A Tool for Calculating the Palmer Drought Indices

User Manual

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Table of Contents

Preparation

Before the tool can be run, the proper files must be downloaded and the input data must be formatted correctly. In this section, the download materials are listed and described and an explanation of the proper input data arrangement is given.

Overview of Download Materials

When the zip file is downloaded, it should contain 19 files: 13 MATLAB files (with .m or .fig file extensions), 3 sample data files (with .txt files extensions), a User_Manual.txt file, this User_Manual.pdf file, and a README.txt file. This list of files, with descriptions, is below. For a full explanation of the order in which the MATLAB functions are called and the technical details of each function, please see Figures 1 and 2 in Jacobi et al. (2013).

MATLAB Files

- BackTrack.m
  - This function backtracks through previous PX1 and PX2 values. Backtracking occurs in two instances: (1) after the PPe reaches 100 and (2) when the PPe is zero. In either case, the backtracking function works by backtracking through PX1 and PX2 until reaching a month where PPe = 0. Either PX1 or PX2 is assigned to X as the backtracking progresses.

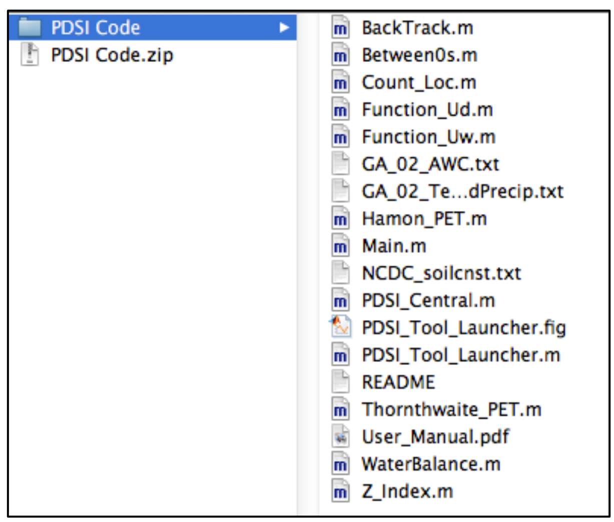


Figure 1: Files included in tool download

- Between0s.m
  - Established dry and wet spells are indicated by PPe = 0, and abatement of such spells are signified by 0 < PPe < 100. Frequently a possible abatement of an established spell is interrupted by a return to dry or wet conditions, without the spell having ended, and this is indicated by a return of PPe = 0. In such instances – i.e., when non-zero, non-one hundred PPe values occur between values of PPe = 0 – this function is called. See Alley (1984) for a more complete explanation.

- Count_Loc.m
  - This is an indexing function that counts the number of locations for which the PDSI is being calculated and logs the beginning and end of each location’s data record.
- Function_Ud.m
  - Called when there is an established wet spell, this function calculates the PPe value for a given month and then either checks for backtracking opportunities or continues through the code.
- Function_Uw.m
  - Called during an established drought, this function calculates the PPe value for a given month and then either checks for backtracking opportunities or continues through the code.
- Hamon_PET.m
  - Hamon_PET.m is a function file that calculates the monthly potential evapotranspiration (PET) using the Hamon method (Hamon, 1963). Latitude is required as an input to calculate the average monthly solar insolation. The average monthly solar insolation and temperature are then used to calculate the monthly potential evapotranspiration.
- Main.m
  - This function calculates PX1 and PX2 and calls the backtracking loop. If the absolute value of PX1 or PX2 exceeds 1, that value becomes the new PX3.
- PDSI_Tool_Launcher.m
  - Running this file opens the graphical user interface (GUI), thus launching the tool.
- PDSI_Tool_Launcher.fig
  - This file contains the supporting image for the GUI.
- PDSI_Central.m
  - This function is the central component of the PDSI calculations. All sub-functions are called from PDSI_Central.m, and once calculations are complete, the PDSI and PHDI values are finalized and tabulated in this function.
- Thornthwaite_PET.m
  - The Thornthwaite_PET function calculates the potential evapotranspiration using Thornthwaite's method (Thornthwaite et al., 1944; Thornthwaite, 1948; Thornthwaite and Mather, 1955 and 1957).

