HydroOffice

TLM 2.1
User's Manual

By Miloš Gregor
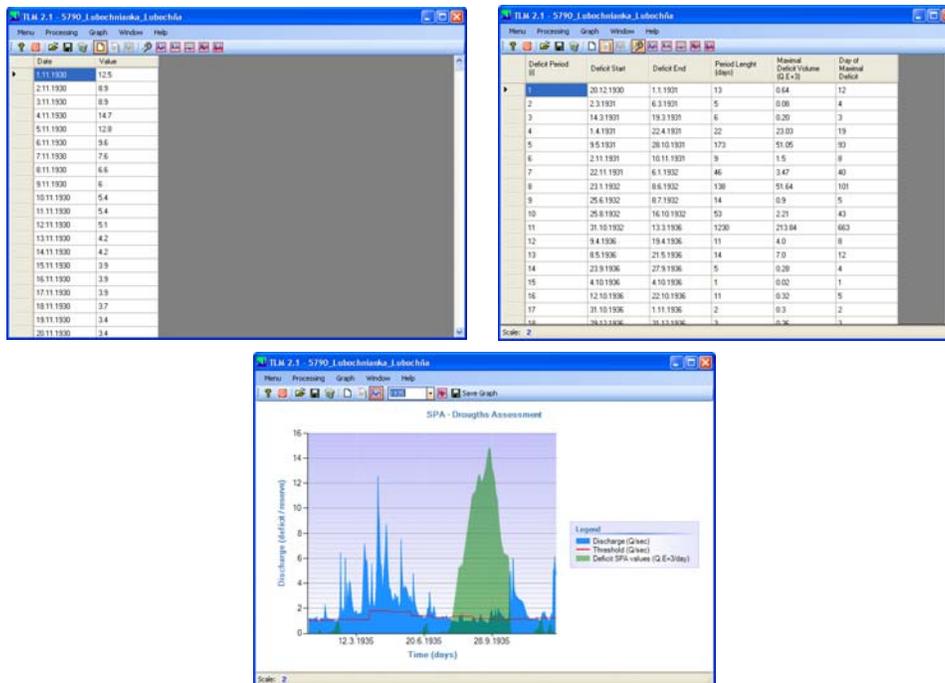
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Build: 6
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INTRODUCTION

This manual was created for the use of the TLM 2.1 module (build 6) of HydroOffice 2010 software. The manual describes the functionality and limit of module use. After studying, you should be able to use the full functionality of the module.

The TLM 2.1 module serves to hydrological drought analysis by using threshold level method. The methodology is based on publication **Tallaksen & van Lannen (2004)**.

The analysis can be used classical threshold level method or the method of sequent peak algorithm. The threshold level can be set in the year as constant year-round, seasonal (1-4 season), monthly, N-daily, daily or as directly user defined threshold. As values in threshold level can be set average, median, percentile values or directly user specified value. After the calculation it is possible to analyse the time-series of deficits or deficits statistic in tabular and graphical form. In addition, user can by these methods analyse not only the extreme minimum values but also the extreme maximum values.

To prepare the input file of time-series values is necessary to study the manual – How to prepare input data for modules. This manual briefly describes the preparation of input data for individual modules. The great advantage of HydroOffice 2010, all modules use the same structure of input data. Therefore, prepared data for one module is possible use than in other modules.

Individual modules of HydroOffice 2010 use the same structure of the graphical user interface, so if you learn to use a one module, than the next transition to other one will be greatly simplified.

I hope that the module you will help in daily work. For further study the use of modules can be used video-tutorials, located on the HydroOffice website. In the case you find a bug in the module, you have an idea for improving it, or any other question, please use the user forums on the site, so that other users can use the solution to your problems. Also, if you know solution to the problem of another user, do not hesitate to help him. The more you can help me on the forums, the sooner can be issued the upcoming new modules for you.

If you are using the HydroOffice tools, please quote them. If you not know what work you can cite, you can find them on this site. If you quoted something, you can send me a citation to your work and I will add this to citation page with the reference to your work site.

Miloš Gregor

(hydrogeologist, HydroOffice developer)

MAIN FUNCTIONS

The basic features of the program are listed under **Menu** (*fig.1*) or the first buttons in application toolbar. The function **Open Data** serve for import of input data to program. After entering the input file that are data stored in the table (*fig.2*).
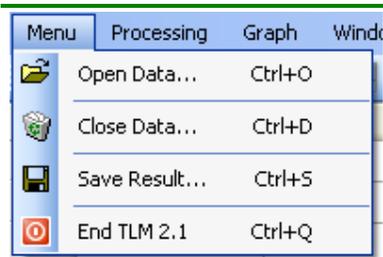
Fig. 1: Basic commands in TLM 2.1 module.

If the input file is formatted correctly, the dates of measurements and values are automatically divided into separate columns. Also at the end of the table should not be more than one blank line. If there are mote after their selection and pressing **Delete** button is possible delete them. Thus prepared data can then be used for further processing. Which will be explained in the next chapter (*fig.3*).

In addition to the described function are in the menu also three other functions. Command **Close Data** serves to complete removal of all data in the application. The command clear the input data table, result data table and chart results. Command **Save Result** serves for saving of calculated results. The forms of results will be presented later. The program allows you to save the results into four types of files (*.txt, *.xls, *.doc and *.rtf). Due to difficulties and problems of compatibility between different versions of programs (e.g. MS Office), the results are not really saving to selected file formats (e.g. .xls). It's always basically just a text file (.txt) that is automatically opened and processed in an associated program (something like *.txt.xls). The last command **End** serves to module termination.

Fig. 2: Input data window in TLM 2.1 module.
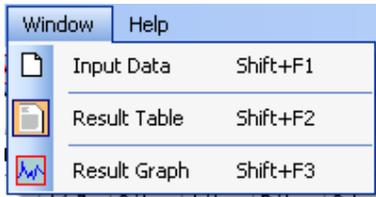
The main window can display three main parts. These parts can be switched by using commands in the **Window** menu (*fig.3*).

The **Input Data** command is used to show the table for imported input data. The **Result Table** command is used to display a table with the calculated results and the command **Result Graph** shows the calculated results in the form of a graph. In addition to functions in the menu you can also use the same commands in the application toolbar.

THRESHOLD LEVEL METHOD THEORY

The good theory about threshold level methods and about its using for hydrological drought analysis is in Tallaksen & van Lanen (2004).

