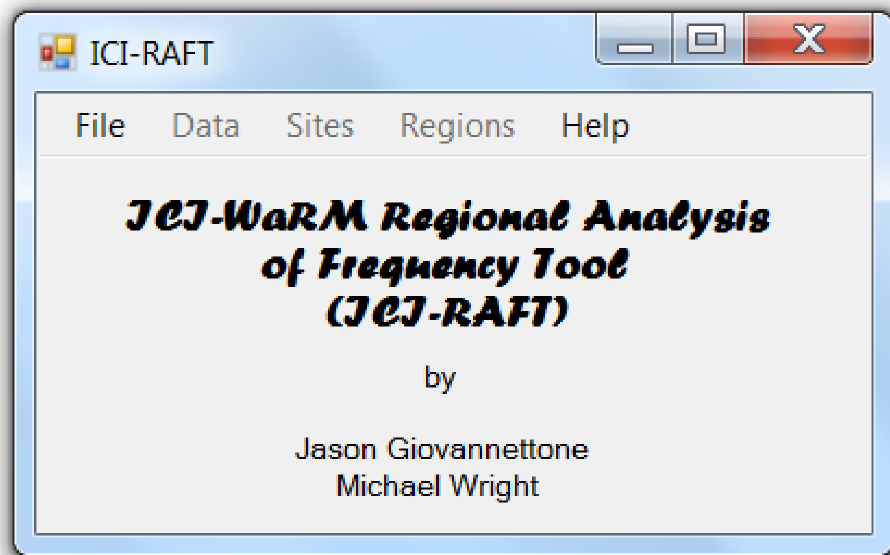
ICI-WaRM Regional Analysis of Frequency Tool (ICI-RAFT)



by

Jason Giovannettone & Michael Wright

Institute for Water Resources (IWR)

United States Army Corps of Engineers (USACE)

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I. INTRODUCTION

Welcome to the International Center for Integrated Water Resources, ICIWaRM's Regional Analysis of Frequency Tool (ICI-RAFT). The tool walks the user through the methodology outlined by Hosking and Wallis in their 1997 book 'Regional Frequency Analysis: An Approach Based on L-Moments' through the medium of a free, stand-alone Visual Basic executable file; in addition, there are some other added features throughout the program. Mapping techniques and other advances made in the field since 1997 will be included in future versions of the program, along with other enhancements in response to user requests.

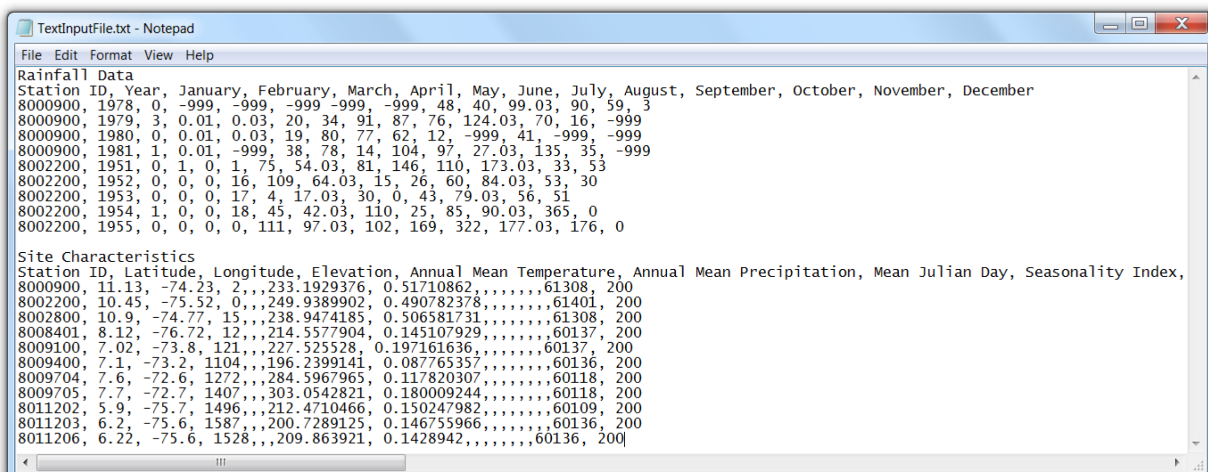
In addition to writing the aforementioned book, Hosking and Wallis have provided a repository of Fortran-77 source code in order to enable regional frequency calculations using L-moments, including regionalization algorithms and distribution fitting routines, at http://lib.stat.cmu.edu/general/lmoments. We thank the authors, Carnegie Mellon University and the IBM Research Division for providing this code, which served as a source of validation and inspiration as the code was written for this program.

Input Data Entry

The first step is to enter your quality-controlled data into the input file template, which can be either a text file (.txt) or an Excel spreadsheet (.xls or .xlsx), both with simple, but specific, formats. An example of a text input file is shown in Fig. 1. There are two sections of input, one for the **Rainfall Data** itself followed by a section where known **Site Characteristics** are given, e.g. mean annual precipitation, elevation, longitude and latitude. The two-row headers seen above each of the two sections in Fig. 1 must be maintained for the program to read the file. All data values in both sections are separated by commas and must be given in the order as indicated in the second header line of each section. The form (and the program in general) does not consider units of precipitation (mm, in, etc.) in the **Rainfall Data** section, only the numbers entered by the user, meaning that users must ensure that all sites' data are entered in the same units. Similarly, the user is not required to provide unit information in **Site Characteristics,** but all values in a column are assumed to have the same units.

The Excel input file contains two sheets: **Rainfall Data** (Fig. 2a) contains the monthly precipitation values to be analyzed, and **Site Characteristics** (Fig. 2b) holds the site characteristics. A one-row header must be maintained on the top row of each sheet for the program to read the file. As in the text file, the form (and the program in general) does not consider units of precipitation (mm, in, etc.), only the numbers entered by the user, meaning that users must ensure that all sites' data are entered in the same units. Similarly, the user is not required to provide unit information in **Site Characteristics,** but all values in a column are assumed to have the same units.

In both types of input files, the **Rainfall Data** sections (Figs. 1 & 2a) contain each Site ID as the first value/column, whereas the second value/column contains each year for each site. As the user moves along a single row for a particular site and year, monthly values of total precipitation are entered. If a particular monthly total is not known or is known to be incorrect, then "-999" is entered. If any value or cell is left blank, an error will occur when running ICI-RAFT.



TextInputFile.txt - Notepad

File Edit Format View Help

```
Rainfall Data
Station ID, Year, January, February, March, April, May, June, July, August, September, October, November, December
8000900, 1978, 0, -999, -999, -999 -999, -999, 48, 40, 99.03, 90, 59, 3
8000900, 1979, 3, 0.01, 0.03, 20, 34, 91, 87, 76, 124.03, 70, 16, -999
8000900, 1980, 0, 0.01, 0.03, 19, 80, 77, 62, 12, -999, 41, -999, -999
8000900, 1981, 1, 0.01, -999, 38, 78, 14, 104, 97, 27.03, 135, 35, -999
8002200, 1951, 0, 1, 0, 1, 75, 54.03, 81, 146, 110, 173.03, 33, 53
8002200, 1952, 0, 0, 0, 16, 109, 64.03, 15, 26, 60, 84.03, 53, 30
8002200, 1953, 0, 0, 0, 17, 4, 17.03, 30, 0, 43, 79.03, 56, 51
8002200, 1954, 1, 0, 0, 18, 45, 42.03, 110, 25, 85, 90.03, 365, 0
8002200, 1955, 0, 0, 0, 0, 111, 97.03, 102, 169, 322, 177.03, 176, 0

Site Characteristics
Station ID, Latitude, Longitude, Elevation, Annual Mean Temperature, Annual Mean Precipitation, Mean Julian Day, Seasonality Index,
8000900, 11.13, -74.23, 2,,,233.1929376, 0.51710862,,,,,,,,61308, 200
8002200, 10.45, -75.52, 0,,,249.9389902, 0.490782378,,,,,,,,61401, 200
8002800, 10.9, -74.77, 15,,,238.9474185, 0.506581731,,,,,,,,61308, 200
8008401, 8.12, -76.72, 12,,,214.5577904, 0.145107929,,,,,,,,60137, 200
8009100, 7.02, -73.8, 121,,,227.525528, 0.197161636,,,,,,,,60137, 200
8009400, 7.1, -73.2, 1104,,,196.2399141, 0.087765357,,,,,,,,60136, 200
8009704, 7.6, -72.6, 1272,,,284.5967965, 0.117820307,,,,,,,,60118, 200
8009705, 7.7, -72.7, 1407,,,303.0542821, 0.180009244,,,,,,,,60118, 200
8011202, 5.9, -75.7, 1496,,,212.4710466, 0.150247982,,,,,,,,60109, 200
8011203, 6.2, -75.6, 1587,,,200.7289125, 0.146755966,,,,,,,,60136, 200
8011206, 6.22, -75.6, 1528,,,209.863921, 0.1428942,,,,,,,,60136, 200
```

Figure 1: Example of a text input file.

	Site	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2	8000900	1952	-999	-999	-999	-999	-999	3	2	3	84.03	4.03	0	1
3	8000900	1953	0	0.01	0.03	0	0	2	0	2	1.03	9.03	0	0
4	8000900	1954	0	0.01	0.03	0	4	22	1	2	61.03	3.03	27	0
5	8000900	1955	0	0.01	0.03	0	2	0	13	25	4.03	-999	0	0
6	8000900	1956	0	0.01	0.03	0	1	1	0	1	0.03	1	1	0
7	8000900	1957	0	0.01	1.03	0	53	9	8	13	57.03	22	0	0
8	8000900	1958	0	0.01	0.03	0	121	7	50	36	0.03	16	0	0
9	8000900	1959	0	0.01	0.03	0	6	26	2	1	5.03	21	0	0
10	8000900	1960	0	0.01	0.03	8	16	54	50	-999	31.03	55	34	3
11	8000900	1961	0	0.01	0.03	4	0	67	78	5	30.03	-999	-999	-999
12	8000900	1962	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
13	8000900	1963	0	18.01	0.03	0	0	1	13	1	25.03	72	82	0
14	8000900	1964	0	0.01	0.03	25	2	51	204.01	60	144.03	71	83	0
15	8000900	1965	-999	-999	-999	-999	-999	3	0	40	43.03	75	110	0
16	8000900	1966	0	0.01	5.03	1	18	104	40	8	21.03	89	26	27.02
17	8000900	1967	0	0.01	0.03	0	1	67	31	6	75.03	38	38	0
18	8000900	1968	0	0.01	0.03	5	11	94	17	17	4.03	-999	9	0
19	8000900	1969	0	0.01	6.03	36	1	79	1	107	62.03	33	96	0
20	8000900	1970	59.01	0.01	2.03	26	124	115	161	73	95.03	14	109	9.02
21	8000900	1971	15	0.01	0.03	4	36	30	6	-999	-999	-999	-999	0
22	8000900	1972	0	0.01	0.03	0	0	45	0	15	43.03	111	4	0
23	8000900	1973	0	1	0.03	5	16	23	166	81	97.03	295	56	0
24	8000900	1974	0	1	1.03	0	101	130	57	32	103.03	150	69	1
25	8000900	1975	0	0.01	6.03	0	3	51	144	54	59.03	153	60	24.02
26	8000900	1976	0	0.01	0.03	1	2	42	2	75	23.03	68	40	0
27	8000900	1977	24.01	0.01	0.03	0	73	127	6	63	147.03	31	12	0
28	8000900	1978	0	-999	-999	-999	-999	-999	48	40	99.03	90	59	3
29	8000900	1979	3	0.01	0.03	20	34	91	87	76	124.03	70	16	-999
30	8000900	1980	0	0.01	0.03	19	80	77	62	12	-999	41	-999	-999
31	8000900	1981	1	0.01	-999	38	78	14	104	97	27.03	135	35	-999
32	8002200	1951	0	1	0	1	75	54.03	81	146	110	173.03	33	53
33	8002200	1952	0	0	0	16	109	64.03	15	26	60	84.03	53	30
34	8002200	1953	0	0	0	17	4	17.03	30	0	43	70.03	56	51

Data | Characteristics | Attribution

(a)

1	Site ID	Latitude	Longitude	Elevation	Annual Mean Temperature	Annual Mean Precipitation	Mean Julian Day	Seasonality Index	Mean Precipitation (Winter)	Mean Precipitation (Spring)	Mean Precipitation (Summer)	Mean Precipitation (Autumn)	Other Site Characteristic (1)	Other Site Characteristic (2)	Other Site Characteristic (3)	Eco-Regions/ Own Regions	Mean Precipitation (Selected Period)
2	8000900	11.13	-74.23	2			233.1929376	0.51710862								61308	200
3	8002200	10.45	-75.52	0			249.9389902	0.490782378								61401	200
4	8002800	10.9	-74.77	15			238.9474185	0.506581731								61308	200
5	8008401	8.12	-76.72	12			214.5577904	0.145107929								60137	200
6	8009100	7.02	-73.8	121			227.525528	0.197161636								60137	200
7	8009400	7.1	-73.2	1104			196.2399141	0.087765357								60136	200
8	8009704	7.6	-72.6	1272			284.5967965	0.117820307								60118	200
9	8009705	7.7	-72.7	1407			303.0542821	0.180009244								60118	200
10	8011202	5.9	-75.7	1496			212.4710466	0.150247982								60109	200
11	8011203	6.2	-75.6	1587			200.7289125	0.146755966								60136	200
12	8011206	6.22	-75.6	1528			209.863921	0.1428942								60136	200
13	8014902	5	-75.6	1295			184.9718123	0.020626232								60109	200
14	8014905	4.9	-75.1	2141			146.9336935	0.00797214								60136	200
15	8014911	4.98	-75.58	1463			228.3568478	0.018161971								60109	200
16	8021000	4.82	-75.8	1186			307.7957521	0.034361705								60109	200
17	8021100	4.5	-75.72	1302			15.41589255	0.073857596								60109	200
18	8021101	4.5	-75.6	2151			325.8450427	0.081081388								60109	200
19	8021400	4.43	-75.15	960			162.8213581	0.030195232								60221	200
20	8021900	4.28	-74.8	284			107.0949758	0.018964508								60221	200
21	8021904	4	-75	326			87.660313	0.062585756								60221	200
22	8021905	3.8	-75	326			344.8226573	0.122110602								60221	200
23	8021906	4.2	-74.9	330			129.0709464	0.036956398								60221	200
24	8021907	4	-75	326			90.82839864	0.016099452								60221	200
25	8021908	4.3	-74.4	1573			360.5458278	0.146726016								60136	200
26	8022200	4.7	-74.13	2550			354.2516696	0.037475064								60136	200
27	8024100	4.55	-70.92	184			186.0963571	0.392823215								60709	200
28	8025900	3.55	-76.38	962			52.00408303	0.080219823								60207	200
29	8025901	3.5	-76.3	991			43.36627263	0.09678166								60207	200
30	8025902	3.8	-76.5	1516			212.3094601	0.037714094								60145	200
31	8025903	3.5	-76.3	991			68.41840873	0.082110351								60207	200
32	8025905	3.4	-76.4	960			69.58678596	0.094160165								60207	200
33	8030800	2.47	-76.6	1737			357.7628545	0.255447306								60109	200
34	8030801	2.45	-76.58	1809			361.345847	0.223939096								60109	200
35	8031500	2.97	-75.3	425			3.958842076	0.258672108								60221	200
36	8031502	3.6	-75.1	322			360.6683265	0.168805494								60221	200
37	8031503	3.7	-75.5	869			356.3201274	0.106873071								60221	200
38	8033700	1.57	-78.68	17			109.0627878	0.255437627								60178	200
39	8034200	1.42	-77.27	1915			18.40327923	0.138653878								60145	200
40	8034204	1.27	-77.47	1873			5.236239721	0.118449082								60145	200
41	8037000	0.82	-77.63	2851			11.24676114	0.119242509								60145	200
42	8037001	1.2	-78	1368			19.64773785	0.104582121								60145	200
43	8040300	11.42	-69.68	15			287.6662599	0.294293794								61313	200
44	8040500	11.8	-66.18	2			317.0452229	0.345958118								61401	200

Data | Characteristics | Attribution

(b)

Figure 2: Example an Excel input file, showing the (a) **Data** and (b) **Site Characteristics** worksheets.

In **Site Characteristics** (Figs. 1 & 2b), each value/column represents a particular site characteristic that can be used when creating homogenous regions if such data are available. Only variables that are known for all sites and years will be used during regionalization; therefore not all values/columns are required to be filled in. It should be noted that each row in the text file must contain the same number of commas, regardless of the amount of data provided, or ICI-RAFT will give an error when run. The user should remember that the more data that are available, the more efficient the regionalization process will be. In addition to the site characteristics shown in Fig. 1 & 2b, the user is welcomed to add up to three of their own site characteristics in the **Other Site Characteristics** columns. A name for each of these "Other" characteristics can be given after running the program.

An alternative to regionalization is to use **Eco-regions**, as defined by the World Wildlife Federation, the U.S. Environmental Protection Agency, or other groups, or to choose to manually set your own region for each site; this can be done using Column P. The final column will be discussed later in the manual.

Descriptions of the Indices

There is contained within the software a database of various climate indices that may help the user to identify modes of climate variability that affect a particular region of interest. Short descriptions of each index are given below, while general ranges are provided in Table 1.

Antarctic Oscillation (AAO)

The AAO is estimated based on mean height anomalies at 700 mb from latitude 20^{o}S to 90^{o}S. Positive values appear to drive cooling in East Antarctica and warming on the Antarctic Peninsula; a trend toward extreme values of this index has been linked to stratospheric cooling driven by ozone loss.

Arctic Oscillation (AO)

The AO is estimated based on mean height anomalies at 1000 mb from latitude 20^{o}N to 90^{o}N. Positive values indicate cold, wet weather at higher latitudes and warm/dry conditions at lower latitudes, with the reverse holding true for negative values.

East Atlantic Index (EA)

The EA is estimated based on the analysis of monthly height anomalies at 500 mb from latitude 20^{o}N to 90^{o}N. The EA's anomaly centers are displaced southeastward compared to the NAO pattern; positive index values are associated with warmer temperatures in Europe and colder temperatures in the USA.

Eastern Atlantic/Western Russian Index (EA/WR)

The EA/WR is estimated based on the analysis of monthly height anomalies at 500 mb from latitude 20^{o}N to 90^{o}N. Positive height anomalies in Europe and China counterbalance lows in the Atlantic and north of the Caspian Sea. The effects of a positive cycle are warmer/wetter weather in East Asia and colder/dryer weather in Europe and surrounding regions.

East Pacific/North Pacific Index (EP/NP)

The EP/NP is estimated based on the analysis of monthly height anomalies at 500 mb from latitude 20 N to 90 N. Positive values feature a high anomaly over Alaska and low anomalies over the north Pacific and the eastern USA, pushing the jet stream southward. Temperatures drop on the American east coast in this scenario, while Canada's Pacific coast is dry.

Madden-Julian Oscillation (MJO)

Unlike other indices, the MJO is characterized by convective rainfall anomalies that are in motion during the course of its cycle, propagating from the Indian Ocean east into the Pacific Ocean. The anomalies are modeled using ten separate indices centered on lines of longitude around the globe, with seven in the eastern hemisphere and three in the western. Indices 1-4 and 10 model the zone through which MJO events move; each of the other five strongly anti-correlate with one of the first set and indicate the worldwide effects of MJO, from facilitating El Niño dynamics to influencing high-latitude rainfall. The longitudes each index represents are given: (1)80E, (2)100E, (3)120E, (4)140E, (5)160E, (6)120W, (7)40W, (8)10W, (9)20E, (10)70E.

North Atlantic Oscillation (NAO)

Key features of the NAO are centers of low pressure near Iceland and high pressure near the Azores, both of which are strong for positive values of the NAO. One important effect of a positive NAO is a wetter and stormier winter season in the eastern USA, with negative values corresponding to a dry, cold winter.

