Perspectives from the National Drought Mitigation Center

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Monitoring Program Area Leader
National Drought Mitigation Center
School of Natural Resources
University of Nebraska-Lincoln

WMO /UNISDR Expert Group Meeting on Agricultural Drought Indices
Murcia, Spain, June 1- 4, 2010

Outline

- **The NDMC**
  - NDMC Program Areas
  - Collaborations: National/International
  - Tools
- **Drought Monitor Process**
  - USDM
  - National + Regional Ag Inputs
  - NADM
- **Primary USDM Ag Indices**
  - SPI, Palmer Suite
- **New Wave of Tools**
  - Remote Sensing
  - Models/Land Data Simulations (LDAS)
- **NIDIS**
- **Summary**

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National Drought Mitigation Center

Founded: **1995 at the University of Nebraska-Lincoln**

Mission: **To lessen societal vulnerability to drought by promoting planning and the adoption of appropriate risk management techniques.**

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NDMC Program Objectives

- ***Improve the science*** of drought monitoring, planning, and mitigation
- Build ***awareness*** of drought and its ***impacts*** on society and the environment, and how human actions affect our vulnerability to drought
- Focus the attention of policy makers on the importance of ***drought policy and planning*** in the wise stewardship of natural resources

RESEARCH, OUTREACH, AND TRAINING

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NDMC Organizational Overview

Staff backgrounds:
Climatology
Meteorology
Hydrology
Water Resources

Staff backgrounds:
Planning
Economics
Public Participation
Rural Sociology
Anthropology
Journalism

Staff backgrounds:
GIS
Remote Sensing
Geography
Ecology

23 diverse faculty & staff

4 graduate students

3 visiting international scientists

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NDMC National Collaborations

Federal

- ***National Integrated Drought Information System (NIDIS)***
  - NIDIS Program Implementation Team, NIDIS Pilots Teams, NIDIS Portal Team, NIDIS Working Groups
- ***NOAA***: RISAs, RCCs, NCDC, NWS Offices (D.C., Regional, RFCs, WFOs), CPC, ESRL/PSD etc…
- ***NASA***: NASA Goddard Space Flight Center (GSFC) and Jet Propulsion Laboratory (JPL)
- ***USDA***: NRCS National Water and Climate Center, RMA, ARS, Joint Agricultural Weather Facility, World Agricultural Outlook Board
- ***USGS*** Center for Earth Resources Observation Science (EROS)
- ***U.S. Army Corps of Engineers***: Institute for Water Research
- ***Bureau of Reclamation:*** Lower Colorado Region

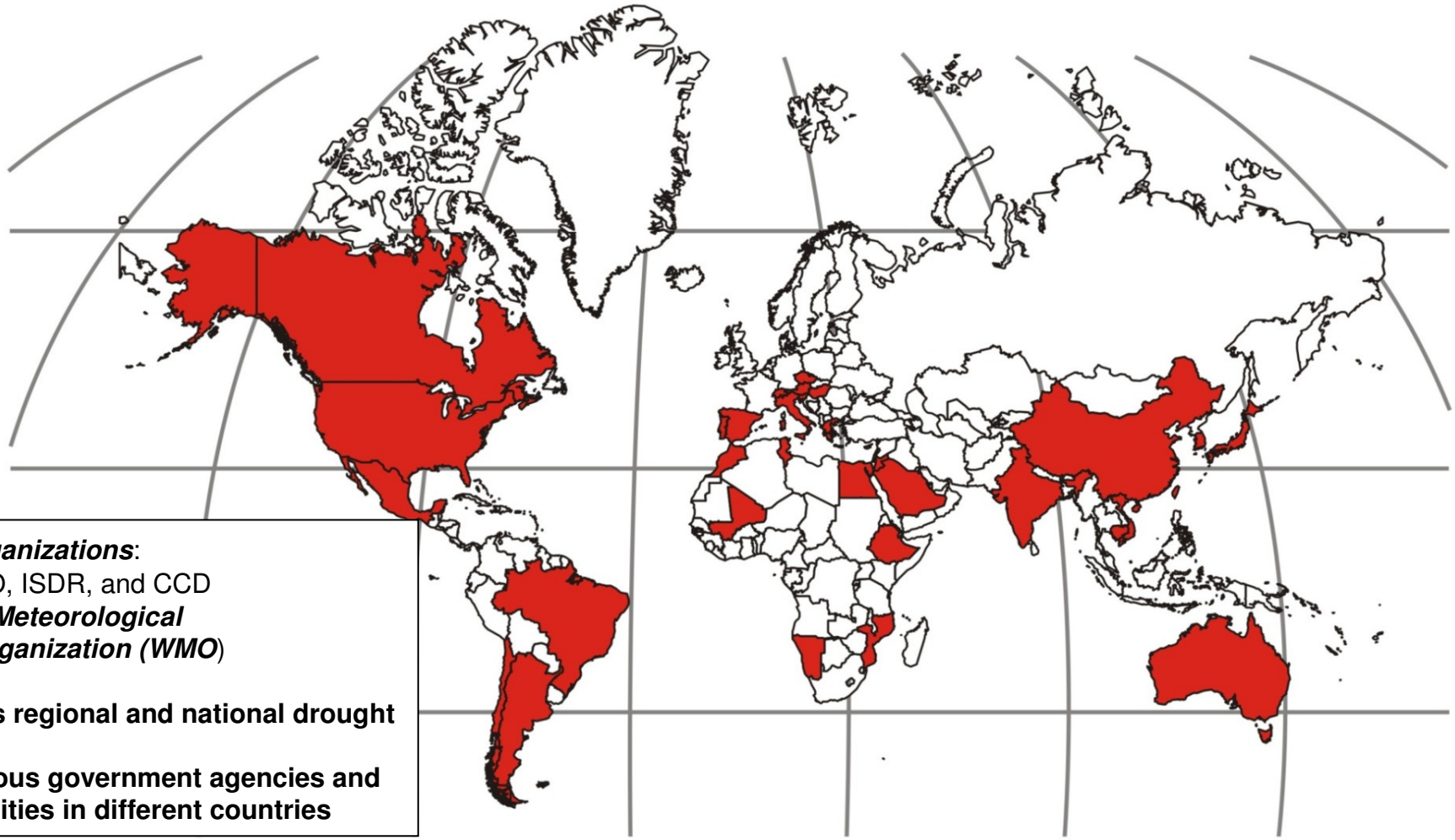
National

- U.S. Drought Monitor Author Group and Listserv
- North American Drought Monitor Author Group and Listserv
- National Phenology Network
- National Conference of State Legislatures

Other

- **Researchers at Universities:** Colorado, Arizona, Iowa State, Missouri, Kansas, Indiana, Purdue, Texas A&M, South Dakota State, Illinois, Oklahoma, New Mexico, UNK, Augustana, Colorado State, UMKC, South Carolina, Washington, Wisconsin, Dartmouth, California-Riverside, Scripps Research Institute, Center for Research on the Changing Earth System
- **States/Tribes**: Hualapai, Hawaii, Colorado, Missouri, Nebraska, Arizona, Illinois, Oklahoma
- **Communities:** Lincoln, NE; Kansas City, MO; Johnson County, KS; Nebraska City, NE; Decatur, IL; Ada, Cordell, Norman, OK
- **Nebraska Natural Resources Districts**

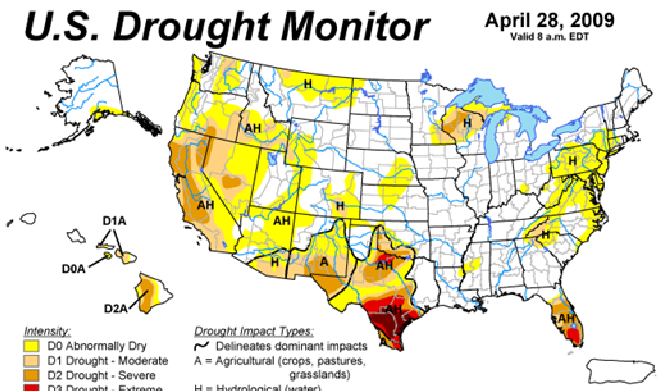
NDMC International Activities

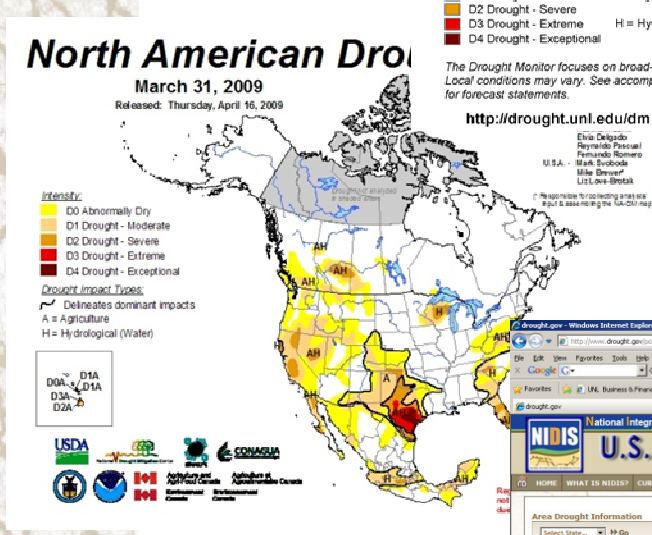


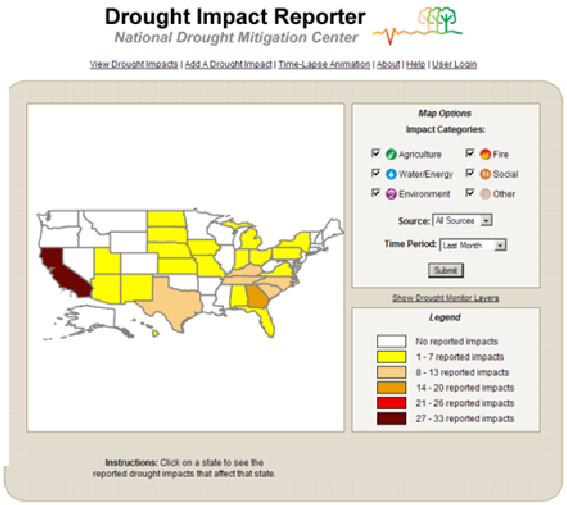
- ***UN organizations***:
  FAO, ISDR, and CCD
- ***World Meteorological Organization (WMO)***
- ***US AID***
- **Various regional and national drought centers**
- **Numerous government agencies and universities in different countries**

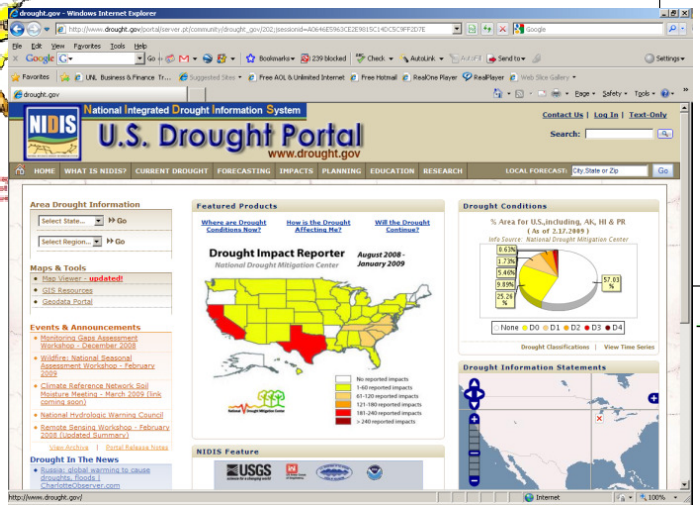
Czech Republic • Italy • Switzerland • Spain • Slovenia • European Union • Southern Europe/Northern Africa • Morocco • Tunisia • Mali • Ethiopia • Mozambique • Namibia • Egypt • Saudi Arabia • Jordan • India • Japan • China • South Korea • Vietnam and Cambodia • Australia • Brazil • Chile • Mexico • Canada • United States

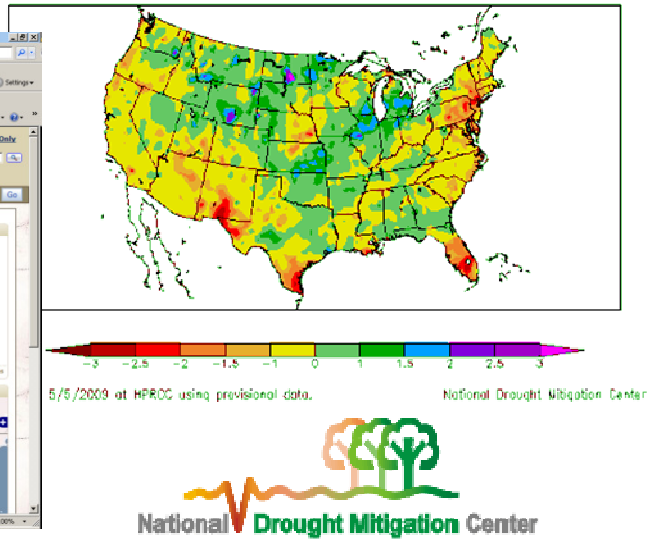
NDMC's Monitoring Program Area











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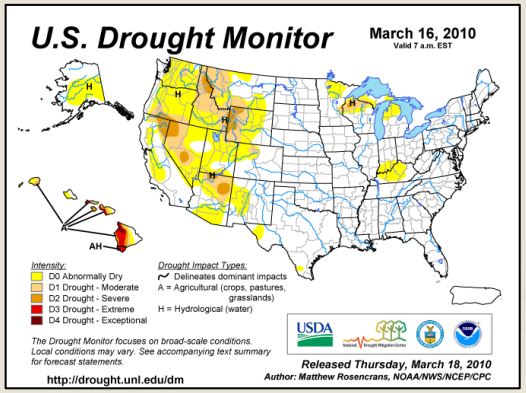
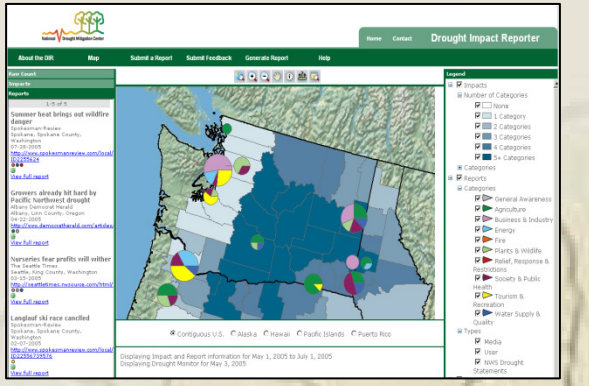
Operational Drought Tools at the NDMC

U.S. Drought Monitor (USDM)



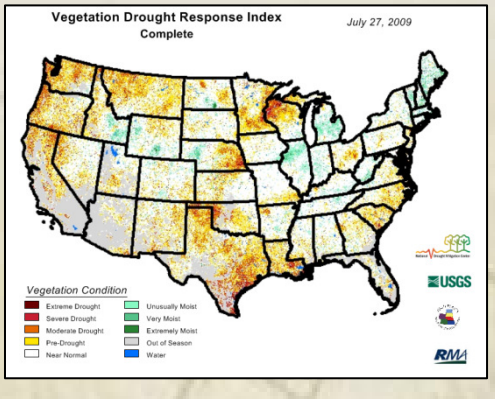
http://drought.unl.edu/dm

Drought Impact Reporter (DIR)



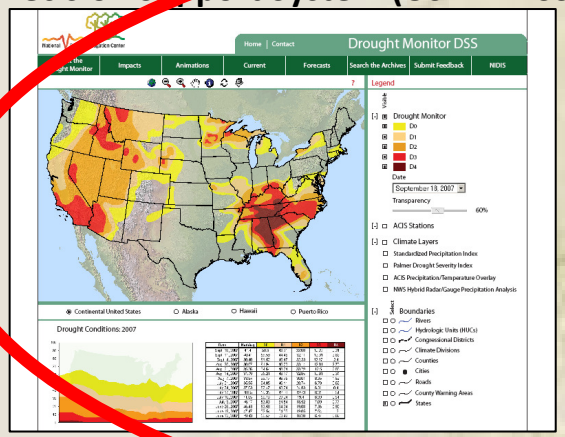
http://droughtreporter.unl.edu/

VegDRI

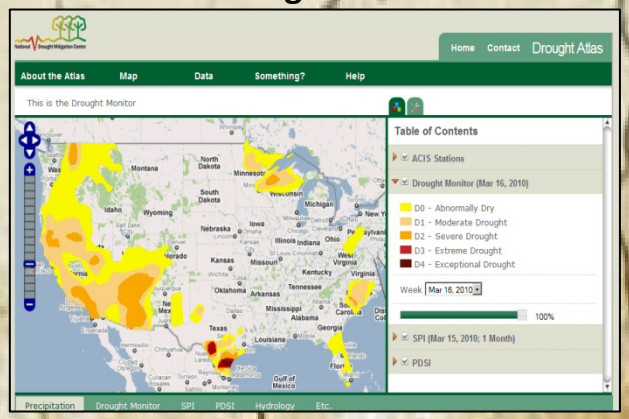


http://drought.unl.edu/vegdri/VegDRI_Main.htm#

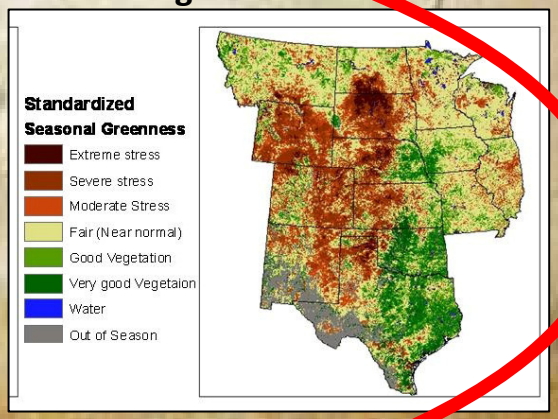
U.S. Drought Monitor Decision Support System (USDM-DSS)



Drought Atlas



Vegetation Outlook



COMING SOON!!

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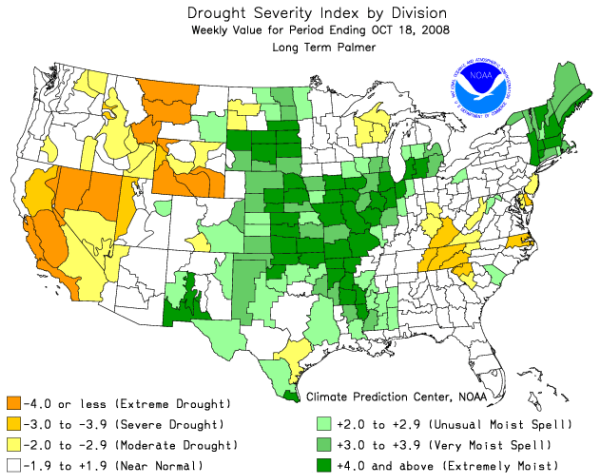
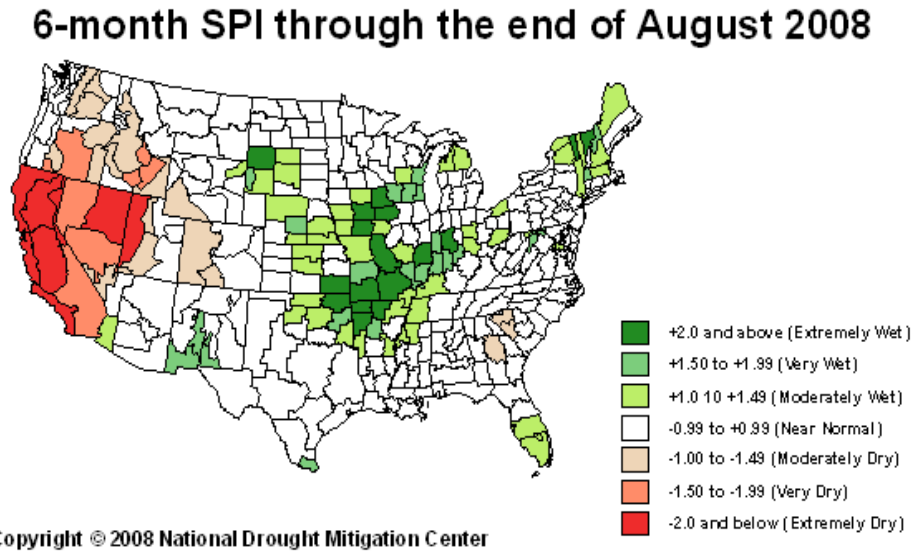
Approaches to Drought Assessment

- Single index or indicator (parameter)
- Multiple indices or indicators
- *Composite Indicator*

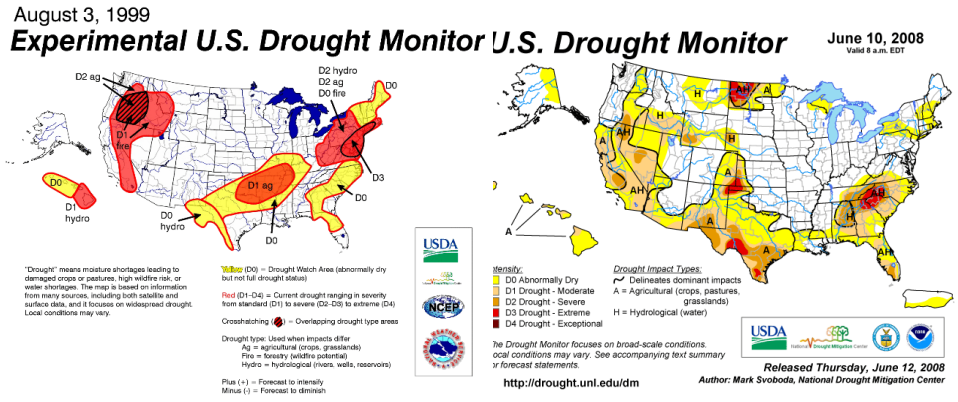




The U.S. Drought Monitor

Since 1999, NOAA (CPC, NCDC, WRCC), USDA, and the NDMC have produced a weekly composite drought map with input from numerous federal and non-federal agencies

- **Western Region Climate Center on board 2008**
  - **CalDry listserver hosted by CA DWR**
- **10 authors in all**
- **Incorporate relevant information and products from all entities (and levels of government) dealing with drought (RCC's, SC's, federal/state agencies, etc.) *(~260 experts)***



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Objectives

- **"Fujita-like"** scale
- Assessment of **current** conditions
- ***NOT*** a forecast!
- ***NOT*** a drought declaration!
- Identify ***impacts*** (A, H)
- Incorporate **local expert** input
- Be as **objective** as possible

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The Drought Monitor Concept

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

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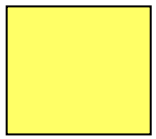
U.S. Drought Monitor Map

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)**

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Key Variables for Monitoring Drought

- *climate data*
- *soil moisture*
- stream flow
- ground water
- reservoir and lake levels
- snow pack
- short, medium, and long range forecasts
- *vegetation health/stress* and fire danger
- impacts

