DAREFFORT

Flood forecasting and IT expert recommendations

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Introduction

In this deliverable of the DAREFFORT project flood forecasting- and IT-expert recommendations for supporting the establishment of a common data exchange system and policy are summarized.

The first chapter gives an overview about the existing data exchange systems of national data providers as well as country specific needs and requirements.

A summarization and recommendation for the implementation of a common data exchange platform based on the existing country specific systems and requirements is provided in chapter 2.

In chapters 3, 4, 5 and 6 the characteristics of the foreseen common data exchange format and system characteristics of the data exchange platform are defined.

The recommendations and requirements of the graphical user interface are described in chapter 7.

Chapter 8 provides the requirements for the user manual of the common data exchange system.

The results presented in this document have been derived and elaborated from the following main sources:

- output WP 3.1 Evaluation report on flood and ice forecasting systems and methodologies in the Danube countries (21/05/2019) and the related country fact sheets and questionnaire
- First Data Providers Conference in Vienna 04/02/2019
- Second Data Providers Conference in Bucharest 29/05/2019
- Software Developers Workshop in Vienna 06/02/2019
- technical discussions with representatives of International Commission for the Protection of the Danube River (ICPDR) and representatives of International Sava River Basin Commission ISRBC about the definition of system characteristics and data policy
- Technical Information Forms provided by the technical contact persons of DAREFFORT project in each country (see Annex 1 technical contact persons)
- discussions about the appropriate software architecture between VIZITERV and STASA based on the proposal of VIZITERV for the software architecture LAELAPS (28/11/2018) and the proposal for DAREFFORT Data Model and Data Exchange Service of STASA (01/02/2019)

The recommendations recognize the existing national and international data exchange methods by utilizing existing exchange APIs and data servers. Existing IT-systems and data formats of data providers in the different countries summarized in chapter 1 will be used as far as this is technically possible. The system characteristics on server side, running the data exchange service, are compliant to ICPDR IT-requirement, as ICPDR will be the operator of the future DanubeHIS in the long term.

The different data formats from data providers will be converted by light-weight conversion filters (plugins) which will run either on the side of the data providers pushing the data to the server or on the side of the data exchange service, pulling the data from the data providers. The conversion filters themselves are developed within the project and should be administrated by the data providers on the long term.

The provided solution uses standardization possibilities with respect to data formats, storage systems and software by using established IT-standards, e.g. Water ML 2.0, Apache Webserver, PHP. The solution will be open source and extendible in the future.

Also with respect to standardization topics and the broad acceptance of the solution, the data exchange policy should be in line with World Meteorological Organization (WMO). Resolution 40 for exchange of meteorological data and Resolution 25 for exchange of hydrological data which recognize the responsibility of the members for the security and well-being of the people of their countries, through mitigation of water-related hazards and sustainable management of water resources.

The common data exchange software service developed in DAREFFORT project is referred to as **Danube Hydrological and Meteorological Common Data Exchange Service (HyMeDES).**

The corresponding data model is called **Hydrological and Meteorological Common Data Exchange Data Model (HyMeDEM)**.

The naming reflects the purpose to exchange hydrological and meteorological data and tries to prevent confusions with other data services with different purposes.

1 Analysis of data providers' systems

Based on the country facts (WP3) and bilateral discussions the following chapters summarizes the technical capabilities for each country to deliver the data for common data exchange.

1.1 Austria

Technical capabilities

Hydrology
All data on the water cycle in Austria is collected and prepared by the Hydrographical Services at the Offices of the Provincial Governments, and processed in a summary procedure by Division I/4 –Water Budget (Hydrographical Central Office) at the Federal Ministry of Sustainability and Tourism.

Real time data from all hydrological measuring points are entered in the hydrographical database called HyDaMS. Aquisition, processing and controlling of hydrological data is be done consistent in all Provinces and in the Central Office. The Provinces as well as the Central Office are using the "Hydrographisches Daten-Management-System"
https://www.bmnt.gv.at/wasser/wasser-wasserkreislauf/hydrographische_daten/HyDaMS.html

All hydrological stations selected for DAREFFORT are connected online. The update interval for the water level, discharge and water temperature is every 30 minutes.

Information on ice periods is not available in real time, but in hydrological Yearbooks.

The data is stored in a relational data base. Unchecked data is replaced by checked data after a while.

Meteorology
Several operators run meteorological networks in Austria. Beside the Hydrological Service the Central Institute for Meteorology and Geodynamics (Zentralanstalt für Meteorologie und Geodynamik, ZAMG) and the large power station companies are to be mentioned as main network operators. Storage precipitation gauges (totalizators), non-recording gauges (ombrometers) and recording gauges (ombrographs) are used to measure precipitation.

Real time precipitation data (from the hydrographic monitoring network) are available on the internet at www.ehyd.gv.at (themes map: "aktuelle Daten"). The update interval for precipitation is 30 minutes. Grid data is not published in real time.

The data is stored in a relational data base. Unchecked data is replaced by checked data after a while.

Metadata

Metadata about each measuring station is included in the water level output file which is available via a Web-API.

Current data delivery method

Real time hydrological data

Real time hydrological data is available via web-service WFS. Technical documentation is provided in 20190213_WFS-Dienst.pdf

Current capabilities of the web-service can be retrieved by calling
http://gis.bmlfuw.gv.at/wmsgw/?key=ACCESSKEY&VERSION=1.0.0&REQUEST =GetCapabilities&SERVICE=WFS

Real time hydrological measurement data can be accessed by calling
http://gis.bmlfuw.gv.at/wmsgw/?key=ACCESSKEY &VERSION=1.0.0&REQUEST =GetFeature&SERVICE=WFS&TYPENAME=pegelaktuell

Currently via web-service WFS only water level is accessible.

Example:


```
▼<gml:featureMember>
  ▼<ms:pegelaktuell fid="pegelaktuell.157">
    ▼<gml:boundedBy>
      ▼<gml:Box srsName="EPSG:31287">
        ▼<gml:coordinates>
            564532.000000,335883.000000 564532.000000,335883.000000
          </gml:coordinates>
        </gml:Box>
      </gml:boundedBy>
    ▼<ms:msGeometry>
      ▼<gml:Point srsName="EPSG:31287">
          <gml:coordinates>564532.000000,335883.000000</gml:coordinates>
        </gml:Point>
      </ms:msGeometry>
      <ms:gid>157</ms:gid>
      <ms:dbmsnr>6001132</ms:dbmsnr>
      <ms:hzbnr>211847</ms:hzbnr>
      <ms:gewasser>Mur</ms:gewasser>
      <ms:hd>Steiermark</ms:hd>
      <ms:messstelle>Mellach (ohne Muehlkanal)</ms:messstelle>
      <ms:land/>
    ▼<ms:internet>
        http://app.hydrographie.steiermark.at/bilder/Hochwasserzentrale/HZB/Q3500.htm
      </ms:internet>
      <ms:parameter>Q</ms:parameter>
      <ms:herkunft>F</ms:herkunft>
      <ms:wert>156</ms:wert>
      <ms:zp>2015-04-20 05:30:00</ms:zp>
      <ms:typ>0</ms:typ>
      <ms:farbe>2</ms:farbe>
      <ms:datum>2015-04-20 08:05:00</ms:datum>
      <ms:symbol>3</ms:symbol>
      <ms:gesamtcode>230</ms:gesamtcode>
      <ms:old_geom/>
      <ms:geol>15,493889</ms:geol>
      <ms:geob>46,902500</ms:geob>
      <ms:wertw_cm>275.0</ms:wertw_cm>
      <ms:prognose>false</ms:prognose>
    </ms:pegelaktuell>
  </gml:featureMember>
```


For DAREFFORT an access key is provided.

The data may only be used in the project DanubeHIS. A sale to third parties is not permitted.

Real time meteorological data

Precipitation real time data is expected to be available in 2020 through the WFS web service. The data exchange format will be similar to that of the hydrological data.

Processed hydrological data

Processed hydrological data are available on the internet with the link: www.ehyd.gv.at (themes map: “Messstellen und Daten”).

Processed meteorological data

Processed meteorological data are available on the internet with the link: www.ehyd.gv.at (themes map: “Messstellen und Daten”).

Future developments

Currently there are no concrete plans for system / software improvements in the foreseeable future which could have an impact on the data exchange within the project and for DanubeHIS in the future.

1.2 Bulgaria

Technical capabilities

The National Institute of Meteorology and Hydrology (NIMH) (www.meteo.bg, http://www.hydro.bg) is a research institute of the Ministry of Education and Science and the official meteorological and hydrological service in Bulgaria. The structure of the institute is preserved - the headquarters (Sofia) and four branches (Pleven, Varna, Plovdiv and Kyustendil).

Hydrology

At NIMH the software product HYDRA has been developed. This software calculates average daily minimum and maximum water levels for the month. HYDRA also calculates the respective water quantity by the velocity-area-method as well as dynamic and geometric characteristics in the stream.

All hydrological stations selected for DAREFFORT are connected online and have an update interval of once a day for water level and discharge. The water temperature is not measured. The ice cover is visually observed near the hydrometric stations. Real time data is stored in a relational data base and available since 2001.

Meteorology

All stations selected for DAREFFORT are connected online and have an update interval of once a day for precipitation. No grid data is available. Real time data is stored in a relational data base and available since 2001.

Metadata

Information about metadata is stored in different files and needs to be combined to be used for HyMeDES.

Current data delivery method

Real time hydrological data
At the moment the most appropriate data format for exchanging the data is discussed at NIMH and it is planned to transfer the data by an FTP-Server. The access to the data to be used in HyMeDES (DanubeHIS in the future) is only given for the continuation of the main goals of the project. The usage of data currently is restricted to tasks within the project aims. The restrictions will be different for the future use, and have to be discussed.

Real time meteorological data
At the moment the most appropriate data format is discussed and it is planned to transfer the data by a FTP-Server. For real time meteorological data the same access restrictions apply as for hydrological data (see above).

Processed hydrological data
Only real time data will be provided.

Processed meteorological data
Only real time data will be provided.

Future developments

Currently there are no concrete plans for system / software improvements in the foreseeable future which could have an impact on the data exchange within the project and for DanubeHIS in the future.

1.3 Croatia

Technical capabilities

Croatian Meteorological and Hydrological Service (DHMZ) is a state administrative and a scientific research legal entity headed by a director, appointed by the government and responsible to the government. Croatian Meteorological and Hydrological Service is the official source of hydrological and meteorological data and information.

Hydrology
DHMZ is the main actor tasked with all activities on the collection, processing, archiving and distribution of hydrological data in the Republic of Croatia.

All selected stations for DAREFFORT are connected online and have an hourly updating frequency. Water temperature isn't measured at every hydrological station. The data is stored in a relational data base with no time limit. No real time ice data is available. Croatian Waters has some historical reports.

Meteorology All stations selected for DAREFFORT are connected online. The update interval of the precipitation, air temperature and snow cover is hourly. No grid data is available.

Metadata

Metadata for hydrological stations is provided via https://hidro.dhz.hr/hidroweb/skripte/hidroba-zahtml.py?funkc=puninfopost&kpost=XYZ. XYZ should be replaced by the code of the station. An example for station codes can be seen below.

STATION NAME	RIVER NAME	MSHISStCode	Internal db code
CRNAC	SAVA	3020	55
DAVOR C.S.	SAVA	3179	58
JASENOVAC	SAVA	3219	65
MAČKOVAC USTAVA	SAVA	3207	68
RUGVICA	SAVA	3096	71
SLAVONSKI ŠAMAC	SAVA	3101	73

Meteorological Metadata are available via https://meteo.hr/infrastruktura/popis_osnovne_mreze_meteoroloskih_postaja.xlsx

Current data delivery method

Real time hydrological data The data format of the hydrological data will be the same as for the exchange for SAVA HIS. It is a csv file with hourly data in the following columns:

```
Station name; Station code (MSCD_HISST); Timestamp (UTC+1); Water level (relative, cm); Discharge; Temperature
```

9999.9 is the code for missing data.

Example:

```
AKUMULACIJA PAKRA;3399;2019-08-01 09:00;327;9999.9;9999.9
AKUMULACIJA PAKRA;3399;2019-08-01 10:00;327;9999.9;9999.9
AKUMULACIJA PAKRA;3399;2019-08-01 11:00;327;9999.9;9999.9
BAČICA;2514;2019-07-31 00:00;9999.9;9999.9;9999.9
BAČICA;2514;2019-07-31 01:00;9999.9;9999.9;9999.9
BAČICA;2514;2019-07-31 02:00;9999.9;9999.9;9999.9
BAČICA;2514;2019-07-31 03:00;9999.9;9999.9;9999.9
BAČICA;2514;2019-07-31 04:00;9999.9;9999.9;9999.9
BAČICA;2514;2019-07-31 05:00;9999.9;9999.9;9999.9
```

The data is provided via ftp server every hour: ftp://radar.dhz.hr/. For the project purposes of DAREFFORT a login has been provided.

After the project the same restrictions as during the project should apply for data access.

Real time meteorological data The data format of the meteorological data will be the same as for the exchange for SAVA HIS. It is a xml file with hourly data. An example can be seen below:

```
<?xml version="1.0" encoding="UTF-8" ?>
- <data id="Croatia_latest_weather">
    <Copyright>DHMZ - meteo.hr</Copyright>
    <Copyright_URL>meteo.hr</Copyright_URL>
  - <DateTime>
      <DateValid>2019-07-29 12:00:00</DateValid>
      <DateIssued>2019-07-29 12:37:07</DateIssued>
    </DateTime>
  - <Weather>
    - <station>
      - <station_data>
          <station_id>Bjelovar</station_id>
          <station_number>14253</station_number>
          <station_name>Bjelovar</station_name>
          <lat>45.910</lat>
          <lon>16.869</lon>
          <altitude_m>141</altitude_m>
        </station_data>
      - <meteo_data>
          <temp_air_C>25.3</temp_air_C>
```


The data is provided via ftp server every hour. ftp://radar.dhz.hr/. For the project purposes of DAREFFORT a login has been provided.

After the project the same restrictions as during the project should apply for data access.

Processed hydrological data Separate csv files for each station and parameter can be produced. First line denotes parameter, second station id.

Example of water level data:
```
Vodostaj (cm)
SIFRA:;3026
2013-01-01 00:00;72
2013-01-02 00:00;32
2013-01-03 00:00;6
```

Processed data is not available online. The DHMZ is the official provider of hydrological data for Croatia and should be contacted for data reusability.

Processed meteorological data Text file can be generated for separate station and parameter. Example of precipitation data:
"." marks a day without precipitation. 0.0 marks a day with trace precipitation.

```
REPUBLIKA HRVATSKA - DRZAVNI HIDROMETEOROLOSKI ZAVOD
 KLIMATOLOSKO METEOROLOSKI SEKTOR
 ZAGREB-GRIC 3

 Postaja:  BJELOVAR
 ddmmgggg  PREC(mm)
 01012018      .
 02012018   11.6
 03012018    0.1
 04012018    0.2
```

Processed data is not available online. The DHMZ is the official provider of hydrological data for Croatia and should be contacted for data reusability.

Future developments

Implementation of WISKI7 (Water information system, Kisters AG) is planned in the next few years. Development of web services for hydrological data exchange is also recognized as a necessity and shall be considered for development in the near future.

1.4 Czech Republic

Technical capabilities

The national hydrological and meteorological service is ensured by the Czech Hydrometeorological Institute (CHMI).

Hydrology

All selected stations for DAREFFORT are connected online and have an updating frequency of once per 10 minutes for water level, discharge and temperature. The data is stored in a relational data base which has no limit of storage.

