Project no. GOCE-CT2003-505572

CarboEurope-IP

Assessment of the European Terrestrial Carbon Balance

Integrated Project

Thematic Priority 1.1.6.3 Global Change and Ecosystems

Second Annual Activity Report

Executive Summary

Period covered: from 01 January 2005 to 31 December 2005

Date of preparation: 15 February 2006

Start date of project: 01 January 2004 Duration: 60 Months

Project coordinator name: Prof. Dr. Ernst-Detlef Schulze

Project coordinator organisation name: Max-Planck-Institut für Biogeochemie

Executive Summary: Activities in the second year of the Integrated Project CarboEurope-IP (GOCE-CT2003-505572)

Main objectives of CarboEurope-IP

The overarching aim of CarboEurope-IP is to understand and quantify the present terrestrial carbon balance of Europe and the associated uncertainty at local, regional and continental scale. In order to achieve this goal, the project addresses three major topics:

1. Determination of the carbon balance of the European continent, its geographical patterns, and changes over time.
2. Enhanced understanding of the controlling mechanisms of carbon cycling in European ecosystems, and the impact of climate change and variability, and changing land management on the European carbon balance.
3. Design and development of an observation system to detect changes of carbon stocks and carbon fluxes related to the European commitments under the Kyoto Protocol.

Contractors involved

CarboEurope-IP integrates and expands the research efforts of 61 European universities and research institutes from 17 European countries as project contractors (Figure 1) and around 30 associated institutes from all over the world. The updated list of contractors is given at the end of this executive summary. The project is co-ordinated by Ernst-Detlef Schulze and Annette Freibauer (project manager), Max-Planck-Institute for Biogeochemistry, Jena, Germany. The four main scientific components of the project are led by

- Riccardo Valentini, University of Tuscia, Viterbo, Italy: Ecosystem Observations
- Philippe Ciais, Laboratory of Climate and Environmental Sciences (LSCE), Gif-sur-Yvette, France: Atmospheric Observations
- Han Dolman, Vrije Universiteit Amsterdam: Regional Experiment
- Martin Heimann, Max-Planck-Institute for Biogeochemistry, Jena, Germany: Continental Integration and Modelling

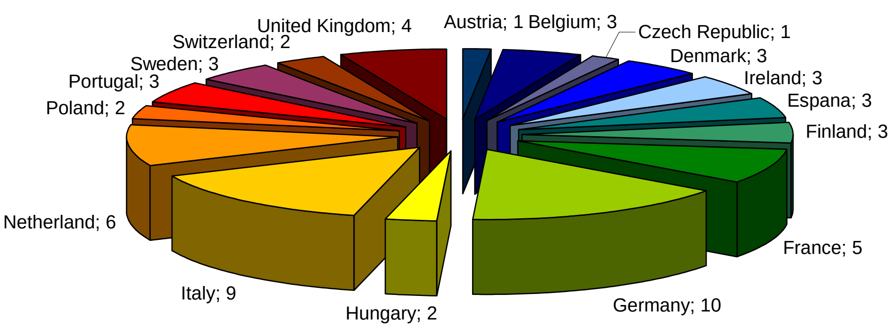

Figure 1: Countries of origin of CarboEurope-IP contractors

Contact details of Co-ordinator

Ernst-Detlef Schulze (Co-ordinator), Annette Freibauer (Scientific manager), Angelika Thuille (Project Manager)
Max-Planck-Institute for Biogeochemistry
P.O. Box 100164
07701 Jena, Germany
Phone +49 3641 576164
Fax +49 3641 577100
E-mail dschulze@bgc-jena.mpg.de, afreib@bgc-jena.mpg.de, athuille@bgc-jena.mpg.de

Project website: www.carboeurope.org

Work performed and results achieved

CERES, the Carboeurope Regional Experiment Strategy in les Landes, South West France, May-June 2005 (Dolman et al., Bulletin of the American Meteorological Society, in revision)

The CarboEurope Regional Experiment Strategy (CERES) aimed to produce aggregated regional estimates of the carbon balance of a region that can be meaningfully compared to those from the smallest downscaled information of atmospheric measurements and continental scale inversion results. A period 6 weeks in the spring of 2005 (from 05/16/05 to 06/25/05) was chosen for high intensity observations of boundary layer development and extra flux aircraft for enhanced spatial sampling. CERES has provided a wealth of data that on its own could prove useful, but should be particularly useful as a comprehensive dataset to narrow down uncertainties in regional carbon balance estimation. It provides considerable insight into the large variability of CO_2 fields (10-20 ppm over 200 km) and the considerable diurnal range in the boundary layer. Analyzing the data for the full experiment, after full quality control, is one of our major tasks.

European heat and drought wave 2003 (Ciais et al., Nature 437, 529-533)

Previous year's work on the European heat and drought wave has been continued and the results have been published in Nature: Severe heatwaves may become more frequent in a changing climate, yet their impact on terrestrial C cycling is unclear. A terrestrial biosphere simulation model was used to assess continental scale changes in primary production during 2003 and the consequences for the net carbon balance. A 30% reduction in GPP over Europe resulted in a strong net CO_2 source of 0.5 PG C yr^{-1}. Productivity reduction can be explained by rainfall deficit and extreme summer heat. An increase in future drought events could turn temperate ecosystems into carbon sources.

Component 1 Ecosystems

Activity 1.1: The database system is built up and data are delivered as planned. Centralized quality checked and gapfilled datasets production is somewhat delayed due to methods testing and improving but it will be finished in the next months. Updated u* threshold selection method and Artificial Neural Network as tools for gap-filling were the most important improvements. Optimal design and current network representativness are under study, one workshop on the topic was organized in Levi, a second is planed in spring/summer.

Activity 1.2: The quality assessment and quality control issues were completed in 2005 and a web site created. Also the footprint analysis for most of the main sites and eddy software comparison were done and reports prepared. A new software TK2 for corrections and quality tests on raw eddy covariance data was developed and will be available in the beginning 2006.

