Application of NLDAS Ensemble LSM Simulations to Continental-Scale Drought Monitoring

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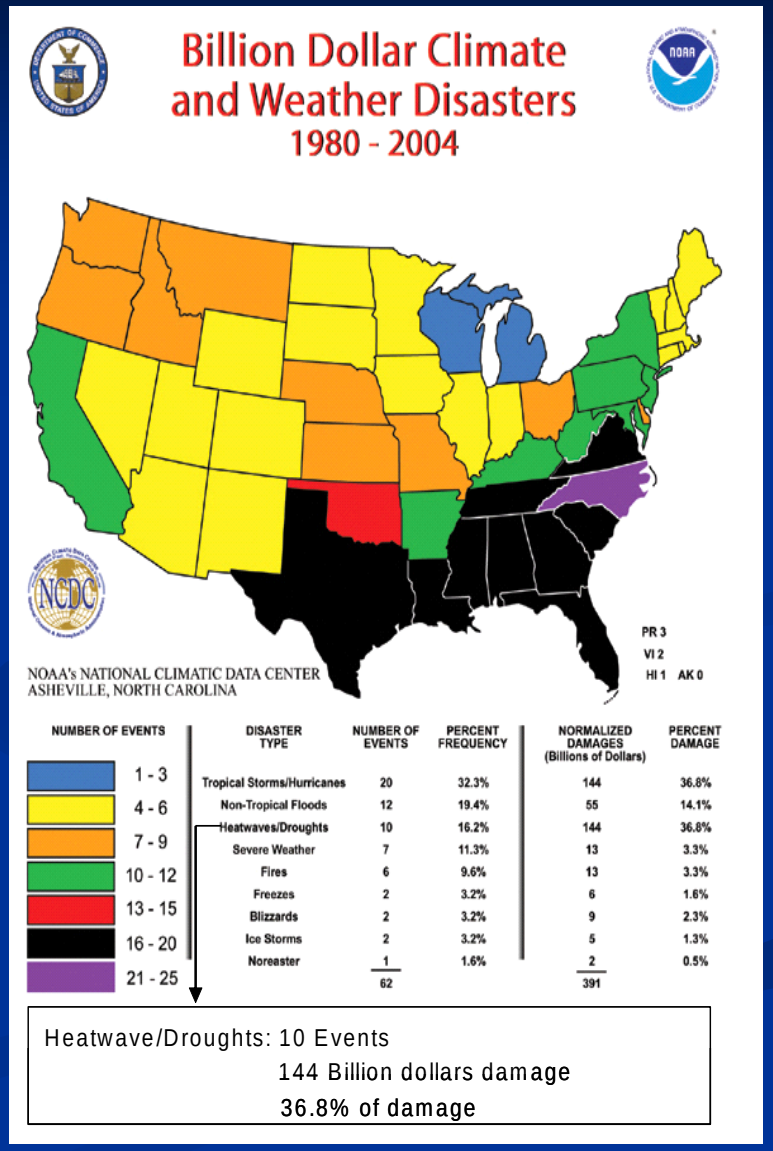
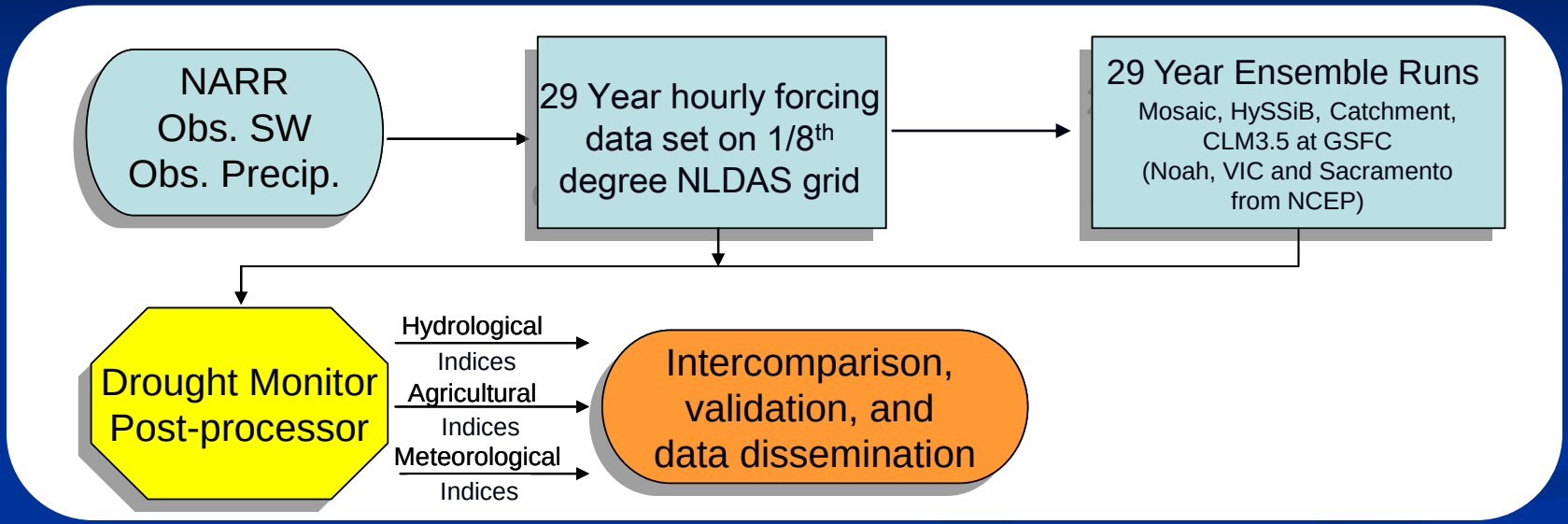
Introduction

- Accurate drought characterization is vital to drought impact assessment and amelioration
- Wide range of drought indices currently exist, each with its own strengths and weaknesses
- Difficult to calibrate and improve upon certain indices due to a lack of long term and spatially continuous soil moisture observations on large scale
- Land Data Assimilation Systems (LDAS) offer high quality soil moisture fields with good spatial and vertical resolution and are a potentially useful tool in monitoring droughts
- Combine NASA's Land Information System (LIS) modeling infrastructure and North American LDAS (NLDAS) resources with long term (29 years+) forcing fields of NOAA's North American Regional Reanalysis (NARR) to form a NARR-based NLDAS drought monitor



NASA GSFC Drought Project Overview



- Analyze drought monitor output to determine effect of model selection, forcing data, NARR climatology length , and ensemble construction on drought characterization
- Transition system to real-time operations, providing objective data to existing drought monitoring efforts such as the U.S. Drought Monitor

Project Forcing and Drought Indices

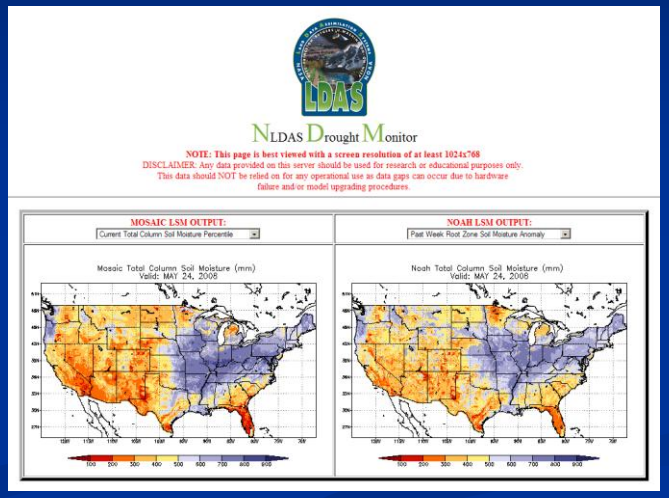
- Forcing is hourly, 1/8th degree, compatible with original NLDAS data
  - NARR model data base (3 hourly, 32km, 1979 – Present)
  - Hourly NARR SW bias correction developed from GOES data for each month
  - Hourly observed precipitation based on daily PRISM-corrected gauge data, and hourly Stage II Doppler radar, CMORPH, and HPD data
  - Elevation correction for temperature, pressure, humidity, and longwave
  - Includes 22 standard sfc/2m/10m and lowest model layer forcing fields
- Drought monitor will compute several drought indices from NLDAS LSM output, NARR land surface states, and forcing

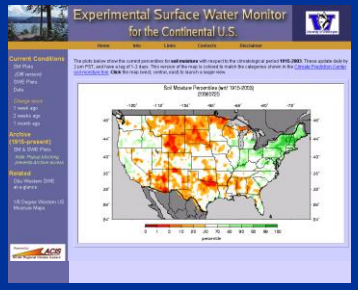
	Drought Index	Drought Type	Required NARR/NLDAS Monitor Data	Comparison Data
Standard Indices	Wtd/UnWtd PDSI	Meteorological	Forcing	NCDC PDSI
	SPI	Meteorological	Forcing	U. Nebraska SPI
	PHDI	Hydrological	Forcing	NCDC PHDI
	TWD	Hydrological	Streamflow Output	USGS Streamflow
	Palmer Z	Agricultural	Forcing	NCDC Palmer Z
	LSM Percentile	Agricultural	LSM Soil Moisture Output	U. Washington
	Self Calibrating (duration and climate characteristic parameters)			
Experimental LDAS Indices	LDAS PDSI	Meteorological	LSM Output and Forcing	NCDC PDSI
	LDAS PHDI	Hydrological	LSM Output and Forcing	NCDC PHDI
	LDAS Palmer Z	Agricultural	LSM Output and Forcing	NCDC Palmer Z
	CLM3 VHI	Agricultural	CLM3 LAI/NDVI Output	NOAA VHI

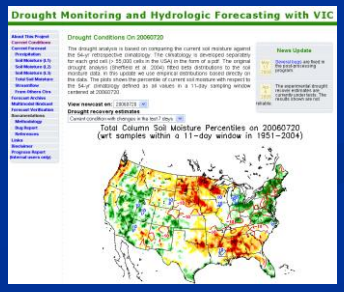
- Selection of indices is a key area for drought community input

