9.1 ESTIMATING SEA-ICE TRANSPORT USING THE ADVANCED SENSOR MICROWAVE IMAGER (AMSR)

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1. INTRODUCTION

This work is part of the international Arctic/Subarctic Ocean Flux program (ASOF) and also contributes to the Arctic Climate Study (CLiC) of the WCRP. The aim of the work is to estimate sea-ice transport as a component of the freshwater flux at key locations in the Canadian Archipelago and Baffin Bay/Labrador Sea using the latest satellite sensors.

The increased spatial resolution of the Advanced Microwave Scanning Radiometer for the EOS (AMSR-E) provides an opportunity to estimate sea-ice transport in Baffin Bay/Labrador Sea, the main channels of the Canadian Archipelago and to improve estimates of sea-ice transport through Fram Strait over those obtained using SSM/I. Several investigators have shown that sea-ice motion can be estimated from passive microwave sensors (Agnew et al., 1997; Kwok et al., 1998; Emery et al., 1997) and Kwok and Rothrock (1999) and Kwok et al. (2004) have combined ice motion and sea-ice concentration to estimate sea-ice area flux through Fram Strait. In this study the new AMSR sensor is used to compare sea-ice area transport through Fram Strait and Baffin Bay for the 2002/03 and 2003/04 winter seasons.

2. METHODOLOGY AND RESULTS

We follow a method similar to Kwok and Rothrock (1999). We define two 'flux gates'. One across Fram Strait (gate 1) running from latitude 78°N on the Greenland coast to roughly latitude 80°N on the Svalbard coast and a second flux gate at roughly 72°N across the widest part of Baffin Bay (gate 2) shown in Figure 1. Sea-ice motion is estimated every day from AMSR 89 GHz horizontal data over the 2002/03 and 2003/04 winters (October-May). Only the daily average of descending orbits were used to reduce the time averaging of overlapping orbits. A maximum cross correlation method is used to estimate sea-ice motion between satellite images (Agnew et al.,1997). The sea-ice area transport across each flux gate is calculated by interpolating the ice motions normal to the flux gate at a 25 km grid spacing and then multiplying by the sea-ice concentration to produce a daily average flux. Sea-ice concentrations are estimated from the 18.7 and 36.5 GHz channels of the AMSR sensor using the NASA Team algorithm. Unlike Kwok and Rothrock, we do not assume 100% ice concentration within the 15% ice concentration edge.

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Some quality control of the AMSR images was done. For example, occasional missing pixels are replaced using the median of nearest 8 neighbors. Occasional missing days in the AMSR-E images resulted in no daily flux estimate. These missing days were estimated using the monthly average flux for that month. This occurred two to four times in the months of October, November and December.

Figure 2 and 3 show the daily ice area flux across Fram Strait and Baffin Bay for the 2002/03 winter. Negative sea-ice flux means transport north. There is considerable variability from day to day for both regions caused mainly by the variability in sea-ice motion. The standard deviation of daily flux is around 3000 km^2 for both regions. In Baffin Bay, sea-ice transport does not usually begin until November because of the lack of sea-ice. The change from southward transport of sea-ice at the end of February 2003 to northward transport two days later was caused by a major storm which moved into Davis Strait and produced very strong southerly winds over the Baffin Bay region.

The error in estimating ice motion is obtained by comparing with drifting Arctic buoy data in the area of Fram Strait. Table 1. shows that the average of the mean difference (AMSR minus buoy motion) is -1.85 km/day indicating that the passive microwave underestimates motion compared to the buoys. This underestimation is large and may be a result of averaging the motions over 2 days and the fact that only buoy data for the 2002/03 winter was compared. The standard deviation of the differences 3.17 km/day is smaller than the mean motion of all the buoys (9.68 km/day).

Table 2 shows the monthly average sea-ice area transport for Fram Strait and Baffin Bay for both winters and Figure 4 plots the average monthly flux over the 2 winters. Baffin Bay sea-ice area flux is within 10% of the value for Fram Strait although it should be kept in mind that sea-ice in Baffin Bay is mainly first year ice and therefore thinner than sea-ice exported through Fram Strait. For the two years of this study period, sea-ice area flux for Fram Strait is 749,000 and 797,000 km^2 which is close to the average transport found by Kwok and Rothrock (1999) of 754,000 km^2 for the 1978 to 2002 period.

Obs.	Mean difference	Standard Deviation	Mean motion
140	-1.85	3.17	9.68

Table 1 Differences between AMSR and drifting buoys (km/day).

