

Variability and trends in extreme precipitation events over Bulgaria

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The series of hazardous events which affected the Balkans and in particular Bulgaria in 2005 are connected with severe convective storms and really heavy rainfall events which produced floods in more than 80% of the territory of the country and caused significant property damage, (more than half a billion EUR) 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.

The aim of this investigation is to study monthly and seasonal distribution of some severe and hazardous events like intense and great 24-hour precipitation for the period 1961 – 2005.

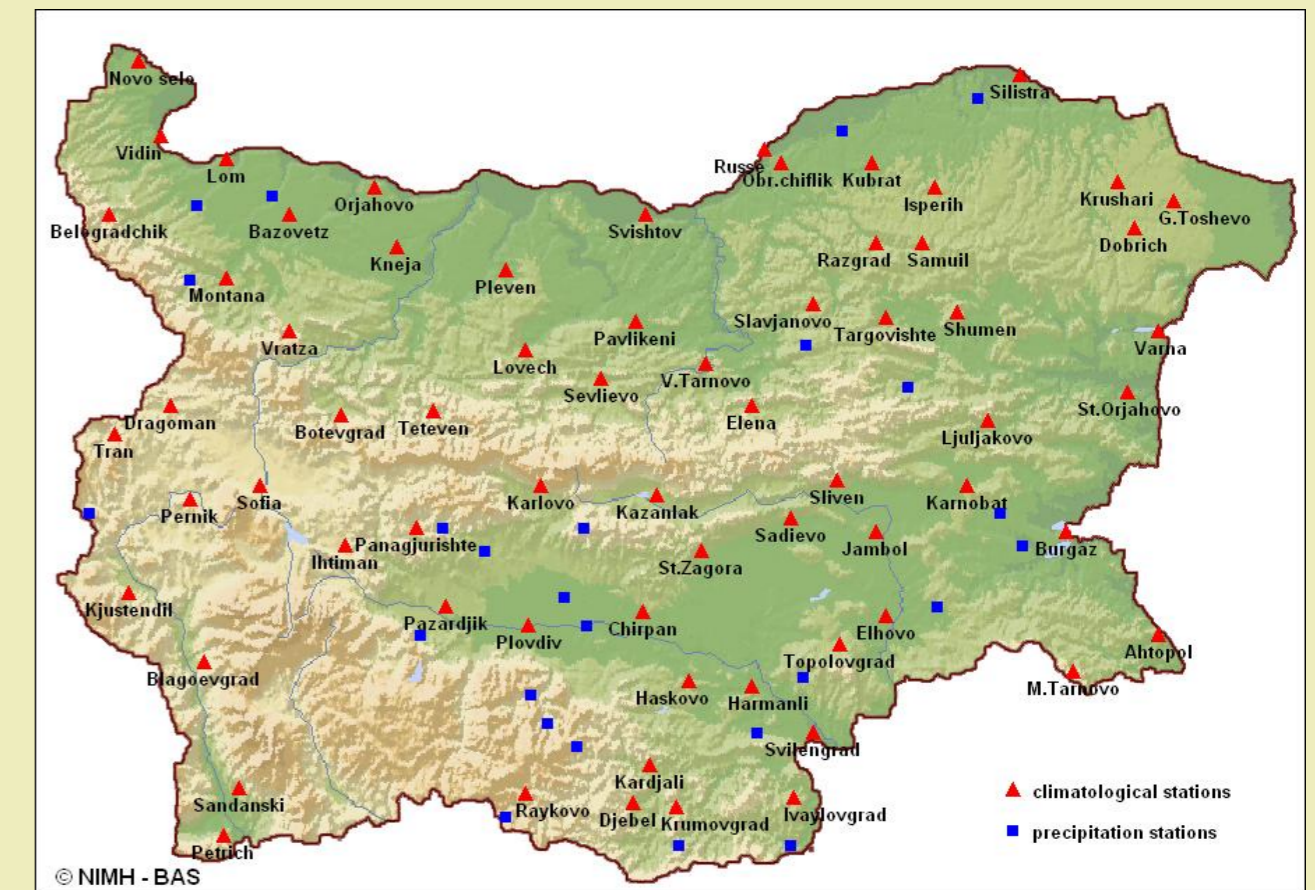
➤ Meteorological data from 65 climatological and 26 precipitation stations below 1000 m of altitude, for the period 1961-2005, have been processed.