The second advection experiment took place in Renon (IT-Ren) from April to September 2005 and data analysis is in progress. Other two experiment are planed in Wetzstein and Norunda in 2006. In waiting for a new criterion to detect the half hour measurements affected by advection, the u* filtering remains the best way to correct data and for this reason is implemented in the database. The group working on this activity reported difficulties for budget limitations.

Activity 1.3: Soil sampling was performed on 7 additional Main sites (12 verification sites were sampled in 2004) and samples analysis started. Soil maps are not yet available but the georeferenced data on sampling points are ready. Stable isotopes analysis will not be possible due to budget problems.

Activity 1.4: In Levi there was a strong request to sites manager to submit LAI measurements and non-fluxes data and also to install web-cams on the towers to observe phenology. NPP and forest structure measurements are in progress but with some delay due to the hard work necessary. An intercomparison workshop of GPP, NEP, NPP & RA for all forest sites will be organised. Effects of management and disturbances are under study in thinned sites (Hyytiala, Griffin) and windthrows affected areas (Tatra mountains and Sweden). Model analysis, parametrization and simulation are also ongoing activities.

Activity 1.5: All the main sites submitted their measurements to the database. Additional local measurements and analysis were done to better understand different croplands proprieties related to NEE, GPP and TER and effect of management. An experiment was conducted in Oensingen to determine the sensitivity of the DNDC model to uncertainties in soil parameters. Information about uniqueness of the cropland sites were collected to support the model parameterization and up-scaling work and a joint grass/cropland workshop on the topic is planed.

Activity 1.6: Light use efficiency and GPP-TER relationship analysis were performed also comparing grassland sites from Europe and North America. Grassland information about main features of the sites in the network were collected to support the model parameterization and up-scaling work. The role of horizontal carbon fluxes has been investigated using modelling and direct measurements. The PaSim model has been also used and evaluated against site data to better understand the key parameters needed. Additional non-fluxes measurements have been planned for grazing, fertiliser and cutting managements.

Component 2 Atmosphere

During the reporting period, the Carboeurope-IP atmospheric network was strengthened and improved. Four continuous atmospheric stations were added to the core network, and several new tall towers have started their operations. Such a ground-based atmospheric network is complemented by regular vertical profiles at bi-weekly intervals, and by flask sampling at approximately 20 surface sites. Altogether, this information has been used successfully in synergy with inversion models 1) to quantify the continental-level changes in CO_2 fluxes over the recent years and, 2) to quantify the error reduction on regional fluxes delivered by quasi-continuous records. In itself, this second achievement is an important result because such a dense atmospheric network has yet no equivalent elsewhere in the world, and the results obtained over Europe will have implications for other regional networks.

Special attention was directed to improve the dialogue between experimentalists and inverse modelers within the whole programme, and to design effective data selection strategies for interpreting the atmospheric records, in particular for removing local influences. To answer that question, two dedicated workshops were held in Heidelberg and Paris. Models were compared with the available CO_2 records, on different characteristic time scales for the variability. In that comparison, higher resolution regional models appeared to have a better degree of agreement with the data than global models did. A surprisingly large coherence scale of the synoptic changes in CO_2 was also discovered when comparing mountain stations over Western Europe more than 1000 km apart.

The long-term intercomparison project of "Sausage Flask" distribution and analysis was very successful in monitoring systematic differences between flask measuring labs, which may now allow us to merge Eurasian and global flask networks. The first rounds of large volume (Grapefruit) intercomparison flask air samples successfully finished. High pressure cylinders rotations have been started lately. A number of ^{222}Radon intercomparisons have been performed/are planned to harmonize the ^{222}Radon observations in Europe.

The use of tracers for quantifying the fossil fuel component of atmospheric CO_2 has delivered very interesting results. Both pollution events and systematic 'integrated' samples were measured. First results indicate that CO is applicable as a proxy for fossil fuel CO_2, even in the study region of Heidelberg with spatially highly variable CO/CO_2(fossil) emission ratios. At a larger scale, routine measurements of ^{14}C across Europe will enable independent testing of transport models and fossil fuels inventories in the year to come.

Finally, the CarboEurope atmospheric component results were the object of many talks and posters at the WMO expert CO_2 meeting and at the International Carbon Dioxide Conference held in Boulder, in Sep. 2005. In particular, the effects of the summer 2003 climate conditions on the continental scale CO_2 fluxes were quantified by assimilating the CarboEurope data into inversion models, confirming that important losses of CO_2 were caused by heat and drought

Component 3 Regional Experiment

The main activity in 2005 was the execution and initial analysis of the regional experimental campaign in Les Landes, South West France during May-June 2005, to determine the variability in concentration gradients and fluxes of CO_2 .

We deployed several aircrafts to sample the CO_2 concentration and fluxes over the whole area, while fixed stations observed the fluxes and concentrations at high accuracy. Several (mesoscale) meteorological modeling tools were used to plan the experiment and flight patterns. We ultimately aimed to produce aggregated estimates of the carbon balance of a region that can be meaningfully compared to those obtained from the smallest downscaled information of atmospheric measurements and continental scale inversions.

All of our equipment worked well, some initial problems were solved in the first week of the campaign. Initial results show that at regional scale the relation between profiles and fluxes is not obvious, and is strongly influenced by airmass history and mesoscale flow patterns. This implies that concentration measurements such as taken over land in the atmospheric component need to be treated with care for impact of land surface and mesoscale flow heterogeneity. For the experiment, we were able to show from an initial analysis of data for a single day, that taking either the concentration at several locations as representative of local fluxes, or taking the flux measurements at those sites as representative of larger regions would lead to incorrect conclusions about the distribution of sources and sinks of carbon. We conclude that joint consideration of the synoptic and regional flow, fluxes and land surface is required for a correct interpretation. This calls for an experimental and modeling strategy that takes into account the large spatial gradients in concentrations and the variability in sources and sinks that arise from different land use types.

