METEOROLOGICAL SITUATIONS THAT GENERATED EXCEPTIONAL DISCHARGES ALONG THE DANUBE RIVER (CASE STUDY- THE SITUATION OF APRIL 2006)

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Abstract. For Europe, the undisputed importance of the Danube can be rendered by some general data: Its hydrographic basin surface exceeds 817000 km^2, i.e. about 10% of that of the continent, its length is 2857 km and its mean multiannual discharge is about 6500 m^3/s, thus ranking second to Volga river. Romania is the country with the largest surface situated within Danube's basin (97.4%), representing 29% of Danube's hydrographic basin. The water resources of the Danube in Bazias section amount to 173 billion m^3, 30 billion m^3 of which are technically usable resources.Our analysis aimed at determining those complex meteorological situations at the European continent level that triggered exceptional discharges along the Danube river, resulting in severe flooding, causing in turn heavy damages, fatalities, population evacuations and considerable rehabilitation costs. A complex analysis was performed, of statistical-synoptic type and those complex meteorological situations were identified that determined the occurrence of such disasters. Discharges and levels of the Danube were used along the whole measuring period, data from the archive of the National Meteorological Administration, and data, map and image archives from Wetterzentrale (Kartenarchiv, NCEP, NCAR, AVN etc.). The complex meteorological situations at the level of the European continent that triggered exceptional discharges along the Danube correlate with intense cyclonic activity, of both the Icelandic and the Mediterranean cyclones, with the negative phase of the North-Atlantic Oscillation and with decreasing or minimum solar activity (according to data from NOAA's Space Environment Center). The most disastrous floods occurred in the spring of 2006. The paper is important for meteorologists, in their weather forecasting activity, for hydrologists, in their hydrological forecasting and for the institutions involvedin flood management.

Keywords: precipitation excess, rainy periods, floods, maximum discharges along the Danube river.

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1. INTRODUCTORY REMARKS

Romania is the country with the largest surface situated in the Danube's basin (97.4%), which represents 29% of Danube's hydrographic basin [1, 2]. Function of the physical-geographic elements' distribution and the character of the hydrological regime, the course of the Danube is divided in three sectors: upper Danube (springing to Devin), middle Danube (Devin- Iron Gates) and lower Danube (Iron Gates-Black Sea). The lower course of the Danube is the state border of Romania with Serbia, Bulgaria and Ukraine, which makes 37.7% of Danube's lengths stretch along the territory of Romania.

The important tributaries of the Danube along its lower sector are the Balkan rivers Timoc, Lom, Ogosta, Iscar, Vit, Osam, Iantra and Rusenski Lom – on the right bank, whereas Jiu, Olt, Vedea, Arges, Ialomita, Siret and Prut rivers flow from Danube's left bank , [13].

Danube's water resources within Bazias section amount to 173 bn. m^3, 30 bn. m^3 of which are technically usable resources, Isaccea site contributing another 256 bn.m^3.

The analysis of the anthropic modifications occurred in the major riverbed - damming, 417 reservoirs, of which the Iron Gates I has the largest volume, of 2,55 bn. m^3, 60 derivations and channels - shows that important modifications have occurred in the flow, alluvia regime and morphology. These modifications are both owed to climate changes in the Danube's basin, and to a number of human-induced changes, through performing hydrotechnical management works for the whole hydrographic basin and for the riverbed, [13].

The frequency of the maximum annual discharges (Q) higher than 12000 m^3/s computed over the 1840-2008 period is 13% at Orsova hydrometric station and 22,5% at Isaccea hydrometric station; for Q > 13000 m^3/s the probability is 2,96 %, and 7,7%; for Q > 14000 m^3 /s it is 1,19% and 5,92% respectively; for Q >15000 m^3/s the probability is 0,6% and 1,19% respectively; and for Q > 16000 m^3 /s Isaccea showed a probability of 1,19% and zero probability at Bazias. For Q > 17 000. m^3/s – occurred at Isaccea in 1,97 the frequency is 0,10%. From the above displayed data, it can be noticed that the highest maximum annual discharges occurred in 1,97 and 2,06, as shown by the values computed on the basis of data series extension, based on Orsova hydrometric situation, settled in the year 1838, [12, p.36].

2. DATA AND METHODS USED

The analysis aimed at disambiguating those complex meteorological situations at European continent level that caused exceptional discharges along the Danube, with consequences materialized in ample flooding, that caused heavy damages, victims, and the evacuation of a large number of people, along with considerable human and material efforts destined to restore the situation and return to normal.

Complex analysis was carried-out of a statistical-synoptic type and those complex meteorological situations were identified, which caused the occurrence of disasters such as those mentioned above.

There were used data concerning the Danube's discharges and levels from the archive of the National Institute of Hydrology and Water Management-Bucharest for the whole measuring period, from the archive of the National Meteorological Administration-Bucharest, from the data, map and satellite data archive existing at Wetterzentrale (Kartenarchiv, NCEP, NCAR, AVN etc.).

The complex meteorological situations at the level of the European continent that caused exceptional discharges along the Danube correlate with intense cyclonic activity, of both the Icelandic cyclones and of the Mediterranean ones, with the negative phase of the North Atlantic Oscillation and with a decreasing or minimum solar activity (according to data from NOAA's Space Environment Center).

