IMPLEMENTATION OF THE MIKE-11 MODEL INTO REAL-TIME FLOOD FORECASTING SYSTEM IN UKRAINIAN PART OF TISZA RIVER BASIN

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1. Introduction

Ukrainian part of Tisza river basin is located in the mountainous zones of the Ukrainian Carpathians. The intensity of rainfall can be extremely high, and the resulting high rates of run-off from the catchments (flash floods) cause inundation of the adjoining low-lying areas forming the floodplains. This type of flooding frequently reaches disastrous proportions, resulting in ever-increasing property damage and social disruption. The last flood catastrophes occurred in 1998 and 2001 causing many casualties and leading to substantial loss of property. Flood occurred in 1998 was caused by intensive rainfalls (during 3-5 of November measured precipitation in region was 100-200 mm) and historical maximums were exceeded on 17 hydrological gauge station. Flood occurred in 2001 was caused by intensive rainfall and snowmelting. Historical maximums of 1998 year were exceeded on 9 hydrological stations.

At the point of time catastrophic events were occurred there was no automatic real-time flood forecasting system in region. In present paper described the first try in the creation prototype of regional real-time flood forecasting system in Ukraine. As a basis for real-time flood forecasting system was chosen the MIKE11 modelling system (DHI Software 2003). MIKE11 is a comprehensive, one-dimensional modeling system for the simulations of flows, sediment transport, water quality. MIKE11 modelling system was used for creation the set of regional hydrological models of Ukrainian part of Tisza river basin. The transformation of flow was calculated using the Mike11 rainfall runoff model NAM (Mike11-NAM) and hydrodynamic module of Mike11 (Mike11-HD).

The main goal was:

1. To collect all available hydro- meteo- data from 1998 till 2001 years. Especially data concern flood events.

2. To collect all available geomorhological data like river channel crossections for Tisza river and tributaries.

1. To create and to calibrate the set of regional rainfall-runoff models.

2. To create and to calibrate the set of hydrodynamic models of Tisza river and main tributaries.

3. To combine rainfall-runoff models with hydrodynamic models in completed regional hydrological model.

4. To create robust algorithm of real-time forecasting system.

5. To combine meteorological forecasting model MM5-Zakarpattia with regional hydrological model in terms of working real-time forecasting system.

It was decided to model the Tisza river and the main Tisza river tributaries with Mike11-HD. The remaining areas were to be modelled with Mike11-NAM. The NAM-models result in discharges at the upstream boundaries of the HD-models and lateral inflows along the HD-models.

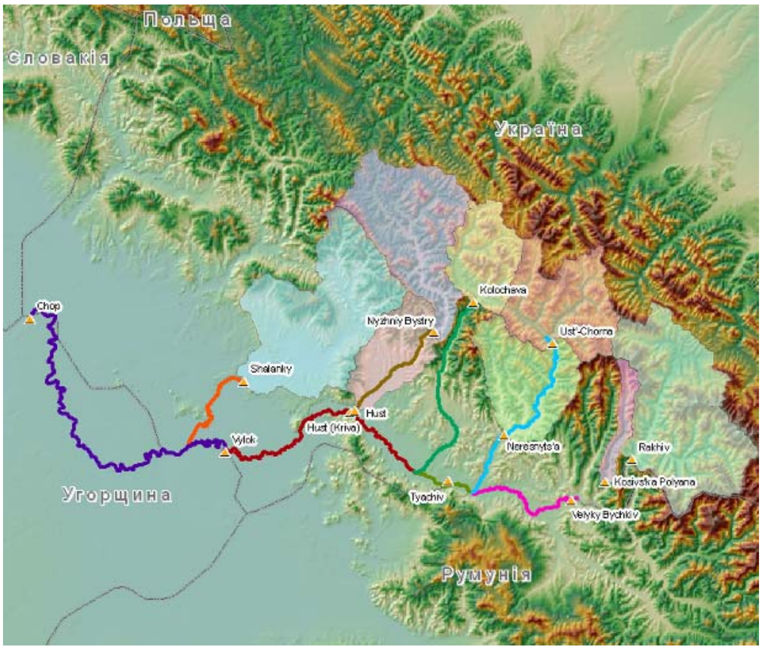

Figure 1.Mike11 HD and Mike11 NAM models coverage.

The areas that have no sufficient hydro-meteorological data for rainfall-runoff model NAM, were not covered by the model. The main concern is that not all watersheds have gauging stations at downstream locations, which determine discharge time series at the NAM-model outlet locations.

