Integrated actions for joint coordination and responsiveness to flood risks in the Cross Border area

PP 4: NATIONAL INSTITUTE OF METEOROLOGY AND HYDROLOGY - BULGARIA

Deliverable 4.4.5

Upgrade and further development of existing flood forecasting systems (FFS) for Maritsa and Arda rivers

The Project is co-funded by the European Regional Development Fund and by national funds of the countries participating in the Interreg V-A "Greece-Bulgaria 2014-2020" Cooperation Programme.

https://floodguard-interreg.eu/

Upgrade and further development of existing flood forecasting systems (FFS) for Maritsa and Arda rivers

1. Assessment of existing hydrological forecasting and early warning system (EWS) for Maritsa River basin

Development of the Early warning system for the Maritsa River and Tunzha rivers watersheds https://maritsa.meteo.bg was finalized in 2009 with the official name of the project "Technical Assistance for Flood Forecasting and Early Warning System for the Maritsa and Tunja Watershed". It was implemented by an international consortium with a Mike 11 type rainfall-runoff hydrological model (NAM) and hydrodynamic model (HD). The system was completed in 2009 with funding from the PHARE program. The water levels of the rivers in 15 settlements in the Maritsa river basin and 6 settlements in the Tunzha river basin are forecast for up to 5 days ahead with a step of 1 hour (Fig. 1).

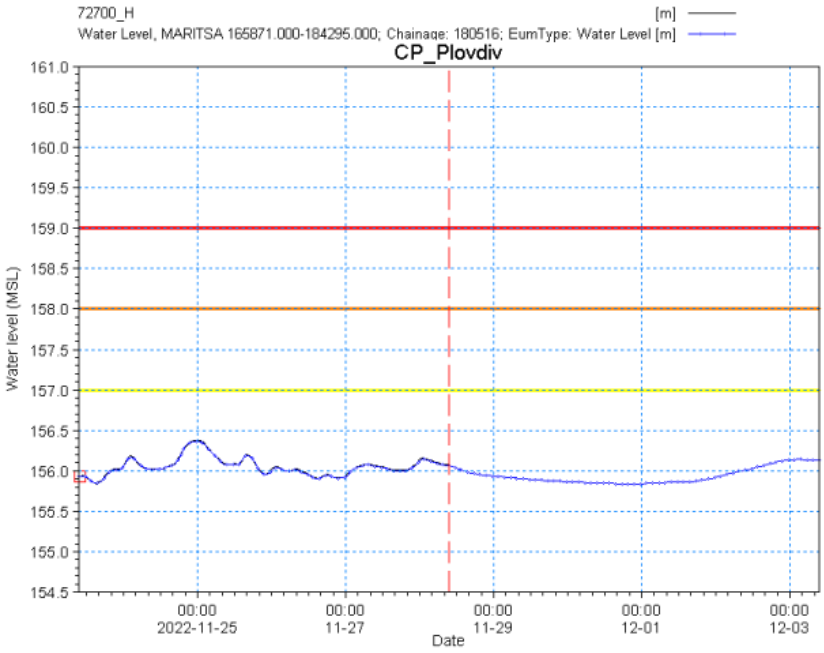


Fig. 1 Forecast of the Maritsa River levels in Plovdiv for the next 5 days is shown after the vertical red line. Waring levels are located at 157, 158, 159 a.s.l. levels associated with the elevation of river embankment.

The system is fed by data measured by NIMH and forecasted by the Limited Area Regional Atmospheric Model ALADIN-BG. Former software Mike-11 FLOODWATCH is using single core of the processor and is not scalable over the modern multi-core processors. Moreover it is built to run in tandem with GIS software ArcGIS version 9 that is not fully supported

anymore The forecast part of the model has the name FLOODWATCH and since 2009 has been superseded by a new version running under Windows 10 with the name Mike-HYDRO. The old version is depreciated and support is not available from the software producer - Danish Hydraulic Institute (DHI). Visualization of the forecasts is performed by a highly intuitive MapServer interface (Fig. 2).

