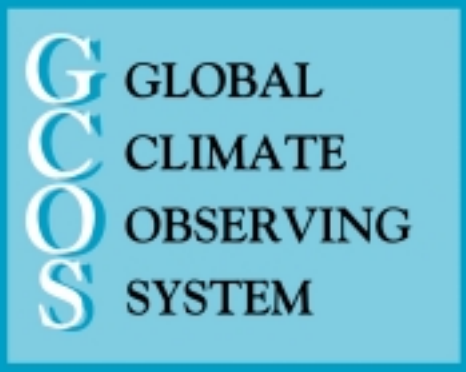

WORLD METEOROLOGICAL ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

GUIDE TO THE GCOS SURFACE AND UPPER-AIR NETWORKS: GSN AND GUAN

(Version 1.1)

September 2002

GCOS - 73

(WMO/TD No. 1106)

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(Harald Daan, De Bilt, Netherlands)

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Notes

1. The GSN and GUAN networks are based mainly on stations which are included in the networks of the WMO World Weather Watch Global Observing System (GOS). For more general standards for observations at these stations, reference is made to the Manual on the Global Observing System (WMO-No. 544) and the Guide on the Global Observing System (WMO-No. 488), published by the WMO.

2. This guide is the first issue of a document which is expected to be updated in the future, as required by significant new developments.

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Guide to the GCOS Surface and Upper-Air Networks: GSN and GUAN

Preamble

Climate and climate change research and applications require historical observational data from sources well distributed across the globe. In particular, it is of major importance that data from different locations and times are comparable or can be made comparable.

In practice, meteorological measurements are made at thousands of places all over the world, more or less regularly. The most essential subset of these observing stations is operating under the regime laid down by the World Meteorological Organization (WMO), involving clear commitments regarding the site, the exposure of instruments, error handling, units of measurement, coding and exchange of reports. In practice, this WMO Global Observing System (GOS) is implemented by National Meteorological and Hydrological Services (NMHSs) of WMO Members. The original prime purpose of the system was the provision of data in support of weather observation and forecasting, but it of course serves many other potential users.

Many requirements for climate applications and research are satisfied very well by the GOS. The needs of the climatological and the synoptic communities have much in parallel. In most situations where climate research notes shortcomings in the available data sets, synoptic meteorology suffers from the same problem. However, there are three main exceptions: homogeneity of the data time-series relating to observing practices; representativeness of the environment; and homogeneity of the environment.

Homogeneity of data:

For climate research and analysis, it is very important that data be inter-comparable over the entire record. This holds in particular for data from the same location for different times. Problems for climate can be encountered over a long-period record through changes in observing practices, including instrumentation. For real-time use, such changes do not negatively affect the applications; in general they will improve operations. For climate research, however, and many applications, such changes can raise major problems. If no specific measures are taken, the value of a historical time series of observations can be severely reduced.

Representativeness of the environment:

Observing sites have been traditionally located at airports, in harbours, and in or near cities. The oldest observing sites can often be found along the seaside (and near the NMHS headquarters, in many cases in the capital city). This is not surprising, as maritime purposes were the first incentive for applications of meteorology. However, these sites do not necessarily provide the best representation for the climate in the area of concern. Current weather information and weather forecasts focus on locations where people are living and working; climate research has different criteria.

Homogeneity of the environment:

A vital requirement for time-series data is homogeneity, not only of observing practices and instrumentation (see above), but also of the environment in which the measurements are taken. Since observing sites are often established where people are living, the environment

has a tendency to change continuously. Stations that have been established with different goals in mind, in particular climatic goals, are sparse. While there are indeed stations on mountain tops and slopes, on uninhabited islands, in deserts, in icy regions, in national parks, and simply in rural areas, these stations are often not operating under NMHS responsibility and with WMO commitments. In many cases there is no organization which can guarantee the continuity of such a station even into the near future.

Considerations regarding the environment and changes are less crucial for upper-air observations than for surface measurements. Except for some influence in the boundary layer, radiosonde observations are generally not affected by an environmental change or even by moving a station over a distance of less than, say, 20 kilometres. On the other hand, a change or variability of observing instruments has a much larger impact. Methods of observing the meteorological conditions in the troposphere and lower stratosphere are developing rapidly, particularly in the case of remote-sensing systems (satellites, profilers). At this time, it is not foreseeable whether or within what time frame a stabilization will take place. In any case, it is extremely important to prepare for a smooth transition that allows for comparison of the results of old and new data acquisition systems.

To date, no new system has proved to be competitive with the radiosonde system with regard to *in situ* accuracy and consistency. The latter has been operated since about 1950, and the results should remain valuable for climate research in future. This implies that a minimum configuration of stations should be preserved well into the 21st century, at least until about 20 years after other new systems may have taken over the basic tasks. Even in that case, this minimum configuration may be useful for a longer time for calibration and validation procedures.

In order to serve specifically the needs of global climate applications, two networks of observing stations have been established as Global Climate Observing System (GCOS) Baseline Networks, mainly on the basis of existing GOS networks. These are:

- the GCOS Surface Network (GSN) (987 stations as of 31/12/01)
- the GCOS Upper-Air Network (GUAN) (150 stations as of 31/12/01)

These networks form a minimum configuration required for global applications. Regional climatic needs can be much more extensive, and it is anticipated that such needs will be served by more dense networks on a regional basis, possibly with more extensive requirements for observing programmes and specifications. The organization of the GSN and GUAN and the implications for stations that are included are described in the following sections.

1. SCOPE AND PURPOSE OF THE NETWORKS

1.1 GSN

The GSN is intended to comprise the best possible set of land stations with a spacing of 2.5 to 5 degrees of latitude, thereby allowing coarse-mesh horizontal analyses for some basic parameters (primarily Temperature and Precipitation). The criteria for selection include:

- The commitments NMHSs can accept with regard to continuity;
- Geographical representativeness of observations;
- Length and quality of historical time series;
- Available parameters.

It is recognized that the coarse network density limits the applicability for some applications. For parameters having smaller-scale horizontal variability (e.g., precipitation), it is accepted that the network data generally should be supplemented by those from networks with a finer mesh.

The purposes of the GSN are the following:

- To establish national commitments for the preservation of a set of valuable climate stations for the foreseeable future;
- To build a collection of validated data from these stations in standardized formats;
- To provide this information to the global climate community with no formal restrictions;
- To create a baseline and benchmark data set for more enhanced regional and subregional climate networks and for newly-developed observing systems, including remote-sensing systems.

