Innovation Workshop "WMO HydroHub Phase II Innovation Roadmap"

2 & 4 February 2022

Workshop Report

March 2022

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Day 1: Wednesday 2 February 2022

Opening

The Innovation Workshop was opened by Harry Dixon, Chair of the WMO HydroHub Advisory Council, who gave some background on the WMO HydroHub and its mission to enhance sustainable monitoring of freshwater environments through 1) increasing the hydromet monitoring capacity of National Meteorological and Hydrological Services (NMHSs); 2) supporting the operationalization of innovations to solving hydrometric challenges; and 3) optimizing engagements and investments in global hydrometry through better connecting the community. Participants were reminded that this is a pivotal point for the Hub with its second Phase that started in September with a new 5-year programme of activities. The Innovation Workshop brings together the operational hydrometry community with research and the private sector to share experiences and co-develop ideas on how best to move forward and shape the future roadmap for the Hub. Harry Dixon acknowledged the co-organizers of the Innovation Workshop, namely the International Association of Hydrological Sciences (IAHS) and its MOXXI Working Group and the WMO Public-Private Engagement Office, as well as the Swiss Agency for Development and Cooperation (SDC) and UK Aid for their financial contribution.

Segment 1: Transitioning innovations into operational use

The Chair of Segment 1, Harry Dixon (UKCEH), introduced the three speakers of the segment that shared their respective experiences on transitioning innovations into operational use.

Elizabeth Jamieson (Environment Canada)

The presentation highlighted the experiences of the Water Survey of Canada (WSC) – *Canada's national hydrometric program that operates a network of over 2,000 active real-time stations* – in transitioning new technologies into operations in the framework of the $90 million investment of the Government of Canada for the renewal of Canada's Hydrological Services, $15 million of which specifically dedicated to innovation.

The renewal started in 2018 and has shown that the path to adopting new technologies or new methods is not straightforward. The main lessons learnt in the process include:

- Essential to engage key users early on
- Ensure that dedicated capacity, staff and time is attributed to the process
- Benefits need to be clearly defined
- Pilot in specific region while being aware of regional differences and requirements
- Importance to opt for a softer optional release when possible as this will ease the transition
- Adequate trainings
- Promote early adopters of new technologies
- Timeline for early use

Finally, the presentation highlighted the need to accept failure at the testing phase and the challenge of not having consistent international standards for transitioning to new technologies in the context of hydrometric operations.

Alice Soares (World Bank)

The presentation provided an overview of how innovation can help and support development partners and countries implementing Capacity Development projects to achieve their expected results. Large public sector investments in National Meteorological and Hydrological Services (NMHSs) and disaster management agencies tend to apply proven but often outmoded solutions based on the experience of past projects. In general, these are scoped well in the overall results expected, but do not account for the rapid development of technology and know-how.

Despite considerable scientific and technical advances, underinvestment in NMHSs, coupled with poor regulation and business practices, prevents the Hydromet enterprise from fully protecting developing economies.

Finally, the presentation highlighted some of the key challenges that should be addressed to help NMHSs to innovate, including:

- Poor regulations and business practices
- Rivalry between public and private actors (due to a lack of understanding of respective roles, which are often not well defined at the national level)
- Limited interactions with the academic sector
- Open data policies which are proven to increase economic benefits are not applied to hydrological data
- Limited or no research and development aspect in the modernization process due to limited resources
- Limited engagement with users is a drawback in the NMHSs modernization process

Kevin Oberg (USGS)

The presentation highlighted the experiences of the United States Geological Survey (USGS) in the transition of hydroacoustic instrumentation from the research environment to an operational tool. The history of the technology changes in hydroacoustics was presented, as was the role of the USGS in making these changes happen.

Six “lessons learned” from this experience that may assist in evaluating and transitioning new technologies in the future were put forward:

1. Technical innovation. Innovation does not necessarily occur in one big step but is rather a continuous change.
2. Incentives for using the equipment (economic, capability, accuracy, and safety).
3. Importance of training and standard operating procedures.
4. Work with manufacturers through informal agreements. Formal agreements may also be useful but require more time. Working with manufacturers in a non-adversarial way is key to transitioning new technology to users.
5. Vital to have a testing program for instrumentation (both lab and field testing).
6. Need for resources to help advance technology. There is a need for staff who are dedicated to work on the technology.

Finally, the presentation highlighted the need to continue innovation, even when the technology has matured or is maturing.

Q&A session

Key highlights of the Q&A are captured below:

Presentation 1:

- Details and availability of publication on software to make data sheet electronic: application is a stand-alone executable, written in Python, open source and have integrated connection points for when the field sheet is finalized and approved. It can then be uploaded into production system Aquarius. Discharge measurements can be imported directly into the field sheet to automate the inputting of data so that it is not all transcribed electronically. Documentation can be shared.

Presentation 2:

- Responsibility of international development agencies in limited success of investments: loans go to the countries and the responsibility to decide on what should be invested on lays on the countries.
- Many partners are bringing many models and types of network leading to crowded environments: coordination of development partners is critical from the design stage to avoid duplication of work.
- Need for open data policies and applicability: data sharing is needed at the internal level not just internationally, especially when National Meteorological Services and Hydrological Services are separated.

Presentation 3:

- Applicability of USGS method for suspended sediment concentration measurement in Patagonia for sand and gravel: not a standard method at this point.

