ASCAT/METOP SCATERROMETER DATA : FIRST RESULTS FOR SEA ICE STUDY

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ABSTRACT

Backscatter values from scatterometers are commonly used to estimate wind field over oceans, their ability to monitor sea ice coverage, age and drift has been also demonstrated. Here, ASCAT backscatter coefficient has been processed for sea ice geophysical interpretation in order to increase the long time series of ice parameters already available. It has been shown that incidence-adjustment is mandatory for geophysical meaning, the backscatter maps enable the discrimination between multi year ice and first year ice, these maps can also be used as a basic product for sea ice drift estimation.

I. ASCAT DATA OVER SEA ICE

I.1 SPATIAL COVERAGE

Fig. 1 shows the number of data for 12.5 x 12.5 km resolution map for a single day over Arctic (a) and Antarctic : b) with ASCAT, c) with QuikSCAT. Data are distributed as rings. The whole spatial ice area is not uniformly covered; in a), missing data are located in the Fram strait and at the East Greenland; in b) some ice areas are not fully monitored compared to QuikSCAT coverage in c (see sea ice extent contour), in particular at low latitudes.

The geographical Pole is not monitored due to near-polar orbit (Fig. 1a), as it is with QuikSCAT. Individual missing data are also visible. For a single day, there is a limited number of data in comparison with QuikSCAT. To avoid this problem, interpolation can be used for example. Also, 36h or 48h maps rather than daily maps could be estimated but sea ice moves and a trade-off must be found between the number of data required for data reliability within a pixel and integrating time.

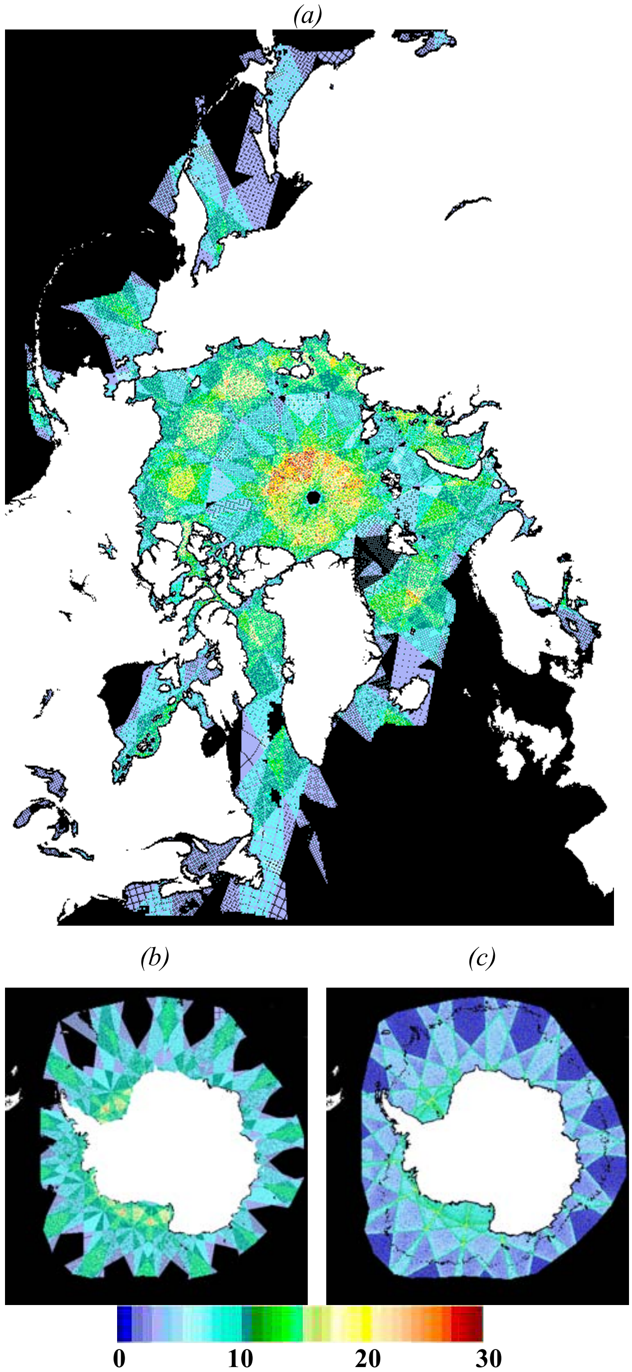


Figure 1. Number of data for 12.5 x 12.5 km pixel : a) ASCAT, February 18, 2007 over Arctic area, b) ASCAT, November 1st, 2008 over Antarctic area, c) QuikSCAT, November 1st, 2008 over Antarctic area, contour of the sea ice limit is visible, in black : no data or no sea ice search area.