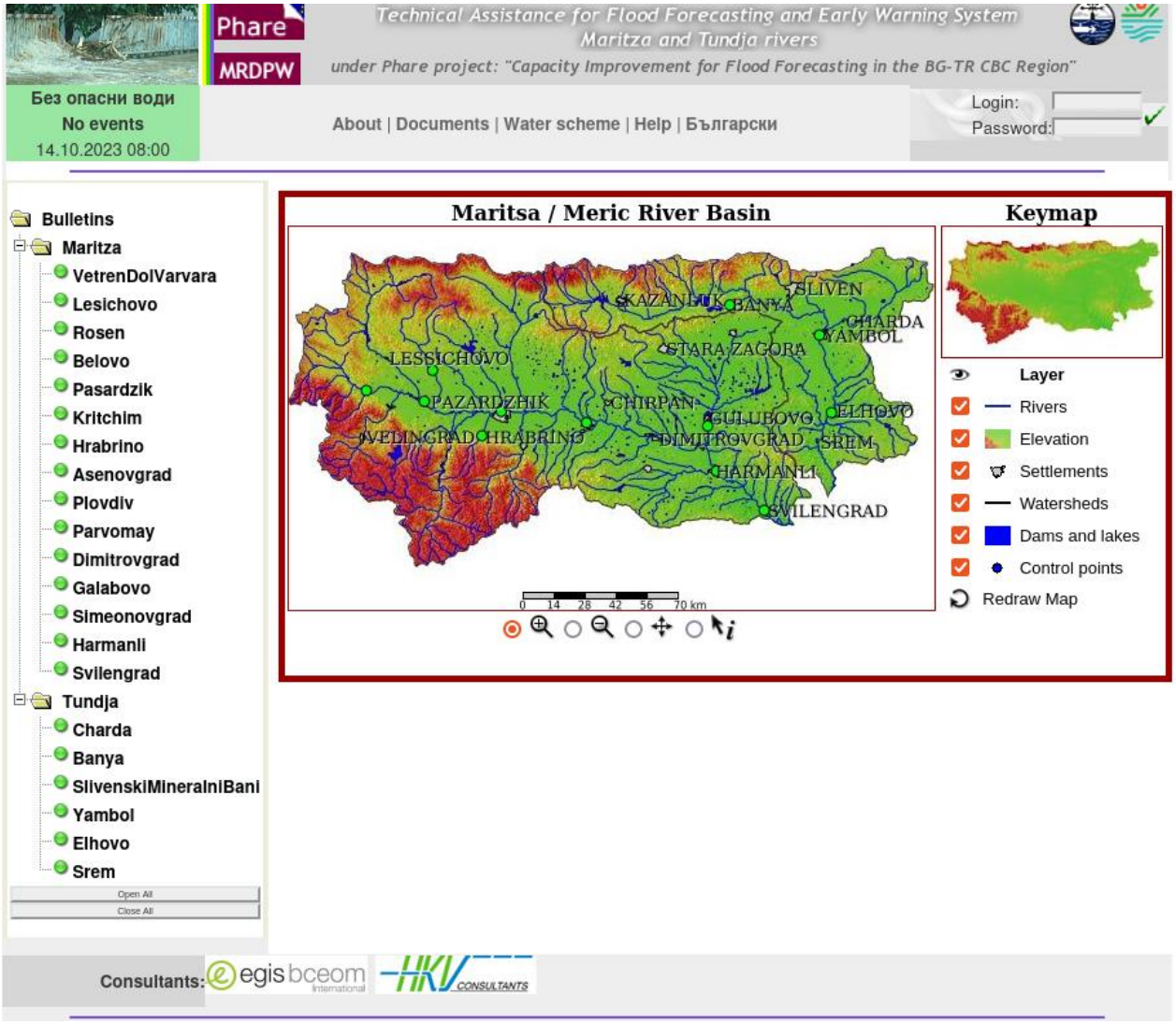


Fig.2 MapServer web interface of the former Maritsa-Tundzha EWS.

2. Evaluation of possible upgrades of the EWS for Maritsa River basin

An upgrade of the software of EWS Maritsa-Tundzha is needed in order to implement the multi-core version Mike-HYDRO and to ensure sustainability of the forecasting and early warning system. Related to that, the database for the forecasting results and visualization of forecasts needed to be adapted to the new Mike-HYDRO output with a modern web interface. It was decided to implement the new version Mike-HYDRO only for Maritsa River

basin as Tunzha River is out the projects eligible area (Tundzha is flowing through Bulgarian-Turkish border).

