TIDAL CORRECTIONS FOR SAR INTERFEROMETRY ON FLOATING ICE SHELVES

Interim Report

JPL Task 1030

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A. OBJECTIVES

Iceberg calving is the process by which the Antarctic ice sheet discharges most of the annual mass gained by snow accumulation. Much of this iceberg calving occurs along the front of two large floating ice shelves: the Filchner-Ronne Ice Shelf and the Ross Ice Shelf. Loss of the ice shelves would not cause a direct change in sea level because the ice is already floating. Their loss, however, would remove an important restraint on ice stream flow and resulting ice discharge. Furthermore, loss of the ice shelves would produce significantly more open water for sea-ice production, potentially affecting global ocean circulation.

Large ice shelves calve infrequently (every few decades at a given point along the shelf), but when they do, they give rise to the large tabular icebergs that are similar in area to small New England States. Because of the infrequent nature of the calving events, it is difficult to get an adequate sampling of these events with which to detect change. If instead we are able to measure the continuous flow of the ice shelves, we will then be in a better position to understand and predict the long-term viability of the ice shelves in response to climate and other change.

A major problem with measuring velocity on ice shelves using Interferometric Synthetic Aperture Radar (InSAR) is the sensitivity of the measurement to both horizontal and vertical motion. This means ice flow and tidal displacements are ambiguously mixed on the floating ice shelves.

The objective of this task is to modify existing InSAR mapping algorithms to incorporate tidal-displacement estimates from the Circum-Antarctic Tidal Simulation (CATS) Model produced by Laurence Padman of Earth and Space Research. This is a 10-constituent model for Southern Ocean tides. The grid is 1/4 x 1/12 degree (lon x lat), and extends from 86 to 58 degrees S. The 10 constituents are the same as those for the model providing the open ocean boundary conditions in the Oregon State University, TOPEX/Poseidon altimetry assimilation model. The CATS model has been refined using data assimilation techniques to include the tidal displacement of floating ice shelves. The results of this work have demonstrated a method for estimating velocity on floating ice shelves, as well as a map of ice shelf velocity for the large Filchner-Ronne Ice Shelf. In addition, these data will be used for initial science applications such as the estimate of melt beneath the ice shelf.

B. PROGRESS AND RESULTS

Over the last several months, the CATS models were successfully integrated with the existing tools for InSAR mapping of ice velocity. The resulting software was used to produce the map of ice shelf velocity, which is shown in Fig 1.

C. SIGNIFICANCE OF RESULTS

The results demonstrate that when used in conjunction with a tide model, InSAR provides a viable means for mapping ice shelf velocity. These results are now being used to estimate melt beneath the ice shelf. This melt forms Ice Shelf Water (ISW), which is an important contributor to Antarctic Bottom Water formation [Foldvik et al., 1985].

D. FINANCIAL STATUS

The total funding for this task was $25,000, of which $5,600 has been expended.

E. PERSONNEL

No other directly-funded personnel were involved. The tide model that was used in this study is courtesy of Dr. Laurence Padman of Earth and Space Research, Corvallis, OR.

F. PUBLICATIONS

[1] I.R. Joughin and L. Padman, "Basal Melt Beneath the Filchner-Ronne Ice Shelf," presented at the West Antarctic Ice Sheet Workshop, Sterling, Virginia, September 18-21, 2002.

[2] I.R. Joughin and L. Padman, "Melt/Freeze Beneath Filchner-Ronne Ice Shelf, Antarctica," in prep.

G. REFERENCES

[1.] A. Foldvik, T. Gammelsrød and T. Tørrensen, "Circulation and Water Masses on the Southern Weddell Sea Shelf," *Oceanology of the Antarctic Continental Shelf*, edited by S.S. Jacobs, pp 5-20, American Geophysical Union, Washington D.C., 1985.

[2.] I. Joughin, "Ice Sheet Velocity Mapping: A Combined Interferometric and Speckle-Tracking Approach," *Ann. Glaciol.* 34, 195-201, 2002.

[3.] K.C. Jezek, "Glaciological Properties of the Antarctic Ice Sheet From RADARSAT-1 Synthetic Aperture Radar Imagery," *Ann. Glaciol.*, 29, 286-290 (1999).

