Management and Impacts of Climate Change Programme
GICC
CRP 2000

4/00 – Quantification of carbon fluxes and stocks at the national and European levels

Summary of Final Report

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The objective of the CARBO-CONTROLE project is **to evaluate the various complementary methodologies used to assess CO_2 fluxes on European (10,000 km), national (1,000 km) and regional (100 km) scales**. The adopted strategy combines the disaggregation – downscaling – of large-scale fluxes by inversing atmospheric CO_2 measurements, and the aggregation – upscaling – of national stocks and fluxes using the climatic fields of an ecosystem model.

To reach this objective, we proposed to use three-dimensional models of atmospheric CO_2 transport and a model of the carbon cycle in vegetation and soils. These pre-existing models were improved to meet the specific requirements and constraints of the project.

For the atmosphere, **we reviewed and summarized estimates of European fluxes using the 'inverse' approach,** i.e. under the direct constraint of observations, and worked out the main uncertainty factors associated with this method. We also **re-calculated European fluxes using three transport models** (TM2, TM3 and GCTM) in 'inverse' mode and various *a priori* biospheric fluxes scenarios. We exceeded our initial objectives since only two models (TM2 and TM3) were originally planned. In addition, our participation in the international project TRANSCOM-3 allowed us to better quantify the uncertainty linked to atmospheric transport through intercomparison of the fluxes estimated by 15 different transport models. Finally, we also developed **a new inverse approach that makes use of the continuous measurements recorded in Europe** and all the synoptic information on regional fluxes they contained. For this, we used the LMDz model of IPSL, which is able to zoom on Western Europe – a crucial characteristic for the correct incorporation of continental readings close to CO_2 sinks and sources.

Given the imperfect coverage of atmospheric CO_2 records in France, we had proposed to add a monitoring station at the Puy-de-Dôme observatory to supplement the existing measuring network over a period of one year, in order to analyse the variability of CO_2 concentrations in the continental atmosphere and to be able to decide, according to the results, whether or not to continue monitoring in the long term. **The Puy-de-Dôme station was installed as scheduled at the end of 2000, and the resulting data have been analysed**. The setting up of the associated radon-222 monitoring allowed us to define (in demonstrator form) **a multi-tracer approach to the assessment of regional CO_2 fluxes** with no explicit modelling of atmospheric transport.

Regarding the continental biosphere, we had proposed to use climatic fields and high-resolution satellite data for France to force the ORCHIDEE biogeochemical model, which

describes the totality of the processes of carbon fixation, transformation and respiration within ecosystems on time scales ranging from one hour to one decade. We succeeded in creating a set of climatic data with a resolution of 10' x 10' (instead of the previous 1° x 1 °**). It then became possible to run the proposed simulations with ORCHIDEE, in particular a long high-resolution simulation spanning the period 1901-2000.** A comparison with observed values (fluxes, biomass) is under way, but it can already be ascertained that the model is capable of reproducing satisfactorily the behaviour of vegetation in response to interannual climate variability. We had also proposed to upgrade the ORCHIDEE model so as to improve the representation of processesat the regional scale. It then became apparent that the main limitation of the model had to do with the representation of cultivated land. We consequently coupled the ORCHIDEE model with a STICS crop model in cooperation with the INRA teams. This coupling now allows us to represent satisfactorily the functioning of cultivated areas and to take into account the role of farming practices in the European carbon balance. A preliminary study underlined the overriding influence of farming practices (in terms of climate and CO_2 concentration changes) on the variations of the carbon balance of crops over the 20^{th} century.