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ICESat altimetry and radar-derived ice thickness in the Scott Coast (Northern Victoria Land, Antarctica): evidences for ice tongues/shelves density variations

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The calculation of the ice discharge at the land-sea interface in the polar regions relies on the correct estimation of ice thicknesses along the grounding line. This parameter is measured with airborne Radio-Echo sounding or with a method based on the hydrostatic relationship: the latter allows, knowing the surface elevation, the mean ice and water densities and assuming that the ice is in hydrostatic equilibrium, to infer its thickness (Bamber and Bentley, 1994). The difficulty with this approach is that the density of the ice must be corrected for the overlying, lower density, firn layer. The thickness of this layer can vary between a few meters and about 120m introducing a potentially source of uncertainty for the averaged, column ice density. In this study, to minimize this error and to provide a more detailed mapping of ice thicknesses at and seaward of the grounding line for several ice tongues/shelves of the Scott Coast (Northern Victoria Land, Antarctica), we integrate ICESat elevation data with radar-derived ice thicknesses obtained during 1995, 1997 (Tabacco and others, 1998) and during 2003 (Tabacco, unpublished). The examined outlet glaciers are Clarke, Harbord, Priestley, Reeves, Drygalski and the Nansen Ice Sheet. We analyse them both spatially and statistically using GIS technologies, to check the possible influence of geomorphological (i.e. bedrock, surface structures) and glaciological (i.e. ice density variations) factors on the empirical relationships between ice elevation and thickness. ICESat greatly improved elevation data sets, acquired by the Geoscience Laser Altimeter System (GLAS) during 2003-2006, were imported from the National Snow and Ice Data Center (NSIDC) and examined for their quality. Landsat imagery was used as a base map to allow the visual detection of glacial flowlines and to subset

data of the different glacial ice tongues/shelves. The statistical relationships between ice elevation and thickness were investigated through scatterplots, cumulated for the total area and computed individually for the various ice tongues. A best-fit linear correlation between elevation and thickness is observed for all the ice tongues/shelves examined. The inclinations of the trend lines derived from these correlations, if interpreted in terms of hydrostatic equilibrium and constant sea water density (1027.5 kg/m3), imply mean ice densities varying geographically from 900 to 935 kg/m3, with the minimum value corresponding to Clark glacier and the maximum to Reeves glacier. From remote sensing analyses it is possible to observe that a large part of Reeves glacier consists of blue ice and this could cause its higher mean ice density value. The average ice density of all the ice tongues remains almost constant around 911 kg/m3 during 2003-2006.

References

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