Accuracy of Surface and Root-zone Soil Moisture Analysis from Three Modeling systems During the 2022 Texas Drought

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Background and Motivations

- Drought intensity often gauged using soil moisture anomalies
- Several soil moisture products are available for US
  - NLDAS-2
  - National Water Model
  - Other regional models
- Existing Moisture products exhibit limitations
  - Long latency (NLDAS-2)
  - Errors in historical and real-time forcings
  - Inadequate physics of land surface models

Objectives

- Develop new soil moisture and anomalies product for State of Texas
- Compare products with existing ones
  - NLDAS-2
  - National Water Model
- Determine combined impacts of
  - Improving seasonal vegetation phenology
  - Correcting biases in historical precipitation

Presentation Outline

- Configuration of UTA-LIS and workflow
- Improvements to forcing and vegetation phenology
- Cross-comparisons of soil moisture norm and anomaly products from three sources
  - NLDAS-2
  - National Water Model (NWM)
  - UTA-LIS
- Key findings and next steps

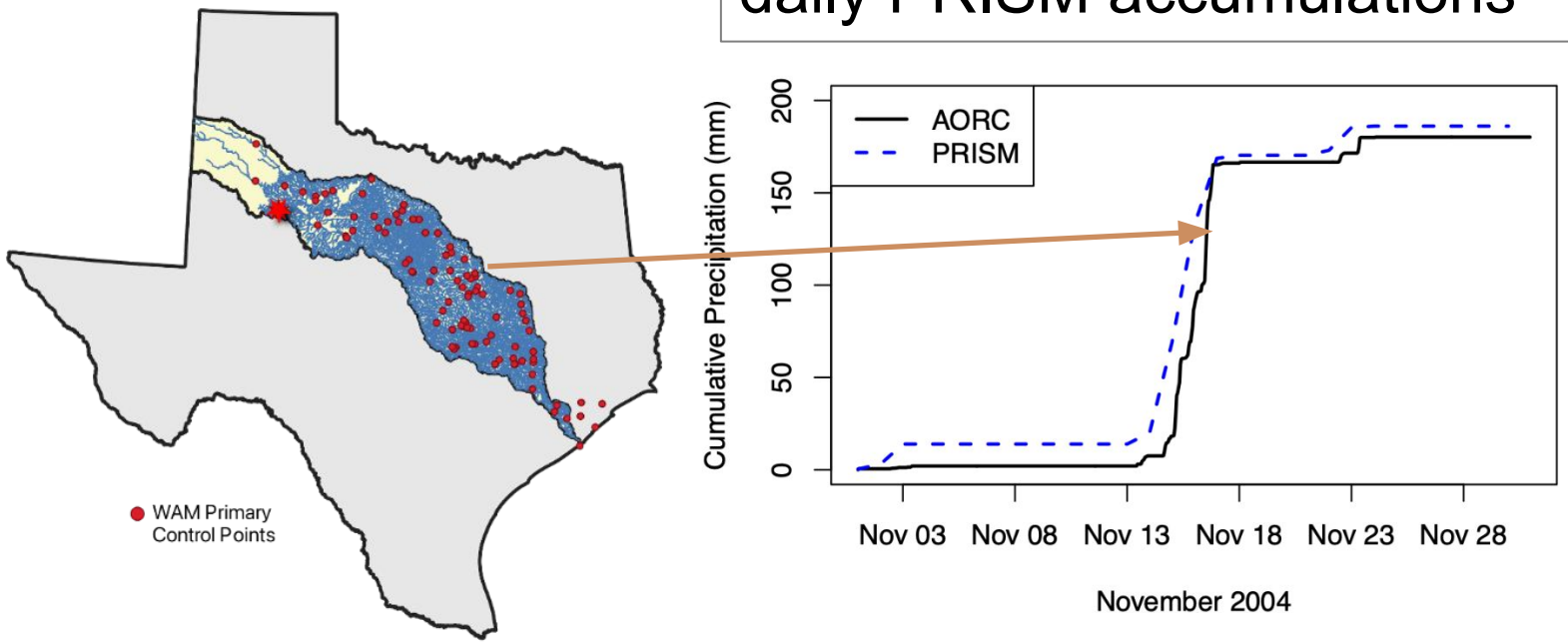
UTA-LIS

- Modeling system: NASA Land Information System (LIS) 7.3
- Forcing: NLDAS-2 (except precipitation)
- Precipitation: Modified AORC
- Land area index (LAI): Improved LAI
- Soil texture data source: STATSGO
- Spatial resolution: 4 km x 4 km
- Temporal resolution: 1 hours
- Model spin up: twice from (1980 - 2020)
- Simulation: 01/01/1980 - 08/01/2022

