On Change in Extreme Daily Precipitation Characteristics in Bulgaria (1961 – 2007)

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I. INTRODUCTION

The upward tendency of damages caused by natural disasters supports the idea that extreme events, such as torrential precipitations, 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 (Bocheva et al., 2006). Many studies aimed at analyzing the variations of heavy and extreme precipitation are interesting as these events cause considerable damage and loss of life worldwide each year. Negative trend in annual and seasonal precipitation totals, associated with an increase in the contribution of heavy rainfall events to total precipitation, is observed in some countries from South Europe especially in Southeastern part of the continent (Alpert et al., 2000; Brunetti et al., 2001; Bocheva et al., 2009; Nastos and Zerefos, 2008).

The main objectives of this study are climatic variations in heavy (30-59.9 mm/24h) and torrential (totals ≥ 60 mm/24 h in one station are considered) precipitation amounts in different parts of Bulgaria. We focused our attention in this group of torrential precipitation, because daily amount ≥ 60 mm/24 h often caused significant damage and loss of life. During the last 10-15 years this events caused floods and economic losses more often in northeastern Bulgaria and in eastern and central parts of South Bulgaria. They are usually connected with severe convective storms.

A classification of synoptic situations for each part of Bulgaria is carried out and some of the most typical ones are presented. The NCEP/NCAR Reanalysis data and the fields of air pressure and wind velocity are considered.

II. METHOD OF INVESTIGATION

Precipitation data from Meteorological database of the National Institute of Meteorology and Hydrology (NIMH) for 112 meteorological stations (29 synoptic, 46 climatological and 37 rain-guage) with altitude below 1000 m (Fig.1), were processed by program procedures for the period 1961-2007. In all station daily precipitation total is measured in 7.30 a.m. (local time) with classic ground-level precipitation gauges. The automatic stations data is not included in this study.

The territory of Bulgaria is small, but it is characterised with very diverse relief. Also our country is located on the transition between two climatic zones – moderate continental and Mediterranean. So by the orographic and climatic features we can divide Bulgaria on 6 parts: North-West (NW), North-Central (NC), North-East (NE), South-East (SE), South-Central (SC) and South-West (SW) Bulgaria (see Fig.1).

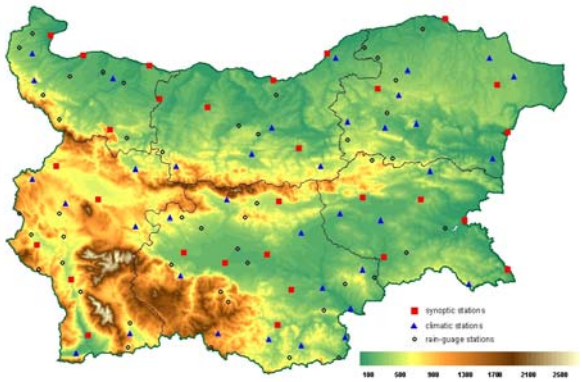


FIG 1: Meteorological stations used in the study.

The results for the periods 1961-1990 (accepted as a basic period) and 1991-2007 were compared. In order to show the contribution to observe annual totals of heavy/torrential rain, five daily rainfall categories were suggested (as percentage from the total annual amounts) 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. The mean annual and mean monthly number of wet days as well as days with extreme precipitation is summarized for each of the six parts of the country for two periods 1961-1990 and 1991-2007. Brief statistical analysis is applied for the assessment of variability and possible differences in the torrential precipitation from long-term data series. The Poisson distribution and corresponding nonparametric tests are applicable to such discrete samples of large-scale heavy rain days.

The NIMH historical archive of synoptic maps and NCEP/NCAR Reanalysis data files were used for analysis and classification of synoptic situations causing torrential precipitation (group D) for each part of the country.