3. Assessment of existing hydrological forecasting and early warning system (EWS) for Arda River basin

To predict riverflow many different methods may be used. In the past more often statistical methods were used for large river basins. Knowing the precipitations and the water levels in the upper part of the basin, with statistical approach were forecasted water levels in the lower part of the basin. Nowadays with the increasing intensive rain and respective flashflood frequencies this approach is no more suitable. Flashfloods occur for periods sometimes as short as one to three hours after the intensive precipitation is registered. Therefore we must if possible predict the event days before its happening. Here come to help numerical weather models that more or less successfully are predicting the precipitation intensity and location. When we feed a hydrological model with data coming from a forecasting meteorological model we can predict to some extend the water levels corresponding to the forecasted precipitation intensity and location. In ARDAFORECAST project finalized in 2013 we combined precipitation and air temperature data from the following weather forecast models: A. Regional scale short range ALADIN model—3 days ahead forecast; B. Global scale model - European Centre of Medium Range Forecast (ECMWF)—5 days ahead forecast.

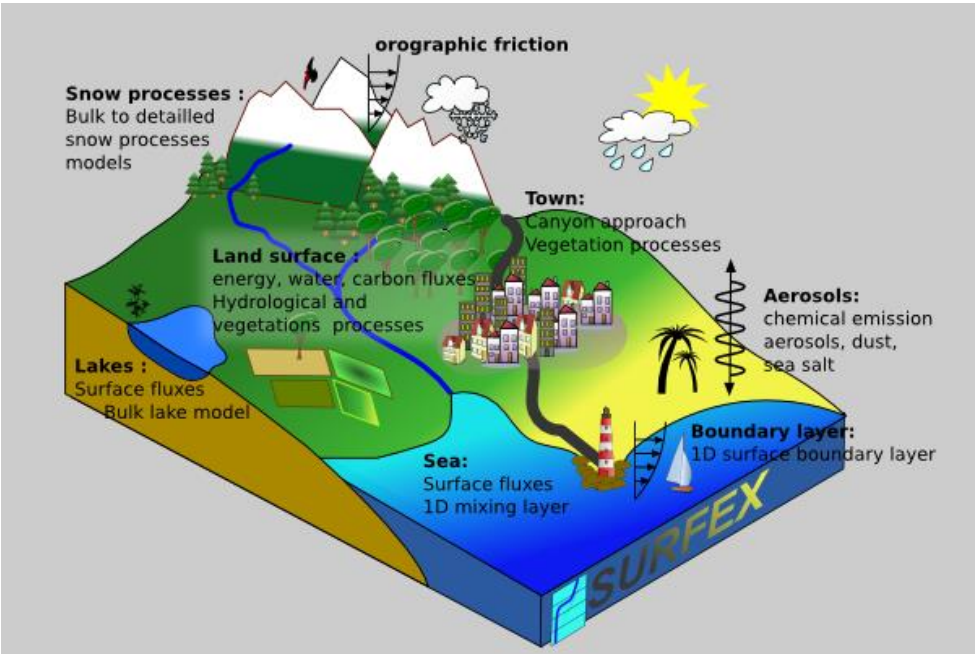


Fig. 3. Schematic of SURFEX LSM with detailed processes parameterization (http://www.cnrm.meteo.fr/surfex)

The hydrological model usually deals with predefined amounts of runoff and drainage water that it routes through the river network until it reaches a river cross-section of interest (that we “hot-point”) for which we compute the forecasted discharges. The computing of surface runoff and drainage per-unit area here is made by the surface scheme ISBA. ISBA (Interface Soil Biosphere Atmosphere) as other specific models is built into SURFEX—the Land and Ocean Surface Platform for the simulation of earth surface variables and fluxes (Fig. 3) developed by the scientific community lead by CNRM—Meteo-France. The hydrological model coupled with ISBA is a version of TOPMODEL that is based on the basin topography. The coupling was firstly developed for the simulation of fast floods in Mediterranean region in France. That makes the models suitable for the ARDAFORECAST project dealing with Mediterranean rivers too.

4. Evaluation of possible upgrades of the EWS for Arda (ARDAFORECAST) and additionally Byala (Erithropotamus) River basins

