Ecosystem and Soil Moisture Controls on Flash Drought Development

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Co-Authors, Collaborators, Contributors

- Jason Otkin, Hayden Mayhan, Rajen Bajgain, Xiangming Xiao
- John Pruger, Lynn McKee (Flux Tower)
- NOAA Climate Program Office's Sectoral Applications Research Program (SARP) grant NA130AR4310122
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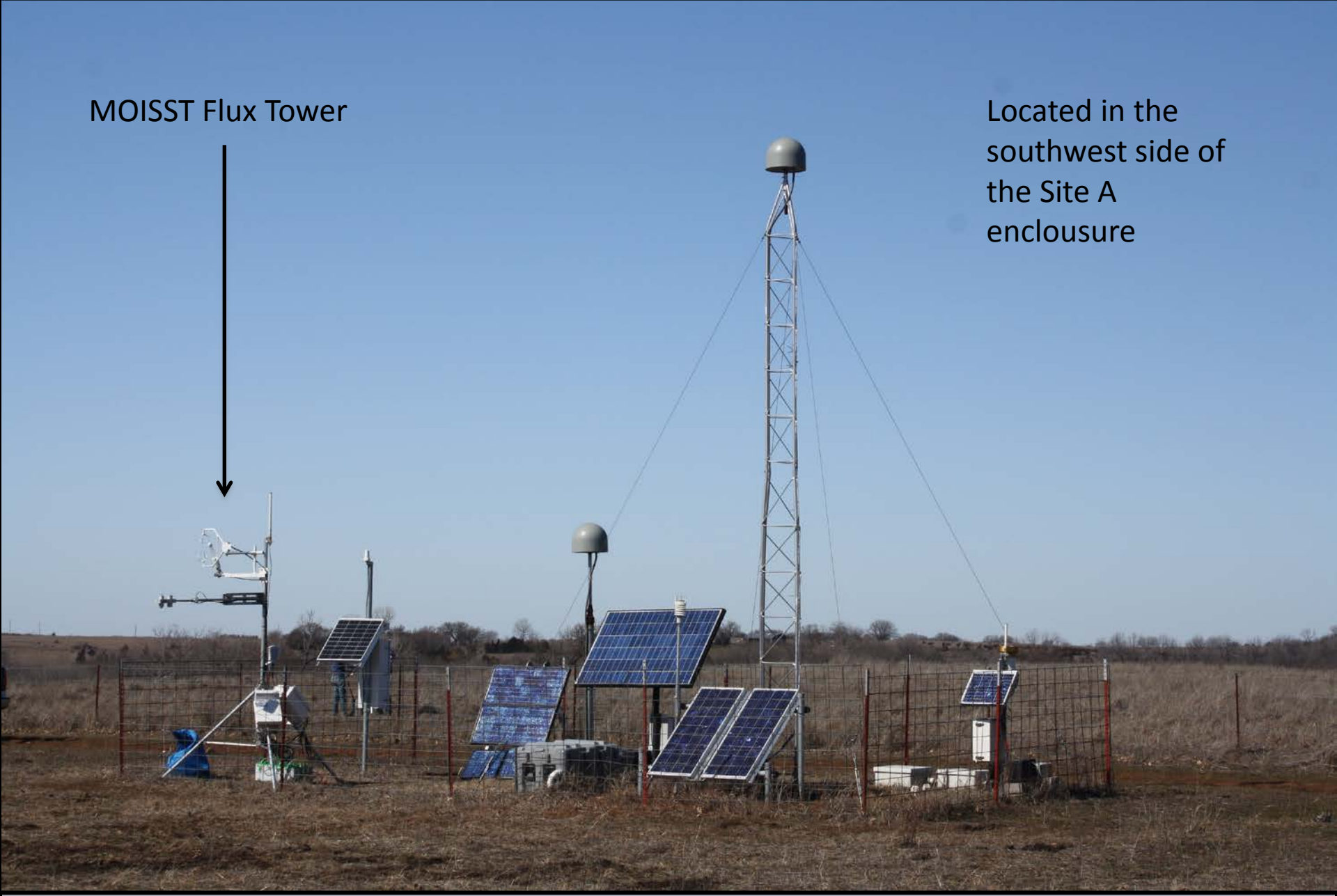


Jeffrey B. Basara, University of Oklahoma, Norman, OK
Lynn McKee, USDA, Beltsville, MD
John Prueger, USDA, Ames, IA

Deployed 7 November 2012

MOISST Flux Tower Looking Northwest

Campbell Scientific CSAT 3 3-D sonic anemometer

Licor 7500 CO_2 and H_2O Open Path System

CNR1 4-component net radiometer

Apogee Infrared Temperature Sensor

Vaisala HMP45C air temperature/humidity sensor

Hydra Probe soil moisture sensor.

REBS soil heat flux plates (3)

PhenoCam -

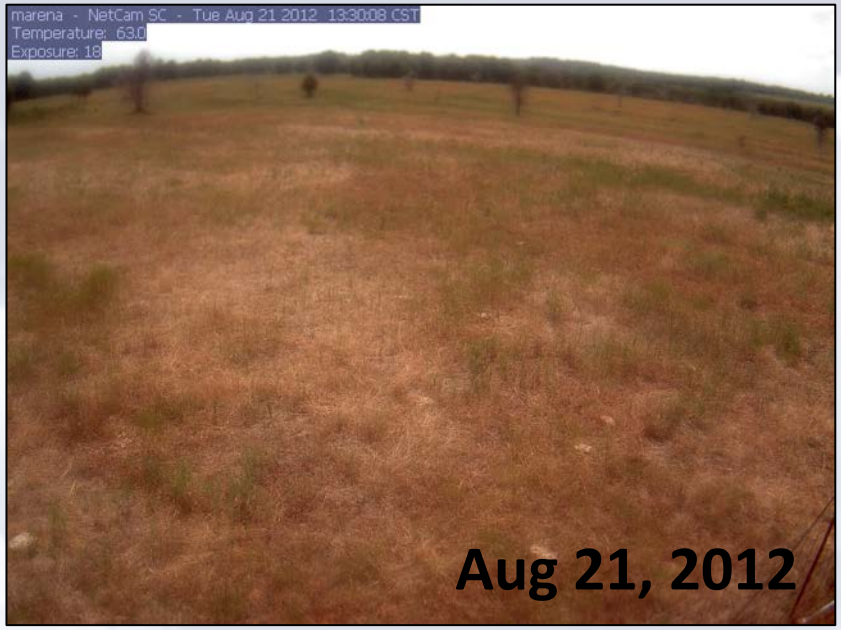
provides automated, near-surface remote sensing of canopy phenology.

