SIXTH FRAMEWORK PROGRAMME
PRIORITY 1.1.6.3
GLOBAL CHANGE AND ECOSYSTEMS

Contract for:

INTEGRATED PROJECT

Annex I – "Description of Work"
5-Years Plan
General Sections

Project acronym:	**CarboEurope-IP**
Project full title:	**Assessment of the European Terrestrial Carbon Balance**
Contract no.:	**GOCE-CT-2003-505572**

Date of preparation of Annex I: **13 November 2003**

Start date of contract: **01 January 2004**

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1. Project Summary

The overarching aim of the 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, the project addresses the three major topics:

1. Determination of the carbon balance of the European continent, its geographical patterns, and changes over time. This is achieved by (1) executing a strategically focussed set of surface based ecological measurements of carbon pools and CO_2 exchange, (2) further enhancement of an atmospheric high precision observation system for CO_2 and other trace gases, (3) execution of a regional high spatial resolution experiment, and (4) integration of these components by means of innovative data assimilation systems, bottom-up process modelling and top-down inverse modelling. The key innovation of the CarboEurope-IP is in its conception as to apply single comprehensive experimental strategy, and its integration into a comprehensive carbon data assimilation framework. It is solving the scientific challenge of quantifying the terrestrial carbon balance at different scales and with known, acceptable uncertainties. The increase in spatial and temporal resolution of the observational and modelling program will allow for the first time a consistent application of a multiple constraint approach of bottom-up and top-down estimates to determine the terrestrial carbon balance of Europe with the geographical patterns and variability of sources and sinks.
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. This is achieved by (1) the partitioning of carbon fluxes into their constituent parts (assimilation, respiration, fossil fuel burning), at local, regional and continental scales, (2) the quantification of the effects of management on net ecosystem carbon exchange based on data synthesis, and (3) the development, evaluation and optimisation of ecosystem process models.
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. This is achieved by (1) atmospheric measurements and a modelling framework to detect changes in atmospheric CO_2 concentrations during the time frame of a Kyoto commitment period, and (2) the outline of a carbon accounting system for the second Commitment period based on measuring carbon fluxes, stock changes by soil and biomass inventories, vegetation properties by remote sensing, and atmospheric concentrations.

CarboEurope-IP integrates and expands the research efforts of 67 European contractors and around 30 associated institutes. CarboEurope-IP addresses basic scientific questions of high political relevance.

2. Project objectives

2.1 Strategic objective

The overarching aim of the CarboEurope-IP is to understand and quantify the terrestrial carbon balance of Europe and associated uncertainties at local, regional and continental scale.

In order to achieve this strategic objective, the project addresses the following topics and associated questions:

- **"The European Carbon Balance"** What is the carbon balance of the European continent and its geographical pattern, and how does it change over time?
- **"Processes and Modelling"** What are the controlling mechanisms of carbon cycling in European ecosystems? How do external parameters such as climate change and variability, and changing land management affect the European carbon balance?
- **"Detection of Kyoto"** Can the effective CO_2 reduction in the atmosphere in response to fossil fuel emission reduction and enhanced carbon sequestration on land be detected in the context of the Kyoto commitments of Europe?

2.2 Main Objectives (MO)

"The European Carbon Balance"

1. To determine the time-varying distribution of atmospheric concentrations of CO_2 and other Carbon Cycle related tracers by taking high precision measurements as input to top-down inverse modelling techniques (MO1).
2. To determine net ecosystem carbon fluxes from eddy covariance towers, changes in carbon pools from land carbon inventories, and biophysical parameters from remote sensing as input to bottom-up process modelling (MO2).
3. To develop an innovative data assimilation framework for the application of a multiple constraint approach where observations of different nature will optimally quantify the European carbon balance (MO3).

"Processes and Modelling"

4. To determine the partitioning of carbon fluxes into its constituent parts (assimilation, respiration, fossil fuel burning), at local, regional and continental scales and its relation to external parameters, and present human activities (MO4).
5. To quantify the effects of management on net ecosystem carbon exchange based on data synthesis (MO5).
6. To develop, evaluate and optimise ecosystem process models (MO6).

"Detection of Kyoto"

7. To provide an observation system of atmospheric measurements and a modelling framework to detect changes in atmospheric CO_2 concentrations during the time frame of a Kyoto commitment period (MO7).

8. To develop the outline of a carbon accounting system for the second Commitment period based on measuring carbon fluxes, stock changes by soil and biomass inventories, vegetation properties by remote sensing, and atmospheric concentrations (MO8).

2.3 Specific Objectives

The Main Objectives are met by organising the IP into **four "Components"** (Figure 1) that deal with

- **ecosystem level measurements (Component 1),**
- **high precision continental scale atmospheric measurements (Component 2),**
- **a regional experiment aimed at reducing uncertainties in scaling (Component 3), and**
- **a Continental Integration Component (Component 4) that merges the various data streams into a comprehensive assessment of the European carbon balance.**

All these Components interact and require additional cross-cutting information. The joint aim is to estimate the European carbon balance in the recent past and present (Figure 2).

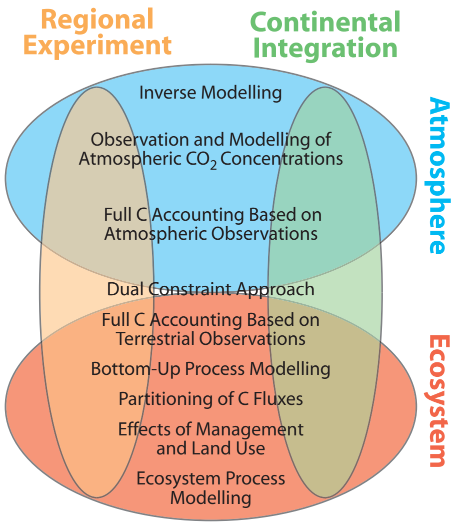


Figure 1 Graphical representation of the main objectives and their implementation as "Components" of the Integrated Project

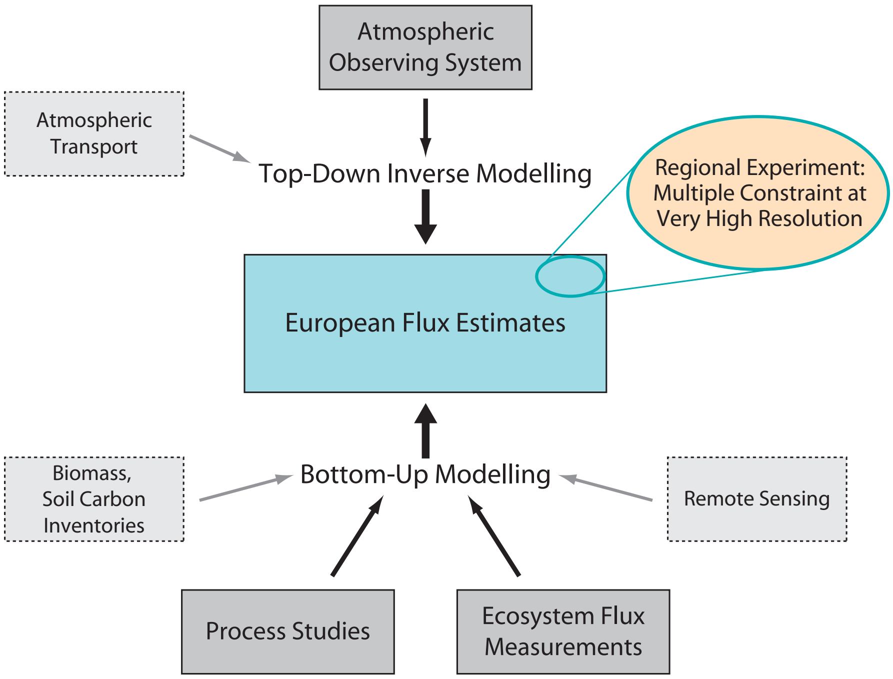
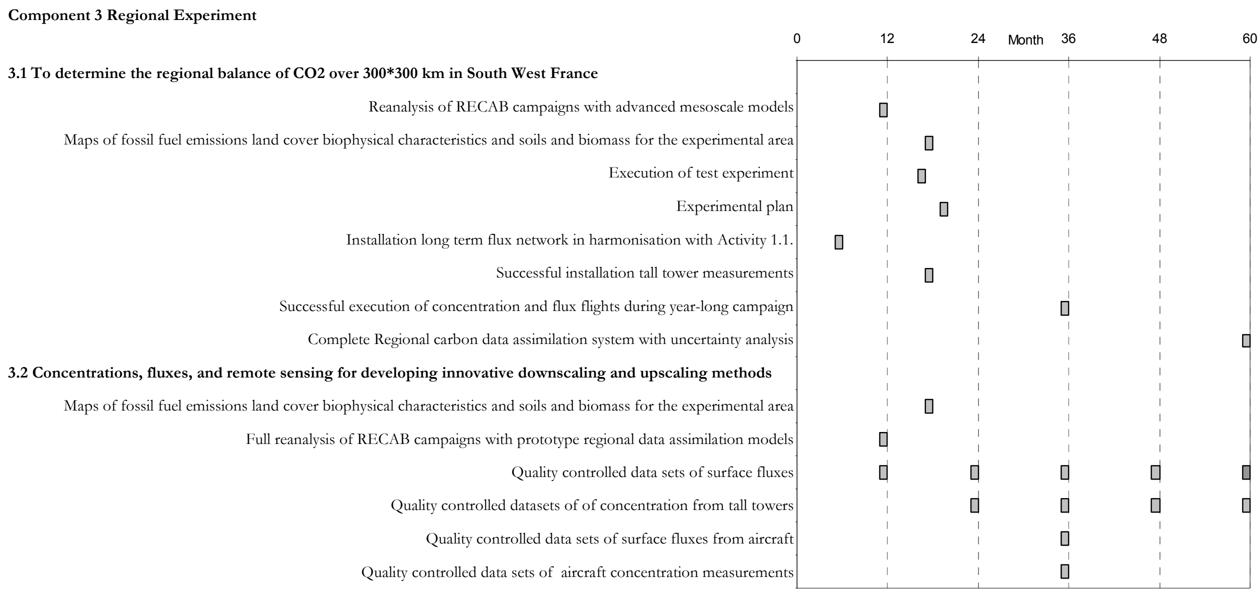


Figure 2 Logic of the flow of data and knowledge in the multiple constraint approach of CarboEurope-IP

The objectives of these Components as based on the Main Objectives are listed below. In order to meet the Main Objectives, the Components are assigned to meet Specific Objectives. We refer to the linkage with the Main Objectives (MO) in brackets. Means to achieve the Specific Objectives are given for each objective. Measures of success and their timing are shown in



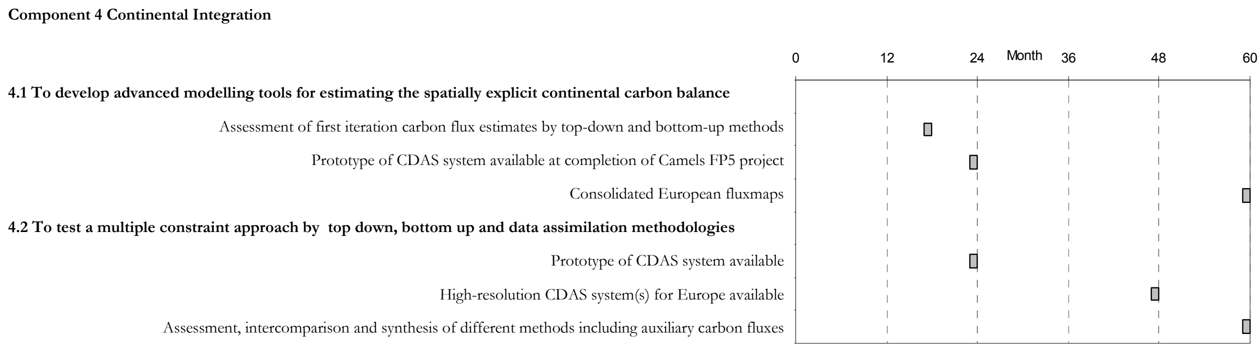


Figure 3.

2.3.1 Component 1: Ecosystem carbon budget and its driving forces ("Ecosystem")

The flux network and its associated ecosystem studies provide the critical interface between ecosystems and atmospheric processes, and thus provide an integrated number at a spatial scale of about 1 km^2. The specific objectives are as follows:

2.3.1.1 To observe the fluxes of carbon, water and energy from representative land use/cover types of Europe by eddy covariance (MO2).

Means to achieve objective (Activities 1.1, 1.2):

- Harmonized measurement and establishing the data quality protocols
- Network of ecosystem flux sites with Main Sites and Associated Sites
- Analysis of representativity of flux network design and possible re-design after 2 years
- Data storage at CarboEurope Data Centre for ecosystem data
- Advection experiment for improving eddy flux methodology
- Quality control of eddy flux measurements at all Main Sites
- Operationalisation of most important measurements at representative sites

2.3.1.2 To partition the net carbon flux of European ecosystems into its constituent parts according to land use types and management, using a spectrum of time scales going from sub-daily to decadal, e.g. by comparing carbon fluxes with stock changes in ecosystem pools (MO4, 5, 6).

Means to achieve objective (Activities 1.1, 1.3, 1.4, 1.5, 1.6):

- Harmonized measurement protocols for C stocks and fluxes in different ecosystems and of the consolidated ecosystem parameters list (Appendix I-E)
- Network of ecosystem flux sites with, originally, 51 Main Sites and up to 50 Associated Sites, with harmonized measurements of relevant ecosystem parameters (Appendix I-E), subject to review after 24 months
- Detailed studies of soil carbon stocks at 12 selected main sites
- Data storage (processed data) at CarboEurope Data Centre for ecosystem data (ecosystem Data Centre) and partly in the Central Database

2.3.1.3 To quantify the effects of land management on the net ecosystem carbon exchange (MO5, 6, 8).

Means to achieve objective (Activities 1.4, 1.5, 1.6):

- Consolidation of flux and ecosystem data by land use and land management
- Meta-analysis of data and process-based modelling at ecosystem scale

2.3.1.4 To provide the basic data for evaluation and parameterisation of models for up-scaling of carbon fluxes to the regional and continental scale (MO5, 6).

Means to achieve objective (Activities 1.1, 1.3, 1.4, 1.5, 1.6):

- Cf. objectives 1.1, 1.2, 1.3
- Interaction with modelling groups regarding data requirements
- Data exchange via CarboEurope Data Centre for ecosystem data (ecosystem database)

2.3.2 Component 2: Continental carbon budget and its driving forces ("Atmosphere")

The Atmospheric Observing System provides an integrated number at a spatial scale of about 1000 km x 1000 km. The specific objectives are as follows:

2.3.2.1 To provide the high precision, high-frequency, long-term atmospheric concentration measurements needed to invert for magnitude and variability of sources and sinks in Europe with a typical resolution of 100 km every week over best sampled areas (MO1, 4, 7).

Means to achieve objective (Activities 2.1; 2.2; 2.4; 2.5; 2.7)
- European network of ground level stations, tall towers and aircraft vertical profiles for in situ atmospheric CO_2 measurements
- Quality control program (intercomparisons; calibrations) to certify the atmospheric measurements from different laboratories
- High frequency vertical profiles at selected locations
- Quality check of atmospheric datasets for storage at CarboEurope Data Centre

2.3.2.2 To develop innovative methodologies using Carbon Cycle related tracers and isotopes to attribute the CO_2 concentration in the European air shed to each of the constituent parts of the fluxes: fossil, oceanic, and terrestrial (MO8).

Means to achieve objective (Activities 2.2; 2.3; 2.5; 2.6):
- Multiple species in situ measurements on tall towers
- Flask air sampling for multiple species analysis at ground stations and aircrafts
- Quality control program (intercomparisons; calibrations) to integrate atmospheric multiple species measurements from different laboratories
- Radiocarbon and CO measurements to separate the fossil fuel component

2.3.2.3 To provide the data for a continental scale carbon data assimilation system (CDAS) (MO3).

Means to achieve objective (Activities 2.1 through 2.7):
- Data exchange via CarboEurope Data Centre for atmosphere data (atmosphere database)

2.3.3 Component 3: Regional carbon budget and its driving forces ("Regional Experiment")

We plan in the Regional Experiment Component of the IP to combine for the first time various types of ground based Carbon Cycle-related measurements and atmospheric observations with remote sensing to infer a regional carbon budget. We will provide an integral C budget at a spatial scale of 2 km x 2 km for the test region. The specific objectives are as follows:

2.3.3.1 To determine the spatially explicit regional balance of CO_2 over an area (300*300 km) in South West France at a typical model grid resolution of 2 km every day during a full year based on atmospheric and ground based measurements (MO2, 4, 8).

Means to achieve objective (Activities 3.1, 3.2, 3.3 & 3.4)
- Data consolidation, data management and experiment planning
- Surface flux and aircraft measurements
- Scalar concentration measurement from aircraft and tall towers
- Modelling and integration

2.3.3.2 To provide combined datasets of concentrations, fluxes, and remote sensing, with the highest possible density for developing innovative downscaling and upscaling methods to quantify the carbon balance of the target region within a multiple constraint framework (MO3).

Means to achieve objective (Activity 3.1, 3.2, 3.3)
- Data consolidation, data management and experiment planning
- Surface flux and aircraft measurements
- Scalar concentration measurement from aircraft and tall towers

2.3.4 Component 4: Integration of Scales and Carbon Data Assimilation Methods ("Continental Scale Integration")

The Continental Integration Component relies on the data streams collected by the other Components of the IP, including syntheses of existing data, and it is expected to provide guidance on how to fill in gaps in the current Observing System and help **design optimal observation strategies** in the future. This integration can only be achieved by means of a **numerical modelling framework** that bridges across scales going from process-studies up to the continental budget. In this framework, diverse approaches of top-down, bottom-up, sectorial, process based and extrapolation techniques have to be employed, compared for consistency and ultimately merged in a most comprehensive way.

In order to produce a best estimate of carbon uptake and its uncertainty, we need to make use of all of the constraints implied by the different data streams, as well as the physiological and ecological constraints embodied in the process-based Terrestrial Ecosystem Models (TEMs). In other words, we need to simultaneously use the observations to constrain the internal parameters of the TEMs, whilst using the TEMs to interpolate the observations to produce useful large-scale estimates of the carbon sink and its causes. This is essentially a **Data Assimilation problem**, requiring a system similar to those used to initialise and constrain weather forecast models with observations.

Using this approach, we expect to reduce the uncertainty in estimates of the present carbon balance to 10 to 20% or better for Western Europe. The specific objectives are as follows:

2.3.4.1 To develop advanced modelling tools for estimating the spatially explicit continental carbon balance and its variability at a resolution of 10 to 50 km for at least the length of a Commitment Period (MO1, 2, 4, 7, 8).

Means to achieve objective (Activities 4.3, 4.4, 4.5):

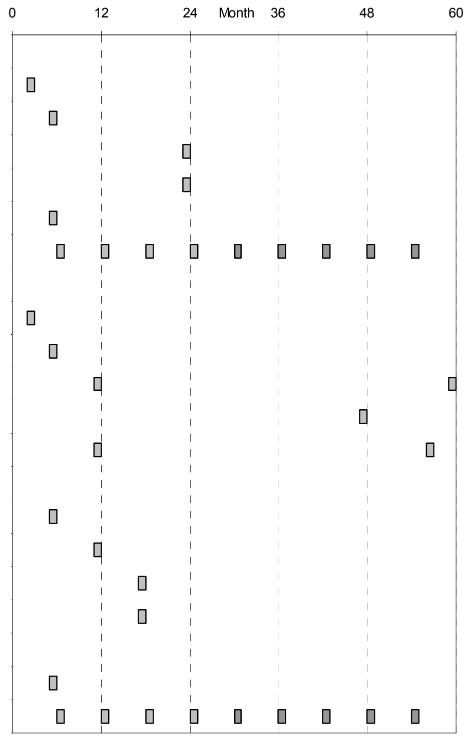
- Implementation of nested atmospheric model hierarchy over the European domain for the top-down determination of surface sources and sinks by means of inverse methods.
- Implementation of bottom-up models for the extrapolation and upscaling of surface flux measurements and carbon inventories.
- Acquisition of remote sensing products for upscaling
- Development and implementation of a carbon data assimilation system for the European domain.

2.3.4.2 To test a multiple constraint approach by applying top down, bottom up and data assimilation methodologies to achieve the best possible estimate of the European carbon balance, its uncertainty and to determine the spatio-temporal variation in biospheric and anthropogenic fluxes over Europe (MO2).

Means to achieve objective (Activities 4.1, 4.2, 4.3, 4.4, 4.5):

- Implementation of high resolution carbon data assimilation systems for the European continent.
- Assessment and intercomparison of surface flux maps determined by top-down, bottom-up and data assimilation methods.

Component 1 Ecosystem



1.1 To observe the fluxes of carbon, water and energy from representative land use/cover types

Network of ecosystem flux sites operational

Harmonized measurement protocols available

Analysis of representativity of network design finished

Flux data from FP5 ecosystem projects available in the ecosystem database

Establishment of the ecosystem data base center connected with the CarboEurope center facility

Half-yearly delivery of flux data to the ecosystem database

1.2 To partition the net carbon flux of European ecosystems into its constituent parts

Network of ecosystem flux sites with, originally, 51 Main and up to 50 Associated Sites operational

Harmonized measurement and data quality protocols for ecosystem parameters available

Intensive soil sampling finished at selected main sites

Soil analyses finished at selected main sites

Delivery of ecosystem, soil and management parameters to the ecosystem database

1.3 To quantify the effects of land management on the net ecosystem carbon exchange

Protocols for measurements of ecological parameters and experimental plot management finished and approved

Stand characteristics, vegetation, if possible site history, management, and NPP of selected main sites collected

Data on the carbon balance for selected sites

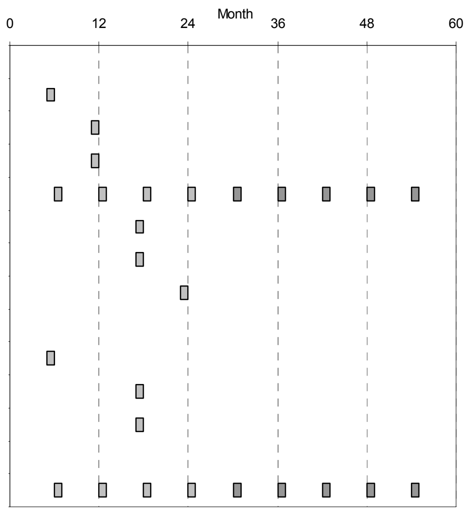
Land-use specific ecosystem models calibrated and first evaluation finshed

1.4 To provide the basic data for evaluation and parameterisation of models for up-scaling of carbon fluxes

Data Centre for ecosystem data operational, FP5 data included in database

Half-yearly update of database according to data delivery (cf. data policy)

Component 2 Atmosphere



2.1 To provide the high precision, high-frequency, long-term atmospheric concentration measurements

Four aircraft sites each 20 days on an east west transect in temperate Europe

An atmospheric network of up to 12 surface CO2 and Rn stations

Flask multiple species data of aircraft profiles at 10 levels per flight

Database of atmospheric measurements updated each 6 months

Intercomparison and routine calibration procedures amongst laboratories as part of FP5 project TACOS

Assessement of the representativity of a mountain station at Schauinsland (scientific paper)

Methodology to use short towers mid afternoon CO2 records of moderate precision in atmospheric inversions

2.2 Innovative methodologies using tracers and isotopes to attribute CO2 concentration to constituent parts

Network of 5 high precision bi weekly integrated 14C monitoring sites

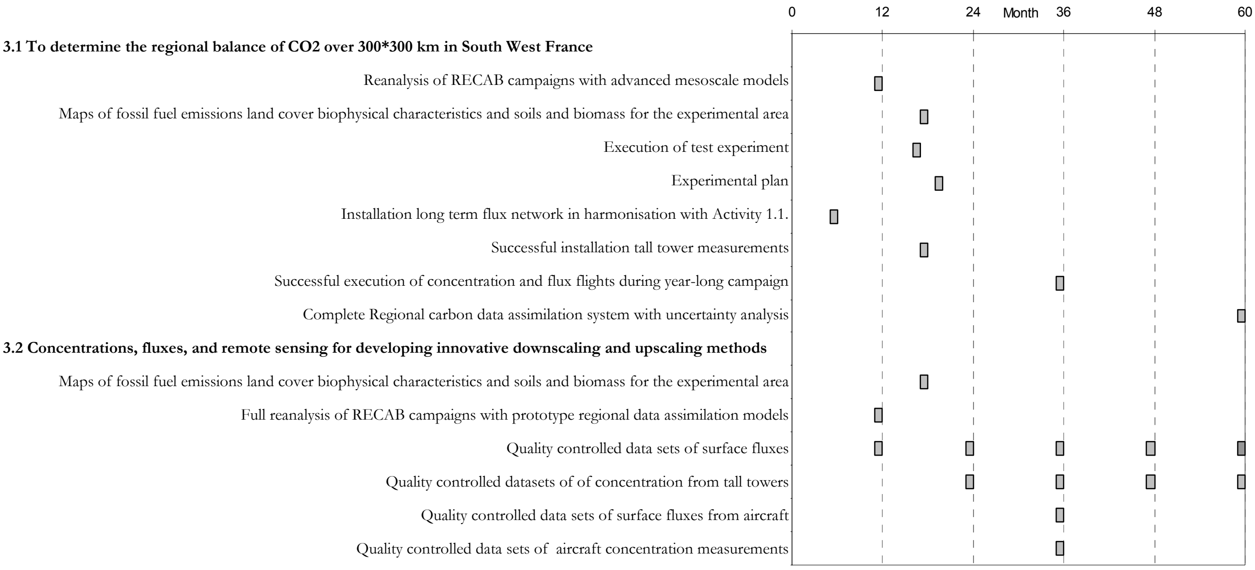
Tall towers network as part of FP5 project CHIOTTO operational

Establishement of first CO calibration site in Heidelberg to infer fossil CO2 component

2.3 To provide the data for a continental scale carbon data assimilation system (CDAS)

Database of all atmospheric measurements updated each 6 months

Component 3 Regional Experiment



Component 4 Continental Integration

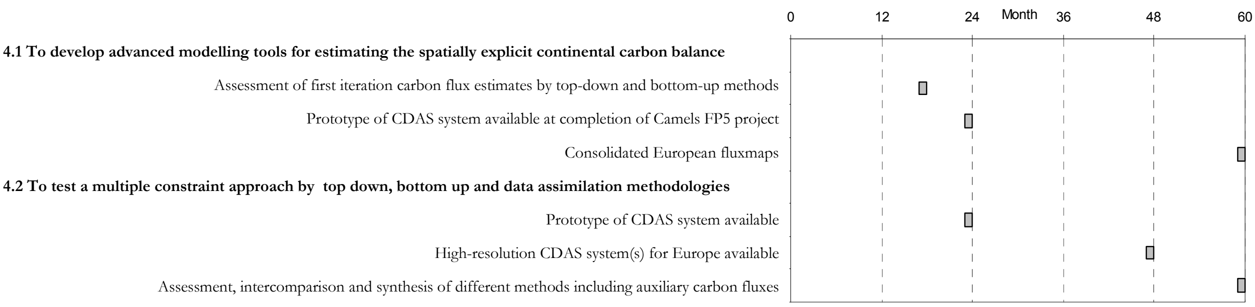


Figure 3 Gantt chart of measures of success and timing for achieving the specific objectives

6. Outline implementation plan for the full duration of the project

6.A Activities

6.1 Research, technological development and innovation activities

6.1.1 Structure

In order to achieve the main objectives and related questions, CarboEurope-IP will be implemented along four interlinked **Components** with several **Activities**. Activities are translated to one or several **Workpackages** in the **18-months Implementation Plan**, which are again split up into **Tasks**, which in turn lead to **Milestones** and **Deliverables** (Figure 4).

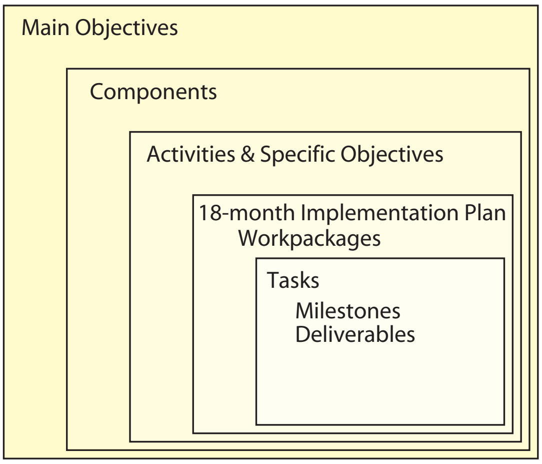


Figure 4 Terminology of blocks of work in CarboEurope-IP

The strength of CarboEurope-IP is primarily in the comprehensive experimental strategy that allows by data analysis the across scale validation and verification through the multiple constraint approach. To achieve this, the IP is set up with a limited number of strongly linked Components (Figure 5). Central in the Components is the notion that increased spatial and temporal sampling is required to resolve the regional carbon balance of Europe, and a better integration between measurements and models will be achieved.

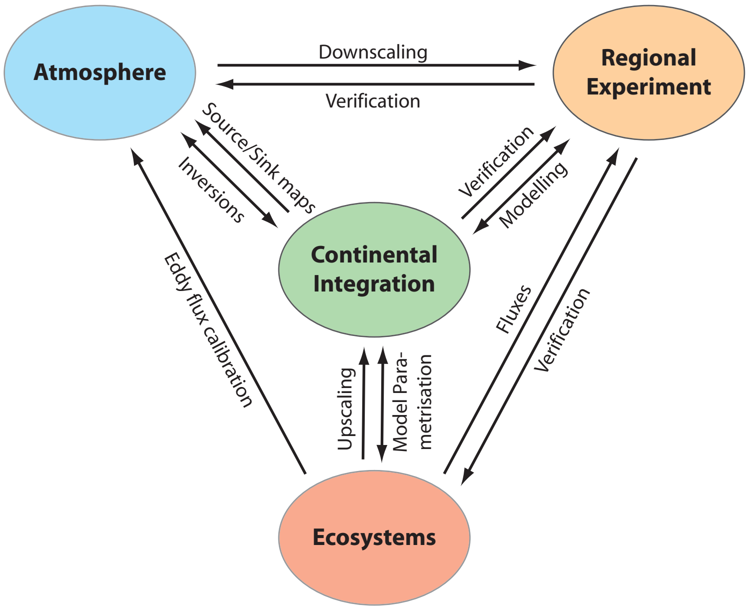


Figure 5 Components and their interactions in CarboEurope-IP

The **Ecosystem Component** will quantify the carbon fluxes of the variety of land cover and uses of the European continent, thus providing input into the spatial scaling and bottom up modelling efforts. The flux data will be verified and supported by ecosystem level data of carbon stock changes in biomass and soil, which also allow estimates of the permanence of sinks. The gathered data will also provide the basis for parameterisation of models for up-scaling of carbon fluxes to the regional and continental scale as well as data synthesis and modelling of effects of driving forces on the Carbon Cycle such as land management, disturbance by harvest, etc. which are not yet included in larger scale biogeochemical models.

In the **Atmosphere Component** we intend to extend the atmospheric network spatial coverage over Southern and Western Europe by adding new continuous monitoring stations, increase the frequency of vertical profiles sampling through the Planetary Boundary Layer and aloft, and finally to optimise the atmospheric data selection, using *in situ* meteorological data and other tracers such as ^{222}Rn, to extract from continuous CO_2 time series representative measurements of regional sources and sinks activity

The measurements at continental scale provide the boundary conditions for both the regional experiment and the integration efforts. Novel in our strategy is the incorporation of CO_2 concentration measurements at the flux tower sites to complement the atmospheric monitoring at free tropospheric sites, tall towers, and aircraft. This provides a strong link between the ecological and continental scale observations.

The **Regional Experiment Component** provides a direct link between the ecology and continental scale measurements and models. Continental scale models provide the important boundary conditions for the regional carbon balance. Upscaling of the flux towers is performed with forward meso-scale models and calibrated biogeochemical models for the long term (20 yrs). At the regional scale we will use inverse model techniques similar to those developed at the continental scale, thus establishing a clear methodological link with the larger scale inverse modelling estimates. This level of integration and co-ordination is typical of our comprehensive experimental strategy, comprising repetition of experimental and modelling design at the three main spatial scales: local, regional and continental. The regional experiment will test and provide aggregation algorithms that will be used in the upscaling efforts in the Continental Integration Component.

Data assimilation will be the key tool to the development of the carbon monitoring system. Both at regional and continental scales this is a considerable effort. We intend to set up a working group in the **Continental Integration Component** that provides an efficient platform for the exchange of modelling techniques.

Within the Continental Integration Component, the generation of bottom up estimates with biogeochemical models and novel spatial extrapolation techniques such as neural networks make use of the flux data to provide a priori estimates for the inverse models. Conversely, when inverse estimates of sources and sinks are available, they provide a check on the bottom up estimates coupled with transport model (forward modelling).

Overall the links between the various Components are expressed strongest in the Continental Integration Component. A central challenge for the integration activity is the bridging of the scales at which the different data streams arise and at which the different models operate. There are at least two distinct spatial scales where the modelling activities are located: site-specific process models for individual ecosystems within the footprint of a flux tower, or within the domain of a ”site cluster” and geographically referenced, grid-based continental ecosystem models. In the CarboEurope-IP we separate explicitly the two spatial scales and will perform modelling activities to bridge the two scales. The common denominator of the two scales is the ”Eurogrid”, i.e. a spatial grid with grid elements on the order of 20-50 (100) km, on which the European carbon balance is calculated.

Dissemination of results via publications, **demonstration** and **training** activities and **advise to policy makers** and activities will synthesise project results in order to support the implementation of observing and monitoring schemes related to the UNFCCC and the Kyoto Protocol. Training activities will increase the skills of young researchers for international, interdisciplinary research about the Carbon Cycle.

We will provide a scientifically sound, independent verification of national and European CO_2 sources and sinks over a five-years period (2004-2008) as a template for the First Commitment period and give scientific advice how to deal with sinks in the Second Commitment Period.

The detailed structure of the Integrated Project as a whole, its scientific Components, their activities and activity leaders, as well as innovation, dissemination and training activities are shown in Figure 6.

