

An Emerging Remote Sensing Toolkit for Drought Monitoring

Recent Efforts to Improve the U.S. Drought Monitor

Brian Wardlow

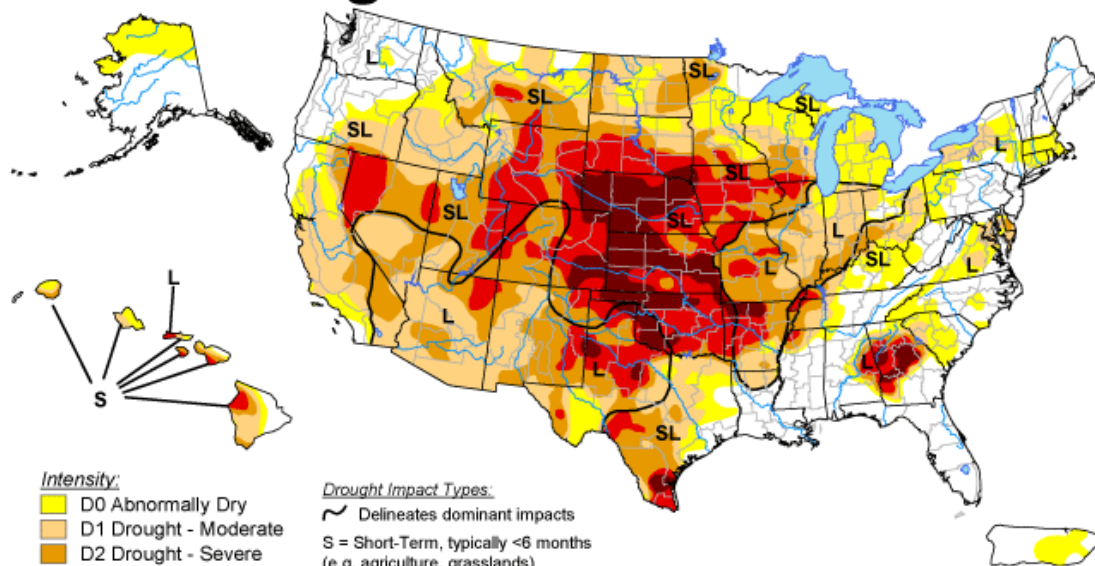
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Remote Sensing Workshop
San Diego, CA
September 27-28, 2012



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

U.S. Drought Monitor September 11, 2012 Valid 7 a.m. EDT



Intensity:

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

Drought Impact Types:

- ~ Delineates dominant impacts
- S = Short-Term, typically <6 months (e.g. agriculture, grasslands)
- L = Long-Term, typically >6 months (e.g. hydrology, ecology)

