

ClimDex - Version 1.3

User's Guide

June, 2001

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Introduction

ClimDex (Version 1.3) is a Microsoft Excel (Version 97 or higher) program designed to assist researchers in the analysis of climate change and detection. More specifically, ClimDex guides a user through a four-step analysis process, using a graphical user interface (Fig. 1.1). This process consists of the following steps:

1. Quality Control
2. Homogeneity Testing
3. Calculate Indices
4. Region Analysis

The first three steps are performed on a single station's data whereas the last step compiles the results calculated in step 3 for multiple stations.

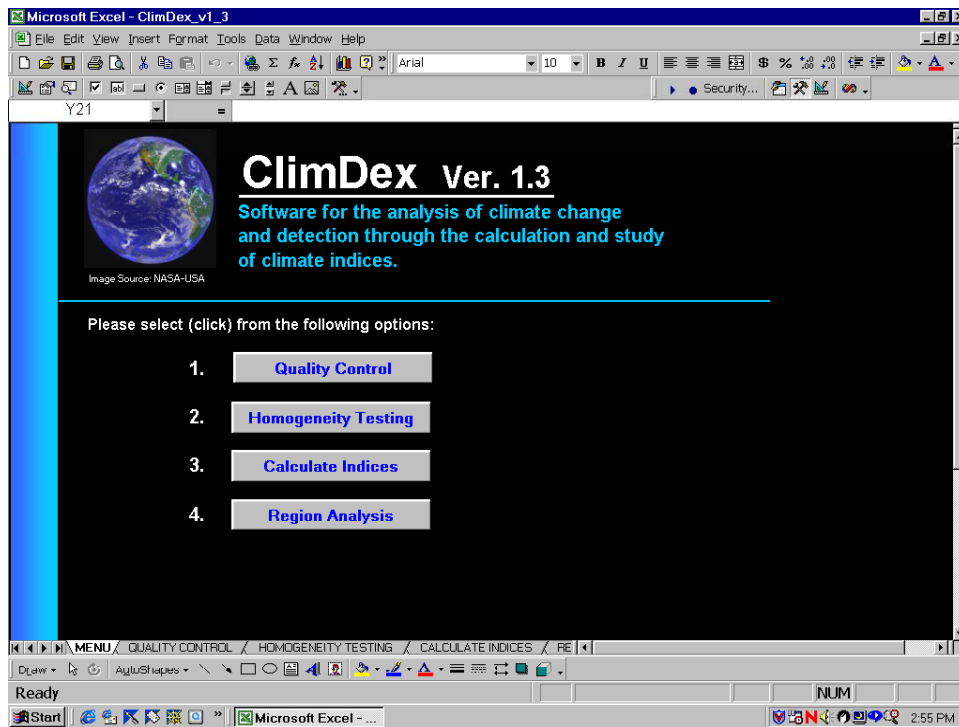


Figure 1.1, Main Menu ClimDex version 1.3

Quality Control

The first step in the analysis process consists of the application of routine quality control procedures to a user's station data. The quality control checks performed are:

1. $TMIN > TMAX$
2. $PRCP < 0.0$ mm
3. Identifying extreme values $>$ or $<$ a specified number of standard deviations

Daily values for both maximum and minimum temperature only are evaluated using the technique described in step 3. Further explanation of step 3 follows with an example:

Example 2.1

A user is analyzing a station with 50 years of daily data (1945 to 1994). The user selects a sigma (standard deviation) value of ± 3 in step 7 of the quality control (Fig. 2.1) procedure:

Microsoft Excel - ClimDex_v1_3

File Edit View Insert Format Tools Data Window Help

3. Station Numerical ID: 123456789

4. Station Latitude: 40.45

5. Station Longitude: -85.88

6. Missing Data Value: -99.9 (REQUIRED)

7. Flag temperatures +/- 3 standard deviations for that particular day. (REQUIRED)

(Please Note: All values that are flagged in step 7 will automatically be set to missing. If you would like to retain these values, please specify a higher value in step 7.)

8. Input Data File Path: Browse C:\SampleDataFile.dat (REQUIRED)

9. Output Excel File Path: Save As C:\Quality_Control_Results.xls

Ready NUM

9:30 AM

Fig.2.1 Quality Control procedure in Climdex 1.3

Therefore, for all 365 of the same day values (leap years excluded) a standard deviation is calculated for each day. Thus, for a particular day, January 25th for example, a standard deviation is calculated for all 50 January 25 values (excluding missing values). Then each January 25th (50 values) is compared to the standard deviation for that day and if it is $>$ or $<$ 3 standard deviations it is set equal to the missing value designated by the user. In addition, values that meet the criteria within the first 2 quality control steps (e.g. TMIN $>$ TMAX, PRCP $<$ 0.0) are also set to missing. Users who desire to preserve as much of their original data as possible should consider using a large sigma value (perhaps 5 or greater). The quality control procedure within ClimDex is not meant to be comprehensive but rather to assist a user in identifying common gross errors that may exist within daily station data.