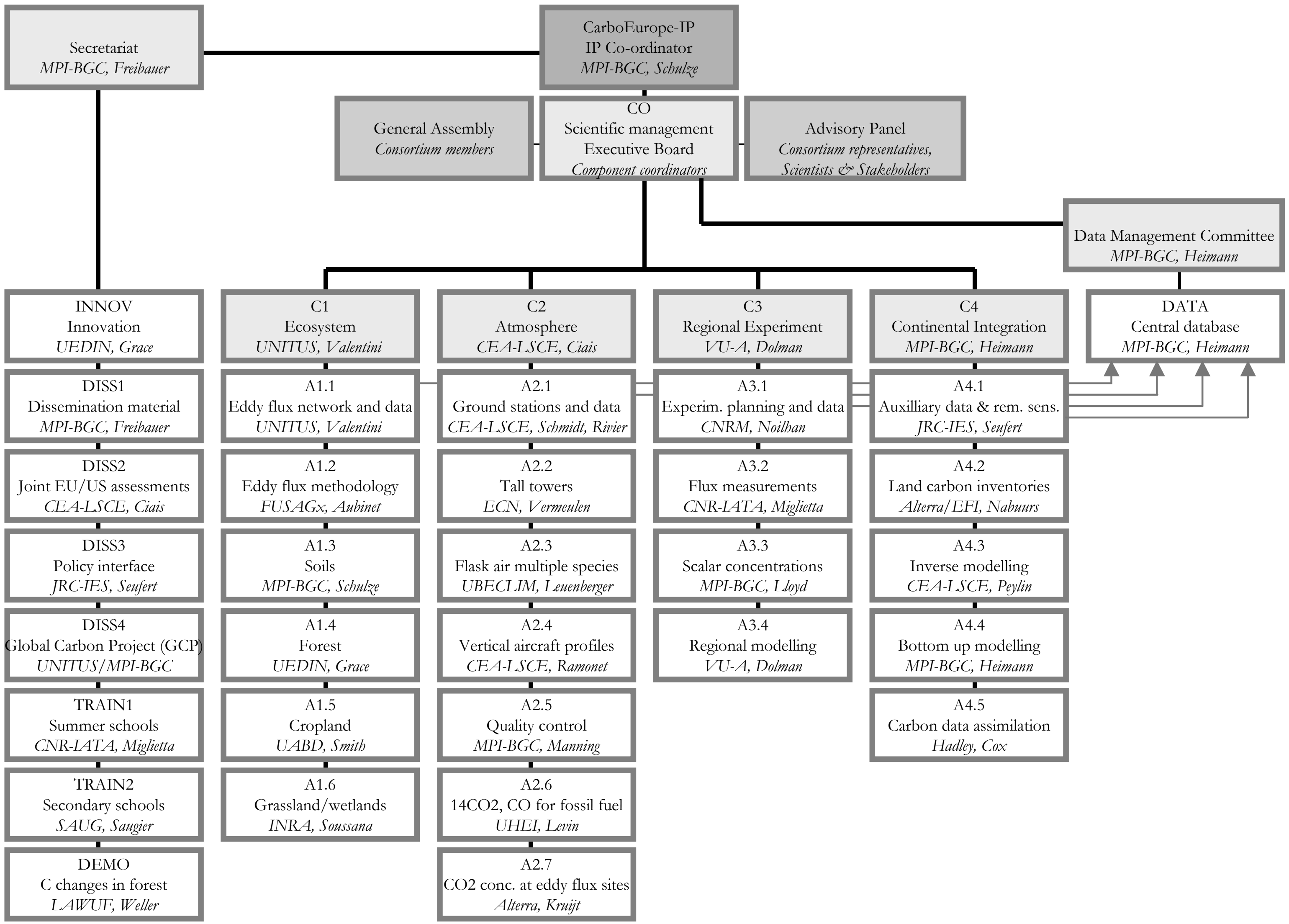


Figure 6 Scientific and organisational structure of CarboEurope-IP

6.1.2 Scientific Components

Component 1. Ecosystem carbon budgets and driving forces ("Ecosystem")
Component Leader: R. Valentini, UNITUS
CarboEurope Data Centre for ecosystem data: S. Dore, UNITUS

Mission

The Ecosystem Component of the CarboEurope-IP will provide the **carbon fluxes in and the carbon balance of major European landscape elements**, reflecting their diversity, the inter-annual variability driven by climate and other factors, the flows of carbon between different ecosystem pools (biomass and soils), their exchanges with the atmosphere, and the magnitude of ecosystem pools themselves, and the controlling biogeochemical processes as a basis for **bottom-up assessments of the European carbon balance**.

Objectives

1.1 To observe the fluxes of carbon, water and energy from representative land use/cover types of Europe by eddy covariance (MO2).
1.2 To partition the net carbon flux in European ecosystems into its constituent parts (C pool changes) according to land use types and management, using a spectrum of time scales going from sub-daily to decadal, e.g. by comparing carbon fluxes with stock changes in ecosystem pools (MO4, 5, 6).
1.3 To quantify the effects of land management on the net ecosystem carbon and CH_4 and N_2O exchange (MO5, 6, 8).
1.4 To provide the basic data for evaluation and parameterisation of models for up-scaling of carbon fluxes to the regional and continental scale (MO5, 6).

Methodology (shortened)

The methodologies of the Ecosystem Component will address:
- The **overall ecosystem net carbon flux**, its inter-annual and seasonal patterns and its partition into photosynthesis and ecosystem respiratory fluxes.
- The **growth and turnover** of biomass (including litterfall) and effects of management (e.g. harvest) on forests, grasslands and crops.
- The **pool size** and **changes of soil carbon**, and the associated fluxes (soil respiration) related to land use and land management.
- **Ecological parameters** and auxiliary information to interpret the results.

Harmonized measurement protocols will be applied. A separate research activity is devoted to resolve also these methodological problems, and to assure quality control and cross calibration between sites of the flux network.

In the present IP the flux network consists of **51 Main Sites** (including 12 intensive verification sites with detailed measurements of soil carbon stocks and turnover) and **up to 50 Associated Sites**. The **distribution** of study sites **covers reasonably well** the distribution of ecosystems by **area** and by estimated **Net Biome Productivity** (NBP, Janssens et al., 2003). The flux network is composed of 16 clusters, which should ideally cover the main land-use types of a landscape or region (Figure 7). A cluster is an ensemble of sites of at least three different major ecosystem types, which consists of three or more intensively studied **"Main Sites"** and less intensively studied **"Associated Sites"**. The Main Sites will supply **continuous data over 5 years**, while the Associated Sites will deliver data for **at least 1 year**. In addition there will be roving eddy covariance systems in order to quantify the effects of land management in forests, grassland and crops.

The Ecosystem Component will develop and apply a range of advanced ecosystem process based models, based on studies carried out during FP5 (e.g. the NUCOM model, Biome BGC, and others). These parameter rich, generally very realistic, models will be used to supply key parameters and to improve the larger scale models that will be applied at the scale of the continent in the Continental Integration Component.

The organisation and the flow of data and information within the Ecosystem Component and with the other Components of CarboEurope-IP are shown in Figure 8. Component 1 links mainly to Component 4 (Continental Integration).

Main expected results

- To establish a carbon flux balance with its components (GPP, NEP, Respiration) and its inter-annual variability for a wide range of European ecosystems
- To quantify soil carbon pools at selected tower sites as a basis for detecting C stock changes
- To quantify changes in permanent biomass at the flux sites and in relation to management
- To improve and to validate ecosystem models as a basis for up-scaling of eddy flux data and ecological studies
- To establish relations between carbon and other GHG budgets (CH_4, N_2O) to climate, management regimes and other disturbances
- To simulate impacts of land management and climate change on the carbon (and CH_4, N_2O) balance and its main components in the main land use types of Europe.

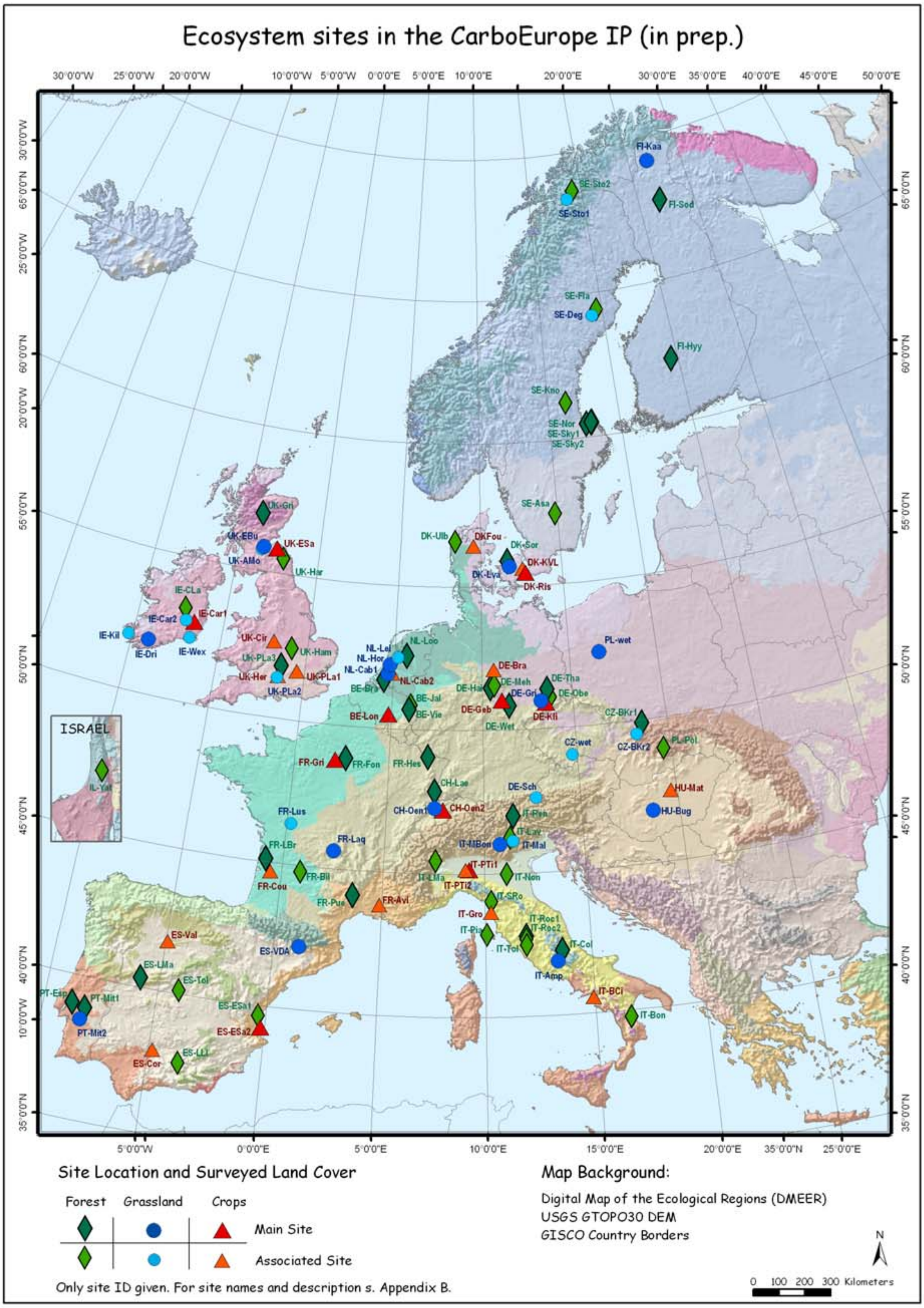


Figure 7 Geographical distribution of ecosystem sites (Appendix I-D)

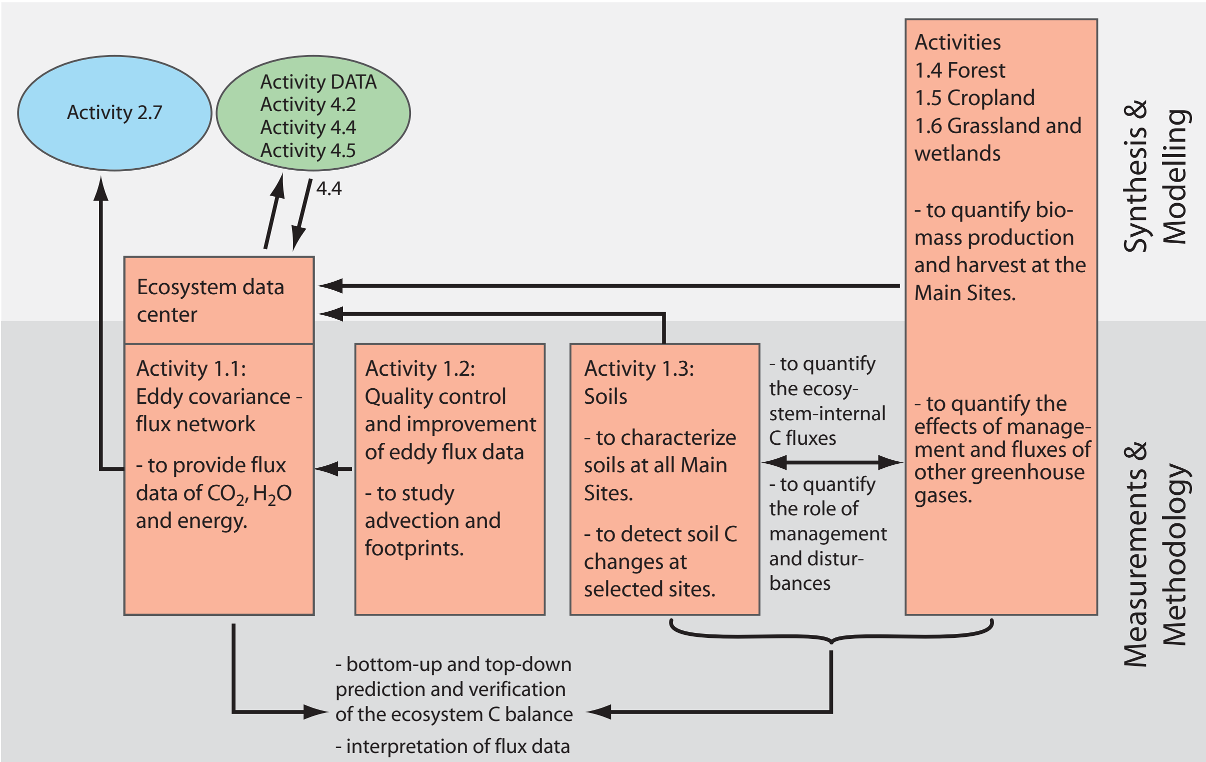


Figure 8 The organisation of the Ecosystem Component through different Activities and their objectives. The arrows indicate the relation to other Activities in the CarboEurope-IP. (Data Centre included)

Activity 1.1 Eddy covariance flux network and data

Activity Leader: R. Valentini, UNITUS

Objectives (5 yr plan)

O1.1.1 To provide flux data of carbon, water and energy from representative land use and cover types of Europe.

O1.1.2 To understand the relationship between the carbon fluxes (GPP, NEP, R) and climate for different vegetation and land use types.

O1.1.3 To provide data on fluxes of non-CO_2 trace gases.

O1.1.4 To provide an optimal design for an operational long term system for monitoring the carbon balance of Europe and of European countries.

O1.1.5 To compile, check, store and make available the data of the Ecosystem Component

Outline of work plan

Task 1.1.1 Establishment of the CarboEurope-IP eddy covariance flux network: The current distribution of flux towers which are coming from past European projects and national programmes, as well as new implemented sites, which have been selected as CarboEurope Cluster network need to be harmonised in terms of methodologies, protocols of measurements and data sharing. This task has the goal of creating a comprehensive and highly standardised network of sites which will be the back-bone of the entire ecosystem component of the IP.

Task 1.1.2 Data on carbon, water and energy exchanges and other non CO_2 trace gases: The eddy covariance network will provide a comprehensive data base of carbon, water and energy fluxes and associated variables based on high standardisation procedures. In selected sites, where these are relevant, other non-CO_2 fluxes will be measured and collected in a data-base.

Task 1.1.3 Assessment of carbon budgets of the European landscape elements: Carbon budget estimates will be carried out by means of annual sums and gap filling with state-of-the-art methodologies and errors and uncertainties will be evaluated. Annual carbon budget data will be used to assess the variability and diversity of European landscape components.

Task 1.1.4 Contribution to develop the CarboEurope carbon observation system through optimisation of the flux network A comprehensive scientific analysis using multivariate statistical analysis and optimisation theory will be carried out to assess the current distribution of flux sites and to redesign the spatial distribution of sampling in terms of ecosystem, climate, soils and management regimes. A new European design of the flux network will be provided taken into account the modelling needs and the representativeness of ecosystems. This result could be used in the future for implementation of an operational carbon data observation system at European level.

Task 1.1.5 Establishment of data centre for ecosystem data. Data coming from the flux network will be sent every 6 months to a centralized data base, located at the University of Tuscia, Laboratory of Forest Ecology. The laboratory is connected to the Italian academic network (10 Gbit) at a bandwith of 4 Mbit and a dedicated server will be installed for this purpose. The Ecosystem data server (ECODB) will be a component of the distributed Central Database facility of the IP.

Task 1.1.6 Operation of data centre for ecosystem data. ECODB will include both flux and ecological and soil data as described in the list of variables to be measured.

Flux data will be subjected to quality checks and gap filling by means of the state-of-the-art in this matter (Aubinet et al. 2000, Papale and Valentini 2003). Gap filling parametrization will be adapted to the specific sites in collaboration with the PIs. Also ecological data will be subjected to scrutiny for consistency and rigorous application of the agreed methods of collection. Every 6 months data will be made available to the CarboEurope central facility and therefore to the integration component of the IP.

Partners and responsibilities (Details in Appendix I-D):

- Responsible PI for Data of the Activity: S. Dore, UNITUS
- Site cluster co-ordinator (co-ordination of measurements of carbon, water and energy fluxes and of measurements of ecosystem and management parameters of site cluster (Appendix I-E); delivery of site cluster data to Responsible PI for Data of the Activity): P. Anthoni, MPI-BGC; R. Valentini, UNITUS; J. Moncrieff, UEDIN; A. Granier, J.F. Soussana, INRA; M. Aubinet, FUSAGx; E. Moors, Alterra; M.J. Sanz, CEAM; G. Matteucci, JRC-IES; A. Lindroth, LUND; J. Fuhrer, FAL; M. Marek, ILE; N.O. Jensen, RISOE; M. Jones, TCD; C. Bernhofer, TUD-IHM; J. Pereira, ISA-UTL; T. Vesala, UH-DPS.

- Manager of Main Site (co-ordination of measurements of carbon, water and energy fluxes and of measurements of ecosystem and management parameters of Main Site (Appendix I-E); delivery of Main Site data to Site cluster co-ordinator): P. Anthoni, MPI-BGC; C. Bernhofer, TUD-IHM; A. Granier, P. Cellier, D. Loustau, J.F. Soussana, INRA; E. Dufrêne, UPS-Orsay; S. Rambal, CEFE-CNRS; R. Valentini, UNITUS; G. Matteucci, JRC-IES; A. Cescatti, CEALP; S. Minerbi, APB; K. Pilegaard, RISOE; H. Soegaard, UCOP; A. Lindroth, LUND; A. Grelle, SLU-PE; M.T. Sebastiá, CTFC; M.J. Sanz, CEAM; J.S. Pereira, ISA-UTL; G. Pita, IST; M.C. Caldeira, UAV; E. Moors, ALTERRA; A.J. Dolman, VUA/E. Veenendaal, WUR; R. Ceulemans, UA; M. Aubinet, FUSAGx;
- J. Moncrieff, UEDIN; D. Fowler, NERC.CEH-EDIN; M. Jones, TCD; G. Kiely, UCC; R. Harding; NERC.CEH-Wal; T. Vesala, UH-DPS; T. Laurila, FMI; M. Marek, ILE; Z. Tuba, SZIU; J. Olejnik, UPOZ, A. Neftel, FAL; N. Buchmann, W. Eugster, ETH.
- Manager of Associated Site (co-ordination of measurements of carbon, water and energy fluxes and of measurements of ecosystem and management parameters of Associated Site (Appendix I-E); delivery of Associated Site data to Site cluster co-ordinator): A. Don, MPI-BGC; J. Weigel, FAL-AOE; C. Bernhofer, TUD-IHM; J. Tenhunen, UBT-PE; J.P. Gaudillère, D. Loustau, A. Olioso, G. Lemaire, INRA; D. Yakir, WEIZ; R. Valentini, UNITUS; E. Magliulo, CNR-ISAFOM; F. Miglietta, A. Raschi, IBIMET; M. Bindi/Vaccari, UNIFI; G. Scarascia Mugnozza, CNR-IBAF; A. Cescatti, CEALP; G. Matteucci, A. Leip, JRC-IES; R. Salandin, IPLA; N.O. Jensen, RISOE; J. Olesen, DIAS; A. Lindroth, T. Christensen, LUND; M. Nilsson, A. Grelle, SLU-PE; L. Klemedtsson, Göteborg; M.J. Sanz, CEAM; J.M. Moreno, Castilla La Mancha; M.L. Sanchez, UVAL; E. Fereres; CSIS; A. Kowalski/Arboledas, UGranada; A. Hensen, ECN; E. Moors, ALTERRA; L. Francois, ULG; J. Grace, K. Smith, UEDIN; M. Sutton, NERC.CEH-EDIN; M. Jones, TCD; B. Osborne, UCD; G. Kiely, UCC; R. Harding, NERC.CEH-Wal; K. Goulding, ROTH; M. Broadmeadow, Forest research; M. Marek, ILE; Z. Tuba, SZIU; J. Mindas, Slovakia
- Establishment and operation of Ecosystem data centre: S. Dore, UNITUS
- Delivery of data according to data policy: all partners of Ecosystem Component

Activity 1.2 Quality control and improvement of eddy flux data
Activity Leader: M. Aubinet, FUSAGx

Objectives (5 yr plan, to be executed in the first three years)

O1.2.1 To provide footprint dependent flux evaluations and data quality tests for all cluster sites.

O1.2.2 To further develop a common standardised and harmonised protocol of quality assurance and quality control for all the flux sites.

O1.2.3 To improve the understanding of the atmospheric processes that develop at night in canopies and better quantify the CO_2 fluxes by measuring the advection and storage during stable nights at four sites characterised by different topographies.

Outline of work plan (to be executed in the first three years)

Task 1.2.1 Footprint and quality assessment of main flux sites: Each of the Main Sites of the cluster flux network will be evaluated by means of quality checks on eddy covariance data as well as for the representativeness of the fluxes of the respective footprints. To this purpose each Main Site footprint will be evaluated on the basis of a georeferenced land use/cover digital map. This information will be provided to the flux database as additional information for modellers as well for further flux corrections and error analysis.

Task 1.2.2 Improvement of quality control procedures on eddy covariance data: New methodological components (planar fit rotation, ogive-test) as well as suitable quality control procedures will be developed. A high quality sensor set-up and associated methodical issues will be developed to investigate the energy balance closure as a control method for eddy covariance measurements. The methodologies will be developed at the Waldstein-Weidenbrunnen site of the University of Bayreuth (Fluxnet site) on a campaign basis, which has unique additional meteorological data. The new methodologies will be applied at all Main Sites in Task 1.2.1.

Task 1.2.3 Analysis of nocturnal fluxes and associated problems due to complex topographies: Accurate measurements of CO_2 fluxes during night conditions will be performed. To this end, a mobile advection and storage measurement system will be set up. The aim of the comparison is to define the topographic and the meteorological conditions under which night advection and storage are important. This will allow the evaluation of the classical u* correction currently used during night periods and the proposition of a more precise method.

Partners and responsibilities

Responsible PI for Data of the Activity: M. Aubinet, FUSAGx

Partners : T. Foken, UBT-MET (Tasks 1.1 and 1.2)
A.Lindroth, LUND (Task 1.3)
A.Cescatti, CEALP (Task 1.3)
Ch.Bernhofer, TUD (Task 1.3)

Activity 1.3 Soils

Activity Leader: E-D Schulze, MPI-BGC

Objectives (5 yr plan)

O1.3.1 To provide the soil information that allows an independent estimate of NBP at selected main tower sites.

O1.3.2 To supply the soil information that is necessary to interpret the spatial variability of carbon fluxes in the footprint of all main tower sites as related to land use and management.

O1.3.3 To increase process understanding of carbon immobilisation in soils.

Outline of work plan

Task 1.3.1 Mapping soil types: Soils in the footprint of the Main Sites need to be mapped in a harmonised way. Based on existing data on carbon concentrations of soil types we will derive an initial estimate of soil carbon pools at Main Sites. This is a first step to link soil respiration, as measured by the flux towers, to carbon stocks and stock changes in soils.

Task 1.3.2 Soil sampling: The flux network offers the opportunity to compare and verify the carbon balance as measured by eddy covariance via measured changes in permanent biomass and in soil carbon stocks. Due to the heterogeneity of soils and due to the high carbon pools in soils the detection of soil carbon pool changes will be difficult, especially if the measuring period is short, as prescribed by the Kyoto Protocol. This will be tested for up to 12 Verification Sites. Based on the measured heterogeneity in forest soils and the expected carbon input a statistical power analysis shows that about 100 soil cores must be taken and analysed by horizon at the beginning and at the end of CarboEurope-IP. Whilst the first round of analyses will be completed in the five years of the project, the second round can only start re-sampling some of the 12 Verification Sites in order to leave enough time between the two sampling dates for detecting carbon stock changes.

Task 1.3.3 Carbon immobilisation in soils: The bulk C/N analysis can only give an insight into the mass balance without information about the carbon fraction or about the processes that result in carbon immobilisation. Any further analysis requires massive analytical work and cannot be carried out on a large number of samples. Therefore, a subset of 10 cores per soil sampling site will be taken for a detailed analysis of soil texture, the light fraction of C-particles as a measure of labile C, and analysis of ^{13}C, ^{14}C, ^{15}N, C mineralisation and specific compounds that indicate change in carbon stocks in specific pools.

Partners and responsibilities

Responsible PI for Data of the Activity: E.D. Schulze, MPI-BGC

Partners:

E.D. Schulze, MPI-BGC: Soil sampling: intensive sampling at up to 12 Main Sites and sampling for standard parameters at up to 39 Main Sites, partial re-sampling of up to 12 Main Sites in last project year

M. Olsson, SLU-FS: C/N analyses of all samples from up to 12 Main Sites without those analysed by SUN (up to 5400 samples + samples from partial re-sampling)

F. Cotrufo, SUN: ^{13}C, ^{15}N and C/N in subsamples (up to 12 Main Sites x 5 depths x 10 separate samples = up to 600 samples)

G. Guggenberger, UHAL: Texture analyses, texture fractionation and density fractionation in subsamples (up to 12 Main Sites x 5 depths x 10 separate samples = up to 600 samples), shared with TUM

I. Kögel-Knabner, TUM: Texture analyses, texture fractionation and density fractionation in subsamples (up to 12 Main Sites x 5 depths x 10 separate samples = up to 600 samples), shared with UHAL

T. Persson, SLU-DEER: C mineralisation rate in subsamples (up to 12 Main Sites x 5 depths x 10 separate samples = up to 600 samples)

Activity 1.4 Forest

Activity Leader: J. Grace, UEDIN

Objectives (5 yr plan)

O1.4.1 To provide data on vegetation, leaf area index, NPP and its components at the forest Main Sites.

O1.4.2 To provide relationships between NPP and NEP and forest structure, age, and global warming potential (e.g., GHGs).

O1.4.3 To investigate the effects of management and disturbance, including afforestation and reforestation on the net carbon balance.

O1.4.4 To simulate with process-based models the seasonal, inter-annual and long-term variations in net trace gas (CO_2, CH_4, N_2O) fluxes for forests at site level.

O1.4.5 To provide data for model parameterisation and up-scaling to the European continent for forests.

Outline of work plan

Task 1.4.1 Harmonise data acquisition: The first step is to identify what is missing, and for those where data are available, to check consistency of the methodology. Visits will be made to all sites to collect structural and management data, and to ensure that NPP measurements are being made to a common protocol. Special attention will be paid to chronosequence sites, and to sites where typical types of disturbance are observed. New measurements of the decay rates of coarse woody debris will be required, as in the FP5 project CarboAge and Forcast it was evident that fluxes from this source remain important over many years.

Task 1.4.2 Model Parameterisation: Flux models developed in FP5 will be parameterised with the data obtained from the forest sites, and verified against the observed flux data. It will be possible from these models to estimate the impacts of climate warming, elevated CO_2 and changes in management practices. The work plan in the period after the first 18 months will consist of refinement of the models; full runs of models with all features and sensitivity testing; meta-analysis of data on the decomposition of woody material, linking with the remote sensing community; linking with the private sector on Kyoto-related issues.

Partners and responsibilities

Responsible PI for Data of the Activity: J. Grace, UEDIN

Associated Partners including the Centre for Terrestrial Carbon Dynamics (optical and radar remote sensing of forest cover and biomass); the Department of Forest Ecology at the University of Helsinki (model code); Dipartimento Colture Arboree, Università di Bologna (model code); Academy for Forestry (comparisons with physiognomically-similar forests in other regions); and the Edinburgh Centre for Carbon Management (Kyoto Issues and dissemination of user-friendly versions of models).

Activity 1.5 Cropland

Activity Leader: P. Smith, UNIABDN

Objectives (5 yr plan)

O1.5.1 To collate data on vegetation, development of leaf area, NPP and its components of cropland Main Sites.

O1.5.2 To investigate emissions of other GHGs under different types of management.

O1.5.3 To collate data on the impact of agricultural practices on soil organic carbon input (root biomass, organic manure, straw etc.) from cropland Main Sites for the present and past.

O1.5.4 To simulate with process-based models the seasonal, inter-annual and long-term variations in net trace gas (CO_2, CH_4, N_2O) fluxes for croplands at site level.

O1.5.5 To provide data for model parameterisation and up-scaling to the European continent for croplands.

Outline of work plan

Task 1.5.1 Data consolidation: We will collate data on vegetation, development of leaf area, NPP and its components from cropland Main Sites. Where other, non-CO2 greenhouse gases (CH_4, N_2O) are also monitored, we will also collate these data and investigate emissions of these greenhouse gases under different types of management. We will also collate other auxiliary data on agricultural practices that impact upon soil organic carbon input (root biomass, organic manure, straw etc.) of cropland Main Sites for the present and past.

Task 1.5.2 Meta-analysis: Using the flux data from cropland sites, and the auxiliary data on management, physiology and other trace gases described above, we will use process-based models to simulate the seasonal, inter-annual and long-term variations in net greenhouse gas fluxes (CO_2, CH_4, N_2O) for croplands at site level. Such models, or derivatives of these, may be used for up-scaling. In addition, we will provide data for model parameterisation to other modelling groups for up-scaling to the European continent.

Partners and responsibilities

Responsible PI for Data of the Activity: P. Smith, UNIABDN

Funded Partner: P. Smith, UNIABDN, with contributions from unfunded contributions:

Modelling: MPI-BGC; CEA-LSCE; Peter Leffelaar - WUR-Wageningen; Uwe Franko - UFZ-Leipzig-Halle; Bas van Wesemael - Université Catholique de Louvain

Soil studies: P. Boeckx, U. GHENT

Activity 1.6 Grassland/wetlands

Activity Leader: J.-F. Soussana, INRA

Objectives (5 yr plan)

1.6.1 To provide ecological parameters and NPP components of the grassland/wetlands sites of the clusters network including harvest and grazing

1.6.2 To adapt, calibrate and evaluate a detailed process-based grassland model

1.6.3 To establish relations of grassland types, management and climate with carbon source and sinks

1.6.4 To simulate the seasonal, inter-annual and long-term variations in CO_2 fluxes for grasslands and wetlands, including both semi-natural and intensive management systems,

1.6.5 To provide data for model parametrization and up-scaling to the European continent for grasslands.

Outline of work plan

In the first project year, activities will be performed as part of the FP5 project Greengrass (EVK2-CT-2001-00105), running until 31/12/2004.

Task 1.6.1 Standardised protocols for measurement of ecological (e.g. vegetation) parameters and of the components of NPP at the grassland/wetland sites: The relevant information on vegetation structure, site history, regime of management will be collected from all sites. Secondly a full protocol of measurements of NPP and its components will be designed. Data on vegetation, development of leaf area, NPP and its components including harvest and grazing will be collected by this activity and provided to the flux data base.

Task 1.6.2. Model parameterisation and validation: A mechanistic grassland ecosystem model (PASIM) developed under the FP5 project 'Greengrass' will be further adapted to predict the net exchange of greenhouse gases from permanent and short duration grasslands. In his first phase the PASIM model will be parameterised and evaluated against the data from the main grassland sites of the cluster network.

Task 1.6.3 Contribution to upscaling. A coupled version of the PASIM and ORCHIDEE first developed under the FP5 project 'GreenGrass' will be parametrised by region and grassland type in order to contribute to the bottom-up simulation of pan-European CO_2 fluxes over grasslands.

Partners and responsibilities

Responsible PI for Data of the Activity: J.F. Soussana, INRA

Grassland modelling: Jürg Fuhrer, FAL

with contribution from unfunded partners:

- Contributions to N_2O analysis, if applicable: Ute Skiba, NERC.CEH-Edin and Robert Rees, SAC.
- Modelling: Joergen Olesen, DIAS: Contribution to farm-scale model; CEA-LSCE: Bottom-up modelling of grassland fluxes; P. Smith, UNIABDN: Uncertainty analysis & arable / grassland integration

Component 2: The Continental Atmospheric Observing System ("Atmosphere")
Component Leader: P. Ciais, CEA-LSCE
CarboEurope Data Centre for atmosphere data: L. Rivier, CEA-LSCE

Mission

The Atmosphere Component of CarboEurope-IP will establish and operate the **Atmospheric Observing System needed to quantify in a top-down approach the average European carbon balance** and its regional distribution at a typical spatial scale of 100 km with temporal resolution of one week.

Objectives

2.1 To provide the high precision, high-frequency, long-term atmospheric concentration measurements needed to invert for magnitude and variability of sources and sinks in Europe with a typical resolution of 100 km every week over best sampled areas (MO1, 4, 7).
2.2 To develop innovative methodologies using Carbon Cycle related tracers and isotopes to attribute the CO_2 concentration in the European air shed to each of the constituent parts of the fluxes: fossil, oceanic, and terrestrial (MO8).
2.3 To provide the data for a continental scale carbon data assimilation system (CDAS) (MO3).

Methodology** **(text shortened)

The atmospheric CO_2 and auxiliary tracers distribution delivered by the Atmospheric Observing System of CarboEurope-IP will serve to quantify the European carbon fluxes using different atmospheric transport models in an inverse mode. Our strategy is to enhance the Atmospheric Observing System over Europe by adding key stations over undersampled areas, by **combining different atmospheric networks into complementary activities and add continuous measurements on tall towers as an additional scaling instrument**, and strongly relying on the infrastructure that is already in place funded through national and former EU efforts.

Given the small differences in atmospheric concentrations over Europe, high-precision, highly accurate measurements are of utmost importance. In a quality control activity, we will therefore quantify and monitor in a dynamic fashion calibration scale differences of GHGs and related tracer measurements between the European laboratories and field stations contributing to the Atmospheric Observing System in order to achieve the precision and accuracy goals given in Table 1.

