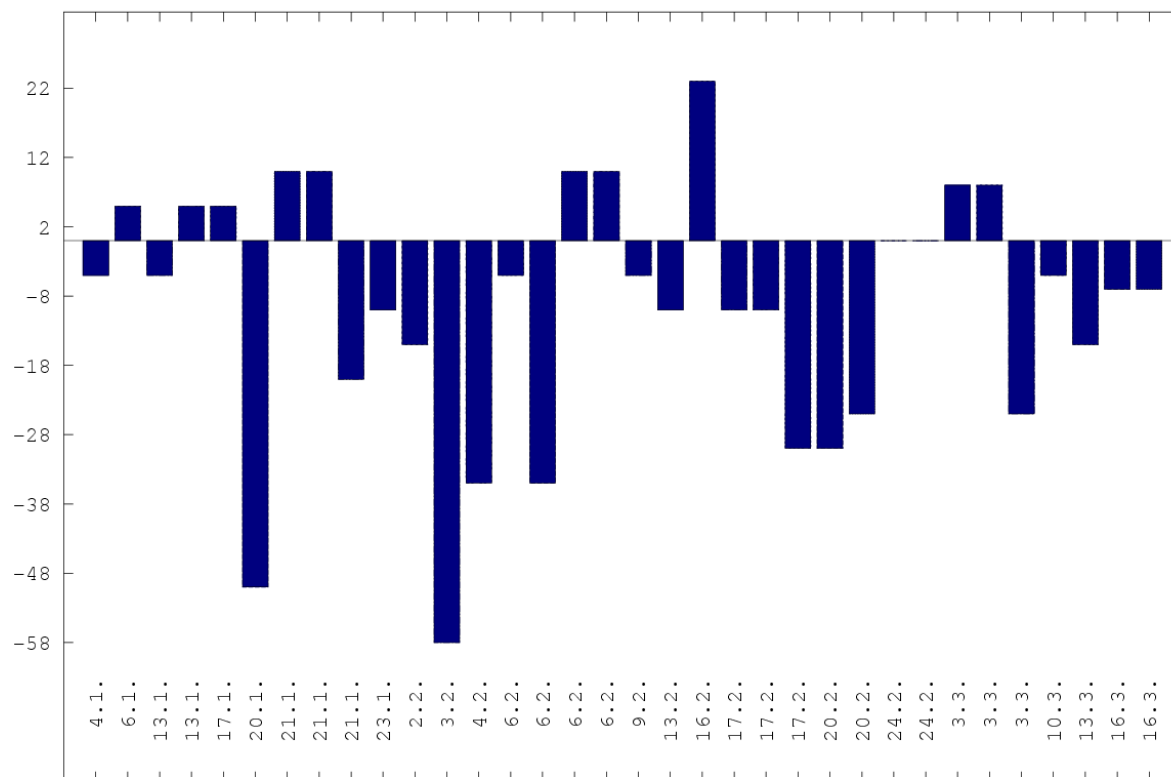


Figure 12. Difference between the icebreaker measurements and the SAR- based ice thickness estimates in centimetres.

There are four measurements where the absolute value of the differences is greater than 30 cm, the locations are shown in Figure 13. Coefficient of correlation between all icebreaker measurement and SAR- based ice thickness value is 0.4. If the mentioned three observations are excluded, the coefficient of determination is 0.69,