Segment 2: River flow and rainfall measurement with innovative non-contact technologies

The Chair of Segment 2, Nick Everard (UKCEH), highlighted that the session focuses on specific examples of innovations and invited participants to reflect during the following presentations on "How do we move forward as a community?", "How do we pick up some of the presented ideas?" and "How to enable others to implement innovations more effectively?".

Presentation "Image analysis for hydrological measurements" by Flavia Tauro (University of Tuscia, Italy and Chair of IAHS MOXXI Working Group)

The presentation of Ms Tauro focused on the use of image analysis for hydrological measurements. The presentation highlighted the following advantages of using images in comparison to other technologies: non-intrusive observations, distributed rather than point-wise, high-resolution in space and time, and diverse spatial scales. The presentation provided a bit of history on river flow measurements with images as well as outlook on latest research advancements in river flow

measurements. The presentation highlighted that image analysis has the potential to advance hydrometric measurements, however, its uptake by operational agencies is still lagging behind. Research needs and limitations of this technology were outlined as well as future perspectives for ameliorations.

Pitch by Mark Randall (Queensland Government, Australia)

The presentation focused on the operationalization of non-contact streamflow methods in Australia. The presentation highlighted that in October 2021, the Australian Bureau of Meteorology (BoM) published Part 11 "Application of surface velocity methods for velocity and open channel discharge measurements" of its National Industry Guideline series for hydrometric monitoring in Australia. Part 11 operationalizes the use of emerging technologies and methodologies associated with surface velocity discharge measurements by establishing a set of operational standards and guidance. The presentation highlighted that the surface velocity measurements achieved through video image analysis have become increasingly popular driven by the use of drone technology, commodity cameras, and the ability to measure velocities and floods that existing methods are unable to. Surface radar systems also provide a popular non-contact method of discharge measurements. Until now these methods have been utilized in an unregulated environment and unable to meet the expectations of a quality-controlled/managed hydrometric data environment. Mr Randall concluded by highlighting the importance of having standardized national guidelines for methodologies to open the doors for funding.

Pitch by Sumit Sen (IIT Roorkee, India)

Mr Sen presented the project that was awarded in the frame of the WMO HydroHub Second Innovation Call and aimed at embedding an open-source non-contact solution for water level monitoring in the Indian Himalayas. The presentation highlighted that the project increased the monitoring capacity and capabilities of the Central Water Commission (CWC, India) through the use of lidar-based sensors for near-real-time measurement of water levels. As lessons learnt, it was highlighted that low-cost sensor networks have the potential to improve monitoring resolution at a fractionally lower cost than traditional monitoring networks. Notwithstanding the interest shown by the NMHS towards a low-cost river stage monitoring solution, the organizational culture and market ecosystem still favor the use of propriety technology. The presentation highlighted that more research into the sociological aspects of technological uptake and organizational change is needed to promote the widespread use of low-cost sensors in operational hydrology.

Pitch by Salvador Peña-Haro (Photrack, Switzerland)

Mr Peña-Haro presented the opportunities and challenges in establishing image-based flow monitoring techniques. The presentation focused on two solutions for river flow monitoring: a mobile application "DischargeApp" and a fixed system "DischargeKeeper". Mr Peña-Haro showed in detail how the application "DischargeApp" is used and explained how does the "DischargeKeeper" work. The presentation highlighted the following advantages of the "DischargeApp": vandalism free, error-free data transmission and on-site evaluation. Mr Peña-Haro also highlighted several challenges associated with image-based flow monitoring such as certification/validation, protocol/guidelines and dissemination. Specifically for the "DischargeApp", the following additional

challenges were highlighted: capacity building and technical support for people who use the application on the field.

Pitch by William Castaings (Tenevia, France)

The presentation focused on camera-based solutions developed for measuring and monitoring river flows. Mr Castaings highlighted that it is now widely acknowledged that cameras, with a wide range of consumer-grade devices, are interesting and cost-effective tools for providing hydrometric variables, for both offline surface gauging and real-time monitoring. Mr Castaings presented a professional tool for offline surface gauging called FlowSnap developed to extend the set of tools available for field hydrometers and based on an end-to-end workflow and intuitive and highly interactive software. Mr Castaings further presented the "CamLevel" and "CamFlow" solutions providing real-time measurements using Edge computing on video surveillance cameras (onboard image processing). It was highlighted that the "CamLevel" application is based on the automatic detection of the waterline on a staff gauge, and the "CamFlow" application measures surface velocities and compute discharge. The presentation further highlighted that for both applications, calibration tools, guidelines and training material were developed. Mr Castaings also presented challenges they tried to address for operational uptake and scaling of these solutions.

Pitch by Jonny Higham (Liverpool Uni, England)

Mr Higham presented "FlowOnTheGo", a lightweight code developed to track flows on the go. The presentation highlighted that the technology primarily works on smartphones but also has been translated to a web-based and desktop app. Mr Higham showed how to use "FlowOnTheGo" and highlighted that everything is free, making it accessible to as many people as possible. The code is based on using the Lucas Kanade method to solve the optical flow equations and determine flow velocity from surface features. The app is available to download as an alpha version in all forms and soon will be launching on several App Stores. Mr Higham concluded the presentation by highlighting that "FlowOnTheGo" is under continuous development and improvement.

