



ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

Field experiments in northern Europe: SNORTEX

Terhikki Manninen



<http://snow.fmi.fi/SNORTEX/>



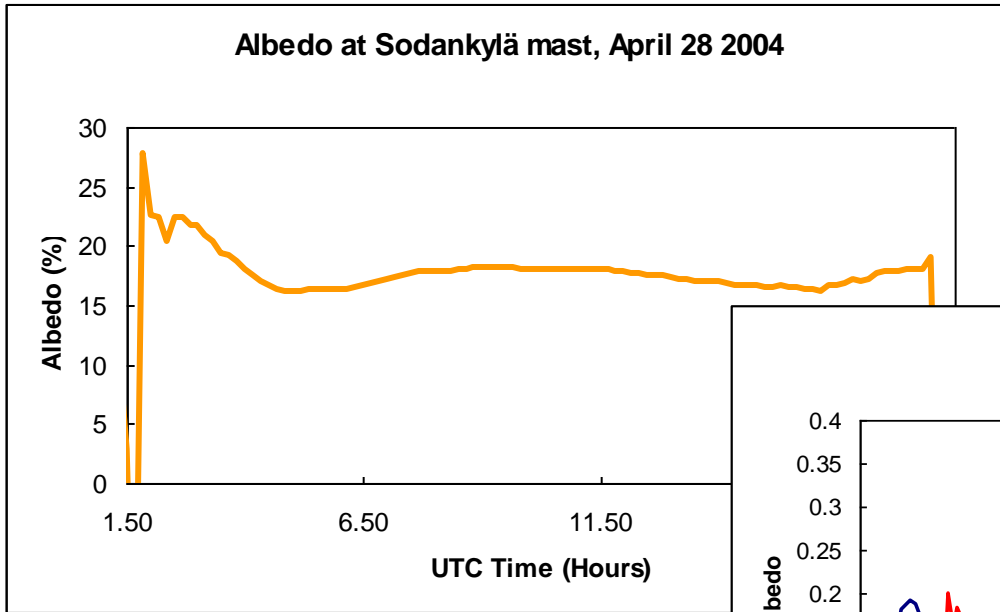


Motivation and goals

- **One of the important questions of climate change is, whether the boreal forest edge will move northwards, which would decrease the surface albedo drastically (80% -> 20%)**
- **The main aim of the SNORTEX investigation is to measure the Bidirectional Reflectance Distribution Function (BRDF) of the European boreal ecosystem on a seasonal basis with the presence of snow.**
- **Normalization improvement of wintertime boreal forest albedo**
- **Validation of satellite based snow and albedo products.**

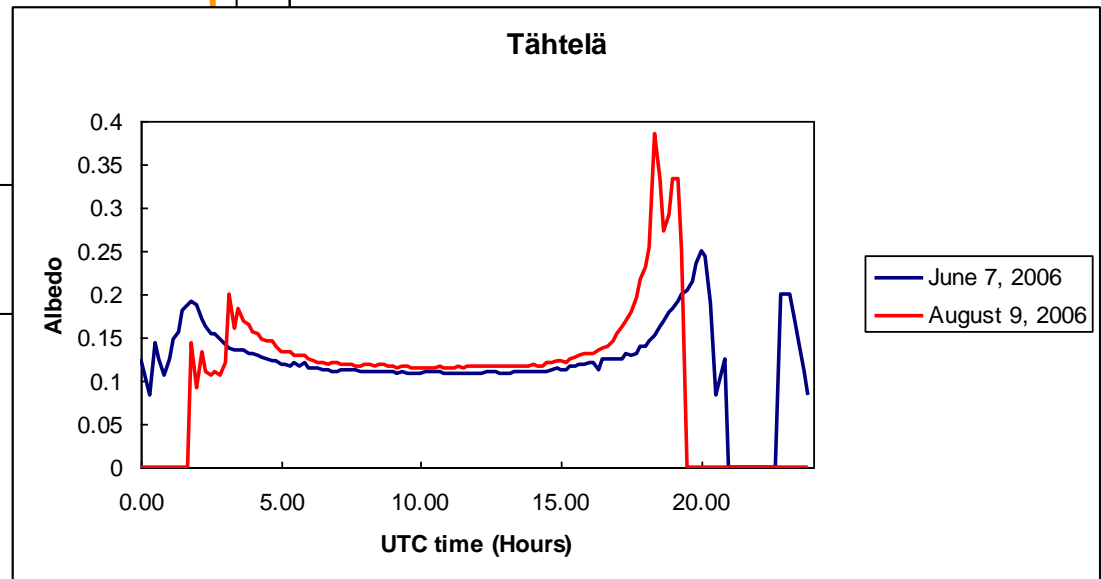


Normalization improvement of wintertime boreal forest albedo



Terhikki Manninen and Pauline Stenberg, 2009, "Simulation of the effect of snow covered forest floor on the total forest albedo", Agricultural and Forest Meteorology, Vol. 149, No.2, pp.303-319.

Summertime normalization scheme may cause 40% overestimation of wintertime albedo





Campaign participants

Météo-France:

Jean-Louis Roujean, Olivier Hautecoeur

LGGE:

Florent Dominé

Finnish Meteorological Institute

Terhikki Manninen, Kati Anttila, Osmo Aulamo, Juha Karhu, Tuure Karjalainen, Stelios Kazantzis, Anna Kontu, Panu Lahtinen, Juha Lemmetyinen, Milla Lötjönen, Outi Meinander, Miia Pasuri, Suleiman Mostamandy, Aku Riihelä, Niilo Siljamo, Timo Sukuvaara, Hanne Suokanerva, Laura Thölix

Finnish Geodetic Institute

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Sanna Kaasalainen, Harri Kaartinen, Antero Kukko, Henri Niittymäki, Anssi Krooks

University of Eastern Finland

Lauri Korhonen

University of Helsinki

Sabine Göke

SYKE (Finnish Environmental Institute)

Olli-Pekka Mattila, Kirsikka Niemi, Kristin Böttcher

Campaigns

2008 April 1-18

2009 I: March 9-20
II: April 19-29
III: May 4-8

2010 March 15-26

Co-operation

University of Helsinki

Pauline Stenberg

Finnish Forest Research Institute

Pekka Voipio





Airborne instruments

OSIRIS, 2008-2009	BRDF
4 Pyranometers	Global and reflected radiation
4 SL501 sensors	Incoming and reflected UV radiation
Humicap	Humidity
Thermometer (Pt-100)	Air temperature
Karhukamera, wide optics lense	Leaf area index (LAI)
Laser scanner, 2009	Height of vegetation
AISA spectrometer, 2010	Spectrum of reflected radiation





