

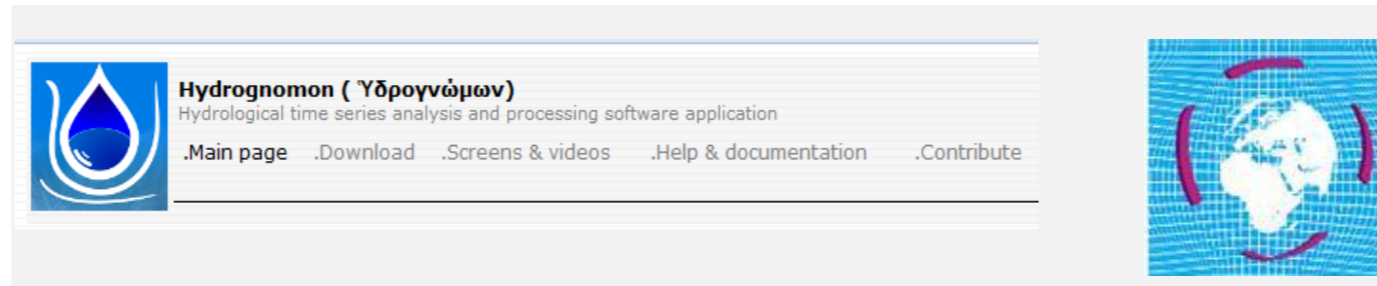
Construction of ombrian curves using Hydrognomon software system

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1. Abstract

Hydrognomon is an application for the analysis of hydrological data and includes several applications for time series processing, such as time step aggregation and regularization, interpolation, regression analysis and infilling of missing values, consistency tests, data filtering, graphical and tabular visualization of time series, etc. Both its source code and the executable program are freely available. The new version of Hydrognomon includes a module for the construction of ombrian (intensity-duration-frequency) curves. It is based on a mathematical framework that expresses ombrian curves with unified relationships giving rain intensity in terms of duration and return period, either for a single gauging station or for a station group over a specified area. In the latter case, it supports either single parameters set or spatially varying parameters. The framework is completed with raw rainfall data processing, data management and storage, graphical user interface, and output data graphs and export facilities.

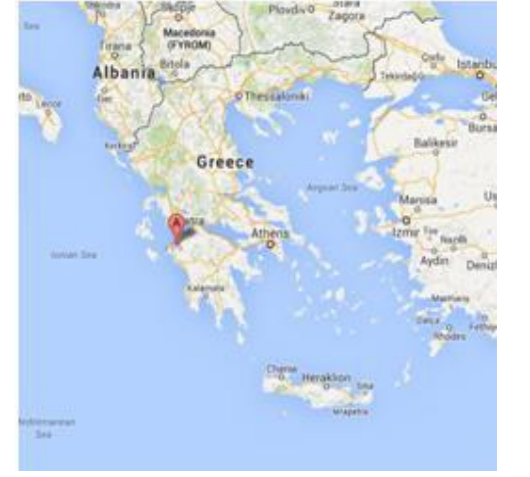
2. Introduction



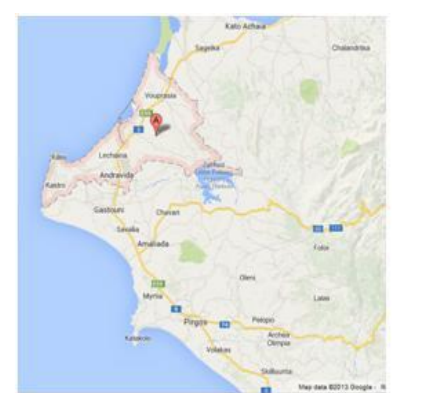
Hydrognomon is provided under the terms of the GNU GPLv3 License and is part of the openmeteo.org framework, where source code can be obtained from www.hydrognomon.org. Hydrognomon has been developed mainly to serve the research activities of the ITIA research group, which is responsible for the design and maintenance of the open source software. Hydrognomon is also one of the software supporting the "Hydroscope" - National Databank for Hydrological and Meteorological Information.

