An Implementation Timetable for the WMO Information System

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Executive Summary

It became apparent already in 1998 that the various WMO Programmes either had or were in the process of developing their own information systems independently of each other. Since the multiplicity of systems resulted in incompatibilities, inefficiencies, duplication of effort and higher overall costs for Members, the continued development of the systems in this uncoordinated manner would have exacerbated these problems and would have further isolated the WMO Programmes from each other and from the wider environmental community. Therefore, a CBS Expert Team developed a concept of a WMO Information System (WIS) suitable for all WMO Programmes providing an integrated approach to meeting the requirements of:

- Routine collection and automated dissemination of observed data and products ("push");
- Timely delivery of data and products (appropriate to requirements);
- Ad-hoc requests for data and products ("pull").

In 2003, the World Meteorological Congress confirmed that such an overarching approach was required as a single coordinated global infrastructure.
Beside the programmes which could benefit from the services offered by WIS for the implementation of their data exchange tasks, the individual users, either a person or an institution, would be the main beneficiary of WIS, because WIS would provide a single entry point for any data request, be it on a routine basis by dissemination of certain user defined information sets or on an ad-hoc basis for a special data set. The current diversification of access points and –methods would be replaced by a common approach. Furthermore, the portal structure provided by WIS would make it possible for programmes to present their data to their users in a programme specific query format.
During EC-LVII in 2005, realising the important role WMO would have to play in contributing the essential data exchange and data management services to the future GEOSS and to facilitate the effective role of all NMHS in Disaster Mitigation and Prevention activities and warning systems, the Executive Council requested to develop a work plan and expedite the development of key components of WIS with a view to facilitating implementation, at least in some countries, in 2006 instead of 2008, as originally planned.
To better describe WIS, a functional view is adopted. Three major components are defined: *National Centres (NC), Data Collection or Product Centres (DCPC)* and *Global Information System Centres (GISC)* together with a data communication network connecting the components. It should be noted that the terms are only used for describing the necessary functions, not actual organisational entities. There may be organisations like NMHS's which combine all three functions within their structure.
Considering the concept of WIS and looking at the necessary software development, the following major tasks can be identified:

- Metadata catalogues
- Internet portal
- Data acquisition service
- Data discovery service
- Data distribution service: push and pull
- Monitoring
- Operational aspects like data synchronisation, back-up, administrative issues, etc.

Taking into account the valuable work already undertaken by the various pilot projects in the different Programmes such as

- the JCOMM GISC-E2EDM prototype,
- the VPN Pilot Project in RA II and V,
- CliWare in the Russian Federation,
- the EUMETNET UNIDART project,
- the RA-VI VGISC project,
- CAgM WAMIS and
- the TIGGE activities

and considering the results of similar activities mainly in the USA, it can be expected that a smooth transition from the current GTS based systems to the new WIS structures could be achieved by the end of 2006 in a semi-operational mode. The following milestones are considered necessary to meet this deadline:

- readiness of the definition of the WMO Core Profile version of metadata in March 2006 and of the reference implementation by 2Q06;
- integration of metadata structures into pilot GISC's and DCPC's by October 2006
- Internet portal in 2Q06
- Basic data acquisition with generation of metadata by 2Q06
- Data discovery service by October 2006
- Agreement on specification of data access rights by relevant CBS Expert Teams in 2Q06
- Data distribution service:
    - push in 3Q06
    - pull in 3Q06
- Define format for basic monitoring information in agreed format by 3Q06.

(Note: the above milestone dates have been revised taking into account the ICG-WIS II - November 2005 outcome)

However, a concerted effort by the WMO Members that crosscuts over and integrates the WMO Programmes, supported by the relevant CBS Expert Teams, is required to reach these ambitious goals. As stated by the WMO Executive Council in 2003:
"*The support and involvement of regional associations and technical commissions [is] needed, as early as possible, in all phases of the WIS development in order to ensure a full and shared ownership of the project, and its effective implementation."*
Furthermore, industrial involvement and a strong project co-ordination are crucial. A crosscutting programme could be set-up in WMO which should undertake these tasks and also act as a channel to the industry. During the Technical Conference to be held prior to the CBS meeting in late 2006, the status of the implementation should be reviewed.
After this event, pilot projects could become semi-operational to gain valuable experience with the WIS concept. The newly created GISC's could implement the global data exchange envisaged. As a next step, various DCPC's could offer their data for access and ease the burden for the related Programmes. Furthermore, at this stage the different Programmes could extend the metadata catalogue held in the GISC's by their own special data requirements and use the WIS features to disseminate their products. In this way, the enhanced functions provided by WIS will be gradually introduced and expanded from 2006 onwards.

1. Background

As stated in [13], it became apparent already in 1998 that the various WMO Programmes either had or were in the process of developing their own information systems independently of each other. Since the multiplicity of systems resulted in incompatibilities, inefficiencies, duplication of effort and higher overall costs for Members, the continued development of the systems in this uncoordinated manner would have exacerbated these problems and would have further isolated the WMO Programmes from each other and from the wider environmental community. It would have increased the difficulty in sharing information between programmes, which was essential for them to fulfil their requirements. Following initial conceptual work by an CBS Expert Team, the World Meteorological Congress in 2003 (see [1]) reviewed the proposed concept and confirmed that an overarching approach was required: a single coordinated global infrastructure, the WMO Information System (WIS):

- WIS would be used for the collection and sharing of information for all WMO and related international programmes.
- WIS would provide a flexible and extensible structure that would allow the participating centres to enhance their capabilities as their national and international responsibilities grow.
- Implementation of WIS should build upon the most successful components of existing WMO information systems in an evolutionary process.
- WIS development should pay special attention to a smooth and coordinated transition.
- The basis for the core communication network should be the communication links used within the World Weather Watch (WWW) for the high priority real-time data.
- WIS should utilise international industry standards for protocols, hardware and software.

In more technical detail, WIS should provide an integrated approach to meeting the requirements of:

- Routine collection and automated dissemination of observed data and products ("push");
- Timely delivery of data and products (appropriate to requirements);
- Ad-hoc requests for data and products ("pull").

In addition, WIS should be:

- Reliable
- Cost effective and affordable for developing as well as developed Members
- Technologically sustainable and appropriate to local expertise
- Modular and scalable
- Flexible and extensible - able to adjust to changing requirements and allow dissemination of products from diverse data sources and allow participants to collaborate at levels appropriate to their responsibilities and budgetary resources.

Once WIS became fully operational, the following services could be expected:

- for WWW, with regard to high priority time-critical data and products, the current GTS dissemination of data should continue. Any foreseeable or possible enhancement of the GTS should be supported;

- further development of satellite transmission systems should enable all participants of WIS, in particular the least developed Members of WMO, to receive the routine global dissemination of products;
- other established international programmes could use the WIS with agreement of WMO to transmit data either in real-time or in delayed mode. The required timeliness and size of the data would determine the media to be used for the data transmission, e.g. leased lines, GTS links, Internet or satellite distribution systems. In addition, the data transmission protocol could be chosen either by the initiating programme or by each recipient from an agreed common set;
- authorised users of WIS could ask for routine or ad-hoc dissemination of data known to WIS;
- any user, even without authorisation, could use WIS via Internet for data directory browsing or access to data which is available to everybody without restriction.

Since WIS would only use off-the-shelf hardware and software systems, it should be affordable and highly flexible.
Beside the programmes which could benefit from the services offered by WIS for the implementation of their data exchange tasks, the individual users, either a person or an institution, would be the main beneficiary of WIS, because WIS would provide a single entry point for any data request, be it on a routine basis by dissemination of certain user defined information sets or on an ad-hoc basis for a special data set. The current diversification of access points and –methods would be replaced by a common approach. Furthermore, the portal structure provided by WIS would make it possible for programmes to present their data to their users in a programme specific query format.
In summary, WIS will add services to the current systems and will allow the exploitation of synergy effects by creating a single, integrated system for all WMO programmes that supports a range of data exchange services adapted to the actual requirements (timeliness, security, volumes). This should facilitate the active participation of the less developed Members in the WMO Programmes, especially the WWW.
Since the endorsement of WIS as a major development project of WMO in 2003, CBS pursued the implementation of WIS through gradual introduction and evaluation of enabling technologies through pilots and prototypes.
In 2004, EC-LVI created an Inter-Commission Coordination Group on WIS (ICG-WIS) as a strong, high-level coordination and collaboration mechanism spanning across the technical commissions to guide the orderly evolution of WIS.
CBS, during its thirteenth session in 2005 (see [14]), emphasised the critical importance of WIS for the WWW, noting that the implementation of WIS would build upon the most successful components of existing WMO information systems, in particular the WWW GTS and Data Management, and that a smooth and co-ordinated transition was crucial. It also emphasised that the WMO Space Programme Integrated Global Data Dissemination Service (IGDDS) should be fully integrated as a communication component. The Commission therefore agreed that CBS should pursue its proactive role in the further development of the WIS through activities relevant to its OPAGs, in particular the OPAG on ISS, and in the framework of the ICG-WIS. To this effect, the Commission agreed to establish within its OPAG on ISS an Expert Team on WIS/GTS Communication Techniques and Structure and an Expert Team on WIS GISCs and DCPCs. It also recalled the critical activities of the Inter-Programme Expert Team on Metadata Implementation for the development of WIS.
Finally, during EC-LVII in 2005, realising the important role WMO would have to play in contributing the essential data exchange and data management services to the future GEOSS, the Executive Council urged the Secretary General, volunteering Members and ICG-WIS, with the

support of relevant technical commissions, to develop a work plan and expedite the development of key components of WIS with a view to facilitating implementation, at least in some countries, in 2006 instead of 2008, as originally planned (see [15]).

2. WIS concept

In view of the decision by the WMO Congress during its fourteenth session that "an overarching approached was required" the relationship between functions to be performed by WIS and similar functions performed by current WMO Programmes is illustrated in Fig. 1 below. More details can be found in [13].

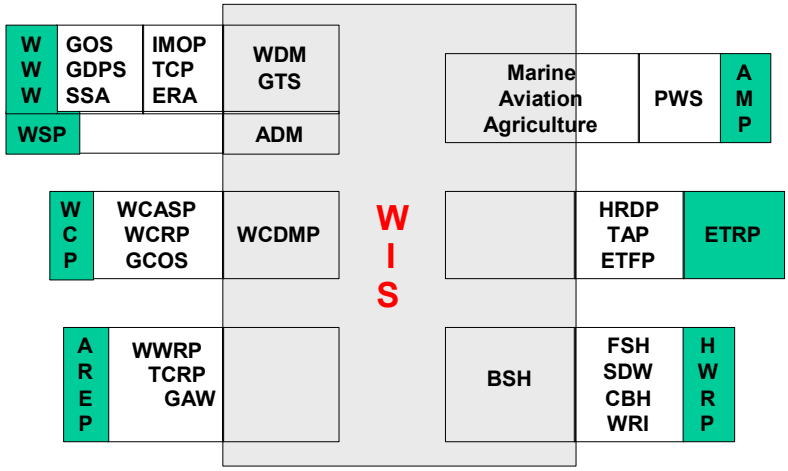

Fig. 1: WIS relationship to WMO Programmes

To better describe WIS, a functional view is adopted. Three major components are defined: *National Centres (NC), Data Collection or Product Centres (DCPC)* and *Global Information System Centres (GISC)* together with a data communication network connecting the components. It should be noted that the terms are only used for describing the necessary functions, not actual organisational entities. There may be organisations like NMHS's which combine all three functions within their structure.

