SOUTH-EAST EUROPEAN MULTI-HAZARD EARLY WARNING ADVISORY SYSTEM

Assessment of capabilities of the South-East European National Meteorological and Hydrological Services in flood forecasting and warning

Final Report

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Background

In 2016, the World Meteorological Organization (WMO) initiated the development of a South-East European Multi-Hazard Early Warning Advisory System (SEE-MHEWS-A) with initial support from the U.S. Agency for International Development (USAID), Office of U.S. Foreign Disaster Assistance. Fully developed SEE-MHEWS-A system will support the National Meteorological and Hydrological Services (NMHSs) in fulfilling their core function: providing timely and accurate forecasts and warnings of hazardous hydrometeorological events in order to reduce loss of lives and other impacts on people, infrastructure and industry.

Developed during the 2016-2017 inception phase, the Implementation Plan for SEE-MHEWS-A (SEE-MHEWS-A Implementation Plan, 2008) provides guidelines for the development of the technical components and activities necessary to establish advisory system operations by mid-2023. World Bank through the Global Facility for Disaster Reduction and Recovery (GFDRR) and Instrument for Pre-Accession Assistance (IPA) of the European Commission is supporting the second phase of the project (February 2018-December 2020), concentrating on implementing a pilot hydrological modelling system connected to a numerical weather prediction system, forming the basis of the comprehensive operational regional advisory system.

During the second phase of the SEE-MHEWS-A project, a pilot hydrological modelling system should be developed for one river basin in the South-East Europe region (SEE). Development of operational flood forecasting and early warning system (flood EWS) at the river basin level requires availability of quality-controlled hydrological and meteorological observational data as well as post-processed high-resolution numerical weather prediction (NWP) model output.

An inventory of the available automatic, real-time reporting weather and hydrological observing station network in SEE should be carried out including, which stations could immediately deliver sufficient quality and representative operational data to SEE-MHEWS-A, and whether National Meteorological and Hydrological Services operating these stations are in agreement to submit these data for the purposes of the regional advisory system. The inventory should also include the availability of historical meteorological, hydrological observing stations data needed for hydrological model calibration and validation, as well as required ancillary information (e.g. snow data, reservoir operation policies and data, topography, land cover data, bathymetric/cross sectional data, etc.).

The availability of the required data, as well as other considerations should be taken into account in the selection of the river basin from the SEE for setting up the pilot hydrological modelling and forecasting system.

Such assessment of capabilities of SEE NMHSs in end to end process of flood forecasting, including data observations and management activities will be an essential component for the development of pilot operational hydrological modelling and forecasting system for the SEE-MHEWS-A. The pilot system is envisaged to be further developed during the upcoming phases of the SEE-MHEWS-A project.

Brief regional summary

There are a number of definitions of South East Europe, starting from territories of Balkan Peninsula countries (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Kosovo (UNSCR 1244/99), Montenegro, North Macedonia, Romania, Serbia, and Slovenia) to more broad term, where territories of bordering countries – Bulgaria, Romania, and Turkey are added to them. In terms of the SEE-MHEWS-A the SEE is considered as even broader region, which includes 18 countries in total: Balkan countries with neighbouring states, as well as Cyprus, Hungary, Israel, Jordan, Lebanon, Moldova, and Ukraine. The region is extremely diverse in terms of climate, physical settings, hydrology, land use, economy, all of which have direct influence on settings of NMHSs of the SEE countries, their present state, needs and ways of future development.

The region is highly diverse in terms of geographic conditions: from Balkan and Carpathian Mountains to steeps in eastern Ukraine. There are several types of climate (and many more subtypes) in the SEE: from humid subtropical climate in eastern Mediterranean to hot desert climate in Jordan. Such significant diversity of natural conditions in the region of interest results in the different nature of floods: flash floods in mountainous areas, riverine floods in plain parts of the river valleys, urban floods due to rainfalls of high intensity, as well as coastal floods of combined sea and riverine influence, or the combination of them. The territory is very dense in terms of rivers, population, damage centers, there is difficult to single out a single significant river, which flows within the borders of a single country – majority of rivers are transboundary rivers. All this requires good shape of hydrological forecasting systems in the countries of the region, high level of cooperation between countries in transboundary aspects.

Many countries, which belong to the SEE region, are developing countries with all specific issues, outlined in the report of the World Bank Group (Assessment of the state of hydrological services in developing countries, International Bank for Reconstruction and Development/The World Bank, 2018). Below several common needs of the SEE countries are outlined.

All countries of the project indicated strong need in improving their national early warning capabilities in flood forecasting, as all of them have particular deficiencies in terms of forecasting of severe floods. In all countries of the SEE there are regional flood forecasting early warning systems in place, which significantly assist flood forecasters in their daily mission – both in terms of flash floods, as well as in terms of riverine floods. However, continuous increase of capacity of such systems is required to allow even more effective applications of such systems in operational practice.

Sustainability of many flood forecasting services remains a big challenge in the region. There are a number of ongoing projects from country to country, but in many cases further support of newly implemented technologies remains an issue due to under insufficient budgets of several Services of the region.

Better cooperation between meteorologists and hydrologists on the step of preparation and issue of flood forecasting products is still required in many countries of the Region. Hydrological forecasters are looking to more suitable meteorological products to be available for them (including timing, format). This is even more valid for the countries with different entities, responsible for meteorology and hydrology (separate NMS and NHS). Taking into account flashy nature of floods in mountainous areas of the region ensemble meteorological products are considered to have significant value in the region, to have ability to account for its uncertainty.

Due to geographical and political conditions of the region there are many rivers, crossing multiple national borders. In many cases Agreements of transboundary data sharing are not developed (or should be significantly improved) to let effective flood forecast and management activities to be implemented. Many countries from the region are still developing their flood forecasting capabilities – from observations to data products communication to end users.

Present report aims to describe the current status of the National Hydrological Services of SEE countries to better understand their existing specific issues in the field of the end-to-end flood forecasting and early warning chain of actions.

South East Europe river basin survey

To fulfil the main goal of the second phase of the SEE-MHEWS-A project – development of pilot flood early warning system (EWS) for one of the river basins in SEE – the assessment of national (as well as a river basin) capabilities in end to end flood forecasting and early warning should be accomplished. The assessment should consider different pieces of flood EWS chain, with special regards to the initial settings (flood prone areas, end-users needs, etc.), observations and data acquisition, historical and ancillary data, data management and existing flood forecasting capabilities. Results of such an assessment would give an idea on the pilot river basin, where flood forecasting services are the most needed, and availability of data (both operational and historical) allows development and implementing flood forecasting techniques.

The assessment survey of the SEE NMHSs (SEE survey), used in this work, is based on the WMO Commission for Hydrology (CHy) Assessment Guidelines for National Hydrological Services (NHSs) (or other water authority, responsible for issuing flood forecasts and warnings within a country) to evaluate their End-to-End Flood Forecasting and Early Warning System to assist WMO Members in improving their understanding of such systems and in assessing their abilities in this regard. The assessment covers specific parts or processes of the flood EWS, from data acquisition to forecast dissemination and communication to end users, it seeks to identify the strengths, weaknesses and gaps of the NHS in flood forecasting to provide recommendations or guidelines on how to improve current practices. The description of the SEE survey, given below, is partly taken from the CHy draft document "Assessment Guidelines for End-to-End Flood Forecasting and Early Warning Systems".

The SEE survey was developed as the tool (framework) used to collect the information and to assess the degree of readiness and ability to deliver services needed for the provision of flood forecasts and warnings that relate to WMO recommended practices and procedures. The survey is organized as the template in excel form. It includes description of the survey, followed by seven sections designed to assist with collecting the information needed for the assessment (Appendix 1).

Description of the SEE survey includes basic information about the assessment: name of the country, river basin name (if it is national assessment, then should be left blank), institution(s) involved in the assessment, evaluator(s) name (who is filling out the template), date of the assessment. Each of the seven sections that comprise the survey are listed below. Each covers a specific link of the chain in the flood forecasting process.

I. Institutional
II. Observations and Data Acquisition
III. Historical and Ancillary Data
IV. Data Management
V. Meteorological Forecast and Products
VI. Hydrological Models and Forecast
VII. Flood Forecasting Products

Each of presented sections has several subsections, which are devoted to specific area of the section's topic. Below definition of the sections is given, which provides generic information about each section's topic.

I. Institutional

This section is focused on the "Institutional" setting and seeks to collect general information about the institutional and legal framework of the country in the context of E2E EWs for flood forecasting, and its national institutional structure for provision of such services.

II. Observations and Data Acquisition

This section focuses on the identification of existing hydrometric stations in the NHS, their time series, and the processes used for data acquisition. This section gathers specific features about each station, such as the type of equipment, the existence of rating curves, and their condition. It also allows the evaluators to capture general elements about stations network conditions. In addition, similar meteorological, climatological, and oceanic information useful for hydrological modelling purposes could be collected. This section might require the use of auxiliary tables to collect station information and other pertinent information.

III. *Historical and Ancillary Data*

This section allows the collection of historical data (e.g., period of record) and additional information useful for selecting practices and procedures that would help improve of the performance or capability of an early warning system. It allows the gathering of information for providing an overview regarding the general availability, quality, and format of the data.

IV. *Data Management*

This section is designed to assist in identifying and documenting the data management system, its architecture, procedures and practices followed in within the NHS to manage data and in sharing them with the main actors linked to EWS. The management of data impacts on the effectiveness of the early warning system. I should also include specifics regarding the database in use.

V. *Meteorological Forecast and Products*

It is of fundamental importance to have access to meteorological forecasts and specific products for the production of hydrology forecasts. This section allows the compilation of information, including the details regarding the availability, frequency, and spatial and temporal scales of meteorological forecast products of pertinence to advancing hydrological modelling to support flood forecasting.

VI. *Hydrological Models and Forecast*

The purpose of this section is to collect information about models, and techniques used to generate hydrological forecasts. It also allows the gathering of information about the interoperability of the flood forecast system, such as the ability of using different models and of visualizing results.

VII. *Flood Forecasting Products*

A description about the type of products generated for flood forecasting is captured under this section. It also is intended to collect information related to the activities involved in generating flood forecast and products to satisfy stakeholders’ and users’ requirements.

The structure of the SEE survey template includes both national and basin level assessments, while the items as well as the information included in either might vary. For example, the national assessment will include only high-level information (i.e. not flood-type specific), while the items included in a basin assessment would be more specific and in-depth, depending on the type of flooding being addressed.

The evaluators should start the national level assessment and then, based on the findings, they should select the pertinent tab(s) to complete the basin assessments. According to proposed structure of the survey, sections have subsections that cover the national assessment and basin level assessments according to different flood types. Each section of the survey is organized as a table (spreadsheet) and includes the following information:

- *Item*

  This is a listing of all the items considered necessary to assess the capabilities of the organization related to a given section.
- *Guidance for Evaluators*

  This part provides guidance information to the evaluator on what elements to consider for determining a score to be applied.
- *Grading scheme*

  This includes a dictionary for grading (or description of the grades) as well as the grades themselves. Not every item in the survey is graded, as some of them require specific detailed answer, rather than grading score. In this case for such items there is no grading description. A qualitative grading scheme is adopted for the AM in which the evaluators have to assign the grade based on the goals and the nature of the item under consideration. The suggested grading scheme includes six scores from 0 (not existing) to 5 (best practices are followed). To ease work for the evaluators, scoring descriptions for grades 1, 3, and 5 are given in the survey. It is left to the discretion of the evaluators if their responses are graded using intermediate scores, e.g., 1.5, 2, and 4. It should be noticed that not every item could be scored quantitatively. For some items only qualitative descriptions can be used. These are filled in the column of the survey under “Evaluators Comments”.
- *Evaluator Comments*

  This part was designed to record additional information that would be helpful in the overall assessment, which might be unique for each case.

The SEE survey is accompanied with the network table “*Observational network table.xlsx*” (Appendix 2), which was designed to collect metadata of existing hydrometric and meteorological stations (including coordinates, elements measured, sampling interval, transmission frequency, equipment used and etc.), to ease analyzing of capabilities of existing observations and data acquisition processes.

Assessment process, designed by the CHy task-team on the Assessment Guidelines, includes several steps of assessment, where one of the most important steps is implementation of the assessment template (survey) in field by external evaluator(s) through interviewing experts of NMHS, National disaster management authority, and other institutions involved in the process of end-to-end flood forecasting. In this particular case, given the large number of the countries – Members of the SEE-MHEWS-A Project, the only feasible way of implementing the assessment is through the self-assessment.

To assist in this quick information note was written (Appendix 3) with several tips on how to fill out the survey.

The SEE survey together with quick information note and observational networks table were send out to focal points of all countries-members of SEE-MHEWS-A (on 25th of April 2019). The survey was filled out by experts of the countries – 12 SEE countries-members of SEE-MHEWS-A responded. Representative of Cyprus provided an overview of their activities regarding capacities in flood forecasting and warning. Representatives of several other countries, which did not provide the filled surveys, excused themselves for not providing results due to urgent operational issues. The assessment can be updated once more countries provide responses. The list of responded countries with information on proposed pilot river basin (from each of the countries), as well as contact person(s), who filled out the SEE survey is given in table 1 below.

Table 1 – Responded countries and proposed pilot river basins for the SEE-MHEWS-A Project

№	Country	River(s) proposed	Institution (NMHS)	Contact person
1	Albania	Drin and Vjosa	Institute of Geosciences and Energy, Water and Environment (IGEWE)	Ms. A. S. Hiraldo amparosamper@hotmail.com
2	Bosnia and Herzegovina	Vrbas, Neretva	Hydrometeorological Service of Republic of Srpska (RHMZ RS), Federal Hydrometeorological Institute (FHMI), Agency for Watershed of Adriatic Sea Mostar (AVPJM)	Mr. Darko Borojevic (RHMZ RS) d.borojevic@rhmzrs.com Mr. Nino Rimac (FHMI) nino.rimac@fhmzbih.gov.ba Mr. Emil Bakula ebakula@jadran.ba
3	Bulgaria	Kamchiya	National Institute of Meteorology and Hydrology	Mr. Eram Artinyan eram.artinian@meteo.bg

№	Country	River(s) proposed	Institution (NMHS)	Contact person
4	Croatia	Neretva	Meteorological and Hydrological Service of Croatia (DHMZ)	Ms. Dijana Oskoruš oskorus@cirus.dhz.hr Ms. Tatjana Vujnović tvujnovic@cirus.dhz.hr Ms. Željka Klemar klemar@cirus.dhz.hr Ms. Dubravka Rasol rasol@cirus.dhz.hr Mr. Kristijan Horvath horvath@cirus.dhz.hr
5	Cyprus	-	Department of Meteorology (CyMET)	Dr. Kleanthis Nicolaides knicolaides@dom.moa.gov.cy
6	Greece	-	General Secretariat for Water	Mr. Dionisios Marinos d.marinos@prv.ypeka.gr
7	Hungary	Marcal	General Directorate of Water Management North Transdanubian Water Directorate	Mr. András Csík csik.andras@ovf.hu
8	Jordan	Jordan, Zarqa	Jordan Meteorological Department	Mr. Dafi Elryalat admin@jometeo.gov.jo dafialryalat@yahoo.co.uk
9	Montenegro	Zeta river, and several others	Institute of Hydrometeorology and Seismology of Montenegro	Mr. Ervin Kalac ervin.kalac@meteo.co.me

№	Country	River(s) proposed	Institution (NMHS)	Contact person
10	North Macedonia	Vardar	Hydrometeorological Service of North Macedonia	Mr. Vasko Stojov stojov@yahoo.com
11	Republic of Moldova	Prut	State Hydrometeorological Service of Republic of Moldova	Ms. Violeta Balan violeta.balan@meteo.gov.md hidrometeo@meteo.gov.md
12	Slovenia	-	Slovenian Environment Agency (ARSO)	Mr. Sašo Petan saso.petan@gov.si
13	Ukraine	Dniester	Ukrainian Hydrometeorological Center (UHMC)	Mr. Ruslan Reviakin icd@meteo.gov.ua

Current state of flood forecasting capabilities in SEE countries

The state of flood forecasting capabilities, with special focus on end-users needs, real-time and historical data availability, data management, available NWP outputs, and hydrological models and techniques being used, is prepared based on the information, provided in the SEE river basin surveys only. Level of details of description and analysis below fully depends on the survey results of a particular county – some countries were much more prescriptive and detailed than the others. Some countries also did not fill out several sections of the survey – thus information of such sections is not described in the text below. Flood forecasting capabilities of 12 responded countries (table 1) are analyzed below. The surveys (initial responses) are given in Attachments 1-12. The filled out network tables are given in the tables of Appendix 4. Below is information about current capabilities of the SEE-MHEWS-A countries responded in general, as well as with respect to the pilot basins provided.

Albania

General context

The Drin and the Vjosa rivers are the two major Albanian rivers, which frequently suffer from severe floods. The Drin River basin (19,000 km^2) runs along North Macedonia, Kosovo (UNSCR 1244/99), Albania and Montenegro, discharging its waters into the Adriatic Sea, in the north of Albania (Figure 1). It has four natural lakes and a cascade of three reservoirs with hydropower plants (HPPs). The main tributaries of the Drin River are the White and the Black Drin, the Moraca and the Buna Rivers. Floods on the Drin River are caused by rainfalls of high intensity and big amount (over 200mm in 24h and/or 500mm in two days or more) sometimes combined with snowmelt and dam release (which causes backwaters effect near the Shkoder/Skadar Lake). This causes floods every year in the floodplain, causing damages especially in the low part of the Drin river – near confluence of the Buna River and the Shkoder (Skadar) Lake area.

The Vjosa River Basin (6,808 Km^2) is located in the south of Albania discharging its waters into Adriatic Sea (Figure 1). The river runs along Greece and Albania and has two main tributaries: The Drino river (also transboundary) and the Shushica river. One third of the headwaters are located in Greece. Floods on the Vjosa river are caused by high intensity rainfalls sometimes combined with snowmelt. Recent construction of bridges has increased the flood risk in some particular areas of the river. Most of the flooding problems are in the flood plain of the river.

Both flash floods and riverine floods happen in these basins. In addition, most of the big cities of Albania suffer from urban flooding, as they do not have effective drainage system due to wrong design or inefficient maintenance, which is unable to cope with frequent high intensity rainfalls (20mm/h and more).

Figure 1. – Observational networks in the Drin and the Vjosa rivers' basins

National Meteorological and Hydrological Service

Institute of Geosciences, Energy, Water and Environment (*IGEWE*) is the NMHS of Albania, and is the former Hydrometeorological Institute that was merged with other institutions in 2008. There are different departments in IGEWE, including the National Centre for Forecasting and Monitoring of natural hazards. The Centre is not legally defined in the structure of the IGEWE, but experts from two departments contribute to its operation (Department of Climate and environment and Department of Water Economy and Renewable Energies). There are two more state meteorological services in Albania: Meteorological Military Service, which is responsible for meteorological stations maintenance, which are in WMO GTS exchange, and providing weather forecast for military operations; and *Albcontrol Meteorological Service*, which provides weather forecast for the airspace within Albanian territory.

There is a *Water Management Agency* (*AMBU*) of Albania which is responsible for development and implementation of policies, strategies, plans, programs and projects regarding water management (water quantity and quality), including the participation in international agreements for transboundary waters.

The *Civil Protection of Albania* is the major end user of *IGEWE* hydrometeorological services. There is a MoU between *IGEWE* and *Civil Protection of Albania*, which clarifies the role of both institutions regarding forecasting of natural hazards. It clarifies the frequency and type of products for weather forecast and issuing additional risk bulletins in case of crisis. According to the MoU, *IGEWE* continuously monitor meteorological and hydrological phenomena in accordance with WMO standards, as well as issue flood warnings within a *Daily risk bulletin* without reference to the specific station (or location) of a river (as alarm levels are not defined for any hydrometric station in Albania). Additional information is provided to Civil Protection during flood events if required. Civil Protection is responsible for warning population, and it requires flood forecast information several days in advance due to its own limitations in mobilizing resources to the areas affected by floods.

IGEWE operate only Monday to Friday, employees are available 24 hours a day only during severe flood events. However, the *Daily Risk bulletin* is issued every day, and there is an assignment of responsible employees for making the bulletin on a daily basis. The fact that *IGEWE* is not officially a 24/7 service complicates the situation during crisis situations.

Currently *IGEWE* is underfunded and has problems with lack of personnel (i.e. there is no money for station maintenance or stream gauging measurements). *IGEWE* suffers from lack of qualified personnel. As stated in the Action Plan of 2016, the job description of every employee should be clearly listed with specific tasks and especially for crisis situations (flood events).

Standard Operating Procedures (SOPs) are not well developed, there is only a check-list available, which is updated regularly and a standard template (on process of being approved) for the daily risk bulletin and a guideline to interpret the daily bulletin.

Cooperation and coordination between national institutions and transboundary institutions

In 2011, the water and environment management ministries of the Drin riparian countries (Albania, Kosovo (UNSCR 1244/99), Montenegro, North Macedonia) signed a MoU to promote joint action for the coordinated and integrated management of the Drin river basin. In 2016 another MoU was signed by four NHMSs of the Drin river basin to timely exchange hydrometeorological data and to cooperate to improve flood early warning services and transboundary flood management. Further work is needed to better coordinate during a flood event and to establish flood alarm levels at different locations in the basin, standard operating procedure (SOP) and the common alerting protocol (CAP). In 2018, a cross-border water resources agreement between Montenegro and Albania was signed to continue work in the field of water quality, flood protection, water regulation and maintenance and exchange of information, as well as resources mobilization to conduct joint activities.

Institutional agreements on data sharing among different ministries/agencies/data sources

There is a MoU between *Civil Protection* and *IGEWE*, which includes data sharing; however, there are interactions with other institutions such as *KESH* (Albanian State Hydropower company), Prime Minister Office, Ministry of Agriculture, *AMBU* and mass media regularly call. There is a MoU between *KESH* and IGEWE to share data and cooperate (however it should be updated). In 2019, a MoU was signed between *IGEWE* and *AMBU* for cooperation and sharing hydrometeorological data.

Observations and data acquisition

There are 49 automatic stations in Albania (24 meteorological, 25 hydrometric). They were installed with the support of the World Bank project (40 stations operated by the General Directorate of Civil Emergencies) and GIZ project (9 stations operated by IGEWE). There are also 11 meteorological semi-automated stations in the WMO GTS exchange, which are within responsibility and maintenance of *Military Meteorological Service of Albania*. Abovementioned stations metadata is given in Appendix 4. Automatic stations are in a poor state, as they have not been maintained since their installation in 2013-2014. In the framework of following projects (*EU PRONEWS* and *GIZ project*) they aim to be rehabilitated. In May 2019 24 stations were visited, assessed and sensors recalibrated when possible as part of the PRONEWS Project activities. No alarm or flood levels are defined for any hydrometric station. There are also around 207 manual stations (115 meteorological and 92 hydrometric). Manual stations do not transmit observations in real time mode (at the end of a month station booklets are delivered to *IGEWE*). Rating curves have not been updated since 2007 and data from 1992 until 2007 have been used to derive the curves, so streamflow calculation cannot be considered as reliable.

Vandalism is an issue – 16 automatic stations suffered from vandalism. It is planned that under the forthcoming *EU funded PRONEWS* project the protection housing and fences will be constructed.

Observational network within proposed river basins (the Drin and Vjosa rivers) are presented in figure 1, list of the stations with metadata – in Appendix 4. Several important tributaries of the rivers do not have gauges. The hydrometric stations coverage could be improved especially in the tributaries of the Drin River (those inflowing into the Cascade) and the Vjosa River basin (especially Shushica River Carcove River – near the border with Greece). The coverage of the meteorological stations could also be improved: by installing stations in mountainous areas, introducing measurements of snow cover and depth, as well as solar radiation. The meteorological stations from the GTS list cover only main cities of the country. Information on the availability of rating curves for the hydrometric stations of the proposed rivers is given in the Appendix 4 (table 1).

The sampling and transmitting cycle of automated stations differ from station to station. The transmitting cycle can be changed during the flood event manually from the office. The sampling cycle of the hydrological stations is 15-30 minutes and the transmission frequency is from 1 to 2 hours. Meteorological stations have a sampling frequency from 10 min to 30 min (depending on the parameter and location) and transmitting every 2-4 hours. Manual hydrological stations are sampled at 7:00 and 17:00 every day and transfer the data at the end of the month to IGEWE. Hydrological manual data is not being digitized regularly. Manual meteorological stations sample one value at 7:00 am however some stations might sample three times a day (7:00, 14:00 and 21:00), data are transferred to *IGEWE* at the end of the month, 50% of the data are digitized regularly without quality control. Furthermore, data are not being stored in a centralized database i.e. MCH, but data are kept in different computers in excel files. Meteorological stations from the WMO GTS exchange network sample and transmit every 6 hours.

The stream gauging measurements were digitized in 2013 under the World bank project (digitizing from 1992 to 2007). Further digitization was done for the full network of pluviometric stations for the period 1991-2001 and for the period 2012 to October 2018 and for hydrological manual stations from 1992 to 2011 with support of the PRONEWS project. The result of both (WB and PRONEWS) digitalisations was unsatisfactory (low quality). The result data base is of low quality due to human errors. In the past, rating curves have been developed graphically in millimetric paper, some of these rating curves are available but only in a hard copy. The frequency of streamflow measurements was once or twice per month, not all hydrological stations have rating curves developed. Rating curves are developed for sites at big rivers (the Drin and Vjosa rivers) and one station in the rest of Albanian rivers. The rating curves require update due to significant change of cross sections.

IGEWE owns one weather radar (X-band type), however it has not been functioning since 2016. It Is located in Durres town (41°24'20''N, 19°23'5''E) covering part of the country. There are several problems with the internet connection there. Serbian radar covers the north part of Albania, as well as the Drin basin River area. The Vjosa river basin is not covered by radar.

There are four marine stations, three of them are not currently operating. The stations observe sea level with 15 min frequency and transmission frequency every two hours. These stations also observe meteorological variables such as rainfall, temperature, humidity, radiation, air pressure and wind. The Drin and the Vjosa rivers coastal areas are not properly covered by these stations.

In case of transboundary data – for the Drin River data from Kosovo (UNSCR 1244/99), North Macedonia and Montenegro arrive sometimes with hours of delay (within the MoU between the Drin riparian countries). For the Vjosa river there is no data exchange with Greece.

Some automatic stations (financed by the World Bank project) measure snow cover at 7 locations in the country: 5 of them are located inside of the Drin river basin or very close surroundings and 1 – in the Vjosa basin. None of the snow measurements are currently working and were not maintained or calibrated when functional. In general, there is a lack of representativeness of the current snow measurements and rainfall gauges especially in the mountainous areas of the basin, Albanian Alps (as most of the snow measurements are taken at low altitude). There are no snowpack conditions measurements. Snow measurements are sampled every 30 min and transferred every 2 hours.

There are several reservoirs for hydropower production and/or irrigation and there are no data received by IGEWE regarding real-time dam release, or plans of operations. This fact constitutes a big issue for the Drin Flood Forecasting System, which will never be able to get right the forecast in the floodplain unless the dam data is transferred in advance to IGEWE. According to the agreements the KESH hydropower state company should share the data during the flood event only, but not on a regular basis that also constitute a challenge for operational flood forecasting on a daily basis. By law civil protection and the members of the emergency commission of the Drin river which includes the director of IGEWE need to receive the data regarding the dam release in real-time which is insufficient. IGEWE needs in advance (2 to 3 days before) the planned dam release and inflows into the dams and in a detailed format that can be reliable to be used in the forecasting system.

Historical and ancillary data

Historical data for manual hydrometric stations are available in paper format, and partly in paper, partly in digital format in case of manual meteorological stations. Automatic stations have short time series – starting from 2013-2014, some of them – with reasonable gaps. The aim is to recover data from the gaps in some of the data loggers of the 24 stations from WB that are still in place. (Appendix 4).

Data management

The existing forecast systems informational component is based on the utilization of MCH database (with group of scripts that gathers, reformat, and upload data into MCH database component, which feed the data into the modelling system), which collects data from all automatic stations, and then provides it to the hydrological model (for Drin river only).

Meteorological forecast products

IGEWE does not run any Numerical Weather Prediction (NWP) model, however it performs analysis of outputs from different models that are available online or within countries agreements. Currently there is shortage of experienced staff to work with NWP activities. There are following NWP products (outputs) which are being used:

- ICON-UE
- ECMWF/VAREPS EVMWF
- GFS
- COSMO-LEPS
- VAREPS ECMWF for flash floods
- Turkish State Meteorological Service NWP outputs: ALADIN/IFS/WRF
- NMHS of Croatia: DHMZ ALADIN
- RHMS: NMMB model 9km GFS/NMMB model 3km GFS/NMMB model 3km ECMWF

IGEWE does not produce any marine forecast in the whole country. Detailed information on the spatial resolution, number of runs per day, and the lead time of the NWP models used are given in the SEE survey (Attachment 1).

Hydrological models and forecasts

Since 2010 different international donors have been providing support to improve flood forecasting capabilities of IGEWE:

- GIZ Project (started in 2013) – automatic stations were installed (Appendix 4), hydrological model for the Drin river basin was implemented; EU Preliminary Flood Risk Assessment for Drin Basin which enumerates high risk areas; first version of a HEC-RAS 2D model of lake Shkoder and Drin-Buna flood plain was implemented (needs improvements to be used as forecasting tool for flood extent, water levels and duration); other additional tools that are elements of the Drin River Flood Forecasting System were produced.;
- Project supported by the Work Bank: Procurement of 40 automatic weather, marine and hydrological stations
- Project supported by the World Bank, WMO and *Central Institution for Meteorology and Geodynamics od Austria* (*ZAMG*) – Action Plan developed with short, medium and long-term goals and investments regarding *IGEWE*. In this document priorities regarding flood forecasting in the major river basins are set as medium/long-term goals.
- *EU PRONEWS* project (ongoing) – improvement of the *EFAS* system in Albania with introduction of a 1km LISFLOOD hydrological model resolution, as well as applying calibration.

In the result there are following flood forecasting capabilities, which exist within the Drin and the Vjosa basins.

There is an implemented flood forecast system in the Drin river basin, based on the *Panta Rhei* hydrological model (developed by Technical University of Braunschweig, Germany) and the reservoir cascade operational rules model. The model was developed by TU Braunschweig under the framework of GIZ project for IGEWE. The model was used under a NEXUS study for the cascade and IGEWE gave permission to be used by KESH (Albanian hydropower company). The first version of the forecast system has been running since November 2018. The system covers all watersheds of the river. It utilizes the data from automatic hydrometric and meteorological stations, satellite rainfall estimates (source: NOAA *Hydroestimator*) and outputs of three Numerical Weather Prediction (NWP) models, produced in Montenegro. The data from automatic stations are stored in MCH database, which is connected to the hydrological model. Time step is 1 hour, lead time is up to 5 days. Described flood forecasting system was developed and implemented under the umbrella of GIZ project, which started in 2013 with four NMHSs (Albania, Kosovo (UNSCR 1244/99), North Macedonia, and Montenegro) as partners.

In addition to these capabilities, the hydrodynamic (2D) model was implemented for the high-risk flood areas in the low coarse of the river (Shkoder Lake area and Buna floodplain). The model is not as accurate as required due to absence of bathymetric data, digital terrain model (DTM) of high precision, as well as appropriate calibration. The status of the model is not operational.

There is no basin level flood forecasting system implemented in the Vjosa river basin.

There are several regional flood forecasting systems, which operationally issue flood forecasts for the whole country, including two proposed river basins. South East Europe Flash Flood Guidance System (*SEEFFGS*) is used to generate flash flood alerts with 1-hour time step, up to 35 hours lead time, and 4 runs daily. Riverine flood prediction is done using European Flood Alert System (*EFAS*). *EFAS* has 5km spatial resolution of a cell, running at the European scale in European Union Joint Research Center (EU-JRC). It has 6 hours' time step, 7-10 days' lead time, 2 runs a day is being made. The models used in both systems are not calibrated. Meteorological data only from the GTS stations (see Attachment 2) are provided to the systems in real time mode. *SEEFFGS* also utilizes satellite data. Both forecast systems outputs are considered by *IGEWE* as inaccurate due to coarse spatial resolution and the lack of real time input data. Nevertheless, the the tools in a daily basis to assess the risk in absence of better methods.

Forecasts performance is not done for the three models for now. Output correction is done in case of *Panta Rhei* – an *ARMA* error model is under experimental testing.

Flood forecasting products

The Albanian Civil Protection and IGEWE signed a MoU were the tasks of IGEWE are clarified, including hydrological forecasting. However, term "hydrological forecasts" are not used in the MoU, only hydrological risks are used within the *Daily risk bulletin*, issued by IGEWE. IGEWE have developed Guidelines)to be approved) to interpret the risk bulletin that will be soon available for the public. The *Daily risk bulletin* is published at 12:00 every day and alerts are provided to the Civil Protection as soon as possible. The risk bulletin is published in IGEWE's web page, Facebook, and disseminated by email to different authorities. In case of an extraordinary event, extra bulleting can be published on demand.

In terms of flood risk products – the EU Floods directive is being implemented in the country. In the Drin river, preliminary flood risk assessment has been done. Other preliminary flood risk assessments have been done under PRONEWS project but the results are of low quality due to the quality of the data used.

In general, there is a lack of products for the forecast horizons most needed – *IGEWE* do not issue hydrological warnings, but rather provides a risk map by prefecture administrative unit. The risk map is standard and the legend for the different risks.

Bosnia and Herzegovina

There are several institutions involved in hydrometeorological services provision (in particular in flood EWS) on the territory of Bosnia and Herzegovina (table 2): *Federal Hydrometeorological Institute of Federation of Bosnia and Herzegovina (FHMI)*, *Agency for Watershed of Adriatic Sea Mostar (AVPJM)*, and the *Agency of the Sava river basin (ASRB)* – for Federation of Bosnia and Herzegovina, and *Hydrometeorological Service of Republic of Srpska (RHMZ RS)* and *Vode Srpske* – for Republika Srpska. There are two river basins proposed as pilots by Bosnia and Herzegovina: the Neretva and the Vrbas rivers basins. There are different capabilities of the flood EWS for these basins, as well as there are different agencies involved in hydrometeorological service provision for – thus description will be given separately basin by basin further below.

Table 2. – Entities hydrometeorological service provision in Bosnia and Herzegovina

Political entity of Bosnia and Herzegovina	**Institution, involved in flood EWS**	**Responsibility**
Republika Srpska	Hydrometeorological Service of Republic of Srpska (RHMZ RS)	Hydrometeorological service, Member of WMO (together with FHMI)
Republika Srpska	Vode Srpske	Water resources management
Federation of Bosnia and Herzegovina	Federal Hydrometeorological Institute of Federation of Bosnia and Herzegovina (FHMI)	Hydrometeorological service, Member of WMO (together with RHMZ)
Federation of Bosnia and Herzegovina	Agency for Watershed of Adriatic Sea Mostar (AVPJM)	Hydrological monitoring and forecasting
Federation of Bosnia and	Agency of the Sava river basin (ASRB)	Hydrological monitoring and

Herzegovina		forecasting

The Vrbas river

The Vrbas river was proposed as a pilot river basin by *RHMZ RS* (Banja Luka), which is responsible for hydrometeorological service for the central and lower part of the river basin. The information in the section below is mostly from *RHMZ RS* perspective. Information on the upper river basin's network is added to the section from the FHMI and ASRB perspective, as this part of the river is under their responsibility in terms of operational hydrometeorology.

General context

The Vrbas river's length is 240 km, it is one of the Sava river's tributaries, with mean annual discharge value of 102 m^3/s. The Vrbas river basin is 5023 km^2. The river's source is located on the Vraniza mount slope at 1780 m alt (Bosnia and Herzegovina part of the Dinaric Alps). The river flows in the north direction, where it inflows into the Sava river near the border between Bosnia and Herzegovina and Croatia. Heavy rainfalls in upper part of the basin of Vrbas river and Vrbanja River (tributary, which inflows into the Vrbas near Banja Luka) are the main source of riverine floods in the river basin. The most significant damages and losses due to flooding occur in Banja Luka area, as well as in the area from Banja Luka to the mouth of the Vrbas River. There is a reservoir in the middle of the river – Bočac reservoir.

Vrbas river basin is located within two political entities in Bosnia and Herzegovina (upper part is located within the Federation of Bosnia and Herzegovina, central and lower parts – within Republika Srpska) – there are two NMHSs and two water management agencies in charge for flood protection and EWS within the basin. Thus there is an issue with national legislations mandating a national agency to provide flood warning information (and other products).

In the Vrbas river basin there are some simple EWS capabilities implemented in 2015 (it was supported by UNDP project): automatic hydrological stations have defined flood thresholds and thus generate SMS to the hydrologists when water level reaches critical values. There are no flood forecasting capabilities implemented on the basin level. Global/regional system for flood prediction is used to provide flood warnings. *RHMS RS*, usually, provide early warnings 3-4 days in advance with indication in which region flood can potentially occur (without predicted water level values). Some high risk areas are covered, but most catchments remain uncovered of early warnings. End users of flood early warning system's products, as well as their needs are collected, but not documented in official report.

Hydrometeorological Service of Republic of Srpska

In the Republika Srpska part of the basin NMS and NHS are merged into the single NMHS – *RHMS RS*, which is in charge by law to produce warnings and forecast for potentially severe weather and flood events. Roles and responsibilities of RHMS RS are not clearly defined – there is some overlapping with the Vode Srpske in terms of hydrological services. Daily operations for supporting the flood EWS carried out only during day hours – evening/night shifts are only used when needed (during severe flood events).

Cooperation and coordination between national institutions and transboundary institutions

Through *International Sava River Basin Commission (ISRBC)* there is established flood early warning system and Sava hydrological information system for real time data exchange in whole Sava river basin. Academia experience is involved in the EWS process occasionally by sharing knowledge and expertise during conferences. There is no monitoring and evaluation of the performance of the relevant players involved in delivering floods EWS. In terms of decision support services there is main flood protection plan where responsibilities of main players are indicated.

Institutional agreements on data sharing among different ministries/agencies/data sources

In transboundary context there is a Policy on data exchange in the whole Sava river basin under the ISRBC.

Observations and data acquisition

There is existing real-time monitoring service in the Vrbas river basin. Most monitoring stations have maintenance plain, except for 2 stations. In general, there is a high level of reliability of data transmission – all data from stations are transmitted in real time via GPRS mobile internet. There is low risk of vandalism – quite a few situations were registered to be damaged (broken solar panel or stolen battery). Additional security measures were introduced to avoid such situations in the future (fence installed etc.). From operational data acquisition perspective, the Vrbas river basin is within responsibility of following entities: *RHMZ RS* provide data acquisition in lower and central parts of the basin, FHMI is responsible for meteorological observation and hydrometric data management in upper part of the basin, ASRB perform hydrometric observations in upper part of the Vrbas basin. The map of observational stations is provided in Figure 2.

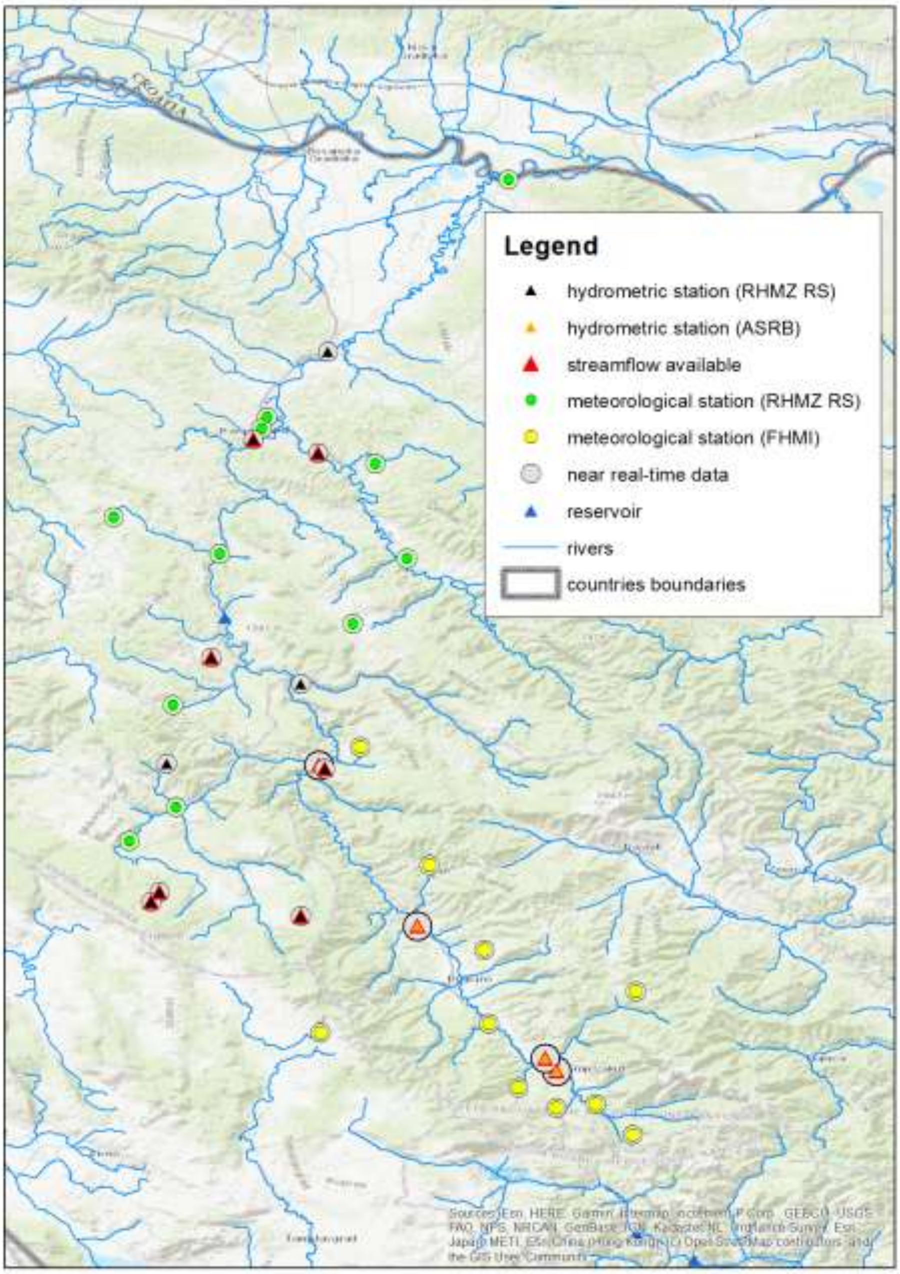


Figure 2. – Observational network in the Vrbas river basin

In terms of adequacy of hydrometric network design – some tributaries of the Vrbas river are not covered by hydrometric observations (for instance, following tributaries of the river: Ugar, Svrakava, Krupa, Suturlija, Turjanica). Most stations are automated (OTT equipment – hydrological stations are with pressure-level sensor). All stations measure and transmit water level and water temperature information, 7 stations (out of 10) additionally perform discharge measurements. In the upper part of the river, there are 4 automatic hydrometric stations only on the main river (no tributaries are covered with hydrometric measurements), maintained by ASRB (Figure 2, Appendix 4). Observations and transmission of water level are conducted every hour. There are discharge measurements performed at these gauges, which allow rating curves updating and streamflow calculation in near real-time mode. Data collection frequency is adequate for flood forecasting – 30 minutes. There is calibration plan developed and followed for hydrometric stations. Rating curves are well maintained – majority of hydrometric stations provide discharge information. All stations are operational – they observe and transmit data in near real-time mode (every 30 to 60 minutes).

