LIFE Project Number

LIFE09 ENV / FI/000571

Progress Report

Covering the project activities from 1/2/2013 to 31/1/2014

Reporting Date

30/1/2014

CLIMFORISK

Climate change induced drought effects on forest growth and vulnerability

Data Project

Project location	Metla Vantaa
Project start date:	1/1/2011
Project end date:	31/12/2014
Total budget	1 485 782 €
EC contribution:	741 738 €
(%) of eligible costs	49.92%

Data Beneficiary

Name Beneficiary	Finnish Forest Research Institute (Metla)
Contact person	Dr. Mikko Peltoniemi / Dr. Aleksi Lehtonen
Postal address	PO Box 18, 01301 Vantaa, Finland
Telephone	+358 10 2111 / +358 40 801 5329
Fax:	xx-xx-xxxxxxx + direct n°
E-mail	mikko.peltoniemi@metla.fi / aleksi.lehtonen@metla.fi
Project Website	www.metla.fi/life/climforisk

Contents

List of abbreviations

GPP – Gross Primary Production (i.e. Gross photosynthesis)

ET - Evapotranspiration

FMI – Finnish Meteorological Institute

ICP I - International co-operative Programme on Assessment and Monitoring of Air

International co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests, level I monitoring plots, few hundred plots in Finland

ICP II – See above, level II monitoring plot (intensive monitoring)

kNN – Methodology to generalize point estimates, k Nearest Neighbours

LAI – Leaf Area Index, a key structural variable of vegetation, which basically says how much leaf area there is in the forest to capture light.

Metla – Finnish Forest Research Institute (primary beneficiary), also FFRI

MCMC – Markov Chain Monte Carlo. Can be applied as a numerical method to estimate parameters of a model

NFI – National Forest inventory (measures thousands of forest plots per year)

RS – Remote sensing

UH – University of Helsinki

Executive summary

Summary of the project contents

Climforisk is a climate change related project that collects and merges forest-related data sources in order to estimate the effects of climate on two ecosystem services provided by the forests. Project prepares estimates of forest carbon exchange in current and changed climate, and assesses the factors influencing the vulnerability of forests to damages. Evaluations of vulnerability of forests to damages focus on damages associated with weather, mainly to changes and variability in soil water availability. Some of the forest damages associated to weather variability can act through the complex food web habiting forests, with the consequence on increased pest/pathogen activity that damages forests. By providing information how forest carbon sinks and sources are distributed in Finland, and providing information about the most vulnerable areas of Finland to biotic damages are, Climforisk aims at providing stakeholders more comprehensive knowledge that can be used in forest management. While aiming at these targets, Climforisk collects information on factors causing uncertainties to such evaluations and reports them.

General progress

Project has progressed well. Most of the tasks reached their deadline.

What comes to tools of the project, we have the basic set up of the prediction models for climate change impacts on forest carbon balances. Some of the submodels need to be integrated to nationwide calculation frame and data. We are currently working with the predictions of net primary production (NPP) that is the total biomass growth of forest stand. We are seeking for improvement of earlier models based on ecophysiological theories, which could allow us to estimate the variation of biomass growth by nutrient properties of sites. We are currently working to incorporate soil organic matter decomposition model and its models of CO2 respiration (carbon output from ecosystem) to nation wide predictions on GPP (carbon input to ecosystem), in order to estimate the total carbon balance of forests (NEE).

Climate scenarios for the model system has been investigated and linked to the models, which allowed drawing model estimates of GPP, evapotranspiration and soil moisture indexes under climate change, and later the corresponding estimates of NPP and NEE for their implementation on online maps. During this work we have learned about the features that cause uncertainty to climate change projections. Indeed the spectrum of predictions from climate change is wide and is an important source of uncertainty to our predictions of forest associated variables.

We have prepared the drought vulnerability map based on forest health monitoring data to finish the work of Action 2.

We have worked with data and data analyses in Action 6, in order to better understand how various factors influence biotic damage vulnerabilities of forests. First maps of Pine Sawfly vulnerabilities are now ready.

We have been working intensively with www-presentation techiques, by investigating the possibilities of HTML5 technology for map presentations. We found out from demostrations that the map-related interactive features that allow computation of maps statistics from user given areas are slow and require powerful computers, and are thus unsuitable for online presentation. Simultaneously we have been iterating the design of web-pages; the current version is now annexed in this report (see Action 5 for link) **.**

We have continued co-operating and communicating with our collaborators, by adopting new ideas and methodologies for the the project. We have worked closely with staff at Finnish Meteorological Institute affiliated to Snowcarbo EU Life + project, in order to conduct methodological comparisons of forest carbon seqestration. We have authored new project now accepted for funding by Life+ (Monimet, coordinated by Ali Nadir-Arslan, FMI), which will make use of the methodologies developed in both earlier projects.

By the end of the year 2013, we have used 81% of total budget, consisting of EC and own contributions. UH has consumed their EU budget (Action 3). Total use of funding is in line with the original plan. Some of the actions may slightly exceed, while some other may not reach budgeted estimates.

Assessment as to whether the project objectives and work plan are still viable.

Project aims are still viable. We have now learned more what existing data reveals about, and have much better idea of results that can be presented online, and what issues to report as gaps of current knowledge, data and model. Uncertainties of data that exists to draw forest carbon balance and vulnerability scenarios for the current century is large, and it has a profound effect what we can and what is meaningfull to present in web application.

Problems encountered

Science suffers from many gaps of knowledge and that hamper ecological and climate change impact evaluations. Uncertainties and substantial variability in ecological processes and data also require plenty from analyses of data as well as from presentation of the results.

We interpret such issues as challenges, not problems; they are essential parts of the topic. In the proposal of the project, we listed many items associated with uncertainties of models and potential lacks of data hampering the estimates we target, ie. predictions of forest their carbon balances and forest damage vulnerabilities. Indeed we have faced such issues during the execution of the project, and challenges lie ahead. We continue to tackle them, and will report the main factors causing the uncertainty to the estimates.

Numerous preliminary tests and comparisons have been prepared to test e.g. the feasibility of model formulations and use with new input data sets, or in the development of vulnerability models. Numerous corrections to the data sets have been made, and many interpretations have been made to join different type of data sets together. The amount of such detail work has be large, but not completely a surprise to us.

Changes in project staff have occurred. However, we expect to reach the overall goals of the project.

Administrative part

Activities related to project coordination and management

As the project has progressed and produced further material, fitting separate works, and consideration of options has required more effort than earlier. This is normal as the complexity of the project entity increases.