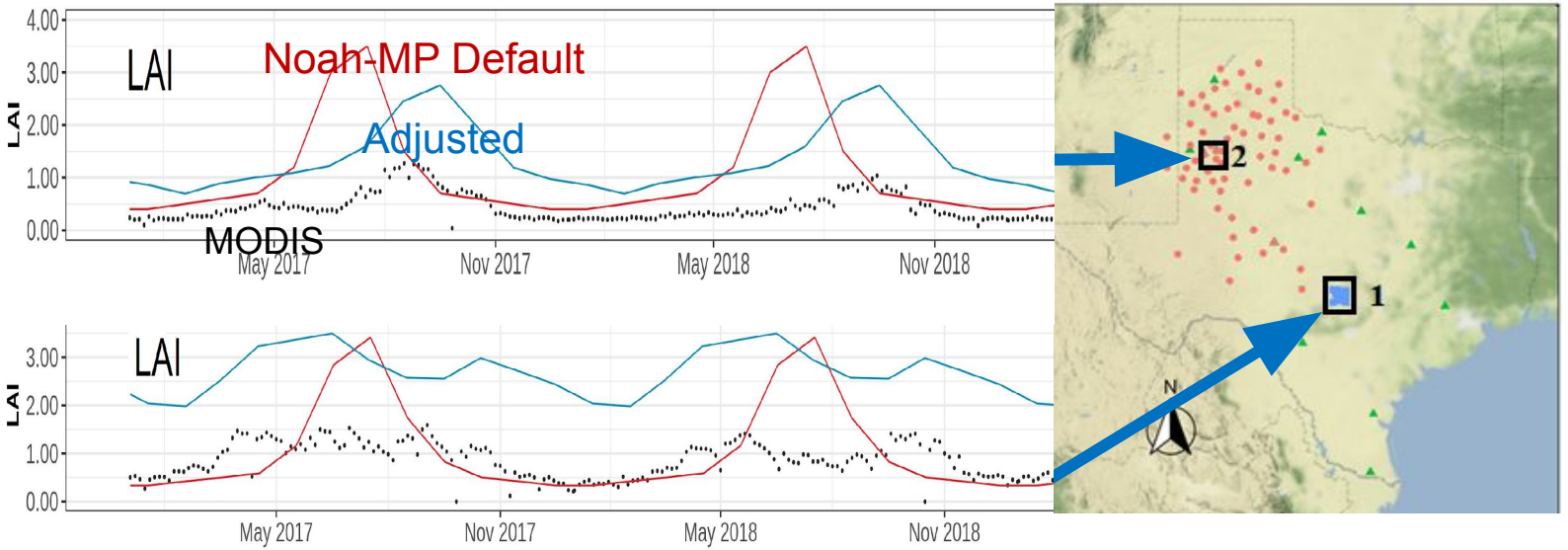
Adjustment of Precipitation Product

- NLDAS-2 precipitation product
  - Based on gauge analysis
  - Severely biased for heavy rain

Hourly AORC for each pixel in Texas is corrected to match daily PRISM accumulations

