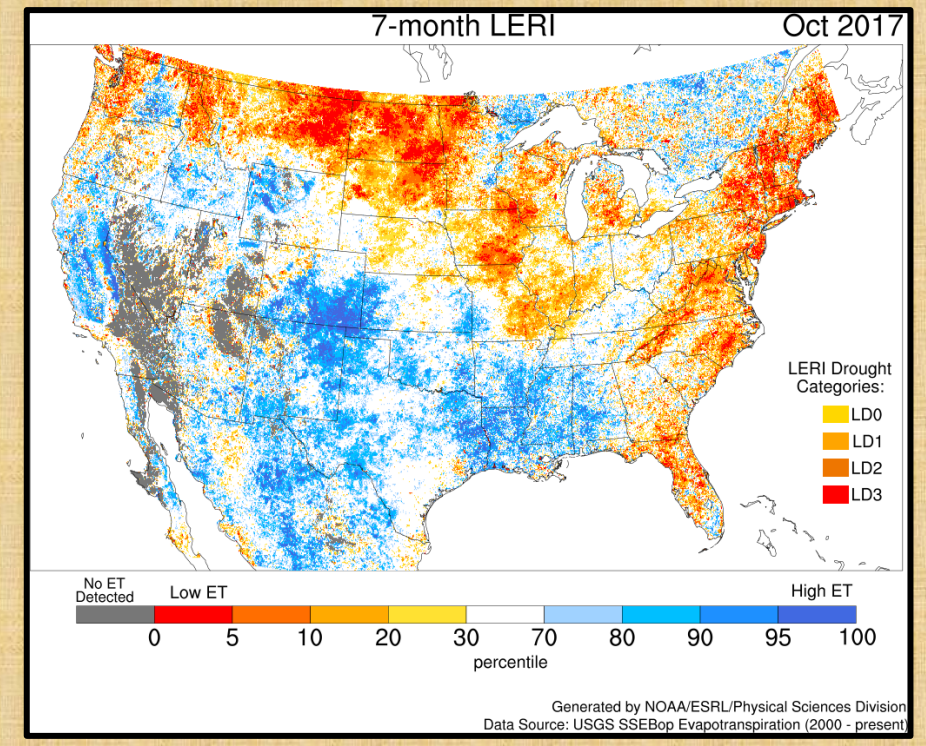
Landscape Evaporative Response Index (LERI)

High-resolution monitoring of evapotranspiration across the Contiguous US

www.esrl.noaa.gov/psd/leri



Imtiaz Rangwala, Lesley L. Smith, Gabriel Senay, Joseph Barsugli, Stefanie Kagone and Mike Hobbins

September 24, 2018
NIDIS Brown Bag

CIRES
Cooperative Institute for Research in Environmental Sciences

Western Water Assessment
A NOAA RISA Team

National Oceanic and Atmospheric Administration
U.S. Department of Commerce

USGS
science for a changing world

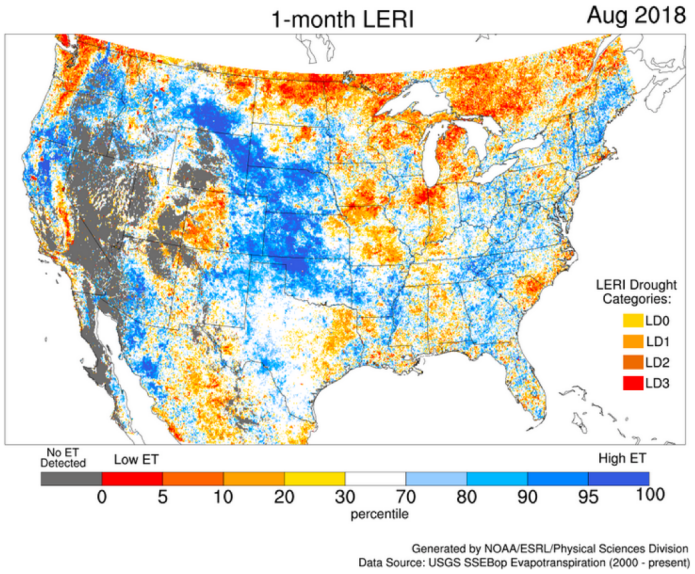
North Central Climate Adaptation Science Center

LERI: A measure of Land Surface Dryness

About

What is LERI?

The Landscape Evaporative Response Index (LERI) is an experimental drought-monitoring and early warning guidance tool that measures the anomaly in the actual evapotranspiration (ET_a) from the land surface. This webpage provides LERI plots based on accumulated monthly, seasonal, growing season, and annual ET_a for the contiguous United States and northern Mexico at a 1-km spatial resolution. LERI data are available from January 2000 to the present — a period that corresponds to the availability of MODIS satellite data on which it depends.



How To Read these LERI Maps

ET_a is the sum of transpiration from vegetation and evaporation from soil (and water bodies), and is accumulated over a given time period for a given location. The ET_a data on which LERI is based are produced by the U. S. Geological Survey using the operational Simplified Surface Energy Balance (SSEBop) model (Senay et al., 2013). SSEBop combines evapotranspiration fraction (i.e., the ability of the land surface to meet the atmospheric demand for water vapor, expressed as a proportion of that demand) generated from remotely sensed MODIS thermal imagery, acquired every 8 days, with climatological atmospheric evaporative demand as represented by reference evapotranspiration derived using the Penman-Montieth formulation and driven by from University of Idaho's Gridded Surface Meteorological Data for that period.

What is LERI?

- An experimental drought-monitoring and early warning guidance tool based on a high-resolution, remotely-sensed (MODIS) evapotranspiration response from the land
- LERI represents the relative evaporative response from the land at 1-km
- By its design, LERI largely reflects the anomalous state of land-surface moisture (i.e., soil moisture) that is readily accessible to plants (for transpiration) and the atmosphere (for evaporation from bare soils and water bodies)
- LERI is available from January 2000 to the present
- LERI is available as maps (and associated data) and historical time series for a user selected domain

Strengths of LERI

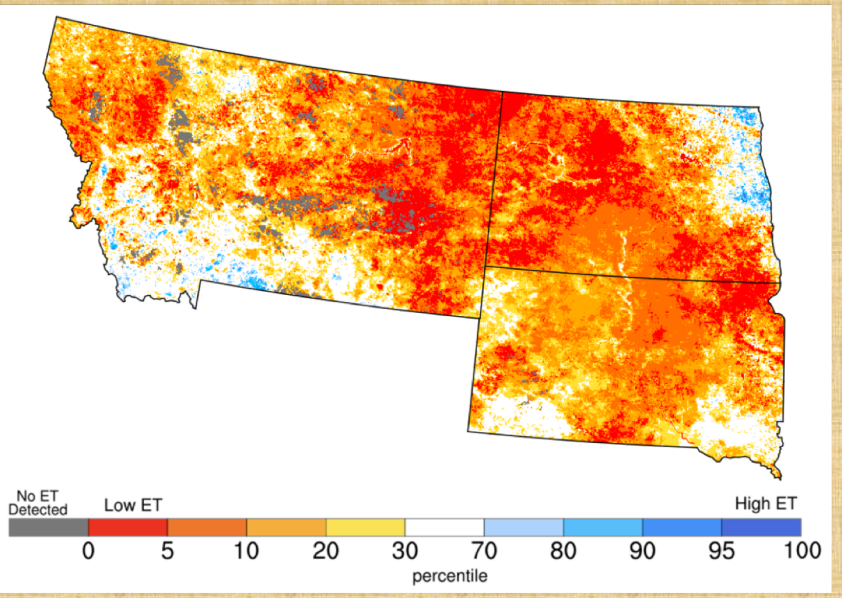
- Direct Observations
- High Resolution (1km)
- Monitoring/Situational Awareness ability with with 1 week latency – Drought Early Warning potential
- Gets us “relative” soil moisture anomalies

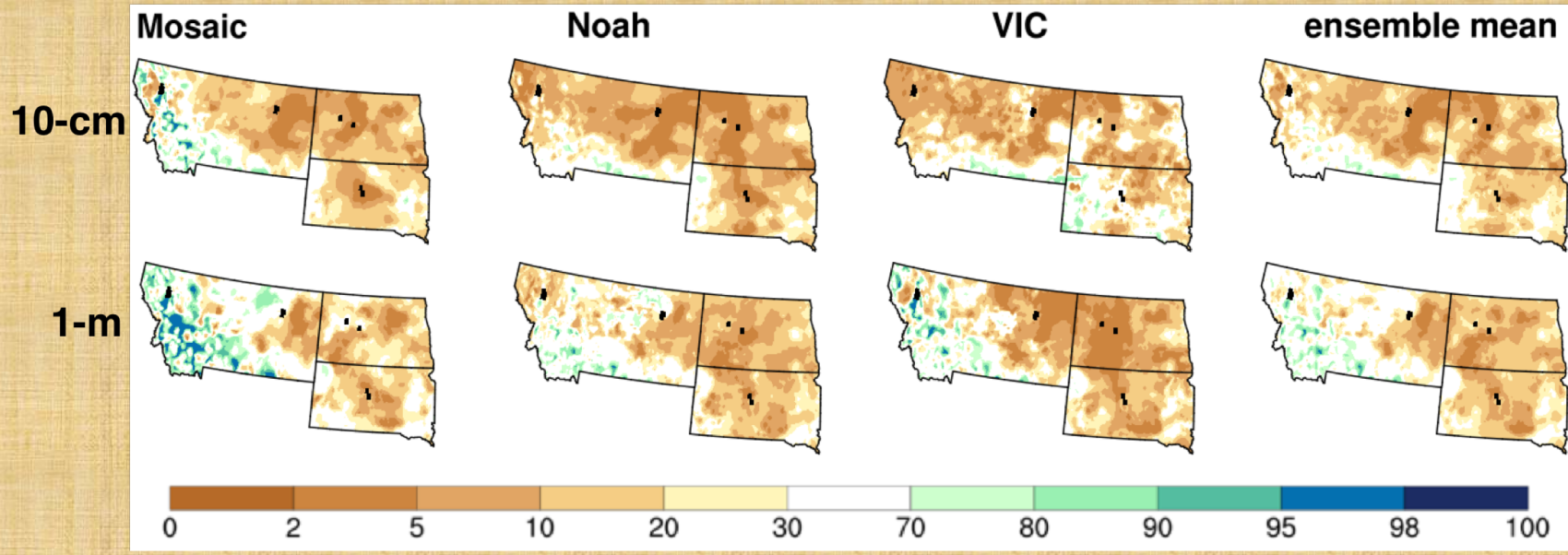
… and potential limitations

- Shorter record (2000-present) to assess relative anomalies
- Possibility of missing data from Remote Sensing
- Temperature calibration could be enhanced
- New --- needs more verification of the tool

