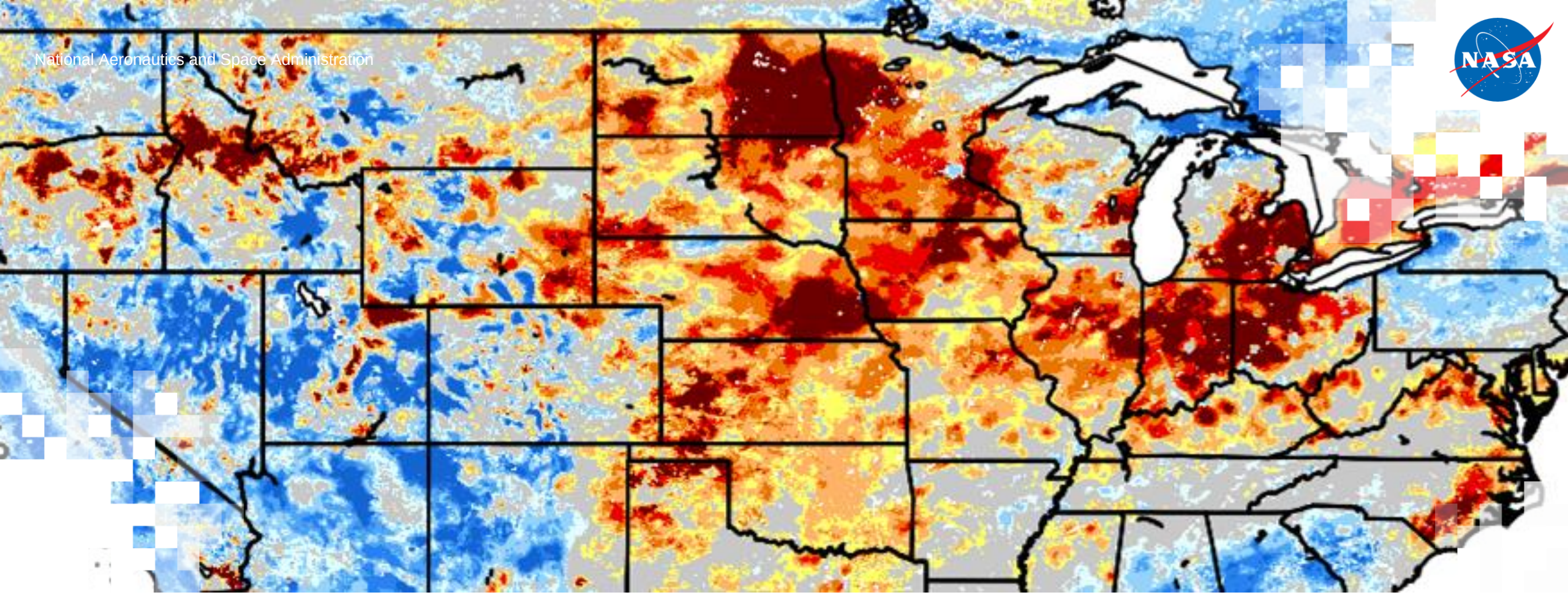


Application of NASA SPoRT-Land Information System (SPoRT-LIS) Soil Moisture Data for Drought

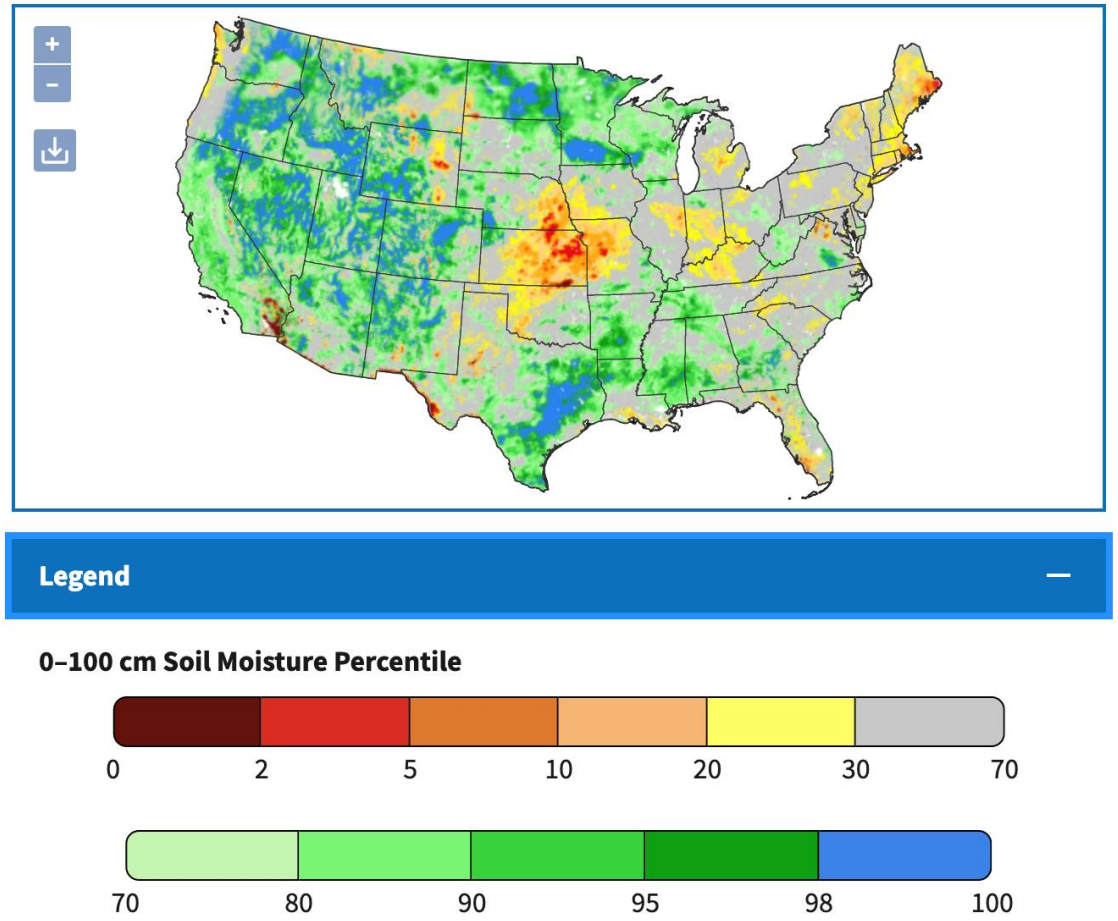
Part 2: Early and Established Applications of LIS for Drought Analysis in Operations

Sean McCartney (NASA/SSAI), Kristopher White (NASA SPoRT), Richard Heim (NOAA), Corey Davis (NC State Climate Office), Barrett Smith (NWS)

May 24, 2023

Overview

- An estimated 55 million people globally are affected by droughts every year (WHO).
- Soil moisture plays an important role in drought monitoring.
- Relatively high-resolution gridded soil moisture products improve situational awareness.
- SPoRT-LIS provides unique, real-time soil moisture information at relatively high spatial resolution (~3 km).



Credit: NASA

Training Learning Objectives

A user will be able to apply LIS output to efficiently analyze drought over large spatial areas in conjunction with current practices and to integrate this capability with existing data.

- Identify the NASA/LIS basics regarding the framework, input forcing, static fields, LSM structure, and output most relevant to drought
- Summarize the derived soil moisture percentile products and how these are created
- Apply SPoRT-LIS output and/or derived products to both complement existing data and overcome limitations to monitoring drought over large areas
- Recognize 'best practices' for LIS impact related to drought
- Configure LIS output file for viewing within a GIS-based display tool and for tailored output products and graphics

Prerequisites

- Fundamentals of Remote Sensing, Session 1
- Download and install QGIS and all accompanying software
- Register for a Google Colab via Gmail or Gmail-enabled account
- Basic Python experience beneficial but not required

Training Outline

Part 1

Foundational Understanding of LIS (Static, Forcing, Models, Output)

May 17, 2023

Self-Paced Microlesson

Part 2

Early and Established Applications of LIS for Drought Analysis in Operations

May 24, 2023

Self-Paced Microlesson

Part 3

Access Data at Organization and Individual Levels

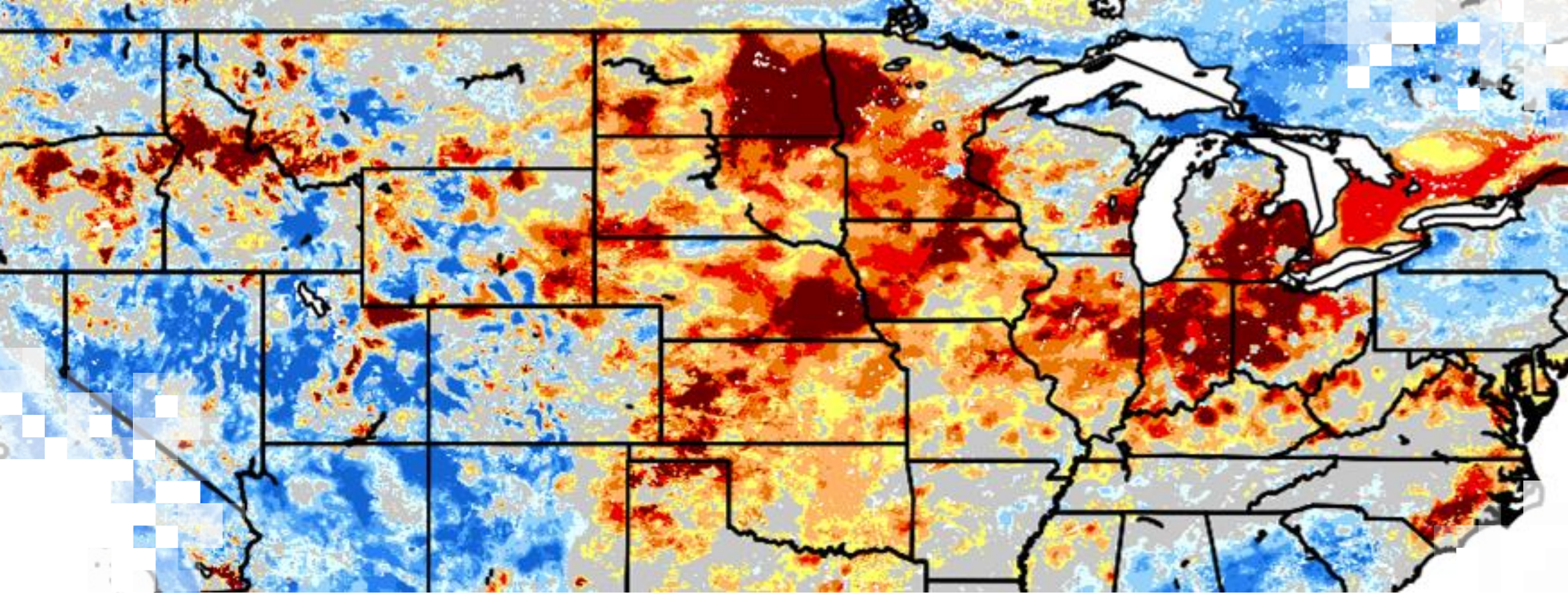
May 31, 2023

Self-Paced Microlesson

Homework

Opens May 31 – Due June 14 – Posted on Training Webpage

A certificate of completion will be awarded to those who attend all live sessions and complete the homework assignment before the given due date.



Part 2: Early and Established Applications of LIS for Drought Analysis in Operations

Part 2 Trainers

Kristopher White

Meteorologist, NOAA/NWS/NASA SPoRT

Richard Heim

Meteorologist, NOAA/NESDIS/NCEI

Corey Davis

Assistant State Climatologist, North Carolina State Climate Office

Barrett Smith

Senior Service Hydrologist, NWS

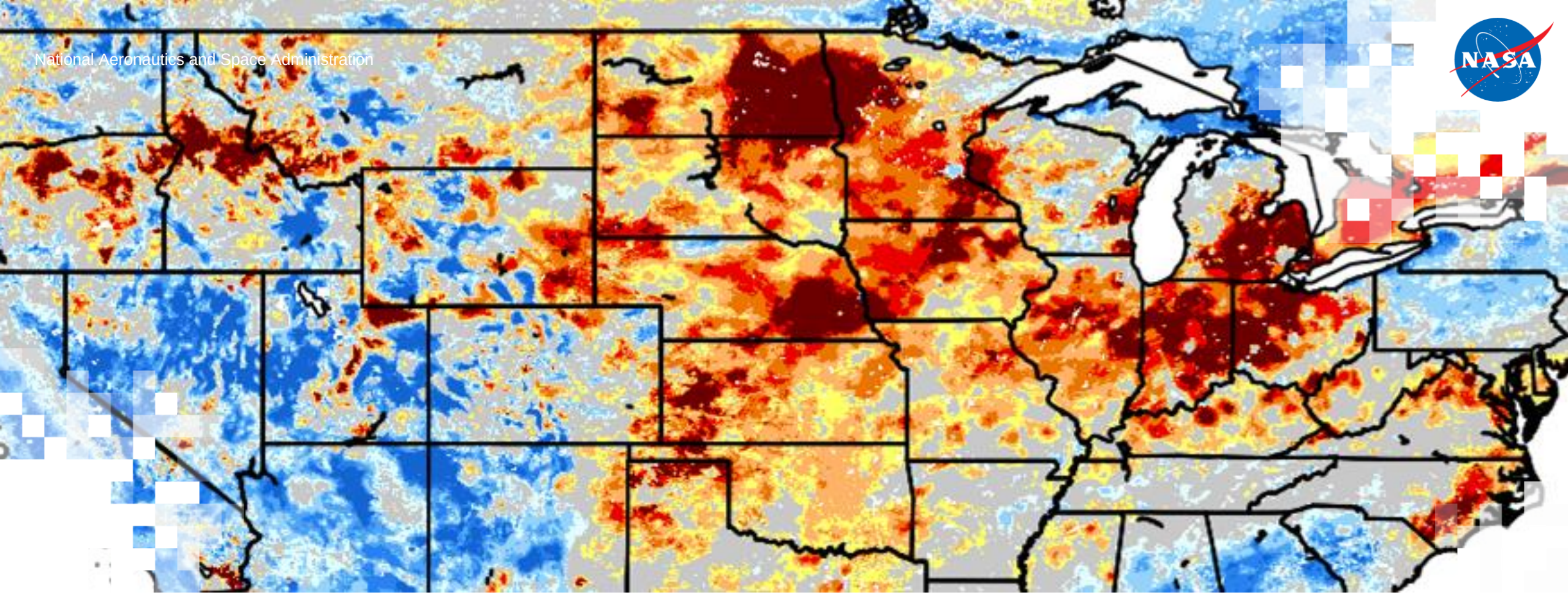
Part 2 Objectives

By the end of Part 1, participants will be able to:

- Summarize the derived soil moisture percentile products and how these are created
- Apply SPoRT-LIS output and/or derived products to both complement existing data and overcome limitations to monitoring drought over large areas

How to Ask Questions

- Please put your questions in the Questions box and we will address them at the end of the webinar.
- Feel free to enter your questions as we go. We will try to get to all of the questions during the Q&A session after the webinar.
- The remainder of the questions will be answered in the Q&A document, which will be posted to the training website about a week after the training.



SPoRT-Land Information System (SPoRT-LIS) for Drought Analysis

Kristopher D. White – Applications Integration Meteorologist, NOAA/NWS / NASA SPoRT

May 24, 2023

Training Objectives

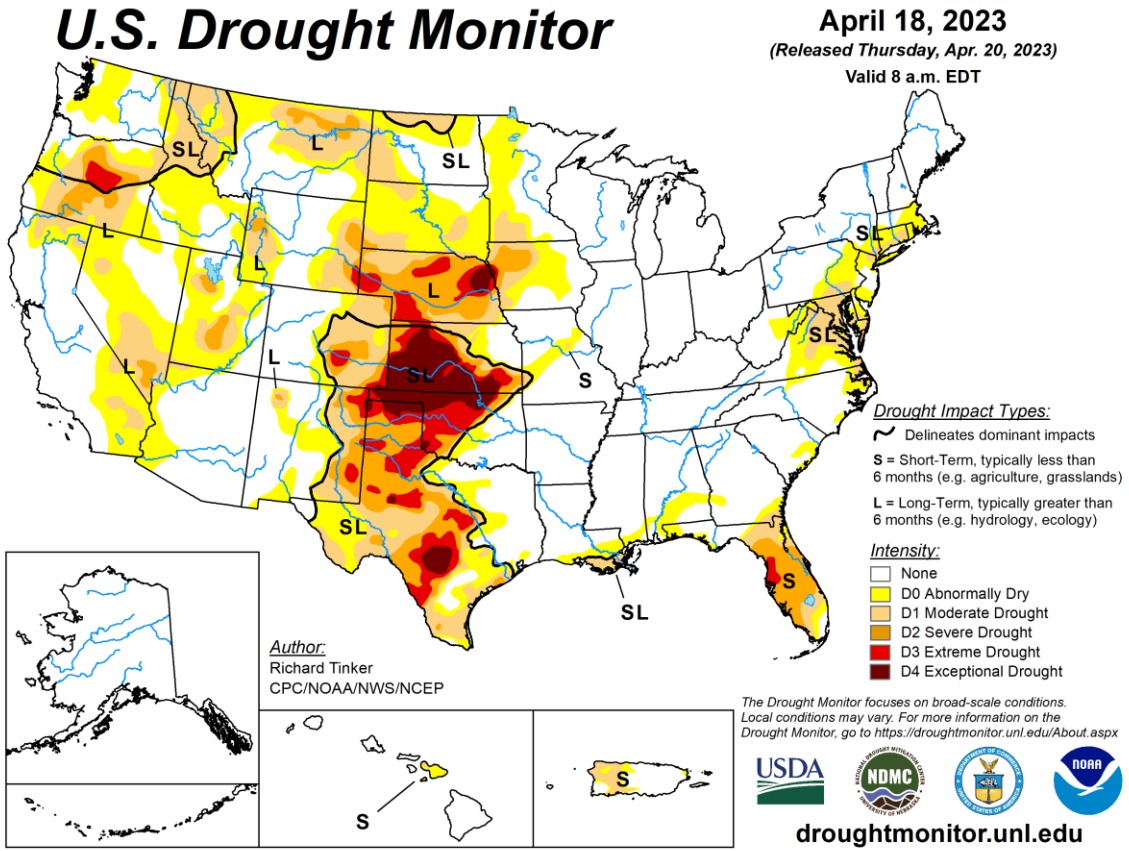
- Introduction to the United States Drought Monitor (USDM) process
- Introduction to drought and drought analysis
- Understanding applications of soil moisture and the SPoRT-Land Information System (SPoRT-LIS) for drought analysis
- Understanding the importance of communication and the Research-to-Operations/Operations-to-Research (R20/02R) Process: The creation of SPoRT-LIS soil moisture change and percentiles data
- Understanding drought analysis from early use cases using soil moisture data, specifically from the SPoRT-LIS

The U.S. Drought Monitor Process

- Who provides input to U.S. Drought Monitor (USDM) can vary widely from state to state and region to region.

USDM Information:

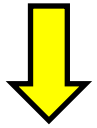
The U.S. Drought Monitor is jointly produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. Map courtesy of NDMC.



The Drought Monitor Process

- From the State Climate Office…

- At the National Weather Service Level…

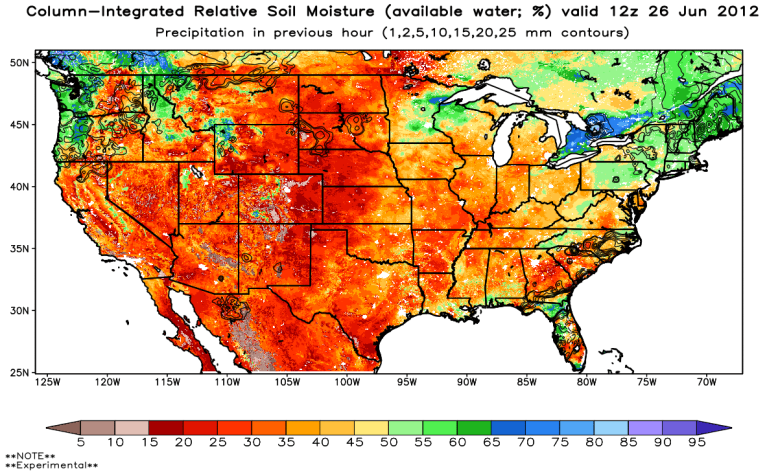


State Climate Office

NWS Regional Office

USDM Author

- Incorporating the SPoRT-LIS into the USDM Process



So, what is drought?

It's actually very complicated! There are many possible definitions.

Drought is…

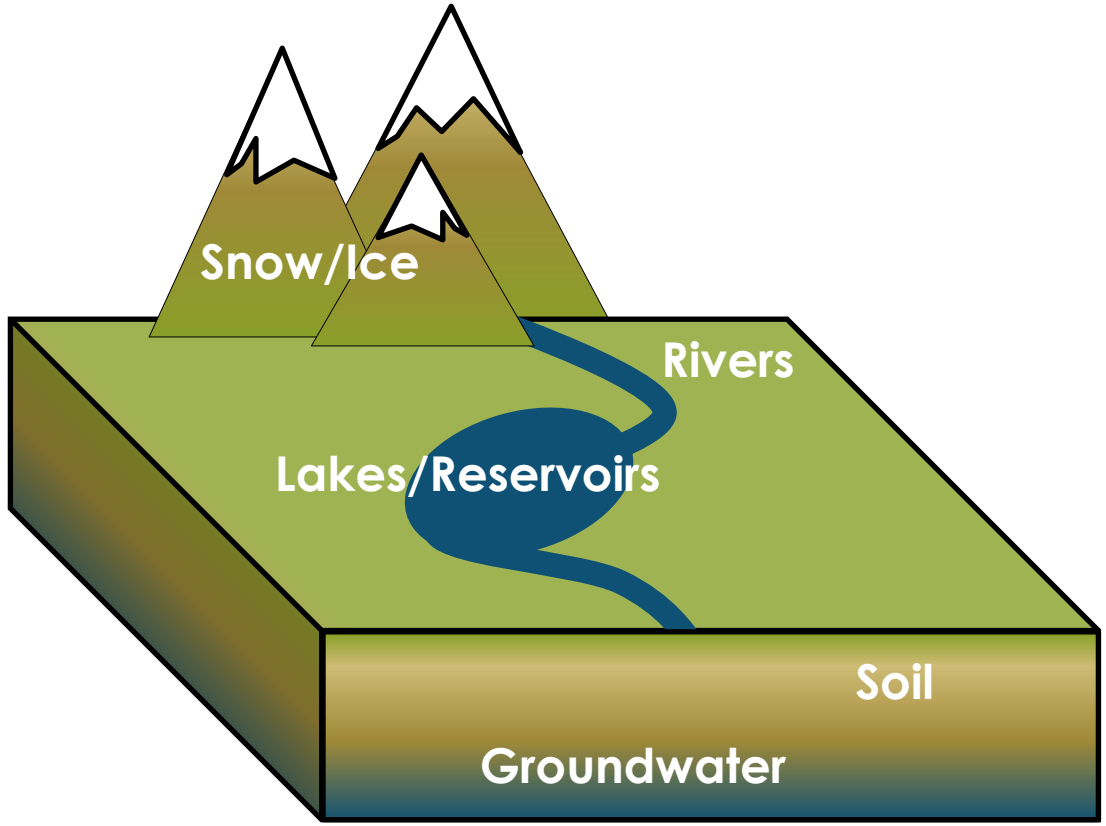
- an imbalance between water supply and demand.
- dependent on the time of year and location.

https://www.drought.gov/

Water Supply **Water Demand**

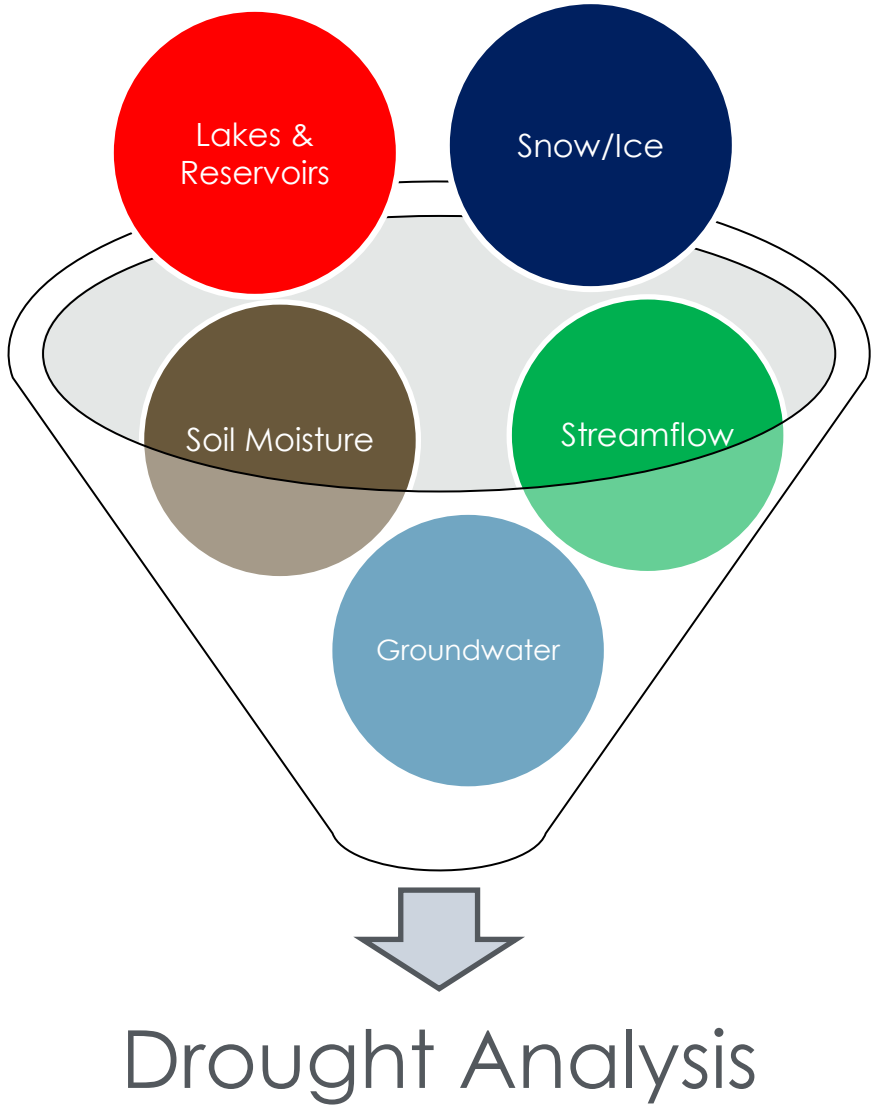
Hydrologic Components of Drought Analysis

- Water resides in different components of the hydrologic system.
- Physical storage systems for water can respond differently to weather and other environmental phenomena and inputs of water.

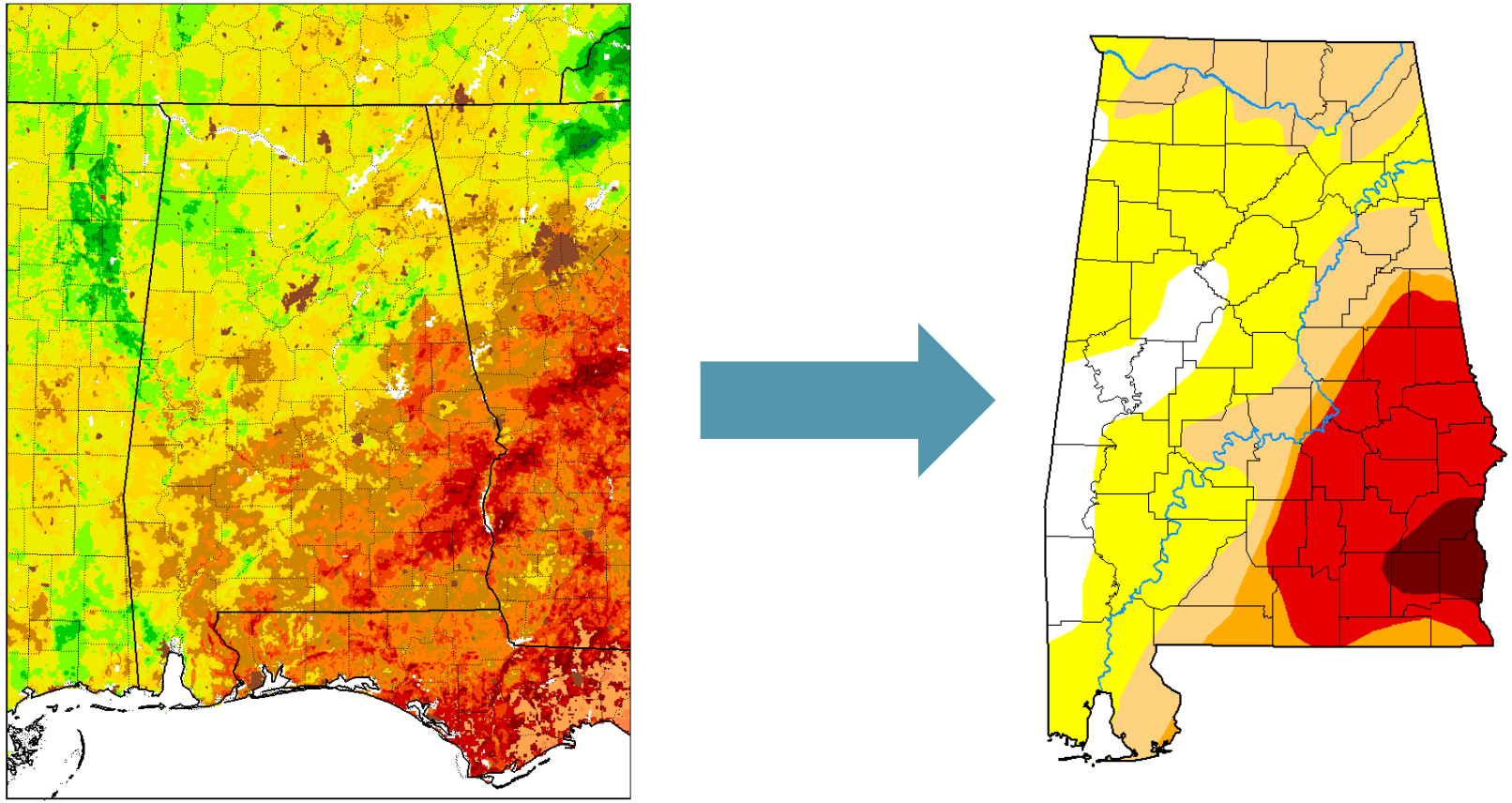


Drought Analysis: Convergence of Evidence

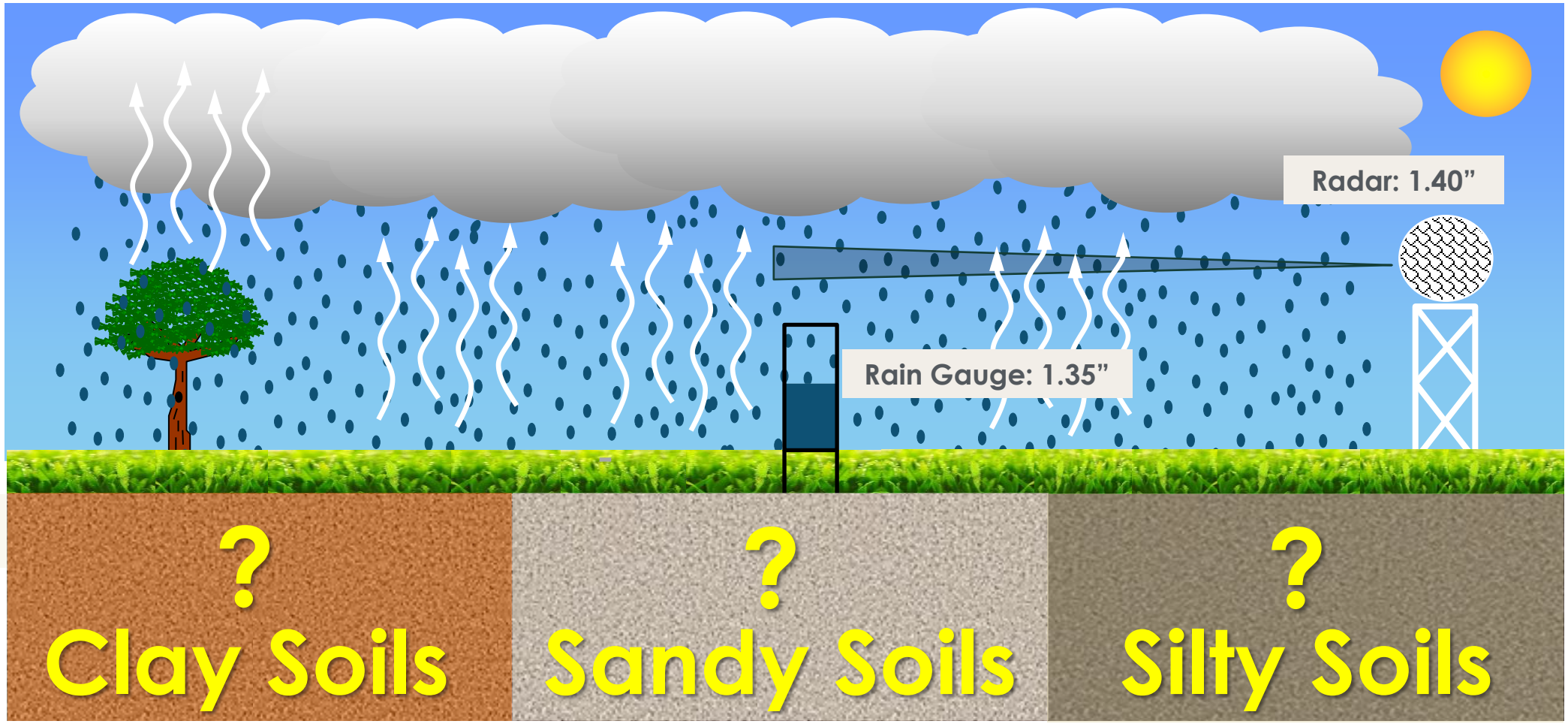
- These factors can complicate the drought analysis process.
- Thus, the USDM works on a principal of convergence of evidence.
- This module will focus on water storage in soils.



Background Information –
Early Applications of NASA SPoRT-LIS for Drought Analysis

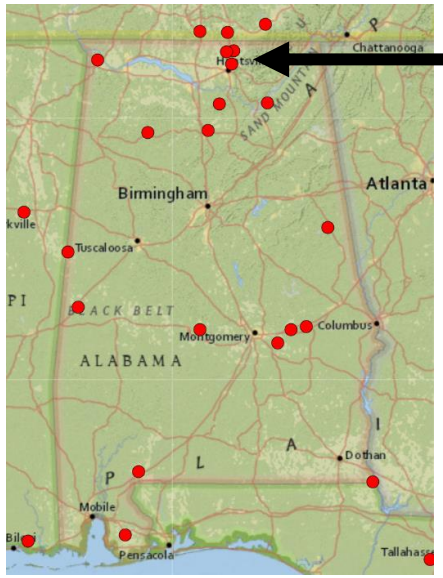


Soil Moisture for Drought Analysis



Soil Moisture for Drought Analysis

In-Situ Sources such as the USDA Soil Climate Analysis Network (SCAN)

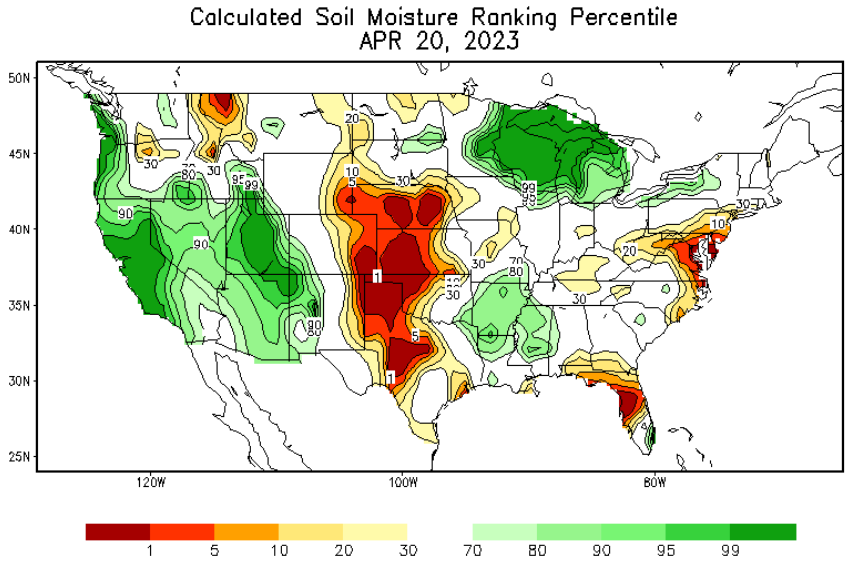


Bragg Farm (2078)
Alabama SCAN Site - 798 ft
Reporting Frequency: Daily; Date Range: 2023-03-23 to 2023-04-21

Date	Station Id	Station Name	Precipitation Increment (in)	Air Temperature Average (degF)	Air Temperature Maximum (degF)	Air Temperature Minimum (degF)	Soil Moisture Percent -2in (pct) Mean of Hourly Values	Soil Moisture Percent -4in (pct) Mean of Hourly Values	Soil Moisture Percent -8in (pct) Mean of Hourly Values	Soil Moisture Percent -20in (pct) Mean of Hourly Values	Soil Moisture Percent -40in (pct) Mean of Hourly Values	Soil Temperature Observed -2in (degF) Mean of Hourly Values
2023-03-23	2078	Bragg Farm	0.00	69.4	80.2	58.3	36.6	36.8	30.9	36.8	33.8	
2023-03-24	2078	Bragg Farm	1.12	72.1	79.9	60.6	34.9	35.4	29.4	36.0	33.6	
2023-03-25	2078	Bragg Farm	0.20	66.4	76.8	54.1	39.0	38.7	32.3	37.8	35.6	
2023-03-26	2078	Bragg Farm	0.00	66.2	79.5	52.0	35.9	35.6	29.7	36.3	33.6	
2023-03-27	2078	Bragg Farm	0.00	64.6	73.0	55.8	33.9	34.2	28.5	35.9	33.3	
2023-03-28	2078	Bragg Farm	0.00	54.1	63.7	44.6	31.0	32.6	27.4	35.6	33.0	
2023-03-29	2078	Bragg Farm	0.00	50.0	63.1	37.4	28.4	31.0	26.3	35.3	32.9	
2023-03-30	2078	Bragg Farm	0.00	57.2	73.0	36.9	26.9	29.6	24.8	34.9	32.6	
2023-03-31	2078	Bragg Farm	0.04	67.3	72.9	59.4	26.6	28.6	23.3	34.7	32.5	
2023-04-01	2078	Bragg Farm	0.24	66.7	78.8	48.9	31.9	27.9	22.4	34.4	32.3	
2023-04-02	2078	Bragg Farm	0.00	55.6	69.6	40.6	27.4	26.7	21.3	34.1	32.2	
2023-04-03	2078	Bragg Farm	0.12	58.8	62.6	54.1	26.6	26.4	20.9	33.9	32.2	
2023-04-04	2078	Bragg Farm	0.00	72.9	84.7	61.5	27.0	26.5	21.0	34.0	32.0	
2023-04-05	2078	Bragg Farm	0.31	73.2	85.8	61.5	29.2	26.3	20.7	33.6	32.0	
2023-04-06	2078	Bragg Farm	0.04	60.8	70.5	50.4	35.5	26.0	20.5	33.4	31.9	
2023-04-07	2078	Bragg Farm	0.44	48.7	50.5	45.9	39.3	26.0	20.5	33.3	31.8	

USDA Soil Climate Analysis Network sites (SCAN, red dots, left), and example SCAN site data (above).

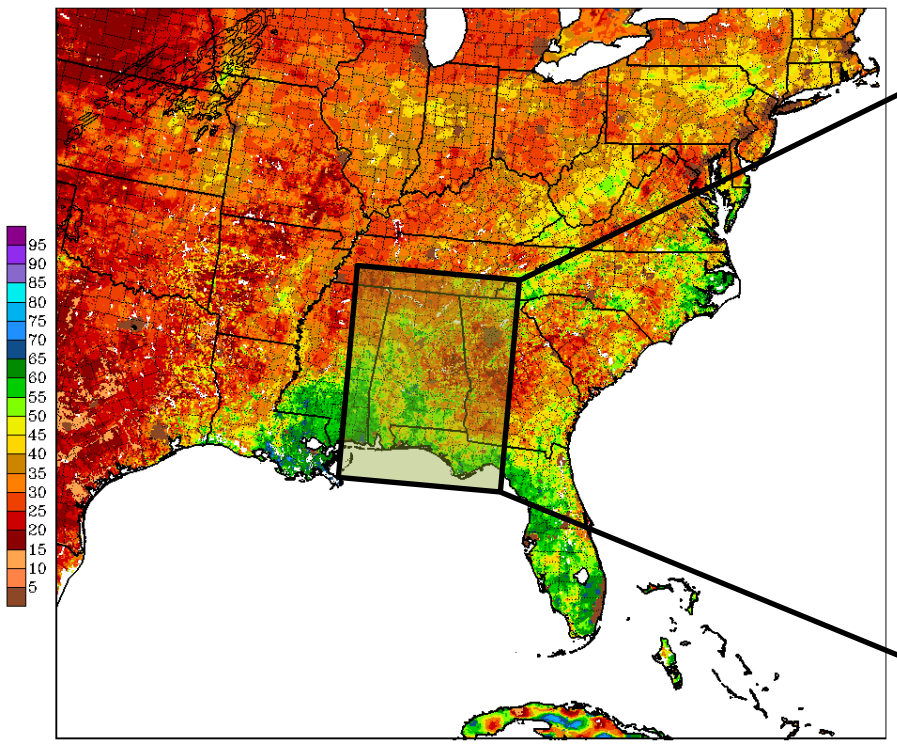
Soil Moisture Analyses from the Climate Prediction Center



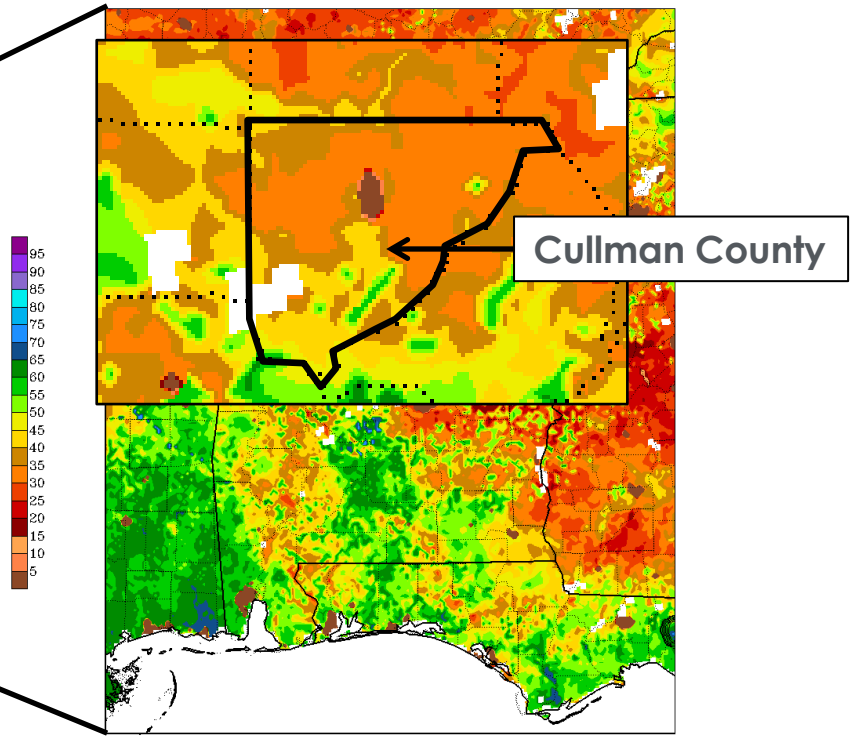
Climate Prediction Center (CPC) 1 m Soil Moisture Ranking Percentile

SPoRT-LIS Soil Moisture for Drought Analysis

3-km SPoRT LIS Relative Column Integrated (0-200 cm) Soil Moisture (%) – "INT-RSOIM"

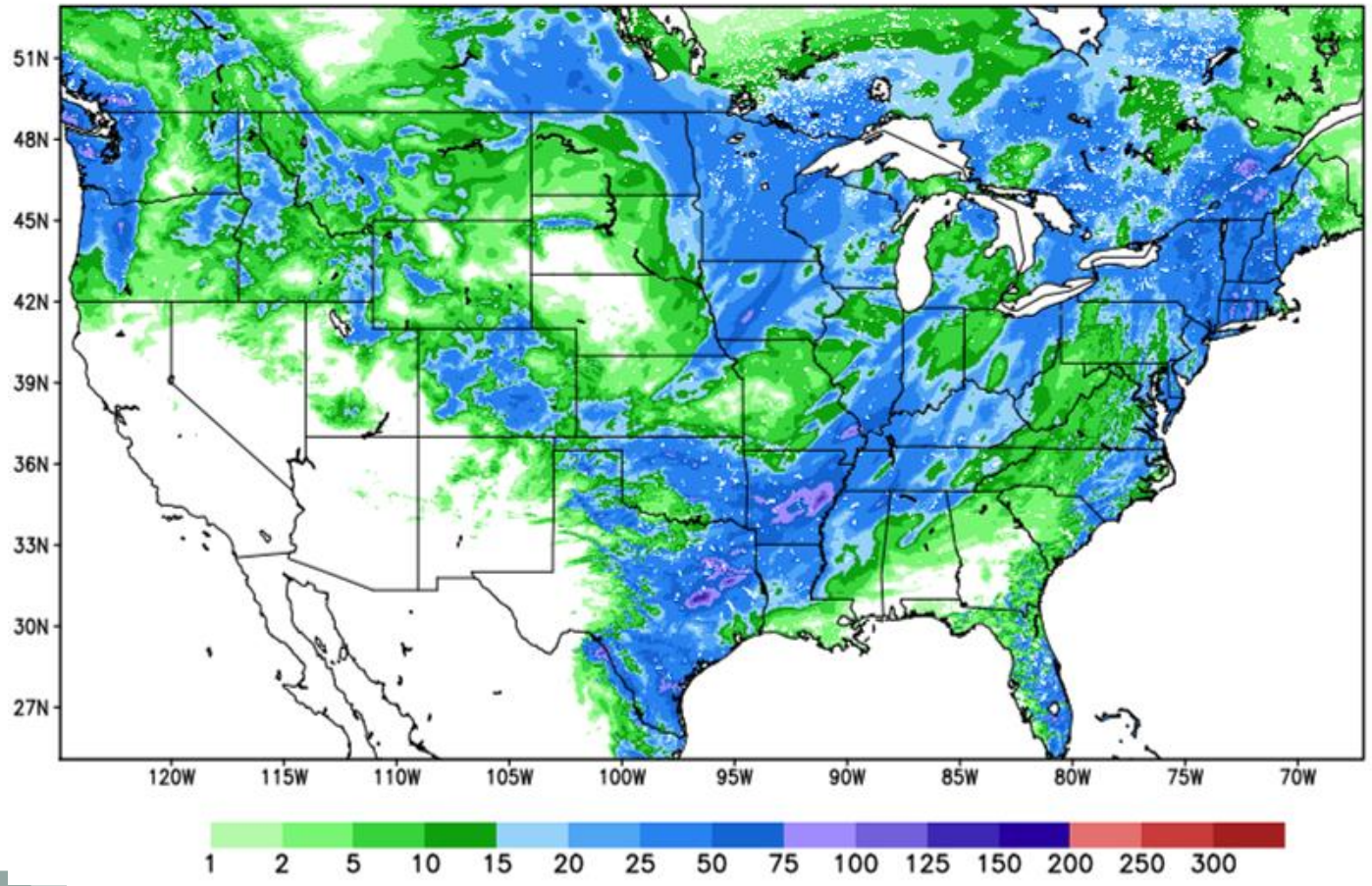


3-km SPoRT LIS Relative Column Integrated (0-200 cm) Soil Moisture (%) – "INT-RSOIM"



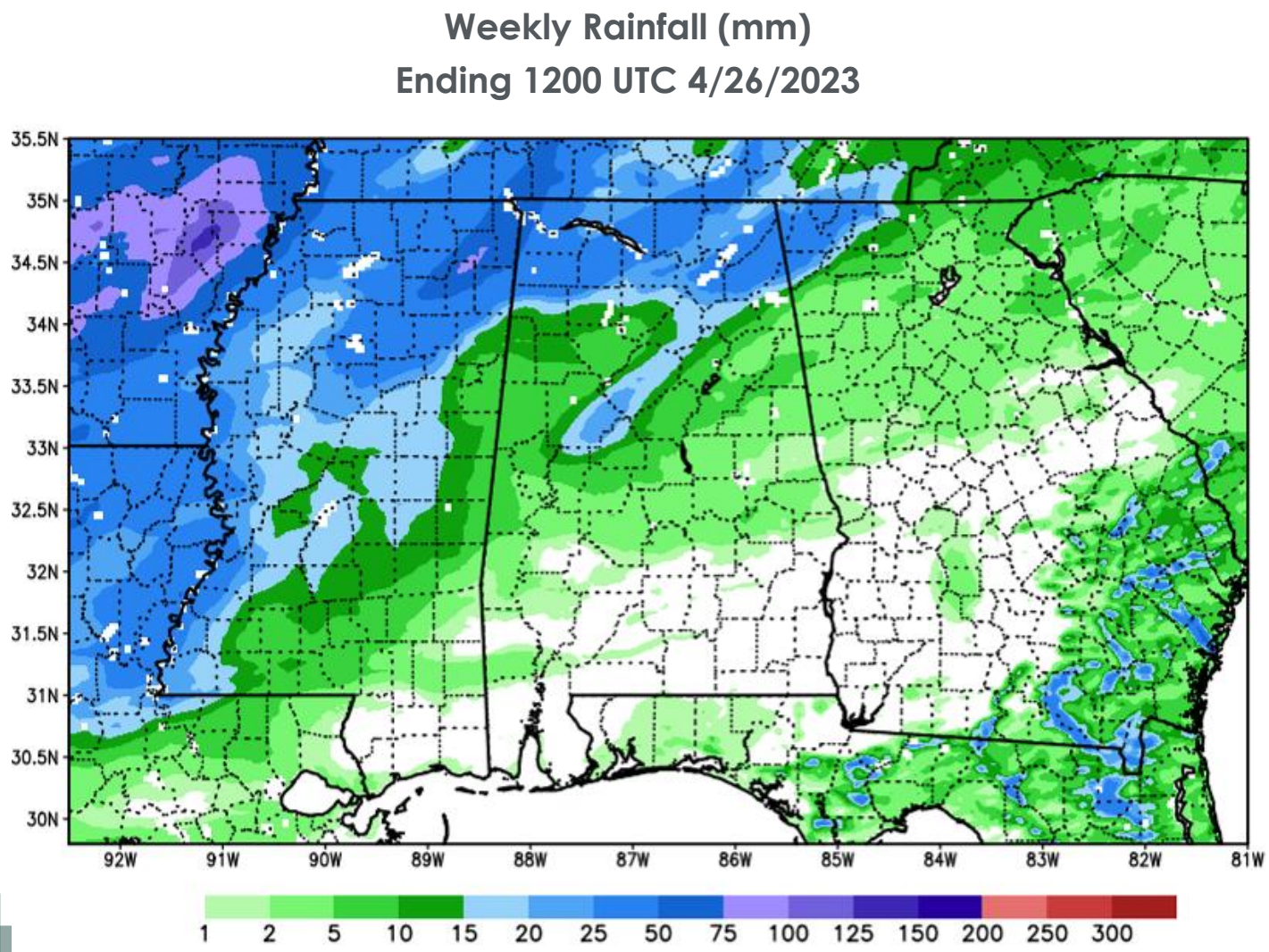
SPoRT-LIS Soil Moisture Data for Drought Monitoring

Weekly Rainfall (mm)
Ending 1200 UTC 4/26/2023



- Multi-Radar/Multi-Sensor (MRMS) Weekly Rainfall
- Rainfall was highly variable across the Continental U.S. (CONUS).
- Swaths of heavy rainfall over portions of the country, but a good gradient across the Southeast CONUS.

