Methods of extreme weather events selection and some results of elaboration

M. Lapin and I. Damborská

Faculty of Mathematics, Physics and Informatics, Comenius University, Bratislava, Slovak Republic
(e-mail: lapin@fmph.uniba.sk, damborska@fmph.uniba.sk)

Abstract Basic approaches and statistically based methods of extreme climatologic characteristics selection, testing and elaboration, including short-term to several days unusual weather events is presented. Some precipitation and temperature characteristics of extremes as examples of climate change in Slovakia are shown. The selection of extremes in the form of time series for statistical elaboration has to fulfill several conditions: 1) Representativeness; 2) Homogeneity; 3) Random choice; 4) Independent choice. Any statistical elaboration of incorrectly designed time series cannot bring usable results for the practice. There are quite good possibilities to prepare time series of about 100-year length from several elements in Slovakia. It seems that at air temperature even 40-year length is suitable, but at precipitation, snow cover and air humidity at least 60-70 year series are needed. Examples for such stations as Hurbanovo (SW Slovakia, 115 m a.s.l.) are shown in the paper.

Key words: *extremes, extreme events, statistical elaboration, scenarios*

1. Introduction

The topic of climate change has been presented mostly as a long term means change, mainly at air temperature and precipitation totals. In the TAR IPCC (2001) there was firstly a discussion on possible change in the distribution curves of individual climatic phenomena (change in probability densities in the time series from different periods). Basic possibilities of distribution curves shift are presented in Figure 1. It is obvious that besides the mean (central) values shift as very important can be considered the changes of values at the left and right margins of distribution curve (extreme design values).

Also from the presented simplified examples it can be clearly seen that there is a possibility for increase of population variability, i.e. increase of extremes at both margins of distribution curve. Most of human socio-economic activities as well as the processes in the natural ecosystems are adjusted according to the natural climatic variability occurred in several past decades. That means most of them can wear without any significant difficulties the occurrence of some extreme values with certain probability. The direct measurements and observations confirmed that the return period of 50 year is probably the limit for natural adapting at most of biological species. It is obvious that also the human activities well fulfill the limit of 50 years return period. On the other hand this time roughly corresponds to mean active period of humans existence. Everybody of us should be prepared to master extreme problems naturally occurring during our active life. The complex of natural ecosystems is probably adapting to the weather and climate variability more complicatedly. The genetic memory of species depends on many factors, some of them can adapt more quickly and some during very long time. We can consider that the return period of 50 years suits well also in this case (IPCC, 1998, 2001).

The statistical analysis of time series based on meteorological (as well as hydrological) observations enables to design (to find) some values in the distribution curves (e.g. probability $p = 0.02$ and $p = 0{,}98$) only at certain conditions and limits. At the beginning of the statistical analysis conditions discussion it needs to be stressed that in the past some statistical characteristics have been calculated also from time series of 10 – 20 years and without any reliability testing. We consider as important the following 4 preconditions:

1) The time series of observations have to fulfill the precondition of temporal homogeneity from the point of view of observing methods and representativeness (it means: observations and measurements at the same place, no significant change of observing site surroundings, not changed methods of observations and comparable measuring instruments). In this case all found inhomogeneities have only climatologic causes (temporary changed atmospheric circulation, temporal trends of some climatologic variable – mainly temperature, etc.), Nosek, 1972, Guide WMO 100, 1983, Lapin and Tomlain, 2001).
2) The time series have to fulfill also another preconditions: independent random choice and sufficiently great population (otherwise, the selected time series should have statistical parameters comparable, if not identical, with much longer ones from the same place

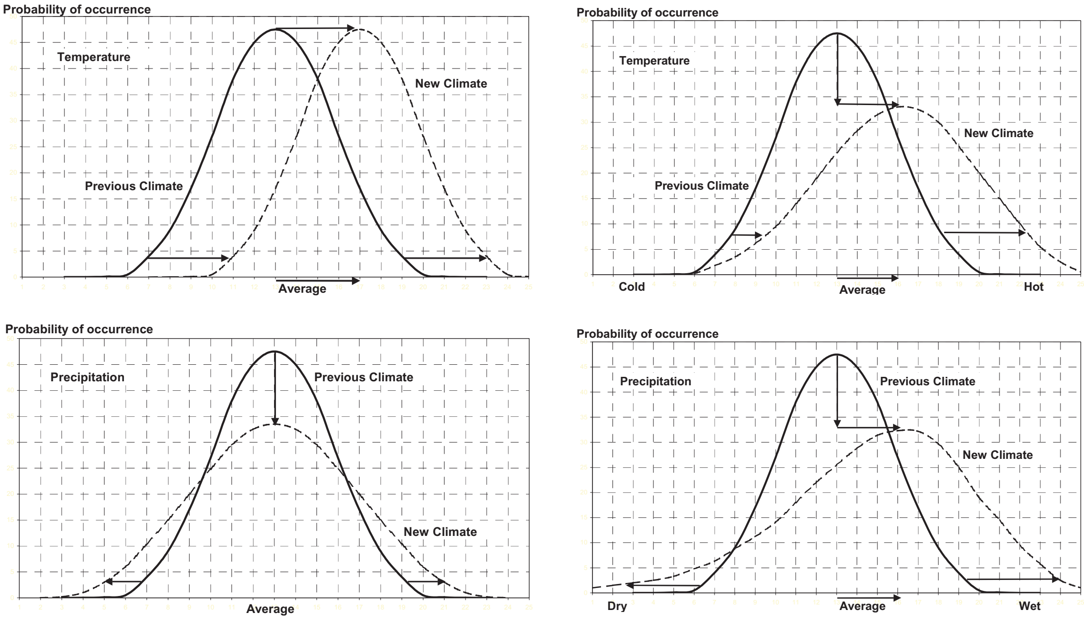

Figure 1 Possible changes in mean and variability of air temperature (top) and precipitation totals (bottom) – modified according to IPCC (2001).

