OPTIMAL SAR PROCESSING BEAMWIDTH FOR HIGH ALTITUDE AIRBORNE RADAR DEPTH SOUNDER DATA

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1. MOTIVATION

Future sea-level rise will have significant impacts on populations living in costal regions, and the development of coastal infrastructure. Adaptation to these changes to minimize the negative consequences requires improved sea-level rise predictions. While there are several contributors to changes in sea level, future changes in the Antarctic and Greenland ice sheets are perhaps the least understood. Accurately mapping the bed topography will contribute greatly to improving predictive ice-sheet models. This makes the accurate sounding of polar ice of paramount importance to predicting sea level rise. One tool for mapping bedrock is the use of Synthetic Aperture Radar (SAR) processing. One variable aspect of SAR processing is choosing an effective beamwidth over which to process. This is of special concern when data is acquired from a high-altitude airborne platform where the radar has a very large footprint on the ground.

2. INTRODUCTION

A target on or below the surface is viewed multiple times from multiple angles along the flight-path of an aircraft carrying the SAR. Each received reflection supplies useful information about the target until it moves out of the range of the radar. In SAR processing these views from various angles, or looks, are combined to improve the SNR of the target. The beamwidth refers to the maximum off-nadir, along-path look angle used in SAR processing. This means the beamwidth determines the number of looks at a target that might contain useful information. In a noise-free environment, broadening the

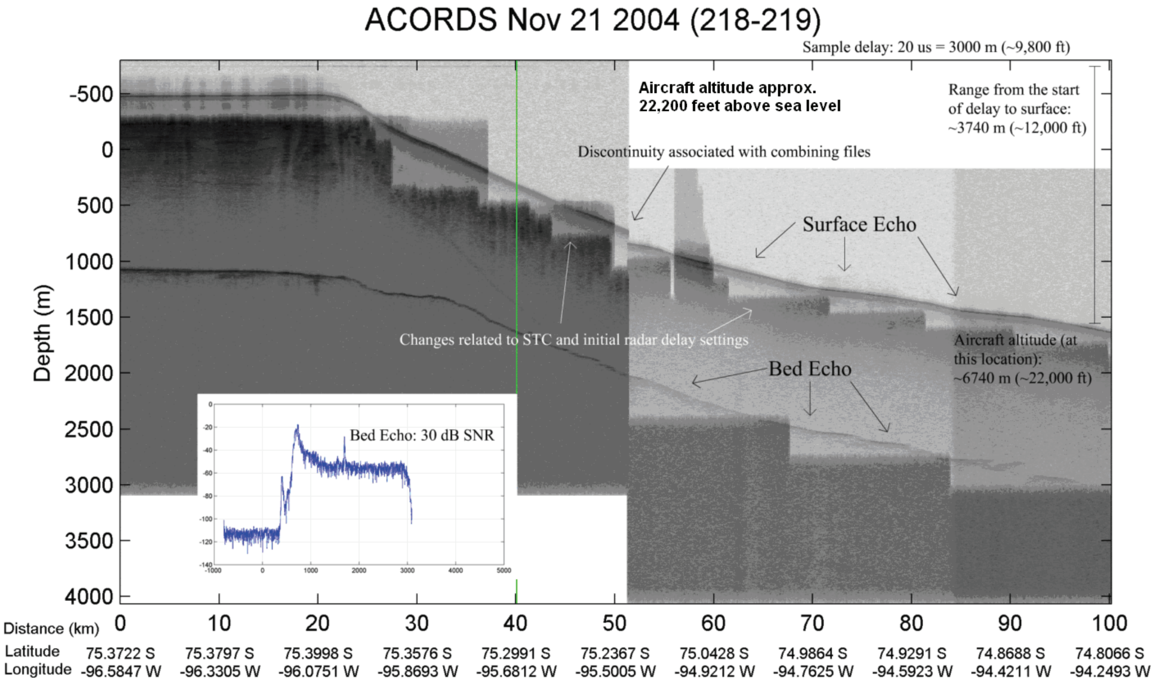

Figure 1: 2004 high-altitude data set over the Antarctic Peninsula showing bedrock through 1,500m of ice from a platform altitude of 7,500m.

beamwidth used for processing would lead to a monotonic increase in a target's reflected power, up to the physical beamwidth of the antenna. In a real world case, however, there is an optimal beamwidth that will render the best results.

A too narrow beamwidth will ignore valid looks, thereby wasting part of the usable data. A too broad beamwidth will use data where the signal has attenuated below the noise floor, causing degradation of the SAR results through phase cancellation. Platform motion and surface slope effects can also degrade the signal and so must also be compensated for before commencing with the SAR processing.

3. EXPERIMENT

In survey missions flown in 2004 from Punta Arenas, Chile over the Antarctic Peninsula, the ACORDS radar recorded data from as high as 7,500m above sea level through 1,500m of ice (Figure 1). An optimal beamwidth for this data set can be found by calculating when the SNR of a particular target will drop below a certain threshold. This threshold marks where the targets reflected energy can no longer be considered free of influence from the noise floor. Taking the 30 dB SNR of the target in figure 1 and assuming an attenuation of 25.3 dB/km [1] and a minimum usable SNR threshold of 10 dB [2], the SAR processing of this data set should see improvement up to 50° beamwidth. This is a gross calculation and the actual usable beamwidth is likely narrower than 50°. If the there is insufficient position data to correct for platform motion or surface slope this usable beamwidth would be reduced significantly as would ice with higher attenuation. The beamwidth could also be limited if the target is obstructed by bedrock topography.

In addition to usable data, an effort should be made to estimate the trade-off between the diminishing return in SNR gain versus the increase in required computational resources at larger beamwidths. The computing requirements for performing SAR processing are already considerable when using a narrow beamwidth. At some beamwidth value the increased computational cost may not justify the additional SNR of the highly attenuated, yet still valid, part of the data.

I will compare the results of multiple processing beamwidths for both simulated and real data of various platform heights and ice thicknesses to find the optimal beamwidth for a given data set and available computing power. Based on preliminary results I expect the optimal beamwidth for real data to be 25° or less.

4. REFERNCES

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[2] F. Ulaby, R. More, A. Fung "Microwave Remote Sensing: Active and Passive-Volume II: Radar Remote Sensing and Surface Scattering and Emission Theory", Artech House, 1986.