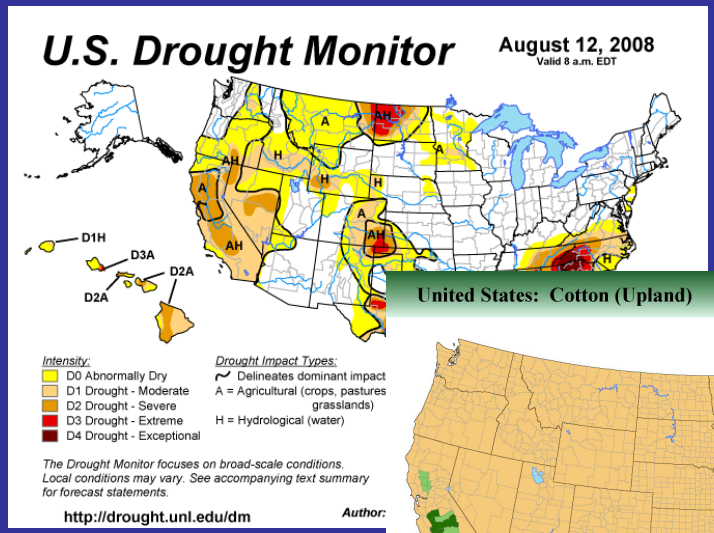
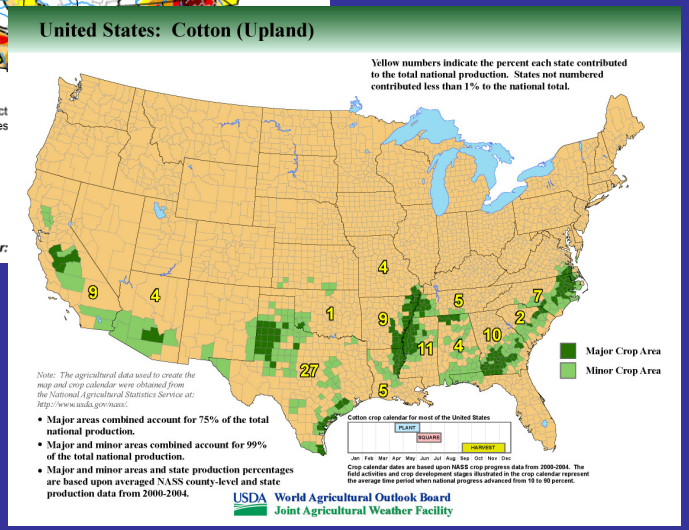
MONITORING AGRICULTURAL DROUGHT

U.S. Department of Agriculture Approach to Monitoring Drought Operationally





Raymond P. Motha
Chief Meteorologist
U.S. Department of Agriculture
Office of the Chief Economist
World Agricultural Outlook Board
Washington D.C., U.S.A.

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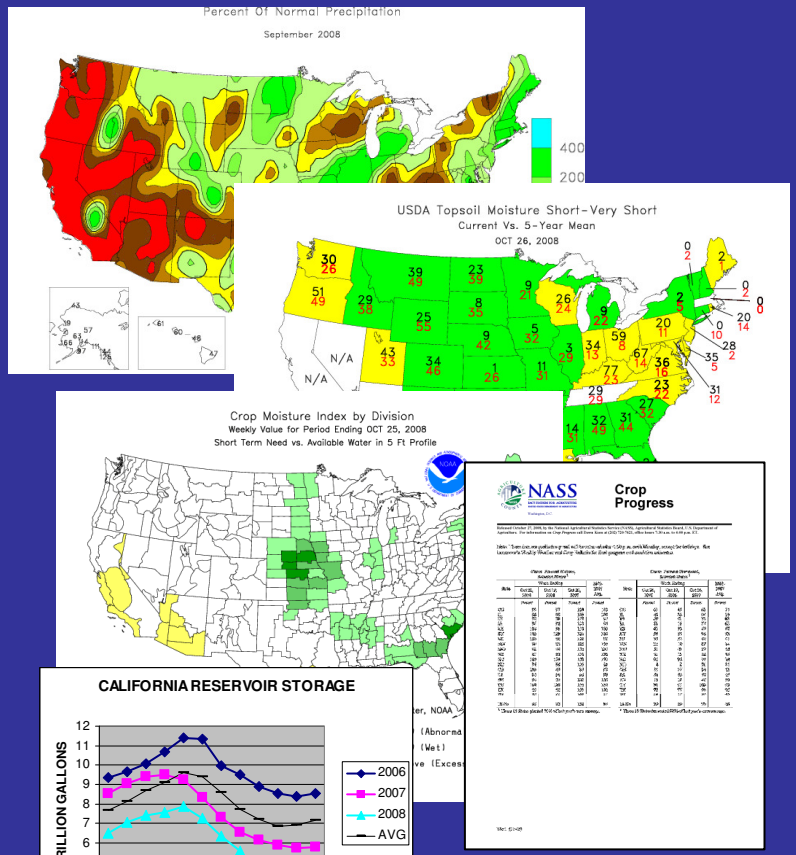
MONITORING AGRICULTURAL DROUGHT

USDA Drought Monitoring Activities



- First Alert Monitoring and Assessment Program (JAWF)
- Crop Modeling Program (ARS)
- In support of World Supply and Demand Estimates (WASDE) Report (USDA/WAOB)

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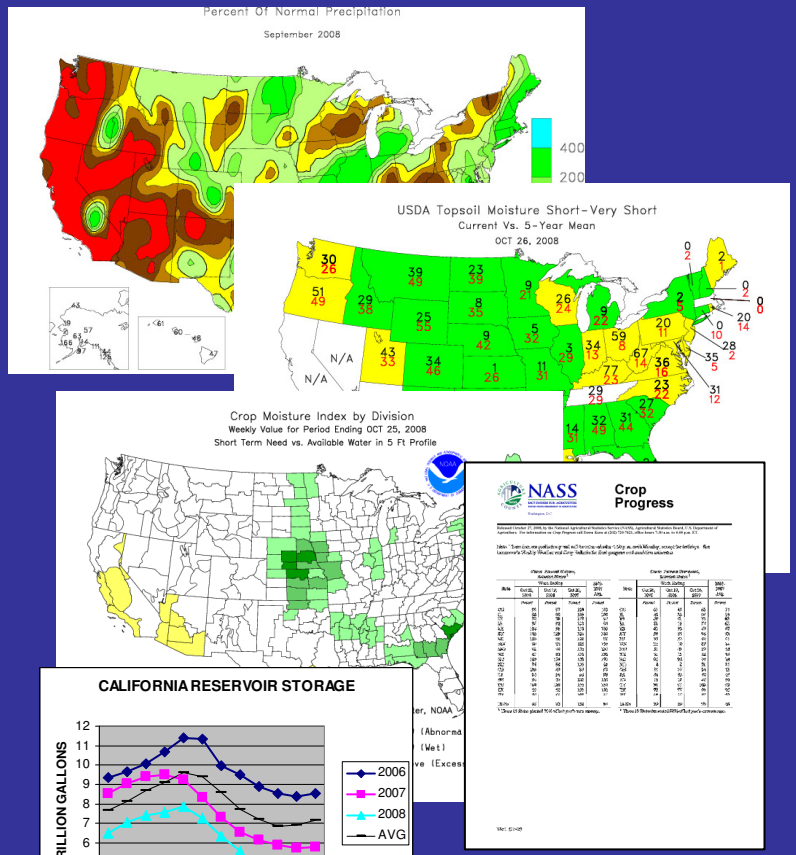
MONITORING AGRICULTURAL DROUGHT

USDA Drought Monitoring Activities



- **Historically, USDA has relied on many products to help identify drought areas**
  - **rainfall & temperature observations**
  - **drought indices (e.g., PDSI, CMI, SPI)**
  - **soil moisture measurements/models**
  - **reservoir/river levels**
  - **crop progress/condition reports**
  - **U.S. Drought Monitor (USDM)**

- **Case Study – Drought impact on Georgia cotton production in 2008**

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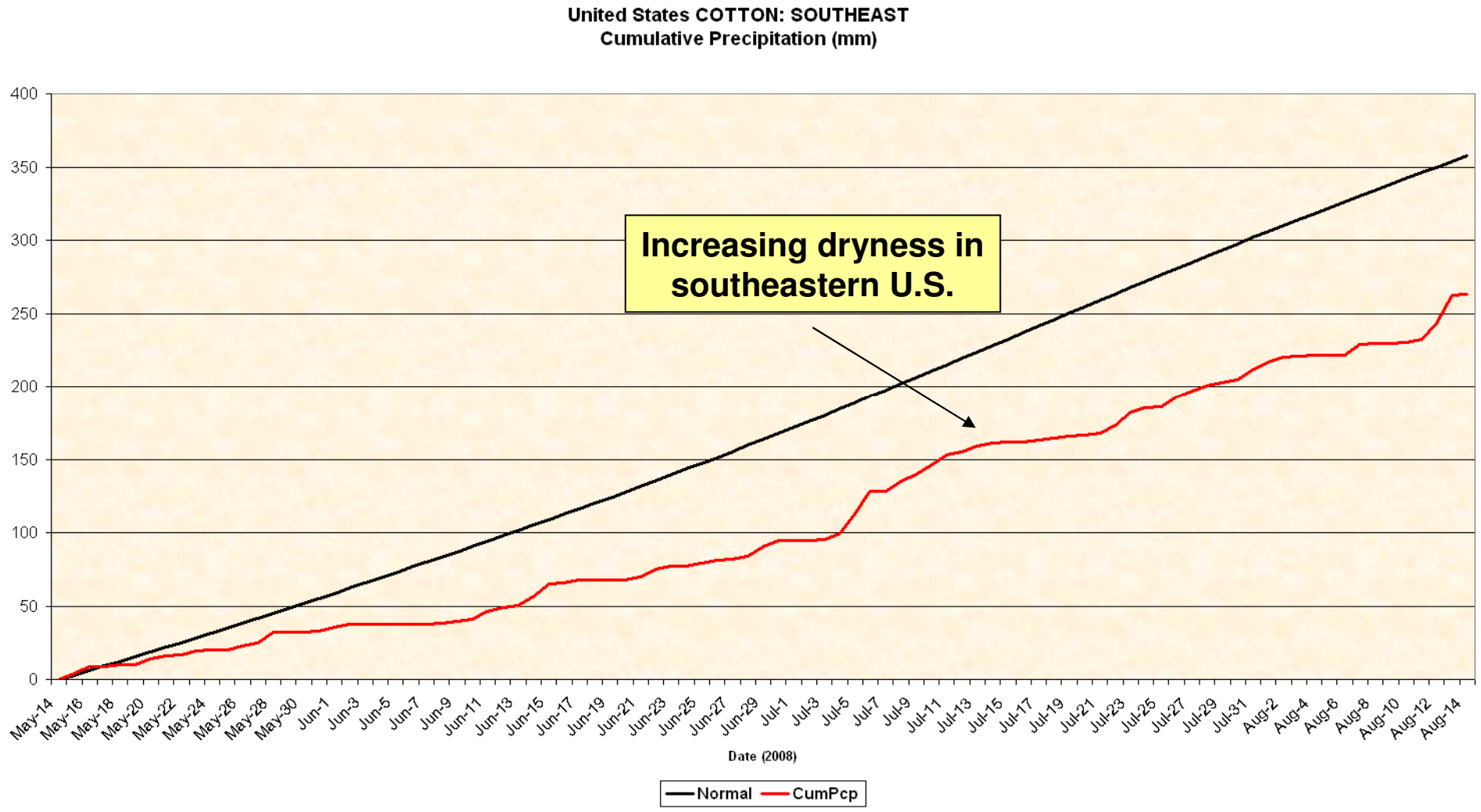
Time Series Analysis – Precipitation