Pitch by Guillaume Valladeau (vorteX.io, France)

Mr Valladeau presented vorteX.io that offers an innovative and intelligent service for monitoring hydrological surfaces, using in-situ remote sensing instruments, based on compact lightweight altimeter inspired from satellite technology: the micro-stations©. The presentation highlighted that the micro-station provides in real-time, with high frequency and accuracy, hydro-meteorological parameters (water surface height, water surface velocity, images & videos - and coming soon rainfall estimates -) of the observed watercourses. It was further highlighted that the combination of these in-situ data with satellite measurements is optimal for downstream services related to water resources management and assessment of flood/drought risks. Mr Valladeau concluded by highlighting that thanks to the large-scale deployment of the innovative micro-station© and the real-time onboard processing using artificial intelligence algorithms, vorteX.io will offer anytime/anywhere hydro-meteorological monitoring and notification services.

Pitch by Mariano Re (Instituto Nacional del Agua, Argentina)

Mr Re presented the application of innovative flow techniques in the framework of water quality management in the Matanza-Riachuelo River Basin. The presentation highlighted that the Matanza-Riachuelo River Basin, located in the Metropolitan Region of Buenos Aires and with six million inhabitants, presents high levels of pollution. Mr Re further highlighted that the good dialogue and joint work between the Basin Authority and the National Hydrological Service made it possible to incorporate innovative techniques for operational management. Mr Re briefly described innovative techniques that were applied and how the information was operationally used. The presentation further highlighted some advantages and limitations of image velocimetry such as the presence of garbage or algae, fixed points do not persist and hydrometric scales maintenance.

Q&A session

After the speakers made their presentations, they took part in a Q&A session moderated by Flavia Tauro.

Main point highlighted during the Q&A session regarding RIVeR-STIV is:

- RIVeR-STIV is commercial software. No license is needed to use it and it is compiled in Matlab.

Main points highlighted during the Q&A session regarding the question “What are your lessons learned on what has worked well and what has been a challenge at scaling or looking at scaling your solutions in LICs, where NHMSs have low resources?”:

- Need to train people on how to use tools and give support on the field.
- It is difficult to convince NMHSs that 6-month or one-year project is going to work, and that new data collected are compatible with their own databases.
- To solve the scalability problem, we rely on the industry of distribution network: to install and set up a system in a given place there is a local distributor which can provide the camera, install it and maintain it.
- More effort should be made to explain the benefits of having improved knowledge and how this can be translated into better identification of catastrophic events.
- The problem of scalability is first of all the fact that in-situ solutions need maintenance, people on the ground to calibrate the sensors, gather data etc. New technologies can solve this problem by using space altimeter (no need of maintenance on the ground). Secondly, the remote supervision of the sensor: when we want a good quality of service, we need to have a large view of all networks which must be homogeneous.

Other point highlighted during the Q&A session is:

- In the following countries, agencies have formally adopted image velocimetry methods within their hydrometrics operations: France, Australia, New Zeeland, Japan, Switzerland.

End of Day 1: Mentimeter vote

At the end of Day 1, the workshop participants were invited to submit their responses on Mentimeter to two following questions:

- What recent innovative solutions can be put into widespread operational use over the next 5 years to improve hydrometric data collection & management?
- What support is needed to accelerate the transition of these innovations into operational use?

For the first question – 35 responses were received; for the second question – 36 responses were received.

The workshop organizing committee reviewed the responses received and organized them into:

- 12 technical innovation areas that the WMO HydroHub could support in its Phase II
- 10 priority areas of support needed to advance these innovations

The selected options for these two categories were used for the Day 2 Mentimeter vote (see below Segment 5).

Day 2: Friday 4 February 2022

Segment 3: Data tools, transmission and interoperability or automated data quality control

The Chair of Segment 3, Mr Christophe Cudennec (Institut Agro, France and Secretary General of IAHS), gave a brief introduction to the session.

Presentation by Jérôme Le Coz (INRAE, France)

The presentation started by highlighting the importance of hydrometric data for water-related issues. The presentation further highlighted that hydrometric data tools are necessary at three levels of the data production process: infrastructure (to make the data available), quality assurance (to make the data reliable) and uncertainty quantification (to make the data informative). These three levels are interdependent and equally important. Further, recently developed tools for the quantification of stream gauging uncertainty (e.g., repeated measures experiments and Oursin/QRevInt for ADCP) and rating curve uncertainty (e.g., BaRatin) were presented. Mr Le Coz highlighted that the ongoing innovation in data tools is a great avenue for improving and extending the production of complete, reliable and informative streamflow data. It was also highlighted that instruments and software are useless without trained and committed field hydrologists and without budgets for running costs.

Pitch by Mirjami Kuoppala (Finnish Environment Institute)

Ms Kuoppala presented the experience of the Finnish Environment Institute with automatization of quality assurance (QA) of numeric data by means of data-analytics / machine learning. Based on experience gained during past three years (2019 – 2021) the automated QA utilizing data-analytics / machine learning looks promising. It is not the answer to every problem you might face but it certainly helps to resolve some of them. E.g.

- When the amount of data is huge it is not possible to validate it manually anymore and thus QA needs to be automated. Utilizing data-analytics / machine learning seems to help with this.
- System enables daily based QA (QA run daily for new data) and thus gives us a way e.g.
    - to react fast for changes in environment
    - to notice immediately if the continues in situ measurement device is malfunctioning
    - to fix erroneous data when e.g., our decision making will be based on more accurate data
- It helps to reduce the manual work and thus saves time and money

The work is in progress thus only preliminary results are available at this point.

