# WIS 2.0 Demonstration Projects Workshop

**13, 14 & 20, 21 September 2021**

**Report**

## 1. Executive Summary

The WIS 2.0 demonstration projects workshop was held on 13-14 and 20-21 September 2021. More than 120 participants from all the Regional Associations and many different WMO Programmes attended the virtual sessions. The discussion covered the following topic areas.

### *Data exchange*

The projects in this adopt modern technologies commonly used for data exchange on the Internet of Things (IoT), messaging applications for mobile phones, and Web applications. Those technologies are called Message Queuing Protocols (MQP) and allow users to declare their interest in a stream of data by subscribing to it in order to receive continuous updates. The effectiveness and simplicity of these protocols have been proven in the demonstration projects belonging to this topic.

- Experimental WIS 2.0 data exchange for data in WMO CF-NetCDF profiles
- Exploring the use of message queuing protocols for GTS data exchange.
- GISC Tokyo cloud project
- EUMETNET Supplementary Observations Data-Hub (E-SOH)

### *Data Discovery*

The adoption of modern data discovery metadata standards is being demonstrated in the projects belonging to this topic. The aim is to enable a rich search experience for each user by using metadata standards, allowing the discovery of authoritative data through commercial search engines (Google, Bing, Yahoo, Baidu) and dedicated portals. Curating a catalogue is a critical task for this purpose. Therefore, the adoption of simple standards providing a low barrier to publishing data will be essential to the success of WIS 2.0. Furthermore, a mechanism to monitor metadata quality and effectiveness for discovery purposes is being implemented and will be used to improve quality and enforce consistency in WIS 2.0 catalogues. The WIS 2.0 demonstration projects in this topic are:

- Discovery metadata exchange and harvesting
- GISC Beijing Web services catalogue

### *Earth systems domain*

WIS 2.0 is designed to be a collaborative system of systems using Web architecture to share data and information through services. The projects in this topic are systems built to serve specific communities linked to different Earth system domains. They demonstrate the benefits of implementing WIS 2.0 with the adoption of several of its principles. The projects are:

- Global Cryosphere Watch

- Open access to the GTS (OpenGTS)

- WMO Hydrological Observing System (WHOS)

- Supporting least developed countries (LDC) and small island developing states (SIDS)

WIS 2.0 will adopt technologies, standards, and specifications, presenting a low barrier to entry and will be built to satisfy the needs of LDCs and SIDS. Several projects are experimenting with WIS 2.0 principles in some African countries to ensure that WIS 2.0 is tailored for LDCs and SIDS. The projects in this topic are:

- Interconnection of GISC Casablanca to the National Meteorological Centers within its area of responsibility

- WIS 2.0 Malawi automatic weather stations data exchange.

**Highlights from the workshop**

The WIS 2.0 Principles [1] underpinning its technical framework are central to its success. They comprise a set of technical and working practices intended to modernize access to promote discoverability and accessibility of data and information resources while improving the efficiency of physical data exchange. Each project presented at the workshop has demonstrated that the adoption of the WIS 2.0 Principles provides enormous benefits for Members. It simplifies the processes used to exchange data, improves discoverability and accessibility, and fosters greater exchange and use of data and products. The lesson learned and the opportunities identified during the workshop for each project are reported in Annex I.

The workshop successfully demonstrated that WIS 2.0 has developed beyond a vision and into something that can realistically be achieved. The projects show that the principles are sound and practical. They can be implemented to support WIS 2.0 in providing simple, timely and seamless sharing of trusted data and information.

The workshop noted the need to evolve the traditional Global Telecommunication System (GTS) to ensure that it is fit for exchanging the increasing variety of data with the required velocity. For this purpose, the message switching, and routing technologies need to be replaced with publish-subscribe protocols providing an effective and seamless way of sharing data.

The projects presented had several aspects that need to be considered in developing and implementing WIS 2.0.

