

Real-time Drought Monitoring Over the U.S., and its Extension Globally.

Eric F. Wood

Princeton University

CEOP/IGWCOS meeting
Paris
Feb. 27 to Mar. 4, 2006

Outline of the Talk

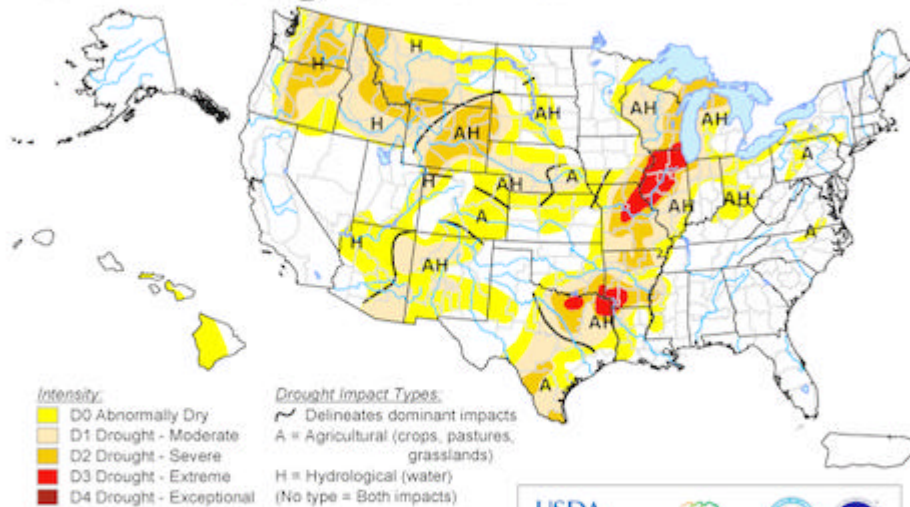
1. Demonstration of the Princeton 'nowcast' of surface soil moisture and drought in the U.S.
2. Briefly discuss the technical approach
3. Application globally, with a focus on Africa
4. Future needs to help CEOP/WISE and IGWCOS.

Realtime Drought Monitoring

(July 26, 2006 assessment)

U.S. Drought Monitor

July 26, 2005
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)
- (No type = Both impacts)

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



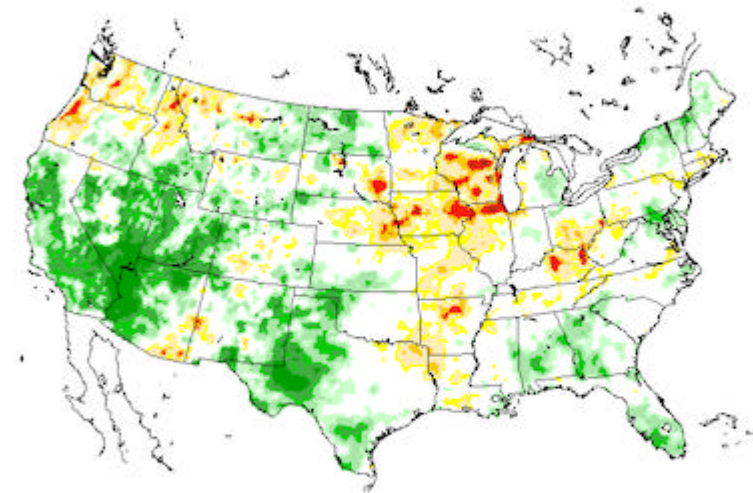
Released Thursday, July 28, 2005

Author: C. Tankersley/J. Enloe, NOAA/NESDIS/NCDC

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

Based on a variety of field information and significant human interpretation.

Total Column Soil Moisture Percentiles on 20050728 (wrt samples within a 11-day window in 1951-2004)

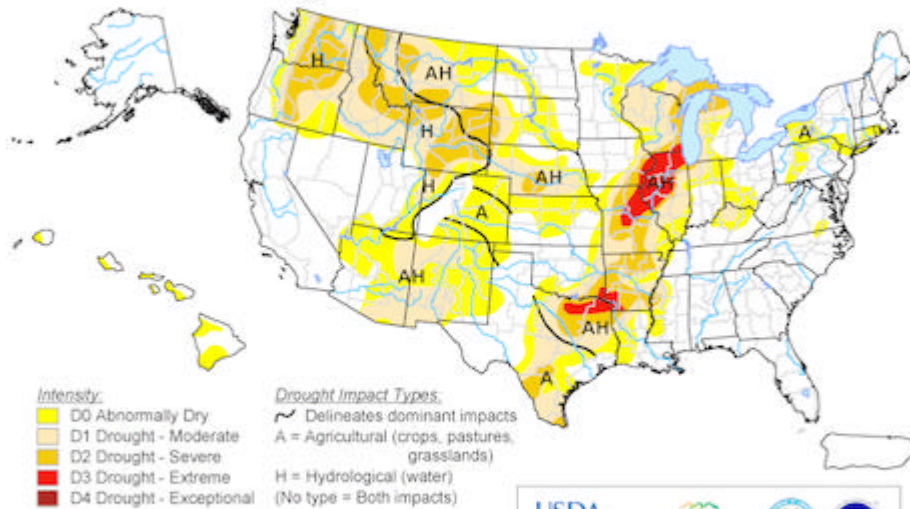


Based on running our VIC LSM forced with real-time NLDAS data. Index is the total column soil moisture, (as a percentile).

August 2, 2005 assessment

U.S. Drought Monitor

August 2, 2005
Valid 8 a.m. EDT



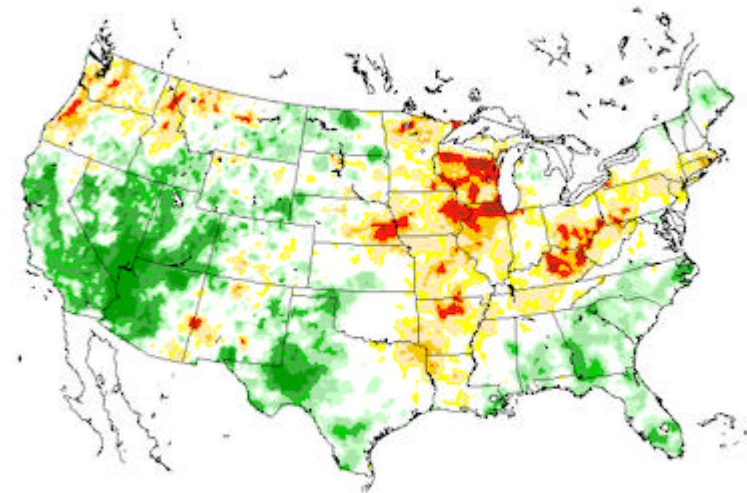
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



Released Thursday, August 4, 2005
Author: Michael Hayes, NDMC

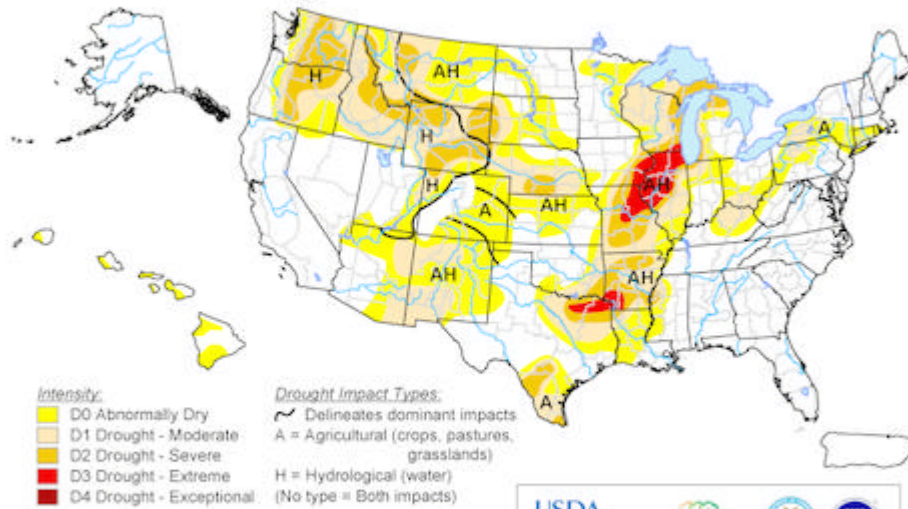
Total Column Soil Moisture Percentiles on 20050804
(wrt samples within a 11-day window in 1951-2004)



August 9, 2005 assessment

U.S. Drought Monitor

August 9, 2005
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)
- (No type = Both impacts)

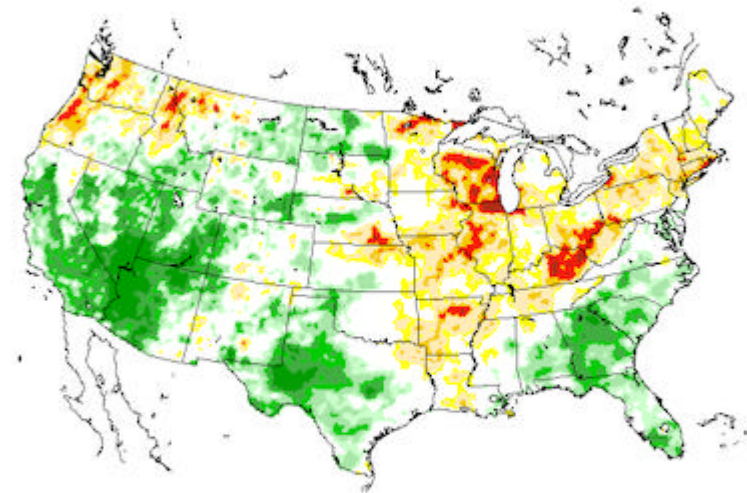
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



Released Thursday, August 11, 2005
Author: Mark Svoboda, NDMC

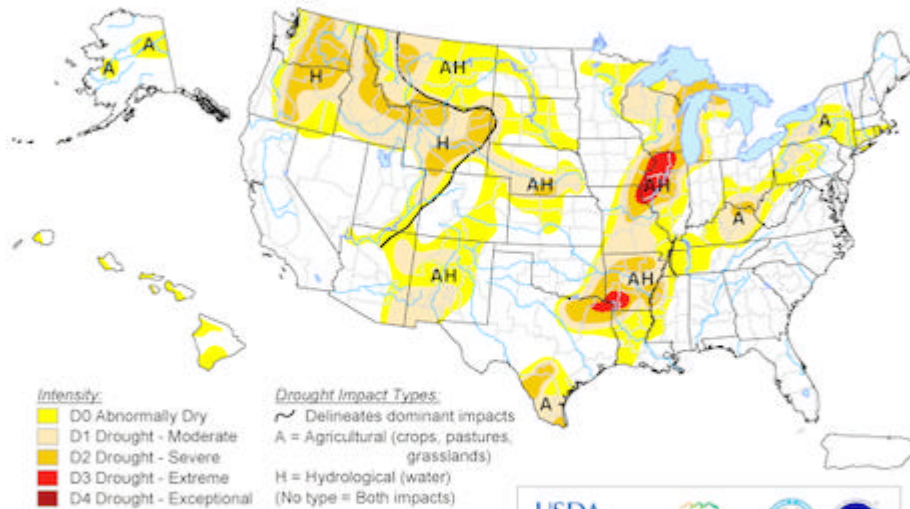
Total Column Soil Moisture Percentiles on 20050811
(wrt samples within a 11-day window in 1951-2004)



August 16, 2005 assessment

U.S. Drought Monitor

August 16, 2005
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)
- (No type = Both impacts)

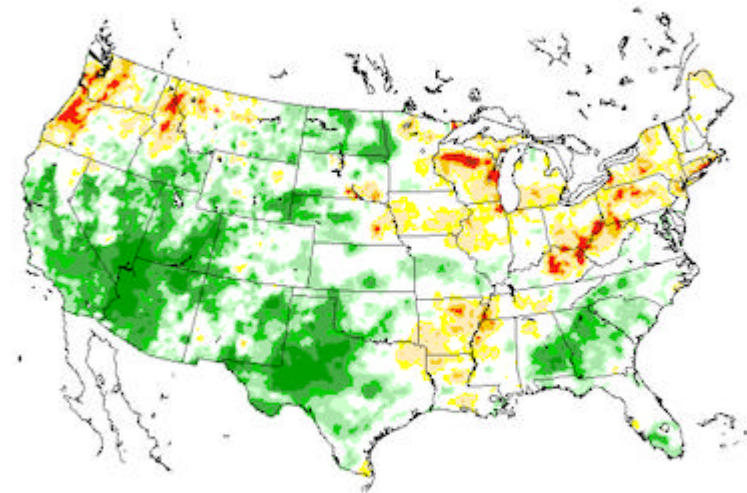
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



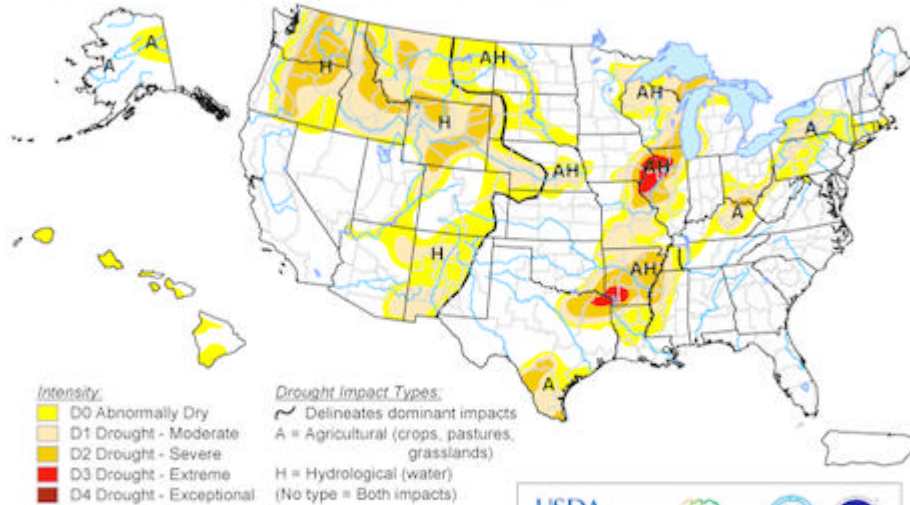
Released Thursday, August 18, 2005
Author: David Miskus, JAWF/CPC/NOAA

Total Column Soil Moisture Percentiles on 20050818
(wrt samples within a 11-day window in 1951-2004)



August 23, 2005 assessment

U.S. Drought Monitor August 23, 2005 Valid 8 a.m. EDT



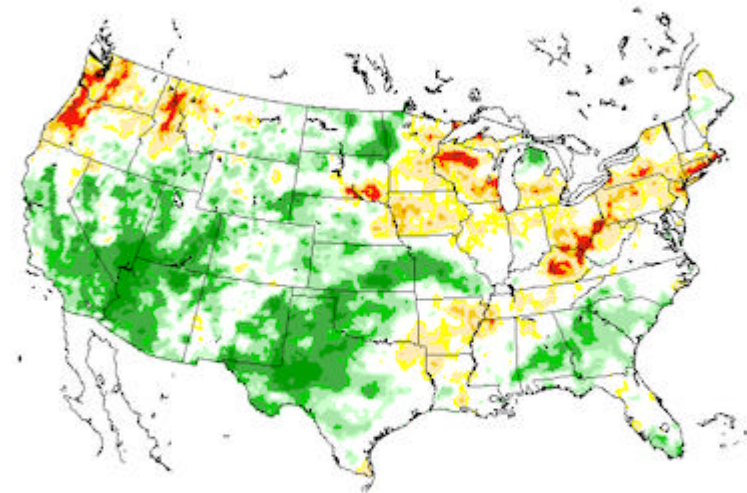
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