Homogeneity Testing

ClimDex provides users with a way to detect temperature (TMAX and TMIN) inhomogeneities. These values can be thought of as discontinuities or shifts in the data record or time series of maximum or minimum temperature. These abrupt or sometimes gradual changes can be traced to both natural and artificial (human induced) changes. User's are generally more interested in eliminating or mitigating the effects of the latter (artificial) and trying to detect and/or explain the former (natural). The scientific literature has many articles devoted to various philosophies and techniques for identifying inhomogeneities. The number of articles is too numerous to list in this guide. ClimDex's homogeneity testing procedure is fairly simple compared to many of these articles in print and therefore a user may want to supplement their data with further testing from these additional techniques. ClimDex utilizes the following techniques to examine a temperature time series for inhomogeneities:

1. Visual inspection of a temperature time series
2. Statistical test (t-test) to test the difference between two adjacent period mean values

In the first step, ClimDex simply provides the user with a time series of annual mean (temperature) and accumulated values (precipitation). These time series can then be examined in conjunction with any existing metadata to identify potential inhomogeneities. The second step involves the user defining a "window" size in years. This window size is then split into two adjacent periods and then the difference between the two mean values are tested for any differences from 0 (e.g. two-sided t-test, for Beta

not equal to 0). The resultant probabilities from this statistical test are plotted for the user.

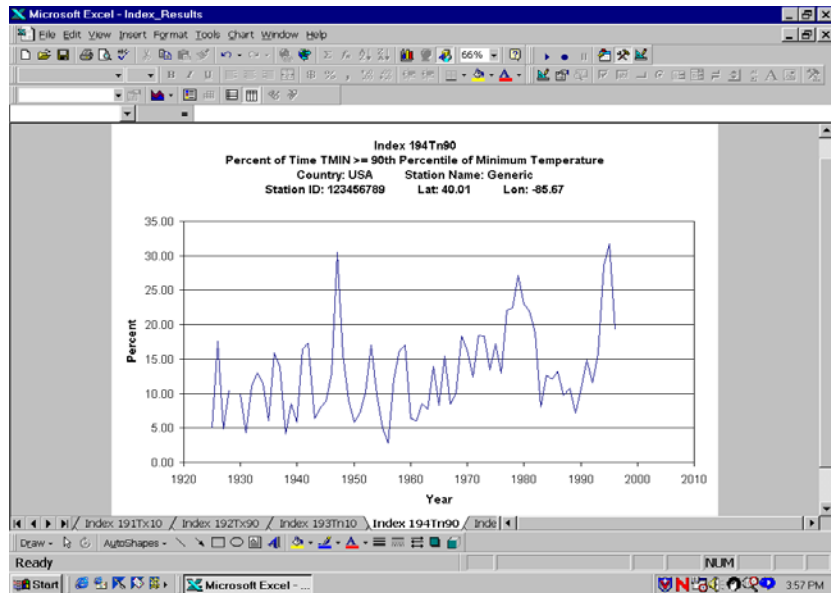
Calculation of Indices

ClimDex will read in the results of the 'homogeneity testing' step and calculate 18 climate indices (see Appendix A for a complete list of indices). The results are displayed in both tabular (Figure 3.1) and graphical form (Figure 3.2).

Fig. 3.1 Tabular Climate Indices

Station ID:	123456789	Begin Yr:	1924	End Yr:	1997						
Lat:	40.0099983	Lon:	-85.6699982	Country:	USA						
Trend (1/yr):	-0.001	-0.027	0.011	-0.103	0.129	-0.153	0.127	-0.038	0.010	-0.498	
Significance:	0.95204	0.01175	0.35162	0.00000	0.00165	0.00000	0.00016	0.31570	0.03795	0.04397	
Year	125Fd	141ETR	143GSL	144HWDI	191Tx10	192Tx90	193Tn10	194Tn90	606R10	641CDD	644R5D
1924											
1925	0.00	34.40		0.00	13.74	14.29	24.38	4.99	50.13	15.00	98.10
1926	4.03	39.50		0.00	17.03	13.19	20.06	17.55	54.00	31.00	193.90
1927	8.00	39.40		0.00	9.89	21.15	24.09	4.76	42.00	20.00	166.70
1928	3.08						24.49	10.54	34.80	26.00	124.70
1929									42.55	19.00	150.90
1930	1.01	36.70		0.00	25.21	6.93	17.31	9.89	45.00	17.00	215.10
1931	3.02	38.40		0.00	14.57	22.69	24.44	4.21	36.00	23.00	86.10
1932	1.00	35.60		0.00	20.61	11.42	22.93	11.05	44.00	33.00	304.90
1933	0.00	34.50		0.00	18.39	11.39	15.75	12.98	39.00	24.00	199.90
1934	2.02	37.80		0.00	15.68	5.49	19.28	11.57	47.00	21.00	134.80
1935	4.00	36.10		6.00	10.25	15.51	26.58	6.03	38.00	37.00	135.90
1936	0.00	33.30		0.00	14.64	9.12	12.36	15.93	43.00	25.00	221.30
1937	1.01	35.60		0.00	17.37	10.36	18.78	13.81	35.00	23.00	177.30
1938	1.00	34.40		0.00	15.62	9.04	21.27	4.14	37.00	17.00	119.90
1939	1.00	34.40		8.00	13.30	12.74	18.90	8.49	49.00	38.00	154.60
1940	4.00	39.40		0.00	19.33	9.24	20.28	5.83	40.00	28.00	202.30