We have strenghtened the collaboration with other projects , as it provides a way to generatr impacts after the project end, and an opportunity for further improvement of methods. Project's after life plans have gained further support from the EU. New Life+ proposal (MONIMET, coordinated by Finnish Meteorological Institute) affiliated to the project has been approved, which means that there will be framework for use of developed model-based methodologies to estimate climate change effects on forests also in future. Both Metla and UH teams participate in this project.

Project has gone through several staff changes. These have occurred in both admistrative and topic matters. Financial officer Mrs. Leena Iisalo has now retired and been replaced by Mrs. Raili Keronen as chief financial administrator. Secretary Tiina Luoto is now working with project's financial issues instead of secretary M. Kuronen. M. Kuronen is still supporting project on other matters. We have had also other staff changes.

Our modelling expert Dr. Sanna Härkönen is now conducting work at 20% contribution, while working 80% elsewhere. While working before with carbon balance estimation and generalisation of forest inventory data, she uses her 20% for the design and coordination of our www-presentation work in Action 5. Dr. Tuomo Kalliokoski has started to work with UH, and is now participating in modelling related work. He is developing the methodologies for estimating carbon balances of forests in changing climate. We have hired a new expert on statistics to join project. Dr. Seija Sirkiä will develop forest damage vulnerabity profiles based on existing data in Action 6.

We have continued reporting project results and we recently involved in the planning of a journal special issue that was initiated by our collaborators at FMI. We submitted several manuscript made with our collaborators to the special issue of Boreal Environment Research special issue titled *Monitoring and Modelling of Snow, Water and Carbon Balance Related Phenomena in Northern Latitudes*. If our reports are accepted to this journal, it provides more solid backbone for further work.

Changes in project management structure

No changes. See changes in project office staff above.

Organigramme of the project team and the project management structure.

Climforisk is a joint project between Metla and University of Helsinki. The majority of work is conducted at Metla. One of the project's actions, Action 3, is conducted at UH. Project is coordinated and managed at Metla, but UH reports about its work and financial management to the project office. Project office personnel at Metla and its changes were reported above. Mervi Kuri at UH deales with financial admistration.

Project has fairly simple organisation (Fig. 1). Management group is consisted of people who are involved in the practical work of the project and who work in day-to-day contact. Each of them leads an action or two. There are no changes in that.

Management team, their tasks, and advisory board have been described in the Inception report.

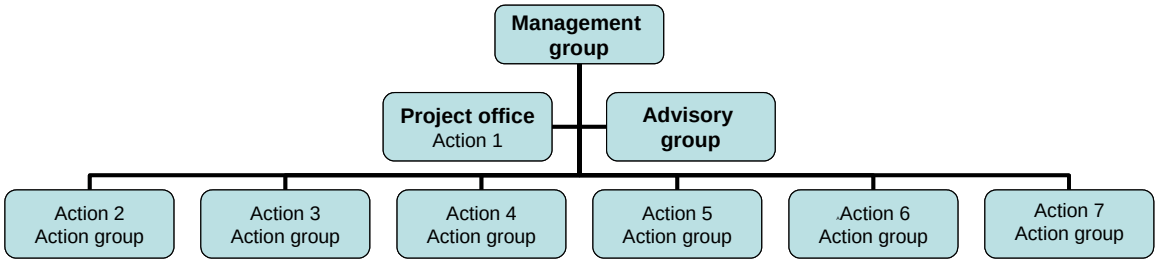


Fig. 1 Organigramme of the project

Reports delivered

We have submitted the Inception Report to the EC, and the deliverable reports accomplished by the date of Inception Report. The Midterm report annexed three reports (31.12.2012) that were listed as project deliverables, namely the Action 3 *Report on modelling methodology for climate change effects on growth and damage vulnerabilit*, Action 2 *Synthesis report*, and Action 6 *Report on using ICP level I data and inventory data on damage modeling.*

Reports delivered with this report, but are not deliverables of the project are the report on Web-application content and technical plan (Annex A) and Detailed report on the status of action 6 (Annex C).

DELIVERABLE PRODUCTS OF THE PROJECT			
Name of the Deliverable	Code of the associated action	Deadline (date)	STATUS
Management plan, including internal communication plan	1	1/3/2011	Delivered on time
Project dissemination plan	7	1/3/2011	Delivered on time (within Detailed Plan)
Public websites	7	1/4/2011	Delivered on time
Project brochure and poster	7	1/4/2011	Delivered on time
Action synthesis report: Report on merging inventory data and other data sources	2	31/12/2012	Delivered with Midterm report
Modelling software and documentation	3	30/6/2012	Delivered on time
Report on modelling methodology for climate change effects on growth and damage vulnerability	3	31/12/2012	Delivered with Midterm report
Report on using ICP level I data and inventory data on damage modelling	6	31/12/2012	Delivered with Midterm report
Web-application for dissemination	5	31/12/2014	
Action synthesis report: Report on simulated climate change effects on forest growth and related variables	4	31/12/2014	
Action synthesis report: Assessment of climate change effects on vulnerabilities of forests to pest/pathogen damages	6	31/12/2014	
Layman's report to general public	7	31/12/2014	
After-LIFE communication plan	7	31/12/2014	

Envisaged extension of the project schedule

No extension requested at this point. Preparation and and submission of the final report is envisaged within three months after the project end.

Technical part

We are very much in the phase of the project where we are drawing from our earlier work, that was mainly conducted in Action 3 that has now prepared most of the tool required for forest carbon balance simulation, and in Action 2, which built data sources for modelling of Action 4 and vulnerability modelling of Action 6. First result maps have been now formatted to Action 5 dissemination, which has developed web-dissemination tool further during the reporting period.

There were now deliverables set for the project during the reporting period. In terms of the milestones of the project, we consider the project is on time, although some of the maps are still under construction.

