Carbon cycling in an old growth forest

J. Kadut, Department of Geography, University of Leicester, Leicester, LE1 7RH, UK
J. Berry, Department of Global Ecology, Carnegie Institution, Stanford, CA 94305-1297
J. Klopotek, School of Life Sciences, Arizona State University, Tempe, AZ 85287-4501

Abstract

Current oceanic and terrestrial biosphere are significant sinks for atmospheric carbon dioxide. The partitioning of the sinks into these two reservoirs can be constrained by observations of the mass and 13C isotope balance of CO2 of the atmosphere, as well as by the terrestrial biosphere. The terrestrial biosphere discriminate more against 13C than does the atmosphere. A large uncertainty in the equations used for the mass and 13C balance of the atmosphere is the isotope disequilibrium that results from shifts in carbon fluxes in the 13C/12C that have occurred since the beginning of the industrial revolution. The atmosphere has become more enriched in 12CO2 because there is a time delay of several years in the carbon cycle to respond to changes in the concentration of CO2 in the atmosphere and of various carbon fluxes. We explore the impact of recycling of respiration derived CO2 on the isotope composition of the carbon pool, using an isotope model of the ecosystem. We start our model simulations in 1765 and assume that the stand has been in isotopic equilibrium with the atmosphere at that time. Using a specific approach we can determine the steady state of the isotope composition of the carbon system as forced by measured changes in the concentration and isotopic composition of CO2 over the past 400 years. The atmosphere has become more enriched in 12CO2. Because there is a time delay of several years in the carbon cycle to respond to changes in the concentration and isotopic composition of CO2, the isotope composition of the atmosphere, as uptake by the terrestrial biosphere discriminates more against 13C than does ocean uptake. We explore the isotopic disequilibrium at the site in model simulations 1765-2000 with different recycling rates of respired carbon within the canopy. The stand has a very large canopy, so some of the respired carbon will have the atmospheric isotope signature. We ran the model assuming that photosynthesis fixes CO2 with 0%, 5%, 10% and 15% respired carbon.

Results

Photosynthetic isotope fractionation varies between -26.0% and -22.5% in summer and -22.9% in winter, respectively. This is in line with measurements cited by Winner et al. (2004) for ecosystem respiration. The fractionation varies between about -25 and -26.0% in summer and -22.9% in winter, respectively. The data for the 13C of respiratory components is shown in Fig. 4. It is obvious that the respiratory components have much lower 13C enrichment than the photosynthetic components. These differences may be due to different metabolic processes. The respiratory components have much more total fluxes compared to the photosynthetic components, and thus may have more impact on the isotopic composition of the atmosphere.

Discussion and conclusion

The simulated values of 13C of the different fluxes and pools and a comparison with observations suggest:

- A 0-5% respiratory fractionation, the simulated 13C for the different fluxes and pools are similar to observed data.

- There was little interaction between respiration and the atmospheric disequilibrium.

The simulations show that a large isotopic signal in the net ecosystem respiration can be observed. This might suggest that annual 13C of canopy respiration is less well suited to elucidate the turnover times of litter and soils due to confounding effects from allocation, respiration and photosynthetic discrimination (Fig. 3). It is probably going to be more useful, and we plan to extend these simulations to examine the propagation of the "bomb spike" through this ecosystem.

Figure 1: The isotope composition of the carbon pool in the canopy and the surrounding forest. The isotope composition of the carbon pool in the canopy and the surrounding forest is shown in Fig. 1. The isotope composition of the carbon pool in the canopy and the surrounding forest is shown in Fig. 1. The isotope composition of the carbon pool in the canopy and the surrounding forest is shown in Fig. 1. The isotope composition of the carbon pool in the canopy and the surrounding forest is shown in Fig. 1.

Figure 2: The isothermal temperature of the carbon pool in the canopy and the surrounding forest. The isothermal temperature of the carbon pool in the canopy and the surrounding forest is shown in Fig. 2. The isothermal temperature of the carbon pool in the canopy and the surrounding forest is shown in Fig. 2. The isothermal temperature of the carbon pool in the canopy and the surrounding forest is shown in Fig. 2. The isothermal temperature of the carbon pool in the canopy and the surrounding forest is shown in Fig. 2.

Figure 3: The isothermal temperature of the carbon pool in the canopy and the surrounding forest. The isothermal temperature of the carbon pool in the canopy and the surrounding forest is shown in Fig. 3. The isothermal temperature of the carbon pool in the canopy and the surrounding forest is shown in Fig. 3. The isothermal temperature of the carbon pool in the canopy and the surrounding forest is shown in Fig. 3. The isothermal temperature of the carbon pool in the canopy and the surrounding forest is shown in Fig. 3.

Figure 4: The simulated values of 13C of the different fluxes and pools and a comparison with observations suggest:

- A 0-5% respiratory fractionation, the simulated 13C for the different fluxes and pools are similar to observed data.

- There was little interaction between respiration and the atmospheric disequilibrium.

The simulations show that a large isotopic signal in the net ecosystem respiration can be observed. This might suggest that annual 13C of canopy respiration is less well suited to elucidate the turnover times of litter and soils due to confounding effects from allocation, respiration and photosynthetic discrimination (Fig. 3). It is probably going to be more useful, and we plan to extend these simulations to examine the propagation of the "bomb spike" through this ecosystem.

Acknowledgements

We thank Drs. Christopher Still and William Riley for help with the 13C programming of this work was supported by grants from National Oceanic and Atmospheric Administration (NAGL), National Institute for Global Environmental Change (NIECG) under Cooperative Agreement No. DE-FG09-9910001010.

References