Regional experiment

April 10-27 2007
September 03-21 2007

Experiment plan

CONTENTS

I INTRODUCTION

I.1 Scientific goals

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.

I.1.1 Objectives:

- To determine the spatially explicit regional balance of CO2 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.
- 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 at the regional scale within a multiple constraint framework.

Going one level of spatial scale lower than the Atmosphere Component, the region, typically 100-500 km in size, is a scale at which both top-down and bottom-up approaches can be reconciled, in such a way that one approach serves to verify the prediction of the other one. This leads to the establishment of the **Regional Experiment (Component 3).**
The scaling problem becomes even more clear, if one considers for instance, that large-scale inversion based sink/source estimates, obtained by a limited number of stations, suffer from a number of errors. On the contrary, measurements from a single location are not necessarily representative of larger regions or grid cells (**representation errors**). Solving for fluxes that do not evenly influence the overall concentration may cause **aggregation errors** and finally, diurnal and seasonal fluctuations in the boundary layer heights are usually poorly represented in large-scale transport models, causing **rectification errors**. These errors can be substantially reduced if at the regional level a good link between the measurements obtained at the surface flux stations and those from high frequency atmospheric concentrations can be established. To achieve this, a region needs to be monitored equally well in spatial and temporal terms. The methodology proposed in 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 which can currently be expected from a continental scale inversion models (of order 50 km).
We propose to execute a **strategically focussed regional field experiment** in the CarboEurope-IP. The aim is to establish an Intensive Observational Programme both at the ground and in the atmosphere, in order **to quantify with high accuracy the carbon balance**. If successful, this will lay the foundations for implementing an optimised observation network across Europe in the future, and for integrating carbon observations of different nature such as eddy covariance fluxes, plot and regional scale inventories, remote sensing and atmospheric concentrations.
In the past, several regional studies of the carbon fluxes have been conducted, either dominantly based on ground level data and remote sensing (e.g. Boreas, Fife, Oasis), or alternatively focused on atmospheric sampling (eg Cobra, Claire). Based on the experience from those studies, 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.

I.1.2 Methodology:

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 propose to apply the multiple constraint method for the first time in a regional experiment.
The advent of small specialized airplanes 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. In a previous FP5 project Recab, a European facility and infrastructure was built to use a small low flying aircraft, the Sky Arrow, equipped with a state of the art mobile flux platform to measure surface fluxes of CO2, heat, water vapour and momentum. Overall, unexpected good agreement was obtained between tower based estimates and those of the Sky Arrow for a number of test sites in Europe.
Atmospheric mesoscale models are now powerful tools to study regional CO2 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 CO2 at resolutions comparable to that of flux aircraft and single flux towers (e.g. 1-2 km). For such limited area transport models, 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 CO2 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) space borne images.
Inverse methods for determining surface CO2 fluxes have been used in first attempts at high-resolution regional scales both in the USA and in Europe (see for instance <http://biocycle.atmos.colostate.edu/html/regional_inverse_modelling.html>). For the Recab winter cam-paign in the Netherlands, for instance, we were able to considerably narrow down uncertainty in regional fossil fuel emissions, indicating not only the strength of the method, but also is usefulness to check fossil fuel emission inventories.
In addition to high resolution atmospheric transport, 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, similar to the use in for instance past field experiments like e.g. Bougeault et al. (1989).
In order to separate the anthropogenic sources of CO2 in the target region, we will collect continuously high precision samples of radiocarbon (14CO2) which can unambiguously trace fossil fuel emissions.
We will install a set of ground based surface flux measurements, extra radiosoundings and wind and temperature profilers and perform aircraft measurements with low flying flux aircraft, perform boundary layer sampling with small aircraft, and perform longer trajectories with a research aircraft.

At the inflown boundary of the domain we will install a tall tower high precision measurements of CO2 and 14C, and a tower with CO2 measurements at the outflow boundary at the domain.

A special, Intensive Observation Period (IOP) of 3 weeks in the spring of 2007 (from 10-5-2007 till 30-05-2007) will have high intensity observation of boundary layer development and e flux aircraft for enhanced spatial sampling. The high temporal resolution will allow us to better parameterize our models to deal with rectification effects.

I.2 Regional vs. global objectives

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.

I.3 CarboEurope vs. side projects

I.3.1 CEFES2, Ground measurements in support of FLEX

I.3.1.1 Background

Earth Explorer missions form the science and research element of the ESA Living Planet Programme and focus on the atmosphere, biosphere, hydrosphere, cryosphere and the Earth's interior with the overall emphasis on learning more about the interactions between these components and the impact that human activity is having on natural Earth processes.

With a recent call for Core Earth Explorer Ideas six different mission candidates were selected by the Agency to initiate assessment studies and one of them (FLEX – Fluorescence EXplorer) is for observation of global photosynthesis through the measurement of fluorescence. Photosynthesis by land vegetation is an important component of the global carbon cycle, and is closely linked to the hydrological cycle through transpiration. Currently there are no direct measurements available from satellites of this parameter. The main aim of the assessment study is to define specification for space instruments to measure high spectral resolution reflectance and temperature, and to provide a multi-angular capability.

One of the most critical aspects of the assessment of the potentials of RS sensors is in the need of having extensive validation of the measurement concept at the most appropriate level of scale. The validation of remote sensing measurements using ground measurements made at single locations or on limited footprint has obvious limitations as this cannot take into account the necessary variability that occurs at the level of scale at which the RS sensors operates. This study will overcome such limitation by performing a comparison between measurements taken at a comparable level of scale by an aircraft fleet doing surface flux measurements at the regional scale and by the AirFLEX sensor in its airborne configuration. Two scientific communities will work on airborne flux measurements and on fluorescence remote sensing and this is one of the crucial and innovative aspects of this study, which opens new perspective of methodological integration and substantial improvement of the measurement capability. The study will be made in the frame of two of the CarboEurope Regional Experiment (CERES, Dolman et al., 2006) field campaigns that are planned in South-West of France in April and September 2007. It will make use of the CarboEurope aircraft fleet and of substantial ground infrastructure including flux towers and a ground measurement team.

I.3.1.2 Objectives

The campaign shall combine airborne, satellite and coincident ground activities to acquire extensive and spatially resolved validation of photosynthesis estimates based on remote sensing fluorescence measurements and to provide feedback to the Agency on key issues related to the FLEX mission definition.

The objective of CEFLES2 campaign is to collect quality and coordinated airborne optical and in-situ measurements to generate spectrally, geometrically and radiometrically representative imagery/transects for addressing specific needs of FLEX mission, notably:

- To provide extensive and spatially resolved validation of photosynthesis estimates based on remote sensing fluorescence measurements
- Integration of airborne and ground measurements to provide well calibrated photosynthesis responses to light, temperature and other variables
- Analysis of the performance of fluorescence detection and definition of space observation techniques and quantitative requirements in terms of effective fluorescence retrieval.

The CEFLES2 campaign will acquire data over agricultural, grassland and forest areas and at two occasions in the spring and late summer thus ecompassing a large fraction of the vegetation cycle of the different land covers and crops.

