



Mapping Drought with Satellite Remote Sensing and Land Surface Modeling

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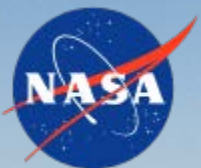
Beltsville, MD

Jason Otkin

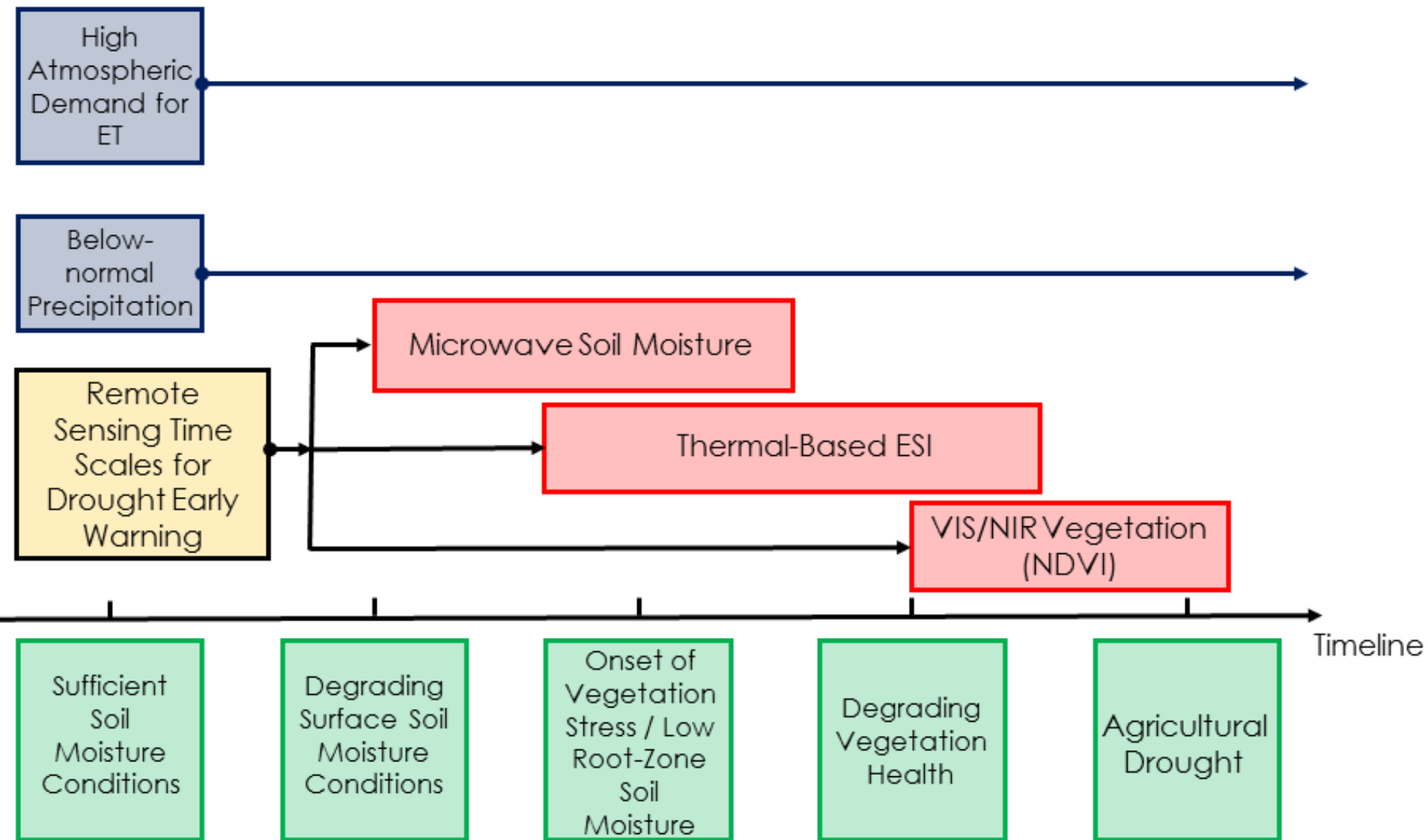
University of Wisconsin

Xiwu Zhan

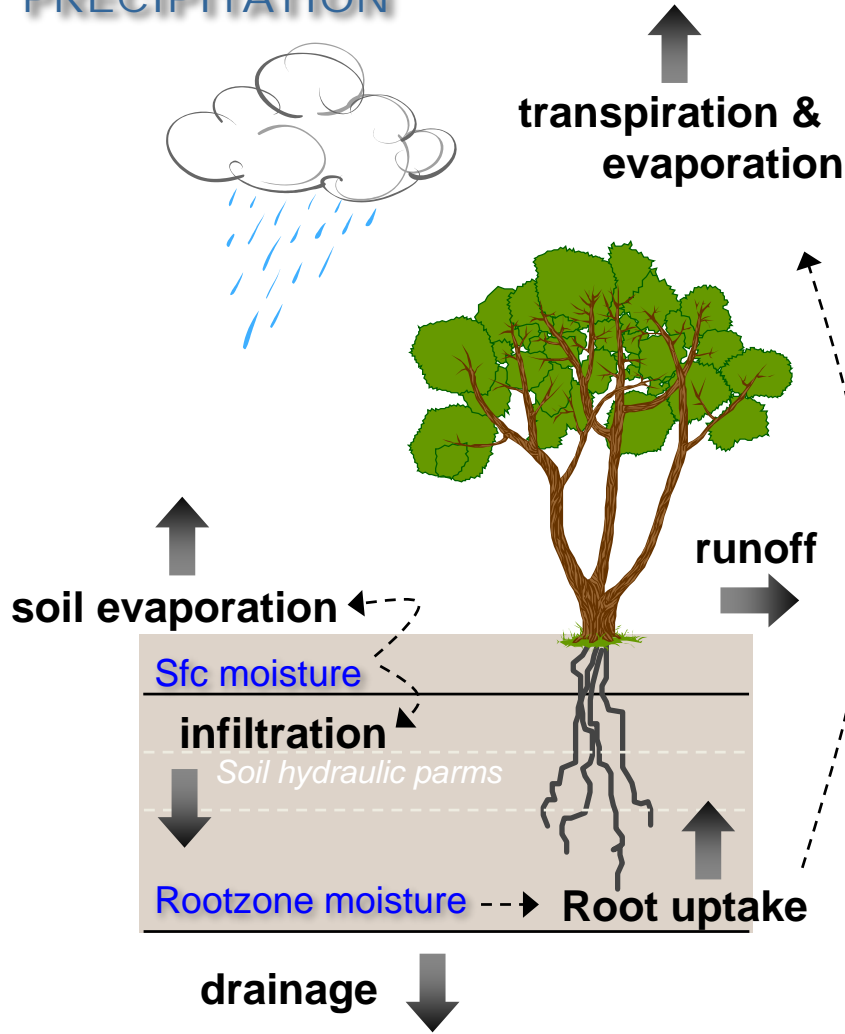
NOAA-NESDIS-STAR



Example of the Evolution of Agricultural Drought

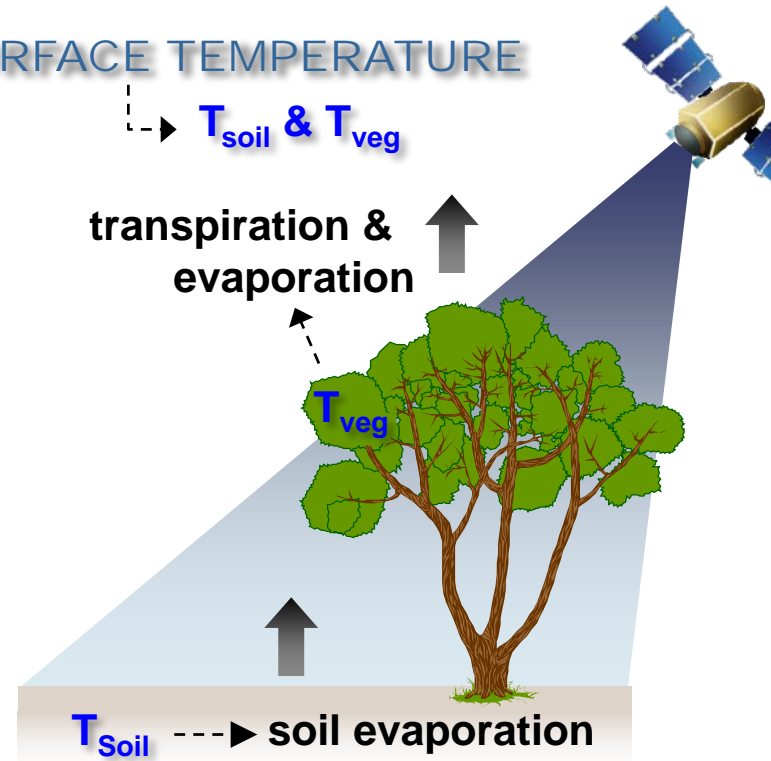