I.2 BACKSCATTER MAPS

I.2.1 Building the constant-incidence backscatter maps

Fig. 2a is a "raw" backscatter map from ASCAT data computed for a single day. High backscatter values are located near the North of Canada and low values at the North of Russia, like QuikSCAT backscatter values (Fig. 2c), but instrumental strait lines are clearly visible (Fig. 2a) and are related to the swath signatures, this prevents geophysical interpretation of such data. Because of conical revolving antennas, QuikSCAT does not require any incidence angle corrections whereas ASCAT needs such correction.

Based on the experience from ERS and NSCAT data, IFREMER has developed algorithms to built incidence-adjusted backscatter maps. Fig. 2b shows incidence-adjusted backscatter map starting from the "raw" backscattered data presented in Fig. 2a. The incidence is 40°, as previously defined for fan-beam scatterometer. This value is in the middle of the incidence range of ASCAT.
Signatures of swaths are corrected in Fig. 2b in comparison with Fig. 2a, and backscatter values have homogeneous geophysical meaning : high values at the North of Canada correspond to thick and multi-year ice (rough surface), and low values at the North of Russia to first-year ice (smooth surface). Geophysical structures are clearly detected and can be compared with QuikSCAT structures (Fig. 2c) with different backscatter values because of the frequency bands (C-band for ASCAT, Ku-band for QuikSCAT) and incidence angles (40° for ASCAT, 54° for QuikSCAT).

Nowadays, daily QuikSCAT backscatter maps are estimated at a pixel resolution of 12.5 km. IFREMER-CERSAT is constructing ASCAT backscatter maps at 40° incidence, daily and for the Arctic and the Antarctic. This will increase the IFREMER-CERSAT backscatter time series over sea ice :

- 1991-2001 with ERS-1 and ERS-2
- 1996-1997 with NSCAT
- 1999-present with QuikSCAT.

From these adjusted-incidence backscatter data, normalized standard deviation can be estimated for each pixel : high values are related to open ocean because of high azimuthal dependence, and low signals are related to sea ice because of the isotropy in azimuth [1].
Fig. 3 is an example of this parameter over Antarctica, low values are clearly linked with sea ice and high values with ocean : this parameter is a good indicator of sea ice and open ocean areas limit.

I.2.2 Comparison of ASCAT data with QuikSCAT backscatter data

Fig. 4 shows QuikSCAT backscatter data as a function of ASCAT backscatter data. Because of the frequency band (Ku for QuikSCAT, C for ASCAT), and also to different incidence angles, values are not similar : Ku-band data are higher than C-band data, with a ratio between 1 to 2 for low values (first year ice) and a ratio between 1 to 4 for high values (multi year ice), as it was estimated in the previous study between NSCAT and ERS data [2].

II. ASCAT sea ice product applications

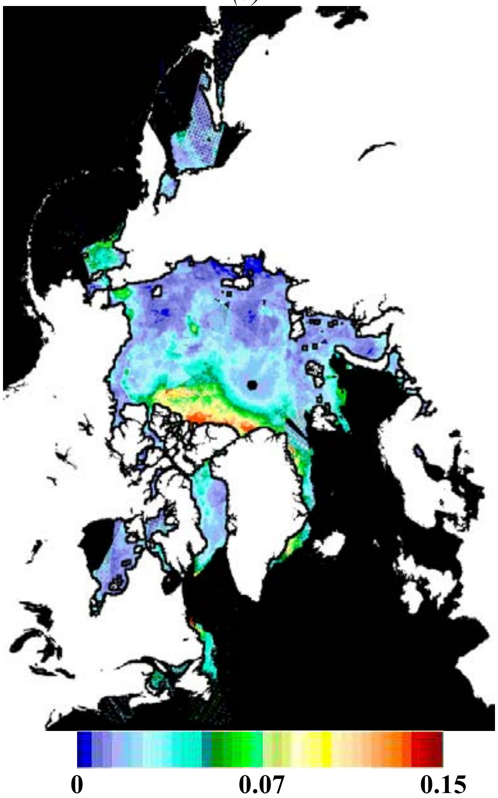
II.1 Ice types discrimination

Scatterometer is a radar, data are related to sea ice roughness, which is linked with sea ice age or sea ice types. Fig. 2 are examples of backscatter maps with weak backscatter values for first year ice, near Siberia and strong backscatter values for multi year ice, North of Canada. The backscatter threshold to distinguish first year from multi year is complex to determine.