I.3.1.3 Acronyms

Acronym	Meaning
CERES	CarboEurope Regional Experiment Strategy
MFP	Mobile Flux Platform
AirFlex	Airborne Fluorescence Instrument

I.3.1.4 Relevant Documents and References

Code	Document
RD-1	Dolman AJ (Dolman, A. J.) et al. 2006 - The CarboEurope regional experiment strategy. BULLETIN OF THE AMERICAN METEOROLOGICAL SOCIETY 87 (10): 1367
RD-2	Gioli B, Miglietta F, De Martino B, Hutjes RWA, Dolman HAJ, Lindroth A, Schumacher M, Sanz MJ, Manca G, Peressotti A, Dumas EJ 2004 Comparison between tower and aircraft-based eddy covariance fluxes in five European regions AGRICULTURAL AND FOREST METEOROLOGY 127 (1-2): 1-16
RD-3	F.Miglietta, B.Gioli, R.Hutjes, M.Reichstein 2007 Measurement of the net regional ecosystem CO2 exchange using airborne and ground-based eddy covariance, land use maps and weather observations. Global Change Biology (in press)

I.3.1.5 Requirements

Location of test sites

It is required to concentrate the activities in the CERES campaign site in South-West of France (Les Landes region) allowing acquiring data over agricultural, grassland and forest areas.

The size of the surveyed area is defined within CERES to include appropriate crops to cope with the campaign objectives. Aircraft measurements will be made along three main transect over the forest of Les Landes, the vineyard region south of Bordeaux and the agricultural area between Bordeaux and Toulouse. The aircraft fleet will be based in the airport of Villeneuve sur Lot.

Time windows and number of acquisitions
The period April until September 2007 is foreseen to optimize good weather meteorological conditions and different crop growth stages and conditions. During this period a number of airborne optical surveys shall be deployed to cope with the campaign objectives.

Acquisitions
Concerning the illumination conditions, flight lines extensions and ground resolutions the acquisitions shall be performed to cope with campaign objectives.
Airborne acquisitions are to be coordinated with in-situ measurements.

Sensors Characteristics
It is foreseen that following airborne and spaceborne datasets will be made available for CEFLES2.

- CHRIS/PROBA, Landsat, MERIS and VALERI spaceborne sensors to collect representative measurements over the test site during the campaign time windows (?)
- HYPER airborne hyperspectral system covering the 400-2450 nm spectral region. The system shall be properly calibrated and operated with flight and instrument modalities to cope with the campaign objectives
- AHS airborne hyperspectral scanner covering the following spectral regions: 445-1015 nm (20 bands), 1550-1750 nm (1 band), 2000-2553 nm (42 bands), 3450-5250 nm (7 bands), and 8400-12450 nm (10 bands). The system shall be properly calibrated and operated with flight and instrument modalities to cope with the campaign objectives
- AIFLEX airborne multi-wavelength passive fluorescence detector operated to cope with the campaign objectives
- FLIR SC500 thermal infrared camera for surface temperature images
- MFP (Mobile Flux Platform) mounted on board of the Sky Arrow ERA

Above sensors deployments requires multi airborne platforms that are to be coordinated above surveyed areas for flight operations and with in-situ measurements. The MFP (Gioli et al.,2004; Miglietta et al., 2007) is the system that will be used on the Sky Arrow aircraft to measure surface fluxes using airborne eddy covariance.

Data post-processing
Concerning the processing level of airborne optical data, it is required to perform the following processing steps:

- Acquisition of surface fluorescence data
- Ortho-rectification using platform attitude systems and detailed DEM and GCPs.
- Absolute and inter-band spectral and radiometric calibration.
- Atmospheric correction (i.e. provide bottom-of-atmosphere reflectances) using airborne and in-situ atmospheric characterisation measurements.

Concerning airborne fluorescence measurements it is required to perform atmospheric corrections using airborne and in-situ atmospheric characterisation measurements. Fluorescence data will be organized to match airborne flux measurement footprint thus providing proper scales for comparison. Two overlapping data sets will be generated by the execution of coordinated flights between the CarboEurope fleet and the RS aircraft. Those datasets will provide the scientific basis for a meaningful comparison to be made at the proper level of scale and, with this, an extensive and accurate validation of the remote sensing measurements and an assessment of its potentials. AirFlex will measure two features of steady state fluorescence (fluorescence peak at 690nm and 740nm) to obtain data to determine the total amount of chlorophyll and to correlate the ratio of the to fluorescence peaks with photosynthetic efficiency and carbon uptake.

In-situ data

Furthermore CEFLES2 campaign shall be deployed in coordination with coincident in-situ data measurements (Table 2.6.1). It is expected from the contractor to propose a methodology to perform the in-situ measurements. Error bars shall be provided for each in-situ measurement.

In-situ measurement	Definition	Measurement Proposed Method
Efficiency of light reaction (leaf level)	Efficiency of light reactions will be determined as $\Delta F/F_m$' over a representative sample of leaves within the canopy. Additionally electron transport rate (ETR) and non-photochemical protection mechanisms (NPQ) will be quantified	Chlorophyll fluorescence measurements according to the saturating light pulse method (Mini-PAM and PAM-2000)
Cardinal points of light response characteristics	Spot measurements of fluorescence parameters will be fitted using a photosynthesis model and maximum electron transport rate (ETR_{max}), initial slope of photosynthesis, and light of saturation (PFD_{sat}) will be determined (definitions: Rascher et al. 2000)	Fitting of fluorescence parameters to mechanis-tic photosynthesis model
Photosynthetic CO_2 uptake rate and water evapo-transpiration	Rate of photosynthetic CO_2 uptake and rate of H_2O release will be quantified by leaf level gas-exchange at a representative number of leaves being exposed to the prevailing range of light intensities	leaf level gas-exchange (LICOR 6400)
Chlorophyll content	Leaf chlorophyll content will be quantified at a representative number of leaves within the canopy using the SPAD. For calibration of SPAD data chlorophyll content will be determined biochemically by pigment extraction	leaf-level absorbance measurements in the red and near-infrared (SPAD) and biochemical pigment extraction
Fluorescence ratio	Fluorescence emission at 690 and 740 nm will be quantified at a representative number of leaves within the canopy	Custom made hand-held instrument
C_w (Leaf Water Content); C_{dm} (Leaf Dry Matter Content)	The amount of water and leaf dry matter in weight per unit of leaf surface will be measured in the lab on fresh and oven dried leaves	Leaf samples in the field and drying and weighing in the lab.
Plant structural parameters	Vegetation height that will be used for the canopy radiative transfer modelling will be determined in the field.	Basic allometric measurements
LAI (Leaf area index)	LAI is the area of foliage per unit area of ground. Actual LAI can be quantified in the field by an indirect method measuring light absorbance within the canopy.	Field LAI measurements with the LAI-2000

Table 2.6.1: List of in-situ measurements.

Summary of campaign requirements

The following table summarizes the requirements described in the previous chapters.

Requirement	Description
Test site	CERES campaign site - Les Landes, Aquitaine, France

Campaigns	2 (April and September 2007)
Airborne instrumentation	Mobile Flux Platform (2) AirFlex Instrument Video camera Airborne AHS and HYPER systems IR-Thermal camera
Ground Instrumentation	Flux towers (10)
Airborne data	Latent and sensible heat fluxes Momentum flux Net Ecosystem Exchange (NEE) Fluorescence data (AirFlex) Thermal images Hyperspectral data (non imaging)
Ecophysiological and biophysical data	Latent and sensible heat fluxes (towers) Momentum flux (towers) Net Ecosystem Exchange (NEE) (towers) Efficiency of light reaction (Ground teams) Photosynthetic Carbon uptake (Ground teams) Leaf pigment and structural parameters (Ground teams) Allometric canopy and LAI (Ground teams)

Table 2.8.1: Summary of the campaign requirements.