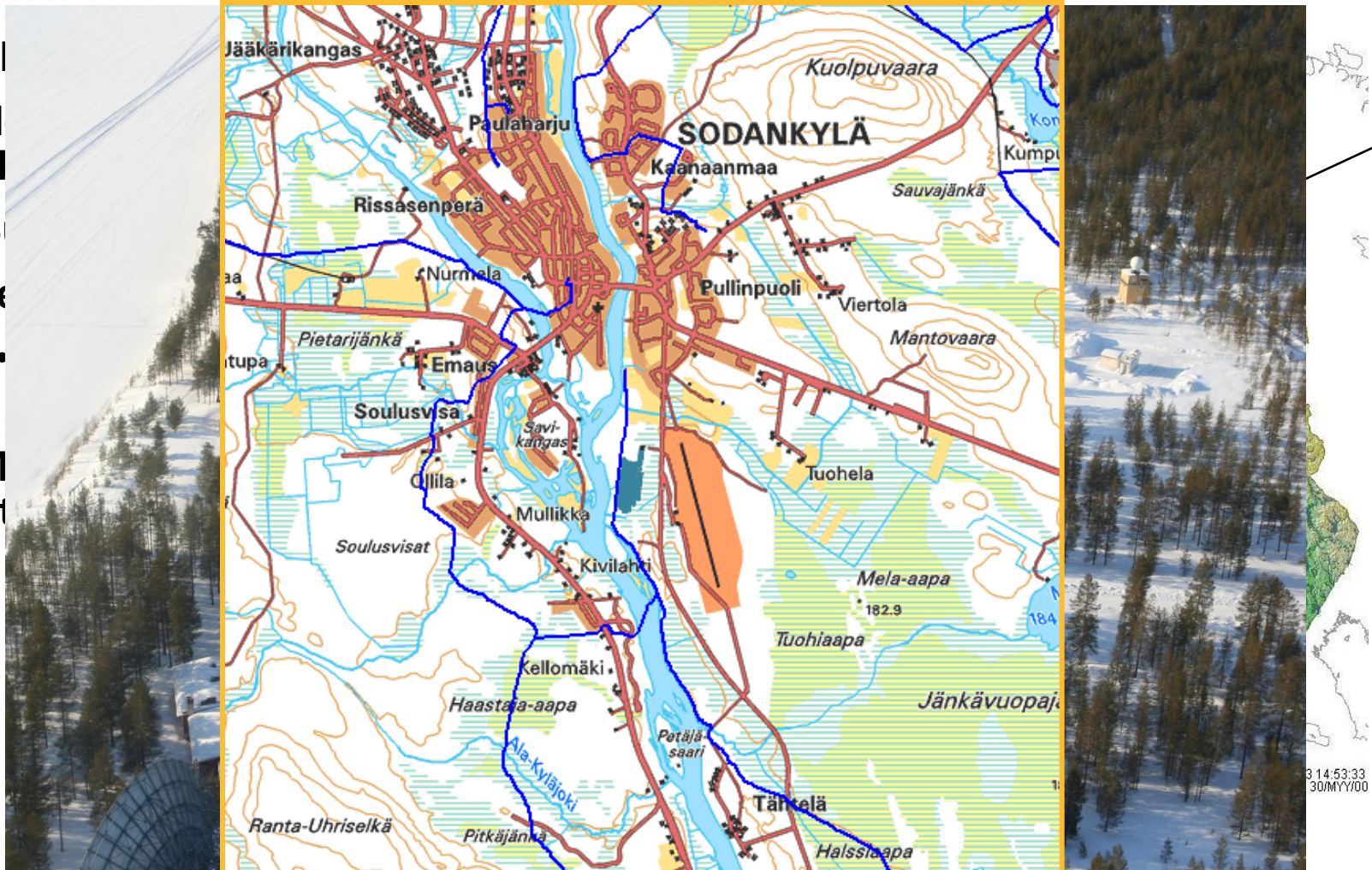
Ground measurement instruments

Measurement stick, GPS	Snow depth, Fractional snow cover
Cylinder, spade and balance, Density measurement system	Snow density and water equivalent (SWE)
Infrared camera, camera and graded plate, Camera system	Snow grain size
Camera, graded plate, tacymeter	Snow surface roughness
Thermometer (Pt-100)	Air and snow temperature
Snow fork	Snow wetness, density
Albedometer	Global and reflected radiation
Spektrometer	Spectrum of global and reflected radiation
Hemispherical camera	LAI
Samples for analysis in Sweden	Snow surface impurities
Bentham	UV radiation
Terrestrial laser scanner (FGI)	3D snow surface
FiGiFiGo (FGI)	BRDF
HSD	Snow shape detector



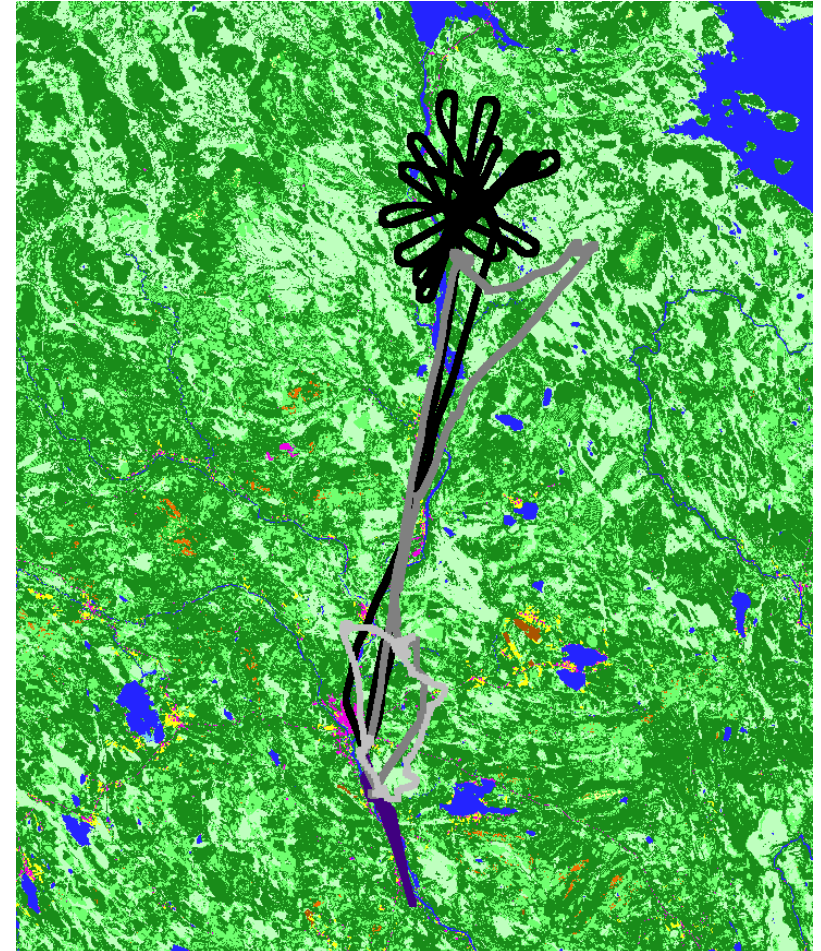
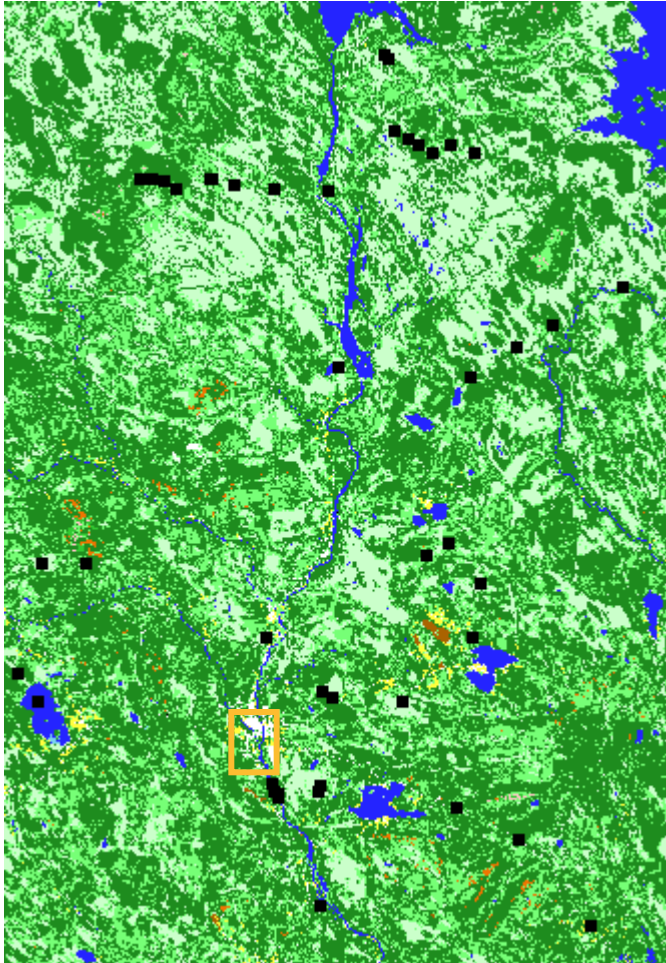
Measurement site