3. Case study area

Andravida is a town and a former municipality in Elis, West Greece. Since 2011 local government reform it is part of the municipality Andravida -Kyllini, of which it is a municipal unit. Its population is about 4,300 people. Andravida is located in the plains of northwestern Elis, 7 km far from the Ionian Sea coast. It is 3 km south of Lechaina, 6 km north of Gastouni, 30 km northwest of Pyrgos and 55 km southwest of Patras.

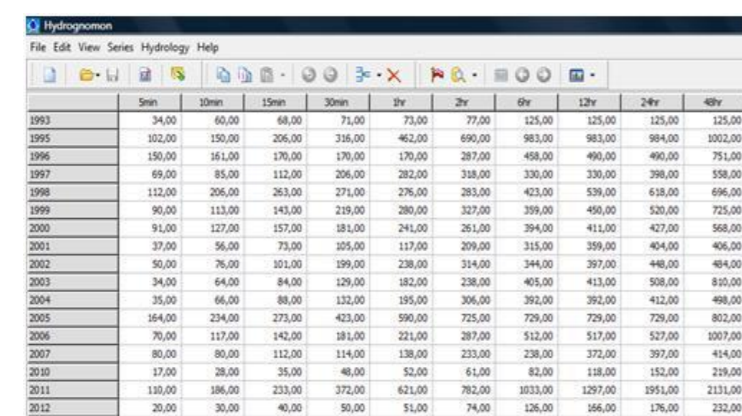


The case study area is located in Andravida. A rain gauge is used as an instrument to measure precipitation at the specific area. The data were extracted by the Hellenic Meteorological Service and are composed from 17 years data records. To this end, we extracted the maximum precipitation height in different time scales, specifically 5min, 10 min, 15 min, 30min, 1hr, 2hr, 6hr, 12hr, 24hr and 48hr.

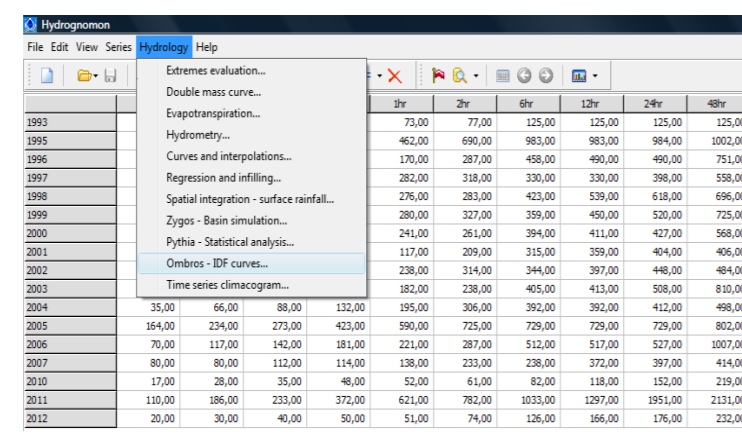


4. Data Set

The user can input data to Hydrognomon, in order to create annual maximum time series of different time scales. Hydrognomon gives the advantage to simultaneously introduce and process several data time series.

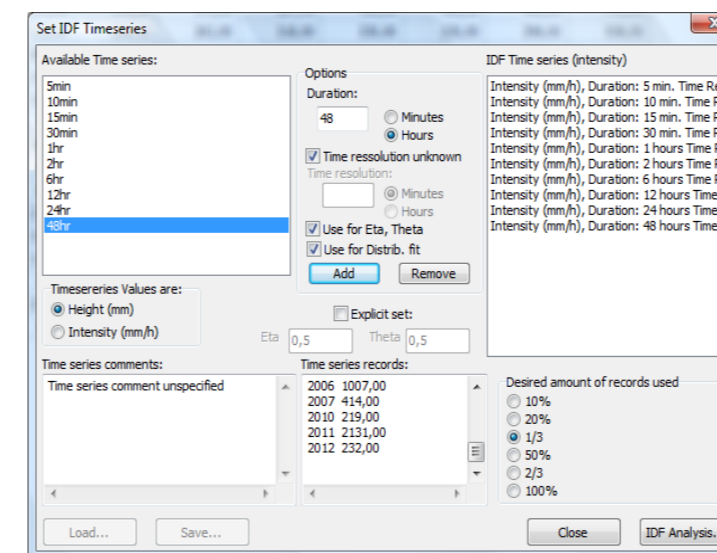


After the input of the data set, we are ready to start the construction of the ombrian curves from the "Hydrology" menu and the option "Ombros- IDF curves".