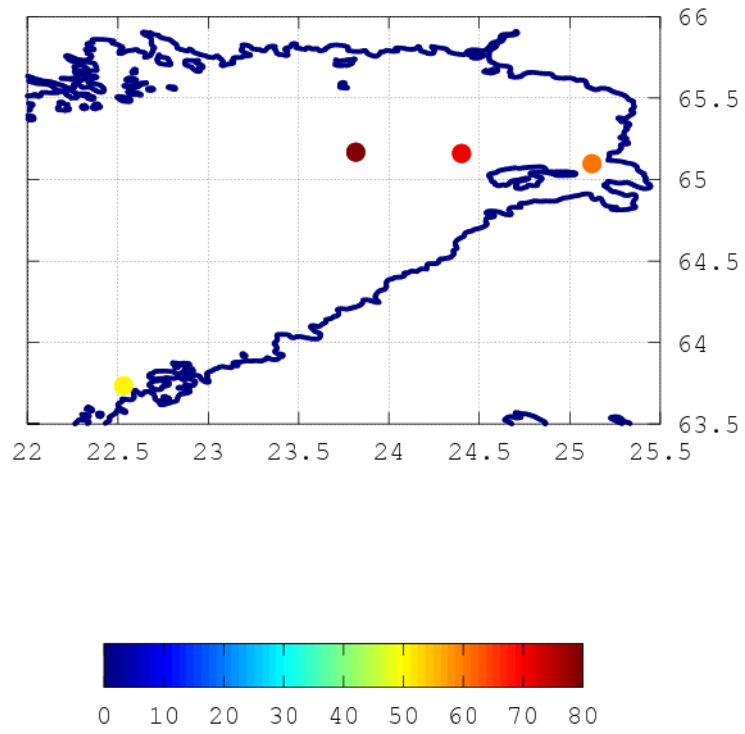


Figure 13. The three measurements where the absolute value of the differences is greater than 30 cm, the SAR thickness.

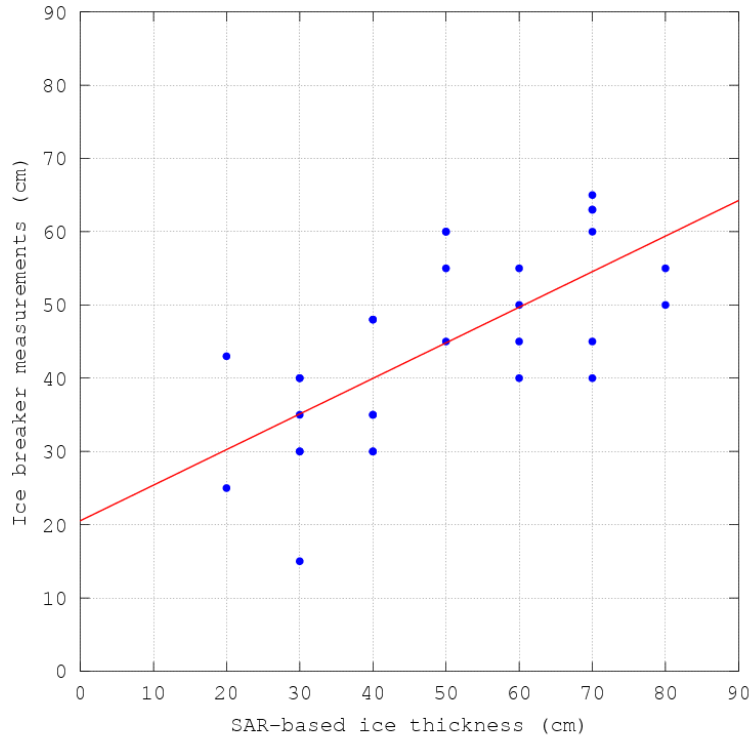


Figure 14. After the removal of the four observations, SAR based ice thicknesses and ice breaker measurements in centimetres. Solid line is the fitted regression line by the least squares method.

#### I.4.5 SAR- Based Ice Drift

The ice drift monitoring period was from Jan 1<sup>st</sup> to Mar 19<sup>th</sup> 2013. All except one the buoys were in the Gulf of Bothnia, for details of the buoy trajectories, see Figure 13.

