Postdoctoral Research Scientist position:

Channelized Ocean Melting Beneath Ice shelves: Non-hydrostatic Ice and Estimating shelf Densities

Primary mentor:
Dave Porter,
Lamont-Doherty Earth Observatory, Columbia University, NY, U.S.A.,

The project

One of the main drivers of mass loss from the Antarctic Ice Sheet is melting at the base of ice shelves. This process, hereafter referred to as sub-shelf melting, varies over a wide range of spatial scales. Varying, for example, between ice shelves with different ice drafts and oceanographic settings, or over 100's to 1000's of meters within an individual ice shelf. One example of small-scale melt variability is the channelization of basal melting; relatively narrow bands of locally elevated melt rates, up to kilometers wide and up to hundreds of kilometers long, are observed in satellite-derived maps melt rates maps. This localized melt incises channels into the base of ice shelves, with potential to significantly impact the stability of ice shelves, despite covering a small proportion of ice shelves by area. Channels can thin ice shelves locally, altering stress distributions, making the ice shelf more susceptible to fracture. They impact the transfer of heat to the ice base, potentially reducing total melting. Where they incise through an entire ice shelf they may directly contribute to shelf collapse.

The only currently viable approach to widespread quantification of basal melt rates uses satellite data and models to estimate ice thickness, flow, and surface mass balance change. Because these satellite data observe only the ice surface, quantification of basal melting requires simplifying assumptions about ice shelf density and stresses.

These assumptions present issues when ice density varies more than depicted by climate models, and also where small-scale variability in melt rates generates small-scale variability in ice shelf draft (i.e. basal channels), leading to incorrect assumptions of hydrostatic englacial stresses.

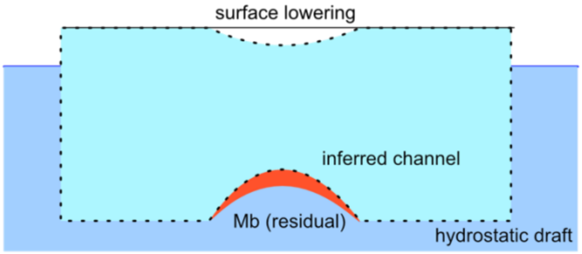


Figure 1. Cartoon of the mass balance residual method from observations of surface elevation time series, and the impact on estimates of subshelf melt and channelization.

There is a pressing need to quantify these processes and understand their impact on satellite-derived melt rates to allow testing of the next generation of coupled ice-ocean modes. Although the effects of hydrostatic disequilibrium have been considered by modeling studies, they have not been tackled observationally with the explicit goal of improving satellite-based basal melt estimates. The launch of ICESat-II and the 1000's of km of aerogeophysical data collected over ice shelves (e.g., NASA's Operation IceBridge (OIB) and the ROSETTA-Ice project over the Ross Ice shelf), present an opportunity to address this need.

The newly-started NASA COMBINED project (grant #80NSSC22K0381) aims to Improve satellite-derived estimates of ice shelf thickness and basal melting at small length scales. We will achieve this using a combination of satellite and aerogeophysical data, ice flow modeling, and geophysical inversions. Our approach involves three primary objectives: 1) compare LiDAR-derived ice surface and radar-derived ice thickness along aerogeophysical flight lines to test the validity of altimetry-inferred basal topography. The second and third objectives, led by the postdoc with significant support from Porter and Co-Is, are to 2) develop an optimized ice-thickness and density model from joint analysis of altimetry and ice-penetrating radar data to test surface mass balance models for small-scale features, and 3) use a numerical ice model to quantify the degree of hydrostatic-disequilibrium in areas of channelized melting and recover small-scale melt rates from high-resolution satellite altimetry.

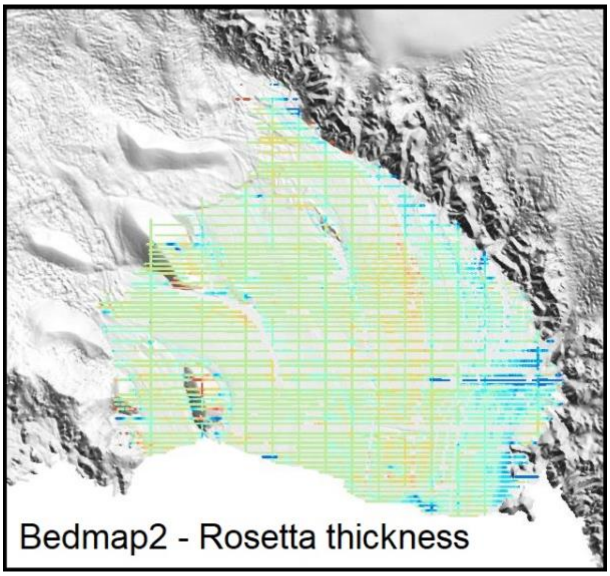
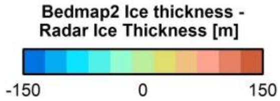


Figure 2. Difference in Ice thickness estimates from Bedmap2 (hydrostatic method using altimetric freeboard) and ROSETTA (radar-derived).