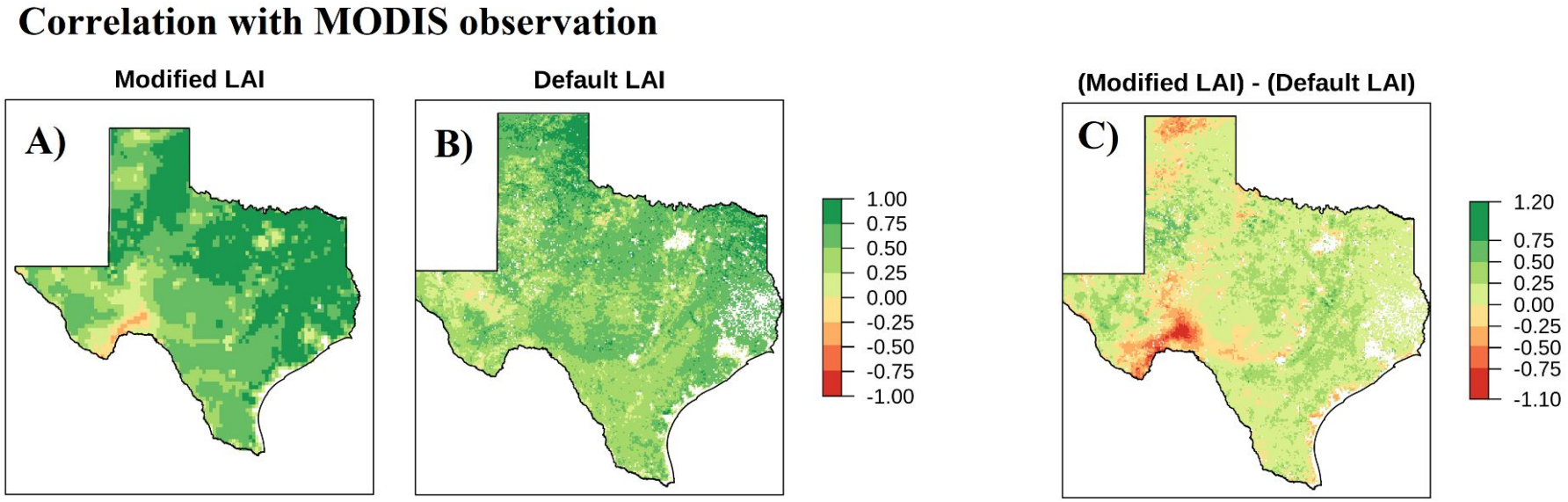


Improving Vegetation Phenology



- Comparison of NLDAS-2 and Noah-MP LAI against MODIS product -> former more accurately represent seasonal cycle of vegetation in TX

Improving Vegetation Phenology



- LAI from NLDAS shows better correlation with MODIS satellite data over most location

Data and Methodology

Soil Moisture Index (SSI)

Monthly data for each product was used to calculate the SSI as drought index as below:

$$SSI = \frac{SM - \overline{SM}}{\sigma_{SM}}$$

$$SM : Soil\ moiture$$

$$\overline{SM} = Monthly\ long\ term\ average\ of\ SM$$

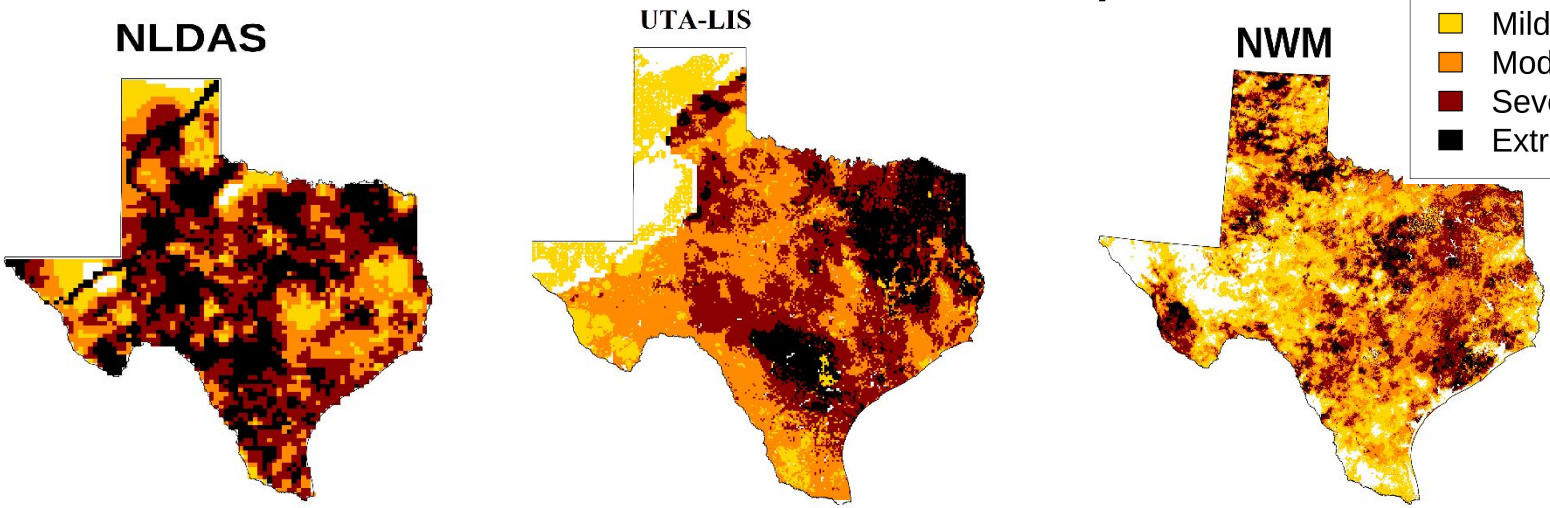
$$\sigma_{SM} = Monthly\ long\ term\ standard\ deviation\ of\ SM$$