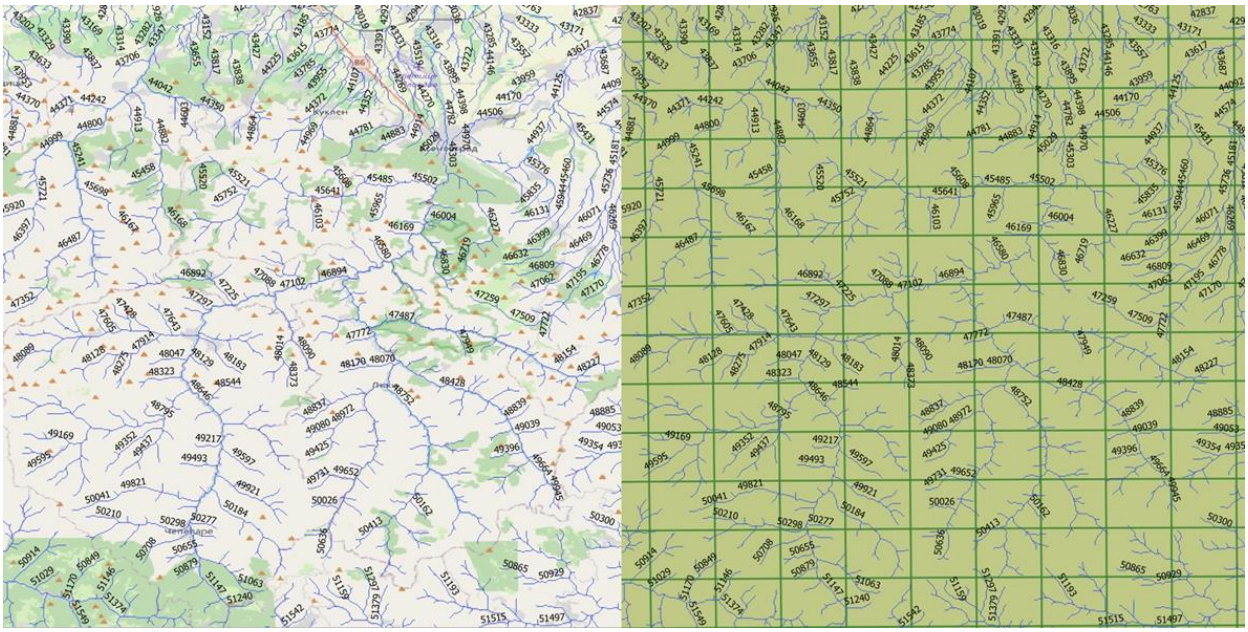


Fig.4 Hydrological (left) and meteorological cells (right) of distributed model SURFEX – RAPID

More detailed approach to the river flow forecasting needed reduction of meteorological grid of the LSM SURFEX. Enhanced resolution (Fig. 4) is permitting better simulation of high flow peaks both in timing and spatial distribution. Therefore we estimated reduction in spatial resolution and additionally a reduction in the temporal step of ARDAFORECAST system from 3 h to 1 h. The new routing model RAPID was chosen in order to simplify extraction and simulation of more river segments as “hot-points”. At the same time we

increased the number of “hot-points” where the streamflow is forecasted from 19 for ARDAFORECAST to 24 including Byala River (Erithropotamus) in FLOODGUARD project.

5. Further development of existing flood forecasting systems (FFS) for Maritsa River

After the purchase, installation and testing of DHI Mike-HYDRO software by DHI staff the NIMH team involved in the FLOODGUARD project studied the new software (Fig. 5), prepared new data base and new dataflow to feed the FLOODGUARD EWS. About Maritsa River basin new Mike-HYDRO model is put into operational regime.

