Development of a Global Evaporative Stress Index Based on TIR and MW LST

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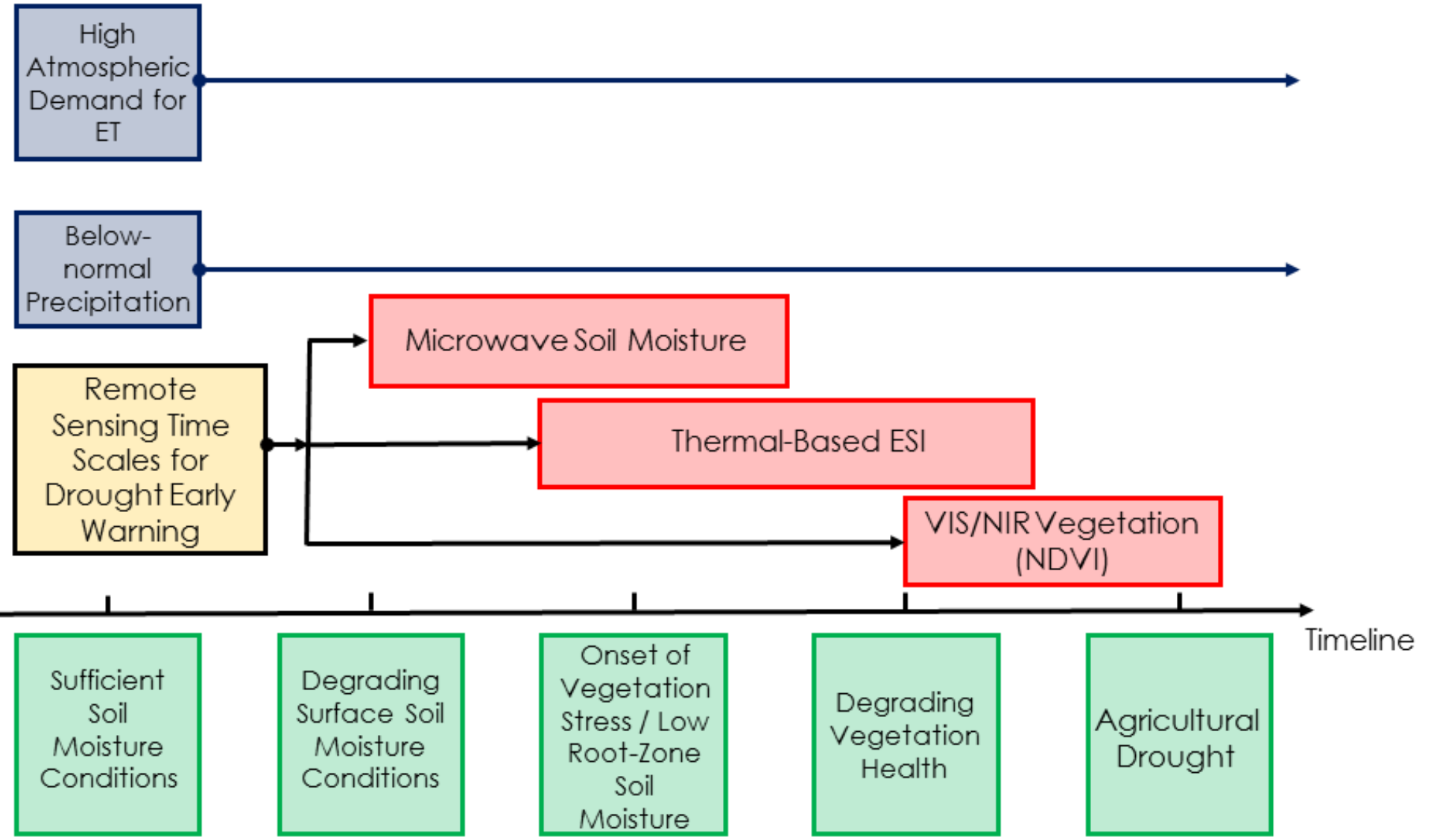