Pitch by Hessel Winsemius (TAHMO, Netherlands)

Mr Winsemius started the presentation by highlighting that image-based river observations are highly promising for low-income countries with complex conditions for monitoring. In particular in Africa, rivers may be difficult to observe due to on the one hand low human and financial resources availability, and on the other, remote, volatile and highly seasonally variable streams. The presentation highlighted that to enable independent local uptake of currently highly successful image-based methods in Africa, two conditions are critical: a wide adoption of methods by students and researchers in African Academia based on an open-source community driven ecosystem of methods; and a fully open-source operational platform that ensures data is sustainably and automatically collected from stations and made interoperable for service provision. Mr Winsemius further presented “OpenRiverCam”: open-source operational discharge monitoring with low-cost cameras. The presentation also provided key messages including (1) strive for fully local O&M and (2) data interoperability is key to create value.

Pitch by Prof. M. Perumal (Indian Institute of Technology Roorkee)

Mr Perumal started the presentation by highlighting that the non-contact discharge estimation techniques are being investigated and used extensively in recent times in countries like Italy, U.S. and Japan. It was also highlighted that discharge is estimated by this technique using surface velocities measured at many water depths of a flow event. Mr Perumal further presented the details of an innovative Real non-contact discharge assessment method, which is more acceptable in terms of the time of measurement as well as the cost of measurement than the existing non-contact methods. It was also highlighted that the proposed entropy concept-based method is more efficient for estimating discharge during high flows and at night times. Mr Perumal concluded the

presentation by highlighting that only one velocity radar is needed to compute the discharge of flow events.

Pitch by François Rainville (Environment Canada)

Mr Rainville started the presentation by highlighting that the National Hydrological Services (NHS) of Canada has adopted methods and tools to help improve the quality of its real-time data more effectively. Further, the context for hydrometric monitoring in Canada was presented. It was highlighted that NHS is traditionally an "archive" organization, but data users need better data faster. To address this, the timing of production activities was modified accordingly. Mr Rainville further presented three approaches used: Connected Fieldwork, Results Fast Track and Eyes-on-Data. It was further highlighted that station conditions and performance are constantly monitored with "eyes-on-data" production tools that allow the program to optimize its field visits, costs and data publication. Mr Rainville concluded by summarizing the benefits, concerns and suggestions for continuous data production.

Pitch by Juan Bianchi (Instituto Nacional del Agua, Argentina)

Mr Bianchi started the presentation by introducing INA's SSIyAH, the hydrological information service and alert system for the Del Plata Basin in Argentina. As such, it is a major real-time and historical data producer and consumer with many links with other hydrological agencies and end-users. It was highlighted that Web services (including Web APIs) are widely used as a means to publish observational data and model results, enabling machine-to-machine interaction. Mr Bianchi further presented the WMO Hydrological Observing System (WHOS) and its implementation in the La Plata River Basin. The roles of standardized and brokering approaches were highlighted. Mr Bianchi concluded the presentation by highlighting the benefits of the WHOS regional implementation on data exchange between neighboring countries as well as on data interoperability.

Pitch by Pete Marchetto (Fieldkit, United States)

The use of uncalibrated sensors and sensing systems is rampant throughout the environmental sciences, and worldwide. Starting in 2018, some initial attempts were made at creating an on-line calibration method, where sensing systems that were emplaced in the field would be calibrated retroactively. In this case, a set of fifty sensor nodes were put out in the field, and their relevant parameters were measured using traceable calibration standards whose values were entered into a form on a webpage. These calibration values were then correlated with the recorded values from the sensor nodes, creating unique calibration functions for each of the six modalities on each node of the fifty. Fast-forward several years, and this same technique is now being used in the FieldKit app, which allows users to do their calibration of their stations either in the laboratory or in the field, either pre- or post-installation and deployment.

Q&A session

After the speakers made their presentations, they took part in a Q&A session moderated by Christophe Cudennec.

Main points highlighted during the Q&A session are:

- When we have continuous velocity measurement, we clearly see any rating shift in the stage-velocity relation so it's a very efficient way to detect rating shifts in real-time. This is the advantage of velocity recording stations.
- Many people are used to make decisions without any consideration for uncertainty and that's a real problem. Data users and decision-makers should be trained to pay attention to uncertainty, and strategies that include the uncertainty of data should be developed.

Segment 4: How standards can support innovation in operational hydrometry

Presentation by Tommaso Abrate (WMO)

The presentation provided an overview of the concept of standards, as requirements or specification that ensure that a product or a process is fit for purpose. Different types of standards were illustrated, from those that allow differentiating acceptable and non-acceptable practices, to those that ensure the comparability and compatibility of products and outcomes.

It was recalled that WMO has a standard setting authority and that the mandatory provision included in its Technical Regulation requires that Members do their utmost to implement them and inform if they are unable to do so. The role of standards in ensuring quality and trust in data and products and facilitating their exchange was also highlighted, especially when applied to citizen science initiative. Finally, the presentation presented those provisions in WMO Technical Regulation vol. III – Hydrology, which are especially relevant in the development of innovative technologies, such as the requirement that instrument should be reliable under adverse conditions.

Presentation by Stewart Child (ISO)

The presentation highlighted the role of international hydrometric standards in supporting innovation hydrometry.

