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The pressure ridge distribution in the Arctic Ocean from submarine sonar data

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The profiling of the underside of the sea ice with upward-looking sonars fitted to submarines is the best method of studying the large scale distribution of morphological features such as pressure ridges and leads.

We present the statistical analysis of the distributions of pressure ridge spacings and heights, and lead spacings and widths observed during two Arctic cruises by the Royal Navy submarine HMS Tireless in the winters of 2004 and 2007 in which more than 10000km of sea ice draft data were collected. We briefly describe the main characteristics of the full ice draft distribution in the several regions of the Arctic Ocean visited by the submarine and discuss the most significant differences between 2004 and 2007. In the area of heavily ridged ice north of Greenland and Ellesmere Island we found an increase in ridge density (number of ridges per unit track length) accompanied by a decrease in modal ice draft, leaving the mean ice thickness essentially unchanged, between 2004 and 2007. This area is likely to be the only one in the Arctic Ocean where the sea ice thickness may not be in decline. We investigate the causes of this invariance in the context of an Arctic Ocean in transition from a multi-year to a first-year ice cover and discuss its relation with the strengthening of the transpolar drift and consequent accumulation of ice north of Greenland and increase in ice export through Fram Strait.

Our analysis shows that the number of deep ridges per km is well described by a Poisson distribution while the corresponding distribution for shallow ridges is more complicated. The tail of the distribution of the pressure ridge heights is approximately a negative exponential, in agreement with similar observations made in previous cruises.

We pay special attention to the uncertainties and biases in the measurement of the ice draft. Specifically, we discuss the effects of the finite beamwidth of the single-beam sonars traditionally used in British submarines on the determination of sea ice draft, which may have been underestimated in previous work.