2.1 National Centre (NC)

Similar to the WWW distribution of functions and that of several other Programmes, e.g. JCOMM, GCOS, WIS assumes the existence of a national component. This part of WIS is responsible for collecting and distributing data on a national basis and to authorise the use of the WIS elements for its accredited national users. Therefore, a national authority must be established, normally the Permanent Representative (PR) of the country, to co-ordinate the use of WIS by the different Programmes (see [3]) which could operate a National Centre each. The role of the National Centres (NC) was summarised as follows by the IPTT on FWIS (see [12]):

- Collect observational data from within their country
- Provide observations and products intended for global dissemination to their responsible GISC (possibly via a DCPC)
- Provide observations and products intended for regional or specialised distribution to the responsible DCPC

- Collect, generate and disseminate products for national use.
- Participate in monitoring the performance of the system
- Authorize their national users to access FWIS, as required.

2.2 Data Collection and Production Centre (DCPC)

Centres, which fulfil within their own WMO Programmes the responsibility of producing data and archiving the information, would undertake data exchange functions within WIS. Examples of Centres taking up those functions are the European Centre for Medium-Range Weather Forecasts (ECMWF) in Reading, UK, and national Numerical Weather Prediction (NWP) Centres.
Similarly, centres which collect information like World Data Centres e.g. in Ashville, Obninsk or Bejing or specialised agencies such as EUMETSAT and NESDIS are also responsible for storing and archiving the information and making them available for standard dissemination or on a request-reply mechanism in accordance with agreed data access policies. Furthermore, some centres would ensure the collection of data on a regional or specialised basis (e.g. ARGOS,…) and thus act as DCPC's .
Their role can be summarised as (see [12]):

- Collect information intended for dissemination to NCs within its area of responsibility (i.e. regional collections)
- Collect special programme-related data and products
- Produce regional or specialized data and products
- Provide information intended for global exchange to their responsible GISC
- Disseminate information not intended for global exchange
- Support access to their products via WMO request/reply ("Pull") mechanisms in an appropriate manner
- Describe their products according to an agreed WMO standard and provide access to this catalogue of products and provide this information as appropriate to other centres, in particular a GISC
- Ensure that they have procedures and arrangements in place to provide swift recovery or backup of their essential services in the event of an outage (due to, for example, fire or a natural disaster).
- Participate in monitoring the performance of the system.

2.3 Global Information System Centre (GISC)

The regional and global connectivity of the WIS structure is guaranteed by the existence of a small number of GISC's whose areas of responsibility in total cover the whole world and which collect and distribute the information meant for routine global dissemination. In addition, they serve as collection and distribution centres for their areas of responsibility and also provide an entry point for any request for data held within WIS, i.e. they maintain metadata catalogues of all information available for any authorised user of WIS, independent of its location or type. In addition, for all environmental data available within WIS which are not subject to any access control, the GISC will provide a portal for data searches by anybody, even without prior authorisation. This new service will greatly facilitate data searches by researchers. The role of a GISC is defined as (see [12])

- Receive observational data and products that are intended for global exchange from NCs and DCPCs within their area of responsibility, reformat as necessary and aggregate into products that cover their responsible area
- Exchange information intended for global dissemination with other GISCs
- Disseminate, within its area of responsibility, the entire set of data and products agreed by WMO for routine global exchange (this dissemination can be via any combination of the Internet, satellite, multicasting, etc. as appropriate to meet the needs of Members that require its products)
- Hold the entire set of data and products agreed by WMO for routine global exchange for at least 24 hours and make it available via WMO request/reply (”Pull”) mechanisms

  Maintain, in accordance to the WMO standards, a catalogue of all data and products for global exchange and provide access to this catalogue to locate the relevant centre

- Provide around-the-clock connectivity to the public and private networks at a bandwidth that is sufficient to meet its global and regional responsibilities.
- Ensure that they have procedures and arrangements in place to provide swift recovery or backup of their essential services in the event of an outage (due to, for example, fire or a natural disaster).
- Participate in monitoring the performance of the system, including monitoring the collection and distribution of data and products intended for global exchange.

2.4 Network structure

The network connecting the various parts of WIS should be based on any agreed technology available to the participating centres and being capable of handling the foreseen traffic according to exchange requirements. There should be satellite communication channels as well as terrestrial links or managed data network services. Similarly, any suitable transmission protocol could be employed from an agreed WMO super-set of industry standards. The user being able to choose from a wide variety of options should decide the format of the selected information. Metadata information should be available as XML documents. The envisaged network structure can be depicted as below. The GTS in its entirety will be part of WIS, especially for meeting real-time exchange requirements.

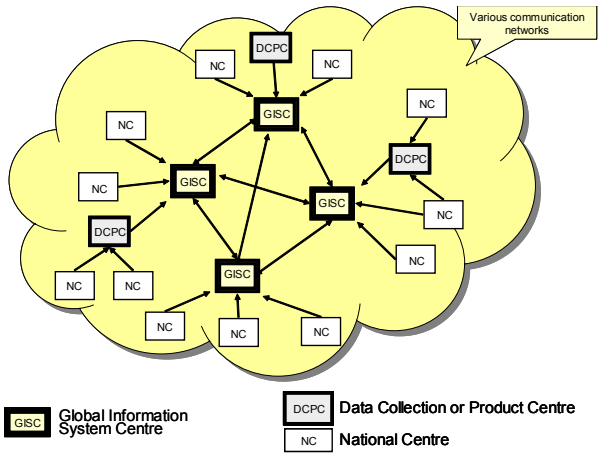

Fig. 2: Information collection data flow

The GISCs are interconnected and exchange data and metadata in order to serve their clients. The NC and the DCPC send data to the GISC within their WMO area. A NC can send its data to a DCPC and the DCPC will provide the GISC with them.

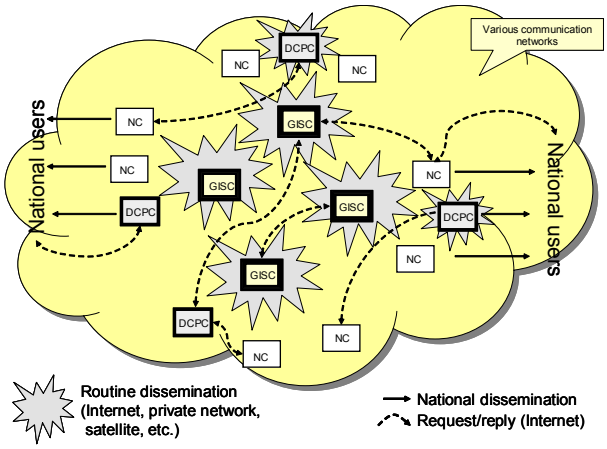

Fig. 3: Information distribution

A GISC will disseminate the data to the National users under its area of responsibility. It will also distribute data to the NC and DCPC falling within its area of responsibility. A DCPC may also disseminate data to its users.

3. WIS implementation

For WIS to become operational at some time in the near future, data processing centres of WMO Members world-wide have to be prepared to accept the different roles as GISC, DCPC or NC and to implement the necessary infrastructure.
As stated in [3], it can be expected that WMC's would host GISC's as well as major RTH's. The coverage of the different WMO RA's has to be ascertained. In addition, the area responsibilities of the various GISC's have to be agreed by the relevant WMO constituent bodies. All WDC 's , RSMC 's and data centres for other programmes, like the TIGGE data centres, should become DCPC's. NMHS's will, of course, function as NC's. However, multiple NC's per country could be envisaged with different programme specialisations.
The general structure of a WIS implementation can be depicted as follows:

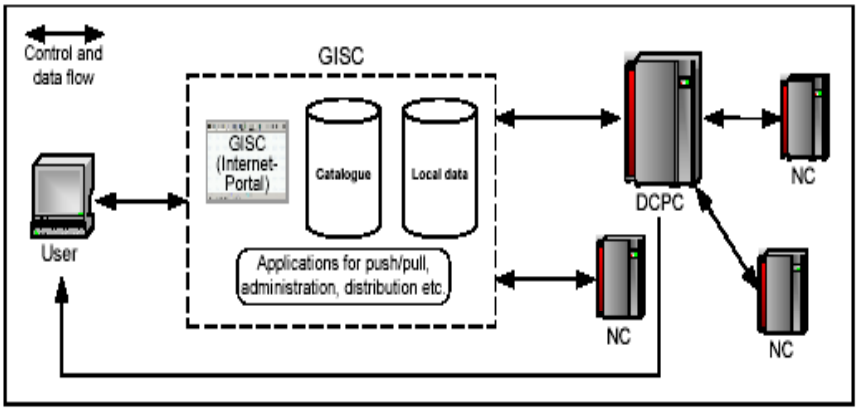

Fig. 4: WIS design concept

Looking at the different components of the system, the following implementation scenarios should be considered:

3.1 GISC

The GISC development is the cornerstone of the WIS implementation, its services are not provided within any WMO Programme at present. The following schematic layout shows the different modules and logical structures which have to incorporated (see [5]). It should be noted that an actual implementation might combine different parts into one program.

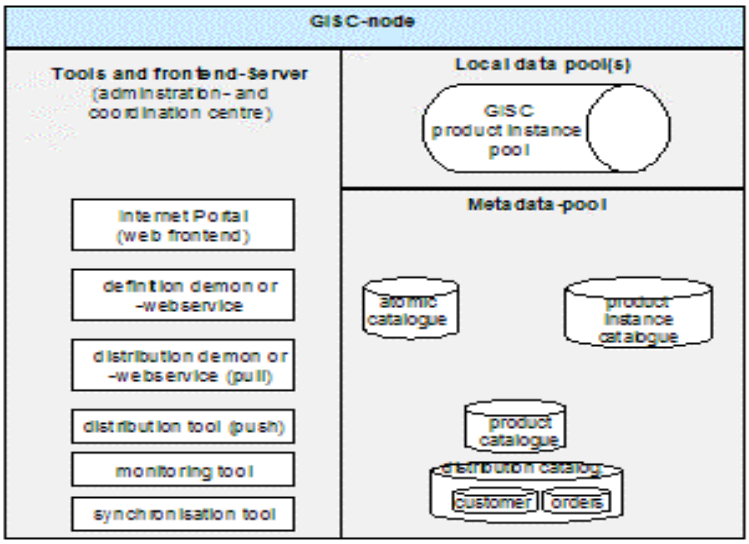

Fig. 5: Schematic logical structure of GISC

The following diagram shows the major role played by the metadata catalogues:

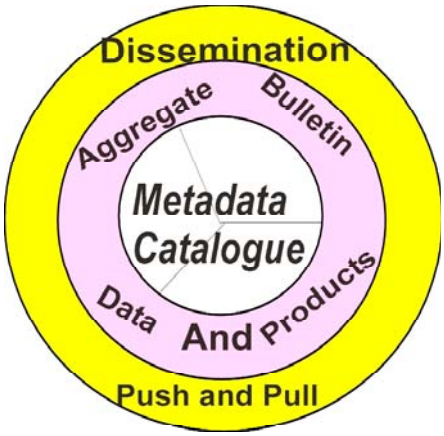

Fig. 6: Layered structure of GISC

3.1.1 Metadata and catalogues

The central part of the innovative GISC development is clearly the metadata catalogue. In more detail, the metadata catalogue has to be seen as four closely integrated sub-catalogues

- the atomic catalogue for defining the inseparable items of information, the "atoms";
- the product catalogue for defining the sets of atoms which together form a "product";
- the product instance catalogue which defines the current state of available products and their composition, and
- the distribution catalogue which lists the recipients of the product instances, the dissemination types, the preferred way of dissemination etc.

The metadata is structured in accordance with the draft WMO Core Profile within the context of the ISO 19115 geographic information standard. Each WMO Programme is expected to develop and maintain its own "community extension" for specific items as required. In view of the importance of the timely creation of metadata information, CBS stressed (see [14]) the necessity for the coordination of the development of:

- A reference implementation of the Profile so that it can be used as a guide by implementers;
- Tools to facilitate the manual creation of metadata;
- Applications to maintain metadata in the standard Profile;
- Mechanisms for users to search globally amongst metadata catalogues;
- Creation of a Core Feature Catalogue compliant with ISO 19110.

