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Precision Gas Sampling (PGS) Validation2011–2014 Final Campaign Report

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Executive Summary

In this field campaign, we used eddy covariance towers to quantify carbon, water, and energy fluxes from a pasture and a wheat field that were converted to switchgrass. The U.S. Department of Energy is investing in switchgrass as a cellulosic bioenergy crop, but there is little data available that could be used to develop or test land surface model representations of the crop. This campaign was a collaboration between Lawrence Berkeley National Laboratory and the U.S. Department of Agriculture Agricultural Research Service. Unfortunately, in 2011, Oklahoma had one of the most severe droughts on record, and the crop in one of the switchgrass fields experienced almost complete die-off. The crop was replanted, but subsequent drought conditions prevented its establishment. Then, in April 2012, a large tornado demolished the instruments at our site in Woodward, Oklahoma. These two events meant that we have some interesting data on land response to extreme weather; however, we were not able to collect continuous data for annual sums as originally intended. We did observe that, because of the drought, the net ecosystem exchange of CO_2 was much lower in 2011 than in 2010. Concomitantly, sensible heat fluxes increased and latent heat fluxes decreased. These conditions would have large consequences for land surface forcing of convection. Data from all years were submitted to the Atmospheric Radiation Measurement Climate Research Facility Data Archive, and the sites were registered in AmeriFlux.

Acronyms and Abbreviations

ARM	Atmospheric Radiation Measurement
NEE	net ecosystem exchange
USDA-SPRRS	U.S. Department of Agriculture Southern Plains Range Research Station

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Figures

1.0 Background

In 2009, a collaborative field campaign was initiated to quantify the carbon, water, and energy fluxes from pasture or wheat fields converted to switchgrass. Collaborators were Margaret Torn and Sebastien Biraud (Lawrence Berkeley National Laboratory), Dave Billesbach (University of Nebraska), Chris Zou (Oklahoma State University), and James Bradford and Stacey Gunter (U.S. Department of Agriculture Southern Plains Range Research Station [USDA-SPRRS]). The facility is located at the western edge of the Southern Great Plains region.

The U.S. Department of Energy is investing in switchgrass as a cellulosic bioenergy crop; however, data that could be used to develop or test land surface model representations of the crop were scarce. Therefore, the purpose of this field campaign was to observe the effects of converting pasture land and extremely marginal cropland to switchgrass (a biofuel stock) production. The campaign was based at the USDA-SPRRS facility in Woodward, Oklahoma, and its field site near Ft. Supply, Oklahoma. The experiment was conducted at the two sites (i.e., Woodward and Ft. Supply), which are separated in distance by ~28 km. The Woodward site was initially a native prairie mix of vegetation, and the Ft. Supply site was marginal wheat in a field with very sandy soil.

2.0 Notable Events or Highlights

The notable events for this field campaign were extreme weather events, specifically droughts and a tornado. Because of inadequate moisture, the Ft. Supply crop did not establish itself in 2010 and was replanted in the spring of 2011. Drought conditions, however, inhibited germination, and very little vegetation grew at the site. The Woodward site (planted in early April 2010) produced a moderate crop at the end of the first year (2010). However, 2011 was one of the most severe drought years on record for Oklahoma, and the crop failed to mature. The effects of the drought can be seen in the half-hourly values of the net ecosystem exchange (net CO_2 flux) (NEE) shown in Figure 1. In addition, the switchgrass in one of the switchgrass fields (P2, converted from wheat) experienced almost complete die-off. The crop was replanted, but subsequent drought prevented its establishment. On April 15, 2012, a large tornado landed in Woodward near our other tower (P3, converted from pasture). It demolished the instruments, and no data were collected while damage to structures and other experiments at the field station were recovered. Because of these two extreme weather events, data collected during the campaign are incomplete, and large data gaps exist.

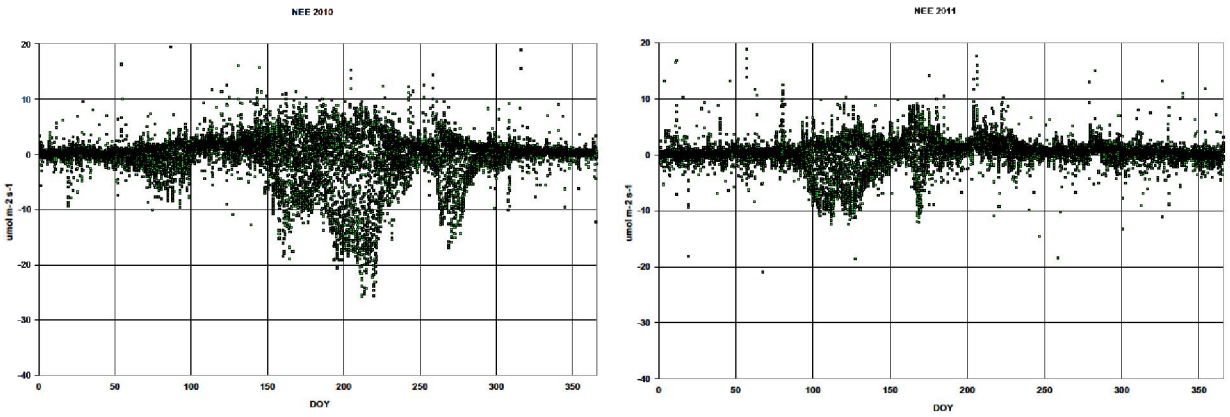

Figure 1. Net Ecosystem Exchanges for 2010 and 2011 at the Woodward, Oklahoma, Switchgrass Site. X-axis is day of year and Y axis is NEE.

