Using the Standardized Precipitation Index (SPI) and the Standardized Precipitation Evapotranspiration Index (SPEI)

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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)

(NOTE: The SPI can be computed using a weekly time step as well.)

- 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
  - Can be calculated with missing data in the input

- ***Cons:*** Based on Precipitation only
  - no Temperature, no ET.
  - Values based on preliminary data may change.

SPI Methodology

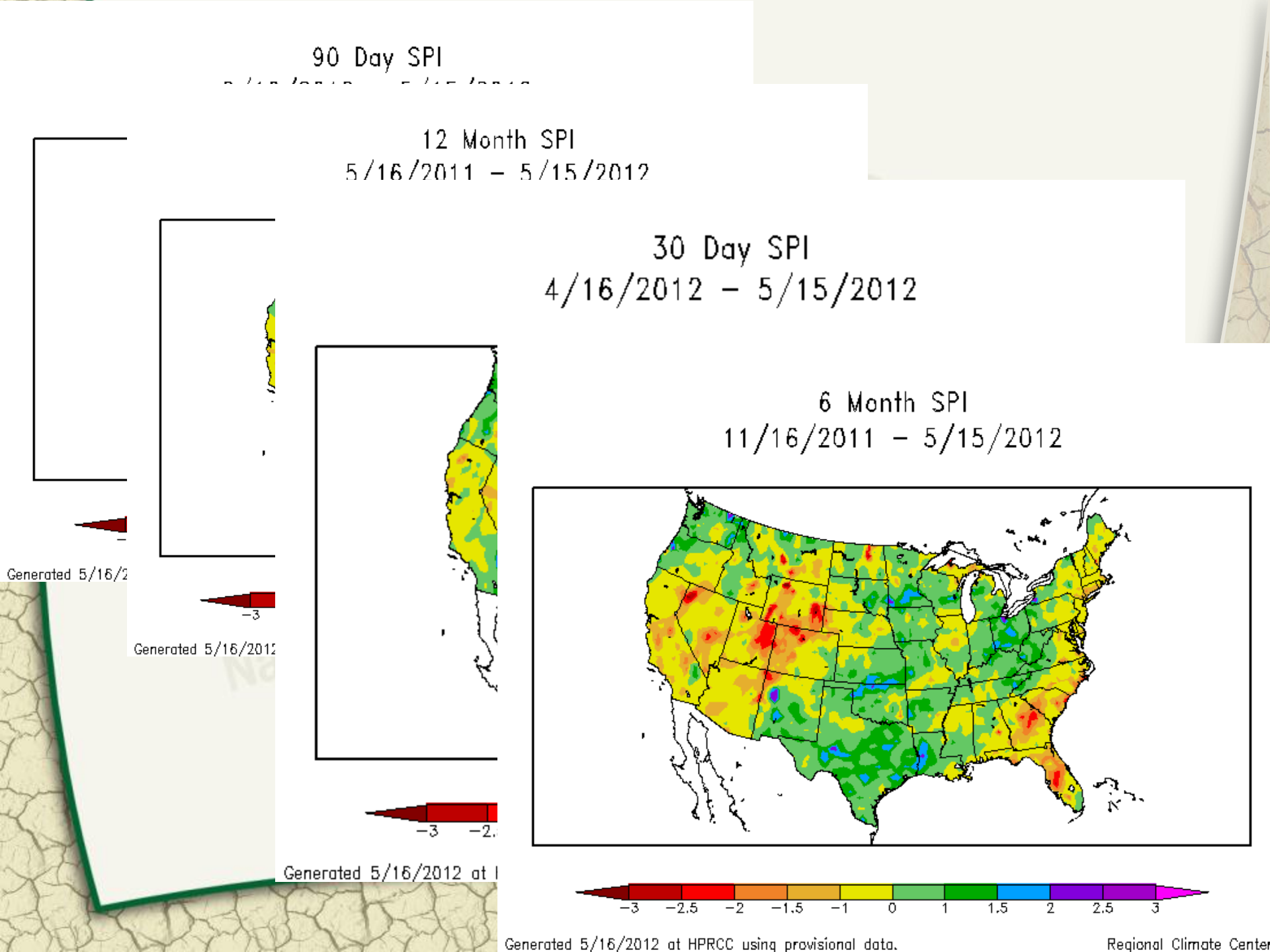
- The SPI was designed to quantify the precipitation deficit for multiple time scales
- These time scales reflect the impact of drought on the availability of the different water resources
- Soil moisture conditions respond to precipitation anomalies on a relatively short scale. Groundwater, streamflow, 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