- WaterBalance.m
  - This function calculates the Thornthwaite water balance using inputs from the PET function and user-loaded precipitation data.
- Z_Index.m
  - This function calculates Palmer's Z index using inputs from the water balance function.

Sample Data and Support Files

- GA_02_AWC.txt
  - This file contains the Available Water Content (AWC) value for the second Georgia climate division. A list of AWC values for U.S. climate divisions can be found in the NCDC_soilcnst.txt file. This file is provided as an example and can be used to test the tool upon download.
- GA_02_TempAndPrecip.txt
  - This file contains temperature and precipitation data for the second Georgia climate division. The first column is the latitude of the division at its centroid (degrees), the second is the year, the third is temperature (°F), and the fourth is precipitation (in.). This file is provided as an example and can be used to test the tool upon download.
- NCDC_soilcnst.txt
  - This file contains the climate division information needed to accurately replicate the NCDC calculations of PDSI. The first column is the climate division number, the second column is the AWC value for that division, the third column is the B value (which is the NCDC equivalent of Thornthwaite's PET exponent, *a*, the fourth column is the climate division heat index, and the fifth column is the negative tangent of the latitude at the centroid of the division.
- User_Manual.txt
  - This is an abridged version of this User Manual any users who may not have the software required to open PDFs.
- User_Manual.pdf
  - This document.
- README.txt
  - Contains the file descriptions above in a .txt file .

Data Inputs

Five data inputs are needed to successfully run the PDSI tool. The types of data needed, and their structure, are explained in this section.

Data Types and Data File Arrangement

The data should be separated into two text files (Table 1). One file should contain only the AWC values. The second file should contain latitude, year, temperature, and precipitation. Neither file should have any column headings. If the user is calculating the PDSI for more than one location, the order of the locations must be consistent between the AWC file and the temperature and precipitation file.

Table 1: Data Type and Arrangement

Data Type	Frequency	Units	File Arrangement
Available Water Content (AWC)	1 per station	Inches	File 1
Latitude	1 every month	Degrees	File 2: 1st column
Year	1 every month	Four-digit years	File 2: 2nd column
Temperature	1 every month	Fahrenheit	File 2: 3rd column
Precipitation	1 every month	Inches	File 2: 4th column

34.35	1895	38.5	5.62
34.35	1895	33	1.49
34.35	1895	50	6.53
34.35	1895	60.7	3.91
34.35	1895	67.2	3.26
34.35	1895	77.2	3.04
34.35	1895	78.5	4.47
34.35	1895	79.2	2.58
34.35	1895	76.8	2.01
34.35	1895	56	2
34.35	1895	50.4	2.68
34.35	1895	43.4	4.17
34.35	1896	41	2.85
34.35	1896	43.9	5.78
34.35	1896	47.9	6.02
34.35	1896	66.8	4.65
34.35	1896	74.2	3.25

Figure 2A.) Sample T and P file

34.35	2011	69.1	6.57
34.35	2011	57.7	1.45
34.35	2011	53.1	4.92
34.35	2011	45.5	6.86
33.25	1895	50.5	2.04
33.25	1895	56.9	0.19
33.25	1895	68.4	0
33.25	1895	70.8	0
33.25	1895	79.4	0
33.25	1895	85.2	0.07
33.25	1895	90.3	0.31
33.25	1895	91.2	0.63

Figure 2B.) Sample T and P file with transition from one location to another

6
7
8
6
7

Figure 2C.) Sample AWC file with matching T and P files

Figures 2A, 2B, and 2C above are sample data files. Figure A shows a piece of the record for a location with a latitude of 34.35°. Notice there is a year and latitude for every entry. Figure B shows how data for more than one location (Location 1 in blue, Location 2 in red) should be handled. Note the change in latitude in the fifth line. Figure C shows the AWC input file for a run of five locations. The order of locations in the AWC file should be the same as the order of locations in the temperature and precipitation file (i.e. the AWC value for the blue location should be listed before the AWC value for the red location since that is the order of the temperature and precipitation file).