Data collection frequency of meteorological stations (including rainfall observations) is from 1 minute to 30 minutes. OTT equipment is used ("Pluvio 2"). In upper Vrbas there are 12 automatic meteorological stations (OTT), managed by FHMI (table X, figure 2). All of them observe precipitation, as well as air temperature every hour. Transmission frequency is one hour. Thus all meteorological stations are operational – they transmit data in near-real time mode (every 30 minutes).

In the Vrbas river basin there is a reservoir with HPP Bočac. There is data exchange of inflow, outflow, as well as other information only before and during the flood event.

Snow variables (depth, SWE) are measured only at the main meteorological station in Banja Luka.

There are radar(s) installed, but data are not adjusted to ground stations, thus it is not suitable to use for the flood forecasting purposes at the moment.

Historical and ancillary data

Metadata for hydrometric, as well as for meteorological stations are available with updated zero readings, coordinates, equipment type, date of installation, and other information. Hydrological data in the lower and central parts of the basin are available mostly for the period from 1950-1960-s until 1990. Then after installing new instruments – since 2015/2016 and until present time. In the upper part of the basin data archives are available beginning from the early 2000s. For majority of meteorological stations in all parts of the basin data time series are available from February 2016, for other 4 station (in the central/lower parts of the river's basin) – from early-mid 1960-s. Most of historical data are available in digital format (in *Excel* and *TXT*).

Data management

All measured data are stored in servers, owned by *RHMS RS* and *FHMI*.

Meteorological forecast products

Meteorological forecasting products are provided by *RHMS RS*. Rainfall and temperature forecasts outputs of at least three deterministic NWP models are used in operational work in digital format. Wind speed and direction forecast maps are available only as image products. Meteorological forecast products of *FHMI* are presented below (in the section, devoted to the Neretva river).

Hydrological models and forecasts

At the moment there is no formal flood forecasting procedure in place for the Vrbas River. As well as there is no model/functionalities used in the basin for flood forecasting.

Flood forecasting products

Threshold-based flood alert and flood forecasting (automatic hydrological stations have defined thresholds and generate SMS to the hydrologist when water level reaches some value). RHMS RS provide early warnings, 3-4 days in advance.

The Neretva river

The Neretva river was proposed as a pilot basin by *FHMI* and the *Agency for Watershed of Adriatic Sea Mostar*. The river is also considered as a pilot by Croatia, where relatively small, but significantly high flood prone coastal area of the river basin is located (see below – in the report section, devoted to Croatia). The Neretva river survey (Bosnia and Herzegovina part) was filled in by the *Agency for Watershed of Adriatic Sea Mostar*, and *FHMI* (section, devoted to Meteorological forecasting products).

General context

The Neretva river's length is 225 km; basin area is 11.798 km^2. It origins in Bosnia and Herzegovina in mountains near the border with Montenegro, then flows 203 km before the border with Croatia. The lower part of the river (22 km) flows in Croatia, then it inflows into the Adriatic Sea. It is considered to be one the largest rivers of the eastern part of the Adriatic basin. There are a number of significant cities and towns, located on the river, including Metković, Ulog, Konjic, Jablanica, Mostar, Opuzen and others. The manmade influence on the regime of the river is significant – there are nine HPPs on the Neretva river and its main tributaries (the Rama and the Trebisnjica rivers), which provide flood protection, power generation and water storage. The river's runoff is significantly influenced by karstic processes. Rain and snowmelt are the main contributors to flooding in the river basin.

Federal Hydrometeorological Institute of Federation of Bosnia and Herzegovina

There is a joint NHMS of Federation of Bosnia and Herzegovina (*FHMI*), which is together with Republic Hydrometeorological Service of Republika Srpska (*RHMZ RS*) is the member of WMO. Roles and responsibilities of *FHMI* are well defined: meteorological forecasting and provision of operational data on water levels at hydrometric stations, which are under *FHMI* responsibilities (every 4 hours, or more often).

The Agency for Watershed of Adriatic Sea Mostar have responsibilities and obligation by law to provide hydrological forecast products and warn civil protection, media, etc. before and during extreme hydrometeorological conditions. However, in terms of regional flood forecasting systems – *EFAS* and *SEEFFGS* – *FHMI* is the main partner, as there are 2 hydrological forecasters on duty in *FHMI* in hydrology sector, as well as meteorologist on duty during extreme hydrometeorological conditions, which is very important for hydrological forecasting. *FHMI* produce hydrological forecasting products based on regional forecast systems and send them to the Agency for Adriatic river basin and civil protection 3 days in advance as informal notifications (*FHMI* do not have law obligation to perform flood forecasting).

End users' needs are known and documented, perhaps it should be reviewed more often.

Cooperation and coordination between national institutions and transboundary institution

Flood EWS is working in transboundary context, and there are open national sharing and agreements in place. Collaboration of main players of EWS for flood forecasting with Universities, academia, and research institutions is done occasionally mainly in conferences. There is a monitoring and evaluation of the performance of the relevant players involved in delivering flood EWS in place. SOPs are developed, documented and reviewed. *AVPJM* provide decision support services to partner agencies via phone contact or embedded forecasters – any institution can call for extended hydrological services without documentation.

Institutional agreements on data sharing among different ministries/ agencies/ data sources

There is a local/national data sharing policy, using interoperability standards. Under this legal framework, spatial data infrastructure has been developed. There is no transboundary data sharing policy, legal framework or agreements between Bosnia and Herzegovina and neighbouring countries and institutions.

Observations and data acquisition

There is a rigorous monitoring service in place with its all aspects maintained (maintenance plans and budgets are in place for all items). High level of reliability of data transmission (statistics and backup paths available). Hydrometric network is considered to be good: many tributaries have gauges at outlets, however several important parts of a river do not have gauges. There are an adequate number of visits for staff gauge readings, operational checks, etc. Hydrometric station equipment is calibrated regularly, calibration sessions are traceable and regular, to WMO or equivalent standards.

There are 18 automatic hydrometric stations and 6 staff gauges in the Neretva river basin, maintained by the *AVPJM* (Table 3). There is also 1 staff gauge, maintained by *RHMZ RS*. All the stations have real time data transmission. Once a day *FHMI* receive data from the Adriatic Sea Watershed Agency, applying QA/QC of the data, calculate discharge, and archive the data. Later *FHMI* publish all data in Hydrology Annual (hard copy and CD).

Table 3. – Monitoring networks in the Neretva river basin

Territory	Owner	Number of hydrometric stations		Number of meteorological stations		Data flow
		Automatic	Manual	Automatic	Manual	
FBiH	Adriatic Sea Watershed Agency - Mostar	18	6	18		Server
	FHMI (Sarajevo)			3	3	
	Elektroprivreda HZHB Mostar (HP)	10				real-time data
	Elektroprivreda BiH Sarajevo (HP)	11		7		real-time data
RS	RHMZ RS (Banja Luka)		1			

Comments: *FBiH* - Federation of B&H (Upper, middle and downstream part of Neretva river); *RS* - Republika Srpska (Upper part of Neretva river).

Spatial distribution of stations is provided in figure 3. Detailed table with hydrometric and meteorological stations together with their metadata is given in Appendix 4. Manufacturers of the hydrometric equipment, which is in use: *OTT Hydrometry*, *SEBA Hydrometrie*, *SIAP+MICROS* with real time transmission. Some stations are with observer. All instruments are installed with adequate resolution, ranges, and no significant interferences. Ratings are well maintained (regularly updated), ratings are available for all important gauges. Meanwhile the hydrometric network is not adequate for the majority of mountainous areas of the Neretva river.

There are nine water river reservoirs in the Neretva river basin (figure 4) – thus there is a huge influence on the river’s streamflow by hydropower. It was mentioned in the river basin survey that data from reservoir manager(s), including storage level, outflows are fully adequate.

Some of a river's catchments in flow formation area have few or no precipitation and temperature measurements, as well as other synoptic elements. There is sufficient number of visits for check gauge readings, gauge maintenance, etc. Calibrations process is traceable and regular, according to WMO standards.

There is no weather radar installed in the river basin. Some pertinent transboundary data are available with delays. Snow courses are evenly distribution (snow depth and coverage are observed).

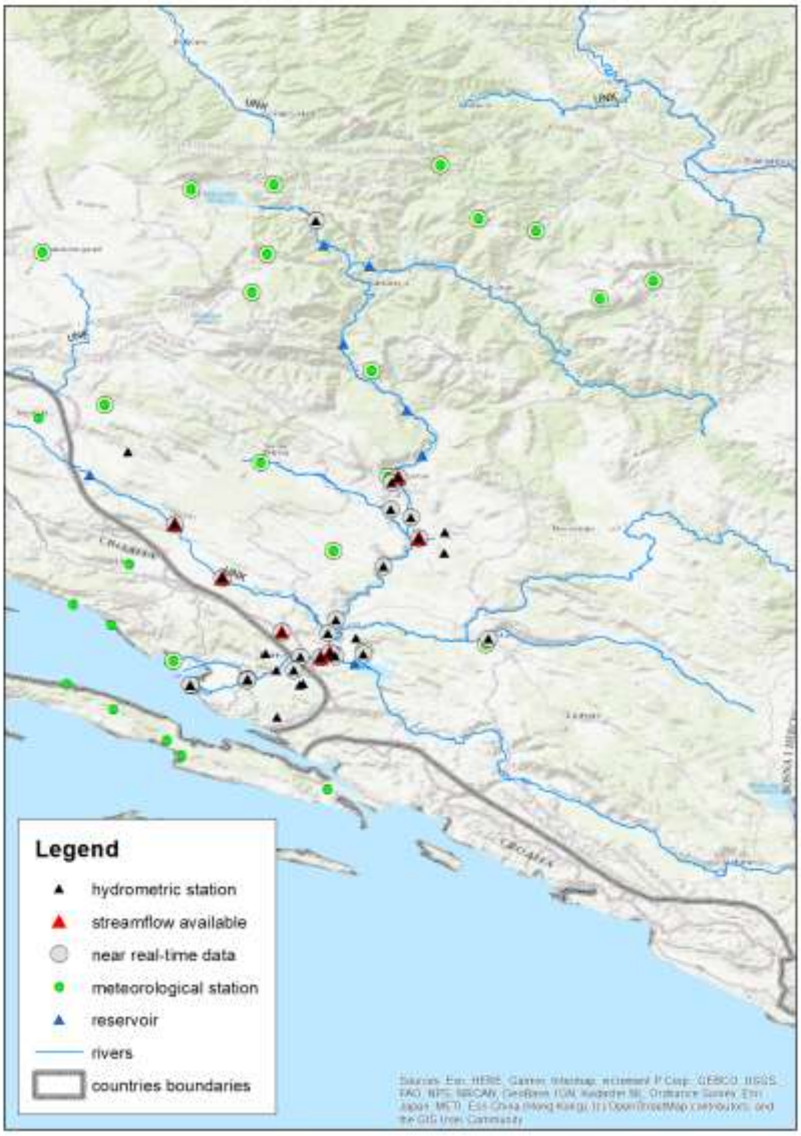


Figure 3. – Observational networks in the Neretva river basin, proposed by Federal Hydrometeorological Institute of Federation of Bosnia and Herzegovina (FHMI) and Meteorological and Hydrological Service of Croatia (DHMZ)

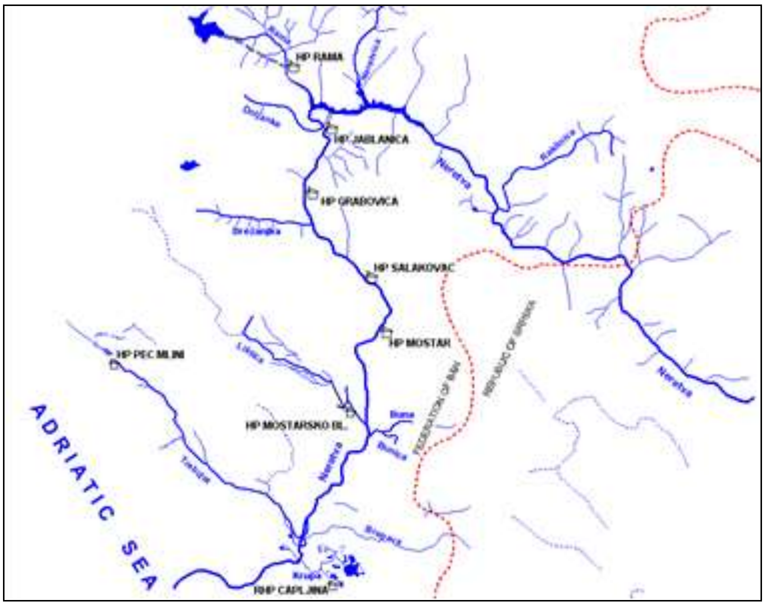


Figure 4. – Hydropower plants location in the Neretva river basin

Historical and ancillary data

FHMI and AVPJM are responsible for maintaining data archives for the Neretva river basin. There are complete metadata available for hydrometric, as well as for meteorological stations – with updated zero readings, coordinates, equipment type, date of installation, and other information. Hydrometric data time series are of reasonable duration – from early 2000s until present time both in paper and in digital format. Meteorological data (air temperature, precipitation) data series are available for the period from 2007 until present time.

There is MAP product available for selected catchment, based on rain gauges' data only.

Up-to-date cross-sections with adequate spacing are available for the most important locations (sections of the river).

Rating curves are updated, they cover different periods of flow, including peaks, low flows and ice conditions.

Spatial data electronic layers are used in hydrological practice (globally available layers). There are impact data available for usage at flood prone locations, including vulnerability, exposure data and flood mapping.

Historical information and traditional knowledge are only applied to a few locations and used for analyses such as flood frequency determination

There are a number of HHPs in the Neretva river basin, thus information on their regime and regulation rules are vital for development a flood forecasting system. Reservoir inflows, storage and outflows, as well as operation rules (both historical and present) are available.

Hydrometric transboundary data are available – all data, including flow data received in near real-time.

There are some snow data available – mostly depth measurements (at stations).

Data management

All measured data are stored in owned servers by *FHMI*. Historical data products are offered according to interoperability standards (data structures and metadata) and are stored in own servers in a client-server scheme providing web services. In terms of real-time data – all pertinent data are readily available when needed; web services are available. The amount of transboundary historical available digital data is close to the optimum according to the current purposes of the flood warning system. Data products are produced according to interoperability standards (data structures and metadata).

Most of the data are ingested automatically from ftp/http repositories or from web pages using web scraping procedures. Some web services are available.

Records and documents are stored digitally according to developed protocols. Most of procedures that must be automated are indeed automatic. Access to records and documents is available by ftp or http clients.

All data (real-time and historical) have passed QA/QC procedures, based on mostly automated methodology with human intervention. Procedures are properly documented and catalogued and have available reliability indexes or metrics.

Data input/output procedures are automated. Some of them with advanced graphical functionality.

Meteorological forecast products

The *ICON* Model from *DWD*, as well as *GFS* data from *NCEP* are used as initial and boundary conditions for NWP. Deterministic forecast of meteorological elements is performed by running *WRF-NMM* with 4 km spatial resolution once a day for the next 96 hours; and *NNMB* (6 km spatial resolution), once a day for the next 96 hours. Additionally, for precipitation accumulations 1-h *ICON* model outputs (7 km resolution) for the next 120 hours are used. Accumulations are calculated with 1-hour interval for the lead time 0-78 hours, and every 3 hours for the interval 78-120 hours.

Hydrological models and forecasts

The *AVPJM* is responsible for providing hydrological forecasts in the Neretva river basin. Overall forecasting approach is considered to be appropriate: performance metrics are met most of time; appropriate time step is used. Forecasts are issued with lead times greater than 5 days. Regarding different aspects of the system (watershed models, routing models, etc.) it was mentioned in the survey, that procedures should be improved.

Flood forecasting products

Flood maps in development and available at a limited number of forecast sites of the Neretva river basin as static libraries. The suite of flood forecasting products is adequate to serve all user's needs and forecast horizons requested. User's feedback indicates the format is adequate and easily understood. All products provided satisfy the timeframe required by users.

Bulgaria

General context

The *Kamchiya* river basin was proposed as the pilot river basin for the SEE-MHEWS-A Project. The river is located in the eastern part of the country, it forms in the result of confluence of two rivers – Golyama Kamchiaya and Luda Kamchiya, which origins in eastern Balkans and flow eastward. It inflows into the Black sea 25 km to the south of the city of Varna. The river's length is 244 km, basin area – 5358 km^2.

The most severe damages from floods occur in *Varna* district (*Avren* municipality, *Dolni Chiflik* municipality), mouth area of the river, for which both rainfalls and intensive snowmelt are the main sources of flooding.

There is no adequate flood EWS developed for the mentioned river basin, rather than regional FFGS – Black Sea Middle East FFGS (*BSMEFFGS*), which is used only for generating flash flood early warnings. However, there is a big need in the system, which will be capable of riverine flood forecasting with up to several days' lead time.

There is well-defined national/subnational legislation in Bulgaria, which reflects clear functions covering the area of flood early warnings. Users and user needs are well documented in the documents of Black Sea River Basin Directorate

National Hydrological Service

NMS and NHS are merged into the single institution – *National Institute of Meteorology and Hydrology* (NIMH), which serves as NMHS of Bulgaria. Roles and responsibilities of NIMH for flood EWS are defined in the *Water Act - Art.171 par. 6*. NIMH operates during day hours, but evening/night shifts exist when needed (during severe flood event).

Cooperation and coordination between national institutions

The basin of Kamchiya is only within Bulgarian territory, thus there is no aspect of transboundary cooperation between institutions.

Academia's experience in the field of flood forecasting and warning is shared occasionally mainly in conferences.

Flexibility of organizational structure is identified as high, it has performed well during recent severe events and has established surge capacity and procedures.

Roles and responsibilities of staff involved in the service, as well as Standard Operating Procedures are documented well and reviewed regularly.

NIMH has established Incident Management policy and procedures. There is a focal point defined for quality management and performance assessment. The Service also provides decision support service to partner agencies via specific arrangements.

Institutional agreements on data sharing among different ministries/agencies/data sources

There is a local/national data sharing policy, using interoperability standards. Under this legal framework, spatial data infrastructure has been developed.

Observations and data acquisition

Only hydrometric station information was provided, which is highlighted in Appendix 4, as well as in Figure 5. There are six hydrometric stations within the *Kamchiya* river basin. Streamflow measurements are performed at all hydrometric stations, and thus streamflow values are calculated in near real-time mode. Sampling interval is 12 hours, which is described in the river basin survey as low frequency of measurements to describe flood formation processes of the river. All hydrometric stations are near-real time data transmission stations. Maintenance of the hydrometric network is considered to be fully appropriate with WMO standards – calibration regime is traceable and regular, there are no significant interferences on sites, rating curves are well maintained (regularly updated), ratings are available for all stations.

Figure 5. – Hydrometric network in the Kamchiya river basin.

There was no information provided regarding meteorological stations network, however it was mentioned in the survey that some river catchments in the flow formation area have too few or even no precipitation and temperature measurements. In total there are eight rainfall gauges and six air temperature stations. Some stations have low frequency of precipitation measurements. There are manual readings of rainfall amounts. Rainfall is transmitted in near real-time, air temperature data are not transmitted in real-time.

There is one synoptic station within the Kamchiya river basin – in the town of Varna (near the river's mouth).

Radars are not used for flood forecasting purposes in *NIMH*.

The Kamchiya river inflows into the Black Sea, there are a number of operational sea level stations used, however near the river mouth's area some gaps in sea level observations and forecasts exist.

There is not enough available data on reservoir management, available in real-time (or near real-time) mode.

There are eight locations where snow depth and cover are manually measured once a month, there are no SWE measurements.

Historical and ancillary data

NIMS is responsible for the storing and managing hydrometeorological data archives. In table 1 (Annex 3) metadata of hydrometric stations of the Kamchiya river basin are presented, highlighting updated zero readings, coordinates, equipment type, date of installation and other. Historical data are available from 1950-s (for some – from 1920-s, 1930-s) until present time. Time series are available mostly in digital format, however paper format is also used at some extent.

Information on cross sections is available, however in majority of cases spacing is not adequate. Cross sections are updated only at sites where hydrometric station is installed.

Impact data information includes vulnerability, exposure and flood maps, which are generally available for all vulnerable flood-prone locations.

There is not enough historical data on reservoir management.

Data management

Some data products are stored in owned servers, or are readily available in partner institutions servers (by public or private access) in a client-server scheme with minimal functionalities (web sites, ftp servers, http servers). Most of data is collected at monthly basis and are available after a month. Most of real time data and products are readily available at the start of the forecasting session. Data and products are available in a timely fashion.

Data ingestion procedures are partially automated. Most of the data ingestion is done manually. Some data are ingested automatically from ftp/http repositories or from web pages using web scraping procedures.

Most historical data have passed QA/QC procedures. Most of the ingested real-time data are subject to QA/QC procedures and some reliability indexes or metrics are available. QA/QC procedures for both historical and real-time data are based on partially automated approaches with human intervention.

Relational databases and DBMS are used in operational practices (e.g. MS Access, MySQL).

TXT and CSV formats are the most widespread data formats in the Service in terms of utilization in operational hydrology.

Data input/output procedures are partly automated (there is an interface to manually and automatically import data).

Meteorological forecast products

Meteorological forecasting products are issued by NIMS. Regarding rainfall forecast – there is a high resolution (both spatial and temporal) QPF, issued with a time step, that meet the needs of preferred potential hydrological model. Outputs of this kind are available in digital format for a forecast horizon for at least 3 days. The same is valid for air temperature forecast, as well as for other major meteorological variables used in operational hydrology (including dew point temperature).

There is no ensemble NWP capability in the moment.

Deterministic seal level forecasts are issued at the *NIMH* with relatively high spatial and temporal resolution.

Hydrological models and forecasts

There is no basin level hydrological model applied or used in the Kamchiya river basin. Regional flash flood warning system *BSMEFFGS* is the only system, which is used to assist in generating flash flood alerts.

Flood forecasting products

As previously said there is only *BSMEFFGS* system, which effectively operates in Bulgaria, and it is the only flood forecast system operating for the proposed basin. Not all end user's needs are met with the products, which are generated by the system, as more long-term lead time forecasts are highly required. There are no flood maps available for Kamchiya River Basin at *NIMH*.

Croatia

The Neretva river basin was proposed by *Meteorological and Hydrological Service of Croatia* (*DHMZ*) as the pilot river basin for the *SEE-MHEWS-A* Project. Description of hydrometeorological services availability in Bosnia and Herzegovina part of the river basin, described above (see section "Bosnia and Herzegovina – river Neretva"). The river system, as well as observational networks of the river is shown in Figure 3.

General context

The most significant damages and losses due flooding on the Neretva river in Croatia happen at Metković town. The sources of flooding in this area are considered to be of complex nature: heavy rainfalls, reservoir operations in Bosnia and Herzegovina, insufficient local drainage and sewer system, river-sea interactions – are all influencing the flooding at this location.

National Meteorological and Hydrological Service

DHMZ is hydrometeorological service of Croatia. Roles and responsibilities within the Service are well defined according to national policies and regulations. Daily operations for supporting the flood EWS in terms of weather forecasting are carried out in 24/7 mode. *DHMZ* is also responsible for hydrological monitoring (water levels), and hydrological forecasts (using existing operative hydrological forecasting system for some basins). Real-time hydrologic monitoring of water levels is 24/7. Other operations for supporting the flood EWS are during day hours, but evening/night shifts are used when needed.

There is no clearly defined legislation at the national level mandating a national agency to provide flood warning information and products, as the new law about meteorological and hydrological activities in Croatia, which covers flood warning topics, is still in final preparation stage. There are two entities, which are responsible for flood warnings: *DHMZ* and *Croatian waters* (*Hrvatske vode*).

Cooperation and coordination between national institutions and transboundary context

Transboundary collaboration with institutions of Bosnia and Herzegovina regarding operation of flood EWS has not been established yet. Academia experience on flood modelling and forecasting is shared with *DHMZ* occasionally mainly in conferences. There is no monitoring and evaluation of the performance of the relevant players involved in delivering flood EWS. Regarding flexibility of organizational structure there is informal surge capacity and procedures in place.

Institutional agreements on data sharing among different ministries/agencies/data sources

There is a local/national data sharing policy, and there is agreement for contributing to basic data infrastructure development (co-financing for a network). There are no agreements for transboundary cooperation that cover Neretva river basin.

Observations and data acquisition

Observational network map is provided in Figure 3, information on stations could be found in tables of Appendix 4. There are 11 hydrometric stations in the Croatian part of the Neretva river basin, which have quite good distribution across the Croatian part of river basin. Nearly half of the stations (seven) transmit measurements in near real-time mode (every hour), and have from 15 to 30 minutes sampling interval. Almost all stations measure water level (and temperature), only one of the (7259, *Prud preljev uzv*.) performs discharge measurements. It is mentioned in the survey, that definition of reliable rating curve is impossible due to sea influence at most locations.

There are 22 meteorological stations in the area with joint air temperature and precipitation measurements (10 stations), and precipitation measurements only (12 stations). There are 7 synoptic stations. There are only 2 automatic stations, which transmit data in near real-time mode (1-hour sampling and transmission frequency). Other stations operate at daily time interval with monthly transmission frequency (climate stations). Synoptic stations are equipped with a shelter for air temperature measurements at 2 m (*Schneider58660*), precipitation Hellman rain gauge, pluviometer (*Lambrecht99.15072.020000*). Automatic weather stations have following equipment: air temperature at 2 m is measured in a shelter (*Rotronic HC2*), precipitation – *Meteoservis MR3* heated. Climate stations: air temperature at 2m in a shelter (Schneider) and precipitation Hellman rain gauge, Precipitation stations: Hellman rain gauge.

Data verification frequency for both hydrometric and meteorological data is regularly done on monthly basis. Station calibration regime is regular, according to WMO standards.

There are no weather radars in the area of interest.

There is only one station that measures sea water level at influence of Mala Neretva (distributary channel of the Neretva river, which inflows into the sea near to the main channel of the Neretva river) to sea (*7499 Ustava ušće nizv., Mala Neretva*).

As it was mentioned earlier, the is no agreement in the transboundary context, thus there is no data available from the upper river basin, located in Bosnia and Herzegovina.

Snow depth is manually measured at all meteorological stations, and snow coverage is measured at synoptic stations.

Historical and ancillary data

DHMZ is responsible for data archiving. There are complete metadata available with updated zero readings, coordinates, equipment type, date of installation, and possible instrument(s) change and other parameters. Hydrometric data time series (water level only) are available in digital format beginning from end of 1930-s (several stations), for the majority of stations – starting from 1960-s, 70-s. All hydrometric data are in digital form. Due to sea influence (tides) there are no reliable rating curves developed at hydrometric gauges of the area.

Regarding meteorological stations metadata – coordinates, station height, date of installation is available, data about the equipment is available in most cases. Notes about changes in instrument(s) and environment are mostly missing. Meteorological long term data series are partly in paper, partly in digital form. For the majority of stations data are available starting from early 1980-s. Mean areal precipitation series are available for selected river catchments, based on rainfall gauges' data.

There are data on cross-sections with adequate spacing in majority of cases, but not up-to-date everywhere.

Vulnerability, exposure data and flood mapping are generally available for all vulnerable flood-prone locations – the data are provided by the Authority of *Croatian Waters*.

Historical information and traditional knowledge on historical flood heights only apply to a few locations and used for analyses such as flood frequency determination.

Snow depth measurements archives are available at all meteorological stations (with more than 6 years' duration) in partly paper and partly digital (more digital) form.

Topographic and land use/cover data are available for urban areas: GIS layers (LC/LU, infrastructure, buildings, etc.).

Data management

Historical as well as real-time data products are stored in *DHMZ* owned servers. Historical hydrological data is available for viewing on website and can be uploaded on request on ftp or sent by e-mail. Real time hydrological data is exchanged in *CSV* files via ftp servers in hourly frequency. All meteorological real time data and products are available on request through web services. Data is ingested automatically from *ftp* repositories for automatic hydrometric stations and manually from non-automatic stations.

Records and documents are stored digitally according to protocols developed by *DHMZ*. Most of procedures that must be automated are indeed automatic. Access to records and documents is available by *ftp* or *http* clients.

All hydrological data have passed QA/QC procedures but there are no available reliability indexes or metrics. Historical QA/QC methodology is based on mainly manual procedures following properly documented protocols. There are no QA/QC procedures implemented for real time hydrometric data.

Database type is of relational type (SQL). Data formats, which are widespread used at the Service – CSV.

Input and output Interfaces - data input/output procedures are partly automated (there is an interface to manually and automatically import data). Real time data is automatically imported and historical data is imported and exported manually.

Meteorological forecast products

DHMZ uses *ALADIN* numerical weather prediction model to produce its in-house meteorological forecast products. Products are derived by an in-house operational suite run at grid spacing up to 2 km for 72 hours ahead with 1-hr output frequency. Model is currently updated every 6 hours through local data assimilation system. *DHMZ* also uses *ECMWF* Integrated Forecasting System (*ECMWF-IFS*). Global Atmospheric Model components in use are: ENS - Ensemble Forecasts (every 12 h, resolution ~ 18 km / 91 level, lead time +15 days); HRES - High-Resolution Forecast (every 12 h, resolution ~ 9 km / 137 level, lead time +10 days); Extended-Range Forecast; Long-Range (Seasonal) Forecast. We also use Ocean Wave Model - ECWAM.

DHMZ runs wave model, which is coupled with *ALADIN* model. No other in-house specific ocean water level forecasts are available. Institute of Oceanography and Fisheries produce short range sea level forecasts (link: http://www.izor.hr/web/guest/visoke-i-niske-vode).

Hydrological models and forecasts

DHMZ does not have its own model for the Neretva river – there are no formal flood forecasting procedures are in place on a basin scale level. However, there are several regional systems used for flood prediction in Croatia, and in particular in the Croatian part of the Neretva river: *EFAS* (EU Flood Awareness System – that is the early warning and monitoring component under the Copernicus Emergency Management Service (*CEMS*), operational since 2012) and *SEEFFGS* (developed by Hydrologic Research Centre, operational since 2015). *EFAS* provides both riverine (up to 10 days ahead) and flash floods (up to 5 days ahead) warnings while *SEEFFGS* gives up to 6 hours in advance warnings on flash floods. Flash flood warnings are disseminated through the *Meteoalarm*.

Some high risk areas are covered with efficient flood warning service, but most catchments of the river still remain uncovered. User needs within the basin area are collected but not documented in an official report. However, requirements of end users (in particular decision makers) are known, documented and reviewed.

Provision of longer lead time alert or watch services is not in operation. Only short to medium lead time alerts are issued.

The hydrological model used for *EFAS* is *LISFLOOD*, that is a hybrid between a conceptual and a physical based spatially distributed (5 km grid cells) rainfall-runoff model combined with a routing module (*Kinematic wave* equations) in the river channel. *LISFLOOD* calculates a complete water balance at a 6-hourly or daily time step for every 5km grid cells of the *EFAS* domain. *FFGS* is considered as a semi-distributed model with the hydrologic model configured and the parameters estimated for each sub-basin within domain.

EFAS and *SEEFGS* have been recently calibrated. There is a regular *EFAS* headline score available at the *EFAS* web page: The Continuous Ranked Probability Skill Score (*CRPSS*) for lead times 1,3,5, and up to 10 days for the previous month across the *EFAS* domain for catchments larger than 2000km^2. There is no systematic efficiency validation of SEEFFGS.

Lead time for the forecast products are as follows: *EFAS* – up to 10 days, *SEEFFGS* – 1, 3, 6 hours (risk product – up to 36 hours with 12 hours' frequency). EFAS runs twice a day automatically at *ECMWF*, *SEEFFGS* runs 4 times per day at Regional center in the FFGS Regional Center (in Turkish Meteorological Service).

There are serious deficiencies of the existing regional flood forecasting systems: EFAS model is not adapted to the specific terrain and hydrological conditions of the focus area, as well as it does not account for strong influence of HPPs in the upper part of the Neretva river basin (in Bosnia and Herzegovina). Flash floods do not have any significant influence on the coastal area of the Neretva river basin in Croatia.

Flood forecasting products

Threshold-based flood alerts and flood forecasting is in operational use: flood threshold levels are set and provided by Croatian Waters for all the territory of Croatia. Flood forecasting service varies across catchments but all catchments are covered: *DHMZ* have well developed hydrological model for the Sava river catchment in Croatia, but not for any river within the Adriatic catchment – only regional flood forecasting systems are used (see above).

Flood maps are not available as Croatian Waters are responsible for flood risk maps and for flood defence system.

DHMZ provides customized products for different users – for example 24/7 hydrological real time monitoring for *Croatian Waters*.

User's feedbacks indicate, that the format is adequate and easily understood – it is standardized interchange of data with *Coastal Waters* for years and it goes well.

Not all areas have appropriate products to satisfy the users – when *DHMZ* receives flood notification for the Neretva river in Bosnia and Herzegovina or Croatia – monitor the situation and according to forecast and its time of forecast vs. real time data we could issue warnings.

Cyprus

General context

Cyprus is the only island state in the SEE region. Cyprus has no transboundary river basins, nevertheless, is suffering from floods and flash flood events resulting in human fatalities and millions of euros of damages. Due to previous flood experience Cyprus joint SEE-MHEWS-A project and was represented to all meetings, from projects early beginning, with high rank personnel.

The most widespread flood events in Cyprus are flash flood events, with time of concentration of less than 3 to 4 hours between the storm event and the resulting flood. The area affected mostly and mainly by flash flood events is the area of the capital, Nicosia, and the suburban areas as also some other coastal urban areas with special geomorphology.

The area of Cyprus is not covered by the WMO/FFGS although it was twice requested by the Department of Meteorology (CyMET) officially from WMO.

The Official Authorities in Cyprus

The Department of Meteorology of Cyprus (CyMET) is the Authority for Meteorology and Climatology i.e. for monitoring the weather and climate and the issuance of forecast and warnings. According to a Decision of the Council of the Ministers, CyMET is responsible to issue all the relevant warnings and distribute them via EMMA, when the forecasted accumulated precipitation is suspected to result in flash flood events.

The Water Development Department (WDD) is the Authority for Hydrology with specific duties and responsibilities as regards floods i.e.:

1. The collection and treatment of hydrological, hydrogeological and other data for the study, design, maintenance and safety of water related development works and the protection and management of water resources and water bodies.
2. The implementation of the technical aspects of the EU Floods Directive and the corresponding national legislation.

CyMET and WDD are in very close collaboration in order to fulfil their responsibilities against floods. The data collected by CyMET are adequately transferred to WDD to be used for the necessary purpose.

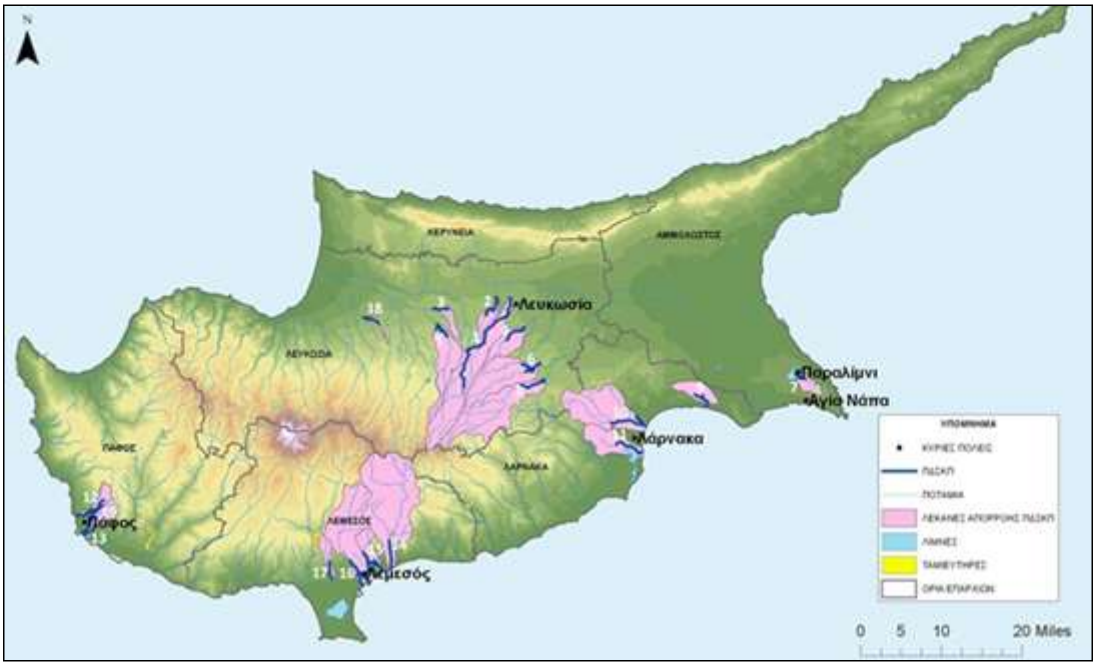
The practice

WDD collected all relevant data regarding historical floods and flash flood events and identified nineteen (19) Areas of Potentially Significant Flood Risk - APSFRs (presented on the following chart).

According to the charts index:

1. the bold blue line represents the APSFRs
2. the light blue line represents the rivers
3. the pink polygons represent the catchment areas of the APSFRs

4. the yellow polygons represent the water reservoirs and
5. the light blue polygons the natural lakes



For all the 19 APSFRs, WDD prepared a Flood Risk Management Plan, according to the standing EU Directive, which includes a program of measures related to:

1. Prevention
2. Protection
3. Preparedness and
4. Recovery

The program of measures includes both horizontal measures that apply generally for the whole island as well as specific measures for each of the 19 APSFR. The preparedness measures include 4 measures (see below) related to the development of flood early warning systems that are currently not available in the country.

The lack of the FFGS limits the abilities of Cyprus to develop its operational early warning systems in order to reduce the severe risks of floods that the country faces.

Greece

General context

The most widespread flood events in Greece are flash floods (with time interval between observable causative event and the flooding of less than 4-6 hours). The Attic peninsula is the area, where most significant damages from floods occur due to heavy rainfalls, and insufficient local drainage. There is a regional flood forecast system *BSMEFFGS* in place.

There is a well-defined national/subnational legislation with clear functions covering the area of flood early warnings. It was indicated that, most or all catchments are not covered by flood EWS. User needs collected but not documented in an official report. User needs are known, documented and reviewed. Occasionally alerts are provided for longer time.

National Meteorological and Hydrological Service

The section was not filled in.

Cooperation and coordination between national institutions and transboundary context

There are a number of transboundary rivers in Greece, so in general flood EWS is working in transboundary context. Open national sharing and agreements in place.

There is a monitoring and evaluation of the performance of the relevant players involved in delivering flood EWS.

No surge capacity and staff overwhelmed during recent events.

Roles and responsibilities of staff involved in the service, as well as SOPs are documented but not updated often.

Formal Incident Management is in place.

Quality management handbook or documented procedures.

Decision support services is decided by the staff at the office.

Institutional agreements on data sharing among different ministries/agencies/data sources

There is no local/national data sharing policy, legal framework or agreements among institutions.

There is a transboundary data sharing policy, and there is agreement for contributing to basic data infrastructure development (co-financing for a network).

Observations and data acquisition

Observational networks metadata was not provided together with the SEE river basin survey, thus there was no possibility to map spatial distribution of observational stations.

Most aspects of networks are maintained, but there is no formal maintenance schedule. Data transmission path (station to forecast center) has reasonable success rate of transmissions, however some limitations exist. There are no or few occurrences of vandalism, mitigation measures are in place at several levels.

Some tributaries have gauges at outlets, other important parts of a river do not have gauges. Some of the basin's gauges have low frequency of measurements to describe flood formation process. Data verification frequency is not adequate for the majority of stations. Calibration was performed prior to service, occasional, with some traceability. All instruments are installed with adequate resolution, ranges, and without significant interferences. Regarding rating curves at hydrometric stations' locations it was mentioned in the survey, that there is a lack of streamflow measurements to update curves, absence of ratings at important points. However, in mountainous areas ratings are well maintained (regularly updated) and available for all important stations (gauges).