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

<http://droughtmonitor.unl.edu/>



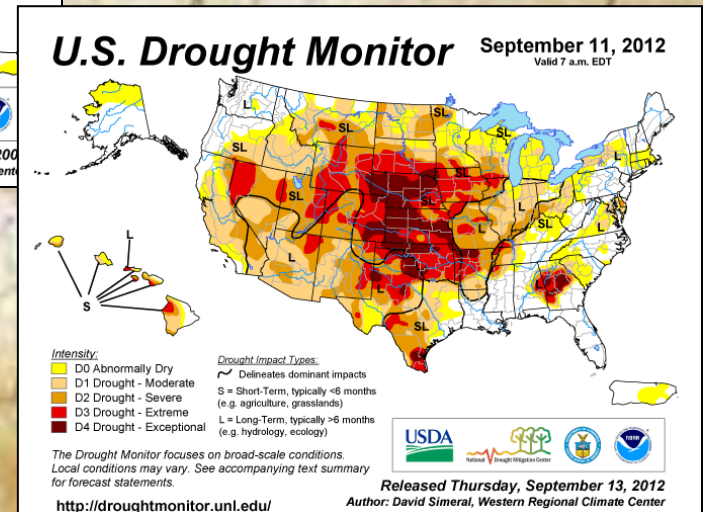
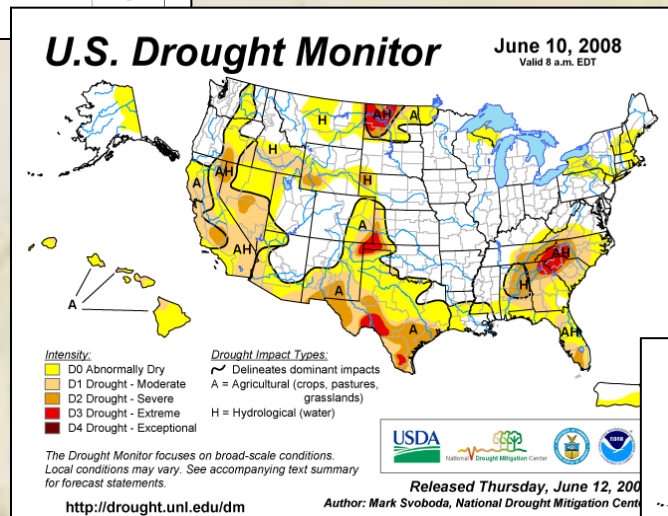
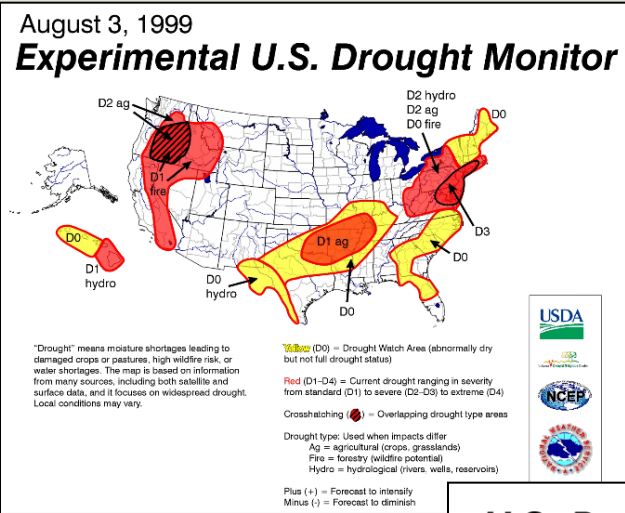
Released Thursday, September 13, 2012

Author: David Simeral, Western Regional Climate Center

- Weekly map produced since 1999 by NOAA (CPC, NCD, 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:

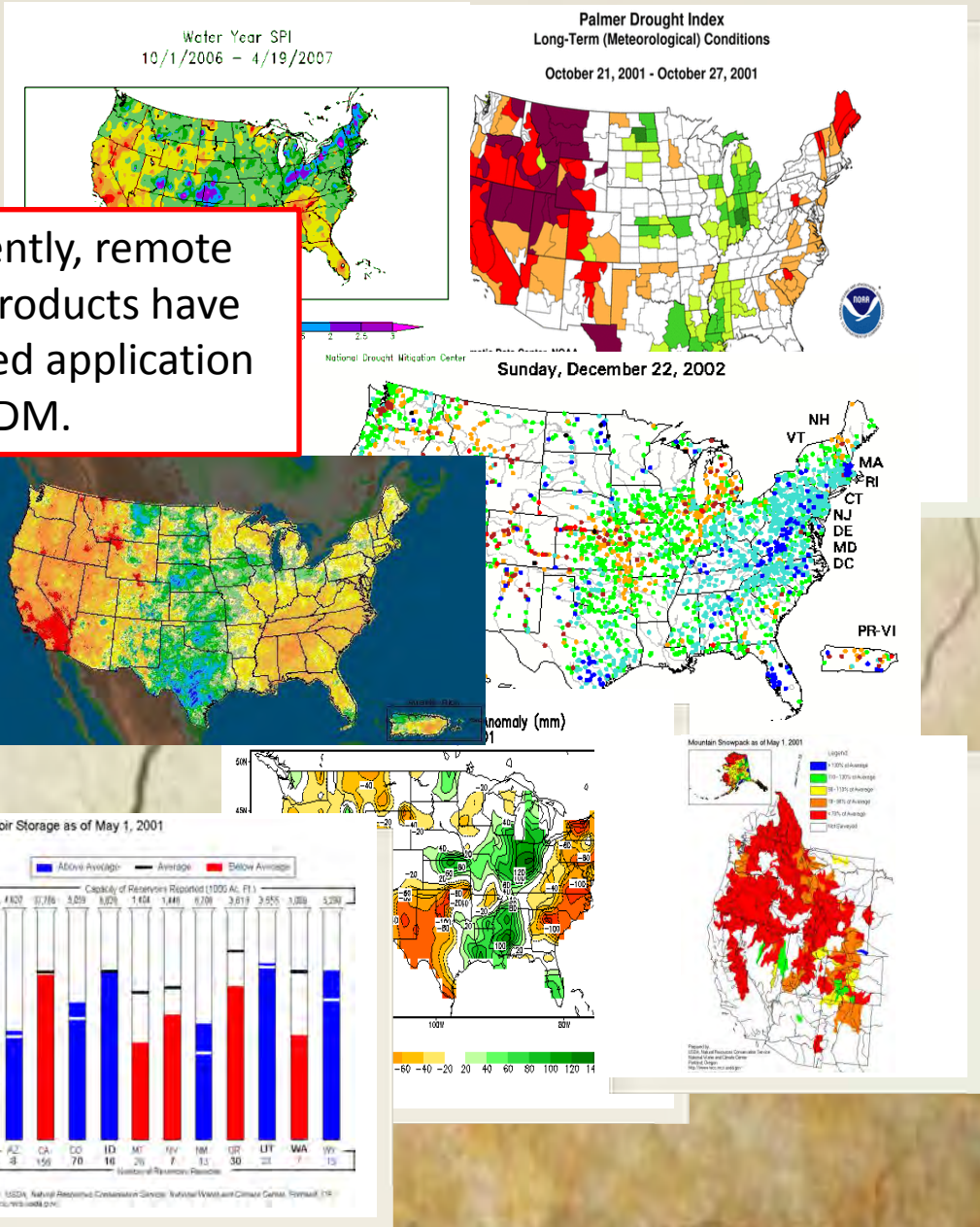
- ~~Crop Moisture Index~~
- **Satellite Veg. Health Index**
- Soil Moisture
- Mesonet data

