

# U.S. Drought Monitoring and Forecasting from a Near-Real Time Operational Aspect

David Miskus

*NOAA/NWS/NCEP/Climate Prediction Center*

*36<sup>th</sup> Climate Diagnostics & Prediction Workshop  
Hilton Ft. Worth, Ft. Worth, TX  
Monday, October 3, 2011*



# USDM – Examination of Indicators

## Integrates Key Drought Indicators:

- Palmer Drought Index
- SPI
- KBDI
- Modeled Soil Moisture
- 7-Day Avg. Streamflow
- Precipitation Anomalies

### Growing Season:

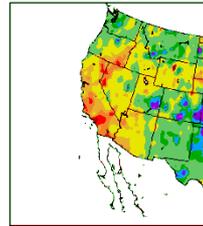
- Crop Moisture Index
- Sat. Veg. Health Index
- Soil Moisture
- Mesonet data

### In The West:

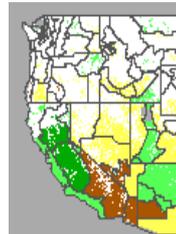
- SWSI
- Reservoir levels
- Snowpack
- Streamflow

Created in ArcGIS using ArcMap

Water Year SPI  
10/1/2006 – 4/19/2007

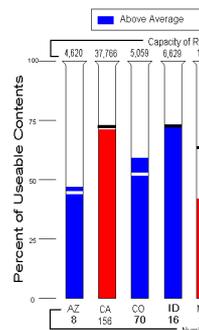


Generated 4/20/2007 at HPRCC using provision



Vegetation Health  
by Climate Division  
12/15/2002

Reservoir Storage as of May 1, 2007



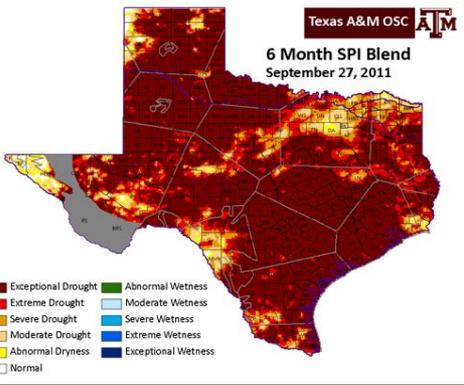
Palmer Drought Index  
Long-Term (Meteorological) Conditions  
October 21, 2001 - October 27, 2001

Standardized Precipitation Index  
Six Months  
June-November 2002

Several “newer” indicators are also being considered:

- Mesonet data
- VegDri
- NWS Precipitation Analysis Tool
- NLDAS Soil Moisture
- VIC Soil Moisture
- Texas SPI Hybrid
- CRN Soil Moisture
- Plus many others...

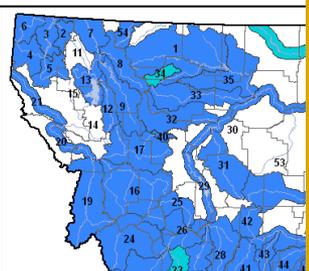
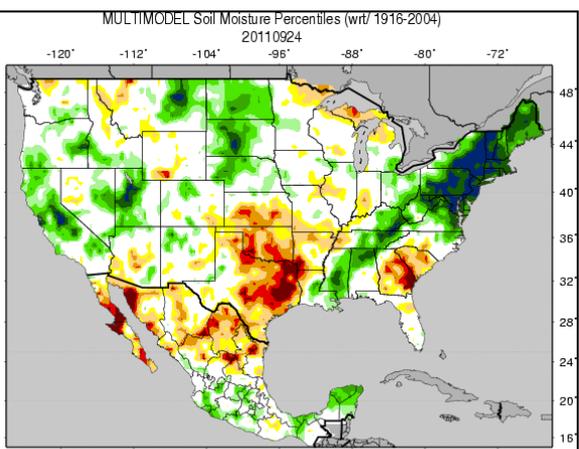
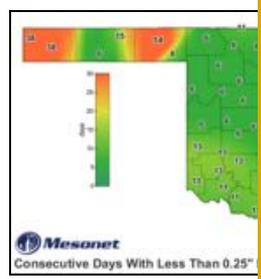
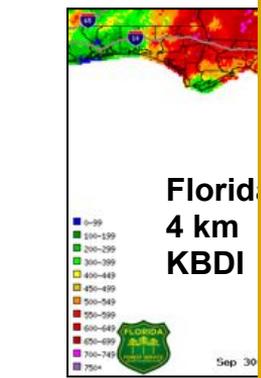
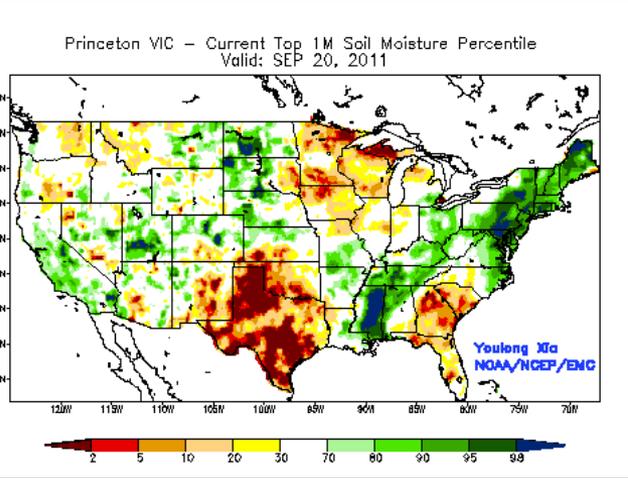
& Future indicators possibly being developed right now by some of you!!



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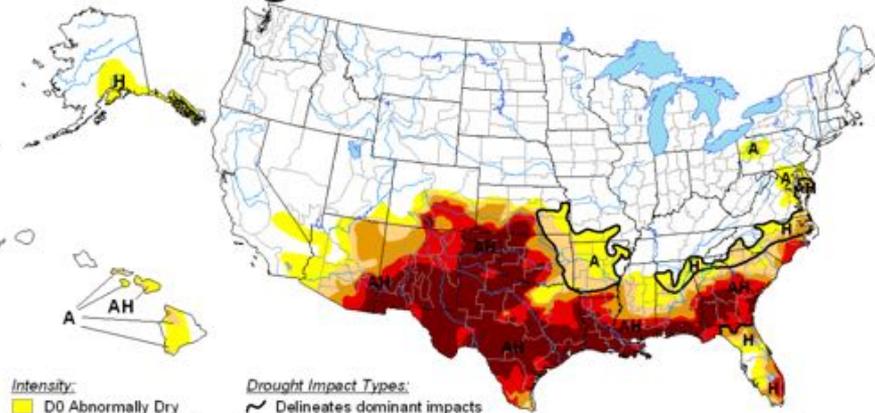
- Mesonet data
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**& Future indicators possibly being developed right now by some of you!**



# U.S. Drought Monitor

July 12, 2011  
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>

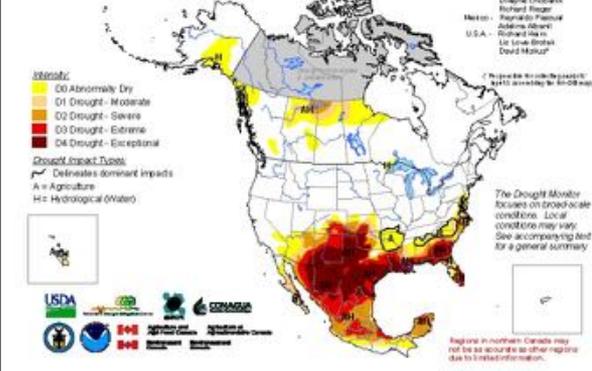


Released Thursday, July 14, 2011  
Author: David Miskus, NOAA/NWS/NCEP/CPC

# North American Drought Monitor

June 30, 2011  
Released: July 5, 2011

<http://www.ndbc.noaa.gov/dm.html>

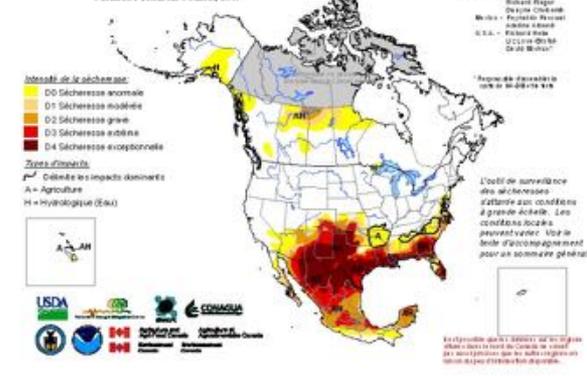


The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text for a general summary.

# Suivi nord-américain des sécheresses

30 Juin 2011  
Parution: Vendredi 2 Juillet, 2011

<http://www.ndbc.noaa.gov/dm.html>



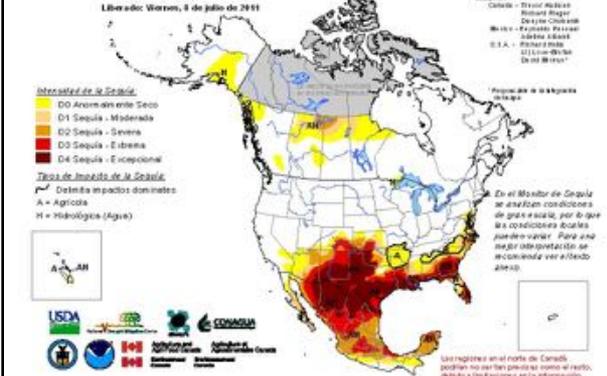
L'outil de surveillance des sécheresses s'attarde aux conditions à grande échelle. Les conditions locales peuvent varier. Voir le texte d'accompagnement pour un sommaire général.

# Monitor de Sequía de América del Norte

Junio 30, 2011

Librado: Viernes, 2 de julio de 2011

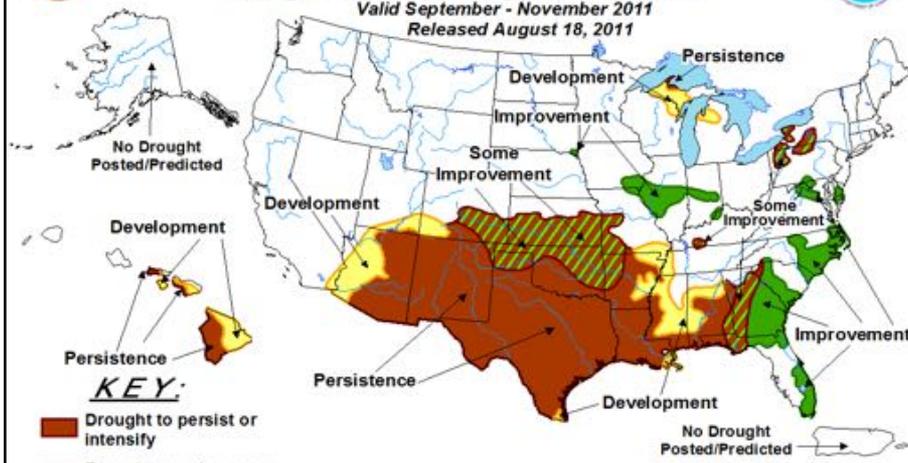
<http://www.ndbc.noaa.gov/dm.html>



Los regiones en el norte de Canadá pueden no ser tan precisas como el resto, debido a limitaciones en la información.

# U.S. Seasonal Drought Outlook

Drought Tendency During the Valid Period  
Valid September - November 2011  
Released August 18, 2011



**KEY:**  
 Persistence: Drought to persist or intensify  
 Development: Drought ongoing, some improvement  
 Improvement: Drought likely to improve, impacts ease  
 Some Improvement: Drought development likely

Depicts large-scale trends based on subjectively derived probabilities guided by short- and long-range statistical and dynamical forecasts. Short-term events – such as individual storms – cannot be accurately forecast more than a few days in advance. Use caution for applications – such as crops – that can be affected by such events. "Ongoing" drought areas are approximated from the Drought Monitor (D1 to D4 intensity). For weekly drought updates, see the latest U.S. Drought Monitor. NOTE: the green improvement areas imply at least a 1-category improvement in the Drought Monitor intensity levels, but do not necessarily imply drought elimination.

# Drought Monitoring before the USDM

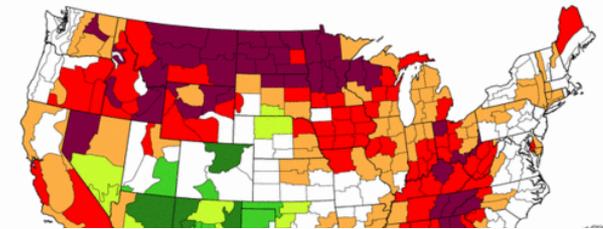
## ✓ 1960s-1990s: Palmer Drought Index Reigned Supreme

- Mostly for U.S. climate divisions on Mainland
- Water budget model with primitive soil moisture component
- Balance between water supply and water demand
- normalized index: - dry, + wet, 0 neutral

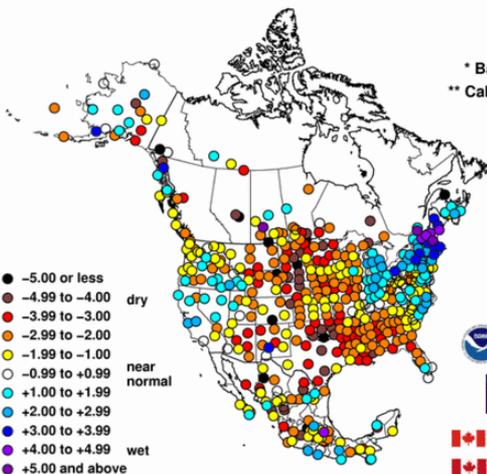
Palmer Drought Severity Index  
August, 1934

Palmer Modified Drought Index  
July, 1954

Palmer Hydrological Drought Index  
June, 1988



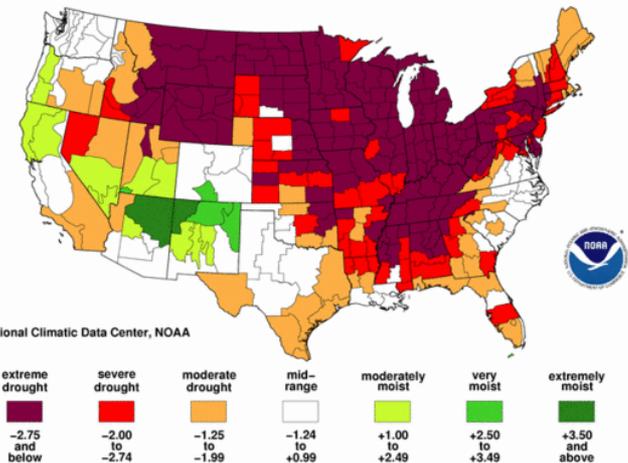
Palmer Hydrological Drought Index  
August 2006



\* Based on Preliminary Data  
\*\* Calibration Period 1951 - 2001



Palmer Z-Index  
June, 1988



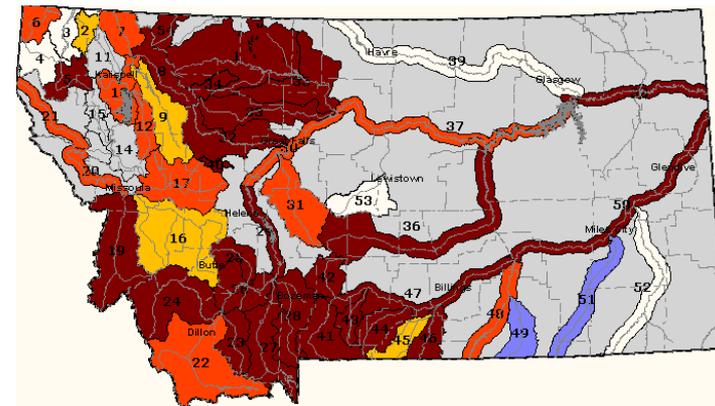
National Climatic Data Center, NOAA



# Drought Monitoring before the USDM

## ✓ Other Drought Indices

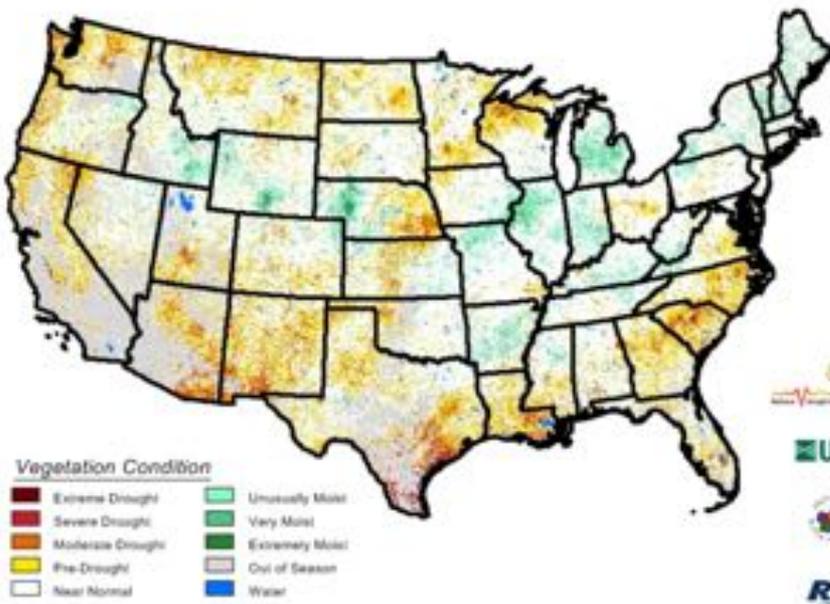
- SWSI (Surface Water Supply Index)
- SPI (Standardized Precipitation Index)
- VegDRI
- many others



<http://www.ncdc.noaa.gov/oa/climate/research/dm/weekly-dm-animations.html>

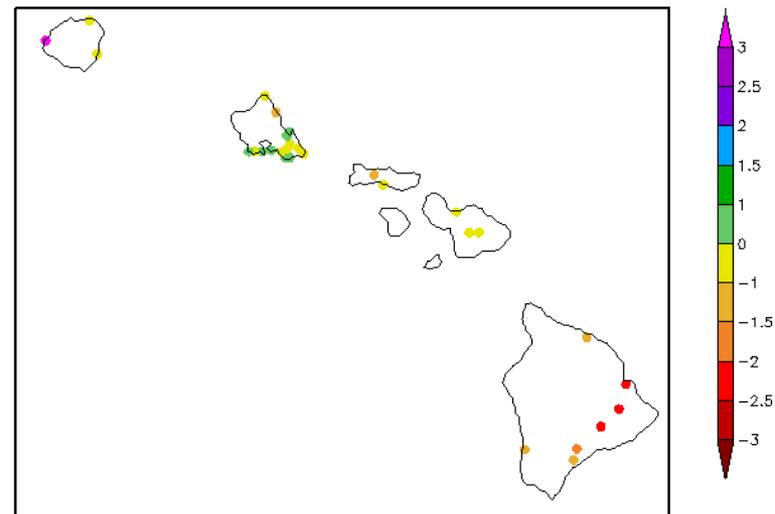
Vegetation Drought Response Index  
Complete

August 24, 2009



120 Day SPI  
11/29/2010 – 3/28/2011

12 Month SPI  
3/30/2010 – 3/29/2011

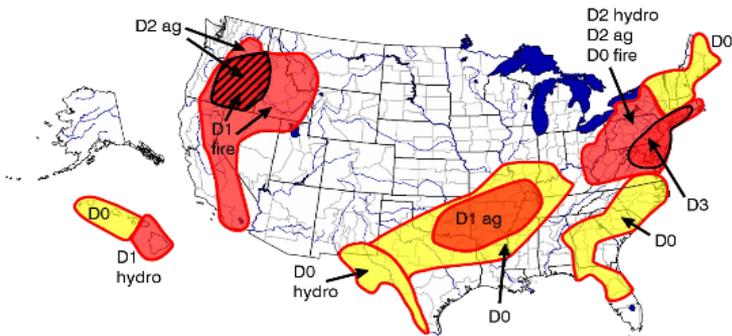


# The U.S. Drought Monitor

Since 1999, NOAA (CPC and NCDC), USDA, and the NDMC have produced a weekly composite drought map -- the U.S. Drought Monitor -- with input from numerous federal and non-federal partners

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

## August 3, 1999 Experimental U.S. Drought Monitor



"Drought" means moisture shortages leading to damaged crops or pastures, high wildfire risk, or water shortages. The map is based on information from many sources, including both satellite and surface data, and it focuses on widespread drought. Local conditions may vary.

