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Greenland's glacier tidal response and ice sheet motion

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The Greenland ice sheet is the largest contributor to global sea-level rise. Large uncertainties remain in sea level rise projections due to limited insights in the dynamics of outlet glaciers in Greenland. Nioghalvfjerdsbræ (79°NG) is an outlet glacier of the Northeast Greenland Ice Stream (NEGIS), which holds 1.1 m sea-level equivalent of ice.

While critical progress has been made in ice sheet modelling, the motion of fast-moving ice streams and their interactions with ocean tides remain poorly understood. We combine GPS observations and two-dimensional numerical modelling to show that tides alter lubrication of the glacier as far as 15 km inland. Modelling these systems is highly complex due to the need for an appropriate material model and the interaction of different components of the physical system. We associate a viscoelastic material with subglacial hydrology and get friction parameters by solving an inverse problem. Steep basal topography enhances creep by 14% locally, whereas in the majority of the fast-moving part of NEGIS the ratio of creep to sliding is below 2%. Based on the viscoelastic material model, it is possible to distinguish between elastic and viscous strains that sum up to the total strain. The elastic strain contribution in the considered cross-section is up to 34%, independent of any tidal forcing. Elastic strain contributes significantly to deformation in fast-moving outlet glaciers and appears to coincide with crevasses representing the solid nature of ice. Including sliding and elastic deformation in ice sheet models to represent recent accelerations of outlet glaciers is an important step forward in reducing uncertainties of Greenland's contribution to future sea-level rise.