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Variability and trends of extreme precipitation events over Bulgaria (1961–2005)

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ABSTRACT

Heavy precipitation events often lead to river floods and flash floods causing significant loss of life and property damage, landslide activation, and other social and economic problems. The upward tendency of damages, caused by natural disasters, supports the idea that extreme events, associated with the effects of climate change, have recently occurred with greater frequency. The series of hazardous precipitation events which affected the Balkans and in particular Bulgaria in 2005 show that further study of such type of phenomena is necessary in order to improve their predictability.

The subject of the present study is the variability and the trends associated with extreme precipitation events in Bulgaria during the period 1961–2005. Total precipitation amounts exceeding 30 mm/day which occur in 4 or more provinces of the country are considered to be risky for floods. We call them here heavy-rain days or events. The regime of such potentially dangerous heavy-rain/snow events is compared to those of total precipitation amounts for two periods: 1961–1990 and 1991–2005. Significant increase (more than 32%) of the days with heavy 24-hour precipitation is revealed during the second period, while the total annual rainfall is almost without changes or shows a slightly decreasing trend in many regions of the country. Besides, the contribution of heavy and torrential rain/snow to the observed annual precipitation totals increases. It is in contrast with the observed trend of decrease for the weak and moderate precipitation amounts.

Two typical synoptic situations, leading to such type of extreme events in the extreme year 2005 are presented. The first is a "winter" one in February and the second – a "summer" one in July.

1. Introduction

Global warming is suggested to be linked to the recent increase of heavy precipitation events due to the increased atmospheric water vapor and warmer air. The upward tendency of damages caused by natural disasters supports the idea that extreme events, such as torrential precipitation, associated with the effects of climate change, occur with greater frequency (Easterling et al., 2000). The same tendency is observed in Bulgaria during the last decade of the 20th century in the cold half of the year from October to March (Bocheva et al., 2007). Annual precipitation totals also show upward trend in many regions other than Bulgaria (Dai et al., 1997). Positive trends in precipitation amounts are reported for many mid- and high-latitude regions of the world. In Bulgaria however several studies (Alexandrov et al., 2004; Sharov et al., 2000) show a dominant downward trend. In most areas of the world, the rainfall trends have the same sign as the trends of 1-day heavy-rain amounts, while in Bulgaria the opposite tendency is observed during the last decade of the 20th century in the warm half of the year from April to September (Simeonov et al., 2006).

Series of hazardous events, affected the Balkans and in particular Bulgaria in 2005. They were associated with severe

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convective storms and heavy rainfall events. They also produced floods in more than 80% of the territory of the country, caused significant property damage (more than half a billion EUR) and loss of life (25 victims), and had a considerable impact on the Bulgarian economy. Gathering and analyzing all the available data for such type of weather phenomena is therefore necessary in order to improve their predictability.

Sections 3.1 and 3.2 give a brief study of the monthly and seasonal distribution of hazardous events like intense and great 24-hour precipitation amounts for the 45-year period 1961–2005. The variability of extreme precipitation cases is studied for two periods: 1961–1990, recommended by the World Meteorological Organization (WMO) for determining the climatic norms, and the recent one 1991–2005. The statistical significance of their changes is calculated by the Mann-Kendall test (for the whole period 1961–2005) and Poisson distribution (for the comparison of the two periods 1961–1990 and 1991–2005). Section 3.3 gives a description of typical synoptic situations, leading most frequently to large-scale extreme precipitation over Bulgaria. Two cases (summer and winter) are presented.

2. Method of investigation

Precipitation data from the meteorological database of the National Institute of Meteorology and Hydrology (NIMH) of Bulgaria for 64 climatological and 26 precipitation stations for the period 1961–2005, has been processed (Fig. 1). These stations are representative for all geographical regions of the country with altitude below 1000 m. Care has been taken to select stations with observations of good quality. The data series have also been examined with respect to continuity of records. Expert quality control of data has been carried out on the basis of the standard monthly and annual reports from the meteorological database. All suspicious data has been compared with data from meteorological stations – analogs. The precipitation totals were calculated for each of the stations and then summarized for the entire country.