I.3.1.6 ScheduLE

The following campaign schedule is suggested assuming the April-June-September window for campaign deployment. The Contractor shall propose an updated schedule in the experiment plan according to the actual time window for campaign deployment.

Event	Place	Date
Kick-off	Contractor Premises or by phone	**March 2007**
Coordination meeting (presentation of a draft experiment plan)	Firenze, Italy	**March 2007**
Delivery of experiment plan		**March 2007**
Delivery of flight readiness report		**April 2007**
Pre-campaign meeting	Villeneuve sur Lot	**April 2007**
Campaign Data acquisition		**April 2007**
Pre-campaign meeting	Villeneuve sur Lot	**September 2007**
Campaign Data acquisition		**September 2007**
Data acquisition report		**October 2007**
Preliminary results meeting	Contractor Premises (TBC)	**November 2007**
Delivery of Campaign Dataset		**February 2008**
Delivery of the Final Report		**February 2008**
Final CEFLES2 campaign presentation	**ESTEC**	**February 2008**

I.3.2 The « Sud-Ouest» Project : land surface functioning at the mesoscale

The general scientific objective of the "Sud-Ouest" project is to understand the respective role of ecosystems, climate and human activities in the evolution of land surface status and functioning at the regional scale, taking into account land use and land cover heterogeneities and the interactions between processes. In terms of applied research, the project addresses

land management issues such as land cover evolution, water consumption by agriculture as well as the possible impacts of climate change and agri-environmental policies.
The main experimental zone of the project is an area of 50 x 50 km2 located near Toulouse, France, in the upper part of the Garonne river basin (see figure). The altitude is of about 100-200 m, the terrain is rather flat with low hills organised around the plain. This zone is mainly devoted to agriculture. Corn, sunflower, and wheat are the dominant crops. The wet seasons are fall and spring, while summer is generally hot and dry. Irrigation is required to obtain reasonable yield with summer crops.
The approach is based on five main components : i) ground experiments performed over three sites located in the experimental zone, ii) modelling of surface processes, iii) combination of models with remotely sensed data and development of upscaling/downscaling techniques, iv) land use mapping and retrieval of surface parameters with remote sensing and v) spatialization of the models over the whole experimental zone.
In a first step, the project focuses on land cover monitoring, the assessment of the surface energy budget, evapotranspiration and carbon fluxes. Time series of SPOT satellite data are acquired continuously since 2002, with a time sampling of about one month. These data are used at their full resolution (20m) for land cover mapping and for driving vegetation and SVAT models in order to estimate water balance, evapotranspiration, irrigation needs, carbon uptake and net primary productivity. Modelling of soil carbon release (heterotrophic respiration) is in progress. In addition to this high resolution data set available over the 50x50 km2 main experimental zone, medium resolution remotely sensed data (SPOT-VEGETATION and ENVISAT-MERIS, 300m to 1km resolution) are also used over a larger area to develop and test upscaling methods.
The "Sud-Ouest" project is lead by CESBIO, and collaborations have been established with several laboratories such as CNRM (Toulouse), ESAP (Toulouse), INRA (Avignon, Bordeaux, Toulouse) and ONERA (Toulouse).

I.4 Experimental area

The experimental domain covers an area of about 250km (W-E) * 150km (S-N). It is bounded to the West by the Atlantic ocean, the shoreline being quite rectilinear along a NNE orientation.
The western half of the domain is characterized by the presence of the Landes forest, 80% of which is included in the Regional Experiment area (see figure below). It is mainly composed of pines (*pinus pinaster)*. It is an artificial and commercial forest, whose parcels are regularly uprooted and then sown again. Clearings of various sizes are composed of agricultural parcels, mainly maize, but also grasslands and pastures (mainly in the southern part of the forest), or other cultivations like vegetables. Close to the western cost, large ponds can be observed. Inside the forest, the population is scarce, and only villages and small cities can be encountered. However, several military areas occupy a large surface (at least partially deforested).The other major landscape of the domain is composed of cultivated parcels. Most of them are cereals, with the exception of the Garonne river valley (crossing the domain from SE to NW) where there are fruit trees, and the large "Bordeaux" vineyards, east of the Bordeaux city.
The NE corner presents the extremity of a vast, little cultivated region, mainly composed of woods and pastures.
Two major cities are located close to the SE (Toulouse) and NW (Bordeaux) corners of the domain. A little less than one million inhabitants live in Toulouse and its suburbs, about one

and half times that of Bordeaux. Given the dominant winds in spring (see wind roses below), the domain could be affected by the plumes of the cities. The population of the other cities inside the domain is one order of magnitude lower than that of Toulouse or Bordeaux.The Landes forest and the valley of the Garonne river are quite flat areas, whereas the rest of the domain is mainly composed of gentle hills. Outside of the domain, to the South, the Pyrenees mountain range presents a W-E barrier culminating above 3000m height. This has a strong influence on the generation of local winds on the domain. To the East and North-East, the terrain elevates progressively toward the so-called Massif Central, culminating at 1800m and reaching about 1000m, 100km far from the domain.

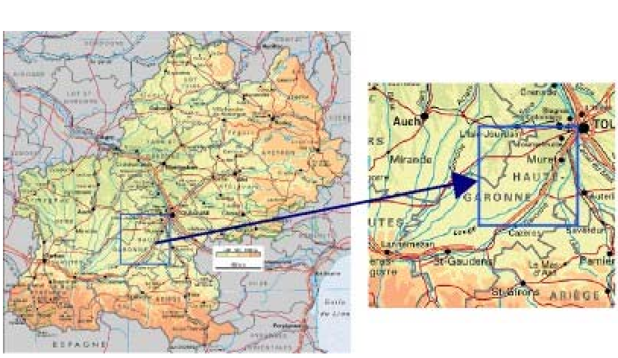


figure I.4-1 ***: Map of the Midi-Pyrénées region and the experimental zone***

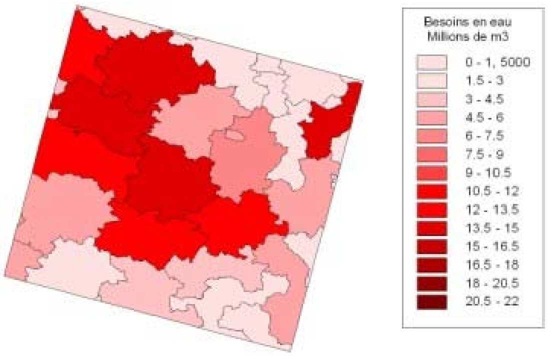


figure I.4-2 : Example of results : crop water requirement per county (106 m3) in july 2002 (for wheat, maïze, sunflower, and soybean)