We will attribute the European CO_2 gradients within the atmosphere to different components of the fluxes: oceanic, terrestrial and fossil, based on the analysis of multiple species in flask air samples and at some *in situ* sites. Assessing the fossil fuel CO_2 component we will use a unique technique where European laboratories have a strong leadership, that is high precision measurements of $^{14}CO_2$, ^{222}Rn and CO. This approach will provide fossil fuel CO_2 mixing ratio determinations on the order of 20% accuracy in moderately polluted areas and respective emissions estimates with an uncertainty of 25-35%.

The planned Atmospheric Observing System thus consists of seven complementary activities that use a balanced choice of sampling and measurement strategies to obtain as complete a representation of the CO_2 field across Europe in the planetary boundary layer, and in the free troposphere as possible. One important consideration underlying the sampling design is to take advantage of the mixing processes in the planetary boundary layer which smooth the high variability of land-biosphere atmosphere exchange CO_2 signals close to the ground.

We expect that the synergetic use of atmospheric measurements and inverse models in CarboEurope-IP will enable us to downscale carbon fluxes using atmospheric measurements to the sub-continental level within Europe (e.g. Eastern European countries, Mediterranean area) and to the level of smaller regions of typical size 1000 km over the best sampled areas within north-western Europe (e.g. France, Germany, Benelux countries). Uncertainties on flux estimates will be assessed by using a suite of different atmospheric transport models, and based on different data selection procedures established for each site. We expect an uncertainty for the overall European carbon balance of 20%, that is about ± 200 Tg C yr^{-1}. We expect an uncertainty for regional fluxes in the best sampled Western European regions of 30% each month. This uncertainty can only be further reduced by applying the integrated approach of Component 4 (Continental Integration).

Table 1 Atmospheric Observing System Precision and Accuracy Goals

Gas species	Intra-laboratory instrumental precision	Inter-laboratory calibration scale accuracy
CO_2	0.05 ppm	0.10 ppm *
CH_4	2.0 ppb	3.0 ppb
CO	1.0 ppb	3.0 ppb
N_2O	0.1 ppb	0.2 ppb
SF_6	0.1 ppt	0.2 ppt
O_2/N_2	5 per meg	10 per meg
Rn	0.2 Bq m^{-3} or 10% **	10% **
$d^{13}C$-CO_2	0.007 ‰	0.01 ‰ *
$d^{18}O$-CO_2	0.03 ‰	0.05 ‰ *

* These values are the WMO/GAW goals for global network accuracy among different laboratories in the northern hemisphere. (In the case of the other species, no official WMO/GAW goals exist at this time).

** For Radon, this value is the detection limit goal.

The organisation and the flow of data and information within the Atmosphere Component and with the other Components of CarboEurope-IP are shown in Figure 9. Component 2 links mainly to Component 4 (Continental Integration). Component 3 delivers high precision measurements of CO_2 and ^{14}C data from two tall towers in Southwest France during the year of the Regional Experiment.

Main expected results

- Establishment of a unified European Atmospheric Observing System to monitor the carbon balance of Europe and its regional distribution (Figure 10)
- European contribution to the global, internationally co-ordinated effort to enhance the set of *in-situ* atmospheric observations for diagnosis of the current distribution of carbon sources and sinks.
- Delivery of a coherent ensemble of atmospheric CO_2 and Carbon Cycle related tracers to atmospheric transport models.
- Attribution of the European CO_2 gradients within the atmosphere to different components of the fluxes: oceanic, terrestrial and fossil.

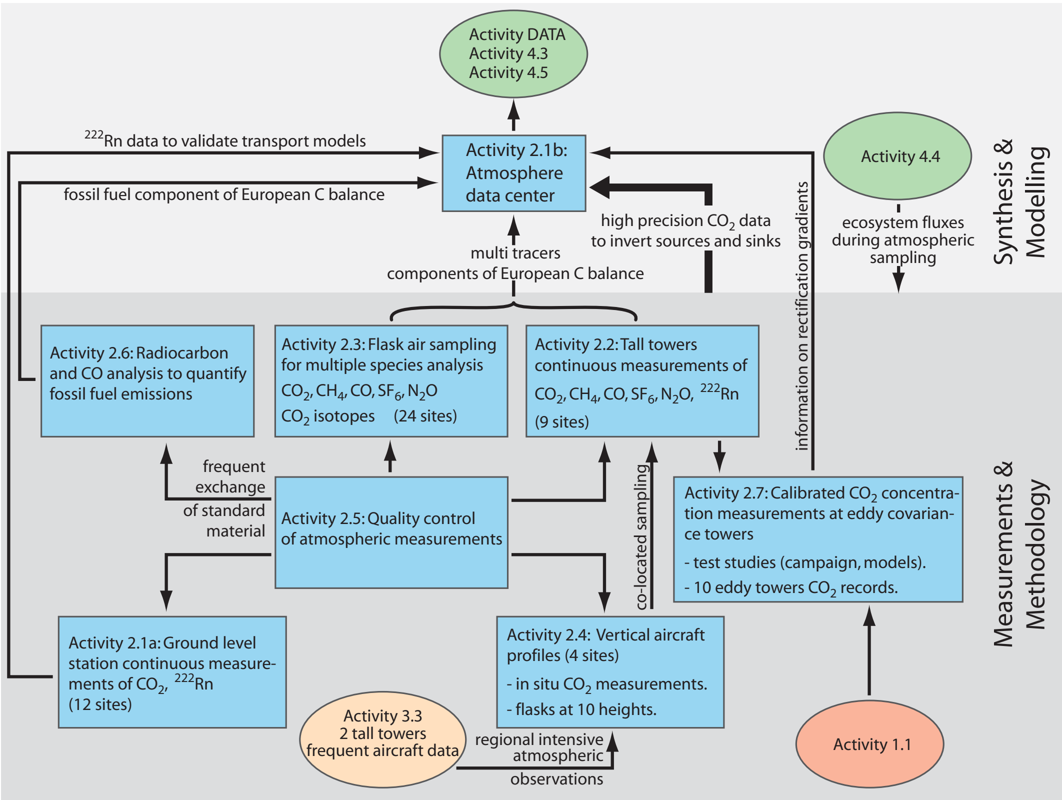


Figure 9 The organisation of the Atmosphere Component through different Activities and their objectives. The arrows indicate the relation to other Activities in the CarboEurope-IP

Activity 2.1 Ground level station continuous measurements of CO_2 and ^{222}Rn and data management

Activity Leader: M. Schmidt, CEA-LSCE (measurements), L. Rivier, CEA-LSCE (data)

Objectives (5 yr plan)

O2.1.1 To provide quality controlled CO_2 records from up to 12 existing ground level stations around and within Europe.

O2.1.2 To provide quality controlled continuous ^{222}Rn measurements at most CO_2 stations for validating transport models and enhancing data selection.

O2.1.3 To develop new data selection procedures at each station for obtaining CO_2 records representative of regional fluxes and filtered from local influences.

O2.1.4 To compile, check, store and make available the data of the Atmosphere Component

Outline of work plan

Task 2.1.1 The European network of CO_2 stations: *In situ* hourly mean CO_2 concentrations and meteorological data from 12 ground-level stations will be collected from 11 laboratories and delivered to the database in a harmonised format. Useful data products such as statistics on concentration variability, seasonal cycles, monthly means will be computed and placed in the database. Data and meta-data will be documented and updated every 6-month.

Task 2.1.2. Continuous sampling of ^{222}Rn at the stations: ^{222}Rn is a tracer of air masses under recent continental influences. It is widely used to validate vertical mixing (e.g. PBL depth) and synoptic transport in models. In Europe, a network of 6 ^{222}Rn stations already exists, but we need to integrate it with CO_2 observations. Then, ^{222}Rn recorded on a quasi continuous basis (every 1/2 hour) will be used to select CO_2 data for regional representativity.

Task 2.1.3. Quantification of representativeness "errors": Near the ground, the variability in concentrations (e.g. diurnal cycle) is huge, because the air is to a large extent influenced by local sources and sinks. In order to filter the effect of local (few tens of km) variability from the regional signal, one needs to continuously monitor concentrations. *In situ* CO_2 continuous data will be selected empirically into "local" and "regional" using meteorological information and back-trajectory analysis. Alternatively, we will test very-high resolution atmospheric transport models fitted with local emission maps to simulate the concentration variability around each site and model the data selection.

Task 2.1.4 Operation of data centre for atmosphere data

The data centre has already been established for the Aerocarb project in FP5. Tasks of the data manager comprise:

- Contact each Responsible PI for Data of the Activity for obtaining the data to be delivered
- Harmonisation check of the data formats
- Regular upgrades of atmospheric database
- Regular links with users and CarboEurope-IP Central Database via data committee meeting

Partners and responsibilities

Responsible PI for Data of the Activity: M. Schmidt, CEA-LSCE

Partners and responsibilities for number of stations (n)

CEA-LSCE (2), UHEI-IUP (2), CIO (1), UBERN (1), FMI (1), ISAC-CNR (1), CESI (1), ENEA (1), SU (1)

Operation of data centre for atmosphere data: L. Rivier, CEA-LSCE

Delivery of data according to data policy: all partners of Atmosphere Component

Activity 2.2 Tall towers continuous measurements of CO_2, CH_4, SF_6, N_2O, CO, ^{222}Rn

Activity Leader: A.T. Vermeulen, ECN

Objectives (5 yr plan)

O2.2.1 To continue to support the operations of 8 tall towers being established in FP5 after the Chiotto project terminates in 2005.

O2.2.2 To add a new tall tower with continuous CO_2 measurements only in Northern Spain by 2004

O2.2.3 To establish new methodologies to connect tall towers concentration profile variability to local fluxes.

Outline of work plan

Task 2.2.1 The network of tall towers: We will continue to support the routine operations of 8 tall towers once the FP5 project Chiotto has stopped in 2005. *In situ* concentration and meteorological records from the tall towers will be delivered to the database in a harmonised format compatible with ground level stations data. One additional tall tower will be equipped in 2004 at La Muela to better constrain regional fluxes over the Iberian Peninsula. Two tall towers respectively near Toulouse and Bordeaux will be added to the network for one year during the Regional Experiment planned in the IP.

Task 2.2.2 Linking tall towers concentration profiles and local ecosystem fluxes: At tall towers where there are eddy covariance systems measuring NEE, this information will be used to screen out local influences and assess regional representativity of tall towers concentration time series. However, to establish a methodology for systematic upscaling of fluxes by combining tall towers concentration records, remote sensing information and nearby eddy covariance towers is beyond the scope of this task. At Norunda and Cabauw, we will simulate the vertical profiles of concentration along the masts and relate them to nearby eddy covariance data using 1-D or 3-D high resolution PBL-transport models. At all sites, the nocturnal accumulation of atmospheric species and ^{222}Rn in shallow night-time boundary layers will offer the unique possibility to obtain independent estimate of night-time Ecosystem Respiration, using ^{222}Rn of known sources to quantify unknown respiratory emissions of CO_2.

Partners and responsibilities

Responsible PI for Data of the Activity: A. Vermeulen, ECN

Partner	*Responsibilities*
ECN	Activity leader
	Activity Data Responsibility
	Operating the Cabauw (NL) tall tower
	Linking of vertical concentration gradient with flux measurements and regional flux estimates
MPI-BGC	Operating Ochsenkopf (G) and Bialystok (PL) tower
	Provision of working standards and round-robin flasks to tall tower sites
CEA-LSCE	Operating Orleans (F) tower

UBARC Setting up and operating La Muela tower (SP)

UNITUS Operating Firenze (I) tower

ELU Operating Hegyhatsal (Hu) tower

LUND Operating Norunda (S) tower

UEDIN Operating Edinburgh (UK) tower

Activity 2.3 Flask air sampling for multiple species analysis

Activity Leader: M. Leuenberger, UBERN

Objectives (5 yr plan)

O2.3.1 To operate a unified co-operative European network of weekly flask sampling sites distributed among five laboratories.

O2.3.2 To use flask multiple-species information to apportion the European carbon balance into components: fossil, air-sea exchange and terrestrial.

O2.3.3 To develop new innovative and improvement of already existing analytical methods for measurements such as Ar/N_2 (an ideal transport tracer over land); NMHC (a pollution tracer) and ^{13}C in CH_4 (tracer of methane sources).

Outline of work plan

Task 2.3.1. The European co-operative flask sampling network: The five European laboratories of this Workpackage have the capability to make high precision multiple species measurements in flask air samples. These laboratories are well experienced at working together within EU programmes for more than 10 years. Common work includes analytical developments, sharing of sampling devices and flasks, as well as frequent intercomparison exercises. We will collect weekly flask samples at up to 21 European locations for analysis of CO_2, CH_4, N_2O, $\delta^{13}C$ in CO_2, $\delta^{18}O$ in CO_2, CO and at a subset of stations for O_2:N_2 as part of a co-operative effort involving Europe, USA and Australia. All flask data will be reported in a harmonised way to a Central Database.

Task 2.3.2. Multiple-species interpretation of the European carbon balance: Co-ordinated flask sampling at aircraft sites, tall towers and ground-level stations will provide multiple species information of unique value to separate air-sea exchange (using O_2:N_2), terrestrial fluxes (^{13}C and ^{18}O in CO_2), and fossil fuel emissions (CO, SF_6, NMHCs). The multiple species inferences will place strong independent constraints on bottom up estimates of the fluxes. Flask data of CH_4 and N_2O, in conjunction with tall towers records will enable us to infer the European sources of these gases. We will analyse $\delta^{13}C$-CO_2 and $\delta^{18}O$-CO_2 isotope records to determine the large scale time-varying isotopic fractionation of European ecosystems via the isotopic source signature of air added to or removed from the mean atmospheric signal.

Task 2.3.3. Development of innovative techniques: We will work on analytical developments for adding new species measurements with high-precision in flask air, focused on Ar:N_2 (tracer of transport over land); linear NMHC (tracers of air pollution), and $\delta^{13}C$ in CH_4 (tracer to apportion CH_4 sources).

Partners and responsibilities

Responsible PI for Data of the Activity: M. Leuenberger, UBERN

Partners and responsibilities for number of stations (n):

CEA-LSCE (6), MPI-BGC (3), CIO (2), UHEI (1), UBERN (1). 10 stations are run by CMDL.

Sites and responsible institute:

- CMDL is responsible for 10 sites, namely: ALT, BAL, BSC, GOZ, HUN, ICE, IZO, MHD, ZEP, STM
- LSCE is responsible for 6(7) sites, namely: MHD (1) 2nd set of data with CMDL, BGU, PUY, PDM, ORL, FIK, BZH
- MPI-BGC is responsible for 3 sites, namely: SIS (2) with CSIRO, OXK, BIK
- CIO-RuG is responsible for 2 sites, namely: LUT, CBW
- UHEI-IUP is responsible for 1 sites, namely: SCH
- ENEA is responsible for 1 sites, namely: LAM
- UNIBE is responsible for 1 sites, namely: = JFJ

Activity 2.4 Vertical aircraft profiles of in situ CO_2 and flask samples

Activity Leader: M. Ramonet, CEA-LSCE

Objectives (5 yr plan)

O2.4.1 To continue to operate a transect of 4 aircraft vertical profiles sites each 20 days with flask sampling at 10 altitude levels within the boundary layer and aloft, in the interval 2004-2006.

O2.4.2 To install *in situ* CO_2 continuous airborne analysers at 4 aircraft sites, and increase the sampling frequency to each 5 days in the interval 2006-2008.

Outline of work plan

Task 2.4.1. The European network of aircraft sites (2004-2006)

We will continue the effort undertaken in 2000-2003 within FP5 to characterise the vertical gradients of CO_2 and other species in the lower troposphere using small aircraft. Two aircraft sites among the 6 operating now will however be stopped: Schauinsland (D) in 2005 and Thüringen (D) in 2004. We will continue to fly four small aircraft each 20 days in the interval 2004-2006 with flask sampling at 10 altitudes in order to obtain a multiple species dataset of 6-years long on an East-West transect across Europe at Hegyhatsal (H); Bialystok (PL); Orleans (FR); Griffin (UK). Those four aircraft sites are geographically co-located with tall towers. The aircraft flask results will be reported to the data base together with *in situ* information on sampling and on atmospheric structure (temperature and humidity). Another aircraft site will be installed in Northern Spain with national funding. An outline of the schedule is shown in Table 2.

Task 2.4.2. The enhanced European network of aircraft sites (2006-2008)

We will enhance the aircraft observations by taking *in situ* continuous profiles of CO_2. At Orleans (Fr) and Bialystok (PL) this is already the case with *in situ* CO being additionally measured at Orleans. We will install continuous CO_2 analysers at Griffin (UK) and Hegyhatsal by 2005 and fly them regularly after that. All *in situ* CO_2, temperature, humidity profiles will be reported to the database. In the interval 2006-2008, we will increase the sampling frequency to each 5 days, covering all possible synoptic weather conditions, with flasks sampled each 20 days. Such dramatic increase in aircraft soundings is essential to establish seasonal vertical and horizontal CO_2 gradients given the natural variability, and reduce uncertainties in regional budgets. Network design studies will be performed using inverse models in the Continental Integration Component of the IP in order to optimise the aircraft sampling strategy and to check on weather biases. An outline of the schedule is shown in Table 2.

Partners and responsibilities

Responsible PI for Data of the Activity: Michel Ramonet (CEA-LSCE)
Flight logistic and in-situ measurements at Orléans: CEA-LSCE
Flight logistic and in-situ measurements at Hegyhatsal: ELU
Flight logistic and in-situ measurements at Griffin: UEDIN
Flight logistic and in-situ measurements at Bialystok: MPI-BGC
Flight logistic and in-situ measurements at Schauinsland: UHEI-IUP
Flask analysis for Orléans, Griffin, Spain, : CEA-LSCE
Flask analysis for Thüringen, Hegyhatsal, Bialystok: MPI-BGC
Flask analysis for Schauinsland: UHEI-IUP
Responsibility for O2/N2 measurements : partners in activity 2.3

Activity 2.5 Quality control of atmospheric measurements

Activity Leader: A. Manning, MPI-BGC

Objectives (5 yr plan)

O2.5.1 To dynamically monitor inter-laboratory concentration scale differences with the aim of achieving the accuracy goals specified in Table 1, and as set by the WMO-Global Atmosphere Watch Programme, via frequent exchange of intercomparison material (flasks, high and low pressure cylinders). This will improve the measurements obtained in Activities 1 through 4.

Outline of work plan

Task 2.5.1. Dynamic monitoring of inter-laboratory comparability of calibration scales

We will continue after FP5 projects stop in 2005 the frequent exchange every 2 months of flask samples filled with air of known concentration to assess differences in CO_2, CH4, 13C-CO_2, 18O-CO_2, N2O, and CO between the 4 laboratories with flask analytical capabilities. We will also develop an O_2/N_2 intercomparison strategy for 3 participating European laboratories, and establish links of these

O_2/N_2 scales with the internationally recognised scales in the USA. Based on the experience gained in the ongoing FP5 projects, we will decide in 2006 whether high pressure or low pressure cylinders are most appropriate and cost-effective to carry out frequent laboratory intercomparisons. Intercomparison results will be reported to the database using web technology, and to the WMO-GAW international CO_2 Experts group.

Partners and responsibilities

Responsible PI for Data of the Activity: A. Manning, MPI-BGC

Other partners: MPI-BGC, UHEI-IUP, LSCE, CIO, UBERN, UNITUS, UEDIN, ECN, ELU, ALTERRA, LUND

Activity 2.6 Radiocarbon and CO analysis to quantify fossil fuel emissions

Activity Leader: I. Levin, UHEI-IUP

Objectives (5 yr plan)

O2.6.1 To continue the existing $^{14}CO_2$ observational network in Europe to directly derive monthly mean fossil fuel CO_2 contributions at polluted and background sites.

O2.6.2 To establish "calibration stations" in Western, Central and Eastern Europe to provide an ongoing calibration of CO as a proxy for fossil fuel CO_2 (determine the mean CO/CO_2 ratio of fossil fuel sources).

Outline of work plan

Task 2.6.1. Determine the fossil fuel CO_2 component in Europe from $^{14}CO_2$ measurements

We will continue high-precision quasi-continuous $^{14}CO_2$ sampling and analysis at the marine stations Mace Head and Izaña to accurately define the changing Atlantic $^{14}CO_2$ background in mid northern latitudes. We will continue high precision (<3‰) $^{14}CO_2$ measurements at the high altitude Alpine site Jungfraujoch, at the mountain site Schauinsland as well as at the coastal site Lutjewad for direct determination of the fossil fuel CO_2 component over Europe.

Task 2.6.2. Provide a calibration of CO as a proxy for fossil CO_2 at three urban stations

We will establish a set of three CO/fossil CO_2 "calibration" stations in urban/industrial polluted environments representative of Western Europe and Eastern Europe. Those sites are Paris, Heidelberg and Krakow. In Paris, France where 90% of the electricity production is non-fossil, the CO/fossil CO_2 ratio is one of the highest in Western Europe because it reflects car traffic only. In Heidelberg Germany, we have both industrial emissions with a "clean" combustion efficiency and car traffic from recent car fleet. In Krakow Poland, we expect industrial processes with higher CO/CO_2 emission ratio and car traffic from older car fleets. We will continue CO_2, CO and weekly-integrated $^{14}CO_2$ measurements at Heidelberg for calibration of CO as a proxy for fossil fuel CO_2. We will establish two new "calibration sites" in urbanised/industrialised European regions (Western Europe:

Paris (48º30'N, 2º12'E), and Eastern Europe: Krakow, 50º23'N, 19º33'E) with weekly integrated precise (better than 4‰) $^{14}CO_2$ observations and parallel continuous CO_2 and CO observations.

Partners and responsibilities

Responsible PI for Data of the Activity: I. Levin, UHEI-IUP

Mace Head, Izana, Jungfraujoch, Schauinsland continuous $^{14}CO_2$: I. Levin, UHEI-IUP

Lutjewad continuous $^{14}CO_2$: H. Meijer, CIO

Heidelberg CO/fossil CO_2 Calibration site: I. Levin, UHEI-IUP

Paris CO/fossil CO_2 Calibration site: P. Ciais, LSCE

Krakow CO/fossil CO_2 Calibration site: K. Rozanski, UKRAK

Activity 2.7 Calibrated CO_2 concentration measurements at eddy-covariance towers

Activity Leader: B. Kruijt, ALTERRA

Objectives (5 yr plan)

O2.7.1 To develop a methodology to calibrate eddy covariance towers CO_2 records with an accuracy target of 0.5 ppm.

O2.7.2 To establish CO_2 calibrated records at 10 existing eddy covariance towers.

Outline of work plan

Task 2.7.1. Feasibility study to calibrate atmospheric CO_2 eddy covariance towers

We will develop a simple instrumental "kit" to calibrate CO_2 on top of Eddy Covariance towers, and test whether the gas analysers used to measure profiles are applicable for atmospheric measurements with accuracy of ± 0.5 ppm. We will develop a methodology to use CO_2 records on short towers as surrogates of PBL concentrations, based on careful analysis of tall tower profile data at Hegyhatsal (Hu), Cabauw (NL), and Pallas (FIN) station where there are nearby eddy covariance towers.

Task 2.7.2. Pilot network of calibrated CO_2 at eddy covariance towers

We will implement CO_2 calibration on top of 10 eddy flux towers selected for flat terrain, as a joint activity with the Ecosystem Component of the IP.

Partners and responsibilities

Responsible PI for Data of the Activity: B. Kruijt, ALTERRA

Further partners to be decided during first 18 months.

Note on ground based remote sensing of atmospheric CO_2

(No funding requested from CarboEurope-IP)

We seek to complete the *in situ* Atmospheric Observing System outlined above by few remote sensing stations measuring CO_2 column integrals, as part of a separate project proposed to the European Space

Agency (ESA). This network, should form the core of ground based calibration and validation activities for a new and powerful type of atmospheric CO_2 measurement, as expected from space-based remote sensing using existing sensors SCIAMACHY, AIRS and IASI, and from the near-future Orbital Carbon Observatory (OCO) mission dedicated to CO_2.

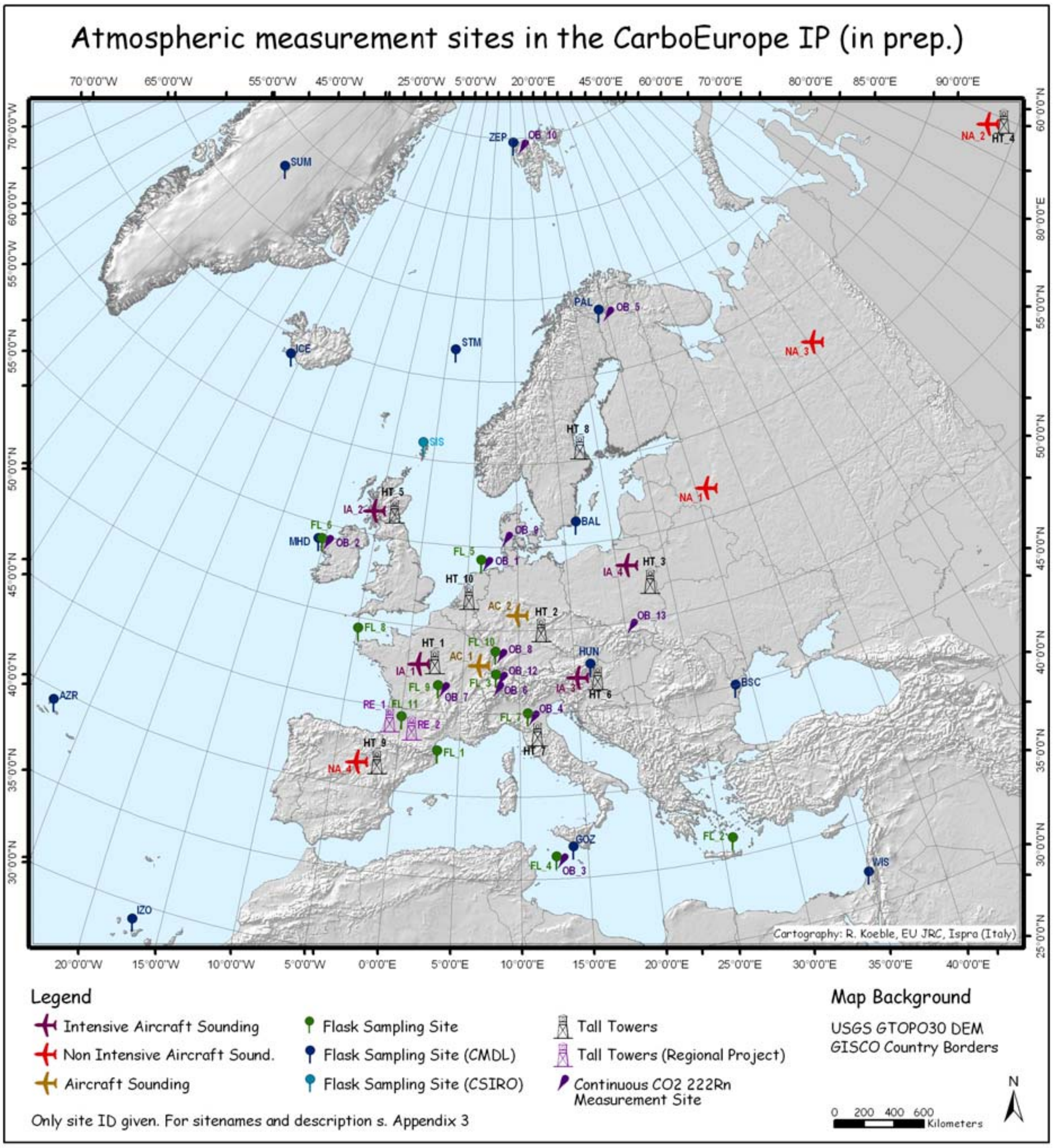


Figure 10 Geographical distribution of atmospheric observation sites (Appendix I-F)

Table 2 Sampling frequency at aircraft sites; Marked in yellow are sites where will be installed in-situ continuous CO_2 analyzers. At intensive aircraft sites (each 5 days) flask sampling at 10 altitudes will only be executed each 20 days. In-situ vertical profiles, aircraft flasks measurements (CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, ^{18}OCO) and information on sampling and atmospheric structure (Longitude, Latitude, Altitude, Date, Temperature, Pressure, Relative Humidity) will be reported on the database each 6 month.

Year	**2003**		**2004**		**2005**		**2006**		**2007**		**2008**	
Semester	*S1*	*S2*	*S3*	*S4*	*S5*	*S6*	*S7*	*S8*	*S9*	*S10*	*S11*	*S12*
Orléans (FR)	Each 20 d	Each 20 d	Each 20 d	Each 20 d	Each 20 d	Each 20 d	Each 5 d	Each 5 d	Each 5 d	Each 5 d	Each 5 d	Each 5 d
Bialystok (PL)	Each 20 d	Each 20 d	Each 20 d	Each 20 d	Each 20 d	Each 20 d	Each 5 d	Each 5 d	Each 5 d	Each 5 d	Each 5 d	Each 5 d
Griffin (SC)	Each 20 d	Each 20 d	Each 20 d	Each 20 d	Each 20 d	Each 20 d	Each 5 d	Each 5 d	Each 5 d	Each 5 d	Each 5 d	Each 5 d
Hegyhatsal (HU)	Each 20 d	Each 20 d	Each 20 d	Each 20 d	Each 20 d	Each 20 d	Each 5 d	Each 5 d	Each 5 d	Each 5 d	Each 5 d	Each 5 d
Schauinsland (D)	Each 20 d	Each 20 d	Each 20 d	Each 20 d								
Thüringen (D)	Each 20 d	Each 20 d										
La Muela (SP)					Each 20 d	Each 20 d	Each 20 d	Each 20 d	Each 20 d	Each 20 d	Each 20 d	Each 20 d

Component 3: Regional carbon budget and its driving forces ("Regional Experiment")
Component Leader: A.J. Dolman, VU-A
CarboEurope Data Centre for regional experiment data: J. Noilhan, CNRM

Mission

The Regional Experiment of CarboEurope-IP will produce aggregated regional estimates of ground based data that can be meaningfully compared to those from the smallest downscaled information of atmospheric measurements and continental scale inversion results.

Objectives

3.1 To determine the spatially explicit regional balance of CO_2 over an area (300*300 km) in South West France at a typical model grid resolution of 2 km every day during a full year based on atmospheric and ground based measurements (MO2, 4, 8).
3.2 To provide combined datasets of concentrations, fluxes, and remote sensing, with the highest possible density for developing innovative downscaling and upscaling methods to quantify the carbon balance of the target region within a multiple constraint framework (MO3).

***Methodology** (slightly shortened)*

The central methodology of the experiment is to make both concentration measurements within and above the boundary layer and to couple those via a modelling/data assimilation framework to the flux measurements at the surface and within the boundary layer. This multiple constraint approach has not been tried before (e.g. HAPEX-Sahel, Boreas, Fife) because in these experiments atmospheric concentration measurements were not made. We will apply the multiple constraint method for the first time in a regional experiment.

The advent of small specialised aircraft in the past decade, measuring fluxes at a resolution of 1 to 2 km and with comparable accuracy to tower fluxes, has greatly increased the possibilities to provide accurate estimates of spatial heterogeneity. Also atmospheric mesoscale models are now powerful tools to study regional CO_2 exchange (e.g. Dolman et al., 2003). This development has been further taken up in Recab, so that non-hydrostatic mesoscale models can simulate the surface-atmosphere exchange of CO_2 at resolutions comparable to that of flux aircraft and single flux towers (e.g. 1-2 km). For such transport models applied to a limited area, the boundary conditions will come from atmospheric coarser scale models used in the Continental Integration Component. A prime requirement to successfully use high resolution meso scale models for CO_2 inversion of sources and sinks is the existence of accurate *a priori* flux distribution and high resolution spatially and temporally distributed map of fossil fuel sources. Realistic mapping of the surface fluxes relies on information on land cover, and surface biophysical parameters (LAI, albedo) that can be obtained from high resolution (e.g. Landsat, Spot, Aster) and high repetitiveness (e.g. Vegetatio, Modis, Meris) spaceborne images.

In addition to high resolution atmospheric transport and inverse methods for determining surface CO_2 fluxes, we will also use high resolution flux modelling. The atmospheric mesoscale transport models are fitted with land surface packages (SVAT) and are excellent tools to act as a host platform for data assimilation of field and model data.

In order to separate the anthropogenic sources of CO_2 in the target region, we will collect continuously high precision samples of radiocarbon ($^{14}CO_2$) which can unambiguously trace fossil fuel emissions. Wherever possible, based on the Atmosphere Component results that will deliver a "calibration" of CO versus $^{14}CO_2$, we will use CO as a tracer to eliminate the influence of anthropogenic CO_2 advected into the area.

We will prove the concept in 2004 by a re-assessment of the Recab results, we will have an intensive test campaign in 2005 to study the effect of heterogeneity and plan a one-year experiment. We will have a one-year, strategically focused high intensity experimental campaign (Extended Observation Period, EOP) in 2006. The last two years are for integration of data and results.

The area chosen for this experiment is in South West France including the "Les Landes" forest, the city of Bordeaux and a large agricultural area to the East. The area for the regional experiment is shown in Figure 11. The area is chosen because of the good contrast of atmospheric scalar concentrations between sea and land, several large areas of homogeneous land cover and existing high-resolution databases and extensive modelling experience of CNRM (Météo-France) in Toulouse. This allows to develop the methodologies for regional carbon monitoring in a relatively simple, well-defined area with excellent data coverage.

We will install a set of ground based surface flux measurements, extra radio soundings and wind and temperature profilers and perform aircraft measurements with low flying flux aircraft, perform boundary layer sampling with small commercial aircraft, and perform longer trajectories with a research aircraft. At the in- and outflow boundaries of the domain we will install at one to two tall towers high precision measurements of CO_2 and ^{14}C.

The Intensive Observation Period (IOP) of 4 weeks in the summer of 2005 will have high intensity observation of boundary layer development and extra flux aircraft for enhanced spatial sampling. The high temporal resolution will allow us to better parameterise our models to deal with rectification effects. We envisage the deployment also of an extra low flying aircraft with a remote sensing platform in the Test Campaign, that will enable us to assess the spatial heterogeneity of the area in greater detail and will provide important data for use in improving and testing future and current satellite retrievals.

This set-up will be used to close the top down atmospheric carbon balance of the region. We will apply also bottom up modelling to account for the slowly varying processes. To have a set of driving variables of surface weather, we will produce a downscaled synoptic weather analysis at 8 km resolution by CNRM, Toulouse. This allows the use of biogeochemical models to produce bottom up estimates periods of up to 20 years at the resolution of the land surface characterisation (1-2 km).