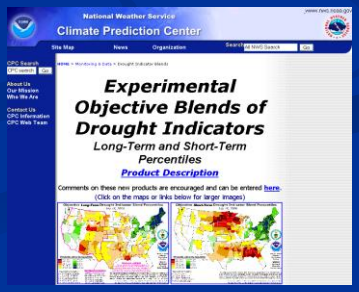
Project Status

- Second year of three year project
- Ongoing collaborations with US Drought Monitor and NLDAS, links to NASA Water Management Program drought project
- Real-time beta drought monitor on NLDAS website
- Follows in footsteps of existing websites (U. Washington, Princeton, and CPC)
  - http://www.hydro.washington.edu/forecast/monitor/index.shtml
  - http://hydrology.princeton.edu/forecast/
  - http://www.cpc.ncep.noaa.gov/soilmst/
- Mosaic, Noah, and SAC runs performed, highlighting several key issues for further investigation
  - Climatology length
  - Meteorological forcing data
  - Model selection

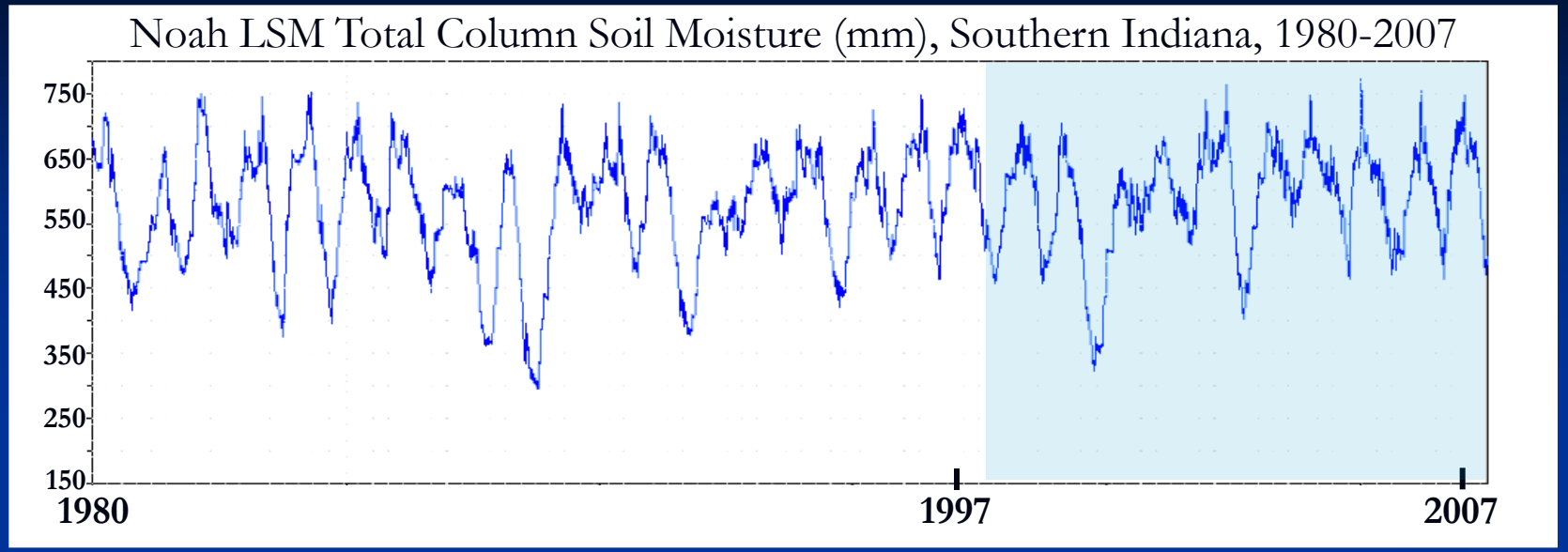


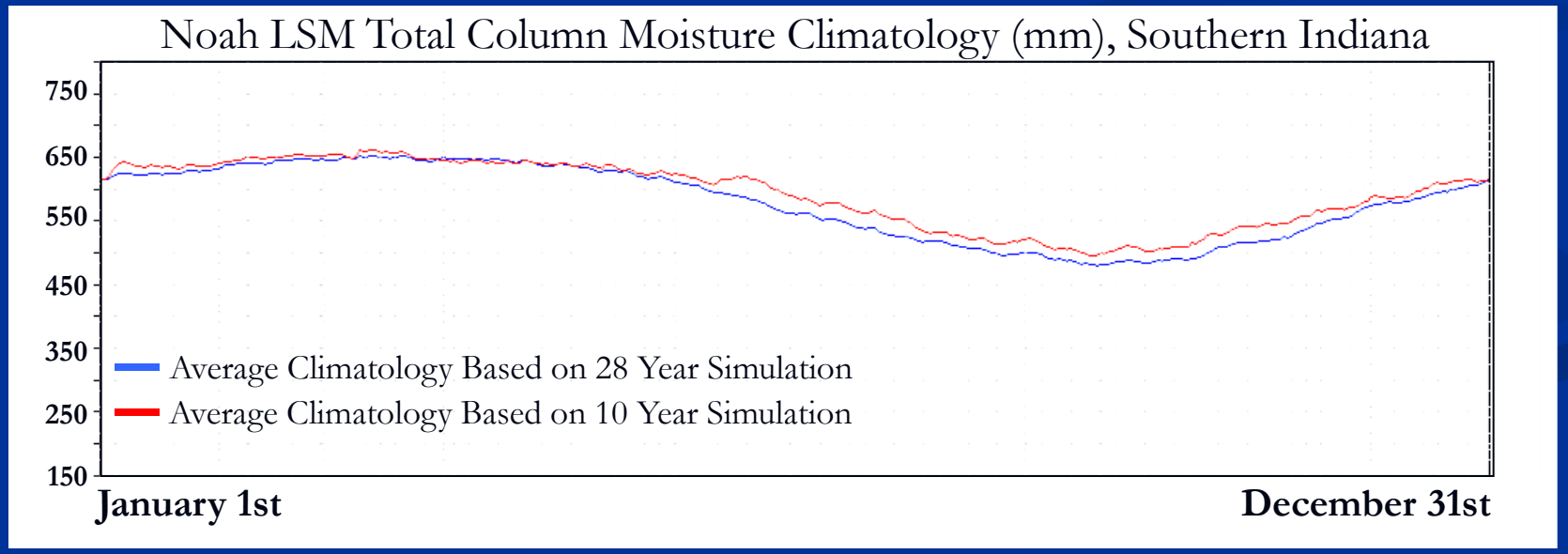






Impact of Climatology Length





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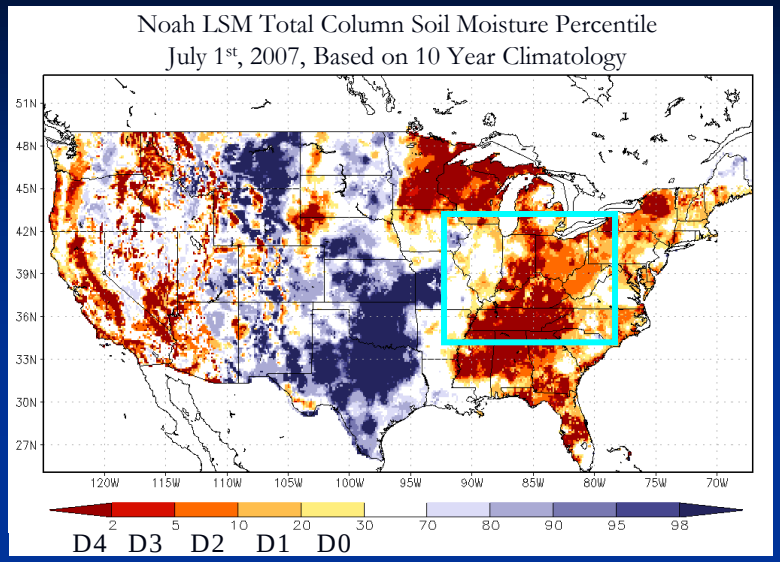
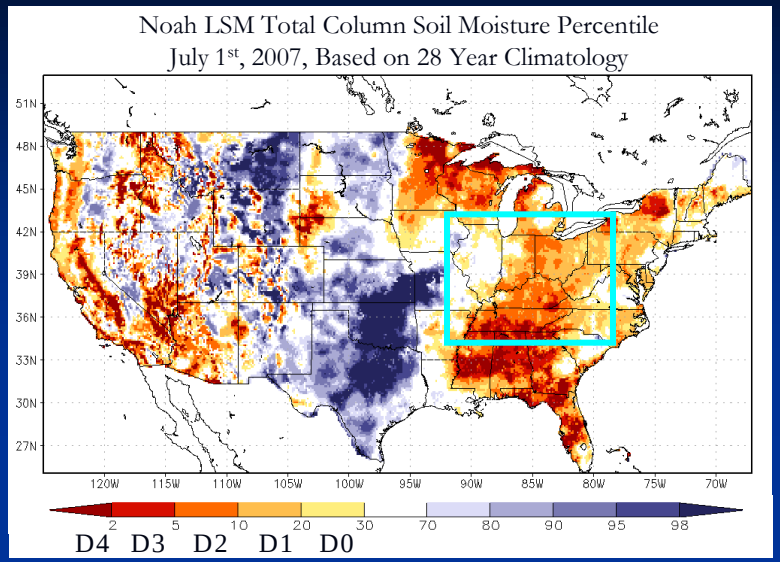
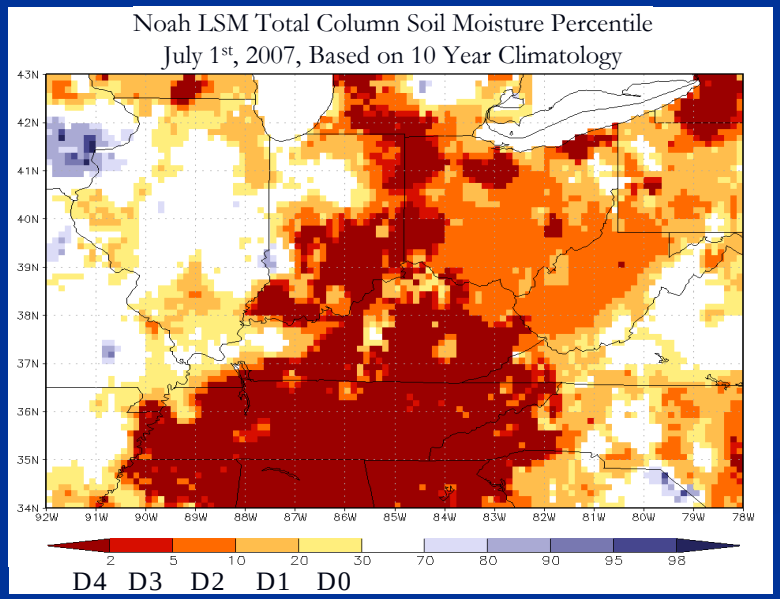
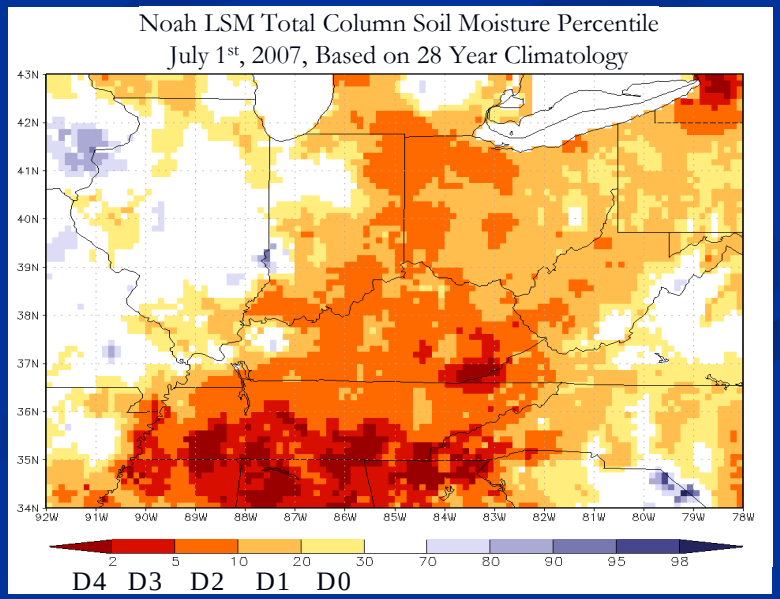