PRECIPITATION



WATER BALANCE APPROACH
(prognostic modeling)

SURFACE TEMPERATURE



Given known radiative energy inputs, how much water loss is required to keep the soil and vegetation at the observed temperatures?

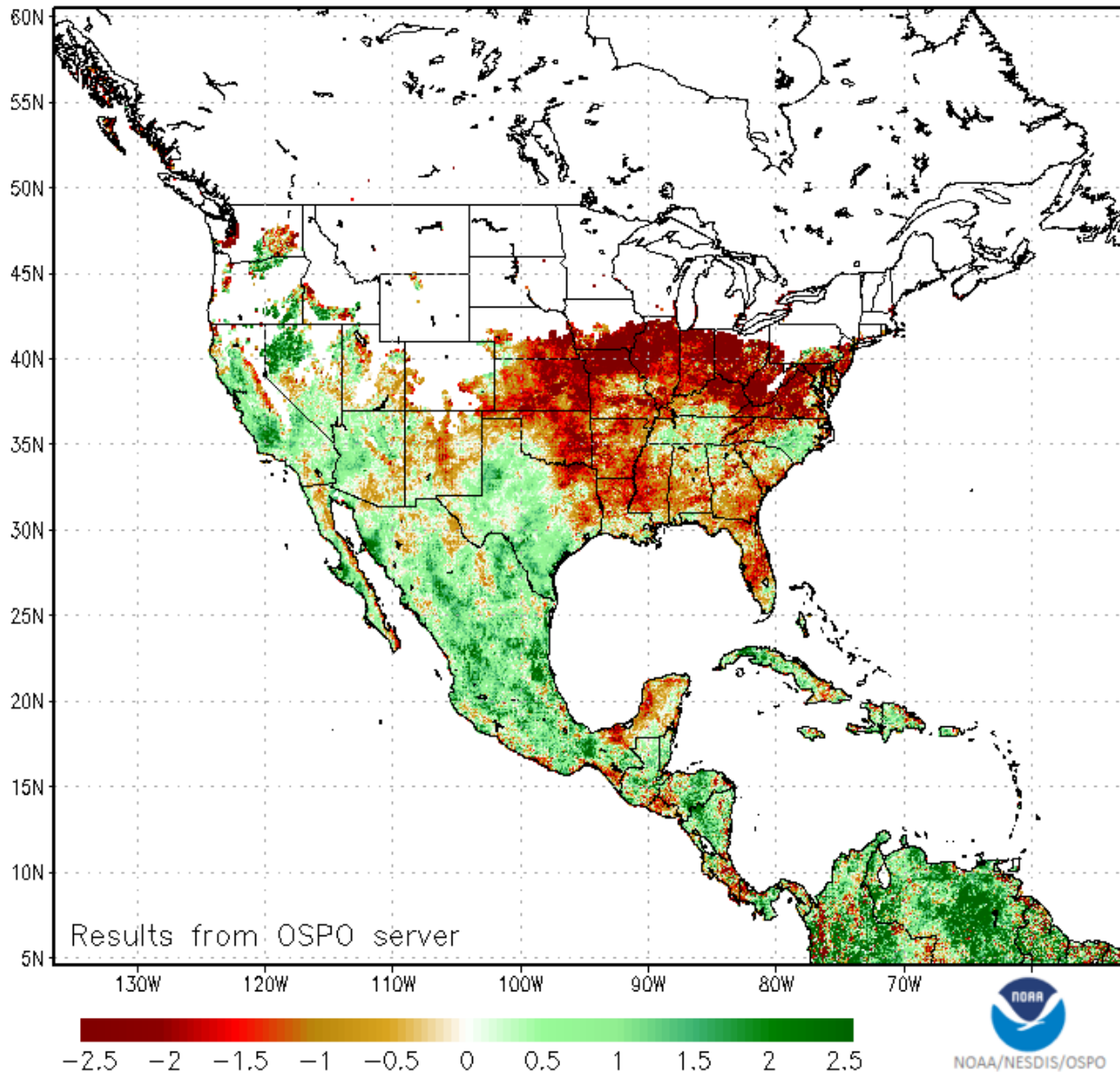
ENERGY BALANCE APPROACH
(diagnostic modeling)

ALEXI ESI represents temporal anomalies in the ratio of actual ET to potential ET.