The use of open standards was common to all projects. Indeed, there was a clear indication from the workshop that WMO needs to avoid developing entire standards for the need of its communities. It should adopt and contribute to existing open standards to ensure that WIS 2.0 systems are accepted and supported by a wider community, leveraging a broader support and technical expertise.

The use of free and open-source software in the projects was significant. The adoption of cloud native or cloud ready solutions was a constant theme. The workshop also highlighted the effectiveness of ready-made software and turn-key solutions to simplify the adoption of WIS 2.0 standards and speed up the transition from WIS/GTS to WIS 2.0.

[1] WMO INFCOM-1-INF04-1-3(1), https://meetings.wmo.int/INFCOM-1/_layouts/15/WopiFrame.aspx?sourcedoc=/INFCOM-1/InformationDocuments/INFCOM-1-INF04-1-3(1)-WIS2-COSTING-AND-DEMO-PROJECTS_en.docx&action=default

The projects proved that WIS 2.0 is beneficial for both developed and developing countries because it provides lower barriers for data sharing and simplified access to data and information.

The workshop concluded that a comprehensive WIS 2.0 component for LDCs and SIDS would be instrumental for the implementation phase. This component called "WIS 2.0 node in a box" should be ready to be used with minimal configuration (a turn-key solution) and based on cloud technologies to provide the options to be deployed indistinctively on cloud services or on-premises. Therefore, a new project will be started to develop such a component under an open-source license for the benefit of LDCs, SIDS and countries willing to adopt and contribute to open-source software.

The workshop welcomed the progress made in all demonstration projects and encouraged them to continue improving the proposed solutions for the benefit of the entire community.

## 2. Workshop Programme

The workshop was held over four days and conducted in English. The workshop was organized in two parts:

a) 13-14 of September: an opening session, followed by introduction to WIS2.O and individual presentations and discussions by WIS2 project coordinators about discovery metadata exchange and harvesting, exploring the use of message queuing protocols for GTS data exchange, open access to the GTS and Global Cryosphere Watch, experimental WIS 2.0 data exchange for data in WMO CF-NetCDF profiles and EUMETNET supplementary Observations Data-Hub.

b) 20-21 September: individual presentations and discussions by WIS2 project coordinators about GISC Tokyo cloud project, GISC Beijing Web services catalogue projects, Interconnection of GISC Casablanca to NMHCs within its area of responsibility, Malawi Surface Observations, WMO Hydrology Observing System, GMAS/CAP message queuing protocols

## 3. Workshop Proceedings (first part 13 – 14 September)

### 3.1. Opening Session

The workshop was opened by chair of SC-IMT, Rémy Giraud, who welcomed participants and thanked the Organizing Committee for their hard work to prepare the workshop. He highlighted that the workshop is an opportunity to share experiences and lessons about WIS2.0 demonstration projects in order to capitalize on these experiences for the implementation of WIS2.0.

Enrico Fucile then provided information on working arrangements for the workshop.

Peiliang Shi, Director of WIS branch remind the establishment of WIS in 2007 and its interest in serving the WMO community. He noted the limits of the first version and the need to have a new version in order to take benefits from technological developments and integrate all WMO programmes. He greatly appreciated the organization of the workshop and wishes success in its meetings.

### 3.2. Background information

Session chair, Jeremy Tandy, vice chair of SC-IMT, introduced the session by outlining how the demonstration projects are needed to support the WIS2.O implementation.

To inform the discussions, a series of talks were given on a number of topics:

#### 3.2.1 Introduction to WIS2.O

Hassan Haddouch, WIS2 manager, introduced the vision, mission and objectives of WMO information system. He noted that WIS intended to support all WMO programmes; however, the reality is that the majority of products and services registered in WIS relate to real-time information, primarily associated with only the World Weather Watch Programme. He introduced the technology shits and then presented WIS2.O vision and principles. He introduced the demonstration projects presented in four categories covering the following parts:

**Data discovery**

- GISC Beijing Web services catalogue projects
- Discovery Metadata exchange and harvesting