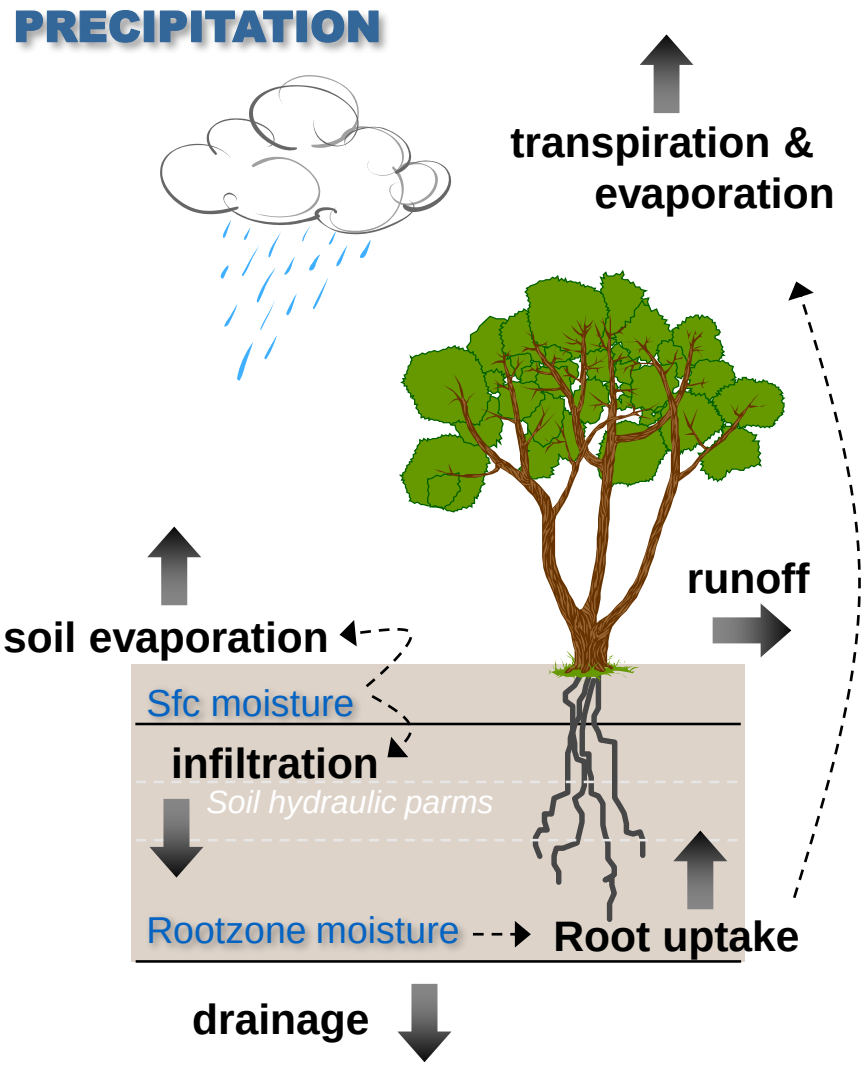
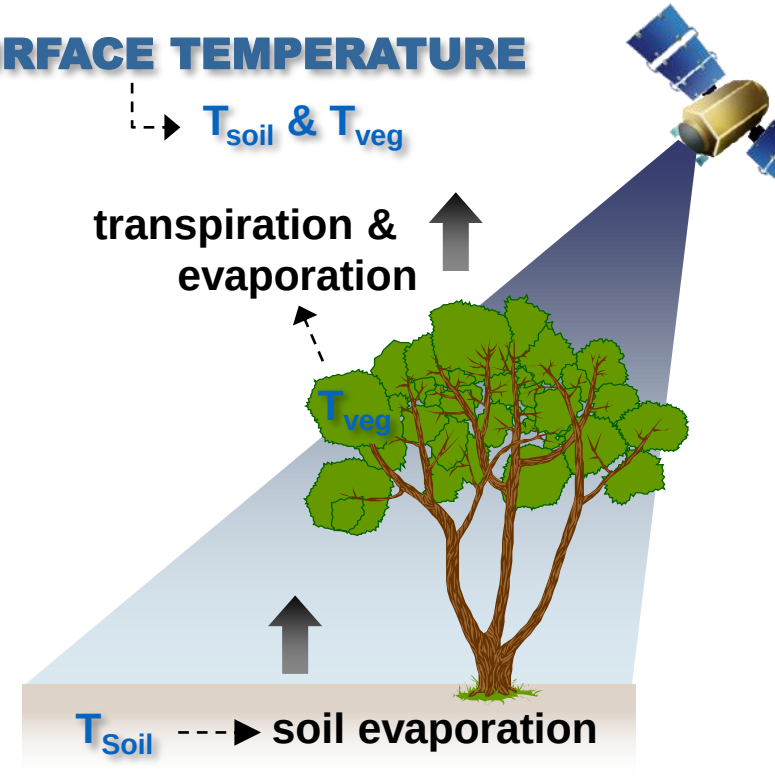
Example of the Evolution of Agricultural Drought





