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1st summary report of flux data

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Climate change indicators and vulnerability of boreal zone applying innovative observation and modelling techniques

Data Project

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Data Beneficiary

Name Beneficiary	Ilmatieteen laitos
Contact person	Mika Aurela
Postal address	Erik Palménin aukio 1, FI-00101, Helsinki, Finland
Telephone	+358-50-377 9722
Fax:	+358-9-323 2970
E-mail	mika.aurela@fmi.fi
Project Website	monimet.fmi.fi

1 Summary

This report describes the data on CO_2, CH_4 and H_2O exchange between atmosphere and different ecosystems. Such flux data have routinely been measured for several years at various stations maintained by FMI and UHEL. In MONIMET project, this data will be exploited in assessing the functionality of the models and calibrating them by means of data assimilation (Actions B4 to B6) and to evaluate the phenological parameters of the EO (earth observation) data (Action B2).

The gas exchange data obtained from the two ecosystem models (JSBACH and PRELES) utilized in Action B4 may be directly compared to these flux observations from different ecosystems. The flux data provides also means to determine detailed phenological and plant physiological data (e.g. growing season stages, their dynamics and interannual variation) which may be used to validate the EO (earth observation) data that is collected in Action B2 and results of webcam exercise in Action B1. The characteristics of the measurement sites and systems together with the data availability will be given in this report.

2. Data

2.1 Flux measurement sites

The validation data set is based on the results obtained by the flux measurement programs of Finnish Meteorological Institute and University of Helsinki (Table 1). Longest running flux sites, Hyytiälä Scots pine forest, Sodankylä Scots pine forest and Kaamanen wetland, provide data sets of over 10 years each. Shorter multi-year flux data sets are available from a spruce forest and a wetland at Pallas area and Lettosuo Scots pine forest on drained peatland in southern Finland. All these measurements continue running and the data will be prepared in the form needed by different Actions during the duration of the project.

Table 1. Flux measurement stations

Site	**Vegetation type**	**Latitude/Longitude**	**Data**	**Measurement/ vegetation height (m)**
Hyytiälä	Scots pine forest	61°50.845'N, 24°17.687'E	1997 -	23 / 18
Sodankylä	Scots pine forest	67°21.712'N, 26°38.270'E	2000 -	23.5 / 18
Kaamanen	Aapa mire	69°08.441'N, 27°16.230'E	1998 -	5 / 0.5
Kenttärova	Spruce forest	67°59.234'N, 24°14.583'E	2003 -	23/ 13
Lompolojänkkä	Aapa mire	67°59.832'N, 24°12.551'E	2005 -	3 / 0.5
Lettosuo	Scots pine on drained peatland	60°38.510'N, 23°57.583'E	2011 -	25 / 18

2.2 Eddy covariance flux measurements

The flux measurements are conducted by the eddy covariance (EC) technique which provides a direct measurement of the net exchange of CO_2, CH_4, water vapour and sensible heat between the biosphere and the atmosphere. In this technique the vertical flux of a scalar constituent is obtained as (e.g., Baldocchi, 2003)

$$F = \overline{w'c'}\,, \qquad (1)$$

where *w* is the vertical wind speed and *c* is the quantity of interest (e.g., CO_2 concentration, temperature or humidity). With the eddy covariance technique the measurements are carried out using fast-response instruments sampled typically at 10–20 Hz in order to cover the entire frequency range of turbulent variations. The EC method has become common during the recent decades, and there have been various extensive research projects on CO_2 exchange covering different ecosystems and different areas in Europe (e.g., CARBOEURO-IP, GHG-EUROPE, ICOS). Together with similar projects conducted on other continents (e.g., AMERIFLUX, FLUXNET-CANADA, ASIAFLUX), these projects form a global network of micrometeorological measurements, FLUXNET (Baldocchi *et al.*, 2001).

The main advantage of micrometeorological methods over the alternative enclosure methods is their ability to continuously measure the surface exchange of matter and energy. This makes it possible to study both the short-term variations (e.g., diurnal cycle) and the long-term balances. The micrometeorological measurements do not disturb the surface under investigation and provide fluxes on an ecosystem scale, thus avoiding the difficult up-scaling problems. The markedly smaller target area of chamber measurements, however, enables a spatially detailed study on different components of the ecosystem, which could complement the micrometeorological measurements.

The instrumentation used presently in the flux measurements at the measurement sites of FMI includes USA-1 sonic anemometer (METEK) and LI-7000 CO_2/H_2O analyzer (Li-Cor). In Hyytiälä the instruments are Solent 1012R2 (Gill Instruments) and LI-6262 (Li-Cor), respectively. The fluxes are calculated as block averages with a 30-min averaging period. A double rotation of the coordinate system is performed according to McMillen (1988). The lag between the time series resulting from the transport through the inlet tube is taken into account in the on-line calculation of the flux quantities by maximizing the absolute value of the covariance in question. The density correction related to the sensible heat flux is not needed (Rannik et al., 1997), but as the LI-7000 does not take into account humidity variations, a partial density correction was performed (Webb et al., 1980). Corrections for the systematic flux loss owing to the imperfect properties and setup of the sensors (insufficient response time, sensor separation, damping of the signal in the tubing and averaging over the measurement paths) were performed off-line using transfer functions with empirically-determined time constants (Aubinet et al., 2000). The data handling procedures for the measurements used in MONIMET have been explained in more detail by Aurela et al. (2002), Aurela (2005), Rannik et al. (2004) and Mammarella et al. (2009).

1.3 Meteorological data

In addition to the actual CO_2 exchange data the flux stations provide additional meteorological data which will be used to run JSBACH and PRELES as point models at the flux measurements sites for the data assimilation and comparison purposes. For regional estimates these models are run in Action B5 utilizing gridded meteorological data obtained from a climate model.. The in-situ meteorological data may also be used for evaluating the representativeness of these gridded meteorological data fields at each flux measurement site. The most important parameters (air and soil temperature together with certain radiation components) are available at all sites. Some data have to be obtained from nearby weather station or a climate model. More detailed parameter list is presented in Table 3.

Table 2. Availability of different parameters at the flux measurements sites of Finnish Meteorological Institute and University of Helsinki

Parameter / **Site**	CO_2 flux	H_2O flux	CH_4 flux	Sensible heat lfux	Snow depth	Prepicitation	Water table depth	PPFD	Reflected PPFD	Short wave (SW) radiation	Reflected SW radiation	Long wave (LW) radiation	Reflected LW radiation	Net radiation	Air temperature	Soil temperature (profile)	Air humidity	Soil moisture	Soil heat flux	Pressure	Wind
Hyytiälä	x	x	-	x	x	x	-	x	x	x	x	-	-	x	x	x	x	x	x	x	x
Sodankylä	x	x	-	x	x	x	-	x	x	x	x	x	-	x	x	x	x	x	x	x	x
Kaamanen	x	x	-	x	o	o	x	x	x	x	x	-	-	x	x	x	x	-	-	o	x
Kenttärova	x	x	-	x	x	x	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Lompolojänkkä	x	x	x	x	x	o	x	x	x	x	x	o	-	x	x	x	x	x	x	o	x
Lettosuo	x	x	-	x	o	x	x	x	x	x	x	o	-	x	x	x	x	x	x	o	x

x) Available at the flux measurement site

o) Available from the nearest weather station

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