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RES ice thickness and frontal ablation of outlet glaciers in Russian Arctic

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Frontal ablation (the sum of ice loss through calving and submarine melt) of tidewater glaciers and ice caps in the Russian Arctic is poorly known. Meanwhile it is an important component of their mass balance, and its knowledge is strongly required when considering the iceberg risk in off-shore industrial activities.

Study area is located in three archipelagoes of the Russian Arctic with total glacierized area 51,591 km^2, including Novaya Zemlya (NZ) 22,128 km^2, Franz Josef Land (FJL) 12,762 km^2, and Severnaya Zemlya (SZ) 16,701 km^2 [1].

To assess the frontal ablation the data on ice thickness, ice velocity and glacier front change are required. Data on ice thickness of 31 glaciers (12 on NZ, 11 on FJL, and 8 glaciers on SZ) were obtained during our airborne 20 MHz RES campaigns in 2014–2016. Data on variations of glacier fronts from 2001 to 2016 were extracted from Landsat satellite imagery. Glacier surface velocities from 2014 to 2016 were based on feature tracking on repeat Landsat-8 imagery using COSI-Corr package and from GoLIVE v.1 [2] data set combined with continuous records from seven GPS beacons installed on five glaciers. ArcticDEM data on glacier ice surface combined with RES ice thickness data were used to compile glacier bedrock maps and transects.

Frontal ablation is estimated for each glacier as a sum of the ice flux through a fixed fluxgate above the position of the calving front, and the ice volume change in the terminus below the fluxgate due to advance or retreat. The spatially fixed fluxgate is defined approximately perpendicular to the ice flow, 250–1500 m upglacier from the actual calving front. The depth-averaged speed is extracted from the surface velocity field in increments of 25 m along the fluxgate and weighted by a correction factor 0.9. The ice thickness is extracted in the same points from the ice thickness maps or transects. Radar two-way time data were converted to ice thickness using radio wave propagation speed 168 m mcs^{-1}. We do not include in our estimations all glaciers without RES data, and also the surging western basin of the Vavilov Ice Cap and disintegrating Matusevich Ice Shelf (both SZ). Mean ice thickness at glacier fronts is in average: from 60 at eastern coast to 105 m at western coast of NZ; 107 m on FJL, and 117 m on SZ. Maximum ice thickness at glacier front has the Inostrantsev Glacier on NZ: 216 m in average (maximum ~400 m) (Fig.1).

Frontal ablation rate of RES surveyed glaciers is assessed as: 2.05 km^3 a^{-1} on NZ (12 glaciers) including 0.51 km^3 a^{-1} on eastern coast (4 glaciers) and 1.54 km^3 a^{-1} on western coast (8 glaciers); 1.66 km^3 a^{-1} on FJL (11 glaciers); and 3.07 km^3 a^{-1} on SZ (8 glaciers). Share of terminus position changes in total frontal ablation is: 28% on NZ (32% eastern coast and 26% western coast), 27% on FJL, and 24% on SZ.

Our assessment of annual frontal ablation of outlet glaciers in the Russian Arctic as 7 km^3 of ice is a minimal one, because it based on the data set of only 31

RES-surveyed glaciers. This set covers less than a quarter of calving glaciers on NZ and SZ, and even less on FJL. But a simple increasing of our assessment in proportion to the number or area of all calving glaciers will not give the correct overall estimate. Input of studied glaciers in our assessment is very unequal. The following 6 glaciers provides nearly 60% of frontal losses in our estimate: No 8, No 7 and Issledovateley Glaciers on SZ, Inostrantsev and Vershinskiy Glaciers on NZ, and Znamenitiy Glacier on FJL (1.04, 0.63, 0.76; 0.71, 0.3; and 0.69 km a^{-1}, respectively). Terminus retreat is an important component, constituting near a quarter of the frontal ablation of studied glaciers.