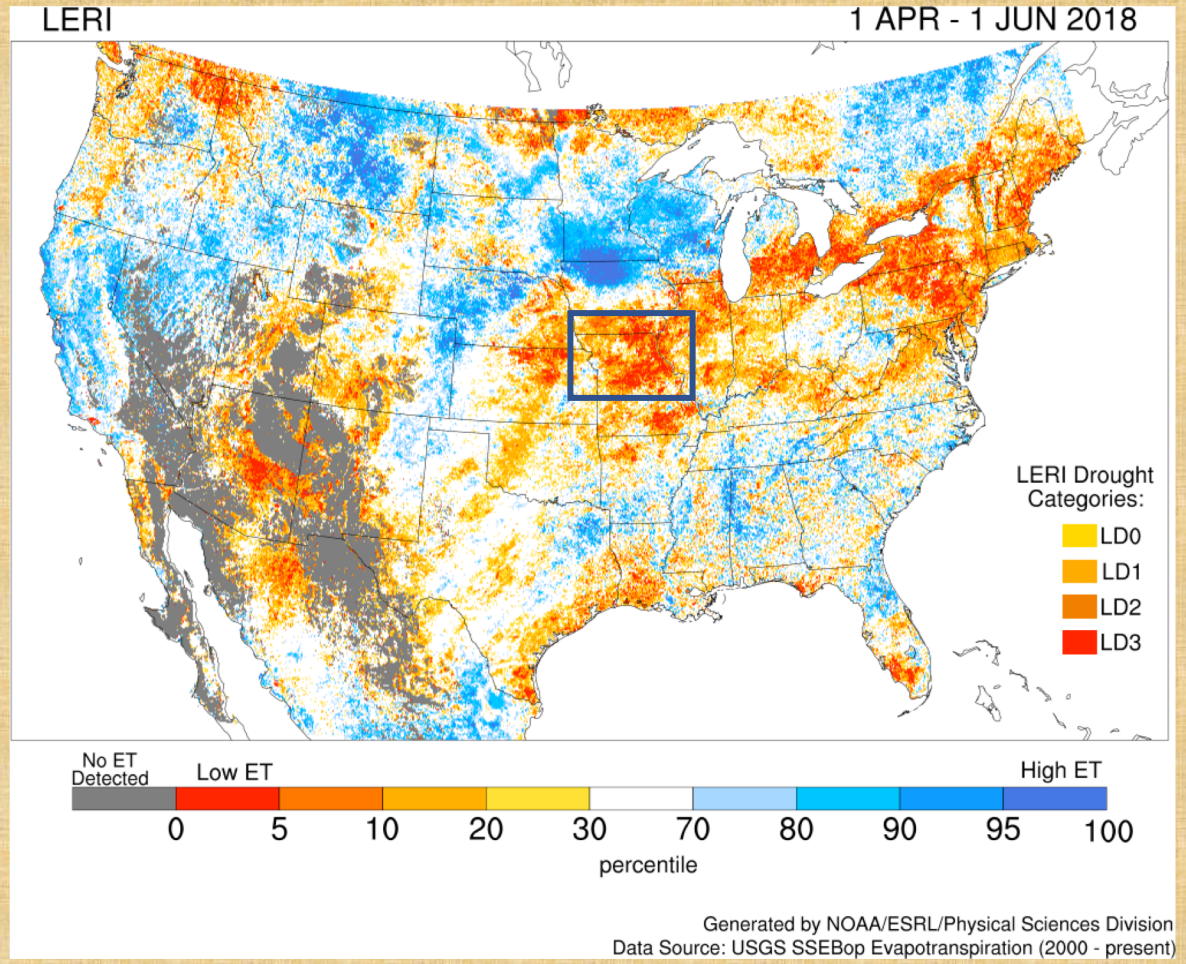
LERI is found to more closely track moisture anomalies in top soil layers

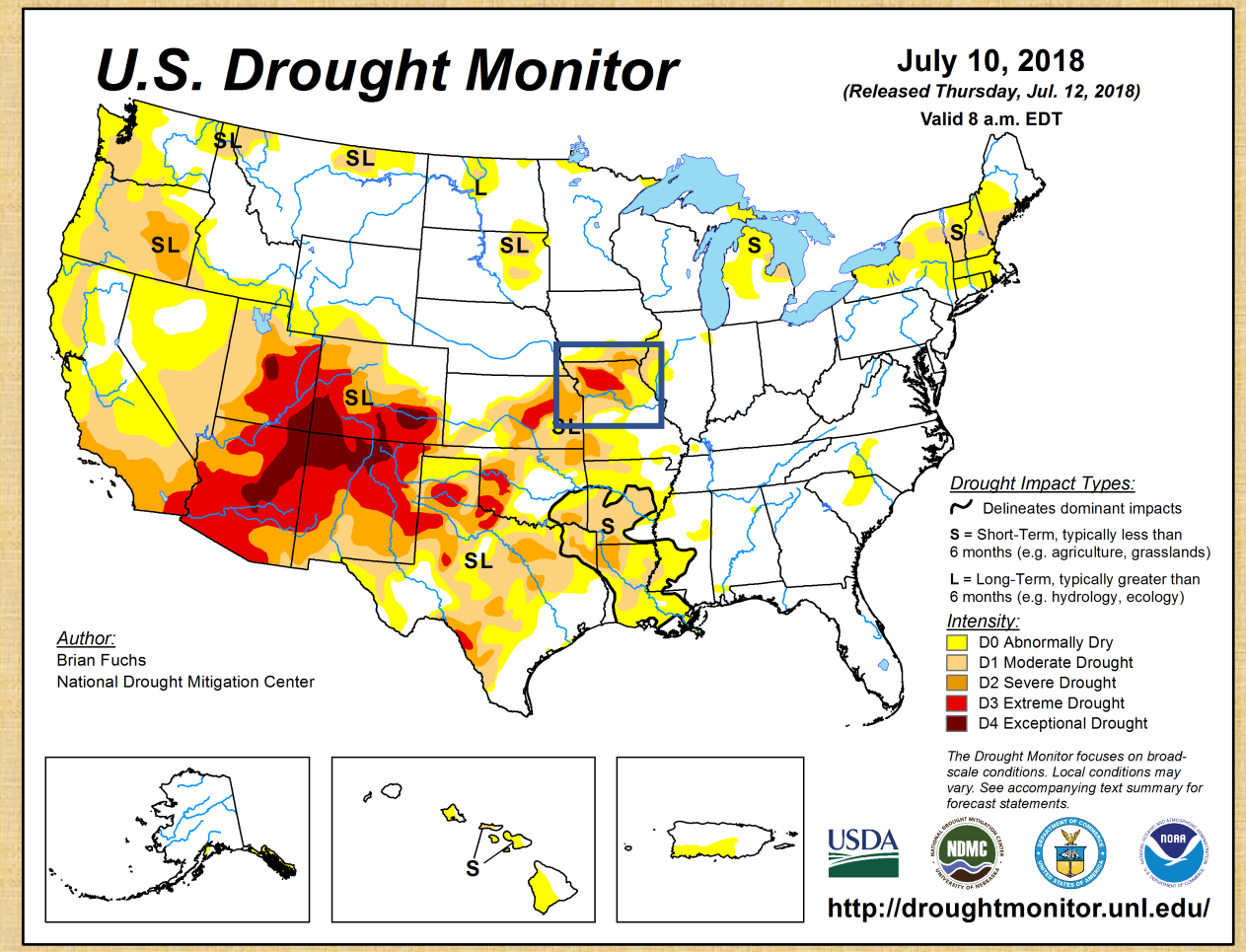
Map Below: LERI compared to NLDAS 10-cm and 1-m (modeled) soil moisture for July 2017





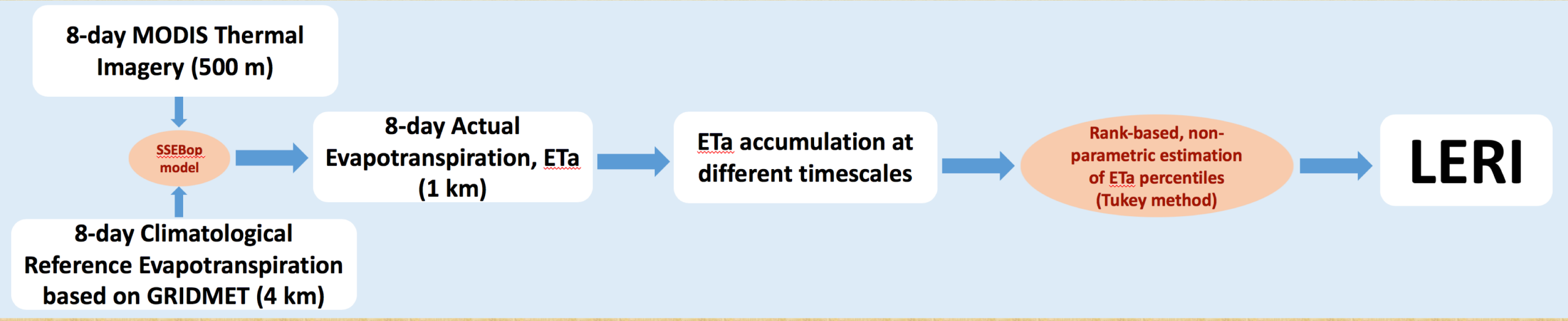
LERI: Drought Early Warning Potential





Example: LERI identifying extreme drought stress in northern Missouri in the summer of 2018 more than a month earlier before it get reported in the U.S. Drought Monitor

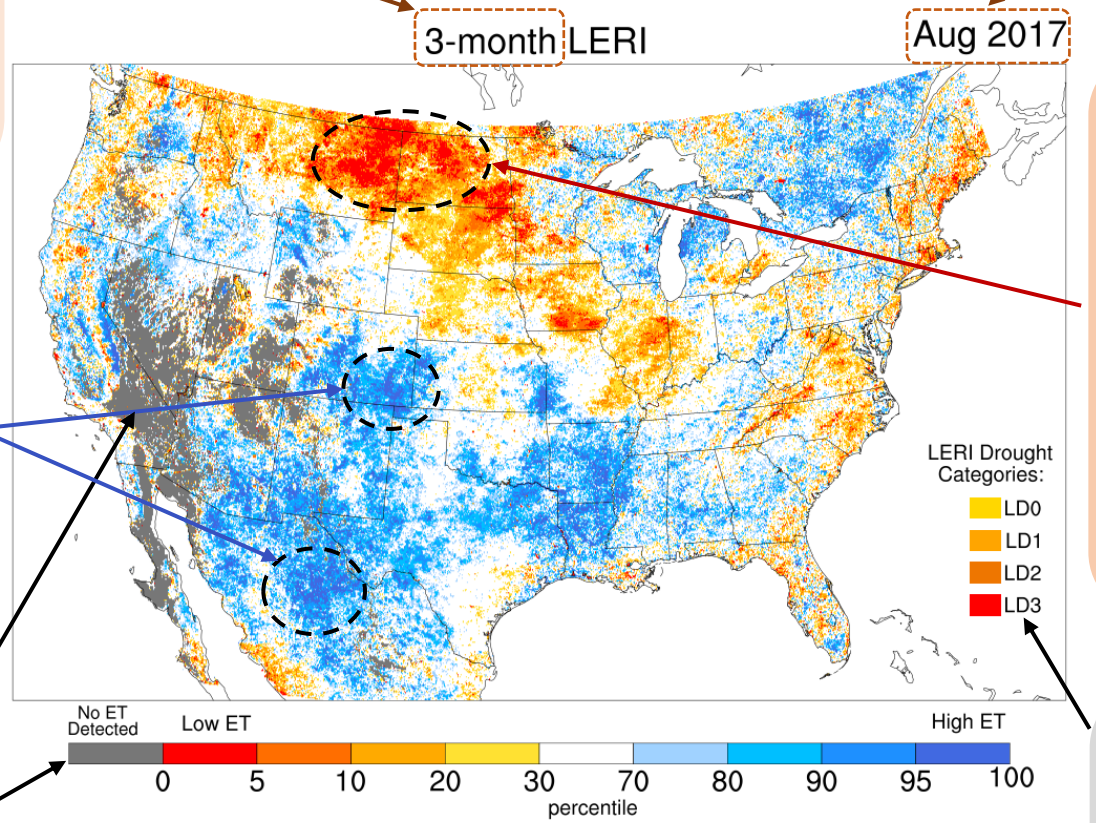
How is LERI calculated?