MILESTONES			
Name of the Milestone	**Code of the associated action**	**Deadline (date)**	**STATUS**
Kick-off meeting	ALL	31/1/2011	DONE
Nomination of project workers	1	31/1/2011	DONE
First advisory group meeting	1	28/02/2011	DONE
Press release at project start	7	1/4/2011	DONE
Operational data platform for project's purposes is ready, and presented to project staff	2	30/6/2011	DONE
Detailed technical plan for internet dissemination application ready and presented for rest of the project	5	~~30/1/2012~~ 30/6/2013	Change of date. By the new date, we expect to have a preliminary plan.
Model bundle, with documentation. Models will be used in action 4, and distributed through project's web pages.	3	30/6/2012	DONE, see also deliverable dated on the same date
Biomass and LAI maps are ready for the use in other actions	2	30/11/2012	DONE.
Project midterm meeting	ALL	31/1/2013	DONE, 08/05/2013
Final version of web-application is ready for data assimilation	5	~~1/3/2013~~ 1/8/2014	Further investigated HTML5 technology for web presentation. New test version existing, see action 5.
Predictions of GPP, NPP, NEP, drought and physiological state for Finland, and their scenarios for future	4	30/6/2013	Partially done. NPP, NEP maps are under construction.
Updated models to generate damage vulnerability assessment profiles for the main damage types.	6	31/12/2013	Pine Sawfly ready
Demonstration of the results at JRC and DG Environment	7	31/12/2011, 31/12/2014	First demonstration at JRC (31/12/2011) replaced by demonstration at FAO Forestry (25/11/2011) Demonstration of the

			project (in relation to Finnish ghg-inventory development) at a technical workshop at JRC, 4-6/11/2013
Final meeting	ALL	30/10/2014	

Action 1

See Admistrative section for additional data.

ACTION 1		STATUS
Smooth execution of the project, achievement of the set goals and outputs, timely delivery of the project deliverables, efficient participation of the advisory group in the project decision making.	1/1/2011-31/12/2014	CONT.
Project handbook (management and communication plan, and detailed work plan)	1/3/2011	DONE
Inception report	1/9/2011	DONE
Mid-term report	01/02/2013	DONE
Progress report	1/2/2014	DONE
Monitoring report on the involvement of key stakeholders	30/6/2014	
Final Report	31/12/2014	

INDICATORS OF PROGRESS		STATUS
~~Internal progress reports:~~	~~30/06/2011, 31/12/2011, 30/06/2012, 31/12/2012, 30/06/2013, 31/12/2013, 30/06/2014, 31/12/2014~~	Project manager communicates actively with all Action leaders and rest of the staff, so coordination of the project does not require additional support from reporting (benefits of small project).
Management group meetings:	31/01/2011, 31/7/2011, 31/01/2012, 31/07/2012, 31/01/2013, 31/07/2013, 31/01/2014, 31/07/2014	31/1/2011, 23/8/2011, 9/1/2012, 30/5/2012, 23/1/2013, 8/5/2013
Advisory group meetings:	28/02/2011, 28/02/2012, 28/02/2013, 28/02/2014	24/2/2011, 26/1/2012, 29/8/2013

Action 2

The work made in Action 2 continued until mid 2013, and has now finished.

During the reporting period, we continued working with the drought vulnerability map in order to provide material for Action 5 web presentations. We analyzed several GIS data sources to find most usable ones for our vulnerability map. We tested national soil profile GIS data set, digital topographic maps, forest monitoring data set ICP Level 1, national forest inventory data (NFI), climate data and digital elevation model (DEM). We derived new variables from those GIS data sets and forest surveys. We produced and tested several derived new variables related to soil properties,

land use properties, climate and topography. We also tested and analysed whether is it possible to derive new variables describing and indicating possible drought damages based on needle loss or needle yellowness observations. Unfortunately this didn't lead to anything usable. All these analyses and tasks are completed and we got selection of new derived GIS data variables such as topographic wetness index based on digital elevation model, tree species proportion maps and water, peatland and bare rock masks, which were utilized in the production of the drought damage vulnerability map for whole Finland. We analyzed two data sets which have observed variables for forest damages. Our analyses proved that we could not use national forest inventory data (NFI) for our purposes to produce drought vulnerability map. The damage classification of the finnish NFI data was too coarse for our purposes. We could not detect drought damages with NFI data accurately enough. Therefore we concentrated our analyses to forest monitoring grid of ICP Level 1, which have more detailed forest damage classification. The concentration to NFI data that seemed potential at first consumed resources. The preparation of drought vulnerability map for whole Finland is completed and it is used by Action 5.

During the reporting period, we prepared separate maps of open rock areas and peat land areas suitable for model integration, based on work reported in Midterm report and 'Refined soil property database 30/11/2012' These maps were used in the preparation of 2000-2011 GPP (=Gross primary production = gross photosynthesis) prediction maps, which we compared to Snowcarbo Life+ project's JSBACH simulator results. This work also used maps of leaf area index (LAI) and map of fraction of absorbed solar radiation to estimate the gross photosynthesis of Finnish Forests. Map information related to forest canopy density and tree species distribution have been used as the input variables have and also as the input variables in the pest/pathogen model tests.

ACTION RESULTS		Status
Biomass map for Finland	30/10/2012	Done, used internally, for generation of LAI and fAPAR maps
LAI map for Finland	30/11/2012	Done, additionally fAPAR-map produced. Published.
Action synthesis report: Report on merging inventory data and other data sources (Report describes the status of forests in Finland with novel approach that utilizes and combines previous and ongoing research. Data for individual polygons includes description of forest biomass (quantity and species), LAI (Leaf Area Index), and soil properties. The status of forest biomass on the map reflects the measurements of the latest NFI.	31/12/2012	Done, Annex to Midterm report
Refined soil property database	30/11/2012	Done.
Refined climate data	30/11/2012	Done.

INDICATORS OF PROGRESS		
Created common data platform for dealing with project's source data and predictions	30/6/2011	Done. Development environment in Linux-server links to weather database and other data.
Implemented methodologies to merge and use different data, e.g. kNN, into the platform	31/8/2011	Done.
Estimated biomasses for NFI and ICP plots (to action 4).	30/9/2011	Done.

Updated digital soil map with NFI data (to action 4).	30/6/2012	Done/Not applicable. See text related to 'Refined soil property database. Digital soil map data and NFI data can be used as parallel data sources, but based on our investigation, they cannot be merged to one map due to resolution differences.
Embedded climate data from the past and climate predictions according to IPCC A2 scenarios (and their interpolation using topographical information) (to action 4).	30/6/2012	Done.
Uncertainty estimates for forest structural variables ready	31.9.2012	Done.

Action 3

In conjunction with the Midterm report of the project, we reported the model that we are using in to estimate GPP and soil water balance. We kind permission from the EC (letter 12th July 2012), we have continued the work of UH with the model to improve it further.

Our work has focussed on the improvement of the of the CO2-response of the model, and it is challenged by the fact that there simply is no proper data at stand level that could be used t create submodels to the GPP-model we are using. We continue this work with modifying the current CO2 submodel parameterisation.

In the elevated CO2 and warming climate we expect increases in GPP of forests. However, only a fraction of this increased may be manifested as the actual growth of the trees. The dominant constraint for this increase is the unavailability of nitrogen in soils. We have started investigating a theoretical framework for NPP based on GPP predictions, which could predict how NPP could increase at different nutrient availabilities.