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U.S. Drought Monitor

Integrates Key Drought Indicators:

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

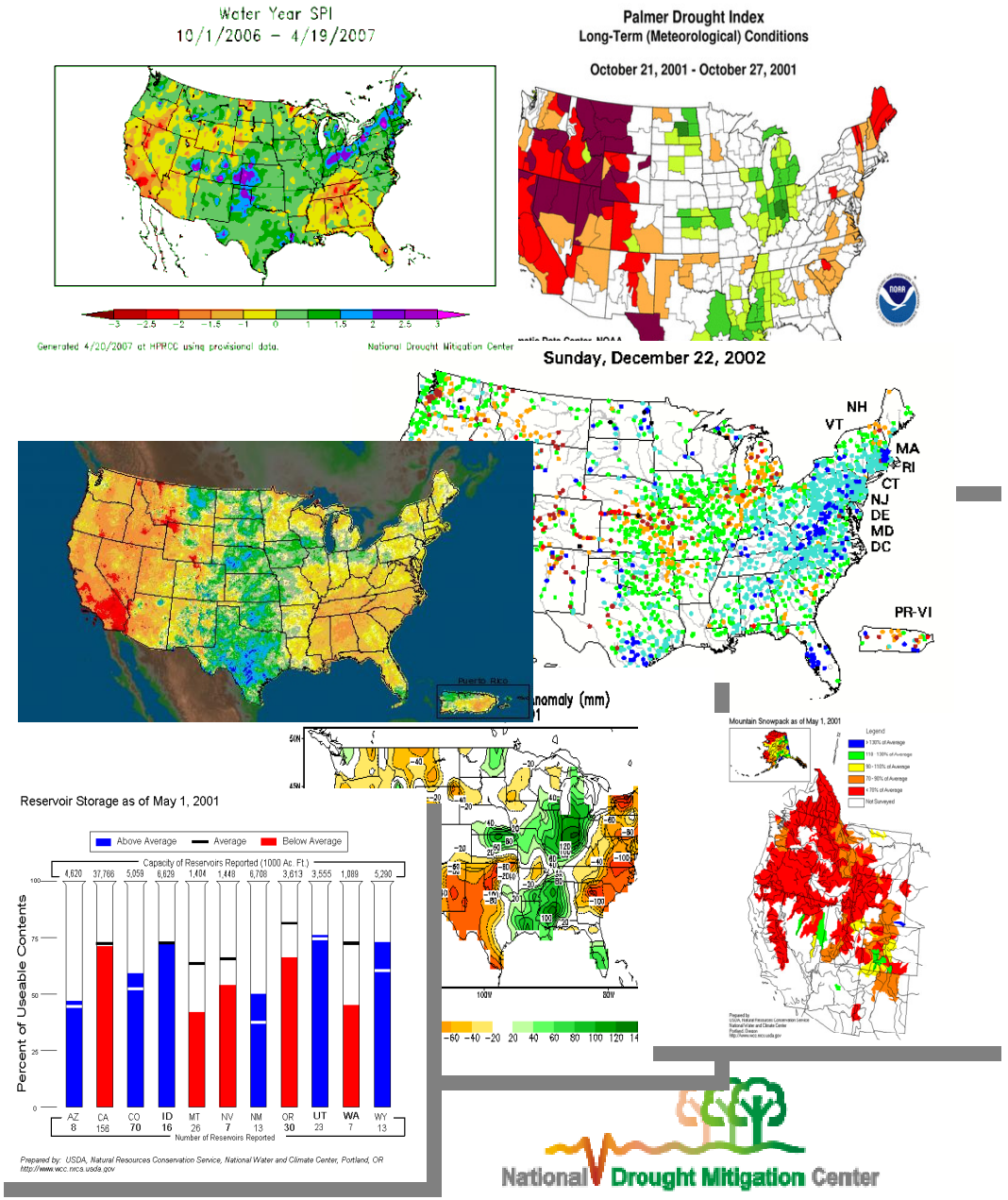
Growing Season:

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

In The West:

- SWSI
- Reservoir levels
- Snowpack (SNOTEL)
- SWE
- Streamflow

Created in ArcGIS



The Importance of Local Expert Input

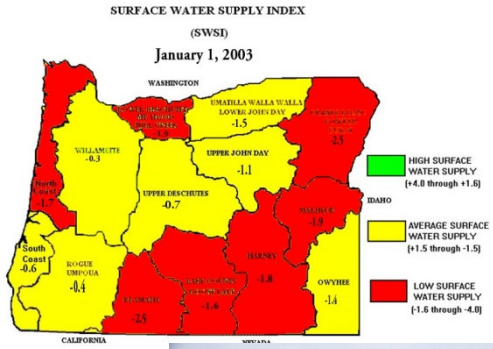
- **The U.S. Drought Monitor Team Relies on Field Observation Feedback from the Local Experts for *Impacts* Information & "Ground Truth"**
  - **Listserver (~270 Participants: 2/3 Federal, 1/3 State/Univ.)**

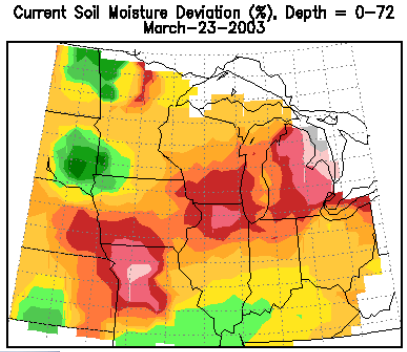
Local NWS & USDA/NRCS Offices

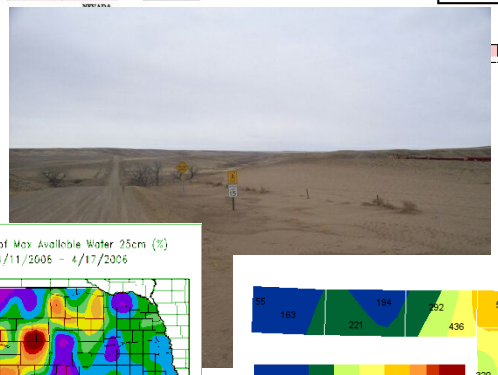
State Climate Offices

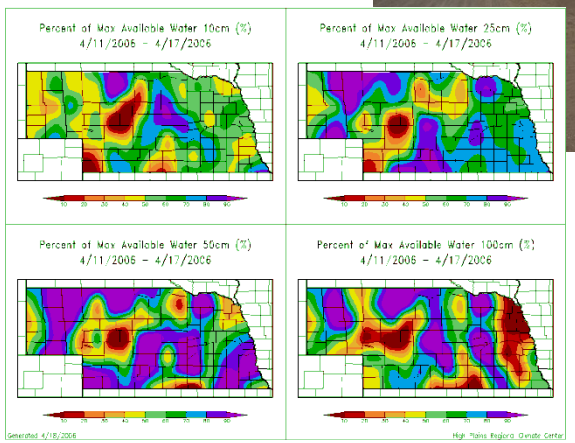
State Drought Task Forces

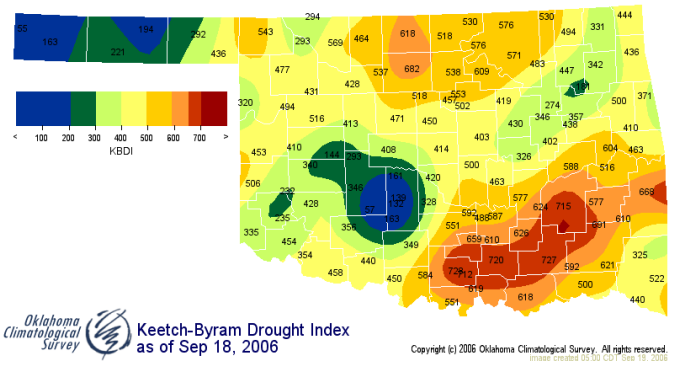
Regional Climate Centers





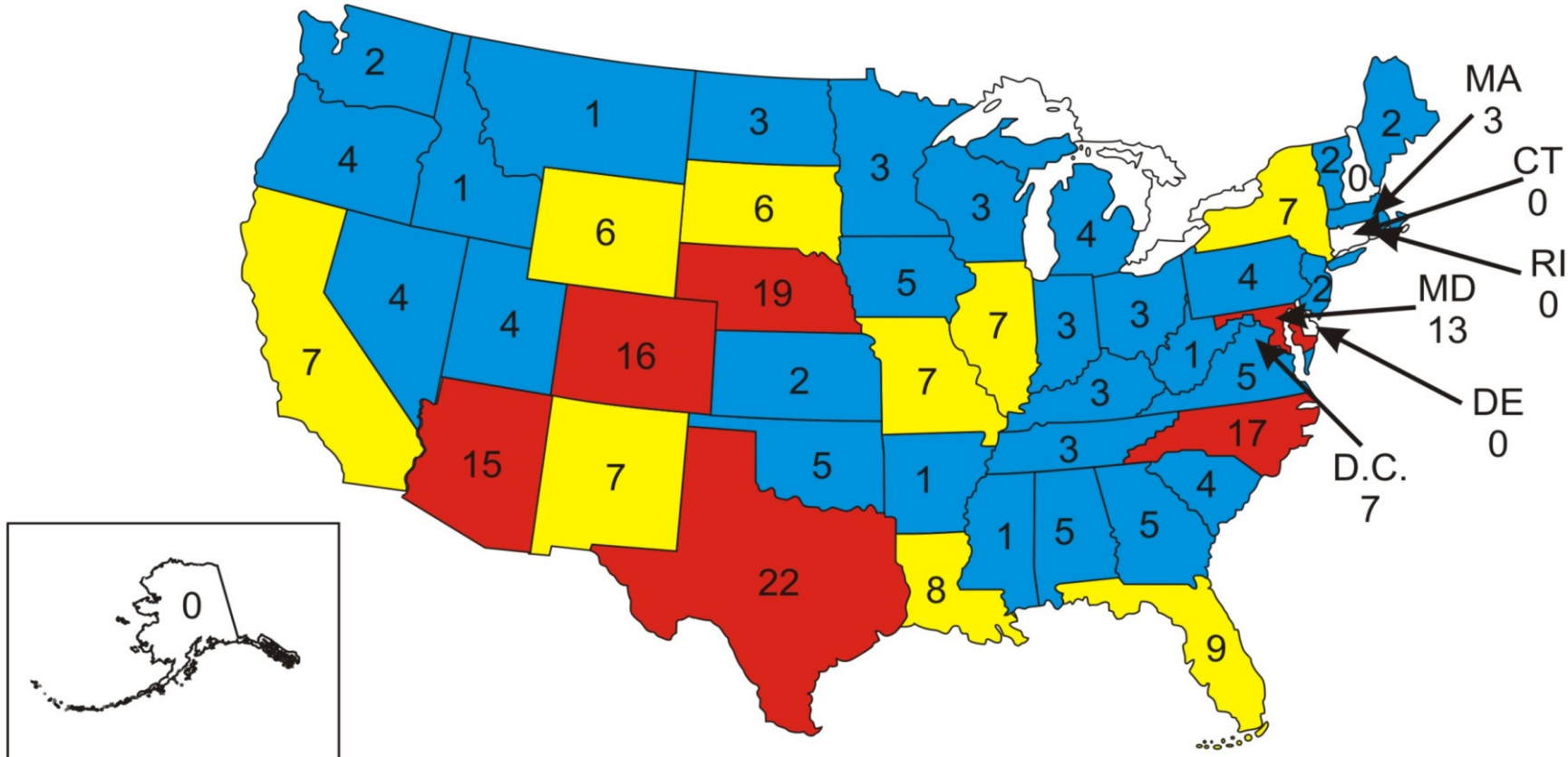






USDM Listserve Subscribers

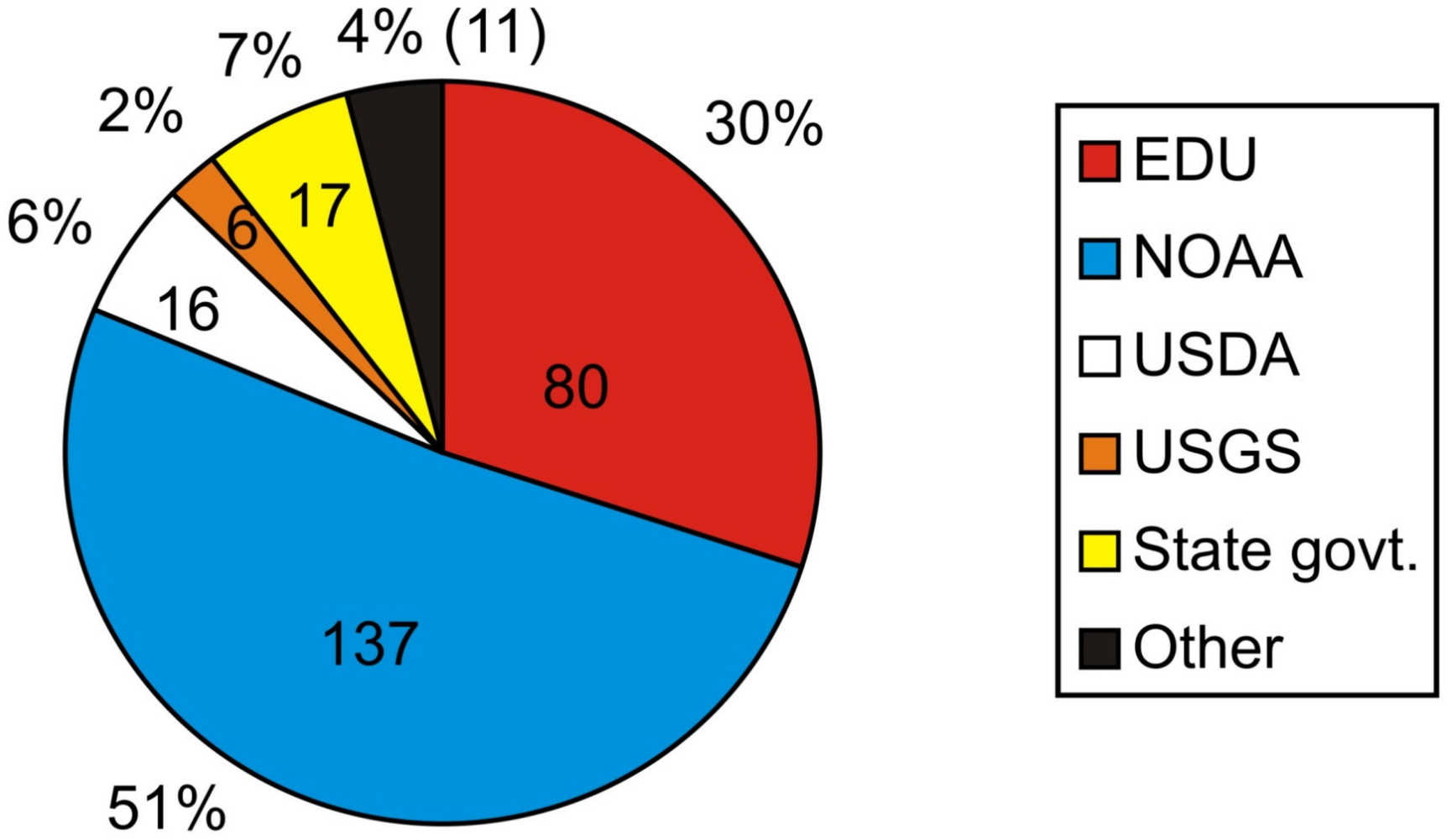
(as of January 13, 2010)



Total: 264 (does not include 1 participant from Canada and 2 participants from Mexico)

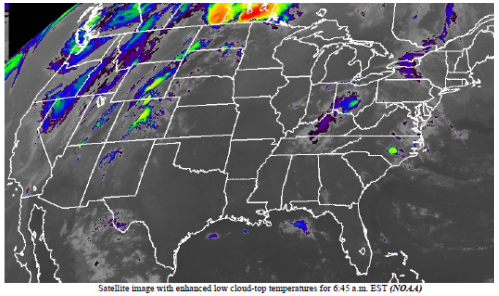
USDM Listserve Subscribers

(as of January 13, 2010)



USDM National and Regional Agricultural Indicators

- USDA Daily Ag Weather Highlights
- USDA Weekly Weather and Crop Bulletin
- USDA National Ag Statistics Service (NASS)
- State Ag Statistics Crop Progress Reports
- Drought Impact Reporter



Satellite image with enhanced low cloud-top temperatures for 6:45 a.m. EST *(NOAA)*

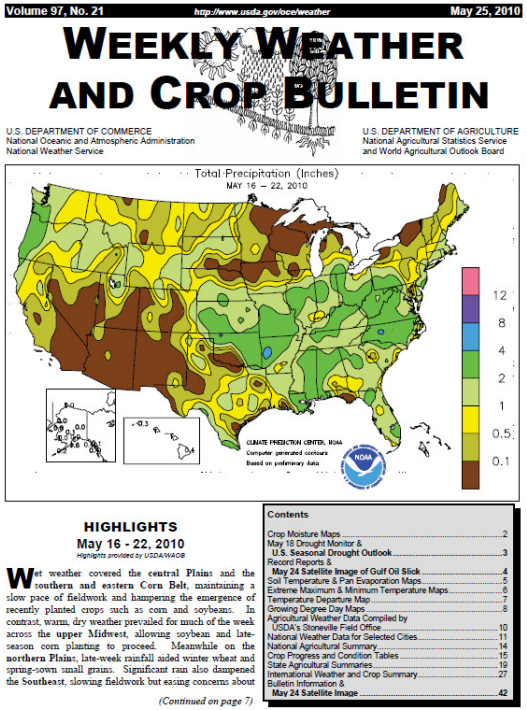
Agricultural Weather Highlights – Friday - May 28, 2010

- *In the West*, cool weather and scattered showers continue to hamper crop development—especially in [illegible] of *California*, the *Great Basin*, and the *Northwest*.
- *On the Plains*, showers and thunderstorms are returning to *northern areas*, where a phenomenal 85% [illegible] the U.S. spring wheat crop was rated in good to excellent condition, according to USDA/NASS, on May 23. Meanwhile on the *central and southern Plains*, warm, dry weather is conductive to fieldwork activities, summer crop emergence and development, and winter wheat maturation.
- *In the Corn Belt*, scattered showers are mostly confined to the *Ohio Valley*. Elsewhere in the *Midwest* combination of warm, mostly dry weather and abundant soil moisture remains favorable for planting activities and corn and soybean emergence and growth.
- *In the South*, warm weather and isolated showers are maintaining generally favorable conditions for pastures, maturing winter grains, and recently emerged summer crops. Developing drought remains a concern, however, from *eastern Texas into the lower Mississippi Valley*.

Outlook: During the next few days, scattered showers and thunderstorms will affect the *Southeast*. Meanwhile, a cold front emerging from the *West* will cross the *Plains* on Saturday and the *Midwest* on Sunday. [illegible] front will reach the *East Coast* next Tuesday, June 1. During the next 5 days, the *Southwest* will remain mo[illegible] dry, while precipitation could total as much as 1 to 3 inches across the *northern Plains* and the *Southeast*. During the weekend, temperatures will rebound to near-normal levels in the *West*. The NWS 6- to 10-day outlook for June 2-6 calls for below-normal temperatures in the *Pacific Northwest* and across the *eastern one-third of the U.S.*, while warmer-than-normal weather will prevail from the *nation's southwestern quadrant* [illegible] *the northern Plains*. Meanwhile, above-normal precipitation in the *Northwest* and across the *eastern one-[illegible] of the nation* will contrast with drier-than-normal conditions in parts of the *north-central U.S.*

Contact: Brad Rippey, Agricultural Meteorologist, USDA/OCE/WAOB, Washington, D.C. (202-720-2397)
Web Site: http://www.usda.gov/oce/weather/pubs/Daily/TODAYSWX.pdf

The outlook is an interpretation of National Weather Service (NWS) forecasts and products.



Volume 97, No. 21 http://www.usda.gov/oce/weather May 25, 2010

WEEKLY WEATHER AND CROP BULLETIN

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service

U.S. DEPARTMENT OF AGRICULTURE
National Agricultural Statistics Service
and World Agricultural Outlook Board

Total Precipitation (Inches)
MAY 16 – 22, 2010

12 8 4 2 1 0.5 0.1

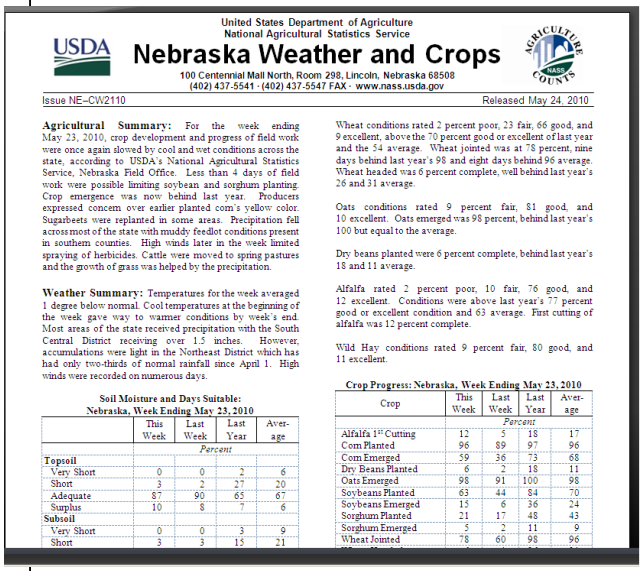
CLIMATE PREDICTION CENTER, NOAA
Computer generated contours
Based on preliminary data

HIGHLIGHTS
May 16 - 22, 2010
Highlights provided by USDA/WAOB

Wet weather covered the **central Plains** and the **southern and eastern Corn Belt**, maintaining a slow pace of fieldwork and hampering the emergence of recently planted crops such as corn and soybeans. In contrast, warm, dry weather prevailed for much of the week across the **upper Midwest**, allowing soybean and late-season corn planting to proceed. Meanwhile on the **northern Plains**, late-week rainfall aided winter wheat and spring-sown small grains. Significant rain also dampened the **Southeast**, slowing fieldwork but easing concerns about

(Continued on page 7)

Contents



United States Department of Agriculture
National Agricultural Statistics Service

USDA

Nebraska Weather and Crops

100 Centennial Mall North, Room 298, Lincoln, Nebraska 68508
(402) 437-5541 - (402) 437-5547 FAX - www.nass.usda.gov

Issue NE–CW2110 Released May 24, 2010

Agricultural Summary: For the week ending May 23, 2010, crop development and progress of field work were once again slowed by cool and wet conditions across the state, according to USDA's National Agricultural Statistics Service, Nebraska Field Office. Less than 4 days of field work were possible limiting soybean and sorghum planting. Crop emergence was now behind last year. Producers expressed concern over earlier planted corn's yellow color. Sugarbeets were replanted in some areas. Precipitation fell across most of the state with muddy feedlot conditions present in southern counties. High winds later in the week limited spraying of herbicides. Cattle were moved to spring pastures and the growth of grass was helped by the precipitation.

