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Action

Action 5 – In situ data collection and processing by SYKE

LIFE+ PROJECT NAME or Acronym

SNOWCARBO

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List of key-words and abbreviations

ARF	Agrifood Research Finland
CORINE	EU Coordination of information on the environment- program. Here CORINE refers to the land cover dataset created under CORINE- program
FMI-ARC	Arctic Research Center of the Finnish Meteorological Institute
Field Spec Pro	Field Spectrometer Professional (model of a measurement device)
GIS	Geographic information system
GSF	Geological Survey of Finland
JSBACH	Jena Scheme for Biosphere-Atmosphere Coupling in Hamburg. A land surface – atmosphere model built in the Max Planck Institute for Meteorology Hamburg.
mmu	Minimum mapping unit
MPI	Max Planck Institute for Meteorology
NDVI	Normalized Difference Vegetation Index
REMO	Regional Climate Model
SCA	Snow covered area
SNOWCARBO	Alias for the project "Monitoring and assessment of carbon balance related phenomena in Finland and Northern Eurasia"
SYKE	Finnish Environment Institute
WMS	Web map service

1 Summary

In 2010 two major field campaigns were conducted. The spring field campaign was conducted in the Arctic Research Center of the Finnish Meteorological Institute (FMI-ARC) in March. The spring field campaign focused on measurements of the physical properties of snow. The autumn field campaign in September was done in Inari, the North-Western part of Finland. The autumn campaign included validation of the land cover datasets and measurements of forest parameters. Additionally, observations on the plant phenology and spectral optical properties of vegetation were made.

The in-situ data has been extensively used while developing the methods for extracting the carbon exchange related features from the time-series (Action 7), describing the development of snow cover and vegetation. The phenological observations have been compared against the time-series of vegetation index from satellite observations. Observations of the physical properties of the snow cover from the operational in-situ observation stations of Finnish Environment Institute (SYKE) and weather station network of the Finnish Meteorological Institute (FMI) have likely been used as a reference for time-series of snow covered area from satellite data. Additionally, the spectral measurements from the snow cover have been used as reference to satellite observations.

In the 1st In-situ Data Document the main datasets used in the SNOWCARBO project were introduced and the field activities from the first year presented. The second in-situ data document will describe the field activities during 2010 and other new in-situ datasets introduced in 2009-2010.

2 New datasets from 2009 and 2010

2.1 Operative datasets of SYKE

The operative observations by SYKE, introduced in the 1st In-situ Data Document (Action 5 – 1st deliverable) have been continued without major changes in 2009 and 2010. The FMI-weather station network, which was also introduced in the previous data document, is going through some what larger changes, as some of the observer based weather measurements have been replaced by automated measurements. A major change, in the view of the snow covered area (SCA) satellite retrieval algorithm, took place in the beginning of 2009 as the e-code observations at FMI- weather station observations were ceased.

2.2 WMS- aerial photograph service

SYKE has access to the Web Map Service (WMS) of aerial photographs library, maintained by the National Land Survey of Finland. The service has been implemented to SYKEs GIS-databases and is easily accessible using ArcGIS- software. The areal images are used as reference material for interpretation of satellite signatures and for planning the field campaigns.

2.3 Developing the SYKE spectral reflectance library

The SYKE SCA-algorithm has been extensively validated with in-situ measurements. Additionally, ground based spectrometer measurements can be used in analysing the accuracy of the algorithm. SYKEs reflectance library for snow cover has been built during several years, but as the field campaigns are temporally relatively short, the weather conditions state strongly the success of the field measurements. Therefore, the library still has some gaps, which are essential to fill in to make correct and accurate interpretations of the snow cover from satellite images. In SNOWCARBO project the reference library will serve in the interpretation of the SCA- time-series. In 2009 and 2010 the focus on the measurements with the spectrometer has been the shadowed and thinning snow covers, but the measurements have also been used in the interpretation of the satellite derived phenological index NDVI (Normalized Difference Vegetation Index)- time-series. Spectral response from the most abundant vegetation species were measured during autumn 2010 campaign.