Modelling methodology of forest water balance we use is highly simplified, which is necessary when doing large scale predictions. Soils present considerable topographic and quality range, which determines how variable the moisture is at the site. Predicting this variability is notoriously difficult, partially because of scarse data on soils. Simple methods negecting lateral transports of water are frequently preferred on large scale simulations, but simple methods suffer from their inability to represent all existing variation of soils. These simplified models can be used generate reference indices of soil moisture, assuming model parameters corresponding to certain soil types. The choise of the model is also important. We cannot say for certain, how good our water balance model is as data is scarse, which means we must find other ways of evaluating it performance. During the reporting period, we made a comparison of our model to other simple methods to estimate soil moisture conditions (published drought indices SPI and SPEI). The same weather data was used to drive all models. The results showed that the scaling interval (a user-defined input parameter of the SPI and SPEI-models, which expresses the period soil water can accumulate, i.e. in practice it expresses the sensitivity of soil to variation of rainfall) is a key parameter when evaluating the forest sensitivity to weather variation. Our model's predictions are fairly parallel to SPEI (and SPI) estimates using scaling parameter close to 4 months, which implies that our model provides estimates for soils that are, qualitatively speaking, fairly sensitive to drought. This confirmed the suspected tendency of the model to estimate moisture conditions of a dryish site. We further implemented our model predictions of actual ET to the SPEI model to create a new index SPE_aI, which showed similar behaviour as the original SPEI-indexes. The seasonal course of our actual ET was therefore parallel to those used in SPEI (Thornthwaite, Samani, or Penman potential evapotranspiration).

We made further tests of the model predicted actual evapotranspiration against potential evapotranspirations estimated with the LocClim simulator (Grieser et al. 2006) FAO had created. Further comparison of the modelled annual GPP was made to the NPP values estimated with the empirical model of Del Grosso et al. (2008). This comparison was made partially by a group of forestry students taking part in the course of prof. Mäkelä at UH. Each student was given a task to use the model with mean climate data and to compare its predictions to the predictions of LocClim simulations.

ACTION RESULTS		STATUS
Model bundle, with documentation. Models will be used in action 4, and distributed through project's web pages.	30/6/2012	Done
Contribution to synthesis report of action 4	31/12/2014	

INDICATORS OF PROGRESS		STATUS
Constructed simplified model of ecophysiological state of trees with core parameterisation.	30/6/2011	In progress. First version integrated. See text for contingency plan.
Scaled ecophysiological model operable elsewhere in the Finland.	30/9/2012	In progress. See text for contingency plan.
Merging of the models to operable bundle	31/12/2012	Done
Tested and parameterised models	30/4/2012	Done. Tested model at one additional eddy-covariance site and all ICP level II sites with soil water data available.

Action 4

The work conducted in this work aims at preparing estimates of climate induced effects on forests. The topic is challenging due to the complexity and large number of processes related to the response of vegetation, and due to the scarcity of data related these responses under elevated CO_2.

As mentioned in the plan of the Action, we are dealing with variables such as GPP (=gross photosynthesis), NPP (net growth of trees), NEP (net ecosystem carbon exchange, includes estimates of soil release of CO_2 through decomposition). The uncertainty of the predictions of these variables increases in the given order. We mention also drought simulations in the plan, which means indexes of moisture, and physiological state response that is affiliated to the GPP and NPP processes. At present, we consider there is too weak scientific basis to include physiological state description to model of GPP and NPP.

As mentioned in the proposal and above uncertainty is in important role in the project. Regarding to the quantifying the uncertainty of the model prediction, we implemented a Bayesian model calibration (reported with midterm report), which showed that the accuracy of the model is fairly good for GPP, but the estimates of forest evapotranspiration and soil moisture are more uncertain, even when the assessment was made with two sites involved in the calibration of the model.

In previously reported model document, we tested our model against soil water data measured at ICP level II sites, in order to estimate the temporal variability of soil water predicted with the model to site measurements. During that time, we did not have information about sites' light absorbing leaf area (LAI), and our soil moisture predictions were based on reference site forest conditions. During the previous reporting period, we collected LAI data from these sites and we plan to repeat these tests with real LAI data.

The model we applied for GPP prediction is only one of the many that exist, and comparing models against each others can shed light on the process and parameter uncertainties implemented in these models. During the reporting period we have worked with the former Snowcarbo Life+ project team in order to compare the predictions of our model to the model JSBACH that is implemented in Finnish Meteorological Institute. The comparison of the models using the weather data from 2000-2011 showed promising results, but it also revealed some further aspects that should be developed further in future.

Models are dependent on data fed to the model, as no model can correct errors in input data. Two key data sources exist, which influence our predictions, and we have conducted work on assessing their reliability and suitability. In the Midterm report we reported that we had estimated light absorbing leaf area of forests over Finland. We have continued evaluating these estimates against two sources of data, namely i) MODIS-derived LAI estimates developed at FMI in Snowcarbo project, and ii) LAI-data maps in conjunction with JSBACH modelling framework. The results showed on the one hand, a large residual variability between the maps of MODIS-derived LAI and out LAI, and on the other hand, they showed a good match of LAI mean estimates and latitudinal gradients. We consider that our LAI products, as well as the others, can be considered as a reliable basis for large scale carbon sink estimation.

For further quantification of uncertainties regarding to the modelled GPP and soil moisture estimates, we have started to lay basis for further improvement of the model in co-operation and calibration of the model with the MONIMET Life+ project. This co-operation provides further information about model applicability in new forest environments.

Uncertainty is not only generated by the input data or the models we used for prognosis, but considerable portion of it stems from the uncertain climate change predictions, which predict a broad envelope between +2- +7C degree warming by the end of the century. In order to understand how an envelope this broad is possible, and what it may mean for our predictions, we have made some investigations of the presently applied climate scenarios. Naturally, such an envelope generates a wide spectrum of forest related predictions. First, we have integrated the climate change predictions to the model of GPP and soil moisture, and see a broad band of predictions generated for forest GPP and soil moisture. By doing this we are generating predictions of climate change effects on these variable for periods 2010-2040, 2040-2070, and 2070-2100, each time using the past cycle data (1981-2010) and prediction scenario (36 scenarios) as input to the model. These scenarios will be still re-iterated, after which they will be connected to the NPP and NEE models. While reiterating the model climate runs, we are doing work in order to derive NPP from GPP predictions, and further to merge these predictions to soil decomposition estimates to get NEE.