2. Development of the hydrodynamic model

Objectives of this part of the main task were:

1) To create the set of hydrodynamic models of Ukrainian part of Tisza with its main Ukrainian tributaries;

2) To create general hydrodynamic model of Tisza with tributaries which will be useful for integrating with rainfall-runoff models of upper Tisza catchments and further creating flood forecasting system.

Sections were only calibrated if proper hydrological data was available. Main problem was lack of proper discharge measurements. Most discharges were based on (sometimes old) rating curves (Q-h relations). The hydrodynamic models have been primarily calibrated on the peak of the flood waves (Murota et al.,1989). Secondary calibration and verification criteria are the mass balance, shape of flood wave and the low flow periods. These were also taken into account and corrected for if possible.

The models are calibrated by varying the hydraulic roughness of sections in between gauging stations. The calibration was made for 1998.

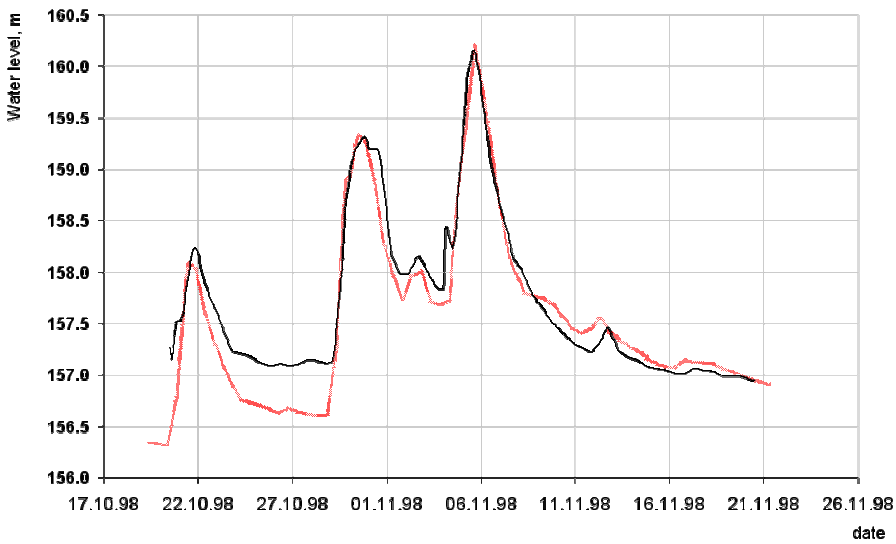

Figure 2. Verification of hydrodynamic model with outlet point Hust, Rika river, flood 1998(red line – simulated, black line - observed)

3. Development of the rainfall-runoff model

Objectives of this part of the main task were:

1. Set up rainfall-runoff models Mike11 NAM for upper Tisza catchments.
2. Calibrate models on data of catastrophic floods of 1998 and 2001.
3. Prepare calculated by model runoff for input in hydrodynamic model of Tisza.

It was derived seven watersheds of Tisza basin for NAM-modeling. For each watershed was established individual NAM-model (see **Ошибка! Источник ссылки не найден.**). As boundary conditions precipitation and temperature data were used.

The models are calibrated by varying the following parameters (Madsen et al.,1999):

- maximum water content in surface storage
- maximum water content in root zone storage
- overland flow runoff coefficient
- time constant for interflow
- time constant for routing interflow and overland flow
- root zone threshold value for overland flow
- root zone threshold value for interflow
- baseflow time constant
- root zone threshold value for groundwater recharge

The calibration was made for 1998-2001. During calibration especial attention was paid to high flood events November of 1998 and March of 2001. Models were verified for the period from January of 1998 to December of 2001. Being a good verification means coincidence of observed and simulated trends of discharge time series and approximately quantitative coincidence (error ~10-15%) of observed (or derived from Q(H) relation) and simulated discharges on flood events (Duan et al.,1992).