The organisation of the Regional Experiment through different Activities, and their main objectives is shown in Figure 12. This figure also shows the interaction between the activities in Component 3 and the other CarboEurope-IP Activities. Component 3 is an important intersection between all Components with regard to data input (Components 1 and 2) and modelling and data assimilation (Component 4).

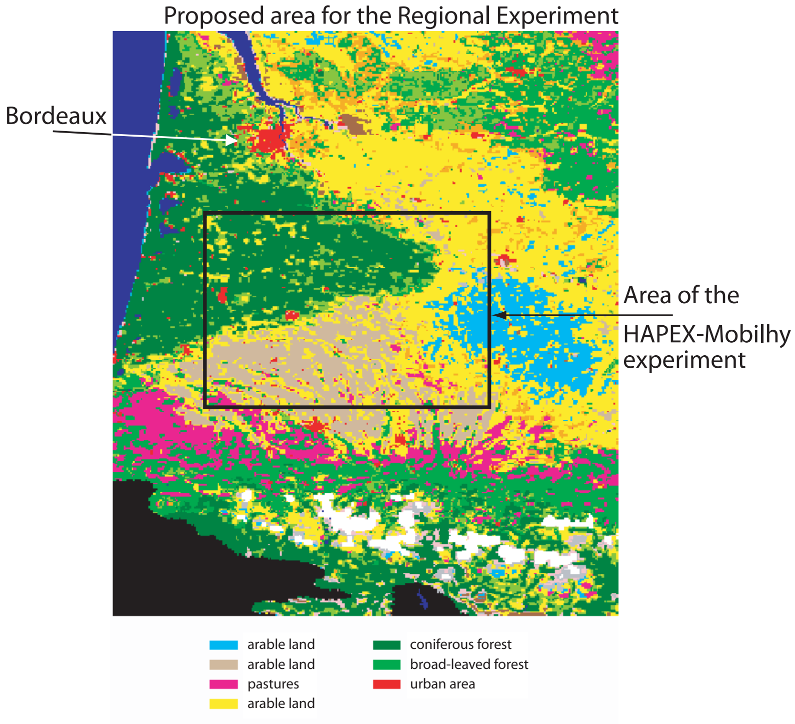


Figure 11 Land cover map of the area for the Regional Experiment of CarboEurope-IP derived from SPOT4/VEGETATIO at 1 km resolution and the Area of the HAPEX Mobilhy experiment.

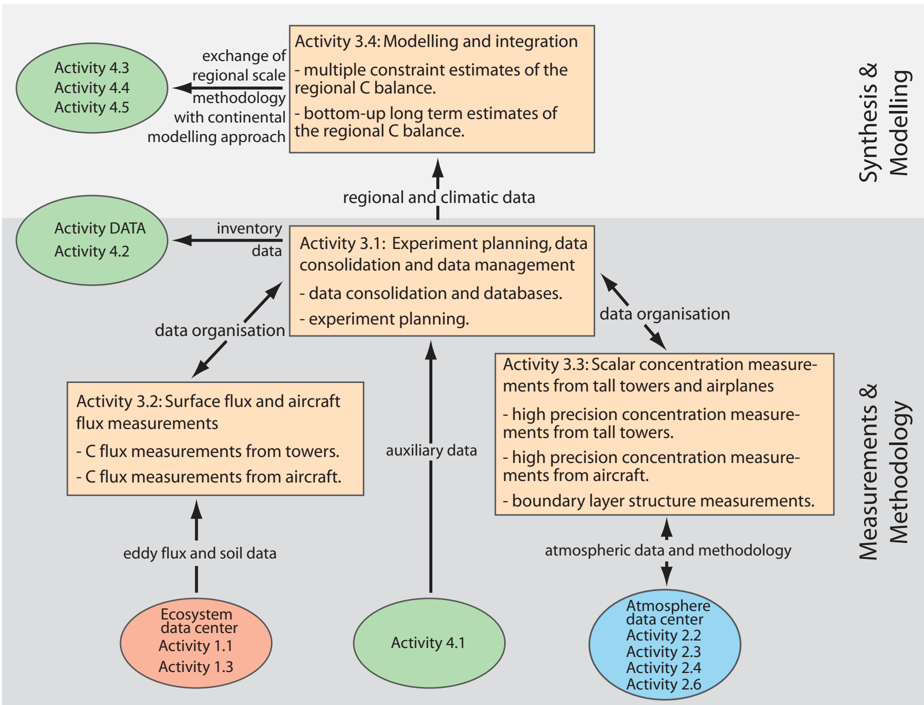


Figure 12 The organisation of the Regional Experiment through different Activities and their objectives. The arrows indicate the to other Activities in the CarboEurope-IP

Main expected results

The Regional Experiment Component will provide a multiple constraint estimate of the regional carbon balance at 2 km x 2 km resolution for 2006 based on a data assimilation system. This innovative data assimilation systems will be capable of assimilating land surface, remote sensing, atmospheric data at regional scale. We will also extend the time frame of the one year analysis with bottom up estimates of the regional carbon balance at typically 2 km x 2 km resolution to the period 1980-2005.

The main expected results of the Regional Experiment are:

- To provide these data assimilation activities with the required input data we will collect datasets of concentration of CO_2 and trace gases in the boundary layer, flux estimates of small towers and aircraft and various supporting data fields of biophysical characteristics and soils and biomass inventories.
- To provide a framework for an observation system, that is capable to derive a regional carbon balance from a limited set of observations and from modelling.

Activity 3.1 Experiment planning, data consolidation and data management

Activity Leader: J. Noilhan, CNRM

Objectives (5 yr plan)

O3.1.1 To collect existing main driving climate, weather, soil and land use characteristics of the area.

O3.1.2 To produce a 2 km resolution database of fossil fuel emission for the area.

O3.1.3 To produce a geo-referenced set of forest growth and land use data since 1980.

O3.1.4 To optimise flight and deployment patterns for the experimental aircraft and ground based systems using a high-resolution modelling framework.

O3.1.5 To develop and maintain an easily accessible system for data entry, storage and retrieval for all regional modelling efforts.

O3.1.6 To compile, check, store and make available the data of the Regional Experiment Component.

Outline of work plan

Tasks 3.1.1. The main purpose of this task is to provide estimates of the carbon balance of the region using all available data and atmospheric model information. It will involve inventories of existing data (Obj 3.1.1), a new assessment at high resolution (2 km) of fossil fuel emissions of the area of the experiment.

Task 3.1.2: For the slow cycle, we will use the 8 km resolution downscaled weather information that is available at CNRM and will be extended for use in biogeochemical models. These models will be calibrated with flux data for the main land use types and then run for a 20-year period. The required input data on land use history and management is obtained in WP1. We intend to use the MesoNH model, which will be extended to carry CO_2 in the simulation.

Task 3.1.3: For the fast cycle we will use a data assimilation system at mesoscale that mirrors the system developed for the large scale (Camels and Continental Integration Component). We will mainly use the French Arome system developed at CNRM for this purpose and extend it to carry CO_2 in the assimilation procedure.

Task 3.1.4 Operation of data centre for atmosphere data

The data base of the regional experiment will primarily be based at CNRM. The Data Centre of the regional component receives, checks and stores the data of the component, delivers meta-data to the Central Database and creates links for data access with the Central Database. The regioanl component has assigned Dr. Noilhan of CNRM as Data Centre manager. It will contain links to the RECAB database and consolidated datasets of the RECAB campaigns. It will contain in an easily accessible form all the data the reanalysis of the RECAB campaigns, main driving climate, weather, soil and land use characteristics of the area of the Regional experiment, the 2 km resolution data of fossil fuel emission for the area and a geo-referenced set of forest growth and land use data since 1980. It will contain all the experimental data collected during the experiment (aircraft data, meteorological data and surface observations and remote sensing).

Partners and responsibilities

Responsible PI for Data of the Activity: J. Noilhan, CNRM

Partners: J. Noilhan, CNRM, A.J. Dolman, VU-A, P. Cias, LSCE, R.W.A. Hutjes, Alterra, S. Reis, Univ. Stuttgart, Y. Brunet INRA

CNRM responsible for running WP1 and Data Centre. Responsible for performing high resolution runs with Meso-NH for experiment planning;

VU-A responsible for performing high resolution runs with the RAMS model for experiment planning;

LSCE responsible for atmospheric CO_2 measurement data,

Alterra for providing links to RECAB data and additional RAMS model runs,

INRA for surface flux and inventory data collection,

Univ. Stuttgart for fossil fuel inventory.

Establishment and operation of data centre for atmosphere data: J. Noilhan, CNRM

Delivery of data according to data policy: all partners of Regional Experiment Component

Activity 3.2 Surface flux and aircraft flux measurement

Activity Leader: F. Miglietta, IBIMET-CNR

Objectives (5 yr plan)

O3.2.1 To take measurements of CO_2 fluxes and energy balance above the main vegetation types in the region during the five year period and during the intensive observation period.

O3.2.2 To perform regular measurements of the fluxes of heat, water vapour, CO_2 and momentum with a low flying research aircraft (Sky Arrow).

O3.2.3 To measure the city emissions of Bordeaux and Toulouse at selected periods.

Outline of work plan

Task 3.2.1 Continuous tower-based measurements. Measurements are taken along the most dominant land cover types in the experimental domain (see detailed 18 month plan) by INRA and CNRM and Alterra additional during the intensive period.

Task 3.2.2 During **the test campaign** IBIMET and ISAFOM will fly their Sky arrow in the domain to test the feasibility and produce test data for modelling development as well as producing high resolution **visible RS images of the area around tower location and selected transects.**

Task 3.2.3 During the **intensive campaigns** Alterra will bring in an additional Sky Arrow for flux measurements.

Partners and responsibilities

Responsible PI for Data of the Activity: F. Miglietta, IBIMET-CNR

Partners: F. Miglietta, IBIMET-CNR, Magliulo, ISAFOM, R.W.A. Hutjes, Alterra J. Noilhan, CNRM, Y. Brunet, INRA

IBIMET responsible for running activity 2 and operating Sky Arrow flights together with ISAFOM and Alterra during test and intensive periods. CNRM and Alterra for operating additional sites during the full intensive observation period, INRA for running continuous sites and one extra site during intensive period.

Activity 3.3 Scalar concentration measurements from tall towers and aircraft

Activity Leader: J. Lloyd, MPI-BGC

Objectives (5 yr plan)

O3.3.1 To take high precision measurements of CO_2 concentrations and ^{14}C at one to two tall towers at the in- and outflow of the domain.

O3.3.2 To perform regular flights with small aircraft to sample the boundary evolution of CO_2 concentrations and ^{13}C.

O3.3.3 To perform at fixed locations continuous measurements of windspeed and temperature in the boundary layer with a profiling system.

O3.3.4 To perform twice daily radio soundings at a regular radio sounding site in Bordeaux, augmented with an intensive campaign in the summer of 2005 where bi-hourly releases will track the evolution of the boundary layer.

Outline of work plan

Task 3.3.1 Tall tower-based scalar concentration measurements. The installation of the two towers is detailed in the 18 month workplan. At the inflow and outflow positions of the domain (near Toulouse and Bordeaux) one to two towers equipped with high precision gas chromatographs will measure the concentrations of CO_2, and ^{14}C (depending on national resources). CMDL NDIR-CO_2 sensors are built for this purpose. Implementation will start in 2005.

Task 3.3.2 Airborne flask sampling. A small commercial plane will sample the boundary layer structure for CO_2, ^{13}C and CO for 3 to 5 days. Flask samples will be analysed at MPI-BGC. During the intensive campaign, flights are planned on 1 day every week to take 3 profiles at 5 levels in the boundary layer.

Task 3.3.3 Radio soundings. We will extend the routine WMO observations at Bordeaux during the test campaign and later during the full campaigns. We will also install UHF profile systems and RASS_Sodar systems at a location where they contribute most to our understanding of the heterogeneity of the area.

Partners and responsibilities

Responsible PI for Data of the Activity: J. Lloyd, MPI-BGC

Partners: P. Cias, LSCE, A.J,. Dolman, VU-A, J. Noilhan CNRM.

MPI-BGC has overall responsibility for activity 3 and is responsible for the CBL flights and subsequent flask analysis,

LSCE will install and maintain the CO_2 sensors at the in- and outflow of the domain and oversee the implementation of a CO_2 chromatograph in the Piper Aztec for transect flights,

CNRM is responsible for the Piper flights and additional radio sounding near Bordeaux and during the intensive campaign,

VU-A will install and maintain a RASS-Sodar system in the experimental area during the campaigns.

Activity 3.4 Modelling and integration

Activity Leader: A.J. Dolman, VU-A

Objectives (5 yr plan)

O3.4.1 To reanalyse the RECAB campaigns with a set of regional models and to apply downscaling techniques with a view to better planning the experiment and guiding the model development

O3.4.2 To develop and apply a multiple constraint data assimilation system that produces the best possible estimates of the regional carbon balance at the grid of the atmospheric model (2 km) for the year 2005.

O3.4.3 To produce a long term (20 years) bottom up estimate at 2 km resolution of the carbon balance of the region.

O3.4.4 To separate the biospheric sink in the region from the contribution of anthropogenic sources.

Outline of work plan

Task 3.4.1 We will reanalyse the RECAB campaigns with mesoscale models (RAMS, Meso-NH) and apply down scaling techniques (inverse models), to guide both the development of the data assimilation system and the planning of the experiments. This will lead to a "proof of concept".

Task 3.4.2 In the first 18 months we will initiate the development of this regional CDAS in parallel with effort in CAMELS. For the **slow cycle**, we will use the 8 km resolution downscaled weather information that is available at CNRM, which will be extended for use in biogeochemical models. These models will be calibrated with flux data for the main land use types and then run for a 20-year period. The required input data on land use history and management is obtained in WP1. The models we intend to use, comprise Orchid, LPJ, ISBA-A-g_s. We will concentrate on setting up uniform calibration and model procedures in the first 18 months, 20 year runs will be ready towards month 48.

Task 3.4.3 For the **fast cycle** we will use a data assimilation system at mesoscale that mirrors the system developed for the large scale (Camels and Continental Integration Component). We will mainly use the French Arome system and Meso-NH developed at CNRM for this purpose and extend it to carry CO_2 in the assimilation procedure. This will be used finally to separate biospheric from anthropogenic sources.

Partners and responsibilities

Responsible PI for Data of the Activity: A.J. Dolman, VU-A

Partners: J. Noilhan, CNRM, P. Cias, LSCE, R. Hutjes, Alterra, M. Sanz, CEAM

VU-A is responsible for the overall running of this activity and will apply RAMS to the area and further develop inverse modelling techniques for regional downscaling and be involved in the calibration of land surface schemes,

CNRM will initially extend Meso-NH to carry CO_2 and will later be central in the development of the carbon assimilation part of Arome, the French assimilation system,

LSCE will provide the CO_2 field from larger scale analysis and run the 20 year model Orchid,

Alterra and CEAM will apply RAMS initially to RECAB runs and be later involved in the high resolution runs.

Component 4: Integration of Scales and Carbon Data Assimilation Methods ("Continental Scale Integration")
Component Leader: M. Heimann, MPI-BGC
CarboEurope Data Centre for synthesis and central meta-database: M. Heimann, MPI-BGC
CarboEurope Data Centre for auxilliary data: G. Seufert, JRC-IES

Mission

To assess the present European carbon balance, its component processes and its variability on a continuum of spatial scales going from local (10 km) to continental (5000 km), by combining the data streams of flux measurements, concentration measurements, forest and soil carbon inventories and merge them with additional information from remote sensing, process understanding and modelling into a continental Carbon Data Assimilation System (CDAS).

Objectives

4.1 To develop advanced modelling tools for estimating the spatially explicit continental carbon balance and its variability at a resolution of 10 to 50 km for at least the length of a Commitment Period (MO1, 2, 4, 7, 8).
4.2 To test a multiple constraint approach by applying top down and bottom up methodologies to achieve the best possible estimate of the European carbon balance and to determine the variation in biospheric and anthropogenic fluxes over Europe (MO2).

Methodology

The primary data streams generated in CarboEurope cover very different spatio-temporal domains. These different scales of the observational data streams have to be bridged by means of a numerical modelling framework. Remote sensing data, which do cover the scales from the individual plot to the entire continent and from weeks to several years, do not record directly the carbon balance, but only certain features of the vegetation, such as the fraction of absorbed photosynthetically active radiation, albedo and, with limitations, aboveground biomass. However remote sensing information can be used to drive numerical models and thus help bridge the scales between the different observational data streams. Using this approach, several independent bottom-up and top-down methods will be applied and compared against each other for consistency and finally merged into a European scale Carbon Data Assimilation System to determine the European carbon balance over the past and present decade. In order to cover the past, present and future evolution of the European carbon balance on longer time scales (100-200 years), however, requires the use of prognostic numerical terrestrial ecosystem models, which have to be tested against the rich observation data sets compiled in CarboEurope.

The common denominator spatial scale will be the "**Eurogrid**", i.e. a spatial scale with grid elements of 20-50 (100) km (to be decided), on which the European carbon balance can be estimated independently by the different methods. This is a grid size that an atmospheric mesoscale model, covering the whole continent and nested in a global weather/climate model, can handle without taking recourse to sophisticated downscaling techniques. Hence terrestrial ecosystem carbon models (TEMs) developed for this grid resolution (E.g. LPJ, ORCHIDEE, BETHY, Biome-BGC, Triffid, ED) have or can all be coupled relatively straightforward with the land-surface model of an atmospheric mesoscale model. On the other hand, the Eurogrid is the grid size which is also accessible by means of upscaling with site-specific models using high-resolution georeferenced surface characteristics (topography, hydrography, edaphic conditions, ecosystem and agriculture distribution, land management information, etc.) from remote sensing and statistical data (see Regional Experiment, Component 3) and information from flux site clusters.

In the **top-down** approach spatio-temporal variations of the atmospheric CO_2 concentration observed by the Atmosphere Component of the CarboEurope-IP (Component 2) are used to infer the net surface exchange fluxes by means of inverse atmospheric modelling. CO_2 inverse modelling will be complemented by multitracer analyses. Thereby, measurements of atmospheric O_2/N_2 and □ ^{13}C in CO_2 ratios will help to separate oceanic from terrestrial contributions, while radiocarbon ($^{14}CO_2$) and CO will independently constrain the fossil emissions within Europe. Transport tracers such as SF_6 and CFCs measured at some stations and ^{222}Rn measured at all stations will be used to check on the performances of atmospheric transport models, and if necessary, used to improve them. As an added value, and although the focus of the project is CO_2, the sources of CH_4 and N_2O will also be analysed using the same inverse modelling method, which will provide a better quantification of the European sources of these species.

The inversion modelling work will be based on the methods established in the Aerocarb project within FP5. Several high-resolution global models of atmospheric transport based on the observed meteorology from weather forecast models, or nested limited area mesoscale atmospheric circulation models will be used to model the atmospheric transport: LMDZ, REMO, DEHM, TM3/5, MM5, RAMS. The problem of atmospheric inversions being mathematically underdetermined is addressed using a Bayesian approach by means of careful inclusion of a priori information on magnitude, location and uncertainty of the various surface-atmosphere CO_2 fluxes.

Bottom-up approaches proceed by extrapolating surface *in situ* process information (e.g. ecosystem functioning, weather and climate, land use, etc.), net ecosystem fluxes observed at individual flux towers, or by extrapolating local or county level carbon inventory data. In the Continental Integration Component we will use four types of bottom-up modelling approaches based on different and complementary concepts:

- high-resolution process based soil-vegetation-atmosphere transfer models (SVAT) using detailed land cover and land use information from remote sensing and georeferenced statistical data to scale up from the footprint of individual flux towers to whole landscapes, and from there to larger regions,
- neural networks trained on *in situ* observations of net carbon fluxes at the flux towers, using remote sensing and weather fields and georeferenced statistical data for upscaling carbon fluxes and their variability over individual ecosystem types,
- statistical extrapolation methods to scale up soil and forest carbon inventory changes) to whole ecosystems and to the entire European terrestrial biosphere,
- process based terrestrial ecosystem models (TEM) which may be coupled to atmospheric mesoscale

circulation models via their SVAT component, operating on the Eurogrid (20-50 (100) km) tiling the continent or the entire terrestrial biosphere of the Earth, and encompassing long time scales such as those involved in soil processes or ecosystem dynamics.

The bottom up approach will also include an enhanced mapping of spatial and temporal patterns of fossil fuel emissions at the Eurogrid scale because fossil fuel burning is the largest flux constituent of the European carbon balance. Building on the work of the CarboEurope-GHG Concerted Action in FP5, where 50 km resolution maps of fossil CO_2 will be created fossil emission maps possibly will have to be improved over targeted areas, and they will have to be extended to cover also the mapping of industrial emissions of key tracers measured in the Atmospheric Component (CO, SF_6, CH_4).

Ultimately, the bottom-up and top-down approaches will be merged into a **Carbon Data Assimilation System (CDAS)**. In this approach, coupled land surface – terrestrial ecosystem models (LSM-TEM) run coupled in an atmospheric high-resolution global or nested limited area mesoscale model (M-AGCM). In this system, data streams of different quality, temporal and spatial characteristics are merged in an optimal way which is mathematically consistent with the dynamics that govern the evolution of the system. This approach is similar to the techniques employed in numerical weather forecasting. This activity will build on the work of the Camels FP5 project. In CarboEurope-IP the very much enhanced observational datasets over the European domain will be used for constraining surface fluxes on much finer spatial and temporal scales (Eurogrid, daily-weekly) using the same methodology as in Camels.

A major goal of the integration activity consists in rigorous, **quantitative consistency checks** addressing fully each of the inherent uncertainties of the different modelling and extrapolation approaches. This will be performed by a series of benchmarking exercises in which modelled carbon flux estimates for defined target areas will be inter-compared and evaluated, where possible, against independent observations. This activity will be closely co-ordinated with the modelling activity in the Regional Experiment Component that provides the high resolution test bed for this. Additional target areas will be defined in several of the major ecosystems in Europe and selected on the basis of data availability and existence of high-resolution mesoscale model analyses.

In order to reconcile the top-down and bottom-up approach, several **additional, minor[1] carbon flows** have to be addressed as well. These include carbon flows through trade products, VOC emissions from the vegetation, CH_4 from natural and anthropogenic sources, CO from incomplete fossil fuel burning, carbon transport by rivers, weathering and erosion fluxes, carbon stored in reservoirs and lakes, and carbon fluxes from marginal seas and continental shelves.

The organisation of the Continental Integration Component through different Activities is shown in Figure 13. This figure also shows the interaction between the activities in Component 4 and the other

[1] we use the term minor in comparison to the main biospheric flows of NPP and fossil fuel emissions, realising that these minor flows can on occasion by relatively large in terms of carbon amounts

CarboEurope-IP Activities. Component 4 is the core link between all Components with regard to data input (Components 1, 2, 3) and modelling and data assimilation (Component 3).

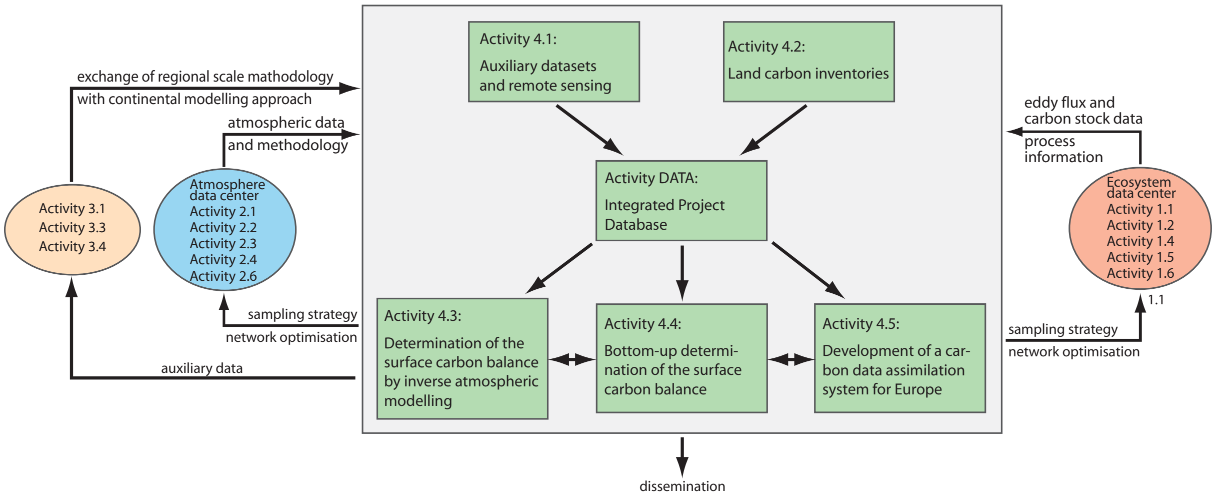


Figure 13 The organisation of the Continental Integration Component through different Activities. The arrows indicate the relation to other Activities in the CarboEurope-IP

Expected Results

The Continental Integration Component will provide several synthesis products:

- Upscaling of local information to landscapes or small regions (20-50 km).
- Assessment of present and past continental and national carbon balance for various sectors (agriculture, forest, grasslands) on a spatial typical grid of 20-50 km.
- Assessment and advanced understanding of variability and uncertainty of net carbon fluxes based on the different modelling/integration approaches.
- Optimisation of the observation strategy in order to determine cost-effective measurement network solutions for longer term monitoring and to further reduce uncertainties.

Activity 4.1 Auxiliary Datasets and Remote Sensing

Activity leader: G. Seufert, JRC-IES

Objectives (5 yr plan)

O4.1.1 To compile the geographically referenced datasets to drive terrestrial ecosystem models (e.g. climate drivers, land use history).

O4.1.2 To compile geographically referenced datasets from remote sensing of the state of the vegetation (e.g. FAPAR, albedo) and of land cover and to provide high resolution land cover information around selected ecosystem Main Sites.

O4.1.3 To compile geographically referenced datasets on "minor" carbon flows that are needed to correctly reconcile atmospheric with surface ecosystem measurements.

Outline of work plan

Task 4.1.1: Primary datasets to be compiled as drivers for the TEMs
Task 4.1.2: Surface biophysical products from various spaceborne instruments
Task 4.1.3: Compilation of minor and background carbon fluxes
Common description of tasks:
The activity aims at compiling European continental datasets required for driving and constraining the different modelling approaches used within the integration component. Datasets of various types and from multiple sources will be checked for consistency and completeness, will be georeferenced and interpolated to a common spatial scale denominator, the EUROGRID. The activity will build on resources developed in FP5 projects CARBODATA and CARBOEUROPE-GHG, as well as on data products available from the CEE focus of GTOS/TCO and from UNECE programmes (ICP, EMEP). It will follow the standards and protocols developed within the INSPIRE initiative (Infrastructure for Spatial Information in Europe) of the European Commission. Major data sets will be compiled through interfacing to and processing of European wide data available / elaborated in different JRC-Actions (e.g., ARSM, MARS, ESDI, INFOREST, AGRIENV, MOSES/PRISM, TEM, MONMAR, TRADEOFF) and in other European services like EEA and EUROSTAT.

We will create a database of a wide range of thematic geographical information layers, to be organised in the framework of the distributed database of the IP through directly linked meta-information to and data exchange protocols.

Partners and responsibilities
Responsible PI for Data of the Activity: G. Seufert (JRC-IES)

Partners: G. Seufert, R. Koeble, V. Pagliari, R. Baritz, A. Leip (IES, Action GHG DATA) M. Verstraete, N. Gobron, B. Pinty (IES, Action ARSM). Several partners of CARBOEUROPE-IP providing datasets from other projects, e.g., M. Heimann, MPI-BGC, R. Valentini, UNITUS, P. Ciais, LSCE, S. Reis, Univ. Stuttgart

IES-GHG Data responsible for primary datasets and minor/background carbon fluxes (task 4.3.1 and 4.3.3)
IES-ARSM responsible for Remote sensing products (Task 4.3.2)

Activity 4.2 Land Carbon Inventories
Activity leader: G.-J. Nabuurs, ALTERRA & EFI

Objectives (5 yr plan)

O4.2.1 To provide georeferenced biomass and soil carbon inventories needed for terrestrial ecosystem models, inverse modelling and the carbon data assimilation system.

O4.2.2 To provide an independent estimate of the contemporary continental scale forest sector carbon balance (forest biomass, soils and wood products).

O4.2.3 To develop methods and algorithms for upscaling of georeferenced soil and forest inventory data and spatial extrapolation using a neural network approach in order to quantify carbon stock changes on 5-10 year averages over the last 50 years.

O4.2.4 To analyse influence of adoption of GPG LULUCF on methods for "Bottom Up" calculation of carbon budgets on plot level (georeferenced) for Kyoto Protocol Art. 3.3. and 3.4

O4.2.5 To develop a network for compiling a European soil carbon balance for forests, croplands and grasslands, to be implemented in the frame of the European Soil Information System (EUSIS).

Outline of work plan

Work will be performed along the 4 main tasks:

Task 4.2.1: Compilation of a European scale high-resolution gridded representation of forest inventory data for use in the inverse (activity 4.3) bottom-up (activity 4.4) and data assimilation modelling (activity 4.5).

Task 4.2.2: A co-operation framework will be developed between JRC and national soil carbon monitoring experts. The network will use COST E21 (Contribution of Forests and Forestry to Mitigate Greenhouse Effects) as well as the CarboInvent soil partners as the basis to extend the study domain into the eastern European countries.

Task 4.2.3: Development and application of suitable methods and algorithms for the integration of georeferenced data (land carbon inventories) by using neural networks and fuzzy techniques..

Task 4.2.4: A study of methods for "Bottom Up" calculation of carbon budgets on plot level (georeferenced) for Kyoto Protocol Art. 3.3. and 3.4 following the acceptance of IPCC Good Practice Guidance for LULUCF.

Partners and responsibilities

Responsible PI for Data of the Activity: G.-J. Nabuurs, ALTERRA

Partners are: ALTERRA, European Forest Institute, Joint Research Centre, Joanneum Research, and Tu Dresden

Main responsible is

O4.2.1. G.-J. Nabuurs, European Forest Institute,

O4.2.2 G.-J. Nabuurs, ALTERRA

O4.2.3 M. Köhl, TU Dresden

O4.2.4. B. Schlamadinger, Joanneum Research

O4.2.5 R. Baritz, Joint Research Centre

Activity 4.3 Determination of the Surface Carbon Balance by Inverse Atmospheric Modelling
Activity leader: P. Peylin, LSCE

Objectives (5 yr plan)

O4.3.1 To develop and apply nested mesoscale modelling systems to infer from atmospheric CO_2 concentration measurements surface sources and sinks and their uncertainty over the European continent with a spatial resolution of 100 km and a weekly temporal resolution for 1998 to 2008.
O4.3.2 To optimise the network and sampling strategy in order to arrive at a cost-effective, optimal atmospheric observation network.
O4.3.3 To investigate new remote sensing methods that may improve the capability of inverse modelling to constrain the sources and sinks of CO_2.

Outline of work plan

Task 4.3.1: Network representativity and optimization studies of atmospheric observations.
Task 4.3.2: Multi-species simulations for different transport models in a forward mode (prior to a multi-species inversion). Simulated isotopic composition of CO2 (^{14}C, ^{13}C, and ^{18}O) and O_2/N_2 ratio will be compared at ground station as well as CO and CH_4 concentrations using existing chemical modules in the atmospheric models.
Task 4.3.3: European single- and multi-species inversions and critical analysis of flux estimates and their uncertainties at high spatial and temporal resolution.
Common description of tasks:
Work relating to this activity will be performed in several iterations, each involving the following steps:

- determination of inversion model setup protocol, including the specification of the network of atmospheric observations to be used in the inversion
- set up (driver datasets, boundary conditions etc.) of the nested atmospheric models of the project partners
- Computation of the base functions
- Inversion computation
- Analysis of the results including uncertainty assessment and comparison with bottom-up flux estimates (Activity 4.4).

The first iteration is expected to take about 18 months. It will employ various subsets of the current and planned atmospheric observation sites (ground sites, towers and aircraft profiles) of the Atmosphere Component in order to assess the resolving power of the respective observational networks. Subsequent iterations will employ increased model resolution, more extended inversion periods and newly obtained observations from the observational program of the Atmosphere Component.

Partners and responsibilities

Responsible PI for Data of the Activity: P. Peylin, LSCE

Partners are : MPI-BGC, HADLEY, VU-A, SRON, NERI
Main responsible is
O4.3.1 P. Peylin, LSCE
O4.3.2 M. Heimann, MPI-BGC
O4.3.3 S. Houweling, SRON

Activity 4.4 Bottom-up determination of the surface carbon balance
Activity leader: M. Heimann, MPI-BGC

Objectives (5 yr plan)

O4.4.1 To provide estimates of NBP and constituent carbon fluxes (e.g. photosynthesis, respiration, disturbance fluxes) in the areas of the ecosystem Main Sites.
O4.4.2 To provide monthly estimates of net ecosystem exchanges of carbon across Europe over the last 200 years based on the past history of climate, land use and nutrient inputs.
O4.4.3 To evaluate and compare mean integrated fluxes and their variability based on the different bottom-up modelling approaches in the areas of the ecosystem Main Sites at the scale of a Eurogrid cell by using prescribed boundary conditions (climate, land use, specified land cover).
O4.4.4 To elucidate the mechanisms responsible for the contemporary land carbon sink (in Europe and elsewhere), isolating the contribution due to direct land management.

Outline of work plan

Task 4.4.1: Neural network modelling with $NETWORK_{NEE}$ to estimate NEE fluxes for the forest sector.
Task 4.4.2: High resolution process-based stand modelling for selected cells of the Eurogrid using the $PROXEL_{NEE}$ (as well as PROXEL derived models for radiation use efficiency – RUE - and PROXEL parameterized BEPS).
Task 4.4.3: TEM simulations on the Eurogrid spatial scale over the entire European continent. These models include LPJ, ORCHIDEE, BETHY, Biome-BGC, and Triffid.
Common description of tasks:
Work to be performed includes the implementation, evaluation, optimization and application of georeferenced surface flux models over the European domain, based on statistical methods (e.g. Neural networks) or based on ecosystem process understanding. These models will be used to (a) bridge the spatial gap between point measurements at individual flux sites and the spatial scale of individual Eurogrid grid cells, and (b) scale up over the entire continent in order to determine the European carbon balance and its constituent mechanisms. Simulations (a) will be relatively short term using high

resolution (1km^2) driver data (e.g. from remote sensing), while the simulations on the Eurogrid (b) will include the full history of land use and land management changes, as well as climate variations over the last 100-200 years.

Driver datasets will consist of GIS based statistical information (e.g. topography, land use, land use history, etc.), meteorology (from ECMWF analyses) and remote sensing data (e.g. fPAR). The models will be either calibrated or evaluated at the individual flux tower sites. A second model evaluation will be performed by comparison of the model results with the carbon inventory datasets obtained in Activity 4.2.

