

Guide to the Direct Broadcast Network for Near-real-time Relay of Low Earth Orbit Satellite Data

Attachment to the *Guide to the WMO Information System*
(WMO-No. 1061)

WMO Information System
WMO Space Programme

2017 edition



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EDITORIAL NOTE

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1. INTRODUCTION

1.1 Purpose and scope

The purpose of this Guide is to define the minimum technical specifications and procedures applicable to the Direct Broadcast Network for Near-real-time Relay of Low Earth Orbit Satellite Data (DBNet) and to provide guidance for implementing these specifications and procedures.

In the present Guide, the term “shall” is used when referring to the technical specifications and procedures that have to be applied for DBNet to work properly, and the term “should” when referring to those that would enhance the proper functioning of DBNet. The DBNet technical specifications are applicable to all voluntary contributions of WMO Members to DBNet.

The aims of these technical specifications and procedures are twofold:

- To help ensure that the data provided by each particular DBNet regional network can be used operationally to meet user requirements as recorded in the WMO Integrated Global Observing System (WIGOS) Information Resource;
- To facilitate interregional data exchange and interoperability around the Earth, with a particular focus on ensuring the global consistency of the DBNet datasets.

This Guide is primarily directed to the DBNet station operators and coordinating entities. It also contains provisions for consideration by providers of processing software and by satellite operators. Furthermore, it can be a useful reference for the users of DBNet products.

Procedures for amending the Guide

A detailed explanation of the procedures for amending WMO Guides that are under the responsibility of the Commission for Basic Systems can be found in the appendix to the General Provisions of the *Manual on the WMO Information System* (WMO-No. 1060).

1.2 Structure of the Guide

This Guide consists of the following sections:

- Section 1: Introduction;
- Section 2: A definition of DBNet and a description of its components;
- Section 3: Overall DBNet coordination processes;
- Section 4: Common technical specifications and procedures applicable to the production of DBNet data across all DBNet regional networks;
- Section 5: Specific technical specifications and procedures applicable to the production of each DBNet service;
- Section 6: Conclusions;
- Annexes: Ancillary information provided separately for easier reference and to facilitate updating.

1.3 Applicable documents

[AD.1]: *Manual on Codes* (WMO-No. 306), Volume 1.2, Part B and Part C;

[AD.2]: *Manual on the Global Telecommunication System* (WMO-No. 386);

[AD.3]: *Manual on the WMO Information System* (WMO-No. 1060).

1.4 Reference documents

[RD.1]: Statements of Guidance for Global Numerical Weather Prediction and High-Resolution Numerical Weather Prediction;

[RD.2]: WIGOS Information Resource, Observing System Capabilities Analysis and Review tool (OSCAR) (<http://www.wmo.int/oscar>);

[RD.3]: DBNet Network Status and Plans (http://www.wmo.int/pages/prog/sat/dbnet-implementation_en.php#DBNetdocs);

[RD.4]: DBNet Coding Summary (http://www.wmo.int/pages/prog/sat/documents/DBNet_Coding-summary.xlsx).

Please note, definitions of acronyms used in this publication representing satellite and instrument names can be consulted on the OSCAR website (<https://www.wmo-sat.info/oscar/>).

2. OVERVIEW OF DBNET

2.1 Aim and functions of DBNet

The aim of DBNet is to provide near real-time access to near-global data from low Earth orbit (LEO) satellites to meet in a cost-efficient manner the timeliness requirements of regional and global numerical weather prediction (NWP) and other applications.

As a system, DBNet performs the following functions:

- Reception and acquisition of satellite direct broadcast (DB) signals at local DBNet stations;
- Processing of the acquired data into products;
- Near real-time delivery of products;
- Performance monitoring and quality control;
- User information;
- Coordination and planning.

2.2 Justification of DBNet

Access to LEO data normally relies on data dumps at one command and data-acquisition (CDA) station, which allows retrieval of complete orbit data but with a data latency resulting from on-board data storage between the time of acquisition and the time when the data are dumped to the CDA station. This on-board storage can be reduced roughly by a factor of two when two high-latitude CDA stations are used, one in the North and the other in the South. Further reduction requires a whole network of mid- or low-latitude stations distributed around the globe, which involves higher ground infrastructure costs and a highly complex scheduling of data storage and dumps.

When satellites have a DB capability, which is the case of most LEO meteorological satellites, an alternative data access route is the acquisition of the DB data stream at a local ground station, which allows real-time acquisition, albeit with coverage limited to the portion of orbit within the area of visibility of the local station.

DBNet overcomes this limitation in offering a cost-efficient trade-off between coverage and timeliness. It coordinates data acquisition through a globally distributed network of local DB receiving stations, their processing in accordance with agreed technical specifications and procedures, and their rapid delivery to the global user community through appropriate telecommunication systems.

The substantial improvement in timeliness is crucial for NWP models with short cut-off, which otherwise cannot take advantage of the most recent satellite passes. This concept was initially promoted by the high-resolution limited-area model (HIRLAM) community and the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) for the collection of Advanced TIROS Operational Vertical Sounder (ATOVS) data to support regional NWP over Europe. It was then extended by WMO to the global scale under the name Regional ATOVS Retransmission Service (RARS) and quickly adopted by the global NWP as the timeliness requirements of global models became more stringent. Impact studies have given evidence of the benefit of RARS for regional and global NWP. Several papers and posters on RARS are available on the WMO RARS web page (http://www.wmo.int/pages/prog/sat/dbnet-implementation_en.php#RARSdocs).

DBNet expands the RARS concept to other data types in support of a wider range of applications. The present Guide thus replaces the former RARS operator specifications and procedures with a wider scope to accommodate new sensor data, ensure interoperability with the National Oceanic and Atmospheric Administration (NOAA) Direct Broadcast Real-time Network, and take into account the WMO Information System (WIS).

2.3 DBNet components

DBNet is composed of several regional or subregional networks of receiving stations. The list of stations contributing to these networks is provided in [RD.3].

A DBNet network coordinator is designated for each DBNet regional or subregional network.

The role of the regional and subregional network coordinators is to:

- Ensure coordination of the regional or subregional network, report to the DBNet Coordination Group, and contribute to the overall DBNet planning and coordination described in section 3;
- Provide guidance to station operators for implementing new services, and oversee the validation procedures defined in Annex 2;
- Ensure performance monitoring as defined in section 3.2;
- Maintain a website providing information as listed in section 3.3.

Table 1 contains the list of DBNet regional or subregional networks and coordinating centres.

Global monitoring centres should perform a systematic control of product consistency. This function is assumed by the EUMETSAT NWP Satellite Application Facility (SAF), led by the Met Office (United Kingdom of Great Britain and Northern Ireland) for the infrared/microwave (IR/MW) sounding service. For other services global monitoring centres have not yet been identified.

The list of network coordinators is maintained by the WMO Secretariat and is available online as operational information (currently at <http://www.wmo.int/pages/prog/sat/>)

[dbnet-implementation_en.php#DBNetcontacts](#)). Each DBNet regional or subregional network contributes to one or several DBNet “services”. A DBNet service is the acquisition and relay of a certain category of satellite data. Table 2 lists current and potential DBNet services.

Table 1. DBNet regional or subregional network components

<i>Regional network</i>	<i>Regional network coordinator</i>	<i>Subregional network</i>	<i>Subregional network coordinator</i>
DBNet–EUMETSAT (EARS European stations and other regional partners)	EUMETSAT		
DBNet-Asia-Pacific	BOM	Asia-Pacific North	JMA
		Asia-Pacific South	BOM
DBNet-South America		South America/North	INPE
		South America/South	SMN/CONAE
DBNet–NOAA (DBRTN US stations and other regional partners) ¹	NOAA/CIMSS		

Note:

¹ DBNet-NOAA is implemented by NOAA/CIMSS in partnership with EUMETSAT and shares some functions with EARS. Not previously defined: BOM – Australian Bureau of Meteorology; CIMSS – Cooperative Institute for Meteorological Satellite Studies; CONAE – Comisión Nacional de Actividades Espaciales; DBRTN – NOAA Direct-Broadcast Real-time Network; EARS – EUMETSAT Advanced Retransmission Service; INPE – Instituto Nacional de Pesquisas Espaciais; JMA – Japan Meteorological Agency; SMN – [Servicio Meteorológico Nacional \(Argentina\)](#).

Table 2. Current and potential DBNet services (as of August 2016)

<i>Categories of services</i>	<i>Services (instruments)</i>
IR/MW sounding	RARS (AMSU-A, MHS, HIRS), ATMS, VASS (MWTS/2, MWHS/2, IRAS)
VIS/IR imaging	VIIRS, AVHRR, MERSI
Hyperspectral IR sounding	CrIS, IASI, HIRAS, AIRS
Scatterometry	ASCAT, Wind RAD
MW imagery	MWRI

Not previously defined: AIRS – Atmospheric Infrared Sounder; AMSU – Microwave Sounding Unit; ASCAT – Advanced Scatterometer; ATMS – Advanced Technology Microwave Sounder; AVHRR – Advanced Very High Resolution Radiometer; CrIS – Cross-track Infrared Sounder; HIRAS – Hyperspectral Infrared Atmospheric Sounder; HIRS – High Resolution Infrared Sounder; IASI – Infrared Atmospheric Sounder Interferometer; IRAS – Infrared Atmospheric Sounder; MERSI – Medium Resolution Spectral Imager; MHS – Microwave Humidity Sounder; MWHS – Microwave Humidity Sounder; MWRI – Microwave Radiation Imager; MWTS – Microwave Temperature Sounder; VASS – Vertical Atmospheric Sounder System; VIS/IR – visible and infrared spectrum range; VIIRS – Visible/Infrared Imager Radiometer Suite; Wind RAD – Wind Radar.