It asked its relevant Expert Team, the Inter-programme Expert Team on Metadata Implementation, to carry out these tasks.

3.1.2 Internet portal and local administration

For the administration of a GISC, i.e. editing tables, databases, catalogues or directories, users have to access the system interactively. In addition, for data pull access, the users have to login as well. All external interactive access to the GISC should, in general, be via the Internet. All users have to be authorized, unless they only wish to use the discovery service for data. Authorization is granted by a NC for data users and by the GISC service provider for local administration use. Mechanisms must be in place for NC's to authorize GISC users. In addition, back-up procedures

for access to other GISC's should be implemented (see 3.1.7). In accordance with current technologies, portal software should be used to provide the interactive service. Local management of the data, like generation of new data conglomerates as defined in the relevant catalogues or by users on demand, storage of globally disseminated data for at least 24 hours, ingest of data from different sources etc. has to be programmed. A possible structure for the generation of new data is shown below (see [5]).

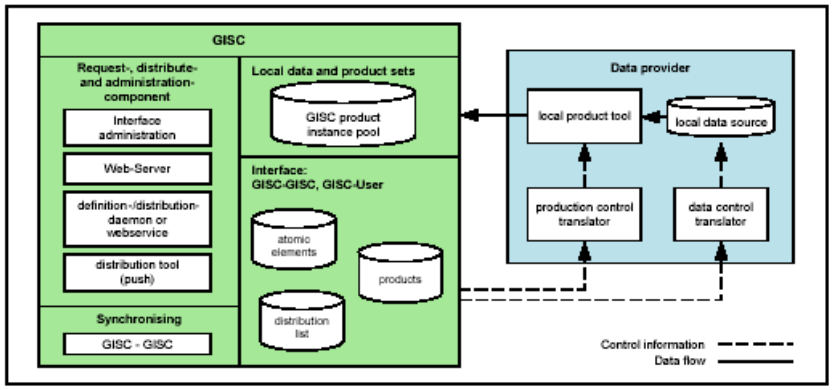

Fig. 7: Logical structure for data generation

3.1.3 Data acquisition service

At any time, the GISC should be ready to accept data from its associated DCPC's or NC's in addition to data from other GISC's. These data will arrive in a similar manner as today in the GTS environment. The name of the data file, the communication path the data uses or some metadata sent together with the data should make it possible for the receiving GISC to ascertain the type and structure of the data transmitted. Depending on the type of data and their associated metadata, the GISC will decide on the next steps to be taken:

- If the data is an update to any local register as e.g. user data base, DCPC contents or similar, the GISC will modify the relevant entries as long as the necessary authentication is submitted as well;
- if the data are products, e.g. new bulletins, warnings or similar entities, the GISC will update its product instance data base and schedule the future actions in accordance with the stored product catalogue;
- for any other data, the GISC will implement the actions as defined in the relevant metadata entries.

The GISC will monitor the communication traffic and store statistics as required.

3.1.4 Data discovery service

The data discovery service is available to any user accessing the GISC. It is a search engine working on the metadata catalogue. The result of the search is the information stored as metadata for the entity and the location of the data. This service is currently not available for the GTS.

3.1.5 Data distribution service: push and pull

The data distribution service should use any communication path available and suitable for the data transmission. A satellite broadcast service should form the backbone for automatic dissemination of essential data. To disseminate data, there are two ways to achieve this:

- the automatic distribution of data based on a defined data list per user triggered either by time-of-day or by availability of requested data, or
- ad-hoc request of data by a registered GISC user.

3.1.5.1 Push dissemination

This method of dissemination is equivalent to the existing store-and-forward methods employed by the WMO GTS. It should ensure a smooth migration from the current GTS system to the WIS structures. It requires a list of products and recipients together with preferred communication paths and protocols, a definition of the trigger mechanism and some monitoring information. The structure of this service (see [5]) is depicted in Fig. 7 below.

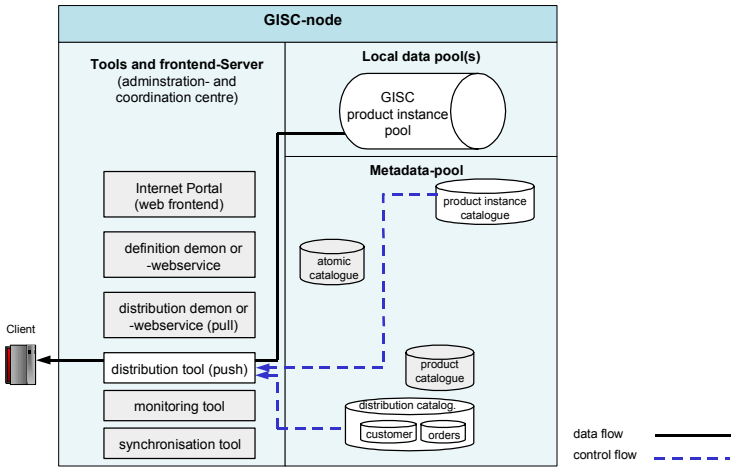

Fig. 7: Dissemination mechanism

3.1.5.2 Pull dissemination

The 'pull' dissemination is a new service to be provided by WIS. In the past, some trials were carried out on the GTS by using data base query mechanisms, but proved not be very satisfactory. The new service relies on the data discovery service (see 3.1.4) for locating the data requested and verifying the access rights of the user to the data. When the user is allowed access then the dissemination service is used for distributing the data if the data is stored locally in the GISC as part of the global distribution set. If the data is not available locally, the pull service will either try to obtain the data from the relevant DCPC or to inform the user where the requested data could be found. Which of these two ways is chosen depends on the trust relationship between the DCPC and the GISC with regard to granting of access rights to users. Fig. 8 shows the basic structure of the service.

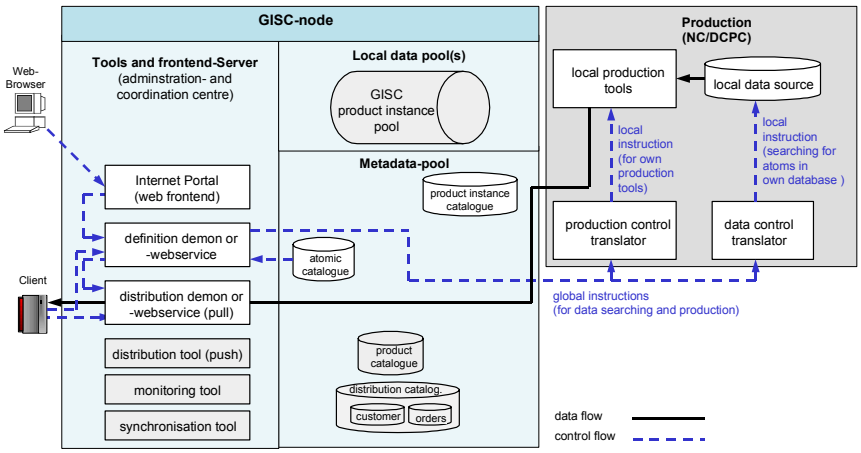

Fig. 8: Request/reply mechanism

3.1.6 Monitoring

The GISC will keep a log of all its activities including data transmissions. Tools should be provided to scan the log entries for different purposes, e.g. monitoring of timely transmission of data, quantity of data transmitted on certain communication channels, response times for interactive use, analysis of error conditions etc. It should be possible for an authenticated user to retrieve the log file remotely.

3.1.7 Synchronisation

The different GISC's should synchronise the product instance data set they keep for global dissemination. In addition, they should ensure that the metadata catalogues are synchronised at regular intervals to allow back-up procedures to be put in place. Furthermore, to some extent, the user databases have to be shared among certain sets of GISC's, again to allow some form of back up in case a GISC is no longer accessible.

3.2 DCPC

The responsibilities of a DCPC are very similar to those of a GISC. The main difference is that a DCPC does not distribute the data set for global dissemination but restricts the data it transmits to its own area of specialisation. Similarly, it will only receive data specific to its tasks. Therefore, the DCPC will support most of the services as provided by a GISC but restricted to its user base and data specialisation. However, it has to support the additional service to update the metadata catalogues of its associated GISC when new or different data sets become available. It may also be possible that a GISC will 'harvest' the metadata catalogues of its associated GISC's in which case the DCPC should support such a procedure (see [18]).

3.3 NC

The scope for the implementation of a NC is very wide, depending on the resources available and the national requirements. Fig 9. below shows the spectrum.

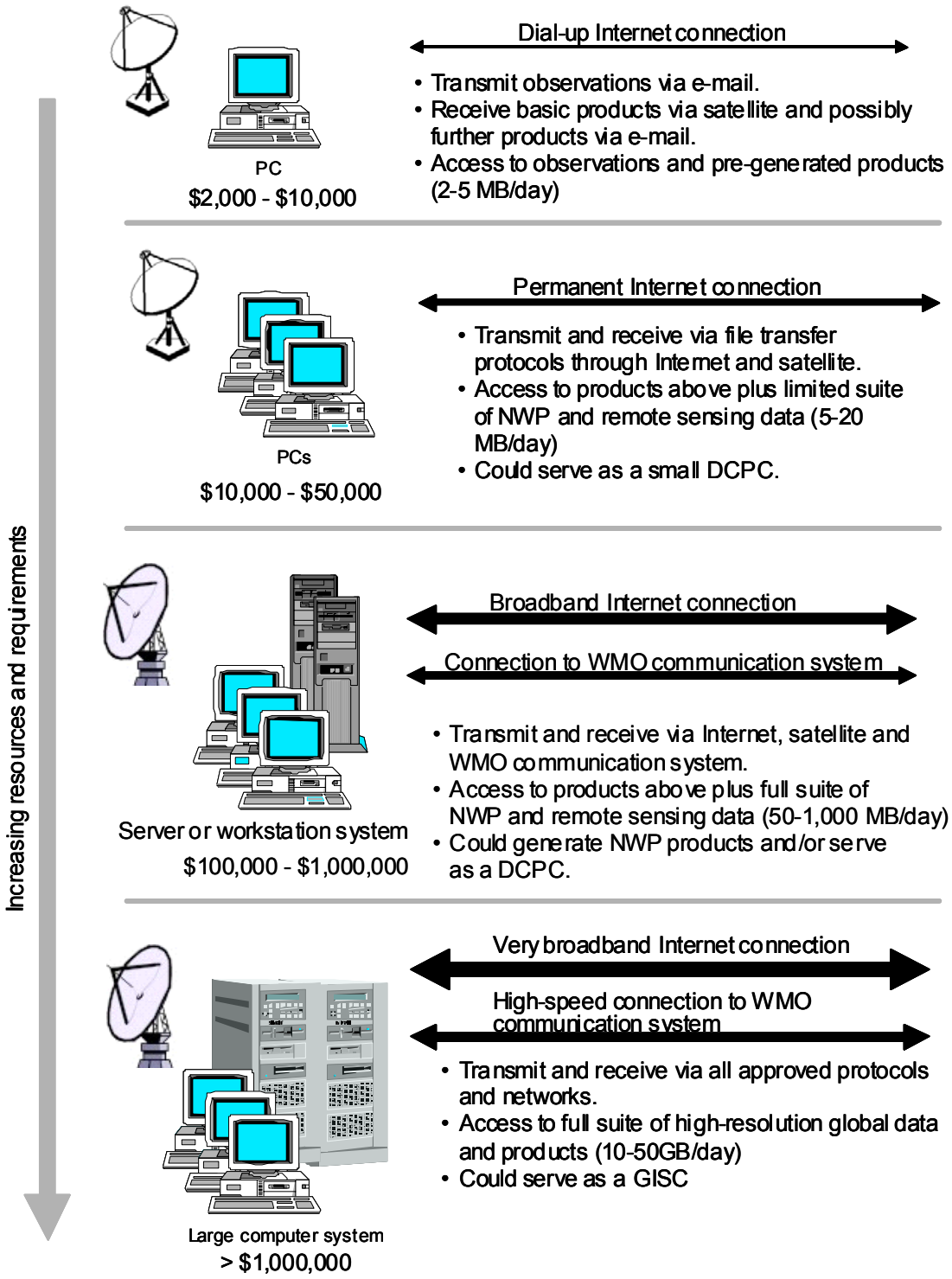

Fig. 9: Possible development of WIS NC

Initially, a NC does not have to change anything: it can continue to serve as a NMHS in the sense of the current GTS. Only when it wishes to use additional services provided by WIS it has to

implement the interfaces necessary. There may exist multiple NC's per country as long as it is made clear who provides the authentication for modifying the relevant GISC data entries.