3. RESULTS AND ASSESSMENTS

The causes that led to the April – May 2006 high flood on the Danube were the following: the meteorological and hydrological situation from the previous months (February and March), the sudden water release from the snow layer existing in the upper and middle basin of the Danube, beginning with the third decade of March, superposed on the effect of the significant liquid precipitation expanded at whole hydrographic basin level throughout April, which triggered important discharges as Danube's inlet into the country.

The liquid precipitation of February – May 2006 superposed on the water release from the snow layer in the heights of Austria and Slovakia.

Snow melting started as early as the third decade of March, on a background of high temperatures that led to significant level increases on the Danube, first along the Linz-Bratislava sector, propagated and amplified during the days that followed in the sector downstream, which triggered important high floods on the territories of Slovakia and Hungary respectively.

The Danube's discharge increases at Bratislava, for instance were owed both to the aggregation of discharges incoming from the tributaries in Germany and Austria (Günz, Mindel, Riss, Würm, Iler, Lech, Isar, Inn, Regen etc.) further propagated along the Danube in Linz section, and to the contribution of Enns tributary from Austria and of the Moravia river from Slovakia. Those increases debuted on 26 March, from a level of 395 cm and a discharge of 3200

m^3/s, and peaked on 2 April, at a level of 829 cm and a discharge of 6900 m^3/s, to further decrease slowly during the following week, then more markedly.

Passing by Bratislava, the high flood went on propagating along the Danube towards the Hungarian territory, which brought as far as Budapest the contribution of other tributaries also, with increasing discharges (Raba, Vah, Nitra, Hron, Ipol), with a first effect a 1000 m^3/s increase in the 27/28 March interval, from 3100 to 4100 m^3/s. Increases enhanced in the following days, culminating on 4 and 5 April, when the maximum levels and discharges were reached, 856 cm and 8500 m^3/s, i.e. a rise of 489 cm and 5400 m^3/s in 8 days (from 27 March to 4 April).

After 6 April, discharges entered a decreasing process in Budapest section, but the high flood propagated downstream towards Bogojevo, where it maintained and was amplified through the contribution of the rising discharges on the Drava river (in 10 days, i.e. the 1-10 April interval, levels increased by 270 cm at Osiek hydrometric station).

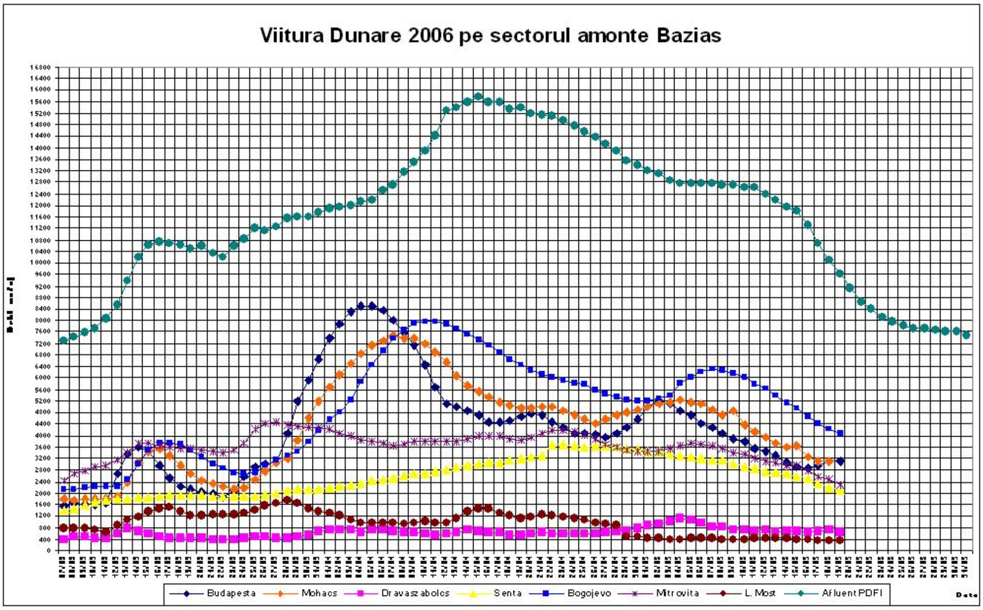

Figure 1. Discharges evolution at the main stations within the Danube basin, upstream the Iron Gates I storage (IGI).

Thus, in Bogojevo section, more important increases commenced on 30 March and peaked on 10 April, at a discharge of about 8000 m^3/s, the level rise being 435 cm in 12 days. From Bogojevo to the inlet in Romania (Bazias section), the large discharges propagated along the Danube aggregated with those along the rivers Tisza, Sava, Timis, Morava and Nera, but only the Tisza river recorded spectacular increases (historical discharges), with a very slow progression.

At Szeged hydrometric station, on the Tisza river, discharges rose continually from 25 March to 21/22 April, and the decreases recorded in the week that followed were in turn rather slow. Thus, on 25 March, a level of 577 cm and a discharge of 1860 m^3/s were recorded, whereas on 21 and 22 April the water level was 1009 cm and the discharge 3900 m^3/s, fig.1, [12].