Reading a LERI map

Time length of ET_a accumulation. This map shows the percentiles for a 3-month accumulated ET_a (Jun 1 - Aug 31, 2017) relative to the period of record (Jan 2000-present)

Date or month & year for which the LERI map is generated



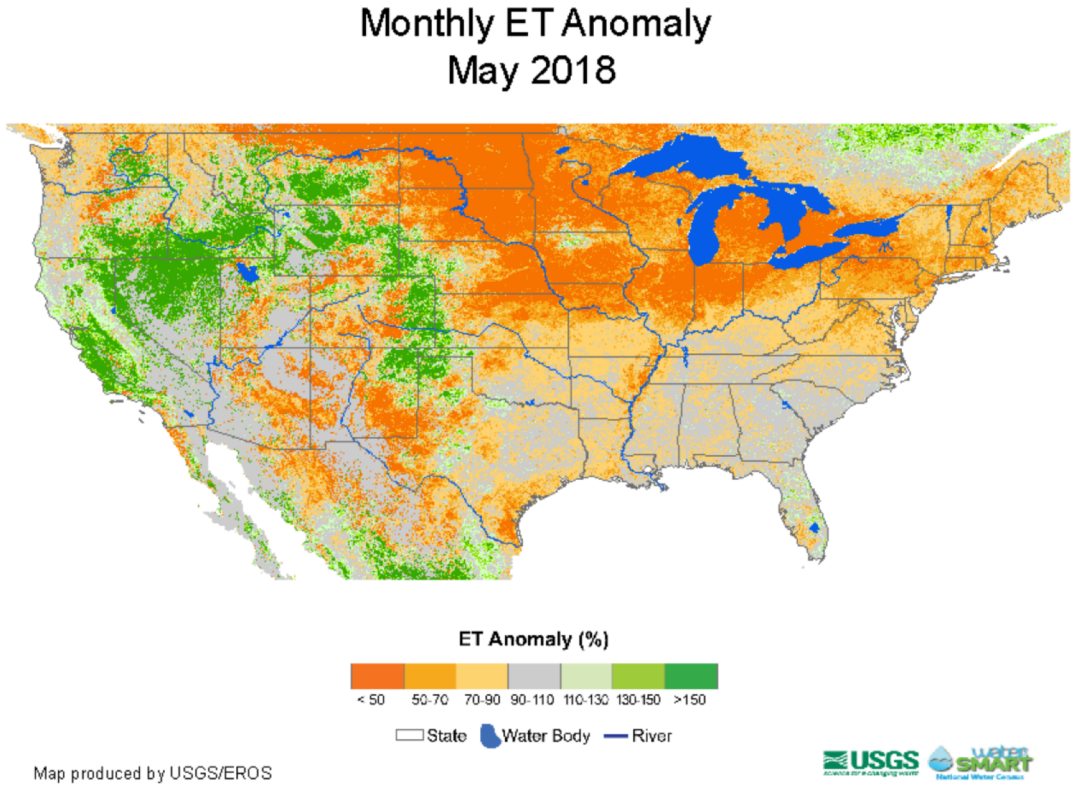
Unusually low evaporative response as accumulated between Jun 1 – Aug 31 signifying unusually dry land-surface conditions. LD3 means that this dryness is expected less than 5% of the time

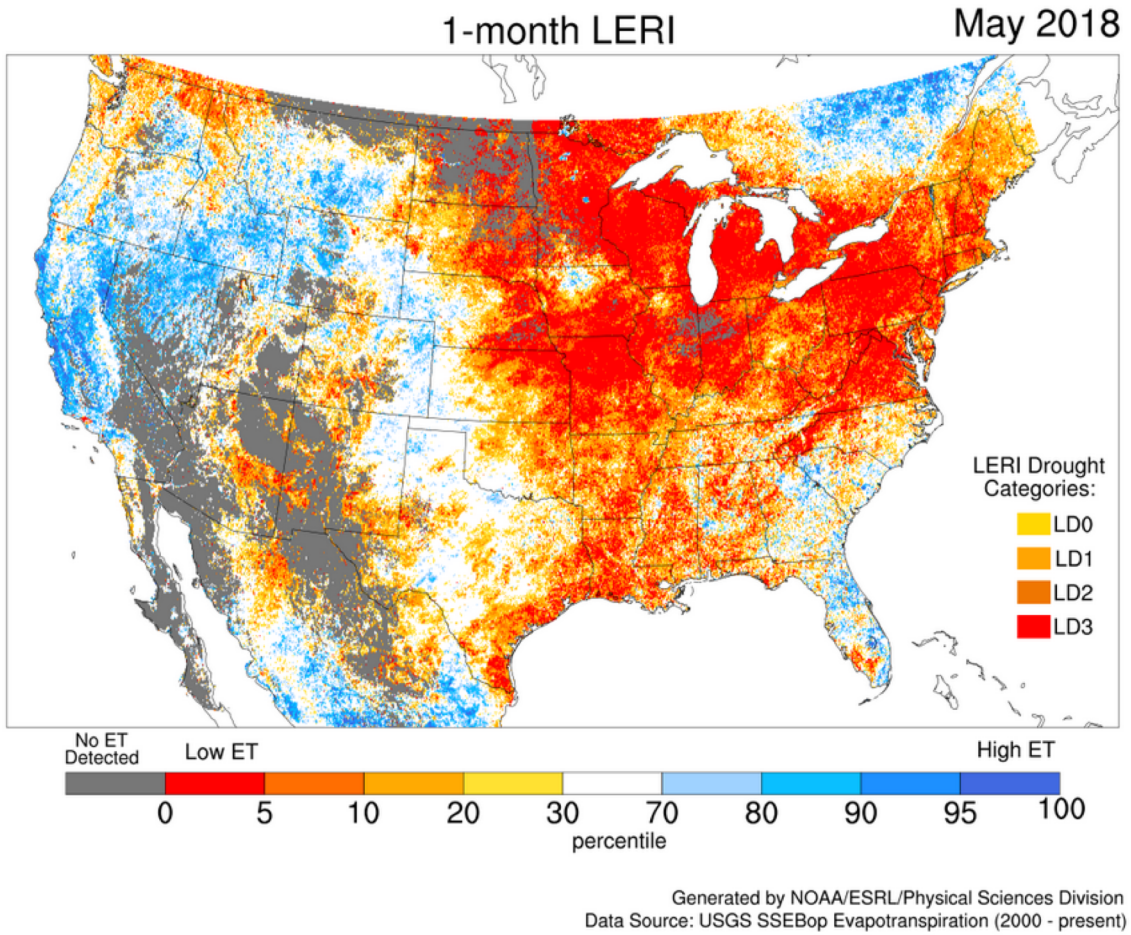
Unusually high evaporative response as accumulated between Jun 1 – Aug 31 signifying unusually wet land-surface conditions

The gray shading shows that no ET_a is detected using the SSEBop method

These categories are analogous to D0-D3 categories in the US Drought Monitor. There is no LD4 category because of the short period of the SSEBop ET_a record

	EDDI	LERI
Spatial Resolution	12 km	1 km
Climate Variable	E_0 or PET *Evaporative Demand*	AET *Evaporative Response*
Underlying Data	Gridded meteorological data NLDAS-2 (T, Pr, Wind, Rad)	Evaporative fraction derived from MODIS thermal imagery
Time Period of Record	1979-present	2000-present
Application	Ag, eco, flash droughts; wildfire risk	Ag, eco, flash droughts; wildfire risk
Access	https://esrl.noaa.gov/psd/eddi/	https://esrl.noaa.gov/psd/leri/
Coverage	CONUS + Southern Canada + Northern Mexico	CONUS + Northern Mexico
Update Frequency	Daily	Weekly & Monthly





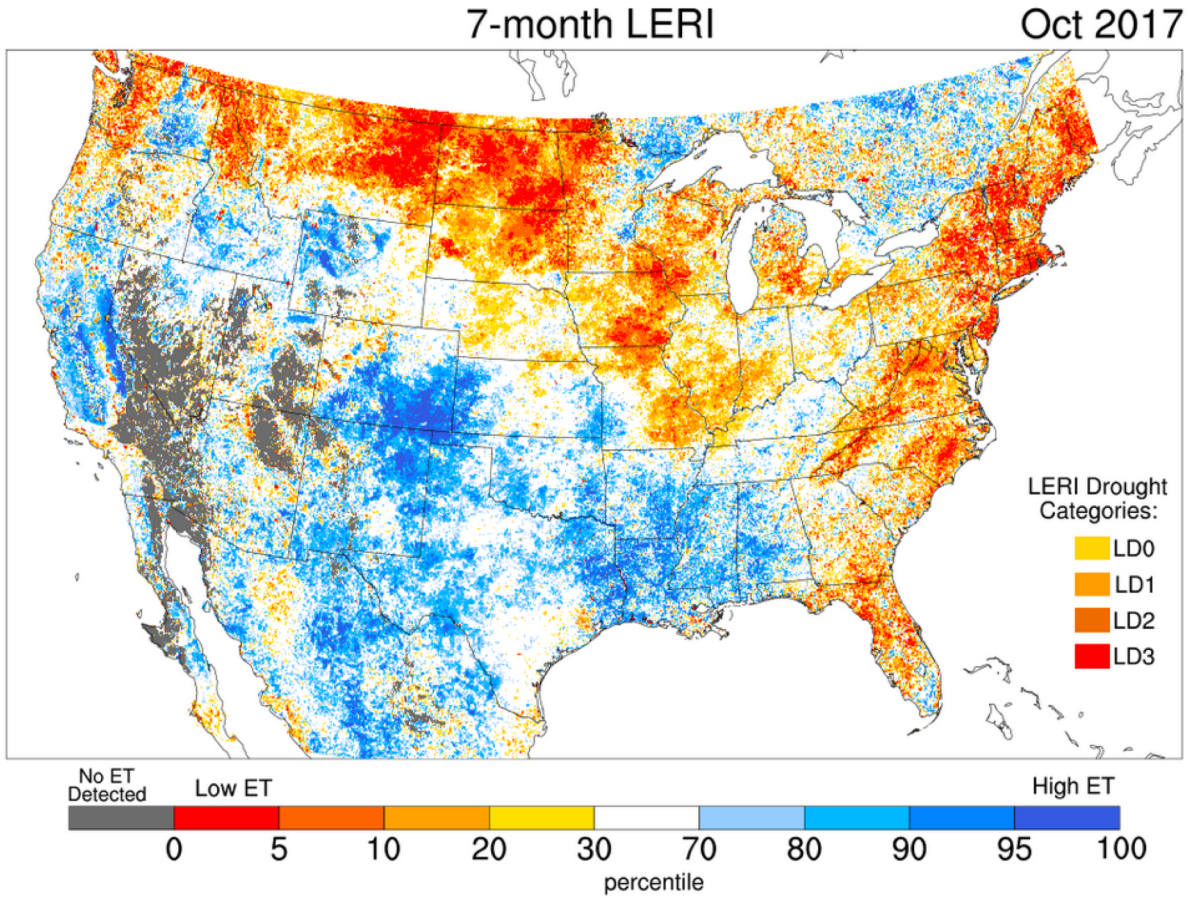
LERI (right) is an improvement on the USGS actual ET anomaly maps (left) produced by USGS EROS. The rank-based non-parametric method used to calculate percentiles for LERI makes it more equally sensitive to both water-limited and energy-limited regions. LERI maps also further distinguish regions where no ET is detected (using the gray shading). Lastly, LERI operates as a drought indicator and identifies drought categories analogous to the US Drought Monitor.

