Palmer Drought Severity Index (PSDI and scPDSI)

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What is the PDSI ?

- A meteorological drought index developed in 1965 by Wayne Palmer to measure the *departure of the moisture supply*.
- 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.
- Developed for the United States and tested using the regional climates of the U.S.
- The objective of the PDSI was to provide measurements of moisture conditions that were standardized so that comparisons using the index could be made between locations and between months

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How the PDSI works

- Responds to both wet and dry conditions.
- 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 evapotranspiration, soil recharge, runoff, and moisture loss from the surface layer.
- Running the PDSI requires temperature, precipitation, and soils information

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How the PDSI works

- The PDSI does not consider human impacts on the water balance, such as irrigation.
- Palmer developed criteria for determining when a drought or a wet spell begins and ends, which adjust the PDSI accordingly.
- In near-real time, Palmer's index is no longer a meteorological index but becomes a hydrological index referred to as the Palmer Hydrological Drought Index (PHDI) because it is based on moisture inflow (precipitation), outflow, and storage, and does not take into account the long-term trend (Karl and Knight, 1985).

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How the PDSI works

- Typically computed monthly, but in modified versions, it can be computed on a weekly time-scale.

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Palmer Classifications

Palmer Classifications	
4.0 or more	extremely wet
3.0 to 3.99	very wet
2.0 to 2.99	moderately wet
1.0 to 1.99	slightly wet
0.5 to 0.99	incipient wet spell
0.49 to -0.49	near normal
-0.5 to -0.99	incipient dry spell
-1.0 to -1.99	mild drought
-2.0 to -2.99	moderate drought
-3.0 to -3.99	severe drought
-4.0 or less	extreme drought

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Using the PDSI

- The Palmer Index is popular and has been widely used for a variety of applications across the United States. It was the first drought index developed for the U.S.

- The PDSI is most effective in measuring impacts sensitive to soil moisture conditions, such as in agriculture production.

- The PDSI has also been useful as a drought monitoring tool and has been used to trigger actions associated with drought contingency plans.

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Why the PDSI is Popular

- The PDSI provides decision makers with a measurement of the abnormality of recent weather for a region.
- The PDSI provides an opportunity to place current conditions in historical perspective.
- The PDSI provides spatial and temporal representations of historical droughts.
- Datasets used in the U.S. have data back to 1895 used to calculate the PDSI.

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Drawbacks of the Palmer Drought Severity Index

- The values quantifying the intensity of drought and signaling the beginning and end of a drought or wet spell were arbitrarily selected based on Palmer's study of central Iowa and western Kansas and have little scientific meaning.
- The Palmer Index is sensitive to the available water content (AWC) of a soil type. Thus, applying the index for a climate division may be too general.
- The two soil layers within the water balance computations are simplified and may not be accurately representative of a location.
- Snowfall, snow cover, and frozen ground are not included in the index. All precipitation is treated as rain, so that the timing of PDSI or PHDI values may be inaccurate in the winter and spring months in regions where snow occurs.
- The natural lag between when precipitation falls and the resulting runoff is not considered. In addition, no runoff is allowed to take place in the model until the water capacity of the surface and subsurface soil layers is full, leading to an underestimation of runoff.
- Potential evapotranspiration is estimated using the Thornthwaite method. This technique has wide acceptance, but it is still only an approximation.

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Other limitations described over time by additional research

- PDSI is designed for agriculture but does not accurately represent the hydrological impacts resulting from longer droughts.
- The PDSI does not do well in regions where there are extremes in the variability of rainfall or runoff.
- The "extreme" and "severe" classifications of drought occur with a greater frequency in some parts of the country than in others (U.S.)
- "Extreme" droughts in the Great Plains occur with a frequency greater than 10%. This limits the accuracy of comparing the intensity of droughts between two regions and makes planning response actions based on a certain intensity more difficult.

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The Self-Calibrated Palmer Drought Severity Index (scPDSI)

- How is it different than the PDSI ?

The SC-PDSI automatically calibrates the behavior of the index at any location by replacing empirical constants in the index computation with dynamically calculated values.

What does "self calibrating" do ?

- By dynamically calculating the climate and duration factors, the overall effect of ***calibrating the index*** based on the actual characteristics of a given location means the conditions of any climate should be realistically represented by the index within the definition of the PDSI.

