An Emerging Remote Sensing Toolkit for Drought Monitoring

Recent Efforts to Improve the U.S. Drought Monitor

Brian Wardlow

Director, Center for Advanced Land Management Information Technologies (CALMIT)
Faculty Fellow, National Drought Mitigation Center (NDMC)
School of Natural Resources
University of Nebraska-Lincoln

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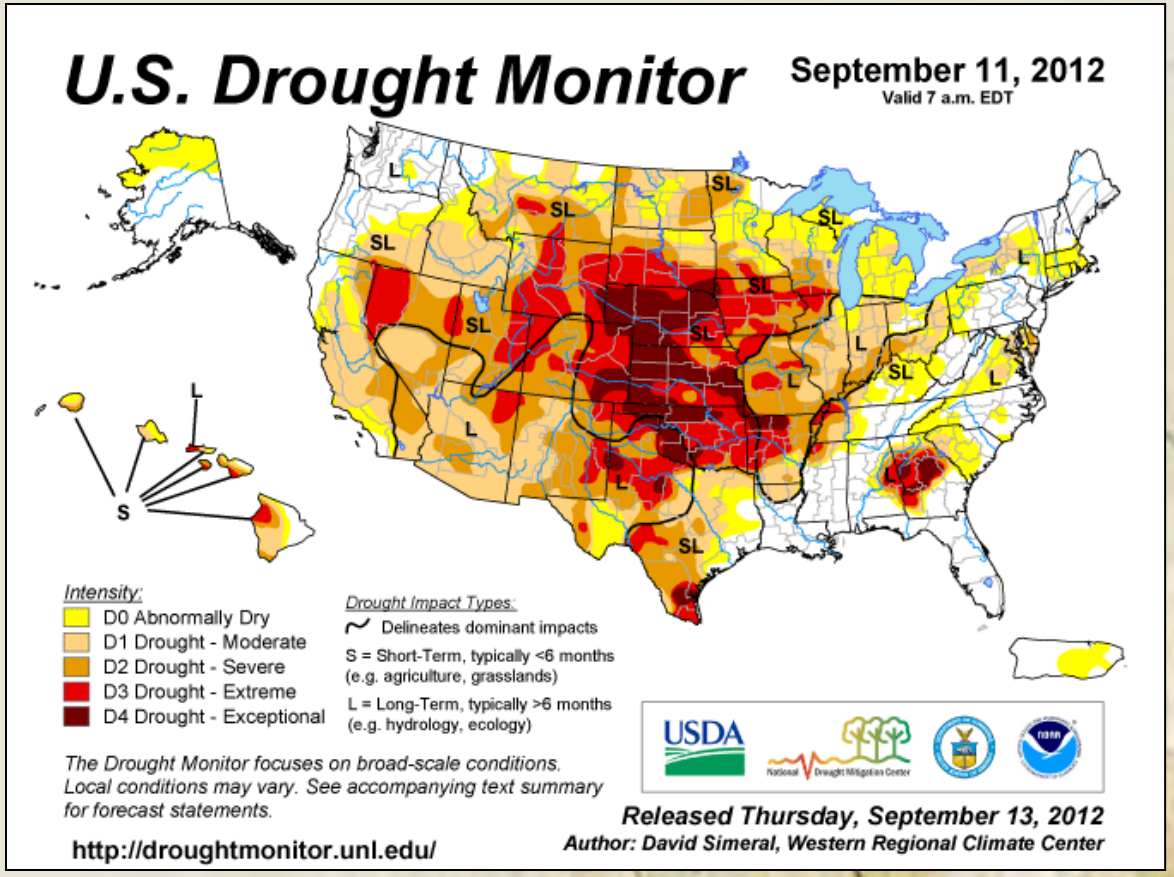
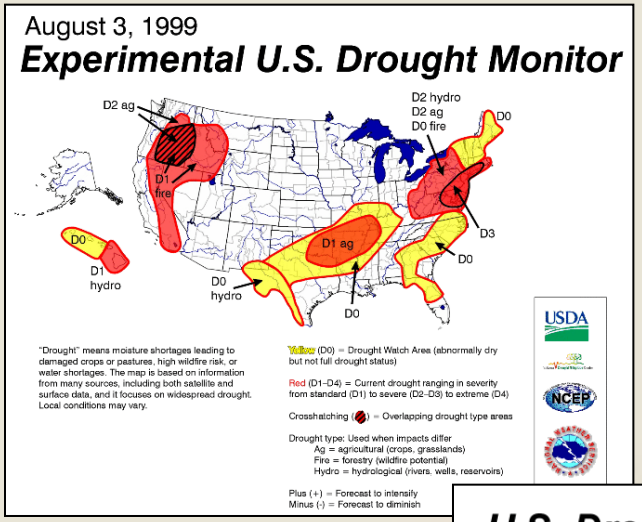
Current State-of-the-Art Drought Monitoring Tool for the United States