LERI Maps (Monthly)

Data available 2000 - 2017

Select Date: 2017 Oct **Select Timescale:** Growing Season (Apr-Oct)

« Back Forward »



Generated by NOAA/ESRL/Physical Sciences Division
Data Source: USGS SSEBop Evapotranspiration (2000 - present)

FTP NetCDF Data for Plot

LERI Maps (Monthly)

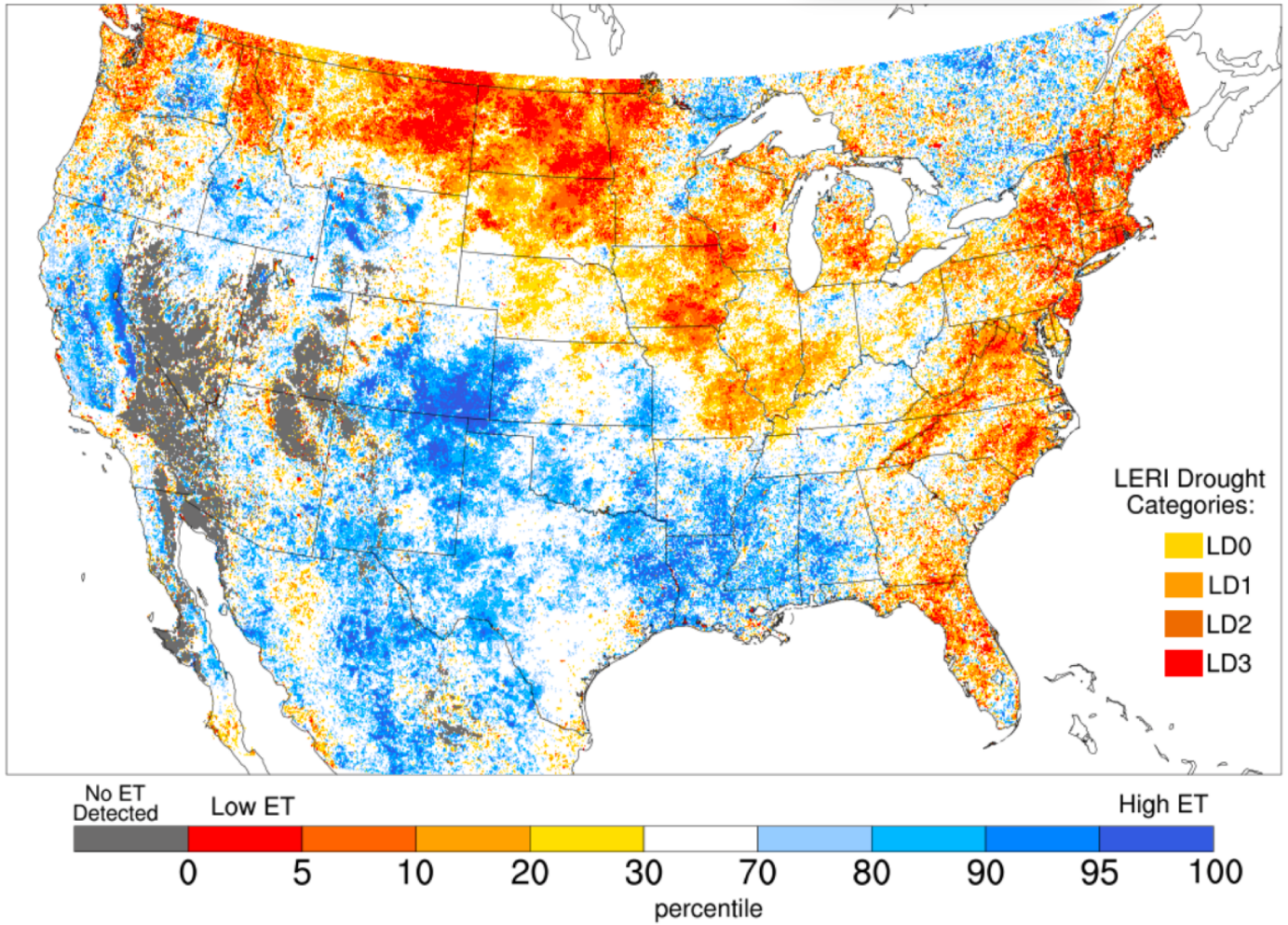
Data available 2000 - 2017

Select Date: 2017 Oct **Select Timescale:** Growing Season (Apr-Oct)

« Back Forward »

- 1 month
- 3 months
- ✓ Growing Season (Apr-Oct)
- Calendar Year
- Water Year

7-month LERI Oct 2017

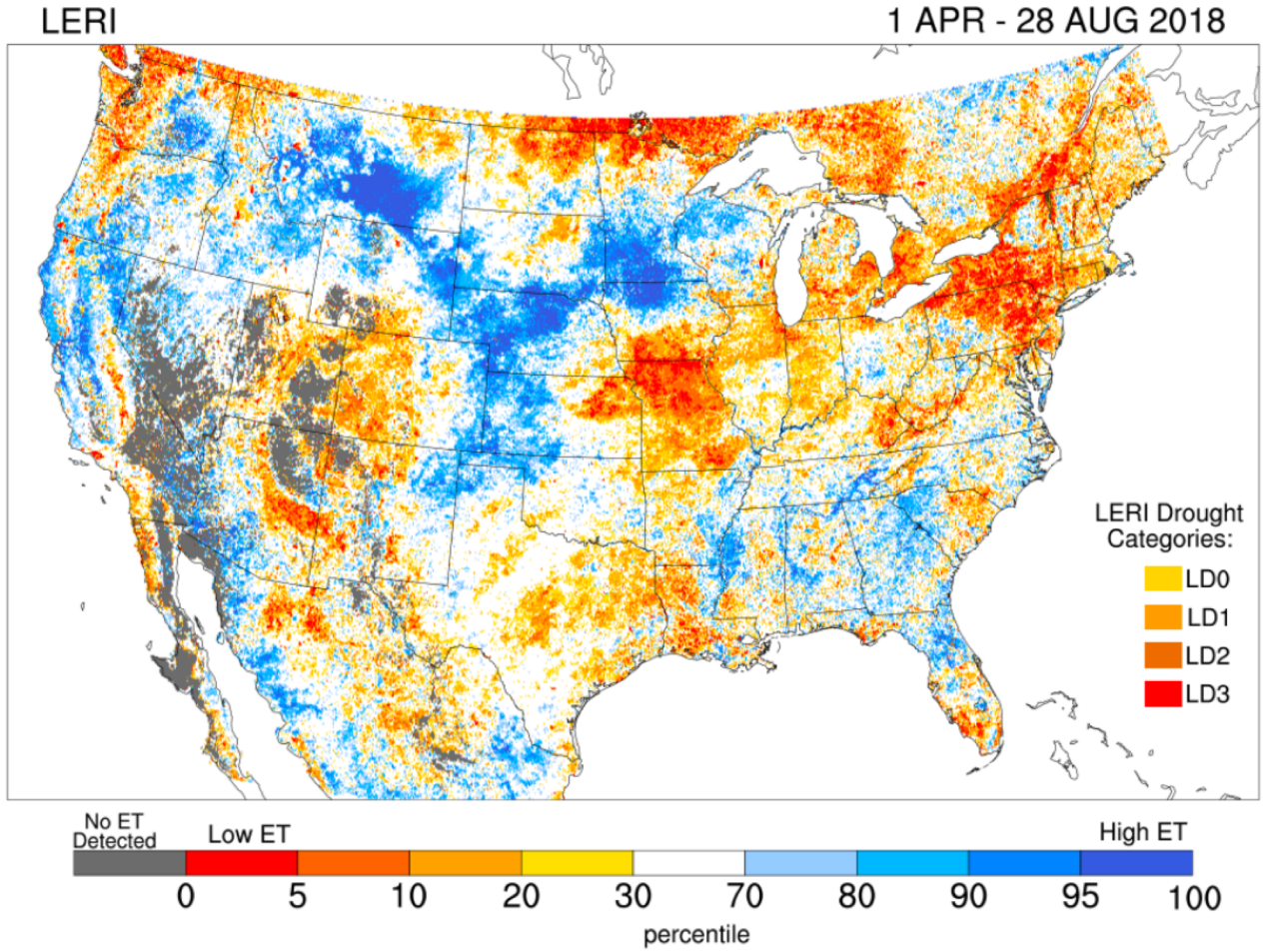


LERI Maps (8-day)