- ESI does not require precipitation data, ***the current surface moisture state is deduced directly from the remotely sensed LST***, therefore it may be more robust in regions with minimal in-situ precipitation monitoring.
- ESI represents the “onset” of actual vegetation stress, not just the potential for vegetation stress and provides an opportunity to supplement products such as EDDI which highlight the atmospheric demand for ET, but lack a physical relationship with the actual vegetation response.
- Signatures of vegetation stress are manifested in the LST signal before any deterioration of vegetation cover occurs, for as example as indicated in NDVI, so TIR-based indices such as ESI can provide an effective early warning signal of impending agricultural drought.
- ALEXI ESI inherently includes non-precipitation related moisture signals (such as irrigation; vegetation rooted to groundwater; lateral flows) that need to be modeled a priori in prognostic LSM schemes.

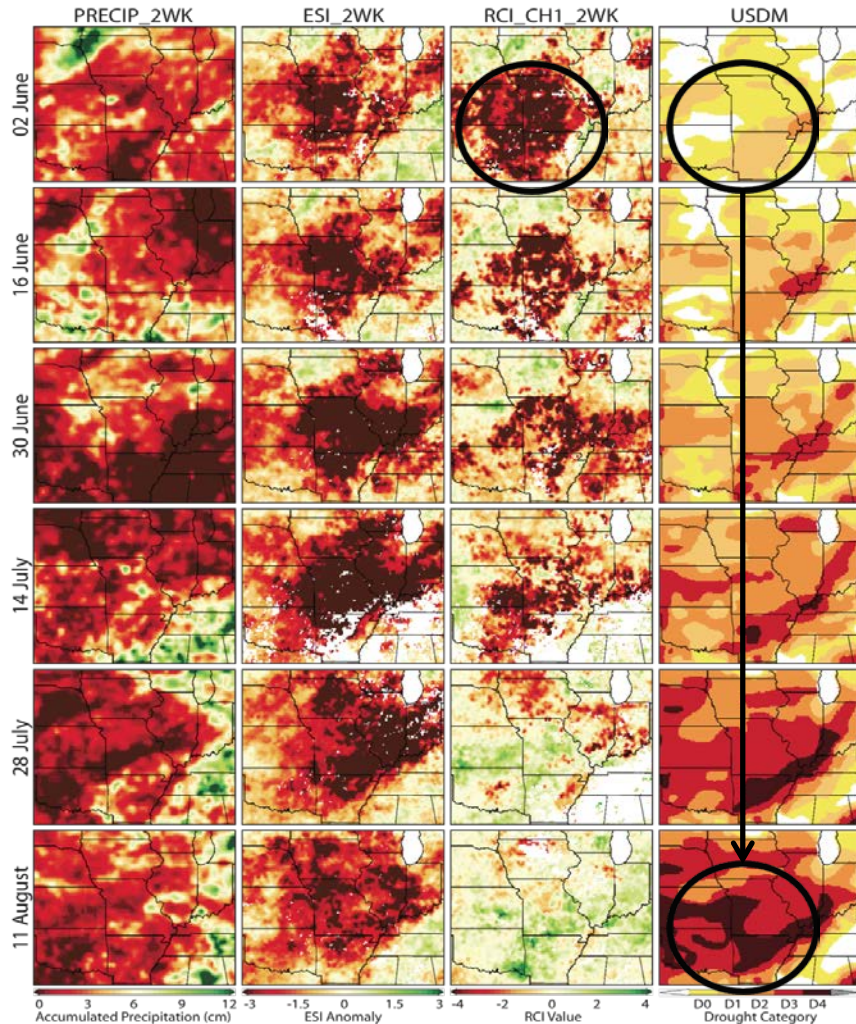
Current 4-wk ESI Composite

GET-D ESI 04 Week Composite
25 Mar 2017



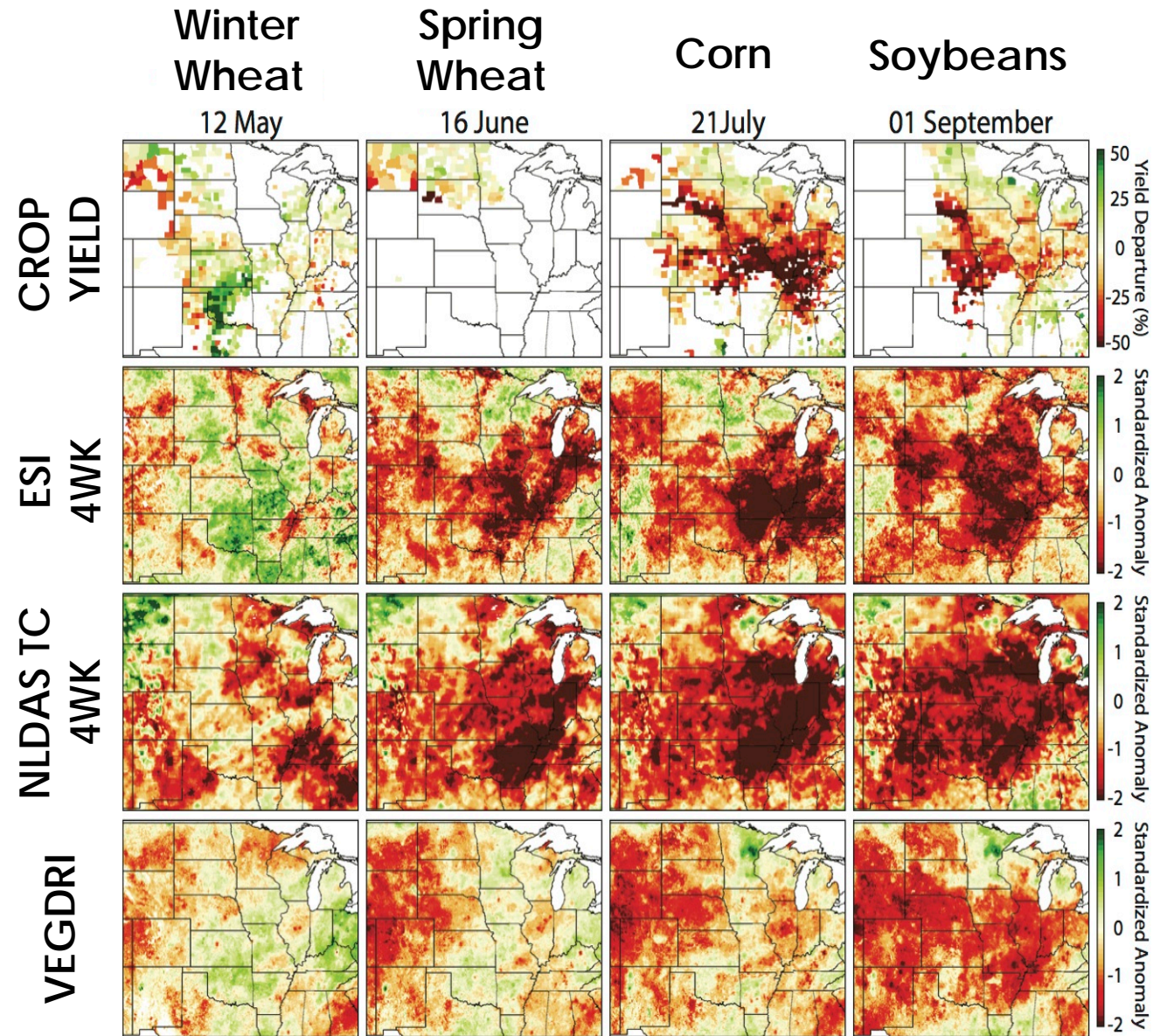
