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CARBONES dissemination material version V0

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1 Introduction

This document provides a description of the products that have been prepared in WP530 in order to disseminate the results obtained by the CARBONES project. This is version V0 of the document-version V1 will be prepared at T0+30 months. This document describes the dissemination of the products obtained with the V0 version of the CCDAS (please see document CARBONES-D410 1-REP-LSCCE-010-01-01.doc for a description of the system). The products that will be available at T0+30 are also briefly mentioned.



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2 Brief presentation of the CARBONES project and its main objectives

CARBONES is a global information system that quantifies the distribution of CO₂ fluxes, carbon pools and underlying processes, based on in situ data as well as space-based information of land and ocean surface biophysical properties.

It relies on a pivotal set of advanced process-based models of the carbon cycle (including atmosphere, land and ocean) to describe the complex biological, chemical and physical processes which regulate CO₂ exchanges over each point of the globe. These models are further optimised using: i) long-term satellite observations of the ocean and land colour, ii) long-term air-sea flux records from ships and fixed stations, iii) eddy covariance networks including online measurements of CO₂, heat and water fluxes, iv) atmospheric CO₂ concentration networks, v) high-resolution anthropogenic emission inventories, vi) global fire emission data, and vii) soil and biomass carbon inventories.

CARBONES aims at providing a calibrated 20 year-long re-analysis of space and time variations of carbon fluxes and pools over the Globe, consistent with as much as possible available *in situ* and satellite data. It provides a clear and necessary added value to GMES Core Services with respect to Climate Users needs. The CARBONES products are tailored to be used by the IPCC climate modellers for testing and improving their simulations of the future evolution of the coupled climate-carbon cycle system.

The CARBONES project also addresses the following complementary key objectives:

1. Interfacing with and integrating Core Service data, in order to provide:
 - Closure of the carbon cycle by coupling slow pool changes and fast flux changes,
 - Independent benchmarking of core service data and methods using in situ derived global C Cycle products,
 - Value added to Core service data,
 - Attribution of C cycle changes to processes in relation to climate change,
 - Integration of relevant ocean-land-atmosphere core service data into a single, coherent C cycle analysis.
2. Interfacing with and adaptation of Existing Carbon Cycle in situ data infrastructures;
3. Implementing state-of-the-art process-based models and assimilation methods through the integration of the CARBONES information system;
4. Developing an interactive visualisation/mapping interface of the C cycle, designed to meet Climate Modellers needs and dedicated for experimentations;
5. Developing tools and analyses for the specification of futures satellite missions (MTG, post EPS, ...) related to Carbon Cycle monitoring;
6. Generating a 20-year re-analyses of C fluxes and pools maps using available in situ and satellite data;



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7. Regular updating of the C fluxes and pools products by using available Core service data;
8. Validation of the CARBONES information system against existing European fluxes monitoring programmes;
9. Analysing user needs and downstream potentialities: exchanges with climate modelling groups for product definition and service design, identification of possible downstream services and institutional/economical end users of a CARBONES operational service.

3 CARBONES dissemination material

The main tool for disseminating CARBONES products and diagnostics is a tailored user-friendly web interface. This portal allows climate modellers, other science communities, as well as the general public, to understand and easily visualize the living C cycle over the past 20 years. In this section we describe the additional material and services made available by the CARBONES project to facilitate the dissemination of the CARBONES results to the above mentioned communities.

3.1 CARBONES product and services catalogue

A separate document is made available in order to provide assistance with accessing the CARBONES results on the public web interface. This document describes the various products and services available through the CARBONES server and contains a brief description of the methodology and processing used for displaying the data (e.g. temporal filtering and spatial averaging). It contains thus: a list of available products together with a brief description, list of available processing and details on available services such as types of available figures and downloading services. The catalogue is included in the annex of the present document and will be also made available through the web portal.

The portal will also provide an INSPIRE-compliant metadata catalogue which will contain metadata on the products and services made available through the portal.

3.2 Tools for evaluating the quality of the data displayed on the CARBONES webpage

The web server will allow the users to compare the generated results against independent data that were not used in the assimilation. These data include:

- Flux estimates from different atmospheric inversion systems or forward simulations from other terrestrial and ocean models
- Estimates of forest biomass increment and biomass stocks
- Soil inventory data (for evaluation of modelled soil C stocks)



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- Air-sea CO₂ flux estimates from an independent model combining the results from ocean-interior inversion and climatological surface Pco₂ from the Takahashi database

The tools for comparisons will be put in place only for the version V1 of the portal.

