# EU Life+ MONIMET

Climate Change Indicators and Vulnerability of the Boreal Zone: Applying Innovative Observation and Modelling Techniques























**THE BOREAL FOREST** is a biome characterised by coniferous forests found throughout the high northern latitudes, between the tundra and temperate forest. The area, which also includes peatlands, plays a significant role in managing global carbon sequestration.

In Finland, the EU Life+ MONIMET project aims to better understand climate change by improving access to indicators of regional fluctuations. Funded by Life+, the EC's financial instrument for supporting environmental conservation projects, the team is consolidating and augmenting information, data and expertise that has to date been fragmented and spread across a number of institutes. As subarctic climates warm, the forests experience enhanced growth, increased soil, wetland emissions and the occurrence of extreme weather events such as heat waves, droughts and flooding. A central undertaking to improve data collection – and therefore enhance appreciation of the significant feedbacks to the climate system – is the creation of a new webcam monitoring system.

The effective implementation of the project's webcam network holds huge potential for forecasting future changes to this unique and valuable ecosystem. If successful, the work could provide a blueprint for observation of boreal zones across the globe.

## A constructive climate for science

Dr Ali Nadir Arslan lays out the details of a project that is improving ecosystem monitoring systems across Finland and adding value to existing global change monitoring efforts

> Could you begin by describing the key objectives of your new project, MONIMET? How does it draw from your previous SnowCarbo project, which came to a close in December 2012?

The MONIMET team's objectives are quite ambitious: we would like to collect information, data and expertise that is currently spread over several institutes in order to build a comprehensive platform for analysing climate change. Specifically, we will investigate the effects of climate change on seasonal dynamics and various



natural phenomena in Finland. In doing so, we hope to create links and add value to existing monitoring mechanisms such as the Integrated Carbon Observation System (ICOS) and Copernicus (formerly Global Monitoring for Environment and Security – GMES).

The project will also make use of data acquired in previous EU Life+ funded projects such as SnowCarbo, and during other investigations related to ecosystem monitoring. One of MONIMET's key goals is to create a new webcam monitoring system in order to facilitate Earth observation systems by providing time series of field observation for calibration and validation. Another goal is to improve the assessment of forest ecosystem services and then to synthesise modelling and observation approaches to identify climate change indicators. This allows us to establish links between indicators and their effects in order to create vulnerability maps of Finland's boreal zone in connection to climate change scenarios.

#### What is the benefit of further enabling Earth observation systems within the context of this work?

Earth observation systems may benefit many kinds of monitoring purposes, and they can also help to cut costs because, if remote visual observation is sufficient, they render travelling to the field unnecessary.

## Why must models of climate change be calibrated with current day observations?

The calibration, evaluation and validation of models, as well as their parameterisation, are limited by the coverage of the observational data in terms of vegetation and soil types. Increasing the coverage of data, and therefore the data used in model calibration, decreases the level of uncertainty when using modelling to predict future climate. This level of uncertainty is, at the regional level at least, currently quite high.

#### What role does the terrestrial biosphere play in global carbon balance within the context of climate change?

The carbon balance is directly related to the Earth's carbon, energy and water cycles. The magnitude of climate change is dependent on the atmospheric load of the two most important greenhouse gases: carbon dioxide and methane. The terrestrial biosphere plays an important role in the global carbon balance, and boreal forests and peatlands are an important part of the global carbon cycle. Global carbon balance of the terrestrial ecosystems is known within an accuracy of about ±35 per cent based on atmospheric concentration increase and versatile use of other observational and modelling methods. The uncertainty increases at the regional level, and obtaining accurate figures of countrybased carbon balances and their future development is a challenge.

#### Will the project be useful to the EU in broader terms? How closely do MONIMET's objectives coincide with EU targets?

The actions to be taken in this project are applicable to support a wide variety of EU

activities. For example, it supports the EU white paper 'Adapting to climate change: Towards a European framework for action', which sets out a framework to reduce the EU's vulnerability to the impacts of climate change. It states that in addition to mitigation we must take adaptive action to deal with the unavoidable impacts; a task that MONIMET is successfully addressing.

Our project aims are also in concordance with the EC Communication 'Winning the battle against global climate change', which calls for more and better-focused research to further improve knowledge on climate change and its global and regional impact. The project objectives are related to 'Limiting Global Climate Change to 2 degrees Celsius – The way ahead for 2020 and beyond', setting out more concrete steps to limit the effects of climate change. Finally, MONIMET also answers the 'Addressing the challenges of deforestation and forest degradation to tackle climate change and biodiversity loss' Communication, calling for the strengthening of forest governance and institutions at the local and national level by rewarding the value of the services provided by forests and by taking account of demand and the responsibility of consumers.