Central US Flash Drought of 2012

Flash drought are rapid onset events typically driven by precipitation deficits, high temperature anomalies and often strong winds. ESI has the potential to provide an early warning component during such events as water stress is able to be detected in the LST signal before degradation in the vegetation health occurs.



- Large negative RCI values in the top row indicate that moisture stress was rapidly increasing at the beginning of summer
- Impressive scope of the unusually rapid decrease in the ESI anomalies is clearly depicted by the large area of negative RCI values
- Initial appearance of negative RCI values led the introduction of severe drought in the USDM by more than 4 weeks

Early Warning Metrics for Onset of Vegetation Stress

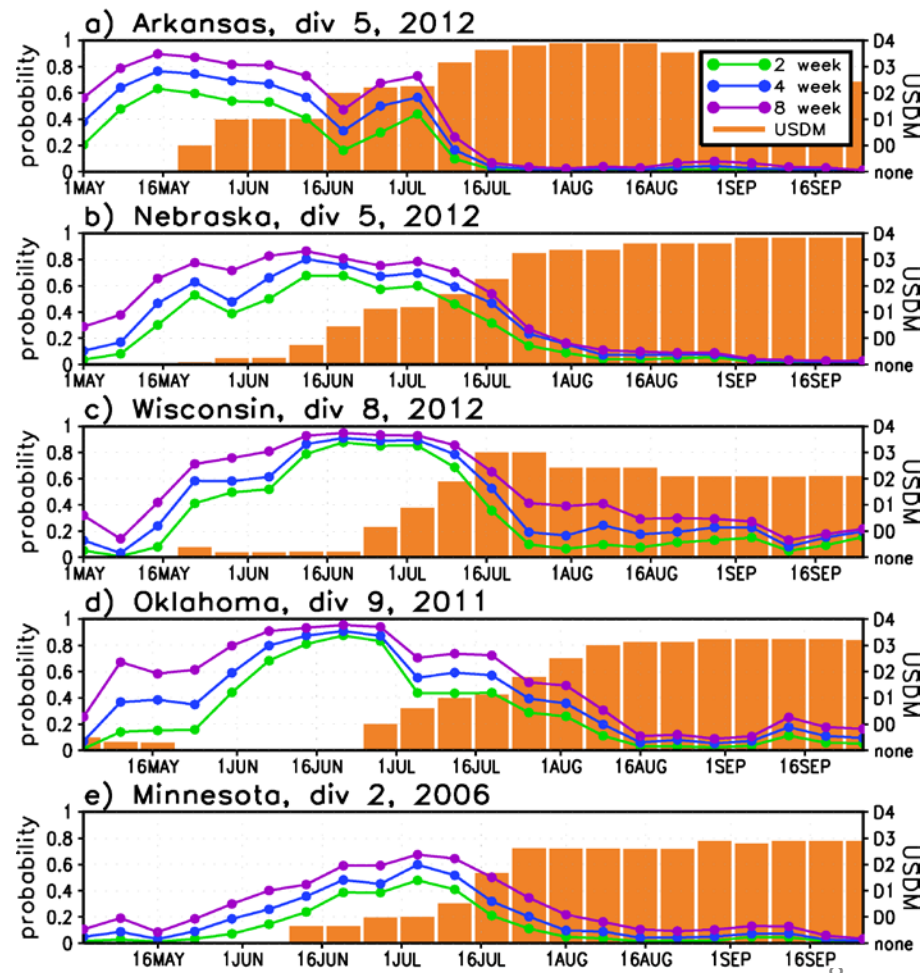


- Examine drought conditions during critical crop stages
- Strong relationship between wheat yield and the ESI and VegDRI during critical crop stages
- NLDAS has strong (weak) relationship to corn/soybeans (wheat) yield
- ESI had strongest correlation to the wheat, corn, and soybean yield departures