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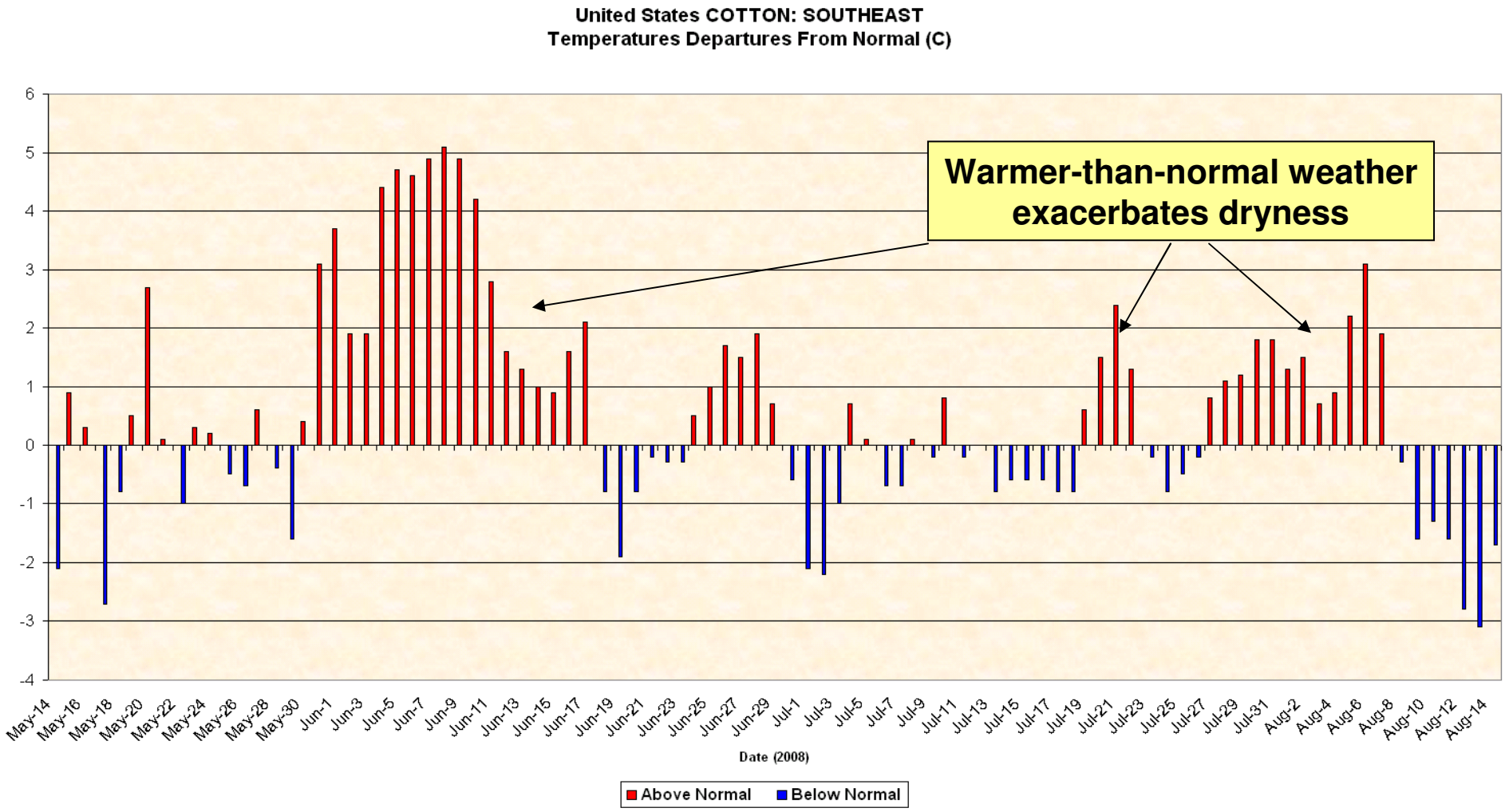
Time Series Analysis – Temperature



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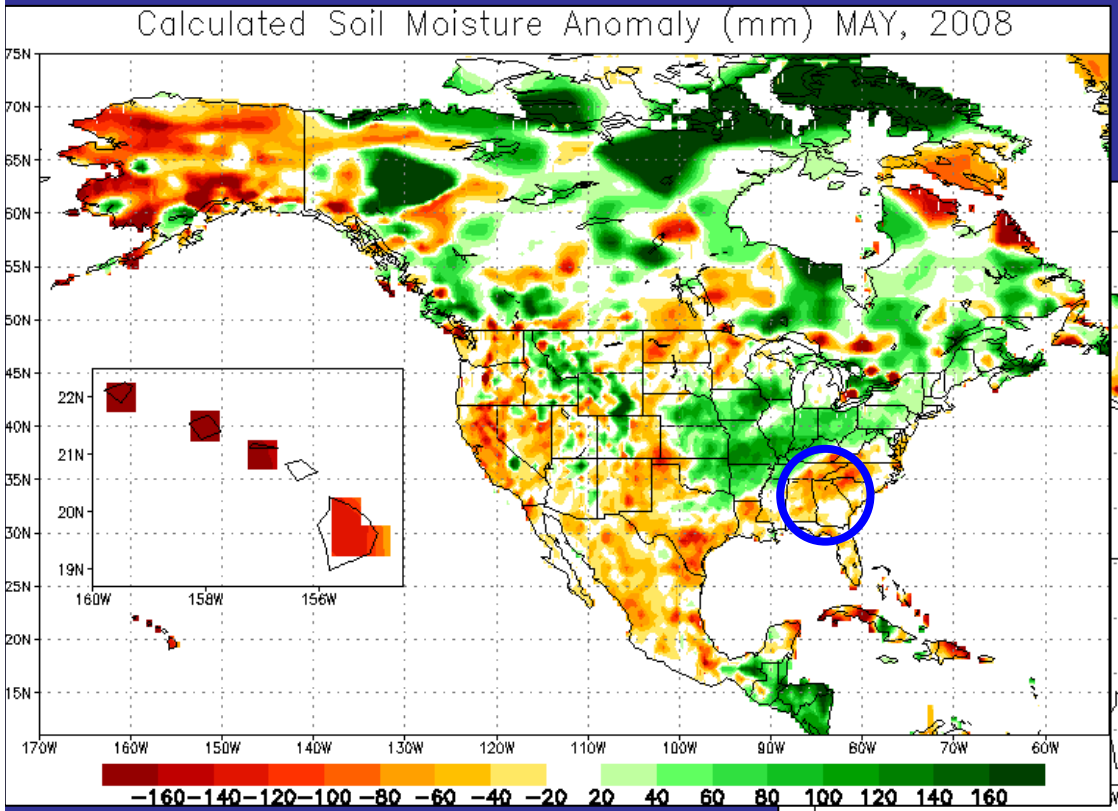
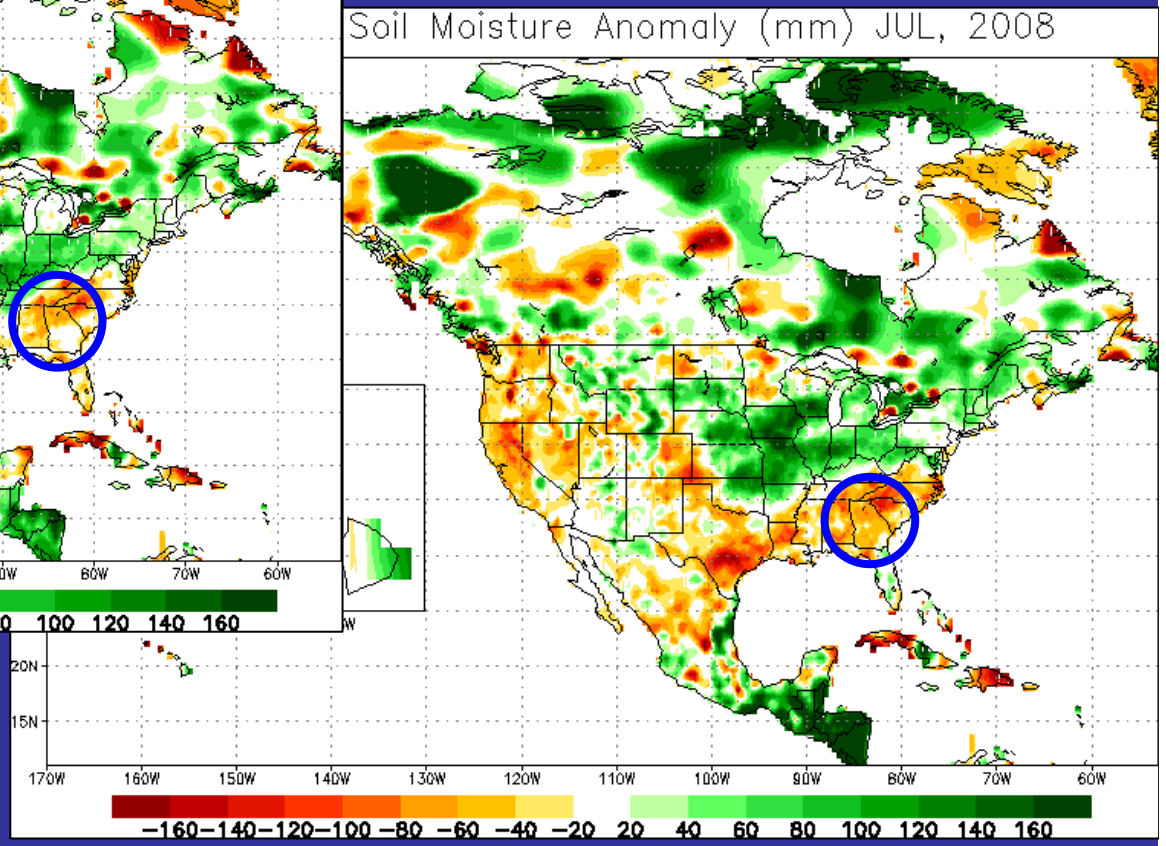
CPC Soil Moisture Model



Soil moisture declining, as evidenced by increasing soil moisture anomalies



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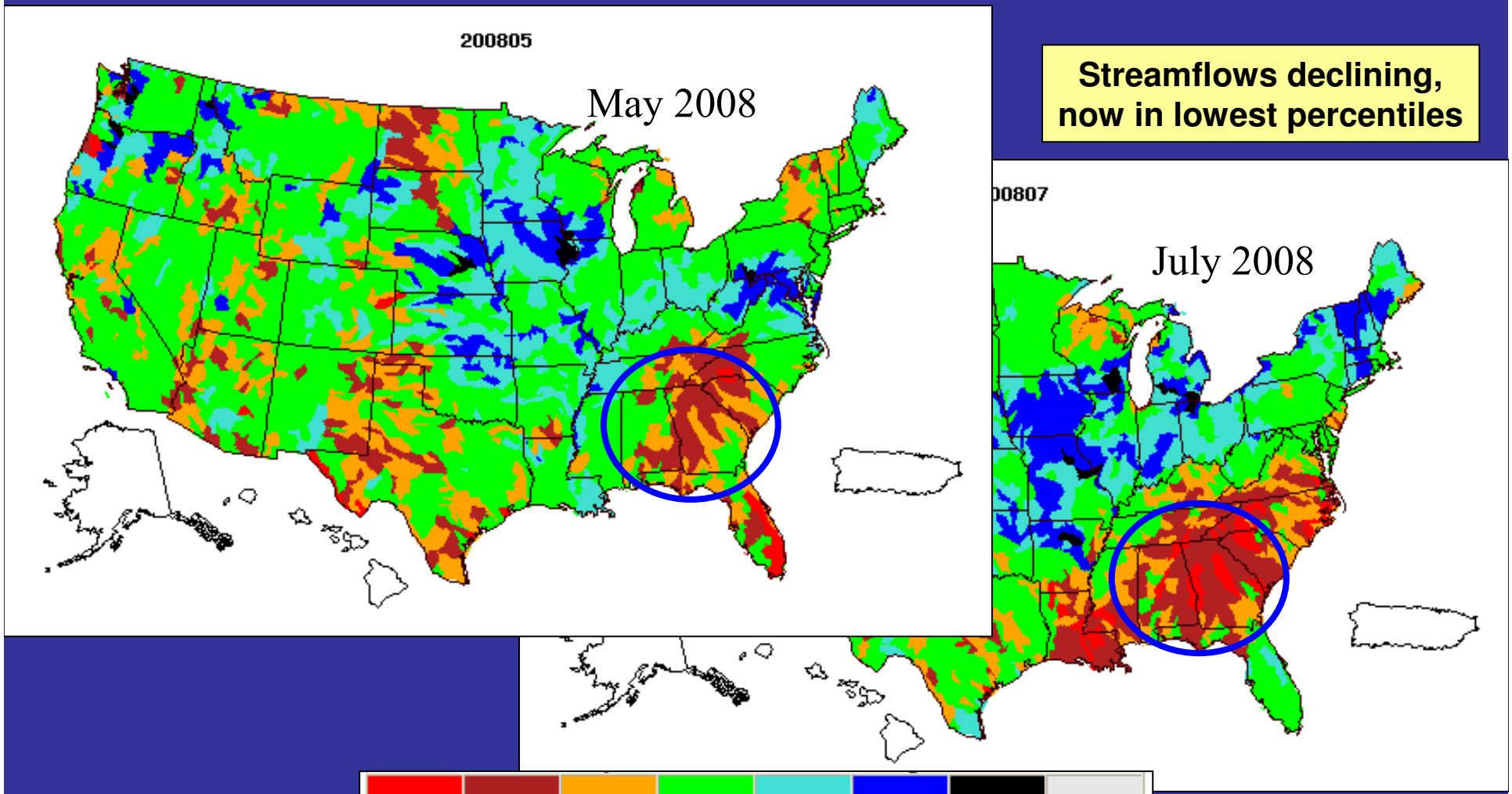
USGS Streamflow Conditions – Computed Runoff