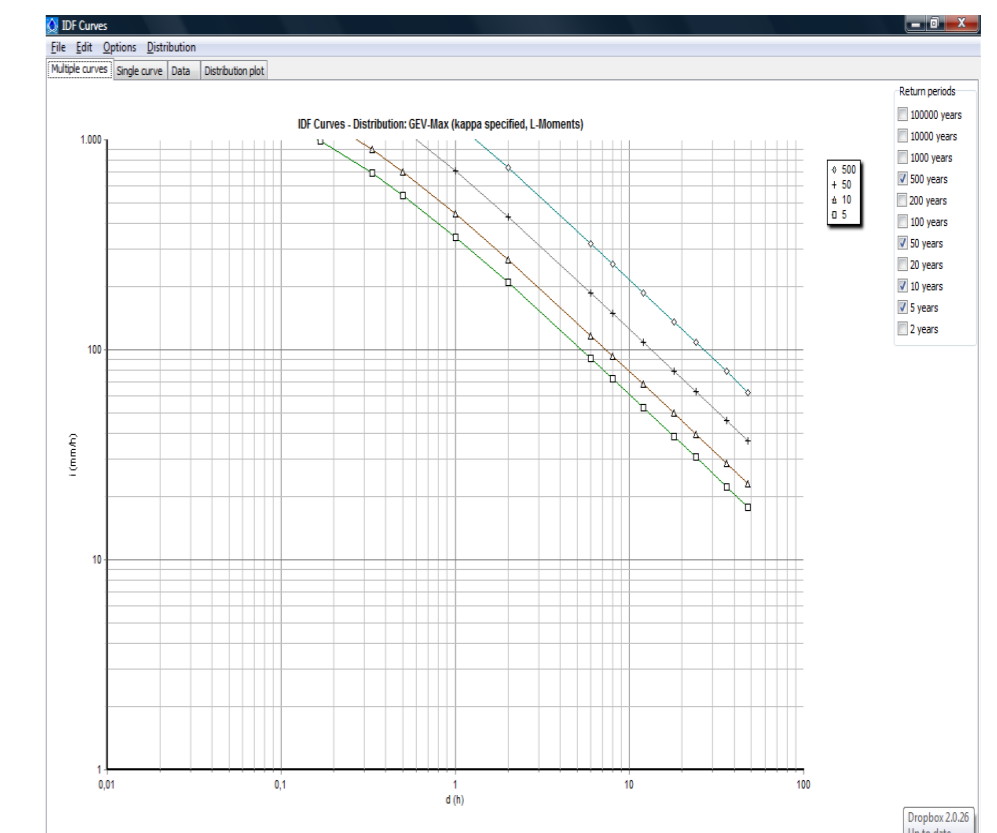
5. Construction of ombrian curves

The user must first determine the time series variable: height in mm (Height) or rainfall intensity in mm / h (Intensity). The type of the variable must be determined before the definition of the time series. Then, the precipitation height time series turn to intensity time series. An additional feature that can be set is temporal resolution (Time resolution). If it is unknown, the button "Time resolution unknown" remains active.



By the use of the "Add" button, time series are transferred to the list of time series to be used in the analysis (IDF Time series), while using the "Remove" button the user deletes time series from the right list, for each of which it is possible to determine the relations for η , θ (Use for Eta, Theta) and to estimate the statistical distribution parameters (Use for Distrib. fit), apart from the duration and temporal resolution.

