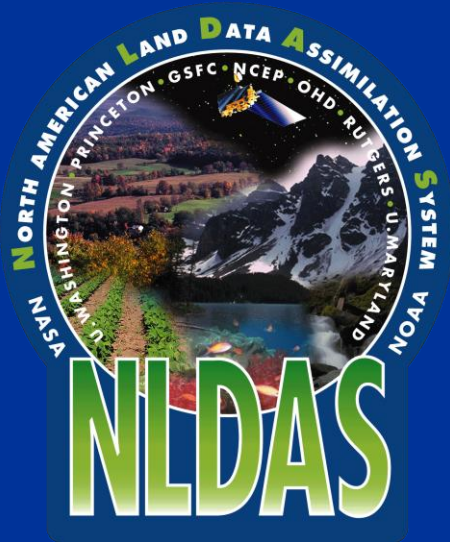




# Application of NLDAS Ensemble LSM Simulations to Continental-Scale Drought Monitoring



Brian Cosgrove and Charles Alonge  
SAIC / NASA GSFC

Collaborators: Kenneth Mitchell<sup>1</sup>, Youlong Xia<sup>1</sup>,  
Kingtse Mo<sup>2</sup>, Wanru Wu<sup>2</sup>, Eric Wood<sup>3</sup>

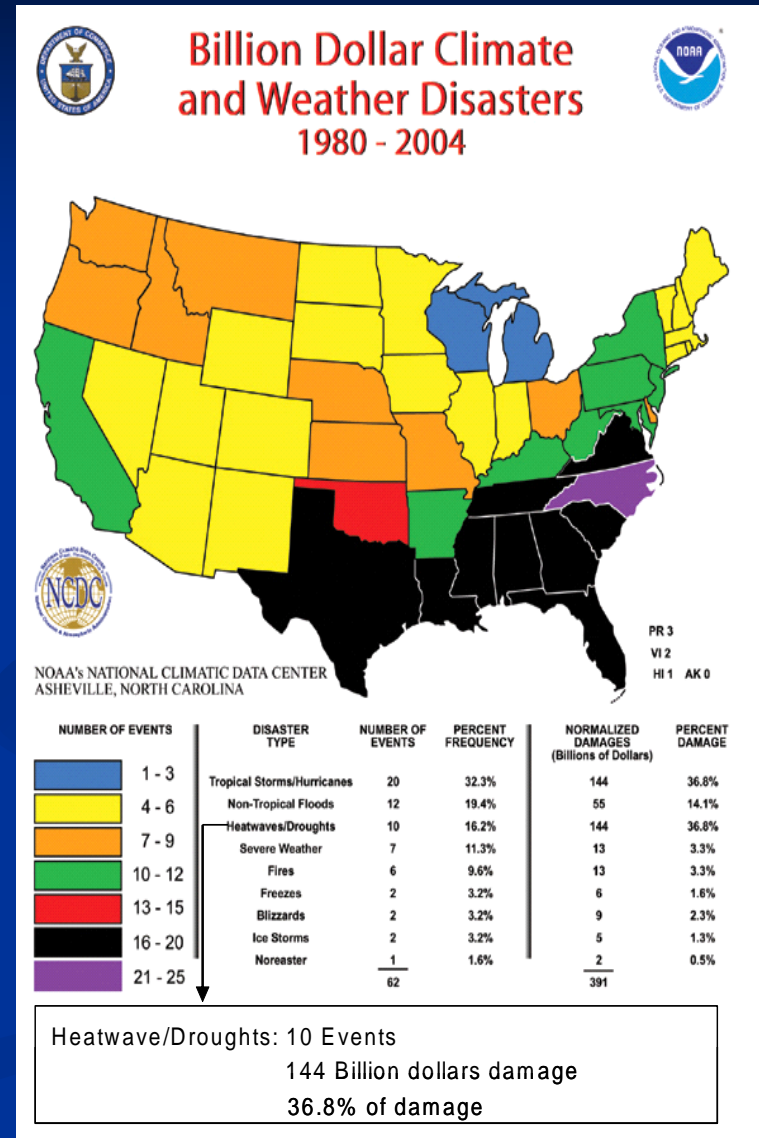
<sup>1</sup>NOAA/NCEP/EMC, <sup>2</sup>NOAA/NCEP/CPC, <sup>3</sup>Princeton University

Funded by NOAA CPPA and NASA WMP

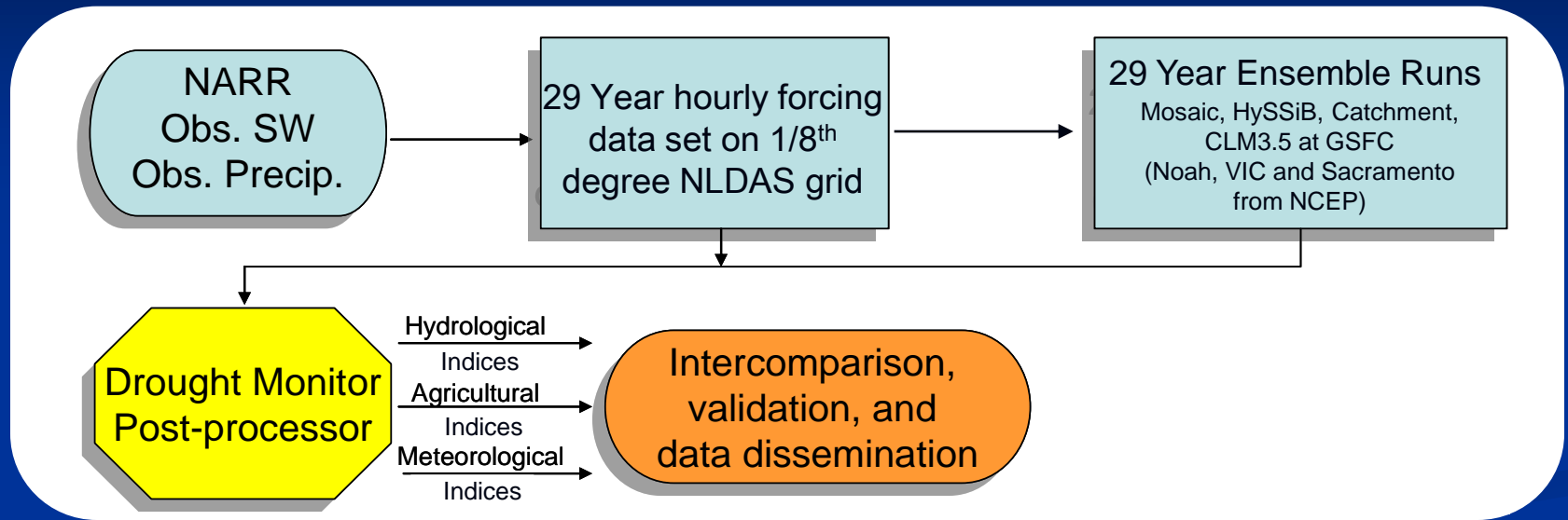


# Introduction

- 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 (28 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

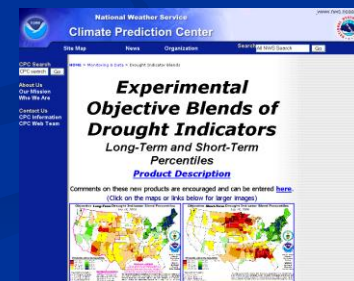
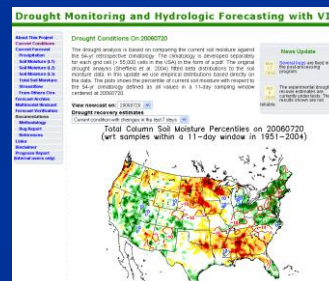
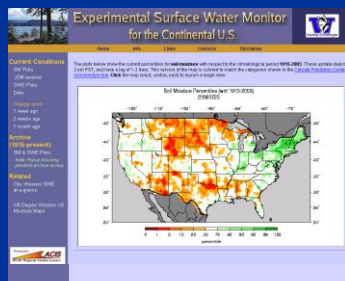
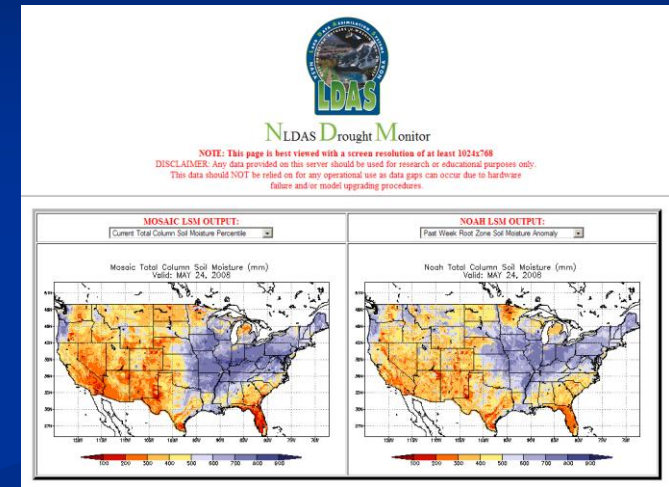
- Forcing is hourly, 1/8<sup>th</sup> degree, compatible with original NLDAS data
  - NARR model data base (3 hourly, 32km, 1979 – Present)
  - Hourly NARR SW bias correction developed from GOES data for each month
  - Hourly observed precipitation based on daily PRISM-corrected gauge data, and hourly Stage II Doppler radar, CMORPH, and HPD data
  - Elevation correction for temperature, pressure, humidity, and long wave
  - 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

