LIFE Project Number

LIFE07 ENV/FIN/000133

Midterm Report

Covering the project activities from 30/06/2009 to 31/12/2010

Reporting Date

31/01/2011

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 €
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(%) of eligible costs	49.09

Data Beneficiary

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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
GPP	Gross Primary Production
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)
MPI-M	Max Planck Institute for Meteorology
NDVI	Normalized Difference Vegetation Index
NEE	Net Ecosystem CO_2 Exchange
QuikSCAT	Quick Scatterometer
REMO	Regional Climate Model of MPI
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 Executive summary

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

The activities of Action 1 such as arrangements of the official project meetings, coordination and monitoring of the project progress, preparation of the project deliverables, and monitoring of the project expenses are according to the project plan.

Processed satellite data retrievals (digital maps) of the following (snow water equivalent (30 years), on-set of snow melt (30 years), snow clearance (30 years), soil freezing (10 years)) weekly products during snow season (September to May) are ready. Earth observation-based extended GMES service dataset for years 2001 – 2010 has been processed and details of the action are described in the deliverable documents of Action 2 & 3.

Gridded time-series of meteorological data covering the whole model domain is adopted from the ECMWF database. Presently the time-coverage is from 2001 to 2007. The remaining years will be adopted before the final evaluation and production runs of the model results. See the 1st and 2nd data reports from Action 4 for details. CO_2 and energy flux measurements have been running as planned. Data availability from different sites varies according to site-specific post-processing schedules.

In Action 5, 4 field measurement campaigns at Sodankylä were executed 2 in 2009 and 2 in 2010.

In Action 6, methods which are used in Action 8 are mostly achieved. JSBACH model development for producing CO_2 fluxes on the way. Transport software REMOTracer implemented and tested in FMI system. Software modules for assimilation of carbon dioxide concentration data for constraining simulations are implemented and tested in FMI computing system. Flux and concentration systems are validated according to Fluxnet and GAW networks' methodologies.

Soil-Vegetation-Atmosphere carbon exchange simulation module, which use high resolution land-use and vegetation data together with environmental parameters obtained via remote sensing and traditional sources are applied for the modelling framework. JSBACH models refinement is on the way.

In Action 7, unfiltered time-series of SCA and NDVI in a gridded form were processed for the years 2001-2008 from MODIS satellite data and are described in the deliverable 1st EO-data document (years 2001-2008). Features of vegetation were extracted for 2001-2008.

First results of methodology demonstration and validation for selected time periods/regions are ready and documented in Action8.

In action 9, analysis of the significance of the effect of snow coverage and NDVI- index anomalies to carbon flux completed (Time series of local areal, e.g. watershed, statistics of snow coverage). Comparisons of NDVI (or other vegetation indices) and phenological observations completed. Comparisons between the snow cover from vegetation-climate models and snow cover from remote sensing and in-situ data first results are ready and reported. Data are shared through three media: 1) web-site for project documents; 2) FTP- for project intermediate data (e.g. satellite products, modelling data) and 3) using external hard drives for satellite image data. Protocol for data sharing completed. Protocol for data archiving completed. EO based services are in use and feedbacks are collected from snow, vegetation and land cover data. First evaluation of benefits and drawbacks of the use of the EO based services are evaluated and reported.

In Action 11, evaluation on the land cover needs was made. Results were reported. Different datasets were produced and accuracy assessments were made. More detailed land cover mapping was produced for northern-Finland covering Sodankylä-Pallas area. Field data collected and accuracies were calculated and reported. Already available land cover data sets have been demonstrated and evaluated.

List of main achievements from SnowCarbo project can be listed as follows,

- Snow water equivalent (30 years), on-set of snow melt (30 years), snow clearance (30 years), soil freezing (10 years) weekly products
- Implemented a modified MODIS cloud masking algorithm and deployed a new data processing server. This increases the quality of raw time-series data.
- Spectral measurements from the winter field campaigns were processed. The measurements are used to aid the interpretation of NDVI and SCA time-series and in accuracy assessments.
- Autumn field campaign was conducted for land cover data validation and accuracy assessment and spectral measurements of vegetation.
- Carbon balance related features, like growing season beginning and end dates, were analyzed from the CO_2 flux measurements.
- A method for the extraction of start of season in boreal coniferous forests from NDVI time-series was developed.
- The start of the growing season, derived from CO_2- flux measurements, was compared with the start of the growing season from NDVI- time-series from satellite data. The two datasets show good correlation.
- The up-to-date versions of both REMO and JSBACH models have been one-way coupled, and the models are now properly running on the FMI supercomputers, producing regional present day climates and CO_2 fluxes with all the different land cover datasets currently available.
- Planning of system functionality validation has been started for the model domain covering Scandinavia and Baltic countries.
- Tools for data extraction from REMO- model data format have been created. First comparisons of modeled snow cover and satellite data time-series are currently being compiled for evaluation of the model performance.
- Up-to-date sets of Nordic land cover information based on Globcover v2, CORINE2006 and TERRA MODIS data have been produced and reported for carbon balance modeling purposes (Törmä & al. 2010. Revision the land cover and use classification of northern areas for climate modeling, SPIE European Remote Sensing, Toulouse 20.-23.9.2010.)

2 Administrative part

All meetings are planned and organized in close collaboration among project manager from FMI (Finnish Meteorological Institutes) and other representatives from SYKE (Finnish Environment Institute) and CEA-LSCE (Commissariat à l'énergie atomique – Laboratoire des Sciences du Climat et de l'Environnement). Collaboration and communication among partners has been good. The project meetings in Finland are organized by FMI and SYKE respectively. The management & steering meetings are organized by FMI.

There are two changes in the project management structure:

Project Manager: Dr. Ali Nadir Arslan, FMI

Project Secretary: Ms. Ulla Haapanen, SYKE

2.1 Organigramme of the project team and the project management structure

The management and monitoring of the progress in the SnowCarbo project is carried out by management and steering groups, who will meet regularly during the project. The Management Board of the project is formed by

- Project Principal Investigator (Prof. Jouni Pulliainen, FMI),
- Project Manager (Dr. Ali Nadir Arslan, FMI),
- Partner Coordinators (Mr. Olli-Pekka Mattila, SYKE and Dr. Philippe Ciais, CEA-LSCE),
- Project secretaries (Ms. Riitta Aikio, FMI and Ms. Ulla Haapanen, SYKE),
- Action Managers.

The project Steering Group includes

- Principal Investigator
- Project Manager, Partner Coordinators
- Institute Evaluators (Prof. Yrjö Viisanen, FMI and Dr. Yrjö Sucksdorff, SYKE)
- The representatives of the stakeholders (Statistics Finland, Ministry of Transport and Communications, Ministry of Environment, Ministry of Agriculture and Forestry).

The project teams within the project partners are lead by the Partner coordinators (except at FMI, where the team is lead by the Principal Investigator). The project teams have assigned Action Managers for each action to lead the daily work.

The Management Board and the Steering Groups will meet twice a year. The Steering Group monitors the project progress based on a Progress Report issued by the Management Board. The feedback and recommendations from the Steering group are provided to the project teams through the Management Board. The action personnel of the project will meet at least quarterly to ensure that all project activities are fully coordinated. Small working meeting relevant to ongoing project activities are organised as necessary.

The organigramme of the SnowCarbo project is presented in Figure 1.

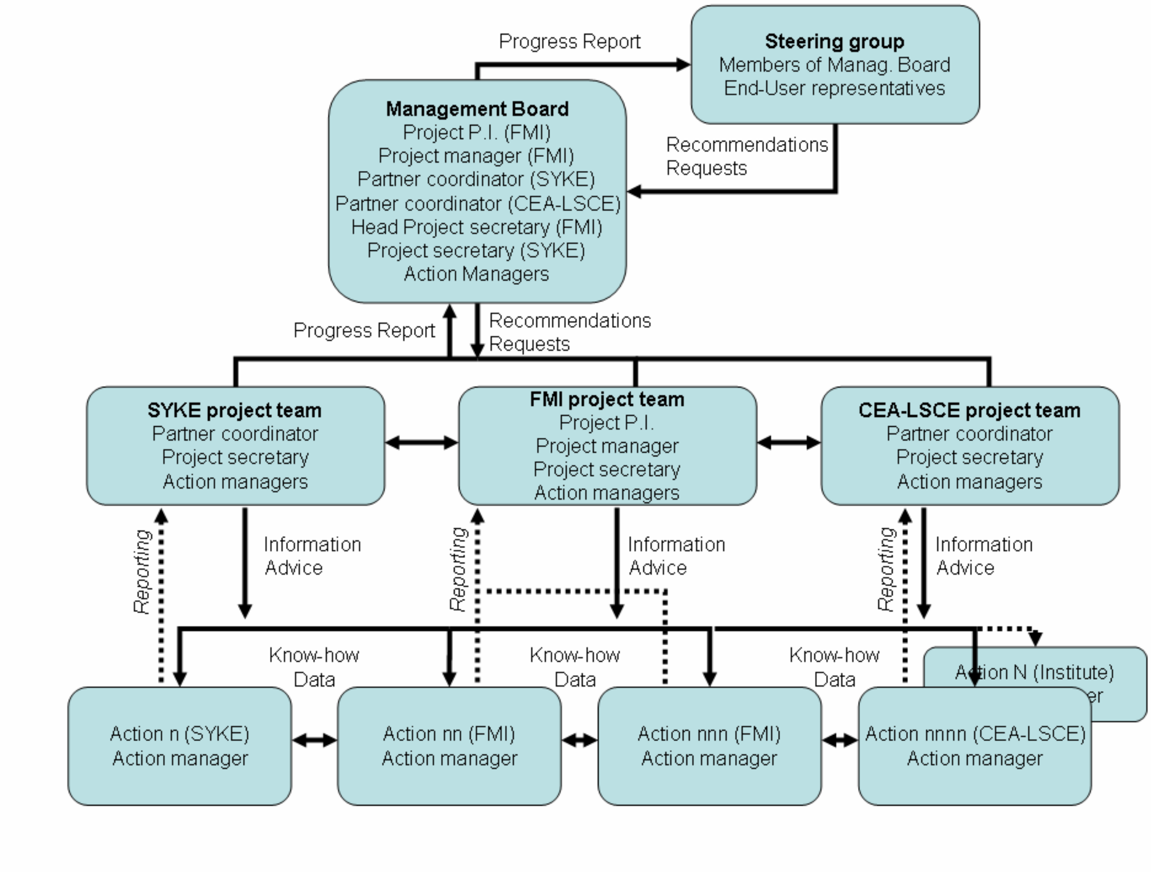


Figure 1: Organigramme of the SnowCarbo project

2.2 Reports completed since the start of the project

The list of the reports delivered since the start of the project can be listed as below

Action 1:

- 18 Months Progress Report
- 1st Monitoring Progress Report
- 2nd Monitoring Progress Report
- 3rd Monitoring Progress Report
- First Year Progress Report
- Inception report

Action 2:

- 1st EO data document (together with Action 3 & 7)
- 2nd EO data document (together with Action 3)

Action 3:

- 1st EO data document (together with Action 2 & 7)
- 2nd EO data document (together with Action 2)

Action 4:

- 1st data document
- 2nd data document

Action 5:

- 1st in-situ data document
- 2nd in-situ data document

Action 6:

- 1st Progress Report on Methodology

Action 7:

- 2nd progress report on filtered time-series 2001-2008
- Progress report on extracted features 2001-2008
- Progress report on filtered time-series 2001-2008

Action 8:

- Preliminary demonstration report

Action 9:

- Preliminary demonstration report
- Documentation of the data exchange method

Action 11:

- Land Cover Data needs for carbon balance mapping
- Land Cover data production and accuracy (combined with report on the suitability of global land cover datasets for carbon balance modelling)

Action 12:

- Update of the project website layout

All reports can be found at the SnowCarbo web-pages: http://snowcarbo.fmi.fi

3 Technical part

3.1 Actions

3.1.1 Action 1: Project management and monitoring

The activities of Action 1 such as arrangements of the official project meetings, coordination and monitoring of the project progress, preparation of the project deliverables, and monitoring of the project expenses are according to the project plan.

The Management Board and the Steering Group meetings have been very successful with good discussions and exchange of opinions between the project managers and the representatives of the stakeholders. Project team meetings and working meetings between project team members have been used to ensure coordination of the project work and clarify any issues related for example to the deliverables between project Actions.

Following activities can be listed as main progresses of Action1:

- 8 Workgroups (from actions) are established in terms of close cooperation & communication among actions
- Organizing project meetings
- Organizing management board meetings
- Organizing steering group meetings
- Activity & Deliverable list continuous update
- SnowCarbo webpages are updated : more info in Action 12
- Progress & monitoring reports

Completed deliverables & milestones since Inception Report

Deliverables:

- 1st Monitoring Report
- First-year progress report
- 2nd Monitoring Report
- 18 month progress report
- 3rd Monitoring Report
- Midterm progress report
- Carbon footprint report (first contributions)

Milestones:

- Project meetings
- Management meetings
- Steering group meetings

3.1.2 Action 2: Satellite data processing by FMI

The objective of Action 2 is to provide following three satellite data products

- Weekly Snow Water Equivalent (SWE) Grids
- Snow Melt Seasonal Grids (Dates of onset of snow melt and snow clearance)
- Date of Soil Freezing Grids

Prototype datasets for weekly gridded SWE are now available for a 18-year period (1992-2009); the production algorithm and database for the final 30 year dataset (1978-present) is finalized and is available. In Figure 2, an example of the product in EASE grid projection is presented.

