

System of monitoring, forecasting and managements by floods in Ukraine

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Statutes of Ukraine, in particular, the Law on hydrometeorological activity and the Water Code, define that study, supervision over the current weather condition and water objects, estimations of tendencies and the forecast of their changes are in the competence of the state hydrometeorological service. The hydrometeorological service of Ukraine as integral structure was created in 1921. But the beginning of supervision at water levels of the rivers date from an earlier time. So, supervision on water levels of Dnipro River at Kiev have been started in 1877, and on a number of the rivers of the western part of Ukraine - in 1850. The first hydrometeorological observatory, which activity has begun development of the basic directions of studying, generalizations and the analysis of a an atmosphere condition, water resources, some other components of the geophysical environment, has been created more than 150 years ago - in 1885 at St. Vladimir's Kiev university.

The Hydrometeorological service of Ukraine now is part the Ministry of emergencies and affairs of population from the consequences of Chernobyl catastrophe of Ukraine. It has own network of hydrometeorological observations, representatives in all administrative regions of the state, corresponding technical, technological and scientific divisions. The State hydrometeorological service represents Ukraine in the World Meteorological Organization.

Ukrainian hydrometeorological centre is one of the leading organizations of the Hydrometeorological service of Ukraine. Its structure includes departments of meteorological, hydrological, agrometeorological forecasts, computer center, and communications service. The basic responsibilities of Ukrainian hydrometeorological centre are the effective analysis of hydrometeorological conditions in Ukraine, drawing up and distribution of operative forecasts and warnings of possible weather changes, a rivers regime, an agrometeorological conditions. Experts of the center also estimate possible consequences of hydrometeorological processes development on the close and removed perspective. Besides this, Ukrainian hydrometeorological centre carries out obligations of Ukraine on the international exchange of the hydrometeorological information and forecasts.

1. Structure and the primary goals of hydrological forecasts service in Ukraine

One of directions of the Hydrometeorological service of Ukraine and Ukrainian hydrometeorological centre activity, connected with monitoring a condition of the rivers and reservoirs, having the aim of their regime study, a forecast of its possible changes, an estimation of influence of such changes on branches of the economy, individual objects and the population is stated in the article.

There are more than 70 thousand rivers and brooks in our country by the general length 248 thousand km. Among them there are 3212 rivers with length more than 10 km. The largest and main river of Ukraine - Dnipro. Its length is 2201 km², the catchments area - 504 thousand km² [7]. Dnipro within the limits of Ukraine represents the cascade of 6th reservoirs; it is the basic source of water supply for almost 30 million inhabitants of Ukraine, a source of water resources for the industry, an irrigation of the grounds in the center, in the south and the east of Ukraine. The last is provided by incoming of Dnipro waters on a lot of the main channels and irrigating systems, such as Crimean, Kahovka, Dnipro-Donbass, Dnipro-Kryvyj Rig, etc. Among other rivers it is necessary to note such big rivers as Desna, Pripyat (these are large Dnipro inflows of the first order), Dniester, Bug, Tysa, Siverskij Donets.

By WMO definition [1], the criterion of an estimation of hydrological forecasts quality there is the fullest its conformity on accuracy and timeliness. It mainly depends on reliability and volume of hydrometeorological information, speeds of its receipt in the forecasting center, reaction time of a watershed on changing natural factors, a kind of a technique or a forecasting model, the necessary time for its reception by the consumer.

In Ukraine the providing of realization of these conditions in the certain degree is complicated. First, there are complexities with information filling of procedures with a real data through a lack of the automated observation network. Second, forecasts of weather parameters are insufficiently exacted and detailed for the lack of adapted national numerical models.

Procedures which are used for forecasts of the hydrological phenomena and processes are developed on the basis of the mathematical models, based on the fullest knowledge and the description of regional regularities of concrete hydrological process development. Frequently good results have empirical connections of a predicted phenomenon parameters from factors caused of it. However, at the flood forecast there are complexities with a prediction of a possible flooding zone due to lack of the adapted operative models of a stream flow.