**Data exchange**

- GISC Tokyo cloud project
- EUMETNET Supplementary Observation Data-Hub (E-SOH)
- Exploring the use of message queuing protocols for GTS data exchange
- Experimental WIS 2.0 data exchange for data in WMO CF-NetCDF profiles

**Earth systems domain focus**

- Global Cryosphere Watch
- Open Access to the GTS (Open-GTS)
- WMO Hydrological Observing System (WHOS)

**Supporting less developed countries and small island developing states**

- modernization of the Malawi Automatic Weather Stations data exchange to support forecasting requirements,
- implementation of interconnections between GISC Casablanca and centres in its area of responsibility and leveraging the Iinternet for data exchange

### Discussion

Some discussion evolved around use of cloud technology and sharing of data available and not yet integrated in WIS (e.g. data from ocean community). Aware of the limitation of data exchanges via the GTS, more coordination and engagement are needed in order to get more data shared.

Other discussion raised the need of more communication about WIS2.0 in order to show how WIS2.0 will help least developed countries to access to data and products.

### 3.2.2 Discovery metadata exchange, harvesting and search

Tom Kralidis gave an overview of the discovery in WMO information system WIS 1.0 and presented the constraints faced when using WMO Core Metadata Profile, as well as Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) for harvesting and Search/Retrieval via URL (SRU) for search. He introduced This project which aims to experiment with implementing WMO discovery metadata using the OGC API - Records draft standard. This project also will experiment search/access of collections of variables of NWP data, as well as enabling search capability against WIS 2.0 topics.

He proposed the following input for WIS2:

- Build out a topic hierarchies with Project 1: Expressed in metadata and in Queryable via OARec API
- Build out a data identification scheme / granularity
- Metadata provisioning via a basic catalogue or API provisioning using OGC API, Records and STAC I t e m s.

### Discussion

Some discussion evolved around link between WIS metadata and WIGOS metadata, Tom Kralidis informed that association can be used to make link with WIGOS metadata.

Rémy Giraud underlined the urgency to give more importance to metadata and to find a mechanism to ensure their quality control.

### 3.2.3 Exploring the use of message queuing protocols for GTS data exchange

Peter Silva, mentioned that the use of WMO FTP is becoming an issue for data exchange due to:

- Confidentiality: files are being exchanged without encryption
- Integrity: it is not possible to identify the data source as messages/files are not signed
- Availability: the protocol in itself does not provide mechanisms in case of telecommunication link failures

He argued that when delivering many files especially over high latency networks, FTP is not efficient and does not make use of all available bandwidth. NMHSs have implemented Automated Message Switching Systems (AMSS) to satisfy the WIS-GTS requirements of message routing using FTP as the exchange protocol.

He presented the use of message queuing protocols for GTS data exchange project witch aims to experiment with the international exchange of GTS data using publication/subscription (pub/sub) protocols such as Advanced Message Queuing Protocol (AMQP) and Message Queuing Telemetry Transport (MQTT) protocols. He mentioned that several Global Information System Centres (GISC), Data Collection or Production Centres (DCPC), and National Centres (NCs) will be involved in the project in order to leverage the existing national experience on the use of pub/sub solutions in the context of international collaboration.

He proposed the following input to WIS2:

- Use of MQP for notifications fills a gap in standards; provides a necessary element for replacement of GTS by WMO members
- MQP notifications permit the standardization of large dataset exchanges currently done exclusively with bilateral agreements (NetCDFpilot)
- MQP notifications could be adopted by wider groups later
- Continued standardization, and pilots recommended for now

#### Discussion

Some discussion evolved around the use of the pub sub for exchange of data in WIS2.O. This mechanism is working for real time data and also for archiving data. Machine to machine is pretty much the main target of this MQP

A discussion about management of MQP versions (AMQP 1.0 for aviation, MQTT …), the mechanism is based on use of open-source tools and free implementation.