**Yellow (D0)** = Drought Watch Area (abnormally dry but not full drought status)

**Red (D1-D4)** = Current drought ranging in severity from standard (D1) to severe (D2-D3) to extreme (D4)

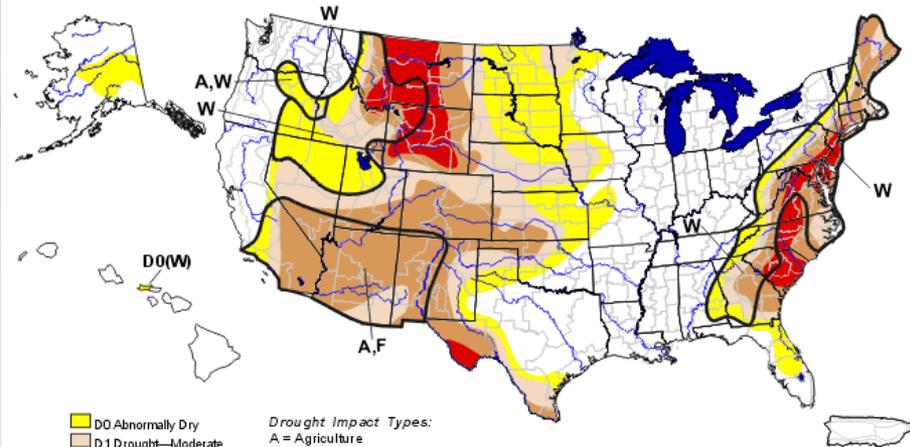
Crosshatching (▨) = Overlapping drought type areas

Drought type: Used when impacts differ  
 Ag = agricultural (crops, grasslands)  
 Fire = forestry (wildfire potential)  
 Hydro = hydrological (rivers, wells, reservoirs)

Plus (+) = Forecast to intensify  
 Minus (-) = Forecast to diminish



## U.S. Drought Monitor April 16, 2002 Valid 8 a.m. EDT



- Yellow D0 Abnormally Dry
- Light Red D1 Drought—Moderate
- Dark Red D2 Drought—Severe
- Red D3 Drought—Extreme
- Dark Red D4 Drought—Exceptional

**Drought Impact Types:**  
 A = Agriculture  
 W = Water (Hydrological)  
 F = Fire danger (Wildfires)  
 ▨ Delineates dominant impacts  
 (No type = All 3 impacts)

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

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



Released Thursday, April 18, 2002  
 Author: David Miskus, JAW/ICPC/NOAA

# The U.S. Drought Monitor Concept

A *partnership* between the NDMC, USDA and NOAA's CPC, NCDC, and RCC's (WRCC) (*11 authors*)

Incorporate relevant information and products from all entities (and levels of government) dealing with drought (RCC's, SC's, federal/state agencies, etc.) (*experts*)

The **Drought Monitor** is *updated weekly* and provides a general up-to-date summary of current drought conditions across the 50 States and Puerto Rico

# The U.S. Drought Monitor Concept

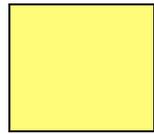
- A ***consolidation*** of indices and indicators into one comprehensive national drought map.

A “***Convergence of Evidence***” approach

- Trying to capture these characteristics:
  - the drought’s magnitude (duration + intensity)
  - spatial extent
  - probability of occurrence
  - Impacts
- Rates drought intensity by **percentile ranks**

# ***U.S. Drought Monitor Map***

## ***Drought Intensity Categories***



**D0 Abnormally Dry (30%tile)**



**D1 Drought – Moderate (20%tile)**



**D2 Drought – Severe (10%tile)**



**D3 Drought – Extreme (5%tile)**



**D4 Drought – Exceptional (2%tile)**

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

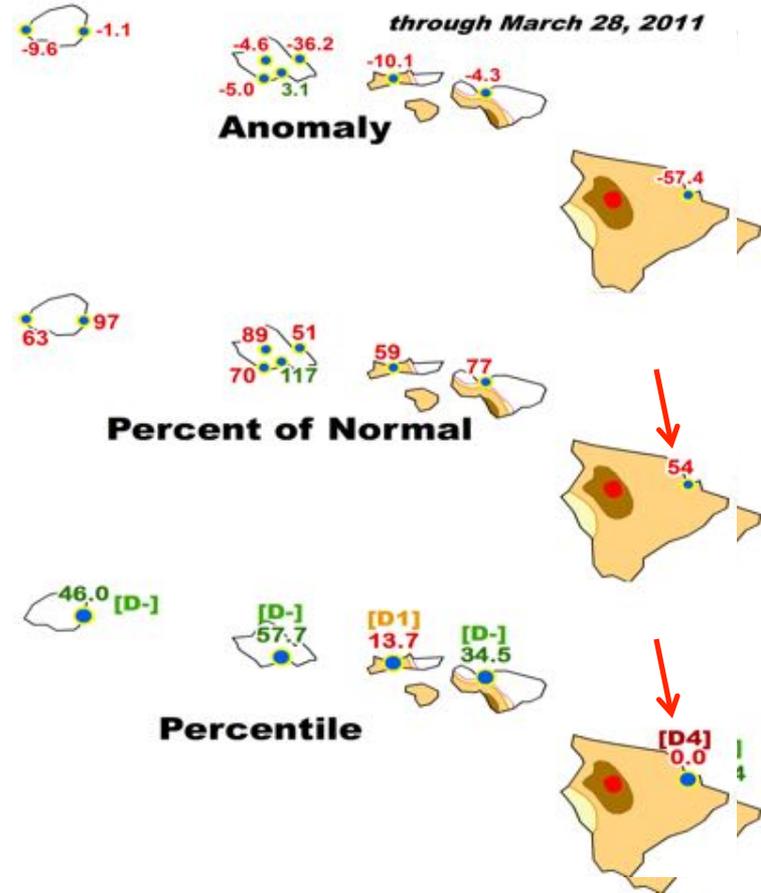
# Percentile versus Percent of Normal

- ✓ **Percent of Normal** compares the value to some base period mean (1971-2000 30-year average)
- ✓ **Percentile** expresses how rare the value is compared to its historical record

## ✓ Examples:

- 30-days: 33% of normal occurs once every 5 years (20<sup>th</sup> percentile) (not a big deal)
- 365-days: 54% of normal occurs rarely (once every 100 years or less often) (0<sup>th</sup> percentile) (rare, record dry?) (*click for map*)

### HAWAII Precipitation -- 365 DAYS ,



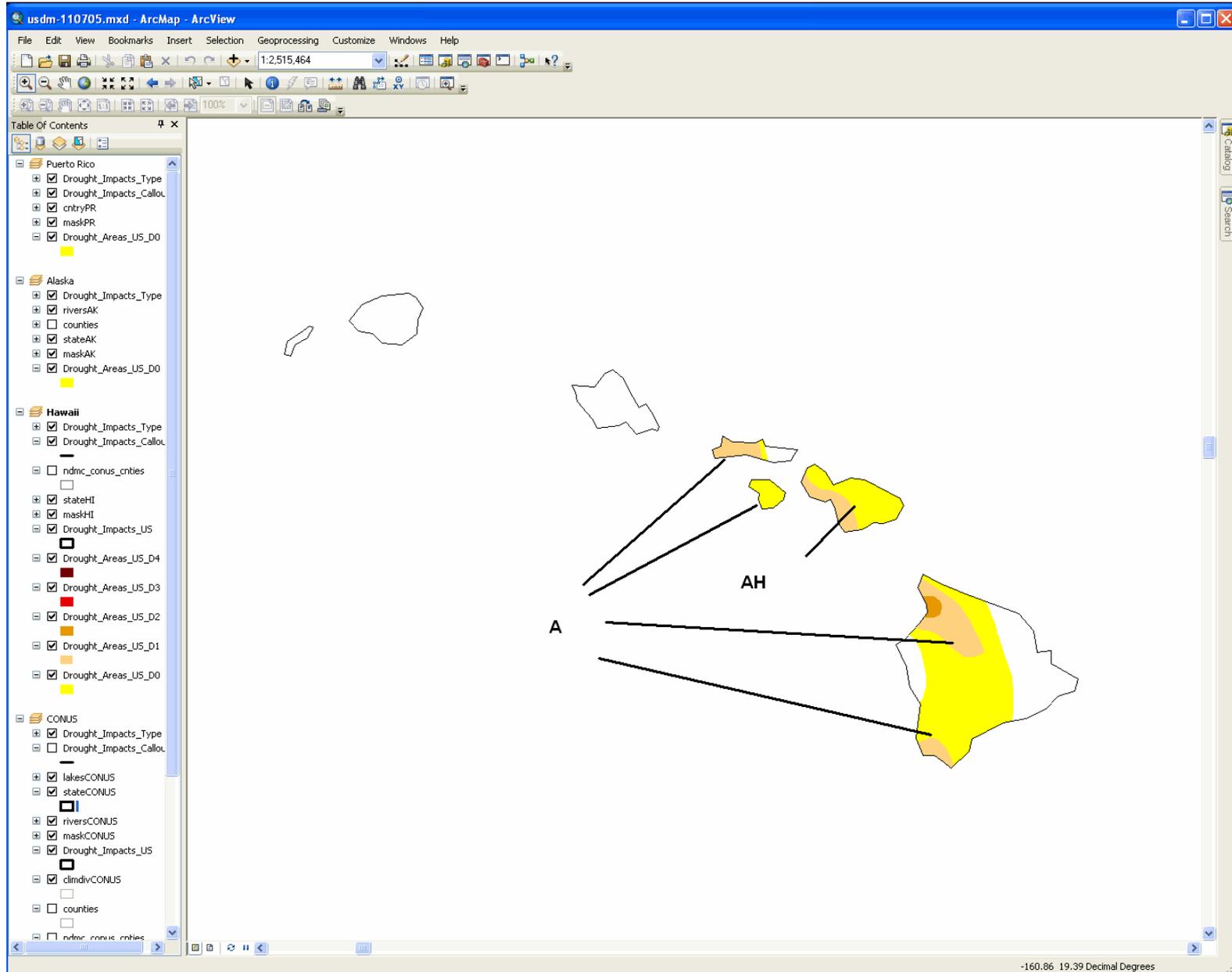
<http://drought.unl.edu/dm/monitor.html>

# USDM – Original Objectives

- “Fujita-like” or “Saffir-Simpson-like” scale
- **NOT** a forecast! (*that’s another product*)
- **NOT** a drought declaration!
- Identify **impacts** (Agricultural and Hydrological) (Short- and Long-Term)
- Assessment of **current** conditions
- Incorporate **local expert** input
- Be as **objective** as possible

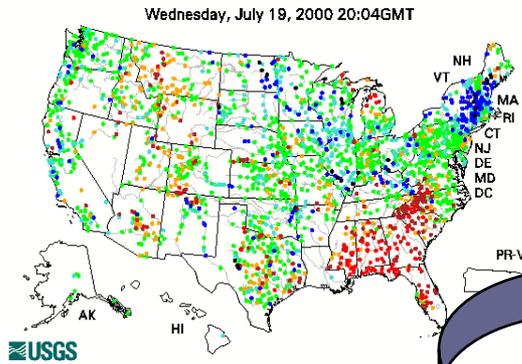
<http://drought.unl.edu/dm/monitor.html>

# ArcGIS – ArcMap 10

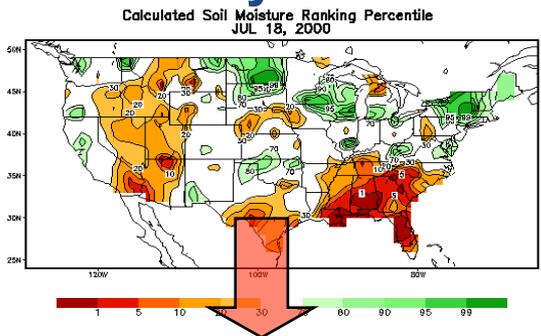


# Principle USDM Drought Indicator Inputs

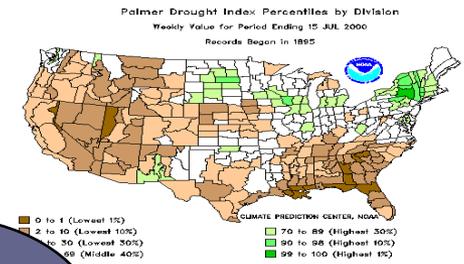
## USGS Streamflow



## CPC Daily Soil Model

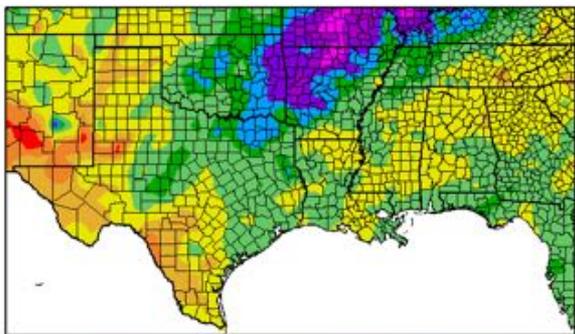


## Palmer Drought Index



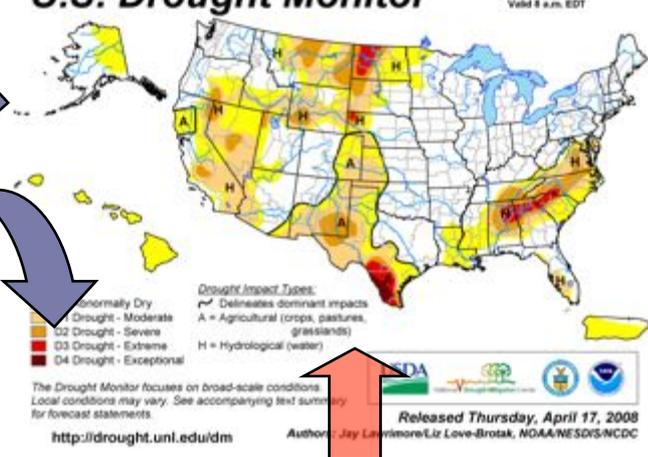
## SPI Drought Index

90 Day SPI  
1/16/2008 - 4/14/2008

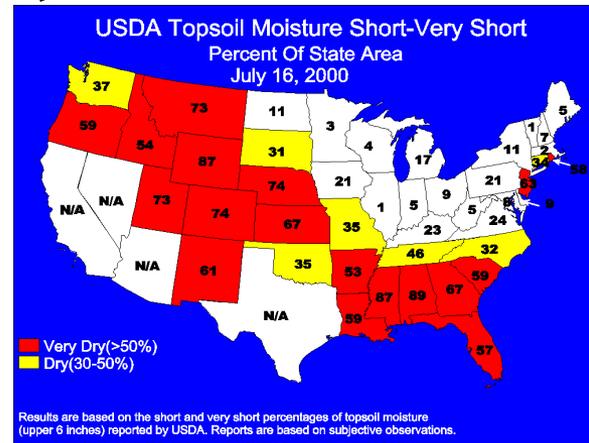


## U.S. Drought Monitor

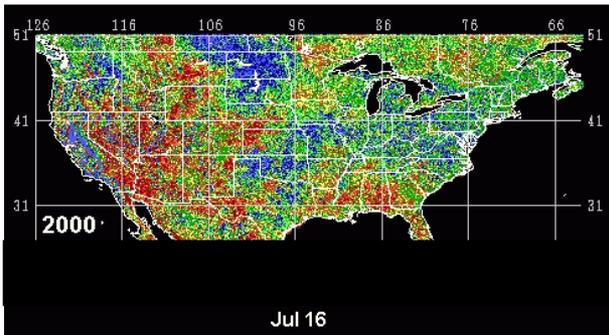
April 15, 2008  
Valid 8 a.m. EDT



## USDA Soil Ratings



## Satellite Veg Health



# USDM – Examination of Indicators

## Integrates Key Drought Indicators:

- Palmer Drought Index
- SPI
- KBDI
- Modeled Soil Moisture
- 7-Day Avg. Streamflow
- Precipitation Anomalies

