LIFE Project Number

LIFE07 ENV/FIN/000133

Progress Report

Covering the project activities from 01/01/2011 to 29/06/2012

Reporting Date

29/06/2012

LIFE+ PROJECT NAME or Acronym

Monitoring and assessment of carbon balance related phenomena in Finland and northern Eurasia

Data Project

Project location	Helsinki
Project start date:	01/01/2009
Project end date:	31/12/2012
Total budget:	2155627 €
EC contribution:	1046759 €
(%) of eligible costs	49.09

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List of abbreviations

AMSR-E	Advanced Microwave Scanning Radiometer – Earth Observing System
ASCAT	Advanced Scatterometer
ASD	Analytical Spectral Device
AVHRR	Advanced Very High Resolution Radiometer
CEA-LSCE	Commissariat à l'énergie atomique – Laboratoire des Sciences du Climat et de l'Environnement
CO2	Carbon dioxide
CORINE	Coordination of information on the environment
EC	European Commission
ECMWF	European Centre for Medium-Range Weather Forecasts
ENVISAT	Environmental Satellite
EO	Earth Observation
ESA	European Space Agency
EU	European Union
FMI	Finnish Meteorological Institute
GAW	Global Atmospheric Watch
GMES	Global Monitoring of Environment and Security
GSE	GMES Services Element
JSBACH	Jena Scheme for Biosphere-Atmosphere Coupling in Hamburg
MERIS	Medium Range Imaging Spectroradiometer (onboard ENVISAT satellite, ESA)
mmu	minimum mapping unit
MODIS	Moderate Resolution Imaging Spectroradiometer (onboard Terra and Aqua Satellites, NASA)
NDVI	Normalized Difference Vegetation Index
QuikSCAT	Quick Scatterometer
SCA	Snow Covered Area
SMMR	Scanning Multichannel Microwave Radiometer
SSM/I	Special Sensor Microwave Imager
SWE	Snow Water Equivalent
SYKE	Suomen ympäristökeskus (Finnish Environmental Institute)

1 Progress

1.1 Actions

1.1.1 Action 1: Project management and monitoring

The general progress in the project has been very good. All activities within the Actions have been started on time and the progress is in line with the planned project schedule.

The project objectives and the work plan are assessed continuously by the project team during the project meetings including management and steering group meetings. All project objectives are so far found fully viable.

Many actions such as Action 2, 3, 4,5,6,7,8,11 are successfully completed. Actions such as Action 1, 9, 10, 12, 13, 14 and 15 are still continuing.

Important progresses of the project during this reporting period:

- 10 year REMO forecast runs with standard land cover
- Hourly climate inputs for JSBACH from REMO are ready
- Latest instantaneous offline JSBACH was implemented
- Site wise JSBACH runs for Hyytiälä and Sodankylä are ready
- Growing Season from site wise results are calculated
- Implementation of spin-up routine applying Cbalone
    - thus spin up is very fast
- Implementation of YASSO

Important part of the project Action 10 Generation of carbon assessment end-products is successfully started at the beginning of 2012. Action 12 Dissemination also was focus of the project during this reporting period. The carbon assessment end-products will be archived to the Sodankylä data centre. Using the erdas apollo data manager, the products will then be cataloged and managed to the Erdas Apollo geospatial server. Erdas Apollo uses the International Standards Organisation (ISO) 19115 for the generating metadata. Thus for SNOWCARBO, the INSPIRE metadata editor is used to generate and validate the metadata template. The carbon assessment end product metadata will be in XML format validated using the INSPIRE metadata validator. Also as part of dissemination SnowCarbo plans to utilize a portal Climateguide.fi which was created in an EU Life+ project (LIFE07 INF/ FIN/000152 CCCRP). This portal offers practical climate change information.

Project has been revised and following plan / milestones are planned and confirmed;

- 1st Project brochure update by 29.06.2012
    - Title “Modeling of natural background carbon balance and utilization of results in national and international greenhouse gas conventions and reporting”

- Snowcarbo Web-dissemination
    - Snowcarbo web-page by October,2012
    - ERDAS Apollo web-system by October, 2012
    - Ilmasto-opas.fi by 31.12.2012
- Dissemination Stakeholder Workshop by second week of January, 2013
- Project Brochure (FINAL) by 31.12.2012
- Layman's Report by 31.12.2012
- Carbon balance atlas for Finland and Baltic EU by 31.12.2012
- Synthesis report of project results for stakeholders and policy makers (in Finnish and English) by 31.12.2012
- After Life+ Plans by 31.12.2012

Following deliverables are successfully completed between 1.1.2011 and 29.06.2012

- 4th monitoring report –Action 1
- 5th monitoring report –Action1
- 6th monitoring report- Action1
- 30 month progress report – Action 1
- Report on End-user stakeholder meeting- Action 1
- 3rd year progress report- Action 1
- 3rd data document- Action 4
- 3rd in-situ data document- Action 5
- 2nd progress report on methodology- Action 6
- Final progress report on extracted features- Action 7
- 1st Brochure update- Action 12

1.1.2 Action 2: Satellite data processing by FMI

Action 2 is completed.

1.1.3 Action 3: Acquisition and extension of GMES-services GSE Polar View and GSE Land

Action 3 is completed.

1.1.4 Action 4: In-situ data collection and processing by FMI

Action 4 is responsible for providing the data used for running and evaluating the climate models. Two different data sets are prepared for these purposes: the input data and the validation data.

The input data set consists of initial and boundary forcing data which is needed by the models (REMO and ECHAM5, see Action 6 for details). The initial data for weather and tracer transport simulations is given in the form of meteorological fields and as maps of surface properties. In addition to the standard meteorological fields such as air temperature, liquid water content and wind velocity fields, the model also needs the initial atmospheric CO_2 concentration fields, fire information, anthropogenic sources and sea ecosystem CO_2 balance.

The validation data is based on the CO_2 flux and concentrations measurements of Finnish Meteorological Institute. The long-term flux sites cover various different ecosystems like wetlands, Scots pine forest and spruce forest in northern Finland and several ecosystems on peatlands in different agricultural and forestry use in southern Finland. These together with the background concentration measurements from Pallas-Sodankylä GAW station will be used for evaluating the model predictions.

The tasks of action 4 have progressed as planned during the reporting period (1.1.2011-30.6.2012). The input data has already been chosen prior to this period, but slight changes have taken place as the initial and boundary fields for meteorology are now taken from the ECMWF ERA-Interim data set. The measurements of the validation data has continued at the flux and concentration measurement stations of Finnish Meteorological Institute. The processing of the data into a form appropriate for model evaluation has been in progress and there are no major problems in the task. Data for model validation has been provided for Action 6 according to the modelers needs. The 3rd data document was written by the due date.

Method for determining the growing season beginning and end dates from CO2 flux data has been developed and the obtained data has been compared to similar information extracted from the satellite data in Action 7.

Deliverables & milestones since Mid-Term Report consist of preparing the data document for input and validation data and processing the data into a form appropriate.

Deliverables:

- 3rd Data document

Milestones:

- Processing the data into a form appropriate for model evaluation

1.1.5 Action 5: In-situ data collection and processing by SYKE

Action 5 has focused on collection and reporting of necessary in-situ and ancillary data to be used together with satellite image data in order to generate time-series from satellite data to describe the phenological events related to carbon exchange (Action 7 & 9). Additionally, in-situ measurements of forest parameters have been made in order to improve and validate the used land cover datasets (in Action 11, mainly the national CORINE- land cover), which again is used as an input to REMO-JSBACH model framework (in Actions 6 & 8) . The measured forest parameters can also be used to improve the satellite algorithm for detection of fractional snow covered area (SCA).

The SCA (snow covered area) algorithm used in the SNOWCARBO project to develop observational time-series and related phenological information from the seasonal snow cover in the Northern-Europe has been proven to perform well in the Boreal region.

The operational observation networks of SYKE and FMI have been producing data also for 2011. This data has been available for Actions 7 and 9 for further analysis. The winter 2010-2011 proved to be a relatively strong with snow fall and freezing lakes and rivers throughout Nordic countries, but also through the Baltic Sea drainage basin (e.g. Baltic countries, Poland Germany and Denmark).

