Capacity Building on Hydrological Data Exchange, Standardization, and Interoperability in Region VI

Online on 25 January 2024 from 13:00 to 16:00 CET and 26 January 2024 from 09:00 to 11:30 CET

Face-to-Face 29–30 January 2024, Zagreb, Croatia

Presentations are available: https://wmo.int/events/workshop/capacity-building-workshop-hydrological-data-exchange-standardization-interoperability-ra-vi

Participant list and agenda attached as annexes.

Introduction

The World Meteorological Organization (WMO) in collaboration with the International Sava River Basin Commission (ISRBC) organized a Capacity Building Workshop on Hydrological Data Exchange, Standardization, and Interoperability in RA VI, on 25 and 26 January (online) and 29 and 30 January 2024 (in person). The face-to-face training took place in the premises of ISRBC in Zagreb, Croatia. The workshop was attended by representatives of Sava Hydrological Information System (Sava HIS) data providers and few experts from Danube HIS, while Rhine basin commission representative was not able to join due to some other engagements. Altogether 26 participants were in Zagreb in presence (including trainers and organizers), and additionally 7 trainers joined online. The training was supported with trainers from WMO experts (Joint Expert Team on Hydrological monitoring-JET-HYDMON), Open Geospatial Consortium- Hydrology Domain Working Group (OGC-HDWG) and WMO partner organizations providing technical solutions like WHOS DAB (Earth and Space Science Informatics laboratory (ESSI-lab) of the National Research Council of Italy - Institute of Atmospheric Pollution Research (CNR-IIA)) and OSCAR/Surface platform (MeteoSwiss), UK Centre for Ecology and Hydrology (UK CEH), and ISRBC. The WMO secretariat representatives served as resource personnel.

Aim of the Training

The aim of the workshop was following:

1. Enable ISRBC, Sava and Danube Members to access and share hydrological data using relevant meta (data) standards and principles supported by WMO Hydrological Observing System (WHOS) as a component of WMO Integrated Global Observing System (WIGOS) and WMO Information System (WIS2.0) for data interoperability.

2. Equip the participants with necessary knowledge to strengthen the existing policy on the exchange of hydrological and meteorological data, and information in the Sava River basin through the implementation of WMO Unified Data Policy.

3. Demonstrate the benefit of system integration, provide training on registration of hydrological stations in OSCAR (Observing Systems Capability Analysis and Review)/Surface and allocation of WIGOS Station Identifiers (WSIs).

4. Acquire skills and knowledge of WHOS core tools and supported technologies for strengthening the existing systems and platforms within the countries and river basins.

5. Explore implementation of the WMO Hydrological Status and Outlook System (HydroSOS), Early Warning For All Initiative (EW4All) initiative and their linkages to WHOS.

Thursday 25th January 13:00-16:00: Summary of the online event:

Opening

The meeting commenced with *Ms. Johanna Korhonen*'s (WMO) introduction, handing over to ISRBC Executive secretary *Mr. Dragan Zeljko* for opening remarks. Gratitude was expressed for the support from WMO and other organizations, welcoming international partners and emphasizing the long-standing priority of data exchange for the International Sava River Basin Commission (ISRBC), underlining WMO's support with data policy and referring to recently signed MoU between WMO and ISBRC. **Mr. Zeljko** outlined significant expectations from the workshop, including supporting the ISRBC activities planned throughout the Sava and Drina Integrated Development Program (GEF/World bank), preparation of the hydrological study and upgrading the Sava Hydrological Information System (Sava HIS).

Ms. Sari Lappi (WMO) followed with remarks, expressing gratitude for ISRBC's hosting and advocating for expanded cooperation with other river basins. ISRBC was acknowledged as a pilot study for the WHOS, contributing to global initiatives like the WMO unified data policy and Global Basic Observing Network (GBON). The importance of data exchange for EW4All and ISRBC's role as an example for other basins were highlighted. **Mr. Silvano Pecora**, INFCOM Vice President, extended thanks for ISRBC's contribution and praised the Sava HIS as a global reference. He stressed the need for data standardization and description, commended ISRBC's implementation of modelling systems for forecasting, and identified the workshop as an opportunity to advance hydrological data exchange technologies, urging consideration of technological evolution. The meeting opening concluded with highlighting collaboration and the advancement of hydrological data exchange in the region.