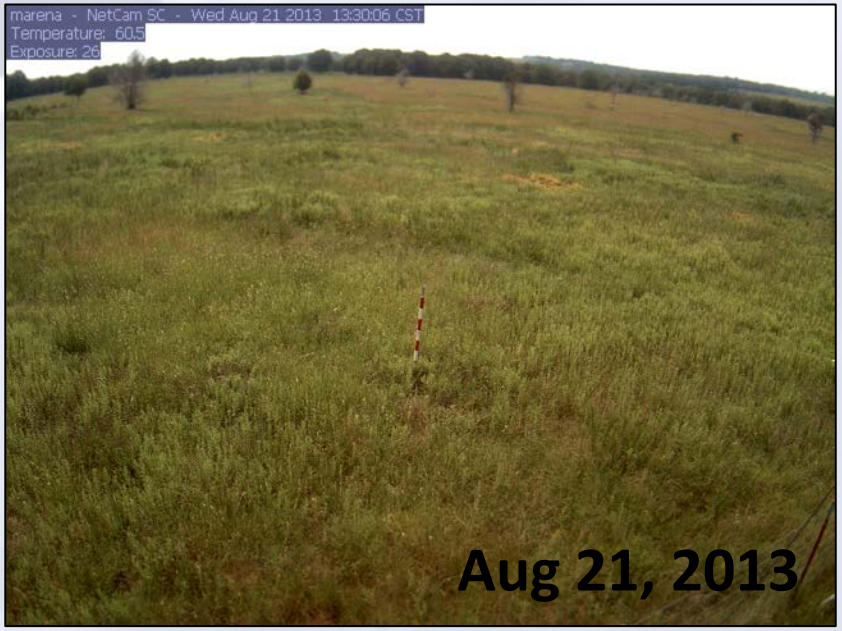
Vegetation Change at MOISST During 2012

July 1, 2012

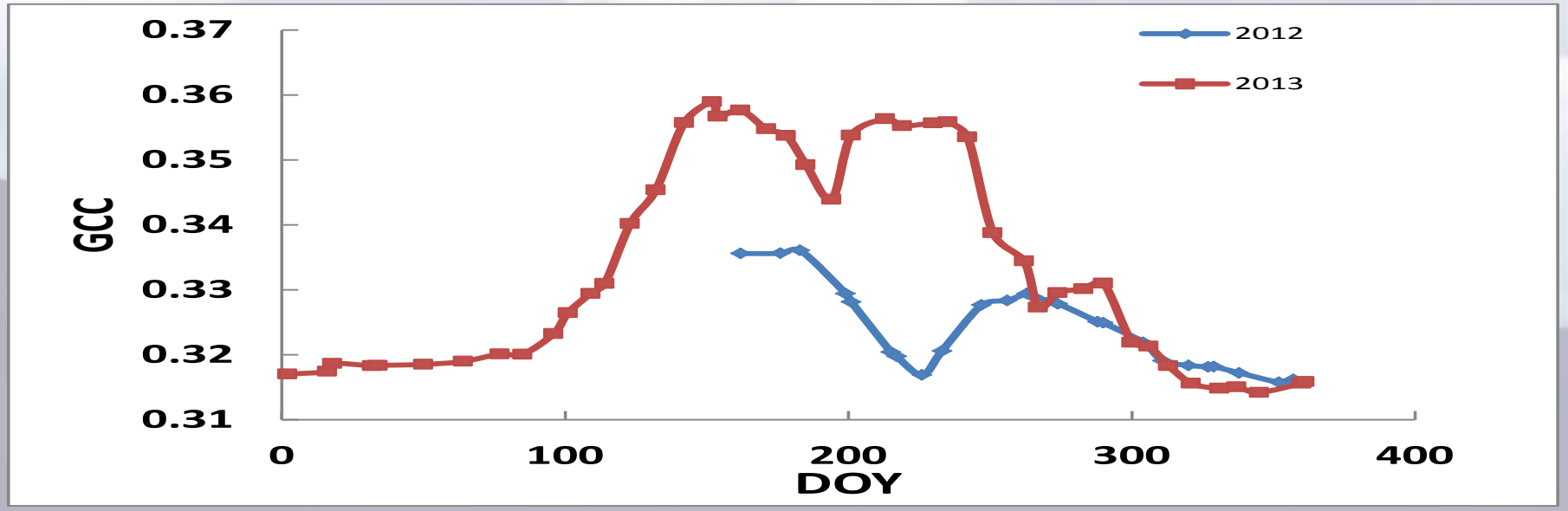
August 13, 2012

PhenoCam Observations

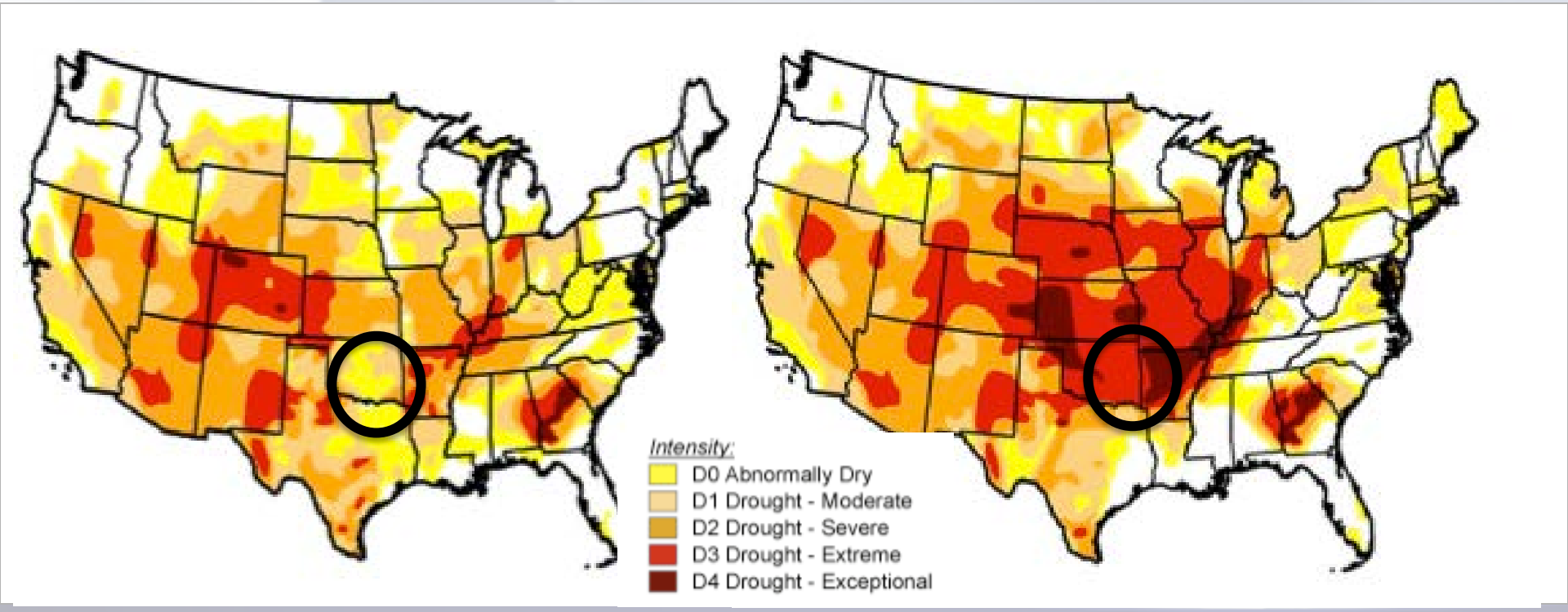




Seasonality of Green Chromatic Coordinate [GCC= G/(R+G+B)]

