TOWARDS A NEW UNDERSTANDING OF RECENT CARBON CYCLE VARIABILITY COMBINING ATMOSPHERIC INVERSION, PROCESS-BASED MODELS AND SPACE-BORN FIRE ESTIMATES

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ABSTRACT

We present a comprehensive analysis of the recent inter-annual variation of the atmospheric CO_2 growth rate, with a special focus on the 2002-2003 period, using a state of the art atmospheric inversion, process driven model simulations (land and ocean), and recent biomass burning estimates. The inverse estimates compare favourably well with the model simulations over North Asia and indicate a large contribution of the fire anomaly to the total anomaly, for that region in 2003. Over Europe, the spatial distribution of the inverse and bottom-up flux anomalies for 2003 have similarities but the time evolution of the total fluxes still need to be reconciled.

INTRODUCTION

During the past 10 years, the atmospheric CO_2 growth rate underwent large variations still poorly understood, with a striking positive anomaly in the northern hemisphere during the years 2002-2003, not associated to a strong El-Niño event. Recently, *Knorr et al*. [2005] claimed that accelerations of atmospheric CO_2 growth rates can be mainly explained by changes in land biosphere fluxes (photosynthesis and/or respiration), driven by large impact of El- Niño related droughts. On the other hand, few studies suggest a large impact of tropical and extra-tropical variations in carbon emissions from fires on the inter-annual CO_2 variability [*Vand Der Werf et al*. 2003] and it is quite admitted that the strong tropical fires in 1998 mainly contributed to the 1998 atmospheric CO_2 anomaly [*Page et al.* 2002]. Whether the recent perturbation directly reflect anomalous sources from natural fires (suggested by satellite observations) and/or partly reflect impacts of climate on the ecosystems functioning, like the extreme 2003 summer drought in Europe, are thus critical challenges to better predict the future of the carbon cycle. In this study, we try to quantify the contribution of the different processes to the overall atmospheric 2002-2003 anomaly, using a comprehensive modelling framework.

METHOD

We establish a new, state of the art, modelling framework of inter-annual CO_2 flux estimates from an atmospheric inversion and from process driven model simulations (land and ocean), for the period 1997-2003. The inverse estimates rely on an advanced technique where 1) we solve for monthly fluxes at the grid resolution of the LMDZ transport model including prior knowledge of the land surface and ocean fluxes and for additional fire sources using prior estimates derived from satellite observations [extension of the work from *Van der Werf et al.* [2003], and 2) we use atmospheric measurements from GLOBALVIEW database, the European TCOS project, and Siberian aircraft profiles (NIES-Japan institute). Inverse estimates are compared with the results from the biosphere model ORCHIDEE [*Krinner et al*. [2005], forced with the NCEP re-analysis, and using advanced parameterisations for crop areas in Europe, and from the ocean model OPA-PISCES [*Le Quere et al.* [2003].

RESULTS

Although the comparison covers the whole 1997-2003 period, we focus the analysis to the recent years in the northern hemisphere in connection with the 2003 summer drought over Europe. De-seasonalized flux anomalies of the different estimates (Fig. 1) present similar time variations over North Asia, with positive anomalies in 2002-2003. The fire anomaly in 2003, as estimated from satellite observations and model estimates (located in eastern Siberia), seems to explain most of the inverse flux anomaly. Over Europe, the phase of the biosphere anomaly is very different from the inversion for most of the period, but the positive anomaly in 2003 estimated by ORCHIDEE is corroborated by the inverse results, although with a much weaker amplitude. New bottom-up model simulations, including crops specificities, are in progress and they should help to resolve these discrepancies.

As for the spatial patterns, coherences between the bottom-up and top-down estimated patterns are also found (not shown). A large dipole between Western Europe (strong reduction of the biosphere uptake) and western Siberia (enhanced uptake) during the summer 2003 is observed. Such agreement is encouraging and will help unravel the contribution of the different processes to the recent atmospheric CO_2 anomaly. The sensitivity of these results to the inverse set up is critical and under deep investigations. Further insights from other carbon cycle observations will be discussed and compared with the model simulations, like flux tower measurements, satellite biophysical indexes, etc.

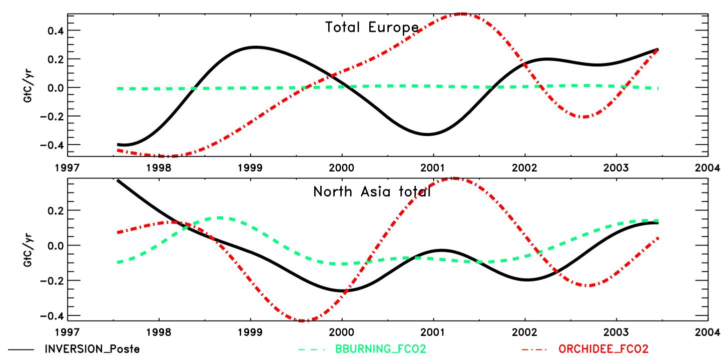

Fig. 1 : Flux anomalies in GtC/yr over the period 1997-2003 from the inversion, the biomass burning estimates of Van der Werf [2003], and the ORCHIDEE biosphere model. Flux anomalies are smoothed using a 12 months running mean and the first and last 6 months are dropped.

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