Threshold level method is the most frequently applied quantitative method where is essential to define the beginning and the end of a drought. It is based on defining a threshold, Q_0, below which the river flow is considered as a drought (also referred to as a low flow spell). The threshold level method, which generally studies runs below or above a given threshold, was originally named "method of crossing theory". The method is relevant for storage and yield analysis, which is associated with hydrological design and operation of reservoir storage systems. Important areas of application are hydropower and water management, water supply systems and irrigation schemes (Tallaksen & van Lannen, 2004).

Figure **4** gives an example of how drought events are identified by the threshold level (red line). When the flow falls below the threshold value, a drought event starts and when the flow rises above the threshold the drought event ends. Hence, both the beginning and the end of the drought can be defined. Statistical properties of the distribution of drought deficit, drought duration and volume of serenity are recommended as characteristics for at-site drought. Simultaneously it is possible define the minimum flow of each drought event (Q_{min}), which can also be regarded as a deficit characteristic (Tallaksen & van Lannen, 2004).
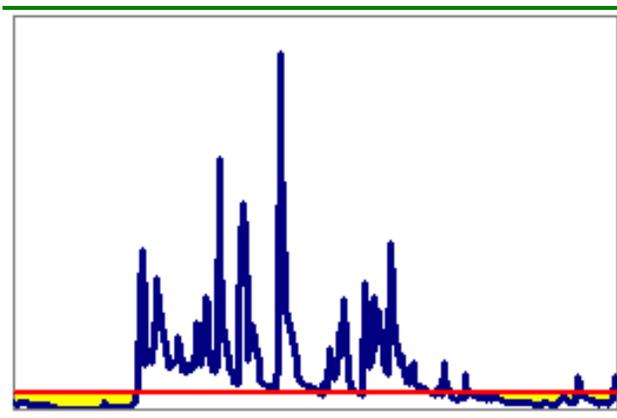
Fig. 4: The definition of threshold level (red line) for hydrological drought analysis.

The time of drought occurrence has been given different definitions, for instance the starting date of the drought, the mean of the onset and the termination date, or the date of the minimum flow. Often another drought deficit characteristic, the drought intensity, is introduced as the ratio between drought deficit volume and drought duration. Based on the time series of drought deficit characteristics it is possible to derive drought deficit indices (Tallaksen & van Lannen, 2004).

The threshold might be chosen in a number of ways and choice is, amongst other things, a function of the type of water deficit to be used. In some applications the threshold is a well-defined flow quantity, e.g. a reservoir specific yield. It is also possible to apply low flow indices, e.g. a percentage of the mean flow or a percentile from the flow duration curve (use FDC module for this purpose). The hydrological regime will influence the selection of a percentile from the FDC as threshold level. For perennial rivers relatively low thresholds in the range from Q_{70} to Q_{95} can be considered reasonable. For intermittent and ephemeral rivers having a majority of zero flow, Q_{70} could easily be zero, and hence no droughts events would be selected (Tallaksen & van Lannen, 2004).

The threshold might be fixed or vary over the year (*fig.5*). The variable threshold approach is adapted to detect streamflow deviations during both high and low flow seasons. Lover than normal flows during high flow seasons might be important for later drought development. However, periods with relatively low flow either during the high flow season or, for instance, due to a delayed onset of a snowmelt flood, are commonly not considered a drought (Tallaksen & van Lannen, 2004).

A variable threshold can thus be used to define periods of streamflow deficiencies as departures or anomalies from the "normal" seasonal or daily flow range. A daily varying threshold level can, for example, be defined as an exceedance probability of the 365 daily flow duration curves. Exceedances derived on a daily basis may be misleading where the number of observations is small because the data series are short (Tallaksen & van Lannen, 2004).
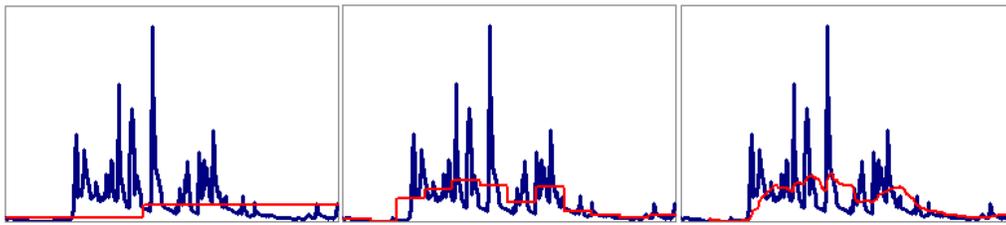
Fig. 5: Examples of threshold levels (left – seasonal varying, middle – monthly varying, right – daily varying).

A procedure for preliminary design of reservoirs based on annual average streamflow data is the mass curve or its equivalent, the Sequent peak algorithm (SPA). SPA can also be used for daily data to derive drought events (*fig.6*). Let Q_t denote the daily inflow to a reservoir and Q_{90} the desired yield or any other predefined flow, then the storage S_t required at the beginning of the periods t reads (Tallaksen & van Lannen, 2004):

$$S_t = \begin{cases} \dfrac{S_{t-1} + Q_{90} - Q_t}{0} & \text{If positive} \\ & \text{otherwise} \end{cases}$$

An uninterrupted sequence of positive S_t, defines a period with storage depletion and a subsequent filling up. The required storage in that period, max{S}, defines the drought deficit volume, w_t, and the time interval, d_i, from the beginning of the depletion period, t_0, to the time of the maximum depletion, w_{max}, defines the drought duration d_i (t(w_{max}) − t(0) + 1).
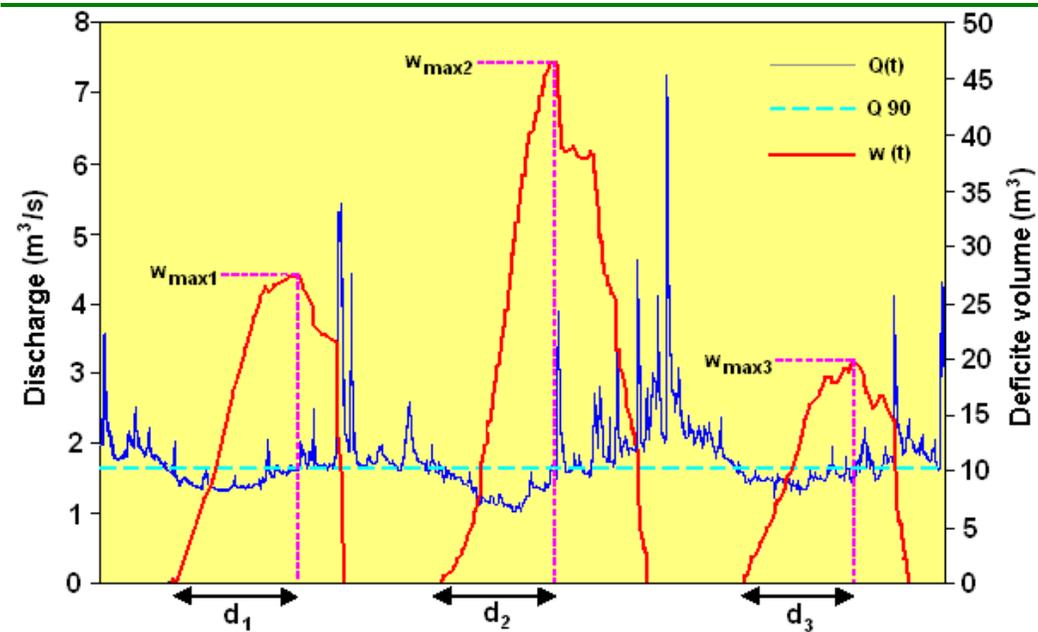
Fig. 6: Example of SPA method.