We started an intercomparison of modeling schemes to be able to quantify the transport error involved in regional inversions. This comparison involves three mesoscale models, several versions of one, and has already attracted attention. A similar intercomparison for the surface fluxes showed some differences and led us to use a single software to calculate all fluxes in a single coherent manner.

Component 4 Continental Integration

Work during the reporting period focused on:

1. Compilation of driver data (WP 4.1). The most important new data sets established are the new FAPAR fields and the land cover and land use history data sets compiled by partner JRC (see report WP4.1). In addition a new homogenous, high-resolution meteorological driver data set for the ecosystem models was compiled in a cooperation of MPI-BGC with a German partner institution (see report WP 4.4, objective 3).
2. Compilation of a spatially explicit database of forest inventories for several countries of Europe (WP4.2). This unique database, covering up to now more than 90’000 plots will be used in several activities in the CE continental integration component: e.g. for validating bottom-up model results, for sectorial (forest) carbon balance estimates, and potentially will provide an important novel data stream for the data assimilation activity later in the project (WP 4.5).
3. Two top-down atmospheric inversion experiments by two partner groups have been performed in order to estimate the net carbon balance of Europe with this approach (WP 4.3). As new atmospheric data become available from the atmosphere component, these calculations have been extended in time for the year 2003. A preliminary comparison with bottom-up calculations shows an encouraging agreement between the two methods (see below).
4. A series of bottom-up simulation experiments have been performed (WP 4.4). Models employed in this activity belong to two classes: diagnostic models, which are primarily data driven (i.e. using FAPAR data, or eddy flux data), and prognostic process based ecosystem models, which, in principle can estimate the carbon balance at a particular location given the prevailing meteorology/climate, vegetation and soil properties.

At a workshop the first bottom-up and top-down estimates were compared and a revised iteration took place at the annual meeting of CarboEurope in November 2005. A preliminary comparison of the modeled seasonal cycle over continental Europe (average 1998-2002) as calculated by two “bottom-up” prognostic terrestrial ecosystem models (BIOME-BGC, LPJ), a diagnostic, FAPAR-driven bottom-up model (MOD17+), and two top-down atmospheric inversion models (INV-BGC, INV-LSCE) shows satisfactory agreement is considering the completely different methods and driver datasets employed by the different modeling approaches.

The magnitude of the anomaly of 2003 with respect to a reference period 1998-2002 is shown in Figure 2. Shown on the left are the modeled climatological (1998-2002) seasonal cycles (red lines) and the seasonal flux cycle in 2003 (dashed blue lines) for the “Western Region” (see map inset) in which the drought anomaly was most prominent. A comparison of the anomalies between the bottom-up and the top-down model shows remarkable agreement, both in phase and magnitude, considering that the two approaches are completely independent, i.e. use entirely different driver data and observations.

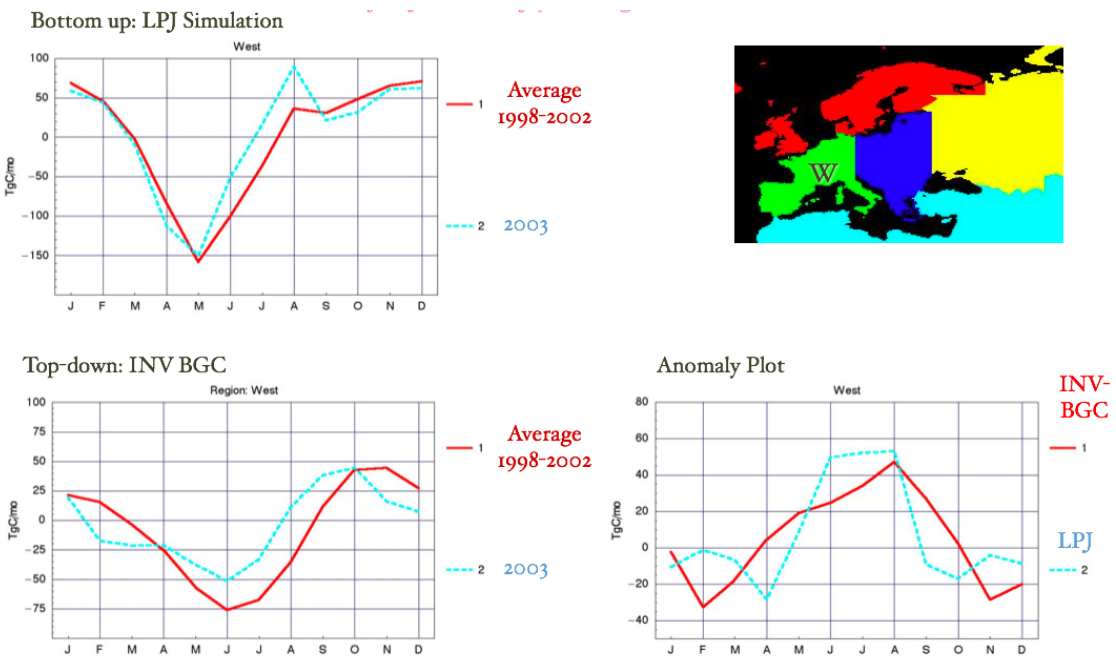

Figure 2: Left panels: Seasonal cycle of the integrated net carbon flux from the "Western Region" (positive: flux to the atmosphere) predicted by a bottom-up model (LPJ) and a top-down atmospheric inversion model (INV-BGC). Red lines: climatological average 1998-2002, light blue dashes: 2003. The "Western region" is indicated on the map inset with the letter "W". Lower right panel: Anomaly (2003 minus average 1998-2002) as computed by the two models.