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Measurement area 2008



Flights: April 2, April 3, April 7 and April 10



Ground measurement area 2009 and 2010

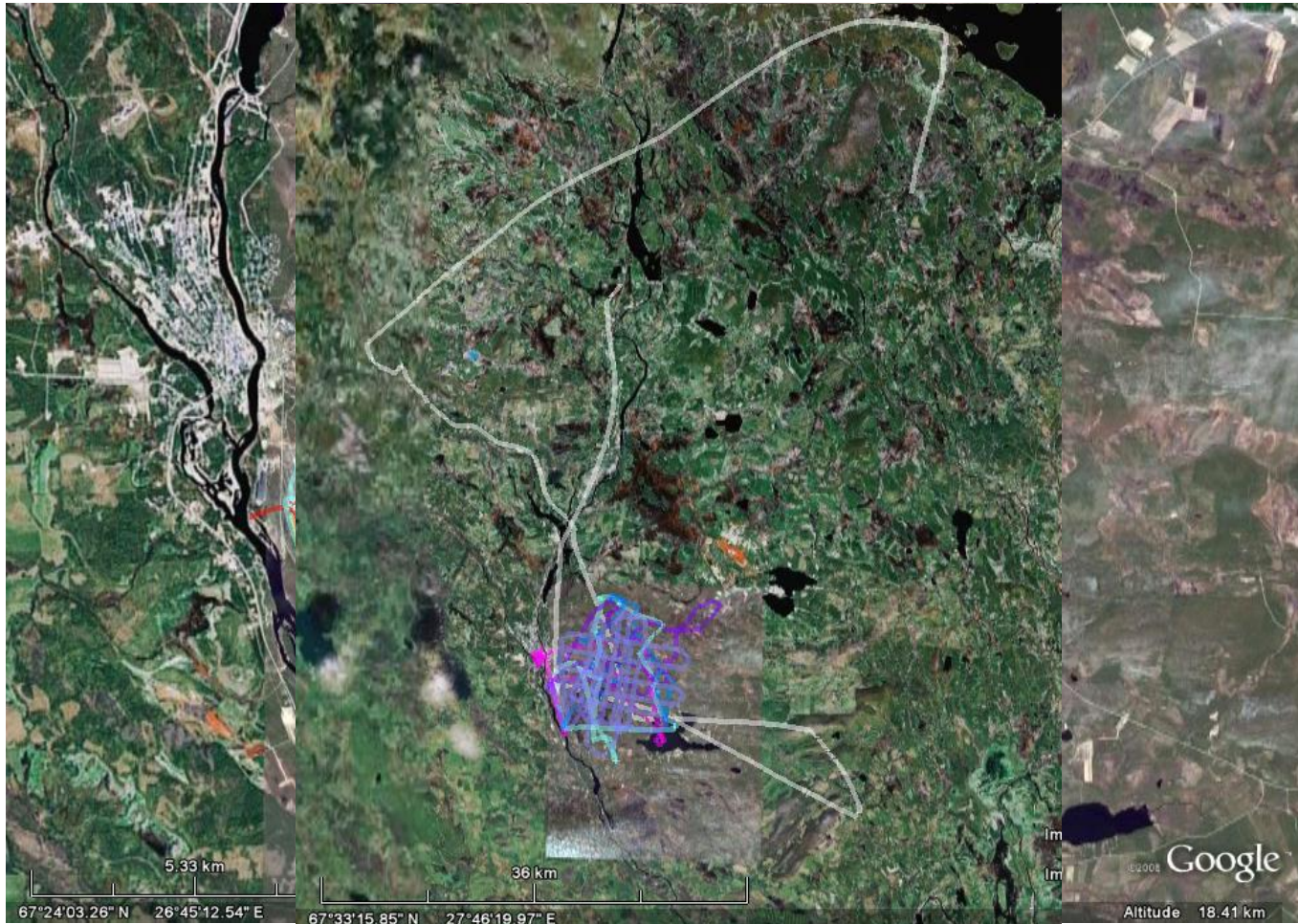


Land cover

Centre 67° 24.637'N, 26° 46.592'E (WGS84)



Flights in April 2009

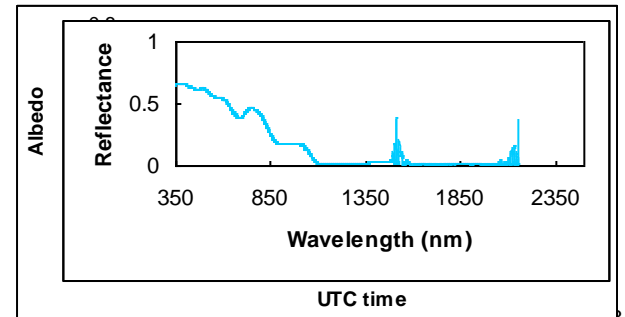
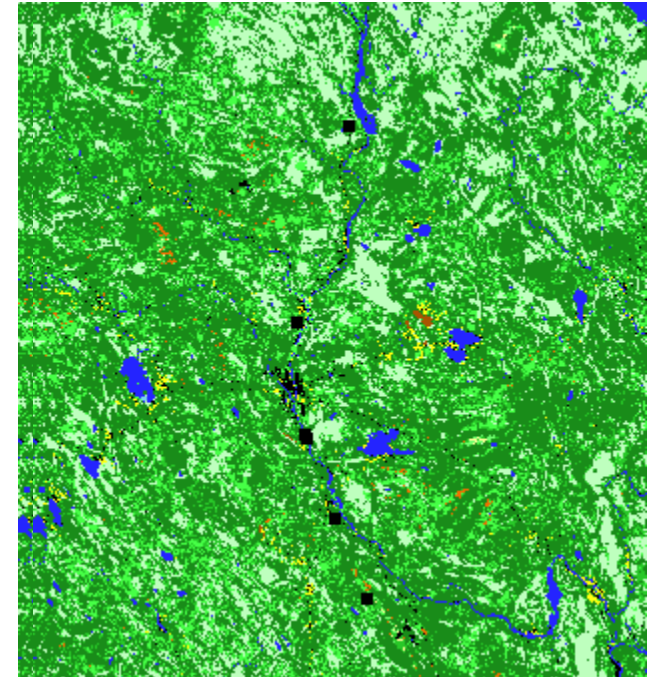
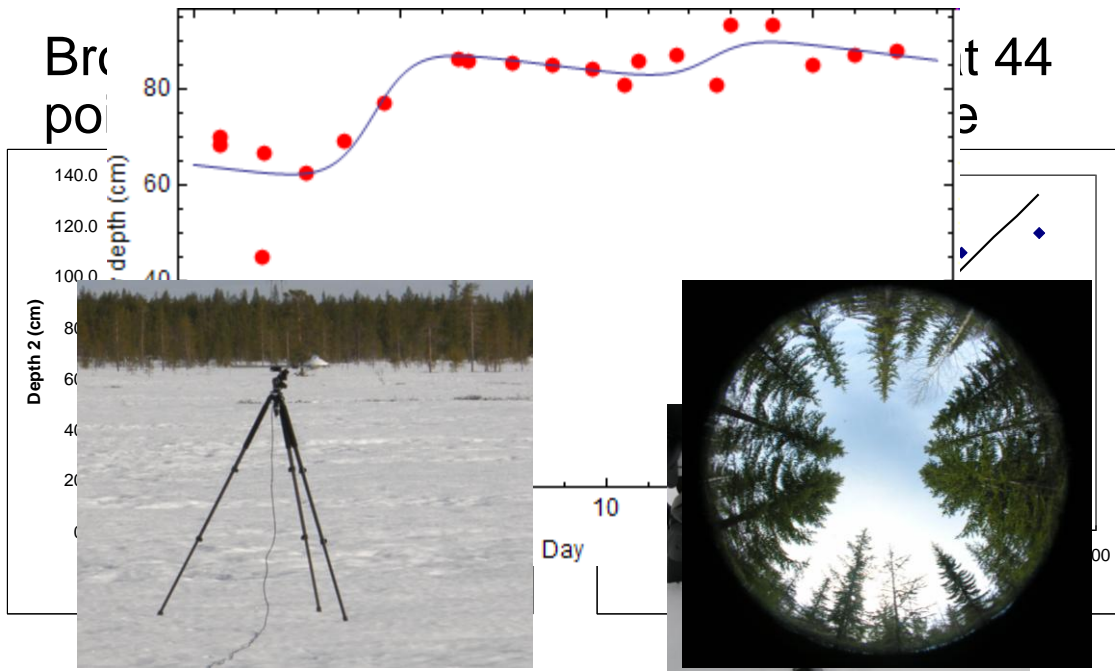