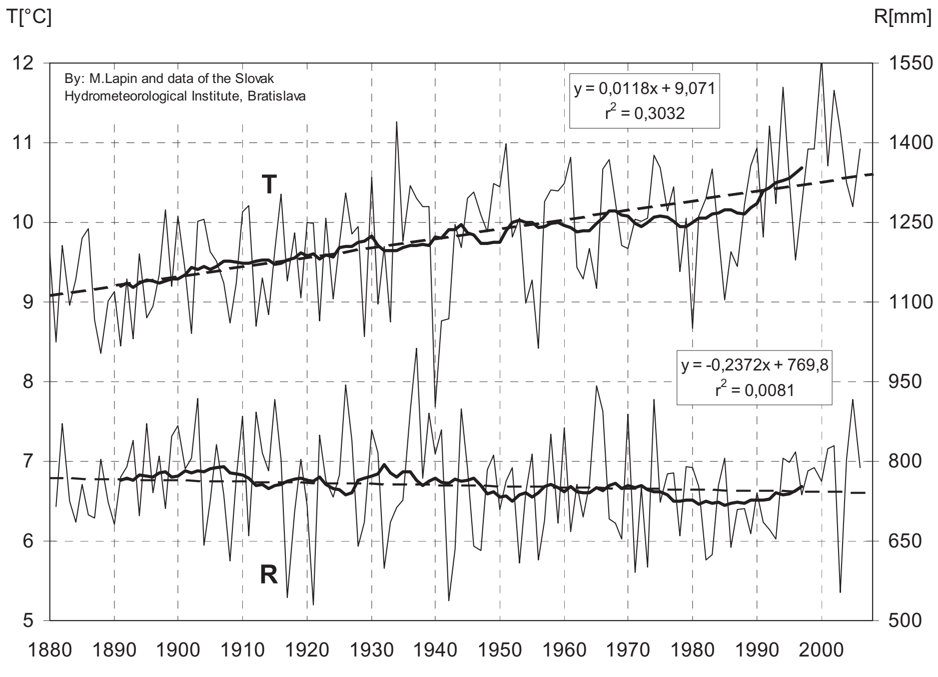

Figure 2 Annual air temperature means (T) at Hurbanovo and annual precipitation totals (R) in Slovakia in 1881-2006 (based on double-weighted averages areal means from 203 stations), T and R changes are shown by 20-year moving averages and linear trendlines of T and R

and its duration should be at least 30 years, Nosek, 1972, Guide WMO 100, 1983). Sometimes the series are selected according to some intention (standard period 1961-1990) however in this case the selection should not be motivated by additional reason, for example an elaboration of unusual weather, because of infiltration another degrees of freedom into statistical analysis.

3) The independent choice has also another dimension. Sometimes it is needed to elaborate the time series created under not fully correct conditions (the individual data are not from the same time of the year, or from different synoptic situations, or from the events with different radiation and atmospheric stability conditions). This is connected mainly with extreme precipitation totals, heat waves, drought spells, etc. The testing of time series reliability and independence of all items in the population must be therefore very careful, otherwise the final statistical characteristics can be confusing. The details are presented in the further text.

4) As the last important condition the temporal stationarity of time series can be listed. Such examples are very frequently found, in Figure 2 the annual mean temperatures from the Hurbanovo Observatory are shown. It is clear that within the whole 1871-2006 period only limited number of stationary 30-year series can be selected. The 1951-1980 one is nearly stationary, but the 1971-2000 one is surely not. The stationarity issue will be also discussed in the next text.

2. Methods

The statistical elaboration of climatic design values with low probability of occurrence is aimed mainly to usable climatic characteristics calculation for practice in socio-economic sphere, research and state administration. In the next text we'd like to propose some basic conditions of the mentioned analysis (Nosek, 1972, Guide WMO 100, 1983, Lapin a Tomlain, 2001).

2.1. Input data

The input data represent some series of observations regularly or irregularly distributed in time and space – the best solution is the use of data and series from regular station network of meteorological and hydrometeorological services. These institutions provide stable long-term measurements from the point of view of methods and management. In case of "extreme values statistics" there is also a question on the extremes definition. Purely in the mathematical statistics terms the extreme is the lowest and the highest value within the selected time interval – the local extreme. We can select as the basic interval one day or one month, so there is one maximum and one minimum in each day or month, resp. Some problems arise if all values within the selected basic interval are the same, e.g. in the month without any precipitation all daily total are zero, during completely overcastted week all daily values are 10. The duration of basic interval can be also the same as the definition length of selected variable, in this case each value is a maximum and minimum as well (daily precipitation totals on July 1st, in 1871-2000 at Hurbanovo, in Figure 3 there are only absolute daily maxima for all year round). Another precondition is that for statistical elaboration we need at least 30 such local extremes from entirely comparable basic intervals (days, months, years…). We can also discuss the independence of extremes choice, if we suspect that various conditions of extremes occurrence exist in different basic intervals, what can increase degrees of freedom (different conditions at the beginning and the end of basic interval, different synoptic situations etc.). Also very different conditions for high daily precipitation totals can be at the beginning and the end of April (convection, circulation, specific humidity…). Even more complex problems arise if all season is selected as basic interval, e.g. grooving period (April 1st to September 30th). These different conditions can surely influence such variables as runoff, soil moisture, relative humidity etc. The entirely subjective appellation of "extreme weather events" is not suitable for any statistical elaboration.

The absolute maxima in daily precipitation totals at Hurbanovo (115 m a.s.l., SW Slovakia) measured in 1871-2000 are presented in Figure 3 as an example. There was selected the most appropriate method of extremes interpretation, because of removed annual course. In spite of this it is clear from the Figure 3 results that annual course of absolute extremes is irregular to the utmost. Also the subjectively assessed envelop curve is not fully reliable. Slightly better situation is at daily air temperature means elaboration (Figure 4), where the selected interval of elaboration is identical with the definition interval of variable. The normalized values have been applied because of removed annual course (in this case each value represents a deviation from long term average for the 1951-2000 period). At precipitation totals we have so 130 values in each day and at air temperature only 50 ones. This is well enough for statistical elaboration (Nosek, 1972), in spite of this the annual course of design values with low probability of occurrence is surely not without any problems.

It needs to be stressed that we have applied there nearly ideal time series of measured data, in other cases much shorter series with disputed data selection are statistically elaborated (individual rain spells for rain intensities, extraordinary weather events, N-day precipitation totals etc.). As a specific problem the regional assessment of weather extremes can be considered, for example maxima in daily precipitation totals within some climatologically homogeneous region according to the measurement in station network (Gaál, 2006). Figure 5 shows only one example based on annual maxima in precipitation totals from 557 stations in Slovakia in 1951-2000.