The operational discharge is derived from the consumption curve – the relationship between water level and discharge. Rating curves are prepared by hydrologists based on regular discharge measurements.

The ice cover is observed from October to April. If the water level measurement is influenced by ice, the data is labelled as influenced.

Meteorology

All stations selected for DAREFFORT are connected online. Precipitation is updated every ten minutes, air temperature, humidity and air quality hourly and snow cover once a week. The data is stored in a relational data base without a time limit.

Grid data is available. The provider is CHMI and the data covers the Czech Republic area. The data is stored in a relational data base in the data formats dbg, txt, csv. Some data is published on the CHMI website in jpg.

Metadata

Some information about gauging stations and measurement can be found for example on following webpages:

hydro.chmi.cz/hpps/hpps_prfbk_detail.php?seq=307007
hydro.chmi.cz/hpps/hpps_prfbk_detail.php?seq=307372
http://portal.chmi.cz/files/portal/docs/poboc/OS/stanice/ShowStations_CZ.html

Current data delivery method

Real time hydrological data
CHMI will export data in WaterML 2.0 format. CHMI plans to share only data that is free for use, so there will be no restrictions in the future.

Real time meteorological data
Same as for real time hydrological data (see above)

Processed hydrological data
Same as for real time hydrological data (see above)

Processed meteorological data
Same as for real time hydrological data (see above)

Future developments

Currently there are no concrete plans for system / software improvements in the foreseeable future which could have an impact on the data exchange within the project and for DanubeHIS in the future.

1.5 Germany

Technical capabilities

Hydrology
For Danube River in Germany the main responsible hydrological service is Bavarian Environment Agency LfU in Augsburg, supervised by the Bavarian State Ministry of the Environment and Consumer Protection. The LfU uses LAMP (Linux, Apache, MySQL, PHP) server systems. In Baden-Wurttemberg, the hydrological service is a unit of the State Office of Environment (Landesanstalt für Umwelt) which is subordinated to the Ministry of the Environment, Climate Protection and the Energy Sector.

The hydrological stations selected for DAREFFORT are connected online. The water level is updated once per 15 minutes, discharge and temperature range between 15 and 60 minutes. The update interval for the water quality and sediment transport also ranges between 15 and 60 minutes, but is not available via web interface.

The height of the ice and the water equivalent is measured (not all stations cover both parameters). Additionally, there are many observers who measure once a day or only during the snow season.

The hydrological real time data is stored in a relational data base. Water level and discharge is stored for one year and one month, water temperature for one month.

Meteorology
The meteorological service is the German Meteorological Service (Deutscher Wetterdienst/DWD) and is, in contrast to the hydrological service, a higher federal authority. It is within the scope of business of the Federal Ministry of Transport and Digital Infrastructure.

All stations selected for DAREFFORT are connected online and have an update interval for precipitation of once per hour.

Grid data for Germany is provided by the DWD. The binary format RADOLAN is available free of charge. The update interval is 5 minutes, hourly or total values every 24 hours. RADOLAN data for Central Europe is also available for clients. Additionally, processed data are published yearly.

The data is stored in a relational database.

Metadata

Hydrological metadata is available online:
https://www.hnd-daten.bayern.de/webservices/export.php?user=XXX&pw=XXX&pgnr=STATIONNUMBER&metainfo=1

Meteorological metadata for a particular station is automatically downloaded when precipitation data for that station is downloaded.

Current data delivery method

Real time hydrological data
Hydrological data can be retrieved by html-web-api: https://www.hnd-daten.bayern.de/webservices/export.php?user=XXX&pw=XXX&pgnr=STATIONNUMBER

Water level: web-api-parameter: “werte=W”
Discharge: web-api-parameter: “werte=Q”
Temperature: web-api-parameter: “werte=WT”

The default format of the data is csv, but data can also be retrieved as xml or zrx (text).

Following table shows an example reply of the web-api in formatted text:

Messstelle	18454003	15207507	10053009	14006000
14.08.2019 00:00	169	239	386	55
14.08.2019 00:15	171	239	386	55
14.08.2019 00:30	172	239	387	55
14.08.2019 00:45	175	239	387	56
14.08.2019 01:00	176	239	387	56
14.08.2019 01:15	177	239	388	56
14.08.2019 01:30	178	239	388	56
14.08.2019 01:45	179	239	388	56
14.08.2019 02:00	180	239	388	56
14.08.2019 02:15	180	240	388	56
14.08.2019 02:30	181	240	388	56
14.08.2019 02:45	181	240	387	60
14.08.2019 03:00	182	240	387	63
14.08.2019 03:15	183	240	386	64

For the project purposes of DAREFFORT a login has been provided.

The data will be made available to a personal user after the conclusion of a user agreement. The usage agreement is not limited to a certain period of time. It contains a list with the desired measuring points as well as the temporal extent.

Real time meteorological data

Documentation in English is available via: https://opendata.dwd.de/climate_environment/CDC/observations_germany/climate/hourly/precipitation/recent/DESCRIPTION_obsgermany_climate_hourly_precipitation_recent_en.pdf

The data can be retrieved in various ways. One option free of charge and freely accessible is via https://opendata.dwd.de. At https://maps.dwd.de, various data sets can be accessed as OGC-compliant (Open Geospatial Consortium) services. Another option is a secure supply where individual requirements are also possible.

Example for hourly precipitation for the station ID 87:

```
STATIONS_ID;MESS_DATUM;QN_8;  R1;RS_IND;WRTR;eor
         87;2018022400;    3;   0.0;   0;-999;eor
         87;2018022401;    3;   0.0;   0;-999;eor
         87;2018022402;    3;   0.0;   0;-999;eor
         87;2018022403;    3;   0.0;   0;-999;eor
         87;2018022404;    3;   0.0;   0;-999;eor
```

Processed hydrological data
Processed hydrological data is available via
https://www.hnd-daten.bayern.de/webservices/ex-port.php?user=XXX&pw=XXX&pgnr=18454003&diskr=60&layout=SPALTE&leerweg=1
For the project purposes of DAREFFORT a login has been provided.

```
Messstelle;18454003
2019-09-02 01:00:00;162,5
2019-09-02 02:00:00;171
2019-09-02 03:00:00;185,5
2019-09-02 04:00:00;190,5
2019-09-02 05:00:00;196
2019-09-02 06:00:00;197
```

The data will be made available to a personal user after the conclusion of a user agreement. The usage agreement is not limited to a certain period of time. It contains a list with the desired measuring points as well as the temporal extent.

Processed meteorological data
Information about processed meteorological data will be provided.

Future developments

It is planned to make the data available at gkd.bayern.de via an interface. There will be historical data, processed data as well as data on chemistry and biology available.

1.6 Hungary

Technical capabilities

Hydrology
Hydrology and water management issues are dealt with by General Directorate of Water Management (OVF). OVF is an independently operated and managed central budgetary authority under the Ministry of Interior. OVF coordinates and supervises the professional activities of the twelve regional Water Directorates.

All stations selected for DAREFFORT are connected online. The update interval for the water level, discharge and water temperature is once per hour.

The data is stored in a relational data base. A continuous dataset of water levels and discharge is available since 1983.

The percentage of the surface covered with ice, the thickness of the ice cover and the duration of the ice cover are typically measured from 1 December to 31 March. The ice cover is updated once per day.

Meteorology

Meteorological issues belong to the authority of Hungarian Meteorological Service (OMSZ), which operates under the Ministry of Agriculture.

All stations selected for DAREFFORT are connected online. The update interval for the precipitation, air temperature, wind speed and wind direction is once per hour and for the snow cover it is once per day.

The data is stored in a relational data base. A continuous dataset is available since 1981.

Metadata

Metadata can be found in native language via http://www.vizugy.hu/?mapModule=OpVizallas&SzervezetKod=0&mapData=VizmerceLista#mapModule. In English metadata of hydrological stations can be found in the excel document *metadata_gauging_stations.xlsx* attached to technical information form. Metadata of meteorological stations can be found in the excel document *metadata_met_stations.xlsx*.

Current data delivery method

Real time hydrological data

OVF receives data from many sources in many forms. For data exchange the FTP protocol, web, e-mail, CSV, formatted TXT, XML and DBF are the most commonly used at OVF. When it comes to sending data, OVF is able to supply data in the requested form.

Real time meteorological data

OVF receives data from the Hungarian Meteorological Service in many forms. OMSZ provides data via FTP protocol, meteorological bulletins (SYNOP, CQ) and e-mail. CSV, formatted TXT are the most commonly used data formats. OVF is going to transmit meteorological data to the DanubeHIS in the requested form.

Processed hydrological data

Processed data is available at the server of OVF and parts of the data is online at http://www.hydroinfo.hu/archivum.html.

Processed meteorological data

Processed meteorological data is available at the server of OVF and OVF is going to transmit these data to the DanubeHIS in the requested form.

Future developments

Currently there are no concrete plans for system / software improvements in the foreseeable future which could have an impact on the data exchange within the project and for DanubeHIS in the future.

1.7 Moldova

Technical capabilities

Hydrology
The State Hydrometeorological Service is a public institution subordinated to the Ministry of Environment. Its activity is regulated by the government. Administration of the Service is ensured by its director, appointed by the Government. Currently, the service has three main areas of activity: Meteorology, Hydrology and Environmental quality monitoring. The supreme governing body of the service is the Technical-Scientific Council, headed by the director of the State Hydrometeorological Service.

All twelve hydrological stations selected for DanubeHIS are connected online. The water level, discharge and the water temperature are updated every 15 minutes and data is stored continuously.
Different ice parameters are measured: the percentage of surface, the thickness of ice cover and the duration of ice cover. They are observed once in five days between November and April.

Meteorology
The following departments are included in the centre's structure: Meteorological Forecasting Centre, Centre of Meteorology and Climatology, Agrometeorological Monitoring Centre, Information Management Centre and National Meteorological Observation Network. The main tasks of the centre are the

- organization, development and methodical management of the state system of meteorological and agrometeorological observations
- elaboration of forecasts of public interest and warnings regarding unfavourable meteorological phenomena, which are regularly transmitted to the central and local public administration bodies and the mass-media services
- providing economic agents with specialized information on the basis of contracts concluded according to the scheme plans coordinated by the Ministry of Environment and others

All meteorological stations selected for DAREFFORT are connected online. The parameter precipitation, air temperature, humidity, air pressure, wind speed and wind direction are updated in real time, air quality is updated twice a day and snow cover daily.

No grid data is available.

Metadata

Metadata is available in electronic format and printed on paper.

To receive access to this data, a written request to the service administration is necessary. The provision of data for commercial purposes is performed according to Government Decision Republic of Moldova no. 330 of 03.04.2006.

Current data delivery method

Real time hydrological data
In general, real time data are transmitted in HYDRA. Real time hydrological data can be retrieved via http://hydrodata.meteo.md/index2.php.

Example:

```
Coste°ti; 25057

Labels:; Level PLS; Wather Temp; Level CBS; Accu voltage; LevelPLS SAT; LevelCBS SAT
Units:; m; °C; m; V; m; m
26.08.2019 08:10:00; 87,39; 23,90; 87,39; 13,8;  ;
26.08.2019 08:20:00; 87,39; 23,90; 87,39; 13,8; 87,39; 87,39
26.08.2019 08:30:00; 87,39; 23,90; 87,39; 13,8;  ;
26.08.2019 08:40:00; 87,39; 23,90; 87,39; 13,8; 87,39; 87,39
26.08.2019 08:50:00; 87,39; 23,90; 87,39; 13,8;  ;
26.08.2019 09:00:00; 87,39; 23,90; 87,38; 13,8; 87,39; 87,39
```

Real time meteorological data
In general, real time data are transmitted in HYDRA. Real time meteorological data can be retrieved via http://hydrodata.meteo.md/index2.php.
Example:

```
meteo Briceni; 25070

Labels:; Rain Int.; SYNOP; Radar reflec; Visibility
Units:; mm/h; -; -; m
20.08.2019 23:10:00; 0,0; 0; 0; 9999
20.08.2019 23:20:00; 0,0; 0; 0; 9999
20.08.2019 23:30:00; 0,0; 0; 0; 9999
20.08.2019 23:40:00; 0,0; 0; 0; 9999
```

Processed hydro- / meteorological data
The systematic hydrometeorological observations carried out on the territory of the Republic of Moldova for 50-100 years made it possible to generalize and publish hydrological data in the form of hydrological guides and monographs such as the "Hydrological Yearbook", the "Multiannual Data on Resources and Surface Waters" and the "State Water Cadastre". Their information shall be used for the planning and implementation of measures against the harmful effects of dangerous and hazardous phenomena and for the protection of the environment.

Processed hydrological data is available in electronic and paper format. To receive access to this data, it is necessary to write a request to the service administration. The provision of data for commercial purposes is performed according to Government Decision Republic of Moldova no. 330 of 03.04.2006.

Future developments

In the future the Republic of Moldova wants to improve the data exchange through the intervention of different international projects.

1.8 Romania

Technical capabilities

Hydrology
The National Institute of Hydrology and Water Management (NIHWM) is a public institution and a subunit of the Romanian Waters National Administration, the national authority in hydrology, hydrogeology and water management. The National Hydrological Network within the Romanian Water National Administration is administrated by the eleven Water Basin Administrations, organized based on the main River Basins as follows: Somes-Tisa, Crisuri, Mures, Banat, Jiu, Olt, Arges-Vedea, Buzau-Ialomita, Siret, Prut, and Dobrogea-Litoral.

The data that will be provided from the stations selected for the scope of DanubeHIS will be based on manual observations. During normal conditions, the water level and discharge manual observations updating frequency is once or twice a day. During flood events if the first flood defence threshold is exceeded the observation frequency is in general every three hours, and if the second flood defence threshold is exceeded the observation frequency is in general every hour.

In general, between December and February the percentage of surface covered by ice, the thickness of ice cover and the duration of ice cover are measured. The time period can differ depending on the rivers and winter.

The data is stored in a relational data base for at least one month.

Meteorology
The National Meteorological Observation Network within the National Meteorological Administration (NMA) is administrated by 7 Regional Meteorological Centres (RMC): North Transilvania (Cluj), South Transilvania (Sibiu), Banat-Crişana (Timişoara), Oltenia (Craiova), Muntenia (Bucureşti), Moldova (Iaşi) and Dobrogea (Constanţa).

Hydrological stations will be also used in the DAREFFORT project for providing the meteorological data, for the scope of DanubeHIS. This may change in the future. The update interval for precipitation and air temperature from manual observations on hydrological stations is every 12 or 24 hours.

Grid data is available as net cdf or grib files and other specific formats.

The data is stored in a relational data base for at least one month.

Metadata

Metadata is not available online. The NHWM will provide metadata as xls or csv file on the FTP-Server 82.78.133.2. For the project purposes of DAREFFORT a login has been provided.

Current data delivery method

Real time hydrological data
Real time hydrological data will be available via FTP: 82.78.133.2. For project purposes of DAREFFORT a login has been provided.

The data restrictions will correspond to the agreements with the ICPDR. Most probably data for DanubeHIS will be public data.

Real time meteorological data
Real time meteorological data will be available via the same FTP-server as real time hydrological data (see above).

Processed hydrological data
Processed hydrological data will be available via the same FTP-server as real time hydrological data (see above).

The format will be xls or csv. The processed data will be updated once a year.

Processed meteorological data
Processed meteorological data will be available via the same FTP-server as real time hydrological data (see above).

The format will be xls or csv. The processed data will be updated once a year.

Future developments

It is planned to test a web service in the future, but the FTP will be kept for the next years.