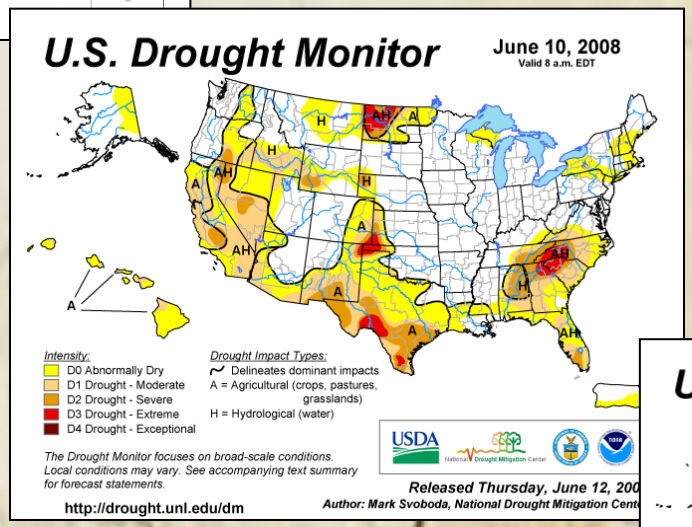


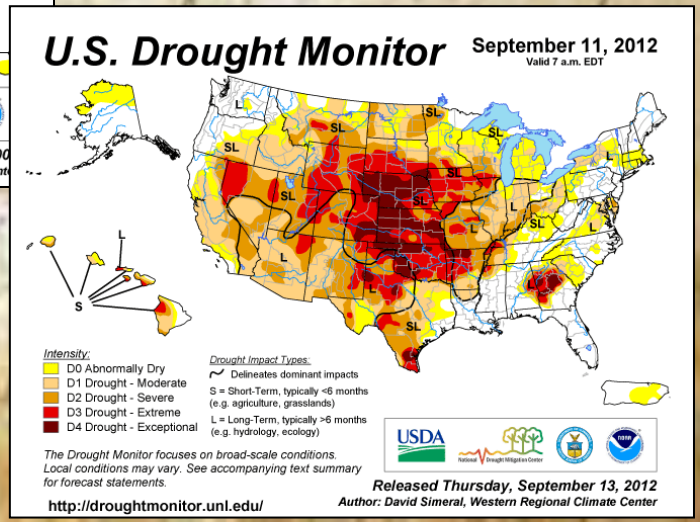
- Weekly map produced since 1999 by NOAA (CPC, NCDC, WRCC), USDA, and the NDMC.
- Composite indicator of both 'short' (S) and 'long' (L) term drought conditions
- Developed through the analysis of many indicators and indices (meteorological, climatological, hydrologic, and ecological) and input from 'experts' on the ground.
- Widely used tool for drought-related decision making:
  - USDA Farm Service Agency (FSA)
  - Internal Revenue Service (IRS)
  - Congressional and White House briefings
  - Media (e.g., major newspapers and television)
  - Federal and state agencies /organizations

Evolution of the USDM

Since the first USDM map in 1999, the geographical depictions and specific classifications of drought (agricultural vs. hydrologic, short- vs. long-term) continue to improve as technology advances and new types of data inputs (including remote sensing) become available.







Examples of Inputs into the USDM

Key Drought Indicators:

- Palmer Drought Index
- SPI
- KBDI
- Modeled Soil Moisture
- 7-Day Avg. Stream flow
- Precipitation Anomalies

Growing Season:

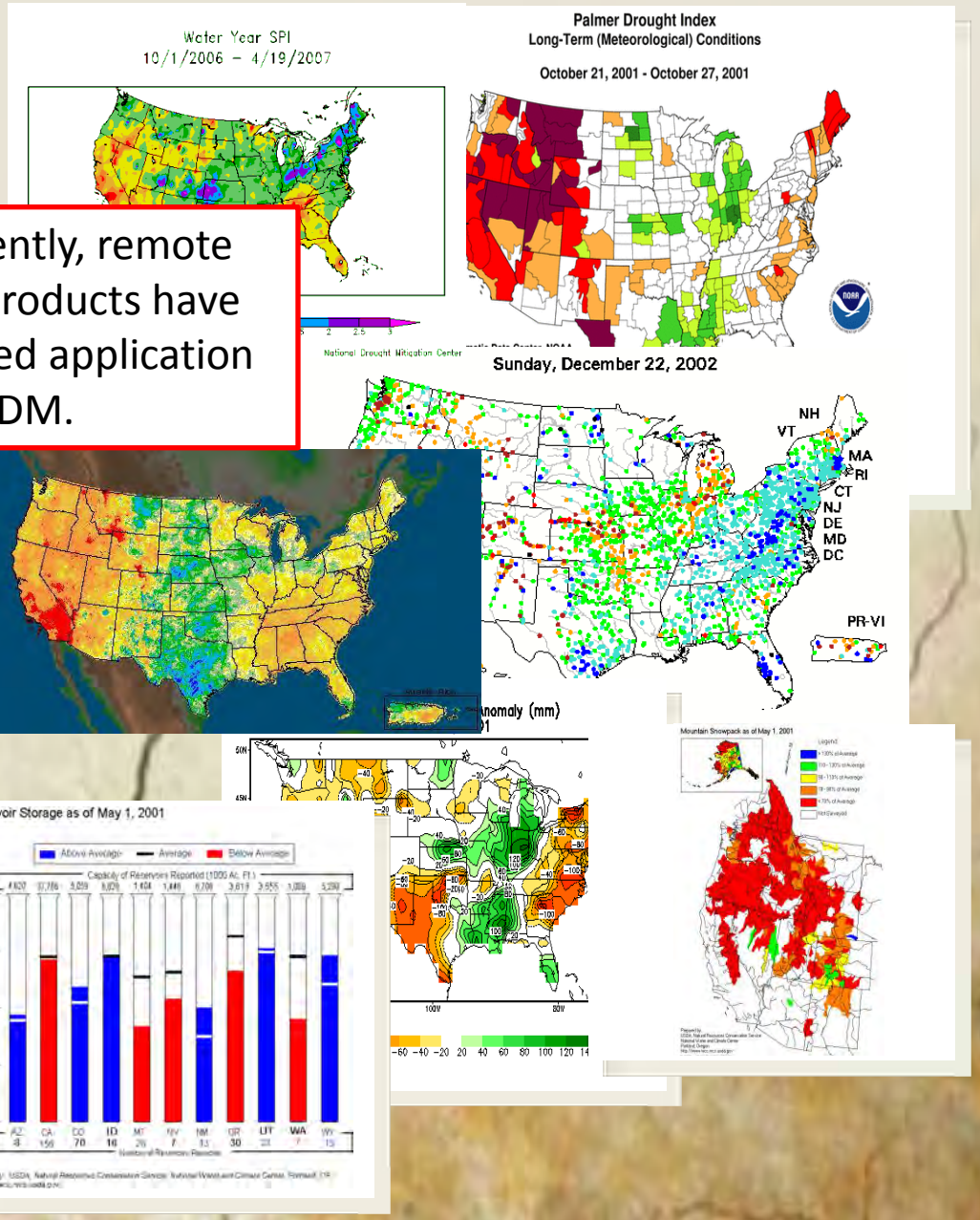
- ~~Crop Moisture Index~~
- Satellite Veg. Health Index
- Soil Moisture
- Mesonet data