WATER BALANCE APPROACH
(prognostic modeling)



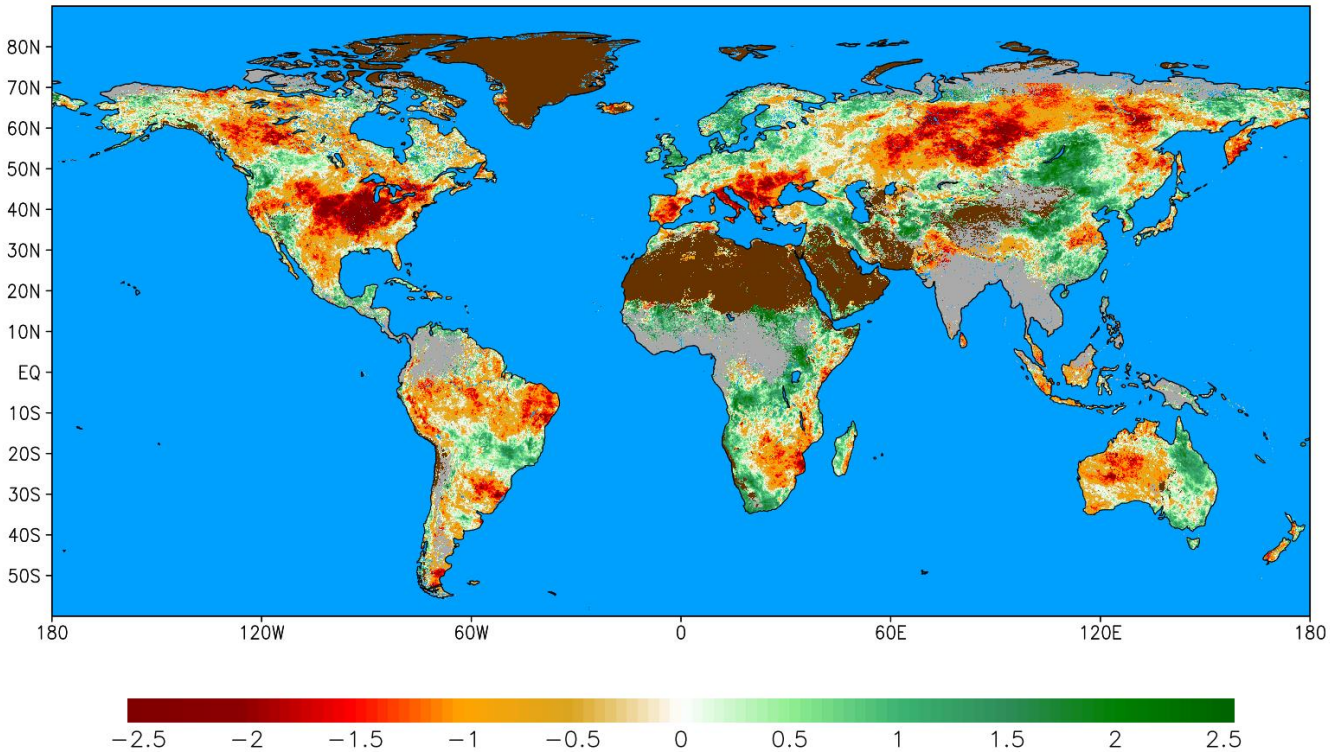
Given known radiative energy inputs, how much water loss is required to keep the soil and vegetation at the observed temperatures?

ENERGY BALANCE APPROACH
(diagnostic modeling)

Global Evaporative Stress Index Methodology

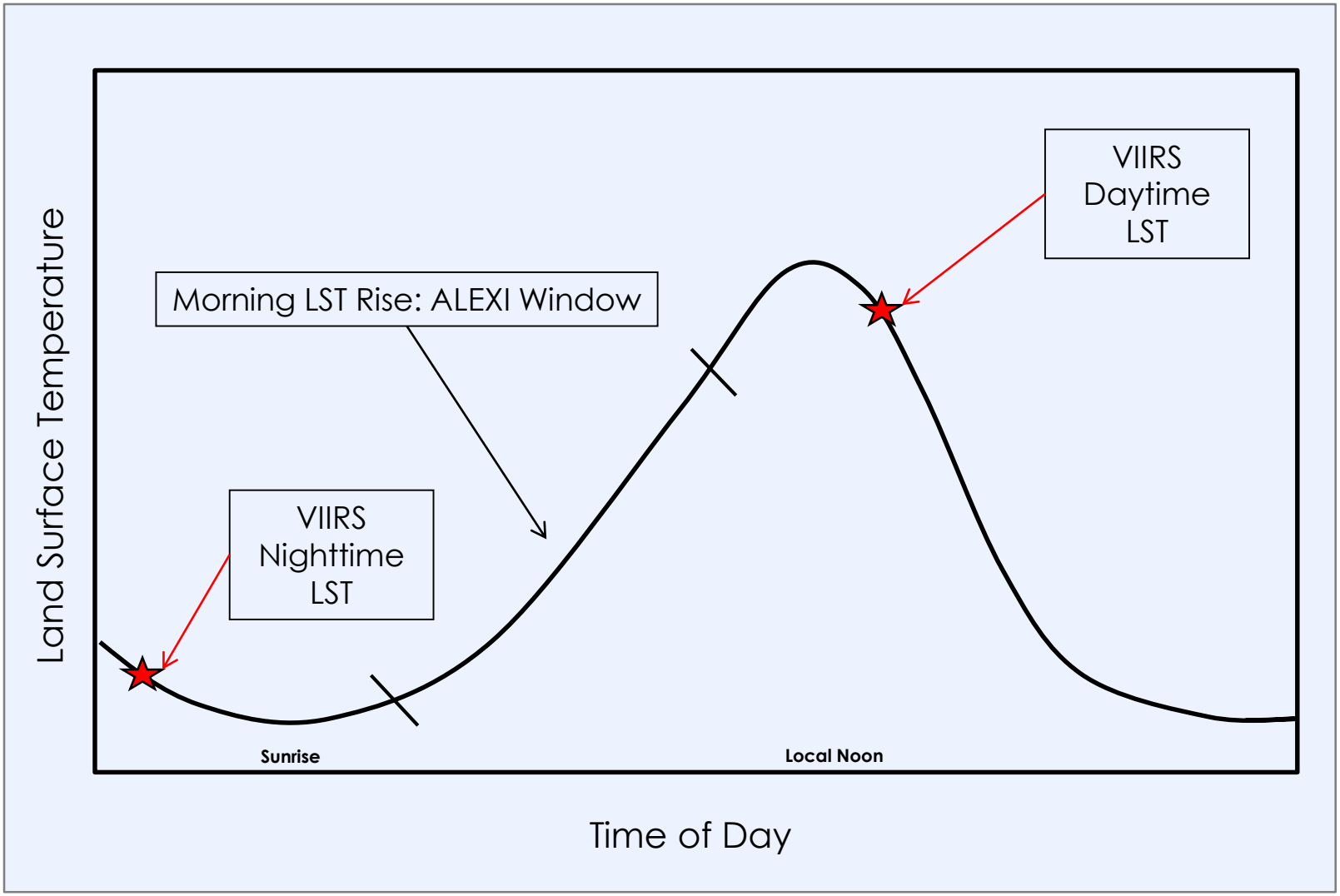
ALEXI ESI represents temporal anomalies in the ratio of actual ET to potential ET.