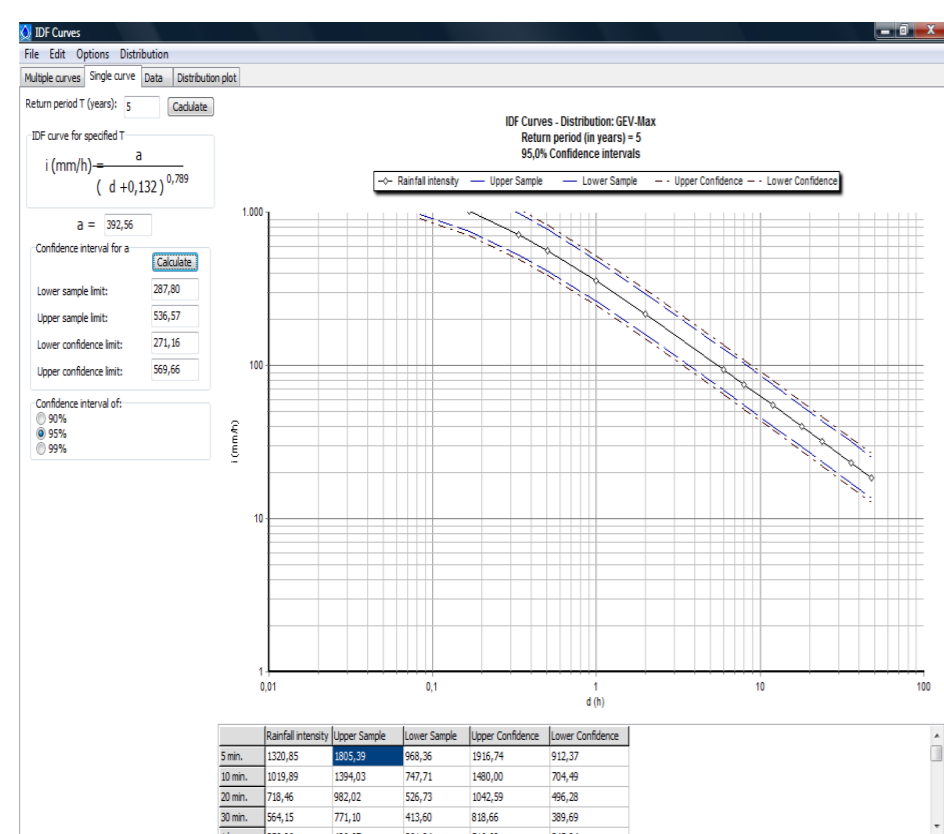
6. Multiple Curves



In the first tab shown in the figure above, the user can form multiple graphs of predefined return periods (2, 5, 10, 20, 50, 100, 200, 500, 1000, 10000 and 100000 years). As it is shown, the ombrian curves do not intersect.

7. Single curve

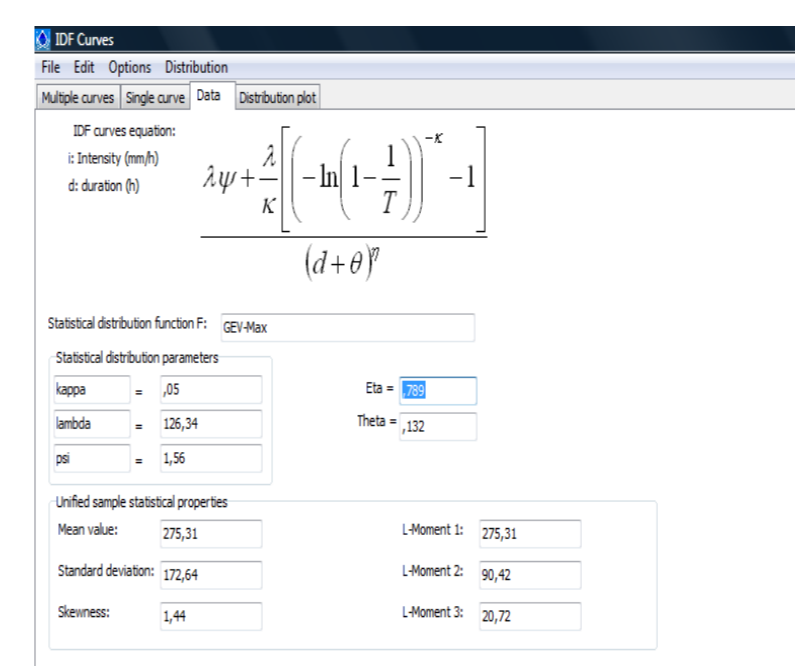
In the second tab, the user specifies a particular period reset (e.g. 5 years) and chooses the button "Calculate". The curve is plotted as well as the equation corresponding to this return period. Then the user can construct confidence intervals for the ombrian curve using Monte-Carlo method.



The table below the graph of ombrian curves contains the points of the curve and the corresponding confidence intervals. It is possible to copy the table in the clipboard and then paste to different software such as Microsoft Excel.