SPoRT-LIS Soil Moisture Data for Drought Monitoring



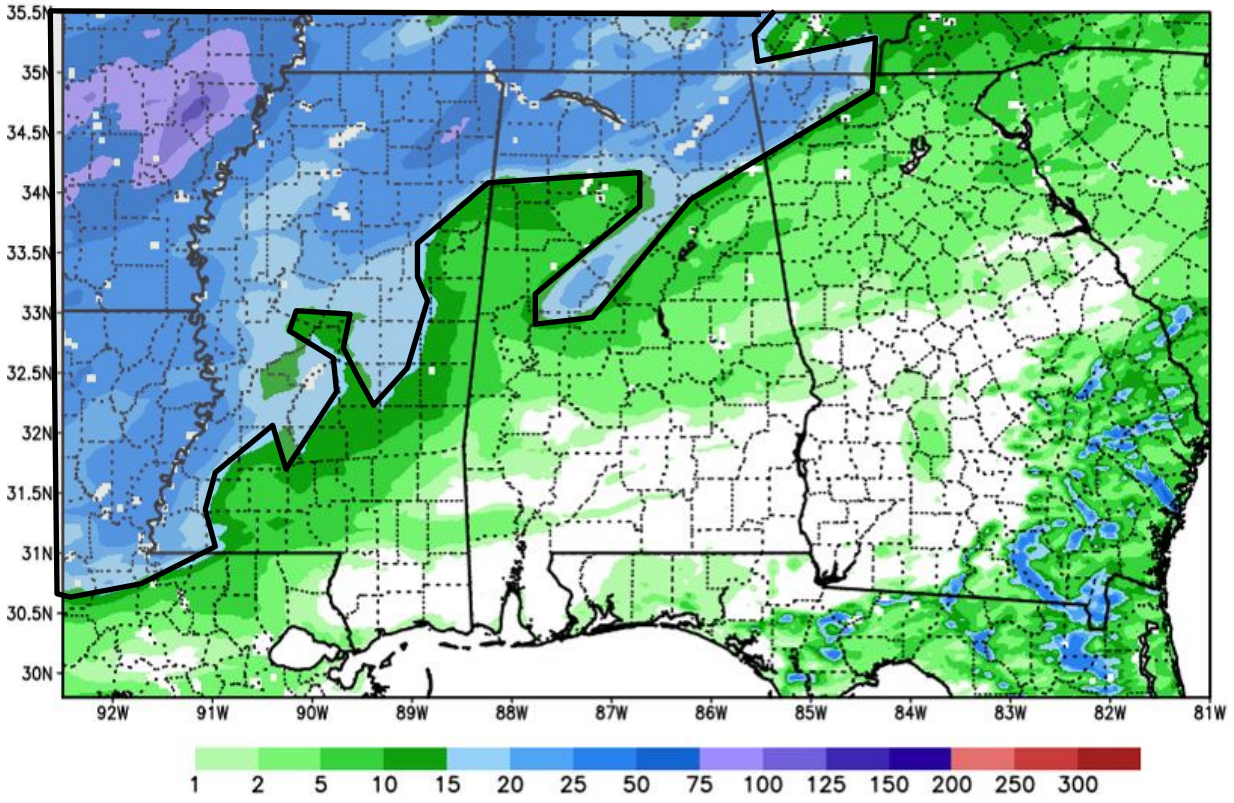
- MRMS 7-day precipitation indicated a maximum over portions of E. Arkansas.
- Precipitation amounts were lesser to the East.

How would soil moisture respond to these inputs of precipitation over the weekly period?

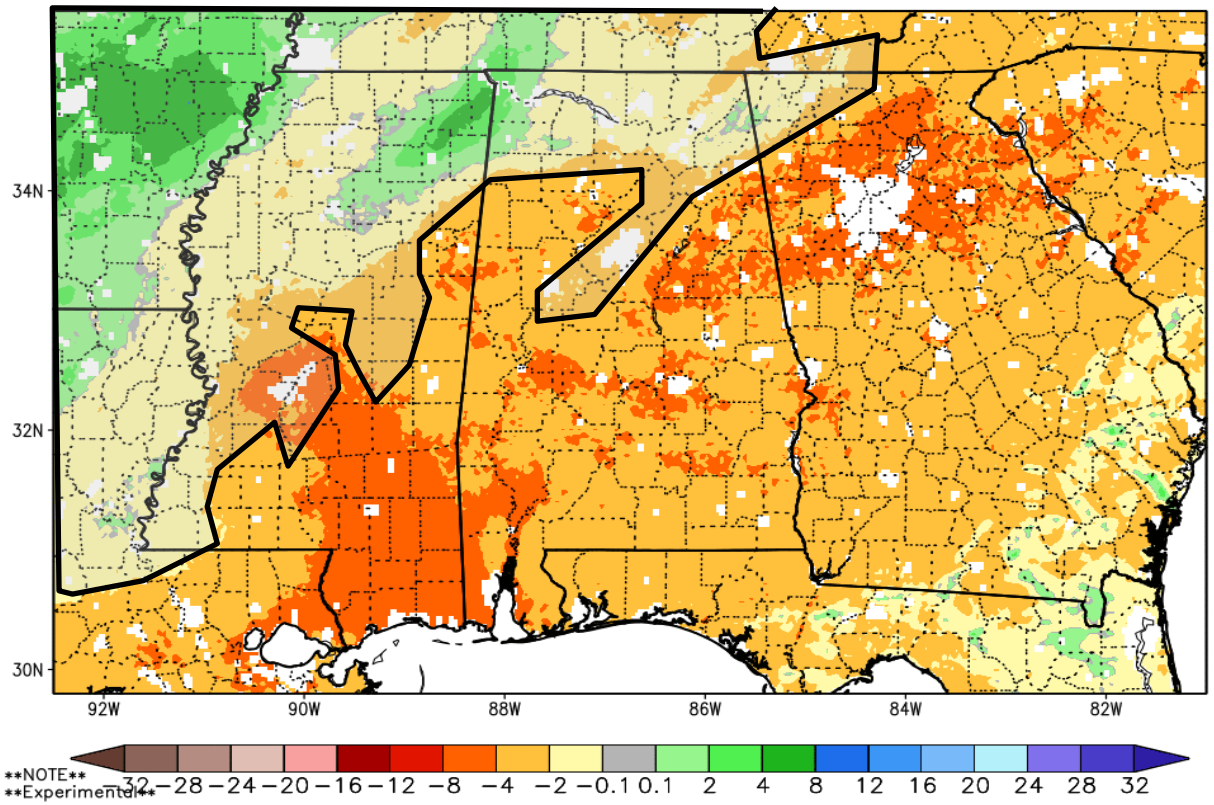
SPoRT-LIS Soil Moisture Data for Drought Monitoring

Precipitation vs. Changes in Soil Moisture

MRMS 7-day Precipitation Totals (mm) Ending 12 UTC 26 April 2023



SPoRT-LIS One Week Change in 0-200 cm Relative Soil Moisture (%)



SPoRT-LIS Soil Moisture Data for Drought Monitoring

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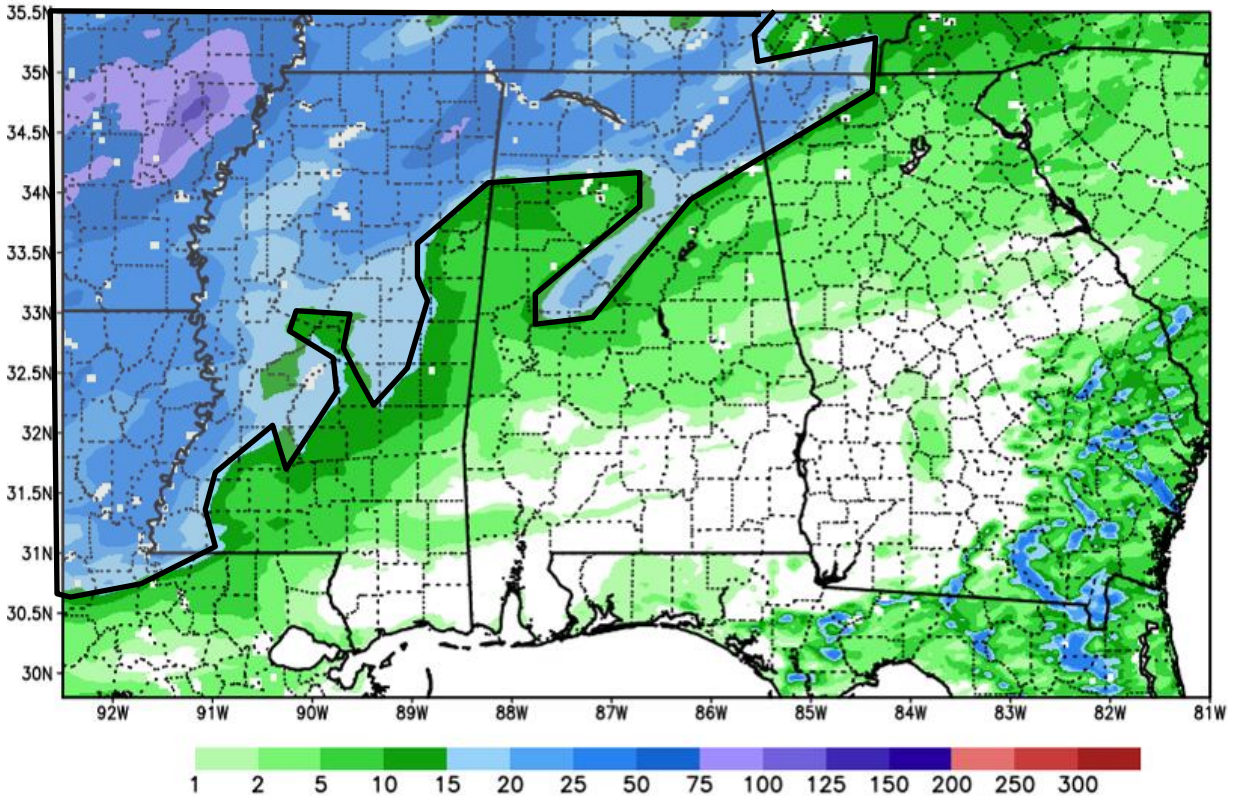
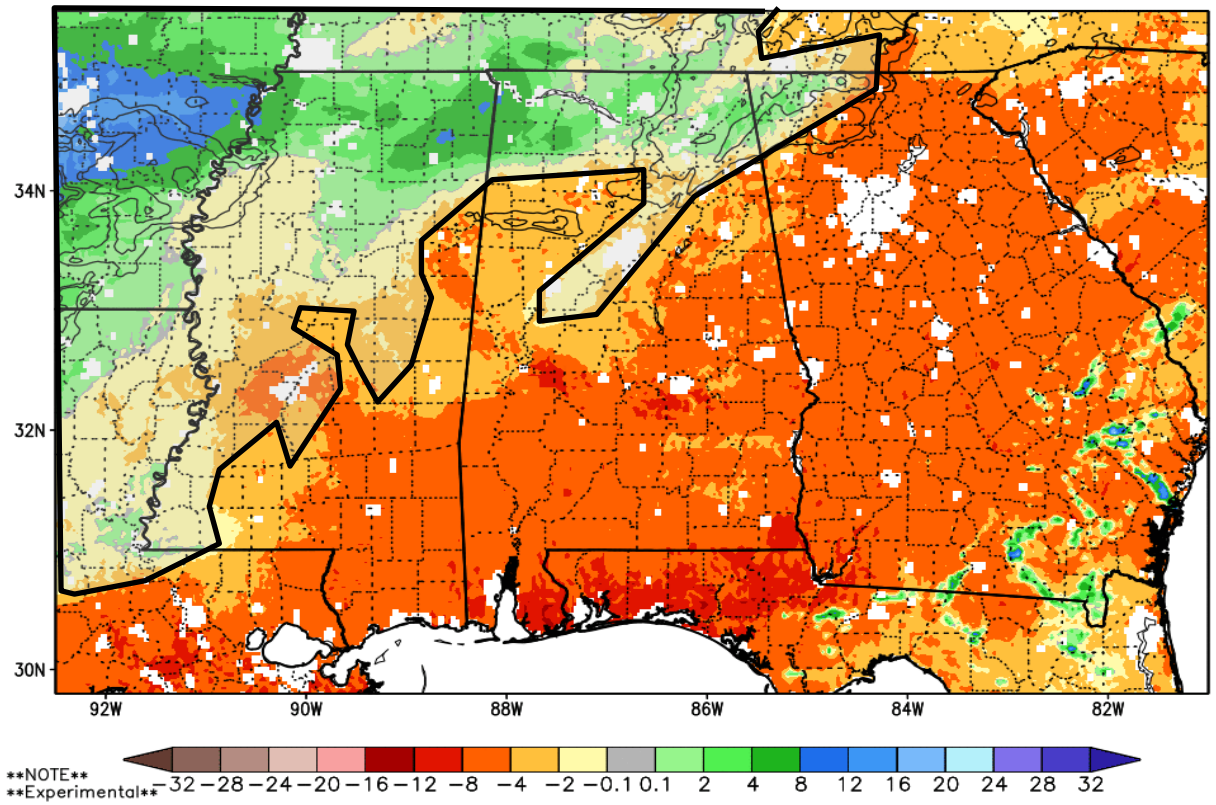
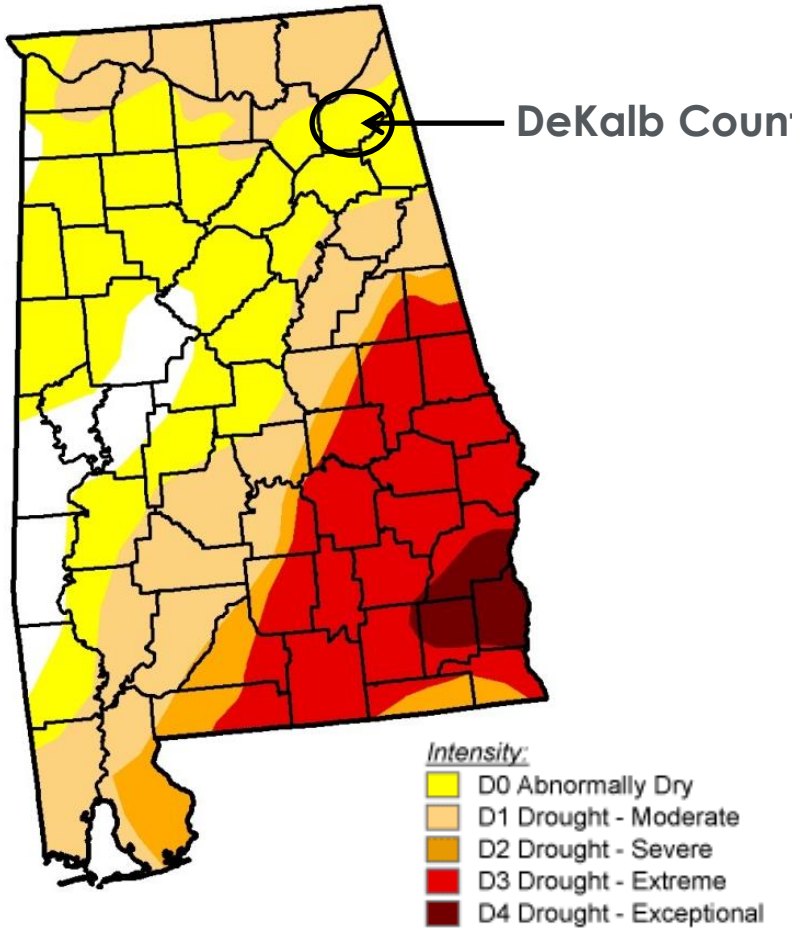


SPoRT-LIS One Week Change in 10-40 cm Relative Soil Moisture (%)



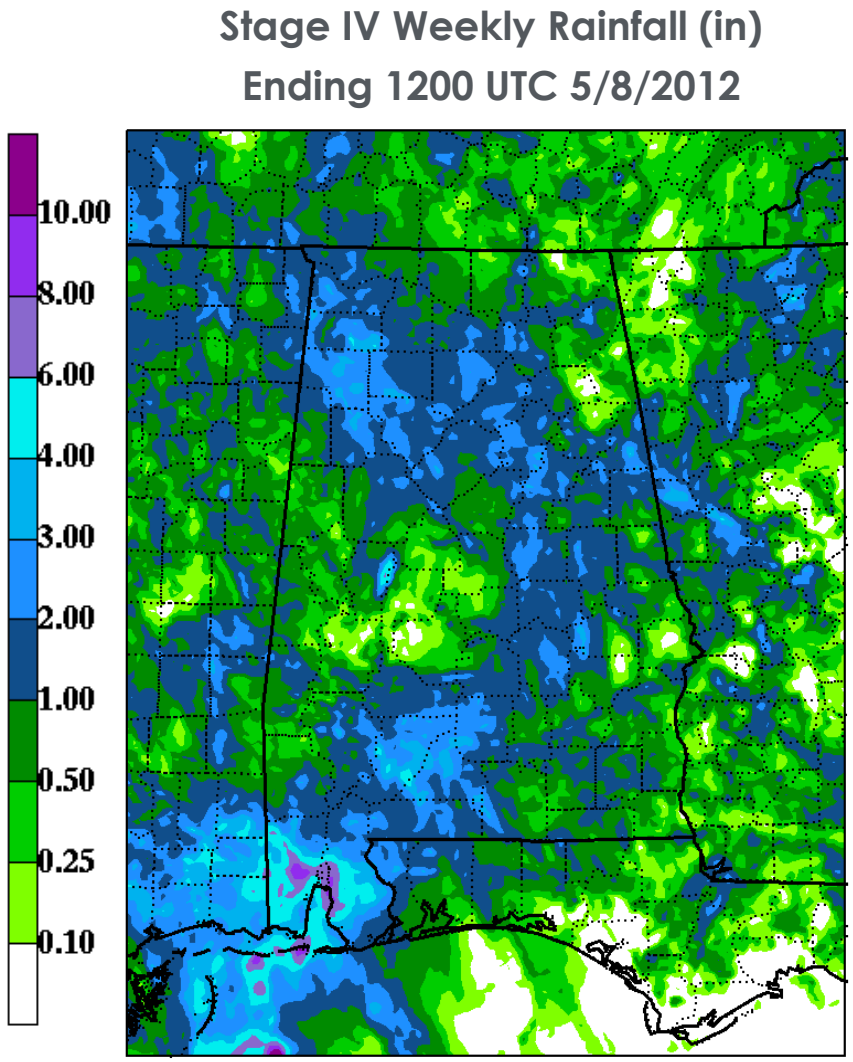
SPoRT-LIS Soil Moisture Data for Drought Monitoring

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



- D1 (moderate) drought extends across portions of Northern Alabama on May 1st, 2012.
- D0 (abnormally dry) conditions existed across much of the rest of Northern Alabama.

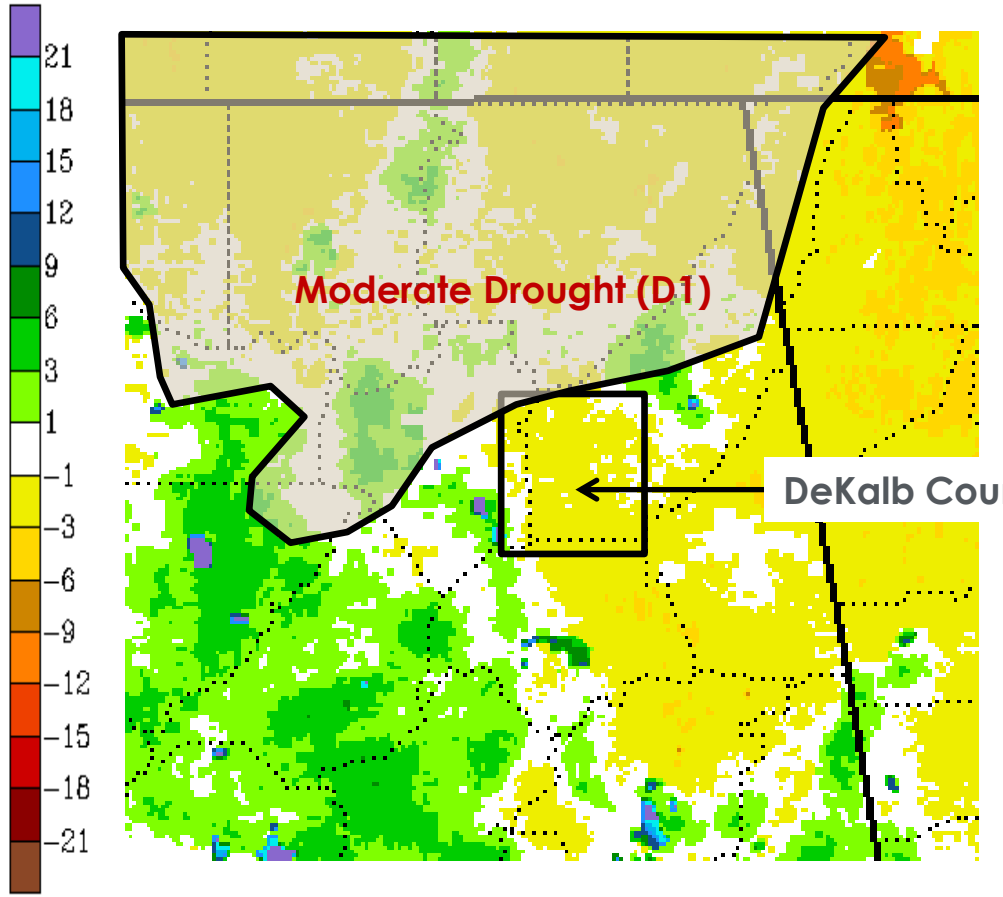
SPoRT-LIS Soil Moisture Data for Drought Monitoring



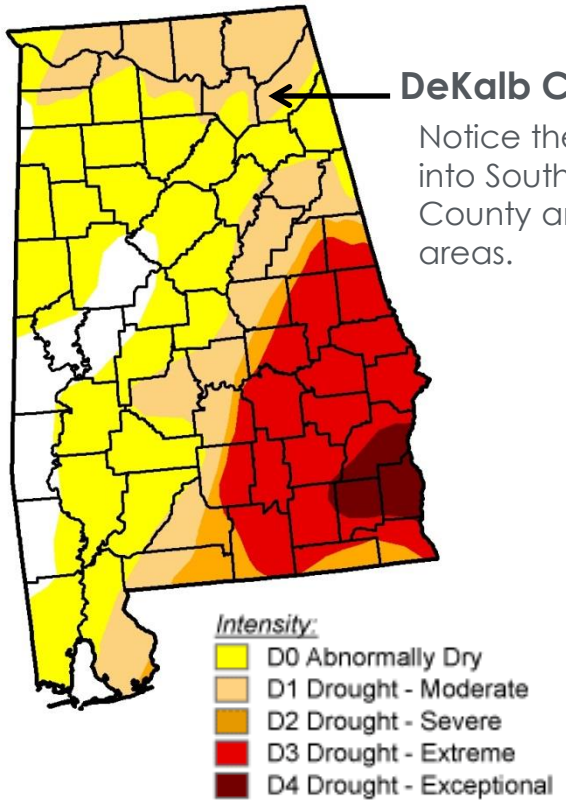
- Rainfall amounts for the weekly period ending 1200 UTC May 8, 2012 were ~1" and greater across much of the area.
- Lesser rainfall amounts occurred in NE Alabama.
- Questions Remain:
  - How will soil moisture respond?
  - Where should I focus my attention?

SPoRT-LIS Soil Moisture Data for Drought Monitoring

0-200 cm Relative Soil Moisture (%)
Weekly Difference Ending 5/8/2012



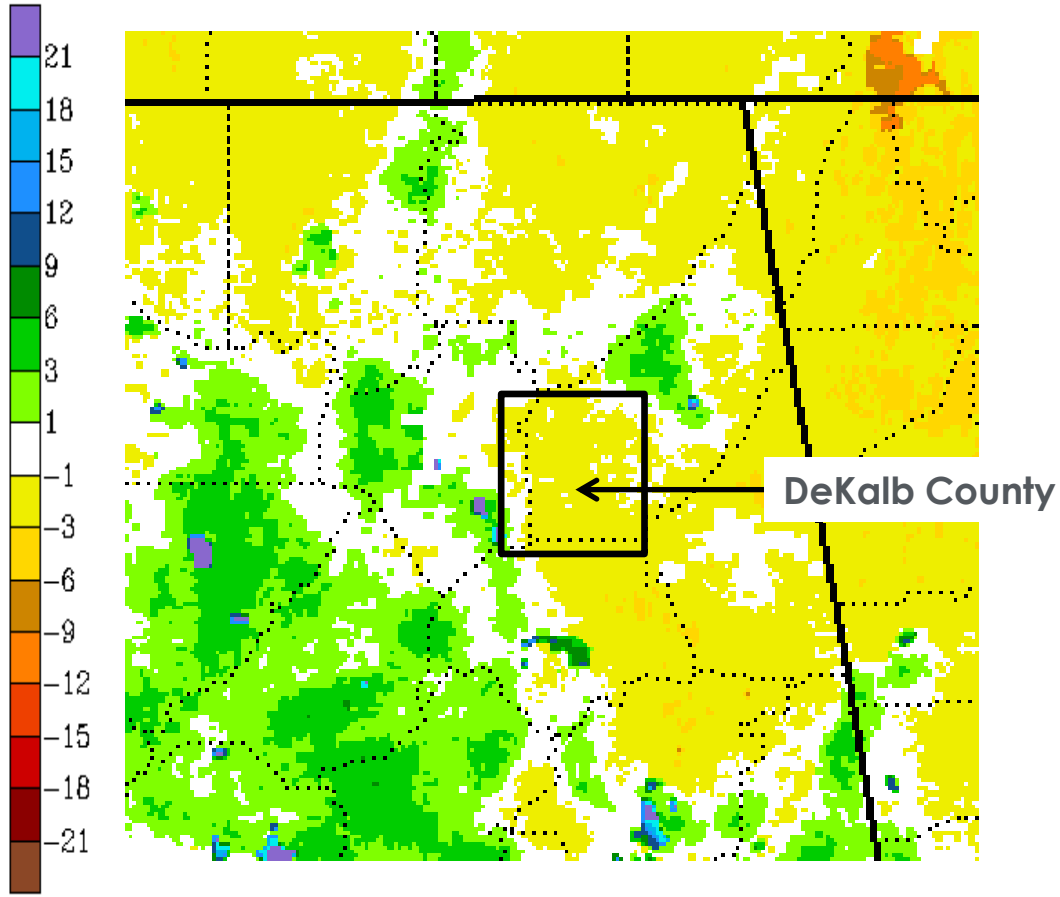
U.S. Drought Monitor Depiction
for Alabama – 5/8/2012



Notice the expansion into Southern DeKalb County and adjacent areas.

SPoRT-LIS Soil Moisture Data for Drought Monitoring

0-200 cm Relative Soil Moisture (%)
Weekly Difference Ending 5/8/2012



U.S. Drought Monitor Depiction
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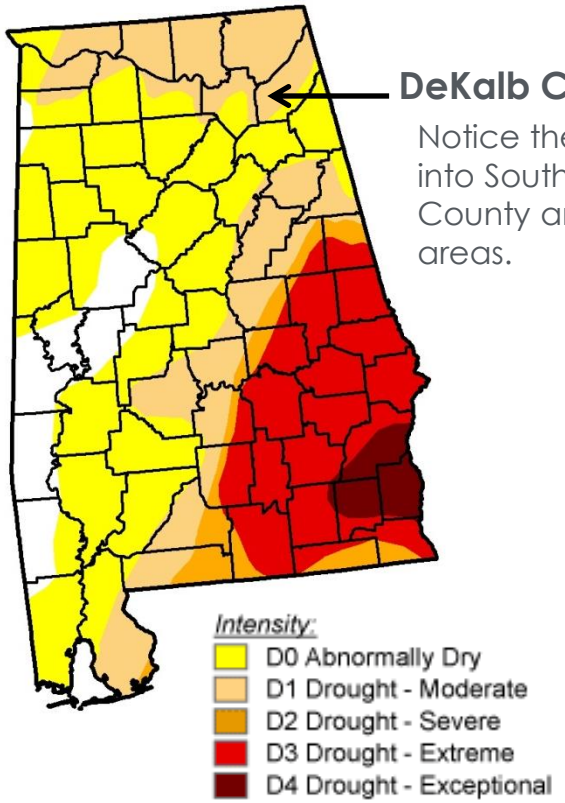
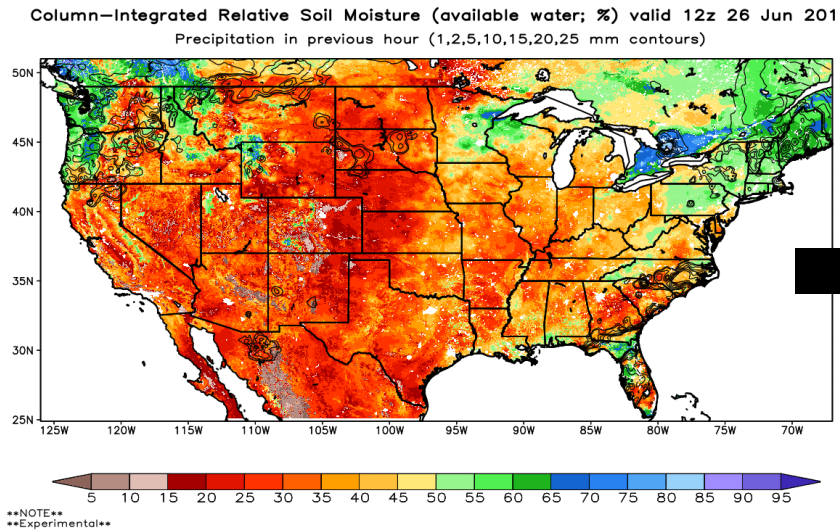


Notice the expansion into Southern DeKalb County and adjacent areas.

SPoRT-LIS Soil Moisture Data for Drought Monitoring

- R2O/O2R activities led to additions in the SPoRT-LIS data suite:
  - **Soil moisture change values**
  - Soil moisture climatology and ranking percentiles



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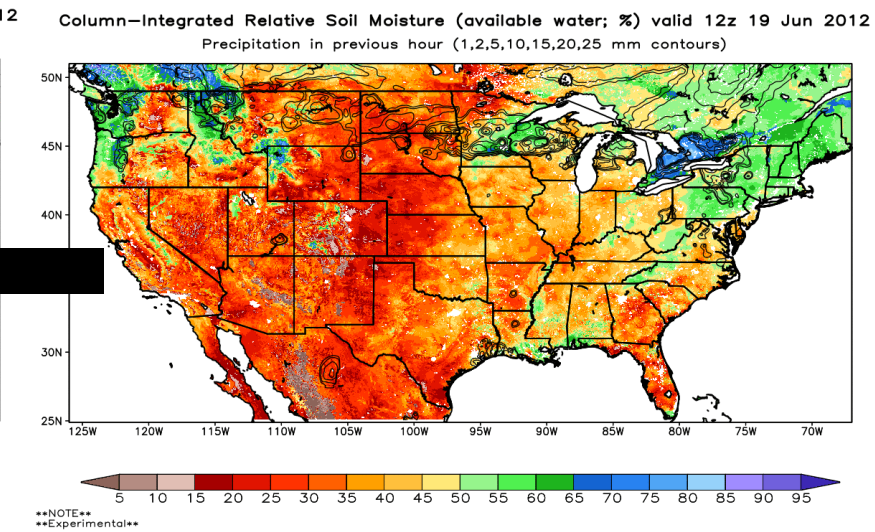

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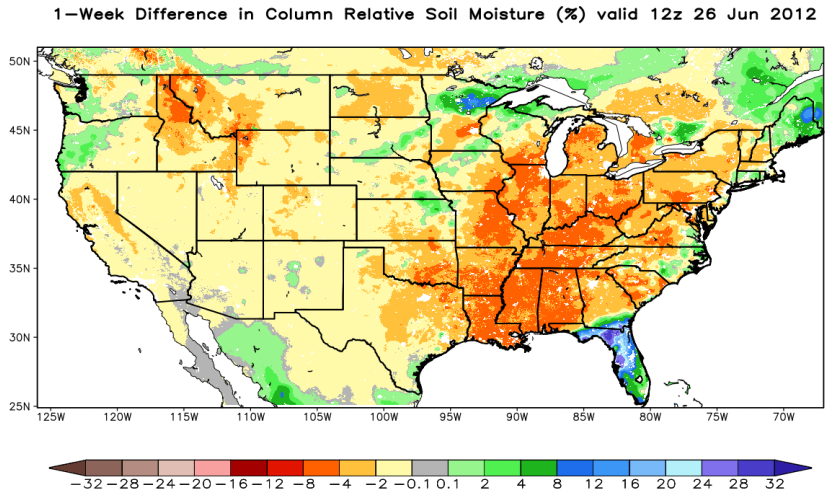

SPoRT-LIS Soil Moisture Data for Drought Monitoring

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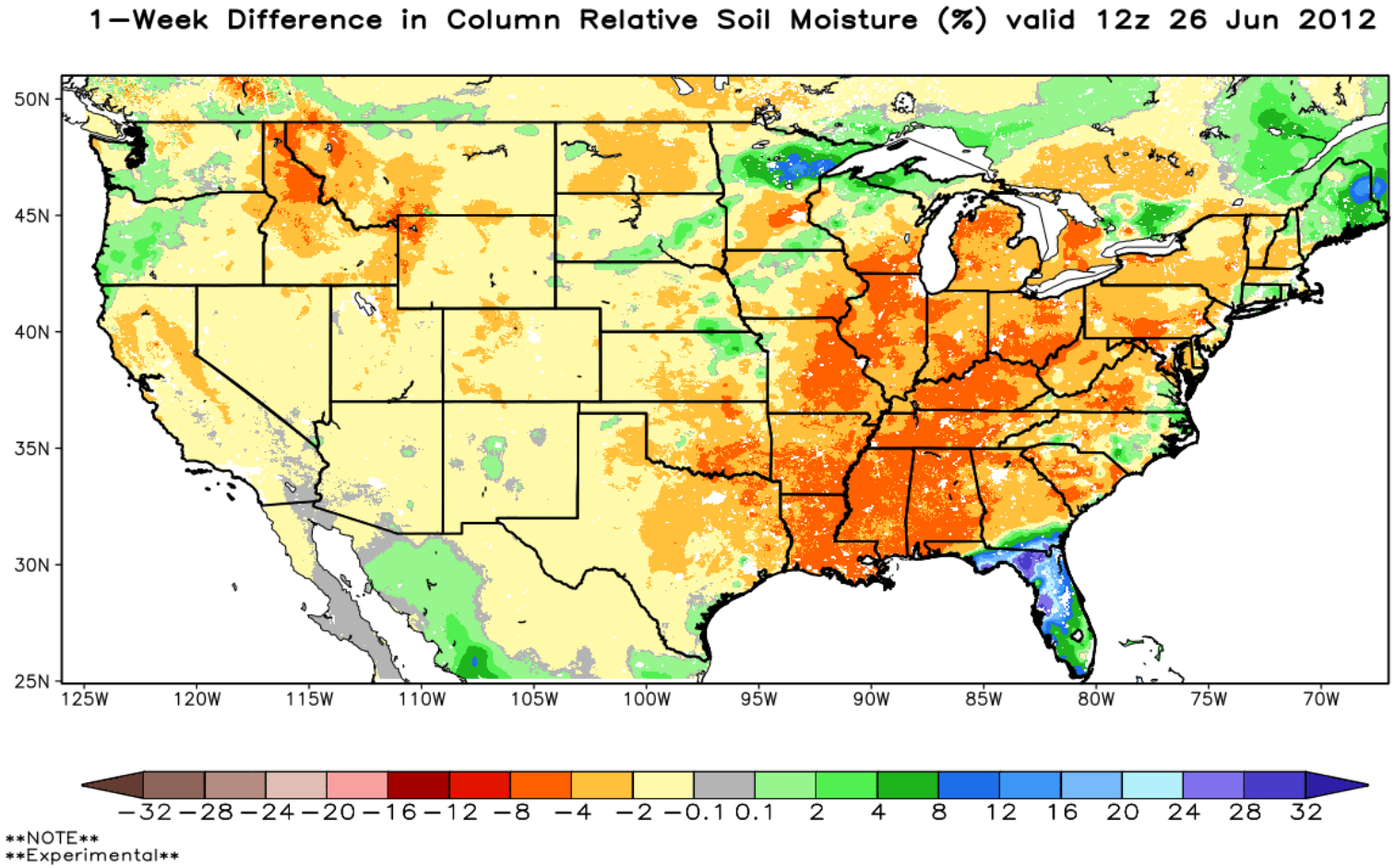

SPoRT-LIS Soil Moisture Data for Drought Monitoring

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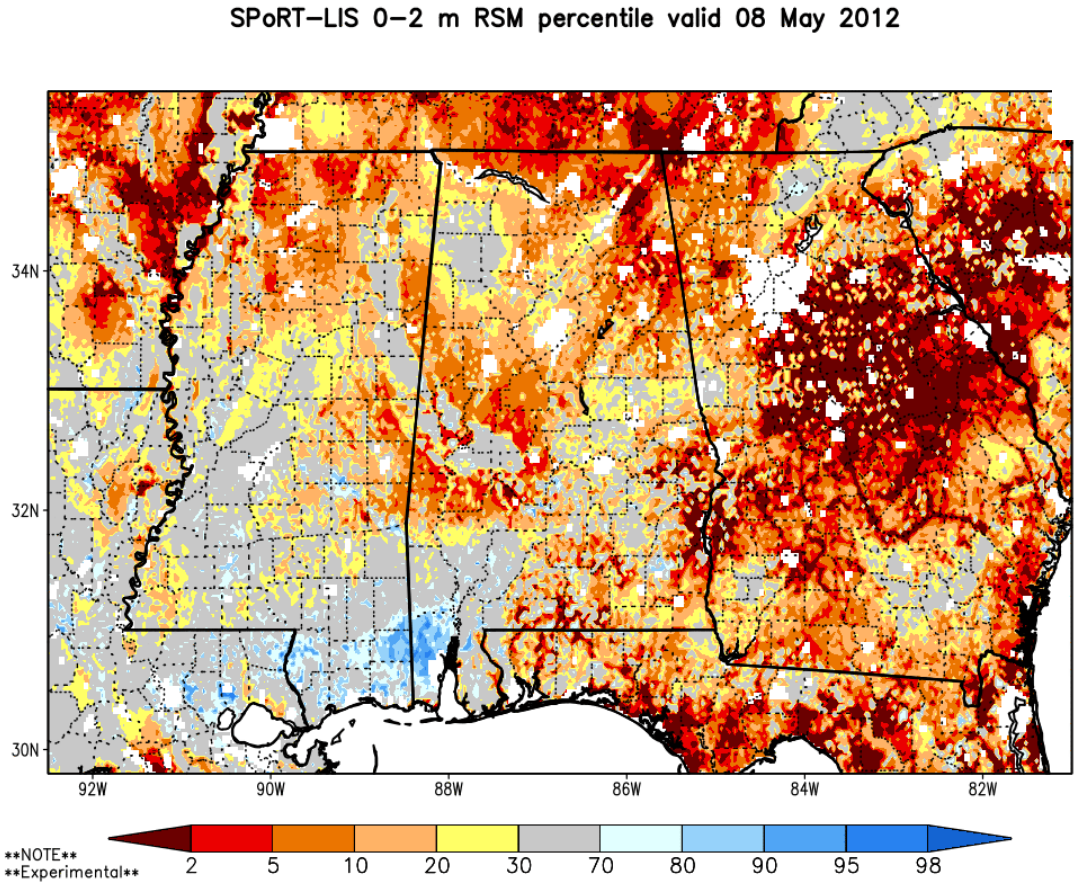
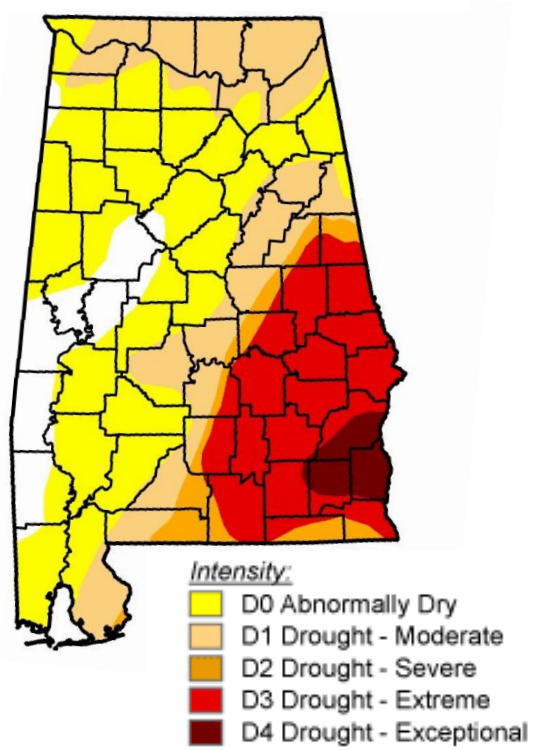
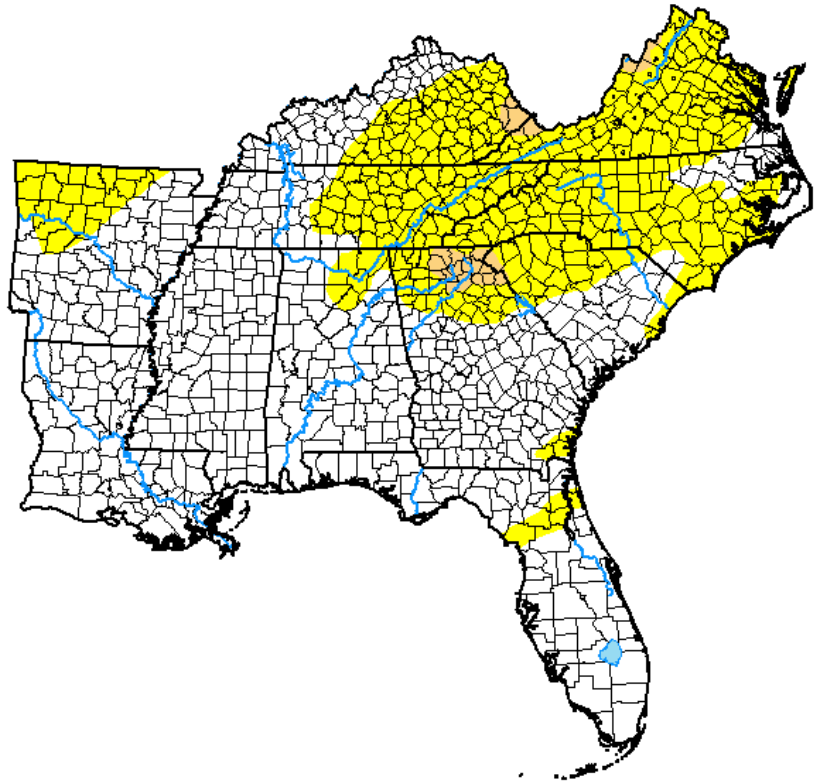


U. S. Drought Monitor Depiction for Alabama – 5/8/2012



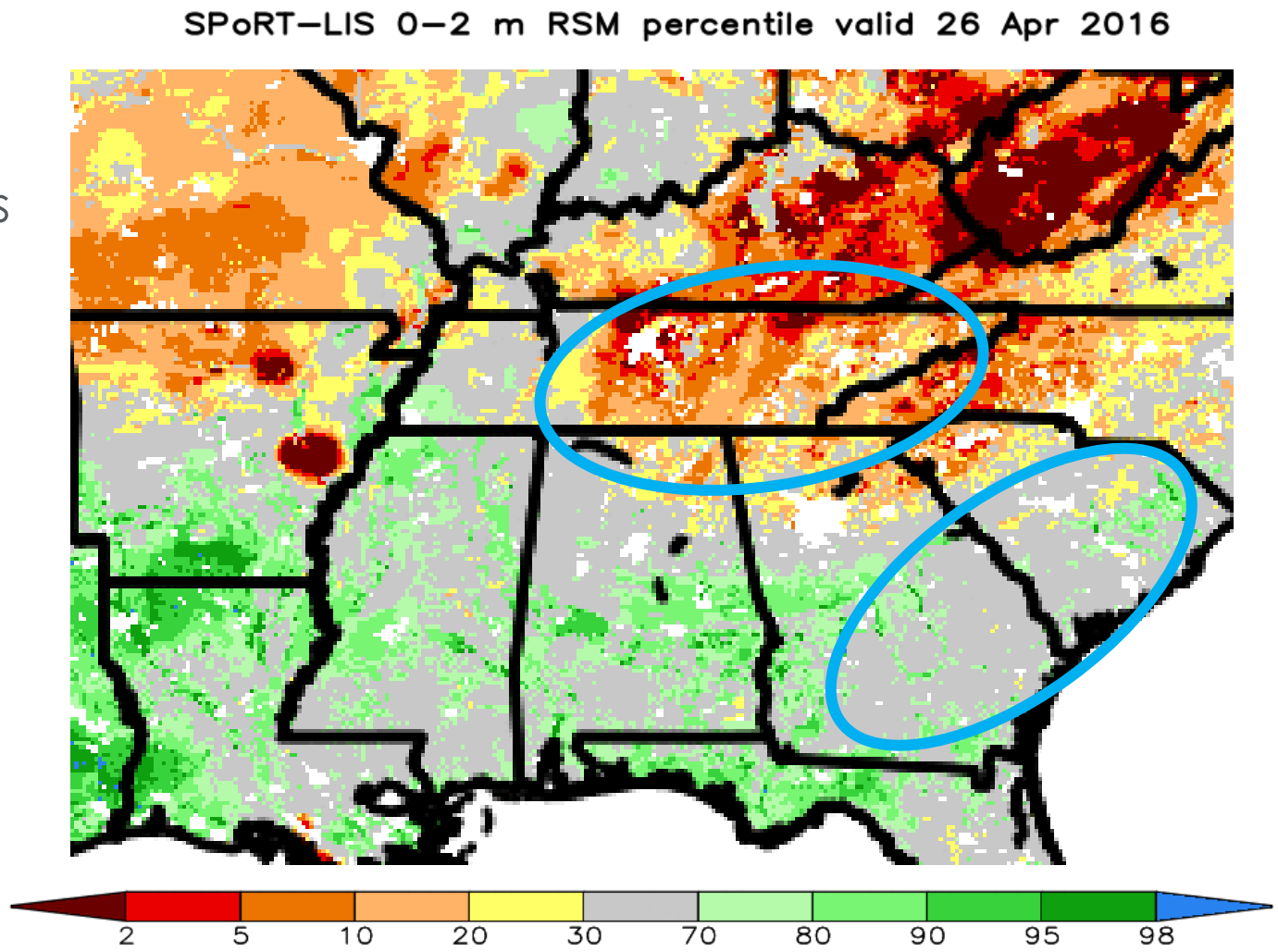
SPoRT-LIS Soil Moisture Data for Drought Monitoring

In April 2016, dry conditions began to develop in portions of the Southeast, which would eventually worsen into summer and fall.