The spatial pattern of the anomaly (average over the growing period May-September) is similarly predicted by the top-down model (INV-BGC) and the bottom-up model LPJ. Quantitatively, evaluated over the "Western Region", the May-September anomaly is estimated between 50-150 TgC by the various models, thus somewhat smaller than estimated previously. These are preliminary data, which need a more thorough analysis and confirmation, which is to be completed in the next phase of the project (months 25-36).
Work during the next phase of the project (months 25-36) in the continental integration component will focus on:

- Consolidation of the bottom-up and top-down model intercomparison simulations
- Improved error/uncertainty analysis of the bottom-up and top-down model simulations
- Begin of work for inclusion of forest inventory plot level data into the bottom-up models.
- Begin of work pertaining to the development of data assimilation schemes for the simultaneous, consistent inclusion of different data streams into the modelling frameworks. This will build on the experience gained in the completed FP5 CAMELS project.

The opportunity of the "drought year 2003" provided a natural experiment which allows an in-depth investigation of how this anomaly is represented by the various methods. Therefore it was decided that this event should constitute a second focal work activity in phase 2 (months 19-36) in the continental integration component.

List of publications related to CarboEurope-IP

The publications listed below result from scientific activities related to the first activities within CarboEurope-IP. They are not an exhaustive list but those indicated to the co-ordinator.

Published papers in peer-reviewed journals

Adiku, SGK; Reichstein, M; Lohila, A; Dinh, NQ; Aurela, M; Laurila, T; Lüers, J; Tenhunen, JD: PIXGRO: A Model for Simulating the Ecosystem CO_2 Exchange and Growth of Spring Barley, Ecological Modelling, 190, 260-276 (2006).

Aubinet M., Berbigier P., Bernhofer CH., Cescatti A., Feigenwinter C., Granier A., Grünwald TH., Havranova K., Heinesch B., Longdoz B., Marcolla B., Montagnani L., Sedlak P. (2005). Comparing CO2 storage and advection conditions at night at different CARBOEUROFLUX sites. Boundary-Layer Meteorology, 116(1), 63-93.

Aubinet M., Heinesch B., Perrin D., Moureaux C. Discriminating Net Ecosystem Exchange between different vegetation plots in a heterogeneous forest. Agricultural and Forest Meteorology, 132, 315-328

Berninger, F., L. Coll, P. Vanninen, A. Mäkelä, S. Palmroth, and E. Nikinmaa. (2005) Effects of tree size and position on pipe model ratios in Scots pine. Canadian Journal of Forest Research, 35, 1294-1304.

Caldeira, M. C., A. Hector, M. Loreau, and J. S. Pereira. (2005) Species richness, temporal variability and resistance of biomass production in a Mediterranean grassland. OIKOS, 110, 115-123.

Ciais P, Viovy N, Reichstein M, Granier A, Ogée J, Rambal S, Ourcival JM, Bernhofer C, Grunwald T, Pilegaard K, Berbigier P, Vesala T, Aubinet M, Heinesch B, Loustau D, Seufert G, Manca G, Matteucci G, Miglietta F, Soussana JF, Knohl A, Sanz MJ, Carrara A, Friend A, Chevallier F, Schulze ED, Valentini R (2005) Europe-wide reduction in primary productivity caused by the heat and drought in 2003. Nature, 437, 529-533

Cotrufo M.F. (2005) Quantity of standing litter: A driving factor of root dynamics. Plant and Soil 258:1-3 (Commentary Article, invited)

Curiel Yuste J., Janssens I.A., and Ceulemans R. Calibration and validation of an empirical approach to model soil CO2 efflux in a deciduous forest. 2005 Biogeochemistry, 73, 209-230.

Curiel Yuste J., Konôpka B., Janssens I.A., Coenen K., Xiao C. W. and Ceulemans R. Contrasting net primary productivity and carbon distribution between neighboring stands of Quercus robur and Pinus sylvestris. 2005 Tree Physiology, 25, 701-712.

Curiel Yuste J., Nagy M., Janssens I.A., Carrara A. and Ceulemans R. Soil respiration in a mixed temperate forest: Contribution to total ecosystem respiration. 2005 Tree Physiology, 25, 609-619.

Czóbel, Sz., Balogh, J., Szirmai, O., Tuba, Z. (2005): Floating chamber a potential tool for measuring CO2 fluxes of aquatic plant communities, Cereal Research Communications 33: 165-168.

Czóbel, Sz., Fóti, Sz., Balogh, J., Nagy, Z., Bartha, S., Tuba, Z. (2005): Chamber series and space-scale analysis of CO2 gas-exchange in grassland vegetation: A novel approach. Photosynthetica 43. (2). 267-272

Davi H , Dufrêne E , Granier A , Le Dantec V , Barbaroux C , François C , Bréda N (2005) Modelling carbon and water cycles in a beech forest. Part II.: Validation of the main processes from organ to stand scale. Ecological Modelling, 185, 387–405

Davidson E.A., Janssens I.A. and Luo Y. On the variability of respiration in terrestrial ecosystems: moving beyond Q10. (2006) Global Change Biology, 12, 177-193.

Dellwik, E., and N. O. Jensen. (2005) Flux-profile relationships over a fetch limited forest. Boundary Layer Meteorology, 115(2), 179-204.

Dufrêne E, Davi H, François C, Le Maire G, Le Dantec V, Granier A (2005) Modelling carbon and water cycles in a beech forest. Part I: Model description and uncertainty analysis on modelled NEE . Ecological Modelling, 185, 407–436.

Erteld T, Gerold D, Mund M, Schulze E-D, Weller E (2005) Vorrat, Zuwachs und Nutzung im plenterwaldartigen Buchenwald. AFZ-Der Wald 13/2005: 702-760

Falge E., Reth S., Brüggemann N., Butterbach-Bahl K., Goldberg V., Oltchev A., Schaaf S., Spindler G., Stiller B., Queck R., Köstner B., Bernhofer Ch., 2005: Comparison of surface energy exchange models with eddy flux data in forest and grassland ecosystems of Germany. Ecological Modelling, 188, 174-216

Flechard, C.R., Neftel, A., Jocher, M. & Fuhrer, J.: Bi-directional soil/atmosphere N_2O exchange over two mown grassland systems with contrasting management practices. Global Change Biology, 2005, 2114-2127.