Data Details in Brief

Temperature and Precipitation File	Available Water Content File
■ Data must be consecutive (i.e., no gaps) and combined into one .txt file. Do not include column headers. ■ Data should be chronologically organized into four columns: Column 1 is the latitude in degrees, Column 2 is the year, Column 3 is temperature, and Column 4 is precipitation. ■ Note that each temperature and precipitation observation must have a latitude and a year associated with it. ■ If there are data for multiple locations, make sure that the temperature and precipitation data are arranged in the same order as the AWC data. ■ Temperature and precipitation data should be input into the program in degrees Fahrenheit and inches, respectively.	■ Different locations have different field capacities. One AWC value (in inches) for each location must be loaded into the program in one text file. ■ AWC data should be organized in a single column in one .txt file. The AWCs should be organized in the same location order as the temperature and precipitation data. ■ Note that only one AWC value is needed per location (i.e. the number of AWC values must equal the number of stations). ■ AWC data should be input into the program in inches. ■ AWC values for US climate divisions are included in the NCDC_soilcnst.txt file in the download materials.

Operation

This section provides instruction on operating the tool. Details of proper placements of files, tool operation specifics, including running the code in a way that matches the NCDC code, and tool output are discussed.

File Placements

MATLAB can be very strict about working folders and file locations. In order for the tool to run smoothly, please adhere to the directions below

MATLAB Scripts

When the tool is downloaded, all the necessary MATLAB scripts will be in one folder. All the scripts (including the .fig file) have to be in the same folder for the tool to run properly. The un-zipped folder can be used as the working folder, or the scripts can be moved to another folder that will serve as the working folder. Just be sure that whatever folder is used contains all the downloaded scripts and the .fig file.

When running the tool, the folder that contains the scripts must be the "Current Folder" that appears on the left side of the MATLAB screen (Figure 3).

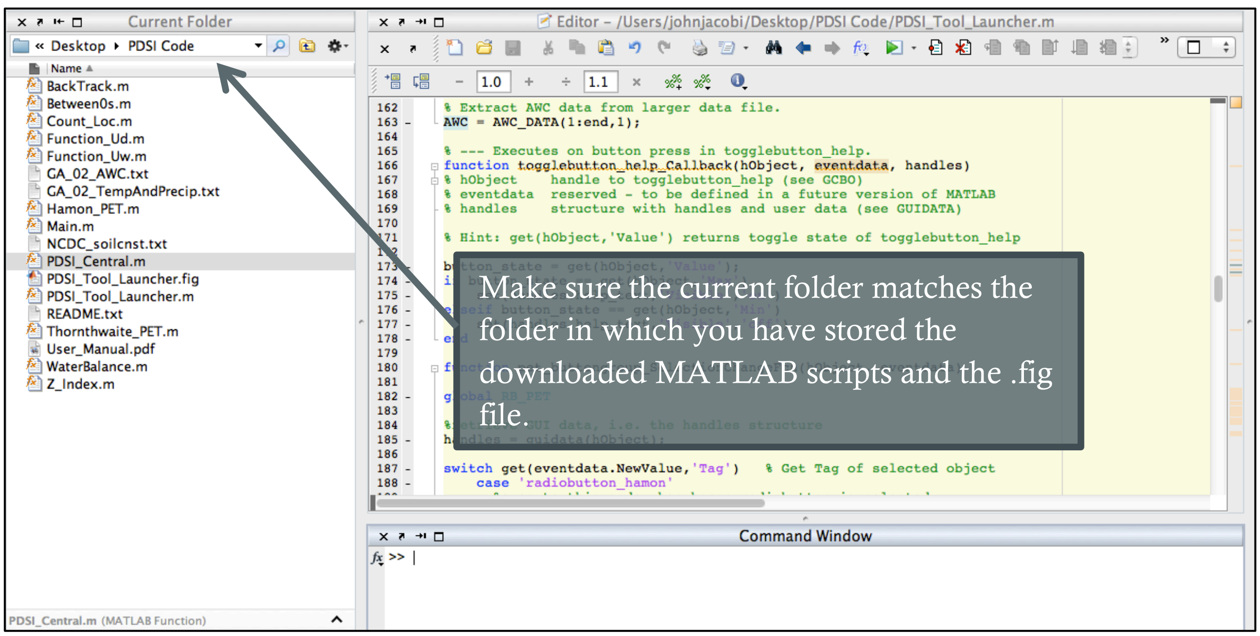
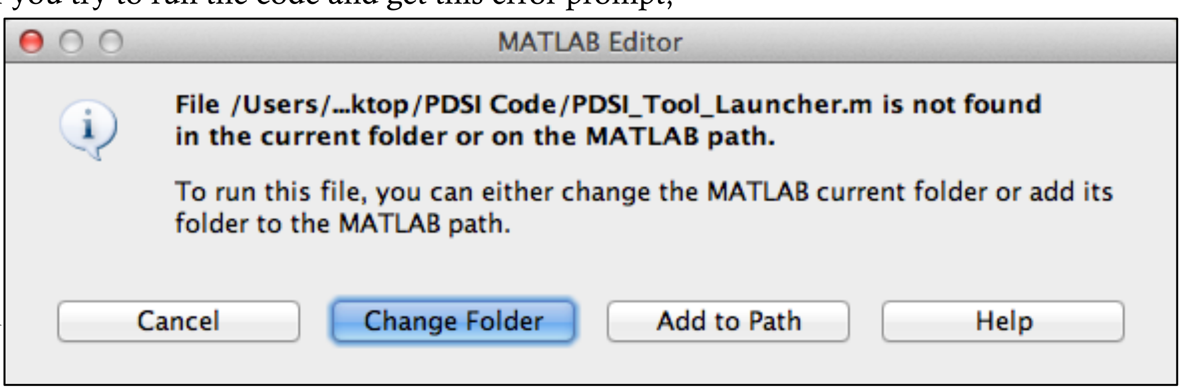