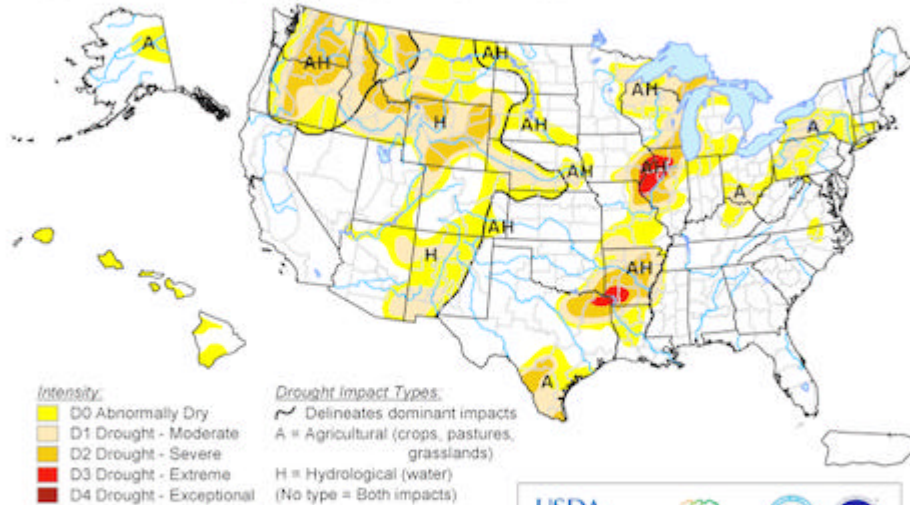
Released Thursday, August 25, 2005
Author: David Miskus, JAWF/CPC/NOAA

Total Column Soil Moisture Percentiles on 20050825
(wrt samples within a 11-day window in 1951-2004)



August 30, 2005 assessment

U.S. Drought Monitor August 30, 2005 Valid 8 a.m. EDT



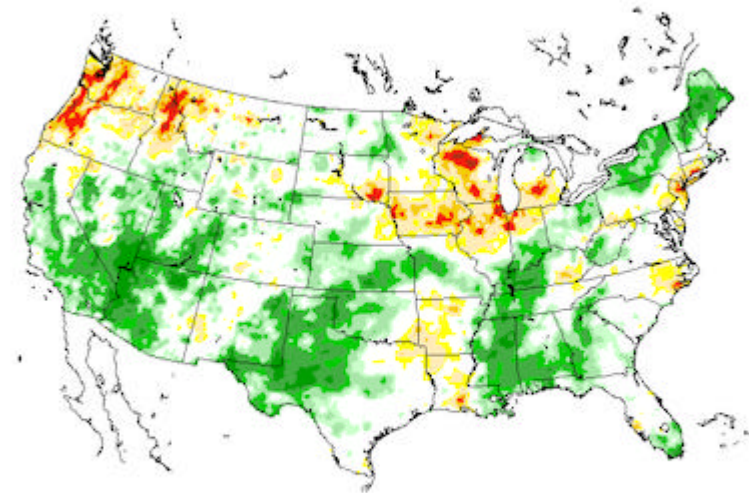
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



Released Thursday, September 1, 2005
Author: Brad Rippey, U.S. Department of Agriculture

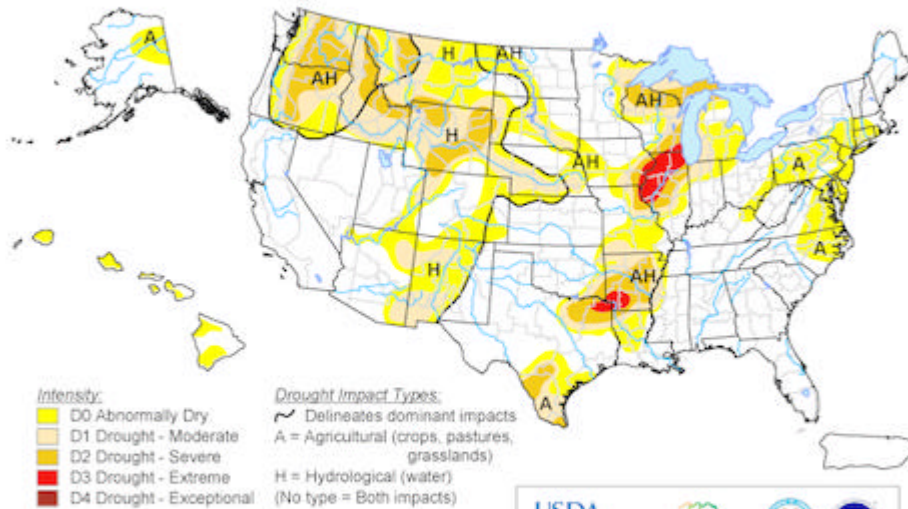
Total Column Soil Moisture Percentiles on 20050901 (wrt samples within a 11-day window in 1951-2004)



September 6, 2005 assessment

U.S. Drought Monitor September 6, 2005

Valid 8 a.m. EDT



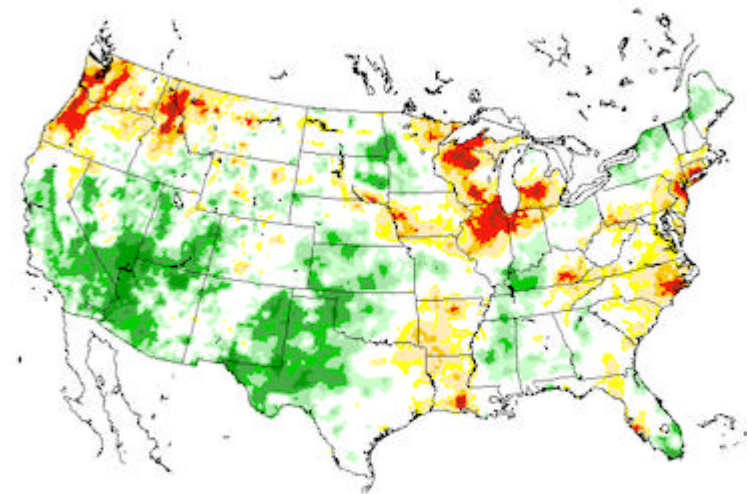
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



Released Thursday, September 8, 2005
Author: Mark Svoboda, NDMC

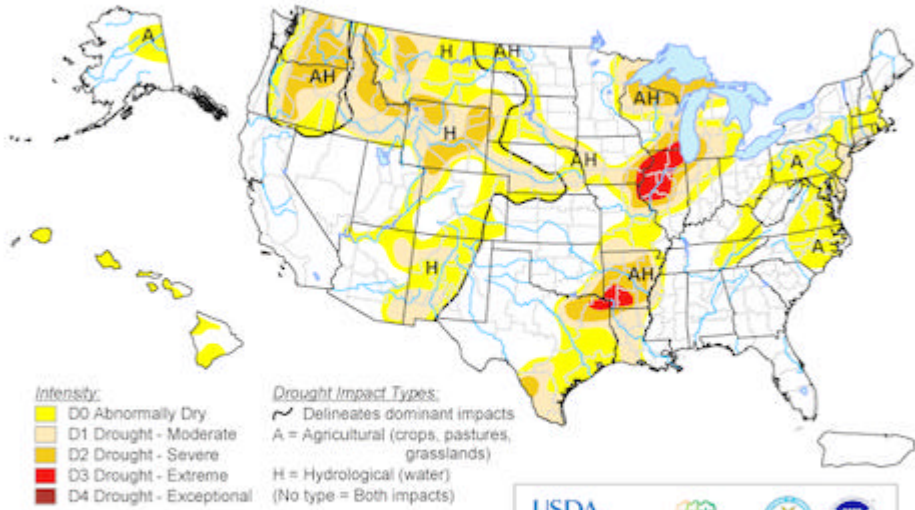
Total Column Soil Moisture Percentiles on 20050908 (wrt samples within a 11-day window in 1951-2004)



September 13, 2005 assessment

U.S. Drought Monitor September 13, 2005

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)
 (No type = Both impacts)

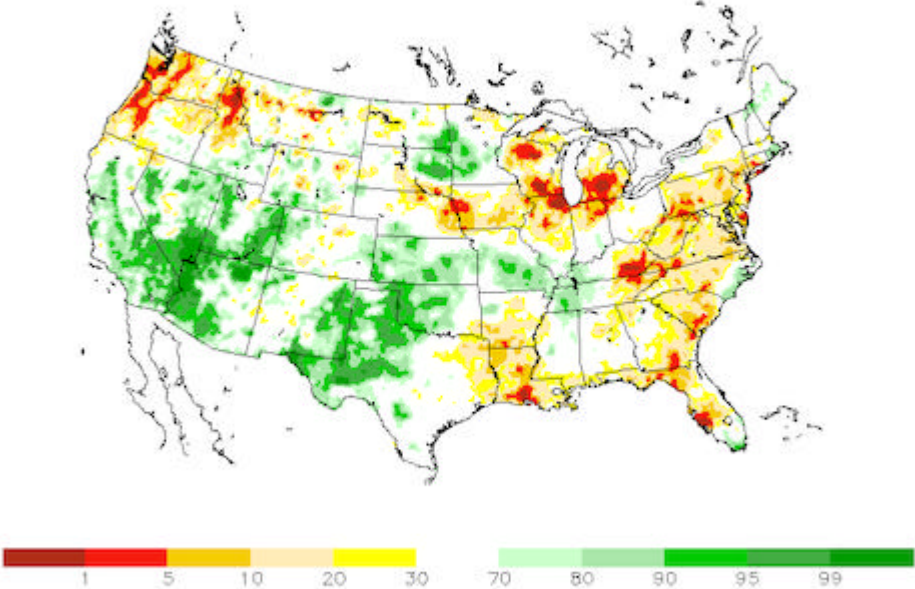
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



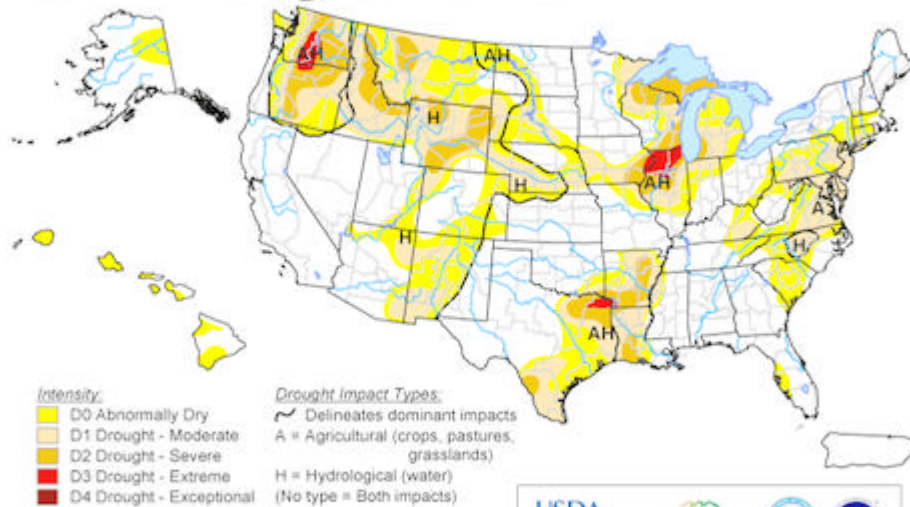
Released Thursday, September 15, 2005
 Author: Michael Hayes, NDMC

Total Column Soil Moisture Percentiles on 20050915 (wrt samples within a 11-day window in 1951-2004)



September 20, 2005 assessment

U.S. Drought Monitor September 20, 2005 Valid 8 a.m. EDT



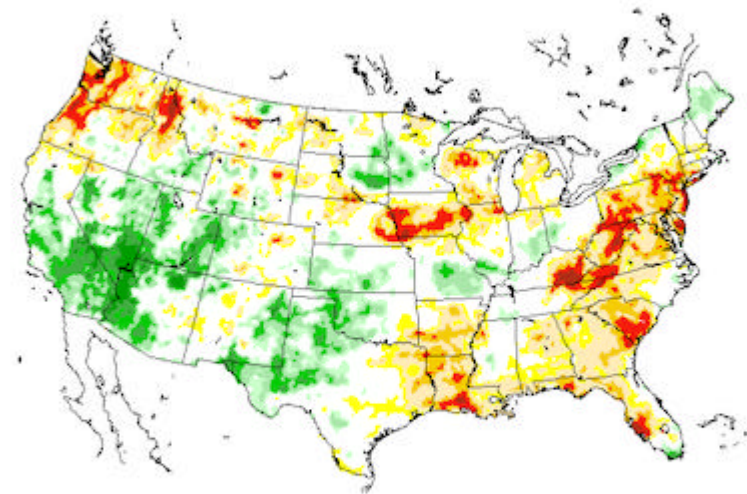
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



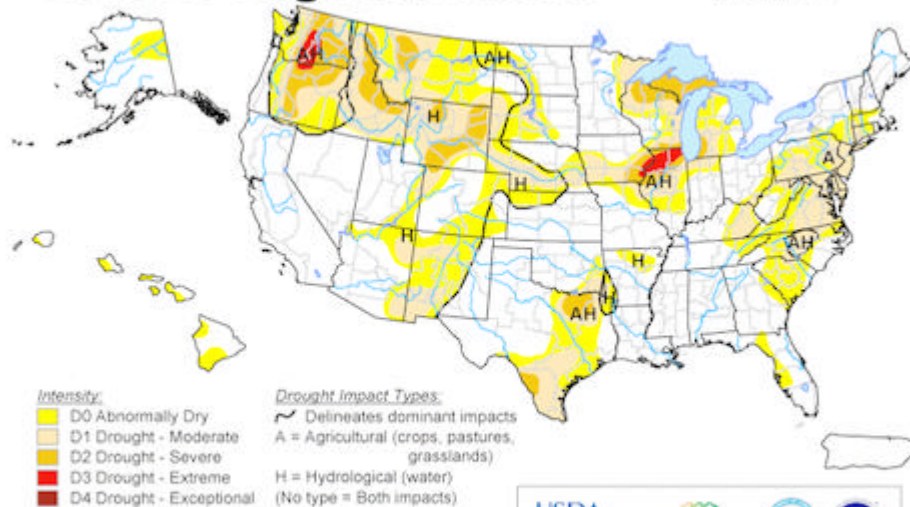
Released Thursday, September 22, 2005
Author: Douglas Le Comte, CPC/NOAA

Total Column Soil Moisture Percentiles on 20050922
(wrt samples within a 11-day window in 1951-2004)



