EOS
EOS, TRANSACTIONS, AMERICAN GEOPHYSICAL UNION

VOLUME 93 NUMBER 8
21 FEBRUARY 2012
PAGES 77–88

Rift in Antarctic Glacier: A Unique Chance to Study Ice Shelf Retreat

PAGES 77–78

It happened again, but this time it was caught in the act.

During the last week of September 2011 a large transverse rift developed across the floating terminus of West Antarctica's Pine Island Glacier, less than 5 years after its last large calving event, in 2007 (Figure 1). Pine Island Glacier's retreat has accelerated substantially in the past 2 decades, and it is now losing 50 gigatons of ice per year, or roughly 25% of Antarctica's total annual contribution to sea level rise [*Rignot et al.*, 2008]. The glacier's recent accelerated retreat is likely triggered by ocean warming and increased submarine melting. As such, it is of significant interest to glaciologists and of heightened societal relevance.

The new rift is more than 9 kilometers inland of the position of the ice front after the 2007 calving event. When rifting is complete and a new iceberg calves off, the new ice front will have retreated farther up glacier than at any other time in its 64-year observational record [*Rignot*, 2002]. While such major calving events have occurred every 5–6 years since 1990, the area of the new iceberg will be at least 50% larger than those previously observed at this glacier. This event may therefore have important implications for the assessment of the long-term stability of Pine Island Glacier.

While the rifting and eventual calving of the floating portions of glaciers are normal and cyclical processes, such events can also provide insight into how ice shelves work and how Pine Island Glacier in particular is responding to external forcing [*Bindschadler and Rignot*, 2001]. For this rifting event an unprecedented array of remote sensing data sets, collected from both air and space, will provide a unique opportunity to understand the processes that govern rifting. This data set is the result of coordinated efforts and collaborations of scores of individuals from many organizations from multiple countries, including NASA, the German Aerospace Center (DLR), DigitalGlobe, Inc., and several universities. The current Pine Island Glacier rifting event also showcases current observational capabilities for monitoring the cryosphere.

Discovering the Rift and Tracking Its Evolution

The new rift was spotted on 10 October 2011 by the flight crew of a NASA DC-8, who were surveying the glacier as part of the third season of NASA's Operation IceBridge (OIB). OIB's mission is to obtain a suite of aerogeophysical data over critical regions of the ice sheets [*Koenig et al.*, 2010]. Following initial spotting of the rift and consultation with the glaciology community, the decision was made for IceBridge to return to Pine Island Glacier on 26 October and 12 November for targeted data collection. Having the flexibility to observe targets of opportunity is an important attribute of OIB, and it is further enabled by the project's use of long-range aircraft.

Data collection on the return visits was highly successful, including measurements of surface elevation from laser altimeters, gravity for bathymetry beneath the ice shelf, radar sounding to probe both the ice shelf's interior and interface with the ocean, and high-resolution optical photography using the Digital Mapping System (Figure 1). Preliminary data show that the rift penetrates ice that is roughly 500 meters thick (a rift through the floating tongue of the glacier must penetrate the tongue's full thickness). Seawater fills the rift so that the rift walls are the height of ice freeboard (ice above the water's surface, in this case 50–60 meters).

In addition to airborne measurements, several satellite platforms are monitoring the rift's evolution. In particular, high-resolution synthetic aperture radar images are available from the DLR's TerraSAR-X satellite, and submeter imagery are available from the DigitalGlobe's WorldView-1 (WV-1) and QuickBird satellites. The range of spatial and temporal resolutions of these data allows researchers to track both the rift's rate of growth and the mechanics of its propagation. WV-1 and additional Moderate Resolution Imaging Spectroradiometer imagery suggest that the new transverse rift grew from a preexisting arcuate shear margin rift sometime between 29 September and 8 October and was coincident with the yearly clearing of sea ice from the ice front during austral spring. Repeat WV-1 imagery shows the rift widened at a rate of about 2 meters per day between 6 and 24 October and that it now extends across nearly the entire width of the ice shelf. The rate of rift propagation is similar to previous events [*Bindschadler and Rignot*, 2001] and slowed as the rift neared completion. As of 3 February, the nascent iceberg still had not calved. The WV-1 imagery also captured a complex pattern of discontinuous thin cracks opening at the leading tip of the rift (Figure 1).