Drought categories from SSI (Mckee 1993)	
SSI	**Drought category**
0 to -0.99	Mild drought
-1.5 to -0.99	Moderate drought
-1.5 to -1.99	Severe drought
-2.00 or less	Extreme drought

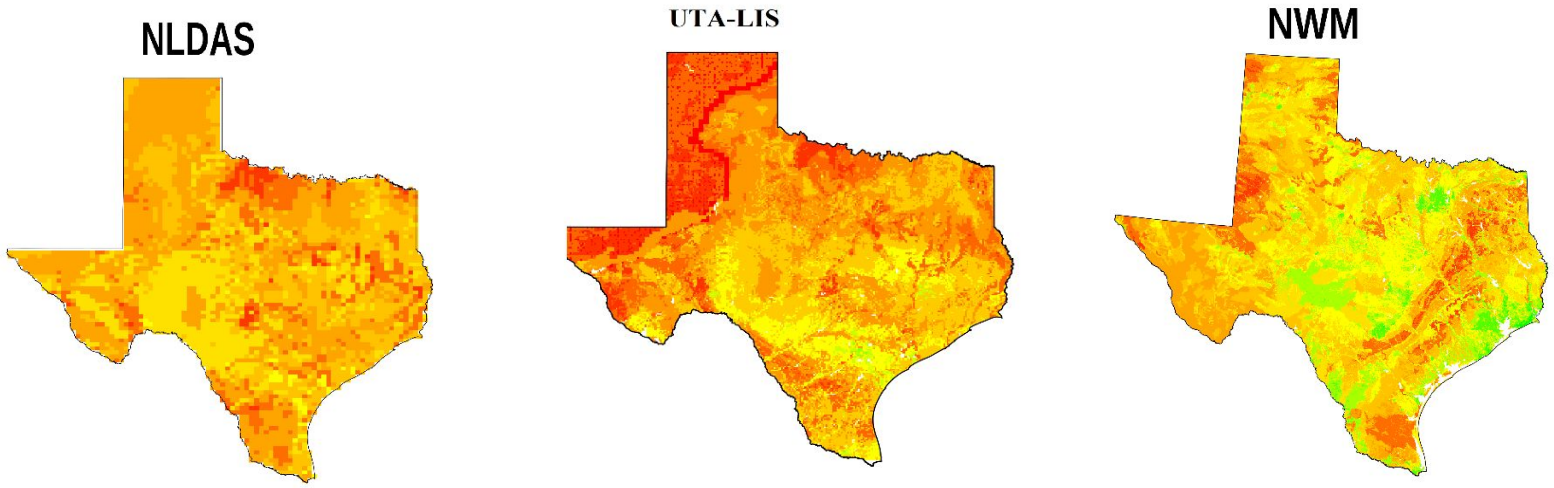