An overview on standards was provided, stressing the fact that hydrometric standards should cover the whole of the hydrological cycle including rainfall evaporation, groundwater and sediments. Standards should be dynamic and not frozen in time and should be able to embrace innovation. Standards should not be determined by fiscal and management constraints and should involve international organizations such as WMO to jointly be developed. Furthermore, the presentation highlighted that the development of standards should involve a mix of governments, hydrometric and water supply organizations, meteorological departments, academia, research Institutes among others and should focus on specific techniques and equipment.

Some specific examples of hydrometric were highlighted including:

- Acoustic Doppler profiler
- Acoustic velocity meters
- Velocity Area Methods
- Stage-discharge relationships
- Dilution measurements, tracers and applications

The presentation also highlighted the development of new ISO non-contact methods proposals for Radar, PIV, Laser and drones and the application of surface water velocity methods for velocity and open channel discharge in Australia.

Finally, the presentation highlighted aspects of data quality and sustainability, making reference to existing recommendations, guidance and research on the topic.

Q&A session

Here is the main highlight of the Q&A that followed:

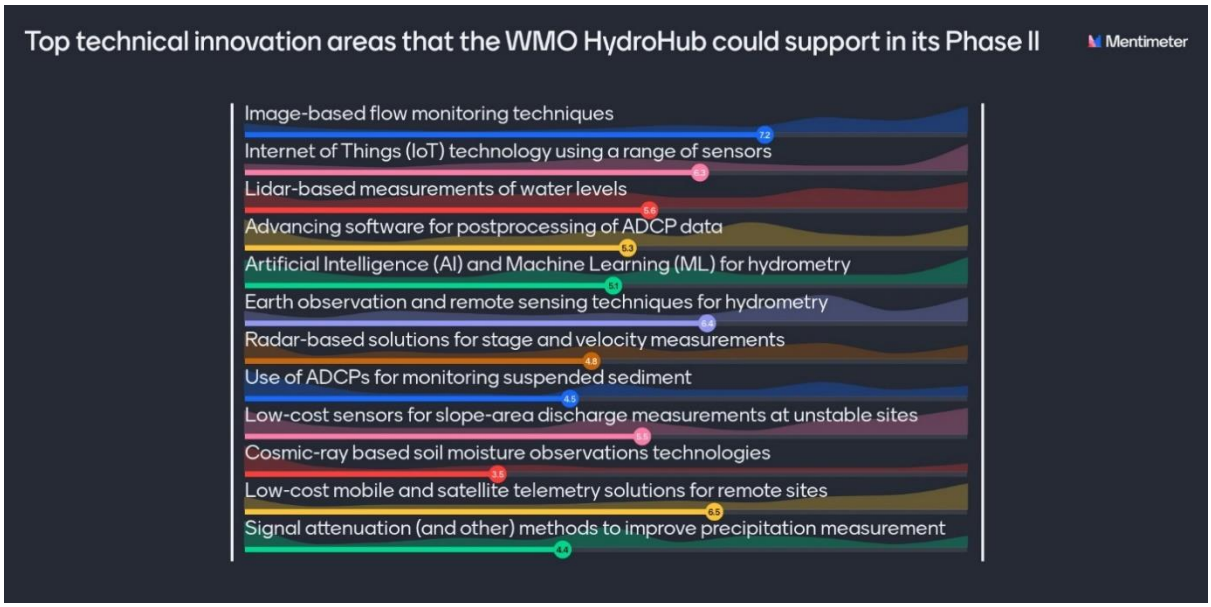
- Any effort by WMO to compile existing standard procedures that have been developed by agencies worldwide? There has been an attempt in the framework of Project X (Assessment of the Performance of Flow Measurement Instruments and Techniques). Also, a recent proposal has been made for WMO to develop a Manual on Hydrometry, building on standards procedures for hydrometric observations established by different Members.

Segment 5: Mentimeter vote

The workshop participants were invited to vote on the selected options of the two following categories:

- 12 technical innovation areas that the WMO HydroHub could support in its Phase II
- 10 priority areas of support needed to advance these innovations

For the first category – 53 participants voted; for the second category – 49 participants voted. The results of the vote are shown below.


Top technical innovation areas that the WMO HydroHub could support in its Phase II
Mentimeter
Image-based flow monitoring techniques
7.2
Internet of Things (IoT) technology using a range of sensors
6.3
Lidar-based measurements of water levels
5.6
Advancing software for postprocessing of ADCP data
6.3
Artificial Intelligence (AI) and Machine Learning (ML) for hydrometry
5.1
Earth observation and remote sensing techniques for hydrometry
6.4
Radar-based solutions for stage and velocity measurements
4.8
Use of ADCPs for monitoring suspended sediment
4.5
Low-cost sensors for slope-area discharge measurements at unstable sites
5.1
Cosmic-ray based soil moisture observations technologies
3.5
Low-cost mobile and satellite telemetry solutions for remote sites
6.5
Signal attenuation (and other) methods to improve precipitation measurement
4.4


