CERS Observer

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"In this research, every image brings new discoveries and possibilities."

Remote Sensing in the News

Perry J. Hardin, Associate Director

As I sat down this morning and began writing, I realized that CERS is officially two years old this semester. On this birthday, I paused to reflect on the exciting activities of the past two years. We have seen our NASA Climate Pathfinder website completed and providing critical data for researchers all over the world. We have seen bright young faculty members join us. We have enjoyed watching our students admitted to top-tier graduate programs in both engineering and geographic remote sensing. We are proud that imagery we produce is being used operationally by the National Ice Center to make the world's oceans safer for shipping while also serving national defense.

The first two years have been a wonderful journey, but the future promises more adventures. I am fascinated by the fieldwork that Drs. Mark Jackson and Jeff Durrant will be conducting with students in Tanzania this summer as they study land use change on the slopes of Mt. Kilimanjaro in the context of both biogeography and culture. When the CERS-KT lab was opened two years ago, I never imagined that it would be the gathering place for students learning Swahili! In a separate project, Dr. David Long and I are continuing work with SeaWinds imagery over South America, trying to comprehend the complicated biophysical character of the savanna and its effect on global climate. In this research, every image brings new discoveries and possibilities.

Inside this semester's edition of the CERS newsletter, you will find articles discussing the current status of some of our current research adventures. Enjoy!

The NASA Scatterometer Climate Record Pathfinder Project

A wind scatterometer is a satellite radar originally designed to measure winds over the ocean from space. It does this by bouncing radar signals off of the ocean's surface and measuring the power in the return echo. The echo power is related to the percentage of the surface covered by small (2-5 cm) wind-generated capillary waves where higher wind speeds produce more waves. Figure 1 illustrates a scatterometer's view of the world.

Under the direction of Dr. David Long, BYU has been conducting research in the design and application of scatterometers for NASA since 1990. Based on an entirely new application of scatterometer data for climate studies, he recently received a large grant from NASA to process, analyze and distribute a unique set of images derived from scatterometer data to other scientists and researchers. This project, known as the NASA *Scatterometer Climate Record Pathfinder* (SCP), formally announced the opening of its 5 TB web and ftp site to the public in Fall 2001 (http://www.scp.byu.edu)

Though scatterometers were originally designed to measure oceanic surface winds, their data are also extremely useful in a broad range of ice and land applications, including climate change. The earliest scatterometer flew in 1978 and provides a baseline against which it is possible to evaluate climate change.

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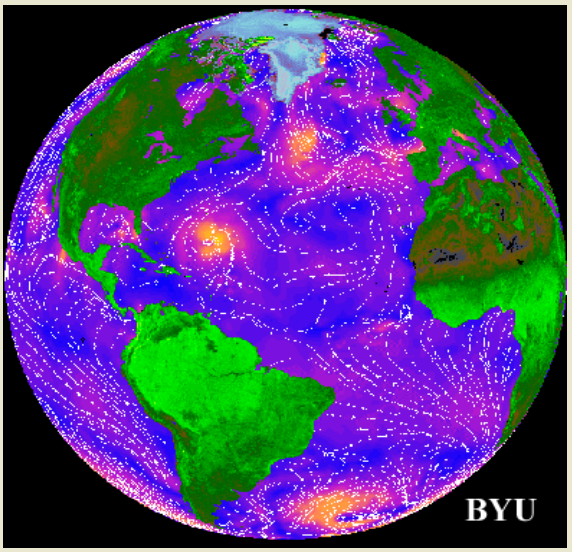

Figure 1. Scatterometer image of the world. Colors over the ocean indicate wind speed (yellow is higher wind speed) while white lines show the wind direction. Winds are what the scatterometer is designed to measure. BYU has developed the techniques to make radar images over land and ice. Over land and ice, the color brightness is related to the surface properties see by the radar signal and provide information about vegetation density, soil moisture, and snow melting.

