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Detection of of ice crust formation on snow with satellite data

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Short term thawing of the snow surface and subsequent refreeze can lead to the formation of ice crusts. These events are related to specific meteorological conditions such us rain-on-snow events and/or temporary increase of air temperature above zero degree Celsius. The structure change in the snow pack has adverse effect especially on wild life and also the local community related to reindeer herding.

A monitoring scheme for refreeze events including ROS has been developed for observation based on data from the active microwave sensor Seawinds QuikScat (Ku-band) which is sensitive to changes on the snow surface.

Seawinds QuikScat Scatterometer

1999 -2009
25 km spatial resolution
13.4 GHz
Swath width: 1800 km
Rotating dish
Daily global coverage ~ 90%

Ground observations on Yamal Peninsula were used for algorithm development (Bartsch et al. 2010). Snow refreezing patterns have been initially analysed for northern Eurasia above 60°N from autumn 2001 to spring 2008. Western Siberia is more affected than central and eastern Siberia in accordance with climate data. Most events occur in November and April.

A minimum short term backscatter increase of 1.5 dB has been determined with respect to severity for ungulates. Russian snow course records* demonstrate that the backscatter difference can be larger the higher the degree of ice crust coverage on the snow surface is. (Figure 1)

The frequency of mid-winter (Nov-Feb) backscatter increase for the entire polar region is shown in Figure 2 (source: Bartsch 2010).

Figure 1: Comparison with snow course data* (entire winter period Oct-April) from field (squares) and forest (diamonds) environment: a) all ice crusts on snow surface and b) for surface ice crust minimum thickness >10 mm and detection performance

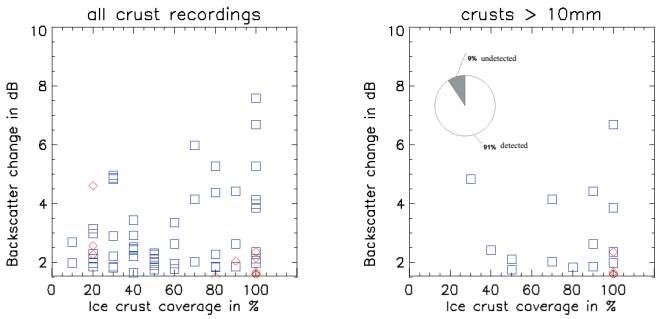
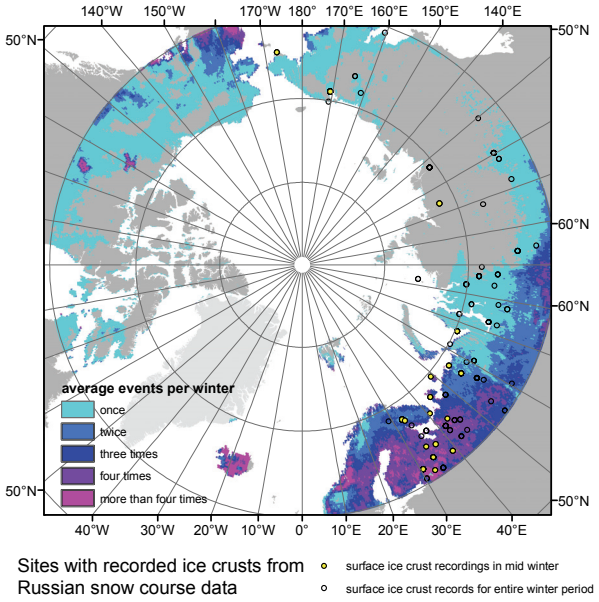


Figure 2: Mid-winter events detected by SeaWinds (Nov 2000 – Feb 2009; Bartsch 2010) and location of snow course records (source: RIHMI)



- Ku-band scatterometer can detect short term mid-winter thaw and refreeze events
- 90 % of on the ground recorded ice crusts on the snow surface (>10mm) have been detected with the method developed for SeaWinds QuikScat

Implications for reindeer herding

Reindeer lichens are a main source of fodder during the winter and are dug up from beneath the snow when it is present. The accessibility of terricolous lichens is therefore in large parts determined by snow properties. Important parameters are the establishment of snow cover in autumn, snow depth, melting of snow in spring and the structure within the snowpack.

Snow profile taken on the 19th of November 2006. (Photo: Florian Stammler)

Southern Yamal peninsula has been affected by a rain-on-snow (ROS) event in November 2006.

The ROS event and subsequent refreezing with formation of ice crusts forced a major change in migration. Some of the brigades were additionally affected by an event to the west in January and as they migrated back northwards across the snowpack, which still consisted of the previous ice layers. **The loss amounted to 25% of the animals including deaths and still-births resulting from exhaustion and poor nutrition of pregnant females.**

References

Bartsch, A. (2010): Ten Years of SeaWinds on QuikSCAT for Snow Applications Remote Sens. 2010, 2(4), 1142-1156; doi:10.3390/rs2041142

Bartsch, A., Kumpula, T., Forbes, B., Stammler, F. (2010): Detection of snow surface thawing and refreezing in the Eurasian Arctic using QuikSCAT: implications for reindeer herding. Ecological Applications e-View. doi: 10.1890/09-1927

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