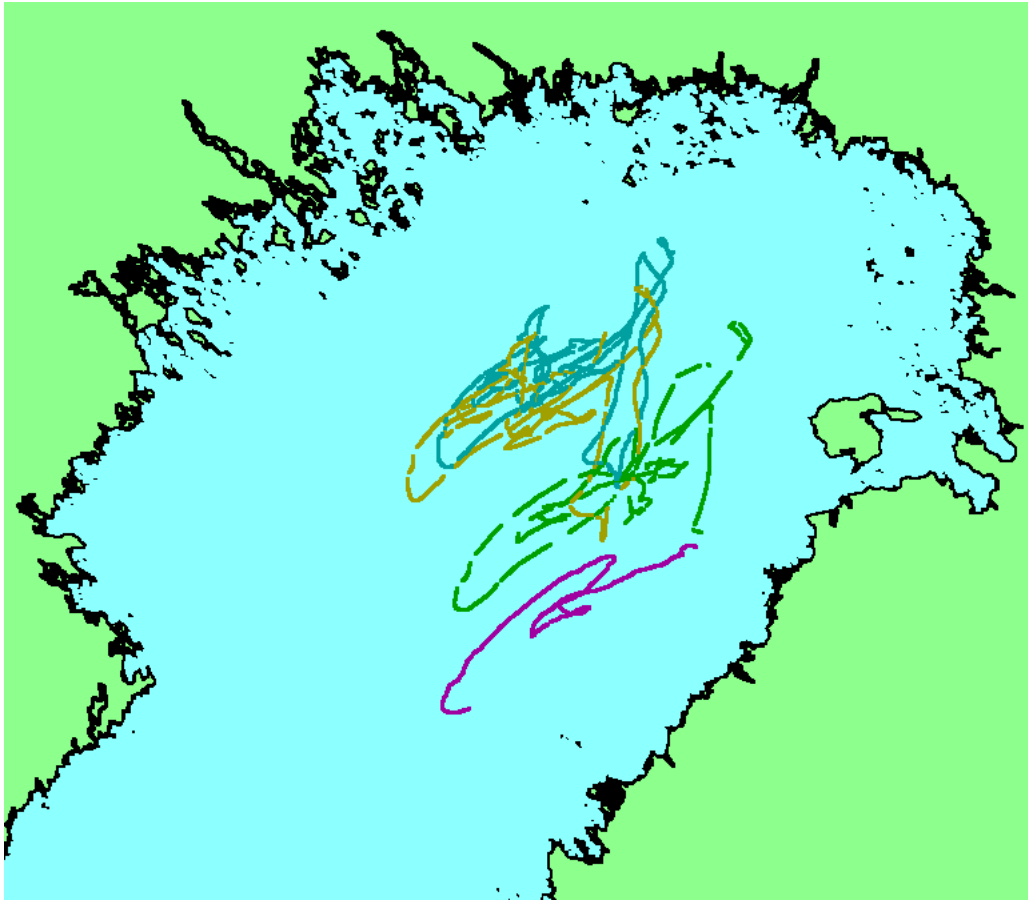


Figure 15. Buoy trajectories (buoys indicated by different colours) during the winter study period in 2013. One buoy not shown here was drifting in the western of Gulf of Finland.

During the monitoring period totally 117 ice drift estimates were used in the comparison, i.e. the two buoy locations was within the overlapping area of the two adjacent SAR images used in the drift estimation for the acquisition times of the SAR images. The ice drift estimates in comparison were divided into two categories: 68 of these were classified to short drift category (buoy motion less than 500m) and 49 measurements to long drift category. The quality given by the SAR algorithm for the short drift data the quality varied from 40% to 80% in both short drift and long drift categories. For the short drift data category only the motion magnitude was evaluated but for the long drift data both magnitude and direction were estimated. The direction couldn't be evaluated in the short drift category because in short drift estimates the SAR registration errors can cause large relative errors and so defining the direction can become ambiguous due to the quantification of the direction. For the long drift data both the magnitude and direction were combined. The results are shown in Figures 16-18.

For the short drift data the L1 errors were 2207m (quality=40%, 63 samples), 5391m (quality=60%, 2 samples), and 237m (quality=80%, 3 samples).

For the long drift the L1 errors were 4692m (quality=40%, 46 samples), and 225 (quality=80%, 3 samples). The corresponding errors for the direction were 44.43 degrees and 39.59 degrees, indicating that the direction is still estimated moderately in these difficult conditions. The estimation accuracy of the motion magnitudes is not very good, except for the high quality value (80%) data. This may be due to that the buoys were located in the marginal ice zone. A

more thorough analysis will be performed in the 2013 Q2 validation report. We have also found an error in a file format conversion software used as part of the ice drift validation, and we have fixed the error after the validation. We will also use the corrected software version in computing the 2013 Q2 report.

To improve the performance of our algorithm in the future, we are going to include detection of features that can be reliably tracked (based on our experiences with coastal radar imagery), and performing drift estimation only for these areas. We are also going to update the algorithm to handle the rotations better by performing a more comprehensive angular search in the low resolution. This can be done without increasing the computation time significantly. Our plan is to update the algorithm for the next season (2013-2014), and to produce improved estimates, especially for marginal ice zones.