Here are some example of verifications (black line – simulated, red line – observed-reconstructed from Q(H) relation):

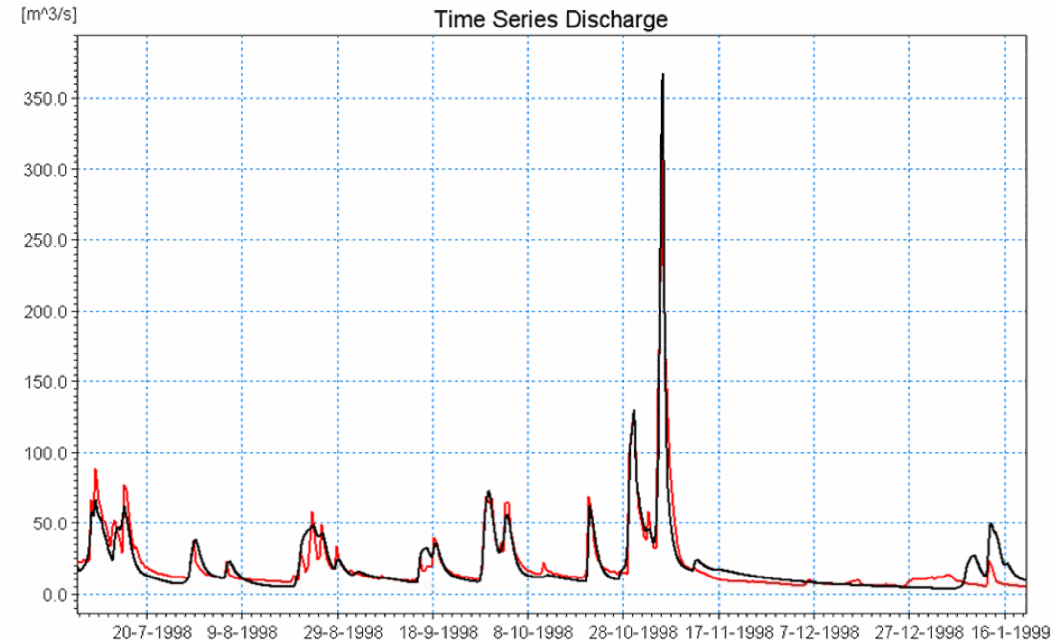

Figure 3. Verification for outlet point Kolochava, Tereblya river, flood 1998

4. Flood Forecasting mode

This task was solved by construction the following chain of models:

1. The 3 days forecast of temperature and precipitation is calculated by MM5-Zakarpattya model. MM5 server locates in Zakarpattya HydroMet Center, though a backup

calculations are performed on the MM5 server in Ukrainian Center of Ecological and Water Projects, Kiev; the calculations are put on the Internet and can be transferred to Zakarpattya HydroMet Center.

2. The forecast data is stored in the common database; the forecast can be viewed/corrected by an operator of database client.

3. Combined historical and forecasting data for temperature and precipitation are converted to Mike11 time series format *.dfs0. The files are put to the Mike11 directory.

4. Mike11 software runs; output - *.dfs0 time series of water discharges in the predefined location of the region (hydrological stations)

5. Calculated discharge time series are extracted and stored in the common database.

6. The forecasted water levels are calculated from the forecasted discharges by the statistical curves H = f(Q), that are the part of the common database.

7. The forecast data can be viewed by the operator of HydroMet Center using the database client.

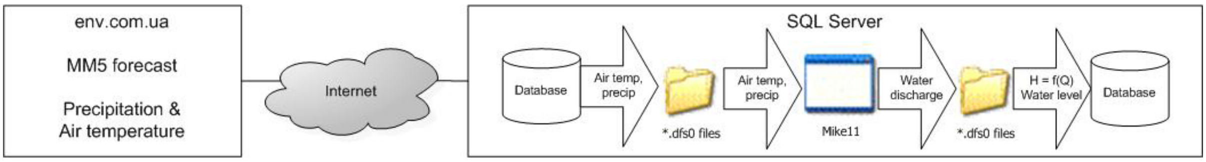

Figure 4. Detailed model chain MM5 – Mike11 – Zakarpattya VodGosp database server.

5. Outputs

The main output of work is prototype of real-time flood forecasting system that based on automatic working chain “meteorological model->set of hydrological models->data base”

Also within work some useful results were obtained:

1. Output of rainfall-runoff modelling is seven calibrated and verified models for main Ukrainian Tisza tributaries. Analysis of verification shows proper result for rainfall flood for all catchments with error is 10-15%. The results of modelling can be used for active hydrological forecasting in automatic mode MM5->NAM->Discharges for outlet point. To use in automatic flood management system. Results of rainfall-runoff models are input data (boundary conditions) for hydrodynamic model of Tisza.

2. Output of hydrodynamic modelling is the set of models which describe the dynamics of channle flow of Tisza and main tributaries. These models are very useful for flood plains forecasting and for design and analysis of flood mitigation measures on Tisza river and tributaries. The hydro data obtained from the system are not as good as desired, but they can reliably predict short-time flood events on Tisza.

6. References

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