These and additional data sets will be freely available to interested investigators. All OIB airborne data sets will be available from the National Snow and Ice Data Center at http://nsidc.org/data/icebridge/ within 6 months after the conclusion of this season's operations (operations ended in November 2011). Georeferenced satellite imagery, including high-resolution products, will be made available by the Rapid Ice Sheet Change Observatory (http://www.rapidice.org/).

Future Monitoring of Ice Sheets

Continuing in these monitoring efforts, OIB will return to the Greenland Ice Sheet every spring and to Antarctica every fall for the next 4 years to dovetail with the expected launch of the ICESat-2 satellite in 2016. The coming year is expected to bring continued expansion of cryosphere observational capabilities as the European Space Agency's CryoSat-2 satellite enters its second year of data collection. In 2013, spaceborne remote sensing capacity will be greatly enhanced with the launch of the NASA/U.S. Geological Survey Landsat Data Continuity Mission and the European Space Agency's Sentinel-1. Several polar data centers, including the National Snow and Ice Data Center, the Polar Geospatial Center, and Polar View, are focused on accelerating data distribution and streamlining accessibility.

These new missions, combined with ongoing data collection efforts, form a comprehensive system of cryosphere observation, enabling rapid detection of change and detailed observations to improve understanding of the mechanisms of change. These overlapping observational pushes will help scientists discover, track, and monitor future rifts that may appear in glaciers that terminate at the ocean and will allow for detailed studies on the causes of such rapid change.

References

Bindschadler, R., and E. Rignot (2001), "Crack!" in the polar night, *Eos Trans. AGU, 82*(43), 497–498, 505, doi:10.1029/01EO00294.

Koenig, L., S. Martin, M. Studinger, and J. Sonntag (2010), Polar airborne observations fill gap in satellite data, *Eos Trans. AGU, 91*(38), 333–334, doi:10.1029/2010EO380002.

Rignot, E. (2002), Ice-shelf changes in Pine Island Bay, Antarctica, 1947–2000, *J. Glaciol., 48*(161), 247–256, doi:10.3189/172756502781831386.

Rignot, E., J. L. Bamber, M. R. van den Broeke, C. Davis, Y. Li, W. J. van de Berg, and E. van Meijgaard (2008), Recent Antarctic ice mass loss from radar interferometry and regional climate modelling, *Nat. Geosci.*, *1*(2), 106–110, doi:10.1038/ngeo102.

—IAN M. HOWAT and KEN JEZEK, Byrd Polar Research Center, Ohio State University, Columbus; E-mail: howat.4@osu.edu; MICHAEL STUDINGER, NASA Goddard Space Flight Center, Greenbelt, Md.; JOSEPH A. MACGREGOR, Institute for Geophysics, University of Texas at Austin; JOHN PADEN, Center for Remote Sensing of Ice Sheets, University of Kansas, Lawrence; DANA FLORICIOIU, German Aerospace Center, Wessling, Germany; ROB RUSSELL, Sigma Space Corporation, Lanham, Md.; MATT LINKSWILER, URS Inc., NASA Wallops Flight Facility, Wallops Island, Va.; and ROSEANNE T. DOMINGUEZ, University of California, Santa Cruz