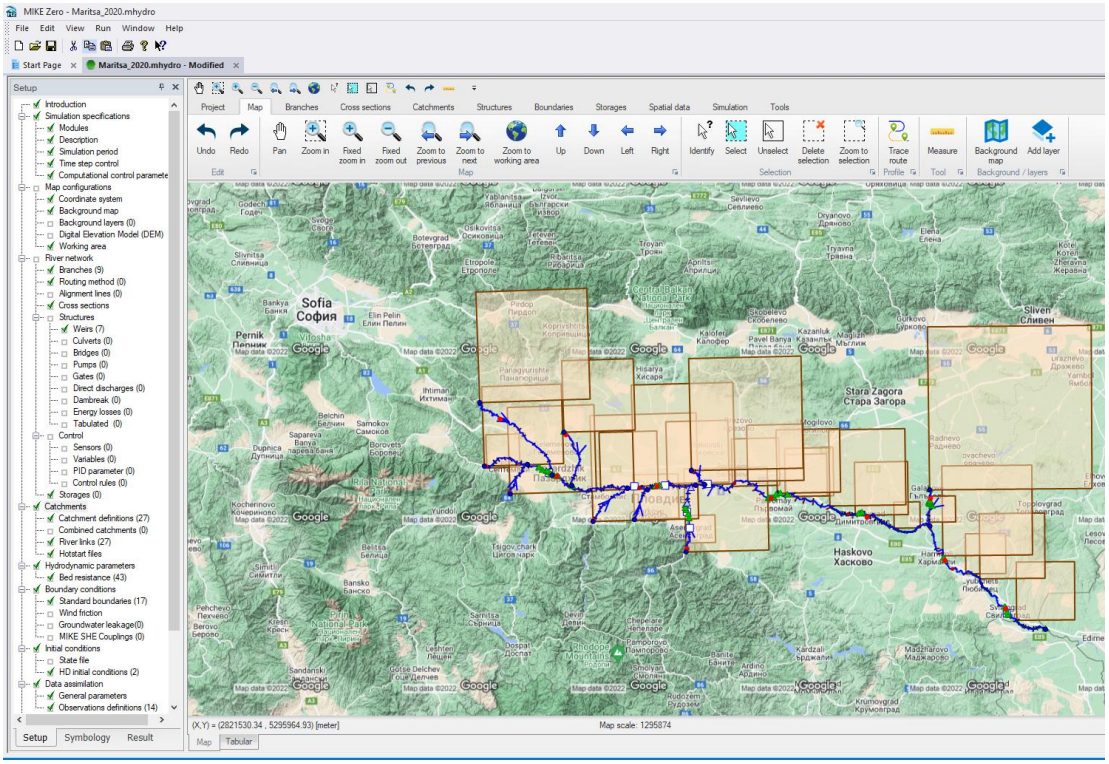


Fig. 5 The screen of development tool for Mike-HYDRO software for Maritsa River

6. Further development of existing flood forecasting systems (FFS) for Arda and Byala river basins

Project	Number of cells	Size of the cell	Number of “hot-points”	Time step
ArdaForecast	129	8 km	19	3 h.
FLOODGUARD	468	4 km	24	1 h.

Tab. 1. Differences between the modeling parameterization of the ARDAFORECAST and FLOODGUARD systems for simulation and forecasting of streamflows of Arda and Byala rivers.

New coupled model SURFEX-RAPID[1] was developed based on knowledge on SURFEX and newly adapted in NIMH RAPID[2] routing software (both with open source software licensing rules, see https://www.umr-cnrm.fr/surfex/spip.php?rubrique8 and http://www.rapid-hub.org/download.html) and tested over Arda River basin and two tributaries of Maritsa River. Hydrological model, consisting of SURFEX land surface scheme and RAPID river routing model over the meteorological grid of 4x4 km grid was developed, calibrated and tested for basins of Maritsa and Arda rivers with RAPID runoff model. Data series with 1h step of measured precipitation, air temperature and relative humidity, global and atmospheric radiation as well as the forecasted fields (ECMWF, ALADIN, AROME models) of the same variables are analyzed and stored continuously in a MySQL database (Fig. 7). The hydrological model and the data series where tested for the catchments in Arda River basin with good results. Automation software (Fig. 6) and Linux shell procedure was programmed in order to implement the new set-up of the hydrological model for Arda river basin in the NIMH working environment.