In The West:

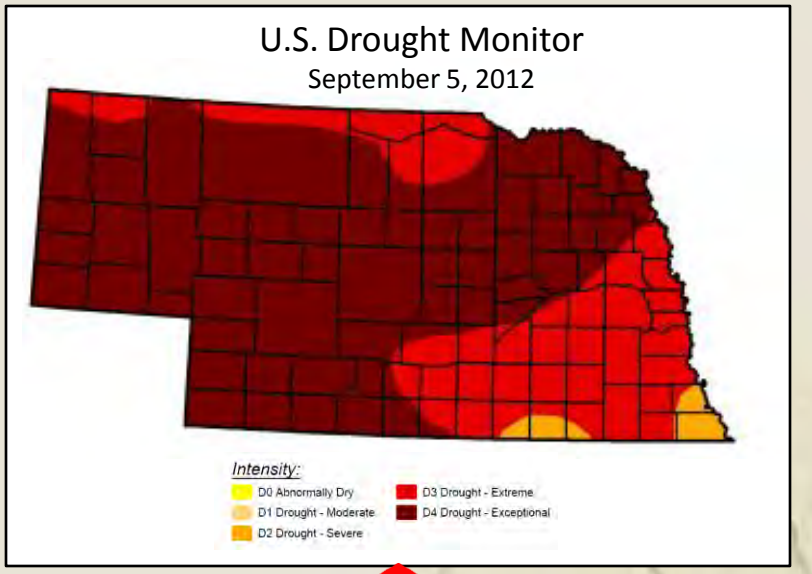
- SWSI
- Reservoir levels
- Snowpack (SNOTEL)
- SWE
- Stream flow

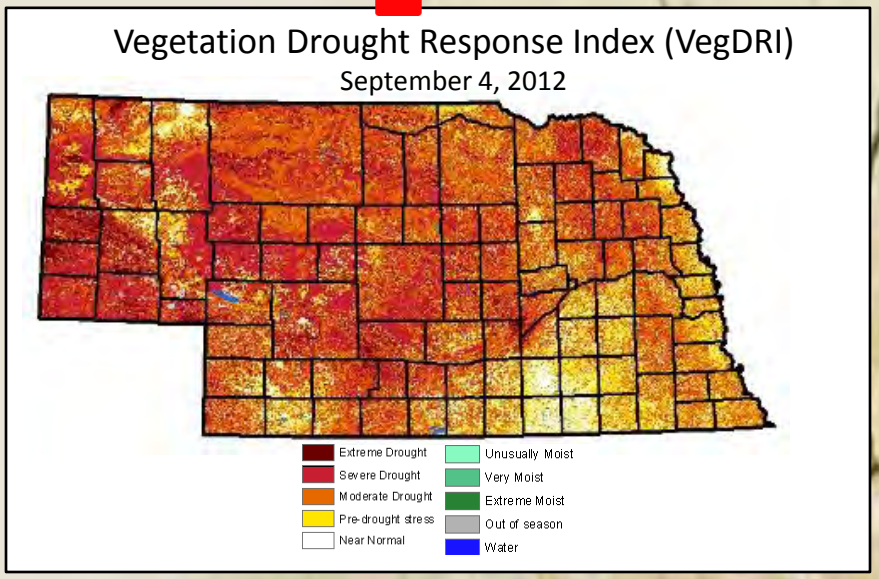
Expert Feedback from the Field

Until recently, remote sensing products have had limited application in the USDM.



What is Needed? - Sharpening the Focus of the USDM





The USDM is increasingly be used for county to sub-county decisions.

Is the spatial precision USDM there yet?

The USDM is improving and will continue to improve with:

- Higher-spatial resolution data inputs
- Increased density of in situ observations and networks of observers/experts

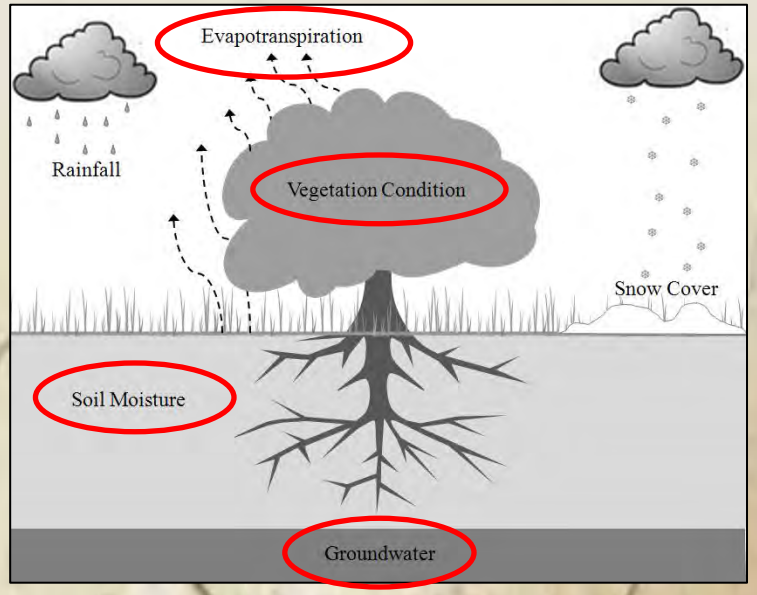
Satellite remote sensing is increasingly being relied upon to fill key informational gaps (e.g., vegetation conditions, water usage, soil moisture, and groundwater) and provide a more detailed snapshot of spatial variations in drought conditions.