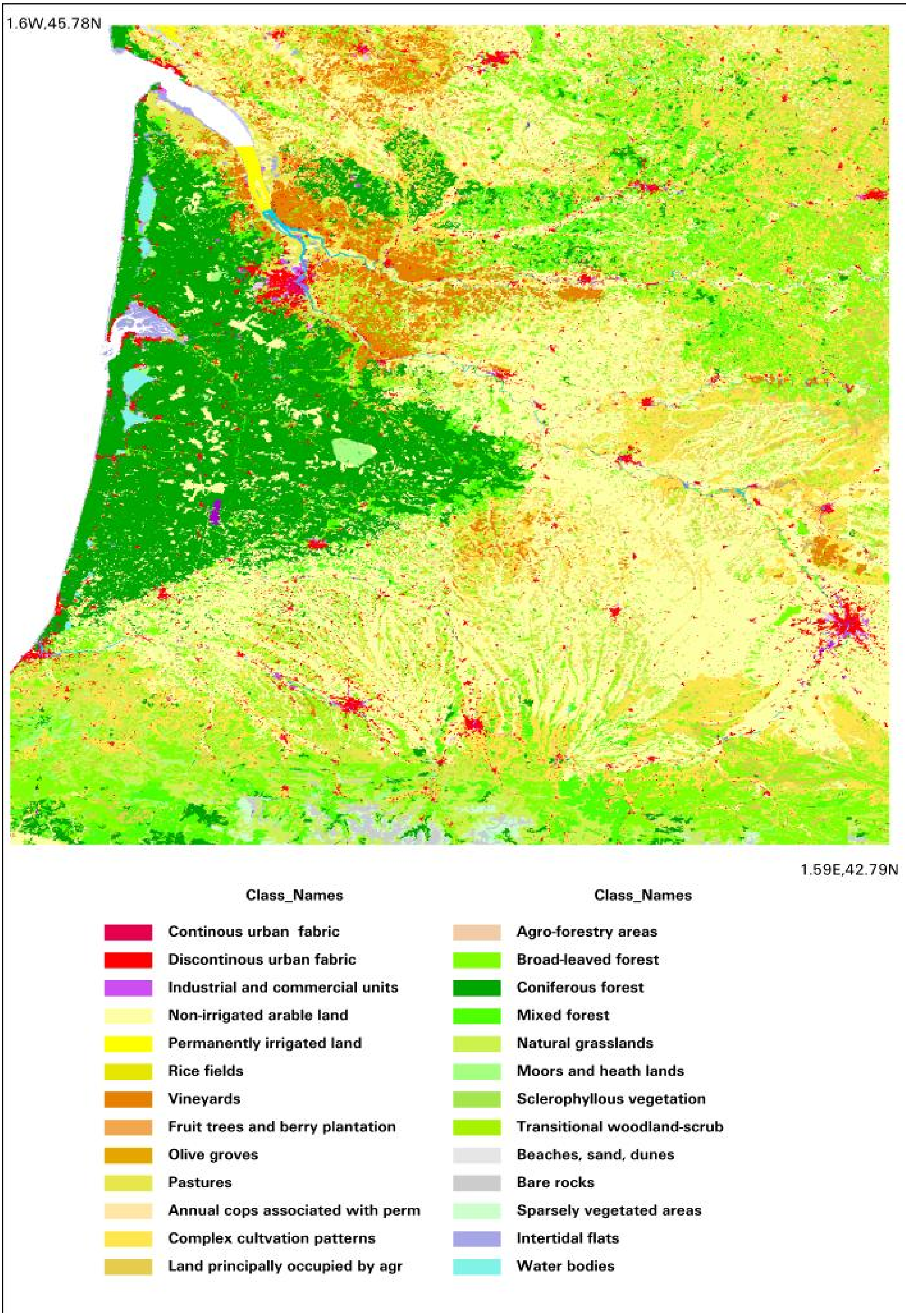


figure I.4-3 ***: Land cover with 250m resolution for the south west region of France***

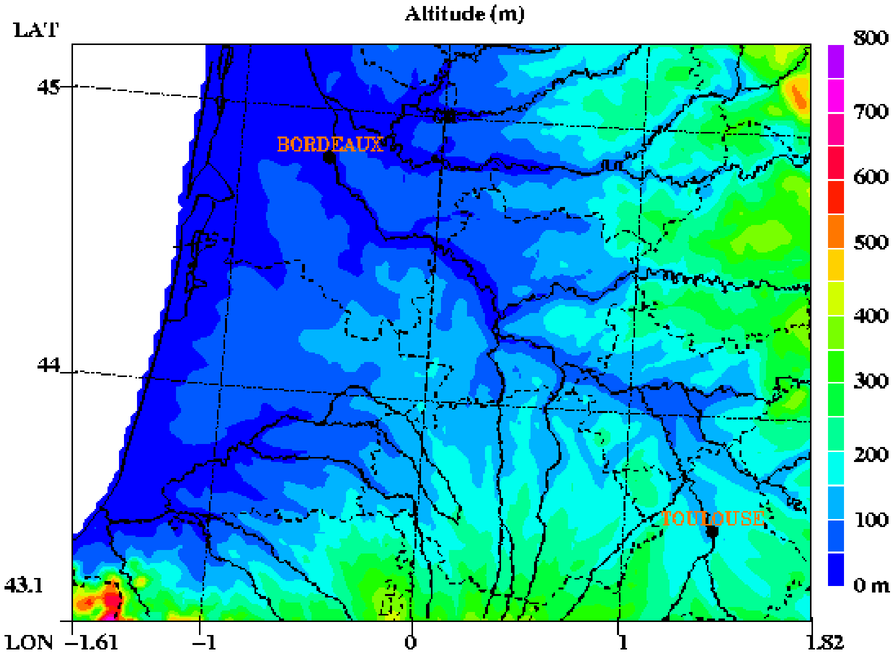


figure I.4-4 *: Orography of south-west of France*

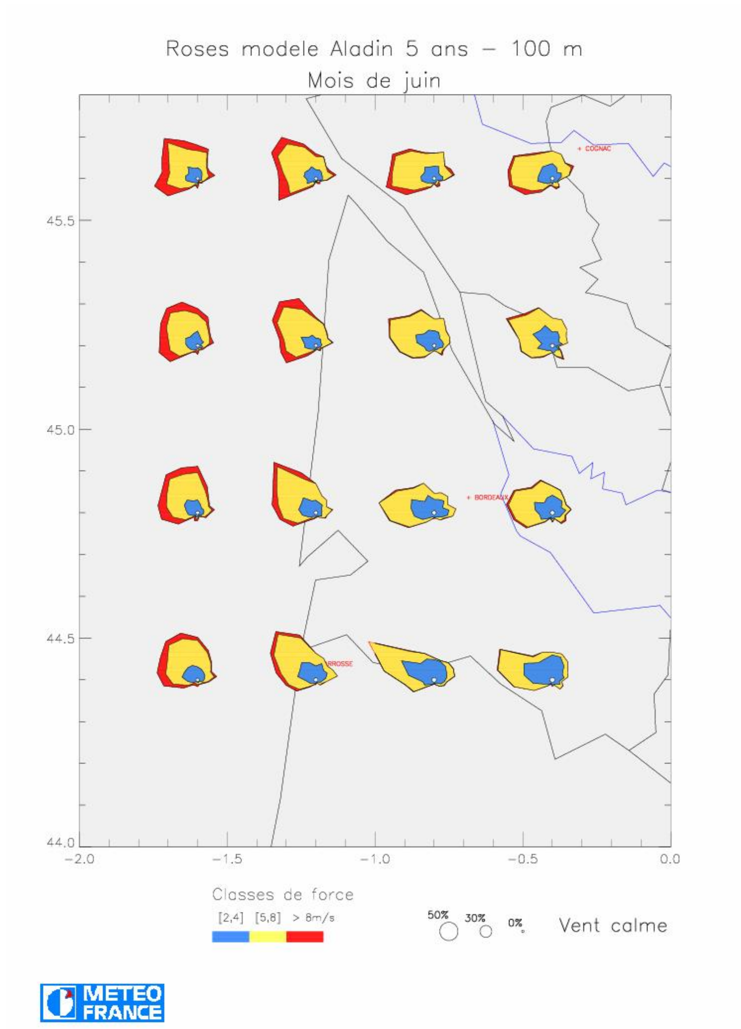


figure I.4-5 ***: Wind roses calculated at 100 m according to ALADIN analysis, statistic over 5 year for june***

