An analysis of Antarctica as a target for first order cross-calibration between QuikSCAT and ASCAT σ_0 data

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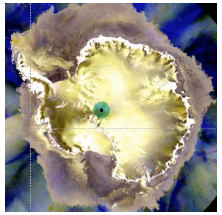
This poster is presented as a sequence of slides describing our recent work and plans.

Abstract

While scatterometers have been measuring the radar cross-section of the earth for decades, differences between scatterometers limit our ability to utilize the entire record in one study. Variations in incidence angle, frequency, beam pattern, and time periods complicate efforts to cross-calibrate data from different sensors and make it difficult to create a homogeneous data set to support long-term climate studies. Land calibration targets with little seasonal variation and volume scattering characteristics help to mitigate some of these differences by enabling cross-calibration of the various sensors. The Amazon is a traditional calibration target because it comprises a large, homogeneous region with backscatter dominated by volume scattering. Unfortunately, resonant behavior with leaves in the Amazonian canopy at Ku band frequencies and the diurnal dew cycle reduce the effectiveness of the Amazon calibration of scatterometers at multiple frequencies.

We show that regions of Antarctica exhibit long-term stability and volume scattering effects. In particular, we study a region near the South Pole in what is known as a 'wind glaze' region, a region characterized by near-zero snow deposition rate and an ice surface over coarse refrozen ice grains. We show that trends in C-band ASCAT data (with respect to azimuth angle or time) are repeated nearly exactly by the trends in Ku-band QuikSCAT and OSCAT data. This means that over the area, the relationship between Ku-band and C-band backscatter measurements can be accurately described by a first-order offset. This presentation shows an area that can be used for cross-calibration, and presents a model that allows us to estimate the calibration offset between scatterometers along with data that supports that model.



Cover photo: False color image of one day (JD 217, 2008) of SIR-enhanced scatterometer data

Red: QuikSCAT h-pol σ^o at 46º inc

Green: QuikSCAT v-pol σ^o at 45º inc

Blue: ASCAT v-pol σ^o at 40º inc

(Resolution was reduced for display)