In The West:

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

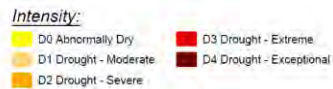
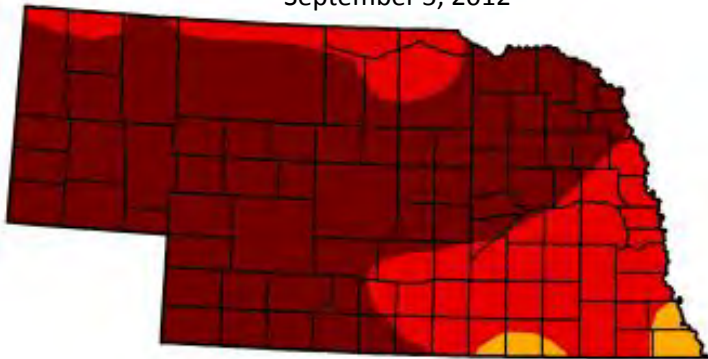
Expert Feedback from the Field

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



What is Needed? - Sharpening the Focus of the USDM

U.S. Drought Monitor
September 5, 2012

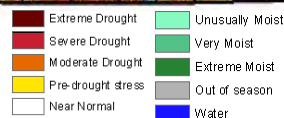


The USDM is increasingly be used for county to sub-county decisions.

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

Vegetation Drought Response Index (VegDRI)
September 4, 2012



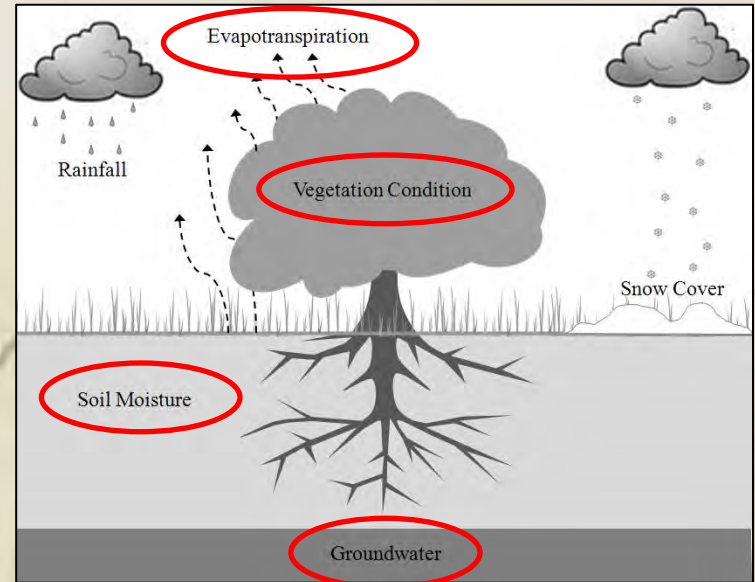
Satellite remote sensing is increasingly being relied upon to fill key informational gaps (e.g., vegetation conditions, water usage, soil moisture, and groundwater) and provide a more detailed snapshot of spatial variations in drought conditions.