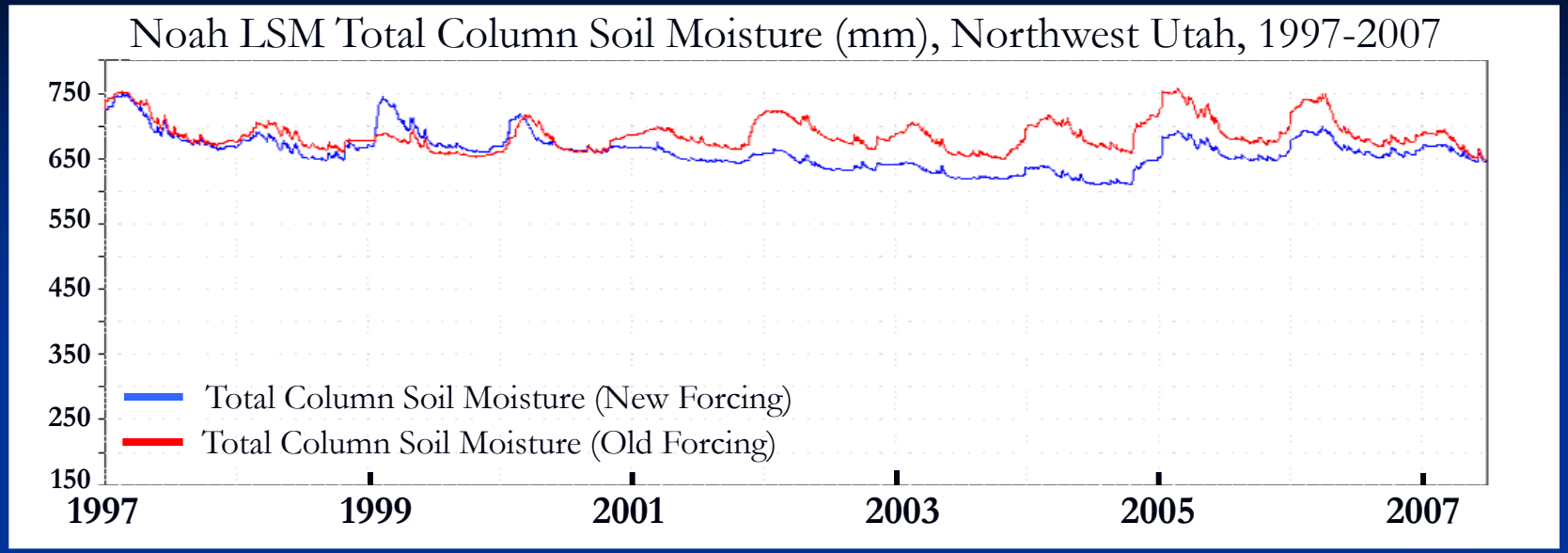


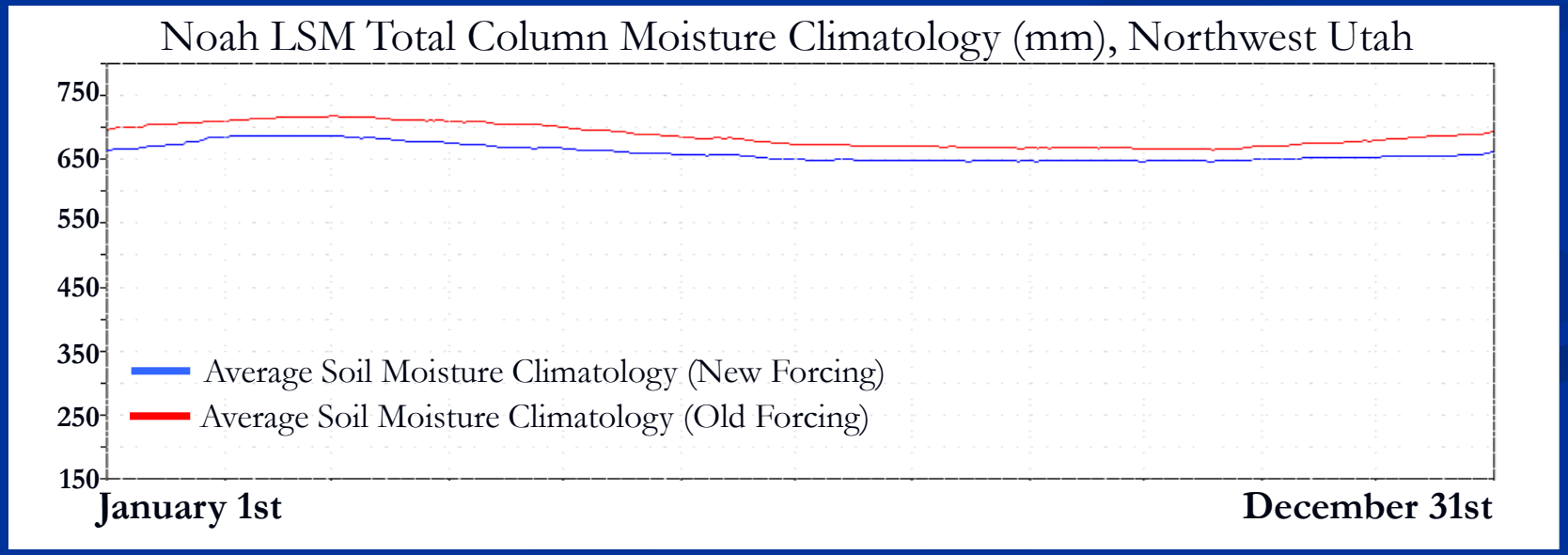
•Use of longer climatology acts to decrease severity of current events by putting them into better historical context