The European scale flux maps determined with these bottom-up model simulations will be critically intercompared in order to assess model uncertainty. The flux estimates will also be compared with the flux estimates from the top-down inversion approach (Activity 4.3), thereby taking into account the auxiliary carbon fluxes not explicitly represented in the surface flux models. By means of factorial simulations turning on or off individual drivers the effects and contributions of particular forcing factors will be studied.

Partners and responsibilities

Responsible PI for Data of Activity: M. Heimann, MPI-BGC

Partners: P. Ciais, CEA-LSCE; M. Heimann, MPI-BGC; P. Cox, MET-OFFICE, W. Cramer, PIK, R. Valentini, UNITUS, J. Tenhunen, UBT-PE

The following groups will be responsible for the simulations with the respective models:

CEA-LSCE:	ORCHIDEE
MPI-BGC:	Biome-BGC, BETHY
PIK:	LPJ
HADLEY:	Triffid
UNITUS:	$\text{NETWORK}_{\text{NEE}}$
UBT-PE:	$\text{PROXEL}_{\text{NEE}}$

Activity 4.5 Development of a carbon data assimilation system for Europe

Activity leader: P. Cox, Hadley Centre (UK)

Objective (5 yr plan)

O4.5.1 To develop a Carbon data assimilation system (CDAS) which optimally combines multiple data streams and models to produce operational estimates of the European carbon balance and its constituent contributions.

Outline of work plan

Task 4.5.1: Model validation and Uncertainty Analysis

Will utilise local flux and inventory data to improve process representation in TEMs, and to define Probability Distribution Functions (PDFs) of the key internal model parameters. Building on results of the Camels FP5 project, results of the carbon data assimilation system (CDAS) will be critically assessed and compared to the direct bottom-up and top-down estimates of surface fluxes. Based on this assessment an "optimal" map of the carbon fluxes over the European domain, including their temporal variability and an assessment of its uncertainty will be performed. The assessment will also include a critical evaluation and intercomparison of methods developed in similar efforts in the US (as part of the North American Carbon Plan), in Australia and in the Global Carbon Project of the IGBP.

Task 4.5.2: Development and application of a Carbon Cycle Data Assimilation System

The Camels FP5 project will upon its completion in 2004 provide a prototype of a which will allow the consistent inclusion of all carbon data streams (atmospheric observations, surface flux measurements and inventory data), together with meteorological information and remote sensing data sets in order to determine the spatio-temporal surface carbon flux fields. Based on this prototype in CarboEurope more refined versions will be constructed (higher spatial and temporal resolution, improved surface model, inclusion of high density of observations over the European domain) and applied on the Eurogrid for the time period 1998-2006. Will assemble all information on land-biosphere processes and observational datastreams into a common Carbon Data Assimilation framework (CDAS), which can estimate carbon sources and sinks over land at a spatial resolution of 50km and a temporal resolution of 1 day.

The assessment will provide the scientific basis for the final synthesis report on the carbon balance of Europe as determined by the observing system established in the CarboEurope IP.

Partners and responsibilities

Responsible PI for Data of Activity: P. Cox, MET-OFFICE

Partners:

Responsible for CDAS construction: P. Cox, MET-OFFICE, M. Heimann, MPI-BGC, P. Ciais, CEA-LSCE

Responsible for synthesis assessment: Lead and working groups with members from all project Components as determined before the synthesis phase (after Month 36).

Data centre of Integration Component: Activity DATA: The data base of Component 4 is located at central data base, which is described as a separate activity in Section 6.1.3. Component 4 has an own data base for remote sensing products and auxilliary data described in Activity 4.1.

Outline of time planning of Components and Activities

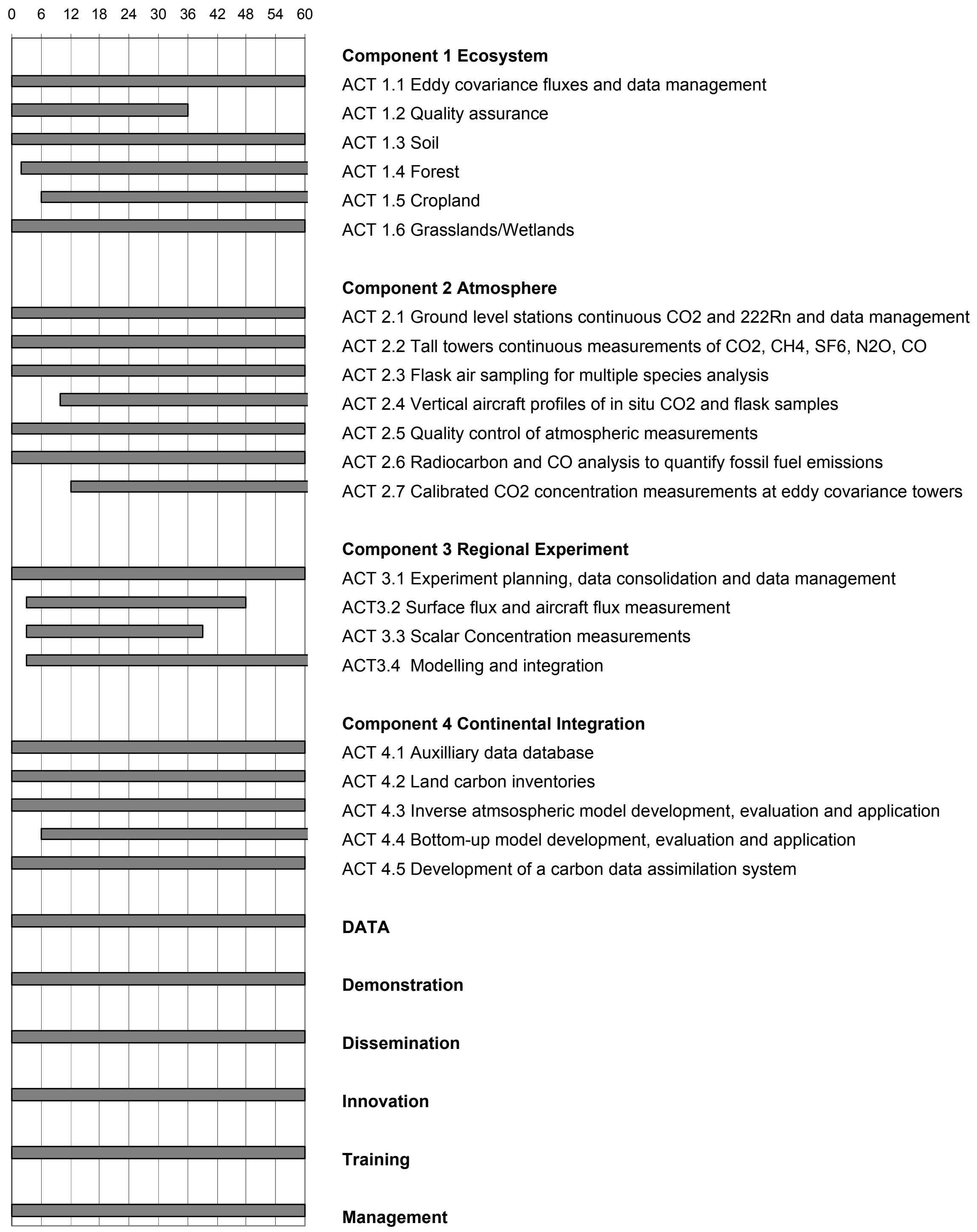


Figure 14 5-years time plan

6.1.3 Management of data and intellectual property rights (IPR)

Protection and exploitation of Intellectual Property

The allocation of Intellectual Property arising under this project between user and owner of Intellectual Property and the responsibilities for protecting and exploiting such Intellectual Property should be negotiated between user and owner in good faith. The user and owner will ensure that authors and inventors of Foreground Results will be compensated according to their applicable internal rules.

Data management

CarboEurope is based on partial funding from the European Commission. The participating Parties have agreed to deliver also data and knowledge produced from other funding sources. The PI and the administration of each participating Party are responsible that their scientific staff is informed about the obligation of data delivery according to this contract.

Data and knowledge are produced by technical staff and scientific staff. The ownership of data is defined in the model contract and the Consortium Agreement.

Data delivery, data exchange and the interaction between measuring and modelling participants is regulated by the data policy (Appendix I-G), which addresses data delivery dates, access rights for internal and external use of data and sets standard data formats.

The data policy is implemented as follows:

- The database of the IP is organised in a decentralized manner.
- Data are produced by scientists in the Activities and Workpackages of the various Components. Each PI is liable that he/she and related scientific staff produces and delivers data timely, completely and in adequate quality. The PI or his/her co-workers deliver data directly to the Data Centre of the respective Component and informs the PI responsible for Data of the respective Activity about the delivery.
- In each Activity, a specific PI has been assigned as person responsible for Data. He/She supervises the timely and complete delivery of data from the Activity to the Data Centre of the respective Component by reminding the partners of the Activity about data formats and deadlines, controlling the status of delivery in collaboration with the Data Centre, and warning the Data Management Committee and the Executive Board about delays or in adequate commitments by partners in the Activity. The PI responsible for the Data of an Activity also supports the manager of the Data Centre in the evaluation of data quality of delivered data upon request.
- The Data Centre of each Component receives, checks and stores the data of the Component, delivers meta-data to the Central Database and creates links for data access with the Central Database. Each Component has assigned a PI as Data Centre manager. Each component Data Centre can publish meta data in agreement with the central data base and data policy rules, making sure that the information is consistent between the component and central data bases.

- The Central Database receives, checks, stores and publishes all meta-data about available data. It serves as interface between the Components and to external users. The Central Database is located at MPI-BGC. Martin Heimann - the PI of the Central Database - assigns a full-time data manager to develop and maintain the Central Database and to perform quality and consistency checks with the data of different components.
- The CarboEurope Data Management Committee supervises questions related to dataset documentation, dataset format, and quality level. The Data Management Committee also supports the Executive Board to adjudicate possible disputes relating to the data policy (Appendix I-G), data delivery and non-compliance. The Data Management Committee is composed of the PI of the Central CarboEurope-IP Database and the four PIs of the CarboEurope Data Centres for ecosystem data, atmosphere data, regional experiment data, and auxilliary data. It is chaired by the PI of the Central CarboEurope-IP Database. He reports to the Executive Board on the status of the database, delivery, compliance status of the partners, possible disputes and their solution. This structure may be adjusted to emerging project requirements.
- Data users have to cite the data owners and agree with them about co-authorship on any kind of publication.

The Data Management Committee also has the tasks

- To design and to maintain the information technology structure and data exchange protocol of the distributed database with centralised data retrieval, stratified public and project internal access.
- To assess the data formats of providers and the needs of users/modellers to create and to maintain the database of project data.
- To define uniform meta-data terminology and compile a catalogue of meta-information on external databases of relevance (clearinghouse).
- To support data quality assessment, standardisation, harmonisation, georeferencing, and final archiving in close collaboration with individual Components and Activities of the IP.
- To make a full inventory of data sources, data and results, create links, and develop a plan to integrate data and results from FP5 projects.
- To ensure that all important data and results, including model codes and model output, are accessible, an that data are transferred if data bases storing relevant data and results are discontinued.

Activity DATA – Central Database

Activity Leader: M. Heimann, MPI-BGC

CarboEurope-IP will produce and use the following knowledge:

- measurement data,
- model simulation results,
- software,
- auxiliary data sets.

Eventually, patents may evolve from the activities dealing with software development, data assimilation techniques and observation technologies and high-precision analyses. The data policy (Appendix I-G) and responsibilities of the Data Management Committee include all types of knowledge.

Objectives

DATA1	To develop a central data base and information system for the CarboEurope IP
DATA2	To assist individual Component data bases in terms of data processing, integration, quality assurance and documentation.
DATA3	To provide a centralized interface for accessing meta information of all data sets compiled by all science teams of all components in a consistent, uniform and thoroughly documented manner.
DATA4	To provide a final archive of the integrated data obtained throughout the entire IP.

Methodology

Task 1: Establishment of central data base: Computing infrastructure (hardware and web-based software) will be provided by MPI-BGC. A specific database manager will supervise the Central Database together with technical staff of the MPI-BGC.

Task 2: Operation of central data base: The database manger will conduct a permanent dialogue with each of the 4 Component data centre PI. The structure of the Central Database will be adjusted according to needs emerging as the project develops and as defined by the Data Management Committee. The interactions between the Component data centres and the central database, and links to external data sources are shown in Figure 15. After 12 months, all links to Component data centres will be active.

Partners and responsibilities

Central database infrastructure and management: M. Heimann, MPI-BGC

Interface to Component databases: Assigned database PIs of each Component

Management of auxiliary datasets (Activity 4.1): JRC

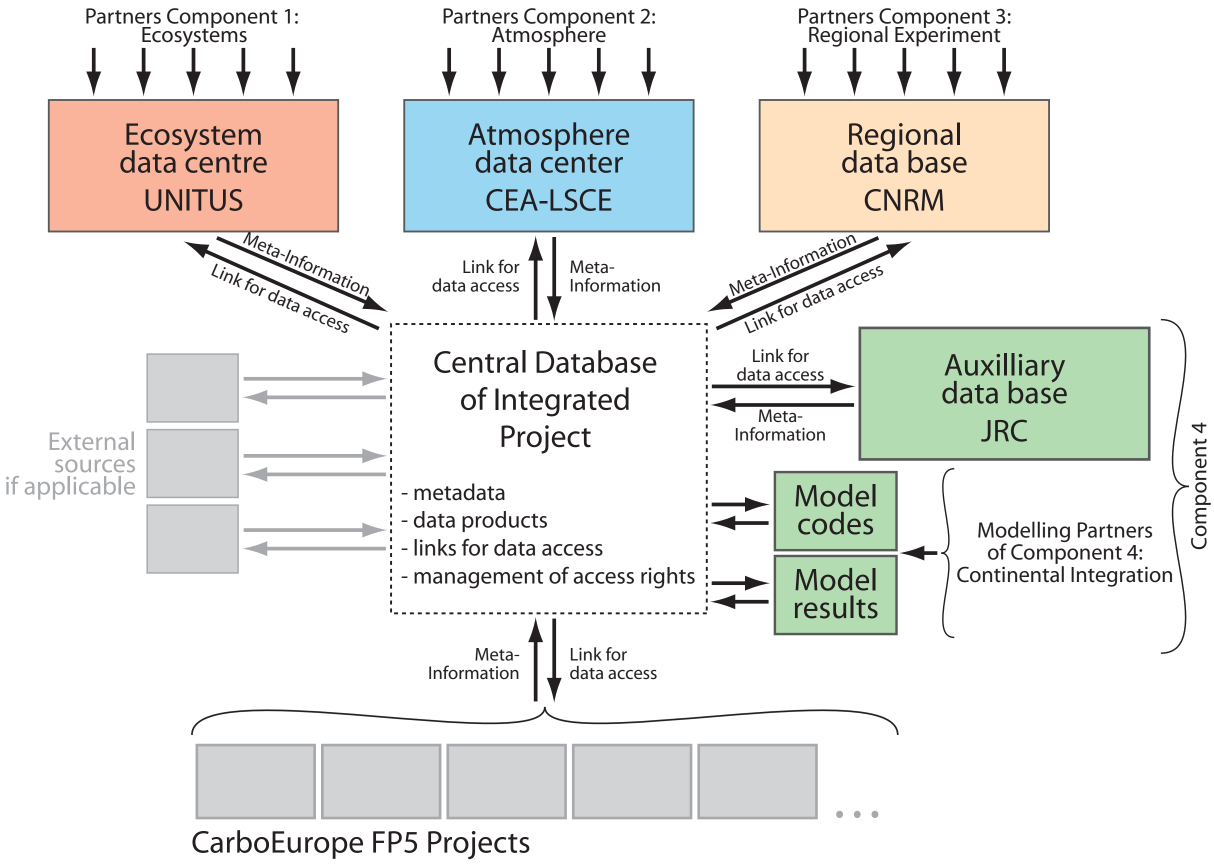


Figure 15 Role of the central database and interactions with Component data centres and external data sources

6.1.4 Stimulation of scientific and technological innovation and exploitation of results

A specific Activity has been created to stimulate scientific and technological innovation inside and outside the CarboEurope-IP in order to facilitate the achievement of the ambitious objectives. It also serves to facilitate the exploitation of results of the CarboEurope-IP.

Objectives

INNOV1	To highlight scientific and technological innovation in the CarboEurope-IP
INNOV2	To stimulate scientific and technological innovation in the CarboEurope-IP
INNOV3	To stimulate scientific and technological innovation outside the CarboEurope-IP, needed to better achieve the IP´s research goals
INNOV4	To stimulate the exploitation of the scientific and technological innovation of the CarboEurope-IP

Methodology

Activity INNOV: Innovation
Activity Leader: John Grace

The Activity aims to serve as a catalyst to produce added value on research activities. It is linked to the secretariat in order to facilitate the communication and create a strong link to dissemination activities. The methodology is flexible in order to allow a creative, efficient stimulation of innovation. Important elements are:

- Yearly innovation report: a synthesis of scientific and technological innovation achieved in the workpackages of the CarboEurope-IP, as well as a list of innovation ideas which could facilitate the achievement of the IP´s research goals
- Contacts with innovation fora at national and European level, e.g. with the Environmental Technology Action Plan (ETAP) of the European Commission
- Links to parallel and evolving projects
- Brainstorming workshops to stimulate scientific and technical innovation, e.g., for in situ measurements of C stocks in litter and soil, data processing tools to facilitate the assimilation of remote sensing data in models, remote sensing of CO_2 and biomass, …
- Contacts to interest groups and potential public and private investors (SMEs, industries) to exploit results, e.g. for an operationalisation of carbon monitoring, or the certification and verification of carbon sequestration projects.

Exploitable results of the CarboEurope-IP encompass a scientifically sound verification system for commitments under the Kyoto Protocol, a very sophisticated integrated network for CO_2 observations at regional and continental scale, and recommendations for land management with regard to the Kyoto Protocol. There is also scope for operationalisation of the observational network, e.g. in GMES. We will try to use instruments of GMES or similar to develop the research infrastructure of CarboEurope-IP for an operationalisation of the prototype monitoring of the European carbon balance, via operationalisation of monitoring facilities and data streams. The research infrastructure could then be directly exploited by EU-wide, national and regional authorities and agencies and private companies. In this context, we will also undertake special attempts to include SMEs.

There are clear opportunities for involvement of SMEs in future research and demonstration activities:

- SMEs working on certification, monitoring and verification of projects under the JI and CDM mechanisms of the Kyoto Protocol,
- Hardware developers (Soil coring, eddy covariance systems development, gas analysers, *in situ* measurement of soil carbon stocks),
- Software developers (eddy covariance software),
- Laboratories for routine soil chemical and physical analyses.
- Results of CarboEurope-IP will be valuable for land owners and industry at large for future land-use planning in a C-restricted world.

Another important area of dissemination is the **capacity building in Eastern Europe and Asia**. Although significant efforts were undertaken to identify appropriate partners in the Candidate Countries, only few research institutions proved adequate skills, especially regarding high-precision atmospheric and continuous ecosystem measurements. However, we could establish contacts with several institutions interested in capacity building. So we plan to attract scientists from Candidate Countries and developing countries to train their skills based on the CarboEurope-IP infrastructure and knowledge. Such kind of support has already been established with groups in Belarus, Poland, Russia and China and is being investigated in Ukraine.

Expected results

- Yearly innovation report of the CarboEurope-IP
- Brainstorming workshops
- Active participation in technology initiatives, innovation panels, interest groups and potential public and private investors (SMEs, industries)
- Capacity building in Eastern Europe and Asia

Partners and responsibilities

Reports, organisation of workshops, implementation of activity: J. Grace, UEDIN

Further partners upon request.

Associated partners for capacity building: ECCM, CAF

- ECCM gives us a lead into development of policy, especially relating to Kyoto-related issues to do with 'monitoring' which might crop up from time to time.
- CAF is important in a different way: A completely new alliance in an area of the world where no other western group has a toe-hold. It might lead to an exchange of students, exchange of data and technology.

6.1.5 Dissemination activities

Dissemination of results and consultation to national and European policy makers in the fields of agriculture, forestry, and climate change have a strong tradition in CarboEurope. Dissemination will build on projects of the CarboEurope Cluster in FP5, which were specifically designed for exploitation and dissemination of data and results by web-based interfaces and online-tools for data, models and model results in Carbodata (EVK2-CT-1999-00044), support to European policies for the implementation of the Kyoto protocol with expert knowledge and information to stakeholders (industries, forestry) about within CarboEurope Accompanying Measure (EVK2-CT-2000-80007), a series of reports on the synthesis of the European greenhouse gas budget within CarboEurope-GHG Concerted Action (EVK2-CT-2002-20014). There is a strong collaboration with local forest research institutes, e.g. in Thuringia.

We will streamline and continue our strong commitment for the dissemination of results. The dissemination plan encompasses a number of interrelated activities aiming at scientific, political and broad public audiences, respectively. The actions listed below will clearly enhance the capacities for dissemination of results and impact of policy advise as compared to FP5.

Objectives

DISS1 To disseminate results to the scientific community and the broad public
DISS2 To contribute to joint EU/US assessments of the Carbon Cycle
DISS3 To give consultation to policy makers
DISS4 To host the European office of the Global Carbon Project (GCP)

Methodology

Activity DISS1: Dissemination material

Activity Leader: A. Freibauer, MPI-BGC

New scientific knowledge will be disseminated in publications in peer-reviewed journals, also as special issues and books if appropriate, on conferences held together with annual project meetings, external conferences and internal and open workshops in specific IP-Activities and for specific questions integrating several Activities and Components such as the harmonisation of measurement protocols and data – model intercomparison. They will be published in the CarboEurope-series and will serve as templates and standards for similar emerging observation networks. Web-based activities will be the central tool for communication within the Integrated Project but will also provide a user-friendly interface for policy makers and the broad public served with up-to-date information.

Partners and responsibilities

All partners upon request by Co-ordinator or Executive Board

Activity DISS2: Joint EU/US assessments

Activity Leader: P. Ciais, CEA-LSCE

- Globally, policy makers will be informed about recent achievements in Carbon Cycle science by joint EU/US assessments of the Carbon Cycle. During the first bilateral "U.S.-EU Joint Meeting on Climate Change Science and Technology Research" in Washington on February 5-6, 2003, the United States and European Union identified Carbon Cycle research as one out of six co-operative research activities. Specific topics of potential co-operation in Carbon Cycle research include the following:
- Define and implement an integrated and optimised carbon observing system over the atmosphere, land, and oceans, with special emphasis on the carbon budget of North America, Europe, and the North Atlantic region;
- Co-ordinate efforts in modelling (future projections, assimilation methods, and analysis of past changes) integration, interpretation, and future data acquisition strategies;
- Enhance georeferenced Carbon Cycle data availability and quality; and
- Develop common assessment methods and state-of-the-art reports.

These four items are central to the objectives of CarboEurope-IP, and we foresee a very active and fruitful collaboration on both sides of the Atlantic between CarboEurope-IP and the North American Carbon Program (NACP). In particular, inter-comparison and evaluation of models, common sampling at atmospheric sites, improvements of eddy-covariance technique, and design for regional budgeting experiments are strong areas of future collaboration. Other issues concern the exchange of data between EU and US programmes, and future common assessment reports on the Carbon Cycle.

Partners and responsibilities

P. Ciais, CEA-LSCE: contact with Americans, co-ordination of European Contribution.
Further partners: All partners upon request

Activity DISS3: Policy interface

Activity Leader: G. Seufert, JRC-IES

We have set up a **Policy Group** who represents the focal point to which policy makers can address requests. The Policy Group will produce policy-relevant syntheses of project results, but also react quickly on ad hoc requests in order to produce a harmonised, consolidated response from the CarboEurope consortium. The policy Group consists of scientists with well-documented expertise at the science-policy interface: G. Seufert, R. Baritz and G. Matteucci (JRC), P. Ciais (LSCE), A. Freibauer (MPI-BGC), G.-J. Nabuurs (Alterra), B. Schlamadinger (Joanneum), P. Smith (UNIABDN), and R. Valentini (UNITUS). Direct contact with the European Council sinks expert group will be maintained and intensified, also via the representation in the Advisory Panel. Direct contributions to ECCP (European Climate Change Programme of the European Commission) will be delivered via written and oral statements in the ongoing stakeholder process. The working groups of the EU Monitoring Mechanism will be supported via the JRC mandate and additional efforts of the policy group upon request. Finally, CarboEurope expertise will be introduced into the ongoing process of developing a EU-carbon sink module within the monitoring schemes of the New Forest Regulation and the European soil monitoring strategy (COM (2002) 179 final). Furthermore, policy-relevant synthesis reports will published as a CarboEurope-series on emerging questions to support the implementation of the Kyoto Protocol and its future development regarding biospheric sinks and sources.

Targeted Stakeholders are EU Monitoring Mechanism Working Groups 1 and 2, European Commission, European Climate Change Programme (DG Environment, DG Agriculture), European Environment Agency, national policy makers involved in international negotiations of the UNFCCC, e.g. national ministries and environmental protection agencies, regional and national forest administration, private forest owners, and SMEs involved in certification and auditing of Kyoto-related projects.

Analyses and consultation will cover issues such as

- To analyse, in light of the research results from the activities, key policy-relevant issues, such as:
  b) the separation of carbon sequestration by terrestrial ecosystems among direct human induced, indirect and natural effects,
  c) suitability of the CarboEurope-developed methods for monitoring and verification of GHG emissions and removals under UNFCCC and the Kyoto Protocol, and how these could be applied on a European-wide basis,
  d) technical possibilities for "full carbon accounting",
  e) effects of land management and land use change on the overall balance of GHG,
  f) linkages between Kyoto Protocol and CBD: integration of biodiversity considerations into the implementation of the Kyoto Protocol,
- To suggest possible implementation of updated and new rules for LULUCF under Kyoto Protocol rules in the second commitment period that would be consistent with the scientifically sound measurement and observation methods such as those developed and applied in this IP.

We expect that one of the most efficient strategies for optimal use of project results works via direct interactions with stakeholders, consultations to the European Commission and national governments by project partners, which is proven by past success. We will continue this successful tradition of consultation and dissemination to ensure optimal use of the project results.

Partners and responsibilities

Ad-hoc Policy Group: G. Seufert, R. Baritz and G. Matteucci (JRC), P. Ciais (LSCE), A. Freibauer (MPI-BGC), G.-J. Nabuurs (Alterra), B. Schlamadinger (Joanneum), P. Smith (UNIABDN), and R. Valentini (UNITUS).

Further partners: All partners upon request

Activity DISS4: European office of the Global Carbon Project (GCP)

Activity Leader: R. Valentini, UNITUS/A. Freibauer, MPI-BGC

CarboEurope-IP will run the **European office of the Global Carbon Project (GCP),** ensuring also a leading role in international collaboration in Carbon Cycle science beyond the USA.

Expected results

- Policy-relevant synthesis reports published as a self-published CarboEurope-series on emerging questions to support the implementation of sinks in the Kyoto Protocol.
- Updated estimates of the "carbon uptake in the European biosphere" in support of the set of climate change indicators of the European Environment Agency (EEA) for 2004 to 2008.
- Joint EU-US Carbon Cycle assessments.
- Contact with European council sinks expert group.
- Direct contributions to ECCP (European Climate Change Programme of the European Commission).
- Direct contributions to EU Monitoring Mechanism Working Groups.
- Contacts with press and mass media.

Partners and responsibilities

European GCP office: R. Valentini and E. Sezzi (UNITUS), A. Freibauer (MPI-BGC)
Further partners: All partners upon request

6.2 Demonstration activities

Activity DEMO: Verification of carbon stock changes according to the Kyoto Protocol
Activity Leader: E.-D. Schulze, MPI-BGC

Objective

DEMO To demonstrate the feasibility of identifying human-induced carbon stock changes at the state forest level for carbon trading under the Kyoto Protocol

Methodology

In a project based on national funding (BMBF, 2000-2003) the MPI-BGC co-operated with the Thuringia State Forest Research Station to establish a carbon inventory of biomass and soils for 1993 and for 2000 based on inventory data which are obtained every 10 years for management purposes. It could be shown that Thuringia has an increase in biomass of about 1 tC/ha/yr, changes in soils have not yet been quantified. Using the Biome-BGC model, we could show that 50% of this increase was human induced since 1990. This inventory exercise is still not a verification in the Kyoto sense. Therefore the Carbo-Invent project will make a counter estimate based on satellite and federal German inventory numbers. Thus, the Thuringia forest is a 200 000 ha region with a certified C-budget, and the state is willing to sell the human induced component under Kyoto Art 3.4 to UNFCCC.

All the preparatory work was nationally funded, but for CarboEurope this becomes an important demonstration project, because we can show to politicians (1) the value of good carbon management, (2) convince the political scene to accept Art 3.4 in view of the problems with deforestation/afforestation in CDM countries and (3) observe how the carbon accounting idea can be applied in the real world of forest owners. (4) Needless to say, that based on the Co-operation, CarboEurope has access to a unique and complete data set of forest inventory data at extremely small scale (operational management unit of 1 to 10 ha), and their changes over time.

The project will provide data and facilities to test models and experiments to verify changes in carbon stocks according to the Kyoto protocol. This means to achieve the following two goals:

- provide a 5yr inventory to verify changes in C-stocks in the area of the Thuringia state forest
- make the link to the political institutions which deal with the Kyoto process.

In order to achieve these goals following **tasks** will be performed:

1. to enlarge the soil observation network
2. to provide test areas in which data exist since 1990 to carry out detailed analyses
3. to implement a regional expansion of the German Forest Inventory, which is based on point observations only
4. to provide the data base to test models of CarboEurope against large scale inventory data

5. to investigate the fate of carbon in the chain of products, because C-storage must economically be balanced by the use of wood in a national economy

Partners and responsibilities

E.-D. Schulze, MPI-BGC: Tasks 4 and 5, co-ordination of demonstration activity

Weller, TLWJF: Tasks 1, 2, 3, 4.

R. Baritz, JRC-IES and M. Köhl, TUD-F within the FP5 project Carbo-Invent.

Further partners will be included as the demonstration activities may be expanded, e.g. R. Valentini, UNITUS

6.3 Training activities

Objectives

TRAIN1	Summer schools about the carbon cycle for graduates and PostDocs
TRAIN2	Training at secondary school level

Methodology

Activity TRAIN1: Summer schools
Activity Leader: F. Miglietta, IBIMET-CNR

CarboEurope Summer Schools Series "Terrestrial Biosphere and Atmosphere Interaction in the Carbon Cycle: From the leaf to the continent"

Training activities in the CarboEurope will include a series of events addressing important components of the IP. Following the multidisciplinary integration science plan of the IP, CarboEurope Summer Schools will consider in particular biological processes understanding in plants and soils that are at the basis of the most important biospheric Carbon fluxes, ecosystem flux monitoring techniques including gradient and eddy correlation methodologies, regional flux assessment methods with emphasis on airborne flux measurement techniques and mesoscale and atmospheric inversion modelling techniques. The courses will attract a significant number of young scientists from Member and Associated States that will have the possibility to acquire knowledge and direct expertise in those areas of research and rise interest in environmental research. The courses will be organised by Institutions participating in the IP and will all involve both theoretical lectures and field exercises. Lecturers will be possibly selected among the participants to the IP but in some cases a few non-EU scientists will be also invited as teachers. Each event will have a duration of approximately one week and will attract 10 to 20 students.

The role of soil, plants and ecosystem processes in the Carbon Cycle
Organiser: G. Gleixner, E-D Schulze, MPI-BGC and N. Buchmann, ETH
The course will consider the most recent advancements in understanding, measuring and modelling some of the most important biological processes that are at the base of carbon uptake and efflux of ecosystems including most recent advancements in understanding, measuring and modelling of carbon turnover and immobilisation in soils.

Theory and application of ground-based flux monitoring techniques
Organiser: M. Aubinet, FUSAGx

This event will provide advanced training about the most important ground-based techniques to monitor carbon fluxes of ecosystems and will provide the theoretical bases of the best micrometeorological techniques that are used to measure gas exchange of plant canopies.

Airborne flux measurements for the regional assessment of the Carbon budget

Organiser: F. Miglietta, IBIMET-CNR

The course will address questions relating to the theory and the practicalities of using Small Environmental Research Aircraft (SERA) to measure surface fluxes at the regional scale. It will also include a field exercise where the students will have the opportunity to conduct, together with their supervisors, a short-term airborne flux measurements campaigns.

Meso-scale and Atmospheric Inverse Modelling

Organiser: A.J. Dolman, VU-A

The course will provide an introduction to the most recent advancement in applied atmospheric meso-scale and inverse modelling for the simulation of atmospheric gas transport associated to the spatial distribution of the main terrestrial Carbon sinks and sources.

Activity TRAIN 2: Educational training at the secondary school level

Activity Leader: Philippe Saugier, SAUG

An experimental training activity will be designed by a specialised SME for secondary schools in Europe in a perspective of research-education liaison. This will consist in:

- producing innovative educational resources explaining global carbon research stakes, their links with our daily lives and the way European research deals with them;
- mobilising a number of relays with high multiplying effect in order that as many young people as possible in Europe benefit from these resources;
- encouraging direct contacts between secondary school students and CarboEurope scientists.

Focused on science in action in an interdisciplinary and societal perspective, the educational contents will attempt to illustrate:

- what we know, what we discuss, and what we don't know yet in climate change issues,
- how scientists work on the field,
- what is the added value of European co-operation in global change research and its complementarity with other programs world-wide, and how the various components of carbon research interact with each other in a systemic manner;
- how our daily lives impact on the global environment,
- how scientific expertise is taken into consideration in international regulations such as UNFCCC and in the debate about social, political and economical responses to climate change.

Approached multipliers will comprise at the European level: European schoolnet, Young reporters for the environment, Science across Europe, Unesco Associated schools, ECSITE (European collaborative for science and technology exhibitions); at national levels: teachers associations (e.g. Association of Danish Biologists, Association of German Biologists), magazines (e.g. Science et Vie Junior in France), science museums (e.g. National Museums of Scotland).

After the kick-off phase this approach will be tuned in discussion with the users (teachers and multipliers) who will be closely involved during all steps of resources development in order to ensure a high level of adaptation to secondary schools needs and to dissemination constraints and channels. The resources will be produced and tested in one or two countries during years 1 and 2, and disseminated throughout the whole duration of the IP involving more groups and countries, especially in Eastern Europe.

6.4 Consortium Management activities

The legal, administrative, and scientific co-ordination of the Integrated Project as a whole is described in section 7 below. This section deals with the scientific co-ordination **within** Components.