Streamflows declining, now in lowest percentiles

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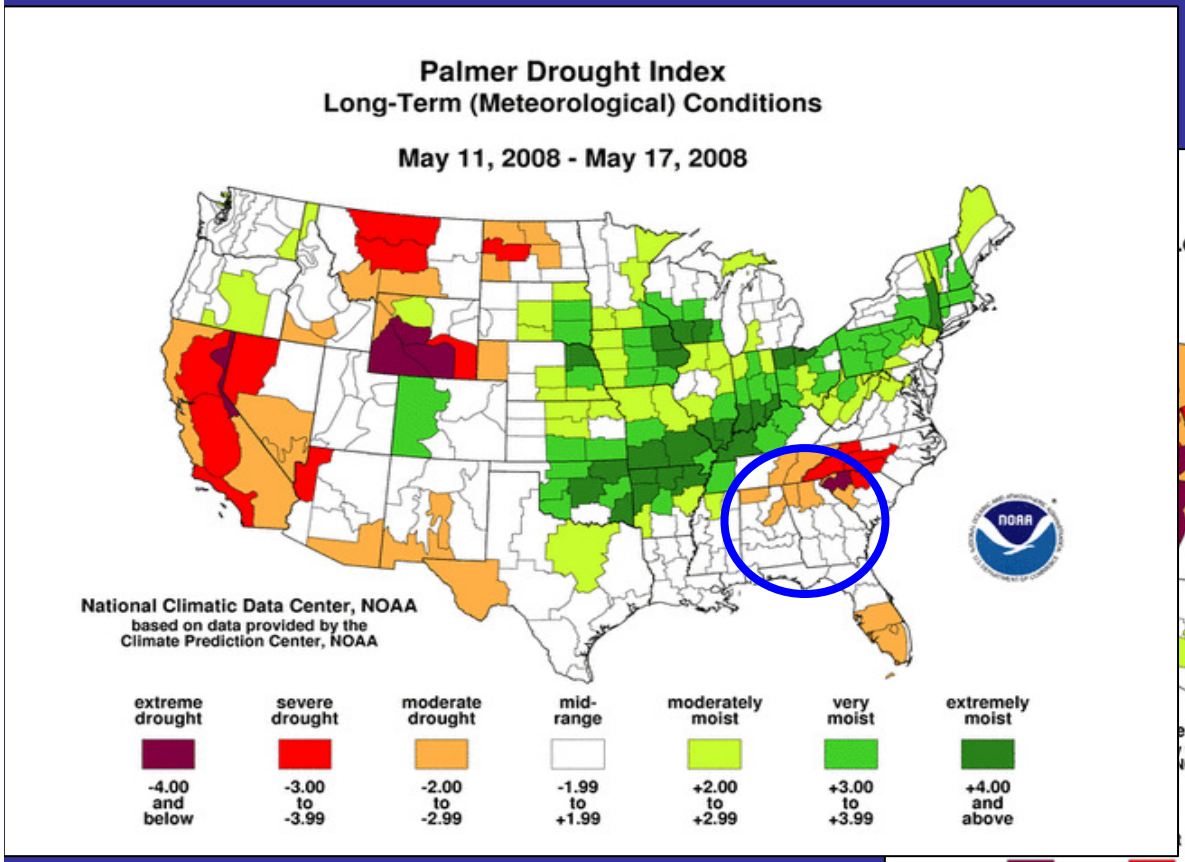
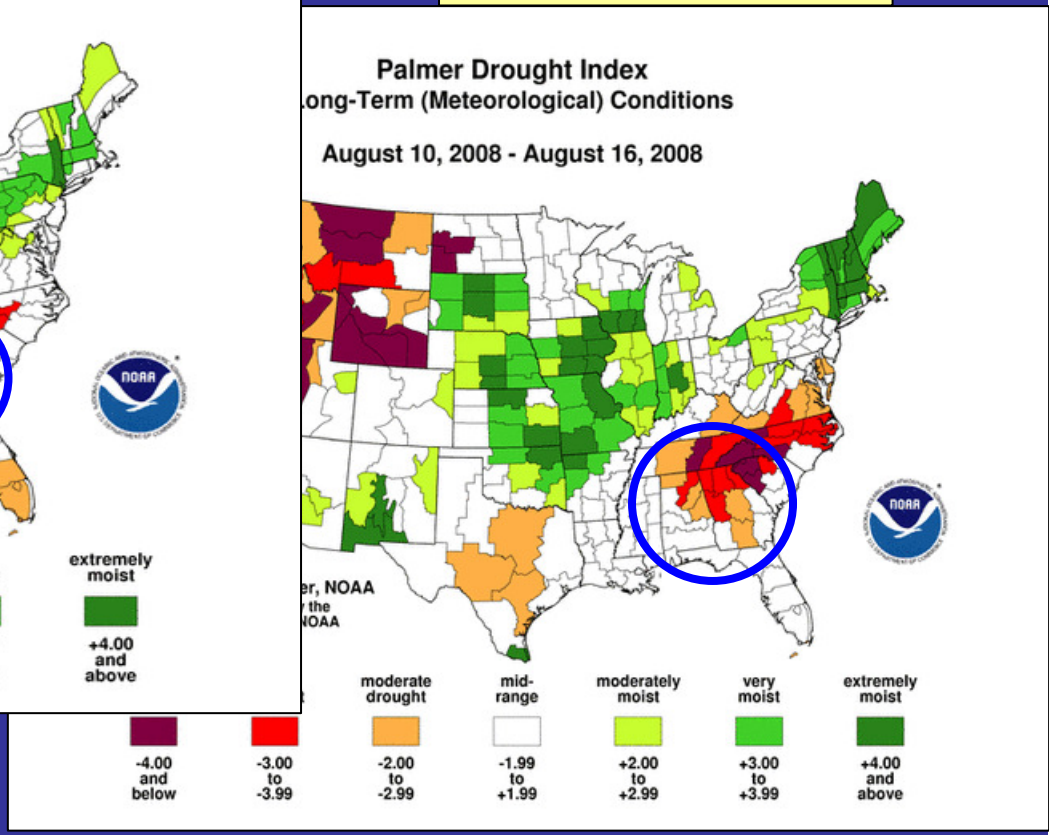
Palmer Drought Severity Index



PDSI indicates intensifying drought



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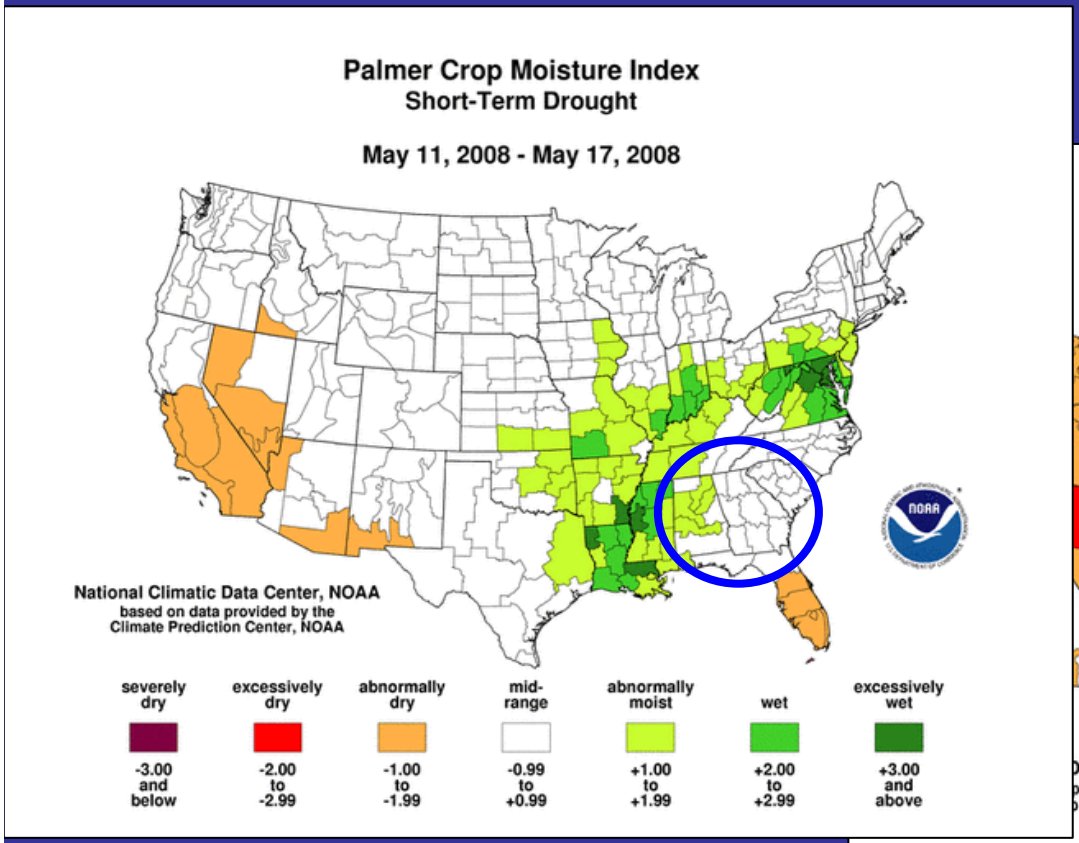
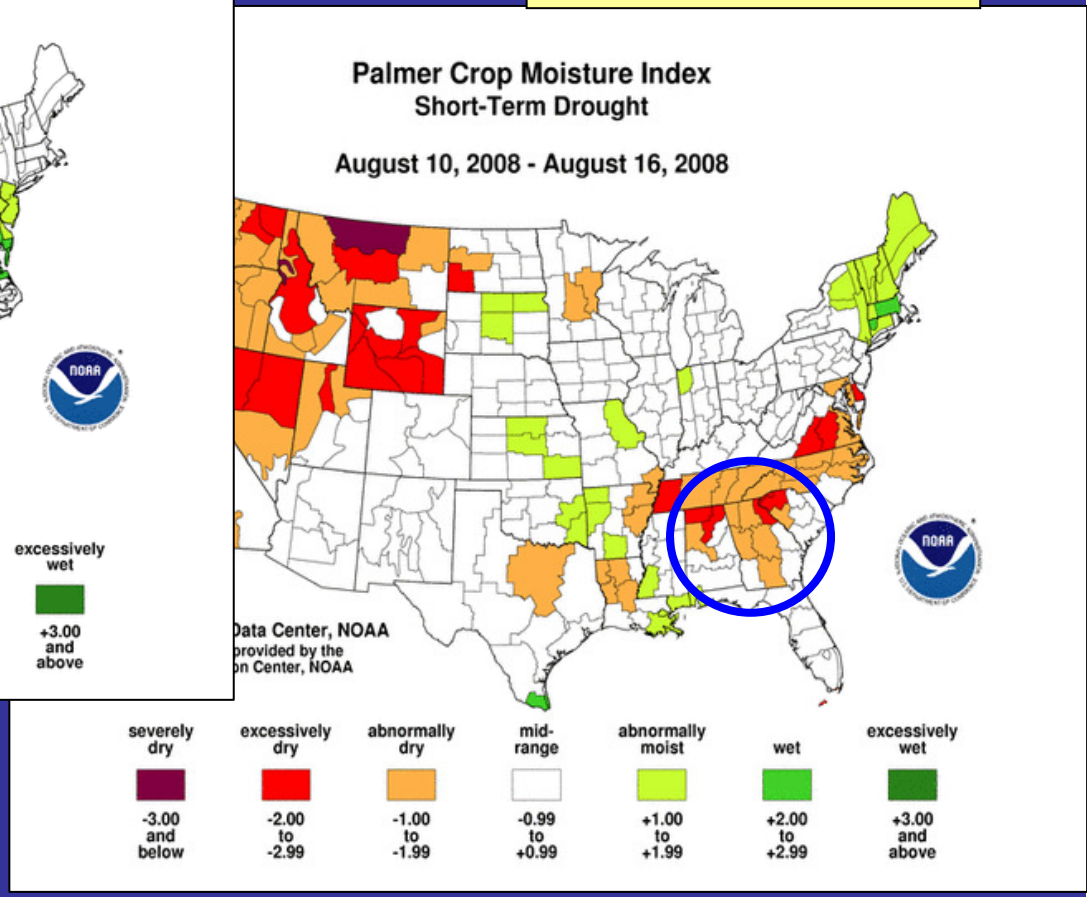
Crop Moisture Index