3.3 Presentation documents

A presentation directed to a general public will be prepared and will be available through the CARBONES web site. It will explain in simple terms the context of the project, the project's objectives and then will propose a guided tour of the different products generated by CARBONES.

In addition to this presentation, the CARBONES web page contains a more detailed description of the project and its objectives.

The CARBONES web page contains links to several other presentations of the project that were communicated to scientific and policy communities at the following events:

- Shanghai World Expo
- Helsinki GMES conference
- Budapest conference

3.4 Preparation of the Users Workshop and the CUAG workshops

The dissemination material produced in WP530 will be disseminated to the members of CUAG and to the identified Users communities.

3.5 Preparation of the CARBONES demonstration portfolio

The CARBONES demonstration portfolio will be prepared for the final delivery.

3.6 Preparation of an executive summary

The executive summary for policy makers and scientists will be prepared near the end of the project, following the major scientific results reached by CARBONES.



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4 ANNEX: CARBONES Product and services catalogue

The objective of this document is to give the users of the CARBONES portal a brief and synthetic overview of the available products and services. This document contains three sections:

- Section 1: gives a rapid overview of the data assimilation system used (CCDAS) in the generation of the data currently available on the portal;
- Section 2: contains a list of products available on the portal;
- Section 3: contains a description of the display processing available;
- Section 4: contains a description of the visualisation tools available.

4.1 Description of the CCDAS version used to generate the data

This section will be updated after each new release of data on the portal. The data to be displayed on the portal (V0.5, to be displayed January 2012) have been obtained by applying a preliminary version of the CCDAS. The products were generated as follows:

- The assimilation system including the atmospheric transport model (LMDz) was used to invert atmospheric CO₂ observations in order to optimize :
 - Net ecosystem fluxes using a priori estimates from the ORCHIDEE model,
 - Biomass burning fluxes,
 - And ocean fluxes using a priori estimates from the climatology of Takahashi,
- The remaining products (land carbon stocks and land gross fluxes) were obtained from the ORCHIDEE model forward simulation (no assimilation) for the concerned 20 year period.

For the next version, V1 which is currently under development, the following sequential approach (shown in Figure 1) will be used:

Step 1: Assimilation of the remotely sensed products of vegetation greenness (NDVI) derived from MODIS into ORCHIDEE; the prior parameters including values and error covariance (X_0 and P_0) are optimized to produce a first set of optimized parameters X_1 with error covariance P_1 .

Step 2: Assimilation of in situ flux measurements ; the parameters X_1 and P_1 are used as input to the optimization system (adding new parameters) and further optimized to produce the second set of optimized parameters (X_2 and their error covariance P_2).

Step 3: Assimilation of ocean pCO₂ measurements into a statistical model (neural network) to produce a priori air-sea fluxes over the 20-year period.

Step 4: Final assimilation step using the atmospheric CO₂ measurements as a global constraint; the parameters X_2 and their error covariance P_2 are used as prior for the ORCHIDEE model and the air-sea fluxes from step 3 are used as prior ocean fluxes. The



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result of this last optimization step will consist of i) final parameters for ORCHIDEE with the associated optimized land fluxes and ii) the optimized ocean fluxes.