Fig. 3.2 Graphical results of the calculation of climate indices.

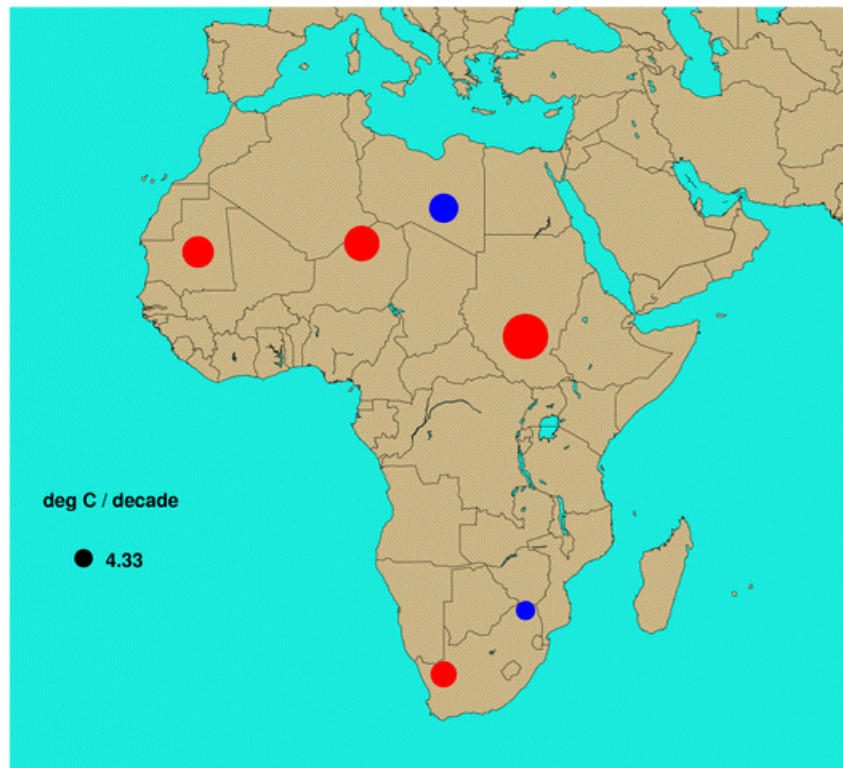


Region Analysis

ClimDex can summarize a single index for many stations by combining the results into a single data file. A user can then use a variety of mapping/analysis software packages to plot the results for a specified region (Fig. 4.1).

Fig. 4.1 A map of climate trends produced using GMT (Generic Mapping Tools, <http://gmt.soest.hawaii.edu>) and the output produced from the 'Region Analysis' part of ClimDex 1.3 (Note: Results shown below are for illustrative purposes only).

Index 646: Simple Daily Intensity Index



APPENDIX A: List of Climate Indices

<u>INDEX NO.</u>	<u>ABBREV.</u>	<u>TITLE</u>	<u>UNITS</u>
125	FD	Number of Days with Frost ($T_{min} < 0$ deg C)	days
141	ETR	Intra-Annual Extreme Temperature Range ($T_h - T_l$)	days
143	GSL	Growing Season Length (when $T > 5$ deg C for > 5 days and: $T < 5$ deg C for > 5 days)	days
144	HWDI	Heat Wave Duration Index	days
191	Tx10	Percent of Time $T_{max} < 10^{th}$ Percentile of Daily Maximum Temperature	% of time
192	Tx90	Percent of Time $T_{max} > 90^{th}$ Percentile of Daily Maximum Temperature	% of time
193	Tn10	Percent of Time $T_{min} < 10^{th}$ Percentile of Daily Minimum Temperature	% of time
194	Tn90	Percent of Time $T_{min} > 90^{th}$ Percentile of Daily Minimum Temperature	% of time
606	R10	No. of days with Precipitation ≥ 10.0 mm/day	days
641	CDD	Maximum Number of Consecutive Dry Days ($R_{day} < 1$ mm)	days
644	R5d	The Greatest 5-day Rainfall Total	mm
646	SDII	Simple Daily Intensity Index	mm / day
695	R95T	Fraction of Annual Total Rainfall due to Events Above the 95 th Percentile	
001	TxGE	Number of Days $T_{max} \geq$ user defined threshold	days
002	TxLE	Number of Days $T_{max} \leq$ user defined threshold	days
003	TnGE	Number of Days $T_{min} \geq$ user defined threshold	days
004	TnLE	Number of Days $T_{min} \leq$ user defined threshold	days
005	Prp	Number of Days Prcp \geq user defined threshold	days