Northern Oscillation Index (NOI)

The NOI represents the surface-level pressure difference between the North Pacific High near North America and Darwin (in Australia's Northern Territory), normalized by the long-term average and standard deviation. Built as a rough north Pacific equivalent of the SOI, it represents the influence of a wide variety of global-scale climatic forces on the North Pacific and North America. A 14-year cycle in the value of this index has been noted.

North Pacific Index (NP)

According to NASA's website, the NP Index is the area-weighted sea level pressure (SLP) over the region 30N-65N, 160E-140W and is used to measure decadal variations linked to El Nino (ENSO) and La Nina events.

Oceanic Niño Index (ONI)

According to the website of NOAA's Climate Prediction Center, the ONI represents the 3-month running mean of ERSST.v3b sea-surface temperature (SST) anomalies in the Niño 3.4 region (5°N-5°S, 120°-170°W), based on centered 30-year base periods updated every 5 years. Warm (El Niño) and cold (La Niña) episodes are based on a threshold of +/- 0.5°C ONI; for historical purposes cold and warm episodes are defined when the threshold is met for a minimum of 5 consecutive over-lapping seasons.

Pacific Decadal Oscillation (PDO)

The PDO is a major cycle sometimes compared to El Niño, but of a longer time period (20-30 years) and with stronger effects in the North Pacific than in the tropics. The index is based on North Pacific monthly sea surface temperature variability. Warm PDO regimes tend to increase coastal ocean biological productivity off Alaska and decrease it further south, while cold PDO regimes have the reverse effect.

Pacific/North American Index (PNA)

The PNA is estimated based on the analysis of monthly height anomalies at 500 mb from latitude 20 N to 90 N. Key features of the PNA are a low center near the Rockies and a high center near the Aleutian Islands, both of which are strong for positive values; high positive values correlate with warm/dry weather in the west USA and wet/cold weather in the east USA, with negative values corresponding to the opposite effects.

Polar/Eurasia Index (POL)

The POL is estimated based on the analysis of monthly height anomalies at 500 mb from latitude 20 N to 90 N. Its main temperature effects are in Siberia (hotter) and China (colder). An oscillation in this index has been noted on the half-decadal scale.

Scandinavian Index (SCA)

The SCA is estimated based on the analysis of monthly height anomalies at 500 mb from latitude 20 N to 90 N. A positive value drives positive height anomalies over western Russia and Scandinavia, with cooling effects in central Russia and western Europe and increased precipitation for central and southern Europe.

Southern Oscillation Index (SOI)

The SOI represents the normalized surface-level pressure difference between Tahiti and Darwin (in Australia's Northern Territory). Negative values of the SOI during the southern hemisphere's summer season indicate an El Niño event; positive values indicate a strong Walker Circulation pattern.

West Pacific Index (WP)

The WP is estimated based on the analysis of monthly height anomalies at 500 mb from latitude 20 N to 90 N. The WP has anomaly centers over the Kamchatka Peninsula and a broad swath of ocean adjacent to Southeast Asia, which are associated with the entrance region of the Pacific jet stream, as well as another center over the southwest USA. Positive values correlate with cooler/wetter weather in the North Pacific and eastern Siberia and drier weather further south.

Table 1: List of indices and their abbreviations and ranges since 1948.

Abbreviation	Full Name	Range since 1948
AAO	Antarctic Oscillation	-3.01 to 2.69
AO	Arctic Oscillation	-4.27 to 3.50
EA	East Atlantic Index	-3.33 to 2.68
EA/WR	Eastern Atlantic/Western Russia Index	-4.17 to 3.68
EP/NP	East Pacific/North Pacific Index	-2.96 to 3.88
MJO	Madden-Julian Oscillation	-2.02 to 2.01
NAO	North Atlantic Oscillation	-3.14 to 3.06
NOI	Northern Oscillation Index	-12.20 to 8.68
NP	North Pacific Index	996.44 to 1020.99
ONI	Oceanic Nino Index	-2.10 to 2.50
PDO	Pacific Decadal Oscillation	-3.60 to 3.51
PNA	Pacific/North American Index	-3.65 to 2.87
POL	Polar/Eurasia Index	-3.44 to 3.53
SCA	Scandinavian Index	-2.44 to 3.15
SOI	Southern Oscillation Index	-3.60 to 2.90
WP	West Pacific Index	-3.45 to 3.39

License & Disclaimer

Upon first running ICI-RAFT, the opening screen (Fig. 3) displays the license and disclaimer for the software. Read through the disclaimer and if you accept the conditions, choose **Accept** and click the **OK** button; the program will continue on to the next screen. If you do not accept the conditions of the disclaimer, choose **Do Not Accept** and click the **OK** button; this will close the program.

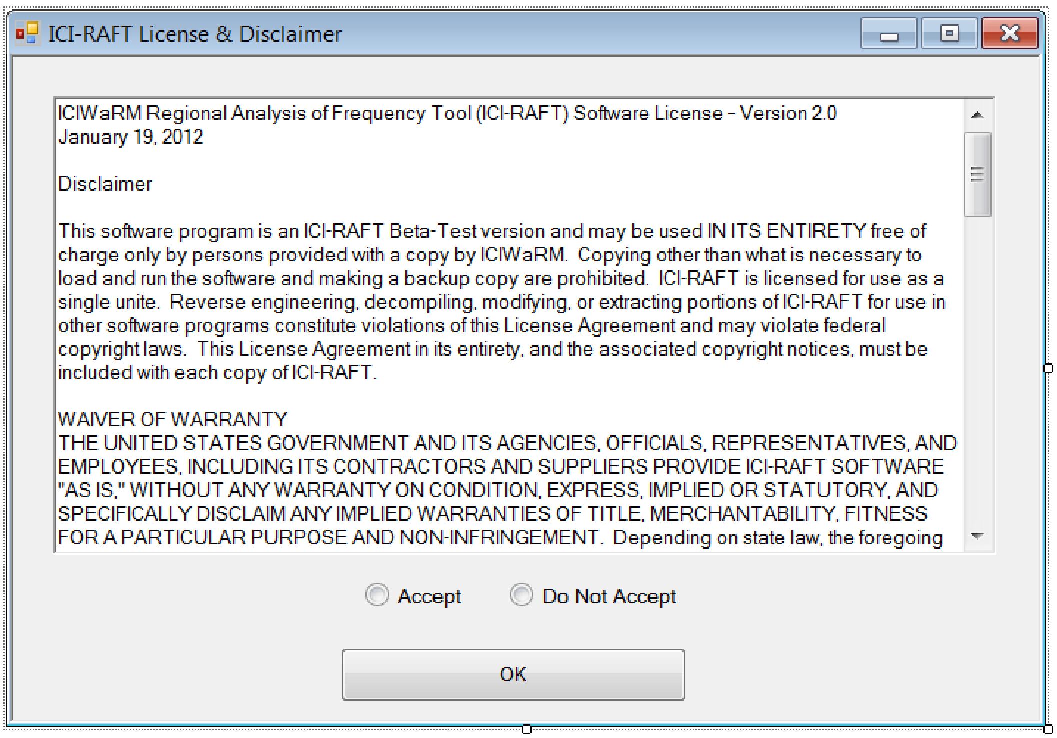


Figure 3: ICI-RAFT License and Disclaimer.

Loading the Data

Upon accepting the license and disclaimer, the title screen will appear with two menu items, **File** and **Help**, enabled. Selecting **File** and choosing **Exit** will close the program; the other options include **Load Data**, **Open File**, and **Save File** (Fig. 4). Selecting **Load Data** opens another window that allows the user to browse their computer files and choose an input file (Fig. 5). The **Save File** and **Open File** options are used to save and later retrieve work performed during the user's current analysis.

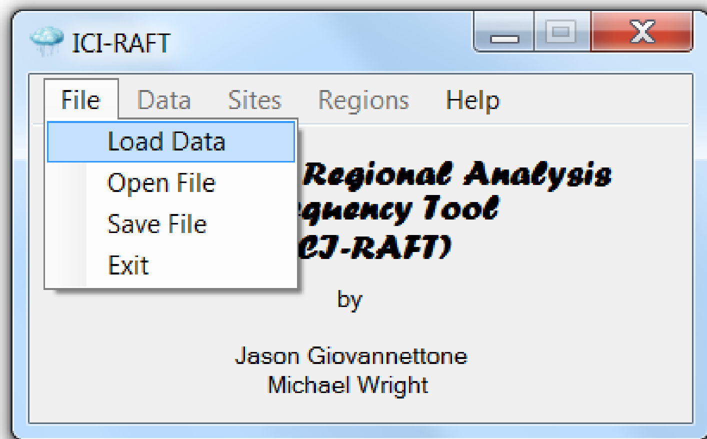


Figure 4: **Title Screen** with the **File** menu opened and **Load Data** option selected.

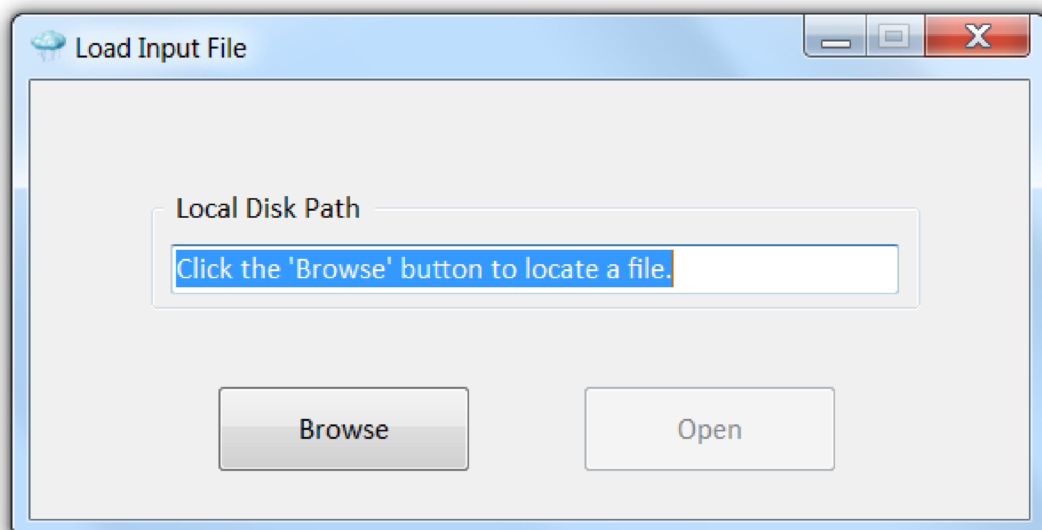


Figure 5: **Load Input File** window.

Displaying and Screening the Raw Data

Once the input file has been loaded, the remainder of the menu items become active (white) and a table appears (Fig. 6) that displays all of the monthly precipitation data that was entered into the **Data** tab of the input file. The data can be edited within this screen. The user can view any of the data within the **Display Data** window by using the horizontal and vertical scroll bars. Click the **Close** button when finished. Under the **Data** menu, the user's options are to **Display Data** or **Screen Data**. Upon selection of **Display Data**, the same window appears as described above.

Upon selection of **Screen Data**, a window appears (Fig. 7) that allows the user to determine the time period over which analysis is to be performed and to specify the units of the data. Initially all labels and boxes under **Data Units** and **Other Characteristics** are disabled. A **Beginning Month** and **Duration in Months** must be entered to define the time frame; individual monthly values within the period chosen are totaled in order to obtain one value for each period, whether it is three months or five years (60 months), which is the maximum period length that can be analyzed. If there are any missing or bad data during a particular year (represented by a -999 in the input file), that year is not used in the analysis for that particular data site. Fewer years of data available for a particular site means that that particular site will contribute less to the overall regionalization process.

A threshold for the number of valid years for a particular site can be set in the **Screen Data** window next to the caption **Minimum Number of Records**. Any sites having fewer than the specified number of annual records with good data will not be used in the regionalization process. This threshold must be greater than four so that all of the program's statistics are calculable for all sites.

A final (optional) piece of information that can be given is a **Lag** time between values of the various global climate indices and the monthly rainfall measurements. The value entered here (in months) will be used whenever an index limit is applied by the user; there are many locations within ICI-RAFT where this can be done. Additional information concerning **Index Limits** is provided later in this document where applicable.

After specifying these three pieces of information the **Filter** button will become active; pressing this button will commence the filtering process. Once this process is finished, certain items within the **Data Units** and **Other Characteristics** sections of the window will become active, depending on the types of data included in the **Characteristics** worksheet of the input file. If desired, the user should enter the appropriate units; if any items within the **Other Characteristics** section of the window become active, the user can enter the name of the data type in addition to the units. Pressing the **OK** button, which becomes active after pressing the filter button, will proceed with the L-moment computations for all sites meeting the conditions specified earlier.

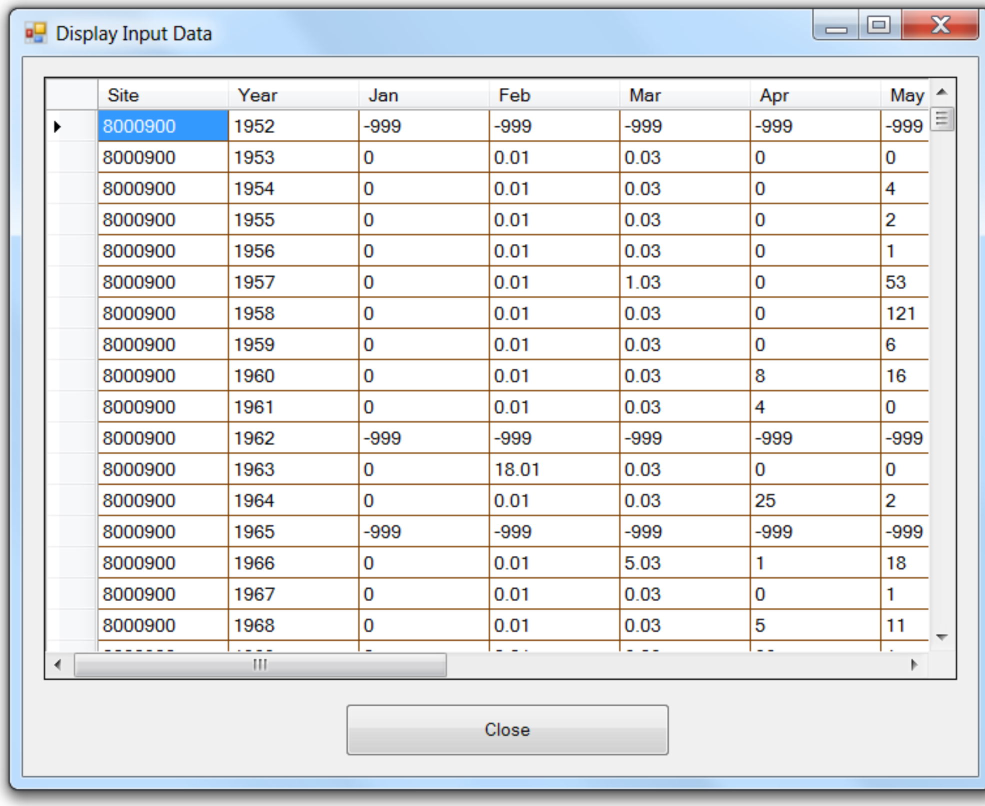


Figure 6: **Display Data** window.

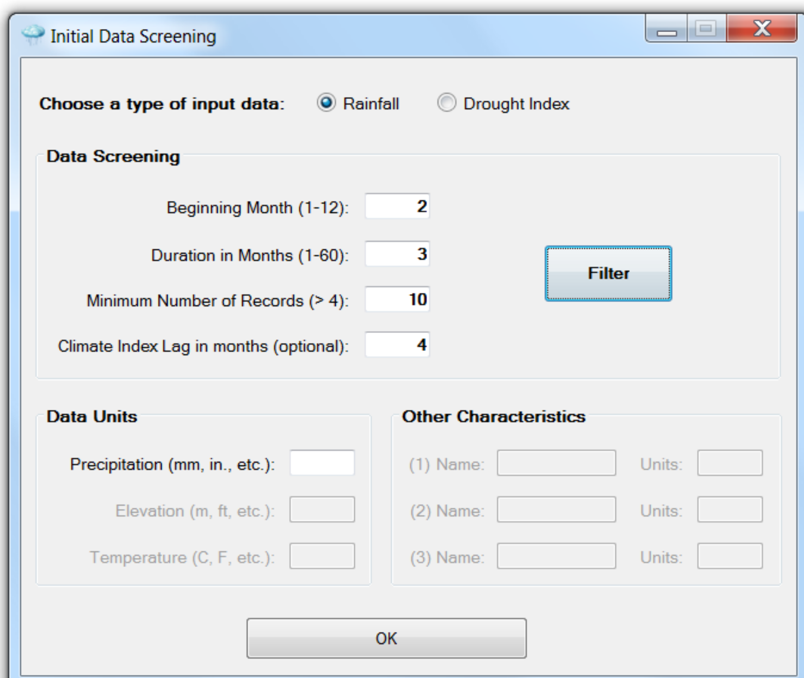


Figure 7: **Initial Screening** window.

II. SITE ANALYSIS

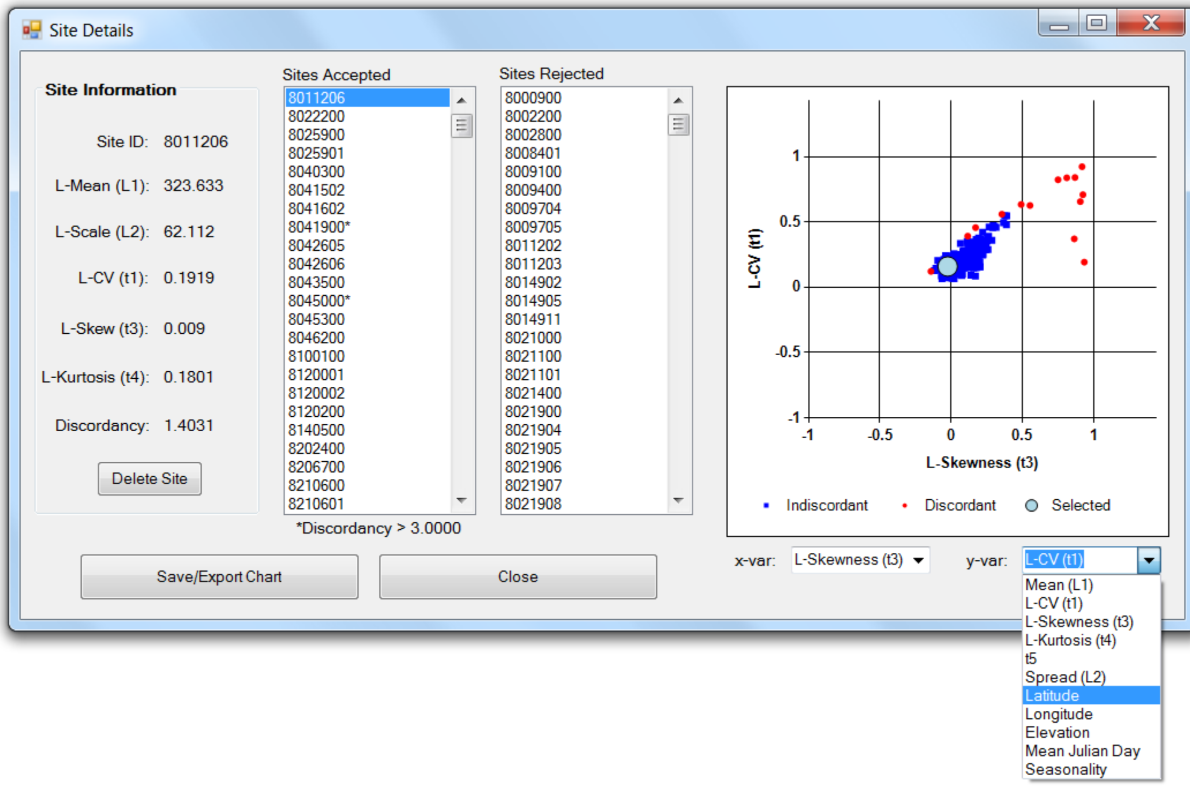
Site Details

Upon completion of the **Initial Screening** form, the **Site Details** form appears (Fig. 8); this window can also be accessed through the **Sites** menu on the title screen. The **Site Details** form contains two lists of sites, one each for accepted and rejected sites based on the number of years of data they contain with no missing or bad data (-999's) compared to the minimum numbers of years specified by the user in the **Initial Screening** window. Sites listed in the **Sites Accepted** column may be selected, which causes their L-moment statistics to be displayed in the left column of the form along with the **Site ID** and the **Discordancy** of that site. In this case, the discordancy is a measure of how a particular site's L-moment ratios compare to the site L-moment ratios of the entire data set. High discordancy could indicate that a site's data may contain some type of measurement error, which may include, for example, an error related to data entry. Accepted sites with a discordancy greater than a critical threshold, which is dependent on the number of accepted sites and is indicated below the list of accepted sites, are considered discordant and are followed by an asterisk.