Priority areas of support needed to advance these innovations
Mentimeter
Intercomparison of tools (software and hardware) including cost-benefit analyses
6.7
Support for the development of open-source code and open-design hardware
6.2
Guidance regarding innovative procurement/contracting models for NMHSs (and IFIs)
3.9
Support for staff training and development in new hydrometric technologies/approaches (inc. Web-based)
8.1
Development of mechanism to provide long-term innovation advice/assistance for NMHSs
5.8
Sharing of information about available approaches/technologies to increase exposure to new innovations
6.6
Encouraging the development of collaborations between industry, academia and operational services
6.7
Publication of standard operating procedures, guidelines and standards
6.9
Support the establishment of hydrometric centers of excellence and innovation champions
5.2
Support networking of hydrometric experts at global and regional scales to share knowledge and skills
7

Segment 6: Moderated public-private-research sectors panel discussion "Fostering uptake of innovative solutions in operational environments"

Moderator: Tatsuya Kimura

Panelists: Alexandre Hauet (EDF), Mark Heggli (Innovative Hydrology), Fabrice Fretz (SDC), Raul Munoz Castillo (IDB), Marie-Claire ten Veldhuis (TU Delft), Louise Croneborg-Jones (Water in Sight), Robert Sunday (Ministry of Water, Tanzania)

Tatsuya Kimura (Director of the WMO Public-Private Engagement Office) moderated a public-private-research sectors panel discussion on "Fostering uptake of innovative solutions in operational environments". Mr Kimura gave a brief introduction on how the public, private and academic sector can work together to address the various challenges of water management, introduce new technologies and ensure developing countries can adopt them.

The panelists then briefly introduced themselves, including their background and affiliation.

In the first round of discussion, the panelists highlighted the following:

- Data show an increase of funding in the hydrometry sector, which will lead to more opportunities if used wisely by the governments.
- Getting more attention on water issues at the global and multilateral level is critical, and it can be done by showing links between water and peace, water and security etc.
- It must be clear that water is central to planning, development and economic growth.

Most governments ask to include water security as a central pillar in the work done with water resources and infrastructure planning.

The discussion proceeded with Mr Kimura asking targeted questions to each panelist. The summary of the main points highlighted in this round is as follows:

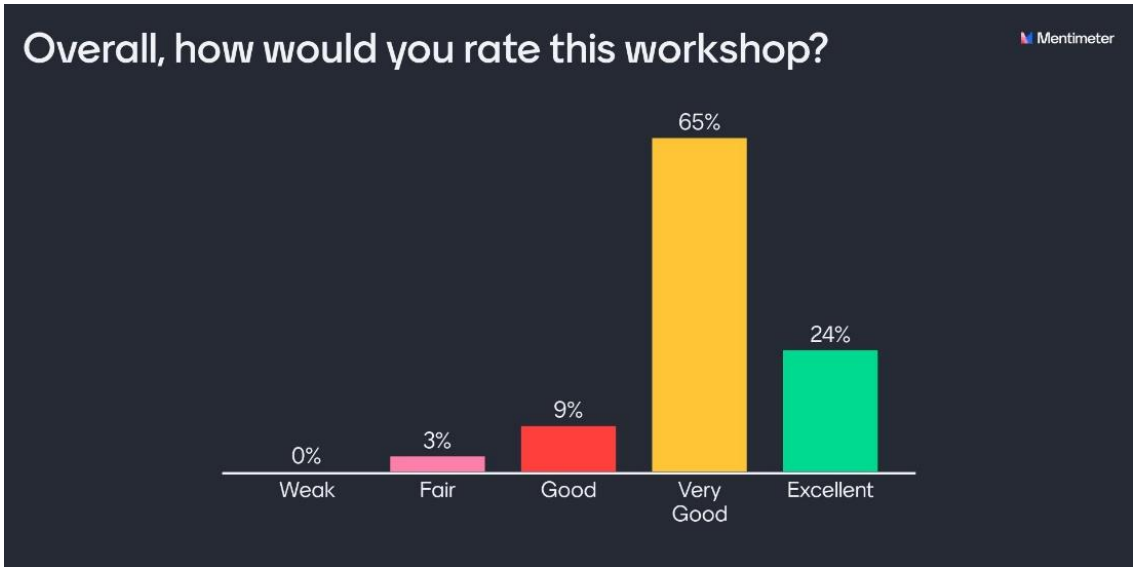
- The qualification process for new tools and methods (testing, putting equipment on the field, comparing and referencing, deploying instruments etc.) is a way to ensure consistency and results, but it demands a lot of time, financial resources, and skilled hydrologists. Thus, it might be affordable only for big companies.
- We need to make sure that new techniques and tools resonate with what is needed (identifying people's needs), to inform people and let them know what tools are available and at what price.
- To work more effectively with tech companies and innovators, we should mitigate financial risks for private companies by co-financing & attracting additional funding; de-risking financial investments where private sector funding is needed; actors such as WMO could act as mediators, liaising between private companies and public sector of the countries in which they are operating.
- We need to understand what the regional challenges in the water management sector are, e.g., lack of access to finance mechanisms, poor coordination, poor innovation culture among service-providers, lack of legal frameworks to promote innovation, lack of regulations etc. Thus, it's necessary to address all these issues to promote development and work with tech companies.