In order to provide the soil decomposition estimates, we implement Yasso07 soil carbon model (Yasso07 2014) to estimate soil carbon stocks and their emissions and sinks. The estimation follows the principles of the Liski et al. (2006) paper, where forest inventory data, biomass- and litter models have been combined with weather data and with soil carbon model. We ran the model on ca. 55000 forest inventory plots, in order to map the gradients and variability of soil carbon stock and their recent change across Finland. Soil carbon stock change estimation requires information about the past litter production of forests, as this litter has generated the stock that is decomposing and releasing CO2 in forests presently. Therefore, we compiled forest inventory data from history to minimize errors in soil decomposition estimates. We started from forest inventory data from 1950s and used data to estimate biomass turnover and soil carbon in forests in a hypothetical steady state. Thereafter, we compiled data from following forest inventories, until to the most recent inventory data that was available at project start (2007 situatation), in order to generate times series of soil carbon stock. This process took somewhat longer than expected, but we consider it was important for reducing the uncertainty of net ecosystem carbon exchange. During the process we have co-operated with a project funded by the Ministry of Agriculture and Forestry (project coordinated by A. Lehtonen), in order to obtain better estimates of litter production rates of conifer needles. Natural litter production of forests is not the only source of litter that influences soil carbon stocks of today. We are currently compiling estimates of harvest related litter and residues, in order to estimate how

much of the soil CO2 emissions of today are related to man-made operations in forests. Unfortunately, this information is a low resolution, and we must satisfy with regional NEP estimates of forests of Finland. However, regional approach is more than enough for making useful comparisons of our estimates to the estimates of national greenhouse gas inventory.

ACTION RESULTS		STATUS
Predictions of GPP, NPP, NEP, drought and physiological state for Finland, and their scenarios for future	30/6/2013	Work in progress. First result set made for GPP and drought.
Action synthesis report: Report on simulated climate change effects on forest growth and related variables. Report describes the expect change in tree growth, GPP, NPP, NEP, and estimated drought vlunerability in terms of soil and tree physiological state). Predictions will map the areas that will suffer and benefit from climate change with current species	31/12/2014	

INDICATORS OF PROGRESS		STATUS
Prepared simulation set up that joins the models of Actions 3 and 6, to data of Action 2	30/4/2013	Done. Data of action 2 has been used by actions 4 and 6
Preparation of site-level simulations for ICP I-sites for the purposes of Action 6.	30/6/2013	DONE
Preparation of site-level simulations for NFI-plots	30/8/2013	Started
~~K-nn-scaling methodology implemented for this action~~	~~30/10/2013~~	NA. Deleted. Instead of kNN-scaled plot level-estimates, we are now doing simulation for whole Finland in 100 m pixels.
~~K-nn-scaled estimates of target variables (tree growth, GPP, NPP, drought, etc) to Finland~~	~~1/3/2014~~	NA. Deleted. See above.
First map ready for Action 5 for dissemination purposes.	30/4/2014	Preliminary maps tested online
Predictions of vulnerability models scaled to Finland (biotic damages)	30/6/2014	Done for Pine sawfly

Action 5

During the reporting period we prepared a web-application dissemination plan. Parallel to development of the plan, we have tested different presentation techniques. In order to build the internet application, several www-programming and GIS routines had to be applied to get the map toolset running in the web. The web pages and database are located in the server of Finnish Forest Research Institute, and this will be our starting point for further work. Possible decisions about including some of the maps in Climate Guide portal will made based on results of the review process of our model and scenario manuscripts, and they may occur after the project has been completed.

Current development version (**http://www.metla.fi/life/climforisk/beta/maps/beta/**) shows Action 2 maps of fraction of absorbed radiation and leaf area index, Action 4 predictions of gross primary productivity, evapotranspiration and soil moisture during the reference period, as well as

their mean, minimum and maximum value predicted by our model using 36 different climate prediction data sets in three different climate scenarios (SRES B1, A1B, A2). Vulnerability information about forests, as occurred accoring to data, is provided for the reference period about drought and pine sawfly damage probabilities.

The previous letter from the EC (3rd May 2013) requested us to provide more detail about our plans to develop our web dissemination tool. It is now included in the Annex A.

ACTION 5		STATUS
Detailed technical plan for internet dissemination application	~~30/1/2012~~ 30/6/2013	Deadline changed
Www-application that is expected to increase awaress of the public and officials on the effects of climate change. Application can be used to support decision making by forest owners and managers and other stakeholders, as well as educative purposes for students. Applications include: - maps of forest state (biomass, soil, LAI) - tree growth, GPP, NPP, NEP and carbon sinks - map of changes in vulnerabilities to damages	31/12/2014	
Presentation material for the application (will appear on www-pages)	31/12/2014	

INDICATORS OF PROGRESS		
Detailed content design of www-application(s)	~~30/1/2012~~ 30/6/2013	Deadline changed
First standing version of the www-application ready	30/10/2012	Started testing
Implemented maps from Actions 2 and 4 into www-application	30/9/2014	
Implemented maps from Action 6 into www-application	30/10/2014	

Action 6

During the reporting period, we have further worked with source data as more sophisticated modelling has revealed several issues required further examination.

Forest health monitoring data from ICP Forests level 1 during a more extended period (1986-2008) were further analysed with more flexible and sophisticated statistical tools. Thus, in the second stage (= work done during 2013) it was considered necessary to use more sophisticated and flexible statistical techniques, which consider the variability and hierarchical structure of the ICP Forest data (trees nested within plots; varying number of observations from year to year). So, we used hierarchical Bayesian modelling to analyze data from all the ICP Forest plots with at least one pine tree (n=627), and we used data from the years 1986-2008). To support this modelling, we further worked with National forest inventory data sets to compiled observations from the 8th – 10th NFIs (1986-2008; totalling ~165'000 observations/plots) for analyses. The data set contains forest stand level information on the type, causal agent of damage, timing and degree of possible damage, and more than 50 explanatory variables, but comes with an unfortunate change of sampling and damage classification. We worked with these data, and they were recently used for further testing and refining of the damage risks as functions of environmental factors.

The analyses so far indicate the potential of using site type as a risk indicator. Site type is also a variable routinely recorded in Forest Inventories and familiar to forest owners. Analyses seem to

confirm the hypothesis of drought increasing the risk of pine sawfly outbreaks. However, the the link between the drought and risk is weak, which undermines the strong data-model driven conclusions of the development of risks with weather/climate.

We provide further information about the status of damage vulnerability modelling in Annex C.