1.2 GUAN

The scope of the GUAN is somewhat different from the GSN in that the relation to the surface environment is not of major importance. For this reason, and also for practical reasons, the spacing is set at 5 to 10 degrees latitude, quite sufficient to resolve synoptic-scale waves. The desired parameters are temperature, pressure (geopotential height), wind, and humidity (at least in the troposphere). The inclusion criteria are:

- The commitments NMHSs can accept with regard to continuity;
- Length and quality of historical time series;
- Current measurement quality.

The purposes of the GUAN are the following:

- To establish national commitments for the preservation of a minimum set of upper-air stations for the foreseeable future;
- To build a collection of validated data from these stations in standardized formats;
- To provide this information to the global climate community with no formal restrictions.

2. COMMITMENTS BY STATION OPERATORS

Inclusion of a station in the networks requires that certain commitments be made by the WMO Member concerned (normally represented by the responsible NMHS). These commitments are:

(i) The NMHS shall make its best efforts to continue the operation of the station at the required performance level for the foreseeable future.
(ii) The NMHS shall provide for the dissemination of monthly CLIMAT and/or CLIMAT TEMP reports in accordance with WMO WWW Regulations.
(iii) The NMHS shall provide for the transfer of historical data to the World Data Centre for Meteorology - Asheville (NCDC, Asheville, USA) in the required formats (e.g. Annex B).
(iv) The NMHS shall provide for the transfer of metadata (station location and altitude, description of environment, exposure, observation practices and instrumentation, past changes) to the World Data Centre - Asheville in the required formats (e.g. Annex B).
(v) The NMHS shall ensure that the information on the station as recorded in WMO Publication No. 9, Volume A, is correct.
(vi) The NMHS shall endorse the classification of all data provided under this commitment as "Essential" in the context of Resolution 40 of the twelfth World Meteorological Congress (Geneva, 1995).
(vii) The NMHS shall nominate a focal point within the Service for direct contact at the working level with the GCOS Secretariat, the Monitoring and Analysis Centres, and the GCOS/AOPC Advisory Group on the GSN and GUAN (AGG).

Notes:

Adherence to the rules for dissemination of CLIMAT and CLIMAT TEMP reports includes the assignment of a WMO block and index number to the station.

According to the WWW Regulations, CLIMAT and CLIMAT TEMP reports should be provided by the 5th day of the month following the month to which the data refer, and not later than the 8th day.

A summary of ‘Best Practices’ involved in discharging these commitments is included in the WMO Manual on the Global Observing System and reproduced in Annex A of this guide. Also included there are the GCOS Climate Monitoring Principles, which have been adopted by the Conference of the Parties (COP) to the UN Framework Convention on Climate Change (UNFCCC) and to which all GCOS systems are expected to adhere.

3. STATION SELECTION CRITERIA

The criteria for inclusion of stations in the networks are defined at two levels:

- Target Requirements (TRQs) are those that are ideally to be satisfied. Stations meeting all the TRQs shall have priority over stations that are deficient in that respect in some way.
- Minimum Requirements (MRQs) are the bare minimum that must be satisfied for inclusion.

The "required performance level" in commitment 2 (i) refers to the Target Requirements.

3.1 Statement of commitment

A written statement of commitment by the responsible NMHS is a Minimum Requirement.

3.2 Observed parameters

(i) For the GSN, the requirements are as follows:

MRQs:

- Monthly means of daily maximum, minimum and mean temperature.
- Monthly precipitation amounts.

TRQs (in addition to the MRQs):

- Temperature: monthly mean, minimum, and maximum.
- Pressure: monthly mean values, station level and mean sea level.
- Precipitation: number of days with precipitation.
- Temperature: daily mean, minimum and maximum.
- Daily precipitation amounts
- Pressure: daily mean, station level and mean sea level.

If only monthly values are available, the number of days used in the calculation should be provided as a Minimum Requirement.

(ii) For the GUAN, the requirements should be interpreted such that every month at least one observation on each of at least 25 days should attain the MRQs. The observing frequency (1 or 2 per day) in itself is not a criterion, although the Target Requirement for observation frequency is 2 per day, in accordance with WWW regulations for radiosonde observations.

MRQs:

- Temperature up to 100 hPa.
- Humidity up to the tropopause.
- Wind direction and speed up to 100 hPa.

TRQs (in addition to the MRQs):

- Temperature and wind up to 5 hPa.

3.3 Accuracy and homogeneity of observations

(i) For the GSN, the accuracy criteria are identical to the WWW requirements for synoptic observations.

(ii) For the GUAN, the criteria are defined as the RMS departures of observed values from 6-hour guess field values, in accordance with the practical verification schemes applied by the GUAN Monitoring Centre (ECMWF) for upper-air observations:

MRQs:

- Geopotential at 100 hPa: 80 metres.
- Wind vector at 300 hPa: 8 m/s.

TRQs:

From practical results, it appears that the minimum (best) values feasible for these parameters are about 10 metres and 4 m/s.

3.4 Homogeneity of observations

The GSN and GUAN biases, including those due to changes in the local environment, should be limited if at all possible to the values in the following table, to prevent misinterpretation of climatic changes:

Network	Parameter	MRQ	TRQ
GSN	Temperature	0.3 °C	0.1 °C
	Dewpoint	0.3 °C	0.1 °C
	Precipitation totals	2%	1%
GUAN	Temperature	0.2 °C	0.1 °C
	Specific humidity	2% of present climatological average	1% of present climatological average
	Wind	2 m/s	1 m/s

3.5 CLIMAT and CLIMAT TEMP submission

For GSN stations, regular submission of CLIMAT reports via WMO/GTS channels in the current code is a Minimum Requirement. The Target Requirement is that reception of reports in the GSN Monitoring Centres should be 100%. In case of GTS failures, other means (mail, facsimile, electronic mail, etc.) should be used.

It is not possible to define exact Minimum Requirements for this provision of data, except by the time limit for submission. However, when an included station fails consistently to provide the expected reports, a decision on exclusion will be taken on the basis of an assessment of whether this failure is of a temporary nature or not.