Results and Discussion

2022 Root: Root (SSI and Mean SM)

Root(0-100 cm) 2022/JUL/25

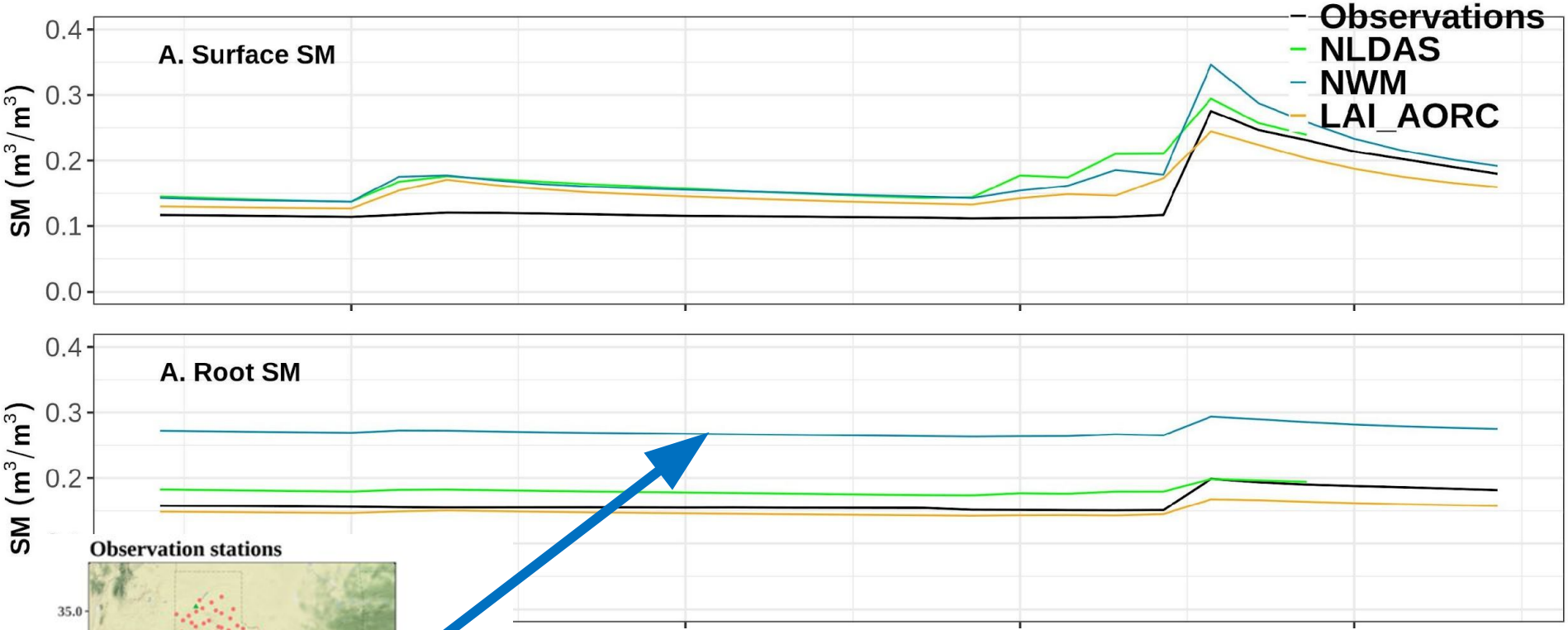


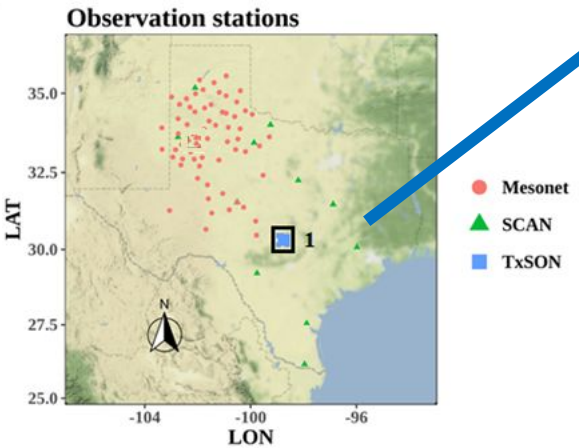
root mean for JUL (40Y)