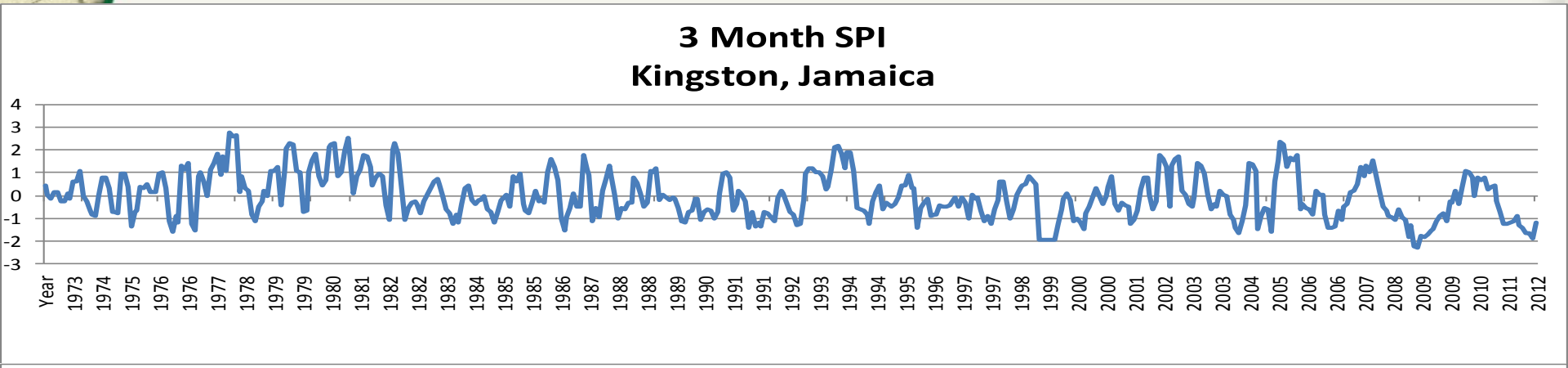

90 Day SPI
12 Month SPI
5/16/2011 – 5/15/2012
30 Day SPI
4/16/2012 – 5/15/2012
6 Month SPI
11/16/2011 – 5/15/2012
Generated 5/16/2012 at HPRCC using provisional data.
Regional Climate Center
−3 −2.5 −2 −1.5 −1 0 1 1.5 2 2.5 3

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

Probability of Recurrence

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


3 Month SPI
Kingston, Jamaica
4
3
2
1
0
-1
-2
-3
Year
1973
1974
1975
1976
1976
1977
1978
1979
1979
1980
1981
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1982
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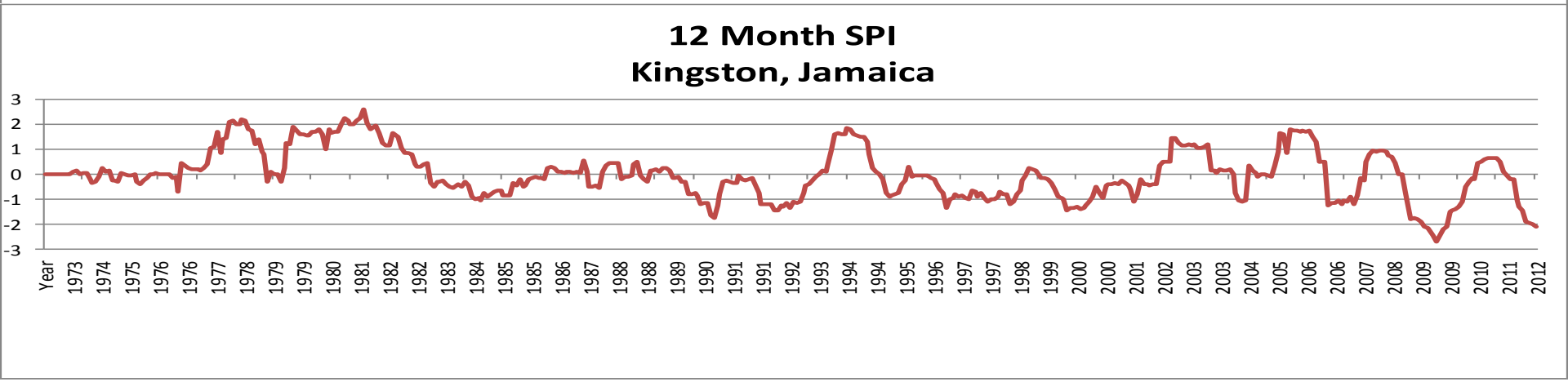
2009
2010
2011
2012