Ground measurements April 1-18, 2008

- Altogether 118 snowpit measurement sets, out of which 23 at the NorSEN-mast (the last measurement of each day)
- 30 snowpit measurement points outside Tähtelä measured twice

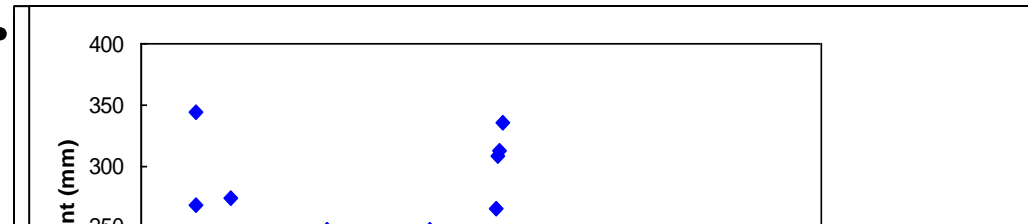
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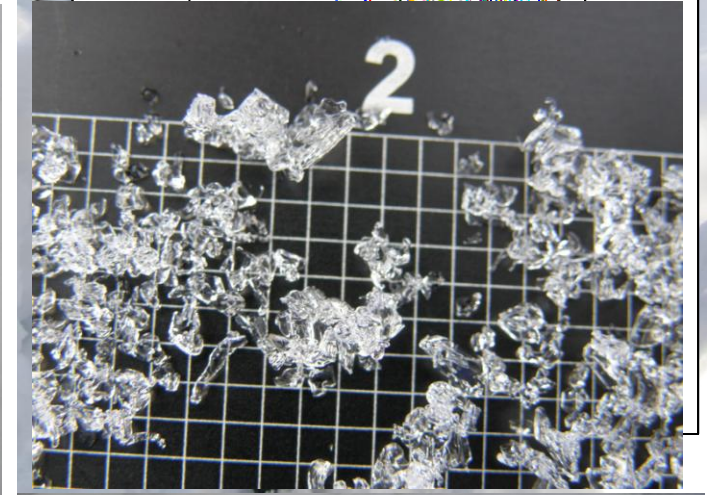
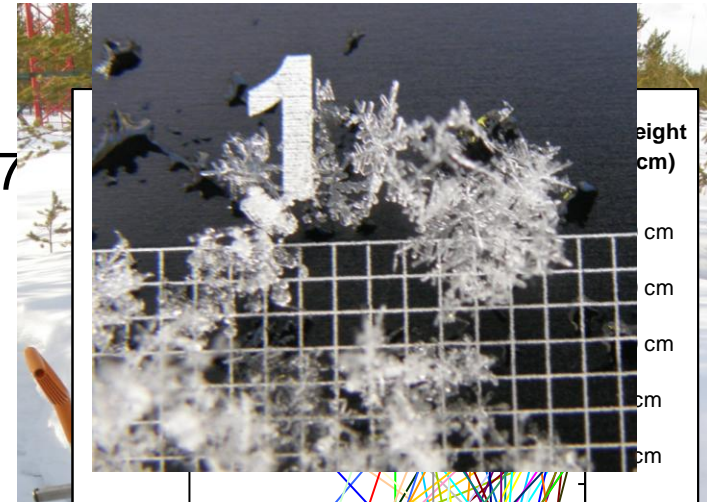


Snow pit measurements April 1-18, 2008

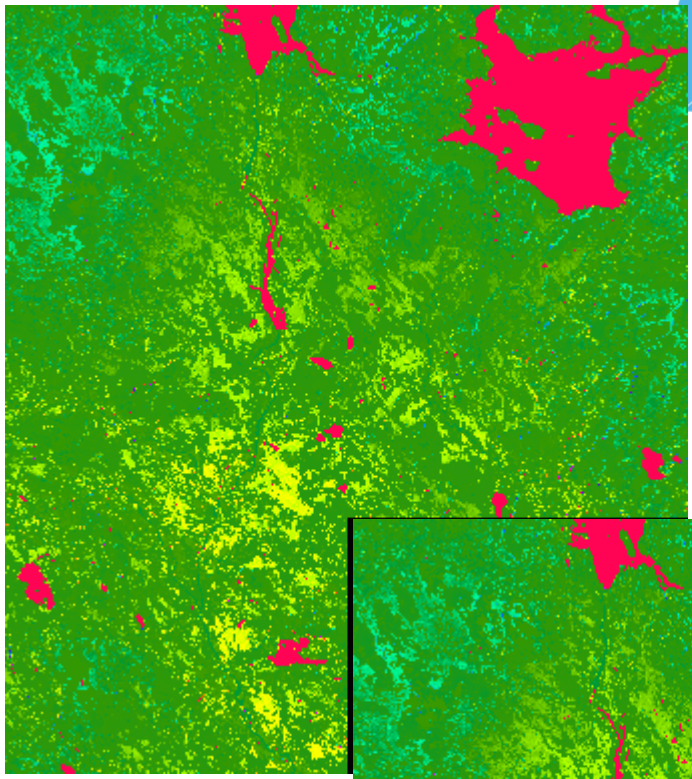
- Snow depth, density, snow water equivalent (SWE): more than 100 values
- Humidity and temperature profiles of snow at 7 measurements points