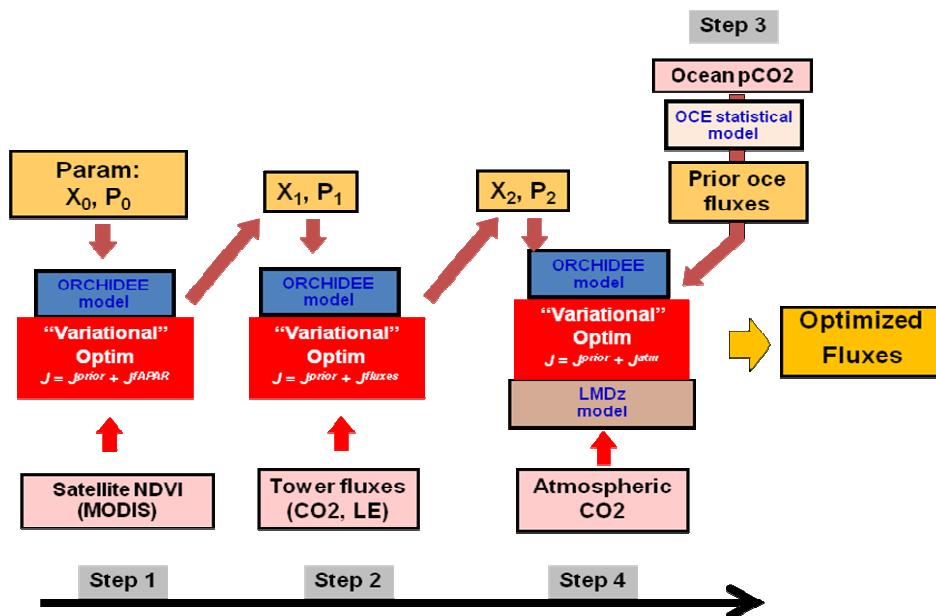


Figure 1: Sequential assimilation of the different data stream into 4 steps.



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4.2 Description of products available on the CARBONES portal

The Carbon Data Assimilation System delivers fluxes and stocks of carbon, as well as latent heat and sensible fluxes over land. These products were generated for a 20 year period (1990-2009) at a resolution of 1° x 1° degrees. The calculations for the current version were done at a coarser resolution of 2.5° x 3.75° and were then interpolated on the 1°x1° degree grid. Future versions will provide an estimate of the uncertainty (Bayesian uncertainty calculated by the CCDAS). The CCDAS products available with the current version are listed in Table 1 below:

| | Type 1 | Type 2 | Comments | units |
|----------------------|-----------------------|---|---|-----------------------------|
| Carbon Fluxes | ecosystem fluxes | Net ecosystem flux | From the assimilation system through assimilation of CO ₂ atmospheric measurements | kgC / m ₂ / hour |
| | | Photosynthetic flux | From the 20 year run of ORCHIDEE model | |
| | | Respiration flux | | |
| | | Forest Net ecosystem | | |
| | | Grass Net ecosystem | | |
| | | Crop Net ecosystem | | |
| | | Total photosynthesis and respiration | Sum of Photosynthesis and Respiration | |
| | Total land fluxes | Sum of net ecosystem flux and biomass burning flux | | |
| | Other natural fluxes | Ocean Flux | From the assimilation system through assimilation of CO ₂ atmospheric measurements | |
| | | Biomass burning | From the assimilation system through assimilation of CO ₂ atmospheric measurements | |
| Total Natural fluxes | | Sum of Net ecosystem flux + Ocean flux + biomass burning flux | | |
| Anthropogenic fluxes | Fossil Fuel Emissions | From the assimilation system through assimilation of CO ₂ atmospheric measurements | | |
| Total C fluxes | Total Carbon flux | Sum of Net ecosystem flux+ anthropogenic+ biomass burning+ ocean | | |
| Other Fluxes | Latent heat | | From the 20 year run of ORCHIDEE model | W / m ₂ |
| | Sensible heat | | | |
| Carbon Stocks | Biomass | Total above ground | From the 20 year run of ORCHIDEE model | kgC / m ₂ |
| | | Total below ground | | |
| | | Total (above and below ground) | | |
| | Soil Organic Matter | | | |
| | Leaf Area Index | | | |

Table 1: List of products provided by the current version of the CCDAS



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4.3 Description of processing available on the CARBONES portal

The processing available with the current version of the CARBONES portal concerns two types of filtering:

- Temporal filtering
- Spatial averaging

4.3.1.1 Temporal filtering

The portal allows displaying the products either at their original temporal resolution or for coarser temporal means (Table 2)

| | Carbon fluxes | Heat fluxes | Carbon stocks | LAI |
|-----------------|---------------------|---------------------|---------------------|---------------------|
| 3 hourly values | Original resolution | Original resolution | No | No |
| 24 hour means | yes | yes | Original resolution | Original resolution |
| Monthly means | yes | yes | yes | yes |
| Yearly means | yes | yes | yes | yes |
| Decadal means | yes | yes | yes | Yes |
| 20 year mean | yes | yes | yes | yes |

Table 2: Information on the original resolution of the products and on the temporal means available