Select Date: 2018 | Apr01-Aug28 | Select Type: Accumulated

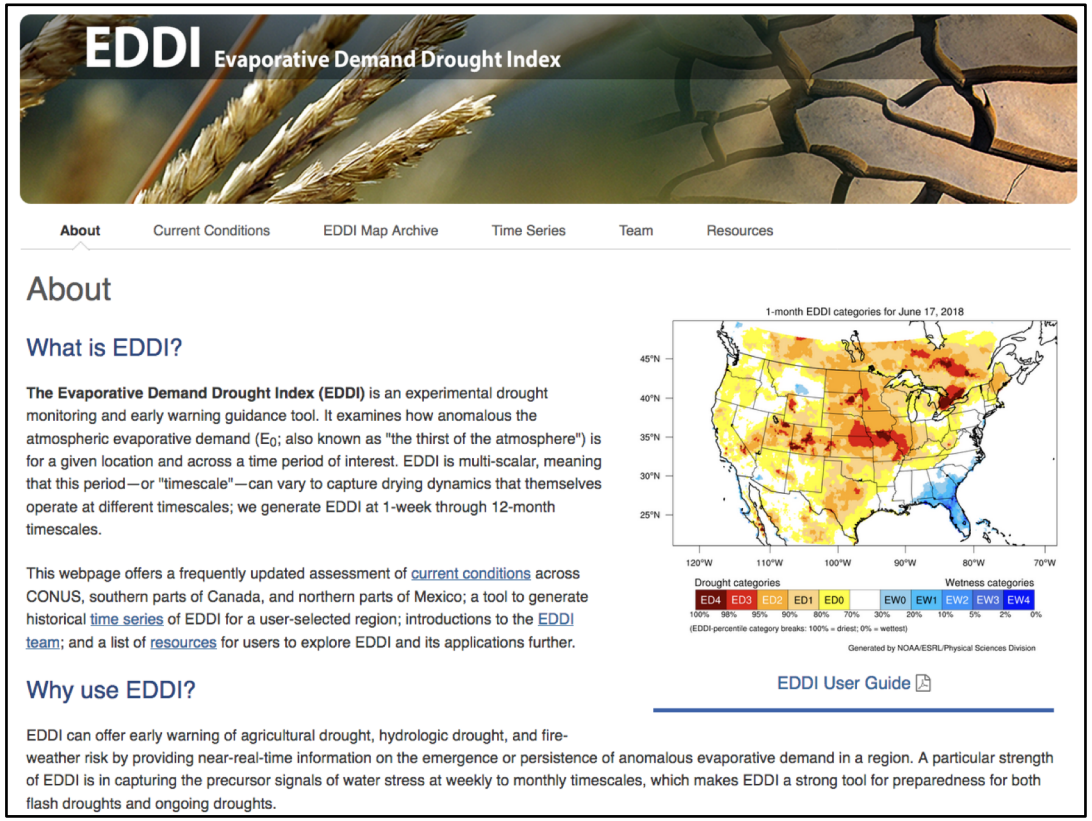
- ✓ Accumulated
- Non-accumulated

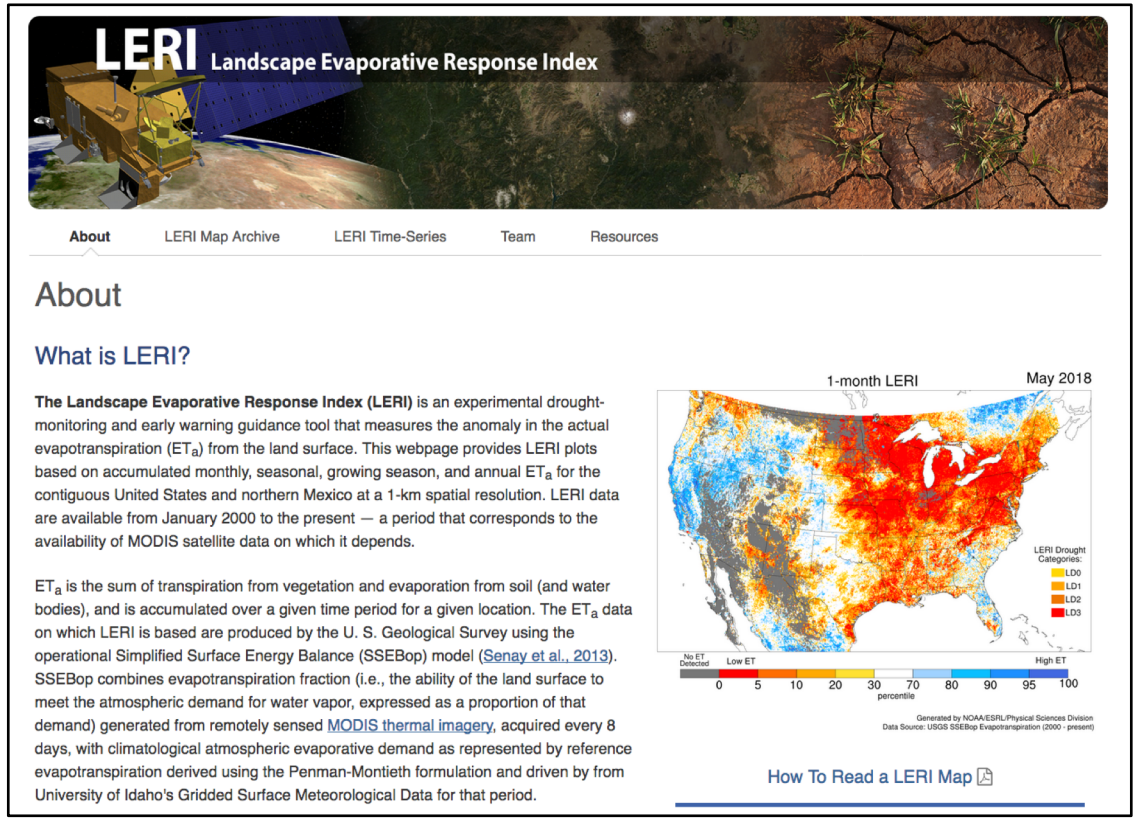
« Back | Forwar



Generated by NOAA/ESRL/Physical Sciences Division
Data Source: USGS SSEBop Evapotranspiration (2000 - present)

EDDI and LERI



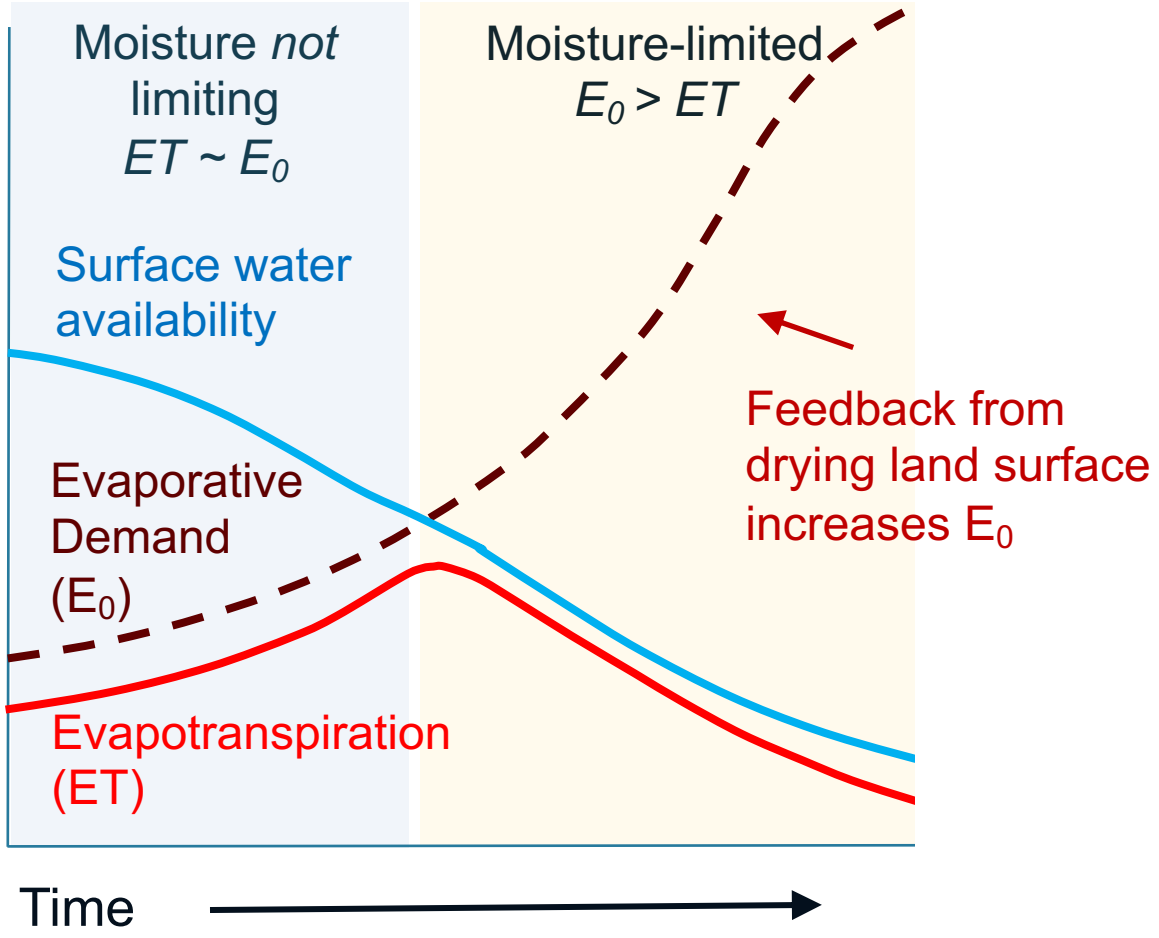


A measure of Atmospheric Dryness

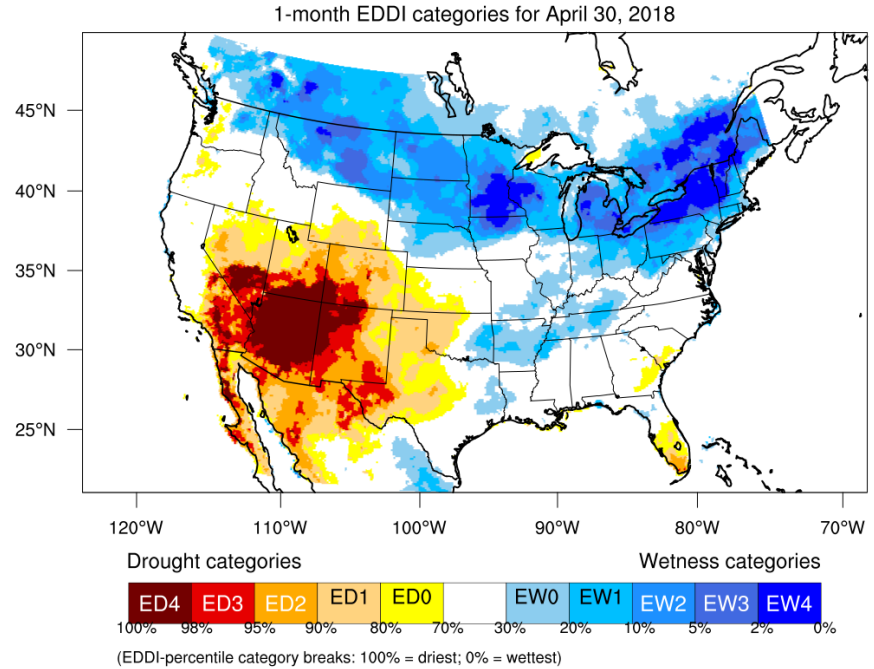
A measure of Land Surface Dryness

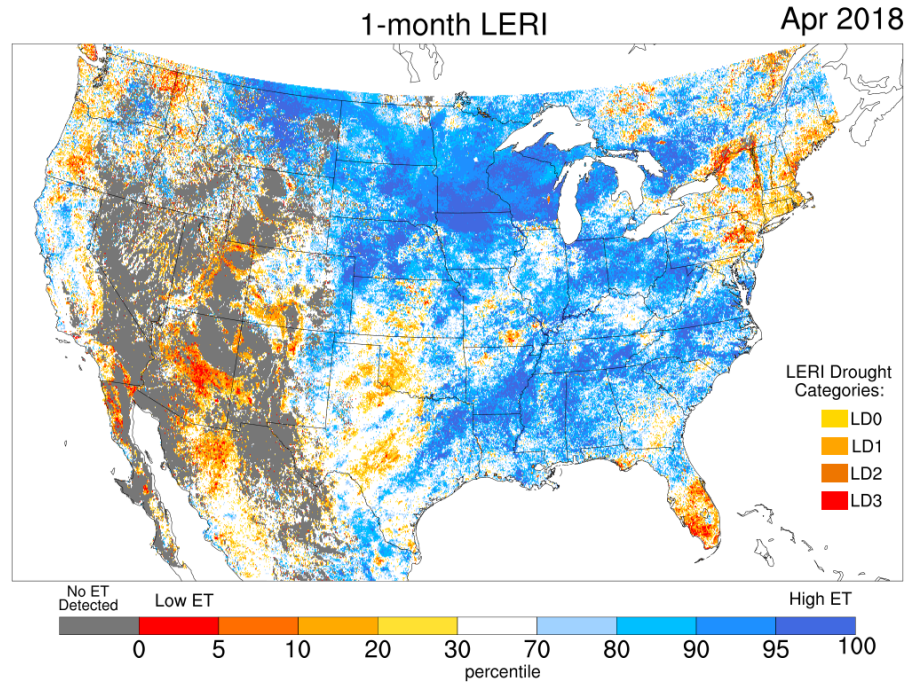
Relationship between E_0 and *ET* changes as land surface dries out