Impact of Meteorological Forcing Data





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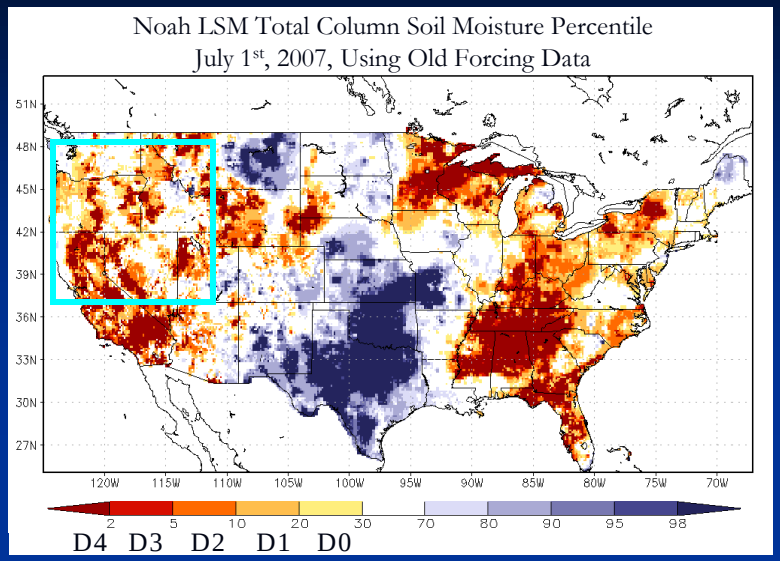
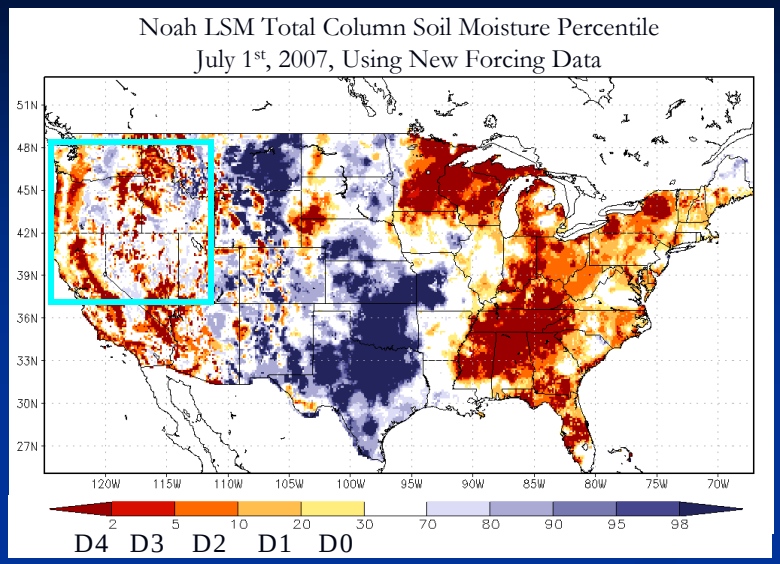
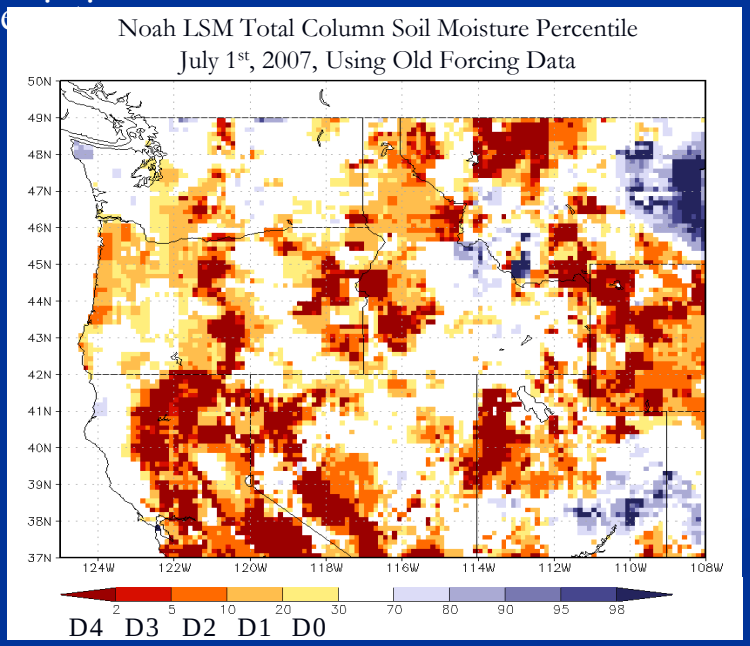
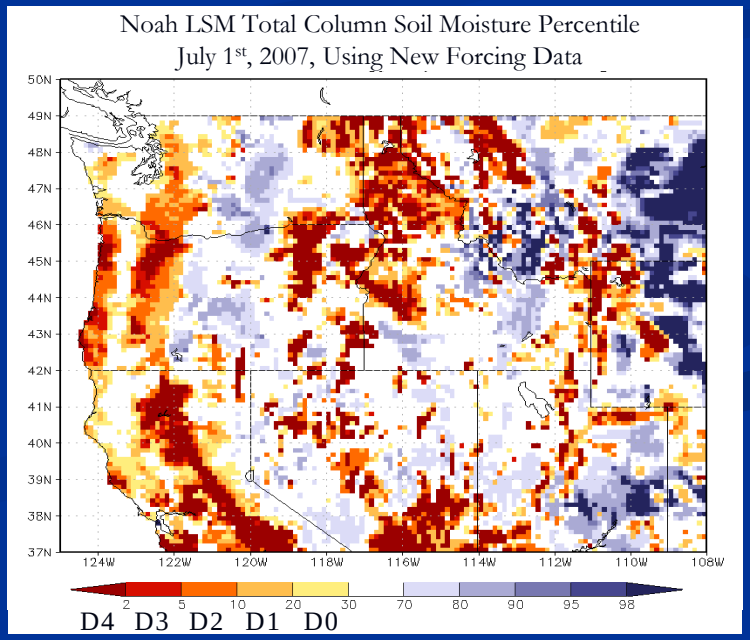


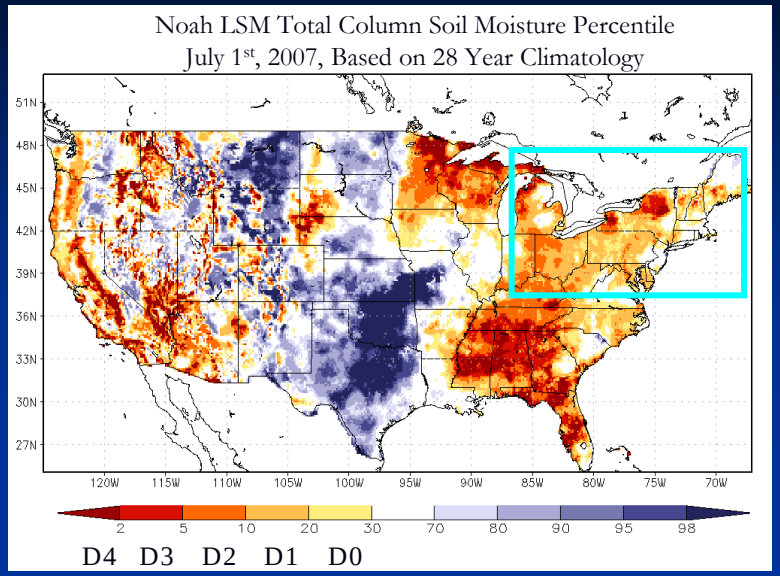


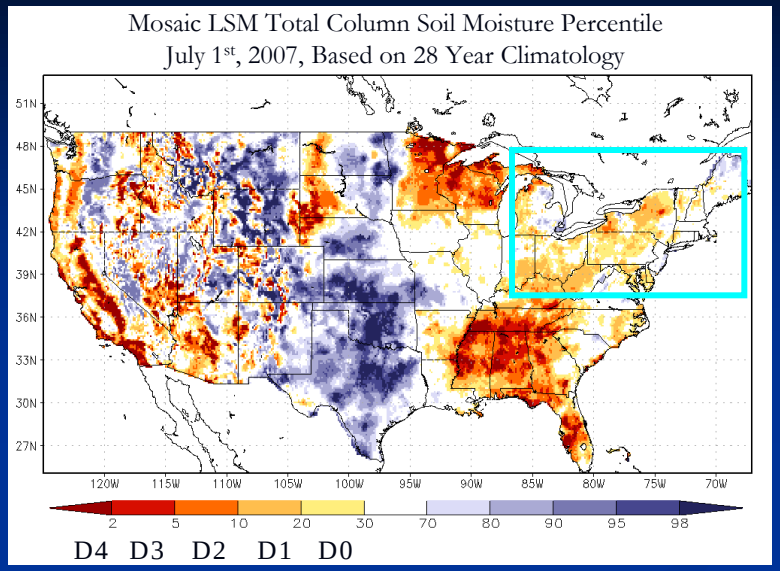
- Use of new forcing data set over same 10 year time period leads to large changes in drought de



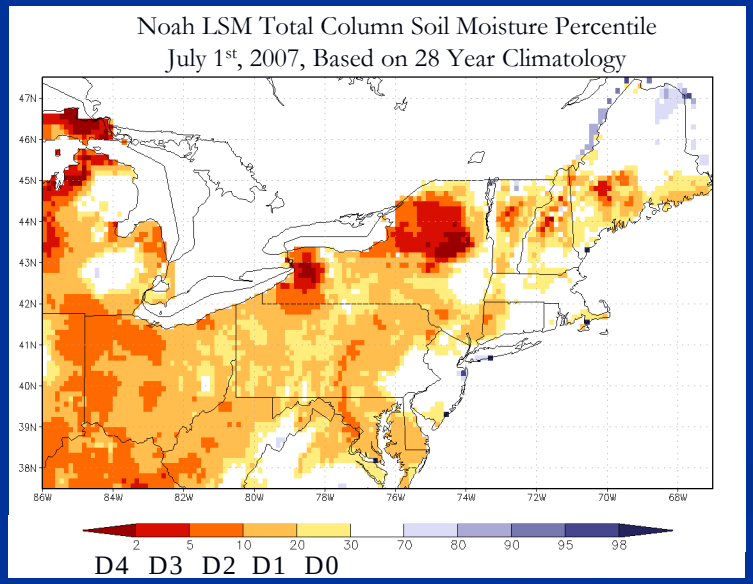


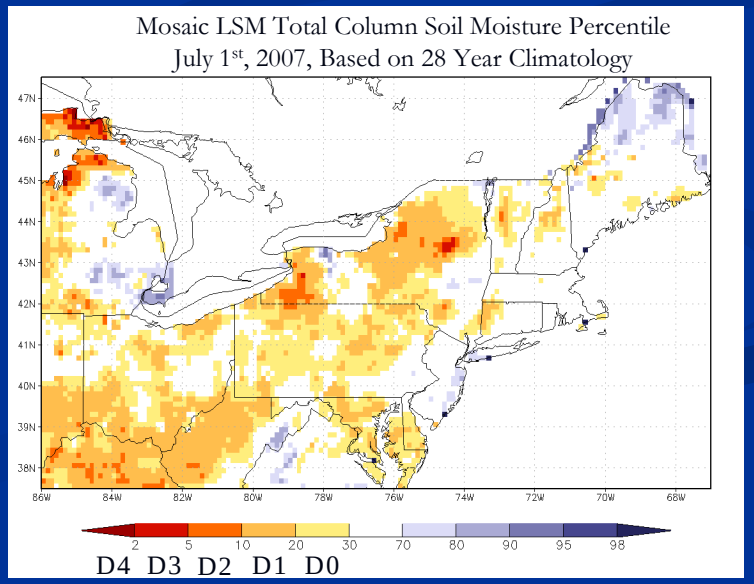
Impact of Model Choice





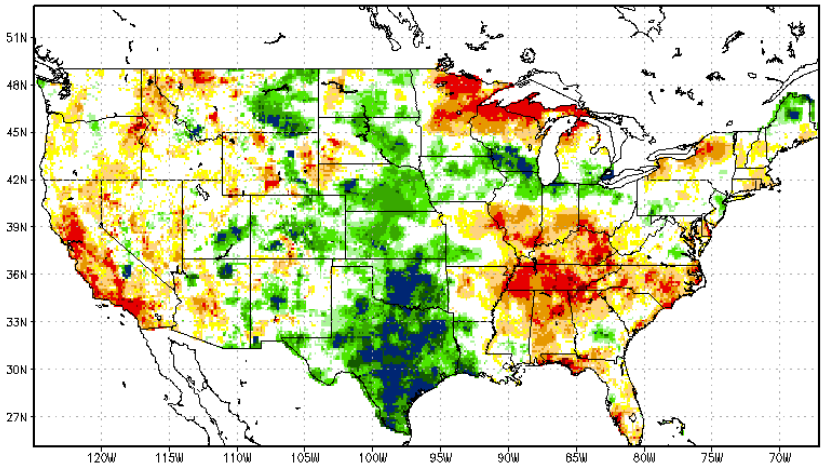
•Choice of land surface model can greatly influence depiction of drought severity due to differences in model physics and parameterizations