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

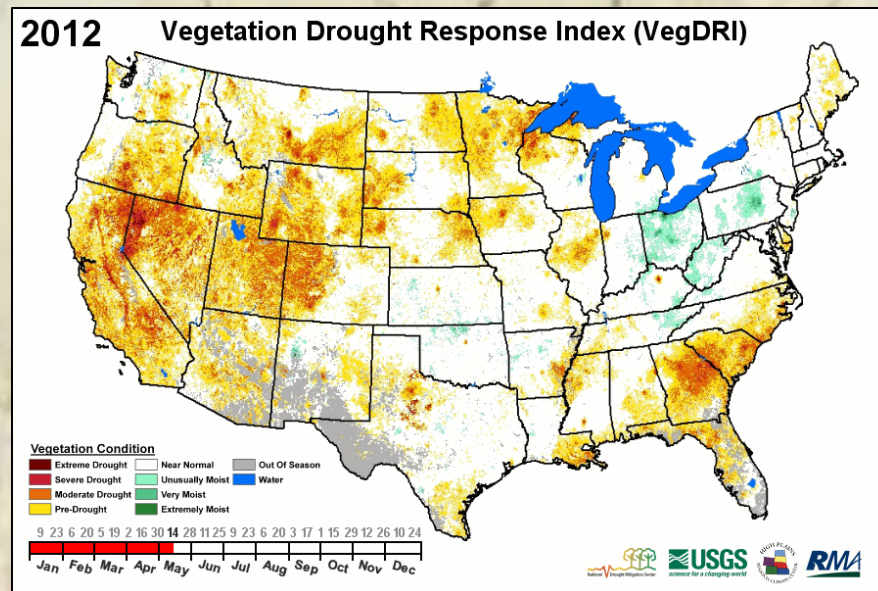


Vegetation Drought Response Index (VegDRI)

VegDRI is a 'hybrid' drought index that integrates:

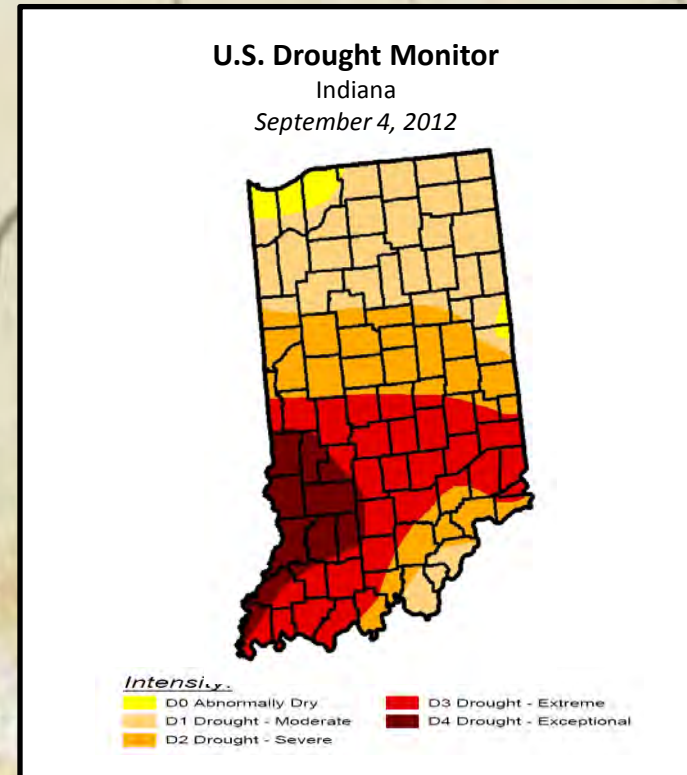
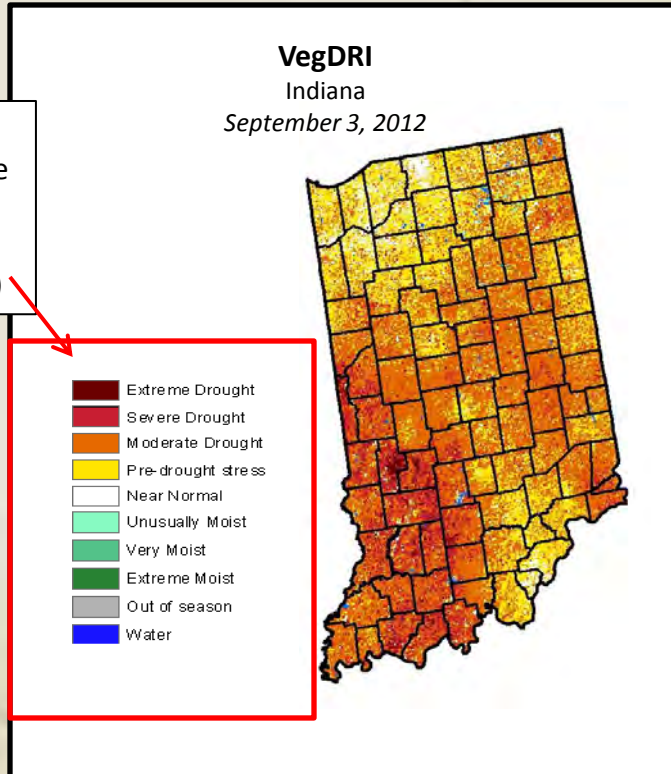
- satellite-based observations of vegetation conditions
- climate-based drought index data
- biophysical characteristics of the environment