How the scPDSI improves upon the PDSI

- Through initial testing in various regions of the United States, the scPDSI shows that it is more spatially comparable than the PDSI, and reports extreme wet and dry conditions with *frequencies that would be expected for rare conditions.*

How the scPDSI improves upon the PDSI

- The range of the scPDSI values is close to an expected range of -5.0 to 5.0, where values below -4 and above 4 represent extreme conditions.
- The sensitivity of the index is based upon the local climate.
- Different sensitivity to moisture and lack of moisture.
- The scPDSI can be updated at different time intervals(e.g., weekly, biweekly, monthly, etc.).

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Derivatives of the PDSI

- Crop Moisture Index (CMI): Identifies potential agricultural droughts.

- The CMI was designed to evaluate *short-term* moisture conditions across major crop-producing regions of the United States. 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.

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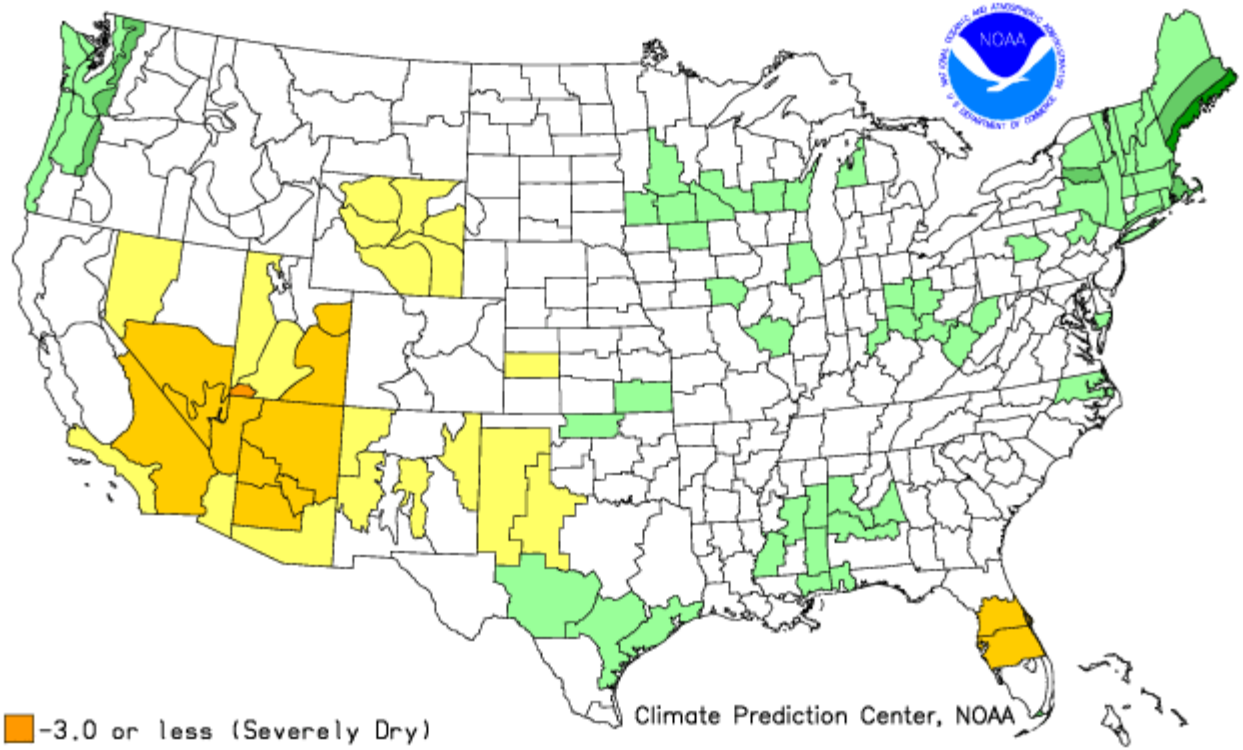
Crop Moisture Index by Division