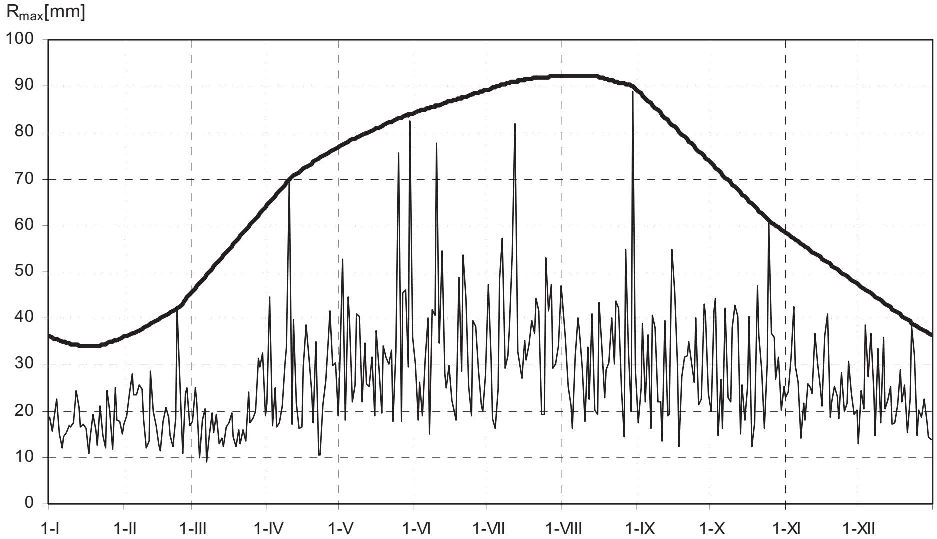

Figure 3 Absolute maxima in daily precipitation totals at Hurbanovo in 1871-2000 and envelop curve constructed subjectively

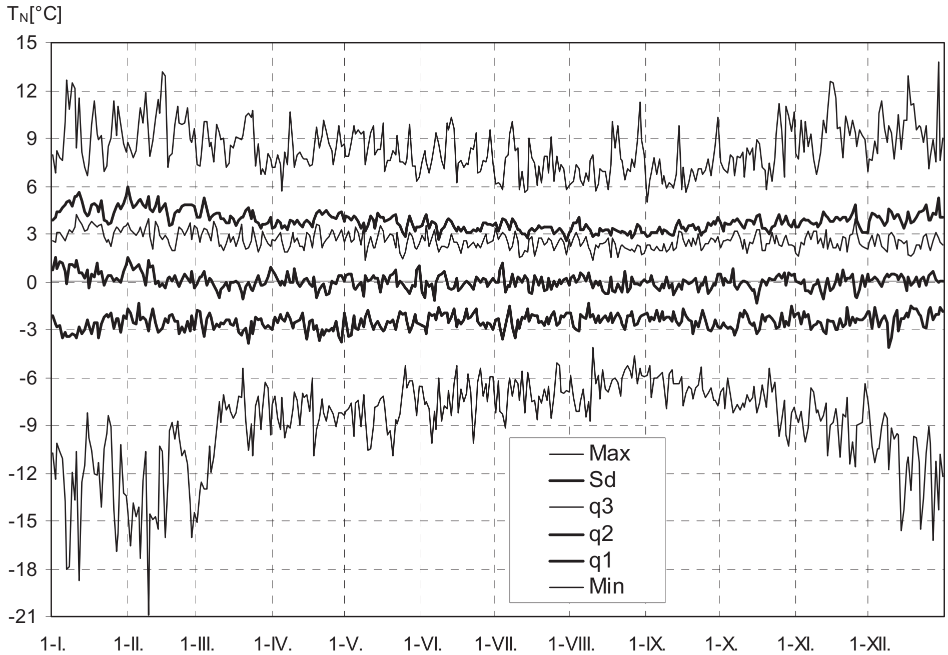

Figure 4 Statistic of normalized daily mean temperatures at Hurbanovo in 1951-2000 (absolute maximum and minimum in daily means, upper and lower quartiles, median and standard deviation of daily means)

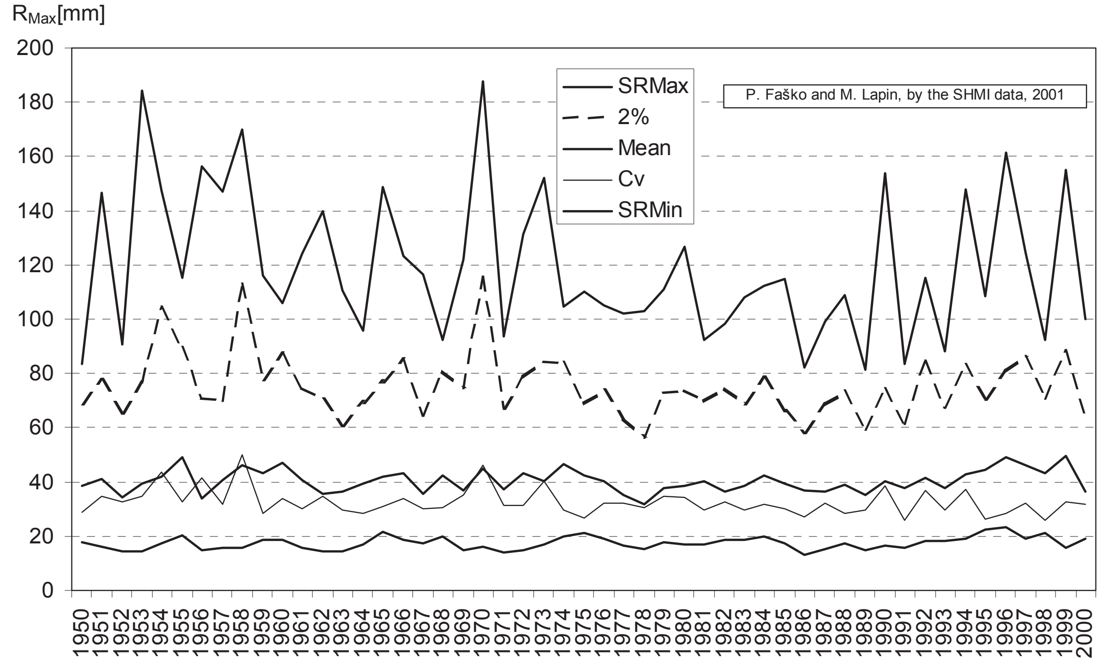

Figure 5 Annual maxima from daily precipitation totals at 557 stations in Slovakia in 1950-2000

Table 1 List of stations with daily precipitation total R ≥ 150 mm in Slovakia in 1951-2000 (based on all station with precipitation measurements evaluation (about 700 each year), Faško et al., 2002).

