Flash Droughts: Their Characteristics and A Proposed Definition

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Primary Drought Types

- A unified definition of drought is difficult to obtain
    - Meteorological drought − precipitation deficits
    - Agricultural drought − soil moisture impacts on vegetation
    - Hydrological drought − surface and ground water deficits
    - Socioeconomic drought − impacts on availability of goods
    - Ecological drought − impacts on natural ecosystems
- A feature common to all droughts is below normal precipitation either locally or at a remote distance (such as mountain snowpack)
- Other factors (high temperatures, sunny skies, strong winds, large vapor pressure deficits) increase drought severity and its rate of intensification

Flash Drought – Another Drought Type?

- Drought is usually thought of as being a slowly-developing climate phenomenon; however, its onset can actually be very rapid

- Rapid drought development is most likely to occur if extreme weather anomalies remain over the same area for several weeks or more

    - Below normal rainfall, hot temperatures, strong winds, low humidity, and sunny skies can lead to rapid drawdown in root zone soil moisture

    - This can lead to the rapid emergence of agricultural and ecological drought conditions even when rainfall departures are not large

- A very intense drought that develops quickly can have an impact similar to or worse than a slower-developing but longer-lasting event

    - Less time to prepare for drought when it develops quickly

Flash Drought – Another Drought Type?

- The term "flash drought" was first coined by Mark Svoboda in 2000 to describe a drought event that developed very rapidly that year

- Its use increased greatly in 2011 and 2012 in response to two drought events that developed very rapidly across the central U.S.

- Despite its widespread use, a formal definition currently does not exist

- Two approaches have been used to identify "flash droughts"

    - Unusually rapid rate of intensification

    - Implicit focus on short duration

- Conflicting approaches introduce ambiguity that affects our ability to detect their onset, monitor their development, and understand the mechanisms that control their evolution

Flash Drought – Proposed Definition

- Based on flash drought review paper by Otkin et al. (2018, BAMS)

- Any definition for "flash drought" should inherently account for its rapid development and the actual occurrence of moisture limitation

- Propose that flash droughts should be viewed as a subset of all droughts that are distinguished solely by their rapid rate of intensification