## Winter warmer

**MONIMET** is an ambitious research project spearheaded by scientists in Finland to increase turnover of climate data by implementing a network of webcams in Finland's boreal forest and wetland environments

WHILE CLIMATE CHANGE is a problem in need of global action, its effects are localised and impact on regions in very different ways. Equally, certain areas exert a greater influence on the global climate and carbon balance than others, and it is this dynamic relationship that makes tackling climate change so complex. One example of such unpredictable feedback is found in Arctic and subarctic regions, where the climate is changing rapidly – and projected changes in years to come suggest a challenging future. Over the next century, scientists predict a mean annual temperature increase of 2-6 °C. This change will be particularly important in the boreal forest biome, which is distributed in a band around the northern subpolar regions of Earth.

Boreal forest represents the world's largest terrestrial biome and exerts a pronounced effect on global climate and weather systems. It is expected that, as well as enhancing annual growth in the boreal forest, climate change will simultaneously increase emissions from soil and wetland sources and alter the occurrence of events including heat waves, droughts, floods and storms. Positive and negative impacts may potentially unfold in unpredictable combinations, and these changes will occur to varying degrees and at different rates in separate areas within the boreal zone. A regional focus will therefore be essential in determining both the regional and global outcomes of climate change, and suggesting possible routes towards correcting the carbon balance.

#### UNTANGLING COMPLEXITY

In Finland, the boreal zone is blended with wetland environments that account for onethird of the country's territory. Moreover, forest growth is estimated to start earlier in spring and end later in autumn in the warming climate. When considering the carbon balance, therefore, the extended period of activity for vegetation brought about by rising temperatures must be set against the increase in methane emissions from unfrozen wetlands. In addition, the effect of shorter winters on the dormant development of trees – as well as the impact of storm events on trees anchored in thawed ground – are open questions, with a further problem posed by the projected decrease in snow depth and coverage. This decline will reduce surface refection, meaning that less heat will be reflected back into the sky. Overall, Finland presents a complex knot of problems for those concerned with the future of the climate.

One team working hard to disentangle this complexity is MONIMET, based at the Finnish Meteorological Institute (FMI). Led by Project Manager Dr Ali Nadir Arslan, MONIMET aims to create a firm base for tackling climate analysis in Finland. The FMI team has joined forces with partners at three other organisations to deliver the project; the Finnish Environment Institute (SYKE), the Finnish Forest Research Institute (METLA) and the University of Helsinki (UHEL) have all added their expertise to the ambitious endeavour, and it is expected that their project, which runs until September 2017, will allow a far greater insight into the Finnish climate and its impact on the world.

#### WATCHING WITH WEBCAMS

MONIMET is funded by Life+, the EC's financial instrument for supporting environmental conservation projects, and builds on the FMI's previous work in related climate projects such as SnowCarbo (see opposite page). The plan is to observe climate change through the use of indicators such as water and carbon cycles and phenology – the study of plant and animal life cycles. This is also the approach used by the EU; the European Environment Agency, for example, lists more than 40 indicators of climate change based around vegetation, water and gas levels. Accordingly, MONIMET's initial aim is to improve the methods by which scientists gather environmental data.

The group's first step is implementing an innovative new system for *in situ* monitoring: a webcam network. Having only started work in September of 2013, the researchers are now at the stage of selecting candidate webcams and determining at which sites they should be placed. Once completed, it is hoped that this new network will provide an unparalleled insight into forest ecosystem services, enabling spatially representative monitoring of vegetative processes and their change over time. Indeed, the team hopes that this work will lead to the design and harmonisation of webcam networks all over Finland.

Furthermore, the aim of MONIMET is to provide the groundwork for efficient and sustainable future observations – the researchers involved espouse sustainable approaches to all aspects of their own work. Their decision to build on the work of others is carbon efficient in itself, but the team also aims to maximise the use of electronic material in dissemination and avoid unnecessary travel by prioritising tele- and videoconferencing as a means of communication between partners. "There are not many possibilities to reduce energy consumption in the office because those measures have already been taken," Arslan explains. "The real potential lies in the reduction of travel and paper use."

#### THE SUSTAINABLE WAY

One of the project's most exciting aspects is its underlying methodology. The first innovation in its approach is to build wherever possible on existing monitoring mechanisms, forming new links and adding value. This involves interacting with a wide variety of stakeholders at the national and international levels, especially meta-networks. To support this effort, the project partners have made use of their existing relationships to throw the endeavour open to the Global Earth Observation System of Systems (GEOSS), Copernicus – the European Earth Observation Programme, the Integrated Carbon Observation System (ICOS) and FLUXNET, a network of regional networks integrating worldwide CO<sub>2</sub>, water and energy flux measurements.

#### MAPS AND MODELLING

Using these new data – and the novel observational approaches the webcam network will facilitate – the team then plans to create and calibrate high-resolution climate models for developing accurate estimates of climate change effects on soil and plants. These models will not only be useful in Finland, but worldwide – and the data produced may contribute to climate models for other regions within the boreal forest or peatland biomes. The project therefore has clear scalability, beginning at the level of individual webcams and building up to local, national and global relevance.

