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Spatial features of glacier changes in the Barents-Kara Sector

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In the 1950s, the total area of glaciers occupying separate islands and archipelagos of the Barents and Kara seas exceeded 92,300 km^2 (Atlas of the Arctic 1985). The overall glacier volume reached 20,140 km^3 and the average ice thickness was given as 218 m. Our recent remote sensing studies and mass-balance estimates using spaceborne ASTER and LANDSAT imagery, ERS and JERS radar interferometric mosaics, and ICESat altimetry data revealed that, in the 2000s, the areal extent and volume of Barents–Kara glaciation amounted to 86,200±200 km^2 and 19,330±20 km^3, respectively. The annual loss of land ice influenced by severe climate change in longitudinal direction was determined at approx. 8 km^3/a in Svalbard, 4 km^3/a both in the Franz Josef Land and Novaya Zemlya archipelagos, and less than 0.3 km^3/a in Severnaya Zemlya over the past 50 years. The average ice thickness of remaining glaciation increased to 224 m. This fact was explained by rapid disintegration of thinner glacier margins and essential accumulation of snow at higher glacier elevations. Both effects were clearly visible in the series of satellite image maps of glacier elevation changes generated within the framework of the INTEGRAL, SMARAGD and ICEAGE research projects. These maps can be accessed at http://joanneum.dib.at/integral or smaragd (cd results).

The largest negative elevation changes were typically detected in the seaward basins of fast-flowing outlet glaciers, both at their fronts and tops. Ablation processes were stronger manifested on southern slopes of ice caps, while the accumulation of snow was generally higher on northern slopes so that main ice divides “shifted” to the north. The largest positive elevation changes (about 100 m) were found in the central part of the study region in the accumulation areas of the biggest ice caps, such as Northern Ice Cap in Novaya Zemlya, Tyndall and Windy ice domes in Franz Josef Land, and Kvitoyjokulen at Kvitøya. The sides of these glaciers steepened. Significant positive height changes of 25 to 50 m were also registered at several insular ice caps smaller than 300 km^2 with top heights of about 300 m. At sub-regional scale the horizontal distribution of glacier changes was not uniform and correlated astonishingly well with the geopotential field represented in existing gravity anomaly maps of the Arctic. The locations of positive glacier changes systematically neighbored with the locations of strong positive gravity anomalies. Conversely, the largest negative changes were situated in the close vicinity of negative anomalies.

Hence we supposed that significant lateral variations of geopotential might influence the local intensity of solid precipitation, snow accumulation rate and glacier regime in the High Arctic. A basic set of simple differential equations describing glacioclimatic settings in the heterogeneous field of gravity was compiled and critically compared with the relevant knowledge obtained by some other investigators. As a result, a new working hypothesis about gravity driven fluctuations in the long-term regime of cryospheric resources was devised and argued. First numerical simulations, statistical analyses of meteorological and tidal data rows, error balance estimates and specific glaciological surveys in 2001, 2006 and 2008 demonstrated major spatiotemporal singularities, principal methodological advantages and a higher feasibility of the proposed hypothesis compared to similar empirical-theoretical concepts developed by “lunarists” and “astro-meteorologists”. New remote sensing data to be obtained from GOCE and CryoSat-2 satellites over the Barents-Kara Sector, which represents the largest cluster of tidewater glaciers and gravity anomalies in the Old World, might essentially contribute to the verification of this still conjectural theory.