Gu L., Falge E.M., Boden T., Baldocchi D.D., Black T.A., Saleska S.R., Suni T., Verma S.B., Vesala T., Wofsy S.C. and Xu L.: Objective threshold determination for nighttime eddy flux filtering. Agricutural and Forest Meteorol. 128, 179-197, 2005.

Haszpra L, Barcza Z, Davis KJ, Tarczay K. 2005. Long-term tall tower carbon dioxide flux monitoring over an area of mixed vegetation. Agricultural and Forest Meteorology 132, 58-77.

Hemming, D., D. Yakir, P. Ambus, M. Aurela, C. Besson, K. Black, N. Buchmann, R. Burlett, A. Cescatti, R. Clement, P. Gross, A. Granier, T. Grünwald, K. Havrankova, D. Janous, I.A. Janssens, A. Knohl, B. Köstner, A. Kowalski, T. Laurila, C. Mata, B. Marcolla, G. Matteucci, J. Moncrieff, E.J. Moors, B. Osborne, J.S. Pereira, M. Pihlatie, K. Pilegaard, F. Ponti, Z. Rosova, F. Rossi, A. Scartazza and T. Vesala. 2005. Pan-European d13C values of air and organic matter from forest ecosystems. Global Change Biology. 11:1065-1093.

Hibbard K., Law B.E., Reichstein M., Sulzman J., Aubinet M., Baldocchi D., Bernhofer C., Bolstad P., Bosc A., Campbell J., Cheng Y., Curiel Yuste J., Curtis P., Davidson E.A., Epron D., Granier A., Grünwald T., Hollinger D., Janssens I.A., Longdoz B., Lousteau D., Martin J., Monson R., Oechel W., Pippen J., Ryel R., Savage K., Scott-Denton L., Subke J.-A., Tang J., Tenhunen J., Turcu V., Vogel C.S. (2005). An Analysis of Soil Respiration across Northern Hemisphere Temperate Ecosystems. Biogeochemistry, 73(1), 29-70.

Hölttä, T., T. Vesala, E. Nikinmaa, M. Perämäki, E. Siivola, and M. Mencuccini. (2005) Field measurements of ultrasonic acoustic emissions and stem diameter variations. New insight into the relationship between xylem tensions and embolism. Tree Physiology 25, 237-243.

Hölttä T., Vesala T., Sevanto S., Perämäki M., Nikinmaa E.: Modeling xylem and phloem water flows in trees according to cohesion theory and Münch hypothesis. Trees Structure and Function (2006), 20, 67-78.

Ilvesniemi H., Kähkönen M.A., Pumpanen J., Rannik Ü., Wittmann C., Nissinen A., Perämäki M., Hari P., Vesala T., Salkinoja-Salonen M.: Wintertime carbon dioxide evolution from a boreal forest ecosystem. Boreal Environment Research. (2005), 10, 1424-1439.

Janssens IA, Freibauer A, Schlamadinger B, Ceulemans R, Ciais P, Dolman AJ, Heimann M, Nabuurs GJ, Smith P, Valentini R, Schulze ED (2005) The carbon budget of terrestrial ecosystems at country-scale – a European case study. Biogeosciences 2: 15-26

Juurola E., T. Aalto, T. Thum, T. Vesala and P. Hari: Temperature dependence of leaf-level CO2 fixation -- revising biochemical coefficients through analysis of leaf three dimensional structure. New Phytologist 166, 205-215, 2005.

Kolari, P., Pumpanen, J., Kulmala, L., Ilvesniemi,H., Nikinmaa, E., Grönholm, T. and P. Hari. (2006). Forest floor vegetation plays´an important role in photosynthetic production of boreal forests. Accepted for publication in Forest Ecology and Management 221, 241-248.

Konôpka B., Curiel Yuste J., Janssens I.A. and Ceulemans R. Comparison of fine root dynamics in Scots pine and Pedunculate oak in sandy soil. 2005 Plant and Soil, 276, 33-45.

Ladekarl, U.L.; Beier, C.; Dellwik, E., in Danish: Fordampning fra landbrug og skov. Vand og Jord (2005) 12 (no.2) , 44-47.

Launiainen S.,Rinne J., Pumpanen J., Kulmala L., Kolari P., Keronen P., Siivola E.,Pohja T.,Hari P. and Vesala T. Eddy covariance measurements of CO2 and sensible and latent heat fluxes during a full year in a boreal pine forest trunk space. Boreal Environment Res. (2005), 10, 569-588.

Liebethal, C; Huwe, B; Foken, T (2005): Sensitivity analysis for two ground heat flux calculation approaches, Agricultural and Forest Meteorology, 132(3-4), 253-262.

Loustau D, Bosc A, Colin A, Ogée J, Hendrik D, François C, Dufrêne E, Déqué M, Cloppet E, Arrouays D, Le Bas C, Saby N, Pignard G, Hamza N, Granier A, Bréda N, Ciais P, Viovy N, Delage J (2005) Modelling the climate change effects on the potential production of French plains forests at the sub regional level. Tree Physiology, 25, 813–823.

Metslaid, M., Ilisson, T., Vicente, M., Nikinmaa, E and K. Jõgiste (2005). Growth of advance regeneration of Norway spruce after clearcutting. Tree Physiology 25:793-801

Metslaid, M., Ilisson, T., Nikinmaa, E., Kusmin, J. and K. Jogiste. (2005). The recovery of advance regeneration after disturbances: acclimation of needle characteristics in Picea abies. Accepted for publication in the Scandinavian Journal of Forest Research 20, 112-121 (Suppl. 6).

Mund M, Schulze E-D (2005) Silviculture and its Interaction with Biodiversity and the Carbon Balance of Forest Soils. Ecological Studies 176: 185-208

Mutke, S., Sievänen, R., Nikinmaa, E., Perttunen, J. and L. Gil. 2005. Crown architedcture of crafted stone pine (Pinus Pinea L.): Shoot growth and bud differentiation. Trees- Structure and Function, 19(1):15-25

Ngao J, Epron D, Bréchet C, Granier A (2005) Estimating the contribution of leaf litter decomposition to soil CO 2 efflux in a beech forest using 13C-depleted litter. Global Change Biology, 11, 1768–1776.