Supervision over a water objects condition and a meteorological regime in Ukraine is carried out on the branched hydrometeorological network. It consists from 460 hydrological and 190 meteorological stations. The most of posts are not equipped with automatic gauges and data measurement technologies. It considerably complicates a process of hydrological estimations and forecasts, especially for the small rivers upstream. The data goes in the forecasting centers by the various ways: mainly on telegraph and phone, in some regions through radio and mobile connection, by satellite or e-mail. Frequency of data acquisition from hydrological posts in standard conditions - 1-2 times per day; at flood development - each 4-6 hours.

Despite of obvious lacks of an information hydrometeorological network, application of uniform techniques, devices and terms of supervision allows to provide a continuity, comparability and generalization of the data, their use for an estimation and the forecast of changes of national water resources condition, both during the nearest period, and on farther perspective.

Based on physico-geographical conditions of territory of Ukraine, on features of its rivers regime and a guidance substantiation the hydrological forecasts service or an operative hydrology is constructed on regional-basin principle and consists from 9 regional organizations.

They are located in:

- Kyiv (Ukrainian Hydrometeocenter, responsibility zone – Dnipro basin);
- Kharkiv (Kharkov hydrometeorology center, responsibility zone – the rivers of the east and southeast of Ukraine);
- Simferopol (Crimean hydrometeorology center, the responsibility - the rivers of the Crimean peninsula);
- Lviv, Uzhgorod and Chernivtsi (Lviv, Transcarpathian and Chernivtsi hydrometeorology centers, the responsibility - the rivers of the Ukrainian Carpathian mountains);
- Odessa (Hydrometeorological center of the Black and Azov seas, a responsibility zone - Southern Bug basin).

Also two hydrometeorological observatories (Danube and Svitlovodsk), in addition to performance of special hydrological works and researches, carry out a forecasting of hydrological regime on Danube and on the cascade of Dnipro reservoirs.

In the listed forecasting centers the gathering, processing and the analysis of primary supervision data are carried out, the current hydrological regime is estimated. Each of the

centers according to regional procedures and models makes and distributes forecasts of parameters of water objects regime for the responsibility zone of various advance time, and also the warnings about dangerous hydrological phenomena and their consequences. Annually Hydrometeorological service of Ukraine makes up and distributes from 750 to 1500 long-term forecasts and 3000-8000 short-term ones.

Concrete consumers of hydrological information and forecasts obtain the necessary data either directly from the center of forecasting, or through the regional and local hydrometeorological organizations. At a national level a distribution of the information is entrusted to Ukrainian hydrometeorological centre without dependence from the authorship of the forecast. The main consumers of hydrological forecasts and information are authorities and managements of all levels, the organizations of the Ministry of emergencies and affairs of Ukraine, of water-, municipal-, agriculture-organizations, water-power engineering and river navigation. Necessary materials are given by traditional communication ways, and also by e-mail, on direct telecommunication channels. Besides it the most of the data can be received on FTP and WEB - servers of Ukrainian hydrometeorological center.

Important aspect of activity of all hydrometeorological service of Ukraine is duly operative informing of subjects who are responsible for acceptance of administrative, organizational decisions, objects of managing and the population on the expected adverse hydrological phenomena. Concrete protective, precautionary or saving actions are carried out by local authorities together with the organizations of the Ministry of emergencies and affairs of Ukraine, of water management etc. at full information support on the part of the hydrometeorological organizations at national, regional, and local levels.

Schematically the order of providing with hydrological forecasts and flood warnings are shown on fig. 1.

Features of the rivers regime of Ukraine.

The geographical situation and orographical features of Ukraine causes a variety of the rivers regime. There are both the rivers with typically mountain character and with lowland one. Floods of various genesis pass on the rivers repeatedly; they are frequently accompanied by significant flooding and bring damage to objects, settlements and population. Among the dangerous hydrological phenomena it is necessary also to note the ice jams causing sharp rises of water levels and flooding; mudflows and snow avalanches which arise in mountain areas of Ukraine - in Carpathian Crimean Mountains. As in Ukraine the significant part of water supply comes from open water sources, the periods of insufficient water due to dryings of the rivers represents a danger also.

