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System Volume II (APPROVED) - WMO
Information System 2.0

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Standing Committee on Information Management and Technology (SC-IMT)^[1]

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Introduction

The *Manual on the WMO Information System* (WMO-No. 1060) is designed to ensure that the data, information and communication practices, procedures and specifications that WMO Members employ in the operation of the WMO Information System (WIS) are adequately uniform and standard.

The present Manual is Annex VII to the *Technical Regulations* (WMO-No. 49), Volume I, which states, in Part II, that WIS is established and shall be operated in accordance with the practices, procedures and specifications described in the Manual.

The WMO Information System cuts across all WMO-related disciplines. It intersects many WMO practices, procedures and specifications that are primarily defined in specialized publications, including the *Manual on the WMO Integrated Processing and Prediction System* (formerly the *Manual on the Global Data-processing and Forecasting System*) (WMO-No. 485) and the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

As part of the Technical Regulations, the present Manual sets out standard and recommended practices and procedures. The General Provisions, included in the *Technical Regulations* (WMO-No. 49), Volume I, define the meaning of the phrase “standard and recommended practices and procedures”.

Note: The procedures for amending the present Manual can be found in the *Rules of Procedure for Technical Commissions* (WMO-No. 1240).

In 2017, the Executive Council at its sixty-ninth session endorsed the WMO Information System 2.0 (WIS 2.0) strategy, which outlines the activities involved in moving towards the next generation of WIS, with an enhanced focus on supporting global agendas, covering all WMO activities and domains, reducing costs, and facilitating the activities of National Meteorological and Hydrological Services (NMHSs).

In 2019, the World Meteorological Congress at its eighteenth session endorsed the WIS 2.0 Implementation Approach and authorized the Executive Council to make decisions on WIS 2.0 during its development.

In 2021, the Executive Council at its seventy-third session endorsed the WIS 2.0 implementation plan, authorizing the development of the WIS 2.0 Technical Regulations.

In 2023, the Executive Council at its seventy-sixth session endorsed the publication of the first edition of Volume II of the *Manual on the WMO Information System* (WMO-No. 1060), containing the Technical Regulations for WIS 2.0. Throughout the present volume of the Manual, “WIS” should be understood to mean “WIS 2.0”.

[1] <https://community.wmo.int/governance/commission-membership/commission-observation-infrastructures-and-information-systems-infcom/commission-infrastructure-officers/infcom-management-group/standing-committee-information-management-and-technology-sc-imt>

[2] <https://community.wmo.int/governance/commission-membership/infcom>

TERMS AND DEFINITIONS

Application Programming Interface (API). A clearly defined set of methods by which software components can interact. APIs may exist for web services and software development toolkits.

Area of responsibility (AoR). A defined region which is assigned to a Global Information System Centre (GISC) for support and coordination.

Data Collection or Production Centre (DCPC). A designated centre for the regional management and production of data and metadata via a WIS Node.

Data consumer (role). An actor that uses data for business needs.

Data publisher (role). An actor that makes data available for discovery, access or visualization.

Data owner (role). An actor that is responsible for the life cycle management of a given dataset.

Dataset. A collection of data with similar and consistent characteristics and attributes (type, subject/topic, ownership, access/usage policy, update frequency, etc.). A dataset may be persisted as one or more files, objects, or database records. Examples of datasets include real-time surface weather data from an observing network, numerical weather prediction models, or a series of satellite data capturing consistent variables over scheduled intervals. See the *Guide to the WMO Information System* (WMO-No. 1061), Volume II for guidance on the scope of datasets.

Discovery metadata. A limited set of information about the dataset for discovery purposes, including identification, citations, spatial and temporal extents, distribution mechanisms, and license and access constraints.

Discovery metadata record. A resource containing the discovery metadata describing a specific dataset.

Global Broker. A Global Service that provides real-time notifications of WIS data availability.

Global Cache. A Global Service that provides highly available access to WIS data via the Internet.

Global Discovery Catalogue. A Global Service that provides discovery and search services for WIS data.

Global Information System Centre (GISC). A designated centre for data sharing, training, support, and the provision of Global Services.

Global Monitor. A Global Service that provides monitoring and performance information of data made available on WIS.

Global Services, Global Service components. The suite of services that provide the core capabilities of WIS.

Granularity. The level of detail in a dataset.

Message Broker. A service that provides publish and subscribe capabilities in support of real-time notifications.

Message Queue. The functionality that allows for asynchronous and inter-process communications and operations.

National Centre (NC). A designated centre for the national management and production of data and metadata via a WIS Node.

Notification, notification message. A structured payload advertising the availability of new, updated, or removed data.

Real time, near real time. For the purposes of Earth system monitoring and prediction, timeliness is measured as the interval between the time an observation is made and the time it is received in a processing centre. Real-time data have a timeliness on the order of minutes and never greater than a few hours, depending on the type of observation. Near-real-time data have a timeliness of more than 12 hours to several days.

Subscription, subscriber. A Message Broker client interested in receiving notifications of new, updated or removed data.

Uniform Resource Identifier (URI). See [RFC 3986, Uniform Resource Identifier \(URI\): Generic Syntax](#).

Uniform Resource Locator (URL). A URL is a subtype of URI – see [RFC 3986, Uniform Resource Identifier \(URI\): Generic Syntax, 1.1.3. URI, URL, and URN](#).

WIS Node. The core capabilities provided by NCs and DCPCs in providing data and discovery metadata to WIS.

PART 1. ORGANIZATION AND RESPONSIBILITIES

1.1 PRINCIPLES OF WIS 2.0

1.1.1 The transition from the first generation of WIS (circa 2007–2024) and the Global Telecommunication System (GTS) to the second-generation of WIS (“WIS 2.0”) will take several years and allow for updates of systems in alignment with Members’ plans.

1.1.2 WIS 2.0 is designed in accordance with the following principles:

- (1) WIS 2.0 adopts web technology and leverages industry best practices and open standards;
- (2) WIS 2.0 uses Uniform Resource Locators (URLs) to identify resources (web pages, data, metadata, application programming interfaces (APIs), and so forth);
- (3) WIS 2.0 prioritizes the use of public telecommunication networks (for example, the Internet) when publishing digital resources;
- (4) WIS 2.0 requires the provision of web services to access or interact with digital resources (for example, data, information, products) published using WIS;
- (5) WIS 2.0 encourages National Centres (NCs) and Data Collection or Production Centres (DCPCs) to provide ‘data reduction’ services via WIS that process ‘big data’ to create results or products that are small enough to be conveniently downloaded and used by users with minimal technical infrastructure;
- (6) WIS 2.0 adds open standard messaging protocols that use the publish-subscribe message pattern to the list of data exchange mechanisms approved for use within WIS and GTS;
- (7) WIS 2.0 requires all services that provide real-time distribution of messages (containing data or notifications about data availability) to cache/store the messages for a minimum of 24 hours and allow users to request cached messages for download;
- (8) WIS 2.0 adopts direct data exchange between the provider and the consumer and phases out the use of routing tables and bulletin headers;
- (9) WIS 2.0 provides a catalogue containing metadata that describe both data and the service(s) provided to access those data;
- (10) WIS 2.0 encourages data providers to publish metadata describing their data and web services in a way that can be indexed by commercial search engines.

Note: The WIS 2.0 principles are further elaborated in Appendix A to this Manual.

Note: More information on the technical specifications of WIS 2.0 can be found in the *Guide to the WMO Information System* (WMO-No. 1061), Volume II (hereinafter *Guide to WIS*, Volume II).

Note: More information on the transition plan for WIS 2.0 can be found in the *Provisions for the Transition from the WMO Information System (WIS) 1.0 and Global Telecommunications System to WIS 2.0* (WMO-No. 1323).

1.2 ORGANIZATION OF WIS

1.2.1 In keeping with the *Technical Regulations* (WMO-No. 49), Volume I, Part II, 1.2.2, centres operated by WMO Members and their collaborating organizations shall be categorized as one of the three types of WIS centres forming the core infrastructure of WIS:

- (a) Global Information System Centres (GISCs);**
- (b) Data Collection or Production Centres (DCPCs);**
- (c) National Centres (NCs).**

1.2.2 NCs and DCPCs are responsible for publishing data and discovery metadata using a component referred to as a WIS node.

