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Determination of Arctic sea ice thickness in the winter of 2007

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The L3H phase of operation of ICESat's laser in the winter of 2007 coincided for about two weeks with the cruise of the British submarine Tireless where upward-looking and multibeam sonar systems were mounted, thus providing the first opportunity for a simultaneous determination of the sea ice freeboard and draft in the Arctic Ocean.

ICESat satellite carries a laser altimeter dedicated to the observation of polar regions, generating accurate profiles of surface topography along the tracks (footprint diameter 70m), which can be inverted to determine sea-ice freeboard heights using a "lowest level" filtering scheme.

The procedure applied to obtain the ice freeboard F=h-N-MDT (where h is the ICESat ellipsoidal height estimate, N is the geoid undulation and MDT is the ocean mean dynamic topography) for the whole Arctic basin (with the exception of points beyond 86N) consisted of a high-pass filtering of the satellite data to remove low frequency effects due to the geoid and ocean dynamics (the geoid model ArcGP with sufficient accuracy to allow the computation of the freeboard was very recently made available). The original tide model was replaced by the tide model AOTIM5 and the tide loading model TPXO6.2. The inverse barometer correction was computed.

As there are no MDT models with enough accuracy, it is necessary to identify leads of open water or thin ice to allow the interpolation of the ocean surface, using surface reflectivity and waveform shape. Several solutions were tested to define the ocean surface and the computed freeboard values were interpolated on a 5x5 minute grid, where the submarine track was interpolated.

At the same time, along-track single beam upward-looking sonar data were recorded using an Admiralty pattern 780 echo sounder carried by the Tireless, from where we have generated an ice draft profile of about 8,000km between Fram Strait and the North coast of Alaska and back.

The merging of the two data sets provides a new insight into the present Arctic sea ice thickness distribution while a comparison with results obtained by previous submarines cruises and previous phases of operations of ICESat allows a fresh evaluation of the rate of sea ice thinning.