This technique differs from the threshold level method in that those periods when the flow exceeds the yield do not necessarily netage the storage requirement, and that several deficit periods may pass before sufficient inflow has occurred to refill the reservoir. Hence, based on this method, two droughts are pooled if the reservoir has not totally recovered from the first drought when the second drought begins (S_t>0) (Tallaksen & van Lannen, 2004).

The described theory is intended to the use of threshold level methods for the analysis of hydrological drought. This methodology, however, can be used in other analysis of time-series analysis, such as changes in air temperatures. It is also possible to analyse by these procedures not only minimal (deficit) values, but also the maximum (above the defined limit) values. Next chapters deal with the features and functionality of TLM 2.1 module.

THRESHOLD MANAGER
The first task at work after loading the input data into module is the definition and calculation of threshold level. For this purpose is used

Threshold Manager (*fig.7*). The window of this tool will show by command in the menu **Processing - Threshold Manager** or by the button in the toolbar.
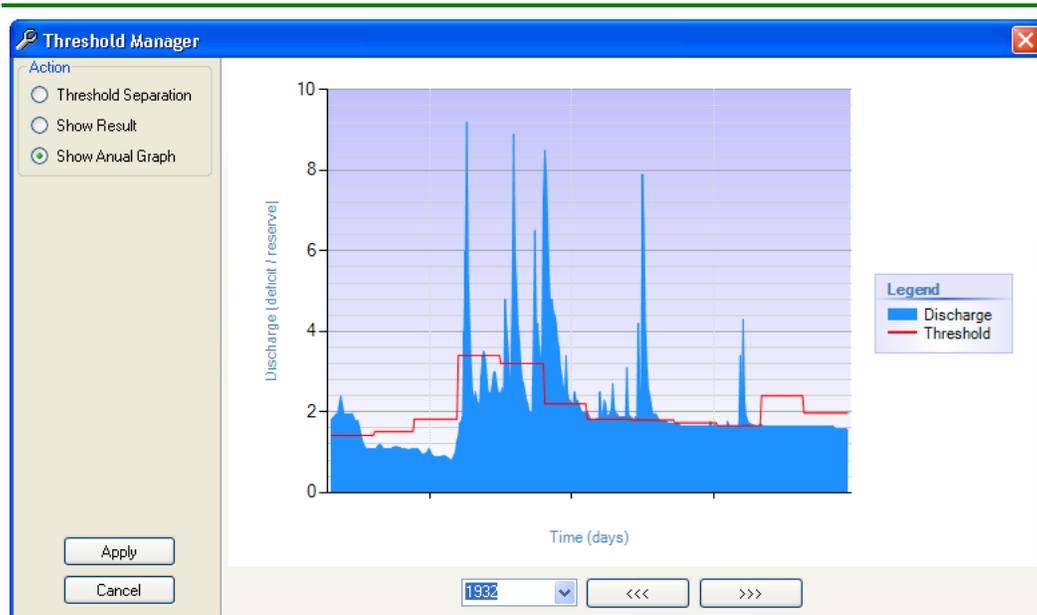
Fig. 7: Tool for threshold level defining, calculating and analysing.
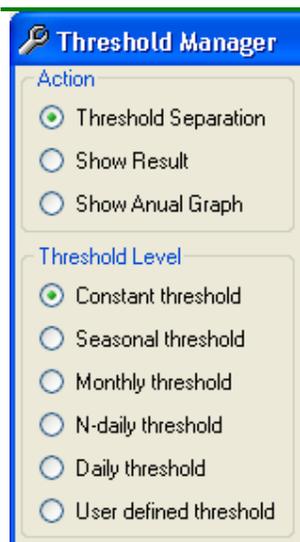
Fig. 8: Setting of threshold level type.

Setting and calculation of threshold level is being made in this window in three steps. To switch between these steps are used the first three **radio buttons** in **Action** Section (*fig.8*).

The first step is to set the threshold type in **Threshold Level** section of radio buttons (*fig.8*). In this step, user set the type of threshold that can use. User can choose a constant year-round, seasonal, monthly, N-daily, daily and user directly defined threshold level type. Changing the threshold level type is always changed the settings window for the threshold level calculations.

The first one type is a constant year-round threshold level. After selecting this type, are displayed settings for their calculation like on figure **9**.

Within each type of threshold level can be used as values long-term average value, median value, selected percentile value, or directly user defined value.

Fig. 9: Setting of threshold level values calculations.

After the definition setting of threshold level are calculated these values by pressing the button **Calculate**.

If users choose a seasonal type of threshold, the values setting will be like on picture **10**.

Fig. 10: Settings of seasonal type of threshold level.

For seasonal type of threshold level can be set from one to four seasons. Use the **Start** and **Stop** parameters set start and end of the season as an integer value (day of year 1-366). One season can go a calendar year as the winter season, which starts in November the first year and ends in February next year. Other parameters are the same as for other types of threshold levels.