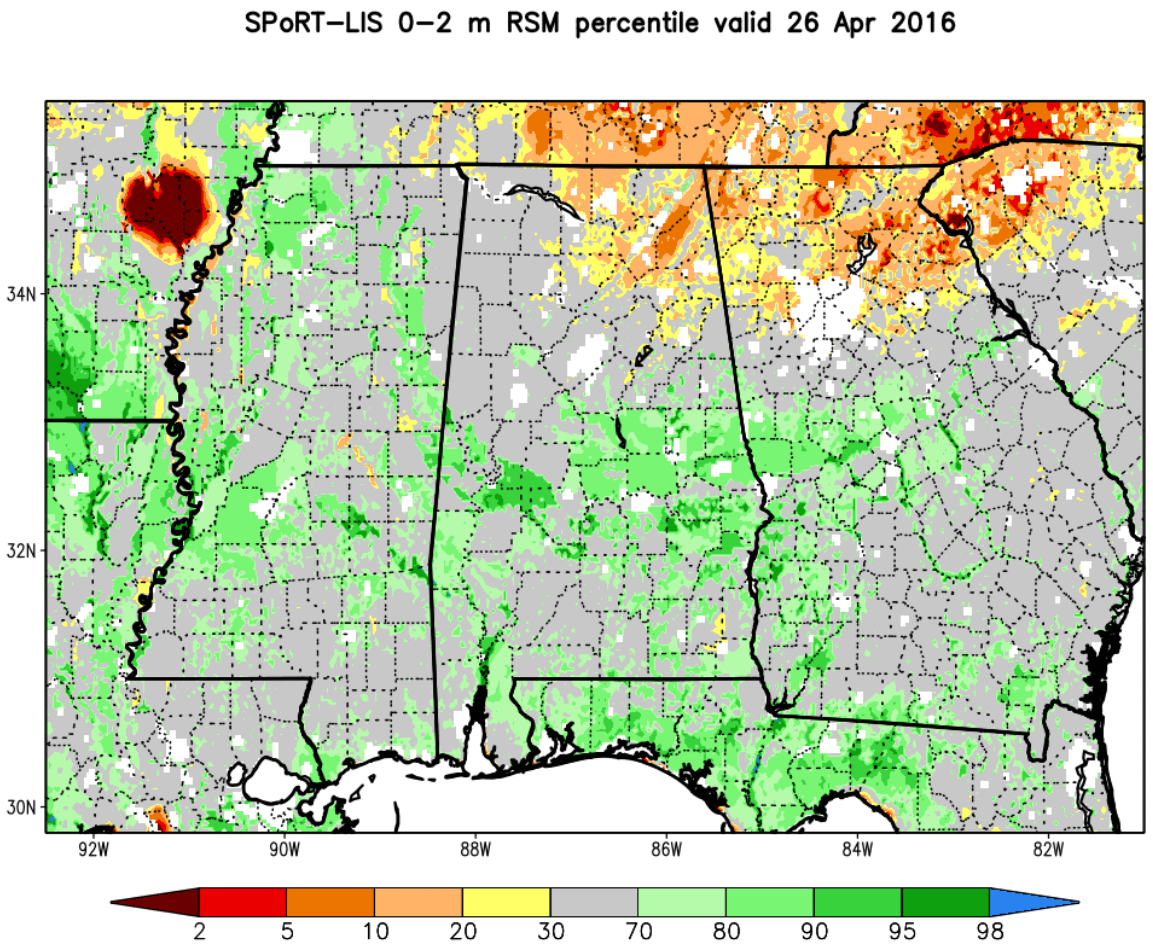
SPoRT-LIS Soil Moisture Data for Drought Monitoring

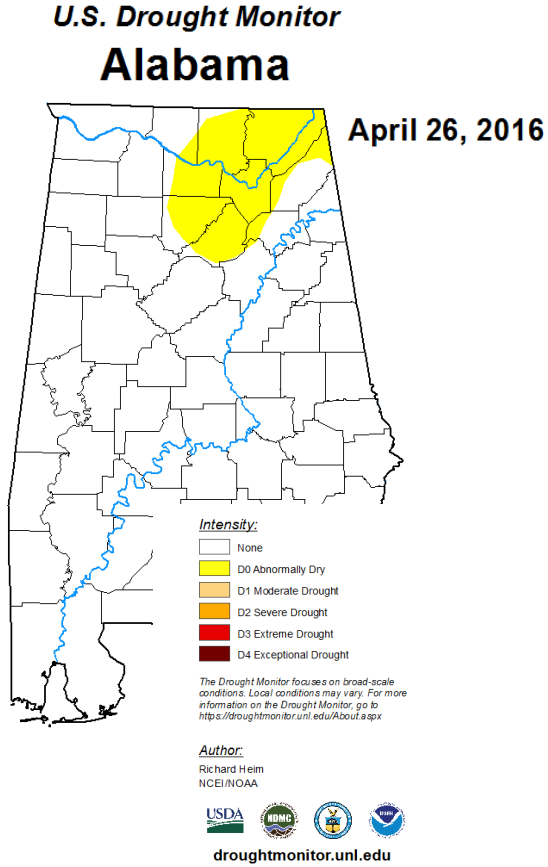
- On April 26th, SPoRT-LIS RSM values indicated comparatively drier soils in portions of the Coastal Plain, as compared to the Tennessee Valley.
- However, soil moisture percentiles put these data into climatological perspective.



SPoRT-LIS Soil Moisture Data for Drought Monitoring

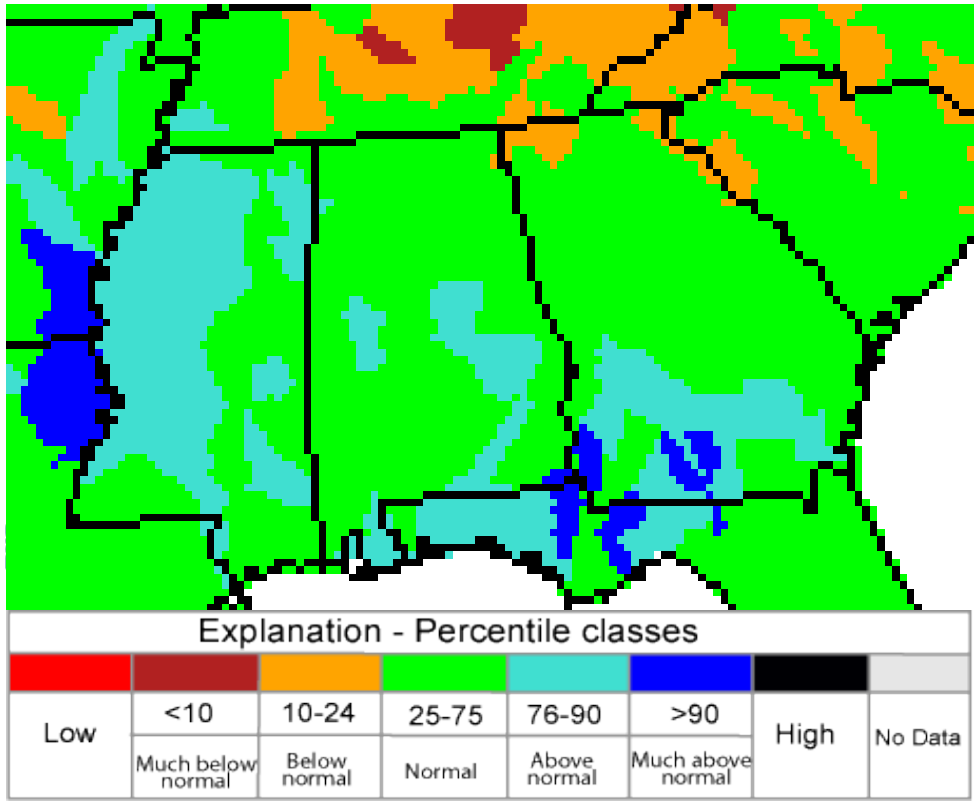
By April 26th, SPoRT-LIS was already indicating 0-200 cm RSM values around the 10th percentile in some areas of Northern Alabama.



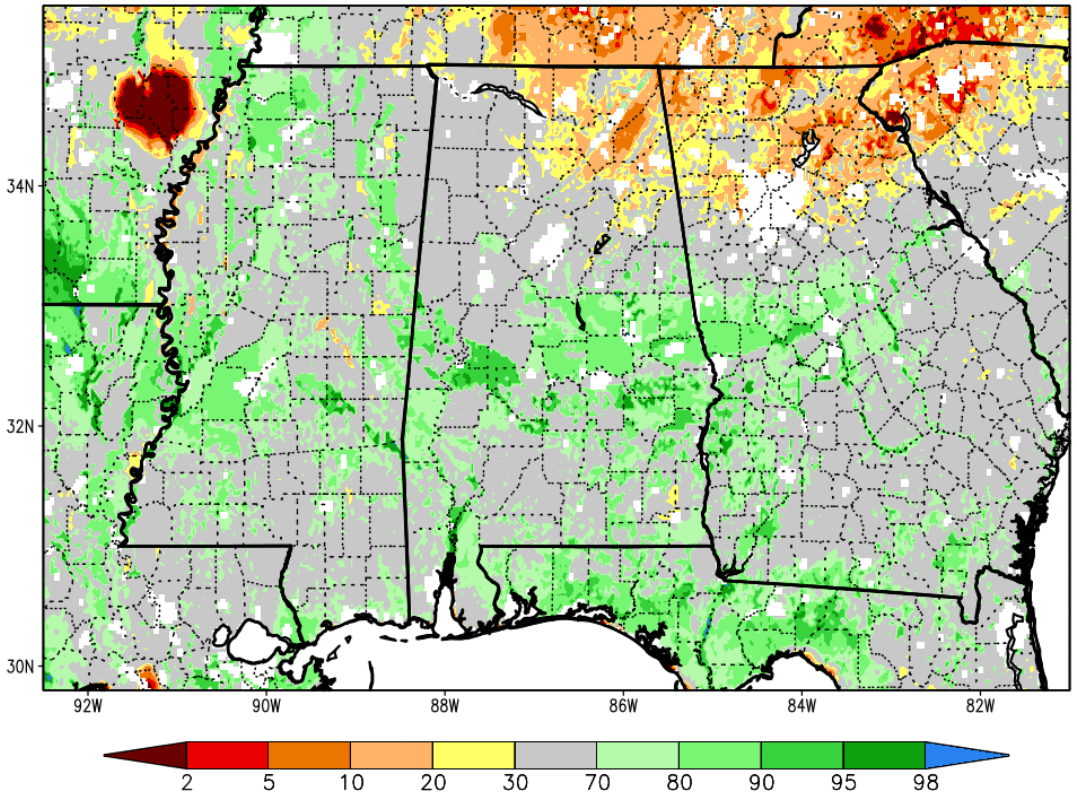


SPoRT-LIS Soil Moisture Data for Drought Monitoring

28-Day Avg Hydrologic Unit Streamflow Percentiles
26 April 2016

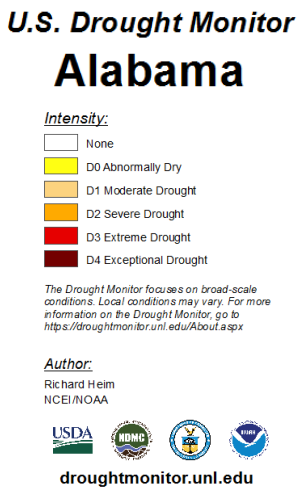


SPoRT–LIS 0–2 m RSM percentile valid 26 Apr 2016



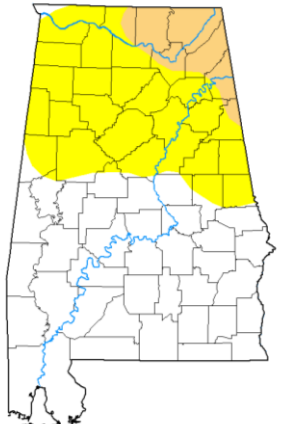
SPoRT-LIS Soil Moisture Data for Drought Monitoring

Relatively dry conditions continued into May, with deterioration in soil moisture conditions.



May 3, 2016

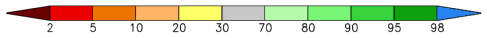
May 10, 2016

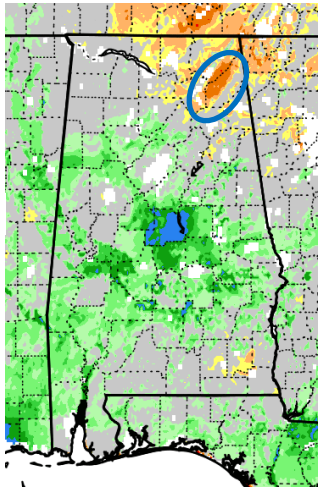


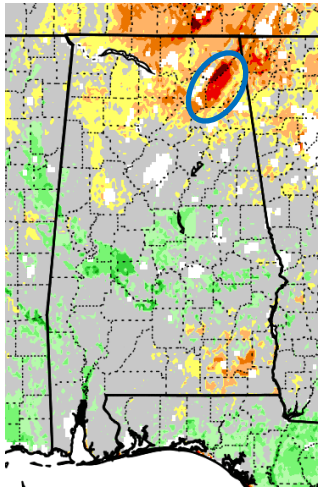
May 17, 2016

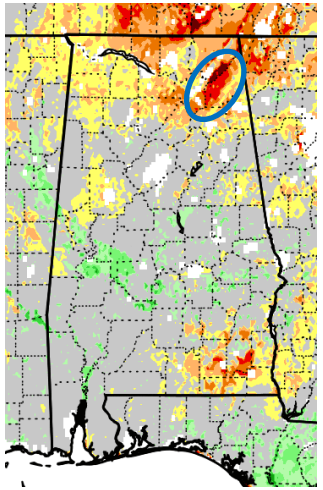
May 24, 2016

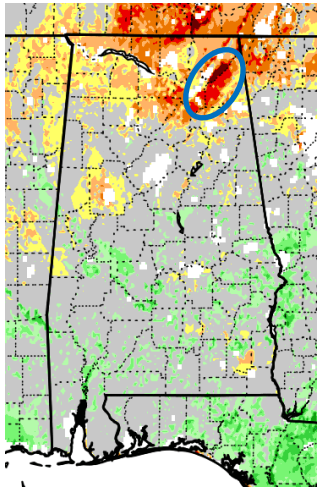
SPoRT-LIS
RSM Percentiles





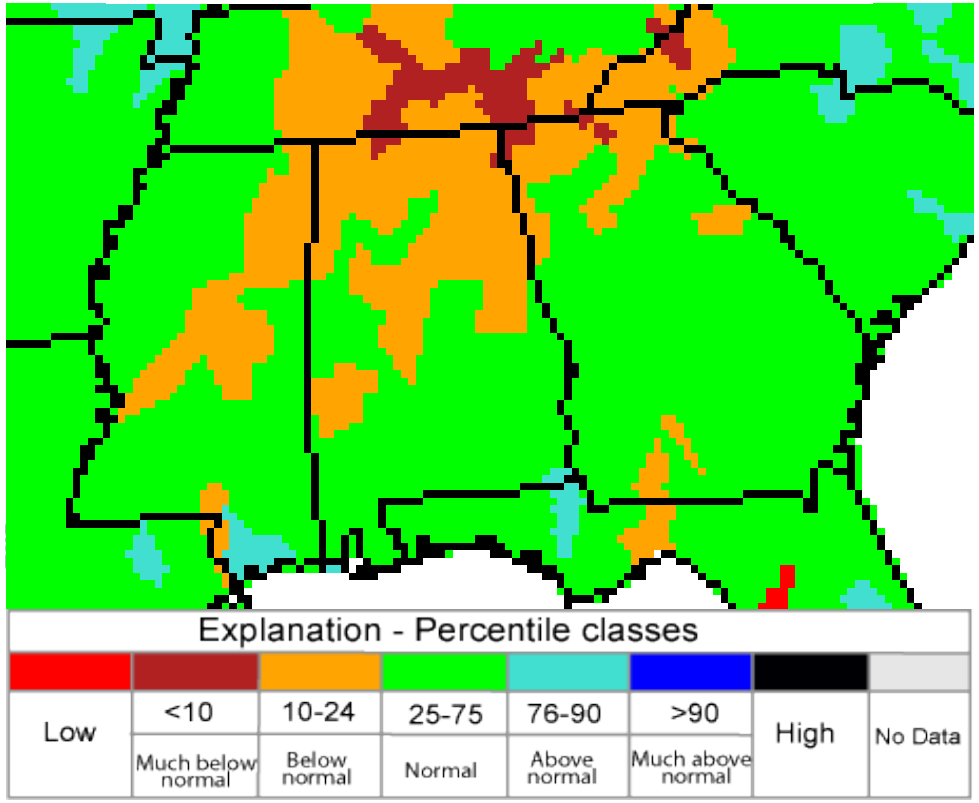




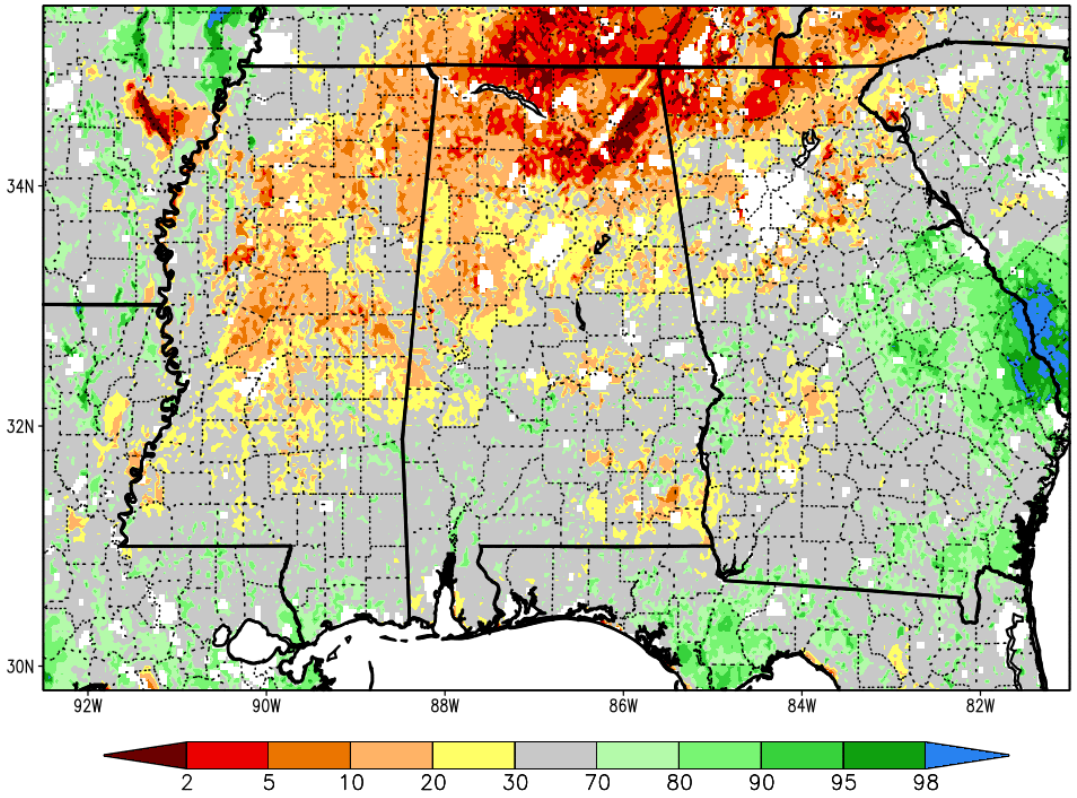


SPoRT-LIS Soil Moisture Data for Drought Monitoring

28-Day Avg Hydrologic Unit Streamflow Percentiles
31 May 2016

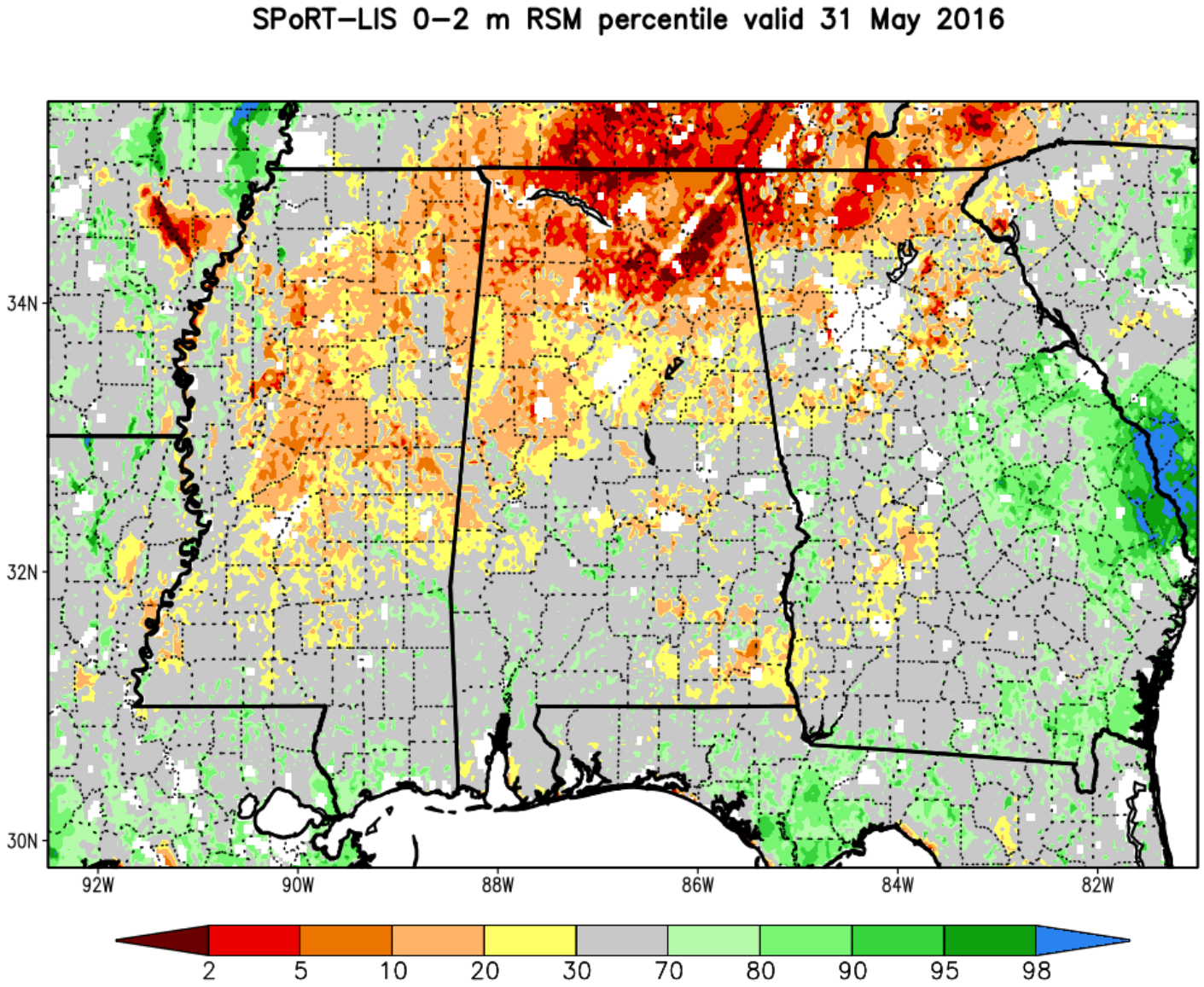


SPoRT–LIS 0–2 m RSM percentile valid 31 May 2016

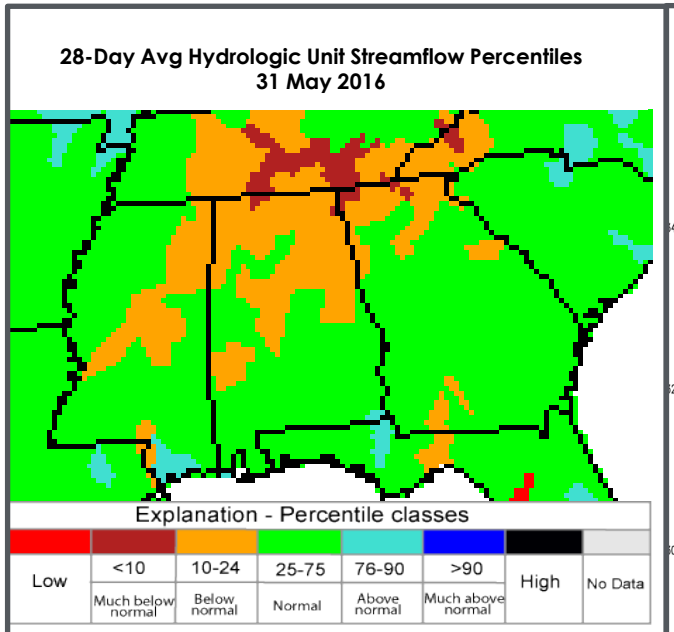


SPoRT-LIS Soil Moisture Data for Drought Monitoring

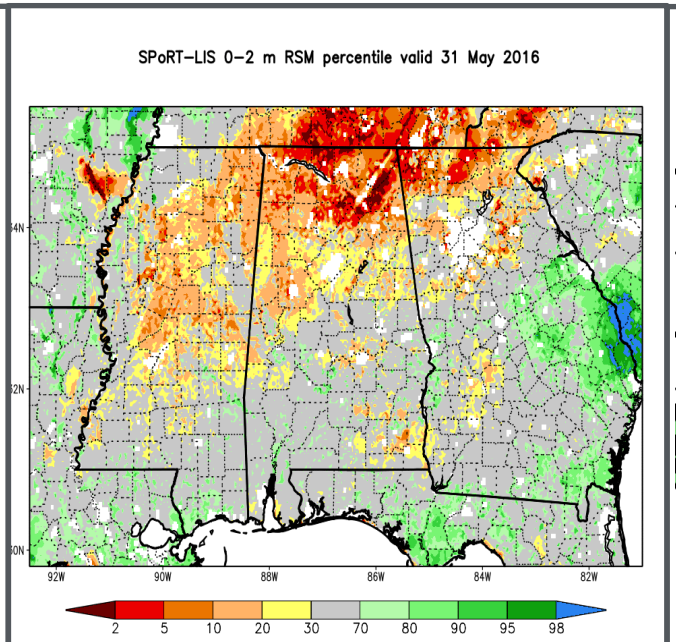
Relatively dry conditions continued into May, with deterioration in soil moisture conditions.



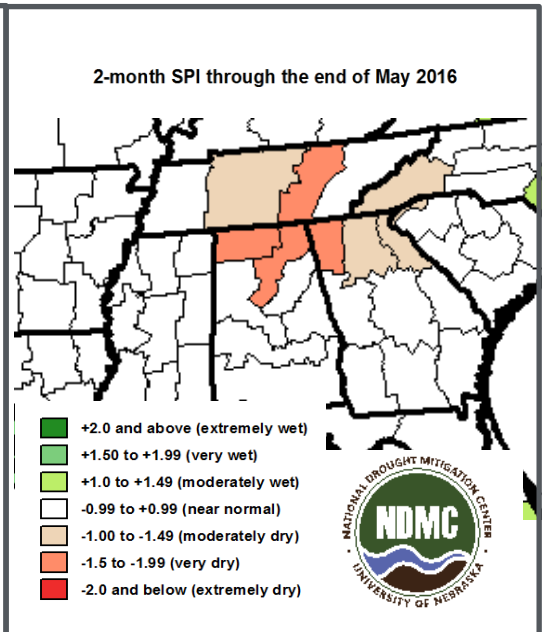
SPoRT-LIS Soil Moisture Data for Drought Monitoring



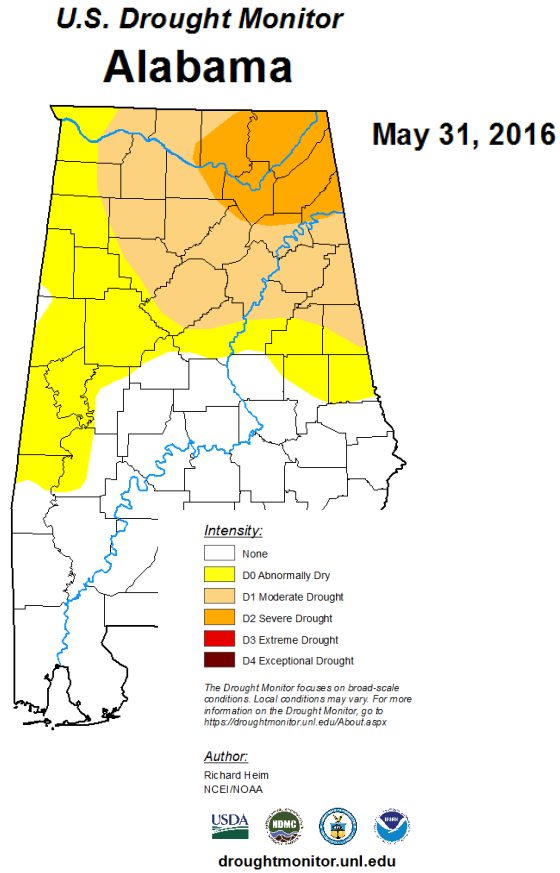
~D1



~D1-D3



~D2-D3

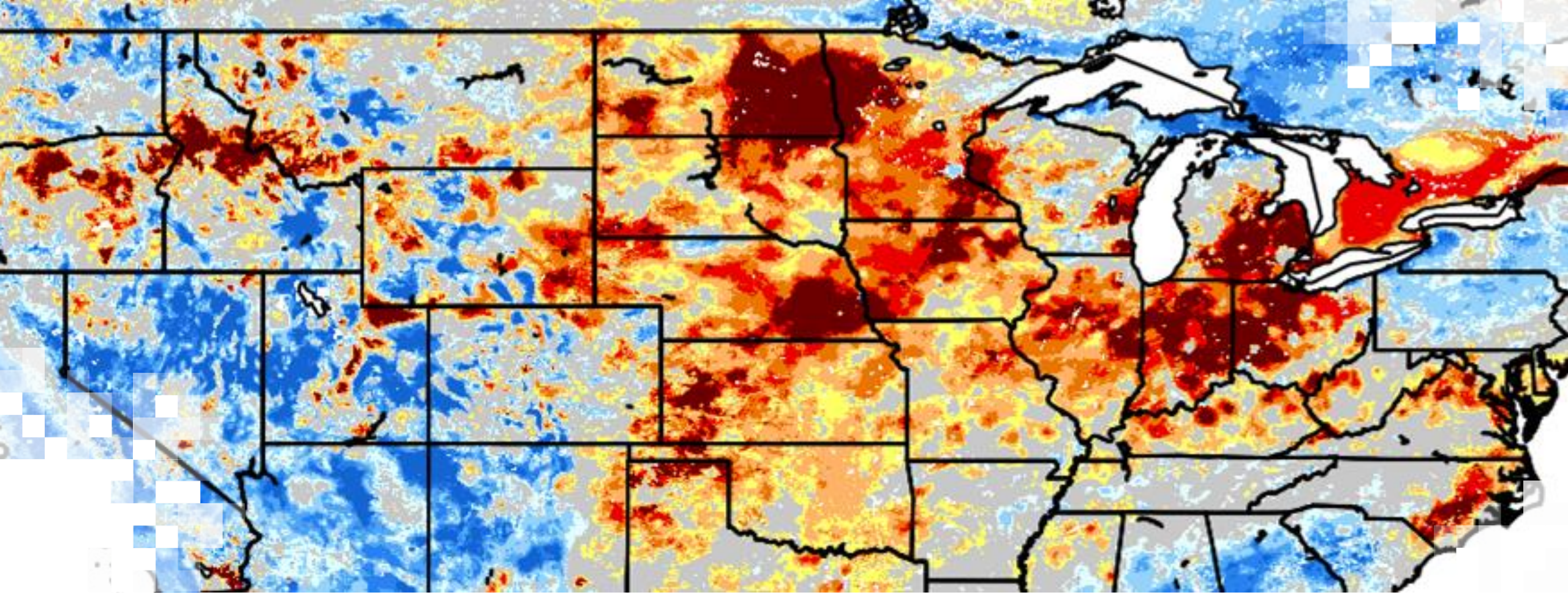


Important Items To Mention

- Drought analysis is a complicated process! Not only is convergence of evidence important, but discussion and consensus of opinion can be a part of that process.
- The focus of this lesson was largely about soil moisture and how it can fit into an overall drought analysis. However, other factors may have more relevance at times, for your situation.
- This lesson focused on specific soil moisture variables that were available and used for analysis at the time. Since then, other soil moisture variables that address water availability in the root zone are available and should be considered for use. These would include the 0-100 cm level, which is often used for drought analysis. However, other more shallow layers are available, such as 10-40, and 40-100 cm.
- Please visit the USDM "About" webpage to see valuable information about the USDM and the process: https://droughtmonitor.unl.edu/About.aspx.

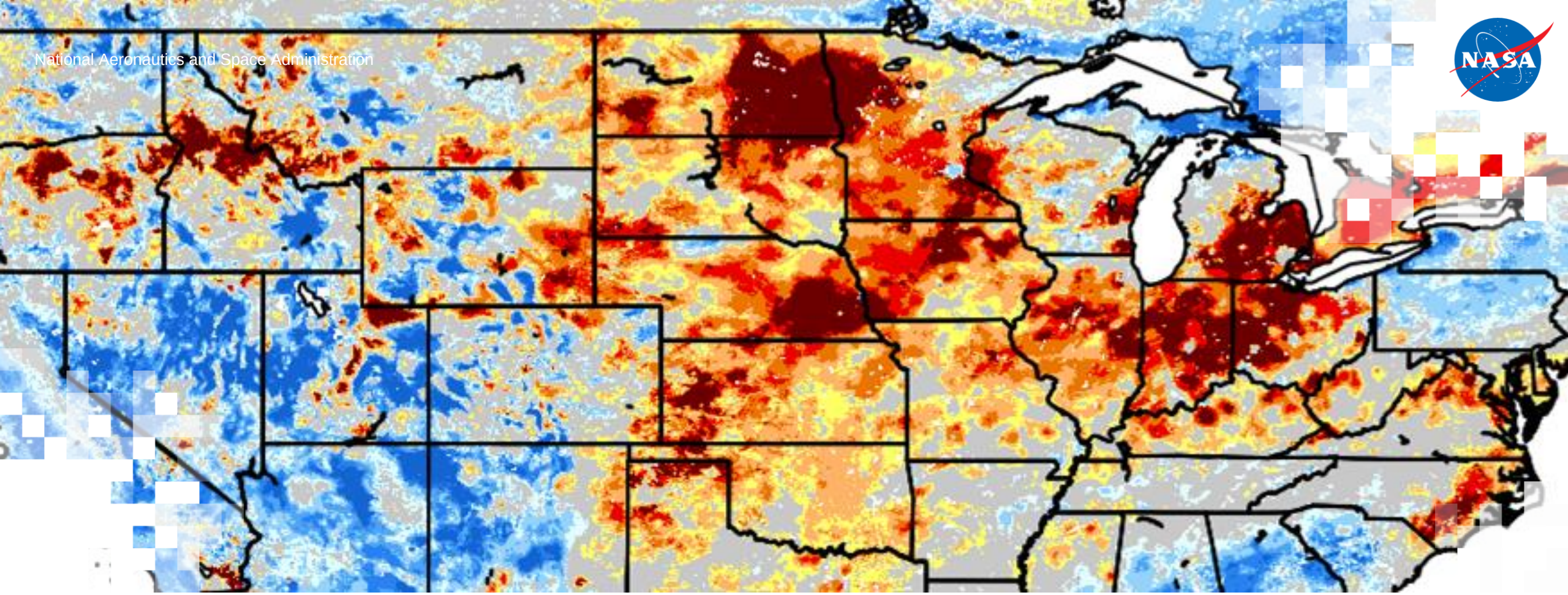
Key Takeaways

- Drought Analysis…
  - A multi-faceted process
  - Requires multiple datasets and coordination
- Soil moisture analysis is important for drought analysis because:
  - Soils are an important source of water
  - Precipitation analyses alone may not account for water in soils
- Soil moisture can be measured directly (in-situ, satellite sensors, etc.) or modeled.
- R20/02R activities are important for application and produce development.
- SPoRT-LIS data were shown to be an effective component as a tool for drought analysis, especially percentiles and soil moisture change data.



Thank you for your time!

Kristopher White
kris.white@noaa.gov



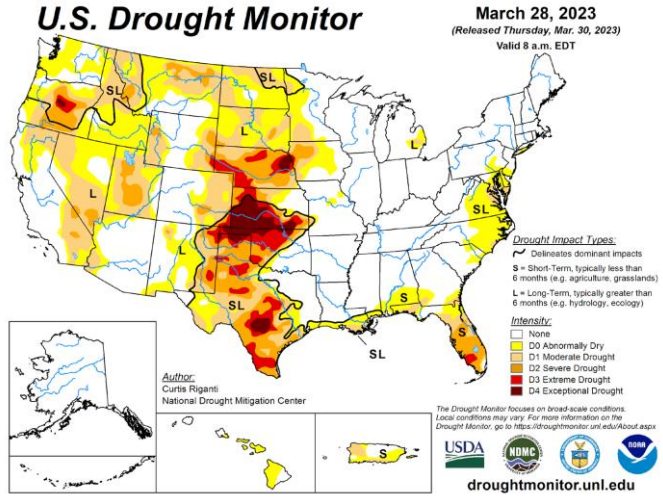
Utilization of the NASA SPoRT LIS Drought Product in U.S. Drought Monitor Operational Drought Monitoring

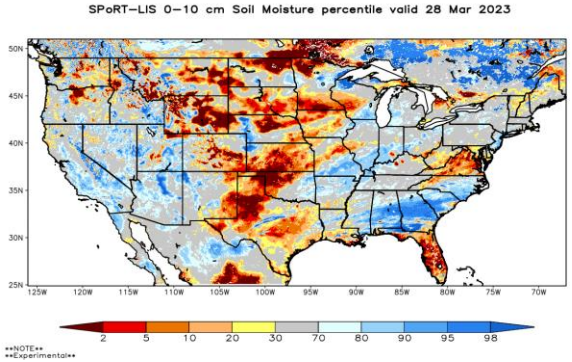
Richard R. Heim Jr. – Meteorologist, NOAA/NESDIS/NCEI

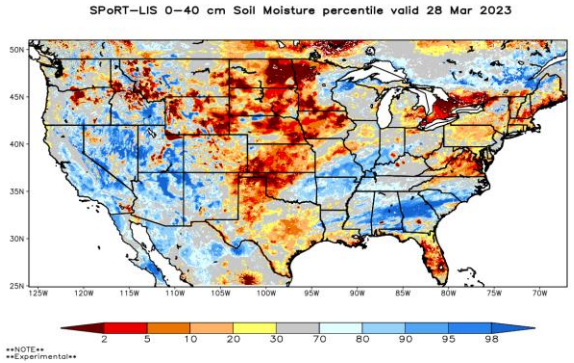
May 24, 2023

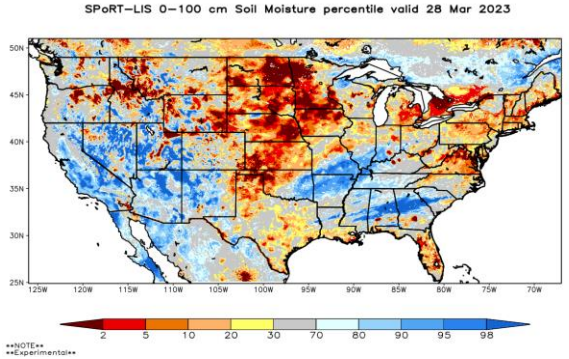
Utilization of SPoRT LIS Drought Product in USDM – Overview

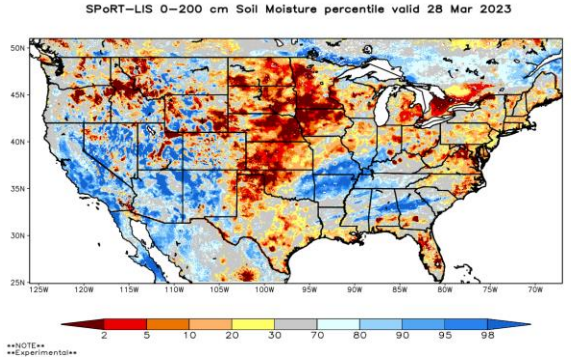
- Background
- U.S. Drought Monitor (USDM) Methodology
- Drought Indicators
- Soil Moisture
- SPoRT LIS Soil Moisture Examples









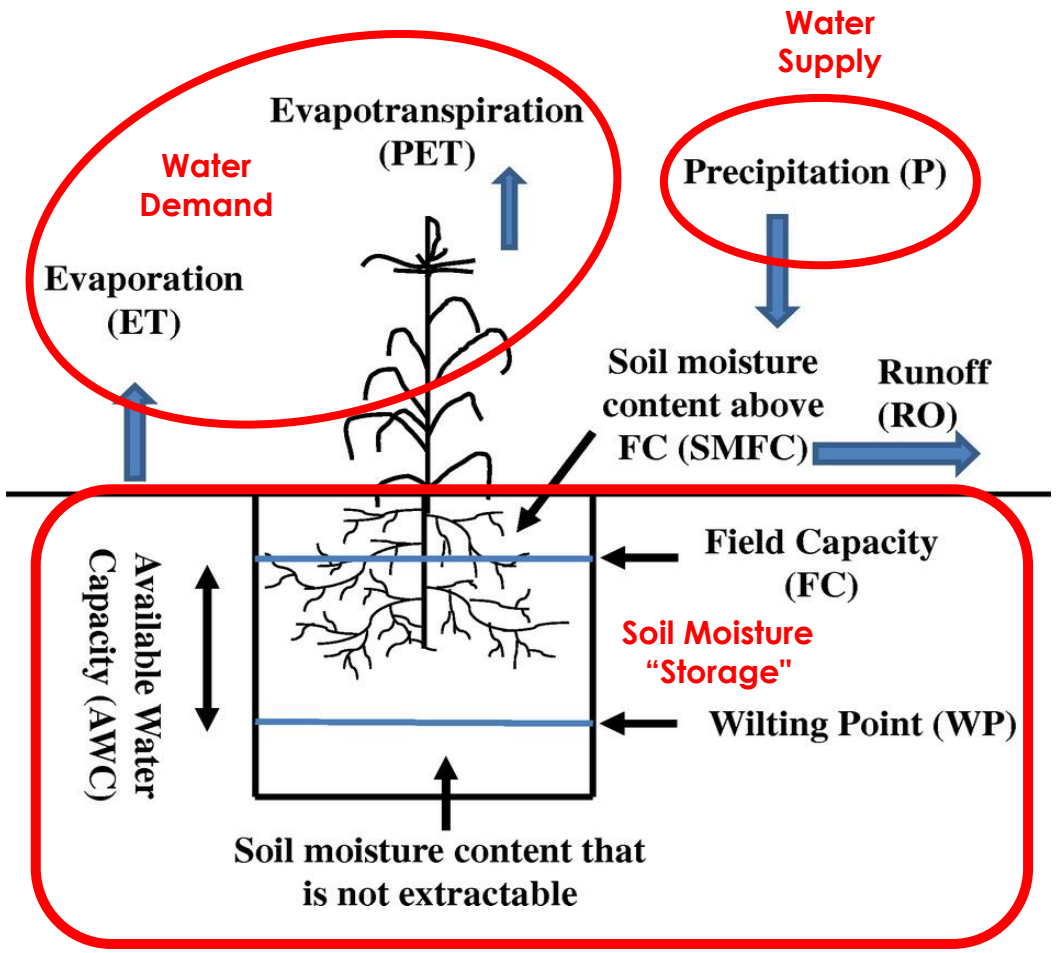


Background

Drought Equation:

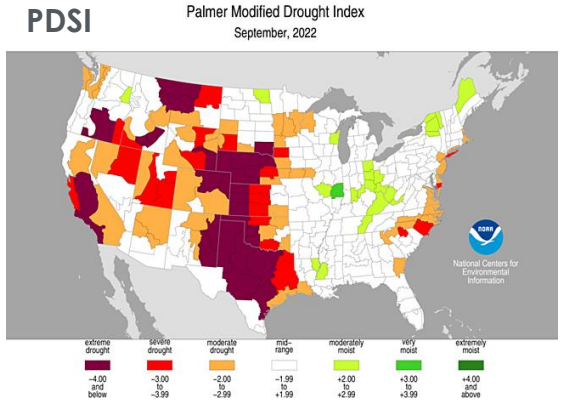
- Drought is an imbalance between water supply & water demand.
- Soil Moisture = "storage term"

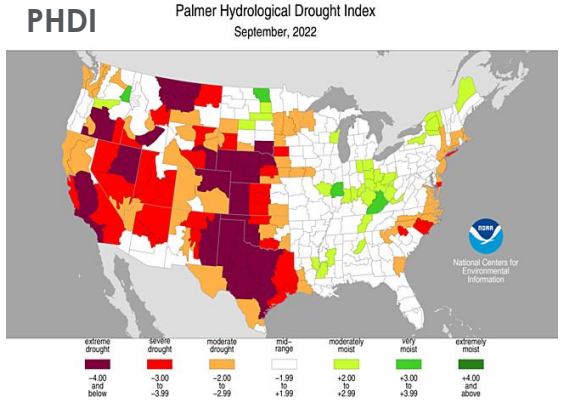
We have good measurements for water supply and water demand, but until recently soil moisture estimations were not as good.

