Evaluation report on flood and ice forecasting systems and methodologies in the Danube countries

WP3 output 3.1

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List of Abbreviations

ANN	Artificial Neural Network
CAP	Common Alerting Protocol
CSI	Critical Success Index
DHI	Dansk Hydraulisk Institut
DLCM	Discrete Linear Cascade Model
DRB	Danube River Basin
FAR	False Alarm Ratio
FB	Frequency Bias
EFAS	European Flood Awareness System
EWS	Early Warning System
FFG	Flash Flood Guidance
FFWS	Flood Forecasting and Warning System
GIS	Geographic Information System
GRDC	Global Runoff Data Centre
GTS	Global Telecommunication System
HBV	Hydrologiska Byråns Vattenbalansavdelning
HEC-HMS	Hydrologic Engineering Center-Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center- River Analysis System
HIS	Hydrological Information System
HPP	Hydroelectric Power Plant
HR	Hit Rate
ICPDR	International Commission for the Protection of the Danube River
ISO	International Organization for Standardization
ISBA	Interactions between Soil, Biosphere, and Atmosphere

ISRBC	International Sava River Basin Commission
IT	Information Technology
JRC	Joint Research Centre
LARSIM	Large Area Runoff Simulation Model
LISFLOOD	Distributed Water Balance and Flood Simulation Model
NA	Not Available
NAM	Nedbor Afstromnings Model
NOAH	National Centers for Environmental Prediction, Oregon State University, Air Force, Hydrology Lab
NSE	Nash-Sutcliffe Efficiency
NWP	Numerical Weather Prediction
NWS	National Weather Service
PBIAS	Percent Bias
POD	Probability of Detection
R	Pearson correlation coefficient
RMSE	Root Mean Square Error
SAC-SMA	Sacramento Soil Moisture Accounting Model
SD	Standard Deviation
SMS	Short Message Service
SRB	Sava River Basin
TOPKAPI	TOPographic Kinematic APproximation and Integration
TOPMODEL	Topography-based hydrological model
SWAT	Soil & Water Assessment Tool
SWE	Snow Water Equivalent
USA	United States of America
WMO	World Meteorological Organization

Introduction

The Danube River crosses Central and South-eastern Europe and flows into the Black Sea with multi-annual mean discharge of 6,855 m^3/s. The Danube River Basin includes the territories of 19 countries (Figure 1). A total area of the basin is 801,463 km^2 with the length of the river 2,857 km.

Figure 1. The Danube River Basin (Source: ICPDR, https://www.icpdr.org/main/publications/maps-danube-river-basin-district-management-plan-2015)

Frequency of floods in the Danube River Basin increased in the last decades (e.g. major floods in 2002, 2005, 2006, 2009, 2010, 2013, and 2014), urging the need for a more effective and harmonized regional and cross-border cooperation in the field of flood and ice forecasting. Reliable and comprehensive hydrologic data are the basis of flood forecasting in any country of the Danube River Basin. None of the flood risk mitigation measures serves better the protection of human lives and the social estate than enhancing the preparation time to avoid catastrophes that could have been caused by unpredicted floods. The most cost-effective non-structural tangible solution, which highly reflects the solidarity principle, is the improvement of forecasting capabilities on basin-wide scale. Therefore, the strong cooperation between countries in the region is necessary.

The main aim of of DAREFFORT (Danube River Basin Enhanced Flood Forecasting Cooperation) project is to give a comprehensive overview about the complex national flood and ice forecasting systems and to eliminate the shortcomings of the existing forecasting practices as well as improve the exchange

and availability of hydrological and meteorological data between the participating countries with establishment of the Danube Hydrological Information System (Danube HIS). In order to achieve this goal, a detailed questionnaire was pripared in WP3. Information about the countries' hydrological and meteorological data availability, recording methods and coverage with the monitoring networks, codings and national database system, data flow, forecasting time intervals and accuracy, response times, cross-border issues and data dissemination etc was covered in the questionnaire.

The evaluation of questionnaires and country reports show an overall picture of 12 Danubian countries on flood and ice forecasting systems and methodologies, and JRC and ISRBC as good practices of cooperation.

DAREFFORT project partners are from 12 out of 19 countries covering almost the whole Danube region (Table 1). From non-participating countries only Bosnia and Herzegovina supported the project by completing the questionnaire. Bosnia and Herzegovina lies mostly within the Danube River Basin with a 4.6% share of the Danube Basin (source: https://www.icpdr.org/main/danube-basin/countries-danube-river-basin). The percentage of the Danube River Basin of other non-participating countries is almost negligible.

Table 1: Territories of the countries in the Danube River Basin (DRB), participating in the DAREFFORT project

Country	Total territory (km^2)	Territory in the DRB (km^2)	% of territory within the DRB	% of the entire DRB area
Austria	83,879*	80,423**	96,1**	10,0
Bulgaria	111,993*	47,235	42,5	5,0
Croatia	88,166	35,101	62,0	4,3
The Czech Republic	78,865	21,688**	24,0	3,0
Germany	357,000	56,184**	17,0	7,0
Hungary	93,030	93,030	100,0	11,7
Moldova	33,846	12,834**	35,6**	1,6
Romania	238,397	232,193**	97,4	30,0
Serbia	88,361	81,560**	92,3**	10,0
Slovakia	49,035	47,084**	96,0**	6,7
Slovenia	20,273	16,381	80,8	2,0
Ukraine	603,628	30,520**	5,4**	3,8

**Wikipedia, ** ICPDR, The Danube River Basin, Facts and Figures*

Country reports on the status quo of the Danube regional flood and ice forecasting system and methodologies were prepared by all partner countries. Additionally, two regional reports were prepared by Joint Research Centre (JRC) and International Sava River Basin Commission (ISRBC) Secretariat showing good practice of collaboration in the Danube region (JRC with EFAS system and ISRBC with Sava HIS system).

On the basis of 12 national and two regional reports a comprehensive overview about hydrological and meteorological monitoring and data as well as the flood and ice forecasting systems in the Danube region is presented in this document as one of the main outputs of WP3 of the DAREFFORT project.

1 General description and status of national (regional) hydrological and meteorological services

National hydrological and meteorological services are responsible for quantitative monitoring for the water cycle components, water resources evaluation and flood forecasting. They perform expert tasks related to monitoring of hydrological and meteorological processes, meteorological and hydrological forecasts; collection, processing and publishing of meteorological and hydrological data, maintenance of data bases; research activities related to atmosphere and water resources as well as different applications of meteorology and hydrology in the fields of climatology, marine meteorology, agrometeorology, aviation meteorology, spatial planning and designing, etc.

Important activities of hydrological and meteorological services are maintenance of monitoring systems and development of weather and hydrological forecasting models. One of the main responsibility of the hydrological services is provision of flood forecasting and warning.

The organizational structure of hydrological and meteorological services by countries of the Danube River Basin is different (Table 2). In most countries (Bulgaria, Croatia, The Czech Republic, Moldova, Serbia, Slovakia, Slovenia and Ukraine), the services are organized together, and in the remaining countries involved in the project, they are separated.. In Germany, the federal states are responsible for hydrological services and each federal state has its own organization and structure.

Table 2: Organizational structure of national hydrological and meteorological services in individual countries

Country	**Hydrological service**	**Meteorological service**
Austria	Hydrographical Central Office and Offices of the Provincial Governments, Federal Ministry of Sustainability and Tourism	Central Institute for Meteorology and Geodynamics (ZAMG)
Bulgaria	National Institute of Meteorology and Hydrology (NIMH), Ministry of Education and Science	National Institute of Meteorology and Hydrology (NIMH), Ministry of Education and Science
Croatia	Croatian Meteorological and Hydrological Service (DHMZ)	Croatian Meteorological and Hydrological Service (DHMZ)
The Czech Republic	Czech Hydrometeorological Institute (CHMI), Ministry of Environment	Czech Hydrometeorological Institute (CHMI), Ministry of Environment
Germany	Baden-Wurttemberg: State Office of Environment, Ministry of the Environment, Climate Protection and the Energy Sector Bavaria: Bavarian Environment Agency (LfU), Bavarian State Ministry of the Environment and Consumer Protection	German Weather Service (DWD)
Hungary	General Directorate of Water Management (OVF), Ministry of Interior	Hungarian Meteorological Service (OMSZ), Ministry of Agriculture
Moldova	State Hydrometeorological Service, Ministry of Environment	State Hydrometeorological Service, Ministry of Environment

Romania	National Institute of Hydrology and Water Management (NIHWM), subunit of the "Romanian Waters" National Administration	The National Meteorological Administration of Romania (RNMA)
Serbia	Republic Hydrometeorological Service of Serbia (RHMSS)	Republic Hydrometeorological Service of Serbia (RHMSS)
Slovakia	Slovak Hydrometeorological Institute (SHMU), Slovak Ministry of Environment	Slovak Hydrometeorological Institute (SHMU), Slovak Ministry of Environment
Slovenia	Slovenian Environment Agency (ARSO), Ministry of the Environment and Spatial Planning	Slovenian Environment Agency (ARSO), Ministry of the Environment and Spatial Planning
Ukraine	Ukrainian Hydrometeorological Center (UHMC), State Emergency Service of Ukraine	Ukrainian Hydrometeorological Center (UHMC), State Emergency Service of Ukraine

European Flood Awareness System (EFAS) is the first operational European system for monitoring and forecasting floods across Europe. It was developed by Joint Research Centre of the European Commission. In 2011 EFAS became a part of the Copernicus Emergency Management Service. The aim of EFAS is to support preparatory measures before major flood events strike, particularly in the large trans-national river basins and throughout Europe in general. It provides complementary, added-value information (e.g. probabilistic, medium range flood forecasts, flash flood indicators or impact forecasts) to the relevant national and regional authorities. EFAS also supports European Civil Protection.

The international Sava River Basin Commission (ISRBC) established a joint Hydrological Information System platform for the Sava River Basin (Sava HIS) in 2015 in cooperation with relevant national institutions from the Sava River Basin. The Sava River basin, which is the largest tributary by discharge to the Danube River, covers an area of approximately 97,700 km^2 including large parts of Bosnia and Herzegovina, Croatia, Montenegro, Serbia and Slovenia, and a very small part of Albania.

In 2018 a Flood Forecasting and Warning System in the Sava River Basin (Sava FFWS) was established. Sava FFWS integrates Sava HIS, as a data hub for the collection of real-time hydrological and meteorological data, as well as various Numerical Weather Prediction models, available weather radar and satellite imagery, outputs of the existing national forecasting systems, different meteorological, hydrological and hydraulic models. With these systems the Sava countries are better prepared for emergency situations.

2 Monitoring and data inventory

Meteorological and hydrological measurements and data collection have a long history in all countries (more than hundred years). Generally, regular network of meteorological and hydrological gauging stations started to develop in the 19th century. Nowadays almost all countries provide a modern network of hydrological and meteorological stations to ensure real-time data used in forecasting and warning procedures and flood forecasting models.

Networks of national meteorological and hydrological stations provide data for different purposes, from monitoring the state to forecasting the phenomena, assessing water resources, water balance and ecological status of waters, modelling, flood protection, time and space variability of parameters, etc. The network density varies by the countries due to river density. Modern equipment is used for data recording and collecting in all countries.

EFAS and ISRBC are not the data providers and have no responsibility in monitoring and data collection. EFAS relies on hydro-meteorological observations, numerical weather predictions and satellite images to produce, enrich and validate its products, improving their accuracy and reliability. For the Danube River Basin 13 authorities provide hydrological data for EFAS. The coverage of the Danube basin with hydrological stations is shown in Figure 2.

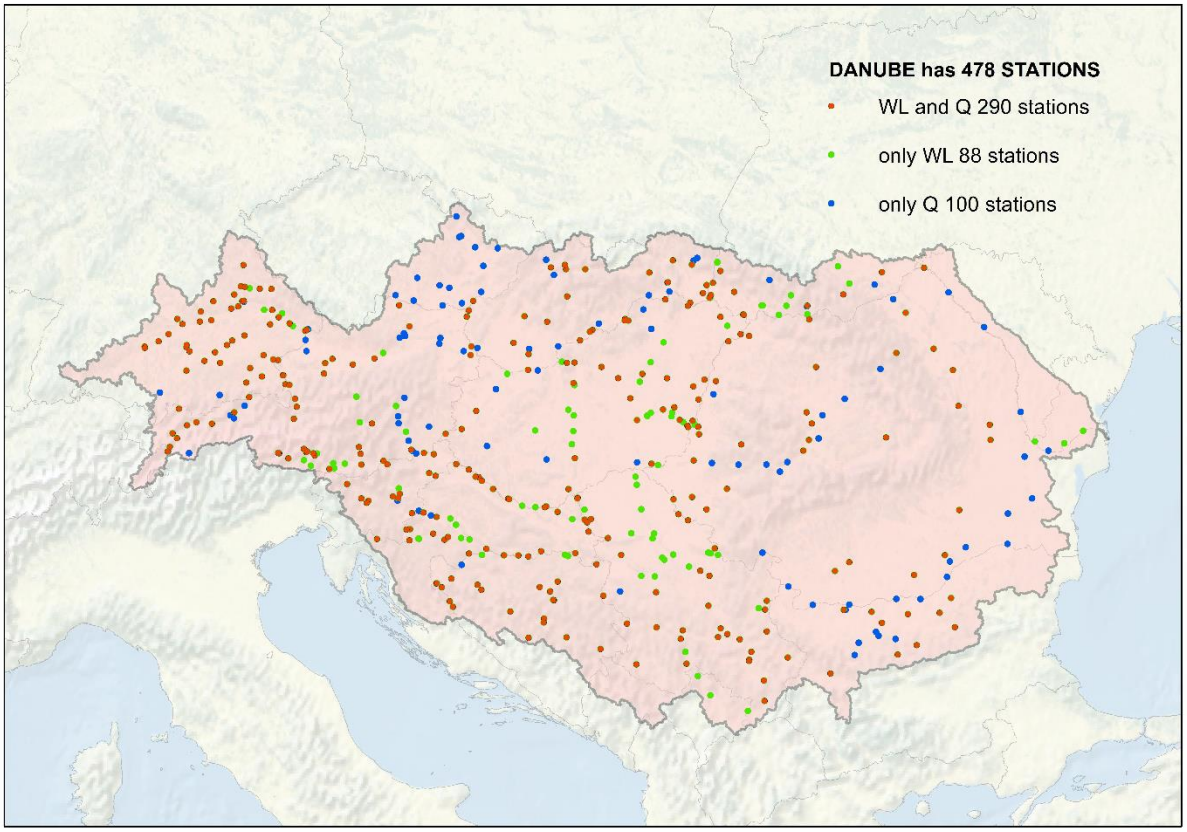

Figure 2. Hydrological stations in the Danube river basin, used in EFAS (Source: DAREFFORT, EFAS Reginal report)

In-situ monitoring of meteorological and hydrological variables from data providers are particularly crucial for the EFAS model input, calibration, validation and post-processing. In-situ data access and use is governed by a data license which has been developed together with the Copernicus and applies to all Copernicus services.

ISRBC in cooperation with relevant national institutions from the Sava River countries (Slovenia, Croatia, Bosna and Herzegovina, Serbia and Montenegro) has established a joint Hydrological Information System for the Sava River Basin (Sava HIS), as platform for the exchange and use of the hydrological and meteorological information and data. Sava HIS is a component of Geographical Information System for the Sava River Basin (Sava GIS) and represents a tool for collecting, storing, analysing and reporting of hydrological and meteorological data (Figure 3).

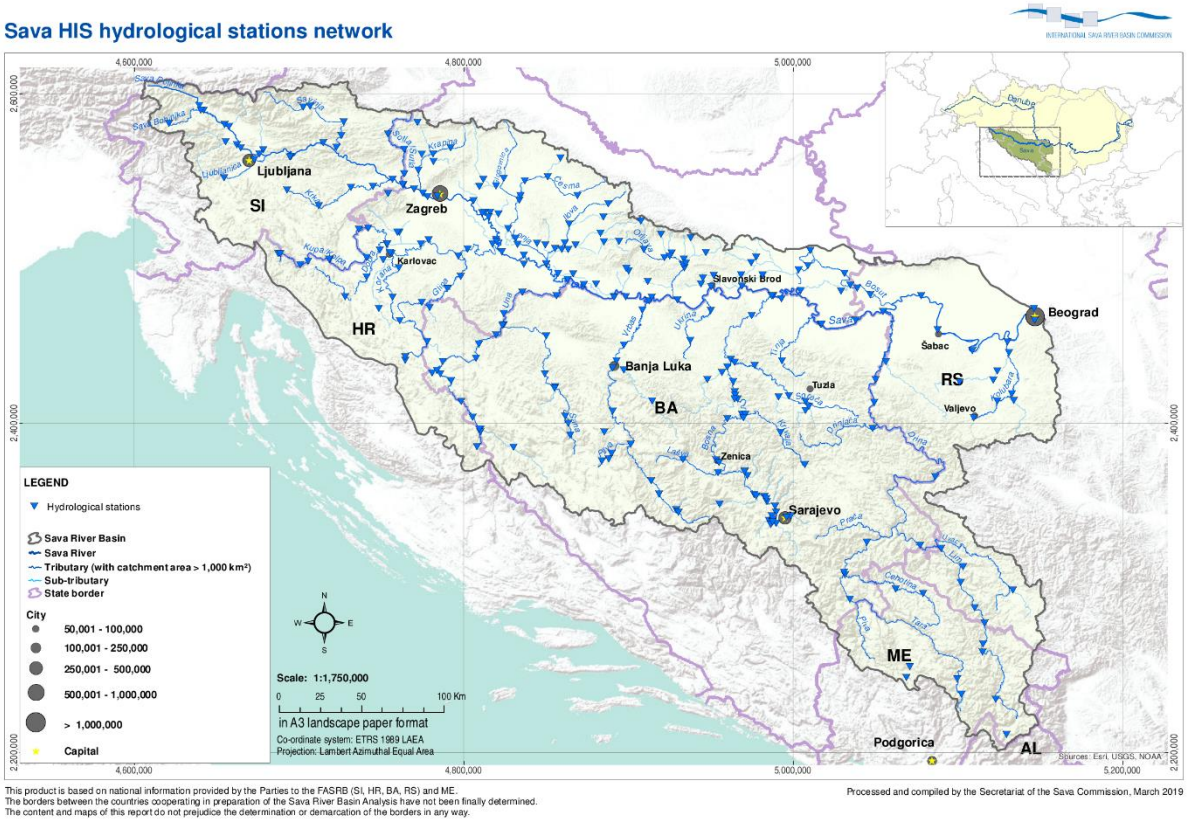

Figure 3. Sava HIS hydrological stations overview (Source: DAREFFORT, ISRBC Reginal report)

2.1 Hydrological network

This chapter summarizes the development and state of the observing networks, parameters and catchment descriptions, maps of stations, number of stations along the Danube and its main tributaries of participating countries in the project.

In the frame of hydrological monitoring all countries collect data on hydrological parameters, namely:

- water level,
- discharge,
- water temperature,
- sediments and
- ice.

Hydrological monitoring can also include the meteorological parameters such as rainfall, air temperature, air pressure and winds and parameters of water quality.