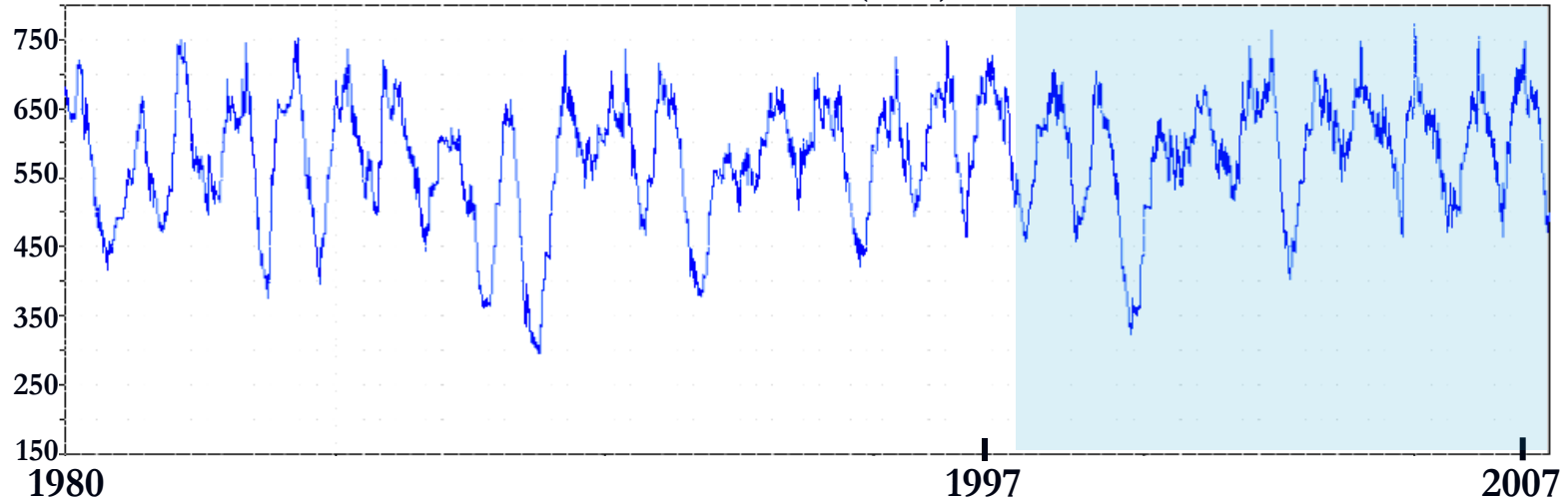
# Project Status

- 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

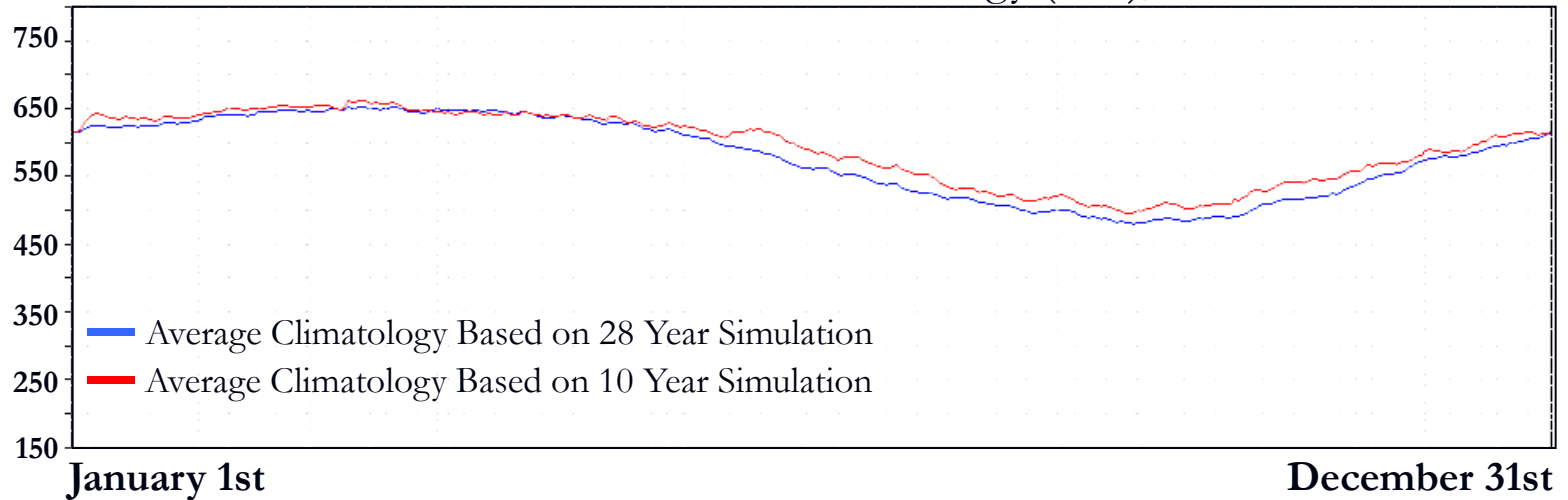


# Impact of Climatology Length

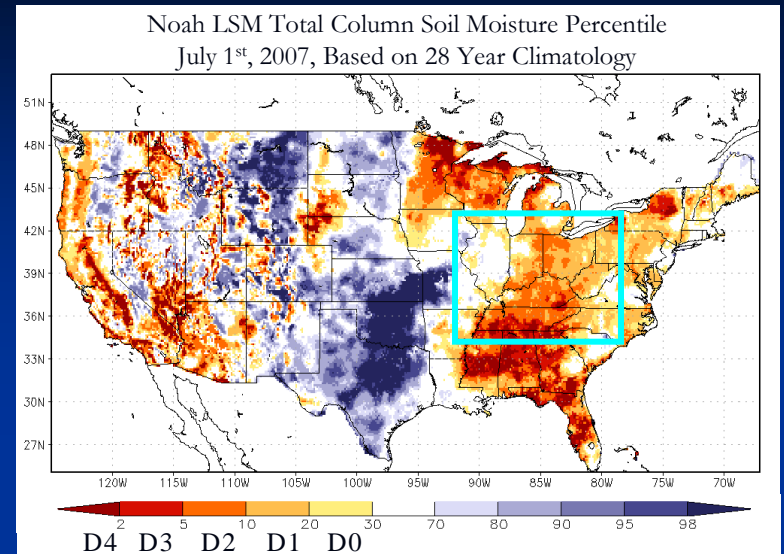
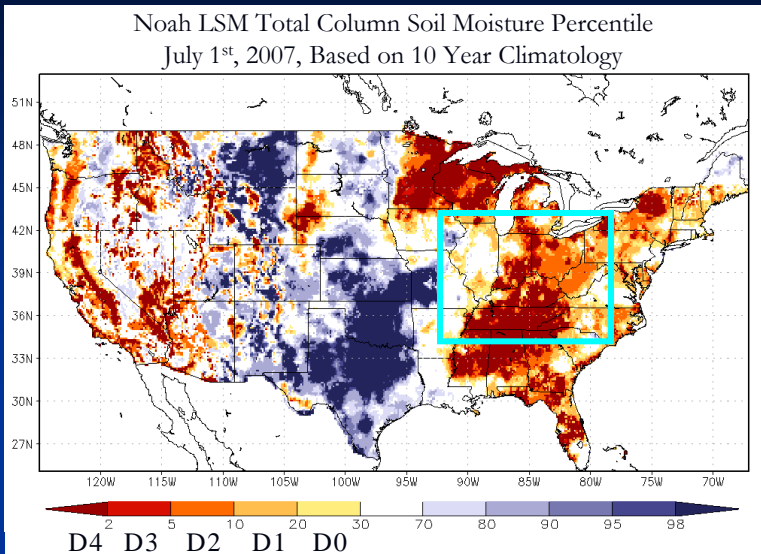
Noah LSM Total Column Soil Moisture (mm), Southern Indiana, 1980-2007



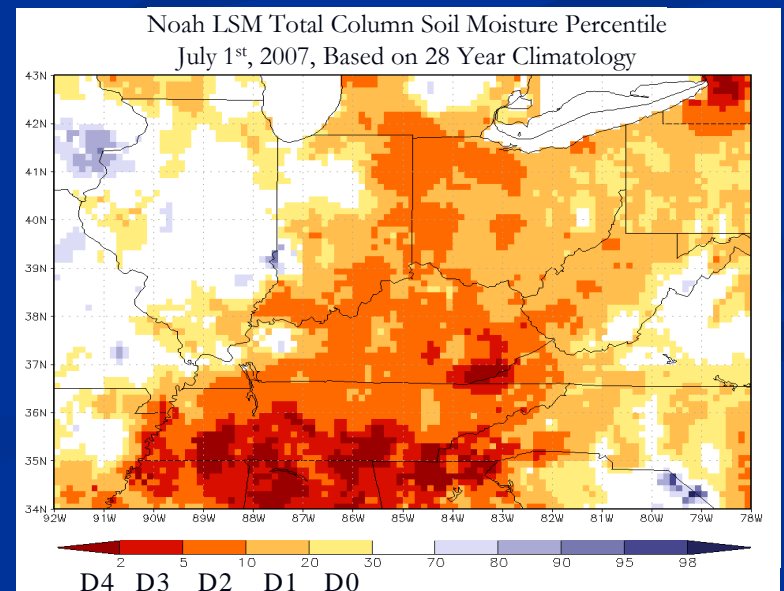
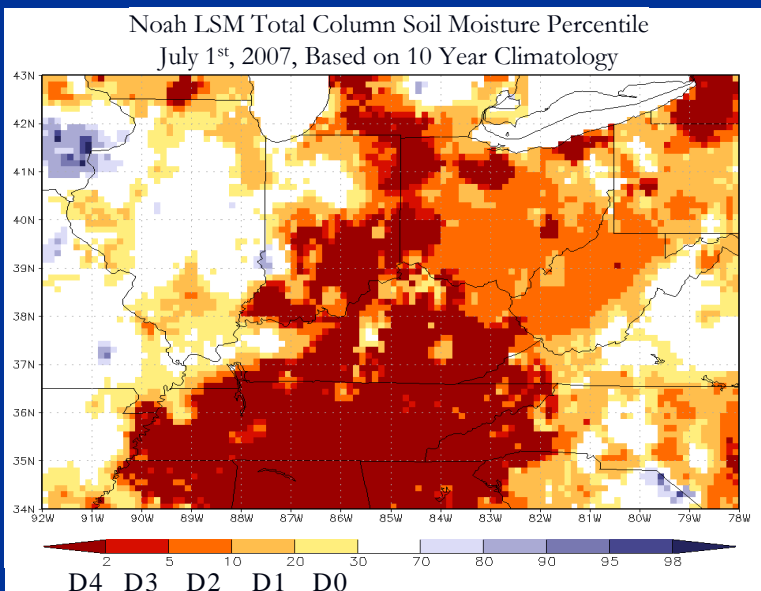
Noah LSM Total Column Moisture Climatology (mm), Southern Indiana