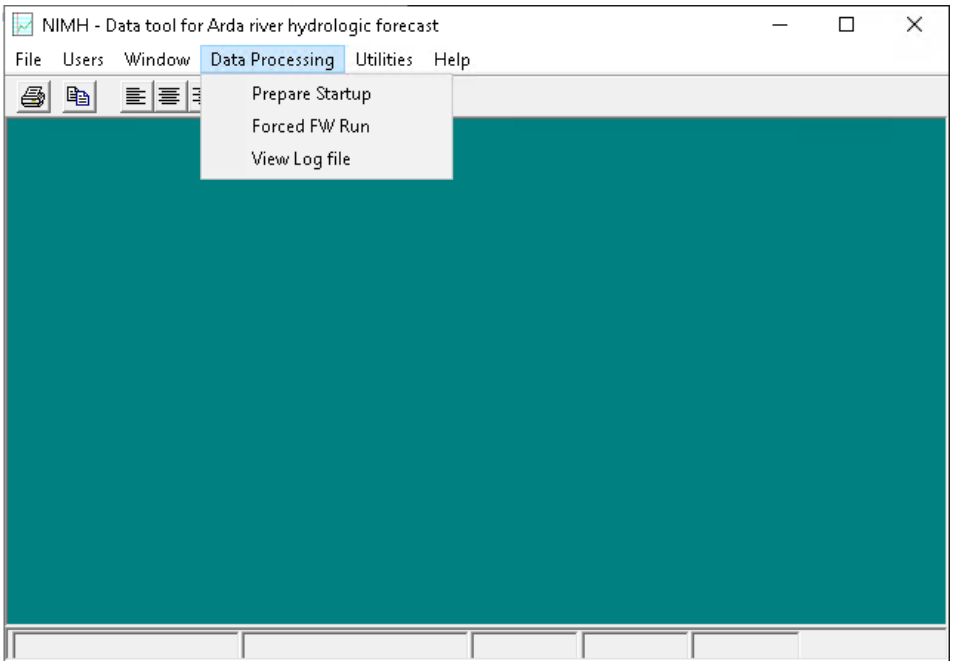
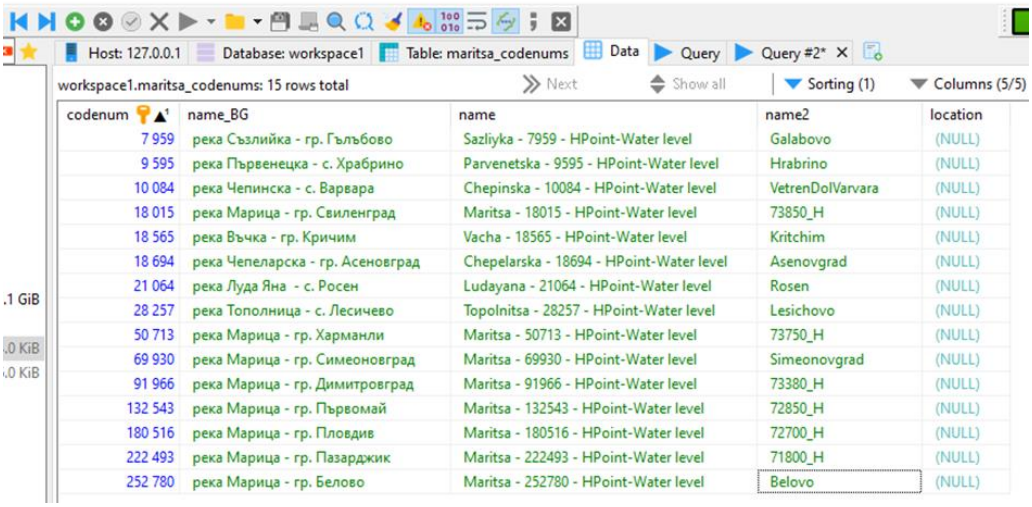


Fig. 6. Interface screen of the new software for model set-up, initialization and starting of the modeling system FLOODGUARD for Arda and Byala river basins

[1] Tsarev, Petko; Artinyan, Eram; David, Cédric. International Multidisciplinary Scientific GeoConference : SGEM; Sofia, Vol. 21, Iss. 3.1, (2021). DOI:10.5593/sgem2021/3.1/s12.08

[2] David, Cédric H., David R. Maidment, Guo-Yue Niu, Zong- Liang Yang, Florence Habets and Victor Eijkhout (2011), River network routing on the NHDPlus dataset, Journal of Hydrometeorology, 12(5), 913-934. DOI: 10.1175/2011JHM1345.



Host: 127.0.0.1 | Database: workspace1 | Table: maritsa_codenums | Data | Query | Query #2*

workspace1.maritsa_codenums: 15 rows total — Next | Show all | Sorting (1) | Columns (5/5)

codenum	name_BG	name	name2	location
7 959	река Сазлийка - гр. Гълъбово	Sazliyka - 7959 - HPoint-Water level	Galabovo	(NULL)
9 595	река Първенецка - с. Храбрино	Parvenetska - 9595 - HPoint-Water level	Hrabrino	(NULL)
10 084	река Чепинска - с. Варвара	Chepinska - 10084 - HPoint-Water level	VetrenDolVarvara	(NULL)
18 015	река Марица - гр. Свиленград	Maritsa - 18015 - HPoint-Water level	73850_H	(NULL)
18 565	река Въчка - гр. Кричим	Vacha - 18565 - HPoint-Water level	Kritchim	(NULL)
18 694	река Чепеларска - гр. Асеновград	Chepelarska - 18694 - HPoint-Water level	Asenovgrad	(NULL)
21 064	река Луда Яна - с. Росен	Ludayana - 21064 - HPoint-Water level	Rosen	(NULL)
28 257	река Тополница - с. Лесичево	Topolnitsa - 28257 - HPoint-Water level	Lesichovo	(NULL)
50 713	река Марица - гр. Харманли	Maritsa - 50713 - HPoint-Water level	73750_H	(NULL)
69 930	река Марица - гр. Симеоновград	Maritsa - 69930 - HPoint-Water level	Simeonovgrad	(NULL)
91 966	река Марица - гр. Димитровград	Maritsa - 91966 - HPoint-Water level	73380_H	(NULL)
132 543	река Марица - гр. Първомай	Maritsa - 132543 - HPoint-Water level	72850_H	(NULL)
180 516	река Марица - гр. Пловдив	Maritsa - 180516 - HPoint-Water level	72700_H	(NULL)
222 493	река Марица - гр. Пазарджик	Maritsa - 222493 - HPoint-Water level	71800_H	(NULL)
252 780	река Марица - гр. Белово	Maritsa - 252780 - HPoint-Water level	Belovo	(NULL)

Fig. 7. Database table for the storage of new “hot-points” attributes for FLOODGUARD project implementation for Arda and Maritsa rivers.

