Challenge of CO2 flux partitioning using chemical tracers

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For the purpose of determining the CO_2 uptake by terrestrial ecosystem, eddy covariance method (EC) is used commonly in the world wide tower-flux measurement network. The flux measured by this method is called ”net ecosystem exchange (NEE)”. NEE has the meaning of difference between photosynthetic uptake and respiratory release of CO_2.

In global scale, the magnitude of annual mean NEE is estimate to be only 1-2 GtC/yr, though both the gross exchange flux, ”respiration” and ”photosynthesis” are ˜60GtC/yr, respectively. If the magnitude of ”respiration” or ”photosynthesis” changes at a few percent, the magnitude of NEE will be affected significantly. Both the gross flux have difference in response function against changes in environmental factors, such as temperature and water. Therefore it is important to evaluate the characteristics of variations in both gross CO_2 fluxes individually in the future prediction of CO_2 uptake by terrestrial ecosystem.

Separation of NEE into both gross fluxes is most likely done by using an approximate temperature expression of respiratory flux. This approximate expression is based on the assumption that the NEE observed at nighttime equals to the respiratory flux. The photosynthetic uptake of CO_2 is defined as difference between the observed NEE and ”respiration” approximated as a temperature-function. Because of its technical simplicity, this approach has provided useful information about climatology of the gross CO_2 fluxes. However, the temperature expression of respiratory flux has several limitations in its application. For example, possible response of respiratory flux against factors other than temperature (water, phenology etc) is neglected in this approach. In development of detailed investigation of variability in the gross CO_2 fluxes, it is highly desired to establish new flux-partitioning method.

We are now planning the development of a flux-partitioning method using chemical tracers (e.g. stable isotopes of CO_2 and carbonyl sulfide) as additional constraints. The flux partitioning using stable isotopes of CO_2 is based on the imbalance of net flux of the CO_2 isotopes between ”respiration” and ”photosynthesis”. On the other hands, carbonyl sulfide (COS) is decomposed by enzyme CA (carbonic anhydrase) in leaf stomata. The uptake rate of COS is dominantly controlled by stomatal regulation of gas exchange as well as CO_2. Because of this similarity in the control factors for uptake ratio, the net flux of COS is regarded as a possible constraints for the functioning of variations in photosynthetic CO_2 uptake by terrestrial ecosystem.

In current circumstances, the measurements of both CO_2 isotopes and COS fluxes by the EC method is quite difficult due to the limitation of performance of analyzers. In our study, we will measure the fluxes of both CO_2 isotopes and COS by using relaxed eddy accumulation (REA) method coupling with glass-flask sampling and high precision lab-analyses. Field observation at a deciduous needle-leaf forest will be started in May 2007. We will present the outline of the observation plan, the result of the methodology assessment, and newly-developed high-precision measurement system of atmospheric COS.