The scientific co-ordination follows the logic of the project Components and their activities. We expect that working within established consortia for specific tasks within the IP allows best to identify and control scientific progress and to manage the integration between parallel well-identified tasks within and between project Components. This structure will maintain high motivation by highest possible maintenance of scientific self-responsibilities of the partners under the clear guidance of the IP co-ordinator and the Executive Board. It should be stressed at this point that all Activity and Workpackage leaders know each other from FP5 projects and have organised joint events such as meetings and conferences in Torgiano 2000, Budapest 2002, and Lisbon 2003.

The Component Leaders are responsible for the contribution of their respective Component to the annual scientific progress reports. Component Leaders are assigned by the Executive Board and confirmed by the General Assembly. Activity leaders as well as the managers of the Component Data Centres are assigned by the respective Component Leader in agreement with the Executive Board and confirmed by the Component participants. The scientific co-ordination within the IP Components is managed by the **Component Leaders**, supported by the **Activity Leaders**. The Component Leader assigns and confirms the PIs responsible for management and quality control of data in each Activity ("Responsible PI for Data of the Activities"). The Component Leaders are responsible for strong interactions between the Components and flow of data and information between Components. The Component Leaders involve the IP co-ordinator in decisions of schedules of Component meetings, experiments etc., in order to avoid delays and to guarantee that there is a perfect information flow, that decisions are transparent, and that the scientific activities are harmonised in time and space. The Component participants can choose to establish **Component Committees** consisting of the Component Leader and its activity leaders, taking day-to-day decisions for scientific work within each Component and preparing strategic decisions for the development of detailed workplans. Component committee meetings are also open to all co-ordinators of other Components and Activities and to the IP co-ordinator. All other Activity leaders will be informed about and invited to the Component committee meetings. Component committees will meet at least half-yearly, either physically or via teleconference.

There will be dedicated scientific staff in all IP Components responsible for the scientific co-ordination of the Components.

Management of the Ecosystem Component (Component 1)

The Ecosystem Component is organised in 6 Activities which are co-ordinated by the Activity Leader. The Activity Leaders reports to the Component Leader who is responsible of the deliverables of the Component. The co-ordination between the 6 Activity Leaders and the Component Leader is carried out by regular consultation through internet. A co-ordination meeting between Activity Leaders and Component Leader is planned at the beginning of the research operation and before the submission of the annual reports.

A particular case which needs a specific co-ordination effort is the management of Activity 1.1. This activity concerns the operations of the eddy covariance cluster network of sites. In total there are 17 clusters with 3 Main Sites each and a variable number of associated sites, summing up to a total of 51 main and up to 50 associated sites. To make efficient the flow of information and data transfers to the Ecosystem Data Centre, a cluster co-ordinator has been selected for each cluster of sites. The cluster co-ordinator has the responsibility of data deliveries, the connections with his partners both for the main and associated sites and the reporting to the Activity Leaders and Component Leader. All the planned workshops for standardisation and harmonisation of protocols will be mandatory for the cluster co-ordinators and optional for the other network participants. In this way the flux network is managed through 17 cluster co-ordinators, who enhance the efficiency of data deliveries, exchange of information, and make the management of the large Component consortium feasible as the main contact addresses reach the same size as previous FP5 projects, which have been successfully managed in this way.

Data are accessible at the Ecosystem Data Centre for modellers in the Integration Component. A close link to the Integration Component will be maintained via workshops and dedicated sessions at annual meetings.

Management of the Atmosphere Component (Component 2)

The workplan of the Atmosphere Component is divided into 7 complementary activities, each being co-ordinated by an Activity Leader. The Activity Leaders responsible for the day-to-day management of their activity, frequently report to the Component Leader who is responsible of ensuring that the milestones are met and the deliverables obtained in due time. The co-ordination between the 7 Activity Leaders and the Component Leader will be carried out by email exchange and teleconferences. The Activity Leaders and the Component Leader are already experienced working together for several years, and they are all familiar with project management techniques in national and EU funded research. A co-ordination meeting between the Activity Leaders and the Component Leader is planned at the beginning of the IP, before preparing each annual report, and if necessary, before submitting any major deliverable.

The Activity Leader responsible for Activity 2.5 dealing with quality control of atmospheric high precision records, will have an especially important task to supervise the calibration and intercomparisons between all other activities.

One specificity of the Atmosphere Component is that there must exist an intimate link between experimental work and inverse modelling. That link was organic in FP5 because modellers and experimentalists were part of the same project, but in CarboEurope-IP inverse modelling is in the

Continental Integration Component. Thus, we will organise joint meetings between the Continental Integration Component and the Atmosphere Component at least once a year.

The link between Activity 2.7 dealing with CO_2 records on top of eddy covariance towers and Activity 1.1 in Ecosystem Component is ensured by appointing as Activity Leader a scientist who is highly experienced both with fluxes and with concentration measurements.

Data are accessible at the Atmosphere Data Centre for modellers in the Integration Component. A close link to the Integration Component will be maintained via workshops and dedicated sessions at annual meetings.

Management of the Regional Experiment (Component 3)

Good planning of the experiment and integration of the several components is required to make the regional experiment a success. The task leader of integration is also the co-ordinator of the Component. This facilitates the overall management of the Component. This Component Leader will see that the activity leaders deliver timely reports of the status of the work. The activity leaders will see to the timely delivery of spatial data, other experimental results, and specific reports. The Component Leader will oversee experimental planning and will ensure good communication between partners and between this Component and the others of CarboEurope-IP. It is foreseen that the participants will meet in the first month of the project, and after the test campaign, to streamline the experimental planning and before the start of the EOP. The management of the EOP will be written down in the experimental plan that will be produced under WP 3.1. This will incorporate elements of decision structure for flight operation, radio sounding based on regional weather forecast.

For the full five year project we will establish yearly Component meetings.

Management of the Continental Integration Component (Component 4)

Each of the 7 activities of the Continental Integration Component is lead by an Activity Leader, who is responsible for the day-to-day co-ordination of the work performed in that activity. The Activity Leaders report to the Component Leader who is responsible for the Component management, and will ensure that milestones are met and deliverables obtained according to the time schedule. Bi-annual workshops of all Continental Integration Component participants are planned in order to synchronise the modelling activities and to harmonise the requests for input data and for the dissemination of the results. The internal co-ordination between activities 4.4, 4.5 and 4.6 of the Continental Integration Component is ensured further by the fact that 4 ”modelling consortia” among the partners are contributing with their atmospheric, surface and ecosystem models to all these three activities (MET-OFFICE, CEA-LSCE, MPI-BGC, SRON/VU-A).

A close link of the Integration Component with the Ecosystem and Atmosphere Components will be maintained via workshops and dedicated sessions at annual meetings.

Central database

A particular important role is attributed to the Activity Leader of the Central Database, which has to ensure that observational results are made timely accessible to the modelling activities and at the same time has to ensure that model results and model based syntheses are also rapidly made available to the entire IP by modern electronic media (WebPages of the database, electronic mailinglists and bulletin boards). Data management, responsibilities and flow of information are described in detail in Section 6.1.3 and illustrated in Figure 15.

Interaction between observations and modelling

Special emphasis will be placed on inviting participants from the observational Components (ecosystems and atmosphere) to the modelling meetings in order to ensure a close horizontal information transfer between observations and modellers. A similar close co-operation with the regional experiment activities is ensured by the fact that many of the measuring and modelling groups are partners in both Components of the IP.

6.B Plans

6.5 Plan for using and disseminating knowledge

The plan for using knowledge is described in the data policy in Appendix I-G.

The plan for disseminating knowledge contains four elements:
- Innovation Activity (Section 6.1.4)
- Dissemination Activities (Section 6.1.5)
- Demonstration Activities (Section 6.2)
- Training Activities (Section 6.3)

All four Activities are linked to the Secretariat.

6.6 Gender action plan

Objective

GENDER To promote the role of female researchers in CarboEurope-IP

Main expected results

- Project gender committee
- Networking and mentoring programme
- Facilitated recruitment of female researchers
- Annual gender action reports

Methodology

Task 1: Project gender committee
The gender committee will actively promote the role of female researchers in the Integrated Project at all levels. It will be responsible for raising awareness of gender equality among the project consortium and will control whether the gender action plan is properly applied at the level of the Integrated Project as a whole and of its major components. In particular, it will act as the platform to channel experience and good ideas via web-based tools, but will also deal with complaints. It will produce the annual gender action report of CarboEurope-IP. The gender committee will consist of 3 members elected by all female project participants

(PIs, PostDocs, PhD students) for a two-years period. Committee members can be re-elected. The Gender Committee is represented by one member in the Advisory Panel.

Task 1.1: Networking

Under the auspices of the gender committee, a female researchers network will be established within CarboEurope-IP to discuss potential conflicts between carrier and family and exchange experience. They also share announcements for jobs and training opportunities. The gender committee helps to recruit females for the CarboEurope-IP.

Task 1.2: Annual gender action report

Annual gender action report will contain an inventory what actions to promote gender equality have been performed at the level of the Integrated Project as a whole and of its major components and will document the overall success as compared to targets of promotion of female researchers. The gender committee will produce the report with the input of all partners of the Integrated Project.

Task 2: Facilitated recruitment of female researchers

Recruiting young female academics is encouraged in CarboEurope-IP. All job announcements will encourage females to apply. The gender committee will produce school material dissemination ”Women in carbon research” in collaboration with national gender programmes. All project partners are encouraged to participate in national events (cf. also ”Training activities”, B4.3).

Task 3: Active promotion of female researchers

11% of the scientists involved in the CarboEurope Cluster in the Fifth Framework Programme were female. Against this background, **CarboEurope-IP sets the target to double the participation of females, and to achieve 20% or more at all organisational levels in the project, within the frame of the national rules of the partners. This applies to the scientific work as well as to the active participation at workshops, conferences and publications.**

In order to achieve this target,

- whenever open jobs are announced in CarboEurope-IP, the PIs commit themselves to contact the female-representatives at their institute, and the project gender committee, to help finding qualified females, and recruiting females.
- directly, or with help of the gender committee, a mentor who helps females to develop perspectives for their research carrier at critical stages when most females drop out of research: when finishing masters degree and at the end of the PhD thesis. The mentor will also encourage and support the mentee to write scientific publications and to co-chair workpackages or workshops (cf. also ”Training activities”, B4.3).
- CarboEurope-IP sets the target to invite 20% or more female researches to workshops, as speakers on workshops and conferences organised at the level of the Integrated Project and its major components (cf. also ”Training activities”, B4.3).

- as far as logistically possible, business meetings of workpackages will be equipped with video-conferencing upon request so that partners who cannot travel to business meetings can attend virtually. This will specifically help women taking care for their children.

Task 4: Consortium Agreement

We will set up in the Consortium Agreement the following minimum requirements to promote gender equality which all partners will have to adhere to:

- Take efforts to meet the gender equality targets of the Integrated Projects
- Encourage applications by female researchers in job announcements and make sure that all positions are advertised and given to the best suited person in a transparent, objective way, with full consideration of gender equity.
- Take formal actions to guarantee that employees are properly informed about their parental obligations and rights
- Encourage female employees to participate in programmes for gender mainstreaming (information and coaching workshops and events, etc.), coaching programmes (communication and conflict management, self-presentation, mentoring) and seminars on project management
- Report annually the type and success of gender actions taken.

Main responsibilities

Task 1: Gender committee
Tasks 2-4: Co-ordinator, all partners

6.7 Raising public participation and awareness

The plan for disseminating knowledge contains four elements:
1. Innovation Activity (Section 6.1.4)
2. Dissemination Activities (Section 6.1.5)
3. Demonstration Activities (Section 6.2)
4. Training Activities (Section 6.3)
All four Activities are linked to the Secretariat.

6.C Milestones

6.8 Major Milestones over full project duration

Major Milestone #1

Integration of data from CarboEurope FP5 projects in CarboEurope database [Month 25]

Expected results and achievements: Data, results and reports from terminated CarboEurope FP5 projects are available to participants of CarboEurope-IP. The exact nature of the deliverables and timing depend on the decision of the FP5 Steering Committee regarding the transition form FP5 to FP6.

Expected deliverables and timing:

Month 3 Protocol of the exact nature, deliverables and timing by joint FP5/FP6 steering group

Component 1 Ecosystems

Major Milestone #2

Consolidated European ecosystem CO_2 flux network [Month 36]

Expected results and achievements: up to 5 full years of operation of eddy flux stations of up to 50 stations, and at least one year at up to 100 stations

Expected deliverables: quantification of the ecosystem related variability of annual carbon budgets

Expected timing:

Month 18: full evaluation of the first year

Month 24: optimization of the flux site network, following discussion with the atmospheric and modelling component

Major Milestone #3

Consolidation of soil carbon sink [Month 60]

Expected results and achievements: full soil sampling on up to 12 sites

Expected deliverables: soil carbon pools and statistical analysis of 12 sites suitable to verify changes in soil C

Expected timing:

Month 12: soil sampling

Month 18: basic soil analyses

Month 24: (synchronous to the eddy flux network discussion) data processing

Major Milestone #4

Effects of disturbance and management on ecosystem C balance („fast out, slow in") [Month 60]

Expected results and achievements: eddy flux and ecosystem data on disturbance (management, natural disturbance,…) derived by data synthesis and meta-analysis of data from flux site network

Expected deliverables: identification of processes and time constants for carbon losses and accumulation

Expected timing:

Month 18: Calibration and first evaluation of land-use specific ecosystem process models

Month 60: Synthesis of management and disturbance effects on ecosystem C balance

Major Milestone #5

Data quality and eddy flux data evaluation [Month 24]

Expected results and achievements: Improvement of data quality analysis and addressing the advection corrections

Expected deliverables: new algorithms and tools for data evaluation

Expected timing:

Month 12: first advection experiment

Month 18: consolidated data quality tools for assessments

Month 24: Evaluation of advection experiments results

Component 2 Atmosphere

Major Milestone #6

Consolidated European atmospheric CO_2 network [Month 24]

Expected results and achievements: In situ continuous records of CO_2 and ^{222}Rn concentration data from a network of ground level stations and tall towers, up to 18 sites in total building upon data from FP5 projects – 6 monthly selected data for use by participants and modellers -

Expected deliverables: Atmospheric network of up to 12 surface CO_2 and ^{222}Rn stations (D2.1.1); Database of atmospheric measurements (D2.1.2)

Expected timing

Month 12 = D 2.1.1 Atmospheric network of up to 12 surface CO_2 and ^{222}Rn stations

Month 18 = D 2.1.2 Database of atmospheric measurements

Major Milestone #7

Multiple gas species assets to attribute the European Carbon balance to controlling processes [Month 36]

Expected results and achievements : Dataset of high precision multiple species measurements in flask air samples, building upon FP5 projects – Formatted data from up to 24 stations for use by participants and modellers comprising CO_2, CH_4, ^{13}C-CO_2, ^{18}O-CO_2, N_2O, CO, SF_6 and O_2:N_2

Expected deliverables: Network of up to 24 flask stations in Europe out of which 10 are run by CMDL (D2.3.1); Dataset to separate the CO_2 gradients into components (D2.3.2), Flask multiple species data at aircrafts (D2.4.1)

Expected timing

Month 6 = D 2.3.1 Network of up to 24 flask stations in Europe out of which 10 are run by CMDL

Month 12 = D 2.3.2 Dataset to separate the CO_2 gradients into components

Month 18 = D2.4.3 Flask multiple species data at aircrafts

Major Milestone #8

Regular CO_2 aircraft vertical profiles over Europe [Month 36]

Expected results and achievements: A combination of low frequency and high frequency CO_2 vertical profiles from four aircraft sites collocated with tall tower – Ancillary information on atmospheric structure - Formatted data for use by participants and modellers

Expected deliverables: 4 aircraft sites on East West Transect (D2.4.1); representativeness of Schauinsland (D2.4.2)

Expected timing

Month 6 = D2.4.1 4 aircraft sites on East West Transect

Month 18 = D2.4.2 representativeness of Schauinsland

Month 24 first high frequency flights

Month 36 dataset with high frequency vertical profiles to be analysed

Major Milestone #9

Identification of fossil fuel component from CO and ^{14}C analysis [Month 48]

Expected results and achievements Dataset of atmospheric tracers combining ^{14}C and CO that can used to determine the fossil fuel emission component in the European carbon balance

Expected deliverables: Network of 5 high precision bi-weekly integrated ^{14}C monitoring sites (D2.6.1); first CO calibration site in Heidelberg (D2.6.2)

Expected timing

Month 6 = D2.6.1 Network of 5 high precision bi-weekly integrated ^{14}C monitoring sites

Month 18 = D2.6.2 First CO calibration site in Heidelberg

Month 36 Krakow calibration site established

Component 3 Regional Experiment

Major Milestone #10

Execution test experiment [Month 18]

Expected results and achievements Successful test of the logistics of the experiment and recommendations for planning the full experiment:

Expected deliverables and timing:

Month 12 = D3.1.6 Experimental plan for the experimental and intensive observation period

Month 18 = D3.3.2 Datasets of concentrations of CO_2 and other trace gases in the CBL and for larger scale transects for the test experiment

Month 18 = D3.3.3 Datasets of boundary layer evolution with radio sounding and profiler systems for test experiment

Major Milestone #11

"Proof of concept" [Month 18]

Expected results and achievements Reanalysis of RECAB data. Identification of weak and strong points of the experimental and modelling approach, recommendations for full experiment and regional data assimilation development.

Expected deliverables and timing: Month 18: Report

Major Milestone #12

Consolidated data for the experiment [Month 18]

Expected results and achievements All soil, weather and surface data and fossil fuel emissions in an easily accessible Data Centre.

Expected deliverables and timing:

Month 12 = D3.1.1 Maps of soil (structure C-content) for fast and slow carbon models

Month 12 = D 3.1.2 Maps of land use for carbon models

Month 12 = D 3.1.3 Maps of biophysical parameters (albedo, roughness etc)

Month 12 = D 3.1.4 Climatology based on downscaled synoptic weather data at 8 km resolution Month 12 = D 3.1.5 Fossil fuel inventory at 2km resolution

Major Milestone #13

Execution full experiment [Month 36]

Expected results and achievements Successful execution regional experiment, including execution boundary layer flights, aircraft transects, flux aircraft operation, additional boundary layer sampling and surface based observations

Expected deliverables and timing:

Datasets of concentrations of CO_2 and other trace gases in the CBL and for larger scale transects for the test campaign, the extended and the intensive test campaign for full experimental campaign

Datasets of boundary layer evolution with radio sounding and profiler systems for full experimental campaign

Major Milestone #14

Regional carbon data assimilation system [Month 60]

Expected results and achievements Regional carbon data assimilation system capable of producing high resolution estimates (with uncertainty) of regional carbon balances, comparable to the highest resolution downscaled regional inversions

Expected deliverables and timing:

Month 30 Design, establishment and test of data assimilation system

Month 60 Regional carbon data assimilation system based on Arome and capable of ingesting both long (inventories) and short term (weather) data .

Component 4 Continental Integration

Major Milestone #15

First assessment of European carbon balance by top-down and bottom-up approach on Eurogrid spatial resolution [Month 18]

Expected results and achievements: Top-down inversion calculation of surface flux on Eurogrid using nested atmospheric high-resolution models. Bottom-up upscaling by neural networks and process-based models. Assessment of consistency by inclusion of auxiliary carbon fluxes not explicitly included in process based models.

Expected deliverables: European flux maps based on the different down- and up-scaling methods.

Expected timing:

Month 18: European flux maps based on the different down- and up-scaling methods.

Major Milestone #16

First assessment of upscaling techniques from point flux measurement to Eurogrid spatial scale [Month 36]

Expected results and achievements: Intercomparison of different bottom-up upscaling methods from point to Eurogrid based on neural networks, process-based models and sectorial inventory data.

Expected deliverables: Report on upscaling techniques

Expected timing:

Month 24: First upscaling exercise completed

Month 36: Synthesis assessment on upscaling techniques completed.

Major Milestone #17

Final assessment of European carbon balance by top-down, bottom-up and data assimilation approach on Eurogrid spatial resolution [Month 60]

Expected results and achievements: Top-down inversion calculation of surface flux and temporal variability on Eurogrid using nested atmospheric high-resolution models. Bottom-up upscaling by neural networks and process-based models. Optimized surface flux maps and temporal variability determined by data assimilation system. Assessment of consistency by inclusion of auxiliary carbon fluxes not explicitly included in process based models.

Expected deliverables: Consolidated European flux map and temporal variability.

Expected timing: Month 60

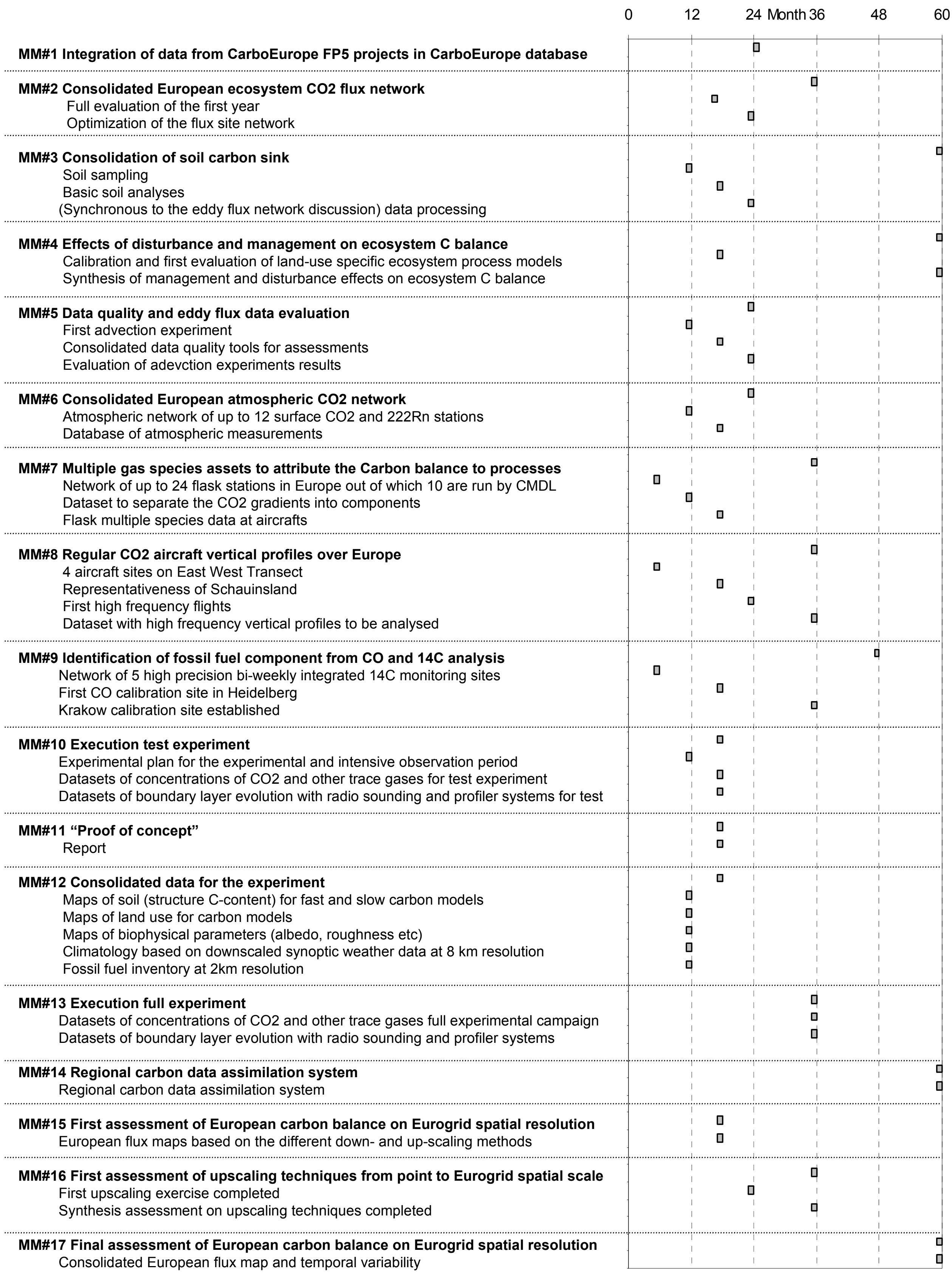


Figure 16 Gantt chart of Major Milestones

7. Project management

7.1 Legal and administrative co-ordination of the Integrated Project

Having the legal and financial matters as well as the final decision on the scientific content in one central hand will organise the administrative work in the most efficient way since many partners are involved in several Activities and Components. The decision structure is illustrated in Figure 17.

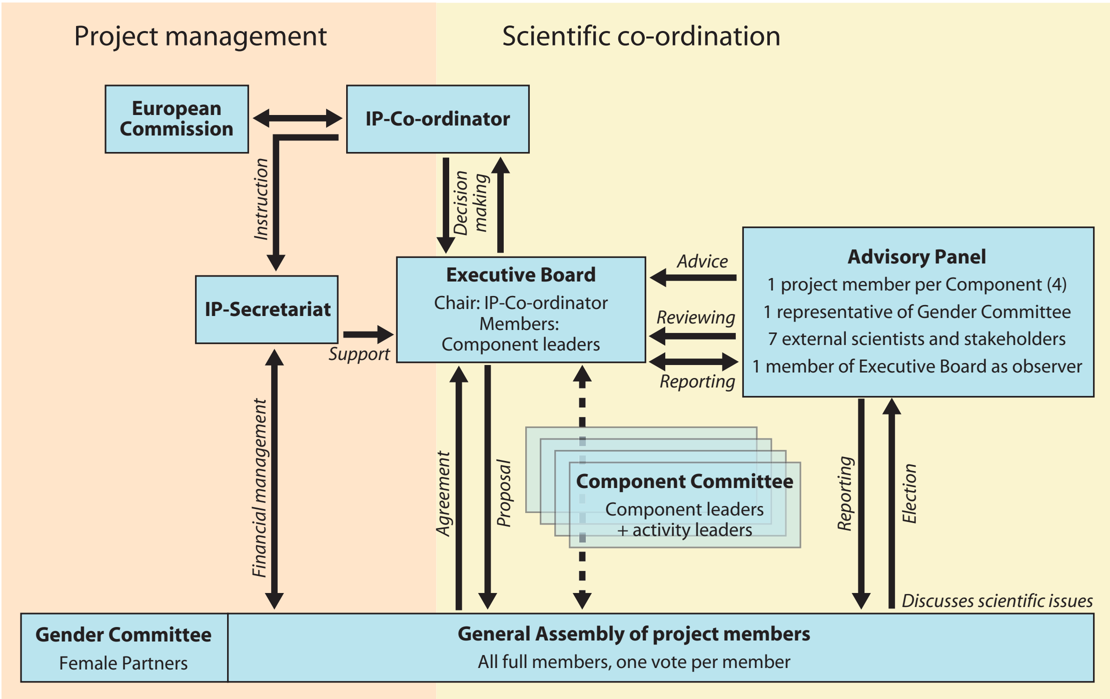


Figure 17 Decision structure of CarboEurope-IP

MPI-BGC, represented by its director Ernst-Detlef Schulze (**IP Co-ordinator)**, will be the **IP Co-ordinating Institute**, supported by the **IP secretariat**. MPI-BGC has a long successful record of co-ordination of international projects, among which three projects belong to the CarboEurope Cluster (Forcast, Tcos Siberia, CarboEurope Accompanying Measure). MPI-BGC has already been hosting the secretariat of the CarboEurope Cluster (FP5) with dedicated staff appointed to it. The General Administration of the Max Planck Society (MPG) will support the IP co-ordination with know-how in dealing with large consortia, and exchange of experiences in project management and financial auditing is assured by the existing MPG-network of EC-project officers and the MPG contact point in Brussels. A lawyer based at the General Administration of the MPG will act as consultant in specific situations (e.g. setting up of consortium agreement).

Tasks of the IP co-ordinator

- legal and financial contact to European Commission

- responsible for IP co-ordination and management
- issuing of all partner contracts and of consortium agreement
- responsible for and dealing with all matters affecting Associated Partners, in collaboration with the respective Activity and Component Leaders
- final decisions about legal, administrative and scientific project management, in collaboration with the Executive Board
- responsible for distribution of the EC financial contribution
- responsible for preparation of annual financial summary report
- responsible for preparation of the annual progress reports and updates of the implementation plan with help of the Component Leaders
- overseeing the decision process at the level of the entire consortium in all legal, administrative and scientific matters

MPI-BGC will enlarge the management team of the present CarboEurope Cluster secretariat to form the new IP secretariat as described below to execute the overall legal, contractual, ethical, financial, administrative and scientific management of the consortium under the lead of ED Schulze.

The **management team** at MPI-BGC comprises
- a scientific officer with broad background in science and policy, experience in co-ordination and dissemination, and proven organisational skills
- a project administrator with background in administration and financial affairs and organisational skills
- MPI-BGC-staff part-time for bookkeeping

Tasks of the scientific officer
- preparing, updating and managing the consortium agreement between the participants
- co-ordination at consortium level of innovation-related activities
- administrative management
- co-ordination of annual report in close collaboration with Component Leaders, who are responsible for their respective parts
- overseeing and reviewing science and society issues, related to the research activities conducted within the project
- overseeing the promotion of gender equality in the project in collaboration with the gender committee (B.10)
- organising meetings, workshops, and conferences for the CarboEurope-IP as a whole
- dissemination of project results to the broad public
- advise to policy makers in collaboration with the Policy Group of the IP
- organisation of and contribution to scientific synthesis of project results

Tasks of the project administrator
- execution of financial management

- distribute EC contribution to partners as decided by Executive Board in agreement with the co-ordinator
- collect financial statements and audits from each of the partners
- assist in project administration and organisation
- assist in editing of reports and dissemination material.

7.2 Scientific co-ordination of the Integrated Project

Organisational structure and decision-making mechanisms

CarboEurope-IP evolves from the CarboEurope Cluster of 15 European projects funded under FP5, which was even larger in size than this Integrated Project. The internal organisation and the management of the consortium reflect this successful history, with adjustments to the new dimension of integration and the EU rules on management and Annex II of the Contract.

The **IP Co-ordinator** leads the scientific management together with the Executive Board, reviewed and advised by the Advisory Panel (Figure 17). Experience in the CarboEurope Cluster in FP5 has shown that this structure allows scientific decisions to be taken on the broadest possible basis, while avoiding the potentially biased view of a single co-ordinating institution. This structure makes decisions transparent as it assures information flow bottom-up as well as top-down. MPI-BGC has participated in the CarboEurope Cluster in FP5 with the greatest diversity of scientific and co-ordination tasks and already hosts the CarboEurope secretariat with dedicated staff, so the institute naturally took the role of the IP co-ordinating institute.

The strong, small **Executive Board** is the central scientific decision making body. The Executive Board consists of the

- IP co-ordinator (member with vote),
- the four leaders of the four main project Components (Component Leaders, members with vote),
- scientific officer (associated member without vote),
- the Activity Leader of the Innovation Activity (associated member without vote), and
- the Chairman of the Data Management Committee (PI of the Central Database, associated member without vote. The present structure foresees that this task is in the responsibility of the Leader of the Integration Component.)

The Executive Board takes the strategic and operational scientific decisions. It takes decisions related to project execution, ensuring a high level of integration. The scientists forming the Executive Board come from the four core partner institutions and have proven in the past that they collaborate well and can efficiently take decisions and solve problems. They have been collaborating for several years and therefore a strong basis of mutual trust, confidence and scientific understanding of each others domain to ensure a smooth, timely and highly Integrated Project performance. The IP Co-ordinator chairs the Executive Board. The Executive Board will meet at least quarterly, either physically or via teleconferences.

The **General Assembly** comprises all contractors. It discusses strategic questions of the science of CarboEurope-IP and eventual problems related to project management. The General Assembly confirms annually the Executive Board, the Data Management Committee, and agrees on the updates of the 18-months implementation plan and budget. It elects the project-internal members of the Advisory Panel and the Gender Committee. Voting rules are specified in the Consortium Agreement. The project-internal members of the Advisory Panel are elected by the partners of the respective Components. Members who are partners in several Components have a vote in each Component.

The **Advisory Panel** is the internal review board of the science of CarboEurope-IP and of eventual problems related to project management. It also assists in solving conflicts (e.g., data delivery, partners in breach of commitments). The Advisory Panel also receives and evaluates critical areas of the half-yearly progress reports of all partners regarding risks of delay or failure of deliverables and suggests actions to resolve eventual problems. This will help the Executive Board to take timely action and to decide about paying the next rates of financial contributions to the partners. It consists of

- 4 project members, representing the General Assembly,
- 1 representative of the Gender Committee,
- 7 external assigned scientists and stakeholders, bridging to international programmes, major national activities outside Europe and stakeholders, and
- 1 member of the Executive Board as an observer in the Advisory Panel, who reports about the decisions and plans of the Executive Board and assures a good flow of information between the Advisory Panel and the Executive Board.

The four project members are elected by the General Assembly, per Component, for a period of two years, ending at latest with the end of the project. Members can be re-elected. Each Component elects two representatives. Partners can only vote for representatives of those Components in which they are involved.

The **Data Management Committee** implements the data policy (cf. Section 6.1.3 for details).

The **Gender Committee** promotes gender equality in the IP (cf. Section 6.6 for details).

Constitution of the scientific co-ordination

IP Co-ordinator: Ernst-Detlef Schulze (MPI-BGC)

Executive Board:

Ernst-Detlef Schulze (Co-ordinator, MPI-BGC),
Riccardo Valentini (Component 1, UNITUS),
Philippe Ciais (Component 2, LSCE),
Han Dolman (Component 3, VU-A),
Martin Heimann (Component 4 and Chairman of Data Management Committee, MPI-BGC),
Annette Freibauer (Secretariat, MPI-BGC), associated member without vote
John Grace (Innovation Activity Leader, UEDIN), associated member without vote

External members of Advisory Panel

Dennis Baldocchi, USA (preliminary acceptance)

A. Scott Denning, USA (accepted)
Roger Francey, Australia (preliminary acceptance)
Neil Turner, Australia (accepted)
EEA: André Jol (preliminary acceptance)
EC sinks experts group: Jim Penman (accepted)
IPCC: Thelma Krug (accepted)
In case of non-acceptance other, equally distinguished experts will be found.

Internal co-ordination and communication

The **secretariat** plays a central role in the co-ordination and communication between CarboEurope partners. It supports the IP co-ordinator and the Component Leaders of the IP in the scientific co-ordination and acts as central place to channel information. The overall project management will rely on frequent contacts between the co-ordinators at all scientific levels.

Communication: Communication among partners and timely information about recent developments in the IP and planning for subsequent detailed work plans will be optimally achieved by a combination of direct contacts by email, mail, phone and meetings, and in particular, by a strong, enhanced web-based communication for better interaction between project Components and WPs within Components. Mailing list will be used to streamline the flow of information between WPs and Components and for special integrated task groups. Advanced interactive web-based management software tools will be used to facilitate the project management and to guarantee an efficient, democratic and transparent execution of the Integrated Project. Regular teleconferences or videoconferences are envisaged.

