

# **Applying the Standardized Precipitation Index as a Drought Indicator**

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**Mali Drought Monitoring Workshop, Bamako September 14-17, 2009**

# Characteristics of the Standardized Precipitation Index (SPI)

- Developed by McKee et al. in 1993
- Simple index--precipitation is the only parameter (probability of observed precipitation transformed into an index)
- Being used in research or operational mode in over 60 countries
- Multiple time scales allow for temporal flexibility in evaluation of precipitation conditions and water supply

# How it Works

- It is **NOT** simply the “difference of precipitation from the mean... divided by the standard deviation”
- Precipitation is **normalized** using a **probability distribution** so that values of SPI are actually seen as standard deviations from the median
- Normalized distribution allows for estimating both **dry and wet** periods
- Accumulated values can be used to analyze **drought severity (magnitude)**

# How it Works

- Need **30 years** of continuous monthly precipitation data (the longer the better)
- SPI time scale intervals longer than 24 months may be unreliable
- Is **spatially invariant** in its interpretation
- **Probability based** (probability of observed precipitation transformed into an index) nature is well suited to **risk management**

# SPI Methodology

- **Overview:** The SPI is an index based on the probability of precipitation for any time scale.
- **Who uses it:** Many drought planners appreciate the SPI's versatility.
- **Pros:** The SPI can be computed for different time scales
  - can provide early warning of drought and help assess drought severity
  - less complex than the Palmer.
  - One number/has historical context
- **Cons:** Based on Precipitation only
  - no Temp, no ET
  - Values based on preliminary data may change.

# SPI Methodology

- 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
- Soil moisture conditions respond to precipitation anomalies on a relatively short scale. Groundwater, streamflow, and reservoir storage reflect the longer-term precipitation anomalies
- For these reasons, McKee et al. (1993) originally calculated the SPI for 3-, 6-, 12-, 24-, and 48-month time scales.

# SPI Methodology

- The SPI calculation for any location is based on the long-term precipitation record for a desired period. 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)
- Positive SPI values indicate greater than median precipitation, and negative values indicate less than median precipitation
- 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.

# NDMC SPI Products

- Updated daily for several time frames using near real time data from the ACIS data stream from the Regional Climate Centers
- SPI map is generated by using Grid Analysis and Display System (GrADS). The discrete station SPI data are interpolated using a Cressman objective analysis. The grid resolution is 0.4 degrees
- Monthly SPI archive by climate division first of its kind and now back to 1900

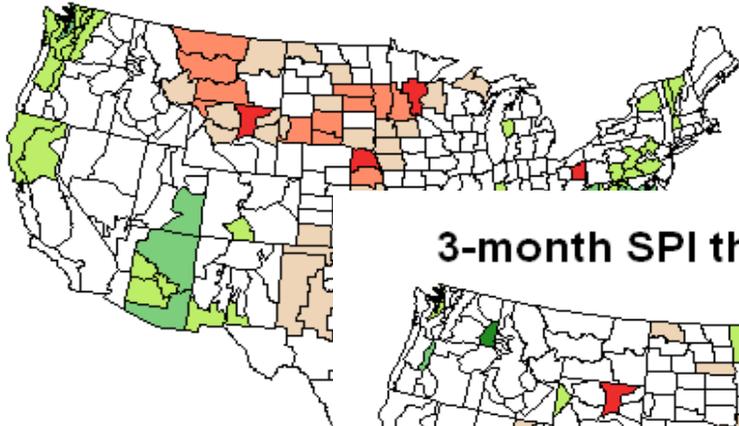
# SPI data used in the U.S. Drought Monitor

- **D0 Abnormally Dry:** SPI value of -0.5 to -0.7
  - **D1 Moderate Drought:** -0.8 to -1.2
  - **D2 Severe Drought:** -1.3 to -1.5
  - **D3 Extreme Drought:** -1.6 to -1.9
  - **D4 Exceptional Drought:** -2.0 or less
- 
- **NDMC Daily Gridded SPI Product**

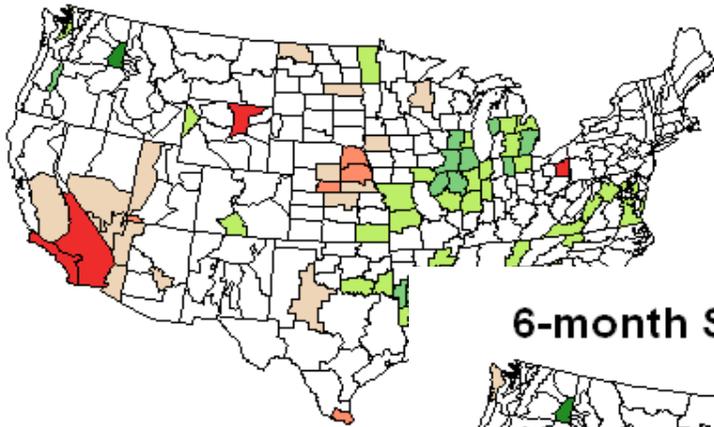
# Probability of Recurrence

<b>SPI</b>	<b>Category</b>	<b># of times in 100 yrs.</b>	<b>Severity of event</b>
<b>0 to -0.99</b>	<b>Mild dryness</b>	<b>33</b>	<b>1 in 3 yrs.</b>
<b>-1.00 to -1.49</b>	<b>Moderate dryness</b>	<b>10</b>	<b>1 in 10 yrs.</b>
<b>-1.5 to -1.99</b>	<b>Severe dryness</b>	<b>5</b>	<b>1 in 20 yrs.</b>
<b>&lt; -2.0</b>	<b>Extreme dryness</b>	<b>2.5</b>	<b>1 in 50 yrs.</b>

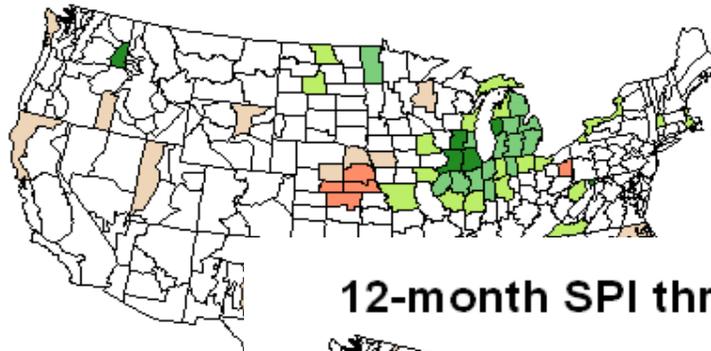
# 1-month SPI through the end of May 2009



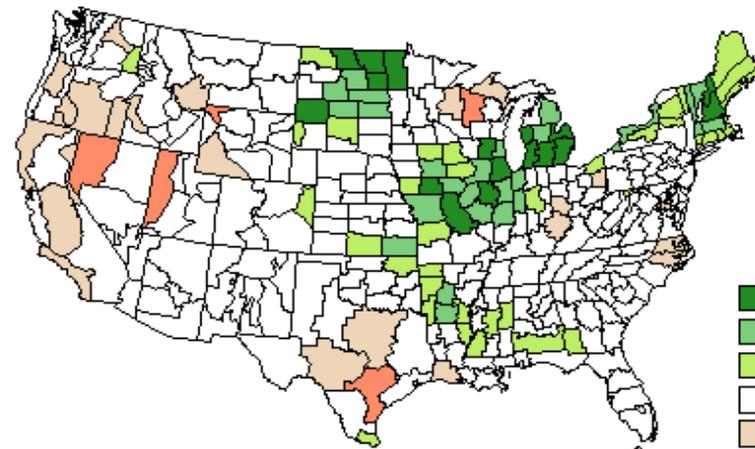
# 3-month SPI through the end of May 2009