➤ The inter-monthly (by decades) distributions of the mean number of days with potentially dangerous precipitation (totals over 30 mm/24 h are considered to be flood risky) registered at least in 4 districts of the country, have been obtained. The results for the periods 1961-1990 (accepted as a basic period) and 1991-2005 have been compared.

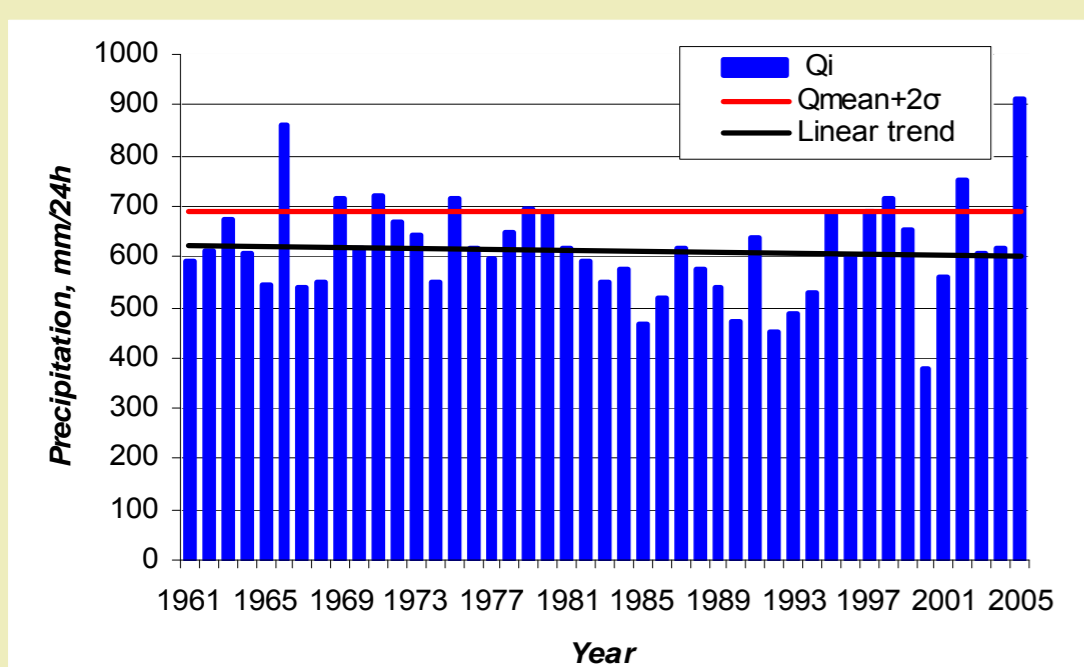
➤ 5 daily rainfall categories have been suggested (as percentage of the total annual amounts) as follows: Light (A) 0.0-4.9 mm; Light-Moderate (B) 5.0-14.9 mm; Moderate-Heavy (C1) 15.0-29.9 mm; Heavy (C2) 30.0-59.9 mm and Torrential (D) 60.0 mm and above.

➤ The risk of extreme precipitation seasons during the studied period (1961-2005) is 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.

