Geophysical Research Abstracts,
Vol. 11, EGU2009-5296, 2009
EGU General Assembly 2009

Retrieval of ice thickness from radar-altimeter data based on empirical relation between ice thickness and freeboard

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The basic technique of computing sea ice thickness by satellite altimetry is to measure freeboard (that is the height of the ice or snow surface above water) from the difference between the surface height of the larger ice floes, and the height of the thin ice or water surface in the major leads. The ice freeboard measurements are then converted to ice thickness by assuming hydrostatic equilibrium and using fixed densities of ice, sea water and snow, as well as snow depth [Laxon et al., 2003]. Our studies revealed that the natural variability of sea ice density results in a significant uncertainty of ice thickness retrieval, which can reach $\pm$ 70 cm for thick first-year ice and multiyear ice. It was found that the interannual and regional variability of snow depth, which is less than 10 cm in most regions, cause uncertainty of ice thickness calculation of $\pm$ 20 cm for multiyear ice, and $\pm$ 30 cm – for first-year ice. The present knowledge on parameterization of ice density and, to some degree snow depth and density, as well as their dependence on ice thickness, precludes accurate calculation of ice thickness from measured ice freeboard values using isostatic equilibrium equation.

Another possible approach for ice thickness retrieval from radar-altimeter data can be based on empirical relations between ice thickness and freeboard. The most extensive data set, containing sea ice and snow measurements, was collected during aircraft landings associated with the Soviet Union's historical Sever airborne and North Pole drifting station programs. The data set contains measurements of 23 parameters, including ice thickness, ice freeboard and snow depth, which were measured at the same time in 688 landings in 1980 - 1982, 1984 - 1986, and 1988. The following regression equation, relating average ice thickness and average ice freeboard has been derived from these data:

Hice= 8.3098 Fest + 35.739

Obtained regression dependence allows estimation of ice thickness from measured ice freeboard values in the range of 0-20 cm. Comparison with the independent dataset of measurements for drifting first-year ice revealed an average uncertainty of 10.8 cm.

References

Laxon, S., Peacock, N., and Smith, D. (2003). High interannual variability of sea ice thickness in the arctic region. Nature, vol. 425, pp. 947-950.