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Land ice contribution to the freshwater budget of the Arctic and North Atlantic Oceans

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The freshwater budget of the Arctic and sub-polar North Atlantic Oceans has been changing due, primarily, to increased river runoff, declining sea ice and enhanced melting of Arctic land ice. Since the mid 1990s this latter component has experienced a pronounced increase. We use a combination of satellite observations of glacier flow speed and regional climate modeling to reconstruct the land ice freshwater flux from the Greenland ice sheet and Arctic glaciers and ice caps for the period 1958-2016. The cumulative freshwater flux anomaly exceeded 6300±316 km3 by 2016. This is roughly twice the estimate of a previous analysis that did not include glaciers and ice caps outside of Greenland and which extended only to 2010. From 2010 onward, the total freshwater flux is about 1300 km3/yr, equivalent to 0.04 Sv, which is roughly 40% of the estimated total runoff to the Arctic for the same time period. Not all of this flux will reach areas of deep convection or Arctic and Sub-Arctic seas. We note, however, that the largest freshwater flux anomalies, grouped by ocean basin, are located in Baffin Bay and Davis Strait. The land ice freshwater flux displays a strong seasonal cycle with summer time values typically around five times larger than the annual mean. This will be important for understanding the impact of these fluxes on fjord circulation, stratification, and the biogeochemistry of, and nutrient delivery to, coastal waters. We suggest that the large, quasi-monotonic trend in freshwater anomalies is driving a change in the large scale pattern of circulation in the Arcitc, as reflected in the Arctic Ocean Oscillation index. Ocean reanalyses (e.g. ORAP5) and satellite data support the inference of a positive freshwater anomaly in Baffin Bay.