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Viscoelastic modeling results of the 79°N Glacier, Greenland

Julia Christmann^{1,2}, Martin Rückamp¹, Ole Zeising^{1,3}, Daniel Steinhage¹, Niklas Neckel¹, Veit Helm¹, Müller Ralf², Mirko Scheinert⁴, Shfaqat Abbas Khan⁵, and Angelika Humbert^{1,3}

¹Alfred-Wegener-Institut Helmholtz Zentrum für Polar- und Meeresforschung, Bremerhaven, Germany

(julia.christmann@awi.de)

²TU Kaiserslautern, Kaiserslautern, Germany

³University of Bremen, Bremen, Germany

⁴TU Dresden, Dresden, Germany

⁵Technical University of Denmark, Lyngby, Denmark

Grounding line/zone dynamics of floating-tongue glaciers is of major importance for changes in their contribution to sea-level rise. For floating-tongue glaciers, thermal forcing of oceanic heat and tidal forcing are the major processes acting in that zone. Here we deal with the response to tidal forcing. The 79°N Glacier, an outlet glacier of the North East Greenland Ice Stream, is the focus of the Greenland Ice Sheet Ocean Interaction project (GROCE) funded by the German Ministry of Education and Research. We present a study of this region considering the deformation of the glacier in response to ocean tidal forcing by means of observations and modeling. GPS measurements realized in 2017-2018 are analyzed for vertical and horizontal displacements of the glacier and its floating tongue. Observations on fully-grounded ice reveal a periodic horizontal displacement in response to ocean tidal forcing in a distance of more than 35 km upstream from the grounding line. In the hinge zone, i.e. the transition between grounded and floating ice, the tidal forcing leads to a measurable vertical bending of the ice and a periodic movement of the grounding line. Understanding the mechanisms of grounding line migration is important to better evaluate the contribution of grounded ice discharge to sea-level rise.

In order to model the measured displacements, a viscoelastic material model is required using the observed vertical displacements at the floating ice tongue as external forcing. Geometries obtained from AWI's new ultrawideband radar form the basis for finite-element simulations in COMSOL. With the viscoelastic Maxwell material model, the response of the ice to ocean tidal forcing can successfully be modeled. Results obtained with a nonlinear Glen-type viscosity agree very well with the observed bending near the grounding line. The expected phase shift of the horizontal displacements upstream from the grounding line is well reproduced in the model.