# Impact of Climatology Length

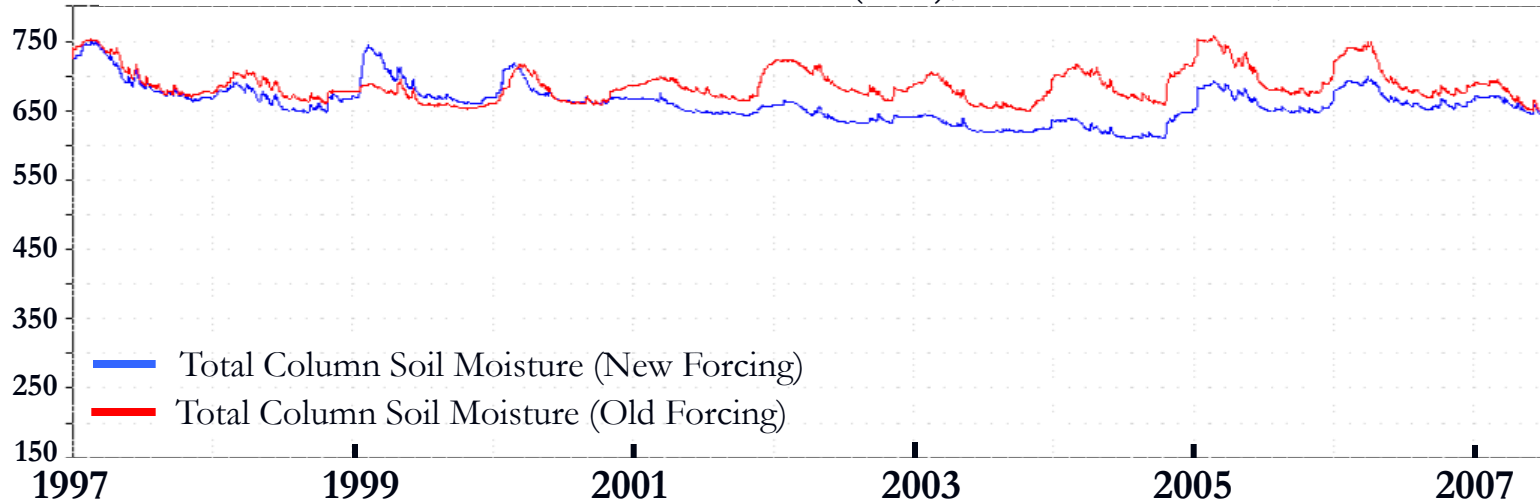


- Use of longer climatology acts to decrease severity of current events by putting them into better historical context

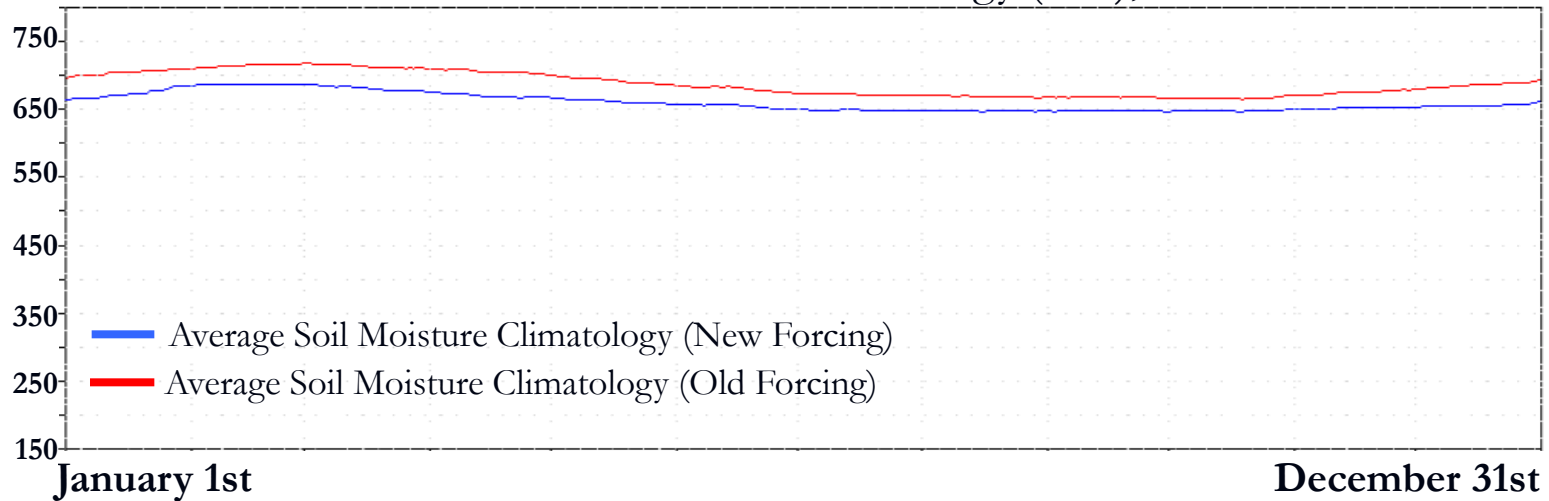


# Impact of Meteorological Forcing Data

Noah LSM Total Column Soil Moisture (mm), Northwest Utah, 1997-2007

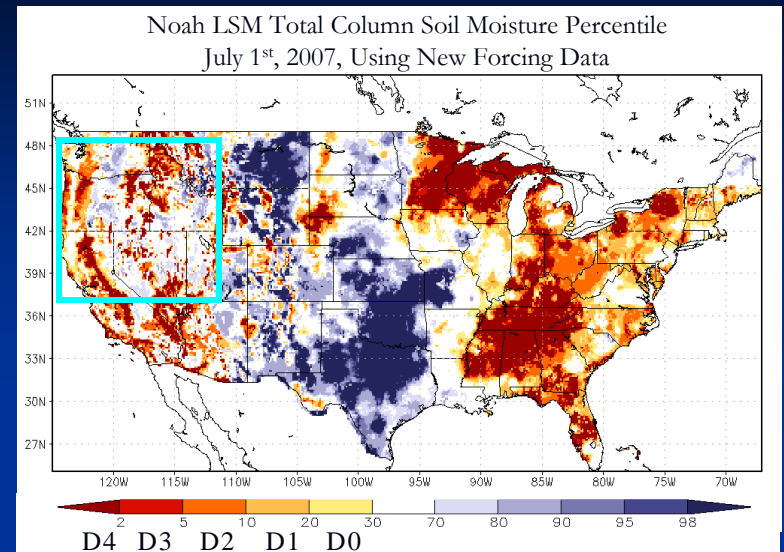
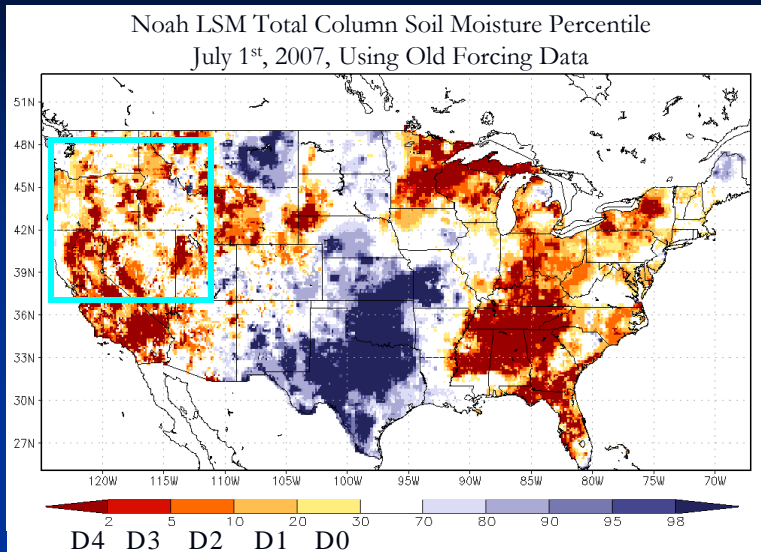