7. Development of new visualization and the web site of EWS Maritsa-Arda-Byala with three warning levels https://plovdiv.meteo.bg/floodguard

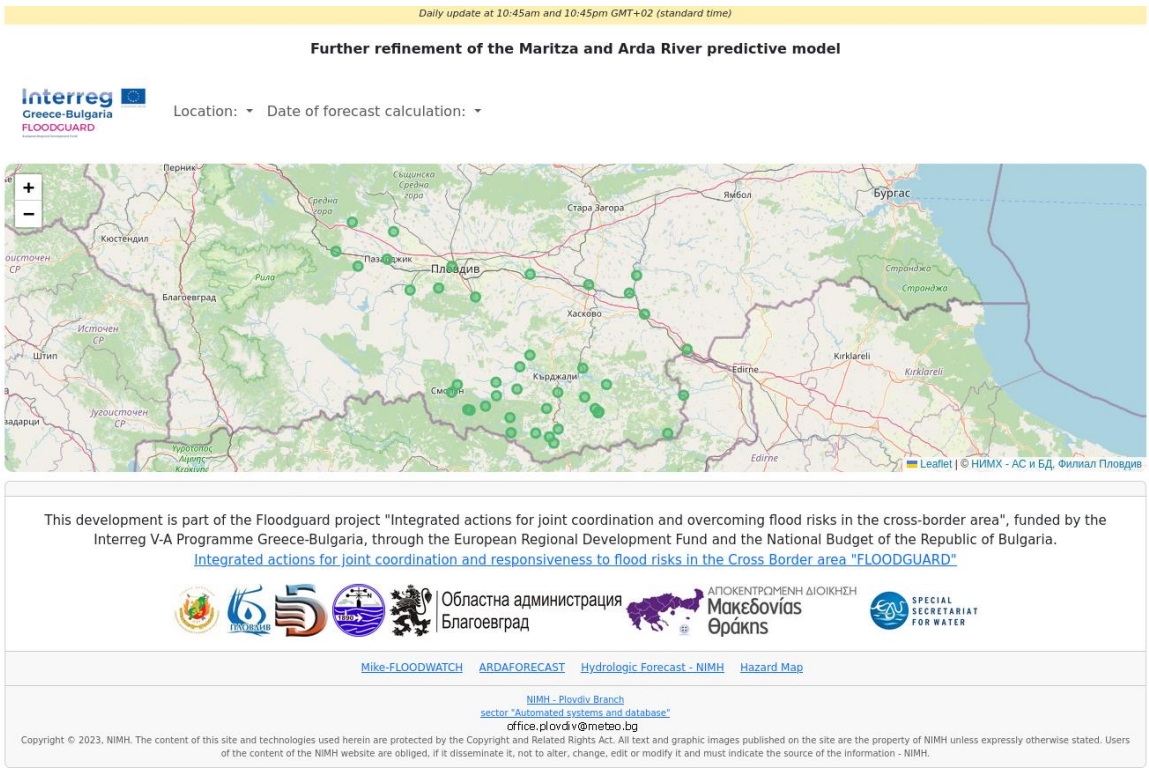


Fig.8. The web site of the project FLOODGUARD with EWS for Maritsa, Arda and Byala rivers.

The new dynamic web site is realised using Leaflet mapping interface and Java script. English version is also available at **https://plovdiv.meteo.bg/floodguard/en.** Warning levels are different for Maritsa Basin Rivers and Arda (Byala) basins because natively the first ones are attached to river embankment levels while those of Arda River basin correspond to 1%, 5% and 50% probability of high flow occurrence (Fig.9, 10).

