

Focused SAR Processing of Airborne Radar Sounding Data from Kamb Ice Stream

*Matthew E. Peters, Donald D. Blankenship, Sasha P. Carter, Scott D. Kempf,
Duncan A. Young, John W. Holt*

Radar sounding is perhaps the most important technique for investigating the internal structure of ice sheets and the underlying interface. This remote sensing technique can be well-suited for estimating the likelihood of melted and/or frozen conditions at the basal interface. Basal water is known to be an important factor affecting the existence and dynamics of the West Antarctic ice streams. Ice streams are generally difficult environments for quantitative radar sounding investigations because crevassing can significantly increase the surface clutter and propagation losses. Furthermore, any internal layer structure can be seriously disrupted due to the complex ice flow and dynamics.

We present focused synthetic aperture radar (SAR) processing of airborne radar sounding data acquired with the High-Capability Radar Sounder (HICARS) system operating at 60 MHz. The SAR processor correlates the radar data with a suite of geometry-dependent reference functions for subsurface point targets. These references can be either 1-D pulse-limited along-track variations (allowing intermediate apertures 375-550 meters) or 2-D variations that also include the echo tails (allowing very long apertures 1200-1700 meters). The advantages of focused SAR include: 1) improved gain and signal-to-noise ratio (SNR), 2) accurately preserved amplitudes of echoes from sloped interfaces, leading to improved basal reflection analysis and water detection, 3) improved internal layer detection and tracking, and 4) improved along-track spatial resolution.

The focused SAR processing and basal reflection analysis are applied to HICARS data from the Kamb Ice Stream. In general, the results show that focused SAR processing provides measurable improvements over unfocused SAR and incoherent integration. However, the "best" processing method may not be the same for all situations, and different processing may be required of the same raw data in order to best answer the variety of scientific questions that radar sounding can address.

Accurate echo amplitudes are necessary for quantitatively predicting the likelihood of water at the basal interface. For airborne radar sounding of Kamb Ice Stream using HICARS, basal echo amplitudes should be accurately preserved from slopes up to about 0.5 degrees for unfocused SAR, up to about 3 degrees for 1-D correlation focused SAR, and up to about 10 degrees for 2-D correlation focused SAR. The amount of detected basal water increases roughly threefold from unfocused SAR to 1-D correlation focused SAR, indicating that significant basal water exists on moderately sloped interfaces. Very little additional basal water is detected using 2-D correlation focused SAR. However, 2-D focused SAR can significantly improve the detection and tracking of internal layers with along-track slopes greater than about 3 degrees, as well as improve the spatial resolution in rough regions.