Current state of terrestrial CO_2 exchange estimations: progresses and remaining issues

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Terrestrial ecosystems play a critical role in formation of a feedback loop of carbon dioxide (CO_2) in atmosphere with atmospheric reservoir and climate, and thus directing a course of the future projection of climate change. The research community has spent significant efforts to understand behaviors of terrestrial ecosystems under a steady rise in atmospheric CO_2 concentration and temperature during the recent decades and deepen knowledge about the regional and global patterns of terrestrial CO_2 sinks and sources. estimate the terrestrial CO_2 exchange, while seeking consistency between simulated and observed CO_2 concentrations. The bottom-up approach estimates the terrestrial CO_2 exchange using ecosystem models, which simulate the ecosystem-scale carbon cycle by considering the internal biogeochemical mechanisms of carbon flows for each prescribed vegetation type and soil.
However, the current estimates of terrestrial CO_2 exchange by the bottom-up and top-down approaches remain inconsistent. As illustrated in the recent IPCC Assessment Report (AR5), the top-down approach tends to indicate stronger CO_2 sinks in temperate and boreal regions than the bottom-up approach does. Furthermore, the two approaches exhibited contrasting CO_2 sink–source patterns in the tropics; the bottom-up approach indicated CO_2 sinks and the top-down approach CO_2 sources. As illustrated by these inconsistencies, a consensus on the geographic distribution of the terrestrial CO_2 exchange has yet to be established among the research community.
In this study, we elaborate the current status and issues of terrestrial CO_2 flux estimations by the top-down and bottom-up approaches. Specifically, we compare the bottom-up estimate from dynamic global vegetation models that are forced by interannual variations of CO_2 concentration, climate and land use changes, with the top-down estimate from atmospheric CO_2 inversions. We show an improved level of agreement between the two estimates in relation to seasonal variability and, regional and global budgets, since the IPCC AR5. We also discuss the remaining issues causing inconsistency between the two estimates.

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