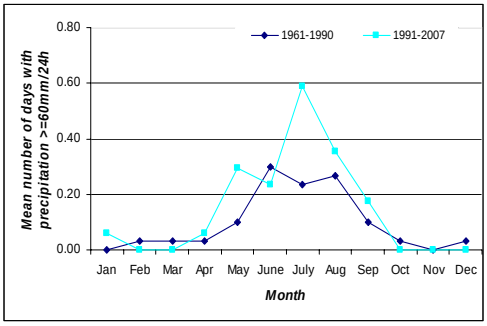
III. RESULTS AND CONCLUSIONS

Climatic study

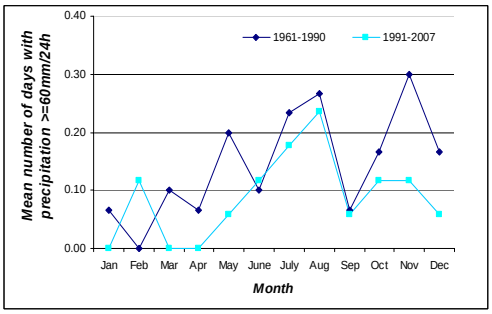
The absence of significant trend in annual precipitation for all country is observed. In the same time the negative trend in wet days (not statistically significant) for almost all examined parts of the country, with exception of NE Bulgaria, is determined. All this indicate an increase in extreme daily precipitation.

The regime of such extreme precipitation events is compared to those of total rain/snow amounts for two periods: 1961 – 1990 and 1991 – 2007. Significant increase

of days with torrential 24-hours precipitation is revealed during the second period in NC Bulgaria (about 50%) and NE parts of the country (about 27%), while in West Bulgaria (especially in SW Bulgaria) these dangerous events decrease with about 20-35%.(Fig. 2a,b).



a) NC Bulgaria



b) SW Bulgaria

FIG. 2: Mean monthly number of days with precipitation ≥60 mm/24 h.

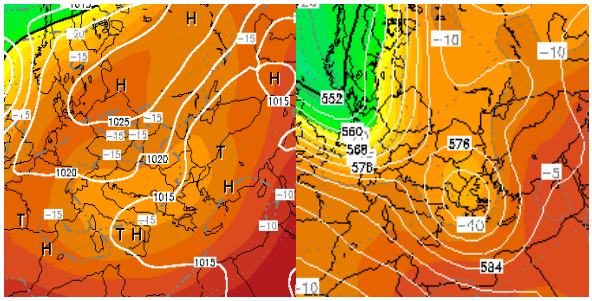
Monthly distribution of wet days as well as the two groups of precipitation C2 and D show a statistically significant increase in all events in September recently. In the same time mean monthly number of wet days decrease during the period 1991-2007 not only in winter (especially in February), but also in June all over the country.

Synoptic classifications

The synoptic situations, connected with 682 days with torrential rain events (≥ 60 mm/24 h) during the period 1961-2007, were examined and classified for each of the 6 parts of the country.

For example, Northeast Bulgaria is endangered by extreme precipitation mostly in late summer and early autumn when cyclonic systems with Mediterranean origin block over the Balkan peninsula suppressed by a well developed anticyclone over Eastern Europe. The combination of warm and humid air from the Black Sea coming inland and the cold air influx from the northeast produce a continuous in time and stationary in space convective systems that generate strong precipitation at one and the same place for as long as 12 to 48 hours. This is illustrated in Fig. 3a with the case of 21-22 September 2005 when the town of Shabla at the north coast of Black Sea is hit by a flood. The reported cumulative amount of precipitation in Shabla for that process is 900% of the monthly normal.

Southwest Bulgaria, as another example, is particularly endangered in late spring and early to mid-summer season when relatively small cyclonic systems, born in the Mediterranean to the south of the Alps, move into the West Balkans and become stationary. They produce powerful mesoscale convective systems particularly over the mountainous central Balkans including Southwest Bulgaria. The convection feeds back the cyclonic circulation with fresh energy and thus sustains the strong precipitation for a couple of days. This is illustrated in Fig.3b with the case of 4-6 August 2005 when the town of Ihtiman in Southwest Bulgaria is flooded. The reported cumulative amount of precipitation in Ihtiman for that process is 356 mm for less than 48 hours.



a) b)

FIG. 3: a) Height (dm) of geopotential surface 500 hPa in color and surface pressure (hPa, white contour), 22.09.2005; b) Height (dm) of geopotential surface 850 hPa (white contour) and temperature (ºC) in color, 06.08.2005.

Conclusions

The observed increase of torrential precipitation events during the last 10-15 years is statistically significant in NC, NE and SE Bulgaria. In the contrary in SW Bulgaria, where precipitation regime is mainly caused by Mediterranean cyclones circulation, the significant decrease of such type of precipitation is established.

The increase in frequency of heavy precipitation days in the autumn months September and October is observed in all parts of the country during the second period (1991-2007).

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