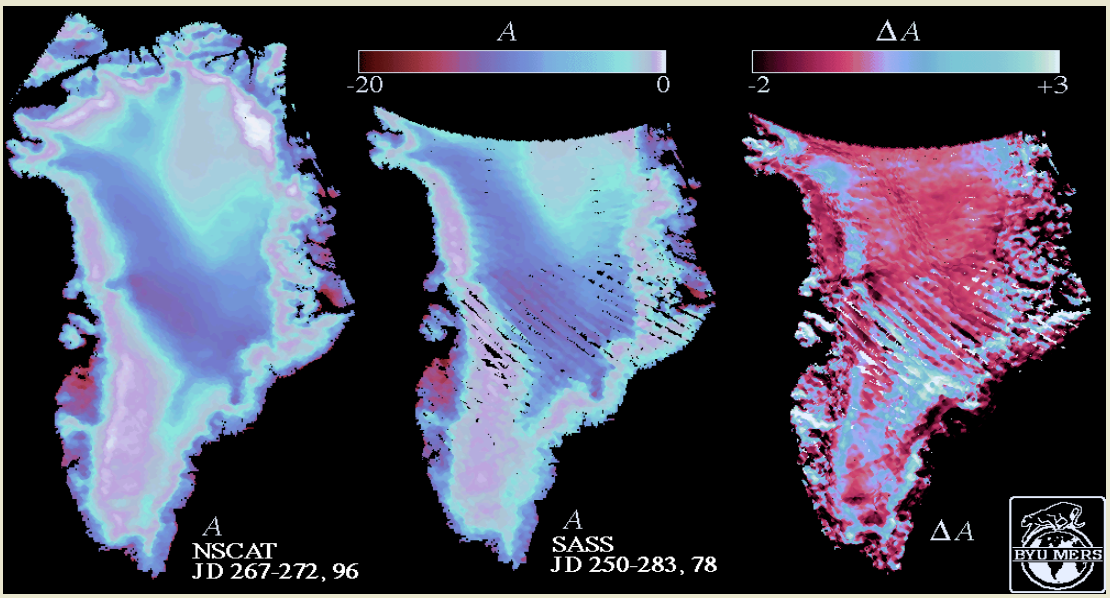

Figure 2. Climate change in Greenland. Colors show radar backscatter intensity. (left) NSCAT image, (center) SASS image, (right) NSCAT-SASS image where blue areas are where substantial change has occurred between 1978 and 1996.

The SCP project is providing a unique new dataset to support such climate change studies. BYU has been a pioneer in developing these new applications. Space limitations preclude touching on more than just a couple of these.

Ice Sheet Applications. The Greenland ice sheet is considered a bellwether of climate change. Global warming leads to additional melting. Mapping the spatial extent of the summer melt can indicate if the climate is warming. Radars are well-suited for this application since they can see through clouds and are very sensitive to melt water within the snow. Data from the Seasat scatterometer in 1978 provides a baseline for melt comparisons. Using a signal processing technique developed here at BYU, Dr. Long and his students have created a time series of radar images of Greenland. In these images the melt-extent can be mapped. Comparing contemporary data with Seasat data shows that more melting has been occurring in Greenland recently compared to 2 decades ago, consistent with global warming (see Figure 2). This is some of the strongest evidences to date of warming in Greenland, though the study results are unable to provide reasons for the warming trend.

Sea Ice Applications. Over sea ice, the scatterometer radar signal is sensitive to roughness and physical properties that vary by ice type and season. Sea ice extent is readily identified in SCP images and BYU has developed computer algorithms for mapping the extent of the sea ice which are being operationally used by weather forecasting agencies.

Iceberg Tracking. The U.S National Ice Center is using BYU-developed code to produce scatterometer images track large icebergs in the Southern Ocean. BYU achieved some fame in 1999 for relocating iceberg B-10A—which was 38 km x 77 km in diameter—in the shipping lanes of the Drake Passage (Figure 3). See the additional article in this issue of the *CERS Observer.* More information is available on the Scatterometer Climate Record Website at http://www.scp.byu.edu/

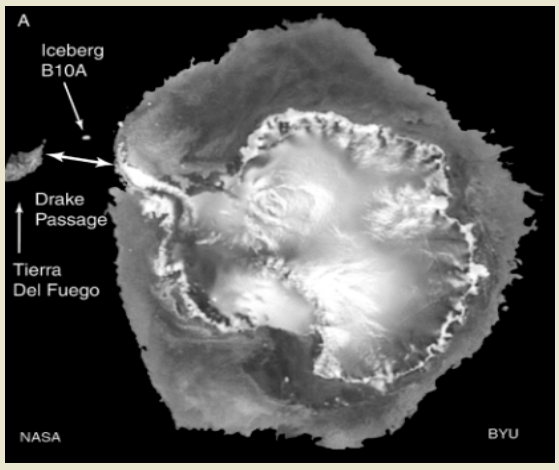

Figure 3. This scatterometer image shows Antartica and surrounding sea ice cover in July 1999. Iceberg B10A (50 km x 100 km) is identified in Drake Passage. Iceberg B10 broke off Thwaites Glacier in 1992 and split into two in June 1995. The complicated backscatter over sea and continental ice is related to ice and snow characteristics, thickness, surface and subsurface topography, katabatic winds, and melt zones.