# 6-month SPI through the end of May 2009

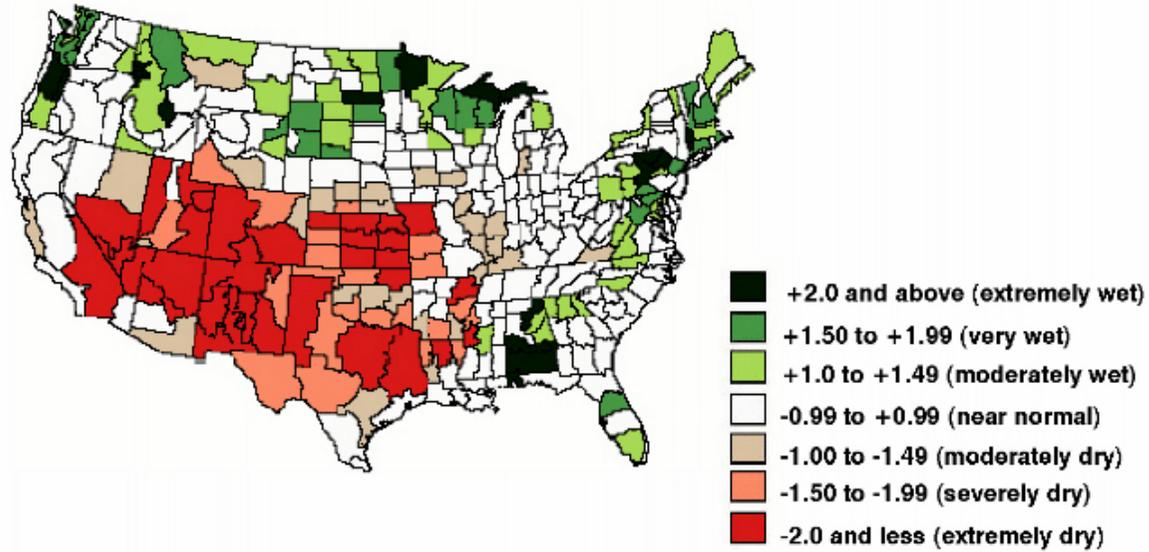


# 12-month SPI through the end of May 2009



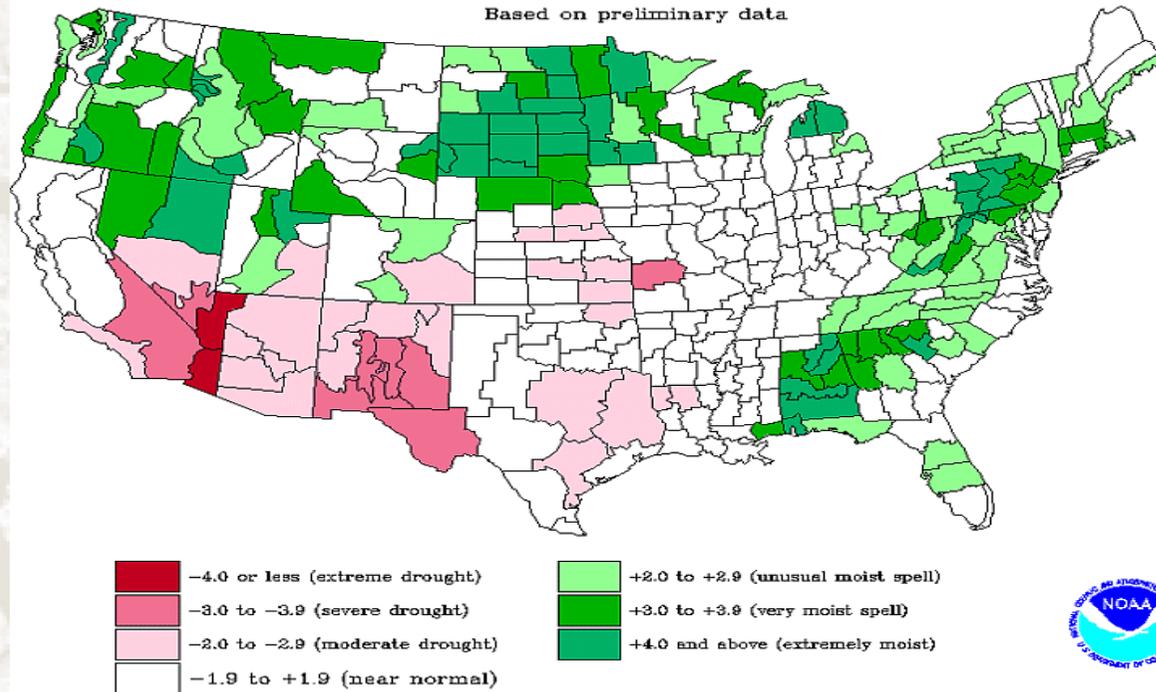
- +2.0 and above (Extremely Wet)
- +1.50 to +1.99 (Very Wet)
- +1.0 to +1.49 (Moderately Wet)
- 0.99 to +0.99 (Near Normal)
- 1.00 to -1.49 (Moderately Dry)
- 1.50 to -1.99 (Very Dry)
- 2.0 and below (Extremely Dry)

# 6-month SPI through the end of March 1996



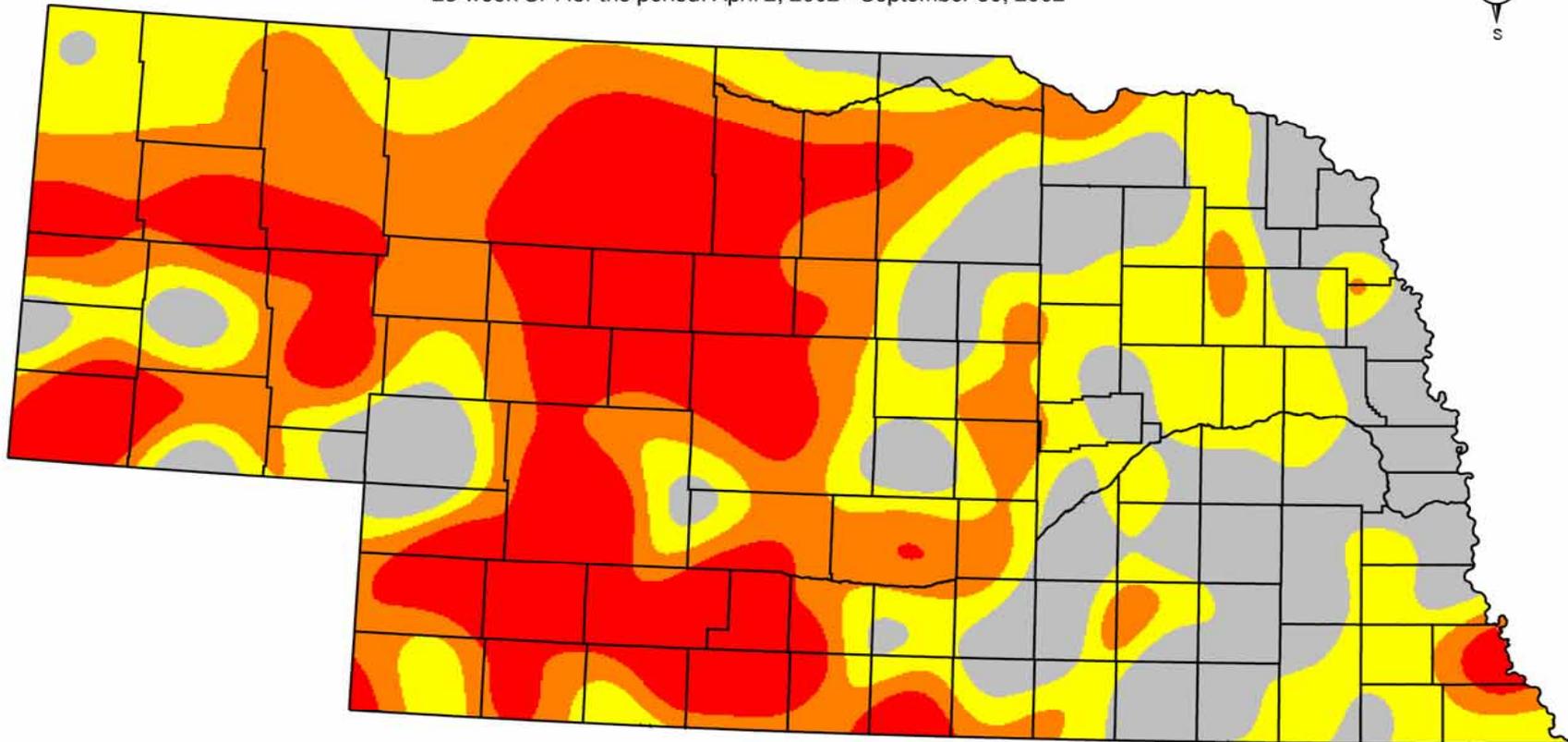
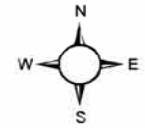
## DROUGHT SEVERITY INDEX BY DIVISION (LONG TERM PALMER)

MAR 30, 1996  
Based on preliminary data



# Standardized Precipitation Index Map for Nebraska

26-week SPI for the period: April 2, 2002 - September 30, 2002



### LEGEND

The SPI can be computed for different time scales, which can provide early warning of drought and also help assess drought severity.

-  +2.00 and above (Extremely Wet)
-  +1.50 to +1.99 (Very Wet)
-  +1.00 to +1.49 (Moderately Wet)
-  -0.99 to +0.99 (Near Normal)
-  -1.00 to -1.49 (Moderately Dry)
-  -1.50 to -1.99 (Severely Dry)
-  -2.00 and less (Extremely Dry)
-  County Boundary

0 50 100 miles

0 50 100 kilometers

Scale 1:3000000

### SOURCES:

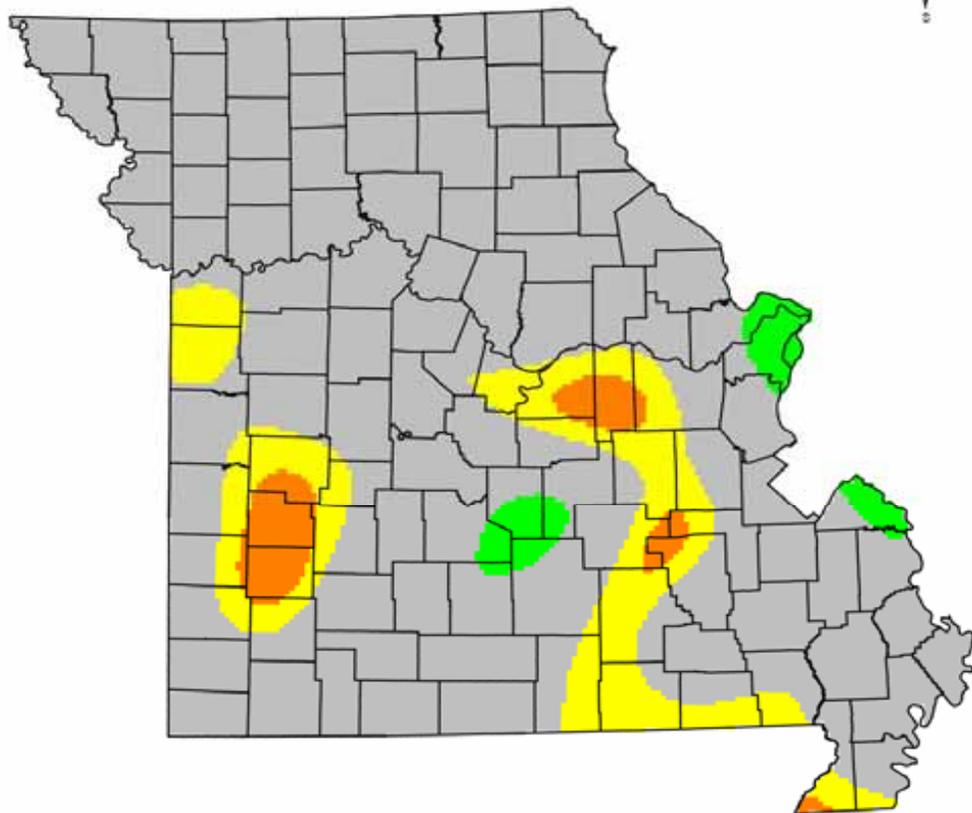
National Drought Mitigation Center (UNL)  
High Plains Regional Climate Center (UNL)  
McKee et al., Colorado State University, 1993; 1995  
Spline interpolation with 198 weather station sites

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National Agricultural Decision Support System  
Supported in part by NSF(EIA-0091539) and  
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### Standardized Precipitation Index Map for Missouri

4-week SPI for the period: May 21, 2003 - June 17, 2003



**LEGEND**

The SPI can be computed for different time scales, which can provide early warning of drought and also help assess drought severity.

