2nd workshop/training course on

EddyUH: a software for eddy covariance flux calculation

Helsinki, 21-25.1.2013

Introduction to the course/workshop

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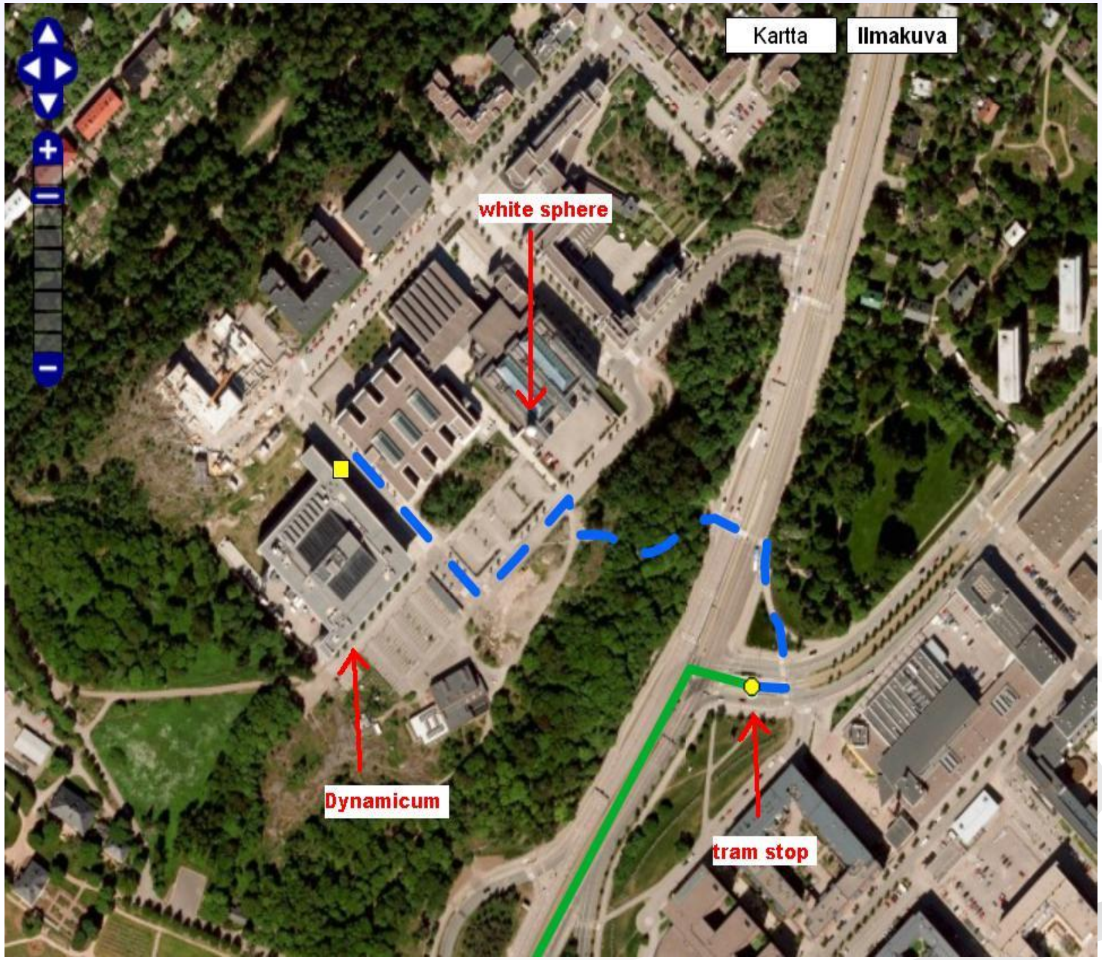
University of Helsinki, Dep. of Physics, Division of Atmospheric Sciences

Where we are : Kumpula Campus



Division of Atmospheric Sciences

- Head: prof. M. Kulmala
- Over 120 scientists and Ph.D. students
- 9 professors
- aerosol- and environmental physics, micrometeorology, chemical meteorology, dynamic and physical meteorology
- National and Nordic Centre of Excellences

