Journal of Glaciology Article Highlights Ground-Breaking Radar Design

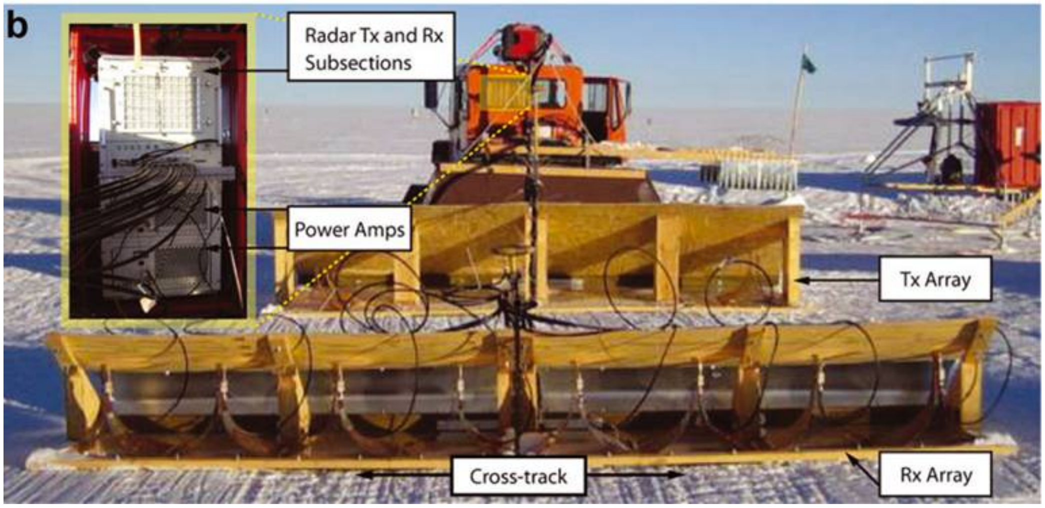
by Katie Oberthaler

John Paden, former CReSIS graduate student, published an article in the January 2010 edition of *The Journal of Glaciology*. The article, entitled "Ice-sheet bed 3-D tomography," outlined the use of Synthetic Aperture Radar (SAR) imaging at Summit Camp, Greenland during a 2005 trip. Paden and his colleagues used the ground-based radar to measure basal conditions and internal layers in an area between two ice core drilling sites at that location.

The study demonstrated foremost that SAR technology could penetrate thick ice. The radar used an eight-channel cross-track array and pulse compression, a novelty above the 2D monostatic SAR radar previously used. 2D monostatic SAR clumps the scattering data in a way makes discriminating between points in the ice difficult.

"Previously, I was looking at a 2D view of the world," said Paden. "We'd like to have a much bigger aperture. If you have targets that aren't moving very fast, you can take a bunch of images. Now we transmit a pulse that has a lot of bandwidth. We're able to discriminate some targets from others."

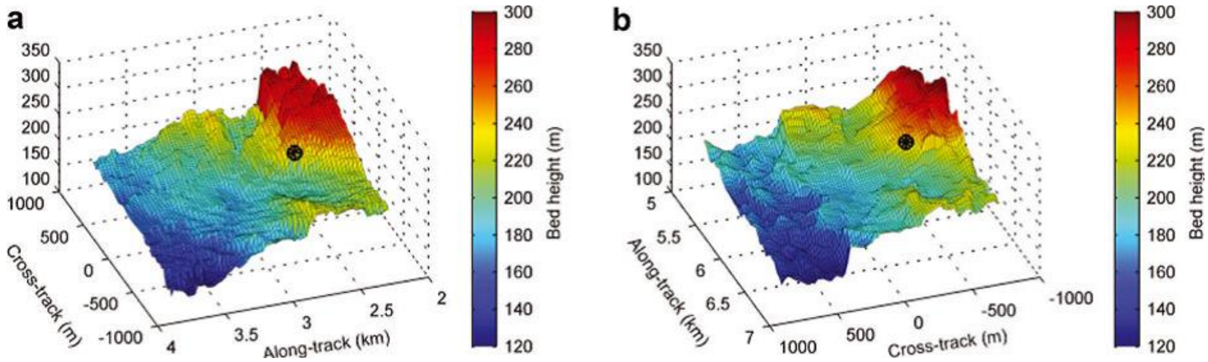
The cross-track aperture array added dimension and detail to the data. 3D SAR imaging enlarged the aperture and created a more directed beam of radar signal. A larger aperture and a tighter beam means that the team can distinguish better between targets and mine out fine images from the piles of signals returning from the ice. Paden and his team accomplished this by adding more antennas and receiving channels in the radar array. They also used a bistatic radar setup in which the transmitter and receiver were not combined near one another.



A tracked vechile pulls the cross-track arrangment of 8 antennas over the ice near Summit Camp, Greenland.

Paden also said this mission was the first attempt to use side-looking SAR radar through thick ice. Previous systems ran in an altimeter mode, which gathers data along a single track of motion. The new array allowed the engineers to steer the radar beam to the left and right, gathering data from a wider sheath of ice. “The side-looking setup allows us to generate an image, like a camera,” explained Paden. Overall, this structure gives the scientist more control over antenna placement and directing the radar beam.

The team also used the unique method of employing the 3D Tomography method algorithm to process the SAR data. This allowed them to produce high-resolution images of the ice sheet’s bed. After collecting the data, they “geo-coded” it by placing it within geographic coordinates. They also folded in information from the dielectric profile of the ice, including ice density and permittivity. Tomography processing then produces a topography map of the side-looking data. From that compilation, a digital elevation model (DEM) mosaic image stitches together grids of lines covered by the radar. The result shows clear, nuanced illustrations of the bedrock’s height.



3D Tomography produces maps of bedrock heights and characteristics. The black dots represent ice core drilling locations.

Paden, who received his bachelor's degree in computer science as well as his masters and PhD degrees in electrical engineering from the University of Kansas, took three years off from research to work for the Vexcel Corporation before publishing his results. He began compiling the article in July of last year and submitted it to the journal in October. "It was definitely one of those things I knew could be published, but I thought it was just going to slip away. It was satisfying. It leveraged all the work we had done for years," says Paden.

The publication coincided with Paden's return to CReSIS. As of this year, he is leading the signal processing efforts at CReSIS. He will work with students to help write the software to process data.
"Since my undergraduate and graduate years, I've always wanted to do academic work. I'm so happy to be doing this again. In a lot of different ways I feel passionate about it in the effect you have on the students and the work itself," Paden said.

Paden will have to adjust to the changes at CReSIS since his student work with engineering professors. An interest in wireless communication led him to enroll in microwave remote sensing classes before CReSIS became a certified NSF Science and Technology research center. Paden especially lauded the increase in field programs, advances in antenna technology and radar systems, and improved cross-discipline dialogues since his student days.

"Involvement with the glaciology community still happened, but at a lower level. It makes a difference to have people here in the Center who use the data," he said.

Paden said a continuing challenge for him will be his commute: Paden currently resides in Boulder, Colorado with his wife and three young children. He will work remotely from his home and travel to Kansas once a month.

An even bigger challenge? Remotely sensing rough, crevassed glaciers with SAR radar. Paden hopes that future versions of SAR and 3D Tomography can determine glacial movements.

“Something that would be interesting would be to look at the position of targets in the ice with a radar system, and then fly that radar a month later and look at how much that target within the ice is moving,” he said.

For now, Paden and his team are working to determine the basal conditions from the DEM mosaic images. Like the glaciers, they inch towards understanding a few terabytes at a time.