### 3.2.4 Open access to the GTS (Open-GTS)

Kevin O'Brien presented the development and implementation of the Open Access to GTS (OpenGTS). The Open-GTS is a project that was initially developed as a pilot project under the GOOS Observations Coordination Group. The objectives of the Open-GTS project are straightforward - to increase the volume of ocean in situ data available through operational workflows and to make that data more accessible in general.
Following a successful pilot phase, the Open-GTS project developed an implementation plan, which was refined through work with the US Integrated Ocean Observing System (IOOS). Currently, the Open-GTS project is the main source of Saildrone data that is exchanged on the GTS, and the project is also involved in a smaller pilot effort to bring more AIS-measured data from ships to the GTS. This is an untapped resource

which illustrates the potential of the Open-GTS to provide an easier path for operational exchange of this type of data.
The Open-GTS project maps cleanly into 9 of the 11 WIS 2.0 principles. The use of the ERDDAP tool allows the Open-GTS to: 1) provide data for humans and machines; 2) provide an accessible RESTful API for programmatic delivery and exchange of data and metadata; 3) supports metadata standards for discovery such as schema.org content and Climate and Forecast (CF) metadata; 4) allows users to connect and use data through formats of their own choice, regardless of the original format of the data.
The Open-GTS project is unique in that it covers both the current WIS and is ready to integrate seamlessly into the WIS 2.0 infrastructure. This connection to the WIS 2.0 is being explored in the "Experimental WIS 2.0 data exchange for data in WMO CF-NetCDF profiles" as Open-GTS services (ERDDAP) are being used as the source of surface ocean data exchange.

Particularly, he recommended the use of:

- CF-NetCDF as a meteorological and oceanographic near real-time data exchange format
- ERDDAP as a federated web service for the exchange/harvesting of data and metadata in near real-time

## Discussion

Discussion evolved around the use of ERDDAP as web service for the exchange of data and metadata. The ERDDAP is built on open source that gives you a simple, consistent way to download subsets of scientific datasets in common file formats

### 3.2.5 Global Cryosphere Watch

Øystein Godoy, gave an overview of The World Meteorological Organization's Global Cryosphere Watch (GCW). He mentioned that it is a mechanism for supporting all key cryospheric in-situ and remote sensing observations, and it facilitates the provision of authoritative data, information, and analyses on the state of the cryosphere. To achieve this, he added that a real-time and long-time series of data and products will have to be made available to all consumers. Data and products are made by NMHSs and other operational and scientific communities. The latter two often have limited resources, relying on a variety of data management approaches, quite different from those of the WMO community. GCW is establishing a link between these communities through WIS and WIGOS. In order to successfully implement GCW, barriers between communities need to be lowered.

GCW aims to provide access to both real time and archived data (in the form of climate consistent time series). This requires cost efficient mechanisms that can be used for both purposes. GCW is currently relying on OGC WMS and OPeNDAP for exchange of information. The combination of NetCDF-CF and OPeNDAP allows data streaming and on the fly services to be built on top of data in a distributed data management system. Currently GCW support on the fly visualisation and transformation of selected gridded products as well as time series. These services need to be extended to new areas. Transformation services include reformatting (e.g. NetCDF/CF to CSV or NetCDF/CF to WMO GRIB), reprojection, subsetting etc.

He proposed the following input for WIS2:

- WMO formats has little traction outside the NMHS, need to be pragmatic and support other standards (each for its specific purpose)
- Improve the usage of CF-NetCDF and ACDD and actively engage in developments–It simplifies interaction with external communities
- Evaluate Zarr as backend for CF-NetCDF

- Include OPeNDAP as a mechanism for data exchange–Used internally in Copernicus services, ESGF etc.
- Connect with external communities on data management

### 3.2.6 Experimental WIS 2.0 data exchange for data in WMO CF-NetCDF profiles

Kai-Thorsten Wirt introduced the project on WIS 2.0 data exchange for data in WMO CF-NetCDF profiles. He mentioned that the project aims to experiment with international real-time exchange of data using publication/subscription (pub/sub) protocols in combination with a distributed storage of the original data along with a central, mirrored repository for easy access to the complete distributed data set. Additionally, the data will be discoverable using WIS Metadata. Thus, this project also assesses the advantages, disadvantages and usability of WMO Core Metadata Profile 1.3 complemented by the exposure of this data to commercial search engines.