Among the most dangerous hydrological phenomena in Ukraine it is necessary to note floods on the mountain rivers and spring floods on lowland rivers. And if, according to WMO estimations, approximately 90 % of all catastrophes for last decade had a hydrometeorological origin, Ukraine is not exception.

Last 15 years in Ukraine were difficult enough from the hydrological point of view. On a background of an abounding in water cycle a frequency of floods formation with various genesis has increased. Many of them have catastrophic consequences. For the period from 1992 to 2004 on the rivers of Ukraine 22 high floods with negative consequences are marked.

The most significant floods have passed on the rivers of mountain territories of Ukraine: on the Transcarpathian rivers – in the autumn 1992, 1993, in the summer and autumn 1998, in March 2001; in Dniester basin - in the summer and autumn 1997, 1998, in the summer 2001; on the rivers of Crimea - July 1997; in Prut basin - June 1996, August 2005. Floods on the lowland

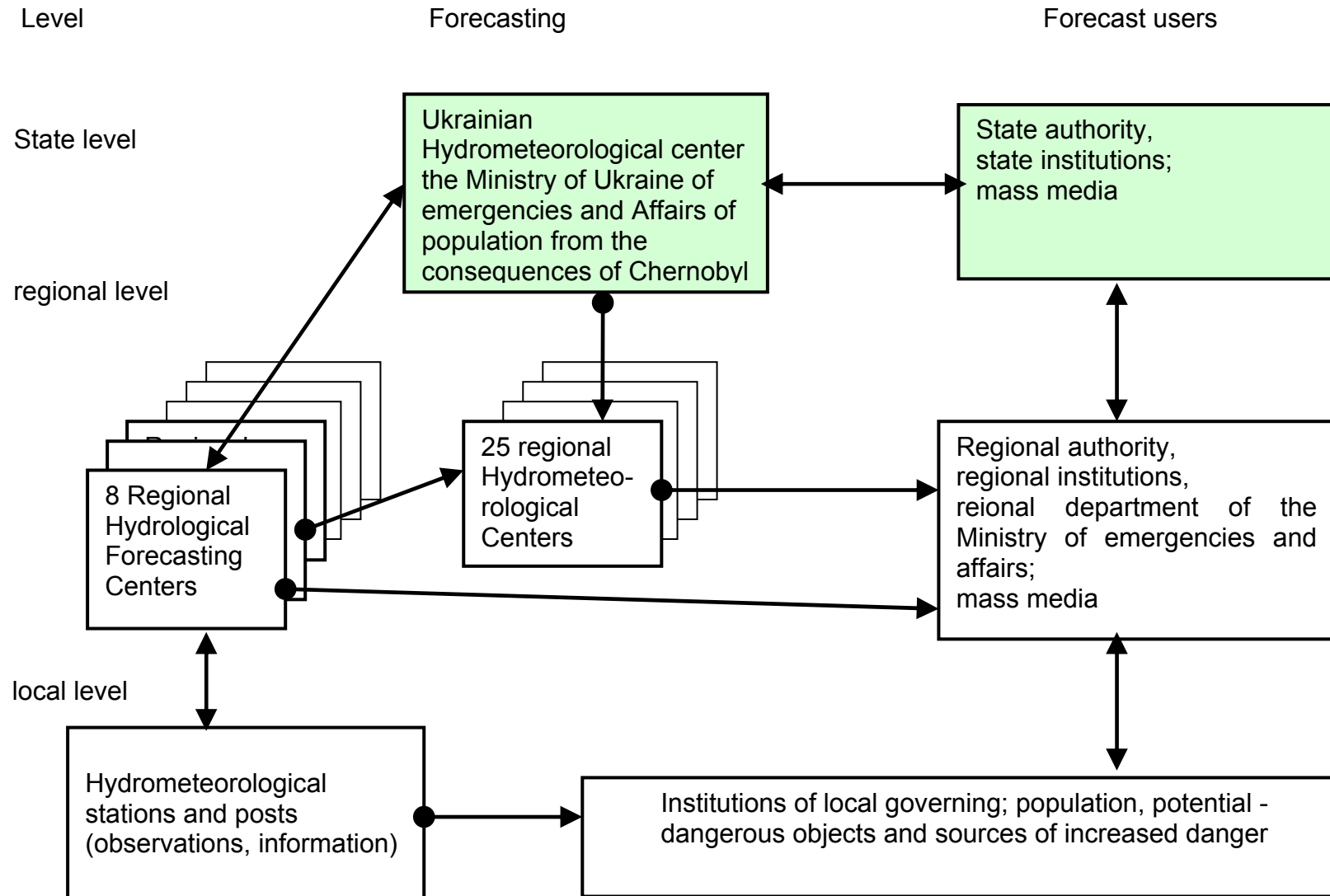


Figure 1. Scheme of providing with hydrological forecasts and flood warnings in Ukraine