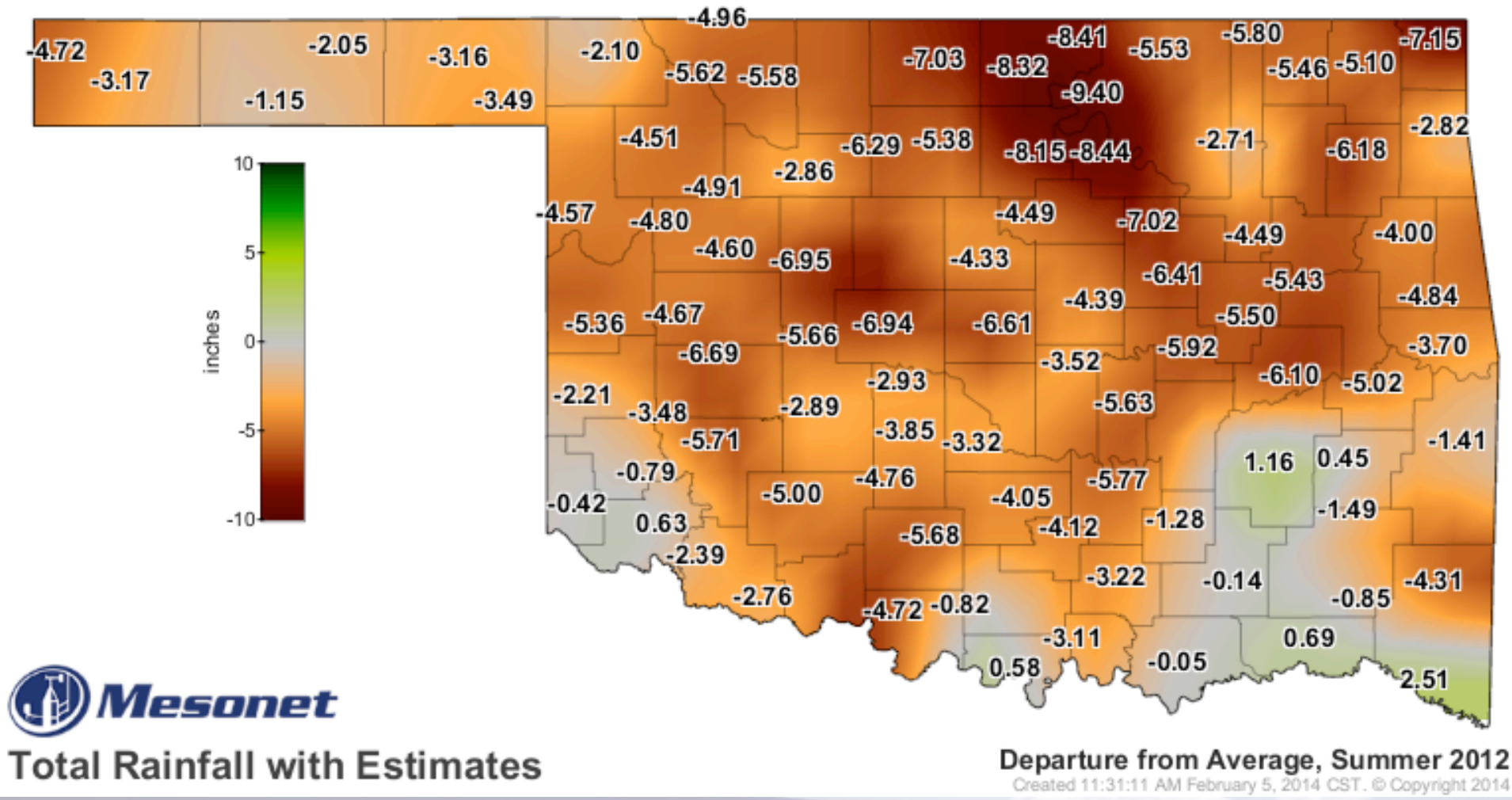


Flash Drought Development During 2012

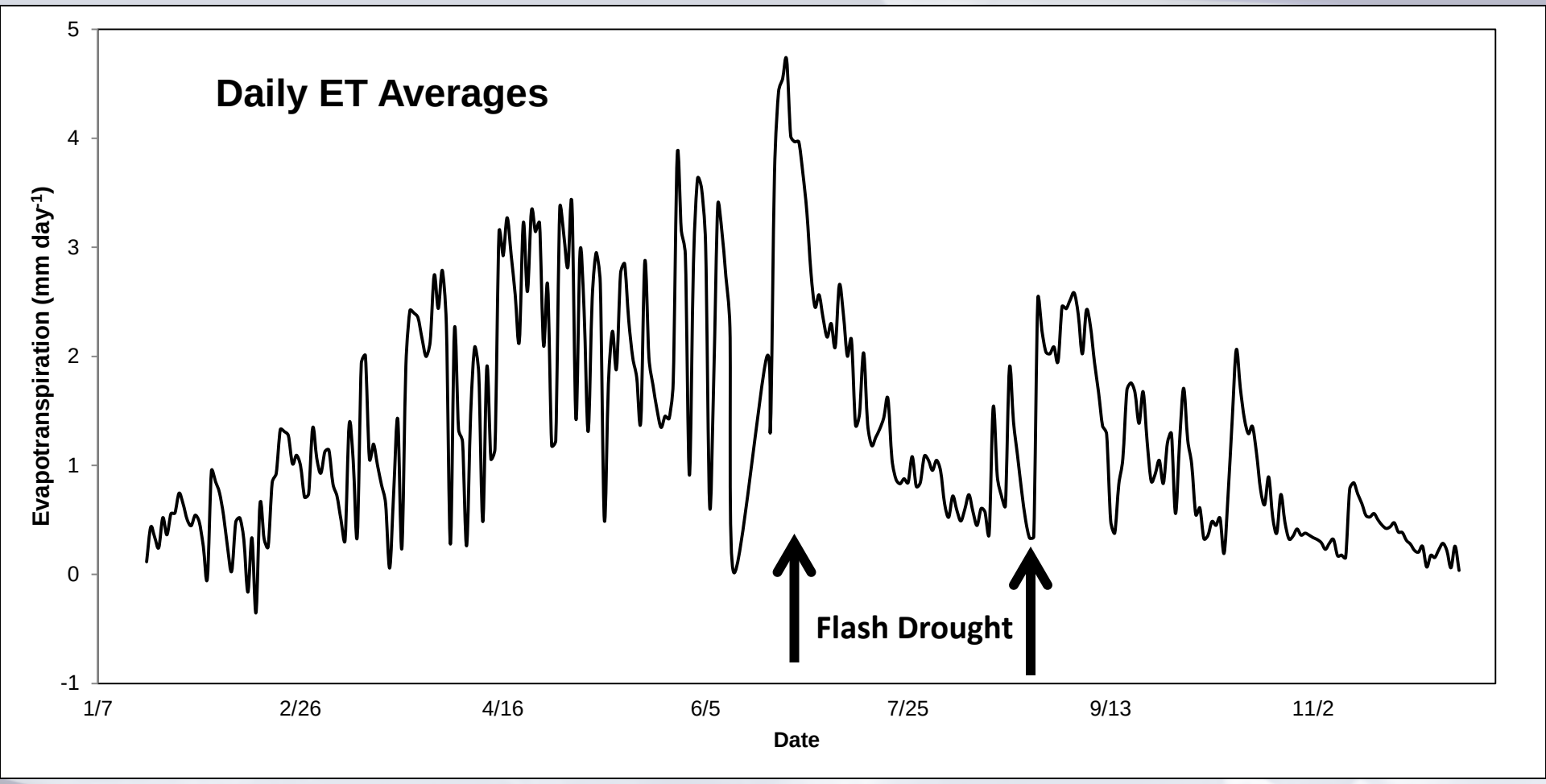


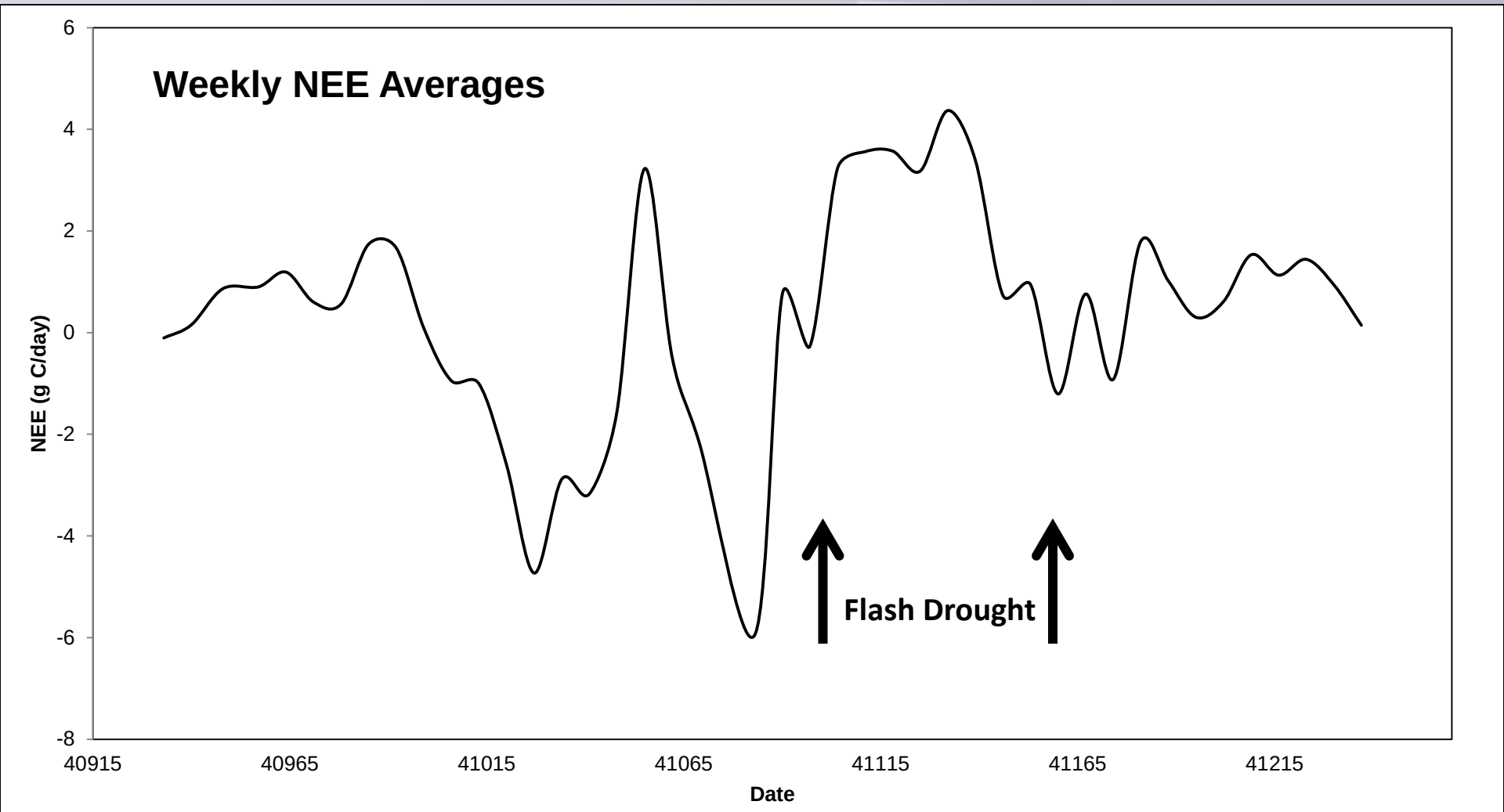
July 3, 2012

August 7, 2012



Departure From Normal Precipitation
Summer 2013


Daily ET Averages
Evapotranspiration (mm day-1)
5
4
3
2
1
0
-1
1/7
2/26
4/16
6/5
7/25
9/13
11/2
Date
Flash Drought


Weekly NEE Averages
NEE (g C/day)
6
4
2
0
-2
-4
-6
-8
40915
40965
41015
41065
41115
41165
41215
Date
Flash Drought

SPECIAL
Advances in Drought Monitoring
COLLECTION

Examining Rapid Onset Drought Development Using the Thermal Infrared–Based Evaporative Stress Index

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# *Earth System Interdisciplinary Center, University of Maryland, College Park, College Park, Maryland*
@ *School of Meteorology, and Oklahoma Climatological Survey, University of Oklahoma, Norman, Oklahoma*
& *National Drought Mitigation Center, University of Nebraska–Lincoln, Lincoln, Nebraska*

(Manuscript received 2 October 2012, in final form 11 April 2013)

ABSTRACT

Reliable indicators of rapid drought onset can help to improve the effectiveness of drought early warning systems. In this study, the evaporative stress index (ESI), which uses remotely sensed thermal infrared imagery to estimate evapotranspiration (ET), is compared to drought classifications in the U.S. Drought Monitor (USDM) and standard precipitation-based drought indicators for several cases of rapid drought development that have occurred across the United States in recent years. Analysis of meteorological time series from the North American Regional Reanalysis indicates that these events are typically characterized by warm air temperature and low cloud cover anomalies, often with high winds and dewpoint depressions that serve to hasten