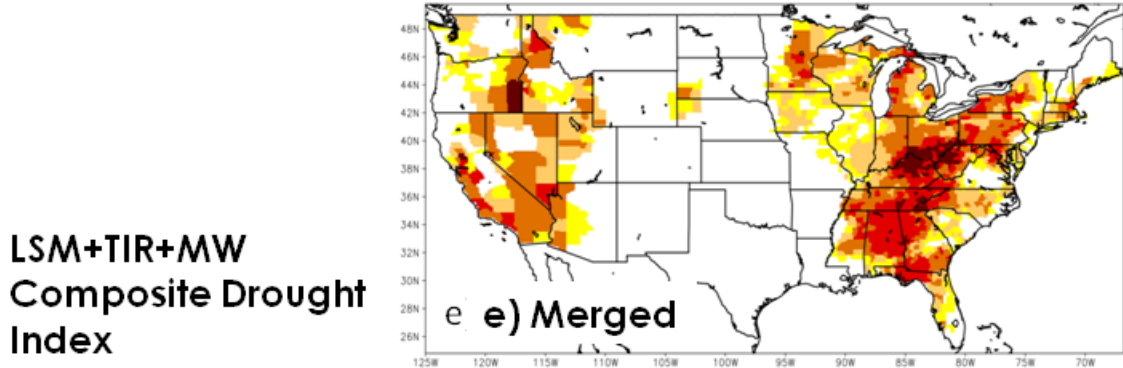
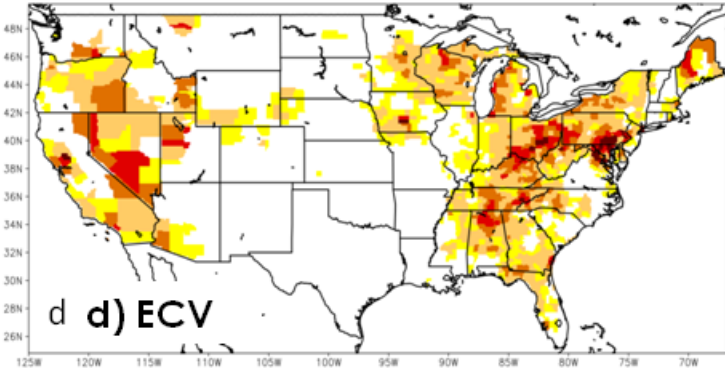
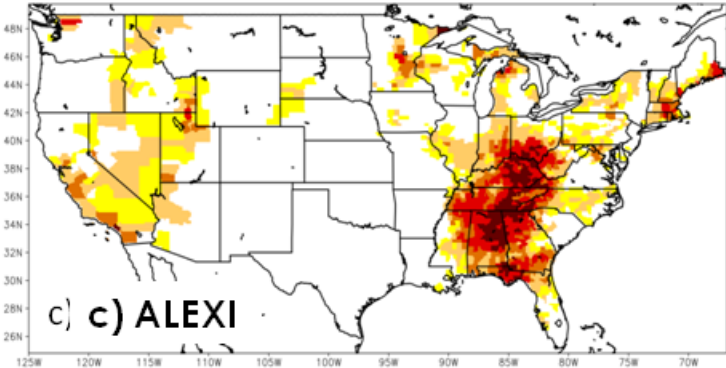
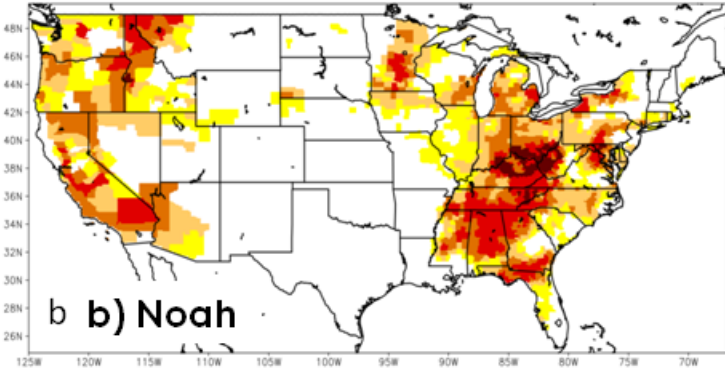
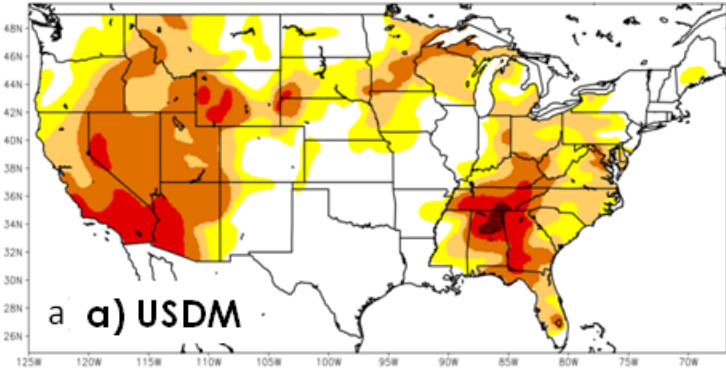
An Empirical Method to Generate Probabilistic Drought Intensification Forecasts Over Sub-Seasonal Time Scales

Jason Otkin (UW/CIMSS), D. Lorenz, M. Svoboda, C. Hain, and M. Anderson

- Empirical method developed to generate probabilistic drought intensification forecasts over sub-seasonal time scales
- Uses precipitation anomalies and time tendencies in soil moisture and evapotranspiration
- Forecasts depicted a high risk for drought development before each flash drought event
- Results show that the method provides useful drought early warning information



Composite Drought Index based on Remote Sensing Drought Indicators



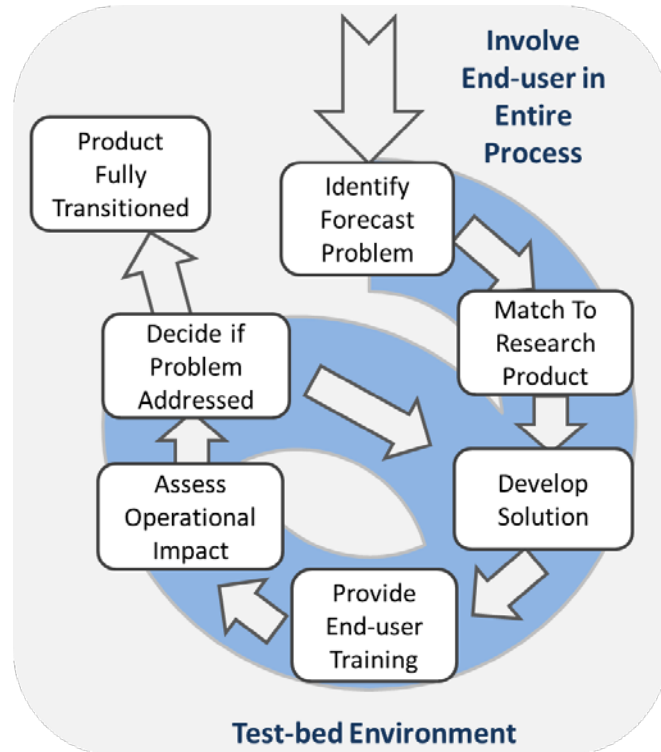
LSM+TIR+MW
Composite Drought
Index

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

NASA/SPoRT Center

Short-term Prediction Research and Transition (SPoRT)

- Transitions unique NASA and NOAA observations and research capabilities to the operational weather community to improve short-term weather forecasts on regional and local scales
- ***Proven paradigm for transition of research and experimental data to operations***
- Close collaboration with numerous NWS WFOs across the U.S.
- Began in 2002; co-funded by NOAA since 2009 through “proving ground” activities