Weekly Value for Period Ending MAY 12, 2012

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



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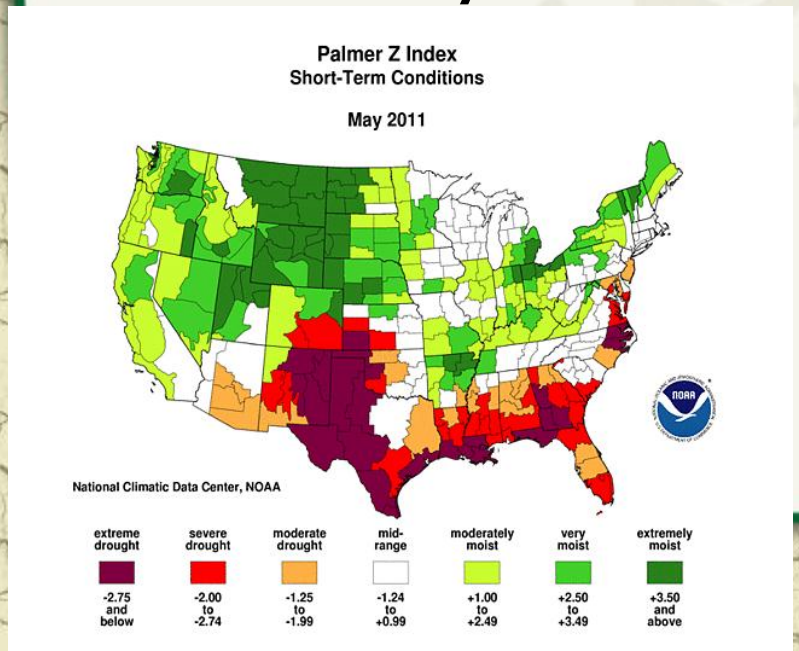
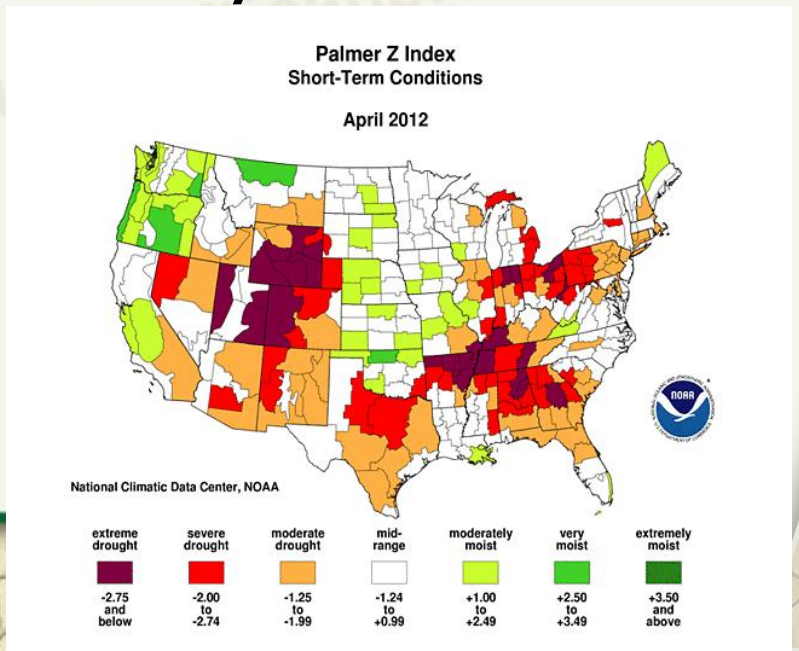
Derivatives of the PDSI

- Palmer Z Index: shows how monthly moisture (short-term) conditions depart from normal. Similar to the CMI, but on a monthly ~vs~ weekly time scale.