Software algorithms and production chain for product have been completed for Date of Snow Clearance Product. A full dataset of 30 years (1978 – 2008) has been created. The product has been verified and validated in a journal publication (Takala et al., 2009). In Figure 3, Gridded date of Snow Clearance for Northern Hemisphere in 2008 is shown as an example. The Snow Clearance product is formed as a gridded (0.25 degree EASE grid) value corresponding to the date (counted as days from Jan1) in the respective year, when the snow clearance threshold (90%) is passed.

The soil freezing grids are based on available historical scatterometer observations. The default instruments are the NASA QuikSCAT/SeaWinds scatterometer (Ku-band). A prototype dataset for the year 2008 has been produced (see Figure 4). The full dataset is under production.

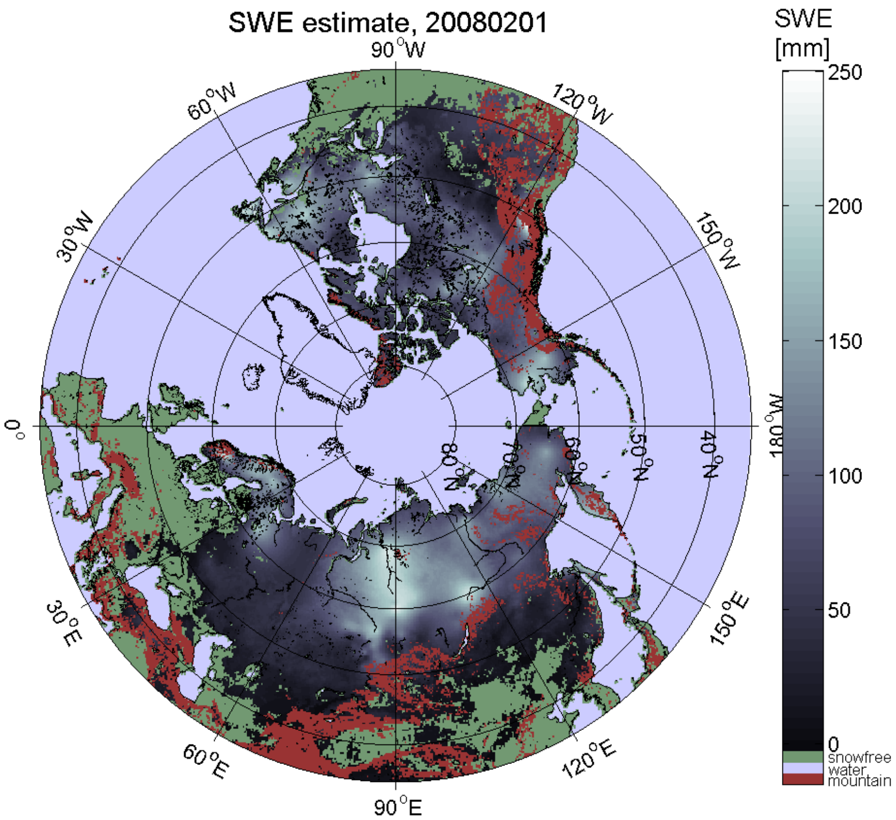


Figure 2: A visualization of the SWE product (in 0.25 degree EASE-grid) over the Northern hemisphere. The lower limit for the latitude is 35° and the upper limit 85°

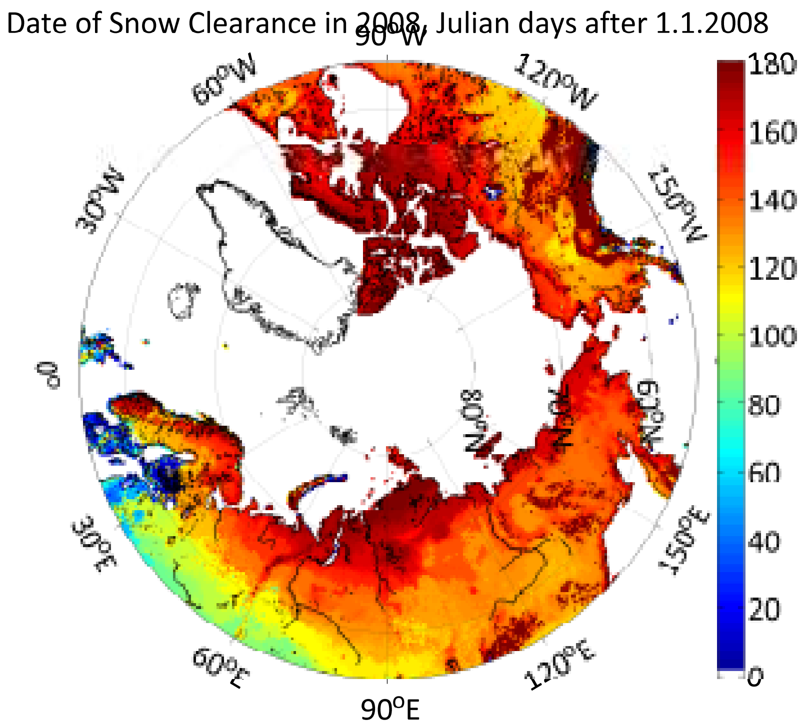


Figure 3: A visualization of the Date of Snow Clearance product (in 0.25 degree EASE-grid) for Eurasia in 2008. Color codes represent amount of days from Jan 1 2008

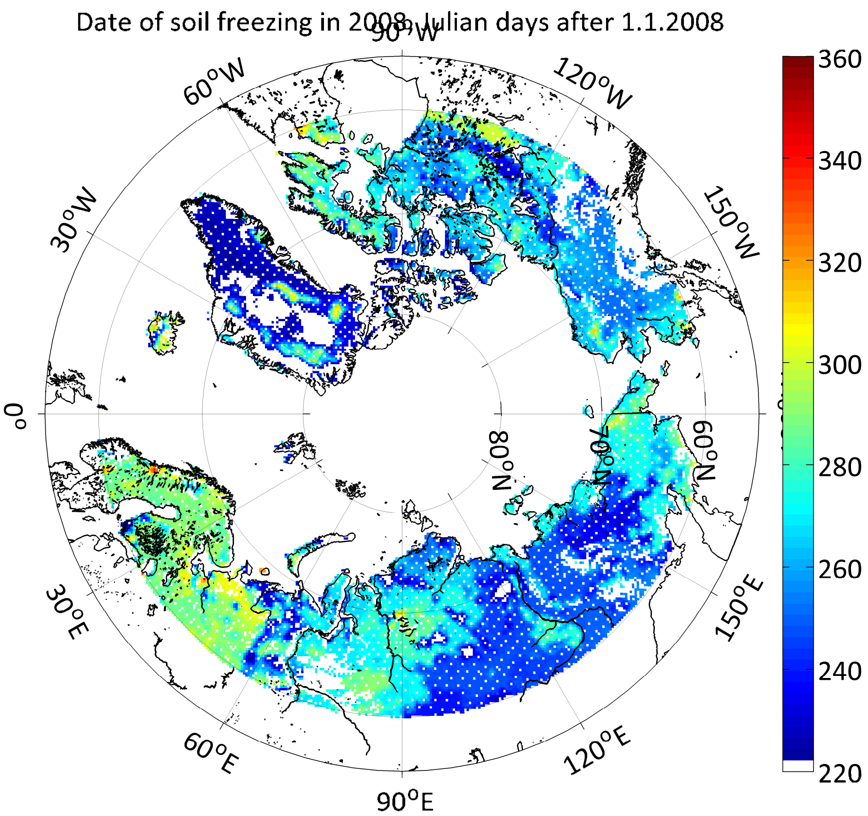


Figure 4: Visualization of experimental soil freezing date product for 2008. Color codes represent days after 1.1.2008

Completed deliverables & milestones since Inception Report

Deliverables:

- Contribution to the 1st EO- data document (years 2001-2008): 1st EO-data document
- Contribution to the 2nd EO- data document (years 2009-2010): 2nd EO-data document

Milestones:

- The SWE product is available for all test sites and covering 30 years
- The SWE product was validated (in scientific publication)
- The onset of snow melts and snow clearance product is available for all test sites covering 30 years
- The snow melt / clearance product were validated in scientific publications
- The soil freezing product prototype dataset for the year 2008. The full dataset is under production.

References:

Takala, M., Pulliainen, J., Metsämäki, S., and Koskinen, J. (2009). Detection of Snowmelt Using Spaceborne Microwave Radiometer Data in Eurasia From 1979 to 2007. IEEE Trans. Geosci. and Remote Sensing, 47:2996-3007.

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

The aim of Action 3 is to produce harmonized EO datasets of the top-of-atmosphere radiances and thermal infrared data for years 2001 – 2011. This dataset is used to produce daily estimates of green vegetation status, snow cover and thermal radiation to be analyzed in Action 7.

Collection of raw EO data has been continued on daily basis and the raw datasets for years 2000 - 2010 have been completed. However, there are still gaps (lacking observations) in the raw product time series although the raw data archive has full temporal coverage. This may be due to corrupted raw data files, poor cloud masks, or more likely, due to extensive cloud cover. This will be investigated and data will be reprocessed if needed. Also a new improved cloud masking algorithm has been implemented for MODIS data during year 2010. Re-computation of the cloud masks for earlier years is ongoing and this may improve the quality of the raw time series used by Action 7.

In addition to the originally agreed EO products some additional indices (NDWI, NDSI) have been computed as requested by Action 7. These changes are documented in the "2nd EO Data Document".

The IT-reform of the institution has been completed during year 2010 and the storage as well as processing of the SnowCarbo EO-data has been transferred to the new environment. This caused small delays for data processing during year 2010 but now the new system is operational.

Current processing scheme of the harmonized dataset corresponds to the GSE Polar View and GSE Land processing. However, the findings of Action 7 suggest that the dataset should include also low sun angle observations (< 30 degrees) to detect the start/end of growing season at the northern parts of the project area of interest. Thus, a change in the calibration procedure may be required and this will be investigated and implemented if required. If implemented, this changes only the coverage of the products and requires no further work on the methods developed in Action 7. Also a new method of combining the overlapping daily EO observations is under evaluation and may be used to re-compute the raw time series product for Action 7. Decision will be made before February 2011.

Methods for the atmospheric correction of MODIS imagery were reviewed. The Simplified Method for Atmospheric Corrections (SMAC) algorithm by Dedieu et al. (1994), implemented in SYKE's processing chain, is used for the correction of dedicated data sets to be used for the derivation of model variables (e.g. Leaf Area Index for specific plant functional type). The SMAC algorithm requires the following input parameters describing atmospheric conditions: the surface pressure, the ozone content and the water vapour content and, most important, the aerosols. Aerosol optical depth measured at Aerosol Robotic Network (AERONET) stations during the overpass time of MODIS were found most suitable as input data for our purposes. Dedicated data sets will be atmospherically corrected only when needed.

Collection and processing the data for year 2011 will be done with the existing system setup and there are no foreseen difficulties. Minor changes to the product calculation may be implemented during the year 2011 if requested by the other actions. The final state of the produced datasets will be documented on the final reports at the end of year 2012.

Completed deliverables & milestones since Inception Report

Deliverables: Datasets have been documented and the status of the EO data processing has been reported in the 1st and 2nd EO Data documents (in co-operation with Action 2).

- 1st EO-data document
- 2nd EO-data document

Milestones: Raw data archives and the initial product datasets of MODIS and AVHRR for years 2001- 2010.

- MODIS dataset for 2001-2008 completed
- AVHRR dataset for 2001-2008 completed
- MODIS dataset for 2009-2010 completed
- AVHRR dataset for 2009-2010 completed

References:

"SMAC: A simplified method for the atmospheric correction of satellite measurements in the solar spectrum" H. RAHMAN, G. DEDIEU Int. J. Remote Sensing, 1994, vol.15, no.1, 123-143.

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

The main objective of Action 4 (In-situ data collection and processing by FMI) is preparing two data sets: ***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 JSBACH, 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 3D 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 (i.e. the in situ data set) is based on the CO_2 flux and concentrations measurements of Finnish Meteorological Institute consisting of data from several flux and concentration measurement sites. Longest running flux sites, Kaamanen wetland and Sodankylä Scots pine forest, provide data sets of about 10 years. Shorter multi-year flux data sets are available from a spruce forest and a wetland at Pallas area and several sites in southern Finland on peatlands in different agricultural and forestry use. The background concentration measurements from Pallas-Sodankylä GAW station will be used for evaluating the concentration predictions of the models.

The tasks have progressed as planned. The 1st and 2nd data documents were written by the due date. The initial and boundary data field sources for the models have been selected (Table 1). More detailed description of the selected and optional data sources is presented in 1st Data document.