3.4 Communication network

As stated in 2.4, the communication network should encompass all possible industry-standard communication methods as agreed between any two adjacent centres. Similarly, the protocols employed should be within an agreed super-set of the set currently approved for the GTS. The development of the communication network should be driven by the needs of the Programmes using WIS, particularly with regard to volume, reliability and timely exchange requirements.

4. Pilot projects and prototypes

There are activities worldwide which are in the process of implementing some or all features of WIS structures. These projects are funded by various bodies some of which are unrelated to WMO. The following list is not exhaustive, but only mentions those, which were brought to the attention of the author.
As a first category, the following projects are recognised as WIS implementation prototypes:

4.1 WIS prototypes

4.1.1 GISC-E2EDM-prototype

The prototype was described (see [20]) by Nick Mikhailov (chair of JCOMM/ ETDMP). It should demonstrate real-time access to, and fusion of, data:

1. at operational and delay-mode time scale
2. across oceanographic and marine meteorological disciplines
3. from multiple data source formats
4. from multiple data providers in different geographic regions.

The E2EDM prototype should utilise pre-existing technologies/systems where possible and should provide the following functionality:

- data centres of local data systems install software and information components of E2EDM technology so that the local data could be available for technology services;
- a user can enter the system via a web browser and request data of single or multiple types from distributed data sources over a single (or possibly multiple) space-time region(s)
- appropriate data, on user's request, will be automatically sourced from wherever they reside and returned to the requesting intermediate portal providing value-added services;
- tools will fuse the aggregated data in real time to produce a newly created data product of value to the user.

The E2EDM prototype should manipulate with data and information on the following parameters:

(i) In-situ data, including marine meteorological data (air temperature, sea surface temperature, pressure, wave height and wave direction, wind speed and wind direction) and oceanographic data (temperature, salinity, oxygen, and some nutrients);
(ii) satellite data (ocean colour imagery data).

The following data sources should be involved in the E2EDM prototype for the above-mentioned list of parameters:

(i) historical (for the last 5-10 years) marine meteorological data;
(ii) historical (for the last 5-10 years) ocean cruise data;
(iii) real-time GTS marine meteorological (SHIP) data;
(iv) real-time GTS ocean (BATHY and TESAC) data;
(v) real-time GTS ocean (TESAC/ARGO) data ;
(vi) monthly climatic fields of ocean parameters (imageries);
(vii) analysis/forecast data from GTS (sea surface temperature and wave);
(viii) ocean SST satellite data (imageries).

The geographic area of the E2EDM prototype operation should cover the North Atlantic, including Norwegian, North and Greenland seas.
The plan is to finish the design (first version) by end of November 2005. The diagram, Fig. 10 below, shows the structure of the prototype.
An operating version of E2EDM prototype should be ready by April 2006 (before IODE-XVIII).
The following data centres are under consideration:

1. Historical (for the last 5-10 years) marine meteorological (air temperature, sea surface temperature, pressure, wave) data from one of the MCSS project data centres. Recommended centre-provider: UKMet Office, type of the data source – local data files;
2. Historical (for the last 5-10 years) ocean cruise data (temperature, salinity, oxygen and, possibly major nutrients) from at least two of the IODE data centres (to be able to test the occurrence of a user request for ocean data which are placed in a number of local systems). Recommended centres-providers:

    1. USA NODC(WDC-A) – Ocean Data Base, type of the data source - local data files.
    2. Russian NODC(WDC-B) – IODE Ocean Data, type of the data source - DBMS.
    3. VLIZ Ocean Data Base for the North Sea and some other regions, type of the data source - DBMS.

4. Delay-mode GTSPP data (temperature, salinity from one of the local data system/data providers). Recommended centre-provider: MEDS Canada, type of the data source – local data files;
5. Real-time GTS marine meteorological (SHIP) data (air temperature, sea surface temperature, pressure, wave, wind from one of the local data system/data providers). Recommended centre-provider: Russian NODC, type of the data source - DBMS;
6. Real-time GTS ocean (BATHY and TESAC) data (temperature, salinity data from one of the local data system/data providers). Recommended centre-provider: Russian NODC, type of the data source - DBMS;
7. Real-time ocean (TESAC/ARGO) data (temperature, salinity data from one of the local data system/data providers) Recommended centre-provider: IFREMER, type of the data source – DBMS (or local data files);
8. Monthly climatic fields (average and deviation, temperature, salinity, standard levels from one of the local data system/data providers). Recommended centre-provider: USA NODC (WDC-A), type of the data source – local data files;

9. Analysis/forecast data from GTS (sea surface temperature and wave from one of the local data system/data providers). Recommended centre-provider: Russian NODC, type of the data source - DBMS;
10. Ocean SST or/and colour imagery satellite data from one of the local data system/data providers.

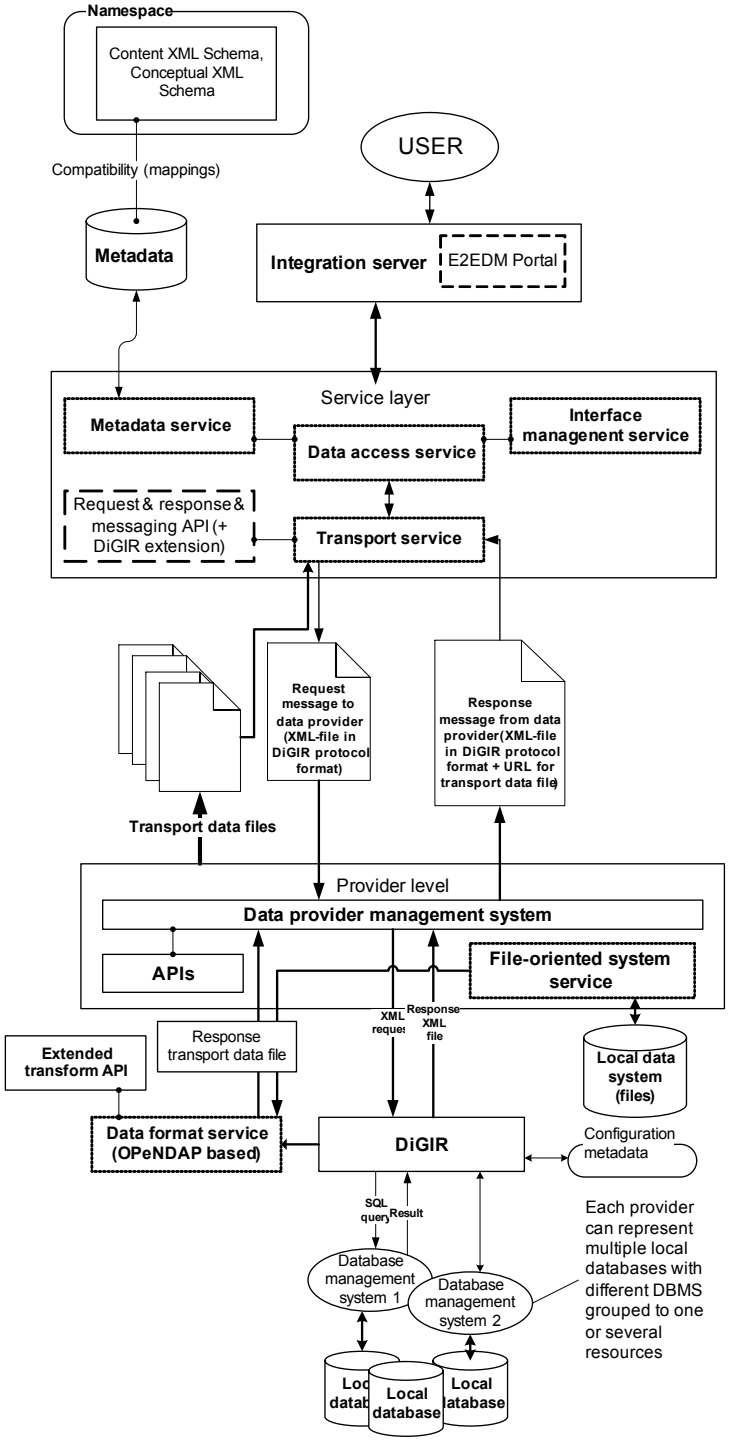

Fig. 10: Diagram of prototype

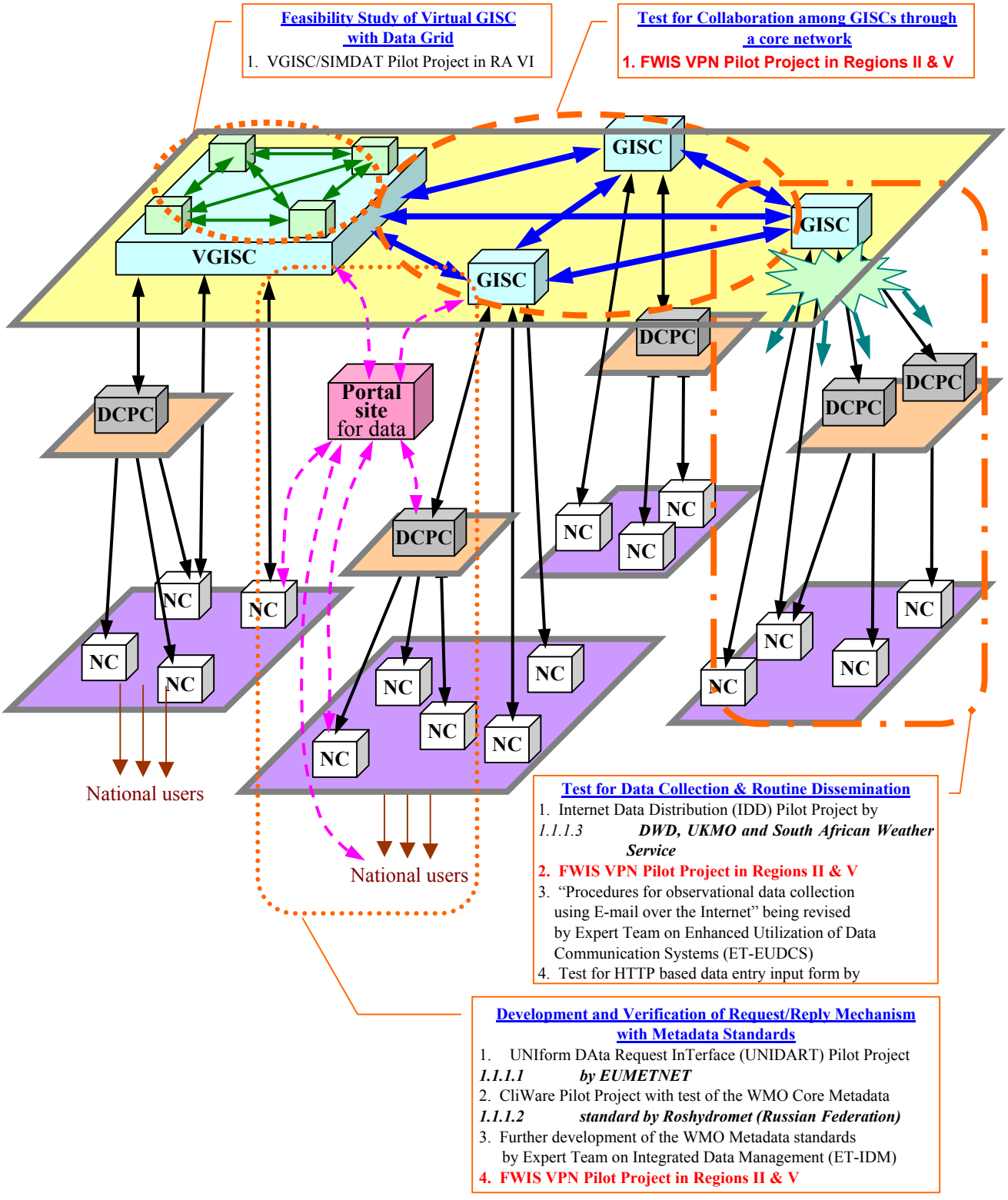

Fig. 11: Scope and location of pilot projects in WIS communication structure

4.1.2 VPN Pilot Project in RAs II and V

The first phase of the Virtual Private Network project in Regions II and V has been completed successfully. The pilot project will be significantly expanded with additional components, including prototype applications, and more participating NMHSs in the years 2005-2006. The participants are at present:

Australia, Brunei, China, Hong Kong, India, Iran, **Japan (project leader),** Macao, Oman, Republic of Korea, Malaysia, New Zealand, Saudi Arabia, Vietnam.