New Directions in Remote Sensing of Drought

Since the late 1990's, the capability to monitor and map key components of the hydrological cycle have become possible using satellite remote sensing because of:

1) the launch of many new sensors collecting a wide array of Earth observations,
2) improved computing capabilities, and
3) more advanced modeling and analysis techniques.

Remote Sensing Estimates of:



New Remote Sensing Instruments

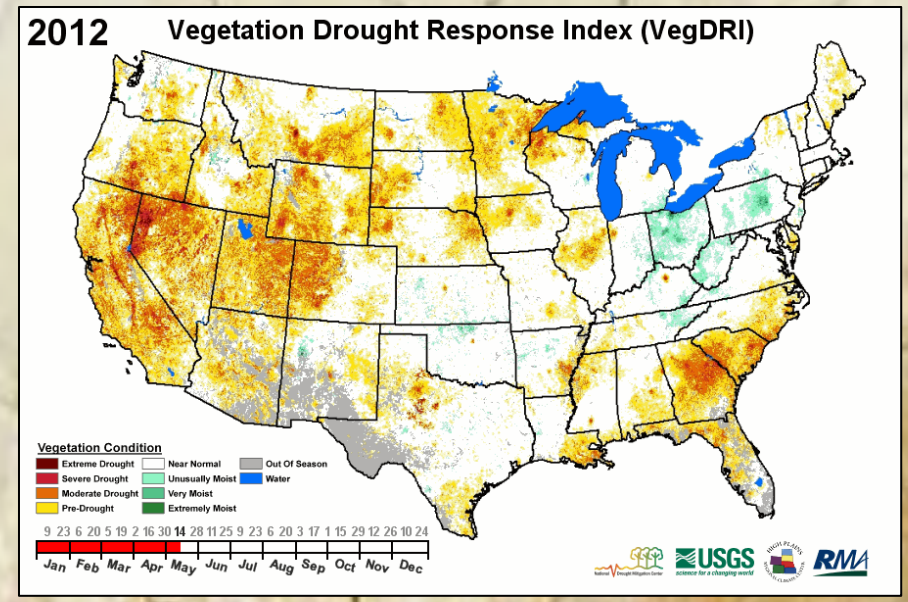
MODIS VEGETATION AMSU AMSR-E GRACE TRMM

Vegetation Drought Response Index (VegDRI)

VegDRI is a 'hybrid' drought index that integrates:

- satellite-based observations of vegetation conditions
- climate-based drought index data
- biophysical characteristics of the environment

to produce 1-km spatial resolution maps that depict ***'drought-related' vegetation stress.***



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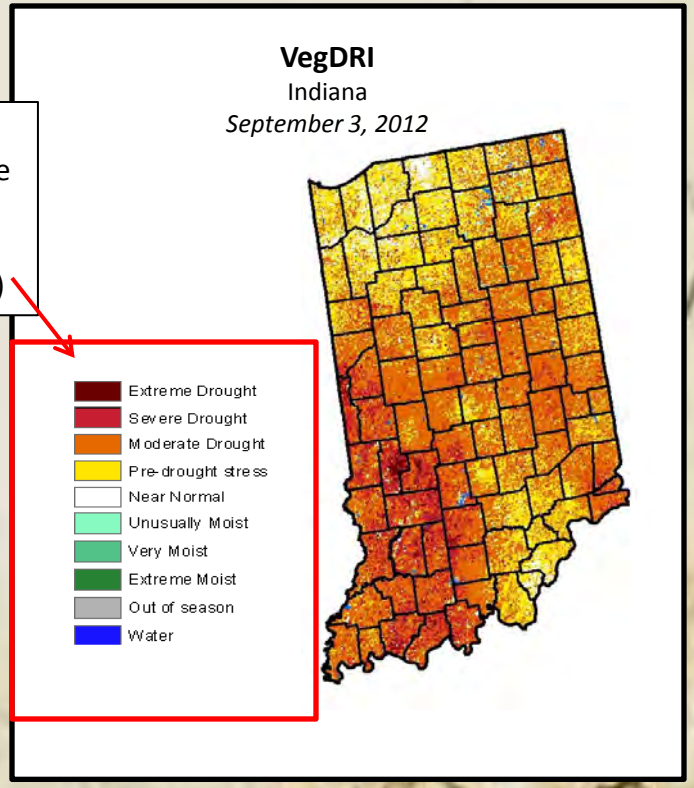
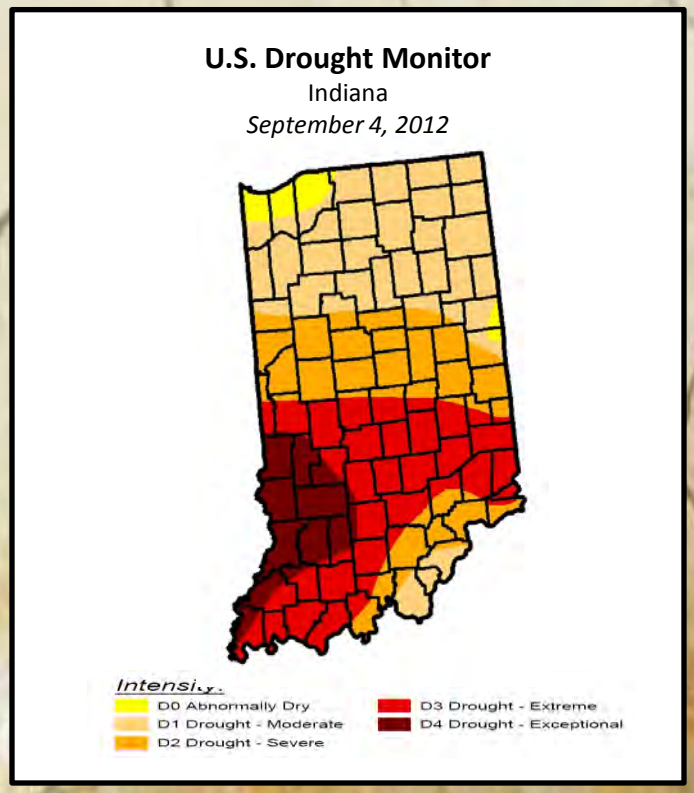
Operational VegDRI