CMI also indicates intensifying drought



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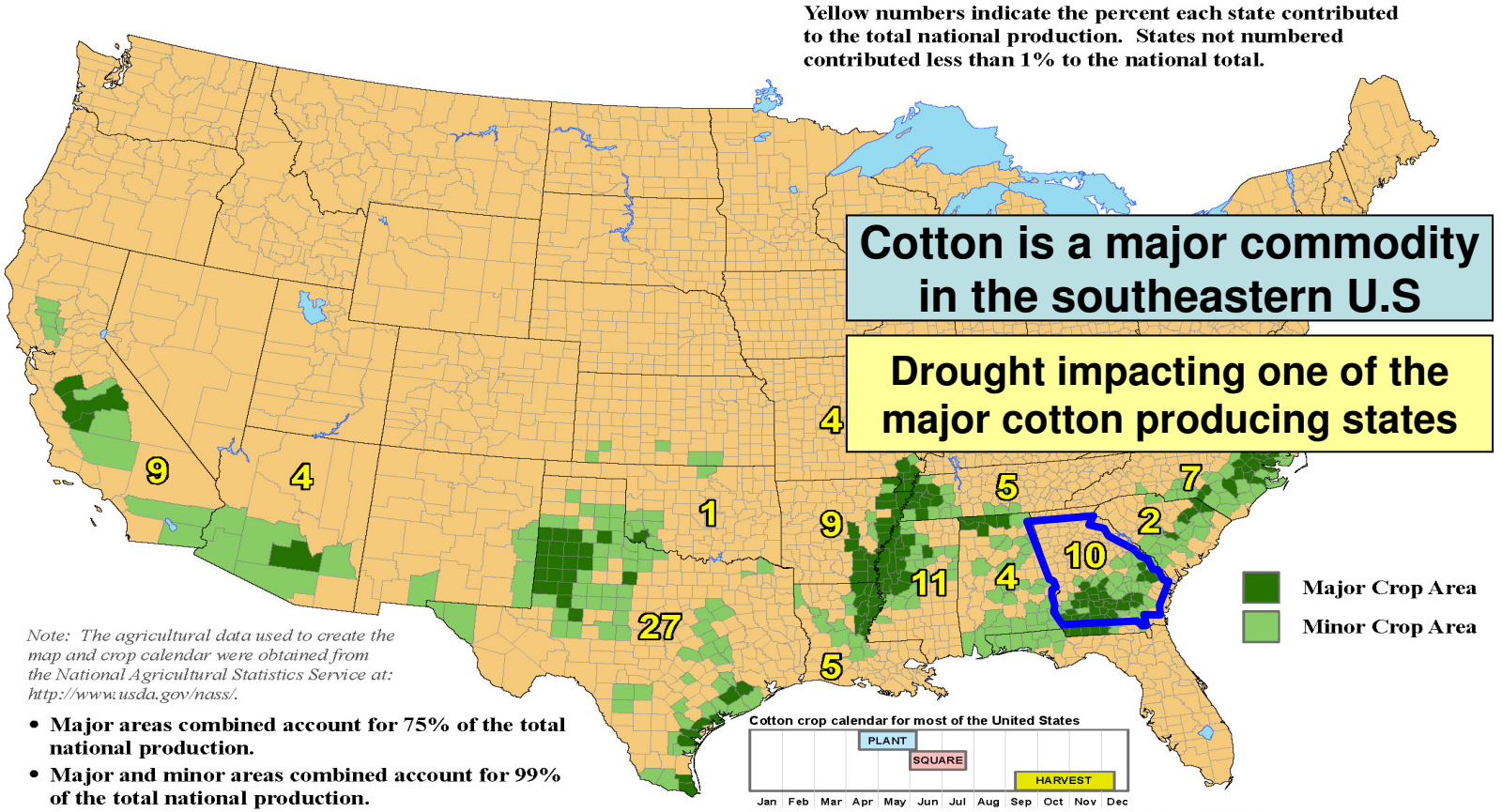
MONITORING AGRICULTURAL DROUGHT

U.S. Cotton Map – Georgia

United States: Cotton (Upland)



Note: The agricultural data used to create the map and crop calendar were obtained from the National Agricultural Statistics Service at: http://www.usda.gov/nass/.

- **Major areas combined account for 75% of the total national production.**
- **Major and minor areas combined account for 99% of the total national production.**
- **Major and minor areas and state production percentages are based upon averaged NASS county-level and state production data from 2000-2004.**

Crop calendar dates are based upon NASS crop progress data from 2000-2004. The field activities and crop development stages illustrated in the crop calendar represent the average time period when national progress advanced from 10 to 90 percent.

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Joint Agricultural Weather Facility

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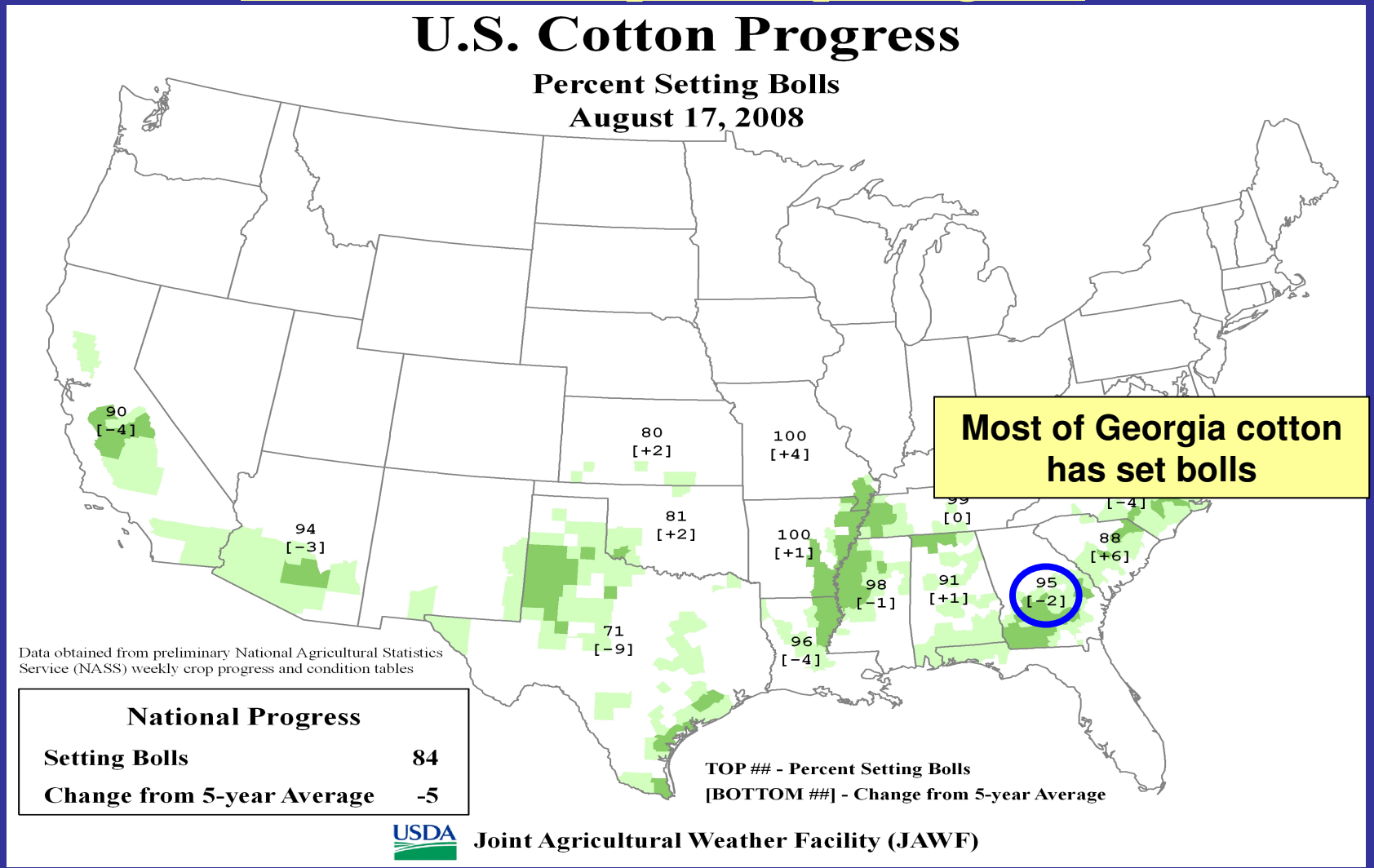
U.S. Cotton Map – Crop Progress



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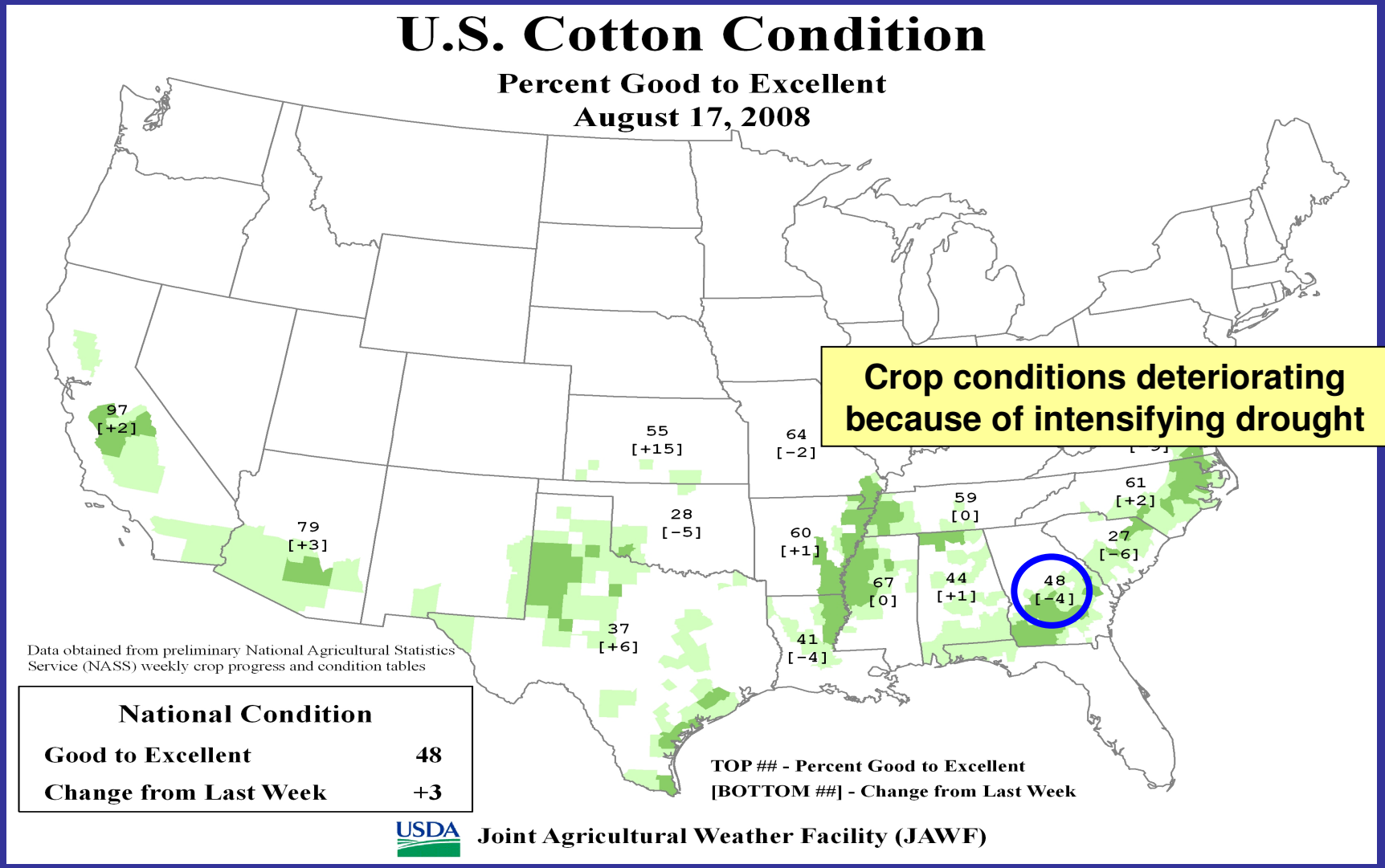
U.S. Cotton Map – Crop Conditions



