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Geodetic estimates of glacier mass balance in Severnaya Zemlya

Aleksey Sharov (1), Dmitry Nikolskiy (2), and Alexandra Tyukavina (3)

(1) Joanneum Research, Institute of Information and Communication Technologies, Graz, Austria (aleksey.sharov@joanneum.at, 0043 316 876 1720), (2) Moscow State University of Geodesy and Cartography, Russia, (3) Moscow Lomonosov State University, Russia

The synergetic combination of differential interferometry and altimetry addressed in this paper represents a highly informative remote sensing method for topographic modelling, change mapping and geodetic measurements of mass balance on arctic ice caps and mountain glaciers in Severnaya Zemlya. Formerly geodetic mass balance measurements in the area were carried out using airborne photography, but such measurements did not reach fully operational status because of mainly financial constraints. The proposed dual-sensor technique offers economically efficient and particularly potent solution to glacier mass balance determinations from space. The technical and economical feasibility of this combined dual-sensor method in a wide range of glacier extents is ensured with the entire coverage of study glaciers, high sensitivity to height variations, reduced field work and large amount of high-resolution and low-price satellite SAR interferometry and altimetry data.

In our practical work, 12 differential ERS-1/2 SAR interferograms of Severnaya Zemlya were processed, geocoded, mosaicked, calibrated and interpreted using 50- and 25-year-old reference elevation models and co-located ICESat altimetry data. The glacier change signal between altimetric transects was determined in a straightforward manner from the local differential phase value. Precise orbital and attitude data available for both types of sensors enabled stringent geometric processing even in the case of insufficient ground control typical of glacial areas. The vertical accuracy of glacier change models proved on several small and large ice caps was given as $\pm$ 0.3 m/a rms and the overall r.m.s.e. of present volumetric estimations in Severnaya Zemlya is assumed to be $\pm$ 0.2 km^3.

The mean change of glacier thickness was determined as -6 m and the annual rate of land ice loss in Severnaya Zemlya was given as 4.8 km^3/a thus indicating a strongly negative net balance of glaciation being very close to the most pessimistic estimates. The rate of ice loss due to calving seems to be, at least, 2 times higher than the maximum value given by other investigators. The study showed a relatively insignificant decrease of less than 0.5 % in the total glacier area. Notwithstanding, the present total area of Matusevich Ice Shelf, the largest in Eurasia, was given as 172 km^2, which means a relative decrease of 29 % in approx. 25 years. The results were analyzed and validated by means of comparison with climatological, oceanographic, rheological, gravimetric and other ground-truth and EO data, and were represented in the form of glacier change maps at 1:500,000 scale. The resultant maps can be accessed at http://dib.joanneum.at/smaragd/index.php?page=results.