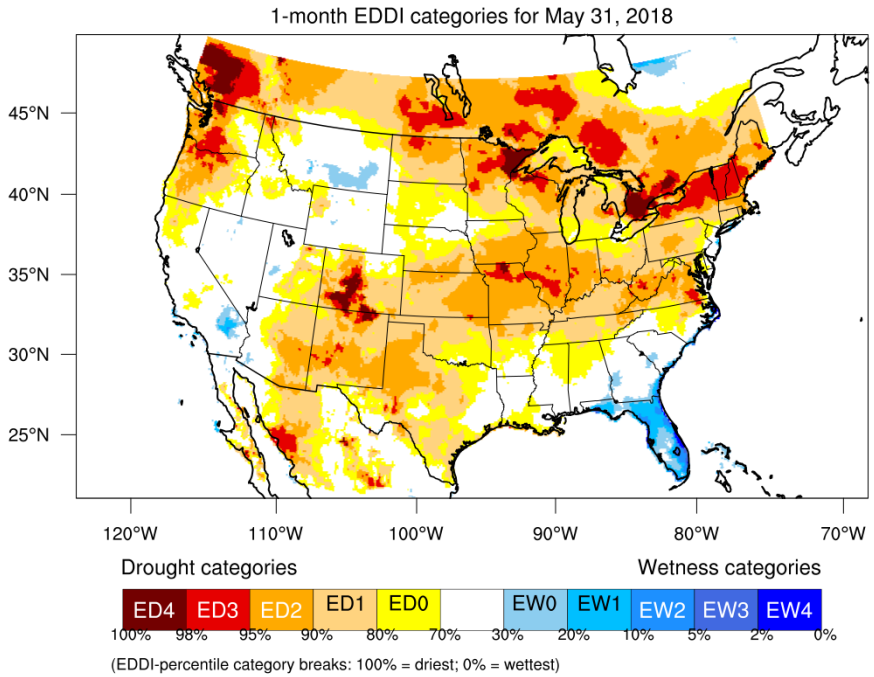
- When surface moisture is sufficient, rising E_0 leads to rising ET
- When moisture is limited, ET declines, while E_0 rises even more steeply

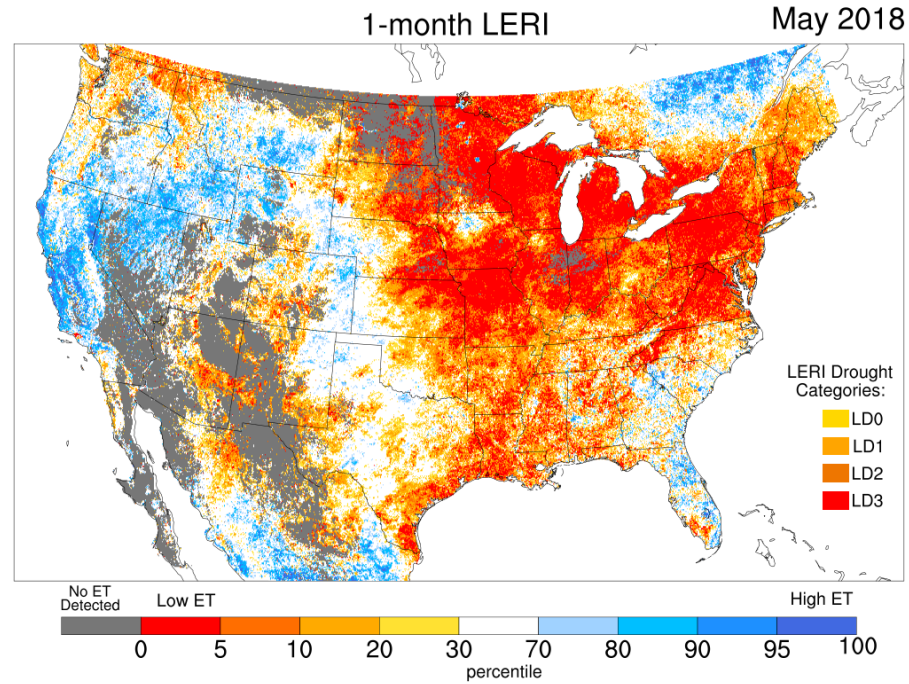


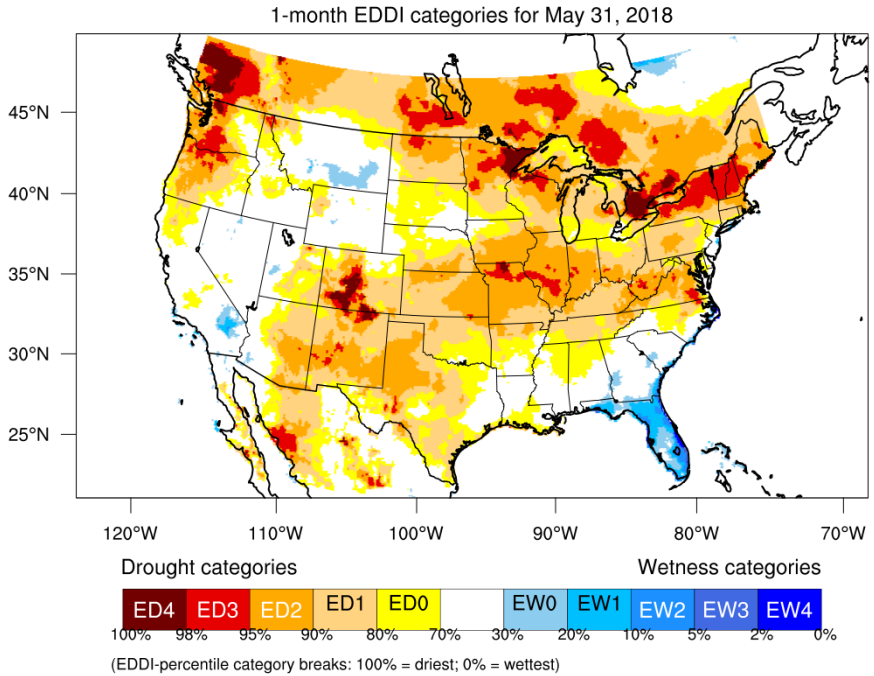
E_0 always increase as drought intensifies


1-month EDDI categories for April 30, 2018
45°N
40°N
35°N
30°N
25°N
120°W
110°W
100°W
90°W
80°W
70°W
Drought categories
Wetness categories
ED4
ED3
ED2
ED1
ED0
EW0
EW1
EW2
EW3
EW4
100%
98%
95%
90%
80%
70%
30%
20%
10%
5%
2%
0%
(EDDI-percentile category breaks: 100% = driest; 0% = wettest)


1-month LERI
Apr 2018
LERI Drought Categories:
LD0
LD1
LD2
LD3
No ET Detected
Low ET
High ET
0
5
10
20
30
70
80
90
95
100
percentile


1-month EDDI categories for May 31, 2018
45°N
40°N
35°N
30°N
25°N
120°W
110°W
100°W
90°W
80°W
70°W
Drought categories
Wetness categories
ED4
ED3
ED2
ED1
ED0
EW0
EW1
EW2
EW3
EW4
100%
98%
95%
90%
80%
70%
30%
20%
10%
5%
2%
0%
(EDDI-percentile category breaks: 100% = driest; 0% = wettest)


1-month LERI
May 2018
LERI Drought Categories:
LD0
LD1
LD2
LD3
No ET Detected
Low ET
High ET
0
5
10
20
30
70
80
90
95
100
percentile


1-month EDDI categories for May 31, 2018
45°N
40°N
35°N
30°N
25°N
120°W
110°W
100°W
90°W
80°W
70°W
Drought categories
Wetness categories
ED4
ED3
ED2
ED1
ED0
EW0
EW1
EW2
EW3
EW4
100%
98%
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70%
30%
20%
10%
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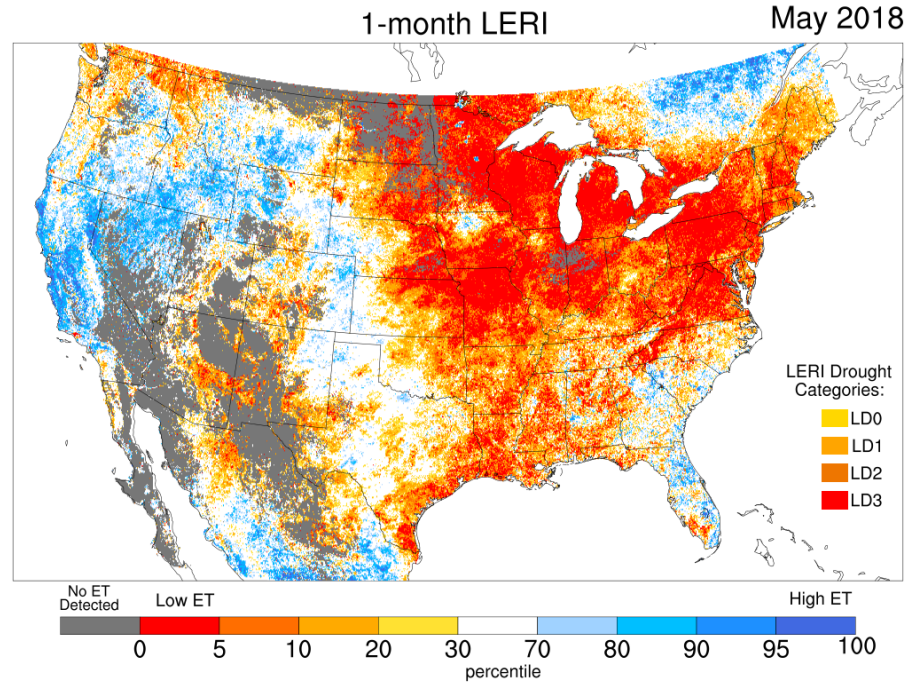
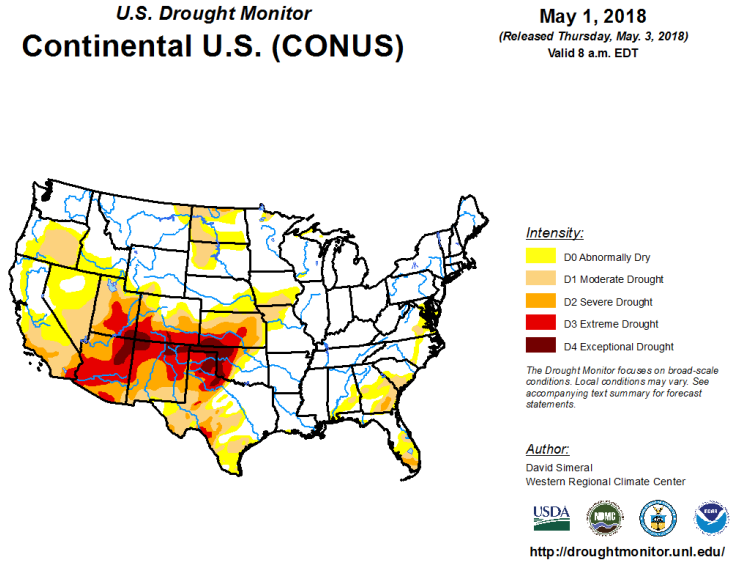
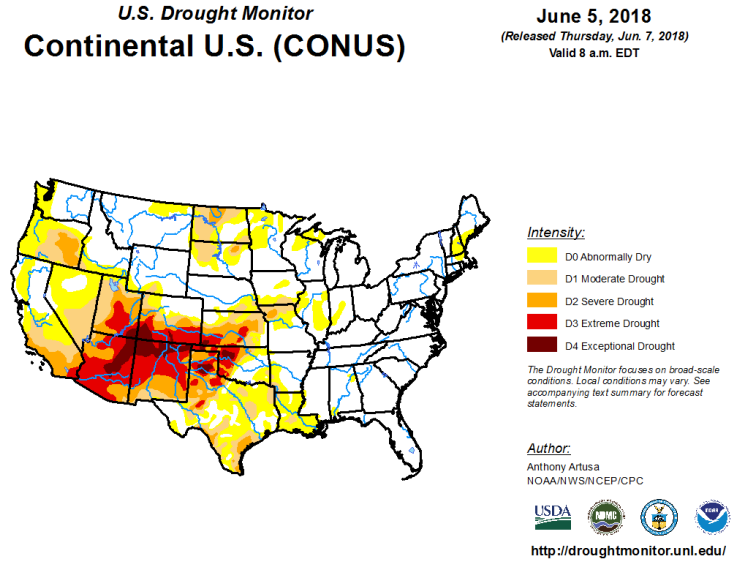
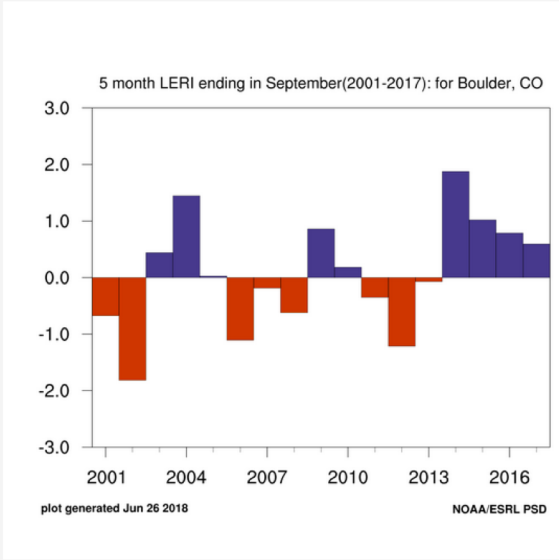
2%
0%
(EDDI-percentile category breaks: 100% = driest; 0% = wettest)