Finally, the group will use its accumulated data in conjunction with more advanced modelling techniques to determine vulnerability maps for wetlands and boreal zones in the context of various climate situations. If such maps can ultimately be created, providing a reliable and clear path towards efficient future strategies, then this would be an invaluable asset to Finland and the EU. The team's studies will also give an indication of the mitigation potential in these habitats, and an estimate of the risk of decrease in the provision of ecosystem resources such as the carbon sequestration of trees, and the nitrogen retention of soil.

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## **SnowCarbo**

**MONIMET IS AN** incredibly ambitious endeavour but it also follows in the footsteps of a number of research projects from FMI that have allowed them to build expertise and a network of collaborators. The previous project was SnowCarbo, another Life+ research programme that shared much of its philosophy and approach with MONIMET, but aimed at different objectives.

SnowCarbo's main goal was to implement and demonstrate a new and innovative approach to the mapping of net carbon balance in Europe and northern Eurasia. By combining data sources in new ways and modelling  $CO_2$  balances on a continental scale, the project

was able to produce carbon balance maps for these regions, producing results that could be implemented in the strategies of Europe as well as individual nations.

After four years of successful study, the SnowCarbo project came to an end at the beginning of 2013. The carbon maps produced, which were designed to focus on accurately portraying otherwise unknown areas, were distributed to key policy makers in Finland and Europe – along with information concerning the distinction between anthropogenic and background carbon levels. Finally, methodologies were refined based on the findings of this project – ensuring that SnowCarbo could pave the way for MONIMET, as well as other future projects.

#### CULTIVATING COLLABORATION

**IN ORDERTO** make a success of SnowCarbo, as well as subsequent initiatives, the project teams have had to bring a high level of collaboration to their work. Several bodies were involved in the progression and successful completion of the project, and the links formed as part of this work have been a continuing asset in future endeavours.

#### FINNISH METEOROLOGICAL INSTITUTE (FMI)

The FMI has been the driving force behind both SnowCarbo and MONIMET, acting as coordinating beneficiary for both project proposals. A service and research organisation within the remit of the Finnish Ministry of Transport and Communications, the FMI focuses on fields of research related to the weather, climate, air quality and geophysics. Its responsibilities include the production of reliable information on the state of the atmosphere, its characteristics and phenomena with the aim of enhancing overall safety as well as serving the needs of the general public, industry and commerce – as well as other branches of science.

#### THE FINNISH ENVIRONMENT INSTITUTE (SYKE)

SYKE has been a long-term collaborator of the FMI, working alongside them in both

SnowCarbo and MONIMET. With a staff of around 600, SYKE is an advanced national research and development centre under the Finnish Ministry of the Environment – and it excels in providing environmental information, publishing assessments on the state of the environment, and conducting research into the environment and environmental effects of human activities. Its expertise also extends to the analysis of methods for preventing and mitigating damage to the environment – a process close to the heart of SnowCarbo.

#### THE LABORATORY OF CLIMATE SCIENCES AND THE ENVIRONMENT (LSCE)

The last of the three partners involved in SnowCarbo is the LSCE. A joint research unit between two major French research agencies – the National Centre of Scientific Research (CNRS) and the Atomic Energy and Alternative Energies Commission (CEA) - the LSCE currently employs almost 250 scientists, and is the home of remarkable expertise in the fields of biogeochemical modelling and observation, past and future climate studies and isotopic markers in the environment. LSCE has world class expertise in carbon cycle modelling and analysis, with a particular focus on modelling land atmosphere CO<sub>2</sub> fluxes and their interactions with the climate system. In the context of SnowCarbo, their knowledge was vital to link snow processes with boreal regions carbon cycling - a crucial step.

#### INTELLIGENCE

### MONIMET

#### CLIMATE CHANGE INDICATORS AND VULNERABILITY OF THE BOREAL ZONE: APPLYING INNOVATIVE OBSERVATION AND MODELLING TECHNIQUES

#### **OBJECTIVES**

- To collect information, data and expertise that is currently spread over several institutes in order to build a comprehensive platform for analysing climate change effects on seasonal dynamics of various phenomena
- To create links and add value to existing monitoring mechanisms such as ICOS and Earth observation systems (GMES/ Copernicus) and make use of data acquired in previous EU Life+ funded projects, and other projects related to ecosystem monitoring
- To create new webcam monitoring system in order to facilitate Earth observation systems by providing time series of field observation for calibration and validation, as well as to improve the assessment of forest ecosystem services
- To synthesise modelling and observation approaches to identify climate change indicators
- To establish links between the climate change indicators and their effects in order to create vulnerability maps of boreal zone in connection to climate change scenarios

#### PARTNERS

Finnish Meteorological Institute (FMI)

The Finnish Environment Institute (SYKE)

University of Helsinki (UHEL)

Finnish Forest Research Institute (METLA)

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