Updated: October 9, 2015

NASA Land Information System (LIS)

LIS modes of operation

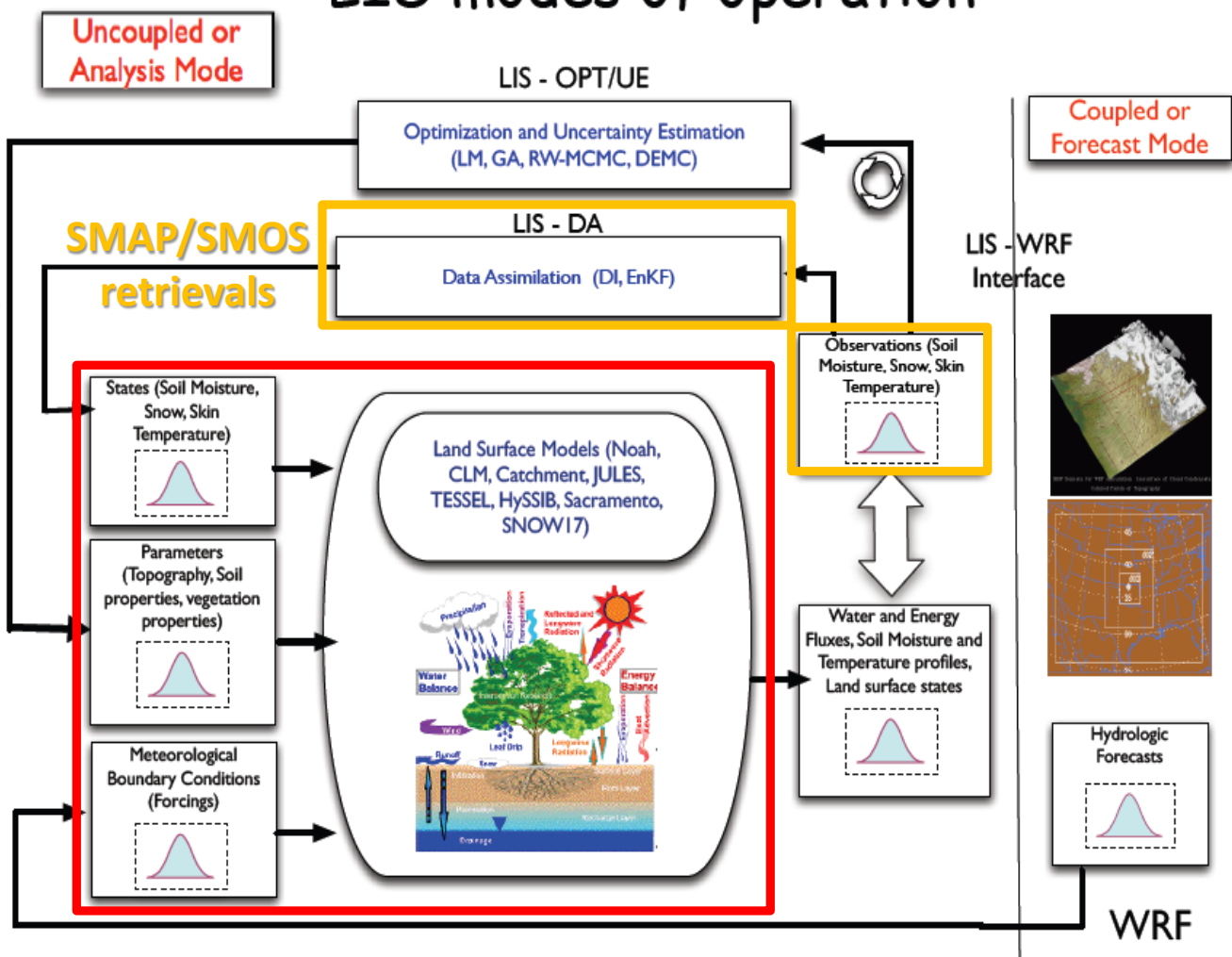
High-performance land surface modeling & data assimilation system

Uncoupled/analysis mode

Forecast mode coupled to WRF model

Currently run Noah LSM v3.3 in analysis mode

LIS References:
 Kumar et al. (2006)
 Peters-Lidard et al. (2007)



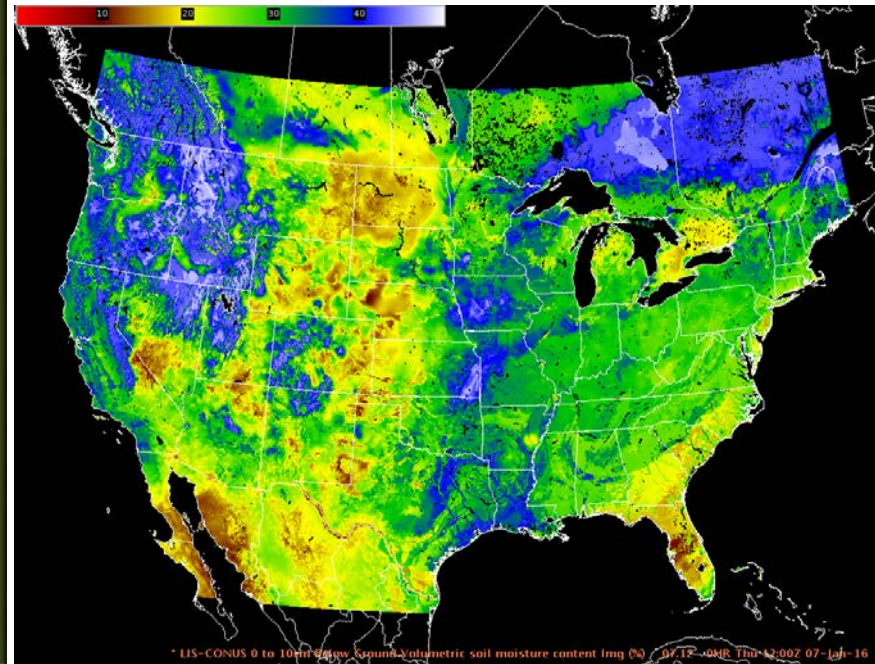
SPoRT Real-time LIS Running Noah LSM

Full Continental U.S. (CONUS) domain with 0.03° (lat/lon) grid resolution

Unique characteristics of SPoRT-LIS:

- Real-time S-NPP/VIIRS Green Vegetation Fraction
- Albedo scaled to input vegetation
- Restart simulation strategy to produce real-time output (timeline below)
- SPoRT-LIS ingested and displayed in AWIPS II at select NOAA/NWS weather forecast offices
- Land surface variables available to initialize modeling applications (WRF and STRC/EMS/UEMS)

SPoRT-LIS CONUS domain, as displayed in AWIPS II



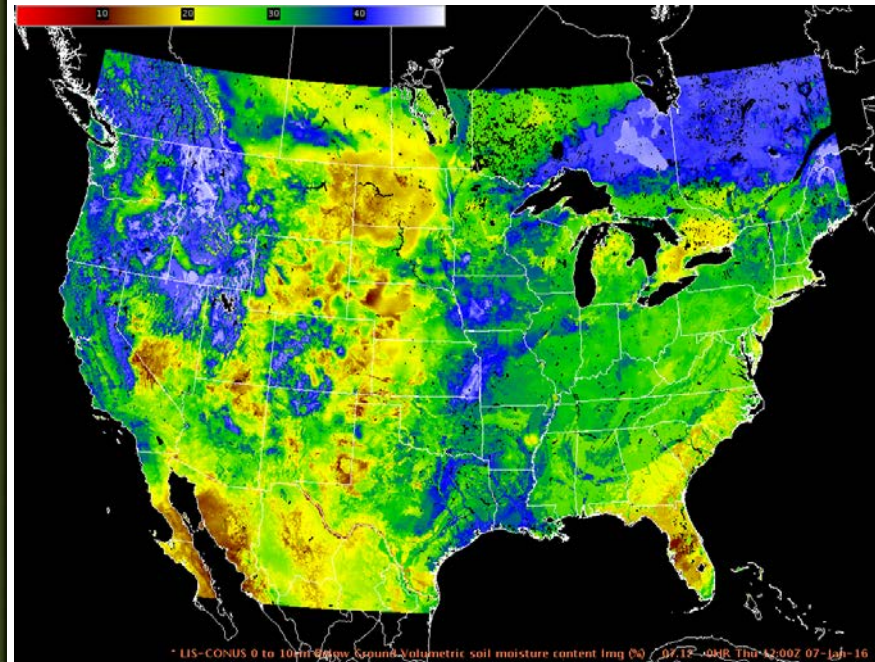
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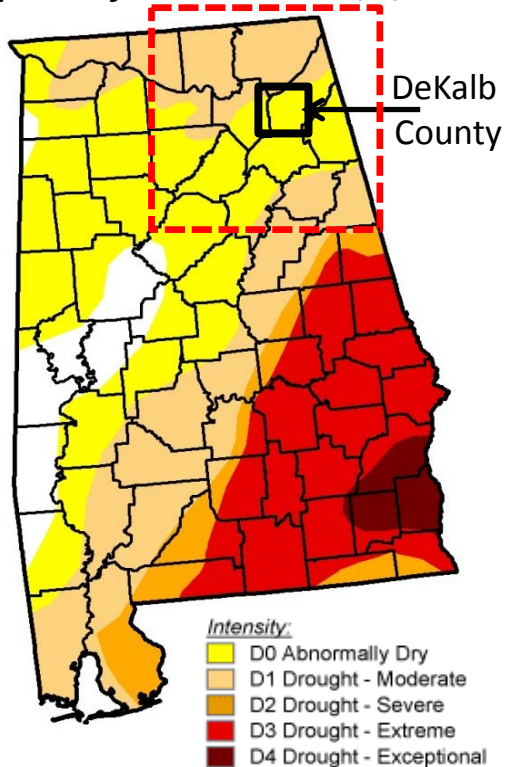
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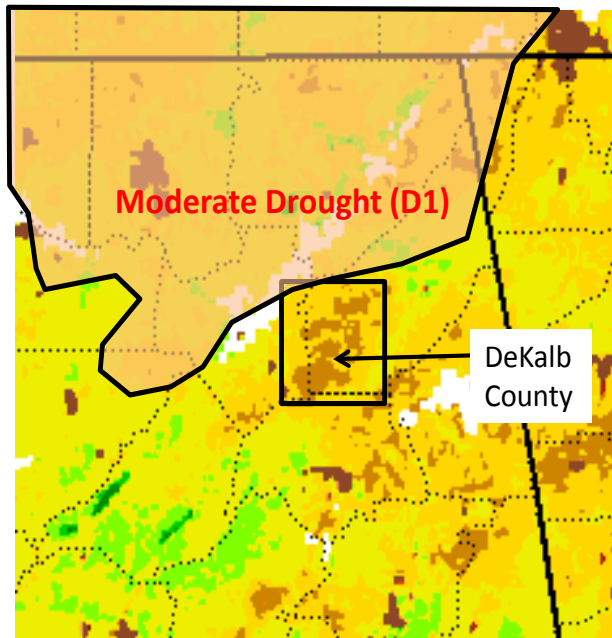
SPoRT-LIS in Testbed Mode: Drought Monitoring at NWS HUN

U.S. Drought Monitor depiction for Alabama – 5/1/2012

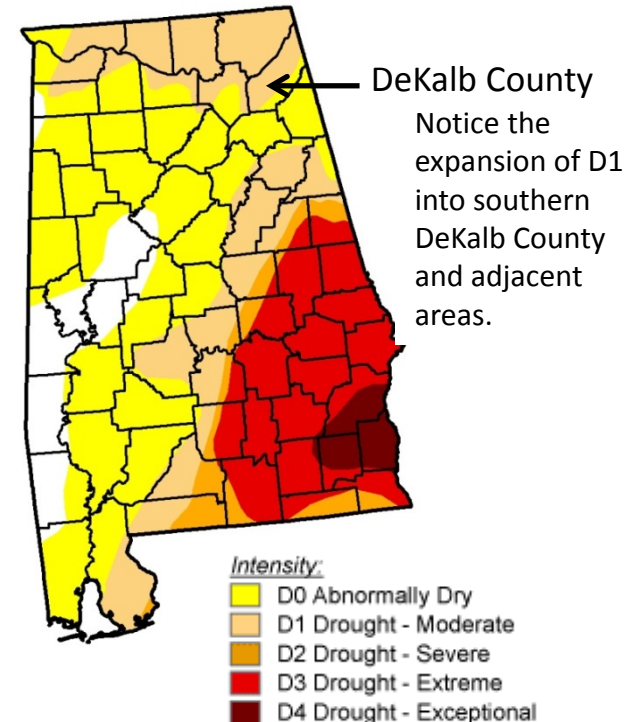


LIS total column soil moisture depicted locally degraded soil conditions over DeKalb county (below)

