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المنظمة العالمية للأرصاد الجوية
世界气象组织

# Manual

## on the Global Data-Processing and Forecasting System

WMO-No. 485

WORLD METEOROLOGICAL ORGANIZATION

# MANUAL ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM

**VOLUME I**

(Annex IV to the WMO Technical Regulations)

## GLOBAL ASPECTS

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**NOTE**

The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the World Meteorological Organization concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries.

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## NOTE ON UNITS FOR ATMOSPHERIC PRESSURE

In order to bring Volume I of the *Manual on the Global Data-processing and Forecasting System* into line with the decision of EC-XXXII to begin the dual use of both the terms *millibar* and *hectopascal* in WMO technical publications as of 1 January 1982, and to allow a gradual transition in the use of these terms for atmospheric pressure, *hectopascal* is used as the unit for atmospheric pressure instead of *millibar*.

The pressure unit *hectopascal* (hPa) is equivalent to the pressure unit *millibar* (mb). Therefore, 1 hPa = 1 mb; 700 hPa = 700 mb; 1021.3 hPa = 1021.3 mb.

## EDITORIAL NOTE

The typographical practice indicated below has been followed in the text.

*Standard* meteorological practices and procedures have been printed in semi-bold.

*Recommended* meteorological practices and procedures have been printed in roman.

*Notes* have been printed in smaller type, roman, preceded by the indication: NOTE.

# CONTENTS

# INTRODUCTION

## PURPOSE

1. The *Manual on the Global Data-processing and Forecasting System* is issued in accordance with a decision of Seventh Congress.

2. This *Manual* is designed:

(*a*) To facilitate cooperation in data-processing and forecasting among Members;

(*b*) To specify obligations of Members in the implementation of the World Weather Watch (WWW) Global Data-processing and Forecasting System (GDPFS);

(*c*) To ensure adequate uniformity and standardization in the practices and procedures employed in achieving (*a*) and (*b*) above.

3. The *Manual* consists of Volumes I and II, which deal with global and regional aspects, respectively. Volume I of the *Manual* consists of Part I (Organization and functions of the GDPFS), Part II (Data-processing and forecasting aspects) and Part III (Data management aspects), which contain regulatory material for the global aspects of the WWW Global Data-processing and Forecasting System. The regulatory material stems from recommendations of the Commission for Basic Systems (CBS) as well as from decisions taken by Congress and the Executive Council.

4. Volume I of the *Manual* – Global aspects – forms part of the *Technical Regulations* and is referred to as Annex IV to the *Technical Regulations*.

## TYPES OF REGULATIONS

5. Volume I of the *Manual* contains both *standard* practices and procedures and *recommended* practices and procedures. The definitions of these two types in the *Manual* are as follows:

The *standard* practices and procedures:

(*a*) Shall be the practices and procedures which it is necessary that Members follow or implement; and therefore

(*b*) Shall have the status of requirements in a technical resolution in respect of which Article 9 (*b*) of the Convention is applicable; and

(*c*) Shall invariably be distinguished by the use of the term "shall" in the English text, and by suitable equivalent terms in the French, Russian and Spanish texts.

The *recommended* practices and procedures:

(*a*) Shall be the practices and procedures which it is desirable that Members follow or implement; and therefore

(*b*) Shall have the status of recommendations to Members to which Article 9 (*b*) of the Convention shall not be applied; and

(*c*) Shall be distinguished by the use of the term "should" in the English text (except where specifically otherwise provided by decision of Congress) and by suitable equivalent terms in the French, Russian and Spanish texts.

6. In accordance with the above definitions, Members shall do their utmost to implement the standard practices and procedures. In accordance with Article 9 (*b*) of the Convention and in conformity with the provisions of Regulation 127 of the General Regulations, Members shall formally notify the Secretary-General, in writing, of their intention to apply the standard practices and procedures of the *Manual*, except those for which they have lodged a specific deviation. Members shall also inform the Secretary-General, at least three months in advance, of any change in the degree of their implementation of a standard practice or procedure as previously notified and of the effective date of the change.