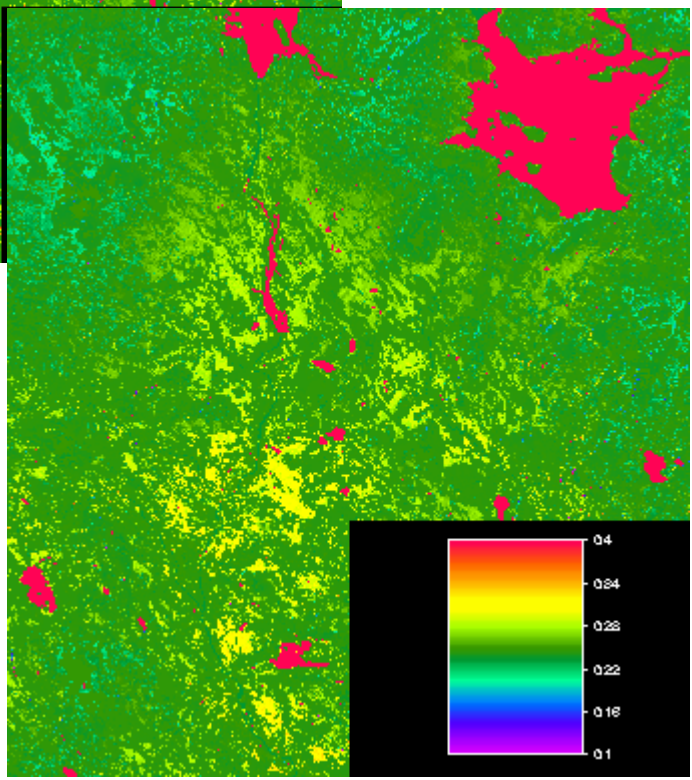
and



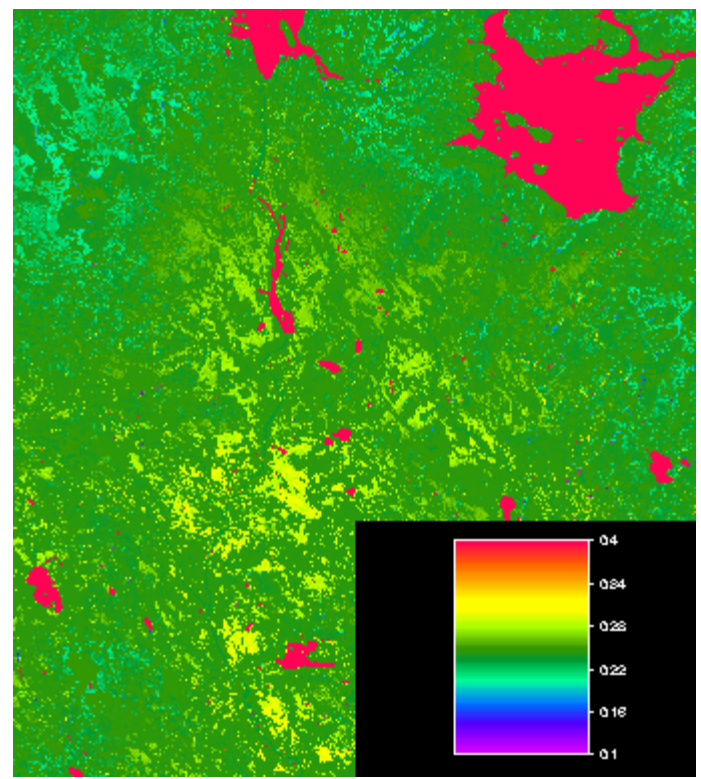
Snow SWE density along the highlights



April 3, 2008



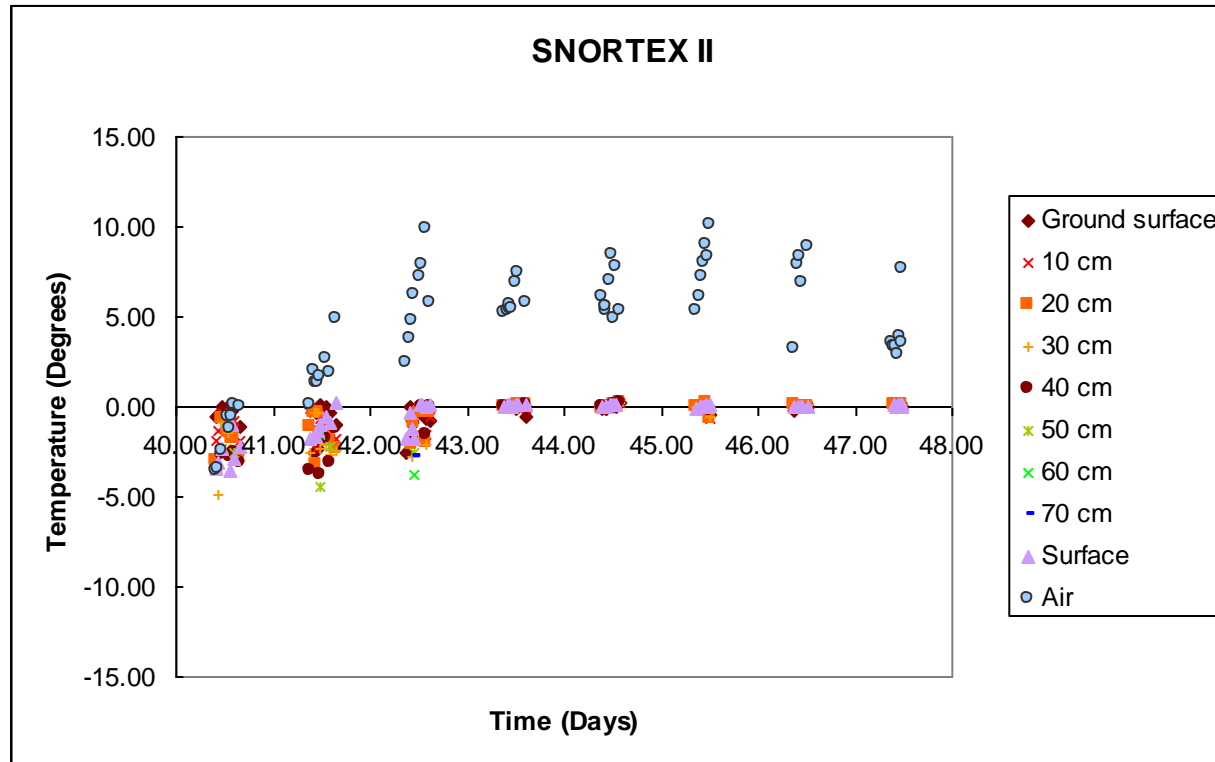
April 7, 2008



April 10, 2008

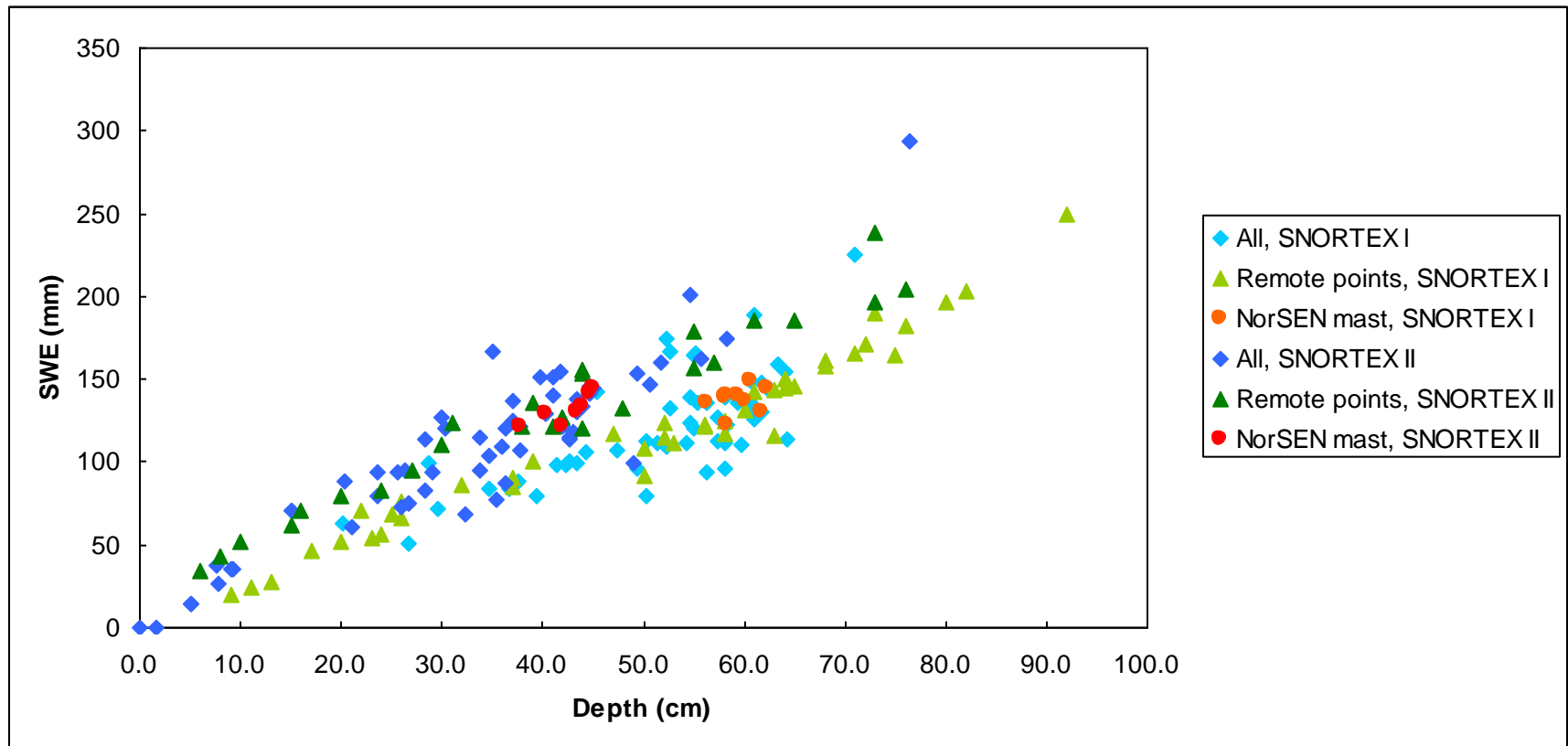


Temperature during SNORTEX 2009 I and II