September 27, 2005 assessment

U.S. Drought Monitor September 27, 2005 Valid 8 a.m. EDT



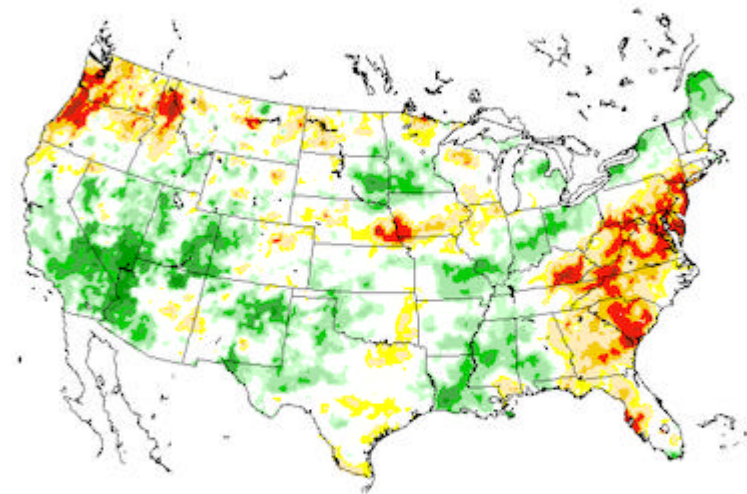
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



Released Thursday, September 29, 2005
Author: Douglas Le Comte, CPC/NOAA

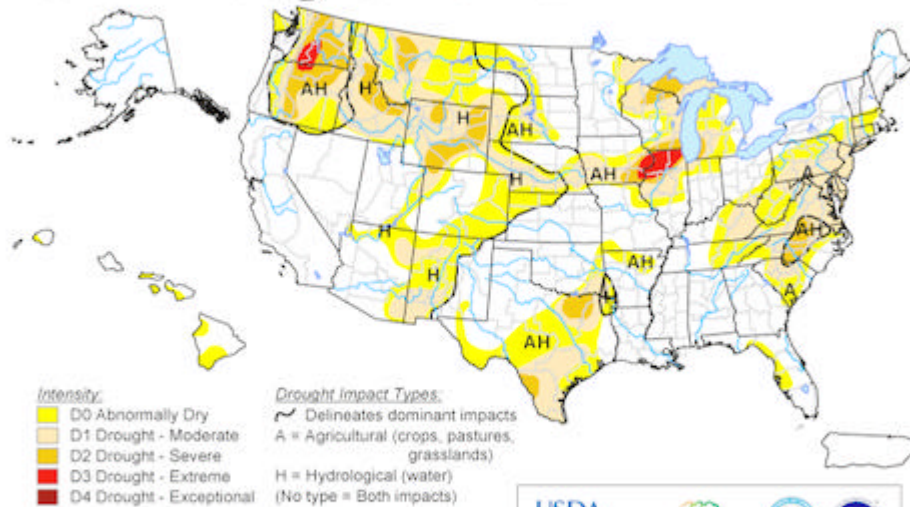
Total Column Soil Moisture Percentiles on 20050929
(wrt samples within a 11-day window in 1951-2004)



October 4, 2005 assessment

U.S. Drought Monitor

October 4, 2005
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)
 (No type = Both impacts)

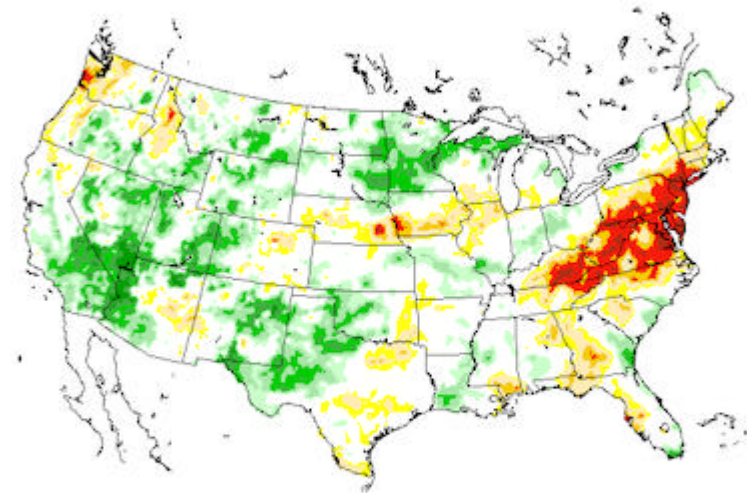
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



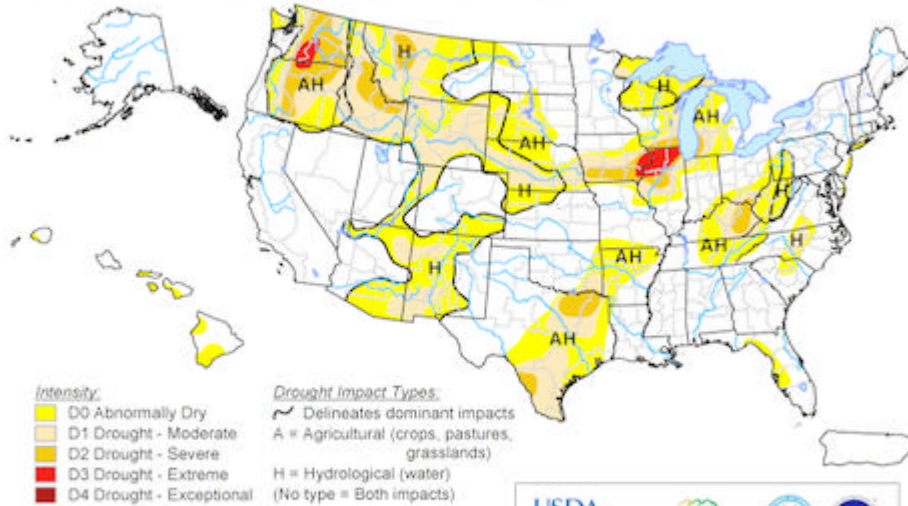
Released Thursday, October 6, 2005
Author: RichTinker, CPC/NCEP/NWS/NOAA

Total Column Soil Moisture Percentiles on 20051006 (wrt samples within a 11-day window in 1951-2004)



October 11, 2005 assessment

U.S. Drought Monitor October 11, 2005 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)
 (No type = Both impacts)

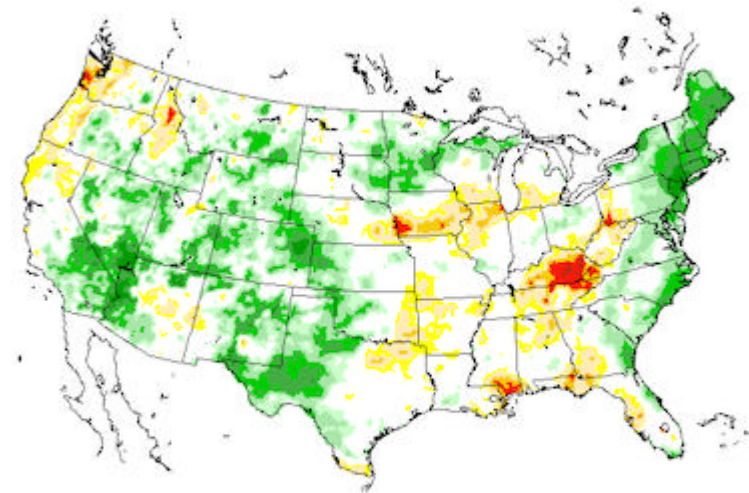
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



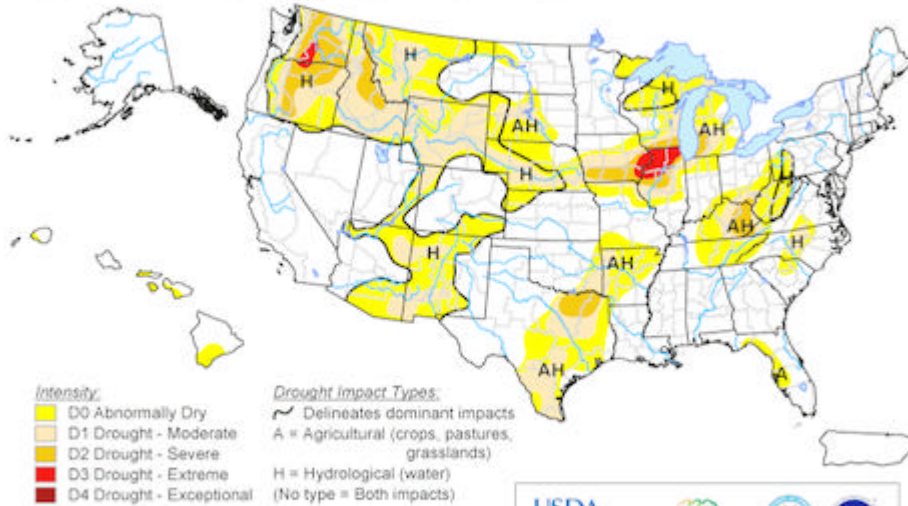
Released Thursday, October 13, 2005
 Author: Rich Tinker, CPC/NCEP/NWS/NOAA

Total Column Soil Moisture Percentiles on 20051013 (wrt samples within a 11-day window in 1951-2004)



October 18, 2005 assessment

U.S. Drought Monitor October 18, 2005 Valid 8 a.m. EDT



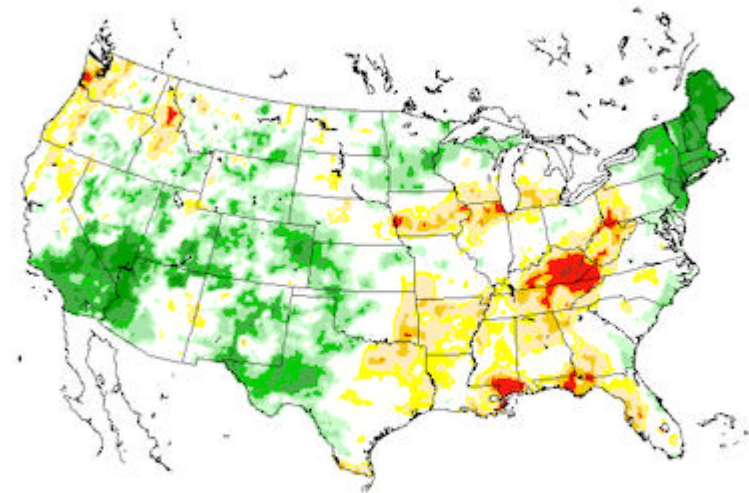
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



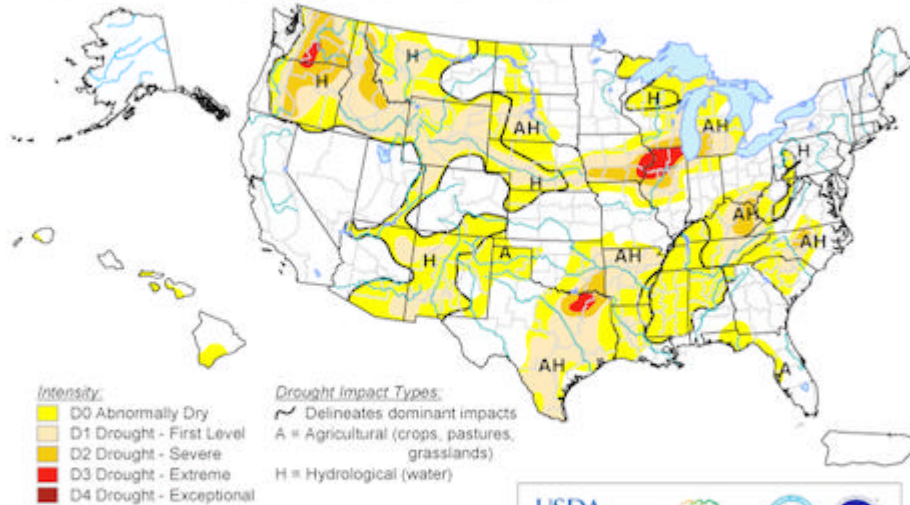
Released Thursday, October 20, 2005
Author: David Miskus, JAWF/CPC/NOAA

Total Column Soil Moisture Percentiles on 20051020 (wrt samples within a 11-day window in 1951-2004)



October 25, 2005 assessment

U.S. Drought Monitor October 25, 2005 Valid 8 a.m. EDT



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

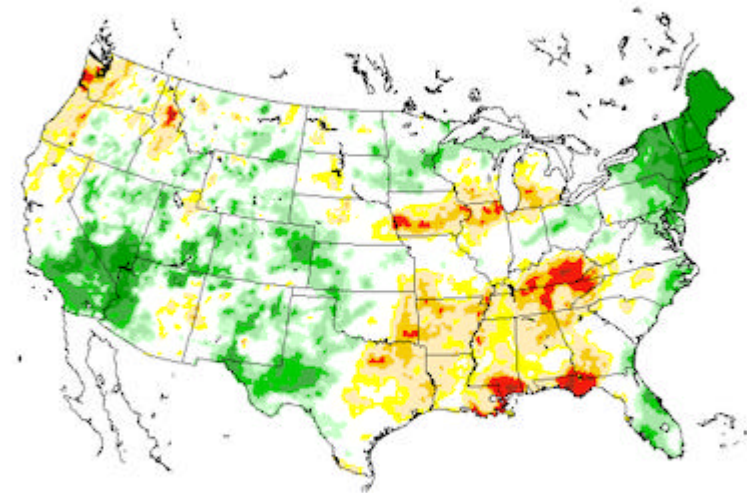
<http://drought.unl.edu/dm>



Released Thursday, October 27, 2005

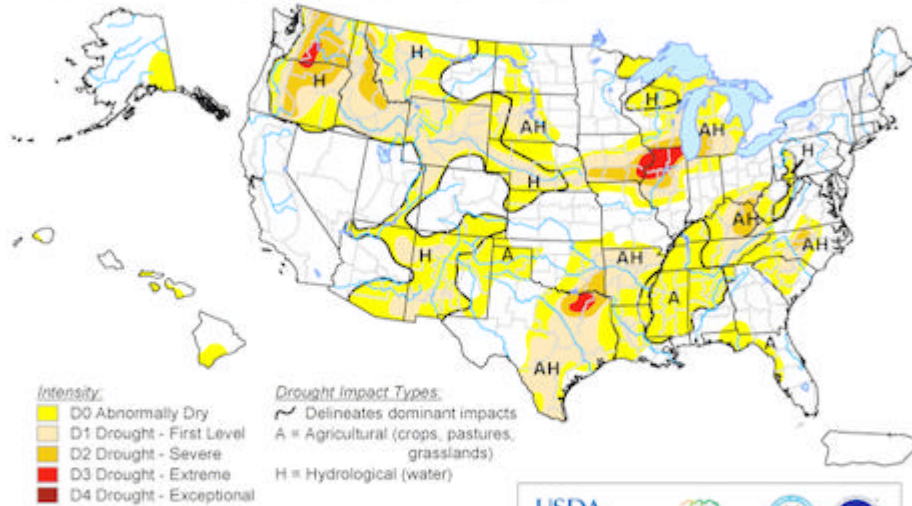
Author: C. Tankersley/L. Love-Brotak, NOAA/NESDIS/NCDC

Total Column Soil Moisture Percentiles on 20051027 (wrt samples within a 11-day window in 1951-2004)



November 1, 2005 assessment

U.S. Drought Monitor November 1, 2005 Valid 7 a.m. EST



Intensity:
 D0 Abnormally Dry
 D1 Drought - First Level
 D2 Drought - Severe
 D3 Drought - Extreme
 D4 Drought - Exceptional