Regarding meteorological network following can be said. Some of the basin's meteorological stations have low frequency of measurements. Data verification frequency is fully adequate. Calibration regime is traceable and regular, to WMO or equivalent standards. There are too few meteorological stations in mountainous areas.

Operational transboundary data are not available.

Some measurements (snow depth and coverage, snow water equivalent) are available with limited distribution at daily time step.

Historical and ancillary data

Decentralized Administrations of Greece, Special Secretariat for Water are responsible for data archiving.

For both hydrometric and meteorological data complete metadata are available with updated zero readings, coordinates, equipment type, date of installation, and possible instrument(s) change and other. Reasonable duration (more than 6 years) of hydrometeorological time series are available for both calibration and validation a model without significant gaps and breaches in stationarity. Mostly all data are available in electronic digital form.

Mean areal precipitation is available for majority of river catchments, based on both radar and satellite estimations and gauge measurements (however there is a doubt about the reliability of radar estimations).

Many synoptic elements are archived (incl. temperature, cloud cover, wind speed, and others).

There are cross-sections available with adequate spacing. They are up-to-date, and cover most of important sections of main rivers.

Historical information on rating curves is available with reasonable updates.

High resolution spatial data are nationally available for important data types for modelling purposes.

Historical information and traditional knowledge – broad programme to incorporate such knowledge into archives and used for analyses such as flood frequency determination.

Data on reservoir inflows, storage and outflows are available with more than 6 years' duration without significant gaps in digital format. Both current and previous reservoir rules are available.

Snow course metadata are limited or unavailable for many gauges.

Reasonable duration (more than 6 years) of snow course data for both calibration and validation a model without significant gaps and breaches in homogeneity.

Combined sewer and storm water (drainage) systems data, as well as DEM and topographic and land use/cover data are available in digital format.

Data management

Historical data products are offered according to interoperability standards (data structures and metadata) and are stored in own servers, or are readily available in partner institutions servers (by public or private access) in a client-server scheme providing web services.

No real time data are provided by own or third party ground networks (point data).

There is a scarce amount of transboundary historical data available (digital, digitalized or digitized) and transboundary real-time point data collected or processed by the Hydrological Service in relation to the needs of the warning system. ftp channels for exchange of data products (i.e. Time series, maps) with key providers have been set up. Communication capabilities are expanding.

Data ingestion procedures are partially automated. Most of the data ingestion is done manually. Some data are ingested automatically from ftp/http repositories or from web pages using web scraping procedures.

Records and documents are stored digitally according to local policies, or according to protocols developed by the Hydrological Service. Most of procedures that must be automated are indeed automatic. Access to records and documents is available by ftp or http clients.

Some QA/QC procedures have been implemented to some of the historical and real-time data. Methodology relies mainly on manual procedures following properly documented protocols.

Relational database and DBMS are in use (e.g. *SQL*, *ORACLE*)

Data input/output procedures are not automated. Manual data ingestion.

Meteorological forecast products

Some meteorological products are provided by NMS and some are derived from other companies. Rainfall deterministic forecasts of resolution (spatial and temporal) and of time step that meet the needs of the preferred hydrological model are available in digital format for a forecast horizon of at least 3 days. Air temperature deterministic forecast is of coarse resolution (e.g. resolution of global NWP);

products are digitally available. Wind speed and direction forecast maps, as well as sea level forecast are available only as image products and not in the preferred time step.

Hydrological models and forecasts

There is not a designated provider. Forecasting approach is not appropriate, or no formal flood forecasting procedures are in place. Rainfall-snowmelt-runoff model type (spatial resolution) (if used as main forecast procedure) fits for its purpose – performance metrics are being met or exceeded. There are several models, which are used in practice: *HEC GEO-HMS*, *HEC-HMS*, and *NRCS*. Model calibration/validation is reviewed every 6 years.

Flood forecasting products

Level of service – occasional flood forecasting. Many catchments are not covered but some services in high risk areas. Flood risk maps available for all forecast sites in real-time. Flood risk maps available for all forecast sites in real-time. The suite of customized products for specific end-users is adequate to serve all user's needs and forecast horizons requested. All products are presented in a standardized consistent manner to avoid confusion among users. Some formats are adequate and others difficult to understand. Not all areas have appropriate products to satisfy the users.

Hungary

General context

The Marcal river basin was proposed as the pilot river basin for the *SEE-MHEWS-A* Project. The catchment area of the river is 3076 km^2, the river's length is 91 km. The Marcal river is the right tributary of the Raba river, which is not far from the confluence with the Marcal (near the town of Gyor) inflows into the Danube.

The river is fed primarily by rainfalls and/or snowmelt in its catchment area. The flood type is considered to be riverine, as the time interval of the observable causative event is normally greater than 6 hours.

There is no approach implemented in terms of models to provide flood warnings on the river, only some local-basin analysis based on monitoring to produce warnings for short-term lead time (occasionally alerts are provided for longer lead time also).

National Meteorological and Hydrological Service

NMS and NHS are separate entities. Roles and responsibilities of the NMS are well defined; daily operations are carried out always during day hours but evenings/night shifts are only used when needed. The same is valid for NHS, which is called General Directorate of Water Management.

Cooperation and coordination between national institutions and transboundary context

Early warning system is not working in transboundary context. There is no data sharing across international boundaries. Relevant players of the EWS are working well together through symposiums, joint publications, open sharing. There is a monitoring and evaluation of the performance of the relevant players involved in delivering flood EWS.

NHS have informal surge capacity and procedures in case extreme events. Roles and responsibilities of staff involved in the service are documented well and reviewed regularly. The same is for the standard operating procedures – they are documented well and reviewed regularly.

NHS have a focal point for quality management and performance assessment, which are existing managers.

There are specific arrangements for selected institutions in terms of decision support service.

Institutional agreements on data sharing among different ministries/agencies/data sources

There is a local/national data sharing policy, using interoperability standards. Under this legal framework, spatial data infrastructure has been developed.

There is a transboundary data sharing policy, and there is agreement for contributing to basic data infrastructure development (co-financing for a network).

Observations and data acquisition

Observational network in the Marcal river is presented in Figure 6. Information about the hydrometric, as well as for meteorological network can be found in Appendix 4.

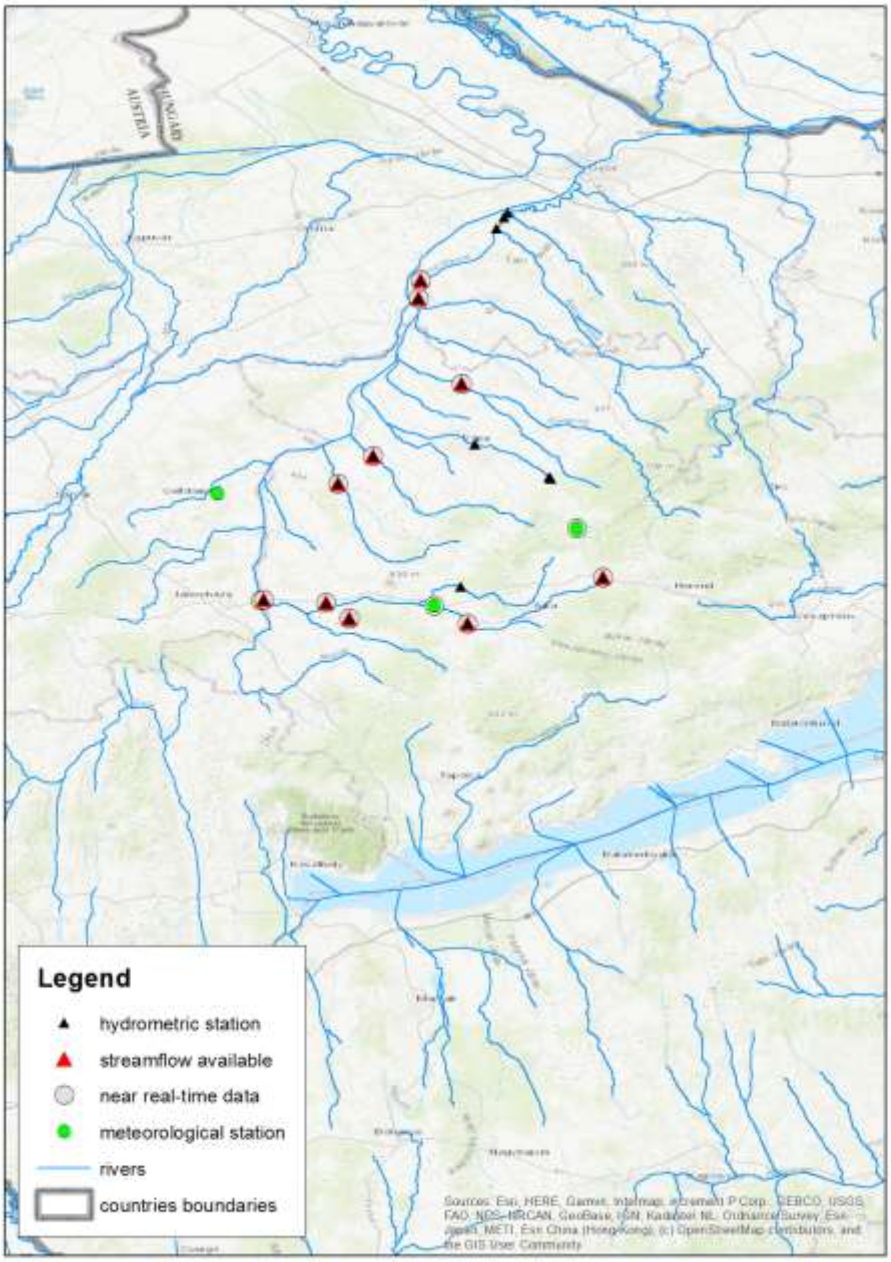


Figure 6. – Hydrometeorological network in the Marcal river basin, maintained by the General Directorate of Water Management of Hungary

There are 23 hydrometric stations in the basin, nearly half of them monitor water level, as well as discharge to maintain and update rating curves (12 stations). These 12 stations provide data in real-time (near real-time) mode – every hour, their sampling interval is 15 minutes. Other gauges provide water level measurements, some of them are manual (staff gauges), their sampling and transmission intervals are longer. Hydrometric network design is considered to be good in the basin with extensive coverage, however some important parts of a river do not have gauges. There are 12 operational real-time stations, other stations have low frequency of measurements to describe flood formation process. Rating curves are well maintained (regularly updated), ratings are available for all important stations.

There 5 meteorological stations in the basin: all of them observe precipitation, 1 of them has additional measurements of air temperature and humidity, another one – air temperature, moisture and pan evaporation. Observational frequency of meteorological stations varies from 15 minutes to 1 hour, and to 24 hours (2 stations). Three meteorological stations out of five can be considered as near real-time stations with transmission frequency from 10 minutes to 1 hour. More information about equipment type can be achieved from in Appendix 4.

Observational data verification frequency is fully adequate – it is done on a regular basis. Calibration regime of both hydrometric and meteorological stations is done prior to service, occasional with some traceability. All instruments are installed with adequate resolution, ranges, and no significant interferences.

The river basin is covered by weather radar data, however these data could not be considered as applicable for flood forecasting, as the radar outputs are not adjusted to ground stations data.

No snow measurements are performed in the Marcal river basin.

Historical and ancillary data

There are quite long time series available of water level and river discharge data – beginning from 1950-s – 1970-s for the majority of gauges. Almost all data are digitized. Time series of observed meteorological elements are available mostly in digital format (paper format – only for 1 station) beginning from: 1970-s for 2 stations, 1992 – for one station, data series of another stations start in 2002 and 2014.

Complete metadata available with updated zero readings, coordinates, equipment type, date of installation, and possible instrument(s) change and other.

Mean areal precipitation is limited, and is available only for several catchments of the river basin.

There are a number of cross-sections available with adequate spacing in majority of cases, but not up-to-date everywhere.

High resolution spatial data are available for important data types, including elevation, soil, land use, land cover. Vulnerability, exposure data and flood mapping are generally available for all vulnerable flood-prone locations of the river basin.

Regarding historical information and traditional knowledge – there is a broad programme in place to incorporate such knowledge into archives and used for analyses such as flood frequency determination

Data management

Historical data products are stored in owned servers in a client-server scheme with minimal functionalities. Most of real time data and products are readily available at the start of the forecasting session. Data and products are available in a timely fashion.

There is a scarce amount of transboundary historical data available (digital, digitalized or digitized) and transboundary real-time point data collected or processed by the Hydrological Service in relation to the needs of the warning system. Ftp channels for exchange of data products (i.e. Time series, maps) with key providers have been set up. Communication capabilities are expanding now.

Records and documents are stored digitally according to protocols developed by the Hydrological Service. Most of procedures are automatic. Access to records and documents is available by ftp or http clients.

Real-time and historical data QA/QC procedures methodologies are manual, following properly documented protocols. In terms of historical data – some QA/QC procedures have been implemented to some of the data. All ingested real-time data are subject to QA/QC procedures and some reliability indexes or metrics are available.

Relational database and DBMS (e.g. *SQL*, *ORACLE*) is used. Widely spread data formats are csv, txt, xls, rtf. Data input/output procedures are partly automated (there is an interface to manually and automatically import data).

Meteorological forecast products

Some of the meteorological products for flood forecasting and warning purposes are provided by NMS of Hungary, some of them are derived from other companies. NWP outputs of major meteorological variables in terms of flood forecasting (air temperature, precipitation, dew point temperature and others) are available of coarse resolution. There are coarse resolution ensemble members (20+) available in terms of rainfall forecast. Probabilistic forecast of air temperature and dew point temperature is based on outputs of several deterministic NWP models.

Hydrological models and forecasts

There is some forecasting approach used for the Marcal river basin, however it should be improved (based on the local basin analysis). Forecast lead time of the existing forecast system is grater then 5 days. "Poor man NWP ensemble" is used as input to the hydrological forecast system. Models of the system are calibrated and validated only at setup. There is no systematic model's performance done in operational mode. Output updating is performed manually.

Flood forecasting products

For now, threshold-based flood alert and flood forecasting are implemented. There are flood maps in development and available at a limited number of forecast sites as static libraries

Customized products for different users are issued - suite of products satisfy part of the users, not all of them. Some of the products are standardized. User's feedback indicate the format is adequate and easily understood. All products provided satisfy the timeframe required by users.

Jordan

General context

The Jordan river and the Zarqa river (significant tributary of the Jordan river) were proposed for the SEE-MHEWS-A Project by Jordan. Most of the damages from floods occur in the Jordan river valley, as well as other different places due to flash floods (flood mechanism – excess rainfall over catchment area). The service provides short lead time flash flood alerts, it is a continuous service, dams overflow alerts are also issued for this river basin.

National Meteorological and Hydrological Service

NHS and NMS are separate entities in Jordan. NMS – Jordan Meteorological Department – is issuing only flash flood warning using *BSMEFFGS* products. Hydrological forecasts are issued by Ministry of Water and Irrigation. The service of NMS is continuous and 24/7 (including for flash flood events). Ministry of Water and Irrigation issue early warning for floods and dams overflow, monitor water resources, develop water strategies. The SEE river basin survey was filled by the Jordan Meteorological Department, and Ministry of Water and Irrigation (which is an NHS of Jordan) did not participate in the survey filling process.

Cooperation and coordination between national institutions and transboundary context

The proposed Jordan river basin is a transboundary river. However, there is no data/products sharing in place across international boundaries. There is an occasional knowledge sharing with Academia mainly in conference. There is no monitoring and evaluation of the performance of the relevant players involved in delivering flood warnings.

Roles and responsibilities of staff involved in the service, SOPs are documented but not updated often. Formal Incident Management is in place. Quality management handbook or documented procedures are used to support quality management framework. There are specific arrangements in terms of decision support services for selected institutions.

There is a local/national/transboundary data sharing policy, and there is agreement for contributing to basic data infrastructure development (co-financing for a network).

Observations and data acquisition

There was no information provided on hydrometric stations in Jordan, however the survey section regarding hydrometric network was filled in (information is provided below). There are 13 meteorological stations, operating in Jordan (Figure 6). Majority of most important meteorological elements are measured with 1 hour (AWS) and 6 hours (manual) time interval. All sites with manual stations are also equipped with AWS. Transmission frequency is 1 hour.

Most aspects of network are maintained, but there is no formal maintenance schedule in place.

Transmission is considered to be reliable – there is a reasonable success rate of transmissions.

Some tributaries have hydrometric gauges at outlets. Some of the basin's hydrometric gauges have low frequency of measurements to describe flood formation process. Some of the basin's stations have missing verification checks. Instruments calibration was done prior to service. Many stations/instruments have inadequate range or accuracy, and/or installed in compromised situations. Majority of gauges are without rating curves, or ratings were updated long time ago.

Some of a river's catchments in flow formation area have few or no precipitation and temperature measurements (as well as other elements, observed at synoptic stations), some of the basin's meteorological stations have low frequency of measurements. Calibration was done prior to service. Different types of instruments are used: automatic and manual from different sources and vendors.

Weather radars installed, but data are not adjusted to ground stations.

Transboundary data are not available.

Snow depth is measured at some meteorological stations with daily time step.

In mountainous there is an even distribution of stations, most parts of mountain/urban areas have coverage.

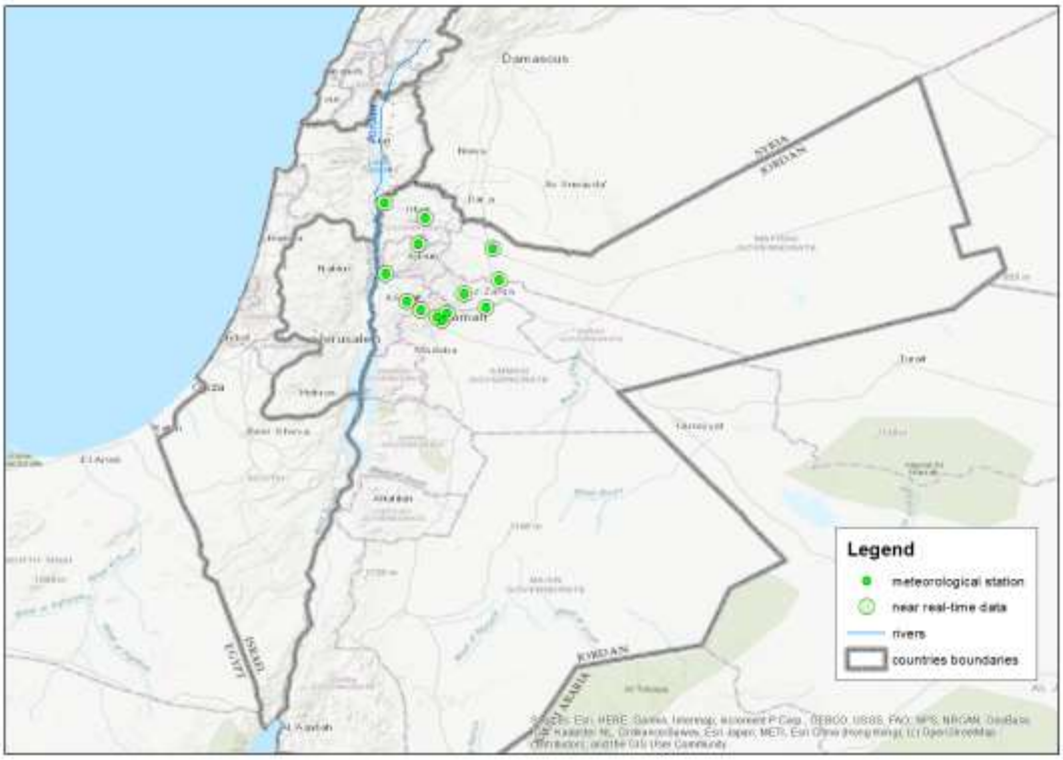


Figure 6. – Meteorological stations in the Jordan river basin (Jordan part of the basin).

Historical and ancillary data

Ministry of Water and Irrigation, Ministry of Agriculture, Jordan Meteorological Department are responsible for storing and archiving the data.

Meteorological data archives have long time period (majority of stations – from middle of 20th century), all series available only from manual stations. All series are digitized (*XLS* format).

Metadata of stations (both hydrometric and meteorological) are not complete (there might be absence of location information, equipment used, or zero readings), not suitable for modelling. Time series of hydrometric data are partly in paper and partly in electronic digital form.

Mean Areal Precipitation (MAP) is available for selected river catchments, and it is based on rainfall gauges only.

Many synoptic elements are archived (incl. temperature, cloud cover, wind speed and others), metadata are not complete (absence of some meta data.), all (mostly) digital.

Some spatial data globally available are used in the Service.

No vulnerability and exposure data etc. are available nationally.

Information on reservoirs (inflows, storage and outflows) is of reasonable duration, without significant gaps, in both paper and digital format; both current and previous reservoir operation rules are available.

Only manual snow depth measurements archives are available (available mainly in digital form).

Combined sewer and storm water (drainage) systems data, as well as topographic and land use/cover data are unavailable.

Data management

Data products are stored in regional servers (private access) for flash flood guidance. There is a server for AWS and meteorological data from manual stations. AWS real time data are available, flash flood data and products are available upon request. No transboundary data are available.

Most of the historical data ingestion is done manually. Some real-time data are ingested automatically from ftp/http repositories or from web pages using web scraping procedures. Some QA/QC procedures have been implemented to some real-time and historical data. QA/QC methodologies are based mostly on manual procedures following properly documented protocols. *ORACLE* data base is used. The most widely spread formats of data are delimited text, *XLS*, and *CSV* formats. Data input/output procedures are partly automated.

Meteorological forecast products

The products are provided by the National Meteorological Service only. Forecast of meteorological elements are available only as image products and not in the preferred time step. Outputs of at least three deterministic NWP models are used in terms of probabilistic forecast.

Hydrological models and forecasts

FFGS (*BSMEFFGS*) is used to generate flash flood warnings. There is no systematic forecast performance of the *BSMEFFGS*. There are also basin-based forecasting systems in use composed of numerical/statistical models connected with local terrain information.

Flood forecasting products

Occasional flood forecasting is being done in the country. Service varies across catchments but all catchments are covered. There are no flood maps available. There is a lack of products for the forecast horizons most needed. No standardization is used. Some formats are adequate for the end users and others difficult to understand (as FFGS products, for example). Not all areas have appropriate products to satisfy the users' needs.

Montenegro

General context

The most vulnerable areas in the country in terms of riverine floods are following hydrological systems:

- floods on the system of the Zeta river – the Moraca river – the Skadar Lake and the Bojana river, which is caused by both rainfalls and snowmelt, as well as reservoir operation in the Albanian part of the basin;
- the Lim River basin, including its tributaries (section Gusinje-Berane-Zaton), where floods are induced by rainfall and snowmelt;
- the region of upper Tara River, before entering the canyon (around the settlements of Kolasin and Mojkovac);
- the valleys of the rivers Ibar and Cehotina;
- small rivers of the Montenegrin coast, which basins are heavily urbanized, are affected by flash floods and urban floods.

National Meteorological and Hydrological Service

In Montenegro NMS and NHS are joined – there is an Institute of Hydrometeorology and Seismology of Montenegro, which cover operational hydrometeorological activities in the country. It provides meteorological forecasts as main input to the EWS for flood forecasting and it also warns in case of potential (or existing) adverse flood conditions in the vulnerable zones, provide hydrological analyses based on meteorological forecast and actual hydrological situation. The roles and responsibilities of the Service are well defined. Daily operations for supporting the flood EWS are carried out always during day hours but evening/night shifts only used when needed.

NHMS structure have informal surge capacity and procedures.

E2E Flood EWS is working in transboundary context for a number of basins of Montenegro. Following national data sharing agreements are in place:

- sharing hydrological and meteorological data on daily basis between riparian countries of the Sava river basin;
- sharing hydrological and meteorological data between on daily basis riparian countries of the Drim and Bojana rivers.

Relevant players of the EWS are working well together through open data/products sharing, symposiums, joint publications. There is no monitoring and evaluation of the performance of the relevant players involved in delivering flood EWS.

Roles and responsibilities of staff involved in the service are understood but not documented. Standard Operating Procedures are documented but not updated often. Incidents are managed informally with best efforts.

There is no quality management handbook or documented procedures in place.

Any institution in Montenegro can request Institute for Hydrometeorology and Seismology for extended hydrometeorological services.

There is a local/national/transboundary data sharing policy, and there is agreement for contributing to basic data infrastructure development (co-financing for a network).

There is a centralized system for risk management in circumstances such as emergency situations including protection, rescuing and recovery, according to National Strategy for Emergency Situations and the Law on Protection and Rescue. The coordination team for emergency situations management is established in the country, which is led by Directorate for Emergency situations (Ministry of the Interior of Montenegro). Institute of Hydrometeorology and Seismology of Montenegro represents ˝the trigger˝ for convocation coordination team in case of emergency situations (for example, in case of precipitations of high intensity and a forecast of big precipitation amounts for next day's – meteorologist notify the sector for hydrology which, after performed analyses notify Directorate for Emergency Situations of Montenegro, which is obliged to notify Government and publicity about possible adverse flood situation.

Bearing in mind the hydrological, geological and morphological characteristics of the terrain of Montenegro, the early warning system consists of the early announcement of possible adverse weather events, which may induce floods in all flood prone areas to the relevant service: the Directorate For Emergency Management, which continues to implement the procedures of the Early Warning System.

Observations and data acquisition

There is a rigorous real-time monitoring service in place in Montenegro. Most aspects of operational networks are maintained, however there is no formal maintenance schedule in place. Data transmission path (station to forecast center) has reasonable success rate of transmissions, with some limitations. The transfer of variables from some stations (data on water level and temperature) is still arranged through the GSM, so real-time data from that locations cannot be provided. There is relatively high risk of vandalism, with no significant mitigation plan developed.

Hydrometric gauges are evenly distributed across the country (Figure 7, Appendix 4). Some of the basin's gauges have low frequency of measurements to describe flood formation process. Some of the basin's stations have missing verification checks. Calibration regime of hydrometric stations is traceable and regular, to WMO or equivalent standards. Details on equipment of hydrometric stations are given in table X. All instruments are installed with adequate resolution, ranges, and no significant interferences. Regarding rating curves maintenance – it could be said, that there is a lack of measurements to update curves, as well as absence of ratings at important points. In the moment there is no discharge measurements at any hydrometric station in Montenegro, thus discharge is not calculated in real-time (at the end of the year, water balance analysis is performed to calculate approximate daily values of discharge for yearbook).

Some catchments in flow formation area have few or no precipitation and temperature measurements (see figure X), some meteorological stations have low frequency of measurements, and missing verification checks. There are significant gaps in rainfall observations in mountainous areas, a lot of upper catchments are without stations. Calibration regime of meteorological stations is traceable and regular, according to WMO standards. Real time data are available every 15 minutes (hydrometric), and every 10 minutes (meteorological)

There are no weather radars in use.

Coastal area of Montenegro is mostly covered by operational sea level station data, however some areas have gaps in observations and seal level forecasts.

Some snowpack conditions measurements and calculations (depth, density, mass, SWE) are available with limited distribution and temporal resolution at the meteorological network sites.

There is no reservoir data available in operational mode.

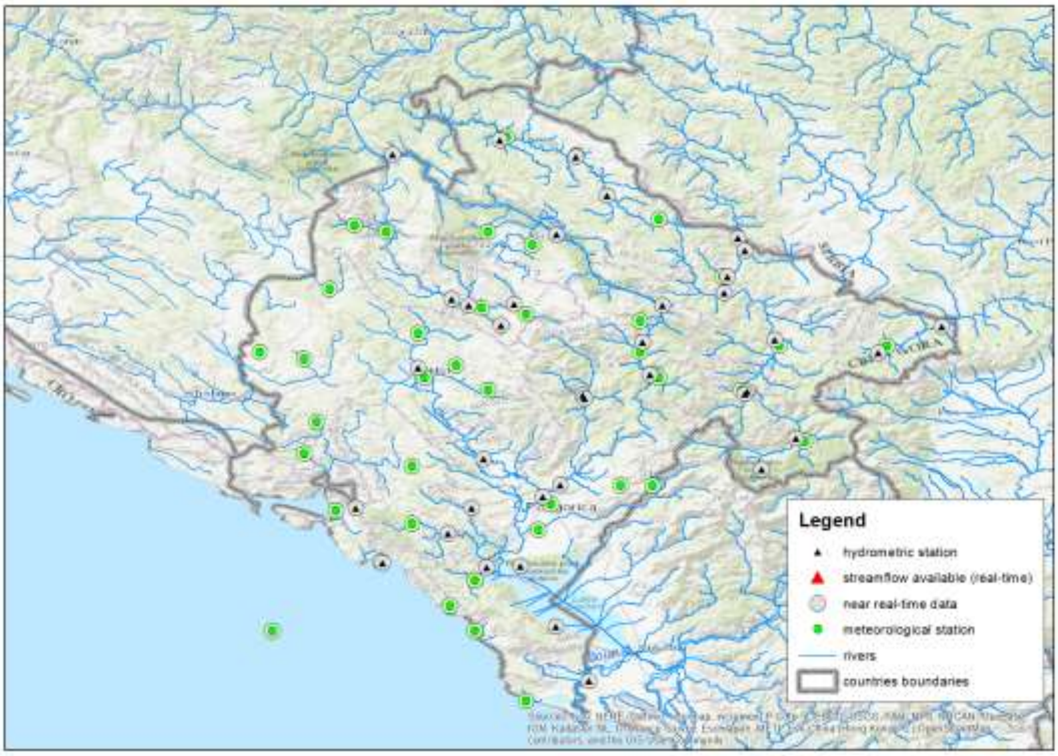


Figure 7. – Hydrometeorological observational networks of Montenegro

Historical and ancillary data

Institute of Hydrometeorology and Seismology of Montenegro is responsible for data archives. There are complete metadata available with updated zero readings, coordinates, equipment type, date of installation, and possible instrument(s) change and other. Long term archives are available for the period of at least 6 years, gaps are present in mostly electronic digital form.

Metadata for meteorological (e.g., precipitation and temperature) gauges are available with coordinates, station height, equipment type, date of installation, and possible instrument(s) change, etc. Time series of meteorological data are of reasonable duration (more than 6 years) for both calibration and validation for modelling, without significant gaps and breaches in stationarity. Meteorological data (e.g., precipitation and temperature) format are partly paper and partly digital.

Mean areal precipitation (MAP) is available for selected river catchments based on rainfall gauges. Many synoptic elements are archived (including temperature, cloud cover, wind speed, …).

Synoptic data format is partly paper and partly digital.

Cross-sections are available with adequate spacing in majority of cases, but they are not up-to-date everywhere.

Historical information on rating curves is available.

Some spatial data globally available are used in the Institute of Hydrometeorology and Seismology of Montenegro.

There is no usage of impact data – no vulnerability and exposure data are available nationally. Historical information and traditional knowledge are only applied to a few locations and used for analyses such as flood frequency determination. Historical information on reservoir inflows, storage and outflows, as well as on reservoir operation rules is not available.

There are some snow data archives with depth measurements available. Snow data record duration is at least 6 years, gaps are present (partly paper and partly digital).

Some pertinent transboundary data are available with delays

As for sea level stations – complete metadata available with updated zero readings, coordinates, equipment type, date of installation, and possible instrument(s) change and other. Sea level data series with at least 6 years are available (with gaps).

Data management

Most of historical data have passed QA/QC procedures. Most of the real-time ingested data are subject to QA/QC procedures and some reliability indexes or metrics are available. Both real-time and historical QA/QC methodologies imply partially automated approaches with human intervention.

Meteorological data are stored in *CLIDATA* Database. Hydrological data are stored in *Hydras Pro* software and in Excel sheets. Input format of meteorological and hydrological data is *MIS*. Output format is *CSV* and *XML*. Data input/output procedures are automated, some of them with advanced graphical functionality.

Meteorological forecast products

Some meteorological forecast products are provided by the Institute of Hydrometeorology and Seismology and some are derived from *ECMWF*. Sea water level forecast are not provided by the NMHS. Precipitation forecast maps (rainfall accumulation), as well as air temperature and other weather elements are available with 3 hours' time step and in *GRIB* data file from *ECMWF* (high resolution for limited area). Prognostic meteograms and maps from the *ECMWF* ensemble numerical system are used as ensemble products with 3 hours' time step.

Hydrological models and forecasts

Currently basin scale models are not used for hydrological forecasting. They are only used as the tool for generating added value for operational forecaster in emergency situations. These models are in the phase of improvement.

There are several regional EWSs implemented in Montenegro:

- *EFAS* (the whole territory of Montenegro is covered);
- *SEEFFGS* (the whole territory of Montenegro is covered);
- *Panta Rhei* hydrological model (developed by Technical University in Braunschweig, Germany), funded by GIZ Project is implemented for the transboundary Drim - Bojana river system catchment (the basin is shared by Republic of North Macedonia, Albania, Kosovo (UNSCR 1244/99), and Montenegro);
- *Wflow* hydrological model (developed by *Deltares* throughout project of International Sava River Basin Commission financed by WBIF) is implemented for the Sava River Basin catchment.

Only short to medium lead time flood alerts are issued.

Consistent flood forecasting services levels are maintained across all catchments in Montenegro.

End users and their requirements are both prescribed by the legal regulations and is dealt by the Directorate for Emergency Management of Montenegro. User needs are understood but not well documented.

Flood forecasting products

Threshold-based flood alerts and flood forecasts are being issued. Service varies across catchments but all catchments are covered. Generation of Flood risk map products is not applicable – no flood maps available. Suite of products satisfy part of the users, not all of them. All products are presented in a standardized consistent manner to avoid confusion among users. User's feedback indicate the format is adequate and easily understood. Not all areas have appropriate products to satisfy the users.

North Macedonia

General context

North Macedonia is a country where floods and droughts are normal natural phenomenon, which can occur on all territory of the country. Evidence of floods exist from ancient times, but also from last century till today. There are three main river basins in the country: The Vardar, the Strumica and the Crn Drim river basins. The most severe floods occur on the Vardar river; catastrophic floods were observed in 1916, 1935, 1937, 1962, 1979 with catastrophic outcomes. Following important cities may be flooded: Tetovo and Polog Area, Skopje and Skopsko Pole, Veles, Gradsko Area, Gevgelija Area). Mainly River Vardar and surrounding areas where affected by floods, but also smaller tributaries were affected as well (significant damage occurred). Many cases of flash floods occurrence were registered near the following cities: Negotino (06.071995), Radovish (04.12.2008 with two casualties), Shipkovica and Tetovo (03.08.2015, 6 casualties), Skopje and Stajkovci (06.08.2016, 23 casualties). The most flood prone areas in the Vardar River are the following:

- upper part of the River Vardar;
- Polog;
- Middle part of River Vardar;
- Skopsko Pole;
- Veles, Gradsko;
- Demir, Kapija;
- Lower part of River Vardar;
- Gevgelija and Valandovo Area;
- tributaries Crna River;
- Pelagonia Area, Borotinsko Blato flat Area, Upper Part of the River Crna;
- Treska River upper part of the catchment above Makedonski Brod town;
- Kumanovo town and surrounding areas;
- Surrounding areas upper Bregalnica Catchment, middle and lower part of the catchment.

The heaviest events of precipitation occur during November – January, and April - May. Those are the periods when heavy rainfalls and snowfalls occur and affect all basin’s area. Snowfalls happen from November till March, and snow melting process occurs from November till May (depends of area and altitude). Floods of mixed origin (heavy rain and snowmelt) occur from November till March. Rainfall induced floods occur in November and May. Flash floods occur during any period of the year, but the most devastating flash floods happen on small catchment during summer time.

Graphoanalytical method has been applied since 70-s to forecast floods before construction of the dams in the Vardar river basin. Later in 70-s and 80-s, some basic flood EWS existed, which covered the whole area of the country, but now it is not operational any more. In the present time Crisis Management Center and Protection and Rescue Directorate with the help of Hydrometeorological Service of North Macedonia are trying to develop new EWS for flood forecasting (however there are several obstacles, including absence of the complete hydrometeorological network of automatic stations and absence of risk and hazard maps). In the present time there is no modern hydrological model used in the basin.

User needs are collected but not documented in an official report. The hydrometeorological service of North Macedonia provide short and long time alerts, it is a continuous service.

There is a well-defined national/subnational legislation with clear functions covering the area of flood early warnings – Law on hydrometeorological activity (*Official Gazette of the Republic of Macedonia*, No.103, from 19.08.2008).

National Meteorological and Hydrological Service

There is merged NMHS in the country – Hydrometeorological Service of North Macedonia. Weather forecasts and Alert Department of Hydrometeorological service detect potentially adverse weather events and issue alerts in 24/7 mode. During the period of adverse weather conditions, they are continuously informing with additional information about the weather.

Hydrological Sector of the NHMS has responsibility to collect data from hydrometric network (13 stations in the Vardar river catchment once per day), process the information, and spread the informational products to Ministries, as well as Crisis Management Center and Protection and Rescue Directorate, general public and media. In case of extreme flood event, several additional informational products are made and spread during a day. Additional information on reservoirs releases is received during the flood event.

Hydrological sector operates during day hours but evening/night shifts only used when needed (during extreme flood event).

Cooperation and coordination between national institutions and transboundary institution

Concerning the Vardar river catchment EWS is not operating in a transboundary context – there was no special agreement concerning this issue neither with Serbia (Pcinja river catchment on Serbian side), nor with Kosovo (UNSCR 1244/99) (Jelashka river catchment is partly in Kosovo (UNSCR 1244/99)), but informal cooperation is on very good level. There is a strong need in Memorandum of Understanding with Serbia, Kosovo (UNSCR 1244/99), and Greece, as well as links to their data. Concerning information from North Macedonia to Greece, in case of high water levels, Hydrometeorological Service of North Macedonia informs Greece Embassy in Skopje.

There is occasional sharing of experience, data and products with Academia mainly during conferences.

Roles and responsibilities of staff involved in the Service are documented but not updated – there is not enough hydrologists to performed their duties. SOPs are documented but updated long time ago.

Incident Management policy and procedures – manage incidents informally with best efforts. No quality management handbook or documented procedures, used in the Hydrometeorological service of North Macedonia.

Institutional agreements on data sharing among different ministries/ agencies/ data sources

In the Vardar River Catchment - there is no transboundary data sharing policy, legal framework or agreements among countries and institutions.

Observations and data acquisition

Maintenance and sustainability of networks – some aspects of the network(s) are maintained, some key ones are not due to budget issues. There is a medium level of reliability of data transmission, statistics and backup paths are available. Some risk of vandalism exists (mitigation measures are in place).

Some tributaries have hydrometric gauges at outlets, other important parts of the Vardar river do not have gauges. Large number of hydrometric gauges have low frequency of measurements (once a day) and once a month transmission. The majority of stations are staff gauges. Some of the basin's stations have missing verification checks (verification of majority of stations is done 3-4 times a year). Information about equipment used at hydrometric stations can be found in the survey (Attachment 10).

Rating curves maintenance is an issue: there is a lack of streamflow measurements (especially during the period of 2010-2015) to effectively update the curves. In the result there is an absence of ratings at important gauges.

There is a good coverage and distribution of meteorological stations in flow formation areas. However, in mountainous and urban areas there are significant deficiencies in rainfall observations – a lot of mountainous catchments are without stations. Significant number of the basin's meteorological stations (table in Appendix 4) are not real-time stations with once a month frequency of data transmission. Calibration regime of both hydrometric and meteorological equipment used is traceable and regular, according to WMO or equivalent standards (not more often then 3 -4 times a year).

There are two weather radars installed, but their usage is very limited due to lack of calibration and adjustments to ground measurements.

Transboundary data are not available as there are no data sharing policy developed and signed (see above).

Snow measurements are performed regularly at two stations (snow depth, weigh, calculation of SWE are measured/calculated). Snow cover and depth are measured at 19 meteorological stations every day during the period when snow cover exists.

There is significant manmade effect on river flow as there are six reservoirs (table 4) in North Macedonia (five of them are within the Vardar river basin). Reservoir data are received only two times a month, and on daily basis during a flood event.