The water level is measured continuously, while the discharge is generally derived from the rating curve – the relationship between water level and discharge. Rating curves are based on regular discharge measurements.

The countries have made great progress in the field of monitoring, from the simple staff gauge, with values observed and noted only once a day, to continuously registering gauges, recording water level on paper, and finally to digitally measured values stored by data loggers and/or transmistted to database directly from measuring points. The update interval for water level data therefore depends on the type of measurement and measurement technique. For automatic stations the time interval is mostly 10 or 15 minutes.

The catchment descriptors are assigned to the gauging stations: identification code of the station, name of the profile, administration district, drainage area, distance of the station to the river junction, data source, geographical coordinates, elevation or "zero" point of the staff gauge altitude, measurement method, map of the location etc.

This report is based on the well structured questionnaire (Attachment 2) and national reports (Attachment 3). Number of hydrological stations which are in operation in the Danube River Basin is summarized by countries in Table 3 and for the sub-basin of the Sava River (SRB), collected by the ISBRC, in Table 4.

Table 3: Number of hydrological stations operating in the Danube River Basin

Country	Number of hydrological stations operated in DRB	Automatic on-line hydrological stations operated in DRB
Austria	150	NA
Bosnia and Hercegovina	82	82
Bulgaria	66	25
Croatia	284	172
The Czech Republic	153	153
Germany	488	488
Hungary	approx. 2850 (350 main stations, 1700 operating	350

	stations and 800 other stations – flood operation or study stations)	
Moldova	17	12
Romania	972	NA
Serbia	183	96
Slovakia	366	306
Slovenia	149	139
Ukraine	51	2

**NA indicates that this information is not available (not provided in the country reports)*

Table 4: Number of hydrological stations available in Sava HIS

	Number of hydrological stations available in Sava HIS	**Automatic on-line hydrological stations available in Sava HIS**
International Sava River Basin Commission	304	195

2.2 Meteorological network

Data from the meteorological network are an important part of flood warning and forecasting system. Generally, meteorological network collects different kinds of data. The most important parameters are:

- precipitation,
- air temperature,
- humidity,
- wind,
- snow depth,
- air pressure,
- solar radiation,
- sunshine,
- evaporation.

Meteorological measurements are performed at different types of stations, described below.

Synoptic meteorological stations are professional meteorological stations, which measure air temperature, air pressure, relative humidity, wind, precipitation, cloudiness, snow depth and other phenomena.

Automatic weather stations provide data in real-time for different parameters: air temperature, ground temperature, air pressure, humidity, wind direction and speed, precipitation amount, duration of precipitation, sunshine, soil temperature, visibility and snow.

Climatological stations perform measurements and observations three times a day, at 07:00, 14:00 and 21:00 local time or CET for parameters: air temperature, maximum and minimum air temperature, relative air humidity, stormy phenomena, wind direction and speed, cloudiness, precipitation, sunshine, snow cover depth and water equivalent, soil surface condition and other atmospheric phenomena.

Manual precipitation stations are operated by observers and provide data about precipitation and atmospheric phenomena on daily basis.

Number of meteorological stations operating in the Danube River Basin summarized from the questionnaires is given in Table 5.

Table 5: Meteorological stations operate in the Danube River Basin

Country	Number of meteorological stations operated in DRB	Automatic on-line meteorological stations operated in DRB	Weather radars*
Austria	130	NA	NA
Bulgaria	141	116	2
Croatia	12	12	3
The Czech Republic	90	90	2
Germany	84 (LfU), additional 330 (DWD)	414	NA
Hungary	appr. 300	appr. 300	4
Moldova	6	6	0
Romania	160	160	7
Serbia	300	28	16
Slovakia	851	271	4
Slovenia	295	113	2
Ukraine	17	0	NA

NA indicates that this information is not available (not provided in the country reports)
** values from national reports*

2.3 Data flow, data control and data processing

Reliable data flow, data control and data processing are extremely important for efficient data management. Countries use different transmission techniques in data flow and different software for data control and data processing. Data from automatic gauging stations is sent directly to the national databases. The transmisson time interval is most often from 10 minutes to one hour (see Chapter 6).

Data control are carried out in accordance with the relevant technical regulations of the World Meteorological Organization (WMO). It is usually provided by several steps. Control measurements of

water level are performed at hydrological gauging stations by hydrological observers in some countries once a day, in others at least once a week. First control of data is automatic and comprises a basic control about realness of data and operation of device. Further data control includes quality control and verification procedures during the processing and calculation of hydrological data, as well as complex control procedures and validation when filling missing data.

2.3.1 Data harmonization with border countries

Hydrological services exchange data and information with neighbouring countries for border and cross-border watercourses. The harmonization of flows for border profiles is performed in accordance with pre-defined hydrological criteria and agreements. Neighbouring countries carry out joint measurements of discharge on the border sections, regularly or if necessary.

Overview of data exchange and harmonization of data with neighbouring countries is given in Table 6.

Table 6: Data exchange and harmonization with neighbouring countries

	Data exchange and harmonization mainly based on bilateral agreements
Austria	Data harmonization is done for the Mura River with the Slovenian hydrological service, with Hungarian service for the cross-border streams between Austria and Hungary, and with the Hydrometerological Institut of the Czech Republic.
Bulgaria	Exist various international agreements regarding hydrological and meteorological data exchange. Data on water levels and discharges at the outlet stations of the six main Danube tributaries is sent daily to the telecommunication hubs in Bucharest, Romania, Belgrade, Serbia and Bratislava, Slovakia.
Croatia	Strong cooperation on transboundary data harmonization with the Slovenian hydrological service, strong cooperation and data harmonization with Hungary, cooperation and data exchange with relevant hydrometeorological and water management institutions from Bosnia and Hercegovina.
The Czech Republic	Within the Morava river basin, the Brno regional branch of CHMI cooperates with Austrian hydrological service (Dyje river) and Slovak Hydrometeorological Institute (Morava river).
Germany	Data is exchanged with the Austrian federal states Tyrol, Salzburg, Upper Austria and Lower Austria.
Hungary	The data harmonization is done for border and cross-border rivers with all neighbouring countries (Austria, Slovakia, Ukraine, Romania, Serbia, Croatia and Slovenia). Joint measurements of discharge on border sections are carried out with neighbouring countries, regularly or if necessary.
Moldova	The hydrological data exchange with the neighbouring countries for hydrological forecasting and in general for water management activity, in the transboundary River Basins, is done according to bilateral agreements.

Romania	The hydrological data exchange with the neighbouring countries for hydrological forecasting and in general for water management activity, in the transboundary River Basins, is done according to bilateral agreements.
Serbia	Exchange of data and information with neighbouring countries for border and cross-border watercourses and harmonization of flows for border profiles according to predefined hydrological criteria. Joint measurements of discharge are carried out on the border sections with neighbouring countries – Croatia, Montenegro and Bosnia and Hercegovina, regularly or if necessary.
Slovakia	The cooperation on bordering surface streams is regulated by intergovernmental contracts and agreements with neighbouring countries.
Slovenia	Exchange of data and information with neighbouring countries for border and cross-border watercourses and harmonization of flows for border profiles according to predefined hydrological criteria.
Ukraine	Data harmonization and data transfer are carried out with Hungary, Slovakia, Romania, Moldova according to previously agreed and defined hydrological criteria. Joint measurements of water discharge with neighbouring countries are carried out, regularly or as necessary.

2.3.2 Exchange of data in the region

All countries have extensive exchange of meteorological and hydrological data and information with domestic and foreign institutions and users. They provide data to international organizations such as Global Runoff Data Centre (GRDC), European Flood Awareness System (EFAS), Hydrological Information System of the Sava River Basin (Sava HIS), for the needs of international exchange by using SYNOP, HYDRA and HYFOR bulletins, and for the needs of international projects. Data is exchanged based on agreements.

Hydrological data exchange includes data on water level and discharge, water temperature, hydrological forecasts and occurrence of ice. Data exchange is arranged through the form where the data and purpose of the exchange with external organizations are listed. The frequency of data transmission, protocol for data exchange, data formats and contact persons are defined in all countries.

Data exchange and interoperability within the Sava River Basin is based on Policy on the exchange of hydrological and meteorological data and information in the Sava River basin.

Hydrological services also receive data from other institutions, for example data from hydropower plant operators, water authorities, local municipalities.

Various solutions exist for the data exchange. The FTP protocol, web, XML and E-mail are the most commonly used (see Chapter 6).

2.4 Data availability and access of data

The hydrological and meteorological services take care for national hydrological and meteorological data archive. The availability and access to data is different across the Danube River Basin countries. Furthermore, not all of the data are free of charge in individual countries.

2.4.1 Availability of hydrological data

Availability of hydrological data and terms of use for the countries involved in the DAREFFORT project is shown in Table 7.

Table 7: Availability of hydrological data and terms of use in individual countries

	Data availability and access	Terms of use
Austria	www.ehyd.gv.at	All data is free of charge and can be used for research purposes as well for commercial purposes. Reference to the data source is required.
Bulgaria	www.hydro.bg	The access to the data is limited. The use of data is not free of charge.
Croatia	http://hidro.dhz.hr	Archiv data are not charged for scientific research use whereas for commercial use a fee is charged according to the price list of services and products.
The Czech Republic	hydro.chmi.cz	Verified hydrological data (time series, daily averages, monthly averages etc.) is charged and available upon request.
Germany	https://m.hnd.bayern.de/ https://www.gkd.bayern.de/	Data for water levels, discharge, water temperature and sediments can be requested for single stations.
Hungary	www.vizugy.hu www.hydroinfo.hu	Data can be provided for a certain fee or free of charge.
Moldova	http://www.meteo.md/index.php/hidrologie/	Hydrological data and forecasts for representative stations are public available.
Romania	http://www.inhga.ro/ http://www.rowater.ro/	Hydrological data and forecasts for representative stations on the Danube and national rivers are public available, on the daily national reports elaborated by the National Hydrological Forecast Centre.
Serbia	http://www.hidmet.gov.rs/	Data published on the web site, both in real time and yearbooks, as well as the data provided to state institutions, is free of charge. Data issued on request is charged.
Slovakia	http://www.shmu.sk/	To the bodies of state and public administration, to the court and the National Council of the Slovak Republic, data is provided free of charge. In other cases, hydrological products are charged.

Slovenia	http://www.arso.gov.si/vode/podatki/	All data is free of charge and can be used for research purposes as well for commercial purposes. Reference to the data source is required.
Ukraine	https://meteo.gov.ua/	The data is provided free of charge to government authorities. In other cases, hydrological data is charged.

NA indicates that this information is not available (not provided in the country reports)

2.4.2 Availability of meteorological data

Availability of meteorological data and terms of use for the countries involved in the DAREFFORT project is shown in Table 8.

Table 8: Availability of meteorological data and terms of use in individual countries

	Data availability and access	**Terms of use**
Austria	www.ehyd.gv.at	All data is free of charge and can be used for research purposes as well for commercial purposes. Reference to the data source is required.
Bulgaria	www.meteo.bg	Data access is limited and use of data is not free of charge.
Croatia	http://www.meteo.hr/	Archiv data is not charged for scientific research use whereas for commercial use a fee is charged according to the price list of services and products.
The Czech Republic	www.chmi.cz	Operational data is available for public on the CHMI website. Verified data are not available on the website and only provided as a paid service.
Germany	https://m.hnd.bayern.de/ https://www.gkd.bayern.de/ https://opendata.dwd.de	The DWD does not give any guarantees for availability and service for its open data service. If a high level of data integrity and continuity is required there is a secured access in the so-called Geodata Service (Geodaten-Serverdienst). The use of this service is fee-based and serves the same data as the Open Data Service.
Hungary	www.met.hu	The data is provided for a fee, but basic data is free of charge.
Moldova	http://old.meteo.md/ http://www.meteo.md/index.php/meteo/	NA
Romania	http://www.meteoromania.ro/	NA
Serbia	http://www.hidmet.gov.rs/	The data that is published on the web site, both in real time and yearbooks, as well as the

		data provided to state institutions, are free of charge. Data issued on request are charged.
Slovakia	http://www.shmu.sk/	To the bodies of state and public administration, to the court and the National Council of the Slovak Republic, the data is provided free of charge. In other cases, meteorological products are provided for remuneration.
Slovenia	http://meteo.arso.gov.si/met/en/	All the data are free of charge and can be used for research purposes as well for commercial purposes. A source of data is required.
Ukraine	https://meteo.gov.ua/	Data is provided to government agencies free of charge. In other cases, the data is charged.

NA indicates that this information is not available (not provided in the country reports)

2.5 Stations for the Danube HIS

Countries used their own criteria for selection of the representative stations on main rivers and tributaries in the Danube River basin proposed for the Danube HIS. Number of the proposed stations by individual countries is given in Table 9 and the location of the selected stations is presented in Figures 4 and 5. Detailed lists of proposed hydrological and meteorological stations by individual countries are presented in Attachment 1 of this report. There are no lists of meteorological stations from Austria, and Romania.

Table 9: Number of stations considered in the Danube HIS

	Hydrological stations considered in the Danube HIS	**Meteorological stations considered in the Danube HIS**
Austria	56	NA
Bulgaria	6	6
Croatia	43	12
The Czech Republic	2	1
Germany - Bavaria	45	414
Germany - Baden-Wurttemberg	3	NA
Hungary	46	14
Moldova	17	6
Romania	30	30
Serbia	26	15
Slovakia	13	22
Slovenia	22	7
Ukraine	21	17

NA indicates that this information is not available (not provided in the country reports)

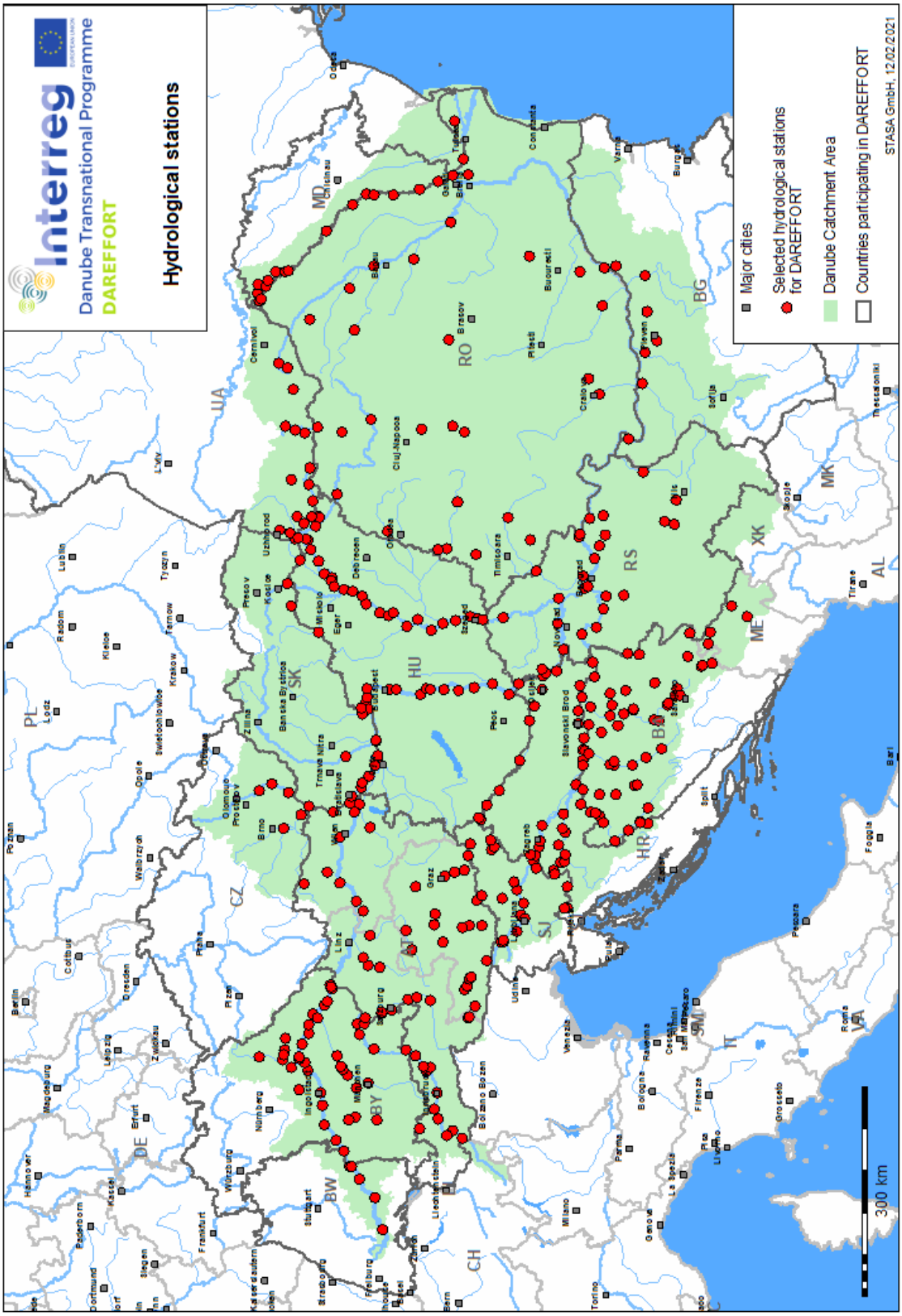

Figure 4. Map of networks and proposed hydrological stations (prepared by STASA; updated on 12.02.2021)

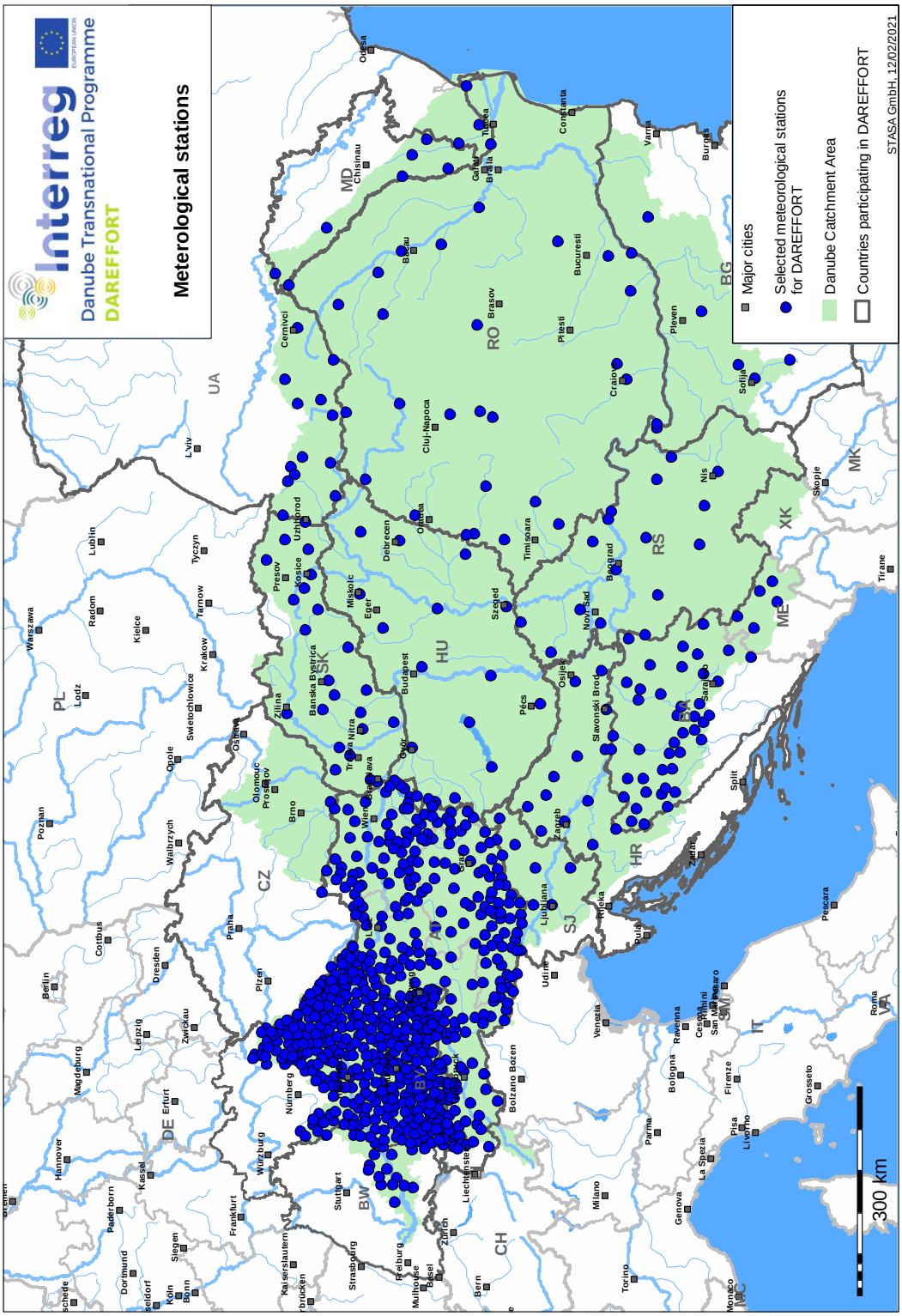

Figure 5. Map of networks and proposed meteorological stations (prepared by STASA; updated on 12.02.2021)

3 National hydrological forecasting service

3.1 Organizational structure

The overview of the national hydrological forecasting services organizational structure is presented in Table 10. Most of the services operate in several regional offices accompanied by a central office. They are usually organized within the national hydrometeorological or water management organization as bodies of ministries from various fields (environment, agriculture, defence, inner affairs).