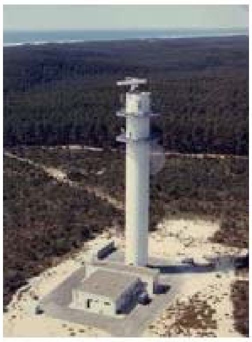
II FIELD ACTIVITIES: PERMANENT STATIONS

II.1 General overview of the sites

The sites layout is presented in the figure below. The sites related to Continental Biosphere programmes are located in the vicinity of Toulouse city, in the eastern part of the domain. The CarboEurope sites are located in the Landes forest area, and in the “intermediate” region, close to the transition between the forested and cultivated areas. This spreading allows us to document the principal land covers:

- the surface energy budget is measured above a mature pine forest, a recently sown forest, a vineyards, maize fields, a wheat field, a rape field, a bean field and grasslands.
- meteorological parameters and temperature and moisture below the surface are measured on most of the above-mentioned sites, plus on a deciduous forest (Agre forest, North of Toulouse city) and a fallow site. Some extra data are collected on operational platforms (close to the sea and the large ponds in the Landes area).

Note that some of these stations are involved in long-term (i.e. > one year) measurement programs.
The CO_2 concentration is accurately measured at the top of two telecommunication towers located at the west and east bounds os the domain. The first tower is a 50m tower located 2 km from the shoreline (Biscarosse, code :BS), in order to monitor the upwind conditions for the westerlies which are the most frequent winds in this period of the year. The tower has been running continuously since mid 2005. At the same place, the CO_2 column is measured with a Fourier transform, infra-red radiometer. The second tower is a 60 m tower located at 30 km west of Toulouse (Bellegarde Sainte Marie, code :BG), in order to monitor the downwind conditions of the domain. If extra funding can be found, this tower will run from April 2007 to September 2007. In the central part of the domain (close to Marmande), the CO_2 profile is measured up to 20m on a mast.




Biscarosse Tower   Bellegarde Sainte Marie tower

Wind profiling systems are located in the western half of the domain: UHF radars, measuring between ~200m and ~3000m altitude are located in Cazaux and la Cape Sud, which are at about 10 and 40 kilometers from the shoreline, respectively. This would allow to control the development and penetration of the sea breeze during the course of the day for weak synoptic wind conditions. At La Cape Sud, a Sodar will complement (with overlapping) the UHF wind profile in the lowest layers (50-500m).
The map below indicates where the sites are located, their name and abbreviation, the land-use and the main groups operating the instruments. The following table summarizes the measured parameters by the surface platforms.