Weather Summary: Temperatures for the week averaged 1 degree below normal. Cool temperatures at the beginning of the week gave way to warmer conditions by week's end. Most areas of the state received precipitation with the South Central District receiving over 1.5 inches. However, accumulations were light in the Northeast District which has had only two-thirds of normal rainfall since April 1. High winds were recorded on numerous days.

Soil Moisture and Days Suitable: Nebraska, Week Ending May 23, 2010

	This Week	Last Week	Last Year	Average
	Percent			
Topsoil				
Very Short	0	0	2	6
Short	3	2	27	20
Adequate	87	90	65	67
Surplus	10	8	7	6
Subsoil				
Very Short	0	0	3	9
Short	3	3	15	21

Wheat conditions rated 2 percent poor, 23 fair, 66 good, and 9 excellent, above the 70 percent good or excellent of last year and the 54 average. Wheat jointed was at 78 percent, nine days behind last year's 98 and eight days behind 96 average. Wheat headed was 6 percent complete, well behind last year's 26 and 31 average.

Oats conditions rated 9 percent fair, 81 good, and 10 excellent. Oats emerged was 98 percent, behind last year's 100 but equal to the average.

Dry beans planted were 6 percent complete, behind last year's 18 and 11 average.

Alfalfa rated 2 percent poor, 10 fair, 76 good, and 12 excellent. Conditions were above last year's 77 percent good or excellent condition and 63 average. First cutting of alfalfa was 12 percent complete.

Wild Hay conditions rated 9 percent fair, 80 good, and 11 excellent.

Crop Progress: Nebraska, Week Ending May 23, 2010

Crop	This Week	Last Week	Last Year	Average
	Percent			
Alfalfa 1st Cutting	12	5	18	17
Corn Planted	96	89	97	96
Corn Emerged	59	36	73	68
Dry Beans Planted	6	2	18	11
Oats Emerged	98	91	100	98
Soybeans Planted	63	44	84	70
Soybeans Emerged	15	6	36	24
Sorghum Planted	21	17	48	43
Sorghum Emerged	5	2	11	9
Wheat Jointed	78	60	98	96

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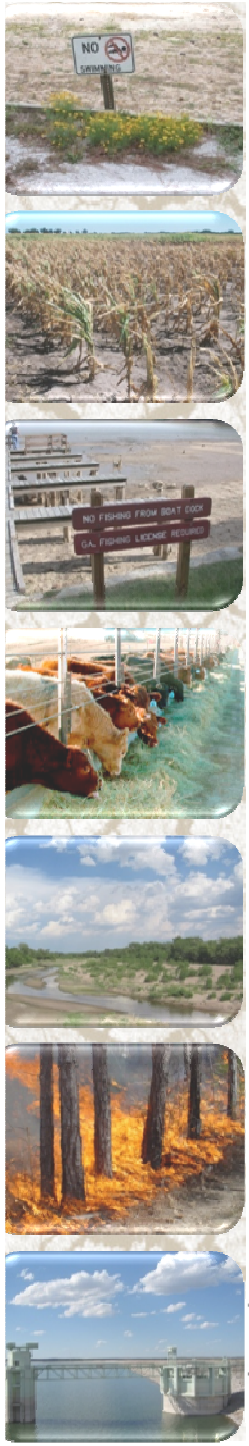
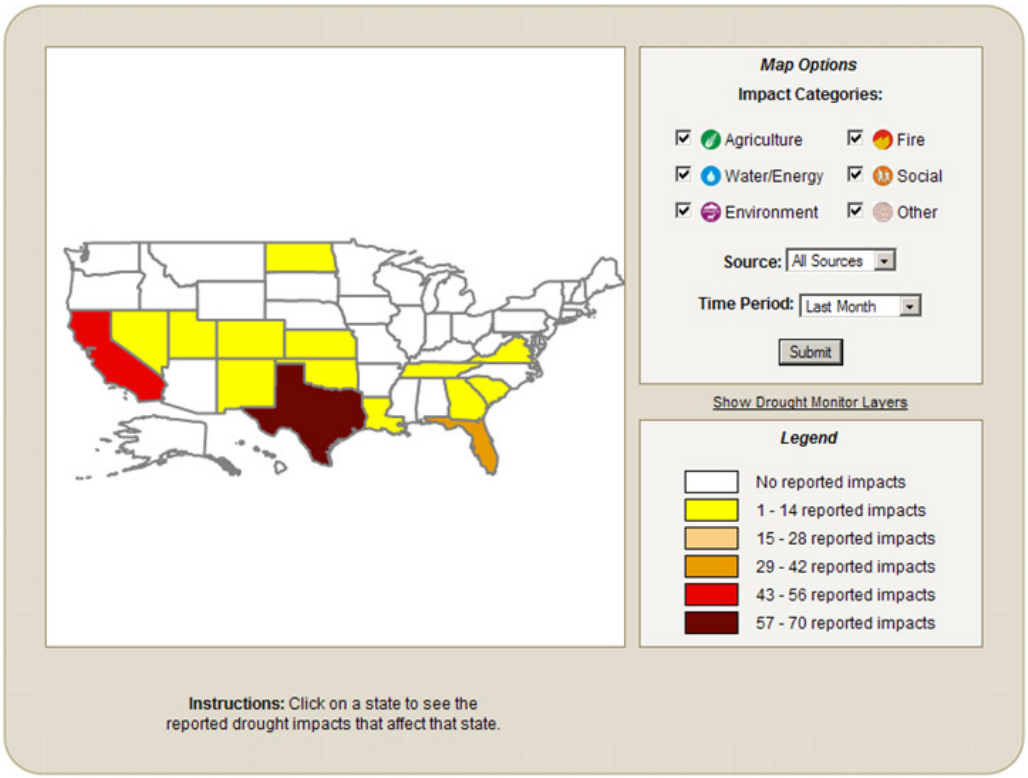


The Drought Impact Reporter v2

http://droughtreporter.unl.edu



Sponsor: USDA-Risk Management Agency and National Oceanic and Atmospheric Administration's Transition of Research Applications to Climate Services Program (TRACS)

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Why Track Drought Impacts?

- Establish an impacts ***baseline*** for monitoring
  - Climate change
- To know where to direct ***relief***
- To help determine, and reduce, ***vulnerability*** in advance of the next drought
- ***"Ground truth"*** indices
- No single method exists for collecting and/or ***quantifying*** drought losses

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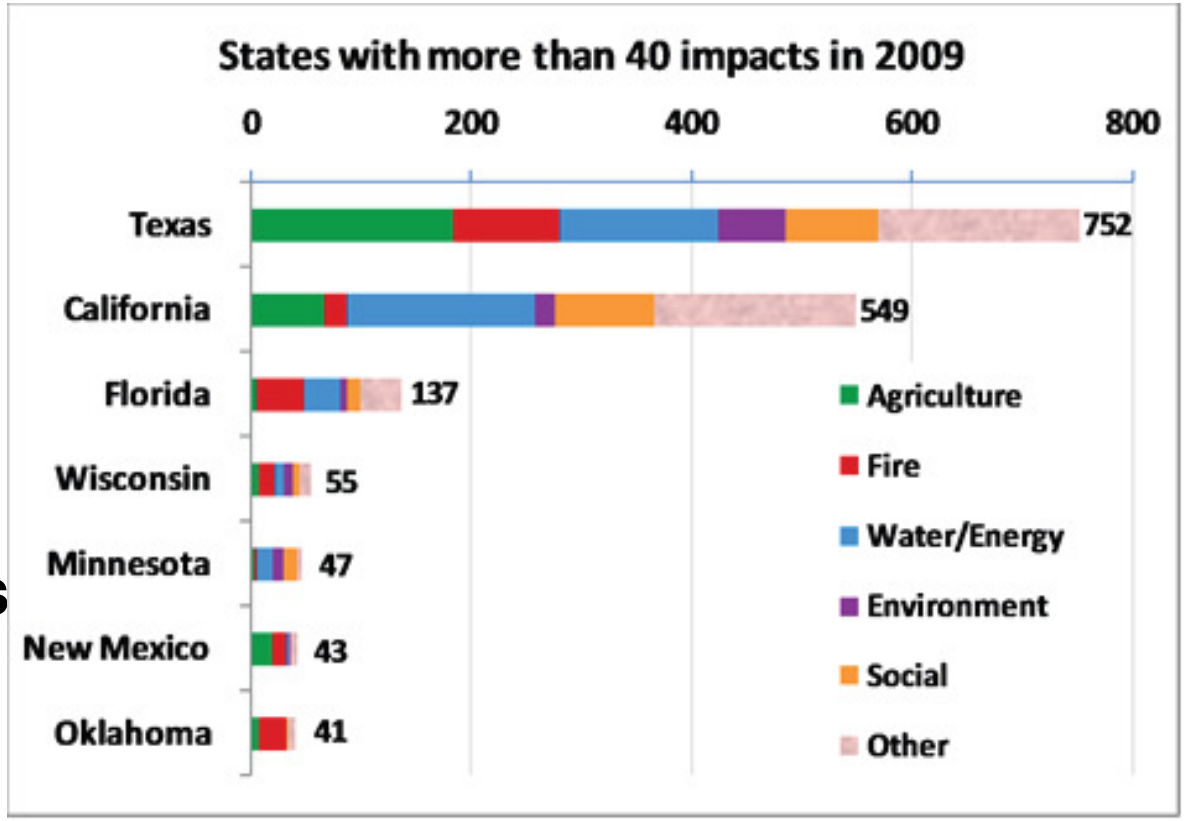
Some DIR Factoids

- Established in 2005
- DIR DB now contains ~11,000 impacts
- 1,891 impacts added in 2009



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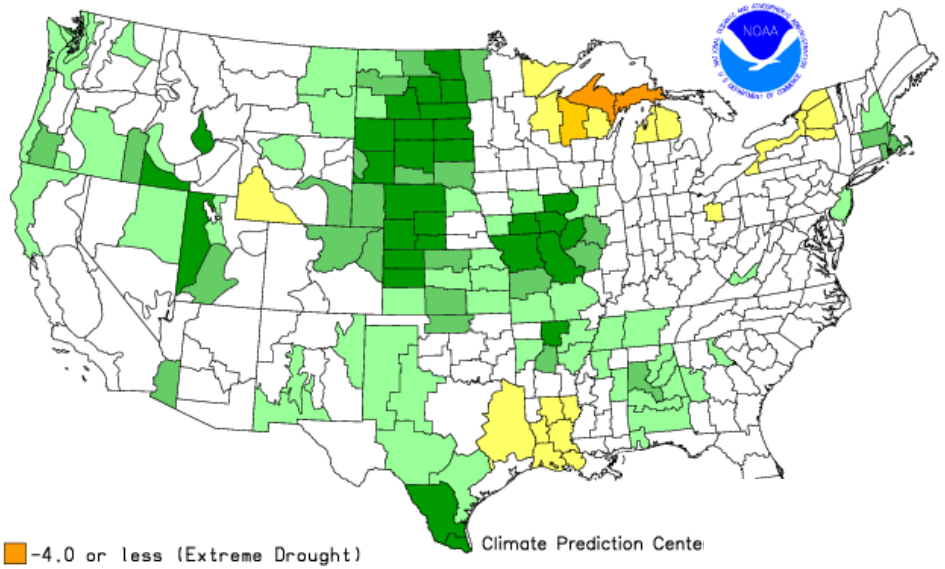
Drought Severity Index by Division

Weekly Value for Period Ending MAY 29, 2010

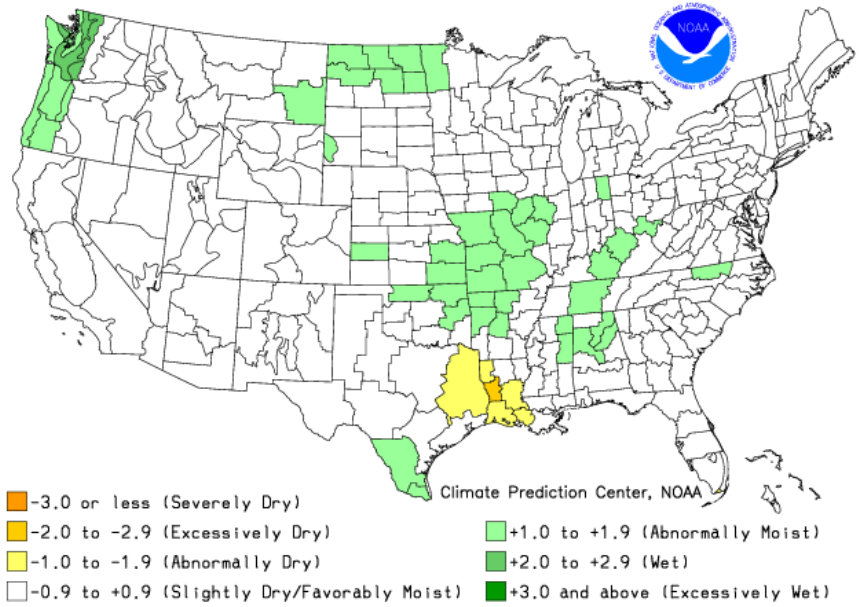
Long Term Palmer

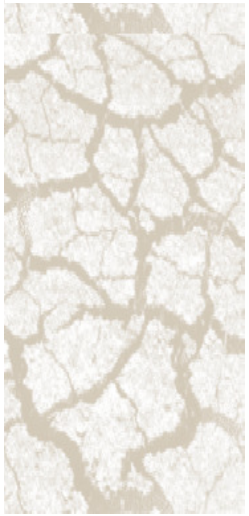


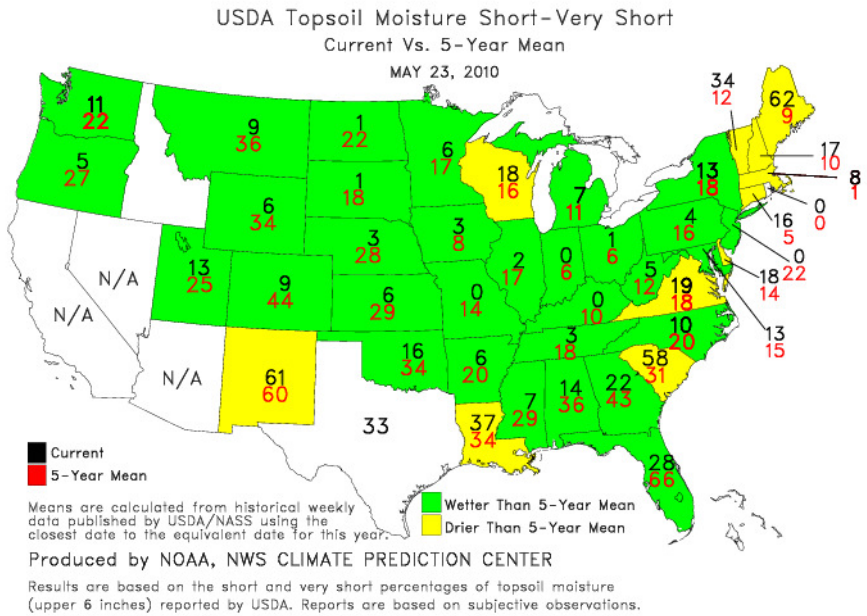
Crop Moisture Index by Division

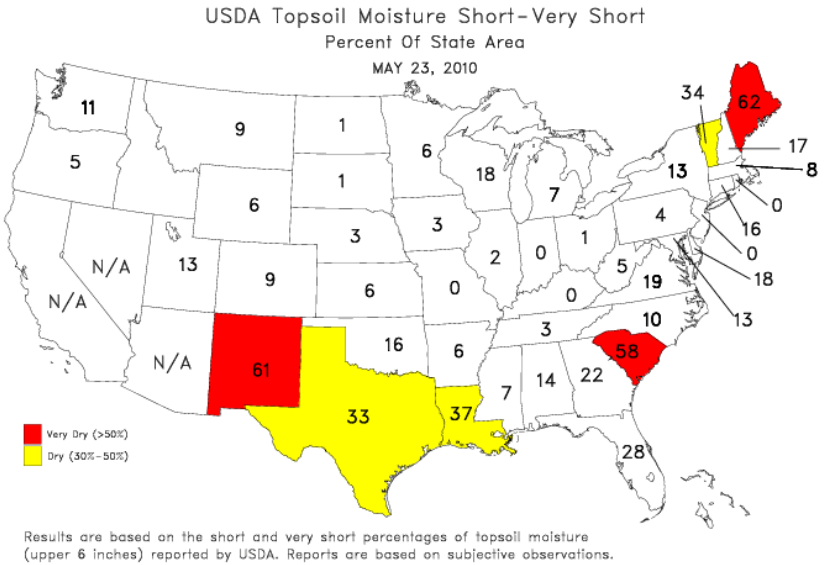
Weekly Value for Period Ending MAY 29, 2010

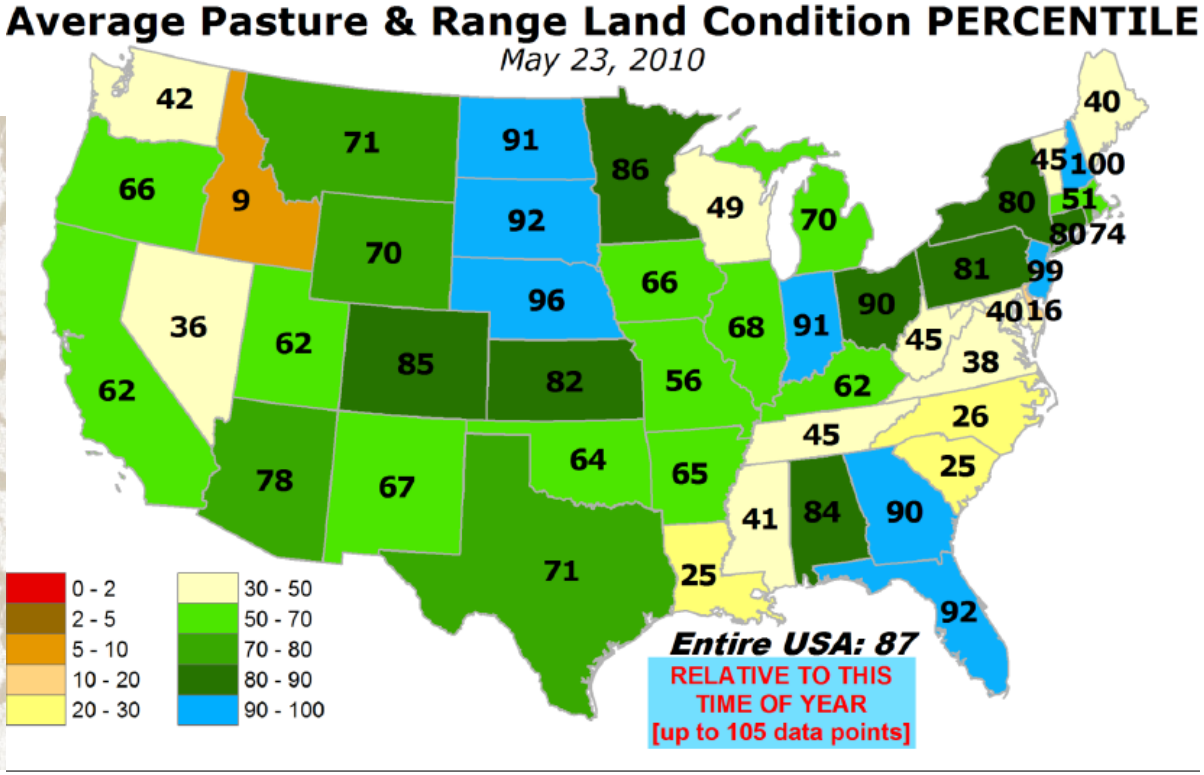
Short Term Need vs. Available Water in a Shallow Soil Profile







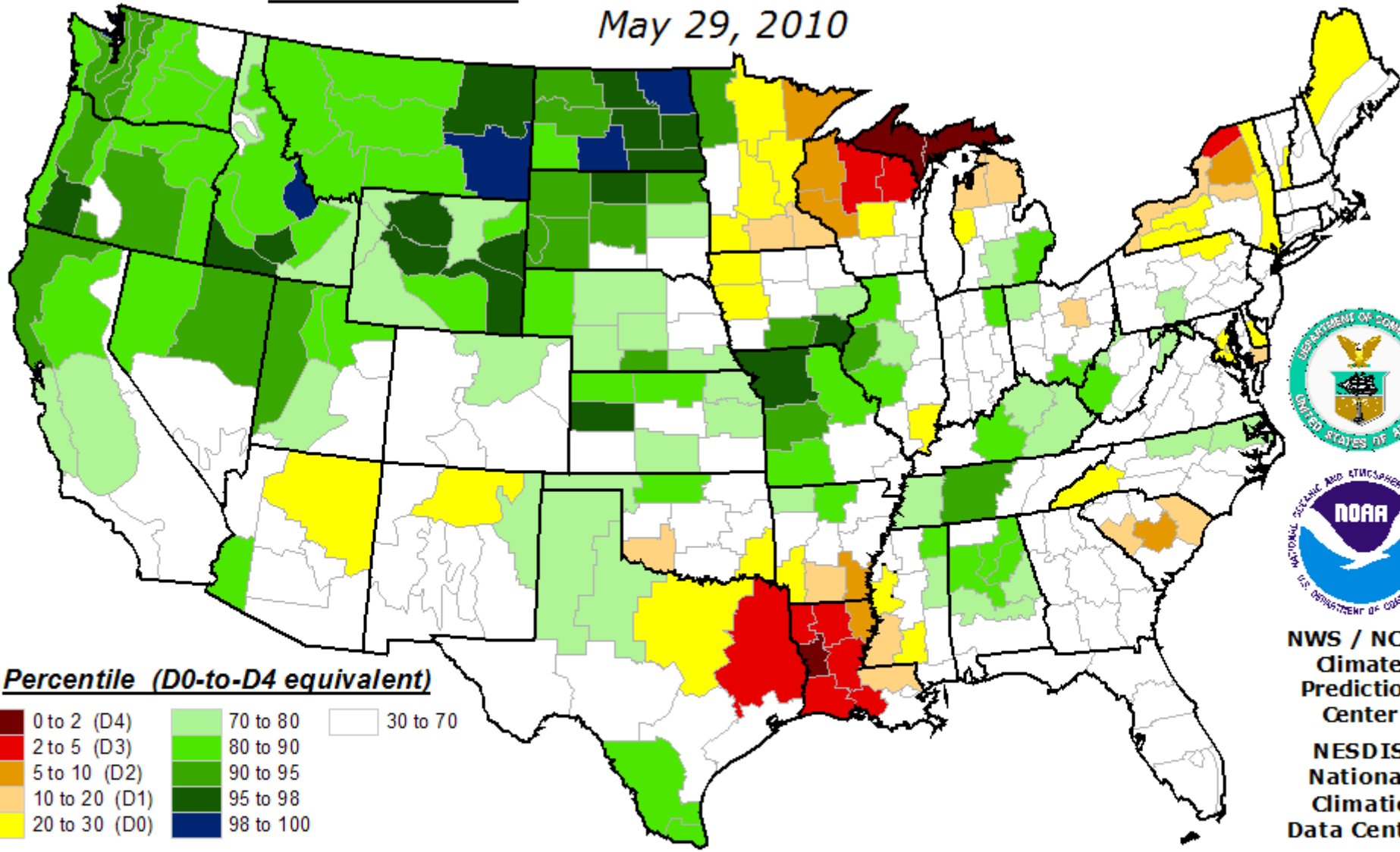




National Drought Mitigation Center

Objective Short-Term Drought Indicator Blend Percentiles

May 29, 2010



Percentile (D0-to-D4 equivalent)