Table 10: Organizational structure of the hydrological forecasting services in different Danube River countries and organizations.

Country / Organization	Offices	Number of forecasters and their background
Austria	1 central + 9 regional	NA
Bulgaria	1 national	7 (civil/hydraulic engineering)
Croatia	1 national	4 (civil engineering, geology)
The Czech Republic	1 central + 7 regional	NA
Germany (Bavaria)	1 warning centre + 5 forecast centres + 17 offices for water management	NA
Hungary	1 central + 12 regional	4 (meteorologists and hydrulic engeeniers)
Moldova	1 national	NA
Romania	1 central + 11 river basin branches	NA
Serbia	1 national	3 (hydrological engineers)
Slovakia	1 central/regional + 3 regional	22 = 10 + 3 x 4 (civil engineering, geography, mathematics and physics)
Slovenia	1 national	6 (civil engineering, geography, environmental sciences)
Ukraine	9 regional (basin principle)	NA
EFAS	3 International dissemination centres	NA
ISRBC	None dedicated, international responsibilities of 9 institutions within the river basin	NA

**NA indicates that this information is not available (not provided in the country reports)*

3.2 Collaboration with the national meteorological forecasting

The national hydrological and the meteorological forecasting services of the Danube river countries mostly operate within the same institution, on a door-to-door principle (Table 11). In such case, the hydrological service have access to the meteorological data and predictions free of charge, daily consultations with meteorologists are practice and usually both services prepare joint warning product as well. On the contrary, the hydrological services that operate separately from the meteorological service have fee-based access to the meteorological data and predictions, limited consultation options

and independent warning products. Since the hydrological phenomena depend on the weather conditions, it is strongly recommended to maintain the relationship with the responsible meteorological service on a high level: the formal collaboration protocols should be continuously subjected to improvements and the meteorological products and services development followed.

Table 11: Collaboration between the national hydrological and meteorological forecasting services in different Danube River countries and organizations.

Country / Organization	Relation with meteo service	Consultation with meteorologists	Meteorological data and predictions availability	Joint warning products
Austria	Separated	NA	Yes, payment-based	No
Bulgaria	Door-to-door	Daily	Yes, free of charge (internal IS)	Yes
Croatia	Door-to-door	Daily	Yes, free of charge (ftp, dBase)	Yes
Czech Republic	Door-to-door	Daily	Yes, free of charge (internal IS)	Yes
Germany (Bavaria)	Separated	Contact person available	Open data service + fee-based service (ftp, web)	No
Hungary	Separated	NA	Yes, free + payment based data (ftp, dBase)	NA
Moldova	Door-to-door	NA	Yes, free of charge (dBase)	NA
Romania	Separated	Daily	Yes, free of charge (internal IS)	No
Serbia	Door-to-door	Daily	Yes, free of charge (internal IS)	Yes
Slovakia	Door-to-door	Daily	Yes, free of charge (internal IS)	Yes
Slovenia	Door-to-door	Daily	Yes, free of charge (internal IS)	No
Ukraine	Door-to-door	Daily	Yes, free of charge (internal IS)	Yes
EFAS	1 separated, 2 door-to-door	NA	NA	-
ISRBC	NA	NA	NA	-

**NA indicates that this information is not available (not provided in the reports)*

3.3 The process of the hydrological forecasting

All national hydrological forecasting services operate in daily (7/365) mode and they are responsible for issuing hydrological, flood or flash flood warnings within the national early warning system (Table 12). Beside the riverine and the flash floods, river icing phenomena is in focus at approximately half of the services, while hydrological droughts, mudflows, karstic and ice floods are followed by individual services. Most of the services use classified warnings in 3 levels with impact oriented origin and defined as water level or discharge stages.

Table 12: Hydrological forecasting practices in different Danube River countries and organizations.

Country / Organization	Forecasting service operation	Phenomena in focus	Role in national EWS	Warning classification (threshold definition)
Austria	NA	Riverine and flash floods	YES, flood warnings	NA
Bulgaria	Daily (7/365)	Riverine and flash floods	YES, flood warnings	3 levels (discharges, statistically derived)
Croatia	Daily (NA)	Riverine (forecast only) and flash floods (forecast and warning)	YES, flash flood warnings	NA
Czech Republic	Daily (7/365)	Riverine and flash floods	YES, flood warnings (central office)	3 levels (discharges, impact oriented)
Germany (Bavaria)	Daily (NA)	Riverine and flash floods	YES, flood warnings (regional offices)	4 alert levels (water levels, impact oriented), 3 warning levels (according to alert levels)
Hungary	Daily (7/365)	Riverine floods, hydrological drought, river icing	YES, flood warnings (Technical Controlling Board at the central office)	3 flood levels (water levels, impact oriented), 3 ice conditions
Moldova	Daily (NA)	Riverine floods, river icing	YES, flood warning	4 flood levels
Romania	Daily (7/365)	Riverine and flash floods	YES, flood and flash flood warning	3 levels (water level thresholds, impact oriented)
Serbia	Daily (7/365)	Riverine and flash floods, river icing	YES, alerts and warnings for hydrological events	3 flood levels (water levels, impact oriented), 3 ice conditions
Slovakia	Daily (7/365)	Riverine, flash and ice floods, river icing	YES, hydrological and flash flood warnings	3 flood levels (water stage, impact oriented), 2 ice conditions
Slovenia	Daily (7/365)	Riverine, karstic and flash floods, hydrological droughts	YES, hydrological warnings (6 types)	3 levels (discharges, impact oriented)
Ukraine	Daily (7/365)	Riverine and ice floods, mudflows, hydrological droughts	YES, hydrological warnings	3 flood levels (water levels)
EFAS	Daily (7/365)	Riverine and flash floods	NO (notifications for EFAS partners only)	-
ISRBC	NA	Riverine floods	NO	-

**NA indicates that this information is not available (not provided in the reports)*

3.3.1 Daily operational practice

The operating hours of the national hydrological forecasting services while performing daily operational practices are mostly during the morning shift, 8 hours or shorter. However, some of the services operate in the afternoon hours as well (Table 13). As a rule, second shift or 24/7 operation is introduced during emergency situations.

The output products of the daily forecasting process are available on-line. They are almost unique for each of the services. Mostly, daily hydrological reports, bulletins and forecasts in written and tabulated format are issued for the next 3 days, rarely for a shorter (2 days) or longer (between 6 and 15 days) period. Approximately half of the services publish numerical or graphical discharge or water level forecasts originating from hydrological model simulations. Majority of the services verify the numerical forecasts prior publishing, however, some are published automatically.

Periodical products (weekly, monthly or seasonal bulletins with hydrological or icing outlooks, long-term or seasonal forecasts) are prepared by several services as well. On a regular base, only few individual services have practice of preparing seasonal hydrological drought maps, snow (SWE) or river ice reports and forecasts.

Table 13: Daily operational practices of the hydrological forecasting services in different Danube River countries and organizations.

Country / Organization	Operating hours	Output product with hydrological forecast
Austria	NA	Data and information on the water balance; runoff forecasts
Bulgaria	8:30-12:00 (5:00-23:00 during emergencies)	Daily report with 3-day forecast (text + data tables)
Croatia	Starting at 7:00 (6:00-22:00 during emergencies)	Daily hydrological bulletin
Czech Republic	6:00-14:00, 6:00-10:30 on weekends (24/7 during emergencies)	Daily report with 3-day forecast + hydrological model forecasts (text + graphs + data tables)
Germany (Bavaria)	NA	Hydrological status report; Automatic water level and discharge forecasts
Hungary	7:00-11:00 (24/7 during emergencies)	Daily hydrological report with water level forecast for next 6 days (shallow river section information, river ice reports and forecasts)
Moldova	8:00-17:00 (24/7 during emergencies)	Daily hydrological report
Romania	24/7	Daily hydrological report with 7 day (10 day on-demand) forecast; Monthly with next 3 months forecast

Serbia	6:00-15:00, 6:00-12:00 on weekends (24/7 during emergencies)	Daily: hydrological data and forecasts bulletins; Periodically: weekly, monthly and seasonal bulletins with hydrological outlook and icing events forecasts
Slovakia	Two shifts, starting at 6:00 + preparedness service	Daily: hydrological report and numerical 48-hour forecasts, hydrological drought map; Seasonal: weekly snow (SWE) report
Slovenia	7:00-10:00 (24/7 during emergencies)	Daily hydrological report with 3-day forecast (text + data tables)
Ukraine	8:00-17:00 (24/7 during emergencies)	Short-term forecasts (up to 15 days); Long-term forecasts and predictions (up to 60 days); Seasonal forecasts (up to 97 days)
EFAS	Twice daily (7:00 and 13:00)	Medium-range flood forecasts; Flood impact forecasts; Flash-flood indicators; Seasonal hydrological outlook
ISRBC	NA	Medium-range flood forecasts

**NA indicates that this information is not available (not provided in the reports)*

3.3.2 Operational practices during emergencies

The most common products issued by the national hydrological forecasting services during emergencies are hydrological or flood warnings and bulletins (Table 14). Only few services prepare specialized warning products for flash floods, the hydrometeorological phenomena that inflict heavy loss of life and significant property and infrastructure damage. Since the flash flood occurrence frequency is increasing recently, the organisations involved in the national EWS should establish warning protocols and products that will address the timely flash flood detection and make the necessary adjustments of the response system.

As a rule, the warning products are issued with a lead time between 36 and 72 hours on a national level, however, regional warnings are being prepared as well. The emergency products mostly contain text, graphics, tables, maps and multimedia. Individual services are preparing warnings in CAP format, flood or special reports, drought bulletins and press conferences (for the highest warning level).

Table 14: Emergency operational practices of the hydrological forecasting services in different Danube River countries and organizations.

Country / Organization	Flood warning lead time	Emergency products
Austria	NA	Regional flood warnings and (automatic) forecasts
Bulgaria	Up to 48 hours (72 hours for flash floods)	Hydrological nowcasting bulletin, Bulletin with riverine and flash flood forecasts, Hydrometeorological bulletin, Flood warning (text + graphics)
Croatia	NA	Hydrological bulletin, Special reports, Flash flood warnings (Meteoalarm)
Czech Republic	NA	Alert proposal, Flood report, Flood warning (text + map + multimedia + CAP format)

Germany (Bavaria)	Adjusted to the reaction times of the local response units	Flood forecasts (charts), Regional warnings (text + map)
Hungary	6 days	Flood warnings, Special bulletins
Moldova	Up to 48 hours	Hydrological warnings, Hydrological bulletins
Romania	NA	National and regional hydrological warnings
Serbia	Up to 72 hours	Hydrological information, Alerts and Warnings (text + map)
Slovakia	Up to 48 hours	Hydrological warnings (text + map + CAP format), 12-, 6- or 3-hourly flood reports according to the alert level (text + tables + data)
Slovenia	Up to 36 hours	Hydrological warning (text + graphics + multimedia), Press conference (3rd level flood warning), Weekly drought bulletin
Ukraine	Up to 48 hours	Flood warnings, Special bulletins
EFAS	Up to 72 hours	Notifications: Formal flood, Informal flood and Flash flood
ISRBC	NA	NA

**NA indicates that this information is not available (not provided in the reports)*

3.3.3 Dissemination of the hydrological forecasts and warnings

The hydrological forecasts and warnings are disseminated to the national early warning system authorities. In most of the cases those authorities are: civil protection and emergency services, flood defence and water management institutions and responsible ministries (Table 15). In some countries regional and local authorities, municipal administrations, the army, fire and rescue forces are directly notified as well. As a rule, the hydrological forecasting services send the warning or special products to other authorities as well. This group of authorities is primarily consisted of local municipalities, district and regional flood mitigation authorities and the neighbouring (or downstream) countries. In some of the countries the navigation, energy, infrastructure and agriculture sector is notified as well. Almost all countries use different set of channels for warning products dissemination. The authorities are mostly informed via e-mails, telephone calls and protected data transfers. On the other hand, the general public is informed about the emergencies and the latest warnings mostly through the web, the national broadcast services and social media.

Table 15: Hydrological forecasts and warnings dissemination in different Danube River countries and organizations.

Country / Organization	National EWS authorities	Other authorities	Dissemination channels for authorities	Dissemination to general public
Austria	National alert offices	Downstream countries (Slovenia, Hungary)	NA	Web, web-services, national broadcast
Bulgaria	Civil protection, responsible	Municipalities and other institutions concerned	Protected website	Web

	ministry and institutions			
Croatia	Flood defence and water management authority	NA	ftp, protected website	Web, Meteoalarm website
Czech Republic	Flood and water authority, national army, fire rescue service	Local municipalities, neighbouring countries (Austria, Slovakia)	National warning service system, SMS, social media, telephone calls	Web, national warning platform, national broadcast, social media, mobile app
Germany (Bavaria)	Local authorities, Municipal administration	NA	Web, Internal communication	Web, telephone, teletext, broadcast service (additional information provided by offices for water management)
Hungary	National Technical Controlling Board (experts of water management, civil protection, ministry representatives)	Riverine navigation authority, nuclear power plant	Direct network access	Web, national broadcast, mobile app
Moldova	Civil protection, Ministry of Environment, Ministry of Economy	Neighbouring countries (Russia, Ukraine, Romania), economic agents	e-mail, fax, telephone calls	Web
Romania	Public Authorities	Stakeholders, neighbouring countries	web, e-mail	Web, e-mail
Serbia	Flood defence and water management authorities	Neighbouring countries, special users	ftp, e-mail, telephone calls, GTS	Web, media, national broadcast
Slovakia	Responsible ministries, district authorities, civil protection, fire and rescue forces, national water management enterprise	District and regional flood mitigation organizations, neighbouring countries	e-mail, https transfer, telephone calls	Web, Meteoalarm
Slovenia	Civil protection, water management agency, responsible ministry	Downstream countries (Croatia, Hungary, Italy)	e-mail, fax, telephone calls, Protected website	Web, national broadcast, press conference, social media

Ukraine	State emergency services, water management authorities	Infrastructure, agriculture, energy and navigation authorities	Disseminated via National Weather Center	Disseminated via National Weather Center
EFAS	National flood forecasting services (EFAS partners only)	European commission services	e-mail, web platform, web services	none
ISRBC	Flood forecasting and management institutions (Sava River basin countries only)	-	Client application, web interface	none

**NA indicates that this information is not available (not provided in the reports)*

3.3.4 Information, modelling and other systems used in the hydrological forecasting practices

The hydrological services in the Danube River Basin within their daily forecasting practices use country specific information systems, data management and visualisation tools as well as dissemination platforms. These are mostly dedicated web-based or stand-alone applications, rarely prepared through a commercial software. Several hydrological services take the advantage from the internationally available flood and flash flood platforms (EFAS, WMO FFG, ISRBC FFWS) also (Table 16). All national services have access to numerical weather prediction forecasts – mostly to short and medium range ones. Additionally, almost half of the services use nowcast and ensemble forecasts, while only few have access to long-term forecasts (monthly and seasonal outlooks). The hydrological models within the national specific forecasting systems enable forecasting intervals between 48 and 144 hours, rarely more. The hydrological model results are usually being automatically updated on regular intervals: daily, several times a day (2 to 4) or hourly. However, manual model runs are also in practice.

Table 16: Information, modelling and other systems used in the hydrological forecasting practices across the Danube River countries.