Starting with 15 February, because of the precipitation recorded upstream and of the melting of a large share of the snow layer from the upper and middle basin, the Danube discharges increased at Bazias starting from the above mentioned date, from a below average (5300 m^3/s) value of 3330 m^3/s, to 8510 m^3/s at the end of February.

This almost 5000 m^3/s increase was caused by the discharges recorded in the latter part of February in the section from the strait close to Devin, near Bratislava, to the junction with Sava river. During that period, increases on the Sava river were not significant.

The rains fallen in the hydrographic basins of the Romanian rivers flowing into the middle Danube, along with the snow melting in Ardeal, induced significant increases and the caution levels were exceeded on the rivers from the west of the country: the 3 rivers Cris, Barcau, Bega, Timis and even the flooding levels were exceeded along Barzava and Moravita rivers, in Banat. From the second decade of March to mid April, discharge increases of more than 8000 m^3/s brought the culmination of the high flood on the Danube, with 15 800 m^3/s on 15 April at Bazias and 16 900 m^3/s at Isaccea and Ceatal Izmail, on 26-27 April, i.e. the propagation interval was 12 days.

The analysis of the maximum annual discharge series recorded at Bazias from 1931 to 2008 shows that the multi-annual mean is 10,216 m^3/s. Given that the spring - summer high waters phase started on 15 February at Bazias and on 22 February at Isaccea exceeded the multiannual mean of the maxima (10600 m^3/sec), as did, starting 15 March 2006, the Danube's discharge at the inlet into the country, exceeding mean of the maximum discharge (10600 m^3/s) we may consider the latter date the beginning moment for the high flood wave, which agrees with the types of air pressure field and atmospheric circulation types. The maximum phase of the flow at Bazias was recorded in the 11 – 27 April 2006 interval, i.e. 17 days during which the discharge was ≥14000 m^3/s ($_{mean}Q$+17.5% $_{mean}Q$), and the flood crest was recorded on 15 April 2006 when the discharge touched a record 15800 m^3/s ($_{mean}Q$+44.9% $_{mean}Q$), which gives an increasing interval, Tc = 32 days, whereas culmination occurred at Isaccea on 26 -28 April (max. Q = 16900 m^3/s), thus lasting three days and yielding Tc = 64 days.

At Isaccea, the maximum flow phase (observing the same criterion) was recorded in the 26 March 2006 – 25 May 2006 interval (61 days) (Fig. 2), a situation largely owed to discharges incoming from the hydrographic basin of the lower Danube and especially from the Romanian territory.
At Bazias hydrometric station, the interval with water discharges greater than 15600 m^3/s lasted for four days (14 – 17 April), whereas at Isaccea the duration was 19 days (17 April – 5 May 2006).

The water flow on the Danube with discharges above the multiannual mean lasted at Bazias until 17 May and until 12 July at Isaccea. Further, the summer minimum discharge type settled in the entire hydrographic basin of the Danube (and even over the whole European continent) (Fig. 2).

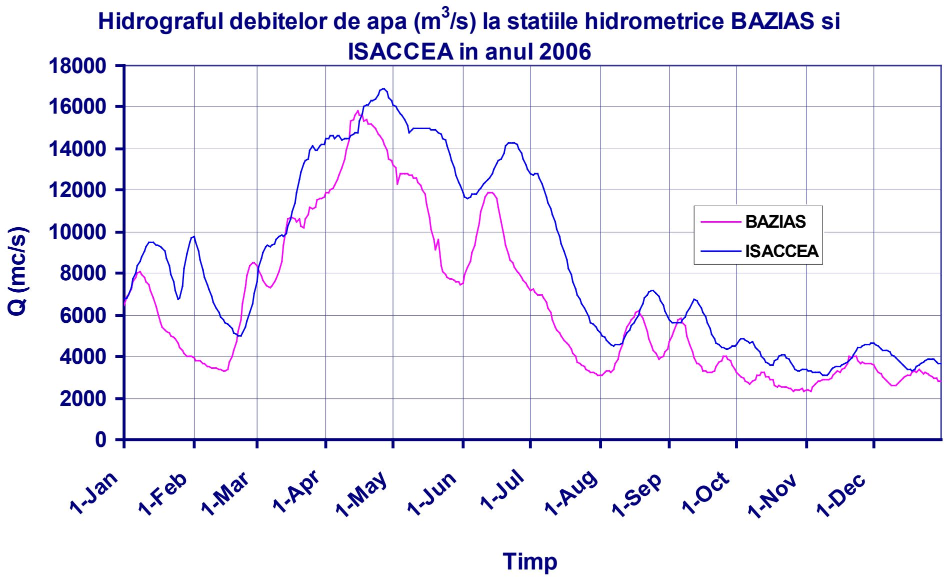

Figure 2. Hydrograph of the 2006 high flood at Bazias and Isaccea

In the spring of 2006 the torrential rainfalls recorded in April and May over the whole of Europe, Romania included, triggered exceptional discharges in rivers and large rivers and caused wide catastrophic flooding, the most severe of which – in Romania. Those torrential rainfalls coincided with a fast weather warming in the former part of April and with the fast snow melting everywhere in Europe.