1.9 Serbia

Technical capabilities

Hydrology
RHMS of Serbia, as a special organization within the framework of state administration performs professional tasks and state administration activities. At present the RHMSS hydrological network consists of 5 regional centres. New technology is adopted during the last years for discharge and water level measurements. For hydrological data management purposes, RHMS of Serbia uses the information system WISKI (Water Information System Kisters) from Kisters.

The stations selected for DAREFFORT are all connected online. Water level, discharge, and water temperature are updated hourly.

Ice Cover percentage, thickness and duration are updated daily and they are measured from November until March.

Real time data is stored in a relational data base for the DAREFFORT project for seven days.

Meteorology

At present the RHMSS meteorological network consists of 28 principal meteorological stations, about 90 climatological stations and about 420 precipitation stations. Measuring and observation at the principal meteorological stations are performed according to the synoptic program. All principal meteorological stations are equipped with automatic weather stations and there are additionally 11 automatic weather stations.

All stations selected for DAREFFORT are connected online. The update interval for precipitation, air temperature, humidity and snow cover is once per hour. For Serbia no grid data is available.

Metadata

Metadata for hydrological stations are available on the RHMSS website via:
http://www.hidmet.gov.rs/eng/hidrologija/povrsinske/pov_stanica.php?hm_id=42010
The link is an example for the hydrological station Bezdan on the river Danube – national id = 42010.

After a detailed discussion which metadata are needed it can be provided as an excel sheet.

Current data delivery method

Real time hydrological data

Real time hydrological data will be provided via http://www.hidmet.gov.rs/korisnici/danube_his/. This is the example file danube_his_201908010700.csv:

```
SRBIJA,42010,DUNAV,BEZDAN,45.8542,18.86,47,8,1500,,,
SRBIJA,42020,DUNAV,BOGOJEVO,45.5302,19.079,104,2,2130,25.4,,
SRBIJA,42035,DUNAV,NOVI SAD,45.2551,19.8552,88,0,2343,25.0,,
SRBIJA,42045,DUNAV,ZEMUN,44.8491,20.4121,214,2,,25.0,,
SRBIJA,42050,DUNAV,PANČEVO,44.8536,20.6368,249,2,,,,
SRBIJA,42055,DUNAV,SMEDEREVO,44.6668,20.9207,440,0,3223,,,
```

No login is necessary and there will be no restrictions for future use. The best solution would be to use the same delivery method as for SAVA HIS.

Real time meteorological data

Real time meteorological data will be provided via http://www.hidmet.gov.rs/korisnici/danube_his/.

In the following the content of an example file is shown:

```
SRBIJA,13160,SOMBOR,   6.0,   18.8,        ,

State - SRBIJA,
Station ID - 13160,
Station name - SOMBOR
Amount precipitation (mm) – 6.0,
Daily mean air temperature (0C) – 18.8.,
Snow cover -
```

No login is necessary and there will be no restrictions for future use. The best solution would be to use the same delivery method as for SavaHIS.

Processed hydrological data

Historical/processed water level, discharge, water temperature and suspended sediment/sediment flow data are provided as an xls file:

Daily average				
Date	Water_Level (cm)	Discharge (m3/s)	Temperature (°C)	Sedimentation (kg/s)
01.01.2017	62	499	3,2	
02.01.2017	63	501	2,9	
03.01.2017	54	470	2,7	
04.01.2017	49	452	2,7	
05.01.2017	49	451	2,3	
06.01.2017	47	445	1,9	
07.01.2017	53	467	1,2	
08.01.2017	58	484	0,3	
09.01.2017	54	468	0,0	
10.01.2017	85	581	0,0	
11.01.2017	110	682	0,0	
12.01.2017	126	755	0,0	
13.01.2017	132	781	0,0	
14.01.2017	126	752	0,5	
15.01.2017	101	643	0,9	
16.01.2017	89	594	0,8	
17.01.2017	100	640	0,7	
18.01.2017	124	744	0,5	

Start	Water level (cm)		
Month	H_MIN_DATE	H_MIN_VALUE	H_MAX_DATE
1	06.01.2017	43	20.01.2017
2	02.02.2017	89	10.02.2017
3	31.03.2017	207	12.03.2017
4	16.04.2017	145	30.04.2017
5	31.05.2017	178	05.05.2017
6	27.06.2017	72	01.06.2017
7	28.07.2017	19	07.07.2017
8	28.08.2017	-2	05.08.2017
9	05.09.2017	-1	25.09.2017
10	24.10.2017	45	29.10.2017
11	09.11.2017	72	30.11.2017
12	11.12.2017	315	18.12.2017

Water level (cm)		
H_YEARLY	H_DATE	H_VALUE
MIN	28.08.2017	-2
MAX	18.12.2017	606
AVG		206

There is no restriction for usage.

Processed meteorological data

Historical/processed precipitation and temperature data are also provided as an xls file. There is no restriction for usage

Future developments

The Water Information System from Kisters - WISKI system will be upgraded and the Wiski Web Portal (WWP) will get implemented. Bearing in mind that the KIWIS module is an integral part of the WWP, it will be possible in the near future to export hydrological data for hydrological station in Serbia in WaterML format

1.10 Slovakia

Technical capabilities

The Slovak Hydrometeorological Institute (SHMÚ) is a specialized organization providing hydrological and meteorological services at national and international level. It is a state-subsidized organization currently operating under the Slovak Ministry of Environment. The SHMÚ obtains most of its data on the quantity and quality of air and water from various monitoring facilities of the state hydrological and meteorological network.

Hydrology
From 1989 onwards, fully automatic monitoring devices of new generation MARS (Measuring And Registration Station) were implemented. MARS stations use a pressure sensor that reads a water level which is digitally recorded.

Hydrological stations selected for DAREFFORT are all connected online. Water level, discharge and water temperature is updated every 15 minutes.

Ice cover is observed every day at 6:00 a.m. local time manually. The months are not strictly specified. Ice cover phenomena are observed when they occur.

The data is stored in a relational data base for 30 days.

Meteorology
All meteorological stations selected for DAREFFORT are connected online. The update interval of precipitation, air temperature, humidity, snow cover, air pressure, wind speed and wind direction are updated every five minutes. The current web service covers only precipitation data in one hour frequency.

Grid data will not be provided for the DAREFFORT project.

Metadata

Metadata information is provided in the word file web_services_DAREFFORT.docx, provided attached to technical information form.

Current data delivery method

Real time hydrological data
Real time data is provided by an api-server: http://www.shmu.sk/feeds/shmu.php

api= unique API key
type=hydro_data_full_15– function name: access to 15minutes full hydrological data
query=station id, if not entered, data for all (allowed) stations will return
dt=date time format in ISO 8601 *(example. 2017-06-28T08:00) – if not entered, latest available will be given*

Example:


```
▼<shmudata>
  ▼<request>
     <requestdt>2019-08-16T15:16:34+02:00</requestdt>
     <type>hydro_data_full_15</type>
     <query nil="true"/>
     <dt nil="true"/>
   </request>
  ▼<response>
    ▼<dataitem>
       <station>5085</station>
       <stationname>Zahorska Ves</stationname>
       <rivername>Morava</rivername>
       <dtmeasure>2019-08-16T15:00:00+02:00</dtmeasure>
       <waterlevel>57</waterlevel>
       <waterflow>31.75</waterflow>
       <watertemp>24.1</watertemp>
     </dataitem>
```


For the project, using data is allowed only for specified and agreed purpose: (Not agreed yet). Restriction: Not for commercial use, not for redistribution to other parties/bodies without permission.

Real time meteorological data

Real time data is provided by an api-server: http://www.shmu.sk/feeds/shmu.php

api= unique API key
type=precip_1h – function name: access to 1 hour precipitation data
query=station id, if not entered, data for all (allowed) stations will return
dt=date time format in ISO 8601 *(example. 2017-06-28T08:00)* – ***if not entered, latest available will be given***

Example:


```
▼<shmudata>
  ▼<request>
     <requestdt>2019-08-16T15:19:52+02:00</requestdt>
     <type>precip_1h</type>
     <query nil="true"/>
     <dt nil="true"/>
   </request>
  ▼<response>
    ▼<dataitem>
       <stationtype>AWSII</stationtype>
       <stationid>11805</stationid>
       <stationname>SENICA</stationname>
       <dtmeasure>2019-08-16T15:00:00+02:00</dtmeasure>
       <precip_1h>0</precip_1h>
     </dataitem>
```


For the project, using data is allowed only for specified and agreed purpose: (Not agreed yet). Restriction: Not for commercial use, not for redistribution to other parties/bodies without permission.

Processed hydrological data

It’s not planned to deliver processed hydrological data.

Processed meteorological data
It's not planned to deliver processed meteorological data.

Future developments

Currently there are no concrete plans for system / software improvements in the foreseeable future which could have an impact on the data exchange within the project and for DanubeHIS in the future.

1.11 Slovenia

Technical capabilities

Slovenian hydrological and meteorological services are organized within the Slovenian Environment Agency (ARSO). The Agency is a body of the Ministry of the Environment and Spatial Planning.

Hydrology
All stations selected for DAREFFORT are connected online. The update interval for water level, discharge and water temperature is 10 or 30 minutes.

The data is stored in the relational data base ORACLE permanently. Access to real time data through the ARSO website is for the last 30 days.

No ice data is measured.

Meteorology
All stations selected for DAREFFORT are connected online. Precipitation, air temperature, humidity, precipitation type is updated every 10 or every 30 minutes. This depends on the type of measurement station. The parameter snow cover is updated once a day.

Data is stored in the relational data base POSTGRES and ORACLE permanently. Access to real time data through the ARSO website is for the last 48 hours.

Grid data is available. Radar data are available on http://meteo.arso.gov.si/met/en/service2/ and grid periodic maps of meteorological variables on http://meteo.arso.gov.si/met/en/climate/maps/.

Metadata

Metadata is available online: http://gis.arso.gov.si/geoportal/catalog/main/home.page

Some metadata of the hydrological stations are available in files on the link http://www.arso.gov.si/vode/podatki/arhiv/hidroloski_arhiv.html

Some metadata of the meteorological stations are available through meteorological data archive http://www.meteo.si/met/en/app/webmet/#web-met==8Sdwx2bhR2cv0WZ0V2bvEGcw9ydlJWblR3LwVnaz9SYtVmYh9iclFGbt9SaulGdugXbsx3cs9mdl5WahxXYyNGapZXZ8tHZv1WYp5mOnMHbvZXZulWYnwCchJXYtVGdlJnOn0UQQdSf;

Current data delivery method

Real time hydrological data

The data is freely accessible via http://www.arso.gov.si/xml/vode/hidro_podatki_zadnji.xml. The structure of the data is described in national language in http://www.arso.gov.si/vode/podatki/opis_hidro_xml.pdf

Example:


```
▼<arsopodatki verzija="1.2">
   <vir>Agencija RS za okolje</vir>
   <predlagan_zajem>5 minut čez polno uro ali pol ure</predlagan_zajem>
   <predlagan_zajem_perioda>30 min</predlagan_zajem_perioda>
   <datum_priprave>2019-06-28 14:31</datum_priprave>
 ▼<postaja sifra="1060" ge_dolzina="16.000253" ge_sirina="46.68151" kota_0="202.34">
     <reka>Mura</reka>
     <merilno_mesto>Gornja Radgona</merilno_mesto>
     <ime_kratko>Mura - Gor. Radgona</ime_kratko>
     <datum>2019-06-28 14:00</datum>
     <vodostaj>122</vodostaj>
     <pretok>174</pretok>
     <pretok_znacilni>srednji pretok</pretok_znacilni>
     <temp_vode>21.2</temp_vode>
     <prvi_vv_pretok>600</prvi_vv_pretok>
     <drugi_vv_pretok>905</drugi_vv_pretok>
     <tretji_vv_pretok>1180</tretji_vv_pretok>
   </postaja>
 ▼<postaja sifra="1070" ge_dolzina="16.059244" ge_sirina="46.648821" kota_0="193.65">
     <reka>Mura</reka>
     <merilno_mesto>Petanjci</merilno_mesto>
     <ime_kratko>Mura - Petanjci</ime_kratko>
     <datum>2019-06-28 14:00</datum>
     <vodostaj>180</vodostaj>
     <pretok>173</pretok>
     <pretok_znacilni>srednji pretok</pretok_znacilni>
     <temp_vode>21.5</temp_vode>
     <prvi_vv_pretok>650</prvi_vv_pretok>
     <drugi_vv_pretok>965</drugi_vv_pretok>
     <tretji_vv_pretok>1250</tretji_vv_pretok>
   </postaja>
```


Publication of information and data must be cited with the information source (Source: Slovenian Environment Agency or abbreviated ARSO). Data policy for hydrological data will be as in the case for the SAVA HIS. Slovenia agrees to use the same delivery method as for SAVA HIS.

Real time meteorological data

Data is freely accessible via the web service http://www.meteo.si/met/sl/service/ in XML, RSS and HTML format.

The structure of the data is described in national language in http://meteo.arso.gov.si/uploads/meteo/help/sl/xml_service.pdf.

Example:


```
-<data id="MeteoSI_WebMet_observation_xml">
   <language>sl</language>
   <credit>Agencija Republike Slovenije za okolje</credit>
   <credit_url>http://meteo.arso.gov.si/</credit_url>
  -<image_url>
     http://meteo.arso.gov.si/uploads/meteo/style/img/logo/ARSO_vreme_blue_small.png
   </image_url>
   <suggested_pickup>25 minutes after hour</suggested_pickup>
   <suggested_pickup_period>60</suggested_pickup_period>
  -<webcam_url_base>
     http://meteo.arso.gov.si//uploads/probase/www/observ/webcam/
   </webcam_url_base>
  -<icon_url_base>
     http://meteo.arso.gov.si/uploads/meteo/style/img/weather/
   </icon_url_base>
   <icon_format>png</icon_format>
  -<docs_url>
     http://meteo.arso.gov.si/uploads/meteo/help/sl/xml_service.html
   </docs_url>
  -<disclaimer_url>
     http://meteo.arso.gov.si/uploads/meteo/help/sl/disclaimer.html
   </disclaimer_url>
  -<copyright_url>
     http://meteo.arso.gov.si/uploads/meteo/help/sl/copyright.html
   </copyright_url>
  -<privacy_policy_url>
     http://meteo.arso.gov.si/uploads/meteo/help/sl/notice.html
```


Publication of information and data must be cited with the information source (Source: Slovenian Environment Agency or abbreviated ARSO). Data policy for meteorological data will be as in the case for the SAVA HIS. Slovenia agrees to use the same delivery method as for SAVA HIS.

Processed hydrological data

Export of mean daily values of hydrological parameters and monthly extreme values is possible in xls and csv format. http://vode.arso.gov.si/hidarhiv/pov_arhiv_tab.php?p_vodotok=Sava. Some information is on the website http://www.arso.gov.si/vode/podatki/arhiv/hidroloski_arhiv.html.

Publication of information and data must be cited with the information source (Source: Slovenian Environment Agency or abbreviated ARSO). Data policy for processed hydrological data will be as in the case for the SAVA HIS. Slovenia agrees to use the same delivery method as for SAVA HIS.

Processed meteorological data

Data is available via
http://www.meteo.si/met/en/app/webmet/#web-
met==8Sdwx2bhR2cv0WZ0V2bvEGcw9ydlJWblR3LwVnaz9SYtVmYh9iclFGbt9SaulGdugXbsx3cs9mdl5
WahxXYyNGapZXZ8tHZv1WYp5mOnMHbvZXZulWYnwCchJXYtVGdlJnOn0UQQdSf;

The documentation can be found via http://www.meteo.si/uploads/meteo/help/en/razlaga_meritev.html

Publication of information and data must be cited with the information source (Source: Slovenian Environment Agency or abbreviated ARSO). Data policy for processed meteorological data will be as in the case for the SAVA HIS. Slovenia agrees to use the same delivery method as for SAVA HIS.