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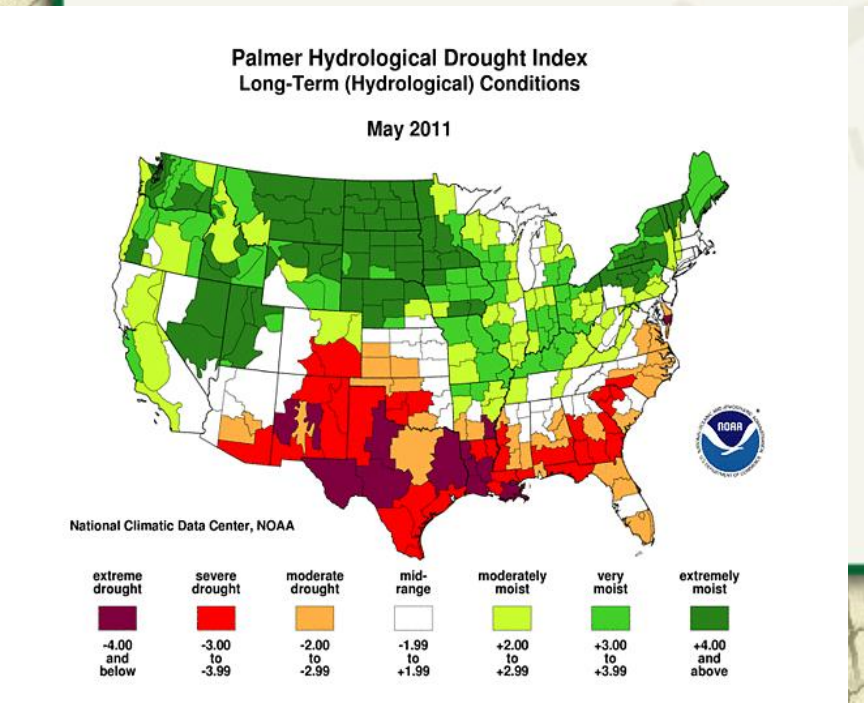
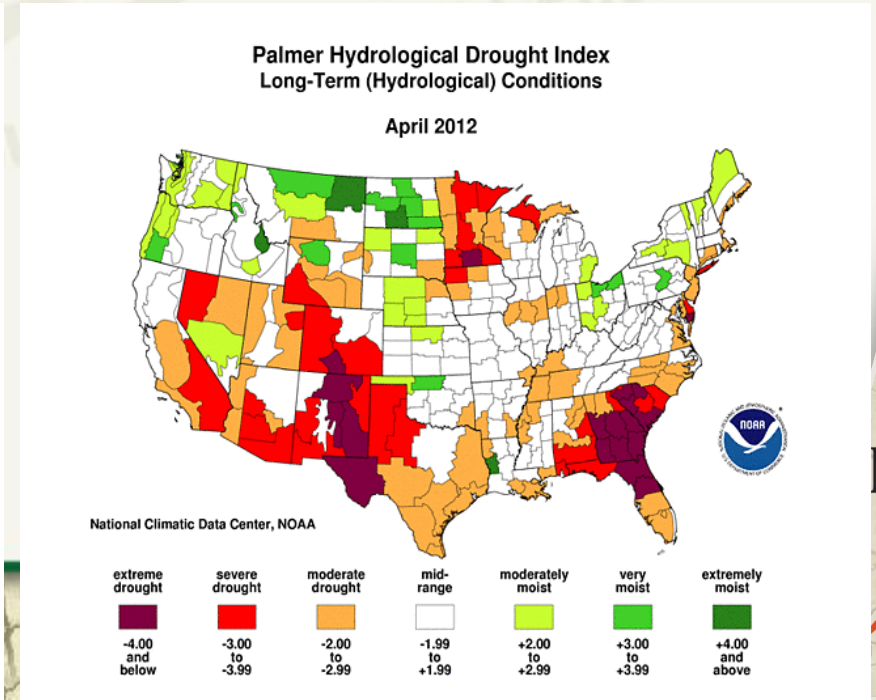
Derivatives of the PDSI

- Palmer Hydrological Drought Index (PHDI): Used to describe hydrological (long-term) drought and wet conditions. This will in turn reflect groundwater conditions, reservoir levels, etc.

- The PHDI responds more slowly to changing conditions than the PDSI.