The last type of threshold level is **User Defined Threshold** level (*fig.11*)
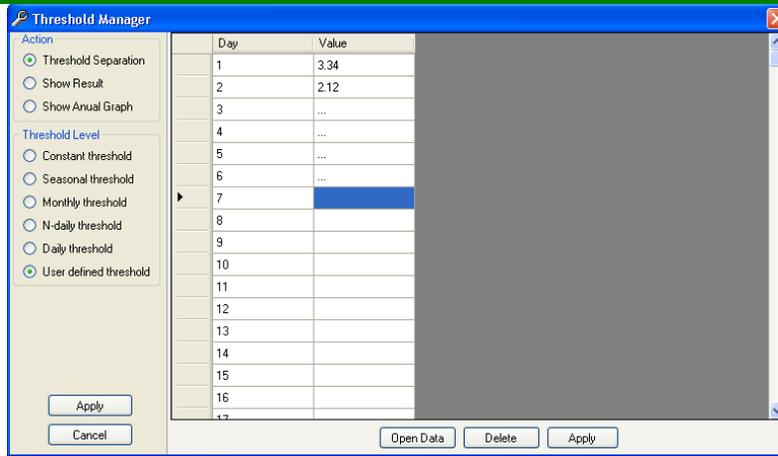
Fig. 11: Setting of directly user defined threshold level.
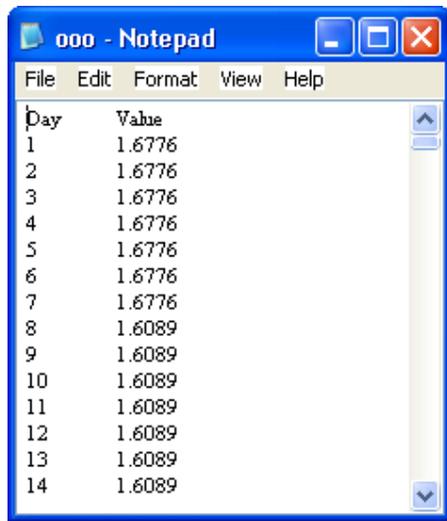
Fig. 12: External input data for directly user defined threshold level.

In this type of threshold user enters directly into table the values for each day of the year (1-366). In the first column of the table are listed days of year and the second column contains a defined threshold level value. These values can be manually defined, or can be imported from an external text file (*.txt). The structure of this file is similar to imported input data of time-series (*fig.12*). This type of file contains in the one line two values and that the value of the day of year (1-366) and threshold level value for this day. Likewise, the values in one row are tab-separated, and each day is on a separate line. The first line is descriptive and does not import into the program. After importing of data, press the **Apply** button for further processing.

After the definition and calculation of the threshold level values can be analysed these results in tabular or graphical form (*fig.13*). To view these tools, click on radio button **Show Result** or **Show Annual Graph** (*fig.8*).
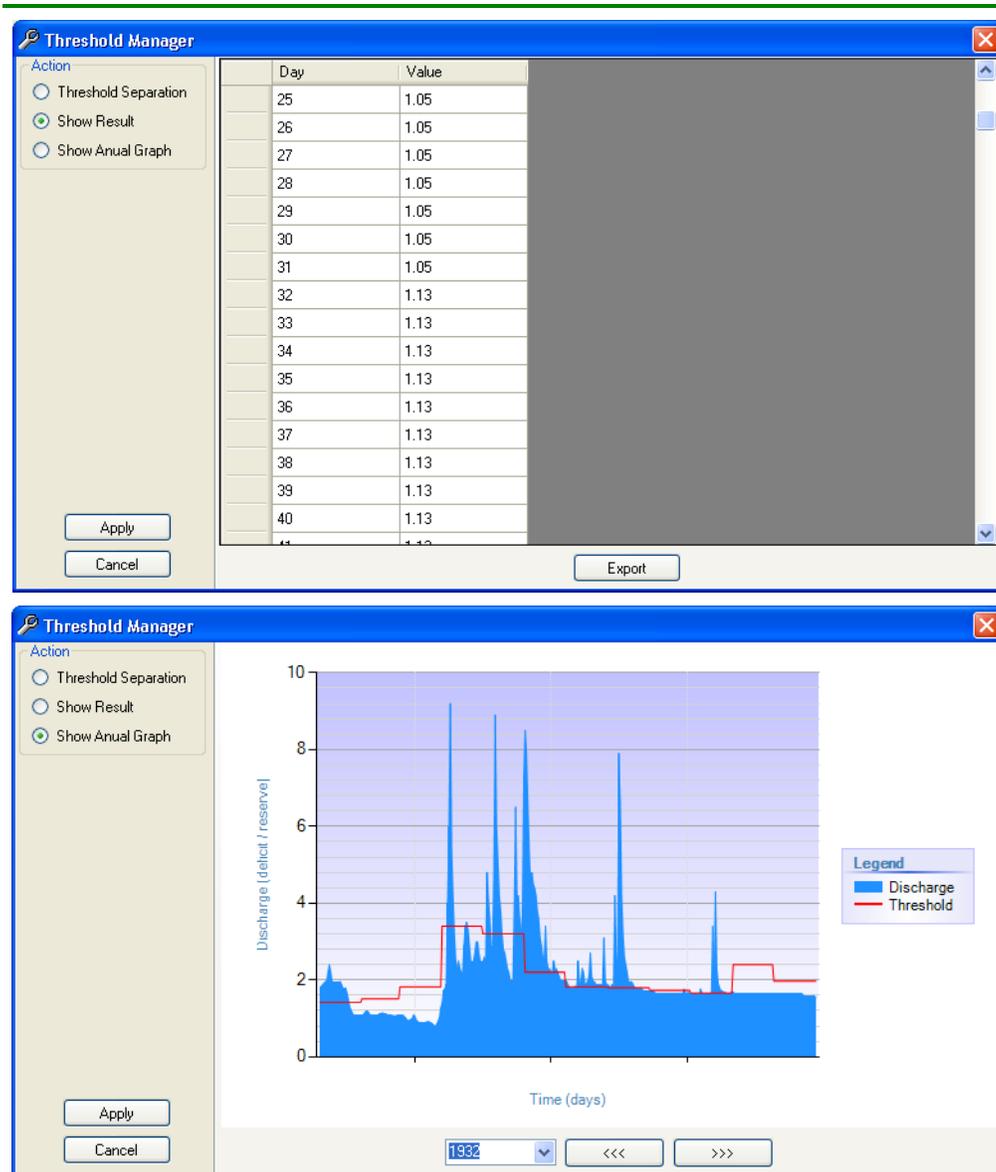
***Fig. 13: The possibilities of calculated threshold level type and values
analysing in tabular and graphical form.***

With these tools, it is possible to analyse the threshold level in either a table or a chart, where user can compare the threshold level values and measured discharge values in time of imported time-series. If users are satisfied with the calculated threshold level, than must click on the **Apply** button in the lower left corner of the window. This command imports calculated data into the main window for following calculations. After closing this window, we can continue in the other analysis.