Table 4. – Information on dams, located in the Vardar river basin

№	Dam	River	Nearby town	Latitude	Longitude	Crown	Spillway	Operator
1	Mavrovo	Mavrovska	Gostivar	41.697	20.746	1236	-	ELEM
2	Kozjak	Treska	Skopje	41.878	21.193	449	-	ELEM
3	Sv.Petka	Treska	Skopje	41.925	21.264	423	-	ELEM
4	Matka	Treska	Skopje	41.697	20.746	334	316	EVN
5	Kalimanci	Bregalnica	Delcevo	41.973	22.581	520	515	ELEM
6	Tikves	Crna	Kavadarci	41.403	21.938	269	265	ELEM

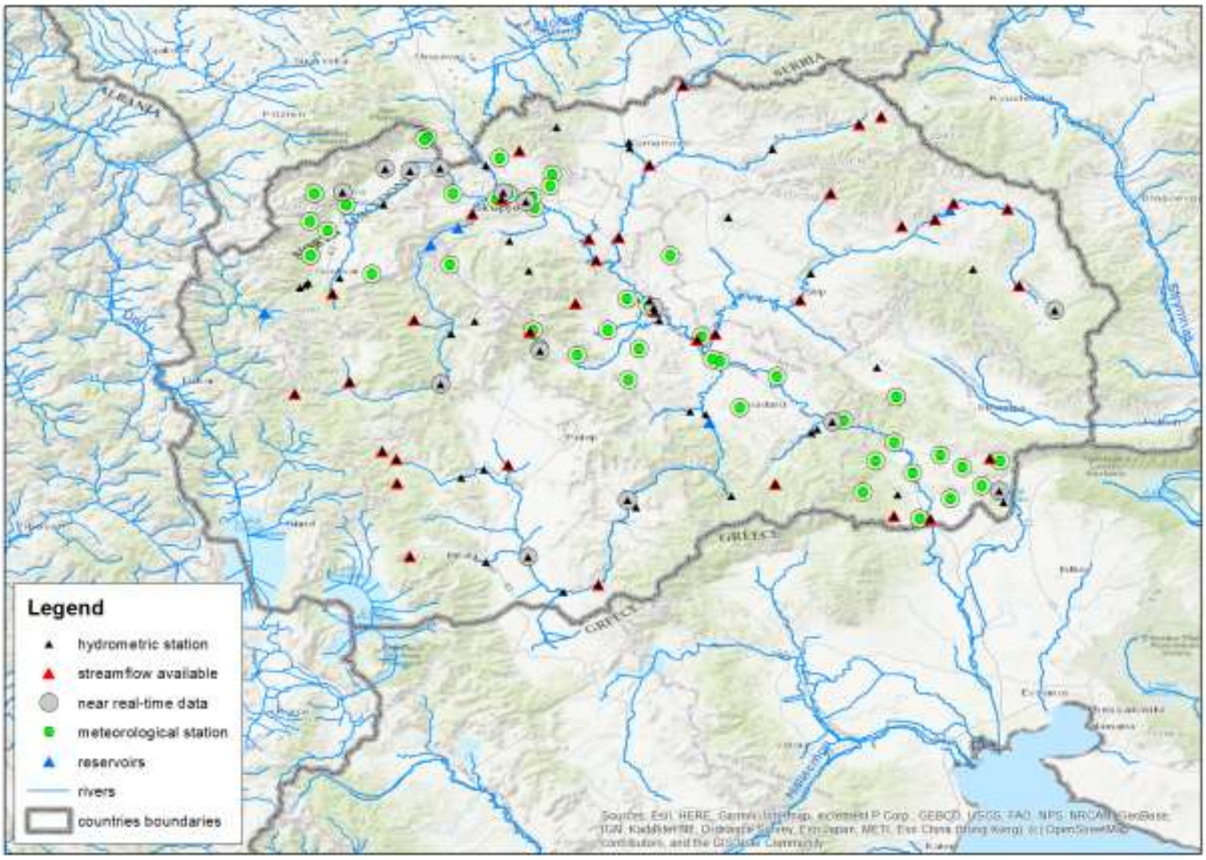


Figure 8. – Observational networks (hydrometric and meteorological) in the Vardar river basin, and reservoirs in North Macedonia

Historical and ancillary data

Hydrometeorological Service of North Macedonia is responsible for data archiving. Complete metadata exist for hydrometric, as well as meteorological stations are available with, coordinates, equipment type, and possible instrument(s) change and other.

Hydrometric data time series are of long duration, however there are some significant gaps (there were no measurements from 2010 to 2015). Format of data series is mainly in paper.

Meteorological data series (e.g., precipitation and temperature) are of reasonable duration - from beginning of 90-s for majority of stations, without significant gaps and breaches in stationarity; available mostly in digital format.

There is no MAP product available (ever produced) in North Macedonia

River cross-sections are not available.

Historical information on rating curves is not available for majority of stations.

Some global spatial datasets are used in operational hydrology studies.

Impact data, such as vulnerability and exposure data, and etc. are available for key locations in the country.

Historical information and traditional knowledge are only applied to a few locations and used for analyses such as flood frequency determination.

Historical data on reservoir inflows, storage and outflows are available with reasonable duration (however there are significant gaps), mainly in paper format. Reservoir operation rules (historical and present) are available for large reservoirs.

Time series of snow data (depth, cover, SWE at several locations) are available.

Hydrometric transboundary (both historical and real-time) data are not available

Combined sewer and storm water (drainage) systems data exist in water enterprise companies.

There are spatial data in use for urban areas, including Digital Elevation Model (DEM), topographic and land use/cover data.

Data management

Real time and historical data from automatic stations (both hydrometric and meteorological) are presented on Internet module for public. The data are raw and stored in DEMAS Data Base System. Historical Data are in Excel files. Hydrometeorological Service Database System (*HydroPro*) is not functioning, there is a shift now to MCH Database System.

Data ingestion procedures are partially automated. Most of the data ingestion is done manually. Some data are ingested automatically from ftp/http repositories or from web pages using web scraping procedures.

Records and documents are stored digitally according to protocols developed by the Hydrometeorological Service of North Macedonia. Most of procedures are automatic. Access to records and documents is available by ftp or http clients. *MCH* Database procedures are being implemented.

Historical data QA/QC procedures have been implemented to some of the data, but main problem is the lack of engineers that are needed to perform their duties. Some part of the ingested real-time data is subject to QA/QC procedures. Mainly manual procedures following properly documented protocols are used as QA/QC methodology.

Databases used are *Demas* database (for data measured at automatic stations), and MCH Database. *CSV* format is widely used in the Service.

Meteorological forecasting products

There is Forecast and Alert Department in the NHMS of North Macedonia, which is responsible for issuing weather forecast. Deterministic forecasts of main meteorological elements are maps are available only as image products and not in the preferred time step. Outputs of several deterministic NWP models are used as probabilistic forecasts.

Hydrological models and forecasts

There are no models developed and implemented in the moment (including rapid-onset events forecasting and warning). Graphoanalytical method is used, based on historical rainfalls and river discharges data. Forecast lead time is 1-2 days. Method is half automated and depend of available data. There is no systematic forecast performance. Output updating is performed manually.

Flood Forecasting Products

Many catchments are not covered with forecasting products but some of them, especially in high risk areas are covered with hydrological forecasting products. There is a lack of products for the forecast horizons most needed. Available products are presented in a standardized consistent manner to avoid confusion among users. Formats are adequate, but for some users maybe is not. Not all areas have appropriate products to satisfy the users.

Moldova

General context

The Prut river was proposed for the SEE-MHEWS-A Project, as potential pilot basin for implementing hydrological modelling and forecasting system. The river length is 953 km, basin area – 27500 km^2. The basin is shared between three countries: Ukraine, Romania and Moldova. The river origins in Ukraine, in Eastern Carpathian Mountains, then flows in east-south direction, forming the border between Republic of Moldova and Romania, then inflows into the Danube river near its mouth. There are two HPPs in the river basin: Stanca-Costesti Dam, operated jointly by Moldova and Romania (built on Prut), and HPP in Snyatyn in Ukrainian part of the river basin.

National Meteorological and Hydrological Service

There is a joint hydrometeorological service in Republic of Moldova – State Hydrometeorological Service of Republic of Moldova (http://www.meteo.md), responsible for both meteorological and hydrological services within the country, including the Prut river basin.

Observations and data acquisition

The hydrometric and meteorological network of Moldova is shown in figure 9 (as well as in the table of Appendix 4). There are two hydrometric stations on the Prut river, at one of them (33885, Cahul) streamflow measurements are performed. There are a number of meteorological stations in Moldova, as well as in the described river basin; all of them are synoptic station with 3 hours' observation and transmission frequency. Equipment specifications are presented in the table of Appendix 4.

Some tributaries have hydrometric gauges at outlets (Figure 9), other important parts of a river do not have gauges, as well as meteorological stations. Some of the basin's gauges have low frequency of measurements to describe flood formation process. Some of the basin's stations have missing verification checks. Calibration of instrument was done prior to service. Equipment is both of manual and automatic type, transmission is near real-time for all stations. Some stations/instruments have inadequate range or accuracy or compromised installations. There is a lack of measurements to update rating curves, as well as absence of streamflow measurements and thus absence of ratings at important locations.

The basin is partly covered by weather radar, but the data are not reliable as it is not adjusted to ground stations.

Transboundary data including streamflow data are received in real time (or near real time).

Snow courses are evenly distribution across the basin (snow depth, density, mass, and SWE are measured/calculated) with 5 days' collection frequency. Snow courses data are collected by staff.

Reservoir data are described in the survey as adequate.

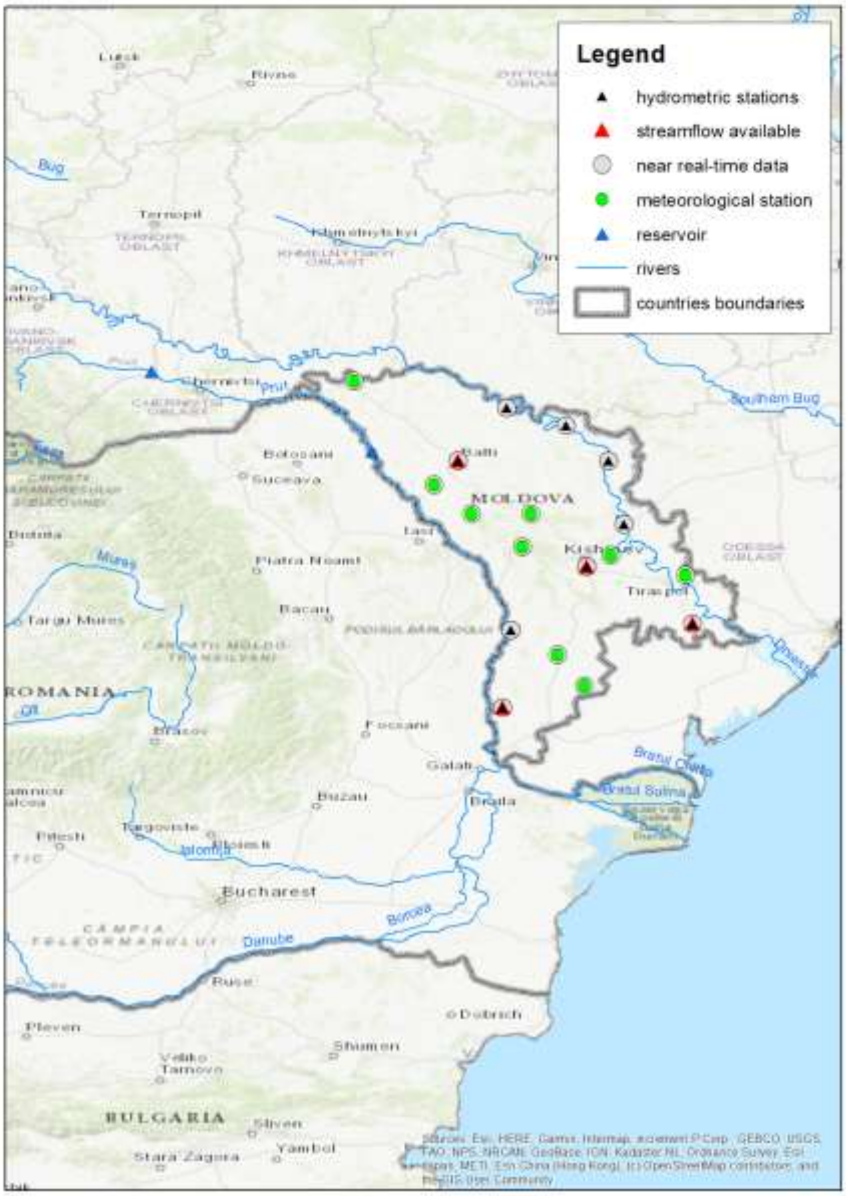


Figure 9. – Hydrometeorological network of Republic of Moldova, and the Prut river basin

<u>Historical and ancillary data</u>

State hydrometeorological service of Republic of Moldova is responsible for data archiving.

Complete metadata are available with updated zero readings, coordinates, equipment type, date of installation, and possible instrument(s) change and other. Historical information on rating curves is not available. Spatial data are not used.

There are no vulnerability and exposure data available nationally.

Hydrometric data time series start from the end of 1940-s. The data are available partly in paper, partly in digital form. Synoptic data time series are available from 1950-s, 1960-s for the majority of stations partly in paper, partly in digital formats.

Information on reservoir inflows, storages and outflows is available of reasonable duration, without significant gaps, in both paper and digital format. Both current and previous reservoirs operation rules are available. Time series of snow courses data (snow depth, density measurements) are available in partly paper, partly digital format.

Data management

Historical data products are stored in owned servers. Most of real time data and products are readily available at the start of the forecasting session. Data and products are available in a timely fashion.

Meteorological forecast products

Meteorological forecast products are all provided by the National Hydrometeorological Service of Moldova. Meteorological elements forecasts are available only as image products and not in the preferred time step. NWP models used to generate forecast products are: *GFS*, *UK MetOffice*, *DWD*, *COSMO*, *Alaro*, *ARPEGE*. These models are used to address probabilistic forecast issue (multi model approach).

Hydrological models and forecasts

There is a rainfall-runoff model in use (no details are given in the survey), which is considered to be appropriate, but should be improved - performance metrics are being met most of the time. Appropriate time step is used. The model can be run twice a day. Model calibration/validation is reviewed only if a problem arises. There is a program executed monthly that provides statistics on performance. Output updating is performed manually.

Flood forecasting products

No flood maps are available. Suite of products satisfy part of the users, not all of them. All products are presented in a standardized consistent manner to avoid confusion among users. User's feedback indicate the format is adequate and easily understood. All products provided satisfy the timeframe required by users.

Slovenia

Representative of ARSO noted that all Slovenian river basins are covered with the national flood forecasting system, and that ARSO and end-users are fully satisfied with existing flood forecast products, thus there was no intent from the ARSO to propose one of Slovenian rivers for the pilot forecast system development. For this reason, only *Institutional setting* section was filled out. It was also mentioned, that ARSO have recently prepared a comprehensive report about the Slovenian Hydrological service (*Evaluation report on flood and ice forecasting systems and methodologies in the Danube countries, 2019*).

General context

There is a well-defined national/subnational legislation with clear functions covering the area of flood early warnings. The most significant damages happen mostly within the Sava river Basin (the cities of Ljubljana and Celje). Mostly torrential rainfall causing rapid rise of the river streams. The time interval of the observable causative event and the flooding for each location is typically greater than 6 hours.

There is an adequate EWS for flood forecasting developed and operational for all important locations. The basin based forecasting system are developed and operative within ARSO. All river basins are already covered with the forecasting system.

The most important end user or the flood forecasting system is within the same institution - the national hydrological forecasting service. The needs of the flood forecasting system end users are known.

The flood forecasting service provides short and long time alerts; it is a continuous service.

National Meteorological and Hydrological Service

NMS and NHS are merged into a single institution – ARSO. The meteorological section of ARSO provide NWP forecasts for the flood EWS as well as daily consultations for the hydrological section on the approaching weather events. The role of hydrological section of ARSO is development and maintenance of the flood forecasting system, issuing bulletins and warnings within the framework of the national EWS for floods and flash floods. Roles and responsibilities of ARSO are well defined.

Cooperation and coordination between national institutions and transboundary institutions

Flood EWS is operating in transboundary context for the Mura river, partly for the Sava river (some casual international sharing of data/products, is in place), but not for the Drava and the Sava rivers. This is conditioned by the relevant institutions decisions within the transboundary basins. There are different levels of interest between the relevant authorities and the academia.

Monitoring and evaluation of the performance of the relevant players involved in delivering flood EWS is not happening.

ARSO is operating with fix organizational structure. SOPs and Incident Management policy and procedures have been recently updated in 2019. There is QMS team established, which assesses performance of the system.

<u>Institutional agreements on data sharing among different ministries/ agencies/ data sources</u>

There is a local/national data sharing policy, using interoperability standards. Under this legal framework, spatial data infrastructure has been developed. There is a transboundary data sharing policy, and there is agreement for contributing to basic data infrastructure development (co-financing for a network).

Ukraine

General context

The *Dniester* river basin (Ukrainian part) was proposed for the SEE-MHEWS-A Project. The river length is 1352 km, basin area – 72100 km^2. It origins in Carpathian Mountains in Ukraine, then flows in south-east direction across Moldova (around 660 km and one third of the basin are in Moldova) to Ukraine again, where it finally inflows into the Black sea. There are two significant HPPs located in the river basin: HPP *Dniester* (Ukraine, near Novodnistrovsk city in Ukraine), and HPP *Dubosari* (near Dubosari city in Moldova).

Rain, snowmelt, and reservoir operations are the main sources of floods. Both flash flood (in mountainous areas in upper part of the river) and riverine flood occur in the river basin. They often cause significant damage to a number of big cities in Ukraine (especially, Lviv, Ivano-Frankivsk, Transcarpathian regions), as well as in Republic of Moldova.

In the moment basin scale flood forecasting system composed of physically based and statistical models connected with local terrain information is used to issue flood forecasts and warnings. However, it needs to be improved, especially taking into account, that the highest risk catchments remain uncovered with flood EWS.

National Meteorological and Hydrological Service

NHS and NMS are merged into the single institution – *Ukrainian Hydrometeorological Center* (*UHMC*). Synoptic forecasts department issue a warning about precipitation to hydrologists, which then use this information for flood forecasts generation. The roles and responsibilities of NMS are well defined. Role of NMHS – storm warnings, informing consumers, assessing the risks of flooding. Daily operations of supporting the flood EWS are always during day hours but evening/night shifts only used when needed (during severe flood event).

Cooperation and coordination between national institutions and transboundary institutions

The flood EWS in the Dniester river is working in transboundary context. Some casual international sharing between Ukraine and Moldova institutions is in place. There is no significant knowledge sharing with academia or research institutes, only providing them archive data for scientific research. There are monitoring and evaluation of the performance of the relevant players involved in delivering flood EWS. *UHMC* have performed well during recent severe events and have established surge capacity and procedures. Roles and responsibilities of staff involved in the service, as well as SOP are documented but not updated often. Incident Management policy and procedures use principles of Incident Management but not formalized in policy. No Quality management handbook or documented procedures are developed so far.

Institutional agreements on data sharing among different ministries/ agencies/ data sources

There is a local, national, as well as transboundary data sharing policy, using interoperability standards. Under this legal framework, spatial data infrastructure has been developed.

Observations and data acquisition

According to provided information in the Appendix 4 there are 32 hydrometric stations, operating in the Ukrainian part of the Dniester river. In general, the basin is well covered with hydrometric stations (Figure 10), however there are some important parts of a river do not have gauges. All of the gauges are manual stations with twice a day measurements. Discharge is regularly measured at almost all stations (28 stations). Rating curves are well maintained (regularly updated), ratings are available for all important stations (gauges). Transmission frequency of operational data is once a day (every morning).

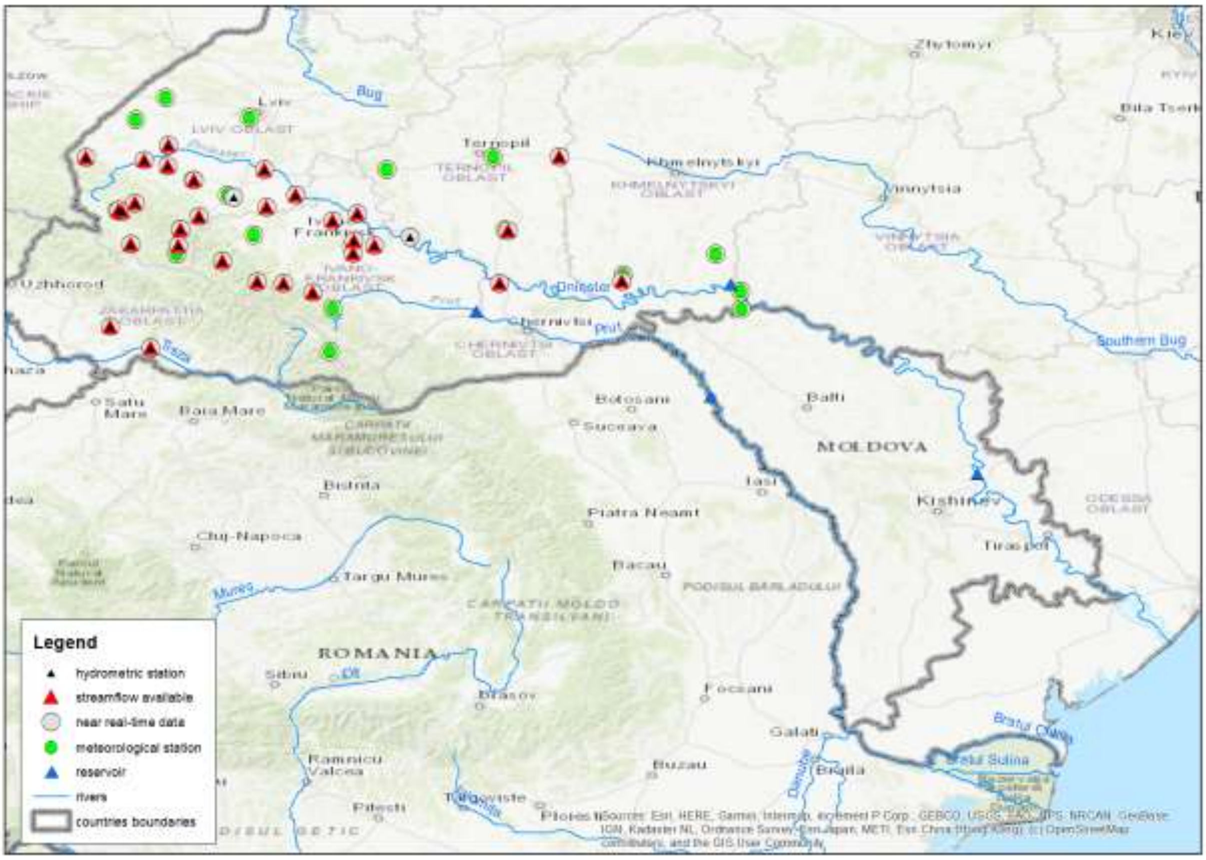


Figure 10. – Hydrometeorological network in the Dniester river basin

There are 18 synoptic station in the basin, which measure and transmit every 3 hours. Stations are equipped with manual measurement instruments. Some of a river's catchments in flow formation area have few or no precipitation and temperature measurements. There are mainly manual stations.

In terms of operational data transmission there is a high level of reliability, statistics and backup paths available. Data verification frequency is fully adequate. Calibration regime of both hydrometric and meteorological stations were done prior to their service,. Some stations/instruments have inadequate range or accuracy or compromised installations.

There is very limited usage of weather radars in the basin due to lack of calibration/adjustments.

Coverage of operational sea level stations in the coastal area of the Dniester river is considered to be poor.

Transboundary data are available, but sometimes with delays.

Some measurements (snow water equivalence) are available with limited distribution and temporal resolution. Measurements of depth, density, mass are carried out manually every 10 and 5 days in winter.

UHMC provide adequate data for reservoir managers.

Historical and ancillary data

UHMC and subordinated regional centers on hydrometeorology, as well as Central Geophysical Observatory named after B. Sreznevsky are responsible for data collecting and archiving.

Hydrometric stations have been operating since the end of 19th century. Data (both synoptic and hydrometric) archives are available since 1885 till present time mainly in paper format. Synoptic data series are available since 1985 till present time mainly in paper format.

Complete metadata for all the stations are available with updated zero readings, coordinates, equipment type, date of installation, and possible instrument(s) change and other information.

Mean areal precipitation (MAP) is available for limited number of catchments based on rainfall gauges only.

Cross sections information is not available. Historical rating curves are not available.

Only globally available spatial data are used. Vulnerability and exposure data etc. are available for key locations.

There is a broad programme to incorporate historical flood knowledge into archives and used for analyses such as flood frequency determination.

Reservoir data (inflows, storage and outflows) are available with reasonable duration, without significant gaps, in both paper and digital format. Reservoir operation rules (historical and present) – both current and previous rules are available. Snow data archives availability with depth and density data. Snow course metadata are not complete (absence of coordinates of some stations, meteorological station height, etc.). Transboundary data are not available in historical context.

Metadata for sea level stations are limited in information. Sea level data are of limited duration, in partly paper/partly digital format.

Data management

The section of the river basin survey was not filled in.

Meteorological forecast products

The section of the river basin survey was not filled in.

Hydrological models and forecasts

Different entities (regional centers) of UHMC provide hydrological forecasts. Forecast efficiency is appropriate, but should be improved. All models, used within the existing flood forecasting system are appropriate, but they should be improved. Flood forecast lead time is 1-2 days. Appropriate time step is used. There is no ability to address uncertainty so far. Models are calibrated and validated only at setup. forecast performance is tracked only during a major event. Output updating is performed manually.

Flood forecasting products

Following flood products are issued: threshold-based flood alert, flood forecasting (discharge and water level), inundation forecasting. There are consistent services levels across all catchments. No flood maps are available in the moment. The suite of products is adequate to serve all user's needs and forecast horizons requested. Some of the products are standardized. User's feedback indicate the format is adequate and easily understood. All products provided satisfy the timeframe required by users.

The pilot river basin

One of the goals of the current phase of the *SEE-MHEWS-A* Project is the development and implementation of flood forecasting and EWS for one of the river basins, proposed by the countries-members of the Project (description of the existing observational, data management and flood forecasting capabilities is given in the previous chapter of the report; SEE river basins surveys are given in Attachments 1-12). This chapter describes the pilot basin selection process.

There were following selection criteria developed and taken into account while selecting the pilot river basin:

1. *Strong need*: There should be a strong need in hydrologic forecast system development and implementation, which can be estimated as existence of flood prone areas in the basin without coverage of the effective flood forecasting system (complete absence or simple level of existing hydrological forecast capabilities, which do not meet the requirements of major end-user's). The system, which is going to be developed and implemented in a pilot river basin, should strongly demonstrate the abilities and benefits of entire system.
2. *Data*: Existing hydrometeorological and ancillary data availability should meet requirements of flood forecasting system. There should be adequate level of spatial observational coverage of the proposed river basin(s), availability of both measured and calculated (e.g. discharge) hydrometeorological elements, historical data availability, reservoir data availability (if applicable), transboundary data availability (if applicable), presence of other ancillary data (e.g. spatial data sets).
3. *IPA county*: the basin should be located within an "IPA-country" (due to project being partially funded by EU through the Instrument for Pre-Accession Assistance (IPA));
4. *Transboundary*: transboundary river basin would be a benefit, as in this case the system will be able to demonstrate the possibility of operation in the transboundary context, which will be reached through strengthening the cooperation of transboundary institutions in terms of data, products, and expertise sharing;
5. *Reservoir*: Reservoir(s) in the river basin would be a benefit, as in such a case the system will be able to show successful cooperation between NMHS (or NHS) with Water resources management institutions, which is very important for successful operation of a flood EWS and not often the case.

Criteria 1, 2 and 3 from the list above must be met (obligatory criteria), while criteria 4 and 5 are not obligatory; however, they give additional points to a basin while the selection process, as transboundary and reservoir's operation aspects of a basin increase the demonstration strength of entire potential flood EWS system. All proposed river basins were analyzed according presented criteria and information, provided in the river basin surveys. The analysis is given below for each river, proposed by the countries. Summary is given in table 5.

Drin river

1. There are significant flood prone areas in the river basin especially in the low course of the river – near the area of confluence of the Buna River and the Shkoder (Skadar) Lake. Floods are caused by rainfalls of high intensity, sometimes combined with snowmelt and dam releases (which additionally causes backwaters effect near the Shkoder/Skadar Lake). The river basin flood forecasting capabilities are of significant scope of several international projects, though which there were observational network improved and some flood forecasting capabilities implemented (hydrological model together with reservoir model). The basin is also covered with two regional flood forecasting systems: *EFAS* and *SEEFFGS*. It is considered, that flood forecasting capabilities of the existing systems could be significantly improved after solving the real-time data issues (see №2 below), performing models calibration, adopting flood alert levels at all flood prone sites, as well as developing and following SOP in the area of flood forecasting and warning. Adriatic Sea influence on the river regime in the mouth areas should be investigated, and in case of significant influence additional observational and modelling capabilities should be established and installed (including additional sea observational stations, sea level forecast system);

   Thus, the is no significant need to start to introduce another flood forecasting system, it will be more efficient to bring existing basin level, as well as regional flood forecasting systems in better shape – models recalibration (based on the improved input data) should be introduced, EFAS model calibration/validation procedures should be performed.

2. The observational networks seem to have following deficiencies, which should be addressed:

   - all automatic stations have not been maintained since their installation in 2013-2014, the process of stations' rehabilitation is highly required;
   - rating curves have not been updated since 2007 – existing curves are developed with using 1992-2007 data, thus calculated streamflow values cannot be considered as reliable (due to significant river bed transformations);
   - there are a large number of manual stations (both hydrometric and meteorological), which do not transmit data in real-time; bringing at least part of them into real-time mode will be of significant use for real-time flood monitoring;
   - stations coverage should be increased (especially in mountainous areas): hydrometric stations coverage could be improved especially in tributaries of the Drin River (those inflowing into the cascade of reservoirs) and the Vjosa River basin (especially Shushica River Carcove River – near the border with Greece). The coverage of the meteorological

stations could also be improved: by installing stations in mountainous areas, introducing measurements of snow cover and depth, as well as solar radiation. The meteorological stations from the GTS list cover only main cities of the country.

Reservoir data provision in operational mode on a daily basis should be agreed, so that IGEWE receive real-time values of outflows, inflows, reservoirs water levels. Rules of HPP operations, as well as other relevant information should also available.

There are a number of international projects, going on in Albania, which will hopefully improve situation with real-time data acquisition – e.g. stations' rehabilitation, introducing of streamflow measurements, as well as rating curves updating, etc. In the moment existing real-time data are inadequate for efficient flood forecasting system implementation.

3. Albania is in the IPA countries list.
4. The Drin River is a transboundary river – it flows along North Macedonia, Kosovo (UNSCR 1244/99), Albania and Montenegro, discharging its waters into the Adriatic Sea, in the north of Albania.
5. There is a cascade of reservoirs on the Drin river. Dam releases contributes to flooding in the downstream of the river. There is a lack of operational data from HPP operators (KESH) – only during severe flood events, as well as information on operational rules of reservoirs' regulation. Agreement between *IGEWE* and *KESH* should be reached in order to supply these data on a daily basis to flood forecasting system.

At this stage of the project the Drin river is not recommended to be selected as the pilot river basin, as criteria 1 and 2 are not met.

Dniester river

1. There is a strong need in efficient flood forecasting system in the Dniester river basin – especially in the upper part – where the river and its numerous mountainous tributaries flow across significant cities of Ukraine (regional capital cities). It was reported that so far there is no efficient flood EWS implemented in the basin – existing flood forecasting techniques must be updated, and preferable flood forecasting model(s) should be developed and implemented. The highest risk catchments remain uncovered by flood EWS. The river basin is shared by Ukraine and Moldova (middle to low parts of the basin). However, the most flood prone areas, indicated in the SEE survey, are located in the upper part of the basin, which fully belong to Ukraine.
2. The upper part of the Dniester river basin (Ukraine territory) is evenly covered with hydrometeorological observations, there are discharge measurements at almost all (28 out of 32) hydrometric gauges' locations and thus streamflow data available in near real-time mode. Hydrometric stations are manual stations with twice a day measurements and once a day (in the morning) transmission, which can be considered as an obstacle to monitor and issue forecasts

for mountainous flashy events, which tend to generate and occur within several hours after heavy rainfall. Meteorological stations have synoptic measurement program – observations and transmission are carried out every 3 hours (rainfall is measured every 12 hours). Some mountainous catchments are not covered with meteorological observations.

3. Ukraine and Moldova both do not belong to the "IPA-countries" list.
4. The Dniester river is a transboundary river (middle part of the basin is in Moldova), the data availability in Moldova part of the basin is under question as the information was not provided (Moldova proposed the Prut river basin). There is a transboundary data sharing policy, using interoperability standards.
5. There are two significant HPPs located in the river basin: HPP *Dniester* (Ukraine, near Novodnistrovsk city), and HPP *Dubosari* (near Dubosari city in Moldova). Reservoir data (inflows, storage and outflows) are available in real-time mode, and also historically with reasonable duration, without significant gaps, in both paper and digital format. Reservoir operation rules (historical and present) – both current and previous rules are available.

The Dniester river basin meets almost all criteria – it is lacking efficient flood early warning system, the data can be considered to be sufficient (however more frequent measurements in mountainous catchments are required), there are several reservoirs, and the river basin has transboundary context. The only formal criteria (3 – IPA) is not met, which is obligatory at this phase of the project. The river basin should be considered to be selected for development flood EWS on the latest stages of the SEE-MHEWS-A Project.

<u>One of the rivers in Greece</u>

1. There are several areas indicated as the most flood prone areas (including area of the Attic peninsula). The Greece is very affected by flash flood events – the regional system BSMEFFGS is used to support flash flood warning issuance. There are some basin scale modelling and forecasting capabilities, but still many catchments uncovered with hydrological modelling and forecasting.
2. Data availability (as in general for the country) is considered to be sufficient for potential flood forecasting system development and implementation. There are sufficient real-time hydrometeorological observations across the country, as well as radar outputs (which are used together with rainfall gauges to produce MAP for major river catchments), there are updated cross-sections available with adequate spacing for most of important sections of main rivers, as well as other important hydrometeorological and ancillary data.
3. The Greece is an *EU* Member state.
4. There are several river basins in Greece, which share their basin area with Albania and North Macedonia.

5. Information on reservoirs were not provided in the SEE river basin survey, however it was mentioned in the *SEE* survey, that data exchange with reservoir managers is effective.

Criteria 1 and 3 are not met, thus at this stage the Greek's river basin cannot be recommended to be selected as the pilot river basin at this stage of the Project.

Jordan river

1. The Jordan Valley, as well as different places in the basin significantly suffer from flash floods. BSMEFFGS is operationally used to support flash flood warnings issue. It was not clear from the SEE survey what is the real need in terms of development/implementation of the flood EWS.
2. The state of the Jordan river basin (which includes its major tributary – the Zarqa river) data availability is not obvious – information only on meteorological network design and features was provided. There was no information provided on hydrometric network conditions. However, it was mentioned, that majority of hydrometric gauges are not supplied with calculated rating curves, or ratings were updated long time ago. The Jordan river is transboundary river, however, there is no data/products sharing in place across international boundaries in the moment.
3. Jordan does not belong to the list of IPA countries.
4. The basin is transboundary – hydrometeorological data availability, as well as the state of flood EWS within Israel, Syria, and State of Palestine is considered to be unavailable. It can be considered as a serious deficiency in terms of flood forecasting system development and implementing.
5. There was no information provided on existing reservoir(s) and reservoirs' data availability.

There are significant obstacles in selecting the Jordan river for the pilot flood forecasting system implementation: there is a serious lack of observational, transboundary, as well as historical data. (criteria 2 is net met), Jordan is not in the IPA countries list (criteria 3). Thus it is not recommended to select this basin as the pilot river basin at this stage of the Project.

Kamchia river

1. The river basin is prone to flooding in the areas near to the coast of the Black sea (in particular several municipalities in the district of Varna). There is no basin level hydrological model applied or used in the Kamchiya river basin. Regional flash flood warning system *BSMEFFGS* is the only system, which is used to assist in generating flash flood alerts. More longer-term lead time forecasts of riverine floods are highly required by end users.
2. Information about hydrometric network features was provided in the river basin survey. More hydrometric stations are required in the middle part of the river basin – there is only 1 hydrometric station in meddle/lower part, which is far not enough for successful implementation of riverine forecasting techniques. All existing hydrometric stations observe

streamflow, and thus have updated rating curves. All of them are near real-time stations. There is no information on spatial distribution of meteorological stations across the river basin, thus it is impossible to estimate the data availability in terms of operational rainfall data. Regarding ancillary date – it should be noticed, that availability of real-time data from HPP (reservoir(s)) should be increased, as mentioned in the SEE survey.

3. Bulgaria is EU member country.
4. The Kamchia river basin is fully within Bulgaria borders, there is no transboundary aspect in terms of this basin.
5. Information on existing reservoir(s) was not provided in the survey, however it was noticed, that availability of information on reservoirs (both real-time and historical, as well as regulation rules) should be improved.

The Kamchiya river basin could not be selected as the pilot river basin at this stage of the project, as the obligatory criteria 2 and 3 are not met.

Marcal river

1. The river is tributary of the Raba river, which inflows into the Danube. The part of the survey regarding existing flood forecast system shows that there are some modelling and forecasting capabilities in place already (based on local basin analysis), which are used to derive flood alerts for short-term period of time. It was noted, that flood EWS should be improved. Information on damage centers in the Marcal river basin were not provided in the SEE.
2. The observational network seems very sufficient for implementing the modelling and forecasting system – there is a good spatial coverage of station, many of them provide streamflow information (rating curves are well maintained) – it should be mentioned that the density of stations for relatively small river basin as very promising. Existing observational data together with existing ancillary data (cross-sections, detailed spatial data) will definitely allow developing and implementing sophisticated modelling and flood forecasting system, for the Marcal river basin.
3. Hungary is EU Member state.
4. The Marcal river basin is fully within Hungarian borders, there is no transboundary aspect in terms of this basin.
5. No information was provided about reservoirs in the basin.

Taking into account current criteria for the selection (criteria 1 and 3 are not met), it is not recommended to select the Marcal river basin as the pilot river basin for the 2-nd Phase of the Project. However, the river has very high potential to be selected for the flood forecast system implementation on a later step of the SEE-MHEWS-A Project implementation.

Neretva river

1. The Neretva river basin is transboundary river basin – it is shared by Bosnia and Herzegovina and Croatia (coastal part of the basin). The basin was proposed by both of these countries, which indicates the importance of improving/implementing flood forecasting capabilities in this basin. There is a strong need in development and implementing efficient flood forecasting system in the river basin – Bosnia and Herzegovina (main part of the basin) suffer from floods of mixed origin (riverine, flash-floods, dam releases), as well as coastal areas of the basin in Croatia suffers from coastal floods (freshwaters from the main river reach significantly influenced by HPP releases meet sea waters from the Adriatic Sea) and typical urban flood issues in coastal cities, as sewage system sometime is not capable to absorb heavy rainfalls. Existing flood EWS capabilities should be substantially improved in both countries. There is no basin level system developed in Croatia (only regional SEEFFGS and EFAS, which is not very effective due to lack of adaptation to the local hydrological conditions, including the influence of HPPs (there is no agreement between Croatia and Bosnia and Herzegovina developed on data and products exchange), as well as complex terrain of the coastal area of the Croatian part of the Neretva river basin. The river is significantly influenced by karstic processes, which is vital to take into account while developing flood forecasting models/techniques for the river basin.
2. The data availability differs across the basin – some parts of the basin are nicely covered with hydrometric and meteorological stations, while other parts of the basin suffer from lack of observations. The largest gaps in terms of operational data availability is absence of data exchange in transboundary context (no data sharing agreement in place between Croatia and Bosnia and Herzegovina), not enough of coastal data (to reflect coastal flooding), absence of discharge measurements in downstream part of the river; there are nine reservoirs in the basin and real-time data are not available on a daily basis (only before and during the flood event). Cross sections are not updated (coastal areas of the river basin in Croatia), so further work should be applied in this direction.
3. Bosnia and Herzegovina is an IPA country; Croatia is EU member country.
4. Neretva river is transboundary river – the basin is shared between Bosnia and Herzegovina and Croatia.
5. There are nine river basin reservoirs (in Bosnia and Herzegovina part of the basin).

Hydrological forecasting services in the Neretva river basin should be substantially improved. The river is significantly influenced by flooding of different origin, as many processes affects flood generation, including rainfall, snowmelt, karst, dam operations (there are 9 HPPs in the basin). There are also coastal processes, affecting the river in Croatian part of the basin (see below), as well as urban issues. Complex basin forecast system should be developed, based on different modelling aspects: routing model of the lower (Croatian part) of the Neretva river, which should be coupled with hydrologic/hydraulic model(s) of the upper part of the river (under Bosnia and Herzegovina jurisdiction). River modelling system (basin level, or regional one) should be coupled with sea forecast system to be able to take into account sea influence, including "back water" effect. Setup of regional flood forecast system – EFAS –should be adapted to the local hydrological conditions, including the influence of HPPs, complex terrain of the coastal area of the Croatian part of the Neretva river basin. Urban data (including drainage system schematization) and detailed DTM should be available for urban flood (drainage flood) model development/implementation.

Under current project settings (the pilot system should be implemented until the end of 2020) it is not feasible to develop and implement all necessary, actions required for successful implementation of the flood forecasting system for the Neretva river, as the criteria 2 is not met. Thus, at this stage of the SEE-MHEWS-A Project it is not recommended to select the Neretva river basin as the pilot river basin for hydrological modelling and forecasting. However, the river is of great importance to the region, and it is vital to pay attention to the issues of the river on the flowing steps of the Project.

Prut river

1. There is a need in flood forecasting system, existing one should be strongly improved. It is not mentioned in the survey where are the damage centers, and what is the real need in the flood forecasting system for the river basin: it was mentioned, that there are some flood forecasting capabilities (a rainfall-runoff model, which should be improved) and that end-users are pretty satisfied with the forecast products, but no details were given.
2. Hydrometric network coverage should be increased: there are only 2 hydrometric stations on the main river, and they are located in the downstream of the river; there are no stations on tributaries. Upper part of the river basin is located in Ukraine, middle part – partly in Romania, and situation with hydrometeorological networks in these countries are not given. Rating curves are not up-to-date, which can be considered as significant obstacle for the development of flood forecasting system.
3. Moldova (as well as Romania and Ukraine) is not an "IPA-country".
4. The Prut river is flowing across three countries, thus there should be transboundary data/products sharing agreement between these countries in order to develop, implement and run the flood forecasting system. In the river basin survey the state of transboundary data was considered to be adequate, however no additional details were provided, as whether there is exchange on operational data, or data and products, what kind of data and products are shared if so. There was no information provided by either Ukraine, nor Romania – these counties historical and real-time data are required to develop and implement the flood forecasting system in the Prut river basin.