1.2.3 GISCs are responsible for supporting WIS centres in their area of responsibility (AoR) and ensuring the effective operation of WIS.

1.2.4 WIS Centres may operate one or more Global Services that collectively ensure the discovery of and access to data within all regions.

1.2.5 Each Permanent Representative with WMO shall be responsible for authorizing users of WIS. The right to manage the authorization process may be delegated.

1.2.6 The functions of WIS centres (GISCs, DCPCs, NCs), WIS nodes, and Global Services are detailed in Part III of the present Manual: Functions of WIS.

1.3 COMPLIANCE WITH REQUIRED WIS FUNCTIONS

1.3.1 WIS centres shall comply with required WIS functions. Parts III and IV of the present Manual contain instructions on practices, procedures, and specifications for WIS functions.

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Note: Supplementary information concerning practices, procedures, and specifications for WIS functions is provided in the *Guide to WIS*, Volume II.

1.4 INTERACTION AND COLLABORATION AMONG WIS CENTRES

1.4.1 GISCs shall collectively ensure that there are sufficient instances of Global Services available to data consumers in all regions to ensure efficient and highly available data discovery and access to data provided by all WIS centres.

1.4.2 GISCs shall collaborate with other GISCs to optimize and coordinate WIS.

1.4.3 GISCs shall support NCs and DCPCs in their area of responsibility to effectively participate in WIS.

1.4.4 A WIS centre operating a Global Cache shall provide access to locally stored copies of core data for real-time or near-real-time exchange and discovery metadata published by all NCs and DCPCs.

Note: Core data are defined in Resolution 1 (Cg-Ext(2021)) – WMO Unified Policy for the International Exchange of Earth System Data (*World Meteorological Congress: Abridged Final Report of the Extraordinary Session* (WMO-No. 1281)) (hereinafter, Resolution 1 (Cg-Ext(2021))).

1.4.5 A WIS centre operating a Global Broker shall enable subscriptions to notifications about the availability of data and discovery metadata published by all WIS centres. A Global Broker subscribes to and republishes notifications from NCs, DCPCs, Global Caches, and other Global Brokers.

1.4.6 A WIS centre operating a Global Discovery Catalogue shall enable the discovery of data published by all WIS centres. A Global Discovery Catalogue harvests discovery metadata from NCs and DCPCs.

1.4.7 A WIS centre operating a Global Monitor shall collect performance and/or data availability metrics from NCs, DCPCs, and other GISCs.

1.5 ROBUSTNESS AND RELIABILITY OF COMPONENTS

1.5.1 Highly robust and reliable components are essential to the operation of WIS. Performance indicators shall be evaluated in the designation procedure for WIS centres. This evaluation shall ascertain, among other things, whether data published via WIS fully satisfy the requirements for security, authenticity, and reliability.

Note: More information on expected service levels and performance indicators is provided in the *Guide to WIS*, Volume II.

1.6 COMPETENCIES OF PERSONNEL

As recommended by the *Technical Regulations* (WMO-No. 49), Volume I, Part V: Qualifications and competencies of personnel involved in the provision of meteorological (weather and climate) and hydrological services, centres should ensure that they have access to an adequate number of people who have the required levels of the WIS competencies therein defined.

Note: More information on the competencies needed to operate a WIS centre is provided in Appendix B to the present Manual. Guidance on developing these competencies is available in the *Guide to WIS*, Volume II.

1.7 WMO DOCUMENTS RELEVANT TO WIS

1.7.1 The following WMO documents are relevant to WIS:

- (a) *Basic Documents No. 1* (WMO-No. 15);
- (b) *Technical Regulations* (WMO-No. 49);
- (c) Resolution 1 (Cg-Ext(2021)) – WMO Unified Policy for the International Exchange of Earth System Data (*World Meteorological Congress: Abridged Final Report of the Extraordinary Session* (WMO-No. 1281));
- (d) *Manual on Codes* (WMO-No. 306);
- (e) *Manual on the WMO Integrated Processing and Prediction System* (formerly the *Manual on the Global Data-processing and Forecasting System*) (WMO-No. 485);
- (f) *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

PART II. DESIGNATION PROCEDURES AND WIS CENTRES

2.1 GENERAL

2.1.1 The establishment and operation of WIS depend on WMO Members and partner organizations taking on the functional roles of GISCs, DCPCs and NCs. Procedures for designating a WIS centre rely on the agreed WIS functional architecture and the WIS compliance specifications.

2.1.2 As required by the *Technical Regulations* (WMO-No. 49), Volume I, Part II, 1.2.3, Congress and the Executive Council shall consider the designation of GISCs and DCPCs based on the recommendations of the Commission for Observation, Infrastructure and Information Systems (INFCOM). The development of INFCOM recommendations includes consultation and coordination with the Commission for Weather, Climate, Hydrological, Marine and Related Environmental Services and Applications (SERCOM) and the regional associations, as appropriate.

2.2 PROCEDURE FOR DESIGNATING A NATIONAL CENTRE

2.2.1 Background

2.2.1.1 As required by the *Technical Regulations* (WMO-No. 49), Volume I, Part II, 1.2.8, each NC shall use WIS to provide data and products that are consistent with its programme responsibilities. These data and products shall be provided with associated metadata in accordance with WIS practices, procedures and specifications. Each NC shall participate, as appropriate, in the relevant monitoring of the performance of WIS.

2.2.2 Procedure

2.2.2.1 Each WMO Member shall notify WMO of the current name and location of each of its centres that is to be designated as an NC. INFCOM, with the involvement of the relevant regional associations and the assistance of the WMO Secretariat, shall ensure that each centre so designated has the support of a GISC, a DCPC or another NC.

2.2.2.2 Each NC shall complete the migration from WIS/GTS to WIS 2.0 in order to be designated as a WIS 2.0 centre and added to the list in Appendix C.

2.2.3 Designated National Centres

2.2.3.1 The NCs designated by Members shall be included in the list of WIS centres in Appendix C to this Manual. Each NC entry shall include the name of the associated GISC.

2.3 PROCEDURE FOR DESIGNATING A DATA COLLECTION OR PRODUCTION CENTRE

2.3.1 Background

2.3.1.1 WMO has determined that all WMO and related international programmes shall be served by WIS. Each established centre shall therefore implement the required WIS functions. INFCOM shall recommend how these centres are categorized as DCPCs within WIS.

2.3.2 Procedure

2.3.2.1 The procedure for designating a DCPC shall consist of three steps:

(1) Service offer by a potential DCPC; (2) Demonstration of DCPC capabilities; (3) Designation as a DCPC.

2.3.2.2 Each DCPC shall complete the migration from WIS/GTS to WIS 2.0 in order to be designated as a WIS 2.0 DCPC centre and added to the list in Appendix C.

2.3.3 Service offer by a potential Data Collection or Production Centre

2.3.3.1 Required DCPC functions should be fulfilled by a centre that has been established under a WMO programme or a related international programme and/or under a regional association. Accordingly, the relevant technical commission and/or regional association shall consider the service offers made by Members for potential DCPCs and shall endorse candidate DCPCs.

2.3.3.2 The service offer of candidate DCPCs shall then be submitted to INFCOM, which shall analyse the compliance of the candidate with the required DCPC functions and specifications and formulate a recommendation.

2.3.4 Demonstration of Data Collection or Production Centre capabilities

2.3.4.1 The Member offering a DCPC shall be invited to demonstrate to INFCOM the ability of the proposed centre to provide WIS services in compliance with DCPC functions and responsibilities, including communication with the Global Services. Compliance shall be demonstrated, where applicable, with respect to the real-time functions of data sharing, provision of relevant, up-to-date discovery metadata, coordination functions with the associated GISC, adherence to WIS standards, and relevant data exchange policies and access rights.

2.3.4.2 After the candidate DCPC has successfully demonstrated its capabilities, INFCOM shall recommend to Congress or the Executive Council that the candidate centre be approved.

2.3.5 Designated Data Collection or Production Centres

2.3.5.1 The list of DCPCs approved by Congress or the Executive Council is included in Appendix C to this Manual. Each DCPC entry includes the name of the associated GISC.

2.4 PROCEDURE FOR DESIGNATING A GLOBAL INFORMATION SYSTEM CENTRE

2.4.1 Procedure

2.4.1.1 The procedure for the designation of a GISC shall consist of four steps:

(1) Statement of WIS requirements; (2) Service offer by a Member for a potential GISC; (3) Demonstration of GISC capabilities; (4) Designation of the GISC.