Drought Impact Types:
 ~ Delineates dominant impacts
 A = Agricultural (crops, pastures, grasslands)
 H = Hydrological (water)

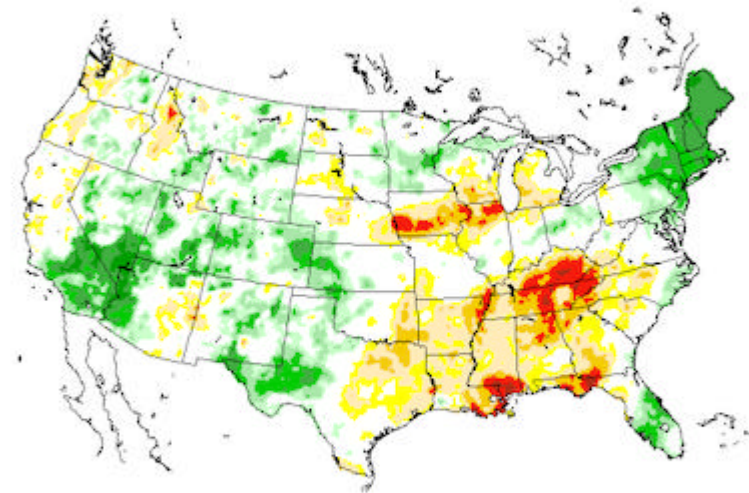
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



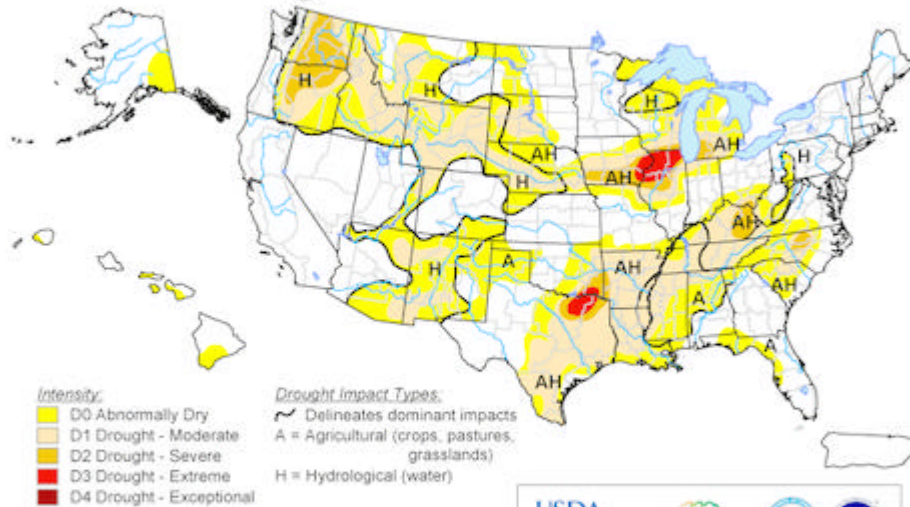
Released Thursday, November 3, 2005
 Author: R. Heim/L. Love-Brotak, NOAA/NESDIS/NCDC

Total Column Soil Moisture Percentiles on 20051103
 (wrt samples within a 11-day window in 1951-2004)



November 8, 2005 assessment

U.S. Drought Monitor November 8, 2005 Valid 8 a.m. EST



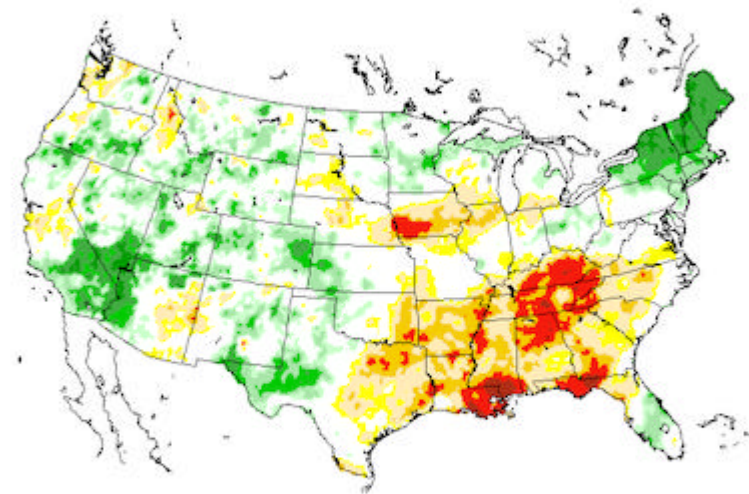
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



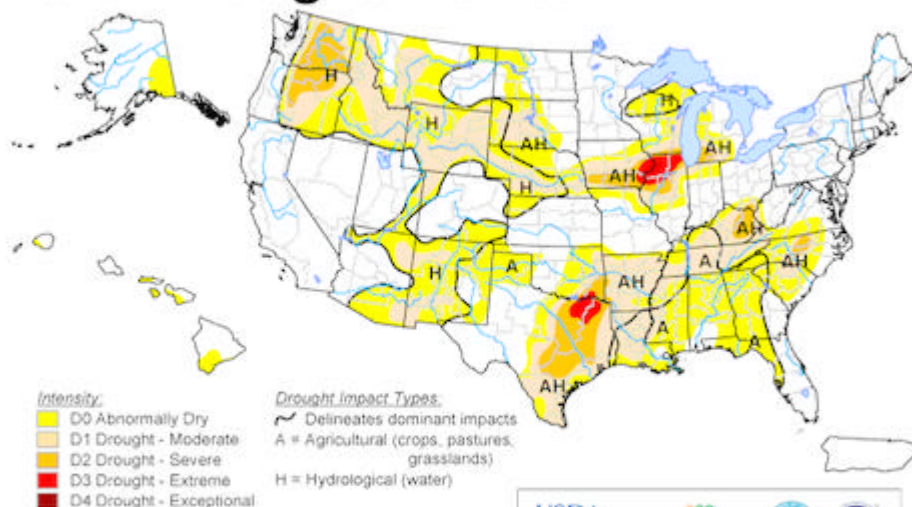
Released Thursday, November 10, 2005
Author: Mark Svoboda, NDMC

Total Column Soil Moisture Percentiles on 20051110
(wrt samples within a 11-day window in 1951-2004)



November 15, 2005 assessment

U.S. Drought Monitor November 15, 2005 Valid 8 a.m. EST



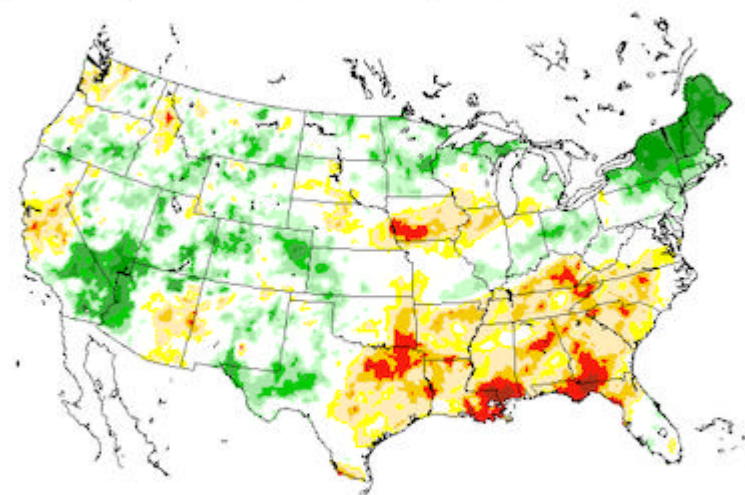
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



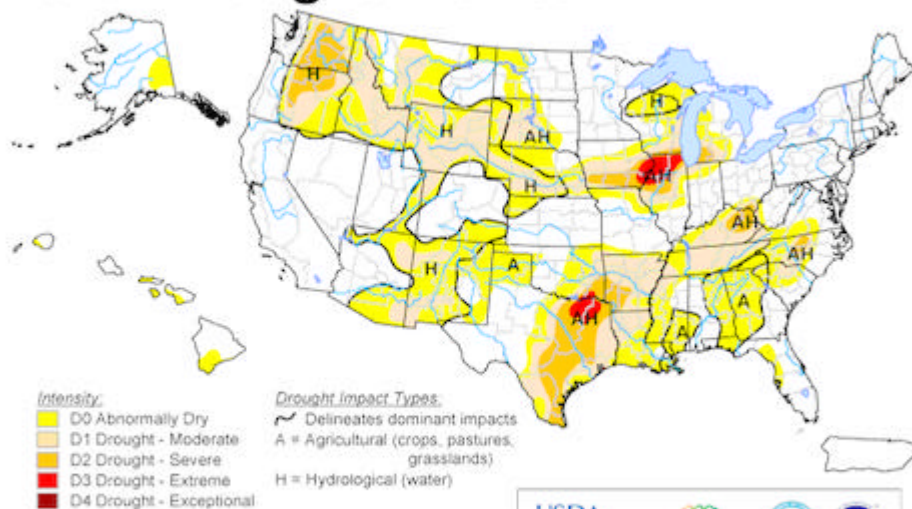
Released Thursday, November 17, 2005
Author: David Miskus, JAWF/CPC/NOAA

Total Column Soil Moisture Percentiles on 20051117
(wrt samples within a 11-day window in 1951-2004)



November 22, 2005 assessment

U.S. Drought Monitor November 22, 2005 Valid 7 a.m. EST



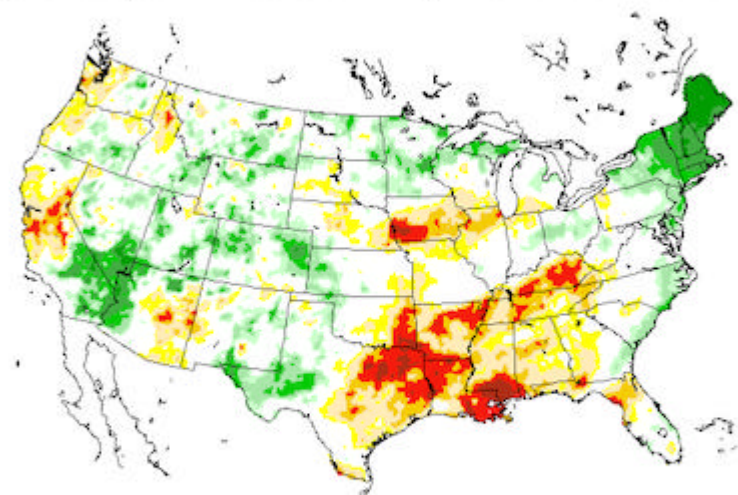
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<http://drought.unl.edu/dm>



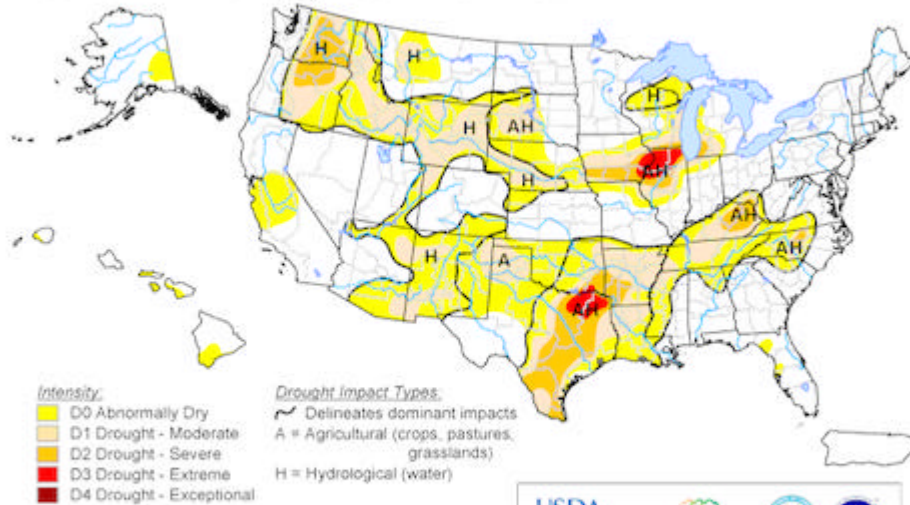
Released Wednesday, November 23, 2005
Author: Brad Rippey, U.S. Department of Agriculture

Total Column Soil Moisture Percentiles on 20051124
(wrt samples within a 11-day window in 1951-2004)



November 29, 2005 assessment

U.S. Drought Monitor November 29, 2005 Valid 8 a.m. EST



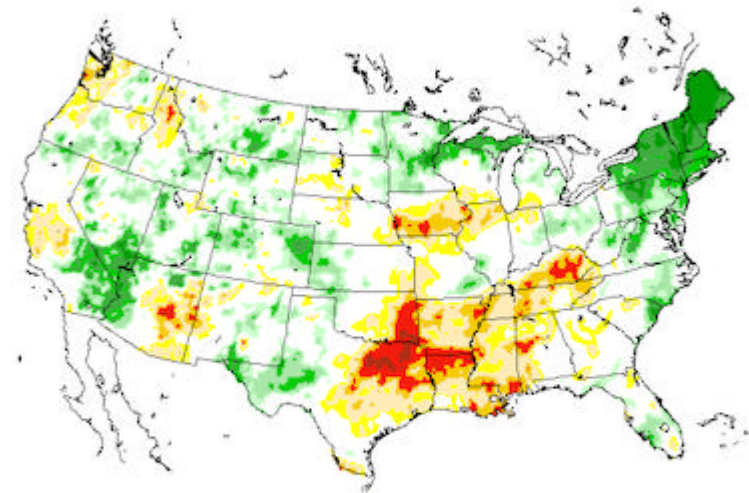
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



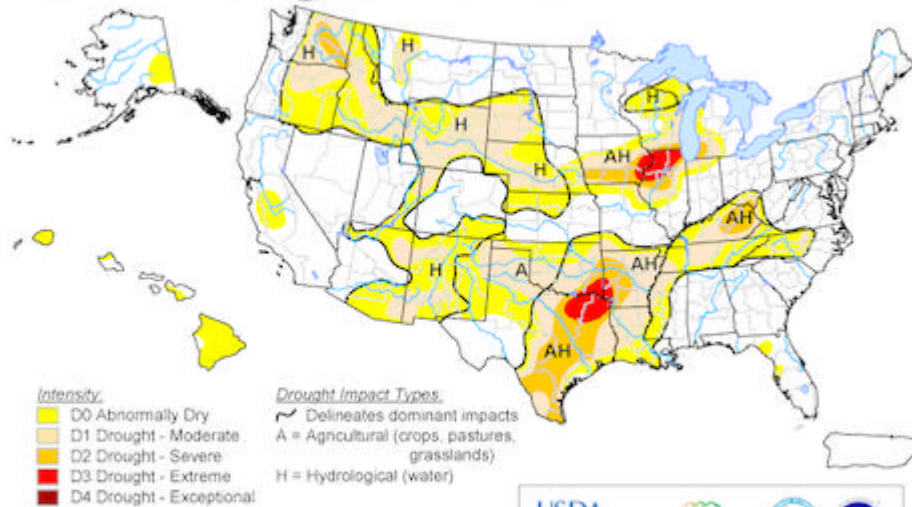
Released Thursday, December 1, 2005
Author: Brad Rippey, U.S. Department of Agriculture