rivers were no less dangerous. So, extensive rain flood was formed in the north of the country in Pripjat basin in July 1993, and there the highest spring flood after Chernobyl nuclear station accident was marked in the spring 1999. And the high spring flood with significant negative aftereffects in 18 of 25 administrative areas has occurred on the majority of the lowland rivers in the 1996th.

Two floods on the Transcarpathians rivers in November, 1998 and March, 2001 [4,5] were the most outstanding in the sizes and consequences. They are attributed to floods of very rare repeatability - 1 time for 100-200 years. Only during a flood in 1998 more than 42 thousand houses, transport highways, protective dams, electric mains have been destroyed and damaged, more than 21 thousand people have been evacuated. A major factor of these catastrophic floods occurrence on the Transcarpathian was the intensive rainfalls which have captured all rivers of the Upper Tysa basin. For three day (November 3-5, 1998 and March 3-5, 2001) the 3-4 monthly precipitation rate - from 100 to 200 mm have fallen, and on small watershed with square up to 100-200 km² - 208-282 mm (fig. 2).

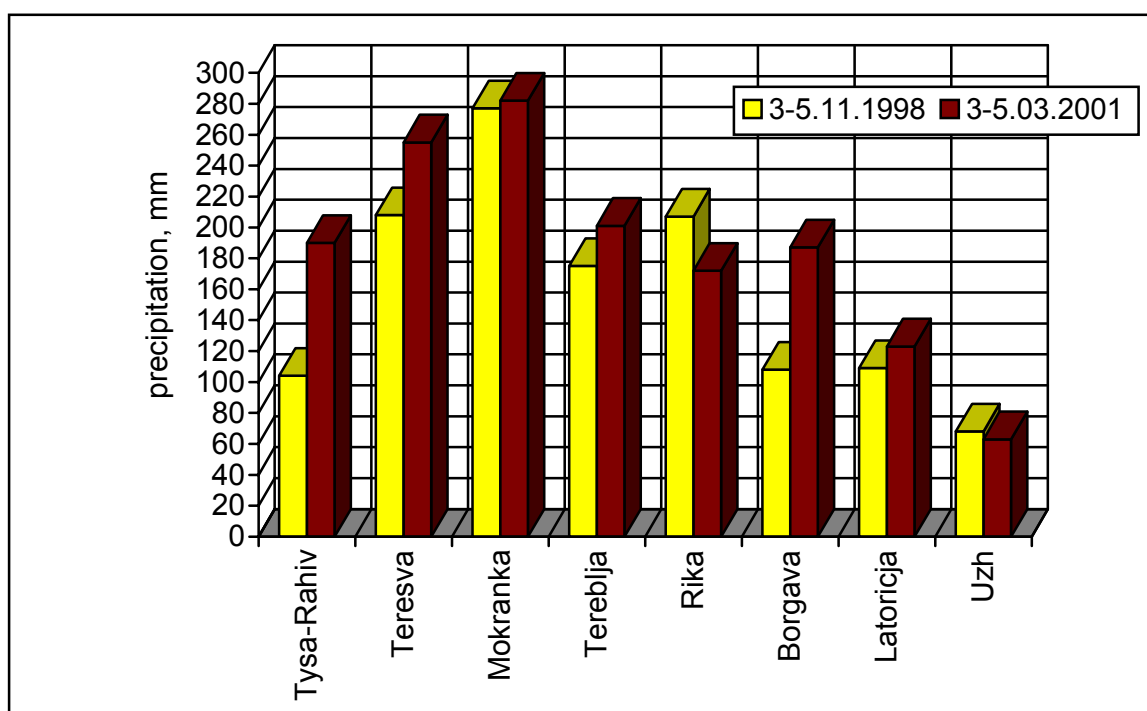


Figure 2. Comparisons of the precipitations sums for floods period in the Transcarpathian basin in November, 1998 and March, 2001