DATA PROCESSING
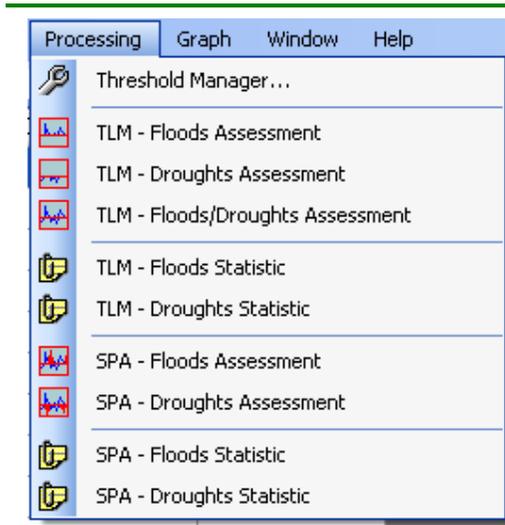
Fig. 14: Main commands in FDC 2.1 module.

All tools and commands necessary for working with TLM 2.1 module are located in the menu **Processing** (*fig.14*).

These commands are divided into two types. The first of type are the **Assessment** commands. These functions generate a new time-series by the selected command. The second of type are **Statistic** commands. These commands will first calculate the new time-series by selecting function and then statistically processed this results into the table.

Functions starting with **"TLM - ..."** use the classic comparison of the measured discharge values to the defined threshold level values. By contrast of previous, function starting with **"SPA -..."** use for analysis sequent peak algorithm method.

The first command **TLM - Floods Assessment** calculates the difference between the threshold level and measured discharges, which are higher than the threshold level. If the discharge values are lower than threshold level, the program inserting zero values into created time-series. Command **TLM - Droughts Assessment** analyses values below the threshold level. If user uses the command **TLM - Floods/Droughts Assessment** than can analyses simultaneously the difference between the threshold level and the measured discharge values (above and below the threshold level). Commands **TLM - Floods Statistic** and **TLM - Droughts Statistic** generated the statistical tables of these types of events in time. The structure of these tables will be described in the following chapter.

An **SPA - Floods Assessment** command counts the reserves and its change over the time above the threshold level. An **SPA - Droughts Assessment** calculates the missing volumes of water reserves below a defined threshold level over the time. The commands **SPA - Floods Statistic** and **SPA - Droughts Statistic** generate statistics tables of drought or floods events in the time.

The next chapter describes the character and structure of tabular results obtained using the described functions and commands.

TABLE RESULT

This chapter is focused to presenting of tabular result forms. The examples of results in tables are on pictures **15** and **16**.
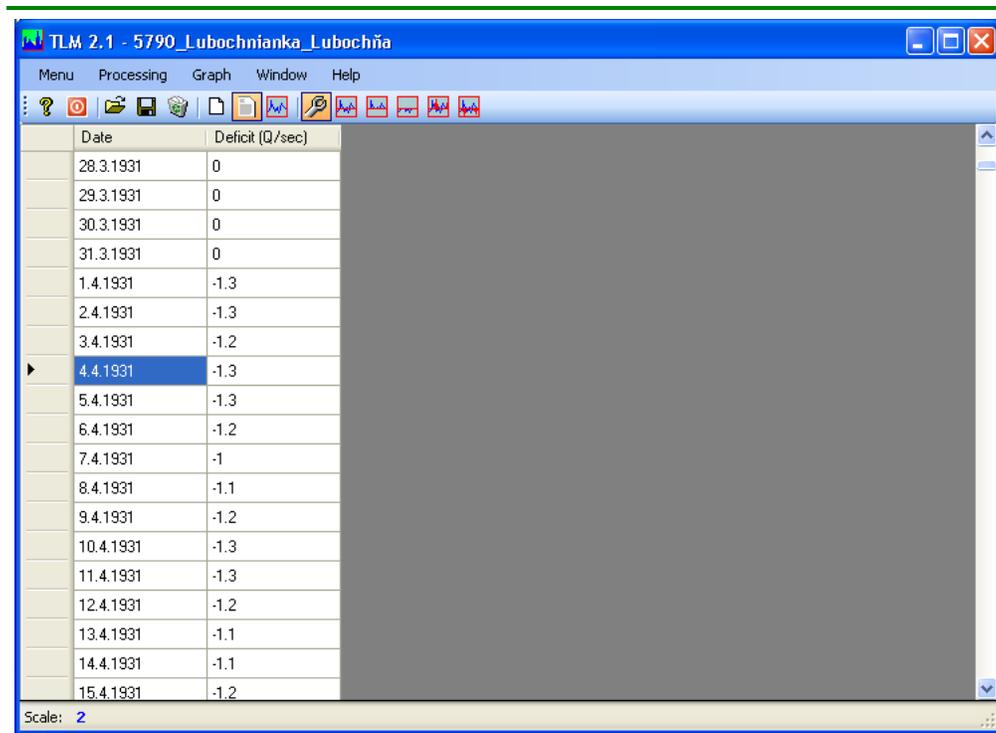
Fig. 15: The example of results obtained by "assessment" type of functions.
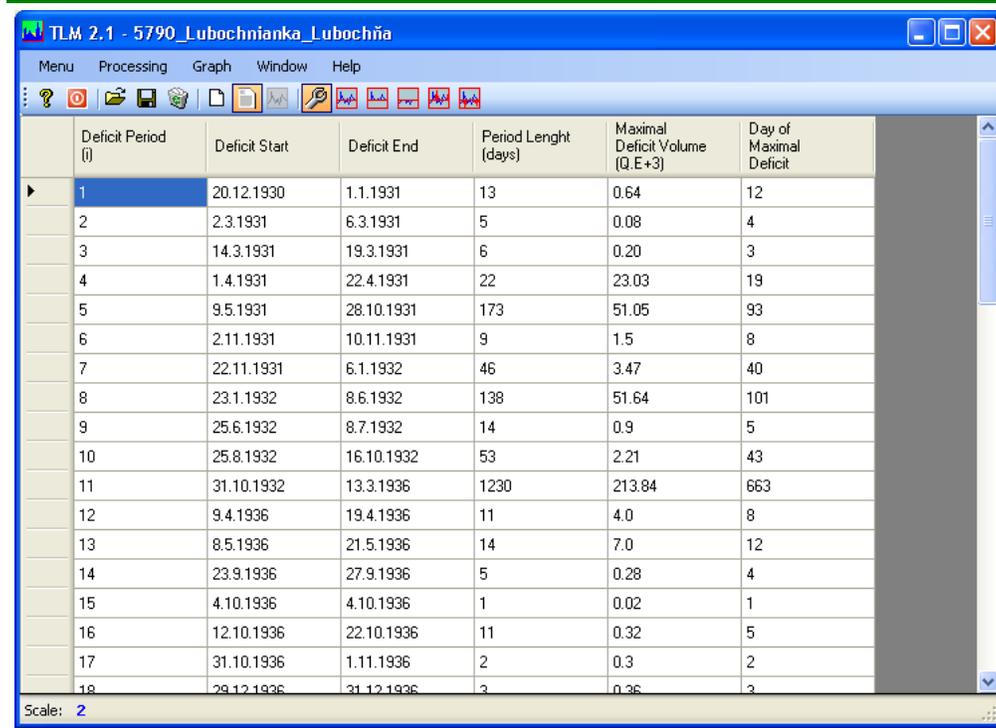
Fig. 16: The examples of results obtained by "statistic" type of functions.