## Growing Season:

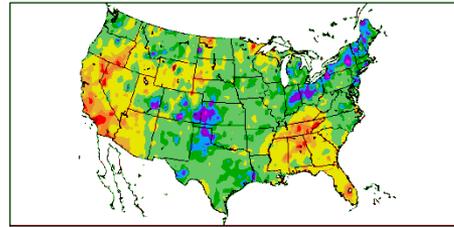
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## In The West:

- SWSI
- Reservoir levels
- Snowpack
- Streamflow

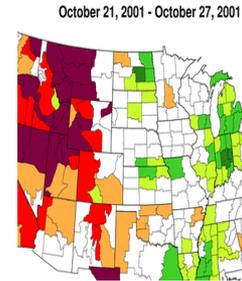
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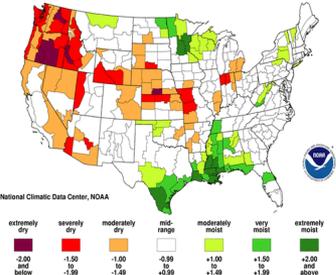


Generated 4/20/2007 at HPCC using provisional data. National Drought Mitigation Center

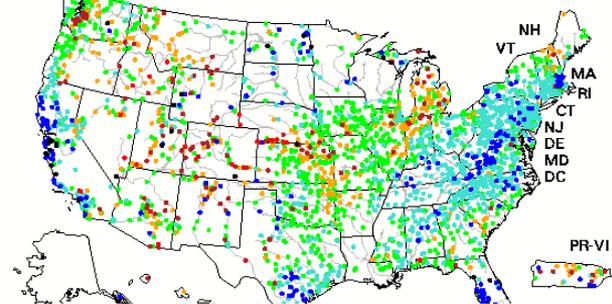
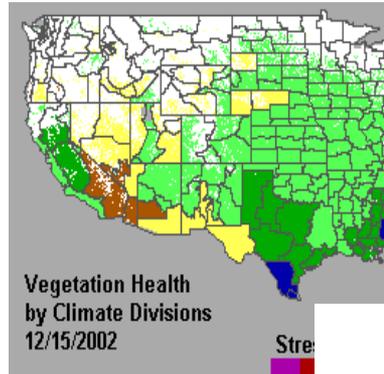
Palmer Drought Index  
Long-Term (Meteorological) Conditions



Standardized Precipitation Index  
Six Months  
June-November 2002

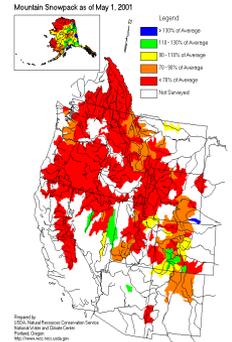
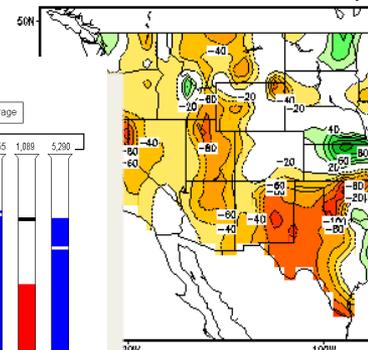
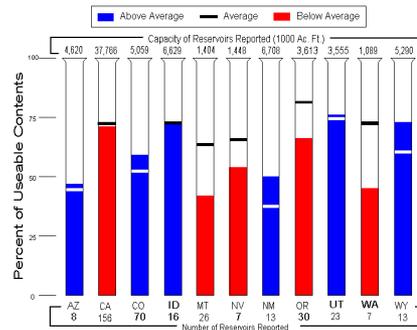


Sunday, December 22, 2002



Calculated Soil Moisture Anomaly (mm)  
OCT 31, 2

Reservoir Storage as of May 1, 2001







# USDM – Examination of Indicators

http://www.drought.gov

The screenshot displays the U.S. Drought Portal website, which is part of the National Integrated Drought Information System (NIDIS). The page features a navigation menu with categories such as HOME, ABOUT US, CURRENT DROUGHT, SUBSCRIPTIONS, CONTACT, PLANNING, EDUCATION, RESEARCH, HISTORY, and REPORTS. The main content area is divided into several sections:

- Area Drought Information:** Includes dropdown menus for "Select State" and "Select Region".
- Maps & Tools:** Lists resources like "Map & Data Center", "Drought Index", "Drought Monitor", and "Data Tool".
- Events & Announcements:** A list of recent events, including "2011 Annual Climate Assessment and National Report" and "2011 Southern US Drought Impacts and Assessment Report".
- Regional Drought Early Warning Systems (EDWS):** A map of the United States highlighting specific regions like the "Greater Lakes and Missouri Basin", "Northwest", "Southwest", and "Appalachian-Chattahoochee-Florida River Basin".
- Drought Impact Reporter:** A map of the United States color-coded by drought severity. A legend indicates the number of reported impacts: 1-99, 100-249, 250-499, 500-999, and 1000+ reported impacts. The map shows the highest impact areas in red and orange, primarily in the southern and central US.
- Drought Information Statements:** A map of the United States with a highlighted area in the central US, indicating the current NIDIS Drought Information Statement.
- Drought Monitor Time Series:** A section for tracking drought changes over time.

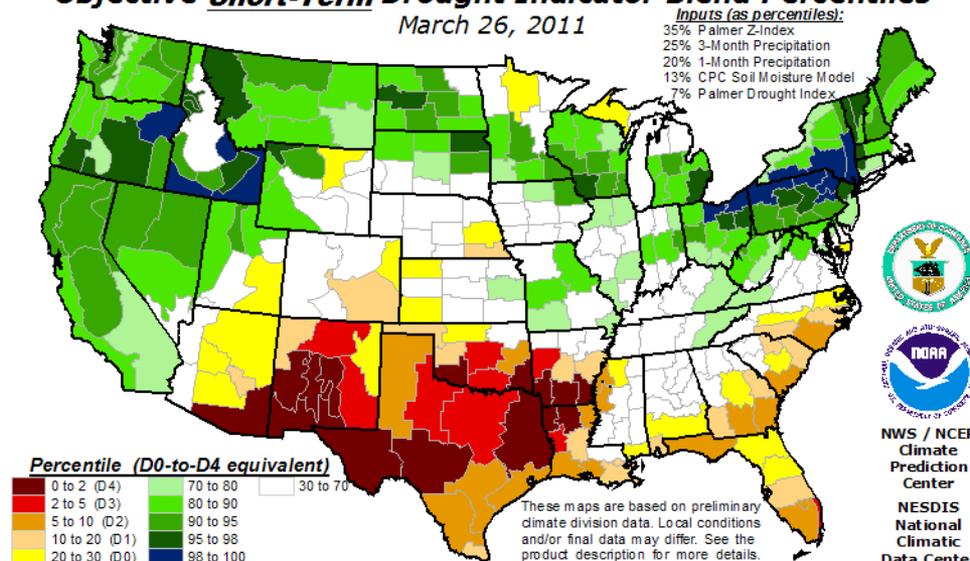
The website also includes a search bar, a contact link, and a footer with the text "U.S. Area for E14 includes AK HI & PR".

# USDM – Objective Blends

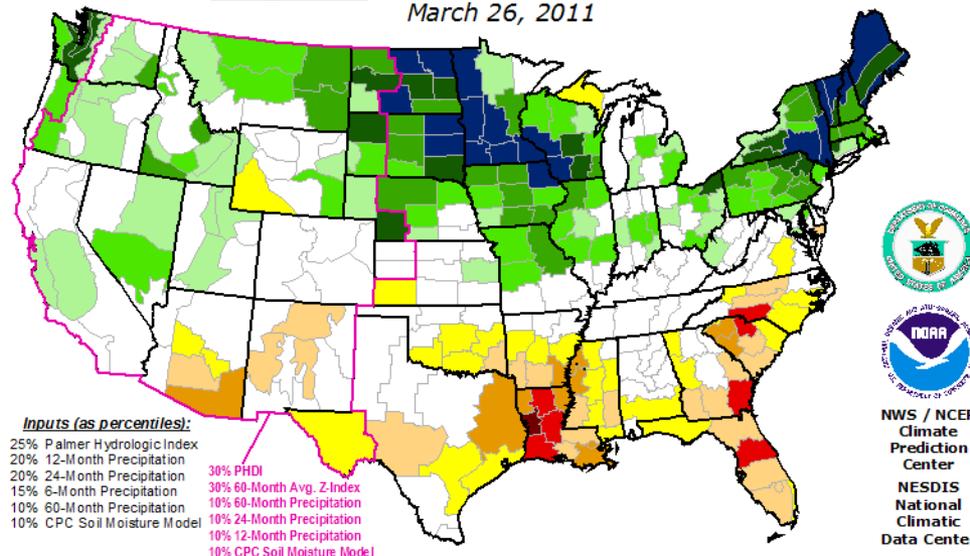
- ✓ The many drought indicators are integrated by the USDM author mentally (subjectively)
- ✓ We want to make the USDM as objective as possible
- ✓ Several drought indices converted to percentiles, weighted, then combined to calculate Short-Term and Long-Term Objective Blends

<http://www.cpc.ncep.noaa.gov/products/predictions/tools/edb/droughtblends.php>

**Objective Short-Term Drought Indicator Blend Percentiles**  
March 26, 2011



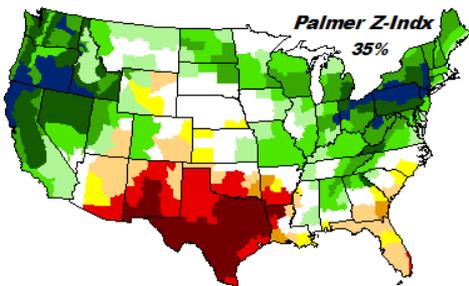
**Objective Long-Term Drought Indicator Blend Percentiles**  
March 26, 2011



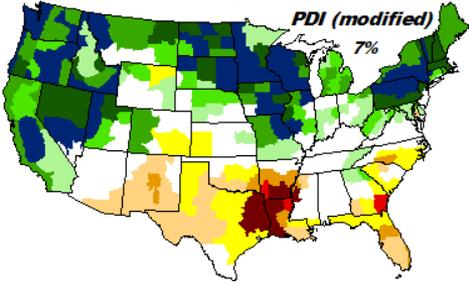
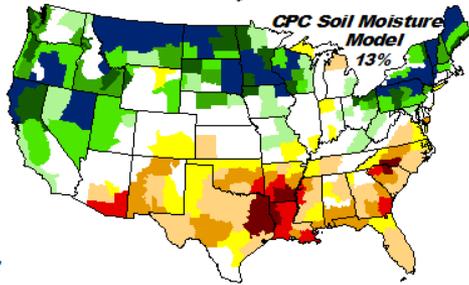
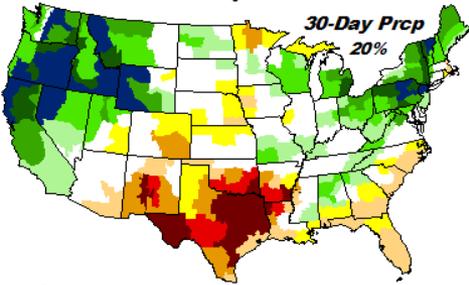
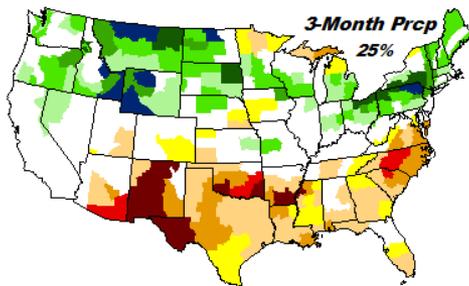
The short-term map (top) approximates impacts that respond to precipitation over the course of several days to a few months, such as agriculture, topsoil moisture, unregulated streamflows, and most aspects of wildfire danger. The long-term map (bottom) approximates impacts that respond to precipitation over the course of several months to a few years, such as reservoir content, groundwater depth, and lake levels. HOWEVER, the relationship between indicators and impacts can vary significantly with location and season. THIS IS PARTICULARLY TRUE OF WATER SUPPLIES, which are additionally affected by source, and management practices

# USDM – Objective Blends

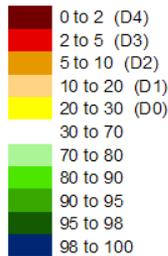
Objective **Short-Term Drought Indicator Blend Percentiles** -- March 26, 2011



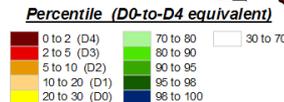
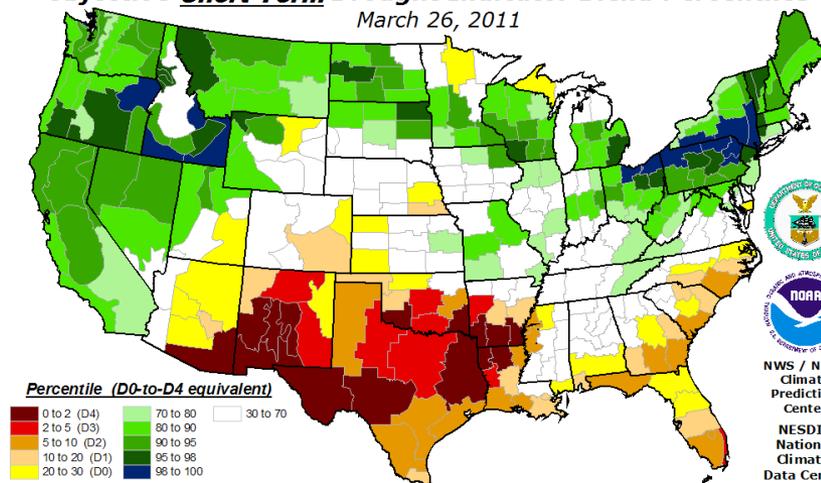
NWS / NCEP  
Climate  
Prediction  
Center  
NESDIS  
National  
Climatic  
Data Center



**Percentile (D0-to-D4 equivalent):**



Objective **Short-Term Drought Indicator Blend Percentiles**  
March 26, 2011



**Inputs (as percentiles):**  
35% Palmer Z-Index  
25% 3-Month Precipitation  
20% 1-Month Precipitation  
13% CPC Soil Moisture Model  
7% Palmer Drought Index



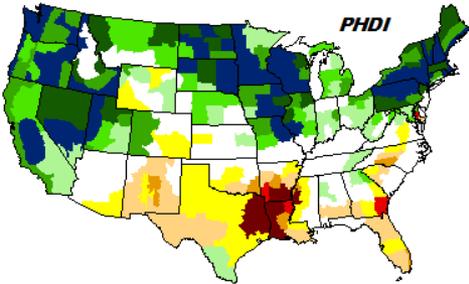
NWS / NCEP  
Climate  
Prediction  
Center  
NESDIS  
National  
Climatic  
Data Center

This map approximates impacts that respond to precipitation over several days to a few months, such as agriculture, topsoil moisture, unregulated streamflows, and most aspects of wildfire danger. The relationship between indicators and impacts can vary significantly with location and season. Do not interpret this map too literally.

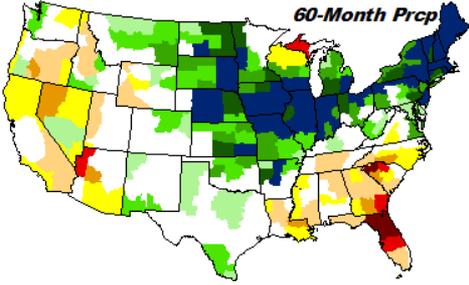
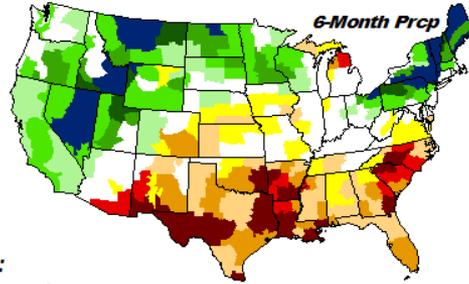
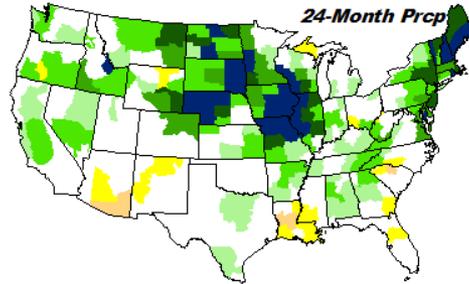
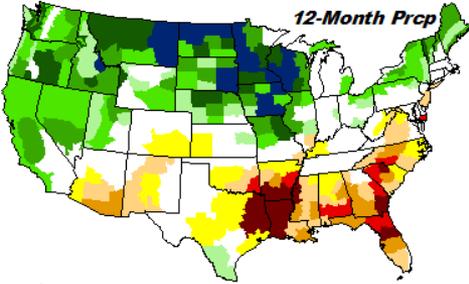
This map is based on preliminary climate division data. Local conditions and/or final data may differ. See the detailed product suite description for more details.