Niemand C., Köstner B., Prasse H., Grünwald T., Bernhofer Ch., 2005: Relating tree phenology with annual carbon fluxes at Tharandt forest. Meteorol Zeitschrift, 14 (2), 197-202.

Perämäki M., Vesala T., Nikinmaa E.: Modeling the dynamics of pressure propagation and diameter variation in tree sapwood. Tree Physiology 25, 1091-1099, 2005.

Rebmann, C; Göckede, M; Foken, T; Aubinet, M; Aurela, M; Berbigier, P; Bernhofer, C; Buchmann, N; Carrara, A; Cescatti, A; Ceulemans, R; Clement, R; Elbers, JA; Granier, A; Grünwald, T; Guyon, D; Havránkova, K; Heinesch, B; Knohl, A; Laurila, T; Longdoz, B; Marcolla, B; Markkanen, T; Miglietta, F; Moncrieff, JB; Montagnani, L; Moors, E; Nardino, M; Ourcival, J-M; Rambal, S; Rannik, Ü; Rotenberg, E; Sedlak, P; Unterhuber, G; Vesala, T; Yakir, D: Quality analysis applied on eddy covariance measurements at complex forest sites using footprint modelling, Theoretical and Applied Climatology, 80, 121-141 (2005)

Reichstein M., E. Falge, D. Baldocchi, D. Papale, M. Aubinet, P. Berbigier, C. Bernhofer, N. Buchmann, T. Gilmanov, A. Granier, T. Grünwald, K. Havrankova, H. Ilvesniemi, D. Janous, A. Knohl, T. Laurila, A. Lohila, D. Loustau, G. Matteucci, T. Meyers, F. Miglietta, J.-M. Ourcival, J. Pumpanen, S. Rambal, E. Rotenberg, M. sanz, J. Tenhunen, G. Seufert, F. Vaccari, T. Vesala, D. Yakir and R. Valentini: On the separation of net eocsystem exchange into assimilation and ecosystem respiration: review and improved algorithm. Global Change Biology 11(9), 1424-1439, 2005.

Reithmaier, L; Göckede, M; Markkanen, T; Knohl, A; Churkina, A; Rebmann, C; Buchmann, N; Foken, T (2005): Use of remotely sensed land use classification for a better evaluation of micrometeorological flux measurement sites, Theoretical and Applied Climatology, DOI 10.1007/s00704-005-0168-6

Reth, S; Göckede, M; Falge, E: CO2 efflux from agricultural soils in Eastern Germany - commparison of a closed chamber system with eddy covariance measurements, Theoretical and Applied Climatology, 80, 105-120 (2005)

Rodeghiero M., Cescatti A. (2005) Main determinants of forest soil respiration along an elevation/temperature gradient in the Italian Alps, Global Change Biology, 11, 1024-1041

Scherer-Lorenzen M, Körner Ch, Schulze E-D (2005) The functional significance of forest diversity: a synthesis. Ecol. Studies 176: 377-389

Schulze E-D, Freibauer A (2005) Carbon unlocked from soils. Nature 437:205-206

Sevanto S., Hölttä T. , Markkanen T., Perämäki M., Nikinmaa E., Vesala T., 2005 Relationships between diurnal xylem diameter variation and environmental factors in Scots pine, Boreal Environment Research 10, 447-458.

Smith, J.U., Smith, P., Wattenbach, M., Zaehle, S., Hiederer, R., Jones, R.J.A., Montanarella, L., Rounsevell, M.D.A., Reginster, I. , Ewert, F., 2005. Projected changes in mineral soil carbon of European croplands and grasslands, 1990-2080. Global Change Biology 11, 2414-2152.

Smith, P., Andrén, O., Karlsson, T., Perälä, P., Regina, K., Rounsevell, M. & van Wesemael, B. 2005. Carbon sequestration potential in European croplands has been overestimated. Global Change Biology 11, 2153-2163.

Sogachev, A., O. Panferov, G. Gravenhorst, and T. Vesala. in press. Numerical analysis of flux footprints for different landscapes. Theoretical and Applied Climatology 80, 169-185..

Sogachev A., Leclerc M.Y., Karipot A., Zhang G., Vesala T., (2005) Effect of clearcuts on footprints and flux measurements made above a forest canopy, Agricultural and Forest Meteorology 133, 182-196.

Thomas, C; Foken, T: Detection of long-term coherent exchange over spruce forest, Theoretical and Applied Climatology, 80, 91-104 (2005)

VanDijk AIJM, Dolman AJ, Schulze E-D (2005) Radiation, temperature, and leaf area explain ecosystem cabon fluxes in boreal and temperate European forest. Global Biogeochemical Cycles 19: GB2029, doi: 10.1029/2004GB002417, 15pp

Vesala, T., T. Suni, Ü. Rannik, P. Keronen, T. Markkanen, S. Sevanto, T. Grönholm, S. Smolander, M. Kulmala, H. Ilvesniemi, R. Ojansuu, A. Uotila, J. Levula, A. Mäkelä, J. Pumpanen, P. Kolari, L. Kulmala, N. Altimir, F. Berninger, E. Nikinmaa, and P. Hari. in press. The effect of thinning on surface fluxes in a boreal forest. Global Biogeochemical Cycles, 19(2), GB2001, doi:10.1029/2004GB002316.

Vetter M, Wirth C, Böttcher H, Churkina G, Schulze ED, Wutzler T, Weber G (2005) Partitioning and indirect human-induced effects on carbon sequestration of managed coniferous forests using model simulations and forest inventories. Global Change Biology 11: 810-827

Wang Q, Tenhunen J, Quoc Dinh N, Reichstein M, Otieno D, Granier A, Pilegaard K (2005) Evaluation of seasonal variation of MODIS derived leaf area index at two European deciduous broadleaf forest sites. Remote Sensing of Environment 96, 475 – 484.

