Impact of a regional drought on terrestrial carbon fluxes and atmospheric carbon: Results from a coupled carbon cycle model

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INTRODUCTION
Understanding the underlying processes that control the carbon cycle is key to predicting future global change. Much of the uncertainty in the magnitude and variability of the atmospheric carbon dioxide (CO2) stems from uncertainty in terrestrial carbon fluxes, and the relative impacts of temperature and moisture variations on regional and global scales are poorly understood. Here we investigate the impact of a regional drought on terrestrial carbon fluxes and CO2 mixing ratios over North America using the NASA Goddard Earth Observing System (GEOS) Model. Results show a sequence of changes in carbon fluxes and atmospheric CO2 induced by the drought. The relative contributions of meteorological changes to the neighboring carbon dynamics are also presented. The coupled modeling approach allows a direct quantification of the impact of the regional drought on local and proximate carbon exchange at the land surface via the carbon-water feedback processes.

RESEARCH QUESTIONS
- To what extent do changes in temperature, rainfall and CO2 driven by a regional Spring drought affect land carbon fluxes and productivity?
- Does interactive phenology help to lengthen or shorten an agricultural drought?

METHODS
- Models: GEOS-5 AGCM with a newly instituted land-atmosphere CO2 coupling; additional offline land only (Catchment-CN) simulations
- The 80-member ensembles of GEOS-5 simulations:
  1) CTRL a control ensemble
  2) DryS (or DryL): an ensemble with an artificially imposed drought on Region S (or Region L) from APR to JUN, followed by a 3-month recovery period.

RESULTS
1. A Spring drought has a footprint on land carbon dynamics that persists during the recovery period, and affects the carbon productivity in neighboring areas mostly due to remote changes in temperature and water availability.
2. The carbon flux change due to the induced CO2 fertilization effect acts only slightly to mitigate the meteorology effects.

Induced Changes by a Spring Drought (DryS example)
(a) DryS - CTRL (Drought period, APR-JUN)
(b) DryS - CTRL (Recovery period, JUL-SEP)

Relative Contributions of Isolated Drivers to GPP (DryS example)

Impact on a Remote Area (Eastern Side of the Region S example)

[Ongoing work] Effect of C Status on Soil Moisture Recovery