APPENDIX B: Frequently Asked Questions

General

1. Why was ClimDex created?

ClimDex software was created to assist users at regional climate conferences in the rapid analysis of their daily data. The majority of scientific conferences range in length from a few days to a week. This is generally not enough time for participants of these conferences to develop programs that can analyze their own data. Therefore, ClimDex can fulfill this need by greatly reducing the programming that is usually necessary to conduct such analyses.

2. Why was ClimDex created using Microsoft Excel (version 97)?

The decision to use Microsoft Excel was based on several different factors. First, Microsoft Excel is used globally and has extensive scientific analysis and graphing capabilities. Second, Microsoft Excel has its own built in programming language (Visual Basic for Applications) that will allow users to customize and/or expand the existing ClimDex software. Third, Microsoft Excel has graphical user interface (GUI) programming capabilities. The GUI allows users to quickly get started using ClimDex and not have to worry about learning a complicated programming language in a short period of time.

3. Where can I learn more about Microsoft Excel (version 97 or higher) and Visual Basic for Applications (Microsoft Excel's programming language)?

Several internet search engines can provide multiple sources of information and web-sites on the above topics.

4. What about developing a version of ClimDex in the most widely used scientific programming language - FORTRAN 77 or FORTRAN 90?

Although future versions of ClimDex could and may be developed using FORTRAN, this language was not desirable for at least two reasons. First, FORTRAN compilers are often very expensive and can vary significantly from system to system. In most cases the commercial version of Microsoft Excel is already available within most institutions and if not can generally be purchased for less than the cost of a new compiler. Second, FORTRAN does not contain built in graphical capabilities for creating maps, graphs, and/or graphical user interfaces. There are of course many third party software packages which can interface with the FORTRAN programming language and provide users with the above mentioned graphical capabilities. However, this would add yet another software package that users would have to obtain, install, and learn to use. In the future FORTRAN will continue to be evaluated as a possible development environment for ClimDex.

5. Can ClimDex be used with Microsoft Windows and a non-English language?

No, currently ClimDex version 1.3 is designed to run under the Windows operating system using only the English language. At this time, international support has not yet been implemented for other languages.

Using ClimDex

1. ClimDex does not appear to be reading in my input data file correctly when I run the "Quality Control" step. What could be the problem?

The format of the input data file for this step must be in a specific format. Please refer to APPENDIX C in this manual.

2. I would like to skip the "Quality Control" and "Homogeneity Testing" parts of ClimDex. Can ClimDex read a simple ASCII file and calculate the indices?

ClimDex was meant to guide a user through a complete series of steps. Therefore it is not possible to skip steps. In addition, ClimDex creates a Microsoft Excel file as 'output' for one step, and this output file becomes the 'input' file for the next step. Other than the first step "Quality Control", where the user's input file must be formatted to meet certain requirements (APPENDIX C), ClimDex takes care of all input/output operations in the remaining steps.

3. Can I alter the source code within ClimDex?

Yes, you may change some or all of the source code within ClimDex. If you would like to view and/or change the source code, you will need to use the Visual Basic Editor that is included in Microsoft Excel.

APPENDIX C: Input Data Format

All of the data files that are read or written are in Microsoft Excel format. The exception is the very first data file that is processed in the "Quality Control" step. This input data file has several requirements:

1. ASCII text file
2. Format: Year, Month, Day, Precipitation, Maximum Temp., Minimum Temp.
(NOTE: Precipitation units = millimeters and Temperature units = degrees Celsius)
3. The format as described in #2 must be space delimited (e.g. each element separated by one or more spaces).
4. The user should choose a single missing data value for all three elements listed in #2, that is LESS THAN any valid data value (e.g. -99.9).

Example Data Format for the initial data file (e.g. used in the 'Quality Control' step):

1999 03 04 12.3 30.2 20.1

1999 03 05 2.1 31.1 21.2

1999 03 06 3.8 -99.9 22.8