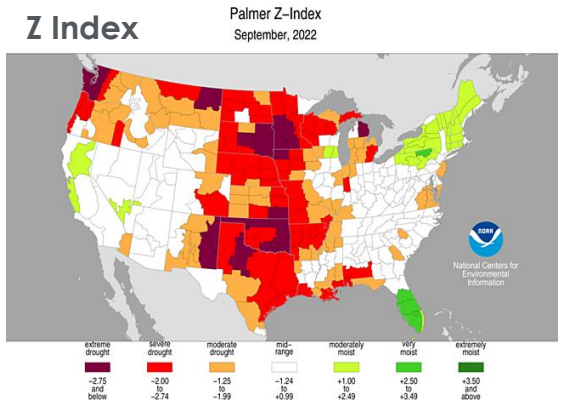


Background: Palmer Drought Severity Index (PDSI)

- Developed in 1965
- First index to incorporate water supply, water demand, and a soil moisture component
- Became the official drought index for US
- Deficiencies
- Other drought indices and indicators developed 1980s-1990s
- USDM developed in 1999 as a composite index that incorporates the strengths of everything that has come before and after







Heim, Jr., Richard R., 2002: A review of Twentieth-Century drought indices used in the United States. Bulletin of the American Meteorological Society, vol. 83, pp. 1149-1165. https://journals.ametsoc.org/view/journals/bams/83/8/1520-0477-83_8_1149.xml

USDM Methodology

- USDM is produced manually every week using GIS tools (ArcMap)
- Expresses drought in terms of recurrence intervals, how rare a drought magnitude is; mathematically as percentiles (D0-D4)
- Dozens of drought indicators; multiple time scales; expressed as percentiles
- Incorporates impact information provided by a network of hundreds of state, regional, and local partners

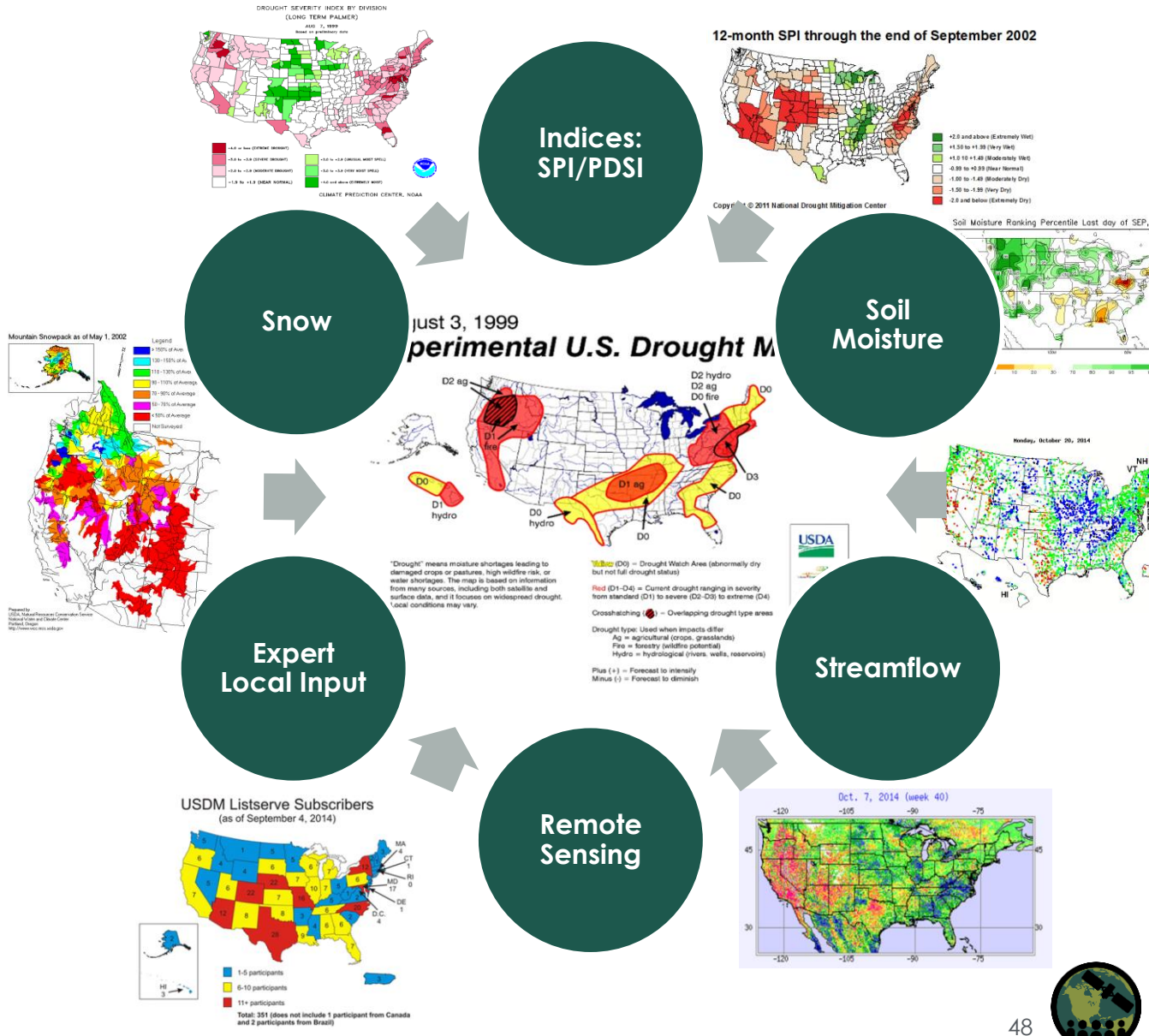
Description	Category	Percentile
Abnormally Dry	D0	0.21-0.30
Moderate Drought	D1	0.11-0.20
Severe Drought	D2	0.06-0.10
Extreme Drought	D3	0.03-0.05
Exceptional Drought	D4	0.00-0.02

Drought Indicators – We Look at Everything!

- **Indicators Include:** Precipitation amount, departures, percent of normal, percentiles; PDSI; SPI; SPEI; EDDI; ESI; mountain snowpack (SWE); streamflow percentiles; groundwater percentiles; soil moisture; reservoir levels & percentiles; vegetation-based indices (VHI, VegDRI, QuickDRI)

- **These indicators can be grouped into 6 broad categories:**

1) Soil Moisture
2) Streamflow
3) Remotely Sensed Data & Indicators
4) Snow (Crucial in West)
5) Other Derived Indices
6) Expert Local Input

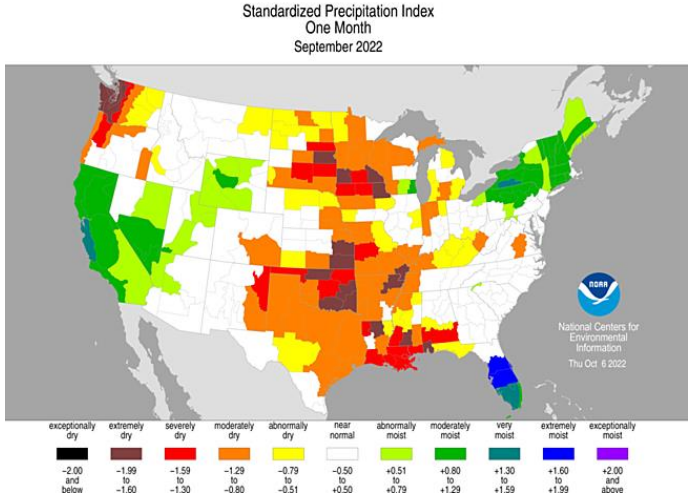


Standardized indices are helpful.

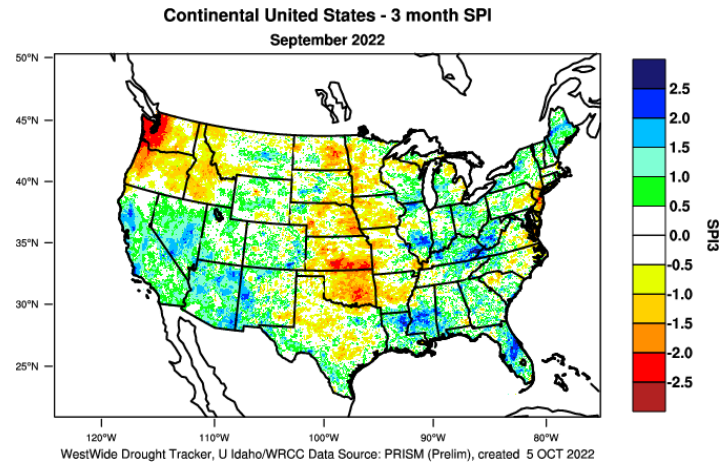
- **SPI = Standardized Precipitation Index**
  Measures water supply (precipitation)
- **SPEI = Standardized Precipitation Evapotranspiration Index**
  Measures water supply (precipitation) and water demand (evapotranspiration derived from temperature)

- Both have standardized units (computed from historical mean & standard deviation) that are directly related to the USDM Dx percentiles. For 1 in 50-year drought (2nd percentile), you need a 50- to 100-year historical record. Precipitation and temperature are the indicators with the longest historical record (NCEI data go back to 1895). Both are computed for multiple time scales (1 month to 72 months).

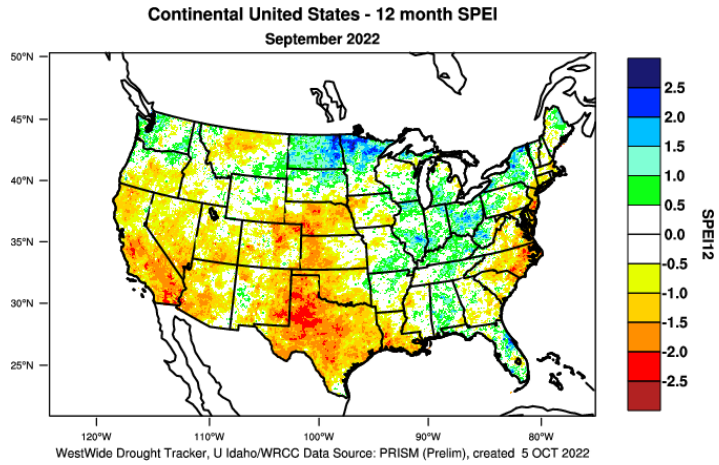
NCEI's 1-Month SPI for Sept 2023



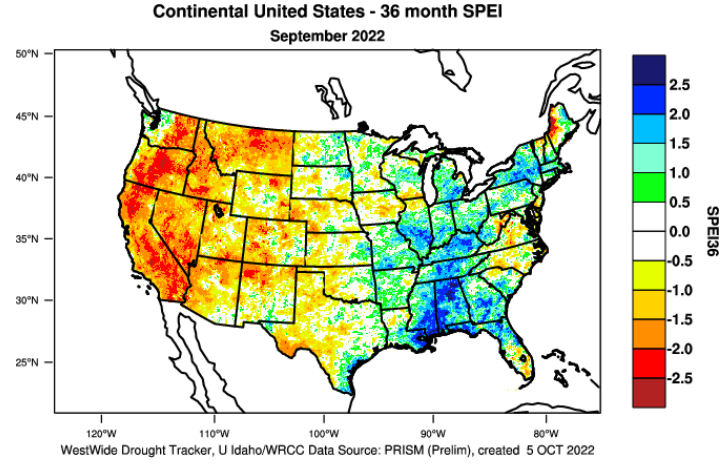
WRCC's 3-Month SPI for Sept 2023



WRCC's 12-Month SPEI for Sept 2023



WRCC's 36-Month SPEI for Sept 2023

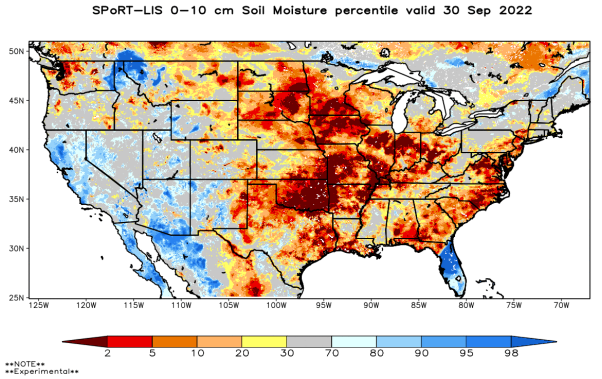


NCEI = National Centers for Environmental Information
WRCC = Western Regional Climate Center

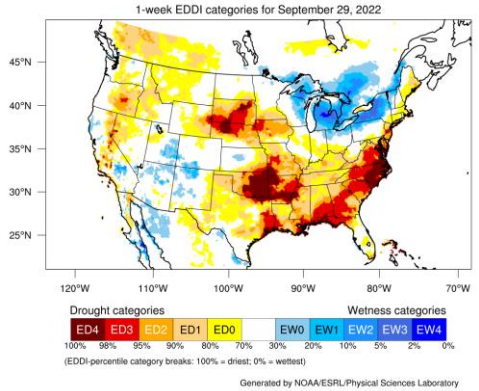
Convergence of Evidence Approach

- What are most of the indicators in each of the data categories saying (what are most "converging" to)?

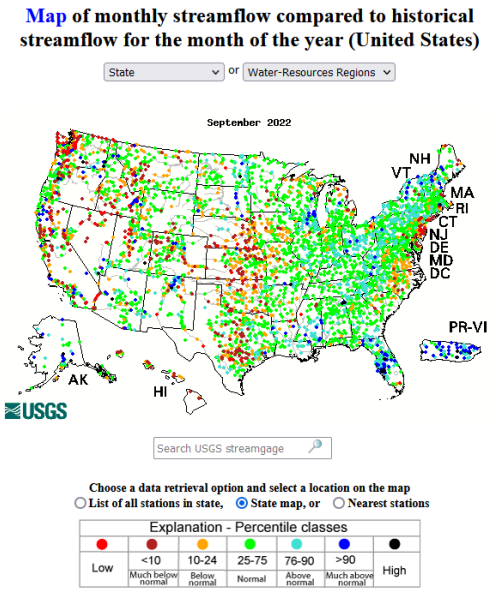
Soil Moisture Data



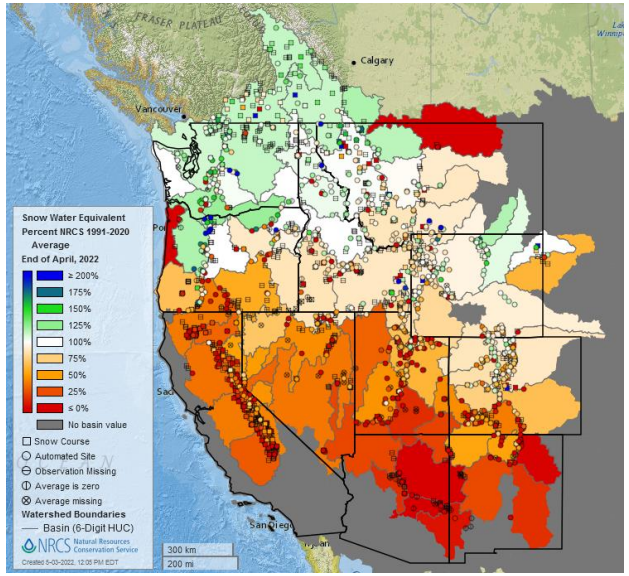
Evapotranspiration Data



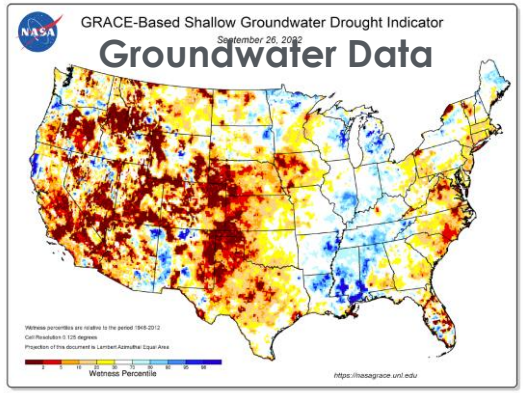
Streamflow Data



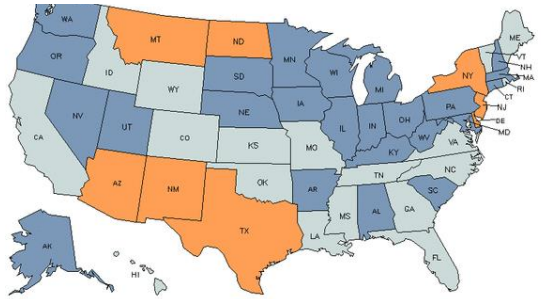
Snow Data



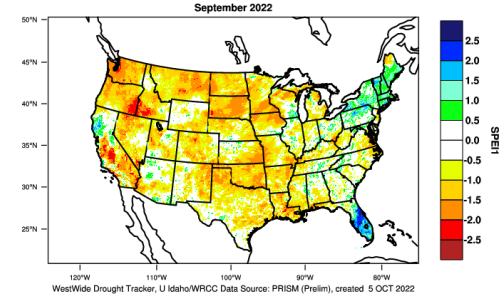
Groundwater Data



Local Expert Recommendations

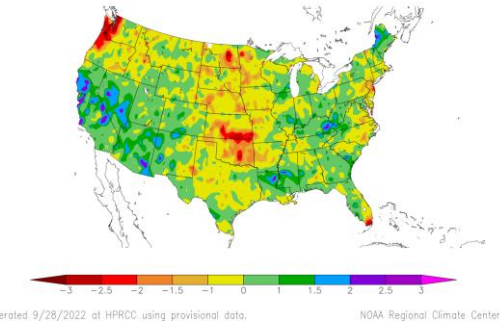


Continental United States - 1 month SPEI



Precipitation Data

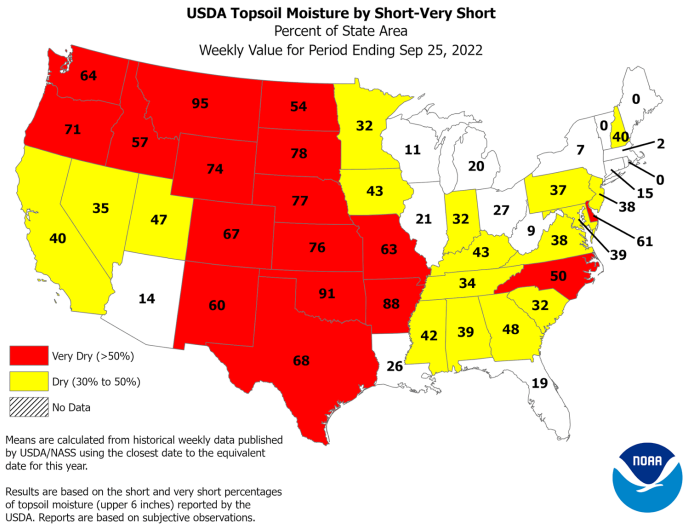
90 Day SPI
6/30/2022 – 9/27/2022



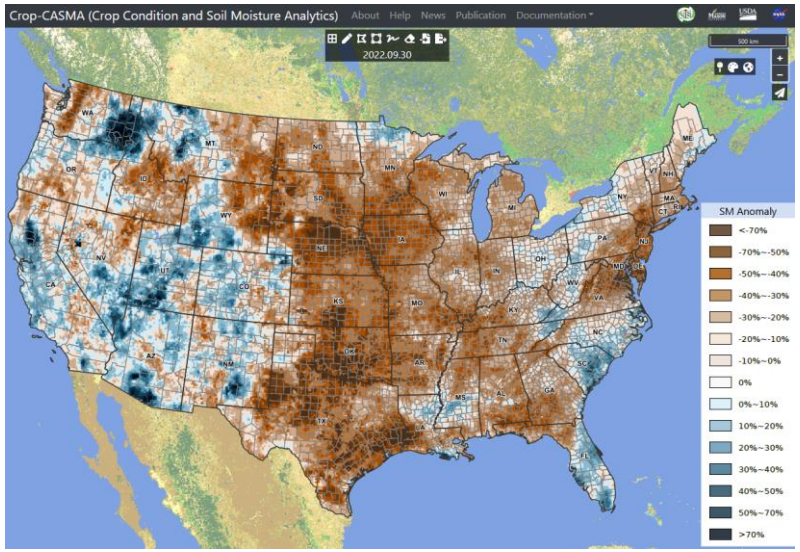
Convergence of Evidence Approach

- What are the relevant indicators and time scales for the location, time of year, and climatology being examined?

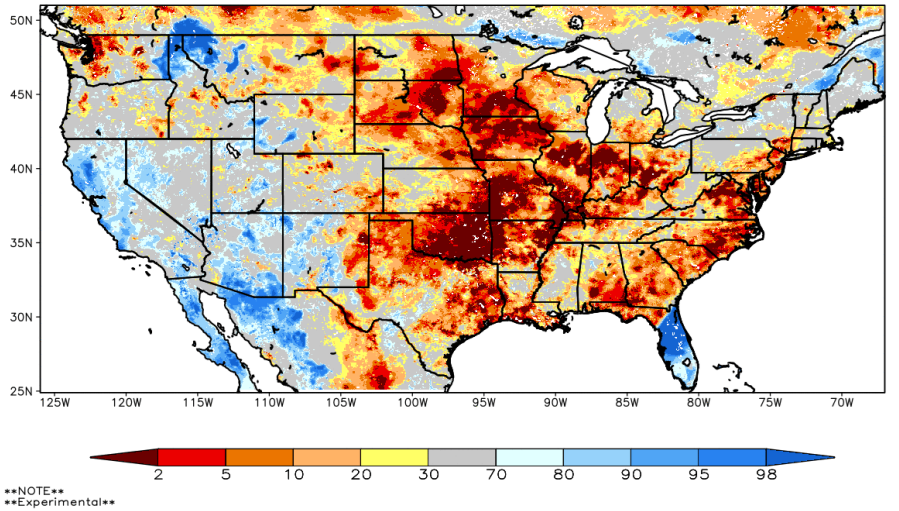
USDA Topsoil Moisture Assessment



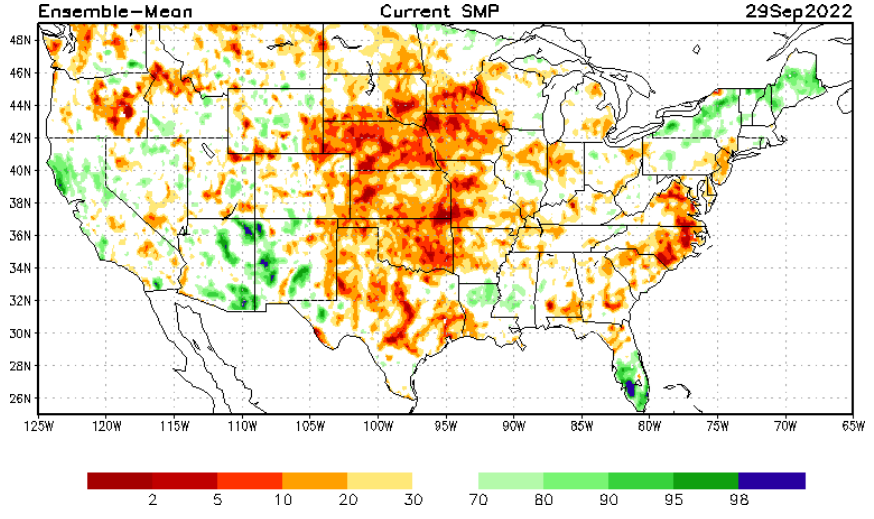
Crop-CASMA Soil Moisture



SPoRT Soil Moisture



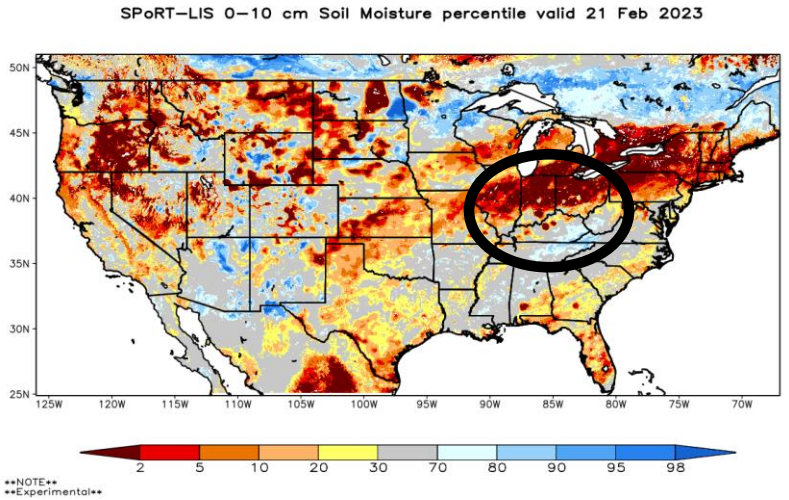
NLDAS Soil Moisture



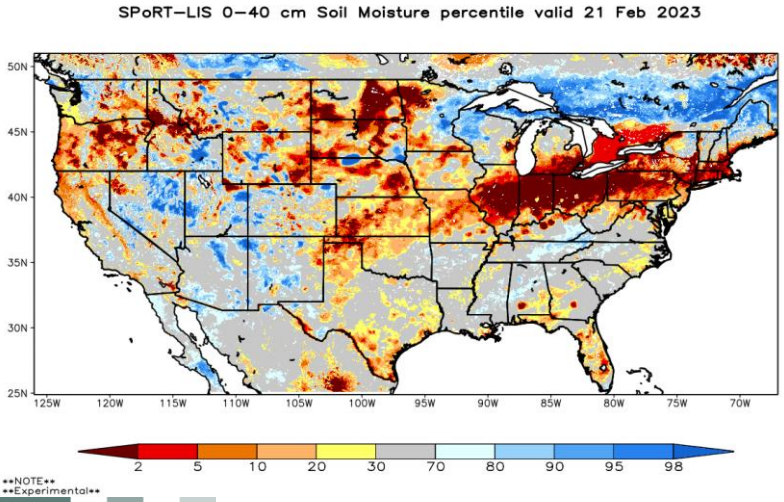
Convergence of Evidence Approach – Example

- In February 2023, SPoRT LIS soil moisture percentile products were depicting massively dry soils for this time of year (compared to the SPoRT history) across the Ohio Valley.

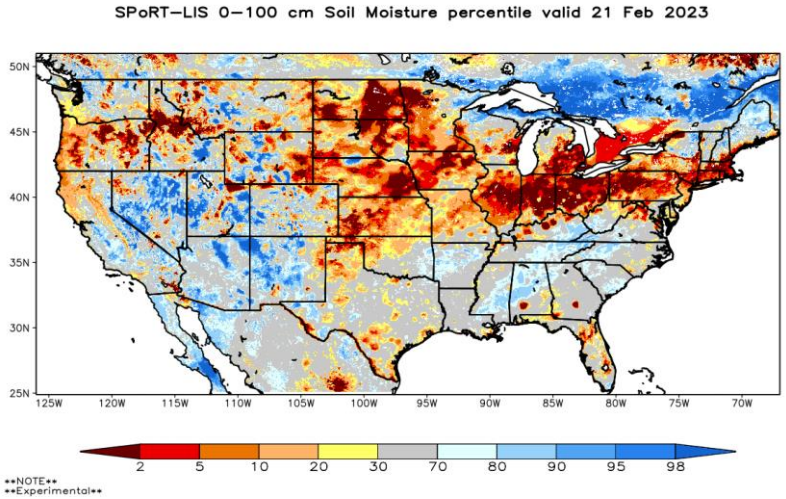
SPoRT 0-10 cm Soil Moisture



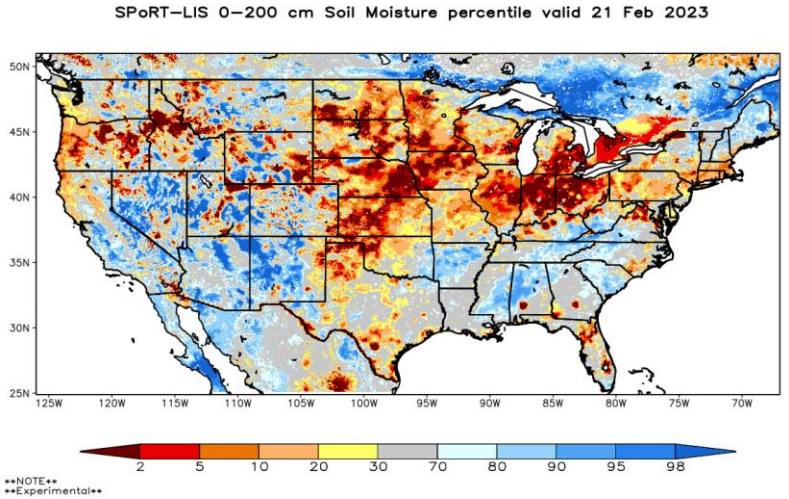
SPoRT 0-40 cm Soil Moisture



SPoRT 0-100 cm Soil Moisture

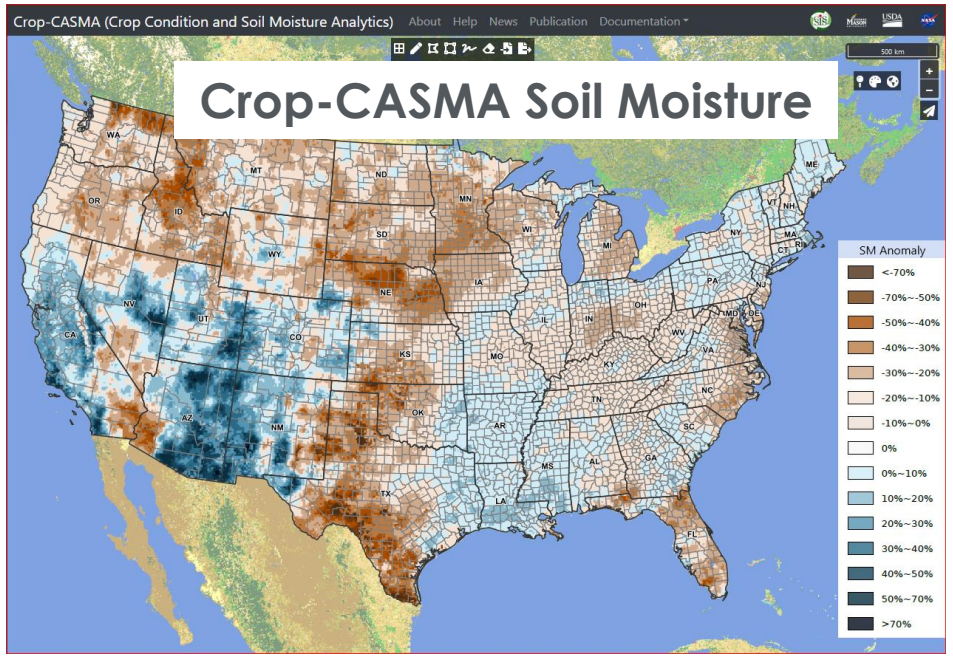


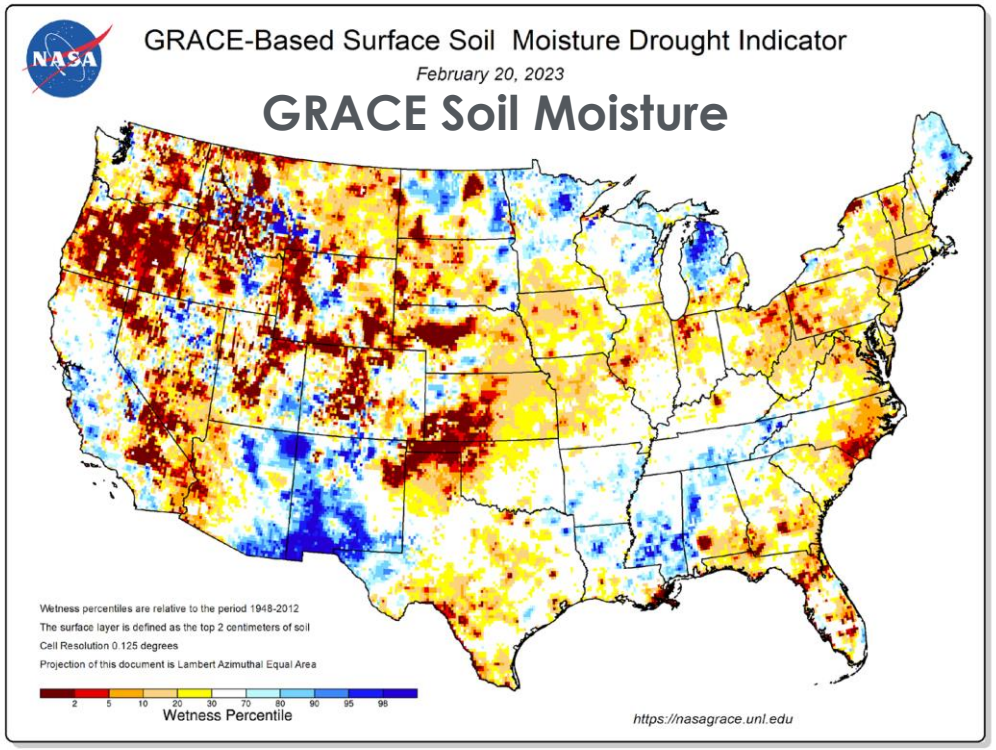
SPoRT 0-200 cm Soil Moisture

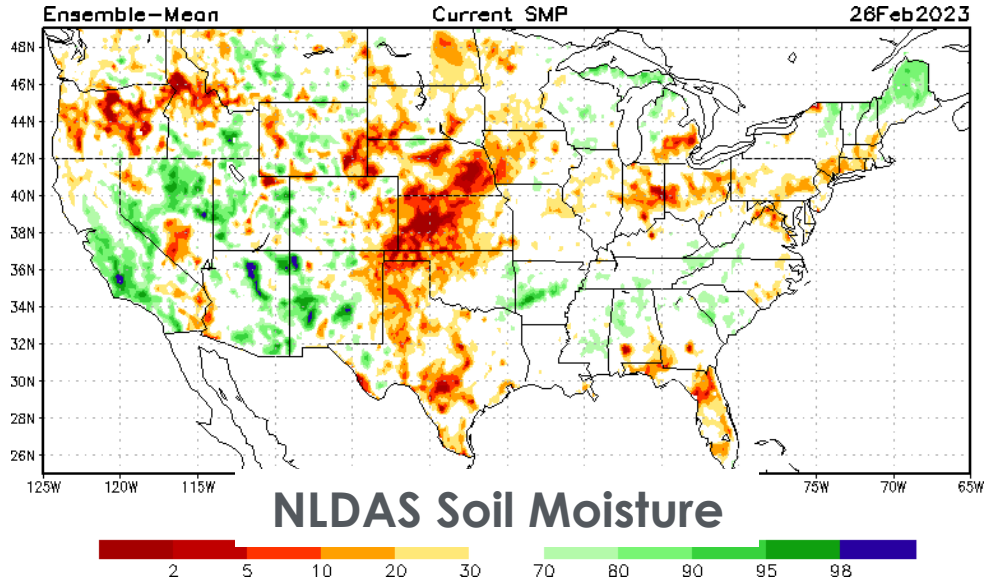


Convergence of Evidence Approach – Example

- Some of the other soil moisture indicators depicted dry conditions in the Ohio Valley (such as NLDAS, Crop-CASMA, and GRACE), but not as bad or extensive.



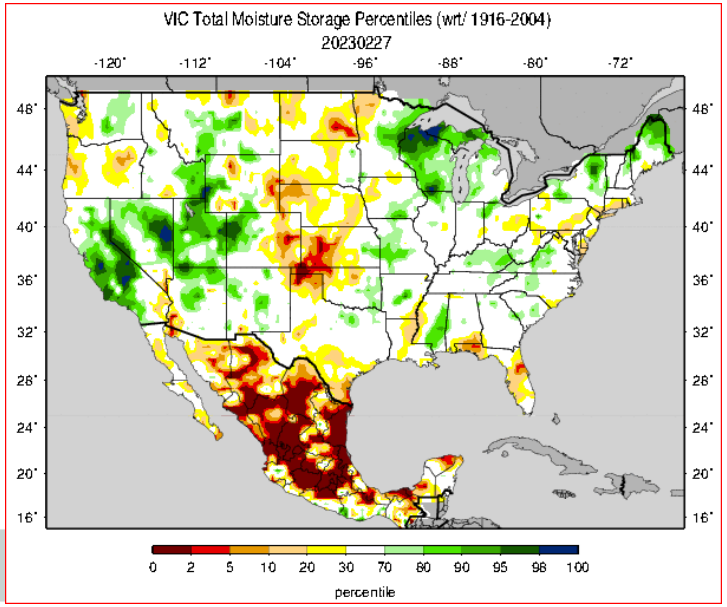




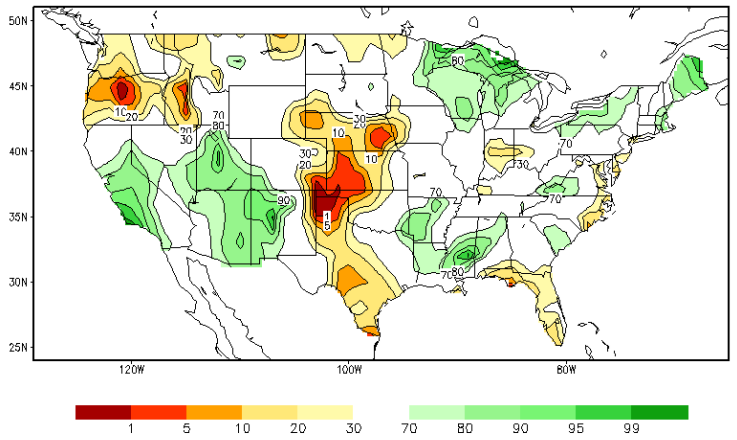
Convergence of Evidence Approach – Example

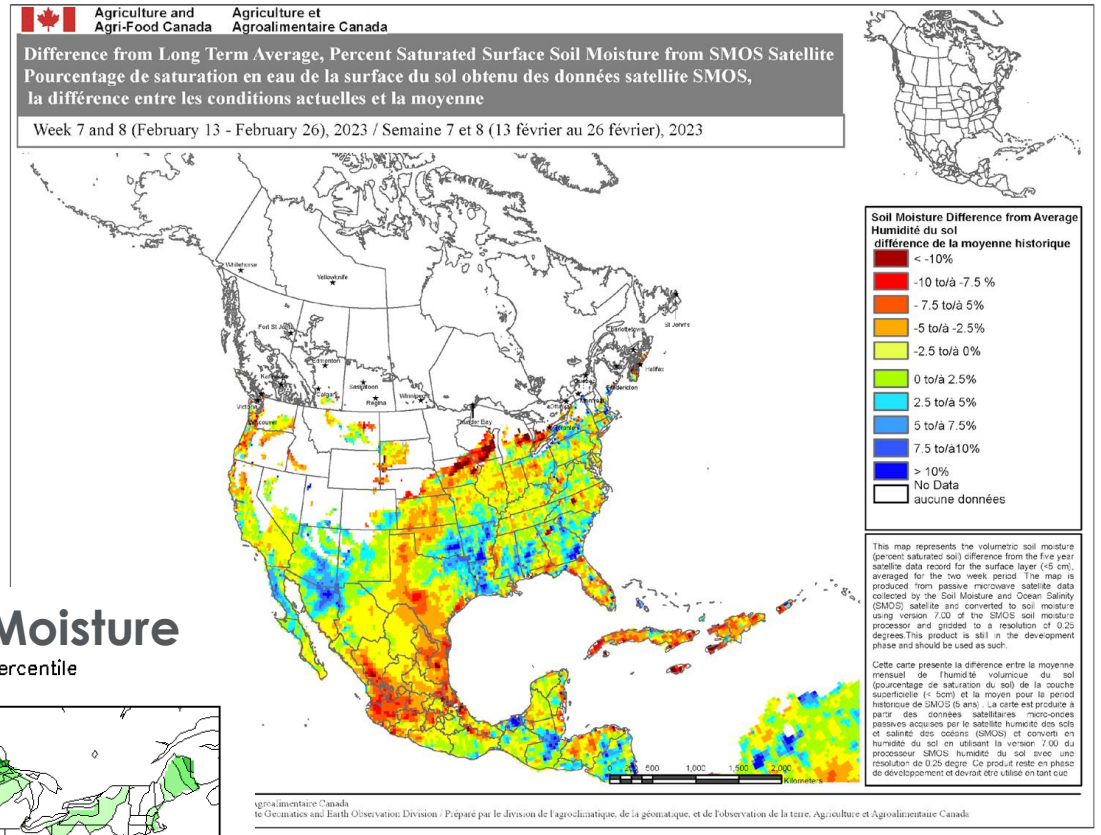
- Other soil moisture indicators depicted barely any dry conditions there (these include SMOS satellite data and the VIC and CPC Leaky Bucket models).

VIC Soil Moisture



Leaky Bucket Soil Moisture

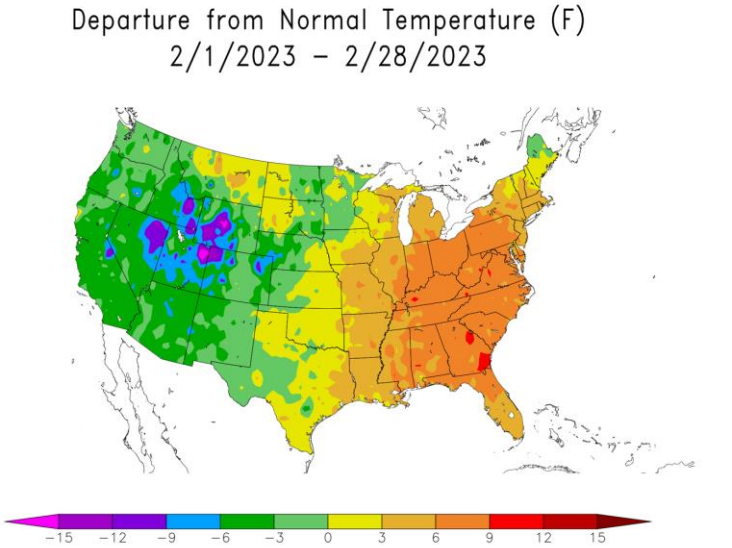




SMOS Soil Moisture

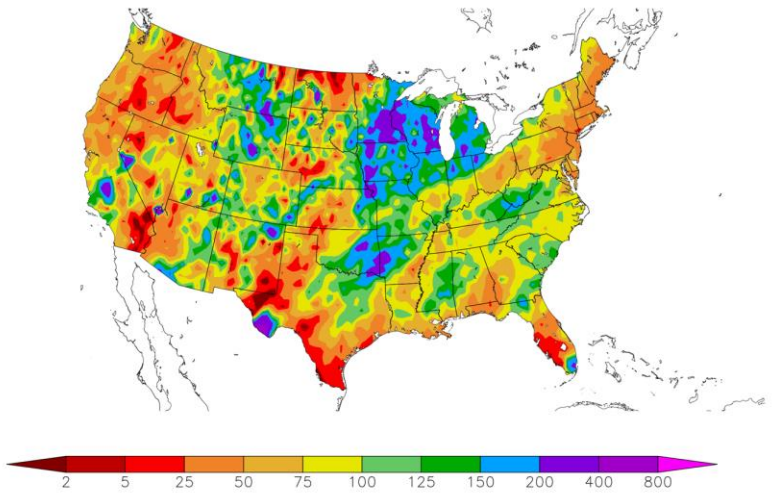
Convergence of Evidence Approach – Example

- It was unusually warm in the Ohio Valley for February, but evapotranspiration is low in the winter.
- The last 1 to 2 months were near to wetter than normal.
- None of the other soil moisture indicators showed conditions as bad.
- Local data from State Drought teams in IL, IN, & OH showed soil moisture conditions normal to wet.

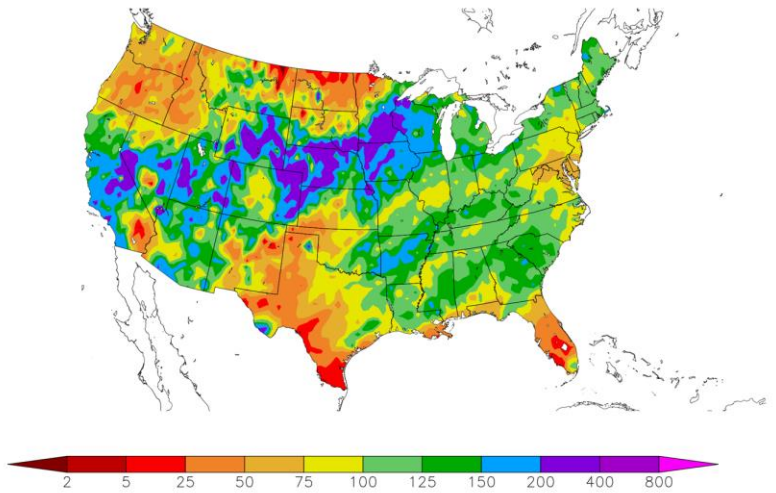


February Temperature Anomalies

February Percent of Normal Precipitation



Jan-Feb Percent of Normal Precipitation

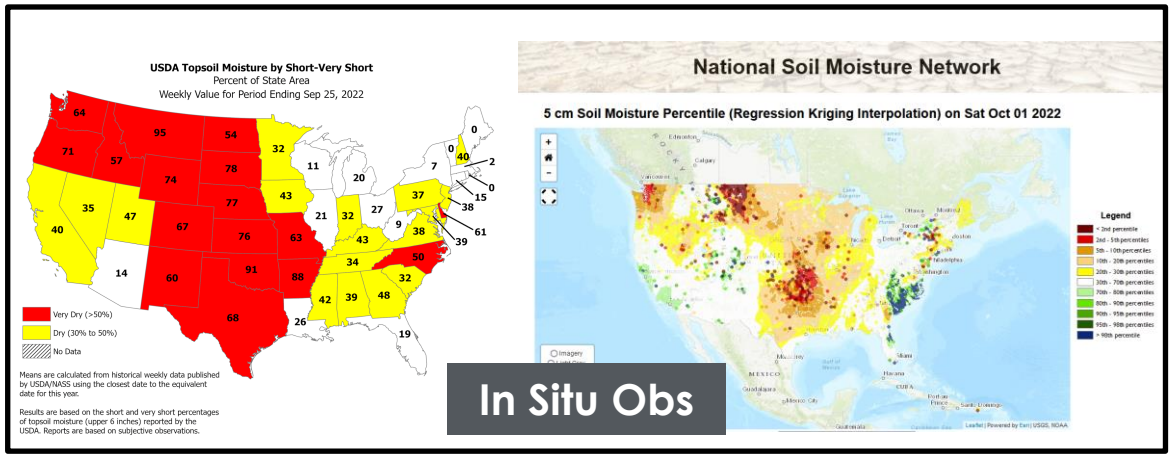


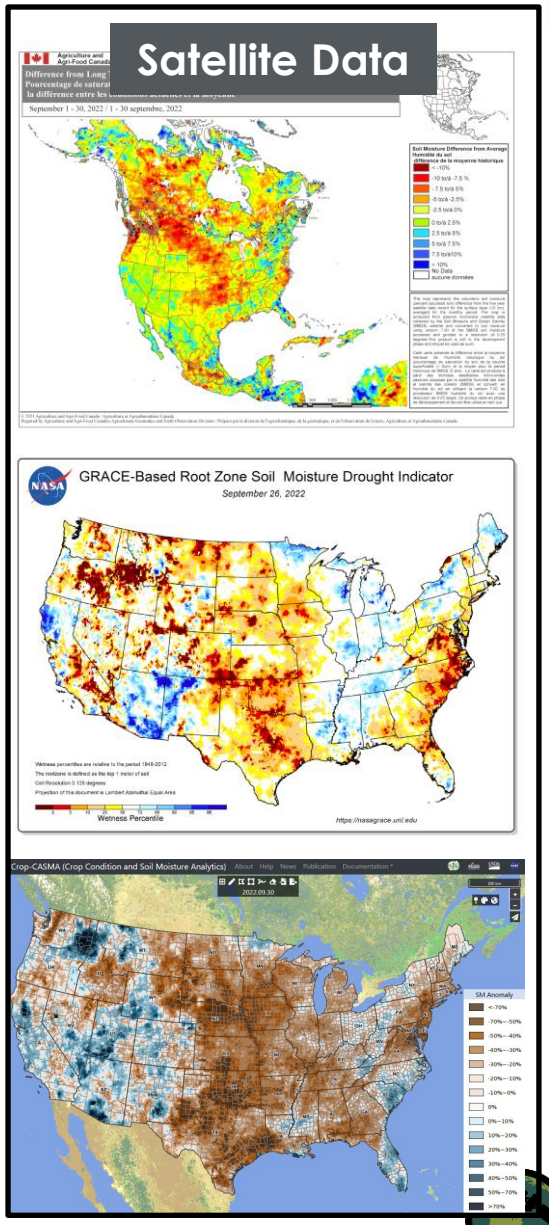
Convergence of Evidence Approach – Example

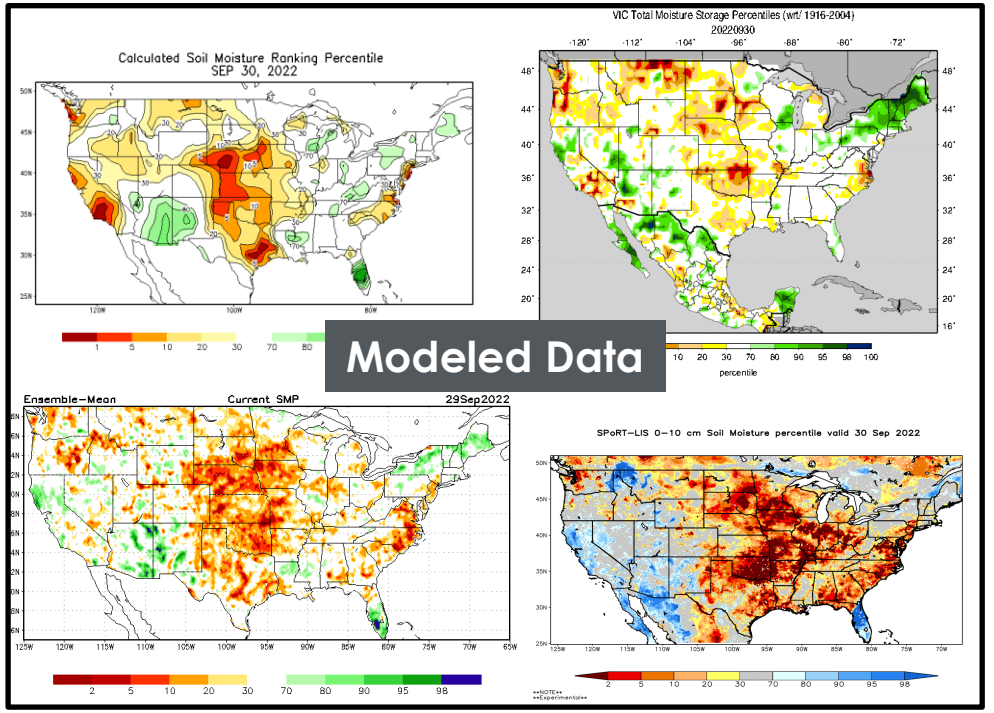
- It was later determined that there was a **problem with the input data** to the SPoRT model which led to the unusually dry conditions in the Ohio Valley at this time of year.
- This example illustrates:
  - **The importance of consistency between indicators ("convergence of evidence" approach);**
  - Soil moisture is less of a factor in winter when temperatures are low, evapotranspiration is low, and vegetation is mostly dormant;
  - The important role state drought teams play in the USDM process.