Significant NWP user interest has been expressed for data from the Russian MW imaging/sounding radiometer (MTVZA-GY), deployed on the METEOR series of satellites. The feasibility of including this instrument in the DBNet services will be further analysed.

A service based on Global Navigation Satellite System Radio Occultation (GNSS-RO) data could be considered for DBNet, as the Metop and FY-3 satellites fly GNSS-RO instruments. Due to the limb-sounding nature of the GNSS-RO, such a service would not produce regional atmospheric profiles, but for space weather applications there is an interest in fast delivery of global data from the ionosphere. The feasibility of such a service requires further analysis, which will be undertaken together with the Coordination Group for Meteorological Satellites (CGMS).

2.4 High-level service specifications

The DBNet service specifications are determined with the aim of responding to user requirements of WMO Application Areas, as recorded in OSCAR [RD.2]. For example, the requirements of global NWP (<http://www.wmo-sat.info/oscar/applicationareas/view/1>) and high-resolution NWP (<http://www.wmo-sat.info/oscar/applicationareas/view/2>) require for atmospheric temperature, humidity profiles and wind vector at sea surface a timeliness of less than 6 to 15 minutes as a goal and 30 minutes as breakthrough. The DBNet specifications represent the agreed commitment by DBNet regional networks to contribute to meeting these requirements, taking into account the technical capabilities and resource constraints. Table 3 summarizes the operational service specification for each DBNet service category. These specifications will be validated in consultation with relevant user groups, for example the Global Operational Data Exchange for NWP (GODEX–NWP), as representing the global NWP data exchange community, and the International TOVS Working Group representing the satellite atmospheric sounding community.

Table 3. DBNet high-level service specifications

Category of service	Driving Application	Products	Data latency goal/threshold	Availability	Coverage
IR/MW sounding	Global and high-resolution NWP	Level 1 brightness temperatures	20 min/ 30 min	95%	90%
VIS/IR imaging	Nowcasting	Level 1 radiance/reflectivity	10 min/ 20 min	95%	30%
High resolution IR sounding	Global and high-resolution NWP	Level 1 radiances and principle component (PC) scores	20 min/ 30 min	95%	90% (60% initially)
Scatterometry	NWP, nowcasting and ocean applications	Backscatter cross-sections	20 min/ 30 min	95%	50% (of oceanic areas)
MW imagery	NWP, nowcasting,	Level 1 brightness temperatures	20 min/ 30 min	95%	30%

Data latency is defined here as the maximum time elapsed between observation time (sensor time) and the availability on the WIS core network to be satisfied by at least 90% of the data.

The availability rate is an indicator of the target uptime for a DBNet station when there is no special operational constraint (that is, not considering particularly remote sites such as Antarctic stations). It is defined here as the percentage of days where the station is operating normally. The number of passes acquired depends on local factors (including the station latitude and the scheduling priorities) and cannot be fixed as a high-level specification, but is monitored (for example, on a monthly basis) as a performance indicator. The availability is defined for an individual station. Adjacent stations with significantly overlapping acquisition areas can back each other up, which is important primarily to solve possible reception-scheduling conflicts.

The coverage is defined as the percentage of the Earth's surface that can be viewed by the relevant satellite instrument and the data transmitted to DBNet stations via DB. This is calculated by merging the areas of visibility of the local stations contributing to the service. As an order of magnitude, an isolated station (not overlapping with the area of visibility of another station) without mask contributes to the global coverage by about 4%. (Note: This index only takes into account the latitudes between 82°S and 82°N that are flown over by sun-synchronous satellites.)

3. **DBNET COORDINATION**

3.1 **DBNet network implementation**

The WMO Secretariat and all DBNet network coordinators strive to ensure smooth operation of the DBNet services across all regional networks, to plan expansion of DBNet, to review the priorities and to take any appropriate measure to meet evolving user requirements. The regional and subregional network coordinators identify candidate stations and negotiate agreements with station operators with a view to expanding the network and filling gaps when necessary.

This coordination is achieved through the DBNet Coordination Group, the terms of reference of which are provided in Annex 1.

The WMO Secretariat maintains a list of DBNet contributing stations associated with each regional network together with the status and plans of the different services [AD.4], based on the reports from DBNet network coordinators. This allows the coverage of the respective DBNet services to be monitored.

The procedure contained in Annex 2 describes the steps to be followed to add a station to DBNet, modify its status, or remove it from DBNet.

3.2 **Quality of service**

3.2.1 **Quality assurance**

To help ensure that the service provided is of an appropriate quality, the DBNet station operator shall:

- Utilize an appropriate system for the tracking and resolution of operational anomalies;
- Ensure that all operations and maintenance staff are appropriately trained;
- Ensure that appropriate provisions are in place to protect against unauthorized access to the DBNet equipment (from both physical and network security points of view);
- Ensure that the maintenance approach (for example, levels of redundancy, spares holdings, maintenance contracts and maintenance team size) is consistent with the service availability targets (see section 2.4);
- Ensure that adequate arrangements are in place to monitor the satisfactory performance of the service (supported by the availability of validated operational and maintenance procedures).

3.2.2 **Quality control**

Each DBNet regional network shall implement appropriate quality control measures to monitor the integrity of the DBNet data disseminated, in particular with respect to timeliness and correct formatting.

The regional or subregional network coordinators:

- Organize the near real-time monitoring function;
- Maintain the list of operational points of contacts of individual station operators;
- Perform overall performance monitoring (including implementation of the technical specifications and procedures);
- Manage software updates to ensure that proper software versions are used on each station;
- Ensure an operational point of contact for resolving anomalies.

For the IR/MW and hyperspectral IR sounding services, global monitoring is performed by NWP SAF to assess the consistency of DBNet data with the global data and their timeliness. The results of this monitoring are sent to the operators and statistics are published online (available at <http://nwpsaf.eu>).

3.2.3 **Issue management**

Each DBNet station operator and network coordinator shall designate an operational point of contact in case of operational problems.

The contact details of operational points of contact of each regional and subregional network will be posted on the DBNet regional network website to allow the users to report operational problems. Depending on the nature of the problem, the DBNet coordinating entity will contact the relevant DBNet station operator, the relevant WIS Data Collection or Production Centre (DCPC) or Global Information System Centre (GISC) as defined in [AD.3] Appendix B and/or the global monitoring unit (NWP SAF help desk).

Each DBNet network coordinator should implement appropriate issue management processes to properly track and manage the resolution of problems, including notification of the providers of preprocessing software packages.

Each DBNet preprocessing software package provider should implement software anomaly management processes for fast resolution of software problems that affect the end users.

3.3 **Publication of service information**

The WMO Space Programme provides and maintains a DBNet e-mail list server, which allows DBNet network coordinators and processing software providers to support all station operators and operational users by keeping them up to date with system changes (for example, announcement of ATOVS and AVHRR Preprocessing Package (AAPP) and Community Satellite Processing Package (CSPP) software releases and their impact on DBNet operations).

Each DBNet regional or subregional network coordinator should also maintain a website containing an up-to-date description of the service, including:

- For each service, the instruments and satellites from which data are collected;
- The geographic coordinates of the collection stations that form part of the DBNet data collection network, together with the associated geographical coverage maps;
- The processing software versions that are used to generate the products for the stations in the regional network;
- The target timeliness and target availability of the service;
- Details of the data distribution mechanism and any associated user reception equipment requirements (for example, for receiving data from a satellite DB system);
- File naming and structure;
- The administrative procedures to be followed by a user to gain access to the data;
- A link to the scheduling priorities (including any instrument/satellite priorities);
- Operational points of contact of the network coordinator allowing users to report problems with the service (including generic e-mail addresses).

When available, the following information may be provided for individual stations:

- Planned acquisition schedule;
- Acquired passes in the last 24-hour period compared to the planned acquisition schedule (referenced to the planned acquisition schedule);
- Long-term planning information that may affect the service in the future (for example, planned outages, upgrade of software version, and the like);
- Quality monitoring results.

Each DBNet processing software provider maintains on its website a record of the current recommended software versions and configurations.

For operational issues related strictly to the distribution of DBNet products through the WIS core networks (including, for example, the Regional Meteorological Data Communication Network (RMDCN)), WIS communication procedures must be followed.

4. COMMON DBNET TECHNICAL SPECIFICATIONS AND PROCEDURES

4.1 Introduction

The common technical specifications and procedures cover aspects of DBNet operations that are not specific to a particular service and should apply for any regional network contributing to the overall DBNet network. The specifications and procedures are mandatory and are only defined in areas that affect the interoperability of DBNet regional networks, the access to and the utilization of DBNet products, and the interface to WIS. For other aspects, some practices are recommended or indicated as guidance, but the actual implementation can be defined in an optimal manner by each DBNet regional network.

A DBNet network coordinator is defined as the managing entity responsible for ensuring an end-to-end service within a particular region (that is, with responsibility for data collection from the high-resolution picture transmission (HRPT) stations; processing, dissemination of the products to users; and interregional data exchange). If responsibility for the implementation of these functions is shared between several parties, then it is the responsibility of the lead entity to ensure that all the parties involved comply with the relevant parts of the technical specifications and procedures.

Overall, DBNet technical specifications and procedures are defined in the following areas:

- Product processing and format;
- Product registration and distribution;
- Quality of service;
- Operations and maintenance including anomaly processing;
- Publication of service information;
- DBNet network coordination.

4.2 Acquisition

4.2.1 *Satellite acquisition-scheduling priorities*

Guidelines for satellite acquisition-scheduling priorities are established by the DBNet Coordination Group considering:

- Availability and timeliness of global data;
- Equatorial crossing time diversity;
- Instrument health;
- DB signal quality;
- Ability of NWP to assimilate instruments.

