



Icebase: A suborbital survey to map geothermal heat flux under an ice sheet

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NASA will solicit suborbital missions as part of its Earth Venture program element in the coming year. These missions are designed as complete PI-led investigations to conduct innovative hypothesis or scientific question-driven approaches to pressing questions in Earth System science. We propose to carry out a suborbital magnetic survey of Greenland using NASA's Global Hawk unmanned aerial vehicle to produce the first-ever map of the geothermal heat flux under an ice sheet. Better constraints on geothermal heat flux will reduce the uncertainty in future sea level rise, in turn allowing a more informed assessment of its impact on society. The geothermal heat flux depends on conditions such as mantle heat flux, and the tectonic history and heat production of the crust, all of which vary spatially. Underneath ice sheets, the geothermal heat flux influences the basal ice. Therefore heat flux is an important boundary condition in ice sheet modeling. Using magnetic data to constrain heat flux is possible because the magnetic properties of rocks are temperature dependent until they reach the Curie temperature. The technique has applications to understanding the response of Greenland ice sheet to climate forcing because the basal heat flux provides one of the boundary conditions. The technique also helps to locate the oldest ice. The oldest ice in Greenland should be found in areas of very low heat flux, and the identification of those areas is provided by this technique. Ice cores from the areas of oldest ice help to decipher past temperatures and CO₂ contents. Our latest model of the geothermal heat flux under the Greenland ice sheet (http://websrv.cs.umt.edu/isis/index.php/Greenland_Basal_Heat_Flux) is based on low-resolution satellite observations collected by the CHAMP satellite between 2000 and 2010. Those observations will be enhanced by the upcoming Swarm gradient satellite mission, but the resolution will improve by less than a factor of two, from 400 km resolution to approximately 250 km resolution. A high altitude, suborbital magnetic survey of Greenland would provide a heat flux model with resolution comparable to the crustal thickness, and would provide details of the high heat flux region associated with the Iceland mantle plume in E/SE Greenland, and the low heat flux region in NW Greenland, adjacent to the Canadian Shield. Magnetic field measurements from 20 km altitude are strongly preferred over lower altitude observations because of their ability to sample the longest wavelengths, provide uniform calibration with sufficient sensitivity, and suppress local remanent magnetic field signatures. We validate our heat flux estimates by assessing the possible contributions from remanent magnetism and variable susceptibility, and from other lithospheric processes such as structure, volcanism and impact, from unmodeled external magnetic fields, and from the assumptions utilized in the heat flux model.