Country / Organization	**Dedicated informational platforms**	**Available numerical weather predictions**	**Hydrological model forecast interval and updates**	**Other systems and tools**
Austria	National WEB-GIS platform for observed data, regional websites	Long-term, short-term and nowcast forecasts	Up to +48 hours (Danube), continuous operation	NA
Bulgaria	Flood forecasting and warning systems	Medium and short range forecasts	Up to +96 hours, updated	data management tools, EFAS and WMO FFG services

			daily (and on demand)	
Croatia	National WEB-GIS platform for observed data, regional websites	Medium and short range forecasts	Up to +120h, updated hourly	ISRBC FFWS platform, EFAS and WMO FFG services
Czech Republic	Data, analyses and forecasts visualisation applications, warning creation and dissemination software	Medium and short range, nowcast and ensemble forecasts	Up to +66h, updated hourly, twice a day manual runs	Modelling input data preparation application, supporting apps for understanding rainfall-runoff processes
Germany (Bavaria)	Tool for data processing, model execution and control, forecasts visualization and publication	Medium range and nowcast forecasts	Up to +96h, updated hourly	Tool for automatic forecasts creation
Hungary	Hydrological information and dissemination platform	Medium and short range forecasts	Up to +144h, updated daily (and on demand)	EFAS services
Moldova	Data visualisation tool	NWP model forecasts	as the case	EFAS and WMO FFG services
Romania	River forecasting system interface, national flash flood guidance system	Long, medium and short range forecasts	Up to +360h, updated 4 times daily, FFG up to +6h, updated every hour	EFAS and WMO FFG services
Serbia	Data acquisition and processing, data and forecasts visualisation, bulletin creation and dissemination software	Seasonal, monthly, medium and short range, nowcast and ensemble forecasts	Between +2 and +5 days, updated daily	EFAS, WMO GTS and FFG services, ISRBC FFWS platform
Slovakia	Informational system for report, forecast and warning products creation; hydrological forecasts processing system	Medium and short range, nowcast and ensemble forecasts	Up to +48h, updated on 6 hours	Data management tools, automatic alerting system, EFAS services, national flash flood guidance system
Slovenia	Hydrological information and	Medium and short range, nowcast and	Up to +144h, updated hourly	Data management tools, automatic

	dissemination platform	ensemble forecasts		alerting system, EFAS services
Ukraine	Hydrological forecasting system	NWP model forecasts	Up to +48h	NWP model results viewer
EFAS	EFAS web platform	Flash flood and medium range forecasts, seasonal outlook	Up to +360h (updated twice a day), 8 weeks seasonal outlook (updated monthly)	-
ISRBC	ISRBC FFWS platform	Medium and short range, ensemble forecasts	Up to +120h, updated every 6 hours, as a rule	Hydrological database (Sava HIS)

**NA indicates that this information is not available (not provided in the reports)*

3.3.5 Structure of the hydrological forecasting models

Table 17 presents an overview of different hydrological and hydraulic models that are used in Danube River countries and two organizations, namely European Flood Awareness System (EFAS) and International Sava River Basin Commission (ISRBC). One can notice large diversity among Danube River countries in terms of hydrological and hydraulic models used, the number of models applied, the complexity of these models, etc. Some countries such as Slovenia or Croatia use the same hydrological model type for the entire country or part of the country that is included in the modelling system, while others such as Austria use different models in different parts of the country (i.e. regional-province based approach). Moreover, some countries such as Bulgaria or Serbia also use catchment-based approach where they use different models for different rivers. In terms of model types one can see that diversity is also large in this context, which means that conceptual (e.g., DHI NAM, HBV), physically based (e.g., TOPMODEL), empirical (e.g., Rational equation) models are used for different purposes in terms of forecasting process. Similar conclusion can also be made for the hydraulic models used where the main purpose of these models is to better simulate flood levels. Different models are used such as DHI 1D model (MIKE 11) or freely available HEC-RAS model. Similarly, as for the hydrological models also for the hydraulic models one can notice that some countries use the same model type for the entire country (i.e. where modelling is carried out) and some countries are using catchment-based approach where they used different models for different catchments.

Table 17: Overview of hydrological and hydraulic models used in different Danube River countries and organizations based on the provided national and organizational reports

Country / Organization	Hydrological model	Hydraulic model/Routing model
Austria	DHI NAM, HBV	DHI 1D Hydrodynamic model
Bulgaria	Rational equation is used for flash-flood forecasting, TOPKAPI (Ogosta River), ANN (Iskar River), SWAT (Vit	DHI 1D Hydrodynamic model (Maritsa and Tundzha Rivers)

	River), ISBA-TOPODYN (Osam River), HEC-HMS (Yantra River), DHI NAM (Rusenski Lom River), DHI NAM (Maritsa and Tundzha Rivers), ISBA-TOPMODEL (Arda River)	
Croatia	DHI NAM (Sava and Danube River)	DHI 1D Hydrodynamic model (Sava and Danube River)
Czech Republic	HYDROG (Morava and Odra Rivers), AQUALOG (Labe River), HEC-HMS (Odra and upper Morava River and other Rivers)	HYDROG Morava and Odra Rivers)
Germany (Bavaria)	LARSIM	FluxFloris (Inn, Lech and Danube Rivers), WAVOS (Danube and Main Rivers)
Hungary	TAPI (Danube, Drava and Tisza Rivers)	Discrete Linear Cascade Model (DLCM)
Moldova	Not using any model	Not using any model
Romania	NOAH-R, SAC-SMA	Lag&K, Muskingum
Serbia	Correspondent discharge method (Danube River), Multiple linear correlation (Sava River), Nonlinear model of river runoff (MANS), HBV (small rivers)	ISRBC FFWS platform
Slovakia	HBV and HEC-HMS	HEC-RAS
Slovenia	DHI NAM	DHI 1D Hydrodynamic model
Ukraine	DOSCH, SNIG, SLOJ models	NA
EFAS	LISFLOOD, conceptual hydrological algorithms for flash flood indicators	LISFLOOD
ISRBC	HEC-HMS (Sava River), WFlow (part of Sava River), DHI NAM (Croatia, Una and Vrbas Rivers), HBV-light (Bosna River), WFlow (Montenegro), HEC-HMS (Kolubara Rivers), HBV (Kolubara, Jadar, Tamnava, Ub, Ljig Rivers)	HEC-RAS (Sava River mainstream, Bosna, Sana, Sanica, Una, Usora, Vrbas, Drina, Kolubara Rivers), MIKE 11 (Rivers in Croatia, namely Una and Vrbas Rivers)

**NA indicates that this information is not available (not provided in the national/organizational reports)*

3.4 Hydrological forecasts and warning efficiency

Next two sub-sections provide an overview of the methodologies used for hydrological forecast and warning efficiency estimation in individual countries. Most of the countries provided information about the efficiency criteria that they are using for the evaluation of the forecasts whereas only a few stated methodology (i.e. standard) that they are using. Sub-section 3.4.2 provides an overview of the forecasts and warnings efficiency evaluation where again the differences in the input to the national reports are quite large.

3.4.1 Methodologies used for efficiency estimation

Table 18 provides an overview of methodology and efficiency criteria used for the hydrological forecasts and warnings based on the provided national and organizational reports. One can notice that some countries in their national reports also mentioned standards that they are using for the efficiency evaluation. However, one should note that most of the countries did not provide this information, which could mean that either they do not have any specific standard related to the efficiency evaluation or this was not mentioned in the report. Furthermore, among the Danube River countries and international organizations there exists a large diversity in the efficiency criteria that are used to evaluate forecasts and warnings. For the evaluation of forecasts (i.e. water level or discharge modelling results based on the meteorological input data), one of the most commonly used criterion is Nash-Sutcliffe efficiency (NSE). However, also other criteria are used such as root mean square error (RMSE), Pearson correlation coefficient (R^2), absolute relative error, mean absolute error. Similar conclusion can also be made for the evaluation of the warning quality where many different indexes are used by the forecasting services in different Danube River countries. For example, in Czech Republic they are using indexes such as Hit rate (HR) or false alarm ratio (FAR), which is for example also used in Romania.

Table 18: Overview of methodology and efficiency criteria used for the hydrological forecasts and warnings based on the provided national and organizational reports

Country / Organization	Methodology used	Efficiency criteria used
Austria	NA	NA
Bulgaria	NA	NA
Croatia	NA	NSE, RMSE, SD (Danube River)
Czech Republic	NA	Peak flow relative difference, Total flow volume relative difference, Hit Rate (HR), False Alarm Ratio (FAR), Frequency Bias (FB), Critical Success Index (CSI)
Germany (Bavaria)	NA	Statistical indexes such as R^2
Hungary	In accordance with the national requirements of ISO 9001: 2000	efficiency index, minimum, mean and maximum error, absolute average error, SD, SRE, NSE, autocorrelation of errors)
Moldova	NA	NA
Romania	NA	absolute error, absolute relative error, probability of detection (POD) and false alarm rate (FAR), Probability of detection, false alarm rate, accuracy, bias score, probability of false detection, success ratio
Serbia	NA	Standard error, mean square deviation, forecast accuracy index

Slovakia	Standard of Slovak Republic OTN 3105:05 published by the Ministry of Environment	Absolute relative error, NSE, mean absolute error
Slovenia	WMO recommendations published in No. 44 Technical reports in Hydrology and Water Resources: Methods for Verification of Hydrological Forecasts	Ratio between the forecasted and the measured mean discharge, R^2 and NSE
Ukraine	NA	Forecast error
EFAS	NA	modified Kling-Gupta efficiency criteria, NSE, R, PBIAS, continuous ranked probability skill score
ISRBC	Users are advised to use WMO manuals and recommendations	NA

**NA indicates that this information is not available (not provided in the national/organizational reports)*

3.4.2 Efficiency analyses results

Table 19 provides an overview of the efficiency analyses results for different Danube River countries. Some countries such as Czech Republic, Slovakia or Slovenia provided information about forecasting efficiency for the longer period, while some countries provided information about the efficiency for shorter time period (e.g., Croatia for 6-months, Hungary for two years) and other countries did not provide any information about the efficiency of the forecasting service. Due to different methodologies used for efficiency evaluation, different models and different time periods presented in the national report it is hard to make a robust comparison about the forecasting performance in different Danube River countries (e.g., to rank countries based on the forecasting efficiency). In general, as expected, better modelling performance can be observed for larger catchments compared to smaller catchments where there is not any upstream gauging station available that can be included in the prediction or modelling process. Moreover, better results can be obtained for shorter lead-time values (e.g., up to 12 hours) compared to forecasts for longer lead-time values (e.g., 120 h) where there is already larger uncertainty/variability in the prediction of the meteorological models such as ALADIN. Moreover, it can be seen that generally satisfactory results are obtained according to the national reports and criteria used. Furthermore, for some cases such as Hungary and Slovenia one can also note a better forecasting performance in the last years compared to the performance in the past (e.g., 10 years ago). This could indicate that due to development of models, gauging station network density increase, incorporation of modern measuring techniques such as meteorological radars one can expect an increase in the hydrological forecasts and warning efficiency in the future.

Table 19: Overview of the efficiency analyses results for different Danube River countries based on the provided national and organizational reports

Country / Organization	**Overview of the provided efficiency analyses**
Austria	NA
Bulgaria	NA

Croatia	NSE for 48 and 120 h forecasts for three stations on the Danube River is above 0.97 and 0.9, respectively for the selected 6 months period; results are above the recommended values
Czech Republic	Above 1/3 of forecasts are classified as hits, 1/3 as missed and 1/3 as false alarms; results are better for larger catchments and for shorter lead times (e.g., for the period 2002-2017 for the lead time up to 7 h hit rate is above 70 %)
Germany (Bavaria)	Forecast accuracy is increasing with catchment area and decreasing with lead time; internal expert reviews are carried out; publication of level ranges in addition to accurate values
Hungary	Efficiency index for the Danube is increasing with catchment size and is generally higher for shorter lead time values; for years 2004 and 2016 based on this index forecasts are mostly classified as good (green colour); similar conclusion can be made looking at the deviation between measured and forecasted water levels, however for higher lead-time (e.g., 144 h) forecasts are also classified as bad (red colour)
Moldova	Data exchange with neigbouring countries
Romania	Romanian Water Administration, HPP and civil protection services, Neighbouring countries (Hungary, Serbia, Bulgaria, Moldova, Ukraine), EFAS
Serbia	In the period from 2012 to 2018, the percentage of accurate hydrological announcements and warnings was from 73 to 89%.
Slovakia	24 h forecast accuracy for Devin is between 89 and 95 %, for some downstream stations on the Danube efficiency is a bit lower but above 75 % (2012-2017) due to Gabčíkovo dam
Slovenia	Quality indicator (standard ISO 9001/2015; in %) provided from 1999 to 2017; range from 72 to 85 % with average value of 79 %; better performance can be detected for the last 5 years
Ukraine	NA
EFAS	The continuous ranked probability skill score for October-November 2018 for catchments larger than 2000 km^2 are mostly above 0.4 for the 1 day lead-time forecast; specific events are also analyzed in detail in order to improve model performance
ISRBC	In operation since October 2018, no efficiency evaluation has been conducted so far

**NA indicates that this information is not available (not provided in the national/organizational reports)*

3.5 Cooperation with expert services within the region

Table 20 provides an overview of the cooperation of the forecasting service with expert services within the region such as hydropower operators, civil protection, rescue units or neighbouring countries. It can be seen that most of the countries have well-developed cooperation (e.g., data exchange, forecasts exchange) with neighbouring countries. Moreover, most of the countries are also cooperating with different national institutions responsible for flood protection (e.g., civil protection or water management services). In some countries such as Austria, Czech Republic, Germany (Bavaria), Hungary, Slovenia also exists cooperation with the HPP operators, which often have their own gauging networks and dams operation can significantly affect the flood forecasting. Therefore, this kind of operation is important for the forecasting service.

Table 20: Overview of the cooperation and data exchange of the forecasting service based on the provided national and organizational reports

Country / Organization	Cooperation with
Austria	Federal provinces, neighbouring countries (Germany-Bavaria, Germany-Baden Württemberg, Switzerland, Czech Republic, Slovakia, Slovenia and Hungary), HPP; civil protection
Bulgaria	For Arda River methodology was developed in a scope of a joint project between Bulgaria and Greece
Croatia	Organizations located in Croatia (Croatian waters (responsible for the flood defence), Ministry of Interior Affairs (ex. National Protection And Rescue Directorate) and Ministry of Defence), ISRBC and neighbouring countries (Slovenia (Slovenian Environment Agency), Bosnia and Herzegovina (two federal Hydrometorological services of BIH, Agency for the Sava River Basin), Serbia (Republic Hydrometeorological Service of Serbia), Hungary (Hungarian Hydrological Forecasting Service), Austria (Hydrographic Service Styria))
Czech Republic	River basin authority and Civil Protection (PovodíMoravy), HPP and neighbouring countries (Austria and Slovakia)
Germany (Bavaria)	Different institutions (e.g., Federal Office of Civil Protection and Disaster Assistance, ICPDR, German ministries, HPP), cooperation between LfU in Bavaria and the forecasting services of the states Baden-Wurttemberg, Rheinland-Pfalz and Hesse
Hungary	Expert services and institutions in the region, regional Water Directorates, HPP and neighbouring countries (Austria, Bulgaria, Croatia, Romania, Serbia and Slovakia)
Moldova	Data exchange with neighbouring countries
Romania	Romanian Water Administration, HPP and civil protection services
Serbia	Water management authorities, Sector for emergency situtions, HPP, neighbouring countries (Romania, Hungary, Bulgaria), ICPDR, ISRBR, EFAS
Slovakia	Water management authorities, civil protection authorities and neighbouring countries (Austria (Department of Hydrology and Geoinformation of Lower Austria in St. Poelten), Hungary (Hungarian Hydrological Forecasting Service, General Directorate of Water Management), Czech Republic (the Regional branch of the Czech Hydrometeorological Institute in Brno), Poland (Institute of Meteorology and Water Management in Krakow), and Ukraine (State Emergency Service of Ukraine - Ukrainian Hydrometeorological Centre))
Slovenia	HPP operators (from 2010) and neighbouring countries (Italy (Civil Protection FVG –Italy), Austria (hydrographic services of Styria, Carinthia and Tyrol, meteorological service of Austria), Croatia (Croatian Meteorological and Hydrological Service), Hungary)
Ukraine	Neighbouring countries (Belorus (hydrometeorological services of the Republic of Belarus), Moldova, Slovakia, Poland, Hungary, Romania)
EFAS	National and regional flood forecasting authorities or other flood risk management authorities (EFAS partners and EFAS third party partners),
ISRBC	Emergency management organizations

**NA indicates that this information is not available (not provided in the national/organizational reports)*

3.6 Relations with stakeholders

Most of the Danube River countries forecasting services indicated that stakeholders are both from the public (e.g., national institutions) and the private (e.g., special users and customers) sectors. Information about the involvement of stakeholders in flood (and ice) management, preparation of the reports for the stakeholders and on which legal basis is provided in Table 21. Forecasting services also prepare regular reports, forecasts and products on demand where relations with special users and customers are based on contracts. Special products are customized and being disseminated according to the user needs. For example, in case of Slovenia most of users come from the electric power production, distribution and trade sector. According to the provided reports, not much differences can be detected among Danube River countries in terms of relationship with stakeholders.

Table 21: Overview of the cooperation and data exchange of the forecasting service based on the provided national and organizational reports (data from the questionnaires)

Country	**The involvement of stakeholders in flood (and ice) management**	**Preparation of the reports for the stakeholders**	**Legal basis** (by law, internal regulation, commercial arrangements)		
Austria (Lower Austria)	Yes	Yes		internal regulation	commercial arrangements
Bosnia and Herzegovina	Yes	Yes	by law		
Bulgaria	No	Yes	by law		
Croatia	Yes	Yes		internal regulation	
Czech Republic	Yes	Yes	by law		commercial arrangements
Germany	Yes	No			
Hungary	Yes	Yes	by law	internal regulation	commercial arrangements
Moldova	Yes	Yes	by law	internal regulation	commercial arrangements
Romania	Yes	Yes	by law	internal regulation	commercial arrangements
Serbia	Yes	Yes	by law		
Slovakia	Yes	Yes	by law		commercial arrangements
Slovenia	Yes	Yes		internal regulation	commercial arrangements
Ukraine	Yes	Yes		internal regulation	commercial arrangements

4 Perspective in development

Table 22 provides an overview of the short- and long-term plans of the forecasting services. One can see that future plans are relatively similar and forecasting services will work on models development (e.g., better calibration, enhanced model structure), gauging networks improvements (e.g., new stations, modern equipment, denser network), forecasting system development (e.g., use of additional data, use of ensemble forecasts, flash-flood forecasting improvements) and warning process improvement. Moreover, some of the forecasting services also indicated that they will work on media relations (e.g., web-page development, data access, social media such as Twitter or Facebook).

Table 22: Overview of future plans of the Danube River forecasting services based on the provided national and organizational reports

Country / Organization	Future plans
Austria	IT system development
Bulgaria	Hydrological forecasting process development (new early warning system, model development), automatic hydrometric stations development (i.e. more stations))
Croatia	Models development, automatic hydrometric stations development (i.e. new modern stations (hydrological, meteorological, air quality, radar, oceanographic buoys,…))
Czech Republic	Models development, widening of the forecast portfolio, flash flood forecasting development, medium-term forecasts for drought events, optimization of gauging network (more stations, use of modern equipment)
Germany (Bavaria)	Use ensemble forecasts, use of supercomputer for hydrological modelling
Hungary	Hydrological forecasting system development (e.g., new 1D hydraulic model), ice-forecasting development
Moldova	Monitoring enhancement and forecasting development
Romania	Flash flood forecasting and warning development, development of snow water equivalent and rainfall grid data, use of ensemble forecasting, hydrological model development, hydraulic model development
Serbia	Hydrological modelling of additional catchment, hydraulic model development, hydrological and meteorological gauging network development (e.g., number of stations)
Slovakia	Forecasting system development (e.g., hydrological models development, use of probabilistic models)
Slovenia	Models development (e.g., Drava, Mura), warning process upgrade, enhanced communication with general public via social media, web-page development
Ukraine	Forecasting system development (use of ALADIN model for prediction, models development), use of meteorological radars, hydrological and meteorological gauging stations development
EFAS	Forecasting system development (e.g., use of additional data, better calibration, model development, use of grand ensemble forecast, better seasonal forecasting, better flash-flood forecasting, increase of spatial resolution), improvement of forecast data access for the EFAS partners

ISRBC	Meteorological data improvement (e.g., spatial coverage improvement, - increase temporal resolution, establish a nowcast,…), hydrological models development (e.g., calibrate models for low and high flows by using observed hydro- meteorological data of sufficiently long record, improvement of the reservoir operation models with real-time data,..), hydraulic model development (e.g., couple the hydraulic model to a hydrological model, calibrate the model for both high and low flows, flood mapping improvement), improvement of computational time taking into consideration also model quality

**NA indicates that this information is not available (not provided in the national/organizational reports)*

Furthermore, also DAREFFORT project will contribute to the development of flood and ice forecasting in the Danube River countries. The need for enhanced cooperation in flood protection was officially recognized in various international and interregional policy documents. One of the project aims is to help implement the Danube Flood Risk Management Plan in line with the Flood Risk Directive. The main aim of this project is to give a comprehensive overview about the complex national flood and ice forecasting systems and to eliminate the shortcomings of the existing forecasting practices. Moreover, one of the objectives of the project is to strengthen inter-institutional collaboration among the Danube countries towards better flood and ice forecasting in the region.