2.3.1 Reflectance from snow cover

While making the interpretation of snow covered area (Metsämäki et. Al, 2005) from the satellite images, the image constitutes of three main contributors: 1) Snow covered ground, 2) snow free ground and 3) forest canopy. Furthermore, in high latitude the sun angle remains relatively low through out the year, and therefore induces shadows on the observed surface. The reflective spectrum of snow varies, depending whether the signal comes from sun lit surface or from snow cover shadowed by the surrounding cannopy. To better interpret the received signal, reflectance signatures from shadowed snow cover were collected to be compared with similar snow under direct sunlight, see Figure 1.

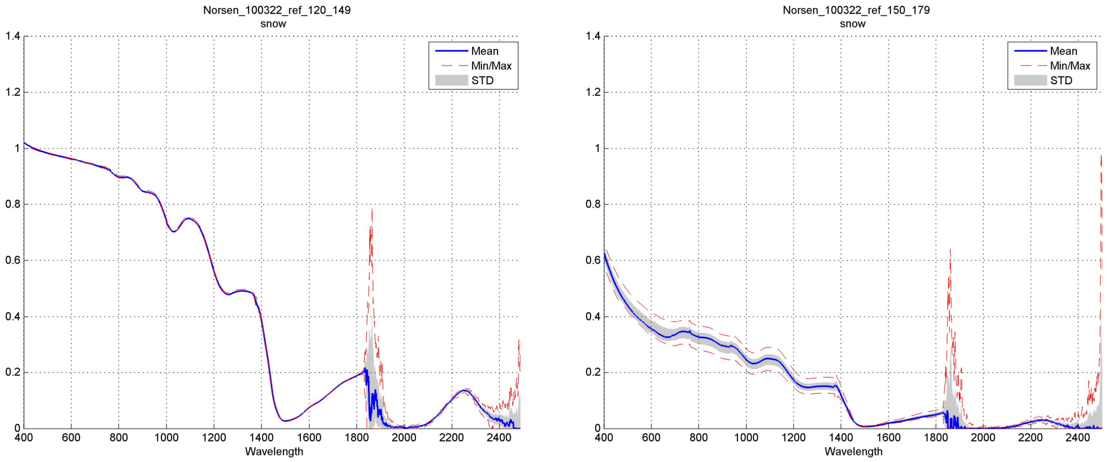

Figure 1. The difference in snow reflectance spectrum from snow under direct sunlight (left) and shadowed snow cover (right).

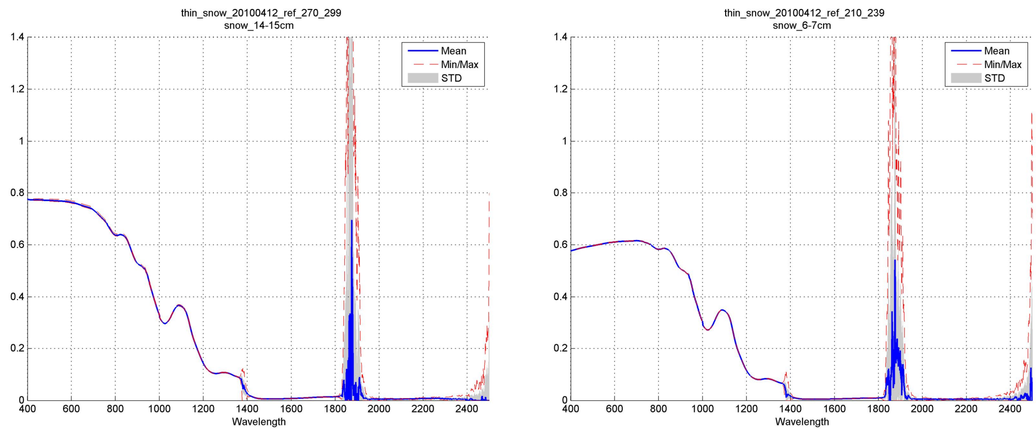

Figure 2. The difference in snow reflectance spectrum from snow under direct sunlight in late stages of melting period. Reflectance from 14-15cm cm snow cover (left) and 6-7cm snow cover (right).

