# Assimilation of CO$_2$ observations in an Ensemble Kalman Filter to diagnose the surface CO$_2$ flux

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Estimation of the surface CO$_2$ flux is crucial to understand the mechanism of surface carbon source and sink. In Asia, there are large uptake regions such as forests in boreal and temperate regions. In this study, to diagnose the surface CO$_2$ flux in Asia, CO$_2$ observations were assimilated in the CarbonTracker developed by NOAA. The CarbonTracker is an inverse modeling system that estimates the surface CO$_2$ flux using an ensemble Kalman filter with atmospheric CO$_2$ measurements as a constraint.

In contrast to the CarbonTracker developed by NOAA, a nesting domain centered in Asia in this study enabled detailed estimations of surface CO$_2$ flux in Asia. The effect of CO$_2$ observations on the estimated surface CO$_2$ flux was also diagnosed by the analysis sensitivity and information content. The analysis sensitivity was inversely proportional to the number of observations used in the assimilation, which was notable in the continuous observations. The information content indicated the imbalance between the observation coverage in North America and that in other regions. Approximately half of the total observational information was provided by the continuous observations located in the North America, which indicates that the continuous observations is the most informative in this system and that the comprehensive coverage of additional observations in the other regions is necessary to estimate the surface CO$_2$ in the other regions as accurately as that in the North America. Finally, the CO$_2$ observations in Siberia provided beneficial impact on the surface CO$_2$ flux analysis in Asia.