Establishing a Calibration Area

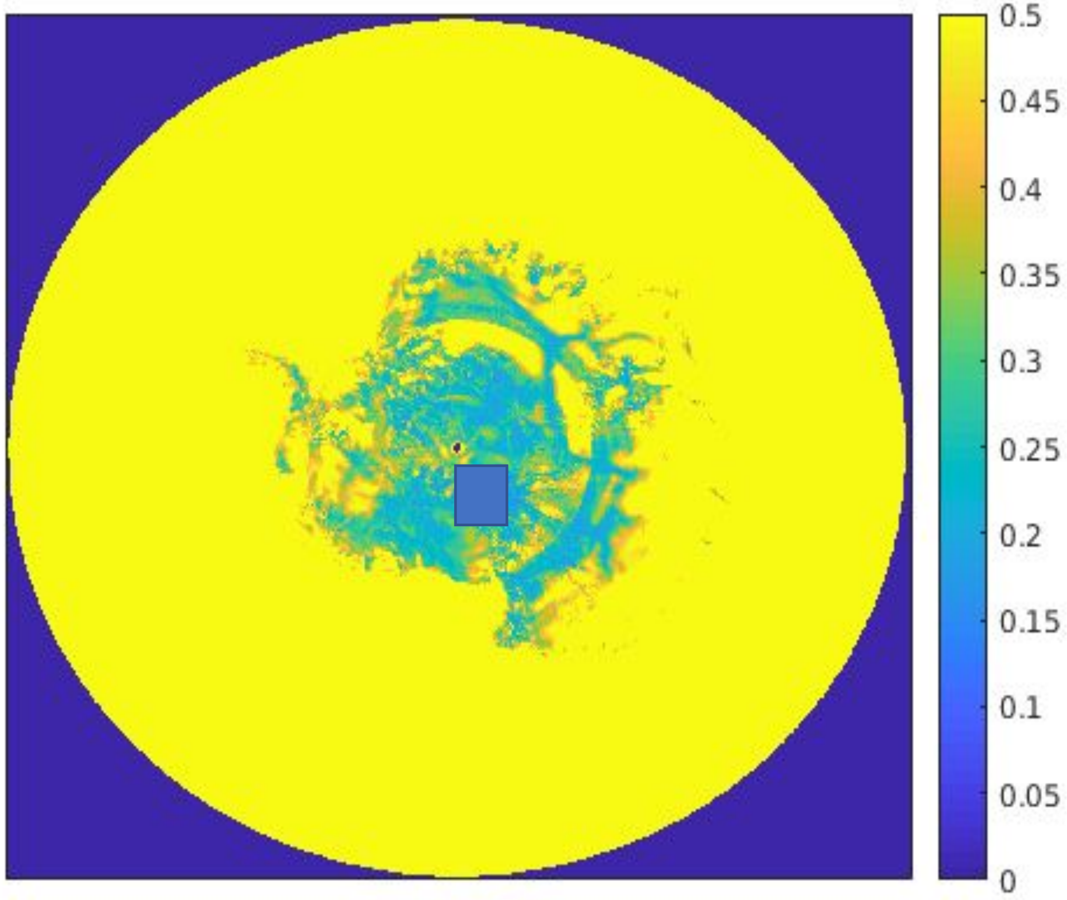


Figure 1. Map of 3-year standard deviation in the daily pixelwise mean difference between ASCAT and QuikSCAT SIR σ_0 data (in dB).

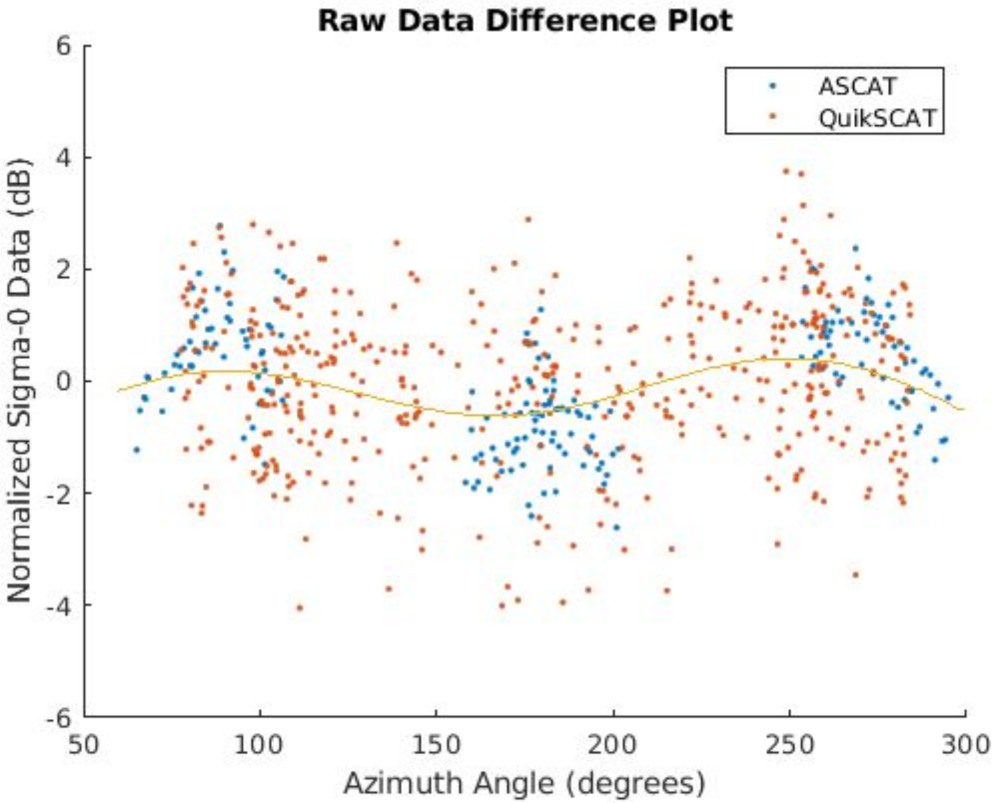
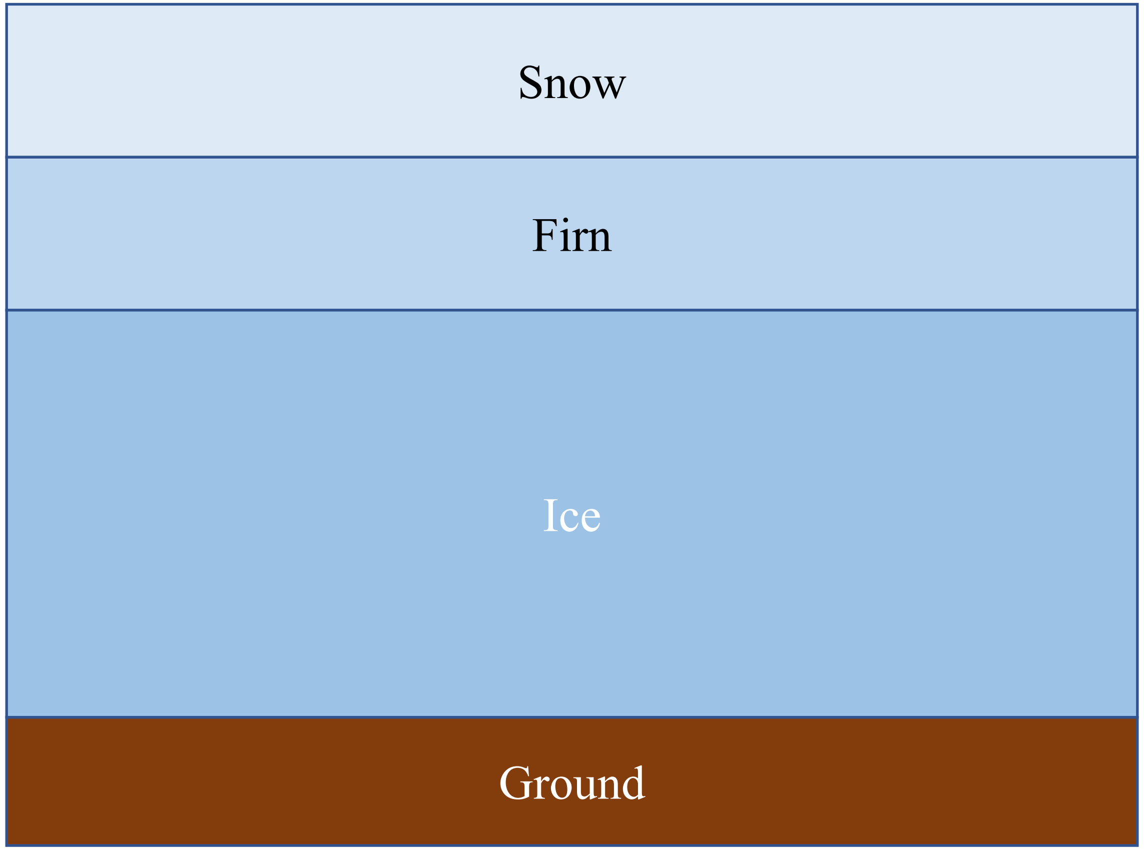