evaporative depletion of soil moisture reserves. Standardized change anomalies depicting the rate at which various multiweek ESI composites changed over different time intervals are computed to more easily identify areas experiencing rapid changes in ET. Overall, the results demonstrate that ESI change anomalies can provide early warning of incipient drought impacts on agricultural systems, as indicated in crop condition reports collected by the National Agricultural Statistics Service. In each case examined, large negative change anomalies indicative of rapidly drying conditions were either coincident with the introduction of drought in the USDM or lead the USDM drought depiction by several weeks, depending on which ESI composite and time-differencing interval was used. Incorporation of the ESI as a data layer used in the construction of the USDM may improve timely depictions of moisture conditions and vegetation stress associated with flash drought events.

1. Introduction

Drought conditions can adversely affect the health of native vegetation and agricultural crops if the abnormal dryness persists for an extended period of time or if it occurs at a sensitive stage of crop development. Nonirrigated agricultural lands are especially vulnerable to drought on both short and long time scales because they depend on receiving adequate rainfall throughout the growing season (Kogan 1997). Depending on its severity and timing, drought can result in significant yield loss, with impacts on both local and global economies signified through reduced economic output and higher grain and food prices. Long-term drought may lead to lower reservoir levels and depleted groundwater levels that could also limit the productivity of irrigated cropland because of water shortages and smaller water allocations.