Additionally, thinning snowpack introduces further variation to the signal from the snow cover. As the snow cover gets thin the penetrating reaches the underlying ground which alters the spectral signature significantly. Simultaneously the melting period introduces strong changes in the optical characteristics of snow, such as the grain size, density, introduction of ice layers etc. Therefore, spectrometer measurements from the late stages of the seasonal snow cover were made. Figure 2 shows the effect of snow depth on measured spectrum.

2.3.2 Reflectance from specific vegetation

Additionally to the snow cover, spectral measurements were carried out in the Kaamanen fen- type mire. The site displays different characteristics, than other vegetation types, in the satellite derived NDVI, which is related to the phenological status of the vegetations (see the Action 7 report: Progress report on extracted features, for details). To have a better understanding of the signal, the spectral response in the beginning of the dormancy season was measured for following species (see Figure 3 for sample measurement targets):

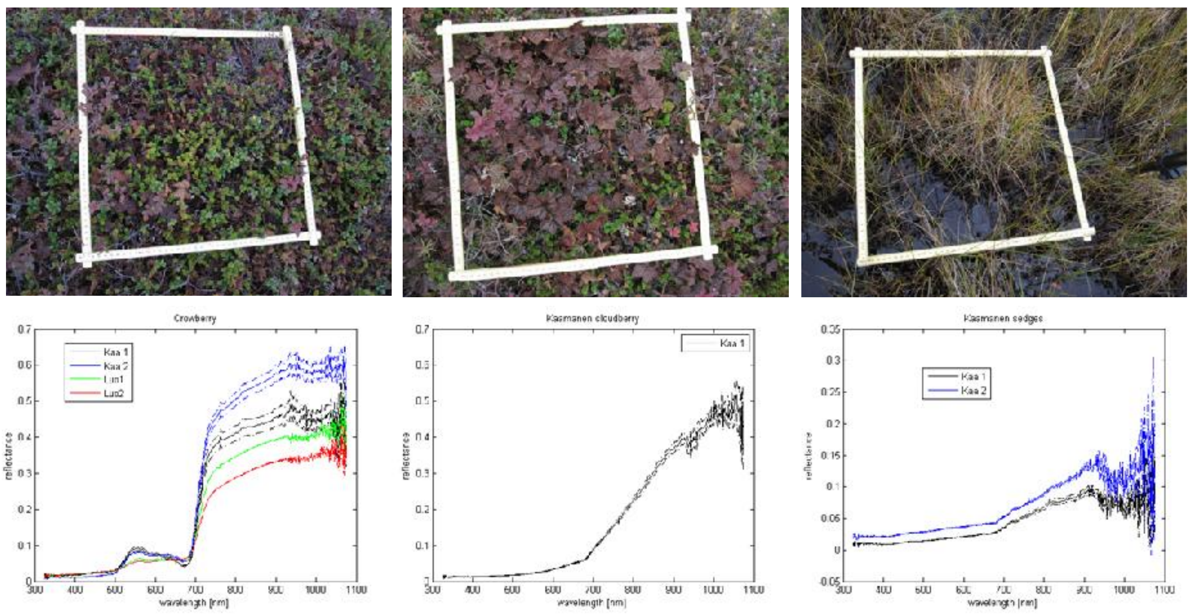

Figure 3. Samples of photographs from ASD spectrometer measurement targets and related measurements. Targets fro left to right: Crowberry, Cloudberry, Sedges. The different colours represent different

2.4 Land cover data validation and reference measurements

During the course of the project, several different land cover datasets have been used to re-allocate the original land cover dataset used in the modelling system of REMO-JSBACH (Regional climate model and the land surface model from the Max Planck Institute for Meteorology Hamburg (MPI)), used in the SNOWCARBO- project for the resulting CO_2- flux and concentration estimates (see Action 11 deliverable: Evaluation of required North-Eurasian land cover information).