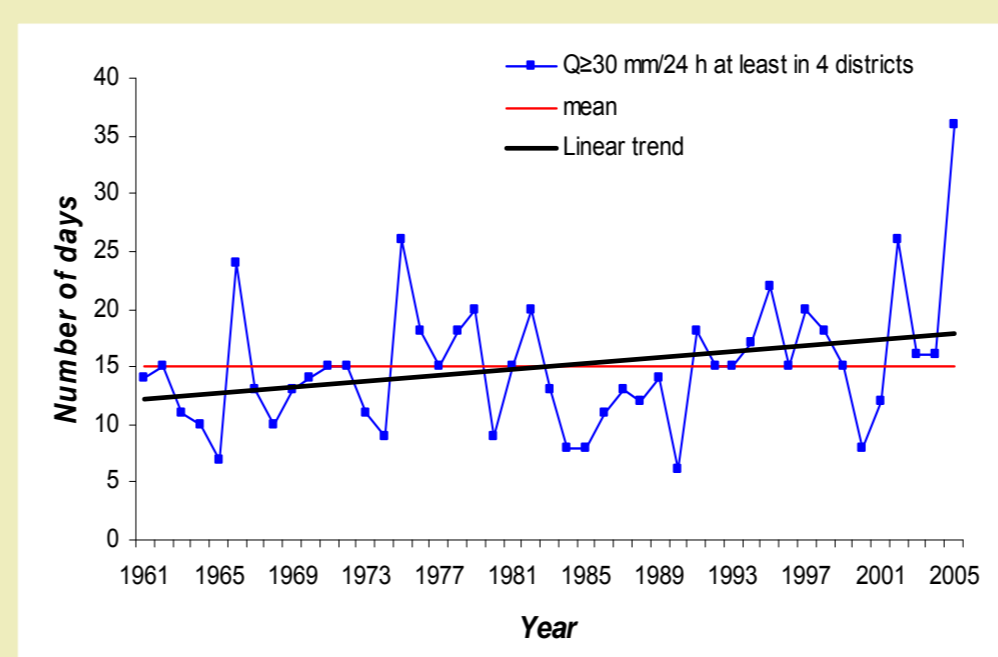
➤ Two typical situations (winter and summer case from the extreme year 2005), associated with extremely severe weather and damages in a large part of the country have been analyzed.



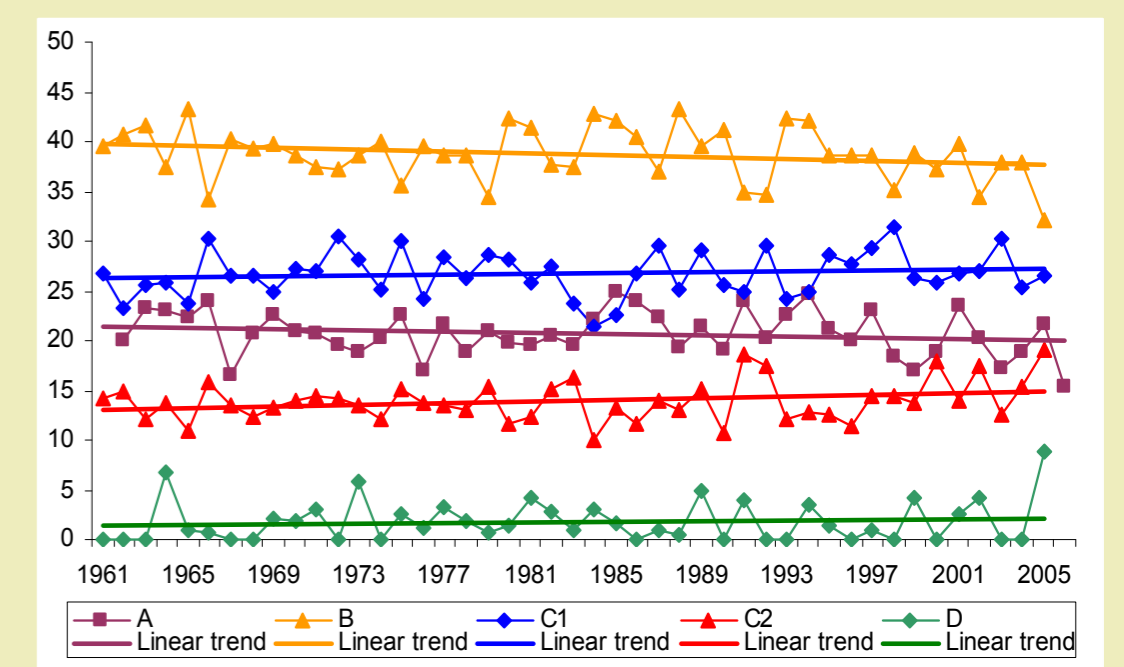
Annual distribution of heavy rain events (1961-2005)



An increase of the mean annual number of days with extreme precipitation (with about 33% during the period 1991-2005 in comparison with 1961-1990) can be identified whereas the annual rainfall sums as a whole decrease.