<u>Accepted papers in peer-reviewed journals</u>

Bouriaud O, Bréda N, Dupouey JL, Granier A (2005) From basal area to whole-stem biomass increments: estimating trees actual sensitivity to climate. A case study in European beech. Canadian Journal of Forest, sous presse.

Carreiras, J. M. B. Pereira, J. M. C. and Pereira , J. S. 2005 Estimation of tree canopy cover in Mediterranean evergreen oak woodland landscapes using remote sensing. Forest Ecology and Management (in press)

Geels, C, Christensen, J. H., Hansen, A. W., Heinemeier, J., Kiilsholm, S., Larsen, N. W., Larsen, S. E., Pedersen, T., Sørensen, L. L., Brandt, J., Frohn, L. M. and Djurhuus, 2005 "Identifying the European fossil fuel plumes in the atmosphere over the Northeast Atlantic region through isotopic observations and nummerical modelling". Accepted for publication in Environmental Monitoring and assessment.

Göckede, M; Markkanen, T; Hasager, CB; Foken, T: Update of footprint-based approach for the characterisation of complex measurement sites, Boundary-Layer Meteorology, accepted (2005)

Jensen, N. O., T. N. Mikkelsen, E. Dellwik, and K. Pilegaard. in press. Inter-annual variation in carbon uptake by a deciduous forest and a comparison to the uptake of a coniferous forest in Denmark. World Resource Review.

Köstner B., Niemand C., Prasse H., 2005: A 40-year study period of tree phenology at Tharandt International Phenological Garden . Arboreta Phaenologica, in press.

Ngao, J., Perrin, D., Vincent, G., Epron, D., Le Dantec, V., Soudani, K., Aubinet, M., Granier, A., Willem, F., Longdoz, B. Cross-calibration functions of soil CO 2 efflux measurement systems. Ann. For. Sc., in press.

Pereira, J.S., A.V. Correia, A.C. Correia, T. Ferreira, N. Godinho, N. Onofre and H. Freitas 2005. Florestas e Biodiversidade. In Alterações Climáticas em Portugal. Cenários, Impactes e Medidas de Adaptação. Eds. F.D. Santos and P. Miranda. Gradiva, Lisboa, p. in press

Sevanto S., Suni T., Pumpanen J., Grönholm T., Kolari P., Nikinmaa E., Hari P., Vesala T., 2005. Wintertime photosynthesis and water uptake in a boreal forest, Tree Physiology (accepted)

Smith, P., Smith, J.U., Wattenbach, M., Meyer, J., Lindner, M., Zaehle, S., Hiederer, R., Jones, R., Montanarella, L., Rounsevell, M., Reginster, I., Kankaanpää, S., 2005. Projected changes in mineral soil carbon of European forests, 1990-2100. Canadian Journal of Soil Science (in press).

Subke J.A., Inglima I, Cotrufo M. F. (invited) Partitioning soil CO2 efflux: a meta-analyses. Global Change Biology –Annual Review Issue: Jan 2006.

Verbeeck H, Samson R, Verdonck F & Lemeur R (2005) Uncertainty and parameter sensitivity of the forest carbon flux model FORUG: a Monte Carlo analysis. Tree Physiology. (accepted)

Book chapters, Reports etc.

Bernhofer , Ch. , B. Köstner, K. Arnold, S. Atashfaraz, J. Bange, A.-B. Baums, F. H. Berger, F. Beyrich, K. Butterbach-Bahl, E. Brüggemann, N. Brüggemann, U. Dämmgen, E. Falge, Ch. Feigenwinter, B. Fischer, Th. Foken, M. Göckede, V. Goldberg,), G. Gravenhorst, A. Grüner, L. Grünhage, T. Grünwald, M. Haggagy, H. Herrmann, M. Herold, F. Imbery, A. Ibrom, M. Kesik, M. O. Letzel, Ch. Li, C. Liebethal, A. Lohse, J. Matschullat, A. Matzarakis, M. Mauder, H. Mayer, P. Miehle, A. Oltchev, K. Pleßow, R. Queck, A. Raabe, S. Raasch, S. Reth, J. Rost, S. Schaaf, M. Schröter, A. Schwiebus, T. Spieß, G. Spindler, B. Stiller, J. D. Tenhunen, R. Vogt, M. Wagner, H.-J. Weigel, A. Ziemann, F. Zimmermann, P. Zittel, 2005: Vertical Transports of Energy and Trace Gases at Anchor Stations and Their Spatial and Temporal Extrapolation under Complex Natural Conditions. In: Results of the German Atmospheric Research Programme - AFO 2000, Federal Ministry of Education and Research (BMBF), 68-90.

Ciais P, Janssens I, Shvidenko A, Wirth C, Malhi Y, Grave J, Schulze E-D, Heimann M, Phillips O, Dolman AJ (2005) The potential for rising CO 2 to account for the observed uptake of carbon by tropical, temperate and boreal forest biomes. In: Griffith H, Jarvis P (eds.) The carbon balance of forest biomes. Taylor and Francis, Milton Park, UK : pp 109-150

Czimczik CI, Mund M, Schulze E-D, Wirth C (2005) Effects of reforestation, deforestation, and afforestation on carbon storage in soils. In: Griffith H, Jarvis P (eds.) The carbon balance of forest biomes. Taylor and Francis, Milton Park, UK : pp 319-330

Ibrom, A.; Dellwik, E.; Jensen, N.O.; Pilegaard, K., Low pass filter correction to turbulence data using a digital recursive filter. In: ACCENT-BIAFLUX workshop 2005. Trace gas and aerosol flux measurement techniques. Abstract book. ACCENT-BIAFLUX workshop 2005, Risø (DK), 6-8 Apr 2005. Werner, A.; Sørensen, L.L. (eds.), Risø National Laboratory (DK). Wind Energy Department. Risø-R-1508(EN) (2005) p. 31

Schimel D., G. Churkina, B. Braswell (2005) Remembrance of weather past: ecosystem response to climate variability. in “A history of atmospheric CO_2 and its effects on plants, animals, and ecosystems” (Ehleringer J.R., Cerling T.E., and Dearing M.D., eds.), Springer-Verlag, Berlin, pp. 350-368.