Drought Monitoring Comparison

Mosaic – Total Column Soil Moisture Percentile
Valid: 20070901



Noah – Total Column Soil Moisture Percentile
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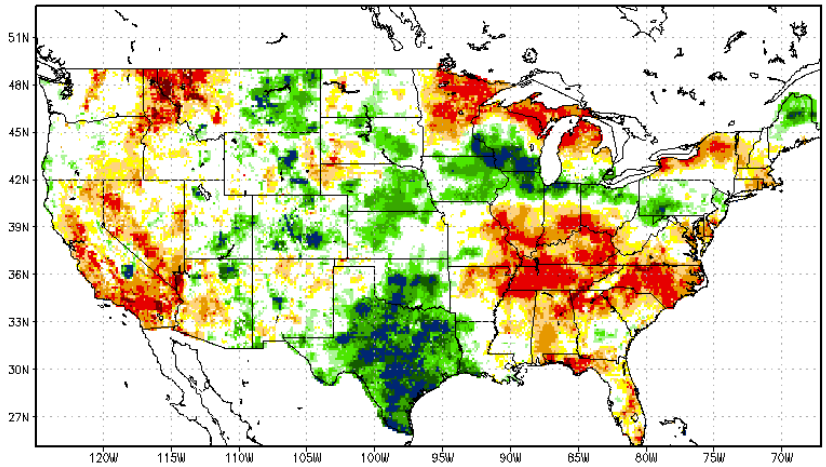

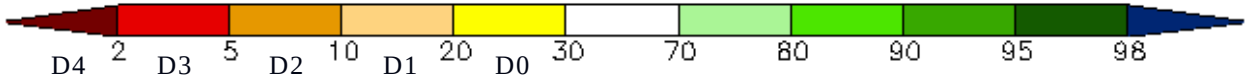

SAC – Total Column Soil Moisture Percentile
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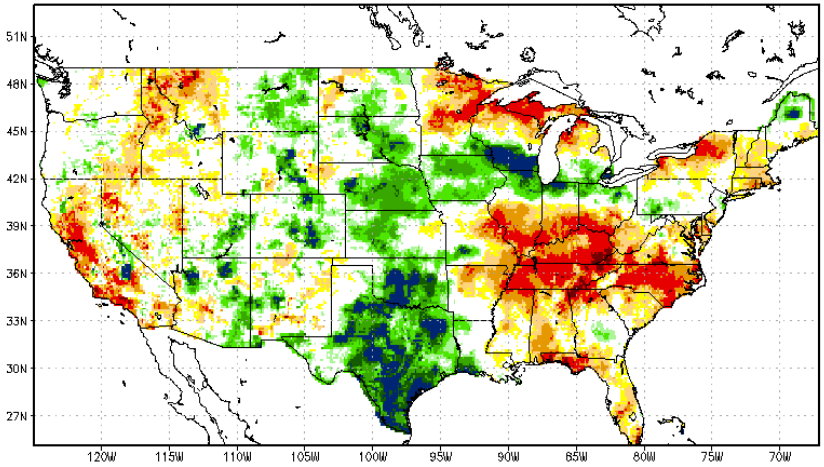

Ens. Mean – Total Column Soil Moisture Percentile
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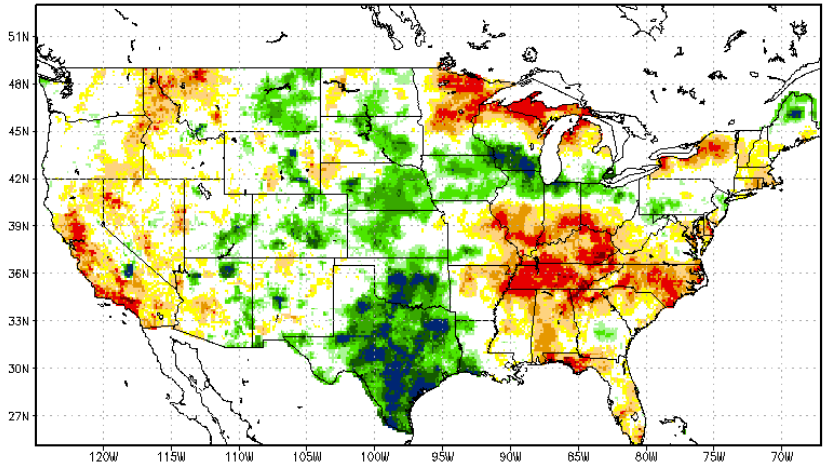
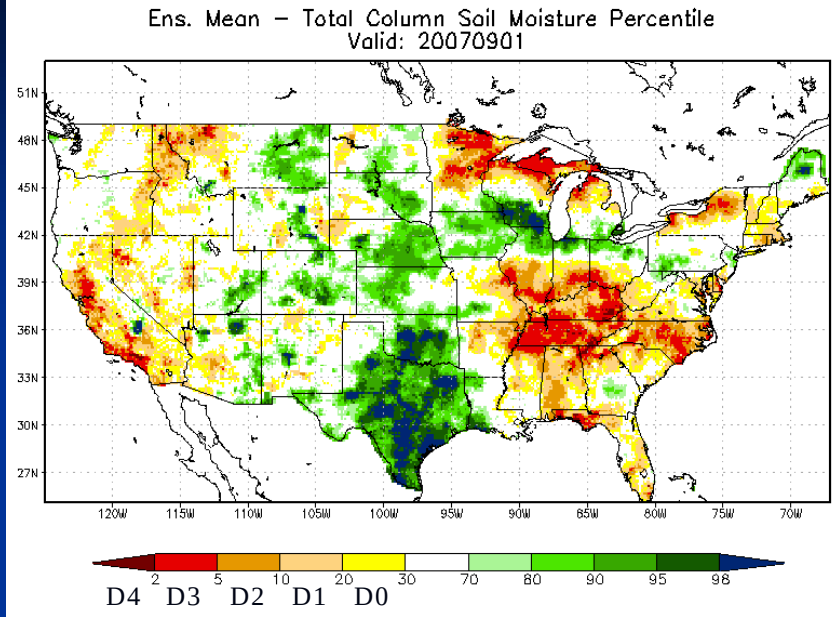
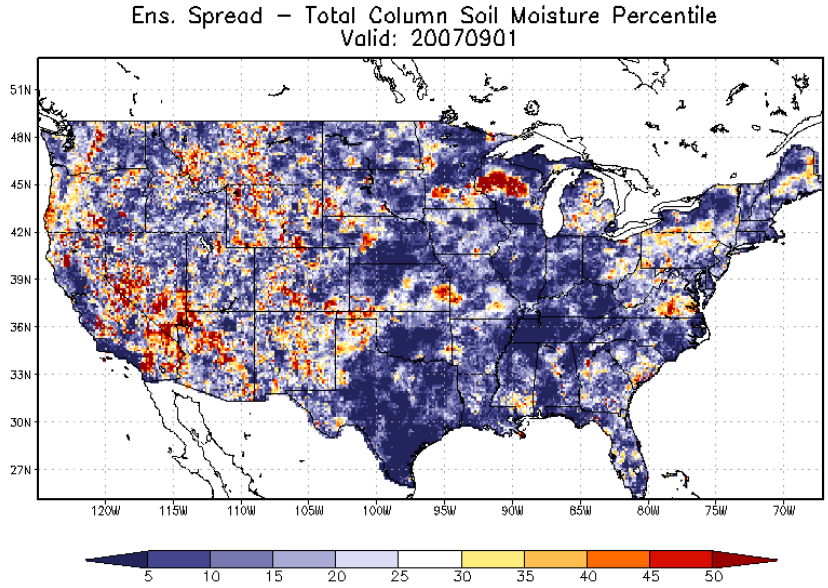
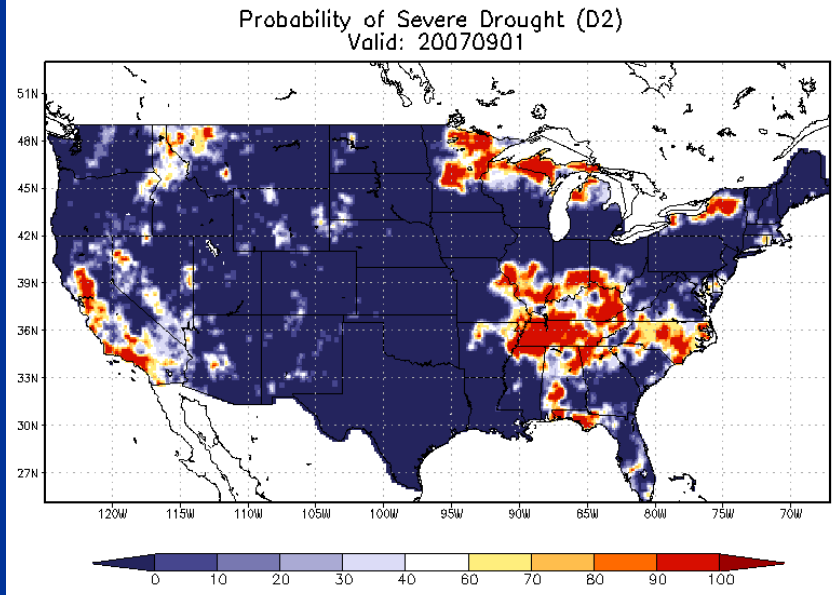
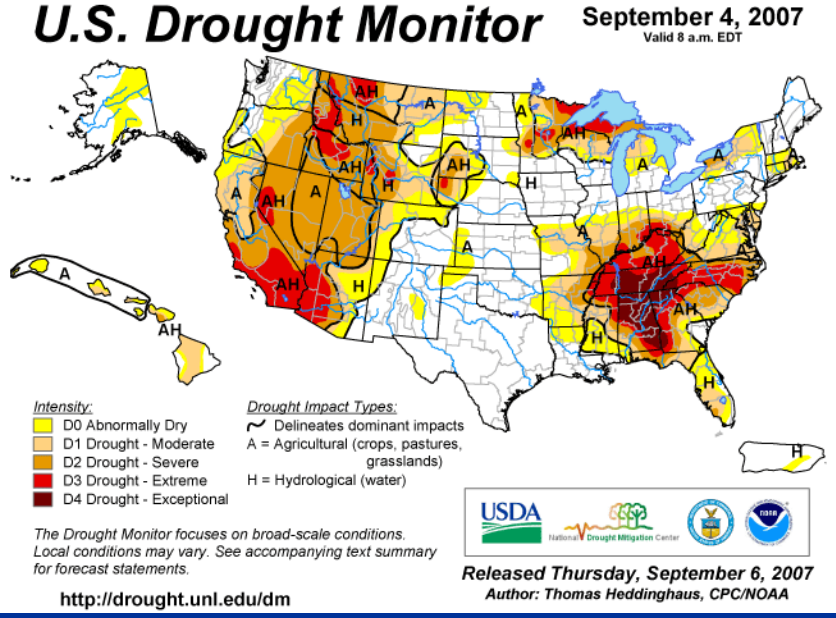