0 to 2 (D4)	70 to 80	30 to 70
2 to 5 (D3)	80 to 90	
5 to 10 (D2)	90 to 95	
10 to 20 (D1)	95 to 98	
20 to 30 (D0)	98 to 100	

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

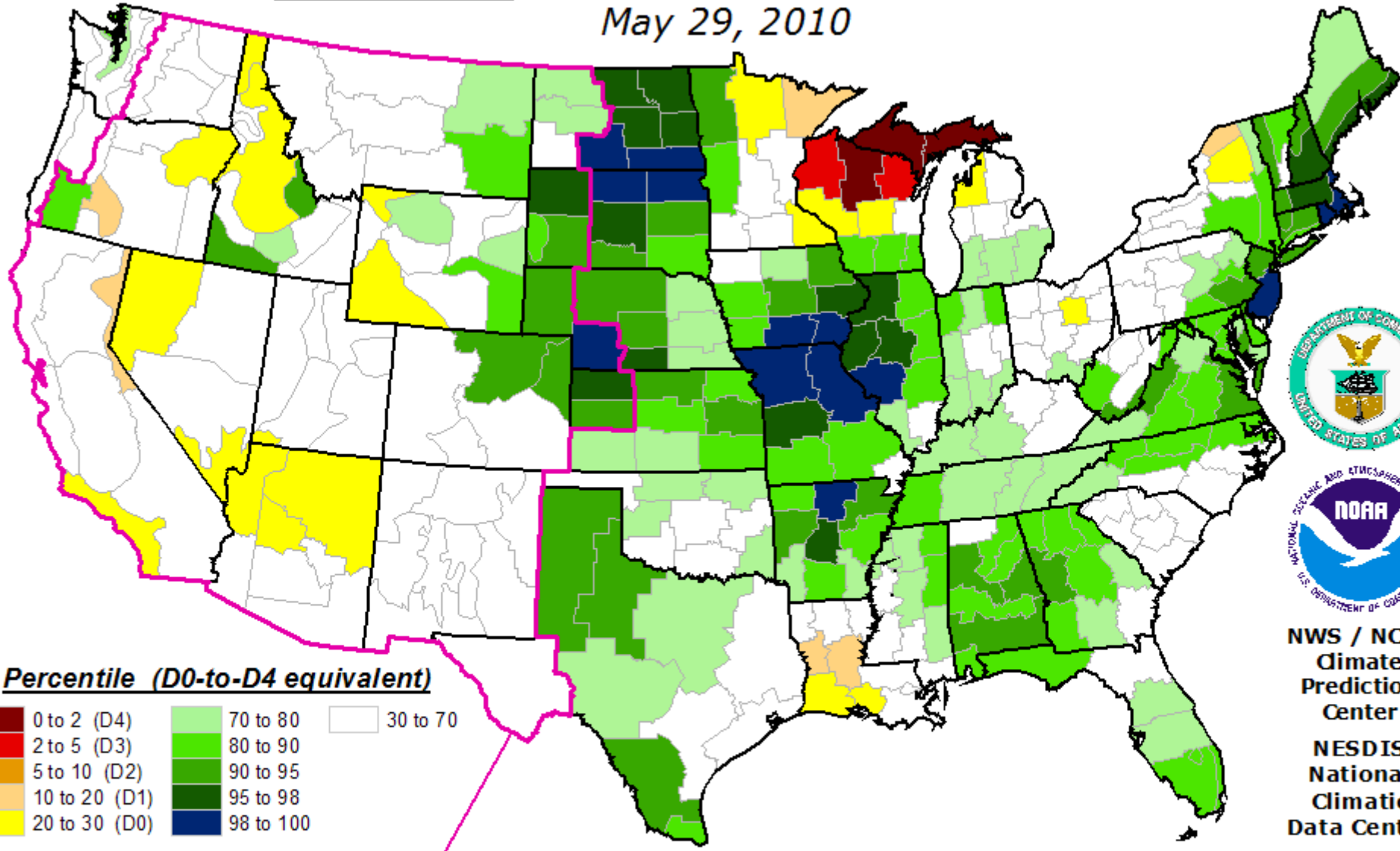
NESDIS National Climatic Data Center

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.

Objective Long-Term Drought Indicator Blend Percentiles

May 29, 2010



Percentile (D0-to-D4 equivalent)

0 to 2 (D4)	70 to 80	30 to 70
2 to 5 (D3)	80 to 90	
5 to 10 (D2)	90 to 95	
10 to 20 (D1)	95 to 98	
20 to 30 (D0)	98 to 100	

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

NWS / NCEP Climate Prediction Center

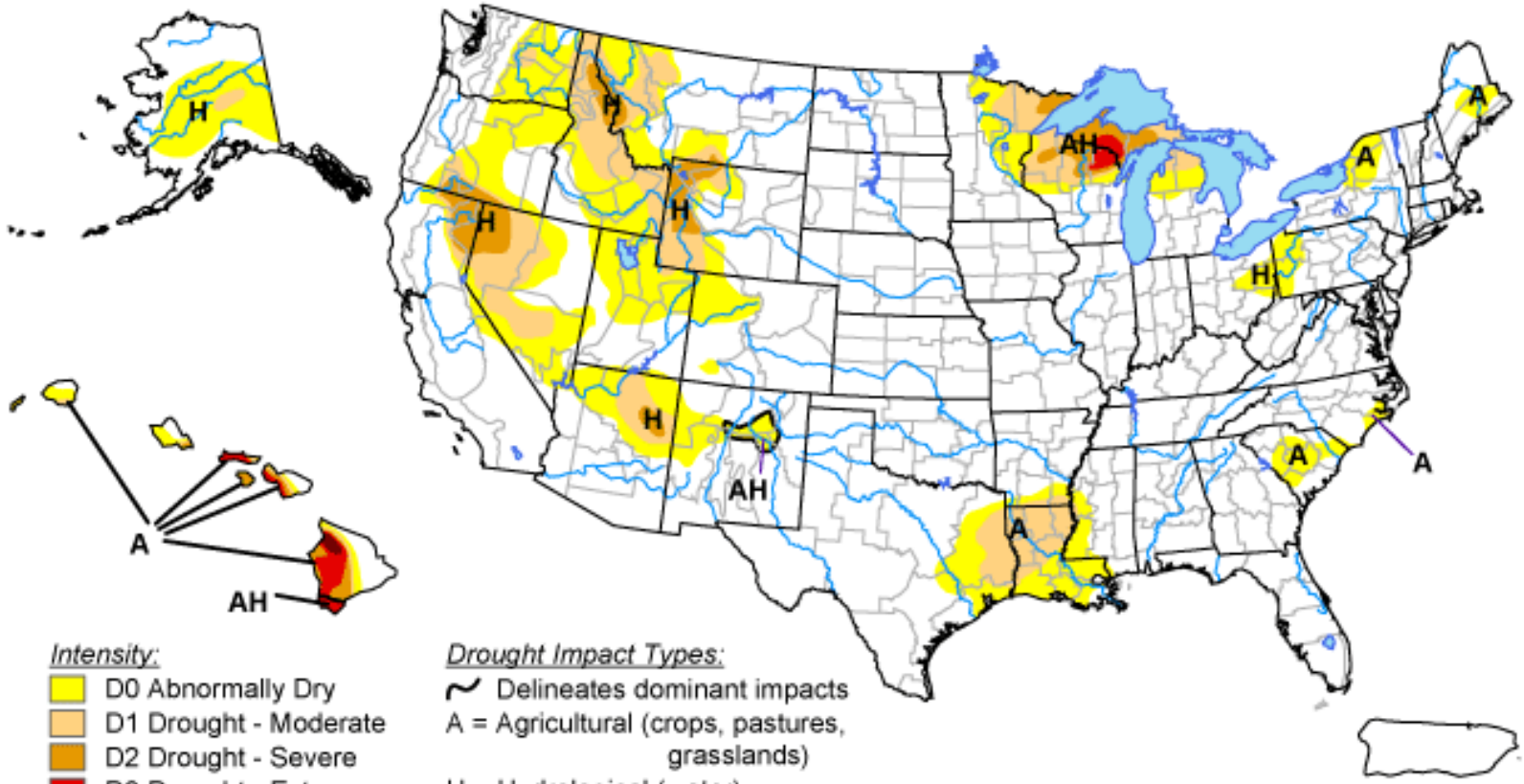
NESDIS National Climatic Data Center

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.

U.S. Drought Monitor

May 25, 2010
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, May 27, 2010

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

University of Nebraska Lincoln

National Drought Mitigation Center

The Drought Monitor is Widely Used

- ***Policy:*** Farm Bill/IRS/USDA/NWS DGT/State drought plan triggers
- ***~3.5M+*** page views and ***~2M+*** visitors/year
- ***Media:*** The Weather Channel/USA Today and all major newspapers/Internet /radio/ Nightly Network News/CNN/NPR/etc.
- Presidential/Congressional/Governor ***briefings***
- ***NIDIS*** portal/portlet
- A ***model*** of interagency collaboration

National Drought Mitigation Center

History of the North American Drought Monitor (NADM)

- The concept for the NADM was developed and discussed in 2002
- The first NADM map was released in **March 2003**
- The first NADM map in all three languages (**English, Spanish, and French**)was released in **October 2003**

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North American Drought Monitor Partners

Canada

- Agriculture and Agrifood Canada
- Environment Canada
- Meteorological Service of Canada

Mexico

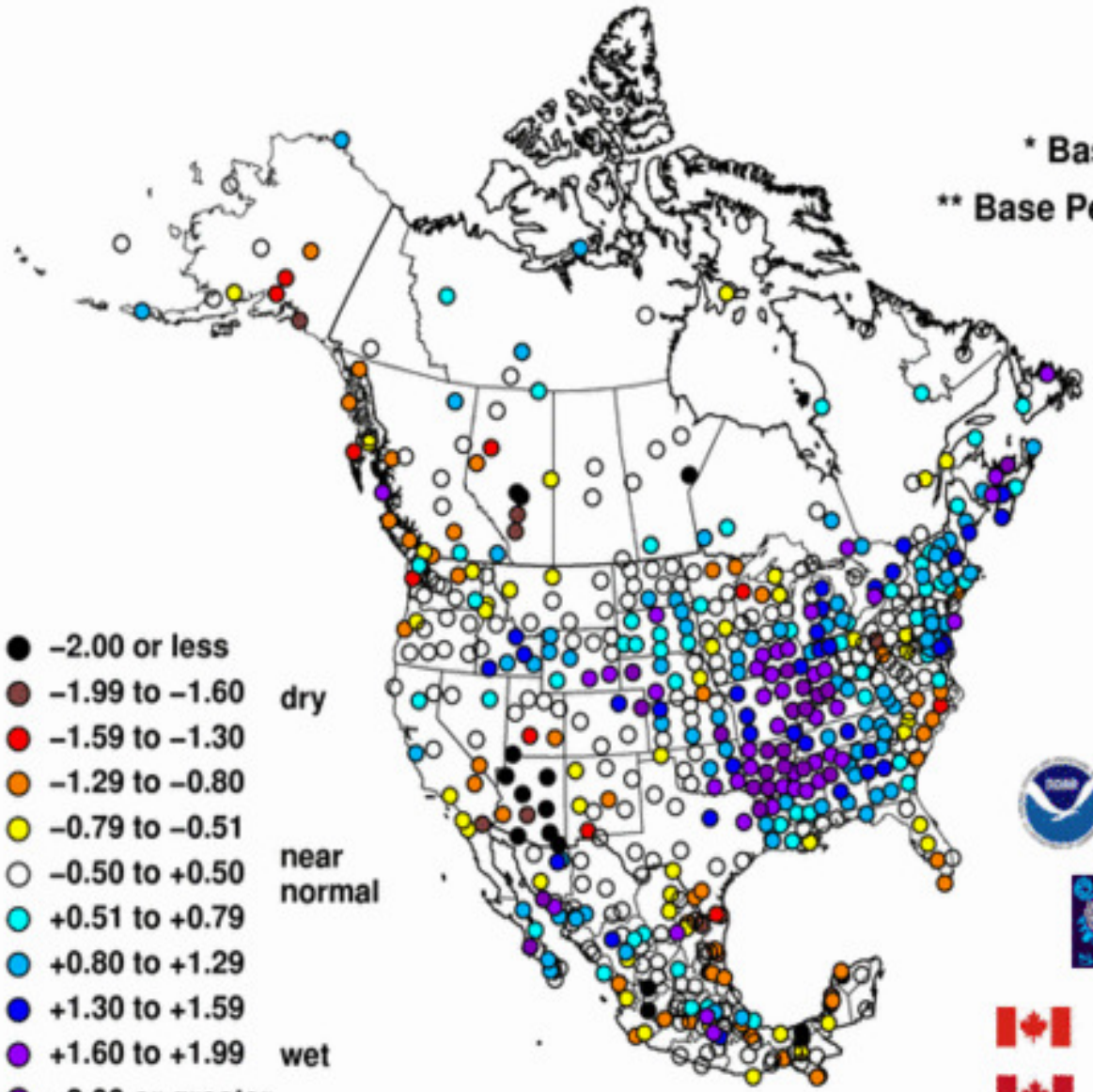
- National Meteorological Service of Mexico (SMN-Servicio Meteorologico Nacional)
- CONAGUA (Comision Nacional del Agua)

United States

- National Drought Mitigation Center
- National Climatic Data Center
- Climate Prediction Center
- United States Department of Agriculture


9–Month Standardized Precipitation Index

February – October 2009



* Based on Preliminary Data

** Base Period for Averages 1951–2001

- –2.00 or less
- –1.99 to –1.60 — dry
- –1.59 to –1.30
- –1.29 to –0.80
- –0.79 to –0.51
- –0.50 to +0.50 — near normal
- +0.51 to +0.79
- +0.80 to +1.29
- +1.30 to +1.59
- +1.60 to +1.99 — wet
- +2.00 or greater

USDA

National Drought Mitigation Center

SMN

COMISION NACIONAL DEL AGUA

Agriculture and Agri-Food Canada

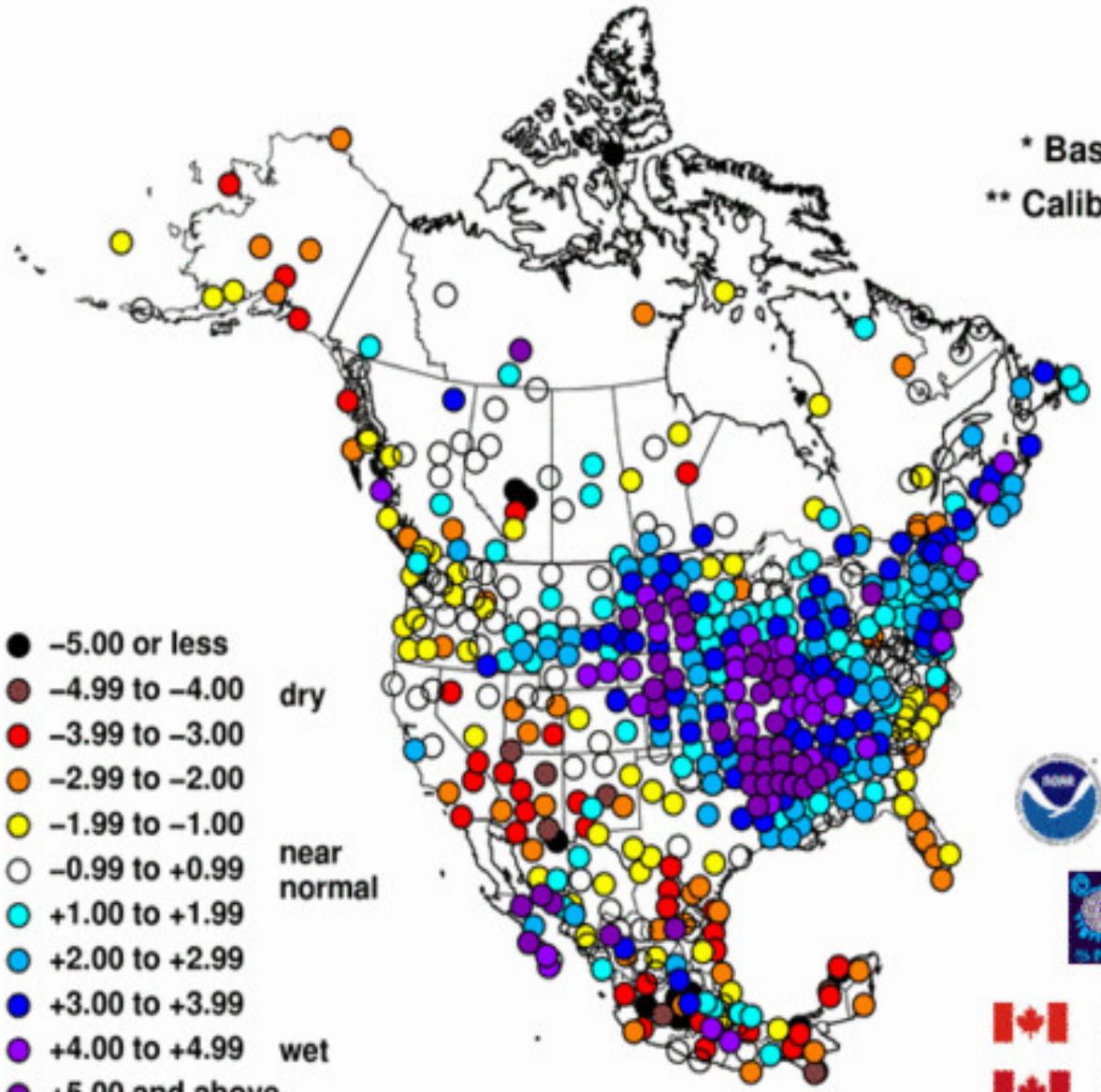
Agriculture et Agroalimentaire Canada

Environment Canada

Environnement Canada

Palmer Drought Index

October 2009



* Based on Preliminary Data

** Calibration Period 1951 – 2001

- –5.00 or less
- –4.99 to –4.00 — dry
- –3.99 to –3.00
- –2.99 to –2.00
- –1.99 to –1.00
- –0.99 to +0.99 — near normal
- +1.00 to +1.99
- +2.00 to +2.99
- +3.00 to +3.99
- +4.00 to +4.99 — wet
- +5.00 and above

USDA

National Drought Mitigation Center

COMISION NACIONAL DEL AGUA

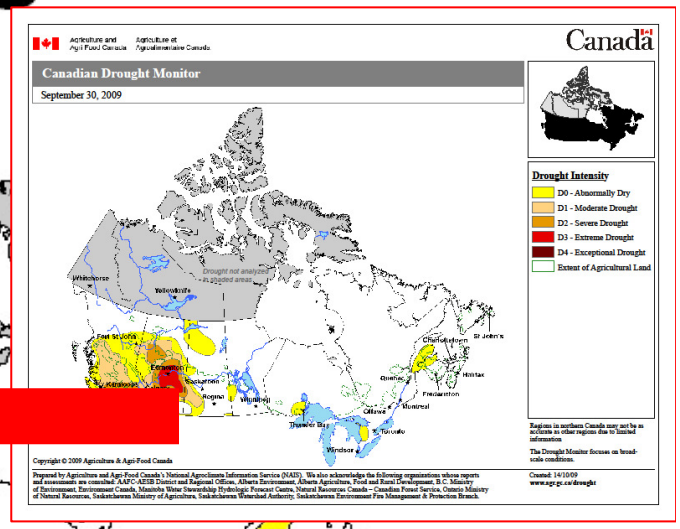
Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Environment Canada | Environnement Canada

North American Drought Monitor

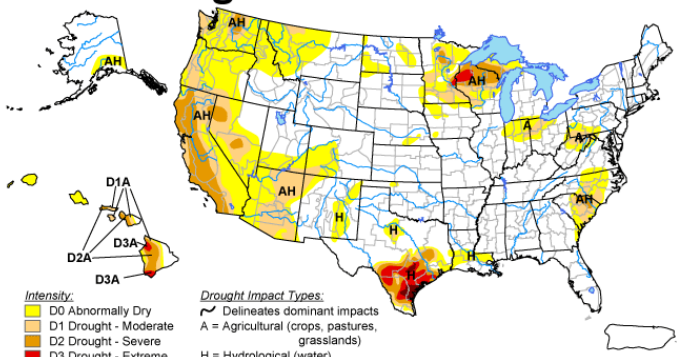
September 30, 2009

Released: Tuesday, October 20, 2009



U.S. Drought Monitor

September 29, 2009
Valid 8 a.m. EDT



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Drought Impact Types:
- ~ Delineates dominant impacts
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- 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

Drought not analyzed in shaded areas

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary

Released Thursday, October 1, 2009
Author: David Miskus, JAWF/CPC/NOAA

USDA National Drought Mitigation Center | NMSU | CONAGUA

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada
Environment Canada | Environnement Canada

North American Drought Monitor

April 30, 2010

Released: Friday, May 21, 2010

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

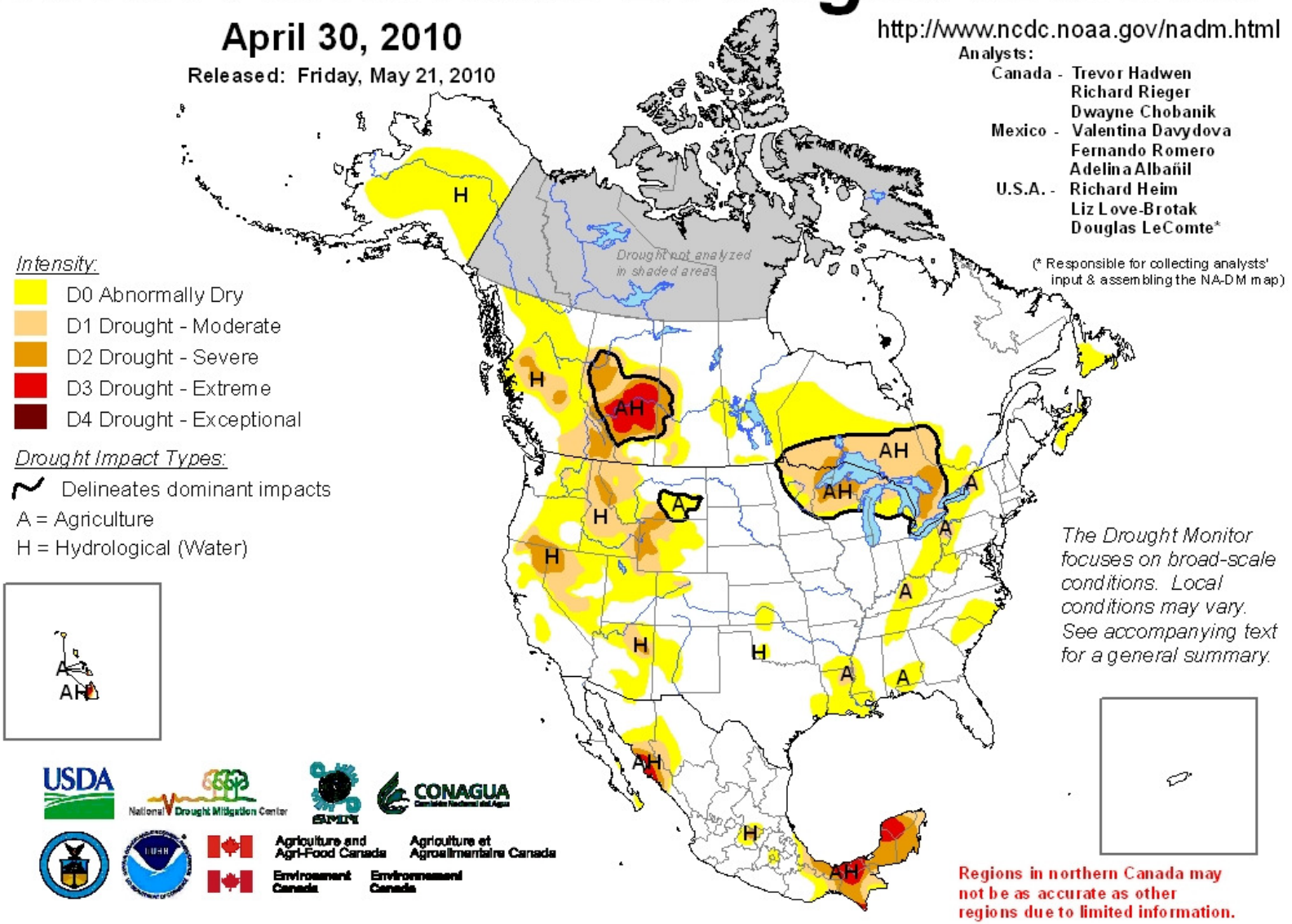
Analysts:

Canada - Trevor Hadwen
Richard Rieger
Dwayne Chobanik

Mexico - Valentina Davydova
Fernando Romero
Adelina Albañil

U.S.A. - Richard Heim
Liz Love-Brotak
Douglas LeComte*

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



Intensity:

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- 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.