7. With regard to the recommended practices and procedures, Members are urged to comply with these, but it is not necessary to notify the Secretary-General of non-observance.

8. In order to clarify the status of the various regulatory material, the standard practices and procedures are distinguished from the recommended practices and procedures by a difference in typographical practice as indicated in the editorial note.

## NOTES AND ATTACHMENTS

9. Certain notes are included in the *Manual* for explanatory purposes. They do not have the status of the annexes to the *Technical Regulations*.

10. A number of detailed guidelines, specifications and formats of data-processing practices and procedures are included in the *Manual*. Taking into account the rapid development of data-processing and forecasting techniques and the increasing requirements of WWW and other WMO programmes, these guidelines etc. are given in "attachments" to the *Manual* and do not have the status of the annexes to the *Technical Regulations*. This will enable the Commission for Basic Systems to update them as necessary.

11. Volume II of the *Manual* – Regional aspects – does not form part of the *Technical Regulations*.

12. The words "shall" and "should" in the attachments and in Volume II have their dictionary meanings and do not have the regulatory character mentioned in paragraph 5 above.

13. In this *Manual*, the term "forecast" is used throughout to indicate a meteorological prediction in word or chart form. This is in accordance with the wording used in the amendments to the *Technical Regulations* adopted by the extraordinary session (1976) of CBS and approved by the Executive Committee* (paragraph 3.1.1.6 of the Abridged Final Report, EC-XXIX). However, it is recognized that the term "prognosis" is used interchangeably with "forecast" in some parts of the *Technical Regulations*.

* By its Resolution 42 (Cg-IX), Ninth Congress (1983) changed the name of the Executive Committee to Executive Council.

PART I

# ORGANIZATION AND FUNCTIONS OF THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM

## 1. PURPOSE OF THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM (GDPFS)

The main purpose of the GDPFS shall be to prepare and make available to Members in the most cost-effective way meteorological analyses and forecast products. The design, functions, organizational structure and operations of the GDPFS shall be in accordance with Members' needs and their ability to contribute to, and benefit from, the system.

## 2. FUNCTIONS OF THE GDPFS

2.1 The real-time functions of the GDPFS shall include:

(*a*) Pre-processing of data, e.g. retrieval, quality control, decoding, sorting of data stored in a database for use in preparing output products;

(*b*) Preparation of analyses of the three-dimensional structure of the atmosphere with up-to-global coverage;

(*c*) Preparation of forecast products (fields of basic and derived atmospheric parameters) with up-to-global coverage;

(*d*) Preparation of ensemble prediction system (EPS) products;

(*e*) Preparation of specialized products such as limited area very-fine mesh short-, medium-, extended- and long-range forecasts, tailored products for marine, aviation, environmental quality monitoring and other purposes;

(*f*) Monitoring of observational data quality;

(*g*) Post-processing of NWP data using workstation and PC-based systems with a view to producing tailored value-added products and generation of weather and climate forecasts directly from model output.

2.2 The non-real-time functions of the GDPFS shall include:

(*a*) Preparation of special products for climate-related diagnosis (i.e. 10-day or 30-day means, summaries, frequencies and anomalies) on a global or regional scale;

(*b*) Intercomparison of analysis and forecast products, monitoring of observational data quality, verification of the accuracy of prepared forecast fields, diagnostic studies and NWP model development;

(*c*) Long-term storage of GOS data and GDPFS products, as well as verification results for operational and research use;

(*d*) Maintenance of a continuously-updated catalogue of data and products stored in the system;

(*e*) Exchange between GDPFS centres of ad hoc information via distributed databases;

(*f*) Conduct of workshops and seminars on the preparation and use of GDPFS output products.

