ГОДИШНИК НА СОФИЙСКИЯ УНИВЕРСИТЕТ „СВ. КЛИМЕНТ ОХРИДСКИ“
ГЕОЛОГО-ГЕОГРАФСКИ ФАКУЛТЕТ
Книга 2 – ГЕОГРАФИЯ
Том 108

ANNUAL OF SOFIA UNIVERSITY “ST. KLIMENT OHRIDSKI”
FACULTY OF GEOLOGY AND GEOGRAPHY
Book 2 – GEOGRAPHY
Volume 108

TORNADO CLIMATOLOGY OF BULGARIA

KALOYAN IVANOV

Department of Climatology, Hydrology and Geomorphology
e-mail: Kaloyan.clm@gmail.com

Kaloyan Ivanov. TORNADO CLIMATOLOGY OF BULGARIA

The topic of tornado occurrence in Bulgaria isn’t very popular and often is underestimated by the academics. The scientific data is not comprehensive enough. This paper presents the most updated georeferenced information and synoptic situations about tornado activity in Bulgaria in the period 1904 – 2014. In this period there were about 16 waterspouts and 31 tornadoes on the land. Analyses show that most of the tornado occurrences were determined in May-June and August and after 12 o’clock at noon. Synoptic situations clarify that there is a complex unit of factors affecting tornado activity, such as atmospheric circulation, cold fronts, orographic effect, higher temperatures on the land etc. According to the reported data it can be implied that the maximum intensity determined for a tornado in Bulgaria was T7 on the TORRO-Scale (F3 on the Fujita-Scale). The most common intensity is T2 on the TORRO-Scale (F1 on the Fujita-Scale). The topic is important in view of the climate variability in the world and events of more frequent tornado occurrences in Bulgaria for the last 30 years.

Keywords: Tornado, waterspout, georeferenced data, synoptic analysis, Bulgaria.

INTRODUCTION

A tornado is a natural wind disaster, which causes many material damages and often takes human lives. The topic of this atmospheric phenomenon isn’t very popular in the Republic of Bulgaria, due to the common knowledge that tornadoes are rare or do not even occur in these latitudes. This is one of the reasons why tornadoes are not an object of many researches. There are a few sporadic publications in the 20th and in the beginning of the 21st century, but

not a complete strategy of studying and research. The lack of scientific data is tangible and makes difficult the further process of exploration.

The goal of this paper is to present historical and spatial data analyses of tornadoes and waterspouts, along with climatological information about the synoptic situations concerning tornado activity. The long term goal is to develop a research strategy in order to support the scientific and economic interests.

This climatological study is based on the research of Bulgarian scientific literature, local and national Internet media.

HISTORICAL RECORDS OF TORNADO ACTIVITY IN BULGARIA

In the climatological literature the definition of a tornado is: "A violently rotating column of air, pendant from a Cumulonimbus cloud, and nearly always observable as a 'funnel cloud' or tuba" (Doswell, Burgess, 1993). Usually the "Cumulonimbus cloud has over 10–15 km of vertical development" (Vekilska, 1983). A tornado has an area of low atmospheric pressure in the centre and a circular anti-clockwise motion in the Northern Hemisphere. It "looks like a small cyclone" (Mardirosian, 2009).

In the period 1904–2014 there were roughly 16 waterspouts and 31 tornadoes on the land (Fig. 1. *Notice*: Tornadoes in Bulgaria are often confused with squalls or downbursts

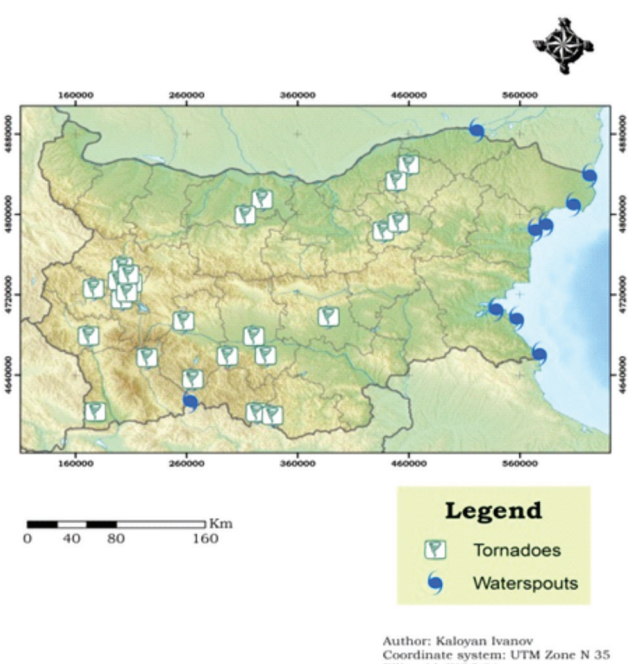

Fig. 1. Tornado activity in Bulgaria (1904–2014)

(Simeonov, Gospodinov, Bocheva, 2011). Still, many cases of potential mountain tornadoes have been reported throughout the years. There are reports of uprooted trees scattered in a circular pattern along their path. They're not officially registered as tornadoes, therefore they're not indicated below (Table 1, 2).

