SURFACE CLUTTER REMOVAL IN AIRBORNE RADAR SOUNDING DATA FROM THE DRY VALLEYS, ANTARCTICA. J.W. Holt[1], D.D. Blankenship[1], D.L. Morse[1], M.E. Peters[1], and S.D. Kempf[1], University of Texas Institute for Geophysics, The John A. and Katherine G. Jackson School of Geosciences, University of Texas, 4412 Spicewood Springs Rd., Bldg. 600, Austin, TX 78759, jack@ig.utexas.edu

Introduction: We have collected roughly 1,000 line-km of airborne radar sounding data over glaciers, rock/ice glaciers, permafrost, subsurface ice bodies, ice-covered saline lakes, and glacial deposits in Taylor and Beacon Valley. These data are being analyzed in order to develop techniques for discriminating between subsurface and off-nadir echoes [1] and for detecting and characterizing subsurface interfaces.

The identification of features on Mars exhibiting morphologies consistent with ice/rock mixtures, near-surface ice bodies and near-surface liquid water [2,3], and the importance of such features to the search for water on Mars, highlights the need for appropriate terrestrial analogs and analysis techniques in order to prepare for radar sounder missions to Mars. Climatic, hydrological, and geological conditions in the Dry Valleys of Antarctica are analogous in many ways to those on Mars.

A crucial first step in the data analysis process is the discrimination of echo sources in the radar data. The goal is to identify all returns from the surface of off-nadir topography in order to positively identify subsurface echoes. This process will also be critical for radar data that will be collected in areas of Mars exhibiting significant topography, so that subsurface echoes are identified unambiguously.

The positive detection and characterization of subsurface (including sub-ice) water is a primary goal of NASA's Mars exploration program. Our data over the Dry Valleys provides an opportunity to implement techniques we are developing to accomplish these goals.

Data Acquisition Methods: Using a Twin Otter airborne platform, data were collected in three separate flights during the austral summers of 1999-2000 and 2001-2002 using multiple systems, including a chirped 52.5 – 67.5 MHz coherent radar operating at 750 W and 8 kW peak power (with multiple receivers) and 1 - 2 microsecond pulse width, and a 60 MHz pulsed, incoherent radar operating at 8 kW peak power with 60 ns and 250 ns pulse width.

A laser altimeter (fixed relative to the aircraft frame) was also used during both seasons. Precise positioning was accomplished through the use of two carrier-phase GPS receivers on the aircraft and two at McMurdo Station. Post-processing of the positioning data yields accuracies of ~ 0.10 m for samples at ~ 15 m intervals.

Data Acquisition Targets: Flights were undertaken in Taylor and Beacon Valleys in 2000 and 2001. Flight elevation was nominally 500 m above the surface. Radar and laser altimetry data were collected over the following targets in Taylor Valley relevant to Mars: Taylor Glacier, Lakes Fryxell and Bonney, debris flows, permafrost and polygonal terrain. In Beacon Valley, we overflew Friedman rock glacier and polygonal terrain.

Data Analysis: Data analysis so far has concentrated on technique development for discrimination of subsurface echoes from surface echoes due to surrounding topography. For this we have used a 24-km portion of the sole 2001 flight in Taylor Valley. Two techniques were developed for echo discrimination. The first method simulates surface echoes using aircraft position data, the modeled radar antenna pattern, and surface topography from a Lidar-based digital elevation model (DEM) acquired by the USGS and NASA in the Dry Valleys with 2-meter postings [4]. The simulated data are compared with the actual data to reveal to identify echoes that are from the surface (Figure 1).

In the second method, we first identify significant echoes in the radar data and then we migrate them to the surface through range estimation. This uses the measured time delay of the echo, aircraft position and known surface topography. We map the echoes onto both the DEM and optical imagery at the appropriate range in order to identify candidate surface return sources (Figure 2).

Combining the two methods yields the most conclusive echo discrimination. The forward model for simulating surface echoes can also be performed separately for left-side and right-side topography. This helps reduce the problem of left-right ambiguity in the radar sounding data through the quantification of expected surface echo strengths from either side.

Conclusions: Two methods of echo discrimination have been developed and used in order to discriminate apparent subsurface reflectors from off-nadir surface echoes: (1) forward modeling of echoes using aircraft position, antenna pattern and topography, and (2) migration of radar echoes to the surface in the cross-track direction to identify features in the topography that could be echo sources.

One obvious result is that the identification of surface echoes is critically dependent on having a good model of topography.

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References: [1] Holt J.W., Blankenship D.D., Peters M.E., Kempf S.D., and Williams B.J. (2003) Eos Trans. AGU, 84(46), Abst. P31B-1058 [2] Malin M. C. and Edgett K. S. (2000) Science, 288, 2330–2335. [3] Baker V.R. (2001) Nature, 412, 228-236. [4] Schenk, T., B. Csatho, W. Krabill, I. Lee, in prep.