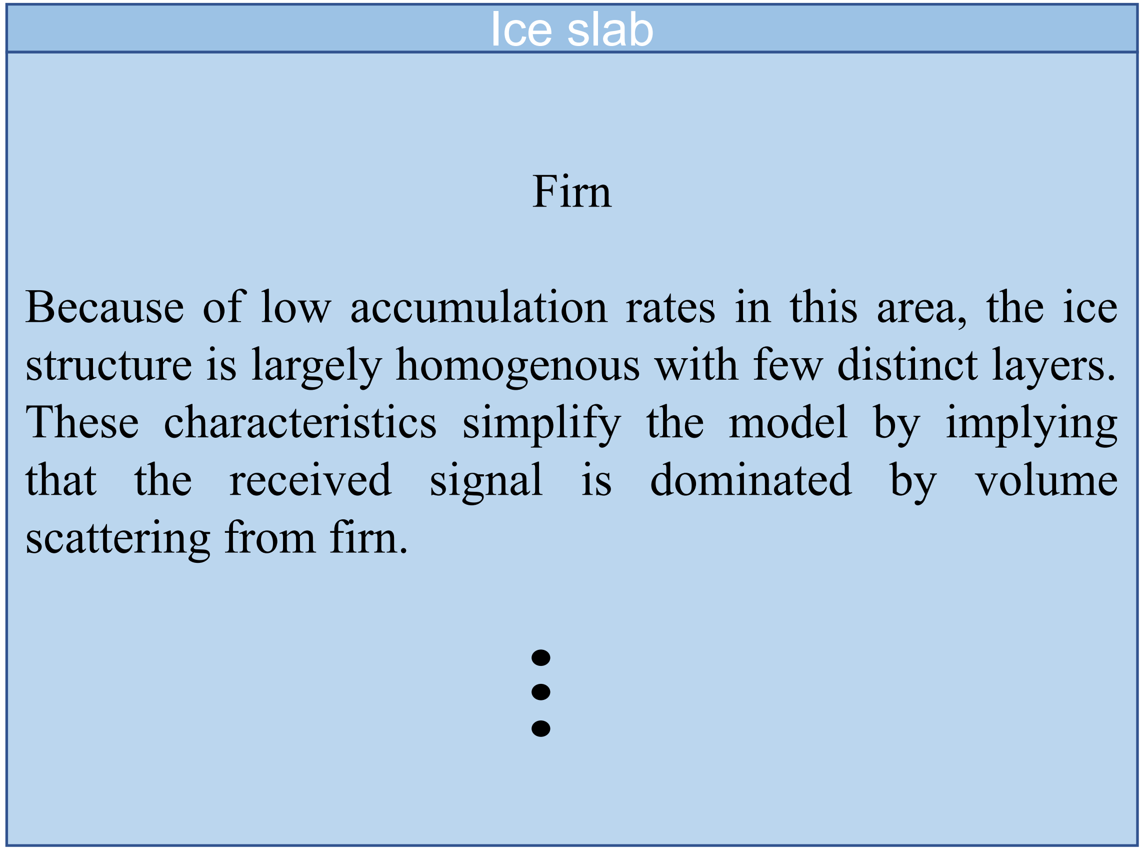
Figure 2. Scatterplot of three years of ASCAT and QuikSCAT average daily σ_0 (centered at 0 dB) for one pixel in the calibration area. The QuikSCAT σ_0 vs azimuth angle closely matches the ASCAT data σ_0 vs azimuth angle. To minimize incidence angle modulation, ASCAT data with an incidence angle in the range of 54.4 ± 5 degrees was used.