Research areas and focus

Head of Division: Prof Markku Kulmala

- Dynamic and physical meteorology
- Radar
- Micrometeorology
- Computational aerosol physics
- Aerosol measurements
- Aerosol phenomenology
- Atmosphere modelling
- Soil dynamics
- Biogenic Hydrocarbon fluxes

Leader: T. Vesala. 15 people

Focus: Micrometeorology / Measurements and modelling of exchange processes between the atmosphere and different ecosystems

- *Nature*, 404, 861-865, 2000; *Nature*, 422, 134, 2003; *Nature*, 437, 529-533, 2005; *Nature*, 451, 49, 2008; *Nature GeoScience*, 3, 529-525-532, 2010

How do we measure EC flux

3D sonic anemometer + fast gas analyzer

High frequency (≥10 Hz) measurements of u, v, w, T, CO_2, H_2O, CH_4, N_2O…

Open-path IRGA Licor 7500 (CO_2 and H_2O)

Sampling tube inlet of closed-path IRGA

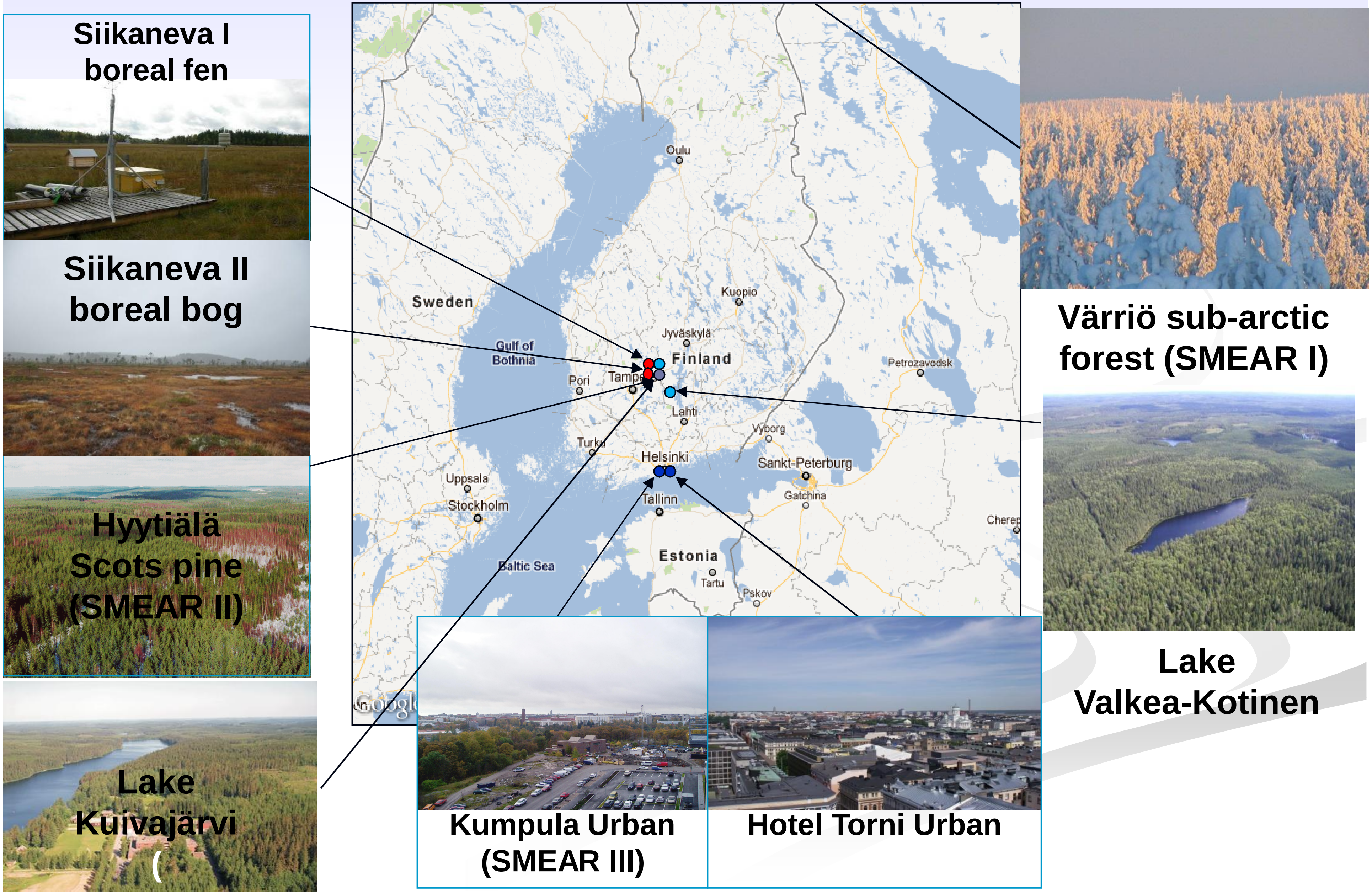
Photos by Sami Haapanala, UH

Eddy covariance technique

- Direct and continuous measurements of net surface exchanges of energy and gases at ecosystem scale.
- Time scale half-hour to interannual.
- Non destructive, non invasive.
- Ecosystem function.