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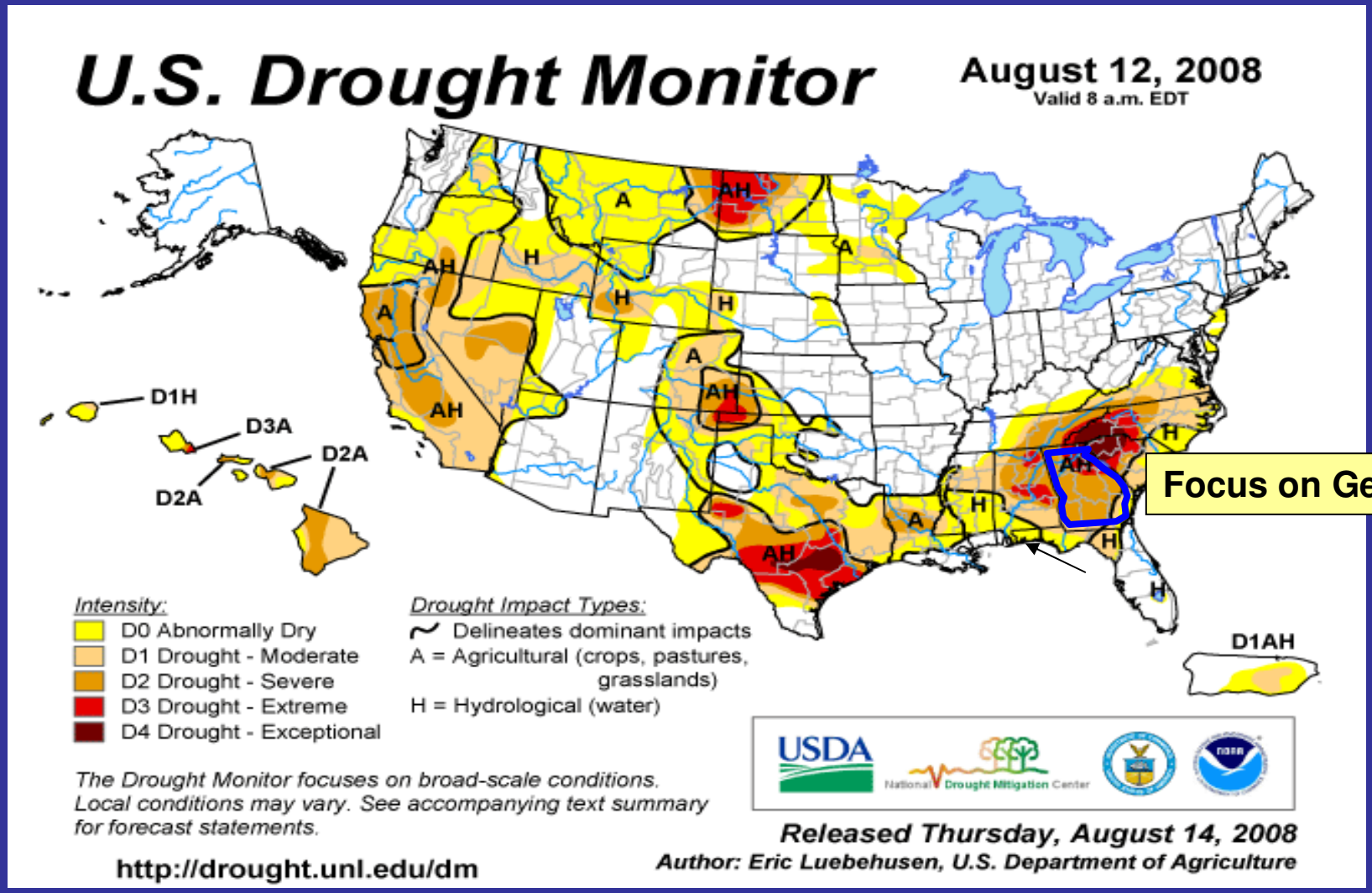
USDM 12 August 2008



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MONITORING AGRICULTURAL DROUGHT

Georgia – USDM 12 August 2008

U.S. Drought Monitor

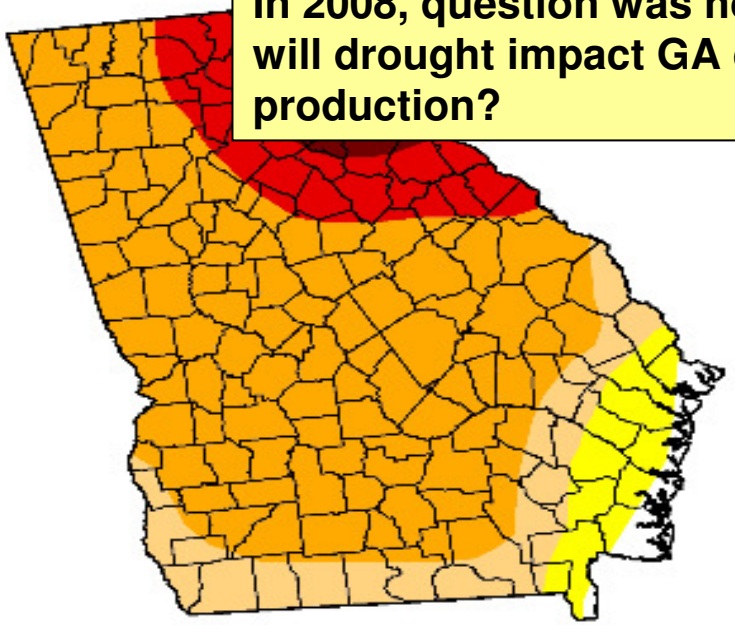
Georgia

August 12, 2008
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	2.0	98.0	91.7	79.0	17.1	6.2
Last Week (08/05/2008 map)	2.0	98.0	87.2	69.7	15.5	6.2
3 Months Ago (05/20/2008 map)	17.8	82.2	43.2	29.9	3.2	0.0
Start of Calendar Year (01/01/2008 map)	2.0	98.0	75.0	65.2	49.4	15.7
Start of Water Year (10/02/2007 map)	24.2	75.8	64.2	52.6	39.4	27.0
One Year Ago (08/14/2007 map)	0.0	100.0	85.7	67.8	52.3	26.9

In 2008, question was how will drought impact GA cotton production?



Intensity:

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

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

http://drought.unl.edu/dm

USDA National Drought Mitigation Center

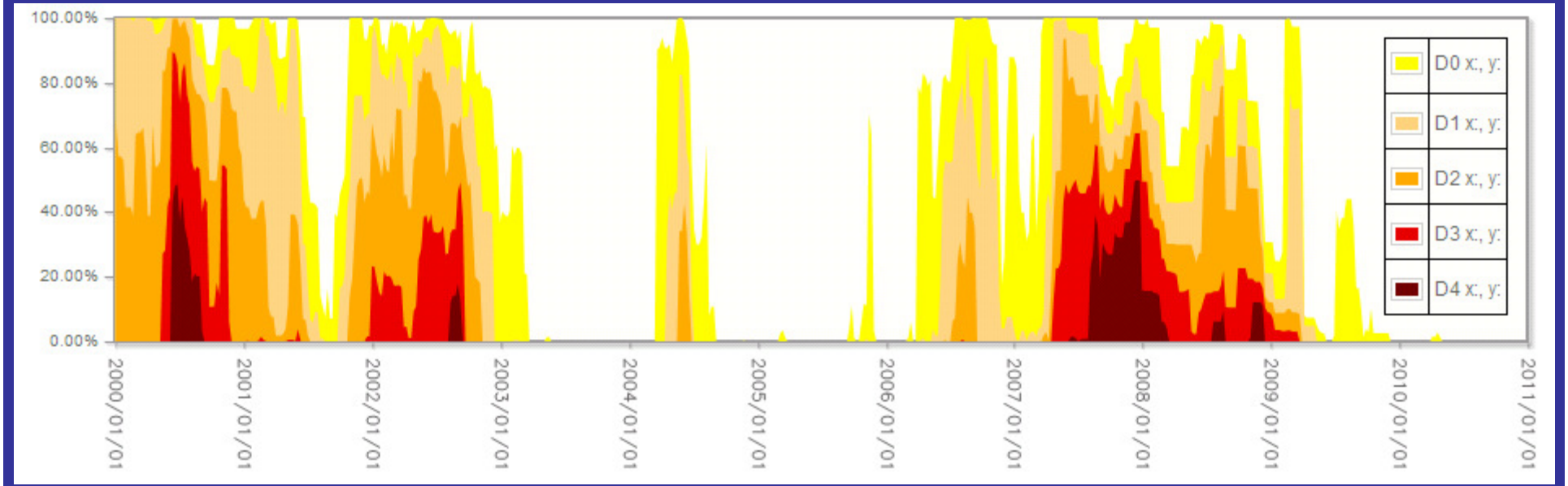
Released Thursday, August 14, 2008

Author: Eric Luebehusen, U.S. Department of Agriculture

MONITORING AGRICULTURAL DROUGHT

Georgia – USDM time series

Use time series to identify other drought years



Drought (2000)

Drought (2002)

Drought (2007)

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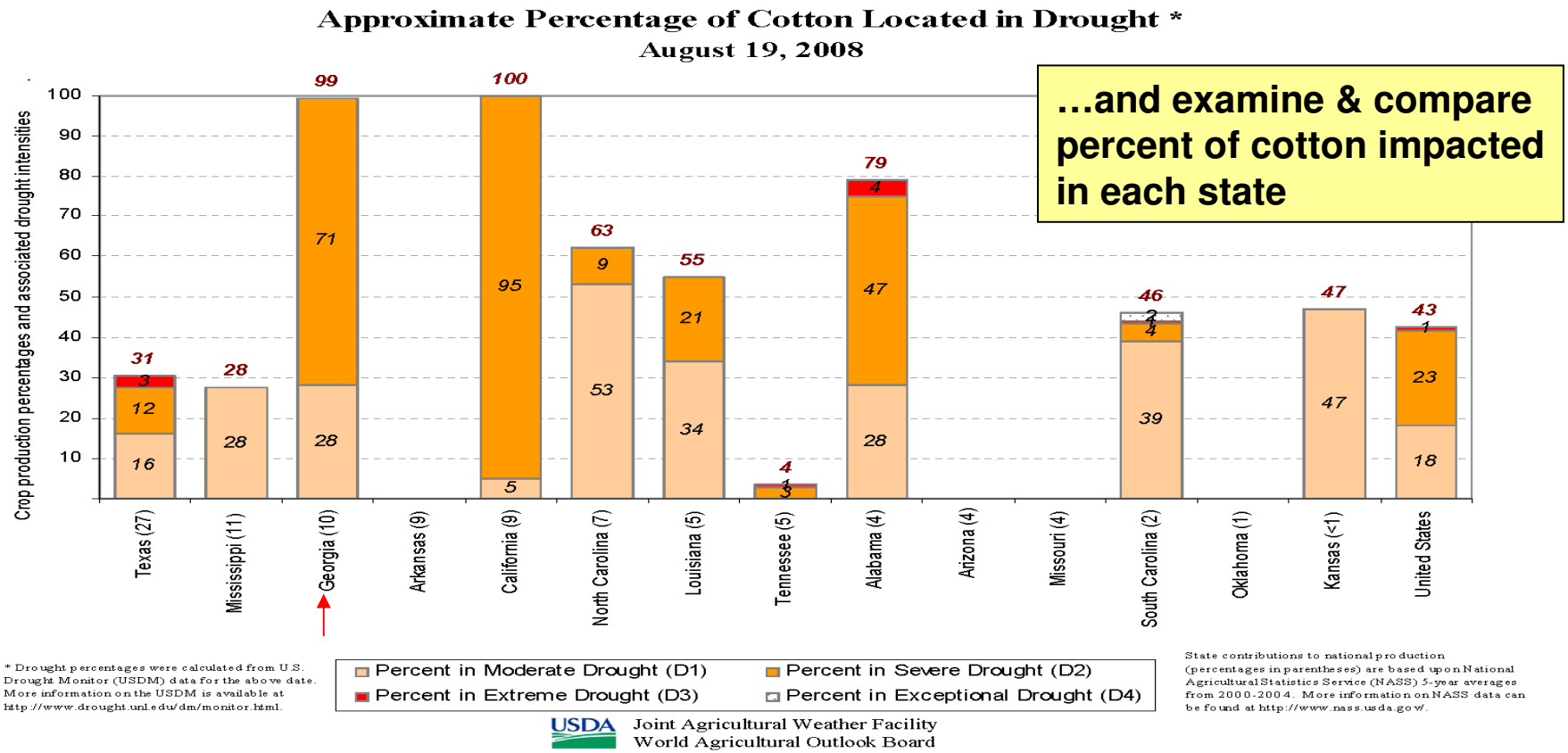
MONITORING AGRICULTURAL DROUGHT

Combining USDA & USDM Information

Can rank states from most to least productive based on crop statistics…



…and examine & compare percent of cotton impacted in each state

* Drought percentages were calculated from U.S. Drought Monitor (USDM) data for the above date. More information on the USDM is available at http://www.drought.unl.edu/dm/monitor.html.