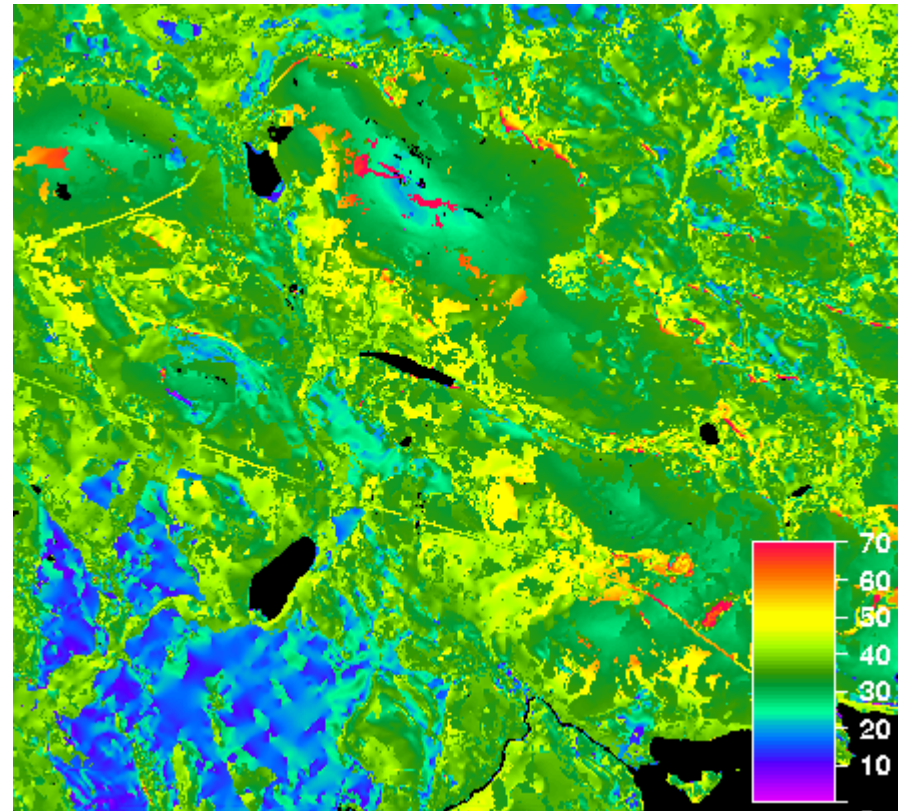
Snow water equivalent vs. depth in 2009





Snow depth generalization in 2009

- The snow depth varies with
 - Time
 - Land cover class
 - Terrain height
 - Terrain slope
 - Terrain aspect
 - Sun zenith angle
 - Sun azimuth angle