Although drought is often thought of as a slowly developing climate phenomenon that can take several months or even years to reach its maximum intensity, drought onset can be very rapid if extreme atmospheric

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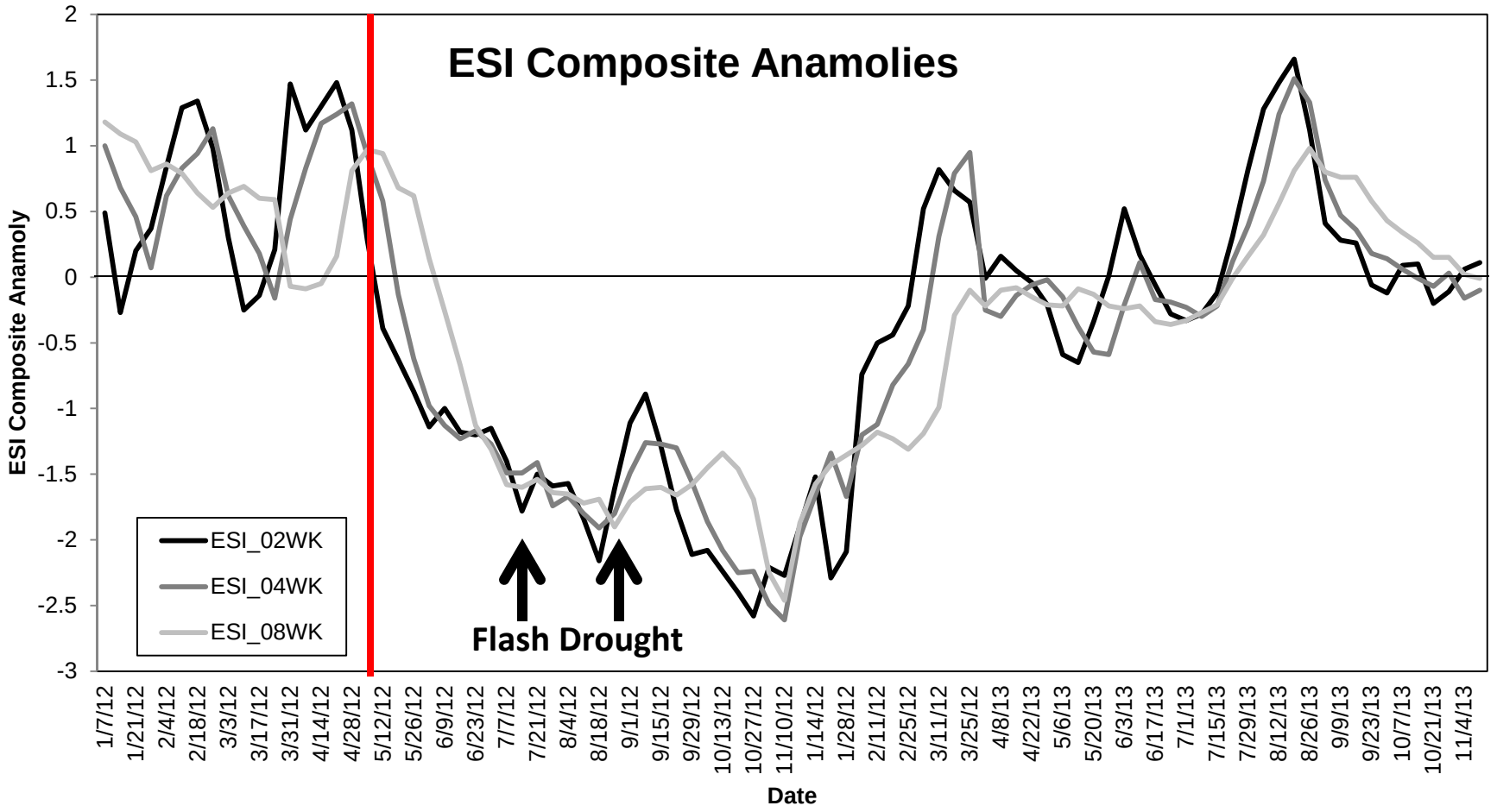
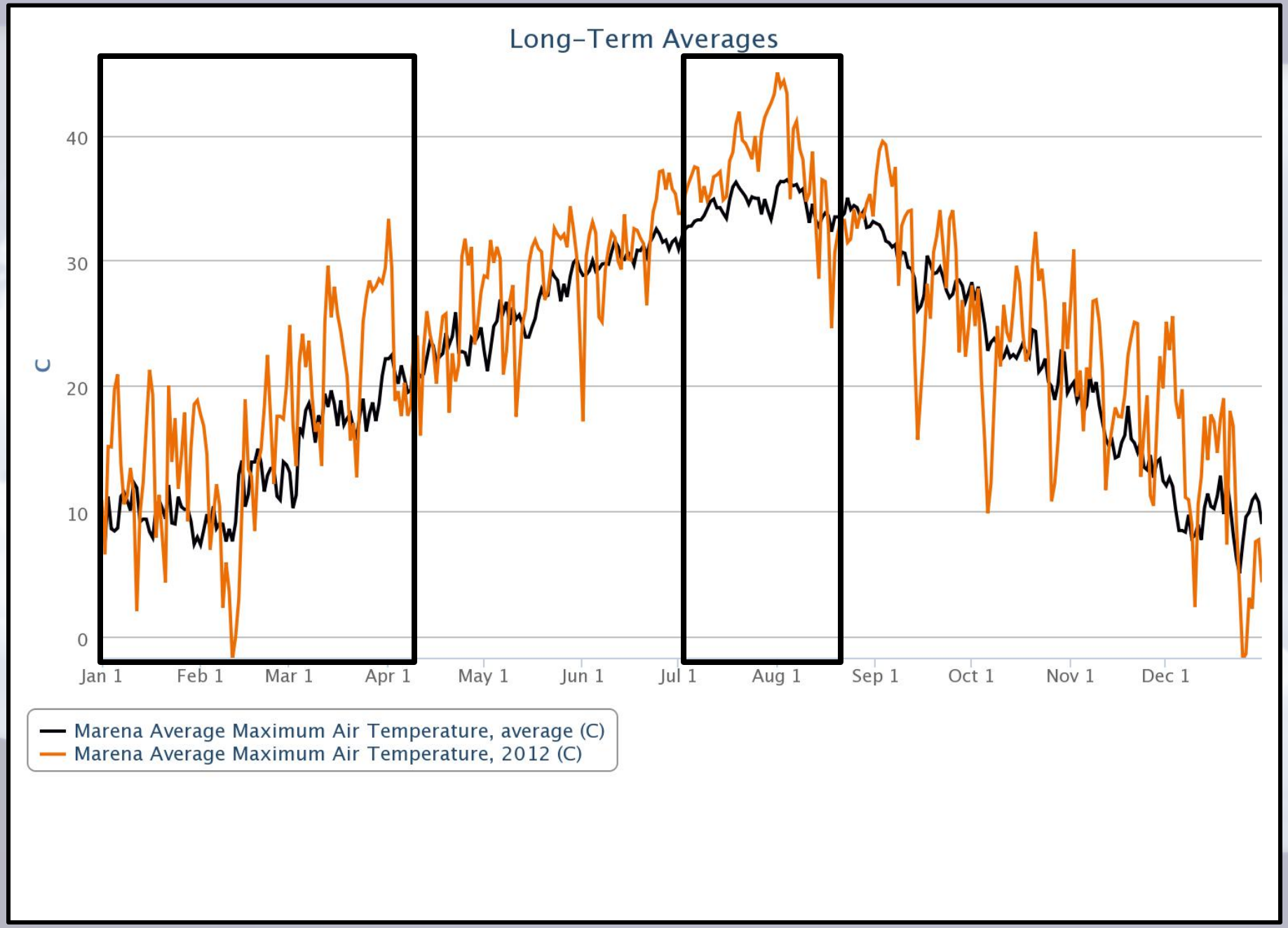
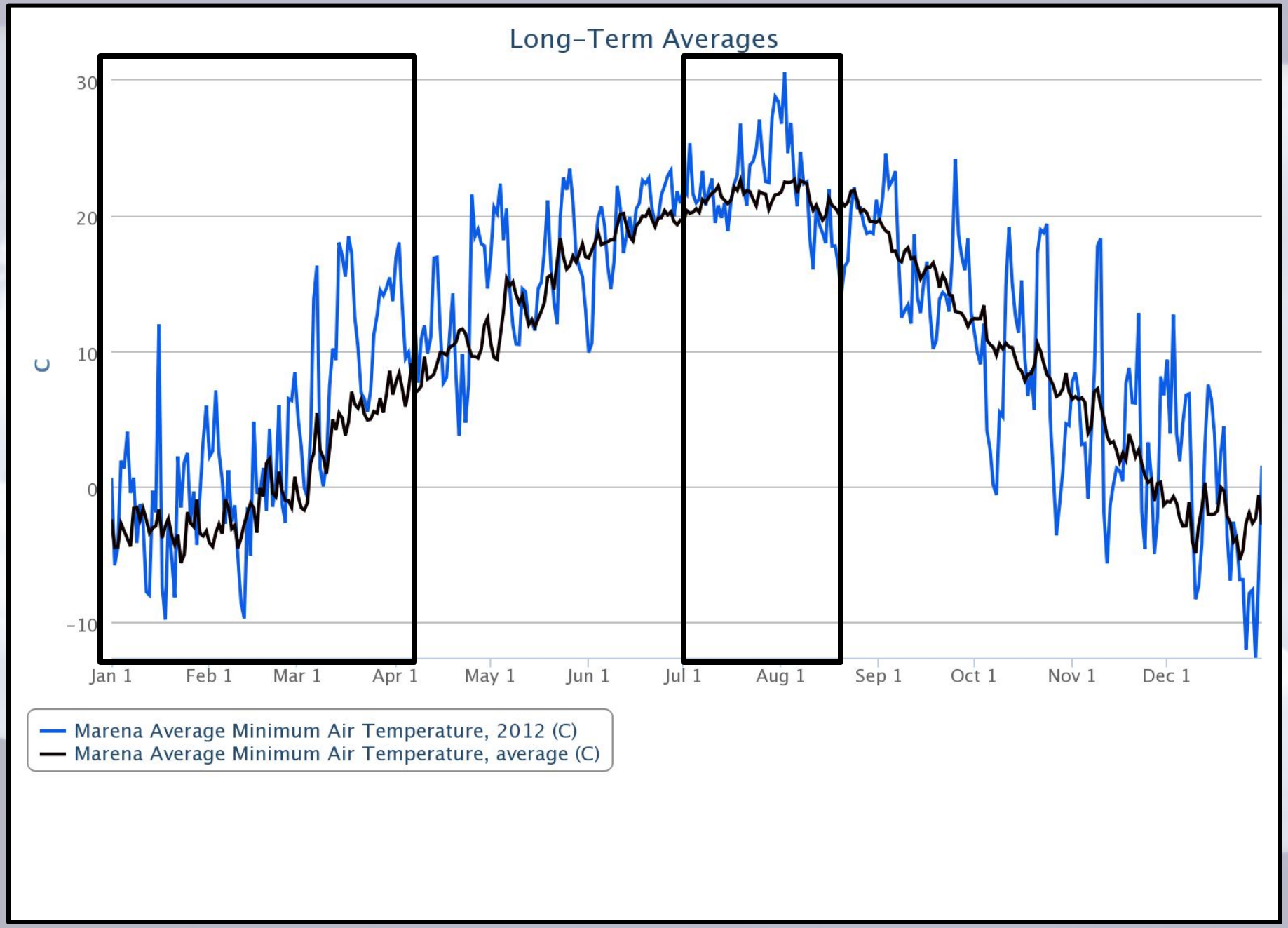


