ICIWaRM Non-Proprietary Drought Atlas Software

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INTRODUCTION

The International Center for Integrated Water Resources Management (ICIWaRM) is developing a non-proprietary software that allows the creation of a drought atlas using Regional Rainfall Frequency Analysis (RFA) and L-moments as presented in Hosking and Wallis (1997)[1]. The method of L-moments is preferred over using regular moments due to the fact L-moment statistics are more robust in terms of accommodating extreme values and characterizing a greater number of frequency distributions. In addition, L-moments are less susceptible to bias in their estimation. RFA is used on the assumption that if the frequencies of rainfall events are similar at several nearby locations within a "region", a statistical analysis of all observations at all sites within the "region" will result in a more accurate frequency distribution at each site compared to limiting the analysis to only the at-site data for each site. Using L-moments allows the development of a drought atlas in arid and semi-arid regions where data is sparse spatially and may be available only over a limited time period at individual sites. The end result will deliver three types of output: storm frequency, duration, and intensity, and will consist of a series of digital maps that answer questions such as:

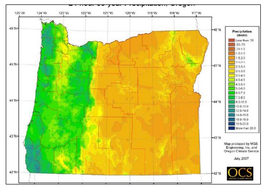

Figure 1: Oregon Drought Atlas.[2]

1. "What is the probability that the current drought will end in X months?"
2. "How long a drought should we prepare for?"
3. "What is the frequency of maximum drought intensity observed?"

Overview of Steps in Creating a Drought Atlas

1. Obtain Data
   a. Peak Rainfall Data
   b. Daily Totals
   c. Monthly Totals
2. Screen data based on starting day/month and duration (Fig. 2).
3. Compute L-moments of each site:
   1. t1: mean
   2. t2: scale
   3. L1: L-Coefficient of Variation (L-CV)
   4. L3: L-Skew
   5. L4: L-Kurtosis
4. Identify homogenous regions.
5. Compute regional L-moments.
6. Choose a frequency distribution.
7. Estimate the parameters of the frequency distribution using the regional L-moments.
8. Compute the regional growth curve.
9. Compute site growth curves/quantiles using regional growth curve and mean precipitation values.
10. Compute off-site quantiles.
11. Produce drought atlas maps.
12. Estimate errors and uncertainties throughout process.

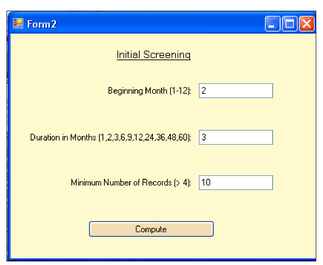

Figure 2: Initial Data Screening window.

Versions 1.0 & 2.0

Version 1.0 (Fig. 3) of ICIWaRM's Drought Atlas Tool was created in Microsoft Excel and meant for use only among members of the Drought Atlas Development team. Its purpose was to allow quick development in order that a preliminary drought atlas of the Latin America/Caribbean region could be created. Version 1.0 comes ahead of a more in-depth and user-friendly Version 2.0. Version 2.0 of ICIWaRM's Drought Atlas Tool is begin created using Visual Studio 2010 and is meant for use within and outside of the ICIWaRM partner organizations. Version 2.0 will have all the capabilities as Version 1.0 in additional to some additional features. This version of the tool guides the user step-by-step through the RFA process with most of the major steps being directly accessible from the title screen (Fig. 4). One current limitation is that the software can only work with monthly total data, but will eventually have the capability to use daily totals and daily/montlhy peak data as well. Version 2.0 should be ready for operation in Summer of 2011.

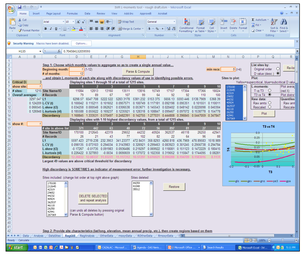

Figure 3: Version 1.0 user interface.

Figure 4: Version 2.0 title screen.

Steps in More Detail

Step #1: Load the monthly rainfall data. The only input file type currently accepted is as an Excel worksheet, and it is required that the rainfall data be in a specific format within the worksheet (Fig. 5). Data should be set up so that the site ID is identified in the first column for each year, years in the second column, and each month's rainfall for that year recorded in the remaining twelve columns. The number -999 is should be entered to identify missing or bad data.

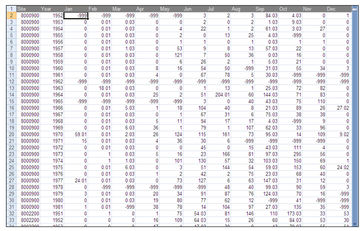

Figure 5: Rainfall input data in Excel format.

Step 2: First screening of the data. The first data screening is performed using the screen in Fig. 2. After the beginning month and duration are entered, the program adds up data over the pertinent months for each year and station, and if one or more values are -999, that year of data is thrown for the particular site. The remaining number of years of usuable data for each station needs to be greater than the minimum number of records provided in Fig. 2. If not, the station is identified as bad and not used in further analysis.