Table 1: Gridded data sources to be used as an input for the model

Included data type	Name of the dataset
Initial and boundary CO_2 concentration fields	TM3 model
Fossil fuel emissions	EDGAR4.0 database
Ocean sources	Takahashi database 2000
Initial and boundary fields for meteorology	ECMWF analysis data

The measurements of the validation data has been continuing 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 during 2010 and there are no major problems in the task. The oldest flux sites have been running over 10 years and during that time there have been slight changes in the flux calculation programs. The data from these sites, Sodankylä and Kaamanen, have now been recalculated according to the latest post-processing procedures in order to ensure homogeneous datasets. This work is going to continue in 2011.

Carbon balance related features, like growing season beginning and end dates, has been analyzed from the CO2 flux data for various sites for a comparison with similar information extracted from time series of NDVI in Action 7. This activity will be continued in 2011.

Limited time coverage of the background CO2 concentration data availability may limit the production of the absolute CO2 concentration fields by the end 2008. However, the impact of the land surfaces within the domain to the CO2 concentrations can be provided even in the lack of background concentration data.

Completed deliverables & milestones since Inception Report consist of selecting the initial and boundary data field sources, preparing the data documents for input and validation data and processing the data into a form appropriate for model evaluation.

Deliverables:

- 1st Data document
- 2nd Data document

Milestones:

- The initial and boundary data field sources for the models are selected

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

The main objective of Action 5 is to collect and process in-situ data from snow and vegetation to be further used in Action 7 (Methodology development and implementation), Action 8 (Demonstration and validation by FMI) and Action 9 (Demonstration and validation of EO services (SYKE)). Several data sources have been used in the course of the first two years of the project. The information available from SYKE information registers have been complemented with datasets from other research institutes in Finland, as well as with 4 dedicated field campaigns, of which two in the autumn and two in the winter time. Data from in-situ field campaigns are used for validation of the satellite-derived datasets and for method and algorithm development.

The snow data coming from SYKE and FMI operational observations and automated stations is updated to the project datasets regularly. Years 2001-2010 provide an interesting period for the carbon balance modelling, since the years include strong variability in the snow cover, e.g. winter 2008/2009 was a year with little snow, especially in the southern Finland, where as the winter 2009/2010 was a cold and snow rich year in Scandinavia and in Northern-Europe.

The changes in the satellite signatures have now been shown to have good correspondence with the phenological events observed in-situ. The phenological data, purchased from the Finnish Forest Research Institute (METLA), was screened out for possible errors and inconsistencies. The feedback was sent to METLA, where the data was checked more thoroughly. They reported corrections to the data and more accurate coordinates for the measurement sites. The data was utilized in Action 7 (Methodology development and implementation), in the development of the method for method for extracting phenological events from the satellite derived NDVI- data time-series.

To better characterize the land cover datasets for the carbon balance modeling purposes, new datasets are being investigated for their feasibility. The steering group of the SnowCarbo recommended the investigation of a soil classification by the Agrifood Research Finland. The data is based on international WRB (World Reference Base for Soil Resources) classification in 1:250 000 scale. Additionally, a geotechnical soil classification in 1:200 000 scale was released by the Geological Survey of Finland (GSF). Neither the WRB- classification nor the new classification from GSF provide direct ways of applying the information to refine the land cover classification built for the models in Action 11 (Evaluation of required North-Eurasian land cover information), since they do not provide suitable quantitative information.

Altogether 4 field campaigns have been carried out during the first two years of the project:

1st winter field campaign: 13.-23.3.2009

The interpretation of the satellite signal from the ground for interpretation of the fraction snow covered area is supported with spectrometer measurements on the ground from the same target. Spectrometer and snow property measurements were carried out in winter 2009 at the Arctic Research Centre of the Finnish Meteorological Institute in Sodankylä (FMI-ARC). The measured data complemented the existing spectral databank from snow cover.

1st autumn field campaign: 1.10.2009 and 12.10.2009

Conditions in autumn 2009 were favourable for observations of soil moisture and temperature dynamics. Measurements of soil moisture and soil temperature were carried out before and after snow fall (above and below 0 degrees Celsius) for in-situ referencing satellite image instrumentation. Measurements were carried out at FMI-ARC. Additionally the target vegetation was characterized.

2nd winter field campaign: 12.-23.3.2010

The satellite observation of snow cover include signature from direct reflection of sunlight from snow, but also a component from diffusely reflected sunlight from shadowed snow cover. Therefore the signature is more complex for interpretation in forested areas. Also the spectral reflectance is altered when the snow becomes wet in the late spring. A shortcoming in was identified in the spectral database. Shadowed snow cover and snow cover under late melting conditions were under represented for statistical analysis. Therefore, measurements were carried out under these conditions during spring 2010 together with snow cover characterization.

2nd autumn field campaign: 5.-9.9.2010

Northern boreal forests are an important component in the CO2- exchange in Northern Europe, therefore the correct representation of them is essential in the land cover classification used as an input in the carbon balance modelling. The autumn 2010 field campaign included measurements of forest parameters and validation of land cover classification. Additionally, measurement of the spectral response from selected (most abundant) vegetation in mires were done to help in the interpretation of satellite images and finally the time-series of satellite- derived indices, which seem to have somewhat different behaviour than in forested areas.

The data will be further processed according to the needs of the other actions. If considerable gaps or deficiencies appear in the dataset, they will be further filled with additional field campaigns in 2011. The possible activity in 2011 and the final in-situ data report will be due to end of November in 2011.

Completed deliverables & milestones since Inception Report

Deliverables:

- 1st in-situ data document
- 2nd in-situ data document

Milestones:

- Field measurement campaign in autumn 2009
- Field measurement campaign in spring 2010
- Field measurement campaign in autumn 2010

3.1.6 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. Some testing and consequent adjustments of the data flows are in progress and will be performed during the last 6 months of the action. This time frame also allows adopting and testing new versions of the models and modules in the case they are updated by the model developers at the MPIs in Jena and Hamburg. The problems that we have encountered, and solutions to them, are described under each milestone achieved.

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

The REMO2008 regional climate model is running on FMI's supercomputer Meteo, as well as on the CSC — IT Centre for Science — supercomputer Louhi. However, recent developments on modelling framework have been concentrated on Meteo, while Louhi serves for the moment as a backup computing platform. Offline land surface model JSBACH and the offline version of the soil carbon model CBALANCE both run on Meteo. The offline version of CBALANCE is called CBALONE. The version of REMO taking tracer transport into account runs on Meteo as well as on Louhi. The running interface facilitating controlled dataflow between the models and to the data end users is written in Python. This makes it easy to use and adaptable for further developments.

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

The set of meteorological variables derived from REMO output for forcing JSBACH were decided and derived in time. However, derivation of one of them needs revision. The variables are the following: Solar radiation, clear sky solar radiation, thermal radiation, precipitation, 2m temperature, surface pressure and wind speed. The above mentioned are predicted variables of REMO except for solar radiation that has to be derived from net and reflected solar radiation terms. In the A8 the magnitude of short wave radiation was found to be too low under cloud cover, thus the derivation of this variable needs revision that will be a task of A8. Depending on the selected solution, some modifications to the existing Python running interface or even to the REMO output stream may be required in this action. This is the first main task of the following six months.

First trials on running the coupled REMO-JSBACH model will be made.

The first attempts to run the coupled model were made in time according to the timeline. JSBACH is forced with REMO-derived high resolution (0.167º) climate in order to produce the present CO_2 balance. REMO was run in forecast mode – i.e. daily cold start of the model with six hourly spin up for atmospheric circulation – and the JSBACH was run in offline (standalone) mode. From here on, it will be referred to as JSBALONE. The model JSBALONE takes in daily climate drivers and generates the respective instantaneous values. Output interval was set to one hour.

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

The REMO-JSBACH production runs comprise three consequent steps as shown in the schematic Figure 5. The REMO Tracer takes care of the CO_2 transport due to anthropogenic and natural sources, which are required for estimating the atmospheric CO_2 concentrations. The deliverables from Action 6 "*1st Report on Methodology*" as well as from Action 4 "*1st Data Document*" describes the data needs and data flows in more detail.

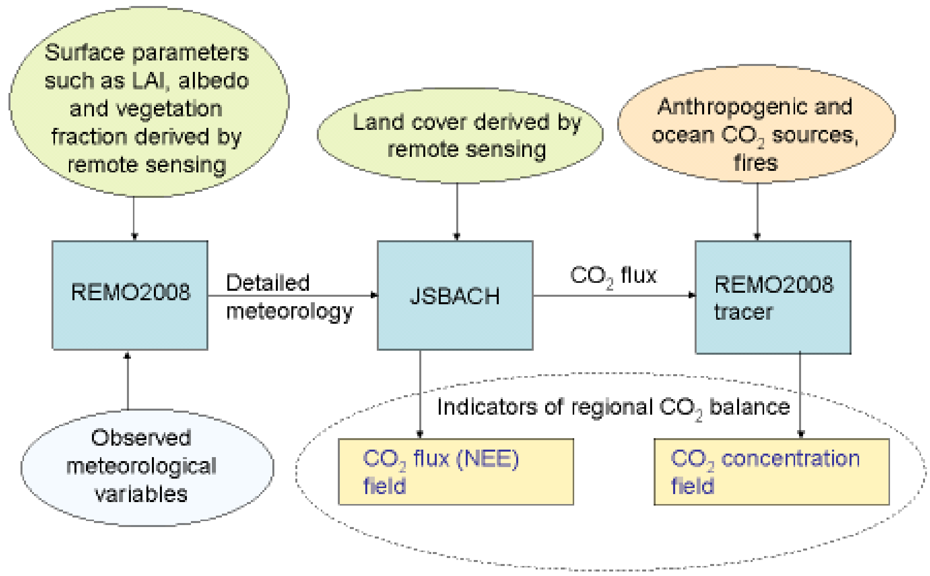


Figure 5: Schematic diagram of the sequence of modelling approach

The other necessary data flows are related both to various sensitivity analyses performed in Action 8 and to various spin up procedures described below. 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 CO_2 balance via heterotrophic respiration due to decomposition of the organic material.

Required spin up procedures for both JSBACH and REMO are taken either offline (e.g CBALONE) or as a part of each production run. The purpose of these spin ups is to ensure the correct base levels for storage variables, on the one hand, and well developed circulation of the atmosphere, on the other hand.

The required spin up procedures and their purpose is listed in Table 2 below.

Table 2: Procedures of model spin ups

Module/model	Variables adjusted	Duration	Spin-up type
REMO2008	Soil water, atmospheric circulation	1 year in climate run 6 hours in forecast run	online
REMO Tracer	Soil water, atmospheric circulation	6 hours	online
JSBACH (including CBALANCE)	Soil water, short term carbon storages	1 (or couple of) year(s)	online
CBALONE	Carbon storages	Up to 1000 years	offline

All the various spin-ups have been implemented. However, their reliability will be assessed during the last months of this action. A8 provides the reference data and methods for the assessment. The main problem foreseen is the realistic allocation of the soil carbon storages as present day land cover maps will be used in the spin-up. Possible solutions include averaging of the storages over larger areas, tuning of the storages according to literature values, and adoption another soil carbon model that is better suited for North-European ecosystems. The solutions to be adopted are dependent on the conclusions of Action 8.

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

REMO and JSBACH use various land use data that are first allocated to respective Olson classes and further aggregated to a grid of a resolution of 1km. The various land cover data have been produced and reported by Action 11. The first trials were made in due time.

Data utilization from the Actions 3, 4, 5 and 11 will be revised according to the status of the models and the results of the initial runs.

Various data have been adopted for use in the modelling framework. So far there has been no need to revision the practices adopted for the utilization of the land cover data of Action 11. However, allocation of surface parameter values may still require some modification. This need will be estimated in other actions. Such modifications necessitate reproduction of the surface boundary maps of REMO and JSBACH. The generation of the boundary data has been implemented at FMI's computing facilities. The procedure can easily be repeated whenever found necessary.

The data from Action 4 is routinely used in REMO climate and forecast runs. As the snow depth of the boundary data has been found partly (see Action 9) unreliable and because the production runs of REMO have been intended to be done in forecast mode which is sensitive to the boundary data, the initial snow depth data source needs to be revised. Either another reanalysis product or data from Action 9 will be used as a substitute. Routines for substituting fields of the REMO boundary data fields have been created and tested for static fields.

Problems are foreseen in utilizing dynamic variables such as Leaf Area Index (LAI), snow depth, and albedo in JSBACH. This is because the model is only externally forced with the meteorological data, whereas the dynamic variables are predicted internally in the model. The means to nudge also JSBACH with observed fields will be further explored. This will be the second main task of the last 6 months of this action.

Completed deliverables & milestones since Inception Report

Deliverables:

- 1st Progress report on methodology

Milestones:

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

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

- First trials on running the coupled REMO-JSBACH model will be made.

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

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

- Data utilization from the Actions 3, 4, 5 and 11 will be reviewed according to the status of the models

3.1.7 Action 7: Methodology development and implementation by SYKE

The objective of Action 7 is to produce time-series from environmental parameters describing the status of snow cover and vegetations, both of which are important components in the processes of carbon exchange between atmosphere and soil and vegetation.