For GUAN stations, the provision of CLIMAT TEMP reports is a Target Requirement. Also in this case a definition of Minimum Requirements is not obvious. Moreover, the provision of

CLIMAT TEMPS depends on the availability of individual observations, which is often a weak spot in practice.

3.6 Historical record

For the GSN, the Minimum Requirements relate to Temperature and Precipitation, for which historical monthly series should have a length of at least 20 years. The Target Requirements for all parameters are set at 50 years. The time series should be homogeneous, or should allow for homogenisation through the provision of appropriate metadata.

The GUAN criteria are defined through numbers of individual observations. The Minimum Requirement is 5,000 upper-air observations, equivalent to about 15 years of 1 observation per day (or 7.5 years at 2 per day). The Target Requirement is 15,000 observations.

3.7 Submission of historical data

This refers mainly to the GSN historical data, since most historical GUAN data are already available in the World Data Centres (WDCs). However, as many of the historical GUAN data were received through sometimes unreliable telecommunication, a TRQ is to replace them by nationally-digitized and quality-controlled data.

The provision of the complete record of historical data for parameters identified under 3.2 "MRQs" is a Minimum Requirement. Provision of other data is a Target Requirement. Submission should be made following the format requested by the World Data Centre-Asheville (see Annex B) if possible, but other formats will be accepted if necessary.

In addition to historical data sets containing the original observations at a GSN station, some Members may have produced a homogenized or adjusted data set. In such cases, Members are requested to provide both the original and modified data set along with appropriate documentation. Knowledge about processing that has already been done on a data set is important to understanding the data.

3.8 Spacing criteria

The following criteria have been agreed:

- The network stations should be well distributed over the globe.
- Particular value is assigned to high-elevation stations.
- Spacing considerations should take account of the fact that interannual and longer-term climate variations show strong spatial patterns in middle latitudes.

For the GSN, the horizontal distance D between two network stations should not be less than the length of 2.5 degrees of longitude at that location (278 km at the equator). For stations beyond 60 degrees latitude (north or south) the minimum distance is fixed at the length of 2.5 degrees of longitude at 60 degrees latitude (139 km). Consequently, the minimum spacing varies from 278 km at the equator to 139 km in the polar regions.

An exception is made in cases where the difference in elevation of two stations is at least 1000 metres, in which case the criteria for minimum horizontal distance are not applicable.

(Note that in the original selection of GSN stations, a more sophisticated approach was used. In a small number of cases, selected stations do not meet the above criteria. In these cases, the new spacing rules are not applied rigorously.)

3.9 Location criteria

A Target Requirement is that the location of GSN stations should not be subject to major changes in the environment, nor to human activities influencing the local climate. In practice this implies a strong preference for stations in rural areas.

4. MONITORING, ANALYSIS AND ARCHIVING ACTIVITIES

The broad responsibilities of the GSN and GUAN monitoring, analysis and archiving facilities are outlined in Annex C of this Guide.

The provision by the station operators of CLIMAT and CLIMAT TEMP reports, and the submission of historical data, will be monitored on a regular basis. In particular, the criteria for inclusion in the networks will be addressed clearly in the monitoring activities.

The following centres have been assigned responsibility in the framework of these activities.

4.1 Monitoring of near-real-time data (CLIMAT and CLIMAT TEMP reports)

GSN Monitoring Centre (DWD and JMA):

Routine monitoring of CLIMAT reports will be done jointly by the Deutscher Wetterdienst (DWD) in Offenbach, Germany (for Precipitation) and the Japan Meteorological Agency (JMA) in Tokyo, Japan (for Temperature) in their capacity as the GSN Monitoring Centre (GSN MC). The results reported will include the degree of availability of monthly reports and a breakdown to identify incorrectly coded and formatted reports, as well as the basic quality of the values for temperature and precipitation.

GUAN Monitoring Centre (ECMWF and Hadley Centre):

Monitoring of daily TEMP messages will be performed by the European Centre for Medium-range Weather Forecasts (ECMWF) in Reading, UK, and monitoring of CLIMAT TEMP reports will be performed by the Hadley Centre of the UK Met Office, in their capacity as the GUAN Monitoring Centre (GUAN MC). The reports on TEMPs will include availability of messages and a breakdown indicating reports attaining certain critical levels of height (100 and 10 hPa), as well as RMS departures of observed values from the model initial guess field values.

The information from the Monitoring Centres will be presented in monthly or semi-annual reports which will include an update of agreed Performance Indicators (see Annex D). Monitoring results will include all stations which are in the GSN and GUAN lists.

4.2 Data analysis and archiving

GSN Analysis Centre (NCDC) and GSN Archive (WDC-Asheville):

The US National Climatic Data Center (NCDC) in Asheville, USA, will examine the quality of the GSN data and carry out analyses in its capacity as the GSN Analysis Centre (GSN AC).

The World Data Center for Meteorology-Asheville (at NCDC) will serve as the archive for all GSN data, both historical and those regularly submitted by the GSN MC through the monitoring activity. Archived results will include the degree of availability of monthly and daily data per decade (10-year period) as well as the metadata. The data themselves will be made available through the regular distribution channels of the WDC-Asheville.

GUAN Analysis Centre (Hadley, NCDC) and GUAN Archive (WDC-Asheville):

Analysis of TEMP and CLIMAT TEMP reports will be performed by the Hadley Centre of the UK Met Office and NCDC in their capacity as the GUAN Analysis Centre (GUAN AC). The Analysis Centre will provide an annual report, including updates of the Performance Indicators (see Annex D).

WDC-Asheville will act as the archive for all GUAN data and make them available through its regular distribution channels.

5. COMPOSITION OF THE NETWORKS

The lists of GSN and GUAN stations are available via the GCOS Web site at http://www.wmo.ch/web/gcos/gcoshome.html, as well as being published in the regular monitoring reports. While it is inevitable that some changes in the networks will occur due to circumstances beyond the control of the station operator, it is a fundamental obligation of the station operators to keep changes to an absolute minimum. When minor modifications to stations are made, WMO will be notified in the normal manner. Requests for additions to, or deletions from, the networks should be made to GCOS through the WMO. Such requests will be considered by the Atmospheric Observation Panel for Climate (AOPC) in the context of the networks as a whole. AOPC recommendations and proposals for modifications will be submitted for endorsement to the WMO Commission for Basic Systems (CBS) and the Presidents of the WMO Regional Associations concerned, since the GCOS network stations are to be included in the Regional Basic Climatological Network (RBCN).