Anomalies of ESI During the Flash Drought of 2012 at MARE/MOISST



Maximum Temperature Values at MARE (2012) Versus Climatology



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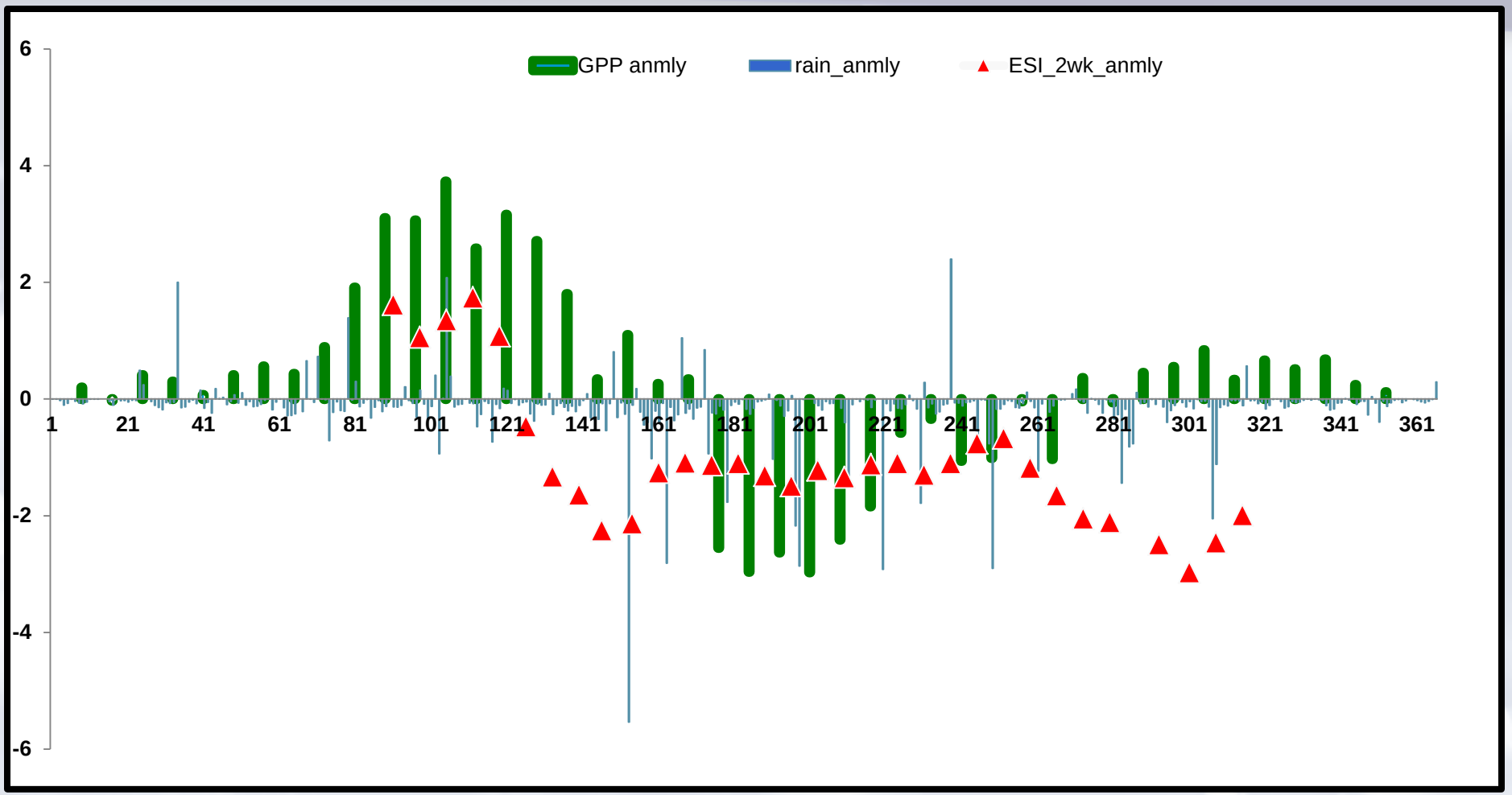
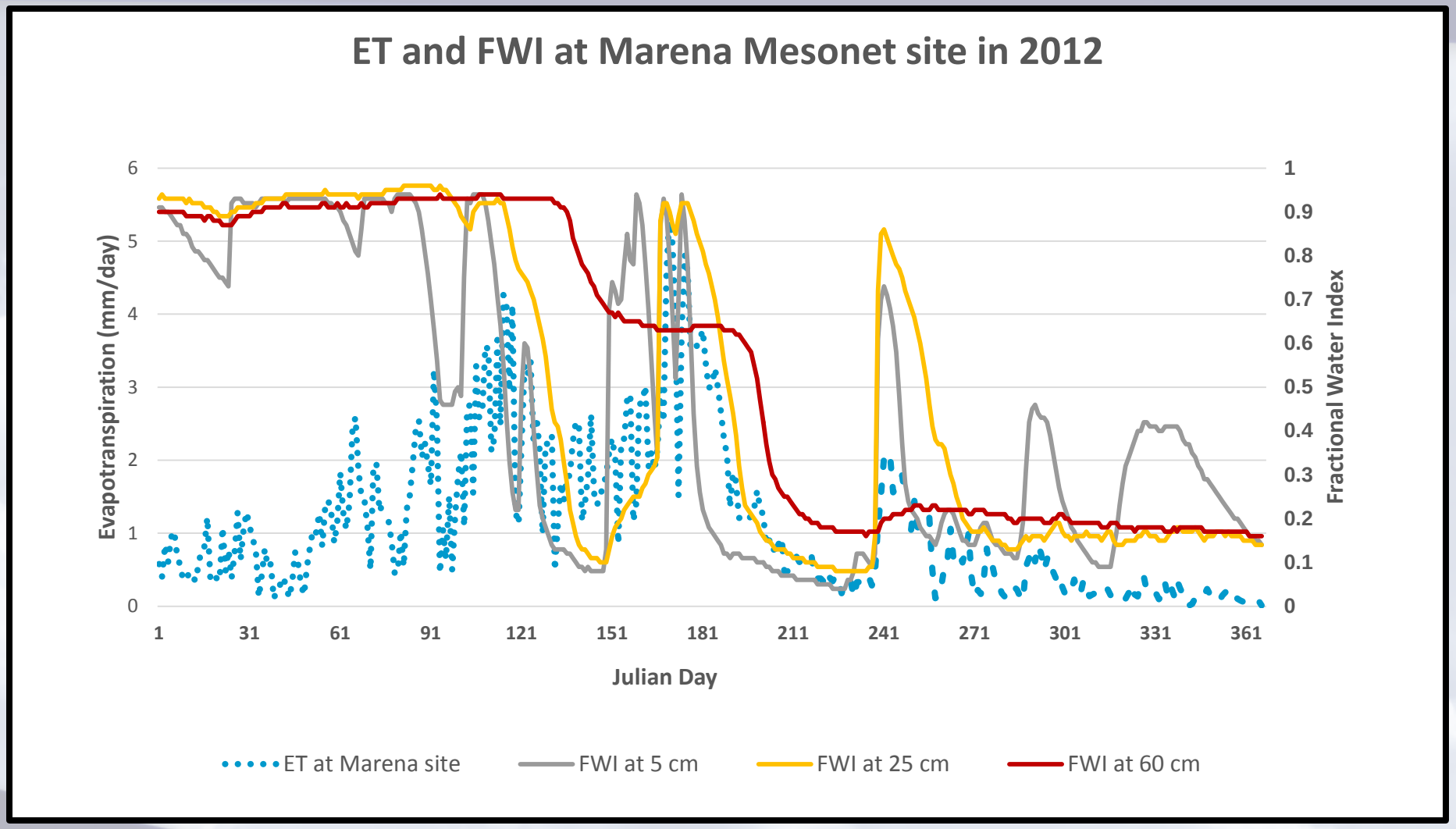