Mr. Mirza Sarač (ISRBC) delivered a presentation on the Sava HIS and its interconnection with the WHOS. The Sava HIS facilitates the exchange of hydrological and meteorological information and was demonstrated during the session (and more in detail on Monday). Key points covered include; the Framework Agreement on the Sava River Basin (FASRB) signed in 2002 among Bosnia and Herzegovina, Croatia, Serbia, Slovenia and the objectives of the agreement were to focus on sustainable water management, international navigation, and hazard management.

The presentation detailed the mechanisms of data exchange and data interoperability, including the Permanent Expert Group for Hydrological and Meteorological Issues (PEG-HMI), Hydrological Year Books, a web portal for real-time data exchange, and joint measurements at border sections. A comprehensive policy on Hydro-Meteorological data exchange, signed in 2014, was highlighted, encompassing principles, routes, organization, international and national legal frameworks. The coordination of data exchange, protocols on flood protection, and the consideration of various data formats and types for exchange were emphasized.

Mr. Mirza Sarač delved into the practical implementation of the Sava HIS, its role as a hub for observed data, and its connection to modelling systems for forecasting, including the use of hydrological HEC-HMS and hydraulic HEC-RAS models. The system's operational status for flood forecasting since 2018, its integration with other systems, and the use of advanced methods like ARMA for data assimilation were discussed. Future projects to upgrade Sava HIS and the collaboration between Sava HIS and WHOS were presented, emphasizing the MoU between WMO and ISRBC. The WHOS, as a standardized platform, offers interoperability and connections to various software. During the discussion, **Mr. Mirza Sarač** addressed challenges in data exchange, emphasizing the careful protocol development, legal ratification, and robust data quality control procedures involving multiple checks at different levels.

Mr. Zoran Major and **Mr. Alexander Höbart** provided insights into the Danube HIS during the presentation. The International Commission for the Protection of the Danube River (ICPDR) ensures the sustainable management of waters in the Danube basin, facilitating the cooperation of 15 Contracting Parties (i.e. 14 countries + EU). The cooperation of the ICPDR's Contracting Parties is guided by the commitment to implementing the EU's Water Framework Directive (WFD), and for this - the ICPDR provides strategic coordination and support to of all CPDR members, including non-EU members. Implementation involves the exchange of data and metadata from various systems, with system development and operation managed by the ICPDR secretariat.

The Danube HIS portal, launched at the end of 2023, offers basin-wide basic hydro-meteorological information, including water level, precipitation, water temperature, and river discharge in the standard format of WaterML2.0. The data policy, involving voluntary data exchange and conceptual principles, was developed by the ICPDR and its acceptance procedure, by all of the Data Providers, contributed to

the launch delay. The data exchange system includes components like the data node, and distribution node software, uploading the data to the central database maintained by ICPDR. DanubeHIS portal provides the Web user interface which is linked to Danubis (for user accounts) and to DanubeGIS (for background data). There is also a separate web interface for system administration, providing access to station metadata, measurement access rules, user roles, and status of data availability per station. The presentation outlined key features of DanubeHIS portal, such as overview of near real-time observed properties, presented in a list and accompanied with an overview map of stations. There are various ways of filtering data, and a visual presentation of time series including graphs of observed properties for a given time interval. Besides WML2.0, the portal provides functionalities for data download in csv and xls formats. The system is accessible at www.danubehis.org

Mr. Sylvain Grellet from BRGM delivered a presentation on WaterML2.0, focusing on standardizing metadata and its dynamic group entry point in Twiki. The presentation outlined the collaborative efforts involving international organizations, members, and private companies, emphasizing a suite of standards supporting the development of WaterML2.0.

WaterML2.0 comprises five parts, covering 1) time series, 2) ratings, gaugings, sections, 3) surface hydrology features, 4) groundwater, and 5) water quality best practices. Part 1, adopted by United States Geological Survey (USGS), Bureau of Meteorology (BoM), WMO, and others, harmonizes timeseries data, including continuous and non-continuous variables.

During the final discussion, it was noted that the Sava River Basin has already utilized WaterML2.0, with a goal to incorporate all timeseries data. Participants inquired about representing high flows within WaterML2.0, emphasizing the use of observation standards and ensembles. The discussion touched upon the worldwide usage of WaterML2.0, with notable implementations in France, the UK, and the US. The potential incorporation of HydroSOS in WaterML2.0 Part 3 was raised, stressing the importance of understanding how to handle quality data alongside quantity data.