Meetings: The **Executive Board** will communicate on a regular basis via email exchange, phone conferences or meetings of Executive Board. The secretariat will report the results to the Advisory Panel. The **Advisory Panel** will meet at least yearly and upon request. Meetings can be replaced by emails and teleconferences. Annual meetings of all project partners will be organised simultaneously at the same venue in order to allow the best integration of WPs, Components and cross-cutting activities. Meetings of the Components and WPs will take place separately and jointly and mixed, to allow also a well integrated planning of subsequent detailed work plans. These annual meetings may be coupled to conferences to interact with parallel activities inside and outside Europe, international programmes. The Advisory Panel will be invited to participate at these annual meetings and will prepare half-yearly project reviews about scientific achievements, the integration within the project, relevance for stakeholders, based on the half-yearly short progress reports by all partners and on the annual meeting, and give recommendations for the development of subsequent work plans.

Settlement of internal disputes

During the last three years of the CarboEurope Cluster, no serious internal disputes asking for official settlement have occurred. Nevertheless, in the unlikely case that such internal disputes will occur in the future, we will deal with them in the most democratic, subsidiary manner:

The activity leader tries to settle the dispute with the respective partner.

- If not successful, the Component Leader tries to settle the dispute with the respective partner, supported by the Component Committee, if applicable.
- If not successful, the Executive Board develops a strategy with assistance by the Advisory Panel and interferes to settle the dispute with the possibility of sanctions. In case of disagreement within the Executive Board, the IP co-ordinator takes the final decision and is responsible for its execution.
- If step 3 was applied, the co-ordinator reports the case and its solution or consequences to the European Commission.
- If a Component Leader is directly involved in the dispute, the procedure starts at step 3. In this case, the Advisory Panel will develop a solution and propose it to the IP co-ordinator.

Integration of running FP5 projects and of national projects

The CarboEurope cluster of projects has created a co-ordination structure under the Fifth Framework Programme. Before the start of the CarboEurope-IP, the FP5 CarboEurope Steering Committee will decide together with the Executive Board about an efficient co-ordination structure. They will also decide about a strategy to integrate data and results of FP5 projects of the CarboEurope Cluster into the IP.

In the transition from FP5 to FP6, there will be a temporal overlap for 6 out of 15 projects of the present CarboEurope Cluster. These projects produce important methodological and scientific innovation on the way towards CarboEurope-IP, so they also contain core deliverables of the early phase of the IP and guarantee continuity in research. In order to best integrate these running activities in the IP, key deliverables of the six projects were integrated in the detailed work plan (B.8), so workpackages covered by FP5 projects are marked and will not be duplicated here. The partners of these projects are also all members of the IP consortium without funding for these deliverables during the period in which the FP5 projects are still running. The respective projects are:

Tacos Infrastructure (EVR1-CT-2001-40015) until 31/10/2004
Greengrass (EVK2-CT-2001-00105) until 31/12/2004
Tcos Siberia (EVK2-CT-2001-00131) until 31/12/2004
Camels (EVK2-CT-2002-00151) until 31/10/2005
CarboEurope-GHG Concerted Action (EVK2-CT-2002-20014) until 31/10/2005
Carbo-Invent (EVK2-CT-2002-00157) until 31/10/2005
Chiotto (EVK2-2001-00324) until 31/10/2005

Strategy for enlargement of consortium

At the moment, no further enlargement of the consortium is foreseen within the present level of resources of the IP. However, the science infrastructure of CarboEurope-IP will be open to associate external scientists and consortia of emerging projects upon request. A collaboration should contribute significantly to the objectives of CarboEurope-IP. Only institutes (not projects) can become member in order to set up clear rights and responsibilities. The formal procedure for enlargement of the consortium and collaboration with externally funded research is as follows:

- The applicant institute commits itself to make a clearly described, significant contribution to activities and workpackages indicated in the 5-years work outline plan and the detailed 18-months work plan.
- The applicant institute commits itself to adhere to the rules of the consortium agreement of CarboEurope-IP, especially to the data policy.
- The applicant institute becomes a member of the consortium of CarboEurope-IP for a limited period of time for which a significant contribution to the objectives of CarboEurope-IP is proven by the applicant. Only contractors can receive funding via the CarboEurope-IP. Associated members contribute to the goals of CarboEurope-IP without funding. Associated members conclude the consortium agreement with the co-ordinating institute. The co-ordinating institute is responsible for the integration of the new members into the CarboEurope-IP.

This means, for instance, if an external institution or consortium asks to use the science infrastructure of the site clusters, the data taken on these sites must be delivered to the respective managers of the site and site cluster and be made available to all members of the IP consortium. Metadata have to be delivered to the central meta-database of CarboEurope-IP. In turn, the external institution or consortium can request data taken in the frame of CarboEurope-IP at an extent related to the significance of the external contribution (e.g. from the site, site cluster or all sites, respectively). This open strategy will further mobilise resources to achieve the goals of CarboEurope-IP.

As CarboEurope-IP evolves new directions of research or demonstration or operationalisation may need to be incorporated in the work plan. New activities may be set up to respond for future developments, whilst the overall structure of main Components will be maintained. The Continental Integration Component, in particular, will be open to new initiatives of coupled earth system modelling and data assimilation, and serve as the contact point for wider integration with emerging research activities. We will particularly try to benefit from the strong observational infrastructure of CarboEurope-IP for training activities within Marie Curie networks. Such emerging projects should be bound to the CarboEurope-IP data policy in the same way as formal members, via membership in the CarboEurope-IP of the project consortium (cf. above). We will also seek collaboration with future projects on carbon-nitrogen cycle interactions.

10 Ethical issues

No research is performed on humans. Measurements on grazing cattle could be performed on some French grassland sites to investigate the full CH_4 flux from enteric fermentation, using the SF6 tracer technique. All experiments will be performed in accordance with the requirements of the national and European law and will meet the requirements of the national committee on animal ethic. This was also achieved in the FP5 project Greengrass. We will respect the environmental integrity: the field measurements are non-intrusive whenever possible and disturb the ecosystems as little as possible in order to measure ecosystem properties in conditions as natural as possible. Vegetation and soil samples will be taken with the agreement of land owners and land users. This has been assured for all ecosystem sites. No potential ethical and/or safety aspects of the envisaged research regarding its objectives, the methodology and the possible implications of the results were identified. The proposal is in full conformity with the ethical requirements of the 6th Framework Programme. We will also consider ethical and safety issues in each detailed work plan and during a potential enlargement of the consortium.

11 Other issues

CarboEurope-IP is open to collaborations world-wide. This will be formally regulated by international collaboration agreements on the basis of individual scientists or small institutional entities.

Chinese Academy of Forestry, Forest Ecology and Environment Institute will help to expand data coverage to temperate Eurasia and will be served by training.

A collaboration agreement with NOAA-CMDL has been established for exchange of atmsospheric measurement data.

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Appendix I-A – Consortium description

Participant List

Contractors

Part. Role	NO.	Participant name	Participant Short Name	Country	Date ENTRY project	Date EXIT project
Co-ordinator	01	Max Planck Institute for Biogeochemistry	MPI-BGC	Germany	Month 1	Project end
Contractor	02	U. of Tuscia, Dept. of Forest Environment and Resources (DISAFRI)	UNITUS	Italy	Month 1	Project end
Contractor	03	Free U. Amsterdam, Dept. Geo-Environmental Sciences	VU-A	Netherlands	Month 1	Project end
Contractor	04	CEA, LSCE, Laboratory of Climate and Environmental Sciences	CEA-LSCE	France	Month 1	Project end
Contractor	05	U. of Edinburgh, School of GeoSciences	UEDIN	United Kingdom	Month 1	Project end
Contractor	06	U. of Aberdeen, School of Biological Sciences	UABDN	United Kingdom	Month 1	Project end
Contractor	07	INRA - National Institute of Agronomic Research	INRA	France	Month 1	Project end
Contractor	08	Faculty of Agronomic Sciences Gembloux (UPB)	FUSAGx	Belgium	Month 1	Project end
Contractor	09	Météo-France/CNRM	CNRM	France	Month 1	Project end
Contractor	10a	CNR, Institute of Biometeorology	IBIMET-CNR	Italy	Month 1	Project end
Contractor	10b	Italian Air Force Meteorological Service, ISAC-CNR Monte Cimone	ISAC-CNR	Italy	Month 1	Project end
Contractor	10c	CNR-ISAFoM	CNR-ISAFoM	Italy	Month 1	Project end
Contractor	11	ECN - Energy Research Center of the Netherlands, Dept. Air Quality	ECN	Netherlands	Month 1	Project end
Contractor	12	U. Heidelberg, Inst. for Environmental Physics	UHEI-IUP	Germany	Month 1	Project end
Contractor	13	ALTERRA (Wageningen University and Research)	ALTERRA	Netherlands	Month 1	Project end
Contractor	14	EC-Joint Research Centre, IES	JRC-IES	Italy	Month 1	Project end
Contractor	15	Joanneum Research	JR	Austria	Month 1	Project end
Contractor	16	Hadley Centre	MET-OFFICE	United Kingdom	Month 1	Project end
Contractor	17	Potsdam Inst. for Climate Impact Research	PIK	Germany	Month 1	Project end
Contractor	18	Autonomous Province of Bolzano/Bozen South Tyrol - Forest Department	APB	Italy	Month 1	Project end
Contractor	19	Centre of Alpine Ecology	CEALP	Italy	Month 1	Project end
Contractor	20	Foundation CEAM	CEAM	Spain	Month 1	Project end
Contractor	21a	Centre of Ecology and Hydrology (CEH) - Wallingford	NERC.CEH-WAL	United Kingdom	Month 1	Project end

Part. Role	NO.	Participant name	Participant Short Name	Country	Date ENTRY project	Date EXIT project
Contractor	21b	Natural Environmental Research Council, CEH-Edinburgh	NERC.CEH-EDIN	United Kingdom	Month 1	Project end
Contractor	22	National Centre of Scientific Research, DREAM CEFE CNRS	CNRS-CEFE	France	Month 1	Project end
Contractor	23	Forest Technology Centre of Catalunya, Laboratory of Plant Ecology and Forest Botany	CTFC	Spain	Month 1	Project end
Contractor	24	Swiss Federal Research Station for Agroecology and Agriculture (FAL)	FAL	Switzerland	Month 1	Project end
Contractor	25	Finnish Meteorological Institute, Air Quality Research	FMI	Finland	Month 1	Project end
Contractor	26	Acad. of Sciences of Czech Republic, Inst. of Landscape Ecology	ILE	Czech Republic	Month 1	Project end
Contractor	27	Superior Technical Institute	IST	Portugal	Month 1	Project end
Contractor	28	Lund U., Dept. of Physical Geography and Ecosystems Analysis	LUND	Sweden	Month 1	Project end
Contractor	29	Risoe National Laboratory	RISOE	Denmark	Month 1	Project end
Contractor	30a	Swedish U. of Agricultural Sciences, Dept. of Ecology and Environmental Research (DEER)	SLU-DEER	Sweden	Month 1	Project end
Contractor	30b	Swedish U. of Agricultural Sciences, Dept. of Forest Soils	SLU-FS	Sweden	Month 1	Project end
Contractor	30c	Swedish U. of Agricultural Sciences, Dept. for Production Ecology	SLU-PE	Sweden	Month 1	Project end
Contractor	33	SRON National Institute for Space Research, IMAU	SRON	Netherlands	Month 1	Project end
Contractor	34	Second U. of Napoli, Dept. of Environmental Science	SUN	Italy	Month 1	Project end
Contractor	35	Trinity College Dublin	TCD	Ireland	Month 1	Project end
Contractor	36	TU Dresden, IHM-Meteorology	TUD	Germany	Month 1	Project end
Contractor	37	TU Munich Dept. of Soil Science	TUM	Germany	Month 1	Project end
Contractor	38	U. of Antwerp (UIA), Dept. Biology	UA	Belgium	Month 1	Project end
Contractor	39a	U. Bayreuth, Chair of Micrometeorology	UBT-MET	Germany	Month 1	Project end
Contractor	39b	U. Bayreuth, Chair of Plant Ecology	UBT-PE	Germany	Month 1	Project end
Contractor	41	U. College of Cork	UCC	Ireland	Month 1	Project end
Contractor	42	Szent István U. of Gödöllö	SZIU	Hungary	Month 1	Project end
Contractor	43	U. of Helsinki, Dept. of Physical Sciences	UH-DPS	Finland	Month 1	Project end
Contractor	44	TU Lisboa, Superior Inst. of Agronomy	ISA-UTL	Portugal	Month 1	Project end
Contractor	45	U. of Poznan	UPOZ	Poland	Month 1	Project end
Contractor	46	CNRS - U. of South Paris, Systematic Ecology and Evolution Unit	UPS-Orsay	France	Month 1	Project end
Contractor	47	Wageningen U., Nature Conservation and plant Ecology	WUR-NCP	Netherlands	Month 1	Project end
Contractor	48	Martin-Luther-U. Halle-Wittenberg, Inst. of Soil Science and Plant Nutrition	MLU	Germany	Month 1	Project end
Part. Role	**NO.**	**Participant name**	**Participant Short Name**	**Country**	**Date ENTRY project**	**Date EXIT project**
Contractor	50	U. de Liège - LPAP	ULG	Belgium	Month 1	Project end
Contractor	52	CESI Business Unit - Environment	CESI	Italy	Month 1	Project end
Contractor	53	Center for Isotope Research (CIO); Rijks-U. Groningen	CIO	Netherlands	Month 1	Project end
Contractor	54	Eötvös Loránd University, Dept.	ELU	Hungary	Month 1	Project end

		of Meteorology				
Contractor	55	ENEA, Global and Mediterranean Environment Division	ENEA	Italy	Month 1	Project end
Contractor	56	Stockholm U., Dept. of Meteorology, Arrhenius Lab.	SU	Sweden	Month 1	Project end
Contractor	57	U. of Barcelona, Climate Research Group	UBARC	Spain	Month 1	Project end
Contractor	58	U. Bern, Physics Institute, Climate and Environmental Physics	UBERN	Switzerland	Month 1	Project end
Contractor	59	U. of Mining and Metallurgy, Faculty of Physics and Nuclear Techniques	UKRAK	Poland	Month 1	Project end
Contractor	61	U. Stuttgart, Institute of Energy Economics and the Rational Use of Energy	USTUTT-IER	Germany	Month 1	Project end
Contractor	62	European Forest Institute	EFI	Finland	Month 1	Project end
Contractor	63	National Environmental Research Institute, Department of Atmospheric Environment	NERI	Denmark	Month 1	Project end
Contractor	64	Thuringia State Forest Research Station	LAWUF	Germany	Month 1	Project end
Contractor	65	International educational projects	SAUG	France	Month 1	Project end
Contractor	66	U. Copenhagen, Inst. of Geography	UKBH.GI	Denmark	Month 1	Project end
Contractor	67	University of Aveiro, Departamento de Ambiente e Ordenamento	UAV	Portugal	Month 1	Project end

Associated Partners (non-funded)

Part. Role	NO.	Participant name	Participant Short Name	Country	Date ENTRY project	Date EXIT project
Associated Partner	A1	CNR-IBIMET Bologna	CNR-BOL	Italy	Month 1	End of contribution
Associated Partner	A2	CNR-ISAFoM Cosenza, Institute for mediteranean agriculture and forest systems	CNR-ISAFoM-Cos	Italy	Month 1	End of contribution
Associated Partner	A3	CSIC, Cordoba	CSIC	Spain	Month 1	End of contribution
Associated Partner	A4	Danish Institute of Agricultural Sciences, Research Centre Foulum	DIAS	Denmark	Month 1	End of contribution
Associated Partner	A5	Swiss Federal Institute of Technology (ETH) Zurich	ETH	Switzerland	Month 1	End of contribution
Associated Partner	A6	Faculté des Sciences Agronomiques de Gembloux FUSAGx LEM	FUSAGx LEM	Belgium	Month 1	End of contribution

Part. Role	NO.	Participant name	Participant Short Name	Country	Date ENTRY project	Date EXIT project
Associated Partner	A7	Institute for Forestry and Game Management	IFGM	Belgium	Month 1	End of contribution
Associated Partner	A8	IPLA	IPLA	Italy	Month 1	End of contribution
Associated Partner	A9	KVL, Copenhagen	KVL	Denmark	Month 1	End of contribution
Associated Partner	A10	Edingborgh Centre	ECCM		Month 1	End of contribution
Associated Partner	A11	Rothamsted Research	ROTH	United Kingdom	Month 1	End of contribution

Associated Partner	A12	Ghent University	RUG	Belgium	Month 1	End of contribution
Associated Partner	A13	Swedish U. of Agricultural Sciences, Dept. of Forest Ecology	SLU-FE	Sweden	Month 1	End of contribution
Associated Partner	A14	Irish Agriculture and Food Development Authority	TEAGASC	Ireland	Month 1	End of contribution
Associated Partner	A15	U. della Basilicata, Dipartimento di Produzione Vegetale	UBAS-DPV	Italy	Month 1	End of contribution
Associated Partner	A16	U. Bern, Institute of Geography	UBEGEO	Switzerland	Month 1	End of contribution
Associated Partner	A17	Univ. Castilla la Mancha,	UCAS	Spain	Month 1	End of contribution
Associated Partner	A18	U. Catholique de Louvain	UCL	Belgium	Month 1	End of contribution
Associated Partner	A19	U. di Firenze, DISAT	UFI-DISAT	Italy	Month 1	End of contribution
Associated Partner	A20	Umwelt-Forschungs-Zentrum-Leipzig-Halle	UFZ	Germany	Month 1	End of contribution
Associated Partner	A21	Göteborg U., Dept. of Botany	UGOE	Sweden	Month 1	End of contribution
Associated Partner	A22	U. Helsinki, Department of Forest Ecology	UHEL-FE	Finland	Month 1	End of contribution
Associated Partner	A23	Scottish Agricultural College	SAC	United Kingdom	Month 1	End of contribution
Associated Partner	A24	U. de Liège -Plant and Microbial Ecology	ULIE	Belgium	Month 1	End of contribution
Associated Partner	A25	U. de Valladolid	UVAL	Spain	Month 1	End of contribution
Associated Partner	A26	Weizmann Inst. of Science, Dept. of Environmental Sciences and Energy Research	WEIZ	Israel	Month 1	End of contribution
Associated Partner	A27	Wageningen U.	WUR	Netherlands	Month 1	End of contribution
Associated Partner	A28	U. di Bologna, Dip. Colture Arboree	UBOL	Italy	Month 1	End of contribution

Collaborating institutes outside Europe

For details about collaborating institutes see section 11.

Part. Role	NO.	Participant name	Participant Short Name	Country	Date ENTRY project	Date EXIT project
Internat. Collabor.	C1	NOAA, ERL, Climate Monitoring & Diagnostics Laboratory	CMDL	USA	Month 1	End of contribution
Internat. Collabor.	C2	Chinese Academy of Forestry, Forest Ecology and Environment Institute	CAF	China	Month 1	End of contribution

Appendix I-B.2 State-of-the-art and enhancement by the Integratéd Project

Appendix I-B.2.1 Terminology

Ecosystem carbon budget

- GPP: Photosynthesis
- NPP: GPP minus plant respiration (= growth)
- NEP: NPP minus heterotrophic respiration
- NBP: NEP minus non-respiratory losses such as harvest, carbon leaching
- NEE: measured carbon exchange between ecosystem and atmosphere

Spatial scales

- **Continent**: Geographical Europe encompassing the European Union and the Candidate States, the new Eastern European States and the former Soviet Union up to the Ural with a focus on the European Union and the Candidate States, with a spatial resolution of the 20 to 50 (to 100) km "Eurogrid", and a weekly temporal resolution. However, the coverage and resolution achievable for Eastern Europe will depend on capacity building and additional funding for measurements and acquisition of land use and management data.
- **Region**: A region in the order of a grid box of 300 km x 300 km, with a spatial resolution of 1 to 10 km, and a typical temporal resolution of hours to one day.
- **Ecosystem**: A landscape with homogeneous land cover in the order of 1 km^2, with a spatial resolution of a few metres, and a typical temporal resolution of eddy flux measurements of 0.5 h.

Ambiguous terms in the science versus policy context

- **Observation**: Measurement, including its calibration, quality control and data processing
- **Monitoring**: Long-term combined measurements and modelling if adequate. The term is used in its scientific sense rather than in the sense of the Kyoto Protocol.
- **Multiple constraint approach:** Scientific check of observations and estimates against independent other observations and estimates. Estimates by ground-based methods and bottom-up modelling must match with estimates from top-down approaches driven by airborne observations in order to produce a robust estimate of the carbon sink.
- **Verification**: Scientific check of observations and estimates against independent other observations and estimates. CarboEurope-IP is developing a multiple constraint approach to quantify the terrestrial carbon sink at local, regional and continental scale: The term "Verification" is used in its scientific sense rather than in the sense of the Kyoto Protocol namely an expert review of validity of calculations.
- **Full carbon accounting**: Quantification of the full carbon balance of an ecosystem, region or continent, including the carbon fluxes in all carbon pools.

Appendix I-B.2.3 State-of-the-Art and Enhancement by the CarboEurope-IP

Based on past experience in FP5 we need to increase the frequency of observation at both the regional and continental scale to better resolve the temporal aspects of the Carbon Cycle. Enhanced spatial resolution of the measurements allows a finer spatial resolution of the sink strength of Europe to be determined. By combining data sources such as land cover and management with atmospheric observations of fluxes and concentrations in a highly innovative modelling framework the newly assigned EUROGRID (20 km x 20 km to 50 km x 50 km (100 km x 100 km)) we are able to reduce the overall uncertainty in our estimates. This is one of the key driving questions of the CarboEurope-IP. New inversion methods at both continental and regional scale have to meet the scale at which ground measurements take place.

We enhance the previous innovation of the CarboEurope Cluster by explicitly improving the methodology for achieving the required instrumental accuracy, for checking of results, and thereby enhancing the credibility of individual methods (or providing grounds for discarding methods that perform badly).

The scientific innovation is also with respect to filling gaps of knowledge that relate to the continental and regional experiments and process knowledge. At the continental level, the enhanced frequency of key observations, the new methods to separate fossil fuel contributions from the total source of emitted CO_2 and an enhanced spatial resolution which is obtained by the integration of the tall tower network will greatly enhance our ability to produce estimates of source and sink strengths of European regions. These estimates will be associated with estimates of uncertainty at increasingly higher spatial and temporal resolution.

At the regional scale, the combination of experimental methods allows high-resolution and accurate estimation of the sinks strength at unprecedented spatial (2-4 km) and temporal resolution (1 week). These estimates will be aggregated up to the level of the EUROGRID scale to provide a true and testable link between the local and continental scale integration efforts. Such an experiment is unique in the world and has not been attempted before at this level of comprehensive planning.

At the local level, the Cluster Site strategy, incorporating measurements of the main land use types in a given region is a key innovation. The process studies and the modelling of allocation of assimilated carbon to compartments for footprint regions (1 km^2) and assimilation/transport schemes are novel.

There is an unrivalled of integration in the measurement protocols for full carbon monitoring at the local site level where harmonisation and linkage of the ground based measurements with the atmospheric measurements (the virtual tower concept) is new. In fact, high precision CO_2 concentration measurements will not only be performed in flasks and on dedicated atmospheric observation sites but also on selected eddy covariance towers.

The CarboEurope strategy provides the data and the modelling tools that eventually will allow us to separate natural from direct and indirect human induced effects. The attention for these issues, based on policy demands, is new

The CarboEurope-IP will attempt to track the impact of the biosphere on atmospheric CO_2 and thus help verifying European reduction measures as committed in the framework of the Kyoto Protocol. We will deliver a prototype monitoring and data assimilation system, which is unique in the world in its comprehensiveness, and in its level of integration and breadth. This will for the first time provide quantitative information to support the implementation of the Kyoto protocol in Europe. Furthermore it will, for the first time, provide the quantitative information for full carbon accounting at local, regional and continental scales. Although this is not yet part of the present arrangement of the Kyoto Protocol, we believe that the CarboEurope results may enter the discussions about Full Carbon Accounting and the protection of carbon stocks that are currently held for Kyoto II.

The bottom-up and top-down approaches will individually not be able to reduce the uncertainties in the estimates of the European carbon balance below 20 to 30%. However, using the multiple constraint approach, we are confident to reduce the uncertainty to a level of 10 to 20% or better.

Appendix I-D: Ecosystem site list

Cluster	Site type	site code	NAME	land use	land cover	lat (°N)	long	mean T °C	precip.	LAI
cluster_DE1	M	**DE-Hai**	Hainich	beech	forest	51°04'45.14	10°27'07.83"E	7.5-8	800	5-6
	M	**DE-Wet**	Wetzstein	spruce	forest	50°27'12.51"	11°27'27.27"E	5.9	840	4-5
	M	**DE-Geb**	Gebesee	crop	crop	51°06'00.13"	0°54'51.90"E	8.5	470	4-5
	A	**DE-Meh**	Mehrstedt	afforestation	forest	51°16'08.50"	10°40'00.40"E	7.8	570	1-2
	A	**DE-Bra**	Braunschweig	crop	crop					
cluster_DE2	M	**DE-Tha**	Tharandt	spruce	forest	50°57'49"	13°34'01"E	7.7	820	7.6
	M	**DE-Gri**	Grillenburg	meadow	grassland	50°57'04"	13°30'51"E	7.2	853	2-5
	M	**DE-Kli**	Klingenberg	crop rotation	crop	50°58'	13°20'E	9	750	
	A	**DE-Obe**	Oberbären-burg	spruce	forest	50°47'12"	13°43'20"E	5.5	996	5
	A	**DE-Sch**	Schönau	meadow	grassland	47° 36'	12°E 58'	7.2	1400	2-6
cluster_FR1	M	**FR-Hes**	Hesse	beech	forest	48°40'	7°05' E	9.2	820	6-8
	M	**FR-Gri**	Grignon	crop	crop	48°51'	1°58' E	11.5	700	0-6
	M	**FR-Fon**	Fontainbleu	oak	forest	48°28'	2°47' E	10.2	720	5
	A	**FR-Lus**	Lusignan	grassland	grassland	46°26'	0°28'E	10	600	2-5
cluster_FR2	M	**FR-LBr**	Le Bray	pine	forest	44°43'	0°46'12" E	13.6	900	4 - 5.5
	M	**FR-Laq**	Laqueuille	grassland	grassland	45°38'35"	02°44'09" E	13.6	1313	2.5
	A	**FR-Avi**	Couhins	wines	crop	44°45'	0°32'56" W	13.3	900	0 - 1.1/1.5
	M	**FR-Pue**	Puechabon	oak	forest	43°44'29"	3°35'45" E	13.5	883	2.9
	A	**FR-Bil**	Bilos	pine	forest	44° 29' 40"N	0° 57' 22" O	12.8	930	2.1
	A	**FR-Cou**	Avignon	crop	crop	43° 55' 00"N	4°52'47"E	14	687	0-6
cluster_IT1	M	**IT-Roc1**	Roccarespampani	oak	forest	42°24'	11°55' E	14	670	4
	M	**IT-Amp**	Amplero	grassland	grassland	41°52'	13°38' E			
	M	**IT-Col**	Collelongo	beech	forest	41°50'57.7"	13°35'17.3" E	6.3	1180	5
	A	**IL-Yat**	Yatir	pinus	forest	31°20'49"	35°03'07" E	22	275	2.5
	A	**IT-Roc2**	Roccarespampani	oak	forest	42°24'	11°55' E	14	670	1
	A	**IT-BCi**	Borgo Cioffi	crop	crop	40°37'	14°56'	18	600	
	A	**IT-Tol**	Tolfa	shrub	forest	42°11'30"	11° 55' 30" E			
	A	**IT-Pia**	Pianosa	shrub/crop	forest/crop	42°35'7.7"	10°4'44.5"	16	500	
	A		Grosseto	crop rotation	crop	43° 43' 00"	10° 17' 00" E	14	900	4-5
	A	**IT-Bon**	Bonis	pine	forest/plantation	39°28' N	16°30' E	8.9	1170	

Cluster	Site type	site code	NAME	land use	land cover	lat (°N)	long	mean T °C	precip.	LAI
cluster_IT2	M	**IT-PTi1**	Parco Ticino	poplar	forest	45°12' 03" N	09°04' 25" E	12.7	984	1-3
	M	**IT-MBon**	Monte Bondone	grassland	grassland	46°00'56" N	11°02'48" E	5.5	1189	5-6
	M	**IT-Ren**	Renon	spruce	forest	46°36' N	11°28' E	4.1	1010	6
	A	**IT-Lav**	Lavarone	spruce	forest	45°57'18.93" N	11°16'52.23" E	7.8	1150	9-10
	A	**IT-Mal**	Malga Arpaco	grassland	grassland	46°07'00" N	11°42' 10" E	6.3	1200	
	A	**IT-Non**	Nonantola	mixed dec	forest	44° 41.389' N	11°05.321 E	14.5	1000	3
	A	**IT-SRo**	San Rossore	pine	forest	43° 43' 47" N	10° 17'13" E	14.2	920	4.2
	A	**IT-PTi2**	Zerbolo'/Parco Ticino	rice	crop	45°12' 03" N	09°04' 15" E	12.7	984	
	A	**IT-LMa**	La Mandria	oak	forest	45°09' N	07°34' E	11.6	1030	
cluster_DK	M	**DK-Sor**	Soroe	beech	forest	55° 29’	11° 38’E	8.2	660	4.8
	M	**DK-Lva**	Rimi	grass	grassland	55° 41’	12° 05’E	8	600	1-6
	M	**DK-Ris**	Risbyholm	crop	crop	55° 32’	12° 33’E	8	580	0-6
	A	**DK-Ulb**	Ulborg	spruce	forest	56° 17’	8° 26’E	7.7	960	8.1
	A	**DKFou**	Foulum	crop	crop					
cluster_SE	M	**SE-Nor**	Norunda	scots pine/spruce	forest	60□ 5’	17°29’E	5.5	527	4.5
	M	**SE-Sky1**	Skyttorp	scots pine (0 y)	forest	60□ 7’	17°54’E	5.5	527	0.5
	M	**SE-Sky2**	Skyttorp	scots pine (30 y)	forest	60□ 7’	17°50’E	5.5	527	3.5
	A	**SE-Kno**	Knottåsen	Norway spruce, 30 years	forest	60□ 59’	16°13’E	3.4	613	3
	A	**SE-Fla**	Flakaliden	Norway spruce, 35 years	forest	64□ 07’	19°27’E	1.9	587	2
	A	**SE-Deg**	Degerö	Aapa mire (Poor sedge fen)	grassland	64□ 11’	19°33’E	1.2	523	2
	A	**SE-Asa**	Asa	Norway spruce/Scots pine ca 60 y	forest	57□ 10’	14°48’E	5.5	688	4
	A	**SE-Sto1**	Stordalen	Sub-arctic mire	grassland	68□ 21'	19°02'E	-0.8	299	1.5
	A	**SE-Sto2**	Stordalen	Birch forest	forest	68□ 21'	19°02'E	-0.8	299	2

Cluster	Site type	site code	NAME	land use	land cover	lat (°N)	long	mean T °C	precip.	LAI
cluster_ES	M	**ES-VDA**	Vall d'Alinyà (Lleida)	grassland	grassland	42º12´06´´	1º26´57´´ E	13	669	
	M	**ES-ESa2**	El Saler-Sueca (Valencia)	crop	crop	39º17´11.5´´	0º20´37.5´´W	18	550	0-5
	M	**ES-LMa**	Las Majadas del Tietar (Caceres)	Dehesa (Open Oakland)	forest	39º 56´58.4"	5º47´17.2" W	18.5	572	2.5
	A	**ES-ESa1**	El Saler (Valencia)	High maquia + pine	forest	39º 20´54.6´´	0º19´2.4´´W	17.85	550.7	3.2
	A	**ES-Tol**	Toledo	High maquia (Cistus and Erica)	maquia			15	400	2-3
	A	**ES-Val**	Valladolid	Wheat	crop	41º48´53.5”	4º 55´56.9” W	11	440	0-4.5
	A	**ES-Cor**	Cordoba	crop	crop					
	A	**ES-LLl**	Los Llanos de Silva	Olive Plantation	forest	37º 20" N	3º 35" W	16	400	1.8
cluster_PT	M	**PT-Mit1**	Mitra II	oak woodlands	forest	38º 32' 26.2"	08º 00' 01.9" W	15.4	665	0.55
	M	**PT-Esp**	Espirra	Eucalyptus plantation	forest	38º 38’	8º 36’ W	16	709	3
	M	**PT-Mit2**	Mitra IV	grassland	grassland	38º 32' 26.2"	; 08º 00' 01.9" W	15.4	665	
cluster_NL	M	**NL-Loo**	Loobos	Scots Pine	forest	52°10'00"	05°44'38" E	9.8	786	1.9-2.2
	M	**NL-Cab1**	Cabauw	grassland	grassland	51.971°	4.927 E	10	800	1-2
	M	**NL-Hor**	Horstermeer	natural fen (peat)	grassland	52°14'23"	05°04'16" E	10	800	1-3
	A	**NL-Lel**	Lelystad	grassland	grassland	52° 30'	05° 30' E	10	780	1-2
	A	**NL-Cab2**	Cabauw extension	arable land/grassland	Crop/Grassland	52° 00'	04° 55' E	10	780	1-6
cluster_BE	M	**BE-Bra**	Braschaat	Pinus Sylvestris+*Quercus robur*	forest	51°18’	4°31’ E	9.8	750	2.4-3
	M	**BE-Vie**	Vielsalm	Fagus sylvatica, Pseudotsuga menziensii	forest	50°18’	5°59’ E	7	1150	3-4.5
	M	**BE-Lon**	Lonzee	Arable crop (rotation)	crop	50°33’	4°39’ E	10	750	
	A	**BE-Jal**	Jalhay	mixed forest, planted	forest	50°33’	6°04’ E	6	1200	

Cluster	**Site type**	**site code**	**NAME**	**land use**	**land cover**	**lat (°N)**	**long**	**mean T °C**	**precip.**	**LAI**
cluster_UK	M	**UK-Gri**	Griffin	Sitka Spruce	forest	56° 36´	3°47´W	8.2	1200	8
	M	**UK-ESa**	East Saltoun	barley/grass	crop	55° 54´	2,51 W	8.5	600	
	A	**UK-Har**	Harwood	Sitka spruce, chronose-quence	forest	55° 14´	2°06'W	9	950	12
	M	**UK-EBu**	Easter Bush	Grassland	grassland	55° 52´	3°10´W	8	890	
	A	**UK-AMo**	Auchencorth Moss	Blanket peat	grassland	55° 46´	3°16´W	7.4	900	
cluster_IE-UK	M	**IE-Car1**	Carlow	Arable	crop	52° 51'	6°54'W	5.5-13	804	0-6
	A	**IE-Car2**	Carlow	Grassland	grassland	52° 51'	6°54'W	5.5-13	804	
	A	**IE-CLa**	Co. Laois	Forest (Sitka spruce)	forest	52° 57'	7° 15' W	5.5-13	804	
	A	**IE-Wex**	Wexford	Grassland	grassland	52° 17'	6° 30' W	7.2-13.8	1049	
	M	**IE-Dri**	Dripsey	Grassland	grassland	51°.55'	8°.45'W	5.3-13	1450	
	A	**IE-Kil**	Killorglin	Bog	grassland	51°.58'	9°.55'W	4.5-12.5	1950	
	A	**UK-PLa1**	Pang/ Lambourne	Arable	crop	51° 32'	1° 29'W	9.2	800	0-6
	A	**UK-PLa2**	Pang/ Lambourne	Grassland	grassland	51° 26'	1° 14' W	9.2	800	
	M	**UK-PLa3**	Pang/ Lambourne	forest broadleaf	forest	51° 27'	1° 16' W	9.2	800	
	A	**UK-Her**	Hertfordshire	Arable	crop	51°46'	0°28' W	5.6-13.3	695	0-6
	A	**UK-Ham**	Hampshire	Forest (broadleaf)	forest	52° 11'	0° 51' W	5.5-13	790	
	A	**UK-Cir**	Cirencester	Arable	crop	52°42'	1°59' W	5.8-13.8	786	0-6
cluster_FI	M	**FI-Hyy**	Hyytiälä	scots pine 41 yr	forest	61° 51'	24□ 17'E	3	700	6-8
	M	**FI-Sod**	Sodankylä	scots pine 100 yr	forest	67° 21' 42.7"	26□ 38'16"E	-1	499	3.6
	M	**FI-Kaa**	Kaamanen	grassland (peat)	grassland	69° 08' 26.5"	27□ 17'	-1.3	395	0.7
cluster_C-EEu	M	**CZ-BKr1**	BKFORES	Coniferous forest	forest	49 ° 30´´	E 18°32´28´´	4.9	1100	8.2-11
	A	**CZ-BKr2**	BKGRASS	Grasslands	grassland	49 ° 30´17 ´'	E 18°32´28´´	4.9	1100	1.2
	M	**HU-Bug**	Bugac	Grasslands	grassland	46,8 °	E 18,9°	11	500	2.5
	A	**HU-Mat**	Matra	Cropland	crop	47,5 °	E 19,7°	11	600	3-5
	A	**CZ-wet**	CZECHWET	wetlands	grassland	49° 01´	E 15° 01´	7.2	740	3
	M	**PL-wet**	POLWET	wetlands	grassland	52°06´	E 14° 07´	9	650	3-5
	A	**PL-Pol**	Polana	forest	forest	48°38´	E 19°32´	5.5	860	5.8
cluster_CH	M	**CH-Oen1**	Oensingen	Grassland	grassland	47°17'N	7°44'E	9	1100	6
	M	**CH-Oen2**	Oensingen	Arable	crop	47°17'N	7°44'E	9	1100	6
	M	**CH-Lae**	Laegern	Mixed forest	forest	47°28'N	7°28E	8.3	1100	8-12

Appendix I-E: Ecosystem site parameters

This list of parameters will be consolidated during the first two months of the project (e.g. how to deal with fine root biomass and turnover).