Updated list of contractors

No.	Code	Institute name	Country
01	MPI-BGC	Max Planck Institute for Biogeochemistry	Germany
02	UNITUS	U. of Tuscia, Dept. of Forest Environment and Resources (DISAFRI)	Italy
03	VU-A	Free U. Amsterdam, Dept. Geo-Environmental Sciences	Netherlands
04	CEA-LSCE	CEA, LSCE, Laboratory of Climate and Environmental Sciences	France
05	UEDIN	U. of Edinburgh, School of GeoSciences	UK
06	UABDN	U. of Aberdeen, School of Biological Sciences	UK
07	INRA	INRA - National Institute of Agronomic Research	France
08	FUSAGx	Faculty of Agronomic Sciences Gembloux (UPB)	Belgium
09	CNRM	Météo-France/CNRM	France
10a	CNR-IBIMET	CNR, Institute of Biometeorology	Italy
11	ECN	ECN - Energy Research Center of the Netherlands, Dept. Air Quality	Netherlands
12	UHEI-IUP	U. Heidelberg, Inst. for Environmental Physics	Germany
13	ALTERRA	ALTERRA (Wageningen University and Research)	Netherlands
14	JRC-IES	EC-Joint Research Centre, IES	Italy
15	JR	Joanneum Research	Austria
16	MET-OFFICE	MetOffice, Hadley Centre	UK
17	PIK	Potsdam Inst. for Climate Impact Research	Germany
18	APB	Autonomous Province of Bolzano/Bozen South Tyrol - Forest Department	Italy
19	CEALP	Centre of Alpine Ecology	Italy
20	CEAM	Foundation CEAM	Spain
21a	CEH-WAL	Centre of Ecology and Hydrology (CEH) - Wallingford	United Kingdom
21b	CEH-EDIN	Natural Environmental Research Council, CEH-Edinburgh	UK
22	CNRS-CEFE	National Centre of Scientific Research, DREAM CEFE CNRS	France
23	CTFC	Forest Technology Centre of Catalunya, Laboratory of Plant Ecology and Forest Botany	Spain
24	FAL	Swiss Federal Research Station for Agroecology and Agriculture (FAL)	Switzerland
25	FMI	Finnish Meteorological Institute, Air Quality Research	Finland
26	ILE	Acad. of Sciences of Czech Republic, Inst. of Landscape Ecology	Czech Republic
27	IST	Superior Technical Institute	Portugal
28	LUND	Lund U., Dept. of Physical Geography and Ecosystems Analysis	Sweden
29	RISOE	Risoe National Laboratory	Denmark
30a	SLU-DEER	Swedish U. of Agricultural Sciences, Dept. of Ecology and Environmental Research (DEER)	Sweden
30b	SLU-FS	Swedish U. of Agricultural Sciences, Dept. of Forest Soils	Sweden
30c	SLU-PE	Swedish U. of Agricultural Sciences, Dept. for Production Ecology	Sweden
33	SRON	SRON National Institute for Space Research, IMAU	Netherlands
34	SUN	Second U. of Napoli, Dept. of Environmental Science	Italy
35	TCD	Trinity College Dublin	Ireland
36	TUD	TU Dresden, IHM-Meteorology	Germany
37	TUM	TU Munich Dept. of Soil Science	Germany
38	UA	U. of Antwerp (UIA), Dept. Biology	Belgium
39a	UBT-MET	U. Bayreuth, Chair of Micrometeorology	Germany
39b	UBT-PE	U. Bayreuth, Chair of Plant Ecology	Germany
41	UCC	U. College of Cork	Ireland
42	SZIV	Szent István U. of Gödöllö	Hungary
43	UH-DPS	U. of Helsinki, Dept. of Physical Sciences	Finland

No.	Code	Institute name	Country
44	ISA-UTL	TU Lisboa, Superior Inst. of Agronomy	Portugal
45	UPOZ	U. of Poznan	Poland
46	UPS-Orsay	CNRS - U. of South Paris, Systematic Ecology and Evolution Unit	France
47	WUR-NCP	Wageningen U., Nature Conservation and plant Ecology	Netherland
48	MLU	Martin-Luther-U. Halle-Wittenberg, Inst. of Soil Science and Plant Nutrition	Germany
50	ULG	U. de Liège - LPAP	Belgium
52	CESI	CESI Business Unit - Environment	Italy
53	CIO	Center for Isotope Research (CIO); Rijks-U. Groningen	Netherlands
54	ELU	Eötvös Loránd University, Dept. of Meteorology	Hungary
55	ENEA	ENEA, Global and Mediterranean Environment Division	Italy
56	SU	Stockholm U., Dept. of Meteorology, Arrhenius Lab.	Sweden
57	UBARC	U. of Barcelona, Climate Research Group	Spain
58	UBECLIM	U. Bern, Physics Institute, Climate and Environmental Physics	Switzerland
59	UKRAK	U. of Mining and Metallurgy, Faculty of Physics and Nuclear Techniques	Poland
61	USTUTT-IER	U. Stuttgart, Institute of Energy Economics and the Rational Use of Energy	Germany
62	EFI	European Forest Institute	Finland
63	NERI	National Environmental Research Institute, Department of Atmospheric Environment	Denmark
64	LAWUF	Thuringia State Forest Research Station	Germany
65	SAUG	International educational projects	France
66	UKBH.GI	U. Copenhagen, Inst. of Geography	Denmark
67	UAV	University of Aveiro, Departamento de Ambiente e Ordenamento	Portugal
68	UCD	University College Dublin	Ireland
69	UHAM	Uni Hamburg	Germany
70	UBOL	Bologna	Italy
71	CNR-ISAC	CNR-ISAC	Italy
72	CNR-ISAFoM	CNR-ISAFoM	Italy