The scheduling priorities are reviewed annually or when needed. The current priorities are recorded in an operational information maintained on the WMO Space Programme website (www.wmo.int/pages/prog/sat). As an example, the 2015 priorities are listed in Annex 3.

4.3 Product processing (common aspects)

4.3.1 *Processing level*

Any products exchanged interregionally shall be at level 1, unless otherwise specified for the specific service.

Level 1 is understood to be radiances, reflectances or brightness temperatures for sounders and imagers, and sigma-0 or kp for scatterometers, all on the original instrument grid with geolocation data.

The AAPP software description (<http://nwpsaf.eu/site/software/aapp/documentation/>) includes the following definition of processing levels:

Level 0: HRPT data (NOAA) or PFS LO (METOP): Raw telemetry data including housekeeping and others raw data. Data of the different instruments are merged into an HRPT stream for NOAA. One file per instrument for METOP;

AAPP level 1a: Separated data for each instrument;

AAPP level 1b: Earth located and calibration coefficients (reversible: calibration coefficients are separated from raw data);

AAPP level 1c: Earth located and converted to brightness temperature data (non-reversible: calibration coefficients are applied to data)

AAPP level 1d: Mapped and filtered data (with optional cloud mask in the case of HIRS);

PFS level 1B (for AVHRR): Earth located and calibration coefficients, flags;

PFS level 1C (for IASI): Gaussian-apodized, resampled radiance spectra, corrected for all geometrical and instrumental effects, with mapped AVHRR. Earth located.

For Suomi National Polar-orbiting Partnership (SNPP), Joint Polar System Satellite (JPSS) and some other programmes (e.g. DMSP), NOAA adopt the following naming convention, and these names are used in the AAPP documentation where applicable:

Raw data records (RDR): Raw data from the instrument;

Temperature data records (TDR): Calibrated, geolocated antenna temperatures from microwave sounder (that is, no correction for antenna pattern). Original instrument grid;

Sensor data records (SDR): Calibrated, geolocated brightness temperatures, radiances or reflectivities. In the case of microwave instruments, antenna correction has been applied. Either original instrument grid or re-mapped;

Environmental data records (EDR): Geophysical quantities.

Processing to level 1, and encoding in binary universal form for the representation of meteorological data (BUFR), can be done at the regional centre or locally at the receiving station location.

The DBNet network coordinator is responsible for ensuring that appropriate local centre and sub-centre codes are defined and are included in the BUFR messages as described in section 4.4.

4.3.2 **Product processing packages**

DBNet network coordinators and station operators shall use agreed processing packages and agreed auxiliary input data such as orbit information and instrument calibration files to ensure that the processed products are fully consistent with the corresponding global datasets preprocessed by the respective satellite operators.

The suite of processing packages to be used by DBNet is described below and is detailed in the sections of this Guide addressing specific services. The list of software processing packages and organizations responsible for maintaining them is provided in Tables 4–6 (see also Figure 1). For the scatterometry and MW imagery services, information about processing packages will be included when they become generally available.

Table 4. Level-0 processing packages

<i>Level-0 processing packages</i>			
<i>Package</i>	<i>Satellites</i>	<i>Provider</i>	<i>Comment</i>
RT-STPS	SNPP, Metop, FY-3, Aqua	NASA DRL	CADU to CCSDS source packets
FY3L0PP	FY-3	CMA	CADU to CCSDS source packets
Metopizer	Metop	EUMETSAT	CCSDS source packets to EPS level-0

Not previously defined: CADU – channel access data units; CCSDS – Consultative Committee of Space Data Systems; CMA – China Meteorological Administration; EPS – EUMETSAT Polar System; FY3L0PP – FY-3 satellite level zero preprocessing package; NASA DRL – National Aeronautics and Space Administration Direct Readout Laboratory; RT-STPS – Real-time Software Telemetry Processing System.

Table 5. Level-1 processing packages

<i>Level-1 processing packages</i>			
<i>Package</i>	<i>DBNet service</i>	<i>Provider</i>	<i>Comment</i>
AAPP	RARS, AVHRR	EUMETSAT (via NWP SAF)	
OPS-LRS	IASI	EUMETSAT (via NWP SAF)	Released as an optional part of AAPP
CSPP	ATMS, CrIS, VIIRS	NOAA (via SSEC, UW-Madison)	
FY3L1PP	VASS, MERSI	CMA	
IMAPP	AIRS, Aqua AMSU	SSEC, UW-Madison	

Not previously defined: FY3L1PP – FY-3 satellite level one preprocessing package; IMAPP – International MODIS/AIRS Processing Package; OPS-LRS – operational software-local reception station; SSEC – Space Science and Engineering Center; UW-Madison – University of Wisconsin-Madison.

Table 6. Encoding packages

<i>Encoding packages</i>			
<i>Package</i>	<i>DBNet service</i>	<i>Provider</i>	<i>Comment</i>
AAPP	RARS, IASI, ATMS, CrIS, VASS	EUMETSAT (via NWP SAF)	Requires BUFR library
IMAPP	AIRS, Aqua AMSU	SSEC, UW-Madison	
CVIIRS	VIIRS	EUMETSAT	Converts between VIIRS SDR and Compact VIIRS SDR

Not previously defined: CVIIRS – Compact VIIRS.

4.3.3 **Auxiliary data**

A DB station requires satellite orbit information in the form of two line elements (TLE) for the prediction of future satellite passes, for antenna pointing during the acquisition of satellite data and for processing and geolocation of the sensor data. Orbital elements shall be updated at least once per day.

Additional instrument processing-related auxiliary data are also required:

- For AAPP, auxiliary data files are provided by NWP SAF (www.nwpsaf.eu);

- For CSPP, auxiliary data files for processing of VIIRS, CrIS, and ATMS are obtained periodically from NOAA operations and are made available for Internet download by the CSPP team. This includes TLEs and Polar Wander files, as well as calibration tables. DBNet operators are encouraged to run the automated look-up table update scripts supplied with the CSPP SDR software regularly to ensure the most up-to-date auxiliary data are available.

Currently (August 2016) orbital data are made available directly by satellite operators at:

- Metop: <http://oiswww.eumetsat.org/metopTLEs/html/index.htm> ("long TLEs") or the multi-mission administration messages contained in the Metop HKTM L0 files;
- NOAA: <https://www.space-track.org> (login needed) or <http://celestrak.com/NORAD/elements/>;
- FY-3: http://www.shinetek.com.cn/eos_data/ or <http://satellite.nsmc.org.cn/>.

For the future, it is planned that each satellite operator will make TLE data publicly available in a standardized manner, along the lines of the service provided by NOAA for the SNPP satellite (see <https://msds.npoess.noaa.gov/MSDS/AUXILIARY/tle/>). This will enable station operators, in an automated manner, to select the most recent reference TLE date and time to propagate the orbit into the future in the most accurate way, taking into account in particular spacecraft manoeuvres. Such a procedure will be further detailed and submitted to CGMS satellite operators for endorsement as a technical specification. The following description is a preliminary overview only:

- TLE files are made publicly available on the Internet based on the Hypertext Transfer Protocol Secure (HTTPS) protocol. The files are standard ASCII text files each containing a single set of TLE data in the well-established two-line format, see for example <https://www.space-track.org/documentation#/tle>.
- As indicated in Table 7, the file name starts with the satellite name and the reference date and time (starting with "r") of the TLE. The reference date and time are defined by the satellite operator and indicate the time of the orbit determination campaign on which the TLE is based.

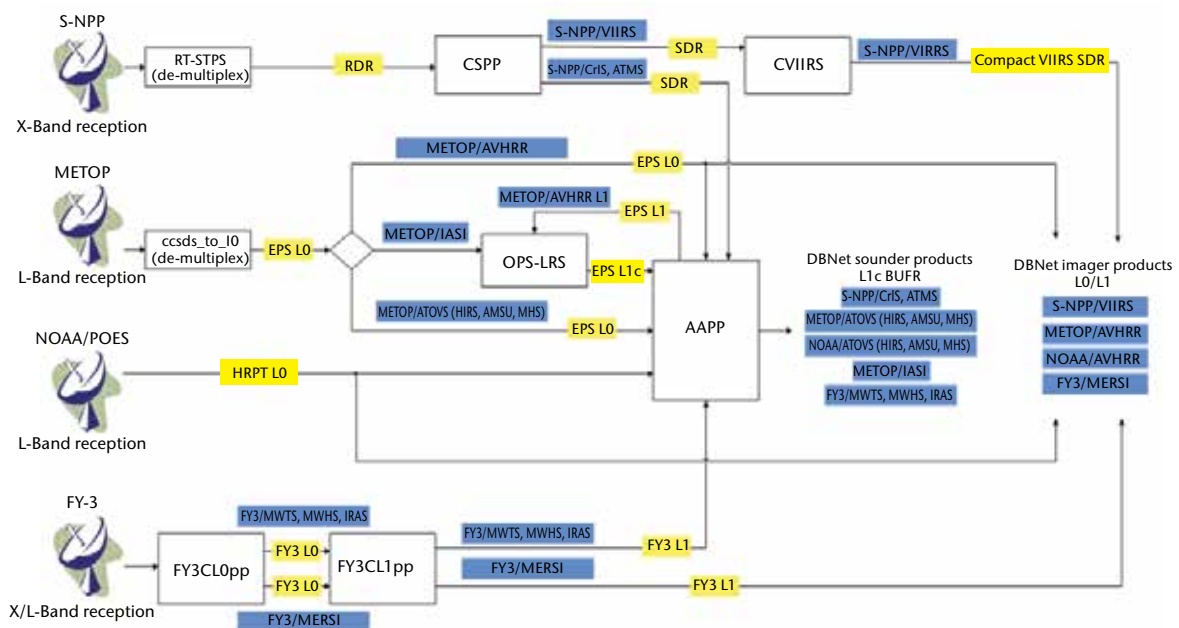


Figure 1. Schematic diagram of processing packages to be used for DBNet

- The newer generations of polar orbiting satellites typically perform manoeuvres as part of routine orbit maintenance. To account for this the TLE filename should systematically include the TLE interval of validity. The interval is defined by the dates and times of the start (starting with “s”) and end (starting with “e”) of the validity, where the start and end are defined by the satellite manoeuvre execution times.
- If the start of validity is left undefined (all zeros), the TLE is valid until a manoeuvre takes place, as shown in the first example in Table 7. If both start and end are defined, the TLE is valid between two manoeuvres as shown in the second example in Table 7. If the end is left undefined, the TLE is valid after a manoeuvre as shown in the third example in Table 7. This scheme supports both the issuing of predicted post-manoevrue TLEs and the issuing of determined post-manoevrue TLEs.
- Finally, both the start and end of the validity interval can be left undefined, as shown in the fourth example in Table 7. This indicates that the satellite is either not performing manoeuvres (for example, NOAA Polar Operational Environmental Satellites (POES)) or that there are no recent or planned manoeuvres for the satellite.