Total Column Soil Moisture Percentiles on 20051201
(wrt samples within a 11-day window in 1951-2004)



December 6, 2005 assessment

U.S. Drought Monitor December 6, 2005 Valid 8 a.m. EST



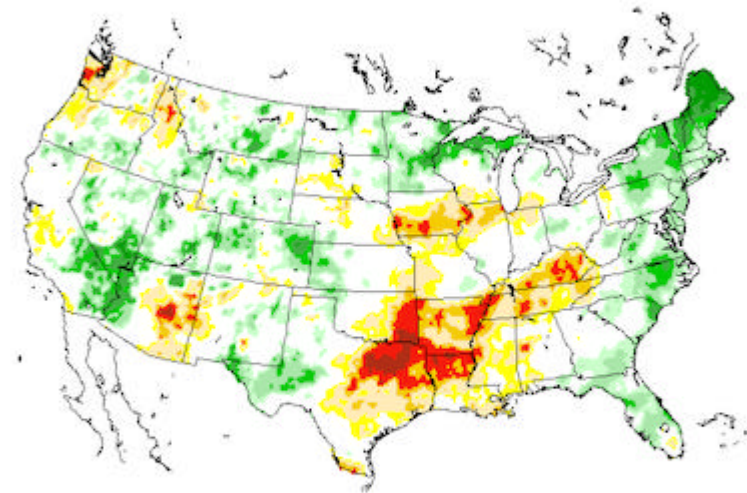
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



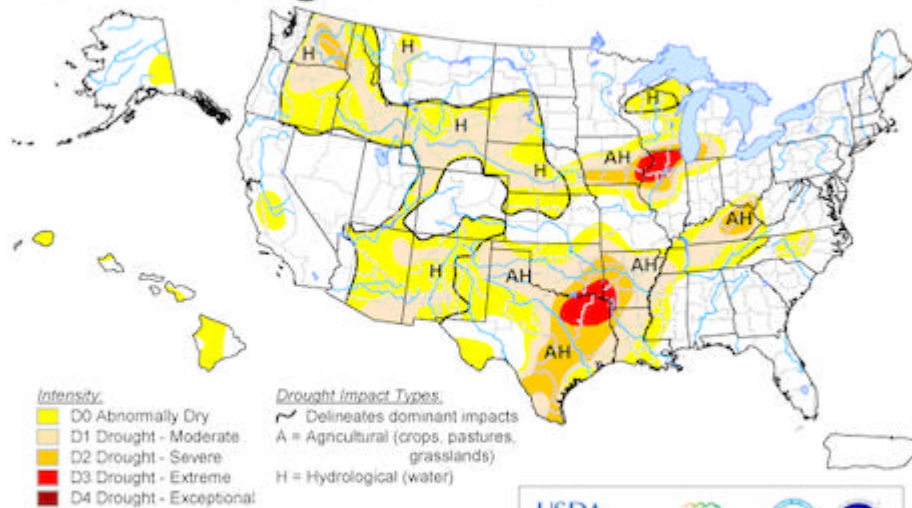
Released Thursday, December 8, 2005
Author: Mark Svoboda and Brian Fuchs, NDMC

Total Column Soil Moisture Percentiles on 20051208
(wrt samples within a 11-day window in 1951-2004)



December 13, 2005 assessment

U.S. Drought Monitor December 13, 2005 Valid 8 a.m. EST



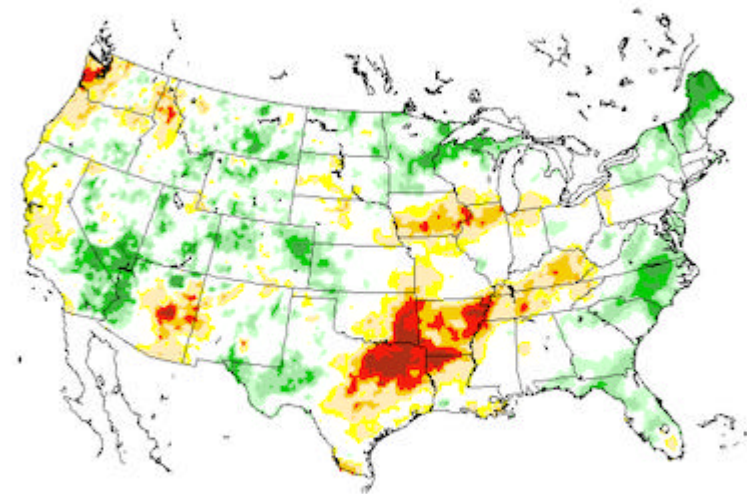
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



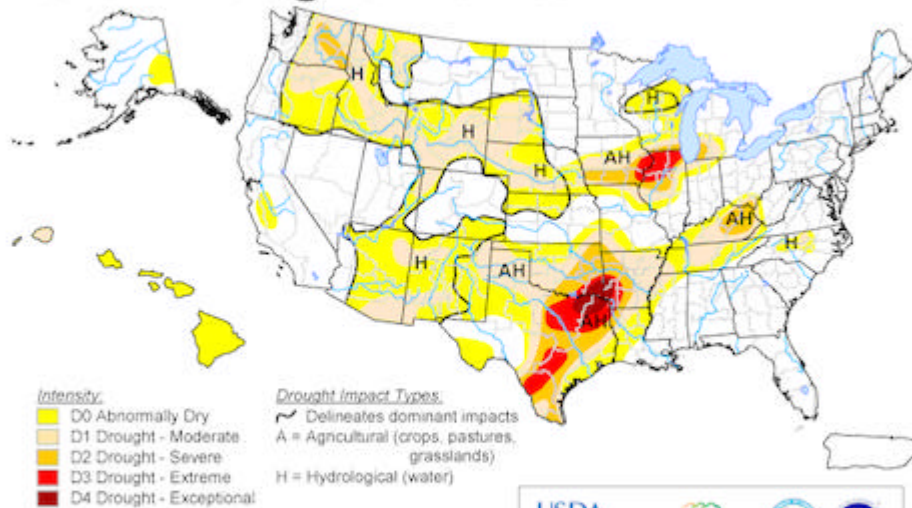
Released Thursday, December 15, 2005
Author: Michael Hayes and Brian Fuchs, NDMC

Total Column Soil Moisture Percentiles on 20051215
(wrt samples within a 11-day window in 1951-2004)



December 20, 2005 assessment

U.S. Drought Monitor December 20, 2005 Valid 7 a.m. EST



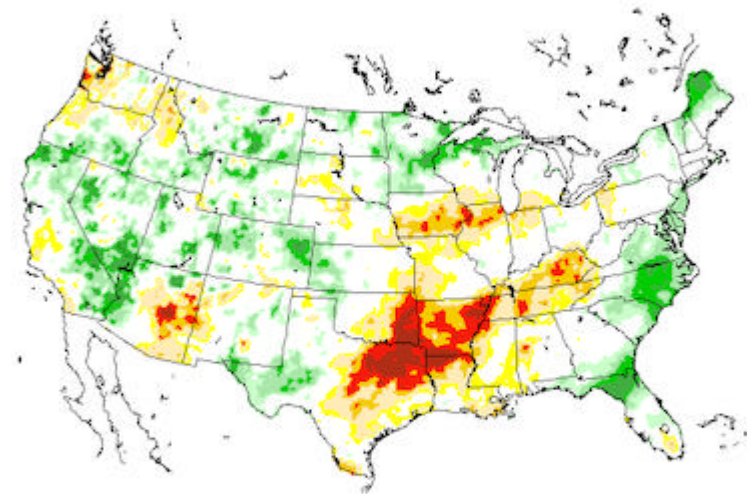
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



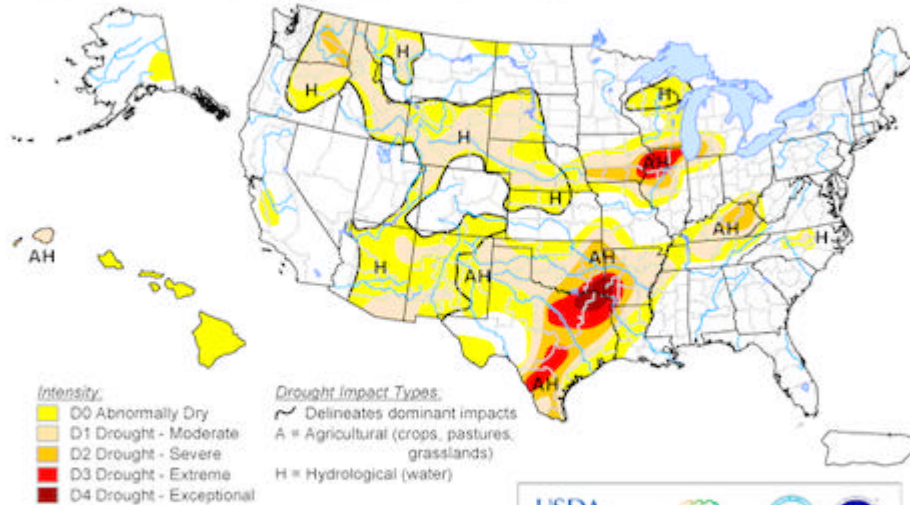
Released Thursday, December 22, 2005
Author: Michael Hayes and Brian Fuchs, NDMC

Total Column Soil Moisture Percentiles on 20051222
(wrt samples within a 11-day window in 1951-2004)



December 27, 2005 assessment

U.S. Drought Monitor December 27, 2005 Valid 7 a.m. EST



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)

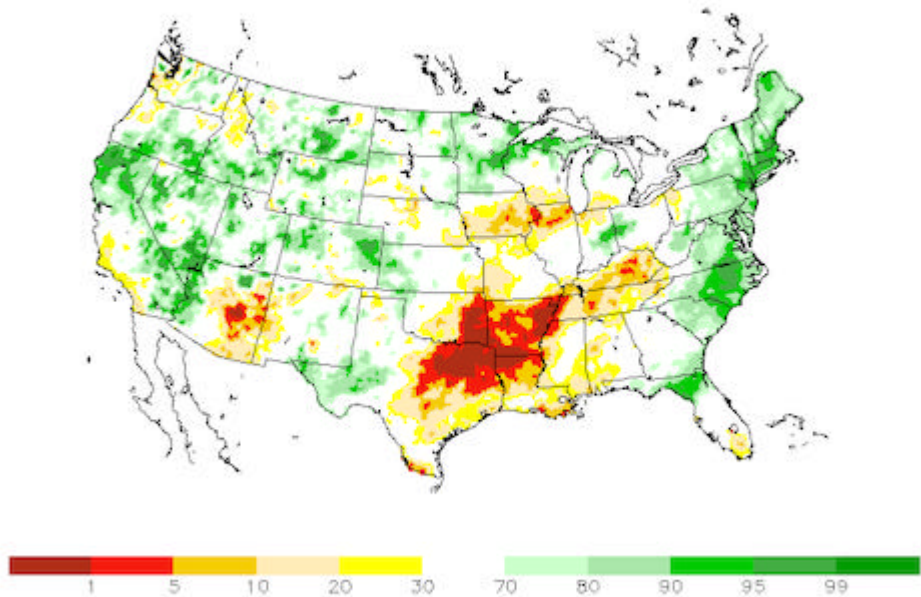
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



Released Thursday, December 29, 2005
 Author: Rich Tinker, CPC/NCEP/NWS/NOAA

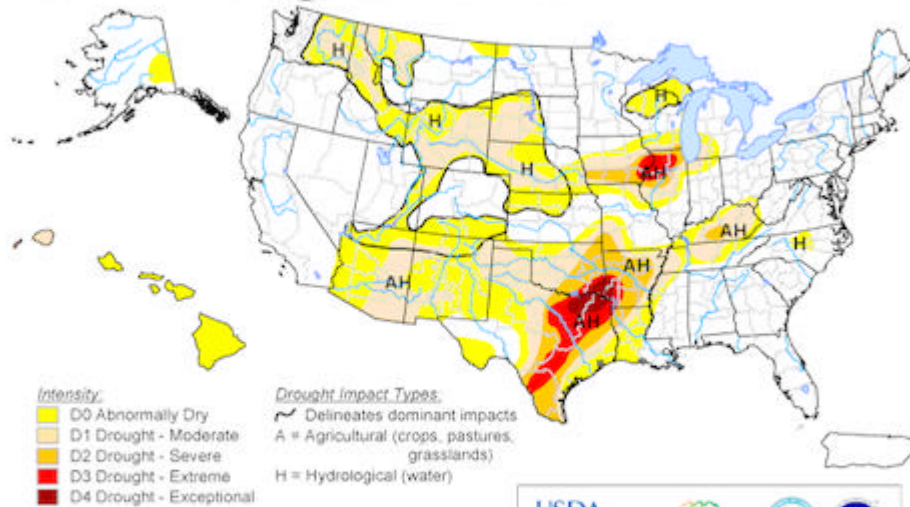
Total Column Soil Moisture Percentiles on 20051229
 (wrt samples within a 11-day window in 1951-2004)



January 3, 2006 assessment

U.S. Drought Monitor

January 3, 2006
Valid 7 a.m. EST



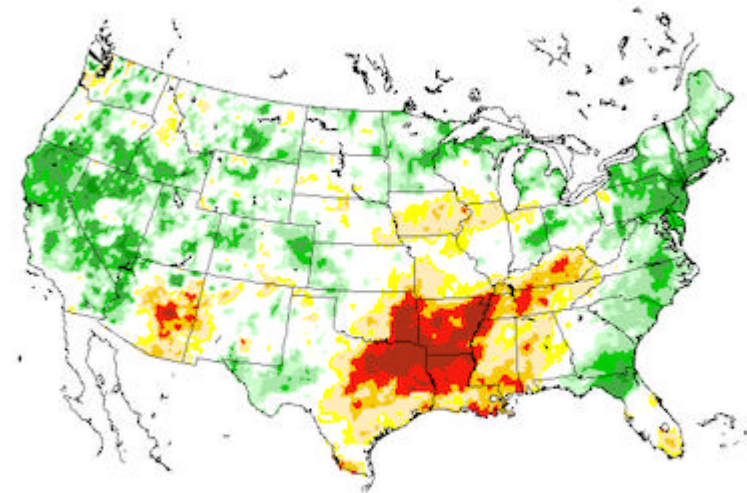
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



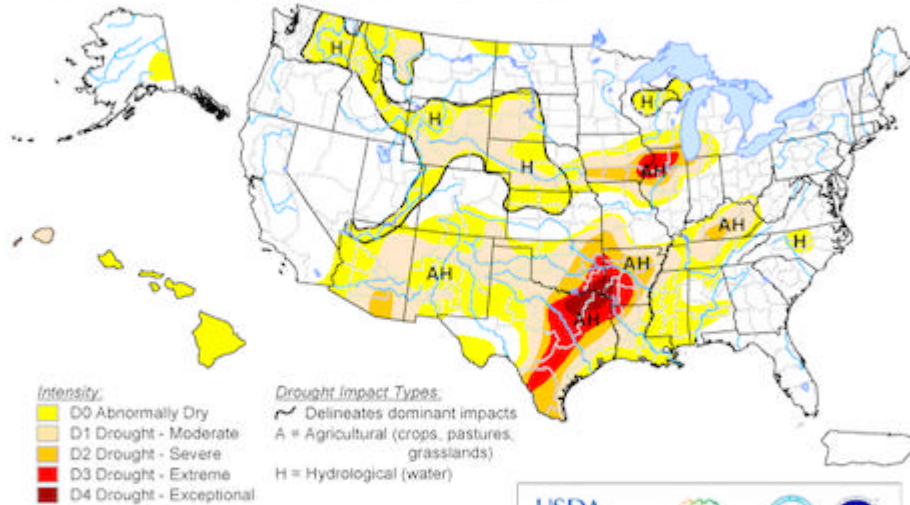
Released Thursday, January 5, 2006
Author: Douglas Le Comte, CPC/NOAA