One of the first descriptions of waterspout occurrence in Bulgaria belongs to rear admiral Sava Ivanov (1891–1958). In his article of 1924 he wrote the following:

"Tornadoes and waterspouts are frequent events during the summer afternoons. Waterspouts have been observed in the Gulf of Varna. Two waterspouts have occurred on the 19th of August 1904 at 3 p. m. in the afternoon in the Black Sea near to the city of Varna.

The second one took place throughout the night on the 1st of June 1906 when the waterspout sucked up water and delivered fish rain on shore – in the city 20 little fishes – Acanthias, about 20 centimetres long were found" (Ivanov, 1924) (Fig. 2, 3, 4).

Table 1

Waterspouts (1904–2014)

Date/Month/Year	Place of occurrence	Damages
19.08.1904 *(two)*	Gulf of Varna	No data (Ivanov, 1924)
01.06.1906	Gulf of Varna	Large amount of fish rain on the shore (Ivanov, 1924)
20.06.1956	Gulf of Burgas	No data (Nojarov, 2005)
08.1982	Gulf of Varna	No data (Grozdev, 1998)
08.1991	Near the town of Ahtopol	No data (Grozdev, 1998)
06.1993	Beach near the town of Sozopol	Uprooted trees, bungalows and little building were destroyed (Mardirosian, 2009)
29.08.1993	Near the town of Silistra	Big damage; 410 ton crane was demolished (Mardirosian, 2009)
06.1995	Near the town of Sozopol	No data (Mardirosian, 2009)
16.08.1998 *(three)*	Near the resort "Golden Sands"	No data (Grozdev, 1998)
20.07.2002	Near the town of Kavarna	No data (Grozdev – www.moreinfo.bg)
30.08.2006	Gulf of Varna	No data (Grozdev – www.moreinfo.bg)
06.08.2007	Dospat Reservoir	No data (bTV the News – http://vbox7.com/play:9f20963b)
26.07.2010	Near the town of Sozopol	No data (Radionov – www.sozopol.org)
16.07.2013 *(three)*	Near the town of Durankulak	No data ("Black Sea" – http://chernomorie-bg.com/obshtestvo/14104-tri-tornado-v-moreto-vtreshtiha-durankulak)
16.06.2014	Near the town of Sozopol	No data (24 hours – Tornado near Sozopol – http://www.24chasa.bg/Article.asp?ArticleId=4306266
15.09.2014	Near the town of Sozopol	No data (24 hours – Tornado near Sozopol – http://www.24chasa.bg/Article.asp?ArticleId=4306266

Table 2

Tornadoes on land (1904–2014)

Date/Month/Year	Place of occurrence	Damages
01.05.1929	Town of Stara Zagora	Blown away roofs, destroyed ramshackle buildings, uprooted century-old trees and cypresses; demolished mosque's minaret (Vekilska, 1983)
26.06.1941	Sofia Valley	No data (Nojarov, 2005)
14.06.1956	Northern slope of Vitosha Mountain	Uprooted coniferous forest with 40 cm wide trees; devastated forest vegetation in the range of 1300 metres; the roof of hut "Kumata" was blown all the way to the top of peak "Cherni vrah". The tornado spin was anticyclonic (Nojarov, 2005, Vekilska, 1983)
15.06.1956	Near the town of Yakoruda (Western slope of Rhodope Mountains)	No data (Nojarov, 2005)
04.08.1956	Eastern part of Sofia Valley	No data (Nojarov, 2005)
29.05.1961	Western Rhodope Mountains	About 33 times stronger than the tornado in Vitosha Mountain. Destroyed 3 thousand hectares of forest in the area of the villages Karatepe, Selishte, Beglika. The border of devastation was 30 km long and 1200–2000 metres wide. (Mardirosian, 2009, Vekilska, 1983)
05.1969	Vrana Palace, Sofia	Uprooted over 100 century-old trees (Mardirosian, 2009)
17.05.1969	Village of Tserovo	Uprooted trees, roofs were blown away, concrete pillar destroyed (Latinov, 2006)
06.1970	Vrana Palace, Sofia	Uprooted over 200 century-old over 30 metres high trees (Mardirosian, 2009)
19.06.1978	In the area of Blazhievo village	Roofs and chimneys were blown away, uprooted trees and destroyed concrete pillars; hail and 4 cm high ice cover (Sirakova, Sirakov, Donchev, 1989)
13.04.1986	Kosnichari village	Blown away roofs (Sirakova, Sirakov, Donchev, 1989)
15.07.1986	Vitosha Mountain (Northern slope)????	Uprooted many century-old trees (Latinov, 2006)
06.08.1986	In the area of city of Varna	Many electric pillars were destroyed (Sirakova, Sirakov, Donchev, 1989)
05.06.1989	Bohot village, Pleven	Many two floored houses were devastated; the border of destruction is about 200 metres; 144 solid houses were completely destroyed and over 186 were partially affected (Latinov, 1991, 2009)
19.05.1999	Zhaltusha village (Eastern Rhodope Mountains)	Damages valued for 250 thousand dollars; 300 blown away roofs and four people injured (Latinov, 2006)
22.05.2001	Zheleznitsa village and Bistrishko Branishte reserve (Northern slope of Vitosha Mountain)	14% of the century-old spruce forest is uprooted; material damages valued for 1 million and 800 thousand levs (Latinov, 2006)