2.4.2 Statement of WIS requirements

2.4.2.1 The WMO technical commissions and other bodies representing the participating programmes, including regional bodies, shall state their requirements for WIS services and

review them periodically. The list of all relevant requirements shall be compiled and regularly reviewed by INFCOM and reported to the Executive Council.

2.4.3 Service offer by a Member for a potential Global Information System Centre

2.4.3.1 A WMO Member may apply for a centre to be designated as one of the GISCs forming the core infrastructure of WIS. The service offer by the Member shall include:

(a) A statement of compliance with the required WIS functions; (b) A proposal regarding the AoR for WIS services; (c) A formal commitment by the Permanent Representative of the Member that such services shall be provided on a routine basis and sustained over time.

2.4.3.2 The service offer shall be addressed to WMO. INFCOM, in consultation with the regional association(s) concerned, shall analyse the proposed service offer with regard to the WIS requirements and compliance with GISC functions and specifications and shall formulate a recommendation.

2.4.4 Demonstration of Global Information System Centre capabilities

2.4.4.1 The Member offering a GISC shall demonstrate to INFCOM the capability of the proposed centre to provide WIS services of the requisite reliability and quality to accredited users. Compliance shall be demonstrated with respect to the following:

(a) Coordination of data sharing within its AoR; (b) Provision of training, support and other capacity building activities to WIS centres within its AoR; (c) Supporting continual improvement in the quality of the discovery metadata published by WIS centres within its AoR; (d) Provision of any Global Services included in the service offer; (e) Monitoring system performance and data availability in its AoR; (f) Coordinating the global operational performance of WIS; (g) Incident management.

2.4.4.2 A formal commitment to implement the GISC and a time schedule for providing GISC services in accordance with the offer shall be given by the Permanent Representative of the Member proposing to operate the candidate GISC.

2.4.4.3 Upon demonstration of the capabilities of the candidate GISC, INFCOM shall submit its recommendation on the designation of the centre as a GISC to Congress or the Executive Council.

2.4.4.4 See also 3.5 (Functional requirements of a GISC).

2.4.5 Designated Global Information System Centres

2.4.5.1 The list of GISCs approved by Congress or the Executive Council is included in Appendix C of this Manual.

2.5 PERFORMANCE REVIEW OF WIS CENTRES

2.5.1 Background

2.5.1.1 The ongoing performance of WIS relies on the continued compliance of WIS centres with agreed standards and practices. To this end, GISCs, DCPCs and NCs should have a performance

review of their compliance with WIS standards and practices.

2.5.2 Responsibility

2.5.2.1 Members are responsible for ensuring that their centres remain compliant with WIS standards and practices. INFCOM will oversee and support the performance review process with the aim of confirming a centre's compliance on a regular basis.

PART III. FUNCTIONS OF WIS

3.1 LIST OF WIS FUNCTIONS

3.1.1 WIS centres collectively support the major functions listed below:

- (a) Collect, share, and archive data;
- (b) Compile and manage datasets;
- (c) Create discovery metadata;
- (d) Manage access to data and services;
- (e) Maintain and expose a catalogue of data and services;
- (f) Monitor data availability, and
- (g) Manage system performance.

Note: Access to data and services may be restricted in order to implement data policies and protect the integrity of WIS.

3.2 FUNCTIONAL ARCHITECTURE OF WIS

3.2.1 There are three main perspectives when considering the function of WIS:

- (a) Data provision;
- (b) Data consumption;
- (c) Global coordination.

3.2.2 A data publisher (NC or DCPC) provides access to a dataset (for example, by publishing data files to a web server or hosting an interactive web service/API). A dataset may consist of one or more files, objects, or database records. Access to a dataset may be restricted in accordance with the data policy specified by the data owner.

3.2.3 A data publisher manages the quality of the datasets it provides to ensure that the data meet the expectations of the data consumers.

3.2.4 A data publisher maintains discovery metadata about the datasets it provides. Each dataset is described by a discovery metadata record providing sufficient information for data consumers to determine whether the dataset meets their needs, where the dataset originated, how they might access the data, and whether there are any restrictions on its use. The discovery metadata record also identifies the points of contact.

3.2.5 A data publisher provides notifications about updates to the datasets it provides and the associated discovery metadata – including notification that a dataset is no longer available in WIS. For example, a data publisher would provide a notification to inform users of the availability of a new observation in a SYNOP dataset, of the availability of a new numerical weather prediction (NWP) model run, and so forth.

3.2.6 The components used by data publishers to provide data and associated discovery metadata are collectively referred to as a “WIS node”.

3.2.7 A Global Broker distributes notifications from data publishers, providing data consumers with highly available access to notifications and other WIS infrastructure components. Multiple Global Broker instances are needed for the effective operation of WIS.

3.2.8 A Global Cache copies, stores, and provides highly available access to discovery metadata records and core data for real-time or near-real-time exchange. Multiple Global Cache instances are needed for the effective operation of WIS. Data are available from a Global Cache for a duration compatible with the real-time or near-real-time schedule of the data and not less than 24 hours.

Note: Core data is defined in Resolution 1 (Cg-Ext(2021)).

3.2.9 A Global Discovery Catalogue copies and stores discovery metadata records from all data publishers and enables data consumers to browse or search for data that meet their needs. A single Global Discovery Catalogue instance is sufficient for the effective operation of WIS, but there may be multiple instances.

3.2.10 Search engines may index discovery metadata records provided to a Global Discovery Catalogue.

3.2.11 Data consumers find data that meet their needs using either a Global Discovery Catalogue or search engines. The discovery metadata for a dataset indicate how to access the data and/or how to subscribe to notifications about the dataset.

3.2.12 Data consumers may subscribe, via Global Brokers, to notifications about datasets and metadata. Upon receipt of a notification, a data consumer determines what action to take, for example, to download the new data identified in the notification.

3.2.13 Data consumers may access data from Global Caches or directly from a WIS node. Data consumers should access real-time and near-real-time core data via Global Caches.

3.2.14 Global Service components (Global Broker, Global Cache, and Global Discovery Catalogue) provide metrics about system performance and data availability. WIS nodes may also provide such metrics. Global Monitors collect these metrics and provide a view of current WIS performance and historical trends.

3.2.15 GISCs ensure the effective operation of WIS. Collectively, GISCs ensure that WIS meets the needs of all WMO programmes, activity areas, and regional associations – including optimizing the distribution of Global Service components, managing threats to the performance of WIS, and responding to incidents to restore system performance. Individually, a GISC supports data publishers and data consumers in its AoR, driving the adoption of good practices and resolving data sharing problems.

Note: The *Guide to WIS*, Volume II provides additional information on the functions of WIS and how these functions may be implemented.

3.3 FUNCTIONAL REQUIREMENTS OF A NATIONAL CENTRE

3.3.1 Collect and manage data

3.3.1.1 As appropriate to its role, an NC shall collect, store, and manage data as defined in Resolution 1 (Cg-Ext(2021)).

Note: Please refer to the *Guide to WIS*, Volume II for further information on Information Management.

3.3.2 Support production of programme-related data

3.3.2.1 As appropriate to its role, an NC shall support the production and management of datasets.

3.3.3 Describe data with discovery metadata

3.3.3.1 An NC shall create discovery metadata about the data it manages and ensure that these discovery metadata remain up to date.

3.3.3.2 See also 4.2 (WIS-TechSpec-1: Managing discovery metadata).

3.3.4 Operate a WIS node

3.3.4.1 As appropriate to its role and in accordance with Resolution 1 (Cg-Ext(2021)), an NC shall provide access to data and the associated discovery metadata.

3.3.4.2 See also 3.6 (Functional requirements of a WIS node).

3.4 FUNCTIONAL REQUIREMENTS OF A DATA COLLECTION OR PRODUCTION CENTRE

3.4.1 Collect and manage programme-related data

3.4.1.1 As appropriate to its role, a DCPC shall collect, store, and manage data as defined in Resolution 1 (Cg-Ext(2021)).

Note: Please refer to the *Guide to WIS*, Volume II for further information on information management.

3.4.2 Support production of programme-related data

3.4.2.1 As appropriate to its role, a DCPC shall support the production and management of regional or specialized datasets.

