Deconvolution of FMCW Radars for Operation IceBridge Missions

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The NASA Operation IceBridge missions have employed two FMCW radar systems designed by the Center for Remote Sensing of Ice Sheets (CReSIS). One is a snow radar (2-8 GHz) for measuring the snow ice thickness on sea ice and the accumulation rate and shallow internal layering of inland ice-sheet ice. The other is a Ku-band radar (12-18 GHz) for measuring ice surface topography.

For FMCW radars, the nonlinearities in signal amplitude and phase introduced by the system and antenna are a major performance-limiting factor that degrade the radar's range resolution and increase the sidelobe level of dechirped beat signals. In particular, the high range sidelobes of strong signals at the air-snow and snow-ice interfaces may mask weaker internal layers and result in ambiguities in interpreting data. These nonlinearities have to be characterized and removed by deconvolution in post data processing to achieve optimal radar performance.

We quantified the system distortions in the laboratory for both the snow and Ku-band radars by taking loopback measurements with delay lines of different lengths. We determined the antenna distortions in the anechoic chamber by measuring the impulse responses of the antennas of the two radar systems. By combining the loopback delay line and antenna measurements and simulating the ideal impulse responses, we derived the system inverse responses as a function of ranges between 350 m and 700 m. The system inverse responses serve as the basis for implementing adaptive filters to deconvolve the signal distortions from real data, which include the system characteristic variations with time.

In this paper, we will first describe the measurement setups and the procedures used to derive the system inverse responses from the calibration measurements. We will then focus on comparing different implementations of adaptive filters. Finally, we will present sample results of applying these adaptive filters to real data, showing the improved range resolution and reduced range sidelobes.