Table 2 (continued)

08.2001	Sofia Valley	50 houses were demolished in Novi Iskar Municipality (Mardirosian, 2009)
19.08.2002	Kalekovets and Trud villages	Uprooted trees (Latinov, 2009)
27.05.2003	Town of Slavyanovo	Uprooted 200 hundred pine-trees, demolished buildings; a woman was injured ("Dnevnik", www.dnevnik.bg)
03.2004	Bolyartsi village	20 houses' roofs were blown away, concrete pillars demolished, uprooted trees (Mardirosian, 2009)
02.2005	Taran village	Damages were valued for 4 million levs (Mardirosian, 2009)
29.05.2005	In the area of the town of Targovishte	90 houses' roofs were blown away; uprooted trees ("New Dobruja tribune" – http://www.ndt1.com/article.php/20050529201341408)
01.07.2005	Near the town of Perushtitsa	No damage reported (Violetova – http://old.duma.bg/2005/0705/040705/bulgaria/bul-4.html)
22.05.2007	Kalekovets village	Damages valued for 1 million levs; 80 houses' roofs were blown away, uprooted trees, devastated hothouses, fences and 5000 acres of crops (Krastev – http://www.monitor.bg/article?id=120765)
24.05.2007	Krivina village, Sofia	8 houses' roofs were blown away, uprooted trees, demolished buildings ("Econ-bg" – http://econ.bg/Новини/Смерч-премина-през-софийското-село-Кривина_l.a_i.113143_at.1.html)
22.04.2008	Near the town of Senovo	Over 300 houses' roofs were blown away; interrupted transmission line and electricity ("Darik News" – http://dariknews.bg/view_article.php?article_id=246098
30.04.2011	Near the town of Kubrat	No damage reported (bTV – http://www.btv.bg/az-reporterut/vashite-galerii/galeria/1171542475-Tornado_se_izvi_v_Razgradsko.html)
30.05.2013	Near the town of Slavyanovo	No serious damage reported ("Mediator" – www.posredniknews.com)
14.05.2014	Village of Chepintsi	The roofs of 15 houses were blown away; uprooted trees (Vesti.bg – http://www.vesti.bg/bulgaria/obshtestvo/smerch-otnese-pokrivi-kraj-sofiia-6012068)
26.05.2014	Village of Yakovo	Uprooted trees; broken chimneys; destroyed crops and streets; farm animals were blown away (Vesti.bg – http://www.vesti.bg/bulgaria/incidenti/tornado-v-petrichko-otnese-pyt-v-niakolko-sela-6013424)
18.06.2014	Village of Chavdar	Uprooted trees, roofs were blown away, damages for 2.5 million levs (24 hours – http://www.24chasa.bg/Article.asp?ArticleId=4146912

Fig. 2. Waterspout – Dospat Reservoir (2007) (bTV the News – http://vbox7.com/play:9f20963b)

Fig. 3. Waterspout – near Sozopol (2010) (Radionov – http://www.sozopol.org/торнадото-край-созопол-не-е-единичен-с-1331.html#axzz2xB6bR3Ht)

Fig. 4. Waterspout – near Durankulak (2013) (Pers. Arch.)

The oldest known tornado occurrence happened in the town of Stara Zagora on the 1st of May 1929. The Bulgarian climatologist Kiro Kirov (1897-1961) described the tornado in the following manner:

"On this day at 15:50 from the side of the Artillery barracks a dark cloudy cone was lowered. The tornado entered the town and blew off roofs, dilapidated buildings and many century-old trees including the imposing cypresses in front of the theatre. The old and solid mosque's minaret looked like it's been sliced off with a knife" (Vekilska, 1983).

