# Estimation of global surface fluxes of a greenhouse gas with LETKF data assimilation system

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We present global $CO_2$ flux estimations using the local ensemble transform Kalman filter (LETKF) system with the GOSAT obtained $XCO_2$ and the WDCGG compiled $CO_2$ concentration data. In the previous study [Miyazaki et. al., 2011], a performance of the LETKF system was evaluated using GOSAT column pseudo-data in reference and the other various types of $CO_2$ concentration data. Here, we use the GOSAT retrievals to estimate the flux with the 4-D data assimilation system.
The data assimilation system used in this study was developed by Miyazaki et al., 2011, on the basis of the LETKF scheme [Miyoshi et al.]. A basic methodology of the LETKF follows the original EnKF [Ott et al., 2004; Hunt et al., 2007].The covariance localization [Houtekamer and Mitchell, 2001] is used to remove long range spurious correlations. The state vector augmentation method [Anderson, 2001; Aksoy et al., 2006; Tong and Xue, 2008] has been applied to simultaneously estimate the atmospheric $CO_2$ concentration as model states together with the surface $CO_2$ flux as uncertain model parameters. The surface fluxes at every model grid points are analyzed with 4-daily assimilation window during 2012 year. The ensemble size is hundreds. The transport model is coupled with the Center for Climate System Research/National Institute for Environmental Studies/Frontier Research Center for Global Change (CCSR/NIES/FRCGC) atmospheric general circulation model (AGCM) version 5.7b [Numaguti et al., 1995]. The model spatial resolutions are horizontally T42 truncation (approximately 2.8 degree) and vertically 32 levels up to 7 hPa. The surface $CO_2$ concentrations used in this study are obtained with the flask sampling data observed at sites in the surface network, which is archived at the WDCGG, and the $XCO_2$ concentrations are retrieved from GOSAT soundings using the RemoTec algorithm [Butz et al., 2009]. These observational data assimilate into the transport model. The LETKF system performance is evaluated by error reduction ratio of the posterior to prior ensemble fluxes.
We show analysis results that are the error reduction ration depending on various types of the observational data and seasonal variability of the optimized fluxes over aggregated land scale.
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Keywords: Carbon cycling, Ggreenhouse gas, Data assimilation, LETKF

 