Figure 3: Sample MATLAB screen that shows proper "Current Folder"

If you try to run the code and get this error prompt,



, be sure to select the “Change Folder” button instead of the “Add to Path”.

Data Files

Data files can be stored in any folder and do not necessarily need to be stored in the working folder. The data import tools allow for navigation to different folders when importing data. However, if the user experiences any difficulties, the data can be moved to the working folder to avoid any potential problems.

Running the Tool

This section provides step-by-step directions for running the tool, details on the help menu, and an explanation of the different options available to the user.

Step by Step Directions

1. Download the tool and place all MATLAB scripts and the .fig file in the same folder.
2. Open MATLAB and make sure the Current Folder is the folder in which you have placed the MATLAB scripts.
3. If for some reason the user is unable to navigate to the folder, MATLAB can be opened by right-clicking on the PDSI_Tool_Launcher.m file and selecting “Open with MATLAB”.
4. Once in MATLAB and in the proper working folder, open the PDSI_Tool_Launcher.m file.
5. Press the run () button. The tool GUI will open.
6. Click on the “Load AWC Data” button.
7. Navigate to the folder in which the user has stored his or her AWC data file.
8. Select the AWC data file and hit open.
9. The preview screen should open. If the data looks correct, press “Next”.
10. Press “Finish” on the next screen. Do not click on any of the other buttons.

11. A confirmation that the AWC data were loaded successfully should have appeared in the command window.
12. Click on the "Load Temperature and Precipitation Data" button.
13. Repeat steps 7 – 11 for the temperature and precipitation data. A confirmation that the data were loaded properly should appear when complete.
14. If a mistake is made while loading the data, X out of the entire GUI and begin the process again from Step 4.
15. Select the desired PET calculation method. The default is the Thornthwaite method.
16. Select the desired calibration period. The default is the NOAA (1931-1990) option.
17. Hit the "Run" button.
18. When the tool is finished running, a confirmation message will appear in the command window. The output file, Palmer.txt, will have appeared in the working folder.

Help Menu

The tool has a built in help menu. To access the help menu, hit the "Help" button when in the GUI. To exit the help menu, hit the "Help" button again.