Soil Moisture

- Types of Data:
  - In Situ Station Obs
  - Satellite Obs
  - Modeled Data
- Soil Moisture Indicators Used in the USDM:
  - State Mesonet Station Obs, USDA NASS Data
  - Satellite (SMOS, GRACE, SMAP/Crop-CASMA)
  - Models (NLDAS, VIC, SPoRT, CPC Leaky Bucket)





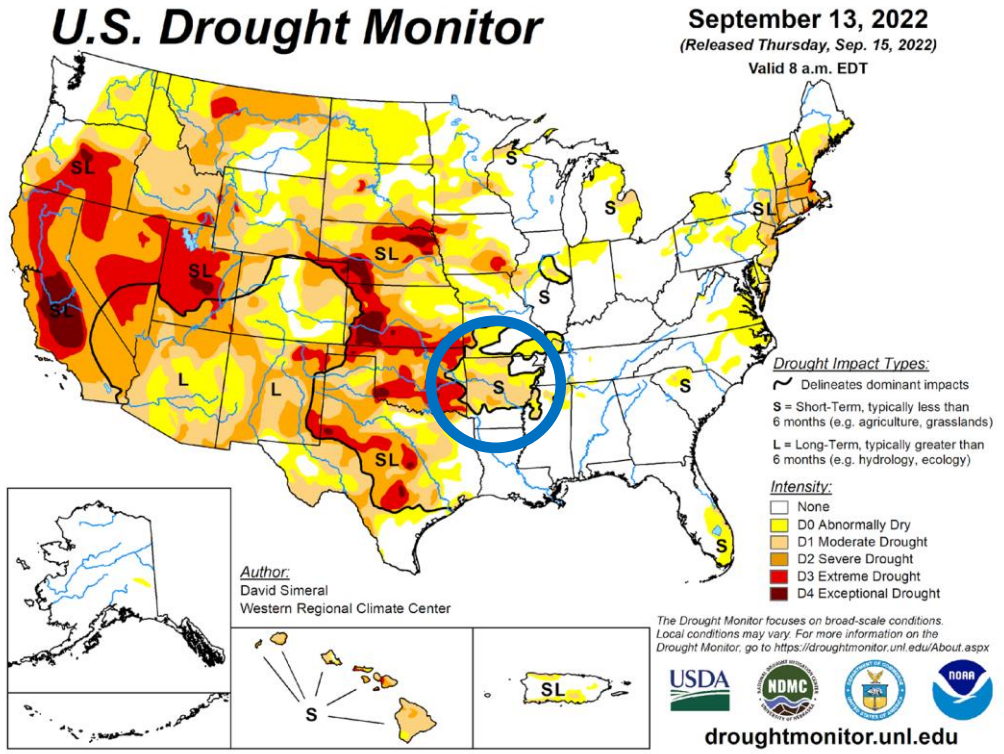


The Importance of Soil Moisture Units

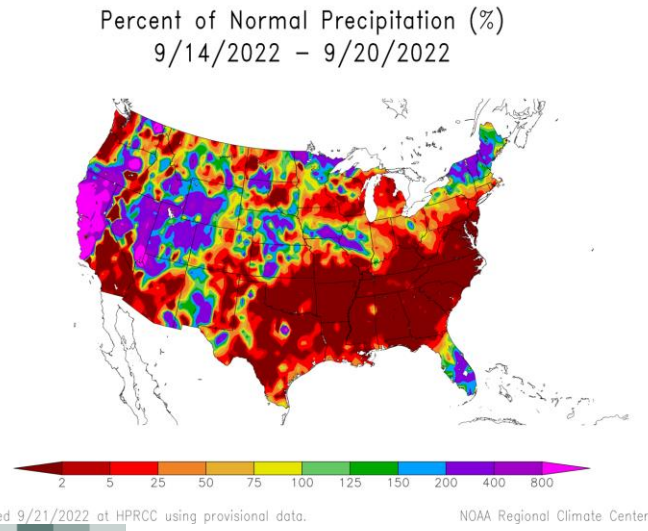
- The best units are percentiles expressing soil moisture content related to the local historical record. But most mesonet soil moisture stations don't have a long period of record.
- The next best are units that relate the soil moisture to history (above, below, near normal) or that are related to moisture needs of vegetation or crops (e.g., USDA's very short, short, adequate, surplus).
- Units like volumetric water content (ratio of water volume to soil volume) by themselves are of little use. The units have to have real-world meaning.

SPoRT LIS Soil Moisture Example – Arkansas, Sept. 2022

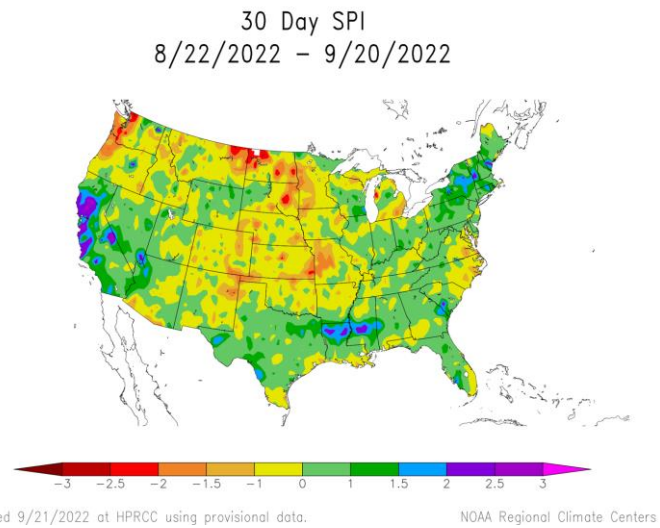
- September 13-20, 2022
  - 9/13 USDM map: D0-D1, some D2 spots
  - Arkansas dry statewide last 7 – 30 days



Last 7 Days Precipitation (Pct)



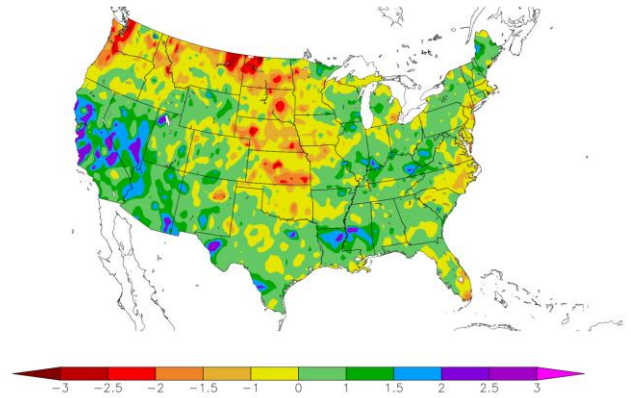
Last 30 Days Precipitation (SPI)



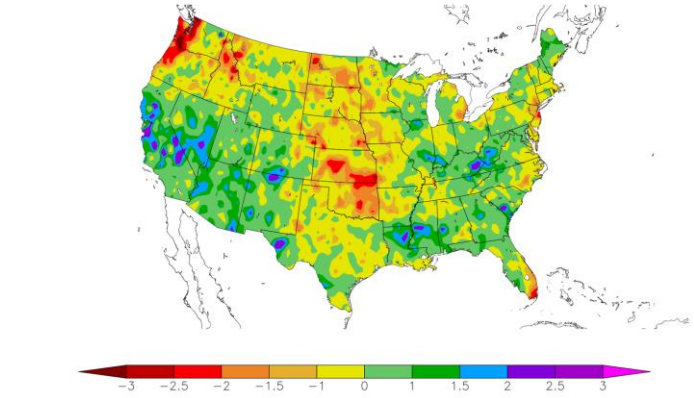
SPoRT LIS Soil Moisture Example – Arkansas, Sept. 2022

- September 13-20, 2022
  - Some wet & dry areas last 2 months
  - Dry statewide @ 3 months, driest in central
  - Dry last 4 months
  - But wet at 6-month time scale

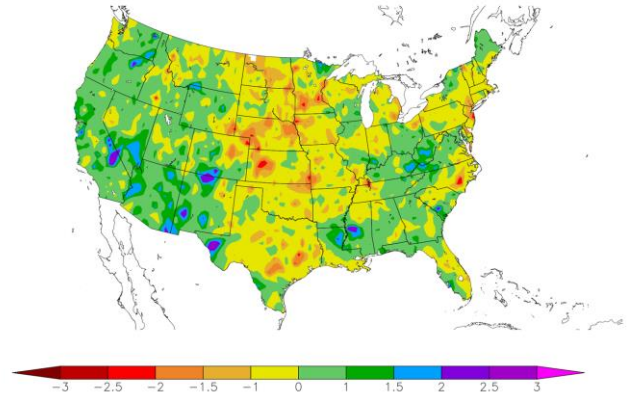
Last 2 Months Precipitation (SPI)
60 Day SPI
7/23/2022 – 9/20/2022



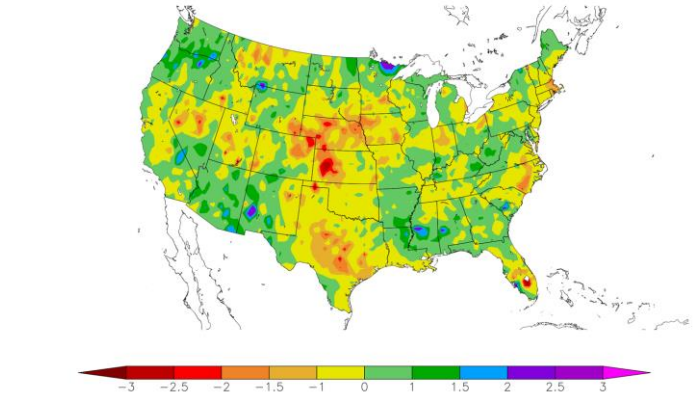
Last 3 Months Precipitation (SPI)
90 Day SPI
6/23/2022 – 9/20/2022



Last 4 Months Precipitation (SPI)
120 Day SPI
5/24/2022 – 9/20/2022

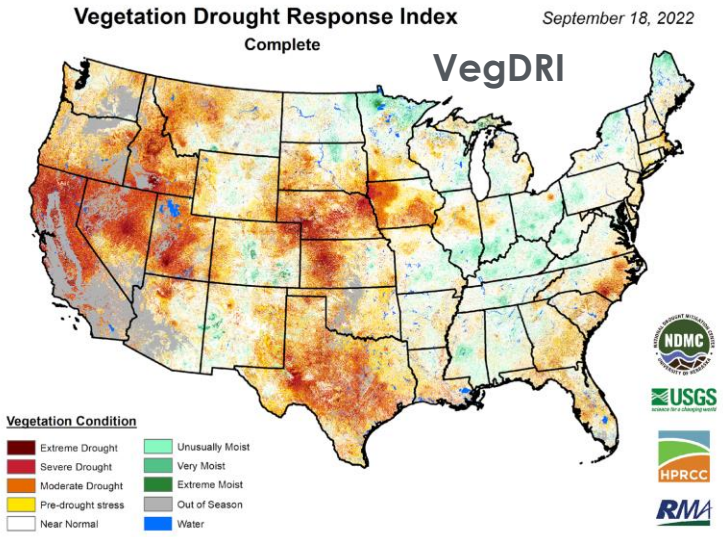


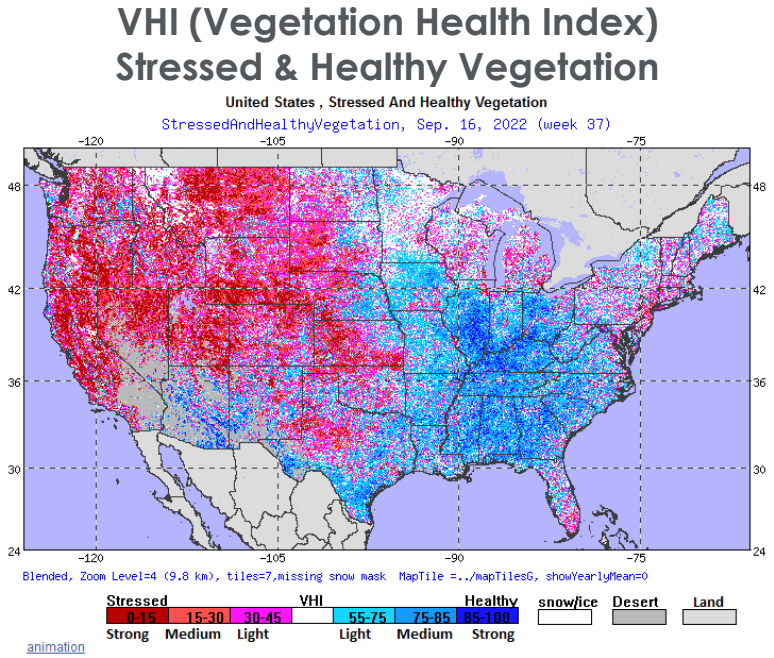
Last 6 Months Precipitation (SPI)
6 Month SPI
3/21/2022 – 9/20/2022

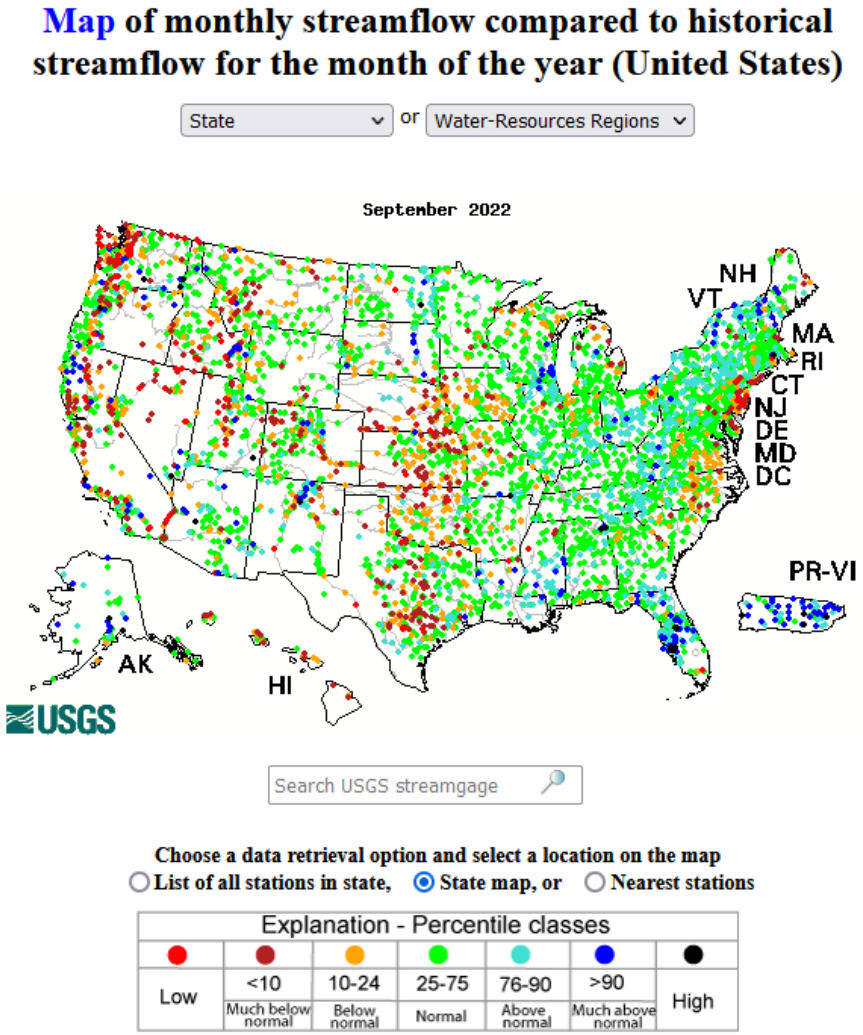


SPoRT LIS Soil Moisture Example – Arkansas, Sept. 2022

- Streamflow normal
- Vegetation not too stressed (VegDRI, VHI)



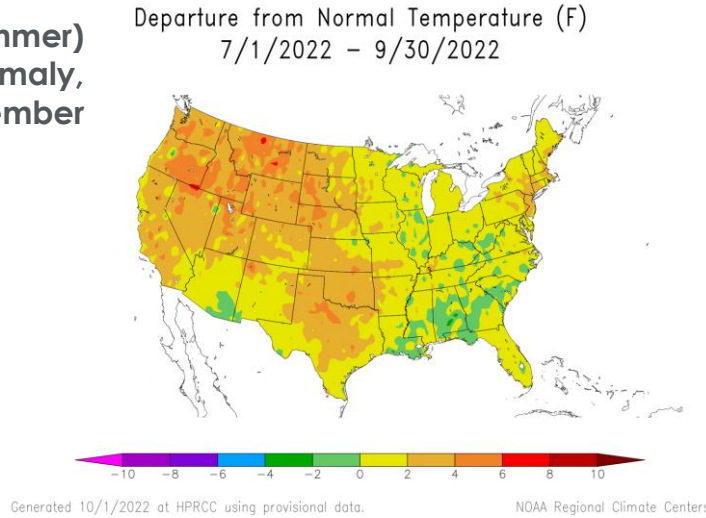




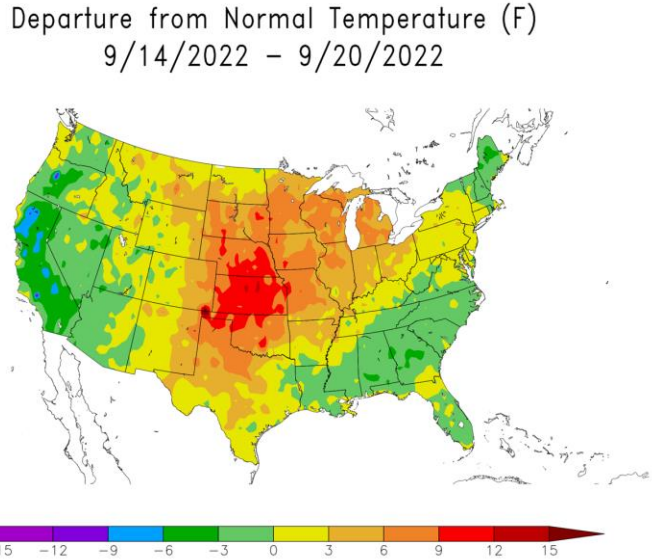
SPoRT LIS Soil Moisture Example – Arkansas, Sept. 2022

- Summer temperatures warm, but not excessively so
  - But a severe heat wave developed the last couple weeks.
  - This rapidly increased evapotranspiration, leading to what is called a "flash drought".

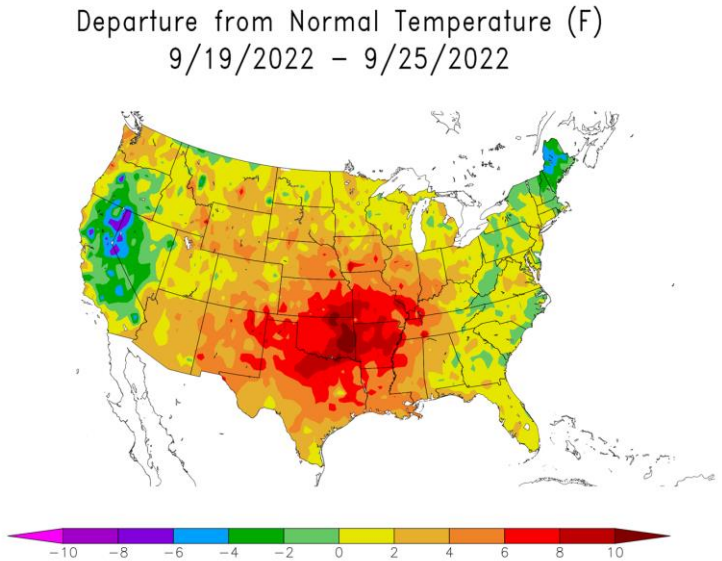
3-Month (Summer) Temperature Anomaly, July-September



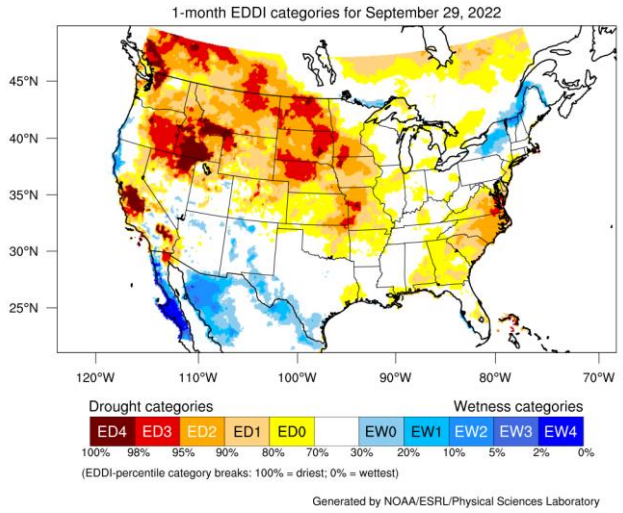
Weekly Temperature Anomaly, September 14-20



Weekly Temperature Anomaly, September 19-25



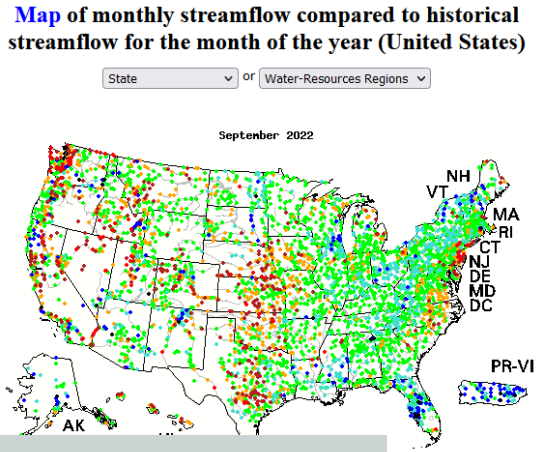
1-Month September EDDI (Evaporative Demand Drought Index)

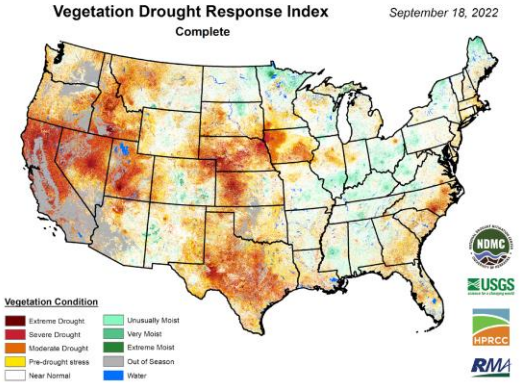


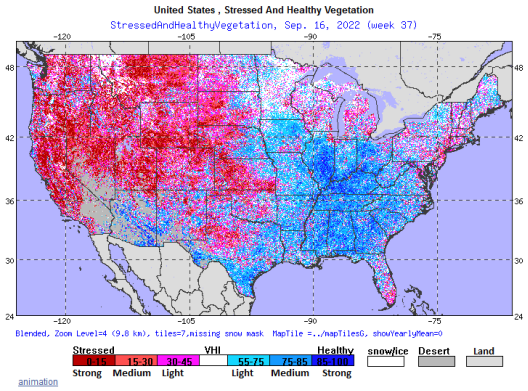
SPoRT LIS Soil Moisture Example – Arkansas, Sept. 2022

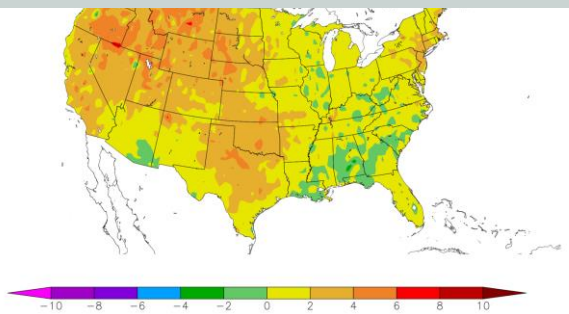
- Streamflow normal
- Vegetation not too stressed (VegDRI, VHI)
- Summer temperatures warm, but not excessively so
  - But last couple weeks getting hotter

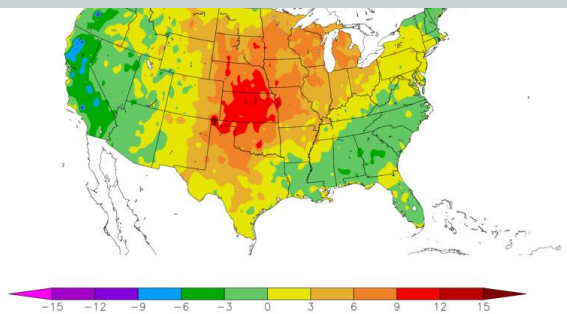
From 9/27/2022 USDM Narrative: "Hot and mostly dry conditions were observed this past week especially across the Arkansas-Louisiana-Texas area, with near record high temperatures recorded each day as readings neared the century mark. This marks nearly the third straight week with near cloud-free conditions, with below normal relative humidity for this time of year yielding high evaporation rates. Grounds have quickly dried out over much of the area …"

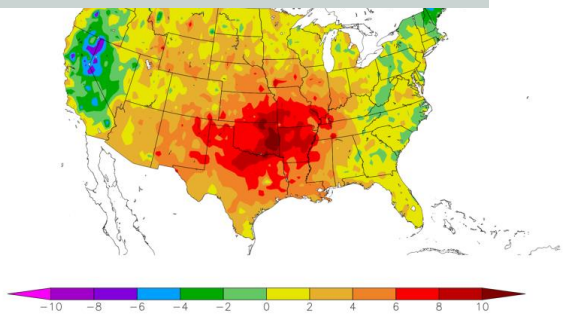


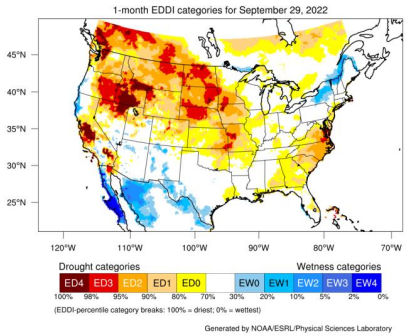








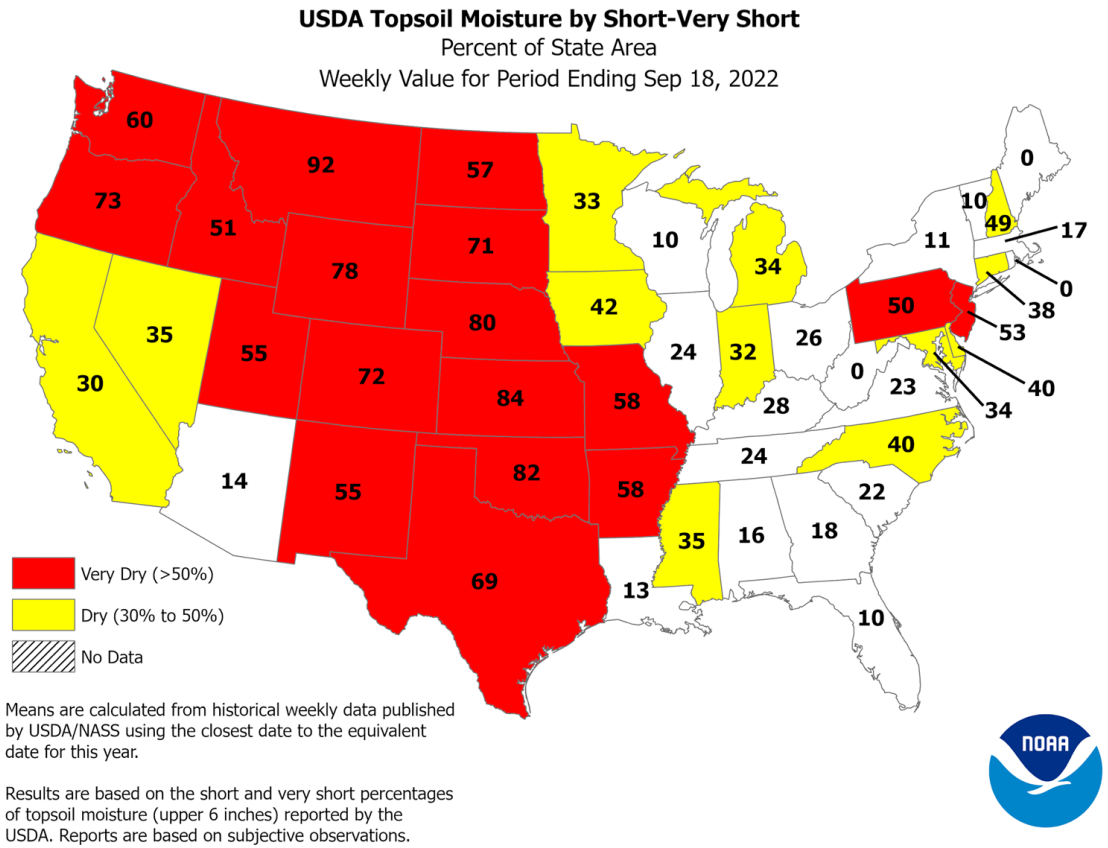


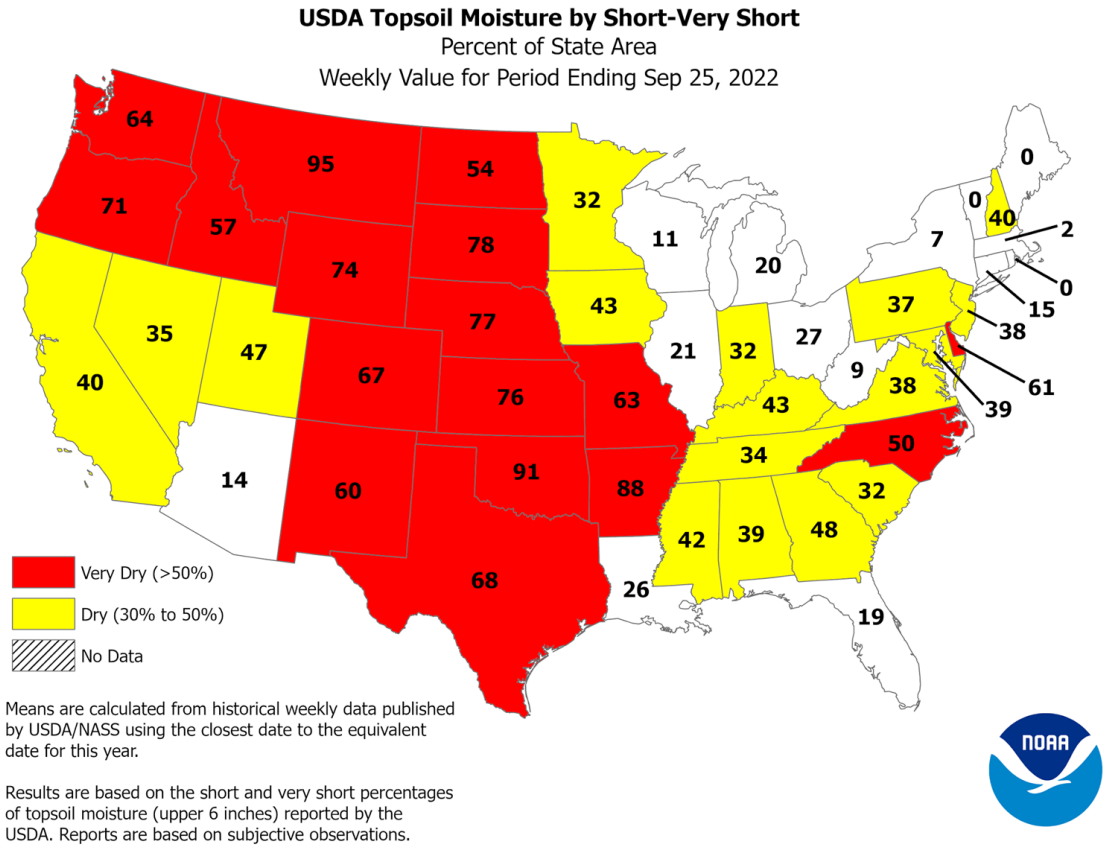


SPoRT LIS Soil Moisture Example – Arkansas, Sept. 2022

- USDA NASS percent area of the state having topsoil moisture dry to very dry (short to very short)
  - 58% of AR on 9/18; 88% of AR on 9/25

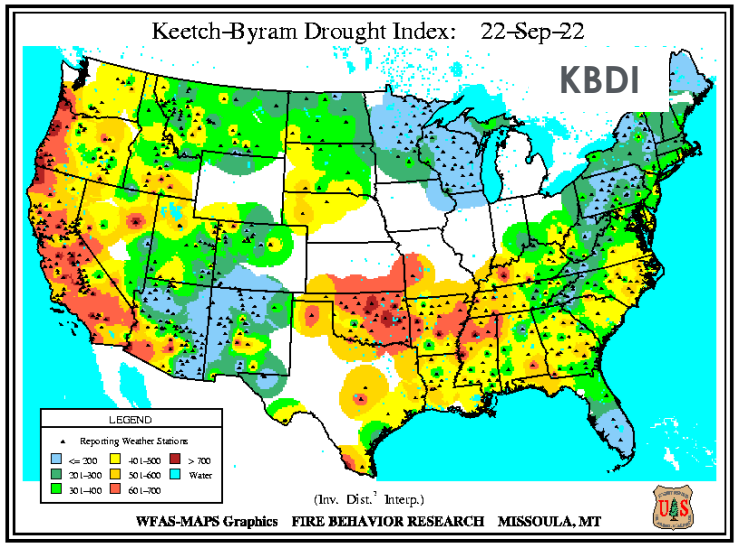
USDA NASS = U.S. Department of Agriculture National Agricultural Statistics Service

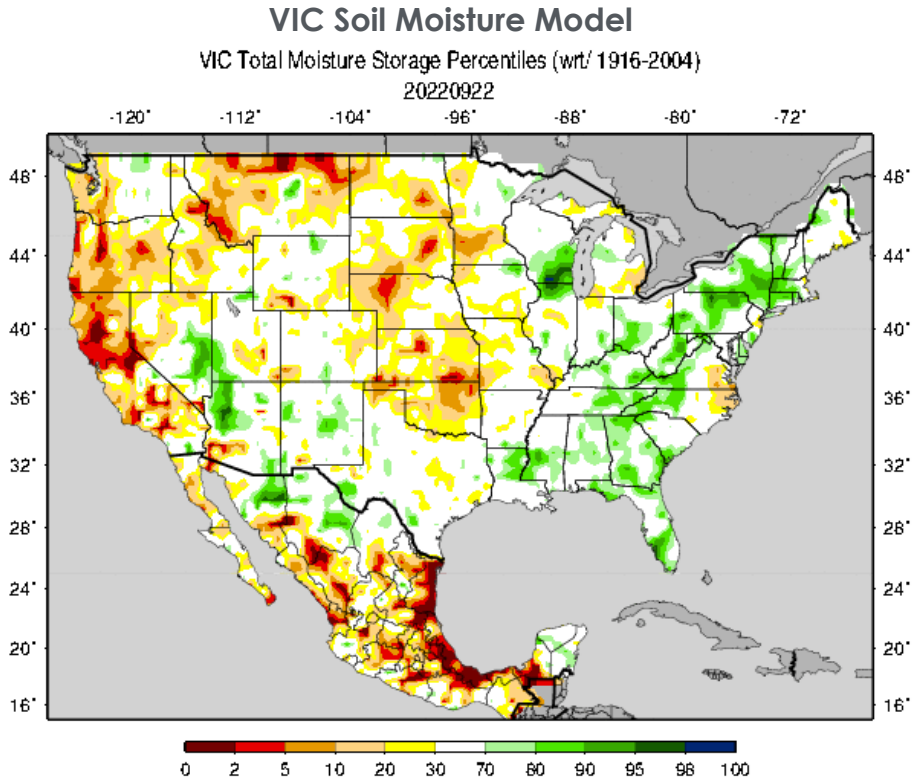


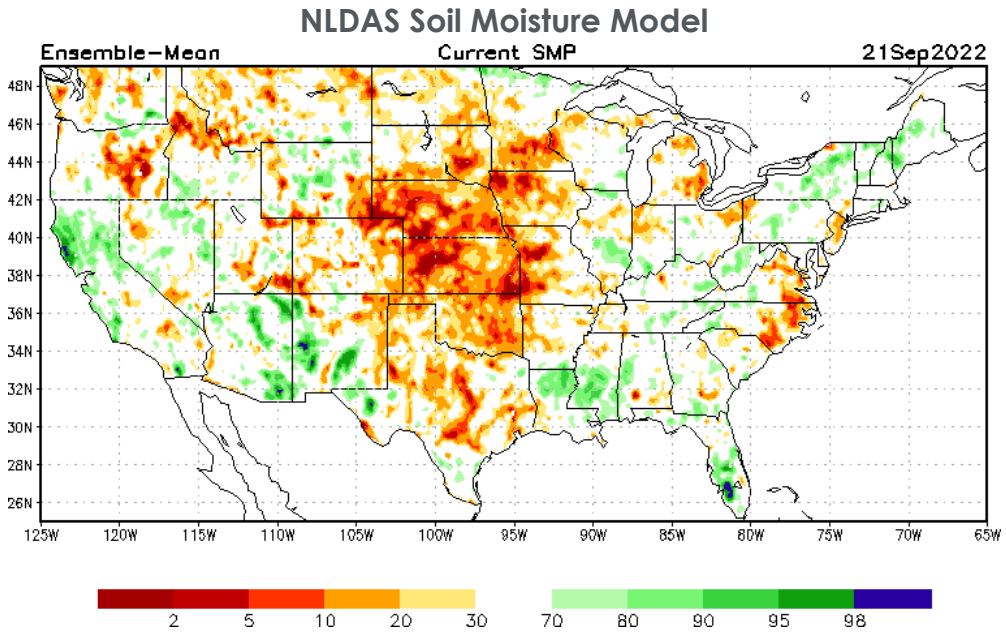


SPoRT LIS Soil Moisture Example – Arkansas, Sept. 2022

- KBDI (fire index) high
- Some soil moisture indicators were showing the rapid drying, others (VIC, NLDAS) weren't at first

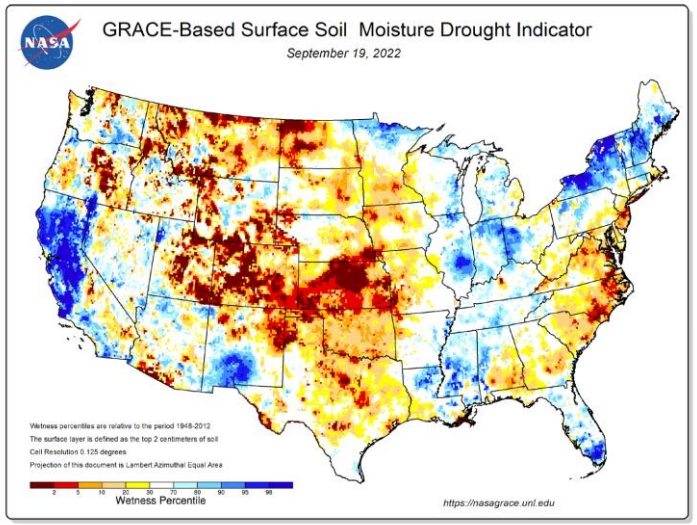






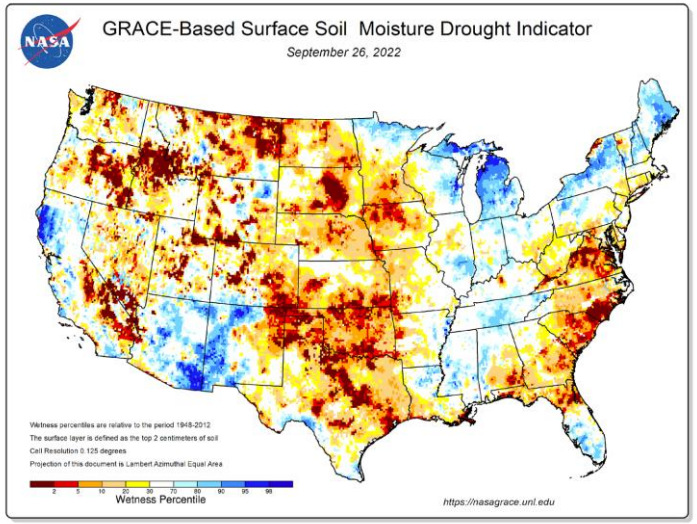
SPoRT LIS Soil Moisture Example – Arkansas, Sept. 2022

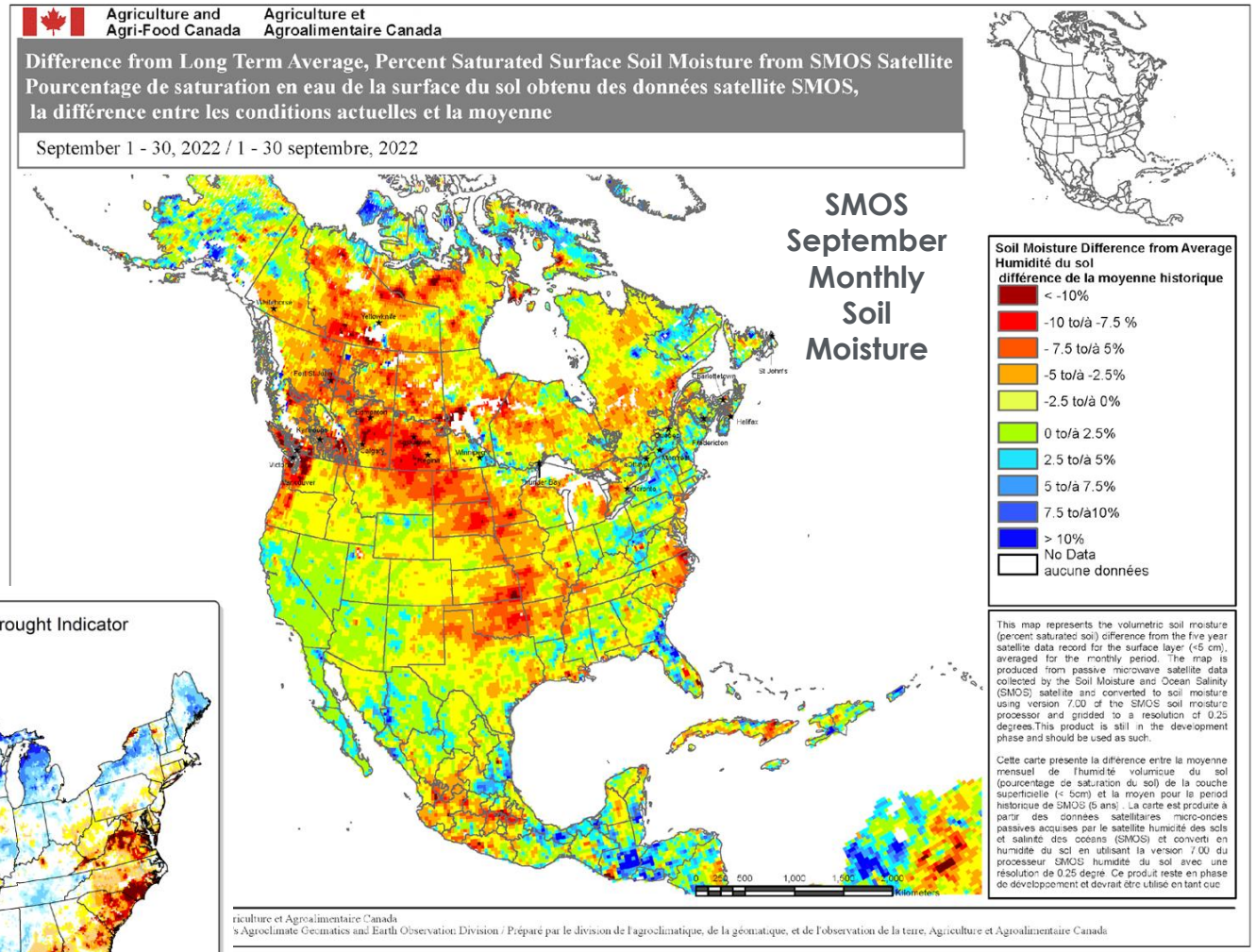
- The dry soils were not reflected much in the GRACE indicator
- But they were in the SMOS indicator



GRACE September 19
Surface Soil Moisture

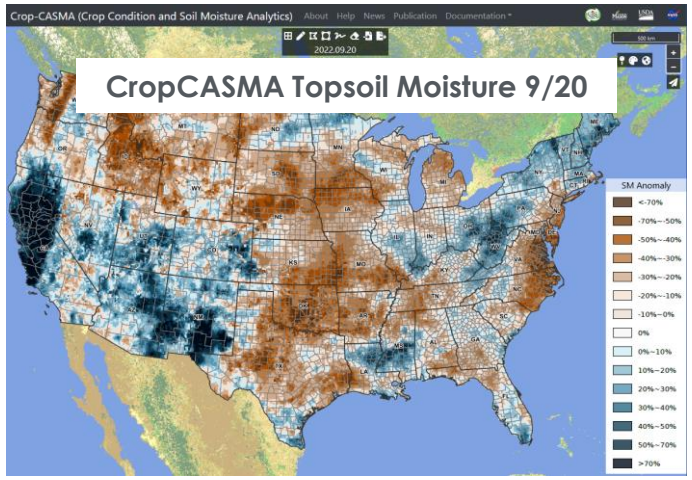
GRACE September 26
Surface Soil Moisture

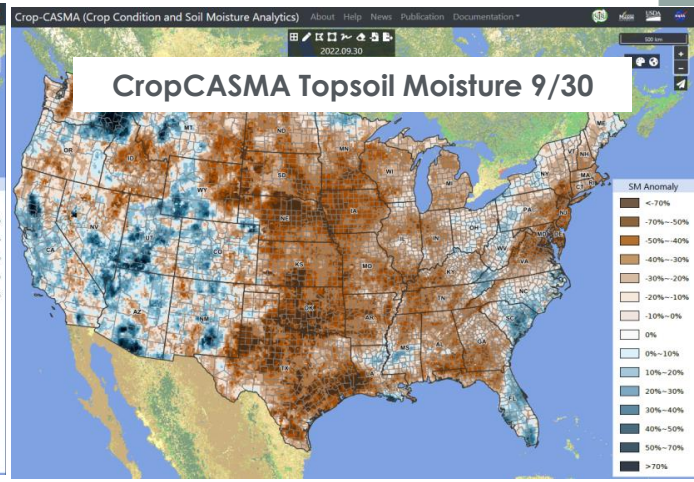




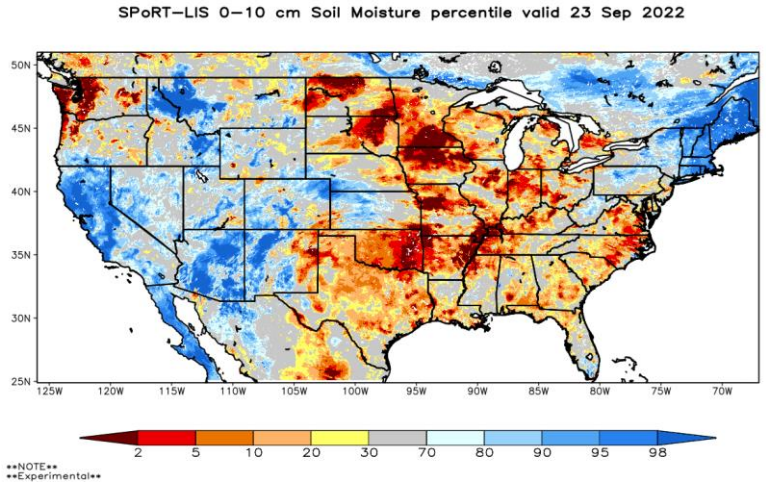
SPoRT LIS Soil Moisture Example – Arkansas, Sept. 2022

- Rapid drying of soils was seen from mid-Sept. to late Sept. in:
  - CropCASMA topsoil & subsoil
  - SPoRT (especially the shallow layers)
- Reports of dried ponds from Arkansas ranchers confirmed the dryness.