At the same time a frequently observed drying of the rivers of a steppe and subtropical zone of Crimea complicates a normal water supply of the population of peninsula if to this period in the basic Crimean reservoirs a sufficient fresh water reserve was not accumulated.

Active development of reservoirs and water resources of Ukraine increases an anthropogenous load, and quite often a negative consequences of the hydrological dangerous phenomena development intensifies a complex interaction both natural and anthropogenous factors. It is very difficult to take into account the last at making up of hydrological forecasts and warnings.

The basic types of hydrological forecasts

Thus, forecasts of the dangerous hydrological phenomena, especially floods, warnings of their development and consequences in Ukraine are very topical. The hydrological forecasts

service releases a short-term forecasts (advance time from several hours till 15 day) and long-term (advance time more than 15 day). It are:

- short-term flood forecasts and spring flooding and the storm warning about their consequences;
- long-term forecasts of elements of a spring flooding - maximum levels and discharges, volumes of a spring run-off;
- forecasts for branches of economy which functioning depends on hydrological conditions. It are, first of all, a water management and water-power engineering;
- storm warning about mudflow and snow avalanches, ice jams.

For stable development of an economic complex of Ukraine long-term forecasts of possible changes of hydrological regime parameters of the lowland rivers in result of snow-melting, i.e. forecasts of a spring flooding elements are very important. They are made up in February, their advance time, as a rule, not less than 20-30 days, and in many cases for the middle and big rivers - more than 40-60 days. Such forecasts, despite of the limited opportunities for the exact account of meteorological factors at the period from the moment of forecasting till time of occurrence of the predicted event, are greatly demanded.

The preliminary estimation of possible raising of water levels in the rivers owing to spring snow melting allows to define beforehand the possible flooding zones and a degree of risk for various territories, to plan actions on minimization of negative consequences. Long-term forecasts of spring rise of water levels in Pripjat River at a zone of Chernobyl nuclear station catastrophe have great value. On their basis the probability of flooding of the polluted flood plain is estimated and necessary protective actions are planned. So, in the spring, 1999 on Pripjat River the highest, after catastrophe on the atomic power station, spring flood was formed. Its exact and the preliminary prediction (for 15 day) has allowed to execute necessary protective actions and to prevent flooding the polluted grounds.

Forecasts of volume of inflow to reservoirs for the spring period, for a month and quarter are without fail used by organizations of a water management and water-power engineering for an establishment of operating regimes for the cascade of reservoirs on Dnipro, in which 44 km³ of waters are concentrated and which is the main source of drinking and industrial water supply in Ukraine [3]. The operating regime of Dnipro's cascade is established monthly by special Interdepartmental commission. It works continuously more than 40 years. Its structure includes the basic participants of a water-economic complex of Ukraine. The commission defines:

- sizes and intensity of the cascade reservoirs depletion before the beginning of spring and during the period of freezing-over,
- order of cascade filling in the spring,
- restrictions of water evacuation and fluctuations of levels by ecological criteria,
- control the order of high water passing through the cascade for prevention of undesirable flooding etc.

Similar tasks are solved by the Commission on use of water resources of Dniester reservoir. Last years the big attention is devoted to preparation and performance of artificial passing of waters from Dniester reservoir for maintenance of ecological equilibrium in Dniester outlet and Dniester firth.

Despite of difficulties of the exact forecast of water inflow to reservoirs on long intervals of time, use of such forecasts has advantages before use of average values. It is illustrated on fig. 3. In table 1 the basic types of forecasts which are made up and distributed by an operative hydrology service for the water-economic organizations and water-power engineering are shown.