Geophysical Modelling

Typical Unglazed Region



Glazed Region



Calibration Modeling

The idea behind the calibration model is that on the calibration area, the difference in reported σ_0 from two scatterometers can be represented reasonably well by

$$\sigma_{Scatt1} - \sigma_{Scatt2} = C_{Calibration} + C_{Area}$$

The goal of the model is to predict C_{Area} so that $C_{Calibration}$ can be isolated.

Using formulas for volume backscattering, we model calibration offset due to the area as

$$\sigma_0(\theta_i,f) = p*\sigma_b*\cos(\theta_i)/(2\kappa_e),$$

where p is the number of particles per unit area, σ_b is the backscatter from one particle, θ_i is the incidence angle of the measurement, and κ_e is the extinction coefficient of the firn.

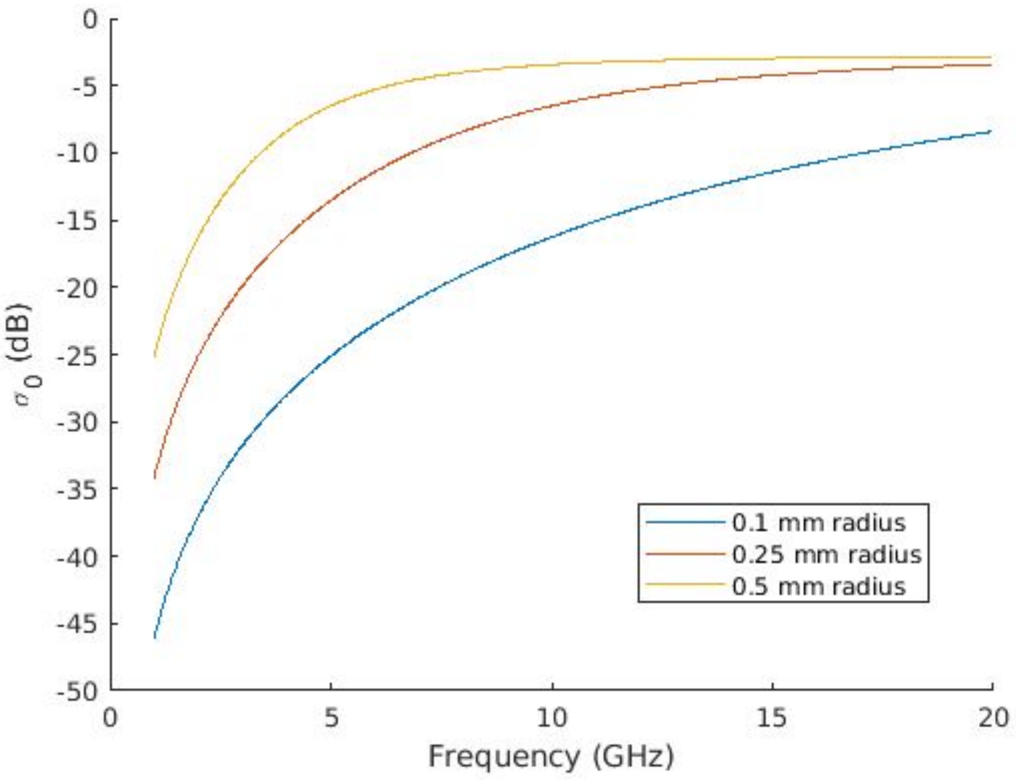


Figure 3. Plot of modeled σ_0 versus frequency for various particle sizes within a reasonable range.