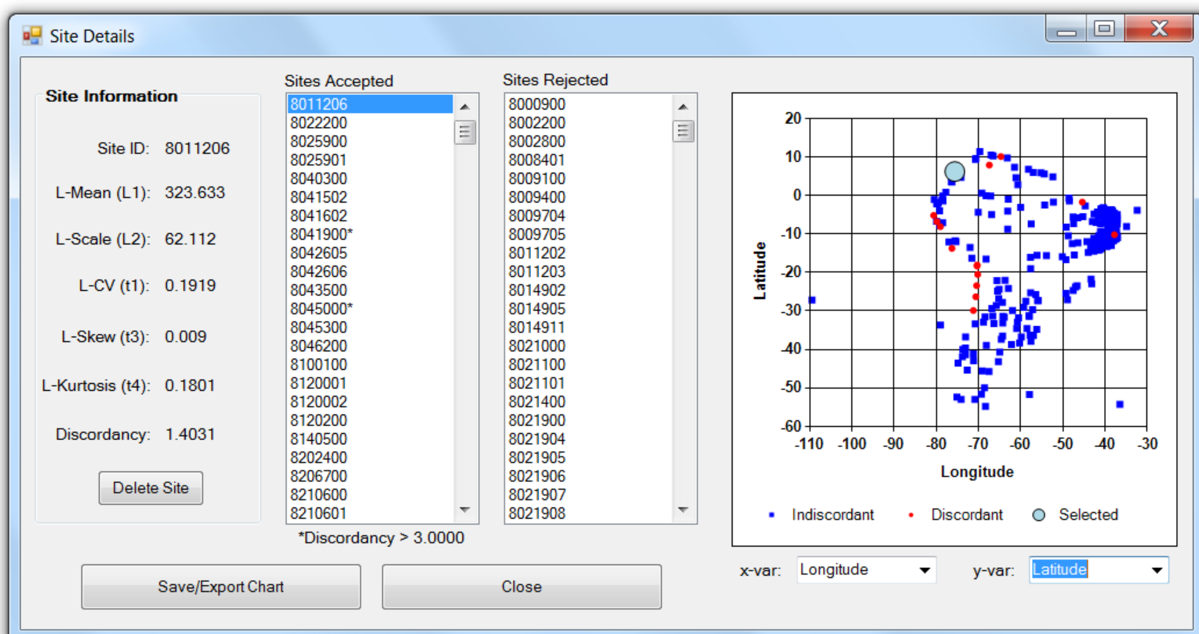
The right side of the **Site Details** window contains a graph of L-Coefficient of Variation vs. L-Skewness (Fig. 8a). Discordant sites are shown on the graph as red dots, whereas the blue dots represent non-discordant site. The site that has been selected in the **Sites Accepted** column to the left is identified in the graph by a large dot, which is either light blue or red depending whether it is discordant or non-discordant. Drop-down menus (as shown in Fig. 8a) allow the user to display L_1, t_1, t_3, t_4, t_5, or any of the at-site information from the **Other Site Characteristics** input sheet on either axis. Figure 7b shows the same graph when **Latitude** and **Longitude** are selected for the y- and x-axes, respectively. Graphing the various L-moments and site characteristics against each other may help to identify why some sites are discordant compared to others. For example, as can be seen in Fig. 8b, many of the discordant sites seem to be located on the West Coast of South America on the windward side of the Andes Mountains.

Any site in the **Accepted** list may be eliminated from the analysis by clicking the **Delete Site** button. A confirmation box (not shown) will appear; clicking **OK** will remove the site from your analysis. The site can only be added back to the analysis by repeating the initial screening procedure from the previous step.

The **Save/Export Chart** button opens the window shown in Fig. 9. Here the user can either save the graph as an image or export the chart data as a table. As an image, the graph can be saved in one of five formats: .jpg (JPeg image), .bmp (Bitmap image), .gif (Gif image), .tiff (TIFF), or .png (Png image). The user is allowed to change the height and width of the graph (given in units of pixels) or can use the default settings that are given. As a table, all data in the graph are exported to a .csv (comma-separated values) file. Click **Close** when finished viewing the **Site Details** window.



(a)



(b)

Figure 8: **Site Details** form showing (a) **L-Skewness** vs. **L-CV** and the drop-down x/y axis menu and (b) **Longitude** vs. **Latitude**. Blue dots represent non-discordant sites while red dots represent discordant sites.

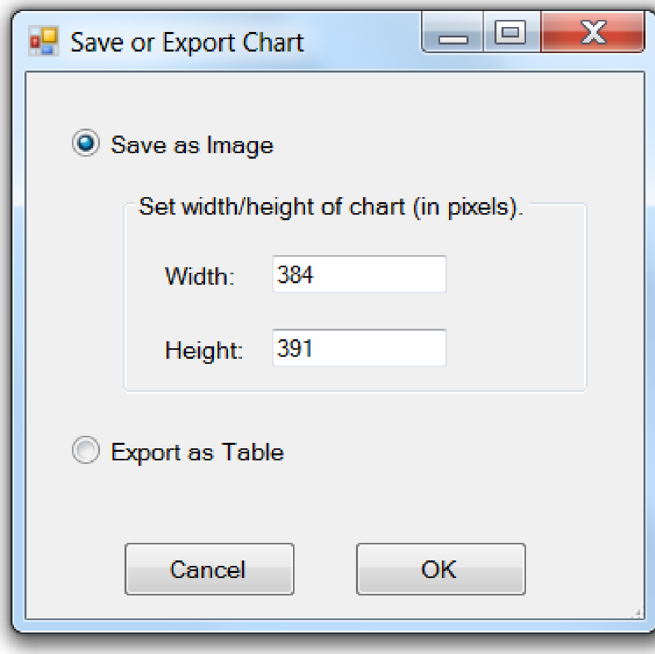


Figure 9: **Save chart** as an image or **export chart** data to as a table to a .csv file.

Site Plots

Choosing **Plots** from the **Sites** menu within the title screen causes a menu with two options to drop down: **General** and **Index Analysis** (Fig. 10). Clicking **General** opens a window allowing the user to view graphs of the data for any individual site. Any site can be chosen using the drop-down box at the top of the window. Radio buttons below the chart window allow the user to view **Raw Data**, **Rescaled Data**, or a $\mathbf{t_4/t_3}$ (L-Kurtosis vs. L-Skewness) plot. Selecting **Raw Data** will allow the user to see a graph of the raw data for the selected site (Fig. 11a), whereas selecting the **Rescaled Data** option produces a graph of the raw data divided by the mean of that dataset (not shown). The value of rescaling the data will be seen in the regionalization portion of the analysis.

The graph of L-Kurtosis vs. L-Skewness (Fig. 11b) illustrates how each individual site's L-moments compare to the other sites (represented by the gray circles) and to the possible L-skew and L-kurtosis values representative of various frequency distributions. The black dot represents the L-Kurtosis and L-Skew for the site selected in the drop-down box. The colored stars represent the L-Kurtosis and L-Skew for the two-parameter frequency distributions that are available within this program, while the curves represent the range of possible values of L-Kurtosis vs. L-Skew for each of the three-parameter distributions, as indicated in the legend on the graph. This graph provides an initial indication of which frequency distribution may best represent the data for a particular site based on the proximity of the sites value of **t4/t3** compared to each distribution. It should be noted that this provides only one clue as to which distribution to use and should never be used alone when making a final decision.

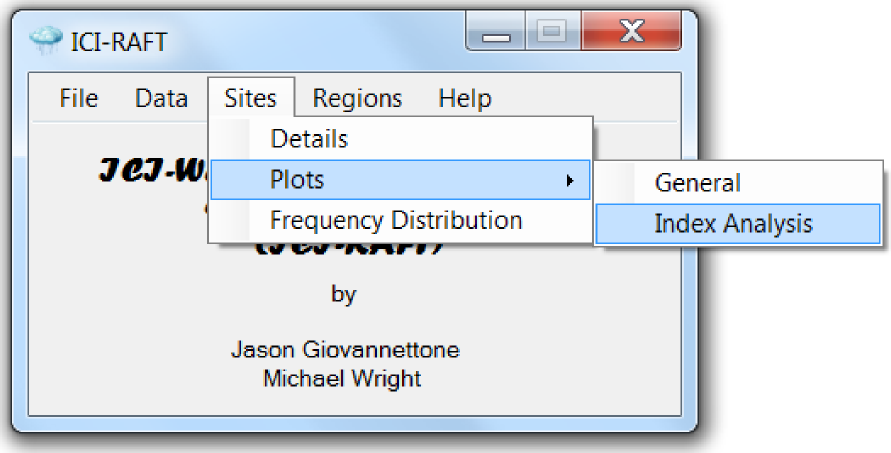


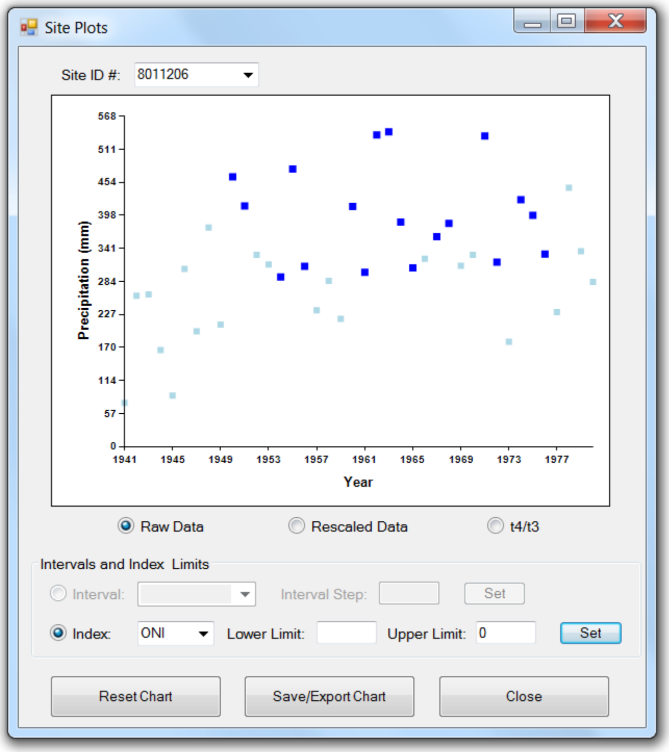
Figure 10: **Site Plots** menu accessed from the **Title Screen**.

There is also the option of further restricting the graphed data and the data used to compute L-Kurtosis and L-Skew by either specifying an interval length and then choosing an interval period, which can only be used on the **t4/t3** graph (Figs. 11b – c), or by specifying an upper or lower limit for a particular climate variability index (Table 1), which can be used on any graph (Figs. 11a – c). In order to create a series of intervals of a particular time length, click the circle corresponding to the **t4/t3** graph; the **Interval** option becomes enabled. Selecting interval causes the interval step textbox and the drop-down box to become enabled. Once an interval step is entered, the **Set** interval button becomes enabled; clicking Set will split the time period associated with the precipitation data into the corresponding intervals. Selecting an interval will restrict the data used to calculate L-Kurtosis and L-Skew to only those data measured within the interval; the result will be a graph similar to the one shown in Fig. 11b.

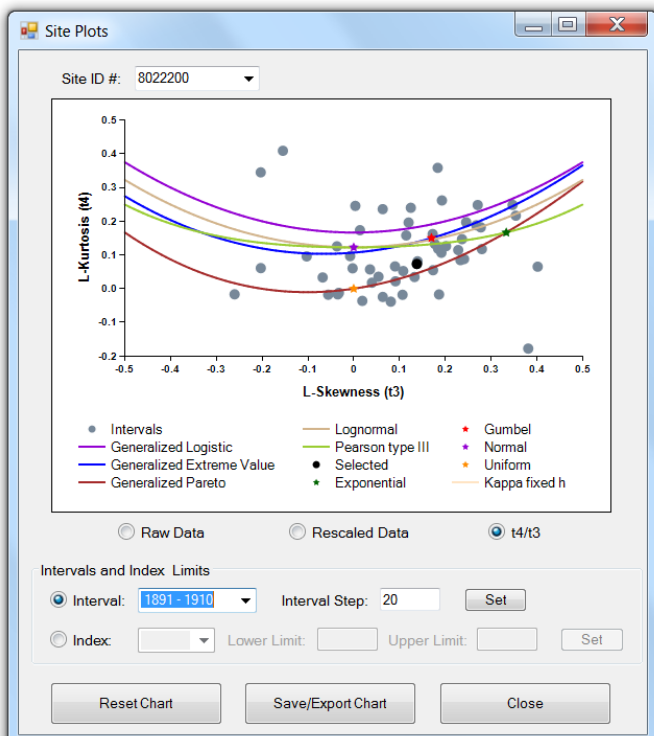
In order to restrict the data displayed and used to compute L-Kurtosis and L-Skew by specifying an upper or lower limit for a particular climate variability index, select **Index** while any of the graph types are displayed; the index drop-down box and the upper and lower limit textboxes become enabled. Select an index type from the drop-down box and specify an upper or lower limit or both. Once this is done, the **Set** index button becomes enabled; clicking **Set** will restrict the data to only those time periods when the selected index meets the restriction imposed; an example of the **t4/t3** graph is shown in Fig. 11c using only rainfall measurements taken during periods when the ONI index was less than 0.

There are three buttons at the bottom of the window: **Reset Chart**, **Save/Export Chart**, and **Close**. Clicking the **Reset Chart** button will reset any time interval or index limitations that were placed on the data; associated textboxes and drop-down menus are cleared and the original graphs are displayed.

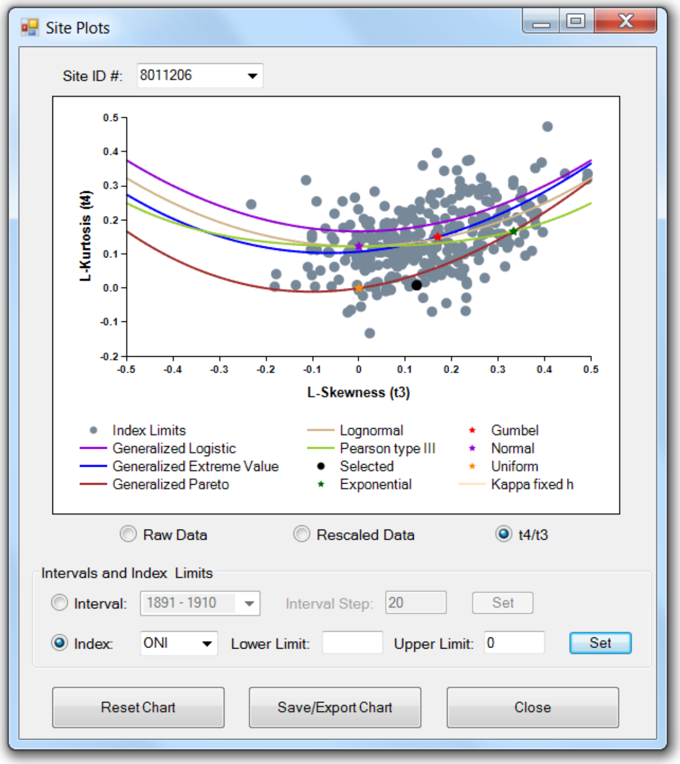
The **Save/Export Chart** button opens the window shown earlier in Fig. 9. Here the user can either save the graph as an image or export the chart data as a table. As an image, the graph can be saved in one of five formats: .jpg (JPeg image), .bmp (Bitmap image), .gif (Gif image), .tiff (TIFF), or .png (Png image). The user is allowed to change the height and width of the graph (given in units of pixels) or can use the default settings that are given. As a table, all data in the graph are exported to a .csv (comma-separated values) file. Click **Close** when finished viewing the **Site Plots** window.


Site Plots
Site ID #:
8011206
Precipitation (mm)
Year
Raw Data
Rescaled Data
t4/t3
Intervals and Index Limits
Interval:
Interval Step:
Set
Index:
ONI
Lower Limit:
Upper Limit:
0
Set
Reset Chart
Save/Export Chart
Close

(a)


Site Plots
Site ID #:
8022200
L-Kurtosis (t4)
L-Skewness (t3)
Intervals
Generalized Logistic
Generalized Extreme Value
Generalized Pareto
Lognormal
Pearson type III
Selected
Exponential
Gumbel
Normal
Uniform
Kappa fixed h
Raw Data
Rescaled Data
t4/t3
Intervals and Index Limits
Interval:
1891 - 1910
Interval Step:
20
Set
Index:
Lower Limit:
Upper Limit:
Set
Reset Chart
Save/Export Chart
Close

(b)



(c)

Figure 11: **Site Plots** window, showing (a) the raw data for a particular site in light blue and the raw data meeting the ONI index criteria of < 0 in blue; (b) the **t4/t3** graph, which includes all acceptable sites within the indicated time **interval** shown as gray dots, the selected site as a black dot, two-parameter distributions as colored stars, and the three-parameter distributions as colored curves; and (c) the same graph as in (b) except showing the data that meet the **ONI index** criteria of < 0 as gray dots. All distributions in (b) and (c) are shown in the legends and given in Table 2.

The other option in Fig. 10 under the **Site Plots** menu is **Index Analysis**. Clicking on **Index Analysis** opens a window similar to the one shown in Fig. 12. ICI-RAFT calculates how well each global climate index correlates with rainfall using the $\mathbf{R^2}$ statistic, taking into account the lag entered in Fig. 7. The top five indices with the highest $\mathbf{R^2}$ values compared to the selected site's precipitation data are displayed and clicking one of the buttons on the right side of the list displays a graph of the selected site's precipitation on the y-axis against the corresponding index value on the x-axis. The equation for the plotted trendline is given below the graph.

The **Save/Export Chart** button opens the window shown earlier in Fig. 9. Here the user can either save the graph as an image or export the chart data as a table. As an image, the graph can be saved in one of five formats: .jpg (JPeg image), .bmp (Bitmap image), .gif (Gif image), .tiff (TIFF), or .png (Png image). The user is allowed to change the height and width of the graph (given in units of pixels) or can use the default settings that are given. As a table, all data in the graph are exported to a .csv (comma-separated values) file. Click **Close** when finished viewing the **Index Analysis** window.

At-Site Frequency Distribution

The final option in the **Sites** menu on the **Title Screen** is **Frequency Distribution.** Once clicked, a window opens that displays the first site's data probability density function (**PDF**) as vertical blue bars (Fig. 13a). Any of the accepted sites for analysis can be viewed using the drop-down box below the graph. In addition, fits of any of the fourteen different standard frequency distribution functions (see Table 2) to the L-moments of the site's data can be displayed on the graph by clicking the box next to the desired distribution; the **EXP**, **GLO**, and **LP3** are compared in Fig. 13a. Distributions are divided based on the number of parameters required. This graph provides a way to visually determine how well each standard frequency distribution fits the site's sample data and offers another clue in determining which distribution may be best for a particular site. In addition, a site's cumulative distribution function or **CDF** (not shown), **non-exceedance** curve (Fig. 13b) and **exceedance** curve (Fig. 13c) can be displayed.