Total Column Soil Moisture Percentiles on 20060105
(wrt samples within a 11-day window in 1951-2004)



January 10, 2006 assessment

U.S. Drought Monitor January 10, 2006 Valid 7 a.m. EST



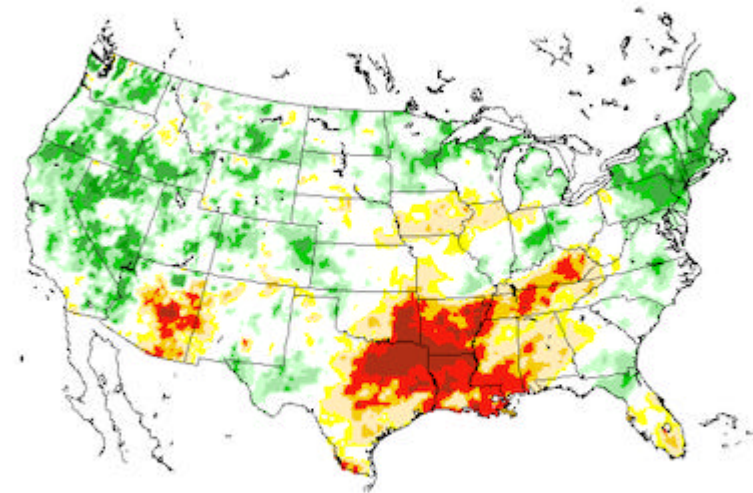
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



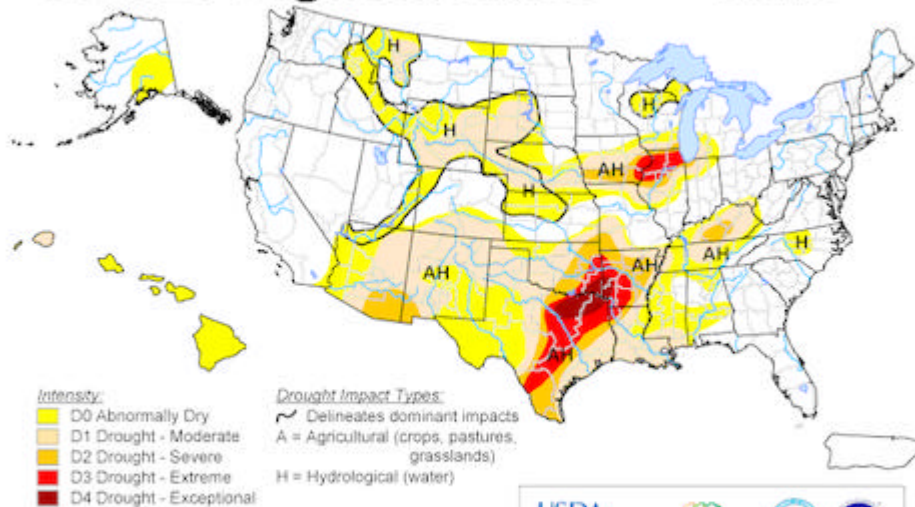
Released Thursday, January 12, 2006
Author: Douglas Le Comte, CPC/NOAA

Total Column Soil Moisture Percentiles on 20060112
(wrt samples within a 11-day window in 1951-2004)



January 17, 2006 assessment

U.S. Drought Monitor January 17, 2006 Valid 7 a.m. EST



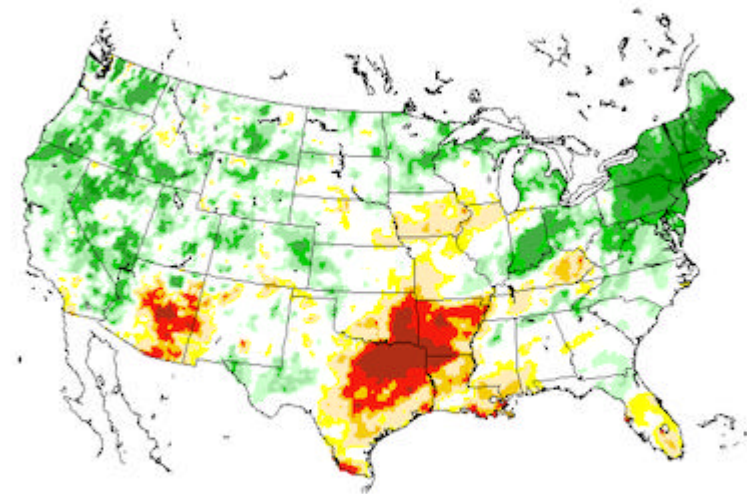
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



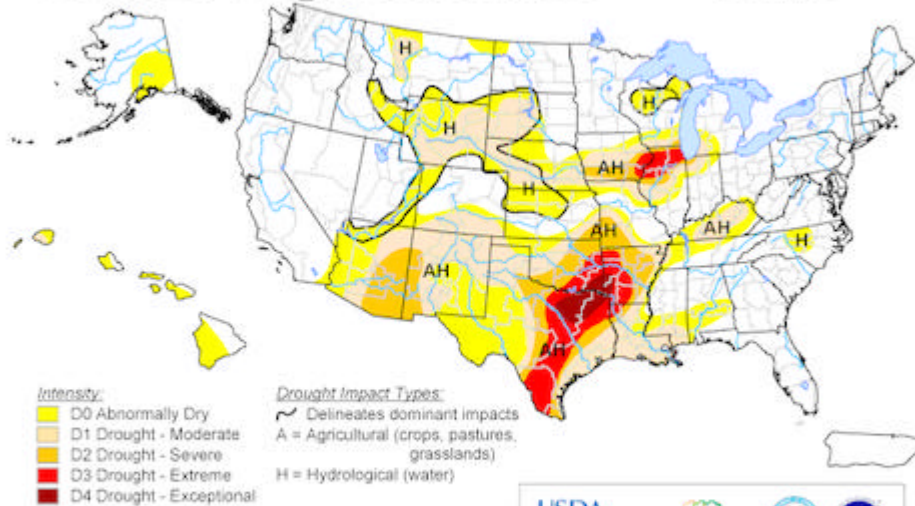
Released Thursday, January 19, 2006
Author: Mark Svoboda and Brian Fuchs, NDMC

Total Column Soil Moisture Percentiles on 20060119
(wrt samples within a 11-day window in 1951-2004)



January 24, 2006 assessment

U.S. Drought Monitor January 24, 2006 Valid 7 a.m. EST



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

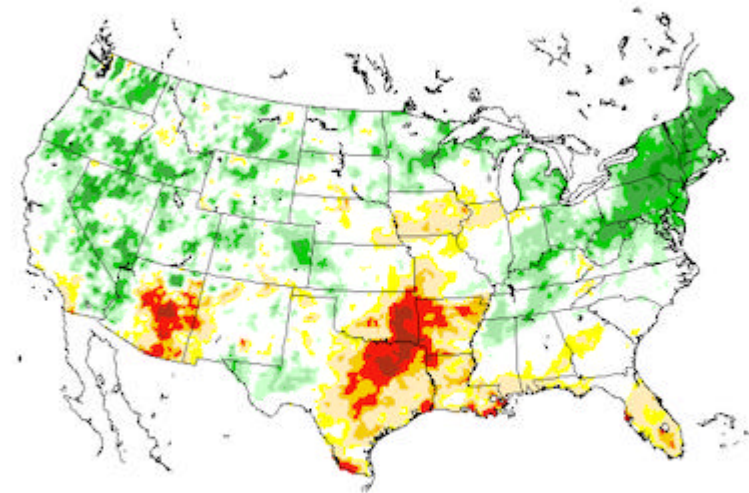
<http://drought.unl.edu/dm>



Released Thursday, January 26, 2006

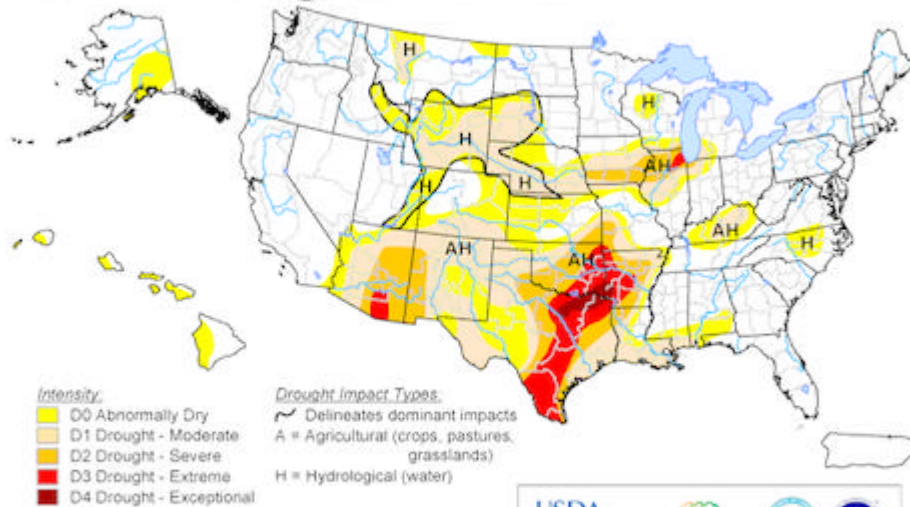
Author: Brian Fuchs, National Drought Mitigation Center

Total Column Soil Moisture Percentiles on 20060126 (wrt samples within a 11-day window in 1951-2004)



January 31, 2006 assessment

U.S. Drought Monitor January 31, 2006 Valid 7 a.m. EST



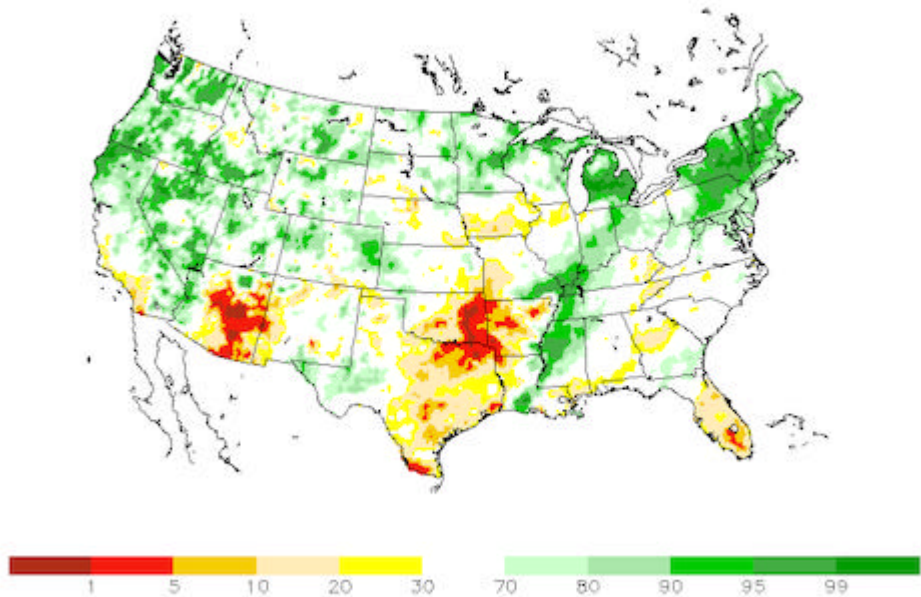
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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



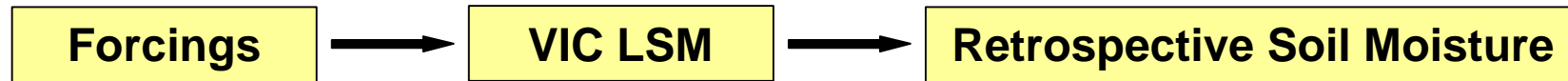
Released Thursday, February 2, 2006
Author: Rich Tinker, CPC/NCEP/NWS/NOAA

Total Column Soil Moisture Percentiles on 20060202
(wrt samples within a 11-day window in 1951-2004)



Development of the Drought Index

1) Retrospective Simulation



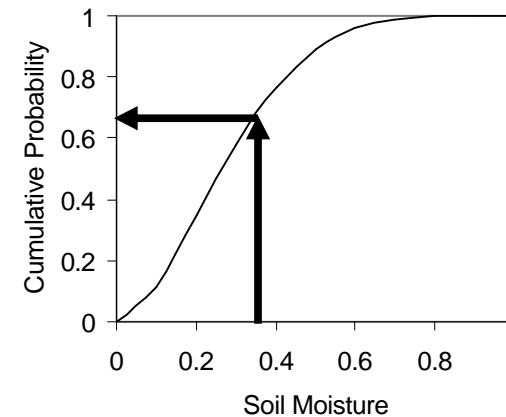
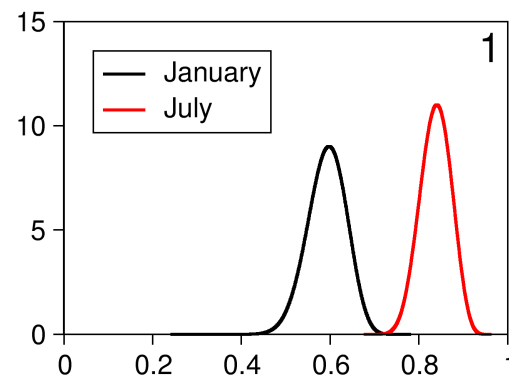
2) Calculate Soil Moisture Index