12 Month SPI
Kingston, Jamaica
3
2
1
0
-1
-2
-3
Year
1973
1974
1975
1976
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1978
1979
1979
1980
1981
1982
1982
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1984
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1985
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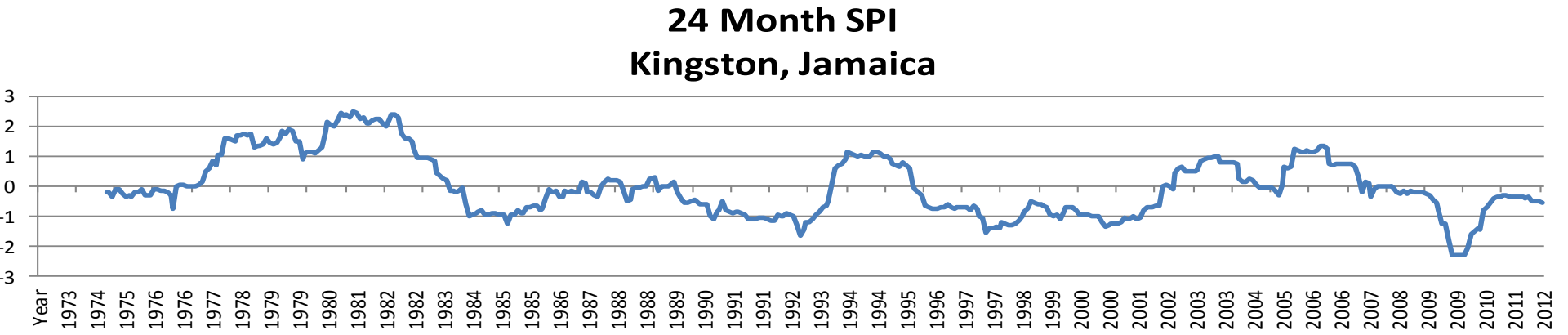
2011
2012


24 Month SPI
Kingston, Jamaica
3
2
1
0
-1
-2
-3
Year
1973
1974
1975
1976
1976
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1978
1979
1979
1980
1981
1982
1982
1983
1984
1985
1985
1986
1987
1988
1988
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1998
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2000
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2002
2003
2003
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2010
2011
2012

Where to find the SPI program?

- http://drought.unl.edu/MonitoringTools/DownloadableSPIProgram.aspx

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Monitoring Tools 〉 Downloadable SPI Program

Login

Program to Calculate Standardized Precipitation Index

To run the SPI_SL_6.exe file, 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. This is a little different from the method described in the alternative method file.

All input files must follow 3-column format: Year, Month and Monthly Precipitation Value. The precipitation total must NOT include decimals and can be in either inches or mm. 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 in the sample file zip to the right). 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.

For further documentation or to download the original UNIX version of the SPI program, please see **http://climate.atmos.colostate.edu/standardizedprecipitation.shtml** . This site includes some user instructions as well as several additional programs. In the UNIX version, a particularly useful program is rundr_m, which allows you to study a site's or region's drought history, including an analysis of frequency and duration for a magnitude ranking of sorts. The main program is runspi, which actually generates the SPI files from monthly precipitation totals files (.cor files).