- Weekly updates over continental U.S.
- First incorporated into the USDM in 2008
- Historical 20+ year time series of maps from 1989 to present

Drought severity classification scheme based on modified Palmer Drought Severity Index (PDSI)





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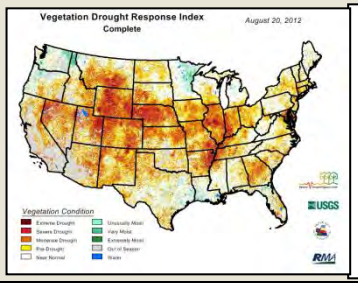
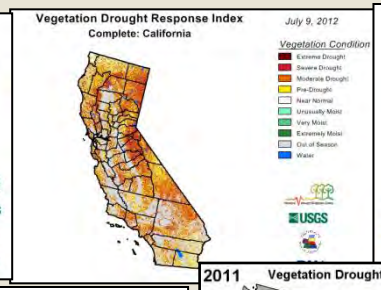
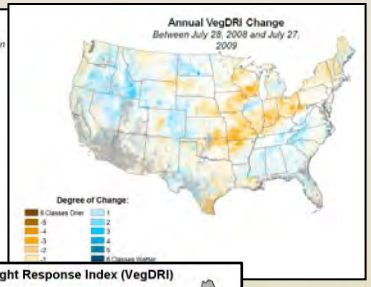
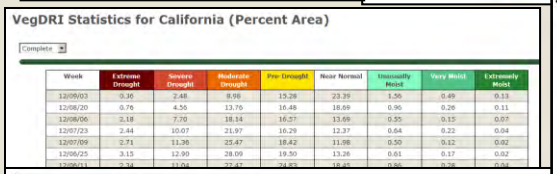
Operational VegDRI Products

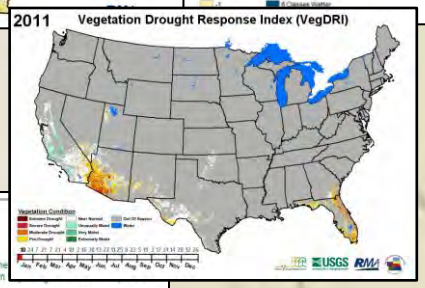
VegDRI Webpage http://vegdri.unl.edu/

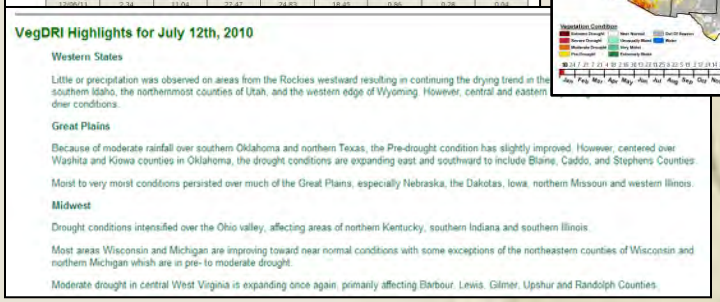








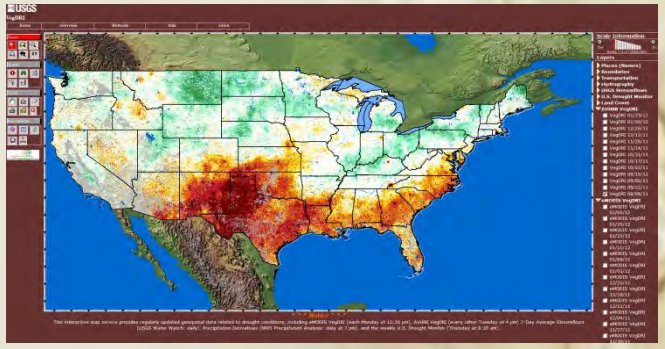




- National, state, and sub-state maps
- Change maps
- Area statistics
- Descriptive map narrative

Examples of Who is Using VegDRI

- USDM
- National Weather Service
- Individual state drought reports
  - Arizona
  - Colorado
  - New Mexico
  - Kansas
- Scientific research community
  - ecological impacts
  - wildfire
  - invasive species