- Only net fluxes.
- Random errors.
- Systematic errors.
- Gaps.
- Flat terrain

UHEL EC flux measurement sites



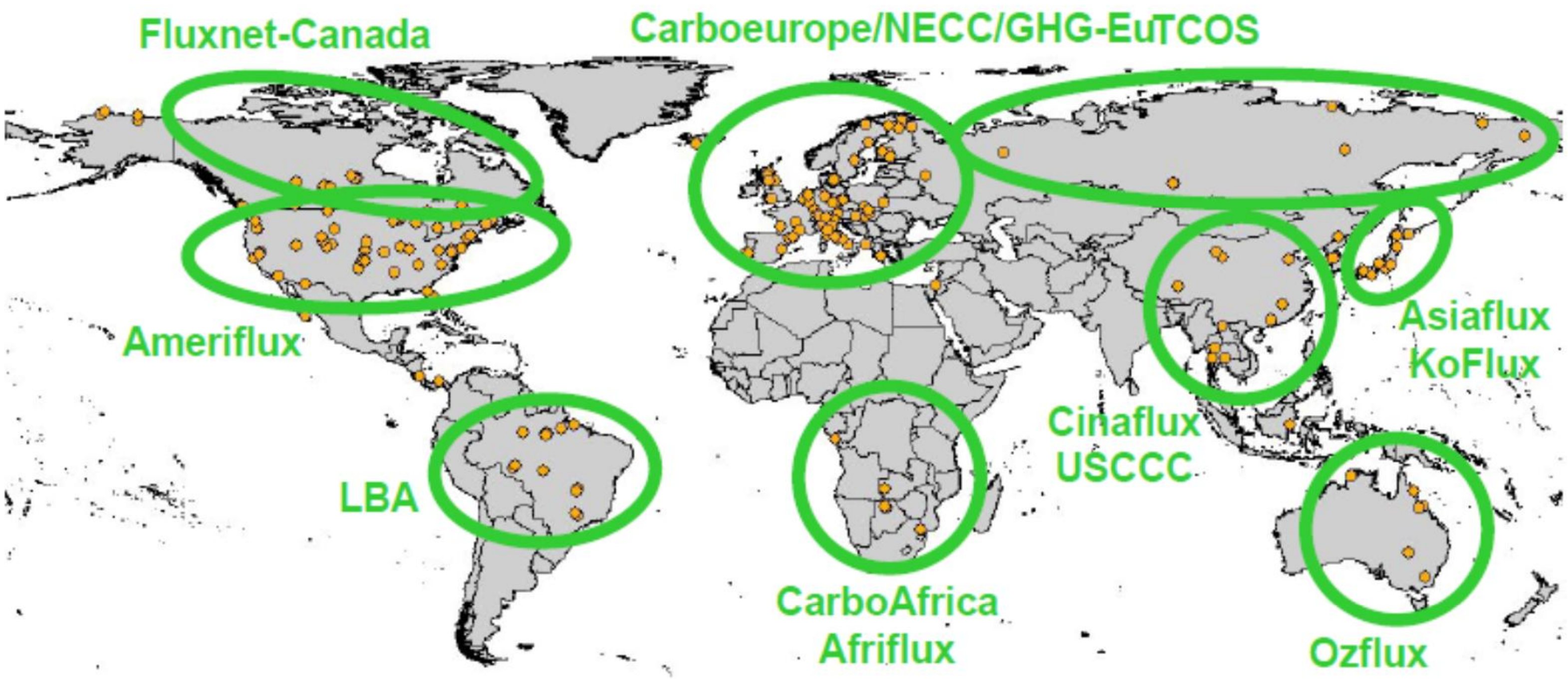
EC sites network in Europe

The situation in Europe

1996-1999	EUROFLUX	about 15 sites
1999-2002	MEDEFLU	about 10 sites
2000-2003	Carboeuroflux	about 35 sites
2004-2008	Carboeurope-IP	about 50 sites + 50 not funded
2008-2011	IMECC	about 13 sites
2009-2012	ICOS	no sites funded
2010-2014	GHG-Europe	about 20 sites

Others projects like NitroEurope and CarboExtreme contribute also to support the eddy covariance sites but not as main objective. Regional projects like NECC, Carboitaly, CarboSpain supported also sites.

Eddy covariance sites are world-wide distributed and organized in regional networks

