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Radar Satellite Images From ASF Used to Study Icebergs in the Weddell Sea

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West Antarctic ice shelves are losing mass and experiencing breakup events, including collapse of the Larsen B ice shelf in January-March 2002 and calving from the Filchner-Ronne ice shelf during 1998-2000. To better understand the consequences of these changes, satellite imagery from the Alaska Satellite Facility (ASF), RADARSAT-1, and more recently, Advanced Land Observing Satellite-Phased Array L-band SAR (ALOS PALSAR), has been used to look at the distribution and abundance of free-drifting icebergs (i.e., free of sea ice) in the Weddell Sea.

A combination of shipboard iceberg surveys and image analysis is being used to quantify size-specific iceberg density and mass over time in the Weddell Sea from 1996-2007. The shipboard data are used to calibrate the areal size estimates made from imagery to mass estimates for an observed population of icebergs. The data show expected seasonal changes in abundance and an apparent increase over time.

The iceberg population shows large increases after major ice-shelf breakup events resulting in a relatively small number of large and mid-sized icebergs that breakup into more abundant and widely-distributed smaller icebergs. The results to date support the hypothesis that iceberg abundance is increasing in the Weddell Sea in response to atmospheric and oceanic warming, although the time series are yet too short to be statistically conclusive. Surprisingly, a considerable portion of the icebergs found in the Weddell Sea originate in other parts of the Antarctic continent, including the Ross, Shackleton, and Amery ice shelves. Because icebergs strongly influence the surrounding air and ocean environments, their shifting abundance has important impacts on ocean biogeochemistry and ecology.

The ship-based sampling of icebergs has been carried out by an interdisciplinary research team supported by funding from the National Science Foundation (NSF) Office of Polar Programs. Field work was conducted in the Weddell and Scotia seas (Figure 1) during 2005 to 2009, across a range of spatial and temporal scales, from meters to hundreds of kilometers and from minutes

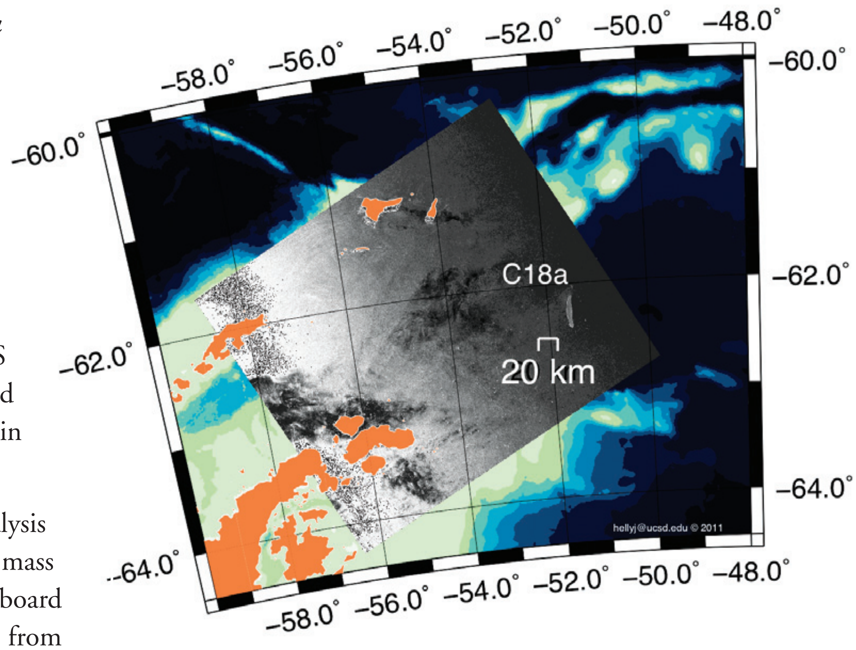

Figure 1: ALOS-PALSAR scene obtained from ASF showing iceberg C18a in the regional setting near the Antarctic Peninsula in the northwest Weddell Sea. Bathymetry is from[4] and the maps are produced with GMT5[5].

to weeks using a wide range of physical, chemical, and biological sensors and sampling methods. Imagery is provided through a grant from the National Aeronautics and Space Administration (NASA) through ASF. Results of the research have been described in detail in recent journal articles[1, 2].