The correlation between daily ice area flux and the pressure difference between the two end point of each flux gate is .82 for Fram Strait and .85 for Baffin Bay. This high correlation reflects the fact that ice motion is largely wind driven.

3. CONCLUSIONS

The amount of sea-ice area flux through Baffin Bay is within 10% of Fram Strait although the ice thickness is higher in Fram Strait.

Although not shown here, the increased spatial resolution of AMSR also allows estimates of sea-ice area transport through the main channels of the Canadian Archipelago and other regions critical to export sea-ice into the North Atlantic.

4. ACKNOWLEDGEMENTS

The authors acknowledge the National Snow and Ice Data Center for providing the AMSR passive microwave data and financial support by the US National Science Foundation and the Canadian Panel on Energy Research and Development (PERD).

5. REFERENCES

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Fig. 1. Location of Baffin Bay and Fram Strait flux-gates

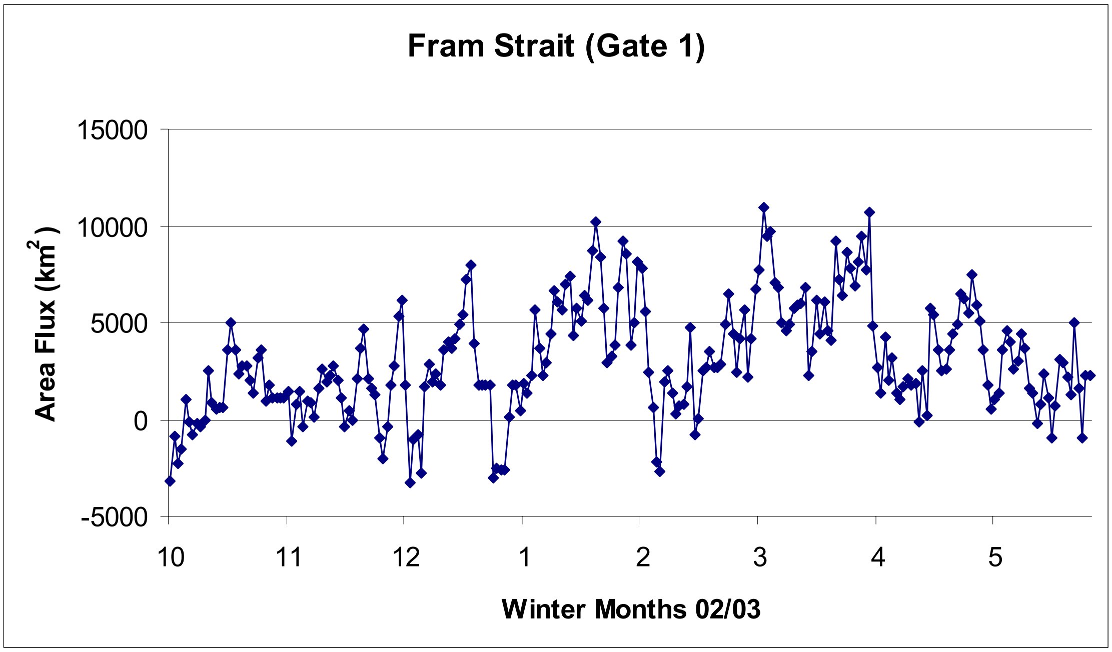

Figure 2. Daily ice area transport for Fram Strait.