5. There two HPPs in the river basin (one is operated by Ukraine, another one – jointly by Moldova and Romania) – the information on outflows and operational rules was marked as adequate without any other details. It should be revealed further what kind of data are available in real-time mode from HPP managers

At this step of the SEE-NHEWS-A Project it seems to be too complicated to select the Prut river basin as the pilot for the flood forecasting system implementation, however it can be done on the following stages of the Project, as the river is very important as is shared by three countries. According to data availability criteria (criteria 2), as well as IPA-country criteria (criteria 3) the river cannot pass the selection process.

Vardar river

1. There are a lot of flood prone areas in the Vardar river basin, which suffer from frequent flooding – both riverine and flash floods (in small mountainous catchments in summer). Graphoanalytical method has been applied since 1970-s, based on historical rainfalls and river discharges data. Method is half automated and depend of available data. Many catchments of the Vardar river basin remain uncovered with flood forecasting services. There are no hydrological models developed and implemented in the moment (including rapid-onset events forecasting and warning). Definitely, there is a big need in development and implementation of a flood forecasting systems in the proposed river basin.

2. Many hydrometric, as well as meteorological stations are not "real-time" stations (transmit data once a month). Some stations do not measure streamflow, thus discharge data are not available for many sites. Hydrometric stations with near real-time data transmission capability do not perform streamflow measurements, and thus there are no discharge calculated at those locations, which is a serious obstacle in terms of hydrological model development.

   It is highly recommended to upgrade existing observational networks (both hydrometric and meteorological) so that more existing stations transmit observational data in real-time (near real-time) mode, as well as introduce streamflow measurements at important sites to allow accurate rating curves maintenance.

3. North Macedonia is supported by IPA mechanism.

4. The river basin spreads across 4 countries: largest part of the basin area is located in North Macedonia, while several tributaries inflow from territory of Serbia and Kosovo (UNSCR 1244/99). Downstream of the river flows in Greece. Transboundary data are not available as there are no data sharing policy developed between listed countries. There is a strong need in Memorandum of Understanding with Serbia, Kosovo (UNSCR 1244/99), and Greece regarding exchange of operational data and hydrometeorological products.

5. There are five reservoirs in the Vardar river basin, which significantly influence the regime of the river. Data on reservoirs' operations are available only two times a month, and on a daily basis during a flood event.

Flood EWS is highly required in the Vardar river basin. To develop the effective system several important steps, have to be accomplished, including improvement of existing observational network (e.g. real-time transmission, as well as streamflow measurements introduced), data sharing agreement (between North Macedonia and neighbouring countries) has to be developed in order to make transboundary data available, data on reservoirs' operations should be available in near real-time mode.

At this phase of the SEE-MHEWS-A Project the Vardar river cannot be recommended as the pilot river basin because data availability criteria (№ 2) is not met.

Vjosa river

1. There is a strong need in flood forecasting system in the Vjosa river basin. There is no sustainable flood EWS in place.
2. Existing operational hydrometeorological data are not of sufficient quality, as there is an issue measurement network in Albania, which is not maintained and thus operational data cannot be considered as reliable (there is an ongoing Project in Albania, which will deal with the network restoration).
3. Albania is in "IPA-countries" list.
6. The basin is shared between Albania and Greece: the river's origin is located in Greece. Data sharing agreement with Greece have to be established in order to receive operational hydro meteorological data of the upper part of the Vjosa river basin (located in Greece);
4. There was no information provided regarding reservoirs in the Vjosa river basin

The Vjosa river basin cannot pass the selection criteria, as there are significant observational data issues in Albania, and thus criteria 2 is not met.

Vrbas river

1. The river basin is located within two political entities of Bosnia and Herzegovina: upper part of the river basin is located in Federation of Bosnia and Herzegovina, while the middle and lower parts of the basin – in Republika Srpska). Thus hydrometeorological service of end users within this basin is done by two hydrometeorological services – FHMI and RHMS RS, as well as by two water management agencies. There are a number of flood prone areas near significant cities, located in the downstream of the river (near the Banja Luka area, capital of Republika Srpska and below to the river's confluence into the Sava river). The river basin has simple early warning system, based on trigger levels at each of hydrometric station. At the moment there is no formal

flood forecasting procedures in place for the river, as well as there are no functionalities used in the basin for flood forecasting.

2. Both real-time and historical data availability can be considered to be on a required level in terms of development and implementation of flood EWS: network coverage is sufficient (however several tributaries remain uncovered by observational networks), data collection frequency is adequate for flood forecasting – 30 minutes. There is calibration plan developed and followed for hydrometric stations. Rating curves are well maintained – majority of hydrometric stations provide discharge information. All stations are operational – they observe and transmit data in near real-time mode (every 30 to 60 minutes).

   There is Bočac HPP and reservoir in the middle river. Outflow data are shared only before and during the flood event, however for successful operation of a flood forecasting system operational data on a daily basis (as well as historical data) are needed, which should include: outflow, inflow, water level of the reservoir and near the HPP, rules of operations; thus HPP managers should be included into the data sharing agreement.

   As mentioned above there are several entities, which are responsible for observational activities in the basin, operational (as well as historical) data exchange between these agencies should be secured to allow successful implementation of flood EWS.

3. Bosnia and Herzegovina is an IPA country.

4. The river is fully located within Bosnia and Herzegovina boundary – thus, there is no transboundary context. However, there are two political entities within the river basin – Federation of Bosnia and Herzegovina and Republika Srpska – with two different NMHSs, respectively. Building coordination and enhanced cooperation between these two Services will be required to implement the flood forecasting system, and can be recognized to some extent as transboundary issues.

5. Bočac HPP and reservoir operates in middle part of the river.

Abovementioned text evidences that mandatory criteria are met, and thus the Vrbas river basin can be recommended as the pilot river basin for this stage of SEE-MHEWS-A Project.

Zeta river (or other)

1. Montenegro is a mountainous country, with rapid river regime, and significant floods of different nature, including flash floods, riverine floods and urban floods. There are a lot of flood prone areas, indicated in the SEE river basin survey, which lack effective flood forecasting and warning service. Currently basin scale models are not used for hydrological forecasting. They are only used as the tool for generating added value for operational forecaster in emergency situations. The Institute of Hydrometeorology and Seismology is making use of some regional products (*EFAS*, *SEEFFGS*), as well as transboundary basin flood forecast system, based on *Panta*

Rhei hydrologic model. It was not described in the survey, but it seems that the models should lack calibration (without discharge data, also this was mentioned in the survey filled in by Albania – as they share the same transboundary basin with Montenegro).

2. Observational networks (both hydrometric and meteorological) seem to have good areal coverage (stations are evenly distributed across the country), however it was mentioned, that some of mountainous areas lack observations.

   There is a serious deficiency of hydrometric network: there is an absence of streamflow measurements, which does not allow rating curves updating, and thus calculating discharge on a real-time basis. Historical ratings are available (based on historical streamflow measurements), but for such a mountainous country as Montenegro it is very important to update ratings often. Organization of routine streamflow measurements is a vital step towards improvements of flood forecasting service in the country.

3. Montenegro is in the IPA countries list.

4. Many river basins (especially the largest ones) are transboundary.

5. There are a number of water river reservoirs in Montenegro.

Several important river systems were proposed as potential pilot (basin) for the *SEE-MHEWS-A* Project. These basins are of great importance, but without accurate discharge information (criteria 2 is not met) it would be difficult to develop and implement efficient modelling and forecasting system for the basin(s) proposed.

Results of the river basins versus 5 criteria analysis are summarized in Table 5.

Table 5. – Proposed river basins versus selection criteria

№	River basin(s)	Country	Criteria				
			1 **Strong need**	**2** **Data**	**3** **IPA**	**4** **Transboundary**	**5** **Reservoir**
1	Drin	Albania, Kosovo (UNSCR 1244/99), Greece, Montenegro and North Macedonia			+	+	+
2	Dniester	Ukraine, Moldova	+	+		+	+
3	One of the rivers in Greece	Greece/ potentially neighbouring country(ies)		+		+	
4	Jordan	Jordan, Israel, Syria, State of Palestine	+			+	
5	Kamchiya	Bulgaria	+				
6	Marcal	Hungary	+	+			
7	Neretva	Bosnia and Herzegovina, Croatia	+		+	+	+
8	Prut	Moldova, Romania,	+			+	+

№	River basin(s)	Country	Criteria				
			1 Strong need	**2 Data**	**3 IPA**	**4 Transboundary**	**5 Reservoir**
		Ukraine					
9	Vardar	North Macedonia, Greece, Serbia, Kosovo (UNSCR 1244/99)	+		+	+	+
10	Vjosa	Albania, Greece	+		+	+	
11	Vrbas	Bosnia and Herzegovina	+	+	+		+
12	Zeta (or other)	Montenegro /potentially neighbouring country(ies)	+		+	+	+

Performed analysis indicated that the Vrbas river basin can be selected as the pilot river catchment at this phase of the SEE-MHEWS-A Project – there is a possibility to develop and implement a flood forecasting early warning system for this river basin under the current Project settings. If resources are available at this stage of the Project another catchment could be also selected for the pilot flood forecasting system implementation. All other rivers from the proposed river list should be taken into account at the next steps of the Project and considered to be priorities for possible expansion of flood forecasting and early warning system of SEE.

Recommendations

Recommendation, listed below, are based on the information provided in the river basin surveys only. It should be said that there is significant variety in level of flood forecasting capabilities across the region; nevertheless, a number of common recommendations are given in this section.

It should be noted that more detailed and targeted recommendations for each of the proposed river basins in the region should be developed based on more detailed assessment of each NMHS, which can be considered on the next steps of the *SEE-MHEWS-A* Project.

Organization of flood forecasting service

The legal mandate to issue hydrological forecasts and warnings should be developed and implemented. It is recommended that clear description of hydrological forecasting products, required by a country, as well as its characteristics (types of forecasts, lead-time, issue format, forecasting phenomena, end-users and etc.) should be well described in the ToR of a Service. Chapter D.1.3 of the WMO *Technical Regulation* Volume III describes different aspects of hydrological forecast and warning services.

Cooperation with other national institutions, involved in the water-related activities, should be clarified. Roles and responsibilities of these institutions, involved in the flood EWS, should be well described (e.g. cooperation between NMHS of NMHS of Bosnia and Herzegovina - Republika Srpska and water agency Vode Srpske are not well defined as there are some overlapping of their activities). It is recommended, that all roles of different institutions, involved in flood EWS, are clarified.

Valid for the river basins: Drin, Neretva, Vjosa, Vrbas

Cooperation with transboundary institutions should be established in several cases. It is highly recommended that transboundary data (and possibly product) sharing agreements should be developed in several cases to let effective exchange of hydrometeorological data and products to support flood EWS development and implementation in transboundary basins.

Valid for: Neretva (Croatia – Bosnia and Herzegovina), Vardar (North Macedonia – neighbouring countries), Vjosa (Albania – Greece)

Sustainability of flood forecasting services regarding different aspects (e.g. staff, knowledge, equipment, software) in several countries is an issue, as there is a persistent underinvestment of the Services.

Observations and data acquisition

Network design should be evaluated in accordance with the requirements of a flood forecasting and warning system (does it reflect data requirements of a flood EWS in a particular part(s) of the basin with respect to major damage centers?). In some cases, it was obvious that there is an absence of required initial observational data (hydrometric, meteorological, as well as snow cover) in some part of river systems, especially in mountainous parts. Additional hydrometric stations should be installed on tributaries of a main river (including especially those inflowing into the cascade of reservoirs). The coverage of the meteorological stations networks should be also improved: by installing stations in mountainous areas, introducing measurements of snow cover and depth.

Valid for the river basins: all basins except for the Marcal

In several countries there is a serious insufficiency in maintenance of hydrometeorological networks. Automatic hydrometric and meteorological stations were installed with the help of different projects (supported by the World Bank, EU etc.). After the projects finish there seem to be serious lack of the networks maintenance – absence of the stations equipment maintenance (including equipment check), as well as calibration which results in malfunctioning of stations. This results in poor quality of observational data, which feeds into the flood EWS. For such particular cases supervision of hydrometric and meteorological observing stations should be arranged according to recommendations of chapter D.1.1 *Hydrological observing networks and stations* of Volume III of the *WMO Technical Regulations* (WMO-No. 49): e.g. every station is inspected at least once every six months to ensure the correct functioning of instruments and maintenance of a high standard of observations and other recommendations. Inspection of meteorological stations for the purposes of flood EWS should be arranged in the manner described in 3.1.1 of Part III of Volume I of the *Manual on the Global Observing System* (WMO-No. 544).

Valid for: Drin, Vardar, Vjosa, Zeta or other Montenegrin river

Real-time streamflow calculation with sufficient quality is of vital importance to hydrological modelling and forecasting (upstream river stage and discharge are the variables, the most required by forecasting techniques). In many countries of the SEE region, there seem to be a lack of discharge data in terms of: measurement sites (discharge is not measured at important locations), quality of data (rating curves require significant update and maintenance). Regular streamflow measurements, as well as technique for rating curves development and updating should be implemented at important sites. Recommendations on appropriate organization of streamflow measurements can be found in WMO *Technical Regulations* Volume III, in Chapter D.1.2 *Observing and reporting programme for hydrological observing stations*, as well as in Chapter 2 *Methods of observations* of WMO *Guide to Hydrological Practices* Volume I (WMO-No.168). Extensive material on streamflow gauging and rating curve updating is given in the WMO *Manual on stream gauging* (WMO-No.1044).

Valid for the river basins: Drin, Vardar, Vjosa, rivers of Montenegro

There are a number of rivers where significant portion of river flow is generated in mountainous areas. Thus snow dynamics plays significant role in their hydrological regime. Snow characteristics measurements which allow snow water equivalent (SWE) calculation is important factor, which can significantly improve flood modelling during spring melt period. Introducing snow courses measurements in mountainous areas will increase reliability of flood forecast during spring melt season.

Valid for the river basins: Neretva, Vardar, Vrbas

Observational frequency at hydrometric stations in mountainous parts of several SEE river basins should be increased, as now it is considered to be inadequate (for example twice a day) with respect to the speed of flood formation process. Existing frequency may miss flood peaks in between the measurements, which results in inadequacy of operational monitoring, as well as unitization of hydrometric time series in modelling process (as they may not include peaks, which were missed during measurements). It is recommended to consider installation of automatic measurement equipment, which will allow performing frequent hydrological measurements.

Valid for the river basins: Dniester, Vardar

There is a significant number of hydrometric stations without real-time transmission of observations. These stations are located at a very sensitive and important parts of the river basin. Adding functionality to transfer observations in real-time (or near real-time) mode will significantly increase the value of observational data from such stations. These data will be of significant importance to flood EWS.

Valid for the river basin: Vardar

Vandalism is reported to be an issue in several countries, thus adequate protection measures should be organized and implemented.

Valid for the river basins: Drin, Vjosa

Several rivers of the SEE region are exposed to sea influence in the coastal areas, including backwater effect, and classical cases of coastal flooding (of mixed nature – caused by marine and riverine processes) of the cities and towns, located in the coastal areas of the rivers (e.g. Metković town in Croatia). Flood forecasting in the coastal areas are always challenging due to different sources of flooding, and thus data and models, which are required in such areas. Influence of a sea the coastal areas should be investigated, and in case of significant influence marine station(s) should be installed (or recovered) to get sea level observations as boundary conditions for hydrological modelling system.

Valid for the river basins: Drin, Neretva, Vjosa

<u>Historical and ancillary data</u>

There are a number of water river reservoirs in the rivers of the SEE regions; some of them have reservoir cascades (e.g. Drin, Neretva, Vardar). Real-time dam release data from reservoirs are not available on a daily basis in many cases. Many countries of the region have MoUs with reservoir operators, according to which dam release data (as well as other operational information) are available only during the flood event. However effective operation of flood EWS requires real-time reservoir data on a daily basis, as forecasting approaches, used in operational forecasting, tend to utilize continuous modelling techniques. Data sharing agreement between NMHSs of the countries and reservoir managers should be developed and implemented to make sure following information (both real-time and historical) is available across the SEE region: dam release, inflow (both calculated and forecasted), storage levels, operation rules.

Valid for the river basins: all rivers with reservoirs.

Information on cross-sections is highly required in the areas, where potentially hydrodynamic model can be implemented. In many cases cross-sections were derived long time ago and need to be updated.

Valid for the river basins: Neretva, Kamchiya

Meteorological forecasts and products

Meteorological forecasting products in several cases are available only as image products and not in preferred time step (the rivers: Jordan, Prut, Vardar). Limited number of SEE countries have probabilistic meteorological forecasts (ensembles), thus one of the SEE-MHEWS-A Project's objectives regarding implementation of ensemble forecasting seem very reasonable.

Hydrological modelling and forecasting

Proposed basins are partly covered with flood forecasting products, but they are based on local basin analysis or simple relationships (developed long time ago). Mostly threshold-based flood alerts are issued. More reliable and sustainable basin level flood forecasting techniques are required, which can operate with utilization of ensemble meteorological forecast products.

Only a few river basins (including the Drin river basin) have flood forecasting system implemented. Existing flood forecasting models were calibrated only at their implementation. Recalibration of watershed models' parameters might be needed.

Operational forecast performance should be implemented to allow constant monitoring of its quality. Information on operational forecast verification is given in the *Guide to Hydrological Practices* (WMO-No. 168), fifth edition, 41.3 and 41.3.1.

It is recommended to make sure that all necessary data are available for operation of existing regional flood forecasting systems (e.g. SEEFFGS, BSMEFFGS, and EFAS). In many countries models, which constitute regional systems, remain uncalibrated, which significantly influence their efficiency. Number of countries have reported, that regional models do not account for the specific terrain and hydrological conditions of the focus area. Hence, recommendations touch provision of historical data to support groups of the models, so that calibration is done, as well as all possible information is taken into account in models' setup. Flood forecasting performance of the regional flood forecasting and warning systems should be introduced.

Valid for the basins: majority of the SEE basins.

Conclusions

Presented report includes description of the river basin survey, developed and implemented in the SEE domain in order to understand current capabilities of the Countries-Members of the SEE-MHEWS-A Project in flood forecasting and early warning process, including overall structure of the Service, data acquisition and management, available meteorological forecast products, as well as hydrological modelling and forecasting techniques.

Criteria for selecting the pilot river basin was developed and described in the report. It is based on the strong need in flood forecasting services in a basin from one hand, and current capabilities of observational networks and data management procedures from the other hand. All proposed river basins for development of the pilot flood EWS have deficiencies in terms of flood forecast products, thus they all indicated strong need in development and implementation of flood forecasting system in all proposed basins. However only the Vrbas river basin met all criteria, required for flood EWS to be developed and implemented on this pilot phase of the SEE-MHEWS-a Project. Other proposed river catchments including river catchments from SEE-MHEWS-A countries that did not at this time respond to the survey will be considered during further phases of the SEE-MHEWS-A project (subject to availability of funds).

Analyzed responses from 12 countries of the region showed variety of current state of flood forecasting and early warning systems. However, there are several commonalities across the countries. Recommendations on what actions should be applied to improve operational flood forecasting capabilities of the NMHSs are given in Recommendation section of the report. It should be noted that more detailed and targeted recommendations for each of the proposed river basins in the region could be developed based on more detailed assessment of each NMHS, which may be considered on the latest steps of the SEE-MHEWS-A Project.

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- WMO-No. 49. WMO Technical Regulations. Volume III. Hydrology. 2006 edition.
- WMO-No. 544. Manual on the Global Observing System. Volume I. 2003 edition.
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- WMO-No.1044. Manual on Stream Gauging. 2010 edition.

Attachments

There are 13 attachments, which include 13 filled SEE river basin surveys.

Appendix 1. The SEE river basin survey - template

General information about basin flood forecasting assessment

Country	
River basin	
Institution	
Evaluator	
Evaluator's incl. e-mail	
Date	

I – Institutional				
Item #	**Item Description**	**Guidance for evaluator**	**Grading Scheme**	**Evaluator comments**
1-	**Establishing the general context**			
1	Are there national legislations/policies mandating a national agency or agencies, or other oders of government to provide flood warning information or products?	Provide information on this aspect (for 5 the law's name and number)	1 - Authority is not provided through legislation 3 - This is no clearly defined legislation at the national/subnational level(s) 5 - There is a well-defined national/subnational legislation with clear functions covering the area of flood early warnings	
2	Where are the most significant damages and losses due to flooding occurring within the country/basin	Specify geographic location(s)	-	
3	What is causing the flooding for each location	(i.e. rain and/or snowmelt, reservoir operations, insufficient local drainage, river-ocean interactions); for the purpose of this assessment causes exclude ice jam, dam break, glacial lake outburst flood (a.k.a. GLOF);	-	

4	What is the time interval of the observable causative event and the flooding for each location	Flash flood - less 4-6 hours, riverine flood - greater than 6 hours	-	
5	Is there an adequate flood early warning system(s) for the above mentioned basin(s)?	Adequate system refers to recommended practices and procedures are being followed. For 3 and 5, provide short description (e.g. since when the system has been operational, or during when it was operational)	1 - No, there has never been an EWS covering a basin or there was a system but it stopped working	
			3 - There are some communities with EWSs or such EWSs are not adequate	
			5 - Yes, there is an adequate EWS developed and operational for all basins	
6	What approaches are used to provide flood warning in above mentioned watersheds?	Provide brief information (e.g. which partners participated or are participating in the development and implementation of the modelling approaches?)	1 - None or some local-basin analysis based on monitoring	
			3 - Global/Regional system for flood prediction	
			5 - Basin-based forecasting systems composed of numerical / statistical models connected with local terrain information	
7	What are the priority areas/basins that would benefit most from having an EWS	Based on the above analysis, a "basin level" survey will be performed for each one. Is there or will there be a consistent level of service throughout the country or a phased approach that prioritizes investments on high risk areas?	1: Most or all catchments are not covered by Flood EWS	
			3: Some high risk areas are covered but most catchments remain uncovered	
			5: Consistent services levels across all catchments	
8	Identification of end-users and consultation	Is there documentation regarding the end users and identification of their requirements?	1: No documentation available regarding user needs	
			3: User needs collected but not documented in an official report	

			5: Users and user needs are documented annually	
9	Requirements of end users (in particular decision makers)	Is there an understanding of the requirements of end-users in terms of timeliness, frequency of updates, accuracy of forecasts, minimum period of advance warning necessary?	1: No understanding	
			3: User needs are understood but not well documented	
			5: User needs are known, documented and reviewed	
10	Provision of longer lead time alert or watch services	Does the NHMS provide early advice of potential flooding allowing emergency responders to prepare early for possible events ?	1: No. Only short lead time alerts are issued	
			3: Occasionally alerts are provided for longer time	
			5: Yes, the service provides short and long time alerts, it is a continuous service	
2-	**Institutional Setting of the National Hydrological Service**			
	Organizational framework			
1	Are the NMS and NHS merged into a single institution?	yes/no	-	
2	Is there a NMS?	Yes	-	
3	What are the roles and responsibilities of NMS for flood EWS?	Provide description	-	
4	Are the roles and responsibilities of the NMS well defined?	yes/no. Provide information	-	
5	Are the daily operations for supporting the flood EWS carried out 24 hours per day?	Does the NMS provide, in particular, an around-the-clock service during emergencies? Explain if there are differences depending on days of weeks, evenings, nights, etc.	1: Day shifts and weekdays only as needed	
			3: Always during day hours but evening/night shifts only used when needed	
			5: Continuous 24x7	
6	Is there a NHS?	yes/no	-	

7	What are the roles and responsibilities of NHS for flood EWS?	Provide description	-	
8	Are the roles and responsibilities of the NHS well defined?	yes/no. if no, provide information about what needs to be improved	-	
9	Are the daily operations for supporting the flood EWS carried out 24 hours per day?	Does the NHS provide , in particular, an around-the-clock service during emergencies? Explain if there are differences depending on days of weeks, evenings, nights, etc.	1: Day shifts and weekdays only as needed 3: Always during day hours but evening/night shifts only used when needed 5: Continuous 24x7	
4-	**Cooperation and coordination between national institutions and transboundary institution** (as required)			
1	Is the E2E Flood EWS working in transboundary context	yes/no (if no - explain weaknesses/gaps)	-	
2	Are the relevant players identified that should be contributing to the transboundary flood EWS and are they fulfilling their obligations?	Are there International memberships and relationships/formal agreements with neighbouring countries to ensure coordination where hazard and risk possibly have transboundary impacts .Explain	1: No sharing across international boundaries 3: Some casual international sharing 5: Open national sharing and agreements in place	
3	Are the relevant players working well together and with Academia to deliver the flood EWS?	Describe relationships. Are there any mechanism of collaboration of main players with Universities, academia, research institutions? Explain	1: No sharing with academia or research institutions 3: Occasional sharing mainly in conference 5: Open sharing, symposiums, joint publications	

4	Is there a monitoring and evaluation of the performance of the relevant players involved in delivering flood EWS?	yes/no	-	
5	Flexibility of organizational structure	Does the NHS have an organizational structure that is scalable for extreme events? Indicate how is works	1: No surge capacity and staff overwhelmed during recent events	
			3: Have informal surge capacity and procedures	
			5: Have performed well during recent severe events and have established surge capacity and procedures	
6	Roles and responsibilities of staff involved in the service?	Does the NHS define and document roles and responsibilities of staff involved in the service? Is everyone is aware of what they have to do and when	1: No - roles understood from working in the team but not documented	
			3: Yes - documented but not updated often	
			5: Yes - documented well and reviewed regularly	
7	Standard Operating Procedures	Does the NHS have Standard Operating Procedures that are developed, documented and reviewed?	1: No - procedures understood from working in the team but not documented	
			3: Yes - documented but not updated often	
			5: Yes - documented well and reviewed regularly	
8	Incident Management policy and procedures	Does the NHS have established Incident Management policy and procedures? For example, this refers to having to elevate operational activities when there is a big event	1: Manage incidents informally with best efforts	
			3: Use principles of Incident Management but not formalized in policy	
			5: Yes formal Incident Management in place	
9	Quality Management and performance assessment	Does the NHS have a focal point for Quality	1: No Quality management handbook or documented procedures	

		Management and performance assessment?	3: Yes - QMS a responsibility of existing managers	
			5: Yes - QMS team established	
10	Decision support services	Does the NHS provide decision support services to partner agencies via phone contact or embedded forecasters ?	1: The staff at the office decides	
			3: Any institution can call for extended services no documentation	
			5: There are specific arrangements for selected institutions	
5-	**Institutional agreements on data sharing among different ministries/ agencies/ data sources**			
1	Local/National context	Indicate if institutional agreements at local/national level for sharing data are in place. Indicate if data infrastructure agreements have been developed.	1 - There is no local/national data sharing policy, legal framework or agreements among institutions.	
			3 - There is a local/national data sharing policy, and there is agreement for contributing to basic data infrastructure development (co-financing for a network).	
			5 - There is a local/national data sharing policy, using interoperability standards. Under this legal framework, spatial data infrastructure has been developed.	
2	Transboundary context	Indicate institutional agreements at bi- or multi-national level applicable to transboundary basins. Indicate specific data sharing and infrastructure agreements developed.	1 - There is no transboundary data sharing policy, legal framework or agreements among countries and institutions.	
			3 - There is a transboundary data sharing policy, and there is agreement for contributing to basic data infrastructure development (co-financing for a network).	
			5 - There is a transboundary data sharing policy, using interoperability standards. Under this legal framework, spatial data infrastructure has been developed.	

II - Observations and Data Acquisition				
Item #	**Item Description**	**Guidance for evaluator**	**Grading Scheme**	**Evaluator comments**
1-	**National**			
1	Existence of Real-time Monitoring Service	Is there a monitoring service in place and operational based on real time data and the dissemination of related products?	1: No Monitoring Service 3: Occasional monitoring is performed 5: There is a rigorous Monitoring Service in place	
2	Maintenance and sustainability of networks		1 - some aspects of the network(s) are maintained, some key ones are not 3 - most aspects are maintained, but no formal maintenance schedule 5 - all aspects are maintained, maintenance plans and budgets are in place for all items	
3	Data transmission path (station to forecast centre)	Describe if transmission path is suitable, reliable, are there any limitations, any back-up transmission path(s), indicate the transmission method (e.g., physical mail, electronically, etc.) and frequency	1 - transmissions frequently fail, and/or no statistics kept 3 - reasonable success rate of transmissions, some limitations 5 - high level of reliability, statistics and backup paths available	
4	Risks of vandalism	Mitigation measures?	1 - high risk, some occurrences, no significant mitigation 3 - some risk and occurrences, some mitigation	

			5 - no or few occurrences, mitigation measures in place at several levels	
2-	**Riverine Flood (RF) and Mechanisms**			
1	Adequacy of hydrometric network design	number of stations, location (provide a table, or map).	1 - absence of gauges (or too few) within a river basin	
			3 - some tributaries have gauges at outlets, other important parts of a river do not have gauges	
			5 - gauges give even coverage over differing parts of the river system and exist at outlet	
2	Data collection frequency	Adequate for riverine flood forecasting requirements?	1 - not adequate for the majority of gauges	
			3 - some of the basin's gauges have low frequency of measurements to describe flood formation process	
			5 - high level of reliability, statistics and backup paths available	
3	Data verification frequency	Sufficient visits for staff gauge readings, operational checks, etc.	1 - not adequate for the majority of stations	
			3 - some of the basin's stations have missing verification checks	
			5 - fully adequate	
4	Calibration regime	Frequency of calibrations, calibrations recorded	1 - rudimentary checks, irregular	
			3 - prior to service, occasional, some traceability	
			5 - are traceable and regular, to WMO or equivalent standards	
5	Equipment	Provide station metadata, noting the type, the manufacturer, manual or automatic, real time transmission or not, etc.	-	

6	Equipment limitations	Sufficient range, mounting OK, lack of interferences	1 - Many stations/instruments have inadequate range or accuracy, and/or installed in compromised situations	
			3 - Some stations/instruments have inadequate range or accuracy or compromised installations	
			5 - All instruments are installed with adequate resolution, ranges, and no significant interferences	
7	Rating curves maintenance	Are gaugings frequent enough and updated regularly?	1 - majority of gauges are without rating curves, or ratings were updated long time ago	
			3 - lack of measurements to update curves, absence of ratings at important points	
			5 - ratings are well maintained (regularly updated), ratings are available for all important stations (gauges)	
8	Adequacy of rainfall and temperature network design	Number of stations, location (provide a table, or map).	1 - main catchment(s) and tributaries without gauges at important locations (near damage centers)	
			3 - some of a river's catchments in flow formation area have few or no precipitation and temperature measurements	
			5 - good coverage and distribution in flow formation areas (upper stream catchments)	
9	Data collection frequency	Adequate for riverine flood forecasting requirements? Taking into account times of	1 - not adequate for the majority of gauges	

		concentration, forecast time step, etc.	3 - some of the basin's gauges have low frequency of measurements 5 - fully adequate	
10	Data verification frequency	Sufficient visits for check gauge readings, gauge maintenance, etc.	1 - not adequate for the majority of stations 3 - some of the basin's stations have missing verification checks 5 - fully adequate	
11	Calibration regime	Frequency of calibrations, calibrations recorded	1 - rudimentary checks, irregular 3 - prior to service, occasional, some traceability 5 - are traceable and regular, to WMO or equivalent standards	
12	Equipment	Obtain station metadata, noting the type, the manufacturer, manual or automatic, real time transmission or not, etc.	-	
13	Adequacy of synoptic network design	number, location (provide a table, or map)	1 - poor coverage in many catchments in upper part of a river basin 3 - some of a river's catchments in flow formation area miss synoptic measurements 5 - good coverage and distribution in flow formation areas (upper stream catchments)	
14	Weather radars	Number, type and location, map of coverage, calibration, etc.	1 - limited usage, lack of calibration/adjustments 3 - radars installed, but data are not adjusted to ground stations 5 - radar mosaic with gauges correction procedures, covering significant part of the basin/region	
15	Adequacy of	number, location of stations; measurements	1 - poor coverage in the relevant	

	operational ocean level station data (downstream boundary conditions)	frequency; forecast locations, etc.	coastal areas	
			3 - mostly covered with measurements, however some parts have gaps in observations and forecasts	
			5 - good coverage and distribution of ocean level stations at coastal zone	
16	Transboundary data	Transboundary data are available in real-time for all pertinent networks?	1 - transboundary data are not available	
			3 - some pertinent data are available with delays	
			5 - all data including flow data are received in real time (or near real time mode)	
17	Adequacy of (operational) snow network design for snow water equivalence	number, location (obtain a table, or map)	1 - no snow measurements	
			3 - some measurements (snow water equivalence) are available with limited distribution and temporal resolution	
			5 - snow courses are evenly distribution	
18	Snowpack condition	depth, areal coverage, density, and SWE	1 – nothing	
			3 - snow depth and coverage	
			5 - depth, density, mass, SWE	
19	Data collection frequency	Adequate for RF requirements? Weekly, monthly, etc.	-	
20	Equipment	Provide station metadata, noting the type, the manufacturer, manual or automatic, real time transmission or not, etc.	-	
21	Reservoir	Adequate data for reservoir manager(s), inflow forecasts, storage level, outflows	-	
3-	**Flash Flood (FF) and Mechanisms**			

1	Adequacy of hydrometric network design	number of stations, location (provide a table, or map)	1 - absence of gauges (or too few) in mountains/urban area	
			3 - some watersheds have gauges at outlets, other important parts of mountains (with different geomorphologic conditions) do not have gauges	
			5 - gauges give even coverage over differing parts of mountainous/urban areas	
2	Data collection frequency	Adequate for flash flood forecasting requirements?	1 - not adequate for the majority of gauges	
			3 - some of the basin's gauges have low frequency of measurements to describe flash flood formation process	
			5 - high level of reliability, statistics and backup paths available	
3	Data verification frequency	Sufficient visits for staff gauge readings, operational checks, etc.	1 - not adequate for the majority of stations	
			3 - some of the basin's stations have missing verification checks	
			5 - fully adequate	
4	Calibration regime	Frequency of calibrations, calibrations recorded	1 - rudimentary checks, irregular	
			3 - prior to service, occasional, some traceability	
			5 - are traceable and regular, to WMO or equivalent standards	
5	Equipment	Provide station metadata, noting the type, the manufacturer, manual or automatic, real time transmission or not, etc.	-	
6	Rating curves maintenance	Are gaugings frequent enough and updated regularly?	1 - majority of gauges are without rating curves, or ratings were updated long time ago	

			3 - lack of measurements to update curves, absence of ratings at important points	
			5 - ratings are well maintained (regularly updated), ratings are available for all important stations (gauges)	
7	Adequacy of rainfall and temperature network design	Number of stations, location (obtain a table, or map) (Note temperature is for snow accumulation and ablation modelling, evapotranspiration estimation)	1 - absence of, or too few, stations in mountainous/urban areas	
			3 - significant gaps in rainfall observations in mountainous/urban areas, a lot of upper catchments are without stations, uneven distribution	
			5 - even distribution of stations, most parts of mountain/urban areas have coverage	
8	Weather radars	Number, type and location, map of coverage, calibration, etc.	1 - limited usage, lack of calibration/adjustments	
			3 - radars installed, but data are not adjusted to ground stations	
			5 - radar mosaic with gauges correction procedures, covering significant part of the basin/region	
9	Adequacy of (operational) snow network design for snow water equivalence	number, location (obtain a table, or map)	1 - no snow measurements	
			3 - some measurements (snow water equivalence) are available with limited distribution and temporal resolution	
			5 - snow courses are evenly distribution	
10	Snowpack condition	depth, areal coverage, density, and SWE	1 - nothing	
			3 - snow depth and coverage	
			5 - depth, density, mass, SWE	

11	Data collection frequency	Adequate for RF requirements? Weekly, monthly, etc.	-	
12	Equipment	Provide station metadata, noting the type, the manufacturer, manual or automatic, real time transmission or not, etc.	-	

III - Historical and Ancillary Data				
Item #	**Item Description**	**Guidance for evaluator**	**Grading Scheme**	**Evaluator comments**
1-	**National**			
1	Organization(s) responsible for data archives	list all organizations involved in storing and managing hydrometeorological data archives (hydrometric, synoptic, snow, etc.)	-	
2-	**River Flood (RF) and Flash Flood (FF) assessment (by basin)**			
1	Metadata for hydrometric stations	incl. coordinates, level datum (if being used in hydrodynamic model application for coastal area, a common datum is needed)	1 - limited in information or unavailable for many gauges	
			3 - not complete (absence of location information, equipment used, or zero readings)	
			5 - complete metadata available with updated zero readings, coordinates, equipment type, date of installation, and possible instrument(s) change and other	
2	Suitability of hydrometric data for modelling purposes	gaps, homogeneity (dams construction, equipment change);	1 - limited duration (less than 6 years)	
			3 - at least 6 years, gaps are	

		minimum requirements for model calibration and validation are considered to be 3 years each	present	
			5 - reasonable duration (more than 6 years) for both calibration and validation a model without significant gaps and breaches in stationarity	
3	Hydrometric data format	paper, digital	1 - paper	
			3 - partly paper and partly electronic digital form	
			5 - all (mostly) electronic digital form	
4	Metadata for meteorological (e.g., precipitation and temperature) gauges	incl. coordinates, equipment	1 - limited or unavailable for many gauges	
			3 - not complete (absence of coordinates of some stations, meteostation height, etc.)	
			5 - complete metadata available with coordinates, station height, equipment type, date of installation, and possible instrument(s) change, etc.	
5	Suitability of meteorological data (e.g., precipitation and temperature) for modelling purposes	gaps, stationarity (changing station locations, equipment change); minimum requirements for model calibration and validation are considered to be 3 years each	1 - not available or limited duration (less than 6 years)	
			3 - at least 6 years, gaps are present	
			5 - reasonable duration (more than 6 years) for both calibration and validation for modelling, without significant gaps and breaches in stationarity	
6	Meteorological data (e.g., precipitation and temperature) format	paper, digital	1 - paper	
			3 - partly paper and partly digital	
			5 - all (mostly) digital	
7	Mean areal precipitation (MAP)		1 - limited, only for several gauges	

			3 - based on rainfall gauges only, for selected river catchments	
			5 - available for majority of river catchments, based on both radar and satellite estimations and gauge measurements	
8	Meteorological/Climatological synoptic data availability	temperature, rainfall intensity, cloud cover, windspeed, direction, solar radiation, soil temperature …	1 - temperature available only	
			3 - temperature and some synoptic	
			5 - many synoptic elements are archived (incl. temperature, cloud cover, windspeed, …)	
9	Metadata for Meteorological/Climatological synoptic stations	incl. coordinates, equipment	1 - limited or unavailable for many gauges	
			3 - not complete (absence of coordinates of some stations, meteostation height, etc.)	
			5 - complete metadata available with coordinates, station height, equipment type, date of installation, and possible instrument(s) change and other	
10	Synoptic data format	paper, digital; consider this question for different synoptic elements	1 - paper	
			3 - partly paper and partly digital	
			5 - all (mostly) digital	
11	cross-sections	number, date of last update, adequacy of spacing	1 - not available, or not up to date	
			3 - adequate spacing in majority of cases, not up-to-date everywhere	
			5 - adequate spacing, up-to-date, coverage of important sections of main rivers	
12	rating curves	number, date of last update, number of	1 - not available, or not up to date, or available only in low flow areas	

		available measurements	of a curve 3 - available with reasonable updates 5 - covering different periods of flow - peaks, ice conditions, regularly updated	
13	Spatial data	type (elevation, soil, land use, land cover), method of acquisition, resolution, format	1 - do not make use of or access existing available data at global level 3 - use some data globally available 5 - higher resolution data nationally available for important data types for modelling purposes	
14	Impact data	vulnerability and exposure data; flood trigger levels defined, census data, flood maps	1 - no vulnerability and exposure data etc. are available nationally 3- vulnerability and exposure data etc. are available for key locations 5 - vulnerability, exposure data and flood mapping are generally available for all vulnerable flood-prone locations	
15	Historical information and traditional knowledge	historical flood heights, etc.	1 - do not consider within national archives 3- only apply to a few locations and used for analyses such as flood frequency determination 5 - broad programme to incorporate such knowledge into archives and used for analyses such as flood frequency determination	
3-	**Additional items - mechanisms**			

1	Reservoir inflows, storage and outflows	storage-elevation relationship, record duration, gaps, formats	1 - not available, or little availability	
			3 - reasonable duration, no significant gaps, both paper and digital format	
			5 - more than 6 years duration without significant gaps, digital format	
2	Reservoir operation rules (historical and present)	need operating rules or policies, how they have changed over time or not, record duration, length, gaps, format	1 - not available, or little availability	
			3 - current rules are available, but previous rules are not available	
			5 - both current and previous rules are available	
3	Snow data archives availability	Which elements are available: SWE, depth, density, others?	1 - not available	
			3 - only depth measurements, point measurements on stations	
			5 - snow courses with depth, density, SWE estimation	
4	Snow course metadata	incl. coordinates, equipment	1 - limited or unavailable for many gauges	
			3 - not complete (absence of coordinates of some stations, meteostation height, etc.)	
			5 - complete metadata available with coordinates, equipment type, date course started, and possible instrument(s) change and other	
5	Snow data record duration	gaps, homogeneity (equipment change); consider this question for different snow elements	1 - not available or limited duration (less than 6 years)	
			3 - at least 6 years, gaps are present	

			5 - reasonable duration (more than 6 years) for both calibration and validation a model without significant gaps and breaches in homogeneity	
6	Snow data archives format	paper, digital; consider this question for different snow elements	1 - paper	
			3 - partly paper and partly digital	
			5 - all (mostly) digital	
7	Hydrometric transboundary data	in case of transboundary river	1 - transboundary data are not available	
			3 - some pertinent data are available with delays	
			5 - all data including flow data are received in real time (or near real time mode)	
4-	**Addition items for Coastal Flood (CF) assessment**			
1	Metadata for ocean level stations	incl. coordinates, equipment	1 - limited in information or unavailable for many gauges	
			3 - not complete (absence of location information, equipment used, or zero readings)	
			5 - complete metadata available with updated zero readings, coordinates, equipment type, date of installation, and possible instrument(s) change and other	
2	Suitability of ocean level data for modelling purposes	gaps, stationarity (equipment change)	1 - limited duration (less than 6 years)	
			3 - at least 6 years, gaps are present	
			5 - reasonable duration (more than 6 years) for both calibration and validation a model without significant gaps and breaches in	

			stationarity	
3	Ocean level data format	paper, digital	1 - paper 3 - partly paper and partly digital 5 - all (mostly) digital	
5-	**Addition items for Urban Flood (UF) assessment**			
1	Combined sewer and storm water (drainage) systems data	if exists, in what format? Drainage network, pipe sizes, surface channel locations and characteristics, outlet locations and control structures, operation policies, inlet locations, elevations to a known datum, etc.	-	
2	Digital Elevation Model (DEM)	Lidar data are useful depending on desired modelling accuracy	-	
3	Topographic and land use/cover data	city layout, incl. bridges, road features, building location (sill elevations), land use and land cover, etc.	-	

IV - Data Management				
Item #	**Item Description**	**Guidance for evaluator**	**Grading Scheme**	**Evaluator comments**
1-	**Accessibility of data (point and gridded)**			

1	Historical	Indicate communication channels, frequency and client server schemes	1- There is no on-going systematic or reliable data or product storage or related infrastructure in place.	
			3 - Data products are stored in owned servers, or are readily available in partner institutions servers (by public or private access) in a client-server scheme with minimal functionalities (web sites, ftp servers, http servers).	
			5 - Data products are offered according to interoperability standards (data structures and metadata) and are stored in own servers, or are readily available in partner institutions servers (by public or private access) in a client-server scheme providing web services.	
2	Real-time	Indicate the availability of real time data and products (point/gridded/both), communication channels and frequency	1 - No real time data provided by own or third party ground networks (point data).	
			3- Most of real time data and products are readily available at the start of the forecasting session. Data and products are available in a timely fashion.	
			5- All pertinent data are readily available when needed. Web services are available.	
3	Transboundary (historical and real time)	Indicate type of data acquired (point/gridded/both), providers, communication channels, frequency and length of available data series	1- There is a scarce amount of transboundary historical data available (digital, digitalized or digitized) and transboundary real-time point data collected or processed by the Hydrological Service in relation to the needs of the warning system. ftp channels for exchange of data products (i.e. Time series, maps) with key providers have been set up. Communication capabilities are expanding.	