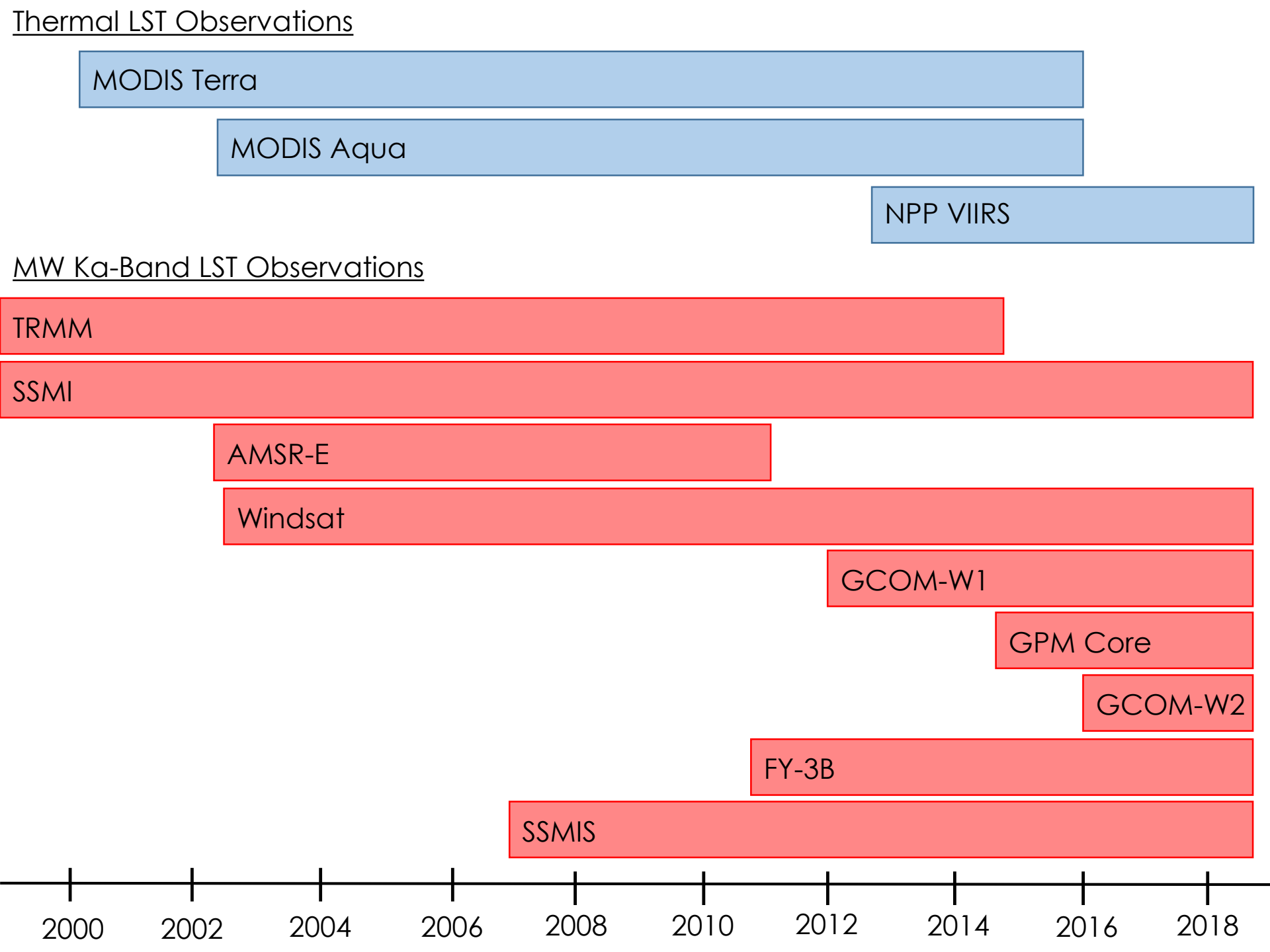
- ESI does not require precipitation data, ***the current surface moisture state is deduced directly from the remotely sensed LST*** , therefore it may be more robust in regions with minimal in-situ precipitation monitoring.
- Signatures of vegetation stress are manifested in the LST signal before any 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.