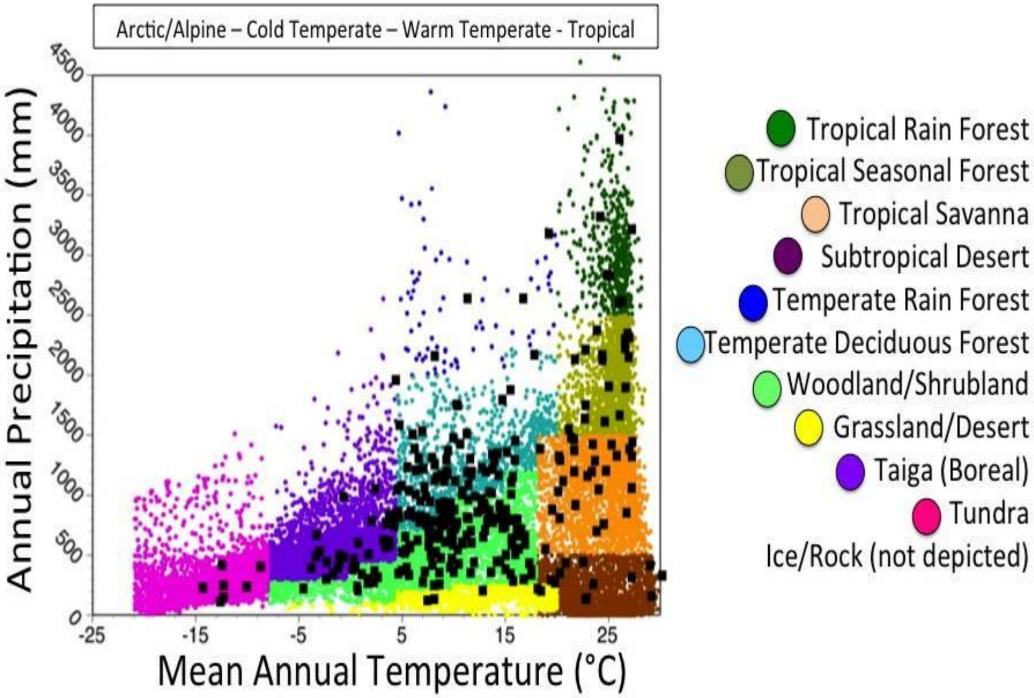


Adapted from D. Papale

www.fluxdata.org

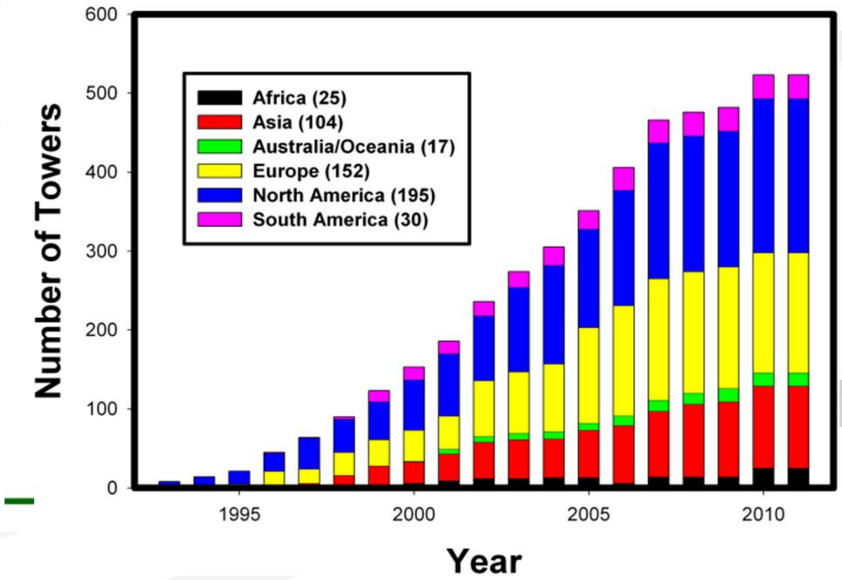
FLUXNET, network of networks