## 3. ORGANIZATION OF THE GDPFS

The GDPFS shall be organized as a three-level system of World Meteorological Centres (WMCs), Regional Specialized Meteorological Centres (RSMCs) and National Meteorological Centres (NMCs), which carry out GDPFS functions at the global, regional and national levels, respectively. The GDPFS shall also support other WMO Programmes and relevant programmes of other international organizations in accordance with policy decisions of the Organization.

## 4. FUNCTIONS OF GDPFS CENTRES

4.1 The general functions of GDPFS centres shall be as follows:

### 4.1.1 *World Meteorological Centres (WMCs)*

These shall consist of centres applying sophisticated high-resolution global NWP models (including ensemble prediction system) and preparing for distribution to Members and other GDPFS centres the following products:

(*a*) Global (hemispheric) analysis products;

(*b*) Short-, medium-, extended- and long-range forecasts and products with a global coverage, but presented separately, if required, for:

**(i) The tropical belt;**

**(ii) The middle and high latitudes or any other geographical area according to Members' requirements;**

**(*c*) Climate-related diagnostic products, particularly for tropical regions.**

**WMCs shall also carry out verification and intercomparison of products, support the inclusion of research results into operational models and their supporting systems, and provide training courses on the use of WMC products.**

### 4.1.2 ***Regional Specialized Meteorological Centres (RSMCs)***

4.1.2.1 *Centres with geographical specialization*

**These shall be either existing national or regional centres which have accepted responsibilities by multilateral or regional agreement, or centres implemented by a joint cooperative effort by several countries in a Region. The functions of RSMCs with geographical specialization shall include:**

**(*a*) Providing the interface between WMCs and NMCs by formatting and distributing global products to meet the needs in a particular Region;**

**(*b*) Providing regional analysis and forecast products for 12–48 hours, for designated areas;**

**(*c*) Providing meteorological assistance to United Nations humanitarian missions, in the event the relevant associated NMC is facing an emergency or is in catastrophic distress and out of service, as specified in Appendix I-5;**

**(*d*) Coordinating with other RSMCs as appropriate.**

4.1.2.2 *Centres with activity specialization*

**The functions of RSMCs with activity specialization shall include, inter alia:**

**(*a*) Providing long-, extended- and/or medium-range forecasting products;**

**(*b*) Providing advisories for tropical cyclones, severe storms and other dangerous weather phenomena;**

**(*c*) Providing tailored specialized products to service users in a particular area;**

**(*d*) Providing trajectories and atmospheric transport modelling products, including backtracking, in case of environmental emergencies or other incidents;**

**(*e*) Providing information on prolonged adverse weather conditions, including drought monitoring;**

**(*f*) Undertaking activities related to the WCP and other WMO international programmes. This includes providing climate diagnostic, climate analysis and prediction products to assist in climate monitoring.**

4.1.2.3 **RSMCs shall also carry out verification and intercomparison of products and arrange regional workshops and seminars on centres' products and their use in national weather forecasting. RSMCs with geographical and activity specialization shall be co-located where possible.**

4.1.2.4 **RSMCs designated by WMO for the provision of atmospheric transport model products shall implement the Regional and Global Arrangements and related procedures as found in Appendix I-3 and/or backtracking in Appendix I-6, respectively.**

4.1.2.5 The designated WMCs and RSMCs are given in Appendix I-1 and the procedures for broadening the functions of existing RSMCs and for designating new RSMCs are given in Appendix I-2.

NOTE: Guidelines to review the status of RSMCs with geographical specialization are given in Attachment I.1.

### 4.1.3 ***National Meteorological Centres (NMCs)***

The NMCs carry out functions to meet their national and international requirements. Typically, the functions of NMCs include the preparation of:

(*a*) Nowcasts and very short-range forecasts;

(*b*) Short-, medium-, extended- and long-range forecasts by applying objective or subjective interpretation methods to products received from World and Regional Specialized Meteorological Centres or by integrating regional models using boundary conditions based on these products;

(*c*) Special application-user products, including warnings of severe weather, climate and environmental quality monitoring and prediction products;

(*d*) Specific products and their delivery in support of United Nations humanitarian missions as specified in Appendix I-5;

(*e*) Non-real-time climate-related analyses and diagnosis.