Again, you only need monthly precipitation values (in inches or mm without decimals) to run these programs, but you must have at least 30 consecutive years without missing monthly data, and more than 60 years is recommended.

Additional documentation on the SPI is available from the NDMC.

Downloads

Program

SPI_SL_6.exe

Documentation

basic-spi-program-information.pdf

spi-program-alternative-method.pdf

Sample Files

SPI_samplefiles.zip - includes wymo.cor, ValeFormosaSPI.dat, and ValeFormosaPortugalppt.cor

NIDIS

University of Nebraska Lincoln

Drought Mitigation Center

Standardized Precipitation Evapotranspiration Index (SPEI)

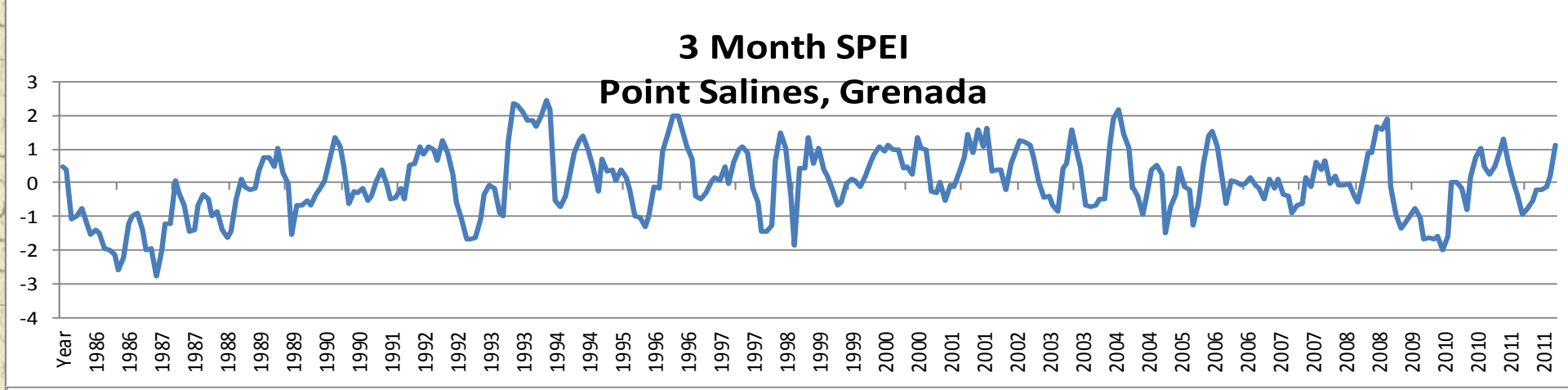
- Based upon precipitation and temperature data
- Has the capacity to include the effects of temperature variability on drought assessment
- SPEI is based on water balance, it can be compared to the self-calibrated Palmer drought severity index (sc-PDSI)
- Developed by Serrano, Begueria and Moreno

Calculating the SPEI

- Based upon the original SPI calculation procedure.
- SPI is calculated using monthly (or weekly) precipitation as the input data.
- Uses the same available time scales as the SPI.

Calculating the SPEI

- The SPEI uses the monthly (or weekly) difference between precipitation and PET(Potential Evapotranspiration) which is a simple water balance *methodology(based upon work by Thornthwaite, 1948)* that is calculated at different time scales to obtain the SPEI.
- A serially complete data set of both temperature and precipitation (weekly or monthly) is needed to calculate the SPEI.
- Software has been created to automatically calculate the SPEI over a wide range of time scales. The software is freely available in the Web repository of the Spanish National Research Council (available online at http://digital.csic.es/handle/10261/10002).