If the user enters a command like **".... Assessment"**, the program generates a table structure like as on figure **15**. This means that, the results

represent the new calculated time-series deficit or limit-exceeding values of discharges. If user use the command **"... Statistic"**, the final table will be in the form like as on figure **16**.

In a statistical analysis of the values calculated using the classical TLM method the table will have structure like as on figure **17**.

Deficit Period (i)	Deficit Start	Deficit End	Period Lenght (days)	Deficit Volume (Q)	Maximal Deviation	
1	14.12.1930	22.3.1931	99	-5043643.2	-0.7245	
2	30.3.1931	18.4.1931	20	-476928	-0.4845	
3	11.5.1931	28.7.1931	79	-5111035.2	-0.9645	
4	30.7.1931	24.8.1931	26	-1515196.8	-0.9145	
5	26.8.1931	24.9.1931	30	-1542672	-0.8545	
6	28.9.1931	28.9.1931	1	-4708.8	-0.0545	
7	9.10.1931	24.10.1931	16	-569548.8	-0.5745	
8	1.11.1931	9.11.1931	9	-171979.2	-0.2545	

Fig. 17: The structure of table when user uses command "TLM – Drought Statistic".

The picture **18** defines each of deficit period parameters used in statistical table.
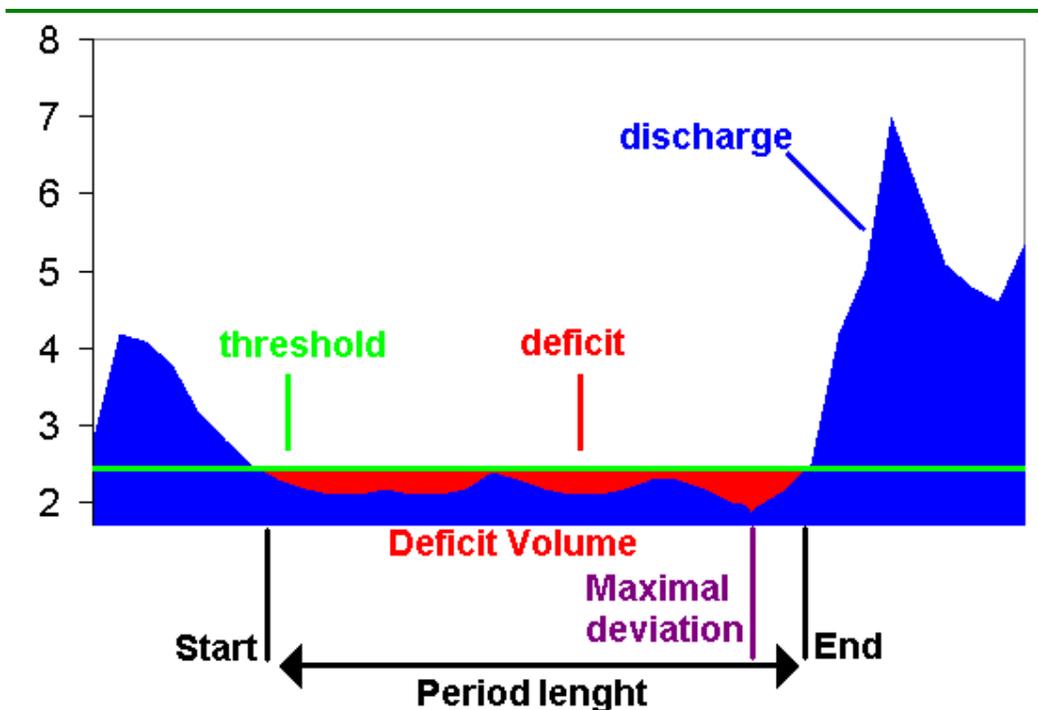
Fig. 18: Explanation of statistical table parameters if user uses classic TLM method.

The first column shows the number of deficit periods in time series. Parameter **Deficit Start** and **Deficit End** define the beginning and the end of the deficit period. **Period Length** column describes the length of the drought. **Deficit Volume** parameter describes the volume of water below the defined threshold. To calculate the correct values must be used daily type of time-

series with values Q/sec. The last parameter, **Maximal Deviation**, describes the maximum difference between the threshold level value and the measured value for the whole deficit period.

If the user runs a command to statistical processing of deficit periods by using SPA method will have the table structure like as in figure **19**.

	Deficit Period (i)	Deficit Start	Deficit End	Period Lenght (days)	Maximal Deficit Volume (Q.E+3)	Day of Maximal Deficit
▶	1	14.12.1930	6.5.1931	144	58.3755	99
	2	11.5.1931	23.5.1939	2935	717.4395	1691
	3	7.6.1939	14.6.1939	8	0.2725	5
	4	24.6.1939	30.8.1940	434	133.4120	276
	5	7.9.1940	16.9.1940	10	1.9560	8
	6	19.9.1940	7.4.1941	201	97.5060	168
	7	28.6.1941	21.8.1941	55	12.0185	33

Fig. 19: The structure of table when user uses command "SPA – Drought Statistic".