Time-series of Snow Covered Area (SCA) and Normalized Difference Vegetation Index (NDVI), in a gridded form, were processed for the years 2001-2008 from MODIS satellite data according to project plan by 30/11/2009. All data sets were described in the deliverable of Action 3: "1st EO-data document".

The generation of time-series of SCA and NDVI for the years 2009 and 2010 will start in the beginning of 2011 and is estimated to be completed according to schedule by 31/03/2011.

In addition to the project plan also Normalized Difference Water Index (NDWI) (Gao, 1996) was calculated, as it was shown to be a good indicator for the derivation of the greening up in the boreal region (Delbart et al., 2005).

The processing of dedicated time-series of daily observations 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 2001-2008. Methods for the smoothing and gap-filling of SCA and NDVI time-series were described in the following deliverables of Action 7: "Progress report on filtered time-series (2001 – 2008)" (date 31/05/2010) and "2nd progress report on filtered time-series (2001-2008)" (date 30/11/2010).

In order to facilitate the generation of time-series from homogenous sites of selected land cover types, the fraction of each land cover class within a MODIS pixel was calculated from CORINE Land Cover 2000 (Härmä et al., 2005) for Finland. NDVI, NDWI and SCA time-series were extracted from homogenous areas around in situ measurement sites (phenological sites and CO_2 flux-measurement sites). Since time-series suffer from missing observation due to cloud cover, extracted time-series were analyzed to fill missing values and to reduce the effect of noise. Time-series of NDVI were interpolated and smoothed using the software TIMESAT version 2.3 (Jönsson and Eklundh, 2004), which was developed for seasonality extraction and noise removal in vegetation index time-series. Time-series of SCA of northern and mid-boreal areas were gap-filled and smoothed by fitting a sigmoid function on the temporal profile. For southern boreal areas linear interpolation and monotone piecewise cubic interpolation was applied.

In order to allow comparisons between satellites derived indices (and/ or derived carbon-balance related features) and modelling results (Action 6), methods for spatial aggregation of time-series to the modelling grid were developed and implemented.

Work on filtering and interpolation of time-series will continue according to plan with processing of time-series for the years 2009 and 2010 (due date 30/09/2011).

The extraction of carbon balance-related features a) beginning of growing season, b) seasonal vegetation peak and c) the end of growing season is in progress. Methods for the calculation of the beginning of growing season were developed, implemented and documented in deliverable: "Progress report on extracted features (2001-2008)" (date 31/08/2010).

For methodology development, satellite-derived time-series from coniferous forests and wetland areas were compared with in situ dates of the beginning of growing season (referred here as flux growing season, FGS) determined at CO_2 flux measurement sites, which were provided by action 4. Furthermore, comparisons were carried out with phenological observations of bud-burst of birch trees and the beginning of height growth of pine trees, which were acquired from Finnish Forest Institute (METLA).

Start of FGS of coniferous forest was determined from NDVI time-series. Comparisons of satellite-derived start of FGS for the period 2001 - 2008 with in situ dates revealed good correspondence for three CO_2 flux sites in Finland. Start of growing season of broadleaved deciduous forest and wetland sites was determined from time-series of NDWI based on the method proposed by Delbart et al. (2005).

Maps of the beginning of FGS of coniferous forest in Finland for different years were provided to action 9 for further analysis of spatial and temporal patterns and comparisons with modelling results.

Further work on extraction of carbon balance-related features will concentrate on the determination of the seasonal vegetation peak and the end of season for different land cover types. First comparisons for the detection of the end of flux growing season in coniferous forest indicate that this event occurs when sun elevation of MODIS observations is already very low (< 30 degrees). Therefore adjustments in the pre-processing of the MODIS data were made by Action 3 and the usability of the data for the extraction of this specific feature need to be investigated further.

It is envisaged that carbon-balance related features for the years 2001 -2010 will be derived and delivered to project partners (Action 6 and Action 9) according to schedule by 30/09/2011.

Completed deliverables & milestones since Inception Report

Deliverables:

- The unfiltered time-series, in the gridded form, of snow covered area (SCA) and normalized difference vegetation index (NDVI), years 2001-2008 (incorporated into the deliverable from Action 2 & 3, entitled, "1st EO-data document")

- Progress report on filtered time-series (years 2001-2008)

- Progress report on extracted features (2001-2008)

- 2nd progress report on filtered time-series (2001-2008)

Milestones:

- Features extracted (years 2001-2008)

References

Delbart, N., Kergoat, L., Le Toan, T., L'Hermitte, J., Picard, G., 2005. Determination of phenological dates in boreal regions using normalized difference water index. Remote Sensing of Environment 97, 26-38.

Gao, B.-C., 1996. NDWI-A normalized difference water index for remote sensing of vegetation liquid water from space. Remote Sensing of Environment 58, 257-266.

Härmä, P., Teiniranta, R., Törmä, M., Repo, R., Järvenpää, E., Kallio, E., 2005. CLC2000 Finland: Final Report. Finnish Environment Institute, Geoinformatics and Land Use Division. URL: http://www.ymparisto.fi/download.asp?contentid=38725&lan=fi, accessed 21.12.2010.

Jönsson, P., Eklundh, L., 2004. TIMESAT-a program for analyzing time-series of satellite sensor data. Computers & Geosciences 30, 833-845.

3.1.8 Action 8: Demonstration and validation by FMI

This action focuses on demonstration of carbon balance methodology/system by applying as input information from actions Action 9, Action 3 and Action 4. The modelling tasks consist of the climate model REMO runs in the modes described in the reports of Action 6 and offline coupled REMO-JSBACH-REMOTracer model runs with various initial and boundary data. The demonstration of the modelling framework consists of sensitivity analysis among the various modelling schemes. Finally the most suitable modelling framework for producing the present day CO_2 balance will be selected according to comparison to the in situ data of Action 4 and phenology data from Action 3.

This action was officially started in the beginning of year 2010. However, the accomplishment of the first tasks in the form described in the research plan was delayed 6 months due to delay in the implementation of the modelling framework in the Action 6, on the one hand, and due to minor revision of the tasks on the other hand. The possibility of delays was foreseen already in the research plan where a time buffering was added to the project timetable. 6 months delay will not cause any difficulties in achieving the objectives of Action 8. This delay will also not affect to allocated budget for Action 8.

The system functionality validation at Sodankylä-Pallas CAL-VAL site consists of comparison of flux site data to model data. For most of the variables this can be performed to all the flux sites in Finland simultaneously and easily extended to further sites within the domain. Thus this task can be combined with the second task that should extend the application of the methodology to all the Finland, as well as with the third task that extends the methodology to the whole Nordic domain that is described in the Preliminary Demonstration Report of this action as well as in the earlier reports of Action 6.

The CO_2 flux data and CO_2 concentration data are available for functionality validation. CO_2 concentration data measured at the Pallas GAW site is combined with trajectory information up to year 2008. All the flux and concentration data is processed and checked for quality according to standards developed in the international measurement networks.

The system validation has been started for the Nordic model domain with comparison of climates predicted by REMO by using different land use maps and climate model running modes. According to the first comparisons the change in the surface parameterizations due to different land cover classifications is reflected by the surface fluxes (see Figure 6). Moreover the forecast and climate modes do produce different weather situations as is expected.

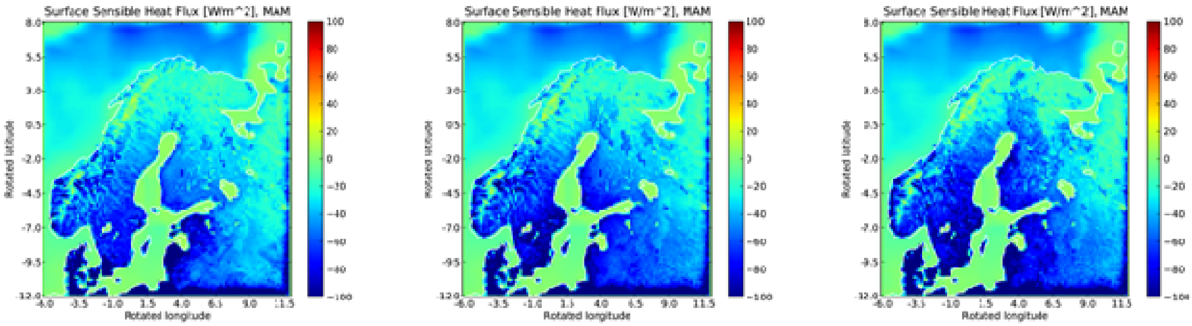


Figure 6: The sensible heat fluxes in spring 2003 estimated using the revised land cover classifications. From left to right: the standard Olson land cover, Globcover and FinnishCLC+Globcover

According to the preliminary CO_2 balance estimates shown in Figure 7 (in terms of the net ecosystem exchange, NEE) the timing of growing season events, including start of the growing season, and the time during the growing season, when the ecosystem respiration exceeds gross assimilation (GPP) – i.e. the NEE turns to positive during the growing season – agree well with the measurements. However, there are still problems with the absolute values of both GPP and the total ecosystem respiration. The problem in GPP estimate is obviously due to too high cloud absorption of short wave radiation in REMO, leading to days with far too low incoming short wave radiation. It may be that this problem is intermingled with unrealistic daily PAR irradiance cycle produced by JSBALONE and with photosynthesis parameters that are suited for more southern areas. The problem in the total ecosystem respiration is due to the erroneous value of soil carbon storages in the preliminary runs. The former problem will be overcome either by applying a different version of JSBACH for the predictions or by an ad hoc increase of the short wave radiation predicted by REMO. The photosynthesis parameterization of JSBACH was already updated but their effect have to be further explored for need for further tuning. The latter problem was already overcome by adopting a former version of the soil carbon model CBALONE.

Selection of system setup and parameterization from validation results and estimation of carbon balance for Baltic EU areas with selected setup have been started. There is a delay due the delay on Action 6.

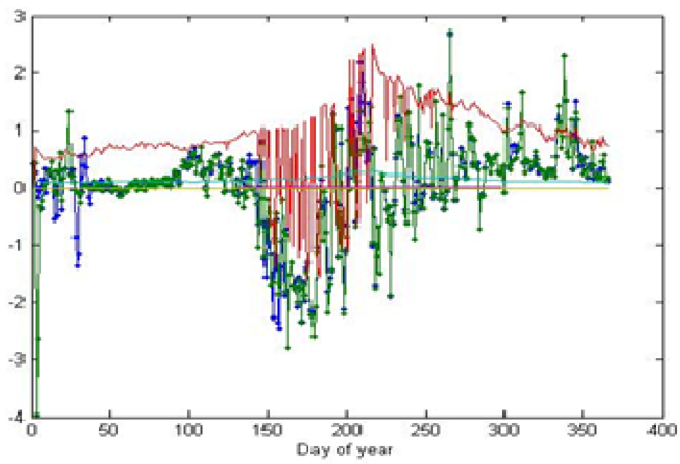


Figure 7: NEE measured at Sodankylä site in 2003 (green and blue) and modeled with JSBACH (red shades)

Completed deliverables & milestones since Inception Report

Deliverables:

- Preliminary demonstration report

Milestones:

- System functionality validation at Sodankylä-Pallas CAL-VAL site
- System validation over Finland with different resolutions on selected test years
- System validation over Baltic test area for selected years
- Selection of system setup and parameterization from validation results
- Estimation of carbon balance for Baltic EU area with selected setup
- Production of preliminary demonstration report

3.1.9 Action 9: Demonstration and validation of EO services

At first phase the relevant documentation is shared via the

The activity of Action 9 started with setting up an ftp- server for sharing the data among project partners. The server was set up in the premises of FMI. Details of the activities related to the data sharing were presented in the first Action 9 deliverable: "Data Exchange Document". The Main activity in Action 9 is the demonstration of the use of remote sensing data in carbon modelling. Two approaches were selected in order to accomplish the work:

- Development of carbon load sensitive indicators directly from remote sensing data
- Investigation of the usability of remote sensing data in REMO (Regional Climate Model)

Carbon load sensitive indicators directly from Remote Sensing data were investigated. Phenology is an important factor influencing the carbon balance of boreal ecosystems and therefore accurate information related to phenological events is needed for calculations of the regional carbon budget. The beginning and end of photosynthetic activity (referred here as start and end of growing season) in an ecosystem can be determined from in situ measurements of the CO_2 fluxes. However, these measurements are only available at very few locations and thus it is necessary to generalize the information provided by these sites. Therefore, the use of satellite-derived time-series for determination of phenological events is investigated. Comparisons between satellite-derived 'beginning of growing' season and in situ measurements are completed. A comparison between satellite-derived 'end of growing season' with in situ measurements is in progress.

In situ measurements of the beginning of the growing season for coniferous forest and wetlands areas were compared with NDVI time-series from flux measurement sites. A method for extraction of beginning of growing season was developed, implemented and documented (Action 7 "Progress report on extracted features (2001-2008)"). Inter-annual changes in the beginning of growing season were analyzed (Action 9 report: "Preliminary demonstration report", date 30/11/2010).