Sample Results

The model is compared to ASCAT data, as shown in figure 5. According to our model the amplitude of the cosine varies with particle size, so the quality of the predicted calibration offset depends on the quality of the particle size information.

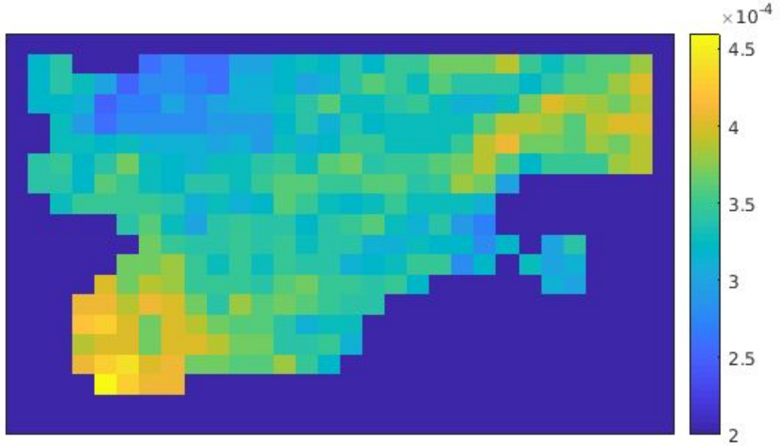


Figure 4. Map of predicted particle size in the section of the calibration region with the least variation. The map assumes calibration offset is zero, by comparing it with maps generated with data from other scatterometers, a better estimate of calibration offset can be made.

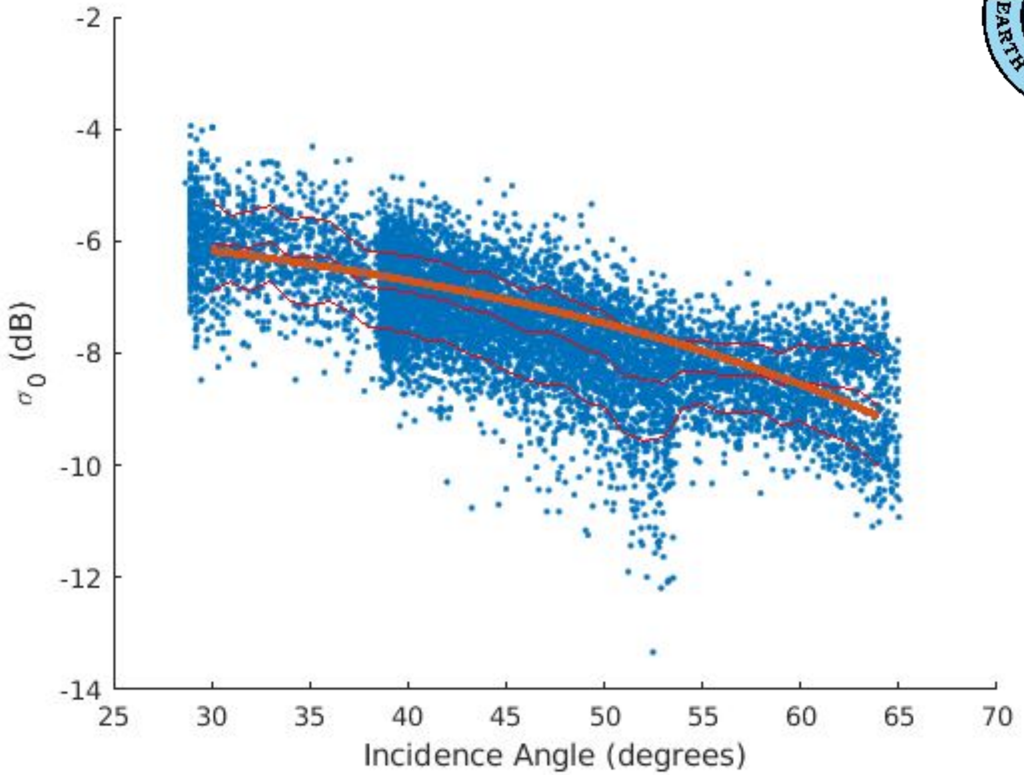


Figure 5. Plot of azimuth corrected ASCAT data with thin red lines indicating the mean of the data with error bars, and a thick orange line marking the modeled fit.

Further Research

- Confirm model with data from NSCAT and SMAP (Ku and L bands)

- Apply the calibration offsets in long-term climate record studies.

- Modify the model to help with detection of liquid water in firn aquifers.

Bibliography and References

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