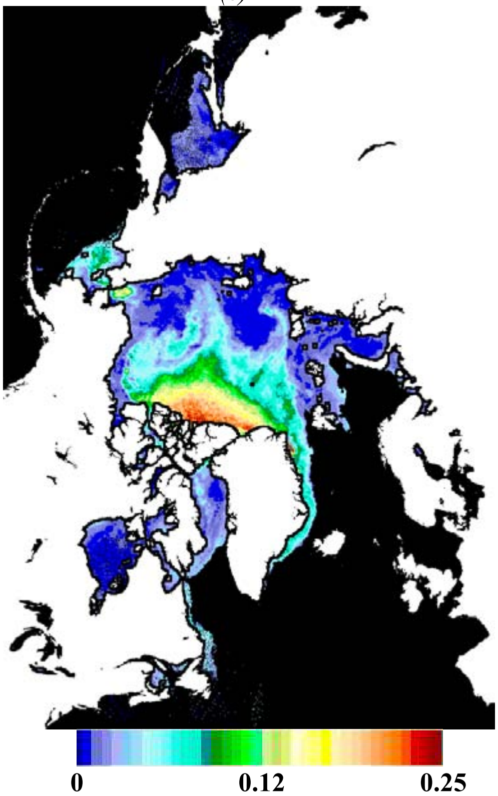
The method we propose to detect first year from multi year ice is to use both radiometer and scatterometer. In September, sea ice is multi-year ice by definition, and multi year ice edge can be determined from the radiometer. The area is then followed using backscatter threshold with scatterometer data during the winter.

Fig. 5 shows the evolution of the multiyear ice area during a winter with this method using SSM/I radiometer and QuikSCAT scatterometer. The main drift direction during this period confirms the evolution of the area. With the Ku-band QuikSCAT (14 GHz) and the C-band ASCAT (6 GHz) simultaneously available data, the ice type discrimination would be greatly improved (example of ERS-2 –C band- and NSCAT –Ku band- during winter 1996-97 [2]). This has to be tested.

(a)



(c)



(b)

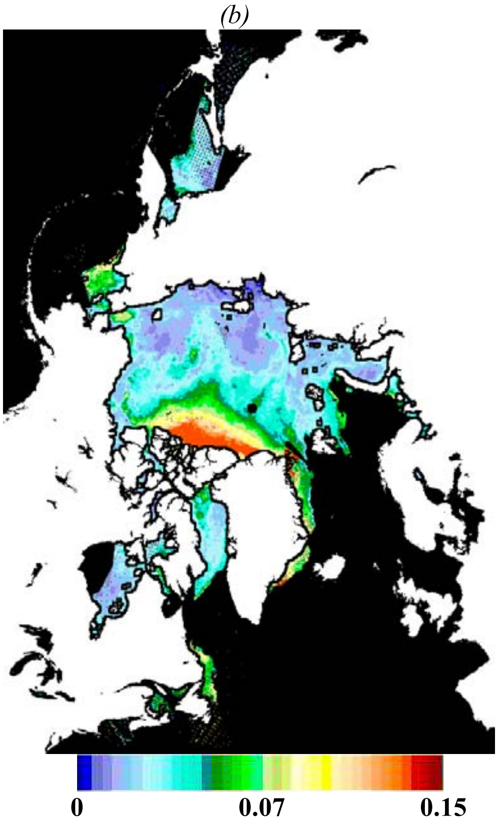


Figure 2. Arctic backscatter maps for February 18, 2007. a) ASCAT raw data, b) ASCAT incidence-adjusted backscatter map at 40° incidence c) QuikSCAT backscatter map at 54° incidence. Ice area is processed only, in black : no data or no ice.