Explanation of Different Options

Different calculation options are provided to the user for exploratory work or for when the user has a data record that does not encompass the NOAA calibration period.

PET Equations

Two PET calculation methods are offered: Thornthwaite and Hamon. For details on the Thornthwaite method used, please see (Thornthwaite et al., 1944; Thornthwaite, 1948; Thornthwaite and Mather, 1955 and 1957). For details on the Hamon method, please see Hamon (1963).

The Thornthwaite method was used by Palmer when the PDSI was first developed. The Hamon method has similar data requirements and was included to allow for exploratory analysis.

Calibration Period

The calibration period is used to calculate the "Climatologically Appropriate for Existing Conditions" (CAFEC) precipitation for a location. The CAFEC is used to calculate weighting factors used in the Z-Index calculation (see Palmer, 1965). NOAA uses the period January 1931 to December 1990 as its calibration period (see Karl, 1986), and this option is provided. In the absence of long data records or to use a more comprehensive timespan, the option is also provided to use the full record as the calibration period.

Running the NCDC Option

This tool uses a slightly different calculation method than the code provided by the NCDC. For a full explanation of the two differences between the two codes, please see Jacobi et al. (2013). For those users who are interested in calculating the PDSI using the NCDC method, the tool provides that option. While no option is provided in the GUI, the user can easily change the code so that either or both of the differences are implemented in the code. Directions for each are below.

Water Balance Equation

The equation to be changed can be found at Line 298 in the WaterBalance.m file. To run the code with the equation used by NCDC in their FORTRAN code prior to April 2013, follow the directions below. To comment out a line in MATLAB, place a % sign at the beginning of the line. To uncomment a line, remove the % sign.

1. Comment out Line 298 in WaterBalance.m.

2. Uncomment Line 301 in WaterBalance.m.

Modified Thornthwaite Equation

Running the modified Thornthwaite equation **can only be done for U.S. climate divisions** due to reliance on tabulated input values for variables in the equation. These input values are provided in the NCDC_soilcnst.txt file included in the download materials and are described on page 3 of this user manual.

Before the tool can be run using the modified Thornthwaite equation, the NCDC_soilcnst.txt file must be changed to match the user's input data. To do so, follow the steps below.

1. Delete any data rows for climate divisions for which the PDSI is NOT being calculated.

2. Rearrange the rows so that the order of the divisions matches of the order in the temperature and precipitation and AWC input files.

3. Make sure the NCDC_soilcnst.txt file is in the same folder as the MATLAB scripts. The tool will not work if this is not done.

Once the input file has been changed and is in the proper folder, follow the directions below to change the code in order to use the modified Thornthwaite equation.

1. Uncomment Lines 195 – 260 in Thornthwaite_PET.m.
2. If the user is running many divisions through the tool, Lines 201 – 208 may be moved above Line 59 to improve the efficiency of the code.
3. Comment out Lines 82 – 191 in Thornthwaite_PET.m.
4. Be sure the Thornthwaite PET method is selected in the GUI when running the tool.

Outputs

Once the tool is finished running, an output file, Palmer.txt, will appear in the current folder in MATLAB (Figure 4). If running the tool multiple times, be sure to either move or change the name of the output file as it will get overwritten during successive runs.