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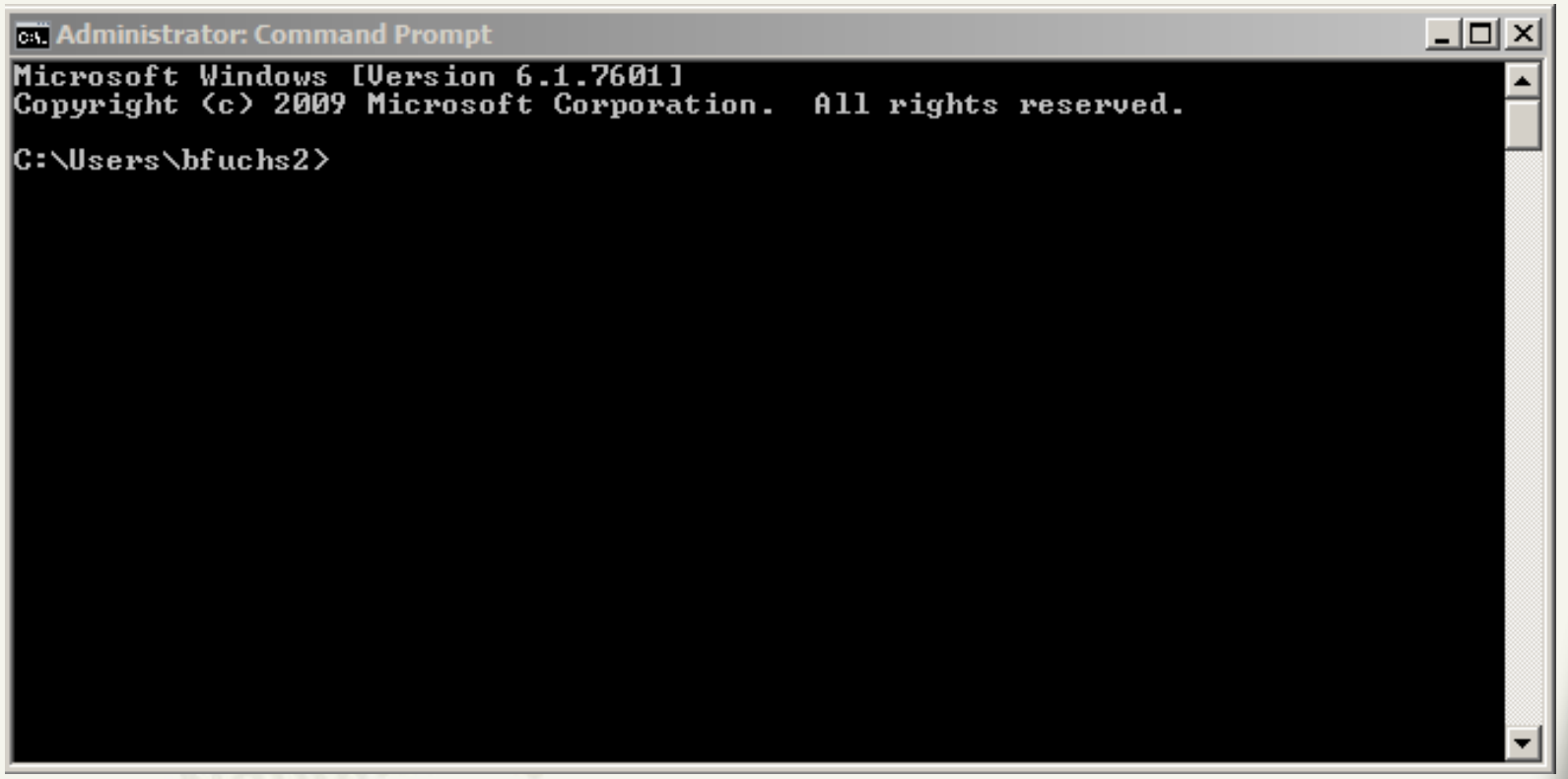