Uncertainty exists also in the spatially more accurate land cover datasets, e.g. GlobCover and CORINE- land cover classifications. Therefore, validation of the land cover datasets is needed. This work has been done for some selected land cover types, where the uncertainty has been the largest, during the autumn field campaign in 2010. Sparse northern boreal forests have proven to be difficult for re-allocation of the model land cover dataset, yet the forest. Quantitative methods can be used to further classify the boreal forest areas for more accurate representation of boreal forests in the modelling system.

Land cover validation

The geographical coordinates were determined with hand held GPS- navigator. The accuracy of the coordinates is ~5-10m, depending on the equipment and the satellite constellation during the measurement. The site was evaluated for the correct CORINE- classification by 2-3 people to determine the correct class. Additionally, photographs were taken at each site for further reference.

Forest parameters

Forests have a strong role in the climate, especially in the boreal areas, where large areas are covered by mainly coniferous forests. Their effects on the local and regional climate depend on the internal properties. Therefore, the forest parameters are used in the classification of different forested areas in the creation of land cover datasets. The forest can be characterized by several parameters. Here the parameters and the measurement methods used in SNOWCARBO- project are described. Following parameters were measured or estimated in the field: tree height, tree basal area, mean tree diameter, mean age of the forest plot and crown cover of the forest plot.

The average tree height in the plot was determined against a 4m reference pole. Tree basal area of growing trees was determined using relascope (see Figure 4), separating the coniferous and deciduous trees. The mean tree diameter was measured from the plot and later the plots were classified in two categories (> 15cm and < 15cm). The mean age of the trees was estimated by the experts on the field, while considering the latitude, height above the sea surface and the width and height of the trees. Also the main ground vegetation species was determined. From the measured forest parameters the crown cover of the forest can be estimated. This is important parameter in determining the stem volume of the forest (Tomppo et. al 2008), which is also an indicator of the forests ability to absorb and store CO_2.

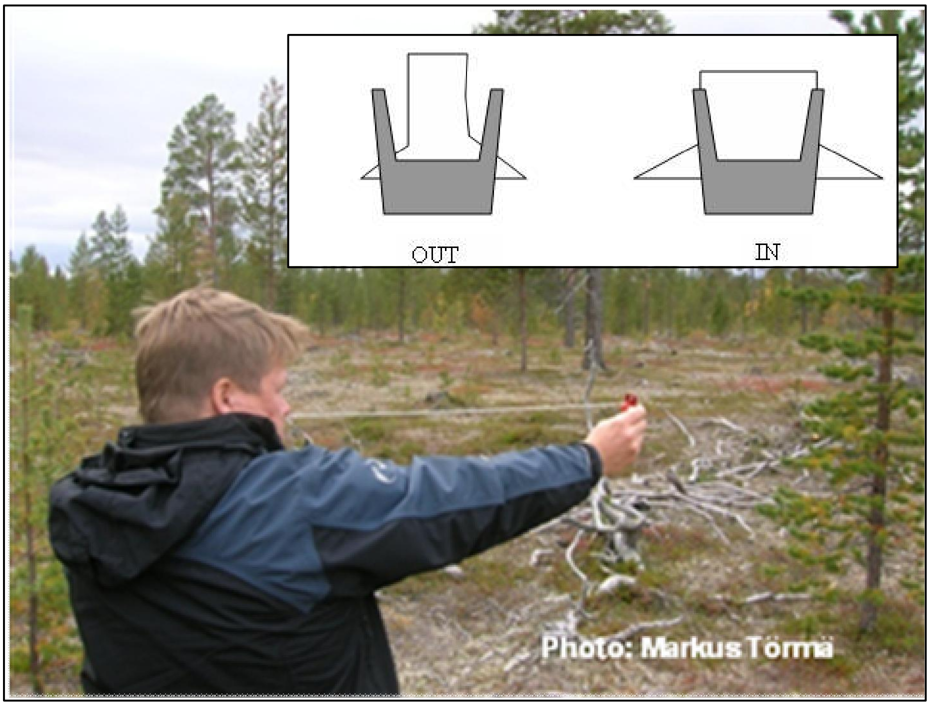

Figure 4. Determination of tree basal area with a relascope (small schematic picture). The observer watches through a gap in a sight-disc at 60cm distance. If a tree fills the inside the gap it is counted in, if the tree does not fill the gap, it is not counted in. If the tree is approximately the size of the gap, every other tree like this is counted in. The number of trees included can be used to determine the basal area of the trees. The method was used during the autumn 2010 field campaign in Inari (photo).