Year	Station	N [° ʻ]	E [° ʻ]	H [m]	R_{Max} [mm]	Datum dd-mm-rr	Sit CS
1951	Trnava	48 22	17 38	155	162,8	03-VI-51	C
1956	Sokolovce	48 31	17 50	165	156,4	19-VII-56	VFZ
1957	Salka	47 53	18 45	111	231,9	12-VII-57	B
1958	Chata Zbojnícka	49 11	20 10	1958	169,0	29-VI-58	C
1958	Hrebienok	49 09	20 13	1285	165,0	29-VI-58	C
1958	Skalnaté pleso	49 11	20 14	1778	170,0	29-VI-58	C
1961	Železnô	48 57	19 23	990	153,7	18-X-61	B
1966	Veľké Pole	48 33	18 34	556	164,0	19-VIII-66	C
1970	Oravská Lesná	49 22	19 10	780	163,2	18-VII-70	B
1970	Novoť	49 25	19 15	770	187,6	18-VII-70	B
1970	Oravská Polhora - Roveň	49 33	19 26	704	182,1	18-VII-70	B
1970	Oravice	49 16	19 45	853	154,3	18-VII-70	B
1970	Zverovka	49 14	19 42	1027	154,5	18-VII-70	B
1973	Podspády, VT	49 16	20 10	910	152,3	30-VI-73	Wal
1990	Luková	48 57	19 35	1661	153,0	29-X-90	SWc3
1990	Jasná	48 58	19 35	1196	154,0	29-X-90	SWc3
1996	Cífer	48 19	17 29	147	161,5	12-VIII-96	B
1999	Limbach	48 17	17 13	181	155,0	10-VII-99	Ec
1999	Pezinok, Grinava	48 05	17 05	159	151,5	10-VII-99	Ec

It is evident that Figure 5 was constructed using the best data available in Slovakia for 1-day precipitation totals elaboration (Faško et al., 2002). In spite of this Figure 5 does not bring all information on absolute precipitation totals (Table 1) and also on their temporal and areal distribution. Some drawback is that the annual maxima have been selected without consideration different conditions during the year and the synoptic situation. That is why here are include also some events from the cold half-year connected with long lasting precipitation in central cyclone (***C***) or trough (***B***) over Central Europe (last column in Table 1). Precipitation maxima in the warm half-year can be originated by one or several thunderstorm, or also by long lasting rain in central cyclone and trough exceptionally occurring also in this time of year (Table 1).

As significantly different method of basic extreme data selection a limited choice of values above some threshold ($\boldsymbol{R} \geq 100$ mm) can be discussed (Figure 6, Faško et al., 2002, completed in 2005). Such selection enables to obtain relatively good review on high daily precipitation totals in the individual years (we have in Slovakia observation at >700 station each year). On the other hand such method of selection is far from correct data preparing for statistical elaboration. There is changeable number of station each year in operation, some stations have only short observations and it is impossible to proof if this selection is independent. In spite of this the Figure 6 graph was very popular since its first issue in 2000, also with similar data from south Poland (Cebulak et al., 2000). Very curious is the extreme on June 29, 1958, when there were daily totals $\boldsymbol{R} \geq 100$ mm at 36 stations in Slovakia and no one in other days in 1958 (in south Poland there were registered more than 100 events of $\boldsymbol{R} \geq 100$ mm on June 29, 1958).

Just limited examples of extremes selection have been presented in this section. We tried to indicate some serious problems in extreme meteorological and hydrological events statistical elaboration. It is obvious that in the case of complex data on extraordinary weather events, where the extremes are considered as a result of interaction of several meteorological variables, the selection is even more problematic. We can count among such extreme events: droughts, heat waves, floods risk, wild fires risk, avalanches risk etc. At such cases of analysis we need to take into account simultaneously several meteorological variables, including soil moisture, vegetation, preceding weather, land use etc. Analyzed extreme event (one or several days) can be included into statistical elaboration as one item only after detail reliability testing of all variables. Also in such cases the series of selected items representing extreme weather events need to be tested according to mentioned 4 preconditions in Introduction. Otherwise the statistical elaboration can be misleading.

2.2 Reliability testing

It is well known that the basic input climatologic data have a set of potential shortages. That is why the reliability testing and the needed modification of data must have several steps. We want to concentrate mainly to the completeness and the temporal homogeneity of temporal time series. It is possible also the testing of stationarity of central values, marginal percentiles and extremes. In this paper there is not enough space for details of these methods (Nosek, 1972, Storch et al., 2000, Lapin and Tomlain, 2001). We will discuss in the further text only selected important problems.

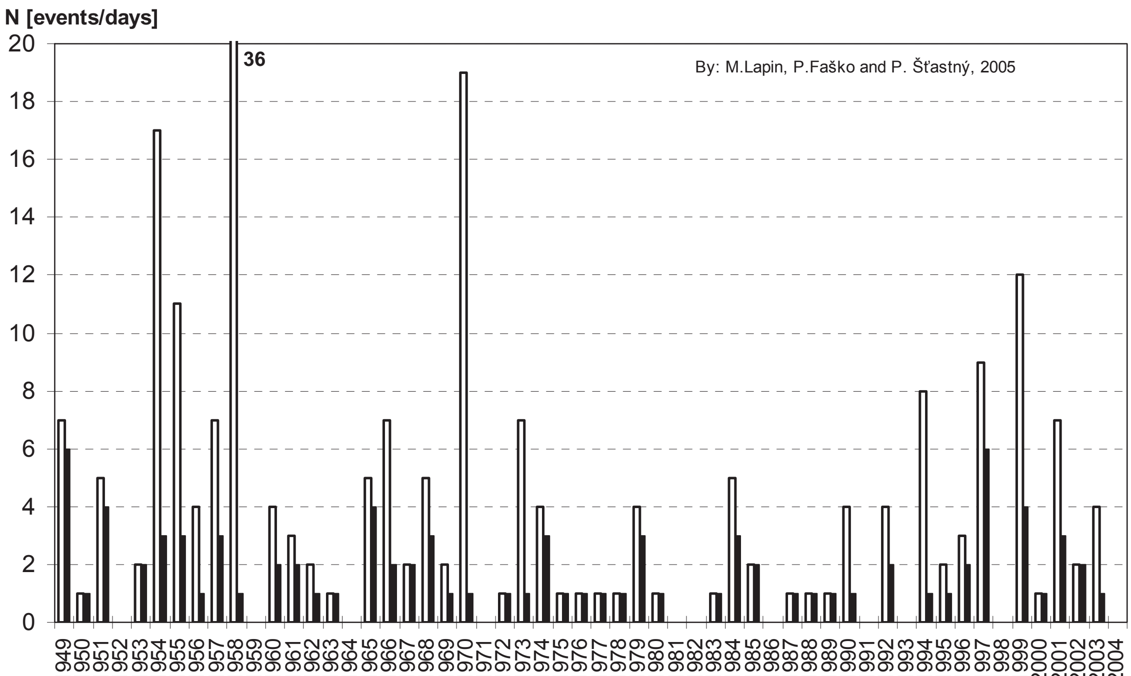

Figure 6 Number of events (each station is considered as one event each day) and days (at least one event in Slovakia) with precipitation total R ≥ 100 mm in Slovakia in the years 1949-2004

At the beginning of extreme data or extreme weather events analysis we are facing usually to incompleteness of data series as a key problem. This is connected with well known fact that at least 30 year long series are needed and the longer the series are the more reliable statistical results can be obtained. Our experiences confirmed that especially rapid decrease of usable stations occurs if the length of series is greater than 50 years. Some times only 10% of stations fulfill all requirements. Another one serious reason exists why very long series are necessary – the outlayers. For example, at daily precipitation total there appears nearly each year maximum value $\boldsymbol{R} \geq 100$ mm at some of 700 stations in Slovakia. At least in half of such cases these totals represent outlayers, because of time series below 30 years. Similar character has also the daily minimum of air temperature, mainly in the winter months. The outlayers usually cannot be taken into account in statistical elaboration, because we do not know its position in the basic distribution curve. That is why outlayers sometimes falsify calculated design values with low probabilities.