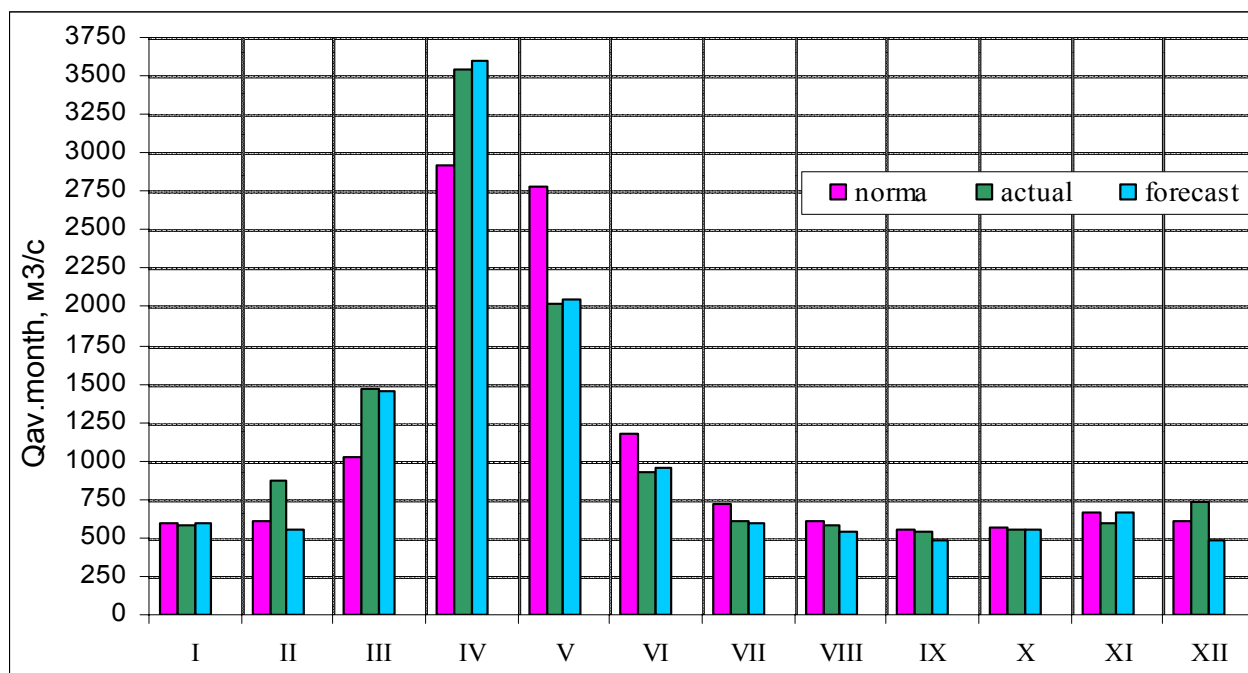


Figure 3. Volume of inflow to Kyivreservoir for a month: norma, actual value and forecast. 2004.

Table 1

List of water objects and main forecasts

Types of forecast	Forecast data	Water object
Average water inflow for - period from IV to XII - quarter - month - decade - day	25.III, 25.VI 25 (XII, III, VI, IX) 25 date of the preceding month 4,10,14,20,25,30 date daily on 1, 4 or 1-4 days	Kyiv, Kaniv, Dniester reservoirs
Spring run-off volumes - average monthly inflow	25.II, 5.III VI-XI	Kremenchuk, Dniprodzerzhinsk, Dnipro reservoirs
Spring run-off volumes	25.II, 5.III	7 reservoirs and 12-15 rivers
Maximum spring discharge	25.II, 5.III	Kyiv, Kaniv (from river Desna), Dniester reservoirs, 10-12 rivers
Spring run-off hydrograph	III-IV	Kyiv and Kaniv (from river Desna) reservoirs

The basic models and procedures of hydrological forecasts.