GEOREFERENCED DATA FOR TORNADO RISK ANALYSES

In his book *Wind- und Wasserhosen in Europa* (1917), Alfred Wegener writes that in the beginning of the XXth century the annual number of tornadoes in Europe was 100 (Dotzek,

N., 2002). Nowadays, according to the European Severe Storms Laboratory there are many more – about 300 yearly and most of them situated in the United Kingdom – 50 per year and the Netherlands – 35 per year (Dotzek, 2002).

In Bulgaria the maximum intensity determined for a tornado was T7 on the TORRO-Scale (F3 on the Fujita-Scale) – presumably for the tornado in the village of Bohot (1989), as well as the one in the Western Rhodope Mountains (1961) (Fig. 5). The most common intensity among the tornados recorded in Bulgaria is T2 on the TORRO-Scale (F1 on the Fujita-Scale) (See Tables section at the end).

On Fig. 6 we can see that most of the country's area falls into the moderate and low risk zones of tornado activity. However, the Northern cost of the Black Sea appears to be the most extreme region because of the many tornado events clustered in that area throughout the years. Northern slopes of Vitosha and Rhodope Mountains fall into the very high zones of tornado activity due to the orographic effect and the synoptic situations in the summer. The northwest of Bulgaria represents the very low to none risk area. So far there's no evidence of tornado activity here.

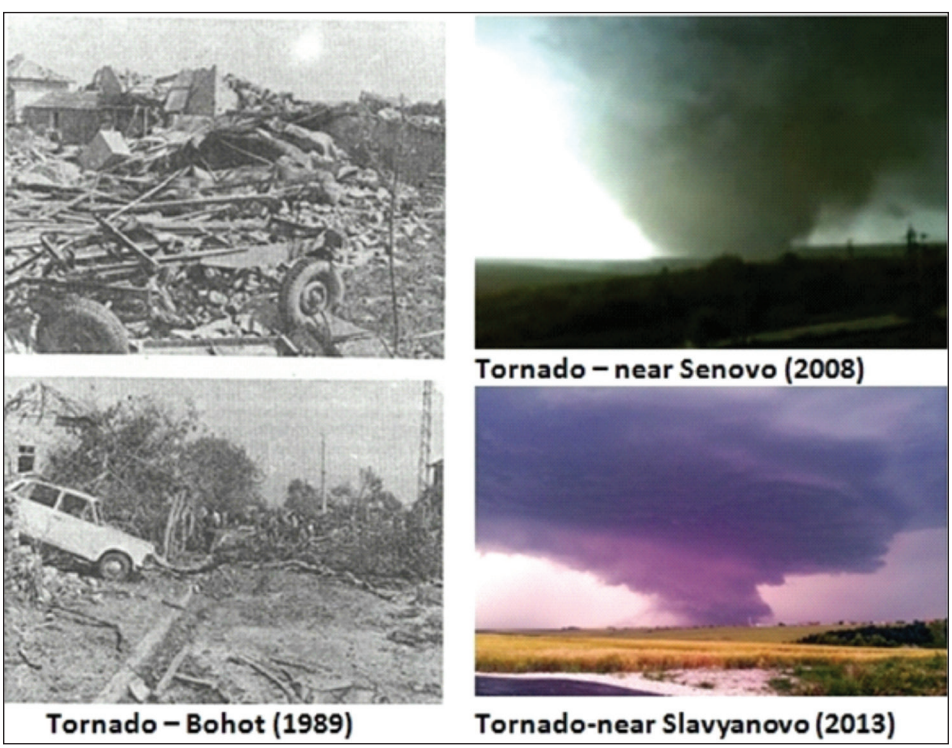

Fig. 5. (Latinov, Matev, Ivanov, 1991; Maksimova – http://www.kliuki.net/tornado-nadvisna-strahovito-nad-balgariya-unikalni-snimki/; Tornado in NE Bulgaria – http://www.youtube.com/watch?v=KLhvAC-b10M)

