Influence of CO_2 Observations on the Optimized CO_2 Flux in the CarbonTracker Framework

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In this study, the effect of carbon dioxide (CO_2) observations on an analysis of surface CO_2 flux was calculated using an influence matrix in the CarbonTracker, which is an inverse modeling system for estimating surface CO_2 flux based on an ensemble Kalman filter. The influence matrix represents a sensitivity of the analysis to observations. The experimental period was from January 2000 to December 2009. The diagonal element of the influence matrix (i.e., self-sensitivity) is globally 4.8 % on average, which implies that the analysis extracts 4.8 % of the information from the observations and 95.2 % from the background each assimilation cycle. Because the surface CO_2 flux in each week is optimized by 5 weeks of observations, the cumulative impact over 5 weeks is 19.1 %, much greater than 4.8 %. Figure 1 shows the time series of the average self-sensitivity and number of observations around the globe and in each region. Globally, two apparent characteristics can be identified in the time series: first, the average self-sensitivity decreases as the number of observations increases, showing an inversely proportional relationship; second, there is seasonal variability in the average self-sensitivity, showing high values in summer and low values in winter, which is attributed to the surface CO_2 flux uncertainty. The time-averaged self-sensitivities in the Northern Hemisphere are greater than those in the tropics and the Southern Hemisphere. The trace of the influence matrix (i.e., information content) is a measure of the total information extracted from the observations. The information content indicates an imbalance between the observation coverage in North America and that in other regions. Approximately half of the total observational information is provided by continuous observations, mainly from North America, which indicates that continuous observations are the most informative and that comprehensive coverage of additional observations in other regions is necessary to estimate the surface CO_2 flux in these areas as accurately as in North America.

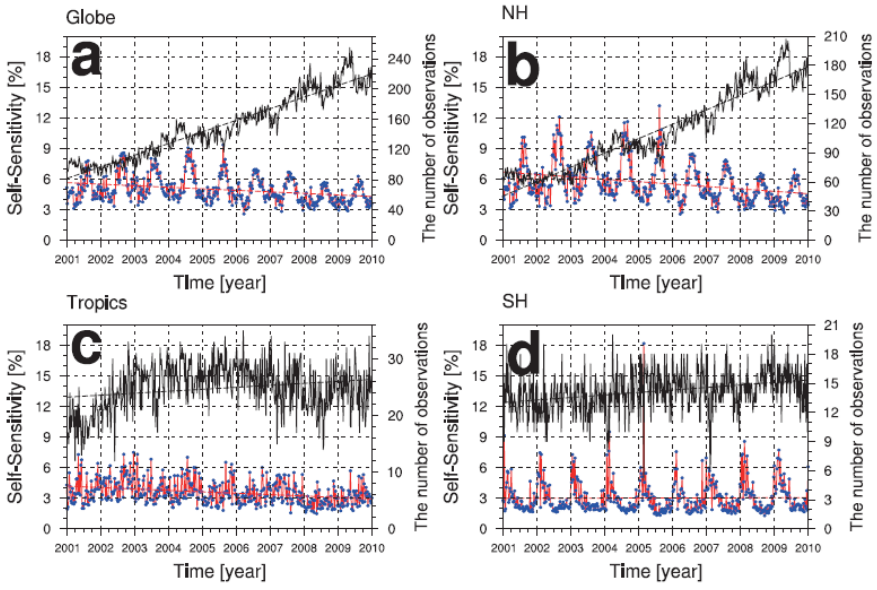

Figure 1. Time series of the average self-sensitivity (red solid line with blue dots) and the number of observations (black solid line) with a weekly temporal resolution (a) around the globe and in the (b) Northern Hemisphere, (c) tropics, and (d) Southern Hemisphere from 2001 to 2009. The dashed lines represent the regression lines for the average self-sensitivity (red dashed line) and the number of observations (black dashed line).