Noah LSM Total Column Moisture Climatology (mm), Northwest Utah

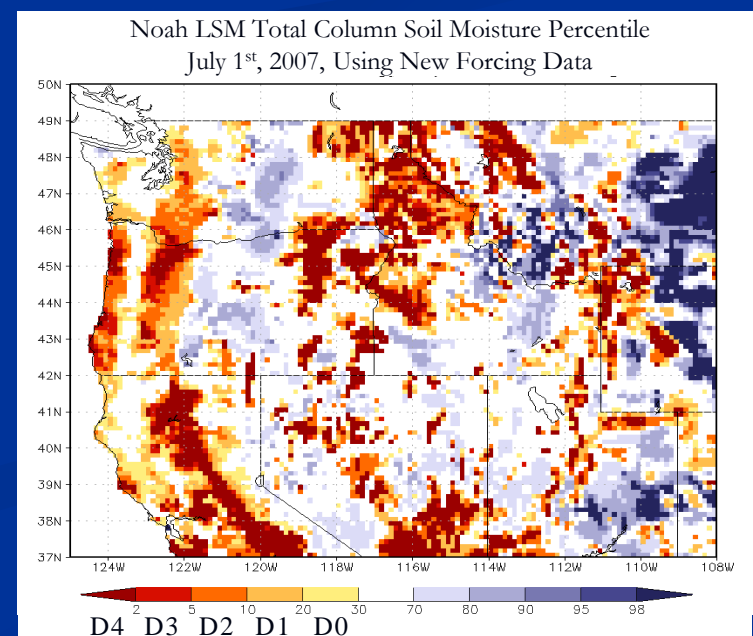
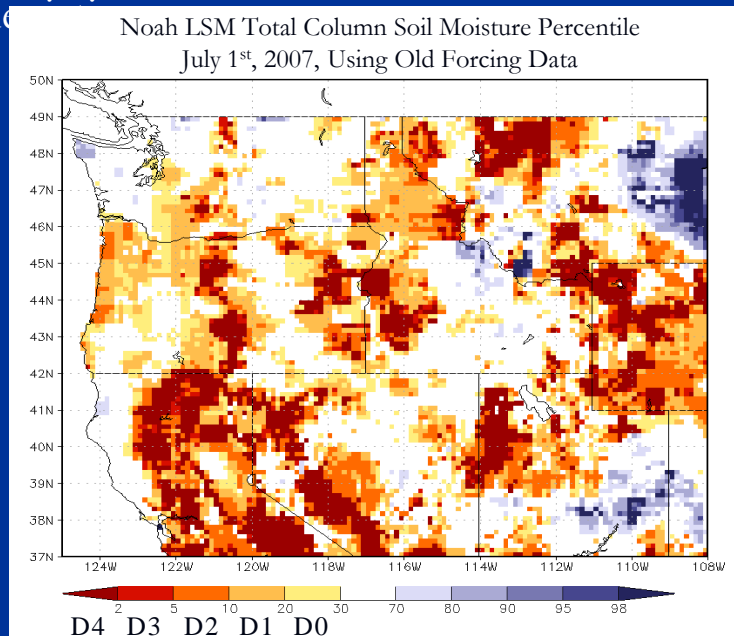




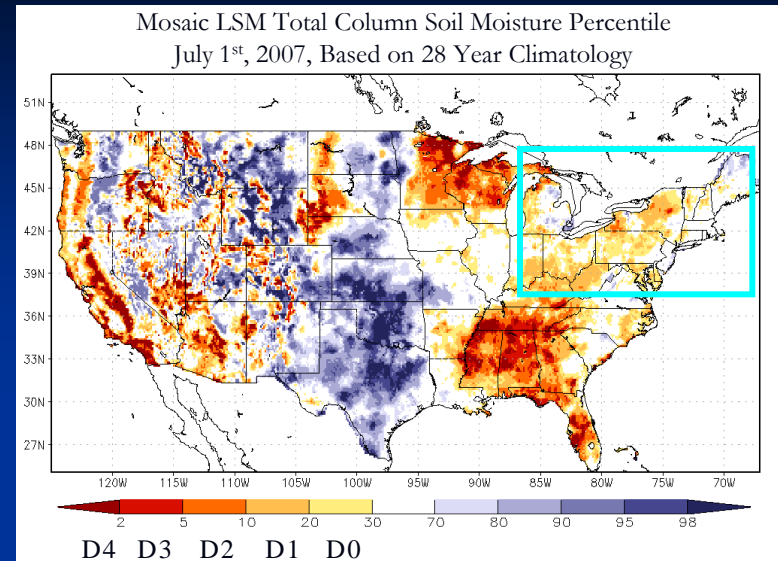
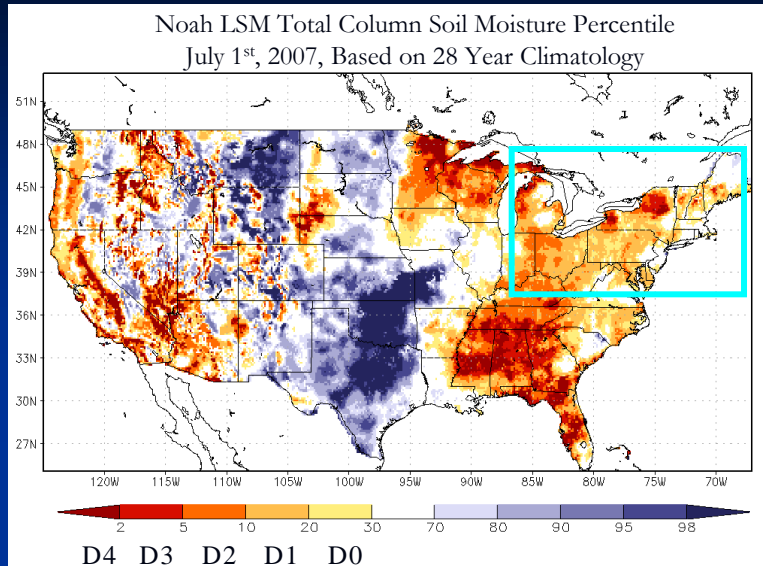
# Impact of Meteorological Forcing Data



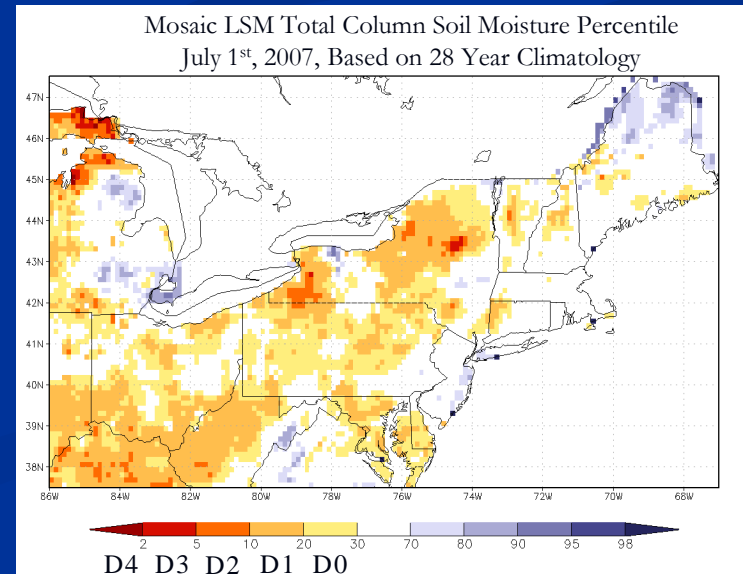
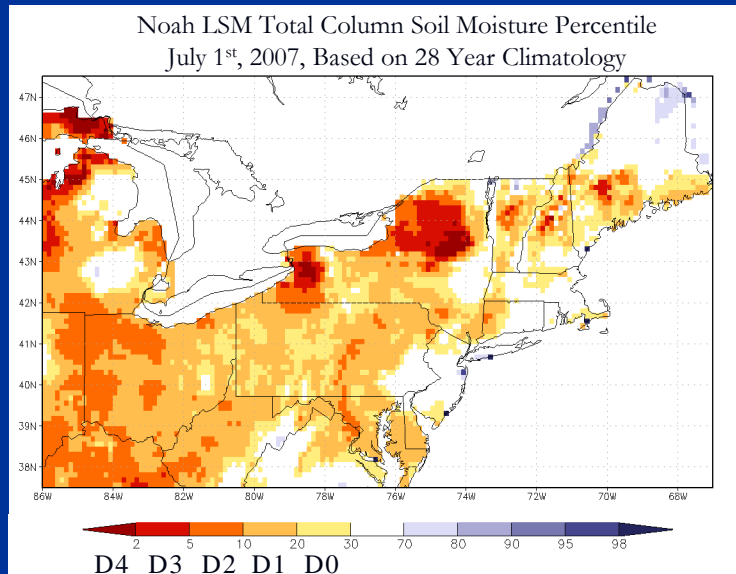
- Use of new forcing data set over same 10 year time period leads to large changes in drought



# Impact of Model Choice

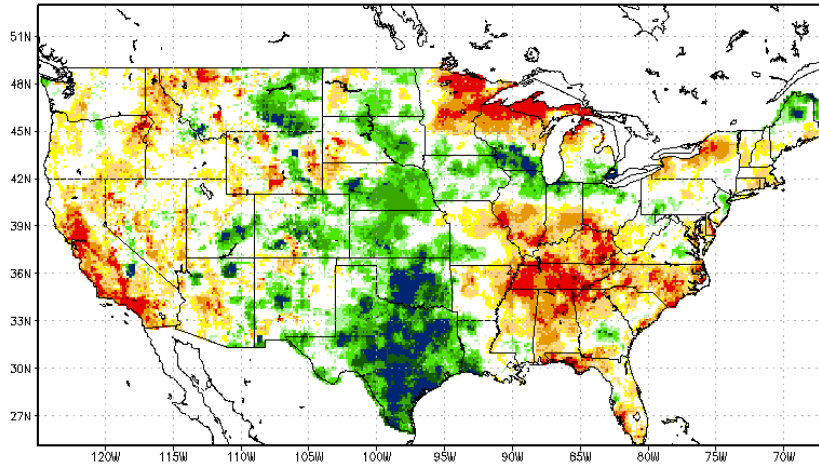


- Choice of land surface model can greatly influence depiction of drought severity due to differences in model physics and parameterizations