- +2.00 and above (Extremely Wet)
- +1.50 to +1.99 (Very Wet)
- +1.00 to +1.49 (Moderately Wet)
- -0.99 to +0.99 (Near Normal)
- -1.00 to -1.49 (Moderately Dry)
- -1.50 to -1.99 (Severely Dry)
- -2.00 and less (Extremely Dry)

— County Boundary



Scale 1:3128050

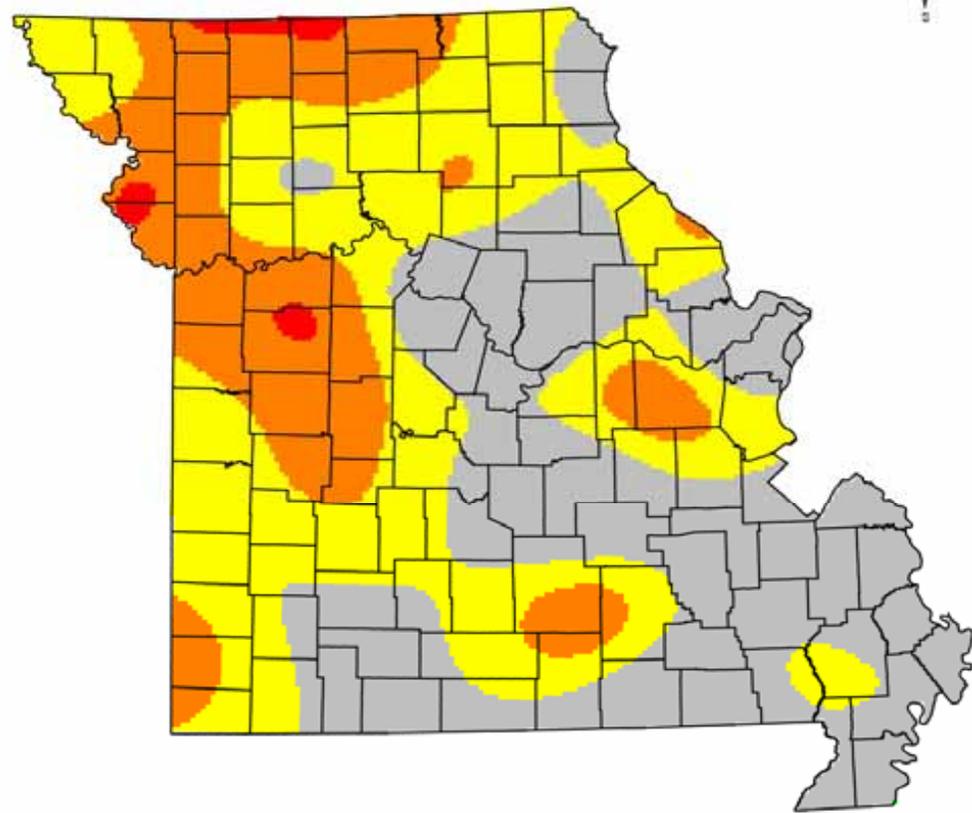
**SOURCES:**

National Drought Mitigation Center (UNL)  
 High Plains Regional Climate Center (UNL)  
 McKee et al., Colorado State University, 1993; 1995  
 Spline interpolation with 72 weather station sites

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### Standardized Precipitation Index Map for Missouri

52-week SPI for the period: June 18, 2002 - June 17, 2003



**LEGEND**

The SPI can be computed for different time scales, which can provide early warning of drought and also help assess drought severity.

- +2.00 and above (Extremely Wet)
- +1.50 to +1.99 (Very Wet)
- +1.00 to +1.49 (Moderately Wet)
- -0.99 to +0.99 (Near Normal)
- -1.00 to -1.49 (Moderately Dry)
- -1.50 to -1.99 (Severely Dry)
- -2.00 and less (Extremely Dry)

— County Boundary



Scale 1:3128050

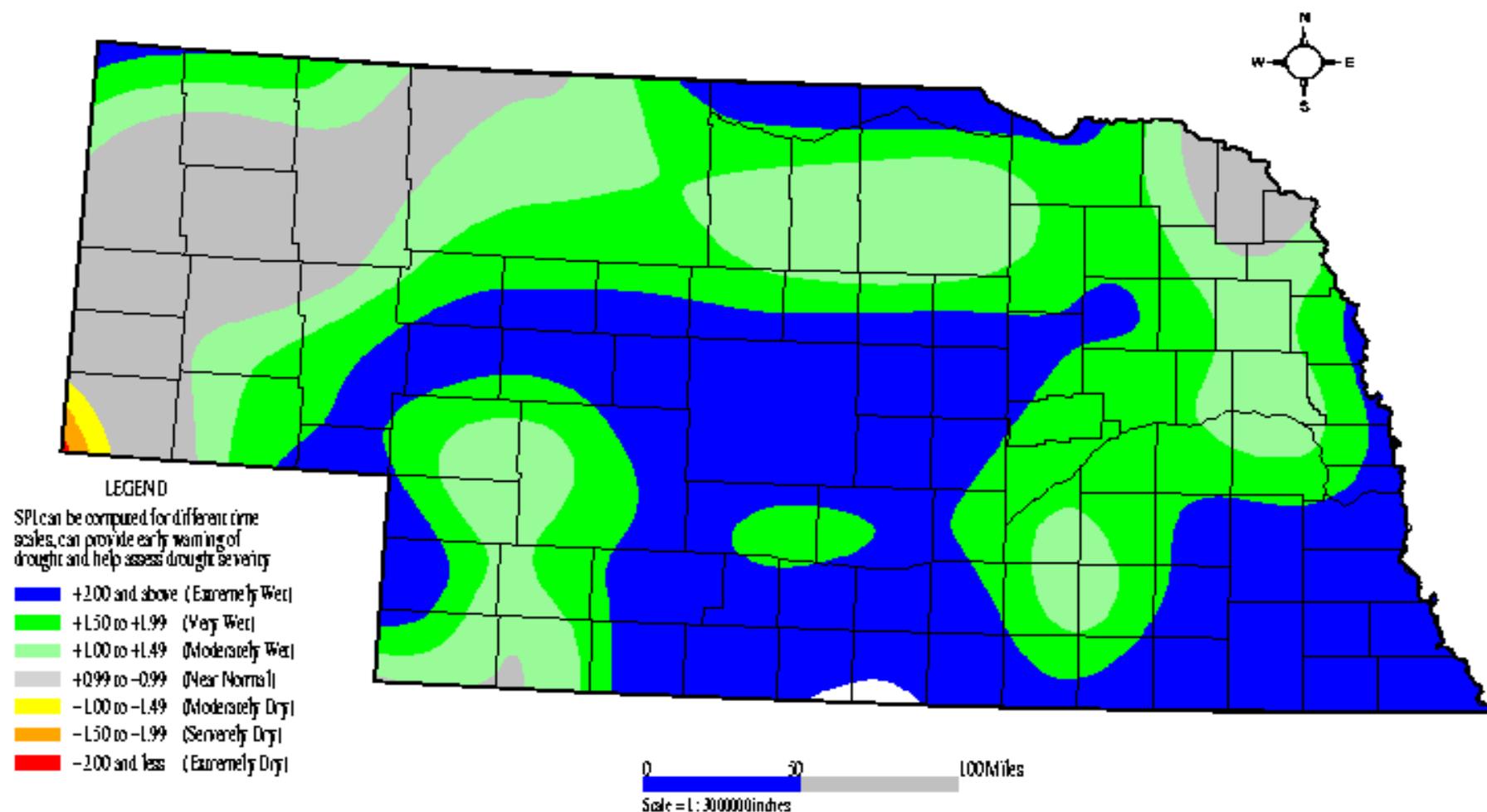
**SOURCES:**

National Drought Mitigation Center (UNL)  
 High Plains Regional Climate Center (UNL)  
 McKee et al., Colorado State University, 1993; 1995  
 Spline interpolation with 72 weather station sites

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# Standardized Precipitation Index Map for Nebraska

12-week SPI for the period: Jun 4, 1993 – Aug 26, 1993

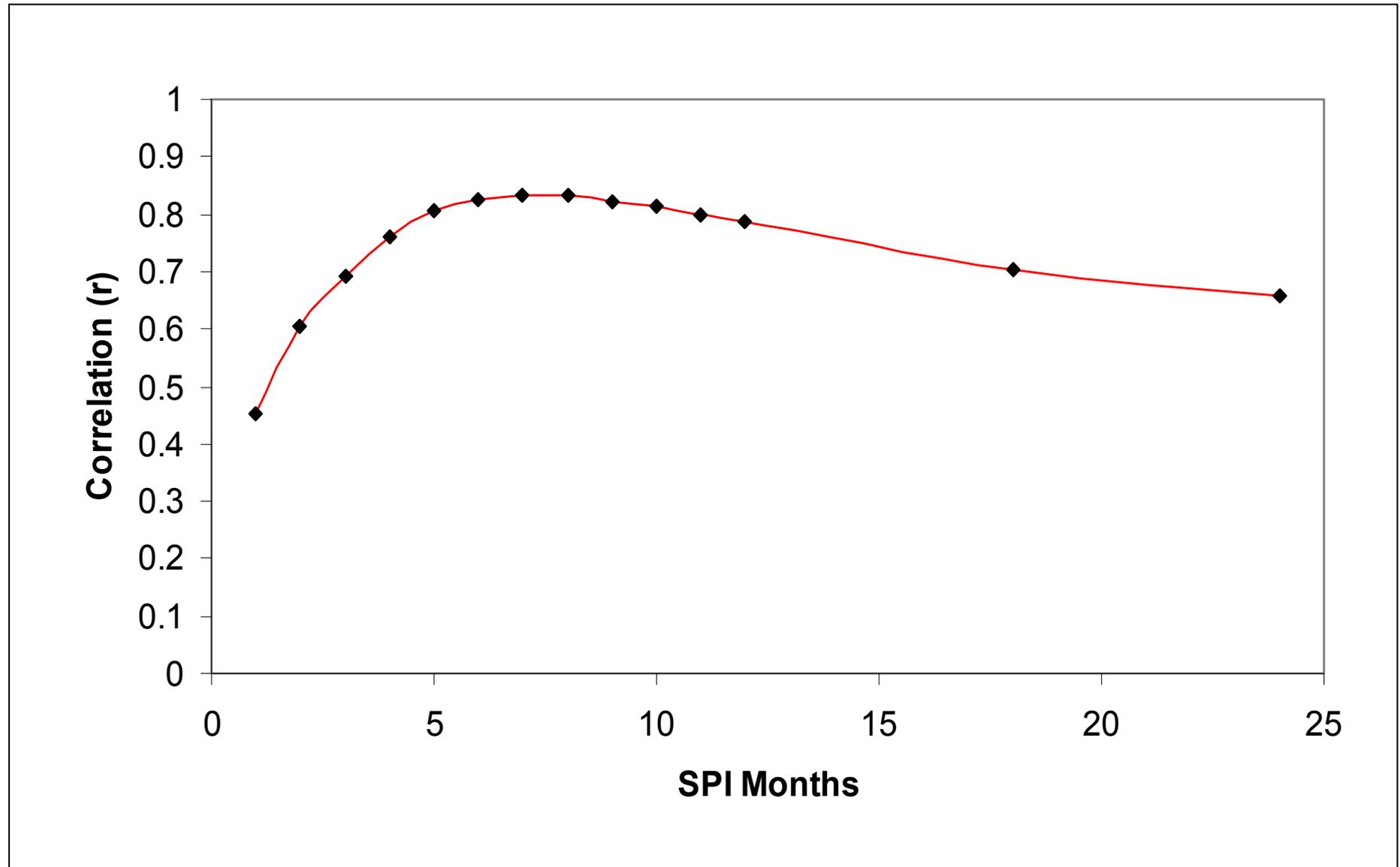


## SOURCES

National Drought Mitigation Center at the University of Nebraska-Lincoln  
 High Plains Regional Climate Center at the University of Nebraska-Lincoln  
 Tom McKee et al., Colorado State University, 1993, 1995  
 Spline Interpolation with 48 Weather Station Sites