Additional topics included the discussion with the OGC academy for learning standards, the need for simplicity in revising standards for developing countries, and ongoing projects in France and the US that could contribute to standard development. Capacity training, open-source tool implementation,

and collaboration with colleagues from Canada and France were highlighted as essential aspects for successful standardization and implementation.

Friday morning session started with recapping of the Thursday event by **Mr. Mirza Sarač**, followed by presentation by **Mr. Sylvain Grellet** and **Mr. Hylke van der Schaaf**. The presentation on WaterML2.0 SensorThings API highlighted its role as a standard for exchanging sensor data and metadata, encompassing both historical and current data in a JSON encoded, RESTful format. It adapts OASIS OData patterns and supports ISO MQTT messaging. The API is easily discoverable with just a web browser, consisting of two components: the data model and the API. Notable features include full explorability, composable responses, powerful filtering, and applicability to water quality sensing. The presentation emphasized that many partners are transitioning to this approach, with a significant improvement in observation data filtering compared to other methods. The suggestion emerged to update WaterML2.0 part 1 and 5, define best practices, and revise river and aquifer models. The ongoing supporting projects include OneWater and Water4All.

Mr. Enrico Boldrini's presentation on WHOS architecture design highlighted key components such as WHOS DAB, ontology, and integration. WHOS serves as a solution for hydrological data discovery and access, supporting harmonized data sharing and aligning with various initiatives like WMO Plan of Action (PoA) for hydrology, WMO Unified Data Policy, HydroSOS, and EW4ALL. The pillars of WHOS include standards and a broker, with stakeholders ranging from NMHS and private sector entities to research entities and publication systems. The discussion emphasized the community's adoption of the SensorThings API for both water quality and quantity data. WHOS aims to connect with CUAHSI-HIS, OGC SensorThings service, and GRDC, showcasing its global portal's capabilities for data download in NetCDF and WaterML formats. Enrico demonstrated WHOS's connectivity with initiatives like HydroSOS and PROHMSAT forecast model, illustrating its potential benefits in the broader hydrological landscape. The WHOS global portal link is provided for further exploration.

HydroSOS, Global Hydrological Status and Outlook System by WMO as presented by **Ms. Katie Facer-Childs**, acts as a vital link between monitoring and decision-making, focusing on the current status and outlook of the hydrological regime. Its aim is to give overview whether the situation is wetter or drier than normal and how the situation is going to change in upcoming weeks and months. HydroSOS aims

to provide an overview of water resources more generally, rather than flood forecasts, with products based on key variables such as soil moisture, soil water equivalent, runoff, streamflow, and groundwater. The R script available facilitates hydrological status calculations, as demonstrated in workshops in the Lake Victoria basin and Ghana, where participants used the script to calculate hydrological status.

Future plans include developing more global implementation projects and enhancing connectivity with the WHOS. The discussion emphasized the need for a regional implementation group for HydroSOS, involving individuals from river basins like the Sava River basin. It's essential to note that HydroSOS does not store data. During the discussion, a question was raised about the ownership of data stored in Sava-HIS, with the response that HydroSOS experts do not need access to background information, and users can directly apply the HydroSOS tools to generate the products themselves, with very little effort. HydroSOS does not have specific model requirements and does not run forecasts but rather consolidates forecast data in a consistent format. The Sava River Commission shared its use of various simulation models for forecasting.

Presentation by **Ms. Lucia Cappelletti** gave an overview on OSCAR/Surface, which is a WMO repository for metadata, hosted by MeteoSwiss. Its goals include documenting current and historical station metadata, identifying and closing observational gaps, and enhancing the quality and availability of exchanged data. Metadata sources encompass international data centers, national organizations like NMHSs, and in the future the WMO Information System. WMO members are required to manage their observing network capabilities in OSCAR/Surface. Besides the productive system a test system is available and can be used by users as sand-box. The GUI and API allow search and management of station metadata. Stations can be also grouped in so called station clusters. The introduction of hydrological stations in OSCAR/Surface is still in testing phase, and feedback is collected. The allocation of WIGOS Station Identifiers (WSI) was discussed, with a demonstration scheduled for the following week. During the discussion, plans for incorporating metadata in WaterML2.0 standard were raised, indicating a potential future task. The use of the WHOS broker to convert metadata to a usable format for OSCAR/Surface was suggested. Challenges related to the registration of hydrological stations and WSI allocation based on meteorological stations were also addressed, along with a call to explore existing variables measurable at hydrological stations and propose additional variables.

