INTERANNUAL VARIABILITY IN TERRESTRIAL CARBON EXCHANGE USING AN ECOSYSTEM—FIRE MODEL

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ABSTRACT

We have incorporated a semi-mechanistic fire model into the SEVER Dynamic Global Vegetation Model (DGVM). The model produces estimates of net primary productivity (NPP), heterotrophic respiration (HR) and fire carbon emission (FE) for the globe. This model was run for the period 1957-2002 with the NCEP climate reanalysis data as an input. Results were compared with the ATSR area burnt maps and a Time Dependent Inverse (TDI) model fluxes of CO_2. We find that on interannual time scales NPP variability explains major part of flux variability simulated by the TDI model, followed by the HR and FE contributions.

INTRODUCTION

Estimates of interannual and seasonal variability of fire carbon emissions at large scale allows to understand their relative role in global carbon cycle in relation to other carbon fluxes between the terrestrial biosphere and the atmosphere, namely NPP and HR. Beside this fires have a regulating role in successional development of major ecosystems affecting global carbon exchange, like the tropical and boreal forests.

METHODS

We combined three different types of information, related to CO_2 sources and sinks on the land from a coupled ecosystem–fire model, a TDI model of atmospheric CO_2 and ATSR burnt area data and studied a relative role of fire emissions on monthly and yearly time steps. The fire model (Reg–FIRE) estimates areas burnt on a macro-scale (10−100 km). It consists of three parts: evaluation of fire danger due to climatic conditions, estimation of the number of fires and the extent of the area burnt [*Venevsky et.al.*, 2002]. The fire model operates at the daily time step. The fire model is incorporated into SEVER DGVM [*Venevsky and Maksyutov*, 2005], which is a modification of the LPJ global dynamic vegetation model [*Sitch et. al.*, 2003] for the daily time step and parallel computation. Inputs to the model are daily weather, i.e., temperature, precipitation and short-wave radiation. Three carbon fluxes connect each grid cell and the atmosphere: NPP of vegetation, soil HR and FE during fire outbreaks. The TDI model derive fluxes of CO_2 from 64–paritions of the globe (42 regions over land) using the atmospheric CO_2 observations at 87 stations and NIES/FRCGC transport model simulations [*Patra et al*., 2005].

NCEP climate data (http://www.cpc.ncep.noaa.gov/) for the period 1957-2002 (46 years) was interpolated to 0.5°x0.5° degree resolution and used for the test run of the SEVER model. The model was run for the globe from the bare soil state 22 times with the climate data for 46 years and the CO_2 atmospheric concentration fixed for the year 1957 (spin-up period) in order to achieve equilibrium of soil carbon pools. From this equilibrium state SEVER was forced by climate data and the CO_2 atmospheric concentration for the period 1957–2002 (transient period). The input soil texture data and CO_2 atmospheric concentration for the period 1957–2002 was the same as in the basic LPJ-DGVM [*Sitch et. al.* 2003]. The ATSR World Fire Atlas is available at 1x1 degree horizontal resolution from nighttime radiometric data only, and we have used the fire maps derived using Algorithm 1 (source: http://shark1.esrin.esa.it/).

RESULTS

Using the coupled SEVER and Reg–FIRE model monthly mean values of NPP, HR, and FE are simulated for the period 1957–2002. To gain confidence our results of net ecosystem exchange (NEE = –NPP + HR + FE), the spatial distributions of fire emissions during 1996–1998 are compared with the ATSR global fire maps (not shown here). For example the east-west differences in simulated fire emissions from Siberian forests between 1996 (greater spread) and 1998 (greater spread to the east) agree well with the ATSR maps. The north–south gradient is also captured well for the south–east Asian fire regimes during the 1997–1998 period; larger emission are observed from its southern region in Jul-Sep 1997 while that during Apr–Jun 1998 are observed from its northern region. The results for some regions are also in fairly good agreement with the results from a Time Dependent Inverse (TDI) model for continental scale regions (see Fig. 1), which estimated CO2 fluxes for 64 regions of the globe from atmospheric data in the period January 1988–December 2001 [*Patra et al.*, 2005]. On the interannual timescales we find that NPP variability explains major part of the TDI flux variability, typically seen as the anticorrelation between NPP and NEE, followed by the HR contribution. Overall the best agreements between TDI and SEVER–DGVM flux anomaly are found for the Tropical South America (Fig. 1f), Boreal Asia for the 1997–2001 period (Fig. 1b). For certain regions notably in the North-Eastern Eurasia the fire emission fluxes in summer months exceeds heterotrophic respiration. However, we believe the fire module requires significant improvements for the tropical rainforest ecosystem since the intense fire recorded by several independent studies are not captured by this version of the model (see Fig. 1e).