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 National Agriculture Decision Support System  
 Supported in part by NSF/EIA-0091539 and  
 The Nebraska Research Initiative

# Correlation between the PDSI and different SPI series as a function of the time scale of the SPI



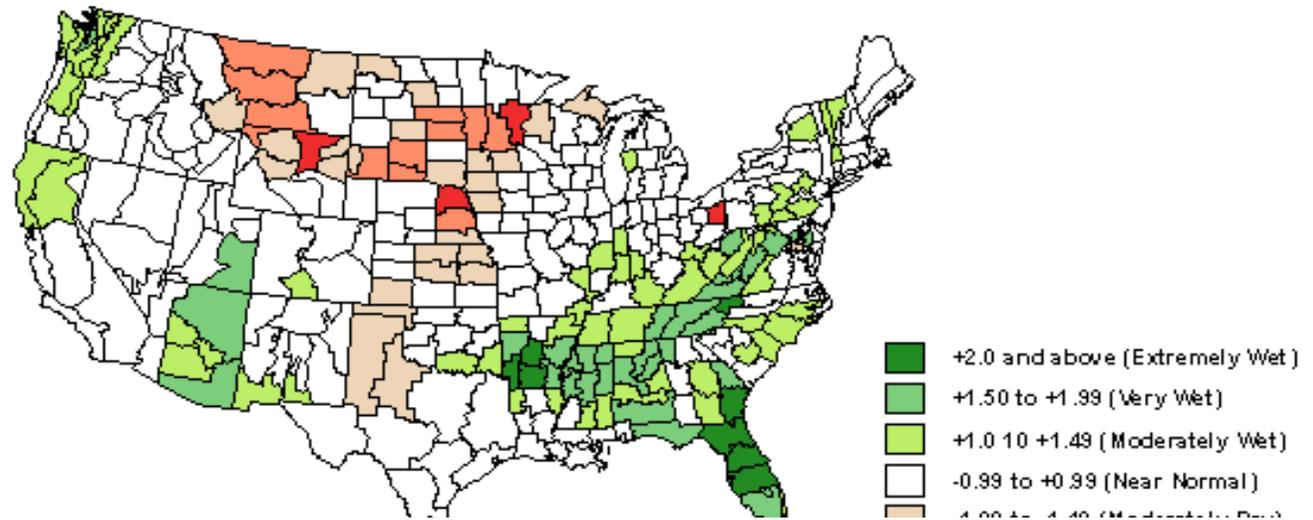
# RESOLUTION:

## Standardized Precipitation Index (SPI)

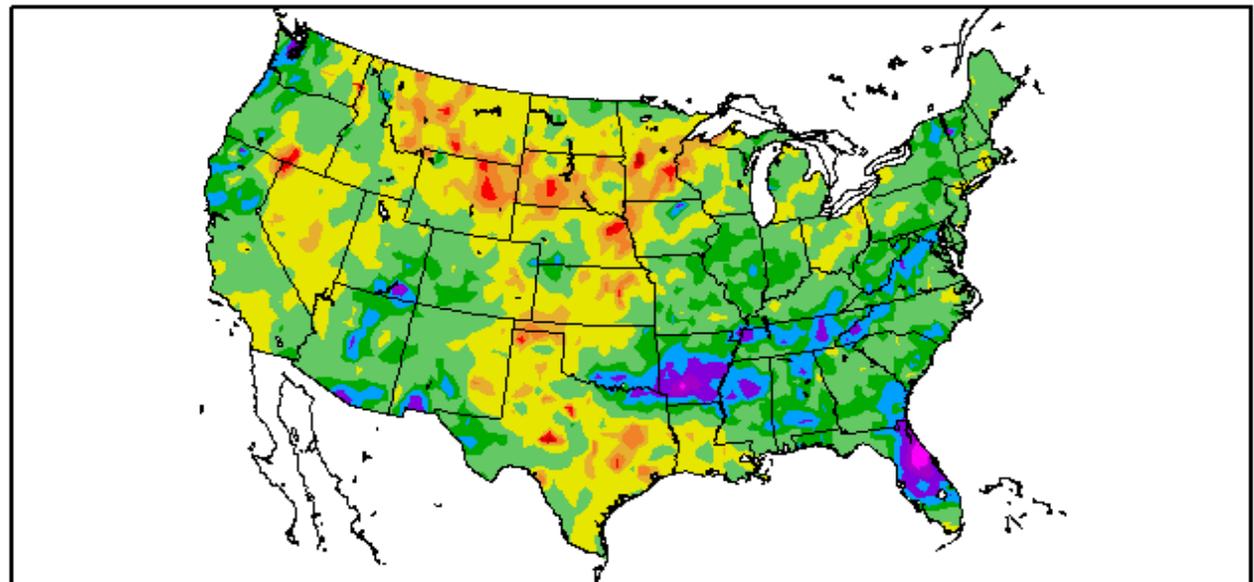
by Climate  
Division (above),  
and by 0.4° grid  
(below)

Source:  
**ACIS/HPRCC/NDMC**

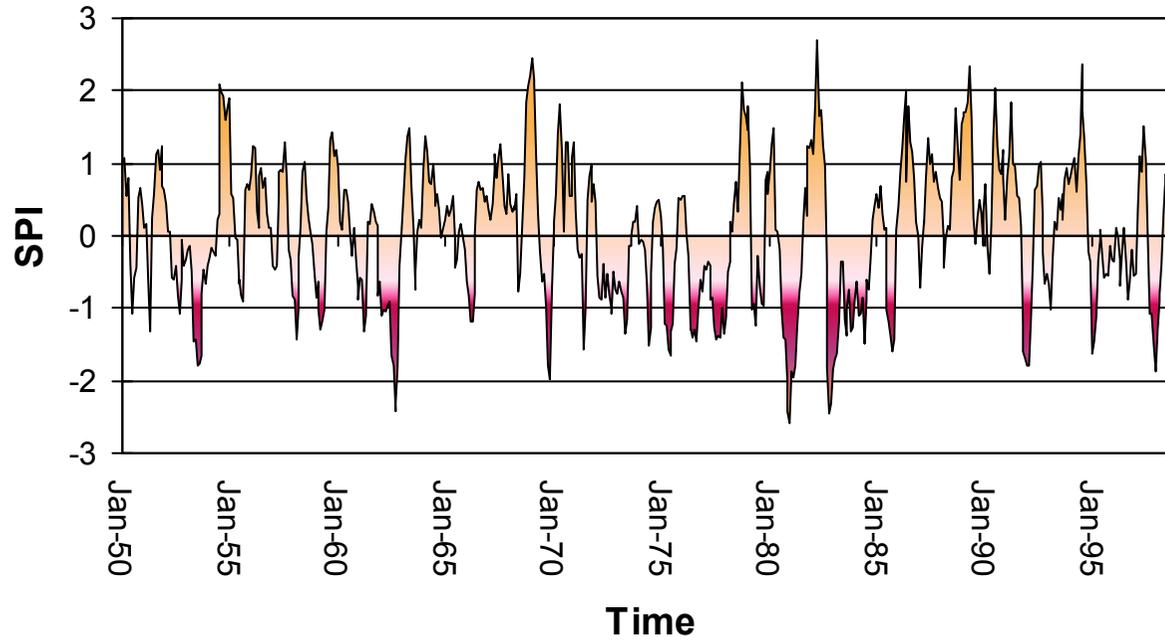
### 1-month SPI through the end of May 2009