He proposed the following input for WIS2:

- Use of Pub-Sub protocols
- Use of CF-netCDF as meteorological data format
- Adopt Web services for the provision of product data (like ERDDAP)

#### Discussion

Some discussion evolved around sub/pub mechanism and restriction access: Should anyone be allowed to subscribe to anything?

This project is a good example for transition. It shows how to build a gateway between WIS1 and WIS2

### 3.2.7 EUMETNET Supplementary Observations Data-Hub (E-SOH)

Stuart Matthews mentioned that a range of user needs, particularly those associated with short-range forecasting and nowcasting, require access to higher spatial and temporal resolution observation data than are currently being exchanged. He listed the priority observation types for E-SOH : Sub-hourly resolution observations from stations operated by EUMETNET members that are or not normally made available, Rain-gauge observations, from gauges operated by EUMETNET Members, Rain-gauge observations, from gauges operationally operated by 3rd parties who currently make their data available to one or more EUMETNET Member, but aren't normally published, Real-time observations from personal weather stations (PWS) in a way that is consistent with other land surface observation and Single unified view of supplementary observations, that is easily accessible and findable, is easily integrated into downstream systems and can be re-used (i.e., following FAIR principles)

He reminded that the objective of this project is to deliver, with European co-operation and collaboration, the first component of a Federated European Meteorological Data Infrastructure, that is sustainable and meets the technical requirements and standards of international bodies. The Project was scheduled to be implemented for around six (6) years, commenced in October 2021 and scheduled to complete in 2026.

The project is currently in its initial stages, focusing on better defining the requirements of EUMETNET Members and undertaking a Scoping Study, identify existing systems and WIS2.0 compliant data standards that could be used to build the E-SOH. Consideration will be given to both centralized and distributed architectural designs.

He proposed the following input to WIS2:

- Strong preference for Open Source, but this might limit potential to re-use existing capability

- Cloud first principle with European Weather Cloud EWC considered as a host for centralised capability (NMHSs free to follow national strategy including public cloud)

### Discussion

Some discussion evolved around data policy and how to control access to commercial services.

Need for mechanism of exchange that support any policy or topology that the WMO chooses.

## 4. Workshop Proceedings (Second part 20 – 21 September)

### 4.1 GISC Tokyo cloud project

Kanno Yoshiaki and Ozeki Ren mentioned that the purpose of this demonstration project is to provide data exchange functions and visualization tools on internet cloud services as a prototype for GISC Tokyo's area of responsibility in accordance to WIS 2.0 principles. They added that the objectives of this project is to enable smooth migration from GTS to cloud based "shard platform" data exchange system, test of the prototype of MQPs system for data exchange and demonstrate the more conventional cloud storage direct download method for countries preferring a more gradual evolution.

They proposed the following inputs for WIS2:

- Use of MQP technology for real-time exchange
- Use cloud-storage downloading for Big data
- Combined approaches (MQP and cloud-storage) may be an option for efficient migration from GTS to WIS2.

### Discussion

Some discussions evolved around the use of messaging queuing protocols versions AMQP and MQTT.

### 4.2 GISC Beijing Web services catalogue projects

Peng Wang from CMA mentioned that the project aims to design metadata for WEB services and APIs and implement a Catalogue of services as a portal website. She noted that service providers can publish their services as service metadata records, describing APIs, data and how to access them. Each service metadata is published to the Web with accessible URLs. Service users can discover their interested services, either via the Catalogue portal or by commercial search engines. As a pilot project, several services covering GISC Beijing area of responsibility members will be implemented and published.

He proposed the following Inputs to WIS2 :

- Use JSON format for metadata
- Provide data reduction services: Data customization, Data visualization and WebGIS
- Use OpenAPIv3 tools for development
- Use Markdown format to present service API documents

### Discussion

Some discussion evolved around metadata and metadata services catalogue. The meeting appreciates the idea of development of web page based on service metadata and proposed the need of connection between metadata and service catalogue.