The units depend on the type of temporal averaging and spatial aggregation: for instance flux in $\text{kgC}/\text{m}^2/\text{hr}$ is transformed into $\text{kgC}/\text{m}^2/\text{day}$ or $\text{kgC}/\text{m}^2/\text{month}$ or $\text{kgC}/\text{m}^2/\text{year}$, and the spatial aggregates are transformed into kgC or GtC (see below)

In addition to calculating the means, the time filtering algorithm can be applied to fit the data to a polynomial of degree 2, with 3 harmonics. The residuals are filtered in the frequency space using a low-pass filter of 667 days and a high-pass filter of 80 days. The output variables from the temporal filtering are listed in Table 3.

| CARBONES post-processing output parameter | Description |
|---|---|
| Means | Algebraic means (Table 2) |
| Smoothed trend | The polynomial fit plus the low-pass filtered residuals using a cut-off value at 667 days |
| Smoothed curve | The fitted function plus the low-pass filtered residuals using a cut-off value at 80days |
| Re-centred parameter | The original data minus the period mean. |

Table 3: Types of temporal filtering available



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4.3.1.2 Spatial Averaging:

All variables (fluxes and stocks) can be aggregated onto predefined regions for the visualization of the time series of fluxes and stocks (not for displaying 2D maps). This aggregation is performed based on 2D masks describing each of the preselected regions at 1°x1° resolution.

- There are 3 general types of regions:
 - land only,
 - ocean only,
 - land+ocean.

All available regions are listed in the Table 4 below.

| Region name | Land/ocean | Region name | Land/ocean |
|-----------------------------|------------|----------------------------------|------------|
| Global | Both | Southern sub-antarctic ocean | Ocean |
| Northern land and ocean | Both | Austral ocean | Ocean |
| Tropical land and ocean | Both | Boreal North America | Land |
| Southern land and ocean | Both | Temperate North America | Land |
| Global land | Land | Canada | Land |
| Northern land | Land | USA | Land |
| Tropical land | Land | Northern Europe | Land |
| Southern land | Land | Central mid-Europe | Land |
| Tundra | Land | Eastern Europe | Land |
| North America | Land | Mediterranean Europe | Land |
| Europe | Land | Boreal Asia | Land |
| North Asia | Land | Temperate Asia | Land |
| Tropical Asia | Land | Boreal Asian forest | Land |
| Southern America | Land | Boreal Asian steppe | Land |
| Africa | Land | China-Korea-Japan-Mongolia | Land |
| Australia and New Zealand | Land | Arabia | Land |
| Global ocean | Ocean | South Asia | Land |
| Northern ocean | Ocean | South east Asia | Land |
| Tropical ocean | Ocean | Equatorial Asia | Land |
| Southern ocean | Ocean | Australia | Land |
| North Atlantic ocean | Ocean | North Africa savannah | Land |
| North Pacific ocean | Ocean | Equatorial African forest | Land |
| Tropical Atlantic ocean | Ocean | South Africa | Land |
| Tropical Pacific ocean | Ocean | Tropical South American forest | Land |
| Tropical Indian ocean | Ocean | Tropical South American savannah | Land |
| Southern sub-tropical ocean | Ocean | South America temperate | Land |

Table 4: List of available regions for spatial aggregation



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Note: For the ocean regions there are no carbon stocks and no estimation of the latent heat and sensible heat fluxes.

4.4 Description of visualisation tools available on the CARBONES portal

The visualisation tools available on the portal allow generating two types of plots:

- Flux and carbon stock time series
- Flux and carbon stock maps



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4.4.1.1 Flux Time Series Plots

To generate a time series plot, the menus listed in Table 5 are available:

| MENU | comment | example |
|----------------------------|---|----------------------------|
| Variable | one of the variables listed in Table 1 | Net ecosystem flux |
| Temporal period | allows zooming to any particular period | Jan 1, 1990 to Jan 1, 1992 |
| Temporal filtering | One or several of the possibilities listed in Table 3. See also Table 6 to see for which temporal resolutions these variables are available | Means |
| Temporal resolution | One or several of the possibilities listed in Table 2 | Daily means |
| Spatial aggregation | one or several of preselected regions in Table 4, only land regions for carbon stocks | Global |

Table 5: List of options available for time series plots

Note: Several variables and results for several temporal filters (e.g. monthly means and daily means) can be displayed on the same graph.