3.4.3 Describe data with discovery metadata

3.4.3.1 A DCPC shall create discovery metadata about the data it manages and ensure that these discovery metadata remain up to date.

3.4.3.2 See also 4.2 (WIS-TechSpec-1: Managing discovery metadata).

3.4.4 Operate a WIS node

3.4.4.1 As appropriate to its role and in accordance with Resolution 1 (Cg-Ext(2021)), a DCPC shall provide access to data and the associated discovery metadata.

3.4.4.2 See also 3.6 (Functional requirements of a WIS node).

3.5 FUNCTIONAL REQUIREMENTS OF A GLOBAL INFORMATION SYSTEM CENTRE

3.5.1 Coordinate data sharing within the area of responsibility of the Global Information System Centre

3.5.1.1 Each GISC shall coordinate with centres in its AoR to provide the capabilities required to fulfil the functional requirements of WIS.

3.5.1.2 Each GISC shall assess compliance with data policies in its AoR, identifying remedial actions, as necessary.

3.5.1.3 Each GISC should support data consumers in its AoR to find and access the data needed for their operations.

3.5.1.4 A GISC should provide web portals or other value-added services to promote the visibility of, and status information about, Global Services, data, and other WIS components available to WIS centres in its AoR.

3.5.1.5 See also 3.3 (Functional requirements of an NC) and 3.4 (Functional requirements of a DCPC).

3.5.2 Capacity building within the area of responsibility of the Global Information System Centre

3.5.2.1 Each GISC shall provide training and support to enable National Meteorological and Hydrological Services (NMHSs) in its AoR to fulfil the functional requirements of WIS, to provide data (as specified in Resolution 1 (Cg-Ext(2021))), to effectively exploit data shared via WIS, and to meet the needs of national stakeholders.

3.5.2.2 See also 3.3 (Functional requirements of an NC) and 3.4 (Functional requirements of a DCPC).

3.5.3 Provision of Global Service components

3.5.3.1 See 3.7.2 (Provision of Global Service components).

Note: GISCs are not required to operate all Global Service components. Collectively, and in accordance with the recommendations of the Standing Committee on Information Management and Technology (SC-IMT), all GISCs work together to provide enough Global Service instances for the effective operation of WIS.

3.5.4 Performance management

3.5.4.1 Each GISC shall participate in managing the performance of WIS nodes in its AoR. This includes monitoring the collection and distribution of data (as specified in Resolution 1 (Cg-Ext(2021))) and supporting WIS centres in its AoR to improve performance and remedy non-compliance or poor practice.

3.5.4.2 Each GISC shall routinely report information concerning the availability of data and the status and performance of WIS centres in its AoR to other GISCs and the WMO Secretariat.

3.5.4.3 Each GISC shall, according to the schedule agreed among GISCs, take responsibility for monitoring the global operational performance of WIS and, with the support of the WMO Secretariat, manage the response to any operational incidents arising.

3.5.4.4 See also 4.7 (WIS-TechSpec-6: Managing operations of the WIS).

Note: More information on expected service levels and other performance indicators is provided in the *Guide to WIS*, Volume II.

Note: More information on the incident response process is provided in the [Guide to the WMO Information System](#) (WMO-No. 1061), Volume I.

3.6 FUNCTIONAL REQUIREMENTS OF A WIS NODE

3.6.1 General

3.6.1.1 A WIS node is the component that enables an NC or a DCPC to publish its data and discovery metadata via WIS.

3.6.1.2 See also 3.3 (Functional requirements of an NC) and 3.4 (Functional requirements of a DCPC).

3.6.2 Provide access to data and discovery metadata

3.6.2.1 A WIS node shall provide access to data in accordance with Resolution 1 (Cg-Ext(2021)).

3.6.2.2 A WIS node shall allow one or more Global Caches to access and download the core data it publishes for real-time and near-real-time exchange. Global Caches provide highly available access to copies of these resources.

3.6.2.3 A WIS node may restrict access to its core data, relying on Global Caches to provide access to data consumers.

3.6.2.4 A WIS node may provide access to data using a web-based API.

3.6.2.5 A WIS node shall provide access to discovery metadata describing the data it makes available and how those data can be accessed. Discovery metadata from a WIS node are added to the Global Discovery Catalogue to create a consolidated view of the data available from all WIS nodes.

3.6.2.6 A WIS node shall have the capability to publish notifications via a Message Broker.

3.6.2.7 A WIS node shall publish notifications via its Message Broker about updates to the data and discovery metadata it provides – including the availability of new data, changes to discovery metadata, and the removal of a dataset from WIS.

3.6.2.8 A WIS node shall use a standardized topic structure when publishing notifications.

Note: More information on the standardized topic structure is provided in Appendix D.

3.6.2.9 A WIS node shall allow one or more Global Brokers to subscribe to notifications published via its Message Broker. Global Brokers provide highly available distribution of notifications published by a WIS node.

3.6.2.10 See also 4.3 (WIS-TechSpec-2: Publishing data and discovery metadata).

Note: More information on the function and implementation of a WIS node is provided in the *Guide to WIS*, Volume II.

3.6.3 Monitor the performance of a WIS node

3.6.3.1 Each WIS node shall contribute to monitoring the performance of WIS.

3.6.3.2 See also 4.7 (WIS-TechSpec-6: Managing operations of the WIS).

3.7 FUNCTIONAL REQUIREMENTS OF GLOBAL SERVICES

3.7.1 General

3.7.1.1 Global Services provide the capability needed by all participants in WIS. As such, it is essential that they be available when needed and offer a level of performance that meets user expectations. **A Global Service operator shall ensure that service levels are met.**

3.7.1.2 According to the needs of the programme or community it serves, any WIS centre may provide web portals and other value-added services that leverage Global Services.

3.7.2 Provision of Global Service components

3.7.2.1 A WIS centre may provide one or more Global Service components (Global Broker, Global Cache, Global Discovery Catalogue, Global Monitor).

3.7.3 Performance management

3.7.3.1 A WIS centre shall manage the performance of the Global Service components it provides, taking remedial action as necessary to ensure their effective operation.

3.7.3.2 Each Global Service instance shall contribute to monitoring the performance of WIS.

3.7.3.3 To ensure that a Global Service can meet its service level expectations, the operator may restrict access during periods of high demand in accordance with its fair usage policy.

3.7.3.4 See also 4.7 (WIS-TechSpec-6: Managing operations of the WIS)

Note: More information on expected service levels, performance indicators, and fair usage policies is provided in the *Guide to WIS*, Volume II.

3.7.4 Functional requirements of a Global Broker

3.7.4.1 A Global Broker shall provide a highly available Message Broker for distributing notifications in near real time to subscribers.

3.7.4.2 A Global Broker shall subscribe to notifications from WIS centres and Global Services.

3.7.4.3 A Global Broker shall republish notifications from WIS nodes and Global Caches.

3.7.4.4 A Global Broker shall republish notifications from other Global Brokers to ensure the redundant and reliable transmission of notifications.

3.7.4.5 A Global Broker shall detect and suppress duplicate notifications to ensure that each notification is republished only once.

3.7.4.6 See also 4.4 (WIS-TechSpec-3: Operating a Global Broker).

Note: More information on the function and implementation of a Global Broker is provided in the *Guide to WIS*, Volume II.

3.7.5 Functional requirements of a Global Cache

3.7.5.1 A Global Cache shall provide a highly available storage and download service for

accessing discovery metadata records and core data for real-time or near-real-time exchange.

Note: Core data is defined in Resolution 1 (Cg-Ext(2021)).

3.7.5.2 A Global Cache shall operate a Message Broker.

3.7.5.3 A Global Cache shall subscribe to notifications about the availability of discovery metadata records and core data for real-time or near-real-time exchange. Duplicate notifications are discarded.

3.7.5.4 Based on the notifications it receives, a Global Cache shall download and store a copy of discovery metadata records and core data from WIS nodes and other Global Caches.

3.7.5.5 A Global Cache shall provide highly available access to the copies of discovery metadata records and core data it stores.

3.7.5.6 A Global Cache shall retain a copy of the discovery metadata records and core data it stores for a duration compatible with the real-time or near-real-time schedule of the data and not less than 24 hours.

3.7.5.7 A Global Cache shall publish notifications via its Message Broker about copies of the discovery metadata records and core data it makes available. A Global Cache shall use a standardized topic structure when publishing notifications.