The maximum discharge of the Danube at the inlet into Romania (Bazias hydrometrical station) in 2006 was recorded on 15 April 2006, 15800 m^3/s, (and 16900 m^3/s at Isaccea), just 100 m^3/s less than the highest discharge ever recorded on the Danube at Bazias, 15900 m^3/s, recorded in June and July 1897, whereas at Isaccea, the maximum level, of 542 cm, recorded in 1,897, [12, p 49], corresponds to a historical annual maximum (reconstructed) discharge of 17300 m^3/s).

At the inlet into Romania, the share of water from upstream, overlapping a background of a 12000 m^3/s discharge, largely above April's multiannual mean (7900 m^3/s), started to increase significantly from 5 April on, with a 1800 m^3/s addition during the first six days, the increase being even greater in the 11 -15 April interval, with another 1,900 m^3/s, which led to the maximum discharge reading of 15800 m^3/s on 15 April.

At brief look into the history of the minimum annual discharges recorded on the Danube discloses that the lowest value was 1040 m^3/s, in 1949, at Bazias.

The minimum annual discharge recorded in August 2003 was 1470 m^3/s., close to the minimum annual discharge of 1200 m^3/s recorded in 1954, which is the last but one value in the series of minimum annual discharges, a phenomenon that speaks about the important changes happened in the precipitation and hydrological regime in the lat 60 years.

Noteworthy that the ***mean multiannual discharge of the Danube at Bazias is 5,475 m^3/s***, which enables a mean power production at Iron Gates I of 16500 megawatt hours and the production unit has been designed to transit a maximum discharge of 22300 m^3/s, probable to occur once in 10000 years.

The mean multiannual discharge of the Danube river at Isaccea is 6516 m^3/s. Comparing the extreme values of the discharges at Bazias, a variation of the Danube's discharges of 14330 m^3/s is noticeable in just three years, which is eloquent for the wide variation of precipitation values at the level of the whole continent in these last three years, in Romania and in the whole hydrographic basin of the Danube river.

To be reminded, the part of Danube's hydrographic basin stretching on the Romanian territory is about 29% [2] of the whole hydrographic basin, which means that the rains fallen in Romania are able to significantly influence the Danube's discharge in its lower course. This brief analysis of the maximum and minimum annual discharges recorded along the Danube also points at the intensity and territorial expansion of extreme values of the hydrological regime, materialized in flooding or drought events over the European continent, affecting wide areas.

Those situations influence the power production from Iron Gates I and II and that of the nuclear power plant from Cernavoda. In low discharge situations at Iron Gates I and II the production decreases dramatically and the nuclear power plant cannot operate, because the small discharges cannot ensure cooling to the reactors. In this sense, the importance of the nuclear power plant can be proved through that it has ranked fifth in its 10 years of operation among the 31 CANDU-type power plants as regards its capacity factor. The price of the produced power is 23 $ / MWh, which includes refunding the credits for erecting the nuclear power plant.

It is estimated that the level and discharge of the Danube fluctuates widely, also function of the precipitation fallen in Serbia. More precisely, the level of the lake Iron Gates I and II is influenced by the precipitation from those territories in a proportion of 78%. In the context of the energetic crisis, which is acutely felt especially in wintertime, a good functioning of those energetic units is important and depends crucially on the precipitation that fall in the whole of Europe.

The maximum annual discharge of April 2006 destroyed the dams along the Danube, not only in Romania, but also in many countries across Europe.

The floods occurred in the spring of 2006 were very severe, their main causes being the following: a deep snow layer accumulated in the Black Forest mountains, in the Alps (348 cm of snow on 23 March 2006) and in the Carpathians (124 cm on the same date, Fig. 8); relatively high temperatures of up to 15-20°C in the latter part of March and the beginning of April led to a sudden snow melting and the abundant precipitation fallen in those periods, besides the added water layer -accelerated the snow melting rate.

High floods occurred both on the Danube and on its important tributaries Drava, Morava, Tisa, Velika Morava etc. The maximum discharge high flood, of 15800 m^3/s was the result of the aggregation of the high flood - on the Danube and on its important tributaries (fig. 1, 2, 8) [3, 6, 10].

Torrential rainfalls causing floods were recorded throughout the spring and summer of 2006, affecting every region of the country. Those floods often affected Oltenia province first, then moved and affected the whole country.

It was remarkable that the floods were induced by precipitation caused by very strong Mediterranean cyclones, whose frequency and intensities have increased markedly compared to the previous century.

Early spring coming has become frequent, but the frequency of late hoarfrosts has increased in turn, as well as the triggered damages, because when the hoarfrosts occurred plants were undergoing an advanced vegetation stage after the fast and early spring coming.

The rainy intervals were intense both in summer –in certain intervals- and in autumn. Seven consecutive rainy autumns were recorded from 2002 to 2008.

The secondary (autumn) precipitation maximum was higher than the main (spring-summer) precipitation one during some six consecutive years.

In 2006, damages recorded until 7 May amounted to approximately 10% of those from 2005. Thus, according to the situation centralized by the Ministry of Administration and Interior (MAI), published on Sunday, 7 May 2006, following Danube’s overflowing its banks, 12000 from 12 counties were evacuated, more than 3000 houses were flooded – 1078 of which destroyed and 122 were in danger to collapse on that date.