ACTION RESULTS		STATUS
Report on vulnerability modelling based on ICP data. Report includes data desriptions, descriptions of first generation models for main damage types (See also action 4 which includes a related report on the use of these models for prediction of climate change effects; reports may be combined to a bigger report if it serves the dissemination purpose better)	31/12/2012	Done, see accompanying deliverable
Updated models to generate damage vulnerability assessment profiles for the main damage types.	31/12/2013	Ready for Pine Sawfly
Maps of forest damage vulnerability profiles delivered to action 5 (in collaboration with action 4).	30/6/2014	Ready for Pine Sawfly
Action synthesis report: Report on possibilities of modelling methodology to predict biotic disturbances in future. Maps of forest damage vulnerability profiles (under selected climate change scenarios)) when information on tree physiological state, size, and environmental information are given (see corresponding deliverable reports). Pinpointed areas where specific monitoring for pest densities should be done with high cost efficiency . (Prepared together with action 4)	31/12/2014	

INDICATORS OF PROGRESS		STATUS
Collected data on pathogen ecologies for model building	30/2/2012	Done.
Compiled dataset from disturbances recorded in the forest health monitoring network (ICP) that is usable for projects use.	30/4/2012	Done.
Compiled dataset from disturbances recorded in the national forest inventory network.	31/2/2013	Done
Test results from the first generation damage vulnerability assessment models against independent damage observations.	30/9/2013	Done, see Annex C

Action 7

While early dissemination actions of the project concentrated on making us visible among stakeholders, the later dissemination actions have been conducted towards stakeholders that are relevant for conducting the actual work and most of them are in the research domain.

We have had several presentations of the project in the seminars, e.g.

- Presented pest model construction work at Workshop in Uppsala 11th – 12th of November "Climate change and forestry in northern Europe" (Action 7, Seija Sirkiä)
- COST STReESS network meeting in Sarajevo, which investigates stress responses of trees (Action 1 and 7, Mikko Peltoniemi, 14-18.10.2013)
- Presented Climforisk for a ministrial delegation from Uzbekistan at Metla (Action 7, 13.9.2013 (Mikko Peltoniemi)

- Presented preliminary project results related to Pine sawfly vulnerability at Forest Management Association Päijät-Häme in Hollola, Finland (Action 7, Seppo Neuvonen, 4.6.2013)
- Demonstration of the project (in relation to Finnish ghg-inventory development) at a technical workshop at JRC, 4-6/11/2013
- International Conference on Climate Change Effects, Potsdam, May 27-30. See also conference proceedings where we reported the work we presented and presentation (Action 7, Sanna Härkönen and Annikki Mäkelä)
- Presented pest/pathogen vulnerability estimation at 2nd ICP Forests Science Conference, Belgrad, Serbia. See poster and abstract book
- Presented project carbon balance work for group working with the topic and green-house gas balances at JRC (4-6.11.2013, Aleksi Lehtonen)
- Participating in Henvi Science days. See presentation (Tuomo Kalliokoski and Annikki Mäkelä , Action 7).

We have updated regularly our www-pages, which is our primary channel of reaching all target groups simultaneously.

Possibly the most significant action associated to dissemination during the reporting period was the participation in the a joint special issue intended to Boreal Environment Research journal with a title *Monitoring and Modelling of Snow, Water and Carbon Balance Related Phenomena in Northern Latitudes.* We participated in altogether 5 submitted manuscripts that were made as collaborative efforts between former Snowcarbo Life+ project staff, and other affiliated projects. Outcomes of the review process await.

Google analytics recorded altogether 1719 visits on our pages, of which 1274 were unique visits during the year 2013. Approximately 68% of the visits were from Finland. Average time consumed on a single page was 1 min 20 s.

We have collected dissemination actions to an annexed Excel table 'DisseminationActivities_Climforisk.xls', which appears also as Annex B.

ACTION RESULTS		STATUS
Increased awareness of climate change induced risks to forests	2011 ->	CONT.
Layman's report to general public	31/12/2014	
After-LIFE communication plan	31/12/2014	
Policy brief	30/9/2014	
Public website	1/4/2011	DONE
Project brochure and poster	1/4/2011	DONE
Project dissemination plan	1/3/2011	DONE. See detailed plan deliverable
Public website, updated regularly	1/4/2011	DONE. CONT
Project brochure and poster, updated	1/6/2013 (update)	No need to update basic poster description. Material created in project start is still in use and useful.

ACTION 7		STATUS
Press releases (additional press releases are made when needed, without yet speficying the dates	1/4/2011, 1/10/2014	Published information about the project 1/4/2011

Newsletters	30/9/2011, 30/9/2012, 30/9/2013, 30/9/2014	Published one just before project started (http://www.metla.fi/uutiskirje/mil/2010-02/uutinen-6.html). Others published when suitable newsletter topics and forums appear. We expect to participate in some during the forthcoming period.
Stakeholder workshop	28/2/2012	Done.
Articles in professional journals	31/1/2013, 30/11/2014	Done 1, Interview of Annikki Mäkelä Done 2, Metla Working paper (http://www.metla.fi/julkaisut/workingpapers/2012/mwp247-en.htm)
Two exhibition stands and two presentations at forestry events	30/11/2013, 30/9/2014,	Done 2: Life+ 20 years and Poster stand at Metsätieteenpäivät
Demonstration of the results at JRC and DG Environment	31/12/2011, 31/12/2014	Done. Visited FAO and JRC.
Demonstration of the results at the Ministries of Agriculture and Forestry, and the Environment	31/12/2011, 31/12/2014	NA, representatives in Advisory Board
Presentation of the results at related European congresses and networks	(depends on congress dates)	Done, several
Final seminar	31/10/2014	

Availability of appropriate licences and authorisations

NA

Envisaged progress until final report

During the last year of the project, we expect to finalise and wrap up ongoing tasks. Much effort will be placed on the reporting of results, and on the formulation of robust conclusions we can draw based on the past work.

Action 1

Action 1 will coordinate project and initiate tasks as planned. Action 1 will organise the preparation of project deliverables.

We will put emphasis on the actions and collaborations that improve the after-life aspects of the project. This involves streering the actual work conducted in topic actions so that it can benefit further projects, as well as using our results in dissemination and co-operative activities.

Action 2

Remaining reporting tasks related to Action 2 will be carried on in other Actions.

Action 3

We will continue the improvement of the model in terms of its reliability with climate change simulations, including estimation of the uncertainties of predictions of GPP and water balance. We will further integrate the soil decomposition model Yasso to the model to the same R-library, we made for PRELES model. This step involves integration of biomass model to the library as well.