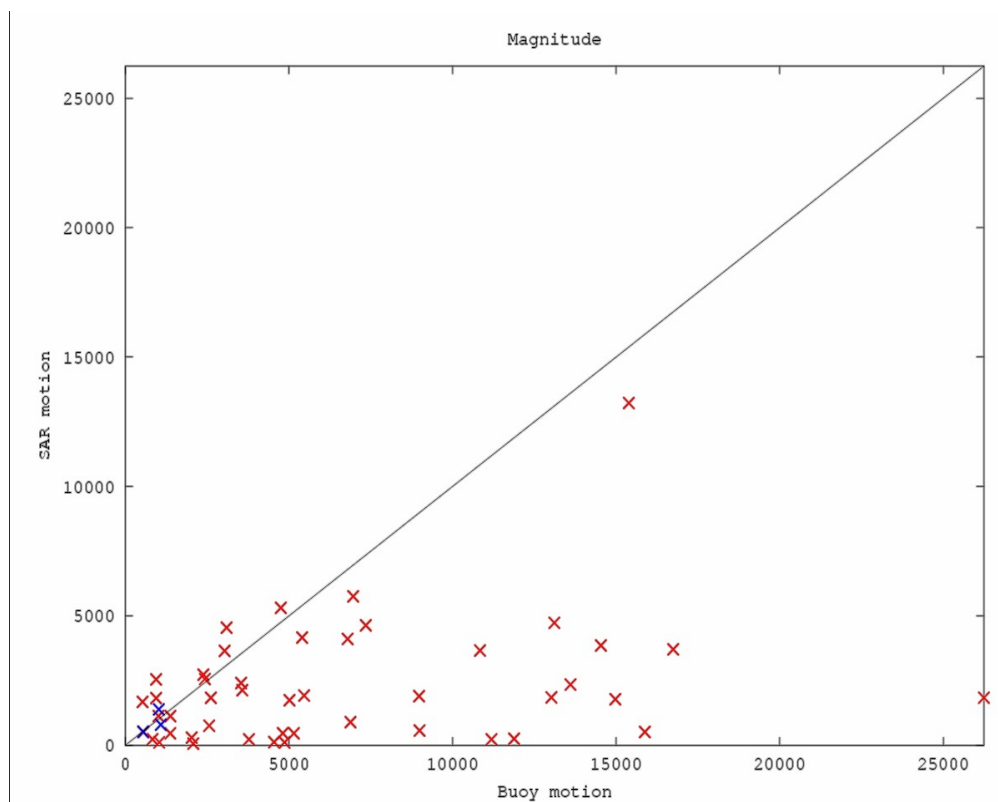


Figure 16. Magnitude comparison for the long motion, the values are in meters. The quality class 40% is coloured red, quality class 60% green (no points for the long motion data), and quality class 80% blue (3 points).