Table 7. Example of TLE filenames for semi-open, closed and open intervals of validity

<i>TLE filename</i>	<i>Explanation</i>
Metop-B_r20150820120000Z_s00000000000000Z_e20150823123000Z.txt	Issued on 20 August 2015. Validity ending on 23 August 2015 at 1230 UTC (first manoeuvre)
Metop-B_r20150820120000Z_s20150823123000Z_e20150823141100Z.txt	Issued on 20 August 2015. Validity starting on 23 August 2015 at 1230 UTC (first manoeuvre) and ending on 23 August 2015 at 1411 UTC (second manoeuvre)
Metop-B_r20150824020000Z_s20150823141100Z_e00000000000000Z.txt	Issued on 24 August 2015. Validity starting on 23 August 2015 at 1411 UTC (second manoeuvre)
Metop-B_r20151005120000Z_s00000000000000Z_e00000000000000Z.txt	Issued on 5 October 2015. No validity limitations

4.3.4 **Segmentation**

Classically the raw satellite data acquired by a DB reception station is transferred to the product processing system after completion of the full satellite pass.

However, to achieve the challenging DBNet timeliness requirements, it is sometimes necessary for certain services (for example, VIS/IR imagery) to transfer the data in segments, shorter than the full satellite pass, during the pass. Each segment is transferred to the product processing system as soon as its acquisition is completed. The duration of a segment is a configurable parameter, typically set to 2 minutes. The last segment of a pass may be shorter to match the overall duration of the pass.

It is recommended to transfer the data as CCSDS CADU, CCSDS virtual channel data unit (VCDU) or CCSDS source packets without adding any additional structure to the data and with each segment containing a sequence of complete CCSDS packets. These formats are well defined and enable easy segmentation and concatenation. CCSDS CADU is recommended as the most generic. CCSDS VCDU or CCSDS source packets can be chosen if data from a subset of instruments is required and the overall bandwidth of the transfer is of concern.

A typical implementation is based on the file transfer protocol (FTP) protocol with the reception station acting as the FTP client and the product processing system as the FTP server. To improve the reliability of the transfer in the presence of equipment resets on either side or short interruptions of the network, the FTP client shall implement a retry mechanism. An appropriate mechanism could be, for example, to retry up to 10 times with a time interval between retries of 30 seconds.

The segment file name should indicate the name of the satellite, start of pass date, start of pass time, segment start time, segment end time, orbit number and station acronym. To simplify the handling of the segments by the product processing system, it is recommended that the last segment of a pass additionally has an indication that it is the last segment, that segments are transferred in order of acquisition, and that during an ongoing FTP transfer the filename has an indication that the file is temporary and incomplete, for example by adding a suffix of “.temp” and atomically renaming the file once its transfer is complete.

Further details can be found in the service-specific paragraphs below.

The data acquisition and processing architecture can further be optimized to eliminate duplication of data. A possible approach is the one used by the EARS pilot AVHRR service, employing line-by-line acquisition planning to ensure no overlaps between neighbouring stations. The issue of overlap will be addressed in future revisions of the Guide.

4.3.5 **Global and local product consistency**

Global (full orbit central processing) and local (usually DB) product consistency specifications are set based on considerations of NWP requirements.

Global and local product processing shall be harmonized in that brightness temperature products derived from both paths agree within tolerances that are not greater than a few tenths (the goal is 10%) of the respective performance requirements for bias error at a reference brightness temperature.

As a concrete example, this implies that for the MWS instrument to be flown on Metop-SG, the relevant performance requirement is the bias variation over an orbit (0.2 K) – because DBNet products will be used regionally to complement global data. So the goal for local–global consistency should be $10\% \times 0.2 \text{ K} = 0.02 \text{ K}$.

The instrument navigation shall be harmonized in that geographical coordinates derived from both paths agree within 10% of nadir instantaneous field of view for sounder instruments and 50% of nadir instantaneous field of view for imagers. Current recommended values are displayed in the NWP SAF monitoring plots for DBNet products.

4.4 **Product coding and format (common aspects)**

4.4.1 **Format harmonization: general principles**

In order to ensure that all DBNet products are fully interoperable, it is important that all DBNet operators use WMO standard formats, with the same implementation of these formats, and follow the agreed DBNet conventions in the implementation of these formats. For instance, for BUFR the same globally defined BUFR table D sequence descriptors (also known as templates, see [AD.1]) shall be used. These templates are embedded within the BUFR tables, which along with the conversion software will be released together with the recommended service-specific processing software. All DBNet operators shall make use of this recommended, or equivalent, BUFR conversion software for format conversion.

A DBNet product is the result of the processing of the data acquired by one station, from one satellite pass, from one instrument. A DBNet product shall be comprised of a series of

BUFR-encoded messages, which shall each be included in a bulletin and which should all preferably be embedded in one file. DBNet formatting specifications are thus defined at three different levels: BUFR message; meteorological bulletin; filenames.

- The first level of standardization of DBNet product format is the BUFR message encoding. For each satellite pass and each instrument (with the exception of imagery products), DBNet products are encoded in BUFR messages. Because of Global Telecommunication System (GTS) message size limitations, a DBNet product exchanged on GTS must be segmented into several BUFR messages. The number of BUFR messages needed for one product depends on the instrument and the duration of the satellite pass. The BUFR message encoding should be in accordance with [AD.1] with DBNet-specific provisions for section 1 (identification) and section 3 (data description) of the BUFR message as described in section 4.4.2.
- The second level of standardization of DBNet product format is the “abbreviated bulletin heading”. An abbreviated heading is assigned to each BUFR message to form a “meteorological bulletin”. The bulletin heading information is used by Regional Telecommunication Hubs (RTHs) to organize the routing of the messages over GTS. The bulletin heading is not generally used by users of the BUFR messages to interpret the information; as all the necessary information to decode the BUFR message is contained within the actual BUFR message (in combination with the associated code tables – see [AD.1]). Hence there is some duplication of information between section 1 of the BUFR message and the bulletin headings (albeit with different representations). The structure of the heading is described in [AD.2], Part II, 2.3.2.2 and Attachment II-5 and also in “Explanation of data designators $T_1 T_2 A_1 A_2 ii$ CCCC” (see http://www.wmo.int/pages/prog/www/ois/Operational_Information/Publications/WMO_386/AHLSymbols/AHLSymbols_en.html). The different bulletins composing a product all have the same headings, with the exception of the number “ii”, which differentiates the individual bulletins of the same product. Specific provisions are defined in section 4.4.3 for the determination of $T_1 T_2 A_1 A_2$ in the case of DBNet products.
- As WIS continues to evolve, and the focus progressively shifts from bulletins to files, it is anticipated that this issue will assume less relevance. However, for the time being bulletins remain a much-used communication mechanism within WIS, and harmonization of bulletin headings is required within the DBNet network.
- The third level of standardization of DBNet products is the file. DBNet production centres can submit products to GTS either directly as meteorological bulletins, or embedded in files. These files shall follow the WIS file naming convention:

pflag_productidentifier_oflag_originator_yyyyMMddhhmmss[_freeformat].type[.compression].

Guidance for DBNet product filenames is provided in section 4.4.4. (Note: More explanations on accumulating messages into files can be found in [AD.2], Part II, Attachment II-15, GTS data exchange methods). The DBNet conventions applicable to the BUFR identification section, the BUFR data description, the abbreviated heading and the file name are summarized in [RD.4].

The template will be reviewed to accommodate the additional DBNet services.

4.4.2 **Encoding of the DBNet BUFR message**

The structure of the BUFR message is defined in [AD.1]. To facilitate identification and use of BUFR messages containing DBNet products, a specific convention shall be followed to determine certain fields of the identification section and the data description section (sections 1 and 3 of [AD.1], respectively).

The BUFR tables and common code tables (CCTs) referred to in this section are extracted from [AD.1] and can also be found at https://www.wmo.int/pages/prog/www/WMOCodes/WMO306_v12/LatestVERSION/LatestVERSION.html.

Section 1, octets 5–6: Identification of the originating or generating centre:

- The originating or generating centre shall indicate the centre responsible for the processing to level 1 and BUFR encoding;
- If processing to level 1 and BUFR encoding are done locally at the station site, then the originating or generating centre is the organization responsible for the station. If the processing to level 1 and/or the BUFR format conversion are performed, or managed by the DBNet regional centre, then the originating or generating centre is the DBNet regional centre;
- The corresponding identification is defined in CCT C-11 and recalled in [RD.4].