# USDM – Objective Blends

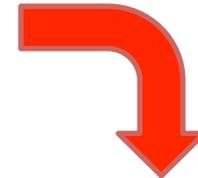
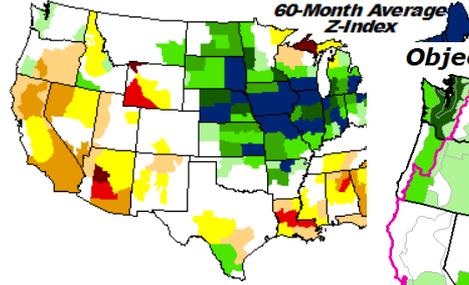
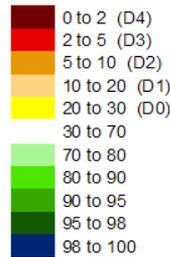
Objective **Long-Term Drought Indicator Blend Percentiles** -- March 26, 2011



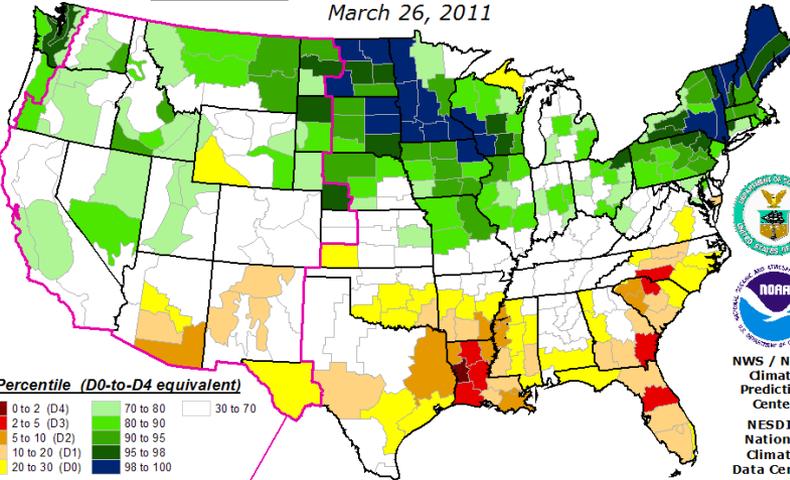
NWS / NCEP  
Climate  
Prediction  
Center  
NESDIS  
National  
Climatic  
Data Center



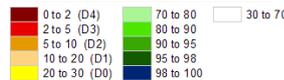
Percentile  
(D0-to-D4 equivalent):



Objective **Long-Term Drought Indicator Blend Percentiles**  
March 26, 2011



Percentile (D0-to-D4 equivalent)



Inputs (as percentiles):

- 25% Palmer Hydrologic Index
- 20% 24-Month Precipitation
- 20% 12-Month Precipitation
- 15% 6-Month Precipitation
- 10% 60-Month Precipitation
- 10% CPC Soil Moisture Model

Western Formulation  
Inputs (as percentiles):

- 30% Palmer Hydrologic Index
- 30% 60-Month Average Z-Index
- 10% 60-Month Precipitation
- 10% 24-Month Precipitation
- 10% 12-Month Precipitation
- 10% CPC Soil Moisture Model

This map approximates impacts responding to precipitation over the course of several months to a few years, such as reservoir content, groundwater, and lake levels. HOWEVER, THE RELATIONSHIP BETWEEN INDICATORS AND WATER SUPPLIES CAN VARY MARKEDLY WITH LOCATION, SEASON, SOURCE, AND MANAGEMENT PRACTICE. Do not interpret this map too literally.

This map is based on preliminary climate division data. Local conditions and/or final data may differ. See the detailed product suite description for more details.



NWS / NCEP  
Climate  
Prediction  
Center  
NESDIS  
National  
Climatic  
Data Center

# Drought Severity Classification

## RANGES

Category	Description	Possible Impacts	Palmer Drought Index	CPC Soil Moisture Model (Percentiles)	USGS Weekly Streamflow (Percentiles)	Standardized Precipitation Index (SPI)	Satellite Vegetation Health Index
D0	Abnormally Dry	Going into drought: short-term dryness slowing planting, growth of crops or pastures; fire risk above average. Coming out of drought some lingering water deficits; pastures or crops not fully recovered.	-1.0 to -1.9	21-30	21-30	-0.5 to -0.7	36-45
D1	Moderate Drought	Some damage to crops, pastures; fire risk high; streams, reservoirs, or wells low, some water shortages developing or imminent, voluntary water use restrictions requested	-2.0 to -2.9	11-20	11-20	-0.8 to -1.2	26-35
D2	Severe Drought	Crop or pasture losses likely; fire risk very high; water shortages common; water restrictions imposed	-3.0 to -3.9	6-10	6-10	-1.3 to -1.5	16-25
D3	Extreme Drought	Major crop/pasture losses; extreme fire danger; widespread water shortages or restrictions	-4.0 to -4.9	3-5	3-5	-1.6 to -1.9	6-15
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses; exceptional fire risk; shortages of water in reservoirs, streams, and wells, creating water emergencies	-5.0 or less	0-2	0-2	-2.0 or less	1-5

*Additional indices used, mainly during the growing season, include the USDA/NASS Topsoil Moisture, Crop Moisture Index (CMI), and Keetch Byram Drought Index (KBDI). Indices used primarily during the snow season and in the West include the River Basin Snow Water Content, River Basin Average Precipitation, and the Surface-Water Supply Index (SWSI).*

<http://www.drought.unl.edu/dm/classify.htm>

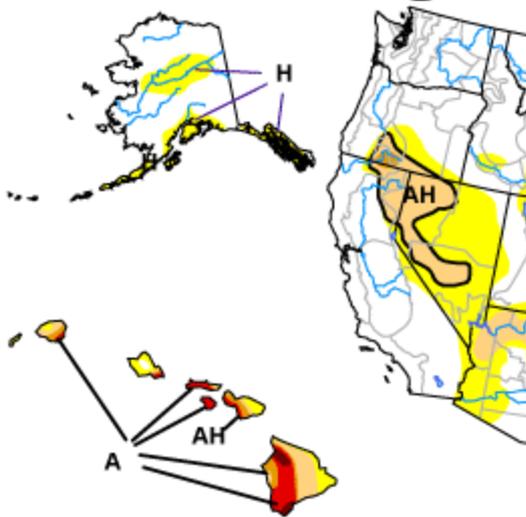
<http://drought.unl.edu/dm/archive/99/classify.htm>

# USDM – Drill Down Capability

Click on Hawaii

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

## U.S. Drought



**Intensity:**

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

**Drought Impac**

- Delineates
- A = Agricultura
- H = Hydrologic

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

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

## U.S. Drought Monitor Hawaii

September 28, 2010  
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D1	D1-D2	D2-D3	D3-D4	D4
Current	2.2	97.8	73.9	46.8	31.5	5.1
Last Week (09/21/2010 map)	2.2	97.8	73.9	46.8	31.0	5.1
3 Months Ago (07/06/2010 map)	0.4	99.6	72.8	44.4	30.6	5.1
Start of Calendar Year (01/01/2010 map)	31.1	68.9	53.8	36.9	6.4	0.0
Start of Water Year (10/01/2009 map)	18.8	81.2	51.4	32.8	6.7	0.0
One Year Ago (09/28/2009 map)	18.8	81.2	51.4	32.8	6.7	0.0

**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>



Released Thursday, September 30, 2010  
Author: R. Heim/L. Lov-Brotak, NCDC/NOAA

# ***USDM Development*** (Period starts 12Z last Tuesday)

**Monday** (5 Days of data available)

- ✓ Draft map sent to local experts

**Tuesday** (6 Days of data available)

- ✓ Local expert feedback
- ✓ Draft map sent to local experts
- ✓ Draft text sent to local experts

**Wednesday** (7 Days available; ending 12Z yesterday)

- ✓ Local expert feedback
- ✓ Draft map(s) sent to local experts
- ✓ Draft text(s) sent to local experts (Outlook)
- ✓ Final map and text sent to secured ftp server

**Thursday**

- ✓ Final map & text released on NDMC Website

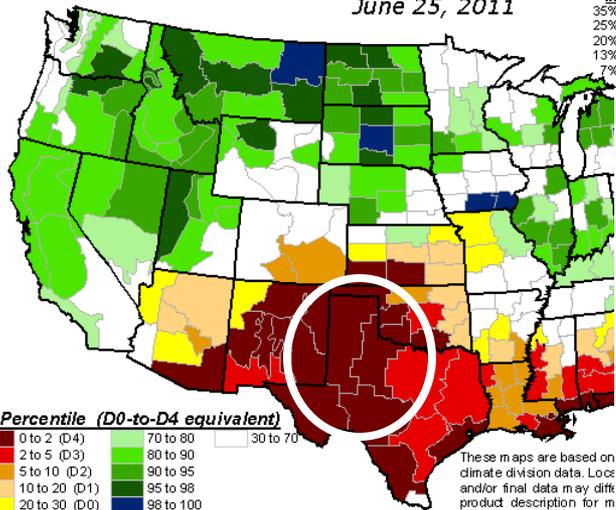
# Sample Run-Through of Drought Indicators

## Objective Short-Term Drought Indicator Blend Percentiles

June 25, 2011

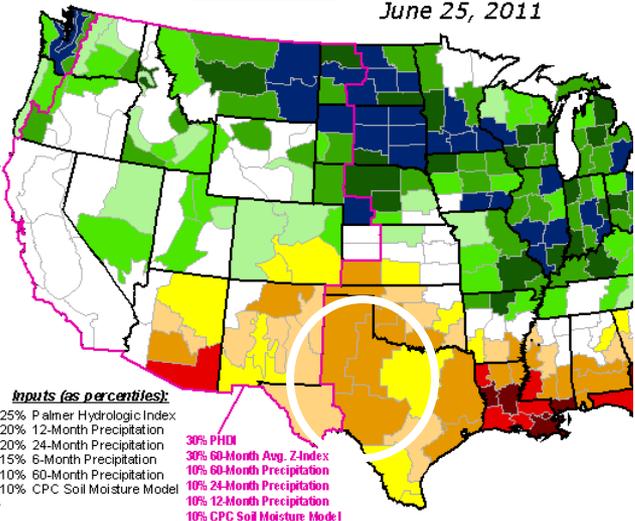
Inputs (as percentiles):

- 35% Palmer Z-Index
- 25% 3-Month Precipitation
- 20% 1-Month Precipitation
- 13% CPC Soil Moisture Model
- 7% Palmer Drought Index



## Objective Long-Term Drought Indicator Blend Percentiles

June 25, 2011



The short-term map (top) approximates impacts that respond to precipitation over the course of several days to a few months, such as agriculture, topsoil moisture, unregulated streamflows, and most aspects of wildfire danger. The long-term map (bottom) approximates impacts that respond to precipitation over the course of several months to a few years, such as reservoir content, groundwater depth, and lake levels. HOWEVER, the relationship between indicators and impacts can vary significantly with location and season. THIS IS PARTICULARLY TRUE OF WATER SUPPLIES, which are additionally affected by source, and management practices.

VIC Total Moisture Storage Percentiles (wrt/ 1916-2004)

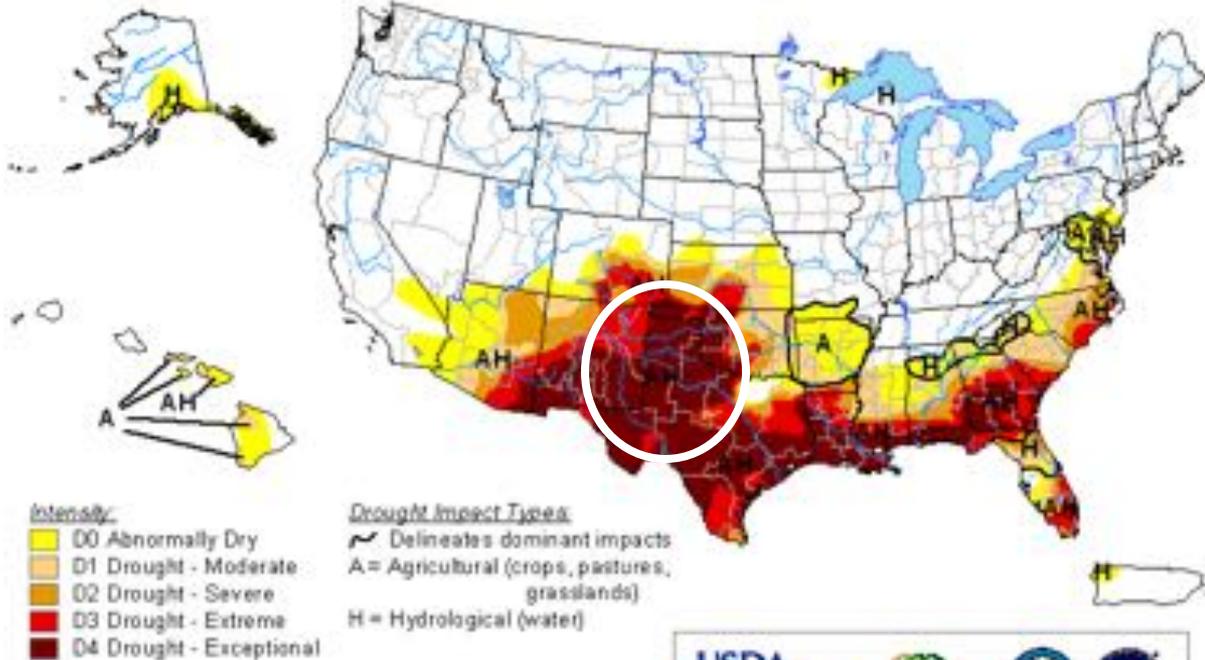
## Current Large Incidents

July 01, 2011

## U.S. Drought Monitor

July 5, 2011

Valid 8 a.m. EDT



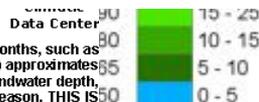
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.



Released Thursday, July 7, 2011

Author: Richard Heim, Liz Love-Brotak, NOAA NESDIS/NCDC

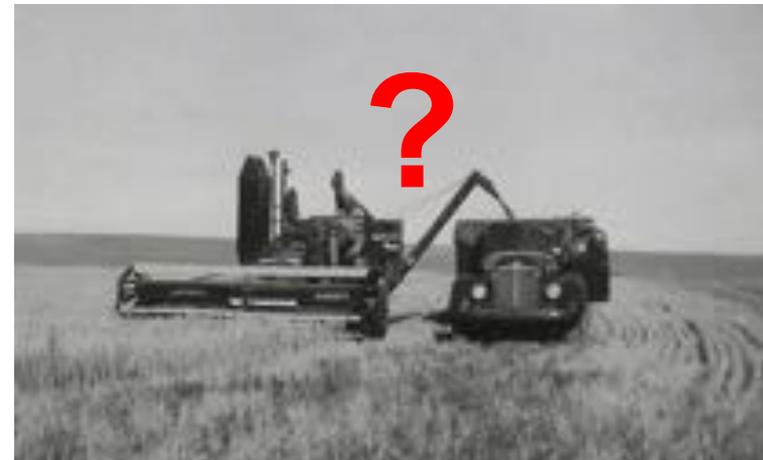
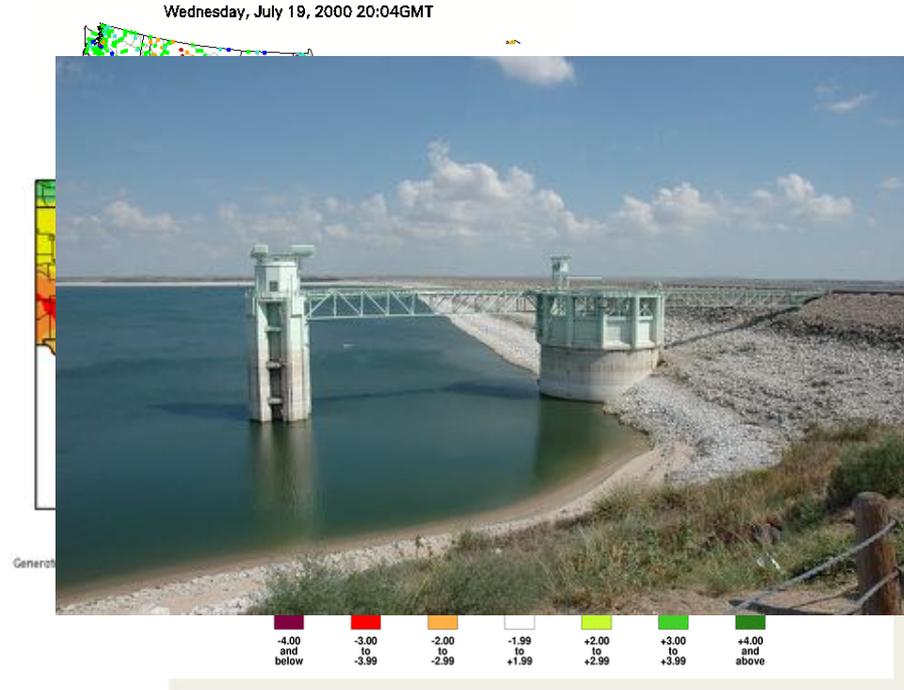
<http://drought.unl.edu/dm>



Entire USA: 26

# Local Feedback – Reports From the Field

- ✓ We have dozens of maps showing dozens of drought indicators.
- ✓ But they don't show us the whole picture. What about impacts? The rainfall may be very low, but is it *affecting* anybody?
- ✓ Local feedback from experts in the field provides the answer.