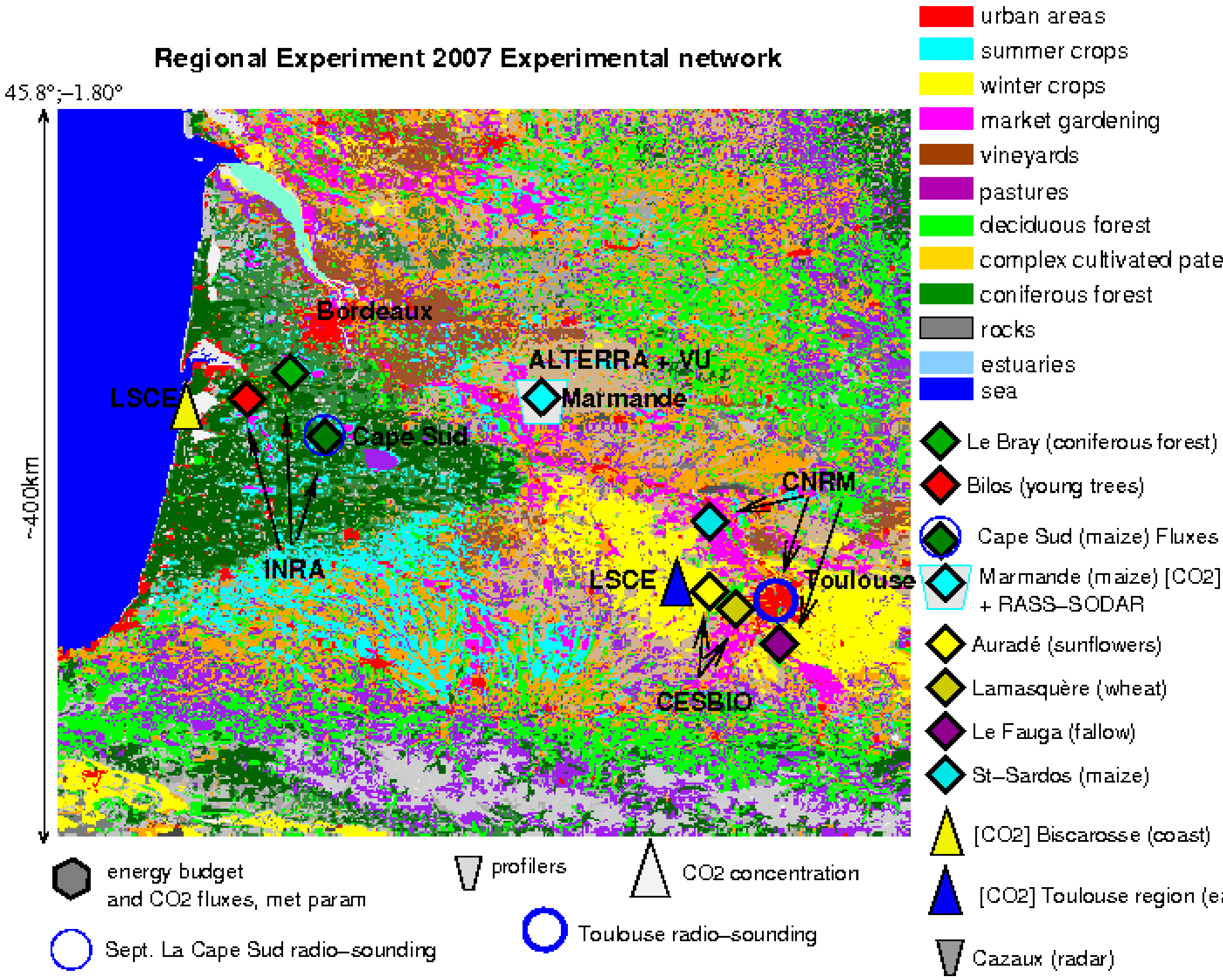


Fig. 1 CarboEurope Measurements in 2007

	Site / Parameter	BS	BE	CZ	BL	LB	CS	CO	MR	SS	LF	AU	LM
		CarboEurope Regional Experiment Sites											
										Continental Biosphere Sites			
Meteorology	Pressure			●	●	●	●	●	●	●	●	●	●
	Temperature	●	●	●	●	●	●	●	4 ● levels	●	●	●	●
	Canopy Temp.												
	Moisture	●	●	●	●	●	●	●	4 ● levels	●	●	●	●
	Incoming radiation			●	●	●	●	●	●	●	●	●	●
	Light interception												
	Net radiation				●	●	●	●	X ●	●	●	●	●
	Wind	●	●	●	●	●	●	●	4 ● levels	●	●	●	●
	Rain	●	●	●	●	●	●	●	●	●	●	●	●
CO2	Concentration	●	●		●	●	●	●	4 ● levels	●	●	●	●
	PPFD				●	●	●	●		●	●	●	●
	Soil emission												
Soil	Temperature				●	●	●	●	X ●	●	●	●	●
	Moisture				●	●	●	●	●	●	●	●	●
	Soil heat flux				●	●	●	●	X ●	●	●	●	●
Eddy flux	Sensible heat flux				●	●	●	●	X ●	●	●	●	●
	Latent heat flux				●	●	●	●	X ●	●	●	●	●
	Momentum flux				●	●	●	●	X ●	●	●	●	●
	CO2 flux				●	●	●	●	X ●	●	●	●	●

Table 1 : Surface measurements

table II.1-a *: Sites abbreviations and land use*

Site and abbreviation	Land use and abbreviation
Le Bray (LB) Bilos (BL) La Cape Sud (CS) Saint-Sardos (SS) Auradé (AU) Lamasquère (LM) Le Fauga (LF) Marmande (MR) Biscarrosse (BS) Cazaux (CZ)	Pine forest (LB) INRA Young trees (BL) INRA Maize (CS) INRA Maize (SS) CNRM Sunflowers (AU) CESBIO; Wheat (LM) CESBIO; Fallow (LF) CNRM; Maize (MR) ALTERRA; Coastal area (BS) Military area (CZ)

III FIELD ACTIVITIES : AIRCRAFTS OPERATIONS

III.1 Dimo Campaigns “Mini-Missions” 2007 within CarboEurope

III.1.1 Main objectives:

- Regional estimate of C exchange between surface and atmosphere at high spatial (2 km) and temporal (hourly) resolution
- Design of a long term measurement strategy for estimating regional scale fluxes, based on “thinning” of the dense network deployed in the Les Landes region
- Reduce uncertainties in quantifying plant mediated exchange processes by direct measurement of physiological variations of photosynthesis

III.1.2 Supporting objectives:

- validation and improvement of C-data assimilation system consisting of a set of coupled scalable models:
- WRF (Weather Research and Forecasting model): uses ECMWF starting and boundary conditions, simulates Atmospheric transport, transports CO2 tracers (fossil fuel, biosph. respiration, biosph. assimilation, CO2 from lateral boundary)
- VPRM (Vegetation Photosynthesis and Respiration Model) diagnostic biosphere using MODIS EVI and LSWI and WRF temperature and radiation
- STILT (Stochastic Time Inverted Lagrangian Transport)

III.1.3 Sampling strategy:

a) Capture the boundary layer tracer distribution (its horizontal variability) on meso-scales: gradients in transport and tracer mixing ratio due to mesoscale effects such as land-sea breeze (e.g. recirculation of nocturnal respired CO2 during the next day in the sea breeze), contrasts in albedo and/or bowen ratio such as transitions forest/crop or wintercrop - summercrop (e.g. change in mixed layer heights).

b) Lagrangian experiment:
Profiling throughout the boundary layer, following the influencing airmass (the air that influences a downstream measurement). Can be done with single or double flights.

c) remote sensing of vegetation:
surface reflectance will be quantified with high spectral resolution (hyperspectral measurements). Changes in the reflectance signature will be correlated with ground based changes in leaf photosynthesis and canopy exchange processes (eddy measurements). Hyperspectral reflectance will be recorded during all the flights and special focus will be on selected vegetation in the catchments of the eddy stations.

For cases a) and b) the flight pattern is ideally a sawtooth, where the top of the sawtooth should slightly exceed the PBL top, and the bottom should be well within the mixed layer so that the profile is characterized (assuming that variability and gradients within the mixed layer are due to eddies that are not interpreted in this framework).

Case a) is ideal for validation of the modelling system, and case b) provides a tight constraint on surface fluxes; it regionalises the problem: without an influence following strategy a lateral boundary condition from a global model is required on the upstream side.

For case c) height transects at different times of the day and under various environmental conditions above the catchments of the eddy stations are desirable. We aim to characterise changes in the physiology of photosynthesis of vegetation under extreme environmental conditions.

For all cases, a frequent flyby near the long-term measurement stations for precise CO_2 mixing ratios Biscarosse, Marmande, and LaCap Sud is desired, since it allows validation of transport in the near field of the stations.

We are optimistic that a flight pattern can be developed, which serves the objectives of cases a) and b) as well as case c). Tentatively a saw-tooth with intermittent intensive measurements above the eddy sites is envisioned.

III.2 Flight plans for the SkyArrows during CERES April and September 2007

The objective of flights performed with the SkyArrow ERA are to measure surface fluxes of energy, CO_2 and momentum, by means of eddy covariance, on some specific tracks representative of the regional context, and to measure vertical profiles of principal atmospheric quantities. Two SkyArrows will be available: the IBIMET plane I-RAWH, the Alterra plane PH-WUR.

The setup of the instrumentation of the SkyArrows is the same as in 2005, with the additional installation on the I-RAWH of a hyperspectral radiometer (model OceanOptics USB2000 NIR) measuring surface reflectance in the range 350-1000 nm during flux flights, by means of upward and downward looking optic fibers.

Flight altitude will be 100m above ground (where allowed and safe), during horizontal transects. Vertical profiles will be performed up to 1500 – 2000 m depending on PBL structure, with the objective to arrive always to sample free troposphere conditions.

Flight track1:

This is a flight track similar to the one performed routinely in 2005, crossing the forest area of Les Landes, the vineyard areas east of Bordeaux, and the agricultural (mainly maize) areas around Marmande. Vertical profiles will be performed in the forest (southern point of track) and in Marmande area.

Flight track2:

This track is new, and needs further refinement based on first operational flights. Basically, it covers agricultural landscape from Marmande/Villeneuve to Toulouse, to cover a region where additional CERES ground sites are available. Vertical profiles will be performed in Marmande area and in the southern part of the transect (Toulouse area).

Flight strategy:

Flights will be performed at different times of the day to catch daily variability in biogenic, atmospheric and PBL conditions, mainly during IOP days but also in days with not clear sky conditions, to detect vegetation behaviour at lower irradiances.

Flights will be coordinated between the IBIMET and Alterra SkyArrows to maximize potential benefits from having 2 aircraft. The two identical aircraft allow to sample both flight tracks simultaneously. Combined flights (in close formation) on selected occasions will allow sampling of flux divergence profiles.
Some combined flights will be also performed as a cross validation study of the two systems and of the methodology.