Anomalies of MODIS Derived Gross Primary Production, Rainfall Anomalies (mm/day), and ESI During the Flash Drought of 2012 at MARE/MOISST



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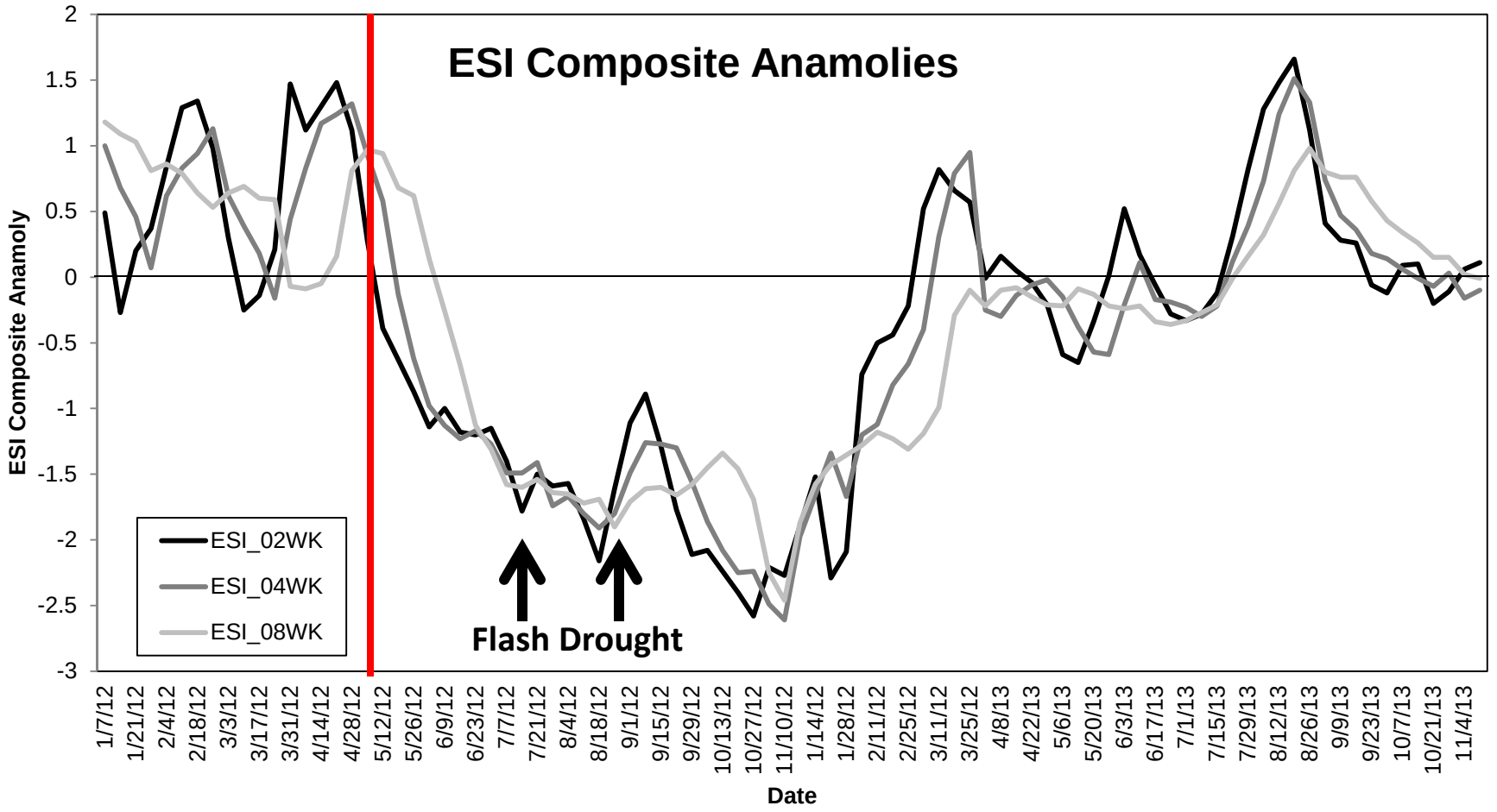