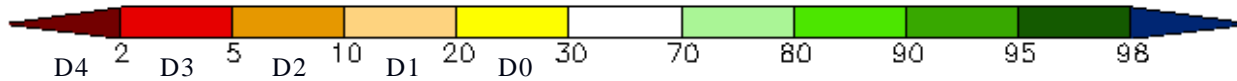
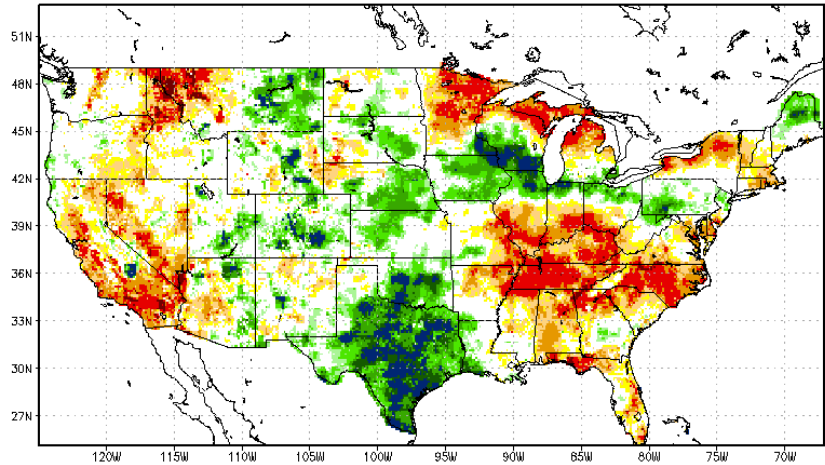


# Drought Monitoring Comparison

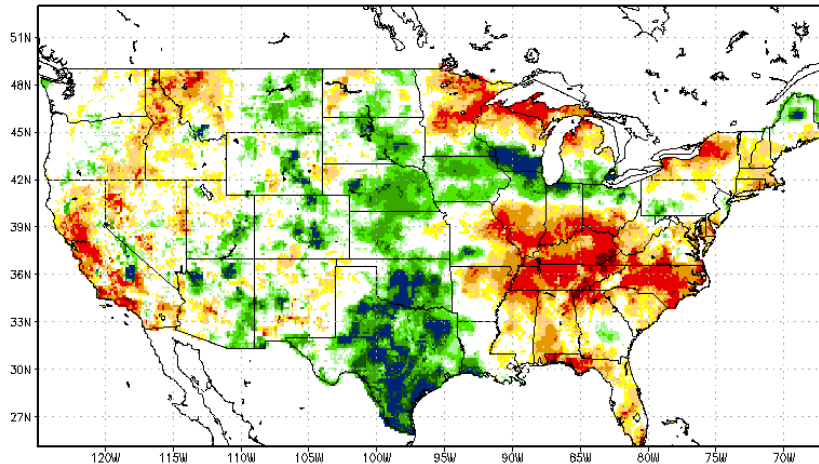
Mosaic – Total Column Soil Moisture Percentile  
Valid: 20070901



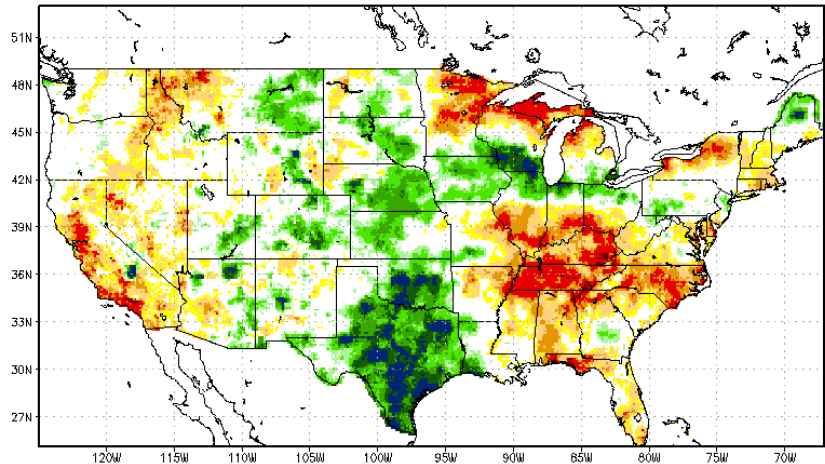
Noah – Total Column Soil Moisture Percentile  
Valid: 20070901



SAC – Total Column Soil Moisture Percentile  
Valid: 20070901

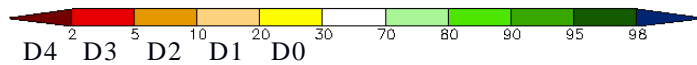
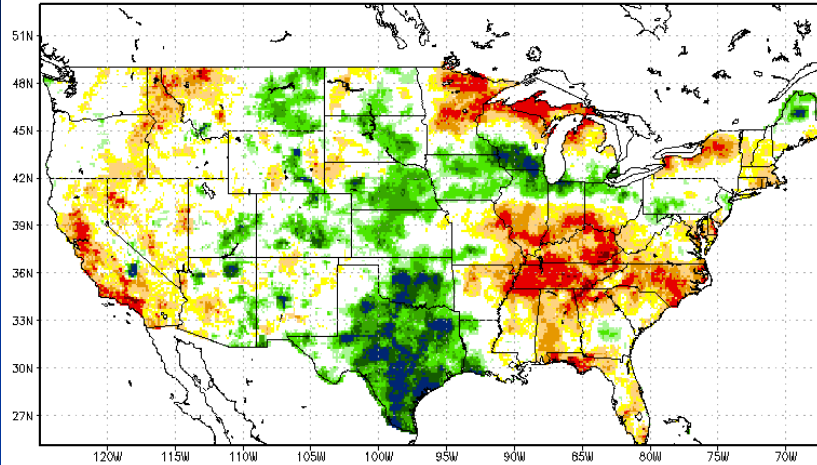


Ens. Mean – Total Column Soil Moisture Percentile  
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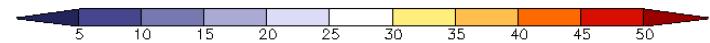
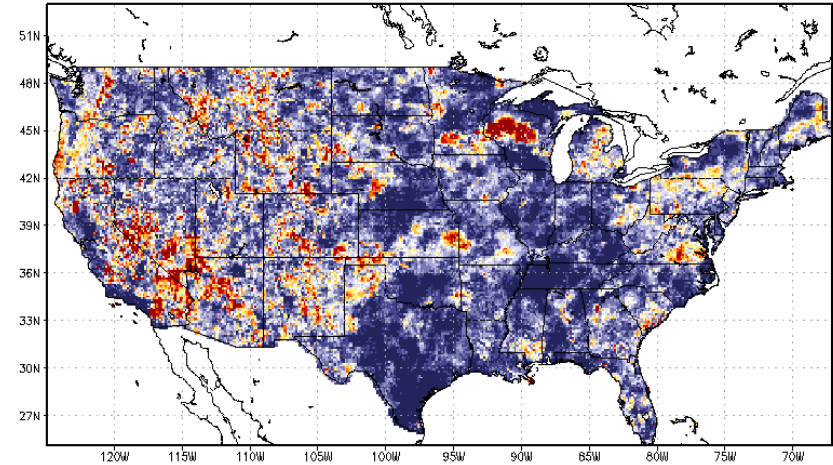


# Drought Monitoring Comparison

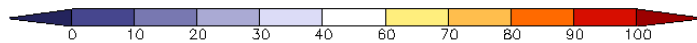
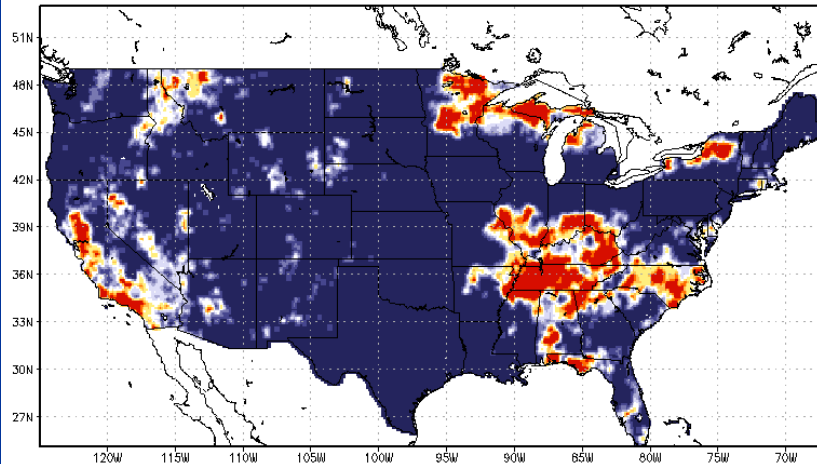
Ens. Mean – Total Column Soil Moisture Percentile  
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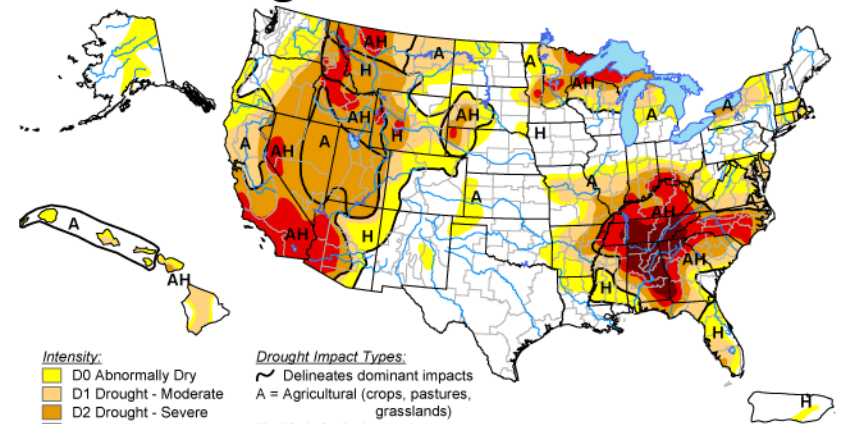
Ens. Spread – Total Column Soil Moisture Percentile  
Valid: 20070901



Probability of Severe Drought (D2)  
Valid: 20070901



**U.S. Drought Monitor** September 4, 2007  
Valid 8 a.m. EDT



**Intensity:**

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

**Drought Impact Types:**

- Delineates dominant impacts
- A = Agricultural (crops, pastures, grasslands)
- H = Hydrological (water)