Figure III.2-1 : Sky Arrow flight track1

Figure III.2-2 : Sky Arrow flight track2

IV COORDINATION, DATA MANAGEMENT AND WEB SITE

IV.1 Web site

The CarboEurope Regional Experiment dedicated web site will allow the data management and provide access to the relevant information for all the teams involved in the project.
As a commitment in the European "Regional Experiment" programme, CNRM is in charge of the Database management. The various tools relative to this Database, as well as the corresponding web site are developed and maintained by Medias-France, a French company under the umbrella of public Institutes (the French space agency (CNES), Météo-France, CNRS and IRD). The principal objectives of these tools are :

- To collect, structure and standardize the various data sets, in a hierarchical way and metadata bank
- To build simple, ergonomics and distributed interfaces to facilitate datasets and metadatasets access
- To archive and secure datasets
- To provide technical support to CarboEurope Regional Experiment (Hardware and Software)

The web site (URL : http://carboregional.mediasfrance.org/) dedicated to CarboEurope Component 3 provides data access, data and metadata upload, focus point for community (news, documents), advertising (partners, organisations) for a simple and fast access to datasets, centralized in a single site.
To upload and download data, two secured ftp sites are available (with login/password) :

- One uploading site: http://carboregional.mediasfrance.org//data/depot/ (Upload data files in specified directory + README file + welcome message, metadata input using specific forms, E-mail to boichard@medias.cnes.fr after downloading)
- Access site : http://carboregional.mediasfrance.org//data/acces/index

A dedicated mailing list : carbo@medias.cnes.fr, archived, secured (Virus), classified (Spam). This is an open mailing-list (without administrator). To subscribe,
http://carboregional.mediasfrance.org/mailinglist/index.en.php .All e-mails are archived.
Two special web pages are dedicated to the field campaign, one for 2005 and the other for 2007. (http://carboregional.mediasfrance.org/campagne/index)
These pages contain all information of a given day :

- Weather forecasting
- Forecast trajectories of STILT model
- Quick look of measurements of the previous days (time series of meteorological parameters, CO2, fluxes for surface stations, aircrafts measurements, etc.
- A message sent by the scientific secretary of the Head Quarter on the news of the campaign (information about the status of the campaign: stand-by, alert, IOP day; the operations planned for the present and next days; etc.

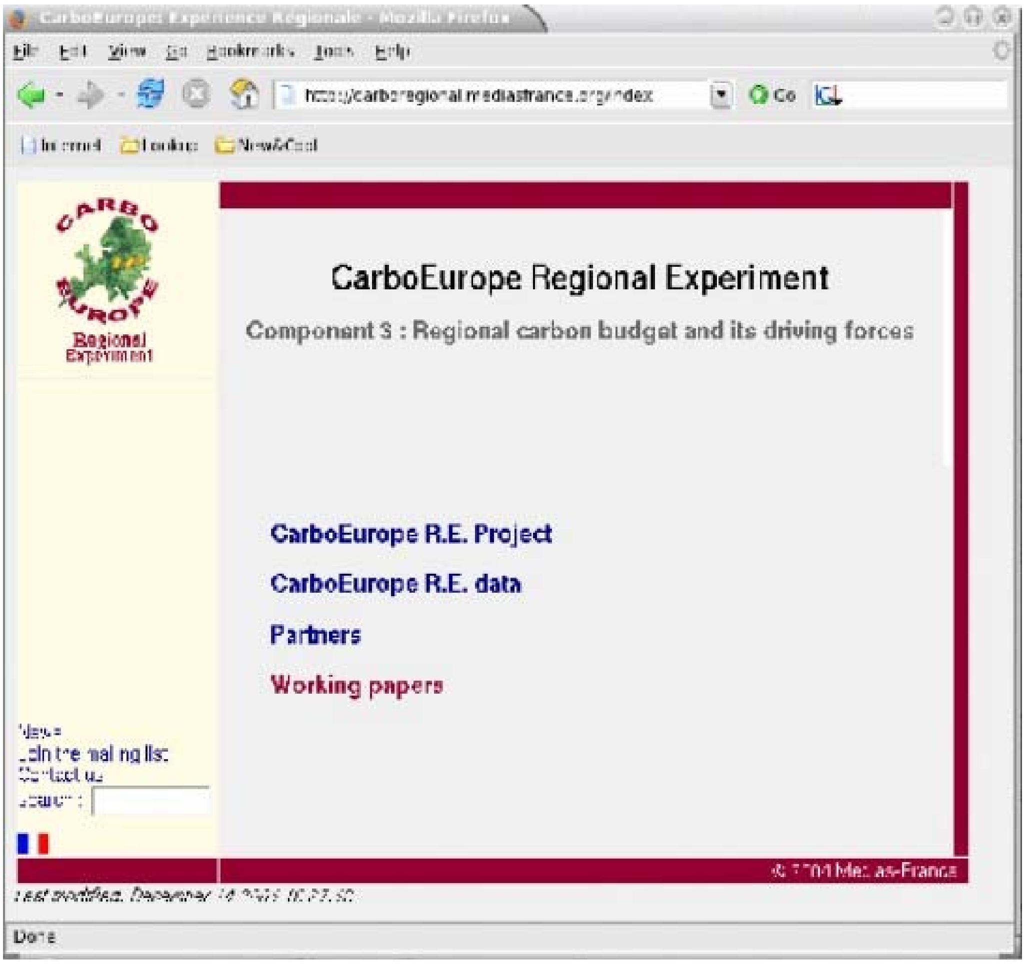


figure IV.1-1 ***: Home page of CarboEurope Regional Experiment***

IV.2 Data policy

The CarboEurope Regional Experiment data policy is in agreement with the general policy of CarboEurope IP.

- **Quality control** : deliverable data are given with a quality level (table 6 Annex 1 Carboeurope IP) :
  - Level-0 version : raw data (no IU needed) and metadata described .
  - Level-1 version: raw data expressed in physically meaning in IUS i.e. physical units.
  - Level-2 version : data corrected with standard procedures

The description level of metadata for all the database has to be defined in agreement for the CarboEurope IP database manager (R. Krause).

- **Access to data** : data and metadata are accessible to all CarboEurope regional partners. However, their access requires a login and password which have to be asked to the database manager (see on the web site).
  - **Deliverable data** : For the Regional Experiment, data must be available on the web site 6 months after the end of the campaign (i.e. March 2006) for level-1 version, and 12 months after (i.e. June 2006) for level-2 version, except for aircraft data, for which level-1 will be available only 12 months after the campaign.
  -

IV.3 Coordination: Toulouse (CNRM)

The headquarter at Toulouse is situated on the 2nd floor at CNRM. The room is equipped with Phone, Fax and a Windows PC.
Up to ~10 people could attend the daily briefing(s).
The meteorological situation as well as the forecast for short- (1-2 days) and long-range (up to 5 days) periods will be taken from the Meteo France Web information and from a meeting with the operational meteo. Office before the morning briefing.
A report, indicating the status of the experiment, and summarizing the daily operations will be send to the Carbo Regional mailing list. This daily report will also be available on the campaign web page.

