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D2.6.2 Ice volume flux time series across the Fram Strait and other outlets based on satellite data.

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PP	Restricted to other programme participants (including the Commission)	
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SUMMARY
Combining ice thickness with ice concentration and ice area flux one obtains sea ice volume flux. Ice flux has been computed along 79^o N and plotted for the six specific ICESat campaigns lasting approximately one month each from where good laser altimetry data are available. The flux is maximum in the center, and tapering off to zero at the sides due to fast ice in the west or no ice to the east. The flux values are found to be comparable to published work, although somewhat on the high side and with considerable interannual variability. An outer maximum in the flux is influenced by a maximum in ice thickness near the ice edge, hence results for the ice margin should be interpreted with caution.

MONARCH-A CONSORTIUM

Participant no.	Participant organisation name	Short name	Country
1 (Coordinator)	Nansen Environmental and Remote Sensing Center	NERSC	NO
2	The University of Sheffield	USFD	UK
3	Universität Hamburg	UHAM	NO
4	Centre National de la Recherche Scientifique	CNRS	FR
5	Scientific foundation Nansen International Environmental and Remote Sensing Center	NIERSC	RU
6	Universitetet i Bergen	UiB	NO
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1 Introduction

The last decade has seen substantial progress and developments in both refined and focused observations in key locations of the Arctic Ocean, essential for understanding variability with specific focus on changes in Arctic Ocean circulation, sea level and sea ice cover. However, lack of long in-situ time series at adequate spatial and temporal coverage are challenging our knowledge. The reason for the ongoing or past major sea ice changes are for example poorly known, nor do we know in detail what the variability of the Arctic Ocean was in the past or what causes a drift in the Arctic system observed during the most recent decades. In fact several existing estimates of the circulation in the high latitude and Arctic Ocean show significant discrepancies in their basic description of the flow field. New merged data from remote sensing (ENVISAT, ICESat and CryoSat altimetry combined with geoid models) may resolve some of these discrepancies.

The changes in sea ice motion and transport, especially in and out of the Arctic straits, can be assessed using satellite data, together with gridded fields of ice thickness and mean sea level anomalies. The total volume of sea ice, its seasonal melting and freezing, the regional variability and the fluxes through the straits can be estimated from a combination of satellite observations, model simulations and in-situ data (upward looking sonar).

The Fram Strait accounts for the major part of sea ice export from the Arctic (Serreze et al., 2006). The variation of sea ice flux is a potential candidate for explaining the recent declines in sea ice in the Arctic (Kwok et al., 2009). Hence, improved estimates of the sea ice volume flux and its variability through the Fram Strait is an important constraint in closing the sea ice and fresh water budgets of the region. This report considers the following task and deliverable in the Monarch-A project:

Task 2.6.2: The time series of sea ice thickness will be used in combination with model results and assimilation results to obtain improved estimates of sea ice volume fluxes. These fluxes represent a component of the freshwater cycle in the Arctic, where freshwater increase and decrease due to melting/freezing of sea ice and freshwater import/export to/from certain regions of the Arctic.

D2.6.2 - Ice volume flux time series across the Fram Strait and other outlets (Bering Strait, Nares Strait) based on satellite data (2003-)

2 Method and material

Ice area flux

Sea ice volume flux is computed by multiplying estimates of ice area flux with ice thickness. Ice area flux time series data across 79^{o}N by Kloster (2011) have been used. This is a product of measurements of profiles of : 1) ice displacement by Envisat WS-mode ASAR images and 2) ice concentration by DMSP SSMI and Aqua AMSR-E , made in consecutive time intervals, generally each of 3 days duration. The data spans the interval August 2004 to July 2011. The displacement is found by visually tracking of features between pairs of images. Although this in some cases can be difficult, for most image pairs it is possible to find reliable displacements vectors in the scene-overlapping area with a spacing of about 30 – 50 km, normally excluding the off-the-fast-ice zone and the ice edge zone. The uncertainty is estimated to +-5%.

