Geophysical Research Abstracts
Vol. 13, EGU2011-6824-1, 2011
EGU General Assembly 2011

Melt-induced speed-up of Greenland ice-sheet offset by efficient subglacial drainage

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Fluctuations in surface melting are known to affect the speed of glaciers and ice sheets[1−4], but their impact on the Greenland Ice Sheet in a warming climate remains uncertain. While some studies suggest that greater melting produces greater ice sheet acceleration[4−5], others have identified a long-term decrease in Greenland's flow despite increased melting[2]. Here, we use satellite observations of ice motion recorded in a land-terminating sector of southwest Greenland to investigate the manner in which ice flow develops during years of markedly different melting. Although peak rates of ice speedup are positively correlated with the degree of melting, mean summer flow rates are not because glacier slowdown occurs, on average, when a critical runoff threshold of about 1.4 cm/day is exceeded. In contrast to the first half of summer, when flow is similar in all years, speedup during the latter half is 62 $\pm$ 16 per cent less in warmer years. Consequently, in warmer years, the period of fast ice flow is three times shorter, and, overall, summer ice flow is slower. This behaviour is at odds with that expected due to basal lubrication alone. Instead, it mirrors that of mountain glaciers[6−7], where melt-induced acceleration of flow is reduced once subglacial drainage becomes efficient. A model of ice sheet flow that captures switching between cavity and channel drainage modes[8] is consistent with the runoff threshold, fast-flow periods, and later-summer speeds we have observed. Simulations of the Greenland Ice Sheet flow under climate warming scenarios should account for dynamic evolution of subglacial drainage; a simple model of basal lubrication alone misses key aspects of the ice sheet response to climate warming.

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