Phone : 05 61 07 97 10
Fax : 05 61 07 97 05

E-MAIL: HQ-CARBOEUROPE@CNRM.METEO.FR

IV.4 Modelling activities: Operational and dedicated out put

Various operational NWP model outputs will be available to help the decision during the field campaign and for the numerical interpretation.
At Météo-France, the new operational assimilation system at mesoscale (3D Var Aladin with a 10 km resolution run every 6 hours) will be in operation during the field campaign. The September radiosounding taken during the special observing period (SOP) at synoptic hours will enter the 3D VAR system real time. The objective here is to improve the mesoscale weather analysis which will be used as initial and lateral conditions for high resolution mesoscale modelling with Meso-NH.
Forecast products from Arpege and Aladin will be of course available at the headquarter of the campaign to help the decision to start a SOP and the choice of the aircraft flight plans.
MPG-BGC will provide forecasts of the airmass history for a number of receptors in the experiment region. For this it is planned during the IOP to implement an operational system. This system will enable to plan airborne sampling in a way that can optimally constrain the exchange between biosphere and atmosphere. Such a system has been successfully used for the COBRA experiments [*Lin et al.*, 2004], see also <http://www.deas.harvard.edu/cobra/Fltplan/>. A recent update was made for the COBRA-Maine experiment in summer 2004, and this version has been transferred to workstations at the MPI-BGC. It will run on a newly purchased Workstation (4 processors, 8 GB RAM).
The forecasting system involves the Stochastic Time-Inverted Lagrangian Transport model (STILT), that is driven by forecasted meteorological fields, and that represents airmasses as individual Lagrangian particles. These particles are released at a given receptor location, and are moved backward in time by mean and turbulent winds [*Lin et al.*, 2003], [*Gerbig et al.*, 2003]. The density of these particles at a given time and location then describe the influence of that location to mixing ratios at the receptor location. That way measurements at different times can be located such that they observe the same airmass, i.e. they are made in a Lagrangian (airmass following) way. The system also suggests flight paths to characterize airmasses at a given time, and picks out nearby airports for missed approaches (missed

approaches are "fake" landings at small airports, that allow to profile down to very low altitudes unreachable over other areas).
Modifications to this system will include adaptation of meteorological forecast fields not used before. The only met fields currently used that covering the intensive operational area, are generated by the gobal NCEP (US National Centers for Environmental Prediction) AVN model (now called GFS model). It is planned to add forecasted fields from the ECMWF model at 50 km resolution, and a file converter/pre-processor is currently being written. It is further planned to use high-resolution output from Aladin, a mesoscale operational forecasting system by Météo-France. This will be done in close collaboration with Joël Noilhan (Météo-France). Further modifications of the forecasting system involve extension of the airport database to Europe, so that the detailed planning of flights can be done in a nearly automated way.
It is planned to have the forecasting system operational and web-accessible to project partners well before start of the IOP, to ensure a high quality during the campaign, but also to allow for a period of getting used to using the information.
Gerbig, C., J.C. Lin, S.C. Wofsy, B.C. Daube, A.E. Andrews, B.B. Stephens, P.S. Bakwin, and C.A. Grainger, Toward constraining regional-scale fluxes of CO_2 with atmospheric observations over a continent: 2. Analysis of COBRA data using a receptor-oriented framework, *Journal of Geophysical Research-Atmospheres*, *108* (D24), 4757, doi:10.1029/2003JD003770, 2003.
Lin, J.C., C. Gerbig, S.C. Wofsy, A.E. Andrews, B.C. Daube, K.J. Davis, and C.A. Grainger, A near-field tool for simulating the upstream influence of atmospheric observations: The Stochastic Time-Inverted Lagrangian Transport (STILT) model, *Journal of Geophysical Research-Atmospheres*, *108* (D16), 4493, doi:10.1029/2002JD003161, 2003.
Lin, J.C., C. Gerbig, S.C. Wofsy, A.E. Andrews, B.C. Daube, C.A. Grainger, B.B. Stephens, P.S. Bakwin, and D.Y. Hollinger, Measuring fluxes of trace gases at regional scales by Lagrangian observations: Application to the CO_2 Budget and Rectification Airborne (COBRA) study, *Journal of Geophysical Research-Atmospheres*, *109*, D15304, doi:10.1029/2004JD004754, 2004.

IV.5 IOP triggering and follow up

During the whole experiment, a scientist (PI) is responsible and takes the decisions (i.e., IOP triggering, flight operations, radio-sonde launches, etc.). He/she is assisted by a scientific secretary. Each of these two functions will be assumed by 4-5 persons, i.e. with a turnover of 1.5 to 2 weeks.
On each day from April 10th to April 30th, there will be a morning briefing (at ~10.30 LT). The briefing will be held at the Toulouse HQ (CNRM). The briefing is led by the responsible scientist. The partners that are not in Toulouse can attend the morning briefing with teleconference connection, available every morning from 10 to 12 am.
This briefing involves:

- A presentation (in the briefing room at Toulouse) of the present meteorological situation, as well as the short- and long-term forecasts, based on information from the operational weather service. Person in charge PI.
- This presentation is completed by the dedicated meteorological tools:; STILT forecasts, AROME outputs and diagnostics, Arpege forecasting….

- An information on the status of the FLEX experiment, and on the operations planned for the next days by this programme.
- A check of the status (in order/out of order) of the various platforms (ground stations and aircraft) involved in the experiment.
- A report of the operations of the previous day, if this was an IOP day.
- A discussion on the opportunity to 1) continue or stop a current IOP; 2) trigger or confirm an alert for a possible IOP in one (D-1), two (D-2), or three (D-3) days; 3) to cancel an alert or maintain the no-alert status.
- A decision on the status of the experiment. This decision is accompanied by the following elements:
    - No alert or D-3alert: no elements required
    - D-2 alert: choice of the flight plans for D-day. This 2-day time is imposed by the air traffic control. Several flight plans could be envisaged, since there is no problem to cancel a planned flight. On the contrary, it is much more difficult to add a flight plan for less than 2 days.
    - D-1 alert: confirm the flight plans; if a several days IOP is envisaged, choice of flight plans for D+1; .
    - D: if the IOP lasts for more than 1 day, confirm the flight plans for D+1; If an IOP of more than 2 days is envisaged, choice of flight plans for D+2.

From D-1 and to the end of the IOP, the HQ meets the meteo forecasting team in order to check if the forecasted meteo situation has changed and sends a report by email to the mailing list.
. This briefing has the following goals:
- to actualize the meteorological situation. Information will be found at the operational meteo center in Toulouse (CDM31), of the day (if IOP day)
- if the next day is an IOP day, to decide the "go-no go" for the operations (airplanes and radiosondes).

The minutes of each briefing will be written by the scientific secretary, and approved by the PI. They will be sent to the e-mail list (participants and interested people).
The meteorological conditions favoured for IOP triggering are those of moderate westerlies, corresponding to a progressive modification of CO_2 concentration of the air mass when travelling from the ocean through the experimental area. Other conditions could also be documented, like weak winds, or moderate SW synoptic flows, giving rise to SE local winds in the eastern part of the experimental area (Toulouse region.) Cloudless or broken clouds conditions have to be preferred, because they favour the photosynthetic activity of vegetation; however, few more cloudy situations could also be analysed, in order to evaluate the impact of clouds on CO_2 budget on the domain.

V COORDINATES

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Thursday	12-avr-07		Joël N.		Claire S.		
Friday	13-avr-07		Joël N.		Claire S.	Lieselotte T.	
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Sunday	22-avr-07	Han D.			Claire S.		
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