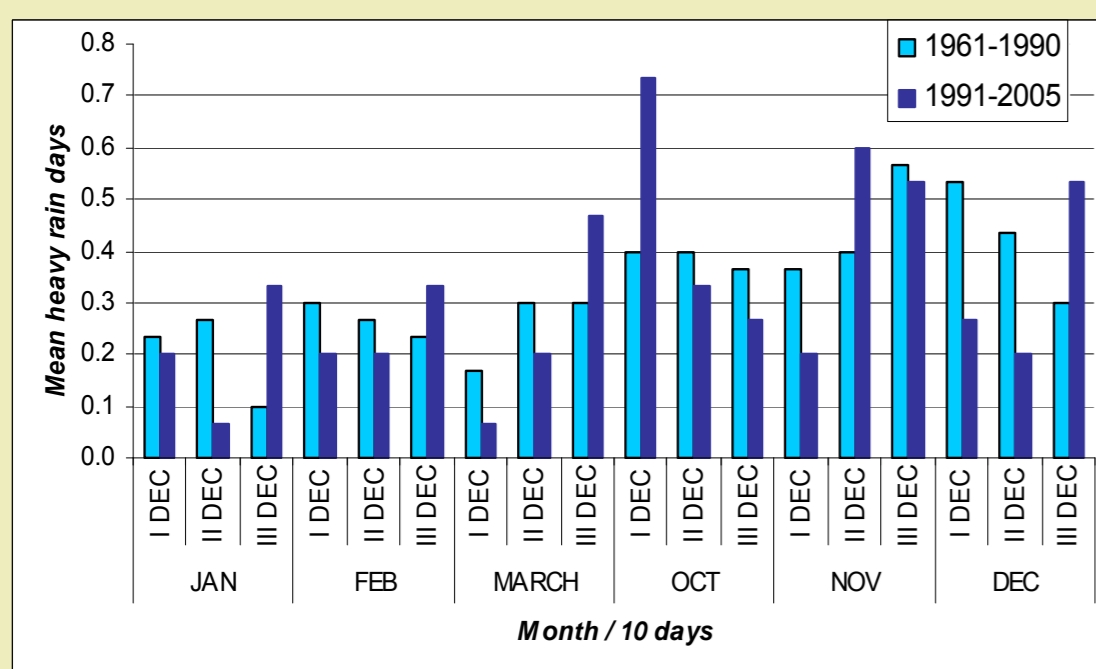
Nine years with frequency of such heavy rain days above the mean value of 15 days are observed during the period 1991-2005, which is more than those for the whole 30-years period 1961-1990.



The contributions to the observed annual precipitation totals of the heavier categories, C1, C2, and D (risky for floods events) increased during the recent decades in expense of categories A and B.