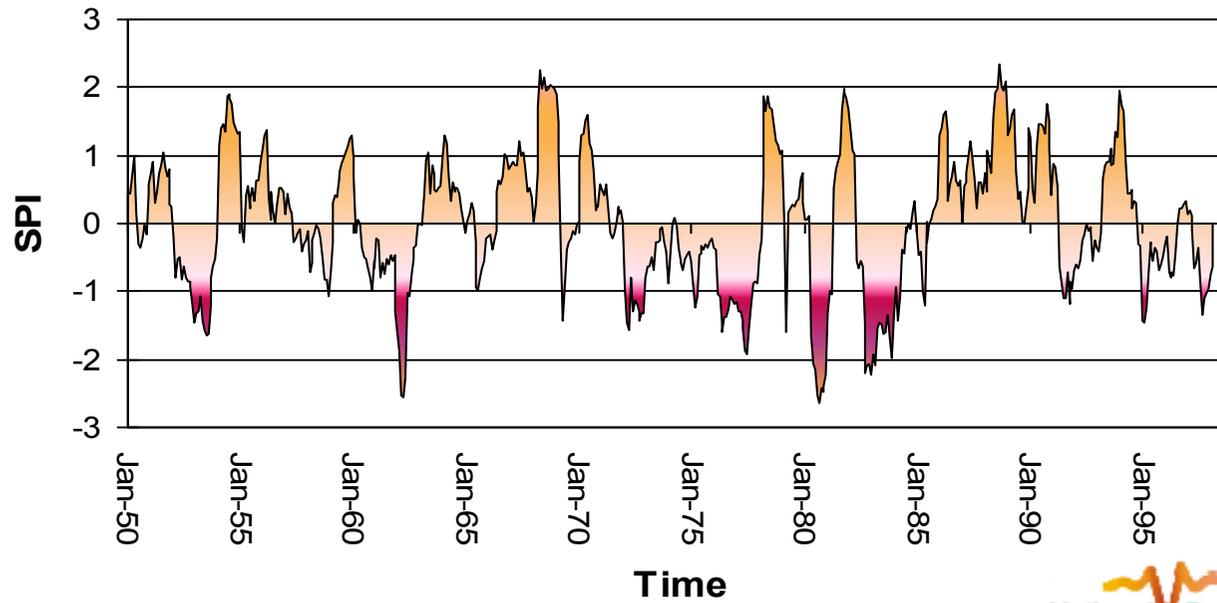
Monthly SPI  
5/1/2009 – 5/31/2009

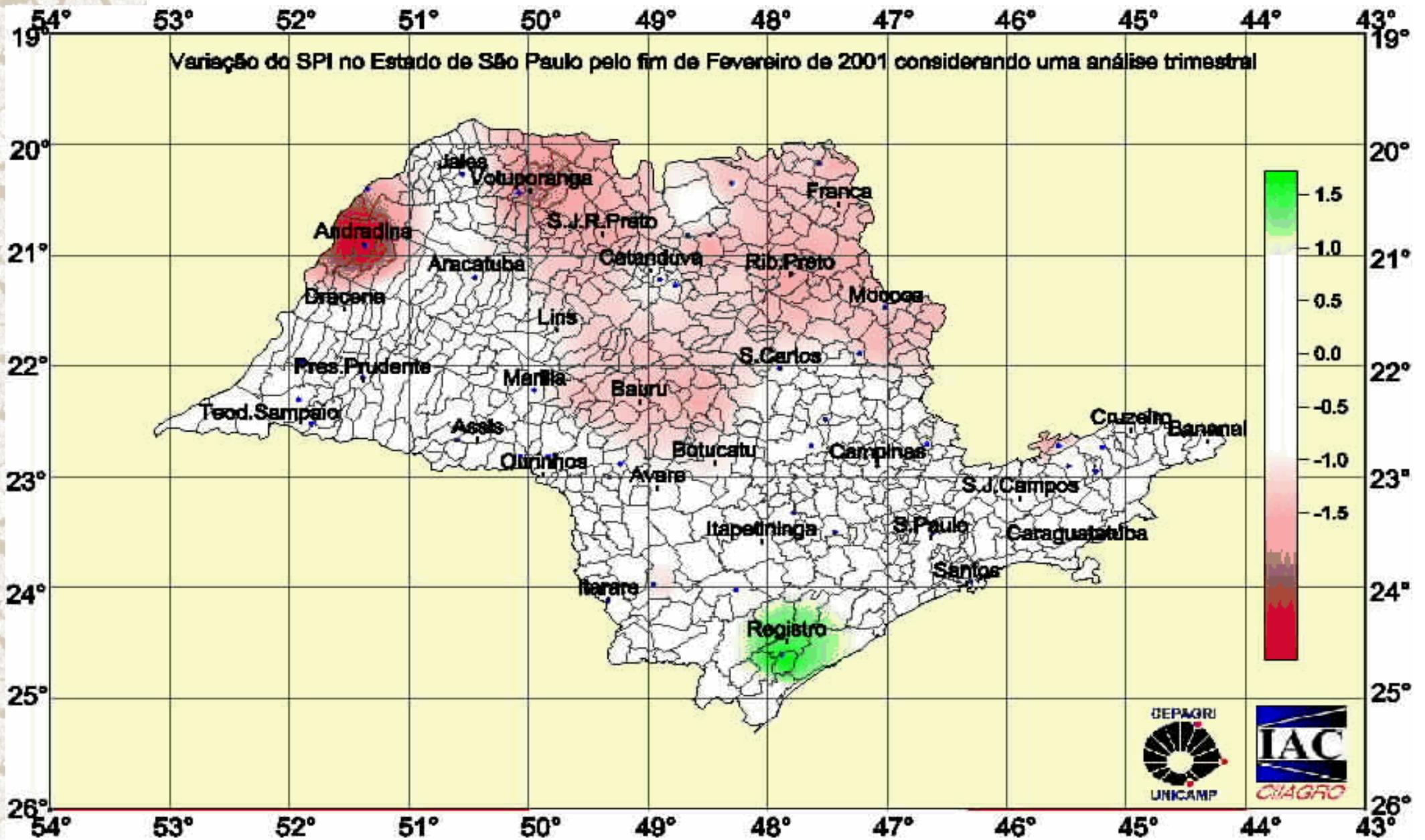


## Hilo 6-Month SPI (1950-1998)



## Hilo 12-Month SPI (1950-1998)





## ■ Monitoring Drought

### ■ The Standardized Precipitation Index

### ■ SPI program files

To run the [SPI SL 6.exe](#) file below, right-click on it and save the file. Then execute (double click) the program; a dialogue box will pop up. Enter the number of SPI monthly intervals (up to six at one time) you wish to run (i.e. 1-, 3-, 4-, 6-, 12-month SPI) and enter the input and output file names. You can include one header line (like the station name) within the data input file (see [sample files](#) below). This is a little different from the method described in the [SPI Zimbabwe.doc](#) file.

All input files must follow 3-column format: Year, Month and Monthly Precipitation Value (see [sample input files](#)). The precipitation total must NOT include decimals and can be in either inches or mm (see [sample input files](#)). Pay attention to column spacing and missing data issues. A zero will work; a missing data flag or -9999 will not.

The program is already compiled and all libraries are included (it was compiled in C++ for PC) so all you have to do is run the [SPI SL 6.exe](#) file and follow the instructions on the pop up screen.

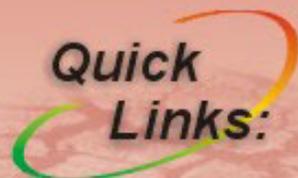
KEEP the header in your file (see [ValeFormosaPortugalppt.cor](#) file below). Also, rename your input (precipitation file) files so that they have a .cor (ex, lincoln.cor) extension.

Name the output file anything you wish with a .dat (or .txt or .spi etc.) extension. (You may have to look in the code to see if it wants the files named in this way.) Save the files as MS-DOS ascii text files; results can be viewed using Microsoft Notepad or Wordpad. This output data can be plotted, graphed or mapped in any spreadsheet or GIS software.

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## ■ Monitoring Drought

## ■ Daily Gridded Standard Precipitation Index






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**Quick Links:**

Select a map from one of the following lists:

### Updated Daily

- Select a map ---
- 30-Day SPI
- 60-Day SPI
- 90-Day SPI
- 6-Month SPI
- 12-Month SPI
- Year-to-date (since Jan. 1) SPI
- Water Year (since Oct. 1) SPI

### Last Month / Season / Year

### Previous Month / Season / Year

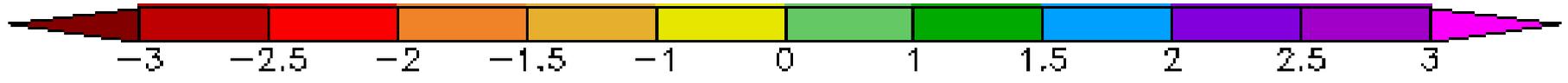
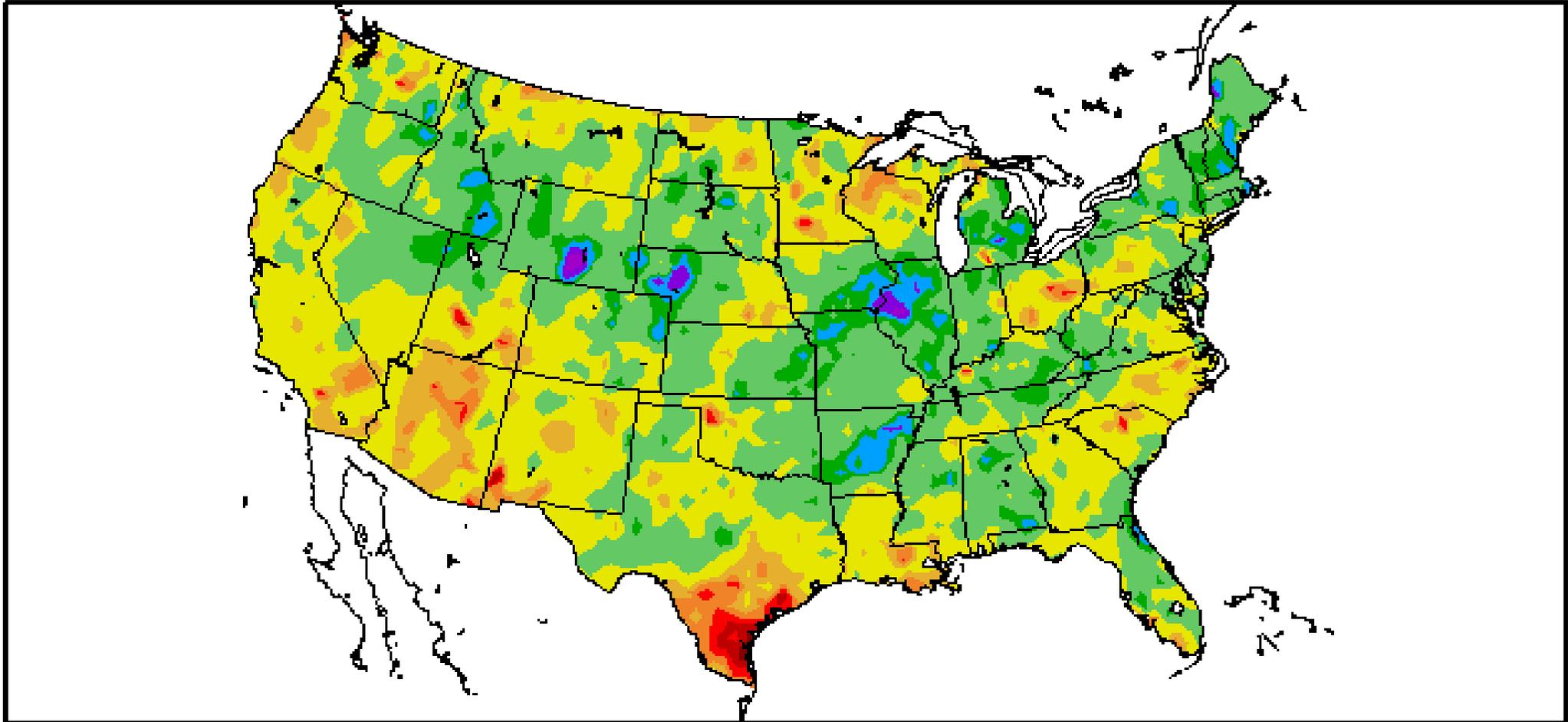



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This is an **Experimental Climate Product!** These maps include provisional, preliminary and final data. Very limited quality control is performed on provisional data, and these products should be used with caution. The best available data is incorporated as it becomes available. For more information, please click here (Coming Soon)