On overview of the planned tests is provided in Fig. 11 above.
It is intended that the pilot project be expanded to the WIS application level in cooperation with other pilot projects for WIS application components such as request/reply portal and metadata standards. Participants in the project will participate in the advanced phase of the project and to contribute to WIS development further. In this context, a draft plan for 2005-2006 is under development from the following viewpoints:

- Possible cooperation with UNIDART and VGISC projects
- Comprehensive tests from transport level to application level
- Simulation of NC operation with prototype applications
- Data management such as WMO metadata standard, code migration
- Study of authorization and authentication methods for secure data reporting and providing
- Expansion of participants

The advanced phase will consist of a few thematic sub-phases. Fig. 12 shows examples of conceptual images in the sub-phases.

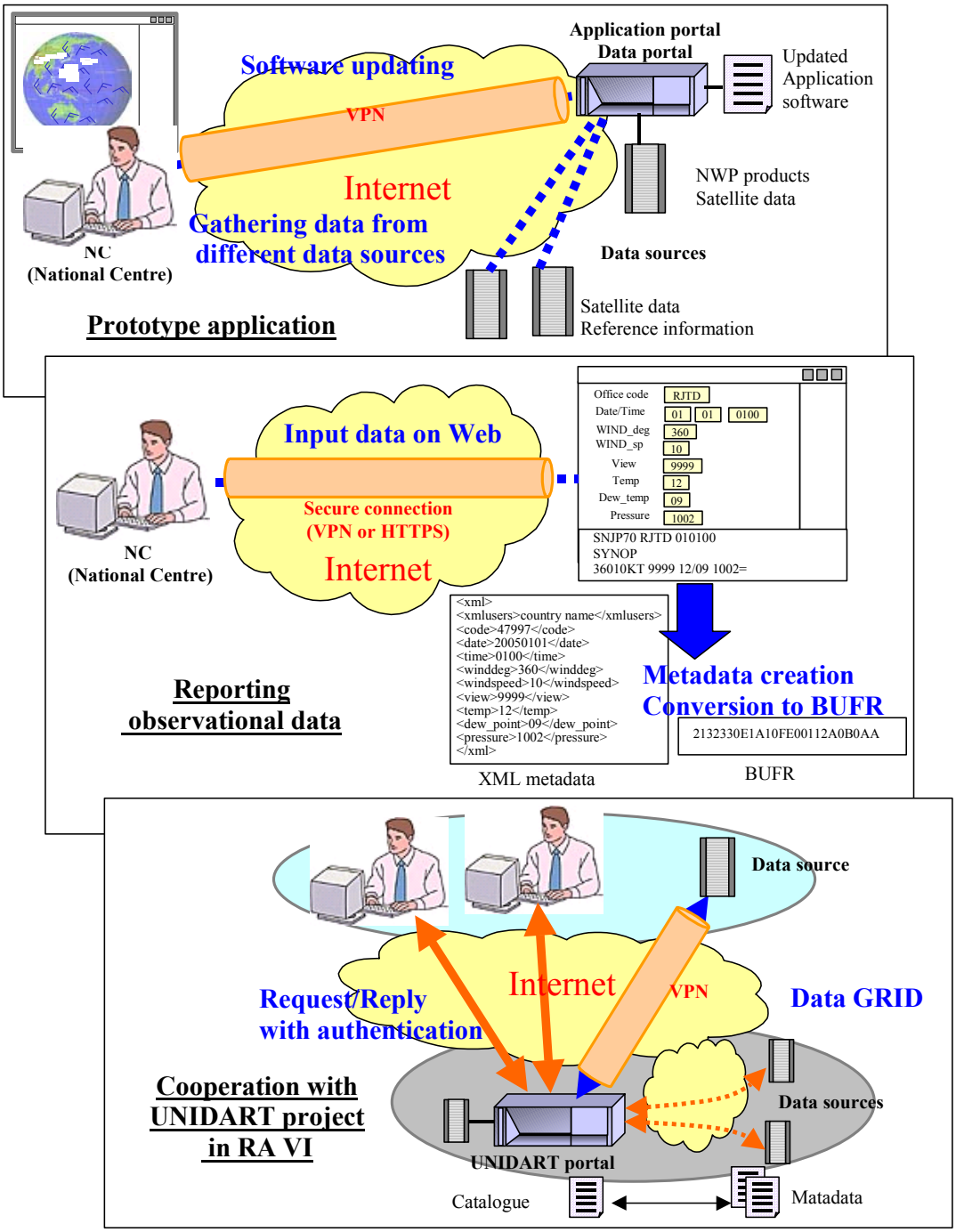

Fig. 12: Advanced phase (2005 – 2006)

4.1.3 CliWare

CliWare is an information system that allows authorized users to access hydro meteorological data and products over the Internet or based on a TCP/IP network. The aim of CliWare is to collect data from different data sources in different formats, to save the data in a database for a long time and to distribute the data to users in generally well-known formats. Unified request

languages for data and metadata and unified data formats for data distribution allow the simplification of access to the data. CliWare is being implemented by the RIHMI-World Data Centre, Obninsk, Russian Federation (see [8]).

4.1.4 UNIDART

The UNIDART Programme (Uniform Data Request Interface) has as its main goal the development of a meteorological Web portal which will provide uniform access to meteorological data and products through the Internet. It is funded by EUMETNET (see [11]), the network of 18 national meteorological services in Western Europe. EUMETNET provides a framework to organise co-operative programmes between the Members in the various fields of basic meteorological activities such as observing systems, data processing, basic forecasting products, research and development, training. Through EUMETNET Programmes, the Members intend to develop their collective capability to serve environment management and climate monitoring and to bring to all European users the best available quality of meteorological information. They will use EUMETNET to make more efficient the management of their collective resources.

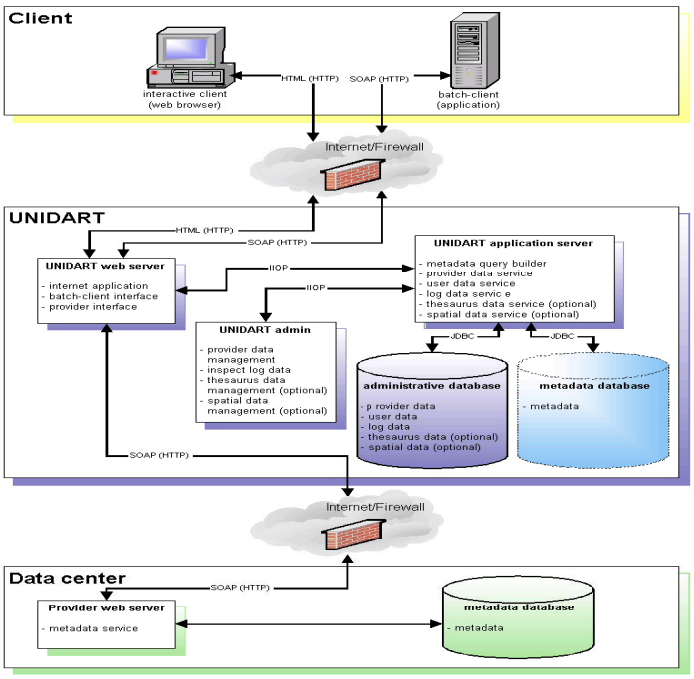

Fig.13: UNIDART structure

The current status of the UNIDART project is as follows:

- The development of a Web Portal prototype continued. A revised version has been released in August 2005.
- The metadata catalogue of the prototype has been filled with further data. The catalogue now contains XML records which describe all climate time series provided by the data centres KNMI, met.no, FMI and DWD.

- A data selection procedure has been developed which allows the access to climate time series. This procedure is implemented as a grid service based on OGSA-DAI (Open Grid Service Architecture – Data Access and Integration), a grid software to access databases with grid technology. The selection procedure has to be installed at the web-enabled grid server of each data centre.
- The UNIDART data grid currently comprises 4 nodes, one node at FMI, KNMI, met.no and DWD. Each node hosts a grid server. A grid server must be Web-enabled in order to use OGSA-DAI. met.no and DWD have Web-enabled their grid server and installed the OGSA-DAI with the UNIDART selection procedure. Hence, it is possible to access and download climate time series from these two data centres via the Web Portal prototype.

4.1.5 RA-VI VGISC project

As a first step towards the establishment of the new WMO information infrastructure, the Regional Association VI of WMO decided in 2001 to create a project for the development of a prototype of a GISC. The national weather services of France, Germany and the UK volunteered to jointly work out the concept of a virtual GISC (VGISC) shared by their services and to include the European Centre for Medium-Range Weather Forecast (ECMWF) and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) as DCPC's into the concept.
The project implemented a GISC prototype (see [4]) which was successfully demonstrated at CBS XIII in February 2005. The different user interfaces served by the prototype are depicted below.

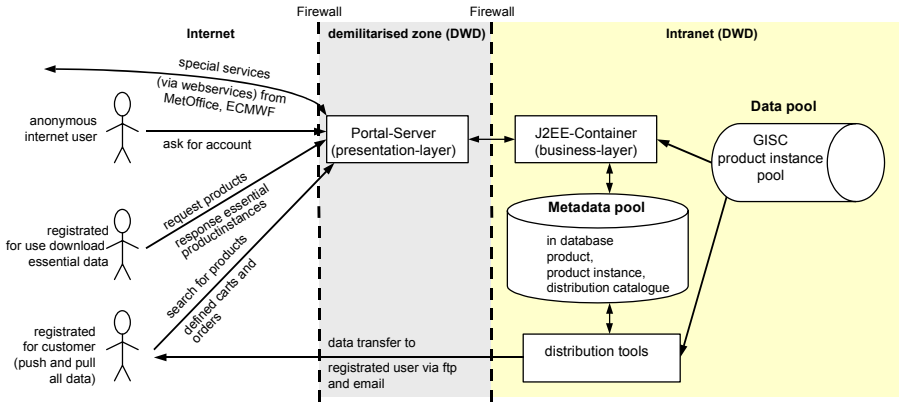

Fig. 14: Use cases for prototype of VGISC project

The internal structure of the program is shown in the Fig. 15.