We will investigating possibilities for more sophisticated predictions of forest NPP based on ecophysiological optimisation theory. This kind of approach has a potential to estimate what fraction of producivity increases at given nutrient availabilitie is allocated to living biomass. Potential outcome of this investigation is the better knowledge on the expected range for the NPP increase.

Action 4

Last period of the project will contain a final report for this action, which will be submitted with the Final report of the project.

Besides GPP, we expect to finish the work with soil moisture, NPP, soil decomposition and NEP scenarios, so that we can draw final predictions maps in Action 5 web-application.

The work associated with vulnerability profiles is expected to progress parallel to their formulation in Action 6.

We will test with data if it is possible to formulate tree species specific and climate sensitive drought vulnerability maps, to extend the applicability of our current drought vulnerability map for generic tree species.

Besides deliverable reports, we expect plenty of reporting associated work during this year for this action. This is necessary as much of the dependance and trust in the estimates we are preparing originates from rigorous peer-review process. Scientific reporting of methodologies has already started, and we expect to get reviewer feedbacks for a number of reports this spring. Based on these comments and decidions we plan further actions.

Action 5

We expect to develop the web-application during the next period by adding more products to map views. We do not expect major changes to the plan annexed with this report, although we do reserve an option to modify it in the event some of the products suffer from bad quality. We aim at providing readers uncertainty information about predictions in some format.

Action 6

During the final year of Climforisk we will continue analyses of pine sawfly and Scleroderris canker damages based on the extensive NFI dataset. Further analysis of the Scleroderris canker damages in relation to environmental factors has just started during the reporting period, and will be completed during the final year of Climforisk. Furthermore, a separate georeferenced dataset of insect damages in spruce forests (mainly dealing with spruce bark beetle damages) has been received from the Finnish Forest Centre, and will be included in analyses and damage risk modelling during 2014.

Based on the results obtained from all previous analyses, we will formulate appropriate indicators of biotic damage vulnerabilities of forest – to the extent allowed by existing data.

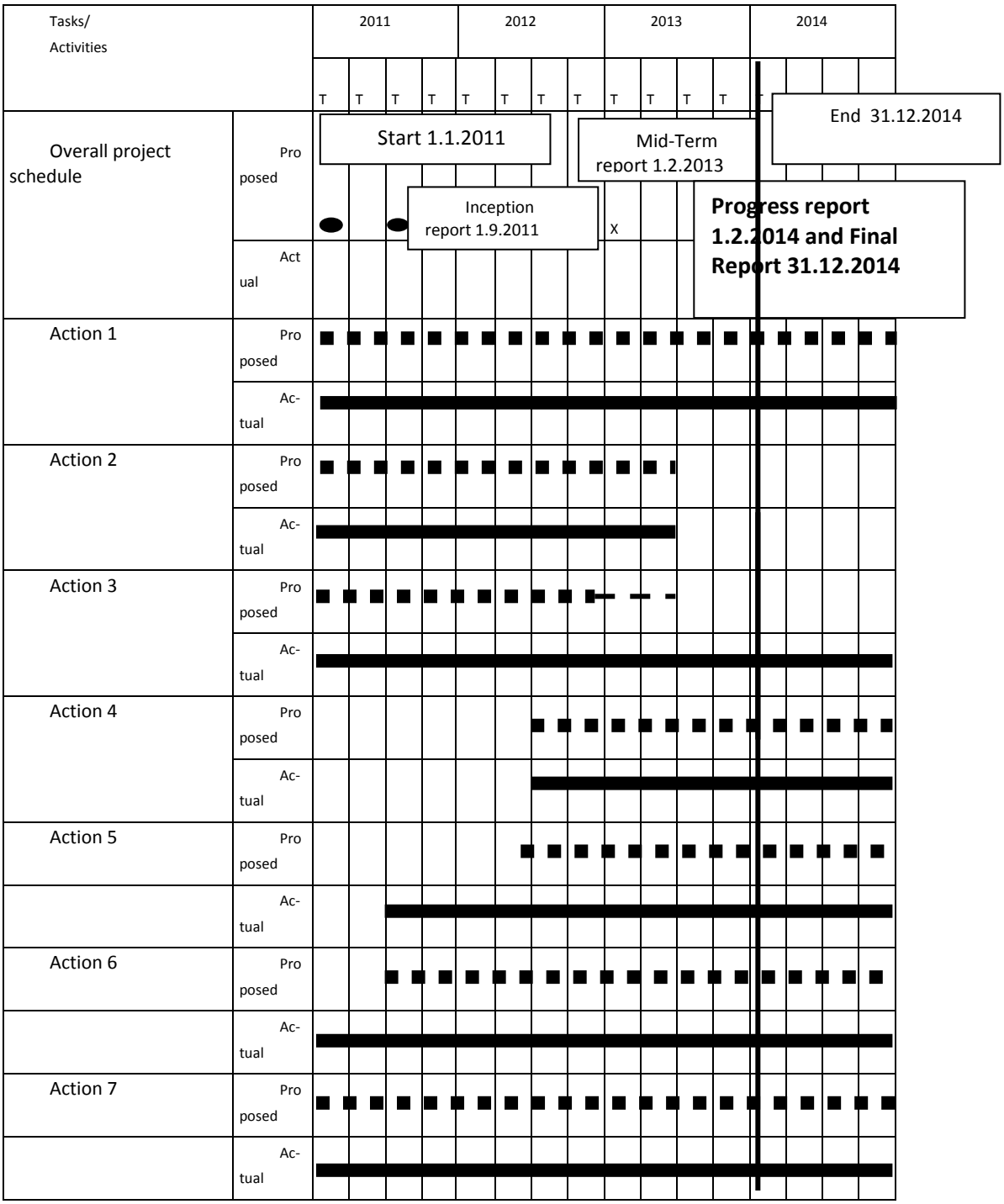
We will report the main advantages, disadvantages of current data sets associated to biotic damage vulnerability modelling, in conjuction with other results in the final deliverable of Action 6.

Action 7

We have kept the web-pages up-to-date and actively disseminated work of the project among stakeholder groups.

We have organised and prepared the Layman's report and the policy brief, as well the dissemination for the final meeting.

We have actively presented our results in congressess, and prepared in other reports.



Financial part

By the end of the year 2013, we have used 81% of total budget, consisting of EC and own contributions. UH has consumed their budget (Action 3). We investigate possibilities for continuing these works with permanent staff funding, and organisation of work conducted in Monimet Life+ project by UH team so that it maximally benefits also Climforisk.