State contributions to national production (percentages in parentheses) are based upon National Agricultural Statistics Service (NASS) 5-year averages from 2000-2004. More information on NASS data can be found at http://www.nass.usda.gov/.

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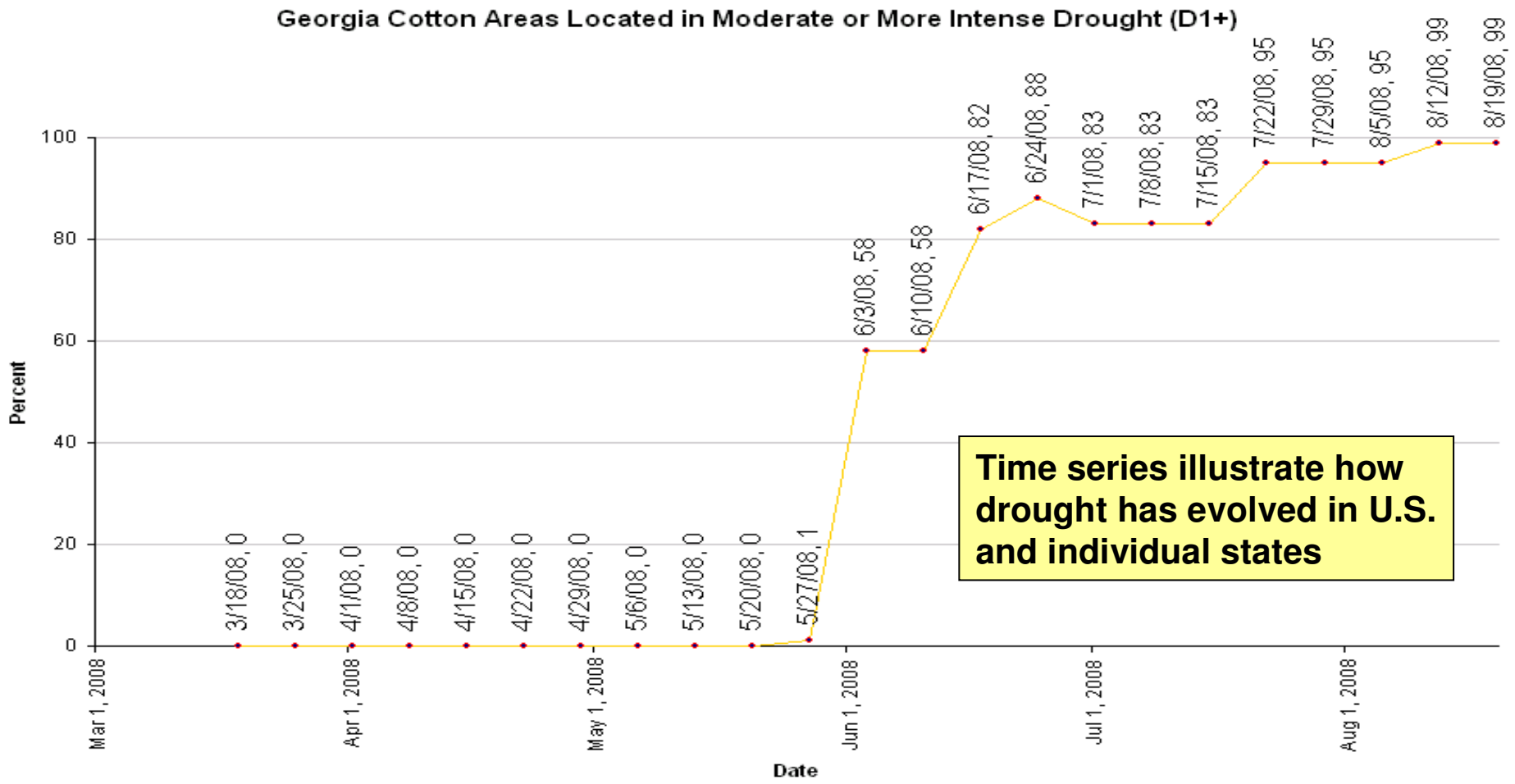
MONITORING AGRICULTURAL DROUGHT

Combining USDA & USDM Information



Time series illustrate how drought has evolved in U.S. and individual states

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Joint Agricultural Weather Facility

Drought Model Criteria

Redmond (1991)

- ***Robustness***: **Usefulness over a wide range of physical conditions; considers some measure of variability.**
- ***Tractability***: **Represents the practical aspects; may require high-level numerical computing, or complicated computation steps.**
- ***Transparency***: **Considers the clarity of the objective and rationale behind the model/index; should be understandable to both scientific community and the public.**

Drought Model Criteria

Redmond (1991)

- ***Sophistication***: **The conceptual and physical comprehension which may be at odds with transparency. The level of sophistication must also be supported by the quality of data and the accuracy of the assessment method.**
- ***Extendibility***: **Degree to which a model/index be extended across time. If it is from basic measured data, then it may be constructed for a long period of time; if it uses satellite data, then only a few decades.**
- ***Dimensionality***: **Fundamental units or a ratio from physical units.**

DSSAT/Cropping System Model

- **DSSAT is one of the principal products developed by the International Benchmark Sites Network for Agrotechnology Transfer (IBSNAT) project supported by the U.S. Agency for International Development from 1983 to 1993.**
- **It has subsequently continued to be developed through collaboration among scientists from the University of Florida, the University of Georgia, University of Guelph, University of Hawaii, the International Center for Soil Fertility and Agricultural Development, Iowa State University and other scientists associated with ICASA.**

DSSAT/Cropping System Model

- **DSSAT is a microcomputer software product that combines crop, soil and weather data bases into standard formats for access by crop models and application programs.**
- **The user can then simulate multi-year outcomes of crop management strategies for different crops at any location in the world.**

- **DSSAT also provides for validation of crop model outputs; thus allowing users to compare simulated outcomes with observed results.**
- **Crop model validation is accomplished by inputting the user's minimum data, running the model, and comparing outputs.**
- **By simulating probable outcomes of crop management strategies, DSSAT offers users information with which to rapidly appraise new crops, products, and practices for adoption.**

DSSAT/CSM

- **Operation of the windows-based Decision Support System for Agrotechnology Transfer (DSSAT) Version 4.5 software (www.ICASA.net/DSSAT/)**

- **Description of the DSSAT-Cropping System Model, CSM and its modules, such as CROPGRO, and CERES, and the science embedded in the models.**

- **Minimum data requirements and experimental data collection for systems simulation.**

- **Integration of crop simulation models with data base management and Geographical Information Systems.**

- **Application of the DSSAT-CSM model to improve management of cropping systems.**

DSSAT/CSM
Conceptual Framework

Four premises underlie the strength of this model.

1) **The analyses should provide a robust and balanced assessment of modeled responses, including not just yield but underlying processes.**

2) **The results of the procedure should be readily interpretable by non-modelers who need to understand how models respond without having to analyze source code. A logical approach is to follow themes from whole-plant physiology such as growth, development, partitioning, and water and nutrient uptake and to use simple response functions to interpret the results.**

3) **The procedure should rely on outputs that are available from most crop models to facilitate comparisons across models.**

4) **The conditions simulated should be standardized and in a format that is easily documented and distributed, allowing other researchers to apply the procedure.**

DSSAT/CSM

DSSAT was designed to allow users to :

- **Input, organize and store data on crop, soil and weather "data base"·**
- **Retrieve, analyze and display data.**
- **Calibrate and evaluate crop growth models.**
- **Evaluate different management practices and compare simulation results with their own measured results to give them confidence that models work adequately.**
- **DSSAT allow users to simulate option for crop management over a number of years to assess the risks associated with each option.**
- **Create different management strategies and the simulated performance indicators that can be analyzed.**

DSSAT/CSM

CSM is comprised of:

- *CROPGRO* module for soybean, peanut, common bean, chickpea, faba bean, cowpea, and other grain legumes;
- *CERES* module for maize, sorghum and millet;
- *CERES-Rice* module for rice;
- *SUBSTOR* module for potato;
- *CROPSIM-CERES* module for wheat and barley;
- ***CROPGRO*** module for tomato, bahia, brachiaria and **cotton**;
- *CANEGRO* model for sugarcane; and,
- *CROPSIM* for cassava.
- *CENTURY* model for the simulation of soil carbon and nitrogen has also been incorporated in CSM.
- DSSAT v4.5 is Windows-based and includes the *CSM model* as well as ***tools and utility programs*** for managing soil, weather, genetic, crop, economic and pest data, and application and analysis programs.

Minimum Weather Data Set (MDS)

- **Minimum Data Set for Weather Data**
- **The minimum data set (MDS) refers to a minimum set of data required to run the crop models and validate the outputs. Validation requires:**
  - **-- Site weather data for the duration of the growing season,**
  - **-- Site soil data, and**
  - **-- Management and observed data from an experiment.**