2.5 New soil databases

Two new soil databases have been acquired to SYKE and their applicability in constructing the land cover datasets for the CO_2- modelling efforts in SNOWCARBO is currently evaluated. The modelling system of REMO-JSBACH (Regional climate model and the land surface model from the Max Planck Institute for Meteorology Hamburg (MPI)) has several soil related parameters, which seem to have relatively strong effect on the local climate. Therefore, it is important to consider the underlying soil in the land cover classification for the modeling system.

Soil database from Agrifood Research Finland

Agrifood Research Finland (ARF) has produced a soil database based on international WRB (World Reference Base for Soil Resources)- classification in 1:250 000 scale. Full national extent for the soil database was completed in 2009. The dataset represents the soil within the top 1m of the soil. Additionally to the distribution of soil types, numerical data on particular soil properties are often required. The WRB classification contains 32 classes. In Finland 10 of these classes are present with certainty and 2 classes are likely to exist, but were not detected in the in-situ observations. The WRB classification is mainly based on morphological properties (such as color and texture etc.). In the ARF soil database information from other soil classifications are additionally given, as well as the land use determined from the CORINE- classification. Numerical values are also provided for five physical and chemical properties (soil pH, cation exchange capacity, clay content, organic content, density). The minimum mapping unit (mmu) for the dataset is 6,25ha.

General soil classification of the Geological Survey of Finland

The survey for 1:200 000 scale soil classification started in 2002 by the Geological Survey of Finland (GSF) to support the construction the ARF- soil database. By 2009 the GSF- soil database covered entire Finland and made it possible to complete the ARF- soil database. The general soil classification of GSF contains 21 classes for the top 1m of soil and for bare rock formations, mmu being 6ha. The classification does not carry any numerical information.

Although neither of the two soil databases offers soil parameters that would be needed in the correct land cover classification for the CO_2- modelling system, they offer a good starting point for further development. In the next steps the possibility of finding numerical information on the water holding capacity of the soil classes will be examined.

3 In-situ field campaigns in 2010

The winter 2010 provided a period of good weather for snow observations in March in Sodankylä. During the week long campaign several good observation periods were conducted. At the same time several other institutes from different parts of Europe were conducting their own field work, which allowed good exchange of information. The aim of the winter 2010 field campaign was to fill some of the gaps identified in the spectral database from snow cover. Additional measurements were conducted later in the spring in the vicinity of Helsinki, but the weather conditions were more difficult during the period. Some valuable observations were still obtained. The autumn campaign 2010 focused on validation of the land cover datasets developed for the modelling in Northern-Finland, where the sparse boreal forest is difficult to classify correctly from satellite images alone.

3.1 Spring 2010 campaign

The winter campaign in 2010 took place at the Arctic Research Centre of the Finnish Meteorological Institute in Sodankylä (FMI-ARC) between 13th and 23rd of March 2010. Main objective of the campaign was to complement the snow reflectance dataset with measurements from shadowed snow cover, under different snow conditions. Altogether 19 sites were measured for spectral reflectance with the Spectrometer from sun lit snow and shadowed snow cover. Other reference data from snow pits were also measured from each site (see Action 5- deliverable: 1st in-situ data document (SYKE) for details).

Thinning snow cover during the melting period was measured on two days. The weather conditions on both days were very good in the morning with clear skies. On the first day the measurements were carried on a grass field between a thick forest and an agricultural field close to Nuuksio national park ~30km north-west from Helsinki. Some thin clouds gathered in the afternoon, but measurements from snow covers between 5 and 20cm depth were obtained, giving a good indication on the variation of reflectance during melting period. On the second day, scattered clouds started to gather quickly and only few measurements were obtained from a small opening in a mixed forest near a small road in Vihti ~50km north-west from Helsinki. Snow pit measurements were gathered at all sites.

