The relationship between variations of terrestrial carbon cycle and El Niño-Southern Oscillation

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Since 1958, records of atmospheric CO_2 concentration from Mauna Loa has been kept and described in detail by Keeling et al. (1989). Besides seasonal cycle, substantial interannual variability of atmospheric CO_2 is superimposed on the underlying elevated growth. This variation can't be explained by the slight increasing trend of fossil fuel burning and land use change.

Lines of evidence show the interannual variability of atmospheric CO_2 Growth rate at Mauna Loa station is strongly correlated with the El Niño Southern Oscillation (ENSO). Using a dynamic terrestrial carbon cycle Model VEgetation-Global-Atmosphere-Soil (VEGAS), forced by the observed climate data, we investigate regional spatio-temporal terrestrial in responses to the ENSO cycle from 1980s'. The composite analysis of 4 El Niño(1982,1987,1994,1997) and 3 La Nina(1988,1996,1998) events indicates that VEGAS simulated global averaged land-atmosphere flux anomaly lags SOI about 4-5 months, while tropical has more 1-2 months lags and dominates the global carbon flux anomaly. These results agree well with atmospheric inversion modeling results. Both bottoms-up and top-down models simulate the interannual variation of growth rate of atmosphere CO_2 except during 1-2 years after Pinatubo eruption. Model highlights the possible underlying mechanism of the robust tropical response to ENSO, and that is caused by conspiracy of NPP and anti-correlated Rh anomalies induced by interannual climate variability in the tropics, and NPP anomaly contribution covers 3/4 of the total. Our simulated land-atmosphere carbon flux anomalies due to fire is in phase of Rh and accounts for 20% of the total flux anomalies during ENSO events. Extratopics are less robust and have more delay in response to ENSO, where model generally agrees with inversion model. Modeled NPP/LAI is in line with observed NDVI anomaly in middle and high latitudes. Lag correlation analysis is supportable. Based on sensitivity simulations, we propose that 6 months after peak of SOI, on global scale, the temperature effect is slightly larger than precipitation effect on flux anomaly. However in the tropics the precipitation effect is comparable to the temperature effect with different mechanisms in regulating Rh and NPP anomaly together. One interesting thing is the indirect temperature effect on NPP variation through soil wetness is significant to cover 1/4 of NPP variation in tropics. Extratopics during El Niño warming is to increase the flux anomaly by increasing dramatically Rh, while more precipitation has the tendency to reduce flux anomaly by stimulating vegetation activity.