Weekly SPI Users Manual

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1. Introduction

The Standardized Precipitation Index (SPI) is a relatively new drought index based only on precipitation. The SPI can be used to monitor conditions on a variety of time scales. This temporal flexibility allows the SPI to be useful in both short-term agricultural and long-term hydrological applications. The weekly SPI program calculates Standardized Precipitation Index over a given period based on weekly average precipitation for that period. Currently these averages are read in from input files as explained in the **Input Files** section. The program outputs one file containing the actual SPI. The **Output Files** section explains the formats available for the file. The mathematics behind the SPI values and the methods used in determining the SPI are covered in the section entitled **Calculating SPI**.

2. Usage

At this time, the weekly SPI program allows only a limited number of options entered as flags on the command line. Table 1 outlines these flags and their uses.

Calibration Period: By default the probability function is calculated for the entire period of record. It is also possible to specify the period of time for which the probability distribution is calculated. This is useful for datasets that don't have identical period of records. The switches -bc and -ec specify the beginning and end of the calibration period; e.g.

```
spi -bc 1961 -ec 1990 12 <temp.dat
```

will use the 1961-1990 period for computing the distribution. SPI values will still be calculated for all the input data.

Table 1. Weekly SPI flag description.

-bc	The begin year of calibrate year.
-ec	The end year of calibrate year.
[length]…	One or more time scales are needed for the SPI values.
[in]	The input file.
[out]	The output file.

3. Usage Examples

These outputs are based on the samples given in the **Input Files** section. The order of the flags given does not matter.

List 3 6 9 and 12 month time scale values for data in in.dat:

Input(no flags):
> spi 3 6 9 12 < in.dat >out.dat
Output(in out.dat):

```
Calibration period=   0-9999   Lengths=  3   6   9  12
1921  4    1.01 -99.00 -99.00 -99.00
1921  5    0.90 -99.00 -99.00 -99.00
1921  6    1.25 -99.00 -99.00 -99.00
1921  7    0.23   0.78 -99.00 -99.00
1921  8    0.13   0.59 -99.00 -99.00
1921  9   -1.97   0.06 -99.00 -99.00
1921 10   -1.43  -0.92  -0.18 -99.00
1921 11   -1.32  -0.91  -0.46 -99.00
1921 12   -1.44  -2.54  -0.95 -99.00
```

4. Input Files

The input to the SPI program consists of one file for each station. The input file contains one single head line, this line may contains any character data; e.g. station name, latitude, longitude, etc. The head line is passed as-is to the output file. Following the header are the data records; each data record has three blank separated fields:

        yyyy ww prec
Where:
        yyyy : years; values > ENDYR and <BEGYR are skipped.
        ww   : 1-52 week numbers.
        prec : precipitation
Special codes:
        -99.00 = Missing

5. Output Files

The format of output file is a space delimitated format exactly like the input format. Each line contains year, week and index datas.

        yyyy ww prec1 ……
Where:
        yyyy   : years; values > ENDYR and <BEGYR are skipped.
        ww   : 1-52 week numbers.
        prec1 … : precipitation; it depends on the time scale parameters
                 in the command lines
Special codes:
        -99.00 = Missing

6. Calculating SPI

Computing of the SPI involves fitting a gamma probability density function to a given frequency distribution of precipitation totals for a climate station. The gamma distribution is defined by its frequency or probability density function:

$$g(x) = \frac{1}{\beta^{\alpha}\Gamma(\alpha)} \chi^{\alpha-1} e^{-x/\beta}$$

The alpha and beta parameters of the gamma probability density function are estimated for each station, for each time scale of interest(3 weeks,12 weeks, etc.), and for each week of the year. The maximum likelihood solutions are used to optimally estimate α and β:

$$\alpha = \frac{1}{4A}(1+\sqrt{1+\frac{4A}{3}})$$

$$\beta = \frac{\bar{x}}{\alpha}$$

    where:

$$A = \ln(\bar{x}) - \frac{\sum \ln(x)}{n}$$

$n =$ number of precipitation observations

The resulting parameters are then used to find the cumulative probability of an observed precipitation event for the given week and time scale for the station in question. The cumulative probability is given by:

$$G(x) = \int_0^x g(x)dx = \frac{1}{\beta^\alpha \Gamma(\alpha)} \int_0^x x^{a-1} e^{-x/\beta} dx$$

Letting $t = x/\beta$ the equation becomes the incomplete gamma function:

$$G(x) = \frac{1}{\Gamma(a)} \int_0^t t^{a-1} e^{-t} dt$$

Since the gamma function is undefined for x=0 and a precipitation distribution may contain zeros, the cumulative probability becomes:

$$H(x) = q + (1-q)G(x)$$

Where q is the probability of a zero. The cumulative probability H(x) is then transformed to the standard normal random variable Z with mean zero and variance of one, which is the value of the SPI.

$$Z = SPI = -(t - \frac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3}) \qquad \text{for } 0 < H(x) \le 0.5$$

$$Z = SPI = +(t - \frac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3}) \qquad \text{for } 0.5 < H(x) \le 1.0$$

Where:

$$t = \sqrt{\ln(\frac{1}{(H(x))^2})} \qquad \text{for } 0 < H(x) \le 0.5$$

$$t = \sqrt{\ln(\frac{1}{(1.0 - H(x))^2})} \qquad \text{for } 0.5 < H(x) \le 1.0$$

$$c_0 = 2.515517$$
$$c_1 = 0.802853$$
$$c_2 = 0.010328$$
$$d_1 = 1.432788$$
$$d_2 = 0.189269$$
$$d_3 = 0.001308$$

7. Bugs

Please send bug reports to dgov@rcf.unl.edu.