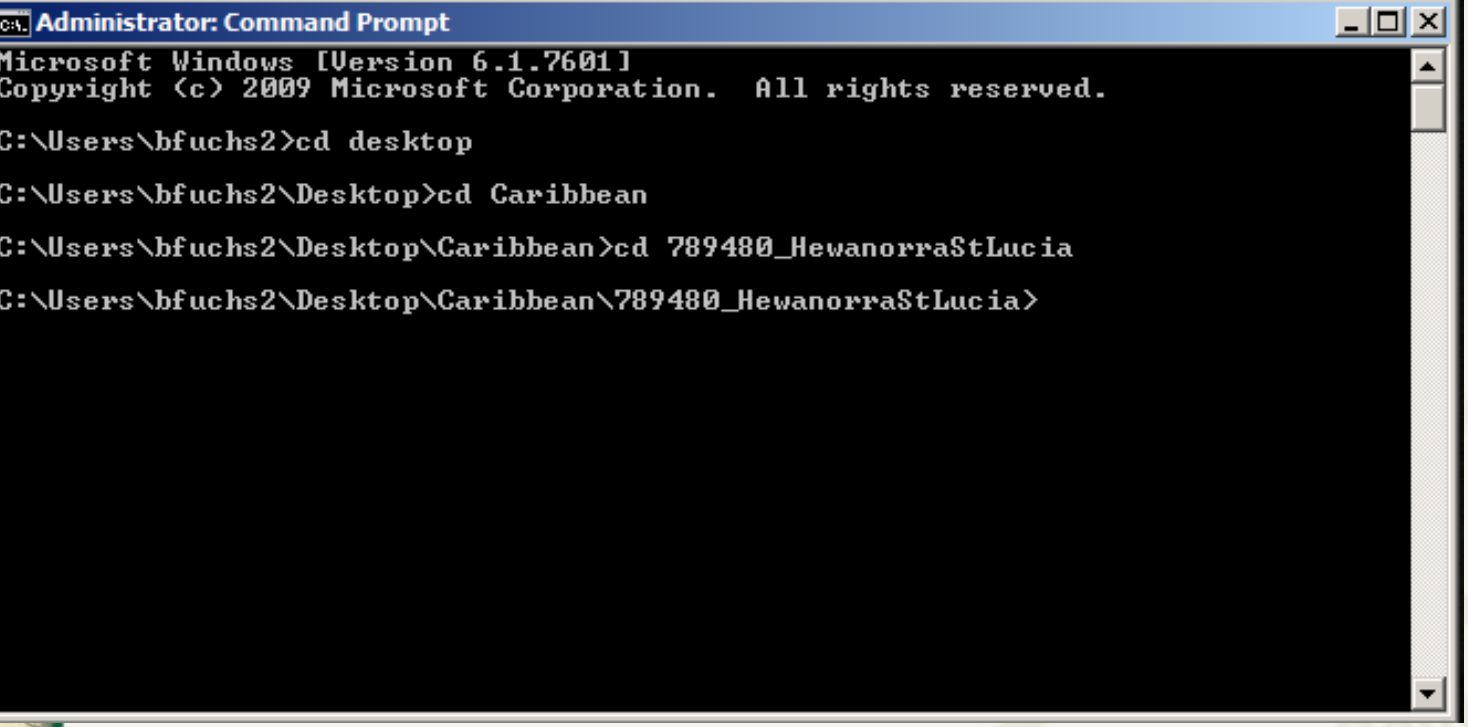
Running the PDSI and scPDSI