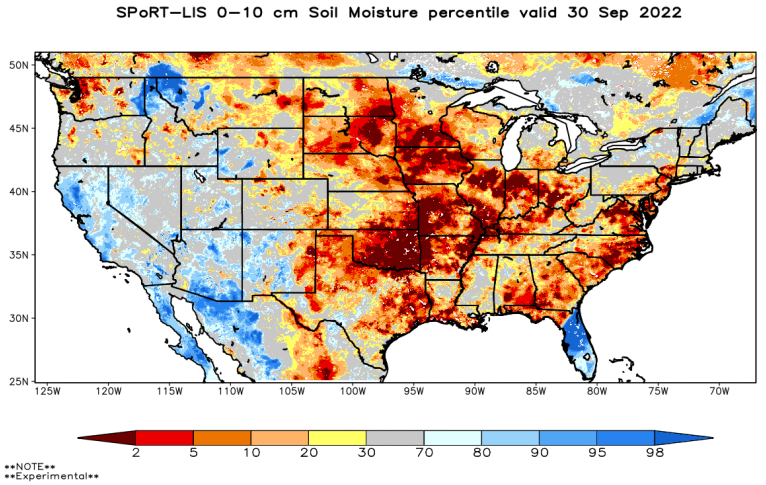




SPoRT 0-10 cm Soil Moisture Percentile September 23



SPoRT 0-10 cm Soil Moisture Percentile September 30

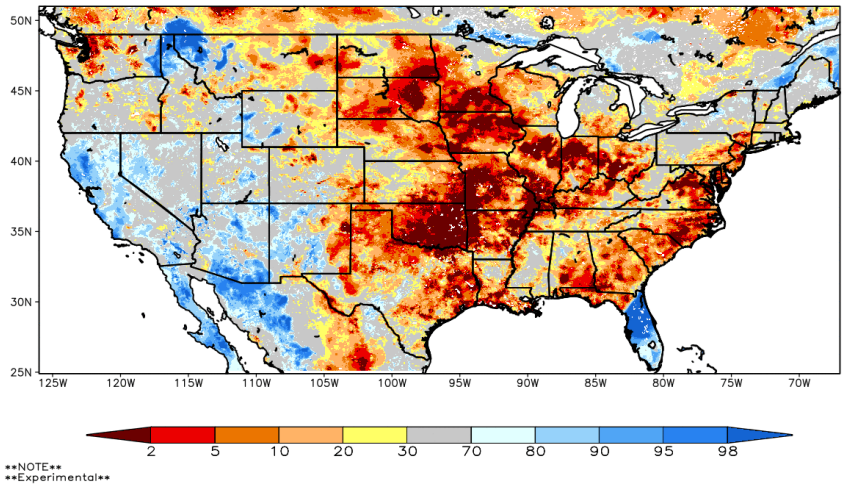


SPoRT LIS Soil Moisture Example – Arkansas, Sept. 2022

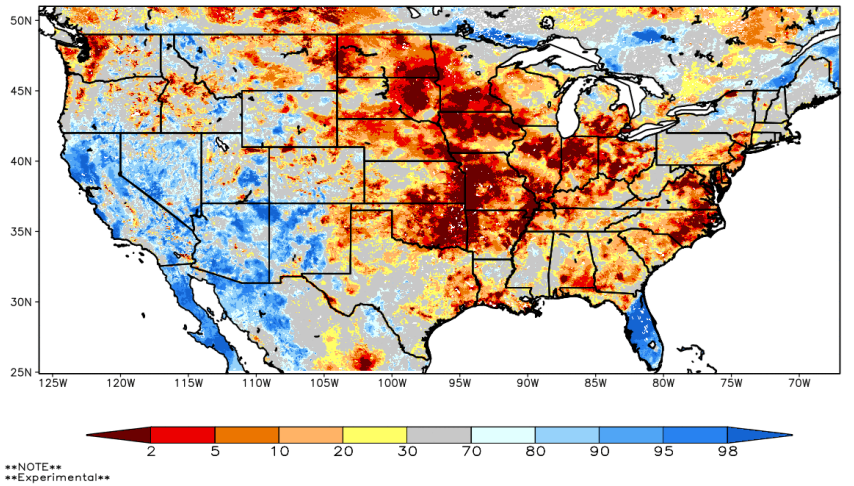
- The SPoRT LIS soil moisture percentile maps show us the degree of drying in 4 soil layers. The top layers reflected the greatest amount of drying.
- The SPoRT product captured the rapid drying the best of all the soil moisture products.

September 30 SPoRT Soil Moisture Percentile for:

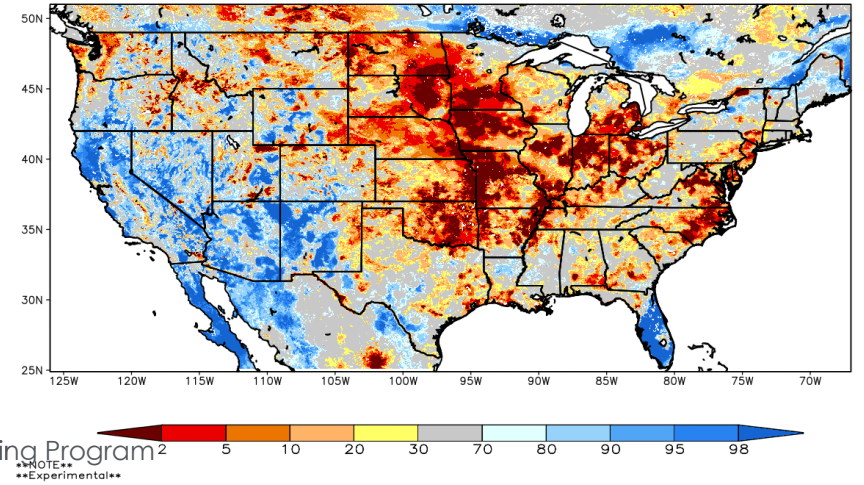
0-10 cm



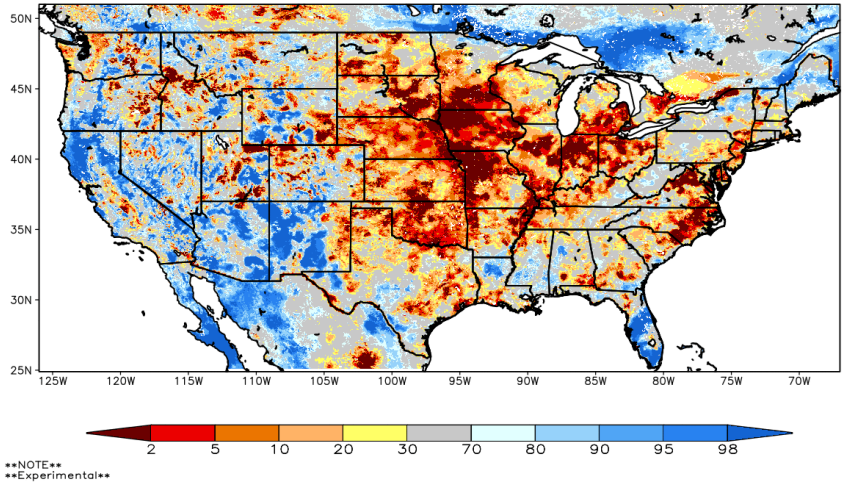
0-40 cm



0-100 cm

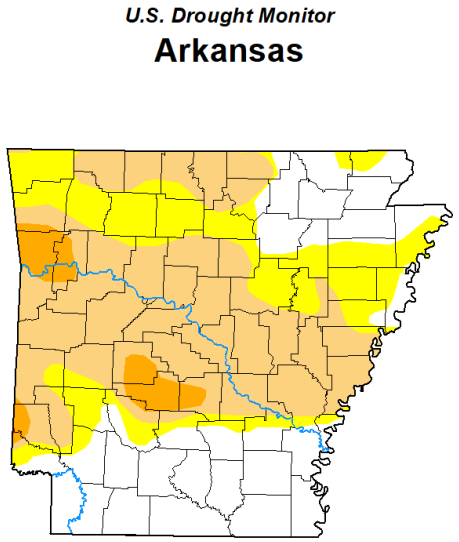


0-200 cm



SPoRT LIS Soil Moisture Example – Arkansas, Sept. 2022

- The lack of rain and very hot temperatures, which increased evapotranspiration during the last half of September, rapidly dried soils.
- The USDM depiction showed rapid expansion of D2 (severe drought) across central Arkansas and the introduction of D3 (extreme drought) into western Arkansas.
- The SPoRT product captured this very well and was an important tool behind the USDM drought expansion.



U.S. Drought Monitor
Arkansas

September 13, 2022
(Released Thursday, Sep. 15, 2022)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

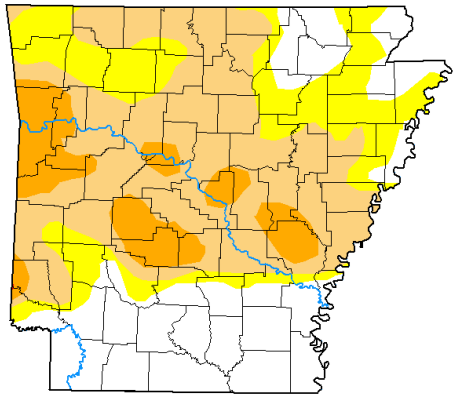
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	31.74	68.26	46.08	4.56	0.01	0.00
Last Week 09-06-2022	31.69	68.31	45.98	4.56	0.01	0.00
3 Months Ago 06-14-2022	99.87	0.13	0.00	0.00	0.00	0.00
Start of Calendar Year 01-04-2022	39.91	60.09	28.99	14.24	0.41	0.00
Start of Water Year 09-28-2021	51.41	48.59	5.17	0.00	0.00	0.00
One Year Ago 09-14-2021	66.15	33.85	0.37	0.00	0.00	0.00

Intensity:
None
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. For more information on the Drought Monitor, go to https://droughtmonitor.unl.edu/About.aspx

Author:
David Simeral
Western Regional Climate Center

droughtmonitor.unl.edu



U.S. Drought Monitor
Arkansas

September 20, 2022
(Released Thursday, Sep. 22, 2022)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

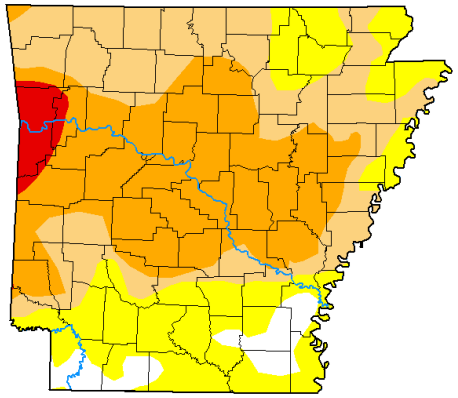
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	28.02	71.98	51.17	11.63	0.01	0.00
Last Week 09-13-2022	31.74	68.26	45.98	4.56	0.01	0.00
3 Months Ago 06-21-2022	97.04	2.96	0.00	0.00	0.00	0.00
Start of Calendar Year 01-04-2022	39.91	60.09	28.99	14.24	0.41	0.00
Start of Water Year 09-28-2021	51.41	48.59	5.17	0.00	0.00	0.00
One Year Ago 09-21-2021	55.08	44.92	2.34	0.00	0.00	0.00

Intensity:
None
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. For more information on the Drought Monitor, go to https://droughtmonitor.unl.edu/About.aspx

Author:
Richard Heim
NCEI/NOAA

droughtmonitor.unl.edu



U.S. Drought Monitor
Arkansas

September 27, 2022
(Released Thursday, Sep. 29, 2022)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	4.99	95.01	69.68	39.30	2.96	0.00
Last Week 09-20-2022	28.02	71.98	51.17	11.63	0.01	0.00
3 Months Ago 06-28-2022	68.12	31.88	1.85	0.00	0.00	0.00
Start of Calendar Year 01-04-2022	39.91	60.09	28.99	14.24	0.41	0.00
Start of Water Year 09-28-2021	51.41	48.59	5.17	0.00	0.00	0.00
One Year Ago 09-28-2021	51.41	48.59	5.17	0.00	0.00	0.00

Intensity:
None
D0 Abnormally Dry
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The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to https://droughtmonitor.unl.edu/About.aspx

Author:
Richard Heim
NCEI/NOAA

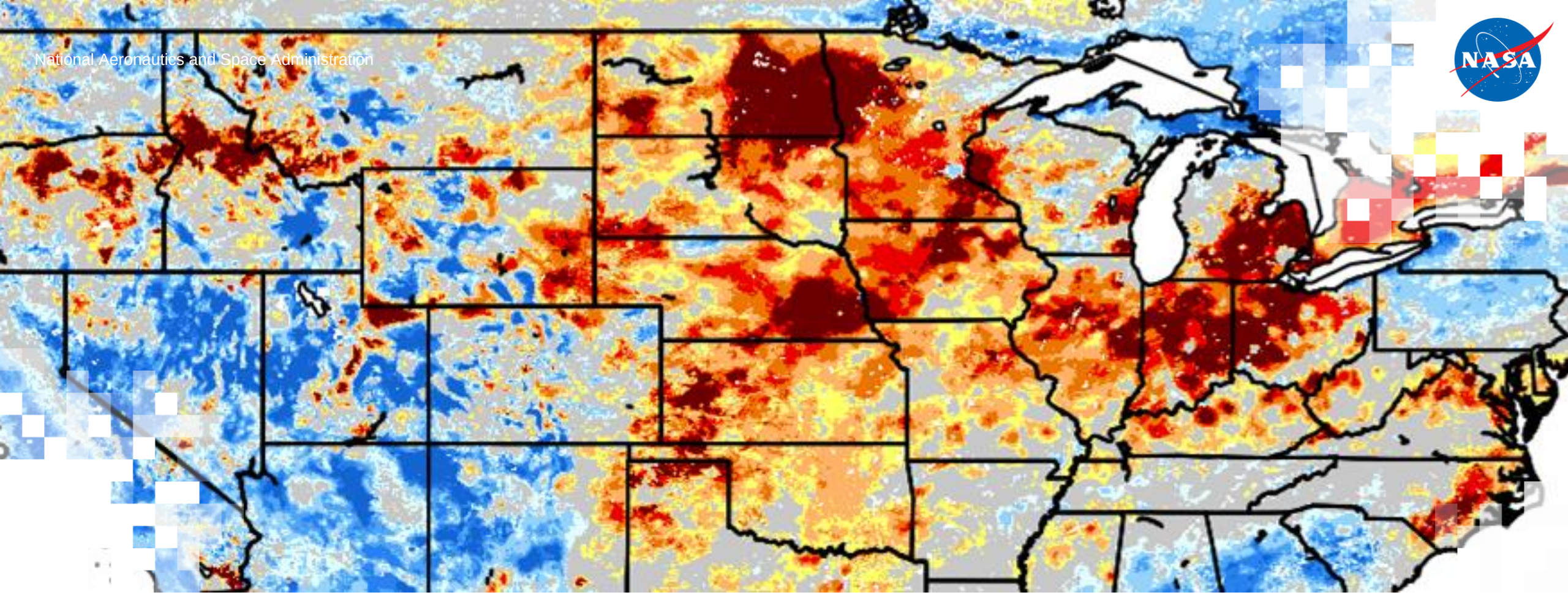
droughtmonitor.unl.edu

Summary – Utility of SPoRT Soil Moisture in USDM

- The SPoRT LIS soil moisture percentile product is a valuable addition to the suite of soil moisture products used to prepare the USDM.
- Its percentile units are directly relatable to the USDM Dx categories.
- The SPoRT product provides information for multiple soil layers:
  - The shallow layers (0-10 cm, 0-40 cm) enable detection of rapid drying of soils (which happens during "flash droughts").
  - The deeper layers (0-100 cm, 0-200 cm) capture relic dryness from past dry periods.
- But like all drought indicator products used in the production of the USDM, the SPoRT product's utility is most effective when it is consistent with other products ("convergence of evidence").

Thank You!

Richard Heim
NOAA/NESDIS/National Centers for Environmental Information
Richard.Heim@noaa.gov



A State-Level Perspective from North Carolina

Corey Davis
Assistant State Climatologist
NC State Climate Office

Barrett Smith
Senior Service Hydrologist
National Weather Service in Raleigh, NC

May 24, 2023

Objectives

- Explain how SPoRT-LIS has been **integrated into routine state-level drought monitoring**
- Offer **examples of how SPoRT-LIS data is considered**, alongside other drought indicators
- Share our **recommendations and best practices** for using SPoRT-LIS soil moisture products

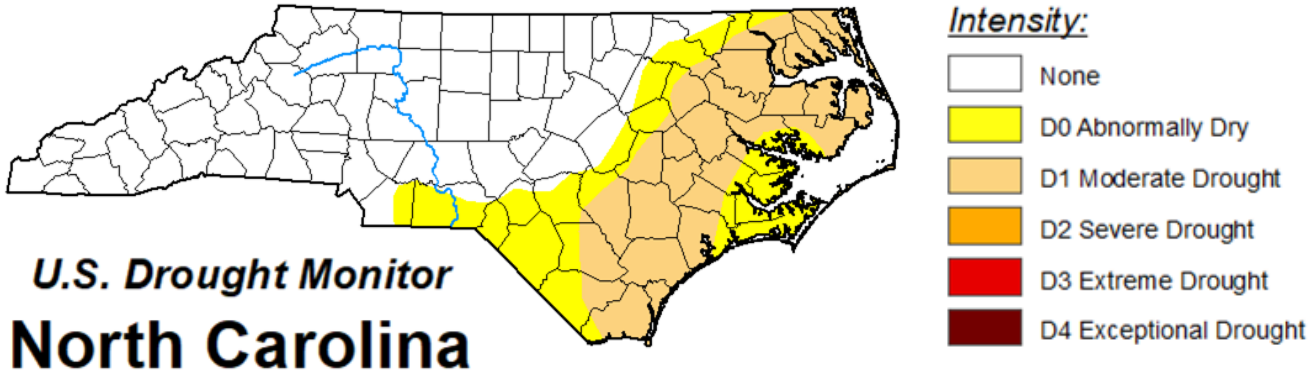
Drought Monitoring in NC

North Carolina
Drought Management Advisory Council

NC COOPERATIVE EXTENSION
N.C. A&T STATE UNIVERSITY
NC STATE UNIVERSITY
DEQ NORTH CAROLINA Department of Environmental Quality
TVA
NORTH CAROLINA CLIMATEOFFICE
DUKE ENERGY
NATIONAL WEATHER SERVICE
NORTH CAROLINA FOREST SERVICE NC
USGS science for a changing world
US Army Corps of Engineers
N★C DPS DEPARTMENT OF PUBLIC SAFETY
CUBE HYDRO CAROLINAS
NORTH CAROLINA Wildlife RESOURCES COMMISSION

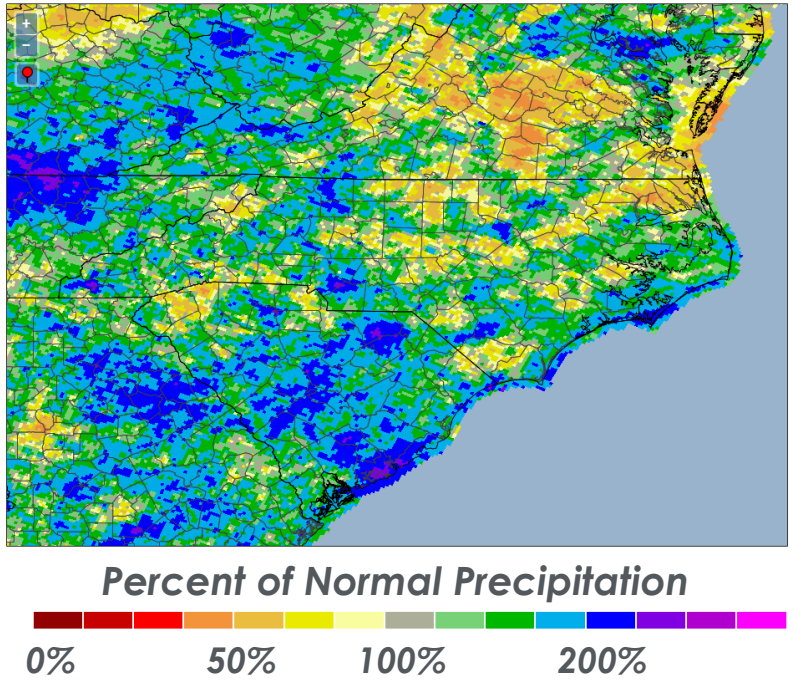
Weekly Calls Review:

- Recent Weather
- Drought Indices
- Observed Impacts

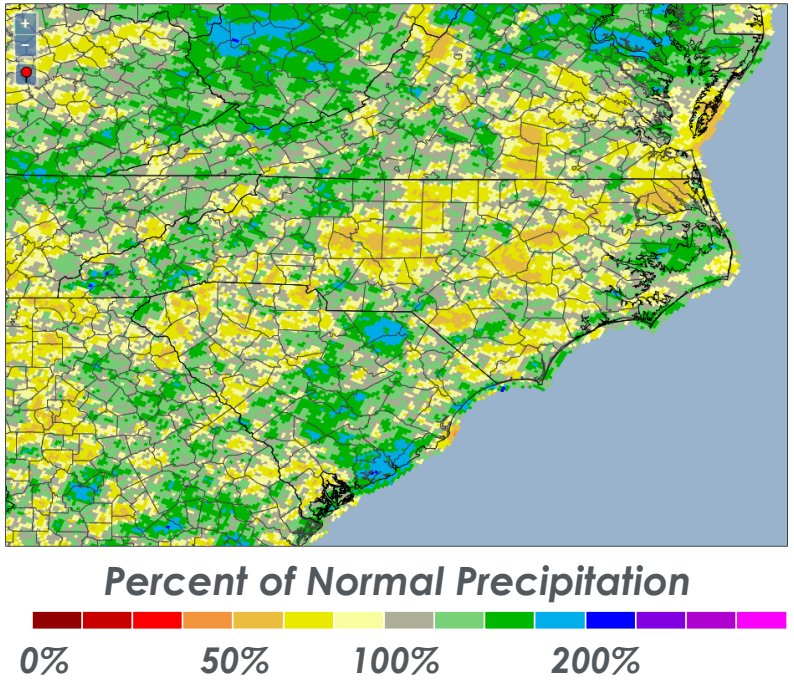


The NC DMAC Process – Precipitation Indices at Multiple Timescales

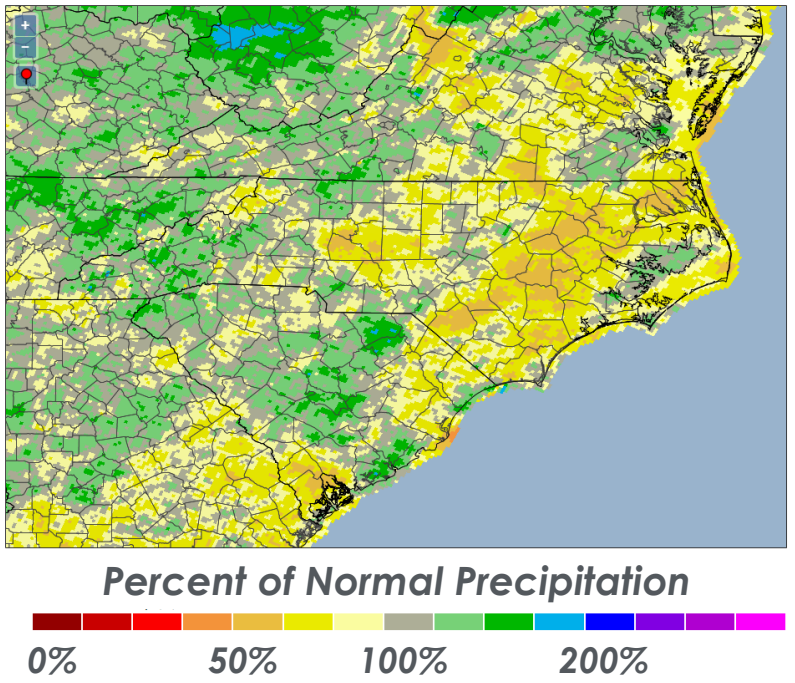
Short-Term (< 30 days)



Medium-Term (30-120 days)



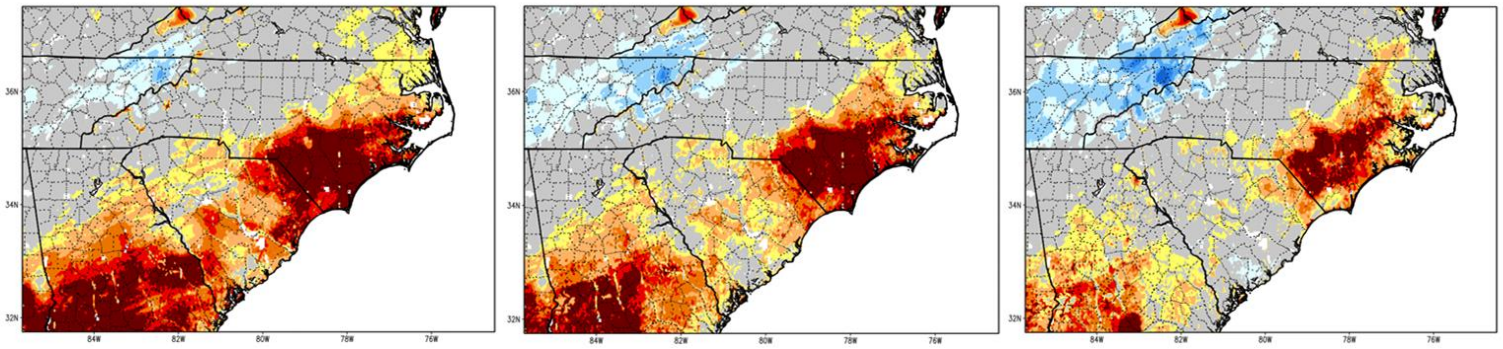
Long-Term (120+ days)

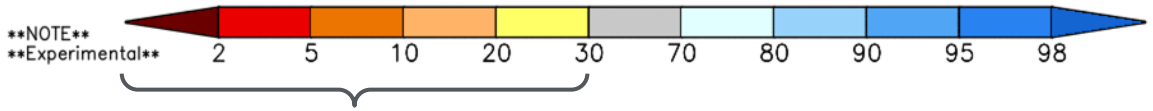


The NC DMAC Process – SPoRT-LIS Soil Moisture Data

Soil Moisture Percentiles over Various Layers

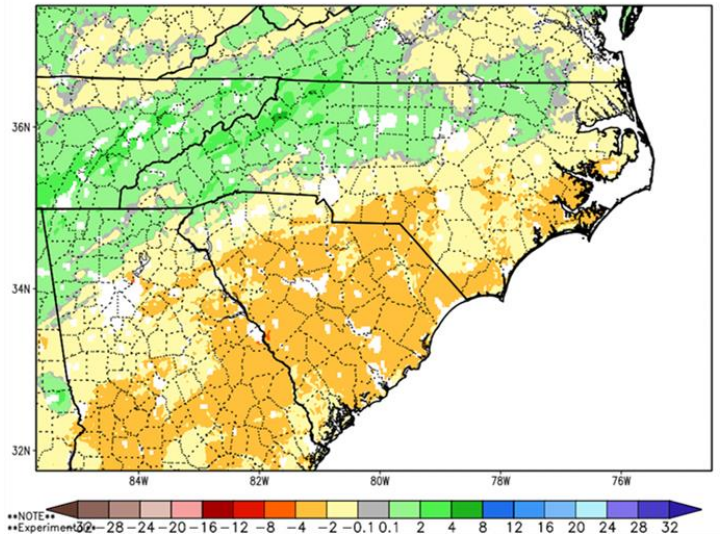
0-40 cm *0-100 cm* *0-200 cm*



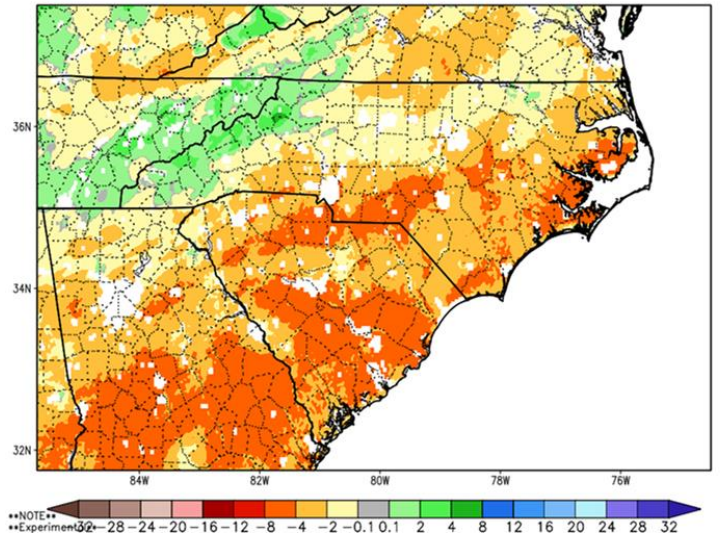


Consistent with USDM Categories

Rel. Soil Moisture: 1-Week Change

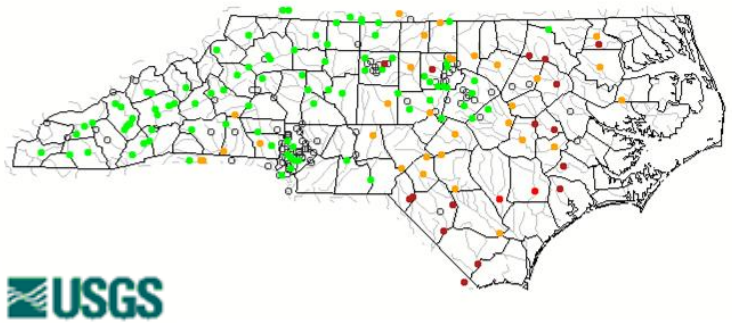


Rel. Soil Moisture: 2-Week Change



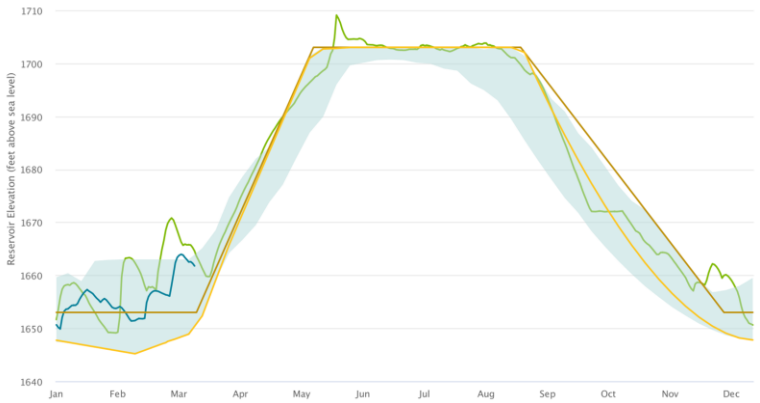
The NC DMAC Process – Surface Water & Groundwater Conditions

Streamflow Levels



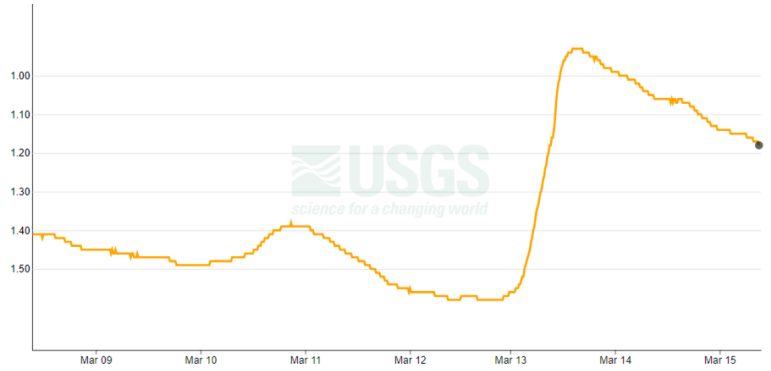
Reservoir Levels

(compared to seasonal targets)



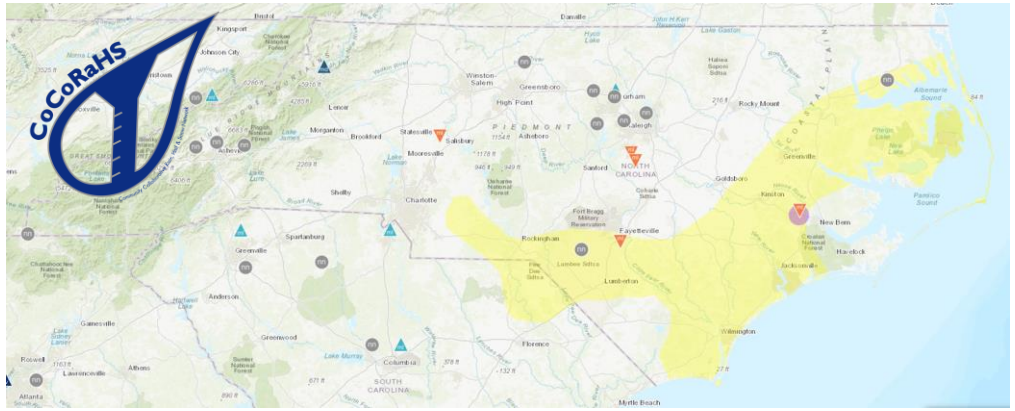
Groundwater Levels

(as historical percentiles by month of the year)

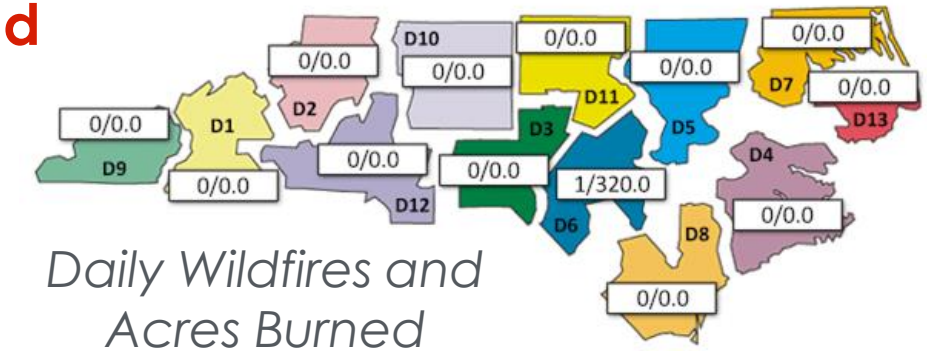


The NC DMAC Process – On-the-Ground Impact Reports

Condition Monitoring Reports
(from citizen scientists)

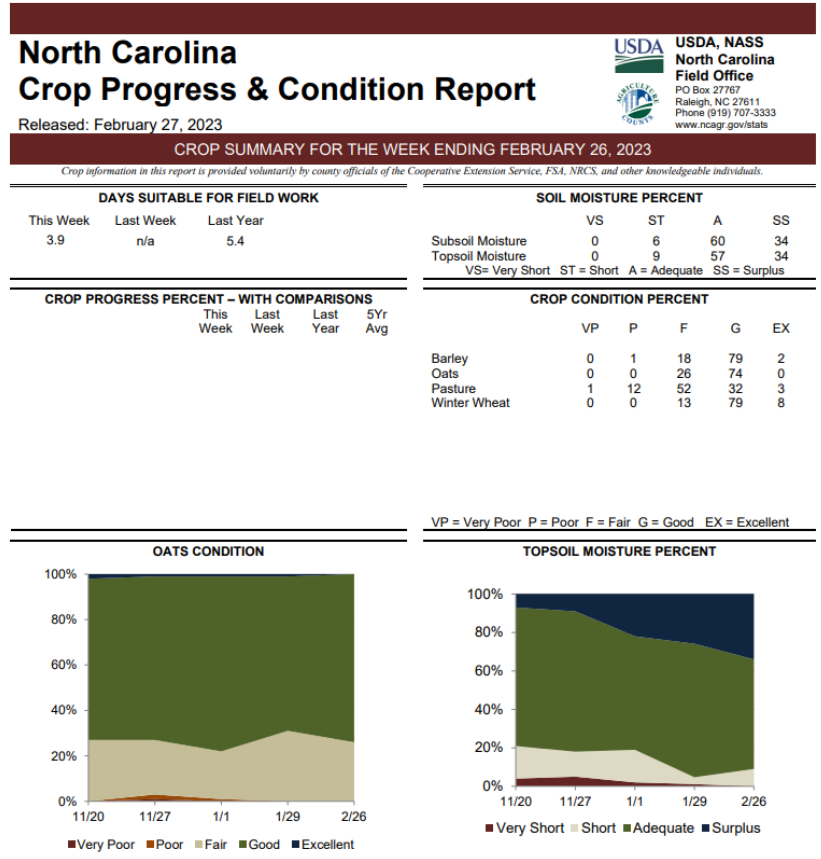


Fire Danger and Fire Activity



Daily Wildfires and Acres Burned

Agricultural Condition Reports
(including crop progress and soil moisture)



North Carolina Crop Progress & Condition Report

USDA, NASS North Carolina Field Office
PO Box 27767
Raleigh, NC 27611
Phone (919) 707-3333
www.ncagr.gov/stats

Released: February 27, 2023

CROP SUMMARY FOR THE WEEK ENDING FEBRUARY 26, 2023

Crop information in this report is provided voluntarily by county officials of the Cooperative Extension Service, FSA, NRCS, and other knowledgeable individuals.

DAYS SUITABLE FOR FIELD WORK

This Week	Last Week	Last Year
3.9	n/a	5.4

SOIL MOISTURE PERCENT

	VS	ST	A	SS
Subsoil Moisture	0	6	60	34
Topsoil Moisture	0	9	57	34

VS= Very Short ST = Short A = Adequate SS = Surplus

CROP PROGRESS PERCENT – WITH COMPARISONS

	This Week	Last Week	Last Year	5Yr Avg

CROP CONDITION PERCENT

	VP	P	F	G	EX
Barley	0	1	18	79	2
Oats	0	0	26	74	0
Pasture	1	12	52	32	3
Winter Wheat	0	0	13	79	8

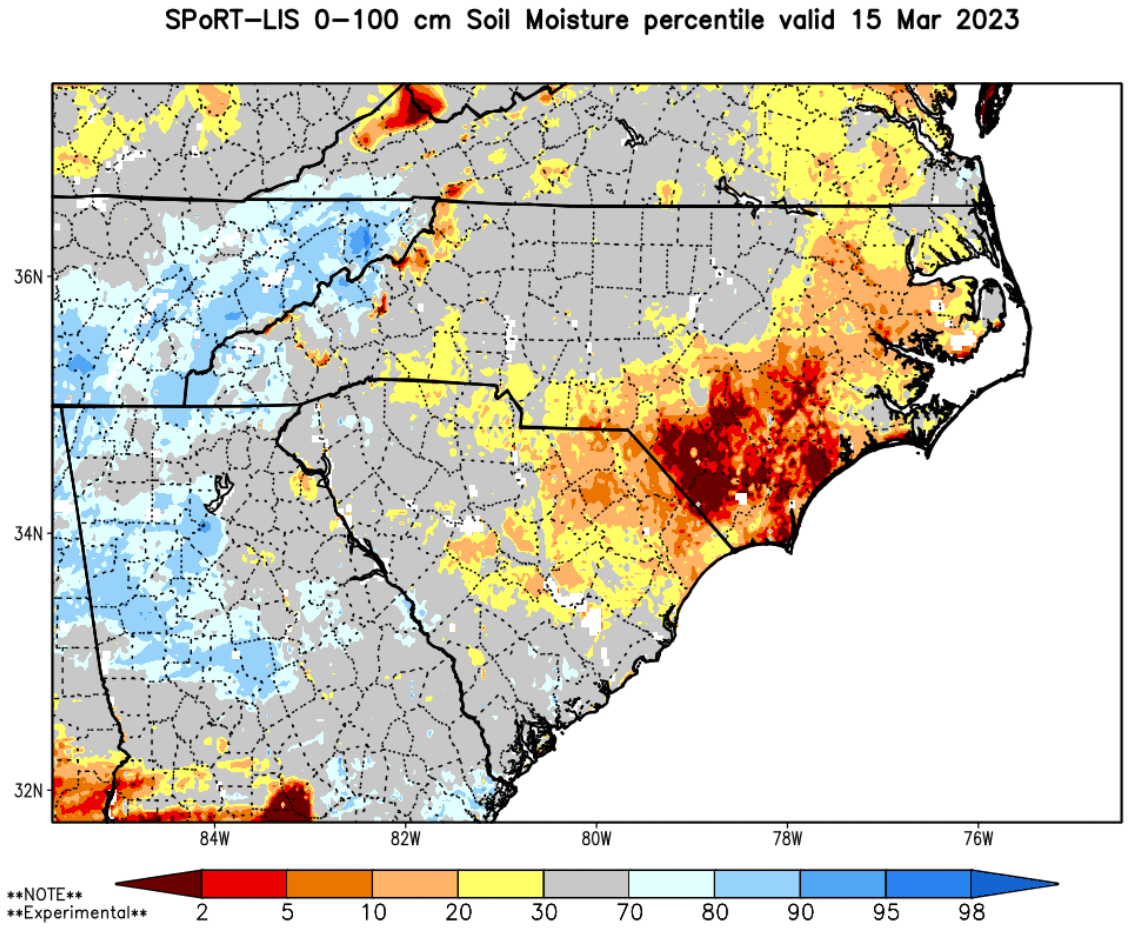
VP = Very Poor P = Poor F = Fair G = Good EX = Excellent

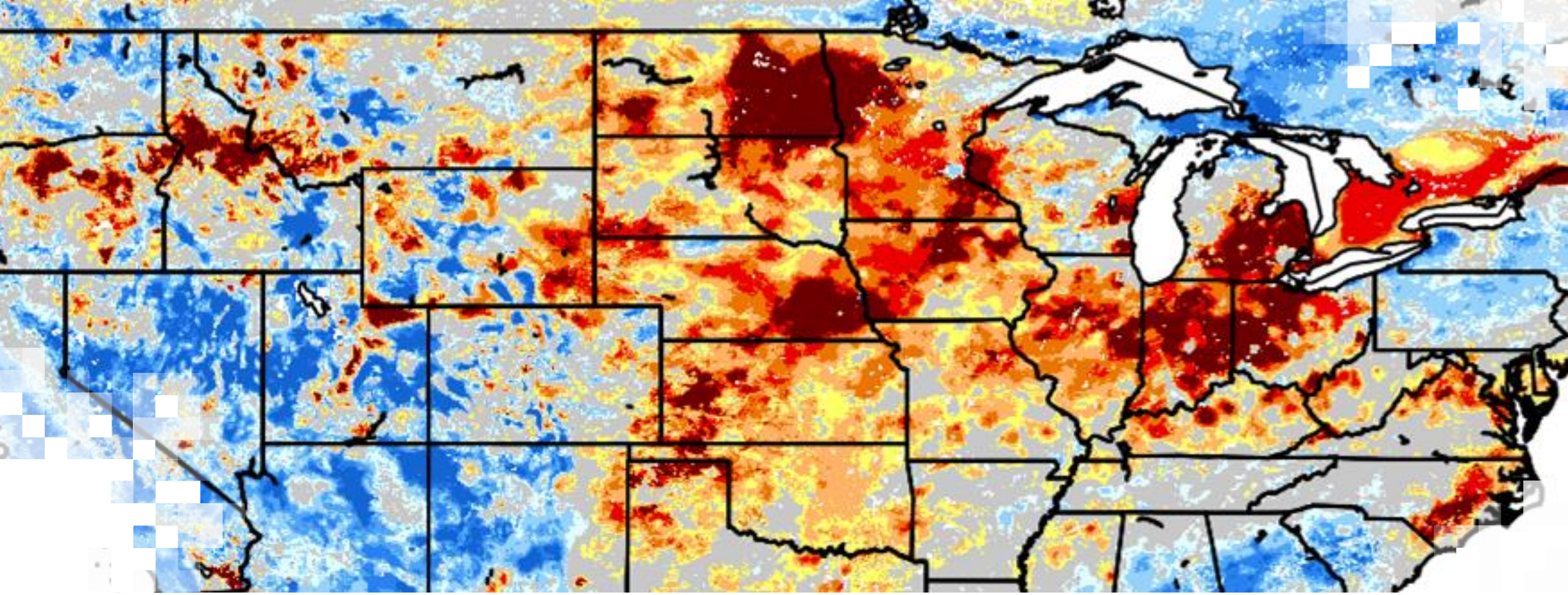
OATS CONDITION

TOPSOIL MOISTURE PERCENT

Key Needs for Drought Monitoring

- High-resolution data
  - Best coverage of soil moisture
- Multiple timescales and levels available
- Data framed as historical percentiles
- Independent datasets





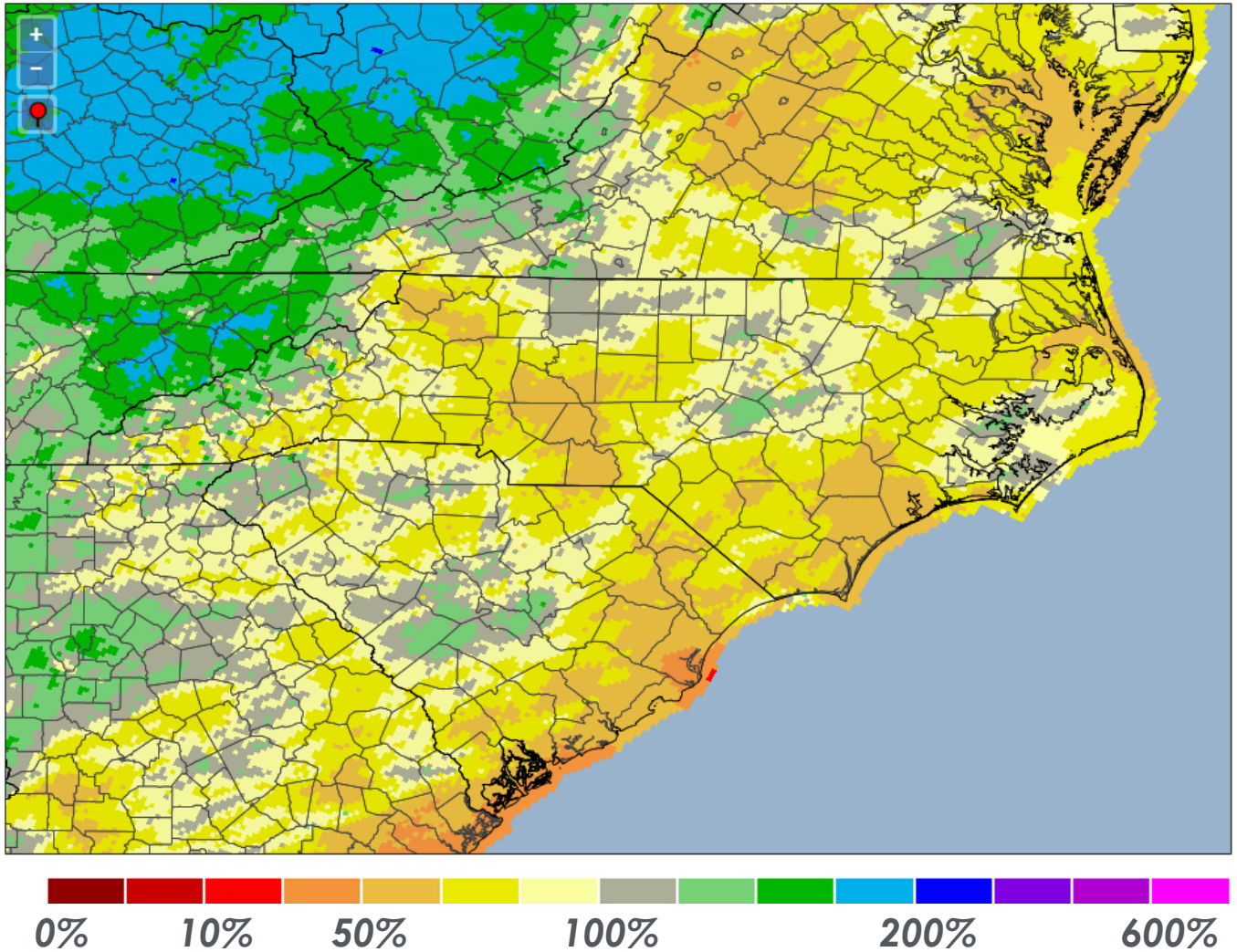
Example 1

March 2022

March 2022 – Background

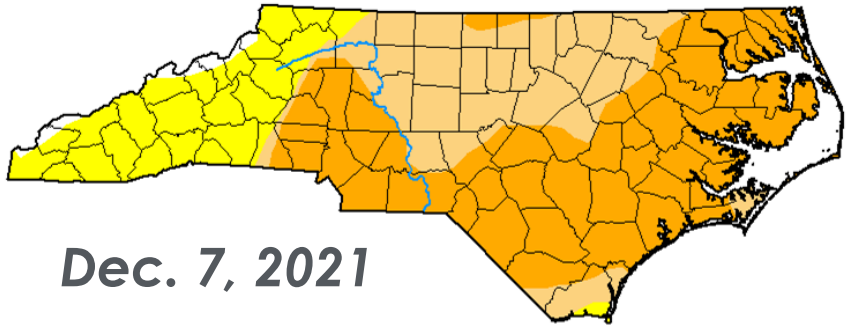
- The winter was drier than normal overall

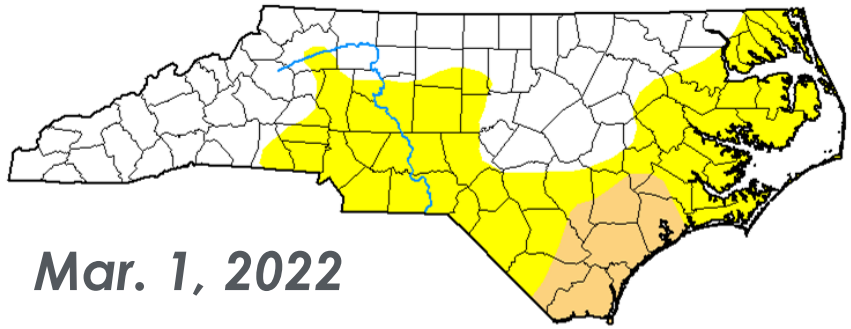
Percent of Normal Precip. *(Dec. 2021 to Feb. 2022)*



March 2022 – Background Continued

- The winter was drier than normal overall
- **January rain and snow events helped saturate the ground and reduce drought impacts and coverage**





Intensity:
- None
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

March 2022 – The Challenge

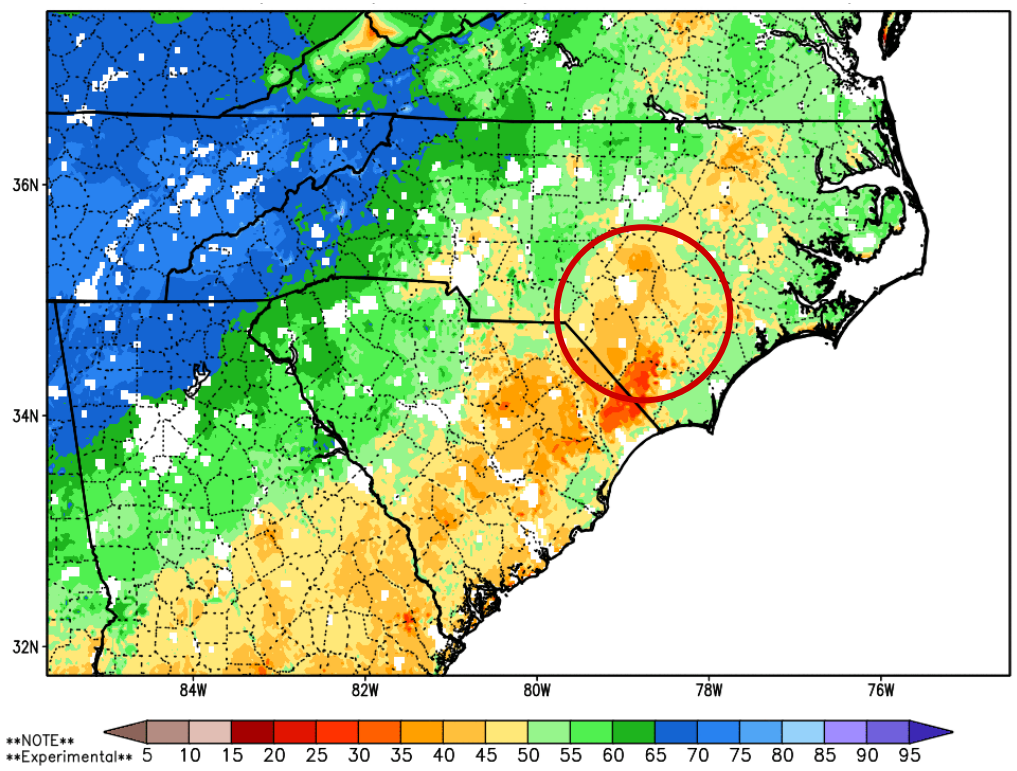
Due to limited impacts over the winter, it can be difficult to determine how well-established or severe drought is entering the spring.