5 Notes on reports of "Status quo of the Danube regional flood and ice forecasting system and methodologies"

This chapter replaces the conclusions and is a basis for a discussion about further work of DAREFFORT project partners on WP3. It was prepared on the basis of the individual national reports and other available literature.

5.1 Introduction

Flood forecasting and hydrological measurements in the Danube River Basin have a long-standing tradition. Early measurements date back to the 18th century; by the end of the 19th century public services for systematic measurements of water levels were introduced in most countries. Flood forecasting services have been established since the mid-20th century. In the late 20th century and early 21st century, IT and the overall digitisation accelerated flood forecasting development all over the world. The development of forecasting services and professional progress can be followed through scientific and professional meetings that have been held biennially since 1961. In 2019, the meeting will take place in Kiev.

The review of national reports reveals a diverse picture of organisation of hydrological forecasting services. In some countries the hydrological service and the meteorological service are under the same roof, while in others they are separated. In large countries, such as Germany, these services are separately organised by different Länder and they operate in the relevant branch departments across individual particular regions. Meteorological services are organised centrally because of the nature and dynamics of meteorological phenomena. Both aforementioned formats of providing services for hydrological forecasts have their strengths and weaknesses. Hydrological forecasts depend on meteorological forecasts and data. The advantage of a common hydrometeorological service lies in closer collaboration of both services, common planning, and faster transfer of development achievements into practice.

The problem of meteorological services and hydrological services is the lack of financing and frequently reduced allocations of budgetary resources of individual countries. As a consequence the number of gauging stations is lower than several decades ago. A consequence of reducing the funds for operation of hydrological as well as meteorological services is that the services raise funds by selling data to acquire additional minimum funding. Commercialisation of hydrological data brings more harm than good for the society. Services are closing down and hiding data, which are expensive, but valuable for users, and nevertheless without a specific market value. The lack of funds makes it difficult to introduce new measurement technologies. In some countries digitisation and automation have been introduced into all observations and in others only partially.

The development of hydrological forecasts and collaboration of countries in their development have a long-standing tradition in the Danube River Basin. The first scientific meeting dedicated to hydrological forecasts was in Budapest in 1961. The history of developing forecasting models and the overall hydrological diversity of the river basin is collected in 27 proceedings.

The Danube River Basin is the second largest river basin in Europe, with various climate conditions. Floods rarely affect the entire river basin with the same intensity. The sources of the water in the catchment are the Alpine, Balkan, and Carpathian mountains. Floods vary from debris flows to flash floods; the entire event may take a few hours or it may take days or weeks in the Lower Danube. The manner of forecasting, significance, and the type of the data necessary depend on the type of the event (Figure 6).

The collaboration between the services is exemplary, well organised, particularly on a bilateral basis. An example of good collaboration is the Hydrological Information System for the Sava River Basin (Sava HIS) allowing for operational exchange of data and information of five hydrological services in the Sava River Basin. The development of methodologies and operational cooperation between services has been supported by many EU research and operational projects.

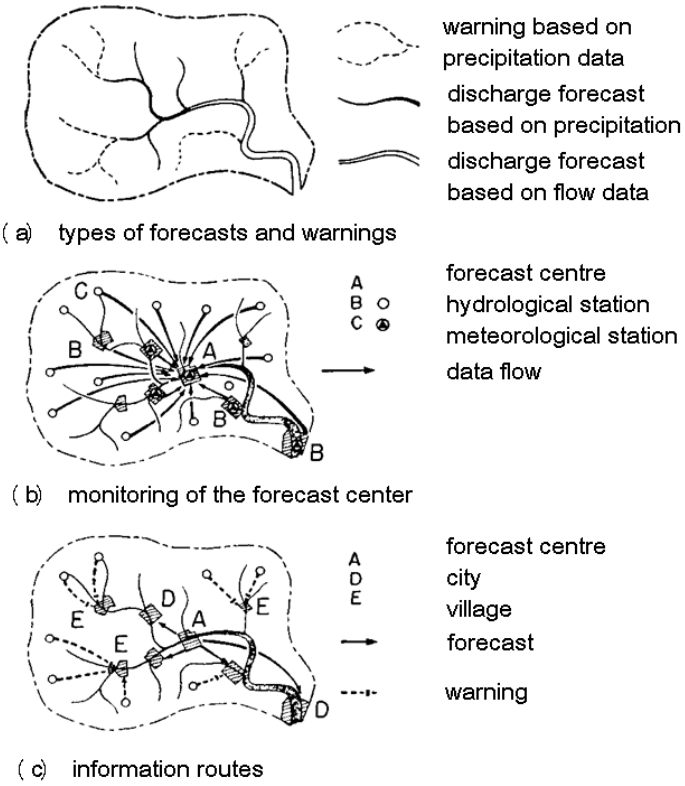

Figure 6. Types of forecasting and monitoring in a catchment (Hoyt et al., 1955)

5.2 Natural conditions and hydrological forecasting

The type and manner of forecasting are subject to natural conditions (Figure 6). The data on precipitation and water volume in the snowpack are particularly relevant in upper river reaches. Rain gauges with as short as possible time steps of data transfer are required for forecasting. Weather radar imagery, satellite imagery, and meteorological precipitation forecasts are used. Forecasting accuracy depends on meteorological data and forecasts. Unfortunately meteorological forecasts fail to achieve

the accuracy necessary for hydrological modelling. Therefore rather than publishing quantified forecasts generated by hydrological models, hydrological services issue forecasts to the public in a descriptive format. The experiences of the team plays an important role.

The forecasts in the middle and, in particular, lower part of the stream, where the water collects in the headwaters and travels along the river channel, are based on discharge data, which are known days or weeks in advance (Figure 7). The water forming a flood is already in the channels, the data are known and the forecast can be prepared using hydraulic models. Long-lasting floods significantly change the regime of groundwater, which must be considered in flood forecasting.

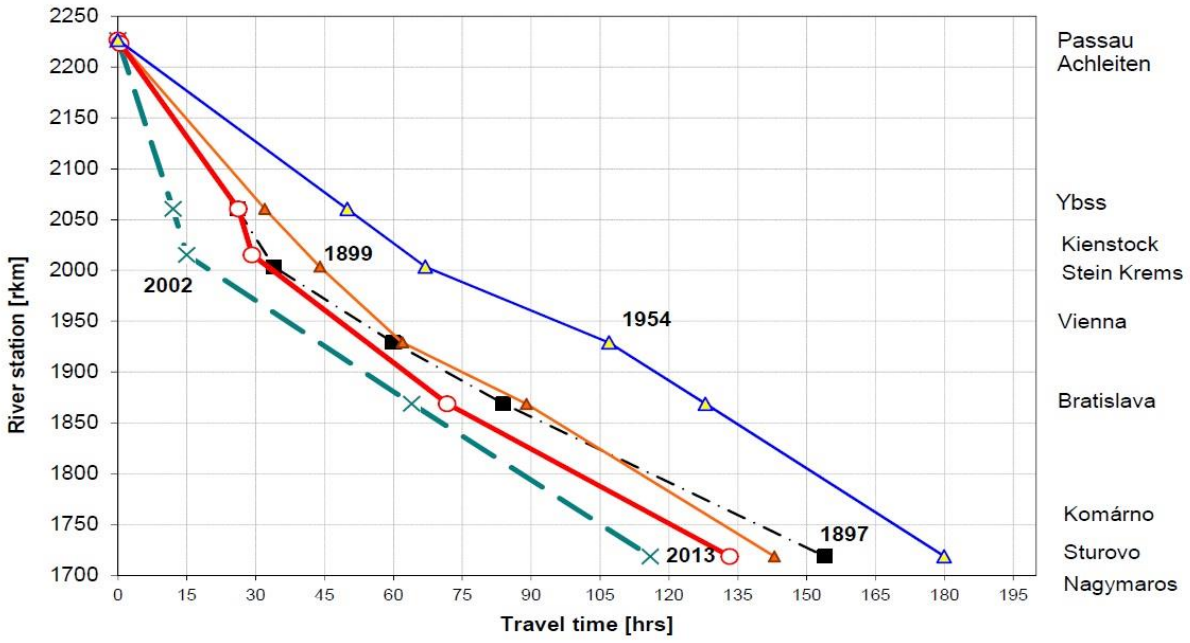

Figure 7. Travel times of the highest floods between Passau and Nagymaros. (Source: Pekárová et al., 2018)

Floods also occur in karst terrain; these floods have specific characteristics and require special attention, where the hydrology and hydraulics of the karst underground need to be considered.

Several different hydrological models are used for forecasting, including simple empirical equations, simple models using several concentrated parameters, or models using distributed parameters. The same applies to hydraulic calculations. This concerns several decades of development in individual services; the development is ongoing. Forecasting accuracy assessment is systematically undertaken only by some individual services, mostly on an occasional basis only, i.e. when looking for improvements in the service's operation or when introducing new technologies, measurements, data transfer, modelling, and similar. Systematic assessments of forecasts are only done by European Commission's Joint Research Centre (JRC) – for its EFAS forecasts, covering EU member states and associate members. In terms of forecasting accuracy assessment, the level of confidence into flash floods forecasting and forecasting of floods in the middle and lower river reaches cannot be assessed

in the same way. The reason lies in the weak reliability of meteorological forecasts, even with only 24-hour lead time.

The lead time between the forecast and the event is extremely important for implementing various measures of protection and defence against floods. The development and efforts of the services focus on prolonging the lead time using state-of-the-art information technology (Figure 8).

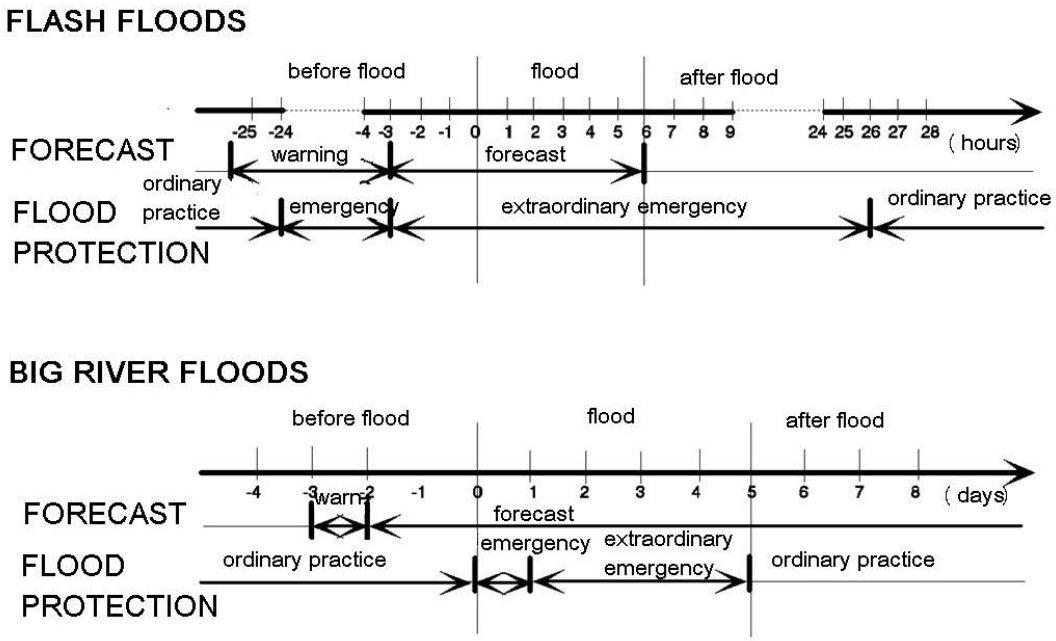

Figure 8. Forecasting and types of flood protection

5.3 Recording of meteorological and hydrological data

Actual measurements of evaporation and transpiration are taken only in some countries at few meteorological stations. Potential evaporation is measured only at some places. Soil moisture measurements are hardly taken.

Composite weather radar imagery to be used in hydrological models are not available anywhere in the river basin. Measurements of water level data, and indirectly of flows, are well developed in all hydrological services. The same applies to precipitation measurements. Over recent decades the number of observation stations has unfortunately decreased and we lost valuable information regarding the heterogeneity and dynamics of the phenomena measured. Digitalisation of historical data is lacking in all services.

The floods in the Danube river basin are mainly generated in mountainous areas in combination with snowmelt. In most countries there are no systematic measurements of water equivalent in snowpack or its spatial distribution.

On hydrological stations there are practically no systematic measurements of water flow velocity undertaken. Only water levels are measured rather than impacts of back water at estuaries of major rivers or obstacles to the water flow.

Bed load transport is hardly ever measured. Suspended solids in water are occasionally measured, however that is no subject of our report and DAREFFORT project. There are also no systematic measurements of channel morphology, with the exception of navigable waterways along the Danube and its tributaries.

5.4 Ice measurement and forecasting

Ice measurements and forecasting are done along the Danube River's main flow and its navigable tributaries, based on the recommendation adopted by the Danube Commission. In other water bodies there are some ice measurements or observations (see ICPDR Report on the ice event 2017 in the Danube River Basin). Because of the frequent problems with ice and historical floods, this services is best organised in Hungary. A review of the problems related to ice on the Danube is provided in the report "Die Donau und ihr Einzugsgebiet - Eine hydrologische Monographie, Folgeband II, Temperatur- und Eisregime der Donau und ihrer wichtigeren Zubringer", published in 1993.

In hilly headwater parts of the basin the ice build-up in the channel does not cause significant back water effect or particular problems during floods. Black ice events are dangerous because in combination with rainfall can cause catastrophic floods.

Currently the combinations of extremely rare events the so-called compound events, such as black ice and rainfall, snow cover and rainfall, are not covered adequately enough by hydrological models or forecasting protocols.

5.5 Hydrological reports on floods

Hydrological reports on floods are made per individual year and individual country, but there are almost no such reports available on the Danube Basin-wide scale. Such reports should include information how flood waves formed in the headwater part, what was their dynamics and progression along the river flow, what was the coincidence of the waves at the confluences, and what was the impact of retention. Here historical data and flood descriptions are particularly significant. The problem is also that all historical data of measurements are not in digital format and available for analysis. Without analysing historical events, which tell us where floods originate in a river basin and what is their dynamics, it is not possible to develop a proper development dynamics and determine the quantity and type of information necessary for exchange between the relevant services.

5.6 Impact of water reservoirs on floods

On the Danube River channel and its tributaries there are many dams in places, which serve various purposes, including hydropower production and water supply. All these structures dam water in the channel and, with their volume, affect the water flow. How is operation of these reservoirs included

into the work of hydrological forecasting services is not known. Data exchange is of course in place, but not also prediction of operation of the reservoirs and their impact on flow forecasts. Good example is 2012 year flood on the Drava River. .

5.7 Connections with users of hydrological forecasts

The development of services for discharge forecasting is closely related to users' needs. Flow forecasting for the main Danube River is subject to navigation needs, as international agreements and protocols on navigation have caused its intensive development after World War II. The Danube is an internationally navigable waterway; navigation largely depends on hydrological conditions, as during low water levels or during floods and ice transport on the River stops for security reasons. The Danube hydrological regime is characterised by ice which is formed in slow-flowing water. Occasionally the entire water surface freezes and the ice builds up, forming a standing ice cover or even an ice dam, which then causes damming and so-called ice floods.

Important users of the forecasts are also hydropower producers. Hydropower plant output levels depend on water availability. On the other hand hydropower plants, with their own reservoirs and power generation needs, change the water regime and affect the reliability of hydrological forecasts.

Thirdly, reservoirs are used for various water management needs, including flood and environmental protection.

The daily use of forecasts by users is highly relevant as it forces a service to improve its products, creating also political pressure to allocate funds for operation and development of the hydrological service.

5.8 Development of common forecasting

Both the Danube River Basin and its many tributaries are divided among several countries and require close operational cooperation. A good example of such collaboration is Sava HIS. To improve the operational functioning we suggest a connection between Sava HIS and Danube HIS in terms of data exchange. This is because Bosnia and Herzegovina and Montenegro are not included in the Dareffort project.

In the future it will be necessary to set up an operational platform for forecasts on the rivers Morava, Drava, Tisa, and Prut.

The European Flood Awareness System (EFAS), which provides European-wide hydrological forecasting information, developed by the Joint Research Centre, has a special significance for forecasting development. The system provides good support to hydrological services of individual countries. In any case, it will remain part of the common forecasts of forecast centres in individual countries in the future. Finally, the system supports the transfer of new meteorological an hydrological knowledge into practice.

6 Questionnaire – evaluation report

This part of the report presents the results of the analysis of the questionnaire prepared in the frame of the WP3 of the DAREFFORT project regarding hydrological and meteorological data and flood and ice forecasting methodologies in individual Danube countries. Additionally, some directions regarding education and training of personnel using e-learning tools are presented. All together 11 countries involved in the DAREFFORT project as well as International Sava River Basin Commission (ISRBC) fulfilled the questionnaire regarding hydrological data, meteorological data and/or national hydrological forecasting service. In addition, Moldova provided information about data and hydrological forecast by e-mail. Furthermore, it should be mentioned that Bosnia and Herzegovina as non-participating country supported the project by completing the questionnaire. Additionally, also the information regarding GIS data and the education and training of personnel using E-learning tools is added supporting WP3, WP4 and WP5 information gathering. The questionnaire is presented in the Attachment 2 of this report.

6.1 Hydrological data

6.1.1 Data provider information

All together 11 countries (including Bosnia and Herzegovina) and International Sava River Basin Commission (ISRBC) fulfilled the questionnaire regarding the hydrological data. Additionally, Moldova and Romania provided the information about hydrological data by e-mail. Data provider information is presented in Table 23.

