

Decadal precipitation totals (1961-2010) in the High Tatras region and occurrence of atmospheric circulation types

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Abstract. An increase tendency of decadal precipitation totals in the High Tatras region during period 1961-2010 was detected. Mean decadal values over the last decades (1991-2010) in comparison with previous climate normal period (1961-1990) have raised about 5 – 23% in dependence on altitude. Clear growth tendency at the peak station Lomnický štít (2635 m a.s.l.) suggests long-term changes in thermodynamical conditions of air above atmospheric boundary layer, predominantly in the beginning (November - December) and at the end (March - April) of the cold season, and also in summer (July). The absolutely highest monthly decadal precipitation totals (1200 - 2800 mm) were recorded in the last decade 2001-2010 at most studied sites in July, except Lomnický štít where the maximum (2098 mm) was in April. Abundant summer rainfalls were formed in air masses controlled particularly by the northeastern cyclonic situation (NEC). Totally decadal July precipitations associated with NEC were almost two times more massive in the last (2001-2010) than previous (1991-2000) decade. Air circulation types as eastern cyclonic situation (Ec), wake of low pressure (Bp) and southwestern anticyclonic situation over Central Europe were also important for formation of summer heavy rainfalls over the High Tatras region.

Introduction

Precipitation reaches the earth's surface in varying amounts and intensity, the average annual rainfall totals ranges from 0 to 12 000 mm (*Pidwirny and Draggan, 2006*). Over the twentieth century, clearly differentiated regional changes in precipitation have occurred, with strong positive or negative trends in some regions (*Gerstengarbe and Werner, 2008*). Most precipitation falls in the humid tropics and high precipitation amounts are typical for mountainous regions due to orographic effect and specific mountain climate. In Slovakia, precipitation is most abundant ($R > 2000$ mm/year) on the High Tatras ridge (*Hrnčiarová et al., 2002*). Complex terrain and its interactions with air masses of different origins and different thermodynamical properties are decisive factors of precipitation regime in mountains. Abundant rainfalls in central Europe often occur in cyclonic atmospheric circulation N-NE-E-type, although heavy rains in the summer can also occur during the other situations including those with high pressure (*Ustrnul and Czekierda, 2001*). In the last century, high precipitation totals in the High Tatras were associated with cyclones advancing into central Europe from the Atlantic Arctic region (*Konček et al., 1974*). Changes of decadal precipitation totals during period 1961-2010 in the High Tatras region and occurrence of typical weather situations over central Europe in 1990-2010 were analysed in this work.

Data and methods

Data of daily precipitation totals (R) measured at selected sites in the High Tatras region (Fig.1, Tab. 1) by standard rain gauge (collecting area of 500 cm²) was used for analysis of decadal changes. Data quality control and test of homogeneity ProcClimDB (*Štěpánek et al., 2009*) showed a significant discontinuity for peak station Lomnický štít in the year 1991, which was solved by adjusting the relatively low values in the years 1961-1990. Decadal precipitation totals (RD) together with other statistical characteristics for climate normal period 1961-1990 (RD CN) and the last two decades 1991-2010 (RD1_2) were calculated. Frequency of typical weather situations for the most abundant rainfall month (July) during years 1991-2010 was evaluated on basis of archival data of SHMI available on the web page www.shmu.sk. Overall number types of weather situations include 10 patterns of anticyclonic (A) and 12 examples of cyclonic (C) situations. Total precipitation amounts (RS) that means overall sum of precipitation totals at all considered rain gauge stations were used for investigation of relation between abundant rainfall amounts and occurrence of types of weather situations.

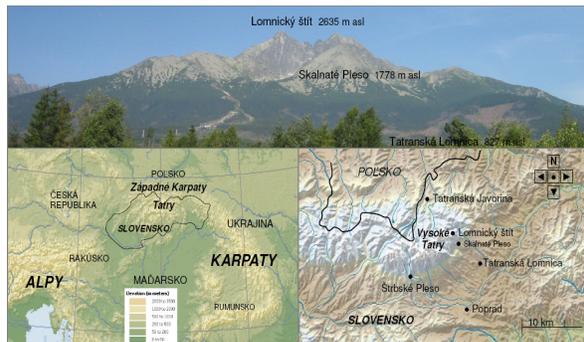


Figure 1. The High Tatras as a part of the Carpathian Mountains (left) and rain gauge network in the High Tatras region (right)

Table 1. Geographical position of rain gauge sites

Measurement sites		Latitude	Longitude	H [m n.m.]
LS	Lomnický štít	49°11' 43" N	20°12' 54" E	2635
SkP	Skalnaté Pleso	49°11' 22" N	20°14' 04" E	1778
TL	T. Lomnica	49°09' 52" N	20°17' 17" E	827
PP	Poprad	49°04' 08" N	20°14' 44" E	694
StP	Štrbské Pleso	49°07' 10" N	20°03' 48" E	1322
TJ	T. Javorina	49°15' 47" N	20°08' 37" E	1013

Results and discussion

Changes of decadal precipitation totals RD expressed as ratio RD1_2/RD CN illustrate fig. 2. An increase of mean RD in range from 5 % to 23% during the last two decades 1991-2010 (RD1_2) in relation to climate normal period 1961-1990 (RD CN) was detected at selected sites in the High Tatras region. The highest difference at peak station Lomnický štít (LS) suggests more appropriate air-moisture conditions above atmospheric boundary layer for precipitation formation, especially in March and November for winter season and in July for summer season over the last decades.