			3 - The amount of transboundary historical digital data available is satisfactory to according to the current purposes of the warning system. Also, transboundary real time data (point or gridded) is gathered according to operational times. Data products are stored in owned servers, or are readily available at partner institutions servers (by public or private access) in a client-server scheme with minimal functionalities (web sites, ftp servers, http servers).	
			5 -The amount of transboundary historical available digital data is close to the optimum according to the current purposes of the warning system. Also, real time data (point and gridded) is gathered according to operational times. Data products are produced according to interoperability standards (data structures and metadata) and are stored in owned servers, or are readily available at partner institutions servers (by public or private access) in a client-server scheme providing web services.	
4	Data Ingestion Procedures	Indicate automation degree of data ingest procedures, use of transfer protocols and web services (in and between local and external context)	1 -Partially automated. Most of the data ingestion is done manually. Some data are ingested automatically from ftp/http repositories or from web pages using web scraping procedures.	
			3 - Mostly automated. Most of the data are ingested automatically from ftp/http repositories or from web pages using web scraping procedures. Some web services are available.	

			5 - Fully automated. All the data are ingested automatically from ftp/http repositories or web services. Data exchange adjusts to interoperability standards.	
5	Records and Document Management Procedures	Indicate if policies or standards for maintaining diverse types of records and documents have been implemented. Indicate automation degree of procedures (in relation to available technology) and modularity (low or simple or high or complex)	1 - Records and documents are stored digitally according to local policies, or according to protocols developed by the Hydrological Service. Most of procedures that must be automated are indeed automatic. Access to records and documents is available by ftp or http clients.	
			3 - Records and documents are stored according to local policies, or according to protocols developed by the Hydrological Service. At least, catalogue protocols and services have been developed. Also, some of the records and documents are stored according to international standards. Most procedures that can be automated are indeed automatic. Access to records and documents is available by ftp or http clients. Some graphical interfaces for records and document management have been implemented.	
			5 - Records and documents are stored according to protocols developed by international consortiums (standards). Catalogue service is fully automated, records and document management web services have been implemented, including graphical user interfaces and web applications.	
2-	**Data Quality Assurance and Quality Control procedures**			
1	Historical data	Indicate portion of data subjected to QA/QC	1 - Some QA/QC procedures have been implemented to some of the data	

		procedures	3 - Most data have passed QA/QC procedures 5 - All data have passed QA/QC procedures and have available reliability indexes or metrics	
2	Historical QA/QC methodology	Indicate QA/QC procedures used to assure the quality of data	1 - Mainly manual procedures following properly documented protocols 3 - Partially automated approaches with human intervention 5 - Mostly automated with human intervention. Procedures are properly documented and catalogued.	
3	Real-time data	Indicate portion of data subjected to QA/QC procedures	1 - Some of the ingested data are subject to QA/QC procedures 3 - Most of the ingested data are subject to QA/QC procedures and some reliability indexes or metrics are available 5 - All ingested data are subject to QA/QC procedures and some reliability indexes or metrics are available.	
4	Real-time QA/QC methodology	Indicate QA/QC procedures used to assure the quality of data	1 - Mainly manual procedures following properly documented protocols 3 - Partially automated approaches with human intervention 5 - Mostly automated with human intervention. Procedures are properly documented and catalogued.	
1	Database type	Indicate type of database, provide software name	1 - No database - data are stored in files (Flat file database) (e.g. delimited text, fixed width text, spreadsheet, gridded data). 3 - Non relational Database Model 5 - Relational database and DBMS (e.g. SQL, ORACLE)	

2	Data formats	Indicate formats of data handled by database system (input and output procedures), e.g. CSV, XML, WaterML2.0	-	
3	Input and output Interfaces	Indicate data I/O main characteristics	1 - Data input/output procedures are not automated. Manual data ingestion.	
			3 - Data input/output procedures are partly automated. (there is an interface to manually and automatically import data)	
			5 - Data input/output procedures are automated. Some of them with advanced graphical functionality. ("machine to machine" plus all the functionalities under 1 and 3)	

V - Meteorological Forecasts and Products				
Item #	**Item Description**	**Guidance for evaluator**	**Grading Scheme**	**Evaluator comments**
1-	**National assessment**			
1	Service provider of the meteorological forecast products	If you have more than one provider, list them all	1- They are not provided by the National Meteorological Service (NMS)	
			3- Some are provided by NMS and some are derived from other companies	
			5- They are all provided by the National Meteorological Service	
1	Provider(s) of the Ocean water level forecast	Needed for the downstream boundary condition	1- They are not provided by the National Ocean Service	
			3- Some are provided by Ocean Service and some are derived from other companies	
			5- They are all provided by the National Ocean Service	

2-	Meteorological forecast products available for River Flood (RF) and Flash Flood (FF) modelling			
1	Rainfall (deterministic Quantitative Precipitation Forecast - QPF)	Ascertain the updating frequency (e.g. every 6 hr), temporal and spatial scales, and its availability	1 - Precipitation maps are available only as image products and not in the preferred time step	
			3 - Coarse resolution (e.g. resolution of global NWP) products are digitally available	
			5 - High resolution (spatial and temporal) at time step that meet the needs of the preferred hydrological model are available in digital format for a forecast horizon for at least 3 days	
2	Rainfall (probabilistic QPF)	Number of ensemble members (spatial and temporal), forecast horizon	1 - Outputs of at least three deterministic NWP models are used ("poor man ensemble")	
			3 - 20+ low resolution ensemble members	
			5 - 20+ high resolution ensemble members	
3	Temperature (deterministic forecast)	Ascertain the updating frequency (e.g. every 6 hr), temporal and spatial scales, and its availability	1 - Temperature forecast maps are available only as image products and not in the preferred time step	
			3 - Coarse resolution (e.g. resolution of global NWP) products are digitally available	
			5 - High resolution (spatial and temporal) at time step that meet the needs of the preferred hydrological model are available in digital format for a forecast horizon for at least 3 days	
4	Temperature (probabilistic forecast)	Number of ensemble members (spatial and temporal), forecast horizon	1 - Outputs of at least three deterministic NWP models are used ("poor man ensemble")	
			3 - 20+ low resolution ensemble members	
			5 - 20+ high resolution ensemble members	
5	Dew point temperature (deterministic forecast)	Ascertain the updating frequency (e.g. every 6 hr), temporal and spatial scales, and its availability	1 - Temperature forecast maps are available only as image products and not in the preferred time step	
			3 - Coarse resolution (e.g. resolution of global NWP) products are digitally available	

			5 - High resolution (spatial and temporal) at time step that meet the needs of the preferred hydrological model are available in digital format for a forecast horizon for at least 3 days	
6	Dew point temperature (deterministic forecast)	Number of ensemble members (spatial and temporal), forecast horizon	1 - Outputs of at least three deterministic NWP models are used ("poor man ensemble")	
			3 - 20+ low resolution ensemble members	
			5 - 20+ high resolution ensemble members	
7	Wind speed and direction (probabilistic forecast)	Number of ensemble members (spatial and temporal), forecast horizon	1 - Wind speed and direction forecast maps are available only as image products and not in the preferred time step	
			3 - Coarse resolution (e.g. resolution of global NWP) products are digitally available	
			5 - High resolution (spatial and temporal) at time step that meet the needs of the preferred hydrological model are available in digital format for a forecast horizon for at least 3 days	
			3 - 20+ low resolution ensemble members	
			5 - 20+ high resolution ensemble members	
3-	**Riverine Flood (RF) forecasting in coastal area**			
1	Ocean water level forecast (deterministic)	Ascertain the updating frequency (e.g. every 6 hr), temporal and spatial scales, and its availability for the downstream boundary condition	1 - Ocean water level forecast maps are available only as image products and not in the preferred time step	
			3 - Coarse resolution (e.g. resolution of global NWP) products are digitally available	
			5 - High resolution (spatial and temporal) at time step that meets the needs of the preferred hydrological/hydrodynamic model, and these are available in digital format for a forecast horizon for at least 3 days	
2	Ocean water level forecast (probabilistic)	Number of ensemble members (spatial and temporal), forecast horizon	1 - Outputs of at least three deterministic NWP models are used ("poor man ensemble")	
			3 - 20+ low resolution ensemble members	

		for the downstream boundary condition	5 - 20+ high resolution ensemble members	

VI - Hydrological models and forecasts				
Item #	**Item Description**	**Guidance for evaluator**	**Grading Scheme**	**Evaluator comments**
1-	**National assessment**			
1	Provider of Hydrological Forecast	If more than one, list all of them. For example River Flood forecast could be provided by NHS or a basin authority, while Flash Flood forecast could be by NMS	1. There is not a designated provider	
			3. There are different organisations that provide the different forecasts	
			5. Different organizations provide the forecasts but all under one agency or they work closely together	
2	Forecasting approach	Describe what type of modelling approach and system are used (e.g. "gauge-to-gauge" correlation, watershed model, routing model).	1. Not appropriate, or no formal flood forecasting procedures are in place	
			3. Appropriate, but should be improved - performance metrics are being met most of the time	
			5. Fit for purpose - performance metrics are being met or exceeded	
3	Procedure(s) for rapid-onset events	Are there any procedure, in particular for rapid-onset events?	1: There are no interactions/procedures	
			3: Some instructions are drafted but not completed	
			5: There are instructions/procedure to address rapid-onset events	
2-	**Hydrological model(s) available for River Flood (RF) and Flash Flood (FF) forecasting (by basin)**			
1	Rainfall-snowmelt-runoff model type (spatial	Spatial resolution (lumped/semi-	1. Not appropriate, or no formal flood forecasting procedures are in place	

	resolution) (if used as main forecast procedure)	distributed/distributed). Please record the model name, provider, software. If unique, then obtain details on its methodologies for runoff generation.	3. Appropriate, but should be improved - performance metrics are being met most of the time	
			5. Fit for purpose - performance metrics are being met or exceeded	
2	Routing model type (if used as main forecast procedure)	Describe routing approach used (e.g. Maskingam, Maskingam-Cunge, hydrodynamic).	1. Not appropriate, or no formal flood forecasting procedures are in place	
			3. Appropriate, but should be improved - performance metrics are being met most of the time	
			5. Fit for purpose - performance metrics are being met or exceeded	
3	Watershed model (if used as main forecast procedure)	Combination of Rainfall-snowmelt-runoff models are combined with a routing model (e.g. hydrodynamic model) to produce the basin forecast. Describe the watershed modelling approached used.	1. Not appropriate, or no formal flood forecasting procedures are in place	
			3. Appropriate, but should be improved - performance metrics are being met most of the time	
			5. Fit for purpose - performance metrics are being met or exceeded	
4	Forecast lead time	This refers as to how far into the future the forecast is issued.	1. Lead times of 1-2 days	
			3. Lead times of 3-5 days	
			5. Lead times of greater than 5 days	
5	Forecast Computational Time Step	Minutes, Hour(s), Daily	1. Too coarse a time step is used	
			3. Temporal resolution could still be improved	
			5. Appropriate time step is used	
6	Ability to address uncertainty	If yes, describe procedure. Indicate if you provide ensemble members or any post processing	1. "Poor man NWP ensemble"	
			3. "Poor man NWP ensemble" + disturb initial hydrological conditions	
			5. NWP multi member ensemble + disturb initial hydrological conditions	
7			3. The model(s) can be run at most twice a day	

			5. The model (s) can be run as many times a day as needed	
8	Calibration / validation	Because river basins characteristics might change with time, models might need to be recalibrated. Indicate frequency and strategy followed for model calibration	1. Models are calibrated and validated only at setup	
			3. Model calibration/validation is reviewed only if a problem arises	
			5. Model calibration/validation is reviewed at least every 5 years	
9	Forecast performance	Indicate practices and procedures used to assess performance	1. There is no systematic forecast performance.	
			3. Forecast performance is tracked only during a major event	
			5. There is a program executed monthly that provides statistics on performance	
10	Forecast updating	Methods used	1. Output updating is performed manually	
			3. Statistical bias adjustment is automated	
			5. Kalman filter(s) is applied	

VII - Flood Forecasting Products				
Item #	**Item Description**	**Guidance for evaluator**	**Grading Scheme**	**Evaluator comments**
1-	**National assessment**			
1	Level of service	What is the type and level of service provided ?	1: occasional flood forecasting	
			3: Threshold-based flood alert and flood forecasting	
			5: Threshold-based flood alert; flood forecasting, vigilance mapping, inundation forecasting	
2	Coverage of service	Is there a consistent level of service throughout the	1: Many catchments not covered but some services in high risk areas	

		country or a phased approach that concentrate on high risk areas?	3: Service varies across catchments but all catchments are covered 5: Consistent services levels across all catchments	
3	Risk based approach/ Generation of Flood (risk) map products	Does the NHMS generate Flood (risk) maps? Indicate what type, the frequency, and what triggers the generation of them. if not, there are any other institutions in charge for flood risk mapping? Explain	1: No Flood maps available 3: Flood maps in development and available at a limited number of forecast sites as static libraries 5: Flood risk maps available for all forecast sites in real-time	
2-	**by basin**			
1	Risk based approach/ Generation of Flood (risk) map products	Does the NHMS generate Flood (risk) maps? Indicate what type, the frequency, and what triggers the generation of them. if not, there are any other institutions in charge for flood risk mapping? Explain	1: No Flood maps available 3: Flood maps in development and available at a limited number of forecast sites as static libraries 5: Flood risk maps available for all forecast sites in real-time	
2	Customized products for different users	Does the NHMS provide a range of products for different users and for different time periods? Time periods in this case is referring to the forecast (warning) lead time	1: There is a lack of products for the forecast horizons most needed 3: Suite of products satisfy part of the users, not all of them 5: The suite of products is adequate to serve all user's needs and forecast horizons requested	
3	Consistency of product presentation	Does the NHMS have a standardized approach of product presentation with a uniform and consistent "look and feel"?	1: No standardization is used 3: Some of the products are standardized 5: All products are presented in a standardized consistent manner to avoid confusion among users	
4	Format in which products are	Are your products in a format	1: Do not know	

	issued	that is easily understood and interpreted by users?	3: Some formats are adequate and others difficult to understand	
			5: User's feedback indicate the format is adequate and easily understood	
5	Timeframes to issue products	Are the products provided in the timeframes required by the users (web, sms, phone, fax, bulletins…sirens)? Timeframes here refer to lead time. For example if a flash flood is in effect the sirens would satisfy better than a fax	1: Do not know	
			3: Not all areas have appropriate products to satisfy the users	
			5: All products provided satisfy the timeframe required by users	

Appendix 2. The SEE river basin survey – observational network table

№	Index	Station name	River*	Latitude, dec. deg	Longitude, dec. deg	Altitude of "0" reading/ meteo site**, m. abs	Elements***	Observation frequency, hr	Transmission frequency, hr	Equipment type	Time of operation: from … to … yyyymm	Data series evaluable from … to …, yyyymm	Format of data series* ***	Comments

* - if hydrological gauge
** - if hydrological gauge - altitude (m. abs) of zero reading, if meteorological - altitude (m. abs) of meteorological site
*** - list elements, which are measured
**** - paper/digital

Appendix 3. Quick guide to the SEE river basin survey

The Survey is based on the materials of WMO Assessment Guidelines for the End-to-End Early Warning Systems for Flood Forecasting (E2E EWS for FF), which was prepared by the WMO Commission for Hydrology. The survey should be filled in for a country's river basin, which is vulnerable to river floods and is suffering from lack of implemented flood forecasting system.

The survey is prepared in a spreadsheet form of the Excel file (*SEE-MHEWS-A River basin survey.xlsx*). There are 8 spreadsheets which should be filled in electronically (in Excel). First spreadsheet (Description) contains basic information about the Survey evaluator (e.g. expert, who is filling the survey), county and the river basin. The other spreadsheets have common structure with 5 columns:

- item № (number of item, e.g. question of the survey)
- Item Description
- Guidance for evaluator (contains brief information about what is needed to be filled in)
- Grading scheme (can be used as additional guidance for an expert/evaluator)
- Evaluator comments – <u>the filled, which should be filled in, preferably in a detailed manner.</u>

Tables (spreadsheets) have different subsections: all subsections of tables I, IV, VI and VII should be filled, however fill only relevant subsections (which reflect flood type and flood mechanisms of floods within proposed basin) of tables II, III, V.

There are several specific items regarding observational stations network metadata for a basin, which should be filled in additional table-template (*Network_table.xlsx*) for every of the following survey items (if applicable):

- Table II "Observations and Data Acquisition": items 2.1, 2.8, 2.13, 2.15, 2.17, 3.1, 3.7, 3.9
- Table III "Historical and Ancillary Data": items 2.1, 2.4, 2.9, 3.4, 4.1

The survey (excel file) should be filled for one basin, if several river basins are proposed please fill in survey for each of them – so that in the result there are one excel file for each basin.

Appendix 4. Observational networks, proposed by the SEE countries for the SEE-MHEWS-A Project

Observational stations networks in the Drin and the Vjosa river basins, proposed by Albania for the SEE-MHEWS-A Project

Index	***Station name***	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt.*, m abs***	***Elements***	***Sampling interval***	***Transmission frequency***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***	***Comments***
SEBA 1	Dajc	Drin	41,9855	19,4151	0,8	Water level	15 min	60 min	SEBA	2014/09-2019/06	2014/09-2016/11; 2018/03-2018/04; 2019/06-pres. time	Digital	Operational. Theoretical rating curve is available
SEBA 2	Fierze	Drin	42,2489	20,0444	Not available	Dam level, rainfall	30 min	60 min	SEBA	2014/09-2019/06	2014/09-2018/07	Digital	To be replaced or repaired soon. Dam storage elevation curve.
SEBA 3	Gri	Drin	42,3163	20,0579	Not available	Water level	15 min	60 min	SEBA	2014/09-2015/07	2014/09-2015/07	Digital	To be replaced or repaired soon.

Index	***Station name***	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt.*, m abs***	***Elements***	***Sampling interval***	***Transmission frequency***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***	***Comments***
SEBA 4	Koman	Drin	42,1078	19,8257	Not available	Dam level	60 min	120 min	SEBA	2014/09-2019/06	2014/09-2019/06	Digital	Operational. Dam storage elevation curve.
SEBA 5	Vai i Dejes	Drin	42,0151	19,6359	Not available	Dam level	60 min	120 min	SEBA	2014/09-2019/06	2014/09-2019/06	Digital	Operational. Dam storage elevation curve.
H1	Kovashica	Drin	41,5967	20,4411	439	Water level, rainfall	15 min	120 min	ETG	2013/04-2013/08	Never worked properly	Digital	To be replaced or repaired soon. Rating curve is available.
H2	Skavice	Drin	41,9236	20,3542	299	Water level, rainfall	15 min	120 min	ETG	2013/04-2014/11	Never worked properly	Digital	To be replaced or repaired soon. Rating curve is available.

Index	***Station name***	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt.*, m abs***	***Elements***	***Sampling interval***	***Transmission frequency***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***	***Comments***
H3	Dragobi	Drin	42,4317	19,9917	505	Water level, rainfall	15 min	120 min	ETG	2013/04-2015/08	Never worked properly	Digital	To be replaced or repaired soon. Rating curve is available
H4	Tamare	Drin	42,4539	19,5578	220	Water level, rainfall	15 min	120 min	ETG	2013/04-2013/07	Never worked properly	Digital	To be replaced or repaired soon. Rating curve is available
H5	Bahcallek	Drin	42,0422	19,4919	4	Water level, rainfall	15 min	120 min	ETG	2013/04-2019/06	2013/4 - 2019/06 with gaps	Digital	Operational. To be replaced or repaired soon. Rating curve is available
H6	Liqeni i Shkoders	Drin	42,0506	19,4919	4,5	Water level, rainfall	15 min	120 min	ETG	2013/04-2018/09	2013/4 - 2018/09; 2019/06	Digital	Operational. To be replaced or repaired soon. Rating curve is available

Index	Station name	River	Lat., deg. north	Long., deg. east	Alt.*, m abs	Elements	Sampling interval	Transmission frequency	Equipment	Period of operation	Data series period	Format of data series	Comments
H7	Fabrika e Cimentos	Drin	42,0394	19,4822	3,2	Water level, rainfall	15 min	120 min	ETG	2013/6-2019/05	2013/6-2019/05 with big data gaps and quality problems, not usable	Digital	To be replaced or repaired soon.
S1	Shengjin	Drini i Lezhes	41,8124	19,5854	-1	rainfall, air temperature, air humidity, air pressure, wind direction and speed, tide water level, global radiation	10 min	120 min	ETG	2013/6-2019/05	2013/6-2019/05 with big data gaps and quality problems, not usable	Digital	To be replaced or repaired soon.

Index	***Station name***	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt.*, m abs***	***Elements***	***Sampling interval***	***Transmission frequency***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***	***Comments***
SEBA 6	Krume	Drin	42,1992	20,4236	516	rainfall, temperature	10 min	240 min	SEBA	2014/09-2016/03	2014/09-2016/03	Digital	To be replaced or repaired soon.
SEBA 7	Peshkopi	Drin	41,6812	20,4197	647	rainfall, air temperature, air humidity, air pressure, wind direction and speed	10 min	240 min	SEBA	2014/09-2018/05	2014/09-2018/05	Digital	To be replaced or repaired soon.
SEBA 8	Theth	Drin	42,4056	19,7644	827	rainfall, temperature	30 min	240 min	SEBA	2014/09-2019/06	2014/09-2019/06	Digital	Operational.
SEBA 9	Ura e Shtrenjte	Drin	42,1440	19,6473	156	rainfall, temperature	30 min	240 min	SEBA	2014/09-2019/06	2014/09-2019/06	Digital	Operational.

Index	***Station name***	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt.*, m abs***	***Elements***	***Sampling interval***	***Transmission frequency***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***	***Comments***
M1	Shupenze	Drin	41,5423	20,4177	480	rainfall, air temperature, air humidity, air pressure, wind direction and speed, snow cover	10 min	120 min	ETG	2013/04-2019/05	2013/04-2019/05 with gaps	Digital	To be replaced or repaired soon. Rating curve is available.
M2	Fushe Lure	Drin	41,8083	20,2282	###	rainfall, air temperature, air humidity, air pressure, wind direction and speed, snow cover	10 min	120 min	ETG	2013/04-2015/08	2013/04-2015/08 with big data gaps and quality problems, not usable	Digital	To be replaced or repaired soon.

Index	***Station name***	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt.*, m abs***	***Elements***	***Sampling interval***	***Transmission frequency***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***	***Comments***
M3	Kukes A	Drin	42,0358	20,4165	354	rainfall, air temperature, air humidity, air pressure, wind direction and speed	10 min	120 min	ETG	2013/04-2013/08	2013/04-2013/08 with big data gaps and quality problems, not usable	Digital	To be replaced or repaired soon.
M4	B Curri	Drin	42,3552	20,0789	360	rainfall, air temperature, air humidity, air pressure, wind direction and speed	10 min	120 min	ETG	2013/04-2018/01	2013/04-2018/01 with gaps	Digital	To be replaced or repaired soon.
M5	Boge	Drin	42,3967	19,6412	###	rainfall, air temperature, air humidity, air pressure, wind direction	10 min	120 min	ETG	2015/08-2019/06	2015/08-2019/06 with gaps	Digital	Operational. To be replaced or repaired soon.

Index	***Station name***	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt.*, m abs***	***Elements***	***Sampling interval***	***Transmission frequency***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***	***Comments***
						and speed, snow cover							
M6	Rapsh	Drin	42,4011	19,4943	600	rainfall, air temperature, air humidity, air pressure, wind direction and speed, snow cover	10 min	120 min	ETG	2013/04-2019/06	2013/04-2019/06 with gaps	Digital	Operational. To be replaced or repaired soon.
M7	Shkoder	Drin	42,0639	19,5105	30	rainfall, air temperature, air humidity, air pressure, wind direction and speed	10 min	120 min	ETG	2013/04-2019/06	2013/04-2019/06 with gaps	Digital	Operational. To be replaced or repaired soon.

Index	***Station name***	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt.*, m abs***	***Elements***	***Sampling interval***	***Transmission frequency***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***	***Comments***
A1	Puke	Drin	42,0510	19,8963	810	rainfall, air temperature, air humidity, air pressure, wind direction and speed, evaporation, soil temperature, soil humidity, global radiation	10 min	120 min	ETG	2013/04-2016/04	2013/04-2016/04 with big data gaps and quality problems, not usable	Digital	To be replaced or repaired soon.
S3	Vlore	Vjosa	40,4501	19,4810	-0	rainfall, air temperature, air humidity, air pressure, wind direction and speed, tide water level, global	10 min	120 min	ETG	2013/04-2014/11	2013/04-2014/11 with big data gaps and quality problems, not usable	Digital	To be replaced or repaired soon.

Index	*Station name*	*River*	*Lat., deg. north*	*Long., deg. east*	*Alt.*, m abs*	*Elements*	*Sampling interval*	*Transmission frequency*	*Equipment*	*Period of operation*	*Data series period*	*Format of data series*	*Comments*
						radiation							
H8	Permet	Vjosa	40,2406	20,3539	218	Water level, rainfall	10 min	120 min	ETG	2013/04-2019/06	2013/04-2019/06 with big data gaps and quality problems, not usable	Digital	Operational. To be replaced or repaired soon. Rating curve is available.
H9	Ura e leklit	Vjosa	40,2592	20,0556	133	Water level, rainfall	10 min	120 min	ETG	2013/05-2019/06	2013/05-2019/06 with gaps	Digital	Operational. To be replaced or repaired soon. Rating curve is available.

Index	***Station name***	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt.*, m abs***	***Elements***	***Sampling interval***	***Transmission frequency***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***	***Comments***
H10	Dores	Vjosa	40,4000	19,8008	63	Water level, rainfall	10 min	120 min	ETG	2013/05-2017/08	2013/05-2019/06 with gaps	Digital	To be replaced or repaired soon.
H16	Mifol	Vjosa	40,6339	19,4611	0,5	Water level, rainfall	10 min	120 min	ETG	2013/05-2013/08	2013/05-2013/08 with big data gaps and quality problems, not usable	Digital	To be replaced or repaired soon.
M12	Brataj	Vjosa	40,2706	19,6648	270	rainfall, air temperature, air humidity, air pressure, wind direction and speed	10 min	120 min	ETG	2013/04-2019/06	2013/04-2019/06 with gaps	Digital	Operational. To be replaced or repaired soon..

Index	***Station name***	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt.*, m abs***	***Elements***	***Sampling interval***	***Transmission frequency***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***	***Comments***
M14	Leskovik	Vjosa	40,1521	20,5991	920	rainfall, air temperature, air humidity, air pressure, wind direction and speed, snow cover	10 min	120 min	ETG	2013/05-2019/06	2013/04-2019/06 with gaps	Digital	To be replaced or repaired soon.
M15	Gjirokaster	Vjosa	40,0802	20,1402	193	rainfall, air temperature, air humidity, air pressure, wind direction and speed	10 min	120 min	ETG	2013/05-2019/06	2013/04-2019/06 with gaps	Digital	Operational. To be replaced or repaired soon.
M16	Tepelene	Vjosa	40,2965	20,0206	220	rainfall, air temperature, air humidity, air pressure, wind direction and speed	10 min	120 min	ETG	2013/05-2019/06	2013/04-2019/06 with gaps	Digital	Operational. To be replaced or repaired soon.

Comments: * - altitude of zero reading (in case of hydrological station), or meteorological site (in case of meteorological station)

Observational stations in Albania, installed with the support of the World Bank project

N	Location	Elevation, m. abs	Latitude, deg. north	Longitude, deq. east	Station Type	Datalogger with GPRS and antenna	box for data logger and battery	TX sat GTX	5m station mast	10m station mast	1,9 m pluviom. mast	pluviom. sensor	heated pluviom. sensor	ultrasonic snow level sensor
M1	Shupenze	480	41,54	20,42	Meteorological	1	1		1		1		1	1
M2	Fushe Lure	1040	41,81	20,23	Meteorological	1	1		1		1		1	1
M3	Kukes A	354	42,04	20,42	Meteorological	1	1	1	1		1		1	
M4	B Curri	360	42,36	20,08	Meteorological	1	1		1		1		1	
M5	Boge	1000	42,40	19,64	Meteorological	1	1		1		1		1	1
M6	Rapsh	600	42,40	19,49	Meteorological	1	1		1		1		1	1
M7	Shkoder	30	42,06	19,51	Meteorological	1	1	1	1		1	1		
M8	Shen Koll	6	41,69	19,65	Meteorological	1	1		1		1	1		
M9	Burrel	309	41,61	20,01	Meteorological	1	1		1		1		1	
M10	Tirana A	89	41,41	19,72	Meteorological	1	1	1	1		1	1		
M11	Prrenjas	590	41,07	20,55	Meteorological	1	1		1		1		1	1
M12	Brataj	270	40,27	19,66	Meteorological	1	1		1		1		1	
M13	Corovode	410	40,50	20,23	Meteorological	1	1		1		1		1	1
M14	Leskovik	920	40,15	20,60	Meteorological	1	1		1		1		1	1
M15	Gjirokaster	193	40,08	20,14	Meteorological	1	1	1	1		1	1		

N	Location	Elevation, m. abs	Latitude, deg. north	Longitude, deq. east	Station Type	Datalog ger with GPRS and antenna	box for data logg er and batte ry	TX sat GT X	5m stati on mast	10m stati on mast	1,9 m pluvio m. mast	pluvio m. senso r	heate d pluvio m. senso r	ultraso nic snow level sensor
M1 6	Tepelene	220	40,30	20,02	Meteorological	1	1		1		1		1	
S1	Shengjin	10	41,81	19,59	Marine	1	1		1		1	1		
S2	Durres	10	41,30	19,45	Marine	1	1		1		1	1		
S3	Vlore	10	40,45	19,48	Marine	1	1	1	1		1	1		
S4	Sarande	10	39,87	20,00	Marine	1	1		1		1	1		
A1	Puke	810	42,05	19,90	Agrometeo	1	1			1	1		1	
A2	Korca	899	40,62	20,78	Agrometeo	1	1	1		1	1		1	
A3	Lushnje	20	40,94	19,71	Agrometeo	1	1			1	1	1		
A4	Elbasan	100	41,11	20,09	Agrometeo	1	1			1	1	1		
H1	Kovashica	444	41,60	20,44	Hydrological	1	1		1		1	1		
H2	Skavice	307	41,92	20,35	Hydrological	1	1		1		1	1		
H3	Dragobi	510	42,43	19,99	Hydrological	1	1		1		1	1		
H4	Tamare	231	42,45	19,56	Hydrological	1	1		1		1	1		
H5	Bahcallek	7	42,04	19,49	Hydrological	1	1		1		1	1		
H6	Liqeni i Shkoders	6	42,05	19,49	Hydrological	1	1		1		1	1		
H7	Fabrika e Cimentos	5	42,04	19,48	Hydrological	1	1		1		1	1		
H8	Permet	230	40,24	20,35	Hydrological	1	1		1		1	1		
H9	Ura e leklit	155	40,26	20,06	Hydrological	1	1		1		1	1		
H1 0	Dores	80	40,40	19,80	Hydrological	1	1		1		1	1		

N	Location	Elevation, m. abs	Latitude, deg. north	Longitude, deq. east	Station Type	Datalogger with GPRS and antenna	box for data logger and battery	TX sat GTX	5m station mast	10m station mast	1,9 m pluviom. mast	pluviom. sensor	heated pluviom. sensor	ultrasonic snow level sensor
H11	Murrash	228	41,19	20,29	Hydrological	1	1		1		1	1		
H12	Ndroq	37	41,27	19,65	Hydrological	1	1		1		1	1		
H13	Kokel	310	40,78	20,29	Hydrological	1	1		1		1	1		
H14	Corovode	271	40,50	20,23	Hydrological	1	1		1		1	1		
H15	Mrostar	10	40,75	19,58	Hydrological	1	1		1		1	1		
H16	Mifol	3	40,63	19,46	Hydrological	1	1		1		1	1		

Observational stations in Albania, installed with the support of the World Bank project (continuation)

N°	Location	ultrasonic 3D anemom.	ultrasonic 2D anemom.	air temp. and humidity sensor	barometric sensor	radar water level sensor	hydrom. staff	Solar radiation sensor	Soil humidity sensor array	Soil temperature sensor	Evaporation pan	CO2 sensor	Leaf wetness sensor	Sea-level (tide) sensor	Pressure wave (see wave) sensor
M1	Shupenze	1		1	1										
M2	Fushe Lure		1	1	1										
M3	Kukes A		1	1	1										
M4	B Curri		1	1	1										

N°	Location	ultrasonic 3D anemom.	ultrasonic 2D anemom.	air temp. and humidity sensor	barometric sensor	radar water level sensor	hydrom. staff	Solar radiation sensor	Soil humidity sensor array	Soil temperature sensor	Evaporation pan	CO2 sensor	Leaf wetness sensor	Sea-level (tide) sensor	Pressure wave (see wave) sensor
M5	Boge		1	1	1										
M6	Rapsh		1	1	1										
M7	Shkoder	1		1	1										
M8	Shen Koll		1	1	1										
M9	Burrel		1	1	1										
M10	Tirana A	1		1	1										
M11	Prrenjas		1	1	1										
M12	Brataj		1	1	1										
M13	Corovode		1	1	1										
M14	Leskovik		1	1	1										
M15	Gjirokaster	1		1	1										
M16	Tepelene		1	1	1										
S1	Shengjin		1	1	1			1						1	
S2	Durres		1	1	1			1						1	1
S3	Vlore		1	1	1			1						1	1
S4	Sarande		1	1	1			1						1	
A1	Puke	1		1	1			1	1	1	1				
A2	Korca	1		1	1			1	1	1	1				
A3	Lushnje	1		1	1			1	1	1	1	1	1		

N°	Location	ultrasonic 3D anemom.	ultrasonic 2D anemom.	air temp. and humidity sensor	barometric sensor	radar water level sensor	hydrom. staff	Solar radiation sensor	Soil humidity sensor array	Soil temperature sensor	Evaporation pan	CO2 sensor	Leaf wetness sensor	Sea-level (tide) sensor	Pressure wave (see wave) sensor
A4	Elbasan	1		1	1			1	1	1	1	1	1		
H1	Kovashica					1	1								
H2	Skavice					1	1								
H3	Dragobi					1	1								
H4	Tamare					1	1								
H5	Bahcallek					1	1								
H6	Liqeni i Shkoders					1	1								
H7	Fabrika e Cimentos					1	1								
H8	Permet					1	1								
H9	Ura e Ieklit					1	1								
H10	Dores					1	1								
H11	Murrash					1	1								
H12	Ndroq					1	1								
H13	Kokel					1	1								
H14	Corovode					1	1								
H15	Mrostar					1	1								
H16	Mifol					1	1								

Observational stations in Albania, installed with the support of the GIZ project

Name	**Latitude, degrees**	**Longitude, degrees**	**Operational**	**Pluviometer installed**	**Water level**	**Air temperature**	**Air humidity**	**Air pressure**	**Wind direction**	**Wind speed**
Dajc	41,9855	19,4151	Yes		1					
Fierze	42,2489	20,0444	Yes	1	1					
Gri	42,3163	20,0579	No		1					
Koman	42,1078	19,8257	Yes		1					
Krume	42,1992	20,4236	No	1		1				
Peshkopi	41,6812	20,4197	Yes	1		1	1	1	1	1
Theth	42,4056	19,7644	Yes	1		1				
Ura e Shtrenjte	42,144	19,6473	Yes	1		1				
Vau i Dejes	42,0151	19,6359	Yes		1					

Meteorological stations in Albania, which are in the WMO Global Telecommunication System

Station ID	**Name**	**Latitude, degrees**	**Longitude, Degrees**	**Altitude, m abs.**
13600	Shkodra	42,1	19,533	43
13601	Tirana-La Praka	41,333	19,8	90
13610	Kukes	42,033	20,417	354
13611	Durres	41,3	19,45	15
13615	Tirana	41,333	19,783	89
13619	Peshkopi	41,683	20,433	657
13622	Vlore	40,467	19,483	1
13623	Sazan Island	40,5	19,283	340
13624	Qyteti Stalin	40,8	19,9	32
13625	Gjirokastra	40,083	20,15	193
13629	Korca	40,6	20,767	889

Hydrometric stations network of the Vrbas river basin (Republika Srpska part of the basin), proposed by Bosnia and Herzegovina for the SEE-MHEWS-A Project

Station name	***River***	***Lat., deg. North***	***Long., deg. east***	***Alt. of zero reading , m abs***	***Elements ****	***Sampling interval***	***Transmission frequency***	***Equip ment***	***Period of operation***	***Data series period***	***Format of data series***
Bočac	Vrbas	44,3413	17,0757	219,67	H,T	0,5 h	0,5 h	OTT	2015.11.	1959-1990; 2015-2019	digital
Banja Luka	Vrbas	44,76466667	17,188718	151,21	H,Q	0,5 h	0,5 h	OTT	2016.09.	1921-1990; 1995-2019	digital
Delibasino Selo	Vrbas	44,480200	17,1331	141,38	H,Q,T	0,5 h	0,5 h	OTT	2015.11.	1925-2019	digital
Klašnice	Vrbas	44,880057	17,285505	124,38	H,T	0,5 h	0,5 h	OTT	2016.12.		digital

Station name	***River***	***Lat., deg. North***	***Long., deg. east***	***Alt. of zero reading , m abs***	***Elements ****	***Sampling interval***	***Transmission frequency***	***Equip ment***	***Period of operation***	***Data series period***	***Format of data series***
Donji Obodnik	Vrbanj a	44,3349	17,2816	335,14	H,Q,T	0,5 h	0,5 h	OTT	2016.02.	1963-1990;20 16-2019	digital
Vrbanja	Vrbanj a	44,747564	17,27283	166,22	H,Q	0,5 h	0,5 h	OTT	2016.09.	1925-1990 1997-2019	digital
Jošavka	Jošavk a	44,4453	17,2507		H,T	0,5 h	0,5 h	OTT	2018.02.		digital
Majevac	Pliva	44,1419	17,2507	461,53	H,Q,T	0,5 h	0,5 h	OTT	2015.11.	1966-1990; 2015-2019	digital

Station name	***River***	***Lat., deg. North***	***Long., deg. east***	***Alt. of zero reading , m abs***	***Elements ****	***Sampling interval***	***Transmission frequency***	***Equip ment***	***Period of operation***	***Data series period***	***Format of data series***
Volari	Pliva	44,1732	17,0654	434,10	H,Q	0,5 h	0,5 h	OTT	2015.11.	1958-1990; 2015-2019	digital
Sarići	Janj	44,1612	17,0548	446,42	H,Q,T	0,5 h	0,5 h	OTT	2015.11.	1949-1990; 2015-2019	digital

Comments: * - H – water level, Q – discharge, T – water temperature

Meteorological stations network of the Vrbas river basin (Republika Srpska part of the basin), proposed by Bosnia and Herzegovina for the SEE-MHEWS-A Project