Simultaneously, 6086 households and annexes were flooded, along with 147 social-domestic units. 21000 ha. of land were subjected to controlled flooding, but 7.9 km of national roads, 408 km of county roads, 189 km of communal roads were however flooded. 44 bridges and 225 small bridges were destroyed and a number of pedestrian crossings were also affected by Danube's overflowing its banks and 13 localities were left without power. Eight electrical lines and 159 transforming posts were totally destroyed.

Until 7 May 2006, more than 140000 ha of agricultural land were affected across Romania by the high floods, foreseeing low agricultural yields with price and, certainly inflation increases. Following the spring 2006 floods, there were 28333 ha of wheat, 3354 ha of rape, 1228 ha of soy bean, 14040 ha of barley, as well as 32239 ha of pastures and hayfields and 33298 ha of early ploughing were affected, according to information released by the Ministry of Agriculture. Given the circumstances, state budget aids were considerable, and the annual investments for consolidating the dams were remade from zero.

In 2006, the restoration of the villages flooded along the Danube river, relocated outside the flooded area lasted for more than one year. The same issues were at stake for the villages that were practically wiped out, buried by the landslides.

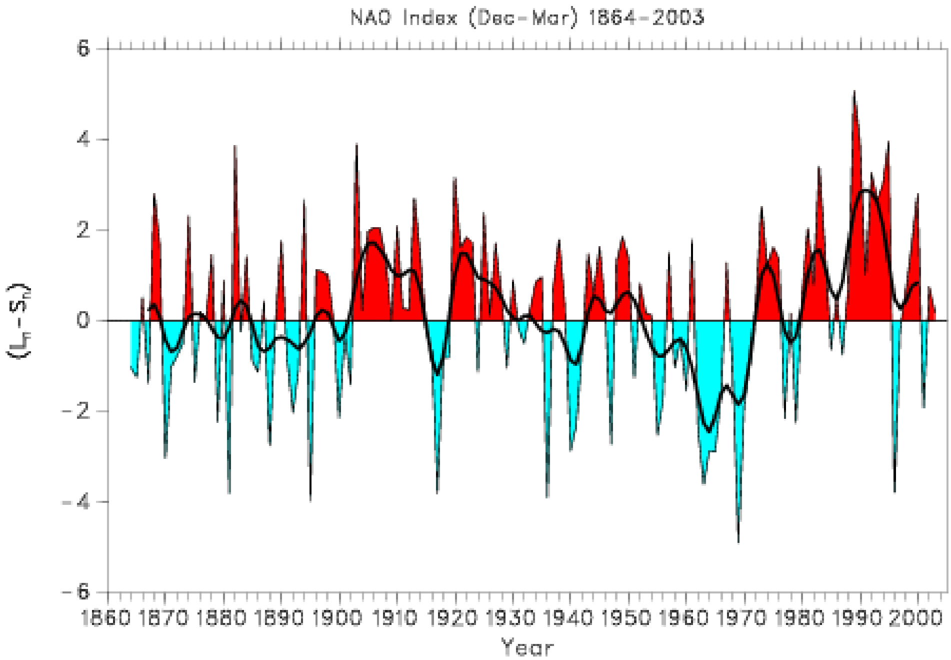

Figure 3 North Atlantic Oscillation Index in the 1864-2003 interval *(according to Todd Mitchell, 2002).*

Further, the meteorological situation in the spring of 2006 will be analysed for having caused the exceptional discharge on the Danube, i.e. the one on 15 April 2006 from Bazias.

It has been proved that the rainy periods correlate with minimum or decreasing to minimum solar activity. Also, the weather warming in wintertime in south-eastern Europe and in Danube's hydrographic basin of the Danube is in tight connection with the occurrence and preservation of the tropical circulations (cited authors). Rainy periods correlate with the negative phase of the North Atlantic Circulation (NAO[4]) [3, 6].

Figure 3 renders the standardized anomaly of the North-Atlantic Oscillation in Lisbon (according to Todd Mitchell, Mitchell@atmos. washington.edu, JIASO data, over the interval 1861-February 2002, NAO being the value of the atmospheric pressure in Lisbon minus the pressure in Stykkisholmur-Iceland, normalized by the mean of the atmospheric pressure anomaly in the March-December interval) [8].

Analysis of the meteorological situation which caused the exceptional maximum discharge of 15 April 2006

For the July 2005 – April 2006 interval, there was used the synoptic maps archive Archiv der AVN-Europaanalysen (ab 07.09.1999)**.**

Table 1 renders the results of the statistical analysis for the July 2005 – April 2006 interval. It can be noticed that the cyclonic-type activity in the hydrographic basin of the Danube prevailed in 76,6% of the days, of which the Mediterranean cyclones were prevalent in 31.0% of the days. Those cyclonic formations produced a large number of days with precipitation- falling as snow in the high mountain area.