- This definition can be seamlessly applied to all drought types

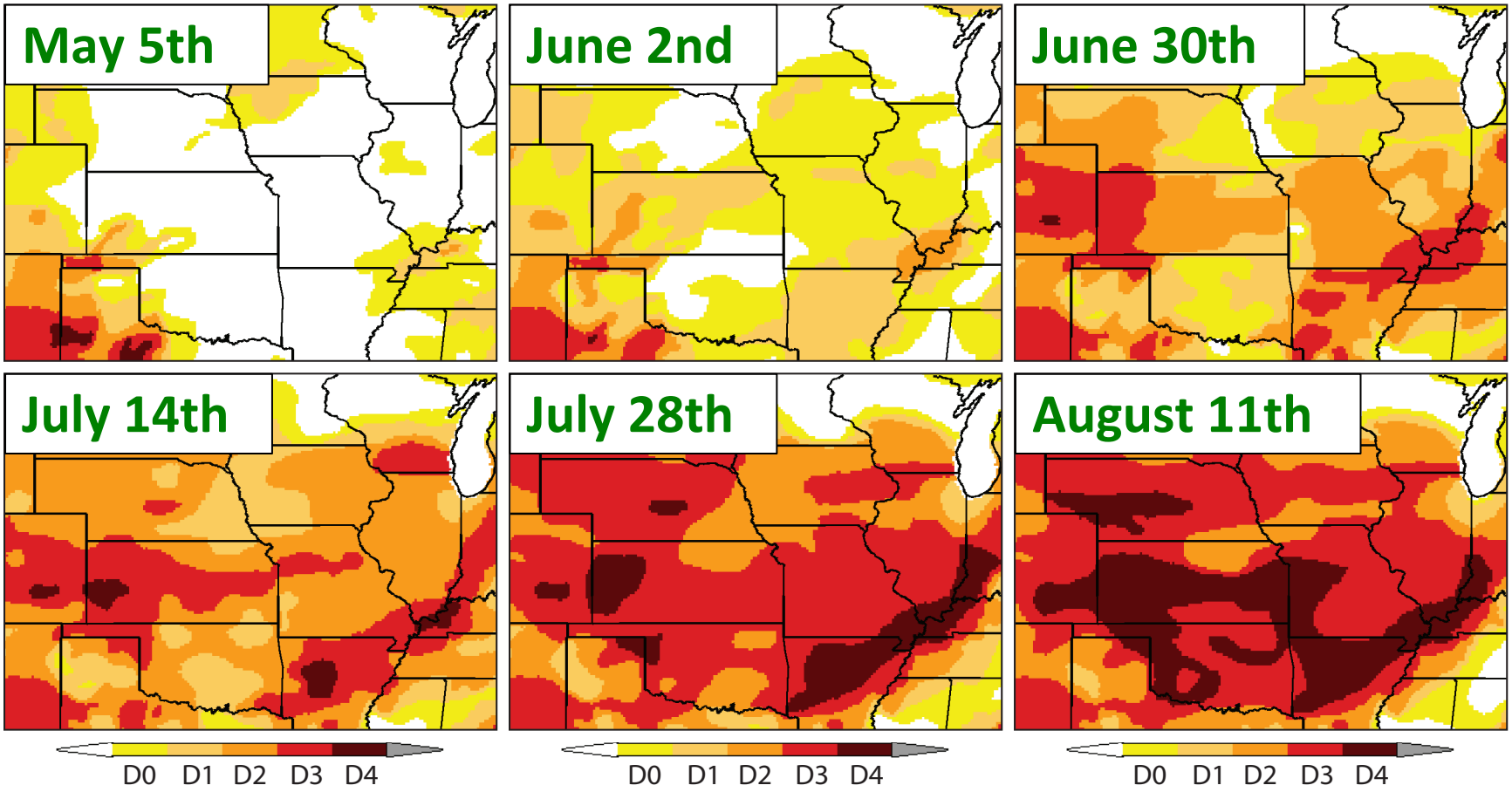
- **Proposed definition has two basic requirements:**

    - A given drought index must change much more rapidly than normal (e.g., the "flash" part of the definition)

    - Drought index must fall below the 20th percentile (e.g., "drought")

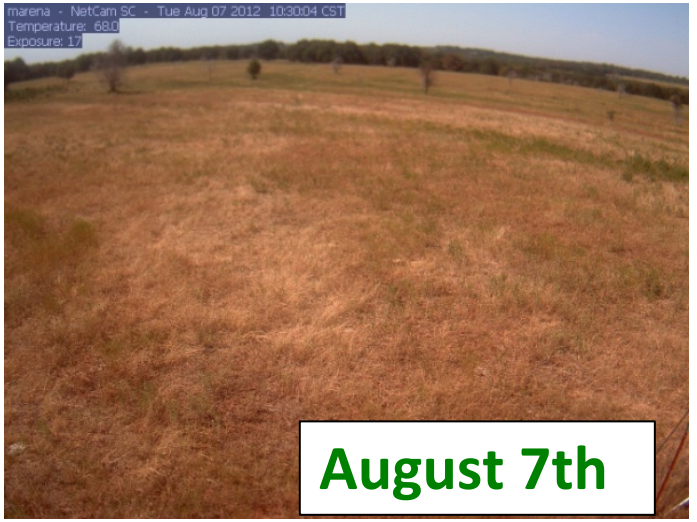
- Definition excludes short periods of anomalous conditions that do not lead to drought impacts

What Does Flash Drought Look Like?