Section 1, octets 7–8: Identification of originating or generating sub-centre:

- The originating or generating sub-centre shall indicate the DB station that receives the data. Each sub-centre is defined with reference to the originating or generating centre it is functionally related to for the considered application;
- The corresponding ID is defined in CCT C-12 and recalled in [RD.4];
- The sub-centres' IDs are allocated by the relevant centres and shall be shared with the WMO Secretariat for inclusion in CCT C-12 and [RD.4].

Section 1, octet 11: Data category:

- The data category indicated in octet 11 is defined by BUFR code table A, which gives, for example, "3" for satellite vertical sounding data, "12" for satellite surface data, "21" for satellite radiance data, "24" for scatterometry, and "101" for satellite image data (see Annex 4).

Section 1, octet 12: International data subcategory:

- Subcategories of the above categories are defined by CCT C-13 for specific instruments (AMSU-A, AMSU-B, HIRS, MHS, IASI, SSMI, ASCAT, CrIS, ATMS, VIIRS) or for generic types of instruments (IR sounding, hyperspectral sounding, MW sounding, radio occultation);
- Octet 12 (BUFR edition 4) must be populated using an appropriate international subcategory. When an instrument-specific entry exists in CCT C-13, this should be used. If there is no specific entry in CCT C-13 for the instrument, the most appropriate generic instrument category entry should be used. If no generic entry in CCT C-13 is applicable, a request should be made to have such an appropriate entry added to the table.

Additional details can be provided in octet 13, which is available to indicate a local subcategory (for example, to differentiate instruments of the same subcategory, or different operating modes of an instrument – see Annexes 4 and 5).

Section 3: The data description section, includes a definition of the elements that are used to build the message. This definition usually takes the form of a single table D sequence descriptor. It is recommended that WMO-approved sequences are used, as given in Table 8.

Table 8. Section 3 data descriptor sequences

<i>Instrument</i>	<i>Sequence (F-X-Y)</i>	<i>Comment</i>
HIRS	3-10-008	20 channels
AMSU-A	3-10-009	15 channels
MHS	3-10-010	5 channels
IASI	3-40-008	Channels + PCs (variable)
CrIS	3-10-060	Channels (variable)
ATMS	3-10-061	22 channels
MWTS-2	To be decided	
MWHS-2	To be decided	
IRAS	To be decided	

If an agreed table D sequence is not available (the case for FY-3 instruments as of August 2016), then a list of table B descriptors may be used.

Consistency with the equivalent global data should be maintained. Usually the agency responsible for dissemination of the global data is responsible for defining the BUFR sequence.

4.4.3 **Bulletin headings**

The structure of the abbreviated bulletin heading is: T₁T₂A₁A₂ii CCCC YYGGgg (BBB) as described in [AD.2], Part II, 2.3.2.2 and Attachment II-5.

For DBNet products, the following implementation shall be applied:

- T₁T₂ should be set to “IN”;
- A₁ identifies the instrument (A=AMSU-A, B=AMSU-B, H=HIRS, M=MHS, and so on). Harmonization of instrument identifiers in the bulletin heading and the filename is desirable (that is, the value of A₁ in the bulletin heading and the <data designator> value in the filename should be harmonized) (see Annex 5);
- A₂ is the geographic area designator – as per [AD.2], Attachment II-5, Table C3 (see https://www.wmo.int/pages/prog/www/ois/Operational_Information/Publications/WMO_386/AHLSymbols/TableC3.html). Concerning the value of A₂, a regional indicator or a global indicator (“X”) can be used, depending on the most appropriate characterization of the coverage. Where meaningful, the use of regional indicators is encouraged (for example, “N” for Arctic and “S” for Antarctic stations).

Example bulletin headings from Casey:

INAS01 AMMC YYGGgg (for AMSU-A data);

INBS01 AMMC YYGGgg (for AMSU-B data);

INHS01 AMMC YYGGgg (for HIRS data).

4.4.4 **Filenames**

- (a) DBNet data files shall follow the GTS file-naming convention (with pflag = W) (see [AD.2]);
- (b) A metadata file (which would generally be static) shall be associated with each DBNet data file.

The filename structure should be of the form:

W_productidentifier_oflag_originator_yyyyMMddhhmmss[_freeformat].type[.compression]

where:

“productidentifier” is a variable length field that describes the nature of the data in the file. It consists of two parts, a “static part” and an “optional part” – the latter not being used in the context of DBNet.

The “static part” is the product description and consists of:

<location indicator>, <data designator>, <free description>

where:

<location indicator> defines the producer: country, organization and production centre. For example: for Brazil <location indicator> could be “br-INPE-cp”;

<data designator> specifies the type of data with reference to the categories and subcategories defined in CCT C-13 of [AD.1], with “+” used to indicate composite data.

In the context of DBNet, the following convention is used:

<data designator> should be the instrument name without a separator, for example: amsua, amsub, hirs, mhs, iasi or ascats (see Annex 6);

<free description> should be used to indicate satellite and originating HRPT station, and should be preceded by “DBNet”. For example, for data from NOAA-17 from Cachoeira Paulista, the <free description> should read “DBNet+noaa17+cpt” (note: for backward compatibility “rars” can be used instead of “DBNet”) (see details in Annex 6);

“oflag”: At this time the only admissible value of oflag is “C” – indicating that the <originator> field will be decoded as a standard CCCC country code (and the use of the CCCC value in filenames and bulletins should be consistent);

“originator” is a variable length field indicating where the file originated from (and is decoded according to the value of <oflag>). For example, “SBBR” for Brasilia Airport;

“yyyyMMddhhmmss” is a fixed-length date- and time-stamp field, containing the time of the BUFR file creation;

“[_freeformat]” in the context of DBNet should be “_(AAPP filename)_bufr”. This usage needs to be shared with users of DBNet data;

“type” in the context of DBNet would typically be set to “bin” to indicate a file containing data encoded in a WMO binary code form such as BUFR.

Thus, a typical filename for AMSU-A data from NOAA-17 provided by Centro de Previsão de Tempo e Estudos Climáticos/INPE in Brazil, from the HRPT station in Cachoeira Paulista, could be:

W_br-INPE-CP,amsua,DBNet+noaa17+cpt_C_SBBR_20110701090858_(AAPP filename)_bufr.bin.

4.5 DBNet products registration and discovery

4.5.1 WMO Information System discovery metadata

To make the DBNet products discoverable in WIS they shall be registered in the WIS discovery metadata catalogue with a metadata entry ([AD.3], Appendix C). This enables any WMO Member to be aware of the availability of these products through the WIS catalogue and, if interested, to request them from the relevant WIS centre (that is, GISCs or DCPCs).

4.5.2 Recording in Weather Reporting (WMO-No. 9), Volume C1

In addition, the abbreviated headings of meteorological bulletins are recorded in *Weather Reporting* (WMO-No. 9), Volume C1 – Catalogue of Meteorological Bulletins. This enables any WMO Member to be aware of the availability of these bulletins and, if interested, to request them from the relevant RTH. However, when DBNet products are embedded in “files” they are not systematically recorded in Volume C1. To make the DBNet products more easily discoverable, it is recommended to record the DBNet bulletins in Volume C1 even if embedded in a file.

The procedure for recording meteorological bulletins is described in Volume C1 under “Updating procedures and methods of notifying the WMO Secretariat of amendments: Advanced notifications” (http://www.wmo.int/pages/prog/www/ois/Operational_Information/VolC1_en.html). The World Meteorological Centres and RTHs on the Main Telecommunication Network shall maintain Volume C1 as regards bulletins issued from the zone for which they are responsible. The format to record a bulletin is described in: http://www.wmo.int/pages/prog/www/ois/Operational_Information/VolumeC1/AN_RecordFormat_en.html.

Table 9 provides guidance to complete the fields 9–15 of this record.

Table 9. Guidance to record a DBNet bulletin sent as a file in Volume C1

<i>Field No.</i>	<i>Field Name</i>	<i>Value</i>
9	Category	“E” (Essential data/products)
10	TTAAii	(Indicate TTAAii as defined by the DBNet coding convention)
11	CCCC	(Indicate CCCC as defined by the DBNet coding convention)
12	CodeForm	“FM 94-XIV”
13	TimeGroup	“AS AVAILABLE”
14	Content	“DBNet”
15	Remarks	“TRANSMITTED AS A FILE”

4.6 Product distribution

The DBNet regional networks shall strive to make DBNet products available to the global user community, and in particular to the NWP centres worldwide, through WIS.

The recommended route for DBNet data access within a region is to be defined at the regional level in consultation between the GISCs/DCPCs and the DBNet regional nodes, taking into account the level of connectivity of the main regional users.

Interregional data exchange shall be implemented between regional nodes and GISCs, taking into account the recommendations of the GODEX–NWP group, which keeps under review the requirements of NWP centres for interregional exchange of satellite data.

There will necessarily be a trade-off between the benefit provided by additional data and the resulting load on the telecommunications. While the primary distribution means will be the GTS

and RMDCN networks, the use of a satellite broadcast service such as EUMETCast or CMACast or Internet is an advantage for users with limited WIS/GTS connectivity. A schematic illustration of the telecommunication scheme is provided in Figure 2.

Specific aspects of DBNet–WIS connectivity are as follows:

- DBNet stations with direct access to a core WIS node (GISC or DCPC) should directly inject into WIS (for example, Kyose/Tokyo, Crib Point/Melbourne);
- DBNet stations with GTS access should directly inject into GTS (for example, New Delhi);
- DBNet station with no WIS/GTS access should send their products either to a GTS or WIS core node via FTP (for example, Maupuia to Melbourne, Cordoba to Buenos Aires, Cachoeira Paulista to Brasilia, Jincheon to Seoul);
- As an alternative, DBNet stations that are part of a coordinated regional/subregional network should send their products to the regional/subregional node that will send the whole DBNet product package to a GTS hub/GISC/DCPC (for example, EARS stations concentrated by EUMETSAT via Virtual Private Network, before being sent to GISC/RTH Offenbach; and Natal, Cuiaba via Cachoeira Paulista, before being sent to GISC/RTH Brasilia).