With the aim to connect scientists and promote synthesis studies



Adapted from D. Papale

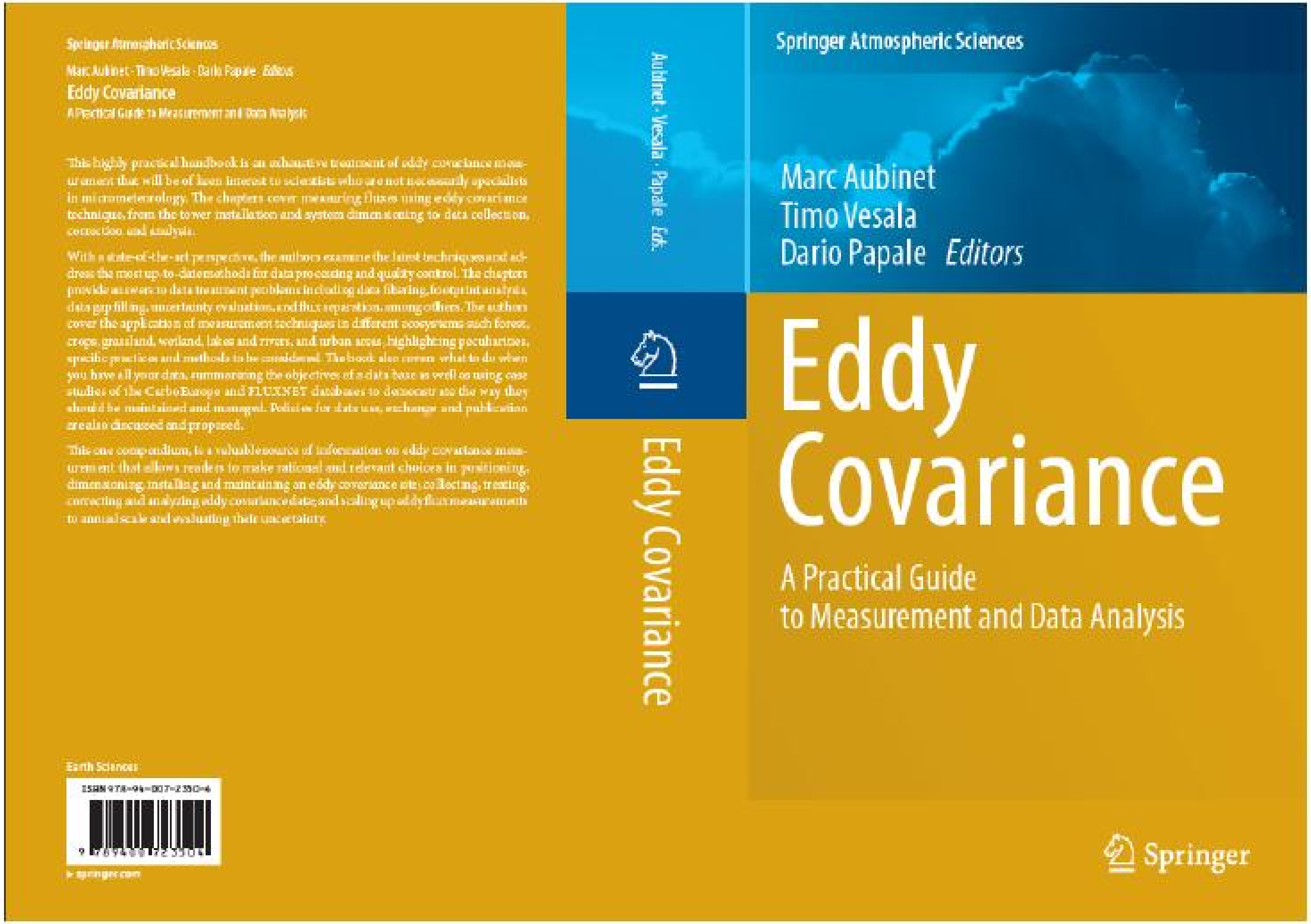
Growth of FLUXNET
523 Towers as of March 07, 2011



