Variability of Observations from the MOISST Flux Tower Associated with Changing Soil Moisture Conditions

Hayden Mahan, Jeffrey Basara, and Rajen Bajgain
Licor 7500 CO$_2$ and H$_2$O Open Path System and CSAT 3 Sonic Anemometer

COSMOS Soil Moisture Sensor

Phenocam
Analysis

• “Flash Drought” period from June – August 2012
• “Flash Recovery” period during May 2015
• Analysis of precipitation, temperature, soil moisture, vegetation index, evaporative fraction, and water use efficiency from MOISST site and Marena Mesonet
U.S. Drought Monitor

Oklahoma

June 12, 2012
(Released Thursday, Jun. 14, 2012)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

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Intensity:
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
David Miskus
NOAA/NWS/NCEP/CPC

http://droughtmonitor.unl.edu/
U.S. Drought Monitor

Oklahoma

June 19, 2012
(Released Thursday, Jun. 21, 2012)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

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Intensity:
- Yellow: D0 Abnormally Dry
- Orange: D1 Moderate Drought
- Red: D2 Severe Drought
- Red: D3 Extreme Drought
- Dark Red: D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Richard Heim
NCDC/NOAA

http://droughtmonitor.unl.edu/
U.S. Drought Monitor

Oklahoma

July 17, 2012
(Released Thursday, Jul. 19, 2012)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

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Intensity:
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Richard Heim
NCDC/NOAA

http://droughtmonitor.unl.edu/
July 24, 2012
(Released Thursday, Jul. 26, 2012)
Valid 7 a.m. EST

U.S. Drought Monitor
Oklahoma

Drought Conditions (Percent Area)

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Intensity:
- Yellow: D0 Abnormally Dry
- Dark Red: D3 Extreme Drought
- Light Red: D2 Severe Drought
- Light Orange: D1 Moderate Drought
- Dark Orange: D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Richard Heim
NCDC/NOAA

http://droughtmonitor.unl.edu/
U.S. Drought Monitor

Oklahoma

August 14, 2012
(Released Thursday, Aug. 16, 2012)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

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Intensity:
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Michael Brewer
NCDC/NOAA

http://droughtmonitor.unl.edu/
U.S. Drought Monitor

Oklahoma

May 5, 2015
(Released Thursday, May 7, 2015)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

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Intensity:

- Yellow: Abnormally Dry
- Brown: Moderate Drought
- Red: Extreme Drought
- Dark Brown: Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Mark Svoboda
National Drought Mitigation Center

http://droughtmonitor.unl.edu/
U.S. Drought Monitor

Oklahoma

May 12, 2015
(Released Thursday, May 14, 2015)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

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Intensity:
- **D0 Abnormally Dry**
- **D1 Moderate Drought**
- **D2 Severe Drought**
- **D3 Extreme Drought**
- **D4 Exceptional Drought**

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Author:
Mark Svoboda
National Drought Mitigation Center

http://droughtmonitor.unl.edu/
May 19, 2015
(Released Thursday, May 21, 2015)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

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Intensity:
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
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- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Brad Rippey
U.S. Department of Agriculture

http://droughtmonitor.unl.edu/
### U.S. Drought Monitor

**Oklahoma**

**May 26, 2015**

(Released Thursday, May 28, 2015)

Valid 7 a.m. EST

### Drought Conditions (Percent Area)

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### Intensity:

- **D0 Abnormally Dry**
- **D1 Moderate Drought**
- **D2 Severe Drought**
- **D3 Extreme Drought**
- **D4 Exceptional Drought**

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

**Author:**

Brad Rippey

U.S. Department of Agriculture

http://droughtmonitor.unl.edu/
• Flash drought period begins with a very low GCC compared to the same time in other years and falls to ~.30 by the peak of the drought.
• The flash recovery period is harder to pinpoint a substantial change in the GCC given the green up due to the start of the growing season.
• However, during the flash recovery the slope of the GCC curve is very steep suggesting a very quick vegetation growth.
• Footprint radius of 130 – 240 m
• Penetration depth 15-83 cm (Kohli et al. 2015)
Evaporative Fraction for 2012 and 2015 at Marena

\[
EF = \frac{Q_e}{Q_e + Q_h}
\]
Flash Drought Timeline

April/May
- No drought
- Anomalously warm and dry period
- Soils start to dry

June
- Early rainfall increased shallow soil moisture but not deep soil moisture
- EF increases
- WUE decreases
- Rainfall ends
- Temperature anomaly increases
- Moderate drought sets in

July
- Vegetation still appears healthy based on GCC
- No rainfall occurs
- EF falls to about .2
- Temps ~10 degrees above normal
- Soil moisture goes from 20% to 5% and FWI below .2 for all depths
- Moderate drought transitions to severe and then extreme
- GCC starts to decrease
- WUE increases

August
- Ecosystem collapsed
- Exceptional drought
- 6 inches of rain below normal
- 15 degrees above normal
- Soil moisture at 5%
- EF ~ .1
- WUE very high
Flash Recovery Timeline

**May:**

**Week 1**
- Severe drought
- GCC ~.35
- 2.62” rain
- Below normal temps
- Soil Moisture rose from 12% to 25%
- EF increases to .7
- WUE low for the entire period

**Week 2**
- Severe/Moderate drought
- 1.79” rain
- Below normal temps
- Soil moisture stayed around 25%

**Week 3**
- Moderate drought/abnormally dry
- 2.82” rain
- Up to 20 degrees below normal temps
- Soil moisture stayed around 25%
- EF increased to .8

**Week 4**
- Drought is gone
- Vegetation healthy
- 4.09” rain
- Below normal temps
- Soil moisture rose to over 30%
Flash Drought Conclusions

• Flash drought occurred from anomalously low precipitation.
  – This led to a negative feedback loop by reducing vegetation health, which led to lower latent heat flux and increased sensible heat fluxes that induced higher temperature anomalies.
• A recharge in shallow soil moisture helped to increase ET rates and deplete deeper soil moisture before flash drought occurred.
  – This recharge resulted in low WUE values
• EF fell below .5 during flash drought signaling a decrease in latent heating and an increase in sensible heating.
• Flash drought resulted in greater WUE as conditions became more water scarce
Flash Recovery Conclusions

• Flash recovery occurred as a result of anomalously high precipitation.
  – Created anomalously low temperature that reduced evaporative demand.
• Flash recovery was not as substantial as the flash drought period. However, there was still 3 drought class changes (Severe $\rightarrow$ None) in less than a months time.
• EF rose above .5 during flash recovery.
• Precursor to flash recovery is much more difficult to deduce than flash drought as it is more atmospherically driven.
• Very different warm season ecosystem compared to flash drought year, as a result of moist conditions
Thanks for your attention!

Questions?