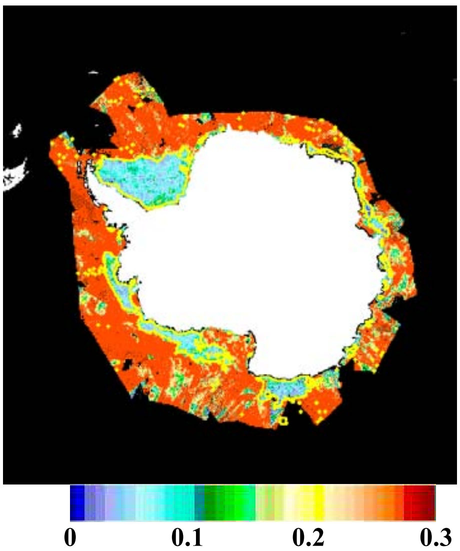


Figure 3. Normalized standard deviation over Antarctica area for February 19, 2007. In yellow, ocean/ice limit from SSM/I radiometer. In black : no data or no sea ice search area.

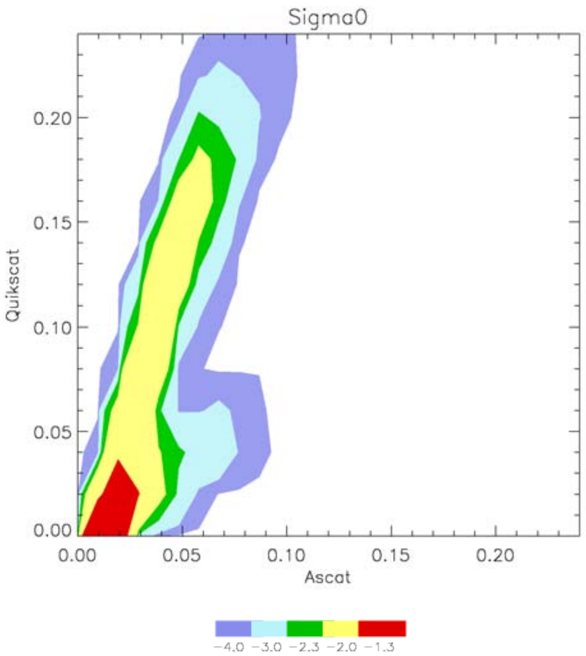


Figure 4. QuikSCAT (Ku-band) backscatter data as a function of ASCAT (C-band) backscatter data over central Arctic. Color are probability in log.

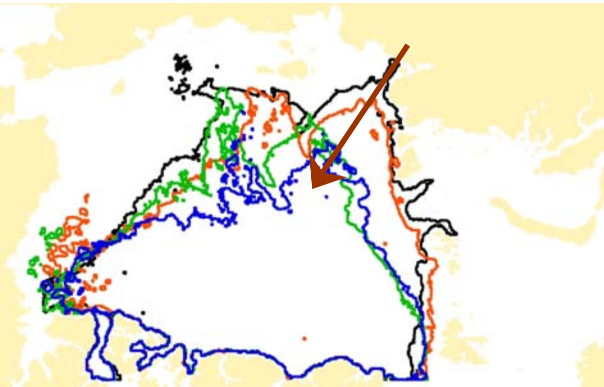
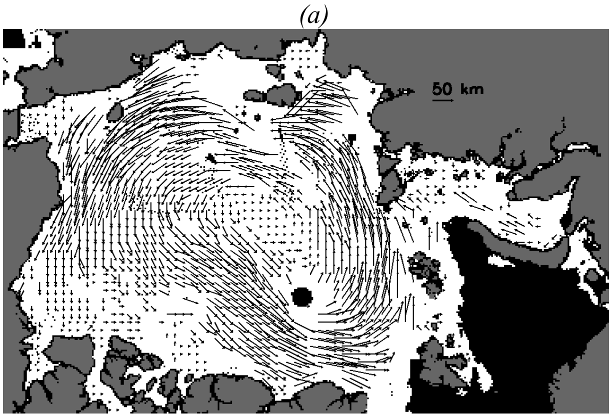


Figure 5. Arctic multi-year ice area detection during a winter : October (black), December (red), March (green), and May (blue). The arrow shows the main drift direction during December-January-February period.

II.2 Sea ice drifts

Another product which can be inferred from ASCAT data is sea ice drift estimation, similarly to QuikSCAT backscatter processing. CERSAT/IFREMER provides every day, during winter, 3 and 6 day lag ice drifts maps since 1992 with SSM/I and since 1999 with the combination of SSM/I and QuikSCAT sensors [3].
We have applied the same technique to ASCAT backscatter data. Fig. 6 shows sea ice drift maps examples from ASCAT and QuikSCAT. The same grid resolution is used (one drift vector each 62.5 km). Given ASCAT geometry and MetOp orbit parameters, it might be inferred that ASCAT drift data are more noisy than QuikSCAT data. The number of valid vectors (Fig. 7) is higher for QuikSCAT drift estimation at the beginning of the winter (about 10% more) due to some ASCAT data gaps at this period, but is about the same for the period January-April except some days. Thus, ASCAT drift data will continue the CERSAT 17-years time series.