Concluding the online part of the meeting, *Mr. Samo Grošelj* from ISRBC invited all participants to the upcoming in-person workshop on Monday. *Ms. Sari Lappi* from WMO expressed gratitude and reassured participants that systems introduced today would become clearer after the workshop next week.

Face-to-Face session

The in-person event began with opening remarks from ISBRC Executive Secretary **Mr. Dragan Zeljko**, who welcomed participants and underscored the importance of the event in enhancing data exchange and providing feedback for improving Sava HIS. He wished everyone a pleasant stay in Zagreb. *Ms. Sari Lappi* referred to and reiterated the opening remarks from the previous week, emphasizing the significance of WMO frameworks and EW4All in fostering active participation. *Mr. Silvano Pecora* emphasized the importance of international collaboration in defining hydrological data sharing in the Sava River basin. He mentioned collaborations with organizations like International Association of Hydrological Sciences (IAHS). Drawing insights from historical figures like **Leonardo da Vinci**, he highlighted the criticality of water management. Additionally, he discussed the role of WHOS as a global data broker and highlighted discussions on data formats during the workshop. He expressed gratitude for support from partners like OGC. Following the opening remarks, all participants introduced themselves.

The face-to-face session first part dived into practical hands-on trainings and demonstrations based on online overview introductions of Sava GIS Geoportal (www.savagis.org), Sava HIS (www.savahis.org). Participants were given Sava system demo and three exercise show to use systems and how to download, edit hydromet meta data and how to use data for their modelling purposes, and how to create WaterML API. After Sava HIS demo, Danube HIS system (www.danubehis.org) was demonstrated in practice, showcasing water level, discharge, precipitation, filtering and visualization of data and stations.

Mr. Jörg Klausen's presentation covered the importance of metadata, particularly within the context of the WIGOS framework, which aims to standardize observations across various disciplines. It emphasized the need for comprehensive metadata to understand and utilize observational data

effectively. The WIGOS metadata standard, based on ISO 19156, was introduced, outlining its 10 categories and over 40 elements, many of which use controlled vocabularies for easier exchange. The presentation also touched on the complexities of describing observations in terms of time and space and highlighted the formal representation of WIGOS metadata using a UML model and XML schema. It also discussed the challenges and processes involved in generating valid WIGOS metadata records and interacting with systems like **OSCAR** Surface through APIs. Additionally, it introduced Key Performance Indicators (KPIs) for assessing the quality and extensiveness of WIGOS metadata records, providing insight into their usage and potential improvements. Finally, he encouraged collaboration to facilitate the exchange of metadata between systems like OSCAR and hydrological information systems (HIS) for enhanced interoperability and data utilization.

Ms. Lucia Cappelletti guided participants through an OSCAR/Surface demonstration. Participants received hands-on training on how to register and edit stations with their own metadata on the test platform. Additionally, *Mr. Washington Otieno* presented the WMO WSI allocation for hydro stations. Participants were also tasked with creating WSIs and providing feedback, as well as identifying any missing metadata for hydrology. During the session, a possibility having a regional WIGOS centre for hydrology from the region was discussed.

Mr. Roberto Roncella presented WHOS API and OSCAR pilot registration of stations.The system, mediated by the WHOS broker, is undergoing interoperability tests with the OSCAR platform to automate data uploads from WHOS providers. Challenges include missing metadata elements, which require discussion for resolution. The OSCAR API, demonstrated in the presentation, offers functionalities for station registration and updates, allowing users to interact programmatically and retrieve data in machine-readable formats like JSON and WIGOS Metadata XML. Live demonstrations highlighted querying stations based on parameters, uploading new station data, and updating existing station information using the OSCAR API.

The last presentation on Monday was by *Mr. Sylvain Grellet and Mr. Hylke van der Schaaf,* who discussed a water quality interoperability experiment aligned with OGC and WMO standards. It tests how these standards can handle specific water quality data needs. The experiment involves collaboration with various organizations and aims to produce best practices for data exchange. They

extended the SensorThings API data model to fit water quality requirements and implemented it in the Frost server for data sharing and visualization. The SensorThings API was highlighted for its potential in metadata management. Collaborative opportunities with other river basin countries, like those in the Plata basin, were also mentioned.