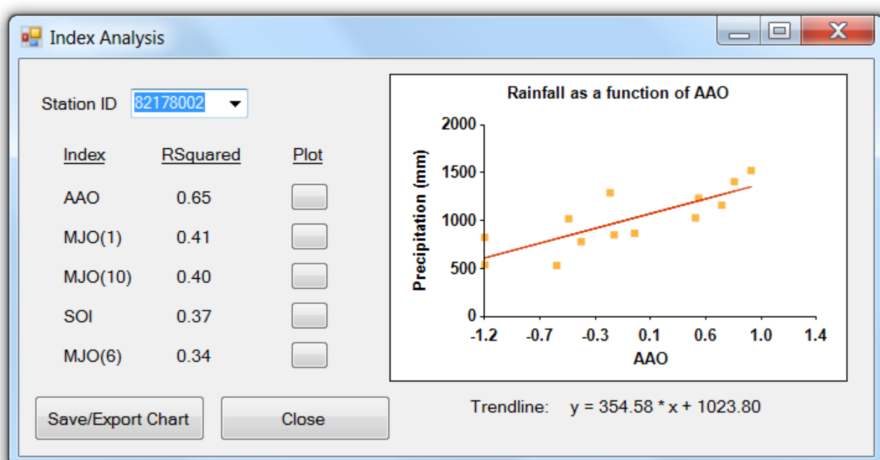


Figure 12: Index Analysis window showing a list of the top 5 global climate indices in terms of their correlation to rainfall at a particular site, one of which is plotted on the right.

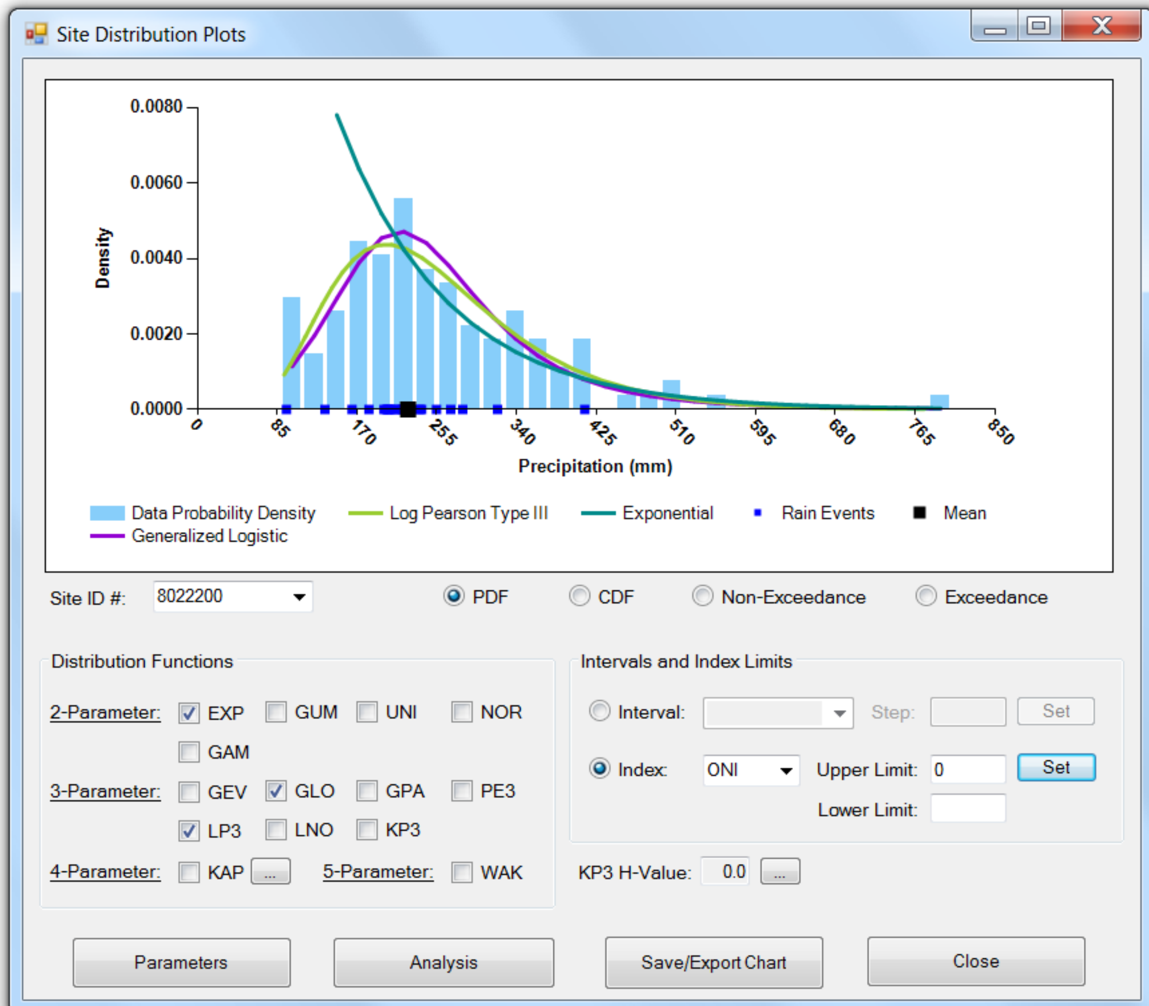
The **CDF** is the integral of the probability density function, summing up the total probability of rainfall at or below a given value, and is used when computing the **non-exceedance** and **exceedance** curves. The **non-exceedance** graph is shown on a logarithmic scale and provides the user with information regarding the frequency at which a particular rainfall amount is not exceeded; this is useful for users concerned with drought events. The **non-exceedance** curve for the sample data along with the best fits of the **EXP**, **GLO**, and **LP3** distributions are shown in Fig. 13b. The **exceedance** graph is also shown on a logarithmic scale and provides the user with information regarding the frequency at which a particular rainfall amount is exceeded; this is useful for users more concerned with flood events. The **exceedance** curve for the sample data along with a best fit comparison between the **GEV**, **LP3**, and **GLO** distributions for a different site are shown in Fig. 13c. The estimated **non-exceedance** and **exceedance** curves of the sample data are represented by the light blue lines, and the distributions are represented as in previous graphs. Each of these graphs can be used to make a visual comparison between how well each standard distribution fits the data of a site. As in the previous screen, these graphs should not be used alone in finally determining which distribution to use to characterize a particular site's distribution curve.

A special note needs to be made regarding two of the distributions: the **KP3** and **KAP**. The **KP3** distribution is similar to the **KAP** distribution except that the fourth parameter (h) is fixed by the user, resulting in a 3-parameter version of **KAP**. The current h-value that is being used to solve the **KP3** is shown near the bottom of the window on the right side (default is $h = 0$); pushing the adjacent unlabeled button allows the user to set the h-value. The KAP distribution is the parent distribution of the **KP3** Distribution and several of the other 3-parameter distributions, and setting h to particular standard values will result in one of these child distributions: $h = -1$ results in the Generalized Logistic distribution (**GLO**); $h = 0$ results in the Generalized Extreme Variable (**GEV**) distribution; and $h = 1$ results in the Generalized Pareto (**GPA**) distribution. Non-standard values of h may be of use if inspection of the **t4/t3** graph (Fig. 12b, c) reveals that sites or regions cluster between the curves of the three child distributions; a strong theoretical backing should be developed in order to defend the h-value that was used. In addition, the small unlabelled button next to the **KAP** distribution allows the user to change the number of iterations used in the four-parameter fitting process; this option should not be used unless the Kappa function is not producing a satisfactory fit to the sample data.

There is also the option of displaying individual data values on the graph by either specifying an interval length and then choosing an interval period or by specifying an upper or lower limit for a particular climate variability index (Table 1). In order to create a series of intervals of a particular time length, click the circle corresponding to the **Interval** option; the interval step textbox and the drop-down box become enabled. Once an interval step is entered, the **Set** interval button becomes enabled; clicking Set will split the time period associated with the precipitation data into the corresponding intervals. Selecting an interval will display the data within the interval as blue squares and the mean of that data as a larger black square; on the **PDF** the squares will appear on the x-axis, whereas on the **CDF** and the **non-exceedance** (Fig. 13b) and **exceedance** curves, the squares will appear along the light blue line that represents the original data.

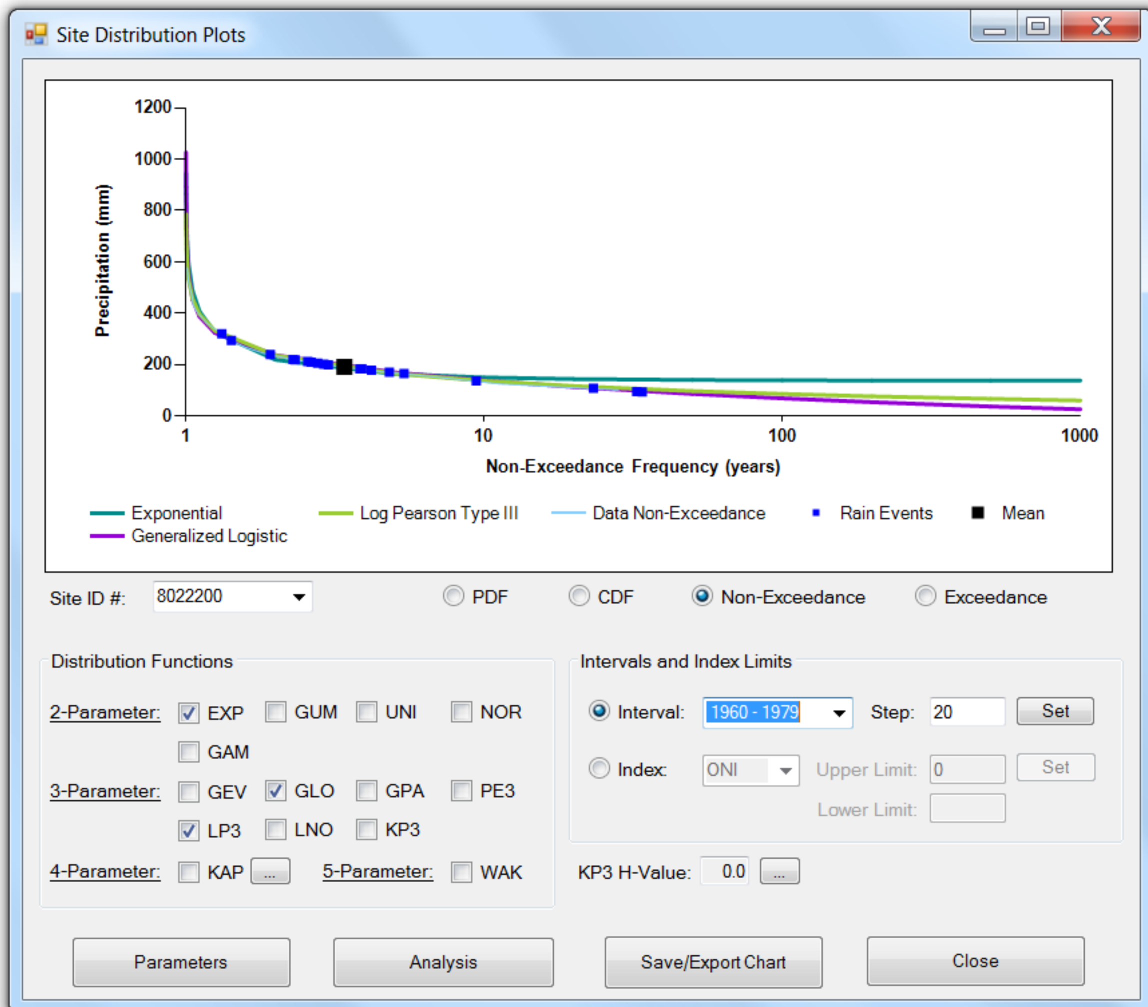
Table 2: Standard frequency distribution abbreviations.

Distribution	Abbreviation
Exponential	EXP
Gumbel	GUM
Uniform	UNI
Normal	NOR
Generalized Extreme Value	GEV
Generalized Logistic	GLO
Generalized Pareto	GPA
Log-normal	LNO
Pearson Type III	PE3
Log-Pearson Type III	LP3
Gamma	GAM
Kappa (3-parameter)	KP3
Kappa (4-parameter)	KAP
Wakeby	WAK

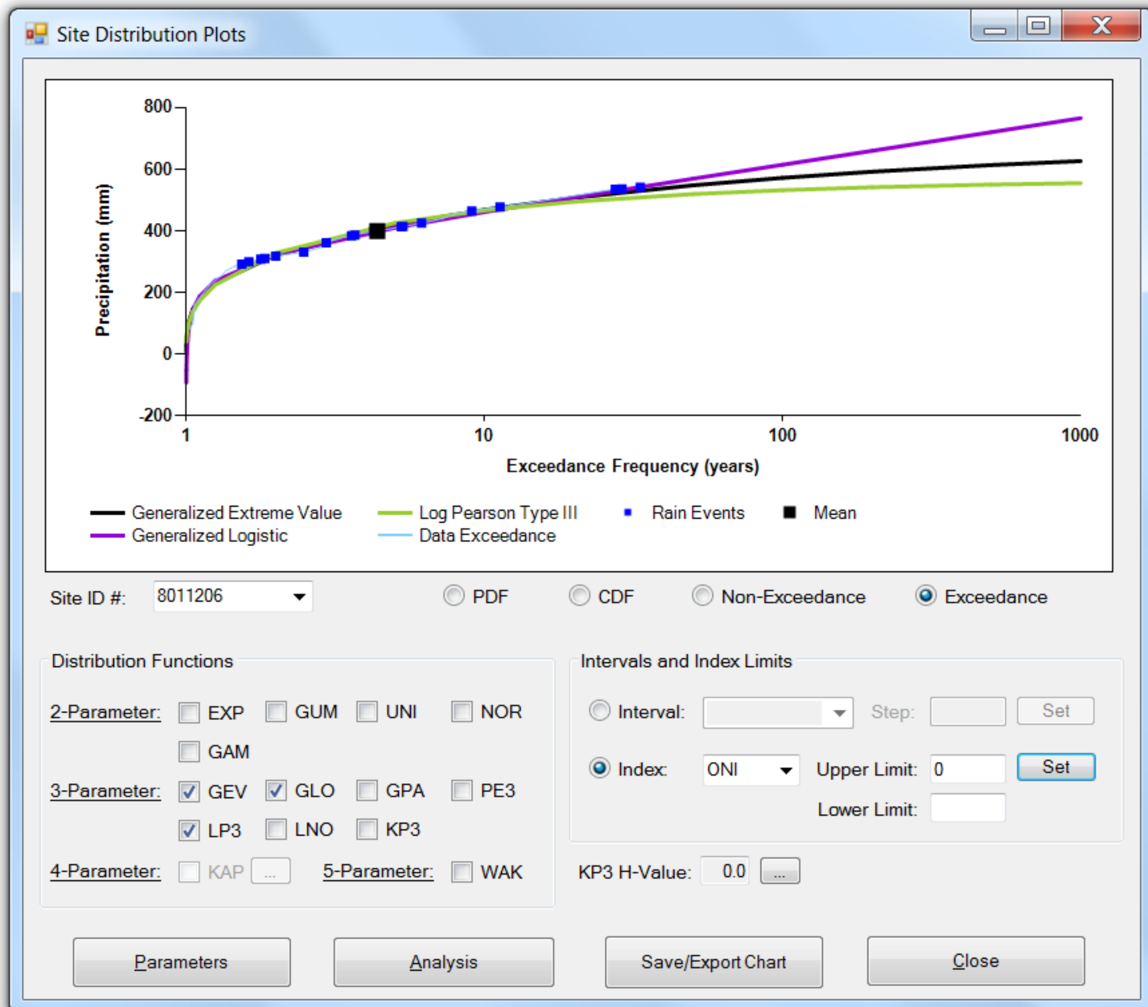


Site Distribution Plots
0.0080
0.0060
0.0040
0.0020
0.0000
Density
0
85
170
255
340
425
510
595
680
765
850
Precipitation (mm)
Data Probability Density
Log Pearson Type III
Exponential
Rain Events
Mean
Generalized Logistic
Site ID #:
8022200
PDF
CDF
Non-Exceedance
Exceedance
Distribution Functions
2-Parameter:
EXP
GUM
UNI
NOR
GAM
3-Parameter:
GEV
GLO
GPA
PE3
LP3
LNO
KP3
4-Parameter:
KAP
5-Parameter:
WAK
Intervals and Index Limits
Interval:
Step:
Set
Index:
ONI
Upper Limit:
0
Set
Lower Limit:
KP3 H-Value:
0.0
Parameters
Analysis
Save/Export Chart
Close

(a)


Site Distribution Plots
Precipitation (mm)
1200
1000
800
600
400
200
0
1
10
100
1000
Non-Exceedance Frequency (years)
Exponential
Generalized Logistic
Log Pearson Type III
Data Non-Exceedance
Rain Events
Mean
Site ID #:
8022200
PDF
CDF
Non-Exceedance
Exceedance
Distribution Functions
2-Parameter:
EXP
GUM
UNI
NOR
GAM
3-Parameter:
GEV
GLO
GPA
PE3
LP3
LNO
KP3
4-Parameter:
KAP
5-Parameter:
WAK
Intervals and Index Limits
Interval:
1960 - 1979
Step:
20
Set
Index:
ONI
Upper Limit:
0
Set
Lower Limit:
KP3 H-Value:
0.0
Parameters
Analysis
Save/Export Chart
Close

(b)



(c)

Figure 13: **At-Site Distribution Plots** screen, showing (a) the probability density function (**PDF**), (b) the **non-exceedance** curve, and (c) the **exceedance** curve for the sample data of the selected region as blue bars (**PDF**) and light blue lines (**non-exceedance** and **exceedance curves**). Also included are the estimations for each curve using various standard frequency distributions; the line color for each is shown in the legend. Also shown in the graph are the rain events that (a) & (c) meet a set climate variability index limit or are (b) within a specified interval as blue squares and the mean as a larger black square.

In order to display individual data values corresponding to limits set for a particular climate variability index, select the **Index** option; the index drop-down box and the upper- and lower-limit textboxes become enabled. Select an index type from the drop-down box and specify an upper- or lower-limit or both. Once this is done, the **Set** index button becomes enabled; clicking **Set** displays the data meeting the limit criteria as blue squares and the mean of that data as a larger black square; on the **PDF** (Fig. 13a) these squares will appear on the x-axis, whereas on the **CDF** and the **non-exceedance** and **exceedance** (Fig. 13c) curves, the squares will appear along the light blue line that represents the original data.

There are four buttons at the bottom of the **At-site Distribution Plots** window. The first button is titled **Parameters**, and when selected a window appears (Fig. 14) that displays the parameters for a particular standard frequency distribution estimated from the L-moments of the site selected in the previous screen. Any frequency distribution can be selected from the drop-down box. It should be noted here that the number of parameters displayed will depend on the frequency distribution chosen. Click the **Close** button to close the **Site Parameters** window.

The second button at the bottom of the **At-site Distribution Plots** window labeled **Analysis** is described in more detail in the next section. The third button, **Save/Export Chart**, opens the window shown earlier in Fig. 9. Here the user can either save the graph as an image or export the chart data as a table. As an image, the graph can be saved in one of five formats: .jpg (JPeg image), .bmp (Bitmap image), .gif (Gif image), .tiff (TIFF), or .png (Png image). The user is allowed to change the height and width of the graph (given in units of pixels) or can use the default settings that are given. As a table, all data in the graph are exported to a .csv (comma-separated values) file. Click the last button, **Close**, to close the **At-site Distribution Plots** window.