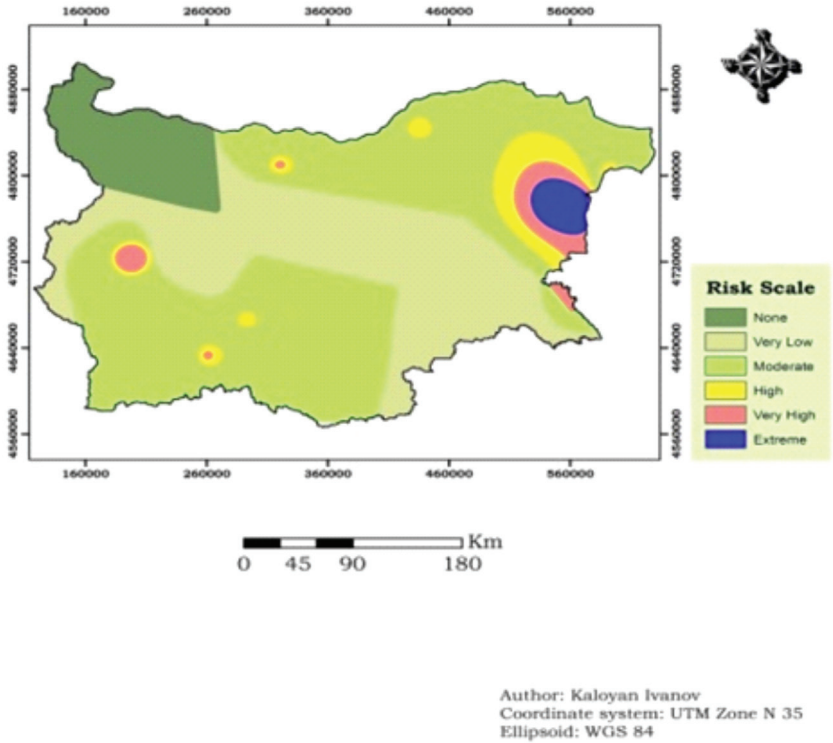

Fig. 6. Tornado risk in Bulgaria (1904–2014)

DISTRIBUTION BY MONTH AND TIME

Figure 7 shows clearly that there are two peaks of tornado activity in Bulgaria. The first one is in the period May-June. This overlaps with the time when we register the annual maximum of precipitation frequency for the humid continental climate in Bulgaria (World Maps of Köppen – Geiger Climate Classification – http://koeppen-geiger.vu-wien.ac.at/). The time is characterized with a transitional moment of the atmospheric circulation accompanied by higher temperatures, higher humidity and evaporation, especially in the afternoon (when most of the tornadoes occur). There is a transition from Stratus to convective Cumulonimbus clouds and conditions for unstable stratification. The second peak is in August when we can observe most of the waterspout occurrences here.

The distribution by hour (Fig. 8) presents three peaks of tornado activity – at 13, 15 and 16 o'clock. All of the events happened after 12 o'clock at noon. Their density increases in the late afternoon, which coincides with the daily peak of Cumulonimbus cloud's development. One case of waterspout occurred before midnight.