3.7.5.8 See also 4.5 (WIS-TechSpec-4: Operating a Global Cache).

Note: More information on the function and implementation of a Global Cache is provided in the *Guide to WIS*, Volume II.

3.7.6 Functional requirements of a Global Discovery Catalogue

3.7.6.1 A Global Discovery Catalogue shall provide a web-based API, enabling data consumers to browse and search metadata for the data published via WIS, review summary information for datasets, and discover actionable links to where they can further interact with those datasets (download data, subscribe to updates, access more detailed metadata, etc.).

3.7.6.2 A Global Discovery Catalogue shall subscribe to notifications concerning the addition, updating, or deletion of discovery metadata records.

3.7.6.3 On receipt of a notification about new or updated discovery metadata, a Global Discovery Catalogue shall download and validate a copy of the discovery metadata record before inserting the record into the catalogue.

3.7.6.4 A Global Discovery Catalogue may amend discovery metadata records to provide details on how to subscribe via Global Brokers to updates about the associated dataset.

3.7.6.5 On receipt of a notification about deleted discovery metadata records, the Global Discovery Catalogue shall remove the identified records from the catalogue.

3.7.6.6 A Global Discovery Catalogue shall provide a mechanism for search engines to crawl and index the discovery metadata it holds.

3.7.6.7 A Global Discovery Catalogue shall assess the quality of the discovery metadata it holds

and provide recommendations for improvement that can be implemented by the originating WIS centre with support from its GISC.

3.7.6.8 A Global Discovery Catalogue shall publish an archive resource once per day, containing all discovery metadata records valid at that time.

3.7.6.9 See also 4.6 (WIS-TechSpec-5: Operating a Global Discovery Catalogue).

Note: More information on the function and implementation of a Global Discovery Catalogue is provided in the *Guide to WIS*, Volume II.

3.7.7 Functional requirements of a Global Monitor

3.7.7.1 A Global Monitor gathers system performance, data availability, and other metrics from all WIS components (WIS node, Global Broker, Global Cache, Global Discovery Catalogue).

3.7.7.2 A Global Monitor shall provide a performance dashboard indicating the current status of WIS and historical performance trends tracked against performance indicators. This performance dashboard is used to help determine acute and systemic performance issues within WIS.

3.7.7.3 See also 4.7 (WIS-TechSpec-6: Managing operations of the WIS).

Note: More information on the function and implementation of a Global Monitor is provided in the *Guide to WIS*, Volume II.

PART IV. WIS TECHNICAL SPECIFICATIONS

4.1 GENERAL

4.1.1 The following six technical specifications (WIS-TechSpecs) define the interfaces to the foundational WIS functions:

- WIS-TechSpec-1: Managing discovery metadata;
- WIS-TechSpec-2: Publishing data and discovery metadata;
- WIS-TechSpec-3: Operating a Global Broker;
- WIS-TechSpec-4: Operating a Global Cache;
- WIS-TechSpec-5: Operating a Global Discovery Catalogue;
- WIS-TechSpec-6: Managing operations of the WIS.

4.1.2 NCs shall support three of the technical specifications: WIS-TechSpec-1, WIS-TechSpec-2, and WIS-TechSpec-6. An NC can arrange through bilateral agreements for another NC, a DCPC or a GISC to perform functions on its behalf.

4.1.3 DCPCs shall support three of the technical specifications: WIS-TechSpec-1, WIS-TechSpec-2, and WIS-TechSpec-6.

4.1.4 GISCs shall support WIS centres in their area of responsibility in meeting their obligations to support WIS-TechSpec-1, WIS-TechSpec-2, and WIS-TechSpec-6.

4.1.5 GISCs shall support one of the technical specifications: WIS-TechSpec-6.

4.1.6 WIS centres operating a Global Broker shall support one of the technical specifications: WIS-TechSpec-3.

4.1.7 WIS centres operating a Global Cache shall support one of the technical specifications: WIS-TechSpec-4.

4.1.8 WIS centres operating a Global Discovery Catalogue shall support one of the technical specifications: WIS-TechSpec-5.

4.1.9 WIS centres operating a Global Monitor shall support one of the technical specifications: WIS-TechSpec-6.

4.1.10 Any DCPC or NC is welcome to implement interfaces beyond the minimum required. Accordingly, the technical specification is mandatory wherever application of the interface is applied.

4.2 WIS-TECHSPEC-1: MANAGING DISCOVERY METADATA

4.2.1 A data publisher shall provide up-to-date discovery metadata describing each dataset it makes available via WIS, including indicating when a dataset is no longer available.

4.2.2 Discovery metadata records describing datasets published via WIS shall comply with the

WMO Core Metadata Profile version 2 (WCMP2), as specified in Part V of the present Manual.

4.2.3 Discovery metadata shall be provided in advance of publication of the associated data.

4.2.4 Discovery metadata should only be amended by the data publisher that generated them.

Note: As an exception, a Global Discovery Catalogue may amend the discovery metadata records that it publishes to include details of how to subscribe to notifications about data availability from Global Brokers.

4.2.5 See also 3.3.3 (Describe data with discovery metadata), 3.4.4 (Operate a WIS node), 3.5.4 (Performance management), 3.7.6 (Functional requirements of a Global Discovery Catalogue), 4.3 (WIS-TechSpec-2: Publishing data and discovery metadata), and 4.6 (WIS-TechSpec-5: Operating a Global Discovery Catalogue).

4.3 WIS-TECHSPEC-2: PUBLISHING DATA AND DISCOVERY METADATA

4.3.1 Data and discovery metadata published via WIS shall be represented in the manner prescribed by the relevant Technical Regulations.

4.3.2 Data and discovery metadata published via WIS shall be accessible via a URL using at least one of the protocols specified in the *Guide to WIS*, Volume II.

4.3.3 URLs provided for accessing core data, as defined in Resolution 1 (Cg-Ext(2021)), and discovery metadata shall be directly resolvable, that is, data or discovery metadata may be downloaded simply by resolving the given URL without further action, such as populating elements of an API.

4.3.4 Data and discovery metadata published via WIS may be accessible via an interactive, self-describing, web-based API. Where a web-based API is provided to access core data and discovery metadata, the API complements the mandatory access mechanism using a directly resolvable URL.

4.3.5 Notifications indicating the availability and access URL of new or updated data or discovery metadata shall be published to a Message Broker using the format and protocol specified in Appendix E.

4.3.6 Notifications indicating the removal of a dataset from WIS shall be published to a Message Broker using the format and protocol specified in Appendix E.

4.3.7 See also 3.6.2 (Provide access to data and discovery metadata), 4.2 (WIS-TechSpec-1: Managing discovery metadata), 4.4 (WIS-TechSpec-3: Operating a Global Broker), and 4.5 (WIS-TechSpec-4: Operating a Global Cache).

4.4 WIS-TECHSPEC-3: OPERATING A GLOBAL BROKER

4.4.1 A Global Broker shall operate a highly available Message Broker using the format and protocol specified in the *Guide to WIS*, Volume II.

4.4.2 At least one Global Broker shall subscribe to notifications published from each WIS node and Global Cache according to the standardized topic structure. The topic structure and process to allocate WIS nodes and Global Caches to Global Brokers are described in Appendix D.

4.4.3 A Global Broker shall subscribe to notifications from other Global Brokers to provide for the redundant and reliable transmission of notifications via WIS. Interconnections between Global Brokers are described in the *Guide to WIS*, Volume II.

4.4.4 A Global Broker shall republish notifications from WIS nodes and Global Services as specified in the *Guide to WIS*, Volume II.

4.4.5 A Global Broker shall republish notifications only once irrespective of how many times it receives each notification.

4.4.6 A Global Broker shall not republish a malformed/non-compliant notification if it would interfere with the correct operation of WIS. If a Global Broker receives such a notification, the WIS centre from where the malformed/non-compliant notification originated shall be alerted as specified in the *Guide to WIS*, Volume II.

4.4.7 See also 3.7.4 (Functional requirements of a Global Broker), 4.3 (WIS-TechSpec-2: Publishing data and discovery metadata), 4.5 (WIS-TechSpec-4: Operating a Global Cache) and 4.7 (WIS-TechSpec-6: Managing operations of the WIS).