Units:

- For carbon fluxes the units depend on the temporal averaging period: GtC/year for yearly data; GtC/month for monthly data; kgC/day for daily data; and kgC/hour for 3-hourly data.
- W for the latent and sensible heat fluxes.
- For carbon stocks the units depend on the temporal averaging period: GtC for yearly and monthly data; and kgC for daily data.



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| Averaging time | C flux and latent heat flux | | | | C stocks including LAI | | | |
|----------------|-----------------------------|--------------|--------------|----------------------|------------------------|--------------|--------------|----------------------|
| | mean | Smooth trend | Smooth curve | Recentered parameter | mean | Smooth trend | Smooth curve | Recentered parameter |
| 3-hourly | | | | | | | | |
| Daily | | | | | | | | |
| Monthly | | | | | | | | |
| Yearly | | | | | | | | |
| 20 years | | | | | | | | |

Table 6: Specification of the temporal averages for which different types of temporal filtering results are available (white boxes) for time series plots.

4.4.1.2 Flux maps

| MENU | comment | example |
|---------------------------|---|----------------------------------|
| Variable | one of the variables listed in Table 1 | Net ecosystem flux |
| Regions | this option allows zooming to one of the regions listed in Table 2 | Global |
| Temporal period | allows selecting a particular period | January 1 2000 (for daily means) |
| Temporal averaging | One or several of the possibilities listed in Table 3. See also Table 8 to see for which temporal resolutions these variables are available | Smoothed trend |
| Range of values displayed | Possibility to choose the minimum and maximum value displayed | 0 to 5 |
| Colour scale | Possibility to select the colour scale | rainbow |

Table 7: List of options available for map plots

Units:

- KgC/m^2 / time step for carbon fluxes;
- W/m^2 for energy fluxes
- kgC/m^2 for stocks



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| Averaging time | C flux and latent heat flux | | | | C stocks including LAI | | | |
|----------------|-----------------------------|----------------|----------------|----------------------|------------------------|----------------|----------------|----------------------|
| | mean | Smoothed trend | Smoothed curve | Recentered parameter | mean | Smoothed trend | Smoothed curve | Recentered parameter |
| 3-hourly | | | | | | | | |
| Daily | | | | | | | | |
| Monthly | | | | | | | | |
| yearly | | | | | | | | |
| 20 yearly | | | | | | | | |

Table 8: Specification of the temporal averages for which different types of temporal filtering results are available (white boxes) for map plots.



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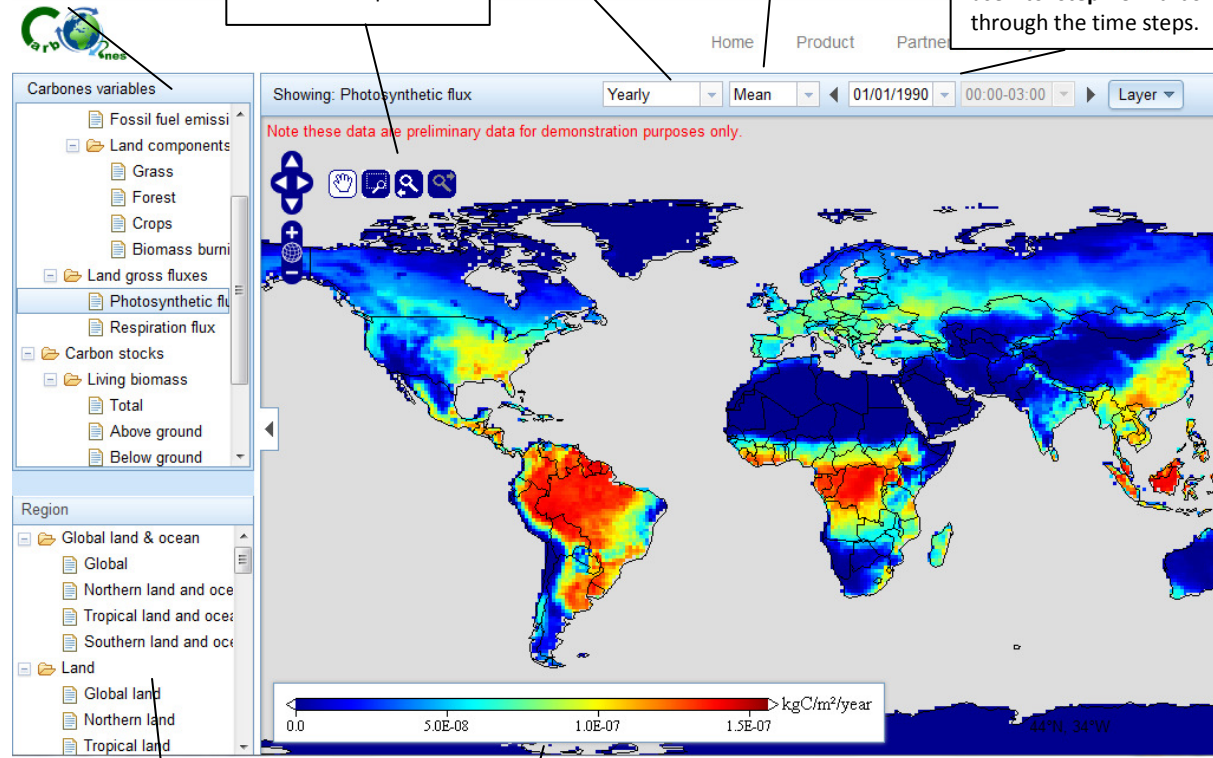
Time period drop-down allows the user to select the **time period for averaging**. The options are "3-hourly", "Daily", "Monthly", "Yearly" and "Period".