### 4.3 Interconnection of GISC Casablanca to the National Meteorological Centres within its area of responsibility

Rabia Merrouchi, introduced the project of interconnection of GISC Casablanca to NMCs which aims to promote the use of the Internet as a support for the exchange of data between GISC Casablanca and the NCs and DCPCs within its area of responsibility, given the difficulties encountered while trying to implement peer-to-peer links or point-to-point internet VPN. He noted that the objectives of the project are :

- Provide contribution to the definition and implementation of WIS 2.0, as a collaborative system of systems using web-architecture and open standards to provide simple, timely and seamless sharing of trusted weather, water and climate data,
- Demonstrate that a Cloud based web application dedicated to data collection from NCs will enable each member to share and access in real time and in secure manner the data collected from the national synoptic stations.
- Provide access to real time data by adopting secure VPN internet connection, internet access and ftp/sftp protocols and via Web Based Services.

#### Discussion

Discussion focused on the importance of this project for RA1. It can be an alternative for collecting data in real time and solving the connectivity problem for the National Met services under area of responsibility of GISC Casablanca. Rémy Giraud suggested to test solutions like ZeroTier and Tailscale, which are very lightweight VPN solutions compare to the traditional IPSEC VPN.

### 4.4 Malawi Surface Observations

Enrico Fucile, mentioned that the product provided by the Global Data Processing and Forecasting System GDPFS, depends on the quality of the data collected through the WIS. He added that data from weather stations managed by the Malawi Department of Climate Change and Meteorological Services are not regular and most of time not available. In order to leverage new technologies, open standard, web, and cloud-based services to provide simple, timely, and seamless sharing of trusted weather, water, and climate data, this demonstrator project has been established.

The objectives of the Malawi project are:

- Continuous and reliable provision of hourly real-time data from 44 stations to Global NWP Centers in BUFR format through GTS and WIS 2.0.
- Optimization of the acquisition system for cloud services for sustainability purposes.
- Development of a turn-key solution to be delivered to other Countries.

He proposed the following inputs to WIS2:

- Important to foster cloud services to provide turn-key solutions.
- BUFR presents a barrier that is extremely difficult to address. More tools and training needed to support BUFR data exchange.
- Difficulties are encountered in data exchange from the station to the acquisition center at national level. Support to improve national exchange is required.
- Internet availability and costs can be a limitation in LDCs.
- Observing station manufacturers provide closed solutions to access data from the stations. Open standards would be helpful at that level.

### 4.5 WMO Hydrology Observing System WHOS

Silvano Pecora informed the meeting that the goal of the WHOS project is to fully implement the concepts of:

- Providing the most comprehensive hydrological component in fulfillment of the WIGOS objective of "an integrated, comprehensive, and coordinated system which is comprised of the present WMO global observing systems"
- Providing contribution to the definition and implementation of WIS 2.0, to provide simple, timely and seamless sharing of trusted weather, water and climate data.

He presented the project plan and proposed the following input to WIS2:

- The brokering architecture is not suitable for hydrology because of diversity of data sharing solutions
- Existing mechanisms of user authentication should be used to strengthen the roadmap for free and unrestricted data sharing according to the new WMO Data Policy
- The WHOS Broker is based on code provided free of charge for education, research and non-commercial usage. The code will be released as open-source with a CC-BY-NC kind of license to support local deployment and personalization (Community Edition)

## 5. Conclusion and lesson learned:

Jeremy Tandy summarized the outcome of the workshop as follow:

- All projects have demonstrated successfully that the Internet can be successfully used for data exchange
- GISC Casablanca also showed that use of Web applications greatly improve data collection in their Area of Responsibility
- DCCMS Malawi have worked with Secretariat, Campbell Scientific, and Amazon Web Services to provide continuous and reliable provision of BUFR-encoded, hourly real-time data from 44 GSM-connected automatic weather stations; hosted on the Amazon cloud platform and including an ecCodes-based BUFR-encoding service that converts output from the Data Logger, this is a turn-key solution that may be deployed in other countries too
- EUMETNET are developing the "Supplementary Observations Data Hub" (E-SOH) to the shared observation data, and provide a simple Web-based API, such as the OGC Environmental Data Retrieval API, for users to access these unified observation data holdings.
- Global Cryosphere Watch (GCW) demonstrates how a heterogeneous community, bridging WMO and academic worlds, can work effectively together, convening around a set of shared requirements to extend the sharing of data
- OpenGTS builds on top of ERDDAP shows how we can use open standards to increase the flow of data, and consequently increase the value derived from that data. For example, sail-drone data shared via ERDDAP could be discovered through Google [dataset search] out of the box.
- GISC Offenbach project investigates the use of pub/sub messaging to distribute data in real time. GISC Offenbach connects to the ERDDAP server to get metadata about the dataset and use it to create a record in the GISC catalogue and create a topic in the message broker to which a client application can subscribe.
- The use of message queuing protocols for GTS data exchange project aims to determine appropriate message que protocols, message structure and Topic hierarchy structure that will enable subscribers to easily locate the topics they want to subscribe to
- GISC Tokyo investigated performance comparison for data distribution via MQP and 'batch' (or periodic request) via HTTPS from a cloud-hosted data server

- GISC Beijing are investigating how to enable users to discover and use all these Web services that we've been talking about so far; making proposals for a Service Catalogue and use of the OpenAPI v3 specification for describing Web service APIs.
- Metadata is a critical challenge. It's way too complicated for many Members.

The workshop provided progress update of WIS 2 demonstration projects and impressive evidence of what is being achieved and the innovation that has been made through closer and hard work.

**Several lessons learned from the workshop:**

- The workshop demonstrated that WIS2 is not only a vision, it's something that we can achieve. All the projects line up perfectly with WIS2 principles and all of them shows concrete solutions for seamless data and service access
- The workshop proved that WIS2 encompasses all WMO programmes: except the satellite community, OCEAN community, Hydrology and cryosphere are well represented in WIS2 demonstration projects
- The workshop highlighted that WIS2 is beneficial for both developed and developing countries (Japan, China, Malawi, Morocco);
- The workshop highlighted that WIS 2.0 will facilitate exchange of the right information at the right time with the right people. It will be built on redundant, resilient, efficient and scalable infrastructure. It will use applications and services based on standard interfaces for data exchange ready for SMAC (Social, Mobile, Analytics (Big Data), Cloud), Web services and APIs;
- The workshop noted that WIS 2.0 platform will support the provision of shared services and components, reducing the need for duplication of components and the overhead of associated data synchronization;
- The WIS 2.0 platform will support a change in user behavior from downloading a copy of information for local processing to using services that process the information at its source;
- Use of cloud computing infrastructure to host shared components (such as data repositories and applications) to provide low-latency global data sharing to enable the WMO community to 'plug' their components into shared infrastructure and easily deliver value-added services to their users and to provide facilities that enable users to work with high-volume data in-situ rather than require download for local usage;
- Use of Web standards, Web services and well-defined APIs enable WIS 2.0 to become machine interoperable;
- Use of common open data formats (e.g. JSON, CSV, XML, netCDF, …) complementing Table-driven Code Forms (GRIB, BUFR), to simplify data provision and use by a broader community;
- Integration with global search engines (such as Google, Bing or Yahoo) to improve visibility of the authoritative information provided by NMHSs while retaining data sovereignty;
- Retirement of traditional GTS message switching as the basis for operational, real time data exchange in favor of industry standard data distribution methods and protocols such as secure file transfer, publish-subscribe messaging and message queuing protocols;
- The workshop demonstrates that WIS2 is designed to enable all NMHSs, particularly from least developed countries and small island developing States, to use infrastructure and services of the WIS 2.0 platform to build services that meet the needs of their domestic stakeholders.

