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Improving Assessment and Monitoring of Droughts in Grasslands

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Summary

Grasslands in the Southern Great Plains of the United States have experienced various degrees of droughts over years and substantial economic losses occurred to many ranchers under severe drought conditions. Since 2013 we set up integrated grassland observation sites (iGOS) to track the land-atmosphere interactions at ecosystem and landscape scales. We also analyze time series satellite images in an effort to develop novel, simple and robust algorithms that better characterize and monitor the impacts of severe drought on grasslands.

1. Integrated Grassland Observation Sites (iGOS)

We established two iGOS sites: (1) native tall grass prairie and (2) improved pastureland at El Reno, Oklahoma, USA.

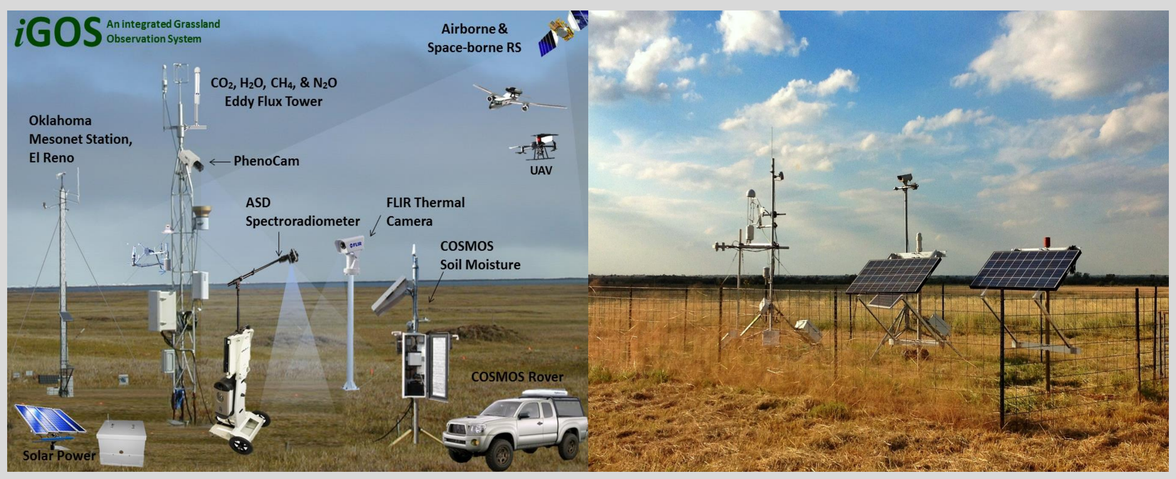

Fig. 1. Left: the schematic vision of Integrated Grassland Observation Site, and Right: flux tower system installed in El Reno, OK, USA. Each site is equipped with an Eddy covariance system for measuring fluxes, a PhenoCam to track vegetation phenology, and a COSMOS instrument to measure integrated soil moisture at the landscape scale.

2. Sensitivity of Vegetation Indices, GPP and ET to Drought

At present, assessment and monitoring of agricultural droughts rely heavily on normalized difference vegetation index (NDVI). We examined the impacts of drought on three vegetation indices: (1) NDVI, related to leaf area index, (2) enhanced vegetation index (EVI), related to chlorophyll, and (3) land surface water index (LSWI), related to canopy water content, as well as CO_2 and evapotranspiration fluxes from several grasslands (Wagle et al., 2014). We analyzed these vegetation index data from MODIS images in 2000-2014.

- ❖ Our results showed that EVI and LSWI were more sensitive to drought than was NDVI.
- ❖ Gross primary production (GPP) was more sensitive to drought than were vegetation indices.
- ❖ A modified water scalar function, calculated as a function of LSWI, helped to account for the rapid decline in GPP during severe droughts and improved the performance of satellite-based Vegetation Photosynthesis Model (VPM).

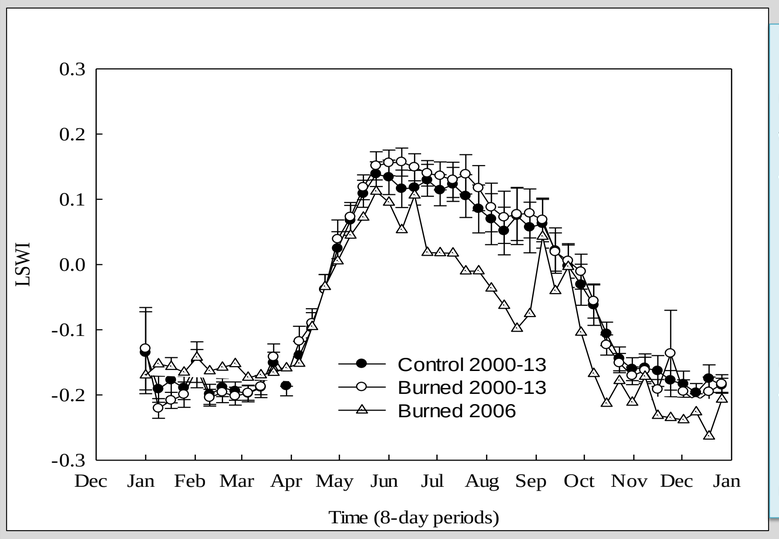

Fig. 2. Seasonal evolution of MODIS land surface water index (LSWI) at two tallgrass prairie sites in El Reno, OK, USA. LSWI values dropped below zero during the active growing season in the drought year, showing its potential to track drought.