SPoRT-LIS in Action – Brought our Attention to an Area of Emerging Dryness

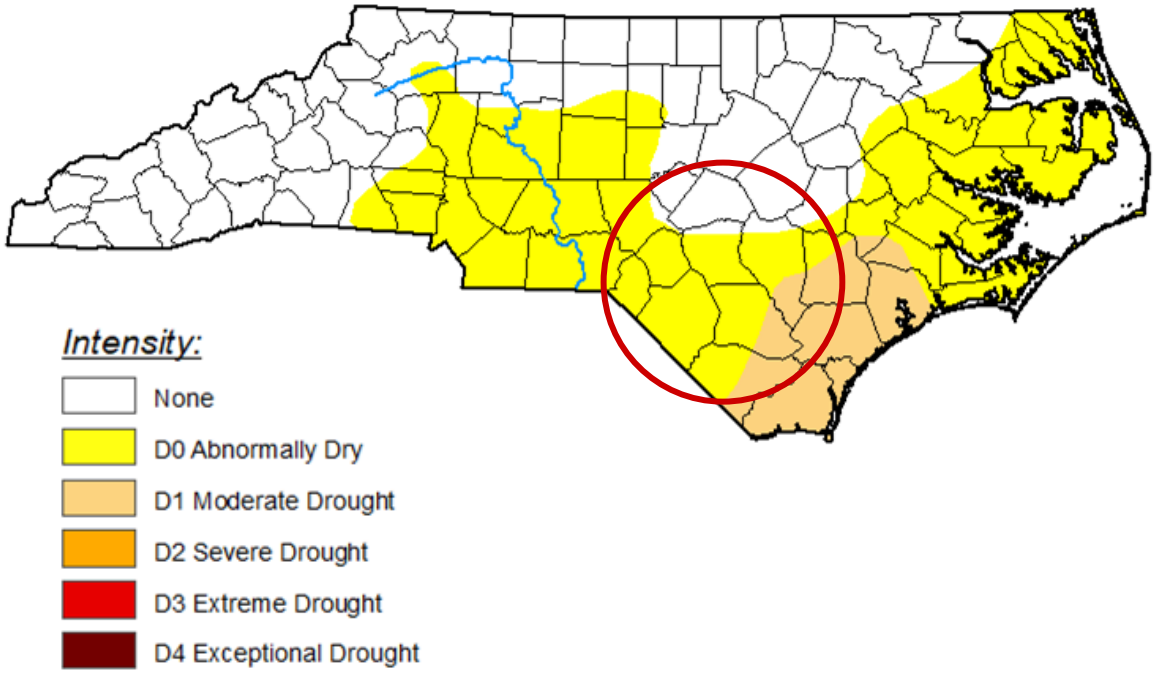
March 2022

1 — 8 — 15 — 22 — 29

0-100 cm Relative Soil Moisture



US Drought Monitor

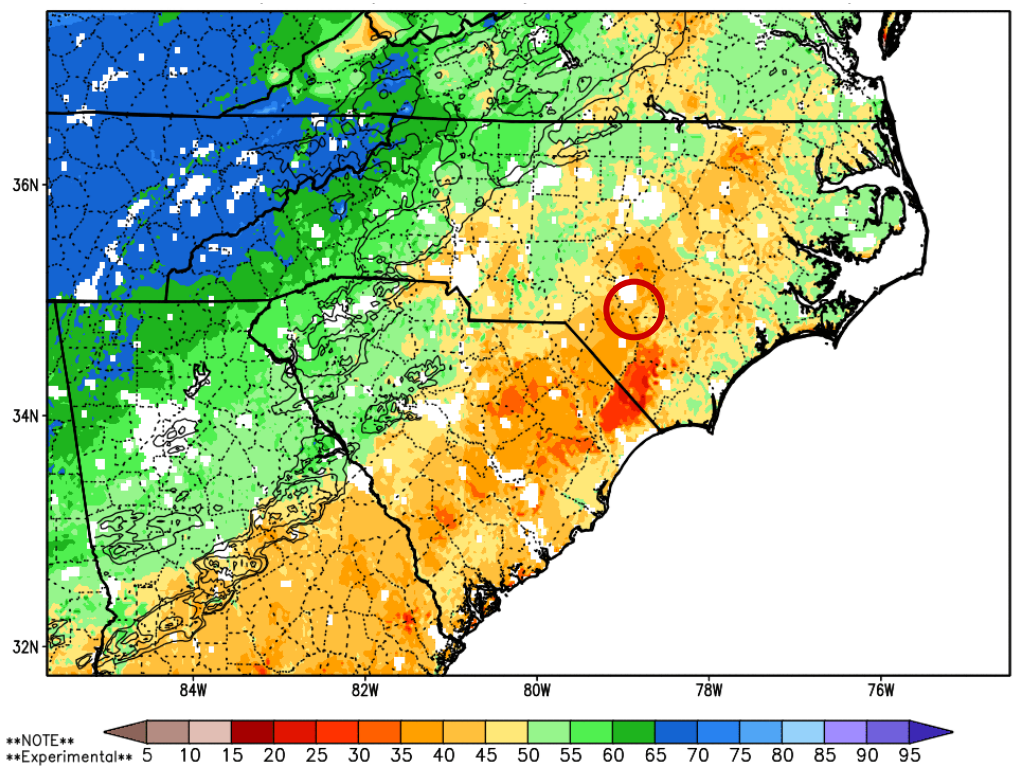


SPoRT-LIS in Action – Helped Assess where Ground-Level Conditions were Getting Dry

March 2022

1 — 8 — 15 — 22 — 29

0-100 cm Relative Soil Moisture



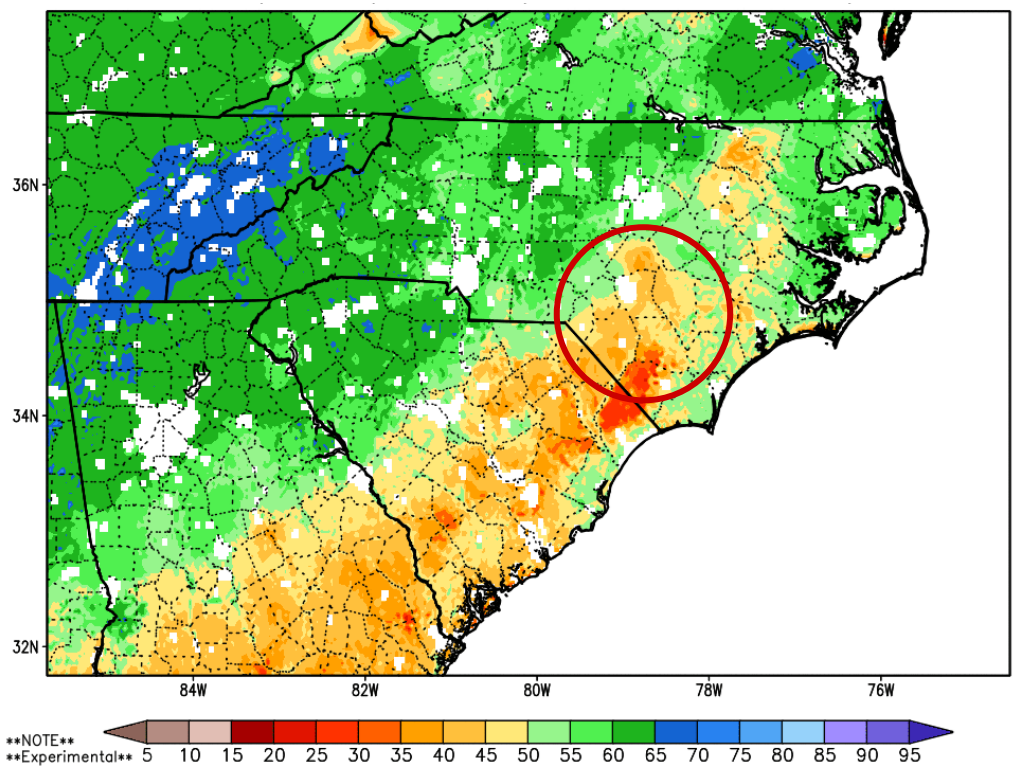
Condition Monitoring Report

SPoRT-LIS in Action – Began Agreeing with Short-Term Indicators

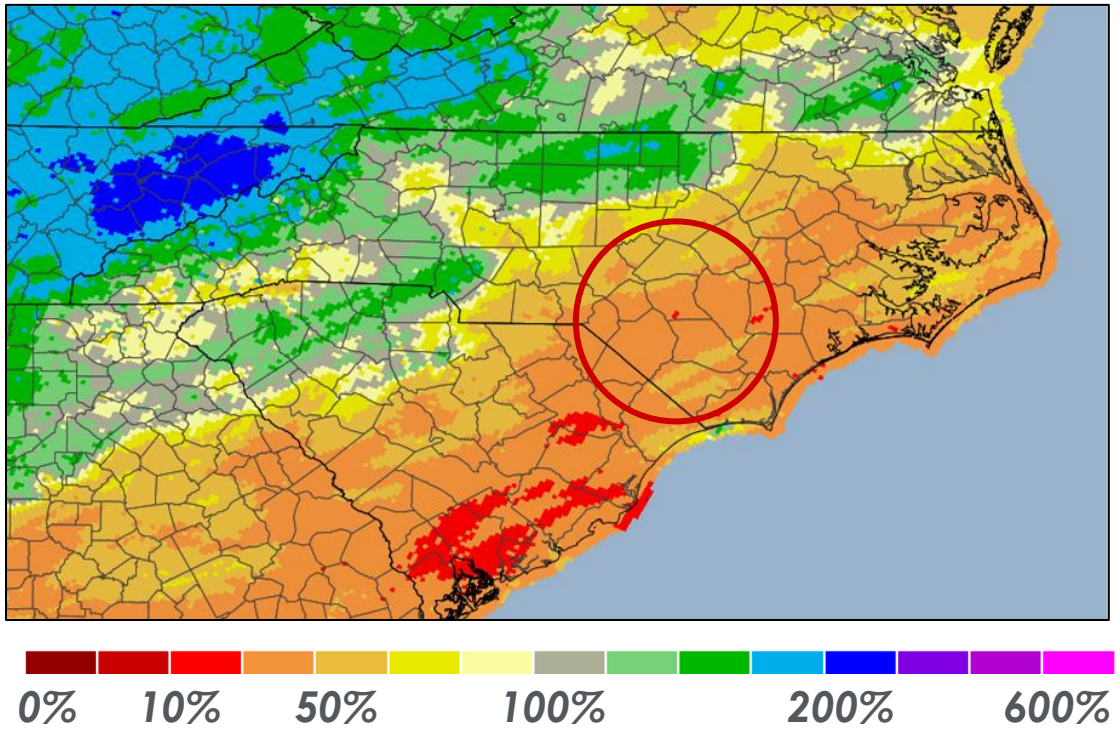
March 2022

1 — 8 — 15 — 22 — 29

0-100 cm Relative Soil Moisture



Percent of Normal Precip. *(past 30 days)*

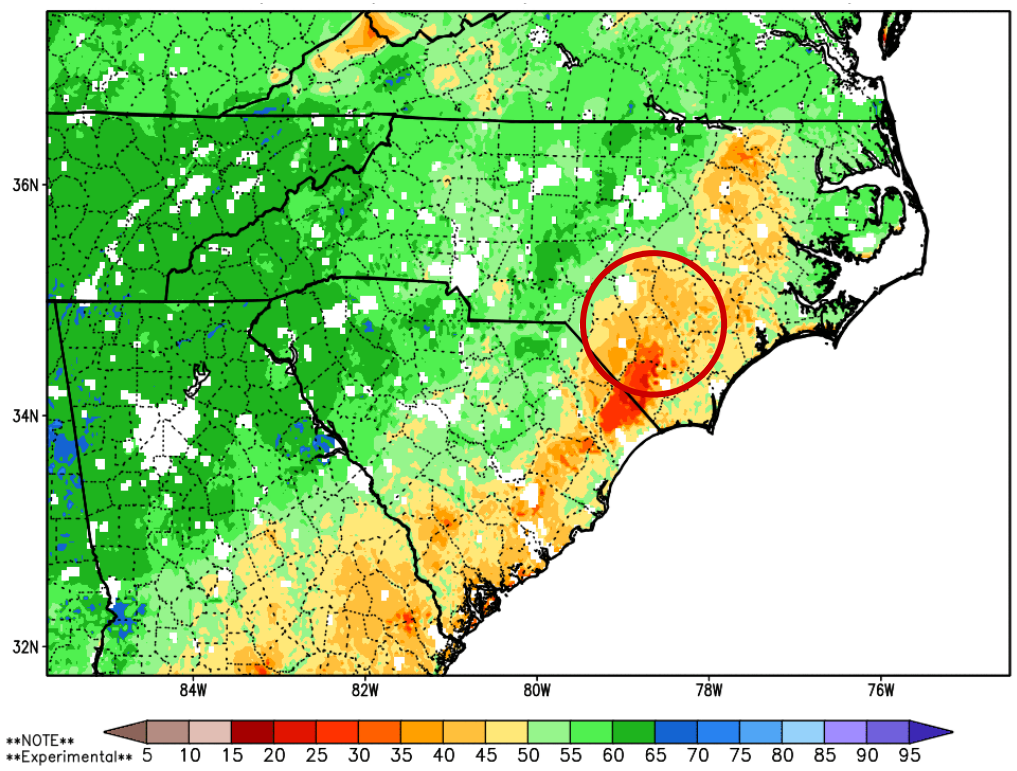


SPoRT-LIS in Action – Supported an Expansion of Moderate Drought (D1)

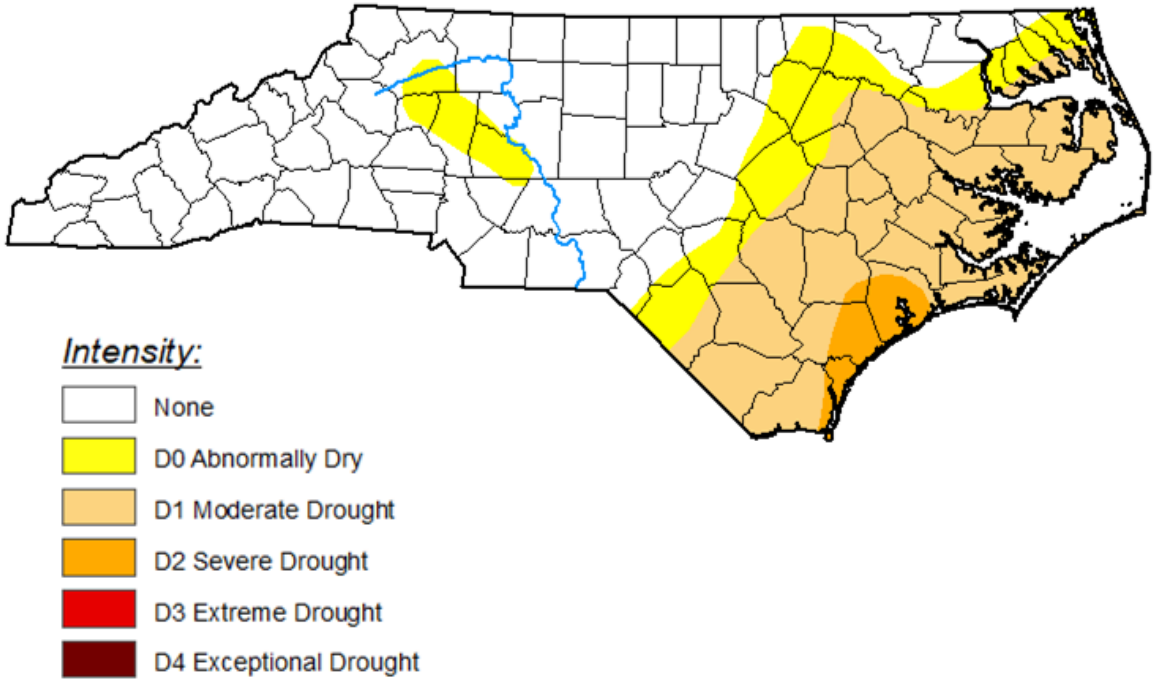
March 2022

1 — 8 — 15 — 22 — 29

0-100 cm Relative Soil Moisture



US Drought Monitor

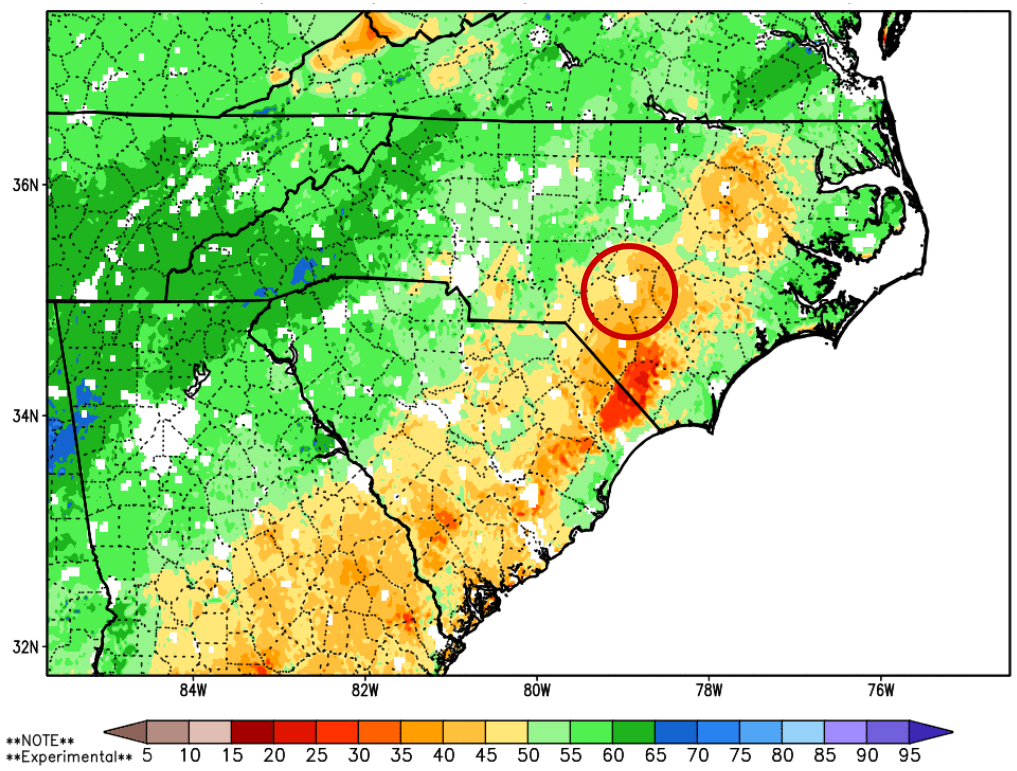


SPoRT-LIS in Action – Highlighted an Area of Drought Impacts

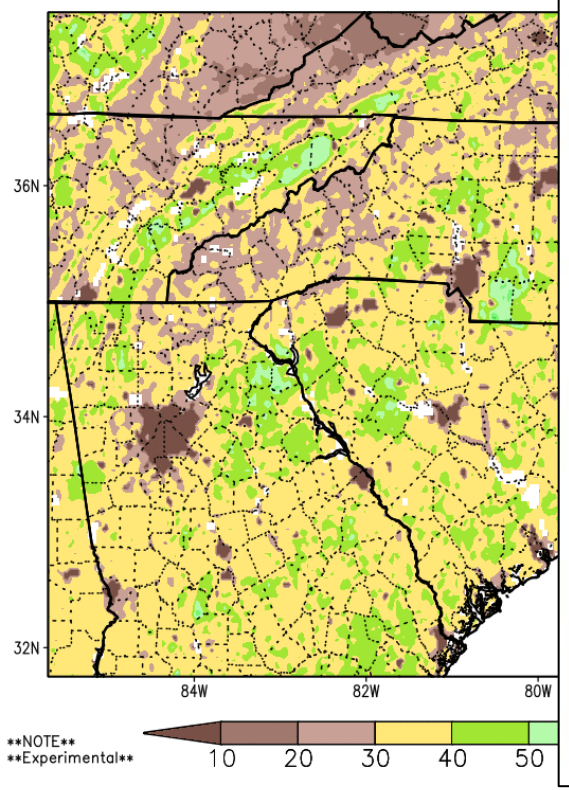
March 2022

1 — 8 — 15 — 22 — 29

0-100 cm Relative Soil Moisture



Green Vegetation Fraction



WRAL NEWS

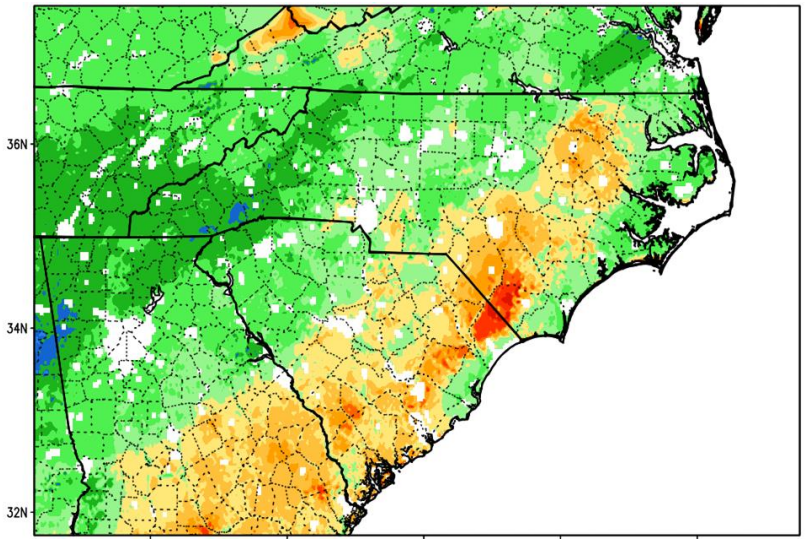
LOCAL NEWS

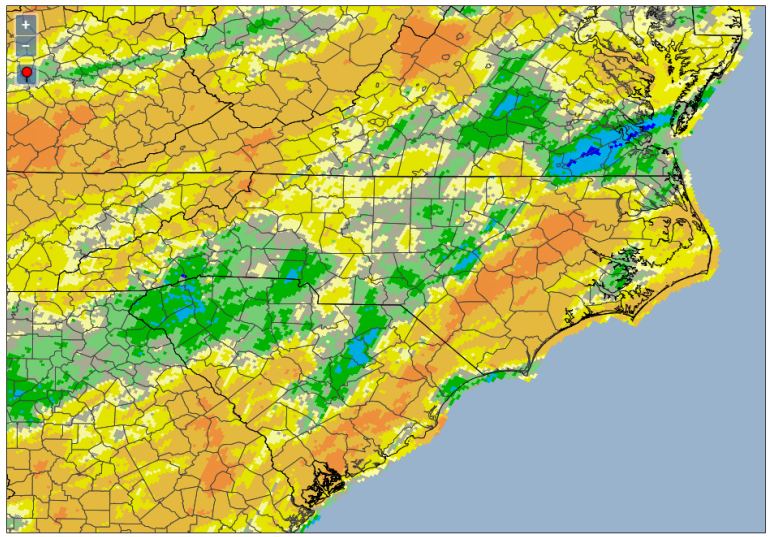
Fire in Cumberland County grows to 900 acres in multi-day battle against flames

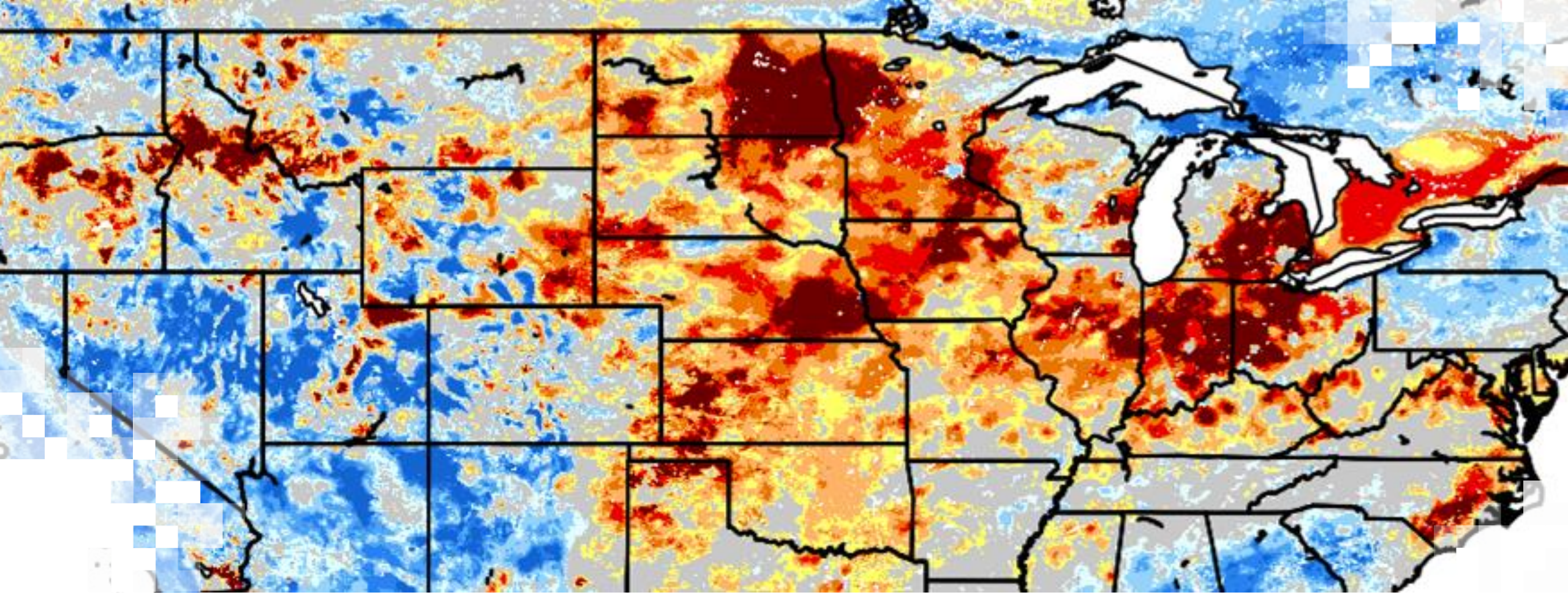
Posted 12:35 p.m. Mar 30 — Updated 12:48 p.m. Mar 30

Example 1 Summary (March 2022)

- SPoRT-LIS was a good indicator of dry areas
- Highlighted its utility for "flash drought" early warning
- Soil moisture data aligned with observed impacts







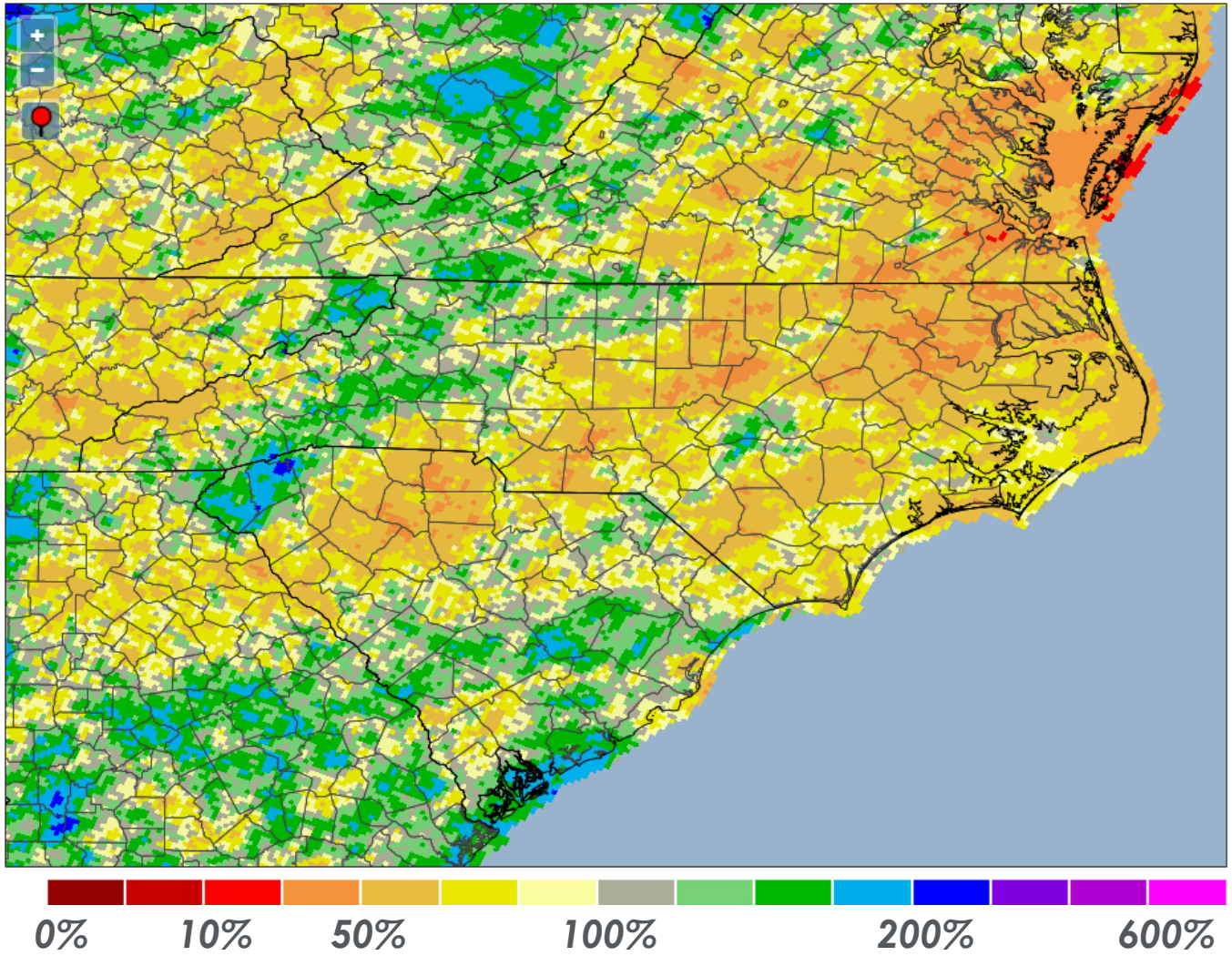
Example 2

Fall 2022 (After Hurricane Ian)

Fall 2022 – Background

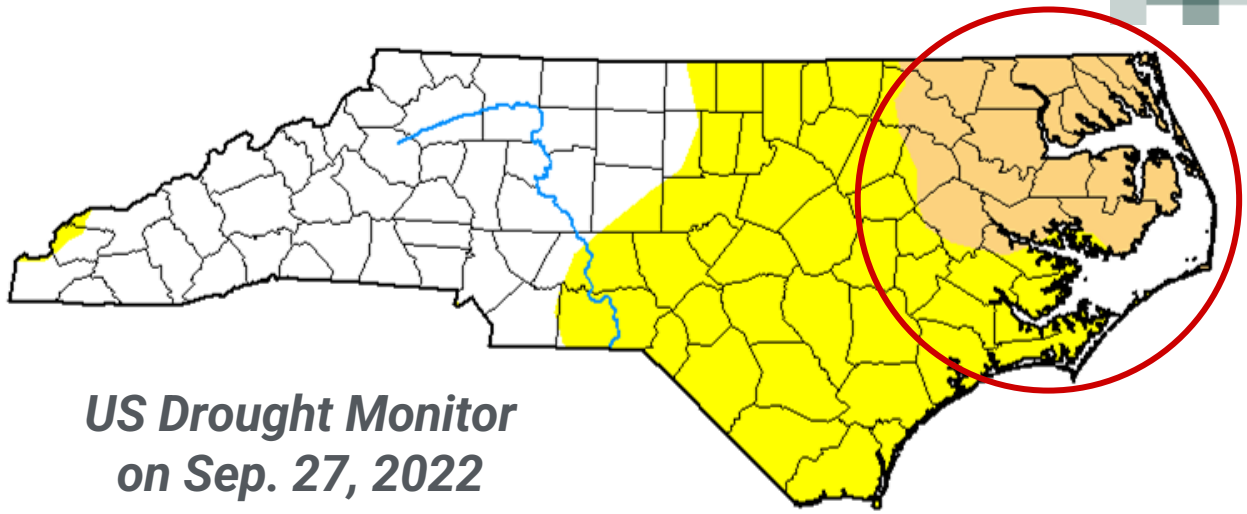
- Eastern NC was getting dry by late September

Percent of Normal Precip. *(Dec. 2021 to Feb. 2022)*

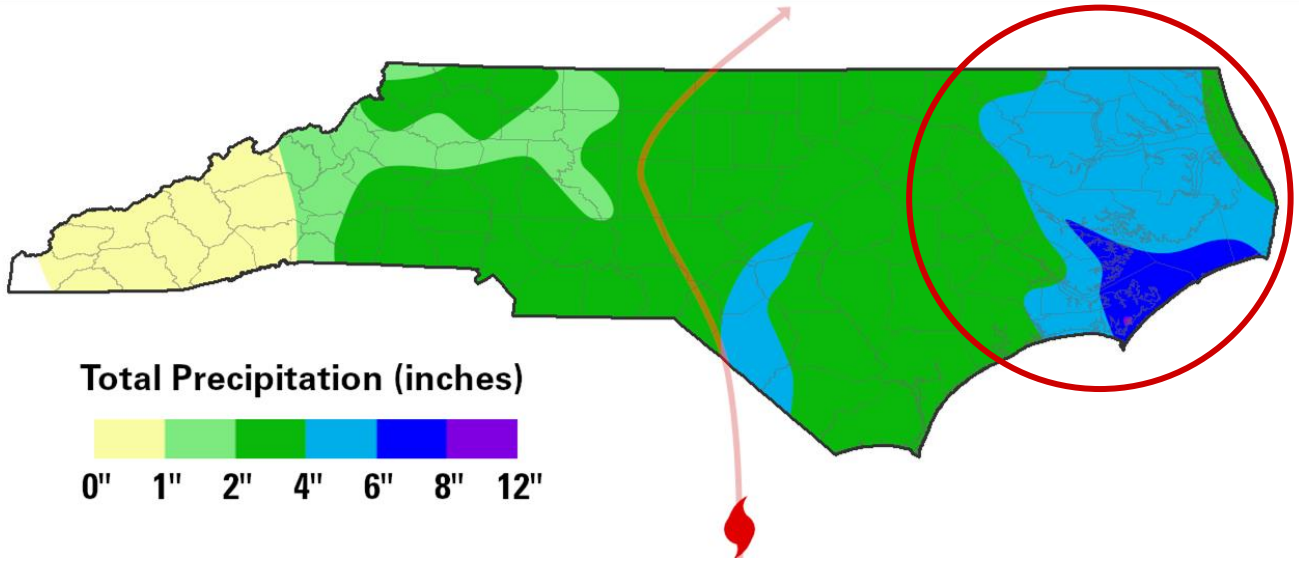


Fall 2022 – Background Continued

- Eastern NC was getting dry by late September
- **Hurricane Ian moved through on Sep. 30 and brought 4 to 8 inches of rainfall**
  - **Including in areas classified in Moderate Drought (D1)**



US Drought Monitor on Sep. 27, 2022

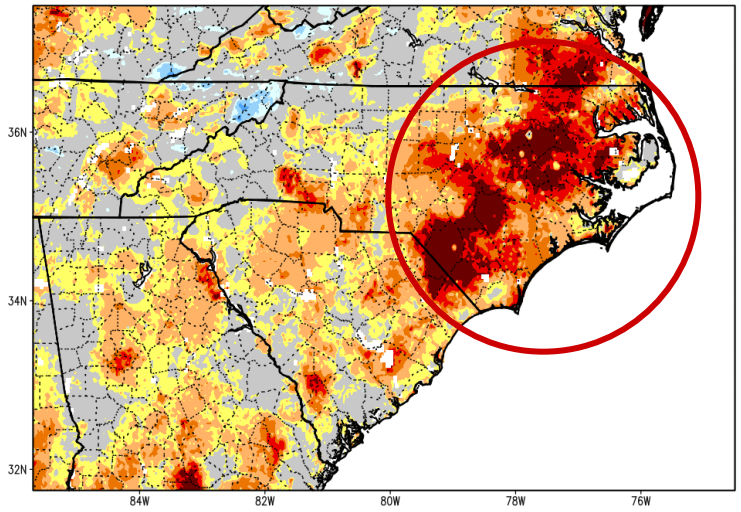


Fall 2022 – The Challenge

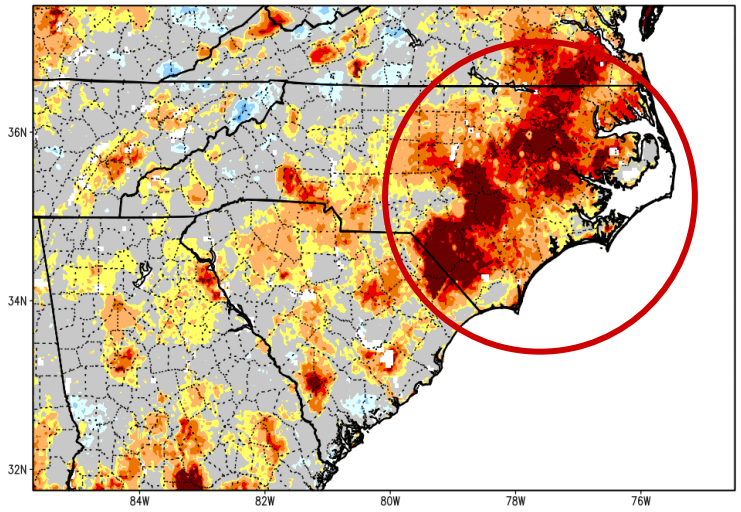
During heavy rain events, not all water infiltrates the ground, so precipitation-based indicators can make conditions seem wetter than they are.