Selected Bibliography

GCOS-26 (WMO/TD-No. 766) Report of the Joint CCl/CBS Expert Meeting on the GCOS Surface Network (Norwich, UK, March 25-27, 1996)

GCOS-34 (WMO/TD-No. 799) Initial Selection of a GCOS Surface Network, February 1997

GCOS-35 (WMO/TD-No. 839) Report of the second Joint CCl/CBS Meeting on the GCOS Surface Network (De Bilt, The Netherlands, June 25-27, 1997)

GCOS-53 (WMO/TD-No. 958) GCOS Surface Network (GSN) Monitoring Centre Implementation Meeting (Offenbach, Germany, January 19-20, 1999)

Peterson, T., H. Daan and P. Jones: Initial Selection of a GCOS Surface Network, Bull. Amer. Met. Soc. **78**, No. 10, October 1997, pp. 2145-2152.

Wallis, T.W.R.: A Subset of Core Stations from the Comprehensive Aerological Reference Data Set (COADS), Journal of Climate **11**, February 1998, pp. 272-282.

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ANNEXES

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Annex A

Best Practices and Principles

A1: Best practices for GSN stations (Manual on the Global Observing System, WMO-No. 544, 2.10.3.17)

- Long-term continuity should be provided for each GSN station. This requires the provision of the necessary resources, including well-trained staff, and keeping changes of location to a minimum.

- In case of significant changes in sensor devices or station location, Members should provide for a sufficiently long period of overlap (at least one, but preferably two years) with dual operation of old and new systems to enable comparisons to be made and the identification of inhomogeneities and other measurement characteristics.

- CLIMAT data should be provided in an accurate and timely manner. CLIMAT reports should be transmitted by the fifth day of the month but not later than the eighth day of the month.

- Rigorous quality control should be exercised on the measurements and their message encoding. CLIMAT reports require quality control of the measurements themselves and their message encoding to ensure their accurate transmission to national, regional and world centres for their use. Quality control checks should be made on site and at a central location designed to detect equipment faults at the earliest stage possible. The Guide to Instruments and Methods of Observation (WMO No 8) provides the appropriate recommendations.

- The site layout should follow the recommended form (Guide on the GOS, WMO No 488).

- The site and instruments should be inspected regularly and maintained according to WMO recommended practices (Guide to Instruments and Methods of Observation (WMO No 8). As part of the maintenance, the necessary calibration practices should be traceable to the standards provide by the Guide.

- A national plan should be developed to archive daily data and metadata pertaining to each climate station. Metadata should include data concerning a station's establishment, subsequent maintenance, and changes in exposure, instrumentation and staff. The data and metadata should be in its original form as well as in digital format.

- Detailed metadata and historical climate data for each GSN station should be provided to the GSN Archive. Both data and metadata should be up-to-date.

A2: Best practices for GUAN stations (Manual on the Global Observing System, WMO-No. 544, 2.10.4.9)

- Long-term continuity should be provided for each GUAN station. This requires the provision of the necessary resources, including well-trained staff, and keeping changes of location to a minimum.

- Changes of bias caused by changes in instrumentation should be evaluated by a sufficient overlapping period of observation (perhaps, as much as a year) or by making use of the results of instrument intercomparisons made at designated test sites.

- Soundings should preferably be made twice a day and should reach as high as possible, noting the GCOS requirements for ascents up to a height of 5 hPa. Because climate data are needed in the stratosphere to monitor changes in the atmospheric circulation, composition and chemistry, every effort should be made to maintain soundings regularly up to a level as high as possible noting the above GCOS requirement.

- CLIMAT TEMP data should be provided in an accurate and timely manner. CLIMAT TEMP reports should be transmitted by the fifth day of the month but not later than the eighth day of the month.

- Rigorous quality control should be exercised at each GUAN site. Periodic calibration, validation and maintenance of the equipment should be carried out to maintain the quality of the observations.

- Basic checks should be made before each sounding to ensure accurate data. Checks should also be made during and at the end of each sounding to assure corrections of incomplete soundings or errors before transmission.

- Back-up radiosondes should be released in cases of failure in order to maintain the record from the GUAN station.

- Detailed metadata should be provided. The batch identifier on the radiosondes should be logged for each flight, so that faulty batches can be identified and the data amended or eliminated from the climate records if necessary. Up-to-date records of metadata in a standard format should be provided to the GUAN Archive so that shifts in the data will not be mistaken for climate change. The metadata should include detailed information about the station such as location, elevation, operating instruments and their changes over time. Changes to operating and correction procedures should also be recorded. Both the corrected and uncorrected upper-air observation should be archived. Climate change studies require extremely high stability in the systematic errors of the radiosonde measurements.

A3: GCOS Climate Monitoring Principles

Effective monitoring systems for climate should adhere to the following principles:*

1. The impact of new systems or changes to existing systems should be assessed prior to implementation.

2. A suitable period of overlap for new and old observing systems is required.

3. The details and history of local conditions, instruments, operating procedures, data processing algorithms and other factors pertinent to interpreting data (i.e., metadata) should be documented and treated with the same care as the data themselves.

4. The quality and homogeneity of data should be regularly assessed as a part of routine operations.

5. Consideration of the needs for environmental and climate-monitoring products and assessments, such as IPCC assessments, should be integrated into national, regional and global observing priorities.

6. Operation of historically-uninterrupted stations and observing systems should be maintained.

7. High priority for additional observations should be focussed on data-poor regions, poorly-observed parameters, regions sensitive to change, and key measurements with inadequate temporal resolution.

8. Long-term requirements should be specified to network designers, operators and instrument engineers at the outset of system design and implementation.

9. The conversion of research observing systems to long-term operations in a carefully-planned manner should be promoted.

10. Data management systems that facilitate access, use and interpretation of data and products should be included as essential elements of climate monitoring systems.

Furthermore, satellite systems for monitoring climate should adhere to the following specific principles:

11. Rigorous station-keeping should be maintained to minimize orbital drift.

12. Overlapping observations should be ensured for a period sufficient to determine inter-satellite biases.

13. Satellites should be replaced within their projected operational lifetime (rather than on failure) to ensure continuity (or in-orbit replacements should be maintained).