Let us come back to completing of missing data in time series. It is well known that such need is mainly at precipitation data, so we are showing annual extremes in daily totals as an example. In Figure 5 there are data from 557 stations in Slovakia in 1950-2000. At elaboration we have found several stations with gaps in individual months what did not enabled to find annual maxima in this year. The monthly totals are possible to fill easily from the monthly maps and the round stations data. At daily totals this is also quite easy in case of cyclonic weather (central cyclone C, or trough B) with equally distributed high daily totals. The selection and filling of missing maxima is not so simple at unequally distributed high daily total connected with severe summer thunderstorms. The filling of missing daily maxima for elaboration presented in Cebulak et al., 2000 realized P. Faško by two steps, firstly he had identified all days with potential extreme daily totals and then he constructed maps of round area using all measuring stations (at some cases he applied also the synoptic maps). As an extreme difficult example we show two stations in Figure 7. Both time series are from the Liptov region in northern Slovakia. The first station (Huty, filled columns) is complete and the second one (Bobrovček, unfilled columns) has gaps in 16 years at the beginning and the end of series.

It is obvious that such method can be applied also at other climatic variables, in spite of this such high number of filled data (31%) is unusual. It was the highest value from all 557 stations and we could do it mainly thank to the dense gauge network and well defined upwind effects. Otherwise also one missing value is sometimes very difficult to complete because of special synoptic situation (isolated thunderstorm).

After the completing of time series on annual maxima in daily precipitation totals at 557 stations in Slovakia we considered on the testing of its temporal homogeneity. No one of tests has brought usable result. There appeared a set of seeming inhomogeneities, similarly as published by Gaál (2006), but no one has been confirmed by metadata. So, we came to the conclusion, that if there are homogeneous series of annual precipitation totals, the annual maxima in daily totals are probably homogeneous as well. At this step

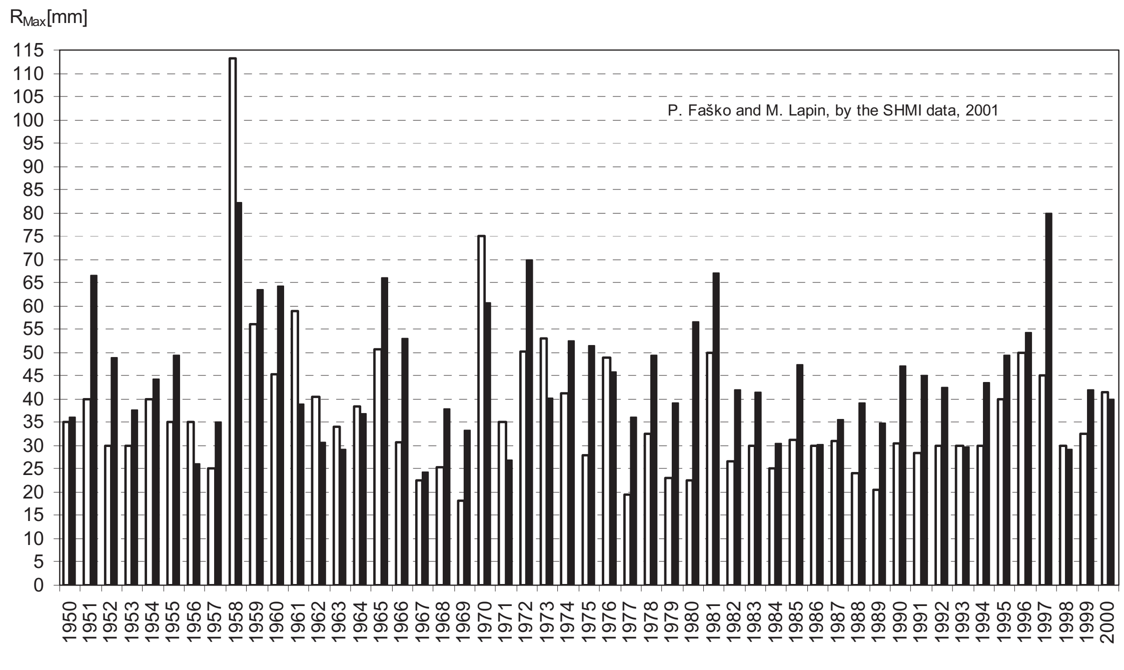

Figure 7 Time series of annual maxima in daily precipitation totals at two close stations in the Liptov (the first one, Bobrovček, 667 m, has 16 filled data, the second one, Huty, 795 m, (black columns) is complete)

of discussion it needs to be stressed that at evaluation of time series with daily air temperature maxima and daily specific air humidity maxima there are much better possibilities of temporal homogeneity testing.

Time series stationarity is another serious problem in the analysis of climatic extremes (Guide WMO, 1983). As it can be seen from Figure 1, there are consequential reasons for not reliable assessment of design values in case of changing climate. In some extend we can see it also within the series of normalized daily temperature averages for modified growing period April 1st to August 31st in 1951-2006 (Figure 8). After the year 1990 we have there significantly different conditions not only at temperature daily means trend but also at the margins of distribution spectrum (upper and lower decile and more). Evaluation of returning periods for values with low probability based on statistical elaboration of series from 1901-1990 has therefore new dimensions recently. It seems that the upper and the lower deciles have shifted by about 1.2 °C to higher values and this is probably valid also for the extremes. In this concrete example the mean of upper deciles is only 4.13 °C in 1951-1991 but 5.39 °C in 1992-2006 (dashed line in Figure 8). For mean values it is – 0.32 and 0.98 °C, for lower decile –4,74 and – 3,51 °C, resp. The year 2007 development shows that we will have probably similar deviations as in 2000 and 2003 for the growing period IV-VIII. From this Figure 8 we can also see that the standard deviation (StDev), skewness (Skew) and the kurtosis (Kurt) have not changed significantly after 1990. This indicates the first option of climate change existence, described in Figure 1. The distribution curve has thus shifted linearly without significant variability change.