3 Month SPEI
Point Salines, Grenada
3
2
1
0
-1
-2
-3
-4
Year
1986
1986
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1988
1989
1989
1990
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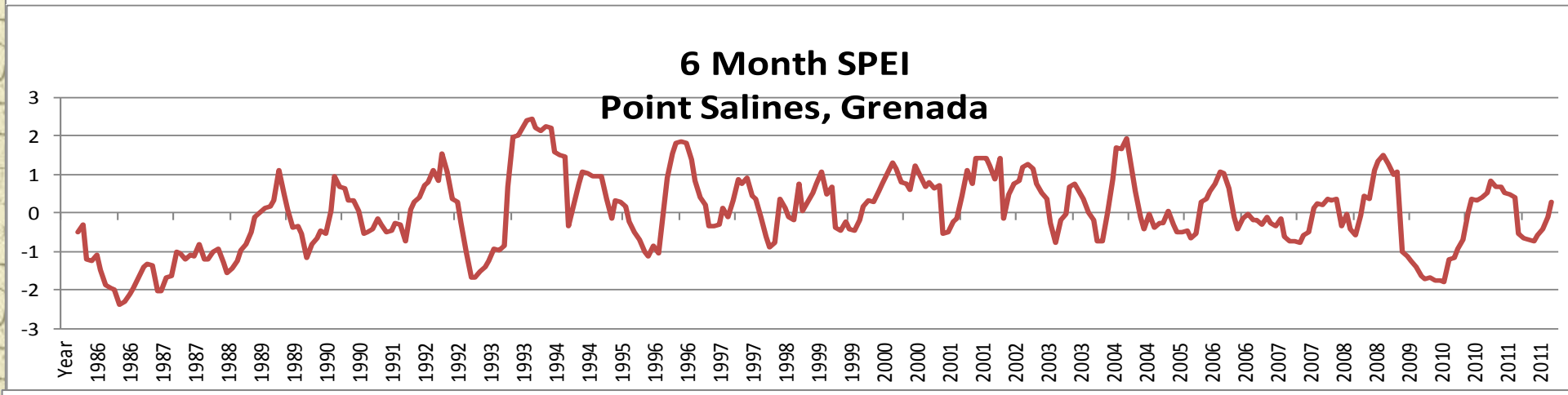
6 Month SPEI
Point Salines, Grenada
3
2
1
0
-1
-2
-3
Year
1986
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1989
1989
1990
1990
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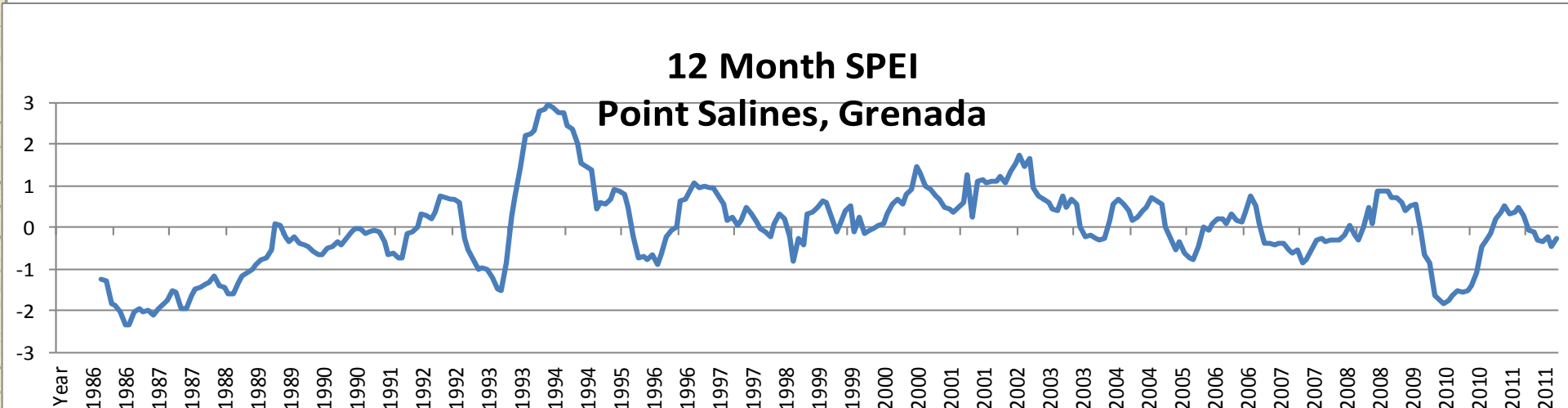
2011


12 Month SPEI
Point Salines, Grenada
3
2
1
0
-1
-2
-3
Year
1986
1986
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1989
1989
1990
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2011
2011

Using the SPI and SPEI Programs

SPI Program

```
C:\Users\bfuchs2\Desktop\Jamaica\spi_sl_6.exe

Standardized Precipitation Index Calculator
Number of time scales: 4
timeScale1 3
timeScale2 6
timeScale3 9
timeScale4 12
Input file: Kingston.cor
Output file: SPI_output_
```

Up to 12 time scales allowed

The input file must be in the correct format and have a .cor extension

For the easiest method of running the program, run the SPI program in the same directory that the input files are located.

