COMPARISON OF MODELED AND OBSERVED SUPRAGLACIAL LAKES AT THE WESTERN MARGIN OF THE GREENLAND ICE SHEET

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Abstract

Interferometric synthetic aperture radar (InSAR) investigations of the Greenland Ice Sheet (GrIS) flow have identified secular accelerations over decadal time periods (Joughin et al., 2004; Rignot and Kanagaratnam, 2006), inter-annual variability (Howat et al., 2007), and periodic seasonal speedup (Joughin et al., 2008; Palmer et al., *submitted*). Recent studies have suggested that a direct coupling between surface melting and ice dynamics ice-motion in western Greenland is responsible for the observed seasonal variability of up to 200 % for land-terminating ice (Joughin et al., 2008; van de Wal et al., 2008; Zwally et al., 2002; Palmer et al., *submitted*). During summer, supra-glacial lakes form in topographic depressions in the ablation zone of the Greenland ice sheet (e.g. Echelmeyer et al., 1991; Luthje et al., 2006; Box & Ski, 2007; McMillan et al., 2007; Sneed & Hamilton, 2007), and drainage of these lakes may play a key role in linking the surface melt signal to ice motion by supplying the volume of water needed to propagate crevasses to the base of the ice (Alley et al., 2005; van der Veen, 2007; Das et al., 2008). Numerous lake drainage events have been identified on the ice sheet's western margin (Box & Ski, 2007), with lakes up to 0.044 km^3 draining in less than two hours (Das et al., 2008). However, both the extent to which water melted at the GrIS surface modulates ice flow and the structure and stability of its englacial and subglacial drainage systems are poorly constrained. An attempt to parameterise the effect of melting-induced secular ice flow variations on ice sheet mass (Parizek and Alley, 2004) has predicted that such changes could result in a 10-25 % greater rate of ice loss over the next century. On the other hand, a recent study (van de Wal et al., 2008) has concluded that, based on 17-years of continuous GPS measurements which show a decrease in motion of the GrIS during a period of increased ablation, the coupling between melting and ice velocity may have only a limited effect on the ice sheet as climate warming continues. An improved understanding of the evolution of the GrIS over the coming century requires that simulations of the ice sheet response to expected climatewarming include an appreciation of the coupling between surface and basal hydrology.

We used an InSAR-derived digital elevation model (DEM) covering 7000 km^2 of the Western margin of the Greenland ice sheet (GrIS) to identify likely supraglacial lake locations (Palmer et al., *submitted*). With daily temperature records from a nearby meteorological station, we modeled runoff for each of the 10 surface hydrological catchments for the period 1995 to 2006 which we used to estimate lake volume and area. Using an automated lake classification method based on 250 m resolution Moderate-resolution Imaging Spectroradiometer (MODIS) surface reflectance data, supraglacial lake location and area was observed over the 2003, 2005, 2006 and 2007 melt seasons (Sundal et al., *submitted*). Comparison of the modeled and observed data shows that lakes form in the same location year to year without being advected downstream, suggesting a subglacial topographic control on lake location. We show that lakes at lower elevations fill and drain earlier in the melt season than those at higher elevations and the differences between the modeled and observed data reveal new detail in the timing of lake formation and drainage. The change in lake volume over time and variations in the evolution of lakes at the same elevation suggest a spatially and temporally varying drainage system, which has consequences for the likely effect of future warming on the mass balance of the GrIS.

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