Modeling ice front dynamics of Greenland outlet glaciers using the levelset method

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ABSTRACT

The recent increase in the rate of mass loss from the Greenland Ice Sheet is primarily due to the acceleration and thinning of outlet glaciers along the coast. This acceleration is a dynamic response to the retreat of calving fronts, which leads to a loss in resistive stresses. These processes need to be included in ice sheet models in order to be able to accurately reproduce current trends in mass loss, and in the long term reduce the uncertainty in the contribution of ice sheets to sea level rise. Today, the vast majority of ice sheet models that include moving boundaries are one dimensional flow line and vertical flow band models, that are not adapted to the complex geometries of Greenland outlet glaciers, as they do not accurately capture changes in lateral stresses. Here, we use the level set method to track moving boundaries within a 3D higher order finite element model (ISSM), and investigate the sensitivity of Zachariæ Isstrøm and Nioghalvfjerdsfrjorden glacier (79 North), in Northeast Greenland, to external forcings with a dynamically evolving ice front. We force the model with observed grounding line and/or calving front retreat and compare the response of the model in terms of acceleration and thinning to observations. In a second set of experiments, we apply different basal melting rates to the model in order to assess the response of the glacier system to warmer ocean currents and to evaluate its contribution to sea level over the next century under different scenarios. This study shows that accurate ocean circulation models and a good representation of calving dynamics are critically need in order to reduce the uncertainty in the contribution of ice sheets to future sea level.

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