The picture **20** defines each of deficit period parameters used in statistical table.
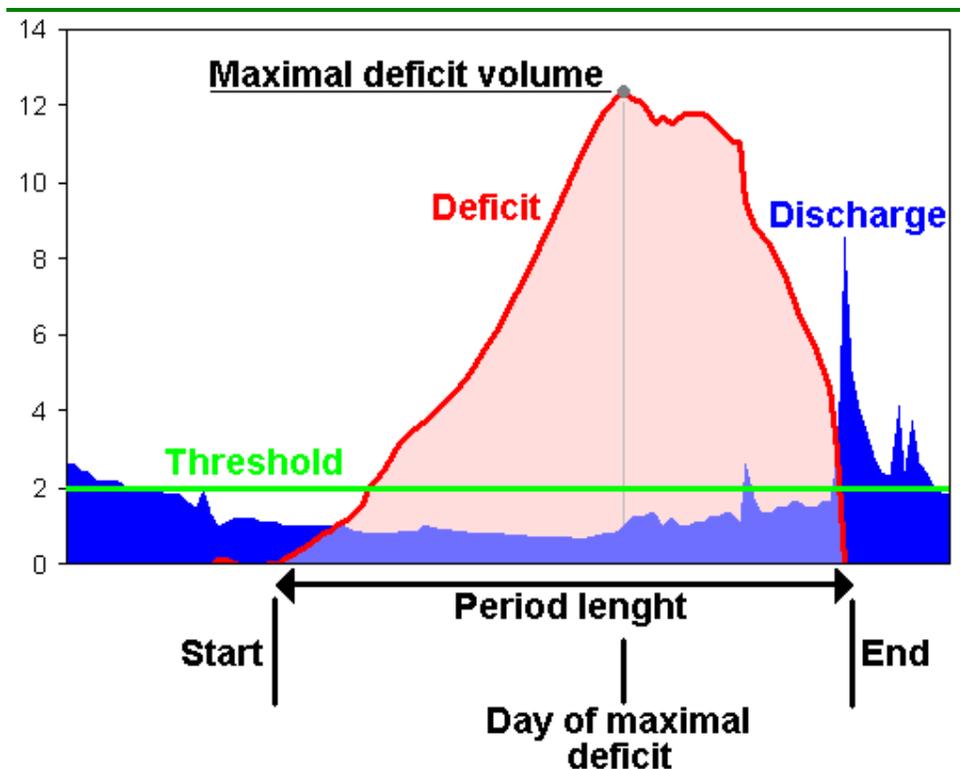
Fig. 20: Explanation of statistical table parameters if user uses SPA method.

Like as in the previous example the first column is the number of the deficit period in time. The second and third column is used to define the beginning and end of deficit period. In the fourth column are calculated the

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length deficit periods. The fifth column contains the maximum deficit and sixth column contain the information about day of maximal deficit in drought period.

If we analyse the values above the threshold level, the structure of tables is identical, except the parameters of minimum values will change to the parameters of maximum values. The result of the statistical command is possible to analyse only in tabular form. Conversely, if the function generates a new time-series result, then can be the result analysed in graphical form. This functionality is covered in the following chapter.

GRAPH RESULT

After launching selected command is except the table result is also generated the graph (*fig.21*).
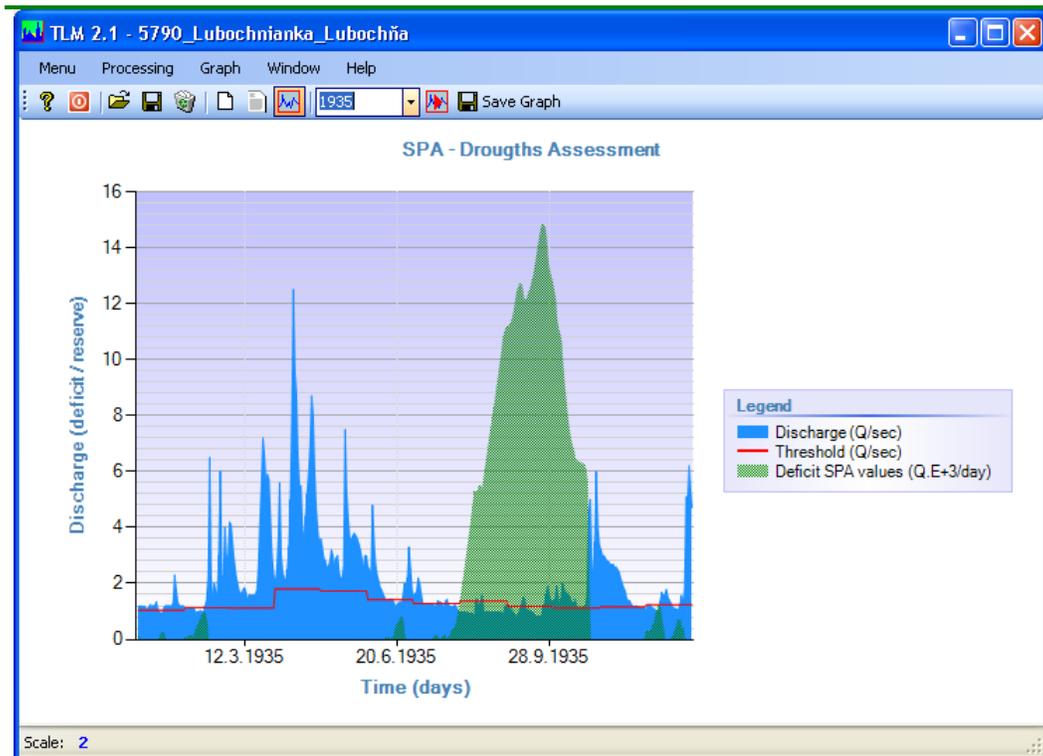
Fig. 21: The example of hydrological drought analyse using monthly types of threshold level and SPA method.
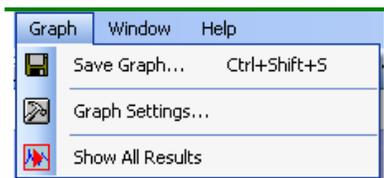
Fig. 22: Functions for graph processing.

Features chart contained in the **Graph** menu (*fig.22*). This menu contains a feature **Save Graph**. Module TLM 2.1 allows you to export chart from the program in six formats (*.bmp, *.emf, *gif, *.jpeg, *.png, *.tiff).