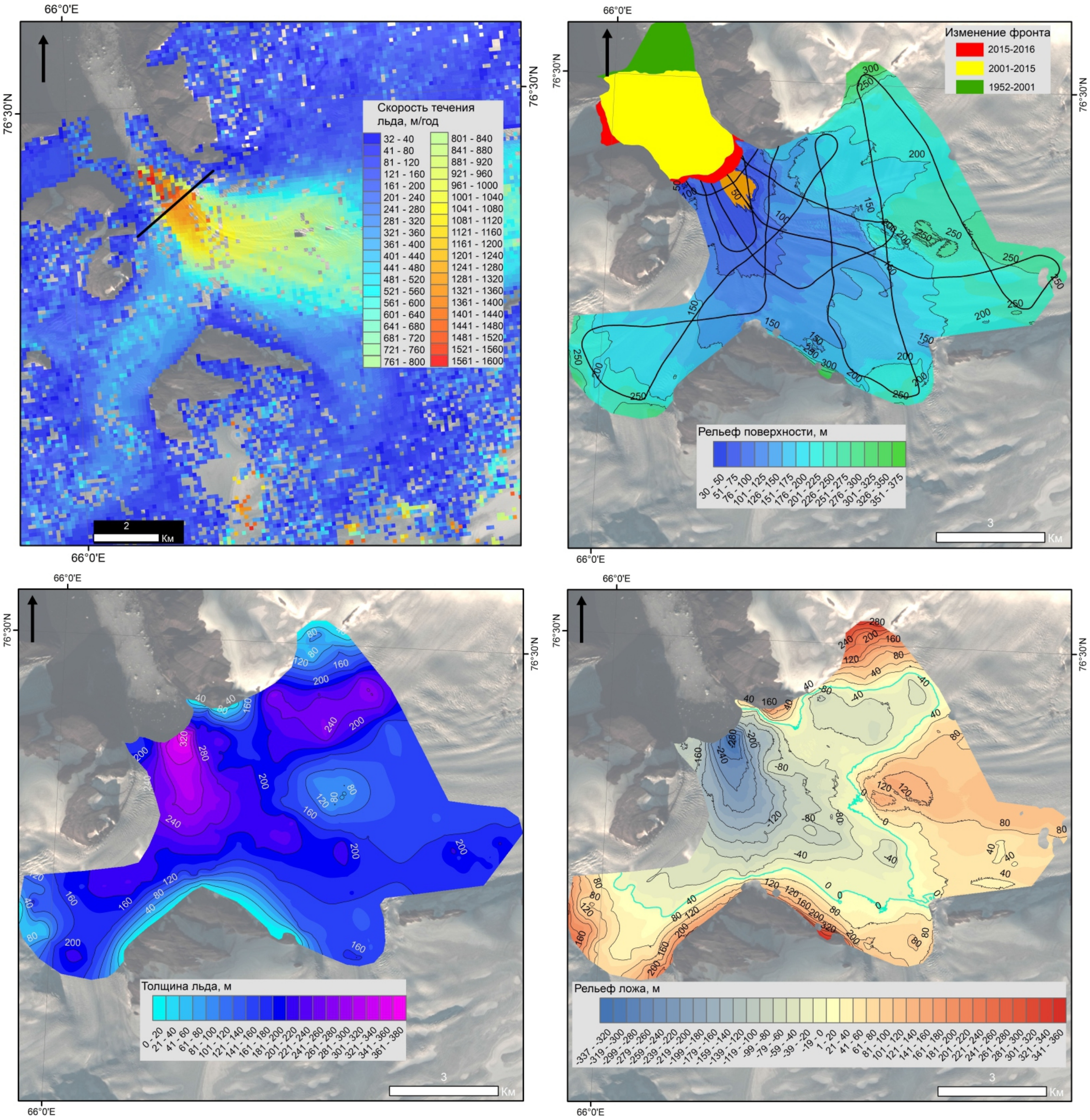

Figure 1. Inostrantsev Glacier, Novaya Zemlya: a) ice surface velocity (m a^{-1}); b) ice surface (m a.s.l.); c) ice thickness (m), d) bedrock elevation (m)

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Nutrient delivery from polar glaciers to downstream ecosystems

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The export of nutrients from polar glaciers to downstream ecosystems can be simplified into small fluxes of highly labile, aqueous products of microbially-mediated rock weathering reactions, and large fluxes of sparingly labile nutrients associated with sediments derived from physical erosion. However, the relative importance of the two pathways can change markedly: for example when tidewater glaciers retreat onto land and glacial tills accumulate organic matter and evolve into soils. At present, almost none of these changes have been integrated into models that represent the past, present or future state of ice-marginal marine ecosystems. This presentation therefore attempts to improve our conceptual understanding of these processes and help us move toward a more interdisciplinary examination of coastal ecosystem dynamics in glacially-influenced polar waters.

In the first part, the importance of constraining nutrient mass balance within glacial systems will be discussed, and its advantages over basic short-term runoff flux calculations made clear. In so doing, it will be shown how glaciers export significant NO3- and sediment-bound (or readily extractable) Fe, P and Si fluxes via runoff and calving. By contrast, glaciers will be shown to be significant sinks of dissolved NH4+ and PO43- after they are leached from snowpacks and subject to assimilation and adsorption to suspended sediments. Nutrient mass balances through proglacial floodplains will also be used to consider their potentially important regulation of riverine glacial inputs. Secondly, linked to the above, the longer-term changes associated with the transition from active calving to riverine glacial inputs, caused by a combination of glacio-marine sedimentation and isostatic uplift, will also be emphasised. Here attention will be given to the role of the sediment infills that greatly affect rock-water interaction due to the establishment of groundwater flowpaths through very reactive fine materials that, at least in the High Arctic, also often contain marine pore waters whose mobility can be climate-dependent due to permafrost. Finally, several case studies of polar fjords will be used to emphasise the above issues and make clear the range of different