Drought Monitoring Comparison

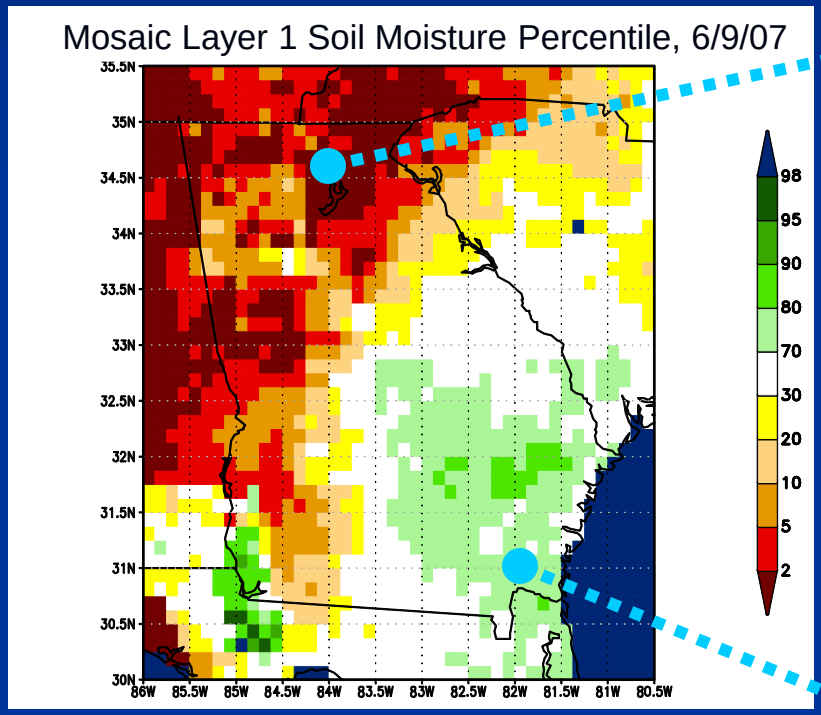


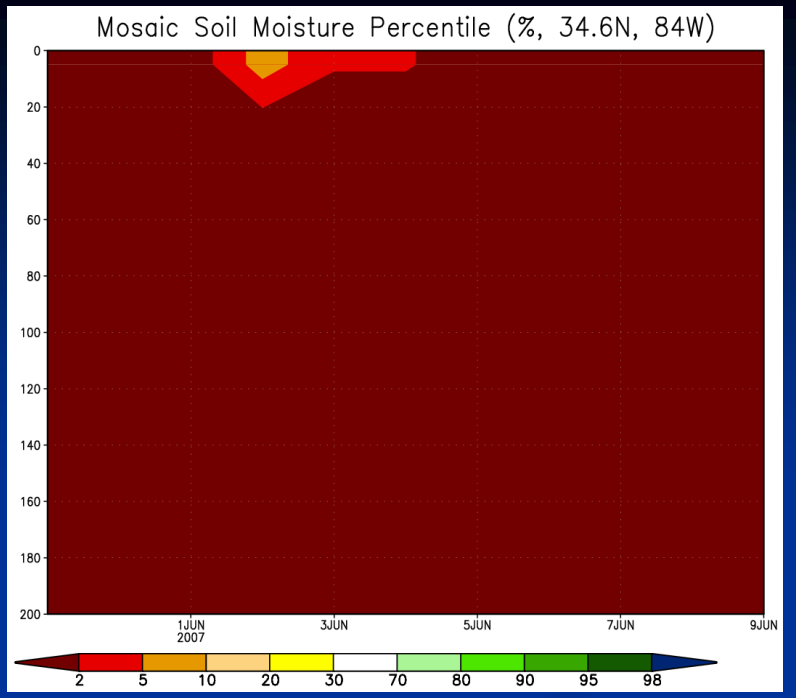


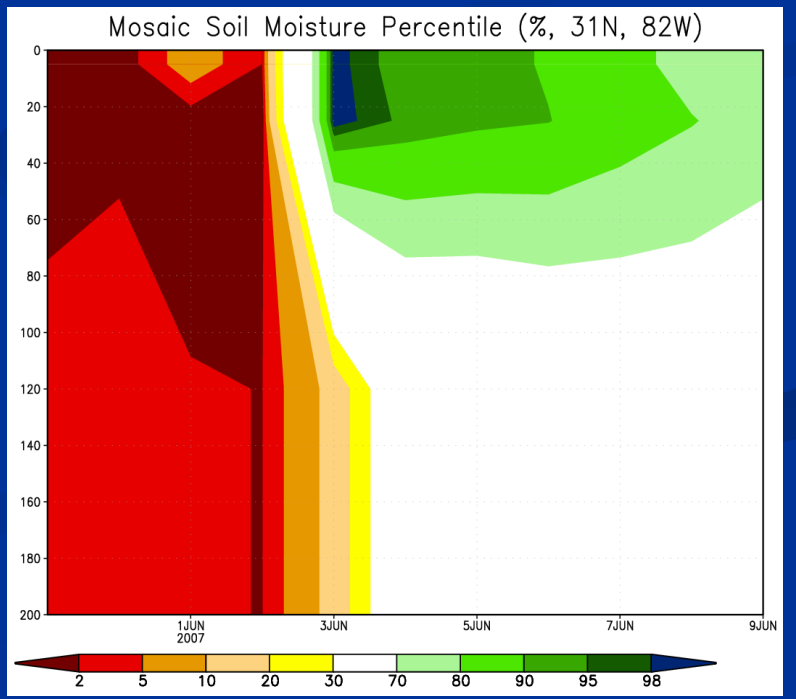




Mosaic LSM Time and Depth Cross Section of Drought Severity





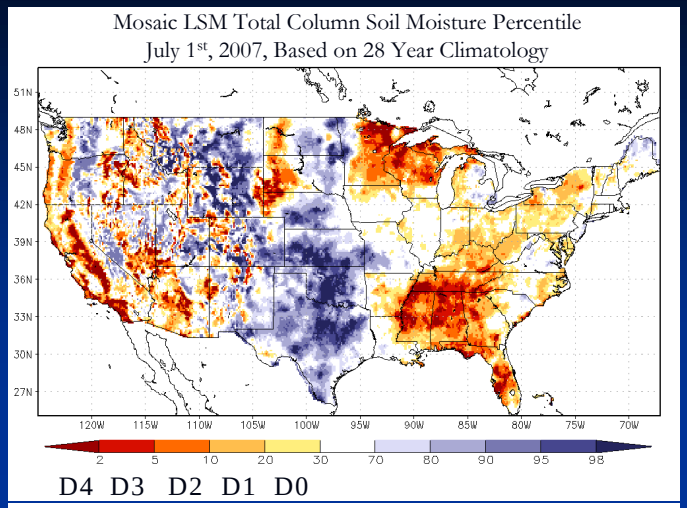


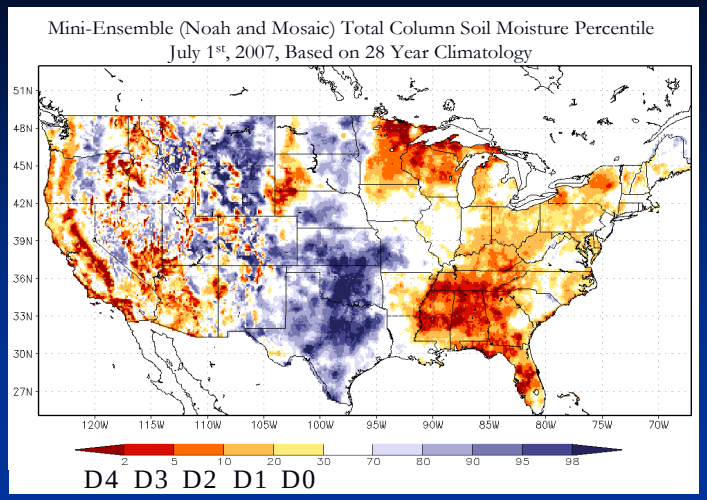
Conclusions

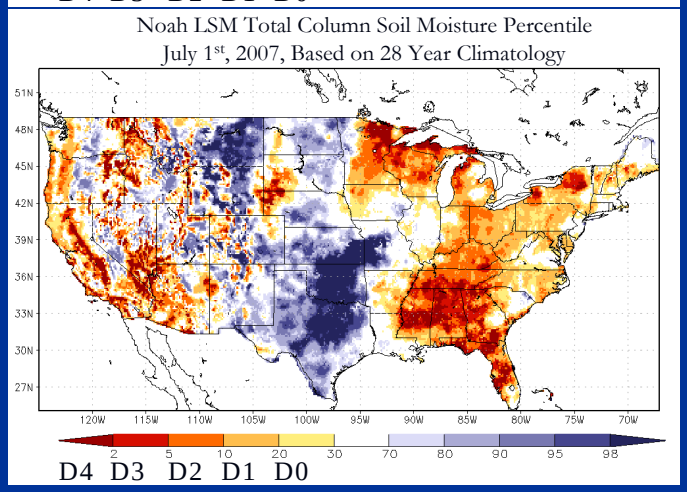
- NLDAS LSM-based drought project underway at NASA GSFC in collaboration with NOAA/NCEP/EMC, NOAA/NCEP/CPC and Princeton University
- Project seeks to leverage ensemble, high quality, multi-layer, spatially continuous soil moisture simulations in NLDAS framework to form a robust real-time drought monitor
- Goals are to investigate climatology, forcing data, model, and ensemble-related issues as well as offer an effective suite of objective drought indices to drought assessment organizations such as NIDIS and the U.S. Drought Monitor
- End user input will be key to the success of this project, and all input is welcome