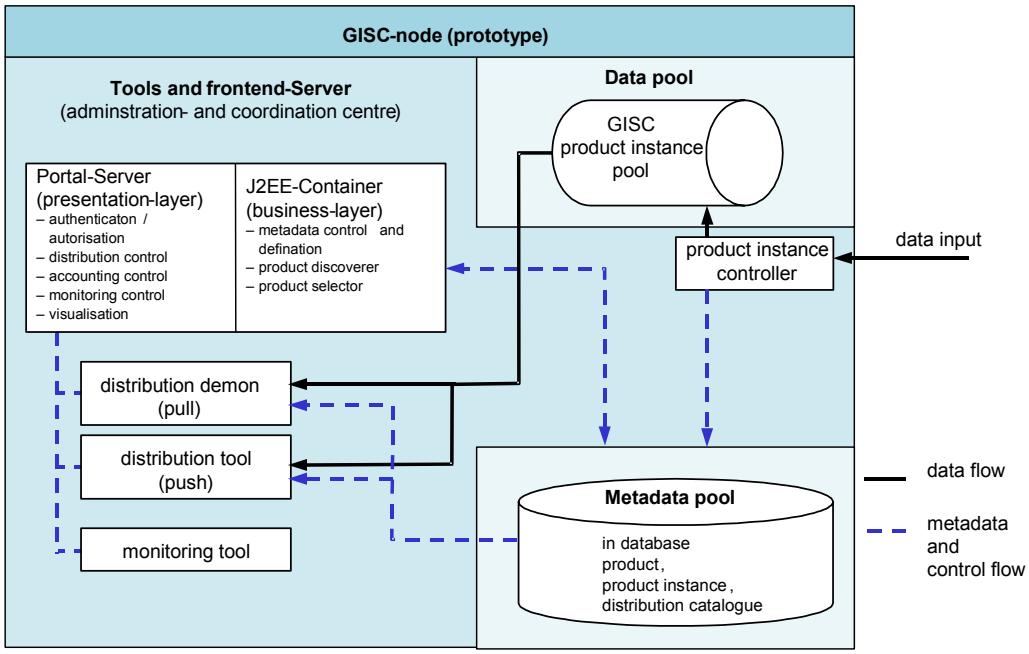

Fig. 15: Internal structure of prototype of VGISC project

The planned communication infrastructure is as follows:

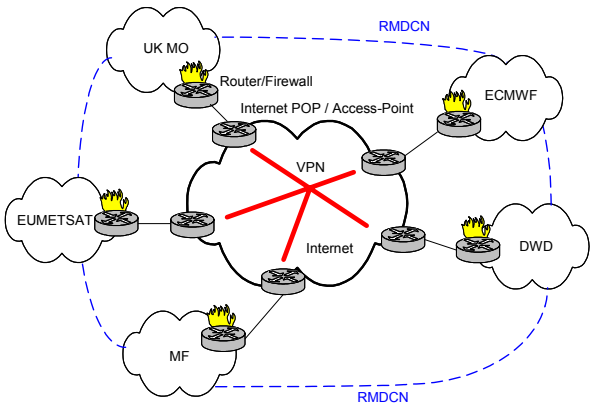

Fig. 16: Communication infrastructure for VGISC project

At the end of 2004, the work for the VGISC project was moved into the newly funded EU project SIMDAT (see [21]). The goal of the meteorology activity within SIMDAT is to build an infrastructure which will permit to improve the load distribution and availability of the system. It will provide a uniform external interface to the user and also will reduce the implementation cost. The virtual GISC (V-GISC) will be seen as a normal GISC and will fulfil the WIS requirements. The users will access the V-GISC like any other GISCs, the datasets being distributed among Météo-France, DWD, UK MetOffice, ECMWF and EUMETSAT.

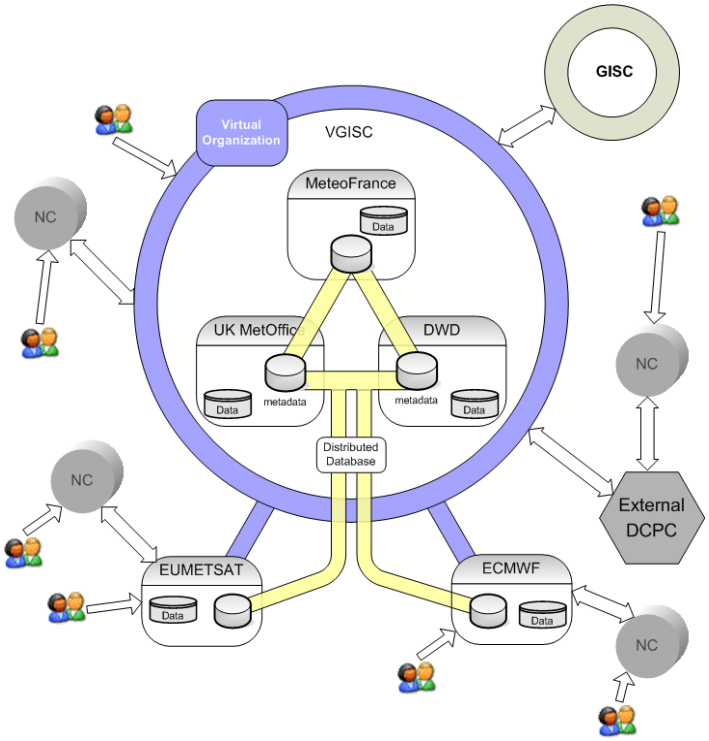

Fig. 17: Data Communication Infrastructure

The data communication infrastructure will provide access to the distributed meteorological databases through the V-GISC. The users can either access the V-GISC or access directly the NCs or DCPCs.
The infrastructure will be developed by the meteorology activity of the SIMDAT project. The first prototype should be ready by the end of 2005.

4.1.6 WAMIS (CAgM)

It was noted during CBS XIII that a project in the framework of WAMIS (CAgM) was planned and supported by KMA. However, there are no detailed plans available yet.

4.1.7 TIGGE

As an initial phase of THORPEX (see [22]) it is planned to generate a global data set of all ensemble prediction forecasts available at any given time. During a workshop held at ECMWF in March 2005 (see [23]), it was agreed that CMA, ECMWF and NCAR would host the data and make them accessible to research groups as required. The methods for accessing the data would be part of a WIS DCPC implementation.

4.2 Other relevant projects

There are a number of projects currently undertaken or planned within the scientific environmental community, which share goals with WIS and in some cases technologies. In the following these projects will be highlighted because they have come to the attention of the authors and reflect high levels of commonality with WIS.

4.2.1 Earth System Grid

The Earth System Grid II (ESG) is a research project (see [6]) sponsored by the U.S. DOE Office of Science under the auspices of the Scientific Discovery through Advanced Computing program (SciDAC). The primary goal of ESG is to address the challenges associated with enabling analysis of and knowledge development from global Earth System models. Through a combination of Grid technologies and emerging community technology, distributed federations of supercomputers and large-scale data and analysis servers will provide a seamless environment that enables the next generation of climate research.

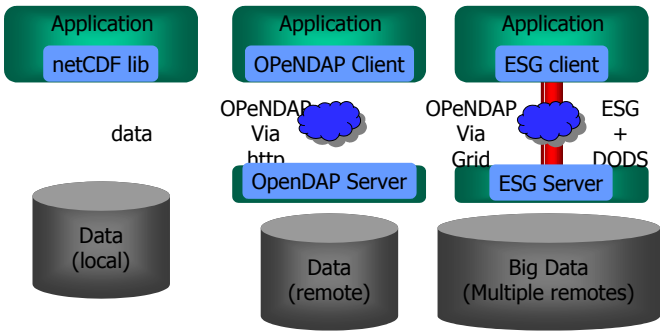

Fig. 18: ESG distributed data access

The functional structure of ESG is represented by the following diagram (© NCAR):

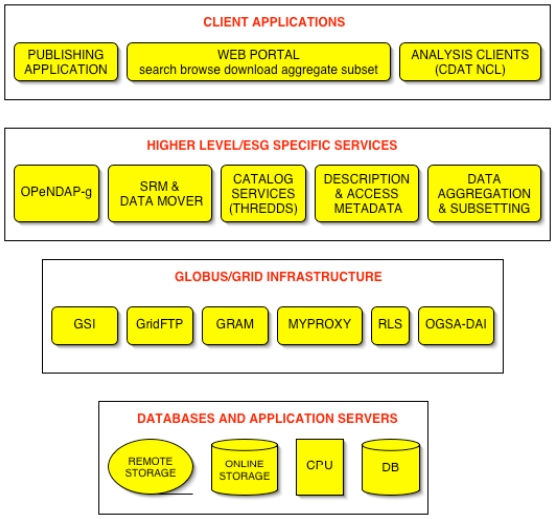

Fig. 19: ESG functional structure

4.2.2 Community data portal

The Community Data Portal (CDP) is a collection of earth science datasets from NCAR, UCAR, UOP, and participating organizations in the following research areas:

- oceanic
- atmospheric
- space weather

• turbulence.

CDP is an NCAR Cyberinfrastructure Strategic Initiative project and is collaboration between UCAR, NCAR, UOP, and the US National Science Foundation (see [9]). Its general architecture is depicted as follows (all pictures © NCAR):

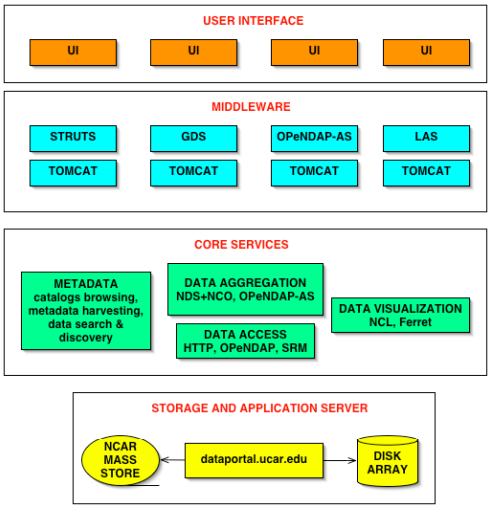

Fig. 20: CDP general architecture

In more detail, the architecture looks like:

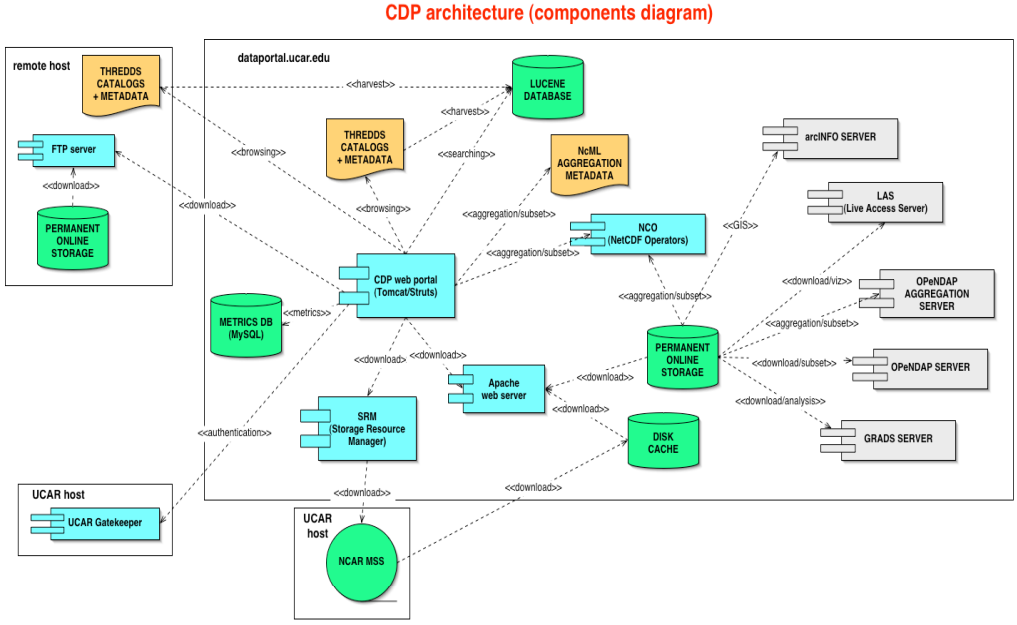

Fig. 21: CDP architecture

The metadata is stored as a THREDDS catalogue (see [17]) as follows:

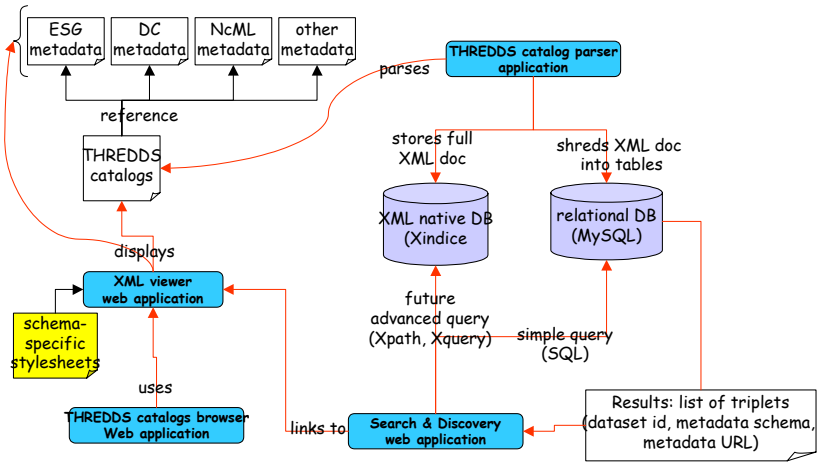

Fig. 22: Metadata structure

The relationship with other external data sources is depicted in the following diagram which shows the use of the Open Archives Initiative Protocol for Metadata Harvesting (OAI) (see [18]):

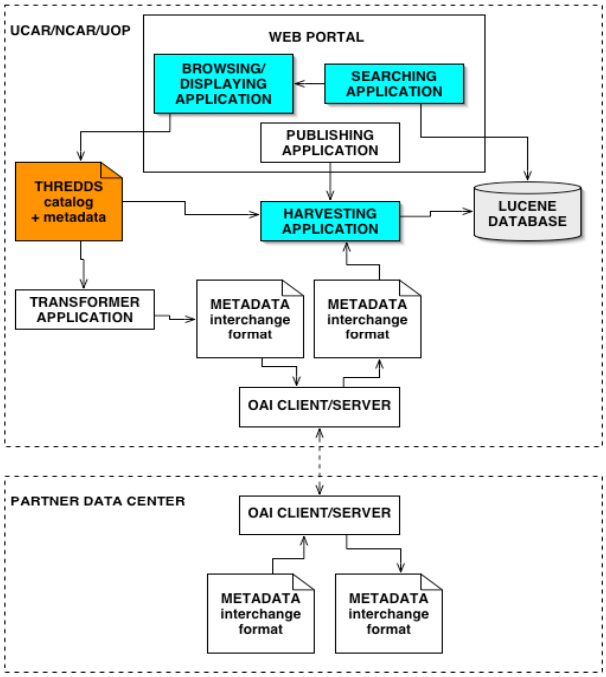

Fig. 23: CDP interface to partner data centres

4.2.3 DMAC

The Data Management and Communications Subsystem of IOOS is called *DMAC*. According to [16], DMAC is described as follows:

“ The DMAC Subsystem will include a data and communications infrastructure that consists of standards, protocols, facilities, software, and supporting hardware systems. DMAC will support:

(1) IOOS-wide descriptions of data sets (Metadata);
(2) the ability to search for and find data sets, products, and data manipulation capabilities of interest (Data Discovery);
(3) the ability to access measurements and data products from computer applications across the Internet (Data Transport);
(4) the ability to quickly evaluate the character of the data through common Web browsers (Online Browse); and
(5) secure, long-term data storage (Data Archive).

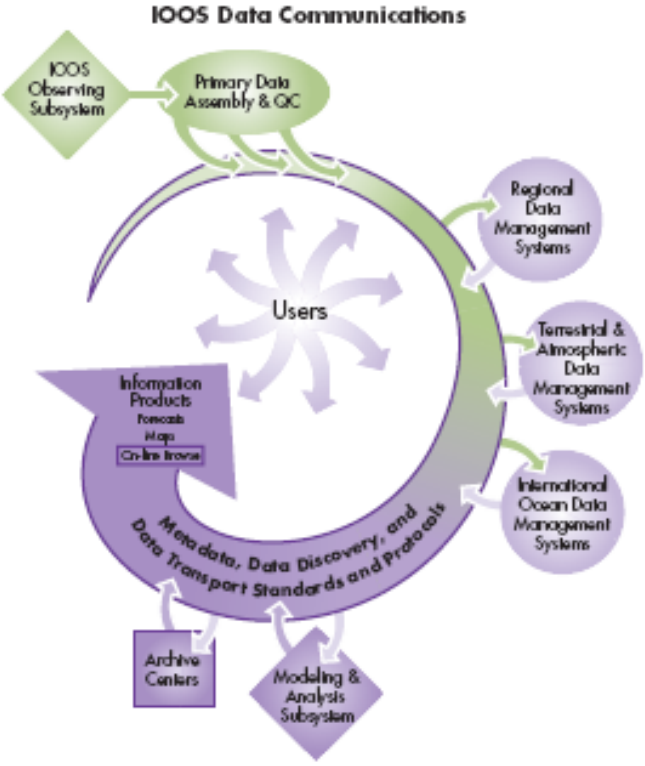

Fig. 24: IOOS Data Communications

DMAC Metadata will be based upon Federal Geographic Data Committee (FGDC) standards. Discipline-specific FGDC profiles will be developed, adopted, and/or harmonized by interdisciplinary working groups drawn from the marine data community. DMAC Data discovery capabilities will complement and extend the publicly accessible search capabilities that are available today through Web search engines such as Google®. The Data Discovery architecture will be determined by a working group that includes representatives from existing metadata management facilities and other metadata experts.
DMAC Data Transport will be built upon a suite of “web services.” A web service is a standardized protocol encoded in eXtensible Markup Language (XML) and transported by the Hyper Text Transfer Protocol (HTTP—the “Web”), through which one computer can request data and/or computations from another. The web services approach has been selected because it has only minimal impacts on the data management choices made by contributors of IOOS data, and is

broadly adaptable to existing and new (client) applications. DMAC web services will connect data management systems operated independently by Regional Associations, state and Federal government entities, academic projects, commercial and international partners, and within other disciplines.
The DMAC Plan designates the OPeNDAP (see [19]) data access protocol, the web service that underlies the National Virtual Ocean Data System (NVODS), as an initial "operational" component for transport of gridded data; and as a "pilot" component for the delivery of non-gridded data. OPeNDAP is a discipline-neutral transport protocol that conveys data, metadata, and structure without regard to the scientific interpretation of the data. A community-based, interdisciplinary working group will be convened to develop a consistent, geospatial semantic data model that will allow the scientific meaning of the data to be fully captured.
Effective management of IOOS requires a basic browsing and visualization capability that extends across the full breadth of IOOS data. The browsing capability will provide geo- and time-referenced graphics and readable tables suitable for the evaluation of IOOS data through standard Web browsers. The On-line Browse capability of DMAC will use the Data Transport web services for access to IOOS data. The DMAC Plan designates the Live Access Server (LAS), which provides browsing capabilities with NVODS, as an initial "pre-operational" component for On-line Browse.
The Data Archive component of DMAC will be assembled from existing and new marine data archive facilities. To be recognized as an official partner in IOOS Data Archive, these facilities must each enter into formal agreements stipulating that they will perform archive and access functions using DMAC standards and protocols and conform to IOOS Data Policy. A community-based interdisciplinary working group of archive specialists and advisors will initiate an orderly strategy to determine DMAC Data Archive policies and procedures, and to ensure that designated archive facilities exist for all IOOS data. "

4.2.4 Unidata

Unidata is a diverse community of North-American education and research institutions vested in the common goal of sharing data, tools to access the data, software tools to use and visualize the data, and resources. The mission of the Unidata Program is to help researchers and educators acquire and use earth-related data. Most of the data are provided in "real time" or "near-real time" -- that is, the data are sent to participants almost as soon as the observations are made. Unidata is a data facilitator, not a data archive centre. It provides a mechanism whereby educators and researchers, by participating in the Internet Data Distribution (IDD) system, may subscribe to streams of current data that interest them (see [7]).

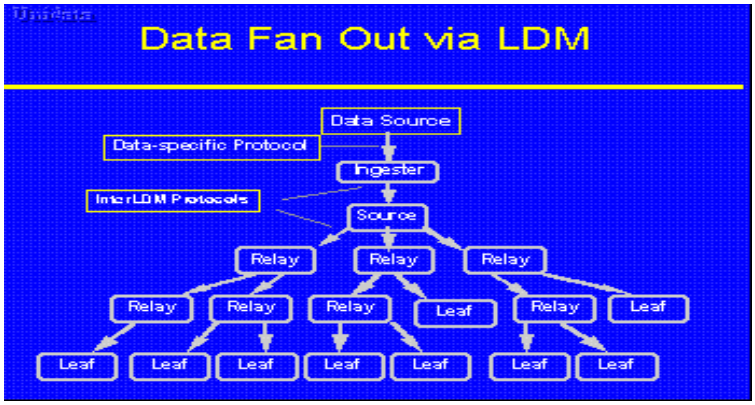

Fig. 25: IDD data distribution schema

4.2.5 NERC DataGrid

The NERC DataGrid is a project funded as part of the E-science initiative in the UK. As quoted from the project proposal (see [10]):

"The NERC DataGrid proposal is to build a grid which makes data discovery, delivery and use much easier than it is now, facilitating better use of the existing investment in the curation and maintenance of quality data archives. Further it intends to make the connection between data held in managed archives and data held by individual research groups seamless in such a way that the same tools can be used to compare and manipulate data from both sources. What will be completely new will be the ability to compare and contrast data from an extensive range of (US, European, UK, NERC) datasets from within one specific context. It will be building on technology developments carried out primarily in the US by collaborators from the Earth System Grid."

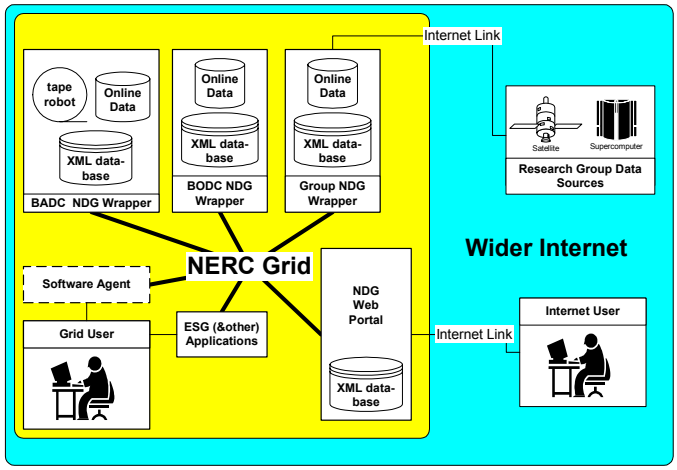

Fig. 26: NERC DataGrid

Although there are no direct environmental science goals to be funded within this project, the underpinning technology that it will create will find immediate use in many aspects of

atmospheric and oceanographic science. The presence of the NERC DataGrid will allow grid based visualisation services to access a wide variety of data held at the British Atmospheric and Oceanographic Data Centres (BADC and BODC respectively) as well as on individual storage systems belonging to groups which register their data with the NERC DataGrid. The structures put in place will also allow NERC data to become part of the putative future semantic grid.