The ongoing field program is a multidisciplinary effort that has produced findings with global implications for climate research. The findings suggest that when icebergs cool and dilute, the seas through which they pass for days, also raise chlorophyll levels in the water that may, in turn, increase carbon-dioxide absorption in the Southern Ocean. The research indicates that iceberg transport and melting have a role in the distribution of phytoplankton in the Weddell Sea. The results indicate that icebergs are especially likely to influence phytoplankton dynamics in an area known as Iceberg Alley, east of the Antarctic Peninsula, the portion of the continent that extends northwards toward Chile.

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The latest findings add a new dimension to previous research by the same team that altered the perception of icebergs as large familiar, but passive, elements of the Antarctic seascape[3]. The team previously showed that icebergs act, in effect, as ocean oases of nutrients for aquatic life and sea birds. The team's research indicates that ordinary icebergs are likely to become more prevalent in the Southern Ocean, particularly as the Antarctic Peninsula continues a well-documented warming trend and ice shelves disintegrate. Research also shows that these ordinary icebergs are important features of not only marine ecosystems, but even of global carbon cycling. "These new findings amplify the team's previous discoveries about icebergs and confirm that icebergs contribute yet another, previously unsuspected, dimension of physical and biological complexity to polar ecosystems," said Roberta L. Marinelli, Director of NSF's Antarctic Organisms and Ecosystems Program, in a recent NSF press release about this work.[1]

An additional dimension of the work uses a combination of conventional ship-based sampling methods and a fast surface-mapping method. We were able to detect and characterize the melt water plume from free-drifting icebergs on an unprecedented spatial scale (1-103 m) that enables the connection of local- and regional-scale, space-based measurements (102-104 m) (Figure 2). The correspondence of regional and local data across temporal scales and spatial extent and resolution are essential to meaningful data fusion. The rapidity of our surface mapping method enables extensive surveys that provide good overlap with regional-scale, space-based measurements across many pixels. This provides a sound basis for data fusion across local- and regional-scales of measurement. The overlap provides an essential means of connecting iceberg-scale processes to synoptic, regional-scale oceanic processes that cannot be observed effectively from a ship. The local-scale maps provide subpixel information within the more coarse regional-scale maps and densify the measurements within the extent of the local-scale maps. This cross-mapping spans 2–3 orders of magnitude, resulting in both a locally high-resolution and regionally-synoptic dataset.

This work was enabled by the availability of RADARSAT-1 and, more recently, ALOS-PALSAR imagery to study the distribution and abundance of icebergs in order to extrapolate the effects of individual icebergs to the larger universe of icebergs in the region and over time. Progress is limited by the irregular coverage by radar satellites in this high-latitude part of the earth since the satellite missions do not regularly collect data there. Especially important, is the capability to have reliable satellite coverage during the time that field sampling is underway to provide contemporaneous estimates of the iceberg population in the sampled areas. Fortunately, the image in Figure 2 was nearly contemporaneous with the 2009 expedition. This image was collected through a tasking request supported by ASF. However, it was the only one collected. An accurate census of the population of icebergs in the area requires a mosaic of area during the time the ship is on station. This is usually 4-6 weeks so, in principle, multiple satellite passes can be employed to construct a contemporaneous composite that would be of great value in estimating the larger impacts of these free-drifting icebergs.