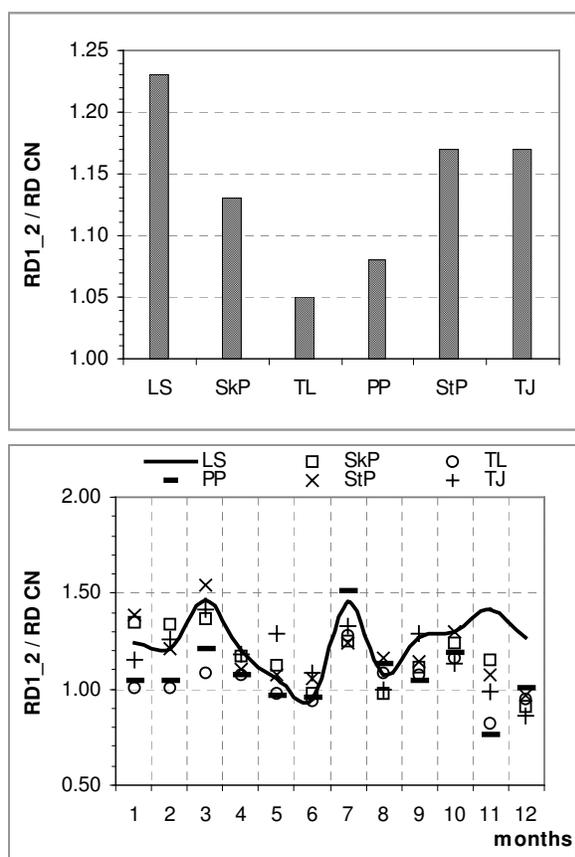


Figure 2. Changes of decadal precipitation totals (RD) in the High Tatras; relation between RD1_2 (last decades period 1991-2010) and RD CN (climate normal period 1961-1990)

Summer heavy rainfalls were formed mostly in the north eastern cyclonic situation over Central Europe – NEc. The frequency distribution of the NEc and overall precipitation totals RS in July 1991-2010 (Fig. 3) shows that in some years NEc is absent. During decade 1991-2001, 2-5 days lasting NEC occurred every third year. NEc in 1991 and 1994 did not affect the rainfall totals as much as in the years 1997 and 2000. The highest rainfall total in July (RS 883 mm) associated with NEc was in 2007. In decade 2001-2010, 1-8 days lasting NEc situations occurred almost every year (except 2007 and 2009). Only in two cases (2003 and 2006) RS value was less than 100 mm.

Although the nearly similar decadal number of NEc, RDS in the High Tatras region associated with occurrence of NEc situations was nearly two times higher during the last decade 2001-2010 in comparison with the previous period 1991-2000.

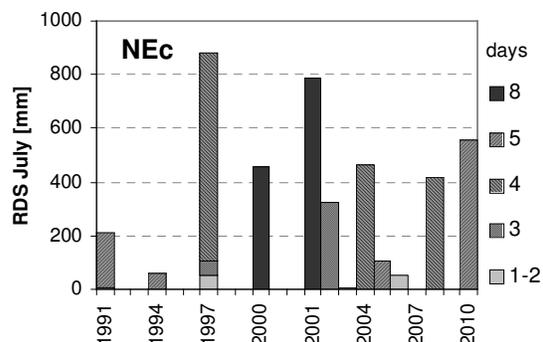


Figure 3. Occurrence of NEc situation and overall precipitation totals RS in the High Tatras region in July during period 1991-2010; number and duration (days) of NEc correspond to different pattern of columns; RS including all investigated sites LS, SKP, TL, PP, StP, TJ

Conclusions

Analysis of decadal precipitation totals in the High Tatras region indicate an increase of precipitation amounts during last decades (1991-2001) in comparison with climate normal period (1961-1991), particularly at peak station Lomnický štít (about 23%). Summer abundant rainfalls occurred almost during the north eastern cyclonic situation over Central Europe – NEc. Decadal precipitation amount associated with occurrence of NEc was nearly two times higher in last (2001-2010) than previous (1991-2000) decade. Obtained results suggest more appropriate air-moisture conditions for precipitation formation in the High Tatra Mountains, especially at altitude over atmospheric boundary layer.

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