# Local Feedback – Reports From the Field: Who's Doing It, and How?

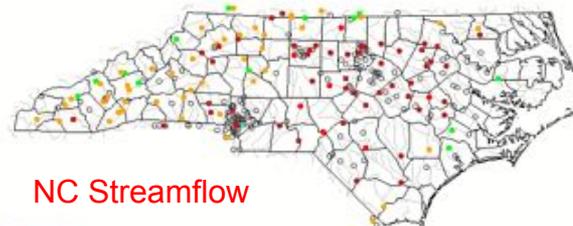
- ✓ Florida – State Climatologist leads email discussions each week between local experts, summarizes recommendations for USDM author via email
- ✓ Alabama – ditto.
- ✓ North Carolina / South Carolina – NC Division of Water Resources leads a weekly conference call each Tuesday of state agencies and offices to discuss drought conditions, make recommendations to USDM author via email
- ✓ Upper Colorado River Basin NIDIS Pilot Project (West) – multi-agency partners have weekly drought assessment conference call
- ✓ Apalachicola-Chattahoochee-Flint Pilot Project (Southeast) – ditto
- ✓ Western U.S. – NWS Western Region HQ coordinates input from NWS offices in western states, forwards to USDM author
- ✓ Hawaii – Kevin Kodama assesses state conditions from local experts each week, makes recommendations to USDM author via email
- ✓ Many states – individual state climatologists & NWS and USDA offices

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SRHWB0 PHFO 301845
RRANFO
HAWAII RAINFALL SUMMARY
NATIONAL WEATHER SERVICE HONOLULU HI
045 AM HST WED MAR 30 2011

:
:
: B NFO 0330 H 0808 /DRH-03/PPT/DRH-06/PPQ/DRH-12/FPF/SSE-24/PPD
:
:AUTOMATED RAIN GAGE REPORTS FROM AROUND THE STATE OF HAWAII.
:THESE ARE PROVISIONAL REPORTS THAT HAVE NOT BEEN QUALITY
:CONTROLLED.
:
:
:T=TRACE RAINFALL, M=MISSING DATA
:
:PRECIPITATION TOTALS ENDING 8 AM HST
:
: ISLAND OF KAUAI
:ID LOCATION 3-HR 6-HR 12-HR 24-HR
: WINDWARD/MAUKA SITES
:
:KRAH1 : KAKAHA RIDGE : M / M / M / M
:PLRH1 : FUU LUA : 0.00 / 0.00 / 0.00 / 0.00
:ROKH1 : KOOKEE (HI46) : 0.00 / 0.00 / 0.00 / 0.00
:WKRH1 : WAIAROAALI (USGS) : 0.00 / 0.00 / 0.00 / 0.00
:KLOH1 : KILOHANA (USGS) : 0.01 / 0.02 / 0.02 / 0.02
:MCRH1 : MOHINI CROSSING (USGS) : 0.00 / 0.00 / 0.00 / 0.00
:WLGH1 : WAILAAE (USGS) : 0.02 / 0.02 / 0.02 / 0.03
:WUHH1 : WAIWHA (HI41) : 0.00 / 0.00 / 0.00 / 0.00
:HNH1 : HANAHEI (HI45) : M / M / M / M
:HLRH1 : HANAHEI RIVER (USGS) : 0.01 / 0.01 / 0.01 / 0.01
:WLLH1 : MOUNT WAIKALE (USGS) : 0.60 / 0.68 / 0.75 / 0.99
:PRH1 : PRINCEVILLE AIRPORT : 0.00 / 0.00 / 0.06 / 0.03
:MLDH1 : MOLOAA DAIRY : 0.00 / 0.00 / 0.00 / 0.00
:ANHH1 : ANAHOA (HI48) : M / M / M / M
:KPH1 : KAPANI (HI50) : 0.00 / 0.00 / 0.00 / 0.00
:OLRH1 : OPAEKA STREAK (USGS) : 0.00 / 0.00 / 0.00 / 0.02
:WLDH1 : N WAILUA DITCH (USGS) : 0.08 / 0.10 / 0.10 / 0.17
:WUHH1 : WAILUA (HI40) : 0.00 / 0.00 / 0.02 / 0.05
:LIHH1 : LINUE VAR. STN. (HI47) : 0.00 / 0.00 / 0.00 / 0.00
:HLI : LINUE AIRPORT : 0.00 / T / T / T
:
: LEeward SITES
:
:POH1 : POIPU : M / M / M / M
:OAH1 : OHAO (HI51) : 0.00 / 0.00 / 0.00 / 0.02
:KHEH1 : KALAHEO (HI43) : 0.00 / 0.00 / 0.00 / 0.00
:PAKH1 : PORT ALLEN : 0.00 / 0.00 / 0.00 / 0.00
:HNPH1 : HANAPEPE (HI49) : 0.02 / 0.02 / 0.02 / 0.02
:POPH1 : FUU OPAE : 0.00 / 0.00 / 0.00 / 0.00
:WHGH1 : WAIHEE HEIGHTS : 0.00 / 0.00 / 0.00 / 0.00
:MNPH1 : HANA : M / M / M / M
:
:
: ISLAND OF OAHU
:ID LOCATION 3-HR 6-HR 12-HR 24-HR
: WINDWARD/MAUKA SITES
:
:KAHH1 : KAHUKU (HI09) : 0.00 / 0.00 / 0.00 / 0.00
:KTAH1 : KAHUKU TRAINING AREA : 0.00 / 0.00 / 0.02 / 0.03
:KFHH1 : KII : 0.00 / 0.00 / 0.04 / 0.04
:PUMH1 : PUNALUU PUMP (HI03) : 0.01 / 0.01 / 0.02 / 0.05
:PNSH1 : PUNALUU STREAM (USGS) : 0.04 / 0.04 / 0.10 / 0.10
:ENRH1 : KAHANA (USGS) : 0.00 / 0.00 / 0.00 / 0.00
:HAHH1 : HAKIPUU MAUKA (HI10) : 0.00 / 0.00 / 0.00 / 0.00
:WPPH1 : WAIHEE PUMP (HI30) : 0.01 / 0.01 / 0.03 / 0.03
:OFHH1 : OAHU FOREST NWR (USFWS) : 0.00 / 0.02 / 0.11 / 0.11
:
:
Done
    