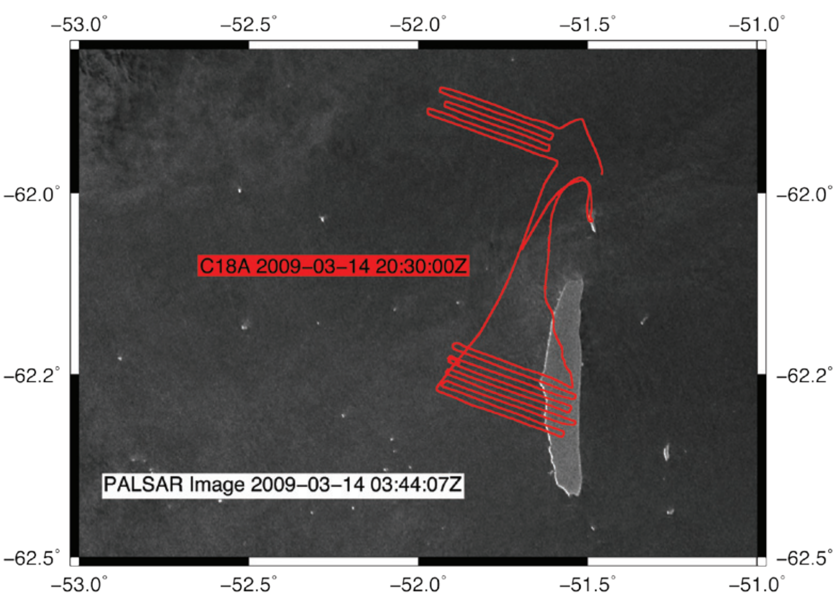

Figure 2: Red line is the navigational track for the RVIB Nathaniel B. Palmer as we executed a surface mapping survey. If we had been about 16-hours earlier, the ship would have been visible in the image. Iceberg C18a was moving north and the outline of the iceberg at the time of the survey is clearly visible in the red trackline.

Literature Cited

[1]John J. Helly, Ronald S. Kaufmann, Gordon R. Stephenson Jr., and Maria Vernet. Cooling, dilution and mixing of ocean water by free-drifting icebergs in the Weddell Sea. Deep Sea Research Part II: Topical Studies in Oceanography, 58(11-12):1346-1363, 2011. Free-Drifting Icebergs in the Southern Ocean.

[2]John J. Helly, Ronald S. Kaufmann, Maria Vernet, and Gordon R. Stephenson. Spatial characterization of the melt-water field from icebergs in the Weddell Sea. Proceedings of the National Academy of Sciences, 108(14):5492-5497, 2011.

[3]Ken Smith, Bruce Robison, John Helly, Ron Kaufmann, Henry Ruhl, Timothy Shaw, and Maria Vernet. Free-drifting icebergs: hotspots of chemical and biological enrichment in the Weddell Sea. Science, 317, 2007.

[4]Walter H. F. Smith and David T. Sandwell. Global seafloor topography from satellite altimetry and ship-depth soundings. Science, 277:1957-1962, 26 September 1997.

[5]P. Wessel and W. H. F. Smith. Free software helps map and display data. EOS Trans. AGU, 72:441, 1991.

[1]http://www.nsf.gov/news/news_summ.jsp?cntn_id=119058

SAR Data for Terrestrial Ecologists From ASF

by Keith Cunningham and Jeremy Nicoll, ASF

NASA recently supported collaboration among ASF, the National Snow and Ice Data Center (NSIDC), and the Oak Ridge National Laboratory (ORNL). This collaboration emphasized the awareness, understanding, and use of synthetic aperture radar (SAR) satellite imagery to support the missions of ORNL terrestrial ecologists and NSIDC climate-change scientists. ASF specializes in SAR, which it typically collects from polar-orbiting satellites.

SAR requires knowledge and experience, in part because its microwave ranging measurements must be manipulated in several highly technical processing steps before an image can be formed. The satellite imagery can be processed to a GeoTIFF format, a universal input for geographic information systems (GIS), but interpretation of the SAR imagery requires an understanding of how radar illuminates the earth and interacts with the features that reflect and scatter the microwave signals.

The physics of SAR microwave interactions determine the various geospatial applications for which it is applicable. Every SAR sensor operates at one of many specific microwave frequencies, allowing various features to be resolved. Some frequencies are optimized for mapping the elevations of urban and vegetative surfaces, useful for digital surface modeling. Other frequencies work well for discerning snow from ice, and are well adapted for monitoring glaciers, icebergs, and global climate change. Another SAR frequency is well adapted for penetrating the leaves of trees. In this case, the microwaves scatter among the woody branches and trunks of trees, allowing estimations of forest biomass. The frequency and scatter of the microwaves determines the application of SAR technology for geospatial applications.

ASF recently developed products to expand the familiarity and use of SAR products, generating approximately 100 SAR images for about 50 research locations of interest to ORNL and NSIDC. Figure 3 provides two examples of the images created. The research locations were selected based on the presence of micrometeorological sensors known as flux towers, which measure changes in atmospheric, riverine, and soil chemistry (specifically carbon dioxide and other isotopes important to understanding climate change). Importantly, these flux tower sites have accompanying geospatial data, primarily from the NASA Moderate Resolution Imaging Spectroradiometer (MODIS). By creating SAR images for locations where flux tower data and MODIS imagery exist, terrestrial ecologists and climatic researchers can validate the use of SAR against existing data. These images are available from ASF at http://www.asf.alaska.edu/program/sdc/project/terrec.