www.fluxdata.org

ICOS integrated carbon observation system

- Monitoring of concentrations and fluxes of CO_2, CH_4 and N_2O
- Tentative period of operational phase 2014 - 2031
- Head Office to be located in Helsinki



Springer Atmospheric Sciences
Marc Aubinet · Timo Vesala · Dario Papale *Editors*
Eddy Covariance
A Practical Guide to Measurement and Data Analysis
This highly practical handbook is an exhaustive treatment of eddy covariance measurement that will be of keen interest to scientists who are not necessarily specialists in micrometeorology. The chapters cover measuring fluxes using eddy covariance technique, from the tower installation and system dimensioning to data collection, correction and analysis.
With a state-of-the-art perspective, the authors examine the latest techniques and address the most up-to-date methods for data processing and quality control. The chapters provide answers to data treatment problems including data filtering, footprint analysis, data gap filling, uncertainty evaluation, and flux separation, among others. The authors cover the application of measurement techniques in different ecosystems such forest, crops, grassland, wetland, lakes and rivers, and urban areas, highlighting peculiarities, specific practices and methods to be considered. The book also covers what to do when you have all your data, summarizing the objectives of a data base as well as using case studies of the CarboEurope and FLUXNET databases to demonstrate the way they should be maintained and managed. Policies for data use, exchange and publication are also discussed and proposed.
This one compendium, is a valuable source of information on eddy covariance measurement that allows readers to make rational and relevant choices in positioning, dimensioning, installing and maintaining an eddy covariance site; collecting, treating, correcting and analyzing eddy covariance data; and scaling up eddy flux measurements to annual scale and evaluating their uncertainty.
Earth Sciences
ISBN 978-94-007-2350-6
▶ springer.com
Aubinet · Vesala · Papale *Eds.*
Eddy Covariance
Springer Atmospheric Sciences
Marc Aubinet
Timo Vesala
Dario Papale *Editors*
Eddy Covariance
A Practical Guide
to Measurement and Data Analysis
Springer

1. Flux measurements in urban ecosystems

>>>> multiple spatio-temporal scale surface heterogeneities

Distribution of the urban flux measurement sites recorded in the Urban Flux Network database (http://www.geog.ubc.ca/urbanflux/)

	Fraction of world population	No of urban flux towers
Cities in tropical climates (A)	28%	3
Cities in arid and semiarid climates (B)	14.5%	3
Cities in temperate climates (C)	44.6%	40
Cities in continental climates (D)	12.4%	15
Cities in polar climates (E)	0.3%	0
Total	100%	**61**