```

OK State Mesonet Soil Moisture



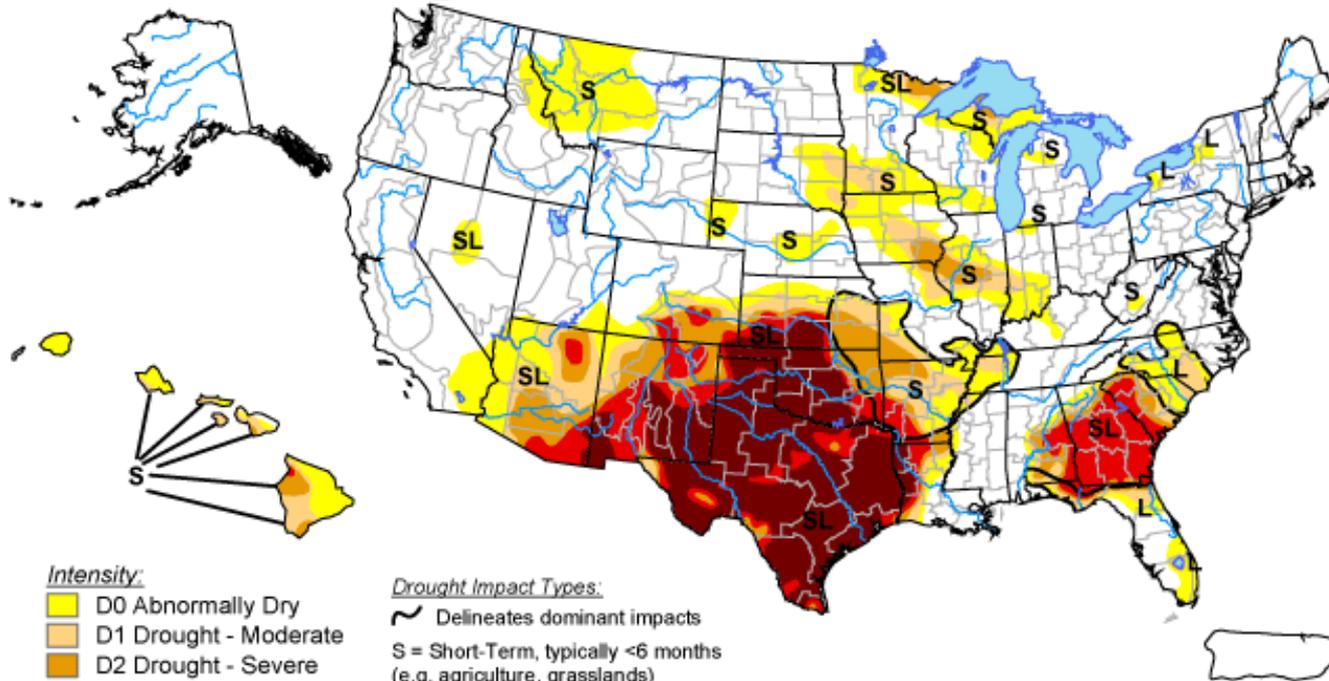
NC Streamflow



# U.S. Drought Monitor

September 27, 2011

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
- S = Short-Term, typically <6 months (e.g. agriculture, grasslands)
- L = Long-Term, typically >6 months (e.g. hydrology, ecology)

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



Released Thursday, September 29, 2011

Author: Michael Brewer/Liz Love-Brotak, NOAA/NESDIS/NCDC

<http://droughtmonitor.unl.edu/>

**For those who need statistics to justify participation in the USDM process...**

*U.S. Payments Disbursed, Livestock Forage Disaster Program (LFP), by Calendar Year:*

2008: \$165.5 Million

2009: \$98.7 Million

2010: \$33.3 Million

2011: \$174.4 Million (thru 9/27)

Total: \$471.9 Million

From January 1-September 27, 2011, nearly two-thirds of the LFP payouts have gone to Texas & Oklahoma. FSA (who administers this program) said LFP is one of the least controversial of USDA's disaster programs.

# North American Drought Monitor

June 30, 2011

Released: July 8, 2011

<http://www.ncdc.noaa.gov/nadm.html>

Analysts:

Canada - Trevor Hachnan  
Dwayne Chobaniak  
Richard Rieger  
Mexico - Reynoldo Pizarro  
Adriano Albani  
U.S.A. - Richard Heim  
Liz Love-Brofski  
David Hruska

© 1999-2011 "NOAA/NCEP/Climate Prediction Center"  
April 15, 2011 10:00 AM EDT

## Intensity

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

## Drought Impact Types

-  Delineates dominant impacts
- A = Agriculture
- H = Hydrological (Water)



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



Regions in northern Canada may not be as accurate as other regions due to limited information.



Taking the Weekly USDM to a Monthly Time Frame and Expanding It to the Northern Hemisphere (Canada & Mexico)

# The North America Drought Monitor

## Primary Participants

- U.S.
  - NCDC, US Dept. of Agriculture, Climate Prediction Center and National Drought Mitigation Center
- Canada
  - Agriculture and Agrifood Canada
  - Meteorological Service of Canada
- Mexico
  - National Meteorological Service of Mexico (SMN - Servicio Meteorologico Nacional)
  - Comision Nacional del Agua

# Development of Monthly NADM Map

- NCDC receive, process, ingest daily/monthly station data ( $T_x$ ,  $T_n$ , P, SF) from U.S., Canada, Mexico
- NCDC compute continental-scale input indicators
  - Monthly station SPI, PCTPCP, Palmer Drought Index
- NADM Author prepare first draft map
  - From continental-scale indicators & national products
  - Use USDM from month's final week for U.S. depiction
  - Draft map sent to each country's experts for feedback
  - Using ArcGIS
- NADM Author prepare final map & text
  - Released on NCDC website by middle of following month

# North American Drought Monitor

March 2003

Released: Wednesday April 16, 2003

Analysts:

Canada-Chester Schmitt  
Ted O'Brien  
Mexico-Miguel Cortez  
Chester Schmitt  
U.S.A.- Chester Schmitt \*  
Douglas Le Corre

(\* Responsible for collecting analysts input & assembling the NA-DM map)

Drought Intensity:

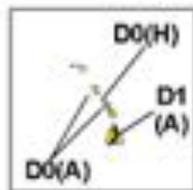
-  D0 Abnormally Dry
-  D1 Drought - Moderate
-  D2 Drought - Severe
-  D3 Drought - Extreme
-  D4 Drought - Exceptional

 Delineates dominant impacts

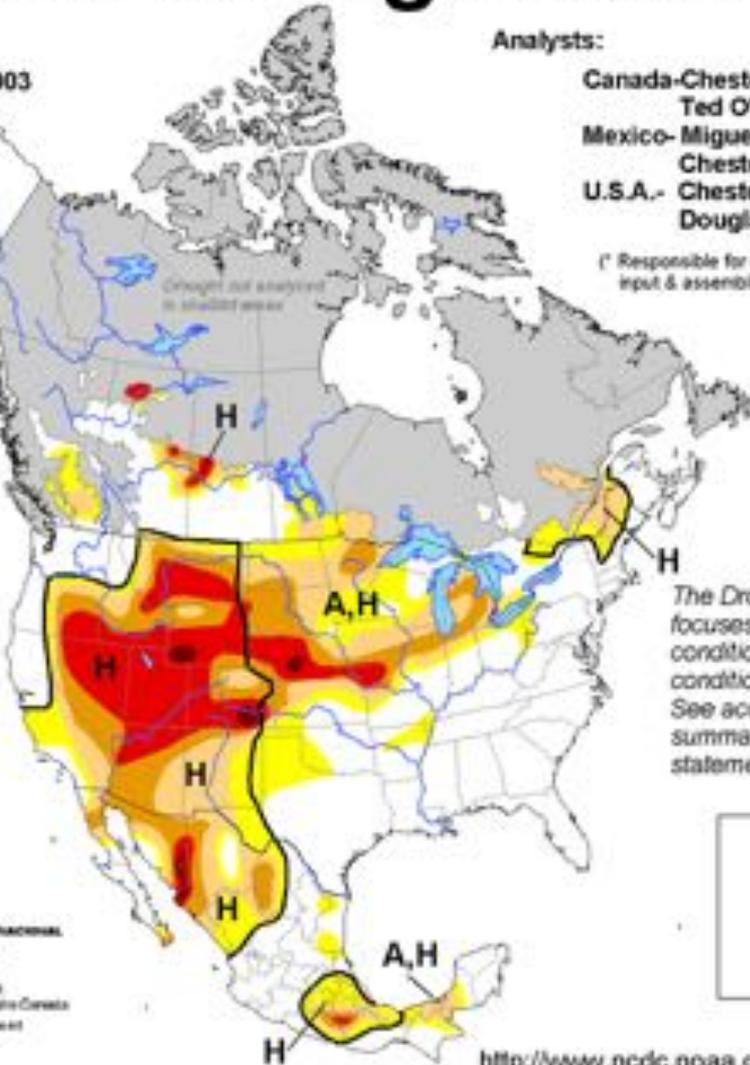
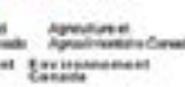
A = Agriculture

H = Hydrological (Water)

(No type = Both impacts)



**Experimental**

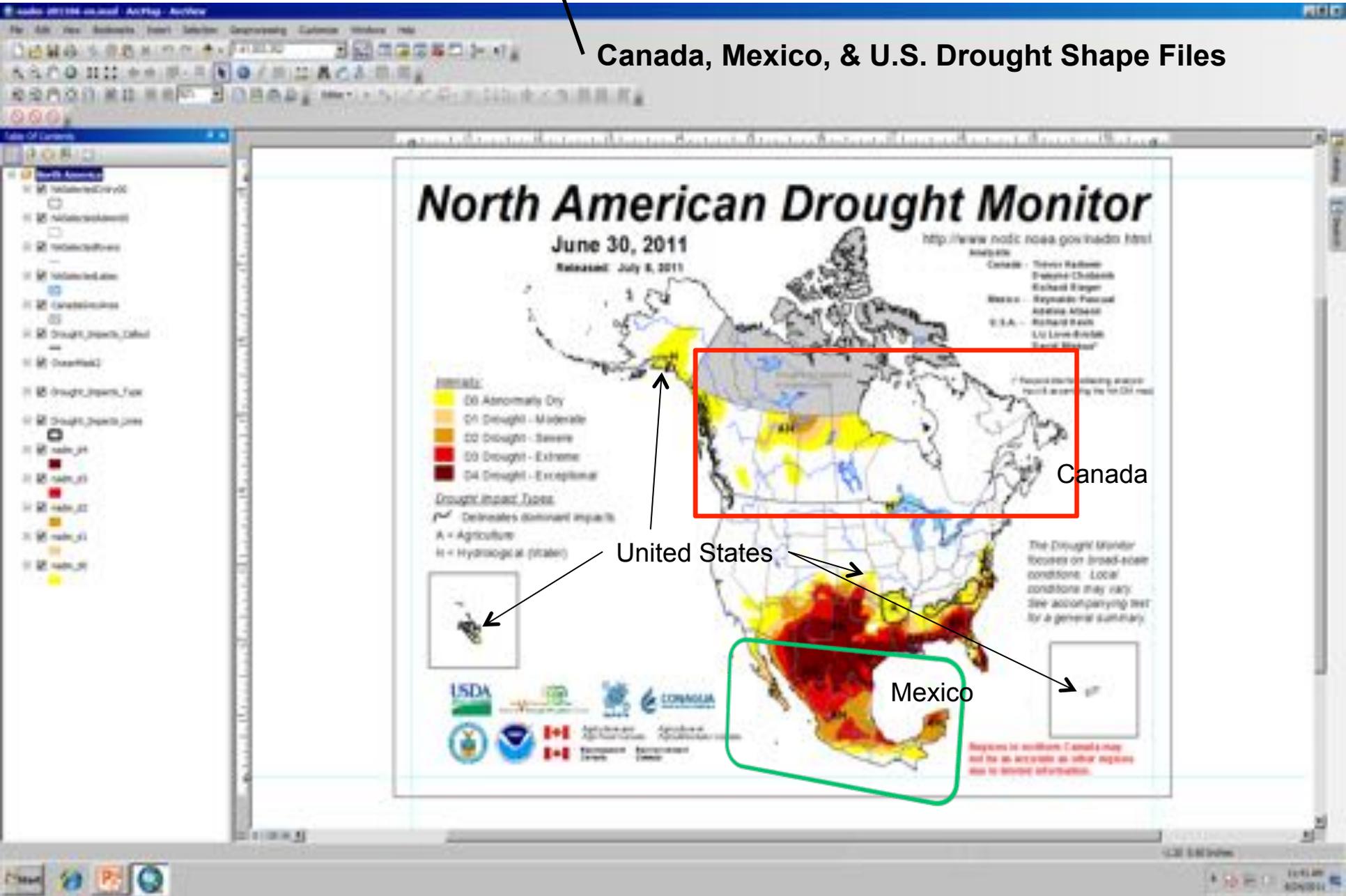


<http://www.ncdc.noaa.gov/nadm.html>

The NADM was initially Experimental, but has since become Operational....

# Using ArcMap (GIS) to merge & create the North American Drought Monitor

Canada, Mexico, & U.S. Drought Shape Files



# North American Drought Monitor

June 30, 2011

Released: July 5, 2011

<http://www.ncdc.noaa.gov/hadm.html>

Analysts:

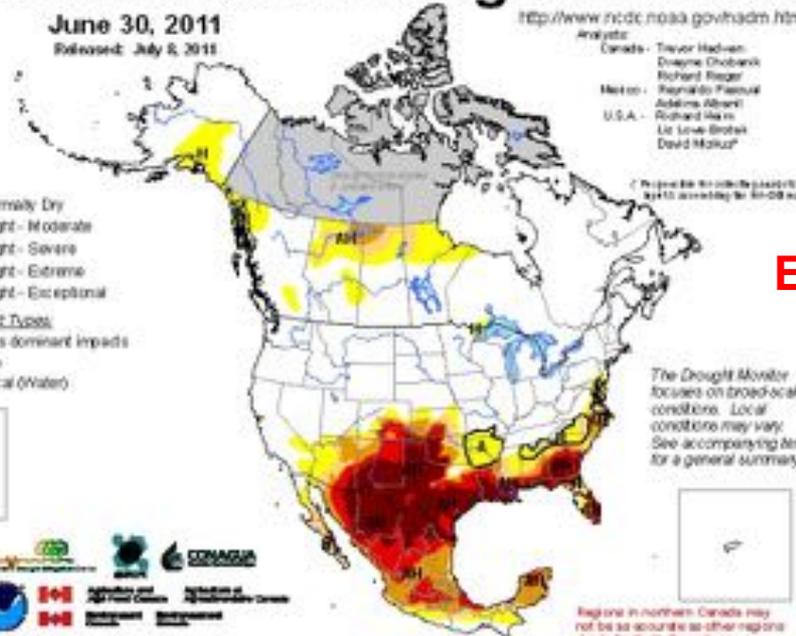
Canada - Trevor Hudson  
Dwayne Chobanian  
Richard Reager  
Mexico - Reynaldo Palacios  
Adelina Albert  
U.S.A. - Richard Viles  
Liz Love-Brook  
David Mielke

## Intensity:

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

## Drought Impact Types:

- Delineates dominant impacts
- A = Agriculture
- H = Hydrological (Water)



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

Regions in northern Canada may not be as accurate as other regions due to limited information.

English

Map and Narrative Available in Three Different Languages:

French

Spanish

# Suivi nord-américain des sécheresses

30 Juin 2011

Parusé le: Vendredi 8 Juillet, 2011

<http://www.ncdc.noaa.gov/hadm.html>

Analyste:

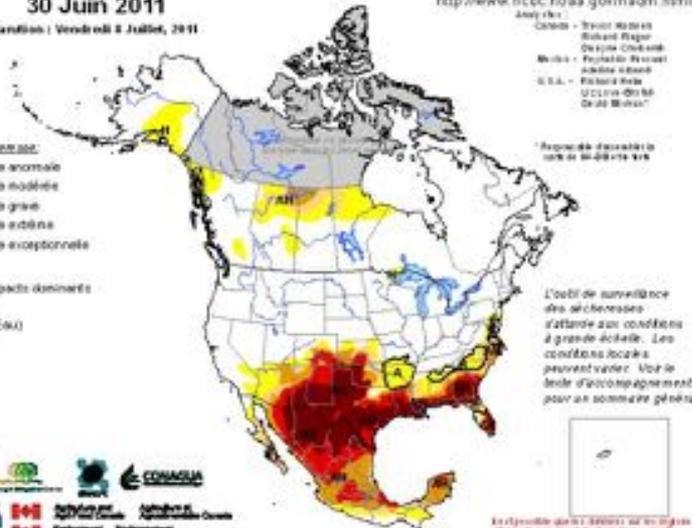
Canada - Trevor Hudson  
Dwayne Chobanian  
Richard Reager  
Mexico - Reynaldo Palacios  
Adelina Albert  
U.S.A. - Richard Viles  
Liz Love-Brook  
David Mielke

## Intensité de la sécheresse:

- D0 Sécheresse anormale
- D1 Sécheresse modérée
- D2 Sécheresse grave
- D3 Sécheresse extrême
- D4 Sécheresse exceptionnelle

## Type d'impacts:

- Deline les impacts dominants
- A = Agriculture
- H = Hydrologique (Eau)



