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Regional analysis of extreme temperature and precipitation indices for the Carpathian Basin from 1946 to 2001

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Abstract

Since human and natural systems may be especially affected by changes of extreme climate events, the main objective of our research is to detect the possible changes of intensity and frequency of these extreme events. Several climate extreme indices are analyzed and compared for Central/Eastern Europe (focusing on Hungary) for the 20th century based on the guidelines suggested by the joint WMO-CCl/CLIVAR Working Group on climate change detection. These climate extreme indices include the numbers of severe cold days, winter days, frost days, cold days, warm days, summer days, hot days, extremely hot days, cold nights, warm nights, hot nights, the intra-annual extreme temperature range, the heat wave duration, the number of wet days (using several threshold values defining extremes, i.e., 10 mm and 20 mm), the maximum number of consecutive dry days, the highest 1-day precipitation amount, the greatest 5-day rainfall total, the simple daily precipitation intensity, the numbers of moderate wet days and very wet days, the annual fraction due to extreme precipitation events, etc. Therefore, daily maximum, minimum and mean temperature observations (from 13 stations) and daily precipitation amounts (from 31 stations) are used in the present statistical analysis. Our results suggest that similarly to the global and continental trends, regional temperature of Central/Eastern Europe has become warmer during the second half of the 20th century. Specifically, the strongest increasing tendency is detected in case of the annual numbers of hot days, summer days, warm days, warm nights, and the heat wave duration index. Before this warming period in the last quarter of the 20th century, most of the indices exhibit a cooling period until the middle of the 1970's. Furthermore, regional intensity and frequency of extreme precipitation has increased (as shown by the annual fraction due to extreme precipitation events, and the numbers of moderate wet days, very wet days, and very heavy precipitation days) between 1976 and 2001, while the total precipitation has decreased (as shown by numbers of precipitation days exceeding 0.1 mm, 1 mm, and 5 mm) in the region.

Keywords: extreme climate index; daily precipitation; daily temperature; Carpathian Basin; tendency analysis

1. Introduction

In the 1998–2002 period, more flood events occurred in the Carpathian Basin (mainly on rivers Tisza and Danube) than in the previous 30–35 years. For instance, water level at many stations exceeded the previous historical record values during these recent floods (e.g., Autumn, 1998; Spring, 1999, 2000, 2001). Annual maximum water level exceeded the 3rd order flood warning level in 6 years out of the last decade on the headwaters of river Tisza (Bárdossy et al., 2003; Dezső et al., 2005). Because of the severe social and economical consequences of these recent floods, enhanced

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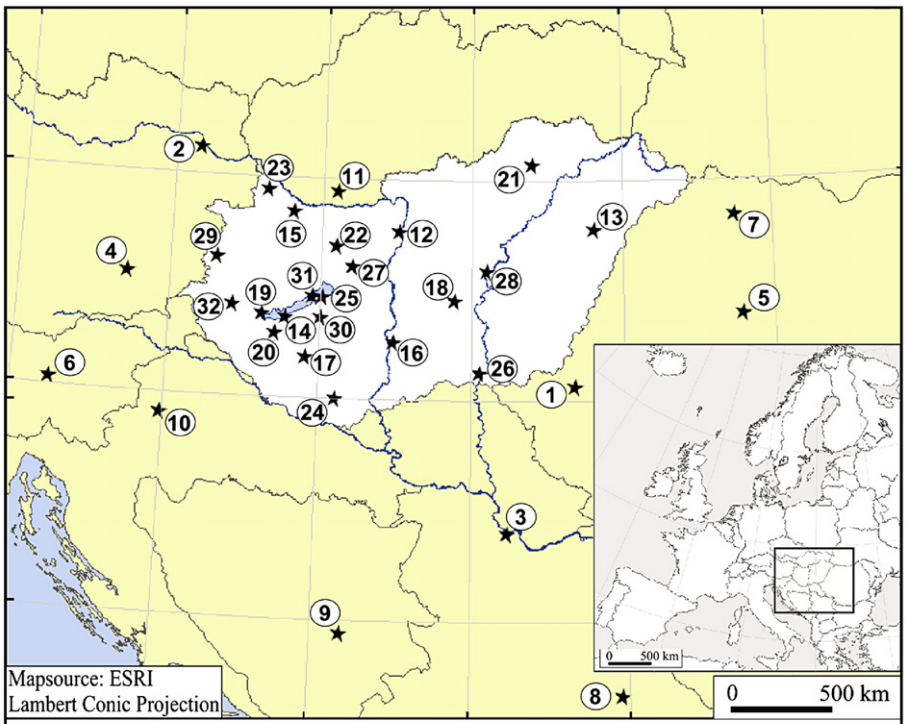
public interest appeared to demand scientific analysis. In order to objectively study the recent climate change, especially, the change of the frequency of the extreme events, extreme precipitation and temperature indices can be used. In 1998, a joint WMO-CCl/CLIVAR Working Group (Karl et al., 1999) formed on climate change detection. One of its task groups aimed to identify the climate extreme indices, and completed a climate extreme analysis on all part of the world where appropriate data was available (Frich et al., 2002). Some results of this working group also appeared in the third assessment report of IPCC (2001). For the European continent, Klein Tank and Können (2003) accomplished and summarized the extreme climate index analysis. In this paper, similar analyses for 13 temperature indices and 12 precipitation indices are presented for a finer spatial scale, focusing on the Carpathian Basin, located in Central/Eastern Europe. First, the database is briefly



Station	N.lat.	E.long.	m	Station	N.lat.	E.long.	m
Stations in neighbouring countries				16 Kalocsa	46°31'	18°59'	92
1 Arad	46°08'	21°21'	117	17 Kaposvár	46°22'	17°50'	152
2 Vienna	48°14'	16°21'	199	18 Kecskemét	46°54'	19°46'	114
3 Beograd	44°48'	20°28'	132	19 Keszthely	46°45'	17°15'	115
4 Graz	47°05'	15°27'	366	20 Marcali	46°35'	17°25'	128
5 Cluj Napoca	46°47'	23°34'	410	21 Miskolc	48°08'	20°48'	118
6 Ljubljana	46°04'	14°31'	299	22 Mór	47°23'	18°12'	203
7 Baia Mare	47°40'	23°30'	216	23 Mosonmagyaróvár	47°53'	17°16'	121
8 Nis	43°20'	21°54'	202	24 Pécs	46°00'	18°14'	202
9 Sarajevo	52°30'	22°30'	211	25 Siófok	46°55'	18°02'	108
10 Zagreb	45°49'	15°59'	157	26 Szeged	46°15'	20°06'	82
11 Hurbanovo	47°53'	18°12'	115	27 Székesfehérvár	47°12'	18°25'	111
Hungarian stations				28 Szolnok	47°10'	20°12'	90
12 Budapest	47°31'	19°02'	118	29 Szombathely	47°15'	16°38'	218
13 Debrecen	47°33'	21°37'	123	30 Tab	46°44'	18°01'	177
14 Fonyód	46°44'	17°33'	166	31 Tihany	46°55'	17°54'	150
15 Győr	47°41'	17°38'	119	32 Zalaegerszeg	46°50'	16°51'	162

Fig. 1. Geographical locations of meteorological stations in the Carpathian Basin.