Comparison of CO_2 fluxes estimated by top-down and bottom-up methods -- a case study at Yakutsk, Siberia --

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Carbon balance of the forested ecosystem is widely recognized as an important component in climate change research, but remains uncertain at the same time. Attempts have been made, recently, to understand the origin of the uncertainty by comparing estimates of carbon budgets with bottom-up and top-down methods. In the Green Network of Excellence (GRENE) Arctic Climate Change Research Project (hereafter as, GRENE Arctic project), terrestrial and atmospheric observations are conducted in the Arctic regions, where observational data were not available otherwise, e.g., in Siberia. At the same time, CO_2 fluxes are estimated using process-based terrestrial ecosystem,models and atmospheric CO_2 inversion models as a part of the GRENE Arctic project.
In the terrestrial sub-program, observation on energy-water-carbon balances are conducted in the Circum-Arctic, and the fluxes are estimated by a suite of terrestrial ecosystem models at four super-sites in the GRENE-TEA model intercomparison project (GTMIP) (Miyazaki et al., 2015). In the greenhouse gas sub-program, atmospheric CO2 concentration is measured at high accuracy using aircrafts and at surface stations and top-down/inverse modeling is performed for estimating regional CO_2 fluxes. We have compared the CO_2 fluxes estimated from tower observation at Yakutsk, Siberia with the CO2 flux estimates by the land-surface models for Yakutsk and CO_2 surface fluxes estimated by inverse models around the Yakutsk region (area ~500 x 500 km^2). The Net Ecosystem Production (NEP) or Net Biome Production (NBP) are considered for this analysis at monthly time intervals over the period of 1980 - 2012 (from 2004 - 2011 for flux observation).
We find that the seasonal cycle of CO_2 flux consists of a large drawdown in June-August from the atmosphere, and weaker emissions or absorptions in other months. This result agrees well among the models and observation. As for the long-term changes, the model variation is smaller in summer (June-August) than for the annual values. That is because respiration takes a dominant part of CO_2 flux in winter, that would have large uncertainty both for the observation and the model estimation. Thus the large uncertainty in CO_2-flux estimates in winter would affect the large fluctuation for the annual values. The year-to-year variations in summer by some models agree, at least in part, with the observation, but the reasons for the agreement/disagreement should carefully be investigated. At first, the difference in the horizontal scale represented by each method should be considered. Besides, different treatments of forest fire are identified as one of the possible causes for model-to-model differences. The extreme climate, such as very humid or hot-and-dry summer, resulted in year-to-year changes in NEP/NBP with the tower observation, but some models do not agree to those changes. Making thorough examination of each case is required to identify the causal process of the disagreements and to reduce the uncertainty in CO_2 balance.

References

Miyazaki, S., K. Saito et al., GRENE-TEA model intercomparison project (GTMIP): overview and experimental protocol for Stage 1, Geosci. Model. Dev., 8, 1-16, doi:10.5194/gmd-8-1-2015

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