Tuesday morning started with recapping of previous day, and additional testing of OSCAR/Surface. Feedback for improving OSCAR metadata was discussed, encompassing various suggestions such as incorporating information regarding the distance from river mouths, ice conditions, river water temperature, and river names for effective filtering. Additionally, there was a recommendation to include statistical information, thresholds, left and right banks, and reference to guide on hydrological practices metadata list. More feedback can be provided to the document provided by *Mr. Washington Otieno*.

Mr. Sylvain Grellet and Mr. Hylke Van der Schaaf gave their third presentation, with a reference to integrating new OGC standards, particularly focusing on SensorThings. They provided an overview of the SensorThings API, discussing its functionality, REST interface, and support for push notifications. They demonstrated the API with live demos, showcasing its ease of use and capability to exchange sensor data and metadata. The discussion emphasized the importance of understanding and utilizing the API for future projects and collaborations.

Mr. Enrico Boldrini provided first an introduction to data providers to share data online efficiently in a global context, introducing and detailing the concepts of metadata, data, web services. Finally, WHOS was presented, as a system of systems based on a brokering approach to share hydrological data at global scale. Focus was given on the WHOS broker component and the hydro ontology.

WHOS broker indeed connects web services implemented by data providers and clients from the hydrology community. Hydro ontology contains a description of the concepts more commonly used by the WHOS community. Demonstrations were given, showing connections and interoperability with different initiatives and organizations, including WIS2.0, WHOS portals, related tools and usage, further expanding from the previous week presentation.

Mr. Juan Bianchi presented on WHOS metadata quality, covering aspects such as discovery metadata, metadata aggregation. He also discussed the components of a discovery broker, emphasized metadata mapping's importance, and outlined minimum requirements for brokering. Bianchi also addressed metadata quality assessment and semantic mapping, aiming to enhance data exchange and interoperability within WHOS.

Mr. Washington Otieno briefly presented the significance of monitoring for understanding data ingestion and system operations. He underscored the importance of agreement on what to monitor and the need for defining indicators and implementing tools. Additionally, he discussed the integration of WHO's and ways for notification purposes, enabling users to subscribe to specific datasets and receive updates. Lastly, he touched on the development of a structured topic hierarchy for data categorization and easy access.

The final presentation session was followed by a discussion session, which involved participant feedback on how to improve the Sava HIS system and gather input from the attendees. During the Sava HIS improvement discussion, key points included enhancing functionality with XML import for multiple stations, setting aims for data sharing, investigating data input harmonization between the Sava and Danube systems, and addressing challenges with file formats. Concerns were raised about data duplications between the Sava and Danube systems, prompting interest in data exchange formats.

It was recognized that the event provided an opportunity to connect with regional colleagues, international experts, and organizations such as WMO, ISBRC, and ICPDR Secretariat.

Participants recommended WMO to focus on improving WIGOS to better incorporate hydrology. They also proposed the need to harmonize the existing standards. Participants also aimed to establish contacts for future collaboration and discussed engagement with vendors to address hardware and software needs regarding data formats, emphasizing the importance of standardization.

The event concluded with following statements and recommendations:

Achievements

- The workshop presented accessing and sharing procedures to the hydrological, meteorological data and metadata using relevant standards and principles supported by WMO through different tools, i.e. Sava HIS, Danube HIS, WIGOS, OSCAR, WHOS as well as their interoperability between each other and with other tools
- The workshop discussed existing policy on the exchange of hydrological and meteorological data and information, particularly in the Sava River basin, through the implementation of WMO Unified Data Policy
- The workshop provided a hands-on training on editing existing data and metadata within Sava HIS, including the export of data through the Water ML 2.0 web services, as well as registration of hydrological stations in OSCAR and allocation of WIGOS Station Identifiers
- The workshop also explored the implementation of the Water ML 2.0 (including Part 5 for water quality), the WMO Hydrological Status and Outlook System (HydroSOS), EW4All initiative and their linkages to WHOS

Assignments to participants:

- The workshop participants from the Sava HIS data providers (NHMSs), will import and/or edit data and metadata related to the available stations in Sava HIS using the HISTORICAL DATA TOOL and will inform the ISRBC Secretariat (msarac@savacommission.org) on the performed actions until March 29, 2024
- All workshop participants will perform testing of the Danube HIS and will send the feedback on findings to the ICPDR Secretariat (alex.hoebart@icpdr.org, zoran.major@icpdr.org) until February 29, 2024
- All workshop participants will perform testing of the OSCAR/Surface and allocation of WSI, and will send their feedbacks and findings to wotieno@wmo.int and lucia.cappelletti@meteoswiss.ch until February 29, 2024 and will send a list of variables and proposed improvements of metadata to whos@wmo.int, msarac@savacommission.org, and lucia.cappelletti@meteoswiss.ch
- The workshop participants asked the ISRBC Secretariat to launch a discussion on the technical level with the members of the ISRBC Permanent Expert Group for Hydrological and

Meteorological Issues (PEG HMI) on the possibility that the Sava HIS will take a role as the Regional WIGOS Center

- The workshop participants will test the WHOS global portals and propose any additions to whos@wmo.int

Recommendation to organizers and lecturers

- The workshop recommended to reference Guide to Hydrological Practices in the OSCAR improvement for hydrology and to compare data management systems (like MCH) metadata to OSCAR
- The workshop invited the Sava HIS data providers, ISRBC, and ICPDR to discuss and express their interest to participate in the Water Quality IE SensorThings API
- The workshop invited the Sava HIS data providers to consider proposing expert representation from the region (Sava, Danube) to the RA VI (Europe) HydroSOS implementation Group that has just been established. A follow-up online event focusing on HydroSOS can be arranged if participants are interested.
- The workshop suggested to the OGC and WMO that Water ML: Part 5 – Water Quality, in its further development, make compliant with the EU Water Framework Directive reporting guidance (https://cdr.eionet.europa.eu/help/WFD/WFD_715_2022) and obligations of the EU countries of reporting water quality parameters to EIONET
- The workshop suggested a continuation of the exchange of knowledge and good practices within the cooperation and joint activities of WMO and ISRBC through a similar events every 2 years

Report and acknowledgements

- Workshop presentations are/will be made available at website: https://wmo.int/events/workshop/capacity-building-workshop-hydrological-data-exchange-standardization-interoperability-ra-vi
- Workshop summary report will be compiled in February 2024 and shared with participants
- The workshop co-organizers WMO and ISRBC expressed gratitude to all participants and lecturers for their active participation and contribution during the workshop with a hope that

the workshop itself will draw the interest of and be useful to the participants in their further work

Annex 1. Agenda
Programme

Time (CET)	Topic	Facilitator/Presenter
Online Session One: 25 January 2024 from 13:00 to 16:00		
13:00–13:20	Introduction and welcome	Dragan Zeljko, ISRBC Executive Secretary Sari Lappi, WMO Secretariat Silvano Pecora, WMO INFCOM Vice-President and Chair JET-HYDMON
13:20–13:50	SAVA HIS	Mirza Sarač, ISRBC
13:50–14:15	WHOS and SAVA HIS (data protocols and tools, data, metadata)	Mirza Sarač, ISRBC Silvano Pecora, WMO INFCOM Vice-President and Chair JET-HYDMON
14:15–14:30	Questions and answers	Johanna Korhonen, WMO Secretariat
14:30-14:45	**Break**	
14:45–15:00	Danube HIS	Zoran Major and Alex Hoebart, ICPDR
15:00–15:30	WaterML2.0 part 1-5	Sylvain Grellet, BRGM
15:30–16:00	Questions and answers, Closing	Johanna Korhonen, WMO Secretariat
Online Session Two: 26 January 2024 from 09:00 to 11:30		
09:00–09:05	Recap of day 1	Mirza Sarač, ISRBC
09:05–09:20	SensorThings API and WaterML2.0	Hylke van der Schaaf, SensorThings API SWG co-chair and implementer of FROST Sylvain Grellet, BRGM