Open bogs $R^2=0.81$

Coniferous forests $R^2=0.86$

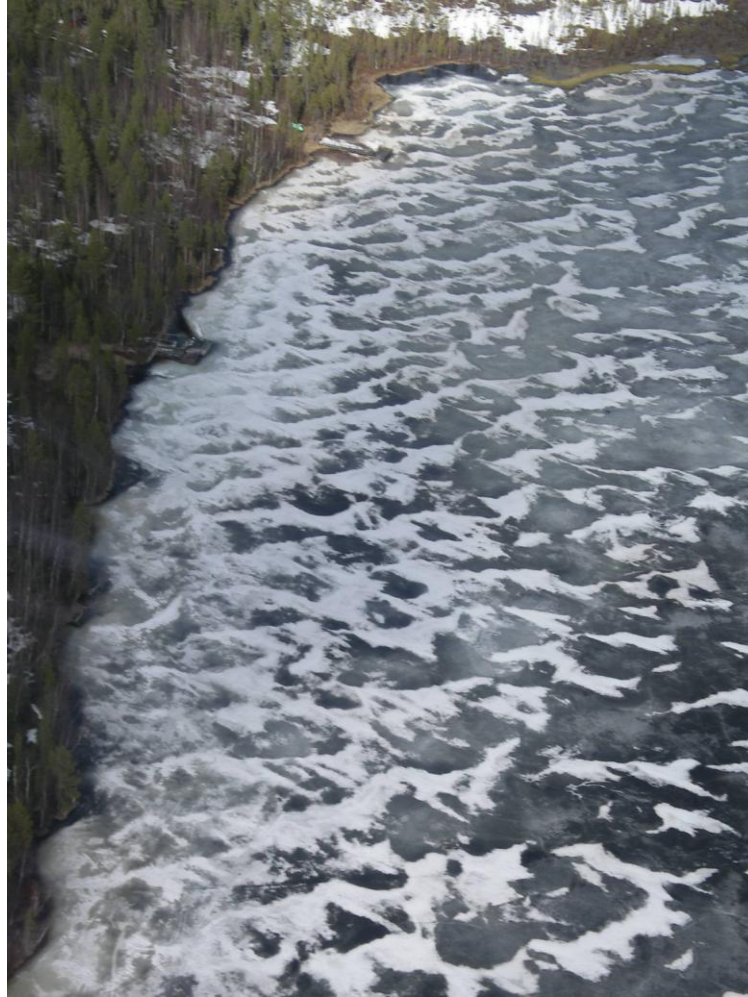
Deciduous and mixed forests $R^2=0.86$

Sparse forests $R^2=0.74$

March 7, 2009



Melting season and fractional snow cover





Grain size

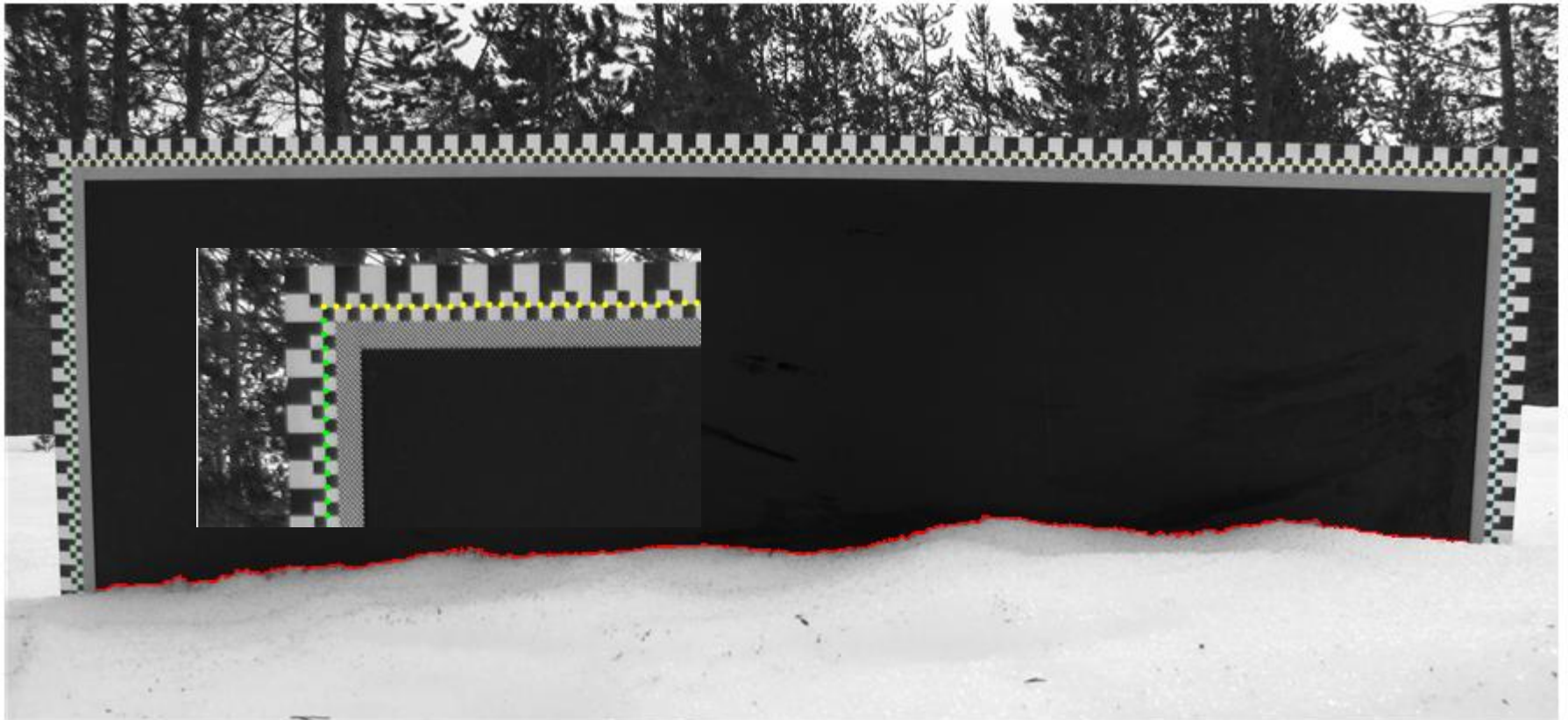




Snow surface roughness measurements

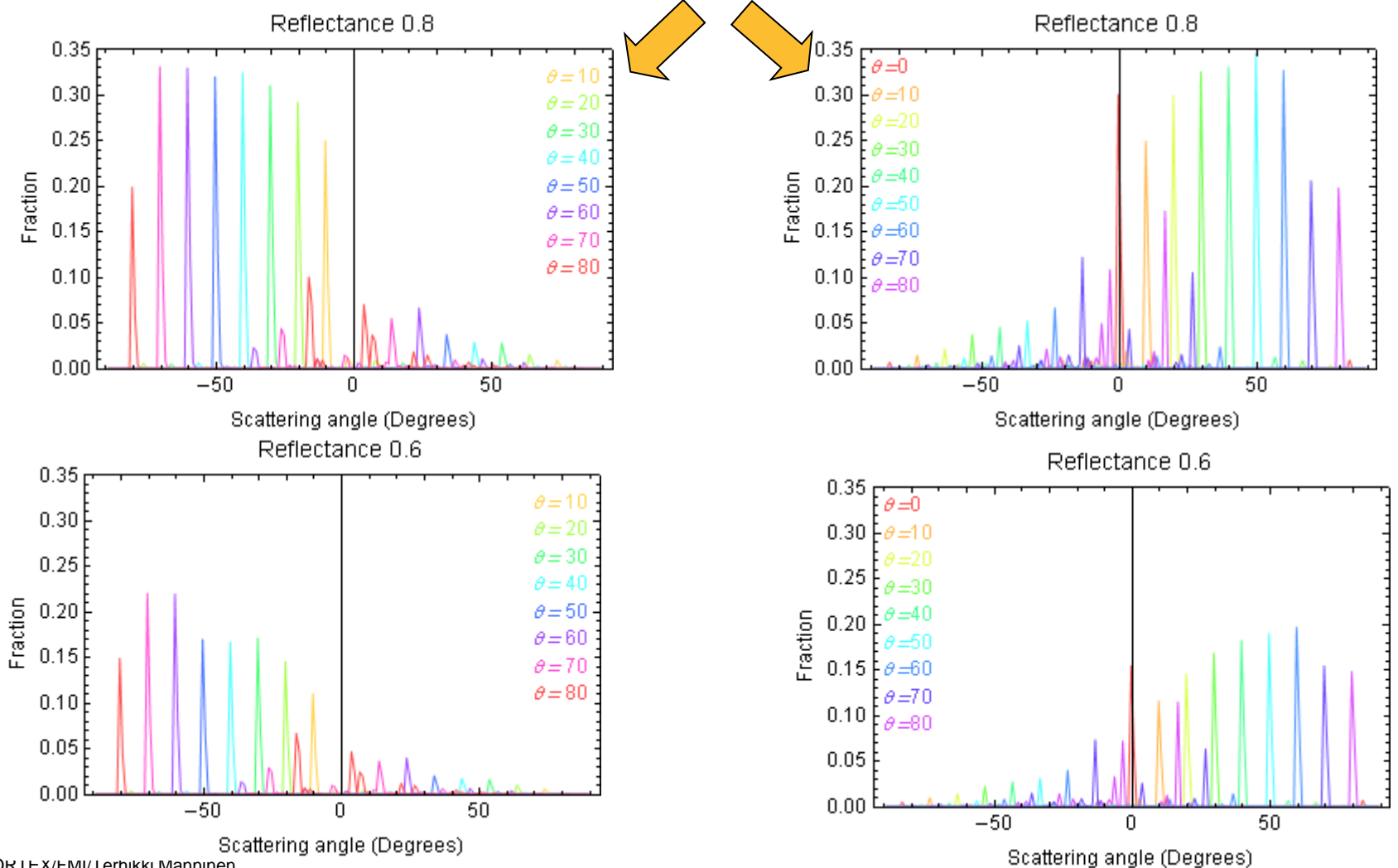
Tacymeter measurements: 0 ... 50 m

Plate measurements: 0 ... 1 m





Snow surface directional reflection at NorSEN mast





Albedo from pyranometer data





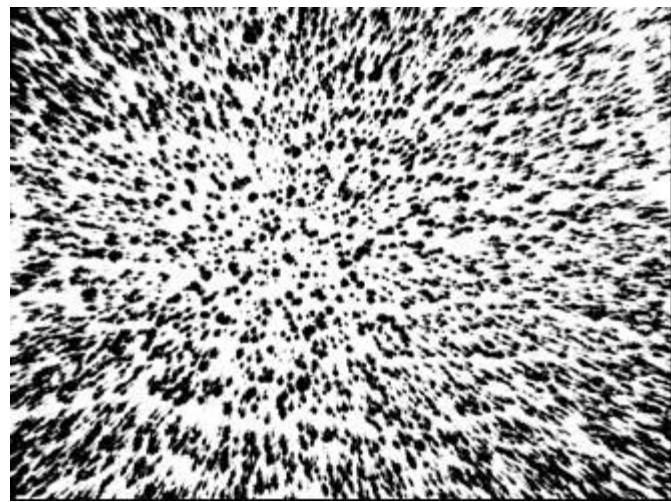
Example of original and thresholded images of one vertical profile of Karhukamera



Altitude
25 m

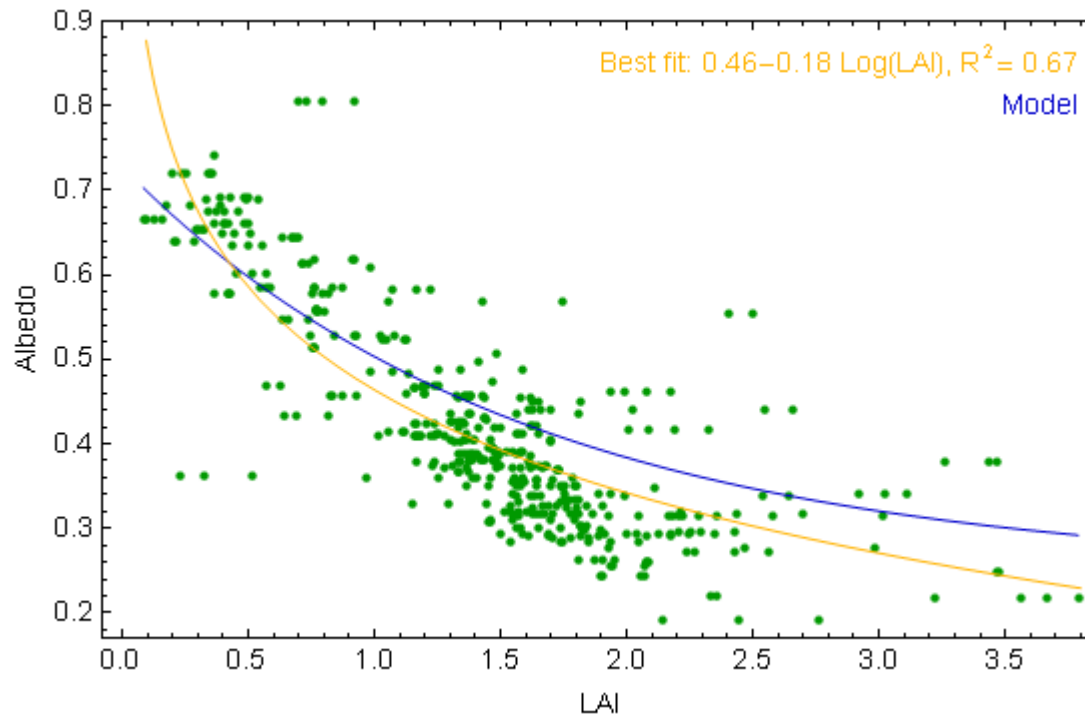


Altitude
210 m





Airborne white-sky albedo vs. LAI profiles





Conclusions

- **Lots of good data to analyze => a lot of work**
- **First publications have come out**
 - **General campaign description:**
 - Roujean, J.-L., Manninen, T., Kontu, A., Peltoniemi, J., Hautecoeur, O., Riihelä, A., Lahtinen, P., Siljamo, N., Suokanerva, H., Sukuvaara, T., Kaasalainen, S., Aulamo, O., Aaltonen, V., Thölix, L., Karhu, J., Suomalainen, J., Hakala, T., and H. Kaartinen, 2009. **SNORTEX (Snow Reflectance Transition Experiment): Remote sensing measurement of the dynamic properties of the boreal snow-forest in support to climate and weather forecast: report of IOP-2008**. 2009 IEEE International Geoscience & Remote Sensing Symposium, July 12-17, Cape Town, South Africa (Paper 1167).