LIS 0-200 cm Relative Soil Moisture (%), 5/8/2012

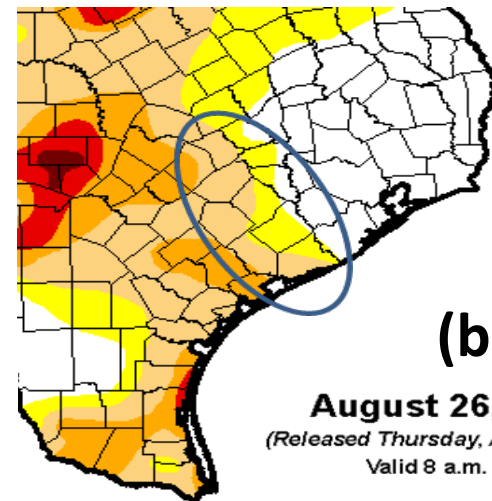
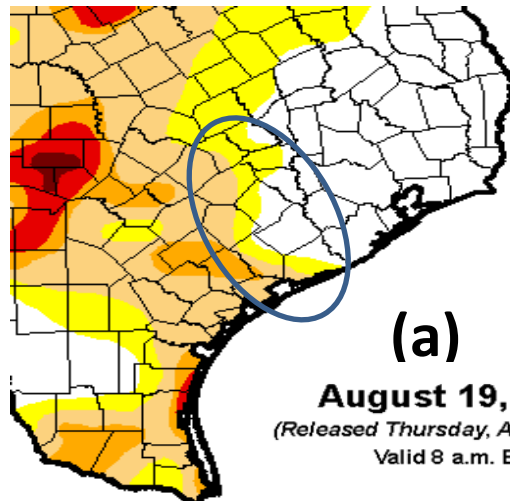
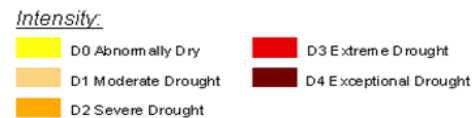
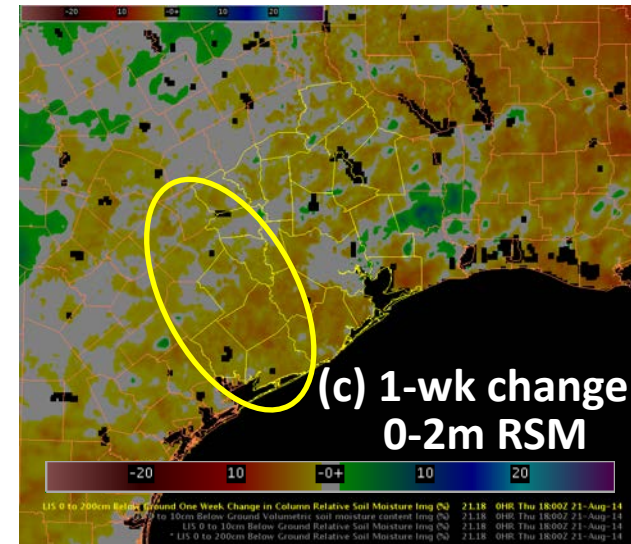
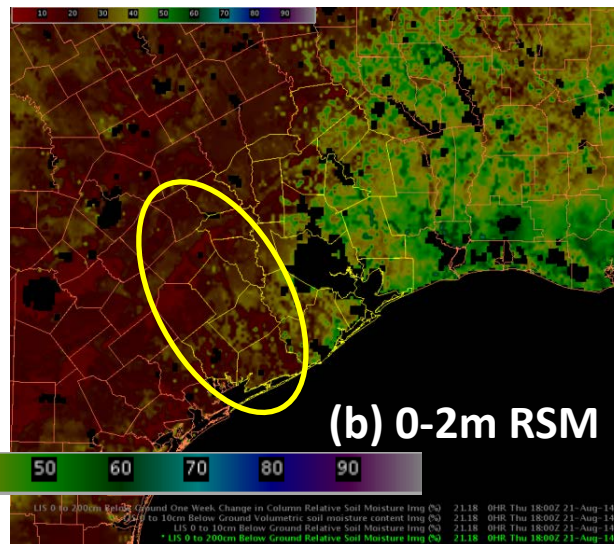
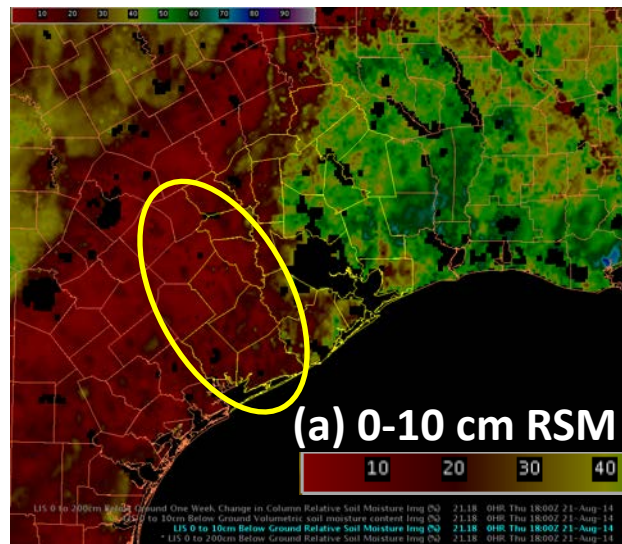


U. S. Drought Monitor depiction for Alabama – 5/8/2012



SPoRT-LIS 2014 Evaluation Example:

Minor adjustments to USDM categories



How do I get these datasets:

Evaporative Stress Index (ESI):

Contact: Christopher Hain (christopher.hain@nasa.gov)
Martha Anderson (martha.anderson@ars.usda.gov)

Data access:

<http://hrsl.ba.ars.usda.gov/drought/> (warm season only)

NOAA Operational FTP (<ftp://satepsanone.nesdis.noaa.gov/GETD/PROD/>)

NASA SPoRT LIS:

Contact: Christopher Hain (christopher.hain@nasa.gov)
Bradley Zavodsky (brad.zavodsky@nasa.gov)
Jonathon Case (jonathan.case-1@nasa.gov)

Data access:

https://weather.msfc.nasa.gov/sport/case_studies/lis_CONUS.html