09:20–09:35	WHOS DAB, Ontology, and other technologies	Enrico Boldrini, ESSI-lab of the CNR-IIA Washington Otieno, WMO Secretariat
09:35–09:50	Questions and answers	Enrico Boldrini, ESSI-lab of the CNR-IIA Washington Otieno, WMO Secretariat
09:50–10:00	**Break**	
10:00–10:15	WHOS Integration with other Systems (including WIS, OSCAR)	Enrico Boldrini, ESSI-lab of the CNR-IIA Washington Otieno, WMO Secretariat
10:15–10:35	HydroSOS	Katie Facer-Childs, UKCEH Sulagna Mishra, WMO Secretariat
10:35–10:50	Questions and answers	Sulagna Mishra, WMO Secretariat
10:50–11:10	OSCAR/Surface and WSI	Lucia Cappelletti, MeteoSwiss Washington Otieno, WMO Secretariat
11:10–11:20	Recap and conclusion	Johanna Korhonen, WMO Secretariat
11:20–11:30	Closing remarks	Sari Lappi, WMO Secretariat Silvano Pecora, WMO INFCOM Vice-President and Chair JET-HYDMON
End of online session		
Physical Session (ISRBC, Zagreb Croatia) 29th January 2024		
09:00–09:30	Introduction and Welcome	Dragan Zeljko, ISRBC Executive Secretary Sari Lappi, WMO Secretariat Silvano Pecora, WMO INFCOM Vice-President and Chair JET-HYDMON
9:30–10:40	SAVA HIS (data interoperability and Tools)	Mirza Sarač, ISRBC
10:40–11:30	Questions and answers	Johanna Korhonen, WMO Secretariat

10:45–11:00	**Coffee Break**	
11:00–11:30	Demonstration of Danube HIS	Zoran Major and Alex Hoebart, ICPDR
11:30–11:40	Open discussions: Learning exchange on SAVA HIS and Danube HIS	Silvano Pecora, WMO INFCOM Vice-President and Chair JET-HYDMON
11:40–12:30	Application of WIGOS Metadata Standard	Jörg Klausen, chair TT-WIGOS Metadata
	KPIs for WIGOS metadata	Jörg Klausen, chair TT-WIGOS Metadata Anna Milan, WMO Secretariat
12:30–12:40	Questions: Application of WIGOS Metadata Standard	Jörg Klausen, chair TT-WIGOS Metadata Lucia Cappelletti, MeteoSwiss
13:00–14:00	**Lunch**	
14:00–14:20	WSI and OSCAR demonstration	Lucia Cappelletti, MeteoSwiss Washington Otieno, WMO Secretariat
14:20–14:40	WHOS DAB and OSCAR API XML template demonstration	Roberto Roncella, ESSI-lab of the CNR-IIA Lucia Cappelletti, MeteoSwiss
14:40–15:45	Pilot registration of Stations in OSCAR	Roberto Roncella, ESSI-lab of the CNR-IIA Lucia Cappelletti, MeteoSwiss Washington Otieno, WMO Secretariat
15:45–16:55	Water Quality Interoperability experiment: Implementation of WaterML2.0 part 5 in SAVA HIS (use sample data)	Sylvain Grellet, BRGM Hylke van der Schaaf, SensorThings API SWG co-chair and implementer of FROST
16:55–17:00	Recap	Sari Lappi, WMO Secretariat and Johanna Korhonen
Physical Session (ISRBC, Zagreb Croatia) 30th January 2024		
09:00– 09:05	Recap on WHOS interoperability overview	Silvano Pecora, WMO INFCOM Vice-President and Chair JET-HYDMON
9:05– 9:25	OSCAR/Surface Recap	Lucia Cappelletti, MeteoSwiss Roberto Roncella, ESSI-lab of the CNR-IIA
9:30 – 10:45	Demonstrations: Implementation of WHOS Ontology; Metadata mappings,	Enrico Boldrini, ESSI-lab of the CNR-IIA