USGS Interactive VegDRI Map Viewer

http://vegdri.cr.usgs.gov/viewer/viewer.htm

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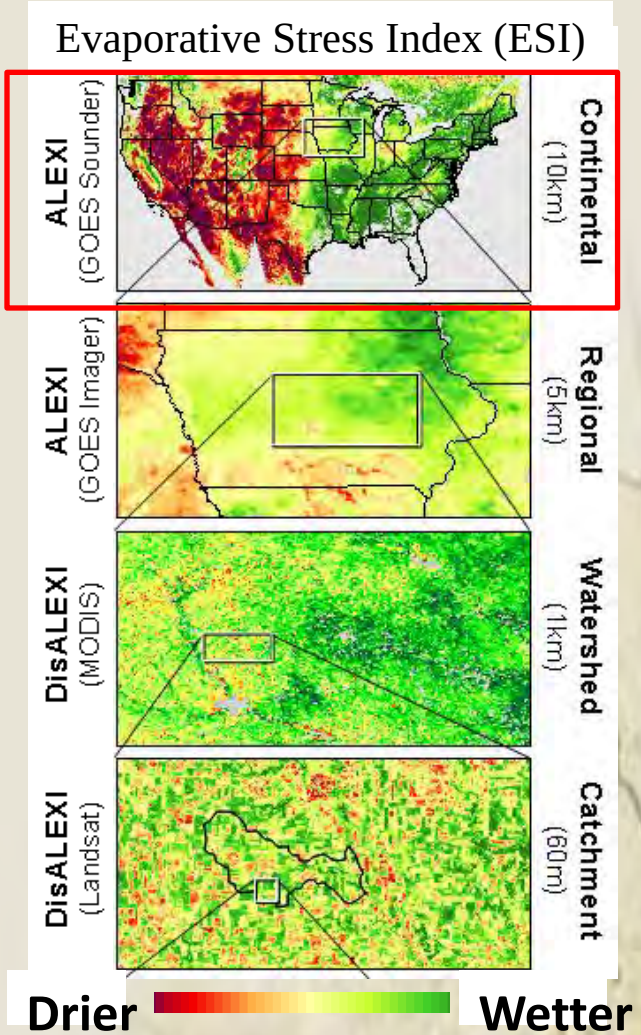
Evaporative Stress Index (ESI)



<u>ESI</u> depicts 'evapotranspiration' flux from vegetation and non-vegetated surfaces (e.g., soils) using thermal observations from satellite in a surface energy balance model.

ESI can be derived separately for the ***vegetation canopy (ESI_c) and soil surface (ESI_s)*** using the a two-source modeling method.

ESI can be calculated from data from many instruments to provide range of ***calculations across multiple spatial and temporal scales.***

<u>*Minutes to Hourly*</u>: GOES- & Meteosat-derived 5- to 10-km ESI maps

<u>*Daily to weekly*</u>: MODIS-derived 1-km ESI maps

<u>*Bi-weekly (16-days)*</u>: Landsat 60- and 120-m ESI maps

Anderson, M.C., C. Hain, B. Wardlow, A. Pimstein, J.R. Mecikalski, and W.P. Kustas. 2011. Evaluation of a drought index based on thermal remote sensing of evapotranspiration over the continental U.S. *Journal of Climate* 24:2025-2044.

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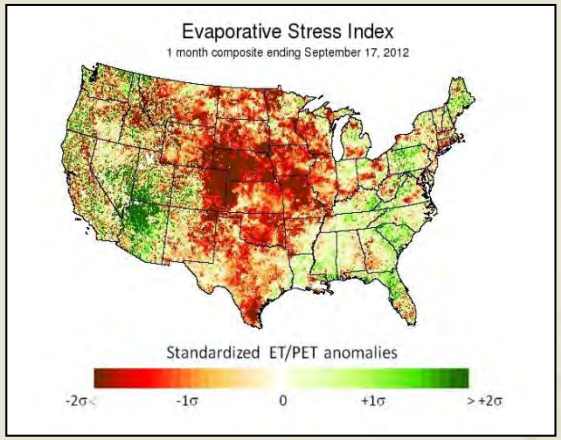
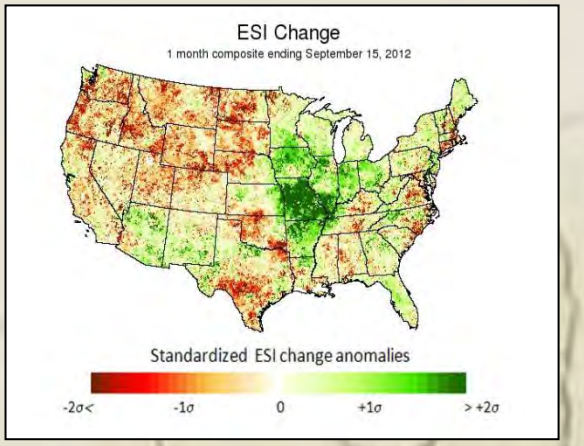
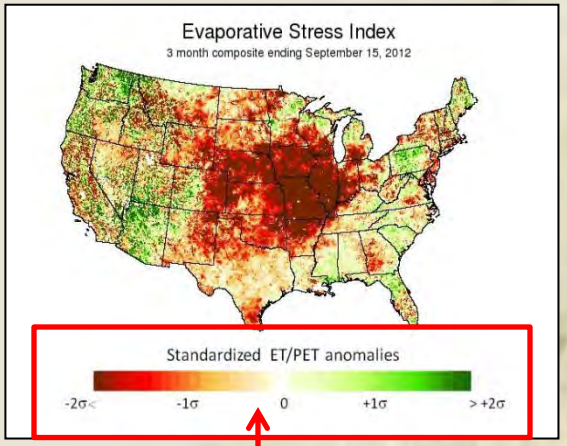
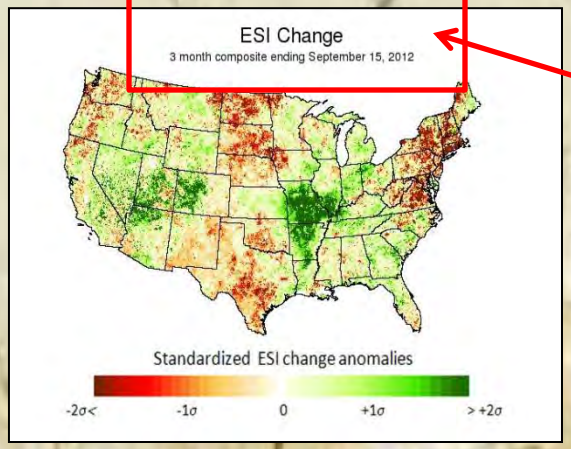
Suite of ESI Anomaly Products









- Weekly, 10-km maps over continental U.S.
- Initial integration into the USDM in 2011
- 12-year historical record of ET-related anomaly products (2000 to present)

Change products over different time intervals (1, 2, and 3 months) to capture shorter and longer-term changes in conditions.