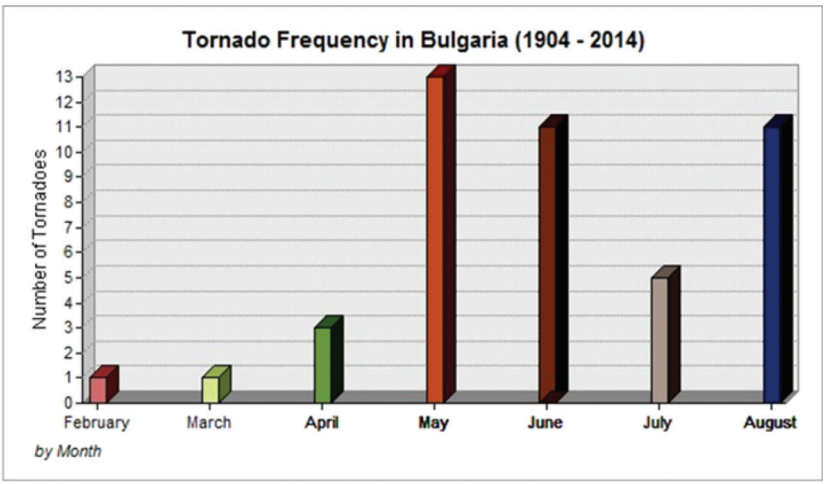

Fig. 7. Tornadoes/Waterspouts frequency by month

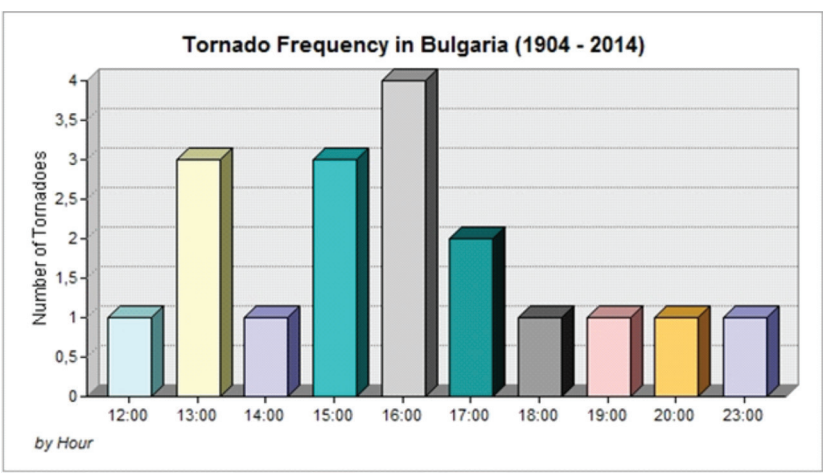

Fig. 8. Tornadoes/Waterspouts frequency by hour

SYNOPTIC SITUATIONS OF TORNADOES FORMATION

Due to the lack of observations and researches, there aren't many analyses of the tornadoes' synoptic situations in Bulgaria. Nonetheless, the study of the available data leads to some general conclusions.

According to Latinov (1991, 2006), the optimum tornado synoptic situations in Bulgaria are two. They can be defined as the following:

First – situation (Fig. 9) in the presence of a clearly identifiable Arctic front around the 65th N parallel and Polar front around the 40th N parallel. Under the Polar front there are moving cyclones, which support the flow of cool air above Bulgaria (Latinov, 2006). The convection's intensification in the mountain areas is sensible.

Second – "temporarily the Arctic and Polar zones are moving towards each other, the space between them is the least above Bulgaria" (Latinov, 1991). This situation (Fig. 10) leads to a sharp increase of the temperature gradient and the formation of heavy Cumulonimbus clouds.

All of these synoptic situations have something in common – all of them happened in the presence of a strong convective movement, supported by a rush of Atlantic cyclones from West-Southwest, which carry moist and hot air. The temperature contrasts between the cold front and the hot surface air are sharp (Nojarov, 2005). In this period of time the "Polar front is situated more in the South than usual" (Latinov, 2009). It looks like a stationary wall with heavy thunderstorm Cumulonimbus clouds, which ensures the advection of cooler air from East-Northeast. Usually tornadoes form in the front of a cold front. One of the most important things in a tornado formation is the heating of the surface, especially in the mountain areas, where it's more intensive due to the orographic effect (Latinov, 2006). Observations show that in a day with tornado occurrence there are higher temperatures than usual, low atmospheric pressure and strong overheating of the surface. The causes of tornado occurrences cannot be viewed separately, they should be regarded as a complex unit. "A tornado, no matter how one chooses to define it, is a kinematic structure that renews itself from instant to instant via one or more dynamic processes" (Doswell, Burgess, 1993).

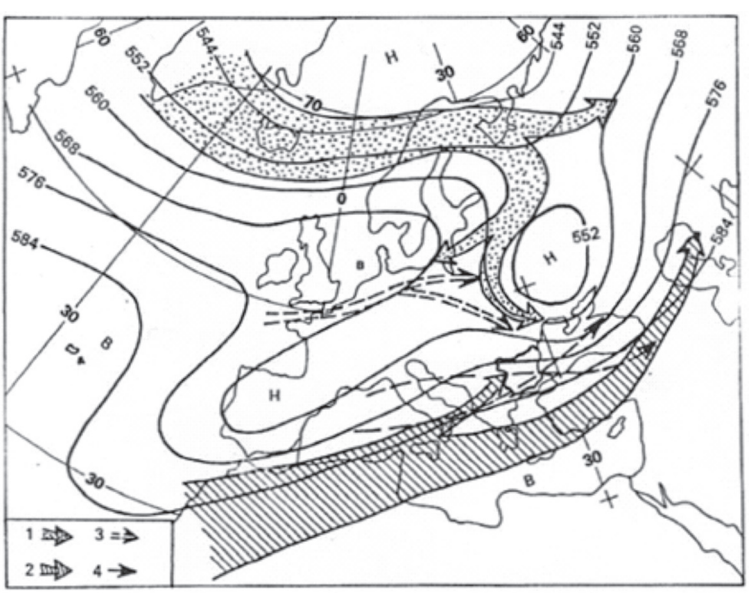

Fig. 9. *1* – cold air; *2* – hot air; *3* – anti-cyclonic flow; *4* – cyclonic flow (Latinov, Matev, Ivanov, 1991)