Future developments

Currently there are no concrete plans for system / software improvements in the foreseeable future which could have an impact on the data exchange within the project and for DanubeHIS in the future.

1.12 Ukraine

Technical capabilities

Hydrology

The modern hydrometeorological service of Ukraine is part of the State Emergency Service of the Ministry of Internal Affairs of Ukraine. It is a holistic monitoring organization that has its own network of hydrometeorological observations, representative offices in all administrative authority bodies of the state, relevant technical, technological and scientific divisions.

The observation data are channelled to the centres of forecasting in different ways: mobile communication, by telephone, by e-mail or right away on the WEB-server of UHMC. Information is transmitted in encrypted form via the WEB-server of the UHMC or through regional structural subdivisions to the FTP server of the Ukrainian Hydrometeorological Center.

Two of the 21 stations selected for DanubeHIS are connected online. The water level and water temperature are updated one to two times a day, the discharge once a day. The data is permanently stored from the date of installation.

Different ice parameter are measured: the percentage of surface covered by ice, the thickness of ice cover and height of snow on ice. Ice measurements are carried out from November to March

Meteorology

The main centre for collecting and processing meteorological information is the Ukrainian Hydromet Center, UHMC and its regional subdivisions. Used in the Forecast Centre AWP (Automated Working Place) - an automated and computerised system for processing and accumulation of meteorological information, allows to effectively and maximum quickly analyse data coming from 165 meteorological stations and meteorological posts. Since the 2000s, information is mostly stored electronically, but most of the information from the past years is in a paper form.

The meteorological stations selected for DAREFFORT are not connected online. Precipitation is measured every six hours, air temperature every three hours, precipitation type daily and snow cover daily during the period from November to March.

Metadata

Metadata is available in Excel or Word.

Current data delivery method

Real time hydrological data
The data will be available via FTP or Web API. The Login for the project purposes will be offered after the development of the method to access the selected project data. The information will be provided only to the extent agreed upon within the project, without transferring it to a third party.

Real time meteorological data
The data will be available via FTP or Web API. The Login for the project purposes will be offered after the development of the method to access the selected project data. The information will be provided only to the extent agreed upon within the project, without transferring it to a third party.

Processed hydrological data
The processed hydrological data is not available online and can be made available on request.

Processed meteorological data
The processed meteorological data is not available online and can be made available on request

Future developments

A transmission system is planned, fitting the needs of DanubeHIS. For the meteorological and hydrological stations an online connection is planned. The data format will be a text file as CSV, via FTP or web-site.

2 Data reporting recommendations and draft specifications

One main result from the questionnaire and the technical information forms is that for data exchange of real time data in the DAREFFORT project and for future DanubeHIS there will be mainly two main types of data delivery: FTP-server or Web-API.

In most countries data delivery methods which already exist for hydrological and meteorological real time data can be used, these are Austria, Croatia, Germany, Hungary, Moldova, Serbia, Slovakia, and Slovenia. In case of Austria there is an existing Web-API by which water-level can be retrieved. This Web-API will be enhanced to retrieve additional hydrological and meteorological parameters. In other countries appropriate data exchange formats will be defined, these are Bulgaria (probably FTP), Czech Republic (Water ML 2.0), Romania (FTP), and Ukraine (FTP or API).

2.1 Data exchange with providers

Real time hydrological data

Based on the results of the technical information forms for real time hydrological data it is recommended for data providers to use an FTP-Server or Web-API for the data exchange. There will be an individual conversion filter for each country (see chapter 6.3).

The minimum common update interval for the parameters is daily. For automatic stations there is a minimum common update interval of one hour. The long-term goal should be to achieve an update interval of at least one hour for the agreed parameters. Parameters exchanged by all countries are **water level, discharge** and **water temperature**.

The exchange of additional available parameters is welcomed, but from the current stage of the project not foreseeable.

Ice data can be provided analogous to the other parameters. The data model described in chapter 4 is flexible to define additional parameters. Ice data is provided on a very heterogonous level regarding periods, parameters and update intervals.

Two countries of the Sava catchment are not involved in the DAREFFORT project: Bosnia and Herzegovina, and Montenegro. One possibility would be to obtain the data of these countries via SavaHIS.

Real time meteorological data

As with hydrological data, an FTP server or a Web API is recommended for data exchange of the real time meteorological data with a request individually adapted to the country.

The data should be updated at least daily, better would be hourly. In addition to precipitation, other parameters such as air temperature and snow cover can also be provided.

Only one meteorological parameter (**precipitation)** can be delivered in all countries using the foreseen data exchange interface at the moment, which meets the draft specifications of minimal set of meteorological data foreseen to be exchanged in future DanubeHIS. Additionally, there could be a possibility to also exchange air temperature in the future because only Austria and Bulgaria do not foresee to provide this information at the moment.

Grid data is not available in each country. It is proposed to upload grid data in the existing data format. They can then be downloaded again in the same format.

An alternative way to provide meteorological real time data could be to use the GTS network (Global Telecommunication System) of WMO. WMO collects meteorological real time data within the framework of its GTS network (Global Telecommunication System). The national weather service of each country which is member of WMO sends data to WMO in BUFR format, which is a complex binary format. BUFR is an abbreviation of "Binary Universal Form for the Representation of meteorological data". A map of stations covered by WMO is shown in Figure 1.

meteorological data exchange does not cover all stations.

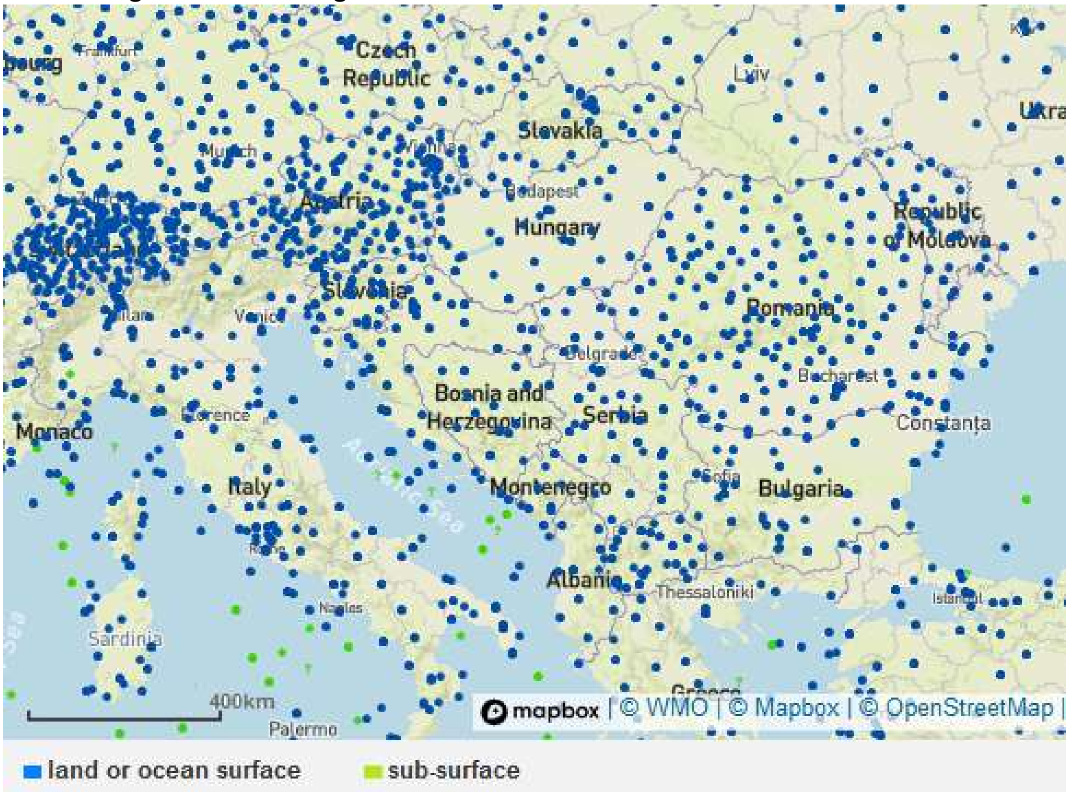

Figure 1 Map of meteorological stations covered by WMO.

Data exchange with WMO could be used as an alternative approach for gathering meteorological data. Data could be acquired either on side of data providers, which could send data to HyMeDES EnviroNet in the same way they send it to WMO, or on side of the WMO, which disseminates data sent to its GTS. Currently, WMO is setting up WIS (WMO Information System) on top of GTS to extend WMO members' ability to disseminate data.

Because it is complex and difficult to implement binary structure of the BUFR format used by WMO, it seems to be more flexible and easier to maintain to use the individual, but human readable national data exchange interfaces described above instead of GTS.

Also, meteorological stations differ from those selected for DAREFFORT project.

Processed hydrological data

Processed/historical hydrological data should be uploaded or made available on an FTP server using a defined template csv or Excel file, because most of the countries already use this method for exchanging processed data.

Processed meteorological data

Like the processed/historical hydrological data, the processed/historical meteorological data should also be uploaded as a defined template as a csv or Excel file or made available via an FTP server.

2.2 Metadata

Data to the measuring stations should either be available via the same interface as the hydrological and meteorological data or be delivered as excel or csv file. Later, individual stations can also be added manually in the graphical configuration interface of the individual conversion filters.

2.3 Data storage and dissemination

Duration of persistent storage of real time data

Currently regular practice is to publish processed data once a year. Therefore the duration of storage of the real time data should be at least one year to avoid temporary data gaps in the database as far as possible. On the other hand, real time / unprocessed data should not be available indefinitely, because of possible data incorrectness.

Duration of persistent storage of processed data

For the processed data an unlimited collection and storage of the data is proposed.

Dissemination of data

The technical aspects of data deliverable formats and software interfaces will be described in chapters 3 and 4 below.

The concrete data policy recommendations of DAREFFORT project will be part of deliverable 4.1.2 (Recommendations by data policy discussions*)*.

3 Conceptual common data exchange model HyMeDEM

This chapter describes **HyMeDEM,** the **Hy**drological and **Me**teorological Common **D**ata **E**xchange Data **M**odel, developed in DAREFFORT.

The data exchange model conceptually covers two different types of data:

- hydrological data
- meteorological data

Exchanged data are time series of observed properties falling in one of these two categories. Metadata associated with time series is also specified in common data exchange model.

Data exchange between data providers and data receivers is accomplished by collecting real time and processed data from the data providers on a regular basis using their native data formats and storing it in a database on a central server. The central server is called distribution node. For data transfer between national data providers and the distribution node individual conversion filters will be implemented using an appropriate API (see chapter 6).

Data receivers query the distribution node for data they need and get it in harmonized WaterML 2.0 format. Data providers can either send data to the distribution node, or the distribution node acquires it from data provider server. More specific details on the process of collecting data from data providers are covered in section 6.

Data exchange model does not prescribe the format in which data is provided by data providers. Instead, it is converted by the HyMeDES Environet system. On the other side, data exchange model defines the format data is output from the system to data receivers. On this way harmonization of data formats is accomplished in input filters of the system. Data is stored in a database in a harmonised way and disseminated in a standardised format using the OGC standard WaterML 2.0.

The sensor observation service (SOS) of OGC, and the related sensor modelling language (SensorML) are not used in the HyMeDES Environet platform because of the following main reasons:

SOS service has available implementations in Java, C++, Perl- and Python. There is no implementation of SOS in PHP/Javascript available, which are the recommended implementation languages for HyMeDES Environet because of its light weight structure. Therefore, SOS would have to be implemented in PHP/Javascript from ground, which would be a huge and complex effort. For example, besides the WaterML 2.0 dissemination format it is mandatory for SOS to also provide data in an additional O&M based XML format different from WaterML.

Whereas SensorML format and SOS are tailored for accessing sensor data directly, HyMeDES Environet will have to access time series in the format provided by the national data providers, and also processed data provided in csv-tables, which not only contain sensor values but also more complex data structures, e.g. min-/max-ranges. Therefore significant modifications to the standards of SensorML would have to be made. Furthermore, an important goal is to support data providers by using the data formats and APIs they offer without requiring them to develop new interfaces. Data providers of the DAREFFORT project do not transfer sensor data using SOS. For meta data, a web interface is implemented which uses conversion filters to convert meta data to internal database, so there is no need for SOS on this side.

Because of these aspects it seems to be more appropriate to implement data exchange methods and an API tailored to the requirements of DanubeHIS, than to adjust and enhance SOS/SensorML, which does not fit the requirements out of the box.

Hydrological and meteorological observed properties agreed to exchange according to "ICPDR Policy on the exchange of hydrological and meteorological data" (Annex B) are:

- water level
- river discharge
- water temperature
- precipitation

Exchanged data consist of real time data in hourly interval and processed data in daily interval. Data exchange model is prepared to include further observed properties and statistical time intervals as they may be needed in future.

Data exchange model falls in two parts: **Database model** which covers storage of harmonized data on a central server, the distribution node, and **output format model** which covers dissemination of data to data receivers. Both parts of the model are specified in the next chapters.

4 Data Base Model

The purpose of the described database is storage of hydrological and meteorological time series data. There are monitoring points (measuring stations) at which observed properties are measured. The monitoring points and observed properties with their attributes are also stored in the data base. Additionally, there are attributes and tables which do not directly serve the purpose of storing time series data but are intended as optional extensions to complete the database. They will be useful for daily work of hydrologists and meteorologists and for possible display on a web site.

The database consists of two different schemas: *hydro* schema and *meteo* schema for hydrological measurements and meteorological measurements respectively. There may be more schemas, for example for administrative purposes, user rights management and conversion filter configuration. The latter are not scope of this document. The software used to implement the database is PostgreSQL with PostGIS extension installed.

The hydro schema consists of 11 tables, the meteo schema has 7 tables. In both schemas, the main entity is *monitoring_point*. It stores all meta data of water gauge stations and meteorological stations. Each station has a list of observed properties it measures and sends to the system (like water level or precipitation). The list of observed properties of a monitoring point, along with statistical data, is stored in the relation *monitoring_point_observed_property* (a m:n relation). A list of observed properties is stored in the entity *observed_property*. Any monitoring point can have any number of observed properties which it measures. Minimum and maximum values for each station and each observed property are also stored in the *monitoring_point_observed_property* table. This design allows for easy addition of observed properties.

Each monitoring point has an international code used to identify it, which consists of a country code, the national code and a suffix which denotes whether it is a hydrological or a meteorological monitoring point. The suffix serves to distinguish between monitoring points in case a monitoring point offers hydrological properties as well as meteorological properties. In this case, the monitoring point is stored as both, as a hydrological and as a meteorological monitoring point.

For each monitoring point and each observed property there is exactly one time series which contains all measured data. Processed data (yearbook data / verified data) is distinguished from real time data by using a different name of the observed property. The naming scheme is described in detail in section "Observed property naming scheme". It was chosen to be easy to use and flexible for extensions.

Each time series has a *result_time* attribute. Forecasted data is identified by the result time. Result time is the time the data was processed last (as opposed to phenomenon time, which is the time the data refers to). If the phenomenon time of a data pair (the time and observed value) is in the future of the result time, it is a forecasted value acquired from a simulation at result time. The actual data pairs of the time series are stored in the entity *result*. Forecasted data is overwritten as observed data gets available.

Along with time series data it is foreseen to store results of discharge calibration measurements in the hydro schema. Discharge calibration measurements are used to calibrate the river discharge measurement at the location of the water gauge station.