Color scheme compatible with USDM.

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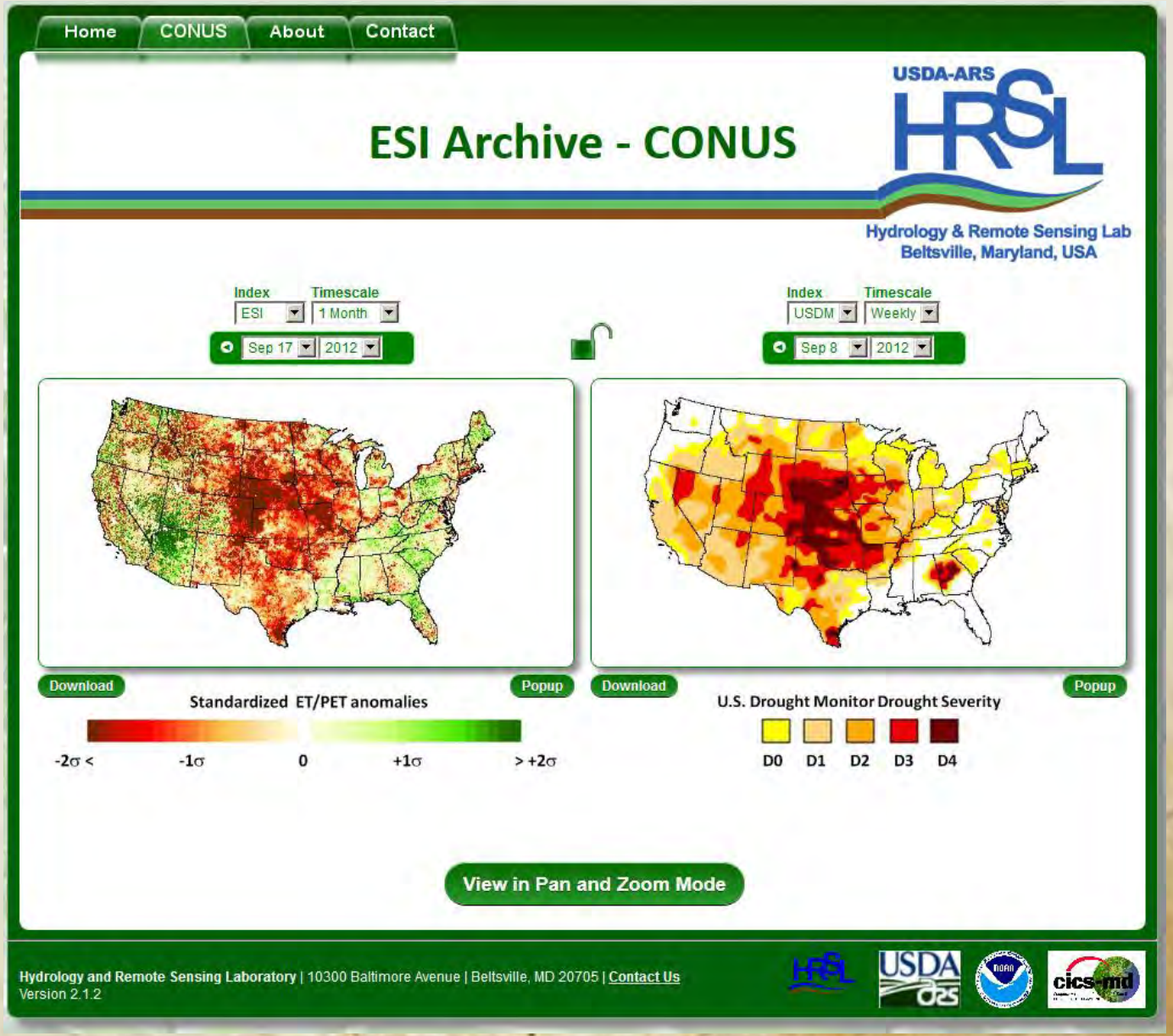


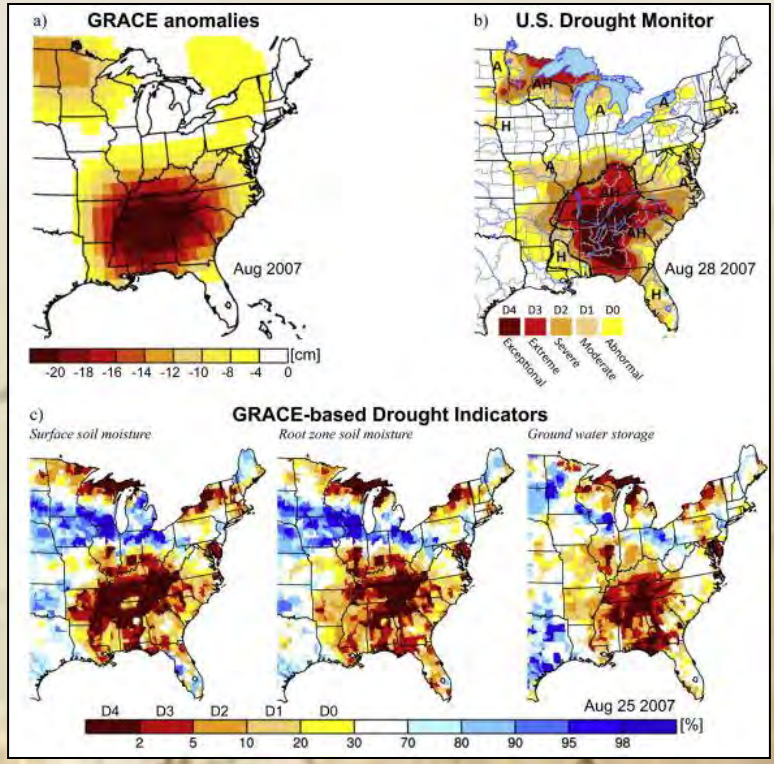
http://hrsl.arsusda.gov/drought/index.php