3.2 Autumn 2010 campaign

The autumn 2010 campaign was done in North-Western part of Finland (see coordinates and map in Annex 1 and Annex 2, respectively). The campaign was conducted between 5th and 9th of September in 2010. To validate the land cover datasets, especially the classification of boreal forests, the validation sites were pre-selected (roughly) and evaluated at the site for correct class. The following parameters were observed at each site:

- Geographical coordinates
- In-situ evaluation of the land cover class
- Measurements of the following forest parameters:
  - Tree height
  - Tree basal area
  - Mean diameter of trees (binary data: <15cm or >15cm)
  - Mean age of trees (estimate)
  - The main species in ground vegetation

One of the CO_2- flux measurement sites is located on the Kaamanen fen in Inari. The vegetation index- time-series derived from the satellite images showed somewhat different behaviour (see Action 7 – deliverable: Progress report on extracted features). Therefore the area and the area covered by the MODIS (Moderate Resolution Imaging Spectrometer)-satellite pixels, used to determine the time-series for the site, were examined in detail from areal images and by visiting the measurement site. Additionally, spectrometer measurements were done on the most abundant vegetation species at the site. Following species were mesured:

- Crowberry
- Cloudberry
- Bilberry
- Sedges (species not determined)
- Downy birch
- Lichen

The weather conditions were favourable during the autumn 2010 campaign and the plan was carried out to the full.