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



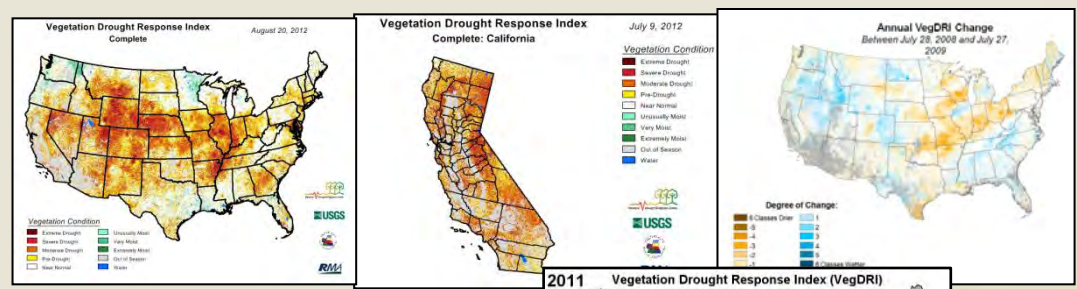
Operational VegDRI

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



Operational VegDRI Products

VegDRI Webpage <http://veg dri.unl.edu/>



VegDRI Statistics for California (Percent Area)

Complete

Week	Extreme Drought	Severe Drought	Moderate Drought	Pre-Drought	Near Normal	Moderately Moist	Very Moist	Extremely Moist
12/09/03	0.36	2.48	8.08	15.29	23.29	1.56	0.49	0.13
12/16/03	0.76	4.30	13.76	16.49	18.69	0.96	0.26	0.11
12/23/03	2.18	7.29	18.84	16.57	13.08	0.52	0.15	0.02
12/30/03	2.44	10.07	21.97	16.29	12.27	0.64	0.22	0.04
12/07/09	2.71	11.36	25.47	18.42	11.08	0.50	0.12	0.02
12/14/09	3.15	12.69	28.09	18.50	11.28	0.61	0.17	0.02
12/21/09	3.15	12.69	28.09	18.50	11.28	0.61	0.17	0.02



VegDRI Highlights for July 12th, 2010

Western States
Little or precipitation was observed on areas from the Rockies westward resulting in continuing the drying trend in the southern Idaho, the northernmost counties of Utah, and the western edge of Wyoming. However, central and eastern drier conditions.

Great Plains
Because of moderate rainfall over southern Oklahoma and northern Texas, the Pre-drought condition has slightly improved. However, centered over Washita and Kiowa counties in Oklahoma, the drought conditions are expanding east and southward to include Blaine, Caddo, and Stephens Counties.

Moist to very moist conditions persisted over much of the Great Plains, especially Nebraska, the Dakotas, Iowa, northern Missouri and western Illinois.

Midwest
Drought conditions intensified over the Ohio valley, affecting areas of northern Kentucky, southern Indiana and southern Illinois.

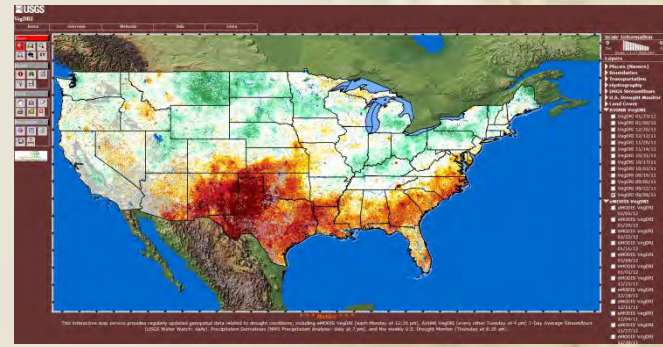
Most areas Wisconsin and Michigan are improving toward near normal conditions with some exceptions of the northeastern counties of Wisconsin and northern Michigan which are in pre- to moderate drought.