Results and Discussion

2022 Drought: Time series

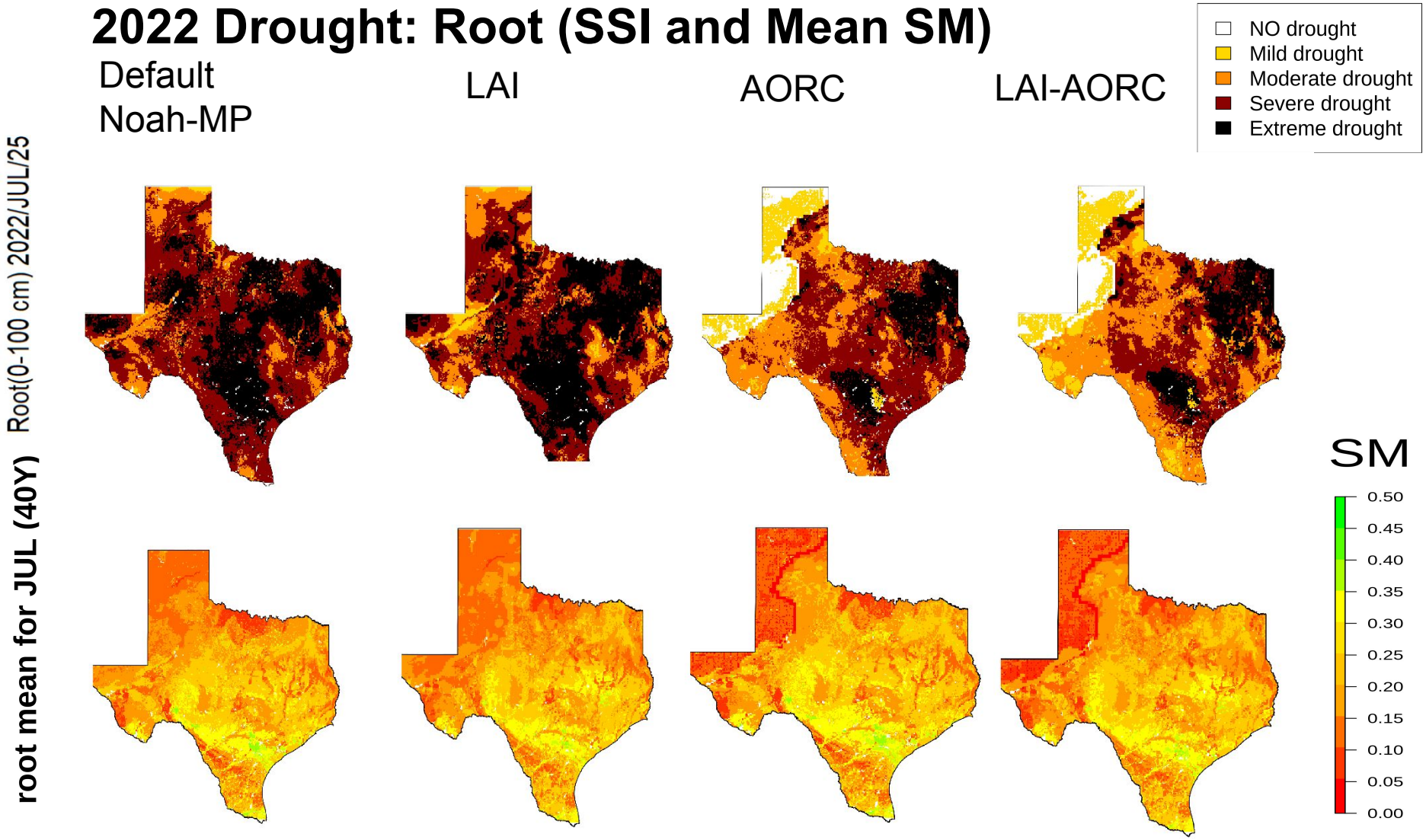




Persistent wet bias in NWM RZSM

Results and Discussion

2022 Drought: Root (SSI and Mean SM)



Summary, Findings, and Next Steps

- UTA-LIS modeling system for Texas
  - Creates real-time soil moisture using real-time NWM forcing
  - Produces a new soil moisture climatology using
    - Improved precipitation
    - Enhanced vegetation phenology
- Comparisons of soil moisture anomalies for drought of 2022
  - NLDAS-2, NWM and UTA-LIS
  - Using climatologies based on respective analysis