Anomalies of ESI During the Flash Drought of 2012 at MARE/MOISST

Concluding Thoughts

- During 2012, the warm, extended growing season led to a rapid, vigorous greenup at the site.
- As atmospheric demand increased, vegetation stress increased and soil moisture was drawn quickly from the soil to support the biomass.
- Once the soil moisture was depleted, the ecosystem collapsed.
- Without ET, the thermal anomaly increased resulting in a significant heatwave that further exacerbated the conditions.

How an Ecosystem Commits Suicide in 45 Days or Less

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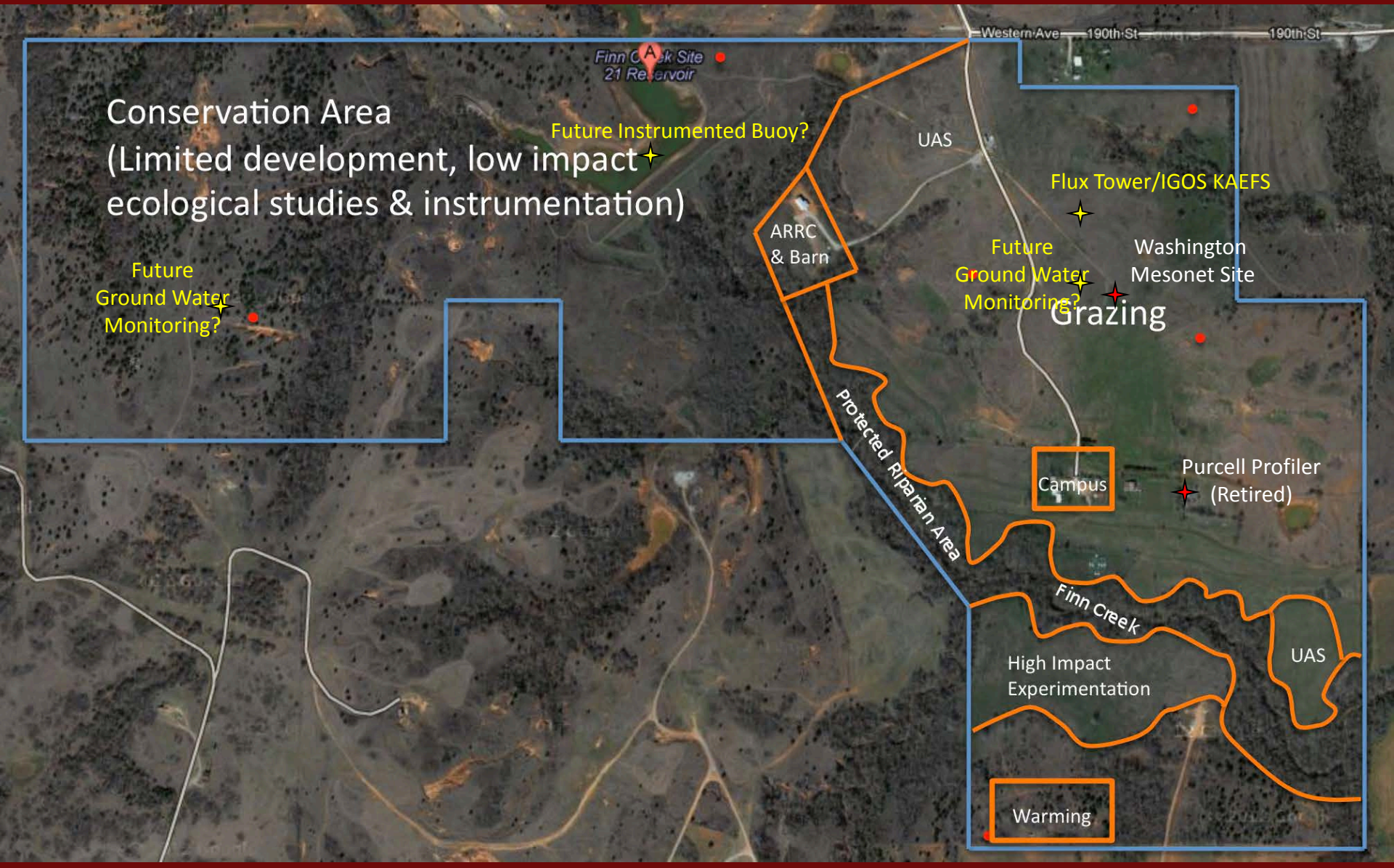
The Kessler Atmospheric and Ecological Field Station (KAEFS)

- ~400 acres south-southwest of Washington, OK
- 14.5 miles south-southwest of the National Weather Center
- Official member of the Organization of Biological Field Stations
- Administered by the Vice President of Research Office at the University of Oklahoma
- Staff:
  - Jeffrey Basara, Director
  - Ben Dixon, Facilities Manager
  - Meghan Conway, Student Assistant
- In “operation” for ~10 years
- Past Directors include Dr. Linda Wallace and Dr. Phil Gibson


NWC
Blanchard
Goldsby
Noble
Cole
Slaughterville
Washington
Dibble
McClain
Purcell
KAEFS


Western Ave
190th St
190th St
Finn Creek Site
21 Reservoir
Conservation Area
(Limited development, low impact
ecological studies & instrumentation)
Future Instrumented Buoy?
UAS
Flux Tower/IGOS KAEFS
ARRC
& Barn
Future
Ground Water
Monitoring?
Future
Ground Water
Monitoring?
Washington
Mesonet Site
Grazing
Protected Riparian Area
Campus
Purcell Profiler
(Retired)
Finn Creek
High Impact
Experimentation
UAS
Warming

Questions?