Station name	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt. of zero reading , m abs***	***Elements ****	***Sampling interval***	***Transmission frequency***	***Equip ment***	***Period of operation***	***Data series period***	***Format of data series***
MS Banja Luka	Vrbas	17,205769	44,79383	153	T;H;P;W10;W2;GR; PI*	1min-30min	30 min	OTT	2016.2.	1961.1.	digital
Šipovo	Pliva	17,087757	44,284209	460	T;H;P;PI	1min-30min	30 min	OTT	2016.2.	1965.4.	digital
Banja Luka PMF	Vrbas	17,198984	44,779073		T;H;P;PI	1min-30min	30 min	OTT	2016.2.	2016.2.	digital
Krupa na Vrbasu	Vrbas	17,143934	44,615134	260	T;H;P;PI	1min-30min	30 min	OTT	2016.1.	2016.2.	digital
Majevac	Pliva	17,026079	44,240238		T;H;P;PI	1min-30min	30 min	OTT	2016.2.	2016.2.	digital
Manjača	Vrbas	17,005643	44,663235		T;H;P;PI	1min-30min	30 min	OTT	2016.2.	2016.2.	digital
Kotor Varoš	Vrbanja	17,388648	44,609544	226	T;H;P;PI	1min-30min	30 min	OTT	2016.2.	2016.2.	digital
Mrkonjić Grad	Crna Rijeka	17,083610	44,418610	575	T;H;P;PI	1min-30min	30 min	OTT	2016.2.	1961.2.	digital
Srbac	Sava	17,52167	45,10417	90	T;H;P;PI	1min-30min	30 min	OTT	2016.2.	1961,1	digital

Station name	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt. of zero reading , m abs***	***Elements ****	***Sampling interval***	***Transmission frequency***	***Equip ment***	***Period of operation***	***Data series period***	***Format of data series***
Kneževo	Vrbas	17,318281	44,524249	808	T;H;P;PI	1min-30min	30 min	OTT	2016.2.	2016.2.	digital
Čelinac	Vrbanja	17,34731	44,733775		T;H;P;PI	1min-30min	30 min	OTT	2016.2.	2016.2.	digital

Comments: * - T – air temperature at 2m, P – precipitation, H – humidity, W10 – wind speed at 10 m, W2 – wind speed at 2 m, GR – global radiation, PI – precipitation intensity

Hydrometric stations network of the Vrbas river basin (Federation of Bosnia and Herzegovina part of the basin), maintained by the "Agency for Sava river basin"

Station name	**River**	***Latitude, dec. deg***	***Longitude, dec. deg***	***Altitude of "0" reading, m. abs***	**Elements**	***Sampling interval***	***Transmission frequency***	**Equipment**	***Period of operation***	***Data series period***	***Format of data series***
HP Gornji Vakuf	Vrbas	43,94	17,58	664,33	h, q	1 hour	1 hour	SEBA, Demas	8.10.2004 - 2019	8.10.2004 - 2019	digital, paper
HP Daljan	Vrbas	44,13	17,40	516,41	h, q	1 hour	1 hour	SEBA, Demas	9.9.2002 - 2019	9.9.2002 - 2019	digital, paper
HP Kozluk Jajce	Vrbas	44,34	17,27	342,51	h, q	1 hour	1 hour	SEBA, Demas	26.10.2004 - 2019	26.10.2004 - 2019	digital, paper
HP Bistrica	Bistrica	43,96	17,57	599.13(rel.)	h, q	1 hour	1 hour	SEBA, Demas	2010 - 2019	2010 - 2019	digital, paper

Comments: h – water level, q – discharge

Meteorological stations network of the Vrbas river basin (Federation of Bosnia and Herzegovina part), maintained by the "Agency for Sava river basin"

Comments: t – air temperature, p - precipitation

Station name	**River**	***Latitude, dec. deg***	***Longitude, dec. deg***	***Altitude of meteo.site, m. abs***	**Elements**	***Sampling interval***	***Transmission frequency***	**Equipment**	***Period of operation***	***Data series period***	***Format of data series***
Gornji Vakuf	Vrbas	43,93972222	17,58916667	**670,00**	p, t	1 hour	1 hour	automatska SEBA, Demas	2008 - 2019	2008 - 2019	digital, paper

Meteorological stations network of the Vrbas river basin (Federation of Bosnia and Herzegovina part), maintained by the Federal Hydrometeorological Institute of Federation of Bosnia and Herzegovina (FHMI)

Station name	**River**	***Latitude, dec. deg***	***Longitude, dec. deg***	**Elements**	***Sampling interval***	***Transmission frequency***	**Equipment**	***Period of operation***	***Data series period***	***Format of data series***
Divičani	Vrbas	44,363	17,328	air temperature, precipitation	1 hour	1 hour	automatska OTT	2016 - 2019	2016 - 2019	digital, paper
Gračanica	Vrbas	44,001	17,496	air temperature, precipitation	1 hour	1 hour	automatska OTT	2016 - 2019	2016 - 2019	digital, paper
Pidriš	Vrbas	43,892	17,584	air temperature, precipitation	1 hour	1 hour	automatska OTT	2016 - 2019	2016 - 2019	digital, paper
Voljice Gaj	Vrbas	43,919	17,534	air temperature, precipitation	1 hour	1 hour	automatska OTT	2016 - 2019	2016 - 2019	digital, paper
Rovna	Vrbas	44,098	17,49	air temperature, precipitation	1 hour	1 hour	automatska OTT	2016 - 2019	2016 - 2019	digital, paper
Kupres	Vrbas	43,99	17,276	air temperature, precipitation	1 hour	1 hour	automatska OTT	2016 - 2019	2016 - 2019	digital, paper
Šeherdžik	Vrbas	44,209	17,419	air temperature, precipitation	1 hour	1 hour	automatska OTT	2016 - 2019	2016 - 2019	digital, paper
Borova Ravan	Vrbas	43,856	17,683	air temperature, precipitation	1 hour	1 hour	automatska OTT	2016 - 2019	2016 - 2019	digital, paper
Dobrošin	Vrbas	43,897	17,636	air temperature, precipitation	1 hour	1 hour	automatska OTT	2016 - 2019	2016 - 2019	digital, paper
Gornji Vakuf	Vrbas	43,937	17,58	air temperature, precipitation	1 hour	1 hour	automatska OTT	2016 - 2019	2016 - 2019	digital, paper
Rat	Vrbas	44,044	17,687	air temperature, precipitation	1 hour	1 hour	automatska OTT	2016 - 2019	2016 - 2019	digital, paper

Hydrometric stations network of the Neretva river basin (Bosnia and Herzegovina part of the basin), maintained by the “Agency for Adriatic Sea basin”

Name	**River**	***Latitude, dec. deg***	***Longitude, dec. deg***	***Altitude of "0" reading***	**Elements**	***Observation frequency, hr***	***Transmission frequency, hr***	**Equipment type**	***Time of operation: from … to … yyyymm***	***Data series evaluable from … to …, yyyymm***	***Format of data series*******
HP Mostar	Neretva	43,35	17,81	40,29	h, q	15 min-1 hour	1 hour	automatska OTT(Kalesto)	1.1.2003 - 2019	1.1.2003 - 2019	digital, paper
HP Baćevići	Neretva	43,28	17,83	30,58	t, chem	15 min-1 hour	1 hour	automatska OTT(Quanta)	13.2.2004 - 2019	13.2.2004 - 2019	digital, paper
HP Jasenica Dom	Jasenica	43,30	17,80	45,72	h	15 min-1 hour	1 hour	auto. OTT **hydras**(Thalimedes)	1.1.2004 - 2019	1.1.2004 - 2019	digital, paper
HP Buna	Neretva	43,25	17,84	30,66	h, q	15 min-1 hour	1 hour	automatska OTT(Nimbus)			
HP Žitomislići	Neretva	43,20	17,79	16,25	t, chem	15 min-1 hour	1 hour	automatska OTT			
HP Dračevo-nizvodno	Neretva	43,05	17,68	-0,25	h, q			automatska OTT-***hydras*-(**Quanta)			
HP Dračevo	Krupa	43,06	17,71	0,50	water level	15 min-1 hour	1 hour	automatska OTT-***RLS***	1.5.2004 - 2019	1.5.2004 - 2019	digital, paper
HP Karaotok	Krupa	43,06	17,75	0,50	t	15 min-1 hour	1 hour	automatska OTT	1.1.2008 - 2019	1.1.2008 - 2019	digital, paper
HP Gabela	Neretva	43,06	17,70	0,78	h, q	15 min-1 hour	1 hour	automatska OTT(RLS)	01.01.2005 - 2019	01.01.2005 - 2019	digital, paper
HP Stolac	Bregava	43,08	17,96	56,02	h	15 min-1 hour	1 hour	automatska OTT **hydras**(CBS)	1.1.2010 - 2019	1.1.2010 - 2019	digital, paper
HMP Humac	Trebižat	43,18	17,52	64,88	h, q	15 min-1 hour	1 hour	automatska OTT	1.9.2003 - 2019	1.9.2003 - 2019	digital, paper
HMP Gračanica	Rama	43,77	17,68	299,41	h	15 min-1 hour	1 hour	automatska OTT	1.3.2008 - 2019	1.3.2008 - 2019	digital, paper

HP Struge	Trebižat	43,09	17,70	5,98	h	15 min-1 hour	1 hour	automatska OTT	29.10.2010 - 2019	29.10.2010 - 2019	digital, paper
HP Klobuk	TMT	43,27	17,44	105,73	h, q	15 min-1 hour	1 hour	automatska OTT	28.10.2010 - 2019	28.10.2010 - 2019	digital, paper
HP Mostar-Radobolja	Radobolja	43,34	17,80	65,05	h	15 min-1 hour	1 hour	automatska OTT	28.3.2008 - 2019	28.3.2008 - 2019	digital, paper
HP Čapljina	Neretva	43,11	17,71	6,32	h	15 min-1 hour	1 hour	automatska OTT ***hydras (RLS)***	1.1.2014 - 2019	1.1.2014 - 2019	digital, paper
HP Grudsko Vrilo	knl Grudsko Vrilo	43,39	17,37	253,73	h	once a day	once a month	*observer*	1.1.2015 - 2019	1.1.2015 - 2019	digital, paper
HP Malo Polje	Bunica	43,22	17,89	37,02	h	once a day	once a month	*observer*	1.1.2010 - 2019	1.1.2010 - 2019	digital, paper
HP Škrka	j.Škrka	43,08	17,74	1,66	h	once a day	once a month	*observer*	1.1.2011 - 2019	1.1.2011 - 2019	digital, paper
HP Boljun Kuk	Deranjsko j.			0,80	h	**0,80**	1 hour	automatska SEBA/Demas	1.1.2011 - 2019	1.1.2011 - 2019	digital, paper
HP Blagaj	Buna	43,26	17,89	37,18	h	once a day	once a month	*observer*	1.1.2006 - 2019	1.1.2006 - 2019	digital, paper

Comments: h – water level, q - discharge

Meteorological stations network of the Neretva river basin (Federation of Bosnia and Herzegovina part), maintained by the Federal Hydrometeorological Institute of Federation of Bosnia and Herzegovina (FHMI)

Name	***Latitude, dec. deg***	***Longitude, dec. deg***	***Altitude of "0" reading/meteo site**, m. abs***	**Elements**	***Observation frequency, hr***	***Transmission frequency, hr***	**Equipment**	***Time of operation: from … to … yyyymm***	***Data series evaluable from … to …, yyyymm***	***Format of data series*******
MP Mostar	43,34833	17,79389	99,00	p, t, h	1 hour	1 hour	automatska SEBA	3.11.2007 - 2019	3.11.2007 - 2019	digital, paper
MP Čitluk	43,2275	17,70444	220,00	p,t	1 hour	1 hour	automatska SEBA	11.10.2007 - 2019	11.10.2007 - 2019	digital, paper
MP Široki Brijeg	43,37194	17,58444	317,00	p	1 hour	1 hour	automatska SEBA	11.10.2007 - 2019	11.10.2007 - 2019	digital, paper
MP Stolac	43,07528	17,95389	55,00	p,t	1 hour	1 hour	automatska SEBA	3.11.2007 - 2019	3.11.2007 - 2019	digital, paper
MP Posušje	43,46611	17,32972	623,00	p,t	1 hour	1 hour	automatska SEBA	11.11.2007 - 2019	11.11.2007 - 2019	digital, paper
MP Rama	43,82694	17,60639	717,00	p,t	1 hour	1 hour	automatska SEBA	12.10.2007 - 2019	12.10.2007 - 2019	digital, paper
MP Tomislavgrad	43,71583	17,2275	900,00	p,t	1 hour	1 hour	automatska SIAP	12.3.2008 - 2019	12.3.2008 - 2019	digital, paper
MP Livno	43,82278	17,00111	725,00	p,t	1 hour	1 hour	automatska SEBA	12.10.2007 - 2019	12.10.2007 - 2019	digital, paper
MP Ivan Sedlo	43,75111	18,03611	984,00	p,t	1 hour	1 hour	automatska SEBA	8.12.2007 - 2019	8.12.2007 - 2019	digital, paper
MP Blidinje	43,65028	17,57028	1283,00	p,t	1 hour	1 hour	automatska SIAP	12.3.2008 - 2019	12.3.2008 - 2019	digital, paper
MP Karaotok	43,06417	17,75444	6,00	p,t	1 hour	1 hour	automatska SIAP	12.3.2008 - 2019	12.3.2008 - 2019	digital, paper
MP Beganovići-Kozo	43,81917	17,47056	1208,00	p,t,h	1 hour	1 hour	automatska OTT	29.2.2008 - 2019	29.2.2008 - 2019	digital, paper
MP Jasenjani	43,5225	17,76639	421,00	p,t,h	1 hour	1 hour	automatska OTT	3.12.2007 - 2019	3.12.2007 - 2019	digital, paper

MP Čuhovići	43,63917	18,14056	1335,00	p,t,h	1 hour	1 hour	automatska OTT	1.12.2007 - 2019	1.12.2007 - 2019	digital, paper
MP Jasenik	43,85889	17,87944	1011,00	p,t,h	1 hour	1 hour	automatska OTT	13.12.2007 - 2019	13.12.2007 - 2019	digital, paper
MP Sovići	43,71306	17,59556	751,00	p,t,h	1 hour	1 hour	automatska OTT	30.11.2007 - 2019	30.11.2007 - 2019	digital, paper
MP Trešnjevica	43,77139	17,94194	891,00	p,t,h	1 hour	1 hour	automatska OTT	13.12.2007 - 2019	13.12.2007 - 2019	digital, paper
MP Umoljani	43,66861	18,22806	1317,00	p,t,h,s	1 hour	1 hour	automatska OTT	30.11.2007 - 2019	30.11.2007 - 2019	digital, paper

Comments: p – precipitation, t – air temperature, h – humidity

Bulgaria

Hydrometric stations network of the Kamchiya river basin, proposed by Bulgaria for the SEE-MHEWS-A Project

Station name	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt. of zero reading, m abs***	***Elements***	***Sampling interval***	***Transmission frequency***	***Equip ment***	***Period of operation***	***Data series period***	***Format of data series***
HMS No43350 Targovishte	Vrana	43,2403	26,5722	180,23	water level, temperature, speed	12 24 per month	-	limnigrafe staff gauge	1931/05 - continue	1947/01 - continue	paper
HMS No43400 Kochovo	Vrana	43,2258	26,7881	102,82	water level, temperature, speed	12 24 per month	per hour	ATS staff gauge	1950/08 - continue	1951/01 - continue	digital paper paper
HMS No43500 Beronovo	Luda Kamchia	42,8336	26,6828	283,23	water level, temperature, speed	12 24 per month	per hour	ATS staff gauge	1950/07 - continue	1951/01 - continue	digital paper paper
HMS No43620 Ticha	Ticha	42,9678	26,4442	312,77	water level, temperature, speed	12 24 per month	-	limnigrafe staff gauge	1959/05 - continue	1960/01 - continue	paper

Station name	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt. of zero reading, m abs***	***Elements***	***Sampling interval***	***Transmission frequency***	***Equip ment***	***Period of operation***	***Data series period***	***Format of data series***
HMS No43700 Preslav	Kamchia	43,1361	26,8100	105,94	water level, temperatu re, speed	12 24 per month	-	staff gauge	1935/11 - continue	1936/01 - continue	paper
HMS No43800 Grozdevo	Kamchia	43,0317	27,5411	13,73	water level, temperatu re, speed	12 24 per month	per hour	ATS staff gauge	1922/09 - continue	1951/01 - continue	digital paper paper

Croatia

Hydrometric stations network of the Neretva river basin, proposed by Croatia for the SEE-MHEWS-A Project

Station name	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt. of zero reading, m abs***	***Elements***	***Sampling interval***	***Transmission frequency***	***Equip ment***	***Period of operation***	***Data series period***	***Format of data series***
HMS No 7052 Metković	Neretva	43,0544 5	17,6508 333333	-0,21	water level, temperatu re	per 0,5 hr	per hour	OTT Thalim edes	1934/01-continue	1934/01 - 2017/12	digital
HMS No 7062 Opuzen	Neretva	43,0179 888889	17,5643 75	-0,181	water level	per 0,25 hr	per hour	OTT Thalim edes	1936/01-continue	1936/01 - 2017/12	digital
HMS No 7506 Opuzen ustava nizv.	Mala Neretva	43,0157 555556	17,5630 527778	-0,031	water level	per 0,25 hr	per hour	OTT Thalim edes	1977/01-continue	1977/01 - 2017/12	digital
HMS No 7501 Ustava ušće uzv.	Mala Neretva	43,0066 805556	17,5630 527778	-0,134	water level	per 0,25 hr	per hour	OTT Thalim edes	1977/01-continue	1977/01 - 2017/12	digital

Station name	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt. of zero reading, m abs***	***Elements***	***Sampling interval***	***Transmission frequency***	***Equip ment***	***Period of operation***	***Data series period***	***Format of data series***
HMS No 7331 CP Veraja	Lateralni kanal	43,0318 583333	17,6395 916667	-0,029	water level	per hour	per hour	TruBlu e Level 555(ve nted)	1994/01-continue	1994/01 - 2017/12	digital
HMS No 7260 Kalebovac	Norin	43,0590 5	17,5931 527778	-0,063	water level	per hour	per >1000 hour	OTT Thalim edes	1986/01-continue	1986/01 - 2017/12	digital
HMS No 7258 Kula Norinska	Norin	43,0319 555556	17,6112 861111	-0,118	water level	per hour	per >1000 hour	OTT Thalim edes	1986/01-continue	1986/01 - 2017/12	digital
HMS No 7259 Prud preljev uzv.	Norin	43,0947 4722	17,6203 5278	1,008	water level, temperatu re, discharge	per hour	per hour	TruBlu e Level 555(ve nted)	2015/01-continue	2015/01 - 2017/12	digital

Station name	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt. of zero reading, m abs***	***Elements***	***Sampling interval***	***Transmission frequency***	***Equip ment***	***Period of operation***	***Data series period***	***Format of data series***
HMS No 7509 Bijeli vir	Lateralni kanal	43,0074 833333	17,6497 611111	-0,023	water level	per hour	per >1000 hour	OTT Thalim edes	1977/01-continue	1977/01 - 2017/12	digital
HMS No 7124 Bijeli vir	Bijeli vir	43,0101 194444	17,6548 027778	-0,203	water level	per hour	per >1000 hour	OTT Thalim edes	1960/01-continue	1960/01 - 2017/12	digital
HMS No 7178 Kuti	Jezero Kuti	42,9551 055556	17,6119 805556	-0,041	water level	per hour	per >1000 hour	OTT Thalim edes	1978/01-continue	1978/01 - 2017/12	digital
HMS No 7499 Ustava ušće nizv.	Mala Neretva	43,0074 5	17,4698	-0,325	sea level	per hour	per hour	OTT Thalim edes	1977/01-continue	1977/01 - 2017/12	digital

Weather stations network of the Neretva river basin, proposed by Croatia for the SEE-MHEWS-A Project

Index	***Station name***	***Lat., deg. north***	***Long., deg. east***	***Alt. of meteo site, m. abs***	***Elements***	***Sampling interval***	***Transmissio n frequency***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***
14462	Ploče	43.0475	17.442 77778	2	precipitation, temperature	1	1	manual and automatic	1957 - continue	1978/01 - continue	digital
14454	Makarska	43.2875	17.019	52	precipitation,	1	1	manual and	1981/01 -	1981/01 - continue	digital

Index	Station name	Lat., deg. north	Long., deg. east	Alt. of meteo site, m. abs	Elements	Sampling interval	Transmission frequency	Equipment	Period of operation	Data series period	Format of data series
			72222		temperature			automatic	continue		
825	Ričice-Brana	43.49666667	17.13416667	402	precipitation, temperature	7, 14, 21 h local time	monthly	manual	1993/01 - continue	1993/01 - continue	digital
790	Imotski	43.44472222	17.22138889	435	precipitation, temperature	7, 14, 21 h local time	monthly	manual	1927 - continue	1981/01 - continue	digital, paper
760	Vrgorac	43.205	17.37027778	245	precipitation, temperature	7, 14, 21 h local time	monthly	manual	1957 - continue	1981/01 - continue	digital, paper
340	Metković	43.04638889	17.64305556	4	precipitation, temperature	7, 14, 21 h local time	monthly	manual	1997/06 - continue	1997/06 - continue	digital
810	Šestanovac	43.44916667	16.92194444	240	precipitation, temperature	7, 14, 21 h local time	monthly	manual	1962 - continue	1981/01 - continue	digital, paper
320	Kuna	42.96777778	17.34333333	357	precipitation, temperature	7, 14, 21 h local time	monthly	manual	1957 - continue	1981/01 - continue	digital, paper
120	Ston	42.83666667	17.695	2	precipitation, temperature	7, 14, 21 h local time	monthly	manual	1950 - continue	1981/01 - continue	digital, paper
350	Opuzen	43.0175	17.55861111	3	precipitation, temperature	7, 14, 21 h local time	monthly	manual	1946 - continue	1981/01 - continue	digital, paper
830	Aržano	43.57916667	17.0025	645	precipitation	daily	monthly	manual	1940 - continue	1991/01 - continue	digital, paper
820	Lovreč	43.48972222	16.98305556	526	precipitation	daily	monthly	manual	1955 - continue	1991/01 - continue	digital, paper
785	Medovdolac	43.44972222	17.04333333	536	precipitation	daily	monthly	manual	2010/08 - continue	2010/08 - continue	digital
780	Zagvozd	43.3947	17.052	370	precipitation	daily	monthly	manual	1949/06 -	1949/06 - continue	digital

Index	***Station name***	***Lat., deg. north***	***Long., deg. east***	***Alt. of meteo site, m. abs***	***Elements***	***Sampling interval***	***Transmission frequency***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***
		2222	77778						continue		
720	Baška Voda	43.35666667	16.95	5	precipitation	daily	monthly	manual	1952 - continue	1991/01 - continue	digital, paper
725	Kotišina	43.28972222	17.04583333	273	precipitation	daily	monthly	manual	1991/01 - continue	1991/01 - continue	digital
740	Podgora	43.23527778	17.07972222	46	precipitation	daily	monthly	manual	1952/07 - continue	1952/07 - continue	digital
380	Zaostrog	43.14	17.27777778	17	precipitation	daily	monthly	manual	1952/07 - continue	1952/07 - continue	digital
370	Gradac	43.10527778	17.34055556	10	precipitation	daily	monthly	manual	1952 - continue	1991/01 - continue	digital, paper
325	Trpanj	43.00861111	17.26694444	2	precipitation	daily	monthly	manual	1951/10 - continue	1951/10-1987/09, 1994/08-2019	digital
330	Janjina	42.91694444	17.43166667	140	precipitation	daily	monthly	manual	1940/02 - continue	1940/02-1944/07, 1951/11-1972/12, 1974/01-2019	digital
331	Žuljana	42.89166667	17.45583333	7	precipitation	daily	monthly	manual	2010/06 - continue	2010/06 - continue	digital

Hungary

Hydrometric and meteorological stations network of the Marcal river basin, proposed by Hungary for the SEE-MHEWS-A Project

Station name	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt. of zero readin g, m abs***	***Elements***	***Sampl ing interv al, hr***	***Trans missio n freque ncy, hr***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***
Karakó	Torna-patak	47.1204 9591	17.2080 3221	127.69	water level, discharge	0.25	4.00	Pressure level + temperature sensor, GPRS	1951/01 - continue	1952/01 - continue	digital
Apácatorna	Torna-patak	47.1163 8638	17.2900 6904	135.62	water level, discharge	0.25	1.00	Pressure level + temperature sensor, GPRS	1970/11 - continue	1970/11 - continue	digital
Kolontár	Torna-patak	47.0889 946	17.4766 5823	183.00	water level, discharge	0.25	1.00	Pressure level + temperature sensor, GPRS	1977/05 - continue	1978/01 - continue	digital
Városlőd	Torna-patak	47.1497 0011	17.6553 5107	295.28	water level, discharge	0.25	1.00	Pressure level + temperature sensor, GPRS	1990/11 - continue	1991/01 - continue	digital
Veszprémgalsa	Kígyós-patak	47.0956 8118	17.3201 2026	133.52	water level, discharge	0.25	1.00	Pressure level + temperature sensor, GPRS	1970/11 - continue	1983/01 - continue	digital
Székpusztai-tározó	Csigere-patak	47.1375 4668	17.4682 9186	180.33	water level	168.00	744.00	staff gauge	1979/03 - continue	1979/03 - continue	paper
Nemesszalók	Hajagos-patak	47.2729 2103	17.3060 6001	127.77	water level, discharge	0.25	1.00	Pressure level + temperature sensor, GPRS	1985/09 - continue	1985/01 - continue	digital
Mihályháza	Bitva-patak	47.3094 3241	17.3517 1962	124.88	water level, discharge	0.25	1.00	Pressure level + temperature sensor, GPRS	1963/05 - continue	1963/06 - continue	digital
Pápa	Pápai-Bakonyér	47.3249 7648	17.4866 9576	143.00	water level, discharge	0.25	1.00	Pressure level + temperature sensor, GPRS	1968/03 - continue	1970/11 - continue	digital
Nagyteveli-tározó	Pápai-Bakonyér	47.2803 3839	17.5868 9801	207.22	water level	168.00	744.00	staff gauge	1981/09 - continue	1981/09 - continue	paper

Station name	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt. of zero reading, m abs***	***Elements***	***Sampling interval, hr***	***Transmission frequency, hr***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***
Nagytevel	Pápai-Bakonyér	47.28236732	17.584436	142.50	water level	168.00	744.00	staff gauge	1981/09 - continue	1981/09 - continue	paper
Takácsi	Gerence-patak	47.40470599	17.46880457	125.66	water level, discharge	0.25	1.00	Pressure level + temperature sensor, GPRS	1957/07 - continue	1958/01 - continue	digital
Apácatorna	-	47.11694264	17.28937847	139.00	precipitation	24.00	744.00	Hellmann Rain Gauge	1966/12 - continue	1970/12 - continue	paper
Devecser	-	47.11203876	17.43283014	169.00	precipitation, temperature, humidity	1.00	1.00	Weighing Rain Gauge, digital sensor measures the relative humidity and temperature, GPRS	1980/02 - continue	1970/05 - continue	digital
Farkasgyepű	-	47.21485387	17.62080795	387.00	precipitation, temperature, moisture, pan evaporation	0.17	0.17	Weighing Rain and evaporation Gauge, digital sensor measures the relative humidity and temperature, GPRS	1962/12 - continue	2002/01 - continue	digital
Karakó (000350)	Marcal	47.11974	17.20366	126,000 m Bf	level	12			1951/09 - continue	1951/09 - continue	digital
						0.25		RVM-3	1983/01 - continue		digital
					discharge	0.25				1998/01 - continue	digital

Station name	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt. of zero reading, m abs***	***Elements***	***Sampling interval, hr***	***Transmission frequency, hr***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***
Mersevát (160082)	Marcal	47.28933	17.21243	120,097 mBF	level	12			1952/02-1967/12	1952/02-1967/12	digital
						0.25		DA-S-LTRB 122	2007/01 - continue	2007/01 - continue	digital
					discharge	0.25			2007/01 - continue	2007/01 - continue	digital
Karakó (006885)	-	47.11970	17.20349	132,000 mBf	precipitation	0.25		OTT Pluvio	2014/01 - continue	2014/07 - continue	digital
Celldömölk (166008)	-	47.26051	17.14720	136,000 mBf	precipitation	24		Hellmann	1992/01 - continue	1992/01 - continue	digital
Mórichida	Marcal	47.51825922	17.41172429	113.000	water level, discharge, temperature	1	1	Pressure level + temperature sensor	1930/01 - continue	1930/01 - continue	digital
Rábaszentmiklós	Marcal	47.54129643	17.41466556	112.300	water level, discharge	1	1	Pressure level	1970/01 - continue	1970/01 - continue	digital
Gyirmót (szivattyútelep külvíz)	Marcal	47.6253331	17.5247006	109.070	water level	1	1	Pressure level	1981/01 - continue	1981/01 - continue	digital
Koroncó	Marcal	47.61002624	17.51484517	109.090	water level	24	24	staff gauge	1990/01 - continue	1990/01 - continue	digital + paper
Holt-Marcal beeresztő zsilip külvíz	Marcal	47.63102567	17.530047	107.500	water level	1	1	Pressure level	2006/01 - continue	2006/01 - continue	digital

Jordan

Meteorological stations network of the Jordan river basin, proposed by Jordan for the SEE-MHEWS-A Project

Index	***Station name***	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt. of zero reading, m abs***	***Elements***	***Sampling interval***	***Transmission frequency***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***
40257	Ras Muneeef	Jordan River	32.380	35.812	1150	most elements	6h (classic), hourly (aws)	hourly	classic, aws	2017/05-till now(aws), 1977/01 till now (classic)	evaluable from 1977/01 till now (classic)	xls
……..	Hussien Garden	Zarqa River	31.987	35.826	1000	most elements	hourly (aws)	hourly	aws	2017/05-till now(aws)	not evaluable yet	xls
……..	Quiesmeh	Zarqa River	31.926	35.953	906	most elements	hourly (aws)	hourly	aws	2017/05-till now(aws)	not evaluable yet	xls
……..	Downtown	Zarqa River	31.945	35.925	770	most elements	hourly (aws)	hourly	aws	2017/05-till now(aws)	not evaluable yet	xls
40268	Salt	Zarqa River	32.040	35.744	935	most elements	6h (classic), hourly (aws)	hourly	classic, aws	2017/05-till now(aws), 1992/01 till now (classic)	evaluable from 1992/01 till now (classic)	xls
40273	Zarqa	Zarqa River	32.085	36.083	644	most elements	6h (classic), hourly (aws)	hourly	classic, aws	2017/05-till now(aws), 2002/01 till now (classic)	evaluable from 2002/01 till now (classic)	xls
40244	Ghabawi	Zarqa River	32.002	36.215	721	most elements	hourly (classic&aws)	hourly	classic, aws	2017/05-till now(aws), 2004/04 till now (classic)	evaluable from 2004/04 till now (classic)	xls

Index	***Station name***	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt. of zero reading, m abs***	***Elements***	***Sampling interval***	***Transmission frequency***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***
40256	Mafraq	Zarqa River	32.351	36.256	686	most elements	hourly (classic&aws)	hourly	classic, aws	2017/05-till now(aws), 1953/01 till now (classic)	evaluable from 1953/01 till now (classic)	xls
40270	Amman Civil Airport (Manned& AWS)	Zarqa River	31.968	35.985	780	most elements	hourly (classic&aws)	hourly	classic, aws	2017/05-till now(aws), 1923/01 till now (classic)	evaluable from 1923/01 till now (classic)	xls
40253	Baqura	Jordan River	32.623	35.611	-170	most elements	6h (classic), hourly (aws)	hourly	classic, aws	2017/05-till now(aws), 1977/01 till now (classic)	evaluable from 1965/01 till now (classic)	xls
40285	Dier alla	Jordan River	32.202	35.620	-224	most elements	6h (classic), hourly (aws)	hourly	classic, aws	2017/05-till now(aws), 1965/01 till now (classic)	evaluable from 1952/01 till now (classic)	xls
40255	Irbid	Jordan River	32.534	35.855	616	most elements	6h (classic), hourly (aws)	hourly	classic, aws	2017/05-till now(aws)	evaluable from 1955/01 till now (classic)	xls
40267	Dhulail	Zarqa River	32.166	36.295	580	most elements	6h (classic), hourly (aws)	hourly	classic, aws	2017/05-till now(aws)	evaluable from 1968/01 till now (classic)	xls

Moldova

Hydrometric stations network of the Prut river basin, proposed by Moldova for the SEE-MHEWS-A Project

Index	***Station name***	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt. of zero reading, m abs***	***Elements***	***Sampling interval, hr***	***Transmission frequency, hr***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***
33664	Briceni		48 22	27 06	261							
33678	Soroca	Nistru	48 10	28 15	172	Levels		3h	Water Level Recorder, Sensor			digital
33745	Balți		47 46	27 53	156	Levels, river flow (Q)		3h	Water Level Recorder, Sensor			digital
33744	Fălești		47 35	27 42	162							
33749	Bravicea		47 22	28 26	78							
33748	Cornești		47 22	27 59	232							
33810	Codrii		47 07	28 22	152							
33824	Bălțata		47 03	29 02	79							
33815	Chișinău	Bic	46 58	28 51	168	Levels, river flow (Q)	12h	-	staff gage			paper
33881	Leova	Prut	46 29	28 17	158	Levels	12h	-	staff gage			paper
33892	Ștefan-Vodă	Nistru	46 32	29 39	173	Levels, river flow (Q)	12h	3h	Water Level Recorder,Sensor			digital/paper
33883	Comrat		46 18	28 38	133							
33886	Ceadîr-Lunga	Prut	46 04	28 50	65							

33885	Cahul	Prut	45 54	28 13	110	Levels, river flow (Q)		-	Water Level Recorder,Sensor			digital
33679	Camenca	Nistru	48 02	28 42	154	Levels	12h	-	staff gage			paper
33754	Rîbnița	Nistru	47 46	29 01	119	Levels	12h	-	staff gage			paper
33821	Dubasari	Nistru	47 17	29 08	40	Levels	12h	-	staff gage			paper
33829	Tiraspol	Nistru	46 54	29 36	40							

Weather stations network of the Prut river basin, proposed by Moldova for the SEE-MHEWS-A Project

Index	***Station name***	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt. of meteo site, m. abs***	***Elements***	***Sampling interval***	***Transmission frequency***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***
33664	Briceni		48 22	27 06	261	T, R, H, P, W, S, Sn, Ts, C, V	SYNOP - 00,03,06, 09,12,15, 18 UTC	3h	Meteorological observation - automatic + classic	Meteo data: 1944-2018	Meteo data: 1944-2018	Meteo data: digital
33678	Soroca	Nistru	48 10	28 15	172	Levels; T, R, H, P, W, S, Sn, Ts, C, V	SYNOP - 00,03,06, 09,12,15, 18 UTC	3h	Water Level Recorder,Sensor Meteorological observation - automatic + classic	Meteo data: 1945-2018	Meteo data: 1945-2018	digital
33745	Balți		47 46	27 53	156	Levels, river flow (Q); T, R, H, P, W, S, Sn, Ts, C, V	SYNOP - 00,03,06, 09,12,15, 18 UTC	3h	Water Level Recorder,Sensor Meteorological observation - automatic + classic	Meteo data: 1945-2018	Meteo data: 1945-2018	digital
33744	Fălești		47 35	27 42	162	T, R, H, P, W, S, Sn, Ts, C, V	SYNOP - 00,03,06, 09,12,15, 18 UTC	3h	Meteorological observation - automatic + classic	Meteo data: 1957-2018	Meteo data: 1957-2018	Meteo data: digital

33749	Bravicea		47 22	28 26	78	T, R, H, P, W, S, Sn, Ts, C, V	SYNOP - 00,03,06, 09,12,15, 18 UTC	3h	Meteorological observation - automatic + classic	Meteo data: 1952-2018	Meteo data: 1952-2018	Meteo data: digital
33748	Cornești		47 22	27 59	232	T, R, H, P, W, S, Sn, Ts, C, V	SYNOP - 00,03,06, 09,12,15, 18 UTC	3h	Meteorological observation - automatic + classic	Meteo data: 1945-2018	Meteo data: 1945-2018	Meteo data: digital
33810	Codrii		47 07	28 22	152	T, R, H, P, W, S, Sn, Ts, C, V	SYNOP - 00,03,06, 09,12,15, 18 UTC	3h	Meteorological observation - automatic + classic	Meteo data: 1996-2018	Meteo data: 1996-2018	Meteo data: digital
33824	Bălțata		47 03	29 02	79	T, R, H, P, W, S, Sn, Ts, C, V	00,03,06, 09,12,15, 18 UTC	3h	Meteorological observation - automatic + classic	Meteo data: 1954-2018	Meteo data: 1954-2018	Meteo data: digital
33815	Chișinău	Bic	46 58	28 51	168	Levels, river flow (Q); T, R, H, P, W, S, Sn, Ts, C, V	12h, SYNOP - 00,03,06, 09,12,15, 18 UTC	3h	staff gage; Meteorological observation - automatic + classic	Meteo data: 1945-2018	Meteo data: 1945-2018	Hidro: paper; Meteo data: digital
33881	Leova	Prut	46 29	28 17	158	Levels; T, R, H, P, W, S, Sn, Ts, C, V	12h, SYNOP - 00,03,06, 09,12,15, 18 UTC	3h	staff gage; Meteorological observation - automatic + classic	Meteo data: 1949-2018	Meteo data: 1949-2018	Hidro: paper; Meteo data: digital
33892	Ștefan-Vodă	Nistru	46 32	29 39	173	Levels, river flow (Q); T, R, H, P, W, S, Sn, Ts, C, V	12h, SYNOP - 00,03,06, 09,12,15, 18 UTC	3h	Water Level Recorder,Sensor Meteorological observation - automatic + classic	Meteo data: 1981-2018	Meteo data: 1981-2018	digital/paper

33883	Comrat		46 18	28 38	133	T, R, H, P, W, S, Sn, Ts, C, V	12h, SYNOP - 00,03,06, 09,12,15, 18 UTC	3h	Meteorological observation - automatic + classic	Meteo data: 1945-2018	Meteo data: 1945-2018	Meteo data: digital
33886	Ceadîr-Lunga	Prut	46 04	28 50	65	T, R, H, P, W, S, Sn, Ts, C, V	12h, SYNOP - 00,03,06, 09,12,15, 18 UTC	3h	Meteorological observation - automatic + classic	Meteo data: 1974-2018	Meteo data: 1974-2018	Meteo data: digital
33885	Cahul	Prut	45 54	28 13	110	Levels, river flow (Q); T, R, H, P, W, S, Sn, Ts, C, V	12h, SYNOP - 00,03,06, 09,12,15, 18 UTC	3h	Water Level Recorder,Sensor Meteorological observation - automatic + classic	Meteo data: 1947-2018	Meteo data: 1947-2018	digital
33679	Camenca	Nistru	48 02	28 42	154	Levels; T, R, H, P, W, S, Sn, Ts, C, V	12h, SYNOP - 00,03,06, 09,12,15, 18 UTC	3h	staff gage; Meteorological observation - automatic + classic	Meteo data: 1950-2018	Meteo data: 1950-2018	Hidro: paper; Meteo data: digital
33754	Rîbnița	Nistru	47 46	29 01	119	Levels; T, R, H, P, W, S, Sn, Ts, C, V	12h, SYNOP - 00,03,06, 09,12,15, 18 UTC	3h	staff gage; Meteorological observation - automatic + classic	Meteo data: 1963-2018	Meteo data: 1963-2018	Hidro: paper; Meteo data: digital
33821	Dubasari	Nistru	47 17	29 08	40	Levels; T, R, H, P, W, S, Sn, Ts, C, V	12h, SYNOP - 00,03,06, 09,12,15, 18 UTC	3h	staff gage; Meteorological observation - automatic + classic	Meteo data: 1957-2018	Meteo data: 1957-2018	Hidro: paper; Meteo data: digital
33829	Tiraspol	Nistru	46 54	29 36	40	T, R, H, P, W, S, Sn, Ts, C, V	SYNOP - 00,03,06, 09,12,15, 18 UTC	3h	Meteorological observation - automatic + classic	Meteo data: 1945-2018	Meteo data: 1945-2018	Meteo data: digital

Montenegro

Hydrometric stations network proposed by Montenegro for the SEE-MHEWS-A Project

Index	***Station name***	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt. of zero reading, m abs***	***Elements***	***Sampling interval, hr***	***Transmission frequency, hr***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***
45823	Plav	Lim	42.608167	19.927339	597.00	water level	15 min	1 hr	radar (OTT)	1948-today	2017/12-today	digital
45824	Andrijevica	Lim	42.731392	19.799736	972.00	water level, temperature	15 min	1 hr	pressure sensor (OTT)	1948-2004, 2018/12-today	2017/12-today	digital
45827	Berane	Lim	42.866653	19.872042	658.05	water level, temperature	15 min	1 hr	pressure sensor (OTT)	1966-2003	-	digital
45834	Dobrakovo	Lim	43.134958	19.775511	531.61	water level, temperature	15 min	1 hr	pressure sensor (OTT)	1961-1995, 2016/01-today	2016/01-today	digital
45826	Andrijevica	Zlorečica	42.723664	19.792481	742.00	water level, temperature	15 min	1 hr	pressure sensor (OTT)	1985-2005, 2008/10-today	2008/10-today	digital
45975	Đurđevića Tara	Tara	43.144692	19.297489	840.00	water level, temperature	15 min	1 hr	pressure sensor (OTT)	1955-2003, 2018/12-today	2018/12-today	digital
45983	Šćepan Polje	Tara	43.353831	18.866872	-	water level, temperature	15 min	1 hr	pressure sensor (OTT)	1949-1978, 2018/11-today	2018/11-today	digital

