Is There Evidence of Okmulgee Forest Decline in ARM Measurements?

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ABSTRACT

The Okmulgee Forest, particularly oak trees, has declined in health in the past two years from a combination of damage caused by ice, wind or stress from several years before, and a resulting fungus infestation. The associated condition is called hypoxylon canker. There is little that can be done to prevent it. In October 2012 about one third of the oak trees in the vicinity of and upwind of the tower had died and another one third are in significant decline. There was evidence of some decline two years earlier, but the progression of the decline was startling this past October. We use SGP EF21 ARM data from the past five years to attempt to detect effects of the forest decline on radiation and eddy correlation flux data.

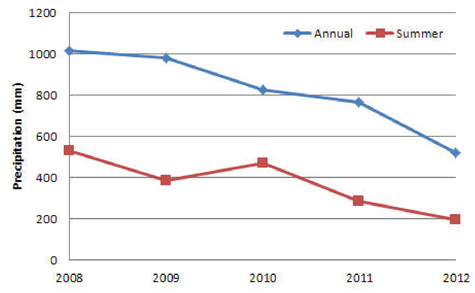
ANALYSIS

We analyzed ECOR, MET, and SIRS data from the SGP ACRF Okmulgee, OK EF21 (Extended Facility 21) for the years 2008-2012. We found evidence of a worsening drought over that period, reflected in changes in radiological and meteorological measurements. We calculated mid-day (1000-1400 CST) averages of most of the data and averaged that into Summer (May-September) averages of each quantity. The exceptions to this procedure were the calculation of total daytime precipitation and night-time (0000-0400 CST) CO_2 respiration.

RESULTS

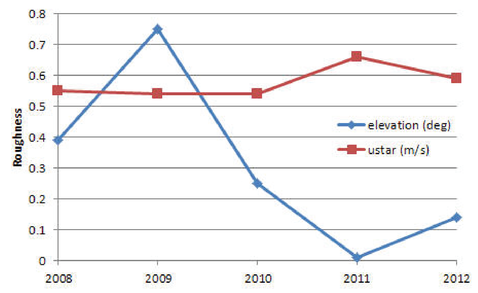
Figure 1 illustrates a dramatic reduction of precipitation from 2008 through 2012, on an annual basis as well as during Summer months. This condition has put stress on the vegetation in Okmulgee Forest, particularly oak trees, leading to the weakening of the defenses of the oak trees, an infestation of hypoxylon canker, and a resultant decrease in forest foliage.

Figure 1 Precip



The decline of the forest can be detected in ARM measurements that reflect on the physical characteristics of the forest, including elevation angle (angle of attack of the wind) and friction velocity (ustar, an indicator of surface roughness and turbulence) as measured by the ECOR sonic anemometer (**Figure 2**).

Figure 2 Roughness



There is significant variation in tree crown height and shape in the forest, resulting in a large friction velocity when fully leafed. The recent decreased extent of forest foliage has led to a more open canopy and therefore a less "smooth" surface, as reflected in a slight increase in friction velocity. The large reduction in elevation angle in 2010-2012 also suggests a more open canopy, such that defoliated taller trees upwind had a reduced effect on the angle of attack of the wind.

While downward longwave and upward shortwave radiation varied little during the five years of data used, **Figure 3** shows that there was an increasing trend in both downward shortwave radiation and upward longwave radiation. Both of these can likely be attributed to a reduction in cloudiness, a contributor to both decreased precipitation and increased forest temperature. The effect of increasing drought and declining forest foliage can also be seen in **Figure 4**, reflected in significantly reduced evapotranspiration (latent heat flux) and significantly increased sensible heat flux the past two years, the two years of accelerated forest decline.

Effects of the reduction of forest foliage can also be seen in **Figure 5** as a decrease of CO_2 flux (less negative value) and slightly decreased CO_2 respiration. Reduced forest foliage naturally caused less CO_2 to be absorbed by leaves, less sequestration of CO_2 in the soil, and therefore reduced respiration of CO_2 from the soil at night.

Figure 3 Radiation

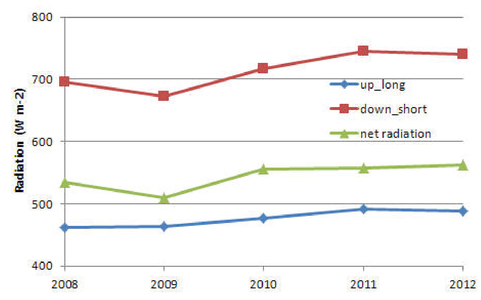


Figure 4 Heat Fluxes

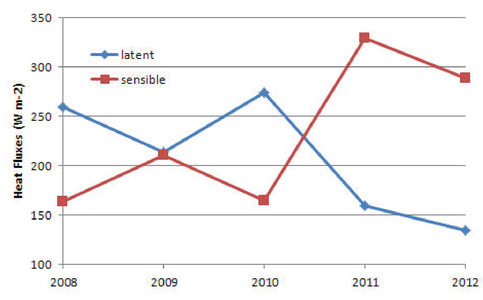
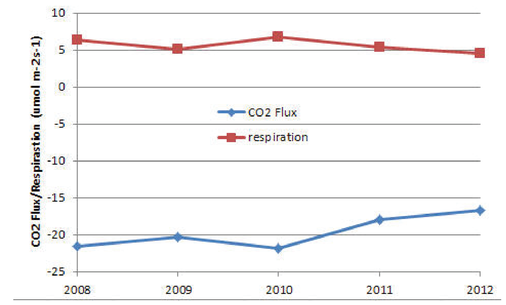


Figure 5 CO_2 Flux



SUMMARY

A dramatic trend in reduced precipitation and therefore increased drought has caused stress and disease in the oak trees of Okmulgee Forest. Effects of the resultant reduced forest foliage are seen in several ARM measurements, including reduced evapotranspiration, increased forest temperature, and reduced sequestration of CO_2. The implications for local and regional climate change may be significant, should these trends continue and/or worsen and the effects spread through adjacent forests.

ARM CLIMATE RESEARCH FACILITY

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