5. TECHNICAL SPECIFICATIONS AND PROCEDURES FOR SPECIFIC DBNET SERVICES

These technical specifications and procedures are applicable to the provision of individual DBNet services. The DBNet services are defined in terms of groups of equivalent or similar instruments, potentially flying on different satellites. A particular DBNet operator may only provide a subset of the defined services. The scope of the overall DBNet includes the services listed in Table 2.

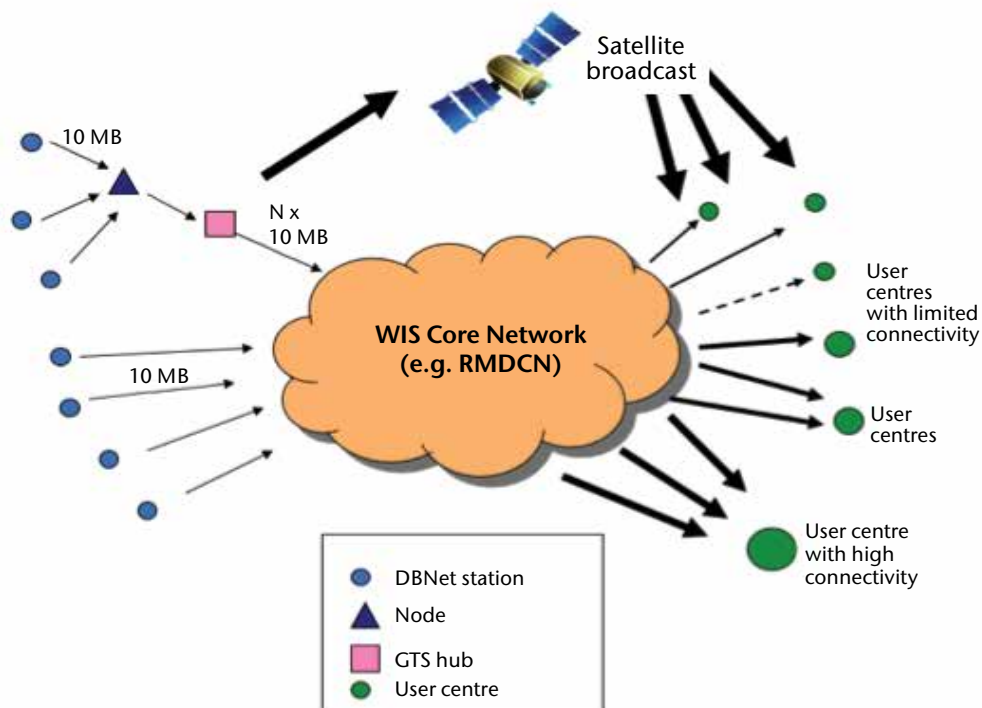


Figure 2. DBNet connectivity to GTS/RMDCN

The areas covered by these specifications and procedures are service-specific aspects of product processing, formats, quality control and monitoring.

5.1 **Infrared/microwave sounding service**

This service is provided for the ATOVS suite of instruments flying on NOAA POES and EUMETSAT Metop satellites, as well as from equivalent instruments flying on CMA FY-3 and NOAA SNPP and JPSS satellites.

5.1.1 **Product processing software**

To ensure global consistency of the DBNet dataset, the DBNet operator shall make use of the AAPP software for product processing for the ATOVS suite of instruments, of CSPP for ATMS and of the FY3L0/L1PP software package for MWTS, MWHS and IRAS.

The AAPP package is supplied and maintained by EUMETSAT's NWP SAF. The package is freely available (subject to the signing of a licence agreement) and the process for obtaining the package is fully described on the NWP SAF AAPP web pages (<http://www.nwpsaf.eu>). General background information on the AAPP software is also available on this web page. The version of the AAPP software to be used shall be the latest release as defined on the AAPP web page.

For changes affecting the data output, this latest release shall be implemented operationally within one month of release by NWP SAF, otherwise the latest release shall be implemented operationally within three months.

For SNPP ATMS, product processing shall be performed by AAPP and CSPP software. CSPP performs level 1 processing that delivers SDR in hierarchical data format 5 (HDF5) for ATMS. AAPP ingests these SDRs and carries out BUFR encoding. CSPP can be downloaded from <http://cimss.ssec.wisc.edu/cspp/>.

FY-3 data are preprocessed by the FY3L0/L1PP software packages distributed by CMA (see <http://satellite.nsmc.org.cn/> "tools").

The AAPP software can ingest the SDRs of MWTS, MWHS and IRAS, and BUFR can encode them.

5.1.2 **Processing level**

Any products exchanged interregionally shall be at the level of brightness temperatures with geolocation on the original instrument grid.

5.1.3 **Quality checking and quality flags**

The preprocessing software includes quality checking, and any products distributed shall include quality flags. For AMSU-A, MHS, HIRS and ATMS, quality flags are available in the BUFR product. It must, however, be noted that at the time of writing (August 2016) quality flags are not available in the BUFR products for VASS (MWTS-2, MWHS-2 and IRAS). Instead, suspect measurements values are set to "missing".

5.1.4 **Product quality monitoring**

Routine monitoring of DBNet IR/MW sounding data quality is performed by NWP SAF. Monitoring results are available on the "monitoring reports" section of the NWP SAF website (<http://www.nwpsaf.eu>).

5.2 **Visible/infrared imaging service**

5.2.1 **Product processing software**

For SNPP VIIRS, the product processing shall be performed by the CSPP software, followed by CVIIRS. For MERSI, the product processing shall be performed by the FY3L0/L1PP software packages.

For NOAA AVHRR, raw data are currently disseminated, therefore no product processing or encoding is required at the time of writing (August 2016).

For Metop AVHRR, Metopizer or similar software is needed to first create EPS level 0.

5.2.2 **Processing level**

The processing level shall be either raw HRPT (NOAA POES/Metop) or at the level of radiances/reflectivities (VIIRS/MERSI).

It is preferable for the orbit pass to be segmented to enable on-the-fly transmission of product segments to ensure low latency and facilitate handling of large datasets.

As it is important to provide seamless imagery (without missing lines or overlaps), the acquisition schedules of the local stations shall be coordinated and where feasible the acquisition source shall be switched from one station to the next at a defined imagery line.

Data compression is critical and efficient compression procedures shall be used. For VIIRS a compact SDR format has been developed and implemented in DBNet-EUMETSAT. This format provides a compact representation of VIIRS geolocation, angular information and measurement data. For further information see http://www.eumetsat.int/website/wcm/idc/idcplg?IdcService=GET_FILE&dDocName=PDF_VIIRS_SDR_PF_UG&RevisionSelectionMethod=LatestReleased&Rendition=Web.

5.2.3 **Quality checking and quality flags**

Not applicable to raw data.

5.2.4 **Product quality monitoring**

Not applicable to raw data.

5.3 **Hyperspectral infrared sounding service**

5.3.1 **Product processing software**

For IASI, EUMETSAT has implemented a computer at each station running AAPP together with the IASI level 1 processor (OPS-LRS). Both AAPP and OPS-LRS are distributed by NWP SAF (<http://www.nwpsaf.eu/>) and are freely available to any interested user. AAPP requires Metop level 0 as input. (Note: If not already delivered by the receiving station, the level 0 can be generated by the Metopizer freeware available from EUMETSAT at <http://www.eumetsat.int/website/home/Data/DataDelivery/SupportSoftwareandTools/index.html>.)

For OPS-LRS, the IASI instrument auxiliary files are made available by NWP SAF (www.nwpsaf.eu) to registered users of the package and announced via the NWP SAF AAPP announcements forum (<https://nwpsaf.eu/site/forums/forum/aapp/announcements/>). Due to the interdependency between on-board instrument configuration and the on-ground processing software, it is

essential that DBNet station operators install the updated auxiliary files into AAPP before corresponding on-board configuration changes are uploaded to Metop by EUMETSAT operations. Details on the installation process are found in the OPS-LRS user manual.

For SNPP CrIS, the product processing shall be performed by AAPP and CSPP software. CSPP performs level 1 processing, which delivers SDR in HDF5 format for ATMS, CrIS and VIIRS instruments. AAPP ingests these SDRs, performs CrIS channel selection, and BUFR encodes. CSPP can be downloaded from <http://cimss.ssec.wisc.edu/cspp/>.

For HIRAS, the availability of a product processing package has not yet been confirmed.

5.3.2 **Processing level**

Any products exchanged interregionally shall be a channel subset of level 1 radiances, optionally supplemented with PC scores that allow a reconstruction of the full spectra with minimal loss of information. The definition of the set of selected channels for each of the hyperspectral sounders as well as the selection of the appropriate PC score representation is performed by the agencies, in consultation with users, according to Table 10.

Table 10. Data selection for hyperspectral sounders

<i>Service</i>	<i>Channel selection responsible</i>	<i>PC score selection responsible</i>	<i>Apodization applied</i>
IASI	EUMETSAT	EUMETSAT	Yes
CrIS	NOAA	To be decided	Yes
HIRAS	CMA	To be decided	Yes
AIRS	NOAA	NA	No

In brief, at the PC encoding step each spectrum is projected onto a set of orthogonal basis functions (eigenvectors) and the resulting amplitudes are the PC scores. In a reverse process, DBNet users can reconstruct radiances when they have the PC scores and the eigenvectors. The number of PCs is defined by the agency, with the aim of preserving as much as possible of the real atmospheric signal, while discarding PCs that contain only instrument noise.