Sample Input/Output Files

input: name.cor format

```
789480
1973  9     0
1973  10    616
1973  11    0
1973  12    316
1974  1     221
1974  2     0
1974  3     0
1974  4     0
1974  5     0
1974  6     0
1974  7     0
1974  8     0
1974  9     0
1974  10    0
1974  11    0
1974  12    0
1975  1     0
1975  2     0
1975  3     0
1975  4     0
1975  5     0
1975  6     0
1975  7     0
1975  8     0
1975  9     0
1975  10    0
1975  11    0
1975  12    0
1976  1     0
1976  2     0
1976  3     0
1976  4     0
1976  5     0
1976  6     0
```

Output: 3,6,9,12,15,18,24 month SPI

```
789480
1973 11  -1.01 -99.00 -99.00 -99.00 -99.00 -99.00 -99.00
1973 12  -0.86 -99.00 -99.00 -99.00 -99.00 -99.00 -99.00
1974  1  -1.07 -99.00 -99.00 -99.00 -99.00 -99.00 -99.00
1974  2  -0.73  -1.20 -99.00 -99.00 -99.00 -99.00 -99.00
1974  3  -1.16  -0.75 -99.00 -99.00 -99.00 -99.00 -99.00
1974  4  -1.25  -1.23 -99.00 -99.00 -99.00 -99.00 -99.00
1974  5  -1.25  -1.07  -1.06 -99.00 -99.00 -99.00 -99.00
1974  6  -1.00  -1.54  -1.13 -99.00 -99.00 -99.00 -99.00
1974  7  -1.12  -1.25  -1.49 -99.00 -99.00 -99.00 -99.00
1974  8  -1.12  -1.25  -1.49  -1.34 -99.00 -99.00 -99.00
1974  9  -1.00  -1.12  -1.60  -1.34 -99.00 -99.00 -99.00
1974 10  -1.00  -1.25  -1.41  -1.57 -99.00 -99.00 -99.00
1974 11  -1.02  -1.25  -1.41  -1.57  -1.47 -99.00 -99.00
1974 12  -1.13  -1.25  -1.41  -1.61  -1.52 -99.00 -99.00
1975  1  -1.27  -1.25  -1.41  -1.41  -1.62 -99.00 -99.00
1975  2  -1.27  -1.27  -1.41  -1.41  -1.62  -1.62 -99.00
1975  3  -1.63  -1.63  -1.62  -1.62  -1.91  -1.65 -99.00
1975  4  -1.25  -1.62  -1.61  -1.61  -1.61  -1.82 -99.00
1975  5  -1.25  -1.62  -1.62  -1.61  -1.61  -1.83 -99.00
1975  6  -1.00  -1.62  -1.62  -1.61  -1.61  -1.91 -99.00
1975  7  -1.12  -1.25  -1.62  -1.61  -1.61  -1.61 -99.00
1975  8  -1.12  -1.25  -1.62  -1.62  -1.61  -1.61  -1.79
1975  9  -1.00  -1.12  -1.62  -1.62  -1.61  -1.61  -1.79
1975 10  -1.00  -1.25  -1.41  -1.62  -1.61  -1.61  -1.90
1975 11  -1.02  -1.25  -1.41  -1.62  -1.62  -1.61  -1.90
1975 12  -1.13  -1.25  -1.41  -1.62  -1.62  -1.61  -1.92
1976  1  -1.27  -1.25  -1.41  -1.41  -1.62  -1.61  -1.61
1976  2  -1.27  -1.27  -1.41  -1.41  -1.62  -1.62  -1.61
1976  3  -1.63  -1.63  -1.62  -1.62  -1.94  -1.94  -1.93
1976  4  -1.25  -1.62  -1.61  -1.61  -1.61  -1.93  -1.91
1976  5  -1.25  -1.62  -1.62  -1.61  -1.61  -1.93  -1.91
1976  6  -1.00  -1.62  -1.62  -1.61  -1.61  -1.93  -1.91
1976  7  -1.12  -1.25  -1.62  -1.61  -1.61  -1.61  -1.91
1976  8  -1.12  -1.25  -1.62  -1.62  -1.61  -1.61  -1.93
1976  9  -1.00  -1.12  -1.62  -1.62  -1.61  -1.61  -1.93
1976 10  -1.00  -1.25  -1.41  -1.62  -1.61  -1.61  -1.93
1976 11  -1.02  -1.25  -1.41  -1.62  -1.62  -1.61  -1.93
1976 12  -1.13  -1.25  -1.41  -1.62  -1.62  -1.61  -1.93
1977  1  -1.27  -1.25  -1.41  -1.41  -1.62  -1.61  -1.61
1977  2  -1.27  -1.27  -1.41  -1.41  -1.62  -1.62  -1.61
1977  3  -1.63  -1.63  -1.62  -1.62  -1.94  -1.94  -1.93
```