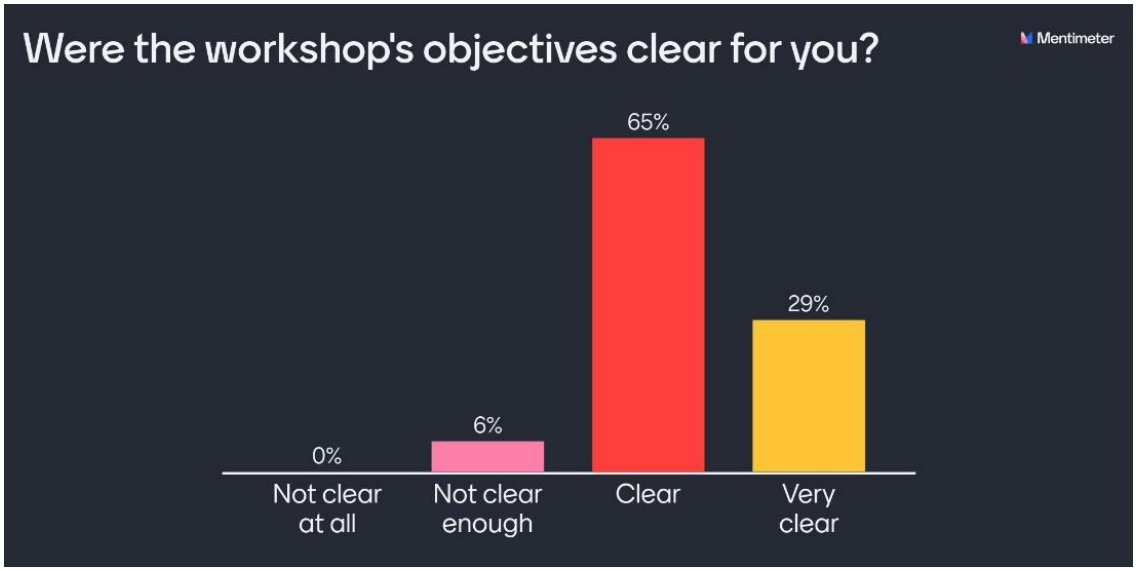
- We need accessible standards and datasets to benchmark and compare new methodologies and the alternatives that already exist.
- Opening up datasets can promote commercial opportunities and revenue sharing mechanisms that can lead to new products. Also, procuring and co-designing products according to users' needs is important when trying to bring a new product to the market.
- Operational agencies' skills are limited because these skills don't cover the full spectrum of operational hydrology. We need to find a balance between local-context and adapting with the state of the technology that is getting invented.

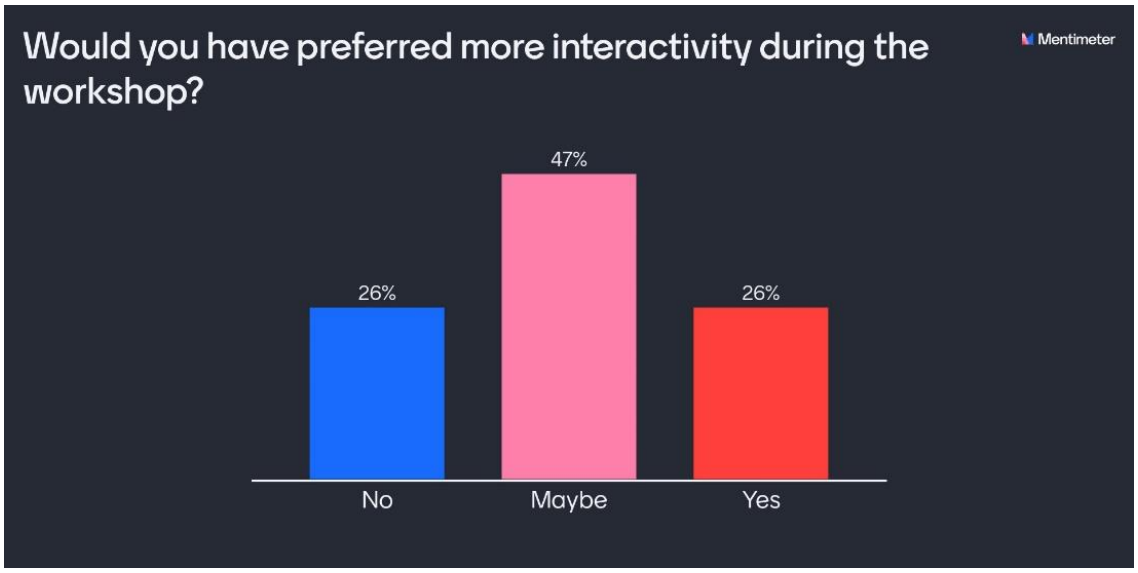
At the end of the panel discussion, Mr Kimura asked the panelists the last question: "How could the WMO HydroHub solve/assist with these issues?" The main message for this question from the panelists is to balance between the local context/knowledge and state of the global technology as well as to help in the general section of hydrological instrumentation maintenance and fixing.