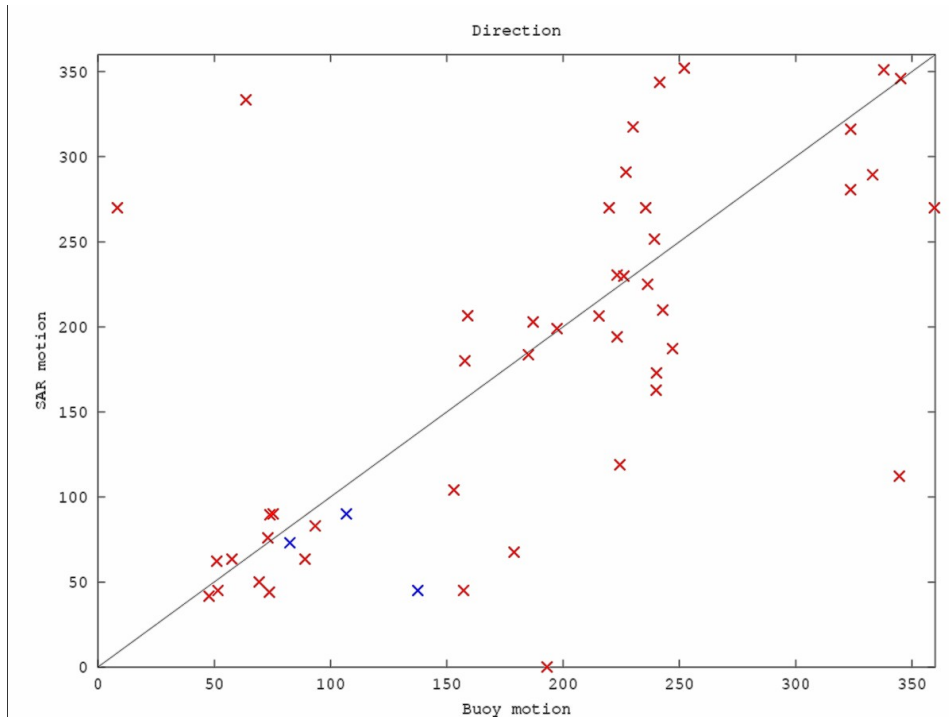


Figure 17. Direction comparison for the long motion, the values are in degrees (directions 0 and 360 are the same direction). The quality class 40% is coloured red (46 points), quality class 60% green (no points for the long motion data), and quality class 80% blue (3 points).

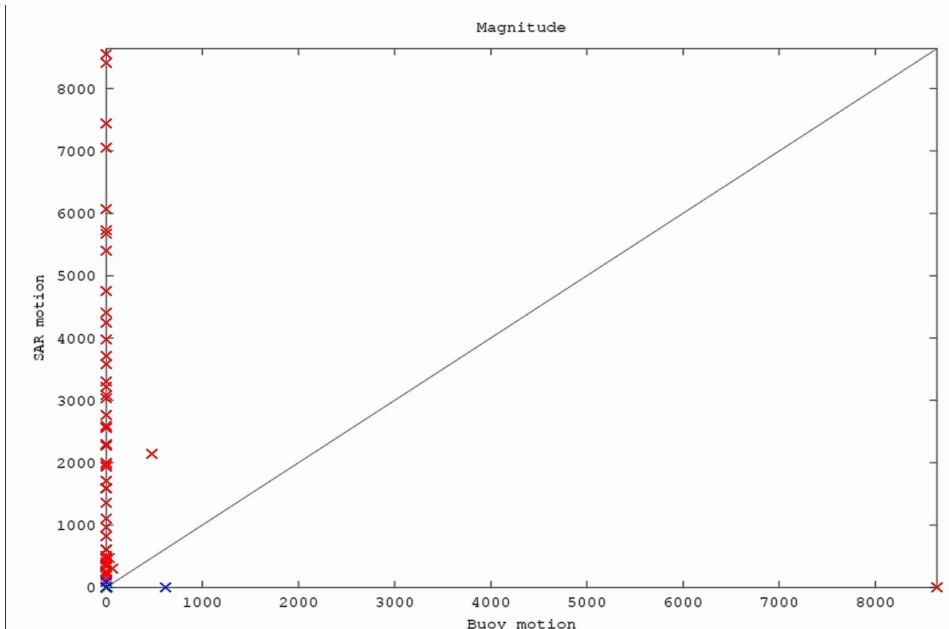


Figure 18. Magnitude comparison for the short motion, the values are in meters. The quality class 40% is coloured red (63 points), quality class 60% green (2 points), and quality class 80% blue (3 points).

## **I.5 Validation summary**

Finnish Meteorological Institute provides Baltic Sea ice charts, ice concentrations, SAR-based ice thicknesses and SAR-based ice drift estimates to OSI TAC. Both ice thickness values from FMI's ice charts and from SAR-based data were validated against ice thickness measurements made on board Finnish icebreakers. We will provide a more thorough analysis of the validation results for the whole season 2012-2013 in our Q2 validation report.

Ice concentrations were validated against ice concentration data from University of Bremen. The ice concentration comparison is more problematic because the products have different resolutions and the ice concentration is a resolution-dependent measure. However, it seems that the concentrations of our product and the reference product correspond to each other rather well.

The direction of the long drift was also studied. The error for the direction was 39.2 degrees. In overall the weather conditions for the SAR drift algorithm were not favourable. The direction was still estimated moderately, but the motion magnitude estimation was not adequate especially for the long drift. A more thorough analysis, covering the whole season, will be performed for the 2013 Q2 report.

### **I.5.2 Future plans**

The validation will be continued and documented in the 2013 Q2 validation report, which will cover the whole season 2012-2013 (11/2012 – 05/2013). In the Q2 report also all the validation data will be studied in more detail, and location where the largest errors were made will be located. It also seems that there has been an error in the code performing conversion from the netcdf format to ascii text (used in ice drift validation), and the affect of this on the ice drift validation results will be studied.

## **I.6 Technical**

**Production Unit: FMI**

OSI-FMI-HELSINKI-FI