**Challenges:**

- How can we bring together the elements presented in the workshop in order to develop WIS2.0 technical regulations?
- How to manage the transition phase: need of more communication and more collaboration?
- Need to make a recommendation on data formats
- More discussion about metadata and service catalogue are needed and consider quality of metadata
- Consider evolution of GTS and transition

## 6. Decision :

- Prepare information document for congress
- WIS2.0 in the box

***Annex I: Contribution of the projects***

In the following table the lesson learned and the opportunities for each project are reported.

| **Project** | **Lesson learned** | **Opportunities** |
|---|---|---|
| Discovery metadata exchange, harvesting and search | WIS 2.0 Centers will provide Web services that enable users to access easily and interact with data, metadata and catalogues. | Advances in technology make it feasible for organizations to provide services and components that serve a global audience.<br><br>Browsers and search engines (google, yahoo, Bing) allow Web users to discover data without the need for specialized software |
| GISC Beijing Web services catalogue projects | Web services technologies present new operating concepts that will improve operational efficiency, information sharing and service delivery, and enable users to more effectively exploit data | Web services and APIs improve data and metadata discovery.<br><br>Users can discover their interested services, either via the Catalogue portal or by commercial search engines (google, Yahoo, Bing…) |
| Exploring the use of message queuing protocols for GTS data exchange | The Message Queuing Protocol MQP mechanism is a good alternative for GTS evolution and data distribution | There isn't any need for Message Switching Systems to route messages via intermediate centres<br><br>Improve data collection |
| Experimental WIS 2.0 data exchange in WMO CF-NetCDF profiles | CF-NetCDF is very much requested and used | Improve data distribution via adoption of publication/subscription (pub/sub) protocols in combination with a distributed storage<br><br>Improve interoperability |
| EUMETNET Supplementary Observations Data-Hub | EUMETNET project "Supplementary Observations Data Hub" (E-SOH) provide a simple Web-based API, such as | Integration into the Hub supplementary observations data in real time |

| | | |
|---|---|---|
| | the OGC Environmental Data Retrieval API, for users to access these unified observation data holdings | Make data easily accessible and findable |
| GISC Tokyo cloud project | Data distribution using MQP and 'batch' via HTTPS from a cloud-hosted data server to be considered when developing WIS2 architecture | Provide data exchange functions and visualization tools on internet cloud services as a prototype for GISC Tokyo's area of responsibility<br><br>No need to download data process it on site |
| Open access to the GTS (OpenGTS) | Open GTS build on top ERDDAP is good example of freely available software, packaged easy for organisations to deploy and get them started in publishing or receiving data | Use of open standards to increase the flow of data, and consequently increase the value derived from that data |
| Global Cryosphere Watch | Heterogeneous community, bridging WMO and academic worlds, can work effectively together, convening around a set of shared requirements to extend the sharing of data. | The approach of providing freely available tools and services enabled WMO to bring cryosphere data from research institutions.<br><br>WIS2 is a bridge establishing a link between heterogeneous communities |
| WMO Hydrology Observing System | WIS 2.0 encompasses all WMO programmes | WHOS and WIS 2 are using a different concept of broker. |
| Interconnection of GISC Casablanca to Centres in its Area of Responsibility | Use of Web applications greatly improve data collection.<br><br>Use of public telecom network resolve the problem of connectivity to GISCs | Extend this project to most of RA I countries will improve data collection.<br><br>WIS2 provide infrastructure and services to least developed countries to build services that meet the needs of their domestic stakeholders |
| Malawi Surface Observations | This is a good example project bridging public and private communities and greatly improving data | Provide hourly real-time data from 44 GSM-connected automatic weather stations. |

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| | collection to be deployed in other countries. | Improve data collection by extension the projects to other countries.<br><br>WIS2 is designed to enable all NMHSs, particularly from least developed countries and small island developing States, to use infrastructure and services of the WIS 2.0 platform to build services that meet the needs of their domestic stakeholders. |


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