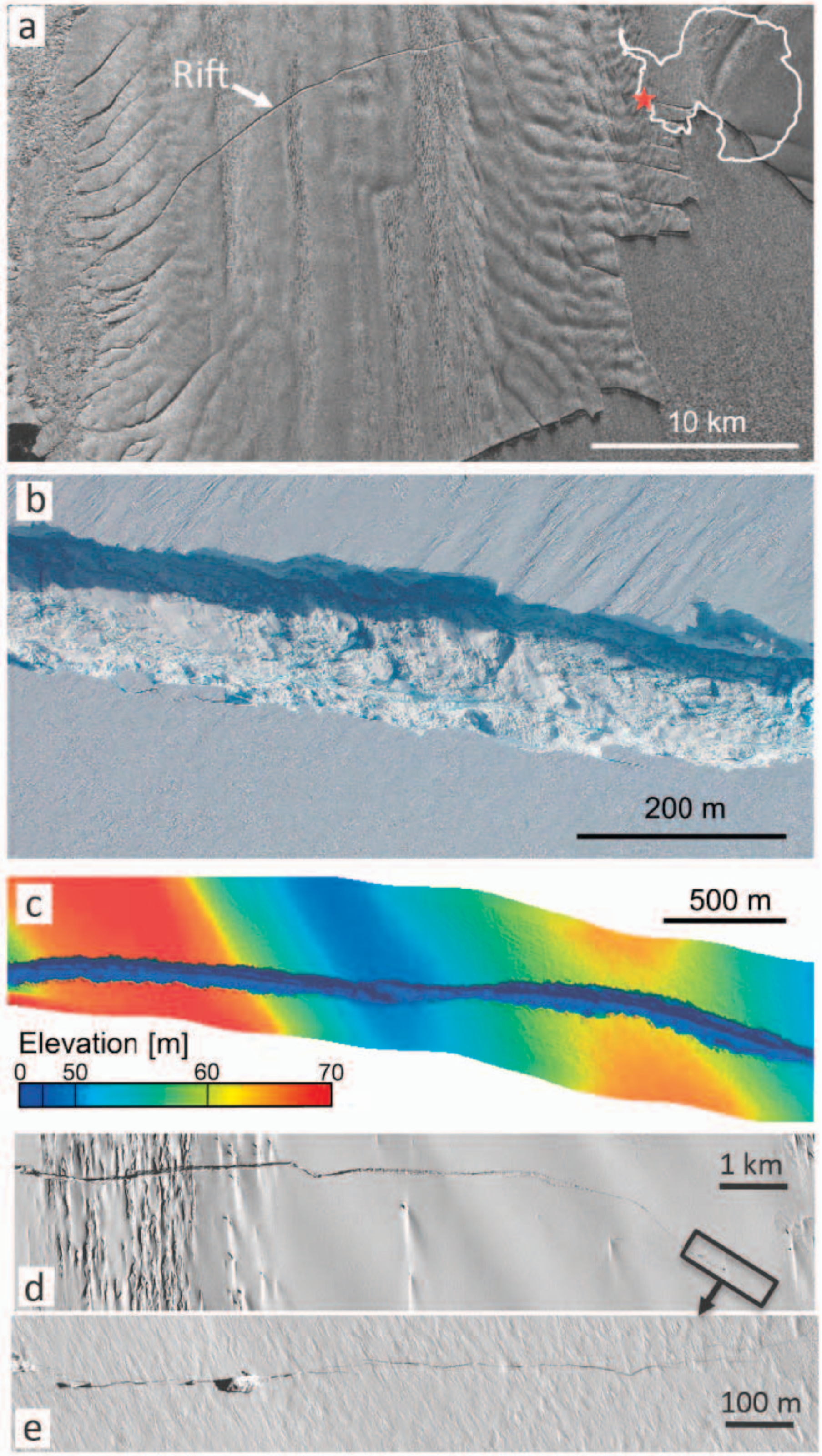

Fig. 1. (a) TerraSAR-X strip map image acquired on 29 October 2011 of Pine Island Glacier's ice shelf and the new rift. The glacier flows from the top of the image to the ice front visible at the bottom. Image is copyright of the German Aerospace Center (DLR). (b) Digital Mapping System image, collected on board NASA's DC-8 aircraft on 26 October 2011, of the rift showing seawater and ice mélange filling the rift. (c) Preliminary digital elevation model produced from Airborne Topographic Mapper laser altimeter data collected on 12 November 2011 on board NASA's DC-8 aircraft. (d) WorldView-1 image of the east end of the rift on 24 October 2011 with (e) magnified view of the leading end of the rift in the WorldView-1 image boxed in Figure 1d. WorldView-1 images copyright of DigitalGlobe Inc., provided through the National Geospatial Intelligence Agency's Commercial Imagery Program.