For information on the implementation of PC scores in AAPP, the reader should refer to the document NWPSAF-MO-UD-022 "IASI Principal Components in AAPP: User Manual", available from <https://nwpsaf.eu/site/software/aapp/documentation>.

Regarding channel selection for CrIS, NOAA has documented a recommended channel selection of 399 channels (see Gambacorta A. and Barnet C.D., 2013, Methodology and information content of the NOAA NESDIS operational channel selection for the Cross-track Infrared Sounder (CrIS), IEEE Transactions on Geoscience and Remote Sensing, 51(6):3207–3216).

Regarding channel selection for IASI, EUMETSAT has documented a recommended channel selection of 500 channels in the "IASI Level 1: Product Guide" (http://www.eumetsat.int/website/wcm/idc/idcplg?IdcService=GET_FILE&dDocName=pdf_iasi_level_1_prod_guide&RevisionSelectionMethod=LatestReleased&Rendition=Web).

The channel selections for the hyperspectral IR sounders will be revisited in the future based on increasing capabilities of the users, improved WIS capacity for global product distribution, and changes in instrument capability (for example, upon transition from SNPP to NOAA-20).

5.3.3 **Quality checking and quality flags**

The processing software includes quality checking, and any products distributed shall include quality flags. For IASI and CrIS, all quality flags in the native sounder product formats are transferred to the BUFR-formatted product.

5.3.4 **Product quality monitoring**

Routine monitoring of DBNet hyperspectral sounding data quality is performed by NWP SAF. Monitoring results are available on the “Monitoring reports” section of the NWP SAF web site (<http://www.nwpsaf.eu>). Consistency between global and local data products is monitored, and also the consistency between raw and reconstructed radiances.

5.4 **Scatterometry service**

This service is currently provided by the EUMETSAT EARS network for the ASCAT instrument flying on Metop-A/B.

5.4.1 **Product processing software**

For ASCAT, the processing software used is the ASCAT Level 1 Product Processing Facility software, ported from the EUMETSAT EPS Central Ground Segment.

Availability of a Wind RAD (FY-3) processing package has not yet been confirmed.

5.4.2 **Processing level**

Any products exchanged interregionally shall be at level 1 (backscatter cross sections) or at level 2 (winds and soil moisture).

5.4.3 **Quality checking and quality flags**

The preprocessing software includes quality checking, and any products distributed shall include quality flags.

5.4.4 **Product quality monitoring**

To be decided.

5.5 **Microwave imagery service**

This service is currently not provided, but is under consideration for the MWRI instrument on FY-3.

5.5.1 **Product processing software**

Availability of an MWRI processing package has not yet been confirmed.

5.5.2 **Processing level**

To be decided.

5.5.3 **Quality checking and quality flags**

The preprocessing software includes quality checking, and any products distributed shall include quality flags.

5.5.4 ***Product quality monitoring***

To be decided.

6. **CONCLUSIONS**

The provisions contained in this publication contain the technical specifications and procedures to be followed by DBNet operators:

- To ensure that an appropriate level of service is provided regionally;
 - To facilitate the interregional exchange of DBNet data;
 - To ensure the global consistency of the DBNet datasets.
-

ANNEX 1. TERMS OF REFERENCE OF THE DBNET COORDINATION GROUP

1. A DBNet Coordination Group is established by the WMO Space Programme to support the development and implementation of the Direct Broadcast Network for Acquisition and Near-real-time Relay of Low Earth Orbit Satellite data (DBNet).

2. The aim of the DBNet Coordination Group is:

- To keep under review the high-level technical specifications of DBNet services, in consultation with the users;
- To coordinate the implementation and expansion of DBNet services in response to user needs;
- To define and maintain the technical specifications and procedures ensuring interoperability and interregional exchange of DBNet products, and consistency with WIS;
- To monitor the performance of DBNet components and define actions to improve this performance as appropriate;
- To keep under review the priorities for filling coverage gaps and for scheduling the acquisition of satellite data;
- To identify issues to be submitted for consideration by CGMS satellite operators.

3. The DBNet Coordination Group is composed of DBNet regional or subregional network coordinators, organizations providing software for level 0 and level 1 processing, technical experts designated by organizations contributing to the global DBNet, planning or considering to contribute to it, and the WMO Secretariat.

4. A focal point is designated within the DBNet Coordination Group to ensure liaison with the Inter-programme Expert Team on Data Representation Maintenance and Monitoring.

5. The DBNet Coordination Group meets nominally once a year, or more frequently if necessary.

6. The DBNet Coordination Group reports on its activities to CGMS and to the WMO Commission for Basic Systems (CBS) through the Inter-programme Expert Team on Satellite Utilization and Products (IPET-SUP). It receives guidance from CGMS, from CBS through IPET-SUP, and from representative user groups such as the International TOVS Working Group.

ANNEX 2. PROCEDURE FOR ADDING, MODIFYING OR REMOVING A STATION IN DBNET

The purpose of this procedure is to guide the station operator on the steps to be followed when including a new station in DBNet, or modifying the operation mode of a station, ensuring appropriate coordination and information sharing between all parties involved.

The following steps shall be followed for adding a new station:

Step 1: The station operator (or the regional/subregional coordinator) informs the WMO Space Programme Office (within the WMO Secretariat's Observing and Information Systems Department) of the characteristics of the new DBNet station:

- The latitude and longitude of the station (in degrees, with decimals);
- The name of the station;
- The three-letter abbreviated name;
- The centre administratively responsible for this station;
- The identifier of the centre in CCT C-1 or C-11 (if available);
- The identifier of the station as sub-centre of this centre in CCT C-12 (if available);
- The RTH or GISC that will transmit the data over the GTS or WIS Core Network;
- The CCCC identifier of this RTH or GISC;
- The DBNet services that will be supported by the station.

Step 2: If the centre is not yet identified in CCT C-11, or if the station is not yet identified in CCT C-12 as a sub-centre of this centre, the operator requests the addition of a code for the centre and/or the sub-centre in the relevant CCT. The procedure for amending the tables is to send a request from the Permanent Representative to the Secretary-General, or from the focal point for codes and data representation matters of the country/territory to the WMO Secretariat (Observing and Information Systems Department/WIS/Data Representation, Metadata and Monitoring Division, with copy to the Observing and Information Systems Department/SAT). The procedures for amending the tables are initiated after each update implementation in May and November.

Step 3: The operator implements the operational processes for acquisition, preprocessing, processing, coding and routing of DBNet products in accordance with the applicable DBNet technical specifications and procedures defined in Sections 3 and 4 of the present Guide.

Step 4: The station operator sends file samples by FTP for validation during a minimum test period of one week:

- To the RTH in charge of transmitting the data into GTS (if different from the operator);
- To the relevant DBNet regional coordinating centre;
- To the DBNet monitoring centre.

Step 5: The RTH and the regional coordinator check the consistency with DBNet conventions and the regularity and timeliness of the products. The global DBNet monitoring centre checks the consistency of the products with global data and their timeliness. They interact as appropriate with the station operator until full compliance is demonstrated.

Step 6: Once the test is successful, the operator:

- Informs the WMO Space Programme Office of the planned start of the routine dissemination, and of any change to the bulletin headings and file naming (if relevant);
- Requests the responsible RTH focal point in an appropriate manner so that the focal point can update relevant parts of *Weather Reporting* (WMO-No. 9), Volume C1 with respect to the new bulletins at least two months in advance. Advanced notification of Volume C1 will be released to WMO Members;
- Updates the discovery metadata record to share with the responsible DCPCs or GISCs.

Step 7: The Permanent Representative of the operator's country/territory or the regional or subregional coordinator informs the WMO Secretariat of changes to the DBNet operation and provides input for inclusion of an announcement in the World Weather Watch operational newsletter (http://www.wmo.int/pages/prog/www/ois/Operational_Information/index_en.html); the WMO Secretariat updates the DBNet documentation accordingly and takes any other appropriate action to inform the satellite community.

In case of modification or termination of a DBNet station operation, the operator informs the Space Programme Office of any change of status of the station – for instance if an additional DBNet service is ready to be implemented at the station. The production associated with the new service is implemented following steps 3 to 7 above.

If a service is cancelled, or the overall operation of a station is terminated, the operator:

- Informs the WMO Space Programme Office of the planned termination;
- Records the end of the bulletins in Volume C1;
- Deletes the discovery metadata record.

The WMO Space Programme Office updates the DBNet documentation accordingly.

ANNEX 3. DBNET RECEPTION-SCHEDULING PRIORITIES

Last update: May 2015

<i>Satellite</i>	<i>Orbit and satellite status (Descending/ Ascending)</i>	<i>Instrument health</i>	<i>Global data (DBNet impact is largest when global data are late)</i>	<i>DB transmission</i>	<i>DBNet priority (High/Medium/ Low)</i>
SNPP	NOAA Prime Polar Orbiter PM 1330A	Good	1 dump per orbit	Good (X-band). Occasional short gaps due to solar array obscuration	H
Metop-B	Primary AM service. 0930D	Good	Very good: Arctic and Antarctic dumps	Good (L-band)	H
NOAA-19	Prime NOAA Services Mission PM. Close to SNPP 1400A/0200D	Good	1 dump per orbit	Good (L-band)	H
NOAA-18	Has drifted to an early morning orbit 1700A/0500D	Good. HIRS degraded	Some blind orbits	Good (L-band)	H
Metop-A	Same orbital plane as Metop-B 0930D	Good	1 dump per orbit	Limited geographically	M
NOAA-15	Close to NOAA-18 0530D	Poor. AMSU-B and HIRS not working. AMSU-A is still useful	Some blind orbits. Low priority in NESDIS L1 processing	Poor signal strength (L-band). Can only be received by large dishes	L
FY-3C	1030D	MWTS-2 not working, MWHS-2 OK	Significant delays	Good (L-band for sounders, X-band for MERSI)	L

**ANNEX 4. EXTRACT OF THE MANUAL ON CODES (WMO-No. 306),
VOLUME I.2 – INTERNATIONAL CODES, PART C – COMMON FEATURES
TO BINARY AND ALPHANUMERIC CODES: EXTRACT OF COMMON CODE
TABLE C-13**

The present extract contains the satellite-related entries as of August 2015.