Site Frequency Analysis

The second button at the bottom of the **At-Site Distribution Plots** window is titled **Analysis**, and once clicked, the screen shown in Fig. 15 appears. The **Analysis** window is used to make a quantitative estimate of the intensity of an event for a particular non-exceedance or exceedance frequency for the site selected in the drop-down box at the top of the window. In order to change the site being analyzed, click the drop-down box and select the desired site. Frequency analysis can be performed using any of the fourteen standard frequency distributions mentioned earlier; initially the **GEV** frequency distribution is selected. The table on the right side of the window displays intensities for a range of exceedance and non-exceedance frequencies. Selecting a different frequency distribution will cause the values in this table to change. Also shown in this window are the **Pearson's R** values and **Z-Scores** for each distribution, which give an indication of the closeness of fit of each standard distribution to the sample data of the site being analyzed. The Pearson's R is determined by computing the square root of the means of the difference squared between the sample data and the standard distribution. The z-score is computed based on the distance between a site's **t4/t3** value on the graph shown in Fig. 11b and that of each 3-parameter distribution; the z-score is only applicable for 3-parameter distributions. A Pearson's R close to 1 and a z-score close to 0 indicate a good fit. These statistics, along with the graph in Fig. 9b and the visual fits of the PDF, CDF, non-exceedance, and exceedance curves, should be used together to determine the preferable standard frequency distribution to use for a particular site.

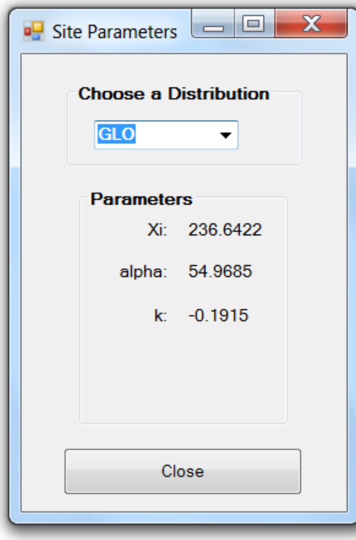


Figure 14: This window displays the parameters for a given distribution estimated from the L-moments of the site selected in Fig. 13.

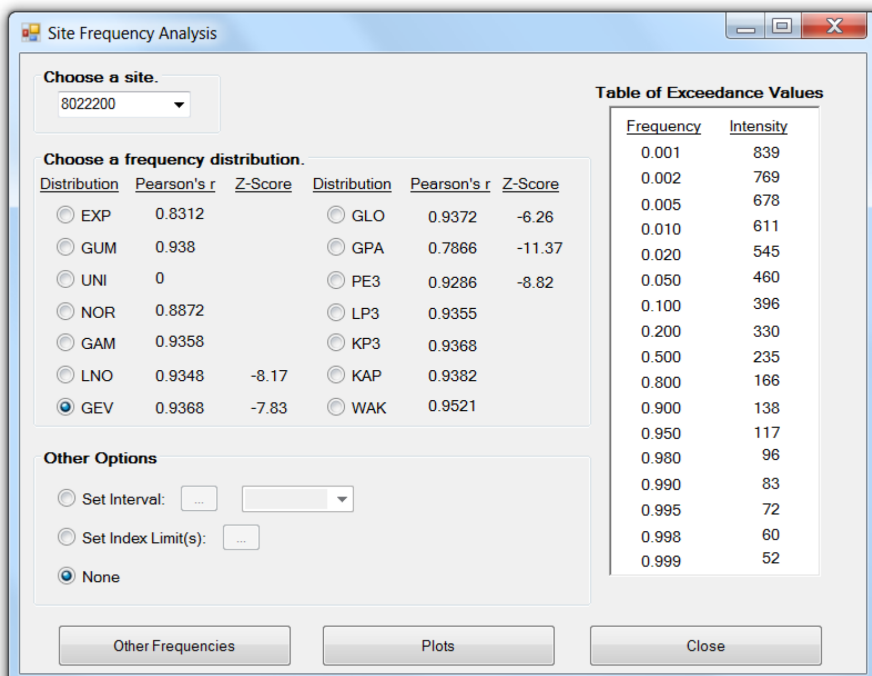


Figure 15: This screen estimates the storm intensity for an event of a particular frequency using one of 14 standard frequency distributions. Closeness-of-fit statistics (Pearson's R and Z-score) are shown for each distribution compared to the sample data of the site selected in the site drop-down box.

There is also the option of computing the intensities for each frequency in the table based on either specifying an interval length and then choosing an interval period in years or by specifying an upper or lower limit for a particular climate variability index (Table 1). The default selection is "**None**". In order to create a series of intervals of a particular time length, click the **Set Interval** option; the button and drop-down box to the right become enabled. Pressing the button brings up a screen asking the user to specify a time interval; enter an interval and select **OK**. The user is returned to the **Analysis** window within which the Intervals drop-down box has now been filled with intervals corresponding to the interval just specified. Selecting the desired interval within the drop-down box limits the computation of intensity to only non-zero sample data within that interval (the number of years of data used is shown); the resulting intensities are displayed within the table to the right for each corresponding frequency (see Fig. 16).

In order to display the individual data values corresponding to limits set for a particular climate variability index, click the **Index** option; the button to the right becomes enabled. Pressing the button brings up the screen shown in Fig. 17. Selecting any index enables the lower and upper limit textboxes associated with that index. There are also Information buttons associated with each index that provide the user with a brief description of that index. For example, pressing the **"?"** button associated with the **ONI** index brings up the screen shown in Fig. 18. Press **Close** to close the information window. Select an index type within the window shown in Fig. 17 and specify the lower and/or upper limits and press **OK**. The program recomputes the intensities for each frequency shown in the table in the **Analysis** window using only non-zero data that meets the index limits that have been set; the resulting intensities are shown in the table.

After computing intensities for interval analysis or using the index limits, the user should re-select "**None**" when desiring to analyze the entire data set without any index limits.

In the case that the user would like to find the intensity for a recurrence frequency not listed in the table, the button titled **Other Frequencies** at the bottom of the window should be selected; this will bring up the window shown in Fig. 19. The user should choose the type of extreme event they are interested in, whether it is a drought or a flood, and enter the desired frequency; the **Compute** button will then be enabled. Pressing the **Compute** button will give the resulting intensity using the frequency distribution that was chosen in the previous window. This feature can be used with or without using the interval and index limit options. Click **Close** to close this window.

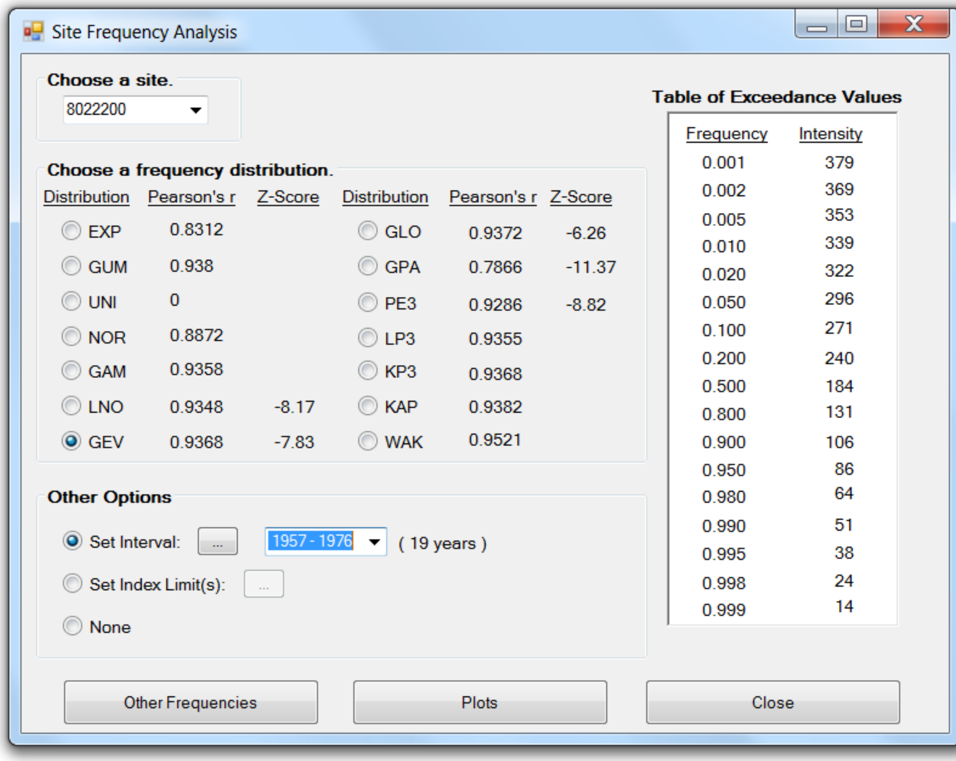


Figure 16: As in Fig. 15 except for using data within the years 1960 to 1979.

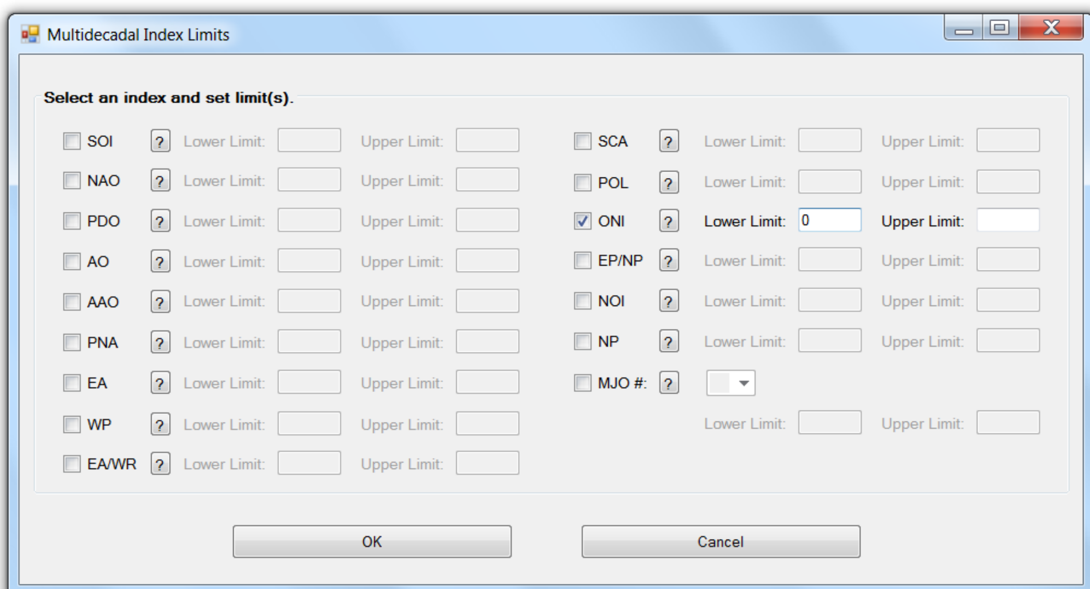


Figure 17: Window in which a multi-decadal index can be chosen and limits on the data used in the analysis can be set. More information is provided on each index by pressing the corresponding "**?**" button. In this example, a lower limit of "0" has been set for the ONI index.

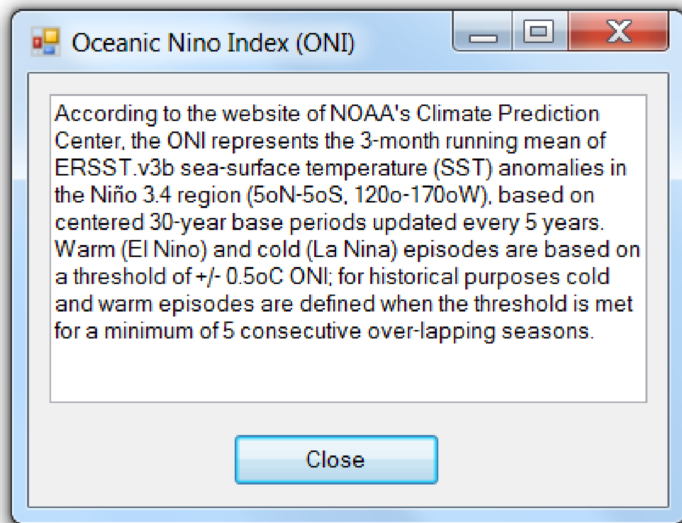


Figure 18: Information window for the Oceanic Niño Index (ONI).

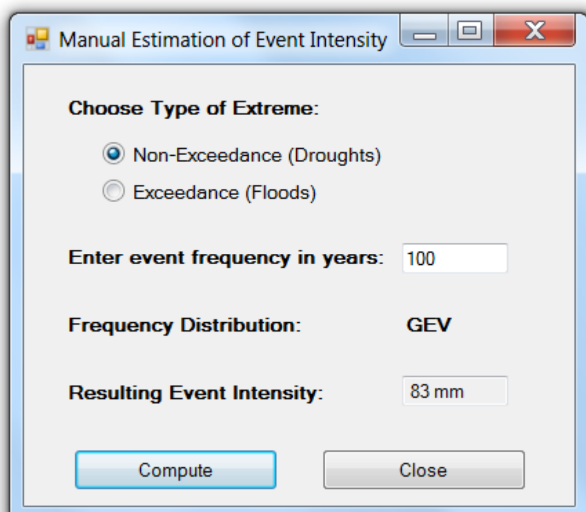


Figure 19: Window for estimating drought and flood frequencies other than those shown in the table in Fig. 15.

The second button titled “**Plots**”, when clicked, displays a window similar to the one shown in Fig. 20. For the site selected in Fig. 15, this window plots the intensity for a rainfall event of a particular frequency over the site’s period of record. If the “**Set Interval**” button is selected and an interval was defined in the previous window (as shown in Fig. 16), then the resulting plot will appear as shown in Fig. 20. The rainfall intensity for each interval will be plotted for the site selected in Fig. 15 over the site’s period of record. The event frequency can be selected using the frequency drop-down box on the left below the plot. The light blue dot on the graph indicates the resulting rainfall intensity for the interval selected in the interval drop-down box. The interval can be changed by selecting a different interval from the interval drop-down box or by clicking one of the arrows on either side of the interval drop-down box. If an interval was not set in the previous window, then the resulting graph will appear as a site exceedance curve (not shown). This curve will either use all of the data available at the site or, if **Index Limits** have been set, only the data that meet these limits. The **Save/Export Chart** button, which is the left button at the bottom of the window, opens the window shown earlier in Fig. 9. Here the user can either save the graph as an image or export the chart data as a table. As an image, the graph can be saved in one of five formats: .jpg (JPeg image), .bmp (Bitmap image), .gif (Gif image), .tiff (TIFF), or .png (Png image). The user is allowed to change the height and width of the graph (given in units of pixels) or can use the default settings that are given. As a table, all data in the graph are exported to a .csv (comma-separated values) file. Click the right button, **Close**, to close the **Frequency Plots** window.

Click **Close** to close the **Frequency Analysis** window.

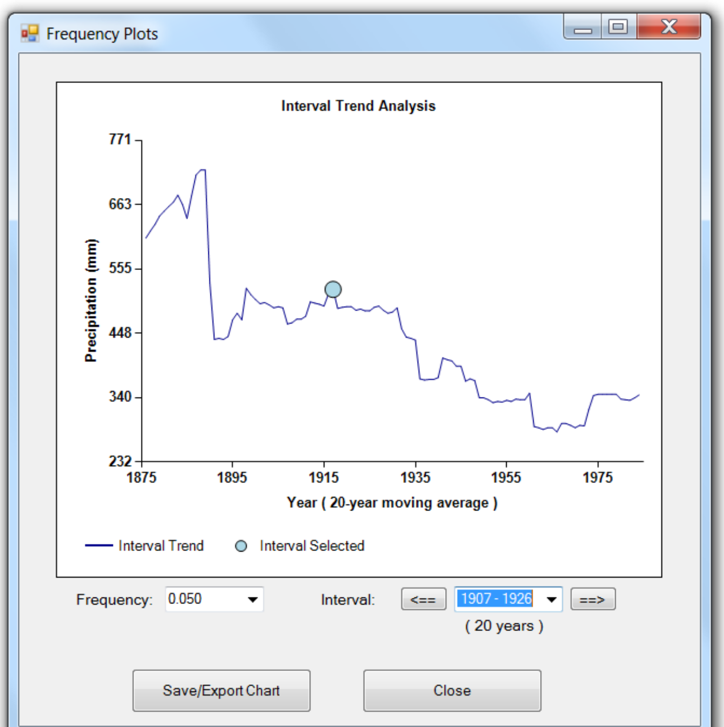


Figure 20: **Frequency Plots** window showing intensities of 20-year rainfall events (selected frequency = 0.050) for the entire period of record for a particular site. The light blue dot represents the 20-year event for the selected interval.

III. REGIONAL ANALYSIS

Regionalization

The final option on the Title Screen's toolbar is **Regions**. The first item of the **Regions** menu, **Regionalization,** should be the only item highlighted when you first open the menu; the other items will become available after the user completes regionalization. Clicking **Regionalization** brings up the window shown in Fig. 21.

The first choice the user needs to make is whether they would like to use the site characteristics in an attempt to create homogenous regions or whether they would like to use the eco-regions (as described earlier in the input data section) or specify their own regions. Prior to choosing the **Eco-regions/Own regions** option, the user needs to enter the eco-region or specify their own region number for each site in the final column of the **Other Site Characteristics** worksheet of the input file. The program will then create the regions based on this information. If the final column of the **Other Site Characteristics** worksheet is not complete for all sites, the user will be unable to use this option and will be required to use site characteristics to create regions.

After the **Use Site Characteristics** button is selected, all site characteristics that are completely filled in the **Other Site Characteristics** worksheet of the input file are enabled in the **Regionalization** window. Prior to entering the weights for each site characteristic, the user will need to specify the number of regions (or clusters) that they would like to create in the box below the regionalization method selection.

Finally the user will enter weights between 0 and 1 for all site characteristics that are enabled. If the user entered data in the **Other** columns of the **Other Site Characteristics** worksheet of the input file, these will be shown in the bottom three rows in the **Regionalization** window. If the user desires to give equal weights to some of the site characteristics, the checkboxes next to the appropriate site characteristics can be checked after which the **Equal Weights** button can be selected. Weights for all site characteristics selected will be divided equally to add up to 1.00. The **Select All** option may be selected if equal weights are desired for all site characteristics, whereas the **Unselect All** option may be selected to clear all checkboxes and enter each weight manually. It is also possible to set all weights back to zero by clicking the **Reset Weights** button. All weights that are entered must total to one (shown in the bottom left corner of Fig. 21), otherwise the **OK** button will not be enabled. Once all of the desired weights are entered, the user can click the **OK** button, which will begin the computation of the regions.

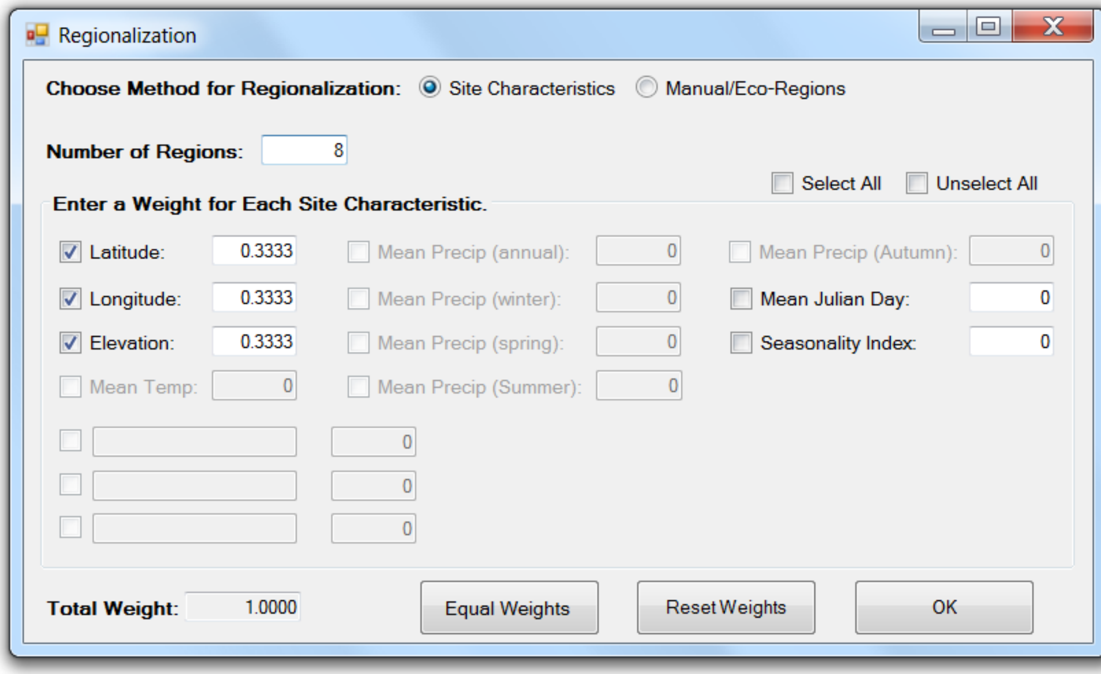


Figure 21: The **Regionalization** window.