4.5 WIS-TECHSPEC-4: OPERATING A GLOBAL CACHE

4.5.1 A Global Cache shall operate as a highly available storage and download service for:

(i) Core data, as defined in Resolution 1 (Cg-Ext(2021)), where programme requirements require sharing in real time or near real time; and (ii) Discovery metadata records.

4.5.2 A Global Cache shall download core data and discovery metadata from WIS nodes and other Global Caches to provide for reliable, low-latency access to those resources via WIS.

4.5.3 A Global Cache shall subscribe to at least one Global Broker for notifications concerning core data and discovery metadata, as specified in the *Guide to WIS*, Volume II.

4.5.4 Based on its received notifications, a Global Cache shall download core data from WIS nodes or other Global Caches and store them for a duration compatible with the real-time or near-real-time schedule of the data and not less than 24 hours.

4.5.5 Based on its received notifications, a Global Cache shall download discovery metadata records from WIS nodes or other Global Caches and store them for a minimum duration of 24 hours.

4.5.6 Data and discovery metadata available for download from a Global Cache shall be accessible via a URL using at least one of the protocols specified in the *Guide to WIS*, Volume II.

4.5.7 A Global Cache shall publish notifications to a Message Broker indicating the availability of data and discovery metadata resources. Notifications shall include the URL for downloading resources from the Global Cache and shall use the format and protocol specified in the *Guide to WIS*, Volume II.

4.5.8 See also 3.7.5 (Functional requirements of a Global Cache), 4.4 (WIS-TechSpec-3: Operating a Global Broker), 4.6 (WIS-TechSpec-5: Operating a Global Discovery Catalogue), and [RFC 3986](#),

[Uniform Resource Identifier \(URI\): Generic Syntax.](#)

4.6 WIS-TECHSPEC-5: OPERATING A GLOBAL DISCOVERY CATALOGUE

4.6.1 A Global Discovery Catalogue shall provide a web-based API, as specified in the *Guide to WIS*, Volume II, for users to search for and discover WIS resources.

4.6.2 A Global Discovery Catalogue shall be populated from discovery metadata provided by data publishers.

4.6.3 A Global Discovery Catalogue shall subscribe to at least one Global Broker for notifications concerning new, updated, or deleted discovery metadata records, as specified in the *Guide to WIS*, Volume II.

4.6.4 A Global Discovery Catalogue shall download new or updated discovery metadata records from a Global Cache for ingest, validation and publication.

4.6.5 A Global Discovery Catalogue shall not publish a malformed/non-compliant discovery metadata record. If a Global Discovery Catalogue receives such a record, the WIS centre from which the record originated shall be alerted as specified in the *Guide to WIS*, Volume II.

4.6.6 A Global Discovery Catalogue shall remove a discovery metadata record when it receives a notification to do so from the original data publisher.

4.6.7 A Global Discovery Catalogue may amend discovery metadata records to enable discovery and access to datasets via Global Services.

4.6.8 A Global Discovery Catalogue shall be able to re-populate its discovery metadata in the event of system incidents.

4.6.9 A Global Discovery Catalogue shall perform quality assessments on discovery metadata records as specified in the *Guide to WIS*, Volume II.

4.6.10 A Global Discovery Catalogue shall create an archive of all valid discovery metadata records at least once per day. This archive resource shall be openly accessible.

4.6.11 A Global Discovery Catalogue shall publish notifications to a Message Broker indicating the availability of a discovery metadata archive resource. Notifications shall include the URL for downloading the archive resource from the Global Discovery Catalogue.

4.6.12 See also 3.7.6 (Functional requirements of a Global Discovery Catalogue), 4.2 (WIS-TechSpec-1: Managing discovery metadata), 4.3 (WIS-TechSpec-2: Publishing data and discovery metadata), 4.4 (WIS-TechSpec-3: Operating a Global Broker), 4.5 (WIS-TechSpec-4: Operating a Global Cache), and 4.7 (WIS-TechSpec-6: Managing operations of the WIS).

4.7 WIS-TECHSPEC-6: MANAGING OPERATIONS OF THE WIS

4.7.1 Operators of WIS nodes and Global Services shall contribute to the monitoring of WIS by providing metrics as specified in the *Guide to WIS*, Volume II.

4.7.2 A Global Monitor shall collect metrics from WIS nodes and Global Services, as specified

in the *Guide to WIS*, Volume II.

4.7.3 A Global Monitor shall provide a portal with visualization of WIS performance.

4.7.4 GISCs, with the support of Global Services, shall coordinate the incident management process described in the *Guide to WIS*, Volume II, in order to satisfy the required service level.

4.7.5 WIS centres shall participate in the incident management process described in the *Guide to WIS*, Volume II.

4.7.6 See also 3.5.4 (Performance management), 3.6.3 (Monitor the performance of a WIS node), 3.7.3 (Performance management), and 3.7.7 (Functional requirement of a Global Monitor).

PART V. WIS DISCOVERY METADATA

5.1 GENERAL

5.1.1 WIS discovery metadata records are provided by the data publisher and enable the discovery, evaluation and use of WIS datasets. WIS discovery metadata records provide a description of a dataset, including identification and spatiotemporal information, as well as direct, actionable linkages to associated data and services. They are also clearly classified and categorized in accordance with Resolution 1 (Cg-Ext(2021)) and the WIS topic hierarchy.

5.1.2 The WMO Core Metadata Profile (version 2) for discovery metadata is specified in Appendix F.

PART VI. INFORMATION MANAGEMENT

6.1 MANAGING INFORMATION AND COMMUNICATION TECHNOLOGY OPERATIONS

6.1.1 All Members shall follow the guidance provided in the *Guide to WIS*, Volume II, and use appropriate information management processes to generate, share, use, archive and dispose of information supporting WMO and partner organization programmes.

6.1.2 Members shall manage their information and communication technology (ICT) to a standard consistent with the requirements of the services that depend on that ICT.

APPENDIX A: WIS 2.0 principles and benefits

The WMO review of emerging data issues cites web services as one of the technologies that:

"present new operating concepts that will improve operational efficiency, information sharing and service delivery, and enable users to [more effectively] exploit data".foot[.small] Note:[[WMO Guidelines on Emerging Data Issues](#) (WMO-No. 1239)]

The World Wide Web Consortium (W3C) states that:

"The Web is the World's most successful vendor neutral distributed information system, enabling people to access applications and services right across the World from their smart phones, tablets, laptops and other computing devices. [...] The Web of data [...] ranges from small amounts of data to vast datasets,[...][which are either] open to all or restricted to a few. Data can be consumed by Web pages, downloaded for local processing, or accessed via network APIs that support remote processing."foot[.small] Note:[See Raggett, D. *W3C Study of Practices and Tooling for Web Data Standardisation*; World Wide Web Consortium (W3C), 2017. <https://www.w3.org/2017/12/odi-study/#introduction>.]

The Web is founded on three pillars:

- (1) Addressing resources (web pages, data, metadata, APIs, etc.) using URIs;
- (2) Open data standards; and
- (3) Open standard network protocols.

The provision of digital resources (e.g. data, information, products) using the Web does not automatically imply that those resources are freely available to all without restrictions on their use. Web technologies allow for authentication and authorization where necessary: resource providers retain control of who can access published resources, and they can force users to accept a license specifying the terms and conditions under which those resources can be used before allowing them access.

Ten technical changes to WIS (the WIS 2.0 principles) and the associated benefits are outlined below.

Principle 1: WIS 2.0 adopts web technologies and leverages industry best practices and open standards.foot[.small] Note:[Particularly open standards from the Internet Engineering Task Force (IETF), W3C, the Open Geospatial Consortium (OGC).]

BENEFIT:

- The use of widely adopted practices and open standards will enable a large population of users to conveniently interact with WIS 2.0 to discover, access, and use authoritative weather, water and climate data.

Note: Many NMHSs already embrace web architecture to meet their business needs.

Principle 2: WIS 2.0 uses URLs to identify resources (i.e., web pages, data, metadata, APIs).foot[.small] Note:[For more information on identifying resources, refer to W3C Technical

Architecture Group. *Architecture of the World Wide Web Volume One, 2. Identification*; World Wide Web Consortium (W3C), 2004. <https://www.w3.org/TR/webarch/#identification>.]