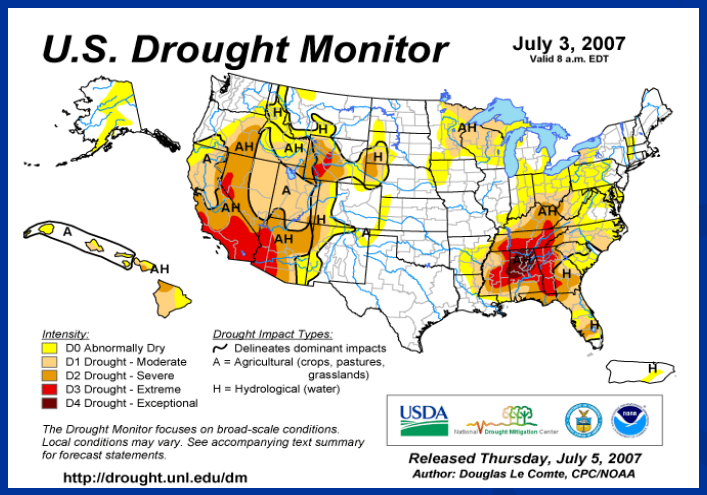
Additional Material Follows

Drought Monitor Comparison



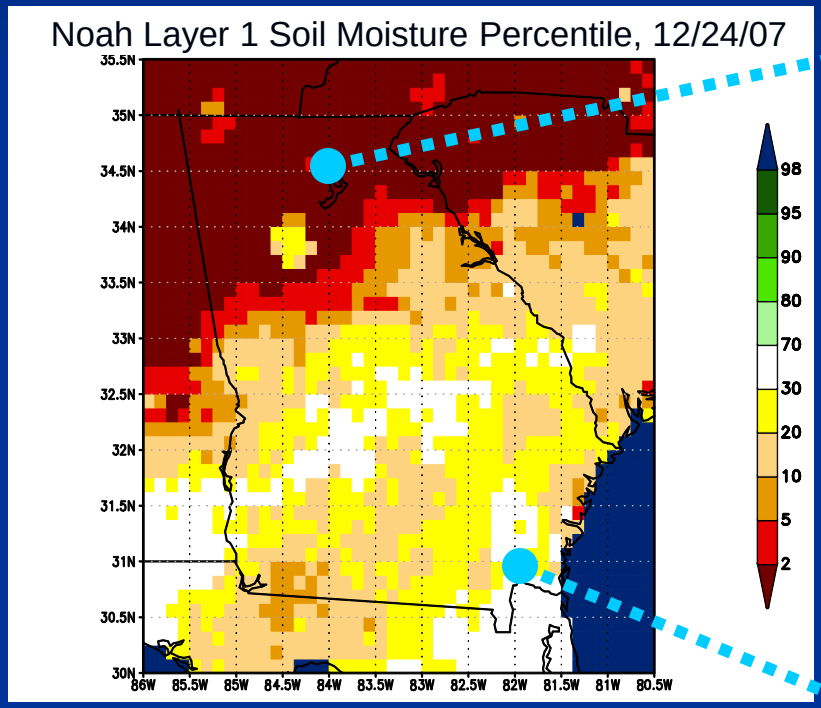


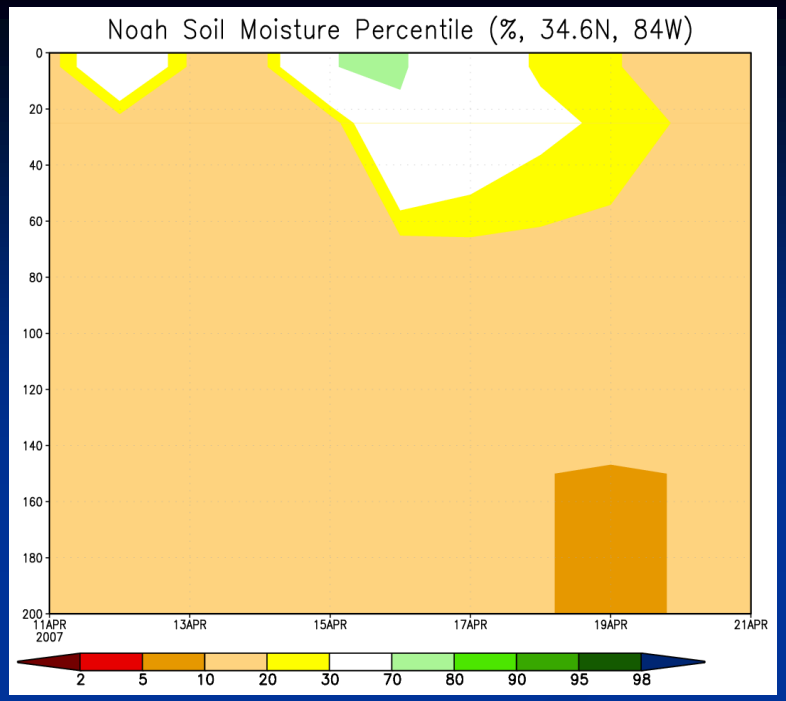


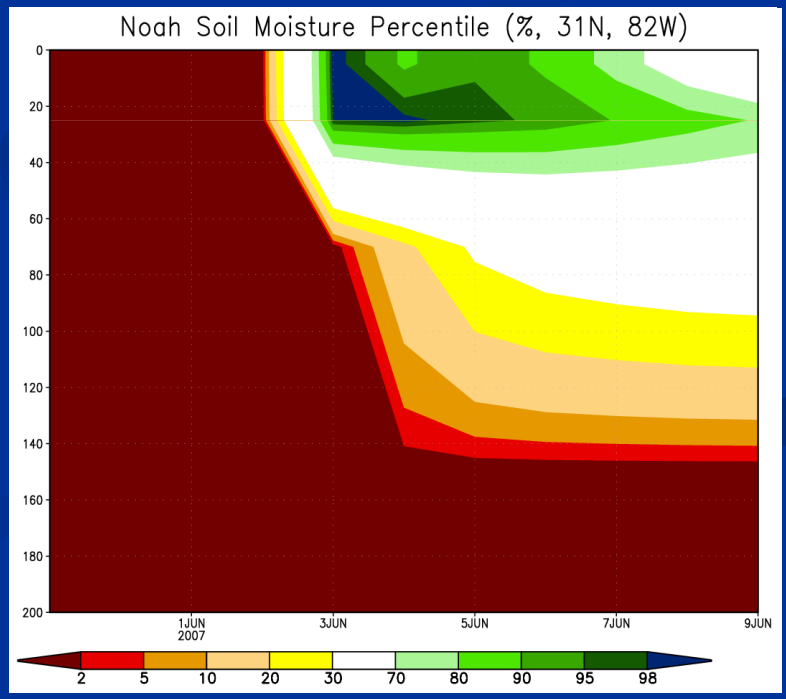


- Soil moisture percentiles from each LSM combined to form ensemble mean percentile map
- Project will eventually use Mosaic, Noah, VIC, Sacramento, CLM3, HySSiB, and Catchment models with a variety of lineages (climate modeling, weather forecasting, hydrological)
- Ensembles often offer more accurate depictions of drought
- Even poor depictions are informative--Large model spread indicates lack of confidence

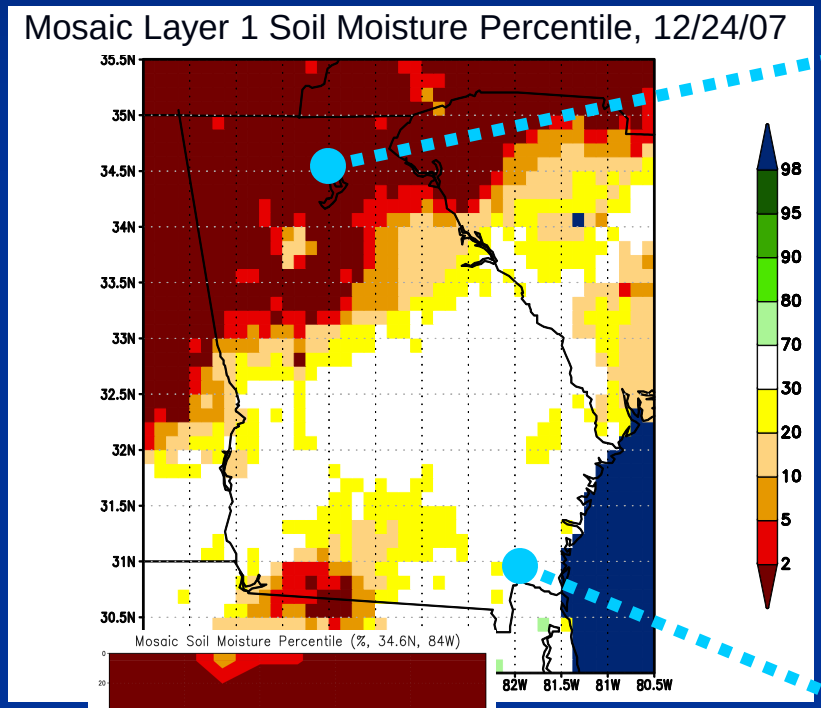
Noah LSM Time and Depth Cross Section of Drought Severity