Generally, enumerable properties like the station classification or bank of river are stored in its own entity as human-readable strings, associated to an index which is used to refer to the property (i.e. it is an 1:n relation). All human-readable strings are in English language and encoded in UTF-8.

All times and dates are stored as timestamps and consist of a date and a time in UTC. The UTC offset of a monitoring point, and thus the offset of all times in time series associated with that monitoring point, is specified in the field *utc_offset* of *monitoring_point*.

Elevations above sea level like the z coordinate of a monitoring station or the gauge zero (for hydrological stations) and altitude (for meteorological stations) are relative to a reference which is specified in *vertical_reference* in *monitoring_point*. There are various vertical reference systems used in the Danube basin. An example of a reference system is European Vertical Reference Frame 2007 (EVRF2007).

The flood warning levels stored for a water gauge station do only have a local meaning, as there is no common standard on flood warning. Warning levels are stored for reference only. Interpretation is different from country to country. There may be any number of warning levels.

Logging of changes in the database (with dates and who changed it) is done separately from the data base. Storing configuration of conversion filters and user access rights is not in the scope of this data model.

Documents and images of monitoring points are not stored in the data base.

Separation of meteorological and hydrological monitoring points and data was chosen to enhance consistency of data base. The design avoids inconsistent states like a meteorological monitoring point having warning levels, or a discharge measurement done at a meteorological monitoring point or hydrological monitoring points measuring meteorological observed properties. A combined monitoring point is entered in both schemas, as a hydrological and meteorological monitoring point.

4.1 Observed property naming scheme

The name of an observed property is just a string which in principle can be chosen freely. To have a common scheme throughout the whole data base and for the WaterML files disseminated to data receivers a convention for naming observable properties is specified in this section.

The observed property name consists of three components separated by an underscore (“_”). The first component is the symbol of the observed property, the second is its statistical characterization and the third component is the statistical aggregation time interval. Components two and three can be omitted which designates the current value (instantaneous measurement) of the observed property.

Each observed property is either real time or processed, which is indicated by a flag.
The first component of the observed property name is the symbol of the observed property. The symbol is case-sensitive. In the following table symbols for observed properties are defined. Symbols and units follow the recommendations of WMO specified in the document “Guide to hydrological practices”. Please note that the symbols are case-sensitive.

Symbol	Meaning and unit of measurement
h	Water level [cm]
Q	River discharge [m³/s]
tw	Water temperature [°C]
Ag	Ice coverage [%]
dg	Ice thickness [cm]
Dn	Ice cover duration [day]
P	Precipitation [mm]
ta	Air temperature [°C]
U	Relative humidity (moisture) [%]
p	Atmospheric pressure [hPa]
R	Solar radiation [W/m²]
E	Evaporation [mm]
dn	Snow depth [cm]
wn	Snow water equivalent [mm]

The symbol may be followed by the statistical characterization of the observed property which is the second component of observed property name. If statistical characterization is omitted, the observed property is the current / instantaneously measured value. Defined statistical characterization strings and their meanings are shown in the following table.

Statistical characterization string	Meaning
min	Minimum value
max	Maximum value
mean	Mean / average value
median	Median value / 50th percentile
total	Integrated sum / total value
	Current value

If there is a statistical characterization of the observed property, the aggregation time interval must follow. The aggregation time interval is the time interval the statistical characterization refers to. This forms the third component of the observed property name. Predefined time interval strings with their meanings are shown in the following table.

Time interval string	Meaning
hourly	One hour
hhourly	Half an hour
qhourly	Quarter of an hour

Time interval string	Meaning
minute	One minute
5minutes	Five minutes
daily	One calendar day
monthly	One calendar month
annual	One calendar year

The naming scheme was arranged to allow users and data providers a maximum of flexibility on defining observed properties they want to provide. The observed property names are easy to read by humans and aimed to be self-explanatory. Arrangement of the components ensures that data receivers can request observed properties using a simple wildcard scheme. Some examples follow:

Observed property name	Meaning
h	Current water level (instantaneous measurement)
Q_mean_daily	Daily mean of river discharge
tw	Current water temperature
tw_max_hhourly	Maximum value of water temperature within 30 minutes
Q_max_annual	Maximum discharge within one year
h_min_annual	Minimum water level within one year
h_mean_monthly	Monthly average of water level
P_mean_annual	Average precipitation within one year

4.2 Description of tables

Hydro schema

In this section the tables (mainly entities) in the hydro schema for hydrological measurements are described. Detailed specifications of all attributes can be found in the section "Attribute and table reference for hydrological data".

hydro.monitoring_point (entity)

This table is the central table of hydro schema. All data characterizing a water gauge station are stored as attributes in this table. Each station has a classification. The classification can be used to store whether it is a regular station or a project station of some special project. The classification points to the table *hydro.station_classification*, in which it resolves to a human-readable string.

Each water gauge station is located on the specified side of a river or on a bridge. Information on the operator of the station is stored as a reference to a separate entity *hydro.operator*. The European code, which links it to the stations stored in the DanubeGIS database, is stored along with the local national code of the station. The European code is built by prepending the national code with the country code (according to ISO 3166-1 ALPHA-2). The appended suffix "_HYDRO" separated with an underscore denotes that it is a water gauge station.

Each water gauge station can be characterized by its coordinates in the coordinate reference system EPSG 4326 (WGS 84) as longitude and latitude in decimal degrees. The coordinates x and y are official ones which may diverge slightly from the real position on a map. For displaying the station on a map, the attribute coords is used if it is specified. If it is NULL, the official coordinates are used. Each water gauge station has a vertical reference which is used to define the sea level relative to which its z coordinate and gauge zero are specified.

Observed properties like water level and discharge, which are measured by the water gauge station, are stored as a m:n relation in the table *hydro.monitoring_point_observed_property*. There may be any number of observed properties per station. Minimum and maximum values of that property at that station and the corresponding times of occurrence are also stored in the *hydro.monitoring_point_observed_property* table. Further statistical data, like percentiles, are not stored in the database.

Measured data pairs are grouped in time series (table *hydro.time_series*) which relate the data pairs to the observed property and the water gauge station at which they were observed.

hydro.observed_property (entity)
This is the second important table of the hydro schema. It stores a list of observed properties like water level and discharge. An observed property is defined by its name, a human readable description and the unit it is measured in. The name of the observed property is a string which has the form specified in section "Observed property naming scheme".

Only hydrological properties (including ice data) are stored in the observed property list of the hydro schema. For monitoring points also measuring meteorological properties, a separate entry for the monitoring point is added to the meteo schema.

All observed properties are stored as time series data, and additional bookkeeping is done of minimum and maximum values per monitoring point and observed property. For example, if the property under consideration is *Q_max_annual*, annual maximum values are stored in a time series for each water gauge station, and the total maximum value over all years for a water gauge station is stored in the table *monitoring_point_observed_property*.

As a definition, the associated timestamp for an observed property which covers a time interval (like a month) is at the beginning of the time interval. An annual value for discharge for the year 2019 has the timestamp 1st Jan 2019 00:00:00 UTC. Times for years, months and days are set to midnight in UTC, while timestamps for values with time intervals below a day have their real start time in UTC.

hydro.station_classification (entity)
This table is a list of possible classifications of water gauge stations. Classifications may be defined as needed, for example, stations may be classified whether they are regular stations of the measuring net or stations belonging to some project (project stations). Classifications are human-readable strings.

hydro.bank (entity)
Here the possible locations of a water gauge station relative to the river are specified. Possible locations are the strings “left”, “right” and “bridge”. “left” and “right” are relative to downstream direction of the river, “bridge” is used if the station is on a bridge or an island.

hydro.operator (entity)
This table defines all organizations operating water gauge stations. An operator is characterized by its official name and address. International phone number and e-mail address of the contact person responsible for operating the stations are specified. It is possible to store the URL to official homepage of the operating organization and other information. All attributes are human-readable strings.

hydro.time_series (entity)
This table has a list of all hydrological time series in the schema. A time series is a coverage of observations of a certain property (like water level). For each water gauge station and observed property there is exactly one time series. Time series are not split. All observations of a certain property at a certain water gauge station are in one time series.

Time series entity holds all data common to all data pairs in the series. This is the water gauge station at which the data pairs were observed, the property that was observed, the phenomenon time, start and end of the time series (these are the times of the observations) and the result time (this is the time when the time series was last updated). Usually, the result time is the same as phenomenon time end. This should be the case for real time data. If the result time is after the phenomenon time end, data is processed, and the result time specifies time of processing. If the result time is earlier than the phenomenon time end, all data after result time is forecasted and the result time is the time the forecast was done.

Data pairs belonging to a time series are assembled in table *hydro.result*.

hydro.result (entity)
This table holds all values and timestamps for all observed hydrological properties. This includes real time data, processed data and forecasts. Each data pair belongs to a time series, which is a reference to the table *hydro.time_series*.

The time of observation is specified in UTC. If the observed property covers a certain time interval, the associated timestamp is set on the beginning of the time interval. For observed properties which cover an interval as long as or longer than a day, the time part of the timestamp is set to midnight in UTC. See also the rules in the description of *hydro.observed_property*.

A value may be NULL to characterize a missing value. The timestamp must not be NULL.

hydro.discharge_measurement (entity)
This table serves the purpose to store discharge calibration measurements. Such field measurements are carried out to determine and calibrate q-h-curves which are used for discharge measurement. Measured parameters are stored in this table together with the water gauge station the measurement was done at, the operator who did the measurement and the equipment used for measurement. The latter is an index into the table *hydro.discharge_measurement_equipment*.

hydro.discharge_measurement_equipment (entity)
List of equipment used for discharge calibration measurements. Entries are free-text human-readable names of the equipment in English. This table is used by *hydro.discharge_measurement* to characterize the equipment the measurement was done with.

hydro.warning_level (entity)
This table stores the warning levels for each water gauge station. The values are just for internal reference as warning level definition and systems differ from country to country. There may be any number of warning levels defined, as defined by country specifications. The meaning of the levels and how they are defined is solely up to the country at which the water gauge station is located.

The only convention here is that warning levels are numbered continuously beginning with one, which denotes the lowest warning level. The water level associated with the warning level is specified in this table. It should be clarified whether the warning levels may be displayed on a public website or not.

hydro.monitoring_point_observed_property (n:m relation)
This table relates water gauge stations to observed properties, which are measured at the specified station. There can be any number of observed properties associated to a water gauge station. Minimum and maximum values and their associated timestamps of occurrence are also stored for each observed property and water gauge station. These values are updated automatically on data insertion. The time interval the minimum and maximum values refer to is the time interval specified in the *time_series* by the attributes *phenomenon_time_begin* and *phenomenon_time_end*.

4.3 Meteo schema

In this section the tables (mainly entities) in the meteo schema for meteorological measurements are described. Detailed specifications of all attributes can be found in the section **“**

Attribute and table reference for meteorological data**”**.

Meteo.monitoring_point (entity)
This table stores all metadata of meteorological stations. It is equivalent to the corresponding table in hydro schema. The difference is that a meteorological station is not necessarily located at a river, thus the attributes *bank*, *river_kilometer*, *catchment_area* and *European river code* are missing. Instead, a meteorological station is in the basin of a river, which is specified with the attribute *river_basin*.

The international code of a meteorological station is suffixed with the string “_METEO” to differentiate it from a hydrological station with the same international code.

As with hydrological stations, observed properties like precipitation which are measured by the meteorological station are stored in the table *meteo.monitoring_point_observed_property*, which establishes a n:m relation between the monitoring points and the observed properties.

meteo.observed_property (entity)
This is the second important table of the meteo schema. It stores a list of observed properties like precipitation and air temperature. An observed property is defined by a name, a human readable description and the unit it is measured in. The observed property naming scheme is defined in section "Observed property naming scheme".

Only meteorological properties are stored in the observed property list of the meteo schema. For monitoring points also measuring hydrological properties, a separate entry for the monitoring point is added to the hydro schema.

meteo.station_classification (entity)
This table is a list of possible classifications of meteorological stations. Classifications may be defined as needed, for example stations may be classified whether they are regular stations of the measuring net or stations belonging to some project (project stations). Classifications are human-readable strings.

meteo.operator (entity)
This table defines all organizations operating meteorological stations. An operator is characterized by its official name and address. International phone number and e-mail address of the contact person responsible for operating the stations are specified. It is possible to store the URL to official homepage of the operating organization and other information. All attributes are human-readable strings.

meteo.time_series (entity)
This table has a list of all meteorological time series in the schema. A time series is a coverage of observations of a certain property (like precipitation). For each meteorological station and observed property there is exactly one time series. Time series are not split. All observations of a certain property at a certain meteorological station are in one time series.
The further description of the corresponding table in hydro schema also applies to the meteo schema. Data pairs belonging to a time series are assembled in table meteo.result.

meteo.result (entity)
This table holds all values and timestamps for all observed meteorological properties. This includes real time data, processed data and forecasts. Each data pair belongs to a time series, which is a reference to the table meteo.time_series. The time of observation is specified in UTC. If the observed property covers a certain time interval, the associated timestamp is set on the beginning of the time interval. For observed properties which cover an interval as long as or longer than a day, the time part of the timestamp is set to midnight in UTC. See also the rules in the description of *hydro.observed_property*.

A value may be NULL to characterize a missing value. The timestamp must not be NULL.

meteo.monitoring_point_observed_property (n:m relation)
This table relates meteorological stations to the observed properties, which are measured at the specified station. There can be any number of observed properties associated to a meteorological station. Minimum and maximum values and their associated timestamps are also stored for each observed property and meteorological station. These values are updated automatically on data insertion. The

time interval the minimum and maximum values refer to is the time interval specified in the *monitoring_point* by the attributes *start_time and end_time*.

Grid data

Grid data is data of an observed property, for example precipitation, acquired over a certain area at equally spaced grid points. Grid data is not related to a single monitoring point and can require huge amounts of storage space. Thus, grid data is stored as an extra file as provided by a data provider and served in this form for dissemination. Grid data is only stored for a couple of days to avoid depletion of storage capacity.

4.4 Attribute and table reference for hydrological data

Abbreviations

PK = Primary Key, unique key, may be multiple fields together,
FK = Foreign Key, a link to the table with the following name,
UK = Unique Key, link to external database (DanubeGIS)
Long = 64 bit signed integer, Integer = 32 bit signed integer
All times and dates stored in database are in UTC.

Table	Attributes	Type	Description
monitoring_point	PK: id	Integer	Identifier of the water gauge station
	FK: station_classification	Integer	Classification of water gauge station
	FK: bank	Integer	Side of the river the measuring station is located
	FK: operator	Integer	Information on the operator of measuring station
	UK: EUCD_WGST	Varchar(64)	International code of water gauge station (Link to DanubeGIS database). [country] & [NCD_WGST] & "_HYDRO"
	NCD_WGST	Varchar(64)	National code of water gauge station
	vertical_reference	Varchar(32)	Reference Vertical Datum identifier, e.g. European Vertical Reference Frame 2007 (EVRF2007)
	long	Double	Coordinates of water gauge station: EPSG 4326 (WGS 84) Longitude [°]
	lat	Double	Coordinates of water gauge station: EPSG 4326 (WGS 84) Latitude [°]
	z	Double	Coordinates of water gauge station: Height [m]
	coords	Geography.point	Coordinates of water gauge station for display on map
	country	Varchar(2)	Country code of water gauge station ISO3166-1 ALPHA-2 (e.g. "DE")
	name	Varchar(128)	Locally used name of water gauge station
	location	Varchar(256)	Closest commune or landmark
	river	Varchar(128)	Name of river
	european_river_code	Varchar(64)	International code of river or canal to which the water gauge station belongs. Same as River.EUCD_RIV in DanubeGIS.