Nowadays for making up of hydrological forecasts the conceptual box models with the concentrated Rainfall-Runoff parameters are mainly used in Hydrometeorological service of Ukraine. These models are combined into complex information-forecasting systems with the suitable software. The author of the majority of guidance developments is Ukrainian hydrometeorological institute (UHMI). Research results of UHMI in the field of hydrological modeling are as much as possible finished with a level of their practical application, and focused on existing information opportunities of Ukrainian hydrometeorological network. They provide modeling and the forecast of flood run-off in view of high-altitude position and landscape-hydrological features of catchments or their parts [6].

Models DOSH and SNIH which are type of models Rainfall-Runoff and Snowmelt- Runoff are used for run-off forecast depending on genesis. The model DOSCH describes processes of non-uniformity of spatial distribution of precipitations, water-formations, evaporation, filtration and accordingly simulates a rain floods. The model SNIH allows to predict a snowmelt runoff through imitation of processes of a snow accumulation, changing in a surface condition of a catchments, snowmelt and runoff forming. A calculated interval is 6 h [6]. Modeling complexes Sloj 2W and System allow to make up the long-term forecast of a spring flooding. They enable to predict maximum levels, discharges and volumes with advance time from 20 till 60 days [2].

Success of the hydrological forecast is substantially defined by accuracy of an estimation of weather parameters change from the moment of its release up to term of beginning of a predicted level (charge). All guidance developments used allow either to obtain the modeling results for 3 (4) scripts of weather conditions, in particular, a precipitations regime during advance time of the forecast, or to input available weather forecast data by manually with the necessary detailed elaboration [2,6].

Application of flood run-off forecasting method described above has allowed to estimate a probability of floods beginning on Transcarpathians rivers the in November, 1998 and March, 2001 for 12 hours before, and to predict the maximum levels depending on current values for 2 - 33 hours before their formation, on the lower Ukrainian length of Tysa - for 75-87 hours. Absolute errors of maxima forecasting changed from 15 up to 30 cm, mean relative error 5% [4,5].

As it was mentioned above, in activity of hydroforecasts service of Ukraine there is a number of problems which constrain her further modern development. But after a catastrophic flood, 1998 on Transcarpathians rivers a number of the international projects in this one of most flood-dangerous region of Ukraine has been performed. As a result of realization of these projects the qualitative changes in Transcarpathians hydrometeorological network have taken place. The 33 hydrological stations were equipped with automatic gages having a full system of continuous observations over levels, water temperature, and precipitations. Also the 5 additional automatic gages were installed in zones of runoff formation. Communication is carried out through a radiocompilers network, and from some stations - through a satellite. All observers of stations have automatic digital terminals for manual input of parameters measured by manually.

Within the framework of project DANCEE "Flood management in Ukraine and Slovakia" the model Mike11 was received. The optimization and adaptation of model parameters were carried out by experts of Hydrometeorological and Water services together with experts of National Academy of Sciences of Ukraine using the continuous hydrometeorological time series 1996-20001 for Uzh and Latoritsja basins (basin of Tysa River).

Test of parameters of NAM and HD models on data of floods 1998, 2001 and their prediction by block Flood forecasting FF has shown good results. So, for the downstream of Uzh River the forecast of flood maxima in Uzhgorod gage station with lead time of 6 hours had an error of less than 10 cm. At that the Flood forecasting FF calibration for Uzh River at Uzhgorod was carried out with updating of calculations data on above located Zarichevo station, the frequency of forecasting was 4 hours.

The application of model Mike11 was expanded by experts of NAS of Ukraine for all Transcarpathians river network within the framework of project Tacis "Flood risk Assessment and Management Zakarpatska oblast". One of results of NASU experts' work under mentioned project is adaptation of the numerical model for weather prediction MM5 for conditions of Transcarpathian region with 5-by-5 km grid cells that is very important for forecast of fast-forming floods.

Wider use in operative work of modern hydrological models together with results of numerical weather forecasts, continuous monitoring of the current condition of rivers and weathers allows to improve essentially a quality, accuracy and information density of flood forecasts. Confirmation of it is higher forecasting degree of the flood for the Transcarpathian rivers in March 2001 in comparison with the flood in November, 1998.

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