USDA | National Drought Mitigation Center | CONAGUA | Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada | Environment Canada | Environnement Canada

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Some closing DM thoughts:

- An explosion of good work and data/tools/models/products/research out there over the past 5 years (DM keeps evolving)
- Some very nice state efforts out there as well
- Moving more into a DSS/GIS/PDA/and mobile realm (user-defined)
- A model for others to follow?
- What resolution are you comfortable with?
  - The plea is obvious: ***"No county left behind!"***
- Progress yes; Perfect, no….we'll keep improving the product as more new tools come on-line

National Drought Mitigation Center

Outline

- The NDMC
  - NDMC Program Areas
  - Collaborations: National/International
  - Tools
- Drought Monitor Process
  - USDM
  - National + Regional Ag Inputs
  - NADM
- **Primary USDM Ag Indices**
  - SPI, Palmer Suite
- New Wave of Tools
  - Remote Sensing
  - Models/Land Data Simulations (LDAS)
- NIDIS
- Summary

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Standardized Precipitation Index (SPI)

Overview: The SPI is an index based on the probability of precipitation for any time scale.

Who uses it: Many drought planners/decision makers appreciate the SPI's temporal versatility.

Pros: Simple to compute/Only need precipitation /Flexible: can be computed for multiple time scales, can provide early warning of drought and help assess drought severity, and is less complex (less data needed as well) than the Palmer. Spatially consistent; Probabilistic for historical context and decision making.

Cons: Precipitation-based only; no soil component; thus no ET/PET calculated.

Developed by: T.B. McKee, N.J. Doesken, and J. Kleist, 1993

Monthly maps: **http://drought.unl.edu/monitor/spi.htm**

Daily maps:

http://www.hprcc.unl.edu/maps/current/index.php?action=update_product&product=SPIData

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SPI

- The SPI was designed to quantify the precipitation deficit for **multiple time scales**. These time scales reflect the impact of drought on the availability of the different water resources. (Meteorological and soil moisture conditions (agriculture) respond to precipitation anomalies on a relatively short scale. Groundwater, streamflow, and reservoir storage reflect the longer-term precipitation anomalies).
- Can be calculated from 1-month out to 72-months. Statistically, **1-24-months is the best practical range** of application (Guttman)

SPI

- The SPI calculation for any location is based on the long-term precipitation record for a desired period
- The **longer the POR**, the better. 30 years is okay, 50-60 years is optimal (Guttman)
- This long-term record is **fitted to a probability distribution**, which is then **transformed into a normal distribution** so that the **mean SPI for the location and desired period is zero (Edwards and McKee, 1997).**

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SPI

- Because the SPI is normalized, **wetter and drier climates** can be represented in the same way, and wet periods can also be monitored using the SPI
- A **drought event occurs** any time the SPI is continuously negative and reaches an **intensity of -1.0 or less**. The event ends when the SPI becomes positive
- Each drought event, therefore, has a **duration** defined by its beginning and end, and an intensity for each month that the event continues
- The **positive sum of the SPI** for all the months within a drought event can be termed the drought's **"magnitude"**

[from Edwards and McKee (1997)]

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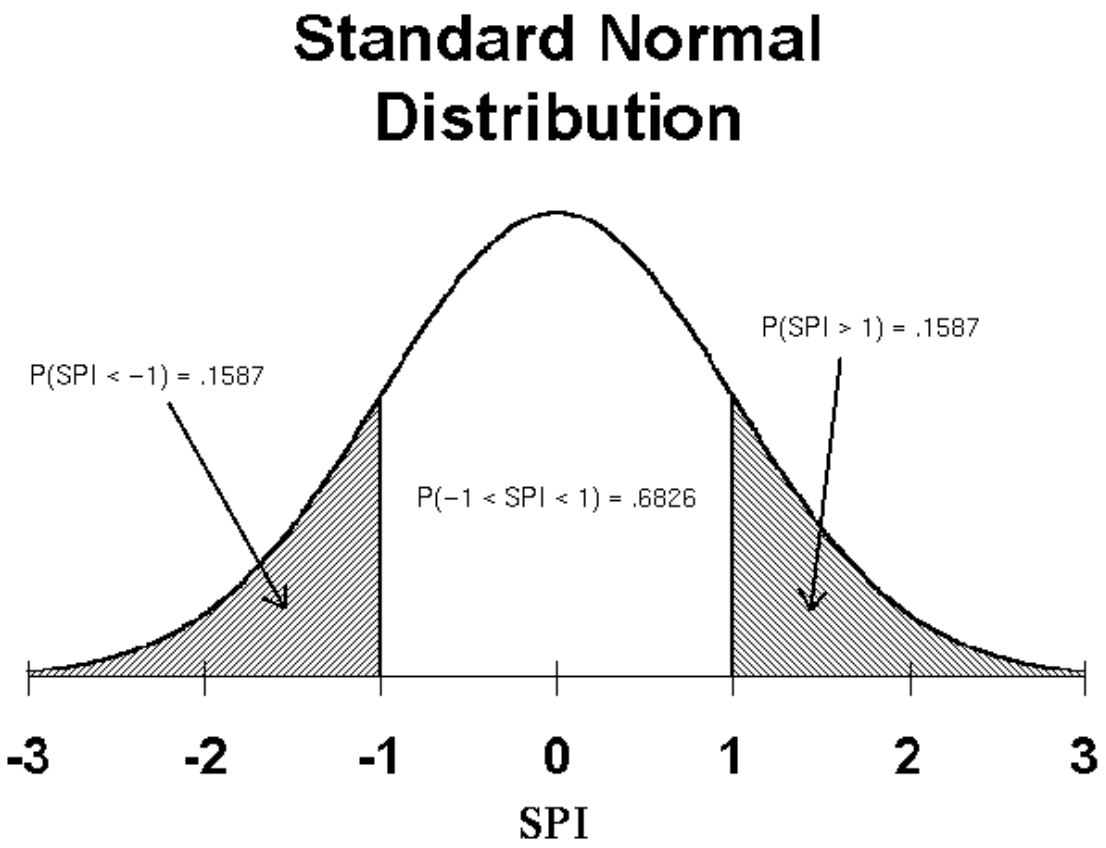
SPI

- Positive SPI values indicate greater than median precipitation, and negative values indicate less than median precipitation (in standard deviations)



from Edwards and McKee (1997), Fig. 3.3. Standard normal distribution with the SPI having a mean of zero and a variance of one.

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SPI

- Additionally, no matter the location or time scale, the SPI represents a cumulative probability in relation to the base period for which the gamma parameters were calculated

SPI	Cumulative Probability
-3.0	0.0014
-2.5	0.0062
-2.0	0.0228
-1.5	0.0668
-1.0	0.1587
-0.5	0.3085
0.0	0.5000
+0.5	0.6915
+1.0	0.8413
+1.5	0.9332
+2.0	0.9772
+2.5	0.9938
+3.0	0.9986

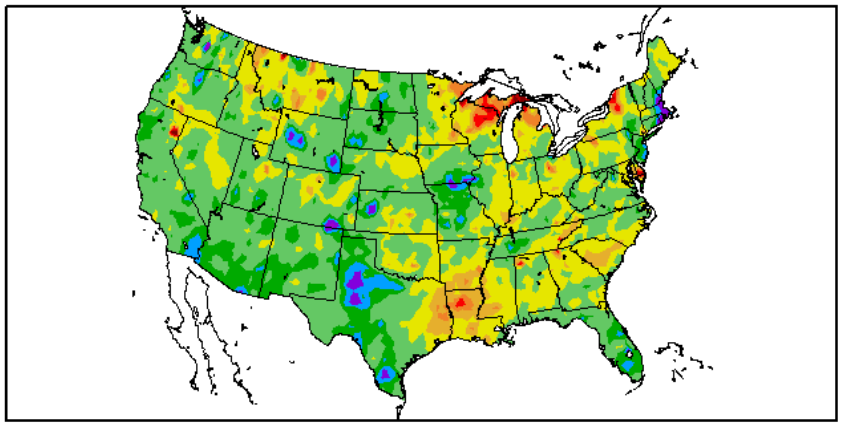
From Edwards and McKee (1997), Table 3.1. SPI and Cumulative Probability Relative to the Base Period.

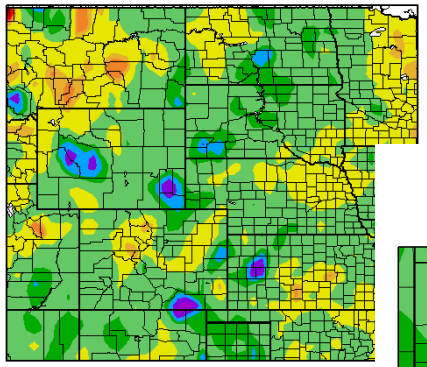
SPI

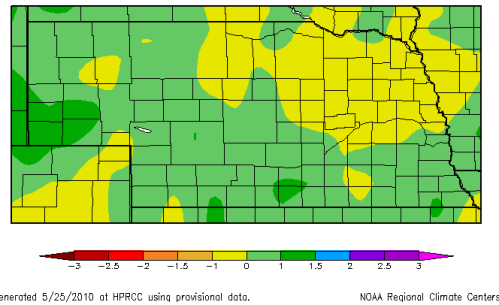
- The SPI is normalized to a station location because it accounts for the frequency distribution of precipitation as well as the accompanying variation at the station (Edwards)

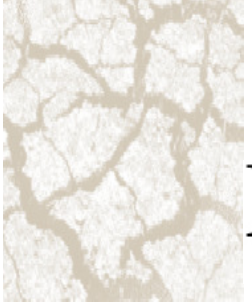
- The SPI is also normalized in time because it can be computed at any number of time scales, depending upon the impacts of interest to the analyst (Edwards)

SPI









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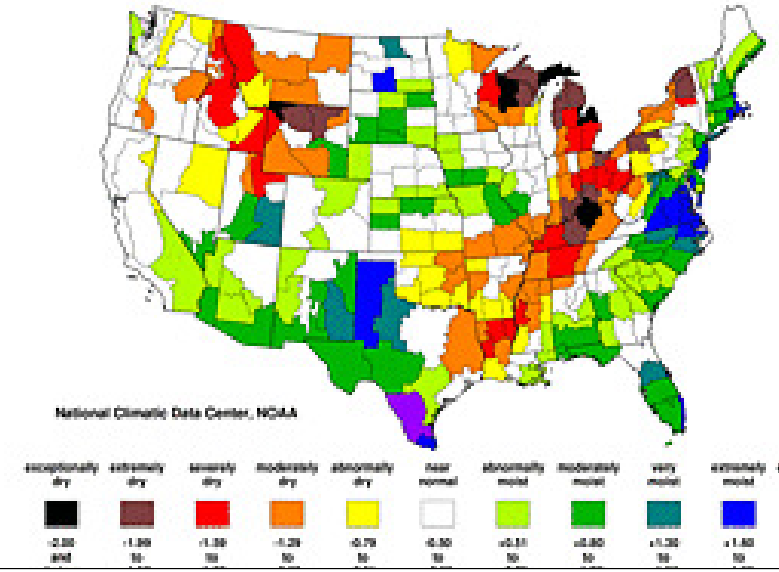
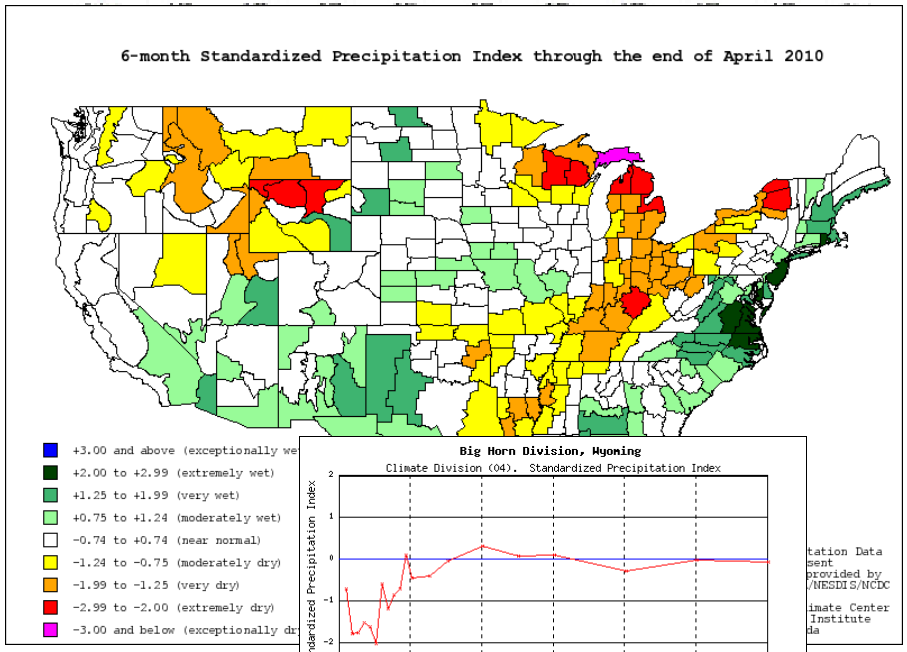
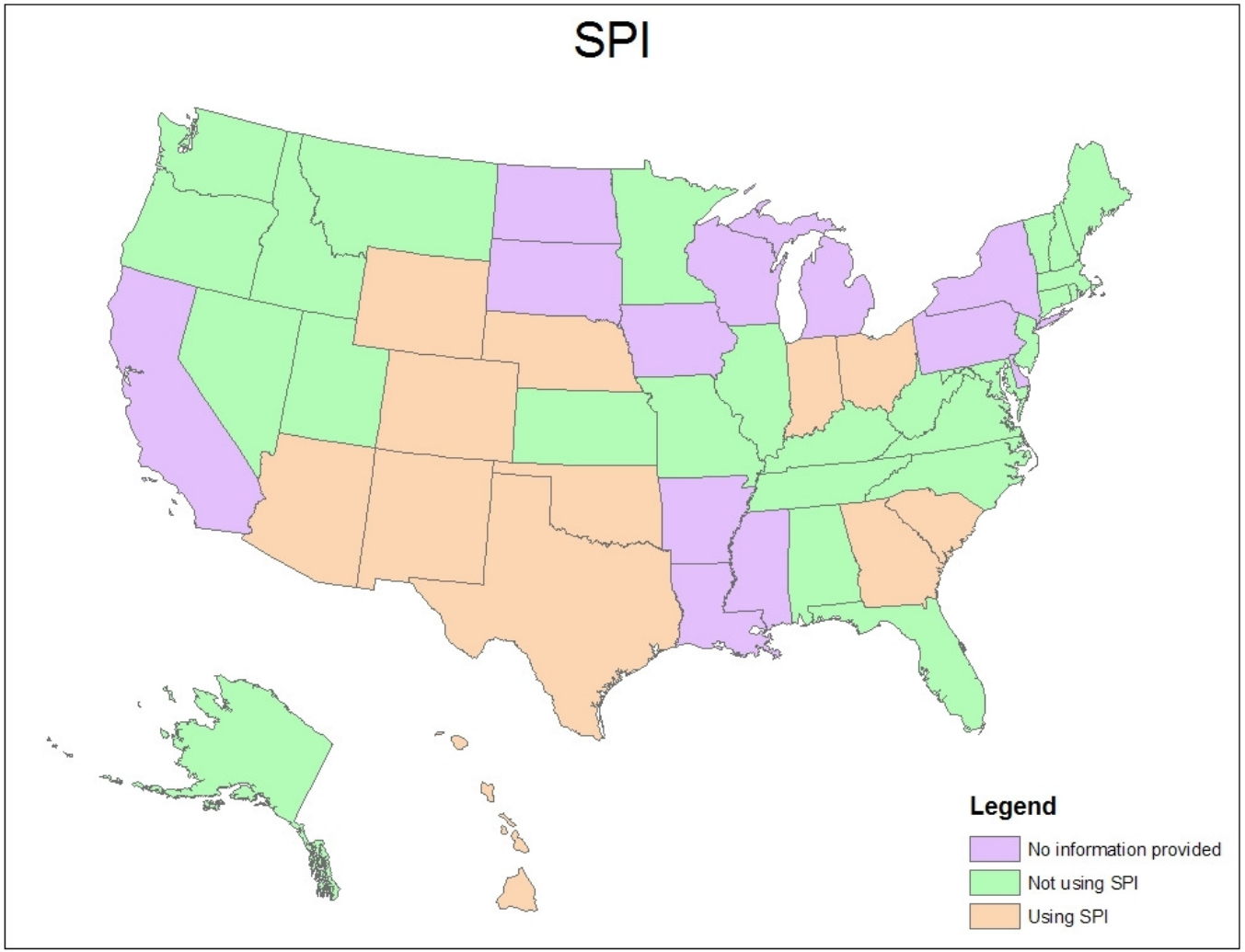




SPI



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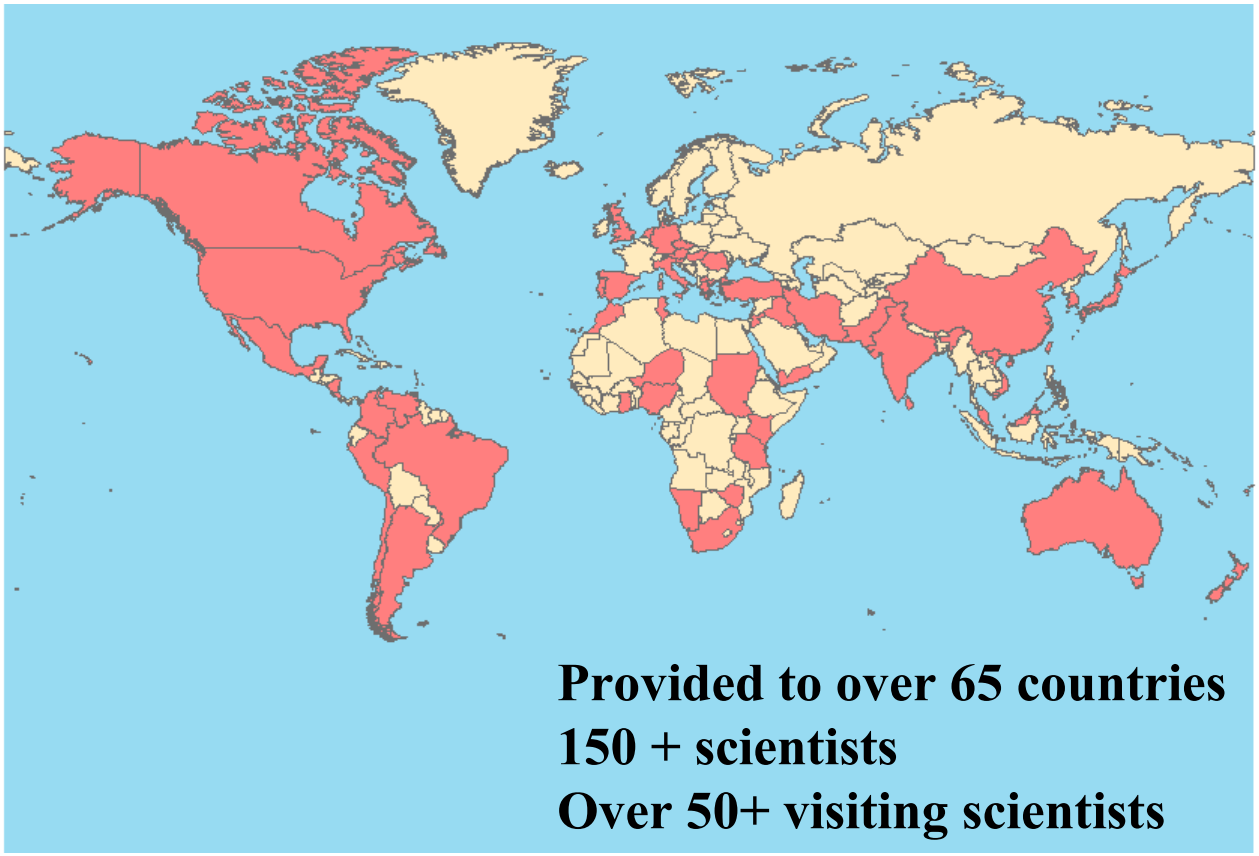
SPI