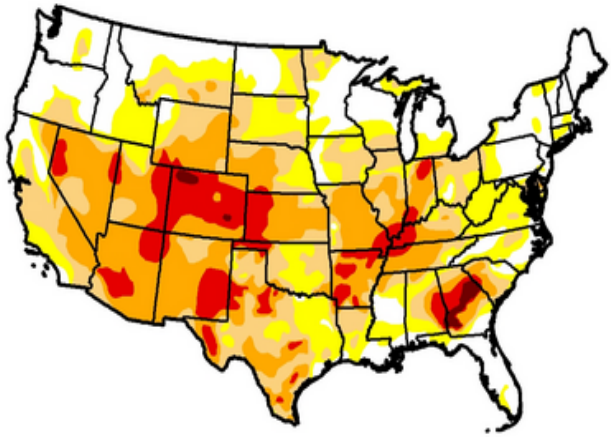


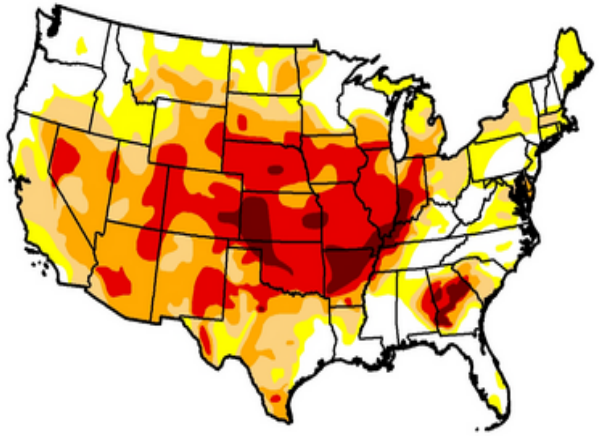
• During 2012, the U.S. Drought Monitor indicated that extreme drought conditions (D2-D4) rapidly developed across the central U.S. in response to extreme heat and dry weather

What Does Flash Drought Look Like?



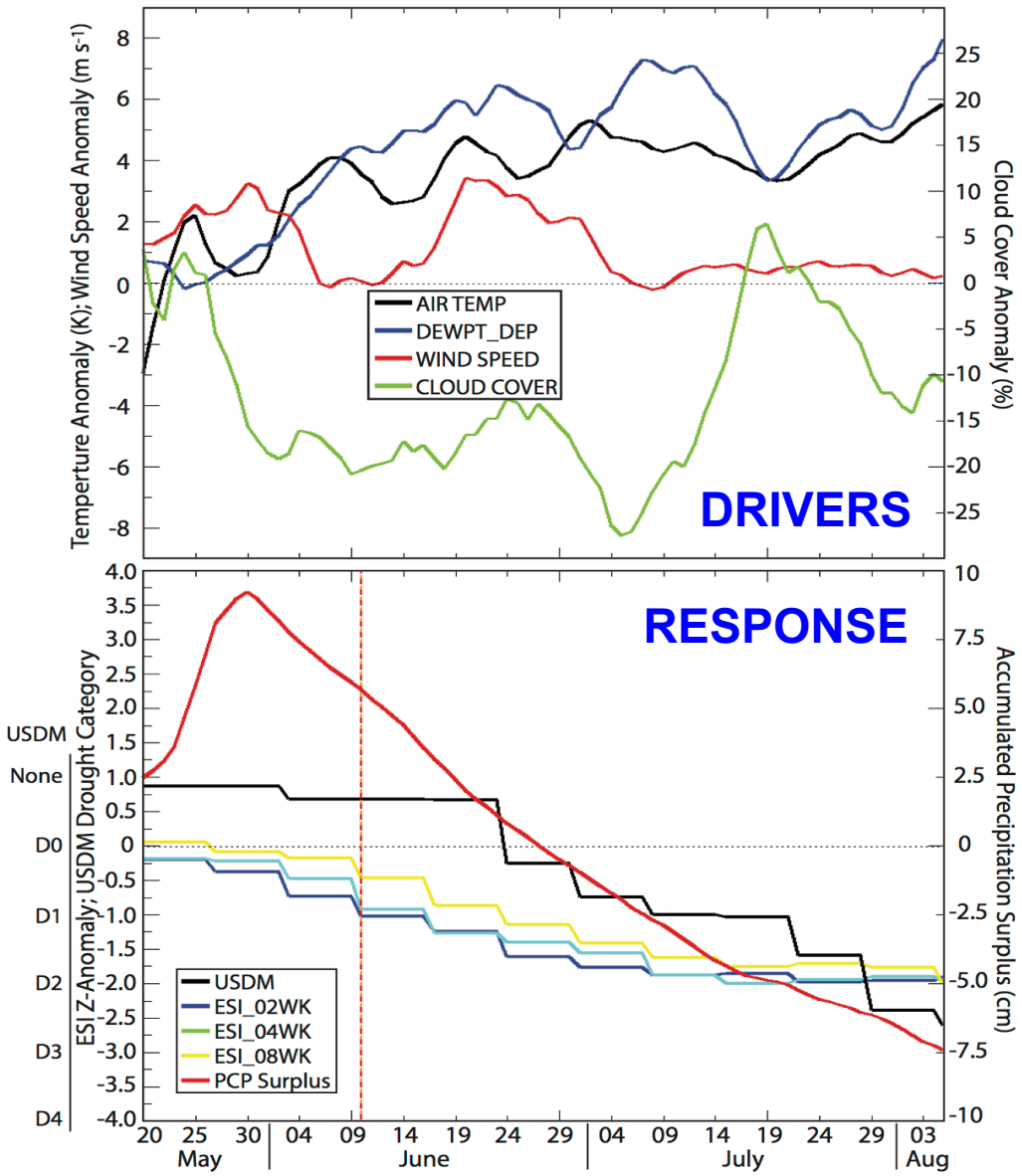
Images from 2012; courtesy of Jeff Basara (OU)





