# A model analysis of the interaction between terrestrial ecosystem carbon cycle and atmospheric environment

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Interannual change in terrestrial ecosystem carbon budget has been addressed with a simulation model. The present author has used the U.S. NCEP/NCAR-reanalysis data for his simulation, but there remains an uncertainty about the accuracy of the data. Then, it was required to examine the data-dependence of model analysis, by using different datasets. In this study, the U.S. NCEP/AMIP-II DOE-reanalysis data and U.K. ECMWF-reanalysis data were employed to compare the interannual change in the terrestrial carbon budget, for the period from 1979 to 1993. In consequence, these simulations exhibited qualitatively similar trend, but there was a substantial quantitative difference among them. This result may suggest that the model analysis is to some extent dependent on input data.

## 1. Introduction

Terrestrial biosphere is an important component in the global carbon cycle, but we can hardly quantify the atmosphere-biosphere $CO_2$ exchange at broad scales. In this study, interannual change in the atmosphere-biosphere $CO_2$ exchange was simulated globally with a mechanistic ecosystem model (Sim-CYCLE) for the recent 47-year period, 1953 to 1999, putting focus on the correlation between climatic anomalies and terrestrial ecosystem carbon budget.

## 2. Method

In Sim-CYCLE, biological $CO_2$ exchange was performed by photosynthesis, plant respiration, and soil decomposition, each of which are affected by such environmental conditions as light, water availability, temperature, and atmospheric $CO_2$ concentration. The ecosystem carbon balance (i.e. net ecosystem production, NEP) was captured by the difference of these $CO_2$ fluxes. Historical change in the atmospheric $CO_2$ concentration was also taken into account, while biome distribution was assumed to be static through the simulation period; a global mapping of Matthews (1983) was adopted. Simulations were conducted monthly, at the spatial resolution of T62 (94 x 192 grid cells). The first experiment addressed the 47-year change in carbon budget, using the U.S NCEP/NCAR reanalysis meteorological dataset: shortwave radiation, surface temperature, soil temperature, soil moisture, evapotranspiration etc. In the second experiment, to examine data-dependence of the model analysis, the NCEP/DOE AMIP-II-reanalysis and the ECMWF 15-year-reanalysis data were adopted for a comparison simulation from 1979 to 1993.

## 3. Results

After the 4700-year spin-up period, global terrestrial carbon budget was fully stabilized, whereas in the simulation period, a considerable range of interannual variability became evident. The annual NEP showed anomalies from 1.84 Pg C in 1971 to -2.54 Pg C in 1998 (SD=1.06 Pg C $yr^{-1}$), which were sufficiently large to induce anomalies in the tropospheric $CO_2$ concentration. Indeed, large negative NEP anomalies took place after ENSO events (e.g. 1973, 1983, and 1998), when atmospheric $CO_2$ increased at anomalously high rates. Performing regression analyses thoroughly, we conclude that the global annual NEP anomaly was most sensitive to temperature anomaly, and secondarily to precipitation anomaly. The temperature dependence (i.e. net emission in anomalously warm years) was attributable to those of plant respiration and soil decomposition. However, statistic robustness of the relationship varied seasonally (most strong in summer) and geographically (most sensitive in tropical rain forests). However, the comparison among three results using different reanalysis data shows a qualitative agreement and quantitative dissimilarity. Using the ECMWF data resulted in a weak correlation between temperature anomaly and NEP anomaly, whereas using the NCEP/DOE AMIP-II-reanalysis lead to a stronger correlation.

## 4. Discussion

Based on the simulation results, interaction between the terrestrial carbon budget and atmospheric $CO_2$ concentration under the global environmental change was discussed. In sum, the terrestrial mechanism had a partial contribution to the observed $CO_2$ anomaly, but determining its magnitude requires more information and research. The climate sensitivity of the biospheric carbon budget may have an important implication with respect to the impact of anticipated global change. At last, we should take care that the model analyses were data-dependent, and an improved model and simulation result covering a longer term will be presented by our forthcoming research.