- Global applications (established)
- Flexible to a variety of needs



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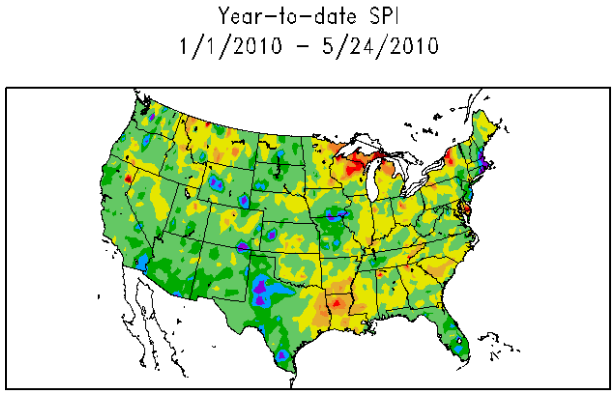
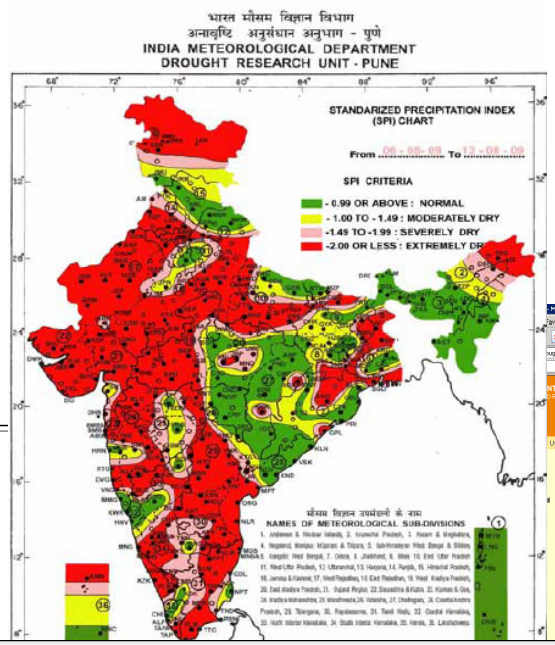
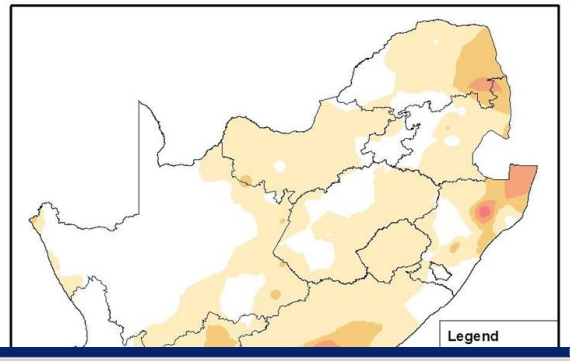
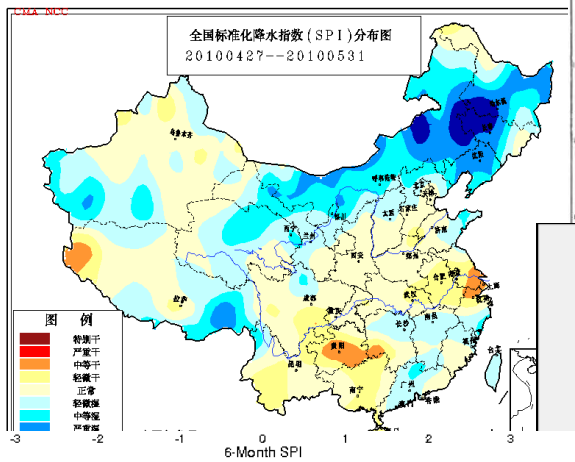
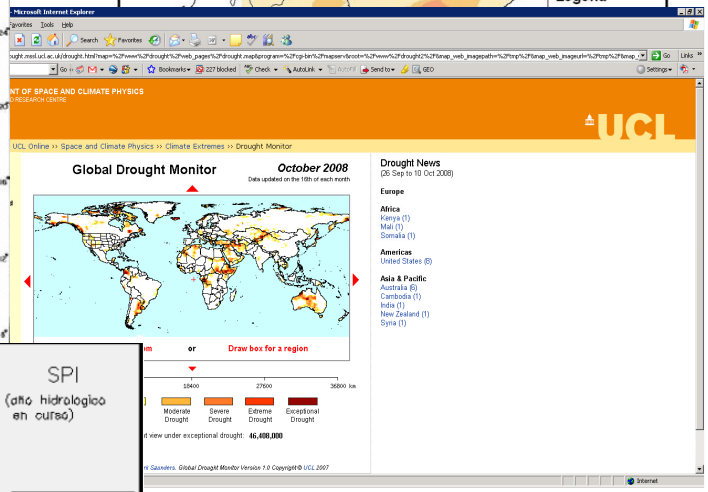
SPI Applications

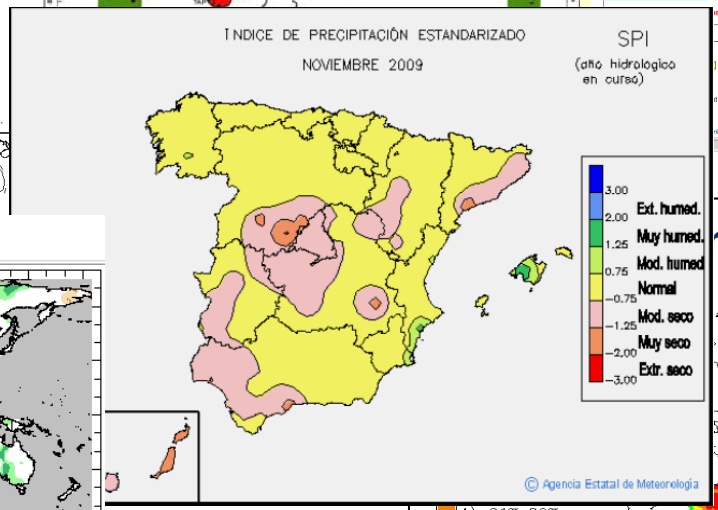


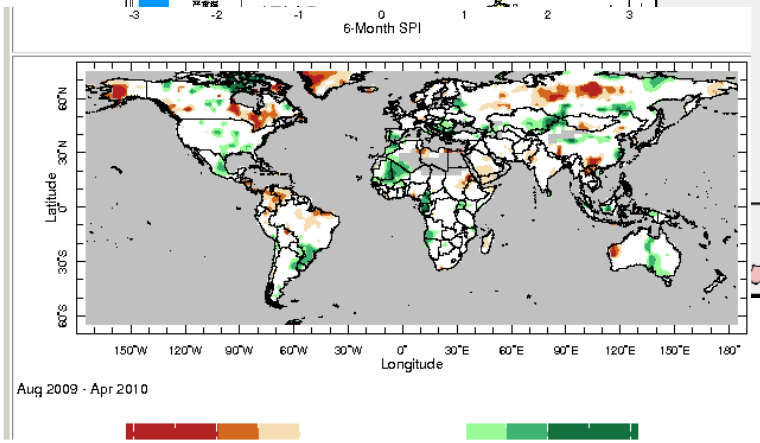


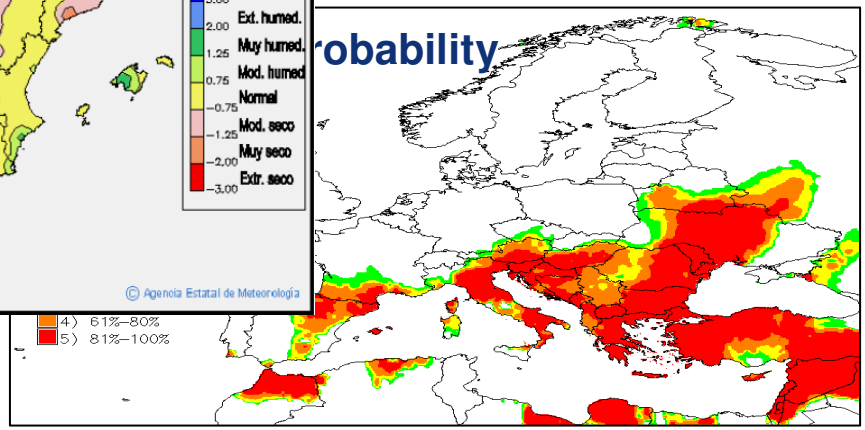












What's New: The SPEI

- A new variation by Vicente-Serrano et al. (Spain)
- The Standardized Precipitation-Evapotranspiration Index (SPEI)
- Inputs: monthly precipitation and mean temperature (and latitude of station site)
- Standardized monthly climatic balance computed from the difference between the cumulative precipitation and PET (Thornthwaite)
- Ability to depict changes due to climate change given the T and derived PET component vs. the regular SPI, which doesn't have T factored in

National Drought Mitigation Center

Palmer Drought Severity Index (PDSI)

Overview: The Palmer (PDSI) is a soil moisture algorithm calibrated for relatively homogeneous regions.

Who uses it: Many U.S. government agencies and states rely (relied) on the Palmer to help trigger drought relief programs. This is changing.

Inputs: Precipitation, Temperature, AWHC if available

Pros: The first comprehensive drought index developed in the United States. Full derivative suite includes the Palmer (Z) and Palmer Hydrological Index (PHDI). Water balance approach.

Cons: Palmer values may lag emerging droughts by several months; less well suited for arid or mountainous land or areas of frequent climatic extremes; complex—has an unspecified, built-in fixed time scale; doesn't take snow into account. Not spatially consistent, difficult to understand.

Developed by: W.C. Palmer, 1965.

Weekly maps: **http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/regional_monitoring/palmer.gif**

Monthly maps:
http://vlb.ncdc.noaa.gov/oa/climate/research/prelim/drought/palmer.html

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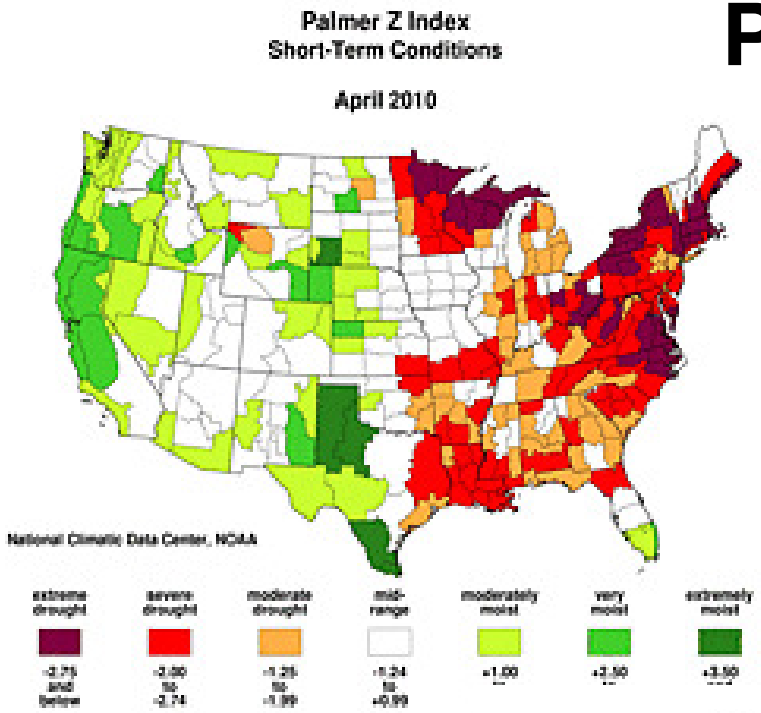
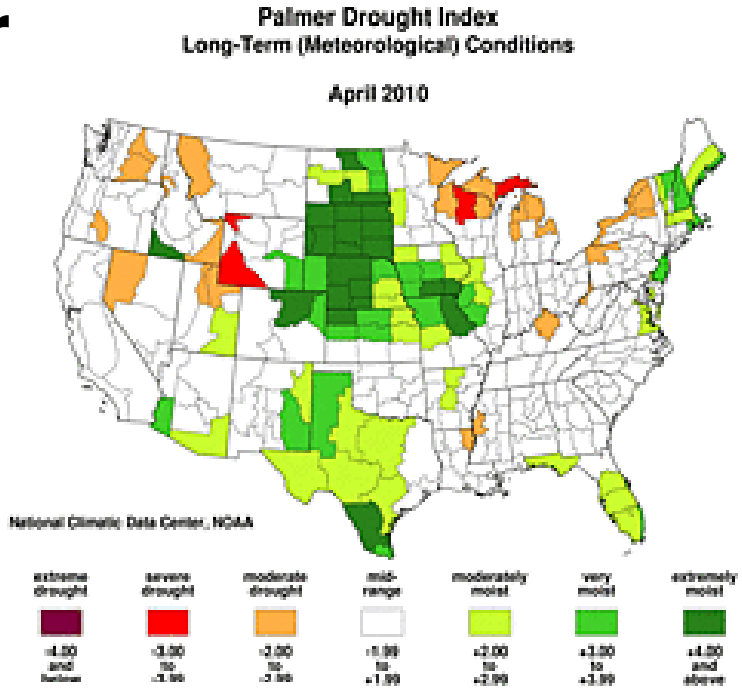
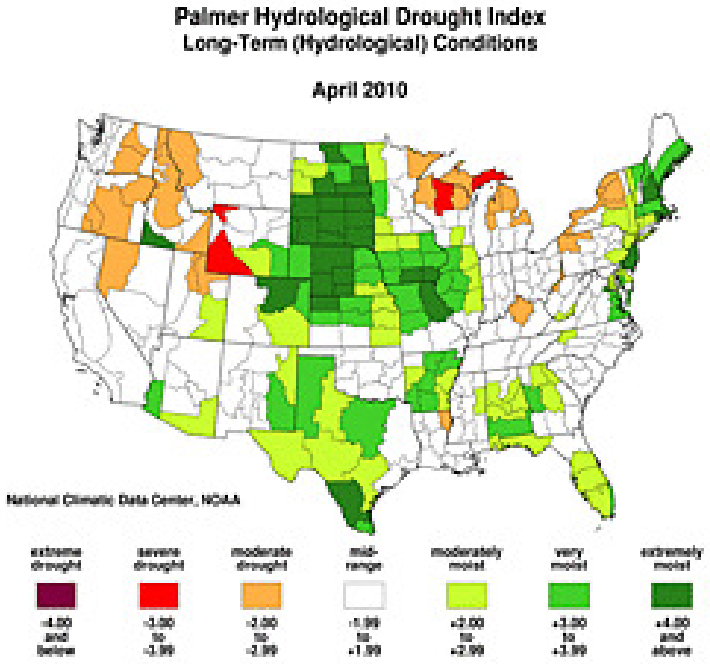
PDSI

- Palmer **based** his index on the supply-and-demand concept of the **water balance equation**, taking into account more than just the precipitation deficit at specific locations
- The objective of the Palmer Drought Severity Index (PDSI), as this index is now called, was to provide measurements of moisture conditions that were standardized so that comparisons using the index could be made between locations and between months (Palmer 1965)
- The PDSI is a meteorological drought index, and it responds to weather conditions that have been abnormally dry or abnormally wet.
- The PDSI is calculated **based on precipitation and temperature data, as well as the local Available Water Content (AWC)** of the soil. From the inputs, all the basic terms of the water balance equation can be determined, including potential evapotranspiration (Thornthwaite), soil recharge, runoff, and moisture loss from the surface layer.

Palmer Suite







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Modified PDSI

- In 1989, a **modified** method to compute the PDSI was begun operationally (Heddinghaus and Sabol, 1991). This modified PDSI differs from the PDSI during transition periods between dry and wet spells (quicker switch)

- Calculated **weekly** by NOAA's-Climate Prediction Center:
  http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/regional_monitoring/palmer.gif

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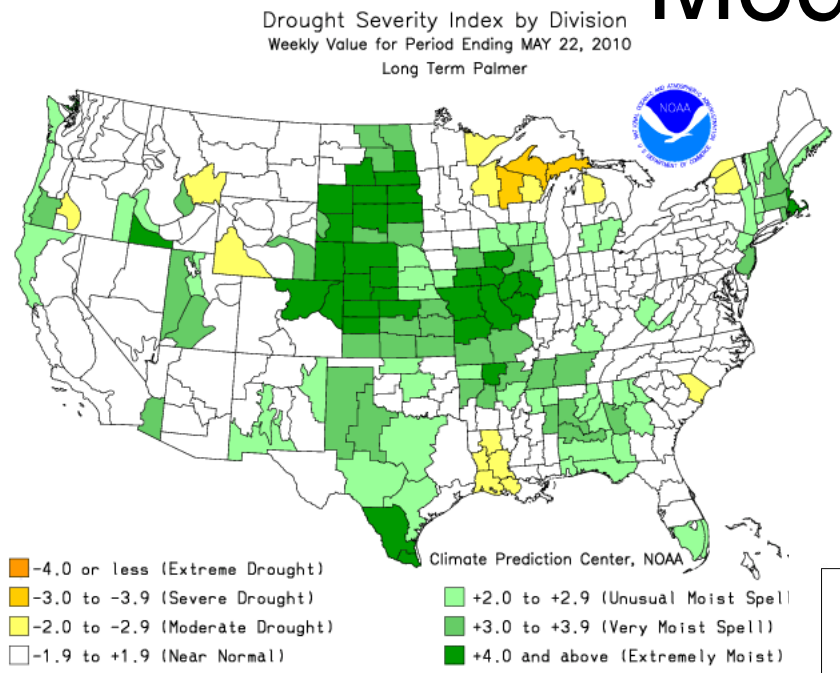
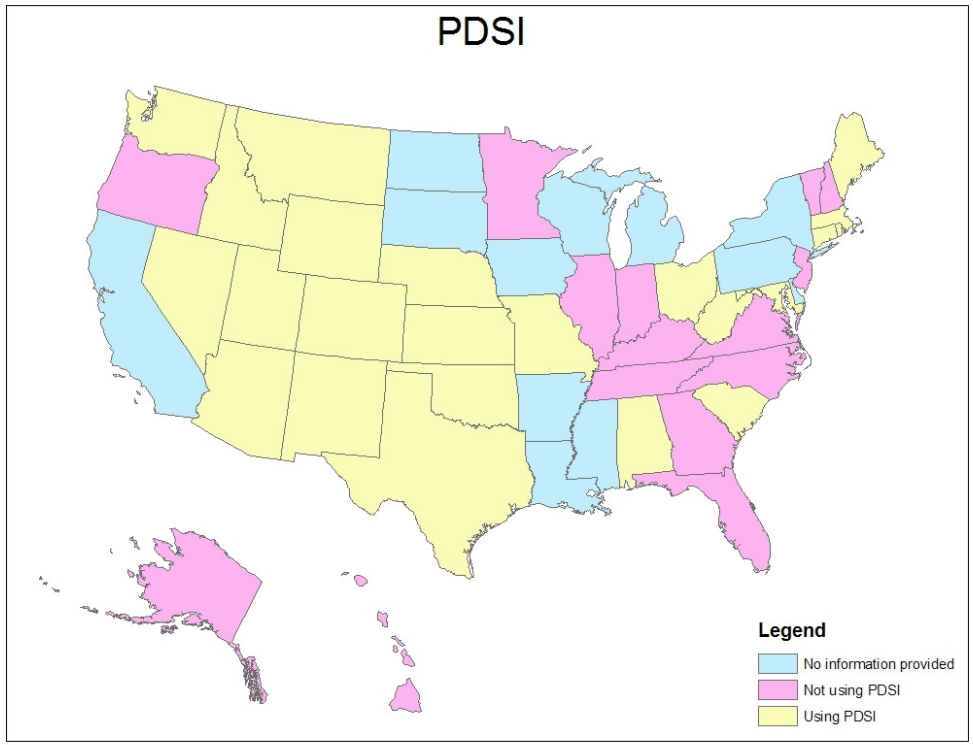
Modified PDSI





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Crop Moisture Index (CMI)

Description: A **Palmer derivative**, the CMI reflects moisture supply in the short term across major crop-producing regions and is not intended to assess long-term droughts. Requires Mean weekly T and weekly total Precipitation.