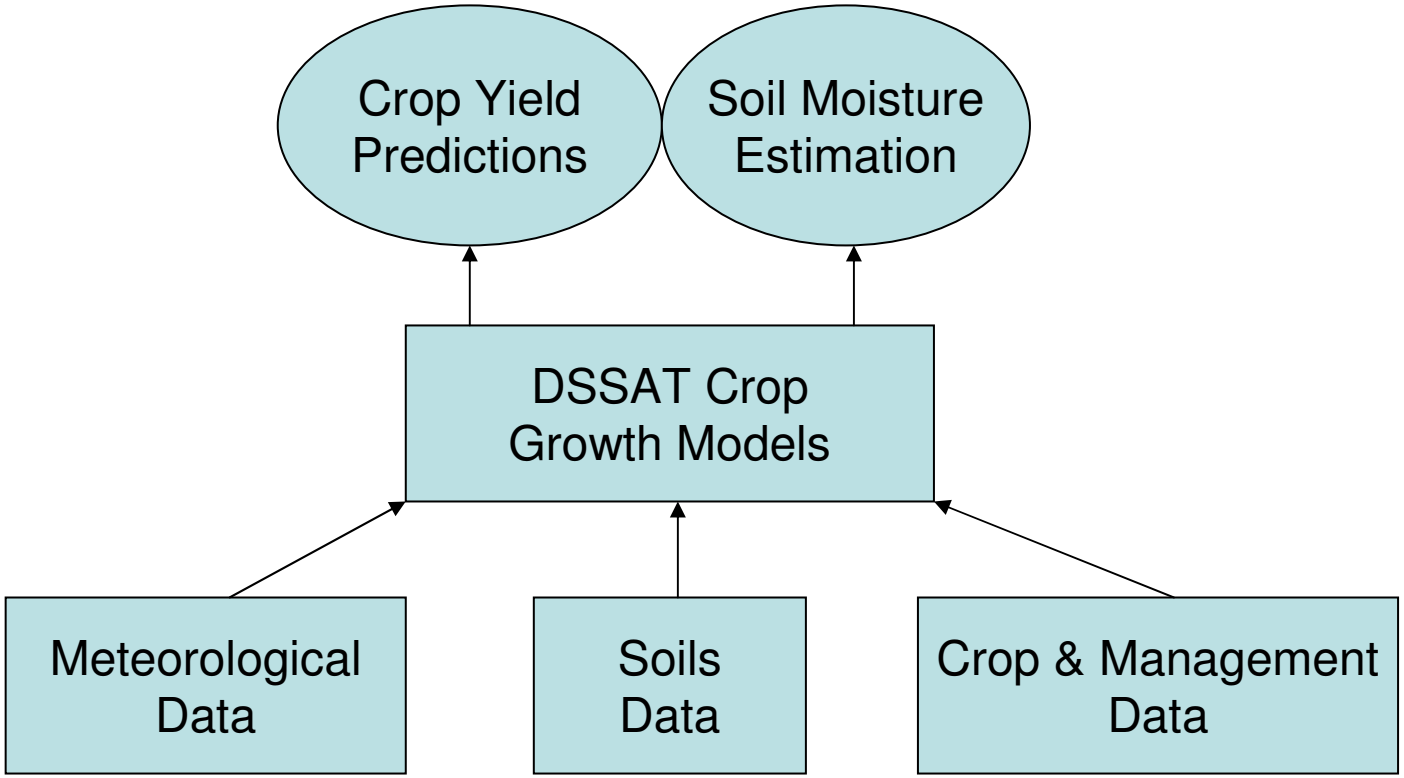
  The required minimum weather data includes:
  - **-- latitude and longitude of the weather station,**
  - **-- daily values of incoming solar radiation (MJ/m^2-day),**
  - **-- maximum and minimum air temperature (^oC), and**
  - **-- rainfall (mm).**
- **Accessory data sets, such as daily dry and wet bulb temperatures and wind speed, are optional.**
- **The period of weather records for validation must, at a minimum, cover the duration of the experiment and preferably should begin a few weeks before planting and continue a few weeks after harvest so that "what-if" type analyses may be performed as desirable.**

- http://www.icasa.net/dssat/minimum.html

Model Simulation Tools

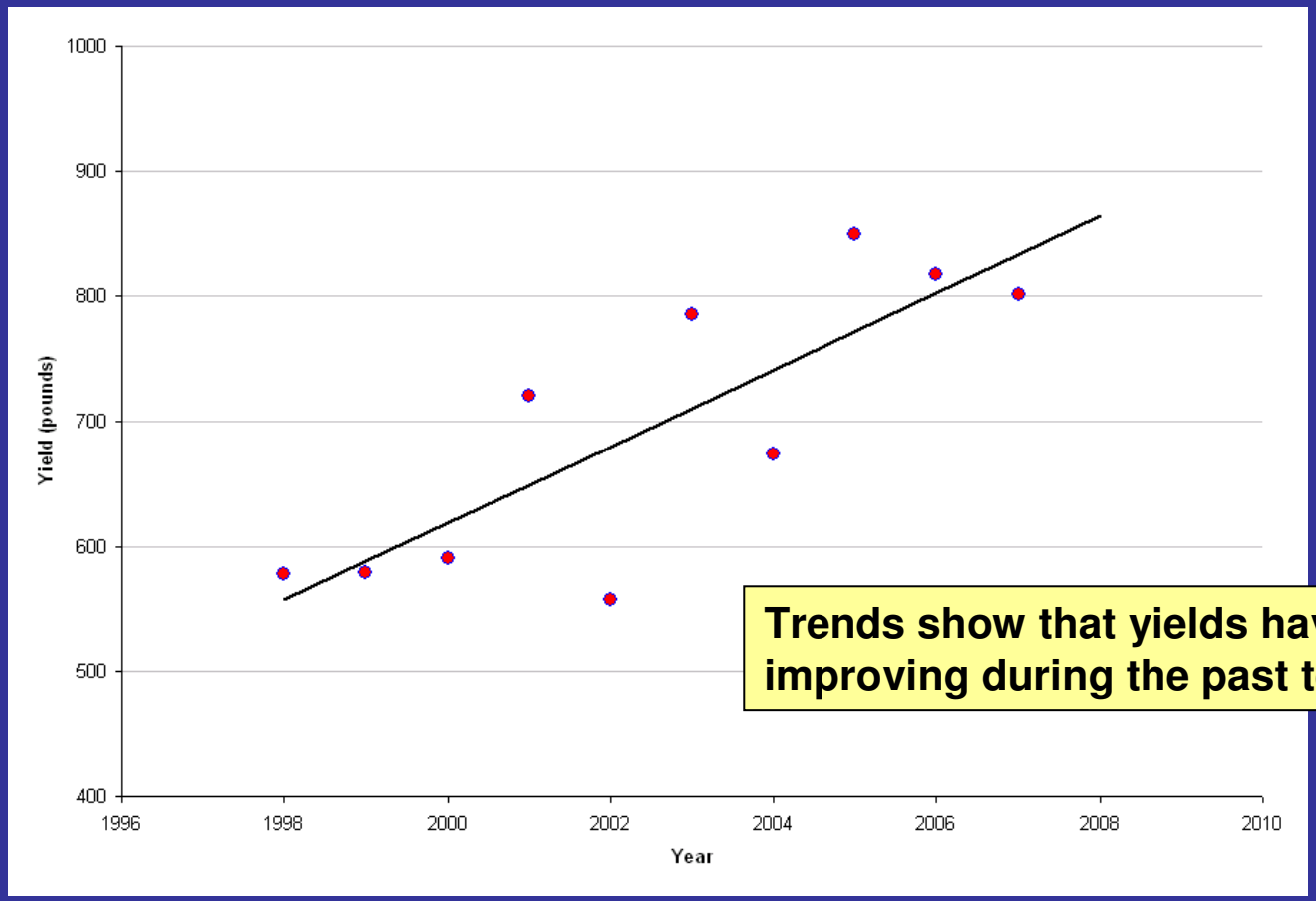
- **Solar Radiation: WGENR Program – daily solar radiation data generator, developed by Hodges, French and LeDuc (1985).**
- **Soil profile characteristics for the main agricultural soil types in each U.S. county were obtained from the soil characterization database of the USDA National Resource Conservation Service.**
- **Missing historical weather data (max. & min. temperature, and precipitation) were estimated with WeatherMan (Pickering et al., 1994), a weather utility program that is part of DSSAT, ver.4**