Locate the station data in the file structure. For the example, I had the information on my desktop. The program assumes that your file structure has “English” units, so we will have to tell it that we are using Metric units. (see the users manual)

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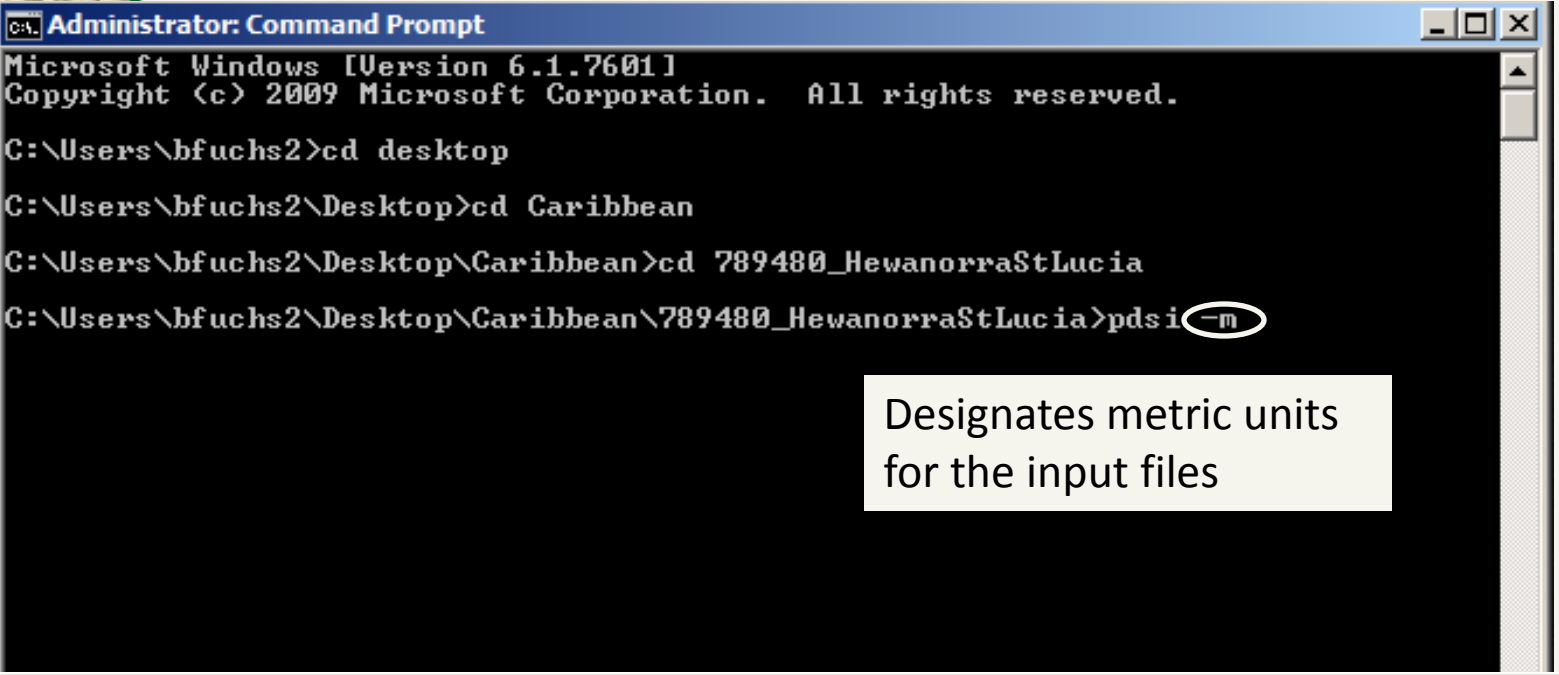