Pros: Identifies potential agricultural droughts; quick response

Cons: Because it is designed to monitor short-term moisture conditions affecting a developing crop, the CMI is not a good long-term (multi-year) drought monitoring tool; resets to zero each year

Developed by: W.C. Palmer, 1968

Weekly maps:

(http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/regional_monitoring/cmi.gif)

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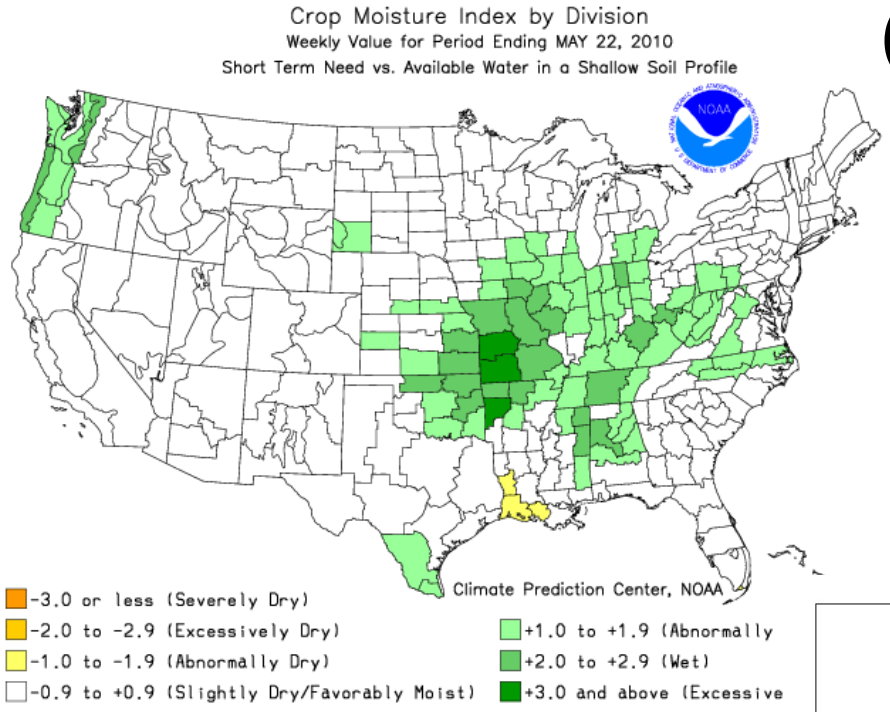
CMI continued

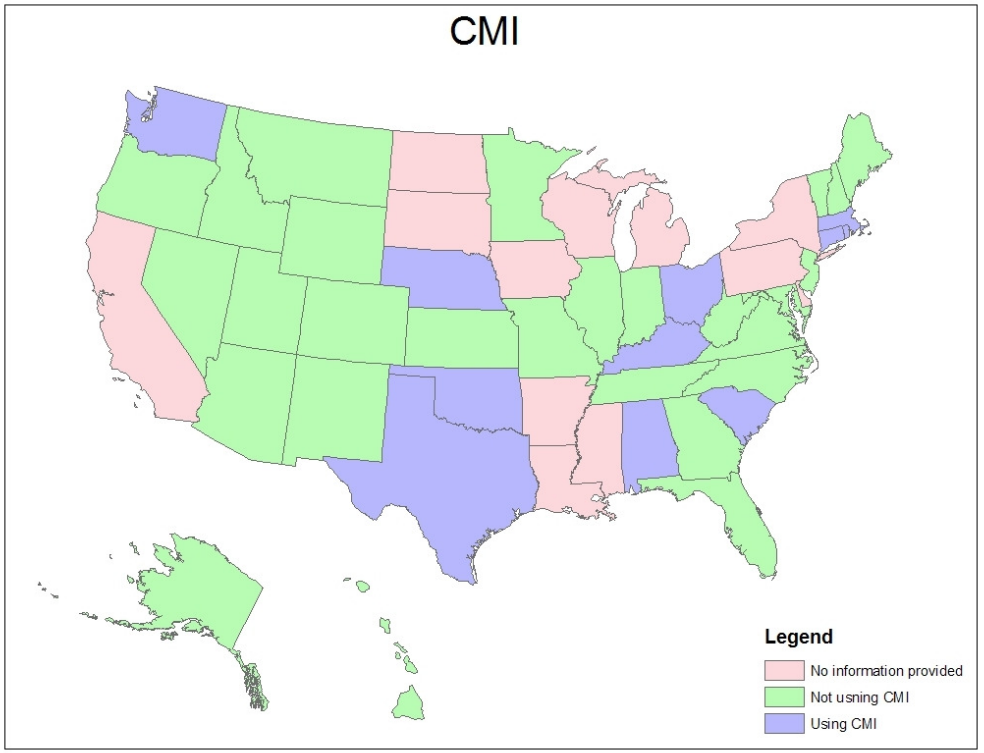
- The Crop Moisture Index (CMI) uses a **meteorological approach** to monitor week-to-week crop conditions
- It was developed by Palmer (1968) from procedures within the calculation of the PDSI. Whereas the PDSI monitors long-term meteorological wet and dry spells, the CMI was **designed to evaluate short-term moisture conditions** across major crop-producing regions
- It is **based on** the mean temperature and total precipitation for each week within a climate division, as well as the CMI value from the previous week

CMI continued

- The CMI **responds rapidly** to changing conditions, and it is **weighted by location and time** so that maps, which commonly display the weekly CMI across the United States, can be used to compare moisture conditions at different locations
- Another characteristic of the CMI that limits its use as a long-term drought monitoring tool is that the **CMI typically begins and ends each growing season near zero**. This limitation prevents the CMI from being used to monitor moisture conditions outside the general growing season, especially in droughts that extend over several years

CMI





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Outline

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  - Collaborations: National/International
  - Tools
- Drought Monitor Process
  - USDM
  - National + Regional Ag Inputs
  - NADM
- Primary USDM Ag Indices
  - SPI, Palmer Suite
- **New Wave of Tools**
  - Remote Sensing
  - Models/Land Data Simulations (LDAS)
- NIDIS
- Summary

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Key Variables for Monitoring Drought

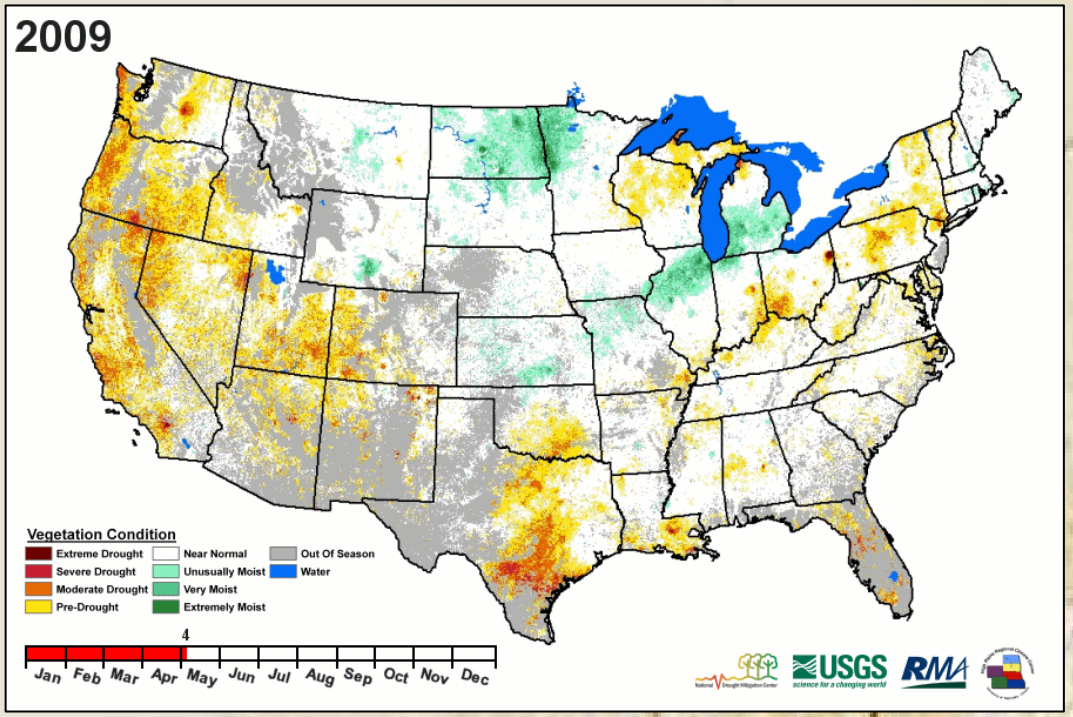
- climate data
- soil moisture*
- stream flow
- ground water*
- reservoir and lake levels*
- snow pack*
- short, medium, and long range forecasts*
- vegetation health/stress and fire danger*
- sectoral impacts*

(*) Opportunities for Enhancing Drought Monitoring & Early Warning Systems

NASA (and others) observations/products can provide spatially detailed information to compliment traditional *in situ* measurements.

Initial Remote Sensing Efforts to Support the USDM

1. <u>Vegetation Drought Response Index (VegDRI)</u> – integrates satellite-based vegetation index (VI) observations, climate-based drought index data, and general environmental information (e.g., LULC type, soils, and elevation).



http://drought.unl.edu/vegdri/VegDRI_Main.htm

Brown, J.F., **B.D. Wardlow**, T. Tadesse, M.J. Hayes, and B.C. Reed, 2008. The vegetation drought response index (VegDRI): a new integrated approach for monitoring drought stress in vegetation. *GIScience and Remote Sensing*, 45(1):16-46.

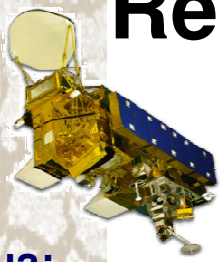
- **NDMC and USGS Center for EROS are working to develop a MODIS-based VegDRI to replace the current AVHRR VI-based operational VegDRI products.**

"National Drought Monitoring System for Drought Early Warning Using Hydrologic and Ecologic Observations from NASA Satellite Data"

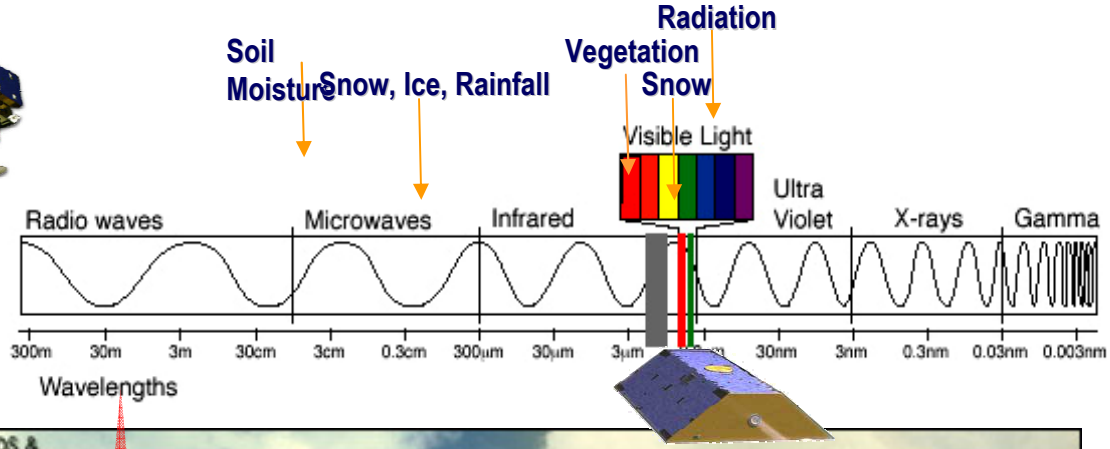
***Investigators: S. V. Nghiem (JPL, PI), J. P. Verdin (USGS, Lead* Co-I), D. A. Wilhite** (NDMC), R. Dole (NOAA PSD), D. LeComte (NOAA CPC), G. R. Brakenridge (Darmouth DFO), E. G. Njoku (JPL)

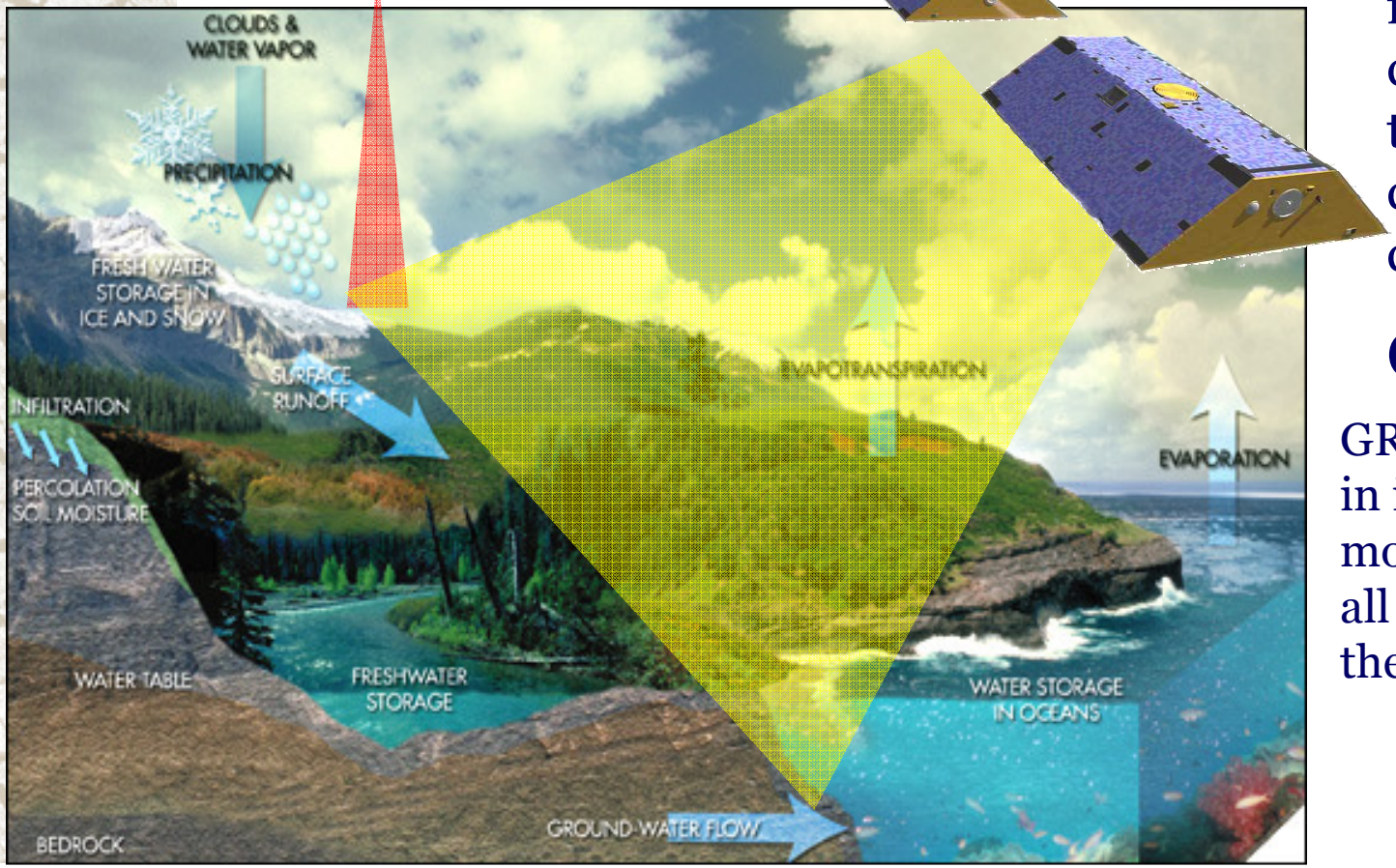
Project supported by: NNH07ZDA001N: NASA Decision Support through Earth Science Research Results

Remote Sensing of the Water Cycle



Aqua: MODIS, AMSR-E, etc.





Traditional radiation-based remote sensing technologies cannot sense water below the first few centimeters of the snow-canopy-soil column

GRACE

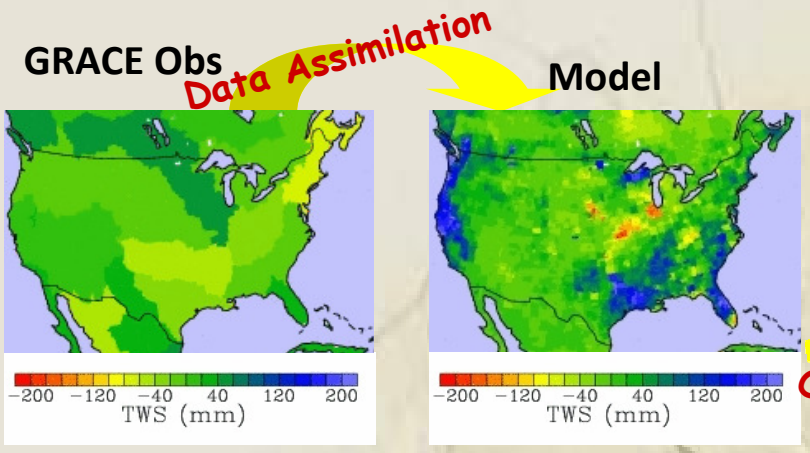
GRACE is unique in its ability to monitor water at all levels, down to the deepest aquifer

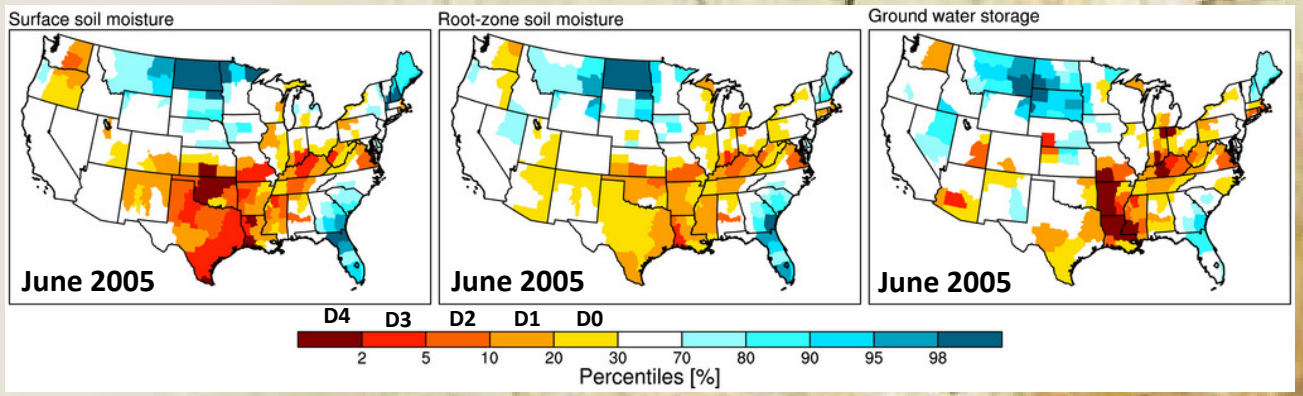
National Drought Mitigation Center

Matt Rodell
NASA GSFC

Initial Remote Sensing Efforts to Support the USDM

2. **<u>Terrestrial Water Storage (TWS)</u>** calculated from GRACE data and the Land Data Assimilation System (LDAS). Several vertical TWS products ranging from surface soil moisture to ground water storage are being developed for the USDM.





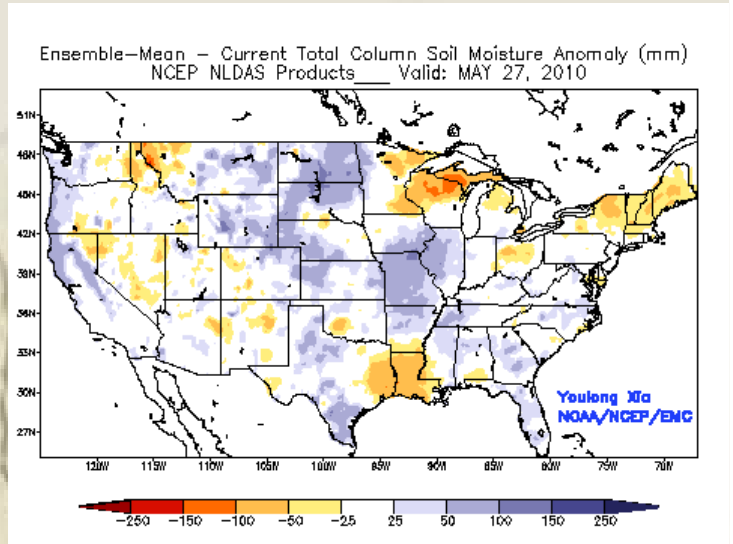
"Integrating Enhanced GRACE Water Storage Data into the U.S. and North American Drought Monitors"

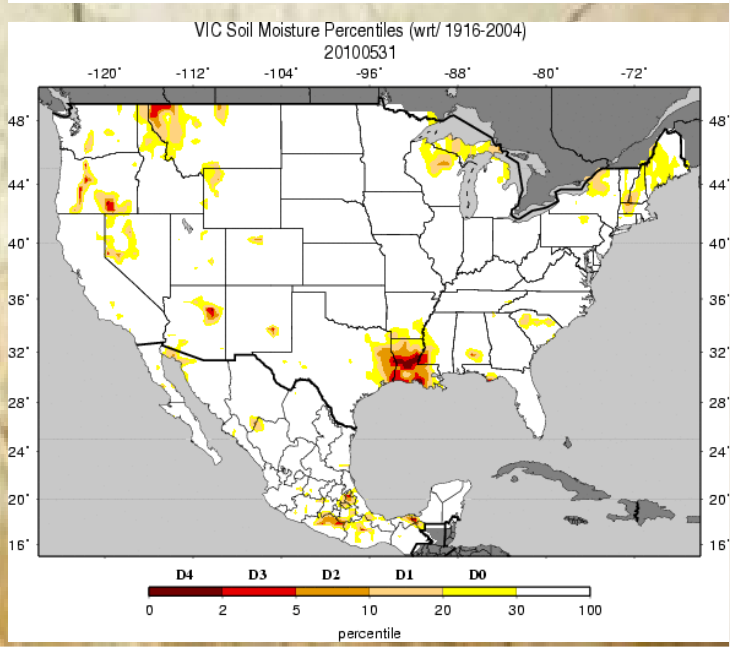
Investigators: M. Rodell, J. Lawrimore, R. Heim, B. Wardlow, M. Svoboda, J.S. Famiglietti, R. Reichle, R. Houborg, B. Li, R. Tinker, M. Rosencrans

Project supported by: NNH07ZDA001N: NASA Decision Support through Earth Science Research Results

What is the National Land Data Assimilation System (NLDAS)?

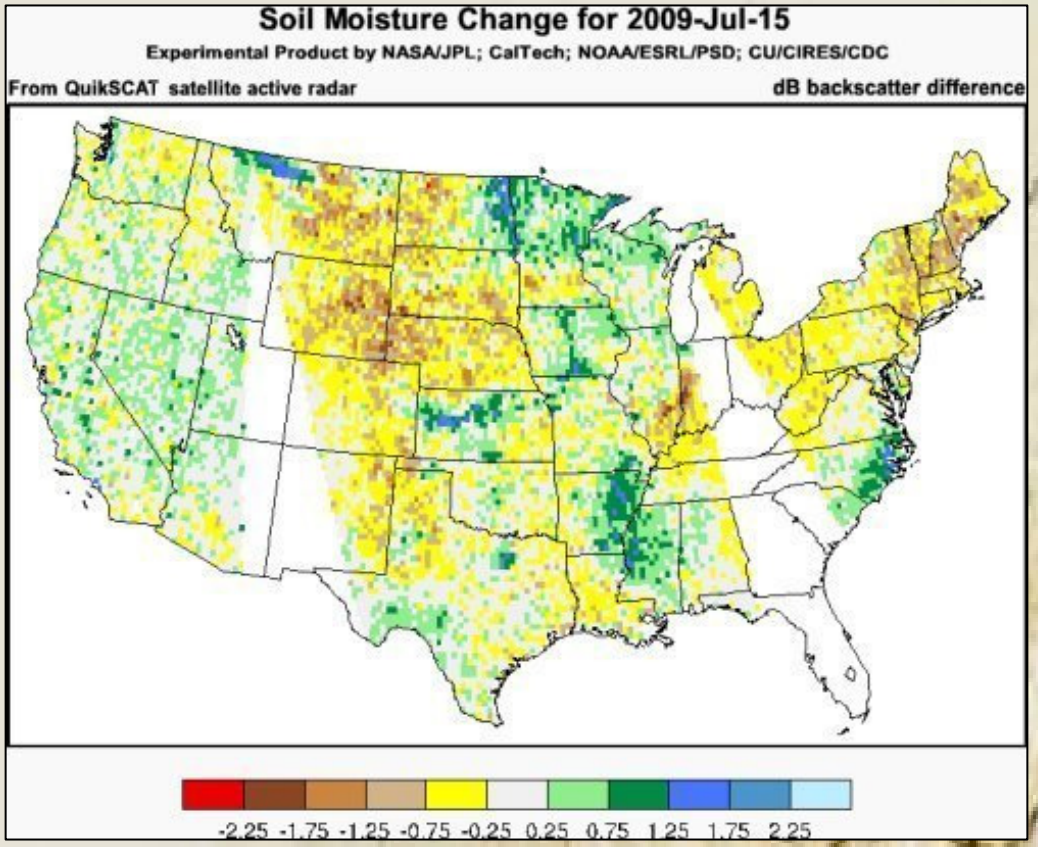
- The Land Data Assimilation System (LDAS) consists of uncoupled models forced with observations, satellite data and radar precipitation measurement, and is therefore not affected by Numerical WP forcing biases.
- Near real-time using existing Surface Vegetation Atmosphere Transfer Schemes (SVATS) by NCEP, NASA, Princeton University, and the University of Washington at 1/8 degree (about 14 kilometer) resolution across North America and at 1/4 degree resolution globally.
- Outputs: soil moisture, snow water equivalent, total runoff, streamflow, evaporation and precipitation.
- The SM anomalies and percentiles are based on a 28 year climatology (1980 - 2007)





Initial Remote Sensing Efforts to Support the USDM

3. **<u>Soil Moisture Change (SMC)</u>** information calculated from QuikSCAT and AMSR-E data.