14. Rigorous pre-launch instrument characterization and calibration should be ensured.

15. Adequate on-board calibration and means to monitor instrument characteristics in space should be ensured.

16. Development and operational production of priority climate products should be ensured.

17. Systems needed to facilitate user access to climate products, metadata and raw data, including key data for delayed-mode analysis, should be established and maintained.

18. Continuing use of still-functioning baseline instruments on otherwise de-commissioned satellites should be considered.

19. The need for complementary in-situ baseline observations for satellite measurements should be appropriately recognized.

20. Network performance monitoring systems to identify both random errors and time-dependent biases in satellite observations should be established.

** The ten basic principles were adopted (in paraphrased form) by the Conference of the Parties to the UN Framework Convention on Climate Change through Decision 5/CP.5 of COP-5 at Bonn in November, 1999.*

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Annex B

Format for Submission of GSN Historical Data

Data Format and Supporting Documentation for WMO Members to Use when Providing Digital Historical Data and Metadata for GCOS Surface Network Sites to the World Data Center for Meteorology – Asheville at the U. S. National Climatic Data Center

Part 1: General Description of Requested Data and Information

Meteorological Data:

Participating Members are asked to provide historical meteorological data in digital form from all GCOS Surface Network (GSN) stations. All parameters that can be made available for each station are requested. The historical data should be provided at one time. Details of the daily and monthly formats for the historical data are described in Part 2. Details of the station history format are described in Part 3.

Meteorological data in a form that is not digital cannot be processed at this time. However, if some observations are available only as non-digital data, information about this data is requested. Copies of the data are also requested.

Following is a list of the meteorological variables that participating Members are asked to provide. Please see "Notes:" after the list for additional information and clarification:

1. Mean daily temperature
2. Daily maximum temperature
3. Daily minimum temperature
4. Mean daily station pressure
5. Mean daily station pressure corrected to sea level
6. Total daily precipitation

7. Mean monthly temperature
8. Mean monthly maximum temperature
9. Mean monthly minimum temperature
10. Mean monthly station pressure
11. Mean monthly station pressure corrected to sea level
12. Total monthly precipitation

Notes:

A "mean", or average, is calculated by using the current method of the Member that operates the station. Each Member is asked to describe the method used.

"Daily" means each day of each month of each year that observations have been taken at a GSN station. It is all data days. In a similar way, "monthly" means each month of each year that observations have been taken at a GSN station.

If frozen precipitation is observed and will be included in the total precipitation, the water equivalent amount of frozen precipitation should be used.

Data Set Documentation:

In addition to data sets containing the original observations at a GSN station, some Members may have produced a homogenized data set or an adjusted data set. In such cases, Members are requested to provide both the original and modified data set along with appropriate documentation. Knowledge about processing that has already been done on a data set is important to understanding the data.

Station History Data (Metadata):

Stations sometimes change location, instrumentation, environment, schedules, and other parameters. Knowledge about these parameters is important to understanding the meteorological data. Participating Members are asked to provide historical information about these station changes for the stations that they operate.

Ideally, historical station information should include the following parameters:

Station identification
Station name
Member name
Dates when changes occurred (year-month-day)
Latitude
Longitude
Elevation
Observation schedule and procedures
Types of instruments used for observations
Height of instruments above ground
Methods used to calculate mean, or average
Environment within 10 metres of the instruments
Land use in 10 square kilometres around the station

Sending the Data/Metadata:

Station operators are kindly requested to send the historical data and related metadata from GSN stations to:

World Data Center for Meteorology, Asheville
National Climatic Data Center
Federal Building
151 Patton Avenue, Room 120
Asheville, NC 28801-5001, U.S.A.
Telephone Number: +1-828-271-4445
Fax Number: +1-828-271-4246
Email: wdcamet@noaa.gov

Part 2: Formats and Media of Requested Daily and Monthly Data

Daily Meteorological Data:

It is important that all GCOS Surface Network data be able to be converted into a single standard format. Rather than converting it yourself to that format, the National Climatic Data Center can do that for you. However, the National Climatic Data Center will need to know exactly how to read your data and what the units are in which the data are stored.

Therefore, please provide the World Data Center with a digital copy of the data and instructions on how to read it. A copy of the program you use to read the data or used to write the data will greatly facilitate this process.

The data and instructions may be provided on a variety of media including standard 3½-inch diskettes, a couple of different types of magnetic tape, or via email or the use of FTP. The National Climatic Data Center has found that data exchange and reformatting of the data work best if communication between NCDC and the individual providing the data is present before the data exchange starts. Therefore, please contact NCDC by calling +1-828-271-4281 or emailing GCOS.NCDC@noaa.gov as the first step in providing digital data to the GSN Archive.

Data Set Documentation:

If an existing meteorological data set is used to provide the meteorological data requested above, documentation for this existing data set is requested.

Part 3: Formats and Media of Requested Station History Data (Metadata)

Station History Data (Metadata):

Station data is of little use without metadata (or data about the data). The most basic metadata that we all rely on are the location and elevation of the station, but a wide variety of other metadata are useful for interpreting the data. These include information on the type of thermometer and shelter used, how the shelter and thermometer might have changed over the years, how the station location moved and when, what the land use/land cover is at the station location and how that has changed over time, etc. Different countries and agencies have different types of station history information. Whatever you provide to the World Data Center will be provided to users of the data.

A variety of formats and media are acceptable for the metadata. Please contact NCDC by calling +1-828-271-4281 or emailing GCOS.NCDC@noaa.gov as the first step in providing station history information to the GSN Archive.

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ANNEX C

GSN-GUAN Data Monitoring, Analysis and Archiving Structure

The GSN-GUAN Data Monitoring, Analysis and Archiving Structure includes monitoring the availability of data, quality control, the analysis of the data, product development, and archiving of the final data sets. Detailed responsibilities of the individual components are given below.

A. GCOS Monitoring Centre (DWD and JMA for GSN; ECMWF and Hadley Centre for GUAN)

The tasks of a GCOS Monitoring Centre are to:

- Monitor the availability, timeliness and completeness of the incoming data and messages received via GTS or other communication medium with the objective of improving the performance of the network being monitored;
- Perform fundamental quality-control and assurance procedures on the incoming data and metadata to ensure the basic quality and completeness of the data set;
- Make basic quality-controlled data available to National Meteorological and Hydrological Services (NMHSs) and World Data Centres (WDCs) and others for their use in a variety of climate applications and products.