Maps of start of season for coniferous forest in Finland completed. Maps for other land cover classes (broadleaved forest, wetlands) are in progress. The start of the growing season for different years in coniferous forest was derived from NDVI time-series based on the methodology developed in Action 7 (see above). Examples of the spatial distribution of the start of season in Finland for years 2003 and 2004 are shown in Figure 8. Details are given in the Action 9 report: “Preliminary demonstration report".

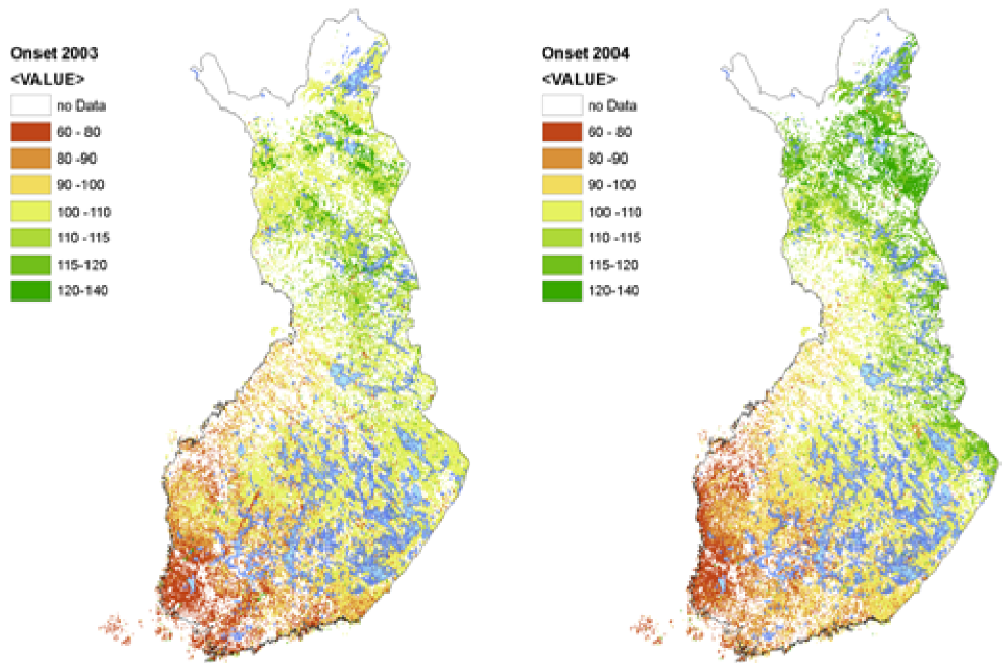


Figure8: Start of growing season [day of year] of coniferous forest in Finland for years 2003 and 2004

The carbon output in SnowCarbo is provided by JSBACH model preceded by REMO Regional Climate Model which provides the input to JSBACH; the focus of the work so far has been in investigating the usability of remote sensing data in REMO. This is because many of the input and output parameters of REMO are directly or indirectly related to those obtained by means of remote sensing. It is therefore justified to investigate how REMO output alters if run by using remote sensing data instead of other (conventional) data sources. More detailed results are presented in the report by Action 9: "Preliminary demonstration report".

Impact of different land cover data set in carbon modelling is assessed. Comparisons between the standard (Olson classification) and the new detailed (best possible) land cover dataset is completed (see Action 11); Different revised land cover data sets recoded into Olsson nomenclature were produced covering the modelling window in Scandinavia and surrounding areas.

Investigating whether REMO snow output (snow depth, snow covered area) are sensitive to Land Cover data is partly completed for REMO- snow depth. In progress for REMO- snow covered area.

Investigating the quality of snow input data to REMO provided by ECMWF is completed for years 2003-2004 and in progress for years 2005-2007. The snow data provided by ECMWF is used by REMO. We investigated the quality of the data by comparing it with remote sensing snow data (Snow water equivalent by AMSR-E data) and with ground truth (snow depth from weather stations). In future, ECMWF snow input may be replaced by remote sensing data. An example of comparison data is presented in Figure 9 for April 24, 2004.

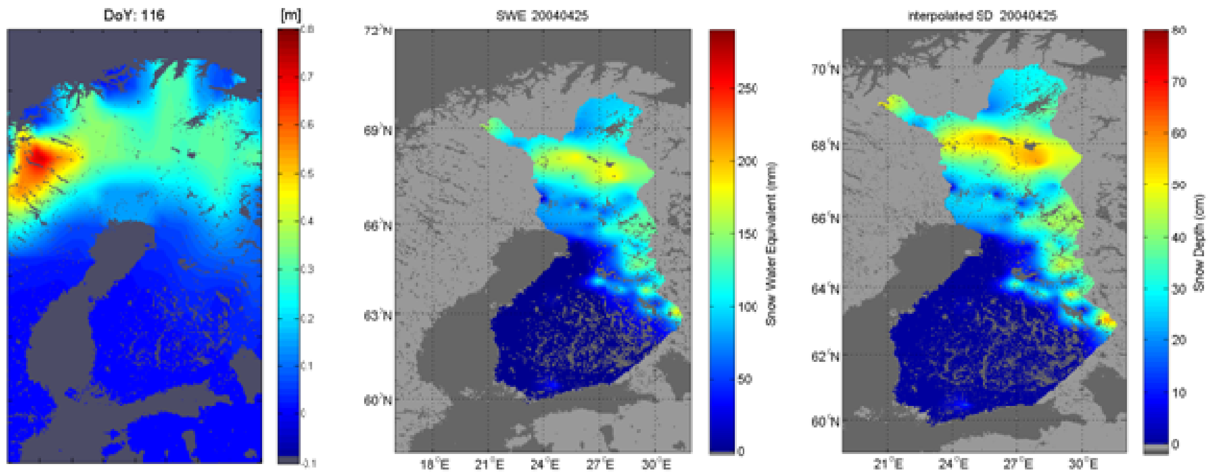


Figure 9: Snow depth by ECMFW (left), snow water equivalent from AMSR-E data (middle) and snow depth interpolated from Finnish Weather station data (right) for April 24, 2004

Completed deliverables & milestones since Inception Report

Deliverables:

- Documentation of the data exchange method
- Preliminary demonstration report

Milestones:

- Implementation of the data exchange method completed

3.1.10 Action 10: Generation of carbon assessment end-products

Activities will be started in 2012.

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

Land cover classification give the spatial distribution of land cover types and surface parameters allocated for each land cover. These characterize each land cover category used by the models. The information needs and content in carbon balance modelling (REMO and JSBACVH) have been studied together with service providers of land cover information at SYKE and modelling group at FMI. Already available land cover data sets have been demonstrated and evaluated. The results of this have been reported and the first deliverable:" Land Cover Data Needs for Carbon Balance Mapping" was available late August 2009. This information will be updated during the project according to modelling experiences.

According to the information needs several sets of gridded land cover maps were produced in different resolutions (scales) and geographical coverage:

1. Detailed (local) land cover information covering intensive in-situ monitoring areas (flux stations in northern Finland)were produced using satellite data (IRS P6 LISSIII, SPOT 4 XS, LANDSAT 5 TM) together with ancillary GIS and in-situ data. Employed methods included estimation of land cover variables using rule-based predictive models. Additionally Finnish national CORINE land cover databases were utilized. Results were validated using in-situ data collected in the measuring campaign, which was organized in September 2010.
2. In standard model versions the surface cover data is a global 1km resolution land cover dataset based on Olson ecosystem classification. Since Olsson data do not describe Nordic land cover properly, alternative land cover information was produced. Different revised land cover data sets recoded into Olsson nomenclature were produced and delivered covering the modelling window in Scandinavia and surrounding areas. Following data were utilized shown in Figure 10:
    a) GlobCover (regional version 2.2)
    b) European Corine Land Cover (CLC2006)
    c) National Corine Land cover (CLC2000 and CLC2006)
    d) Clusters of MODIS products (MOD15 Leaf Area Index and MCD43 Albedo)

Additionally feasibility of surface parameters (Forest ratio and LAI) allocated to each land cover category was evaluated using local estimates of crown cover and LAI in Nordic conditions. Reliable characterization of forests is essential in Scandinava, where conifer boreal forests cover the most of land areas. It was found that local estimates of LAI and forest ratio deviate significantly from corresponding original values allocated to Olsson land cover categories in Scandinavia. This information was utilized when revising land cover data for modeling.

When considering thematic accuracy of data, European and national version of Corine Land Cover should be used as input data source for land cover information over Scandinavia. However, the feasibility of proposed, enhanced land cover information in carbon balance modelling will be evaluated by comparing model outputs with in-situ carbon fluxe measurements and EO based observations. This work is in progress and will be reported year 2011.

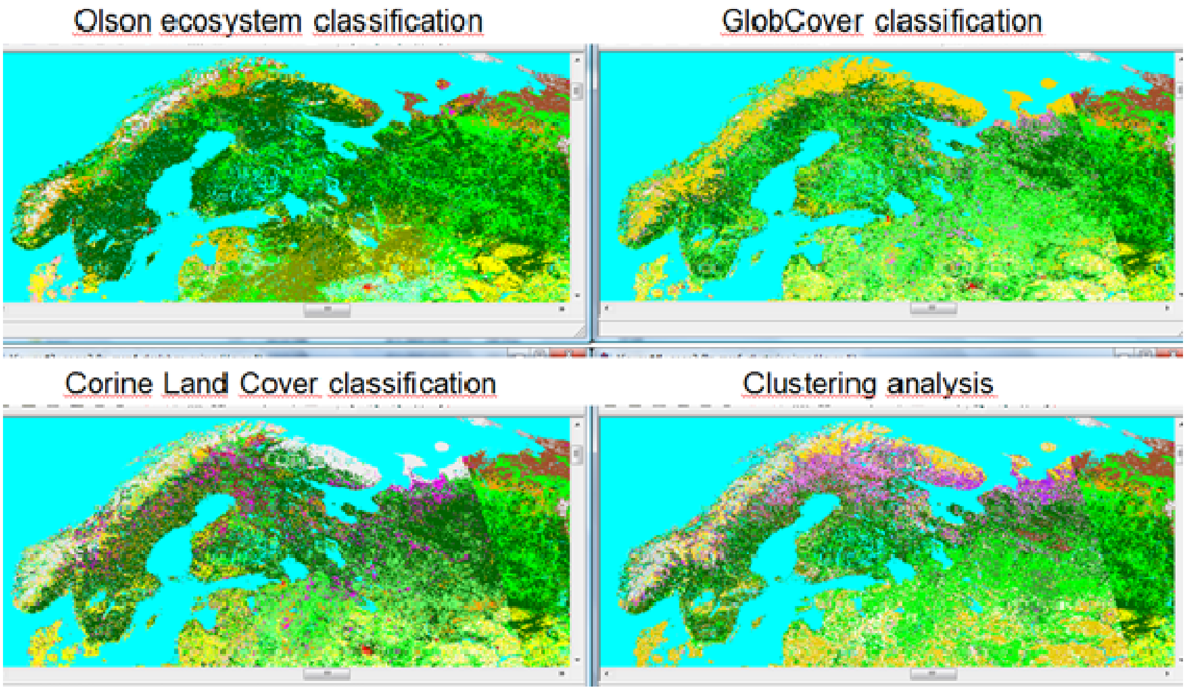


Figure 10: Regional land cover data sets for Snowcarbo produced using Globcover, CORINE2006 and MODIS data

Completed deliverables & milestones since Inception Report

Deliverables:

- Report on land cover data needs
- Combined Report on data production and accuracy and on produced land cover datasets and estimated geophysical parameters

Milestones:

- Analysis on land cover data needs for carbon balance mapping
- Production of land covers dataset

3.1.12 Action 12: Dissemination

Dissemination in the framework of SnowCarbo primarily means the distribution of the end products from Action 10. This will start during the last year of the project in 2012.

From October 19, 2009 the project website layout has been revised. This was based on information or feedback from the users and external monitors. The website now contains only internal password protected pages and public pages. The user protected pages where eliminated. An internal document library page was established for internal purposes of sharing and exchanging files. Also to support the data exchange, an ftp server was set up. On October 20 2009, users where supplied with guidelines on how to upload files to the ftp server. Files on the ftp server are then uploaded to the project website.

Following publications and presentations were disseminated from SnowCarbo project:

1. Arslan A., Mattila O-P., Markkanen T., Böttcher K., Susiluoto J., Törmä M., Lemmetyinen J., Metsämäki S., Aurela M., Kervinen M., Takala M., Härmä P.,

Pulliainen J.,SNOWCARBO: CO2 Balance of Northern Terrestrial Ecosystem, AGU, December 13-17, 2010, San Francisco, USA.