Table	Attributes	Type	Description
	river_kilometer	Double	Location at river the water gauge station is located, distance from mouth
	catchment_area	Double	Drainage basin area of water gauge station [km²]
	gauge_zero	Double	Gravity-related altitude of the zero level of the gauge above the sea level [m]
	start_time	Timestamp	Starting time of time series measurements on this water gauge station (UTC)
	end_time	Timestamp	Ending time of time series measurements on this water gauge station (UTC)
	utc_offset	Integer	Time zone the water gauge station belongs to UTC+X [min], disregarding daylight-saving time.
station _classification	PK: id	Integer	Identifier
	value	Varchar(256)	String to describe current classification of water gauge station within hydrological network (e.g. “project station”, “basic-network station”)
bank	PK: id	Integer	Identifier
	value	Varchar(256)	String to describe side of river “left” / ”right” / ”bridge” in downstream direction.
operator	PK: id	Integer	Identifier
	name	Varchar(256)	Name of organization which operates water gauge station
	address	Varchar(256)	Address of operating organization
	phone	Varchar(256)	Phone number of operating organization
	email	Varchar(256)	Email address of operating organization
	url	Varchar(256)	Website of operating organization
	other_info	Varchar(256)	Information on the operator not fitting in above fields
time_series	PK: id	Long	Identifier
	FK: monitoring point	Integer	Water gauge station the time series was measured with
	FK: observed _property	Integer	Observed property in time series
	phenomenon _time_begin	Timestamp	Starting phenomenon time of time series (UTC)
	phenomenon _time_end	Timestamp	End phenomenon time of time series (UTC)
	result_time	Timestamp	Result time, when time series was processed (UTC)
observed _property	PK: id	Integer	Identifier
	symbol	Varchar(32)	Abbreviation of observed property (e.g. “h_max_daily” for daily maximum of water level)
	type	Integer	Real time: 0, processed: 1
	description	Varchar(64)	Human readable description of observed property (e.g. “Daily maximum of water level”)
	unit	Varchar(12)	Unit of parameter, e.g. “cm”

Table	Attributes	Type	Description
result	PK: id	Long	Identifier
	FK: time_series	Long	The time series the data pair belongs to
	time	Timestamp	Phenomenon timestamp of measured property (UTC)
	value	Double	Value of the measured property, NULL for not available
discharge _meas-urement	PK: id	Integer	Identifier
	FK: operator	Integer	Operator of the discharge calibration measure-ment
	FK: equipment	Integer	Equipment used for measurement
	FK: monitoring_point	Integer	Water gauge station for which discharge cali-bration measurement was done
	date	Timestamp	Date of discharge calibration measurement (UTC)
	Q	Double	Discharge at time of measurement [m^3/s]
	h	Double	Water level at time of measurement [cm]
	width	Double	Width of water surface [m]
	area	Double	Area of cross-section [m^2]
	wetted_perimeter	Double	Wetted perimeter [m]
	depth_max	Double	Maximum depth [m]
	velocity_max	Double	Maximum velocity [m/s]
	velocity_average	Double	velocity_ average [m/s]
	temperature	Double	Water temperature at time of measurement [°C]
discharge _meas-urement _equip-ment	PK: id	Integer	Identifier
	description	Varchar(256)	Description of equipment of discharge calibra-tion measurement
warning_level	PK, FK: monitor-ing_point	Integer	Water gauge station for which flood warning level is defined
	PK: warning_level	Integer	Flood warning level to define
	water_level	Double	Water level at which flood warning level is is-sued for water gauge station. For information only.
monitoring _point_ob-served_property	PK, FK: monitoring _point	Integer	Water gauge station which supports observa-tions of property
	PK, FK: observed _property	Integer	Observed property supported by water gauge station
	last_update	Timestamp	Time of last update of this parameter at this water gauge station (UTC)
	min_value	Double	Minimum value of parameter in time series measured at this water gauge station
	min_value_time	Timestamp	Time at which minimum value was measured (UTC)
	max_value	Double	Maximum value of parameter in time series measured at this water gauge station

Table	Attributes	Type	Description
	max_value_time	Timestamp	Time at which maximum value was measured (UTC)

4.5 Attribute and table reference for meteorological data

Table	Attributes	Type	Description
monitoring_point	PK: id	Integer	Identifier of the meteorological station
	FK: station _classification	Integer	Classification of meteorological station
	FK: operator	Integer	Information on the operator of meteorological station
	UK: EUCD_PST	Varchar(64)	International code of meteorological station (Link to DanubeGIS database). [country] & [NCD_PST] & "_METEO"
	NCD_PST	Varchar(64)	National code of meteorological station
	vertical_reference	Varchar(32)	Reference Vertical Datum identifier, e.g. European Vertical Reference Frame 2007 (EVRF2007)
	long	Double	Coordinates of meteorological station: EPSG 4326 (WGS 84) Longitude [°]
	lat	Double	Coordinates of meteorological station: EPSG 4326 (WGS 84) Latitude [°]
	z	Double	Coordinates of meteorological station: Height [m]
	coords	Geography.point	Coordinates of meteorological station for display on map
	country	Varchar(2)	Country code of meteorological station ISO 3166-1 ALPHA-2 (e.g. "DE")
	name	Varchar(128)	Locally used name of meteorological station
	location	Varchar(256)	Closest commune or landmark
	river_basin	Varchar(128)	Name of river basin to which meteorological station belongs
	altitude	Double	Gravity-related altitude of the zero level of the gauge above the sea level [m]. Same as gauge_zero for water gauge stations.
	start_time	Timestamp	Starting time of time series measurements on this meteorological station (UTC)
	end_time	Timestamp	Ending time of time series measurements on this meteorological station (UTC)
	utc_offset	Integer	Time zone the meteorological station belongs to UTC+X [min], disregarding daylight-saving time.
station _classification	PK: id	Integer	Identifier

Table	Attributes	Type	Description
	value	Varchar(256)	String to describe current classification of meteorological station within meteorological network (e.g. "project station", "basic-network station")
operator	PK: id	Integer	Identifier
	name	Varchar(256)	Name of organization which operates meteorological station
	address	Varchar(256)	Address of operating organization
	phone	Varchar(256)	Phone number of operating organization
	email	Varchar(256)	Email address of operating organization
	url	Varchar(256)	Website of operating organization
	other_info	Varchar(256)	Information on the operator not fitting in above fields
time_series	PK: id	Long	Identifier
	FK: monitoring point	Integer	Meteorological station the time series was measured with
	FK: observed _property	Integer	Observed property in time series
	phenomenon_time_begin	Timestamp	Starting phenomenon time of time series (UTC)
	phenomenon_time_end	Timestamp	End phenomenon time of time series (UTC)
	result_time	Timestamp	Result time, when time series was processed (UTC)
observed _property	PK: id	Integer	Identifier
	symbol	Varchar(32)	Abbreviation of observed property (e.g. "P_total_daily" for daily total of precipitation)
	type	Integer	Real time: 0, processed: 1
	description	Varchar(64)	Human readable description of observed property (e.g. "Daily total of precipitation")
	unit	Varchar(12)	Unit of parameter, e.g. "mm"
result	PK: id	Long	Identifier
	FK: time_series	Long	The time series the data pair belongs to
	time	Timestamp	Phenomenon timestamp of measured property (UTC)
	value	Double	Value of the measured property, NULL for not available
monitoring _point_observed_property	PK, FK: monitoring _point	Integer	Meteorological station which supports observations of property
	PK, FK: observed _property	Integer	Observed property supported by meteorological station
	last_update	Timestamp	Time of last update of this parameter at this meteorological station (UTC)

Table	Attributes	Type	Description
	min_value	Double	Minimum value of parameter in time series measured at this meteorological station
	min_value_time	Timestamp	Time at which minimum value was measured (UTC)
	max_value	Double	Maximum value of parameter in time series measured at this meteorological station
	max_value_time	Timestamp	Time at which maximum value was measured (UTC)

5 Common Output Format

To disseminate hydrological and meteorological data to data receivers, WaterML 2.0 Part 1 – Timeseries (abbreviated as WaterML 2.0 in the following) as a standardised data exchange format has been chosen. This document defines the data format and its connection to the DAREFFORT database.

Upon a request by a registered data receiver (for example, one of the organizations also providing data or a website), the HyMeDES EnviroNet distribution node responds by sending a WaterML 2.0 file. The form of the request must contain the European codes of the monitoring points the receiver is interested in, the observed properties (e.g. water level, discharge, precipitation, daily/hourly), and the start and end time of the time interval the receiver is interested in. European code of a monitoring point is the ISO 3166-1 ALPHA-2 two-letter country code followed by the national code of the monitoring point. The European code is suffixed with the type of the monitoring point, "_HYDRO" or "_METEO". An example of a request is:

https://<server_name>/waterml?monitoring-Points=HR3121_HYDRO&observedProperties=Q_mean_hourly&dateFrom=2019-01-01T00:00:00Z&dateTo=2019-03-31T00:00:00Z

The WaterML 2.0 file which is sent as the response to a request contains information on the requested monitoring points like their names, coordinates and time zone offset. It also contains meta information on the time series like unit and types of observed properties. Finally, it contains the time series data. A WaterML 2.0 file may contain data for several monitoring points and several observed properties.

A WaterML 2.0 file as generated by HyMeDES EnviroNet is an XML file in UTF-8 encoding. All dates and times are in UTC in ISO 8601 format. It complies with the WaterML 2.0 standard, which utilizes the GML 3.2 (Geography Markup Language) standard and the Observations and Measurements 2.0 standard, which are developed by the Open Geospatial Consortium (OGC). Coordinates are specified in EPSG 4326, which is equivalent to WGS 84. The order of the coordinates is latitude, then longitude, which maps to y, then x in terms of database fields. As with XML in general, tags are case-sensitive.

To provide the European code of a monitoring point, a code space must be defined in WaterML 2.0. A code space is just a URI as a unique identifier, which serves to distinguish between different naming schemes like a namespace in some programming languages. It is recommended that the code space URI should be under control of the organization generating the WaterML 2.0 file. The exact URI to use is specified in the configuration tool of the HyMeDES EnviroNet software. The string describing the generation system in WaterML 2.0 document metadata section is specified in the configuration tool also.

In the next sections a mapping of the relevant database fields to the WaterML 2.0 output file is described. Additionally, a template/example for an output file is defined, which denotes the database fields in its comments at the places they fit in.
For future extensions, custom fields may be defined in WaterML 2.0 to transmit additional data which is available in the database. This is described briefly in the last section.

5.1 Mapping from database to WaterML 2.0 output format

The following table shows the location at which a particular attribute in the database is put in the WaterML 2.0 file. In the left column there is the name of the table (independent of the meteo or hydro schema), in the second column the name of the attribute in the table. The third column describes the WaterML 2.0 tags in which the content of the field is enclosed. For some tags, the values are not specified as the contents of the tag, but as an attribute to the tag. In these cases, this is denoted as an extra comment in the third column. For some cases, also an example or description of the contents is shown.

Table name	Attribute name	WaterML 2.0 Tag Hierarchy
monitoring_point	name	wml2:Collection, wml2:observationMember, om:OM_Observation, om:featureOfInterest, wml2:MonitoringPoint, gml:name
	location	wml2:Collection, wml2:observationMember, om:OM_Observation, om:featureOfInterest, wml2:MonitoringPoint, gml:description
	EUCD_WGST (hydro), EUCD_PST (meteo)	wml2:Collection, wml2:observationMember, om:OM_Observation, om:featureOfInterest, wml2:MonitoringPoint, gml:identifier [codeSpace must be specified as xsd:anyURI]
	lat, long	wml2:Collection, wml2:observationMember, om:OM_Observation, om:featureOfInterest, wml2:MonitoringPoint, sams:shape, gml:Point, gml:pos (EPSG 4326, order latitude, longitude)
	utc_offset	wml2:Collection, wml2:observationMember, om:OM_Observation, om:featureOfInterest, wml2:MonitoringPoint, wml2:timeZone, wml2:TimeZone, wml2:zoneOffset

Table name	Attribute name	WaterML 2.0 Tag Hierarchy
result	time	wml2:Collection, wml2:observationMember, om:OM_Observation, om:result, wml2:Measure-mentTimeseries, wml2:point, wml2:MeasurementTVP, wml2:time (ISO 8601: 2011-11-21T13:05:00Z)
	value	wml2:Collection, wml2:observationMember, om:OM_Observation, om:result, wml2:Measure-mentTimeseries, wml2:point, wml2:MeasurementTVP, wml2:value
time_series	phenomenon_time_begin	wml2:Collection, wml2:observationMember, om:OM_Observation, om:phenomenonTime, gml:TimePeriod, gml:beginPosition (ISO 8601: 2011-11-21T13:05:00Z)
	phenomenon_time_end	wml2:Collection, wml2:observationMember, om:OM_Observation, om:phenomenonTime, gml:TimePeriod, gml:endPosition (ISO 8601: 2011-11-21T13:05:00Z)
	result_time	wml2:Collection, wml2:observationMember, om:OM_Observation, om:resultTime, gml:TimeInstant, gml:TimePosition (ISO 8601: 2011-11-21T13:05:00Z)
observed_property	symbol	wml2:Collection, wml2:observationMember, om:OM_Observation, om:observedProperty as attribute “xlink:href”
	description	wml2:Collection, wml2:observationMember, om:OM_Observation,

Table name	Attribute name	WaterML 2.0 Tag Hierarchy
		om:observedProperty as attribute “xlink:title”
	unit	wml2:Collection, wml2:observationMember, om:OM_Observation, om:result, wml2:Measure- mentTimeseries, wml2:defaultPointMetadata, wml2:De- faultTVPMeasurementMetadata, wml2:uom as attribute “code”

5.2 WaterML 2.0 output format template and example

In the following, a template for a response to a request for time series data is shown. The template is filled with example values for a water gauge station in Zagreb. At each location which is variable, the corresponding attribute of the database is specified in an XML comment. This template complements the mapping shown in the section before.

The WaterML 2.0 file begins with the XML declaration and the first tag, a “wml2:Collection” tag, which includes namespaces and the XML schema. Metadata on the document follows, which includes generation system and generation date.

There may be time series of many monitoring points with different observed properties in a WaterML 2.0 file. Each monitoring point / observed property combination has its own “wml2:observationMember” section. In this section, the monitoring point is described with its identifier, name, coordinates and time zone. The start and end time of the time series of the observed property is defined in this section, also the result time when data was generated. The observed property is set here also.

Each “wml2:observationMember” section has a “om:result” section. It consists of a default for all points of the time series, which declares the unit the values are in. A list of all points (time / value pairs) in the time series follows. There may be any number of “wml2:observationMember” sections in the WaterML 2.0 file.

The template was checked with a GML validator (some fields required by GML have been left out, because they are pointless for this application) and imported successfully in HydroDesktop 1.8, a software typically used by hydrologists to examine time series data.