3.0 Lessons Learned

The dramatic changes between the 2010 and 2011 growing seasons illustrate the fragile nature of the emergent and immature switchgrass crop. We can also see the overall effect of drought on grassland productivity in the Southern Great Plains.

4.0 Results

The observed response to drought illustrates the risky nature of agricultural industry in this region. While the crop started well, showing good germination and establishment in the first growth year (2010), the lack of moisture during the second year would have caused economic failure in a crop production scenario. On the other hand, native prairie grasses (such as switchgrass) should be adaptable to drought. We continued the experiment to see if the crop recovered in the next growing season (2012), but there was never sufficient moisture for full establishment and growth.

Figure 2 shows that NEE fluxes were much lower in 2011 due to the drought. Concomitantly, sensible heat fluxes increased, and latent heat fluxes decreased. This is not surprising, but would have large consequences for land surface forcing of convection. Before the crop had failed, our preliminary analysis of cumulative NEE suggested that the carbon costs of conversion would be recovered at the Woodward site very quickly.

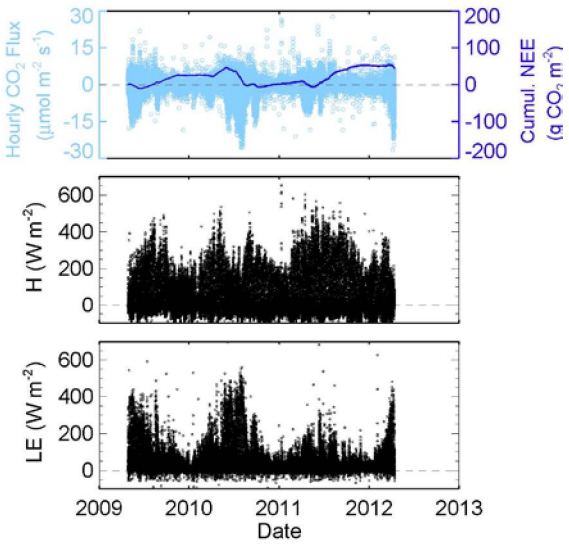

Figure 2. Switchgrass Field that Replaced a Pasture (Field P3). NEE (top panel), sensible heat fluxes (middle), and latent heat fluxes (bottom).

Data from all years were submitted to the ARM Data Archive on December 28, 2014. We incorporated the site into the AmeriFlux network and are submitting data to the AmeriFlux archive. Data from 2009 through 20012 were archived with AmeriFlux. We were contacted directly to share data with T. Twine at the University of Minnesota and T. Gillmanov at South Dakota State University, and we shared data through the ARM Facility and AmeriFlux websites as well.

5.0 Public Outreach

We contributed photos and written material to the Agricultural Research Service anniversary event in 2014. The campaign was described in public talks on the subjects of bioenergy and soil sequestration by Torn and co-workers (see citations in Section 6.2).

6.0 PGS Validation Publications

6.1 Journal Articles/Manuscripts

The following articles and manuscripts used the data from the field campaign or the understanding gained from the campaign.

Billesbach, DP. 2011. "Estimating uncertainties in individual eddy covariance flux measurements: A comparison of methods and a proposed new method." Agricultural and Forest Meteorology 151(3):394–405, doi:10.1016/j.agrformet.2010.12.001.

Raz-Yaseef, N, ML Fischer, DP Billesbach, SC Biraud, SA Gunter, JA Bradford, and MS Torn. 2015. "Drought sensitivity of three U.S. southern plains ecosystems." Submitted for publication, in revision.

Torn, MS, SC Biraud, CJ Still, WJ Riley, ML Fischer, and JA Berry. 2011. Seasonal and inter-annual variability in ^{13}C composition of ecosystem carbon fluxes in the U.S. Southern Great Plains." *Tellus B, Chemical and Physical Meteorology* 63(2):181–195, doi:10.1111/j.1600-0889.2010.00519.x.

6.2 Meeting Abstracts/Presentations/Posters

Torn, MS, DP Billesbach, J Bradford, C Zou, U Mishra, ML Fischer, and S Gunter. 2011. "The effects of converting marginal lands to switchgrass on carbon, water, and energy fluxes." Poster presented at the Joint North American Carbon Program and AmeriFlux Annual Meeting, January 31–February 4, 2011, New Orleans, Louisiana. Abstract available at http://www.nacarbon.org/meeting_2011/abs_and_discussions/mtg2011_ab_searchab_id256.html.

Torn, MS, SC Biraud, CJ Still, WJ Riley, ML Fischer, and JA Berry. 2011. Seasonal and inter-annual variability in ^{13}C composition of ecosystem carbon fluxes in the U.S. Southern Great Plains." ASR Science Team Meeting, March 28–April 1, 2011, San Antonio, Texas.

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