 - Jean-Louis Roujean, Terhikki Manninen, Timo Sukuvaara, Jouni Peltoniemi, Sanna Kaasalainen, Olivier Hautecoeur, Panu Lahtinen, Aku Riihelä, Niilo Siljamo, Milla Lötjönen, Tuure Karjalainen, Anna Kontu, Hanne Suokanerva, Osmo Aulamo, Juha Lemmetyinen, Juha Suomalainen, Teemu Hakala, Harri Kaartinen, Laura Thölix, Outi Meinander and Juha Karhu, 2010, **SNORTEX: Remote sensing measurement of snowmelt in European boreal forest**, iLEAPS Newsletter Issue No. 9, April 2010, 56-58.
 - **Snow BRDF ground measurements:**
 - Peltoniemi, J., Hakala, T., Suomalainen, J., and E. Puttonen, 2009. **Polarised bidirectional reflectance factor measurements from snow, soil and gravel**. *J. Quant. Spectrosc. Radiat. Transfer*, Vol. 110, 1940-1953.
 - Jouni I. Peltoniemi, Terhikki Manninen, Juha Suomalainen, Teemu Hakala, Eetu Puttonen and Aku Riihelä, 2010, **Land Surface Albedos Computed from BRDF Measurements with a Study of Conversion Formulae**, *Remote Sens.* 2010, 2, 1918-1940; doi:10.3390/rs2081918.
 - **Airborne LAI measurements:**
 - Terhikki Manninen, Lauri Korhonen, Pekka Voipio, Panu Lahtinen and Pauline Stenberg, 2009, **Leaf Area Index (LAI) Estimation of Boreal Forest Using Wide Optics Airborne Winter Photos**, *Remote Sensing*, 2009, 1(4), 1380-1394.
 - Terhikki Manninen, Lauri Korhonen, Pekka Voipio, Panu Lahtinen and Pauline Stenberg, 2010, **ESTIMATION of Boreal forest LAI in winter conditions: test of a new method using wide optics airborne images**, *Proc. of IGARSS'10*, July 25 - 30, 2010, Honolulu, Hawaii, CD, 4p, in press.



Thank you
for
your
attention!