Steps in More Detail cont…

Step #3: Second screening of data. This step involves the computation of site L-moments and discordancy (shown on left side of Fig. 6), which is a measure of how different a site is from the others. List boxes show sites accepted or rejected from Step #2. The graph on the right gives an illustration of discordancy by plotting L-CV against L-Skew. Depending on discordancy, the user is able to delete a site.

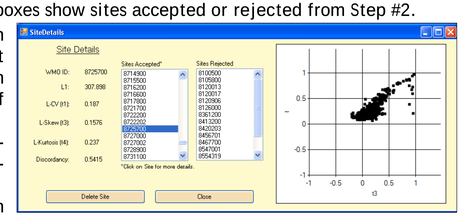

Figure 6: L-moments and discordancy.

Steps #4 & 5: Creating homogenous regions and computing regional L-moments. The software is able to create regions, but much more work is required to make this important part of the software operational.

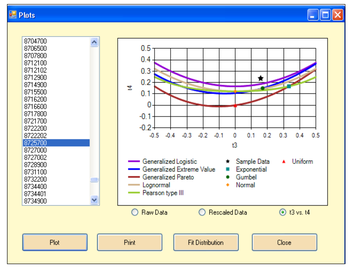

Figure 7: t4 vs. t3 for all distributions.

Steps #6 - 8: Fitting of Frequency Distributions and Growth Curves. The next three steps allow the fitting of various probabilty distributions to the data. Figure 7 allows a first impression to be made on which distribution will give the closer fit according to the relationship between L-Kurtosis and L-Skew for the data and for each the data and for each distribution. The resulting fits are shown in Fig. 8a. The closeness of the black star in Fig. 7 and the fit in Fig. 8a suggest GLO is best. Shown in Figs. 8b & 8c are the associated cumulative distributions and growth curves, respectively. The x-axis of the growth curves has been adjusted to accommodate closer study of the tails of the each curve.

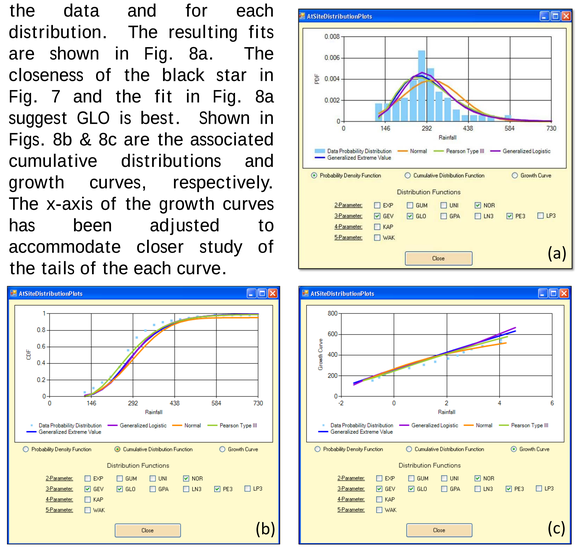

Figure 8: Graphs showing (a) probability density, (b) cumulative density, and (c) growth curves.

Deliverables

The final product of to come out of using the ICIWaRM Drought Atlas tool consists of a set of maps for different frequencies and durations of rainfall events. One such map is shown in Fig. 9. This map answers the question: "For droughts that occur every 20 years, how much total precipitation can be expected over 5 years?" A total number of 558 stations was used for this analysis, which is the current limit of data available to us within South America (Source: NOAA's Global Historical Climatology Network). As can be seen in Fig. 9, the analysis is crude due to the small amount of data available on a continent scale. Also, attempting to divide a continent into detailed regions with such little data is not recommended. Individual countries are also aware of the factors that can cause localized changes in climate (topography, rivers, circulations patterns, etc.). Experts from each country are thus needed to be trained and willing to use their respective data to develop drought atlases at a national scale, which can then be used to improve the map above.

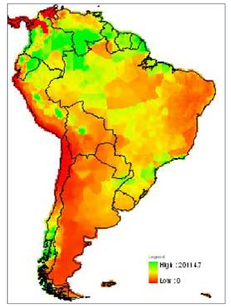

Figure 9: South America Drought Atlas.

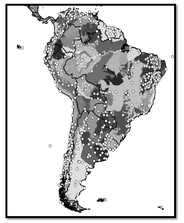

Figure 10: GHCN Gage Network.

Future Work

- Finish development of the ICIWaRM Drought Atlas tool, Version 2.0, which includes completing the component on regionalization
- Planning of workshops to build capacity in other countries to use the ICIWaRM Drought Atlas tool
- Improve the South America drought maps, including a clickable map similar to the U.S. National Drought Atlas, through analyses performed by ICIWaRM and individual nations/regions
- Climate change vs. climate variability study
- Drought Atlas for Rwanda, Africa

References

[1] Hosking, J.R.M., and Wallis, J.R. (1997). "Regional Frequency Analysis: An Approach Based on L-Moments", New York: Cambridge University Press.

[2] Schaefer, M.G., Barker, B.L., Taylor, G.H., and Wallis, J.R. (2007). "Regional Precipitation-Frequency Analysis and Spatial Mapping of 24-Hour Precipitation for Oregon", 84 pp.

Acknowledgements

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