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[4] The North Atlantic Oscillation is one of the important phenomena influencing the climatic fluctuations in the Northern hemisphere, from the eastern coast of the United States to Siberia and from the Arctic area to the subtropical region of the Atlantic. Although analyses based on data observed or simulated with global climate models indicated that predicting the Oscillation is theoretically possible to certain limits, the complexity of the phenomenon where diverse mechanisms are involved, at characteristic time scales, from several days to decades, makes it difficult to elaborate a complete predictive strategy.

Though limited, the predictability of the winter North Atlantic Oscillation phase can be important from the socio-economic standpoint, because of the impact that the phenomenon has on agriculture and on the management of the energetic resources- in Romania, as well as in almost the whole Europe. Necessary cooperation of climatologists with specialists in economy would allow optimum utilization by the potential users of the prognostic information concerning the North Atlantic Oscillation, with an evaluation of the ratio between the costs demanded by the preemptive actions and the losses inflicted if the prognostic information were not used (Roxana Bojariu, North Atlantic Oscillation, Ad. Astra 1 (4) 2002, www.ad-astra.ro).

In April 2006 there were 26 days with cyclonic activity, 15 of which in the 1-15 April interval, with 8 of those days marked by the activity of Mediterranean cyclones. That cyclonic activity brought precipitation mostly as rain, in significant amounts in the hydrographic basin of the Danube and not only. The induced atmospheric circulations in the various evolution stages of the cyclones, along normal or retrograde trajectories were: western, south-western, southern, south-eastern and north-western, thus maintaining for 15 days (26 in all throughout the month), warm or very warm air advection (if considering that calendar period).

That continuous, rapid and marked weather warming, associated with the liquid precipitation determined the fast melting of the snow cover in all the relief forms within the hydrographic basin of the Danube. In such circumstances the high flood wave formation lasted about 15 days.

Table 1. Number of days with cyclonic field in the hydrographic basin of the Danube in the July 2005-April 2006 interval (Source: processed archive data).

	Number of days with a cyclonic regime				
Luna	Cyclonic field in the upper and middle basin of the Danube	Cyclonic field in the lower basin of the Danube	Cyclonic field all over the basin.	Total number of days	Of which Mediterranean cyclones
VII-2005	13	10	7	30	13
VIII-2005	12	9	7	28	14
IX-2005	4	8	2	14	9
X-2005	6	7	3	16	10
XI-2005	4	11	5	20	4
XII-2005	7	6	9	22	10
I-2006	4	2	2	8	3
II-2006	6	4	6	16	4
III-2006	15	10	5	30	10
IV-2006	11	4	11	26 of which 16 in (1-15 April), 10 after 15 April	Of which 5 in (1-15 April), 3 after 15 April
Total	82	71	57	210	85
Total %	29,9%	25,9%	20,8%	76,6%	31,0%

The weather warming process on the European continent was initiated as early as on 21 March 2006 (Fig. 4), when north of the 45° N parallel cyclonic fields started to prevail, and south of it – the Azores High, thus ensuring permanence to the western circulation (warm air advection).

On 25 March 2006, the snow layer in the mountain area within the hydrographic basin of the Danube reached depths of up to 348 cm (Fig. 8).

In the 12-13 April 2006 interval, a strong Mediterranean cyclone affected the middle and lower basin of the Danube, yielding large precipitation amounts; and the intense warm air advection, as well as the liquid precipitation drastically accelerated the snow melting process (Fig. 5). As a result of the passage of this Mediterranean cyclone, Romania experienced floods that began in Banat, afterwards expanding all over the country.

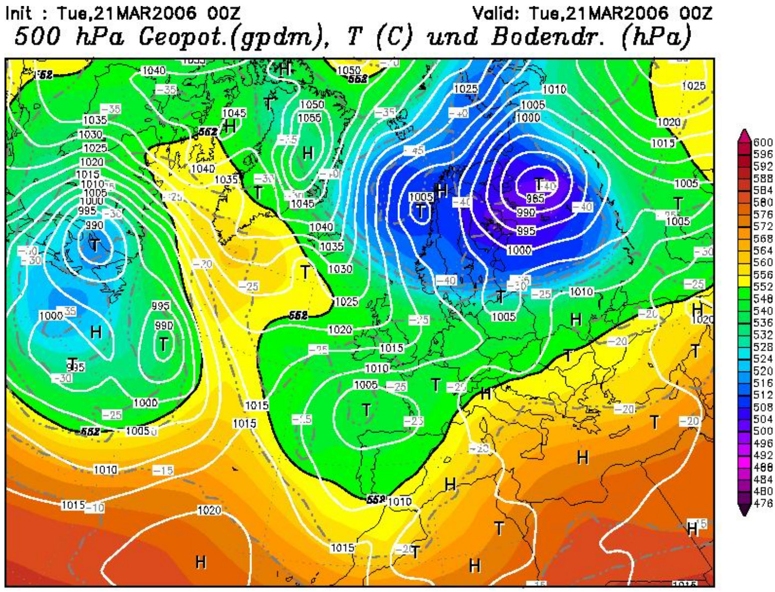

Figure 4. Synoptic situation at ground level and in the altitude at the level of 500 hPa over the European continent and at ground level, on 21 March 2006, 00 UTC (after Archiv der AVN-Europaanalysen, ab 07.09.1999, wetterzentrale.de).