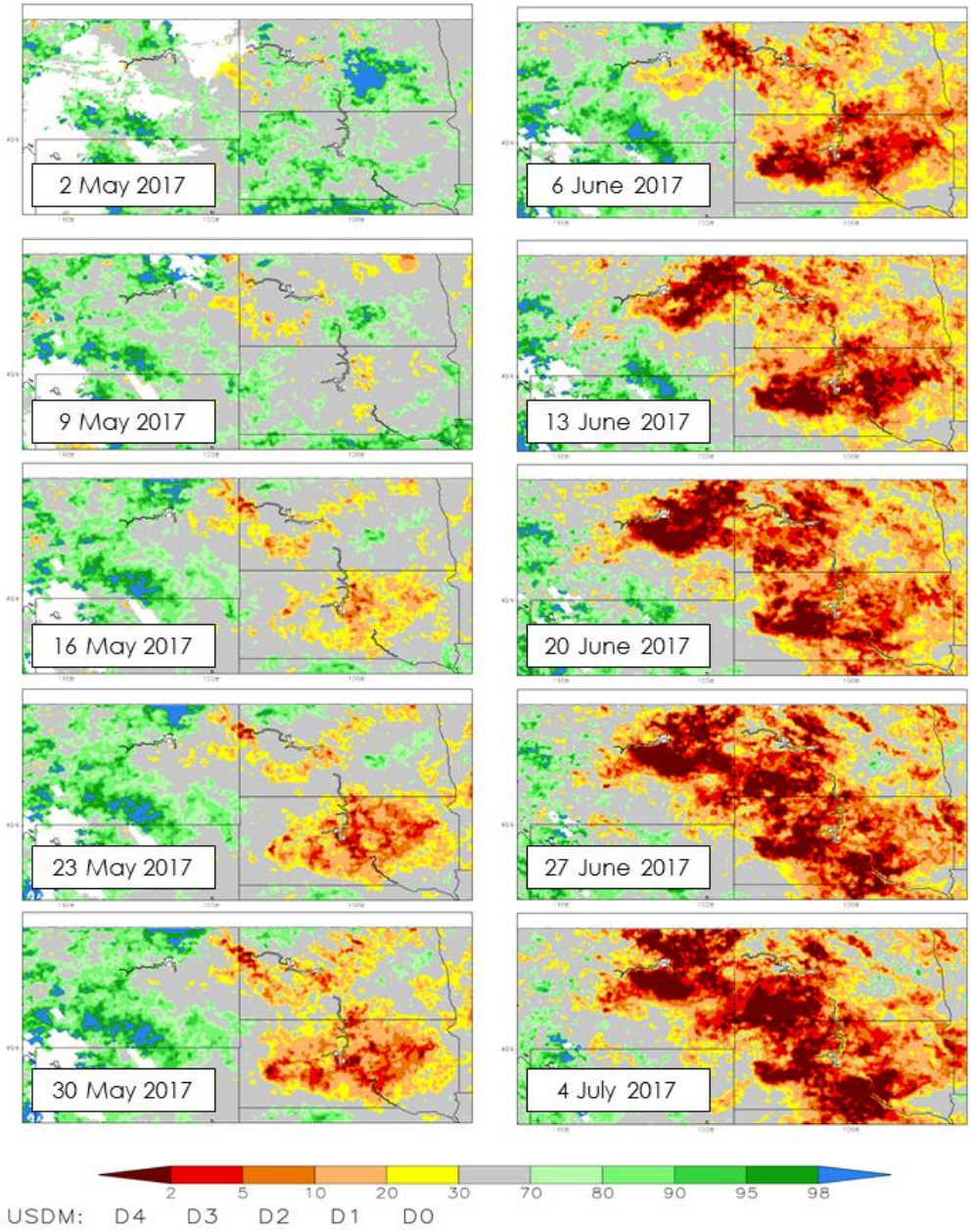
Supplementing ALEXI Capabilities with Polar Orbiting Sensors

A technique has been developed and evaluated using GOES data to train a regression model to use day-night LST differences from MODIS to predict the morning LST rise needed by ALEXI.




Thermal LST Observations
MODIS Terra
MODIS Aqua
NPP VIIRS
MW Ka-Band LST Observations
TRMM
SSMI
AMSR-E
Windsat
GCOM-W1
GPM Core
GCOM-W2
FY-3B
SSMIS
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018