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

<http://drought.unl.edu/dm>

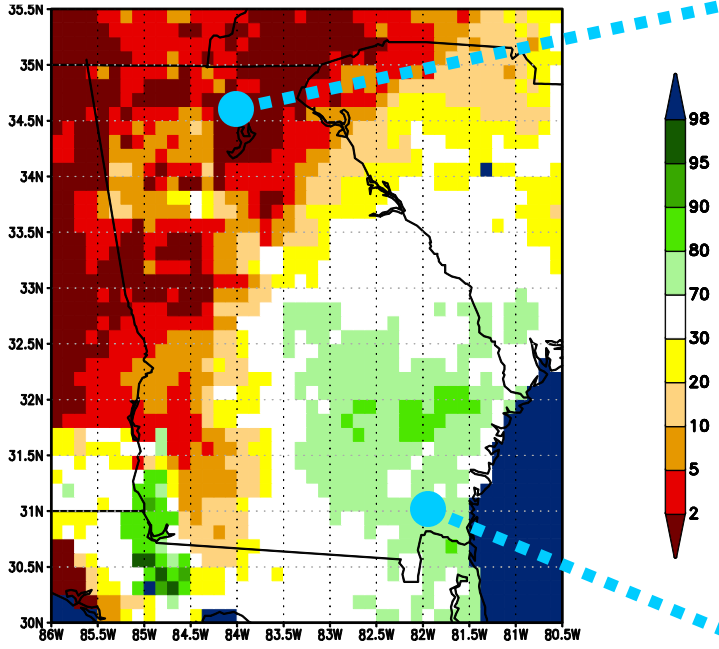


Released Thursday, September 6, 2007  
Author: Thomas Heddinghaus, CPC/NOAA

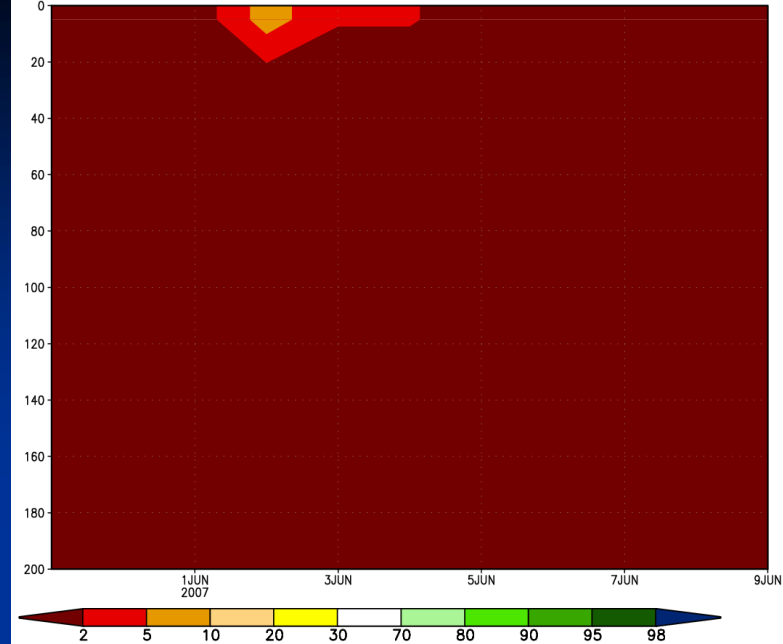
# Mosaic LSM

## Time and Depth Cross Section of Drought Severity

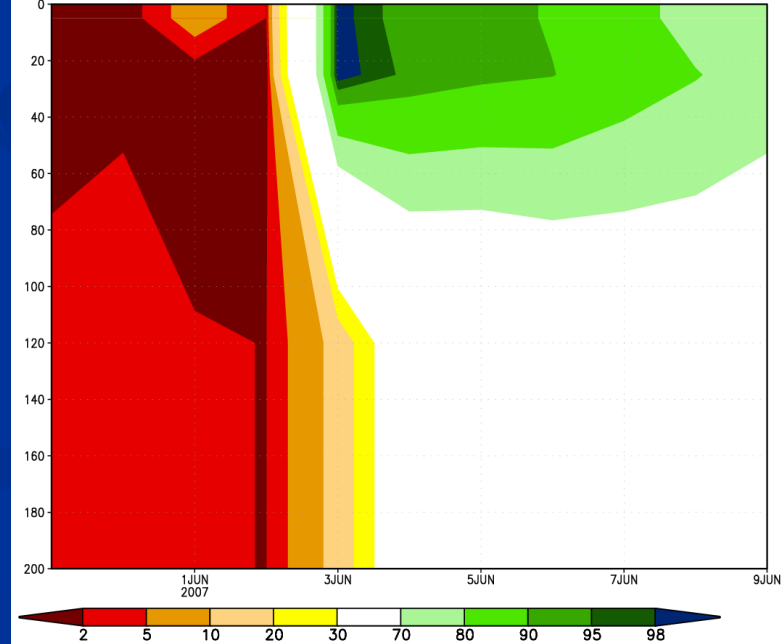
Mosaic Layer 1 Soil Moisture Percentile, 6/9/07



Mosaic Soil Moisture Percentile (% , 34.6N, 84W)



Mosaic Soil Moisture Percentile (% , 31N, 82W)

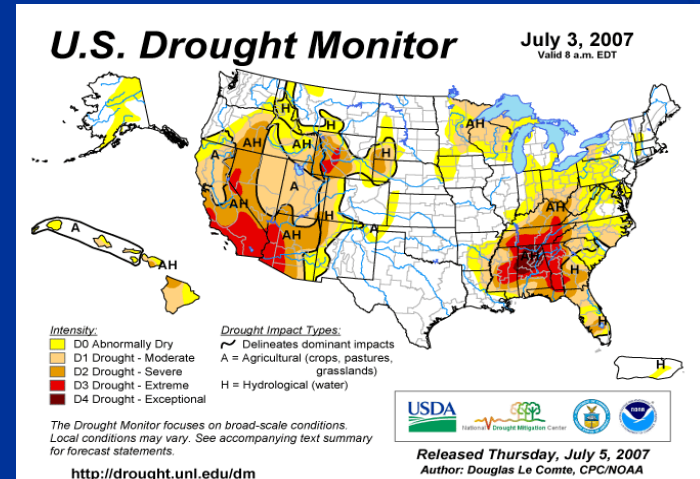
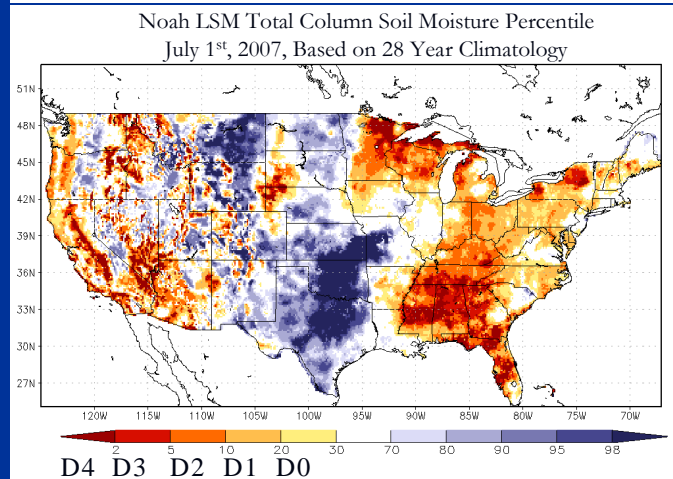
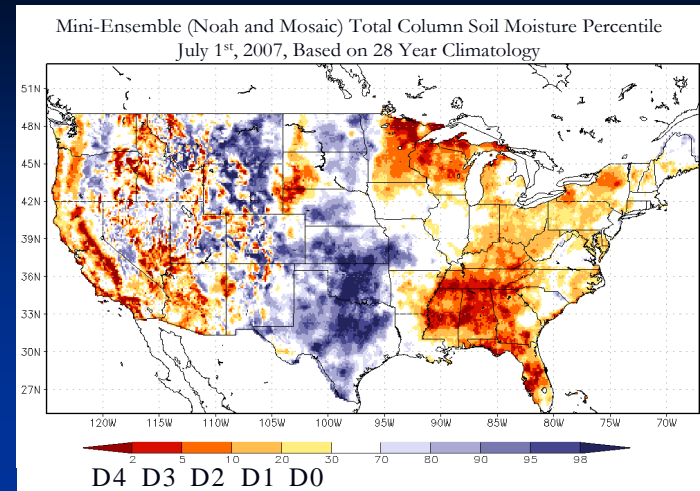
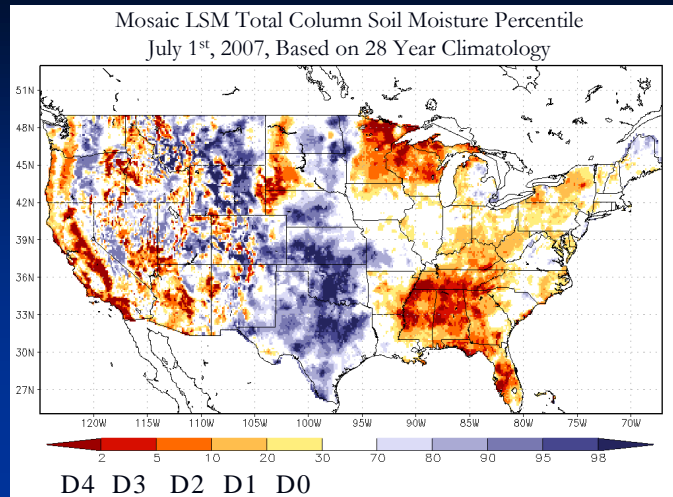