(a.)

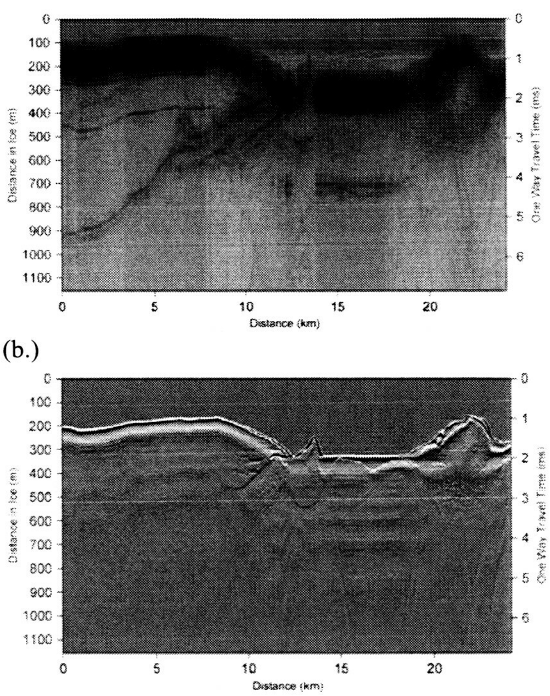

Figure 1. Comparison of (a) airborne radar data and (b) simulated surface-echo data from a portion of the Taylor Valley flight (red line in center of valley in Figures 2b and 2c). Note the prominant echo in (a) that mimics surface topography. This is clearly a double-bounce reflection between the surface and the bottom of the aircraft and is ignored. The simulated data in (b) are derived from a surface elevation model, the aircraft flight path and the antenna pattern. Some of the echoes can be positively correlated with predicted surface echoes, while true subsurface reflectors lie below Taylor Glacier (at left).

(a.)

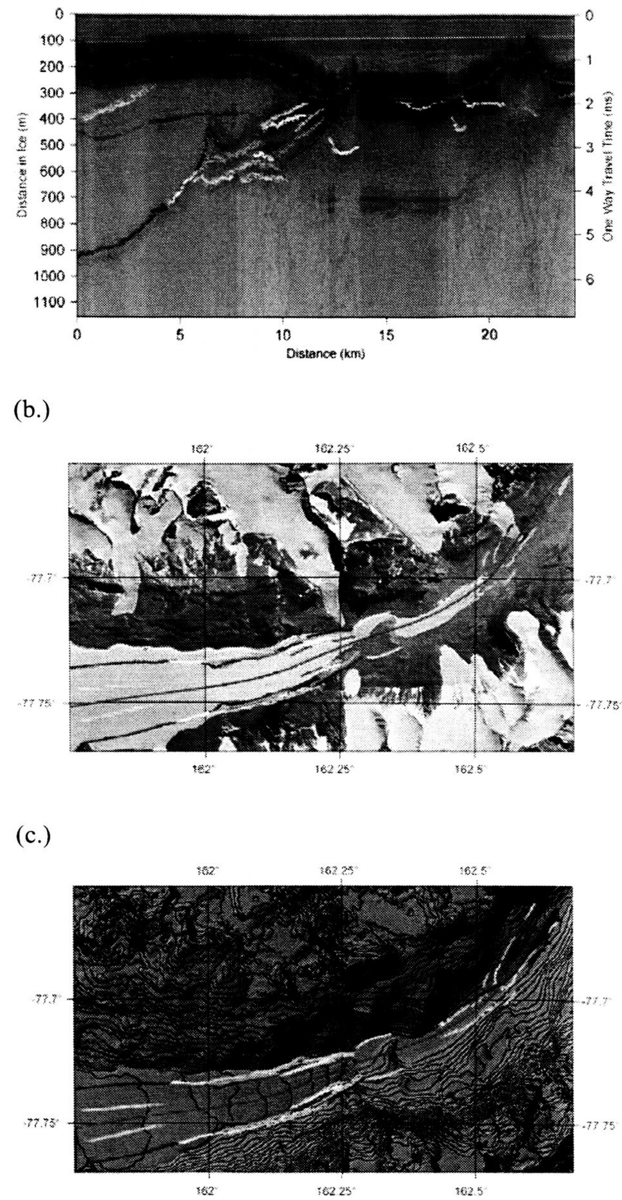

Figure 2. Distinct radar echoes indicated by separate colors (a) are migrated to the surface in the across-track direction using surface topography and aircraft position, and then overlayed on (b) an optical image and (c) the DEM (shown with 50-m contour intervals). This helps in identifying surface features that may be the source of echoes in the radar sounding data. Taylor Glacier flows down the valley from the left side of the image and terminates at Lake Bonney.