- Phenocam images from the Marena, OK mesonet site
- Vegetation rapidly went into dormancy as drought intensified

2011 Flash Drought Example – OK & AR



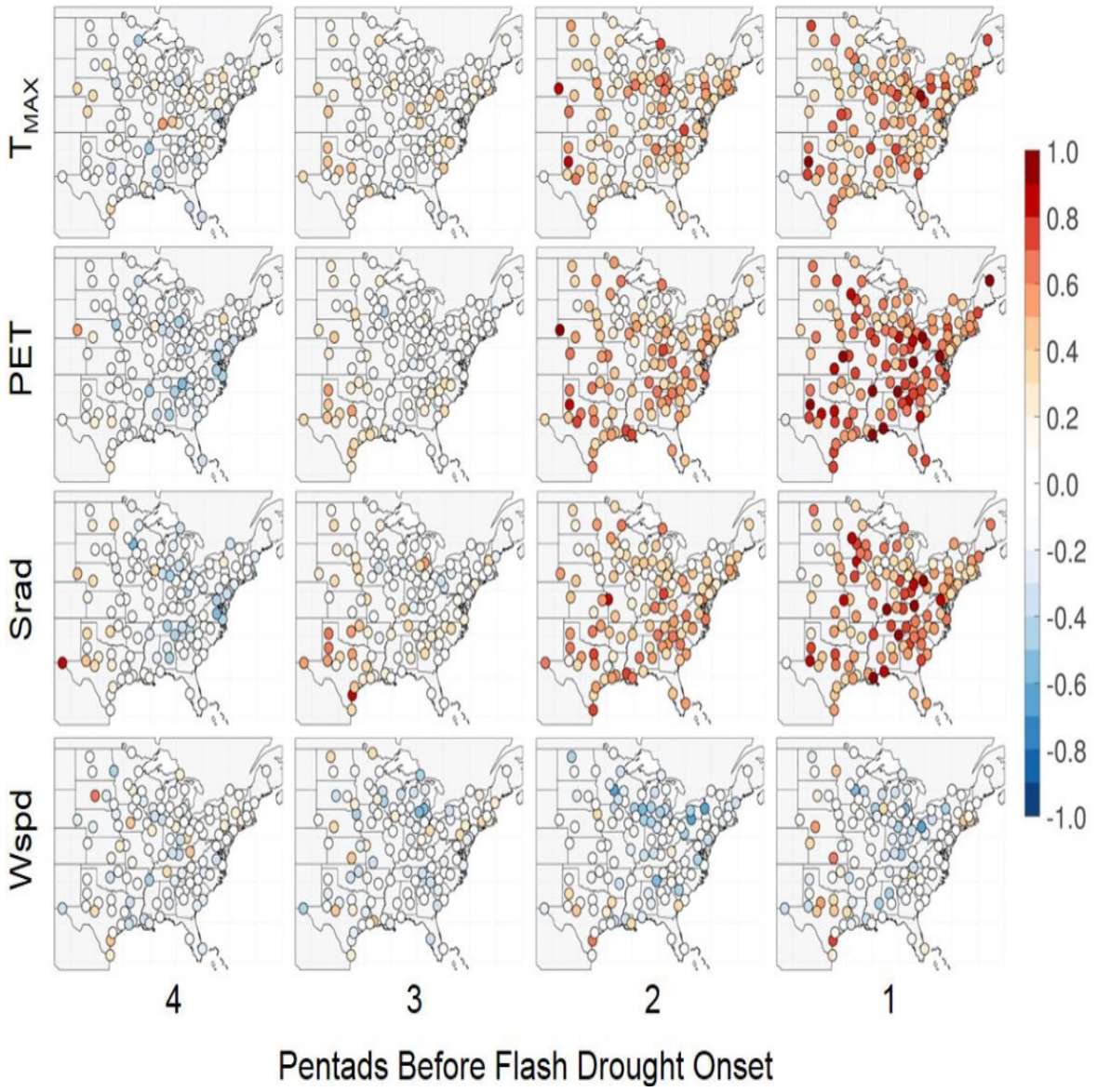
- Time series of surface weather conditions across eastern OK and western AR

