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Numerical modeling of Drangajökull Ice Cap, NW Iceland

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Over the past century the Arctic has warmed twice as fast as the global average. This discrepancy is likely due to feedbacks inherent to the Arctic climate system. These Arctic climate feedbacks are currently poorly quantified, but are essential to future climate predictions based on global circulation modeling. Constraining the magnitude and timing of past Arctic climate changes allows us to test climate feedback parameterizations at different times with different boundary conditions. Because Holocene Arctic summer temperature changes have been largest in the North Atlantic (Kaufman et al., 2004) we focus on constraining the paleoclimate of Iceland. Glaciers are highly sensitive to changes in temperature and precipitation amount. This sensitivity allows for the estimation of paleoclimate using glacier models, modern glacier mass balance data, and past glacier extents. We apply our model to the Drangajökull ice cap ($\sim$150 sq. km) in NW Iceland. Our numerical model is resolved in two-dimensions, conserves mass, and applies the shallow-ice-approximation. The bed DEM used in the model runs was constructed from radio echo data surveyed in spring 2014. We constrain the modern surface mass balance of Drangajökull using: 1) ablation and accumulation stakes; 2) ice surface digital elevation models (DEMs) from satellite, airborne LiDAR, and aerial photographs; and 3) full-stokes model-derived vertical ice velocities. The modeled vertical ice velocities and ice surface DEMs are combined to estimate past surface mass balance. We constrain Holocene glacier geometries using moraines and trimlines (e.g., Brynjolfsson, etal, 2014), proglacial-lake cores, and radiocarbon-dated dead vegetation emerging from under the modern glacier. We present a sensitivity analysis of the model to changes in parameters and show the effect of step changes of temperature and precipitation on glacier extent. Our results are placed in context with local lacustrine and marine climate proxies as well as with glacier extent and volume changes across the North Atlantic.