B. GCOS Analysis Centre (NCDC for GSN; Hadley Centre and NCDC for GUAN)

A GCOS Analysis Centre will provide higher-level quality control of both the daily and monthly GCOS network data.

- For the daily data, this will include updating and quality-controlling the data, applying bias corrections, calculating monthly statistics from daily data and providing daily and derived monthly data, metadata and products to users;
- For the monthly data, this will include analyzing the data; improving bias adjustments and the monthly station data base; creating global and regional monthly statistics; and developing and providing gridded products with reduced biases;
- The centre will also report on historical data and metadata reception.

C. GCOS Archive (WDC-Asheville for GSN and GUAN)

A GCOS Archive should be co-located with a World Data Centre (WDC) or recognized, established data centre, if possible.

- It will archive both the monthly and the daily data (in delayed-mode), as well as historical data, including metadata, for each station.
- A GCOS archive will make all GCOS data and products available to all potential users on a free and unrestricted basis.
- Data in the WDC may come either from data available at WDCs (e.g., from the Global Historical Climatology Network (GHCN)); from quality-controlled data available at the Monitoring Centres; from data submitted, upon request, by national centres (e.g., NMHSs) and available digitally and updated on a routine basis, or from any other source openly available to the archive for unrestricted further distribution.

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ANNEX D

Presentation of Performance Indicators

Performance Indicators for semi-annual reports will be provided in the following formats:

Notes:
The information should be provided in a fixed-width format or fixed field delimiters, allowing for importing in a spreadsheet or database.
In the symbolic forms below, spaces and new lines denote field delimiters.
The number of characters in each field denote the length of the field.
The location indicator refers to the location of the station on the globe and allows for a quick sorting.

GSN:

Symbolic form:
LLll IIiii NNNNNNNNNN CCC R
a p m h s
CA CC CT CR
SYSY EYEY TTTTTTTTTT tttttttttt RRRRRRRRRR rrrrrrrrrr M

Legend:

- Identification:

LLll location indicator
IIiii WMO block and index number
NNNNNNNNNN First 10 characters of station name
CCC UN 3-letter country code
R WMO Region

- Status:

a "y" if inclusion approved by AOPC
p "y" if inclusion approved by PR
m "t" or "m" if Monitoring Centres report accordance with TRQs or MRQs
q "y" if overall quality of actual reports is within the MRQ limits
h "t" or "m" if Data Centres report accordance with TRQs or MRQs
s "y" if spacing requirements are met

- Monitoring Centres provide:

CA number of months for which a CLIMAT report was received in the last 12 months
CC number of months for which a correct CLIMAT report was received
CT number of available non-suspect monthly mean temperature values
CR number of available non-suspect monthly precipitation amounts

- Archives provide:

SYSY starting year of the first available data
EYEY end year: last year for which data were stored
T availability of monthly temperature data for each decade in the past 100 years
t availability of daily temperature data for each decade in the past 100 years
R availability of monthly precipitation data for each decade in the past 100 years
r availability of daily precipitation data for each decade in the past 100 years
M M=1 if metadata (including station history) were supplied; otherwise M="."

Note: Availability is provided in tenths: 0=1-10%, 1=11-20%, ... , 9=91-100%.
Non-availability of data is recorded with a period (".")

GUAN:

Symbolic form:
LLll IIiii NNNNNNNNNN CCC R
a p m h s
UA UT0 UT1 UT2 UDH UBH UDW
SYSY EYEY UUUUUU WWWWWW M

Legend:

- Identification:

LLll location indicator
IIiii WMO block and index number
NNNNNNNNNN First 10 characters of station name
CCC UN 3-letter country code
R WMO Region

- Status:

a "y" if inclusion approved by AOPC
p "y" if inclusion approved by PR
m "t" or "m" if Monitoring Centres report accordance with TRQs or MRQs
q "y" if overall quality of actual reports is within the MRQ limits
h "t" or "m" if Data Centres report accordance with TRQs or MRQs
s "y" if spacing requirements are met

- Monitoring Centre provides:

UA number of months for which a CLIMAT TEMP report was received in the last 12 months
UT0 number of received TEMP reports
UT1 number of received TEMP reports up to 100 hPa
UT2 number of received TEMP reports up to 10 hPa
UDH RMS departure of 100 hPa geopotential height from guess field in metres
UBH bias in departure of 100 hPa geopotential height from guess field in metres
UDW RMS departure of 300 hPa wind vector from guess field in 0.1 m/s

- Data Centres provide:

SYSY starting year of the first available data
EYEY end year: last year for which data were stored
U availability of radiosonde data for each decade in the past 60 years
W availability of wind data for each decade in the past 60 years
M M=1 if metadata (including station history) were supplied; otherwise M="."

Note:
Availability is provided in tenths: 0=1-10%, 1=11-20%, ... , 9=91-100%.
Percentage calculation is based on a maximum of 730 obs/year.
Non-availability of data is recorded with a period (".")