2. Markkanen T., Susiluoto J., Törmä M., Härmä P., Arslan A., Mattila O-P., Pulliainen J.,Impact of Refined Land Cover Data on Regional Climate and CO2 Balance, ESA-iLEAPS-EGU Earth Observation for Land-Atmosphere Interaction Science Conference, 3-5 November 2010, ESA-ESRIN, Frascati, Italy, 2010.
3. Arslan A., Mattila O-P., Markkanen T., Böttcher K., Susiluoto J., Törmä M., Lemmetyinen J., Metsämäki S., Aurela M., Kervinen M., Takala M., Härmä P., Pulliainen J.,SNOWCARBO: CO2 Balance of Northern Terrestrial Ecosystem,ESA-iLEAPS-EGU Earth Observation for Land-Atmosphere Interaction Science Conference, 3-5 November 2010, ESA-ESRIN, Frascati, Italy, 2010.
4. Pulliainen J., Laaksonen A., Laurila T., Luojus K., Rautiainen K., Aurela M., Lemmetyinen J., Vehviläinen J., Kontu A., Arslan A., Aalto T., Markkanen T., Susiluoto J., Böttcher K., Törmä M., Mattila O., Metsämäki S., Kervinen M., Härmä P., Mapping Of CO2/CH4 Annual Fluxes At High Latitude Continental Areas Applying Microwave Radiometer Observations, ESA-iLEAPS-EGU Earth Observation for Land-Atmosphere Interaction Science Conference, 3-5 November 2010, ESA-ESRIN, Frascati, Italy, 2010.
5. Böttcher,K., Kervinen, M, Aurela, M., Mattila, O-P.,Determination of spring events of boreal coniferous forest from MODIS time-series,Finnish Remote Sensing Days,4-5.11.2010, Helsinki, Finland
6. Törmä M., Arslan A., Hatunen S., Härmä P., Markkanen T., Susiluoto J., Pulliainen J., Revising the land cover and use classification of Northern areas for climate modeling, SPIE European Remote Sensing, Toulouse-France, 20-23.09, 2010.
7. Pulliainen J., Lemmetyinen J., Kontu A., Arslan A., Wiesmann A., Nagler T., Rott H., Davidson M., Schuettemeyer D., Kern M., Observing seasonal snow changes in the boreal forest area using active and passive microwave measurements, Geoscience and Remote Sensing Symposium (IGARSS), 2010, pp. 2375 - 2378. DOI 10.1109/IGARSS.2010.5653105, 2010.
8. Takala M., Pulliainen J., Luojus K., Lemmetyinen J., Kangwa M., Metsämäki S., Koskinen J., Combined hemispherical scale SWE and snow clearance monitoring Geoscience and Remote Sensing Symposium (IGARSS), 2010. Digital Object Identifier: 10.1109/IGARSS.2010.5650728 Publication Year: 2010 , Page(s): 1765 – 1768, 2010.
9. Metsämäki S., Mattila O., Kärnä J., Pulliainen J., Luojus K., New approach for the global mapping of fractional snow coverage in boreal forest and tundra belt applicable to various sensors, International Geoscience and Remote Sensing Symposium (IGARSS), 2010.
10. Luojus K., Pulliainen J., Takala M., Derksen C., Rott H., Nagler T., Solberg R., Wiesmann A., Metsämäki S., Malnes E., Bojkov B., Investigating The Feasibility Of The GlobSnow Snow Water Equivalent Data For Climate Research Purposes, Geoscience and Remote Sensing Symposium (IGARSS), 2010.
11. SnowCarbo presentation at the Life+ Climate Change Seminar, 18-19 January, 2010, Helsinki, Finland.

12. Takala, M., Pulliainen, J., Metsämäki, S., and Koskinen, J., Detection of Snowmelt Using Spaceborne Microwave Radiometer Data in Eurasia From 1979 to 2007, IEEE Trans. Geosci. And Remote Sensing, 47:2996-3007.
13. Mattila, O-P., Böttcher K., SNOWCARBO:Monitorung and Assessment of Carbon Balance related Phenomena in Finland and Northern Eurasia, METIER-Final Conference, 4-6 November 2009, Brussels, Belgium.
14. Törmä, M., Aalto, T., Hatunen, S., Härmä, P., Markkanen, T., and Pulliainen, J., Spatial Data Requirements of Carbon Balance Modelling, SPIE Europe Remote Sensing Conference, 31 August-3 September 2009, Berlin, Germany.

Completed deliverables & milestones since Inception Report

Deliverables:

- Update of the project website layout

Milestones:

- FTP server for data exchange (performed in Action 9)
- Project poster describing SnowCarbo project, background and objectives
- Preparation of an online newsletter presenting first project results.
- Preparation of the 2nd online newsletter presenting achievements project results.

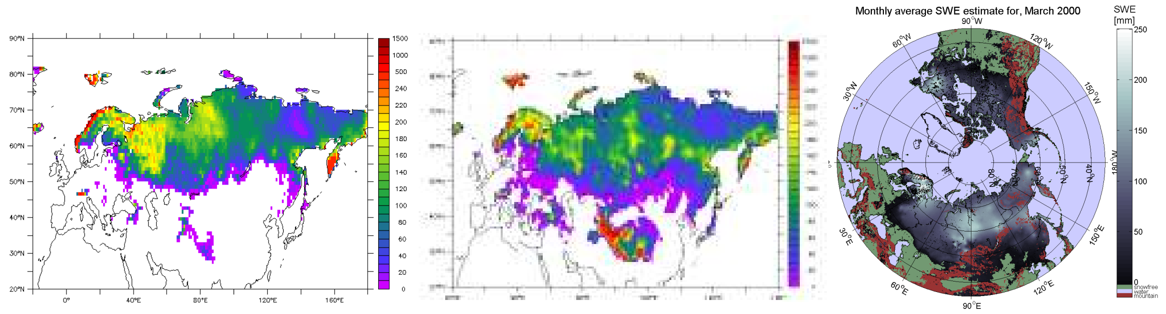
3.1.13 Action 13: Auditing

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

3.1.14 Action 14: Project advisory co-operation

The project advisory team has assisted in all teleconferences and communicated with the coordinator as to the set of deliverables and their deadlines for Action 14.

The work presented here has been conducted by Martin Menegoz, a post-doctoral researcher which has been recruited within the action 14 of the Snowcarbo project, from December, 2009 to May, 2010. This work is centered on the modelling of the snow cover in the Arctic region, using the global land surface model ORCHIDEE (Krinner et al., 2005), component of the coupled climate-aerosol-chemistry model LMDZ-INCA. Once checked the ability of the model to describe heat fluxes within the snow cover, we performed snow simulations with relevant meteorological forcing (Sheffield, 1995). Similar approaches based on comparison with observations data are used to validate the snow cover simulated by the two models used within the SNOWCARBO project, ORCHIDEE and the REMO-JSBACH model system. Snow Water Equivalent (SWE) modeled with ORCHIDEE is similar to those estimated by the Canadian Meteorological Center observations-based product (Brasnett, 1998) in boreal regions (As an example, see the March comparison in Figure 11, left and middle). Concordance between model and observations is however smaller in temperate regions (especially in Himalaya), where sublimation fluxes were found to be too strong, inducing an underestimation of SWE. SWE features are also well described by satellite data analyzed within SNOWCARBO, even if mountainous areas are not covered by this product (Figure 11, right).



ORCHIDEE **CMC** **Satellite products**

Figure 11: SWE in March 2000 modeled by ORCHIDEE (left), estimated with CMC observations (middle) and estimated upon satellite data (right)

Since the validation of simulated SWE with our land-surface model, two specific studies are currently carried out: the first one consists in estimating the climatic impact induced by aerosols deposition in the Arctic region. This analysis takes into account future ships emissions expected in this region. The second one focus on the link between snow conductivity and permafrost and carbon pools in boreal regions. These two studies are detailed in the following paragraphs.

1. Aerosol deposition on snow in boreal regions

A first step of this study consisted in establishing a budget of all the aerosol sources and sinks in the Arctic atmosphere (Menegoz et al., submitted). In a second step, a representation of the black carbon and the dust content in the snow has been implemented in ORCHIDEE. Modeled aerosol concentration in the snow cover is concordant with observations, with small values far from polluted areas: typical values range from 10 to 50 µg.m-3 in the Arctic snow (Doherty et al., 2010), vary around 20-30 µg.m-3 in Sodankyla (SNOWCARBO site measurement) and exceeds 500 µg.m-3 near polluted areas (e.g. Huang et al, 2010, in press). A parameterization calculating the snow albedo has been integrated into the model. It is based on the work of Warren and Wiscombe (1980) and Krinner et al. (2006). A first estimation showed that snow albedo variations induced by dust and black carbon deposition yields same order of magnitude in Eurasia (see Figure 12), with declines reaching 1% to 3% over large regions, and exceeding 10% close to emissions areas. This first simulation has been performed with the output of global aerosols simulations considering total aerosols anthropogenic sources (Menegoz et al., 2009). However, arctic ships emissions are not supposed to be taken into account in this simulation performed with the AEROCOM global emission inventory (Dentener et al., 2006). A new aerosol global simulation with arctic ships emissions estimated by Corbett et al (2010) has been performed with the chemical transport model LMDz-INCA (Balkanski et al, 2010) to describe the aerosol burden and deposition variations induced by ships transport in the Arctic region (see Figure 13).

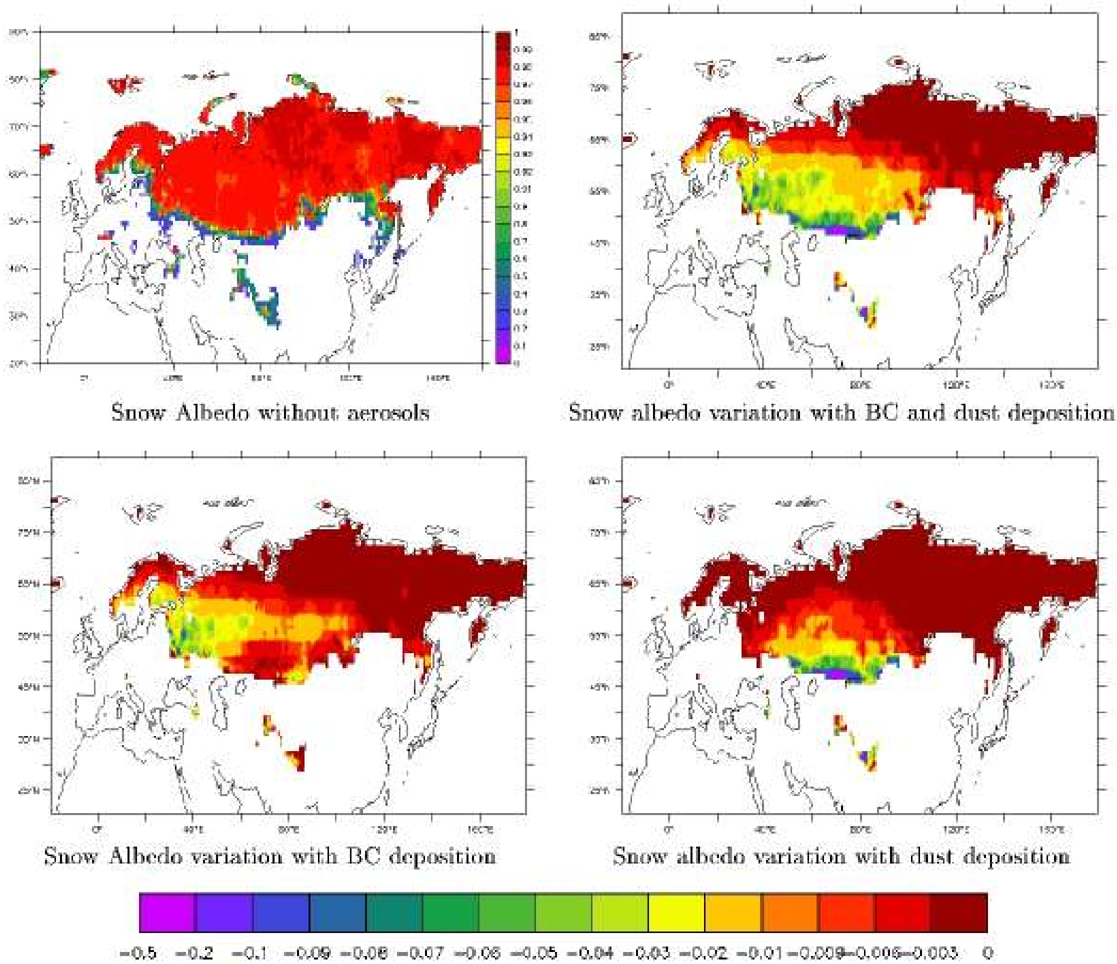


Figure 12: Snow albedo in March and snow albedo variations with BC and dust deposition, with BC deposition, and with dust deposition

