THE CHANGING CARBON CYCLE

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ABSTRACT
The carbon cycle has undergone changes from 1998-2003 as a result of extensive droughts. The CO_2 seasonal amplitude at MLO halted its increase, and the CO_2 growth rate accelerated as a result of a slowing down of the North American carbon sink. In a series of coupled carbon-climate model experiments, we show a greater probability of drier soils in the 21st century, especially in the tropics and in mid-latitude summers as temperature-driven evapotranspiration exceed precipitation, and a positive feedback between the carbon cycle and climate. This positive feedback reduces the land and ocean's capacity to store fossil fuel CO_2 and accelerates the warming. A fossil fuel emission accelerating rapidly as the sink capacities decrease leads to further increases in the airborne fraction of fossil fuel CO_2.

SHORT TERM CHANGES IN THE CARBON CYCLE
Interannual variations in CO_2 are known to be affected by climate perturbations. While global temperatures have continued to increase in the recent decades, there have been shifts in the hydrologic regime. Northern hemisphere photosynthesis, which has been increasing through the decade of the 1980's, has halted its increase at high latitudes and started decreasing in mid latitudes in the 1990's [*Angert et al*. 2005], as a result of the extended droughts. The seasonal amplitude of CO_2 at MLO, which has been increasing since the 1960's, has also started to decrease since 1990's (Fig. 1).

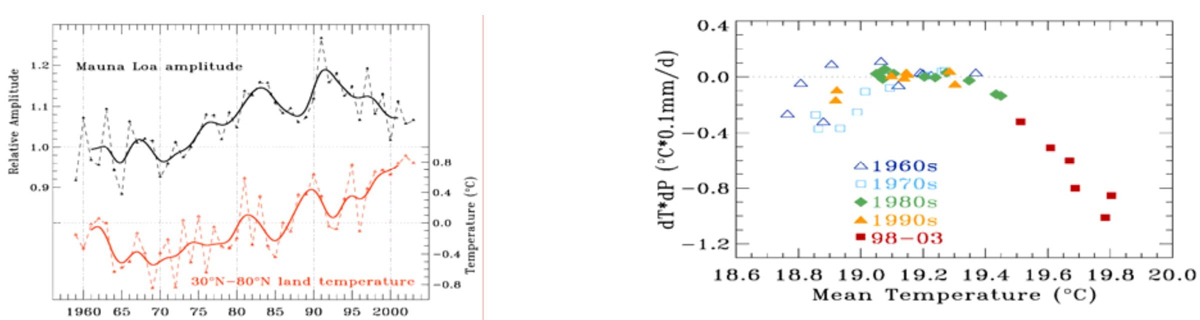

Fig. 1. Left Panel: Temporal changes in the relative amplitude of the MLO CO_2 seasonal cycle and zonally averaged land temperature for 30-80°N. Right Panel: The product of May-October temperature (dT) and precipitation anomalies (dP) as a function mean summer temperature, showing the anomalously hot and dry summers of 1998-2003 [from *Buermann et al*. 2005].

Using trajectory and correlative analysis, we have traced the amplitude decrease to the drought-induced slowing in photosynthesis in North America, and infer that the North American carbon sink declined from 1998-2003 [*Buermann et al*. 2005]. With the return of the rains to North America in 2004, we expect that MLO seasonal amplitude will rebound with the growth rate.

LONG TERM CHANGES IN THE CARBON CYCLE

It is expected future warming will be accompanied by changes in the hydrologic regime. We carried out a series of experiments with the NCAR global three-dimensional carbon-climate model [*Doney et al.*, 2005; *Fung et al.*, 2005] forced by historical fossil fuel emissions in the 19th and 20th centuries and by two fossil fuel emission scenarios SRES A1B and A2 in the 21st century. Fig. 2 shows the modeled evolution of the airborne fraction as a function of atmospheric CO_2. Implicit is the positive feedback between the climate and carbon cycle, which climate warming reducing the carbon storage potential of both the land and the oceans, and accelerating atmospheric CO_2 growth and climate change. A major finding is that with faster fossil fuel emissions (SRES A2), the land and oceans cannot remove the fossil fuel CO_2 fast enough, and the airborne fraction increases with increasing CO_2, further enhancing climate warming and destabilization of the carbon sinks.

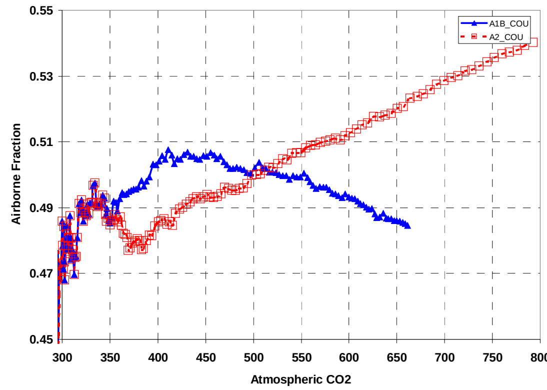

Fig. 2. Evolution of the airborne fraction of fossil fuel CO_2 as simulated by the NCAR carbon-climate model for fossil fuel emission scenarios SRES A1B (blue triangles) and A2 (red squares).

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