To better understand the signal from satellite sensors the same target can be viewed with several different spatial resolutions (figure 1). The additional 5th field campaign allowed the snow cover in Sodankylä Cal/Val- supersite, to be viewed with in-situ spectrometry, airborne spectrometer AISA (Airborne spectrometer by Specim ltd.), which was operating in the area during the campaign (the data was also made available for SNOWCARBO- project) and from a mast-based spectrometer. As before measurements of snow characteristics were carried out in conjunction with the spectrometer measurements. Additional information also consisted of forest stand characteristics in the area. The main findings from these datasets, in view of the SCA- algorithm used (in Action 7) have been:

- Snow scatters more in forward and vegetation to backward direction. This should be remembered when interpreting signal from winter time where sun angle is still low and therefore, the imaging geometry plays a major role.
- Forest canopy dominates the signal even with relatively small (~40 %) crown covers Scandinavia is largely covered with dense forests, where the satellite signal is therefore largely affected by the scattering from vegetation.
- Reduction of snow reflectance is increasing with increasing snow grain size, irrespective of illumination conditions. The snow characteristics can have considerable effect on the signal during late stages of melting season, when effective grain size is at its seasonal maximum.

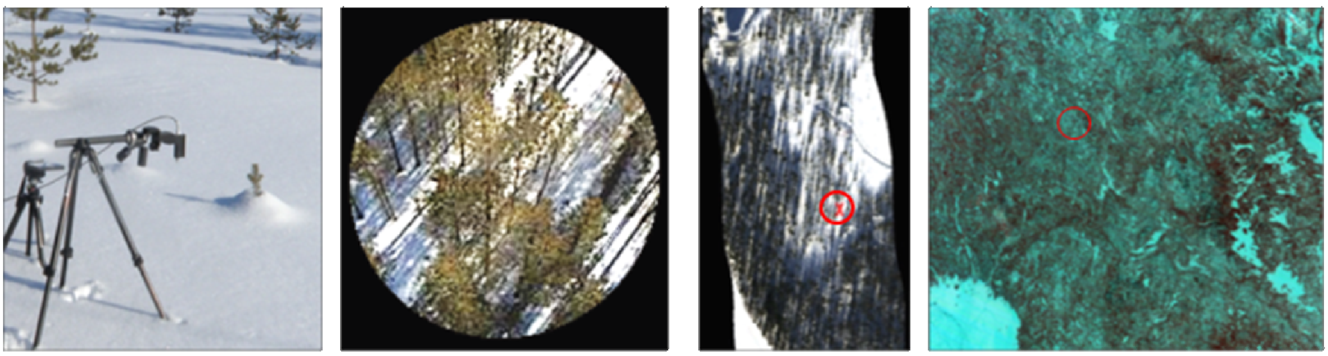


Figure 1: Different resolution of spectral imaging of snow cover. From left (1) Field spectrometer measurement setup; (2) Digital image from the footprint of mast based ASD FieldSpec Pro; (3) Sample dataset from AISA- airborne spectrometer (true colour image). Site of the mast based ASD spectrometer marked with red circle; (4) Subset from MODIS- Terra image from northern Finland. Sodankylä circled with red.

An additional field campaign was conducted at the Sodankylä Cal/Val supersite of Finnish Meteorological Institute:

5th field campaign: 2.-6.5.2011

The 5th field campaign had several functions. The timing of the critical stages of the melting is difficult in the latitudes of boreal forest in Scandinavia. The season rarely hosts long periods of clear weather. Scattered openings in cloud cover can be used to satellite observations of snow cover. The previous field season in the spring contributed to the spectral library from spring melting period, but the spectral measurements during the melting period were continued together with related snow pit measurements. The additional campaign was timed together with other activities in the area in order to receive most benefits from simultaneous measurements and exchange data with other experts in the area. Additionally, the forest parameters were measured from plots marked in figure 1, this information was used for reference for mast-based spectrometer measurements in Sodankylä supersite as well as for AISA.

Completed deliverables & milestones since Mid-Term Report:

Deliverables:

- 3rd in-situ data document

Milestones:

- Field measurement campaign in spring 2011

- Time-series for 2001-2010 processed, seasonal features extracted and data delivered

1.1.6 Action 6: Methodology development and implementation by FMI

REMO and JSBACH models (all needed versions) have been implemented and adjusted to be suitable for the modelling needs of the project. Testing and consequent adjustments of the data flows were completed. A new, more reliable version of instantaneous JSBACH by MPI, Jena, was implemented.

REMO2008 model, taking into account the tracer transport, will be running reliably on at least one of the computational facilities available for FMI personnel.

Recent model implementations and runs have been done on FMI's supercomputer. Most importantly instantaneous JSBACH version was upgraded as soon as it was included to the standard distribution of COSMOS model framework. The boundary data requirements of the newest version differed slightly to those of the previous versions and the boundary data was revised consequently. The pre-processing and post-processing codes have been re-scripted according to the needs of the updated model version.

The set of variables which are necessary to transfer in between REMO and JSBACH models will be decided and derived.

The data transfer between the two models was revised as the model version was changed. Presently hourly REMO output is used to drive JSBACH. Specifically lowest resolved level temperature and specific humidity from REMO have been selected. Comparison between lowest resolved level temperature and a 2 meter temperature that is based on a parameterisation made in REMO were performed. As the differences were relatively small and because the specific humidity is only available from the resolved level, for consistency, that data was selected for both variables.

The sequence of REMO-JSBACH model runs including the required data flows between the models will be initialized.

The sequences of runs shown in figure 2 were not revised since the midterm report. However, the data flows were partly revised as described above.

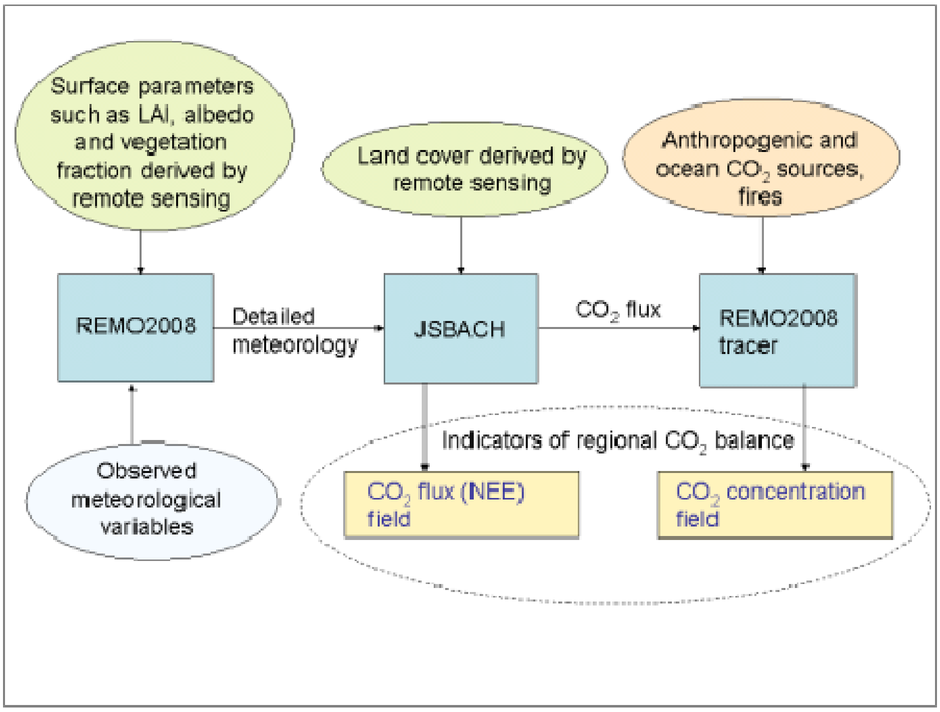


Figure 2: Schematic diagram of the sequence of modelling approach.

The spin-up procedure of the soil carbon storages was implemented for site-level and regional JSBACH runs. In this process CBALONE is constrained with net primary productivity (NPP) in order to accumulate organic carbon into its storages in soil and vegetation. The magnitude of these storages influences the present CO2 balance via heterotrophic respiration due to decomposition of the organic material. Figure 3 shows stabilisation of the carbon storages in a run with site-level meteorological data. In addition to the stabilisation of slow carbon pools as described above, a stabilisation of soil moisture and temperature and other variables of relatively long response times were performed by running the whole 10 year period of climatic input data twice. The last 9 year of the latter cycle is considered reliable data for further inspections.

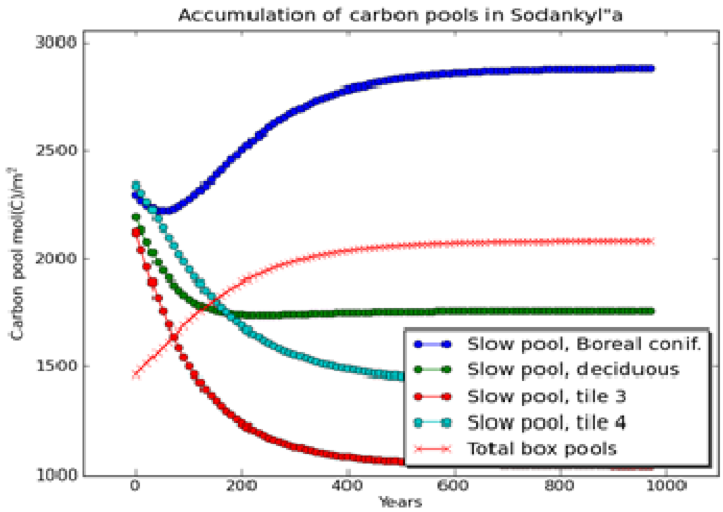


Figure 3: Spin up of slow soil carbon pools in JSBACH for Sodankylä flux measurement site (see Action 4 for the description of the site).