Link to current version: http://www.wmo.int/pages/prog/www/WMOCodes/WMO306_v12/LatestVERSION/WMO306_v12_CommonTable_en.docx.

<i>DATA CATEGORIES</i>		<i>INTERNATIONAL DATA SUBCATEGORIES</i>	
<i>BUFR edition 4 Octet 11 in Section 1</i>		<i>BUFR edition 4 Octet 12 in Section 1</i>	
<i>Code figure</i>	<i>Name</i>	<i>Code figure</i>	<i>Name (corresponding traditional alphanumeric codes are in brackets)</i>
3	Vertical soundings (satellite)	0	Temperature (SATEM)
		1	TIROS (TOVS)
		2	ATOVS
		3	AMSU-A
		4	AMSU-B
		5	HIRS
		6	MHS
		7	IASI
		20	IR temperature/humidity sounding
		30	Hyperspectral temperature/humidity sounding
		40	MW temperature/humidity sounding
50	Radio occultation sounding		

<i>DATA CATEGORIES</i>		<i>INTERNATIONAL DATA SUBCATEGORIES</i>	
<i>BUFR edition 4 Octet 11 in Section 1</i>		<i>BUFR edition 4 Octet 12 in Section 1</i>	
<i>Code figure</i>	<i>Name</i>	<i>Code figure</i>	<i>Name (corresponding traditional alphanumeric codes are in brackets)</i>
12	Surface data (satellite)	0	ERS-uwa
		1	ERS uwi
		2	ERS-ura
		3	ERS-uat
		4	SSM/I radiometer
		5	Surface temp./radiation (SATOB)
		6	Quikscat
		7	ASCAT data
		8	Soil moisture
		9	Normalized differential vegetation index (NDVI)
		10	Normalized radar backscatter
		11	Surface emissivity
12	Sea-surface temperature		
21	Radiances (satellite measured)	0	Earth radiation budget
		5	Cross-track infrared sounder
		6	Advanced technology microwave sounder
		7	Visible/infrared imager radiometer suite
22	Radar (satellite) but not altimeter and scatterometer	0	Cloud and precipitation radar
		1	Synthetic aperture radar
23	Lidar	0	Lidar based missions (for wind, for cloud/aerosol, for water vapour, for altimetry)

<i>DATA CATEGORIES</i>		<i>INTERNATIONAL DATA SUBCATEGORIES</i>	
<i>BUFR edition 4 Octet 11 in Section 1</i>		<i>BUFR edition 4 Octet 12 in Section 1</i>	
<i>Code figure</i>	<i>Name</i>	<i>Code figure</i>	<i>Name (corresponding traditional alphanumeric codes are in brackets)</i>
24	Scatterometry (satellite)	0	Wind scatterometry
25	Altimetry (satellite)	0	Radar altimetry
26	Spectrometry (satellite)	0 1 2 3 4	Cross nadir shortwave spectrometry (for chemistry) Cross nadir IR spectrometry (for chemistry) Limb sounding shortwave spectrometry Limb sounding IR spectrometry Limb sounding sub-millimetre wave spectrometry
30	Calibration dataset (satellite)	0	Subsetting data
		1	Collocated data
		2	On-board calibration data
		3	Bias monitoring
		4	Near real-time correction
		5	Re-analysis correction
101	Image data (satellite)	0	Multi-purpose VIS/IR imagery
		1	Conical scanning MW imagery (intermediate frequencies)
		2	Low frequency MW imagery
		3	Ocean colour imagery
		4	Imagery with special viewing geometry
		5	Lightning imagery
		6	High-resolution shortwave imagery for land observation
		7	SMOS data

ANNEX 5. EXISTING OR PROPOSED CODE VALUES FOR INSTRUMENTS USED IN DBNET

<p>"A₁" data type designator in GTS headings "T₁T₂A₁A₂ii" defined in the <i>Manual on the Global Telecommunication System</i> (WMO-No. 386) [AD.2] See current values in Table C6 in the "Explanation of Data Designators": http://www.wmo.int/pages/prog/www/ois/Operational_Information/Publications/WMO_386/AHLSymbols/TableDefinitions.html</p>		
Definition	Comment	Corresponding category/ subcategory in the Manual on Codes (WMO-No. 306), Volume 1.2, CCT C-13 [AD.1]
With T ₁ T ₂ = IN: A AMSU-A	Level 1 sounding products (Code values extracted from Table C6 as of 1/01/2016)	003 / 03
B AMSU-B		003 / 04
C CrIS (selected channels)		021 / 05
H HIRS		003 / 05
I IRAS		003 / 20
J HIRAS		003 / 30
K MWHS/MWHS-2		003 / 40
M MHS		003 / 06
Q IASI (PC scores)		003 / 07
S ATMS		021 / 06
T MWTS/MWTS-2		003 / 40
Additional codes (for information only)		
With T ₁ T ₂ = IE: A AMSU-A/METOP D IASI L2 products H HIRS/METOP M MHS/METOP Q IASI (PC scores)	Used by EUMETSAT with T ₁ T ₂ = IE for products from EUMETSAT satellites	003 / 03 003 / 07 003 / 05 003 / 06 003 / 07

ANNEX 6. PRODUCT IDENTIFIER FOR DBNET PRODUCT FILENAMES

Product identifier = <location indicator>, <data designator>, <free description> In the filename structure defined in the <i>Manual on the Global Telecommunication System</i> (WMO-No. 386) [AD.2]		
<i>DBNet convention for the location indicator</i>	<i>DBNet convention for the data designator</i>	<i>DBNet convention for the free description</i>
<Country ID - Organization- Production Centre>	<Instrument> Where: IASI = iasi CrIS = cris ATMS = atms MWTS = mwts MWHS = mwhs IRAS = iras HIRAS = hiras AMSU-A = amsua AMSU-B = amsub MHS = mhs	"DBNet+<satellite>+<station>" Where <satellite> is: NOAA-xx = noaaxx METOP-A = metopa METOP-B = metopb Suomi-NPP = snpp FY-3A = fy3a FY-3B = fy3b FY-3C = fy3c FY-3D = fy3d JPSS-1 = noaa20 JPSS-2 = noaa21 Where <station> is the DB receiving station (same as "originating sub-centre" in BUFR Section 1)
Example: "br-inpe-cpt" for a product generated by INPE in Cachoeira Paulista (Brazil)		Example: "DBNet+metopb+ath" for a DBNet product generated with METOP-B data received in Athens

Notes:

1. More explanations on "Accumulating messages into files" can be found in [AD.2], Part II, Attachment II-15, GTS data exchange methods.
2. The identifiers "rars" and "npp" are accepted as alternatives to "DBNet" and "snpp" for backward compatibility.

ANNEX 7. GLOSSARY

ATOVS	Advanced TIROS Operational Vertical Sounder (instrument package including HIRS, AMSU-A and AMSU-B)
CCSDS	Consultative Committee for Space Data Systems (http://public.ccsds.org/default.aspx); "CCSDS" also designates the data format standard defined by this committee
CCSDS to L0	The conversion from CCSDS to EPS level 0 is generally included in the receiving station software. It is also available from EUMETSAT as part of the Metopizer software
CDA station	A command and data acquisition station is a major ground facility of an LEO satellite programme
CSPP	Community Satellite Processing Package provided by NOAA through the University of Wisconsin for DB users
DBNet	A system based on the concept of RARS, but expanded to address a broader range of data and products, and a variety of formats and protocols, while complying with a set of technical specifications and procedures that are described in the present Guide
DBNet coordinator	Regional coordinator in charge of providing technical guidance to operators, monitoring timeliness, and maintaining online information for users, for a regional component of the global DBNet
DBNet monitoring centre	Organization in charge of DBNet product quality monitoring at the global scale (NWP SAF, Met Office)
DBNet operator	Organization responsible for data acquisition and preprocessing
DBNet station	Facility including a direct readout station that acquires the data
GODEX-NWP	Group for establishing and maintaining requirements for global data exchange for NWP centres
HIRLAM	High-resolution limited-area model, developed and maintained through a cooperation of European meteorological institutes for operational short-range weather forecasting
JPSS	The Joint Polar Satellite System programme's JPSS-1 and JPSS-2 satellites will be renamed NOAA-20 and NOAA-21 after successful launch
OPS-LRS	(Table 5) Level-1 processing package, which processes IASI instrument data from level 0 (raw instrument data) through to level 1c (calibrated, geolocated, Gaussian-apodized radiances). OPS-LRS is provided by EUMETSAT through NWP SAF as part of the AAPP deliverable
RARS	The Regional ATOVS Retransmission Service is an arrangement among HRPT station operators to acquire, preprocess, and share satellite sounding data from ATOVS instrument packages aboard NOAA and Metop satellites, in near real time, in accordance with agreed technical specifications, in support of NWP
RTH	Regional Telecommunication Hub of GTS

RT-STPS The Real-time Software Telemetry Processing System is a generalized CCSDS data processing package that ingests telemetry data from a spacecraft transmission in real time, performs multi-mission protocol processing, and produces output to a file or TCP/IP socket. RT-STPS is provided by the NASA Direct Readout Laboratory

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