Introduction

The knowledge of snow pack properties and its temporal and spatial variability are of importance for the interpretation of backscatter signals in the microwave region. Scatterometers provide valuable information on backscattering characteristics at low spatial but high temporal resolution. In addition, the surface is illuminated at different viewing angles during a single overflight.

This investigation focuses on the area of Dronning Maud Land, Antarctica. The backscattering properties from the two satellite borne scatterometers NSCAT (NASA) and ERS (ESA) as well as SAR (Synthetic Aperture Radar) images with high spatial resolution are compared to snow pack properties, in the first place accumulation rates derived by stake readings. This is done along a traverse route from the German Neumayer base (74°12'S, 16°44'W) to the German base camp on the ice shelf Ekströmisen to the German base camp Kottas (74°12'S, 16°44'W).

Differences in the backscattering signatures reflect the variable pattern in the snow morphology, although the relation is not straightforward. The signature study provides additional information for a better understanding of signals like radar altimeter and high resolution SAR.

Snow accumulation

Accumulation data was gathered by repeated stake readings along Kottas Traverse in the years 1997 to 2001. The measured snow fall in meters was transformed into accumulation rates (kg m⁻²) by using density profiles of the snow pack's upper 2 m. They were derived by snow pits studies, done at several points along the way. The single profiles reveal a high variability in accumulation in time and space.

Note: Mean accumulation values for a time period of 5 years had to be calculated from an increasing number of measurements along the profile (see Fig. 2).

Accumulation - dB cross correlation

By looking at Fig. 9 it seems obvious, that the variations in the backscatter coefficients of a snow surface are related to snow cover variations. Comparing both parameters along Kottas Traverse, an increase in snow accumulation goes together with a decrease of dB. For quantification of this phenomena, a scatterplot was done (Fig. 10) and a correlation factor estimated for each of the two traversed snow zones. They form distinct clusters, with dB as well as the accumulation rate being on a higher level for the percolation zone, compared to the dry snow zone.

Conclusion

Scatterometers provide valuable information about incidence and azimuth angle dependence of the snow surfaces backscatter coefficient σ₀, which shows strong variations across the ice sheet of Antarctica. This can serve for normalization of high resolution Envisat ASAR data, SAR in turn can be used to study the relation between the snow's morphology and SAR backscatter. Additional investigations are required, taking into account influences like the wind field, snow grain size or the temperature of the snow.

References


Figure 1. Route of Kottas Traverse from the German Neumayer base (74°12'S, 16°44'W) to the German base camp on the ice shelf Ekströmisen to the German base camp Kottas (74°12'S, 16°44'W). The blue line represents an mean value for the time period. Red asterisks mark the location of snow pits, providing density profiles. Examples are shown above.

Figure 2. Snow accumulation along Kottas Traverse in the Dry Season. In: 2nd International Conference on Antarctic Meteorology and Glaciology, volume 2, 25-26, 1995

Figure 3. VV polarized Escat (a) and NSCAT (b) data as mean of all measurements between incidence angle 30° ≤θ ≤45°. The signal is normalized to 35°, 1200 dBdBRA = 10log1000. The red line on top represents the mean of all NSCAT-ERS V V and ASAR HH data, required, taking into account influences like the wind field, snow grain size or the temperature of the snow.

Figure 4. Scatterometer data (Escat and NSCAT) at 35° incidence angle, showing differences in the backscatter energy mainly from snow surface. Though beginning at an elevation of about 500 m the profiles are not significantly separable. Around this height the dry snow is reached, where the longer ERS C-band microwaves can penetrate deeper into the snow, than the Kuanbd NSCAT signals. Thus the absorbed part of energy increases stronger for ERS and less energy is backscatterer towards the satellite sensor. The result corresponds with surface findings (Drinkwater and others, 2001).

Figure 5. Ratio for Escat (a) and NSCAT (b) images reflecting the variable pattern in the snow morphology, although the relation is not straightforward. The signature study provides additional information for a better understanding of signals like radar altimeter and high resolution SAR.

Figure 6. Scatterometer data from Fig. 3 along Kottas Traverse. The red line on top represents the difference of the VV polarized NSCAT and ERS σ₀ values.

Figure 7. Ratio for Escat (a) and NSCAT (b) images reflecting the variable pattern in the snow morphology, although the relation is not straightforward. The signature study provides additional information for a better understanding of signals like radar altimeter and high resolution SAR.

Figure 8. NSCAT data as mean of all measurements between incidence angle 30° ≤θ ≤45°. The signal is normalized to 35°, 1200 dBdBRA = 10log1000. The red line on top represents the mean of all NSCAT-ERS V V and ASAR HH data, required, taking into account influences like the wind field, snow grain size or the temperature of the snow.

Figure 9. Envisat ASAR wide swath data from March 2004, plotted against accumulation rates derived by stake readings. This is done along a traverse route from the German Neumayer base (74°12'S, 16°44'W) to the German base camp on the ice shelf Ekströmisen to the German base camp Kottas (74°12'S, 16°44'W). The blue line represents an mean value for the time period. Red asterisks mark the location of snow pits, providing density profiles. Examples are shown above.

Figure 10. Envisat ASAR data as mean of all measurements between incidence angle 30° ≤θ ≤45°. The signal is normalized to 35°, 1200 dBdBRA = 10log1000. The red line on top represents the mean of all NSCAT-ERS V V and ASAR HH data, required, taking into account influences like the wind field, snow grain size or the temperature of the snow.

Figure 11. Ratio for Escat (a) and NSCAT (b) images reflecting the variable pattern in the snow morphology, although the relation is not straightforward. The signature study provides additional information for a better understanding of signals like radar altimeter and high resolution SAR.