First trials by using the land cover data (from the Action 11)

The first trials were made in due time. The final results with National Corine data will be produced in the framework of Actions 8 and 10.

Completed deliverables & milestones since Mid-term Report

Deliverables:

- 2nd Progress report on methodology

1.1.7 Action 7: Methodology development and implementation by SYKE

The objective of Action 7 is to produce time-series from satellite observations describing snow cover and vegetation and furthermore to extract carbon-balance-related features from those time-series, which will serve for evaluation of model outputs provided by Action 6. During the year 2011 Action 7 worked on processing of time-series for years 2009 and 2010 and on the development and implementation of methods for the extraction of the seasonal vegetation peak and the end of season of coniferous forest from NDVI time-series.

Time-series of Snow Covered Area (SCA), Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI) in a gridded form, were processed for the years 2009-2010 from MODIS satellite data following methods described in the deliverable of Action 3: "2ndEO-data document (years 2001-2010)" (Reporting date 30/11/2010).

Processing of dedicated daily time-series for selected areas of interest describing a) the extent of snow cover during the melting period and b) the vegetation status during the growing season was completed for the years 2009-2010. The beginning of growing season for years 2009-2010 was estimated from NDVI and SCA time-series and compared to *in situ* observations. Processing followed methods described in the first and second progress report on filtered time-series ("Progress report on filtered time-series (2001–2008)" (Reporting date 31/05/2010); "2nd progress report on filtered time-series (2001-2008)" (Reporting date 30/11/2010) and the report on extracted features ("Progress report on extracted features

(2001-2008)" (Reporting date 31/08/2010). The seasonal vegetation peak and the end of season in coniferous forest were determined from NDVI time-series and compared to *in situ* observations of the end of pine growth and end of growing season indicators derived from CO_2 flux measurements.

Since good correspondence of satellite-derived start of growing season and *in situ* observations was obtained (figure 4), maps of the start of the growing season of coniferous forest in Finland will be used in support of REMO-JSBACH model evaluations.

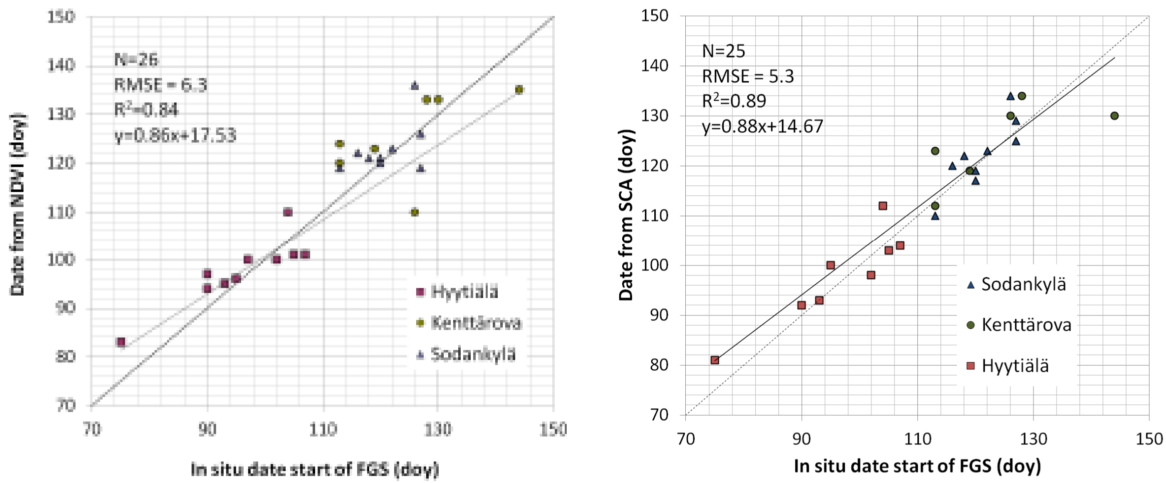


Figure 4: Comparison of *in situ* measurements of start of growing season (flux growing season, FGS) for years 2001-2010 with satellite estimates: a) from NDVI and b) from SCA time-series. Doy is day of year.

Completed deliverables & milestones since Mid-term Report:

Deliverables:

- Features extracted (years 2001-2010), final phase progress report ("Final progress report on extracted features (2001-2010)" (Reporting date 31/12/2011)

Milestones:

- Time-series of years 2009-2010
- Time-series for 2001-2010 processed, seasonal features extracted and data delivered

1.1.8 Action 8: Demonstration and validation by FMI

Demonstration of the system functionality was started based on the local, site-level model results. Also the regional results using the standard land cover data have been produced facilitating the complete modelling framework developed in Action6. The time resolution of the model results used for the evaluations so far, have been one day. The final results will be integrated in time to monthly and yearly totals.

The system functionality validation at Sodankylä-Pallas CAL-VAL site consists of comparison of flux site data to model data. The comparison of site level CO2 balances was started simultaneously for a Southern Finnish (Hyytiälä, 61°31' N, 24°17' E, 181 m above the sea level) and a Northern Finnish (Sodankylä, 67°21' N, 26°38' E, 179 m above the sea level) Coniferous sites (dominant species Scots pine).

In Sodankylä the modelled daily GPP was at the same level as the measured GPP (see figure 5), but the model had some tendency to earlier spring time uptake compared to the measurements. Modelled total ecosystem respiration (TER) and consequently net ecosystem carbon balance in term of net ecosystem exchange (NEE) deviate more from the observation. The reasons are discussed in detail in the Demonstration report of Action 8.

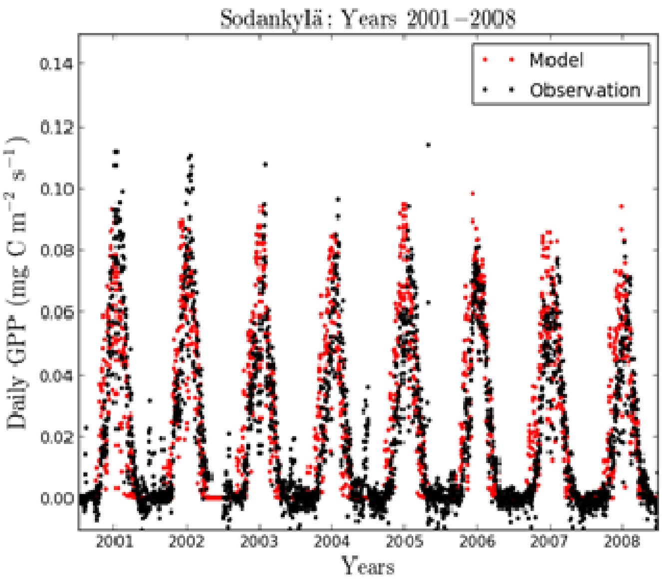


Figure 5: Daily values of measured (in black) and modelled (in red) GPP at Sodankylä CAL-VAL site in 2001-2008.

According to comparison of growing season onset days with those derived from the flux measurements from Action 4 (see figure 6); the model typically predicts the onset couple of days before the observed onset.

The system functionality validation in the whole Baltic EU area

The regional system validation of the model results produced in resolution of 0.167 degrees with the standard land cover data shows, first of all, a reasonable maximum leaf area index (LAI) shown figure 7 as compared to the LAI map of Finland shown in the “Land Cover data production and accuracy” report of the Action 11.

Monthly average NEE shows year to year variability in figure 8 that is due to variability of climatic drivers, such as air temperature and precipitation. These values can be compared to the carbon budgets produces in National GHG inventories. For this comparison the area covering Finland will be extracted from the model results, the results will be further processed to give forest and agricultural fractions separately and the units will be homogenized to match with those used in the GHG inventories. In addition to yearly CO2 balances, monthly values will be calculated (Action 10).