Moderate drought in central West Virginia is expanding once again, primarily affecting Harbarbour, Lewis, Gilmir, Upshur and Randolph Counties.

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

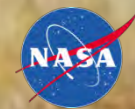
Examples of Who is Using VegDRI

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



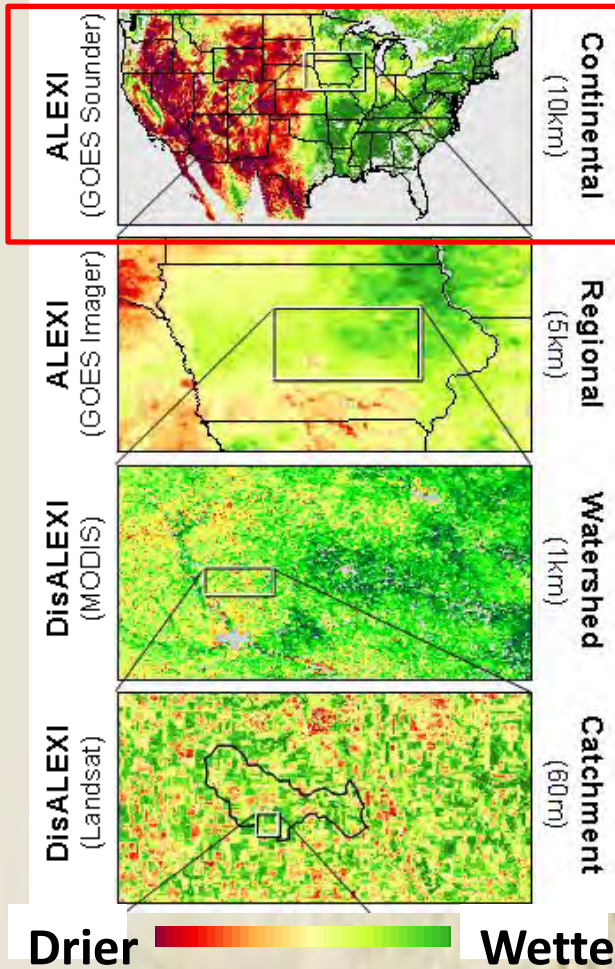
USGS Interactive VegDRI Map Viewer

<http://veg dri.cr.usgs.gov/viewer/viewer.htm>



Evaporative Stress Index (ESI)

Evaporative Stress Index (ESI)



ESI 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*.