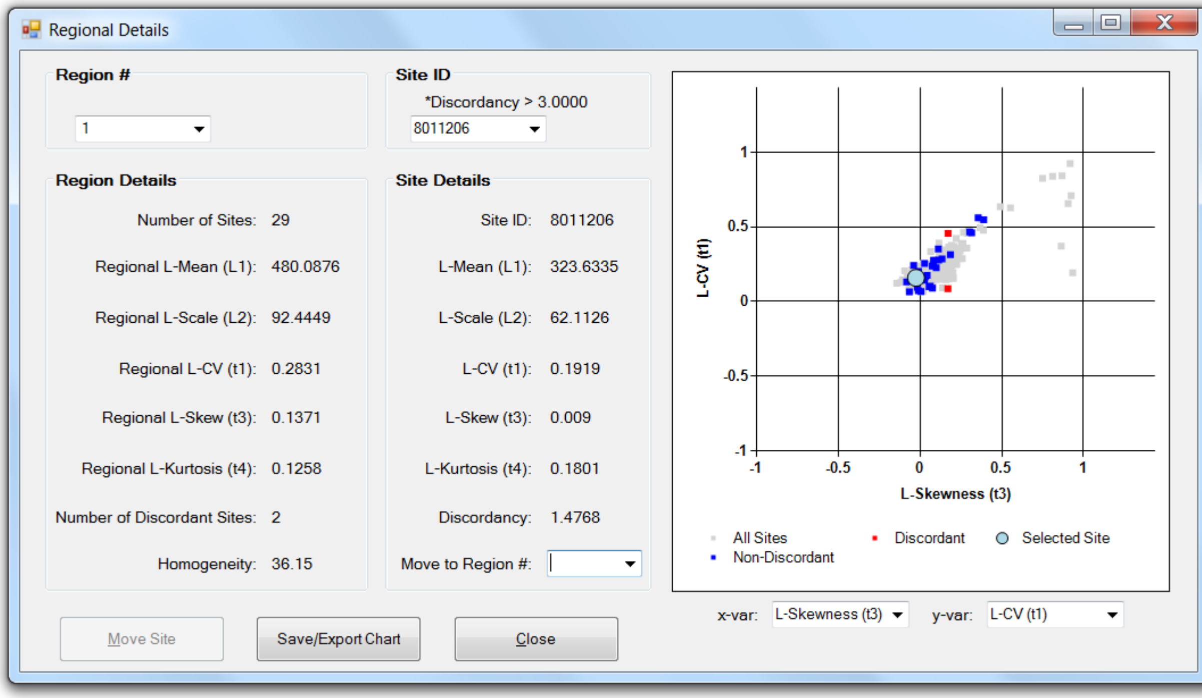
Region Details

After regionalization is completed, the **Regional Details** window (Fig. 22) appears; this window can also be accessed through the **Region** menu on the **Title Screen**. There are two drop-down boxes near the top of the window by which the user can select a desired region and site within the selected region. The regional L-moments and **homogeneity** for the selected region are shown in the first column, while the L-moment statistics and **discordancy** of the selected site are shown in the second column. In this case, the site discordancy is a measure of how a particular site's L-moment ratios compare to the site L-moment ratios of the other sites within the selected region. High discordancy could indicate that a site's data may contain some type of measurement error, which may include, for example, an error related to data entry. The homogeneity statistic gives an idea of how close the frequency distributions of all sites within the region are to each other.

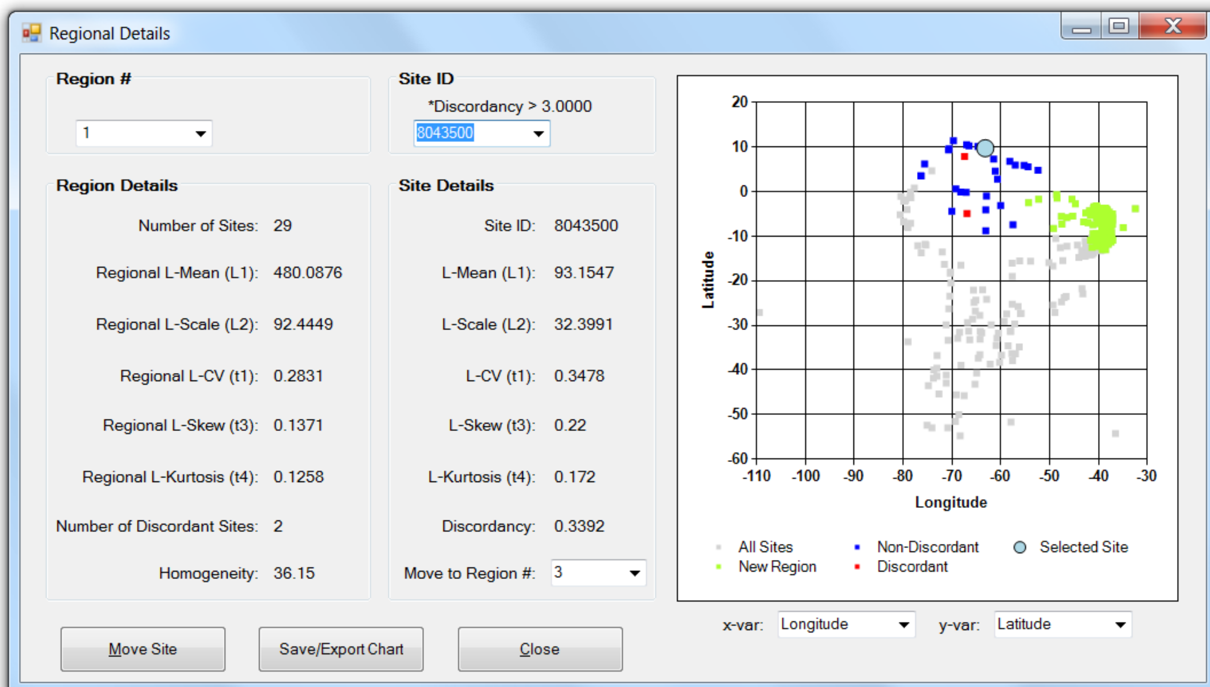
The right side of the **Regional Details** window contains a graph of L-Coefficient of Variation vs. L-Skewness (Fig. 22a). All sites not included in the selected region are shown as gray dots, whereas discordant sites within the selected region are shown as red dots and non-discordant sites are shown as blue dots. Discordant sites are also identified with an asterisk after their site-id within the **Site ID #** drop-down box. The site that has been selected is identified in the graph by a large dot, which is either light blue or red depending whether it is discordant or non-discordant compared to other sites within the region. Drop-down menus (as were shown in Fig. 8a) allow the user to display $\mathbf{L_1}$, $\mathbf{t_1}$, $\mathbf{t_3}$, $\mathbf{t_4}$, $\mathbf{t_5}$, or any of the at-site information from the **Other Site Characteristics** input sheet on either axis. Figure 22b shows the same graph when **Latitude** and **Longitude** are selected for the y- and x-axes, respectively. Graphing the various L-moments and site characteristics against each other may help to identify why some sites are discordant compared to others within the selected region, which may lead to moving a particular site to a different region.

When the **Move to Region** box is clicked, a list of the other region numbers is shown, from which a new region can be selected. The selected region appears in light green as illustrated in Fig. 22b. Upon clicking **Move Site**, the selected site will be relocated from its current region to the designated new region, a recalculation will occur, and the regional statistics, graphs, and site discordancy values will be updated to reflect the new grouping.

The **Save/Export Chart** button opens the window shown earlier in Fig. 9. Here the user can either save the graph as an image or export the chart data as a table. As an image, the graph can be saved in one of five formats: .jpg (JPeg image), .bmp (Bitmap image), .gif (Gif image), .tiff (TIFF), or .png (Png image). The user is allowed to change the height and width of the graph (given in units of pixels) or can use the default settings that are given. As a table, all data in the graph are exported to a .csv (comma-separated values) file. Click **Close** when finished viewing the **Regional Details** window.



(a)



(b)

Figure 22: Images of the **Region Details** window with the graph showing (a) L-Coefficient of Variation vs. L-Skewness and (b) Latitude vs. Longitude. Blue dots represent non-discordant sites, red dots represent discordant sites, and light green sites represent the receiving region chosen for a site move.

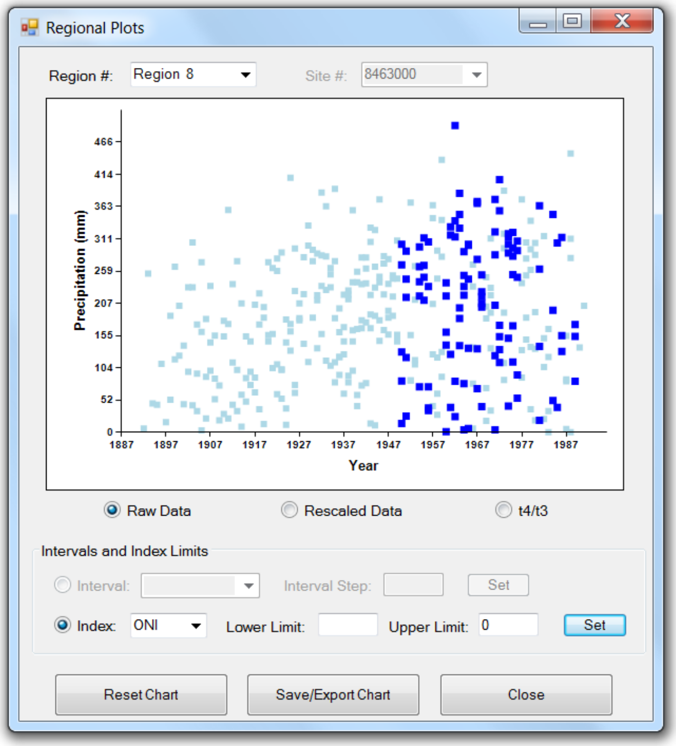
Regional Plots

Choosing Plots in the **Regions** menu within the title screen opens a window allowing the user to view graphs of the data for any individual region. Any region can be chosen using the drop-down box at the top of the window. Radio buttons below the chart window allow the user to view **Raw Data**, **Rescaled Data**, or a **t4/t3** (L-Kurtosis vs. L-Skew) plot. Selecting **Raw Data** will allow the user to see a graph of the raw data for all sites within the selected region (Fig. 23a), whereas selecting the **Rescaled Data** option produces a graph of the raw site data for all sites divided by each sites respective mean (not shown). This rescaling according to each site's mean allows all of the site data within a region to be analyzed as one large pool of data, which is the purpose of Regional Frequency Analysis. The frequency distribution that is fitted in the next step will be applied to all sites with that region, even sites with very little data compared to other sites.

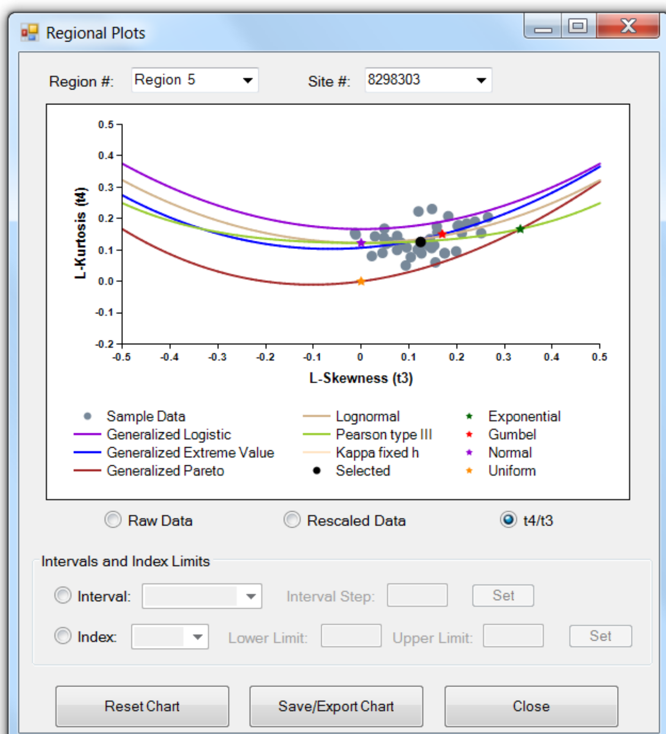
The graph of L-Kurtosis vs. L-Skew (Figs. 23b and 23c) gives an initial idea of how well each individual site's L-moments (represented by the gray circles) compare to the possible L-Skew and L-Kurtosis values representative of various frequency distributions. The colored stars represent the L-Kurtosis and L-Skew for the two-parameter frequency distributions that are available within this program, while the curves represent the range of possible values of L-Kurtosis vs. L-Skew for each of the three-parameter distributions, as indicated in the legend on the graph. The black dot shows the location of **t4/t3** for the site selected in the site drop-down box near the top of the window. This graph provides an initial indication of which frequency distribution may best represent the data for a particular region based on the proximity of the sites value of **t4/t3** compared to each distribution. It should be noted that this provides only one clue as to which distribution to use and should never be used alone when making a final decision. As shown in Fig. 23b, it can be difficult to determine a good frequency distribution to use when only looking at the **t4/t3** graph.

There is also the option of further restricting the graphed data and the data used to calculate the L-Kurtosis and L-Skew by either specifying an interval length and then choosing an interval period, which can only be used on the **t4/t3** graph (Fig. 23c), or by specifying an upper or lower limit for a particular climate variability index (refer to Table 1), which can be used on any graph (see Fig. 23a for an example). In order to create a series of intervals of a particular time length, click the circle corresponding to the **t4/t3** graph; the **Interval** option becomes enabled. Selecting interval causes the interval step textbox and the drop-down box to become enabled. Once an interval step is entered, the **Set** interval button becomes enabled; clicking **Set** will split the time period associated with the precipitation data measured within the selected region from the drop-down box near the top of the window into the corresponding intervals. Selecting an interval will restrict the data used to calculate L-Kurtosis and L-Skew to only those data measured within that interval; the result will be a graph similar to the one shown in Fig. 23c. In contrast to Fig. 23b, when only using rainfall measurements made between 1970 and 1989, the **Generalized Pareto** distribution seems to be a good fit for much of the data.

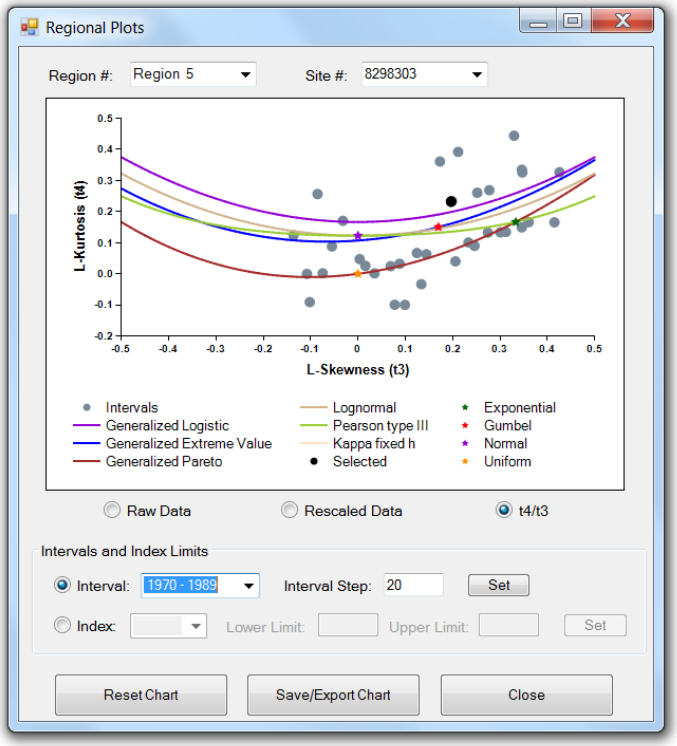
In order to restrict the data displayed by specifying an upper or lower limit for a particular climate variability index, select **Index** while any of the graph types are displayed; the index drop-down box and the upper and lower limit textboxes become enabled. Select an index type from the drop-down box and specify an upper or lower limit or both. Once this is done, the **Set** index button becomes enabled; clicking **Set** will restrict the data shown in the graphs and the measurements used to calculate L-Kurtosis and L-Skew to only those time periods when the selected index meets the restriction imposed. An example of the graph displaying the raw data measured during periods when the ONI index was less than 0 is shown in Fig. 23a.


Regional Plots
Region #: Region 8
Site #: 8463000
Precipitation (mm)
Year
Raw Data
Rescaled Data
t4/t3
Intervals and Index Limits
Interval:
Interval Step:
Set
Index: ONI
Lower Limit:
Upper Limit: 0
Set
Reset Chart
Save/Export Chart
Close

(a)


Regional Plots
Region #: Region 5
Site #: 8298303
L-Kurtosis (t4)
L-Skewness (t3)
Sample Data
Generalized Logistic
Generalized Extreme Value
Generalized Pareto
Lognormal
Pearson type III
Kappa fixed h
Selected
Exponential
Gumbel
Normal
Uniform
Raw Data
Rescaled Data
t4/t3
Intervals and Index Limits
Interval:
Interval Step:
Set
Index:
Lower Limit:
Upper Limit:
Set
Reset Chart
Save/Export Chart
Close

(b)



(c)

Figure 23: **Regional Plots** window, showing (a) the **Raw Data** measured during periods for ONI < 0; (b) the **t4/t3** graph for a selected region, which includes all sites within the selected region as gray dots, the selected region as a black dot, two-parameter distributions as colored stars, and the three-parameter distributions as colored curves, with no restrictions imposed; and (c) the **t4/t3** graph for the same region except where L-Kurtosis and L-Skew have been calculated using only rainfall measurements taken between 1970 and 1989. All standard distributions are shown in the legend.

There are three buttons at the bottom of the window in Fig. 23: **Reset Chart**, **Save/Export Chart**, and **Close**. Clicking the **Reset Chart** button will reset any limitations that were placed on the data based on time intervals or index limits; all associated textboxes and drop-down menus will be cleared and the original graphs will be displayed. The **Save/Export Chart** button opens the window shown earlier in Fig. 9. Here the user can either save the graph as an image or export the chart data as a table. As an image, the graph can be saved in one of five formats: .jpg (JPeg image), .bmp (Bitmap image), .gif (Gif image), .tiff (TIFF), or .png (Png image). The user is allowed to change the height and width of the graph (given in units of pixels) or can use the default settings that are given. As a table, all data in the graph are exported to a .csv (comma-separated values) file. Click **Close** when finished viewing the **Regional Plots** window.