	profiles, discovery and WaterML2.0 standards	Silvano Pecora, WMO INFCOM Vice-President and Chair JET-HYDMON
10:45–11:00	**Break**	
11:00-11:30	Integration of new OGC Standards e.g SensorThings API,	Hylke van der Schaaf, SensorThings API SWG co-chair and implementer of FROST Sylvain Grellet, BRGM
11:30-12:00	WHOS new integrations: CUAHSI, HydroServer, WIS (MQTT, WMCP2.0)	Enrico Boldrini, ESSI-lab of the CNR-IIA
12:00–12:30	WHOS monitoring WIS Monitoring, and topic hierarchy	Washington Otieno, WMO Secretariat Enrico Boldrini, ESSI-lab of the CNR-IIA
12:30–13:00	Questions and Answers	Enrico Boldrini, ESSI-lab of the CNR-IIA Washington Otieno, WMO Secretariat
13:00-14:00	**Lunch**	
14:00 –14:30	WHOS metadata quality	Juan F. Bianchi, Instituto Nacional del Agua, Argentina
14:30–15:00	Reflections/discussions on SAVA HIS and Danube HIS	Silvano Pecora, WMO INFCOM Vice-President and Chair JET-HYDMON Washington Otieno, WMO Secretariat
15:00–15:30	Open Discussion: Improvement of SAVA HIS	Mirza Sarač, ISRBC
15:30–15:45	**Break**	
15:45–16:15	Open discussion and next steps: WHOS interoperability for SAVA HIS and Danube HIS	Silvano Pecora, WMO INFCOM Vice-President and Chair JET-HYDMON Enrico Boldrini, ESSI-lab of the CNR-IIA Washington Otieno, WMO Secretariat
16:15–16:30	Conclusion, next steps for WHOS support to HydroSOS in Sava	Johanna Korhonen, WMO Secretariat Mirza Sarač, ISRBC

16:30–16:45	Closing and final remarks	Sari Lappi, WMO Secretariat
		Zoran Major, International Commission for the Protection of the Danube River
		Silvano Pecora, WMO INFCOM Vice-President and Chair JET-HYDMON
		Dragan Zeljko, ISRBC Executive Secretary
End of Training		

Annex 2. List of participants (in person Zagreb)

Name	Country	Organization
TRAKO, Merima	Bosnia and Herzegovina	Federal Hydrometeorologic Service (FHMZ)
Babić, Azra	Bosnia and Herzegovina	Federal Hydrometeorologic Service (FHMZ)
Stanic, Stefan	Bosnia and Herzegovina	Republički hidrometeorološki zavod Republike Srpske (RHMZRS)
MARIC, Sasa	Bosnia and Herzegovina	Republički hidrometeorološki zavod Republike Srpske (RHMZRS)
Haris Fišeković	Bosnia and Herzegovina	Sava River Watershed Agency
Maja Radić Čaušević	Bosnia and Herzegovina	Sava River Watershed Agency
Živadinović, Predrag	Serbia	Hydrometeorological Service of Serbia (RHMZ)
Ćatović, Samir	Serbia	Hydrometeorological Service of Serbia (RHMZ)
Vesna Vidmar	Slovenia	Slovenian Environment Agency (ARSO)
Jože Miklavčič	Slovenia	Slovenian Environment Agency (ARSO)
Željka Klemar	Croatia	Croatian Meteorological and Hydrological Service (DHMZ)
Nevenka Kadić Vlahović	Croatia	Croatian Meteorological and Hydrological Service (DHMZ)
Ervin Kalac	Montenegro	Institute of Hydrometeorology and Seismology (ZHMS)

Danijela Bubanja	Montenegro	Institute of Hydrometeorology and Seismology (ZHMS)
MATREATA, Marius	Romania	National Institute of Hydrology and Water Management
STOVICEK, Vit	Czechia	Czech Hydrometeorological Institute (CHMI)
Major, Zoran	Austria	International Commission for the Protection of the Danube River (ICPDR)
Höbart, Alexander	Austria	International Commission for the Protection of the Danube River (ICPDR)
Mirza Sarač	Croatia	International Sava River Basin Commission (ISRBC)
Samo Grošelj	Croatia	International Sava River Basin Commission (ISRBC)
BOLDRINI, Enrico	Italy	National Research Council (CNR)
PECORA, Silvano	Italy	Ministry of Environment and Energy Security, Italy
Cappelletti, Lucia	Switzerland	MeteoSwiss
KORHONEN, Johanna	Switzerland	WMO
OTIENO, Washington	Switzerland	WMO
LAPPI, Sari	Switzerland	WMO

Online

Name	Country	Organization
Juan Bianchi	Argentina	National Water Institute
Katie Facer-Childs	UK	UK Centre for Ecology & Hydrology
Sylvain Grellet	France	French Geological Survey
Jörg Klausen	Switzerland	MeteoSwiss
Roberto Roncella	Italy	National Research Council (CNR)
Hylke van der Schaaf	Germany	Fraunhofer Institute of Optronics, System Technologies and Image Exploitation IOSB
Peter Wasswa	Switzerland	WMO
Yirgalem Gebremichael	Switzerland	WMO