Geophysical Research Abstracts
Vol. 19, EGU2017-15085, 2017
EGU General Assembly 2017

Groundwater flow modulation of basal heat budget and melt rates near Dome C, Antarctica

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Subglacial thermodynamics impact the evolution of ice sheets through melting/freezing and ice dynamic feedbacks, which may enable or discourage fast flow. An under-considered aspect of the basal heat budget is subglacial groundwater flow. Water flow in basal substrate can advect heat towards or away from the ice base up to an order of magnitude greater than geothermal flux commonly assumed beneath the Antarctic Ice Sheet. We use a three-dimensional steady state groundwater model with a range of hydrological parameters to estimate the effect of groundwater on the basal heat distribution. Near an ice divide, gradients in groundwater pressure primarily depend on basal topography and the applied hydrological parameter field. Model results indicate that topographic highs of the glacier bed generally lose water into the underlying substrate. Conversely, valleys are the location of groundwater discharge and advection of heat towards the glacier bed. We apply this model to a region near Dome C of East Antarctica, to address how groundwater modulation of heat availability at the glacier bed may impact the survivability of basal ice. This question is particularly relevant to the attempts to identify a ice core drilling site to recover ice between 800 kyr to 1.2 Myr in age. Dome C is a candidate for such an ice core site and a dense grid of airborne geophysical survey at this location supplies model boundary conditions from basal topography and ice thickness. In addition, observed gravity and magnetic potential fields constrain possible subglacial substrates and a likely hydrological parameter range. Strongly vertical vectors of water flow, seen in some model configurations, can produce rapid advection of heat indicating that groundwater flow vectors can be a significant indicator of basal ice survivability.