Agricultural Monitoring System



MONITORING AGRICULTURAL DROUGHT

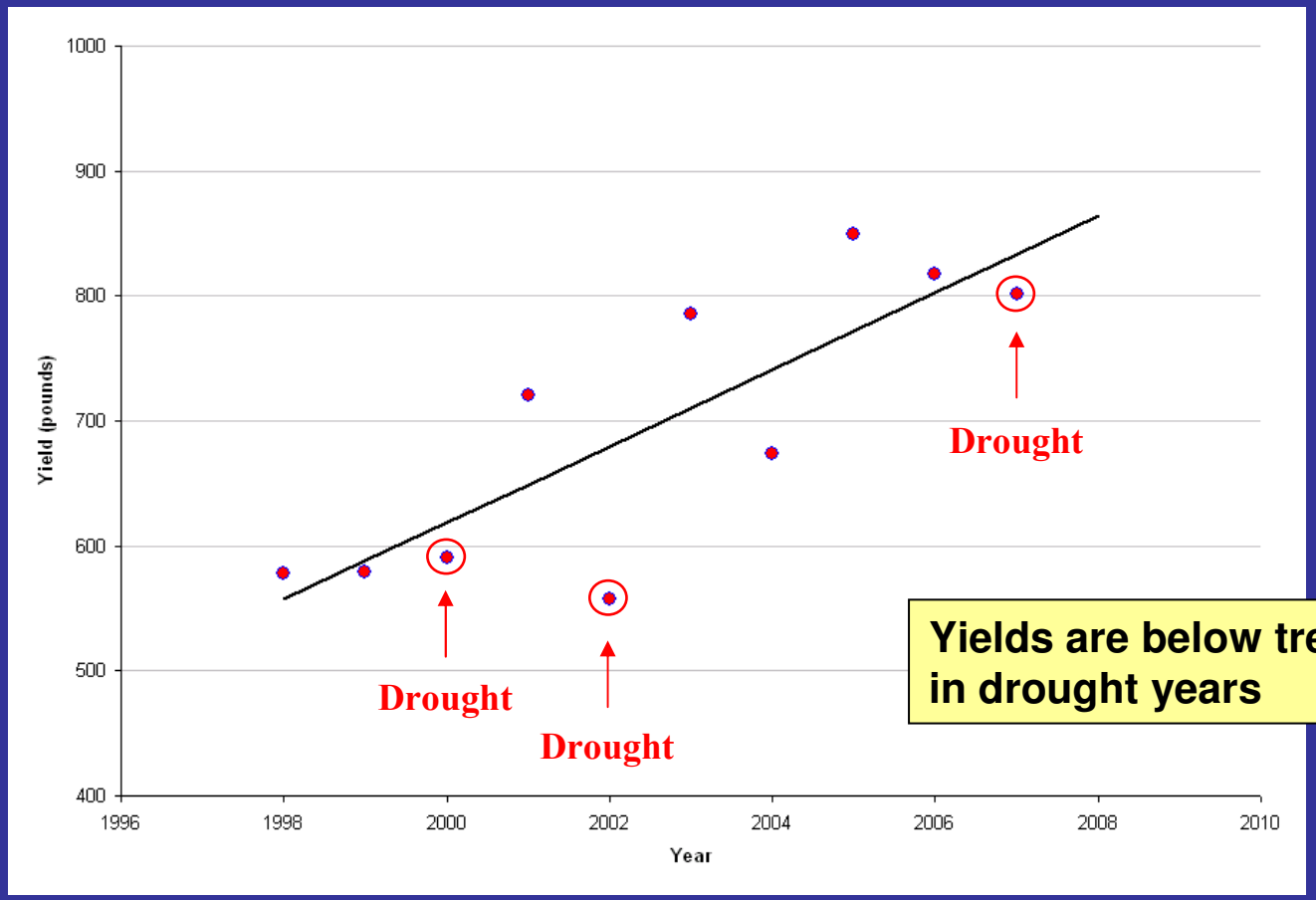
Georgia – Cotton Yields & Trends



Trends show that yields have been improving during the past ten years

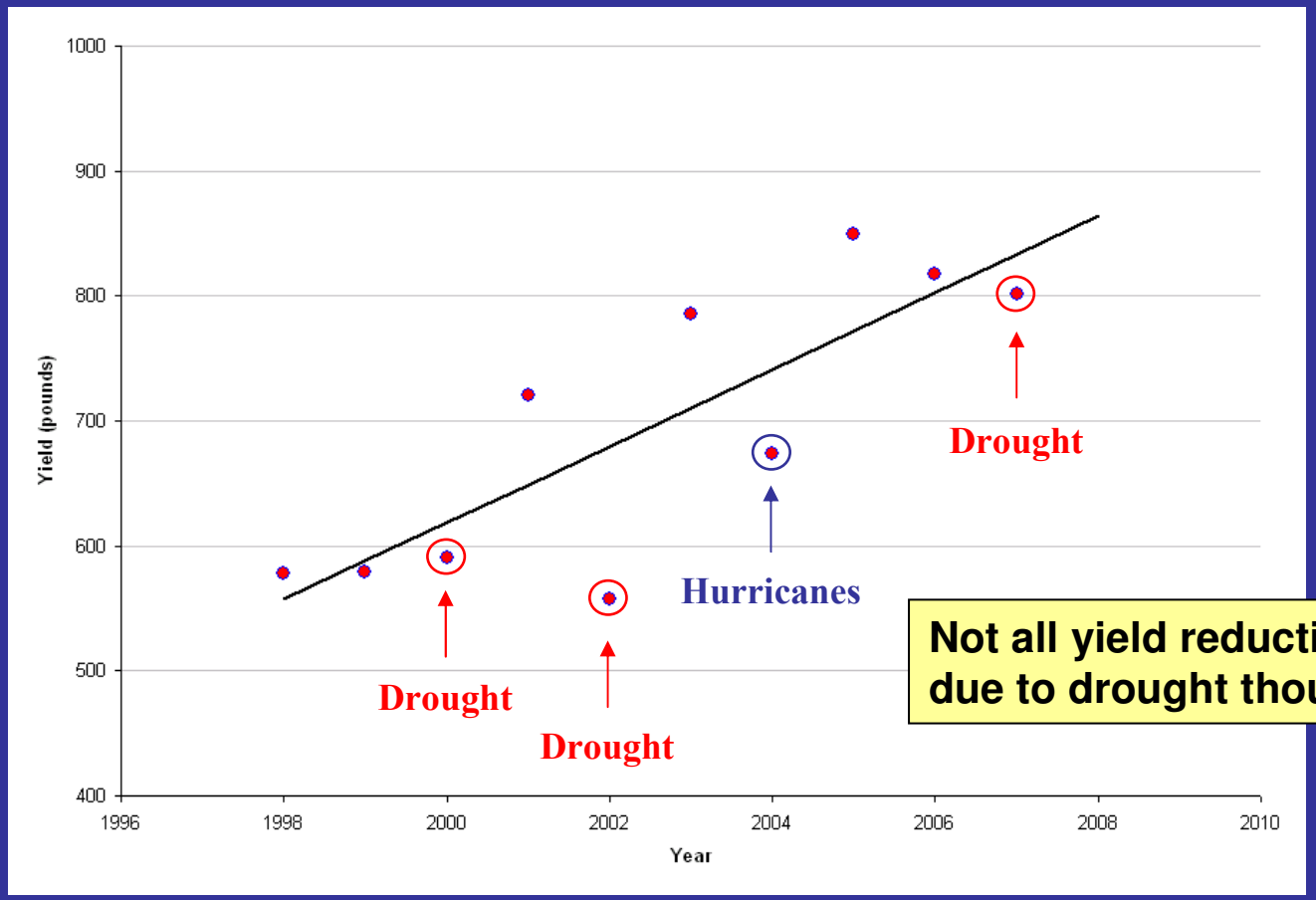
MONITORING AGRICULTURAL DROUGHT

Georgia – Cotton Yields & Trends



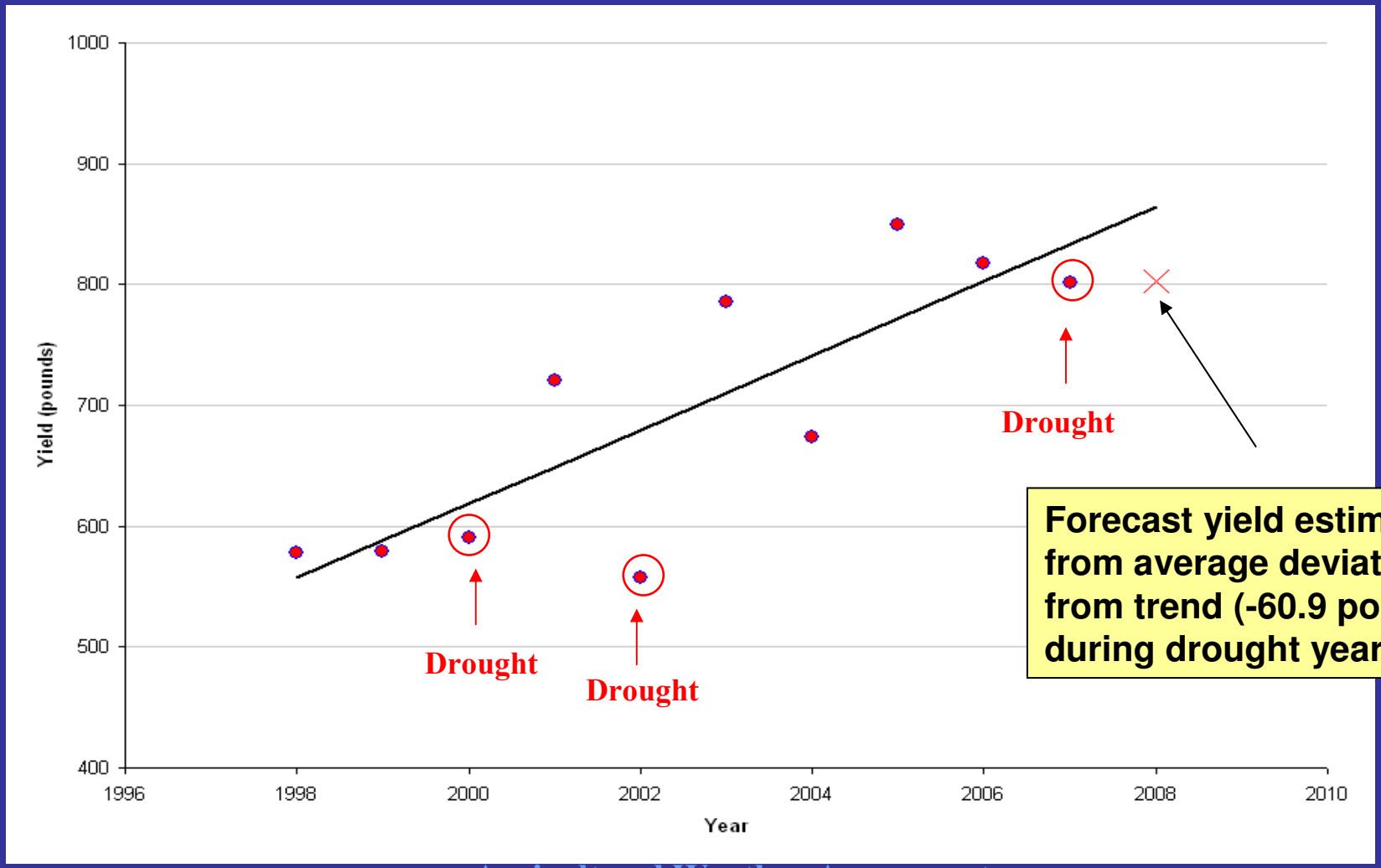
MONITORING AGRICULTURAL DROUGHT

Georgia – Cotton Yields & Trends



MONITORING AGRICULTURAL DROUGHT

Georgia – 2008 Forecast Cotton Yield



JAWF Integrated Analysis

- **Historical Data: climate and yield trends; impact of climate variability; pattern shifts (JAWF).**
- **Weather and commodity monitoring: current seasonal conditions and baseline projections for evaluating crop production risks under various weather and climate scenarios (JAWF).**
- **DSSAT suite of models (ARS, SECC).**
- **Climate and agricultural outlooks: Outlooks provide specialists with alternative management practices and adaptation strategies for future planning (NWS, ARS, JAWF).**

Agricultural Drought Indices Complexities

- **Onset & end of agricultural drought is difficult, related to various crop developmental stages.**
- **Impact of drought varies by region (arid to tropical) and by application (field crop to tree crop to forests).**
- **Crops are susceptible to drought at different stages of crop development.**
- **Prolonged droughts may extend for several crop seasons, with both duration and severity having significance impacts on agriculture.**

U.S. Drought Monitor

Integrates Key Drought Indicators:

- Palmer Drought Index
- SPI
- KBDI
- Modeled Soil Moisture
- 7-Day Ave. Streamflow
- Precip. Anomalies

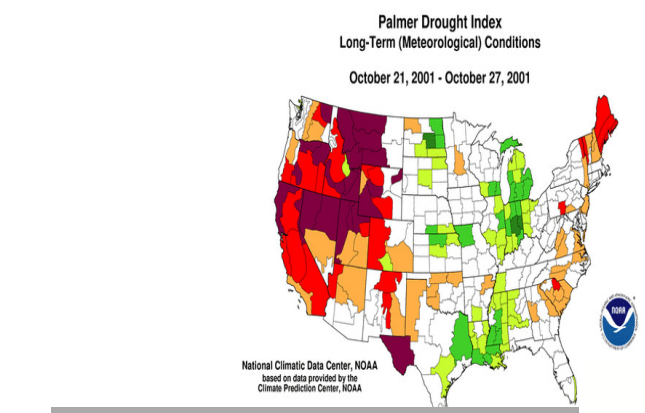
Growing Season:

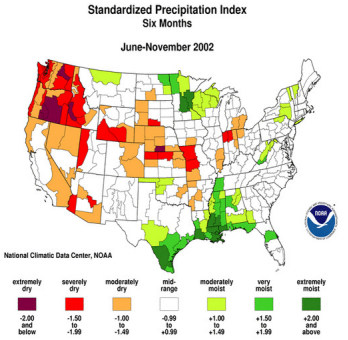
- Crop Moisture Index
- Sat. Veg. Health Index
- USDA Soil Ratings

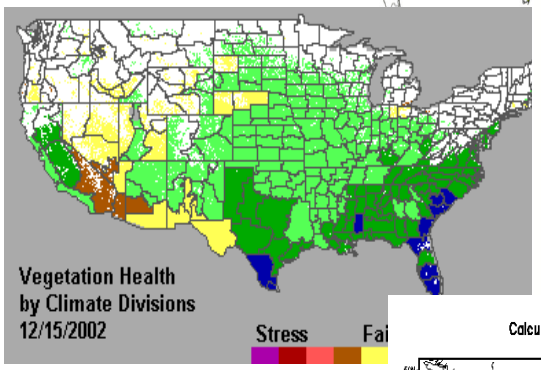
In The West:

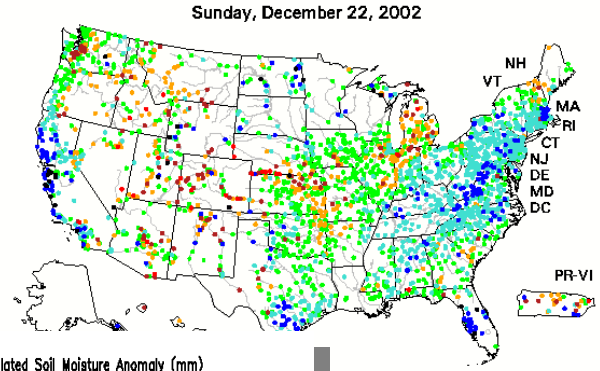
- SWSI
- Reservoir levels
- Snowpack

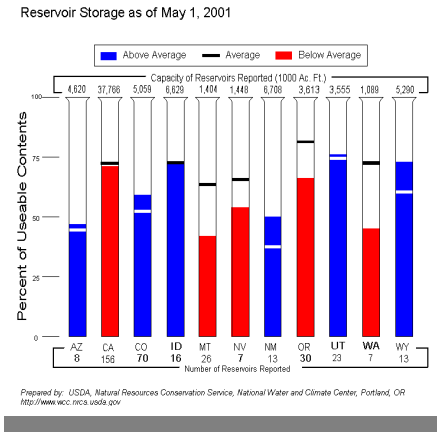
Created in ArcGIS

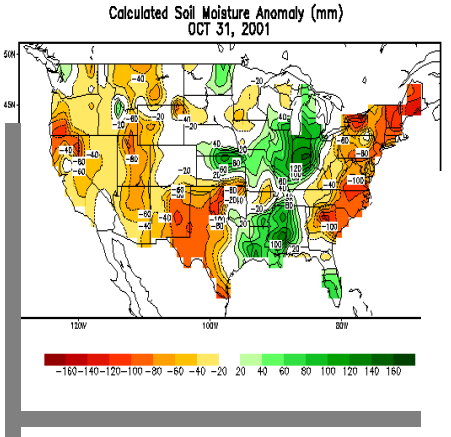


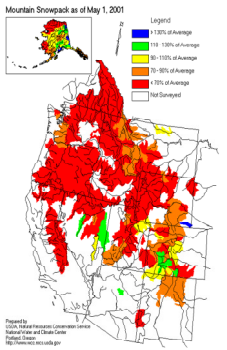












Agricultural Drought Indices

- **Aridity Index Concept: A form of normal climate conditions vs. some degree to which climate lacks effective moisture to sustain growth.**
- **Aridity Index: Moisture Surplus –Moisture Deficit**

  Precipitation/PET

  PET-AET/PET
- **Indian Aridity Anomaly Index: AI**

  $$AI = \frac{PE - AE}{PE} \times 100$$

  PE = Penman's formula

  AE = Thornthwaite

  AI <0 to >50 (severe drought)
- ***Composite Agricultural Index: Soil Moisture, NDVI, Water Balance, Heat Stress!***

MONITORING AGRICULTURAL DROUGHT

U.S. Department of Agriculture Approach to Monitoring Drought Operationally

Thank you!

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