Filtering drop-down allows the user to select the **temporal filtering**. The options are "Mean", "Smooth trend", "Smooth curve" and "Re-centred parameter".

Tree control allows the user to select a **variable** to display in the map.

Map controls allow the user to pan and zoom the map.

Calendar control and hour drop-down allow the user to choose the date and time to display. The buttons allow the user to **step forwards and backwards** through the time steps.



Regions tree control allows the user to view specific regions of the world.

Legend gives the colour shading and units used in the map to display the variable. User can click the legend to alter the colour shading

Figure 2. Portal view of flux maps



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Dropdown menu allows the user to select a **variable** to display in the chart.

Time period drop-down allows the user to select the **time period for averaging**. The options are "3-hourly", "Daily", "Monthly", "Yearly" and "Period".

Filtering drop-down allows the user to select the **temporal filtering**. The options are "Mean", "Smooth trend", "Smooth curve" and "Re-centred parameter".

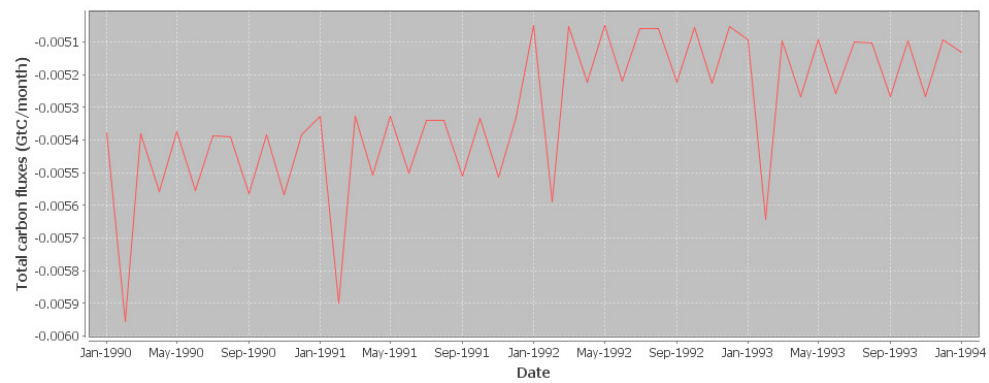
Regional time series

Time series of regionally aggregated carbon fluxes, carbon stocks and other fluxes

CARBONES is a EU FP7-funded project aiming to provide a 30-year long re-analysis of carbon fluxes and pools over Europe and the globe, in form of a user-friendly interface. The project is a partnership between teams in France, the UK, Germany, Switzerland, the Netherlands and China, and is coordinated by Noveltis.
Note these data are preliminary data for demonstration purposes only.

Total carbon fluxes Month Mean Regions

Regions dropdown allows the user to time series for one or more specific regions.



Start Date: 01/01/1990 00:00-03:00 End Date: 01/01/1994 00:00-03:00



Start date and end date calendar control and hour drop-down allow the user to precisely specify the time period to display. The **slider control** allows the user to change the time period with the mouse.

Download button allows the user to download the data being displayed as a text file.

Figure 3. Portal view of regional time series charts