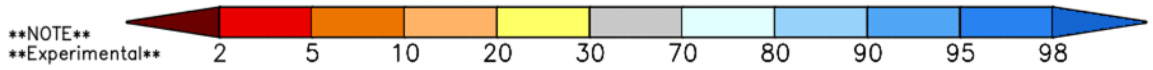
SPoRT-LIS in Action – Shallow and Deeper Soils were Dry Before the Storm

0-40 cm Soil Moisture Percentile

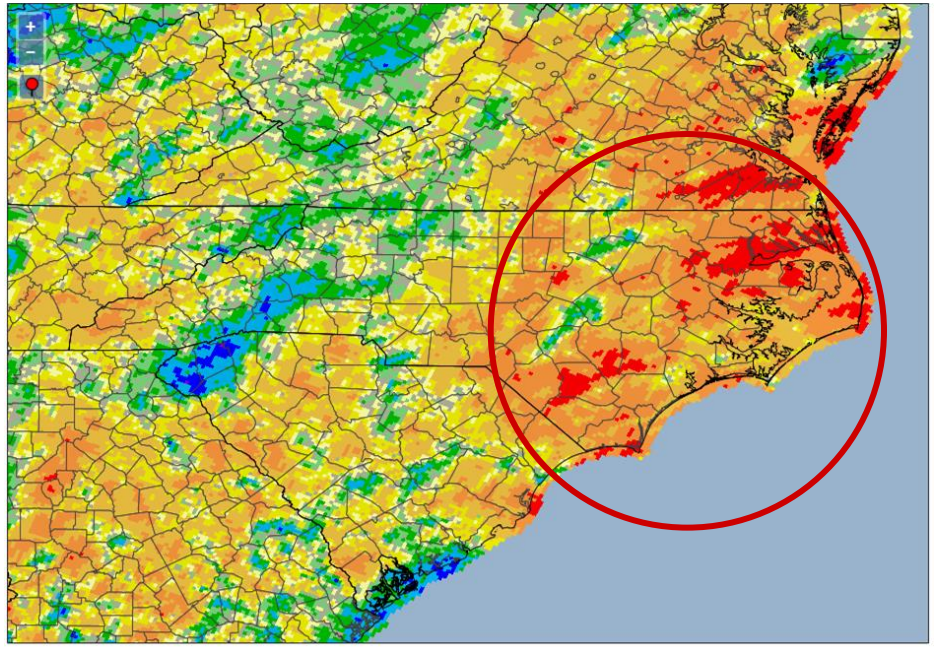


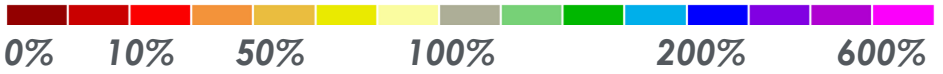
0-100 cm Soil Moisture Percentile





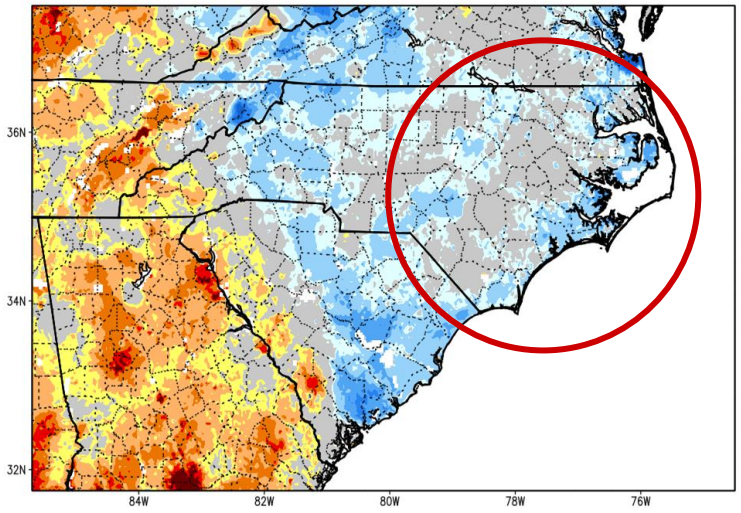
Percent of Normal Precip. *(past 30 days)*



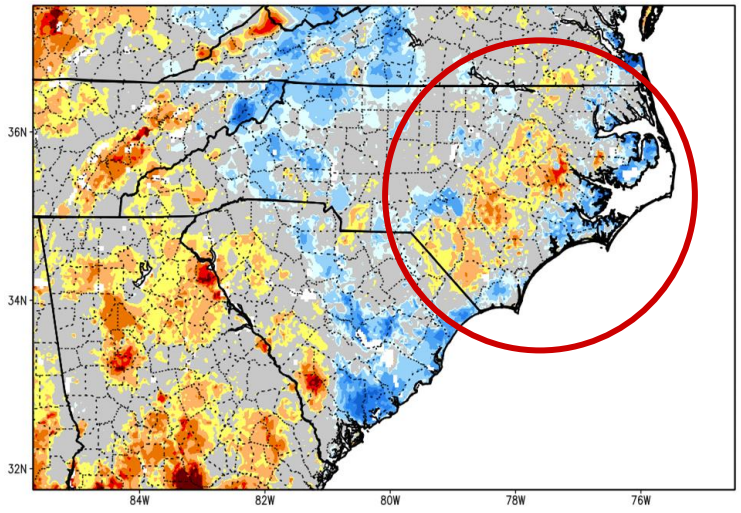


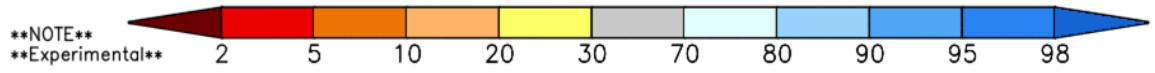
SPoRT-LIS in Action – Significant Soil Moisture Increases after the Storm

0-40 cm Soil Moisture Percentile

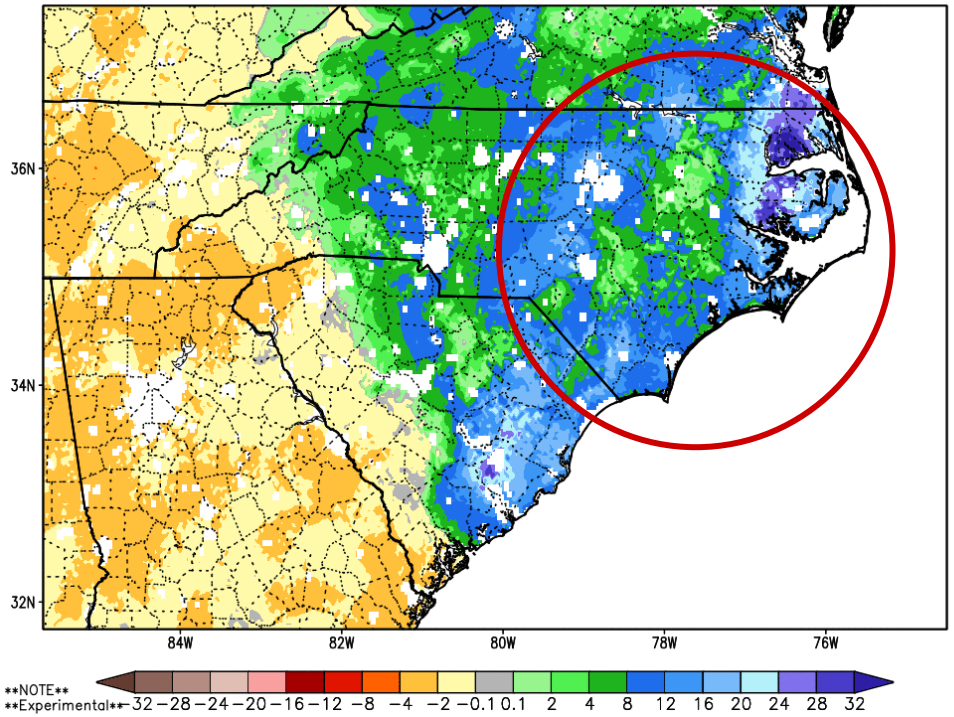


0-100 cm Soil Moisture Percentile



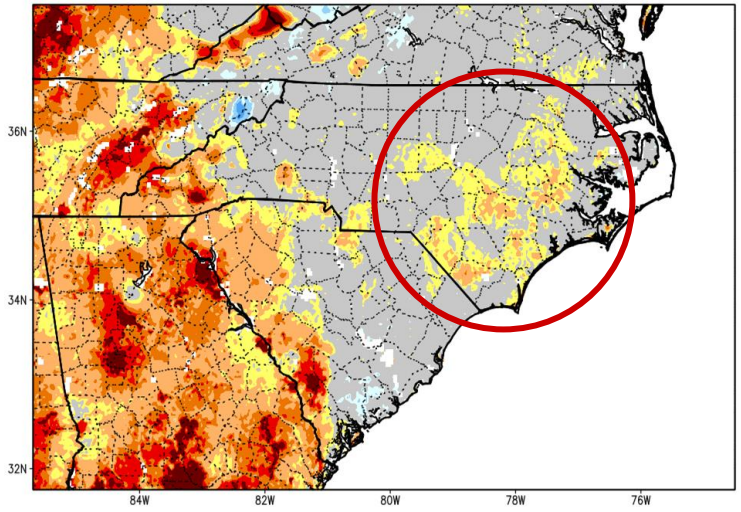


40-100 cm RSM: 1-Week Change

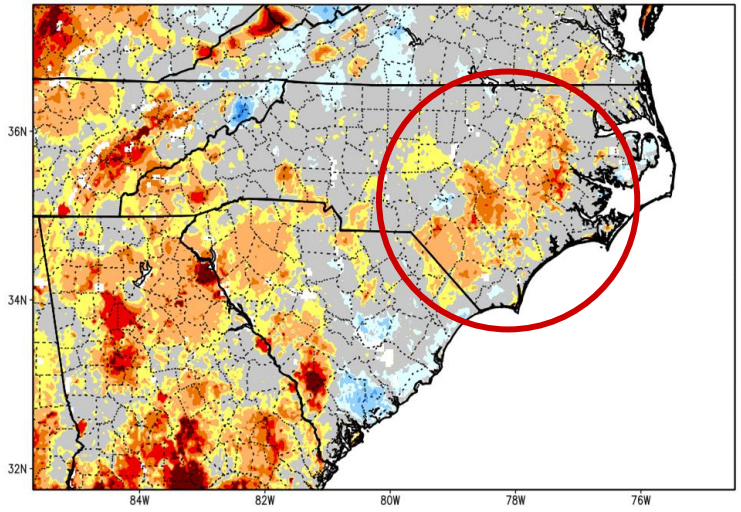


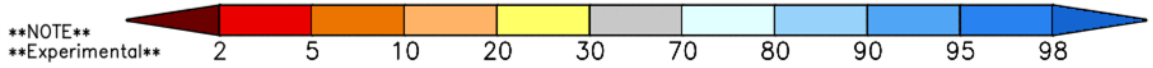
SPoRT-LIS in Action – Soil Moisture Below Normal Despite Recent Wet Weather

0-40 cm Soil Moisture Percentile

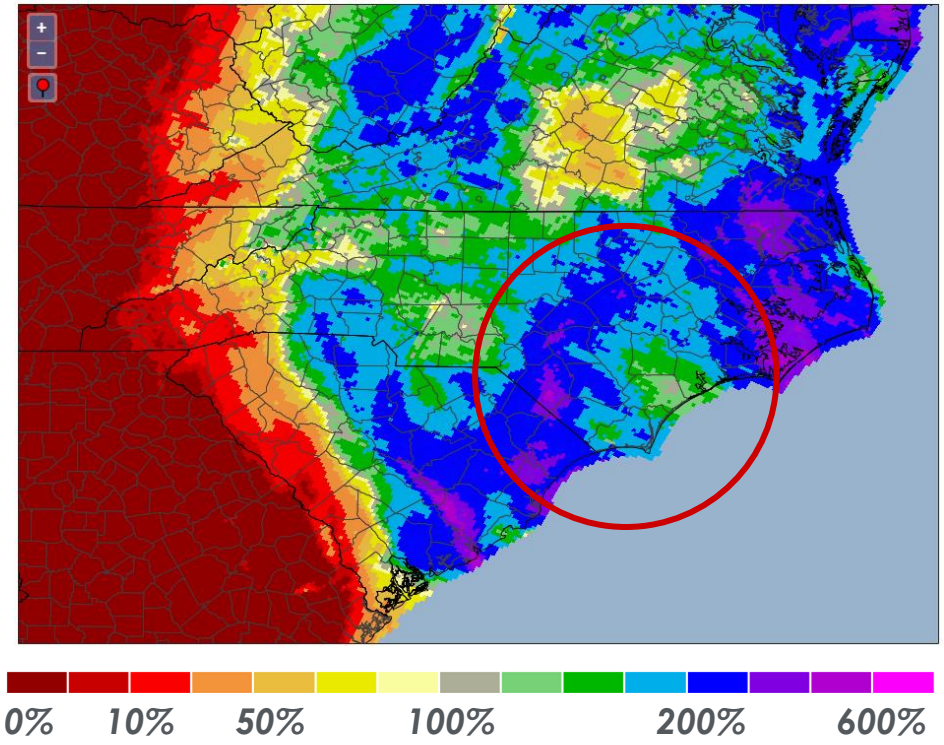


0-100 cm Soil Moisture Percentile



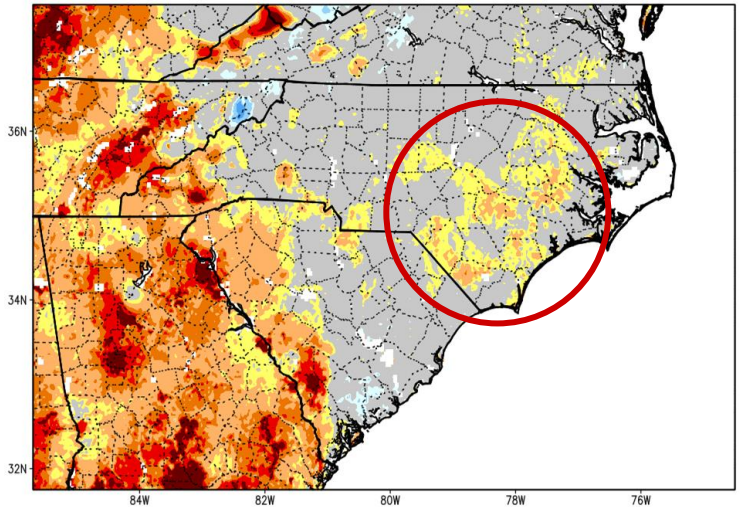


Percent of Normal Precip. *(past 14 days)*

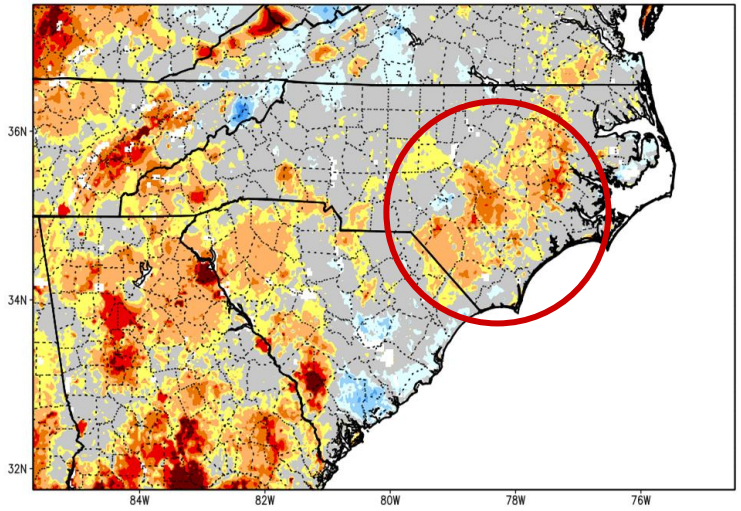


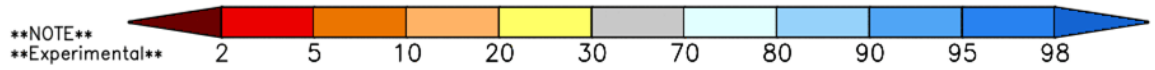
SPoRT-LIS in Action – Soil Moisture Below Normal Despite Recent Wet Weather

0-40 cm Soil Moisture Percentile

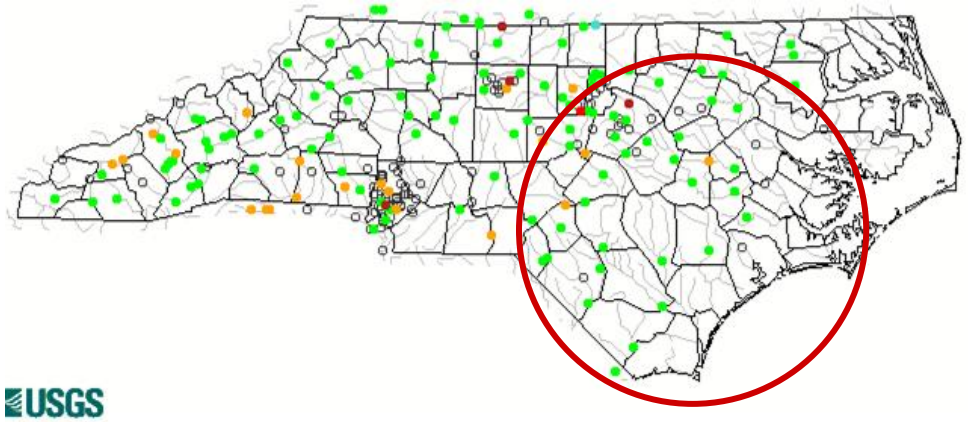


0-100 cm Soil Moisture Percentile





Streamflows *(7-day average)*



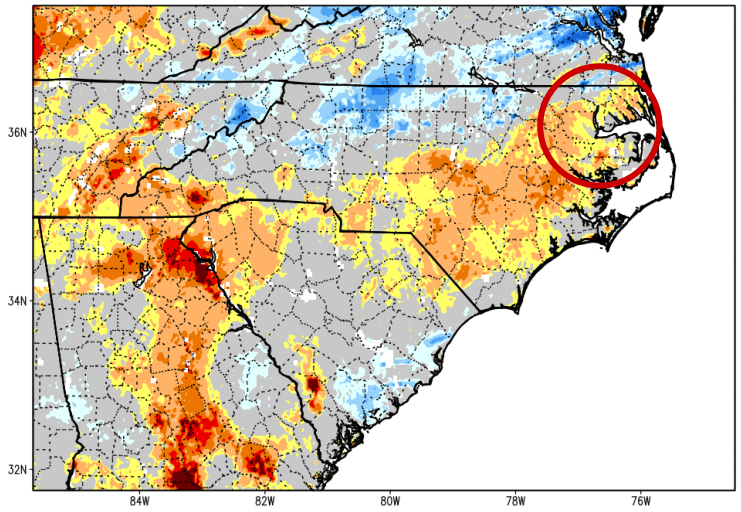
Explanation - Percentile classes						
Low	<10	10-24	25-75	76-90	>90	High
	Much below normal	Below normal	Normal	Above normal	Much above normal	

SPoRT-LIS in Action – Surface Soils Dry Out Even More

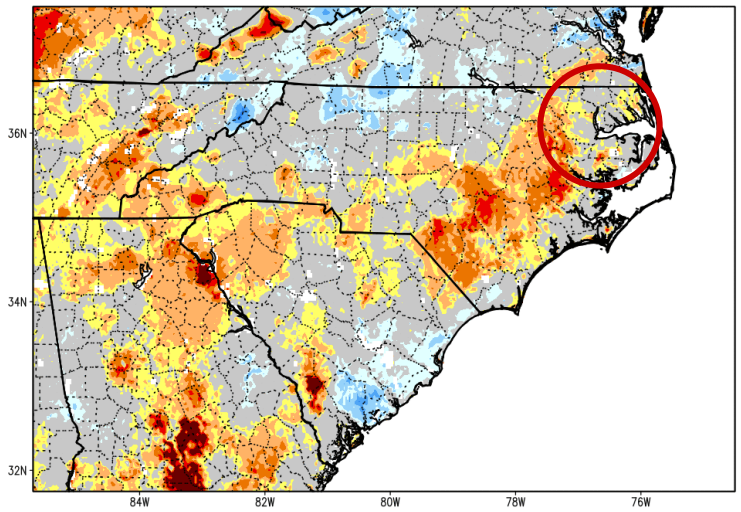
Sep. October 2022

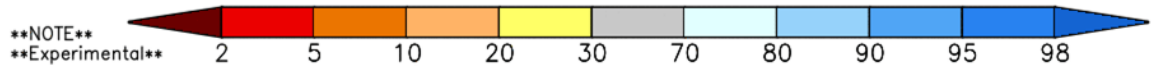
27 4 11 18 25

0-40 cm Soil Moisture Percentile



0-100 cm Soil Moisture Percentile

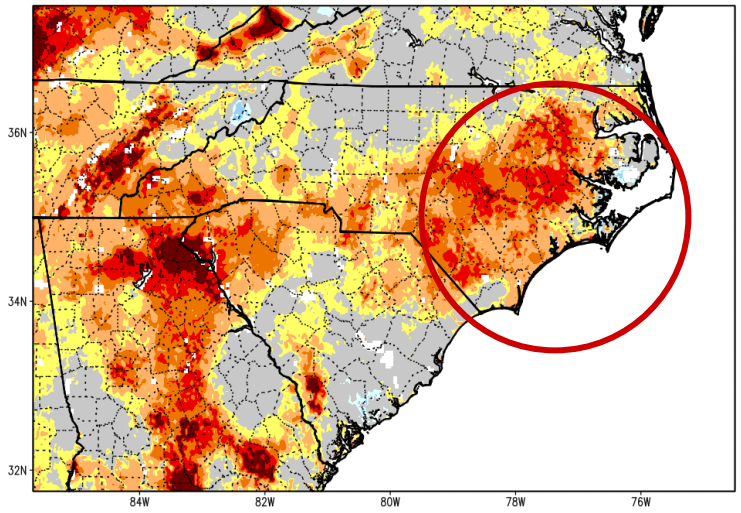




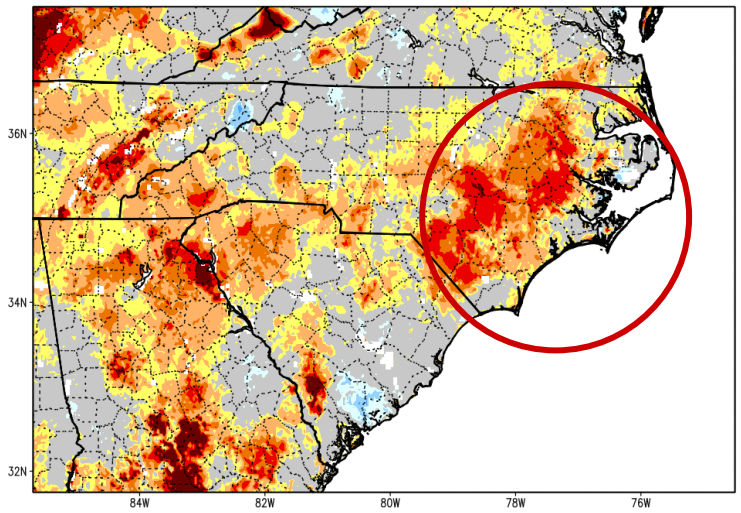
CoCoRaHS *Condition Monitoring Report*

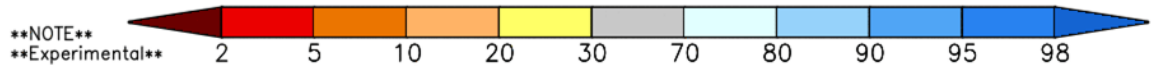
SPoRT-LIS in Action – Drought Re-Emerges in Eastern NC

0-40 cm Soil Moisture Percentile

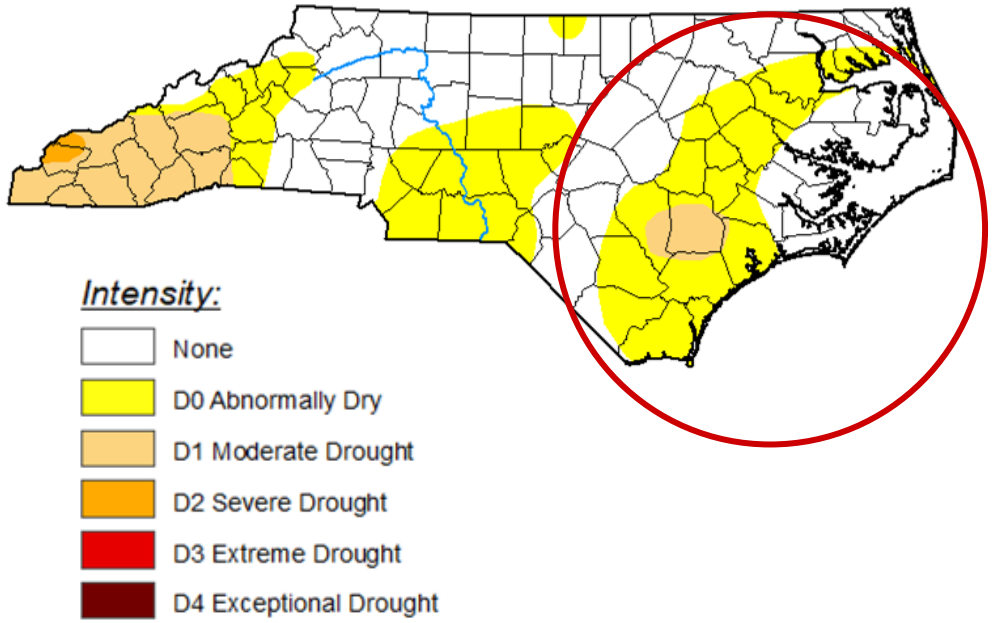


0-100 cm Soil Moisture Percentile



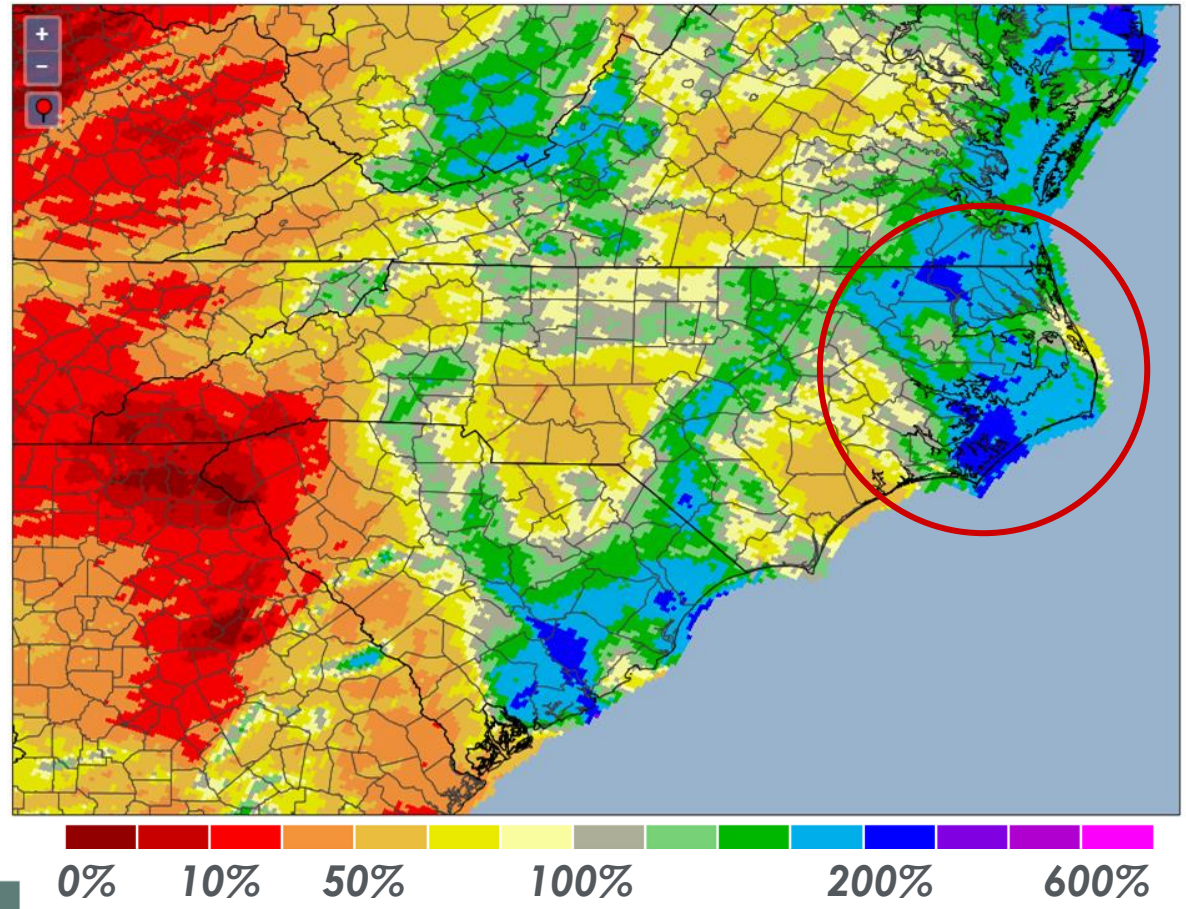


US Drought Monitor

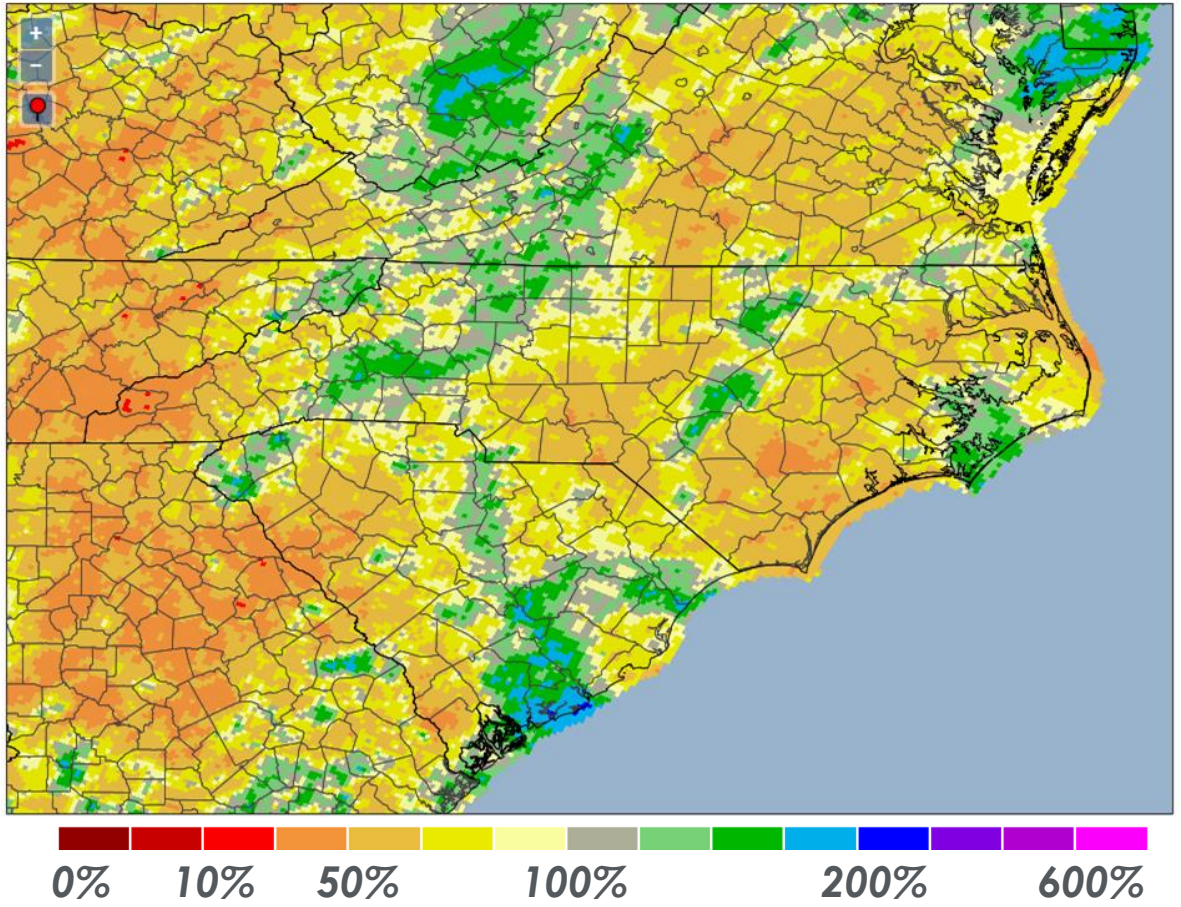


Differences Between Timescales

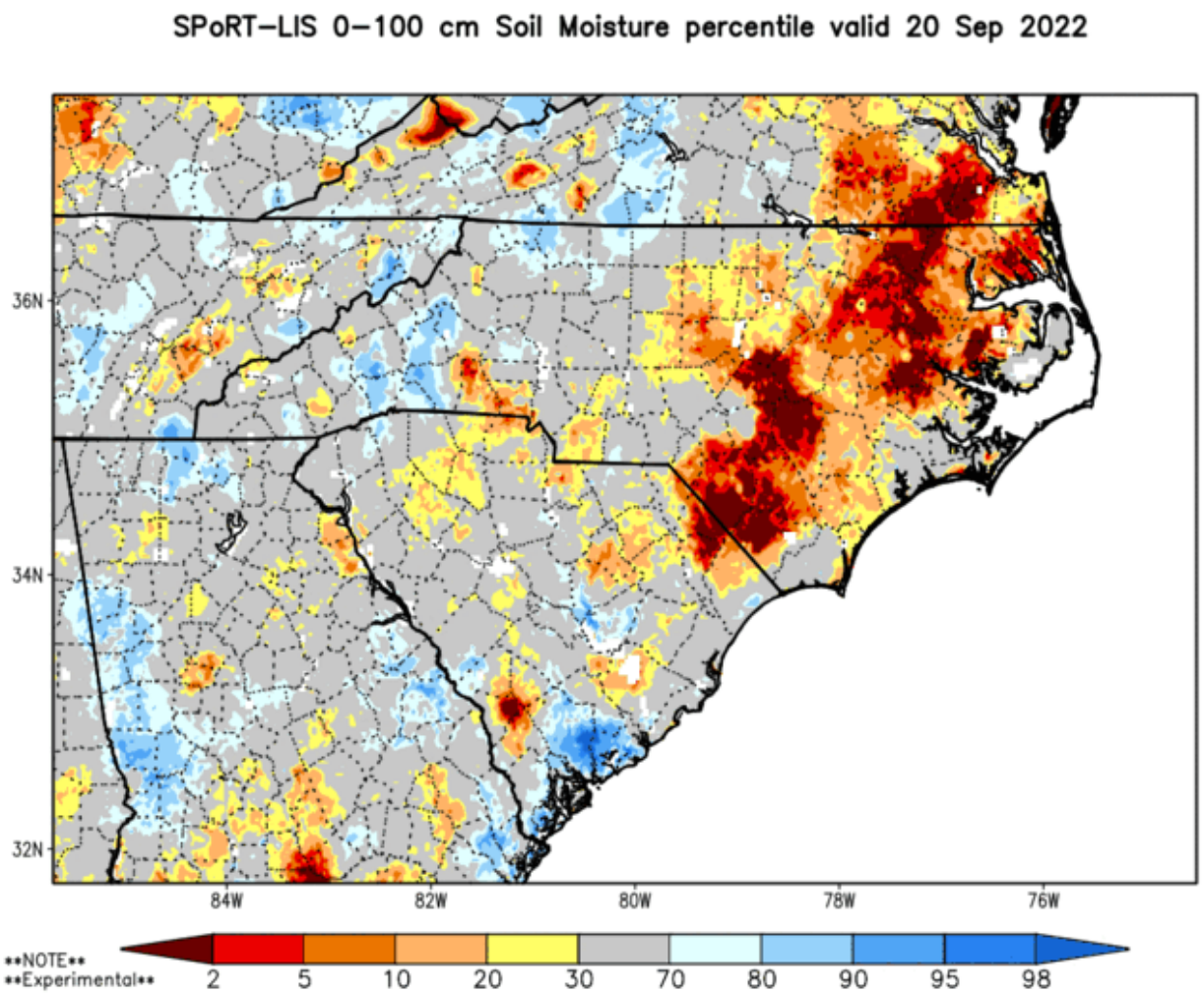
Percent of Normal Precip.
*(**30 days** ending Oct. 25, 2022)*

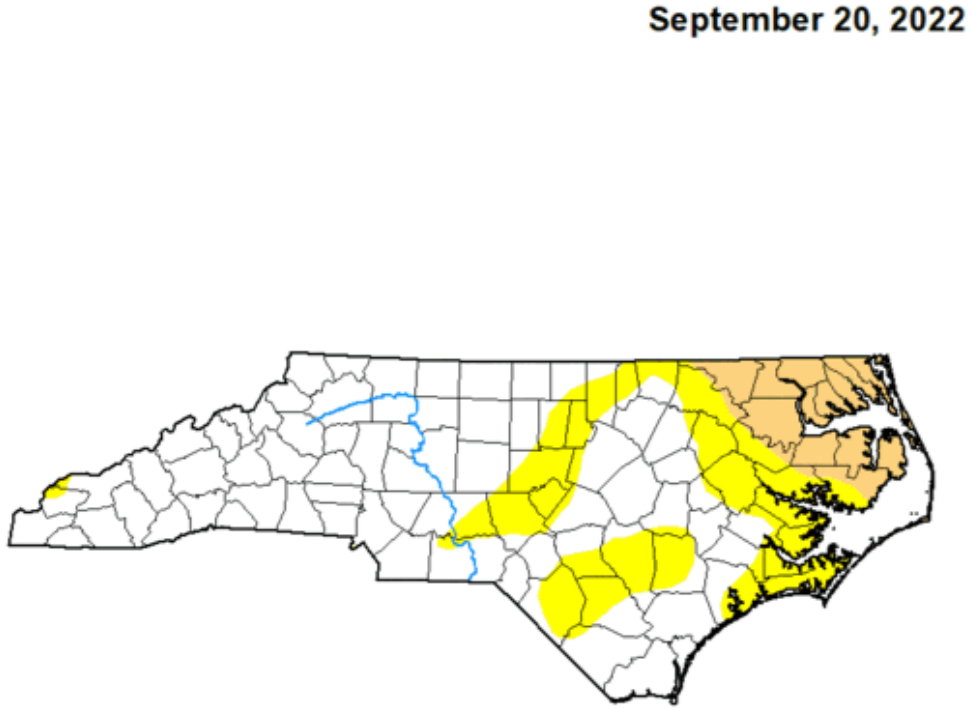


Percent of Normal Precip.
*(**60 days** ending Oct. 25, 2022)*

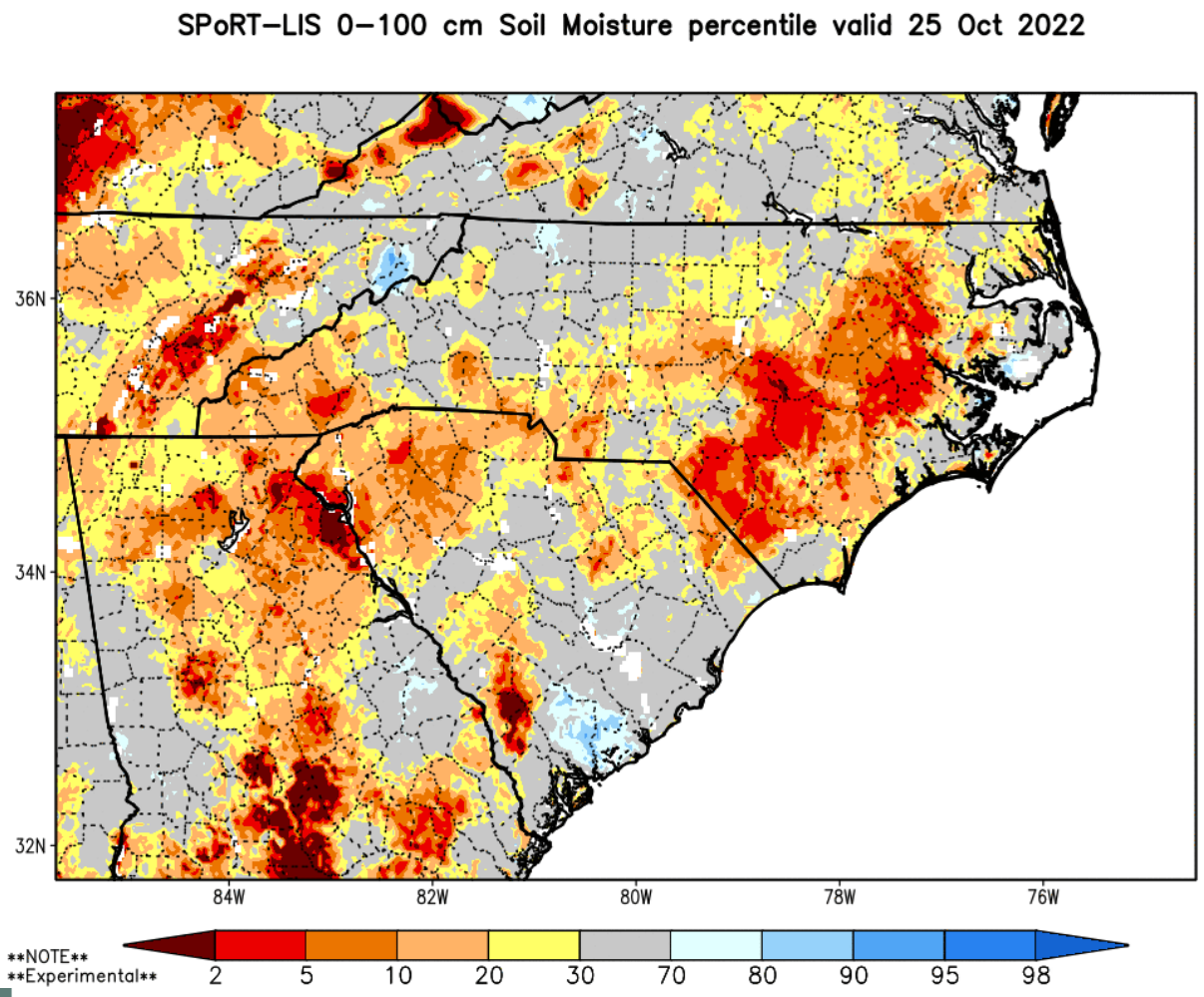


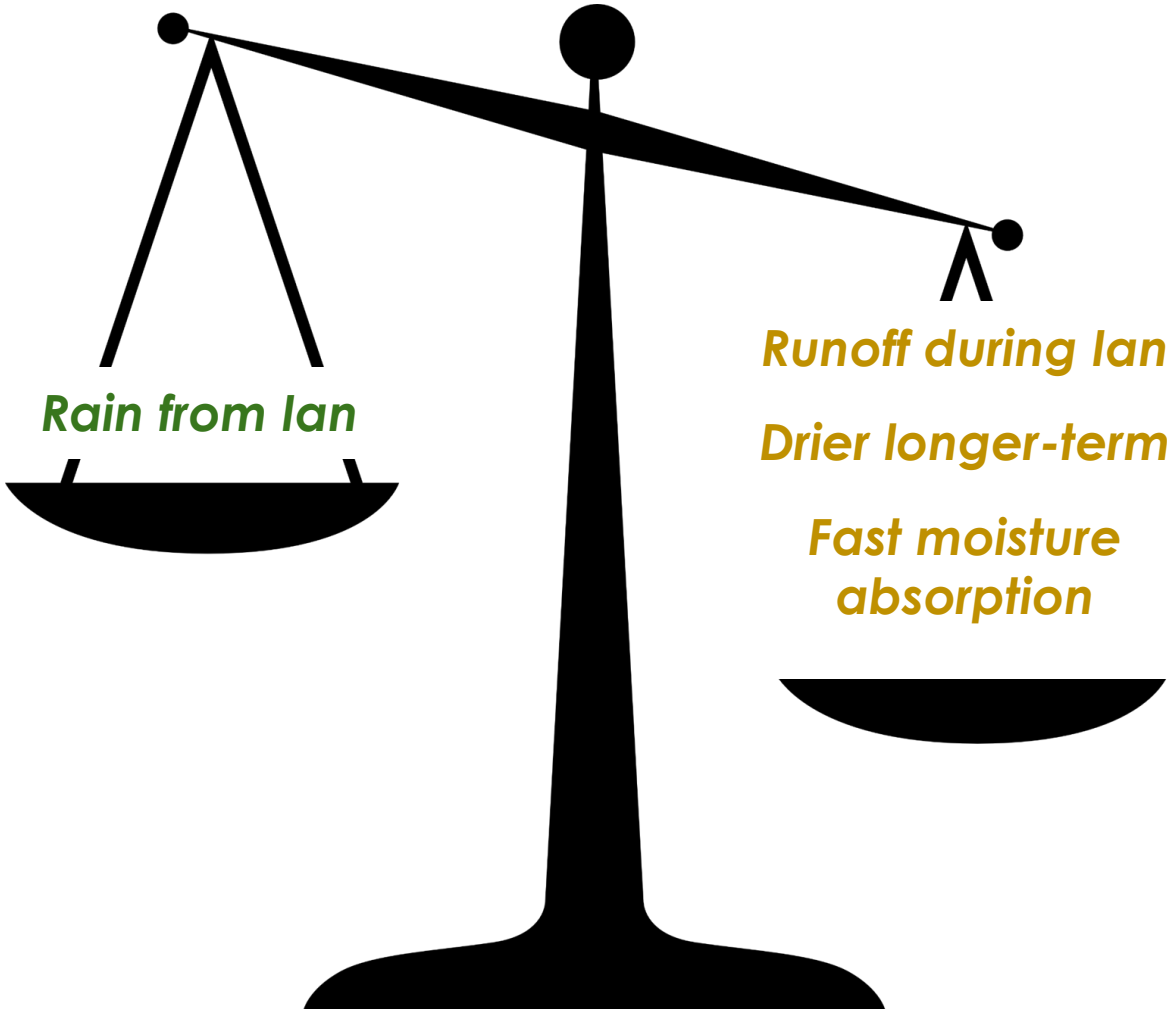
Evolution of Soil Moisture & Drought Conditions





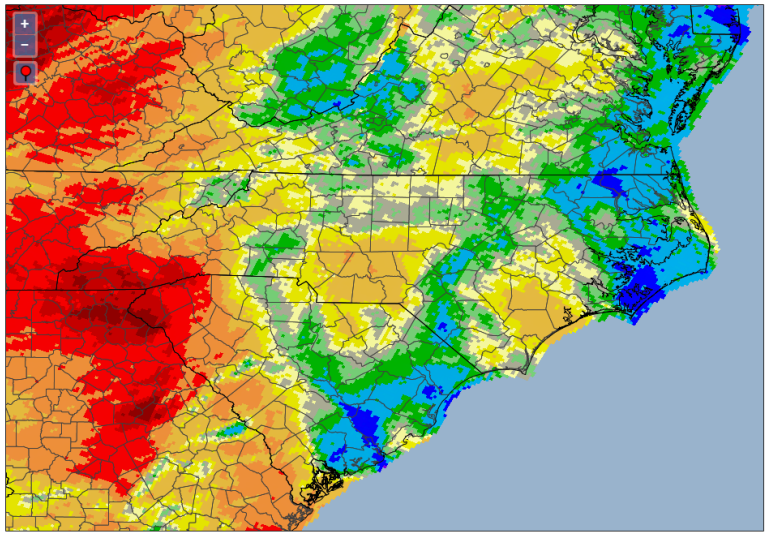
SPoRT-LIS Tells the Story

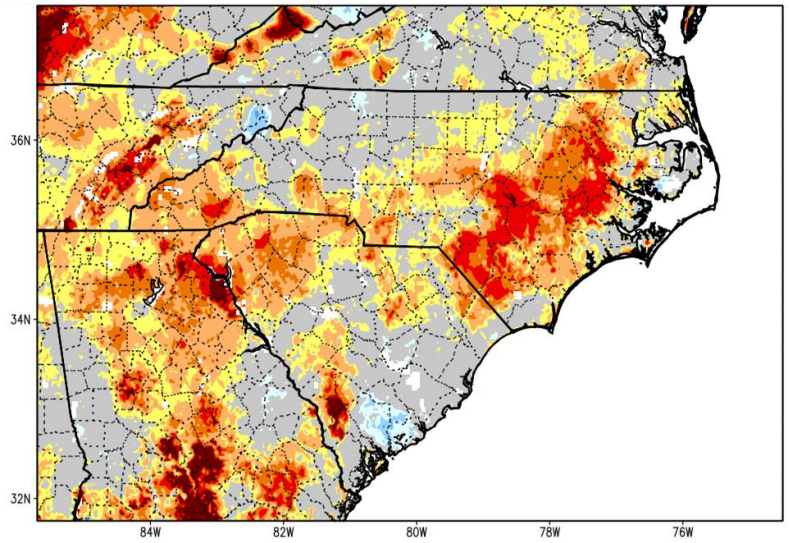




Example 2 Summary (October 2022)

- Heavy rain from Ian brought soil moisture recovery
- Surface-level soils responded differently than deeper soils
- SPoRT-LIS matched impacts better than precip. indicators





What to Watch For

- It can be time-consuming to analyze multiple layers and products, and to understand which is most representative.
- Be aware of soil characteristics in your area and how SPoRT-LIS represents (or doesn't!) those features.
- Note the varied response times of each layer.
- SPoRT-LIS should not be interpreted as instantaneous; it shows the "state of the soil" over a wide time period.

Our Recommendations

- Look at it often to get familiar with its characteristics in your area – including any potentially error-prone spots.
- Use it in tandem with other indicators, and seek out verification from on-the-ground reports.
  - Convergence of evidence
- Consider its potential as a drought early warning tool.
  - And its applications for fire and flooding

Thank You!

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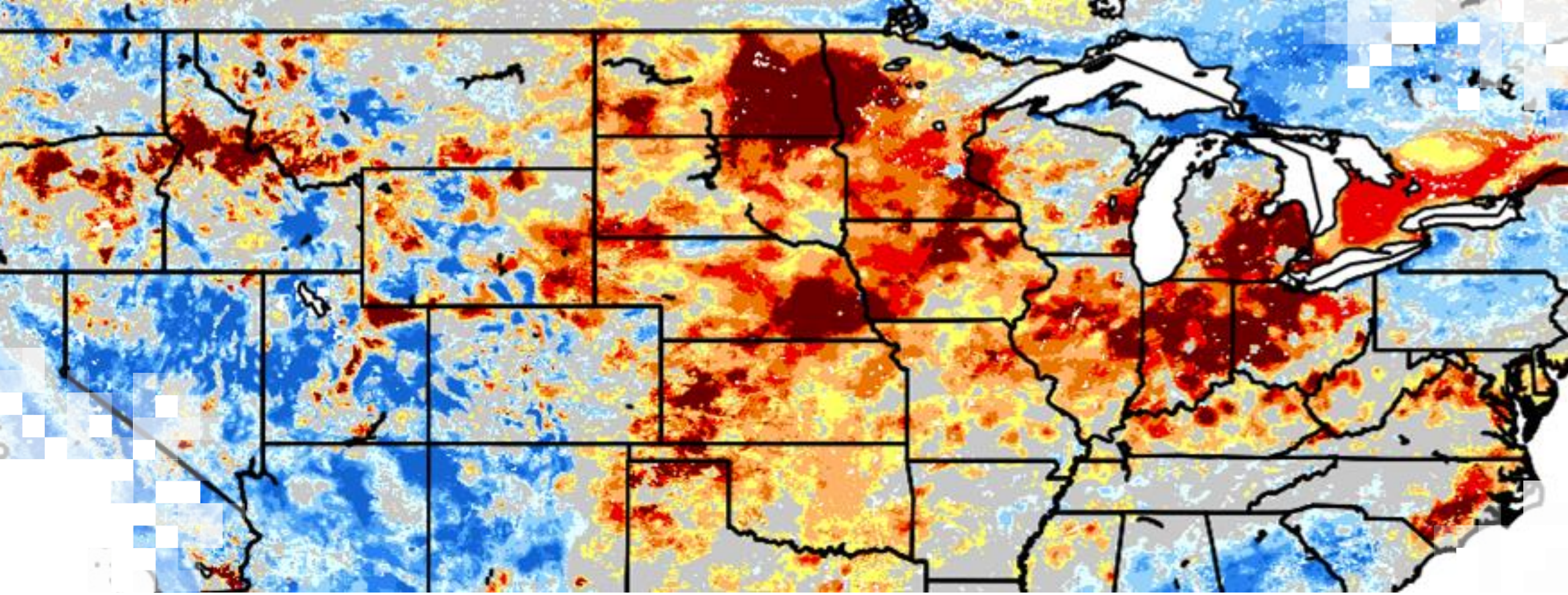
Barrett.Smith@noaa.gov



Part 2

Summary

Summary

- Soil moisture analysis is important for drought analysis because:
  - Soils are an important source of water.
  - Precipitation analyses alone may not account for water in soils.
- Drought Analysis is a multi-faceted process requiring multiple datasets and coordination.
- Research to Operations (R2O) / Operations to Research (O2R) activities are important for application and product development.
- SPoRT-LIS percentiles and soil moisture change data were shown to be an effective component as a tool for drought analysis.
- The SPoRT product provides information for multiple soil layers:
  - The shallow layers (0-10 cm, 0-40 cm) enable detection of rapid drying of soils.
  - The deeper layers (0-100 cm, 0-200 cm) capture relic dryness from past dry periods.
- The SPoRT product's utility is most effective when it is consistent with other products ("convergence of evidence").

Looking Ahead

- In order to reinforce what we learned today, and to prepare you for part 3, we have a Microlesson which can be found on the training page.
- The Microlesson will allow you to independently practice the knowledge and skills from today's webinar.
- Part 3 will extend the concepts covered today to focus on data access at organization and individual levels.

Homework and Certificates

- **Homework:**
  - One homework assignment
  - Opens on 31 May, 2023
  - Access from the training webpage
  - Answers must be submitted via Google Forms
  - **Due by 14 June, 2023**

- **Certificate of Completion:**
  - Attend all three live webinars (attendance is recorded automatically)
  - Complete the homework assignment by the deadline
  - You will receive a certificate via email approximately two months after completion of the course.

Contact Information

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TRAIN - EMPOWER - ADVANCE

Thank You!