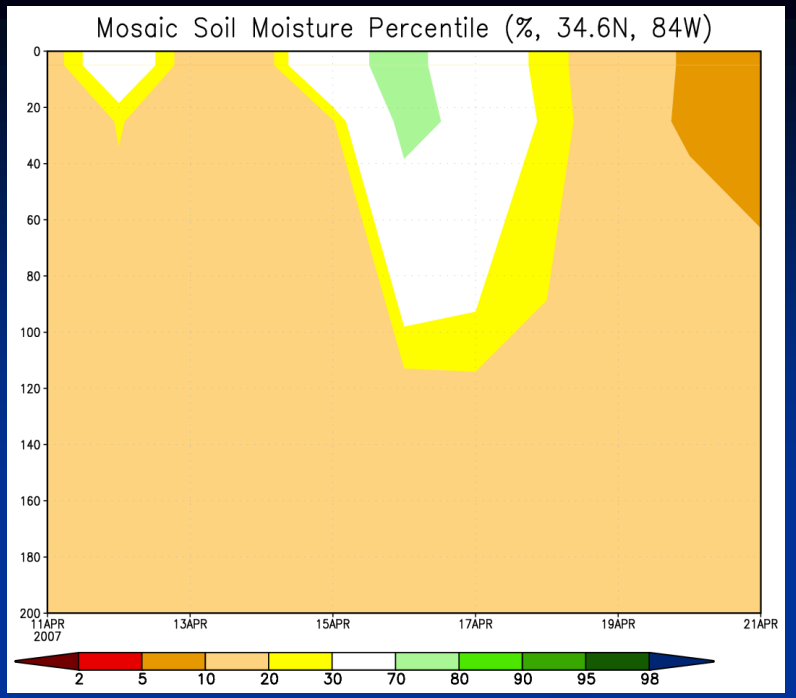


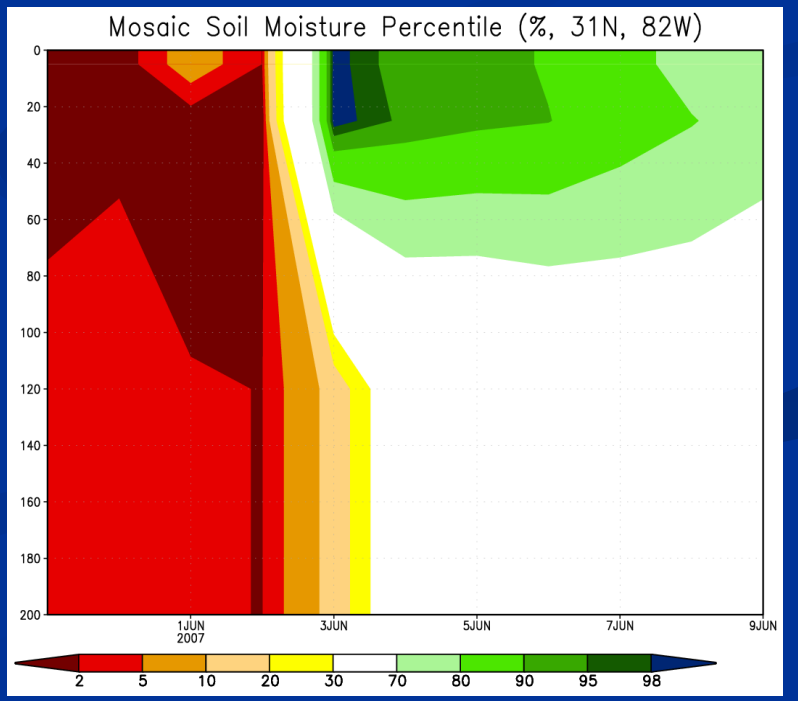




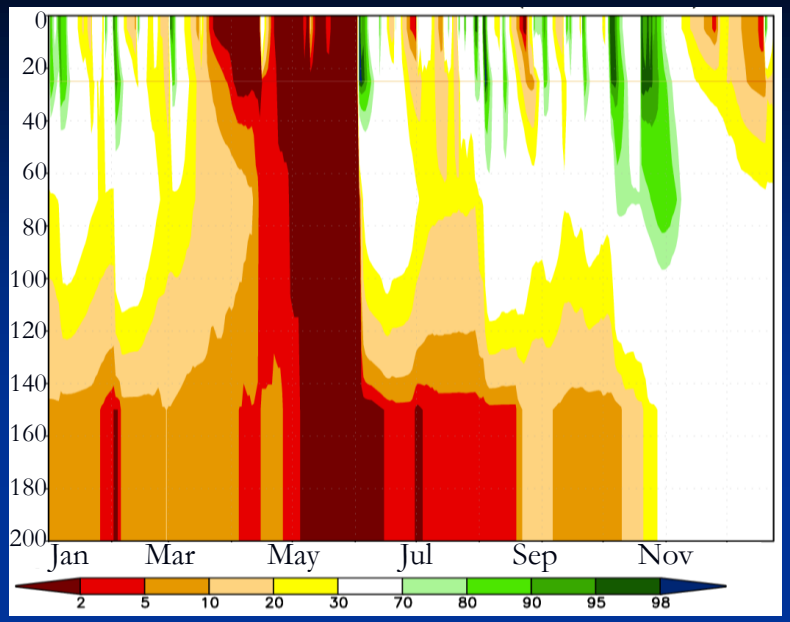
Mosaic LSM Time and Depth Cross Section of Drought Severity



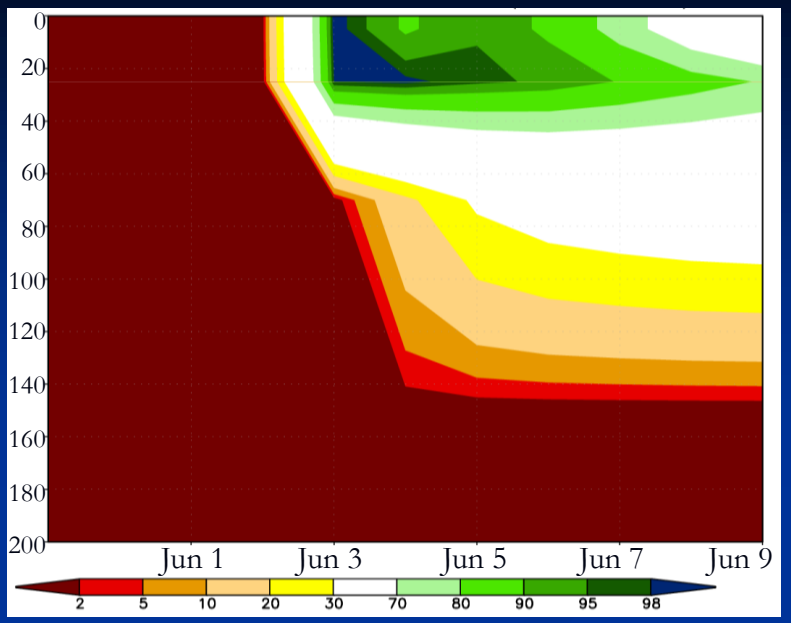




Time and Depth (cm) Cross Section of Drought Severity (Soil Moisture Percentile)

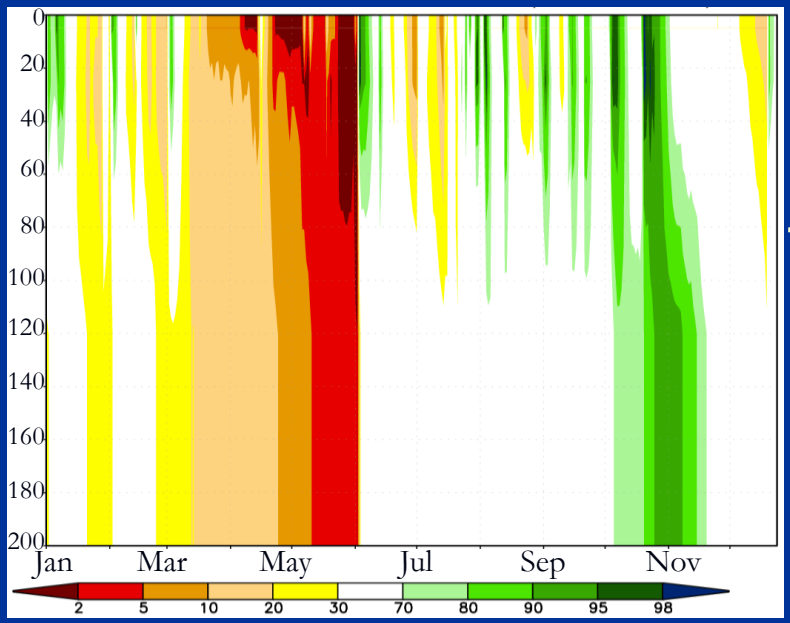


-Noah LSM-

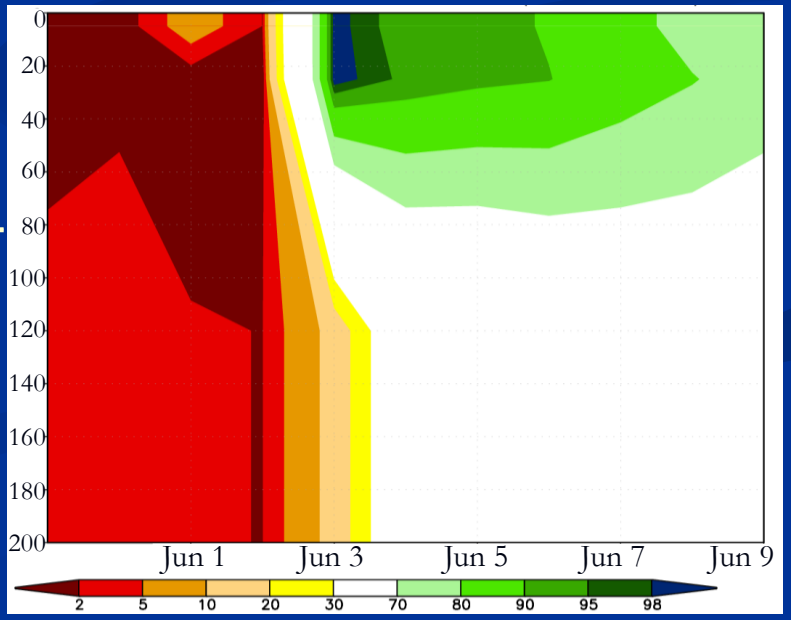


January to December 2007

May 31 to June 9, 2007



-Mosaic LSM-



NASA GSFC Drought Project Outline

Forcing Data

- Construct and validate 1/8th degree forcing dataset based on NARR, supplemented with observed precipitation, and bias corrected with observed radiation

LSM Runs

- Execute and validate 1/8th degree 28 year-long ensemble runs using Noah, CLM3, and NASA's Mosaic, HySSiB, and Catchment LSMs within NASA's Land Information System (LIS) modeling framework

Drought Monitor

- Construct and execute drought monitor processing system using individual as well as 7 member ensemble output (includes VIC and Sacramento output from NCEP)
- Analyze drought monitor output to determine effect of model selection, forcing data, NARR climatology length , and ensemble construction on drought characterization, and to benchmark performance versus existing drought monitoring systems
- Transition system to real-time operations, providing objective data to existing drought monitoring efforts such as the U.S. Drought Monitor DST where possible

Impact of Model Choice