L'outil de surveillance des sécheresses s'appuie sur des conditions à grande échelle. Les conditions locales peuvent varier. Voir le texte d'accompagnement pour un sommaire général.

Les régions au nord du Canada peuvent ne pas être aussi précises que les autres régions en raison de données limitées.

# Monitor de Sequía de América del Norte

Junio 30, 2011

Liberado: Viernes, 8 de julio de 2011

<http://www.ncdc.noaa.gov/hadm.html>

Analista:

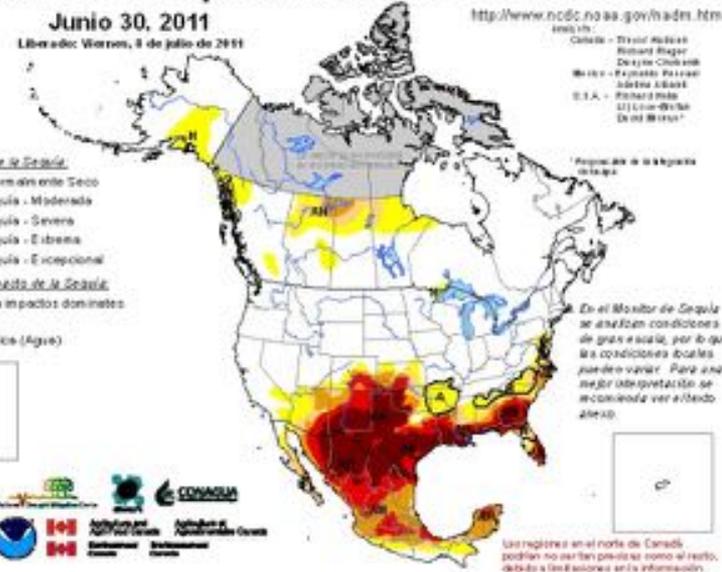
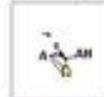
Canada - Trevor Hudson  
Dwayne Chobanian  
Richard Reager  
Mexico - Reynaldo Palacios  
Adelina Albert  
U.S.A. - Richard Viles  
Liz Love-Brook  
David Mielke

## Intensidad de la Sequía:

- D0 Anormalmente Seco
- D1 Sequía - Moderada
- D2 Sequía - Severa
- D3 Sequía - Extrema
- D4 Sequía - Excepcional

## Tipo de Impacto de la Sequía:

- Delinea impactos dominantes
- A = Agrícola
- H = Hidrológico (Agua)



El Monitor de Sequía se analiza condiciones de gran escala, por lo que las condiciones locales pueden variar. Para una mejor interpretación se recomienda ver el texto de apoyo.

Las regiones en el norte de Canadá podrían no ser tan precisas como el resto, debido a los datos limitados.



# U.S. Seasonal Drought Outlook

## Drought Tendency During the Valid Period



Valid September - November 2011

Released August 18, 2011



Development

Persistence

**KEY:**

-  Drought to persist or intensify
-  Drought ongoing, some improvement
-  Drought likely to improve, impacts ease
-  Drought development likely

Depicts large-scale trends based on subjectively derived probabilities guided by short- and long-range statistical and dynamical forecasts. Short-term events -- such as individual storms -- cannot be accurately forecast more than a few days in advance. Use caution for applications -- such as crops -- that can be affected by such events. "Ongoing" drought areas are approximated from the Drought Monitor (D1 to D4 intensity). For weekly drought updates, see the latest U.S. Drought Monitor. NOTE: the green improvement areas imply at least a 1-category improvement in the Drought Monitor intensity levels, but do not necessarily imply drought elimination.

# North America Drought Monitor

- **Strengths**

- Continental-scale depiction of drought
- Consistent across international borders
- Pool resources, increase communication
- Each country does their own monthly analysis
- Created via GIS for portability & consistency

- **Future Goals**

- Move U.S. from climate divisions to station network
- Increase spatial density of stations across North America

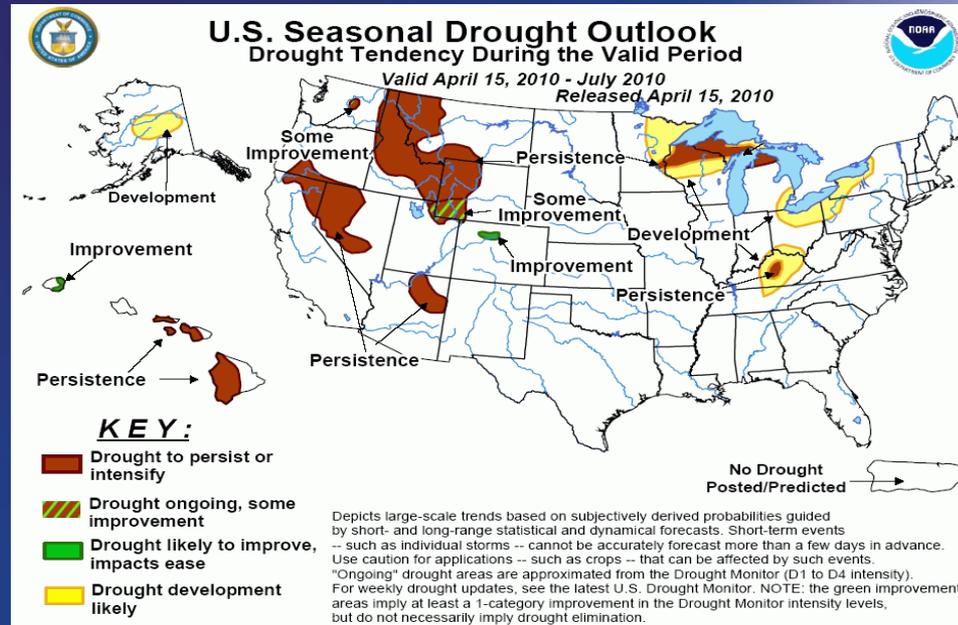
# U.S. Seasonal Drought Outlook History

An aerial photograph of a large reservoir, likely a dam, with a concrete structure on the right side. The water is a deep blue, contrasting with the surrounding dry, brownish landscape. The terrain is hilly and appears to be in a semi-arid region. The sky is clear and blue.

- Originated in August 1999 (shortly after the US Drought Monitor became operational)—went public in March 2000
- Intent is to present a simple national picture of where droughts will improve, persist, or develop
- Issued continuously each month (3<sup>rd</sup> and 1<sup>st</sup> Thursdays), with updates as required, by a scheduled rotation of 5 CPC forecasters



# Drought Forecasting: Short and Long-Term Forecast Contributions



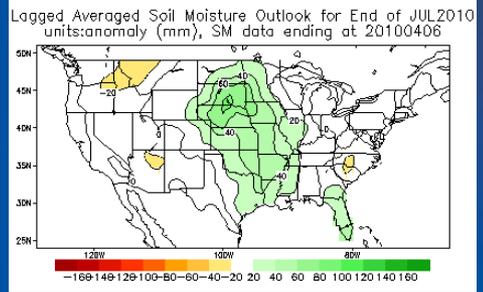
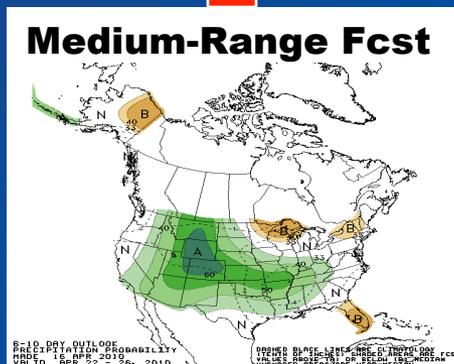
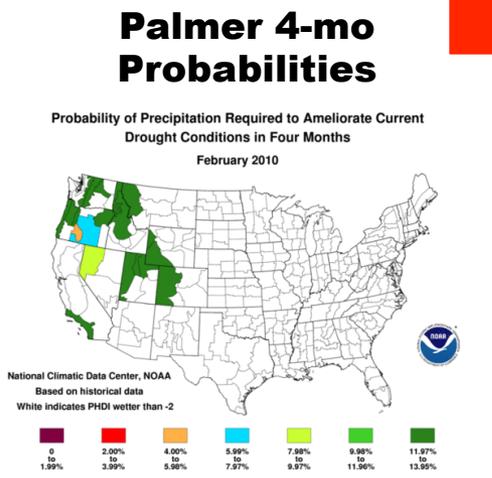
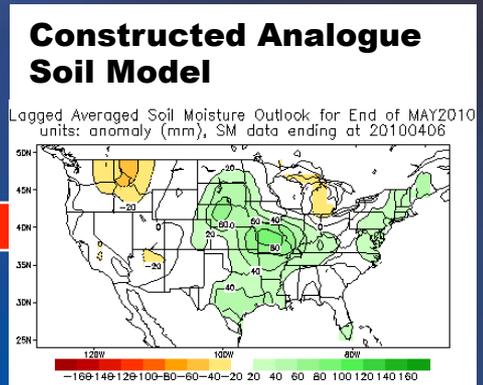
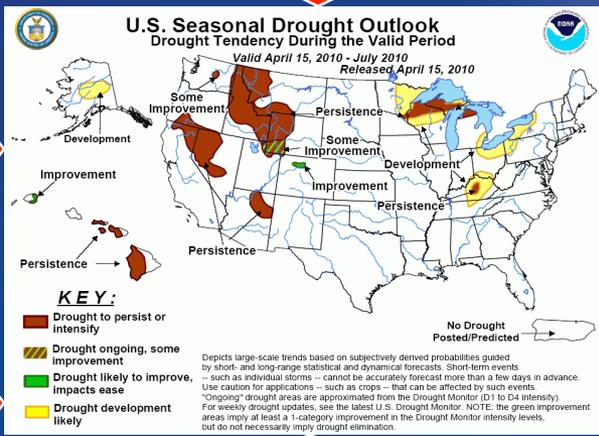
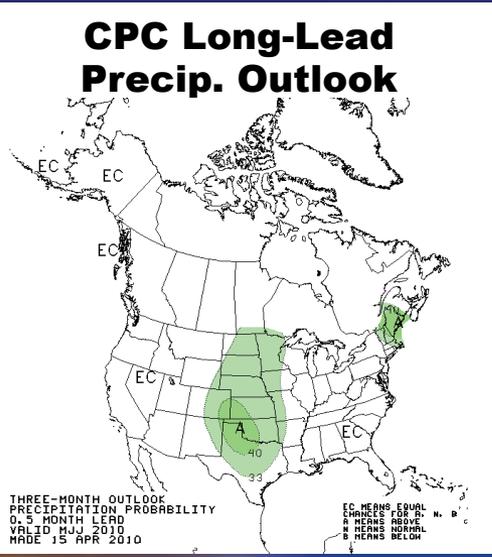
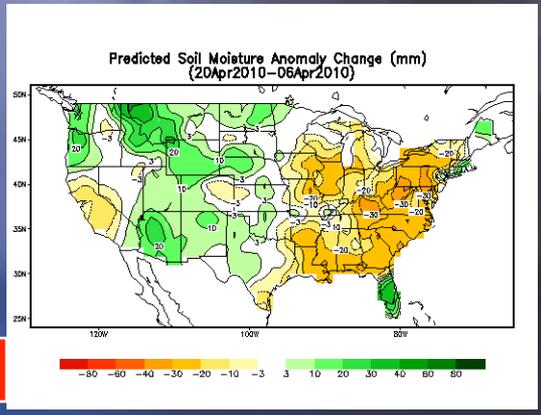
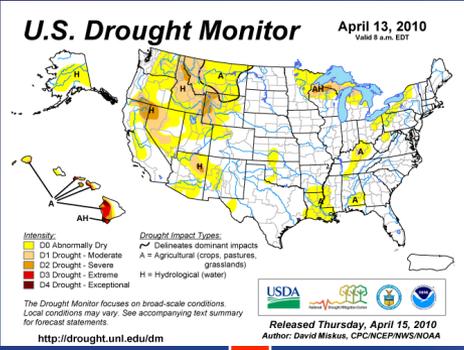
Start with latest U.S. Drought Monitor, D1-D4 areas

Extended Range (e.g. 2-week Soil Moisture Forecasts)

1- & 3-month Precipitation and Temperature Outlooks



# Primary Drought Outlook Inputs



# Numerous Guidance Tools available via the CPC Sanity Check Web Page (Restricted)

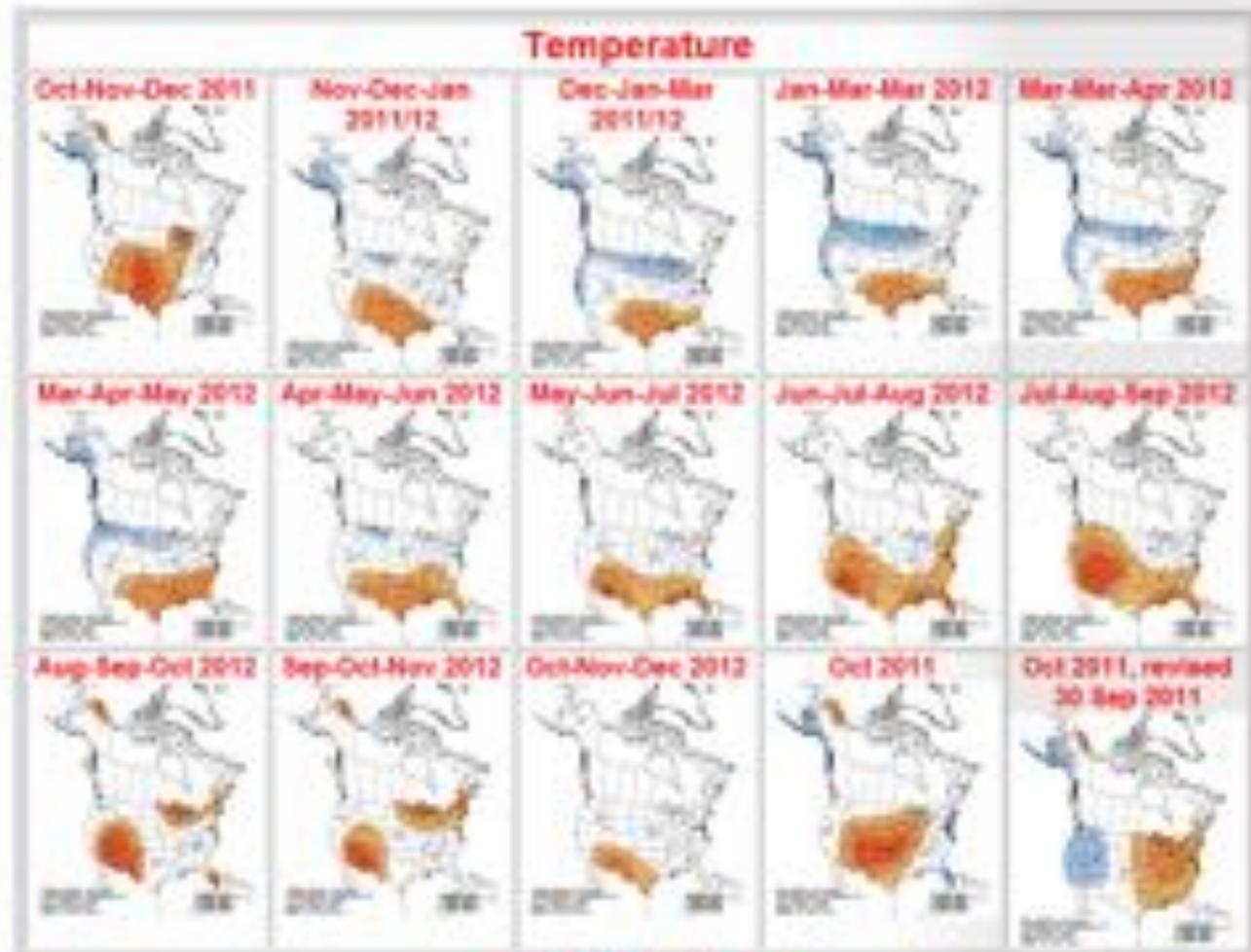
- 1. Power Point:
  - [Seasonal Monthly](#)
- 2. Verifications: [Mon. Sea, CMP](#)
- 3. Man to Day Obs:
  - [Temp, Prec](#)
  - [Weekly ENSO Update](#)
- 4. SST Forecasts
  - a. CES
  - b. CDC East
  - c. CDC Niño 3.4 SSTA
  - d. Scripps SST Anom. Est
  - e. Cons. SST
  - f. IRI Phone Diagram
  - g. Markov Eq. Pac. SST, Niño 3.4 Est
  - h. US El Niño Temp. & Prec. S.
  - i. SST CAI: 50mb. Temp, Prec, SST
- 5. Drought
  - a. Soil Moisture
  - b. Western Water Supply
  - c. NCDG Termination Ann.
- 6. Snow
  - a. NDIRSC
  - b. Rodgers
  - c. NESDS Analysis
  - d. NH Snow

Work in Our Mission: Who We Are

Contact Us: CPC Information, CPC Web Team

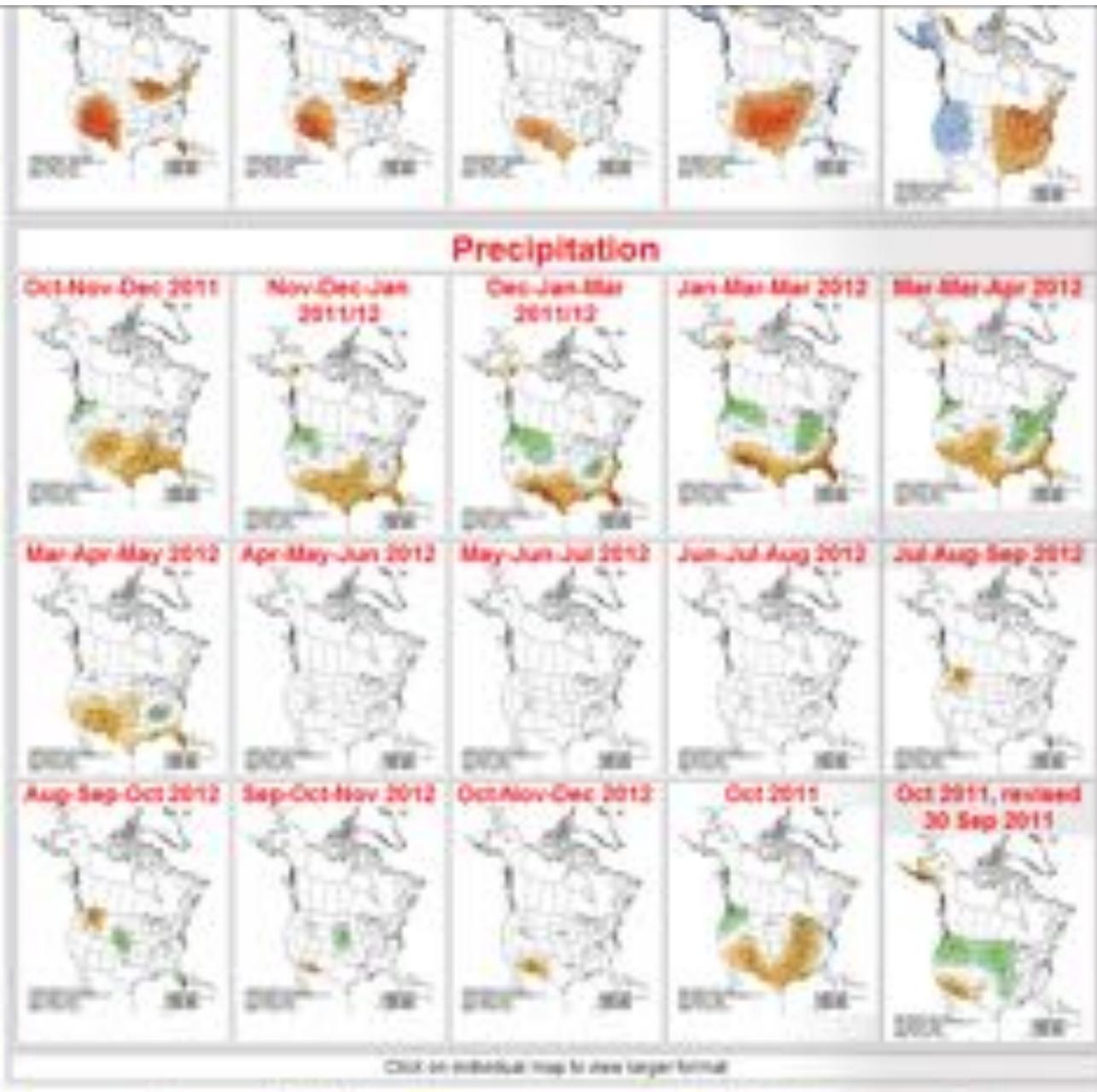
Obtain 30-day Outlooks: 30-day Outlooks are issued every second month from mid-November through Eastern Time. Please consult the schedule of 30 & 60-day outlooks for exact release dates.

## Monthly & Seasonal Forecast Sanity Check Maps Updated: 30 Sep 2011

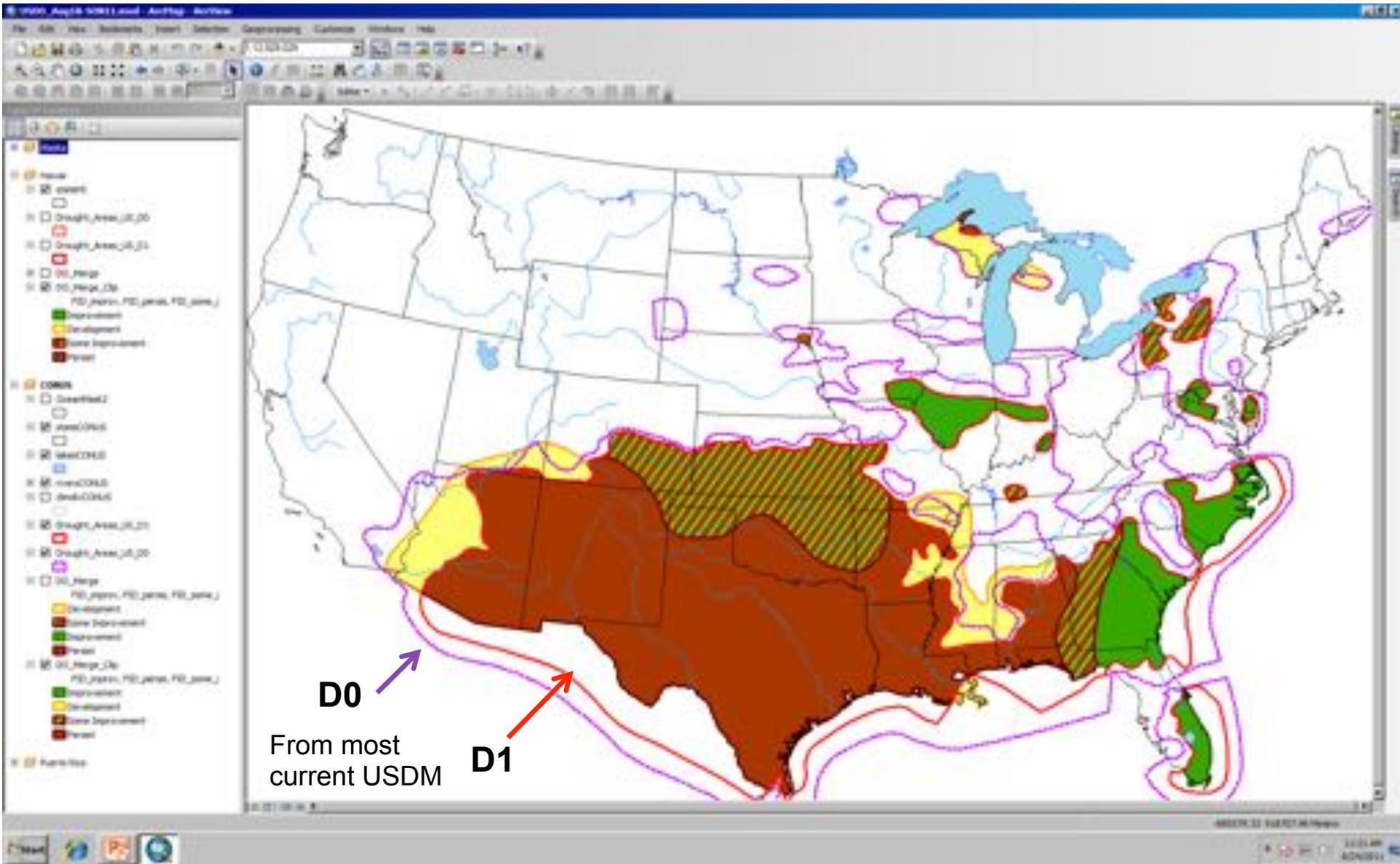