North Central US Flash Drought of 2017



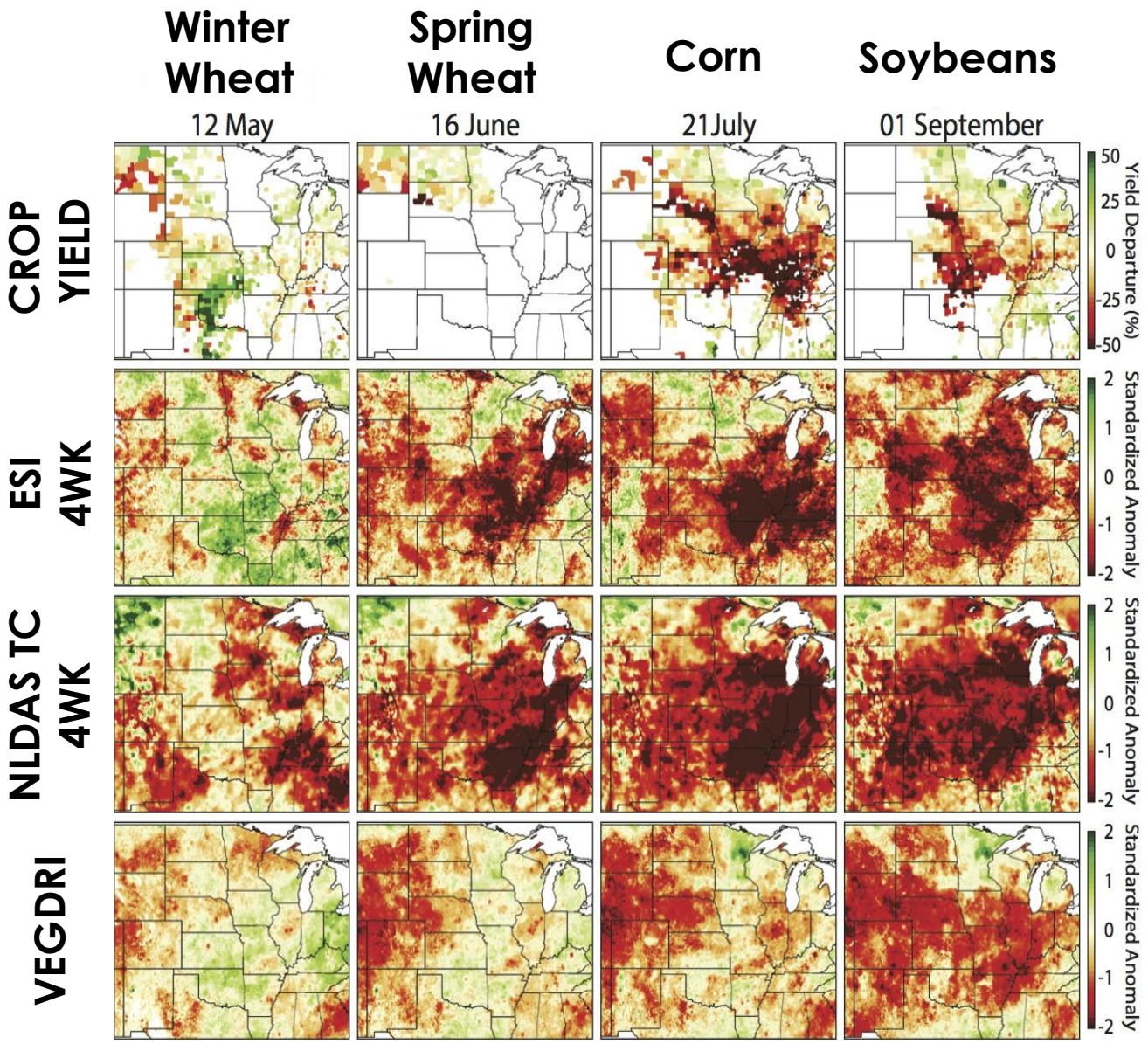
Flash drought are rapid onset events typically driven by:

1) precipitation deficits,
2) high temperature anomalies;
3) strong winds;
4) Anomalous incoming solar radiation.

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.

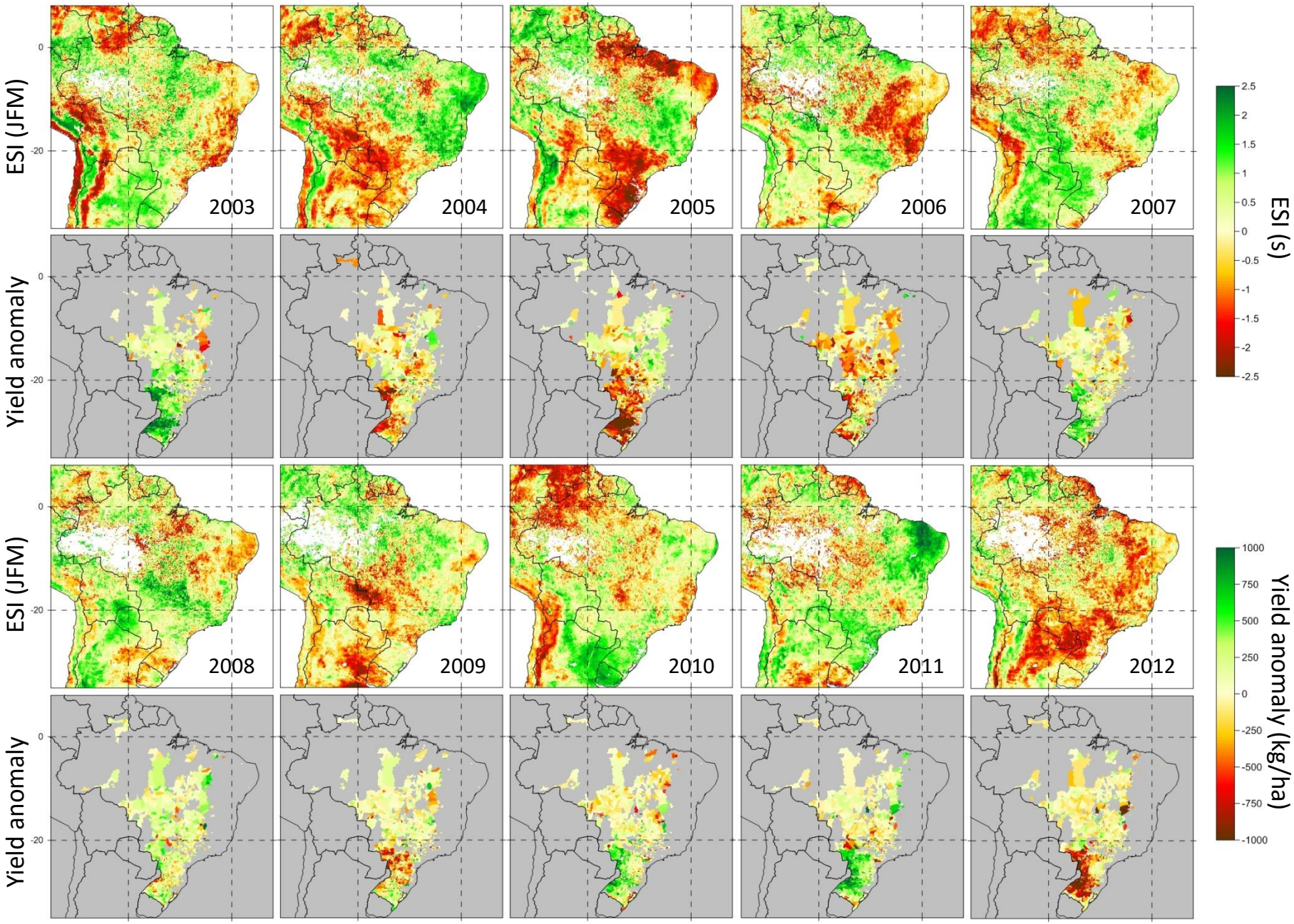
While providing information about actual vegetation stress and not just the potential for vegetation stress (e.g., PET-driven drought indicators).