(a)



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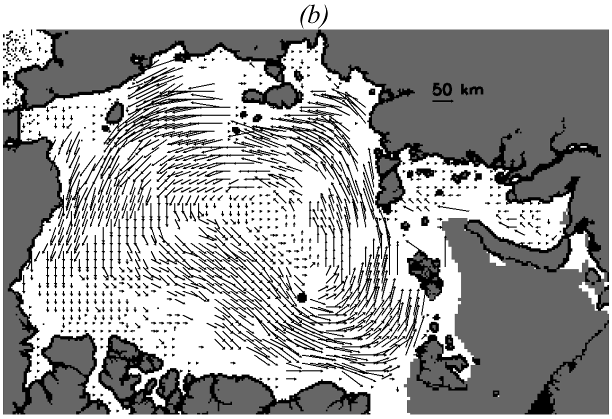

Figure 6. Arctic sea ice drift from backscatter data over 6 days period (March 22-28, 2007). Drift vectors less than one pixel are marked with a cross. From ASCAT data (a), from QuikSCAT data (b).

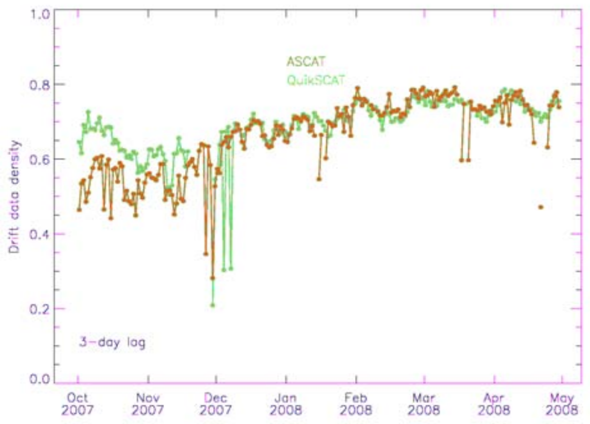

Figure 7. Number of valid vectors available on the sea ice area during a winter. In red : ASCAT drifts vectors, in blue : QuikSCAT drifts vectors.

III. CONCLUSIONS

ASCAT/MetOp can be used for sea ice monitoring because of the satellite polar orbit and the global coverage at high latitudes but a first assessment of the data shows that there is a limited number of data for single day and not monitored areas do exist, in comparison with QuikSCAT scatterometer spatial coverage.

We have shown that ASCAT "raw" backscatter map can not be used for geophysical studies and that incidence-adjusted backscatter maps are mandatory. Algorithms have been developed based on the experience of IFREMER with ERS and NSCAT data. The incidence-adjusted backscatter maps are compared with QuikSCAT maps and show identical patterns. The estimation of normalized standard deviation shows that this parameter can be used to discriminate ice from open ocean.

A method to discriminate ice types has been tested with QuikSCAT data, and will be adapted to ASCAT data. ASCAT data at C-band and QuikSCAT data at Ku-band will be combined to improve ice type discrimination, as it was done with ERS and NSCAT. Sea ice drift processing has been tested with ASCAT data and compared with QuikSCAT data.

The IFREMER/CERSAT continuous time series of backscatter and drift maps since 1992 will be extended for long term monitoring for ocean modelling. ASCAT products will be available at IFREMER/CERSAT ftp.

REFERENCES

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2. Ezraty, R., and A. Cavanié, 1999 : Intercomparison of backscatter maps over Arctic sea ice from NSCAT and the ERS scatterometer, *J. Geophys. Res*, vol. **104**, n. C5, 11471-11483.
3. Girard-Ardhuin, F., R. Ezraty, D. Croizé-Fillon and J.F. Piollé, 2008 : Sea ice drift in the Central Arctic combining QuikSCAT and SSM/I sea ice drift data. User's manual, version 3.0. LOS/IFREMER, Technical report C2 – MUT – W – 05 – IF. April 2008. Available at http://cersat.ifremer.fr/