H. APPENDIX: *Figures*

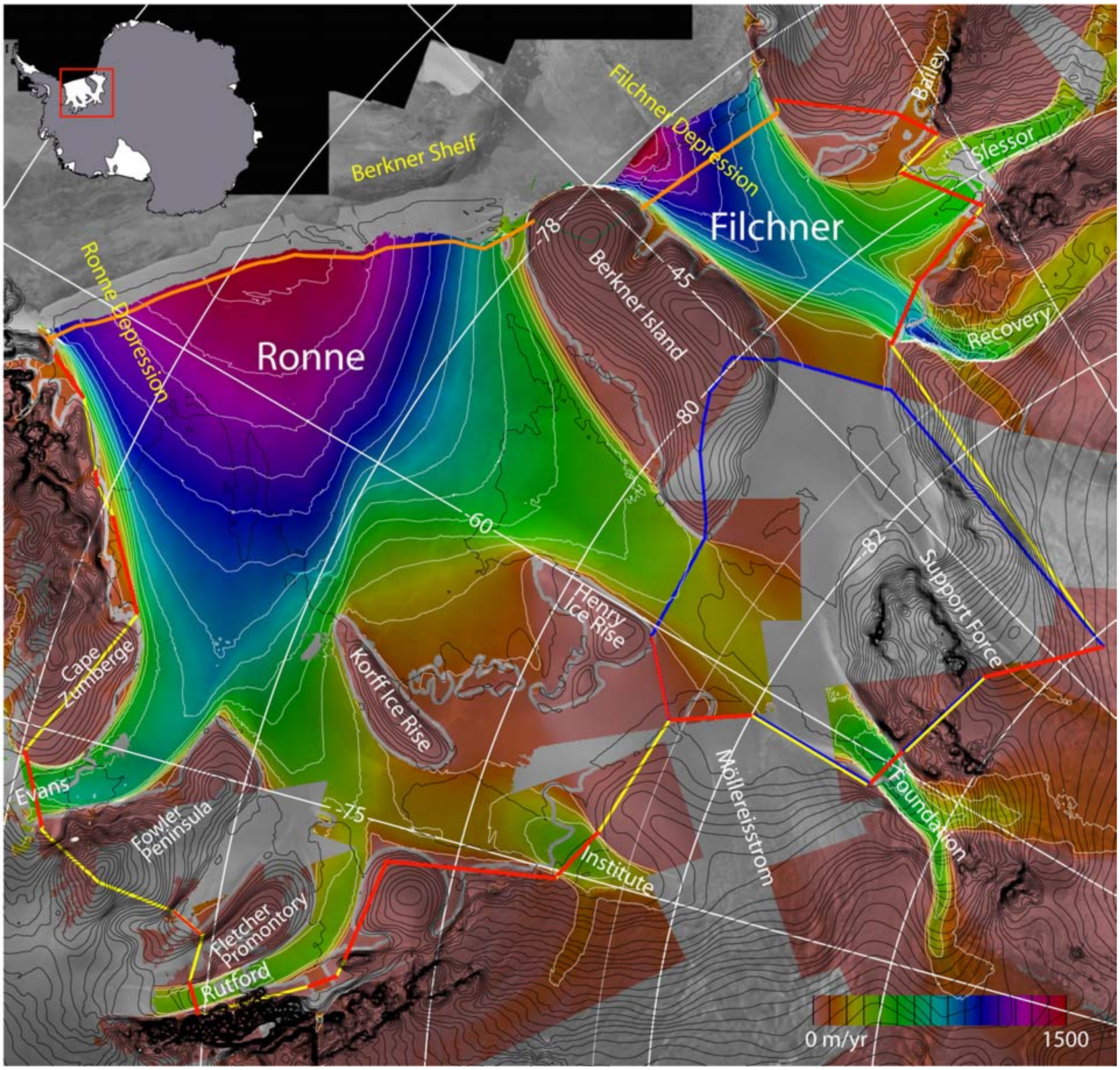

Figure 1. Ice flow speed (color) for the Filchner-Ronne shelf and surrounding ice streams. Speed is also contoured at 100 m/yr intervals (white). Velocities were determined using InSAR and speckle-tracking [Joughin et al., 2002]. Tidal displacements on the floating ice were corrected using the CATS tide model. Surface elevation is shown with 100-m contours (black). The basemap SAR image is from the RADARSAT Antarctic Mapping Mission mosaic [Jezek, 1999]. The red lines show gates where the inflow flux was measured and the yellow lines show gates with negligible flux. Outflow was measured through gates (orange) at the ice shelf front. The gates also surround Berkner Island, ice rises, and some surrounding catchment not included by the ice stream gates. The blue and red lines surround the region downstream of Foundation Ice Stream where the data were insufficient to evaluate melt locally. The velocity data indicate the ice front position in September 2000, while the SAR basemap shows the ice front position in September 1997 prior to the calving of several icebergs.