BENEFIT:

- URLs uniquely identify a resource and describe the primary mechanism for retrieving or interacting with it (i.e. the network ‘location’ and the communications protocol to be used).

Principle 3: WIS 2.0 prioritizes the use of public telecommunication networks (for example, the Internet) when publishing digital resources.

BENEFITS:

- Publishing digital resources on the Internet enables the meteorological community to retrieve or interact with those resources – it is unlikely that most of the community would be permitted to join managed networks such as Area Meteorological Data Communications Networks (AMDCNs) employed by NMHSs for data exchange with guaranteed service levels.
- Internet connections are significantly cheaper than the same bandwidth delivered through a managed network.

Note: The WMO Integrated Global Data Dissemination Service (IGDDS) remains an important component of WIS, providing data distribution where there is no Internet connectivity using Digital Video Broadcast by Satellite (DVB-S) broadcasts.

The first generation of WIS was primarily concerned with datafoot[.small] Note:[The term ‘data’ is used loosely here to cover everything from products to information to data.] as traditionally exchanged via the GTS. A major issue with this data-centric approach is that often it is unclear to users how they might access (download or otherwise interact with) data that are of interest to them. In line with industry practice, WIS 2.0 recognizes that users, whether humans or software systems, will always interact with data published using WIS through some form of web service. Web services are used for a broad range of functions – to download data for local use, to request routine delivery of data, to view or display data, and so forth.

Principle 4: WIS 2.0 requires the provision of web service(s) to access or interact with digital resources (for example, data, information, products) published using WIS.

BENEFITS:

- Web services support ‘machine-actionability’ (the capacity of software systems to access, interoperate, and reuse data with little or no human intervention) – as the volume, complexity and velocity (creation speed) of data have increased, human reliance on computational support to deal with those data has also increased.
- NMHSs develop their capacity to build and operate web services, allowing them to extract more value from their data holdings through delivery of higher value services to users.

Note: Based on the standards and conventions commonly used in their target user community (or communities), WMO programmes may identify additional technical specifications to which participating centres should conform in addition to the specifications in the present Manual.

When designing their web service offerings, NCs and DCPCs publishing ‘big data’ into WIS should consider the capability of their users to work with those data. The World Meteorological Congress, at its seventeenth session, noted that most Members were ill-prepared for the predicted explosion

in data volumes. Many Members are already unable to effectively use the data published and made available today. Data volumes are rapidly increasing to sizes that require a significant investment in technical infrastructure to manage and use those data. It is also often impractical to move such large volumes of data between collaborating organizations fast enough to meet operational requirements.

Web services may be used to provide a network API to process or simplify complex or high-volume data to better match the needs of the user or to create a product. These services may range in complexity from simple query APIs that allow the user to extract only a geographic subset of data corresponding to the user's area of interest through to remote execution of a local area weather prediction model according to the user's specification and visualization of the model output. What both of these examples have in common is that the data are processed using the data provider's infrastructure to create a result or product that is small enough to be conveniently downloaded and used. Where the data processing is complex, intensive or requires significant user-specific configuration, NCs and DCPCs should consider the use of cloud technologies to underpin their data processing services.

Principle 5: WIS 2.0 encourages NCs and DCPCs to provide 'data reduction' services via WIS that process 'big data' to create results or products that are small enough to be conveniently downloaded and used by users with minimal technical infrastructure.

BENEFIT:

- Using 'data reduction' web services to process high-volume, complex data remotely, Members' agencies and institutions can deliver high-value, high-quality services to their governments and citizens, helping them to meet their national mandates more effectively and without the need to invest in and operate their own data management infrastructure.Note:[The provision of data processing services in this way supports the WMO principles that no Member should be left behind and that no Member stands alone – through cooperation, all Members should have access to the necessary capability to work with the predicted increase in data volumes.]

Real-time delivery of data and products in support of the World Weather Watch programme remains a core requirement for WIS. Data exchange methods permitted on the GTSNote:[File Transfer Protocol (FTP) and Secure File Transfer Protocol (SFTP); see the *Manual on the Global Telecommunication System* (WMO-No. 386), Attachment II-15.] require manual intervention in response to each user request for real-time data delivery, for example, to set up and configure a new data delivery path. This practice will not scale to meet the demand for real-time data from across the meteorological community.

Modern messaging protocols, such as those that underpin social media platforms, solve this problem by automating how the relationship between the data provider and the consumer is established. Data providers create a channel ('Message Queue') and categorize which data are published to that channel. Data consumers determine which channels contain data of interest and, assuming they have the necessary access rights, subscribe to them. Once a subscription to a channel is established, data published to that channel are then automatically sent to the subscriber. This is known as the publish-subscribe messaging pattern ('pubsub'). With such modern messaging protocols, there is no manual configuration burden on data providers to add new subscribers.

Note: These modern messaging protocols may also be used to send notifications to subscribers, for example, to alert subscribers that new data or products are available for them to access or download at their convenience.

Principle 6: WIS 2.0 adds open standard messaging protocols that use the publish-subscribe message pattern to the list of data exchange mechanisms approved for use within WIS and GTS.

BENEFIT:

- Low effort for data providers to distribute data in real time to large numbers of consumers.

Principle 7: WIS 2.0 requires all services that provide real-time distribution of messages (containing data or notifications about data availability) to cache/store the messages for a minimum of 24 hours and allow users to request cached messages for download.

BENEFIT:

- Software systems that consume real-time data or notifications can recover from failure by requesting the delivery of messages that were missed while the system was offline.

Notes:

1. From a WIS 2.0 perspective, open standard message protocols using the publish-subscribe pattern are considered to be web services.
2. Digital resources may be made available through multiple web services. For example, an NC may publish synoptic reports via both download (e.g. a user queries the service to access data – “pull”) and real-time delivery (e.g. a user subscribes to the service and data is sent when available – “push”).
3. Many Message Switching Systems (MSS) already use the channels concept to organize the distribution of data. MSS could be amended to support these new data exchange methods, thereby minimizing disruption to the core business of NMHSs (internal, national and international data distribution).

During its lifetime, the GTS – a core component of WIS – has seen continual evolution, notably, the establishment of managed regional networks or Area Meteorological Data Communication Networks (AMDCNs) using high-performance managed networks and the Internet. Within such networks, all nodes are visible to each other; there is no longer any need to manually route data through an intermediate chain of nodes to reach an eventual destination. Instead, data routing is delegated to underlying network infrastructure that is able to avoid the use of network segments suffering from poor performance and is thus able to determine the optimal (i.e. quickest) path from the origin to the destination.

The “store and forward” data dissemination pattern, routing data through an intermediate chain of nodes, remains central to GTS operations. Each node on the GTS operates a ‘message switch’ to control data flow based on the static configuration of the routing tables and the unique identifier (header) of each data package (bulletin). Routing tables and bulletin headers are rendered obsolete in modern telecommunication networks.

Note: Many NMHSs already meet bilateral data sharing arrangements using direct file transfer, avoiding the need for a routing table entry and effectively bypassing the GTS altogether (albeit often using the same underpinning telecommunication network infrastructure).

Principle 8: WIS 2.0 adopts direct data exchange between the provider and the consumer and phases out the use of routing tables and bulletin headers.

BENEFITS:

- Faster transmission of real-time data by avoiding the latency introduced by message switches at intermediate GTS nodes.
- Simplified message switching operations for all Members because routing table maintenance is no longer required.
- Faster setup of new data sharing arrangements as there is no need to wait for intermediate nodes to update their routing table configuration.

With the elevation of web services to a primary concern of WIS 2.0, the WIS Catalogue and the WMO Core Metadata specification have been updated.

Principle 9: WIS 2.0 provides a catalogue containing metadata that describe both data and the service(s) provided to access those data.

BENEFIT:

- Users will be able to easily find the data in WIS that interest them, locate the most convenient web service with which to access those data, and determine how to best use that web service to meet their needs.

WIS 2.0 enables data and web services to be discovered via commercial search engines, thereby enhancing the discoverability of authoritative weather, water and climate data.

Principle 10: WIS 2.0 encourages data providers to publish metadata describing their data and web services in a way that can be indexed by commercial search engines.

BENEFIT:

- Indexing by commercial search engines will help users discover data and associated services using their preferred search engine[small] Note:[As an example of how Google uses schema.org structured markup to enable users to find datasets, see Castelvecchi, D. Google Unveils Search Engine for Open Data. *Nature* **2018**, 561 (7722), 161–162. <https://doi.org/10.1038/d41586-018-06201-x>.] rather than having to find and use a WIS portal.