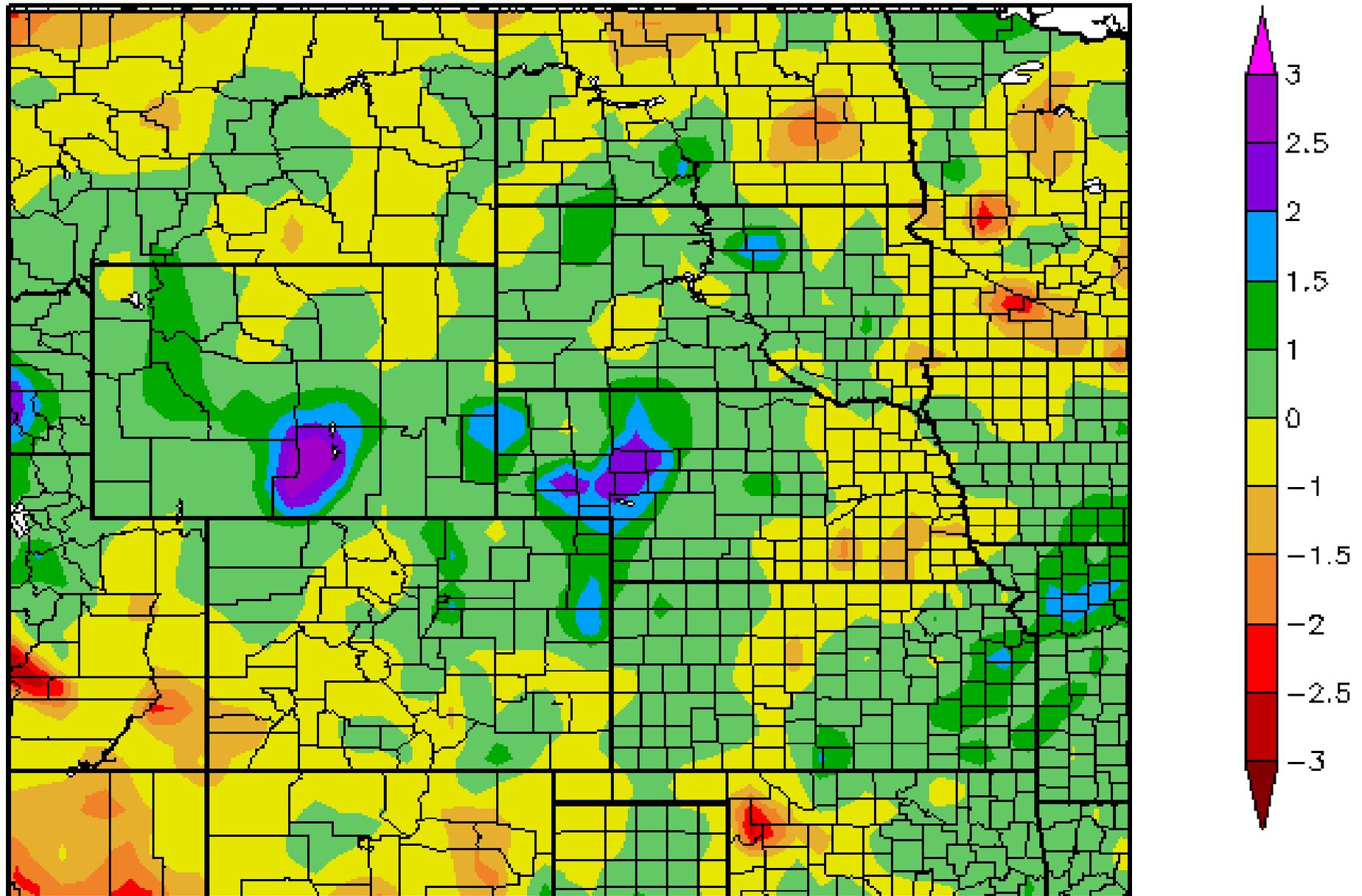
# Year-to-date SPI

1/1/2009 - 9/7/2009



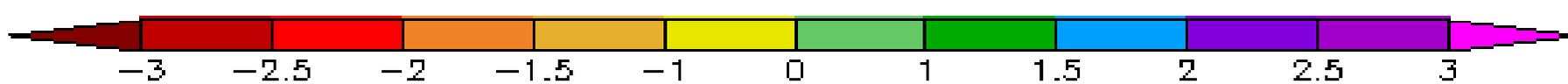
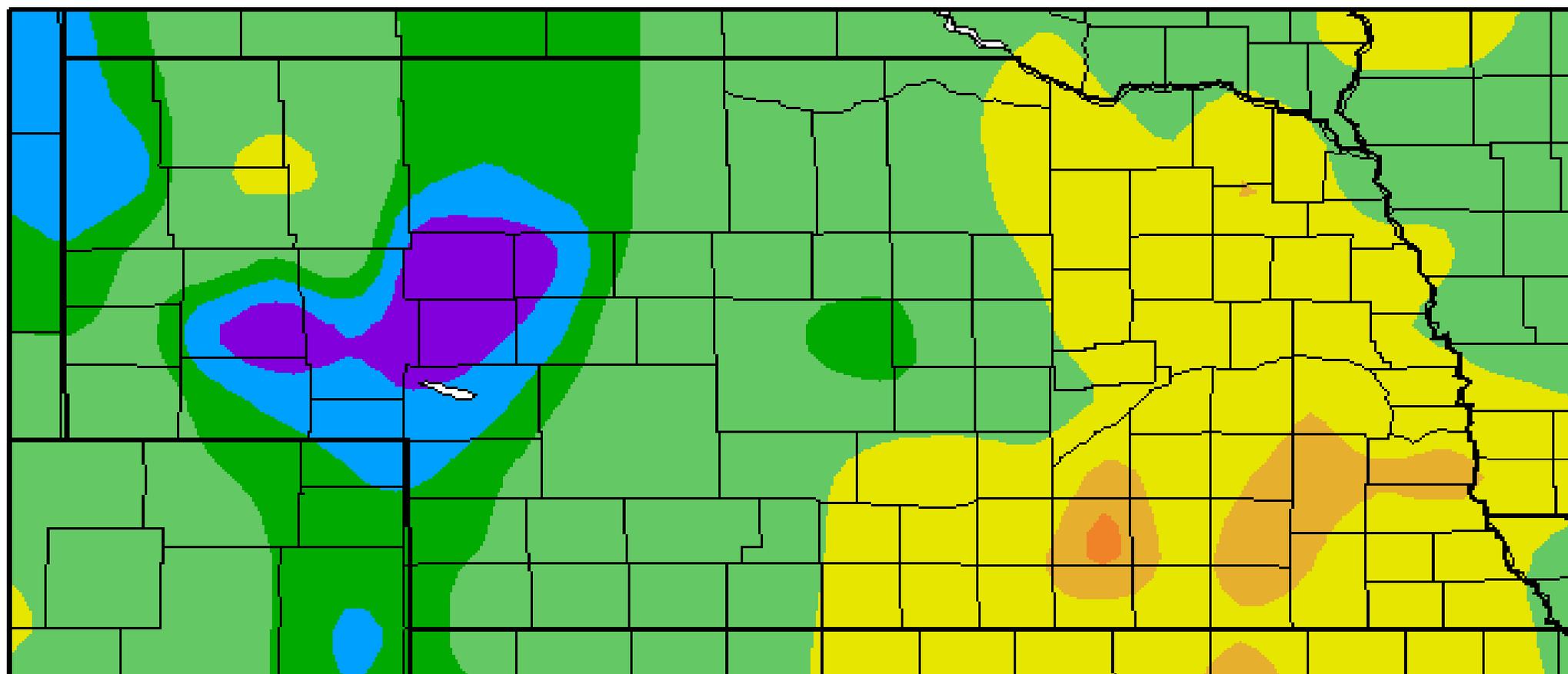
# Year-to-date SPI

1/1/2009 - 9/7/2009



# Year-to-date SPI

1/1/2009 - 9/7/2009



# Using the SPI Program

- Monthly PC version is coded in C++
- Available at the NDMC
- Easy to use
- UNIX version also available (more robust)
- Weekly version now available as well

fall2 - Notepad

File Edit Format Help

Falls	City, NE
1949 1	478
1949 2	108
1949 3	259
1949 4	245
1949 5	450
1949 6	1538
1949 7	179
1949 8	520
1949 9	220
1949 10	220
1949 11	37
1949 12	113
1950 1	80
1950 2	112
1950 3	80
1950 4	126
1950 5	649
1950 6	235
1950 7	637
1950 8	665
1950 9	350
1950 10	145
1950 11	75
1950 12	15
1951 1	89
1951 2	225
1951 3	384
1951 4	537
1951 5	682
1951 6	982
1951 7	668
1951 8	1018

C:\SPI\SPI\_SL\_6.exe



Standardized Precipitation Index Calculator

Number of time scales:



C:\SPI\SPI\_SL\_6.exe



# Standardized Precipitation Index Calculator

Number of time scales: 5

timeScale1 1

timeScale2 3

timeScale3 6

timeScale4 9

timeScale5 12

C:\SPI\SPI\_SL\_6.exe



# Standardized Precipitation Index Calculator

Number of time scales: 5

timeScale1 1

timeScale2 3

timeScale3 6

timeScale4 9

timeScale5 12

Input file: fall.cor

Output file: fall1\_12mospi.dat



Falls City, NE

1949	1	2.82	-99.00	-99.00	-99.00	-99.00
1949	2	0.32	-99.00	-99.00	-99.00	-99.00
1949	3	0.47	1.61	-99.00	-99.00	-99.00
1949	4	-0.16	0.11	-99.00	-99.00	-99.00
1949	5	0.21	0.10	-99.00	-99.00	-99.00
1949	6	2.62	2.18	2.43	-99.00	-99.00
1949	7	-0.76	1.44	1.20	-99.00	-99.00
1949	8	0.47	1.35	1.15	-99.00	-99.00
1949	9	-0.69	-0.57	0.82	1.14	-99.00
1949	10	0.06	-0.24	0.81	0.72	-99.00
1949	11	-1.07	-1.30	0.67	0.57	-99.00
1949	12	0.42	-0.62	-0.82	0.57	0.91
1950	1	0.06	-0.81	-0.56	0.62	0.56
1950	2	0.37	0.25	-1.00	0.66	0.56
1950	3	-0.82	-0.54	-0.96	-0.97	0.40
1950	4	-1.16	-1.20	-1.37	-1.01	0.26
1950	5	1.02	-0.20	-0.17	-0.93	0.49
1950	6	-0.79	-0.41	-0.64	-0.92	-1.07
1950	7	0.62	0.37	-0.18	-0.40	-0.52
1950	8	0.87	0.38	0.16	0.19	-0.31
1950	9	-0.04	0.61	0.25	0.07	-0.12
1950	10	-0.39	0.22	0.31	-0.05	-0.21
1950	11	-0.57	-0.90	-0.08	-0.21	-0.17
1950	12	-1.64	-1.40	0.12	-0.16	-0.30
1951	1	0.18	-1.24	-0.22	0.06	-0.28
1951	2	1.37	0.43	-0.62	-0.04	-0.16
1951	3	1.02	1.18	0.04	0.46	0.17
1951	4	1.33	1.66	0.92	0.65	0.61





