Effect of snow over lake and sea ice on the backscatter coefficient retrieved from airborne SnowSAR data

Katriina Veijola[1], Marko Mäkynen[1], Juha Lemmetyinen[1], Jaan Praks[2]

[1]Finnish Meteorological Institute, P.O.Box 503, FI-00101 HELSINKI, Finland, email: Katriina.Veijola@fmi.fi
[2]Aalto University, Department of Radio Science and Engineering, P.O.Box 13000, FI-00076 AALTO, Finland

Snow on ice has a major impact on the evolution of ice both in sea and lake areas. It insulates the ice from cold air and thus reduces the growth of ice. On the other hand, it restricts the sunlight accessing the snow-ice interface, thus retarding the ice from melting in spring. In addition, snow on ice is an important factor in well-being and breeding of Saimaa and Baltic ringed seals. Furthermore, snow on ice is a significant source of uncertainty in sea ice thickness products and thus influences the accuracy of climate change studies.

Typically, microwave radiometer data has been used to estimate snow depth on sea ice. In this study, we use airborne SnowSAR data to investigate the effect of snow over ice on the backscatter coefficient by using SAR data, which has higher spatial resolution compared to radiometers. We concentrate on analysing the backscattering coefficients retrieved from both lake ice and sea ice areas covered with snow.

In this study, we used data collected in Finland, in spring 2012, during Phase A studies of the ESA's CoReH2O (Cold Region Hydrology High Resolution Observatory) mission, which was a candidate for the ESA's Earth Explorer program. This study was a part of ESA's SILIRIS (Sea Ice, Lake Ice and River Ice Study) -study focused on development of sea ice and lake and river ice retrieval algorithms for CoReH2O. The used data consisted of SAR backscattering data at X- and Ku-bands with VV- and VH-polarisations and co-incident in-situ measurements of snow and ice properties. The SAR data was acquired with the ESA's airborne SnowSAR sensor and had the ground resolution of 2 meters. The measurements were conducted on landfast ice in the Bay of Bothnia of the Baltic Sea and on Lake Orajärvi, in Northern Finland.

The SAR backscattering coefficient from snow covered ice can be thought to consist of surface scattering and volume scattering. We investigated the correlation between backscatter and snow depth with different frequency and polarization combinations. For sea ice, we show that Ku-band VV-polarization and the KuVV/XVV-ratio has the best sensitivity to snow depth. Whereas for lake ice, the best sensitivity was found from XVH and KuVH/XVH-ratio. When the snow depth on ice increases, the KuVV backscattering coefficient increases as well, possibly due to increase of snow volume scattering as the size and amount of snow grains increase. Nevertheless, the correlations were quite weak. The different results for lake and sea ice might be due to different dataset sizes or differences in stratigraphy and properties in snow cover over sea and lake ice.

Many factors may contribute to the retrieved value of backscattering coefficient. We show that used polarisation and frequency affects the retrieved backscattering coefficient. In addition, used incidence angle may have an impact. Along with snow depth, the radius of snow grains, the amount of liquid water in the snowpack and the surface roughness presumably contribute to the retrieved value of backscattering coefficient.