Note: The Global Discovery Catalogue will provide the necessary functionality to support indexing WIS discovery metadata by commercial search engines.

APPENDIX B: WMO INFORMATION SYSTEM COMPETENCIES

1. INTRODUCTION

1.1 A variety of skilled personnel, including project managers, engineers, technicians and information technology staff may provide WIS services within an NMHS or a related service. Third party organizations, such as universities, international and regional institutions and centres, private sector companies and other providers, may also supply data, products and information for WIS services.

1.2 This document sets out a competency framework for personnel involved in the provision of WIS services. It is not necessary for each individual staff member to have the full set of competencies; rather, within specific application conditions (see 2 below), which are different for each organization, it is expected that an institution providing WIS services will have staff members somewhere within the organization who together demonstrate all the competencies at the institution's infrastructural capacity level. The performance and knowledge requirements that support the competencies should be customized based on the particular context of an organization. However, the general criteria and requirements provided here apply in most circumstances.

2. APPLICATION CONDITIONS

- (a) The organizational context, priorities and stakeholder requirements;
- (b) The way in which internal and external personnel are used to provide WIS services;
- (c) The available resources and capabilities (financial, human and technological resources, and facilities) and organizational structures, policies and procedures;
- (d) National and institutional legislation, rules and procedures.

3. COMPETENCIES

Seven competencies across four basic functional areas have been defined as follows:

Infrastructure

- 1. Manage the physical infrastructure;
- 2. Manage the operational applications.

Data

- 1. Manage and share data;
- 2. Manage data discovery.

External interactions

- 1. Manage interactions among WIS centres;
- 2. Manage external user interactions.

Overall service

1. Manage the operational service.

COMPETENCY 1: MANAGE THE PHYSICAL INFRASTRUCTURE

Competency description

Prepare, plan, design, procure, implement and operate the physical infrastructure, networks and applications required to support the WIS centre.

Performance components

Management of information technology operations

1a. Maintain the system in optimal operational condition by setting and meeting service levels in areas including:

- Configuration;
- Preventative and corrective maintenance and servicing;
- Equipment replacement or upgrades;
- Networking and processing capacity;
- System monitoring and reporting procedure, and corrective actions;

1b. Provide contingency planning, operation backup and restoration;

Management of facilities

1c. Manage the security of the physical site;

1d. Manage the environmental control of the physical site.

Knowledge and skill requirements

- General ICT skills;
- Operation, configuration and maintenance of equipment and applications;
- Recognized information technology service management frameworks;
- Current technologies and emerging trends;
- Service level agreements.

COMPETENCY 2: MANAGE THE OPERATIONAL APPLICATIONS

Competency description

Prepare, plan, design, procure, implement and operate the applications required to support WIS functions.

Performance components

2a. Meet service levels by maintaining applications in optimal operational condition by:

- Configuring applications;
- Monitoring and responding to the behaviour of applications;
- Carrying out preventative and corrective maintenance;
- Replacing or upgrading applications;

2b. Provide contingency planning and application backup and restoration;

2c. Ensure data integrity and completeness in the event of system failure;

2d. Ensure system security.

Knowledge and skill requirements

- General ICT skills;
- Operation, configuration and maintenance of applications;
- Recognized information technology service management frameworks;
- Current technologies and emerging trends;
- WIS functions and requirements;
- WIS security policies.

COMPETENCY 3: MANAGE AND SHARE DATA

Competency description

Manage the collection, processing, storage and sharing of data through scheduled and on-demand services.

Performance components

3a. Ensure that data are collected and shared as per the data policy;

3b. Provide access to data (publish data) as per the data policy;

3c. Publish and subscribe to notifications about data availability;

3d. Encode, decode, validate and package data;

3e. Manage the compilation of datasets;

3f. Manage connectivity.

Knowledge and skill requirements

- System and network monitoring and viewing tools;
- Data formats and Message Queue protocols;
- Licensing and data policies.

COMPETENCY 4: MANAGE DATA DISCOVERY

Competency description

Create and maintain discovery metadata records describing data and services and publish them to the Global Discovery Catalogue.

Performance components

- 4a. Create and maintain discovery metadata records describing data and services;
- 4b. Add, update, replace or delete metadata records within the catalogue;
- 4c. Provide access to discovery metadata records;
- 4d. Publish and subscribe to notifications about discovery metadata availability;
- 4e. Ensure that all data and service offerings from a WIS centre have complete, valid and meaningful discovery metadata records uploaded to the catalogue.

Knowledge and skill requirements

- Discovery metadata concepts and formats (WMO Core Metadata Profile);
- Metadata entry and management tools;
- Message Queue protocols;
- Policies;
- Written English.

COMPETENCY 5: MANAGE INTERACTION AMONG WIS CENTRES

Competency description

Manage relationships and compliance between WIS centres.

Performance components

- 5a. Exchange information with other centres on operational matters;
- 5b. Facilitate the registration of new WIS centres;
- 5c. Facilitate the registration of new datasets;
- 5d. Subscribe to notifications from other WIS centres about data availability;
- 5e. Create and respond to WIS service messages.

Knowledge and skill requirements

- Knowledge of current exchanges and requirements for the notification of operational changes;
- Procedures and practices for the registration of WIS centres and datasets;

- Message Broker concepts;
- Service level agreements;
- Written English.

COMPETENCY 6: MANAGE EXTERNAL USER INTERACTIONS

Competency description

Ensure users, including data publishers and data consumers (users), can publish and access data and products through WIS.

Performance components

- 6a. Register data consumers where needed and maintain a service agreement;
- 6b. Set and implement data and service access criteria;
- 6c. Provide systems and support for data consumers to access data and services;
- 6d. Manage user relations to ensure a high satisfaction level.

Knowledge and skill requirements

- Data policies;
- WIS Global Services;
- WIS registration and monitoring tools and policies;
- User support documentation and help files;
- Written English.

COMPETENCY 7: MANAGE THE OPERATIONAL SERVICE

Competency description

Ensure the quality and continuity of the service.

Performance components

- 7a. Coordinate all WIS functions and activities of the centre;
- 7b. Ensure and demonstrate compliance with regulations and policies;
- 7c. Monitor and meet quality and service performance standards;
- 7d. Ensure service continuity through risk management, planning and the implementation of service contingency, backup and restoration, and ensure data continuity in the event of system failure;
- 7e. Plan and coordinate the delivery of new functionalities.

Knowledge and skill requirements

- General management skills;
- Overview of local and external WIS operations and associated service agreements;
- WIS regulations and policies;
- Functional specifications;
- Written English.

APPENDIX C: APPROVED WIS 2.0 CENTRES

1. GENERAL

1.1 The WIS centres previously approved by Congress or the Executive Council, included in the list in Appendix B of the *Manual on the WMO Information System* (WMO-No. 1060), Volume I, are candidate WIS 2.0 centres.

1.2 WIS centres shall complete the migration from WIS/GTS to WIS 2.0 in order to be designated as WIS 2.0 centres and added to the list in the present Appendix.

2. GLOBAL INFORMATION SYSTEM CENTRES

WMO Member	Centre name	Region

3. DATA COLLECTION OR PRODUCTION CENTRES

WMO Member or contributing organization	Centre name	Centre location (region/city)	Function	Technical commission/ + programme	GISC

4. NATIONAL CENTRES

WMO Member or contributing organization	Centre name	WIS function	Centre location (region)	Principal GISC	Constituent body

APPENDIX D: WIS2 TOPIC HIERARCHY

https://wmo-im.github.io/wis2-topic-hierarchy/standard/wis2-topic-hierarchy-STABLE.html#_wis2_topic_hierarchy

APPENDIX E: WIS2 NOTIFICATION MESSAGE

https://wmo-im.github.io/wis2-notification-message/standard/wis2-notification-message-STABLE.html#_wis2_notification_message

APPENDIX F: WMO CORE METADATA PROFILE (VERSION 2)

[https://wmo-im.github.io/wcmp2/standard/wcmp2-STABLE.html#
_wmo_core_metadata_profile_version_2](https://wmo-im.github.io/wcmp2/standard/wcmp2-STABLE.html#wmo_core_metadata_profile_version_2)