2.3 Use of theoretical models for probability density statistical distribution

Short time series, temporary non-stationarity of series as well as complex patterns and temporal course of basic statistical characteristics of climatic variables results in the fact that the theoretical statistical models of probability distribution have in climatology several limits. Only seldom there is possible to apply the Gauss normal (symmetric) distribution with good interpretation of all statistical characteristics. This is important mainly at extreme values analysis. Climatic extremes occur very rarely and their volume is only partly influenced by random processes. Exact forecast of such events is not basically possible, but there are several opportunities to assess them by the mathematical tools of statistical climatology (Nosek, 1972, Storch et al., 2000).

There exist the cases when the deviations from normal distribution are so great that the normal distribution curves apply would significantly misrepresent the real state, e.g. the distributions limited by zero, or when the highest values are expressed by some whole number. In such cases it is better to apply asymmetric distribution more suitable expressing the behavior of studied phenomenon, Pearson III distribution is suitable mainly for some climatic and hydrologic (precipitation, runoff) events. The character of Pearson III distribution function is determined

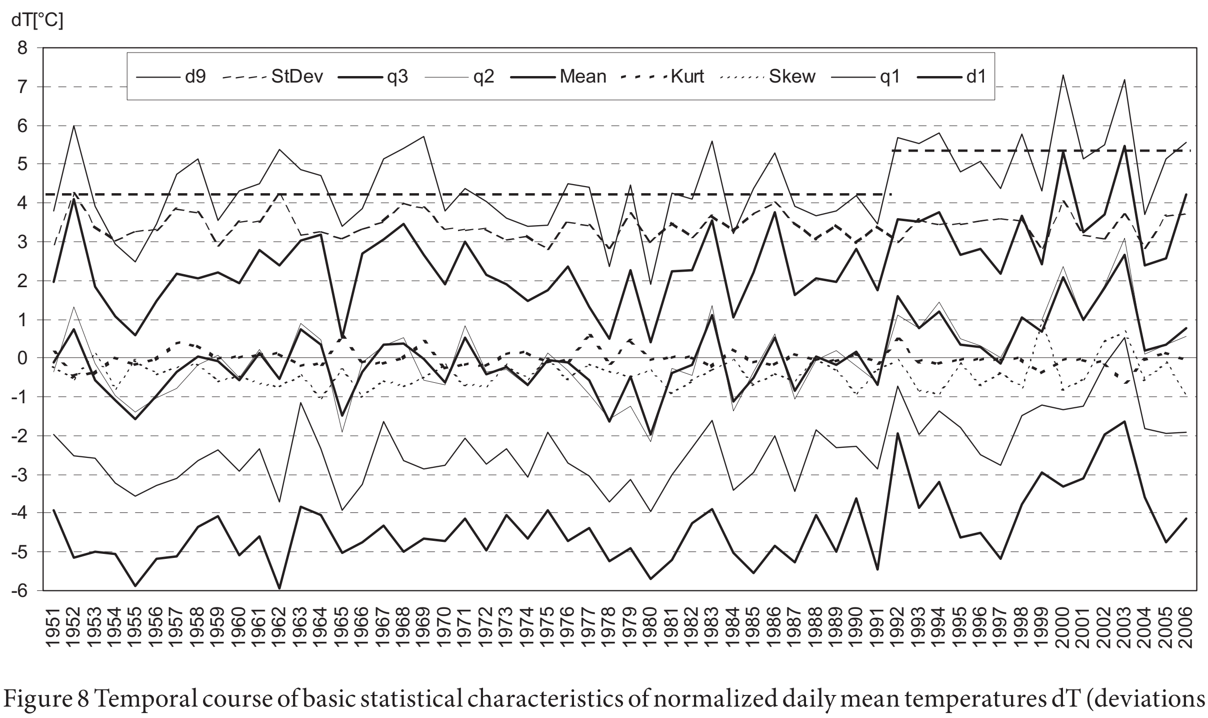

Figure 8 Temporal course of basic statistical characteristics of normalized daily mean temperatures dT (deviations from normal) at Hurbanovo for the season April 1st to Aug. 31st in 1951-2006 (from the top: upper decile d9, Standard deviation, upper quartile q3, Median q2, Mean, Kurtosis, Skewness, lower quartile q1, lover decile d1); not significant change in StDev, Kurt and Skew, increase in other values since 1990 by about 1-2 °C indicates climate change category No.1 from in Figure 1 (the year 2007 seems comparable with the extreme years 2000 and 2003)

by 3 parameters: arithmetic mean, variance coefficient and asymmetry. Similarly as at Gauss curve there we are interesting in probabilities of some values or return period occurrence. We want also to know the possibilities of distribution curves apply. Because there are usually only short time series to disposal, and the number of population in time series influences significantly the calculated results, we utilize theoretical distribution functions where only three basic parameters are needed. At shorter series we are usually facing the problem of great deviations (or mistakes) in asymmetry measure assessment (Nosek, 1972).

The Gumbel formula is one of the extremal distributions. It is based on asymptotic order of maxima/minima in independent series of items. Using the Gumbel distribution function, and the statistical theory of extremes, we can, with some probability, calculate the forecast of extremes in given series for needed return period. At the use of this statistics we can select from each year the maximum (highest value, longest period etc.) according to specific criteria. Analyzing the correspondence of theoretical and empirical distribution curves the most of experts came to the conclusion that the Gumbel function is not entirely suitable for extrapolation at low probabilities $\boldsymbol{p} = 10^{-2}$ to 10^{-4}, because of underestimation of obtained empirical extremes. In spite of this the Gumbel formula has been very popular, especially among the hydrologic community.

Another possibility in extreme phenomena statistical elaboration is an analysis of frequency distribution (occurrence of events number). Based on this we can obtain also a probability assessment of extreme events volume at any return period. Such assessed values enable the comparisons with observed data at some site or region.

General condition of climatic extremes frequency analysis is based on independence of observed data or phenomena. In such case the natural variance of population can be analyzed. This variance then does not influence the statistical distribution of extremes. The risk of extremes occurrence is considered as equally possible and independent on prevailing climate forming mechanisms. At present the regional approach to frequency analysis is considered as the most perspective. The aim of phenomena occurrence analysis is to obtain reliable assessment of values for important return periods (design values). The regional analysis is reasonable only at the precondition of climatic similarity in given region for the analyzed statistical characteristic (Gaál, 2006). The recent analyzes require an assessment of uncertainty for elaborated design values. This desires suitable mathematical methods apply to enable the calculation as much narrow intervals of reliability of design values as possible. There exists wide offer of theoretical distribution functions representing universal characteristics of continuous and discrete random variables. In the practice we have also several tools for methods of their parameters estimation. The selection of suitable distribution function, or method of its parameters estimation, influences significantly the final design values. That is why it is one of the most important and most complicated tasks at extreme phenomena frequency analysis.