5. Milestones

For the WIS to become operational, a number of prerequisites have to be in place. There must be at least one functional GISC and some co-operating DCPC's. The pilot projects in RA II and V (see 4.1.2) and the VGISC project in RA VI (see 4.1.5) fulfil the requirements. In addition, the DMAC activity (see 4.2.3) could form the basis for a working GISC if the data coverage was to be extended to cover all meteorological data and RA IV would adopt the project as a pilot. Similarly, CliWare (see 4.1.3) could be expanded to provide GISC services.
The actual implementation can be seen as smooth transition from the current GTS services to the new WIS environment with the use of metadata directories as the major differentiator. Industrial companies who offer MSS systems for the GTS today should be made aware and possibly involved in WIS development, and be encouraged to enhance their products to use WIS concepts.
In more detail, looking at the required services (see 3.), the following steps are foreseen:

5.1 GISC

5.1.1 Metadata and catalogues

The CBS Inter-programme Expert Team on Metadata Implementation met in Beijing in September 2005 and, during a workshop, agreed upon the WMO Core Profile version which will then be implemented by a consultant as a reference. It is expected that the WMO Core Profile be consolidated in March 2006 and the reference implementation should be ready by 2Q06. It will then have to be incorporated into the different GISC and DCPC prototypes. The work should be finished by October 2006.

5.1.2 Internet portal and local administration

The VGISC prototype (see [4]) already contained a working Internet portal based on BEA software and some local administration. Enhancing this implementation, a new version is expected to be ready for an international workshop on GISC development to be held in February 2006 under the auspices of the Inter-Commission Co-ordination Group on WIS. In addition, CliWare (see 4.1.3) and UNIDART (see 4.1.4) employ working Internet portals. It can be expected that these services will be fully supported by 2Q06.

5.1.3 Data acquisition service

Since the initial phase of the data acquisition service could be a copy of the current GTS implementation it should be relatively easy to adept to the new WIS environment. The major difference is the use of the different catalogues to store the receipt of the data and to control their processing. As long as GTS conventions like abbreviated headers and file names are used and the bulletins received are handled as an entity, the data acquisition service could be part of the enhanced GISC pilot expected by 2Q06. The additional modules for it would have to be added later during 2006.

5.1.4 Data discovery service

As soon as the metadata structures are defined and contain real data, the data discovery service should be ready, because versions already exist in multiple variations like in CliWare, UNIDART, CDP etc. Depending on the conclusion of the work outlined in 5.1.1, the service should be ready by October 2006.

5.1.5 Data distribution

5.1.5.1 Push dissemination

Similar to the data acquisition service, the push dissemination could in the first instance be a slightly modified version of the current GTS dissemination service. Again, the major differences are caused by the use of databases instead of routeing tables. Depending on the progress of implementation of the different catalogues, a first test could be carried out in 3Q06 restricted to the current GTS dissemination. Additional data types and protocols could be added during 2006 as required by the WMO Programmes.

5.1.5.2 Pull dissemination

The pull dissemination service requires the data discovery service and the push dissemination service to work. In addition, the access rights to data have to be defined, agreed upon by GISC's and DCPC's, stored in the relevant metadata directories and be acted upon by the software in accordance with the authentication received from a NC for the registered users. A lot of co-ordination between aspiring GISC's and DCPC's together with NC's is still necessary in this work area. It is hoped that the relevant CBS expert teams are ready to agree on a set of practices early in 2006. Except for essential data which are not subject to any restrictions of access, the remaining data will probably not be ready for a general pull dissemination service before the end of 2006. Special data sets should be available earlier, as can be seen from the VGISC prototype which allowed pull access to certain data from ECMWF and NCAR.

5.1.6 Monitoring

As creating a log-file of all activities undertaken is considered to be state-of-the-art programming practice for all new software development projects, it can be assumed that monitoring data will be generated by the various GISC and DCPC implementations. However, the structure of the monitoring information and the tools to be made available need to be agreed upon. It is hoped that the relevant CBS expert teams are ready to undertake this task early in 2006. Then the format for basic monitoring information should be defined by 3Q06.

5.1.7 Synchronisation

The scope and frequency of synchronisation for the various databases between GISC's, and to some extent also DCPC's, are still not completely resolved. There is a common understanding that the synchronisation requirements for back-up purposes are far exceeding those for unrelated centres. However, even for those it is not agreed how often which databases should be synchronised. It seems that a real-life pilot project is required to find out which data sets need to be kept at the same modification level across the GISC community. The synchronisation with DCPC's seems to be less time critical and cycles of days or even week could probably be accepted.

Since the resolution of the synchronisation issue seems to require the actual trial operation of at least two GISC's for some time, this question, therefore, can only be settled early in 2007.

5.2 DCPC and NC

With regard to DCPC's, the comments above for GISC's apply to a large extent. Since CMA, ECMWF and NCAR plan to act as TIGGE data centres starting in 2006, it can be assumed that they will implement most, if not all, of the WIS services during 2006.
As stated earlier, the implementation of a NC is not time-critical, because current NMHS's as GTS nodes will be able to participate in the WIS.

6. Outlook

As outlined above, the major innovation is needed in the development of metadata directories for which all Programmes should contribute. Furthermore, authentication and synchronisation issues need to be resolved. In order to implement these features in a cohesive manner and within the time frame expected by EC-LVII, project co-ordination is required which goes beyond the task and resources of the ICG-WIS. A WIS project office which could be set up at WMO would be needed to undertake the task and also to act as a focal point to involve industry. The workshop on GISC development planned for early 2006 would provide the best opportunity for raising the industrial awareness.
Since the different Programmes will be gaining from the synergy savings, implicit in WIS, they should be prepared to invest in its implementation and maintenance. As stated by the WMO Executive Council in 2003 (see [2]):
"*The support and involvement of regional associations and technical commissions [is] needed, as early as possible, in all phases of the WIS development in order to ensure a full and shared ownership of the project, and its effective implementation."*
It is planned to hold a technical conference on WIS prior to the next CBS meeting in autumn 2006. After this event, pilot projects could become semi-operational to gain valuable experience with the WIS concept. The newly created GISC's could implement the global data exchange envisaged. As a next step, various DCPC's could offer their data for access and ease the burden for the related Programmes. Furthermore, at this stage the different Programmes could extend the metadata catalogue held in the GISC's by their own special data requirements and use the WIS features to disseminate their products. In this way, the enhanced functions provided by WIS will be gradually introduced and expanded from 2006 onwards.

7. References

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8. List of acronyms

ADM	Alternative dissemination methods
AMP	Applications of Meteorology Programme
API	application program interface
ARGOS	Global Data Telemetry and Geo-positioning Services
BADC	British Atmospheric Data Centre
BATHY	FM 63 X Ext. BATHY
BODC	British Oceanographic Data Centre
BUFR	Binary Universal Form for the Representation of meteorological data
CAgM	Commission for Agricultural Meteorology
CBH	Capacity Building in Hydrology and Water Resources
CBS	Commission for Basic Systems
CDP	Community Data Portal
Cg	WMO Congress
CMA	Chinese Meteorological Agency
CREX	Character Representation form for data Exchange
DB	Data Base
DBMS	database management system
DCPC	Data collection or product centre
DIGIR	Distributed Generic Information Retrieval
DMAC	Data Management and Communications of the Integrated Ocean Observing System
DWD	Deutscher Wetterdienst (German Weather Office)
E2EDM	"end-to-end" data management system
EC	Executive Council of WMO
ECMWF	European Centre for Medium Range Weather Forecasts
ERA	Emergency Response Activities
ESG	Earth System Grid
ET	Expert team
ETDMP	JCOMM Expert Team on Data Management Practices
ETFP	Education Training and Fellowships programme
ETRP	Education and Training Programme
EU	European Union
EUMETNET	European Meteorological Network (18 national meteorological services)
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites.
FGDC	Federal Geographic Data Committee
FM12	Report of surface observation from a fixed land station

FMI	Finnish Meteorological Institute
FR	Frame Relay
ftp	File transfer protocol
FWIS	Future WMO Information System
GAW	Global Atmosphere Watch
GB	Gigabyte, 10^9 octets
GCOS	Global Climate Observing System
GDPS	Global Data Processing System
GEOSS	Global Earth Observation System of Systems
GISC	Global information system centre
GOS	Global Observing System
GRIB	FM 92-VII Ext-GRIB (Gridded Binary) processed data in the form of grid-point values expressed in binary form
GridFTP	Universal data transfer for the Grid (http://www.globus.org/datagrid/deliverables/C2WPdraft3.pdf)
GTS	Global Telecommunications System
GTSPP	Global Temperature-Salinity Profile Program
HRDP	Human Resources Development programme
http	Hypertext Transfer Protocol
HWRP	Hydrology and Water Resources Programme
ICG-WIS	Intercommission Coordination Group on WIS
IDD	Internet data distribution system
IFREMER	French Research Institute for Exploitation of the Sea
IGDDS	WMO Space Programme Integrated Global Data Dissemination Service
IMOP	Instruments and Methods of Observations programme
IMTN	Improved MTN
IOOS	Integrated Ocean Observing System
IPTT	Interprogramme Task Team
ISO	International Standards Organization
ISS	Information System and Services
J2EE	Java 2 Enterprise Edition
JCOMM	Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology
KMA	Korean Meteorological Agency
KNMI	Koninklijk Nederlands Meteorologisch Instituut
LAS	Live Access Server
LDM	Unidata's local data manager of IDD
MB	Megabyte, 10^6 octets
MCSS	Marine Climatological Summaries Scheme
MEDS	Marine Environmental Data Service
met.no	Norwegian Meteorological Institute
MPEG	Moving Picture Experts Group
MSS	Message Switching System
MTN	Main Telecommunications Network (of the GTS)
NC	National Centre
NCAR	National Center for Atmospheric Research
NcML	NetCDF Markup Language
NDG	NERC Data Grid
NERC	Natural Environment Research Council

NESDIS	National Environmental Satellite, Data and Information Service
NetCDF	Network Common Data Form
NMC	National Meteorological Centre
NMHS	National Meteorological or Hydrological Service
NODC	National Oceanographic Data Center
NVODS	National Virtual Ocean Data System
NWP	Numerical Weather Prediction
OGSA-DAI	Open Grid Service Architecture – Data Access and Integration
OPAG	Open Program Area Group
OPeNDAP	Open Source Project for a Network Data Access Protocol
PC	Personal computer
PR	Permanent Representative
PWS	Public Weather Services
RA	Regional Association
RA-II	Regional Association II of the WMO (covering mainly Asia)
RA-IV	Regional Association IV of the WMO (covering mainly North America)
RA-V	Regional Association V of the WMO (covering mainly the Pacific)
RA-VI	Regional Association VI of the WMO (covering mainly Europe)
RIHMI	All-Russian Research Institute of Hydrometeorological Information
RMDCN	Regional Meteorological Data Communications Network
RSMC	Regional Specialised Meteorological Centre
RTH	Regional telecommunications hub
SciDAC	Scientific Discovery through Advanced Computing
SDW	Sustainable Development of Water Resources
SHIP	FM 13 - SHIP
SST	sea surface temperature
SYNOP	Colloquial name for code form FM 12 IX
TAP	Training Activities programme
TCP	Tropical Cyclone programme
TCP/IP	Transport control protocol, internet protocol
TCRP	Tropical Cyclone Research Programme
TESAC	FM 64 IX TESAC
THORPEX	**TH**e **O**bserving System **R**esearch and **p**redictability **ex**periment
TIGGE	THORPEX Interactive Grand Global Ensemble
UCAR	University Corporation for Atmospheric Research
UKMet	The Met Office, UK
UNIDART	Uniform Data Request Interface
UOP	UCAR Office of Programs
URL	Uniform Resource Locator
VGISC	Virtual Global information system centre
VLIZ	Vlaams Instituut voor de Zee / Flanders Marine Institute
VPN	virtual private network
WAMIS	World AgroMeteorological Information Service
WCASP	World Climate Applications and Services Programme
WCP	World Climate Programme
WCRP	World Climate Research Programme
WDC	World Data Centre
WDM	World Weather Watch Data Management
WIS	WMO Information System

WMC	World Meteorological Centre (Melbourne, Moscow, Washington)
WMO	World Meteorological Organization
WRI	Water-related Issues
WSP	WMO Space Programme
WWRP	World Weather Research Programme
WWW	World Weather Watch
XML	Extensible mark-up language