Regional Frequency Distribution

The final option in the **Regions** menu on the **Title Screen** is **Frequency Distribution.** Once clicked, a window opens that displays the first region's data probability density function (**PDF**) as vertical blue bars. Any of the regions can be viewed using the drop-down box below the graph; for example, the PDF of Region #1 is shown in Fig. 24a. In addition, fits of any of the fourteen different standard frequency distribution functions (see Table 2) to the L-moments of the region's data can be displayed on the graph by clicking the box next to the desired distribution; the **GEV**, **GLO**, and **LP3** are compared in Fig. 24a. Distributions are divided based on the number of parameters required. This graph provides a way to visually determine how well each standard frequency distribution fits the region's sample data and offers another clue in determining which distribution may be best for a particular region. In addition, a region's cumulative distribution function or **CDF** (not shown), **non-exceedance** curve (Fig. 24b), and **exceedance** curve (Fig. 24c) can be displayed. The **CDF** is the integral of the probability density function, summing up the total probability of rainfall at or below a given value, and is used when computing the **non-exceedance** and **exceedance** curves. The **non-exceedance** graph is shown on a logarithmic scale and provides the user with information regarding the frequency at which a particular rainfall amount is not exceeded; this is useful for users concerned with drought events. The **non-exceedance** curve for the sample data along with the best fits of the **GEV**, **GLO**, and **LP3** distributions are shown in Fig. 24b. The **exceedance** graph is also shown on a logarithmic scale and provides the user with information regarding the frequency at which a particular rainfall amount is exceeded; this is useful for users more concerned with flood events. The **exceedance** curve for the sample data along with best fits of the **GEV**, **GLO**, and **LP3** distributions for Region #1 are shown in Fig. 24c. The estimated **non-exceedance** and **exceedance** curves of the sample data are represented by the light blue lines, and the distributions are represented as in previous graphs. Each of these graphs can be used to make a visual comparison between how well each standard distribution fits the data of a site. As in the previous screen, these graphs should not be used alone in finally determining which distribution to use to characterize a particular region's distribution curve.

A special note needs to be made regarding two of the distributions: the **KP3** and **KAP**. The **KP3** distribution is similar to the **KAP** distribution except that the fourth parameter (h) is fixed by the user, resulting in a 3-parameter version of **KAP**. The current h-value that is being used to solve the **KP3** is shown near the bottom of the window on the right side (default is $h = 0$); pushing the adjacent "**...**" button allows the user to set the h-value. The **KAP** distribution is the parent distribution of the **KP3** distribution and several of the other 3-parameter distributions, and setting h to particular standard values will result in one of these child distributions: $h = -1$ results in the Generalized Logistic distribution (**GLO**); $h = 0$ results in the Generalized Extreme Variable (**GEV**) distribution; and $h = 1$ results in the Generalized Pareto (**GPA**) distribution. Non-standard values of h may be of use if inspection of the **t4/t3** graph (Fig. 23) reveals that sites or regions cluster between the curves of the three child distributions; a strong theoretical backing should be developed in order to defend the h-value that was used. In addition, the small unlabelled button next to the **KAP** distribution allows the user to change the number of iterations used in the four-parameter fitting process; this option should not be used unless the Kappa function is not producing a satisfactory fit to the sample data.

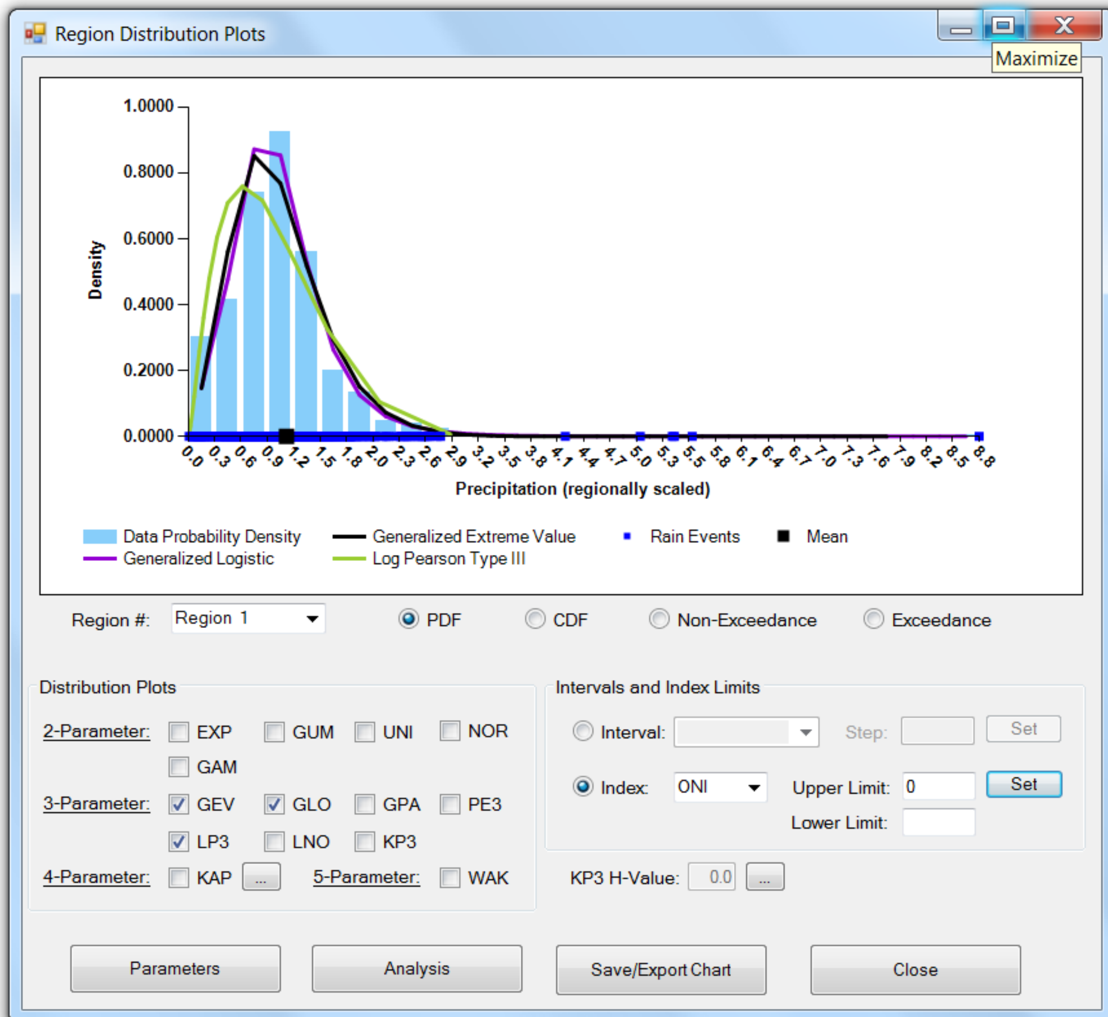
There is also the option of displaying individual data values on the graph by either specifying an interval length and then choosing an interval period or by specifying an upper or lower limit for a particular climate variability index (refer to Table 1). In order to create a series of intervals of a particular time length, click the circle corresponding to the **Interval** option; the interval step textbox and the drop-down box become enabled. Once an interval step is entered, the **Set** interval button becomes enabled;

clicking **Set** will split the time period associated with the precipitation data for the region into the corresponding intervals. Selecting an interval will display the data within the interval as blue squares and the mean for that data as a larger black square; on the **PDF** these squares will appear on the x-axis, whereas on the **CDF** and the **non-exceedance** (Fig. 24b) and **exceedance** curves, the squares will appear along the light blue line that represents the original data.

In order to display the individual data values corresponding to limits set for a particular climate variability index, select the **Index** option; the index drop-down box and the upper and lower limit textboxes become enabled. Select an index type from the drop-down box and specify an upper or lower limit or both. Once this is done, the **Set** index button becomes enabled; clicking **Set** will display the selected region's data meeting the limit criteria as blue squares and the mean of that data as a larger black square; on the **PDF** (Fig. 24a) these squares will appear on the x-axis, whereas on the **CDF** and the **non-exceedance** and **exceedance** (Fig. 24c) curves, the squares will appear along the light blue line that represents the original data.

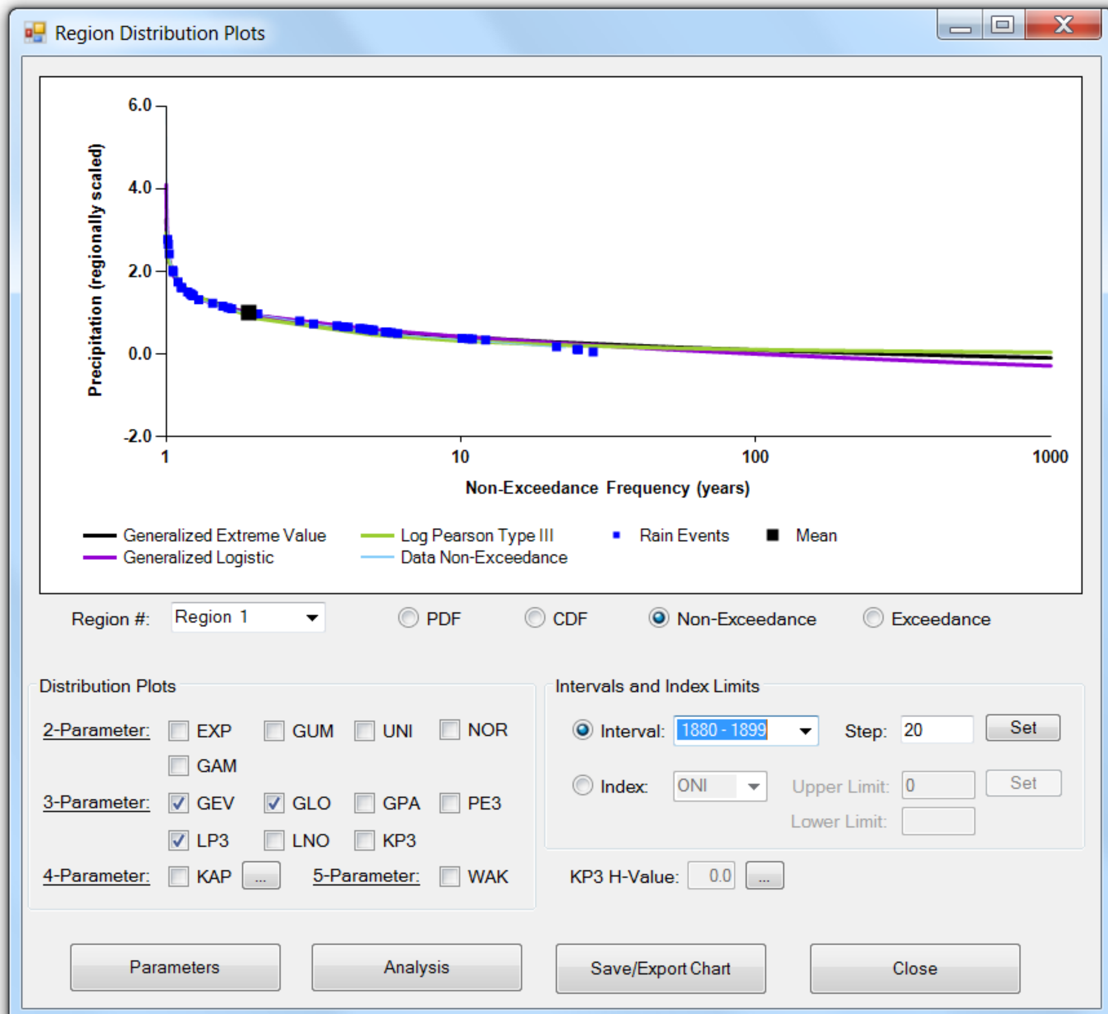
There are four buttons at the bottom of the **Regional Distribution Plots** window. The first button is titled **Parameters**, and when selected a window similar to that shown in Fig. 14 appears that displays the parameters for a particular standard frequency distribution estimated from the L-moments of the region selected in the previous screen. Any frequency distribution can be selected from the drop-down box. It should be noted here that the number of parameters displayed will depend on the frequency distribution chosen. Click the **Close** button to close the **Regional Parameters** window.

The second button at the bottom of the **Regional Distribution Plots** window labeled "**Analysis**" is described in more detail in the next section. The third button is the **Save/Export Chart** button, which opens the window shown earlier in Fig. 9. Here the user can either save the graph as an image or export the chart data as a table. As an image, the graph can be saved in one of five formats: .jpg (JPeg image), .bmp (Bitmap image), .gif (Gif image), .tiff (TIFF), or .png (Png image). The user is allowed to change the height and width of the graph (given in units of pixels) or can use the default settings that are given. As a table, all data in the graph are exported to a .csv (comma-separated values) file. Click the **Close** button on the **Regional Distribution Plots** window when finished.



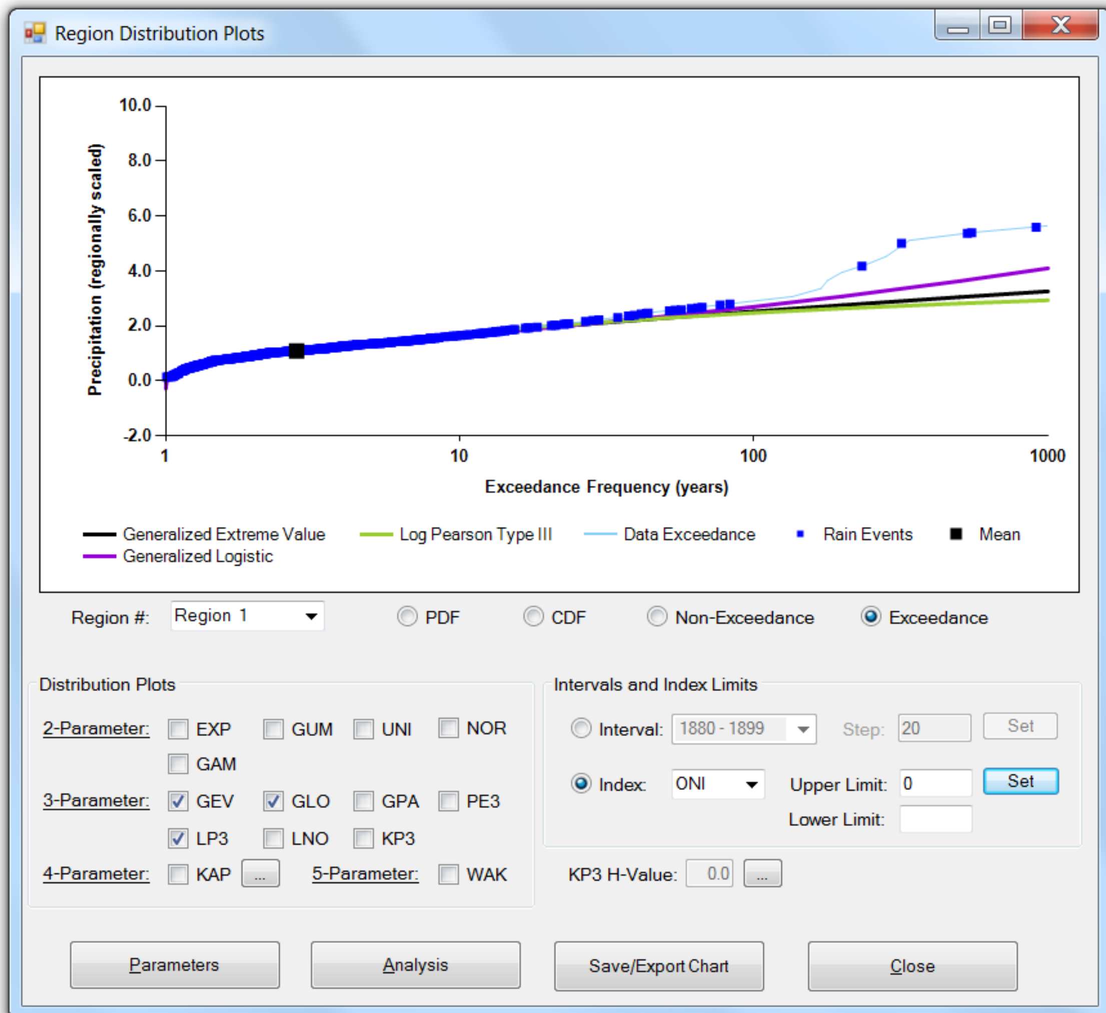
Region Distribution Plots
Maximize
1.0000
0.8000
0.6000
0.4000
0.2000
0.0000
Density
Precipitation (regionally scaled)
Data Probability Density
Generalized Extreme Value
Rain Events
Mean
Generalized Logistic
Log Pearson Type III
Region #:
Region 1
PDF
CDF
Non-Exceedance
Exceedance
Distribution Plots
2-Parameter:
EXP
GUM
UNI
NOR
GAM
3-Parameter:
GEV
GLO
GPA
PE3
LP3
LNO
KP3
4-Parameter:
KAP
5-Parameter:
WAK
Intervals and Index Limits
Interval:
Step:
Set
Index:
ONI
Upper Limit:
0
Set
Lower Limit:
KP3 H-Value:
0.0
Parameters
Analysis
Save/Export Chart
Close

(a)



Region Distribution Plots
6.0
4.0
2.0
0.0
-2.0
Precipitation (regionally scaled)
1
10
100
1000
Non-Exceedance Frequency (years)
Generalized Extreme Value
Generalized Logistic
Log Pearson Type III
Data Non-Exceedance
Rain Events
Mean
Region #:
Region 1
PDF
CDF
Non-Exceedance
Exceedance
Distribution Plots
2-Parameter:
EXP
GUM
UNI
NOR
GAM
3-Parameter:
GEV
GLO
GPA
PE3
LP3
LNO
KP3
4-Parameter:
KAP
5-Parameter:
WAK
Intervals and Index Limits
Interval:
1880 - 1899
Step:
20
Set
Index:
ONI
Upper Limit:
0
Lower Limit:
KP3 H-Value:
0.0
Parameters
Analysis
Save/Export Chart
Close

(b)



(c)

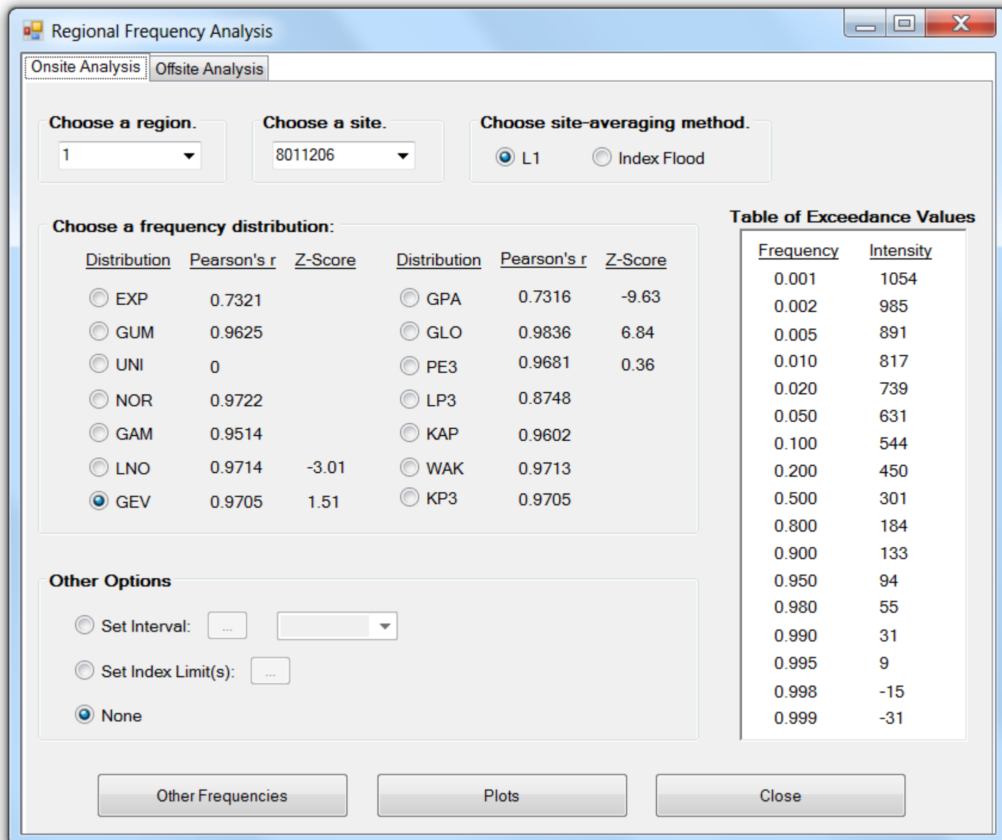
Figure 24: **Regional Distribution Plots** screen, showing (a) the probability density function (**PDF**), (b) the **non-exceedance** curve, and (c) the **exceedance** curve for the sample data of the selected region as blue bars (**PDF**) and light blue lines (**non-exceedance** and **exceedance curves**). Also included are the estimations for each curve using three different standard frequency distributions: **GEV, GLO, and LP3**; the line color for each is shown in the legend. Also shown in the graph are the rain events that (a) & (c) meet a set climate variability index limit or are (b) within a specified interval as blue squares and the means as a larger black square.