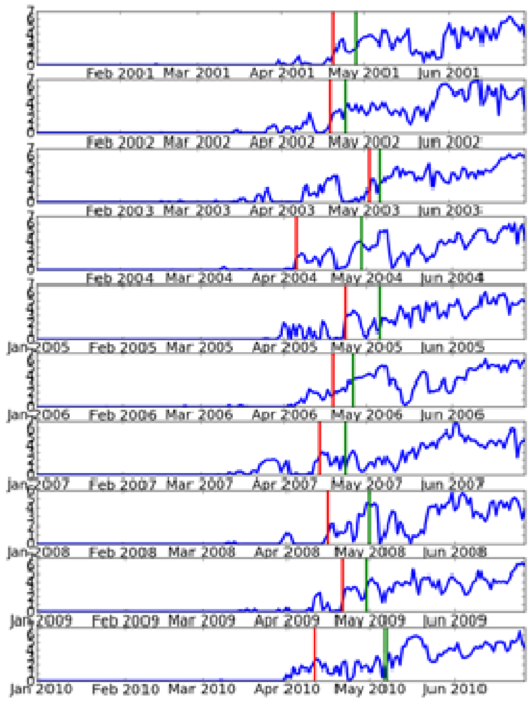


Figure 6: Daily GPPs in the beginning of the years 2001 to 2010 together with growing season onset dates in Sodankylä site in Northern Finland (67°21' N, 26°38' E, 179 m above the sea level). Growing season onset derived from the model and from the measurements is shown in red and green vertical bar, respectively.

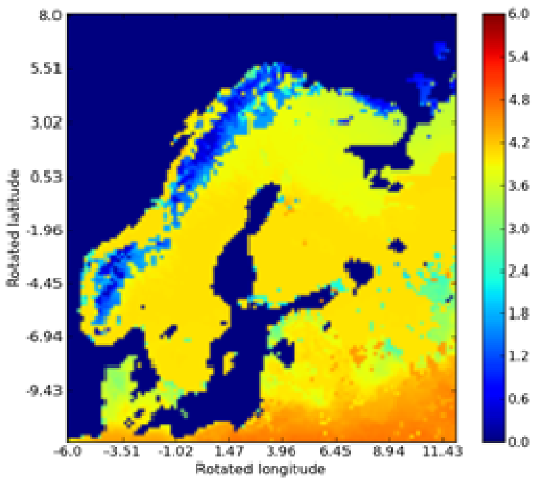


Figure 7: LAI (m2/m2) in July 2001 predicted by JSBACH.

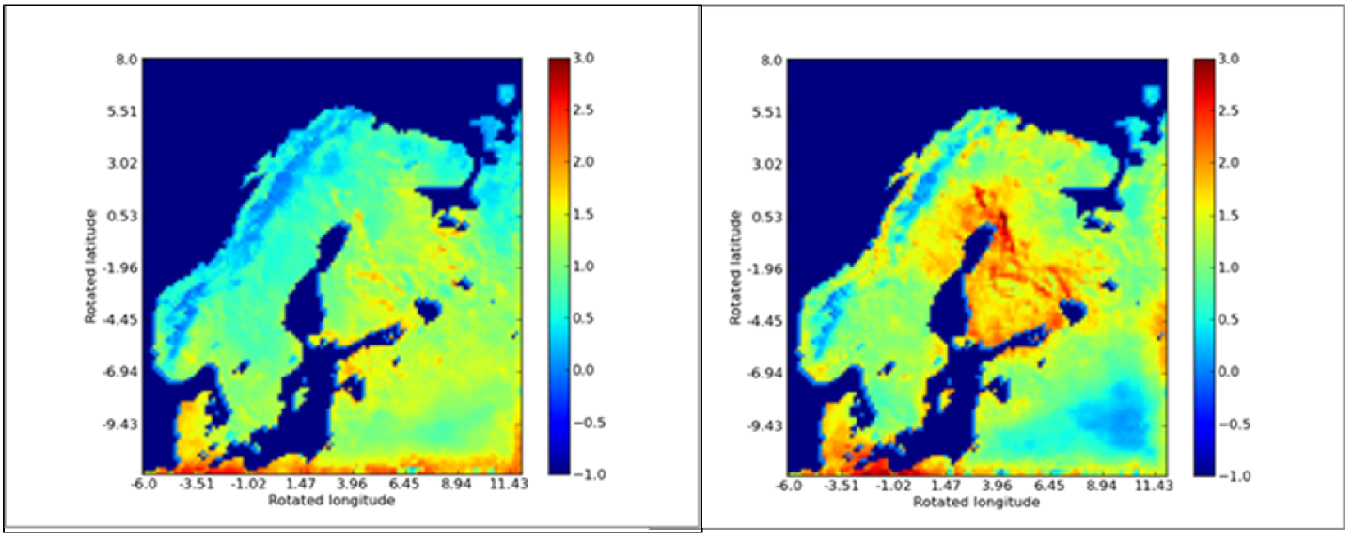


Figure 8: Monthly average NEE (µmol/m2/s) in July a) 2001 and b) 2006.

Milestones:

- Production of Demonstration report

1.1.9 Action 9: Demonstration and validation of EO services

Action 9 collects the data from other actions (Actions 5, 7, 8 and 11) to give some indications of the model performance, by comparing some of the main surface parameters and phenological events extracted from model data and from in-situ and satellite data.
Due to slight delay in receiving the modelling results the work has focused on constructing the necessary software pieces for quick evaluation of the results as they become available. First comparisons with modelling results were conducted for "fractional snow cover" from both data sources. Figure 9 shows an example from the first comparison. In figure 9 the top row shows the fractional snow cover from three days in 2003 from JSBACH- output and the lower row shows the same parameter from MODIS- satellite data. The results indicate that the model is a few weeks behind the true melting (from satellite data). This may be artificial and related to temperature control of the model, but needs some more analysis.

Another comparable indicator between model and satellite derived data is the beginning of the growing season. A phenological indicator "start of flux growing season" was determined from satellite image time-series in Action 7. This was compared with JSBACH- model results run site wise in two sites in Finland: 1) University of Helsinki Hyytiälä forest research station in Southern Finland and 2) FMI Sodankylä supersite, in northern Finland. The "start of the flux growing season" was compared from 10 years (2001-2010) and for three data sources: i) in-situ measurements of CO2- fluxes, ii) satellite data time-series and iii) JSBACH- site wise modelling (only for 2001-2008). The results, in figure 10, show good agreement between in-situ and satellite datasets. The modelling results display higher discrepancy, but the inter-annual pattern is relatively good for both sites, excluding few years.

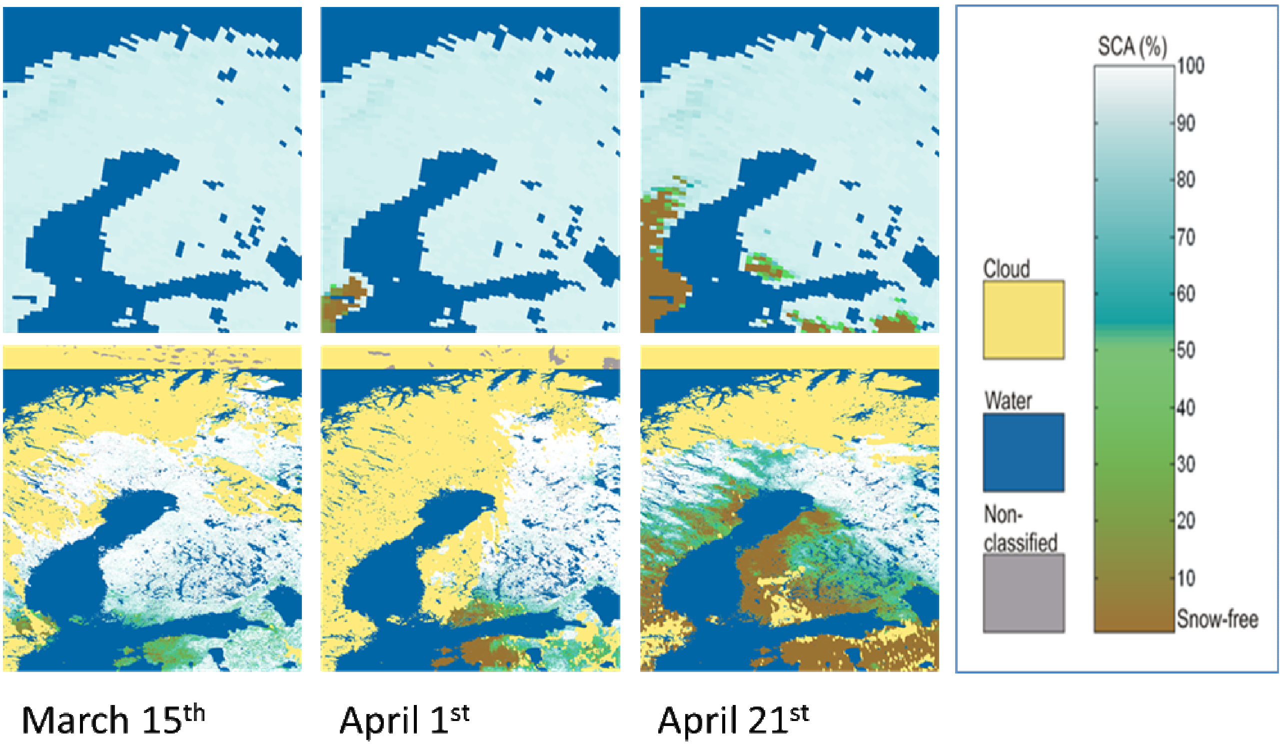


Figure 9: Snow Cover Area comparison between JSBACH model and Sattellite interpretation.