"BYU has been conducting research in the design and application of scatterometers for NASA since 1990."

"...BYU has developed computer algorithms for mapping the extent of the sea ice which are being operationally used by weather forecasting agencies."

Researcher Profile: Dr. Salvador Gutierrez

Born in Mexico, Salvador has a BS degree in actuarial sciene, an MS in advanced technology (systems science) and an PhD in computer science (computer vision). He works as a postdoctoral fellow in the BYU Center for Remote Sensing in the Microwave Earth Remote Sensing (MERS) Lab. His advisor is Dr. Long. Salvador is using satellite images to study the motion of sea ice in Antarctica. He expects to stay in BYU for at least another year. He has three sons, one of them serves in a mission in Atlanta, GA. He brought his wife and his youngest son, age 12, from Mexico.

Dr. Salvador Gutierrez hard at work

"For his Master's thesis, [a BYU Student]... examined ... radar scatterometer data to retrospectively track icebergs around Antarctica. Such images have proven to be very useful in finding 'lost' icebergs..."

CERS Work Published in National Geographic Magazine

The work of BYU researcher (and CERS director) Dr. David Long appeared on a map insert included in the January issue of National Geographic Magazine. The insert shows a beautiful radar map of Antartica. The map is actually a composite image of radar data from two different radars.

The image of the ice-covered continent was made by the Radarsat high resolution synthetic aperture radar over a period of about a month.

Around the continent, the map shows an image of sea ice made from one day of QuickSCAT scatterometer data. This image was processed at BYU on our SGI supercomputer Marylou. Details of the history of formation and structure, along with several major icebergs, are visible in the sea ice image.

"The work of [a] BYU researcher ...appeared on a map insert included in the January issue of National Geographic Magazine."

Icebergs Around Antarctica

The U.S. National Ice Center (NIC) is tasked to operationally map sea ice and track iceberg hazards. Examination of the NIC's Antarctic database reveals a trend toward increasing numbers of icebergs around the Antarctic continent over the past 25 years. Since one of the signs of warming in the Antarctic is an increase in the number of icebergs, this represents a significant concern to scientists concerned with global warming. Faculty and students at BYU recently provided an important input to this debate by retrospectively analyzing radar scatterometer data dating back to the late 1970's.

For his Master's thesis, Jarom Ballantine of the Electrical and Computer Engineering (ECEn) Dept. examined Scatterometer Climate Record Pathfinder (SCP) images made from radar scatterometer data to retrospectively track icebergs around Antarctica. Such images have proven to be very useful in finding "lost" icebergs (see accompanying article) and his advisor, Dr. David Long, regularly provides real-time iceberg tracking information to the NIC using SCP images. Originally designed for wind measurement, radar scatterometer data is very effective in studying the polar regions. BYU has developed a computer-based signal processing technique to enhance the resolution of the raw scatterometer data from 25 km to as fine as 2.225 km resolution, adequate for tracking the very large icebergs regularly produced by Antarctica.

Separately examining the time series of scatterometer images for each sensor, Jarom identified and tracked each visible iceberg as a function of time. Icebergs were subjectively identified using either motion or as isolated stationary high backscatter ice mass. Motion was observed by animating sequences of images and played a key role in ensuring proper identification. Image resolution limits the minimal size of an iceberg that can be observed to a few pixels in extent, resulting in some variations in the number of concurrent icebergs visible in different sensors, e.g. ESCAT and NSCAT. However, all icebergs of minimal size identified by the NIC were were observed and many additional icebergs were found, resulting in an extensive database of iceberg positions as a function of time. The retrospective tracking database provides higher temporal resolution (positions every 1-5 days) than the NIC's and extends the range of iceberg tracking beyond the northern limit (60 S) used by the NIC. In addition to more frequent position reporting, the database also corrects some errors in the NIC database such as inadvertent name changes, lost tracks, and reporting errors.

Comparing his comprehensive new database to the NIC tracking database, Jarom found that prior to 1999 when the information into its database, the NIC underestimates the number of icebergs. Further, the underestimate is more severe the further the back in time the comparison is made.