The return period $\boldsymbol{t}$, representing number of years of average exceeding of design value, is the mostly used measure as the climatic design value significance. Another very important measure of design value significance is the periodicity (annual mean frequency of occurrence) $\boldsymbol{P}$ representing the quotient of total occurrence number of giving climatic variable and the number of observation years. The complement to probability of exceeding is the probability of non-reach of design value, it follows directly from the distribution function general definition.

Generally it is valid that the design values with return period $\boldsymbol{t}$ can be reliably calculated (assessed) on the base of $\boldsymbol{n}$-year series of observations only in case $\boldsymbol{t} \leq \boldsymbol{n}$ (Hosking a Wallis, 1997). Besides this it is suitable to take into consideration only values of $\boldsymbol{t}$ not exceeding three times the $\boldsymbol{n}$. The design values cannot be assessed sufficiently reliably for longer return period. This issue can be solved using an alternative, or supplementary, source of information properly offered by the regional analysis procedures. In fact it is necessary to assess the design values of meteorological elements very frequently with much longer return periods than the observing ones. Insufficiently great selective series could be unsurpassable barrier from the mathematical point of view. Additional extending of series back to the history is possible to do only using very complicated tools of mathematical statistics. These difficulties can be solved by a regional approach successfully replacing the temporal dimension by the areal one. In meteorology, hydrology as well as in other branches of environmental sciences there are usually to disposal numerous related data series. If the local frequency distribution characteristics of phenomena in different sites have similar statistical properties then the parallel analysis of all available data it facilitates to gain more reliable design values compared to individual stations data analysis. Just based on this assumption it is projected the regional frequency analysis of extreme events.

The construction of selective series from all measured data can be considered as a very important step of extreme events statistical analysis. The choice of suitable method of selective series is crucial. We can take into account the series of annual maxima from observed data, or complete time series, resp. The most frequently applied method is an annual maximum selection, in spite of some information loss. As it was said before the principle of independent choice must be respected. Individual synoptic situations can be represented in the selection only by one value (item).

Because of numerous references on this topic we do not go into details here. It is possible to find more information in the sources as follows: Dzubák, 1969, Nosek, 1979, Gaál, 2006, Guide WMO, 1983, Storch et al., 2000 a i..

3. Examples of elaboration

In this section only several examples based on the recent elaboration of precipitation extremes will be shown. From the illustration of extreme daily and several day precipitation totals extremes it is possible the most markedly seen the set of troubles connected with correct assessment of usable design values.

At the beginning the 1-, 2- and 5-day precipitation totals are shown in Figure 9, based on 55-year series (1951-2005) elaboration and published by Faško et al., in 2006. In case of 5-day precipitation totals we have selected events with at least 0.1 mm everyday precipitation. The area of the High Tatras mountains is relatively small, in spite of this the design values are of great range for the same return periods. Even the altitude does not play any important role here. Much more significant are there the upwind effects,

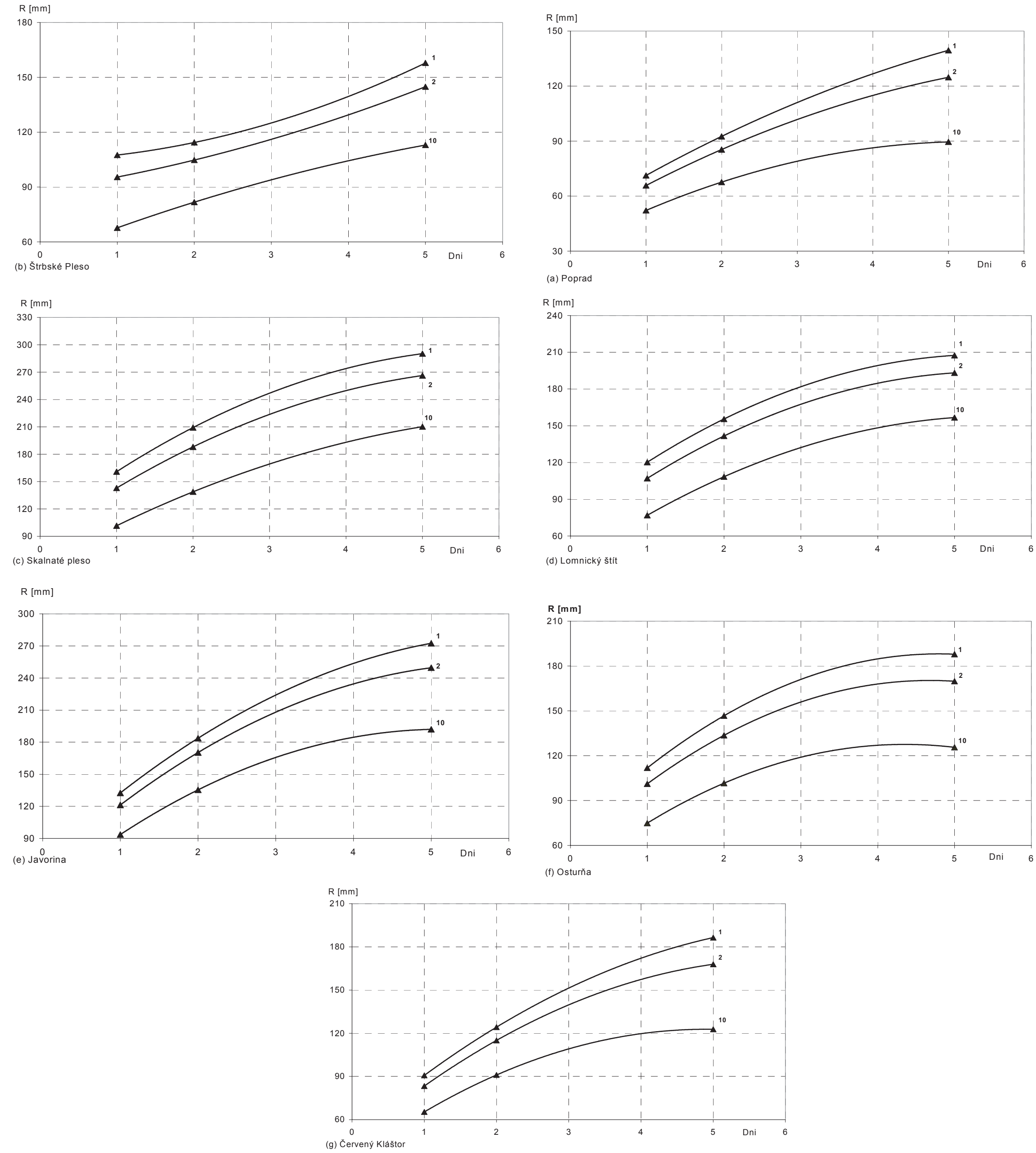

Figure 9 Calculated assurance of 1%, 2% and 10% probability of overstep the daily precipitation total R [mm] at the stations round the High Tatras: Poprad (a), Štrbské Pleso (b), Skalnaté Pleso (c), Lomnický štít (d), Javorina (e), Osturňa (f) a Červený Kláštor (g) based on measured data in 1951-2005 and the Pearson III theoretical distribution function (Faško et al., 2006)