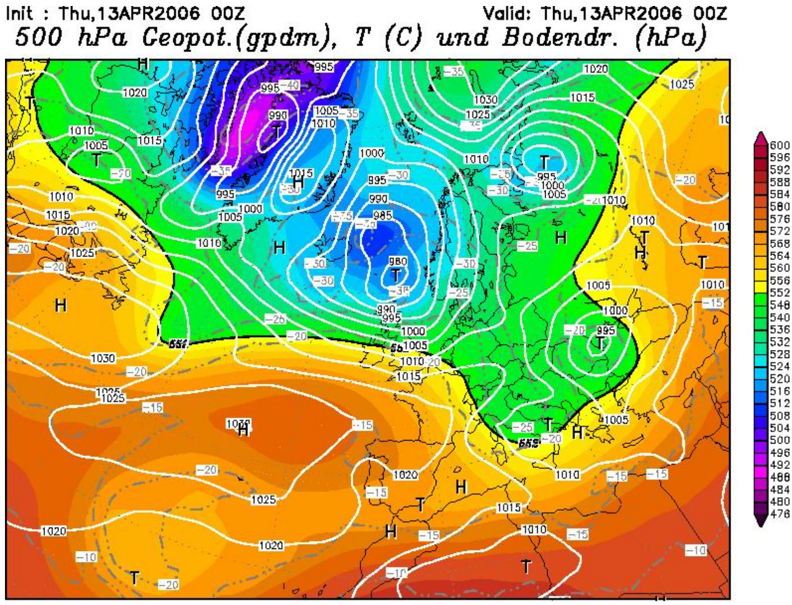

Figure 5. Synoptic situation at ground level and in the altitude at the level of 500 hPa over the European continent and at ground level, on 13 April 2006, 00 UTC (after *Archiv der AVN-Europaanalysen, ab 07.09.1999, wetterzentrale.de).*

The immense water volume flown on the Danube created a huge lateral pressure on the dams that gave in one by one, causing floods along most of the course, Figs. 6 and 7. Unlike in the 19th century the course of the large river is dammed up in most part and anthropization is heavy; thereafter the impact of the high flood and of the flooding was exceptionally severe. Figures 6 and 7 render the flooding caused by the Danube in the Rast-Negoiu-Bistretu Nou area, on 19 April and 3 May 2006 respectively.

It can be noticed that the general hydrometeorological situation is particularly complex, consisting in: the existence of a significant snow layer in the hydrographic basin of the Danube- especially in the mountain area; intense cyclonic activity, especially of the Mediterranean cyclones; prevalence of atmospheric circulations that preserved warmed air advection for about 25 days etc.

North Atlantic Oscillation Index in the analysed interval

The monthly North Atlantic Oscillation Index in the 2005-2006 interval is rendered in Table 2. Negative values are noticeable in most of the interval, which correlates with the abundant recorded precipitation, whereas the return to the positive +0.57 value correlates with the weather warming in that month.

The value of this index (pressure Gibraltar minus pressure Iceland version of the NAO index is really most applicable to the winter half of the year, Tim Osborn, 2009***) for the 2005-2006 winter period (December-March) was -0.82, according to the above mentioned authors, which again correlates very well with the plentiful precipitation of the 2005-2006 winter [8].***

Table 2. Monthly values of the North Atlantic Oscillation in the 2005-2006 interval *(after Phil Jones, cited by Tim Osborn, 2,009).*

Year	Months											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2005	+1.82	-2.25	-1.29	+0.71	-0.13	-1.00	-0.08	+0.94	+0.50	-0.45	-1.01	-0.81
2006	-0.10	-1.24	-1.12	+0.57	-0.22	-0.41	+0.83	-2.47	-1.02	-1.97	+1.70	+3.08

Figure 6. *Flooding along the Danube in the Rast-Negoiu-Bistretul Nou area, on 19 April 2006* (NMA archive, satellite, processed image).

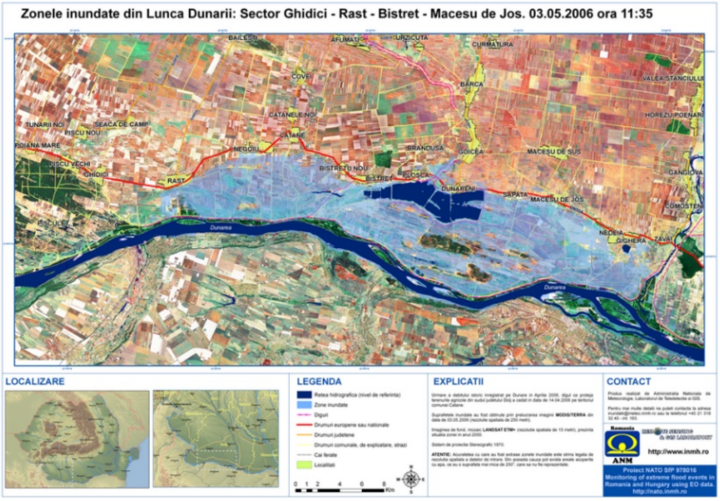

Figure 7, *Flooded areas in Danube's Meadow: Ghidici-Rast-Bistret-Macesu de Jos, on 3 May 2006, at 11:35 (upstream the confluence with Jiu river)* (NMA archive, satellite, processed image).