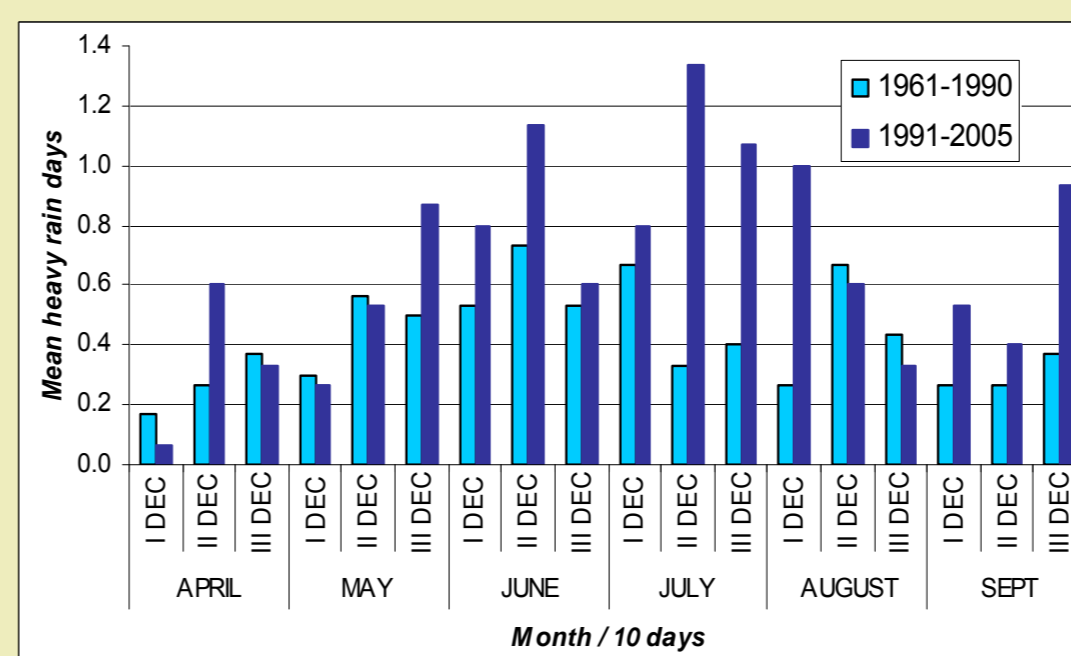
The distribution of the average annual precipitation sums with the accepted limit ($Q_{mean} + 2\sigma$) and it brings to evidence the extreme cases (Simeonov et al., 2006). In this 45-years period there are 3 extremely wet years: 1966, 2002, and 2005.

Inter-monthly distribution of heavy rain days in more than 4 districts in Bulgaria



Cold half of the year:

✓ The average number of observed heavy rain days during the two investigated periods (1961-1990 and 1991-2005) is almost the same.



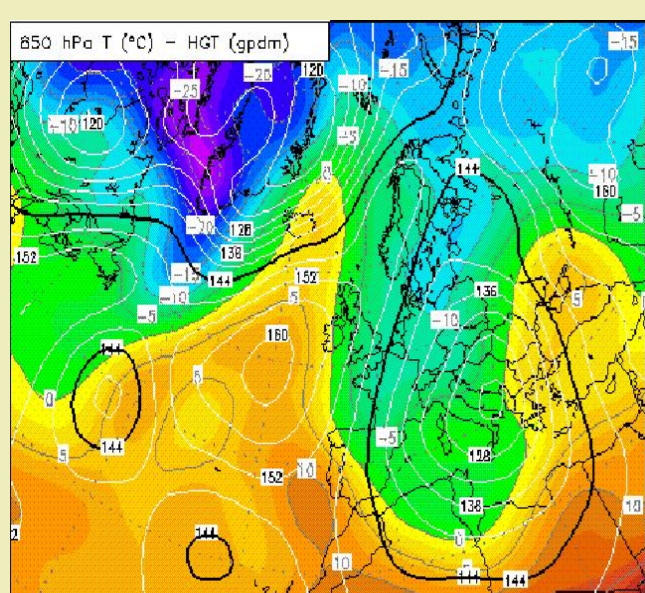
Warm half of the year:

✓ Increase of potential dangerous heavy rain events with about 60% is observed during the last 15 years.

✓ Untypical increasing in frequency of heavy rain episodes in all decades of September (average with 50–100%) is observed during the period 1991 - 2005.