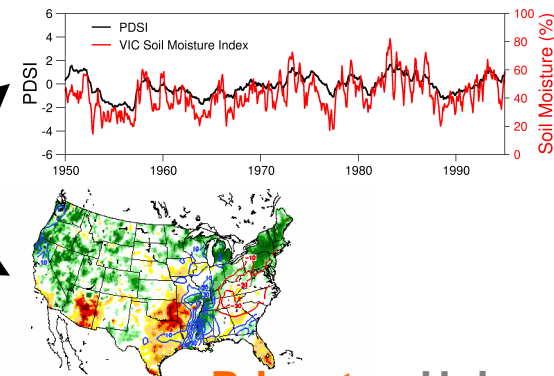
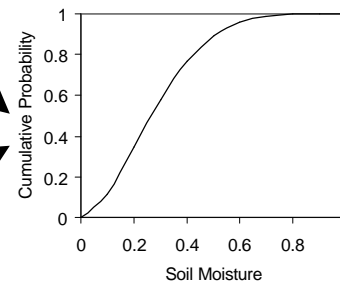
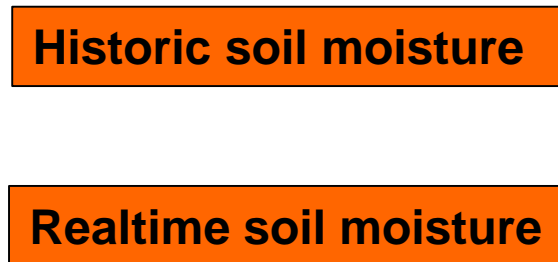
$$L_{mean}(\mathbf{m}_s) = I_1$$

$$L_{CV}(\mathbf{s}_s / \mathbf{m}_s) = \frac{I_2}{I_1}$$

$$L_{skew}(\mathbf{g}_s) = \frac{I_3}{I_2}$$



3) Drought Analysis

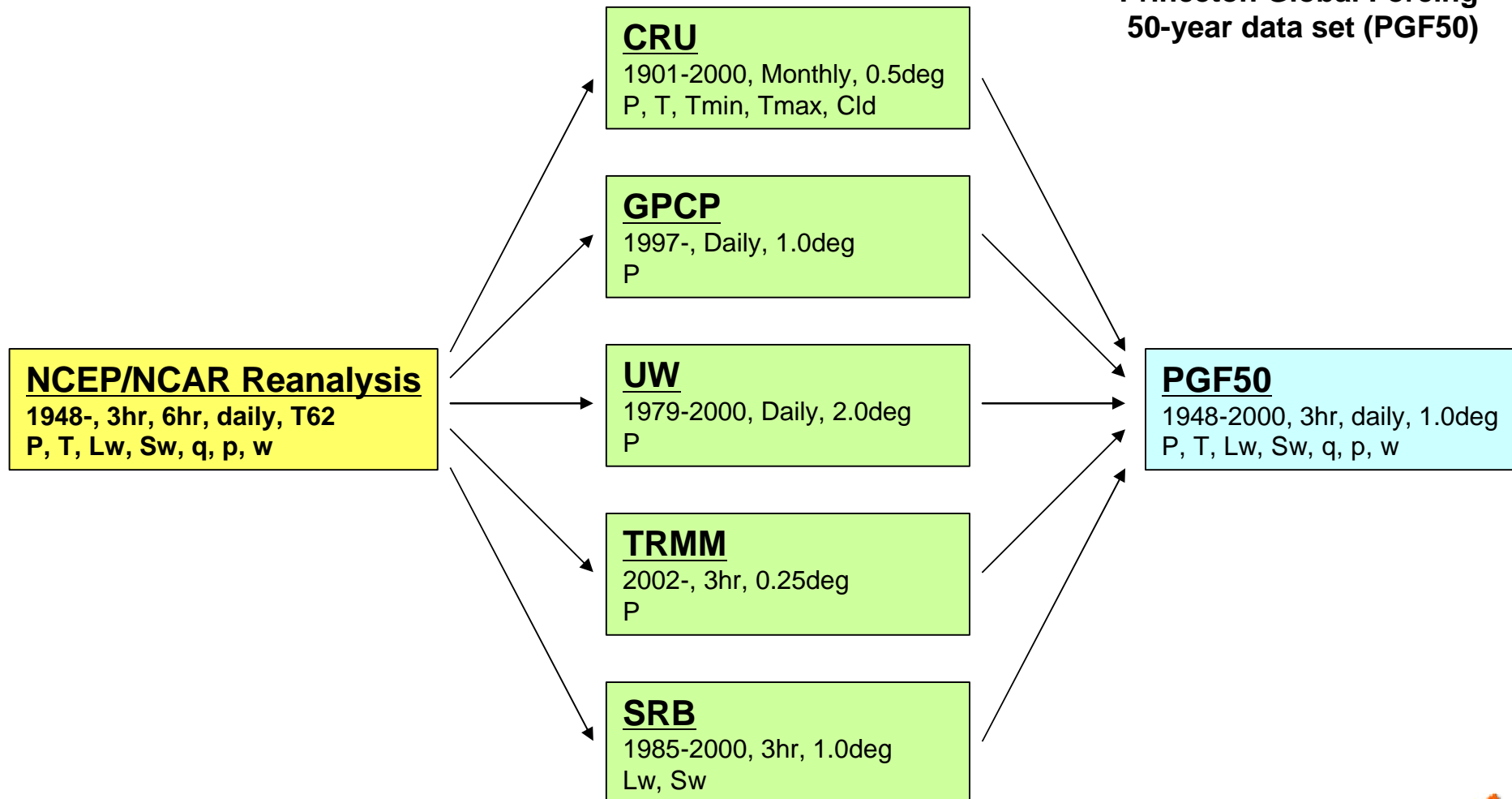


Global Forcing Dataset

Reanalysis
High temporal/low
spatial resolution

Observations
Generally low temporal/high
spatial resolution

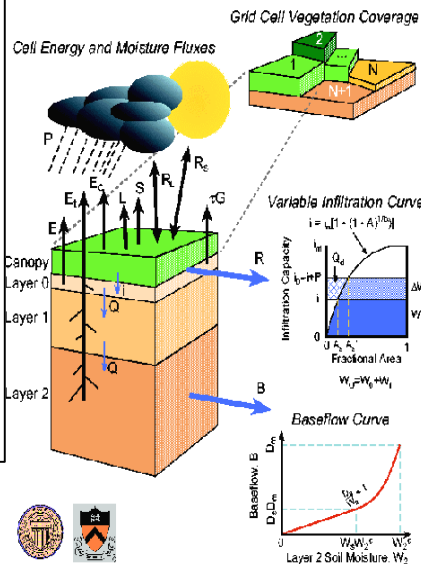
Bias-Corrected
High temporal/high
spatial resolution:
Princeton Global Forcing
50-year data set (PGF50)



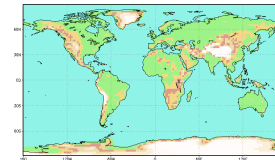
Global Retrospective Hydrology Simulations

VIC Land Surface Model

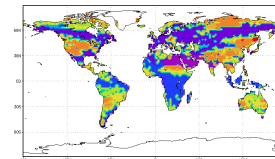
- Three soil moisture layers;
- Variable vegetation coverage;
- Infiltration and runoff are controlled using a variable infiltration capacity curve;
- Baseflow is controlled by a non-linear function for high moisture content.



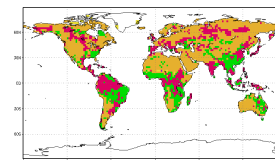
Input Parameters



Elevation

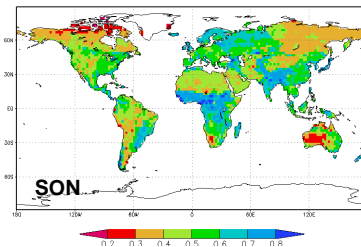
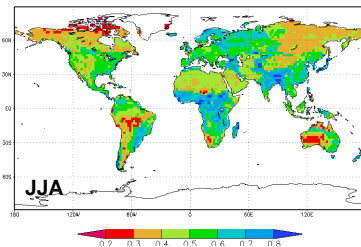
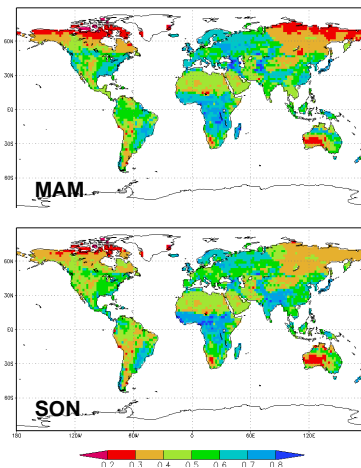
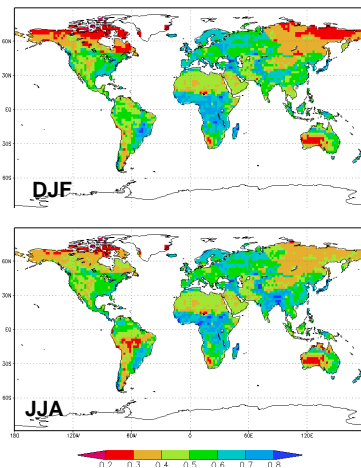


Dominant Vegetation

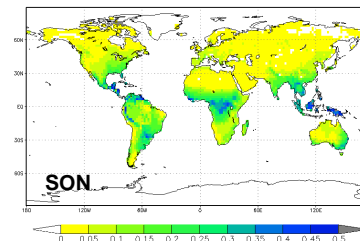
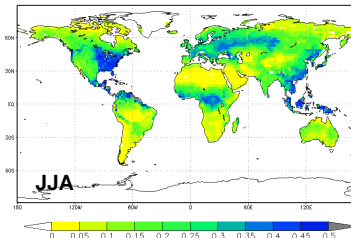
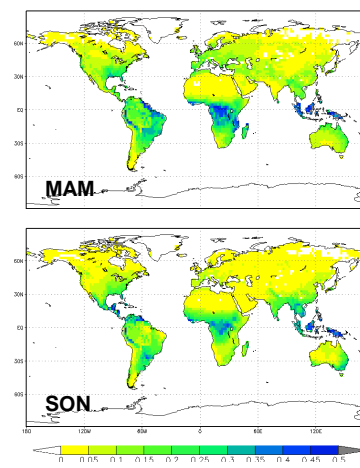
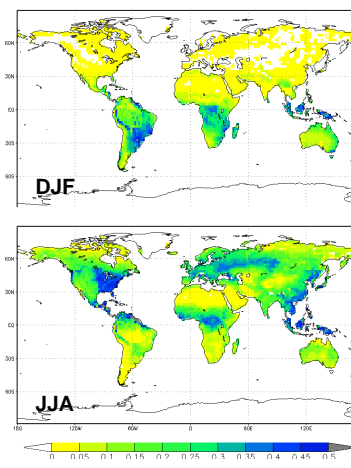


Soil porosity

Results



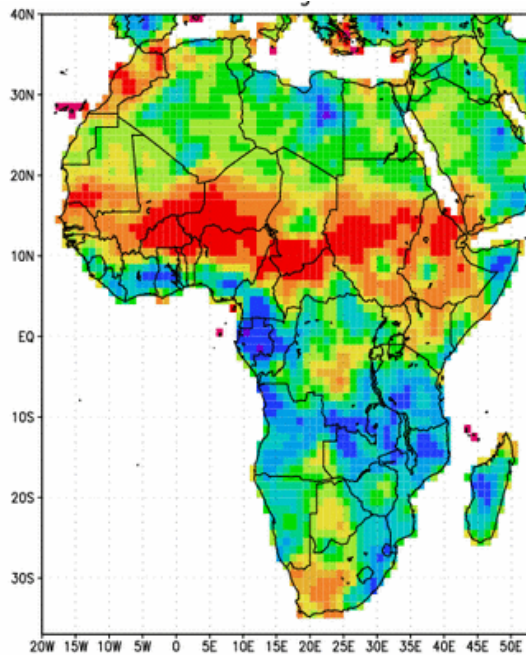
Mean seasonal relative saturation



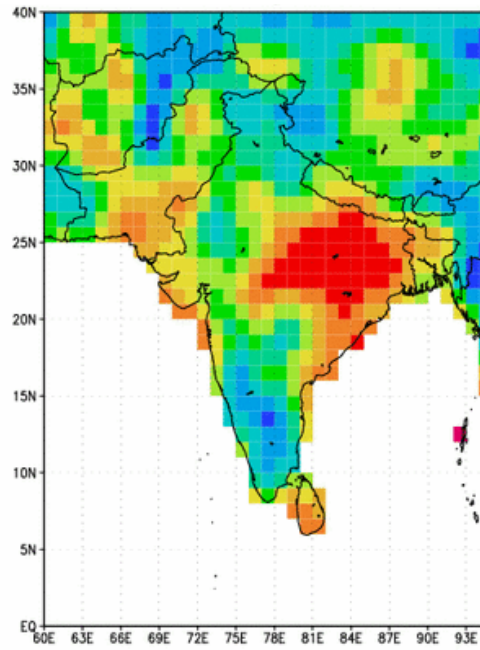
Mean seasonal evapotranspiration (mm)