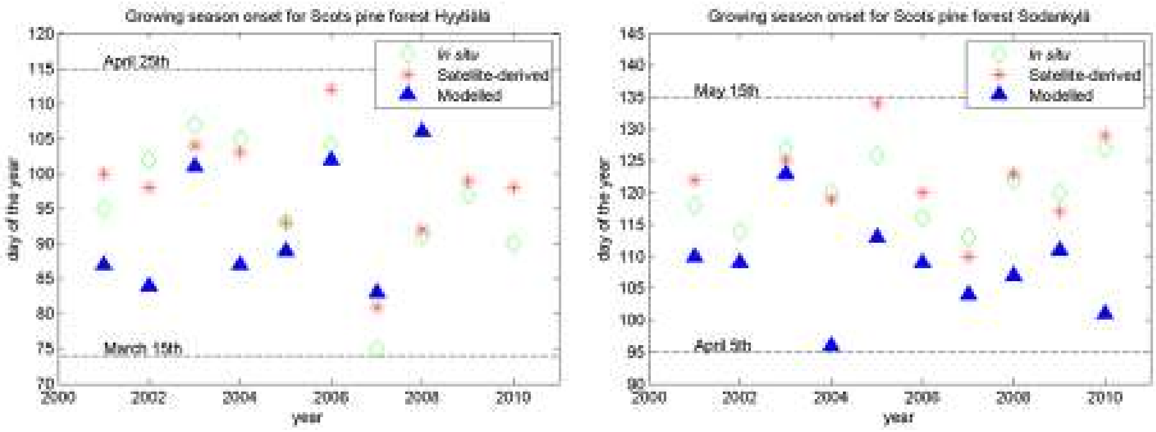


Figure 10: Comparison of in situ measurements of the “start of the flux growing season” (GSSD, determined from CO2 flux-measurements) with satellite-derived estimates and model simulations with JSBACH (period 2001–2010) in (left) Hyytiälä, Southern Finland and (right) Sodankylä, Northern Finland.

Additionally, a trial was made to relate an index (NDVI – normalized difference vegetatitino index) calculated from satellite data to the gross primary production (GPP) to gain another spatially extensive indicator for evaluation of model performance. There is a relation between the two, but the correlation is not strong enough to make solid enough estimates of the GPP, using the NDVI as reference. Figure 11 shows the relation between daily NDVI and GPP.

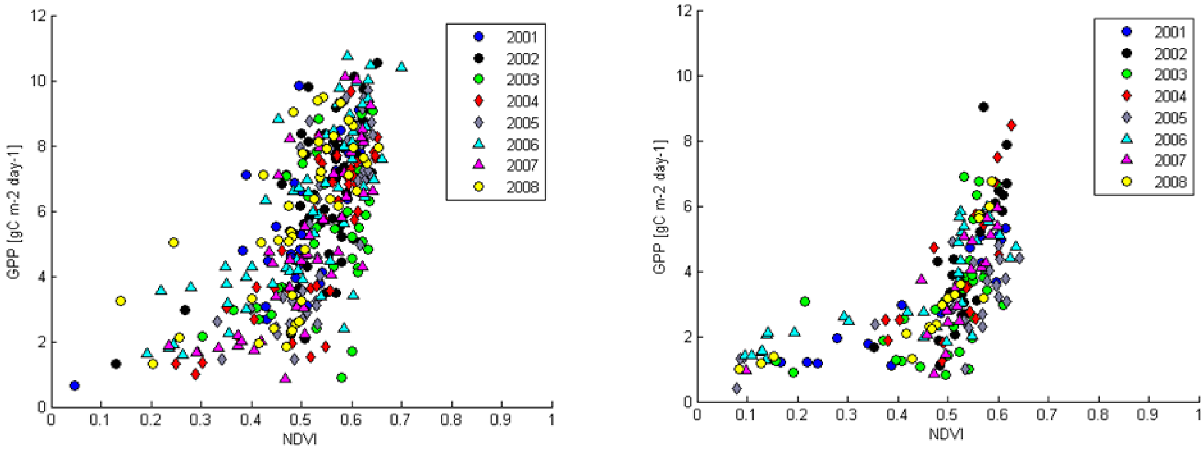


Figure 11: Scatter diagrams of NDVI and gross primary production [gC m-2 day-1] for Scots pine forest at CO2 flux measurement sites (a) Hyytiälä and (b) Sodankylä. GPP data includes daily integrated values of gross primary production based on Net Ecosystem Exchange filled with the Marginal Distribution Sampling method.

For the evaluation of the regional JSBACH predictions of the "start of the flux growing season", maps derived from satellite data (from Action 7) were aggregated to a coarser grid (0.1×0.1 degrees) in order to reduce noise and gaps and to allow later comparison with modelled "start of the flux growing season" (Figure 12).

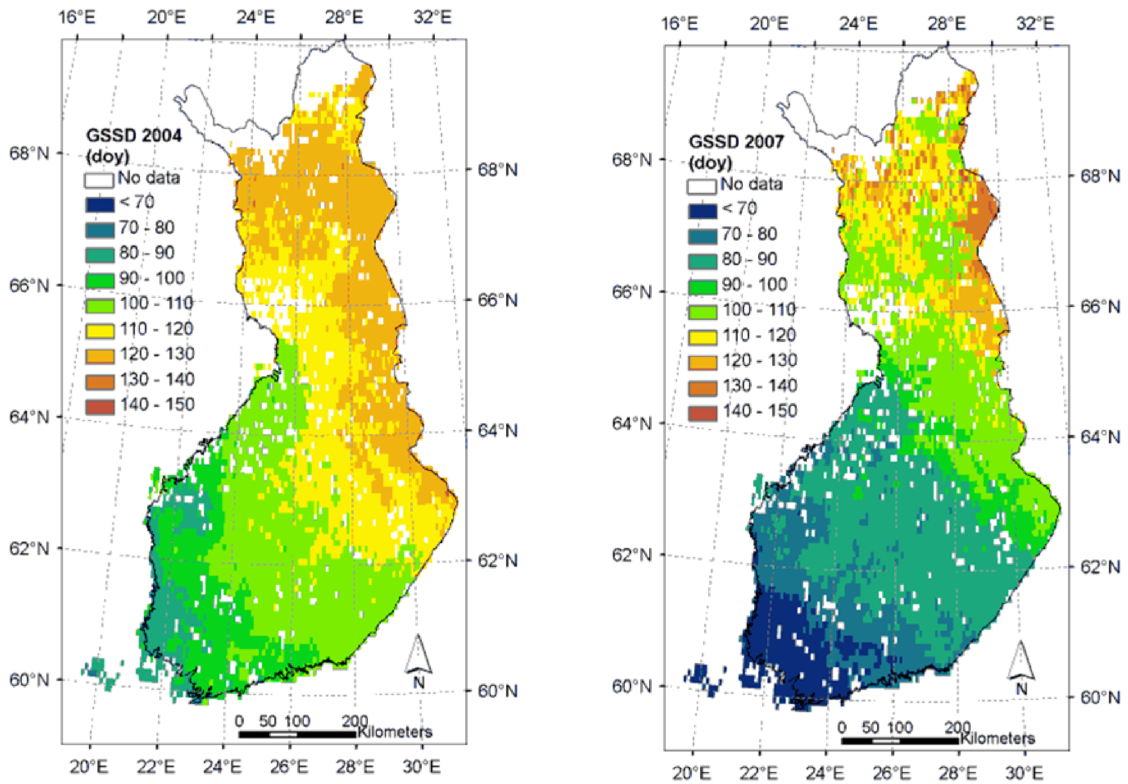


Figure 12: Satellite derived maps of "start of the flux growing season" in coniferous forest in Finland for years (left) 2004 and (right) 2007.

Completed deliverables & milestones since Mid-Term report:

Deliverables:
- Demonstration report postponed to 30/09/2012, due to missing modelling results.