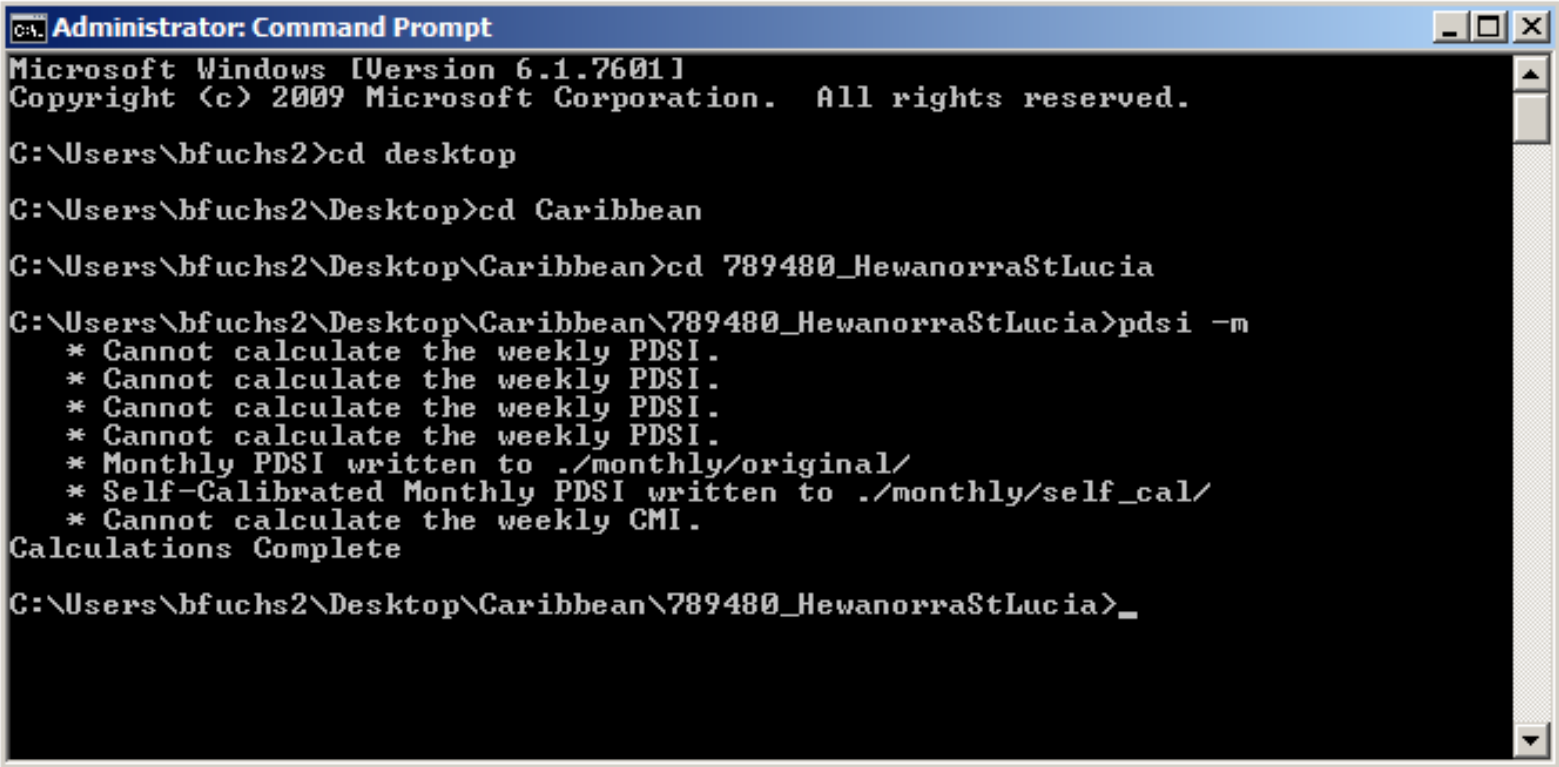

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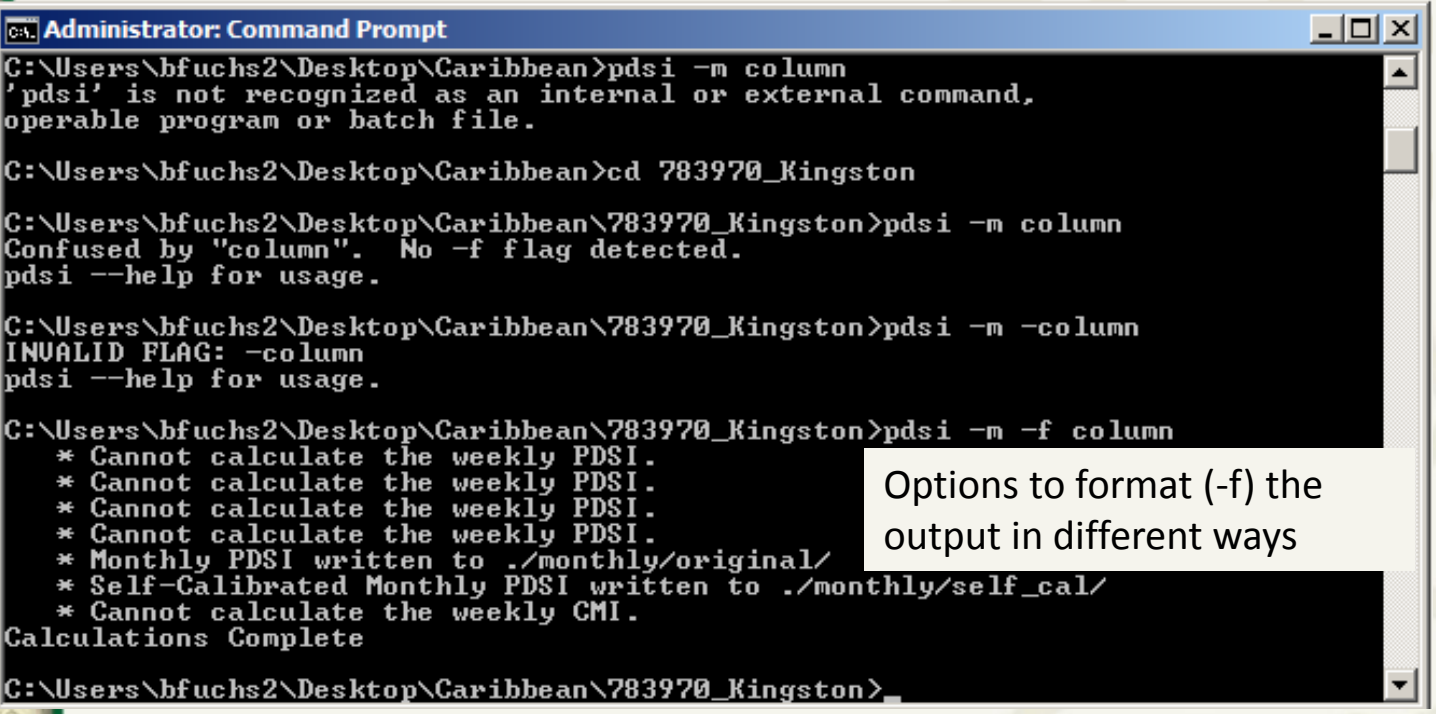

Options to format (-f) the output in different ways

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Any Questions ?

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