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Diagnosis of influence matrix in a carbon data assimilation system

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Various state-of-the-art data assimilation schemes based on linear estimation theories have been used in atmospheric CO_2 inversion studies. The influence matrix of the linear statistical analysis scheme can diagnose the impact of individual observations on the analysis in observational space. The diagonal elements of the influence matrix are analysis sensitivities (i.e. self-sensitivities) that represent the sensitivities of an analysis to various observations. The trace of the diagonal elements of the influence matrix is the information content that denotes the amount of information extracted from various observations. The influence matrix can be calculated using analysis error covariance and observation error (i.e. model-data mismatch) covariance. In this study, to estimate the impact of CO_2 observations on the CO_2 analysis and the relationship between CO_2 observations and optimized surface CO_2 fluxes, both analysis sensitivity and information content are calculated in the CarbonTracker which is an inverse modeling system to estimate the surface carbon flux using Ensemble Kalman Filter. The experimental period is from January 2000 to December 2009.

The analysis sensitivity is inversely proportional to the number of observations used in the assimilation, which is noticed distinctly in the continuous observations with sufficient observation numbers. The time series of globally averaged analysis sensitivities show seasonal variations of greater sensitivities in boreal summer and smaller sensitivities in boreal winter. The time averaged analysis sensitivities in the Northern Hemisphere are greater than those in the Tropics and Southern Hemisphere. These results are related to the surface CO_2 flux uncertainties. The information content indicates the imbalance between the observation coverage in North America and that in other regions. Approximately half of the total observational information is provided by the continuous observations mainly located in the North America, which indicates that the continuous observations is most informative in this system and that the comprehensive coverage of additional observations in the other regions is necessary to estimate the surface carbon flux in the other regions as accurately as that in the North America. In addition, the high information content implies the large surface CO_2 flux optimization in an assimilation cycle. More detailed results will be presented in the meeting.