Milestones:
- Tools for model comparison between model results and in-situ and satellite data

1.1.10 Action 10: Generation of carbon assessment end-products

This action produces the digital carbon balance maps covering years from 2001 to 2009. The maps of highest degree of detail will be produced with the land cover based on the National Corine data (Action 11). The raw data from the model is given in the rotated latitude-longitude grid with resolution of 0.167 degrees. The time resolution of the raw data is one hour and it comprises all the predicted variables of JSBACH model and a wide selection of 2D and 3D meteorological variables predicted by REMO. The carbon balance related JSBACH output fields, such as GPP, NPP and soil respiration will be stored in daily resolution in the original rotated grid. These files are available for the scientific community by demand.

For public, monthly and yearly the CO_2 balance mapped data will be transformed into non-rotated latitude-longitude grid and made accessible via Erdas Apollo database. Furthermore, a table of monthly and yearly CO_2 balance values for Finland will be produced for comparison with the National GHG inventories.

1.1.11 Action 11: Evaluation of required Northern-Eurasian land cover information

Land cover classifications have been previously constructed to be used in the REMO-JSBACH modelling framework. The main datasets are ready, consisting of four different land cover schemes for modelling:

- The original Olsson classification, used in REMO-JSBACH modelling framework .
- GlobCover- land cover dataset by ESA and JRC.
- European CORINE- land cover dataset complemented with GlobCover in Eastern Europe.
- National CORINE- land cover complemented with European CORINE and GlobCover.

For these datasets some reallocations of Olsson land cover categories were completed in order to provide seamless data of surface parameters, which describe the characteristics of water in soil in the modelling window.

Peat lands are numerous, although also very small fragmented, in Finland and Scandinavia. They have also presented to be more difficult to model from remote sensing data. To give reference to the recently finished final modelling results, an additional classification was made for peat lands in Finland. The dataset consists of discrimination between peat lands in natural conditions; drained peat lands and peat extraction sites was constructed. The data is only available from Finland, but can be used there to analyse the resulting CO_2- exchange. Figure 13 shows an extraction from the dataset.

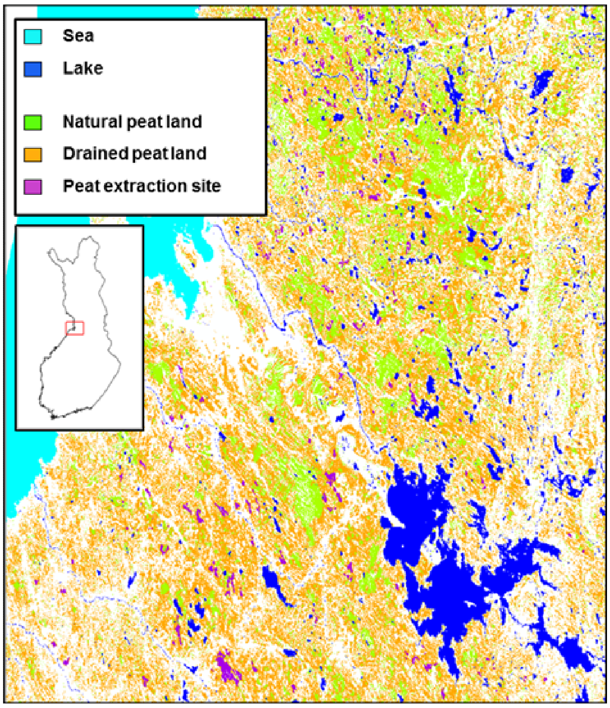


Figure 13: Classification of peat lands in Finland. Example is from region with large fraction of peat lands.

Completed deliverables & milestones since Mid-Term Report:

Deliverables:

- Report on suitability of global land cover datasets for carbon balance modelling postponed to 30/09/2012, due to missing model data.

Milestones:

- Dataset describing the differentiation between natural and dried wetlands

1.1.12 Action 12: Dissemination

The carbon assessment end-products will be archived to the Sodankylä data centre. Using the erdas apollo data manager, the products will then be cataloged and managed to the Erdas Apollo geospatial server. Erdas Apollo uses the International Standards Organisation (ISO) 19115 for the generating metadata. Thus for SNOWCARBO, the INSPIRE metadata editor is used to generate and validate the metadata template. The carbon assessment end product metadata will be in XML format validated using the INSPIRE metadata validator.

Also as part of dissemination SnowCarbo plans to utilize a portal Climateguide.fi which was created in an EU Life+ project (LIFE07 INF/ FIN/000152 CCCRP). This portal offers practical climate change information.

The data will then be delivered using Erdas Apollo OGC Services (that is web coverage service wcs and web map service wms). The end-users of the products will have direct access to the data products using an out of the box erdas apollo web client (shown in the figure below) and OGC compliant http requests. An example of a http request would be; http://erdas-apollo.fmi.fi/erdas-apollo/coverage/EAIM?REQUEST=GetCoverage&SERVICE=WCS&VERSION=1.0.0&COVERAGE=GlobSnow_SWE_L3A_20100102_v1_2__0_10_grid&CRS=EPSG:4326&RESPONSE_CRS=EPSG:4326&BAND=band1&BBOX=-10.0,-10.0,10.0,10.0&WIDTH=500&HEIGHT=500&FORMAT=GeoTIFF&INTERPOLATION=nearest%20neighbor&EXCEPTIONS=application/vnd.ogc.se_xml

The apollo web client is interactive, hence enabling the users to search, consume and interact with the web services. Some of the features of the web client include

1. Download KML to view in Google Earth and Download Shoebox to work in ERDAS IMAGINE: opening the data of interest in google earth or erdas imagine directly from the web client
2. Download the original files: when this option is clicked, it provides the option of downloading the original data file including the XML metadata file, delivered as a compressed zip file.
3. The Clip, Zip, Ship method allows the user to define a bounding box of the area of interest, and also choose from other options such as output file format eg GeoTIFF, IMG, NITF,ECW, JP2/JPEG 2000. The server then prepares the package and a link to the package is then sent to the user.

Apart from the above mentioned, users can use any other OGC compliant client of their choice to access the data from the server. For example gdal for web coverage data, import web map service data in qgis and so forth.

Some future developments include developing a customized web application client (see figure 14).

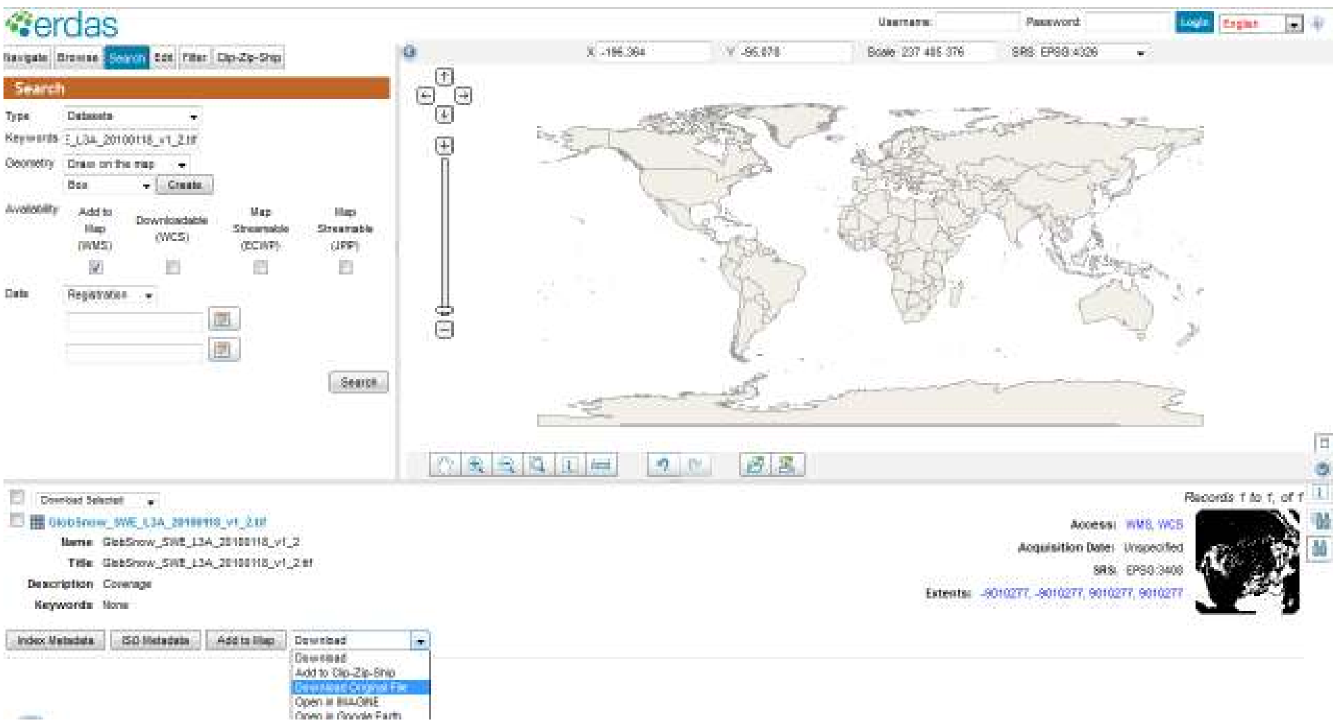


Figure 14: APOLLO web client

1.1.13 Action 13: Auditing

This action is only performed at the end of the project.