The displacement profile is tabulated in 21 intervals (bins), each of one degree longitude with centers from 15W to 5E along 79N, by interpolation between the measured vectors nearest to this line. In the shear zone, linear interpolation from zero motion in the stable fast ice to the first measured motion vector is made. Ice concentration is measured on the dates of the SAR images along the same profile at 79N, and a mean ice concentration is computed from the values at the start date and the end date of the displacement interval. An early version of the computed ice flux was seen to agree with other analyses of the Arctic sea ice system (Smedsrud et al., 2008)

Ice thickness

Ice thickness data are downloaded from the NSIDC web-site and taken from six specific ICESat campaigns lasting approximately one month each from where good laser altimetry data are available (Kwok and Cunningham, 2008). The underlying freeboard to thickness conversion factor is contributing to the uncertainty of the measurements. To reduce the noise level the data were binned and averaged over 40km by 40 km boxes centered along 79N and at each 1 degree longitude.

3 Result

Combining ice thickness with ice concentration and ice area flux one obtains sea ice volume flux. In Figure 1 the ice flux has been computed along 79° N and plotted for the six specific ICESat campaigns lasting approximately one month each from where good laser altimetry data are available. As expected the flux is maximum in the center, and tapering off to zero at the sides due to fast ice in the west or no ice to the east. The flux values are found to be comparable to Spreen et al., 2009, although somewhat on the high side and with considerable interannual variability. A bimodal pattern is apparent during February 2006 and October 2007, indicative of an ice edge jet separate from an inner jet. The outer maximum is influenced by a maximum in ice thickness near the ice edge (not shown). High values near the edge could indicate compaction by surface waves or a contamination of the signal of the same waves. Hence, the results for the outer 5-6 data points should be interpreted with caution.

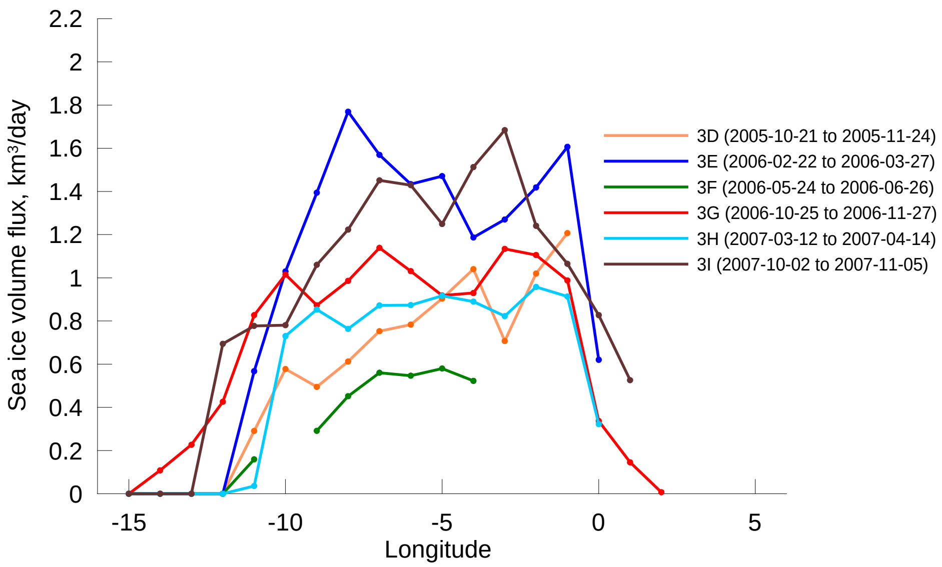

Figure 1. Sea ice volume flux [km3/day] southward across 79°N for six different ICESat campaigns. The quantity is derived from thickness data from ICESat, ice concentration from passive microwave observations and area flux data from Kloster et al, (2009)

4 References

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