Western Sahara

Algeria

Mauritania

TESSALIT

Mali

TOMBOUCTOU

MENAKA

Niger

Senegal

KITA

Bamako

Burkina Faso

Nigeria

Guinea

SIKASSO

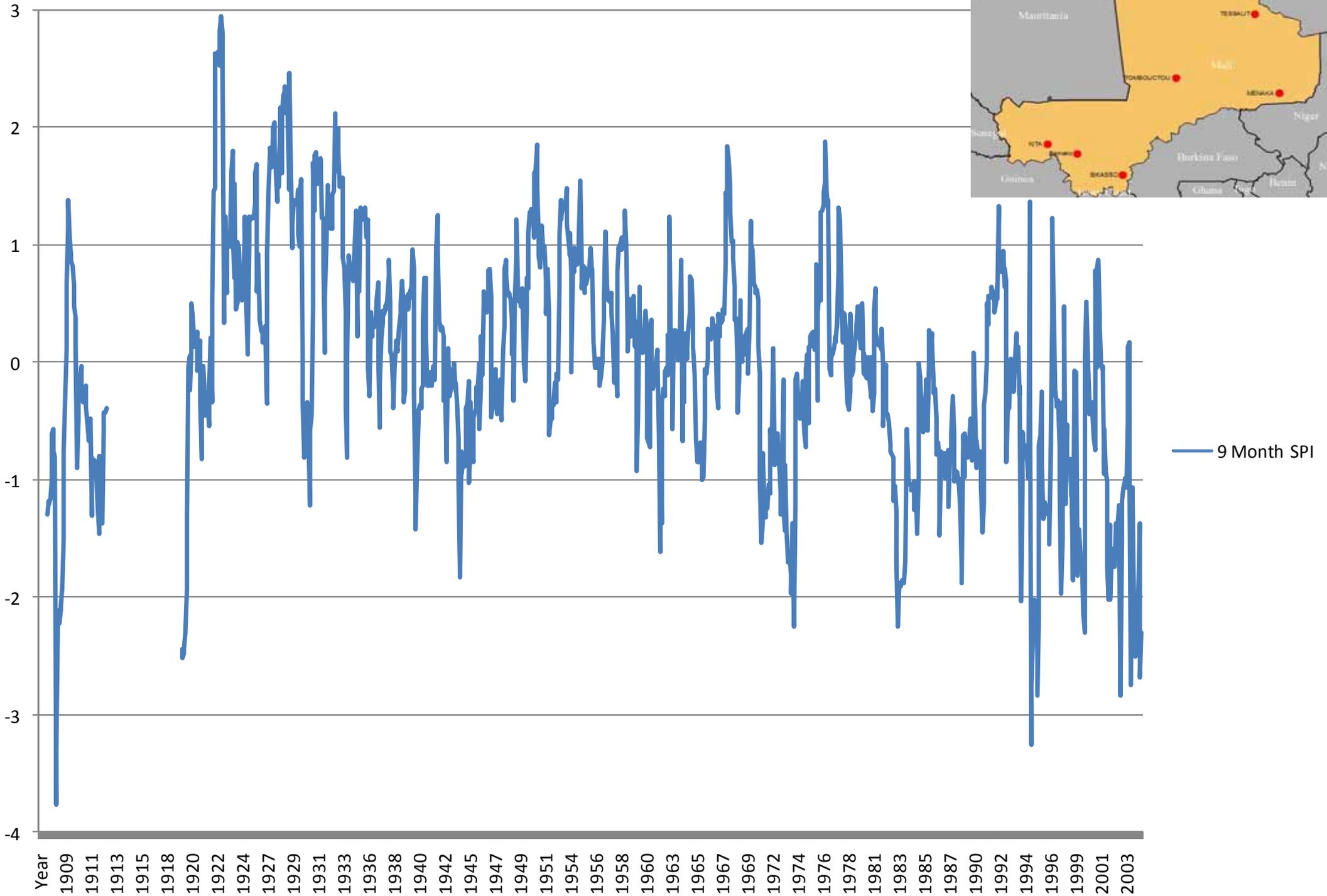
Ivory Coast

Ghana

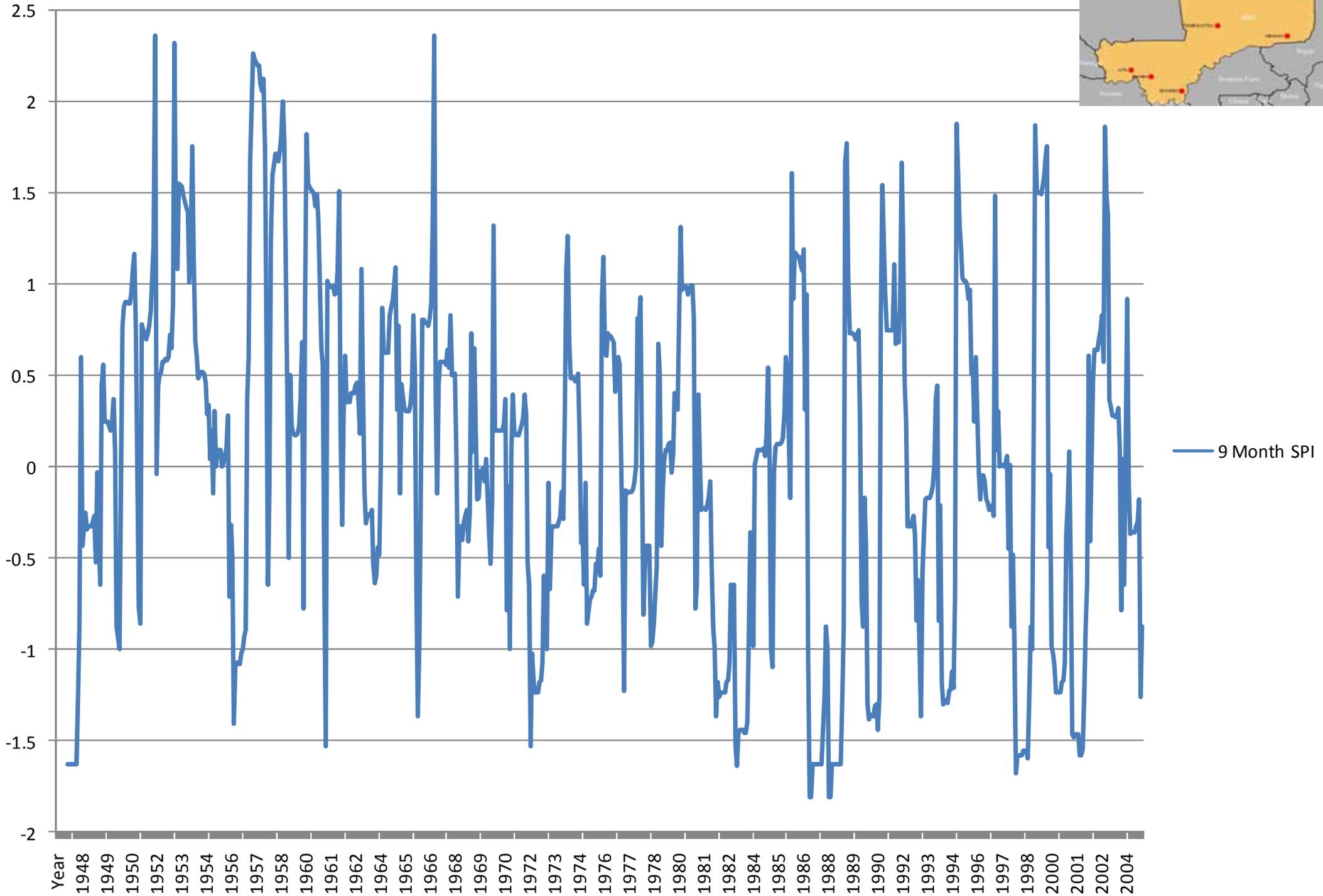
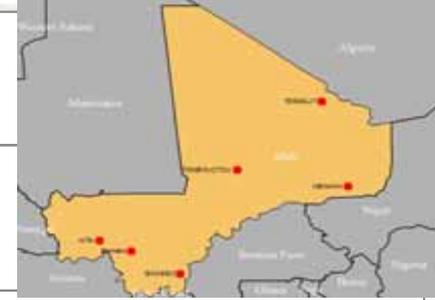
Togo

Benin

# 9 Month SPI for Sikasso, Mali



# 9 Month SPI for Tessalit, Mali



# ***A Case Study:***

## **Monitoring Drought in Hungary with the Standardized Precipitation Index**

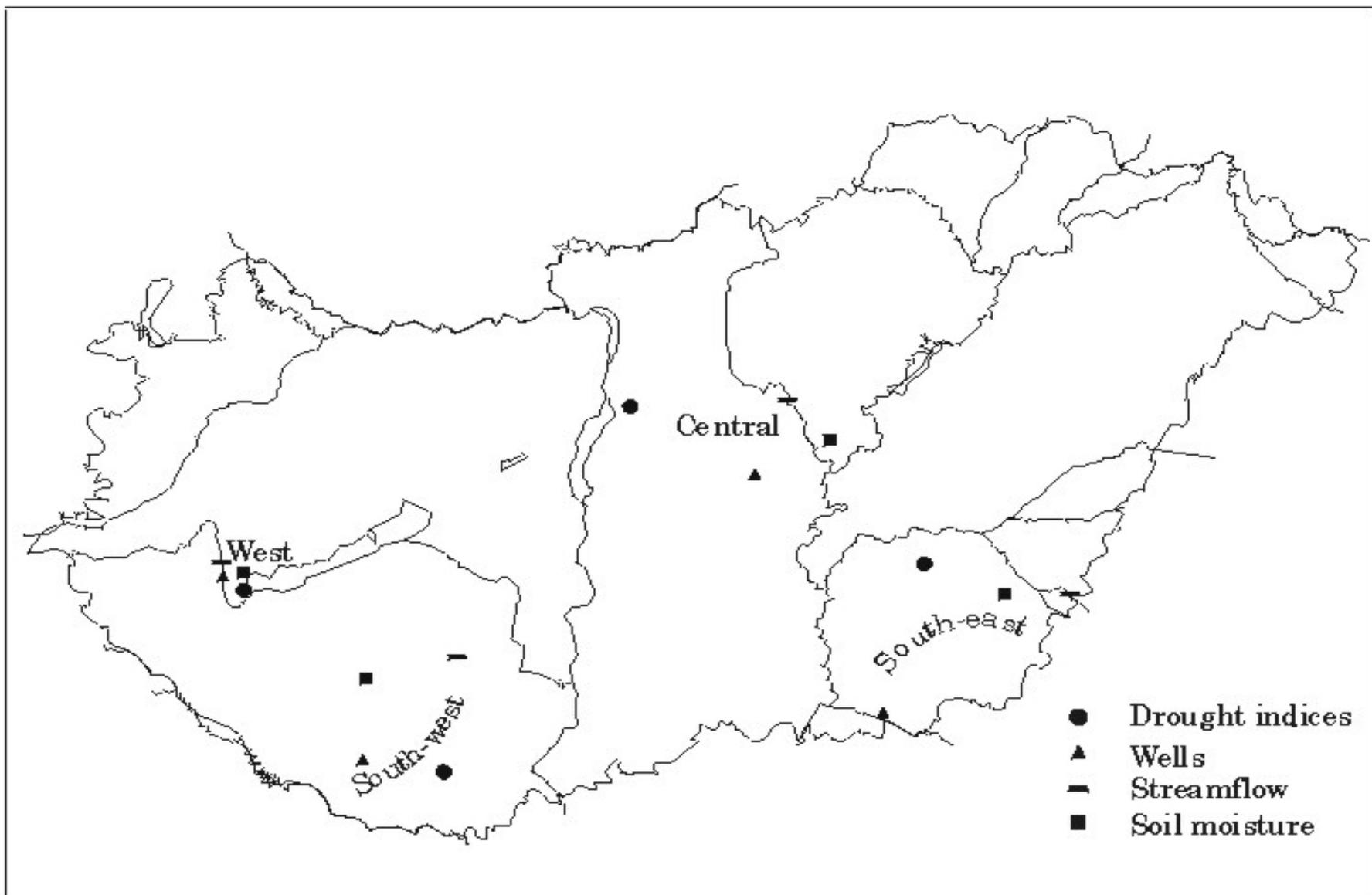
***A. Bussay<sup>1</sup>, M. Hayes<sup>2</sup>, Cs. Szinell<sup>1</sup>,  
and M. Svoboda<sup>2</sup>***