1.1.14 Action 14: Project advisory co-operation

Collaboration between FMI, SYKE and the French partner CEA-LSCE

Collaboration between FMI, SYKE and their French partner CEA-LSCE on regional climate modelling issues has been on-going since the beginning of the project, though with increased intensity in the second period, where the initial technical difficulties linked with the familiarisation to the models have been overcome.

This collaboration has for now included regular communication on the crucial modelling issues at the instance of the accuracy, biases and inter-comparisons of forcing data for the area of interest of the Snowcarbo project, and methodological aspects concerning the build-up of soil carbon in a land surface model (timing, forcing data to be used).

Moreover, partner CEA-LSCE regularly participated to project meetings and to particular events such as the Snowcarbo stakeholder meeting.

Soil carbon sensitivity to the snow cover over the Pan-Arctic domain (LSCE/LGGE)

Extensive work has been performed by the LSCE in collaboration with the LGGE (Grenoble, France) to assess the impact of the snow cover on the soil carbon balance in the Pan-arctic area, including the Baltic EU and Finland as the area of interest for SNOWCARBO. This work was recently published in JGR-Biogeoscience (I. Gouttevin, M. Menegoz, F. Domine, G. Krinner, C. Koven, P. Ciais, C. Tarnocai, J. Boike, 2012 : How the insulating properties of snow affect soil carbon distribution in the continental pan-Arctic area. J. Geophys. Res., 117, G02020) and publicized by Nature Climate Change as a research highlight.

We demonstrate and evaluate the effect of an ecosystem differentiated insulation by snow on the soil thermal regime and on the near-equilibrium soil carbon stocks distribution simulated by the land surface model ORCHIDEE in the continental pan-Arctic area (>50°N). Based on field campaigns reporting higher thermal conductivities and densities for the tundra snowpack than for taiga (ie. forest) snow, two distributions of near-equilibrium soil carbon stocks are computed, one relying on uniform snow thermal properties and the other using ecosystem-differentiated snow thermal properties. Those modelled distributions strongly depend on soil temperature through decomposition processes.

Considering higher insulation by snow in taiga covered areas induces warmer soil temperatures by up to 12K in winter at 50 cm depth. This warmer soil signal persists over summer with a temperature difference of up to 4K at 50 cm depth, especially in areas exhibiting a thick, enduring snow cover such as Western Siberia and Eastern Canada. These thermal changes have implications on the modelled near-equilibrium soil carbon stocks, which are reduced by 8% in the pan-Arctic continental area when the vegetation induced variations of snow thermal properties are accounted for. Higher soil temperatures increase water stress on plant species, slightly reducing their productivity (-0.3% over the study area). Concomitantly, higher soil temperatures result in reduced permafrost extents and deeper active layers, exposing greater volumes of soil to microbial decomposition. This yields enhanced soil respiration rates (+22% over the study area) and lower soil carbon stocks (see figure 15).

Our study highlights the role of snow in combination with vegetation in shaping the distribution of soil carbon stocks and permafrost at high latitudes.

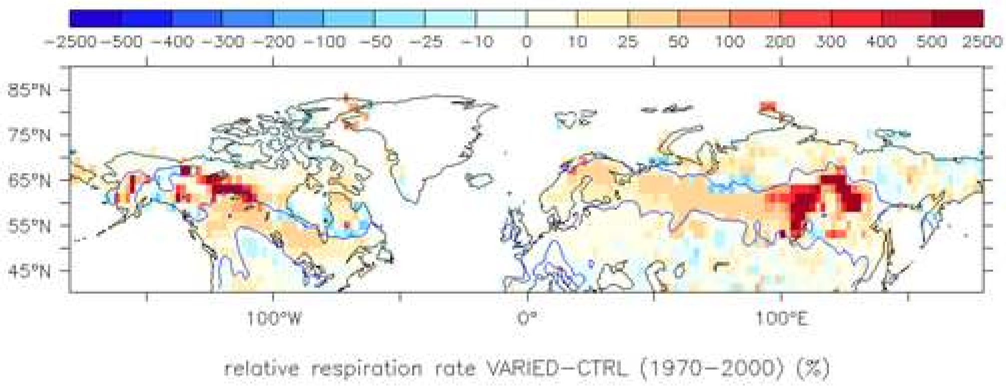


Figure 15: Change in relative respiration rate upon the use of distinct snow properties for a taiga and a tundra land-cover over the Pan-Arctic area. Taiga areas are contoured in blue.

Snow cover variation induced by aerosol emissions in the Arctic in the mid-21st century

The snow-cover modifications in the pan-Arctic continental were evaluated considering different emissions scenarios for the middle of the XXIst century. A present-day simulation and three 2050-2060 simulations were performed based on the RCP8.5 gas and aerosol anthropogenic emission inventory, characteristic of a scenario with no additional policies in place to limit greenhouse gas emissions. Local aerosol emissions in the Arctic are very low in comparison with the aerosol transport from North America, Europe and Asia. Future aerosol concentration in the Arctic is therefore very dependent on the evolution of the emissions in these countries. Aerosols emissions in Northern America and Europe have reached maximum values at different period of the XXth century, depending on the countries and on the species. They are now decreasing significantly. This is not the case for the Asiatic emissions, which are still increasing. They will probably begin to decrease in the next decades, but it is quite difficult to estimate when, as emissions inventories for these emissions vary widely from one scenario to another. In addition with the anthropogenic continental emissions, it seems that two local sources could affect the Arctic atmosphere in the next century: ships emissions could increase significantly, as the retreat of the sea-ice in summer should open new routes in the Arctic ocean. Moreover, biomass burning activity has been observed at latitudes higher and higher, but also stronger and earlier in the season. It was estimated elsewhere that climate change will induce an increase of the fire activity, both in temperate and boreal regions. The goal of our study is to estimate the snow-cover variations in the middle of the XXIst in the continental pan-Arctic area using global climatic simulations (S1, S2, S3 and S4) with different aerosol local emissions scenario in the Arctic region. We evaluate the snow-cover modifications in a particular 2050-2060 scenario, and analyse thereafter the role of possible local enhanced Arctic emissions.

The probable drastic decrease of the anthropogenic aerosol emissions expected for the middle of the XXIst century in Northern hemisphere should limit the decrease of snow albedo due to absorbing aerosol deposition. However, it should not prevent the snow-cover from a significant reduction: In comparison with the present-day, the mean number of days per year with snow at the surface (MNDWS) could be reduced from 10 to 100 days in the major part of the continental areas of the Northern Hemisphere in the mid XXIst century (figure). This decrease is explained by the temperature enhancement, converting snowfall in rain, and accelerating melting. We have to keep in mind that this finding has been established in a future scenario with strong greenhouse gases emissions. The decrease of the aerosol impact on snow-cover should be relatively more important in a scenario with lower greenhouse gases emissions. This is what is seen in our simulations (see figure 16).

This work is in the final stage of preparation for being submitted as an article to an international scientific journal, probably The Cryosphere (Menegoz, M., Krinner, G., Balkanski, Y., Yan, N., Boucher, O., Ciais, P., Cozic, A., Snow cover variations induced by aerosol emissions in the Arctic in the mid XXIst century).

Activities for the last period of the Project

The last period of the project for Action 14 will focus on the soil carbon balance in Finland and determine the added value of the use of regionalised input-data (vegetation map provided by Actions 3 and 5, REMO meteorological forcing provided by Action 8) for the modelling of carbon stocks and fluxes over the area of interest of the SNOWCARBO project.

The setup of the ORCHIDEE simulations over the Scandinavian region (complementary to the simulations to be carried out with JSBACH) is being finalized currently. Mechanisms for transferring the forcing data into the ORCHIDEE format are being devised.

