ICE REGIME OF THE DANUBE TRIBUTARIES OF BULGARIA

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Abstract: Hydrological measurements and observations in Bulgaria have started since the very beginning of the 20th c. by water level and discharge measurements. Since 1924 they have included the water temperature and from 1935 – the ice regime.
Two main features characterize the river water temperature – the daily amplitude is rather narrow and the changes develop with a delay due to the higher specific heat of water, compared with the air.

Based on the existing Bulgarian hydrological information data bank we have discovered several general and local relationships. We have designed a map of the water temperature distribution across the area of the country, according to the prevailing water temperature in any one region. The regions with equal values of the temperature are united, because the uniformity in their values is being accepted as the index of the thermal homogeneity of surface water courses.
The analysis of the hydrological information, stored on the data bank have revealed a great diversity in the time of appearance/obsolete and the duration of the ice regime on the rivers in Bulgaria.

The area distribution of the ice regime's duration is presented on a map, made on the presumption of homogeneity of hydro-thermal conditions in the catchment areas, limited by any two successive hydrometrical gauge stations.
Thus, diversity of requirements of ecologists, engineers, geographers, hydrologists, pollution control administration etc. are matched.

INTRODUCTION

Studies on the ice regime of rivers are a natural continuation of those dealing with the thermal regime of rivers, since they comprise the forms and properties of water below 0ş C when it is converted into ice. The problem of ice formation draws the attention of ecologists because of the deteriorating living conditions of river biocenoses resulting from partial or complete freezing of rivers. Hydrologists also take keen interest in ice phenomena causing problems with safety ness of equipments, its normal operation and the safety ness of navigation on the Danube.

A close look at the Bulgarian scientific literature devoted to ice phenomena and ice regime reveals scarcity of information. These topics have been extensively dealt with by Petkov during the sixties of the last century. There are a few publications by Ivanov et al (1961), Marinov (1990), Penchev (1972) etc.

For reasons relating to the navigation on the Danube and the commitment of Bulgaria to the international agreements, approved by the Danube commission , the pioneering investigations on ice phenomena date back to 1936/37. Initially they were carried out at 15 ports along the Bulgarian Danube coast but their number was subsequently reduced to 7 including Novo selo, Lom, Orjahovo, Somovit, Svishtov, Russe and Silistra. Relevant data on the ice regime of Danube can be found in references listed in Thermal (1993).

Consistent observations of the internal Bulgarian rivers have been performed since 1950 (Ivanov et al, 1961, Marinov, 1990).

During 2001 and 2002 the total available information on ice phenomena was classified and filled in an open dialogue hydrological data base (Gergov, Karagiozova, 2002). This affords new approaches to be taken in studying ice phenomena.

QUANTITATIVE CHARACTERISTICS OF ICE PHENOMENA

The following quantitative parameters are generally used to characterize ice phenomena in rivers:

- Dates of appearance and disappearance Duration (in terms of days) in a given year.
- Frequency of a phenomenon over many years expressed as % versus the total number of years of observation.
- Thickness of ice in cm etc.

As evidenced by numerous observations the onset of ice phenomena occurs after “accumulation” of negative air temperatures above a certain critical level which depends on local peculiarities and conditions. This relationship is accounted for by the successive application of a simplified equation of the energetic balance

$$H_{er} = C_o (T_w - T_a)$$

Where Her is the thermal radiation across the water surface, C_o is an empirical coefficient of thermal radiation and T_w and T_a are temperatures of water and air respectively.

In some countries where advanced studies of ice phenomena are carried out as well (Hirling, 1982, Jovanovic and Vlasak, 1994), the sum of the negative temperatures serves as a basic prognostic factor. It depends on local factors and is considered an empirical characteristic.

The date of stable transition of air temperatures through 0°C is accepted as the beginning of winter and following it, ice phenomena are likely to occur. Fig. 1 shows how this date has been determined in two gauge stations in the watershed area of river Eleshnitza.