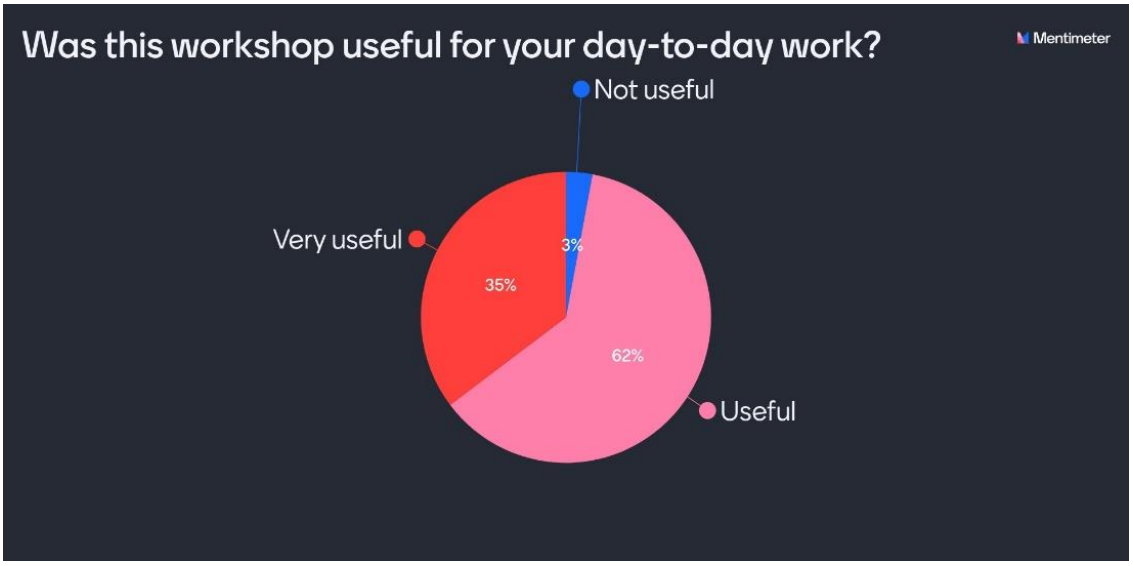
ANNEX 1: Workshop evaluation from participants

After the workshop, the evaluation survey was sent to all participants. The results of the survey completed by 34 participants are shown below:



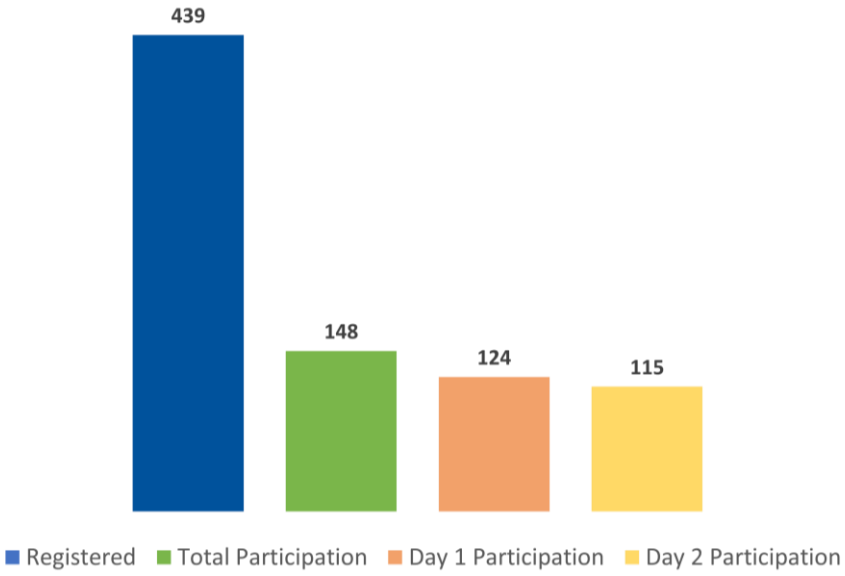



Would you have preferred more interactivity during the workshop?
Mentimeter
47%
26%
26%
No
Maybe
Yes

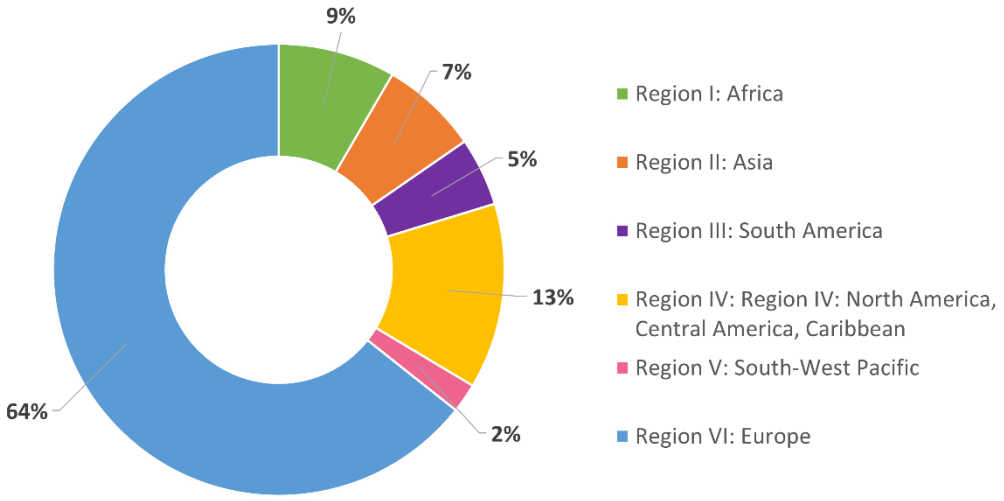

Was this workshop useful for your day-to-day work?
Mentimeter
Not useful
Very useful
3%
35%
62%
Useful

ANNEX 2: Participants statistics

The chart below shows the total number of people who have registered for the workshop, the total number of the workshop attendees, including those of the workshop Day 1 and Day 2.



The chart below shows the distribution of the total workshop participation by WMO region.



The chart below shows the distribution of the total workshop participation by participants' institution type.