SPEI Program

```
Administrator: Command Prompt
Microsoft Windows [Version 6.1.7601]
Copyright (c) 2009 Microsoft Corporation.  All rights reserved.

C:\Users\bfuchs2>cd Jamaica
The system cannot find the path specified.

C:\Users\bfuchs2>cd Desktop

C:\Users\bfuchs2\Desktop>cd Jamaica

C:\Users\bfuchs2\Desktop\Jamaica>spei 3 Kingston_SPEI.txt Kingston_SPEI_test.txt


series: 783970
latitude: 17.590
initial date: 1/1973
seasonality: 12
471 registers
calculating SPEI at 3 months

C:\Users\bfuchs2\Desktop\Jamaica>
```

Time scale

Input file name

Output file name

Metadata showing the program did run

For the SPEI, the user will need to open a command prompt window and locate the directory that both the program and input files are located. For this example, I had the data on my "desktop" in a folder named "Jamaica". The output file will be placed in this same directory when it is created.

Sample Input/Output Files

input: name.txt format

```
789480
13.44
1973;9
12
0.0;29.0
156.5;28.2
0.0;28.0
80.3;26.5
56.1;26.3
0.0;27.0
0.0;26.8
0.0;27.1
0.0;27.8
0.0;28.4
0.0;29.1
0.0;28.7
0.0;28.5
0.0;28.0
0.0;27.9
0.0;26.8
0.0;26.3
0.0;26.1
0.0;26.6
0.0;27.0
0.0;27.9
0.0;28.6
0.0;28.7
0.0;28.9
0.0;28.6
0.0;27.6
0.0;27.2
0.0;26.0
0.0;26.2
0.0;25.4
0.0;25.9
0.0;26.8
0.0;27.6
0.0;27.4
0.0;27.8
0.0;28.1
0.0;28.3
0.0;28.0
0.0;27.9
0.0;26.0
0.0;26.6
0.0;26.8
4.1;27.1
0.0;27.2
0.0;27.8
7.9;28.5
0.0;28.4
0.0;28.4
0.0;28.4
0.0;27.8
```

Output: 6 month SPEI

HenwanorraApt_6SPEI - Notepad

File Edit Format View Help

```
789480
13.440000
1973;2
12
-1.267418
-1.106032
-1.395566
-1.205097
-1.553573
-1.727913
-1.731503
-1.693516
-1.752794
-1.801092
-1.844756
-1.788939
-1.707447
-1.766623
-1.772650
-1.825819
-1.688856
-1.656976
-1.722670
-1.697487
-1.748996
-1.777602
-1.797869
-1.747713
-1.625659
-1.608531
-1.553984
-1.522290
-1.424772
-1.417046
-1.514850
-1.560023
-1.662436
-1.720433
-1.772105
-1.755284
-1.707758
-1.792811
-1.824823
-1.901021
-1.761023
-1.674112
-1.680143
```

Any Questions ?

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