3. Algorithms to track drought duration and severity

Algorithm development

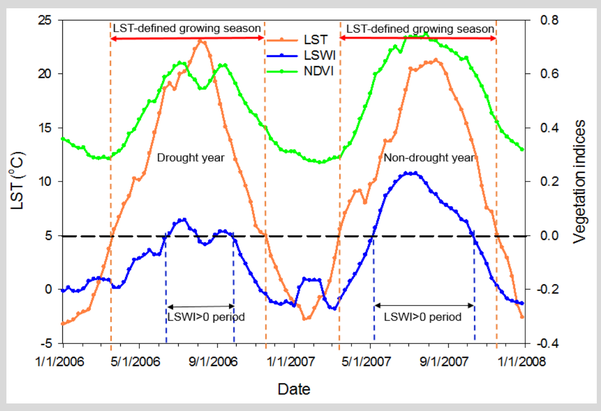

Fig. 3. Seasonal dynamics of temperature (LST), LSWI, and NDVI in drought year (2006) and non-drought year (2007) at grassland site in OK, based on MODIS images at 8-day and 500-m resolutions.

Drought duration

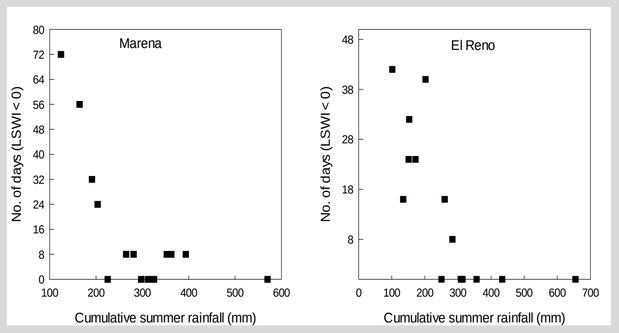

Fig. 4. Relationship between drought duration (number of days) and rainfall during summer (June-August) at grassland sites in OK, USA.

Drought severity

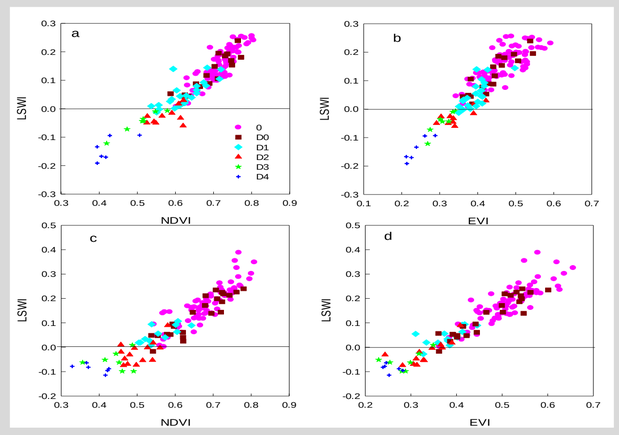

Fig. 5. Relationship between our drought severity (LSWI) and the drought severity categories provided by the US Drought Monitor at two grassland sites in OK, USA for June – August in 2000-2013.

4. Regional mapping of drought duration and severity

We use the LSWI-based drought algorithms and MODIS images in 2000-2014 to map drought duration and severity in the Southern Great Plains, USA over years.

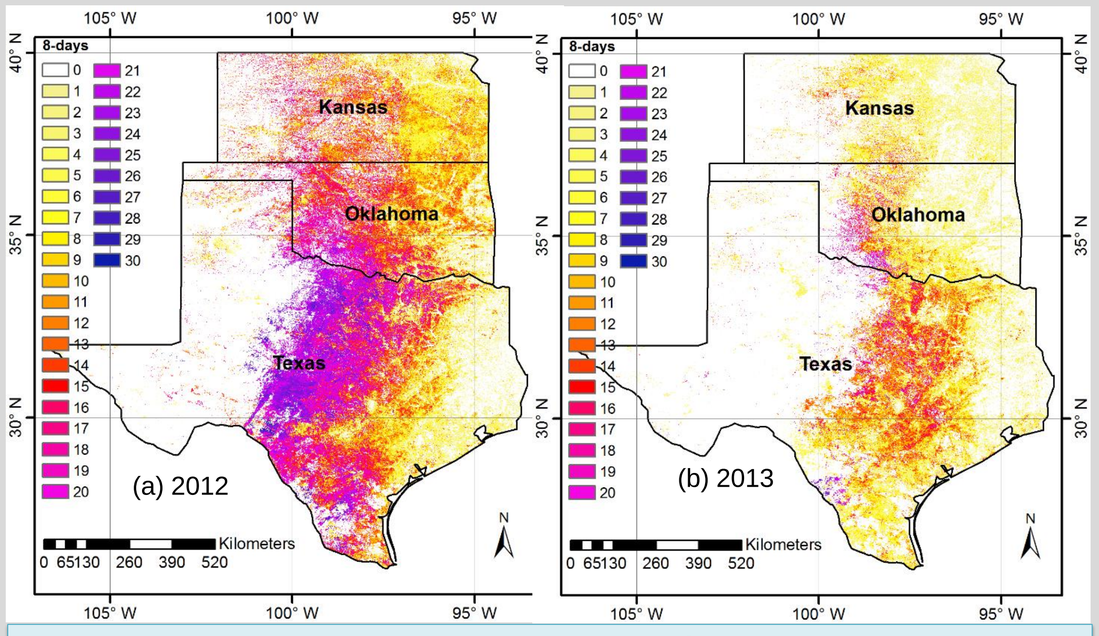

Fig. 6. Maps of drought duration for grasslands in the Southern Great Plains in 2012 and 2013. Numbers in the legend indicate drought duration (defined as number of 8-day periods with LSWI<0 during the growing season). 2012 was a severe drought year, and 2013 was a wet year.

References

Wagle, et al., (2014). Sensitivity of vegetation indices and gross primary production of tallgrass prairie to severe drought. *Remote Sensing of Environment.* 152: 1-14.

Acknowledgement

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