LIST OF GCOS PUBLICATIONS*

GCOS-1 (WMO/TD-No. 493)	Report of the first session of the Joint Scientific and Technical Committee for GCOS (Geneva, Switzerland, April 13-15, 1992)
GCOS-2 (WMO/TD-No. 551)	Report of the second session of the Joint Scientific and Technical Committee for GCOS (Washington DC, USA, January 11-14, 1993)
GCOS-3 (WMO/TD-No. 590)	Report of the third session of the Joint Scientific and Technical Committee for GCOS (Abingdon, UK, November 1-3,1993)
GCOS-4 (WMO/TD-No. 637)	Report of the fourth session of the Joint Scientific and Technical Committee for GCOS (Hamburg, Germany, September 19-22, 1994)
GCOS-5 (WMO/TD-No. 639)	Report of the GCOS Data System Task Group (Offenbach, Germany, March 22-25, 1994)
GCOS-6 (WMO/TD-No. 640)	Report of the GCOS Atmospheric Observation Panel, first session (Hamburg, Germany, April 25-28, 1994)
GCOS-7 (WMO/TD No. 641)	Report of the GCOS Space-based Observation Task Group (Darmstadt, Germany, May 3-6, 1994)
GCOS-8 (WMO/TD No. 642) (UNEP/EAP.MR/94-9)	Report of the GCOS/GTOS Terrestrial Observation Panel, first session (Arlington, VA, USA, June 28-30, 1994)
GCOS-9 (WMO/TD-No. 643)	Report of the GCOS Working Group on Socio-economic Benefits, first session (Washington DC, USA, August 1-3, 1994)
GCOS-10 (WMO/TD-No. 666)	Summary of the GCOS Plan, Version 1.0, April 1995
GCOS-11 (WMO/TD-No. 673)	Report of the GCOS Data and Information Management Panel, first session (Washington DC, USA, February 7-10, 1995)
GCOS-12 (WMO/TD-No. 674)	The Socio-economic Benefits of Climate Forecasts: Literature Review and Recommendations (Report prepared by the GCOS Working Group on Socio-economic Benefits), April 1995
GCOS-13 (WMO/TD-No. 677)	GCOS Data and Information Management Plan, Version 1.0, April 1995
GCOS-14	Plan for the Global Climate Observing System (GCOS), Version 1.0, (WMO/TD-No. 681) May 1995
GCOS-15 (WMO/TD-No. 684)	GCOS Plan for Space-based Observations, Version 1.0, June 1995
GCOS-16 (WMO/TD-No. 685)	GCOS Guide to Satellite Instruments for Climate, June 1995
GCOS-17 (WMO/TD-No. 696)	Report of the GCOS Atmospheric Observation Panel, second session (Tokyo, Japan, March 20-23, 1995)

*GCOS publications may be accessed through the GCOS World Wide Web site at:
http://www.wmo.ch/web/gcos/gcoshome.html

GCOS-18 (WMO/TD-No. 697) (UNEP/EAP.MR/95-10)	Report of the GCOS/GTOS Terrestrial Observation Panel, second session (London, UK, April 19-21, 1995)
GCOS-19 (WMO/TD-No. 709)	Report of the GCOS Data Centre Implementation/Co-ordination Meeting (Offenbach, Germany, June 27-29, 1995)
GCOS-20 (WMO/TD-No. 720)	GCOS Observation Programme for Atmospheric Constituents: Background, Status and Action Plan, September 1995
GCOS-21 (WMO/TD-No. 721) (UNEP/EAP.TR/95-07)	GCOS/GTOS Plan for Terrestrial Climate-related Observations, version 1.0, November 1995
GCOS-22 (WMO/TD-No. 722)	Report of the fifth session of the Joint Scientific and Technical Committee for GCOS (Hakone, Japan, October 16-19, 1995)
GCOS-23 (WMO/TD-No. 754) (UNEP/DEIA/MR.96-6) (FAO GTOS-1)	Report of the GCOS/GTOS Terrestrial Observation Panel for Climate, third session (Cape Town, South Africa, March 19-22, 1996)
GCOS-24 (WMO/TD-No. 768) (UNESCO/IOC)	Report of the Joint GCOS/GOOS/WCRP Ocean Observations Panel for Climate, first session (Miami, Florida, USA, March 25-27, 1996)
GCOS-25 (WMO/TD-No. 765) (UNEP/DEIA/MR.96-5)	Report of the GCOS Data and Information Management Panel, second session (Ottawa, Ontario, Canada, May 14-17, 1996)
GCOS-26 (WMO/TD-No. 766)	Report of the Joint CCl/CBS Expert Meeting on the GCOS Surface Network (Norwich, UK, March 25-27, 1996)
GCOS-27 (WMO/TD-No. 772) (UNEP/DEIA/MR.96-7)	Report of the Expert Meeting on Hydrological Data for Global Observing Systems (Geneva, Switzerland, April 29-May 1, 1996)
GCOS-28 (WMO/TD-No. 793) (UNEP/DEIA/MR.97-3)	*In Situ* Observations for the Global Observing Systems (Geneva, Switzerland, September 10-13, 1996)
GCOS-29 (WMO/TD-No. 794) (UNEP/DEIA/MR.97-4)	Report of the Global Observing Systems Space Panel, second session (Geneva, Switzerland, October 16-18, 1996)
GCOS-30 (WMO/TD-No. 795)	Report of the sixth session of the Joint Scientific and Technical Committee for GCOS (Victoria, British Columbia, Canada, October 28-November 1, 1996)
GCOS-31 (WMO/TD-No. 803)	Proceedings of the fifth meeting of the TAO Implementation Panel (TIP-5) (Goa, India, November 18-21, 1996)

*GCOS publications may be accessed through the GCOS World Wide Web site at:
http://www.wmo.ch/web/gcos/gcoshome.html

GCOS-32 (WMO/TD-No. 796)	GCOS/GTOS Plan for Terrestrial Climate-related Observations, version 2.0, June 1997
GCOS-33 (WMO/TD-No. 798)	GHOST - Global Hierarchical Observing Strategy, March 1997
GCOS-34 (WMO/TD-No. 799)	Initial Selection of a GCOS Surface Network, February 1997
GCOS-35 (WMO/TD-No. 839)	Report of the second Joint CCl/CBS Meeting on the GCOS Surface Network (De Bilt, The Netherlands, June 25-27, 1997)
GCOS-36 (WMO/TD-No. 844) (UNESCO/IOC)	Report of the Joint GCOS/GOOS/WCRP Ocean Observations Panel for Climate, second session (Cape Town, South Africa, February 11-13, 1997)
GCOS-37 (WMO/TD-No. 845) (GOOS-10) & (GTOS-9)	Report of the Global Observing Systems Space Panel, third session (Paris, France, May 27-30, 1997)
GCOS-38 (WMO/TD-846) (GTOS-10)	Report of the Meeting of Experts on Ecological Networks (Guernica, Spain, June 17-20, 1997)
GCOS-39 (WMO/TD-No. 847) (GOOS-11) & (GTOS-11) (UNEP/DEIA/MR.97-8)	Report of the GCOS/GOOS/GTOS Joint Data and Information Management Panel, third session (Tokyo, Japan, July 15-18, 1997)
GCOS-40 (WMO/TD-No. 848)	Report of the GCOS/WCRP Atmospheric Observation Panel for Climate, third session (Reading, UK, August 19-22, 1997)
GCOS-41 (WMO/TD-No. 849) (GOOS-33)	Report of the Joint GCOS/GOOS/WCRP Ocean Observations Panel for Climate (OOPC) Ocean Climate Time-Series Workshop, (Baltimore, MD, USA, March 18-20, 1997)
GCOS-42 (WMO/TD-No. 857)	Report of the seventh session of the Joint Scientific and Technical Committee for GCOS (Eindhoven, The Netherlands, September 22-26, 1997)
GCOS-43a (GOOS-36)	TAO Implementation Panel, sixth session (Reading, U.K., November 4-6, 1997)
GCOS-43b (GOOS-55)	International Sea Level Workshop (Honolulu, Hawaii, USA, June 10-11, 1997)
GCOS-44 (GOOS-61)	Report of the Joint GCOS/GOOS/WCRP Ocean Observations Panel for Climate (OOPC), third session (Grasse, France, April 6-8, 1998)
GCOS-45 (WMO/TD-No. 922) (GOOS-58) & (GTOS-16) (UNEP/DEIA/MR.98-6)	Report of the Joint Meeting of the GCOS/WCRP Atmospheric Observation Panel for Climate and the GCOS/GOOS/GTOS Joint Data and Information Management Panel, fourth session (Honolulu, Hawaii, USA, April 28-May 1, 1998)