Latitude	Year	PET	Z-Index	PPe	PX1	PX2	PX3	X	PDSI	PHDI
34.3000	1895	0.2473	2.5582	0.0000	0.8527	0.0000	0.0000	0.8527	0.8527	0.8527
34.3000	1895	0.0088	-2.1396	0.0000	0.0517	-0.7132	0.0000	0.0517	0.0517	0.0517
34.3000	1895	1.1542	1.4039	0.0000	0.5144	-0.1718	0.0000	0.5144	0.5144	0.5144
34.3000	1895	2.2859	0.6853	0.0000	0.6898	0.0000	0.0000	0.6898	0.6898	0.6898
34.3000	1895	3.5694	0.6020	0.0000	0.8194	0.0000	0.0000	0.8194	0.8194	0.8194
34.3000	1895	5.4137	0.1862	0.0000	0.7971	0.0000	0.0000	0.7971	0.7971	0.7971
34.3000	1895	5.6689	0.2700	0.0000	0.8050	0.0000	0.0000	0.8050	0.8050	0.8050
34.3000	1895	5.4543	4.0350	0.0000	0.0000	0.0000	2.0671	2.0671	2.0671	2.0671
34.3000	1895	4.5607	-1.4452	39.2661	0.0000	-0.4817	1.3725	-0.4817	-0.4817	1.3725
34.3000	1895	1.6653	-0.7809	66.6760	0.0000	-0.6924	0.9708	-0.6924	-0.6924	0.9708
34.3000	1895	0.9251	-1.7099	100.0000	0.0000	0.0000	-1.1910	-1.1910	-1.1910	-1.1910
34.3000	1895	0.3949	-0.8975	0.0000	0.0000	0.0000	-1.3675	-1.3675	-1.3675	-1.3675
34.3000	1896	0.2510	-1.3617	0.0000	0.0000	0.0000	-1.6805	-1.6805	-1.6805	-1.6805
34.3000	1896	0.3903	0.6493	26.4466	0.2164	0.0000	-1.2910	-1.2910	-1.2910	-1.2910
34.3000	1896	0.8932	-0.8079	5.0992	0.0000	-0.2693	-1.4273	-1.4273	-1.4273	-1.4273
34.3000	1896	3.0075	-1.6356	0.0000	0.0000	0.0000	-1.8255	-1.8255	-1.8255	-1.8255
34.3000	1896	4.8970	-1.6916	0.0000	0.0000	0.0000	-2.2014	-2.2014	-2.2014	-2.2014
34.3000	1896	5.1513	-2.0164	0.0000	0.0000	0.0000	-2.6468	-2.6468	-2.6468	-2.6468
34.3000	1896	6.0199	1.7136	33.1452	0.5712	0.0000	-1.8030	-1.8030	-1.8030	-1.8030
34.3000	1896	5.9238	-2.5009	0.0000	0.0000	0.0000	-2.4509	-2.4509	-2.4509	-2.4509
34.3000	1896	3.9977	-1.5883	0.0000	0.0000	0.0000	-2.7279	-2.7279	-2.7279	-2.7279
34.3000	1896	1.8384	-1.0294	0.0000	0.0000	0.0000	-2.7900	-2.7900	-2.7900	-2.7900
34.3000	1896	1.0985	1.3214	24.4916	0.4405	0.0000	-2.0622	-2.0622	-2.0622	-2.0622
34.3000	1896	0.3070	-2.3811	0.0000	0.0000	0.0000	-2.6435	-2.6435	-2.6435	-2.6435
34.3000	1897	0.1796	-1.5407	0.0000	0.0000	0.0000	-2.8848	-2.8848	-2.8848	-2.8848
34.3000	1897	0.5559	0.4155	9.0294	0.1385	0.0000	-2.4492	-2.4492	-2.4492	-2.4492
34.3000	1897	1.4350	3.1390	68.1459	1.1706	0.0000	-1.1506	-1.1506	-1.1506	-1.1506
34.3000	1897	2.1337	0.2787	78.5805	1.1429	0.0000	-0.9392	-0.9392	-0.9392	-0.9392
34.3000	1897	3.4629	-1.8403	48.8248	0.4117	-0.6134	-1.4559	-1.4559	-1.4559	-1.4559
34.3000	1897	5.7354	-1.1952	30.8887	0.0000	-0.9486	-1.7043	-1.7043	-1.7043	-1.7043
34.3000	1897	5.9870	-0.2279	31.7187	0.0000	-0.9268	-1.6047	-1.6047	-1.6047	-1.6047
34.3000	1897	5.1942	0.0739	39.4979	0.0246	-0.8067	-1.4148	-1.4148	-1.4148	-1.4148
34.3000	1897	4.0465	-3.0465	0.0000	0.0000	0.0000	-2.2846	-2.2846	-2.2846	-2.2846

Figure 4: A sample portion of the output file, Palmer.txt.

The full details of the output variables are available in Palmer (1965) and Alley (1984). The output units for PET are inches.

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