Use of funding by action is also in balance with the original plan. Action 2 slightly exceeded its budget, but has now finished. Action 6 may cost somewhat more than planned originally, due to complexity of data analyses, while we may not be able to use fully Action 7 budget. Still dissemination, mainly in the form of travelling costs have exceeded the

planned costs. Planned budget transfers to travel category during the forthcoming period are expected to remain within the limits allowed in Common Provisions. Total costs of the project may slightly increase from expected, currently expecting max 5% exceedance.

Table: Budget breakdown

Budget breakdown categories	Total cost in €	Costs incurred from the start date to 31.12.2013 in €	% of total costs
1. Personnel	1 358 183	1 095 906	81 %
2. Travel and subsistence	18 400	19 285	105 %
3. External assistance	4 000	0	0 %
4. Durable goods			
5. Land purchase / long-term lease			
6. Consumables	1 000	638	64 %
7. Other Costs	7 000	2 219	32 %
8. Overheads	97 199	78 264	81 %

Table: Incurred costs by action. Costs by actions are calculated without overheads. Projected final cost is unchanged. Without overheads.

Action number and name	Foreseen costs	Spent so far	Remaining	Projected final cost
Action 1 "Name"	120 368	89 712	30 656	120 368
Action 2 "Name"	299 760	311 156	-11 396	311 156
Action 3 "Name"	139 211	131 426	7 785	139 211
Action 4 "Name"	305 159	178 580	126 579	305 159
Action 5 "Name"	117 147	78 770	38 377	117 147
Action 6 "Name"	296 152	277 546	18 606	350 000
Action 7 "Name"	110 789	50 859	59930	90 000
TOTAL	1 388 586	1 118 049	270 537	1433341

Auditor data:

The current auditor of Metla is KPMG Oy Ab, Mannerheimintie 20 B, PL 1037, 00101 Helsinki, contact@kpmg.fi , Raija-Leena Hankonen, registration number 1805485-9. The contract with the current auditor expires 31.12.2014. Metla will merge with MTT Agrifood Research Finland, the Finnish Game and Fisheries Research Institute (RKTL) and the statistical services of the Information Centre of the Ministry of Agriculture and Forestry (Tike) under a new entity called Natural Resources Institute Finland as of 1 January 2015. Auditor for the new institute will be chosen by the end of the year 2014.

Impact:

Nature & Biodiversity:

Our project does not directly deal with this topic, and there are no impacts related. However, there is a potential for extending our model-data collection for evaluation of species occurrences at broad spatial scales, a bit similarly than we plan to use forest damage data to generate prediction of damage vulnerabilities.

Environmental Policy & Governance:

University of Helsinki team participates also in Henvi Climate Change project, which produces methodologies for the estimation of the total effect of forests to climate change, including models of albedo and particle formation. We have provided our data platform for their use in making scenario studies of climate change, in order to more rapidly advance in this work. Our project has identified affiliated plans with the HENVI project, which aim at implementing climate change growth modifiers to MELA system, which is a long term forest planning simulator used to inform Finnish decision makers.

Information and Communication:

Stakeholders

Presentations and posters have increased the awareness of the stakeholders (administrators, scientific audience) regarding to methodologies related to carbon and water balance estimation, and climate effects on forest damages.

Our project has been allocated to Metla's Forests and Water programme. Our methodologies developed for soil water simulations are considered as a tool for predicting excess moisture situations. More importantly, expert knowledge exchange occurs between projects within this programme, and it may generate further topic associated plans to assess water-climate relationships in forests in future.

Climforisk staff (Mikko Peltoniemi and Risto Sievänen) participates in LYNET-ILMU work, which seeks for co-operation and common procedures across governmental institutes (Metla, Finnish Environment Institute, MTT Agrifood, Finnish Game and Fisheries Research Institute, Finnish Geodetic Institute, Finnish Food Safery Authority Evira, and TEKES) related to climate change work and dissemination of the work conducted at different institutes. This group of people has now taken first steps in the planning of new climate change related Life-IP project to be submitted to Life+ instrument in 2015.

Dr. Mikko Peltoniemi has prepared an R-version of the model, which integrates to common statistical programmin environment. This version is now used in MONIMET project.

Climforisk modelling tools are now used in the North State project (coord. VTT Finland, Tuomas Häme), which is part of the EU seventh framework programme

Public

NA

Education

Project has participated in education of students also in last reporting period. We have engaged students to project associated work in two occasions. We have used our model in education of forestry student during the spring of 2013 in a research oriented group work in the course MET240 "Forest ecosystems of the world, their structure and function" organised by prof. Mäkelä at UH. Related to another work package, we have given enviromental engineer students of MAMK University of Applied Sciences (teacher Anne-Marie.Tuomala@mamk.fi) a practically oriented task of

acquiring information about European spruce bark beetle, and scetching potential visual presentations methods for www-dissemination.

Ruirui Wang, a geography MSc student is still working with her thesis, but she has already finished her internship in our project, and has returned her home country.

Indirect impacts:

Our project has been cited in some research proposals as a collaborator and provider of data-model platform, which could be utilized during the project execution.

Outside LIFE:

Aleksi Lehtonen obtained funding for a international meeting funding from Ministry of Agriculture and Forestry in order to organize a high-level seminar on factors causing uncertainty to forest carbon sinks (http://www.metla.fi/ghg/events/2013-09-11-uncertainties-of-forest-carbon-balance.htm). We participated in the organisation and selection of key note and presentations to the sesion. This funding is not included as co-funding.

We have been participating in EU COST FP1106 that concentrates on understanding stress responses and mechanisms of trees. Dr. Mikko Peltoniemi and Prof. Annikki Mäkelä are in key roles in this COST, as the substitute member and as the member of the Management Committee, respectively. Prof. Mäkelä recently hired a post doc through this COST action to work in Finland with the model we have recently developed.

Prof. Mäkelä is responsible for education of forestry students at Department of Forest Sciences, University of Helsinki, so she will distribute ideas generated during the work of the project to future experts in the topic. Sanna Härkönen and Seppo Neuvonen have been educating MSc students on project affiliated topics.

Prof. Mäkelä obtained funding for the North State, FP7 project (participating as a beneficiary), and her team will use the Climforisk models in this project.

Annexes

A. WWW-application plan (ANNEX_A_LIFE09ENV000571_Climforisk_WebApplicationPlan.docx)
B. Dissemination activities of the project (ANNEX_B_LIFE09ENV000571_Climforisk DisseminationActivities.xlsx)
C. Technical report on the status of Action 6 vulnerability modelling (ANNEX_C_LIFE09ENV000571_Climforisk_Action6status.docx)