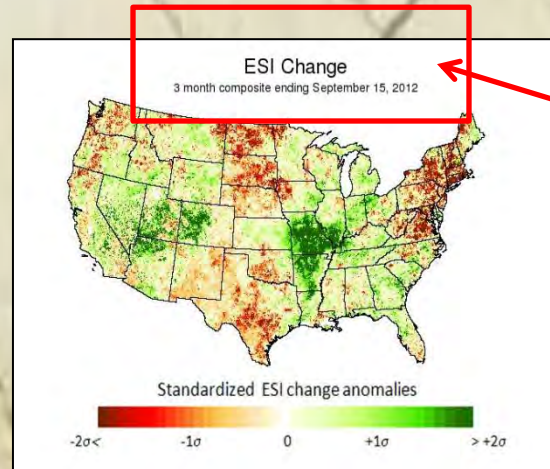
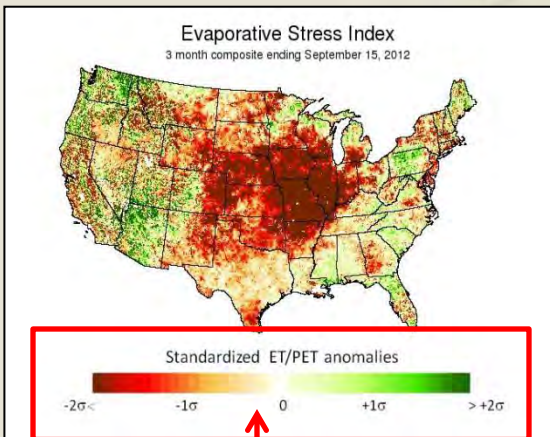
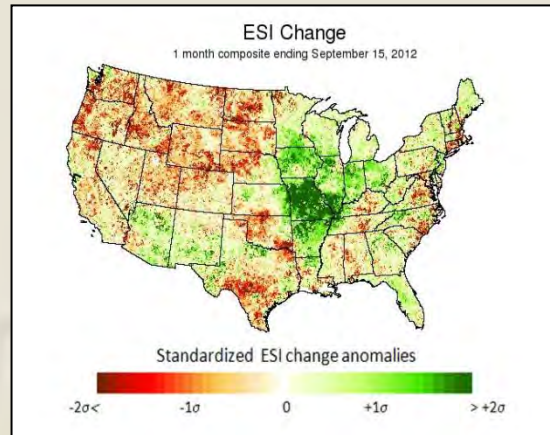
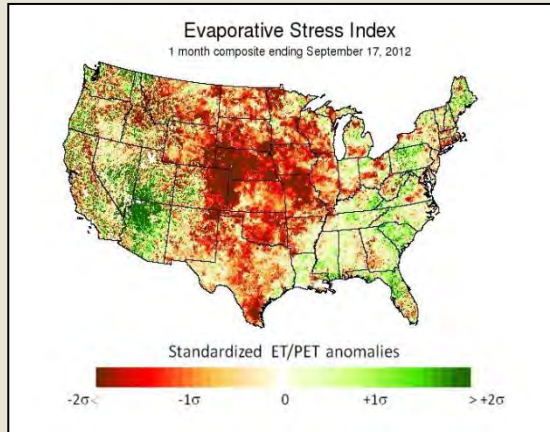
Minutes to Hourly: GOES- & Meteosat-derived 5- to 10-km ESI maps

Daily to weekly: MODIS-derived 1-km ESI maps

Bi-weekly (16-days): 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.

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.