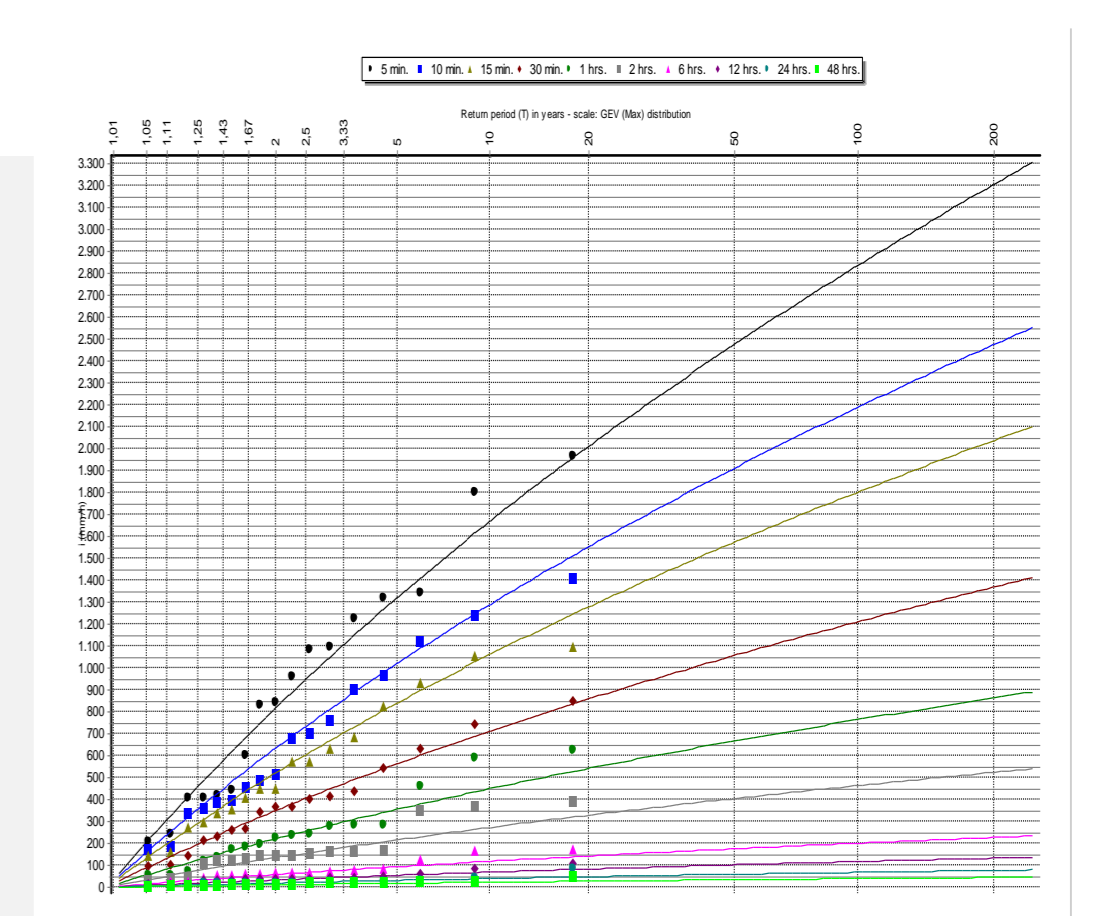
8. Data

The third tab displays the general equation of ombrian curves (IDF curves equation), the name of the distribution function, the parameters of distribution function (Statistical distribution parameters), the parameters η and θ (Eta, Theta) and the statistical properties of the consolidated sample.