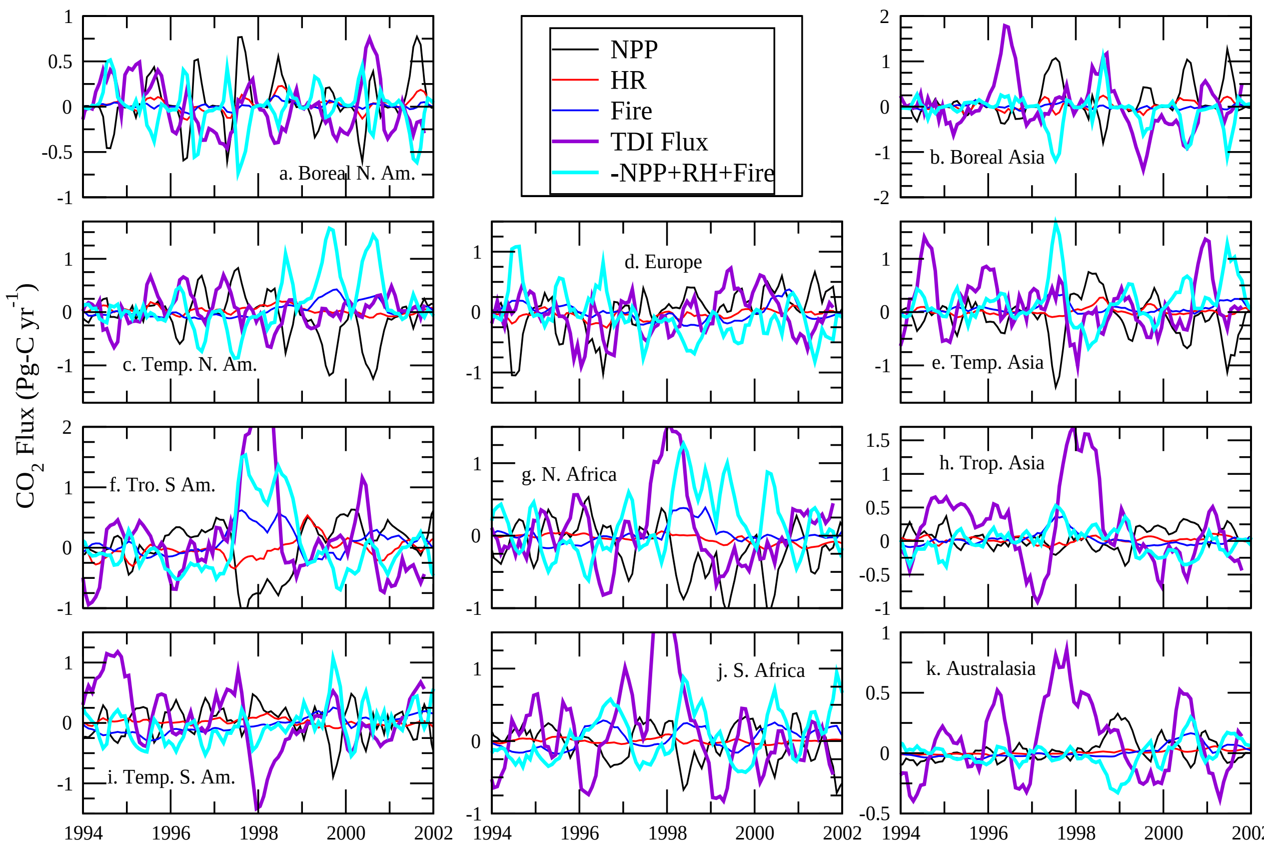

Fig. 1: Comparison of CO_2 flux anomalies estimated using SEVER–DGVM ecosystem model due to NEP, HR, and FE with those obtained from a TDI model of atmospheric CO_2. The individual components of ecosystem fluxes as well as the NEE of carbon to the atmosphere are shown for 11 continental scale regions. NEE positive indicates net flux to the atmosphere and negative NEE corresponds to a net sink in the terrestrial biosphere.

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