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

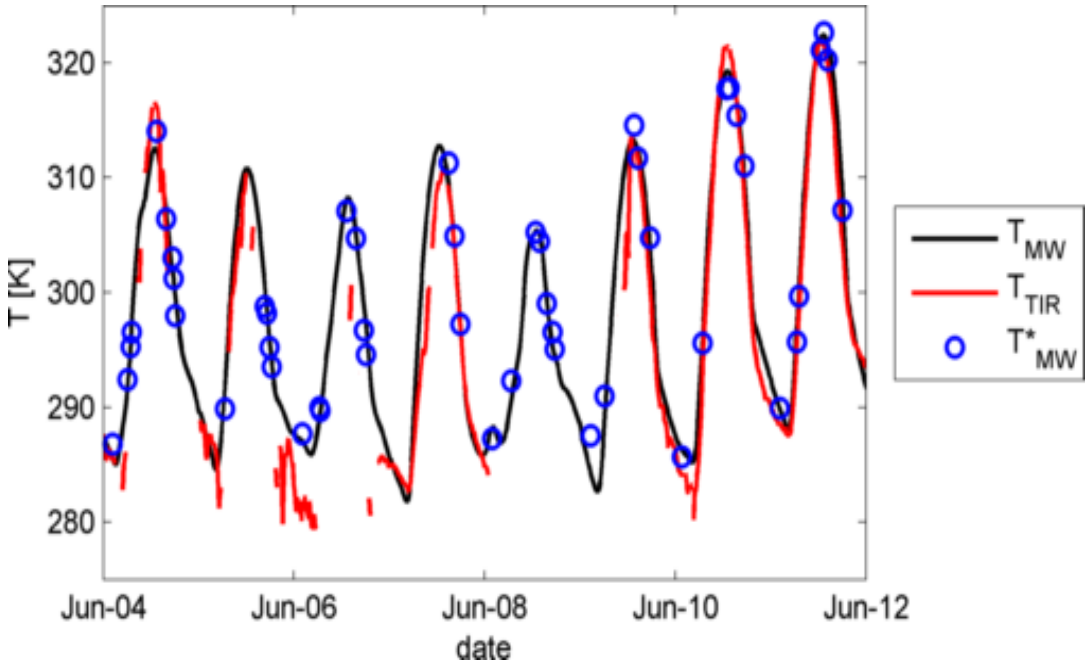
ANNUAL MUNICIPAL LEVEL SOYBEAN YIELD ANOMALIES