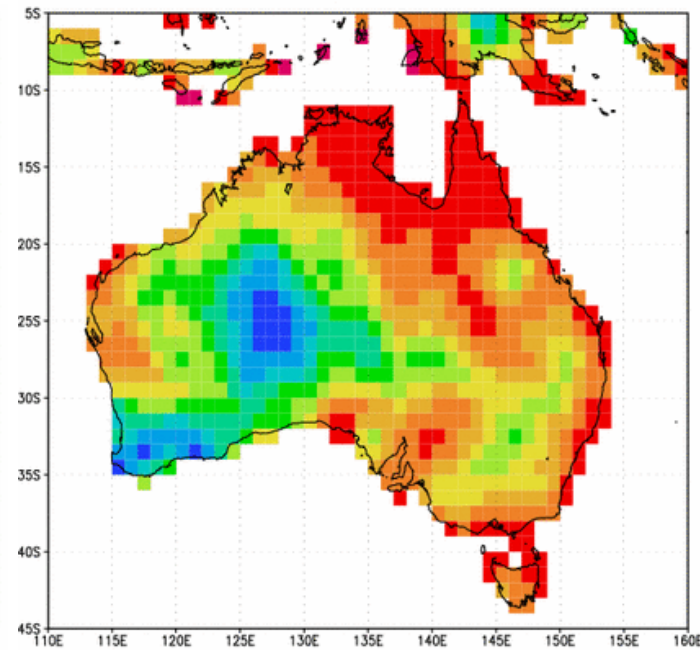
Historic Global Drought Events



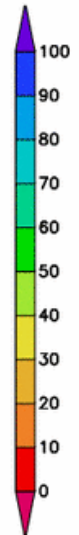
Africa, Aug. 1984



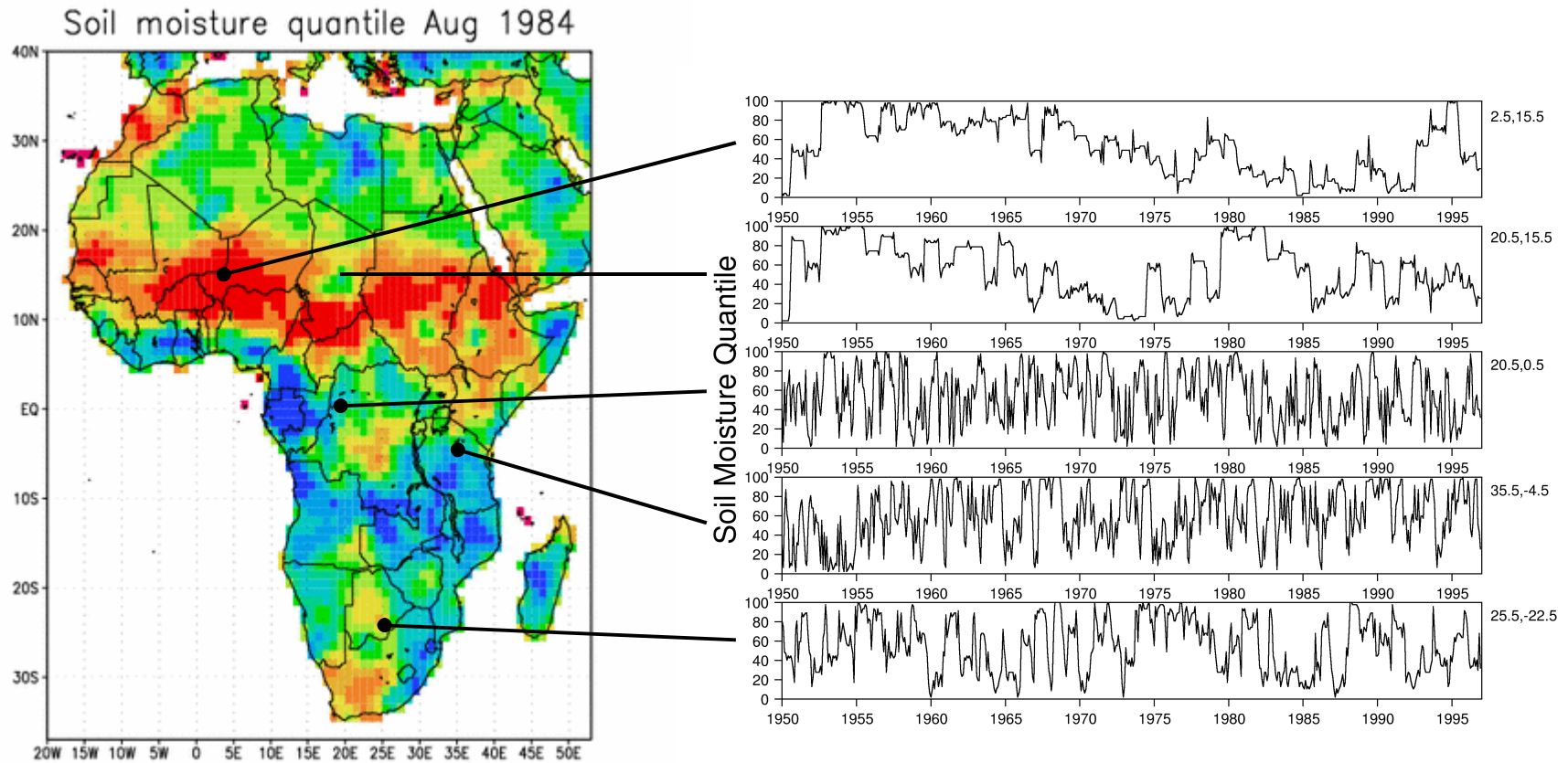
India, Sept 1966



Australia, Feb. 1983

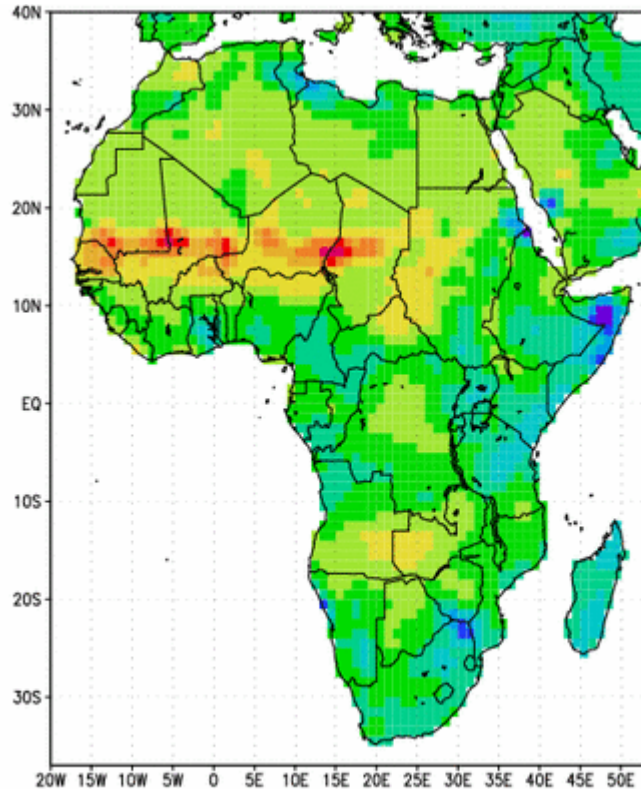


Focus on African Drought



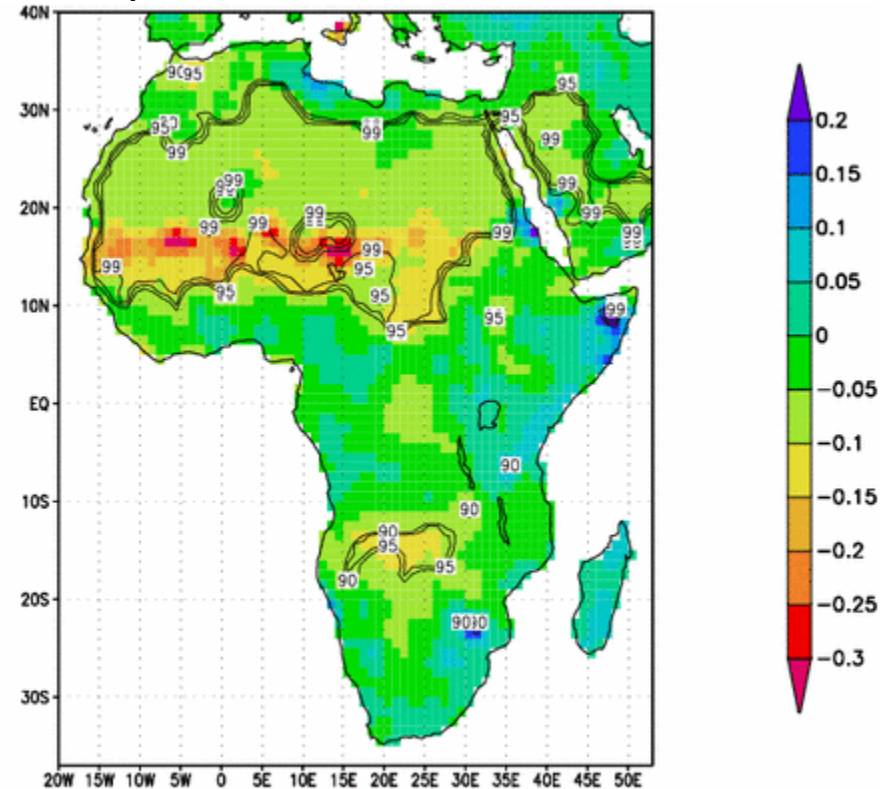
Soil Moisture Trends (% saturation/year) 1950 - 2000

Linear trend estimation



2006-02-1

Non-parametric trend estimation

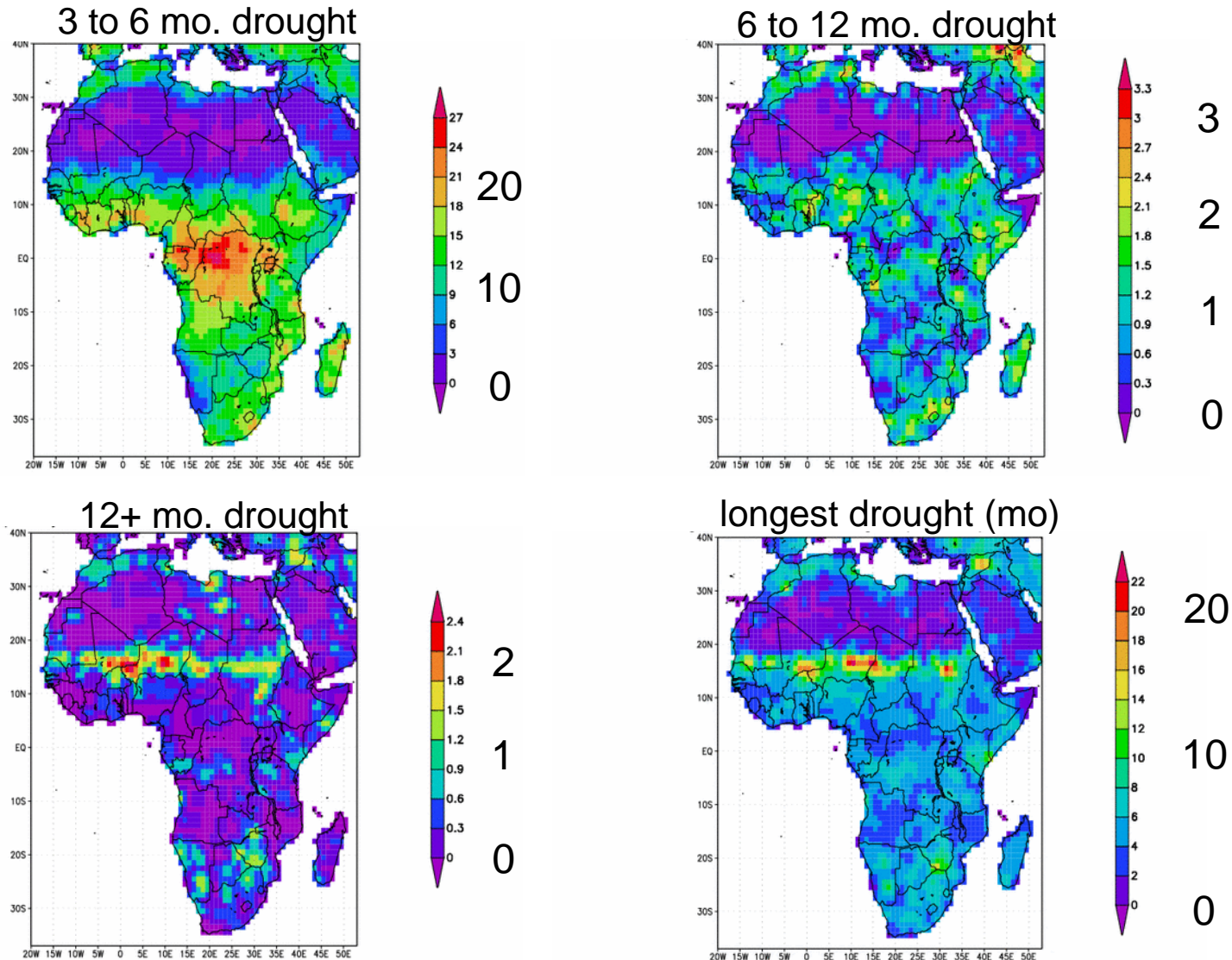


2006-02-1

The linear trend is calculated as the slope of the linear regression.

The Mann-Kendall non-parametric trend is plotted with contours of 90, 95 and 99% statistical confidence levels. The significant trends in the Sahara and the Middle East are a result of monotonically decreasing soil moisture in the absence of precipitation.

African Drought Frequency (1950 – 2000)

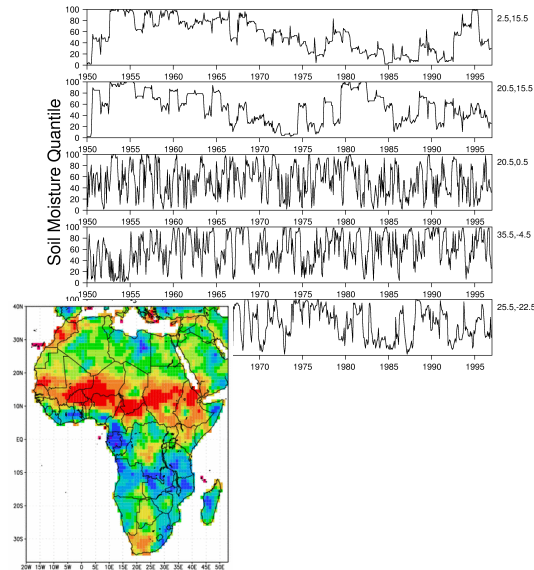
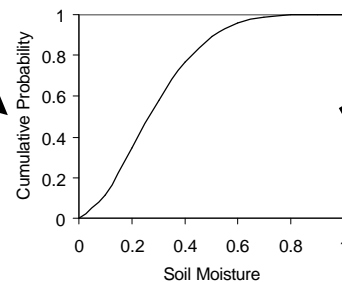


An N-month duration drought is defined as N consecutive months with total column soil moisture < 10th percentile. Data are taken from 1.0-deg daily VIC simulations driven by PGF50 near-surface meteorology data set.

Development of Global Real-Time Drought Monitoring

- 1) Retrospective Simulation -- **DONE**
- 2) Calculate Soil Moisture Index -- **DONE**
- 3) Historical Drought Analysis -- **DONE**

Historic soil moisture



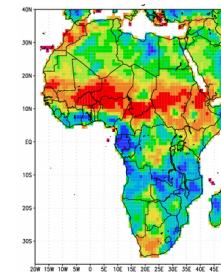
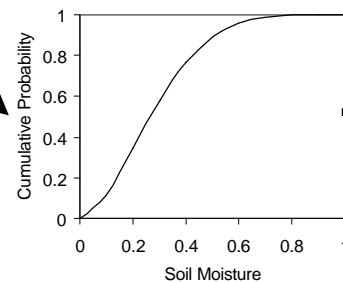
- 4) Real-time Drought Analysis -- **NEED REAL-TIME FORCINGS**

Realtime soil moisture

GTS observations

ECMWF analysis

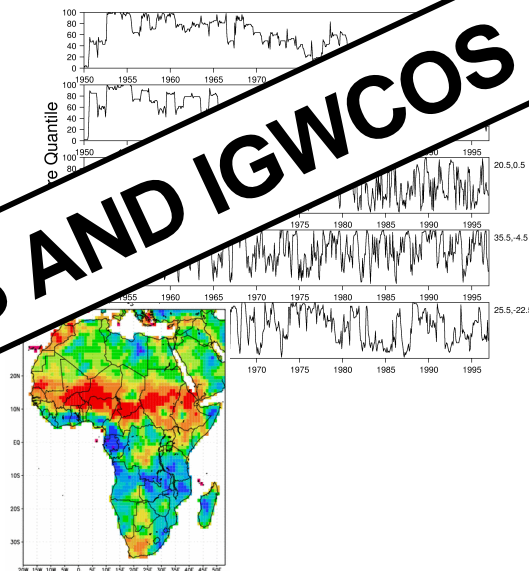
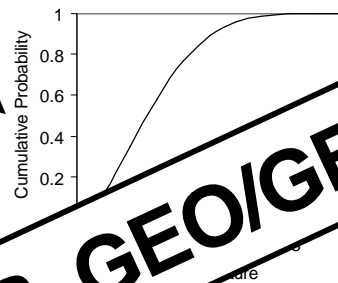
**Satellite observations
(NASA, ESA, JAXA)**



Development of Global Real-Time Drought Monitoring

- 1) Retrospective Simulation -- **DONE**
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Historic soil moisture



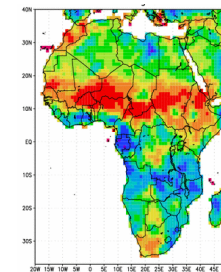
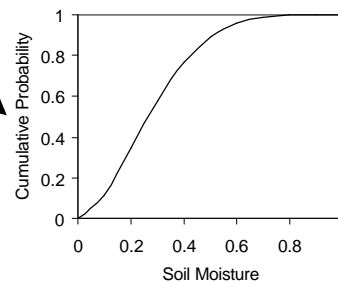
- 4) Real-time analysis -- **NEED REAL-TIME FORCINGS**

Real-time soil moisture

GTS observations

ECMWF analysis

Satellite observations
(NASA, ESA, JAXA)



CRITICAL TO CEOP, GEO/GEOSS AND IGWCOS

Thank you