45991	Šavnik	Pridvorica	42.956836	19.066967	820.00	water level, temperature	15 min	1 hr	pressure sensor (OTT)	1949-1987, 2018/12-today	2018/12-today	digital
45993	Duži	Komarnica	42.973022	19.022181	760.00	water level, temperature	15 min	1 hr	pressure sensor (OTT)	1957-1996, 2018/12-today	2018/12-today	digital
45803	Ćirovići	Ćehotina	43.246461	19.430319	695.00	water level, temperature	15 min	1 hr	pressure sensor (OTT)	1978-2004, 2018/12-today	2018/12-today	digital
45967	Mojkovac	Tara	42.956569	19.576997	865.00	water level	15 min	1 hr	radar (OTT)	2018/12-today	2018/12-today	digital
45831	Ravna Rijeka	Ljuboviđa	42.989356	19.738153	255.00	water level, temperature	15 min	1 hr	pressure sensor (OTT)	1948-today	2008/08-today	digital
47207	Bać	Ibar	42.901416	20.31169	810.00	water level, temperature	15 min	1 day	pressure sensor (OTT)	1978-1993, 2017/08-today	2017/08-today	digital
60080	Ckla	Skadar Lake	42.112947	19.296625	4.86	water level, temperature	15 min	1 day	pressure sensor (OTT)	1950-2000, 2008/01-today	2008/01-today	digital
45954	Crna Poljana	Tara	42.774972	19.543703	965.80	water level	15 min	1 day	thalimedes (OTT)	1957-today	2008/10-today	digital
60155	Danilovgrad	Zeta	42.553925	19.106281	33.30	water level, temperature	15 min	1 hr	pressure sensor (OTT)	1948-today	2014/11-today	digital
60055	Donja Plavnica	Skadar Lake	42.271994	19.202956	4.56	water level, temperature	15 min	1 hr	pressure sensor (OTT)	1948-today	2006/12-today	digital

45821	Donje Vusanje	Grlja	42.526164	19.838006	-	water level	15 min	1 day	thalimedes (OTT)	1959-2001, 2008/01-today	2008/01-today	digital
60135	Duklov Most	Zeta	42.793169	18.934186	615.20	water level	15 min	1 day	thalimedes (OTT)	1955-today	2006/02-today	digital
60010	Fraskanje I	Bojana	41.969381	19.383653	-0.07	water level, temperature	15 min	1 day	pressure sensor (OTT)	1960-today	2005/12-today	digital
45987	Gornja Bijela	Bijela	42.903953	19.151739	-	water level	15 min	1 day	thalimedes (OTT)	2006-today	2008/12-today	digital
45833	Gubavač	Bistrica	43.101492	19.793567	-	water level, temperature	15 min	1 day	thalimedes (OTT)	1949-2000, 2008/11-today	2008/11-today	digital
60113	Međurečje	Mrtvica	42.720325	19.367139	183.34	water level, temperature	15 min	1 day	thalimedes (OTT)	1948-today	2006/10-today	digital
45806	Pljevlja	Ćehotina	43.348281	19.348692	755.00	water level, temperature	15 min	1 day	thalimedes (OTT)	1948-2008/03, 2008/10-2010/30, 2015/09-today	2008/10-2010/03, 2015/09-today	digital
45807	Gradac	Ćehotina	43.391914	19.148822	665.00	water level, temperature	15 min	1 day	pressure sensor (OTT)	1963-2004, 2015-today	2015/09-today	digital
60115	Pernica	Morača	42.712872	19.371047	178.72	water level, temperature	15 min	1 hr	pressure sensor (OTT)	1948-today	2014/03-today	digital
60160	Podgorica	Morača	42.453244	19.261875	24.60	water level, temperature	15 min	1 hr	pressure sensor (OTT)	1948-today	2005/06-today	digital

60061	Brodska Njiva	Rijeka Crnojevića	42.356817	19.012353	8.32	water level, temperature	15 min	1 day	pressure sensor (OTT)	1987-today	2008/10-today	digital
47205	Rožaje	Ibar	42.831689	20.144269	1035.74	water level, temperature	15 min	1 day	thalimedes (OTT)	1968-2003, 2016/12-today	2016/12-today	digital
45986	Timar	Bukovica	42.961008	19.186597	-	water level, temperature	15 min	1 day	thalimedes (OTT)	2006-today	2006-today	digital
45960	Trebaljevo	Tara	42.860411	19.524672	894.08	water level, temperature	15 min	1 day	thalimedes (OTT)	1959-today	2008/09-today	digital
60060	Vranjina	Skadar Lake	42.268	19.113114	-	water level, temperature	15 min	1 hr	pressure sensor (OTT)	1965-2000, 2014/05-today	2014/05-today	digital
60128	Zlatica	Morača	42.483836	19.306853	59.00	water level, temperature	15 min	1 hr	pressure sensor (OTT)	1983-today	2014/04-today	digital
45832	Bijelo Polje	Lim	43.031883	19.746975	246.00	water level	15 min	1 day	thalimedes (OTT)	1948-today	2007/03-today	digital
177760	Bar mareo	Adriatic Sea	42.423333	19.075	-	water level	15 min	1 day	thalimedes (OTT)	2007/03-today	2007/03-today	digital
202	Budva mareo	Adriatic Sea	42.28	18.84	-	water level, temperature	15 min	1 day	pressure sensor (OTT)	2013/09-2017/04	2013/09-2017/04	digital
201	Kotor mareo	Adriatic Sea	42.423333	18.77	-	water level	15 min	1 day	thalimedes (OTT)	2010/05-today	2010/05-today	digital

777	Rose mareo	Adriatic Sea			-	water level, temperature	15 min	1 day	pressure sensor (OTT)	2014/04-2019/02	2014/04-201902	digital

Weather stations network proposed by Montenegro for the SEE-MHEWS-A Project

Index	***Station name***	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt. of meteo site, m. abs***	***Elements***	***Sampling interval***	***Transmission frequency***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***
13461	Bar	Adriatic sea	42.100	19.083	6.00	precipitation, temperature	10 min	1 hr	Lambrecht	1949-today	1949-today	digital
13455	Herceg Novi	Adriatic sea	42.100	18.550	37.00	precipitation, temperature	10 min	1 hr	Lambrecht	1948-today	1948-today	digital
13708	Bijelo Polje	Lim	43.033	19.733	606.00	precipitation, temperature	10 min	1 hr	Lambrecht	1950-today	1950-today	digital
13465	Kolašin	Tara	42.833	19.517	944	precipitation, temperature	10 min	1 hr	Lambrecht	1948-today	1948-today	digital
13459	Nikšić	Zeta	42.767	18.950	647	precipitation, temperature	10 min	1 hr	Lambrecht	1947-today	1947-today	digital
13363	Pljevlja	Ćehotina	43.350	19.350	784	precipitation, temperature	10 min	1 hr	Lambrecht	1948-today	1948-today	digital

13463	Podgorica	Skadar lake	42.433	19.283	49	precipitation, temperature	10 min	1 hr	Lambrecht	1948-today	1948-today	digital
13464	Ulcinj	Adriatic sea	41.917	19.217	29	precipitation, temperature	10 min	1 hr	Lambrecht	1946-today	1946-today	digital
13361	Žabljak	Tara	43.150	19.117	1450	precipitation, temperature	10 min	1 hr	Lambrecht	1949-today	1949-today	digital
13360	Cetinje	Skadar lake	42.383	18.917	640	precipitation, temperature	10 min	1 hr	Lambrecht	1958-today	1958-today	digital
13462	Golubovci	Skadar lake	42.367	19.250	33	precipitation, temperature	10 min	1 hr	Lambrecht	1946-today	1946-today	digital
13457	Tivat	Adriatic sea	42.417	18.717	5	precipitation, temperature	10 min	1 hr	Lambrecht	1976-today	1976-today	digital
13710	Andrijevica	Lim	42.733	19.783	772	precipitation, temperature	7,14,21hr	7,14 hr	conventional	1957-today	1957-today	digital
13467	Berane	Lim	42.850	19.883	691	precipitation, temperature	7,14,21hr	7,14 hr	conventional	2004-today	2004-today	digital
13458	Budva	Adriatic sea	42.283	18.833	2	precipitation, temperature	7,14,21hr	monthly	conventional	1950-today	1950-today	digital

	Crkvice	Adriatic sea	42.567	18.633	937	precipitation, temperature	7,14,21hr	monthly	conventional	1949-today	1949-today	digital
	Grahovo	Adriatic sea	42.650	18.667	695	precipitation, temperature	7,14,21hr	monthly	conventional	1952-today	1952-today	digital
	Krstac	Adriatic sea	43.000	18.700	1017	precipitation, temperature	7,14,21hr	monthly	conventional	1953-today	1953-today	digital
13703	Plav	Lim	42.600	19.950	933	precipitation, temperature	7,14,21hr	7,14 hr	conventional	1954-today	1954-today	digital
13704	Rožaje	Ibar	42.850	20.167	1007	precipitation, temperature	7,14,21hr	7,14 hr	conventional	1966-today	1966-today	digital
13706	Šavnik	Piva	42.950	19.100	825	precipitation, temperature	7,14,21hr	7,14 hr	conventional	1968-today	1968-today	digital
13707	Plužine	Piva	43.150	18.850	780	precipitation, temperature	7,14,21hr	7,14 hr	conventional	1999-today	1999-today	digital
	Velimlje	Trebišnica	42.817	18.633	833	precipitation	7 hr	monthly	conventional	1999-today	1999-today	digital
	Virpazar	Skadar lake	42.233	19.083	14	precipitation	7 hr	monthly	conventional	1954-today	1954-today	digital
	Župa	Zeta	42.733	19.117	789	precipitation, temperature	7,14,21hr	7,14,hr	conventional	1951-today	1951-today	digital

	Boan	Piva	42.933	19.217	1000	precipitati on	7 hr	monthl y	conventional	2005-today	2005-today	digital
	Čevo	Zeta	42.533	18.917	760	precipitati on	7 hr	monthl y	conventional	1948-today	1948-today	digital
	Gradac	Ćehoti na	43.400	19.167	700	precipitati on	7 hr	monthl y	conventional	1952-today	1952-today	digital
	Jasenovo Polje	Zeta	42.883	18.933	940	precipitati on	7 hr	monthl y	conventional	1956-today	1956-today	digital
	Kovačica	Skadar lake	42.483	19.550	944	precipitati on	7 hr	monthl y	conventional	1949-today	1949-today	digital
	Kovren	Lim	43.183	19.567	1050	precipitati on	7 hr	monthl y	conventional	2009-today	2009-today	digital
	Lukovo	Zeta	42.800	19.033	840	precipitati on	7 hr	monthl y	conventional	1946-today	1946-today	digital
	Mateševo	Lim	42.767	19.567	990	precipitati on	7 hr	monthl y	conventional	1954-today	1954-today	digital
	Mišići	Adriati c sea	42.167	19.017	150	precipitati on	7 hr	monthl y	conventional	1948-today	1948-today	digital
	Njegovuđ a	Lim	43.117	19.233	1315	precipitati on	7 hr	monthl y	conventional	1946-today	1946-today	digital
	Orahovo	Skadar lake	42.483	19.467	875	precipitati on	7 hr	monthl y	conventional	1956-today	1956-today	digital
	Stabna	Tara	43.167	18.767	780	precipitati on	7 hr	monthl y	conventional	1958-today	1958-today	digital
	Štitarica	Tara	42.917	19.517	1050	precipitati on	7 hr	monthl y	conventional	1946-today	1946-today	digital
	Vraćenovi ći	Trebiš nica	42.833	18.517	1010	precipitati on	7 hr	monthl y	conventional	1956-today	1956-today	digital

Hydrometric stations network of the Vardar river basin, proposed by North Macedonia for the SEE-MHEWS-A Project

Index	***Station name***	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt. of zero reading, m abs***	***Elements***	***Sampling interval, hr***	***Transmission frequency, hr***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***
63010	Vrutok	Vardar	41° 45’ 53”	20° 50’ 32”								
63015	Raven	Vardar	41° 46’ 40”	20° 51’ 49”								
63020	Balin Dol	Vardar	41° 47’ 29”	20° 56’ 54”								
63025	Sarakinci	Vardar	41° 59’ 16”	21° 03’ 58”								
63030	Jegunovce	Vardar	42° 04’ 34”	21° 08’ 13”		H,Q,T	Daily+ 15min	4 hours	Automatic Station			
63035	Radusa	Vardar	42° 05’ 06”	21° 13’ 01”		H,Q	Daily+ 15min	1 per month/ 8 hours	Automatic Station			
63040	Vlae	Vardar	42° 00’ 12”	21° 22’ 59”		H,Q	Daily+ 2min	1 per month/ 3 month				
63050	Skopje(Zelezen Most)	Vardar	41° 59’ 41”	21° 26’ 50”		H,Q,T	Daily+ 2min	1 per day/3 month				
63055	Taor	Vardar	41° 53’ 48”	21° 36’ 57"		H,Q	Daily+ 2min	1 per month/ 3 month				
63060	Basino Selo	Vardar	41° 43’ 47”	21° 46’ 40"					Automatic Station			

63065	Veles	Vardar	41° 42’ 38”	21° 47’ 26”		H	Daily	1 per day				
63070	Nogaevci	Vardar	41° 37’ 30”	21° 54’ 22”		H,Q	Daily	1 per month	Automatic Station			
63080	Demir Kapija	Vardar	41° 24’ 17”	22° 16’ 01”		H,Q,T	Daily+ 2min	1 per day/3 month				
63090	Gevgelija	Vardar	41° 08’ 48”	22° 31’ 50”		H,Q	Daily	1 per month	Automatic Station			
63165	Vrutok	Dufska	41° 46' 23"	20° 51' 21"								
63175	Lakavica	Lakavica	41° 45’ 00”	20° 55’ 45”		H,Q	Daily+ 2min	1 per month				
63115	Tetovo	Pena	42° 01’ 13”	20° 57’ 22”		H,Q,T	15min	4 hours	Automatic Station			
63125	Tearce	Bistrica	42° 05’ 00”	21° 04’ 15”		H,Q,T	15min	8 hours	Automatic Station			
63501	Izvor	Treska	41° 28' 51"	20° 49' 43"		H,Q						
63504	Makedon ski Brod	Treska	41° 30’ 19”	21° 13’ 09”		H,Q,T	Daily+ 2min	1 per day/3 month				
63505	Modriste	Treska	41° 38’ 27”	21° 14’ 47”		H						
63508	Sv.Bogor odica	Treska	41° 57’ 47”	21° 18’ 18”		H,Q	Daily	1 per month	Automatic Station			
63525	Kicevo	Kicevska	41° 30’ 50”	20° 58’ 30”		H,Q						
63535	Samokov	Mala Reka	41° 40’ 47”	21° 08’ 55”		H,Q,T	Daily+ 2min	1 per month/ 3 month				
63575	Belica	Belicka	41° 40' 33"	21° 18' 33"								
63135	Blace	Lepenec	42° 05' 32"	21° 20' 23"								

63139	Vliv Lepenec	Lepenec	42° 01' 08"	21° 23' 09"		H,Q	Daily	1 per day				
63145	Pobozje	Poboska	42° 07' 54"	21° 25' 47"		H,Q	Daily	1 per month				
63601	Markov Manastir	Markova Reka	41° 53’ 27”	21° 24’ 12”								
63605	Krusa	Kadina	41° 48' 35"	21° 27' 20"								
63609	Smesnica	Kadina	41° 50’ 22”	21° 38’ 05”		H,Q						
63205	Pelince	Pcinja	42° 18’ 29”	21° 52’ 07”		H,Q,T	Daily+ 2min	1 per month/ 3 month	Automatic Station			
63208	Katlanovska Banja	Pcinja	41° 53’ 58”	21° 41’ 49”		H,Q,T						
63215	Zidilovo	Kriva Reka	42° 13' 25"	22° 23' 59"		H,Q						
63220	Kriva Palanka	Kriva Reka	42° 12’ 07”	22° 20’ 23”		H,Q,T	Daily+ 2min	1 per day/3 month				
63230	Trnovec	Kriva Reka	42° 08’ 07”	22° 06’ 30”								
63255	Glaznja	Lipkovska	42° 11' 45"	21° 31' 47"								
63265	Kumanovo	Lipkovska	42° 08’ 24”	21° 43’ 31”								
63275	Kumanovo	Konjarka	42° 09’ 16”	21° 43’ 21”								
63280	Dobrosane	Kumanovska	42° 05’ 35”	21° 46’ 40”		H,Q	Daily	1 per month				
63701	Drenovo	Topolka	41° 43’ 19”	21° 34’ 51”		H,Q	Daily	1 per month				
63702	Veles	Topolka	41° 42’ 07”	21° 47’ 33”		H,Q	Daily	1 per month				

63707	Nezilovo	Babuna	41° 38' 48"	21° 27' 31"		H,Q	Daily	1 per month				
63708	Bogomila	Babuna	41° 35' 45”	21° 29' 03”		H,Q,T	Daily	1 per day				
63709	Babuna Stopanstvo	Babuna	41° 40' 40”	21° 48' 15”		H	Weekly	1 per month				
63302	Berovo	Bregalnica	41° 42' 13”	22° 51' 48”		H,Q,T	Daily	1 per day				
63303	Budinarci	Bregalnica	41° 46' 10”	22° 46' 05”		H,Q	Daily	1 per month				
63304	Oci Pale	Bregalnica	41° 58' 32”	22° 44' 15”		H,Q	Daily	1 per month				
63305	Istibanja	Bregalnica	41° 56' 53”	22° 32' 40”		H,Q	Daily	1 per month				
63306	Dolen Balvan	Bregalnica	41° 48' 12”	22° 12' 41”								
63307	Stip	Bregalnica	41° 43' 56”	22° 10' 52”		H,Q,T	Daily		Automatic Station			
63309	Ubogo	Bregalnica	41° 38' 25”	21° 57' 19”		H,Q	2 min	1 per 3 month	Automatic Station			
63365	Makedonska Kamenica	Kamenicka	41° 59' 29”	22° 35' 35”		H,Q	Daily					
63315	Laki	Osojnica	41° 48' 51”	22° 38' 40								
63375	Orizari	Orizarska	41° 55' 50”	22° 27' 17”		H,Q	2 min	1 per 3 month				
63385	Zletovo	Zletovska	42° 01' 07”	22° 15' 53”		H,Q	Daily					
63345	Gabrevci	Kriva Lakavica	41° 33' 06”	22° 23' 13”								
63395	Orel	Mavrovica	41° 57' 13”	21° 59' 20”								

63800	Zeleznec	Crna Reka	41° 19’ 34”	21° 03’ 45”		H,Q	Daily, 2 min	1 per month/ 3				
63801	Dolenci	Crna Reka	41° 18’ 19”	21° 06’ 00”		H,Q	Daily, 2 min	1 per month				
63802	Sveta	Crna Reka	41° 15’ 22”	21° 16’ 28”								
63803	Bucin	Crna Reka	41° 16’ 41”	21° 20’ 07”								
63805	Novaci	Crna Reka	41° 02’ 36”	21° 27’ 07”		H,Q	Daily	1 per day				
63806	Skocivir	Crna Reka	40° 58’ 08”	21° 38’ 29”		H,Q	2 min	1 per 3 month				
63807	Rasimbeg ov Most	Crna Reka	41° 11’ 46”	21° 43’ 10”		H,Q	Daily	1 per day				
63808	Vozarci	Crna Reka	41° 25’ 30”	21° 55’ 42”								
63855	Boiste	Boiska	41° 14’ 29”	21° 06’ 10”		H,Q	2 min	1 per 3 month				
63829	Borotino	Blato	41° 17’ 25”	21° 23’ 57”		H,Q	Daily	1 per month				
63865	Maloviste	Semnica	41° 02’ 44”	21° 08’ 10”		H,Q	Daily	1 per month				
63868	Bitola	Dragor	41° 01’ 50”	21° 20’ 23”								
63875	Germijan	Eleska	40° 56’ 57”	21° 32’ 53”								
63885	Smagovo	Buturica	41° 10’ 36”	21° 44’ 35”								
63895	Mrezicko	Blasnica	41° 12’ 26”	21° 59’ 47”								
63835	Drenovo	Raec	41° 25' 59"	21° 53' 13"								

63903	Konopiste (T.Zafat)	Bosava	41° 14’ 23”	22° 06’ 52”		H,Q	Daily/2 min	1 per month/ 3 month				
63905	Ciflik (Ergela)	Bosava	41° 22’ 37”	22° 12’ 45”								
63955	Ciflik	Dosnica	41° 23’ 05”	22° 13’ 38”								
63405	Basiboz	Anska	41° 18’ 26”	22° 41’ 24”		H,Q	Daily	1 per month				
63906	Kovanci	Kovanska	41° 12' 39"	22° 26' 35"								
63908	Gornicet	Konjska Reka	41° 09' 14"	22° 26' 03"		H,Q	Daily	1 per month				
63492	Nov Dojran	Ez. Dojran	41° 13’ 15”	22° 42’ 53”		H	Daily	1 per day				
63494	Star Dojran	Ez. Dojran	41° 11’ 25”	22° 43’ 35”								

Weather stations network of the Vardar river basin, proposed by North Macedonia for the SEE-MHEWS-A Project

Station name	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt. of meteo site, m. abs***	***Elements***	***Sampling interval***	***Transmission frequency***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***
Bogdanci	Vardar	22.5833	41.2	130	rain, snow	1/24 h	1/month	manual	1948/06 - continue	1990/01 - continue	digital
Bogomila	Vardar	21.4833	41.6	510	rain, snow	1/24 h	1/month	manual	1949/10 - continue	1990/01 - continue	digital
Bulachani	Vardar	21.5167	42.0667	510	rain, snow	1/24 h	1/month	manual	1947/11 - continue	1990/01 - continue	digital
Chashka	Vardar	21.6667	41.65	330	rain, snow	1/24 h	1/month	manual	1945/09 - continue	1990/01 - continue	digital
Creshevo	Vardar	21.51206	42.03741	273	rain, snow	1/24 h	1/month	manual	2011/05 - continue	2011/05 - continue	digital

Crnichani	Vardar	22.6667	41.2333	200	rain, snow	1/24 h	1/month	manual	1947/11 - continue	1990/01 - continue	digital
Dedeli	Vardar	22.6167	41.2833	180	rain, snow	1/24 h	1/month	manual	1951/07 - continue	1990/01 - continue	digital
Demir Kapija	Vardar	22.2972	41.4086	126.02	t, tmax, tmin, p, rh, wind, rain, snow, ground temp,clouds, sunshine duration	24/24 h	3 h	manual	1945/03 - continue	1990/01 - continue	digital
Gevgelija	Vardar	22.5025	41.1467	61.02	t, tmax, tmin, p, rh, wind, rain, snow, ground temp, clouds, sunshine duration, evaporations	24/24 h	3 h	manual	1949/08 - continue	1990/01 - continue	digital
Gjorche Petrov	Vardar	21.3667	42	262	t, rh, rain, snow	1/24 h	1/month	manual	1951/03 - continue	1990/01 - continue	digital
Gornjane	Vardar	21.3764	42.1108	631	rain, snow	1/24 h	1/month	manual	1955/01 - continue	1990/01 - continue	digital
Gradsko	Vardar	21.9667	41.5667	164	rain, snow	1/24 h	1/month	manual	1945/05 - continue	1990/01 - continue	digital
Gradsko	Vardar	21.945028	41.57216	197	t, tmax, tmin, p, rh, wind, rain, snow, ground temp,soil humidity, solar radiation	10 min	30 min	automatic	2017/11 - continue	2017/11 - continue	digital
Ivankovci	Vardar	21.8333	41.85	480	rain, snow	1/24 h	1/month	manual	1948/06 - continue	1990/01 - continue	digital
Jasen	Vardar	21.242388	41.82547	1423	t, rh, wind, rain	10 min	30 min	automatic	2013/01 - continue	2013/01 - continue	digital
Jasenovo	Vardar	21.72165	41.51767	367	t, rh, wind, rain	10 min	30 min	automatic	2016/01 - continue	2016/01 - continue	digital
Jazince	Vardar	21.1833	42.1667	830	rain, snow	10 min	30 min	manual	1947/11 - continue	1990/01 - continue	digital
Jazince	Vardar	21.175625	42.16136	784	t, rh, rain	10 min	30 min	automatic	2017/04 - continue	2017/04 - continue	digital
Kavadarci	Vardar	22.019722	41.44222	244	t, p, rh, wind, rain	10 min	30 min	automatic	2010/03 - continue	2015/11 - continue	digital
Korito	Vardar	21.0333	41.8	1420	rain, snow	1/24 h	1/month	manual	1954/11 - continue	1990/01 - continue	digital
Krivolak	Vardar	22.1189	41.5267	137	rain, snow	1/24 h	1/month	manual	1995/01 - continue	1990/01 - continue	digital

Lisice	Vardar	21.4692	41.9769	237	rain, snow	1/24 h	1/month	manual	1990/01 - continue	1990/01 - continue	digital
Nezilovo	Vardar	21.4667	41.65	680	rain, snow	1/24 h	1/month	manual	1945/05 - continue	1990/01 - continue	digital
Nogaevci	Vardar	21.9167	41.6333	160	rain, snow	1/24 h	1/month	manual	1947/07 - continue	1990/01 - continue	digital
Novo Selo/Gostivar	Vardar	20.86727	41.94187	1171	rain	10 min	30 min	automatic	2017/04 - continue	2017/04 - continue	digital
Organxali	Vardar	22.7167	41.3	440	rain, snow	1/24 h	1/month	manual	1947/11 - continue	1990/01 - continue	digital
Petrovo	Vardar	22.3833	41.3	340	rain, snow	1/24 h	1/month	manual	1947/11 - continue	1990/01 - continue	digital
Pirok	Vardar	20.9167	41.9167	525	rain, snow	1/24 h	1/month	manual	1947/12 - continue	1990/01 - continue	digital
Popova Shapka	Vardar	20.879009	42.01587	1784	t, tmax, tmin, p, rh, wind, rain, snow, sunshine duration	15/24 h	3 h	manual	1957/12-200103	1957/12 - continue	digital
Popova Shapka	Vardar	20.879009	42.01587	1784	t, tmax, tmin, p, rh, wind, rain, snow, solar radiation	10 min	30 min	automatic	2016/10 - continue	2016/10 - continue	digital
Pozar	Vardar	22.4381	41.4711	1030	t, tmax, tmin, p, rh, wind, rain, snow	15/24 h	3 h	automatic	1980/01-2016/10	1981/01 - continue	digital
Pozar	Vardar	22.4381	41.4711	1030	t, tmax, tmin, p, rh, wind, rain,	10 min	30 min	automatic	2013/04 - continue	2013/04 - continue	digital
Pozarane	Vardar	20.8706	41.8508	874.34	t, tmax, tmin, rh, wind, rain, snow	24/24 h MS	3 h	manual	1981/01 - continue	1981/01 - continue	digital
Pozarane	Vardar	20.8706	41.8508	874.34	t, tmax, tmin, p, rh, wind, rain,	10 min AWS	30 min	automatic	2015/08 - continue	2015/08 - continue	digital
Rashche	Vardar	21.25	42.0167	380	rain, snow	1/24 h	1/month	manual	1995/12 - continue	1990/01 - continue	digital
Rashtani	Vardar	21.7167	41.7333	380	rain, snow	1/24 h	1/month	manual	1952/06 - continue	1990/01 - continue	digital
Sermenin	Vardar	22.35	41.2167	580	rain, snow	1/24 h	1/month	manual	1956/01 - continue	1990/01 - continue	digital
Skopje/Gazi Baba	Vardar	21.464444	42.00741	256	t, tmax, tmin, p, rh, wind, rain	10 min	30 min	automatic	2016/02 - continue	2016/02 - continue	digital

Skopje/Karposh	Vardar	21.387044	42.00664	257	t, tmax, tmin, p, rh, wind, rain	10 min	30 min	automatic	2013/06 - continue	2013/06 - continue	digital
Skopje/Zajchev Rid	Vardar	21.399855	42.01661	301	t, tmax, tmin, p, rh, wind, rain, snow, gorund temp, clouds, sunshine duration, evaporations	24/24 h	3 h	manual	1978/01 - continue	1978/01 - continue	digital
Skopje/Zajchev Rid	Vardar	21.399855	42.01661	301	t, tmax, tmin, p, rh, wind, rain, solar radiation	10 min	30 min	automatic	2015/03 - continue	2015/03 - continue	digital
Smokvica	Vardar	22.4833	41.2667	95	rain, snow	1/24 h	1/month	manual	1948/06 - continue	1990/01 - continue	digital
Teovo	Vardar	21.5833	41.5833	380	rain, snow	1/24 h	1/month	manual	1951/08 - continue	1990/01 - continue	digital
Udovo	Vardar	22.4333	41.35	75	rain, snow	1/24 h	1/month	manual	1945/07 - continue	1990/01 - continue	digital
Valandovo	Vardar	22.556264	41.31505	109	t, tmax, tmin, p, rh, wind, rain, solar radiation	10 min	30 min	automatic	2012/10 - continue	2012/10 - continue	digital
Veles	Vardar	21.775278	41.71444	228	t, tmax, tmin, p, rh, wind, rain	10 min	30 min	manual	2015/04 - continue	2015/04 - continue	digital
Vojnica	Vardar	21.75	41.6	360	rain, snow	1/24 h	1/month	manual	1948/07 - continue	1990/01 - continue	digital
Tetovo	Vardar	20.965024	41.9861	453	t, tmax, tmin, p, rh, wind, rain, ground temp,sunshine duration	24/24 h	3 h	manual	2009/11 - continue	2009/11 - continue	digital
Tetovo	Vardar	20.965024	41.9861	453	t, tmax, tmin, p, rh, wind, rain, ground temp,solar radiation	10 min	30 min	automatic	2017/02 - continue	2017/02 - continue	digital

Ukraine

Hydrometric stations network of the Dniester river basin, proposed by Ukraine for the SEE-MHEWS-A Project

Index	***Station name***	***River***	***Lat., deg. north***	***Long., deg. east***	***Alt. of zero reading, m abs***	***Elements***	***Sampling interval, hr***	***Transmission frequency, hr***	***Equipment***	***Period of operation***	***Data series period***	***Format of data series***
81015	Strilky	Dniester	48º 19' 44''	22º 58' 42''	405.49	H,Q,P,t	12	24	manual	01.10.1907 - today	01.01.1985-31.12.2015	paper
81017	Sambir	Dniester	49º 30' 21''	23º 13' 16''	284.17	H,Q,P,t	12	24	manual	1850- today	01.01.1985-31.12.2015	paper
81028	Rozdil	Dniester	49º 26' 19''	24º 04' 12''	243.18	H,Q,P,t	12	24	manual	1878- today	01.01.1985-31.12.2015	paper
81030	Zhuravne	Dniester	49º 15' 31''	24º 17' 33''	231.52	H,Q,P,t	12	24	manual	1878- today	01.01.1985-31.12.2015	paper
81033	Halych	Dniester	49º 07' 35''	24º 43' 49''	211.26	H,Q,P,t	12	24	manual	1876- today	01.01.1985-31.12.2015	paper
81036	Nyzhniv	Dniester	48º 57' 40''	25º 06' 06''	190.36	H,P,t	12	24	manual	1850- today	01.01.1985-31.12.2015	paper
81041	Zalischyky	Dniester	48º 38' 03''	25º 44' 09''	140.69	H,Q,P,t	12	24	manual	1850- today	01.01.1985-31.12.2015	paper
81078	Khyriv	Strviazh	49º 31' 26''	22º 48' 40''	343.5	H,Q,P,t	12	24	manual	1897- today	01.01.1985-31.12.2015	paper
81080	Luky	Strviazh	49º 36' 42''	23º 23' 24''	263.31	H,Q,P,t	12	24	manual	1863- today	01.01.1985-31.12.2015	paper
81087	Ozymyna	Bystrytsia	49º 27' 52''	23º 23' 22''	274.35	H,Q,P,t	12	24	manual	1932- today	01.01.1985-31.12.2015	paper
81092	Drohobych	Tysmenytsia	49º 21' 44''	23º 34' 29''	267.56	H,Q,t	12	24	manual	1897- today	01.01.1985-31.12.2015	paper
81102	Matkiv	Stryi	48º 54' 45''	23º 07' 41''	656.71	H,Q,P,t	12	24	manual	11.11.1926- today	01.01.1985-31.12.2015	paper

81103	Zavadivka	Stryi	49º 08' 32''	23º 03' 56''	550.76	H,Q,P,t	12	24	manual	09.07.1961- today	01.01.1985- 31.12.2015	paper
81468	Iasenytsia	Stryi	49º 12' 19''	23º 09' 20''	518	H,Q,P,t	12	24	manual	01.08.1982- today	01.01.1985- 31.12.2015	paper
81108	Verkhnie Syniovyd ne	Stryi	49º 06' 29''	23º 36' 24''	369.62	H,Q,P,t	12	24	manual	1902- today	01.01.1985- 31.12.2015	paper
81109	Stryi	Stryi	49º 14' 31''	23º 51' 22''	291.3	H,P,t	12	24	manual	1866- today	01.01.1985- 31.12.2015	paper
81113	Turka	Iablunka	49º 09' 19''	23º 02' 33''	547.84	H,Q,P,t	12	24	manual	06.06.1929- today	01.01.1985- 31.12.2015	paper
81120	Skole	Opor	49º 01' 01''	23º 28' 37''	443.19	H,Q,P,t	12	24	manual	1913- today	01.01.1985- 31.12.2015	paper
81122	Slavske	Slavska	48º 10' 48''	23º 16' 07''	593.15	H,Q,P,t	12	24	manual	1926- today	01.01.1985- 31.12.2015	paper
81126	Tukhlia	Holovchanka	48º 54' 07''	23º 27' 50''	538.57	H,Q,P,t	12	24	manual	1926- today	01.01.1985- 31.12.2015	paper
81140	Myslivka	Svicha	48º 47' 36''	23º 46' 27''	643.3	H,Q,P,t	12	24	manual	19.07.1935- today	01.01.1985- 31.12.2015	paper
81147	Zarichne	Svicha	49º 10' 15''	24º 05' 12''	278.5	H,Q,P,t	12	24	manual	1887- today	01.01.1985- 31.12.2015	paper
81161	Osmoloda	Limnytsia	48º 38' 39''	24º 01' 06''	712.79	H,Q,P,t	12	24	manual	06.07.1950- today	01.01.1985- 31.12.2015	paper
81169	Perevozet s	Limnytsia	49º 04' 43''	24º 33' 09''	236.03	H,Q,P,t	12	24	manual	1904- today	01.01.1985- 31.12.2015	paper
81191	Pasichna	Bystrytsia Nadvirniansk a	48º 34' 18''	24º 24' 37''	531.81	H,Q,P,t	12	24	manual	25.03.1956- today	01.01.1985- 31.12.2015	paper
81471	Cherniiv	Bystrytsia Nadvirniansk a	48º 50' 53''	24º 41' 56''	272.6	H,Q,P,t	12	24	manual	20.09.1983- today	01.01.1985- 31.12.2015	paper
81197	Tysmenyt sia	Vorona	48º 54' 06''	24º 51' 07''	238.74	H,Q,P,t	12	24	manual	1910- today	01.01.1985- 31.12.2015	paper

81199	Huta	Bystrytsia Solotvynska	48º 38' 02''	24º 12' 33''	635.7	H,Q,P,t	12	24	manual	1911- today	01.01.1985-31.12.2015	paper
81203	Ivano-Frankivsk	Bystrytsia Solotvynska	48º 56' 14''	24º 42' 16''	237.15	H,Q,P,t	12	24	manual	1887- today	01.01.1985-31.12.2015	paper
81225	Chortkiv	Seret	49º 00' 31''	25º 47' 49''	208.85	H,Q,P,t	12	24	manual	1897- today	01.01.1985-31.12.2015	paper
81232	Volochysk	Zbruch	49º 31' 50''	26º 09' 31''	269.3	H,Q,P,t	12	24	manual	09.11.1944-today	01.01.1985-31.12.2015	paper
81244	Tsybulivka	Smotrych	48º 38' 55''	26º 35' 52''	130.91	H,Q,P	12	24	manual	10.08.1930-today	01.01.1985-31.12.2015	paper
81015	Strilky	Dniester	48º 19' 44''	22º 58' 42''	405.49	H,Q,P,t	12	24	manual	01.10.1907 -today	01.01.1985-31.12.2015	paper
81017	Sambir	Dniester	49º 30' 21''	23º 13' 16''	284.17	H,Q,P,t	12	24	manual	1850- today	01.01.1985-31.12.2015	paper

Meteorological stations network of the Dniester river basin, proposed by Ukraine for the SEE-MHEWS-A Project

Index	***Station name***	***River****	***Latitude, dec. deg***	***Longitude, dec. deg***	***Altitude***	***Meteo site**, m. abs***	***Elements***	***Observation/transmission frequency, hr***	***Equipment type***	***Time of operation: from … to … yyyymm***	***Data series evaluable from … to …, yyyymm***	***Format of data series*******
33391	Mostyska	Dniester	49º47′30″	23º09′48″	234,5	232	P, t, f, R,	3	manual	15.09.1950-31.05.1986 01.07.1986-31.12.2018	01.01.1985-31.12.2018	paper
33392	Yavoriv	Dniester	49º56′46″	23º22′29″	253,2	254	P, t, f, R,	3	manual	01.04.1948-31.12.1969 01.03.1970-31.12.2018	01.01.1985-31.12.2018	paper

33393	Lviv	Dniester	49º48′27″	23º57′55″	323	319	P, t, f, R,	3	manual	01.07.1940-31.12.2018 01.01.1945-31.12.2018	01.01.1985-31.12.2018	paper
33398	Drohobych	Dniester	49º21′44″	23º34′01″	277,2	275	P, t, f, R,	3	manual	01.01.1941-23.06.1941 01.10.1944-31.12.2018	01.01.1985-31.12.2018	paper
33409	Berezhany	Dniester	49º26′19″	24º56′11″	304,5	303	P, t, f, R,	3	manual	01.01.1941-31.05.1941 01.08.1944-31.08.1944 01.10.1944-31.12.2018	01.01.1985-31.12.2018	paper
33415	Ternopil	Dniester	49º31′40″	25º41′28″	329,2	327	P, t, f, R,	3	manual	01.01.1941-31.05.1941 01.05.1944-31.12.2018	01.01.1985-31.12.2018	paper
33511	Turka	Dniester	49º09′01″	23º01′47″	529,9	594	P, t, f, R,	3	manual	01.10.1945-31.12.2018	01.01.1985-31.12.2018	paper
33513	Stry	Dniester	49º15′28″	23º48′30″	305,9	302	P, t, f, R,	3	manual	01.01.1941-31.05.1941 01.11.1944-31.12.2018	01.01.1985-31.12.2018	paper

33516	Slavske	Dniester	48º50′31″	23º26′57″	593,9	592	P, t, f, R,	3	manual	20.04.1946-30.06.1984 01.08.1984-31.12.2018	01.01.1985-31.12.2018	paper
33524	Dolyna	Dniester	48º58′37″	23º59′52″	467,6	470	P, t, f, R,	3	manual	01.03.1940-30.06.1941 01.04.1945-31.12.2018	01.01.1985-31.12.2018	paper
33526	Ivano-Frankivsk	*Dniester*	48º53′22″	24º41′20″	279,8	275	P, t, f, R,	3	manual	01.01.1941-31.05.1941 01.09.1944-31.12.2018	01.01.1985-31.12.2018	paper
33536	Chortkiv	Dniester	49º00′53″	25º46′11″	318,3	320	P, t, f, R,	3	manual	01.01.1941-31.05.1941 01.06.1944-31.12.2018	01.01.1985-31.12.2018	paper
33557	Nova Ushicha	Dniester	48º50′35″	27º15′39″	290,4	292	P, t, f, R,	3	manual	01.01.1941-31.05.1941 01.08.1944-31.01.1992 01.03.1992-31.12.2018	01.01.1985-31.12.2018	paper
33645	Yaremcha	Dniester	48º27′10″	24º33′12″	531,3	531	P, t, f, R,	3	manual	01.06.1946-30.11.1947 01.01.1948-31.12.2018	01.01.1985-31.12.2018	paper

33646	Pozhezhevskaya	Dniester	48º09′14″	24º32′03″	1451,2	1451	P, t, f, R,	3	manual	01.07.1959-30.11.1990 01.01.1991-31.12.2018	01.01.1985-31.12.2018	paper
33662	Novodnistrovsk	Dniester	48º34′43″	27º26′14″	242,7	241	P, t, f, R,	3	manual	01.01.1985-31.12.2018	01.01.1985-31.12.2018	paper
33663	Mogilev-Podolsky	Dniester	48º27′08″	27º26′47″	78	77	P, t, f, R,	3	manual	01.02.1927-30.04.1927 01.10.1927-30.06.1928 01.06.1929-30.01.1930 01.07.1930-31.07.1930 01.01.1933-30.04.1935 01.01.1936-30.06.1941 01.06.1944-31.12.2018	01.01.1985-31.12.2018	paper

3354 8	Kam'yants'- Podil's'kyi	Dniester	48º41′3 6″	26º36′31″	218,6	217	P, t, f, R,	3	manual	01.04.1844- 30.11.1848 01.12.1865- 30.11.1868 01.11.1893- 31.07.1894 01.05.1895- 31.05.1904 01.07.1904- 31.07.1915 21.03.1916- 30.06.1916 01.04.1923- 31.05.1933 01.07.1933- 31.05.1941 01.05.1942- 30.11.1943 01.01.1944- 31.12.2018	01.01.198 5- 31.12.201 8	paper