1-month LERI
May 2018
LERI Drought Categories:
LD0
LD1
LD2
LD3
No ET Detected
Low ET
High ET
0
5
10
20
30
70
80
90
95
100
percentile


U.S. Drought Monitor
Continental U.S. (CONUS)
May 1, 2018
(Released Thursday, May. 3, 2018)
Valid 8 a.m. EDT
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 Simeral
Western Regional Climate Center
http://droughtmonitor.unl.edu/


U.S. Drought Monitor
Continental U.S. (CONUS)
June 5, 2018
(Released Thursday, Jun. 7, 2018)
Valid 8 a.m. EDT
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:
Anthony Artusa
NOAA/NWS/NCEP/CPC
http://droughtmonitor.unl.edu/

Plot LERI Time Series



This webtool allows a user to generate historical (2001-latest complete year) timeseries data of the Landscape Evaporative Response Index (LERI) for a specified region in the Contiguous United States or northern Mexico. The time series is generated as a table for different timescales, i.e. 1 to 12 months of integrated evaporative demand at the end of a given month. This tool also allows users to generate time series plots with user specified timescales.

1 Region

Drag to move map; SHIFT-Drag to select region

N 41.000
W -109.00 -102.00 E
S 37.000

Reset Map

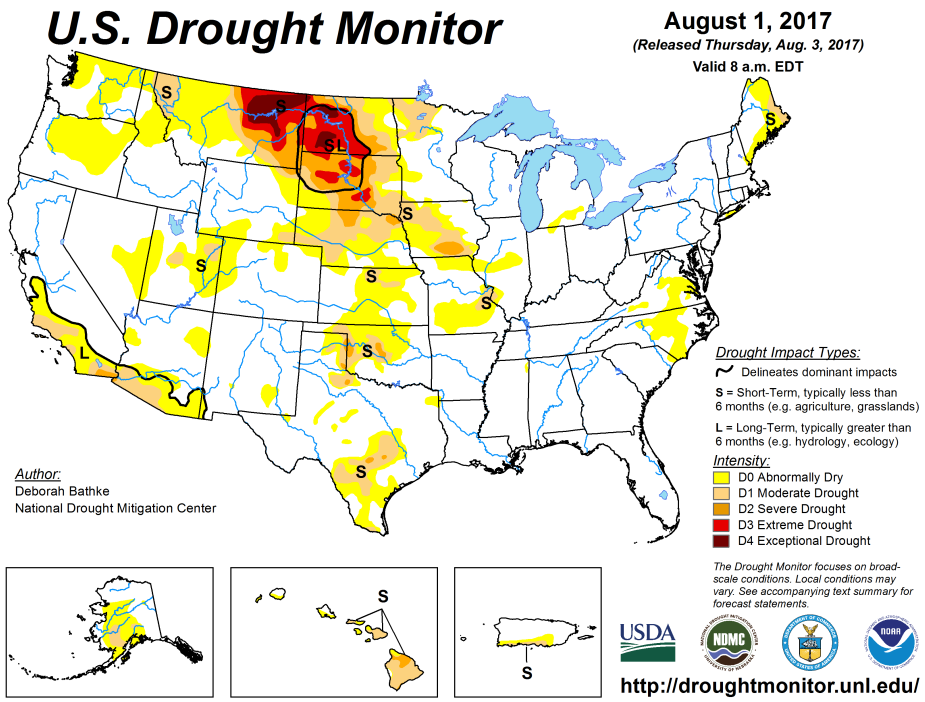
2 Plot Options

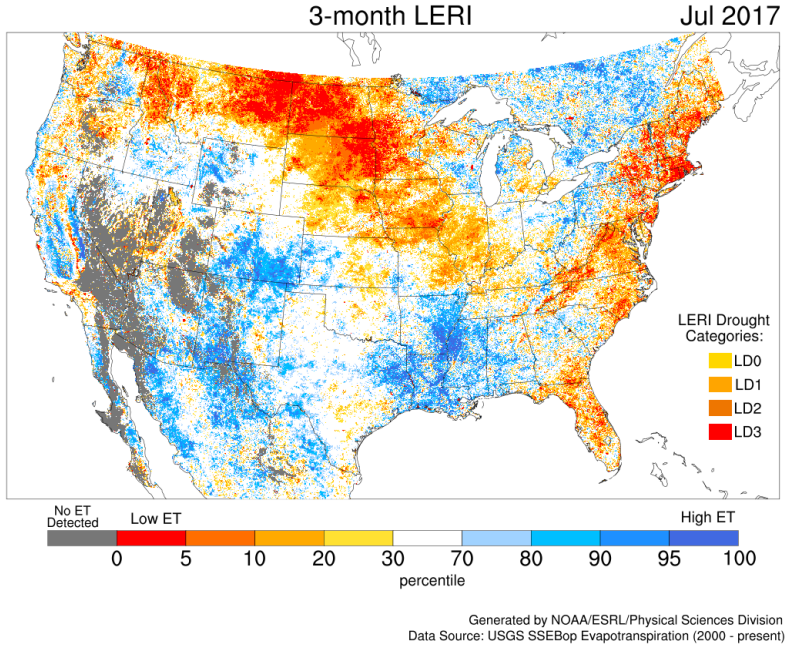
Averaging Period (Months)? 5 **Ending Month?** Sep
(ending month includes values through the end of that month)

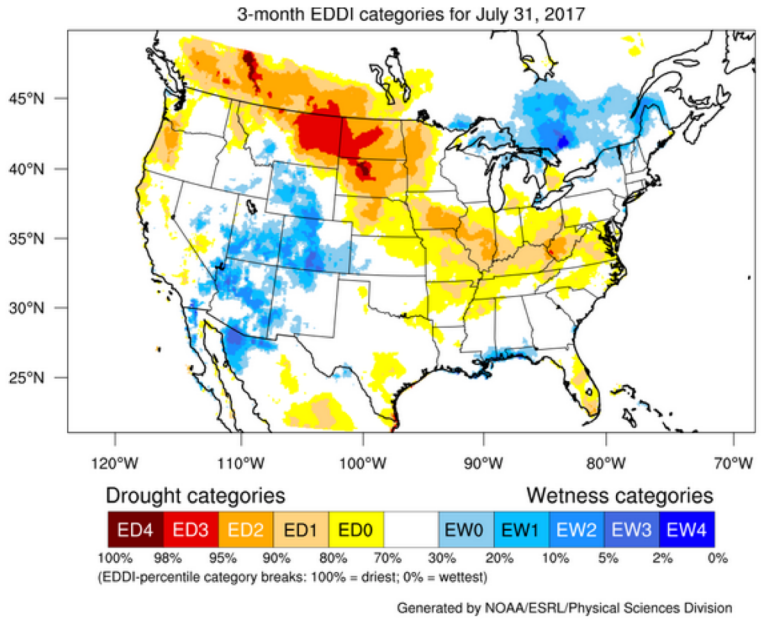
Enter Region Title (OPTIONAL: Used in the plot title: default is the lat/lon range)