- Hot temperatures, strong winds and diminished cloud cover anomalies developed by the end of May and then persisted all summer

- Strongly negative ESI values by the middle of June indicate that the vegetation was unable to adequately respond to the extreme conditions

Climatological Near-Surface Conditions

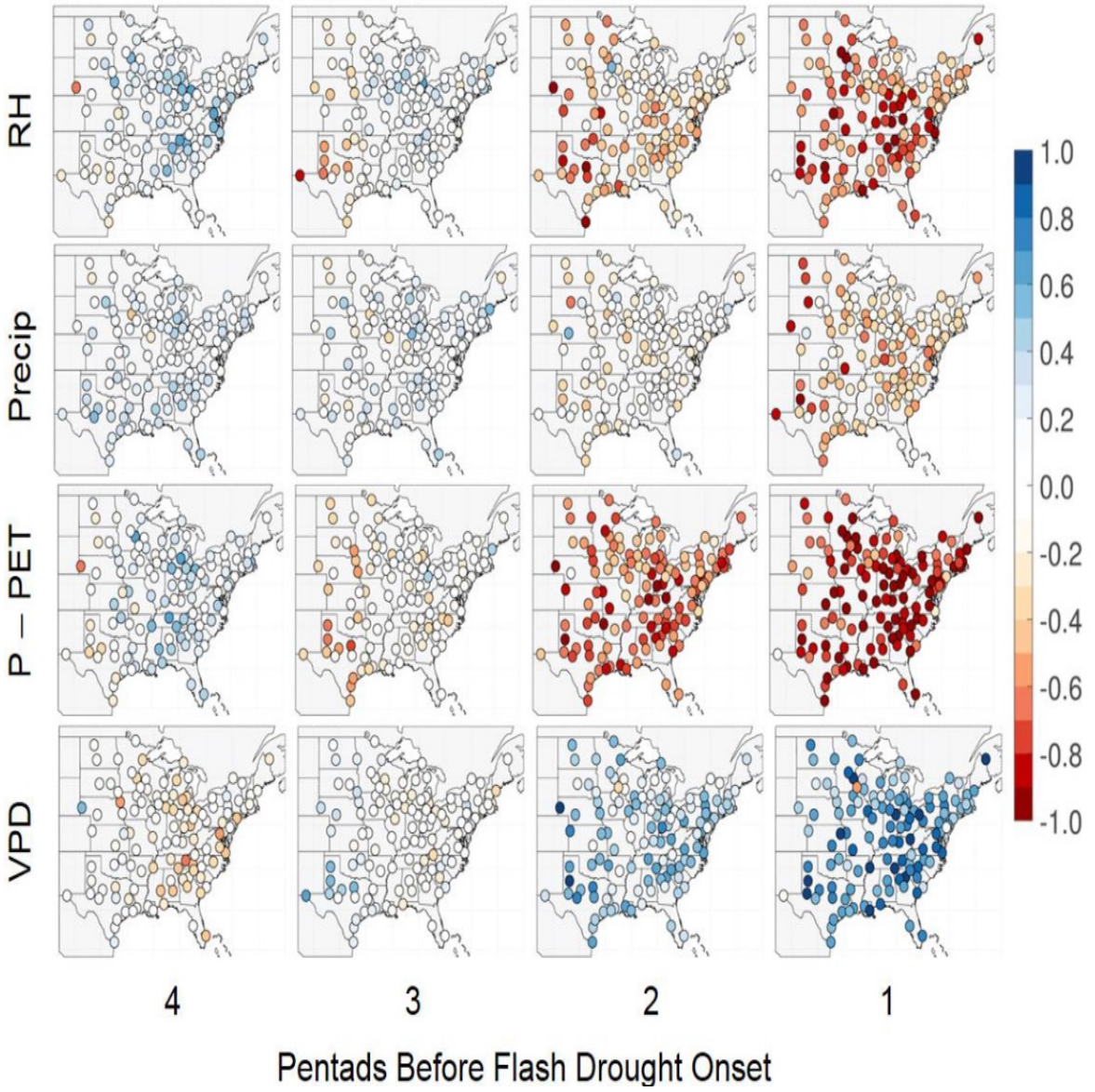
- Maps show correlations in maximum temperature, PET, net radiation, and wind speed for pentads preceding a flash drought
- Correlations are largest for PET and net radiation
- Increased PET and net radiation associated with flash droughts
- Lower correlations for maximum temperature
- Very weak correlations for wind speed



Ford and Labosier (2018)

Climatological Near-Surface Conditions

- Largest correlations occurred for P − PET, relative humidity, and vapor pressure deficit
- Shows that the balance between the supply and demand of surface and near surface moisture are most closely tied to flash droughts
- Correlations are much weaker for precipitation
- Precipitation deficits alone are insufficient to cause a flash drought



Ford and Labosier (2018)

Flash Drought References