# Conclusions

- 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



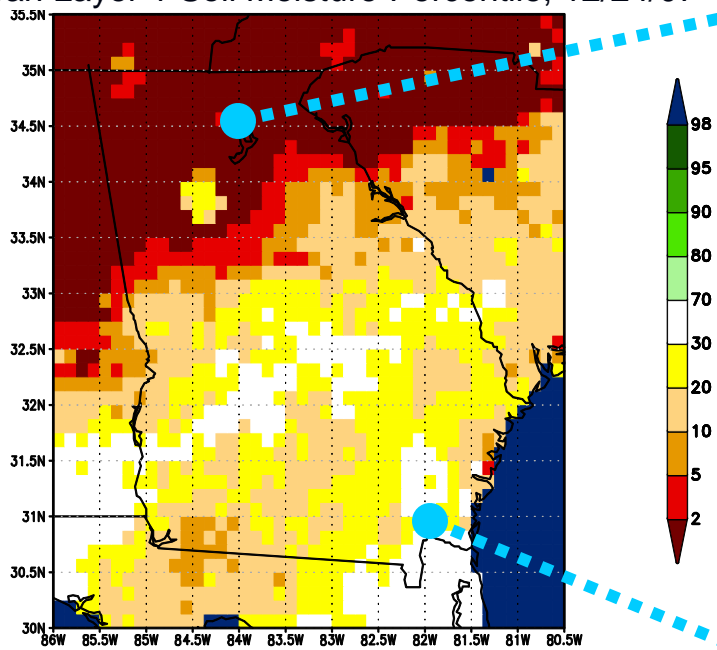
- Soil moisture percentiles from each LSM combined to form ensemble mean percentile map
- Project will eventually use Mosaic, Noah, VIC, Sacramento, CLM3, HySSiB, and Catchment models with a variety of lineages (climate modeling, weather forecasting, hydrological)
- Ensembles often offer more accurate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



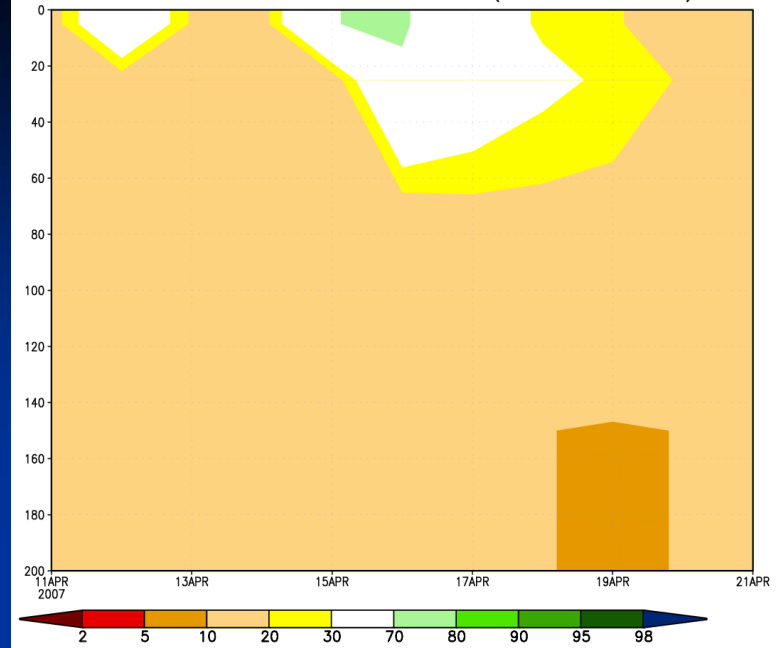
# Noah LSM

## Time and Depth Cross Section of Drought Severity

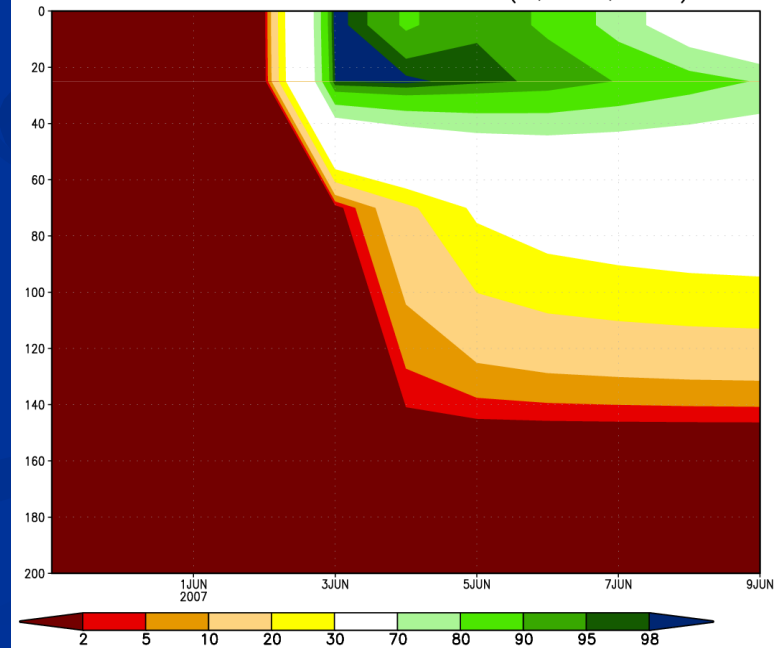
Noah Layer 1 Soil Moisture Percentile, 12/24/07



Noah Soil Moisture Percentile (% , 34.6N, 84W)



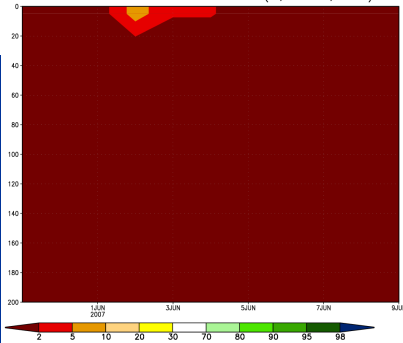
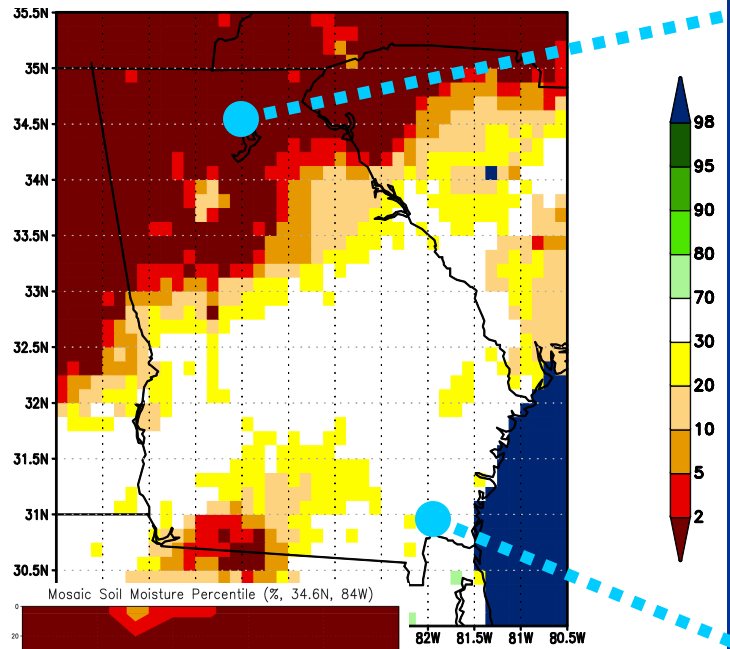
Noah Soil Moisture Percentile (% , 31N, 82W)



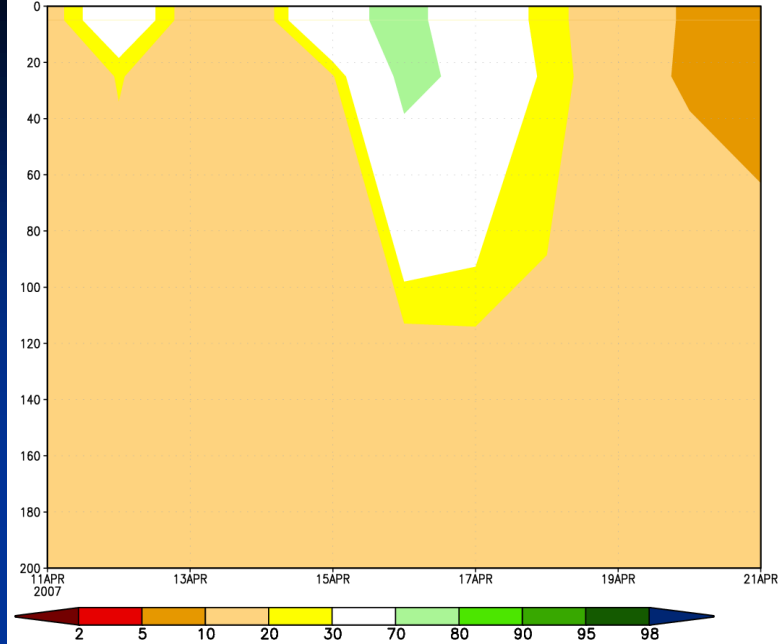
# Mosaic LSM

## Time and Depth Cross Section of Drought Severity

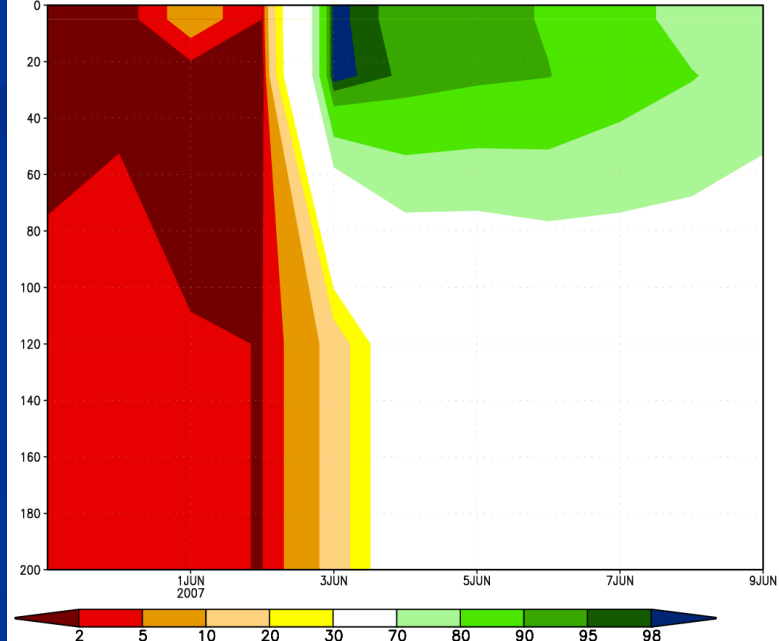
Mosaic Layer 1 Soil Moisture Percentile, 12/24/07