The first two objectives will leverage extensive high-resolution ice penetrating radar and LiDAR line data over ice shelves. We will compare two-way travel time (TWTT) and hydrostatic-based estimates of ice thickness, assess channel incision rates from time series of repeat radar, and compare shapes and amplitudes of the surface and base using normalized cross-correlation. This component of the work will also involve close collaboration between the postdoc and Co-Is Kirsty Tinto and Renata Constantino of LDEO to process and analyze the airborne data. The result will be new maps of mean ice shelf densities, and associated uncertainties.

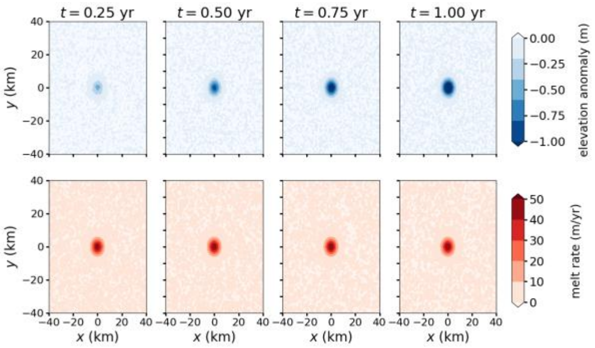


Figure 3. Example inversion of synthetic data. The synthetic data (top row) and basal melt rate inversion (bottom row) are shown at several time steps in the map-plane (x,y) coordinates. The initial elevation is uniform. A depression in surface elevation

The third objective, to be led by the postdoc, could include any of the following, depending on the individual's skills and interests: numerical modeling of ice shelf flow, machine-learning-based parameterizations for ice sheet models, or inversions of ICESat-II freeboard changes for basal melt/freeze. The last of these could build on a recently developed inverse model that accounts for full-Stokes flow (non-hydrostatic) and variable density. The postdoc will have flexibility to build on this work or develop their own methods to achieve similar goals.

These inversions will identify where non-hydrostatic stresses have historically prevented accurate melt estimations, as well as quantify uncertainties using a Monte-Carle ensemble approach. This component will involve close collaboration with Co-I Jonny Kingslake of LDEO as well as Dr. Martin Wearing, University of Edinburgh.

The position

The postdoc will primarily work at Lamont-Doherty Earth Observatory, Palisades, NY, a leafy campus 16 miles north of Columbia's main campus in Manhattan (a ~1 hr bike or 40-min free shuttle ride from 120th and Broadway, Manhattan). Often Lamont scientists live in New York City, but many others live near Lamont in Rockland County, NY.

Approximately 40 postdoctoral scientists work at LDEO. Lamont-wide resources for postdoctoral researchers at LDEO include career mentoring, an annual postdoctoral symposium, and an annual assessment process that ensures pay equity.

Glaciology at Lamont

At Lamont we have many (>40) scientists working on all aspects of glaciers and ice sheets, from measuring the deformation of ice and snow in the lab, to reconstructing past changes in ice sheet size. The group the postdoc will join is primarily interested in ice-ocean interactions and ice-solid earth interactions (5-10 people), consisting of professors, post docs, graduate students, undergraduates and scientific and non-scientific support staff. More information on our work can be found here.

Our commitment to improving diversity, equity and inclusion

We are dedicated to improving diversity, equity and inclusion (DEI) on our campus and within geosciences more broadly. Many of us are actively involved in initiatives to achieve this. For example, all Co-Is were participants in 2021 URGE pods, and also members of the new Lamont DEI task force and of the International Thwaites Glacier Collaboration DEI group. See also the Lamont director's anti-racism statement. We are committed to attracting a large and diverse pool of applicants for this position, so please share this opportunity with your networks to help us achieve this.

The ideal candidate

Candidates should be recent recipients of a PhD in the earth sciences, geophysics, applied mathematics, ML/AI, or a similar field. Experience with interpreting geophysical observations and/or geophysical fluid modeling is required.

Experience with processing and analyzing glacier geophysics observations (e.g., ice-penetrating radar, scanning lidar, etc.), ICESat-II data, or forward or inverse modeling of ice flow is desirable.

More information

More information about the position and how to apply can be found here.

Please also feel free to contact us if you want more information about the position:
Dave (dporter@ldeo.columbia.edu)
Jonny (j.kingslake@columbia.edu)