# Numerous Guidance Tools available via the CPC Sanity Check Web Page (Restricted)

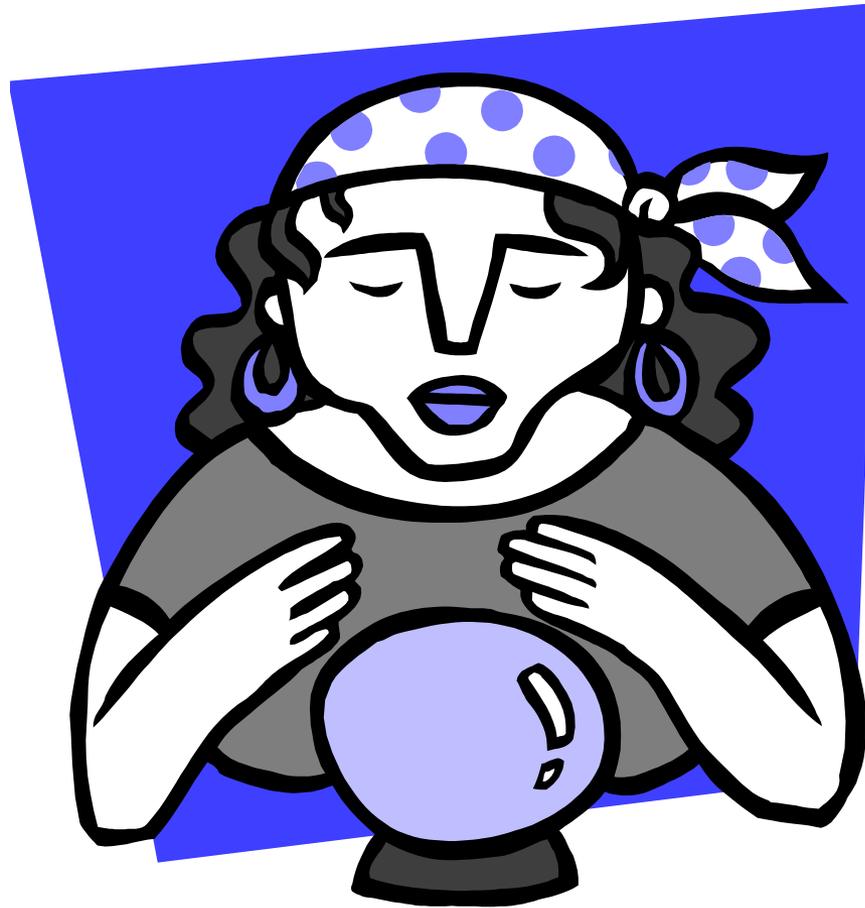
- 1. SST
- 2. CDC Feet
- 3. CDC Niño 3.4 SSTA
- 4. Scripps SST Anom Feet
- 5. Com SST
- 6. IRI Phone Diagram
- 7. Marker: Eg. Pac SST, Niño 3.4 Feet
- 8. US El Niño Temp & Prec by
- 9. SST CA: 50mb, Temp, Prec, SST
- 10. Drought
  - a. Soil Moisture
  - b. Western Water Supply
  - c. SCDC Termination/Ann
- 11. Snow
  - a. NHERSC
  - b. Rutgers
  - c. SENSIS Analysis
  - d. NH Snow Cover
  - e. NRCS SNOTEL
- 12. Tools: 80-Deg, 20-Deg
- 13. Medium Range: CDC, CPC, Tools
- 14. Long Lead Briefing Sequence



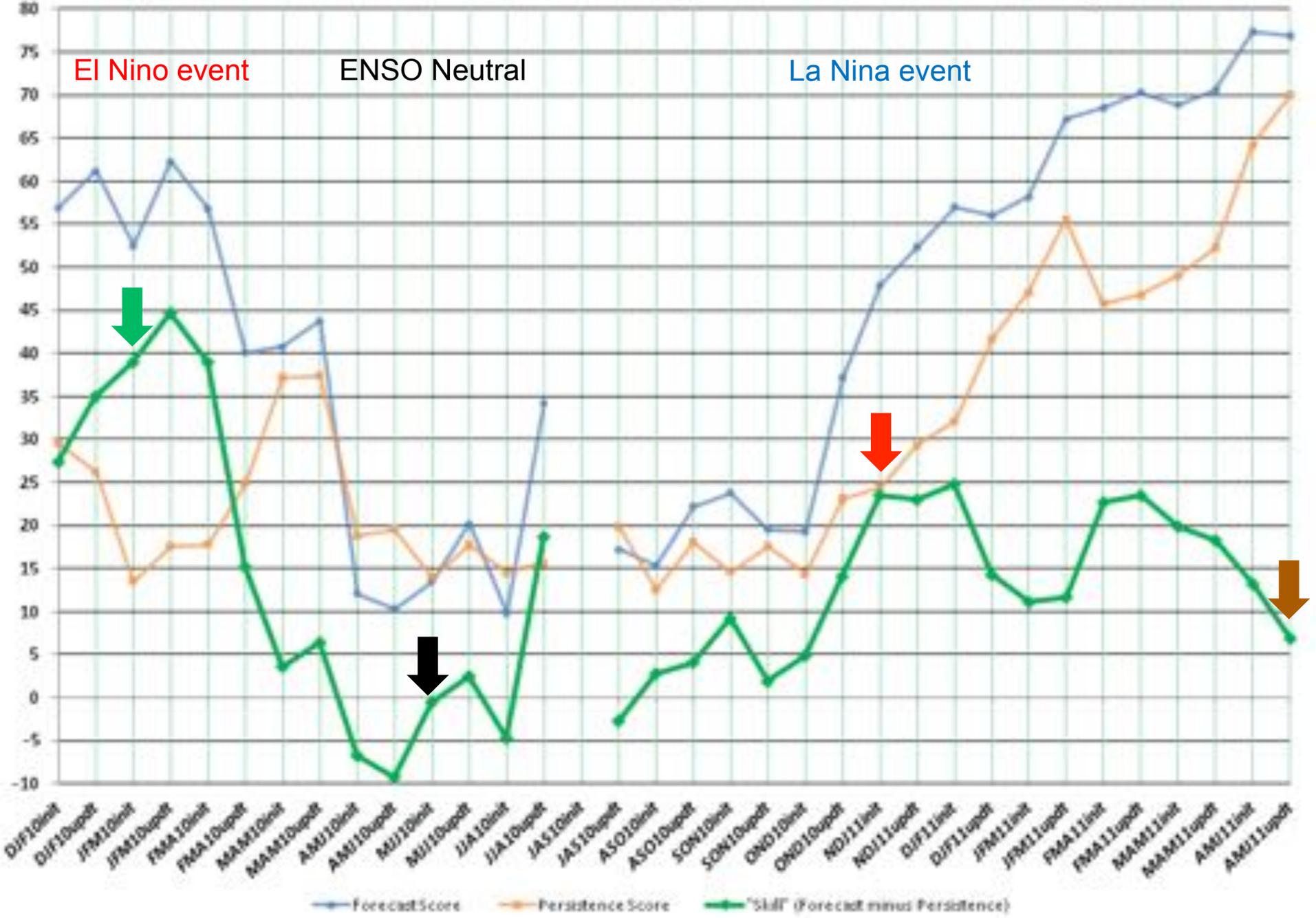
# Using ArcMap (GIS) to create the US Drought Outlooks



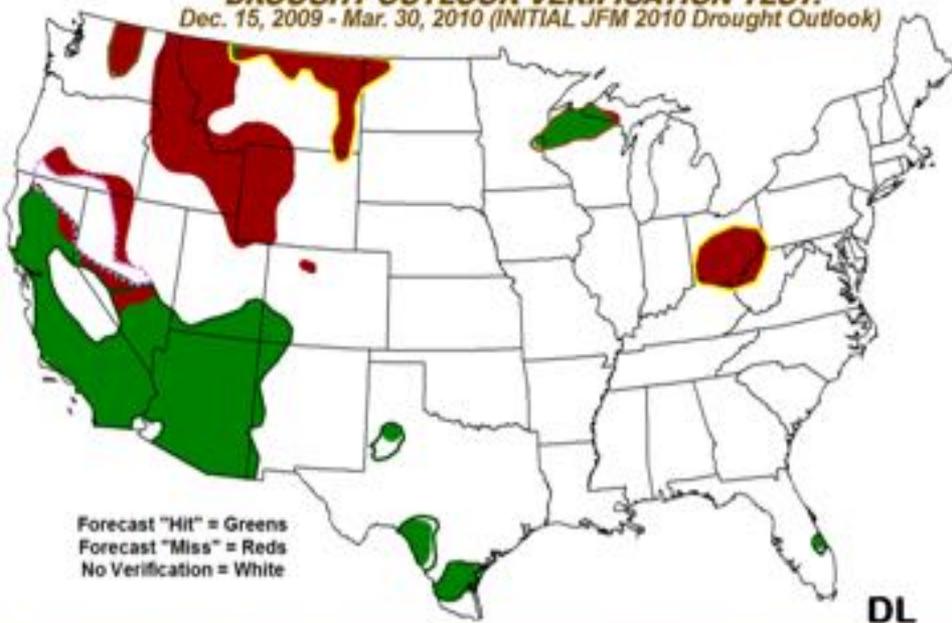
How Are We Doing?



# Drought Outlook Verification Scores (% of Forecast Pixels Hit) & Skill



**DROUGHT OUTLOOK VERIFICATION TEST:**  
Dec. 15, 2009 - Mar. 30, 2010 (INITIAL JFM 2010 Drought Outlook)



FORECAST	HIT	MISS
Improvement	46,471	2,519
Persistence	2,701	1,832
Development	163	40,276
<b>TOTAL</b>	<b>49,335</b>	<b>44,627</b>
<b>SCORE</b>	<b>52.5%</b>	
PERSISTENCE FORECAST BASELINE	12,150	77,905
<b>PERSISTENCE FORECAST SCORE</b>	<b>13.5%</b>	
<b>"SKILL"</b> (forecast score) minus (persistence score)	<b>+39.0</b>	

Good Improvement Forecast during El Nino

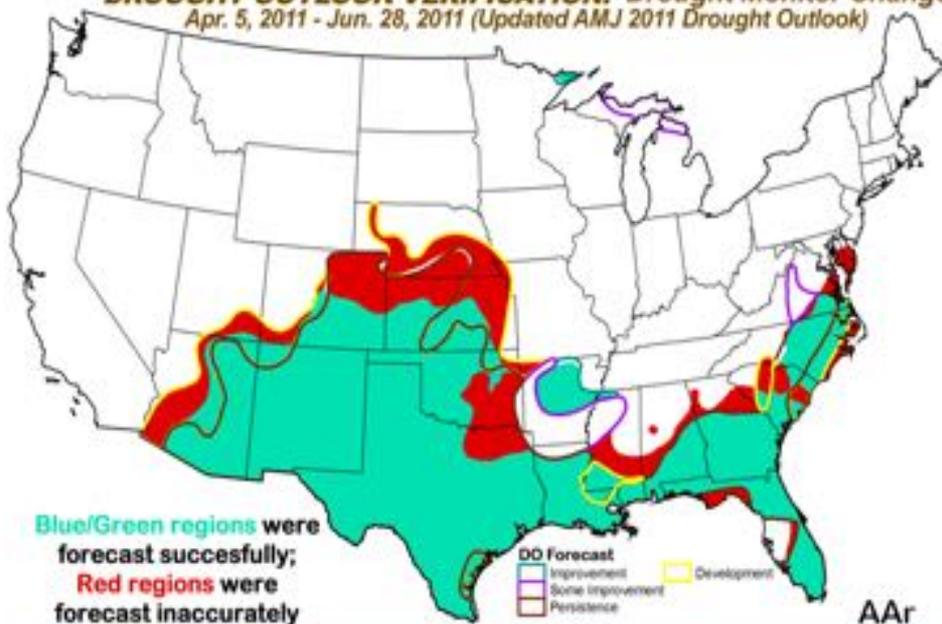
**DROUGHT OUTLOOK VERIFICATION: Drought Monitor Change**  
Oct. 19, 2010 - Feb. 1, 2011 (Initial NDJ 2010/11 Drought Outlook)



FORECAST	HIT	MISS
Improvement	8,759	437
Persistence	33,049	20,537
Development	30,686	58,999
<b>TOTAL</b>	<b>73,494</b>	<b>79,973</b>
<b>SCORE</b>	<b>47.9%</b>	
PERSISTENCE FORECAST BASELINE	35,039	108,616
<b>PERSISTENCE FORECAST SCORE</b>	<b>24.4%</b>	
<b>"SKILL"</b> (forecast score) minus (persistence score)	<b>+23.5</b>	

Decent Development Forecast during early La Nina

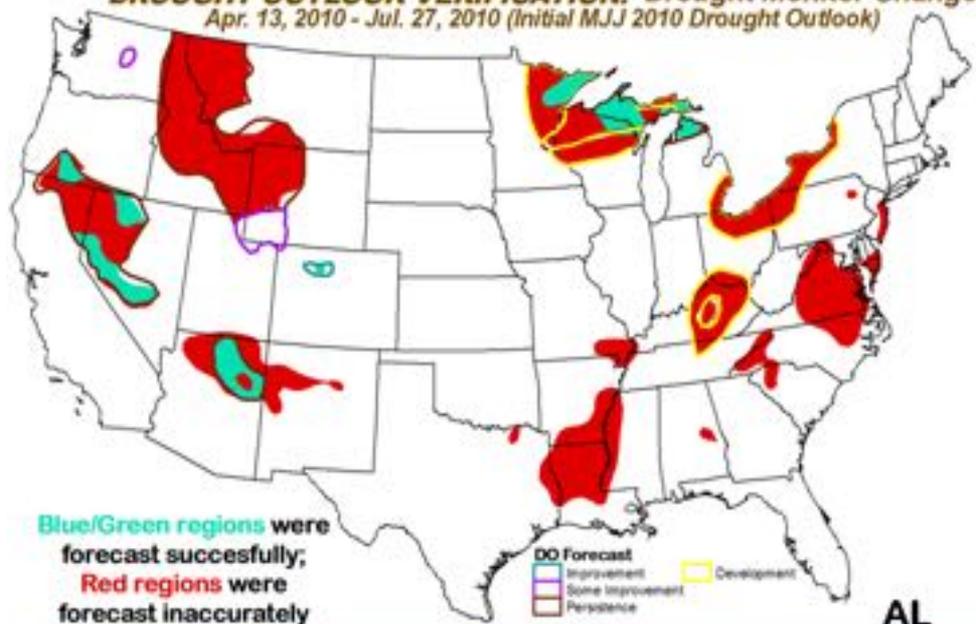
**DROUGHT OUTLOOK VERIFICATION: Drought Monitor Change**  
Apr. 5, 2011 - Jun. 28, 2011 (Updated AMJ 2011 Drought Outlook)



FORECAST	HIT	MISS
Improvement	3,413	0
Persistence	110,621	14,884
Development	12,146	23,034
<b>TOTAL</b>	<b>126,180</b>	<b>37,918</b>
<b>SCORE</b>	<b>76.9</b>	
PERSISTENCE FORECAST BASELINE	111,810	47,981
<b>PERSISTENCE FORECAST SCORE</b>	<b>70.0</b>	
<b>"SKILL"</b> (forecast score) minus (persistence score)	<b>+6.9</b>	

Good Persistence Forecast, but not Skill-wise

**DROUGHT OUTLOOK VERIFICATION: Drought Monitor Change**  
Apr. 13, 2010 - Jul. 27, 2010 (Initial MJJ 2010 Drought Outlook)



FORECAST	HIT	MISS
Improvement	108	0
Persistence	9,009	30,213
Development	1,728	39,065
<b>TOTAL</b>	<b>10,845</b>	<b>80,123</b>
<b>SCORE</b>	<b>13.5%</b>	
PERSISTENCE FORECAST BASELINE	9,717	59,728
<b>PERSISTENCE FORECAST SCORE</b>	<b>14.0%</b>	
<b>"SKILL"</b> (forecast score) minus (persistence score)	<b>-0.5</b>	

With ENSO-Neutral Conditions, no Development Forecast Skills

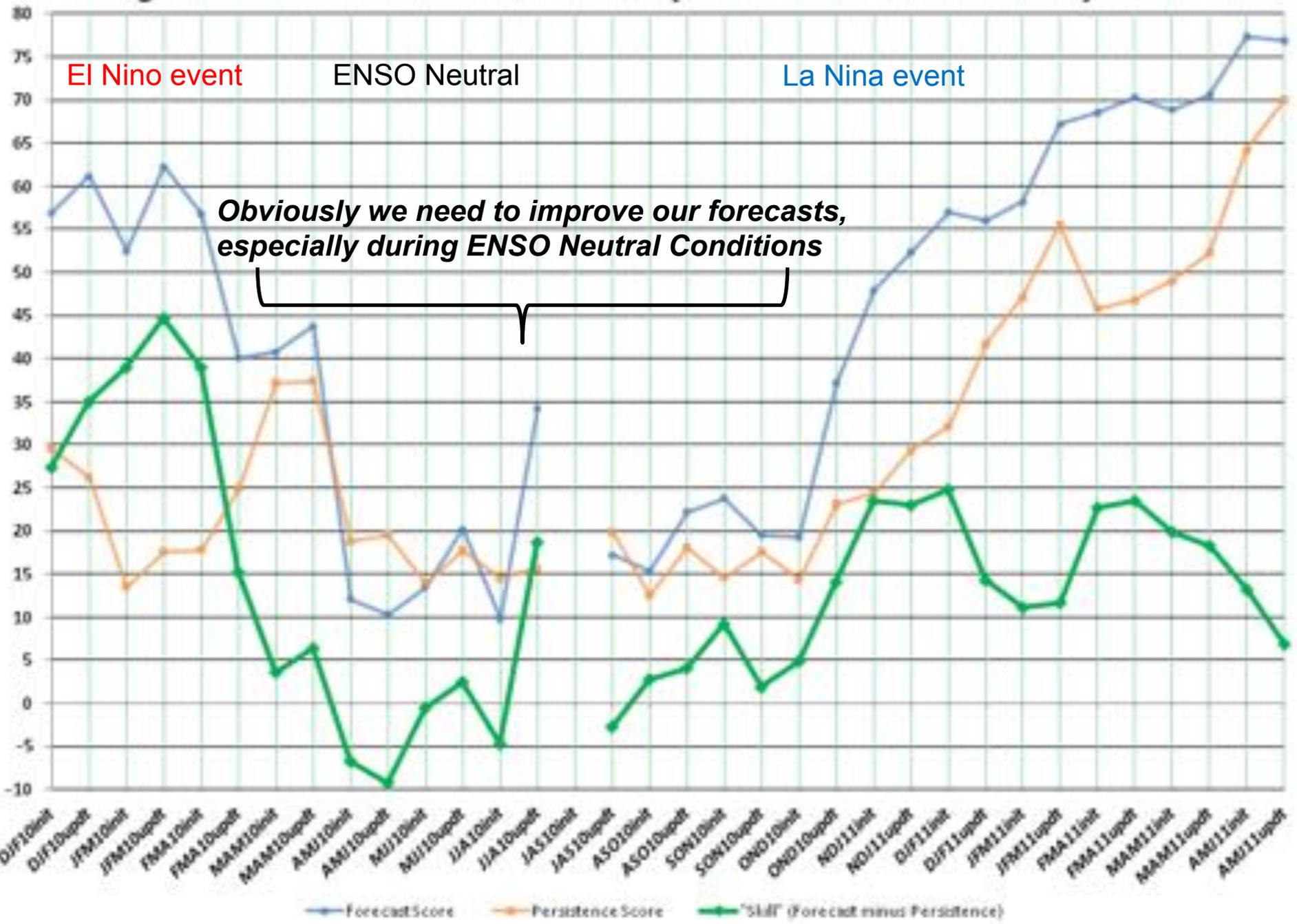
# Drought Outlook Verification Scores (% of Forecast Pixels Hit) & Skill

El Nino event

ENSO Neutral

La Nina event

*Obviously we need to improve our forecasts, especially during ENSO Neutral Conditions*





## Challenges:



- **Blending short-term forecasts with seasonal forecasts**
- **Improving skill of forecasts at all time ranges**
- **Providing useful information for both the agricultural and hydrologic community**
- **Develop an objective & probabilistic outlook**

## Next Steps in Drought Forecasting

- **Consideration of agriculture and hydrology (short-term and long-term drought)**
- **Modify 3-Month Outlook Categories & Create a 1-Month Drought Outlook (agriculture-related)**
- **Integration of Temperatures, Precipitation, and Soil Moisture Forecasts**
- **A seasonal forecast of drought probabilities**
- **Continuation of the current manual forecast, with the objective forecasts used as input and run in parallel**
- **Expansion to include Canada/Mexico (similar to NADM)**

# Proposed Modifications to the U.S. Seasonal Drought Outlooks

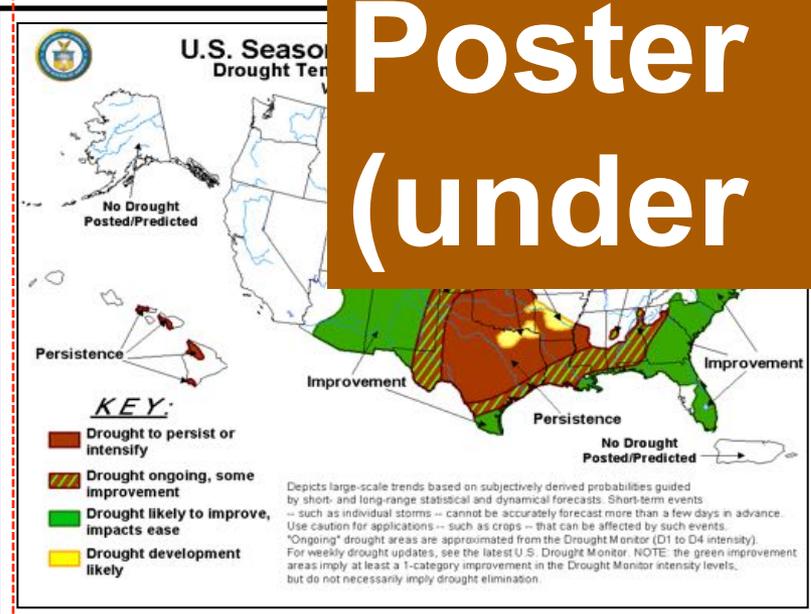
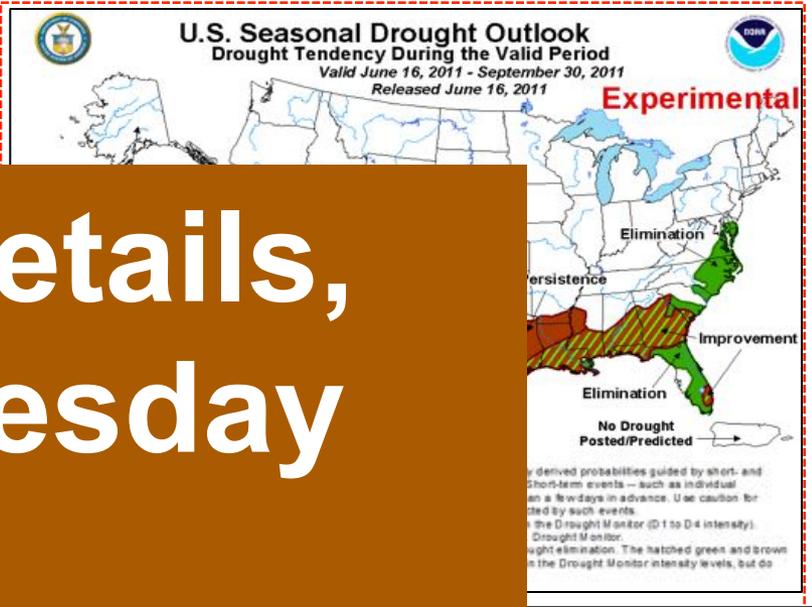
By CPC USDO Authors: David Miskus, Brad Pugh, Adam Allgood, Rich Tinker, and Anthony Artusa

For More Details,  
visit the Tuesday  
Evening  
Poster Event  
(under Drought)



Initial JAS' 11 USDO:  
Produced 3<sup>rd</sup> Thursday  
each Month

Created an **Elimination** category where Drought (>D1) is forecast to improve to D0 or none at end of period.

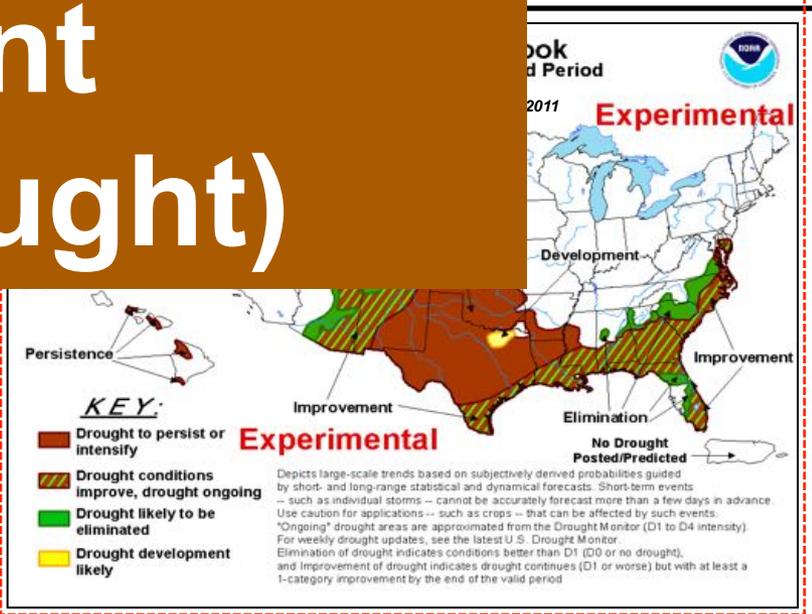


Thursday of Month to Last Day of Previous Month;

Created an **Elimination** category where Drought (>D1) is forecast to improve to D0 or none at the month;

Changed **Some Improvement** (a buffer zone between Improvement & Persistence; not scored) to **Improvement** where at least 1 category improvement is expected, but drought (>D1) is expected to remain at end of the month;

**Development** & Persistence remain the same;



Hopefully we'll see Clouds instead of  
Smoke in future Texas satellite images



Thank You!  
Any Questions?

David.Miskus@noaa.gov