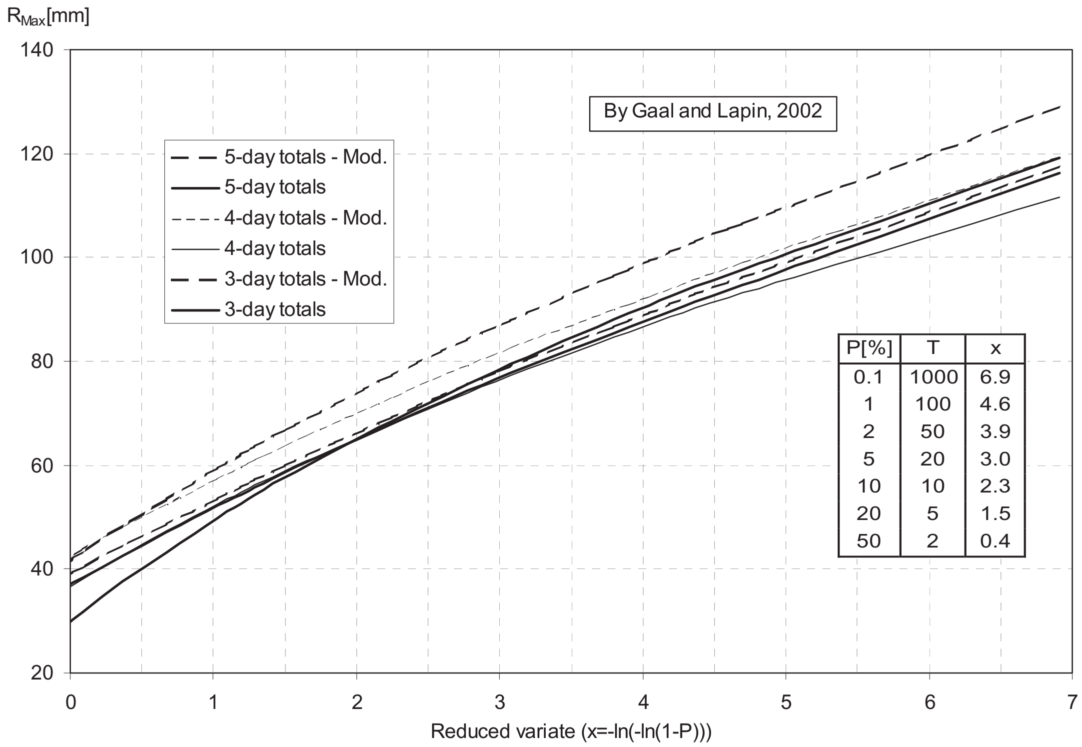

Figure 10 Basic and modified DDF-curves (Mod. – with 1-day gap in precipitation totals) of maximum 3- to 5-day precipitation totals (R_{Max}) for warm half-year (April-Sept.) at the Hurbanovo Observatory in 1901-2000 (Gaál et al., 2002)

mainly at such stations as Javorina (northern slope foot) and Skalnaté Pleso (southeastern slope). Concerning the 5-day totals, the design values are nearly 2-times higher than at other stations in comparable altitudes (Poprad and Štrbské Pleso). At 1- and 2-day totals the deviations are not so great, what is probably related with different physical conditions of short-term (thunderstorms) and long-term (cyclonic) precipitation events. In case of 30- to 180-minutes precipitation intensities the differences based on altitude would be probably even insignificant (Šamaj and Valovič, 1973). These topics have been analyzed also by other authors: Dzubák, 1969, Šamaj et al., 1985, Kyselý et al., 2004, Lapin et al., 2003, Parajka et al., 2004.

The second example presents similar elaboration for the Hurbanovo Observatory (Gaál et al., 2002 and 2004). It is obvious that the lowland localities in southern Slovakia have different precipitation regime compared to the northern mountains. That is why a changed method was introduced here. The events of 3- to 5-day continual precipitation are only rarely occurred at Hurbanovo. We proposed a modified method of selection with possible one-day gap in precipitation. Great differences between the basic and modified method of selection can be recognized mainly in the warm half-year (April-Sept.). Suchlike method has applied also Kohnová et al., (2005) for 10-day precipitation events, moreover at consideration of evapotranspiration effects during 1- or 2-day gaps in precipitation. It can be stressed that 5- to 10-day precipitation events play very important role in the regional floods occurrence in Slovakia.

4. Conclusion

The presented paper is only briefly showing series of problems with reliable selection and elaboration of extreme weather events. We have used and cited mostly the results published by Slovak authors in recent years. The Slovak Hydrometeorological Institute Observatory at Hurbanovo (SHMÚ, 115 m a.s.l., since 1871) was the main source of observed series for this paper. It is clear that there was impossible to mention and to analyze all potential possibilities and risks in data series reliability. We can them summarize briefly as follows: 1) Extreme weather events must be correctly defined, selected and tested, otherwise the elaborated results cannot be reliable; 2) At elaboration we can apply several theoretical distribution functions, the three-parametric ones have an advantage; 3) The return period of design values t should be lower than 3-times of number of observing years n, the best way is an apply of values with $t \leq n$; 4) Any complex events of extraordinary weather (droughts, wild fire risks, etc.) should be selected very carefully, otherwise the elaborated statistical characteristics will be impossible to interpret and apply correctly; 5) Special attention should be devoted to long-term time series stationarity. This short review indicates also the importance of climate change impacts on extreme events frequency distribution and return periods. Climate change can cause that the design values calculated from the historical observations could be invalid even at present and nearly surely in the next decades. The methods of design values elaboration should be modified therefore. From the point of view of more detailed reliability testing of input data we recommend to re-elaborate also the design values of extremes published in the past decades. It is clear that those authors have sometimes not kept the basic principles of selection, testing and statistical elaboration. Scientific interpretation and use of such elaborated results can be therefore often problematic.

Other climatic and hydrologic elements have been elaborated (from the point of view of extreme events) by several authors, for example by: Zrinji et al., 1994, Faško et al., 2003, Szolgay et al., 2003, Majerčáková et al., 2004, Lapin et al., 2005, 2007 etc. In some papers we tried also to point out the difficulties at scenarios of extreme events design under climate change impacts: Lapin et al., 2001, 2002, 2003, 2004).

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