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GCOS-46 (GTOS-15)	Report of the GCOS/GTOS Terrestrial Observation Panel for Climate, fourth session (Corvallis, USA, May 26-29, 1998)
GCOS-47 (WMO/TD-No. 941) (GOOS-67) (GTOS-20)	Report of the Global Observing Systems Space Panel, fourth session, (College Park, Maryland, USA, October 22-23, 1998)
GCOS-48	Report on the Adequacy of the Global Climate Observing Systems (United Nations Framework Convention on Climate Change, November 2-13 1998, Buenos Aires, Argentina)
GCOS-49 (GOOS-64)	Implementation of Global Ocean Observations for GOOS/GCOS, first session (Sydney, Australia, March 4-7, 1998)
GCOS-50 (GOOS-65)	Implementation of Global Ocean Observations for GOOS/GCOS, second session (Paris, France, November 30, 1998)
GCOS-51 (GOOS-66)	Global Ocean Observations for GOOS/GCOS: An Action Plan for Existing Bodies and Mechanisms
GCOS-52 (GOOS-68)	TAO Implementation Panel, 7th Session (Abidjan, Ivory Coast, November 11-13, 1998)
GCOS-53 (WMO/TD-No. 958)	GCOS Surface Network (GSN) Monitoring Centre Implementation Meeting (Offenbach, Germany, January 19-20, 1999)
GCOS-54 (WMO/TD-No. 953)	Report of the eighth session of the WMO-IOC-UNEP-ICSU Steering Committee for GCOS (Geneva, Switzerland, February 9-12, 1999)
GCOS-55	Report of the GCOS/WCRP Atmospheric Observation Panel for Climate (AOPC), fifth session (Silver Spring, MD, USA, April 20-23, 1999)
GCOS-56 (GOOS-75)	Special Report of the Joint GCOS/GOOS/WCRP Ocean Observations Panel for Climate (OOPC), fourth session (May 17, 1999); The CLIVAR Upper Ocean Panel (UOP), fourth session (May 21, 1999); A Joint Planning Meeting of the OOPC and the UOP for the OCEANOBS99 Conference (Woods Hole, MA, USA, May 18-20, 1999)
GCOS-57 (WMO/TD-No. 978) (GOOS-79)	Report of the OOPC/AOPC Workshop on Global Sea Surface Temperature Data Sets (Palisades, N.Y., USA, November 2-4, 1998)
GCOS-58 (GOOS-71**)**	Report of the 6th Session of the IOC Group of Experts on the Global Sea Level Climate Observing System (GLOSS)
GCOS-59 (GTOS-22)	Report of the GCOS/GTOS Terrestrial Observation Panel for Climate, fifth session (Birmingham, UK, July 27-30, 1999)
GCOS-60 (WMO/TD-No. 1004) (GOOS-70)	GCOS/GOOS/GTOS Joint Data and Information Management Plan, Version 1.0, May 2000

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GCOS-61 (WMO/TD-No. 1031)	Report of the ninth session of the WMO-IOC-UNEP-ICSU Steering Committee for GCOS (Beijing, China, September 12-14, 2000)
GCOS-62 (WMO/TD-No. 1038)	Report of the Pacific Islands Regional Implementation Workshop on Improving Global Climate Observing Systems (Apia, Samoa, August 14-15, 2000)
GCOS-63 (WMO/TD-No. 1047) (GTOS-26)	Establishment of a Global Hydrological Observation Network for Climate. Report of the GCOS/GTOS/HWRP Expert Meeting (Geisenheim, Germany, June 26-30, 2000)
GCOS-64 (GOOS-107)	Report of the eighth session of the TAO Implementation Panel (TIP-8) (St. Raphael, France, October 15, 1999)
GCOS-65 (WMO/TD-No. 1055)	Report of the sixth session of the GCOS/WCRP Atmospheric Observation Panel for Climate (AOPC) (Geneva, Switzerland, April 10-13, 2000)
GCOS-66 (GOOS-108)	Report of the ninth session of the TAO Implementation Panel (TIP-9) (Perth, Australia, November 16-17, 2000)
GCOS-67 (WMO/TD-No. 1072)	GCOS Implementation Strategy: Implementing GCOS in the New Millennium
GCOS-68 (WMO/TD-No. 1093)	Report of the seventh session of the GCOS/WCRP Atmospheric Observation Panel for Climate (AOPC) (Geneva, Switzerland, April 30-3 May, 2001)
GCOS-69 (GOOS-98)	Report of the fifth session of the Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC), Bergen, Norway, June 20-23, 2000.
GCOS-70 (GOOS-113)	Report of the sixth session of the Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC), Melbourne, Australia, April 2-5, 2001
GCOS-71 (WMO/TD-No. 1099) (GTOS-29)	Report of the GCOS/GTOS/HWRP Expert Meeting on the Implementation of a Global Terrestrial Network - Hydrology (GTN-H), Koblenz, Germany, June 21-22, 2001
GCOS-72 (GOOS-95)	Report of the 7th Session of the IOC Group of Experts on the Global Sea Level Observing System (GLOSS), Honolulu, April 26-27, 2001
GCOS-73 (WMO/TD-No. 1106)	Guide to the GCOS Surface and Upper-Air Networks: GSN and GUAN, September 2002

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