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Projections of 21st century sea-level contribution from the retreat of Humboldt Glacier, North Greenland

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Humboldt Glacier drains ~5% of the Greenland Ice Sheet and has retreated and accelerated since the late 1990s. The northern section of the terminus has retreated towards an overdeepening in the glacier bed that extends tens of kilometers towards the ice sheet interior, raising the possibility of a rapid increase in ice discharge and retreat in the near future. Here we investigate the potential 21st century sea-level contribution from Humboldt Glacier with the MPAS-Albany Land Ice (MALI) ice sheet model. First, we optimize the basal friction field using observations of surface velocity and ice surface elevation to obtain an initial condition for the year 2007. Next, we tune parameters for calving, basal friction, and submarine melt to match the observed retreat rates and surface velocity changes. We then simulate glacier evolution to 2100 under a range of climate forcings from the Ice Sheet Model Intercomparison Project for CMIP6 (ISMIP6), using ocean temperatures from the MIROC5 Earth System Model, with surface mass balance and subglacial discharge from MAR3.9/MIROC5. Our simulations predict ~3.5 mm of sea-level rise from the retreat of Humboldt Glacier by 2100 for RCP8.5, and ~1 mm for RCP2.6. The results are insensitive to the choice of calving parameters for grounded ice, but a low stress threshold for calving from floating ice is necessary to initiate retreat. We find that a highly plastic basal friction law is required to reproduce the observed acceleration, but the choice of basal friction law does not have a large effect on the magnitude of sea-level contribution by 2100 because much of the ice is at present close to floatation in the areas that retreat most significantly. Instead, the majority of ice mass loss comes from increasingly negative surface mass balance. Preliminary results from experiments with a subglacial hydrology model suggest that the simple treatment of subglacial discharge used in our 21st century projections (as used in the ISMIP6-Greenland protocol) underestimates spatial variability of melting at the glacier front but gives a reasonable approximation of total melt. When compared to the recent ISMIP6 estimates of 60–140 mm sea-level rise from the entire Greenland Ice Sheet by 2100, our estimate of 3.5 mm from Humboldt Glacier indicates a significant but far from dominant contribution from this single large outlet.