Table 23: Hydrological data provider information

Country / Region	Name and e-mail	Organisation	Position
Austria (Lower Austria)	DI Franz Higer franz.higer@noel.gv.at	Department BD3 – Hydrology and Geoinformation, Office of the Lower Austrian Provincial Government	NA
Bosnia and Herzegovina	Maja Radić radic@voda.ba	Sava River Watershed Agency	Senior Associate
Bulgaria	Snezhanka Balabanova snezana.balabanova@meteo.bg	National Institute of Meteorology and Hydrology	Assoc. Prof. head of hydrological forecast
Croatia	Željka Klemar klemar@cirus.dhz.hr	Croatian Meteorological and Hydrological Service	Head of Hydrological Data Control, Archiving and Distribution Department

Czech Republic	Petr Janal petr.janal@chmi.cz	Czech hydrometeorological institute	Director of a branch in Brno
Germany	Dr. Alfons Vogelbacher alfons.vogelbacher@lfu.bayern.de	Bayerisches Landesamt für Umwelt	Leiter des Referats Hochwassernachrichtendienst, Hochwasservorhersage Donau und Inn, Gebietshydrologie
Hungary	Amarilla Mátrai matrai.amarilla@ovf.hu	General Directorate of Water Management (OVF)	Hydrological advisor
Moldova	Valeriu Cazac valeriu.cazac@meteo.gov.md	State Hydrometeorological Service	Chief of Hydrological Center
Romania	Marius Matreata marius.matreata@hidro.ro	National Insitute of Hydrology and Water Management (NIHWM)	Director National Hydrological Forecast Center
Serbia	Samir Catovic samir.catovic@hidmet.gov.rs	Republic Hydrometeorological Service of Serbia	Head of the Hydrological Analysis Department
Slovakia	Marcel Zvolenský marcel.zvolensky@shmu.sk	Slovak Hydrometeorological Institute	Hydrologist
Slovenia	Mira Kobold mira.kobold@gov.si	ARSO	Head of section
Ukraine	Oleg Skoropad som@meteo.gov.ua	UHMC	Leading Specialist
International Sava River Basin Commission (ISRBC)	Mirza Sarač msarac@savacommission.org	Secretariat of International Sava River Basin Commission	Advisor for protection against detrimental effects from waters and extraordinary impacts on the water regime

6.1.2 Hydrological network

Table 24 presents information about the number of hydrological stations in operation in the Danube River Basin as well as the number of hydrological stations in operation connected on-line and the number of hydrological stations to be considered in the Danube HIS.

Table 24: Data about hydrological network

Country / Region	Hydrological stations in operation	Connected on-line	Considered in the Danube HIS
Austria (Lower Austria)	150	NA	NA
Bosnia and Herzegovina	82	82	36
Bulgaria	66	25	6
Croatia	284	172	43
Czech Republic	153	153	2
Germany	488	488	45 (Bavaria) + 3 (Baden-Wurttemberg)
Hungary	approx. 2850 (350 main stations, 1700 operating stations and 800 other stations – flood operation or study stations)	350	46
Moldova	17	12	1
Romania	Approx. 1000	Approx. 800	30
Serbia	183	96	26
Slovakia	366	306	13
Slovenia	149	139	22
Ukraine	51	2	21
ISRBC	304 (Sava HIS, meaning BA, HR, ME, RS, SI)	195 (Sava HIS, meaning BA, HR, ME, RS, SI)	If data providers (countries) decide, all could be through Sava HIS WML2.0 web service

**NA indicates that this information is not available (not provided in the questionnaire)*

6.1.3 Flood data

Table 25 demonstrates information about the existence of historical flood event reports, as well as existence of maps with flood contour lines, and especially the existence of maps with flood contour lines of historical flood events and the corresponding year. Information about maps with flood contour lines of design floods with corresponding return periods is presented in Table 26. Table 27 presents

which other information is provided in the flood maps, namely water discharge, water level, ice impact, local flash floods or something else.

Table 25: Information about historical flood data

Country / Region	Historical flood event reports	Maps with flood contour lines	Maps with flood contour lines of historical flood events	Year
Austria (Lower Austria)	Yes	NA	Yes	2013
Bosnia and Herzegovina	Yes	Yes	Yes	2014
Bulgaria	Yes	Yes	No	NA
Croatia	Yes	Yes	Yes	2011
Czech Republic	Yes	No	No	NA
Germany	Yes	Yes	Yes	NA
Hungary	Yes	Yes	Yes	NA
Moldova	Yes	No	No	2010
Romania	Yes	Yes	Yes	NA
Serbia	Yes	Yes	Yes	2014
Slovakia	Yes	Yes	No	NA
Slovenia	Yes	Yes	Yes	NA
Ukraine	Yes	No	No	NA
ISRBC	NA	NA	NA	NA

**NA indicates that this information is not available (not provided in the questionnaire)*

Table 26: Information about maps with flood contour lines of design floods

Country / Region	Maps with flood contour lines of design floods	Return period (10, 20, 50, 100, 500, 1000, other)						
Austria (Lower Austria)	Yes				100			
Bosnia and Herzegovina	Yes		20		100	500		
Bulgaria	Yes		20		100		1000	

Croatia	Yes				100		1000	25
Czech Republic	No							
Germany	Yes							HQhäufig, HQ100 and HQextrem (1000) according to the EU floods directive
Hungary	Yes				100		1000	33
Moldova	NA							NA
Romania	Yes	10			100		1000	
Serbia	Yes				100		1000	
Slovakia	Yes				100		1000	
Slovenia	Yes	10			100	500		
Ukraine	No							
ISRBC	NA							

**NA indicates that this information is not available (not provided in the questionnaire)*

Table 27: Other information provided in the flood maps

Country / Region	**Information provided in the flood maps** (water discharge, water level, ice impact, local flash floods, other)				
Austria (Lower Austria)	water discharge	water level			
Bosnia and Herzegovina	water discharge	water level			
Bulgaria		water level			
Croatia		water level			
Czech Republic	water discharge	water level		local flash floods	
Germany					water depths
Hungary				local flash floods	water depth, flood hazard and risk

Moldova					NA
Romania					water depth
Serbia	water discharge	water level			water depth
Slovakia		water level			water velocity, water depth
Slovenia					polygons - range reached at Q100
Ukraine					NA
ISRBC					NA

**NA indicates that this information is not available (not provided in the questionnaire)*

6.1.4 Ice data

Table 28 demonstrates the information about ice data reports, namely the existence of ice event reports and information provided concerning ice events. Table 29 shows information about the existence of ice maps and information provided in the ice maps.

Table 28: Information about ice data reports

Country / Region	**Ice events reports**	**Information provided concerning ice events** (% of surface covered by ice, thickness of ice cover, duration of ice cover, other)			
Austria (Lower Austria)	No			duration of ice cover	
Bosnia and Herzegovina	Yes	% of surface covered by ice			
Bulgaria	Yes				Type of ice event
Croatia	Yes		thickness of ice cover	duration of ice cover	
Czech Republic	No			duration of ice cover	
Germany	Yes			duration of ice cover	
Hungary	Yes	% of surface covered by ice	thickness of ice cover	duration of ice cover	

Moldova	Yes		thickness of ice cover	duration of ice cover	Type of ice event
Romania	Yes	% of surface covered by ice	thickness of ice cover	duration of ice cover	
Serbia	Yes	% of surface covered by ice	thickness of ice cover	duration of ice cover	
Slovakia	Yes	% of surface covered by ice	thickness of ice cover		
Slovenia	No				
Ukraine	Yes	% of surface covered by ice	thickness of ice cover	duration of ice cover	
ISRBC	NA				

**NA indicates that this information is not available (not provided in the questionnaire)*

Table 29: Information about ice maps

Country / Region	**Ice maps**	**Information provided about ice in maps** (% of surface covered by ice, duration of ice cover, other)		
Austria (Lower Austria)	No			
Bosnia and Herzegovina	No			
Bulgaria	No			
Croatia	No			
Czech Republic	No		duration of ice cover	
Germany	No			
Hungary	Yes	% of surface covered by ice		
Moldova	No			
Romania	No			
Serbia	No			
Slovakia	No			no ice data are provided in the flood maps
Slovenia	No			
Ukraine	No			
ISRBC	NA			

6.1.5 GIS system

Information about GIS systems and coordinate systems used in individual countries are provided in Tables 30 and 31. Additionally, Table 32 provides information about parameters used to describe catchments.

Table 30: Information about GIS system

Country / Region	**GIS system** (ArcView, QuantumGIS, MapInfo, none, other)				
Austria (Lower Austria)				none	
Bosnia and Herzegovina					Esri ArcGIS
Bulgaria	ArcView				
Croatia	ArcView	QuantumGIS			
Czech Republic	ArcView				
Germany					ArcGIS
Hungary	ArcView				
Moldova					ArcGIS
Romania	ArcView	QuantumGIS			Esri ArcGIS
Serbia	ArcView				
Slovakia	ArcView				
Slovenia	ArcView		MapInfo		
Ukraine				none	
ISRBC					NA

**NA indicates that this information is not available (not provided in the questionnaire)*

Table 31: Information about coordinate system

Country / Region	**Coordinate system** (ETRS89/UTM_33N, ETRS89/UTM_34N, WGS84/Geographic, other)			
Austria (Lower Austria)			WGS84/ Geographic	
Bosnia and Herzegovina				MGI Balkans 6
Bulgaria			WGS84/ Geographic	
Croatia				HTRS96/TM

Czech Republic	ETRS89/ UTM_33N		WGS84/ Geographic	
Germany				EPSG: 31468 (DHDN/3 degree Gauss Krueger Zone 4)
Hungary			WGS84/ Geographic	
Moldova				SB
Romania			WGS84/ Geographic	Stereo 70 (National system)
Serbia		ETRS89/ UTM_34N		
Slovakia				S-JTSK Krovak East-North
Slovenia				D48/GK
Ukraine			WGS84/ Geographic	
ISRBC				NA

**NA indicates that this information is not available (not provided in the questionnaire)*

Table 32: Information about parameters used to describe catchments

Country / Region	**Parameters used to describe catchments** (elevation, land cover, geology, soil, other)				
Austria (Lower Austria)	elevation	land cover			catchment area
Bosnia and Herzegovina	elevation				river hydrography
Bulgaria	elevation	land cover		soil	
Croatia	elevation	land cover			
Czech Republic	elevation	land cover	geology	soil	slope, area, length of the valley, shape
Germany	elevation	land cover	geology	soil	
Hungary	elevation	land cover		soil	slope
Moldova	elevation	land cover	geology	soil	river hydrography
Romania	elevation	land cover	geology	soil	catchment area, slope
Serbia	elevation	land cover			area

Slovakia	elevation	land cover			area
Slovenia	elevation	land cover	geology	soil	
Ukraine	elevation				
ISRBC					NA

**NA indicates that this information is not available (not provided in the questionnaire)*

6.1.6 Data management and data formats

Table 33 provides the information about operating system of the server that collects the data from the stations in individual countries in the Danube river catchment. Additionally, Table 34 shows the information about a database the hydrological data are stored in. Table 35 demonstrates the information about data formats of individual countries used to transfer the measured values and Table 36 shows the frequency of data updating on the collecting servers of individual countries and usage of automatic and/or manual data quality control procedures. Table 37 provides the information of the time zone of data provided.

Table 33: Information about operating system of the server that collects the data from the stations

Country / Region	**Operating system of the server** (Microsoft Windows Server, Red Hat Enterprise Linux, Ubuntu Server, SUSE Enterprise Linux Server, Oracle Linux Server, Debian Linux)					
Austria (Lower Austria)	Microsoft Windows Server					
Bosnia and Herzegovina	Microsoft Windows Server					
Bulgaria						Debian Linux
Croatia	Microsoft Windows Server					
Czech Republic	Microsoft Windows Server	Red Hat Enterprise Linux			Oracle Linux Server	
Germany			Ubuntu Server	SUSE Enterprise Linux Server		
Hungary	Microsoft Windows Server					Debian Linux

Moldova	Microsoft Windows Server					
Romania	Microsoft Windows Server	Red Hat Enterprise Linux	Ubuntu Server			
Serbia	Microsoft Windows Server					
Slovakia					Oracle Linux Server	
Slovenia					Oracle Linux Server	
Ukraine						Debian Linux
ISRBC	NA					

**NA indicates that this information is not available (not provided in the questionnaire)*

Table 34: Information about a database

Country / Region	**Database** (Relational Database Management System (e.g. MS SQL Server, Oracle, PostGreSQL), other)	
Austria (Lower Austria)	Relational Database Management System (MS SQL Server, Oracle, PostGreSQL, other)	
Bosnia and Herzegovina	Relational Database Management System (MS SQL Server, Oracle, PostGreSQL, other)	
Bulgaria	Relational Database Management System (MS SQL Server, Oracle, PostGreSQL, other)	
Croatia	Relational Database Management System (MS SQL Server, Oracle, PostGreSQL, other)	
Czech Republic	Relational Database Management System (MS SQL Server, Oracle, PostGreSQL, other)	
Germany	Relational Database Management System (MS SQL Server, Oracle, PostGreSQL, other)	MySQL, (MariaDB), Oracle
Hungary	Relational Database Management System (MS SQL Server, Oracle, PostGreSQL, other)	Unique Binary Database
Moldova	NA	
Romania	Relational Database Management System (MS SQL Server, Oracle, PostGreSQL, other)	
Serbia	Relational Database Management System (MS SQL Server, Oracle, PostGreSQL, other)	
Slovakia	Relational Database Management System (MS SQL Server, Oracle, PostGreSQL, other)	

Slovenia	Relational Database Management System (MS SQL Server, Oracle, PostGreSQL, other)	
Ukraine	NA	
ISRBC	NA	

**NA indicates that this information is not available (not provided in the questionnaire)*

Table 35: Information about data formats used to transfer the measured values

Country / Region	**Data formats** (CSV, formatted TXT, HTML Document, XML, XLS, XLSX, DBF, other)							
Austria (Lower Austria)								Flat tables/binari, blobs
Bosnia and Herzegovina	CSV	formatted TXT			XLS	XLSX	DBF	
Bulgaria	CSV				XLS			
Croatia	CSV	formatted TXT						
Czech Republic	CSV	formatted TXT		XML				
Germany	CSV			XML				
Hungary	CSV	formatted TXT	HTML Document	XML			DBF	
Moldova	CSV				XLS			
Romania	CSV	formatted TXT		XML			DBF	
Serbia	CSV	formatted TXT						
Slovakia		formatted TXT						
Slovenia	CSV	formatted TXT	HTML Document	XML	XLS	XLSX	DBF	
Ukraine		formatted TXT						
ISRBC	NA							

**NA indicates that this information is not available (not provided in the questionnaire)*

Table 36: Information about the frequency of data updating on the collecting servers and existence of quality data control procedures

Country / Region	**Frequency of data updating** (once per minute, once per hour, other)			**Data control**
Austria (Lower Austria)			once per 5 minutes	No
Bosnia and Herzegovina		once per hour		Yes
Bulgaria			continuous	Yes
Croatia		once per hour		No
Czech Republic	once per 10 minutes			Yes
Germany	once per minute			Yes
Hungary		once per hour	daily	Yes
Moldova	NA			NA
Romania	once per 10 minutes	once per hour	daily	Yes
Serbia		once per hour		Yes
Slovakia			once per 15 minutes	Yes
Slovenia			10 minutes; 30 minutes	Yes
Ukraine				Yes
ISRBC	NA			NA

Table 37: Information about the time zone of data provided

Country / Region	**Time zone** (UTC, CET, EET, other)			
Austria (Lower Austria)		CET		
Bosnia and Herzegovina	UTC			
Bulgaria			EET	
Croatia		CET		
Czech Republic		CET		
Germany		CET		

Hungary		CET		
Moldova	UTC			
Romania			EET	
Serbia				UTC+1
Slovakia		CET		
Slovenia		CET		
Ukraine	UTC			
ISRBC				NA

6.1.7 National Data Exchange

Table 38 shows the information about the existence of the national data exchange, information about the restrictions on data access and frequency of the data exchange. Table 39 provides the information about the existence of public website with information about water/flood data in individual countries and URL. Additionally, Table 40 demonstrates the information about the type of data provided on the public website.

Table 38: Information about the national data exchange (procedures, restrictions, frequency)

Country / Region	**Existence of procedures for national data exchange**	**Existence of restrictions on data access**	**Frequency of the national data exchange** (Real time, hourly, daily, other)			
Austria (Lower Austria)	Yes	Yes		hourly		15 min
Bosnia and Herzegovina	Yes	Yes	Real time			
Bulgaria	Yes	Yes				3 hours
Croatia	Yes	Yes		hourly		
Czech Republic	Yes	Yes		hourly		
Germany	Yes	No	Real time			
Hungary	Yes	Yes			daily	
Moldova	Yes	Yes			daily	
Romania	Yes	Yes	Real time	hourly	daily	

Serbia	Yes	Yes			daily	
Slovakia	Yes	Yes	Real time	hourly		
Slovenia	Yes	Yes		hourly		30 min
Ukraine	Yes	Yes			daily	
ISRBC	NA	NA				NA

**NA indicates that this information is not available (not provided in the questionnaire)*

Table 39: Information about the existence of public websites with information about water/flood data and URL

Country / Region	**The existance of the public website**	**URL**
Austria (Lower Austria)	Yes	http://www.noel.gv.at/wasserstand/#/de/Messstellen
Bosnia and Herzegovina	Yes	www.voda.ba/vodostaj
Bulgaria	Yes	https://maritsa.meteo.bg/ https://arda.hydro.bg/ http://hydro.bg/
Croatia	Yes	http://hidro.dhz.hr/ http://vodostaji.voda.hr/
Czech Republic	Yes	http://hydro.chmi.cz/hpps/index.php?lng=CZE
Germany	Yes	https://www.hnd.bayern.de , https://www.gkd.bayern.de
Hungary	Yes	www.vizugy.hu www.hydroinfo.hu
Moldova	Yes	https://www.meteo.md/
Romania	Yes	http://www.inhga.ro
Serbia	Yes	https://www.hidmet.gov.rs
Slovakia	Yes	http://www.shmu.sk/en/?page=1&id=hydro_vod_all http://www.shmu.sk/en/?page=1&id=ran_sprav
Slovenia	Yes	http://www.arso.gov.si/vode/podatki/
Ukraine	Yes	https://www.meteo.gov.ua
ISRBC	NA	NA

**NA indicates that this information is not available (not provided in the questionnaire)*

Table 40: Information about the type of data provided on the public website

Country / Region	**Type of the data provided on the public website** (water level, discharge, water temperature, water quality, sediment transport, ice cover)					
Austria (Lower Austria)	water level	discharge	water temperature			
Bosnia and Herzegovina	water level					
Bulgaria	water level	discharge				
Croatia	water level	discharge				
Czech Republic	water level	discharge	water temperature			
Germany	water level	discharge	water temperature	water quality	sediment transport	
Hungary	water level	discharge	water temperature			ice cover
Moldova	water level	discharge				ice cover
Romania	water level	discharge				ice cover
Serbia	water level	discharge	water temperature			ice cover
Slovakia	water level	discharge	water temperature			ice cover
Slovenia	water level	discharge	water temperature		sediment transport	
Ukraine	water level		water temperature			
ISRBC	NA					

**NA indicates that this information is not available (not provided in the questionnaire)*

6.1.8 International Data Exchange

Table 41 provides the information about the existence of the procedures for international data exchange, the way of the exchange and the existence of the restrictions on data access. Table 42 demonstrates the updating frequency of the international data exchange.

Table 41: Information about the existence of the procedures for international data exchange, the way of the exchange and the existence of the restrictions on data access.