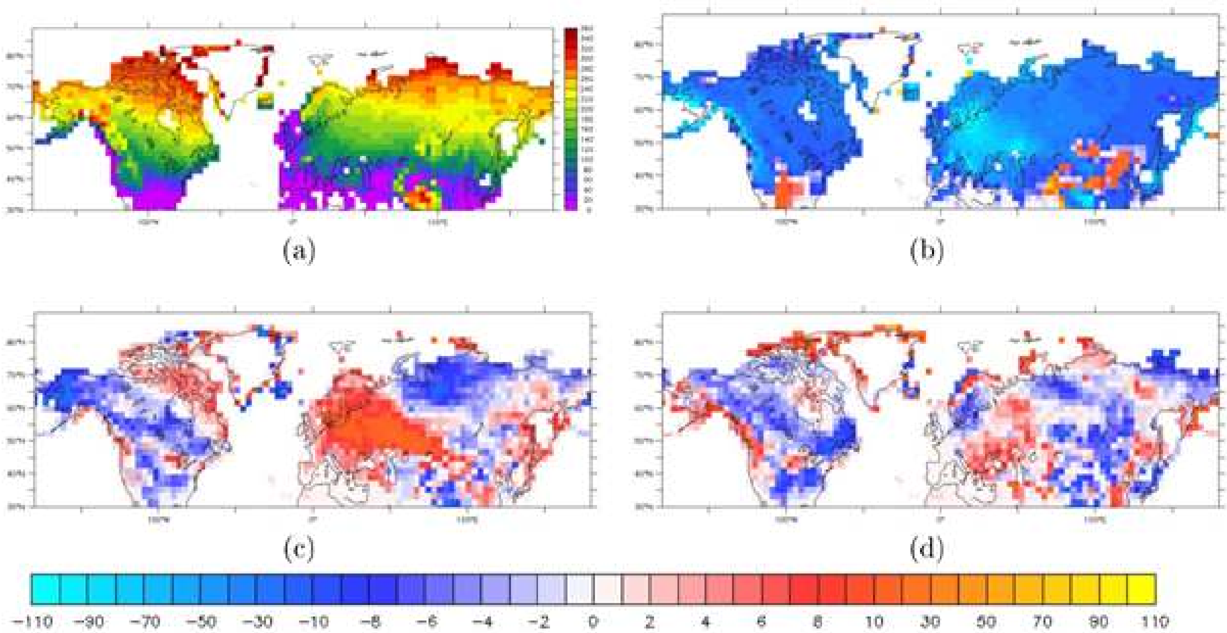


Figure 16: Mean number of day per year with snow at the surface (MNDWS); (a): Current (S1); (b): MNDWS difference between 2050 RCP8.5 scenario and current simulation (S2-S1); (c): MNDWS difference between a 2050 scenario with high-level ships traffic in the Arctic in comparison with 2050 RCP8.5 scenario (S3-S2); (d): MNDWS difference between a 2050 scenario with increased biomass burning activity in comparison with 2050 RCP8.5 scenario (S4-S2).

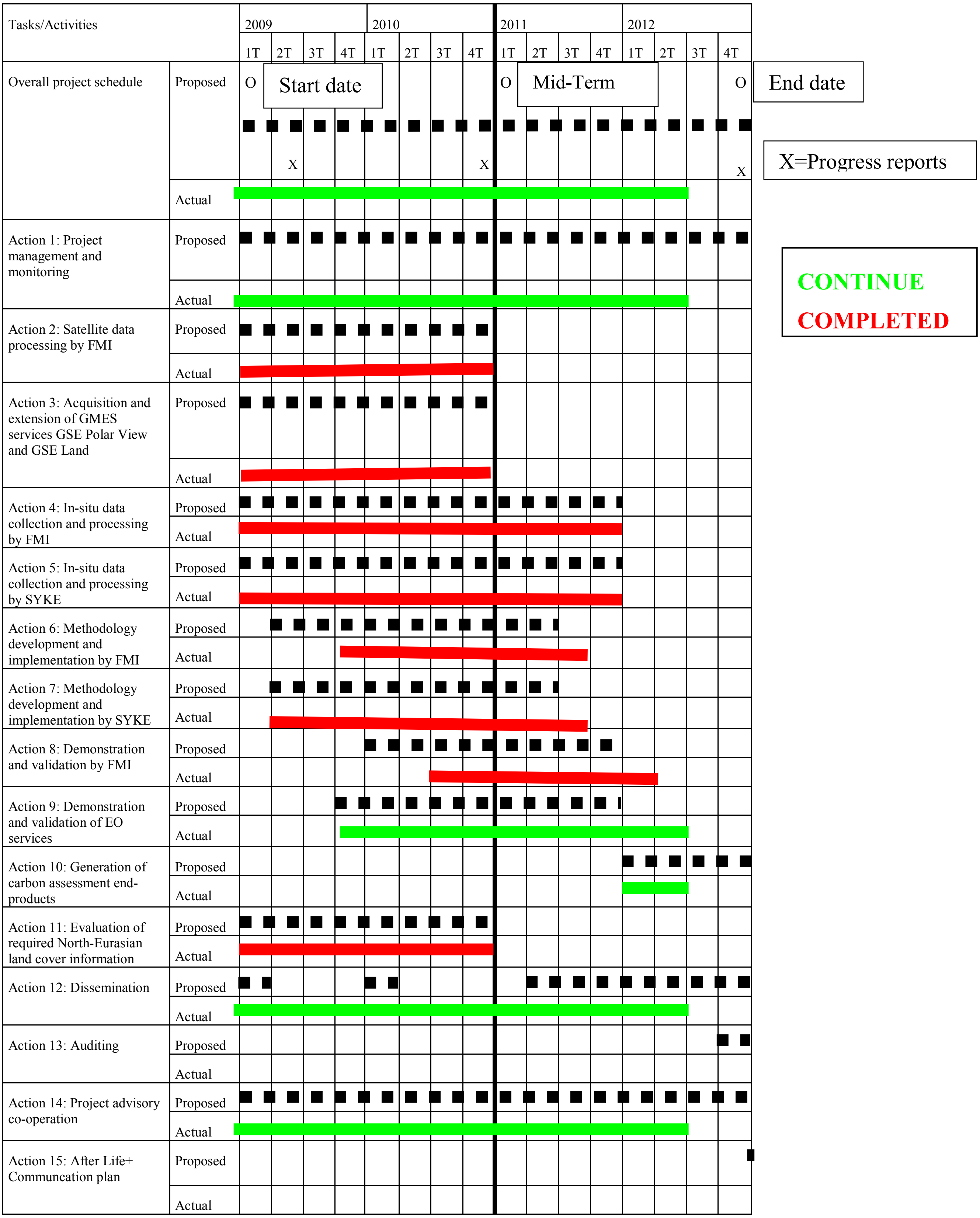
1.1.15 Action 15: After Life+ Communication plan

The detailed plan for communications and actions after the end of the Life+ project will be made during the last project year in 2012.

1.2 Envisaged progress until next report

Envisaged progress until next report can be found under **Timeline** in the project website Project website: http://snowcarbo.fmi.fi and Gantt chart given in Table 1.

Table 1: Gantt chart of the SnowCarbo actions.



1.3 Impact

National Greenhouse gases inventory (under the United Nations Framework Convention on Climate Change (UNFCCC)) under mandate of the National Stakeholders such as Ministry of Transport and Communications, Ministry of the Environment, Statistics, Agrifood Research, Forest Research Institute and etc. in Finland. They need carbon balance map products to validate and support the national greenhouse inventory techniques. Developed methodology on Carbon Balance Mappings and output products of SnowCarbo project such as CO2 flux maps with error estimates, CO2 concentration maps with error estimates, Carbon balance atlas for Finland and Baltic EU, and Guidelines for stakeholders and policy makers (in Finnish and English) will be utilized on validation the emission/removal estimated in the national greenhouse inventory.

1.4 Financial review by actions

The status of budget of SnowCarbo project can be seen action by action in Table 2.

Table 2:Status of Snowcarbo Budget

Action number and name	Foreseen costs	Spent so far	Remaining	Projected final cost
Action 1 Project management	145919	118105	27814	145919
Action 2 Satellite Data	123792	126042	-2250	123792
Action 3 GMES-Services	178495	109835	68660	178495
Action 4 In situ data FMI	106260	103012	3248	106260
Action 5 In situ data SYKE	75221	85413	-10192	75221
Action 6 Methodology FMI	215946	219511	-3565	215946
Action 7 Methodology SYKE	219198	130724	88474	219198
Action 8 Demonstration FMI	124880	121718	3162	124880
Action 9 Demonstration SYKE	105300	123094	-17794	105300
Action 10 Carbon assessments	224904	176576	48328	224904
Action 11 Evaluation land cover	99600	137842	-38242	99600
Action 12 Dissemination	200543	107373	93170	200543
Action 13 Auditing	10000		10000	10000
Action 14 Advisory	176260	158938	17322	176260
TOTAL	**2006318**	1718183	**288135**	2006318