Template for WaterML 2.0 output format:

```
<?xml version="1.0" encoding="UTF-8"?>
<wml2:Collection xmlns:wml2="http://www.opengis.net/waterml/2.0"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:om="http://www.opengis.net/om/2.0"
      xmlns:sa="http://www.opengis.net/sampling/2.0"
      xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:sams="http://www.opengis.net/samplingSpatial/2.0"
      xsi:schemaLocation="http://www.opengis.net/waterml/2.0 http://schemas.opengis.net/waterml/2.0/waterml2.xsd">

    <wml2:metadata>
        <wml2:DocumentMetadata>
            <wml2:generationDate>2019-04-11T11:53:00Z</wml2:generationDate>
            <wml2:version xlink:href="http://www.opengis.net/waterml/2.0" xlink:title="WaterML 2.0"/>
            <wml2:generationSystem>HyMeDES EnviroNet</wml2:generationSystem>
            <!-- generation system string is configurable -->
        </wml2:DocumentMetadata>
    </wml2:metadata>

    <wml2:observationMember>
        <om:OM_Observation>

            <om:phenomenonTime>
                <gml:TimePeriod>
                    <gml:beginPosition>
                        2019-01-01T00:00:00Z<!--hydro.time_series.phenomenon_time_begin-->
                    </gml:beginPosition>
                    <gml:endPosition>
                        2019-03-31T00:00:00Z<!--hydro.time_series.phenomenon_time_end-->
                    </gml:endPosition>
                </gml:TimePeriod>
            </om:phenomenonTime>

            <om:resultTime>
                <gml:TimeInstant>
                    <gml:timePosition>
                        2019-03-31T00:00:00Z<!--hydro.time_series.result_time-->
                    </gml:timePosition>
```

```
            </gml:TimeInstant>
        </om:resultTime>

        <om:procedure>
            <wml2:ObservationProcess>
                <wml2:processType
                    xlink:href=http://www.opengis.net/def/processType/WaterML/2.0/Sensor
                    xlink:title="Sensor"/>
            </wml2:ObservationProcess>
        </om:procedure>

        <om:observedProperty xlink:href="http://www.icpdr.org/DanubeHIS/observedProperty/Q_mean_hourly"
                             xlink:title="Hourly mean of river discharge"/>

        <om:featureOfInterest>
            <wml2:MonitoringPoint>
                <gml:description>
                    Sava at Zagreb<!--hydro.monitoring_point.location-->
                </gml:description>
                <gml:identifier codeSpace="http://www.icpdr.org/DanubeHIS/monitoringPoint">
                    HR3121_HYDRO<!--hydro.monitoring_point.EUCD_WGST-->
                </gml:identifier>
                <!-- gml:identifier code space is configurable -->
                <gml:name>Zagreb<!--hydro.monitoring_point.name--></gml:name>
                <sa:sampledFeature xlink:title="Zagreb"/> <!-- hydro.monitoring_point.name -->
                <sams:shape>
                    <gml:Point>
                        <gml:pos srsName="urn:ogc:def:crs:EPSG::4326">
                            45.78448 15.95335
                            <!--hydro.monitoring_point.lat hydro.monitoring_point.long (in WGS 84)
                                [Latitude Longitude] -->
                        </gml:pos>
                    </gml:Point>
                </sams:shape>
                <wml2:timeZone>
                    <wml2:TimeZone>
                        <wml2:zoneOffset>+02:00<!--hydro.monitoring_point.utc_offset--></wml2:zoneOffset>
                    </wml2:TimeZone>
                </wml2:timeZone>
```

```xml
        </wml2:MonitoringPoint>
    </om:featureOfInterest>

    <om:result>
        <wml2:MeasurementTimeseries>
            <wml2:defaultPointMetadata>
                <wml2:DefaultTVPMeasurementMetadata>
                    <wml2:uom code="m³/s"/><!--hydro.observed_property.unit -->
                    <wml2:interpolationType
                        xlink:href="http://www.opengis.net/def/waterml/2.0/interpolationType/Continuous"
                        xlink:title="Instantaneous"/>
                    <!--<wml2:interpolationType
                         xlink:href="http://www.opengis.net/def/waterml/2.0/interpolationType/AverageSucc"
                         xlink:title="Average in succeeding interval"/>-->
                    <!--<wml2:interpolationType
                         xlink:href="http://www.opengis.net/def/waterml/2.0/interpolationType/TotalSucc"
                         xlink:title="Total in succeeding interval"/>-->
                    <!--<wml2:interpolationType
                         xlink:href="http://www.opengis.net/def/waterml/2.0/interpolationType/MinSucc"
                         xlink:title="Minimum in succeeding interval"/>-->
                    <!--<wml2:interpolationType
                         xlink:href="http://www.opengis.net/def/waterml/2.0/interpolationType/MaxSucc"
                         xlink:title="Maximum in succeeding interval"/>-->
                </wml2:DefaultTVPMeasurementMetadata>
            </wml2:defaultPointMetadata>
            <wml2:point>
                <wml2:MeasurementTVP>
                    <wml2:time>2019-01-01T00:00:00Z<!--hydro.result.time--></wml2:time>
                    <wml2:value>22.1242<!--hydro.result.value--></wml2:value>
                </wml2:MeasurementTVP>
            </wml2:point>
            <wml2:point>
                <wml2:MeasurementTVP>
                    <wml2:time>2019-01-01T01:00:00Z<!--hydro.result.time--></wml2:time>
                    <wml2:value>21.4129<!--hydro.result.value--></wml2:value>
                </wml2:MeasurementTVP>
            </wml2:point>
            <!-- More data points omitted -->
            <wml2:point>
```

```
                        <wml2:MeasurementTVP>
                            <wml2:time>2019-03-31T21:00:00Z<!--hydro.result.time--></wml2:time>
                            <wml2:value>21.4212<!--hydro.result.value--></wml2:value>
                        </wml2:MeasurementTVP>
                    </wml2:point>
                    <wml2:point>
                        <wml2:MeasurementTVP>
                            <wml2:time>2019-03-31T23:00:00Z<!--hydro.result.time--></wml2:time>
                            <wml2:value>22.4532<!--hydro.result.value--></wml2:value>
                        </wml2:MeasurementTVP>
                    </wml2:point>
                </wml2:MeasurementTimeseries>
            </om:result>

        </om:OM_Observation>
    </wml2:observationMember>

    <!-- Further wml2:observationMember objects may follow if multiple monitoring points and/or
         observable properties were requested -->

</wml2:Collection>
```

5.3 Possible extensions

For future use and custom applications, there is more information in the database than the information required as a response to a request for time series data of monitoring points. If required, this information can be added to WaterML 2.0 files.

Additional information not covered by the definition of the WaterML 2.0 output format can be transferred by defining custom fields in WaterML 2.0. The tag “om:NamedValue”, which is within a “sa:parameter” tag, can be used to define a custom field. The name of the field is defined by the “om:name” tag with the attribute “xlink:href”, which refers to a URI describing the field uniquely, and the attribute “xlink:title”, which is a human-readable name of the field. To set the value for the field, the tag “om:value” is used.

There may be numerical fields (like the catchment area) and string-valued fields (like the catchment). An example follows.

```
<wml2:MonitoringPoint>
      <sa:parameter>
            <om:NamedValue>
                  <om:name
                  xlink:href="http://www.icpdr.org/DanubeHIS/namedValu
                  e/Catchment_area"
                           xlink:title="Catchment area"/>
                  <om:value xsi:type="gml:MeasureType"
            uom="km²">22.1</om:value>
            </om:NamedValue>
      </sa:parameter>
      <sa:parameter>
            <om:NamedValue>
                  <om:name
                  xlink:href="http://www.icpdr.org/DanubeHIS/namedValu
                  e/Catchment"
                           xlink:title="Catchment"/>
                  <om:value xsi:type="gml:CodeType">Danube</om:value>
            </om:NamedValue>
      </sa:parameter>
</wml2:MonitoringPoint>
```

6 Specifications of the common data exchange service

In the following the recommended specifications of the common data exchange service referred to Danube Hydrological and Meteorological Common Data Exchange Service **(HyMeDES Environet)** are described. The suffix "Environet" stands for environmental information network which indicates the software service is able to deal with a variety of environmental data and could be easily extended in the future.

The architecture of HyMeDES Environet will serve to establish a stable, common ground to collect and make available existing hydrological data from data providers and handle all the conversion, transport, security and standardisation requirements attached to that goal.

To achieve the aims of the project the hydrological and meteorological data provided in each country in the Danube basin has to be converted to the common data exchange format (HyMeDEM), stored and distributed in an appropriate way.

Since there are many partners involved in this process, especially data providers, it is necessary to develop a decentralised and modularised solution. This ensures that horizontal growth is possible easily which respect to data providers, the maintenance effort is kept to a minimum for each partner, and the accessibility and availability of data for the end users is maximised.

Nevertheless, the data from national data providers collected and converted to the common data exchange format will be stored in a centralised storage solution, from which the data will be distributed to clients. The centralised service is necessary and preferred over cloud based or distributed software solutions to achieve a stable running and broadly accepted solution on the long run. Besides compliance to ICPDR IT-infrastructure as the foreseen operator of the future DanubeHIS, it is necessary to ensure to have a broadly accepted and renowned institution / organisation like ICPDR to be in responsibility of running the system, also with respect to data policy agreements which have to be agreed on for the future use of DanubeHIS.

To achieve these aims the requirements for the software architecture of HyMeDES are:

- data from national data providers should be exchanged using existing data exchange interfaces where available, in order to keep the effort for the national data providers as low as possible in order to enhance the acceptance. This implies that the national data providers only host their own data, not the data of other countries,
- data has to be converted into the common data exchange data model HyMeDEM by the common data exchange service and comprised to a common data pool (common data base) according to the HyMeDEM data model,
- the common data exchange service provides the common data pool to clients,
- the development of the software has to be based on established coding standards and to be well commented to be easy maintainable,
- the common data exchange service will be a web driven application, light-weight, and easy to implement and to maintain,
- to make the system as open and platform independent as possible the core structure only uses simple and proven web technology (server side: HTTPS, PHP, Cron/Task scheduler, client side [for configuration and administration]: Html5, JavaScript),

- the software will be open source,
- data security: authentication will be verified using appropriate encryption methods,
- the interaction will be managed by Web APIs,
- using plug-ins (plug-in libraries) is encouraged,
- no direct writing interaction with the underlying databases will be allowed (only access via API), reading data from the data base can be allowed for special use cases,
- missing data may be imported as files (e.g. csv) triggered by administrator user manually,
- to be compliant with ICPDR future developments regarding DanubeHIS following IT infrastructure has to be supported (all of them are open source):
    - web server: Apache
    - PostgreSQL with PostGIS extension
    - sharing geospatial data: GeoServer
    - interoperability with the DanubeGIS
    - compatible user management system (e.g. CIS)

In order to avoid a bunch of different software solutions for each data provider and distribution purposes there will be only one HyMeDES Environet software service which consists of several modules and can run in different modes according to the functionality which is needed for the specific purpose. An overview about the platform architecture is shown in Figure 2.

According to the different roles in the common data exchange service HyMeDES Environet can act in two different main modes, which are described in detail in 6.1 and 6.2.

In the first mode the software is used as **distribution node** which collects data from national data providers and stores the data in the HyMeDEM data model in a database. As distribution node HyMeDES Environet can provide the data in Water-ML 2.0 format via a web-API to clients. The distribution node will be part of Danube-HIS in the future and it is foreseen that ICPDR will host this HyMeDES Environet distribution node after the project. Therefore, the technical specifications have to be kept compliant to ICPDR future developments (see also detailed description below).

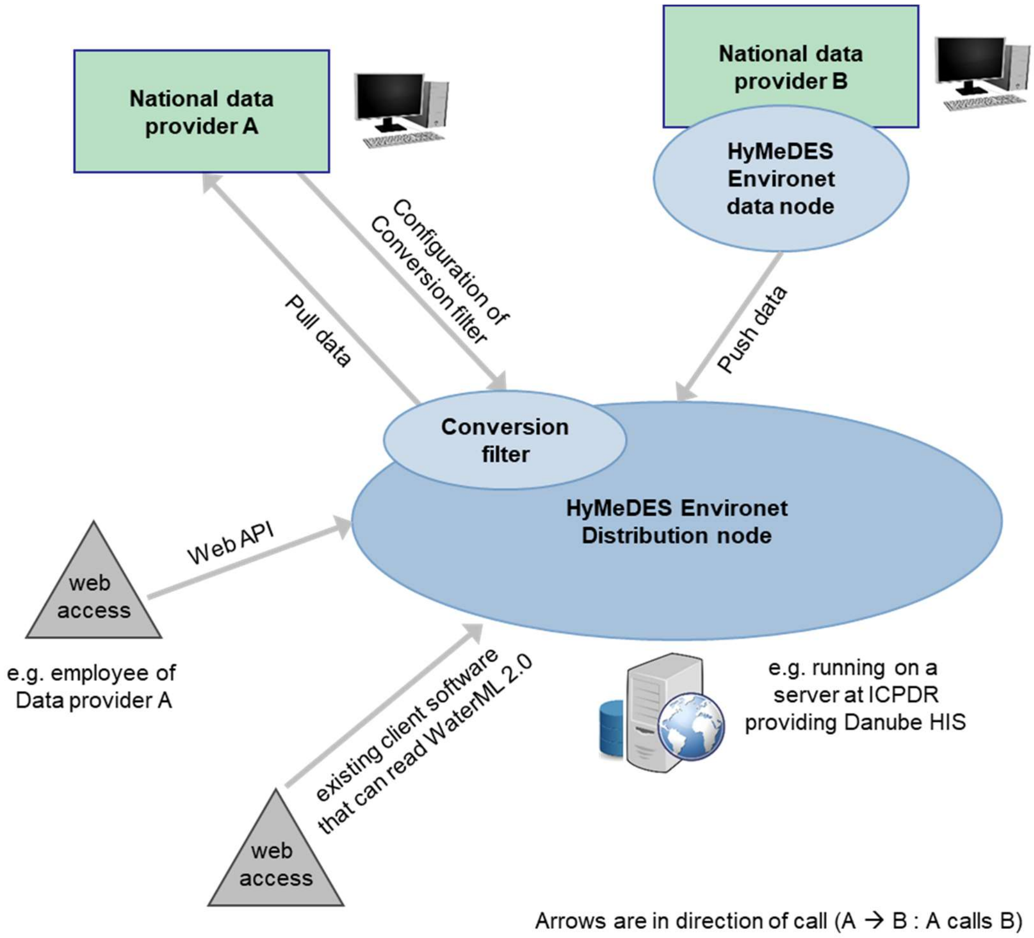

Figure 2 Schematic overview of use cases of HyMeDES Environet.

The second operation mode is called **data node**. Data nodes are foreseen to be used by data providers who want to send their data actively to the distribution node.

HyMeDES Environet will consist of a common code base which can be used as distribution node, data node. Communication with the distribution node will be done via https.

In the data node **conversion filters** (plug-ins) will be used to convert the data from national data format to the common HyMeDEM data format. The conversion filters have to be tailored to the national data formats.

The conversion plugins can also run directly in the HyMeDES Environet distribution node and pull the data from the data providers' servers. In this case the data providers have to ensure that the data to be exchanged can be accessed via a web-API or an FTP-server, providing an access account for Hy-MeDES Environet.

To keep the maintenance effort in balance between data providers and host of the data exchange service, configuration of the conversion filters should be manageable by the national data providers. Necessary maintenance tasks should be limited to situations in which data providers make significant changes like adding new stations to future DanubeHIS, changing server addresses or making changes

to the data exchange protocol, e.g. by assigning national data fields to corresponding HyMeDEM entities. Therefore, the conversion plugins running directly in the HyMeDES Environet distribution node will have to be accessible by the data providers for configuration.
To keep the maintenance effort low, especially if a national data provider makes changes in the local data format or Web API, the conversion plugins have to be configurable by easy maintainable configuration files or a configuration web-user-interface, without making changes in the source code. This ensures that national data providers can maintain their conversion plugins as easy as possible. No programming skills are required to maintain the conversion filters.

Data security is ensured by authentication using appropriate encryption methods (separate tool for generating key pair on data providers side). The public key list for authentication should be managed by the host of HyMeDES Environet distribution node in the future, which is foreseen to be ICPDR.