Source: Fluxnet Newsletter May 2012

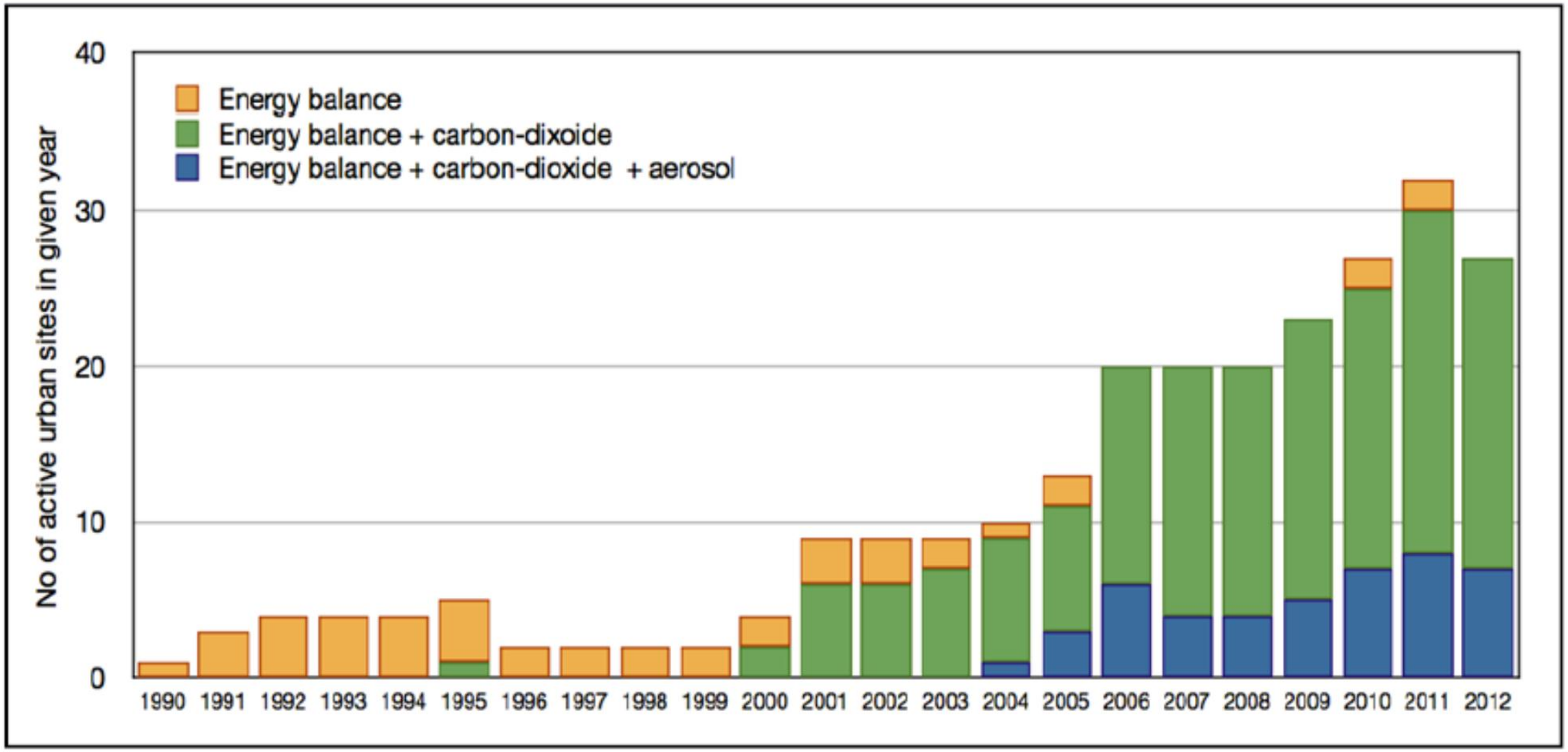
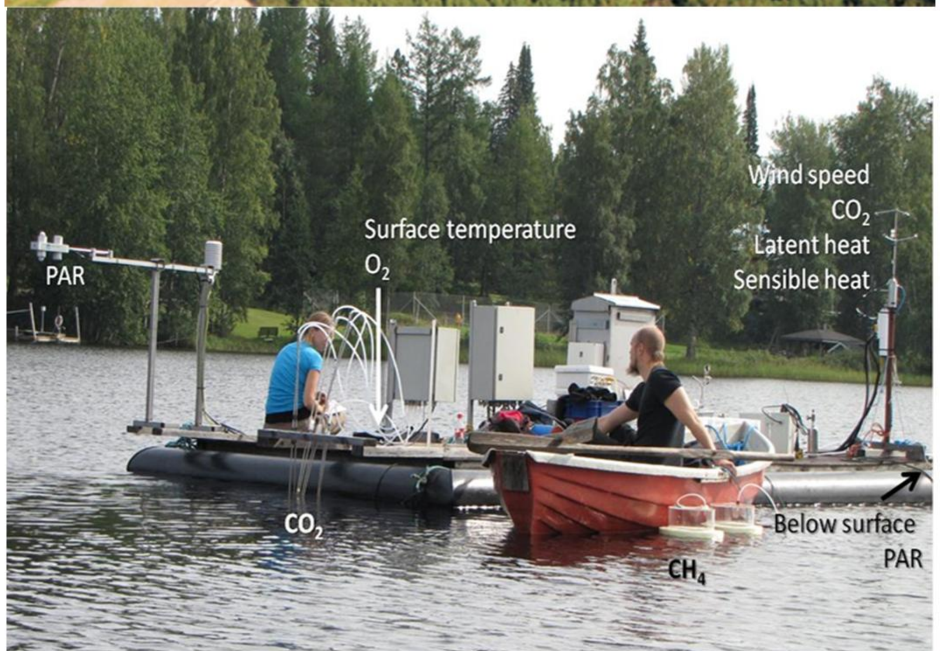