The following tables reflect different "ranking" of the sites (verification, main, associated) and contain the indication of mandatory (M) and optional (O) parameters that a specific site type has to measure/deliver. The last column contains the ecosystem-type code indicating for which ecosystems a certain measurement has to be collected (A: all, F: forest, C:cropland, G: grassland).

The column indicating the "symbol" of the parameter/variable, is to be considered preliminary and will be made consistent with generally used definitions, abbreviations and nomenclature.

Legend of tables:

Verification sites: up to 12 sites where the soils will be analysed in details (Schulze's WP on soils)
Main sites: the 3 sites per cluster/supersites
Associated sites: all the other sites
M: mandatory; O: optional
Ecosystem types: A: all; F: forests; C: croplands; G: grassalands.
If needed, the ecosystem code has been mentioned also in other columns (sites, step).

Site description

FORESTS

1a. Description of site

- Site history
- species composition of main canopy
- brief description of accompaining species / assessment of ground cover (species, cover)
- location, topography, site maps

1b. Management and disturbances

- management scheme and rotation lenght
- site preparation (if ploughed, planted)
- dates and description of main management operations (thinning, harvesting, others)
- dates and description of main disturbance events (windthrow, fire, similar)

CROPLANDS

1a. Description of site

- Site history (at least previous crop and time since under crops)
- Rotation / long-term cropping practice
- Crop details – crop, cultivar etc.

1b. Management

- Activity dates and description – tillage / disturbance
- Sowing / harvest dates
- Fertilizer application – dates, amounts, type, description of the application system
- Herbicide / pesticide use – type, dates, amounts, description of the application system

2) Desirable:

- Previous measurements / data for the site before the flux measurements began
- Historical meterological records

GRASSLANDS

1a. Description of site

- Site history (at least previous land use over 30 y and time since under grasslands)
- Past grassland management (or other land use): eg grazing, cutting, organic & inorganic fertilizers, other treatments, events...
- Botanical composition and cover

1b. Management

Sown grasslands

- Activity dates and description – tillage / disturbance
- Crop details – crop, cultivar etc.
- Sowing / harvest dates
- Herbicide / pesticide use – dates, amounts, description

All grassland types

Fertilization

Timing, forms and amounts (inorganic and organic)

Grazing

Type and number of animals, live-weight, supplementary feeding, stocking rate, timing and duration of grazing events

Cutting

Timing, cutting height

2) Desirable

- Previous measurements / data for the site before the flux measurements began
- Historical meterological records
- Livestock farming systems close to the site.

1. Fluxes and meteorology

PARAMETER CLASS/TYPE	**PARAMETER MEASURED**	**SYMBOL**	**UNITS**	**METHOD**	**STEP**	*VERIFICATION SITES*	*MAIN SITES*	*ASSOCIATED SITES*	*ECOSYS-TEM TYPE*
CANOPY FLUX DENSITIES	carbon dioxide	Fc	□ mol m-2 s-1	eddy covariance	30 min	M	M	M	A
	sensible heat	H	W m-2	eddy covariance	30 min	M	M	M	A
	latent heat	LE	W m-2	eddy covariance	30 min	M	M	M	A
	water vapor	E	mmol m-2 s-1	eddy covariance	30 min	M	M	M	A
	momentum	□	Kg m-1 s-2	eddy covariance	30 min	M	M	M	A
	tree transpiration	TR	l hr-1	sap flow	30 min	O	O	O	F
STORAGE FLUXES	canopy heat storage	S_b	W m-2	biomass temperature	30 min	M	M	O	F
	CO_2 storage in canopy air layer	Sc	□ mol m-2 s-1	profiles/discrete approach	30 min	M profiles	M profiles	M discrete approach O profiles	F
	Latent heat in canopy air layer	Sw	W m-2	profiles/discrete approach	30 min	O	O	O	F
	heat storage in canopy air layer	Sa	W m-2	profiles/discrete approach	30 min	O	O	O	F
SOIL FLUXES	soil heat flux density	G	W m-2	sensors	30 min	M	M (C-G) O (F)	O	C-G (A)
	carbon dioxide emision	FCSOIL	□ mol m-2 s-1	cuvette or estimates	campaign mode	M	M (F) O (C-G)	O	F (C-G)
METEOROLOGY	global radiation (SW, LW incoming/outgoing)	Rg	W m-2	sensor	30 min	M	M	M	A

	net radiation	Rn	W m-2	sensor	30 min	M	M	M	A
	photosyntetic photon flux density, **direct and diffuse**	PPFDdir PPFDdif	□ mol m-2 s-1	sensor	30 min	M	M	M	A
	light interception	APAR		sensor		O	O	O	F, C
	air temperature	Ta	°C	sensor	30 min	M	M	M	A
	pressure	Pa	Kpa	sensor	30 min	M	M	M	A
	precipitation	P	mm	pluviometer	30 min	M	M	M	A
	canopy radiative temperature	Tc	°C	infra-red sensor	30 min	O	O	O	A
	bole temperature	TBOLE	°C	sensor	30 min	M	M	M	F
	soil temperature profile	Ts	°C	sensor	30 min	M	M	M	A
	relative humidity	RH	%	sensor	30 min	M	M	M	A
HYDROLOGY	snow depth	SNOW D	mm	sensor/pole	15 days (30 min)	M if relevant	M if relevant	M if relevant	A
	soil water content profile	SWC	% by volume	TDR	30 min surface layer, periodic for profiles	M	M	M	A
	Soil water table	SWD	cm from ground	diver	seasonal (30min)	M if relevant	M if relevant	M if relevant	A
DEPOSITION	wet deposition	WD	mm	wet-only sampler	15 days	O	O	O	A
	stemflow	SF	mm	tree collectors	15 days	O	O	O	F
	throughfall	TF	mm	pluviometer	15 days	O	O	O	F
	NO_x dry deposition	NOx	kg ha-1 month-1	passive sampler	1 month	O	O	O	A

	ammonia dry deposition	NH_3	kg ha-1 month-1	passive sampler	1 month	O	O	O	A

DEPOSITION Desirable, but cannot be requested in the context of this project, if possible, should be executed as a completed package, including chemical analysis of soil solution, WD, SF and TF, following the ICP-manuals.

For agriculture and grasslands continuous or campaign-targeted measurement of trace gases (especially N_2O and CH_4) from the site is desirable.

2. Structural, biomass, NPP and harvest

For structure and biomass the sampling scheme based on a carefully designed combination of inventory (e.g., wood, leaves, LMA, biomass density, tree height, age, dead wood, woody roots, fine roots, litter pool, drymass and C/N content), beginning and end of the 5ys period, continuous sampling: traps for litter, dendrometers for stem growth, LAI, possibly nets on the ground for branches, desirable ingrowth cores for fine root production.

PARAMETER CLASS/TYPE	PARAMETER MEASURED	SYMBOL	UNITS	METHOD	STEP	VERIFICATION SITES	MAIN SITES	ASSOCIATED SITES	ECOSYSTEM TYPE
STRUCTURE and BIOMASS	wood biomass	B_W	Kg m-2	inventory/sampling/site based allometric relationship	once/twice/annual	M	M	O	F
	aboveground biomass		kg m-2	sampling	annual/seasonal	M	M	O	C-G
	harvested biomass (incl. crop/grass productivity)		kg m-2	sampling/statistic	annual/seasonal	M	M	O	A
	residues after management practice		kg m-2	sampling	when relevant/at harvest	M	M (C-G) O (F)	O	A
	standing leaf biomass	B_L	Kg m-2	inventory/sampling/site based allometric relationship	annually in deciduous (connected to litterfall), once/twice in conifers	M	M	O	F
	fine root biomass	WR	Kg m-2	method to be decided	once/twice	M (to be decided)	O	O	A
	coarse root biomass	CWR	Kg m-2	inventory/sampling/site based allometric relationship	once	(M)	O	O	A

	wood increment	WI	Kg m-2	inventory/sampling/site based allometric relationship/dendrometers	annual	M	M	O	F
	fine root turnover	WR	Kg m-2	sampling	annual	O	O	O	A
	leaf (litter) production	W_{LL}	Kg m-2	litter traps	month/annual	M	M	O	F
	litter and leaf C/N	C/N		analysis	annual	O	O	O	A
	leaf litter pool of the forest floor	LLP	Kg m-2	sampling/survey	once/twice	M	O	O	F
	Fine woody debris	FWD	Kg m-2	sampling/survey	Connected to LLP	M	O	O	F
	Coarse woody debris pool (standing, laying)	CWD	Kg m-2	sampling/survey/site based allometric relationship	once/twice	M	O	O	F
	Leaf Mass per Area	LMA	g cm-2	sampling	annual (seasonal in deciduous, campaigns)	O	O	O	F
	leaf area index	LAI	m2 m-2	direct / indirect sampling	annual (direct or indirect sampling), at critical moment of the season (deciduous)	M	M (annual max) O (seasonal)	M (annual max)	A
	mean canopy height	h	m	inventory	annual (max)/twice/seasonal (G)	M	M	M	A
	Tree age	AGE	yr	inventory	once	M	M	M	F
	Tree density	n ha-1		inventory	twice	M	M	M	F
	mean diameter	DBH	cm	inventory	twice	M	M	M	F

	basal area	Gb	m2 ha-1	inventory	twice	M	M	M	F
SOIL	soil organic carbon stocks (profile)	SOC	kg m-2	sampling	once/twice	M (soils WP)	M (once)	O	A
	soil description			survey	once	M (soils WP)	M (soils WP)	M	A

3. Biology and Physiology

For Biology/Physiology a *campaign* approach is proposed, in order to characterize the vegetation/canopy at least once in the five IP years and to derive functional relationship with parameters that can then be measures more easily (e.g. Nitrogen, Leaf Mass per Area, chlorophyll, light, position in the canopy). The idea is to characterise a site for physiological parameters once and then use modelling or proxy variables. A yearly check at season peak of Psat can give hints on possible interannual differences.
Considering the limited budget, the measurements although desirable, are to be considered Optional.

PARAMETER CLASS/TYPE	PARAMETER MEASURED	SYMBOL	UNITS	METHOD	STEP	VERIFICATION SITES	MAIN SITES	ASSOCIATED SITES	ECOSYSTEM TYPE
BIOLOGY PHYSIOLOGY	photosyntetic max capacity	P_{max}	□ mol m-2 s-1	gas exchange under T/RH/CO2 control	campaign to characterize the vegetation	O	O	O	A
	leaf stomatal conductance	gs	cm s-1	gas exchange	campaign to characterize the vegetation	O	O	O	A
	leaf dark respiration	R_{LD}	□ mol m-2 s-1	gas exchange	campaign to characterize the vegetation	O	O	O	A
	bole respiration	R_B	□ mol m-2 s-1	gas exchange	campaign to characterize the vegetation	O	O	O	A
	nutrient content in component with rapid turnover (foliage, fine roots)	N, P, K	mg g-1	analysis	annual/campaign	O	O	O	A
	pre-dawn water potential	□		pressure chamber	campaigns	O	O	O	F (C-G)

	canopy development crop phenology	*CanDev*	descriptive /days	survey	seasonal/main events	O	O	O	A

Appendix I-F: Atmospheric site list

Ground Level stations continuous

	Site	Code	Latitude	Longitude	Altitude m asl	Country	Species measured
1	Mace Head	MHD	53°19' N	09°53'W	26	IRL	CO_2, ^{222}Rn, CH_4, CO, N_2O, CFCs
2	Zeppelin	ZEP	78°54' N	11°53' E	475	NW	CO_2 , ^{222}Rn (2)
3	Lampedusa	LAM	35°31' N	12°38' E	40	I	CO_2
4	Puy de Dôme	PUY	45°45' N	03°00' E	1465	FR	CO_2, ^{222}Rn
5	Schauinsland	SCH	47°55' N	07°55' E	1205	D	CO_2, ^{222}Rn, CH_4, N_2O, SF_6, CO
6	Monte Cimone	CMN	44°11' N	10°42' E	2165	I	CO_2, ^{222}Rn (2)
7	Plateau Rosa	PRS	45°56' N	07°42' E	3480	I	CO_2
8	Jungfraujoch	JFJ	46°33' N	07°59' E	3580	CH	CO_2 , ^{222}Rn, O_2/N_2
9	Lutjewad	LUT	53°23' N	06°22' E	0	NL	CO_2, CH_4, CO, ^{222}Rn (2)
10	Westerland	WES	54°56' N	08°19' E	12	D	CO_2, ^{222}Rn (2)
11	Kasprowy Wierch	KAS	49°14' N	19°56' E	1987	PL	CO_2, CH_4, SF_6
12	Pallas	PAL	67°58' N	24°07' E	560	FIN	CO_2, ^{222}Rn
(13)	Alert (1)	ALT	82°27' N	62°31' W	210	CAN	CO_2, CH_4, CO, ^{222}Rn

Tall towers continuous

	Site	Code	Latitude	Longitude	Tower height	Country	Species measured
1	Cabauw	CBW	51°58' N	04°55' E	213	NL	CO_2, CH_4, CO, N_2O, SF_6
2	Orléans	ORL	47°58' N	02°06' E	180	FR	CO_2, CH_4, CO, N_2O, SF_6, ^{222}Rn
3	Ochsenkopf	OXK	50°09' N	04°52' E	163	D	CO_2, CH_4, N_2O, SF_6, O_2/N_2
4	Bialystok	BIK	53.20°N	22° 75' E	300	PL	CO_2, CH_4, CO, N_2O, SF_6, O_2/N_2
5	Angus	TTA	55°57' N	3°13' W	220	UK	CO_2, CH_4, N_2O, SF_6, ^{222}Rn (2)
6	Hegyhatsal	HUN	46°57' N	16°39' E	115	HUN	CO_2, CH_4, CO, N_2O, SF_6
7	Firenze	FIR	43°48' N	11°12' E	210	I	CO_2, CH_4, N_2O, SF_6
8	Norunda	NOR	60°05' N	17°28' E	103	S	CO_2, CH_4
9	La Muela	MUE	41°35' N	1°50' W	200	ES	CO_2 (2)
(10)	Labouheyre (3)	LAB	44°12'N	0°54' W	100	FR	CO_2

Flasks sampling sites

	Site	Code	Latitude	Longitude	Labs	Country	Species measured
1	Alert	ALT	82°27' N	62°31' W	CMDL,AES	CAN	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$
2	Baltic Sea	BAL	55°30' N	16°40' E	CMDL	PL	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$
3	Black Sea	BSC	44°10' N	28°41' E	CMDL	RO	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$
4	Gozo	GOZ	36°03' N	14°11' E	CMDL	MT	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$
5	Hegyhatsal	HUN	46°57' N	16°39' E	CIO, CMDL	HUN	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$,
6	Iceland	ICE	63°15' N	20°09' W	CMDL	IS	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$
7	Izaña	IZO	28°18' N	16°29' W	CMDL	SP	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$
8	Mace Head	MHD	53°20' N	09°54' W	LSCE,CIO,CMDL	IRL	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$,
9	Zeppelin	ZEP	78°54' N	11°53' E	CMDL	NW	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$
10	Station 'M'	STM	66°00' N	02°00' E	CMDL	NW	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$
11	Shetland Islands	SIS	60°17' N	01°17' W	MPI, CSIRO	UK	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$,
12	Lampedusa	LAM	35°31' N	12°38' E	ENEA	I	CO_2, CH_4, N_2O
13	Begur	BGU	41°50' N	03°20' E	LSCE	SP	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$
14	Finokalia	FIK	35°19' N	25°40' E	LSCE	GR	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$
15	Portsall	BZH	48°35' N	04°40' W	LSCE	FR	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$
16	Puy de Dôme	PUY	45°45' N	03°00' E	LSCE,UNIBE	FR	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$,
17	Pic du Midi	PDM	43°04' N	00°09' E	LSCE	FR	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$
18	Lutjewad	LUT	53°23' N	06°22' E	CIO	NL	CO_2, CH_4, CO, $^{13}CO_2$, $CO^{18}O$, O_2/N_2
19	Schauinsland	SCH	47°55' N	07°55' E	UHEI	D	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$
20	Jungfraujoch	JFJ	46°33' N	07°59' E	UNIBE	CH	CO_2, $^{13}CO_2$, $CO^{18}O$, O_2/N_2
21	Cabauw (4)	CBW	51°58' N	04°55' E	ECN, CIO	NL	CO_2, CH_4, CO, $^{13}CO_2$, $CO^{18}O$
22	Orléans (4)	ORL	47°58' N	02°06' E	LSCE	FR	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$
23	Ochsenkopf (4)	OXK	50°09' N	04°52' E	MPI	D	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$,
24	Bialystok(4)	BIK	53.20°N	22° 75' E	MPI	PL	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$,

Vertical aircraft profiles

	Site	Code	Latitude	Longitude	Labs	Country	Species measured
1	Griffin (5), (8)	GRI	56°36' N	03°47' W	UEDIN,LSCE,UN	UK	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$,
2	Orléans (5), (7)	ORL	48°50' N	02°30' E	LSCE, CIO	FR	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$,
3	Hungary (5), (8)	HUN	46°57' N	16°39' E	ELU, LSCE, CIO,	HUN	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$
4	Bialystok (5), (7)	BIK	53°12' N	22°45' E	MPI	D	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$
5	Schauinsland (6), (7)	SCH	47°55' N	07°55' E	UHEI, CIO	D	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$
7	La Muela (9)	MUE	41°35' N	01°50' W	UBA	SP	CO_2
8	Fyodorovskoe (9)	TVE	56°28' N	32°55' E	LSCE, CIO	RU	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$
9	Zotino (9)	ZOT	60°75 N	89° 38' E	MPI	RU	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$
10	Syktyvkar (9)	SYK	61° 38 N	52° 28'E	UHEI	RU	CO_2, CH_4, CO, N_2O, SF_6, $^{13}CO_2$, $CO^{18}O$

(1) Associated site

(2) ^{222}Rn monitors that will be added during the IP

(3) Tall tower for the Regionalisation workpackage

(4) Tall towers

(5) Every 20 days until 2006 ; then every 5 days

(6) Every 20 days ; discontinued before 2006

(7) Continuous in situ CO_2 airborne measurements existing

(8) Continuous CO_2 airborne measurements to be installed in 2005

(9) Associated aircraft sites funded by other projects. Fyodorovsoye, Zotino, Syktyvkar may not continue after 2004 if FP5 project TCOS-Siberia is not continued

Appendix I-G: Data Policy

1. Rights and responsibilities

CarboEurope-IP is based on partial funding from the European Commission. The participating Parties have agreed to deliver to the project also data and knowledge produced from other funding sources. The principle investigator (PI) and the administration of each participating Party are responsible that their scientific staff is informed about the obligation of data delivery according to this contract and that the data delivery is considered in the work contracts.

Data and knowledge are produced by technical staff and scientific staff. The scientists (e.g., PI, PostDoc, PhD student, master student) own the data. Each scientist owns his/her own data and all rights pertaining to these data, and may make these data available at any time to anyone.

Each participant (institution) in the CarboEurope-IP who handles the CarboEurope database, will produce data from measurements and models to be used within the CarboEurope-IP. Rights and responsibilities of participants are defined at the level of data owner (individual scientist). A participant may be represented by several scientists with different rights and responsibilities.

Each scientists shall make data available through the database, according to the rules in this policy document, to other scientists within the CarboEurope-IP, unless other regulations exist.

Each scientist is responsible for making data available directly, according to the rules of the CarboEurope-IP, to participants in the CarboEurope-IP.

The CarboEurope Data Management Committee determines questions related to dataset documentation, dataset format, and quality level. The Data Management Committee also adjudicates possible disputes relating to this data policy. The Data Management Committee is composed of the PI of the Central CarboEurope-IP Database and the four PIs of the CarboEurope Data Centres for ecosystem data, atmosphere data, regional experiment data, and auxilliary data. It is chaired by the PI of the Central CarboEurope-IP Database.

2. Documentation of datasets

- All datasets should be documented according to a standard. This standard is an integral part of the database and consists of the following main elements: (i) Title, (ii) Authors/owners, (iii) Introduction (incl. objectives), (iv) Theory and type of measurements, (v) Equipment (incl. instrument description, calibration, procedures), (vi) Observations, (vii) Parameter/variable description, (viii) Data manipulations, (ix) Errors, (x) Notes, (xi) References, and (xii) Glossary of acronyms.

- Documentation of a given measurement site or region is also part of the Central CarboEurope-IP Database. This documentation should also be available on the web site of the CarboEurope-IP.

3. Access to data in the CarboEurope-IP

Access to data from version 1.0 and higher (cf. paragraph 9) is granted to each SCIENTIST.

Data access is initially restricted to participants of the CarboEurope-IP. The access of Associated Partners to data is restricted to the period of time in which they contribute to the project, and dependent on the significance of their contribution. All data from version 1.0 and higher (cf. paragraph 8.d) are immediately available as soon as they have been inserted into the database.

All datasets delivered to the CarboEurope database may eventually be published on CD (or another suitable medium existing at the time of publication). Such publication will open free access to the published CarboEurope-IP data. A possible publication will take place in certain intervals, e.g. at mid-term and after the project is finished, *i.e.*, after 1st of January, 2009. The publication of data during the running time of the CarboEurope-IP requires the written agreement of the data owner.

The CarboEurope-IP data policy follows the subsidiary principle, *i.e.*, all datasets are organized in databases at the level of the scientific Components, called "CarboEurope Data Centres", with a reference to and access from the central CarboEurope-IP database, which includes the common meta-database. Participants requesting data from Components in which they are not involved will be served by the Central Database.

The manager of the Central Database will be responsible for the collection of metadata from each Data Centre. MPI-BGC is responsible for the management of this central CarboEurope-IP database.

The Data Management Committee, in agreement with the Executive Board and the IP Co-ordinator, is responsible for publishing, and making available on the Internet, a list of scientist names in the CarboEurope-IP who are authorised to request data from the CarboEurope database (*i.e.,* project participants).

The Data Management Committee shall facilitate the publication of data from FP5 projects of the CarboEurope cluster and provide access to these data via the CarboEurope database.

4. Protection and exploitation of data and knowledge

The allocation of Intellectual Property arising under this project between user and owner of Intellectual Property and the responsibilities for protecting and exploiting such Intellectual Property should be negotiated between user and owner in good faith. The user and owner will ensure that authors and inventors of Foreground Results will be compensated according to their applicable internal rules.

Data users have to seek agreement with the data owners about co-authorship or acknowledgement on any kind of publication. It is important that the data owners are cited properly when the data are used for any further analysis. The CarboEurope-IP database shall be treated as a publication. For all data, you will find information on who collected this data, the version of the data (c.f. paragraph 9) and date of the latest update. Thr citation should include NAME (year of publication), SUBJECT (e.g., tree biomass data) with VERSION and DATE of latest update, CarboEurope-IP database with web site (URL). CarboEurope – Integrated Project „Assessment of the European Terrestrial Carbon Balance"; Contract No. 505572, supported by European Commission, DG Research, Global Change and Ecosystems.

5. Internal use of data from CarboEurope-IP

Use of data, to any significant degree, belonging to another scientist for the purpose of scientific publication must always be based on an agreement between the scientist and the data requester. The CarboEurope database shall offer the possibility to trace all downloads of a given dataset.
Procedure:

1) The scientist who wishes to use data from another scientist sends a written request to the data owner, indicating the purpose for which the data will be used.
2) The data owner writes an his agreement in which his involvement in the use of the data (e.g., co-authorship, acknowledgement) is regulated.
3) In case of conflict, the rules for Settlement of Internal Disputes (Section 7.2) apply.

Data which have been accessed by a scientist must only be used for purposes necessary to carry out his/her own work in the CarboEurope-IP.

Data which have been accessed must only be used for scientific purposes, *i.e.*, commercial use of data is not allowed.

It is prohibited to distribute other scientist's data to a third party without the written consent of the scientist.

The termination of the participation of a participant shall in no way affects its obligation to grant access rights to the other participants until the end of the CarboEurope-IP.

6. External use of data from CarboEurope-IP

A meta-database located at the Central Database will contain information about all datasets in the CarboEurope database and about the scientists responsible for them. The meta-database will be accessible via the internet for external users.

Access to data for external users is restricted to published data from version 2.0 or 3.0 (paragraph 9) and higher.

Access to unpublished data for external users can be granted if there is a written consent of the data owner (scientist). Access to data in the CarboEurope database requires a written request to the Data Management Committee, which explains the purpose of using the data.

External use of data is subject to the rules set in paragraphs 4 and 5.

7. Delivery of data to CarboEurope-IP

Data and knowledge must be delivered as specified in the Contract and Work Plan.
Data delivery implies delivery of (i) a documentation of a given dataset according to the prescribed format, and (ii) a dataset according to the documentation. Data will be inserted into the database when both parts are available.

Datasets must be specified in advance such that the database managers at the Data Centres, the Data Management Committee, and the External Advisory Board can determine whether a delivery is fulfilled or not. This information is also necessary for the time schedule of the database managers and for identification of hardware requirements. The Data Management Committee is responsible for collection of information about data intended for submission to the database.

Even if the scientist does not know exactly what the dataset will look like, she/he should submit tentative information about (i) type and number of variables, (ii) frequency of collection, (iii) time period covered, and (iv) approximate size of the dataset file. This information will be relatively straightforward to assemble for continuous time-series data but must be subject to scientific discussions within the review panel when it comes to model output and airborne measurements. This information should be gathered as early as possible. Datasets will be registred by the database manager when there are tentative descriptions of them, accepted by the Data Management Committee. Registration dates for data deliveries from the respective scientists, together with acceptance dates by the Data Management Committee, will be documented and available as part of the database.

Data from continuous and regular measurements such as fluxes shall be delivered to the database half-yearly, as specified in Workpackages, with a month delay after the start of the project, *i.e.*, 1 August 2004, 1 February 2005, 1 August 2005, 1 February 2006, 1 August 2006, 1 February 2007, 1 August 2007, 1 February 2008, 1 August 2008, and at the end of the project. The datasets shall cover the time period up to one month before data delivery.

Data from time-limited field campaigns, irregular measurements, and model results shall be delivered to the database within one month after the end of the campaign, or finalization of the measurements or modelling.

Incomplete or non-delivery will be reported to the Data Management Committee and the Executive Board.

8. Composite and external datasets

- Pursuant of paragraph II.35.1.c) of Annex II of the Contract, CarboEurope-IP participants have agreed to enter pre-existing know-how into the database. As minimum, participants shall provide metadata to the database containing information about all available datasets potentially useful for the activities within the CarboEurope-IP and about the scientists responsible for them so that data can be requested directly from the scientist.
- Data provided by organisations, external to the CarboEurope-IP and not bound by this data policy, can be entered into CarboEurope database once the Data Management Committee has appointed a specific scientist for those data. This scientist has the same duties towards the database for such data as a scientist delivering data from his/her own activities.
- Datasets used for various modelling and analyses may be composed of a mixture of data from external and internal sources. The review panel can appoint a specific scientist for such datasets. This scientist has the same duties towards the database for such data as a scientist delivering data from his/her own activities.
- Delivery deadlines for composite and external datasets should be set by the Data Management Committee and will be specified in the 18-months implementation plan.

9. Quality assurance

- Quality control of data in CarboEurope-IP relies on a careful review of different components submitted to the database. The Data Management Committee determine when submitted components are acceptable. Data will be inserted into the database after such acceptance.
- The Data Management Committee determines what should be accepted as a dataset. Technical and scientific reasons may require that several datasets be merged or a given dataset split to achieve functionality of the database.
- Datasets must be submitted to the database before deadline, independent of the quality level of the data. The scientist should suggest, and the Data Management Committee determine, a suitable quality rating for each dataset. The scientist has the chance to submit improved versions of a given dataset until the 55th month of the project.
- Each dataset will have a version number assigned to it where the first digit signifies the quality level, and the decimal number signifies successively improved versions at a given quality level (Table 3):

Table 3 Version management of data

Version	**Quality requirements**	**Documentation requirements**
0.x	Raw data (it is up to each scientist to define the meaning of "raw") which have no physical meaning to an end user (*e.g.*, mV values)	A short, simple text file is sufficient

1.x	Raw data expressed in physically meaningful units (*e.g.*, W m^{-2})	A documentation according to the standard format where only information about scientist, equipment, and variable/parameter description need to be complete
2.x	Removal of erroneous data caused by obvious measurement problems (electronic spikes, *etc.*), and physically impossible or extremely rare values. Correction of data by standard procedures.	A complete documentation according to the standard format. The quality control measures must be documented.
3.x	Removal of erroneous data after comparison with other, independently measured variables (e.g., clear-sky radiation is not accepted during heavy rain), or model-derived variables. Correction of data by novel procedures.	High-level documentation of calibration and quality-control procedures
4.x	Closure of gaps in the dataset with scientifically well-defined interpolation methods.	High-level documentation of gap-filling procedures. Documentation of the quality level as a function of time.

- The decimal "x" in the version number starts with 1 for the first delivery and is followed by 2, 3, *etc.* for successive deliveries. Successive deliveries could be caused by new variables added to a dataset, additional time periods, measurement errors being corrected, *etc.* Each new version should be followed by a documentation stating what has been changed since the previous one.
- Delivery of datasets with version 0.x is primarily meant as a backup service and to simplify data exchange within a project
- Delivery of datasets labelled 1.x are intended as a quick way to exchange data for various modelling and analysis purposes within the CarboEurope-IP.
- It is the goal of the CarboEurope-IP to publish datasets after peer review in an integral and referable form together with traditional scolarly papers. Datasets will only be accepted for such a publication when they have reached version 2.x or higher.

Appendix F: Abbreviations

A	Activity
AS	Associated site
BEF	Biomass Expansion Factor
BMBF	German Ministry of Education and Science
C	Component
CBD	Convention on Biological Diversity
CBL	Convective Boundary Layer
CDAM	Carbon Data Assimilation Methods
EB	Executive Board
EC	European Commission
ECCP	European Climate Change Program
EOP	Extended Observation Period
ETAP	Environmental Technology Action Plan
EU	European Union
FP	Framework Program
GCP	Global Carbon Project
GEE	Gross ecosystem exchange
GHG	Greenhouse gas
GMES	Global Monitoring for Ecosystems and Security
GPG	Good Practice Guidance
GTOS	Global Terrestrial Observing System
ICP	International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests operating under UNECE
IGBP	International Geosphere-Biosphere Program
IGCO	International Global Carbon Observations
IHDP	International Human Dimensions Program
IOP	Intensive Observation Period
IP	Integrated Project
IPCC	Intergovernmental Panel on Climate Change
IPR	Intellectual Property Rights
LAI	Leaf area index
LSM	Land Surface Model
LUCF	Land Use Change and Forestry
LULUCF	Land Use, Land Use Change and Forestry
Lustra	Land Use Strategies for Reducing Net Greenhouse Gas Emissions
MS	Main site
NACP	North American Carbon Program

NBP	Net Biome Production
NCEP	National Centers for Environmental Prediction
NEE	Net Ecosystem Exchange
NPP	Net Primary Production
PBL	Planetary Boundary Layer
Reco	Ecosystem respiration
SOP	Special Observing Period
SR-LUCF	IPCC Special Report on Land Use, Land Use Change and Forestry
SS	Supersite
SSC	Scientific Internal Advisory Board
SVAT	Soil-Vegetation-Atmosphere Transport Model
TAR	IPCC Third Assessment Report
TC	Test Campaign
TCO	Terrestrial Carbon Observation
TEM	Terrestrial Ecosystem Model
UNFCCC	United Nations Framework Convention on Climate Change
WCRP	World Climate Research Program
WP	Workpackage