Otkin, J. A., M. Svoboda, E. D. Hunt, T. W. Ford, M. C. Anderson, C. Hain, and J. B. Basara, 2018: Flash droughts: A review and assessment of the challenges imposed by rapid onset droughts in the United States. *Bull. Am. Meteorol. Soc*., in press.

Ford, T. W. and C. F. Labosier, 2018: Meteorological conditions associated with the onset of flash drought in the eastern United States. *Agr. Forest Meteorol*., in press.

Otkin, J. A., and CoAuthors, 2016: Assessing the evolution of soil moisture and vegetation conditions during the 2012 United States flash drought. *Agr. Forest Meteorol.*, **218–219**, 230–242.

Otkin, J. A., M. Shafer, M. Svoboda, B. Wardlow, M. C. Anderson, C. Hain, and J. Basara, 2015: Facilitating the use of drought early warning information through interactions with stakeholders. *Bull. Am. Meteorol. Soc.*, **96**, 1073-1078.

Otkin, J. A., M. C. Anderson, C. Hain, and M. Svoboda, 2014: Examining the relationship between drought development and rapid changes in the Evaporative Stress Index. *J. Hydrometeor.*, **15**, 938-956.

Otkin, J. A., M. C. Anderson, C. Hain, I. Mladenova, J. Basara, and M. Svoboda, 2013: Examining flash drought development using the thermal infrared based Evaporative Stress Index. *J. Hydrometeor.,* **14***,* 1057-1074.