Country / Region	**The existence of the procedures for international data exchange**	**Type of international data excange** (web, email, other)			**Restrictions on data access**
Austria (Lower Austria)	Yes			ZRXP, csv; national hydrocodes	Yes
Bosnia and Herzegovina	Yes			FTP	Yes
Bulgaria	Yes	web		FTP	Yes
Croatia	Yes			via ftp	Yes
Czech Republic	Yes	web		FTP	Yes
Germany	Yes	web			Yes
Hungary	Yes	web	email	FTP	Yes
Moldova	Yes		email		Yes
Romania	Yes		email	FTP	Yes
Serbia	Yes			FTP	Yes
Slovakia	Yes	web		FTP server	Yes
Slovenia	Yes	web		FTP, XML	Yes
Ukraine	Yes	web	email	FTP	Yes
ISRBC	NA				

**NA indicates that this information is not available (not provided in the questionnaire)*

Table 42: Information about the updating frequency of the international data exchange.

Country / Region	**The updating frequency of the international data exchange** (hourly, daily, other)		
Austria (Lower Austria)	hourly		5 min, 15 min, 6 hours
Bosnia and Herzegovina	hourly		
Bulgaria		daily	
Croatia	hourly		
Czech Republic	hourly		
Germany			15 min (if driven by user request)

Hungary		daily	
Moldova		daily	
Romania		daily	
Serbia		daily	
Slovakia	hourly	daily	
Slovenia	hourly		30 minutes
Ukraine		daily	
ISRBC			NA

**NA indicates that this information is not available (not provided in the questionnaire)*

6.1.9 Education and training of personnel (E-learning tool)

Table 43 provides the information about the education and training of personnel using e-learning tools.

Table 43: Information about the education and training of personnel using e-learning tools.

Country / Region	**The usefulness of E-learning material**	**Recommended format for the E-learning material** standard university course format, Short synthesis presentation documents for three specific levels, other)		
Austria (Lower Austria)	NA	NA		
Bosnia and Herzegovina	Yes		Short synthesis presentation documents for three specific levels (beginner, medium, experts) with extensive collection of references to technical documents for details on different topics, and which will be also made available in electronic format	
Bulgaria	Yes	Standard university course format		
Croatia	Yes		Short synthesis presentation documents for three specific levels (beginner, medium,	

			experts) with extensive collection of references to technical documents for details on different topics, and which will be also made available in electronic format	
Czech Republic	Yes		Short synthesis presentation documents for three levels (beginner, medium, experts) with extensive collection of references to technical documents for details on different topics which will be also made available in electronic format	
Germany	No			
Hungary	Yes			Interactive e-learning presentation with Q&A
Moldova	No	NA		
Romania	Yes		Short synthesis presentation documents for three levels (beginner, medium, experts) with extensive collection of references to technical documents for details on different topics which will be also made available in electronic format	
Romania	NA	NA		
Serbia	Yes		Short synthesis presentation documents for three levels (beginner, medium, experts) with extensive collection of references to technical documents for details on different topics which will be also made available in electronic format	

Slovakia	Yes	Standard university course format		
Slovenia	Yes		Short synthesis presentation documents for three specific levels (beginner, medium, experts) with extensive collection of references to technical documents for details on different topics, and which will be also made available in electronic format	
Ukraine	Yes	Standard university course format		
ISRBC	NA	NA		

**NA indicates that this information is not available (not provided in the questionnaire)*

6.2 Meteorological data

6.2.1 Data provider information

All together 10 countries fulfilled the questionnaire regarding meteorological data. Additionally, Moldova provided the information about meteorological data by e-mail. There was no contribution regarding meteorological data from Romania. Data provider information is presented in Table 44.

Table 44: Meteorological data provider information

Country / Region	**Name and e-mail**	**Organisation**	**Position**
Austria (Lower Austria)	NA dion@zamg.ac.at	Zentralanstalt für Meteorologie und Geodynamik	NA
Bulgaria	Snezhanka Balabanova snezana.balabanova@meteo.bg	National Institute of Meteorology and Hydrolody	Assoc. Prof. head hydrological forecast
Croatia	Željka Klemar klemar@cirus.dhz.hr	Croatian Meteorological and Hydrological Service	Head od Hydrological Data Control, Archiving and Distribution Department
Czech Republic	Petr Janal petr.janal@chmi.cz	Czech hydrometeorological institute	Director of a branch in Brno

Germany	Joachim Stoermer hnd@lfu.bayern.de	Bayerisches Landesamt fuer Umwelt (LfU)	Referat 86
Hungary	Amarilla Mátrai matrai.amarilla@ovf.hu	General Directorate of Water Management (OVF)	Hydrological advisor
Moldova	Lidia Trescilo lidia.trescilo@meteo.gov.md	State Hydrometeorological Service	Chief of Meteorological Center
Serbia	Goran Mihajlovic goran.mihajlovic@hidmet.gov.rs	Republic Hydrometeorological Service of Serbia	Assistant Director for the Meteorological Observation System
Slovakia	Marcel Zvolenský marcel.zvolensky@shmu.sk	Slovak Hydrometeorological Institute	Hydrologist
Slovenia	Miha Demšar miha.demsar@gov.si	ARSO	Head of section
Ukraine	Oleg Skoropad som@meteo.gov.ua	UHMC	Leading Specialist

6.2.2 Meteorological network

Table 45 presents information about the number of meteorological stations in operation in the Danube River Basin as well as the number of meteorological stations in operation connected on-line with a forecast centre and the number of meteorological stations to be considered in the Danube HIS. Table 46 provides meteorological data information regarding the availability and frequency of updating the gridded data. The frequency of updating the measured data on the server and the time zone the data is provided is presented in Table 47. Table 48 shows the number of meteorological stations with real evapotranspiration measurements, potential evapotranspiration measurements, snowfall measurements and snow water equivalent measurements.

Table 45: Information about the meteorological network

Country / Region	**Meteorological stations in operation**	**Stations connected on-line**	**Stations considered in the Danube HIS**
Austria (Lower Austria)	130	NA	NA
Bulgaria	141	116	6
Croatia	12	12	12
Czech Republic	90	90	1
Germany	84 (LfU), additional 330 (DWD)	414	414
Hungary	appr. 300 automatic stations	appr. 300 automatic stations	14

Moldova	6	6	0
Serbia	300	28	15
Slovakia	851	271	22
Slovenia	295	113	7
Ukraine	17	0	17

**NA indicates that this information is not available (not provided in the questionnaire)*

Table 46: Information about the availability and frequency of updating the gridded data

Country / Region	**Availability of meteorological data as gridded data**	**Frequency of updating the gridded data** (once per hour, other)	
Austria (Lower Austria)	Yes		15 min
Bulgaria	No	once per hour	
Croatia	No		
Czech Republic	Yes	once per hour	
Germany	Yes		daily (with a delay of 1 to 2 days to current date)
Hungary	NA	NA	NA
Moldova	NA	NA	NA
Serbia	Yes	once per hour	
Slovakia	Yes	once per hour	
Slovenia	Yes		10 minutes
Ukraine	No	NA	NA

**NA indicates that this information is not available (not provided in the questionnaire)*

Table 47: Information about the frequency of updating the measured data on the server and the time zone the data is provided

Country / Region	**The frequency of updating the measured data on the server (**once per hour, other)		**Time zone** (UTC, CET, EET)		
Austria (Lower Austria)		5 min		CET	
Bulgaria		continuous			EET
Croatia	once per hour			CET	

Czech Republic		once per 10 min		CET	
Germany		about every 15 min		CET	
Hungary	once per hour	daily	UTC		
Moldova	once per hour		UTC		
Serbia	once per hour		UTC		
Slovakia	once per hour		UTC		
Slovenia		10 min, 30 min, 6 hours	UTC	CET	
Ukraine		once per 3 hours	UTC		

**NA indicates that this information is not available (not provided in the questionnaire)*

Table 48: Number of meteorological stations with real evapotranspiration measurements, potential evapotranspiration measurements, snowfall measurements and snow water equivalent measurements

Country / Region	**Number of meteorological stations with measurements**			
	real evapotranspiration	**potential evapotranspiration**	**snowfall**	**snow water equivalent**
Austria (Lower Austria)	0	0	120	NA
Bulgaria	2	20	367	4
Croatia	10	0	12	9
Czech Republic	0	10	80	80
Germany	none	none	82	82
Hungary	none	none	125	none
Moldova	0	2	6	6
Serbia	NA	NA	300	28
Slovakia	23	23	229	183
Slovenia	0	calculated for 70 stations	141	6
Ukraine	0	0	17	7

**NA indicates that this information is not available (not provided in the questionnaire)*

6.2.3 GIS system

Information about GIS systems and coordinate systems used in individual countries is provided in Tables 49 and 50. Additionally, Table 51 provides information about the availability of meteorological data in GIS.

Table 49: GIS systems used in individual countries

Country / Region	**GIS system** (ArcView, MapInfo, none, other)			
Austria (Lower Austria)			none	
Bulgaria	ArcView			
Croatia			none	
Czech Republic	ArcView			
Germany				ArcGIS
Hungary				HAWK (self developed)
Moldova			none	
Serbia	ArcView			
Slovakia				Visual Weather, GMT, R, Epygram, Gnuplot
Slovenia	ArcView	MapInfo		
Ukraine			none	

Table 50: Information about coordinate systems used in individual countries

Country / Region	**Coordinate system** (ETRS89/UTM_33N, WGS84/Geographic, other)		
Austria (Lower Austria)		WGS84/ Geographic	
Bulgaria		WGS84/ Geographic	
Croatia			NA
Czech Republic	ETRS89/ UTM_33N	WGS84/ Geographic	
Germany			EPSG: 31468 (DHDN/3 degree Gauss Krueger Zone 4)
Hungary			several, e.g. Mercator, WGS84

Moldova			SB
Serbia		WGS84/ Geographic	
Slovakia		WGS84/ Geographic	Lambert conformal projection
Slovenia		WGS84/ Geographic	D48/GK
Ukraine		WGS84/ Geographic	

**NA indicates that this information is not available (not provided in the questionnaire)*

Table 51: Information about the availability of meteorological data in GIS

Country / Region	**Meteorological data in GIS** (temperature, humidity, precipitation, precip. type, snow cover, air quality, other)						**other**
Austria (Lower Austria)	temperature	humidity	precipitation				
Bulgaria							none
Croatia							NA
Czech Republic	temperature	humidity	precipitation		snow cover		
Germany	temperature		precipitation				
Hungary	temperature	humidity	precipitation	precip. type	snow cover	air quality	all
Moldova	temperature	humidity	precipitation	precip. type	snow cover	air quality	
Serbia	temperature		precipitation	precip. type			
Slovakia							none
Slovenia	temperature		precipitation		snow cover		
Ukraine	temperature		precipitation	precip. type	snow cover		

**NA indicates that this information is not available (not provided in the questionnaire)*

6.2.4 Data management and data formats

Table 52 presents information about the availability of data developed by meteorological numerical forecasts, how much time in advance the meteorological forecast provide data and the frequency the modelled data are updated on the server.

Table 52: Information about the availability of data developed by meteorological numerical forecasts, how much time in advance the meteorological forecast provide data and the frequency the modelled data are updated on the server

Country / Region	**The availability of data developed by meteorological numerical forecasts**	**How much time in advance the meteorological forecast provide data** (how many hours, how many days, other)			**The frequency the modelled data are updated on the server**
Austria (Lower Austria)	Yes	48h		once per hour	
Bulgaria	Yes	72h	5 days		12 hours
Croatia	Yes	72h (ALADIN)	10 days (ECMWF)		6h (ALADIN) 12h (ECMWF)
Czech Republic	Yes	72h (ALADIN)	10 days (ECMWF)		once per 6 hours (ALADIN)
Germany	Yes		15 days		2-8 times per day
Hungary	Yes	24h	10 days	once per hour	ECMWF: twice a day, AROME: four times a day, MEANDER: once per hour
Moldova	Yes	24h	7 days		Once per 3 hours
Serbia	Yes	72-120h			two times per day
Slovakia	Yes	78h			once per 6 hours (ALADIN)
Slovenia	Yes	72h	3 days		6 hours
Ukraine	Yes		3-5 days		

6.2.5 National Data Exchange

Table 53 shows the information about the procedures for national data exchange, information about the restrictions on data access and frequency of the data exchange. Table 54 provides the information about the existence of public website with information about meteorological data in individual countries and URL. Additionally, Table 55 demonstrates the information about the type of data provided on the public website.

Table 53: Information about the national data exchange (procedures, restrictions, frequency)

Country / Region	**Existence of procedures for national data exchange**	**Existence of restrictions on data access**	**Update frequency of the data exchange** (real time, hourly, daily, other)			
Austria (Lower Austria)	Yes	Yes		hourly		
Bulgaria	Yes	Yes				3 hours
Croatia	Yes	Yes		hourly		
Czech Republic	Yes	Yes		hourly		
Germany	Yes	Yes				individual solutions
Hungary	Yes	Yes		hourly	daily	
Moldova	Yes	Yes	real time			
Serbia	Yes	Yes		hourly		
Slovakia	Yes	Yes		hourly		
Slovenia	Yes	No	real time	hourly		
Ukraine	Yes	No			daily	

Table 54: Information about the existence of public websites with information about meteorological data and URL

Country / Region	**The existance of the public website**	**URL**
Austria (Lower Austria)	Yes	http://www.noel.gv.at/wasserstand/#/de/Messstellen/Map/Niederschlag12h
Bulgaria	Yes	http://hydro.bg/
Croatia	Yes	http://meteo.hr/ http://vrijeme.hr/hrvatska1_n.xml
Czech Republic	Yes	https://www.chmi.cz
Germany	Yes	https://www.hnd.bayern.de https://www.gkd.bayern.de
Hungary	Yes	www.met.hu

Moldova	Yes	https://www.meteo.md/
Serbia	Yes	https://www.hidmet.gov.rs
Slovakia	Yes	www.shmu.sk
Slovenia	Yes	http://meteo.arso.gov.si/
Ukraine	Yes	https://www.meteo.gov.ua

**NA indicates that this information is not available (not provided in the questionnaire)*

Table 55: Information about the type of data provided on the public website

Country / Region	**Type of data provided on the public website** (air temp., humidity, precipitation, precip. type, snow cover, air quality, other)						
Austria (Lower Austria)	air temp.	humidity	precipitation				
Bulgaria			precipitation	precip. type	snow cover		
Croatia	air temp.	humidity	precipitation		snow cover		
Czech Republic	air temp.	humidity	precipitation		snow cover	air quality	
Germany	air temp.	humidity	precipitation		snow cover		wind, global radiation, air pressure
Hungary	air temp.	humidity	precipitation	precip. type	snow cover	air quality	wind
Moldova	air temp.	humidity	precipitation		snow cover	air quality	air pressure, wind speed, wind direction
Serbia	air temp.	humidity	precipitation		snow cover		
Slovakia	air temp.	humidity	precipitation		snow cover	air quality	air pressure, precipit., wind speed, wind direction
Slovenia	air temp.	humidity	precipitation	precip. type	snow cover		

Ukraine	air temp.		precipitation	precip. type	snow cover		

**NA indicates that this information is not available (not provided in the questionnaire)*

6.2.6 International Data Exchange

Table 56 provides the information about the existence of the procedures for international meteorological data exchange, the way of the exchange and the existence of the restrictions on data access. Table 57 demonstrates the updating frequency of the international meteorological data exchange.

Table 56: Information about the existence of the procedures for international meteorological data exchange, the way of the exchange and the existence of the restrictions on data access.

Country / Region	**The existence of the procedures regarding for international data exchange**	**Type of international data excange** (web, e-mail, other)			**Restrictions on data access**
Austria (Lower Austria)	Yes			ZRXP, csv; national hydrocodes	Yes
Bulgaria	Yes	web		FTP	Yes
Croatia	Yes		e-mail	via ftp	No
Czech Republic	Yes	web		FTP	Yes
Germany	Yes	web		File Transfer Server	Yes
Hungary	Yes			GTS	Yes
Moldova	Yes		e-mail	special conection	
Serbia	Yes			WWIS under WMO procedure	Yes
Slovakia	Yes			Global Telecommunication System (GTS) Inside RC LACE - OPLACE	Yes
Slovenia	Yes	web		GTS	No
Ukraine	Yes		e-mail		Yes

**NA indicates that this information is not available (not provided in the questionnaire)*

Table 57: Information about the existence of the procedures for international meteorological data exchange, the way of the exchange and the existence of the restrictions on data access.

Country / Region	**Updating frequency of the meteorological data exchange** (hourly, daily, other)		
Austria (Lower Austria)	hourly		5 min, 15 min
Bulgaria		daily	
Croatia	hourly		
Czech Republic	hourly		
Germany			real time using data download and individual solutions
Hungary	hourly	daily	
Moldova		daily	
Serbia	hourly		
Slovakia	hourly		atm. precipitation - 5 min. inside INCA bilateral agreement, others met. variable 1h - GTS
Slovenia	hourly		
Ukraine		daily	

**NA indicates that this information is not available (not provided in the questionnaire)*

6.2.7 Education and training of personnel (E-learning)

Table 58 provides the information about the education and training of personnel using e-learning tools.

Table 58: Information about the education and training of personnel using e-learning tools

Country / Region	**The usefulness of E-learning material**	**Recommended format for the E-learning material** (standard university course format, short synthesis presentation documents for three specific levels, other)		
Austria (Lower Austria)	No			
Bulgaria	Yes	standard university course format		
Croatia	Yes		Short synthesis presentation documents for three specific levels (beginner, medium, experts) with extensive collection of references to	

			technical documents for details on different topics, and which will be also made available in electronic format	
Czech Republic	Yes		Short synthesis presentation documents for three levels (beginner, medium, experts) with extensive collection of references to technical documents for details on different topics which will be also made available in electronic format	
Germany	No			
Hungary	Yes			Interactive e-learning presentation with Q&A
Moldova	NA			NA
Serbia	No			
Slovakia	Yes	standard university course format		
Slovenia	Yes		Short synthesis presentation documents for three specific levels (beginner, medium, experts) with extensive collection of references to technical documents for details on different topics, and which will be also made available in electronic format	
Ukraine	Yes	standard university course format		

**NA indicates that this information is not available (not provided in the questionnaire)*

6.3 National hydrological forecasting service

6.3.1 Contact of national hydrological forecasting service

All together 12 countries (including Bosnia and Herzegovina) fulfilled the questionnaire regarding national hydrological forecasting service. Additionally, Moldova provided the information about hydrological forecasting service by e-mail. Data provider information is presented in Table 59.