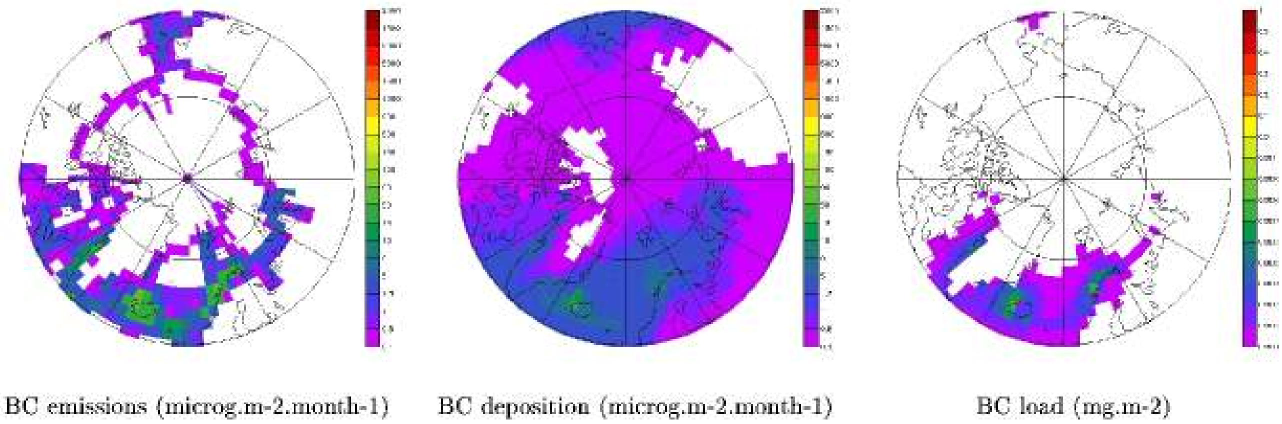
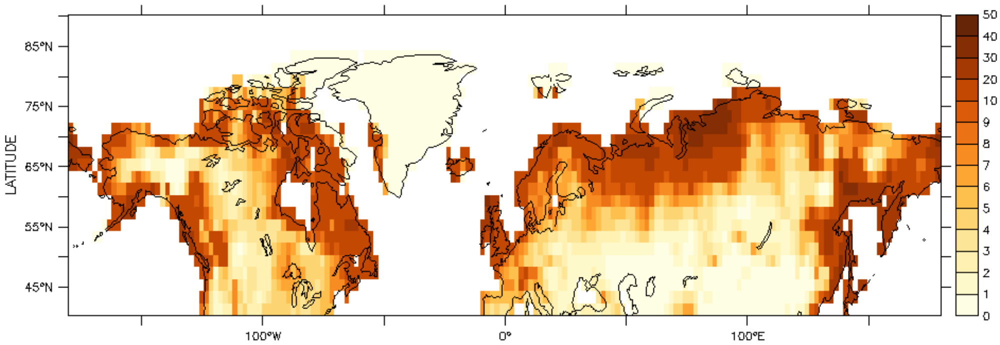


Figure 13: BC emissions, deposition and load differences between simulations with and without Arctic ships

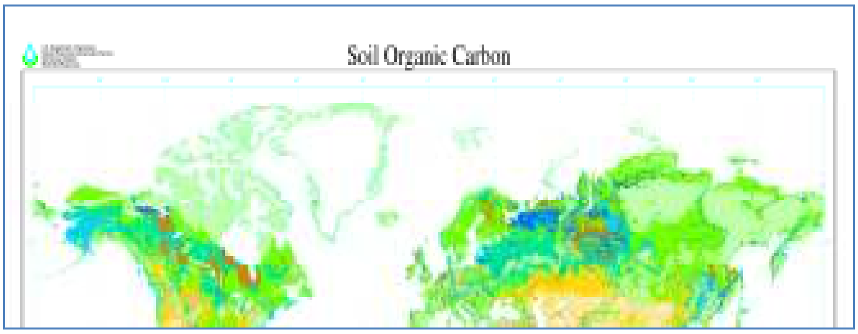
Next step of this study will consist in estimating snow albedo variations and radiative forcing induced by ships aerosols emissions in two future scenarios for 2050.

2. Snow conductivity function in boreal permafrost and carbon pool formation

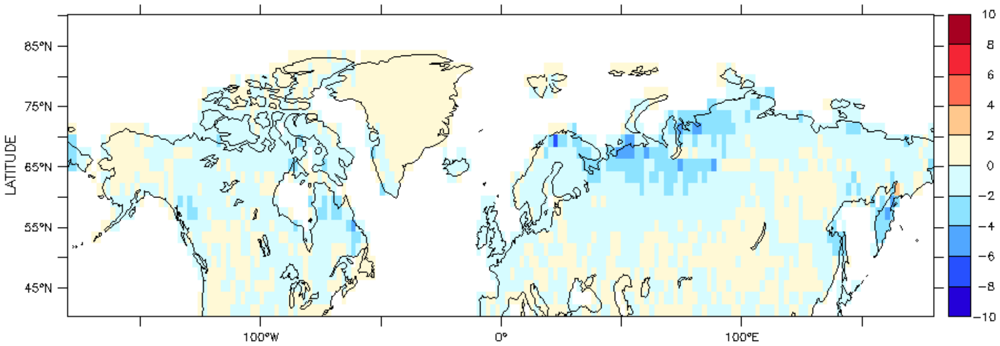
In addition to the study described previously, ORCHIDEE land surface model is also used here to evaluate the impact of snow conductivity variations linked to an evolution of the vegetation on the soil temperature, and therefore on the carbon stocked into the permafrost. This task is performed by I. Gouttevin, M. Menegoz, G. Krinner, F. Dominé and P. Ciais, all researchers at the LSCE or the LGGE. The first results of this study were presented at the International Polar Year Oslo science conference (Domine et al. 2010). Both in model (see Figure 14a) and in Tarnocai observations (see Figure 14b, Tarnocai, 2010), carbon soil content exceeds 30 mg.m-2 in large areas of North America and North Eurasia. Overall, considering higher snow conductivity in the woodlands than in bare soils yields lower levels of carbon stock in most of boreal region (see Figure 14c).



(a)



(b)



(c)

Figure 14: (a): Carbon pool simulated by ORCHIDEE after a 10000 year spin-up. (b): Carbon pool estimated by Tarnocai (2010). (c): Carbon pool differences between simulations with constant snow conductivity and snow conductivity dependent on vegetation. All values correspond to 1 meter deep carbon stock in kg.m^{-2}

The status of the different activities performed within the action 14 is detailed in the following Table 3.

Table 3: Status of Action 14

Tasks	Sub-task	Current completion	Date for completed task
Snow cover simulations	Validation of ORCHIDEE	100%	July 2010
Snow-aerosols interactions	Aerosol balance in the Arctic	80%	Paper submitted
	Implementation of snow albedo calculation dependant on aerosol deposition	100%	September 2010
	Emissions scenarios of ships emissions in the Arctic region	100 %	December 2010
	Climatic impact of ships in the Arctic region (LMDz-INCA simulations)	30%	May 2011
Snow conductivity, boreal permafrost and carbon pools	Impact of snow conductivity variations on permafrost	100%	June 2010
	Impact of snow conductivity variations on carbon pool	50%	April 2011

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3.1.15 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.

3.2 Envisaged progress until next report

This section provides an overview of the SnowCarbo project progress. An overview for the status of all of the project deliverables and milestones is provided in section 3.2.1.

3.2.1 Envisaged progress until next report

All project completed deliverable products & milestones and future deliverables & milestones for 2012 presented in Table 4 and Gantt chart given in Figure 15.

Table 4: SnowCarbo project deliverables & milestones status

Envisaged activities for SnowCarbo Actions for 1.1.2009-31.12.2012 (Deliverable items marked with red text color)		
Action 1: Project management and monitoring		
Activity	**Due date**	**Completion (%)**
• 1st Project brochure	30/03/2009	100%
• Inception report	30/06/2009	100%
• Answers to EC comments on Inception Report	15/09/2009	100%

• Project meeting	18/09/2009	100%
• 1st Management Board meeting	14/10/2009	100%
• Project meeting	28/10/2009	100%
• 1st Steering Group meeting	13/11/2009	100%
• 1st Monitoring Report	27/11/2009	100%
• Project meeting	27/11/2009	100%
• Quarterly meeting	18/12/2009	100%
• First-year progress report	31/12/2009	100%
• Project meeting	25/01/2010	100%
• Project meeting	10/03/2010	100%
• 2nd Management Board meeting	10/03/2010	100%
• Quarterly meeting	08/04/2010	100%
• 2nd Steering Group meeting	22/04/2010	100%
• 2nd Monitoring Report	29/04/2010	100%
• Project meeting	09/06/2010	100%
• Quarterly meeting	27/08/2010	100%
• 18 month progress report	30/06/2010	100%
• 3rd Management Board meeting	16/09/2010	100%
• Quarterly meeting	07/10/2010	100%
• 3rd Steering Group meeting	13/10/2010	100%
• 3rd Monitoring Report	29/10/2010	100%
• Project meeting	09/12/2010	100%
• Midterm progress report	31/01/2011	100%
• Carbon footprint report (first contributions)	31/12/2010	100%
• Midterm end-user/stakeholder consultation workshop	31/05/2011	0%
• Report on end-user/stakeholder consultation workshop	15/06/2011	0%

• Project meeting	04/02/2011	0%
• 4th Management Board Meeting	15/03/2011	0%
• Project meeting	11/04/2011	0%
• 4th Steering Group meeting	15/04/2011	0%
• 4th Monitoring Report	28/04/2011	0%
• Project meeting	08/06/2011	0%
• 30 month progress report	30/06/2011	0%
• Project meeting	03/08/2011	0%
• 5th Management Board Meeting	15/09/2011	0%
• Project meeting	05/10/2011	0%
• 5th Steering Group meeting	12/10/2011	0%
• 5th Monitoring Report	28/10/2011	0%
• Project meeting	14/12/2011	0%
• Third year progress report	31/12/2011	0%
• Project meeting	15/02/2012	0%
• 6th Management Board Meeting	15/03/2012	0%
• Project meeting	04/04/2012	0%
• 6th Steering Group meeting	11/04/2012	0%
• 6th Monitoring Report	25/04/2012	0%
• Project meeting	06/06/2012	0%
• 42 month progress report	29/06/2012	0%
• Project meeting	02/08/2012	0%
• 7th Management Board Meeting	12/09/2012	0%
• Project meeting	03/10/2012	0%
• 7th Steering Group meeting	11/10/2012	0%
• 7th Monitoring Report	25/10/2012	0%
• Project meeting	12/12/2012	0%

• Carbon footprint report	31/12/2012	0%
• Final report	31/01/2013	0%
Action 2: Satellite data processing by FMI		
Activity	**Due date**	**Completion (%)**
• Contribution to the 1st EO- data document (years 2001-2008)→1st EO-data document	30/11/2009	100%
• The SWE product will be available for all test sites and covering 30 years	31/12/2010	100%
• The SWE product will be validated (in scientific publication)	31/03/2010	100%
• The onset of snow melt and snow clearance product will be available for all test sites covering 30 years	30/09/2009, 30/09/2010	100%
• The snow melt / clearance product will be validated in scientific publications	30/09/2010	100%
• Contribution to the 2nd EO- data document (years 2009-2010)→ 2nd EO-data document	30/11/2010	100%
• The soil freezing product will be available for all test sites covering 10 years.	31/12/2010	100%
• All (2001-2010) EO data processed, seasonal features extracted and data delivered	31/09/2011	80%
Action 3: Acquisition and extension of GMES-services GSE Polar View and GSE Land		
Activity	**Due date**	**Completion (%)**
• MODIS dataset for 2001-2008 will be completed. • Data retrieval trough ftp (7/8) • TOA coverages (5/8) • Products (NDVI, SCA) (0/8)	30/11/2009	100%
• AVHRR dataset for 2001-2008 will be completed • Data retrieval through ftp • Night time brightness temperatures	30/11/2009	100%
• 1st EO- data document	30/11/2009	100%
• MODIS dataset for 2009-2010 will be completed • Data assembled from operative archive • TOA coverages • Products (NDVI, SCA)	30/11/2010	100%
• AVHRR dataset for 2009-2010 will be completed • Date retrieval through ftp • Night time brightness temperatures	30/11/2010	100%

• 2nd EO- data document	30/11/2010	100%
• All (2001-2010) EO data processed	31/09/2011	80%
• Contribution to final report	30/11/2012	0%
Action 4: In situ data collection and processing by FMI		
Activity	**Due date**	**Completion (%)**
1. The initial and boundary data field sources for the models are selected.	28/02/2010	100 %
2. 1st Data document	31/12/2009	100%
3. 2nd Data document	31/12/2010	100%
4. 3rd Data document	30/11/2011	0%
5. Contribution to the final report	30/11/2012	0%
Action 5: In-situ data collection and processing by SYKE		
Activity	**Due date**	**Completion (%)**
• Field measurement campaign in spring 2009	31/05/2009	100%
• Field measurement campaign in autumn 2009	31/10/2009	100%
• 1st in-situ data document	30/11/2009	100%
• Field measurement campaign in spring 2010	31/05/2010	100%
• Field measurement campaign in autumn 2010	31/10/2010	100%
• 2nd in-situ data document	30/11/2010	100%
• 3rd in-situ data document	30/11/2011	0%
Action 6: Methodology development and implementation by FMI		
Activity	**Due date**	**Completion (%)**
• REMO2008 model taking into account the tracer transport, will be running reliably on at least one of the computational facilities available for FMI personnel.	31/12/2009	100%
• The set of variables which are necessary to transfer in between REMO and JSBACH models will be decided and derived.	28/02/2010	100%
• First trials on running the coupled REMO-JSBACH model will be made.	31/05/2010	100%