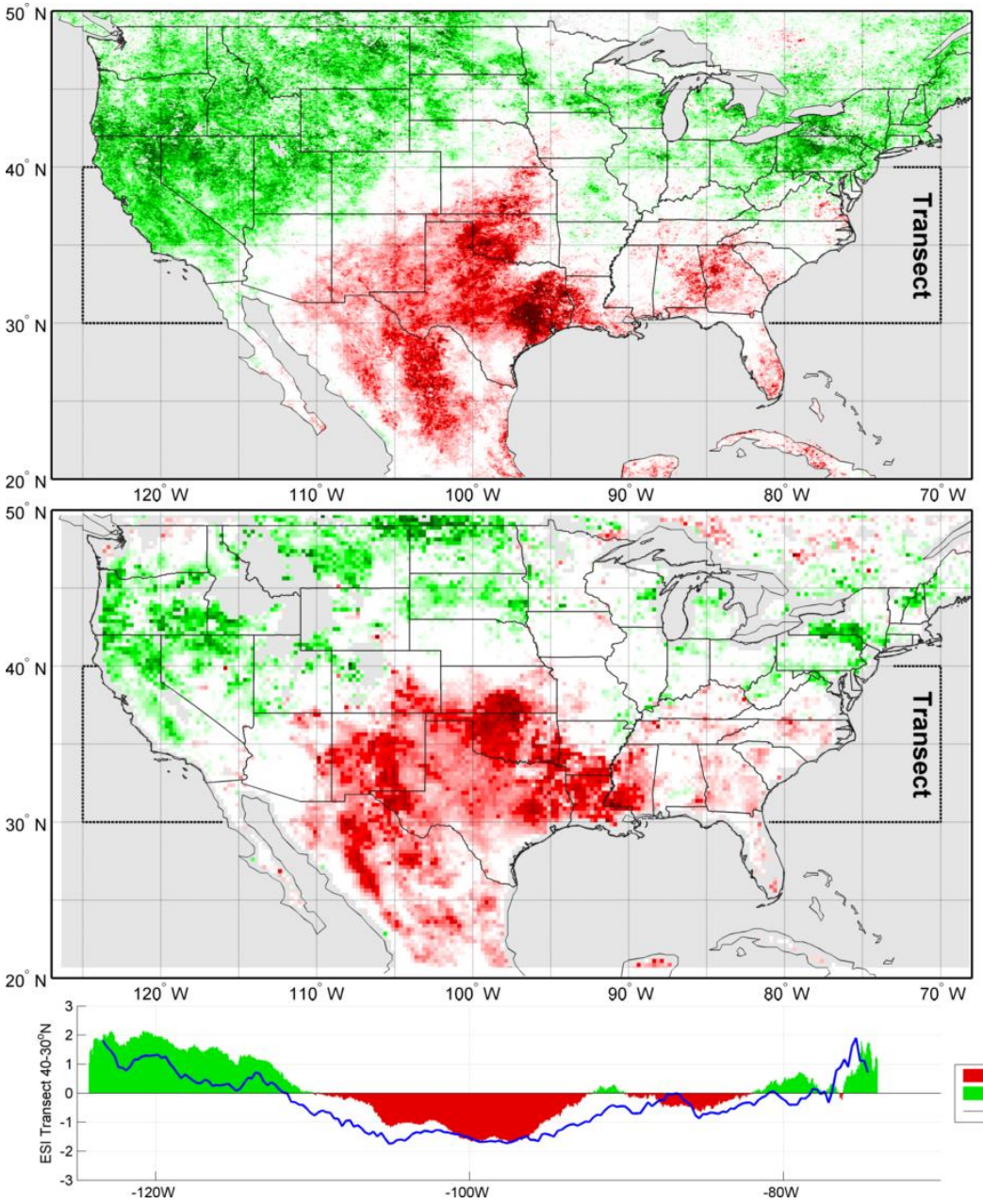
The synergy between TIR and MW observations is further being exploited by the development of LST observations from MW observations(Ka-band).

The integration of MW LST into a coupled TIR/MW ALEXI system will allow for retrieval of surface fluxes under cloud cover (where TIR-only retrievals are not possible).

This capability fills in a significant gap in a TIR-only system over tropical equatorial regions where clear-sky retrievals may only be possible 1 to 3 times per month, particularly during the wet season .



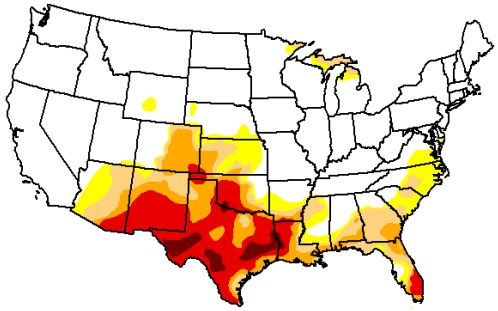
Anomaly analysis with MW-ALEXI
ESI 12week moving window



U.S. Drought Monitor

CONUS

June 7th, 2011



Transition Strategy:

- Thermal-only ESI is already being produced weekly in near-real-time mode at NASA SPoRT – data is available to stakeholders via ftp.
- Merged TIR+MW ESI will be ready for near-real-time production at NASA SPoRT in spring 2018.
- NASA SPoRT will continue to support near-real-time production during the project life cycle while internal funding requests are submitted at NOAA NESDIS to facilitate inclusion of the global ESI into the operational GET-D processing system.
- Feasibility of Google Earth Engine Integration
- **New stakeholders:**
  - NASA SERVIR – ESI will be available to all SERVIR hubs in Fall 2017 via SERVIR's ClimateSERV platform.
  - Regional partners in Czech Republic, Brazil, India, Canada supporting drought monitoring activities

LST-Based Drought Indicators

- Diagnostically captures non-precipitation related moisture sources/sinks (irrigation, shallow groundwater, drainage)
- Provides early warning of on-set of actual vegetation stress
- Provides information about current soil moisture state without the need for knowledge of antecedent precipitation

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Conclusions