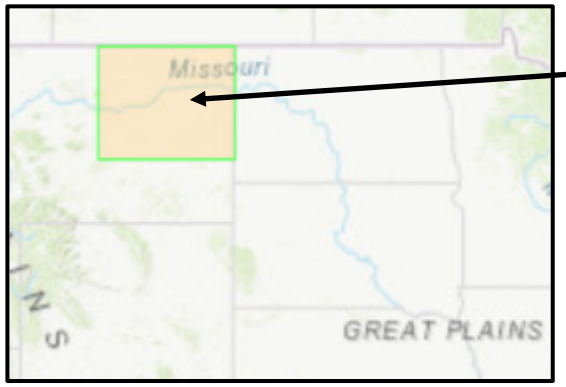
Generate Data & Plot | Reset Options

2017 Northern Plains (Flash) Drought



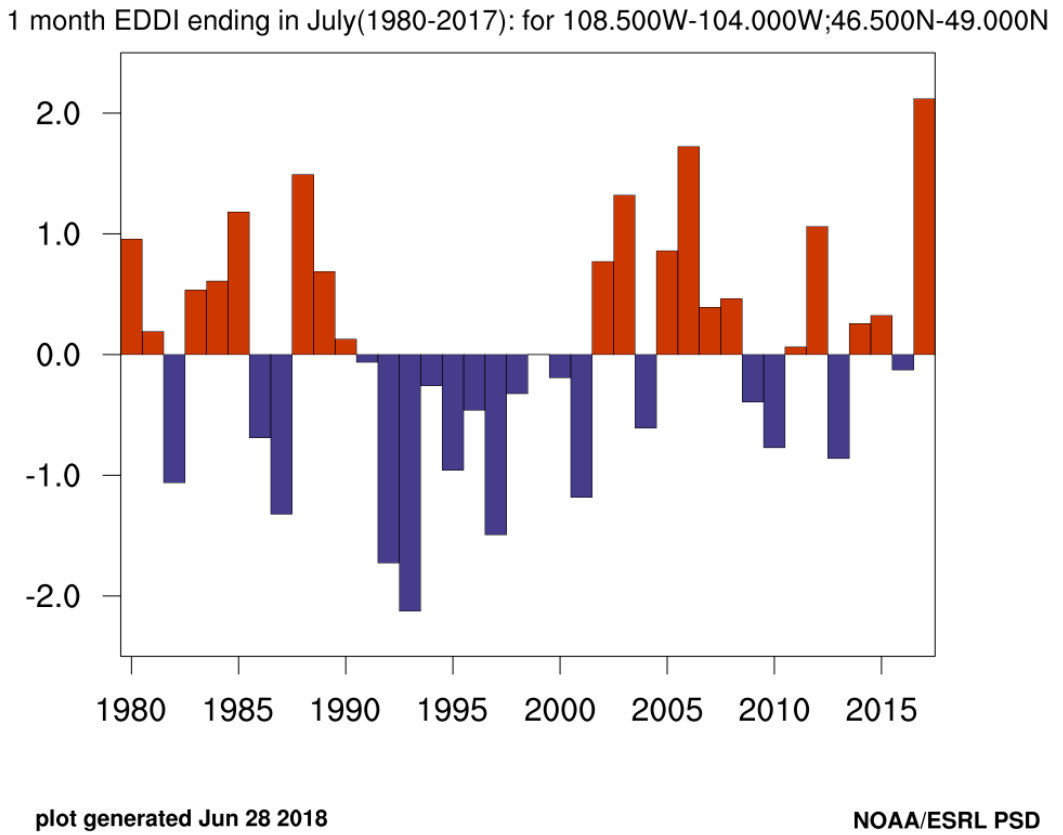


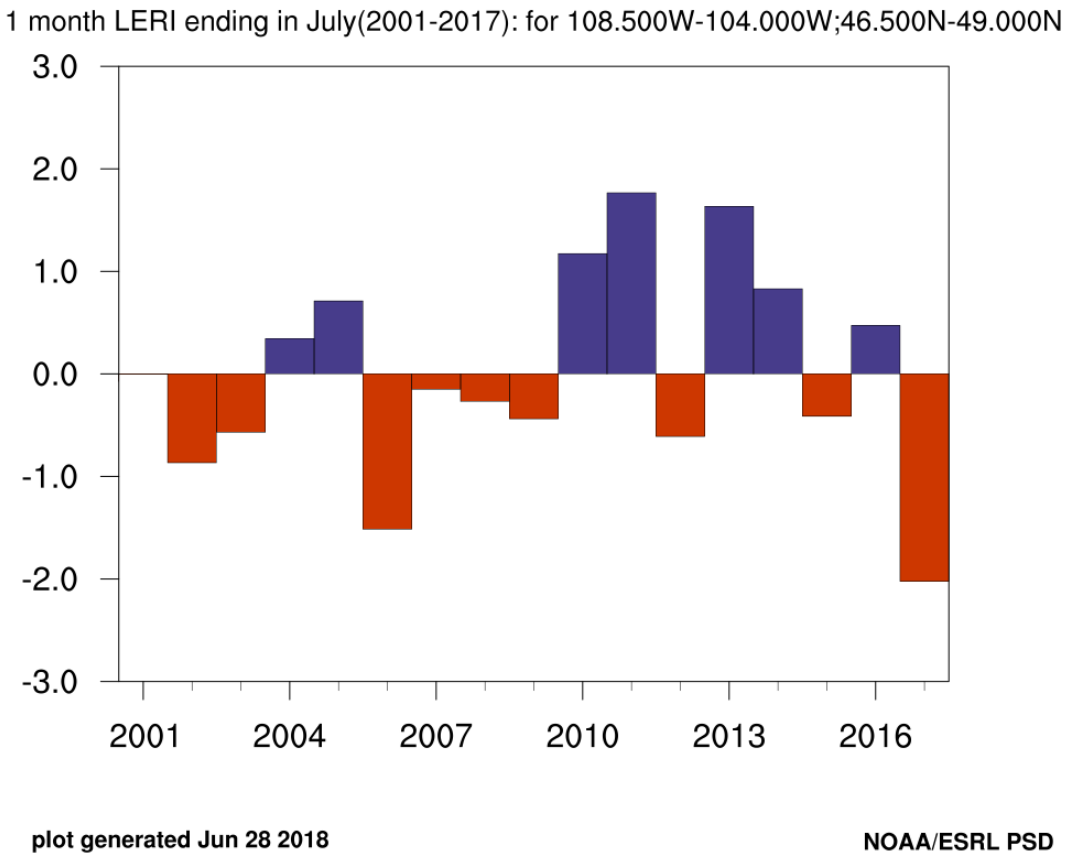


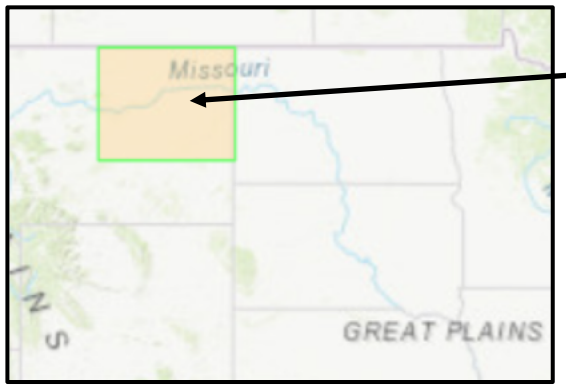


Results below
for NE Montana

Both LERI and EDDI timeseries show record dry conditions for 1-month July in northeast Montana in 2017

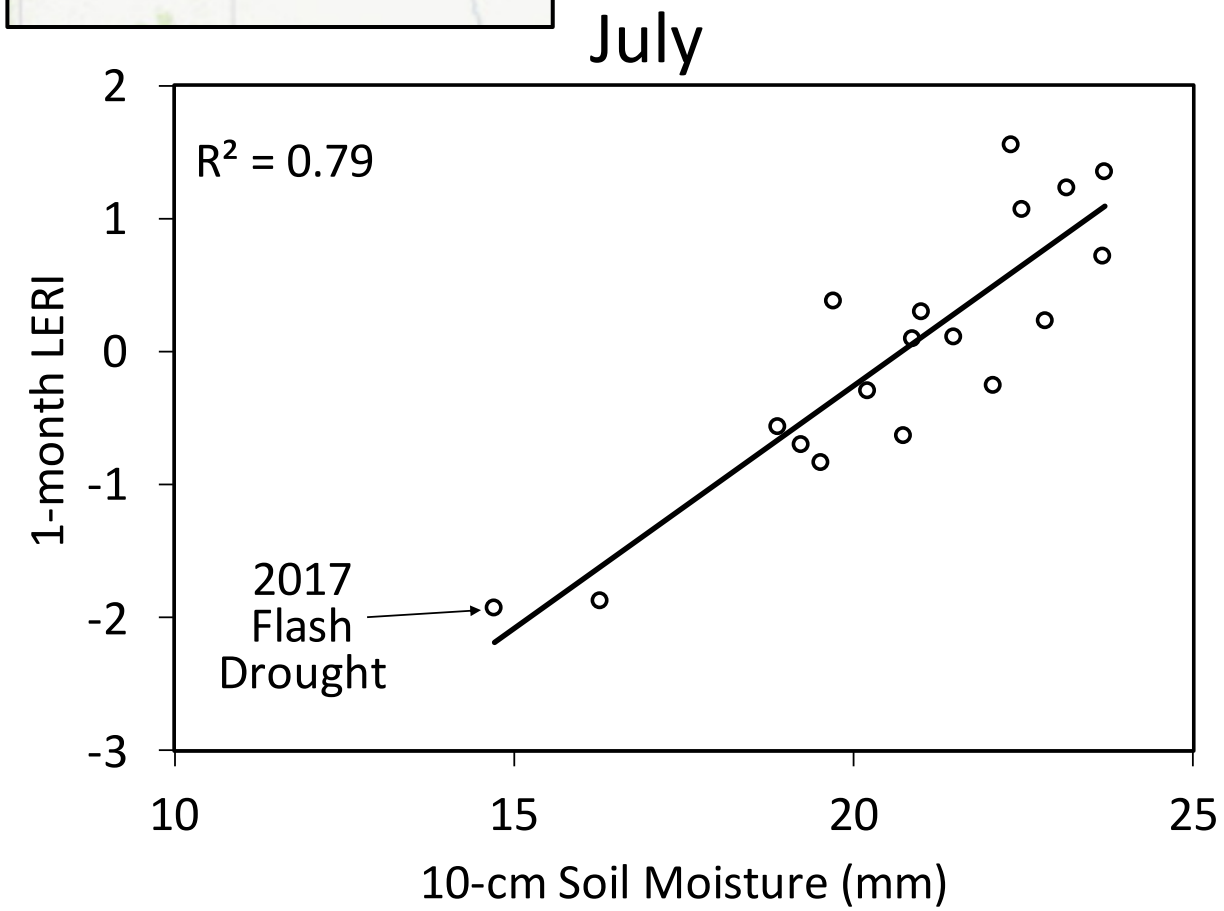


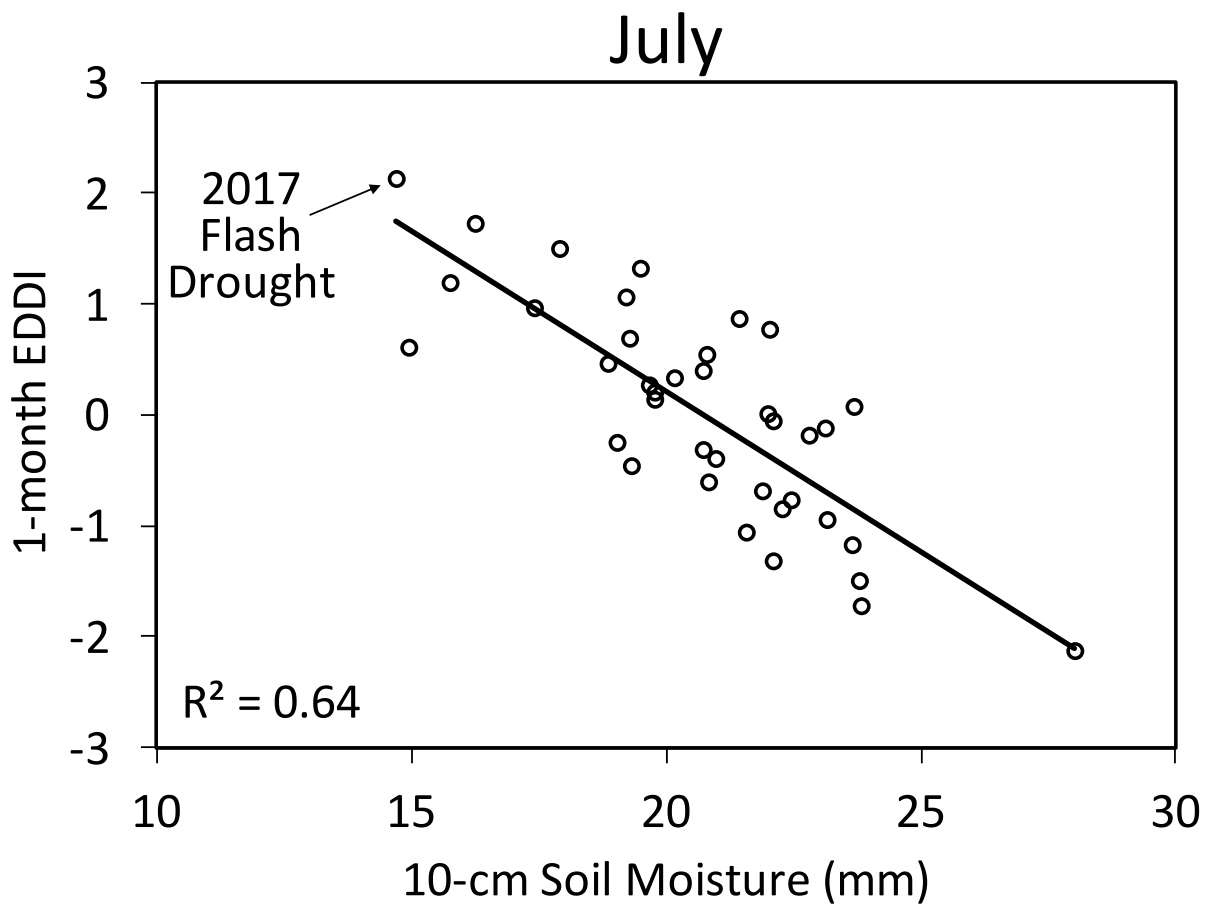




Results below for NE Montana

LERI and EDDI as indicators of extreme dry conditions





10-cm soil moisture is based on the operational NLDAS-Noah LSM data