The most common synoptic situations, leading to heavy rain events in many parts of Bulgaria: winter and summer cases

More than 600 synoptic situations, connected with heavy rain events, registered at least in 4 districts of the country during the period 1961-2005, were examined and classified. More of the winter cases are connected with development of the Mediterranean cyclones, while the summer cases mostly associated with cold front system. The comparative study of two cases (one “winter” in February and second “summer” in July) – both producing local tornado events over closed areas in Rodopi Mountain and causing the damages – present an example of the observed increasing of the cases, connected with development of severe convection not only during warm half of the year, but also in not typical “cold” months as October and February.



Temperature and geopotential at 850hPa at 12 UTC on 15 February 2005

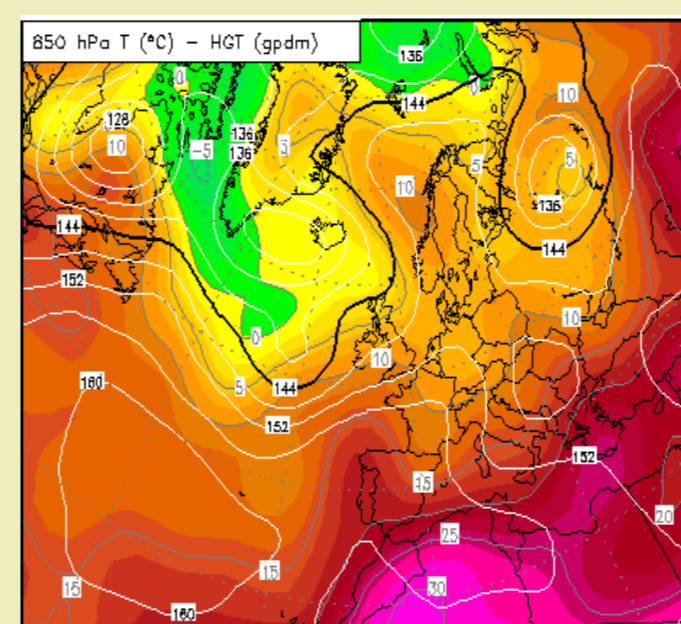
On 13 and 14 February 2005 a cold air sinks into the Western Mediterranean and generates a cyclone over Italy. The air transport over the Balkans therefore turns northwards and strengthens. It brings warm and humid air alongside the cold-front line associated with the Mediterranean cyclone and crossing Bulgaria northeastwards. The conditions are therefore favorable for the generation of rapidly moving northeastwards convective systems which indeed materialize in the Rodopi Mountain in the southeast corner of the country on 15 February. Those systems bring heavy downpours in the region together with thunderstorms, gust winds and tornado-like whirls.



Meteosat IR satellite image of the storm area over the Rodopi Mountains, February 2005 and storm area contoured by circle

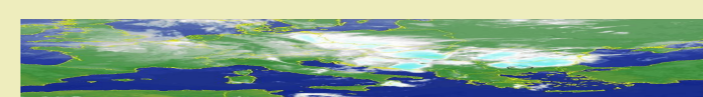


Windfall in the East Rodopi caused by the tornado associated with the storm on 15 February 2005



Temperature and geopotential at 850hPa at 00 UTC on 02 July 2005

On 30 June-01 July there is a well defined polar front with zonal extend to the north of Bulgaria. It dominates the circulation. To the south of the polar front there are lingering patches of an old frontal system which dictated the weather in Western Europe a couple of days before but lost momentum. Now its remains are being sucked by the polar front northeastwards. One of them crosses Bulgaria during the night from 30 June to 1 July and generates thunderstorms across the country and then moves away into the Black Sea. However, on 1 July, the backside part of that system stretches diagonally through the country from northwest to southeast. A new series of thunderstorms pop-up alongside that line in the late 1 July and move northeastwards with the predominant mid-troposphere flow. The southernmost of them generates in the West Rodopi Mountain. The complex mountainous terrain along its path favors apparently the generation of a tornado-like whirls.



Meteosat IR satellite image of the storm area over the Rodopi Mountains, July 2005 and tornado place contoured by circle



Windfall in the West Rodopi caused by the tornado on 01 July 2005