According to the accepted limits for extreme events in the meteorological practice of NIMH (Fuchedjiev et al., 1981) all days with precipitation amounts exceeding 30 mm/24 h in at least one station is considered in the study. Part of these extreme precipitation events which occur in 4 and more provinces of the country (15% and more of total 27 in Bulgaria) are considered to be risky for floods. We call them here heavy precipitation days (HPD) or events. This threshold is similar with those accepted in the annual reviews on the weather extremes issued by the National Service for Civil Protection of Bulgaria and the Annual Bulletin on the Climate in WMO Region VI. The intra-monthly (by 10-day periods) distributions of the mean number of heavy-rain days have been obtained. The choice of 10-day period is motivated by the needs of the medium-range forecasting of extreme precipitation events. The results for the periods 1961–1990 (accepted as a basic period) and 1991–2005 have been compared. In order to study the contribution of the heavy/torrential precipitation to the observed annual totals, 5 daily rainfall categories have been defined as follows: Light (A) 0.0–4.9 mm; Light-Moderate (B) 5.0–14.9 mm; Moderate-Heavy (C1) 15.0–29.9 mm; Heavy (C2) 30.0–59.9 mm and Torrential (D) 60.0 mm and above. The contribution of each category as percentage of the total annual amounts has been calculated using specially developed Transact SQL stored procedures. The risk of extreme precipitation seasons during the studied period (1961–2005) has been assessed by means of general statistical approach applied for each single value i: $X_i \geq X_{mean} + 2\sigma$, where X_{mean} is the mean value of the variable X (for example, mean long-term value), σ is the mean deviation from the mean value.

Statistical analysis of the extreme precipitation data series has been carried out in order to reveal their variability and

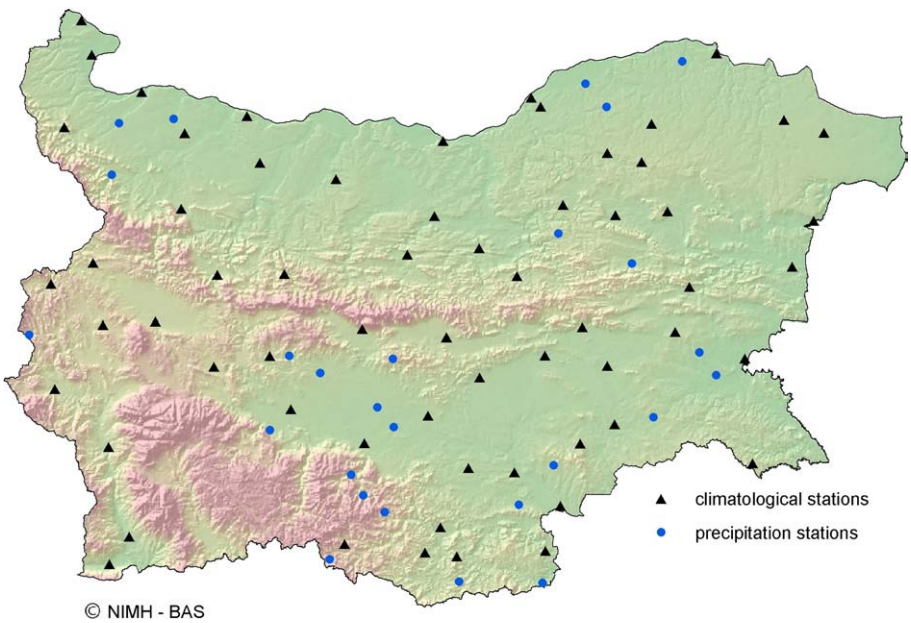

Fig. 1. Climatological and precipitation stations used in the study.