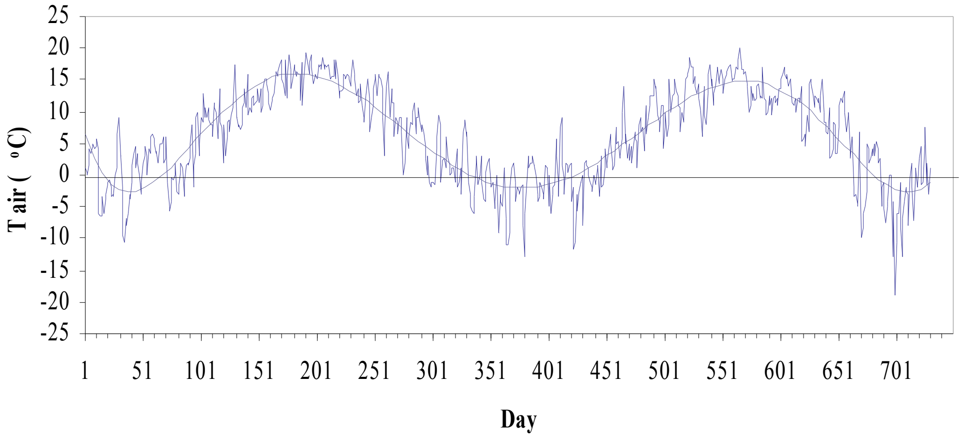


Fig.1. Determination of the “zero” transition of air temperature in gauge station Vaksevo at Eleshnitza river

The end of winter is determined by the stable rise in air temperature above 0°C as evident from the lines showing the air temperature and its transition through 0°C (Fig. 1). The interval between the two transitions defines the duration of an ice period. It has been established that the latter ranges from months XI to III in lowlands and from months XI to V in high lands (Ivanov et al 1961).

Long term observations and studies of a phenomenon and the diversity of its manifestations under various natural conditions have led to the formulation of the major dynamic factors underlying its appearance, namely

- Minimal river outflow
- Low aqueous temperatures
- Accumulation of low temperatures in the air
- Inflow of cold water or sludge from upstream or rivers
- Sudden drop in air temperature etc.

Some authors claim that intensive anthropogenic effects on rivers do not always bring about simple results for the ice phenomena and yield non homogeneous statistical information, the latter necessitating its preliminary examination by means of suitable criteria and methods (Thermal…,1993).

DURATION AND INCIDENCE OF ICE PHENOMENA

Table I presents data on the initial and the final dates of appearance of ice phenomena.

The statistical processing of the data led to the conclusion that the parameters, determined for any hydrometric gauge station, are representative of a watershed area above the corresponding station stretching to the boundaries of the upper gauge site or to the boundary of the area.

The average long term duration of ice phenomena was calculated as an arithmetic mean only for years when they have occurred. The characteristics of the ice phenomena are summarized in Table 2. Analogous data are shown in (Geography, 1982, Petkov, 1974) etc.

Table 1. Average duration and frequency of ice phenomena in some Bulgarian rivers.

River	Gauge Station	Ice phenomena 1960/61-89/90 1980/81-89/90		Duaration Month (XI XII I II III)	Frequency
		Start	End		(%)
Lom (Burza)	G.Lom	13.XI	30.III		100
Lom (Golyama)	G.Lom	17.XI	22.III		73
Lom	G.Lom	16.XII	16.III		30
	Traikovo	01.XII	06.III		93
Ogosta	Martinovo	02.XII	18.III		67
	Chiprovtzi	04.XII	10.III		97
	Givovtzi	05.XII	28.II		76
	Kobilyak	01.XII	04.III		70
	Mizia	28.XI	03.III		80
Skut	Nivyanin	12.XII	05.III		97
	Mizia	07.XII	06.III		97
Iskur	Govedartzi	01.XI	31.III		90
	B.Iskur	01.XII	31.III		87
	Novi Iskur				0
	Reburkovo	08.XII	03.III		50
	Kunino	12.XII	18.II		43
	Orehovitza	07.XII	28.II		80
Maluk Iskur	Etropole	07.XI	15.III		83
	Svode	28.XI	28.II		80
Vit	Teteven	01.XII	03.III		50
	Sadovetz	01.XII	04.III		70
	Turnene	01.XII	28.II		73
Ocum	Ch.Osum	07.XI	20.III		100
	Troyan	06.XI	05.III		80
	Lovech	15.XI	15.III		90
	Izgrev	20.XI	28.II		45
	Sanadinovo	09.XII	28.II		37
Yantra	Gabrovo	10.XII	28.II		30
	V.Turnovo	01.XII	14.III		63
	Karantzi	06.XII	02.III		53
Rositza	Valevtzi	02.XI	16.III		97
	Sevlievo	02.XI	17.III		90
	Vodolei	11.XI	14.III		87
Cherni Lom	Kardam	27.XI	03.III		30
	Shirokovo	18.XII	02.III		30
Tzartzar	G.Porovetz	08.XI	28.III		57
Senkovetz	G.Voda	08.XI	28.III		67
Kanagyol	Osenovetz	09.XI	20.III		67
Souha reka	Novo Botevo	21.XI	18.III		70