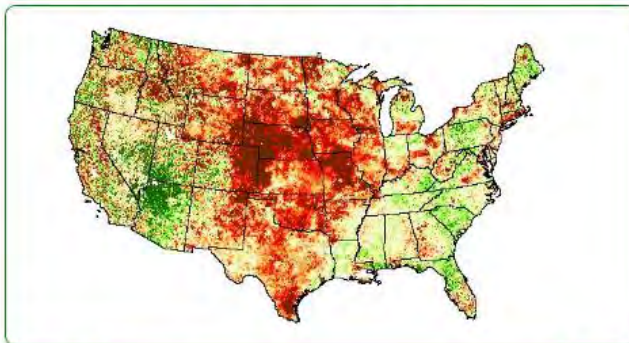
ESI Archive - CONUS



Hydrology & Remote Sensing Lab
Beltsville, Maryland, USA

Index Timescale
ESI 1 Month

Sep 17 2012



Download

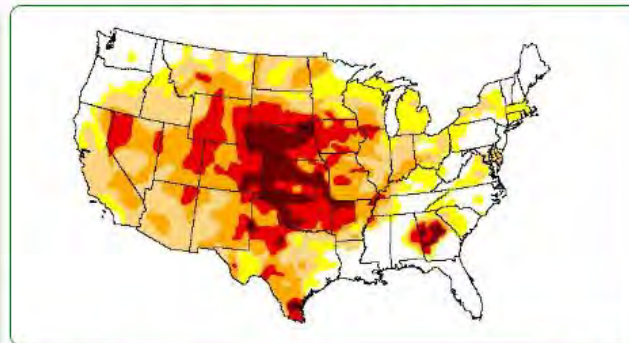
Popup

Standardized ET/PET anomalies



Index Timescale
USDM Weekly

Sep 8 2012



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Popup

U.S. Drought Monitor Drought Severity



View in Pan and Zoom Mode

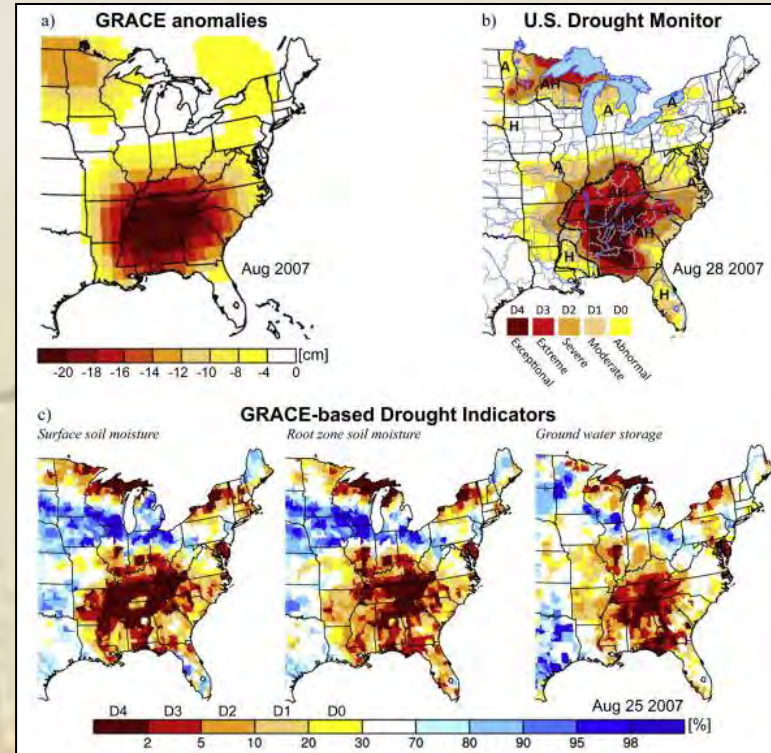


Terrestrial Water Storage (TWS)

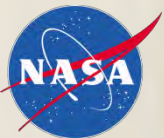
Terrestrial Water Storage (TWS) is the sum of :

- 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. Reichle, 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.

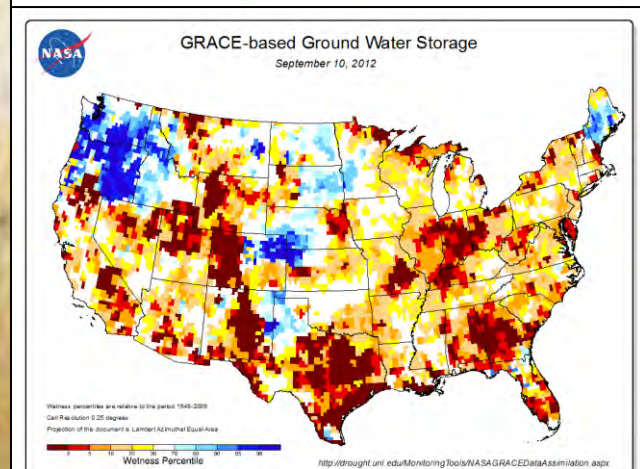
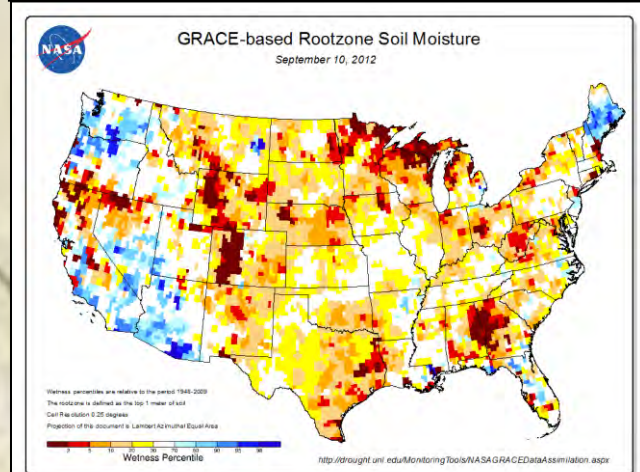
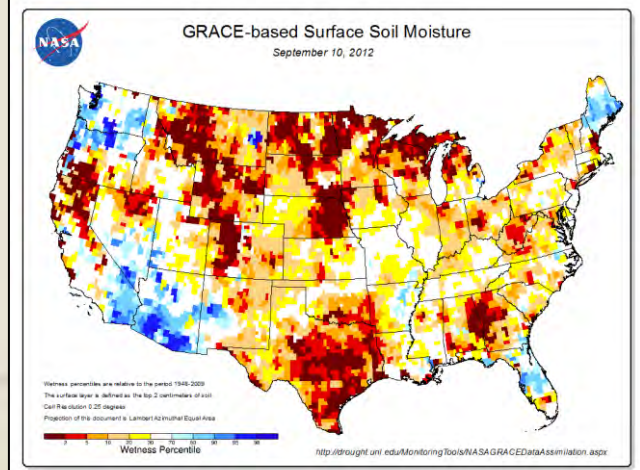


GRACE Hydrologic Drought Indicator Products

- 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
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