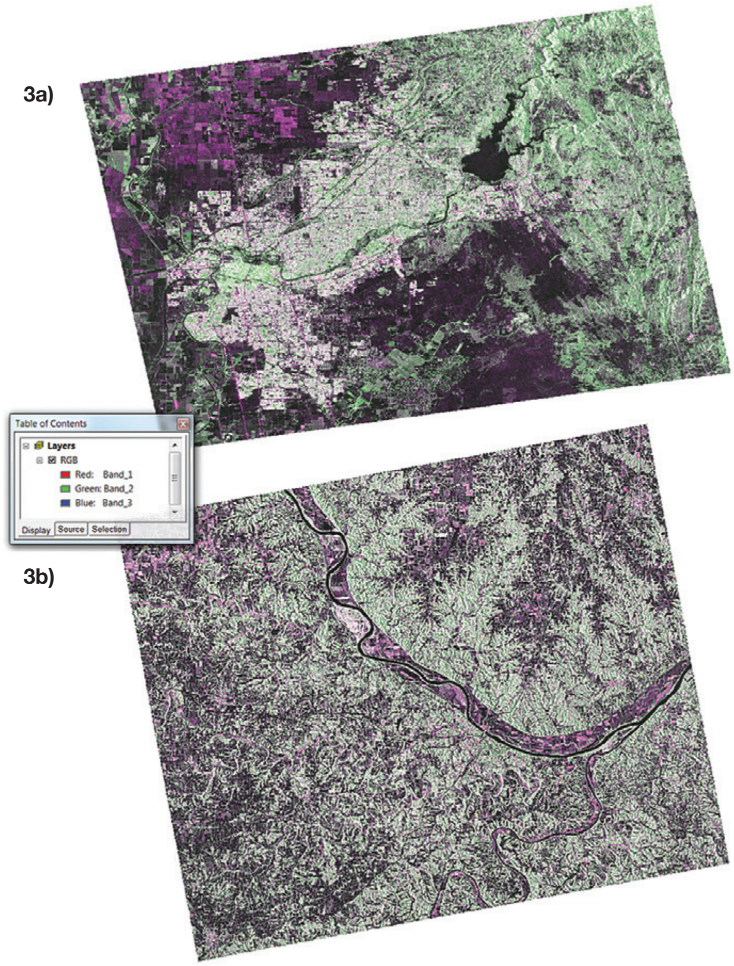

Figure 3: Two images generated as part of the Project are displayed in a GIS environment. The GeoTIFFs generated by the Project can be used in a GIS environment to examine a wide range of research questions. The colors in the images represent signal returns at different polarizations. Green is the cross-polarization (horizontally-polarized send, vertically-polarized receive). Red and blue are the co-polarization (horizontally-polarized send and receive). **(3a)** is a false color, ALOS-PALSAR image of Sacramento, California, region, acquired on 17 September 2010. **(3b)** is a false color, ALOS-PALSAR image of the Columbia, Missouri, region, acquired on 31 October 2010.

ASF chose the ALOS-PALSAR instrument for the Project, because the L-band sensor is well adapted for terrestrial-ecology applications such as land cover and biomass mapping. ALOS was launched in 2006 and ASF serves as an archive site for the data this satellite acquired over the Americas through 31 March 2011.

ALOS-PALSAR data are archived in a format known as CEOS (Committee on Earth Observation Satellites). In contrast, NASA's Earth Observing System (EOS), the primary data repository for understanding global climate change, uses the self-describing hierarchical data format (HDF). HDF is well-suited

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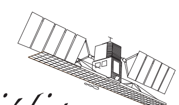
to specific needs of the climate change archive, with its vast variety of communities, datasets, and acquisition formats. It is scalable, accommodating of variability in data object size, and efficient.

Because SAR is a key remote-sensing technology for monitoring global climate change, ASF and NASA were interested in exploring the feasibility and utility of storing SAR data in the HDF file format, specifically the version of the format called HDF5. ASF has developed software tools to ensure that the existing CEOS data and future SAR missions could be archived and distributed in HDF. These tools have been prototyped for a future release of ASF's MapReady software, a robust SAR data processing application. The modified MapReady software performs several data processing tasks to make SAR imagery accessible for GIS use and is integral to expanding the use of SAR data products from ASF. Sample products in HDF5 are available to approved users. If interested in working with the HDF5 products, please contact ASF's User Support office at uso@asf.alaska.edu.



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