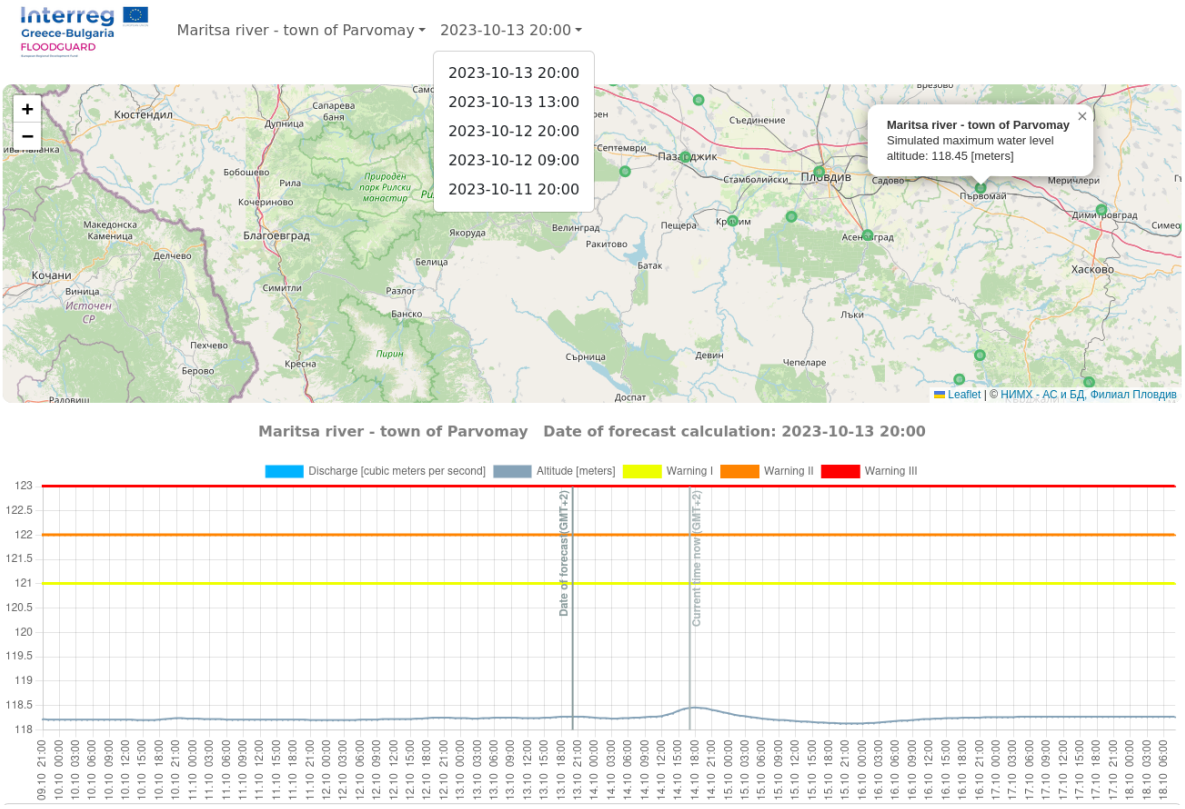


Fig. 9. Choice of starting time of the forecast

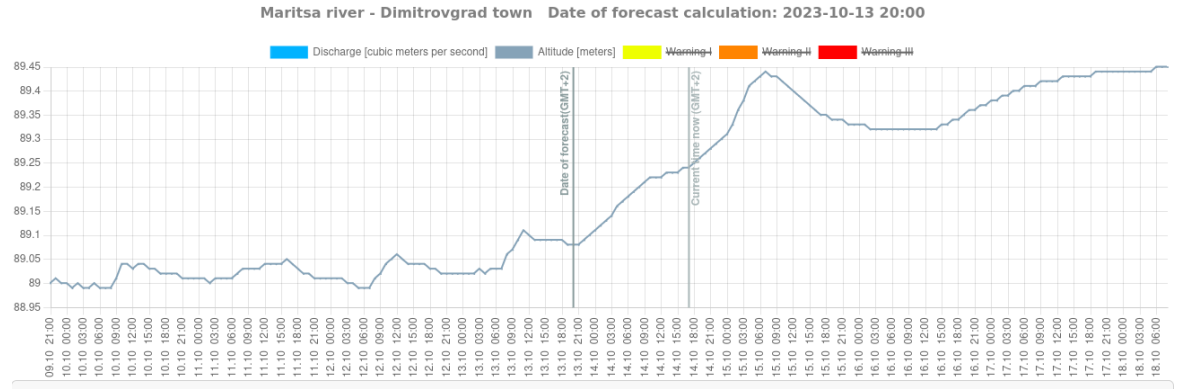


Fig.10. Example of visualization of forecasted levels from the web site for Maritsa – at Dimitrovgrad