Two periods were included: the first ranges from 1961 to 1990 and the second ranges from 1981 to 1990. The establishment of these periods was motivated by the abruptly changed conditions for development of ice phenomena namely prolonged drought after 1981 in combination with decreased thermal and chemical pollution of the rivers the latter being due to the ensuing economic crisis and the closing down of numerous factories. Table 1 shows that:

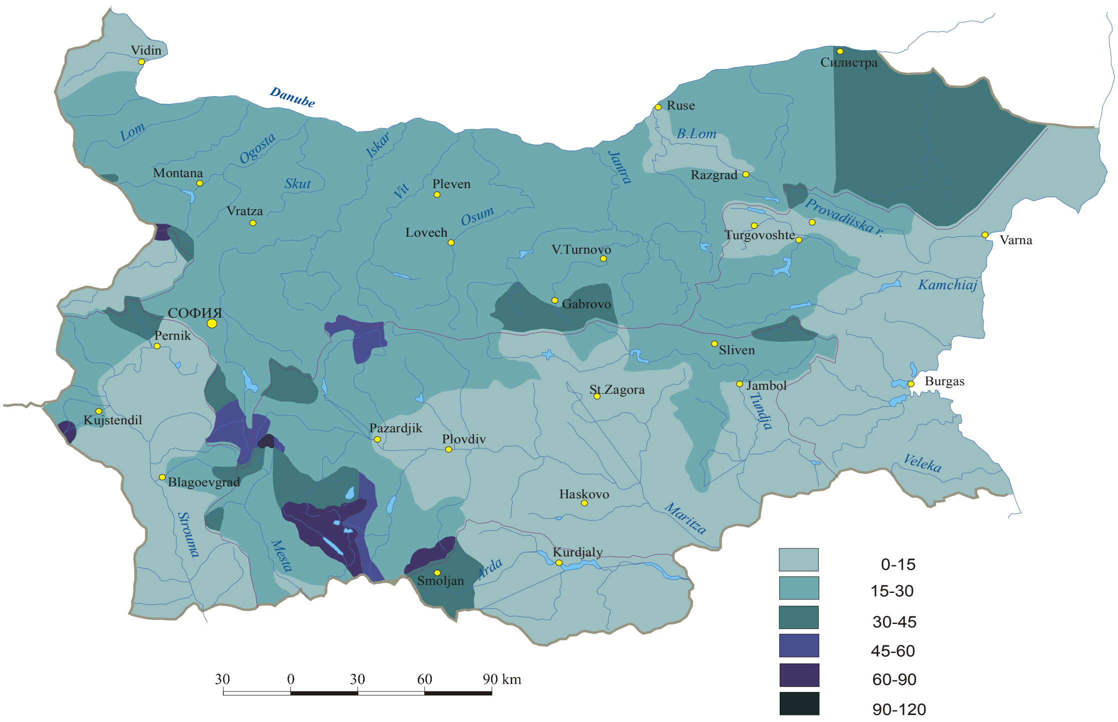
- The duration of ice phenomena reaches maximum values upstream of rivers and tends to gradually decrease downstream.
- Elevated temperatures and reduced water discharge in the rivers cause shorter living ice phenomena during the second period.

The presence of large and persisting sources of thermal and chemical pollution causes either shorter life of ice phenomena or their total elimination from the hydrologic regime of rivers, such being the case with the rivers Iskar, Maritza, Tundja, Struma etc.

MAPPING OF THE ICE PHENOMENA

Assuming homogeneity of the thermal conditions, which determine ice formation and encompass parts of water areas enclosed between two adjacent hydrometric gauge stations, the authors succeeded in mapping the duration of ice phenomena in Bulgarian rivers.

The ice phenomena with an average annual duration between 15 and 30 days proved to be the most widely spread, judging by the largest zone they occupied. As shown in Fig.2 this zone encompassed nearly the whole of Northern Bulgaria including the Balkans mountains. The duration of ice phenomena in all other zones ranges from 30 to 60-80 days. Climatic factors seem to be primarily responsible for their appearance. Ice phenomena (10-15 days per annum) are observed around the city of Russe and Targovishte. They are ascribed to the thermal pollution of air and water, caused by the big factories, which are situated in Russe, Razgrad, Targovishte and Omurtag.



Areas in Bulgaria, acording to the mean numbers of days with ice phenomena

(After Gergov, Karagiozova, 2002)

Fig.2 Zones in Bulgaria according to the average number of days with ice phenomena over a 30-year period from 1961 to 1990

The frequency parameters of ice phenomena, which are characteristic of the corresponding river area, are demonstrated by suitable coloring along the river course only in areas for which specific hydrologic data are available.

The incidence of the ice phenomena for the rivers in the Danube plain turns out to be around 37%, whereas in Mediterranean areas it reaches 28%.

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