- 1. Hungarian Meteorological Service**
- 2. National Drought Mitigation Center,  
University of Nebraska-Lincoln**

# Goals of the Study

- One of the first applications of the SPI in Hungary and in Europe
- To identify the relationship of the SPI with streamflow, groundwater levels and soil moisture values
- To assess and compare the monitoring capabilities between the SPI and the Palmer Drought Severity Index

# The Study Area

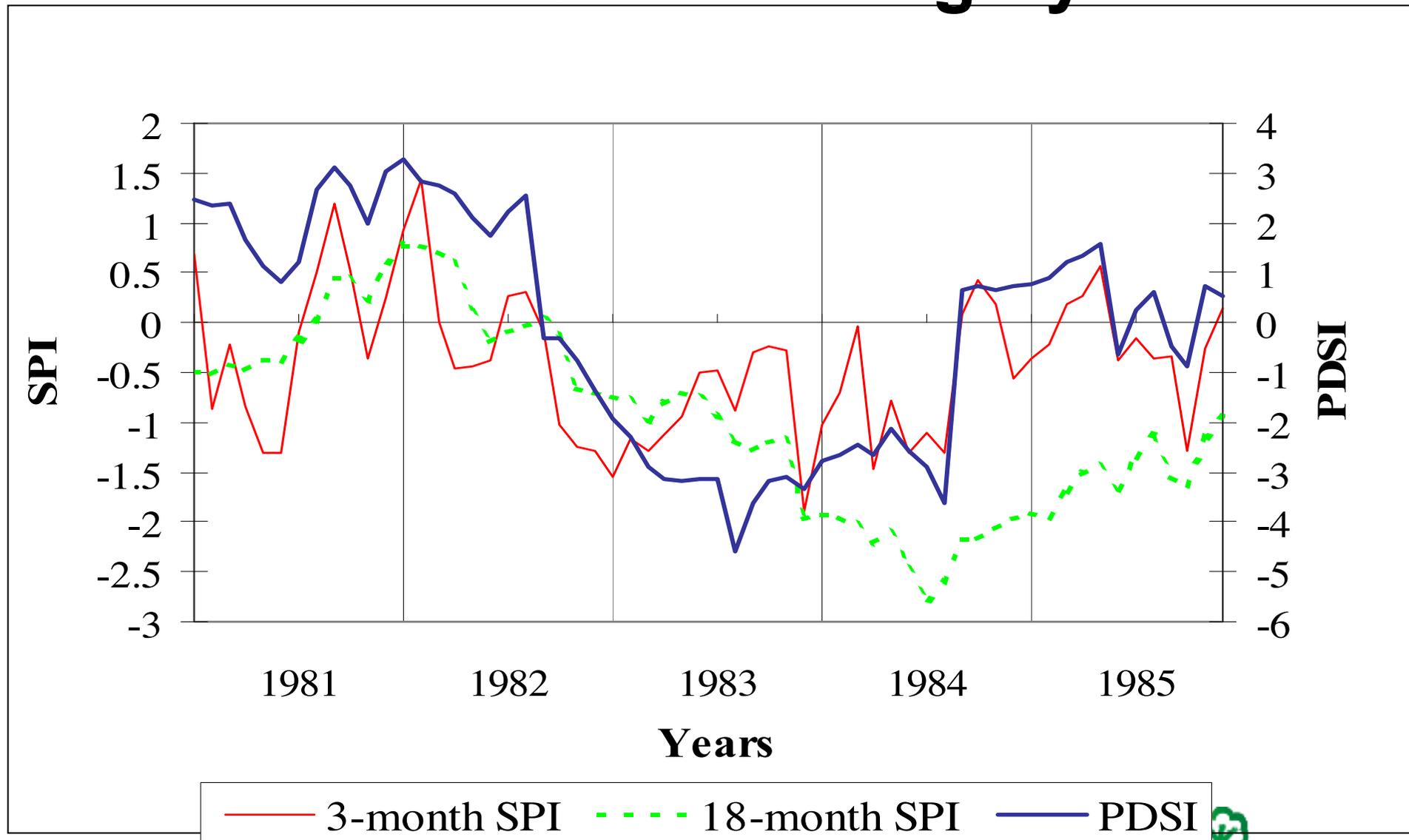


# Classification Scale for SPI Values

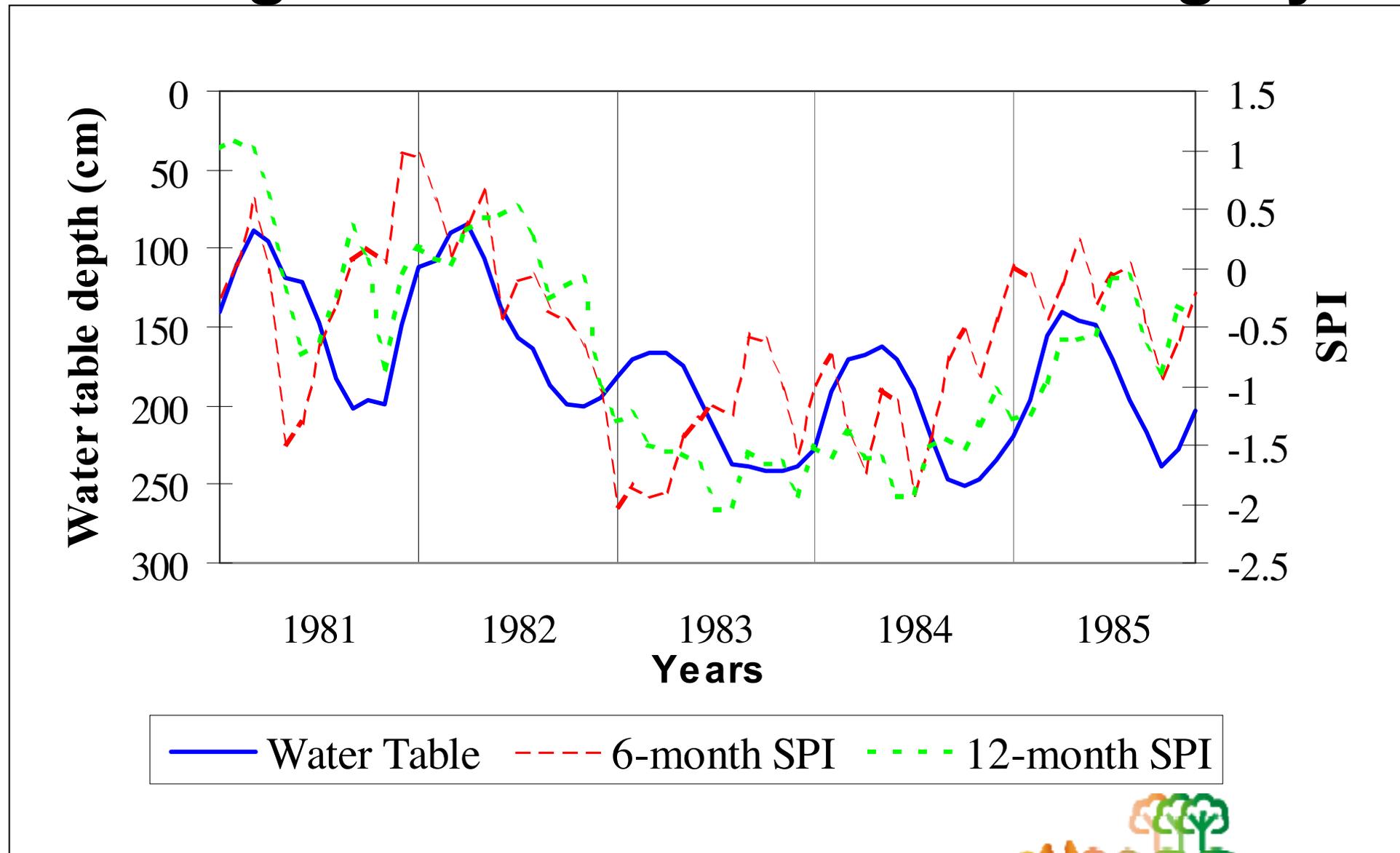
Table 1.  
Classification scale for SPI values (after Edwards and McKee 1996)

<b>SPI Values</b>	<b>Category</b>	<b>Time in Category (%)</b>
$\geq +2.00$	Extremely Wet	2.3
+1.50 to +1.99	Very Wet	4.4
+1.00 to +1.49	Moderately Wet	9.2
-0.99 to +0.99	Near Normal	68.2
-1.00 to -1.49	Moderately Dry	9.2
-1.50 to -1.99	Severely Dry	4.4
$\leq -2.00$	Extremely Dry	2.3

# The course of 3-month SPI, 18-month SPI and PDSI during the 1983 drought in the southeast of Hungary



# The course of the 6-month SPI, 12-month SPI and water table depth during the 1983 drought in the southeast of Hungary



— Water Table    - - - 6-month SPI    - - - 12-month SPI

# *Findings*

- The SPI and PDSI showed the strongest relationship at around 6 or 7 months
- Shorter time scales worked best with soil moisture and streamflow (2 to 3 months)
- Longer time scales worked best with groundwater levels (12 to 24 months)
- In all cases, the SPI captured tendencies and characteristics of these variables

# How to get the SPI Program

The free PC-based version of the SPI can be found at the NDMC:

[http://drought.unl.edu/monitor/spi/program/spi\\_program.htm](http://drought.unl.edu/monitor/spi/program/spi_program.htm)

The free UNIX version of the SPI can be found at:

<http://ccc.atmos.colostate.edu/standardizedprecipitation.php>

OR..the free weekly SPI code is also at:

<http://greenleaf.unl.edu/downloads>

**Thank you!**

**Questions?**

**For SPI monthly code  
(PC or UNIX based),**

**E-mail me at: [msvoboda2@unl.edu](mailto:msvoboda2@unl.edu)**