Onsite Regional Frequency Analysis

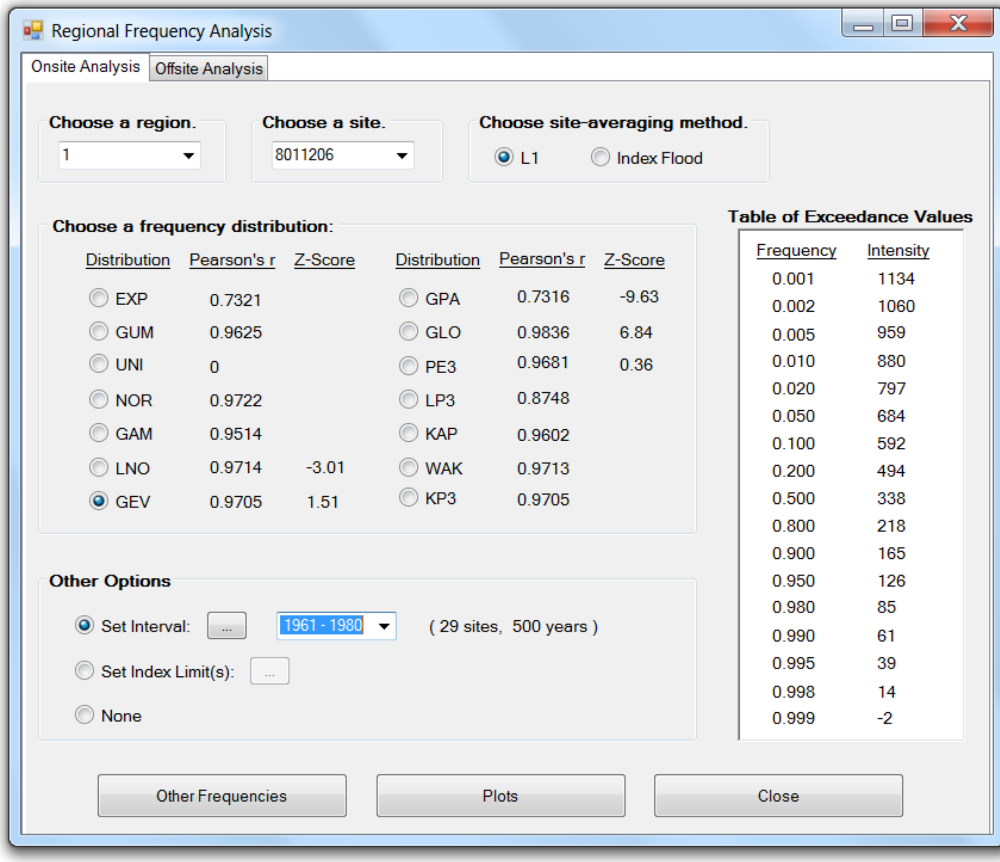
The second button at the bottom of the **Regional Distribution Plots** window is titled **Analysis**, and once clicked, the screen shown in Fig. 25a appears. The **Regional Frequency Analysis** window is divided into two tabs titled **Onsite Analysis** and **Offsite Analysis**. Onsite analysis refers to estimating the magnitude of a storm event of a particular frequency for a particular site where data is available. This is similar to what was done in the **Site Frequency Analysis** window described earlier. A desired region and a site within that region can be selected from the two drop-down boxes at the top of the window. As was also done in the **Site Frequency Analysis** window, any of the fourteen standard frequency distributions mentioned earlier can be used to estimate the event intensity for a particular site; initially the Generalized Extreme Value (GEV) frequency distribution is selected. The table on the right side of the window displays intensities for a range of exceedance and non-exceedance frequencies computed from the selected distribution; selecting a different frequency distribution will cause the values in this table to change. Once the desired distribution has been selected, the user needs to choose which site averaging method to use to estimate the storm intensity for a particular site using the regional frequency distribution. Because the regional distribution was fit to scaled or normalized site data, the resulting regional exceedance curve needs to be multiplied by a mean value representative of the selected site. Two options are available: using the L-Mean (**L1**) computed from the selected sites rainfall data provided in the input file or using an **Index Flood** value for that site. The **Index Flood** method uses the **Mean Precipitation** for the period entered in the **Initial Screening** window; the mean precipitation for this period needs to be entered by the user in the final column of the **Other Site Characteristics** worksheet at the data entry phase, if available. An external source, such as a Mean Annual Precipitation map or database, is needed to use this option. If this information is not available, then the user must use the **L1** option. This method of computing the at-site estimate of the X-year storm event should be an improvement over direct at-site estimates as was done earlier.

Also shown in this window are the Pearson's R-values and z-scores for each distribution, which give an indication of the closeness of fit of each standard distribution to the sample data of the region being analyzed. The Pearson's R-value is determined by computing the square root of the means of the difference squared between the sample data and the standard distribution. The z-score is computed based on the distance between a region's **t4/t3** value and that of each 3-parameter distribution; the z-score is only applicable for 3-parameter distributions. A Pearson R-value close to 1 and a z-score close to 0 indicate a good fit. These statistics, along with the graphs similar to the one in Fig. 23 and the visual fits of the curves shown in Fig. 24 should be used together to determine the preferable standard frequency distribution to use for a particular region.

There is also the option of computing the intensities for each frequency in the table for a particular site based on either specifying an interval length and then choosing an interval period or by specifying an upper or lower limit for a particular climate variability index (Table 1). The default option is "**None**". In order to create a series of intervals of a particular time length, click the **Interval** option; the button and drop-down box to the right become enabled. Pressing the button brings up a screen asking the user to specify a time interval; enter an interval and select **OK**. The user is returned to the **Analysis** window within which the Intervals drop-down box has now been filled with intervals corresponding to the interval just specified and the range of the site data (this does not include all years within the region). Selecting the desired interval within the drop-down box limits the computation of intensity to only non-zero sample data within that interval (the number of sites and total years used in the computation of the regional L-moments are shown); the resulting intensities are displayed within the table to the right for each corresponding frequency (see Fig. 25b).


Regional Frequency Analysis
Onsite Analysis
Offsite Analysis
Choose a region.
1
Choose a site.
8011206
Choose site-averaging method.
L1
Index Flood
Choose a frequency distribution:
Distribution
Pearson's r
Z-Score
Distribution
Pearson's r
Z-Score
EXP 0.7321
GUM 0.9625
UNI 0
NOR 0.9722
GAM 0.9514
LNO 0.9714 -3.01
GEV 0.9705 1.51
GPA 0.7316 -9.63
GLO 0.9836 6.84
PE3 0.9681 0.36
LP3 0.8748
KAP 0.9602
WAK 0.9713
KP3 0.9705
Table of Exceedance Values
Frequency
Intensity
0.001 1054
0.002 985
0.005 891
0.010 817
0.020 739
0.050 631
0.100 544
0.200 450
0.500 301
0.800 184
0.900 133
0.950 94
0.980 55
0.990 31
0.995 9
0.998 -15
0.999 -31
Other Options
Set Interval:
Set Index Limit(s):
None
Other Frequencies
Plots
Close

(a)



(b)

Figure 25: Shown are the input screens for regional **Onsite Analysis**; the difference between (a) using the entire data set and (b) using data only within a specified interval to compute intensities for the frequencies in the table is illustrated.

In order to display the individual data values corresponding to limits set for a particular climate variability index, click the **Set Index Limit(s)** option; the button to the right becomes enabled. Pressing the button brings up the screen shown earlier in Fig. 17. Selecting any index enables the lower and upper limit textboxes associated with that index. There are also Information buttons labeled with a "**?**" associated with each index that provide the user with a brief description of that index. For example, pressing "**?**" button next to the **ONI** index option brings up the screen previously shown in Fig. 18. Press **Close** to close the information window. Select an index type and specify the lower and/or upper limits and press **OK**. The program recomputes the intensities for each frequency shown in the table in the **Analysis** window using only non-zero data from the selected region that meet the specified index limits; the resulting intensities are shown in the table.

After computing intensities for interval analysis or using the index limits, the user should re-select "**None**" when desiring to analyze the entire data set without any index limits.

In the case that the user would like to find the intensity for a recurrence frequency not listed in the table, the button titled **Other Frequencies** at the bottom of the window should be selected; this will bring up the window previously shown in Fig. 19. The user should choose the type of extreme event they are interested in, whether it is a drought or a flood, and enter the desired frequency; the **Compute** button will then be enabled. Pressing the **Compute** button will give the resulting intensity based on the frequency distribution chosen in the previous screen. This feature can be used with or without using the interval and index limit options. Click **Close** to close this window.

The third button titled "**Plots**", when clicked, displays a window similar to the one shown in Fig. 26. For the site selected in Fig. 25, this window plots the intensity for a rainfall event of a particular frequency over the site's period of record. If the "**Set Interval**" button is selected and an interval was defined in the previous window (Fig. 25), then the resulting plot will appear as shown in Fig. 26. The rainfall intensity for each interval will be plotted for the site selected in Fig. 25 over that site's period of record. The event frequency can be selected using the frequency drop-down box on the left below the plot. The light blue dot on the graph indicates the resulting rainfall intensity for the interval selected in the interval drop-down box. The interval can be changed by selecting a different interval from the interval drop-down box or by clicking one of the arrows on either side of the interval drop-down box. If an interval was not set in the previous window, then the resulting graph will appear as a site exceedance curve (not shown). This curve will either use all of the data available at the site or, if **Index Limits** have been set, only the data that meet these limits. The left button at the bottom of the screen is the **Save/Export Chart** button, which opens the window shown earlier in Fig. 9. Here the user can either save the graph as an image or export the chart data as a table. As an image, the graph can be saved in one of five formats: .jpg (JPeg image), .bmp (Bitmap image), .gif (Gif image), .tiff (TIFF), or .png (Png image). The user is allowed to change the height and width of the graph (given in units of pixels) or can use the default settings that are given. As a table, all data in the graph are exported to a .csv (comma-separated values) file. Click the right button, **Close**, to close the **Frequency Plots** window.

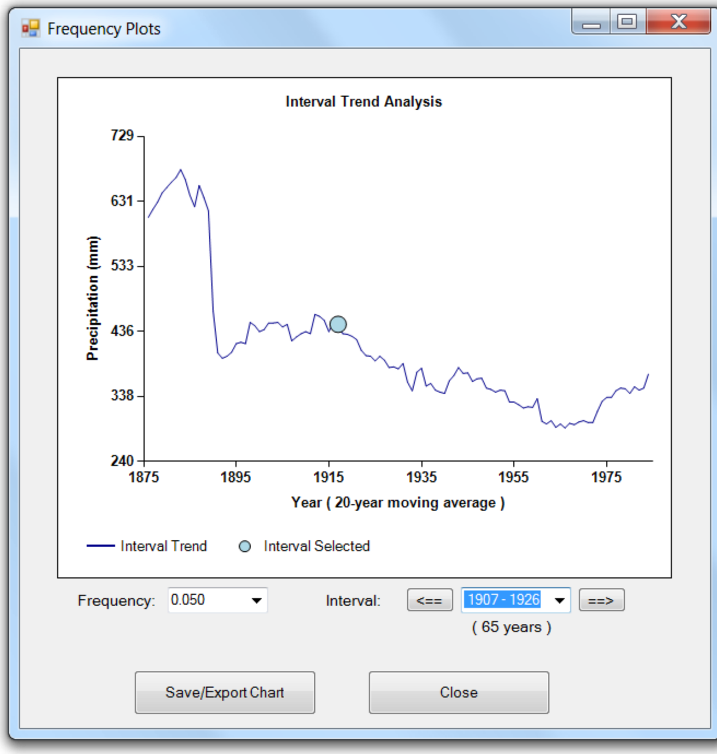


Figure 26: **Frequency Plots** window showing intensities of 20-year rainfall events (selected frequency = 0.050) for the entire period of record for a particular site in Region 4. The light blue dot represents the 20-year event for the selected interval.

Offsite Regional Frequency Analysis

When the user clicks the **Offsite Analysis** tab of the **Regional Frequency Analysis** window, the screen in Fig. 27 appears. Offsite analysis is performed when attempting to estimate the intensity of storms of a particular frequency at sites where there are no data. This is accomplished using the sites that do contain data and an interpolation scheme, such as linear interpolation or inverse distance weighting, to estimate the values between these sites. The first step in this process is to identify the region over which the user would like to estimate storm intensities. This is accomplished by entering the range of latitudes (northern and southern limits) and longitudes (eastern and western limits) that the region is to cover. In addition the user needs to enter a Resolution in units of degrees; the resolution entered must be less than the lesser of the latitude and longitude ranges. Next, and as was done in the **Onsite Analysis**, the user must select a standard frequency distribution and a site averaging method and also enter the desired rainfall frequency.

After all of the required information is obtained, the **Export** button will become enabled. Clicking the **Export** button will bring up a dialog box prompting the user to select where they would like the output file saved; the user also needs to provide a name for the file. Clicking the **OK** button creates a text output file similar to the one shown in Fig. 28. The Information provided in the output file include the

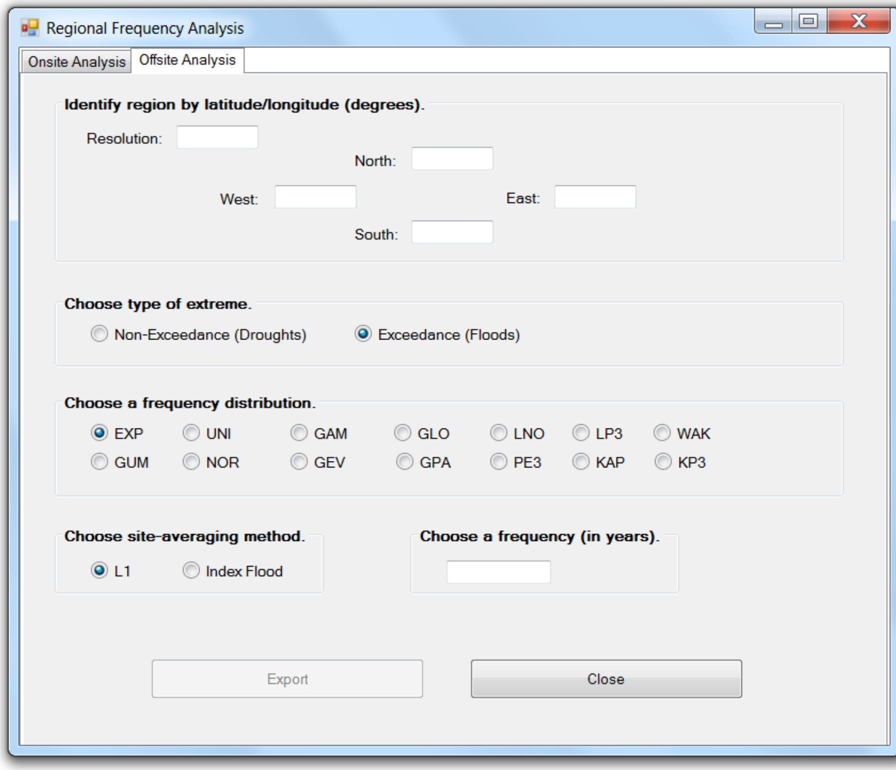
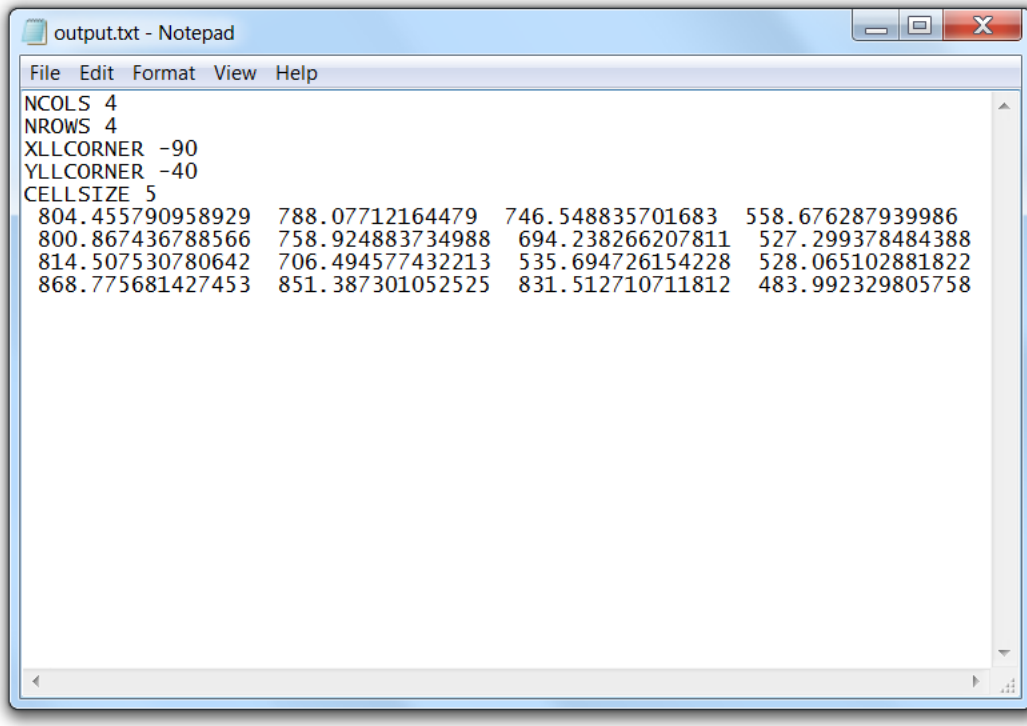


Figure 27: Shown is the input screen for regional **Offsite Frequency Analysis**.

number of rows and columns of the output data, the x- and y-coordinates of the lower left corner of the desired region, the resolution in degrees, and the actual offsite data organized into rows and columns. The method currently used to interpolate between onsite observations and create the resulting export file is Inverse Data Weighting (IDW). The program has determined the number of cells in the region by the ranges of latitude and longitude divided by the desired resolution. For example, in Fig. 28 the region has been divided up into a 4 x 4 grid containing a total of 16 cells (20 degrees longitude / 5 degrees resolution = 4 longitude cells; 20 degrees latitude / 5 degrees resolution = 4 latitude cells). If the latitude and/or longitude range does not divide evenly by the resolution, the program always round the number of cells up and adjusts the borders of the region accordingly.

Click the **Close** button to close the **Regional Frequency Analysis** window. Click **Close** to close the **Regional Distribution Plots** window.

As already mentioned, the program can be closed by either selecting **File** and **Exit** from the **Title Screen** or by clicking the "**X**" in the upper-right corner of the window.



output.txt - Notepad

File Edit Format View Help

```
NCOLS 4
NROWS 4
XLLCORNER -90
YLLCORNER -40
CELLSIZE 5
 804.455790958929  788.07712164479  746.548835701683  558.676287939986
 800.867436788566  758.924883734988  694.238266207811  527.299378484388
 814.507530780642  706.494577432213  535.694726154228  528.065102881822
 868.775681427453  851.387301052525  831.512710711812  483.992329805758
```

Figure 28: Example output file when performing offsite analysis.

IV. CONTACT INFORMATION

This tool is being designed by ICIWaRM staff with the use of our collaborators specifically in mind. Please feel free to **contribute your thoughts on the program** and **the ways in which this program could better help you conduct your frequency analysis** to ICIWaRM. Staff members responsible for the continuing development of the program can be reached at the following e-mail addresses:

Jason Giovannettone	Jason.P.Giovannettone@usace.army.mil
Michael Wright	Michael.J.Wright@usace.army.mil