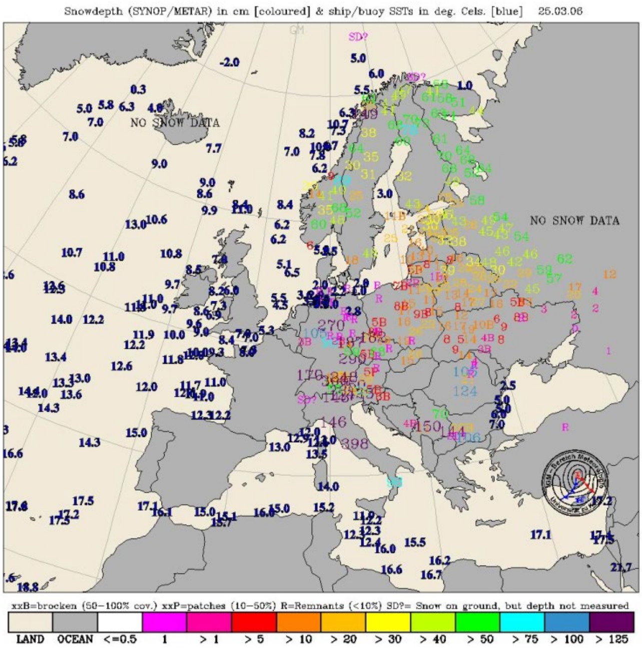

Figure 8. *Snow layer depth over the European continent on 23 March 2,006, at 00 UTC* (after wetterzentrale.de).

Solar activity

It can be noticed that the solar activity was on the decrease (Table 3), and that the monthly Wolf numbers variation points at a fast increase in April 2006, from 9,9 in March to 32,2 – a very good correlation with the fast weather warming and with the North Atlantic Oscillation.

Table 3. Wolf numbers in the 2,004-2,008 interval. (processed after ftp.ngdc.noaa.gov)

Year	Monthly Wolf numbers												Sum	No Wolf yearly
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII		
2004	39,4	50,0	50,8	37,9	47,4	41,9	55,9	48,5	32,8	49,7	46,7	18,9	519,9	43,3
2005	31,5	28,3	24,5	24,9	39,7	38,7	42,9	39,2	24,8	8,9	18,7	50,3	372,4	30,2
2006	**15,1**	**3,0**	**9,9**	**32,2**	**22,6**	**14,7**	**13,9**	**13,3**	**14,7**	**9,6**	**21,5**	**13,5**	**184,0**	**15,4**
2007	19,5	11,2	3,7	3,6	12,5	12,8	10,1	6,5	2,8	0,9	1,0	10,6	95,2	7,9
2008	2,3	1,6	9,8	2,2	2,5	3,0	0,4	0,2	0,5	2,4	3,6	0,5	29,0	2,4

4. CONCLUSIONS

The analysed hydrometeorological hazard situations are exceptional through the magnitude of the water volume flown on the Danube, the proportions of the triggered floods and their vast area, as well as through the impact on the affected localities and the value of the inflicted damages.

The described situations, a hydrometeorological hazard, consisted in a complex combination of factors: the existing deep snow layer, especially in the mountain area, the fast and continuous weather warming and the intense activity of the Mediterranean cyclones which yielded large amounts of liquid precipitation over wide areas, contributing decisively to the increase of the discharges of rivers within the hydrographic basin under scrutiny.

All those, in turn, contributed to the formation of the high flood wave on the Danube river, a process which lasted more than two weeks, the same as the high flood decline and the return to acceptable water levels, close to the normal values. Associated were the other factors, like the water-soaked soil, the slow infiltration processes, the almost non-existent vegetal cover, which caused rapid runoff from the slopes and yielded retention small values – all these leading to a higher runoff coefficient. Archive data show that the probability for such a situation to occur is once in a century.

The situation of April 2006 occurred in the second spring month, and the type of combination of the hydrometeorological processes was very complex. It occurred after a winter rich with precipitation, which was itself a continuation of the rainiest year ever recorded in the whole history of precipitation data existing in archives- the year 2005. In those circumstances the phreatic layers were saturated, having a reduced capacity to undertake a fraction of the water resulted from snow melting and precipitation, all of which augmented the volume of water discharged from Danube's hydrographic basin.

In today's circumstances of global climate warming, a phenomenon which enhances and accelerates the activity of the Mediterranean and Icelandic cyclones, and thus the hydrological cycle, the occurrence frequency of such hazardous situations is expected to increase. Forecasting the discharges on the Danube river is important from the economic standpoint and especially as regards the water uses. Irrigating the Romanian Plain in situations of intense drought seems impossible, because drought settles over wide areas on the continent and affects the whole hydrographic basin of the Danube river, with serious adverse repercussions on the economy and especially the agriculture of many countries. The unusual situations that produce exceptional discharges on the Danube river can be as serious as regards the effects as those when low discharges are at stake. The above displayed also show the wide climatic and hydrological variability in this hydrographic basin, and the highlighted correlations prove their complexity. That is why the cooperation of the two distinct departments, meteorology and hydrology, is essential in forecasting such situations.

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