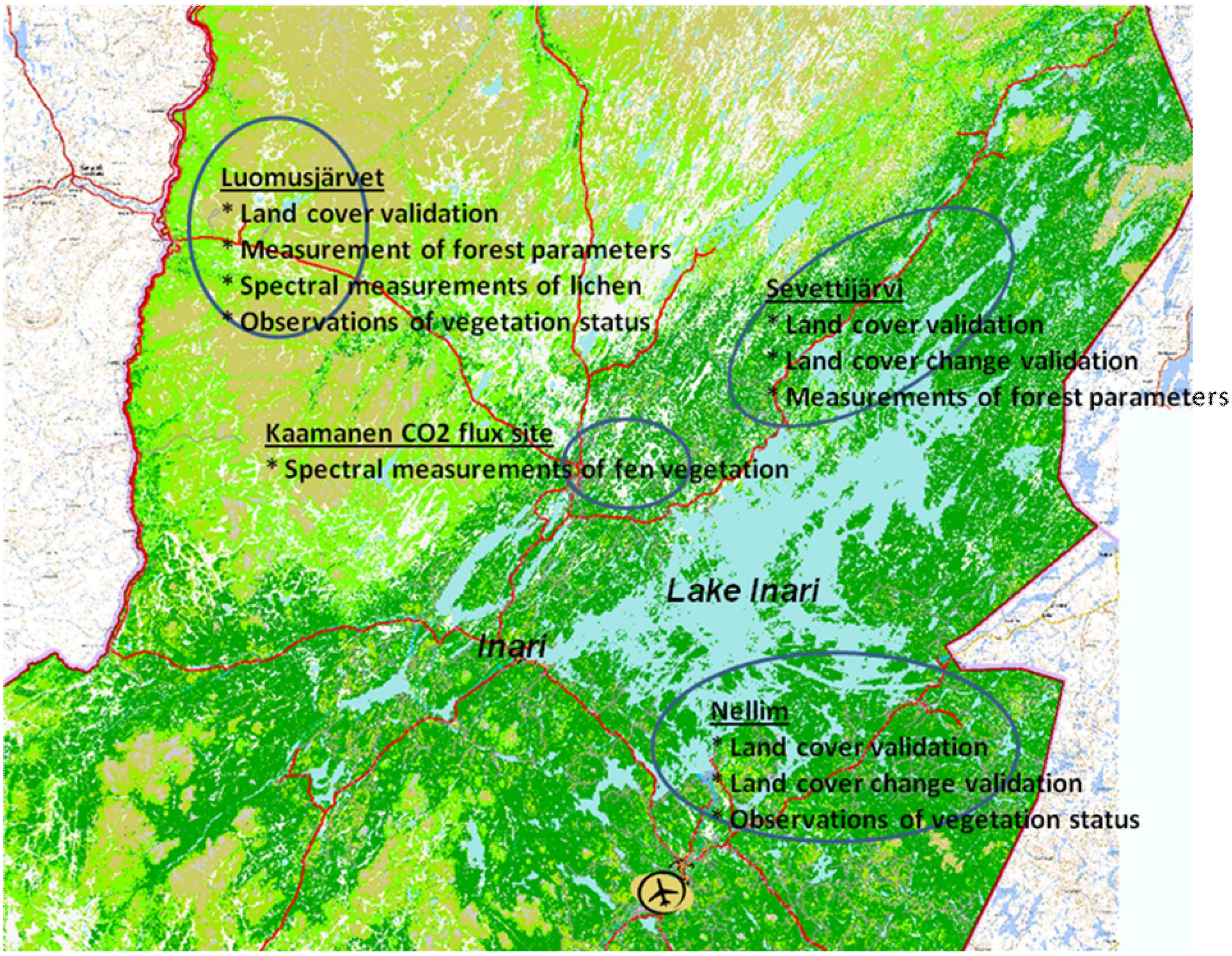

Figure 5. Field campaign sites in autumn 2010 in Inari and activities.

References

Metsämäki, S., S. T. Anttila, M. J. Huttunen and J. M. Vepsäläinen. 2005. A feasible method for fractional snow cover mapping in boreal zone based on a reflectance model. *Remote Sensing of Environment*, Vol. 95, p.77-95. 2005.

Tomppo, E., H. Olsson, G. Ståhl, M. Nilson, O. Hagner and M. Katila. 2008. Combining national forest inventory field plots and remote sensing data for forest databases. *Remote Sensing of Environment*, Vol. 112, p. 1982-1999. 2008.

Annexes

Annex 1. Locations of land cover validation and forest parameter measurement sites.

id	Ykj- north	Ykj- South
1	7630742	3541450
2	7639769	3549855
3	7639709	3549923
4	7639681	3549967
5	7639710	3550026
6	7639808	3549957
7	7642165	3553241
8	7642175	3553289
9	7642155	3553409
10	7642049	3553472
11	7641997	3553597
12	7640711	3554547
13	7640454	3554633
14	7639490	3558020
15	7639522	3557983
16	7639608	3558046
17	7637362	3559187
18	7637438	3558650
19	7630499	3550998
20	7713179	3564863
21	7713101	3564971
22	7713200	3565154
23	7713332	3565284
24	7713405	3565346
25	7713418	3565592
26	7713380	3566037
27	7713334	3566140
28	7713669	3566031
29	7713620	3566050
30	7713920	3566021
31	7714024	3566032
32	7714104	3566021
33	7714373	3565731
34	7714266	3565532
35	7714031	3565282
36	7716746	3558527
37	7716776	3558587
38	7716651	3558472
39	7716602	3558482
40	7681514	3533310
41	7681550	3533266
42	7677993	3533400

43	7673270	3510770
44	7673308	3510674
45	7673449	3510535
46	7673497	3510581
47	7673470	3510680
48	7673244	3510832
49	7652124	3504864
50	7649933	3502420
51	7649688	3502364
52	7701763	3465422
53	7701938	3465392
54	7702200	3465680
55	7702440	3466024
56	7702661	3466369
57	7702959	3466728
58	7703497	3466881
59	7703805	3467242
60	7704147	3467414
61	7704395	3467676
62	7704763	3467950
63	7705200	3468189
64	7706397	3469126
65	7706624	3469116
66	7706708	3469091
67	7706510	3468764
68	7706375	3468904
69	7706365	3469072
70		
71	7704229	3460002
72	7704767	3460240

Annex 2. Map illustrating the land cover validation sites.