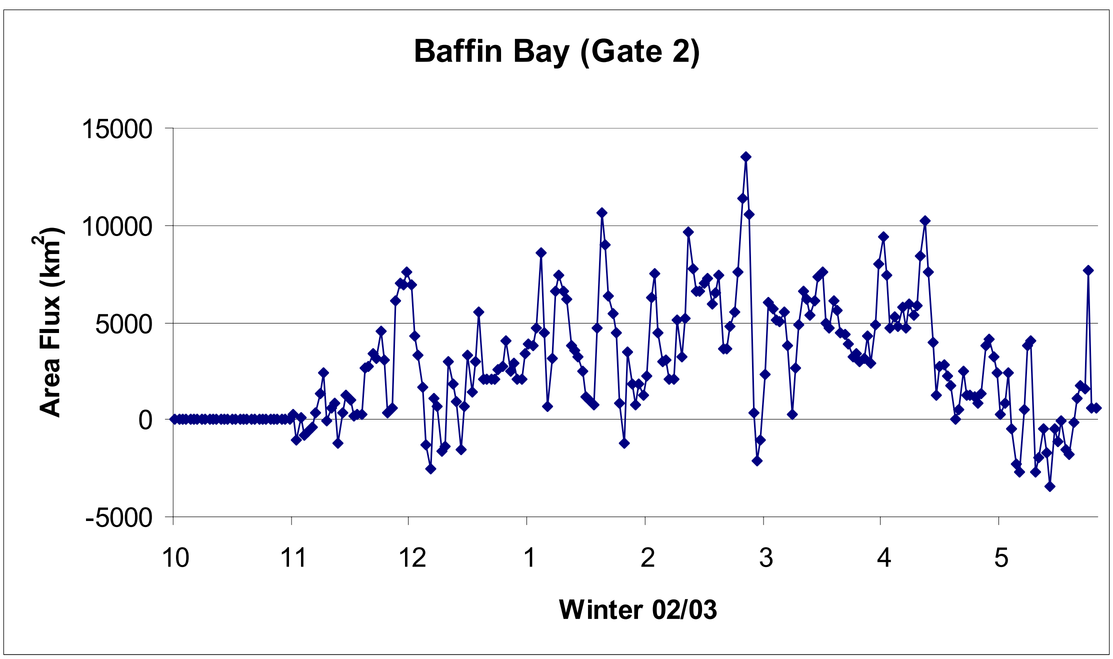

Figure 3. Daily ice are transport for Baffin Bay

Fram Strait											
Winter	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Total	Mean	Std. Dev.
02/03	34	41	56	162	73	195	117	72	749	94	59
03/04	43	39	199	193	151	79	57	37	797	100	70
Mean	38	40	127	178	112	137	87	54	773		
Baffin Bay											
Winter	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Total	Mean	Std. Dev.
02/03	0	45	64	124	160	135	128	19	676	85	60
03/04	0	72	75	167	127	92	62	32	626	78	52
Mean	0	59	69	145	144	113	95	26	651		

Table 2. Monthly sea-ice area flux in 10^3 km^2 for 2002/03 and 2003/04 winters.

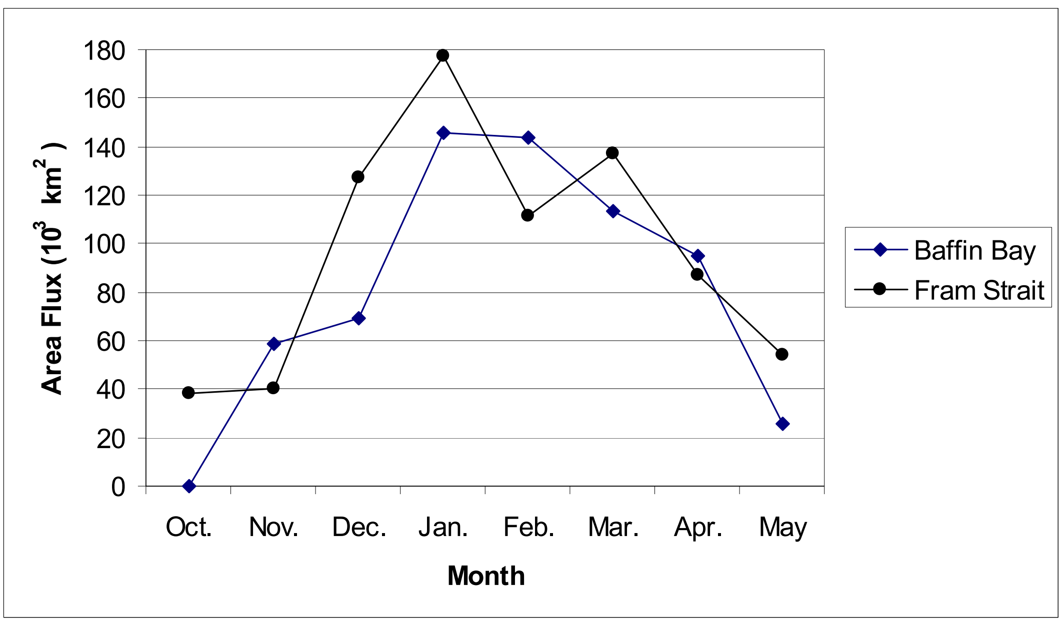

Figure 4. Mean monthly ice area flux for Fram Strait and Baffin Bay for 2002/3 and 2003/04.