An advantage of the DAREFFORT's HyMeDES Environet engine is to provide data that can be validated to be original. This is proven by the use of a public key infrastructure that makes it technically impossible to falsify measurement data after it was entered. Authentication will be verified using appropriate encryption methods. There will be a separate tool for generating key pairs for data providers.

An alternative to the centralized data hosting solution would be to get the data one-by-one by streaming or scraping information directly from the sources from data providers. The problem with this is that the more sources there are, the more of a problem it becomes that data sources can be changed or go offline without notice. Then users have to adapt and keep their scripts up to date, after noticing the change, not to mention the possibly different formats that users need to work with. Therefore, the centralized data hosting solution provided with HyMeDES Environet is preferred.

Nevertheless, there are use cases in which for example a forecasting service wants to retrieve data from specific data providers not using the HyMeDES Environet data exchange service or DanubeHIS in the future. This could be the case if additional data has to be accessed which is not provided be the centralized server. In such a case it will be possible to install the HyMeDES Environet data exchange service at the forecasting service, making use of the existing conversion filters, and optionally enhanced by the additional specific data entities which should be exchanges in addition. This use case is described in more detail in section 6.6.

6.1 HyMeDES Environet Distribution Node

The HyMeDES Environet Distribution Node is the back bone of the common data exchange platform. It has to be ensured that the distribution of the commonly shared data is possible using one HyMeDES Environet Distribution Node, which will likely be the case in foreseeable future. The distribution node stores all data which is received from data providers in a local data base. **The data can be received via conversion filters (see below) running as plugins either on data providers side or on side of the distribution node.**

The synchronisation with the national data providers is done according to the update frequency of the national systems.

The use case for the distribution node will be to act as main access points to the common data base. Regarding the scope addressed by DAREFFORT project it is not a requirement to have more than one distribution node for sub-serving ICPDR in the development of DanubeHIS (as described in WP4).

Also, for maintaining the system by ICPDR after the project end, it is foreseen that there is no more than one distribution node.

The distribution node manages following topics:

- receive data from national data providers via conversion filters (see below)
- answers to API requests for data access, e.g. of clients who want to retrieve data in the common data exchange format (WaterML 2.0)
- verification of data accesses
- initiation of network level maintenance and administration tasks
- management of authentication of data nodes (see below)
- administer access control policies and user rights
- has a copy of all the data from all data sources available
- logging data transactions

The data is stored on the distribution node in a PostgreSQL data base. Data is disseminated by the distribution node to third-party users in WaterML 2.0 timeseries format after authentication via an API.

6.2 HyMeDES Environet Data Nodes

Data nodes can add new data to the data distribution node and initiate their addition with an appropriate authentication method. Data nodes can be used by data providers to actively send their data to the distribution node. In this sense they act as a new data source for the network.

It is important that data nodes will not have to store any data but only convert the local data format to the commonly agreed data format (HyMeDEM) and send to a distribution node. This enhances acceptance of national data providers to install a data node.

A typical use case for a data node is a data provider to convert the local data to the common data format and to send it to the distribution node (project partner or later after the project end a third party institution).

Data nodes will be kept extremely light weight. They consist of a PHP-Script for managing the communication with the distribution node and the conversion filter with data provider specific settings.

6.3 Conversion Filters (plugins)

The original data formats of the data providers are converted to the HyMeDEM data model by using conversion filters which are tailored to the data providers data exchange format and transfer method (in general web-API or FTP).

The conversion filters are plugins running either on data provider side or on side of the distribution node.

Each data provider involved in the DAREFFORT project will have a conversion filter with provider specific conversion rules.

They can be configured via a web interface by the data providers using a web browser. In case that the data provider specific conversion filter runs on side of the distribution node, it has to be accessible from outside for configuration.

The conversion plugins have to be easy to maintain, so that an average database user can administrate and adjust the plugins.

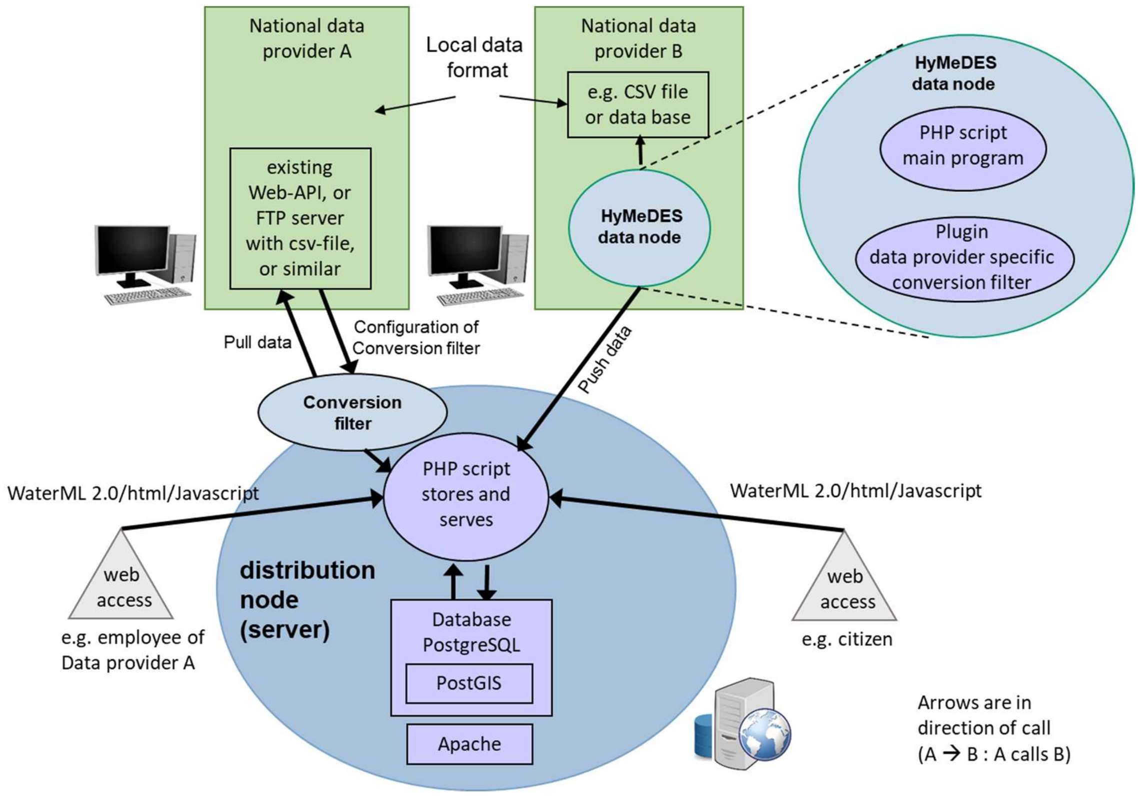

Figure 3 Required components of HyMeDES Environet (distribution node, data nodes, conversion filters) and data exchange concept

6.4 User rights management

The assignments of different access rights to the data in HyMeDES Environet Distribution Node will be managed via an access control list. The granularity of access control should be by station, parameter, type of data and temporal for unprocessed data, as agreed during the Software Developers' Conference in Vienna, February 2019.

6.5 Server infrastructure requirements

To keep the budget required to install and maintain a central server in the future as low as possible, existing infrastructure must be used. This poses some conditions onto software to use. As already mentioned scripts should be coded in PHP, and the following packages are used: web server is Apache and the data base on distribution nodes available is PostgreSQL with PostGIS extension.

It is foreseen that these packages are distributed in a pre-configured state together with HyMeDES to keep the effort for local implementation at a minimum. All of the mentioned software packages are available for Windows and Linux systems.

Server requirements HyMeDES distribution node:

- PHP, minimal Version: 5.6.40, recommended max. 7.3.x
- Apache (Linux / Windows), minimal Version: 2.4.6, recommended max. >= 2.4.6
- PostgreSQL, minimal Version: 9.6.12, recommended max. 11.2.x with PostGIS
- Cron/Task scheduler

System requirements for data providers

- no server installation required

Use case data pulled by server (conversion plugin running on the distribution node)

- access provision for data pulling from external party (via FTP or existing Web-API)
- client web browser for configuration of conversion filter

Alternative use case data pushed to server (conversion plugin running on data providers side in a data node)

- PHP minimal Version: 5.6.40
- Client Web browser for configuration of conversion filter
- Cron/Task scheduler

Maintenance of conversion filters should be done by data providers if they change their internal formats.

6.6 Outlook on alternative use cases

Separate distribution nodes

There are use cases in which the installation of a separate distribution node could be useful, for example if a forecasting service wants to retrieve data from specific data providers not using the HyMeDES Environet data exchange service or DanubeHIS in the future. This could be the case if additional data has to be accessed which is not provided by the centralized server.

In such a case it will be possible to install the HyMeDES Environet data exchange service at the forecasting service and to use the existing conversion filters, enhanced by the additional specific data entities which should be exchanged in addition (see Figure **4**).

Whereas the technical capability of HyMeDES Environet is available to address this use case, separate data exchange agreements could be necessary between the forecasting centre and the specific data providers, depending on the specific use case.

This separate distribution node is completely independent from DanubeHIS server, but may acquire data from it and use same conversion filters. Even different and additional observable properties can be defined for this distribution node.

The server requirements to install this distribution node are the same as described in caption 6.5.

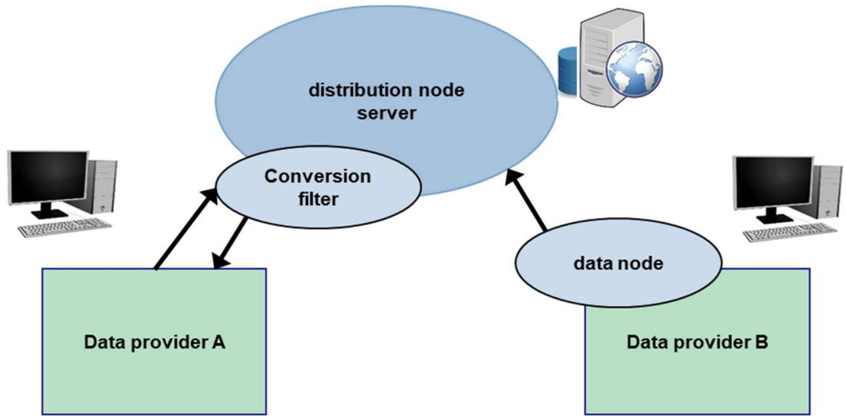

Figure 4 Additional distribution node installed e.g. by a forecasting center to receive specific data from several data providers in the common exchange format

Client node (optional future addition for caching)

Client nodes which can be optionally developed for future purpose act as caching services for local usage.

These nodes cannot add new data sources but can read data from other services provided. They basically can do the following things:

- authenticate at distribution node with appropriate method

- read and interact with distribution node
- join the network
- service API and WEB client request locally

A typical use case for a client node is if a national data provider or other institution which wants to have the commonly shared data cached for fast access for local usage, e.g. for the employees.

7 Graphical user interface requirements and recommendations

A graphical user interface (GUI) will be implemented within the DAREFFORT project for following purposes:

- configuration tasks of HyMeDES Environet Distribution node
- configuration tasks of HyMeDES Environet Data node
- configuration tasks of conversion filters
- meta data management: manual upload of meta data of measuring stations, manual editing of measuring stations
- manual upload of processed / historical hydrological and meteorological data

The GUI will be available via a platform independent web-interface, developed in Html5 and Javascript/CSS. To ensure a platform independent design which is easy to use also on mobile devices like tablet computers it is a requirement and recommended that common rules for responsive web design are followed during development. Therefore, it is recommended to use open source Javascript/CSS-library Bootstrap for development of the GUI.

Compatibility to following browsers is recommended: Google Chrome, Mozilla Firefox, Safari, Microsoft Edge, Internet Explorer 11 and Opera.

The language of the graphical user interface will be English. The texts of the GUI should be written in easy to understand language.

8 User manual requirements and recommendations

The user manual for the common data exchange service has to address several different target groups and user roles as well as user levels.

In the horizonal dimension the following target groups which may use the software have to be considered:

1. **Data providers** who deliver their data to the distribution node of HyMeDES EnviroNet
2. The **host organisation** of the distribution node (ICPDR)
3. **End users** who retrieve the common data in WaterML 2.0 format (e.g. forecasting centres, universities, public bodies, …)
4. **Software developers**

Within the target groups organizations there can also be several user roles and levels:

1. **IT experts**: e.g. administrators who install the distribution or a data node, generate keypairs, or configure the conversion filters
2. **Normal users**: e.g. users who add a measuring station, upload processed data

It can be expected that the technical and IT skills of the groups will be very different. Therefore, it is recommended to design the user manual in a modular way, e.g. by subdividing the manual in several independent parts (modules). This way, a user with a specific role can pick up the specific parts of the manual according to his role.

With this in mind the following modular structure is proposed. Each part should be implemented as standalone document, addressed to the user groups listed in brackets:

1. **General Part** (all target groups and roles):
    a. List of content (available modules of the manual)
    b. Short description of the aims of HyMeDES EnviroNet
    c. Short overview over the participating countries
    d. Short overview over the architecture of HyMeDES EnviroNet
    e. Terms of use (if available)
    f. Terms of warranty / warranty exclusions
    g. Remarks on data protection
    h. Software license regulations
    i. Link to contact person (e.g. at host organization, if available)
    j. Glossary
2. **Technical Documentation of the Database Data Model**:
   (target groups: host organization, software developers | user level: IT experts)

    Description of the data base model

3. **Technical Documentation of the WaterML 2.0 format**:
(target groups: host organization, end users, software developers | user levels: IT experts and normal users)

    Description of WaterML 2.0 format and entities

4. **Technical Documentation of the Software architecture, source code and API**:
(target group: software developers | user level: IT experts)
    a. internal API reference
    b. conversion filter API reference
    c. REST / web interface
    d. Source code documentation created from doxygen
    e. Short documentation of original national data formats used for conversion
5. **Installation, configuration and maintenance guide for distribution node**:
(target groups: host organization, software developers | user level: IT experts)
    a. Description of key generation
    b. Technical requirements
    c. Step-by-step guide for installation
    d. Description of the graphical user interface (GUI)
    e. Description of user rights management
    f. Description of un-installation procedure
6. **Installation guide for data node**:
(target groups: data providers, software developers | user level: IT experts)
    a. Description of key generation
    b. Technical requirements
    c. Step-by-step guide for installation
    d. Description of un-installation procedure
7. **Configuration Guide for conversion filters**:
(target groups: data providers | user level: IT experts, maybe normal users)
    a. Description of the graphical user interface (GUI)
    b. Description of configuration functionality
    c. Description of error messages
8. **GUI description for conversion filters:**
(target group: data providers | user level: normal users)
    a. Description of the graphical user interface (GUI)
    b. Step-by-step description of use cases:
        i. Metadata and adding/editing/deleting stations
        ii. Uploading processed data
        iii. Manual upload of missing data, and other data

9. **Guide for end users** (target group: end users | user levels: IT experts and normal users):
    a. Step-by-step description of using the API to retrieve common data in WaterML 2.0, (how to download data?)
    b. Description of available data and update intervals
    c. Description of WaterML 2.0 format and entities

In general, the following guidelines should be considered for implementation of the user manual:

- short and precise descriptions
- the text should be easy to read
- when writing the text, the target group should be kept in mind regarding the use of technical language
- the guides in the manual should be implemented using step-by-step descriptions with examples

The proposed modular concept of the user manual also supports its integration or parts of it into the e-learning tool developed in WP 5.

It is recommended that the user manual should be available as an electronic document in PDF format.

The use manual will be written in English language. To enhance the acceptance of the comm data exchange platform each partner country should translate the manual (at least the modules intended for normal users) in their native language.

Interreg
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DAREFFORT

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