Terrestrial Water Storage (TWS)

Terrestrial Water Storage (TWS) is the sum of :

1) surface water
2) snow
3) soil moisture
4) groundwater

Soil moisture and groundwater information calculated using sophisticated computer modeling that **combines measurements of TWS from the NASA Gravity Recovery and Climate Experiment (GRACE) observations with meteorological and other biophysical data**.

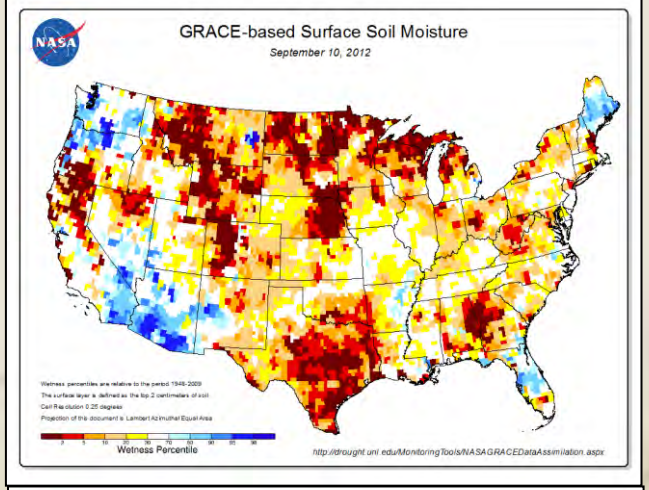


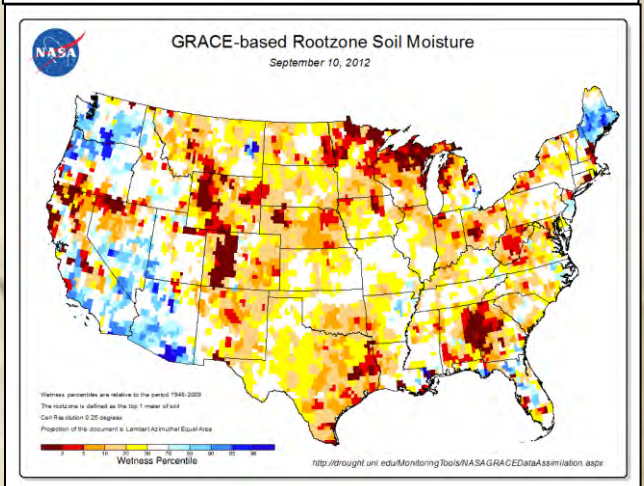
Houborg, R., M. Rodell, B.Li, R. Reichhle, and B.F. Zaitchik. 2012. Drought indicators based on model-assimilated Gravity Recovery and Climate Experiment (GRACE) terrestrial water storage observations. *Water Resources Research* 48, W07525, doi:10.1029/2011WR011291.

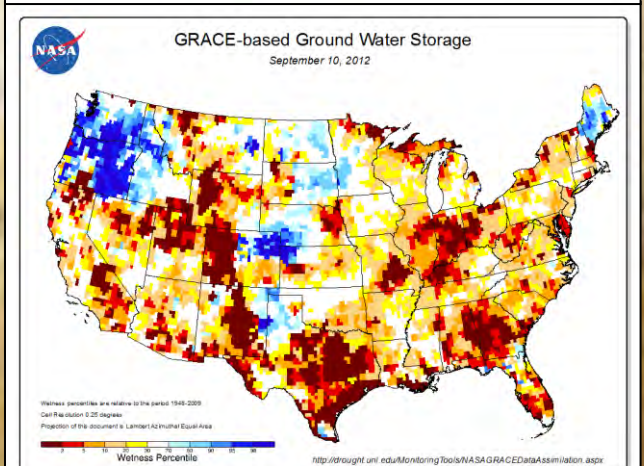
GRACE Hydrologic Drought Indicator Products

- Weekly updated, 0.25-degree maps of **surface and root zone soil moisture and groundwater conditions** over continental U.S.
- Conditions are represented as 'percentiles' that **relate how the 'current' conditions relate to historical conditions over a 64+ year record** (1948 to present).
- First integrated into the USDM in 2011
- Historical time series of GRACE-based products dating back to 2002

GRACE TWS Drought Products Webpage:
http://drought.unl.edu/MonitoringTools/NASAGRACEDataAssimilation.aspx







Final Thoughts

- **Benefit of early engagement of decision makers in remote sensing tool and product development** - more rapid adoption of information into drought monitoring activities
- **Customization of tools and products for drought has fostered a broader group of decision makers using the information.**
- **Continued validation of remote sensing products within a 'drought' context is still needed.** Early feedback is positive, but more thorough and sustained quantitative validation required.
- **Operational product support and the availability of long-remote sensing observations, particularly for research instruments, is an issue.** *Key concern:* Will these operational drought products and the necessary remote sensing data inputs be available in the future?

Thanks for your attention.

For questions and further information, please contact:

Brian Wardlow
402-472-6729
bwardlow2@unl. edu

University of Nebraska Lincoln
CALMIT University of Nebraska - Lincoln Center for Advanced Land Management Information Technologies
National Drought Mitigation Center