Work is ongoing with NASA JPL, NDMC, and the USDM authors to:

1) define specific SMC products,

2) evaluate the utility of the SMC data for drought applications, and

3) develop strategies to integrate the SMC information into the USDM process and NIDIS portal

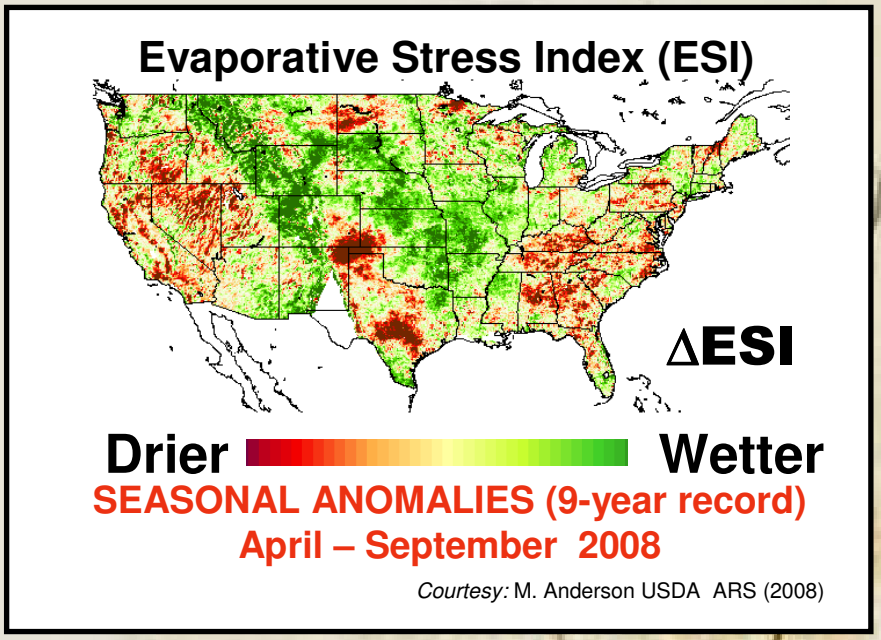
"National Drought Monitoring System for Drought Early Warning Using Hydrologic and Ecologic Observations from NASA Satellite Data"

***Investigators: S. V. Nghiem (JPL, PI), J. P. Verdin (USGS, Lead* Co-I), D. A. Wilhite** (NDMC), R. Dole (NOAA PSD), D. LeComte (NOAA CPC), G. R. Brakenridge (Darmouth DFO), E. G. Njoku (JPL)

Project supported by: NNH07ZDA001N: NASA Decision Support through Earth Science Research Results

Initial Remote Sensing Efforts to Support the USDM

4. **<u>Evaporative Stress Index (ESI)</u>** depicts 'moisture' stress from both the soil and vegetation canopy based on ET flux estimates from a land surface model (ALEXI & DisALEXI) that relies primarily on remotely sensed thermal observations.



"A GOES Thermal-based Drought Early Warning Index for NIDIS"

Investigators: *M.C. Anderson (USDA ARS), K.C. Mo (NCEP-CPC)*, M. Svoboda (NDMC), B. Wardlow (NDMC), X. Zhan (NESDIS), J.R. Mecikalksi (U of Alabama), W.P. Kustas (USDA ARS), and J.F. Brown (USGS-EROS)

Project supported by: OAR-CPO-2009-2001430: NOAA Climate Dynamics and Experimental Prediction (CDEP_ Competition – Drought Forecast Products and Applications

Anderson, M.C., Norman, J.M., Mecikalski, J.R., Otkin, J.A., Kustas, W.P. 2007. A climatological study of evapotranspiration and moisture stress across the continental U.S. based on thermal remote sensing. II. Surface moisture climatology. Journal of Geophysical Research. 112, D11112. http://dx.doi.org/10.1029/2006JD007507.

USDM Concept Expanded to North America

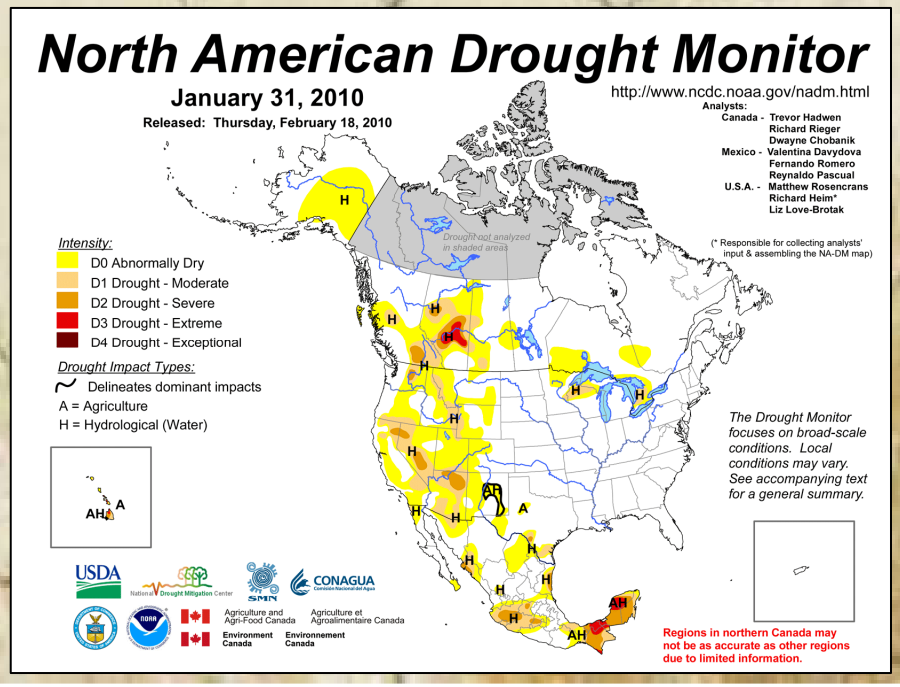
The monthly North American Drought Monitor (NADM) was introduced in 2003 and built upon the USDM concept.

Challenges:

1.Limited number of data inputs compared to the USDM

2.Data inconsistencies (e.g., specific measure, format, and quality) among countries

3.Currently, limited use of remote sensing-derived inputs (primarily NDVI).



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  - Remote Sensing
  - Models/Land Data Simulations (LDAS)
- **NIDIS**
- Summary

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National Integrated Drought Information System (NIDIS)

A NOAA-led Federal, State, Tribal and Local Partnership

(Public Law 109-430, 2006)

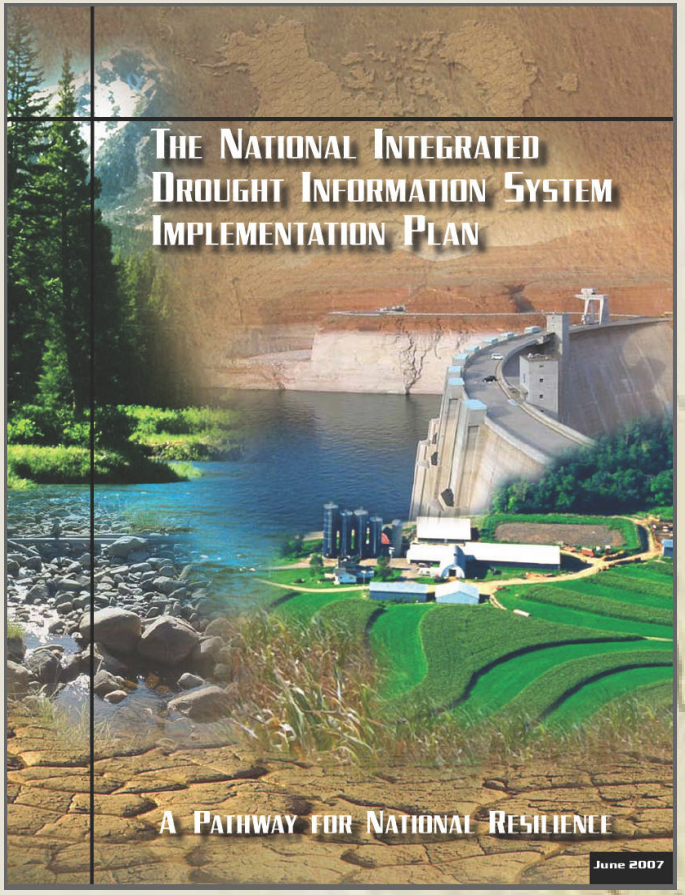
Goal of NIDIS: Improve the nation's capacity to 'proactively' manage drought-related risks by **providing decision makers with the best available information and tools** to assess the impact of drought and to better prepare for and mitigate the effects of drought.

NIDIS

NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM

www.drought.gov

NIDIS Implementation Team Partners (to date): ⟶



www.drought.gov

Other Partners:

Western Governors Association (WGA)

National Drought Mitigation Center (NDMC)

Regional Climate Centers

American Association of State Climatologists

Indigenous Waters Network

Weather Channel

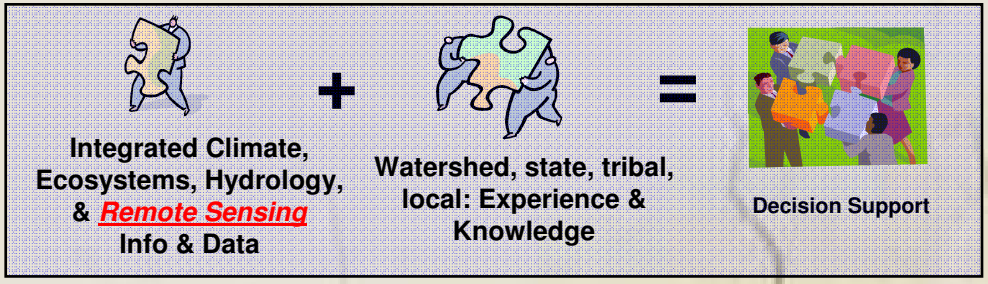
Numerous Universities including:
University of Oklahoma, University of South Carolina, University of Washington, South Dakota State University, and Cornell University.

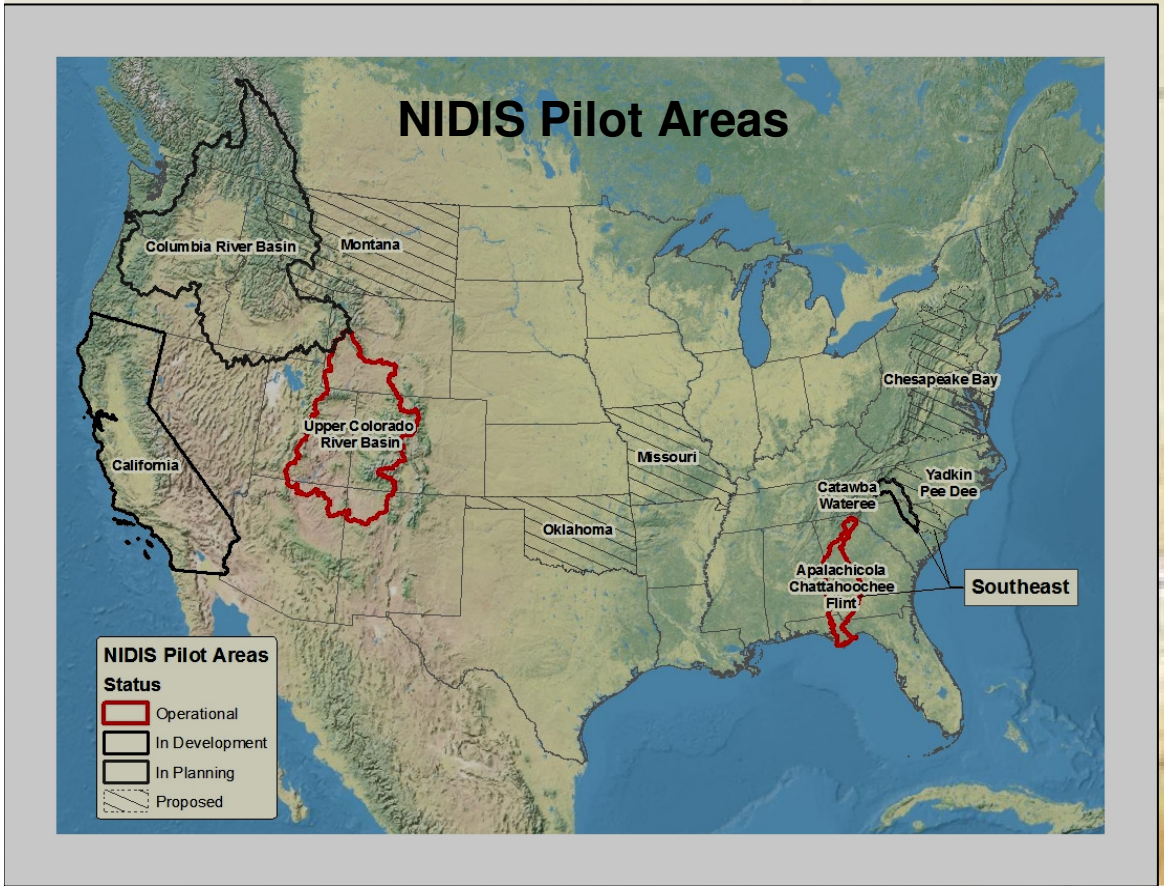
Roles of the NDMC in NIDIS

- Co-Chair of the NIDIS Executive Council
  - Wilhite, Director of UNL-SNR
- NIDIS Program Implementation Team (Hayes Co-Chair)
  - Svoboda, Bathke, and Hayes
- U.S. Drought Portal Co-Chair (Svoboda)
- Engaging Preparedness Communities Co-Chair (Bathke)
- NIDIS Portal Help Desk
- NIDIS Pilot Project Coordination Workshops
- NIDIS Regional Drought Monitor/EWS Projects (Svoboda, Wardlow and Fuchs)

NIDIS Pilots

A Geographic Framework for Developing Drought Early Warning Systems (EWS) for Local-Scale Decision Making

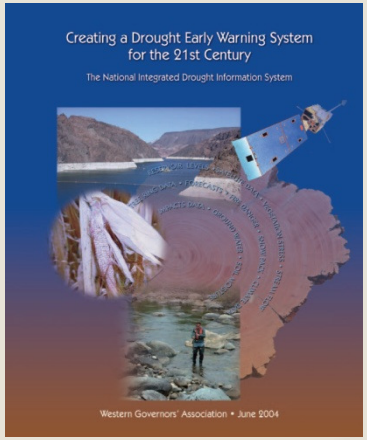




- **'Issue-based' EWS tailored to the critical decisions and issues facing each basin**
- **Each EWS will be unique with specific inputs and methods developed and implemented by local experts**
- **Partnerships between:**
  1) **federal, state, and local agencies,**
  2) **tribal groups,**
  3) **other types of NGOs;and**
  4) **private sector**

The Role of Remote Sensing

The Push for Drought Information to Support Local-Scale Decision Making

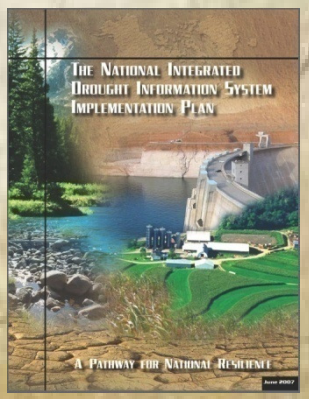


"Create a *drought "early warning system" capable of providing* ***accurate, timely, and integrated information on drought*** **conditions** and associated risks ***at relevant spatial scales*** to facilitate proactive decisions."

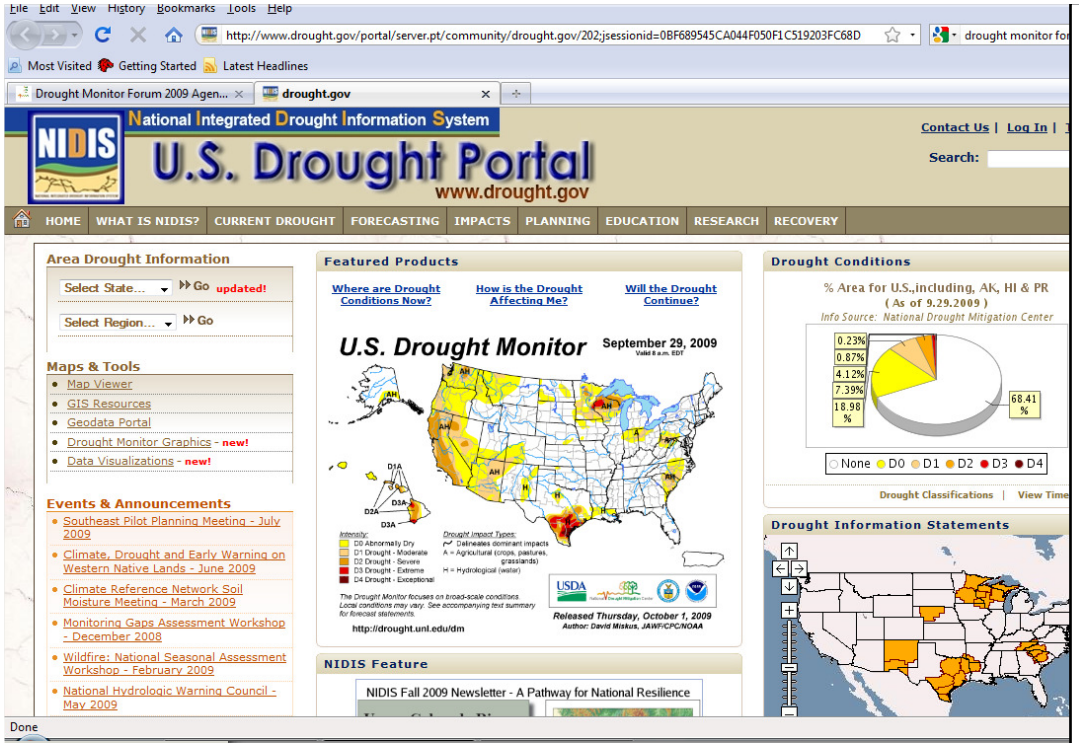
- Creating a Drought Early Warning System for the 21st Century, Western Governors' Association, 2007

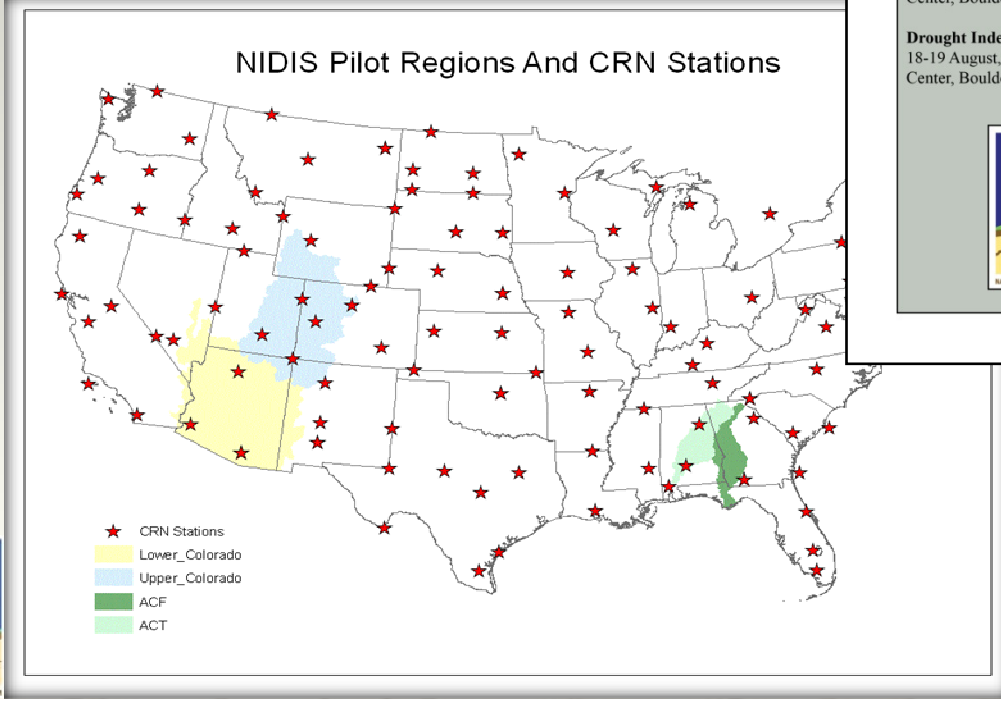
Complementary ***data from remote sensing, satellites, radar, aircraft*** and other technologies **must be explored**, encouraged and incorporated ***to fill important data gaps***.

NIDIS Workshop on Satellite Remote Sensing for Drought Monitoring – Boulder, CO February 6-7, 2008.



- NIDIS Implementation Plan, 2007





National Integrated Drought Information System - NIDIS

A Pathway for National Resilience

Fall 2009 *Volume 1 Issue 1*

Upper Colorado River Basin Pilot

The first NIDIS drought early warning and information system pilot was successfully launched during October 2008 with a meeting of stakeholders in Boulder, CO. In this newsletter, find these related articles...

Welcome!

Welcome to the first edition of the NIDIS Newsletter. A lot has happened in the past year, and we want to update the drought risk management and water resources communities on NIDIS activities. In our newsletter you will find information about the various NIDIS meetings that have been held in the past year, along with the key outcomes from each meeting. We will also highlight early warning information system pilot and research activities.

Also in this issue...

Courtesy: NIDIS

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Drought Monitoring State of the Science: Where are we now?

- Heightened awareness as a result of IPCC AR4
- A vast amount of good work, tools, products and lessons learned out there over the past several years
- Impediments remain
  - Lack of coordination
  - Lack of trigger ties to any drought plans
  - Resources
  - Lack of data/long-term data
  - Lack of institutional cooperation
  - Lack of drought “mitigation” plans

National Drought Mitigation Center

Drought Monitoring State of the Science: Where are we now?

- WCC-3,GDPN/GEOSS is a way to learn/leverage from one another
  - Canada/Mexico/United States
  - UN/WMO/others
- Many regions/countries are working together to better monitor drought
- Global monitoring of drought impacts is virtually non-existent
- Early warning/monitoring just one key: **THEN WHAT?** Need linkages to risk/vulnerability assessment and planning for adaptation
- Many indicators don't reflect reality in various regions, or for various season(s)……or for both!

National Drought Mitigation Center

Future Drought Monitoring Challenges

The Big Five:

- Impact collection/quantification
- Soil moisture (especially *in situ*)
- Hydrology (surface and groundwater)
- Application of Remotely Sensed/Modeled products operationally (trust)
- Ecological/Environmental (D-x E?)
  - ***"If a drought occurs in the desert, does anybody see it?"***

National Drought Mitigation Center

Thank You

Please contact me at:

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msvoboda2@unl.edu