Figure 2 - Number of active urban flux sites active per year (1990-2012) and measured turbulent fluxes. Source of data: Urban Flux Network database (May 2012).

Source: Fluxnet Newsletter May 2012

2. Flux measurements in lake ecosystems



- Inland water are important source of carbon (CO2 and CH4) to the atmosphere (Bastviken etal., 2011, *Science*)
- Chamber methods and gas exchange models are often used >>> very large uncertainty.
- Less than 10 papers published on EC CO2 flux.
- Less than 20 papers published on EC energy flux.
- Less than 5 papers published on EC CH4 flux.

EC post-processing software

- EDIRE (University of Edinburgh, UK)
- ALTEDDY (Alterra)
- TK3 (University of Bayreuth, Germany)
- EddySoft (Max-Planck-Institute Jena, Germany)
- Eth-flux (Technical University Zürich, Swiss)
- ECPack * (University of Wageningen)
- ECO2S* (IMECC-EU Univ. of Tuscia, Italy)
- EddyPro* (www.licor.com)
- EddyUH* (University of Helsinki, Finland)

* = open source

EddyUH version 1.3

The software **EddyUH**, developed by UHEL/DPAS, includes state-of-art methodologies for EC flux estimates.

Supported instruments	
Sonic anemometers	Gill-R2, Gill-R3, Gill-HS, Campbell CSAT3, Metek-USA-1
Gas analyzers	Licor-6262 (CO_2, H_2O), Licor-7000 (CO_2, H_2O), Licor-7500 (CO_2, H_2O), Licor-7200 (CO_2, H_2O), Licor-7700 (CH_4), Campbell TGA100 (CH_4, N_2O), Los Gatos –RMT200 (CH_4), Picarro G1301-*f* (CH_4, CO_2, H_2O), Aerodyne QCLAS (N_2O, CO_2, H_2O, CH_4)
Implemented methods/corrections	
Raw data level	Units conversion and Calibration; Spike detection; Cross-wind correction (Liu et al., 2001); Dilution correction point by point; Angle of attack correction (Nakai et al., 2006); Block averaging, linear detrending and autoregressive running mean filter; Time lag estimation
Coordinate rotation of sonic wind components	Planar fit (Wilczak et al., 2001); Streamwise rotation (1D, 2D or 3D) according to McMillen (1988)
Quality statistics	Skewness, kurtosis, flux non-stationarity, random flux error, flux intermittency
High frequency loss	Theoretical (Moncrieff et al., 1987, Moore et al., 1986); Empirical estimation of the transfer function (Aubinet et al., 2000; Mammarella et al., 2009)
Low frequency loss	According to Rannik (1999)
Humidity corr to sensible heat flux	According to Schotanus et al. (1983)
WPL correction	Based on Webb et al.(1980), Ibrom et al.(2007) for closed-path GA, additional cross-talk correction for Licor-7700, Los Gatos –RMT200 and Aerodyne QCLAS

Acknowledgements

Nordic Centre of Excellence (NORDFORSK)

- DEFROST (www.ncoe-defrost.org)
- CRAICC (www.atm.helsinki.fi/craicc)

Research Networking Programmes

- TTORCH (www.ttorch.org)
- NORDFROST (www.nateko.lu.se/nordfrost/home.html)