• 1st Progress report on methodology	31/05/2010	100%
• The sequence of REMO-JSBACH model runs including the required data flows between the models will be initialized.	31/07/2010	100%
• First trials by using the land cover data (from the Action 11)	31/10/2010	100%
• Data utilization from the Actions 3, 4, 5 and 11 will be reviewed according to the status of the models and the results of the initial runs.	31/12/2010	100%
• 2nd Progress report on methodology	31/08/2011	0%
Action 7: Methodology development and implementation by SYKE		
Activity	**Due date**	**Completion (%)**
• The unfiltered time-series, in the gridded form, of snow covered area (SCA) and normalized difference vegetation index (NDVI), years 2001-2008 (incorporated into the deliverable from Action 2 & 3, entitled, "**1st EO-data document**")	30/11/2009	100%
• Progress report on filtered time-series (years 2001-2008)	31/05/2010	100%
• Features extracted (years 2001-2008)	31/08/2010	100%
• Progress report on extracted features (2001-2008)	31/08/2010	100%
• 2nd progress report on filtered time-series (2001-2008)	30/11/2010	100%
• Time series of years 2009-2010	31/03/2011	0%
• Features extracted(years 2001-2010), final phase progress report	31/09/2011	0%
• Time series for 2001 -2010 processed, seasonal features extracted and data delivered	31/09/2011	0%
Action 8: Demonstration and validation by FMI		
Activity	**Due date**	**Completion (%)**
• System functionality validation at Sodankylä-Pallas CAL-VAL site	01/09/2010	100%
• System validation over Finland with different resolutions on selected test years	01/09/2010	100%
• System validation over Baltic test area for selected years	01/09/2010	100%
• Selection of system setup and parameterization	01/10/2010	50%

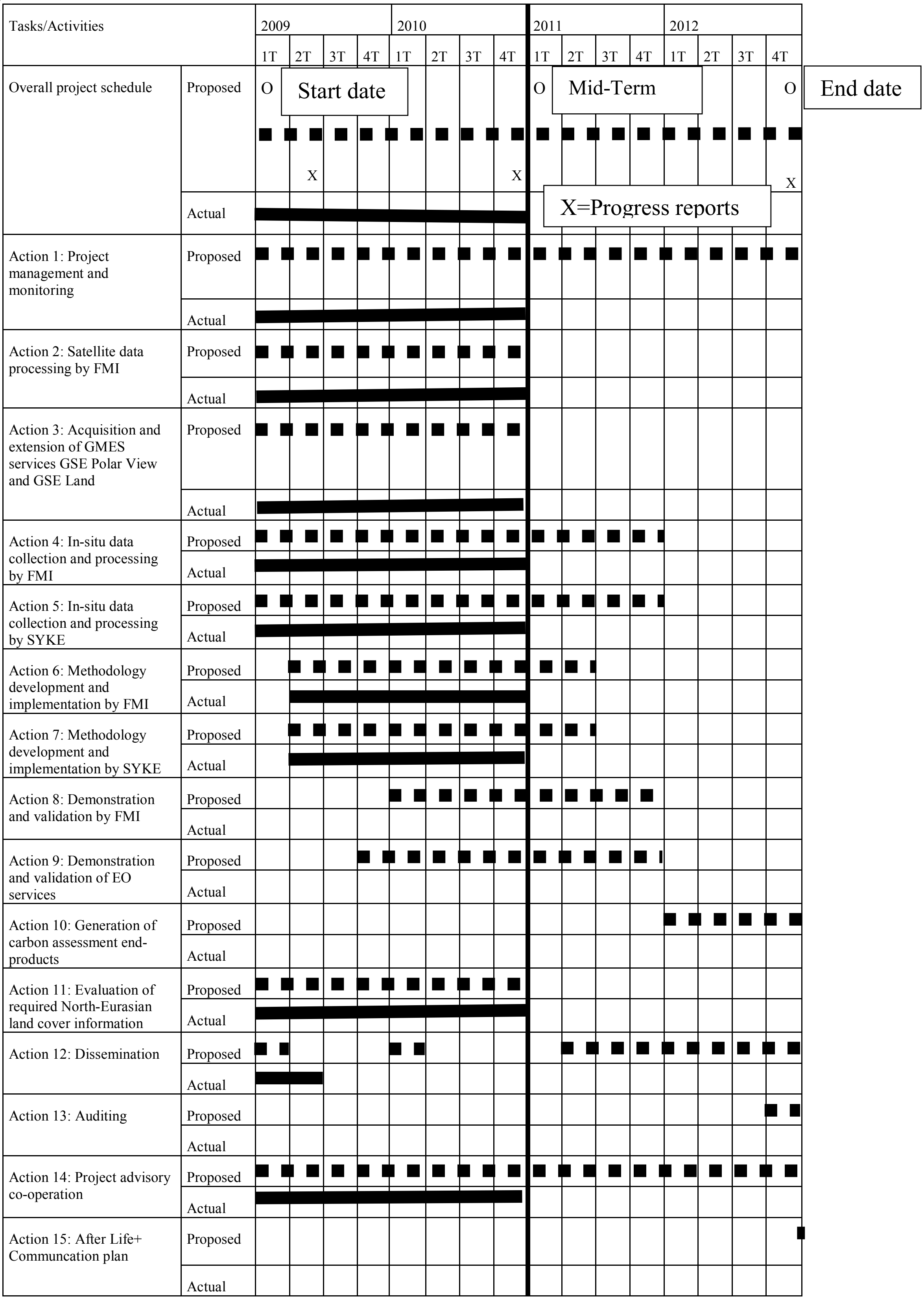
from validation results		
• Estimation of carbon balance for Baltic EU area with selected setup	30/11/2010	50%
• Production of preliminary demonstration report	30/11/2010	100%
• Preliminary demonstration report	31/12/2010	100%
• Demonstration report	31/12/2011	0%
Action 9: Demonstration and validation of EO services		
Activity	**Due date**	**Completion (%)**
• Implementation of the data exchange method completed	30/11/2009	100%
• Documentation of the data exchange method	30/11/2009	100%
• Preliminary demonstration report	30/11/2010	100%
• Demonstration report	31/12/2011	0%
Action 10: Generation of carbon assessment end-products		
• Evaluations of continental and Finnish carbon balances	31/08/2012	0%
• Report on carbon balance mappings (FMI)	31/08/2012	0%
Action 11: Evaluation of required Northern-Eurasian land cover information		
Activity	Due date	Completion (%)
• Analysis on land cover data needs for carbon balance mapping	31/08/2009	100%
• Report on land cover data needs	31/08/2009	100%
• Production of land cover dataset	01/06/2010	100%
• Report on data production and accuracy	31/10/2010	100%
• Produced land cover datasets and estimated geophysical parameters (SYKE)	31/10/2010	100%
• Evaluation of continental and regional land cover data completed	30/06/2011	0%
• Report on suitability of global land cover datasets for carbon balance modelling	01/04/2012	0%
Action 12: Dissemination		

Activity	Due date	Completion (%)
• Project website	01/01/2009	100%
• 1st project brochure	30/03/2009	100%
• Update of the project website layout	31/12/2009	100%
• FTP server for data exchange (performed in Action 9)	30/11/2009	100%
• Project poster describing SnowCarbo project, background and objectives.	31/12/2009	100%
• Preparation of an online newsletter presenting first project results.	16/04/2010	100%
• Preparation of the 2nd online newsletter presenting achievements project results.	31/12/2010	100%
• 1st project brochure (updated)	30/06/2011	0%
• Dissemination workshop (for stakeholders)	30/11/2012	0%
• Layman's report	31/12/2012	0%
• 1st project brochure (final)	31/12/2012	0%
• Carbon balance atlas for Finland and Baltic EU	31/12/2012	0%
• Synthesis report of project results for stakeholders and policy makers (in Finnish and English)	31/12/2012	0%
Action 13: Auditing		
• 13.1. Auditing reports for FMI, SYKE and CEA-LSCE	31/12/2012	0%
Action 14: Project advisory co-operation		
Activity	**Due date**	**Completion (%)**
• Participation to the 1st Management Board meeting	14/10/2009	Not possible
• Telecon to the Project meeting	28/10/2009	Not possible
• Contribution to the 1st Monitoring Report of Steering group	31/10/2009	100%
• Inputs for the 1st Steering Group meeting	31/10/2009	100%
• Climate Scientist will be hired by December 2009.	01/12/2009	100%
• Telecon to the Quarterly meeting	18/12/2009	100%

• Contribution to the First-year progress report	31/12/2009	100%
• Participation to the 2nd Management Board meeting	10/03/2010	100%
• Telecon to the Quarterly meeting	08/04/2010	100%
• Inputs for the 2nd Steering Group meeting	15/04/2010	100%
• Contribution to the 2nd Monitoring Report of Steering group	29/04/2010	100%
• Telecon to the Project meeting	09/06/2010	100%
• Telecon to the Quarterly meeting	27/08/2010	100%
• Contribution to the 18 month progress report	30/06/2010	100%
• Participation to the 3rd Management Board meeting	16/09/2010	100%
• Telecon to the Quarterly meeting	07/10/2010	100%
• Inputs for the 3rd Steering Group meeting	13/10/2010	100%
• Contribution to the 3rd Monitoring Report of Steering group	29/10/2010	100%
• Telecon to the Project meeting	09/12/2010	100%
• Contribution to the Midterm progress report	31/12/2010	100%
• Contribution to the Carbon footprint report (first contributions)	31/12/2010	100%
• Adaptation and use of the Orchidee land surface model to support the objectives of the SnowCarbo project	31/12/2010	100%
• Advice, comments and inputs for the activities in Action 2	31/12/2010	100%
• Advice, comments and inputs for the activities in Action 3	31/12/2010	100%
• Telecon to the Project meeting	17/02/2011	0%
• Participation to the 4th Management Board Meeting	15/03/2011	0%
• Inputs for the 4th Steering Group meeting	15/04/2011	0%
• Contributions to the 4th Monitoring Report of Steering group	28/04/2011	0%
• Telecon to the Project meeting	04/05/2011	0%
• Telecon to the Project meeting	03/08/2011	0%

• Participation to the 5th Management Board Meeting	15/09/2011	0%
• Inputs for the 5th Steering Group meeting	15/10/2011	0%
• Contributions to the 5th Monitoring Report of Steering group	28/10/2011	0%
• Contributions to the 30 month progress report	30/06/2011	0%
• Contributions to the Third year progress report	31/12/2011	0%
• Telecon to the Project meeting	15/02/2012	0%
• Participation to the 6th Management Board Meeting	15/03/2012	0%
• Telecon to the Project meeting	04/04/2012	0%
• Inputs for the 6th Steering Group meeting	11/04/2012	0%
• Contributions to the 6th Monitoring Report	25/04/2012	0%
• Telecon to the Project meeting	06/06/2012	0%
• Contributions to the 42 month progress report	29/06/2012	0%
• Telecon to the Project meeting	02/08/2012	0%
• Participation to the 7th Management Board Meeting	12/09/2012	0%
• Telecon to the Project meeting	03/10/2012	0%
• Inputs for the 7th Steering Group meeting	11/10/2012	0%
• Contributions to the 7th Monitoring Report	25/10/2012	0%
• Telecon to the Project meeting	12/12/2012	0%
• Contributions to the Final report	31/01/2013	0%
•		

Figure 15: Gantt chart of the SnowCarbo actions.



3.3 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 CO_2 flux maps with error estimates, CO_2 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.

4 Financial review by actions

The status of budget of SnowCarbo project can be seen action by action in Table 5.

Table 5: Status of SnowCarbo budget

Action number and name	Foreseen costs	Spent so far	Remaining	Projected final cost
Action 1 Project management	145919	73741	72178	145919
Action 2 Satellite Data	123792	101818	21974	123792
Action 3 GMES-Services	178495	95123	83372	178495
Action 4 In situ data FMI	106260	90840	15420	106260
Action 5 In situ data SYKE	75221	62117	13104	75221
Action 6 Methodology FMI	215946	193542	22404	215946
Action 7 Methodology SYKE	219198	93393	125805	219198
Action 8 Demonstration FMI	124880	62440	62440	124880
Action 9 Demonstration SYKE	105300	50031	55269	105300
Action 10 Carbon assessments	224904	0	224904	224904
Action 11 Evaluation land cover	99600	79828	19772	99600
Action 12 Dissemination	200543	45376	155167	200543
Action 13 Auditing	10000	0	10000	10000
Action 14 Advisory	176260	85223	91037	176260
TOTAL	**2006318**	1033472	**972846**	2006318

5 Annexes

5.1 Deliverables

5.2 Dissemination materials

5.3 Financial Report

- Standard Payment Request
- Consolidated Cost Statement for the Project
- Project Statement of Income
- Financial Statement of the Participant, FMI, SYKE, CEA-LSCE
- LIFE FORM F1, Direct Personnel Costs, FMI, SYKE, CEA-LSCE
- LIFE FORM F2 Travel and subsistence FMI, SYKE, CEA-LSCE
- LIFE FORM F3 External Assistance Costs, SYKE, CEA-LSCE
- LIFE FORM F6 Consumables, SYKE
- LIFE FORM F7 Other costs, FMI
- VAT Certification, FMI, SYKE