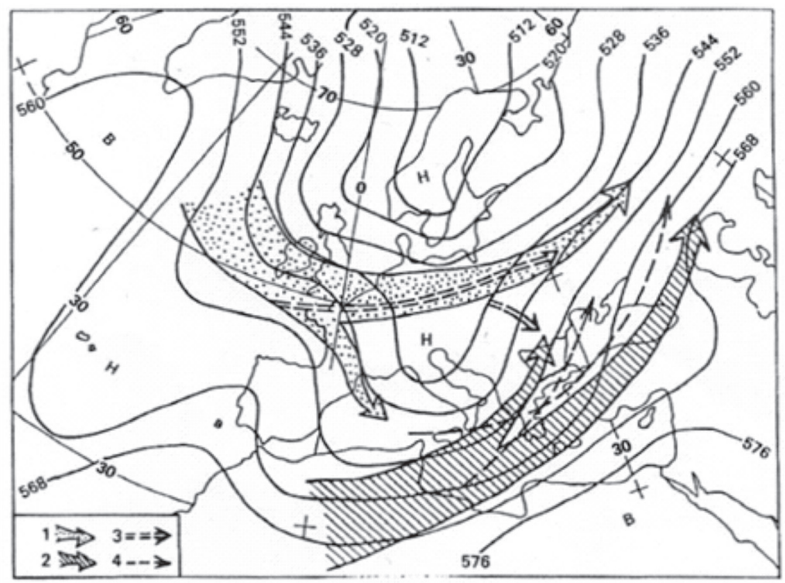

Fig. 10. *1* – cold air; *2* – hot air; *3* – anti-cyclonic flow; *4* – cyclonic flow (Latinov, Matev, Ivanov, 1991)

DISCUSSION

Contrary to popular belief that tornadoes don't occur in Bulgaria, the results of this research show the exact opposite. It gives an impression that in the last 10–15 years there is no year without a tornado occurrence. This can be related to the development and usage of digital technologies, satellite and radar observations (Simeonov, Gospodinov, Bocheva, 2011). Possibly in the XXth century the tornado activity could've been even more intensive if the same resources were available.

CONCLUSIONS

1. Tornadoes and waterspouts do occur in Bulgaria – for the last 90 years there have been reported over 40 cases of tornado activity. Only in the last 10–15 years the number is more than 15 due to the digital and satellite revolutions and better access to information by the population. We can assume that there are more cases which haven't been reported. The maximum intensity attributed to a tornado was T7 on the TORRO-Scale (F3 on the Fujita-Scale) – presumably for the tornado in the village of Bohot (1989) and the one in Western Rhodope Mountains (1961). The most common intensity is T2 on the TORRO-Scale (F1 on the Fujita-Scale). Tornadoes generate damages for millions of levs.

2. Based on reliable data the risk zones in Bulgaria are divided as follows: *a* – extreme – Black sea (especially the Northern coast); *b* – high risk – the northern slopes of Vitosha and

Rhodope Mountains; *c* – moderate and low risk – larger part of Bulgaria; *d* –none – in the northwest of Bulgaria; there haven't been any reported cases of tornado activity yet.

3. There are two peaks of tornado activity in Bulgaria – May-June and August. Daytime peak is after 12 o'clock at noon.

4. Synoptic data is essential in realizing what causes tornadoes in Bulgaria. Frontal zones, Atlantic cyclones, heating of the surface and the orographic effect form a complex unit of tornado factors.

Since tornadoes occurrences are related to higher land surface temperatures and in the last 30 years the average temperatures in Bulgaria have risen, we can forecast a higher frequency in the future of this atmospheric phenomenon (Nojarov, 2005). Although tornadoes in Bulgaria haven't got the force of the "supercell" tornadoes (Doswell, Burgess, 1993) in the United States of America they still cause many damages to the agricultural and mountain lands, natural reserves and settlements, which can be estimated in millions of levs. Problems nowadays begin with the lack of scientific researches, through the absence of technology for study and finish with the underestimation of the problem. The harmonization of tornadoes geographic data in EU is essential (the first step was made by the late Dr. Nikolai Dotzek in the year 2000 (Dotzek, 2002), as well as coordinating actions within the countries of the Balkan and Central European region, when the climate conditions of tornado occurrenc are similar. The tornado is a serious atmospheric disaster which is becoming more frequent in Bulgaria and the experts, along with governmental or non-governmental scientific organizations, should carefully track its development and act accordingly.

Acknowledgements. The author thanks Assoc. Prof. Georgi Rachev, PhD (Sofia University "St. Kliment Ohridski", Bulgaria) and the members of the "National geographic" forum of Bulgaria.

REFERENCES

Doswell, C., Burgess, D. 1993. Tornadoes and Tornadic Storms: A Review of Conceptual Models. – In: Church, C., Burgess, D., Doswell, C., Davies-Jone, R. The Tornado: Its Structure, Dynamics, Prediction, and Hazards, American Geophysical Union, 161–172. http://www.flame.org/~cdoswell/publications/Doswell&Burgess_93.pdf

Dotzek, N. 2002. An updated estimate of tornado occurrence in Europe. Paper presented at the 2nd European Conference on Severe Storms Prague, Czech Republic, 26–30 August 2002. http://www.tordach.org/pdf/ecss02s.pdf

Grozdev, D. 1998. A tornado on the Bulgarian coast. – *Marine science forum Magazine*, March, 270–272.