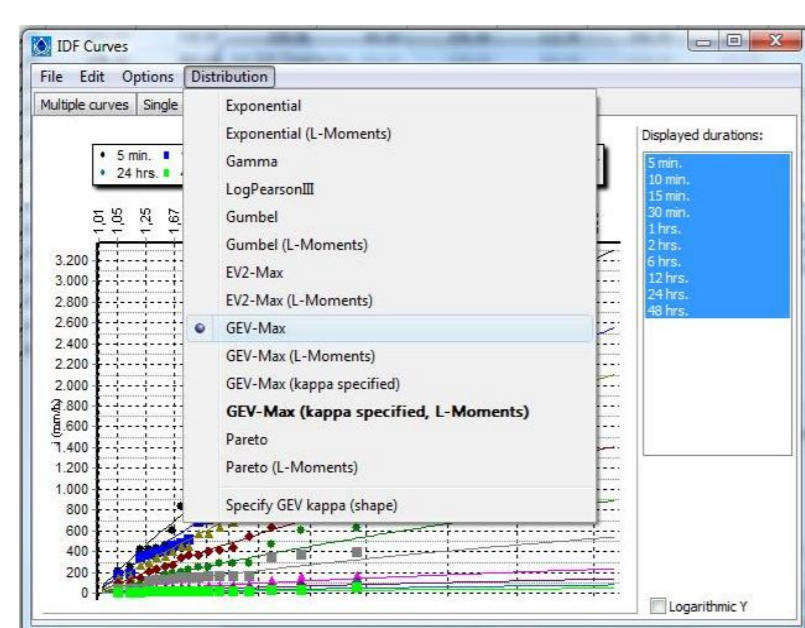
9. Distribution Plot

In the fourth tab, the user controls the adjustment of the theoretical statistical distribution in the sample. From the list "Displayed durations" the selection of duration will be displayed in the chart.



10. Type of statistical distribution

The type of the statistical distribution applied to analysis is determined through the menu Distribution. The default option is the GEV-peak with a fixed parameter value k and method of L-moments "GEV-Max (kappa specified, L-Moments)". By selecting "Specify GEV kappa", the user can modify the default value $k = 0.15$.



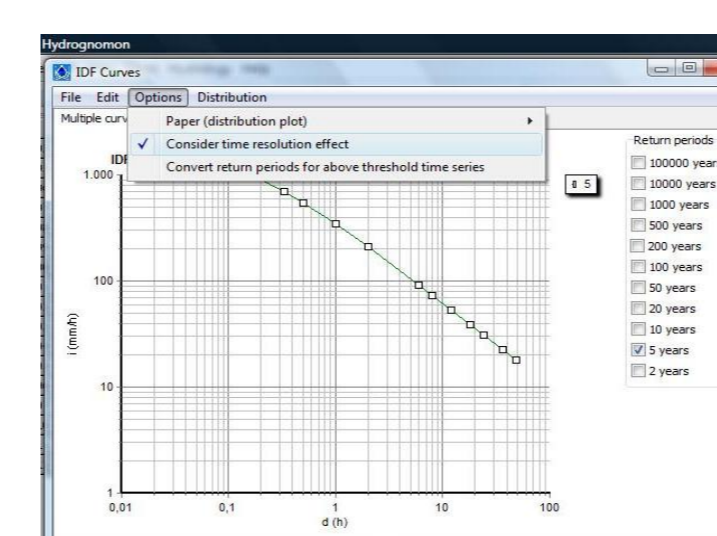
At the specific example, it was not necessary to use the "Specify GEV kappa", so the distribution that was selected was GEV, which was the same distribution that correspond to the confident intervals that were selected.

11. Time resolution effect - Additional functions

The user may include in the analysis the effect of time definition. The selection is made via the menu Options → Consider time resolution effect.

Additional functions are controlled through the following menu options:

- File → Print ... : Printing capabilities of graphs
- File → Single IDF curve evaluation: assessment IDF curves
- specific return period with the classical methodology (minimum blocks)



- Edit → Copy ... : Copying tables and graphs to clipboard initially (clipboard) and then in software, e.g. Microsoft Excel type or editors (Word processors).
- Options → Papers (distribution plot): the distribution map for design of distribution functions exactly the same with the unit "Pythia".

12. Conclusions

The main conclusions of our study are:

- Hydrognomon is an open software which has automated the construction of ombrian curves.
- Time series extracted from Andravida station, for 17 years time period and for several time scales indicated that the same process could be followed for several time stations in Greece in order to construct a map of ombrian curves at a specific area.
- Hydrognomon offers the option of simulating several statistical distributions and facilitates the user to choose the one that applies best to the data set.
- The program through the options print/copy helps the user to export the results of the analysis for further process to other softwares (e.g. Microsoft Excel).
- The ombrian curves must not intersect because in this case we would have for the same intensity (i-mm/hr) and for the same duration (d-hr) different return periods, which is irrational.