Table 59: Hydrological forecasting service information

Country	Name and e-mail	Organization	Position
Austria (Lower Austria)	Dipl.-Ing. Franz Higer franz.Higer@noel.gv.at	Office of the Lower Austrian Provincial Government, 3.1.2. Department BD3 – Hydrology and Geoinformation	NA
Bosnia and Herzegovina	Milan Blagojevic m.blagojevic@rhmazrs.com	Republic Hydrometheorogical Institute Republic of Srpska	Hydrologist
Bulgaria	Snezhana Balabanova snezana.balabanova@meteo.bg	National Institute of Meteorology and Hydrology	Assoc. Prof. head hydrological forecast
Croatia	Dijana Oskoruš oskorus@cirus.dhz.hr	Croatian Meteorological and Hydrological Service	Head od Hydrological Research, Analysis and Forecasting Department
Czech Republic	Petr Janal petr.janal@chmi.cz	Czech hydrometeorological institute	Director of a branch in Brno
Germany	Dr. Alfons Vogelbacher Alfons.Vogelbacher@lfu.bayern.de	Bayerisches Landesamt fuer Umwelt (LfU)	Hochwassernachrichtenzentrale, Hochwasservorhersage Donau und Inn, Gebietshydrologie
Hungary	Amarilla Mátrai matrai.amarilla@ovf.hu	General Directorate of Water Management (OVF	Hydrological advisor
Moldova	Valentina Ceres valentina.ceres@meteo.gov.md	SHS	Chief of Hydrological Forecasting Department
Romania	Marius Matreata marius.matreata@hidro.ro	National Institute of Hydrology and Water Management (NIHWM)	Director National Hydrological Forecast Center

Serbia	Dejan Vladikovic dejan.vladikovic@hidmet.gov.rs	Republic Hydrometeorological Service of Serbia	Coordinator of hydrological forecasts and early warnings
Slovakia	Marcel Zvolenský marcel.zvolensky@shmu.sk	Slovak Hydrometeorological Institute	hydrologist
Slovenia	Janez Polajnar janez.polajnar@gov.si	Slovenian Environment Agency (ARSO)	Head of Hydrological Forecasting Section
Ukraine	Oleg Skoropad som@meteo.gov.ua	UHMC	Leading Specialist

**NA indicates that this information is not available (not provided in the questionnaire)*

6.3.2 Collaboration with the national meteorological forecasting service

Table 60 presents data provided by the national meteorological forecasting service. Table 61 provides the information about the frequency the data are provided and the information about the availability of all-meteorological data for hydrological forecasting.

Table 60: Data provided by the national meteorological forecasting service

Country	**Data provided by the national meteorological forecasting service** (precipit., air temperat., humidity, snow cover depth, snow water equivalent, wind, other)						
Austria (Lower Austria)	precipit.	air temperat.	humidity	snow cover depth		wind	
Bosnia and Herzegovina	precipit.	air temperat.	humidity	snow cover depth	snow water equivalent	wind	
Bulgaria	precipit.	air temperat.	humidity	snow cover depth	snow water equivalent	wind	
Croatia	precipit.	air temperat.		snow cover depth			
Czech Republic	precipit.	air temperat.		snow cover depth	snow water equivalent	wind	
Germany	precipit.	air temperat.	humidity	snow cover depth	snow water equivalent	wind	global radiation, sunshine duration
Hungary	precipit.	air temperat.				wind	

Moldova	precipit.	air temperat.	humidity	snow cover depth		wind	solar radiation
Romania	precipit.	air temperat.		snow cover depth	snow water equivalent	wind	
Serbia	precipit.	air temperat.		snow cover depth		wind	
Slovakia	precipit.	air temperat.	humidity	snow cover depth	snow water equivalent	wind	all other meteorol ogical variables
Slovenia	precipit.	air temperat.	humidity	snow cover depth		wind	solar radiation
Ukraine	precipit.	air temperat.		snow cover depth	snow water equivalent	wind	

Table 61: Data provided by the national meteorological forecasting service

Country	**Frequency of the meteorological data provided for hydrological forecasting** (real time, hourly, daily, other)				**Availability of all-meteorol. data for hydrological forecasting**
Austria (Lower Austria)	real time				No
Bosnia and Herzegovina	real time	hourly	daily		
Bulgaria				12 hours	Yes
Croatia		hourly			No
Czech Republic	real time	hourly			Yes
Germany	real time				Yes
Hungary			daily		Yes
Moldova		hourly	daily		Yes
Romania	real time				Yes
Serbia	real time		daily		Yes

Slovakia	real time	hourly	daily	depends on variable and/or station	Yes
Slovenia	real time				Yes
Ukraine			daily		Yes

6.3.3 Collaboration with the neighbouring countries and international sources

Table 62 provides information about the existence of data from neighbouring countries used in the national hydrological forecasting model, the procedures for international data exchange, the frequency of data exchange and the information about the usage of data from international data sources.

Table 62: Information about the international data exchange for hydrological forecasting.

Country	**The existence of data from neighbouring countries used in the national forecasting model**	**The existence of the procedures for data exchange**	**The frequency of data exchange** (real time, hourly, daily, other)				**Usage of data from internat. data sources**
Austria (Lower Austria)	No						No
Bosnia and Herzegovina	Yes	Yes	real time	hourly	daily		Yes
Bulgaria	Yes	Yes				3 hours	Yes
Croatia	Yes	Yes		hourly			Yes
Czech Republic	Yes	Yes		hourly			Yes
Germany	Yes	Yes		hourly			Yes
Hungary	Yes	Yes			daily		Yes
Moldova	Yes	Yes			daily		NA
Romania	Yes	Yes	real time		daily		Yes
Serbia	Yes	Yes	real time		daily		Yes
Slovakia	Yes	Yes		hourly			Yes
Slovenia	Yes	Yes		hourly			Yes

Ukraine	Yes	Yes					Yes

6.3.4 Dissemination of hydrological forecasts and warnings

Table 63 shows the information about the way the national hydrological forecasts are disseminated. Table 64 provides the Information about the availability of a public website to provide information about hydrological forecasts and URL of the website. The frequency the hydrological forecast information is disseminated is presented in Table 65. Table 66 shows institutions having access to hydrological forecasts in each individual country. Responsibility of forecast service to proclaim emergency and the existence of estimation of forecast and warnings efficiency is provided in Table 67.

Table 63: Information about the way hydrological forecasts are disseminated.

Country	**The way the hydrological forecast is disseminated** (On-line, e-mail, other)		
Austria (Lower Austria)	On-line	e-mail	
Bosnia and Herzegovina	On-line	e-mail	
Bulgaria	On-line	e-mail	
Croatia	On-line		
Czech Republic	On-line	e-mail	other media
Germany	On-line		other media
Hungary	On-line	e-mail	other media
Moldova	On-line	e-mail	other media
Romania	On-line	e-mail	other media
Serbia	On-line	e-mail	other media
Slovakia	On-line		other media
Slovenia	On-line	e-mail	other media
Ukraine	On-line	e-mail	other media

Table 64: Information about the availability of a public website to provide information about hydrological forecasts and URL of the website

Country	The availability of a public wesite about hydrological forecasts	URL
Austria (Lower Austria)	Yes	NA
Bosnia and Herzegovina	Yes	www.rhmzrs.com
Bulgaria	Yes	http://hydro.bg/ https://arda.hydro.bg/ https://maritsa.meteo.bg/
Croatia	No	NA
Czech Republic	Yes	NA
Germany	Yes	https://www.hnd.bayern.de
Hungary	Yes	www.hydrionfo.hu www.vizugy.hu
Moldova	Yes	http://www.meteo.md/index.php/hidrologie/
Romania	Yes	www.inhga.ro
Serbia	Yes	https://www.hidmet.gov.rs
Slovakia	Yes	http://www.shmu.sk/sk/?page=1&id=hydro_vod_all
Slovenia	Yes	http://www.arso.gov.si/vode/napovedi/
Ukraine	Yes	https://meteo.gov.ua/ua/

**NA indicates that this information is not available (not provided in the questionnaire)*

Table 65: The frequency the hydrological forecast information is disseminated

Country	The frequency of the forecast information dissemination (hourly, more than once a day, daily, other)				Availability of data exchange server	Restrictions on accessing forecast data
Austria (Lower Austria)				6 hours	No	No
Bosnia and Herzegovina			daily		Yes	Yes
Bulgaria		more than once a day			Yes	No
Croatia	hourly	more than once a day			Yes	Yes

Czech Republic		more than once a day			Yes	Yes
Germany	hourly				No	Yes
Hungary			daily		Yes	Yes
Moldova			daily		Yes	Yes
Romania		more than once a day	daily		No	No
Serbia			daily		Yes	Yes
Slovakia		more than once a day			Yes	Yes
Slovenia			daily		Yes	Yes
Ukraine		more than once a day			Yes	Yes

Table 66: Institutions having access to hydrological forecasts

Country	**Institutions having access to hydrological forecasts** (Hydrological, meteorological and water management services, HPP operators, civil protection, rescue units and others, data are publicly available, other)					
Austria (Lower Austria)	Hydrological, meteorological and water management services		civil protection	rescue units and others	data are publicly available	
Bosnia and Herzegovina	Hydrological, meteorological and water management services					
Bulgaria	Hydrological, meteorological and water management services	HPP operators	civil protection	rescue units and others	data are publicly available	
Croatia	Hydrological, meteorological and water management services		civil protection			Agency for Inland Waterways
Czech Republic	Hydrological, meteorological and water management services	HPP operators	civil protection	rescue units and others	data are publicly available	

Germany					data are publicly available	
Hungary					data are publicly available	
Moldova	Hydrological, meteorological and water management services		civil protection	rescue units and others	data are publicly available	
Romania	Hydrological, meteorological and water management services	HPP operators	civil protection	rescue units and others		
Serbia	Hydrological, meteorological and water management services	HPP operators	civil protection	rescue units and others		
Slovakia	Hydrological, meteorological and water management services	HPP operators	civil protection	rescue units and others	data are publicly available	
Slovenia	Hydrological, meteorological and water management services	HPP operators	civil protection	rescue units and others		
Ukraine	Hydrological, meteorological and water management services		civil protection	rescue units and others		

Table 67: Responsibility of forecast service to proclaim emergency, the existence of estimation of forecast and warnings efficiency

Country	**Responsibility of forecast service to proclaim emergency**	**The existence of estimation of forecast efficiency**	**The existence of estimation of warnings efficiency**
Austria (Lower Austria)	No	No	Yes
Bosnia and Herzegovina	Yes	No	No

Bulgaria	No	No	Yes
Croatia	No	No	No
Czech Republic	No	Yes	Yes
Germany	No	Yes	Yes
Hungary	No	Yes	No
Moldova	Yes	Yes	Yes
Romania	No	Yes	Yes
Serbia	No	Yes	Yes
Slovakia	No	Yes	Yes
Slovenia	No	Yes	Yes
Ukraine	No	Yes	No

6.3.5 The process of the hydrological forecasting

Table 68 shows the information about the number of models used for hydrological forecasting, collaboration with other regions and/or countries regarding Danube-related hydrological forecasting and information about additional information used in hydrological forecasting practices in individual countries.

Table 68: Information about the process of the hydrological forecasting

Country	**No. of models used for hydrological forecasting**	**Collaboration with other regions and/or countries regarding Danube-related hydrological forecasting**	**Additional information used in hydrological forecasting practices**
Austria (Lower Austria)	2	Yes	No
Bosnia and Herzegovina	3	Yes	Yes
Bulgaria	6	Yes	Yes
Croatia	5	Yes	No
Czech Republic	3	Yes	Yes
Germany	3 (LARSIM, WAVOS, FLUX FLORIS)	Yes	Yes
Hungary	5 (OLSER, DIWA, IPOLY, RÁBA, MURA)	Yes	Yes

Moldova	0	Yes	Yes
Romania	3 - 5	Yes	Yes
Serbia	7	Yes	Yes
Slovakia	2 rainfall runoff models, 1 hydraulic model	Yes	Yes
Slovenia	5	Yes	Yes
Ukraine	9	Yes	Yes

6.3.6 Relations with stakeholders

Table 69 provides the information about the involvement of stakeholders in flood (and ice) management, preparation of the reports for the stakeholders and on which legal basis. Information about the existence of general and special requirements to fill in the reports and additional requirements/needs/wishes to be considered in the future development are presented in Table 70.

Table 69: Information about the involvement of stakeholders in flood (and ice) management, preparation of the reports for the stakeholders and on which legal basis

Country	**The involvement of stakeholders in flood (and ice) management**	**Preparation of the reports for the stakeholders**	**Legal basis** (by law, internal regulation, commercial arrangements)		
Austria (Lower Austria)	Yes	Yes		internal regulation	commercial arrangements
Bosnia and Herzegovina	Yes	Yes	by law		
Bulgaria	No	Yes	by law		
Croatia	Yes	Yes		internal regulation	
Czech Republic	Yes	Yes	by law		commercial arrangements
Germany	Yes	No			
Hungary	Yes	Yes	by law	internal regulation	commercial arrangements
Moldova	Yes	Yes	by law	internal regulation	commercial arrangements
Romania	Yes	Yes	by law	internal regulation	commercial arrangements
Serbia	Yes	Yes	by law		

Slovakia	Yes	Yes	by law		commercial arrangements
Slovenia	Yes	Yes		internal regulation	commercial arrangements
Ukraine	Yes	Yes		internal regulation	commercial arrangements

Table 70: Information about the existence of general and special requirements to fill in the reports and additional requirements/needs/wishes for the future development

Country	**The existence of general and special requirements to fill in the reports**	**The existence of additional requirements/needs/wishes for the future development**
Austria (Lower Austria)	Yes	NA
Bosnia and Herzegovina	Yes	Yes
Bulgaria	Yes	Yes
Croatia	Yes	Yes
Czech Republic	Yes	Yes
Germany	NA	NA
Hungary	Yes	Yes
Moldova	Yes	Yes
Romania	No	Yes
Serbia	Yes	Yes
Slovakia	Yes	No
Slovenia	Yes	Yes
Ukraine	No	No

**NA indicates that this information is not available (not provided in the questionnaire)*

6.3.7 Flood data

Table 71 provides the information about the existence of historical flood event reports, the existence of maps with flood contour lines, especially for historical events and for which year. Table 72 demonstrates information about the existence of maps with flood contour lines of design floods and return periods. Other information provided in the flood maps is presented in Table 73.

Table 71: Information about the existence of historical flood event reports, the existence of maps with flood contour lines, especially for historical events and for which year

Country	Historical flood event reports	Maps with flood contour lines	Flood contour lines of historical flood events	Year
Austria (Lower Austria)	Yes	Yes	Yes	2013
Bosnia and Herzegovina	Yes	Yes	Yes	2014
Bulgaria	Yes	Yes	No	NA
Croatia	Yes	Yes	Yes	NA1964, 1998, 1999, 2000, 2007, 2008, 2009, 2010, 2012, 2013, 2014
Czech Republic	Yes	No	No	NA
Germany	Yes	Yes	Yes	events of 2013, 2005, 2002, 1999 and others depending from river reaches
Hungary	Yes	Yes	Yes	NA
Moldova	Yes	Yes	No	1960 and other years
Romania	Yes	Yes	Yes	2005, 2008
Serbia	Yes	Yes	Yes	2014
Slovakia	Yes	No	No	NA
Slovenia	Yes	Yes	Yes	2010
Ukraine	Yes	No	No	NA

**NA indicates that this information is not available (not provided in the questionnaire)*

Table 72: Information about the maps with flood contour lines of design floods and return periods

Country	The exsistence of maps with flood contour lines of design floods	Return period (10, 20, 50, 100, 500, 1000, other)						
Austria (Lower Austria)	Yes				100			

Bosnia and Herzegovina	Yes	10	20	50	100	500		
Bulgaria	Yes		20		100		1000	
Croatia	Yes				100		1000	25
Czech Republic	No							
Germany	Yes							HQhäufig, HQ100 and HQextrem (1000) according to the EU floods directive
Hungary	Yes				100		1000	30
Moldova	NA							NA
Romania	Yes	10			100		1000	
Serbia	Yes				100		1000	
Slovakia	Yes	10		50	100		1000	5
Slovenia	Yes	10			100	500		
Ukraine	No							

Table 73: Other information provided in the flood maps

Country	**Other information provided in the flood maps** (water velocity, water depth, other)		
Austria (Lower Austria)	NA	NA	NA
Bosnia and Herzegovina	water velocity	water depth	
Bulgaria		water depth	
Croatia		water depth	
Czech Republic	NA	NA	NA
Germany		water depth	
Hungary		water depth	
Moldova	NA	NA	NA
Romania		water depth	

Serbia		water depth	
Slovakia	water velocity	water depth	contour lines of design flood, flood risk
Slovenia	water velocity	water depth	
Ukraine	NA	NA	NA

**NA indicates that this information is not available (not provided in the questionnaire)*

6.3.8 Perspective in development

Table 74 demonsrates the information about plans regarding modification or development of the IT system or data formats in the near future (next 3 years) as well as data measurement and collection for forecasting purposes and the information about wishes or suggestions for additional or improved cooperation with other countries.

Table 74: Information about perspectives and development

Country	**Plans to modify or develop the IT system or data formats**	**Plans to modify or develop the data measurement and collection for forecasting purposes**	**Wishes or suggestions for additional or improved cooperation with other countries**
Austria (Lower Austria)	Yes	Yes	No
Bosnia and Herzegovina	Yes	Yes	Yes
Bulgaria	Yes	Yes	Yes
Croatia	Yes	Yes	Yes
Czech Republic	Yes	Yes	Yes
Germany	Yes	Yes	No
Hungary	Yes	Yes	Yes
Moldova	Yes	Yes	Yes
Romania	Yes	Yes	Yes
Serbia	Yes	Yes	Yes
Slovakia	No	No	No
Slovenia	No	No	No
Ukraine	Yes	Yes	Yes

6.3.9 Education and training of personnel (E-learning)

Table 75 provides the information about the usefulness of online learning tools in order to solve some of the problems related to the personnel training and recommended format/structure of E-learning material.

Table 75: Information about the usefulness of online learning tools and recommended format/structure

Country	**The usefulness of online learning tools**	**Recommended format/structure of E-learning material** (standard university course format, short synthesis presentation documents for three specific levels, other)		
Austria (Lower Austria)	Yes	NA	NA	NA
Bosnia and Herzegovina	Yes	standard university course format	short synthesis presentation documents for three specific levels (beginner, medium, experts) with extensive collection of references to technical documents for details on different topics, and which will be also made available in electronic format	
Bulgaria	Yes	standard university course format		
Croatia	Yes		short synthesis presentation documents for three specific levels (beginner, medium, experts) with extensive collection of references to technical documents for details on different topics, and which will be also made available in electronic format	
Czech Republic	Yes		short synthesis presentation documents for three levels (beginner, medium, experts) with extensive collection of references to technical documents for details on different topics which will be also made available in electronic format	
Germany	No			
Hungary	Yes			Interactive e-learning presentation with Q&A

Moldova	NA	NA	NA	NA
Romania	Yes		short synthesis presentation documents for three specific levels (beginner, medium, experts) with extensive collection of references to technical documents for details on different topics, and which will be also made available in electronic format	
Serbia	Yes		short synthesis presentation documents for three levels (beginner, medium, experts) with extensive collection of references to technical documents for details on different topics which will be also made available in electronic format	
Slovakia	Yes	standard university course format		
Slovenia	Yes		short synthesis presentation documents for three specific levels (beginner, medium, experts) with extensive collection of references to technical documents for details on different topics, and which will be also made available in electronic format	
Ukraine	Yes	standard university course format;		

**NA indicates that this information is not available (not provided in the questionnaire)*

7 Attachments

List of hydrological and meteorological stations proposed for DanubeHIS by individual countries is provided in the Attachment 1. The questionnaire is presented in the Attachment 2. All national and regional reports as well as relevant documents on presented subjects in national and foreign languages are presented in the Attachment 3 of this report.