Ivanov, S. 1924. Storms and tornadoes in Black sea. – *Marine agreement Magazine*, April, 2–3.

Latinov, L. 2009. Caprices of weather in Bulgaria within the beginning of the XXth and the XXIst centuries, Sofia. Avenir Press.

Latinov, L., Martinov, M., Stoicheva, An. 2006. Synoptic conditions for snowstorms, black ice, tornadoes and sandstorms in Bulgaria. Sofia. Avenir Press.

Latinov, L., Matev, Iv., Ivanov, P. 1991. Tornado in Bulgaria. – *Nature Magazine*, February, 23–27.

Mardirosian, G. 2009. Natural and ecological disasters: Studying, prevention, protection. Sofia. Prof. Marin Drinov Press.

Nojarov, P. 2005. The destructive force of the Atmosphere. "Institute of geography – BAS". 23 May 2005, 33–38 – http://www.prokarstterra.bas.bg/geo21/2005/23--05/pp33-38.html

Simeonov, P., Gospodinov, I., Bocheva, L. 2011. On space-time distribution of tornado events in Bulgaria (1956-2010): Analyses of Two Severe Tornadic Storms. Paper presented at the 6th European Conference on Severe Storms, Palma de Mallorca, Balearic Islands, Spain, 3–7 October http://www.essl.org/ECSS/2011/programme/posters/189.pdf

Sirakova, M., Sirakov, D., Donchev, K. 1989. Meteorology for everyone. Sofia. Science and Art Press.
Vekilska, B. 1983. Atmosphere in motion. Sofia. Narodna prosveta.

Websites:

Black Sea, Three tornadoes in the sea terrified the town of Durankulak. 2013 – http://chernomorie-bg.com/obshtestvo/14104-tri-tornado-v-moreto-vtreshtiha-durankulak
bTV, I, the reporter, Tornado in Razgrad municipality. 2011 – http://www.btv.bg/az-reporterut/vashite-galerii/galeria/1171542475-Tornado_se_izvi_v_Razgradsko.html
bTV the News. Tornado above Dospat Reservoir. 2007 – http://vbox7.com/play:9f20963b
Darik News. Tornado left 200 families without roofs over their head in the town of Zavet. 2008 – http://dariknews.bg/view_article.php?article_id=246098
Dnevnik. Tornado uprooted 200 trees in Pleven Municipality. 2003 – http://www.dnevnik.bg/bulgaria/2003/05/27/136419_smerch_izkoreni_200_durveta_v_plevensko/
Econ-bg. Tornado passed through the village of Krivina. 2007 – http://econ.bg/Новини/Смерч-премина-през-софийското-село-Кривина_l.a_i.113143_at.1.html
Grozdev, D. 2006. Tornado above the city of Varna. –http://more.info.bg/article.asp?topicID=170&issueID=1708
Krastev, N. 2007. Monitor Newspaper. Tornado attacks the village of Kalekovets. – http://www.monitor.bg/article?id=120765
Maksimova, L. 2013. Tornado above Bulgaria (unique photos). – http://www.kliuki.net/tornado-nadvisna-strahovito-nad-balgariya-unikalni-snimki/
Mediator. Tornado passed through Pleven Municipality. 2013 – http://www.posredniknews.com/site/component/content/article/127-nai-vazhnoto/40980-tornado-premina-prez-plevensko
New Dobruja tribune. Strong tornado in Targovishte Municipality. 2005 – http://www.ndt1.com/article.php/20050529201341408
Radionov, T. 2010. Sozopol Media. The tornado in the town of Sozopol is not the only event here. – http://www.sozopol.org/торнадото-край-созопол-не-е-единичен-с-1331.html#axzz2xB6bR3Ht
Tornado in NE Bulgaria – 22 april 2008 Senovo. 2008 – http://www.youtube.com/watch?v=KLhvAC-b10M
Vesti.bg – http://www.vesti.bg/bulgaria/incidenti/tornado-v-petrichko-otnese-pyt-v-niakolko-sela-6013424
Vesti.bg – http://www.vesti.bg/bulgaria/obshtestvo/smerch-otnese-pokrivi-kraj-sofiia-6012068
Violetova, D. Duma Newspaper. Tornado in the town of Perushtitsa, 2005 – http://old.duma.bg/2005/0705/040705/bulgaria/bul-4.html
World Maps of Köppen – Geiger Climate Classification. – http://koeppen-geiger.vu-wien.ac.at/
24 hours – http://www.24chasa.bg/Article.asp?ArticleId=4146912 ; Tornado near Sozopol – http://www.24chasa.bg/Article.asp?ArticleId=4306266

Received April 2015