Summary, Findings, and Next Steps

- Rootzone soil moisture anomalies of July 2022
  - by wetness
    - NLDAS-2 comparable to UTA-LIS < NWM
    - Persistently positive bias in NWM simulations
    - Artifacts in northwest TX

Summary, Findings, and Next Steps

- Will investigate the causes of differences in soil moisture norms
  - Impacts of precipitation improvements offset by enhanced ET?
  - Issues in prescribed LAI for the northwest/panhandle?
- Will leverage additional sensor product to determine the physical realisms of dry spots in NLDAS-2 surface soil moisture for July 2022

THANK YOU

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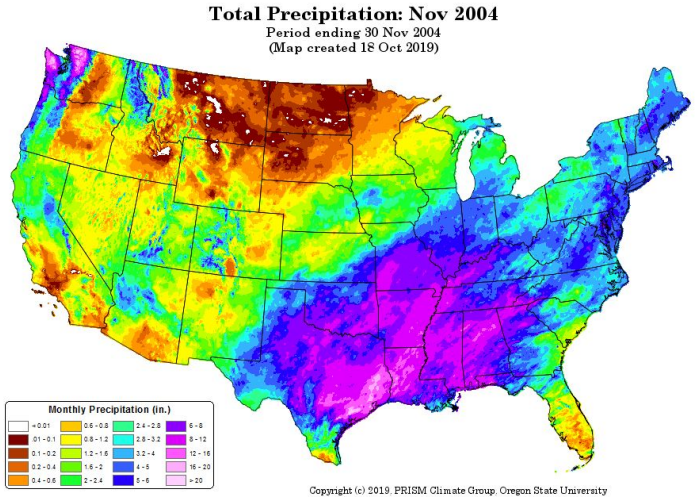
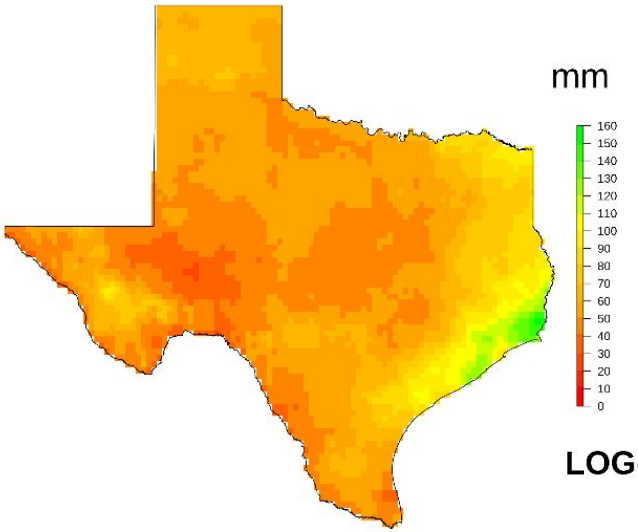
Additional information

- Analysis of Record for Calibration (AORC)
  - 1979- 2003: NLDAS-2 daily precipitation (re-disaggregated)
    - Inherits bias in NLDAS-2 product
  - 2003- present: NWS Stage-IV (radar-gauge product)

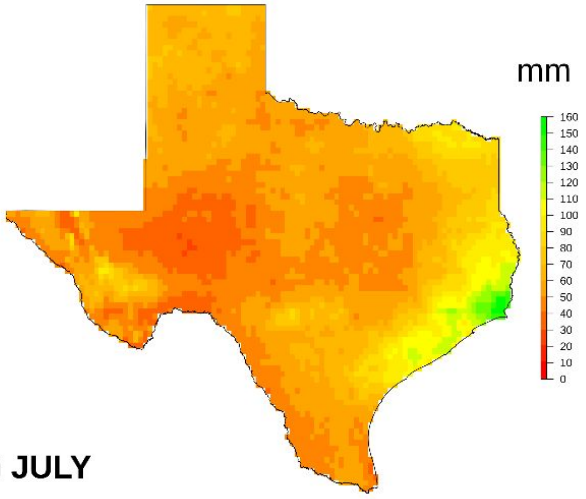


Additional information

40y July mean precipitation for NLDAS



40y July mean precipitation for AORC



LOG(AORC/NLDAS) JULY