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Estimation of polynya area and thin ice thickness using satellite microwave radiometry in the Ross Sea, Antarctica

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Coastal polynyas play an important role in sea ice formation and thus water mass modification during winter. They act as starting point for summer melt once energy input into its open water area allows lateral melt of the sea ice. Particularly in the Antarctic, recent estimates of Flocco et al. (EGU, 2006) suggest that despite the fact that they only cover up to 0.15 % of the total ice-covered area, the ice production in polynyas can reach 7 % of the total winter ice production, which can contribute to about 10 % of the dense water formation. Alone the small polynya in Terra Nova Bay has been observed to contribute towards 10% of the ice production in the Ross Sea. For this reason and because of a number of secondary polynyas generated in the lee of tabular icebergs, which broke off in 2001/2002 and left the Ross Sea in 2003 and 2006, we have chosen this region for our investigations. The main goal is to obtain an accurate estimate of the amount of ice produced in the coastal polynyas and to find out whether and how much the mentioned secondary polynyas increased the typical amount of ice produced.

Two steps required to achieve this goal: estimation of polynya area and frequency of opening and closing, and estimation of the ice thickness. We apply and combine two different methods based on brightness temperature measurements of the Special Sensor Microwave / Imager (SSM/I) at frequencies of 37 GHz and 85 GHz, horizontal and vertical polarization. One method uses 37 GHz SSM/I data to get an estimate of thin-ice thickness (up to 20-30cm) using an empirical relationship between this data and the thickness (Martin et al., 2004). This relationship is based on this data and independent thin-ice thickness estimates using Advanced Very High Resolution Radiometer (AVHRR) and numerical model data (Yu and Rothrock, 1996). Martin

et al. (2004) developed and applied the method for the Chuchki Sea polynya. We did similarly for the Ross Sea and Terra Nova Bay polynyas and applied the method for winters 2002-2004 to get a weather- and daylight-independent estimate of the ice thickness at a 5 km x 5 km grid spacing.

The second technique is the Polynya Signature Simulation Method (PSSM) of Markus and Burns (1995). This method allows to obtain the polynya area (i.e. open water and thin ice up to a thickness of around 20 cm, depending on weather conditions and region), with an accuracy of around 200 km^2 also at a 5 km x 5 km grid spacing. It is based on an iterative classification of resolution-enhanced 37 GHz SSM/I data (also using information of the finer resolved 85 GHz SSM/I data) into the surface types: open water, thin ice and thick ice. Two modifications compared to the original PSSM have been made: a manual improvement of the coast and ice shelf line using AVHRR imagery, and filtering of iceberg and fast-ice areas, which can exhibit the same microwave signature than polynyas and may therefore be misinterpreted as such.

We used the modified PSSM to obtain time series of the polynya area of the Ross Sea for 1995 – 2006. Results show that during years with secondary polynyas, the average polynya distribution was significantly different from other years, with extensive open water and thin ice areas further to the North than normal. These locations are also identified correctly by the ice thickness algorithm. We found out that combining both methods effectively reduces false ice thickness estimates over fast ice and icebergs. Moreover, the area of each polynya is obtained with two independent methods from similarly spatial and temporal resolved satellite data so that more confidence can be put on the obtained results. These findings will be presented and ice thickness and polynya area compared with independent estimates using AVHRR data.