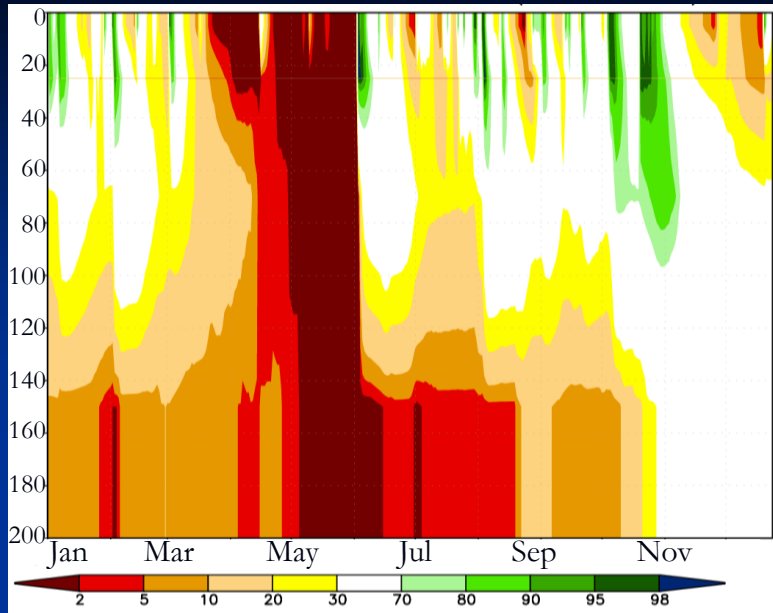
Mosaic Soil Moisture Percentile (% , 34.6N, 84W)



Mosaic Soil Moisture Percentile (% , 31N, 82W)

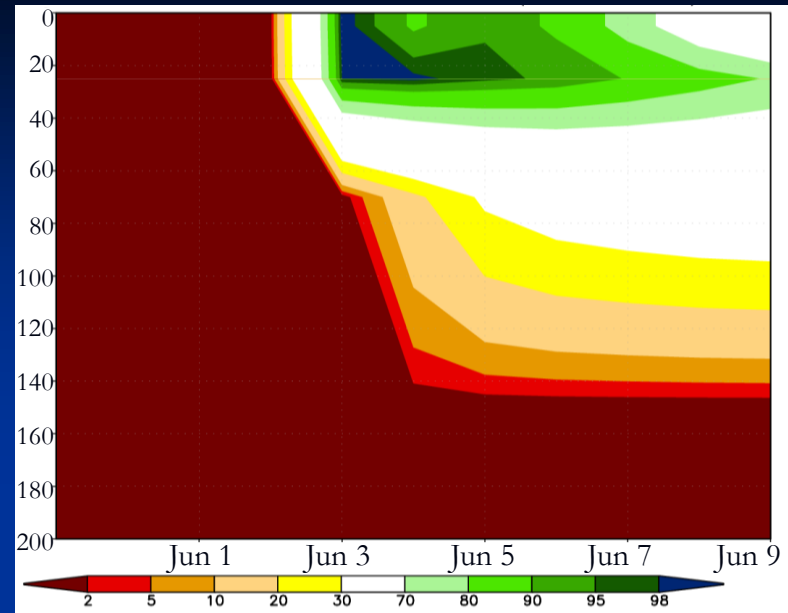


# Time and Depth (cm) Cross Section of Drought Severity (Soil Moisture Percentile)

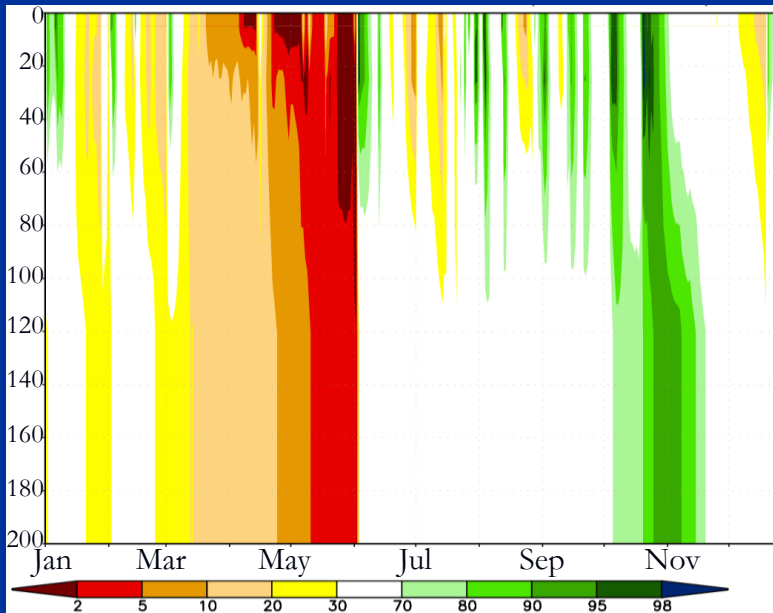


-Noah LSM-

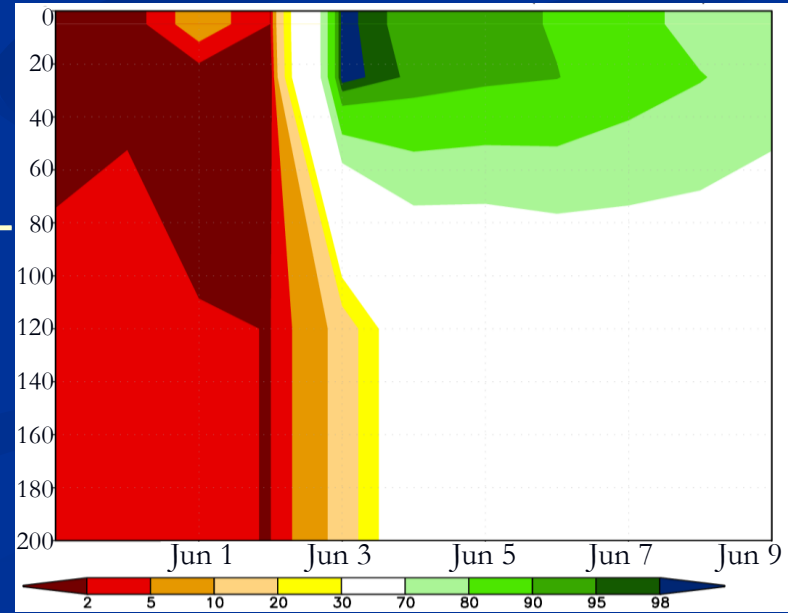
January to December 2007



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

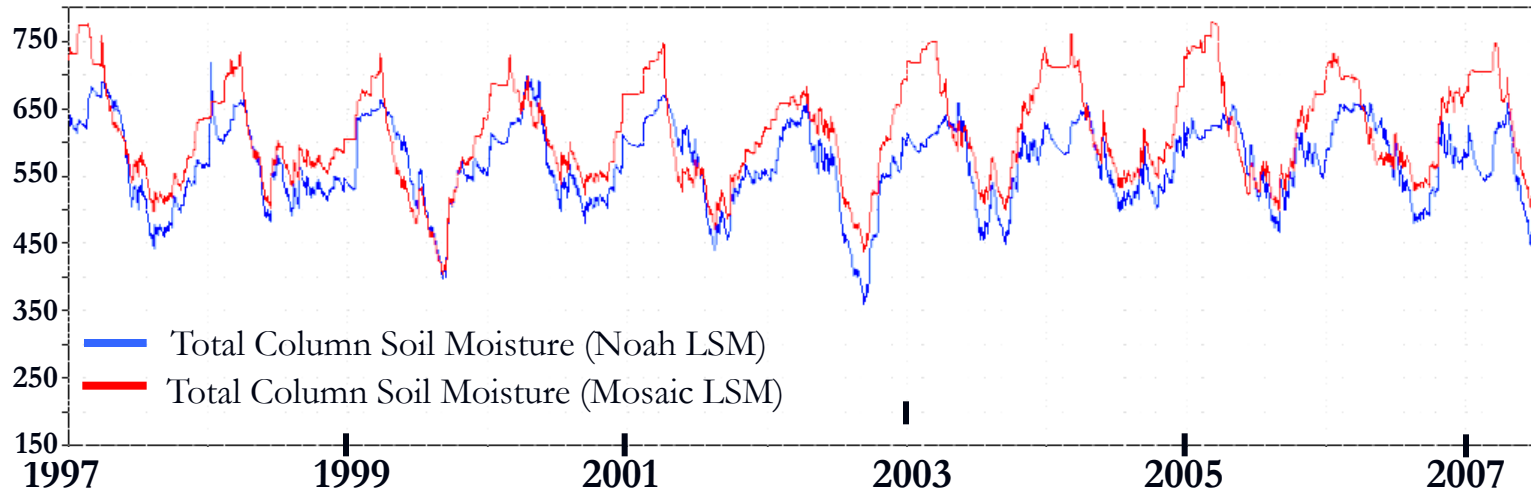
- Execute and validate 1/8th degree 28 year-long ensemble runs using Noah, CLM3, and NASA's Mosaic, HySSiB, and Catchment LSMs within NASA's Land Information System (LIS) modeling framework

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

LSM Total Column Soil Moisture (mm), Northern New York, 1997-2007



LSM Total Column Moisture Climatology (mm), Northern New York