The second function **Graph Settings** is for visual adjustments of generated chart. For processing is **Graph Settings** window showed (*fig.23*). In it can be set everything visible in the graph (e.g. legend, lines, area chart, axis, chart titles, etc.).
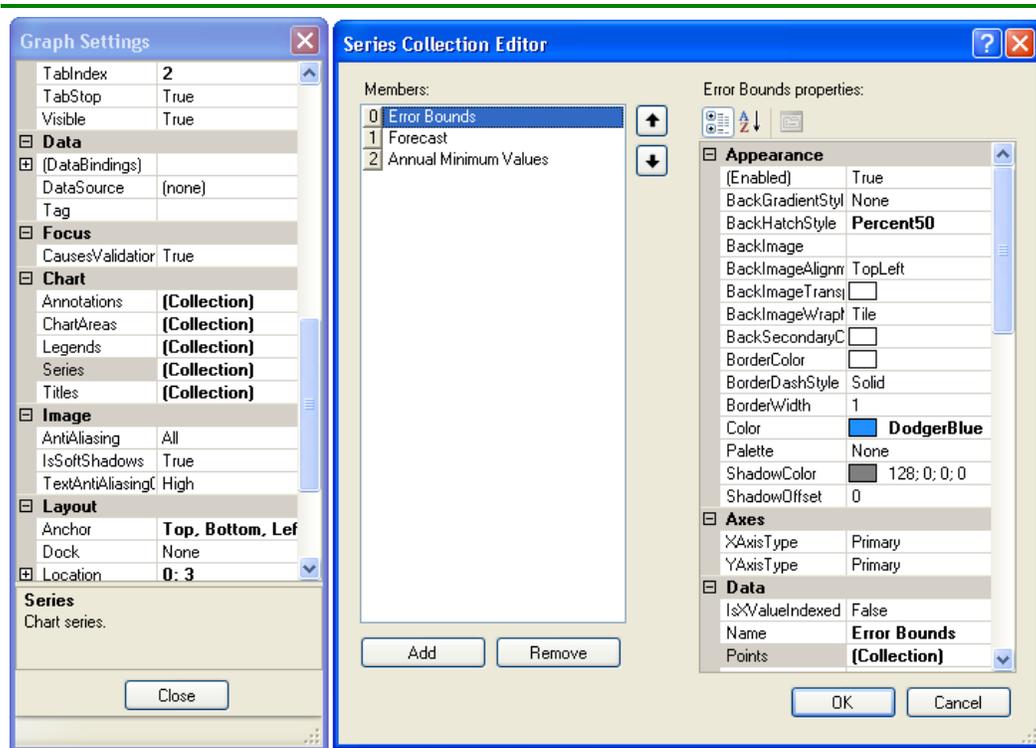
Fig. 23: Tools for visual settings of graph.

Examples of different settings are shown in figure **24**. Graph is able to show annual view of the imported time-series or whole calculated time-series. The selection of the year is displayed combo box in the toolbar of applications and to view the whole time-series can use command **Show All Results** in toolbar or in the **Graph** menu.
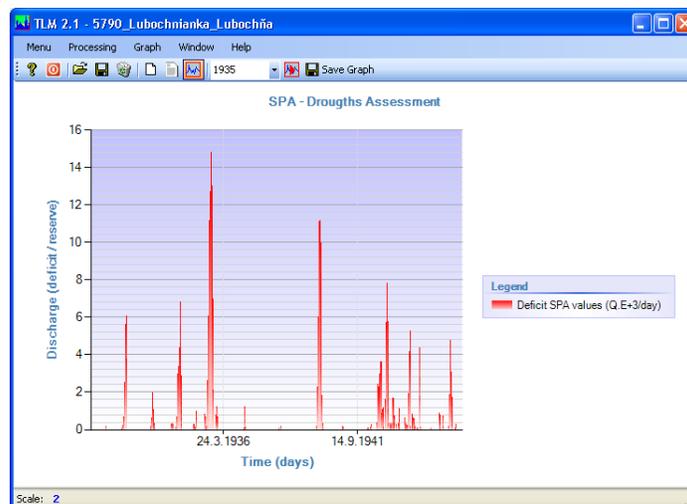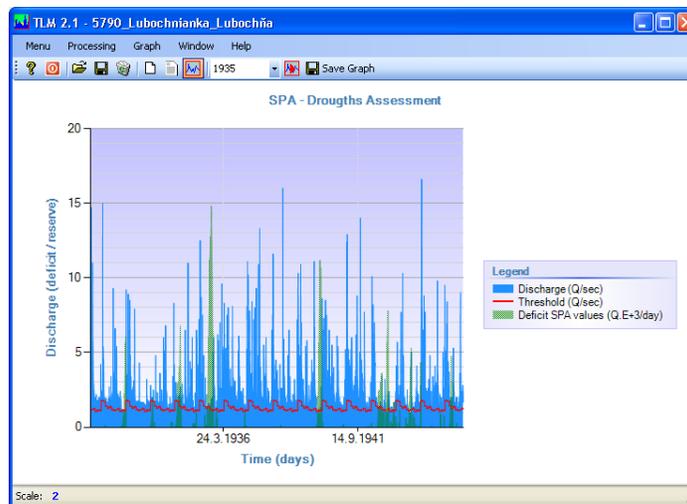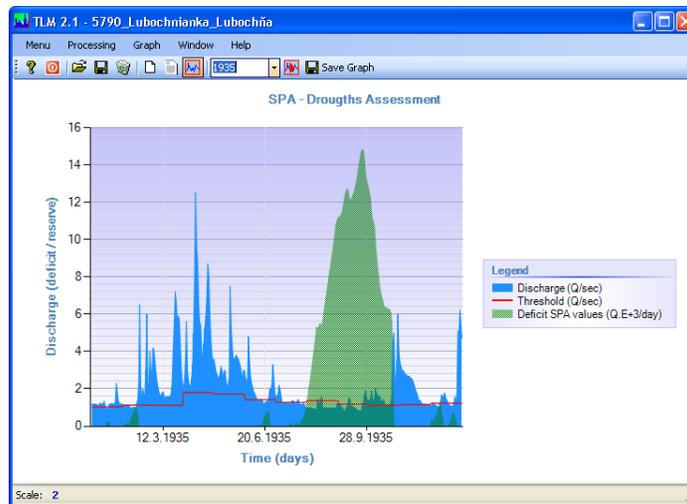
Fig. 24: The examples of graph settings (top – annual view; middle – whole calculated time-series; beneath – visually adapted previous example).

CONCLUSION

This manual describes the functionality and uses of TLM 2.1 modules focused to hydrological analysis.

The module is used for calculations and analysis of extreme values in time-series using the threshold level methods. The module contains a number of settings and features. These functions can be applied to different types of time-series measures, but the program was primarily developed for the analysis of hydrological drought.

Application has several features that are detailed described in the text. In case of problems with the module can be use user's forum on the HydroOffice.org web. To further study of the module functionality can be used videotutorials. Freely can be downloaded in the Downloads section of web.

If in program absence any function or feature, you can inform me in forum on web. If you find a bug in the program, I will be grateful for the notification. You can inform me about it via forum or via my email. If you use this module, it would be good to cite it in your work. If you do not know what to quote, on this page you can find the publications focused to HydroOffice software and its modules. If you quoted something of HydroOffice project, I'll be happy if you inform my and give me a quote to your work. I can add a link to your site on this page of HydroOffice web. This can also help you with better placement in search engines.

REFERENCES

TALLAKSEN, L., M., VAN LANEN, H., A., J., van eds., 2004: Hydrological Drought – Processes and Estimation Methods for Streamflow and Groundwater. Developments in Water Science, 48. Amsterdam, Elsevier Science B.V, ISBN 0-444-51688-3, pp. 579