Prior to 1996, there is little variation in the number of large icebergs present in the seas around Antarctica. During

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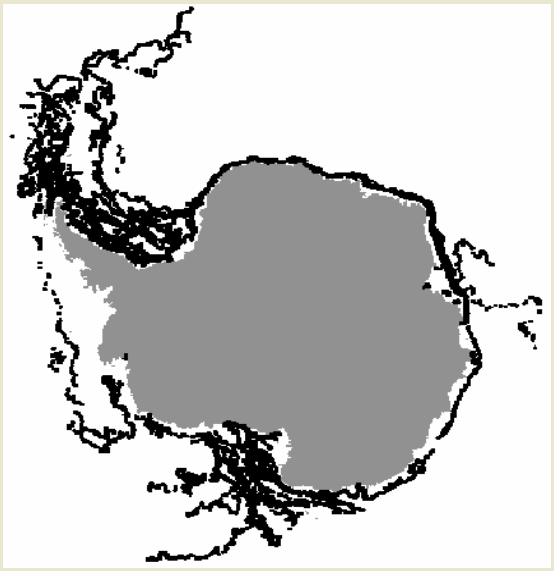
Icebergs continued...

this time, we conclude that much of the apparent increase in icebergs in the NIC's database is the result of improved tracking technology.

During the Southern Hemisphere summer of 1999 and again in 2000, there are large jumps in the number of icebergs. These jumps result from very large iceberg calving events from the Ronne and Ross ice shelves. The Ross Ice Shelf calving release the largest iceberg every observed, B15, which was approximately 185x65 miles in size. Icebergs released in these calvings have since further fragmented, resulting in large numbers of icebergs. Such large calving events are not unexpected with major calvings occurring very 50-100 years as the ice sheet advances into the ocean. The last major events were approximately 50 years ago. Thus, these major ice calving events appear to be part of the normal cycle of glacier and ice shelf evolution.

Thus, while the recent collapse of the Larsen Ice Shelf, which produced only small icebergs below the tracking limits of both BYU and the NIC, has been clearly tied to regional warming, the evidence for warming in the number of large tabular icebergs is inconclusive. While the number of icebergs tracked by the NIC has risen markedly over the last 25 years, Jarom's retrospective analysis of historic scatterometer data suggests this increase is largely due to improved sensors and tracking techniques. As part of this study he prepared a comprehensive database of tracking information for large Antarctic icebergs based on wind scatterometer data has been prepared and is now available for use by other investigators. This database is a recent addition to the Scatterometer Climate Record Pathfinder (SCP) database (http://www.scp.byu.edu/).



Map of all the locations of large tabular icebergs in the BYU iceberg database (1978-2001).

Mount Kilimanjaro Land Use/Land Cover Change Detection

Drs. Mark W. Jackson and Jeff O. Durrant recently received a mentoring grant from BYU to support ongoing research into land use/land cover changes taking place on Mount Kilimanjaro, Tanzania. One aspect of this study involves classification and change detection using Landsat TM and ETM+ image data of Mount Kilimanjaro acquired over the last seventeen years. Ezra Owen, a master's student working for CERS will spend fifteen weeks in Tanzania this summer collecting field data using a handheld spectroradiometer and recording the reading in a geographic information system (GIS) along with locational data from the global positioning system (GPS). Drs. Jackson and Durrant are seeking to move beyond simply generating an accurate land cover map and monitoring change with this project. The goal is to also understand the forces behind the changes and attempt to develop policy that will protect not only the ecological integrity of the mountain, but also the way of life of the people living there.

In order to connect the people to the pixels, eight undergraduate students (primarily from The Department of Geography) will also spend fifteen weeks this summer in Tanzania interviewing local people about property ownership, the types of crops they are currently growing, water availability, sources of income, property availability, attitudes towards current conservations methods (e.g. Kilmanjaro National Park) social structure and gender roles. Preliminary soil sampling will also be carried out this year. All information will be geocoded using GPS and entered into the GIS. This is the first year of a multiyear project that eventually will include low altitude, large scale aerial photography acquired using CERS unmanned aerial vehicle (UAV). Work is also underway for a portable X-band radar system. Ezra Owen will represent CERS on the project as a graduate student field facilitator. As a field facilitator Ezra will serve as an additional mentor to the undergraduate students, aiding them in the data collection and processing in order to meet the overall goals of the project.

New CERS Staff Member

We are pleased to announce our newest addition of Kristi Amundson to the CERS family. Kristi will be assistaning Mindy with secretarial tasks. Kristi is a Minnesotan, served a mission in Helsinki Finland and is majoring in Elementary Education. Kristi loves geography, history, spending time with her friends and family, and teaching. We are happy to announce her upcoming marriage to Lance Smemoe this Spring.

The *CERS Observer* is published by the BYU Center for Remote Sensing. Electronic copies of the newletter (in PDF format) are available on the CERS web site at http://www.cers.byu.edu If you would like to be added to the Center email list, send email to cers@byu.edu

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