NMCs should be linked via suitable terminals to computer systems at other GDPFS centres in order to carry out inter-processing activities between centres, according to bilateral or multilateral agreements among Members. The definition of forecast ranges is given in Appendix I-4.

4.1.3.1 The basic organization of the GDPFS is also given in Chapter A.2.1 of the *Technical Regulations*.

NOTES:

(1) The national data-processing and forecasting activities may also be concerned with large-scale analyses and forecasts.

(2) Detailed specifications of the real-time and non-real-time functions of WWW centres are given in Parts II and III, respectively.

(3) Procedures for the elaboration of observational data requirements are given in Attachment I.2.

(4) In some instances, WMCs, RSMCs and NMCs are co-located and the functions of one centre are included in those of the other.

4.2 The above functions of the various centres shall not affect the status of any international commitments of Members for support to shipping and aviation, nor determine the manner in which Members execute these responsibilities.

APPENDIX I-1

# LOCATION OF WMCs AND RSMCs WITH GEOGRAPHICAL SPECIALIZATION AND RSMCs WITH ACTIVITY SPECIALIZATION

1. The WMCs are located at:

Melbourne (southern hemisphere only)
Moscow
Washington

2. The RSMCs with geographical specialization are located at:

Algiers
Beijing
Brasilia
Buenos Aires
Cairo
Dakar
Darwin
Exeter
Jeddah
Khabarovsk
Melbourne
Miami
Montreal
Moscow
Nairobi
New Delhi
Novosibirsk
Offenbach
Pretoria
Rome
Tashkent
Tokyo
Tunis/Casablanca
Washington
Wellington

Broadened RSMC functions:

Offenbach — Provision of ultraviolet-index forecasts for Region VI (Europe)

3. The RSMCs with activity specialization are the following:

RSMC Nadi – Tropical Cyclone Centre

RSMC New Delhi – Tropical Cyclone Centre

RSMC Miami – Hurricane Centre

RSMC Tokyo – Typhoon Centre

RSMC La Réunion – Tropical Cyclone Centre

RSMC Honolulu – Hurricane Centre

RSMC European Centre for Medium-Range Weather Forecasts (RSMC ECMWF)

Provision of atmospheric transport modelling (for environmental emergency response and/or backtracking)

RSMC Beijing

RSMC Exeter

RSMC Melbourne

RSMC Montreal

RSMC Obninsk

RSMC Tokyo

RSMC Toulouse

RSMC Washington

APPENDIX I-2

# PROCEDURES FOR BROADENING THE FUNCTIONS OF EXISTING RSMCs AND FOR DESIGNATION OF NEW RSMCs

The procedures are as follows:

1. Establishment of a statement of requirements for WWW products and services initiated and endorsed by the WMO constituent body or bodies concerned.

2. Identification of capabilities of relevant existing RSMCs and/or candidate RSMCs, to meet the requirements.

3. Determination in principle whether there is a requirement to:

   (*a*) Broaden the functions of an existing RSMC; and/or

   (*b*) Establish a new RSMC.

4. Formal commitment by a Member or a group of cooperating Members to fulfil the required function(s) of a centre;

   - The prospective RSMC should:

     (*a*) Establish a closely defined relationship between the RSMC and the WWW Meteorological Centres as users of RSMC products;

     (*b*) Commit itself to make available a set of products and services designed to meet the given requirements, where appropriate, in terms of specific forecast parameters and formats, the frequency of their issue and targets for timeliness, overall reliability and quality;

     (*c*) Propose method(s) and procedures by which such products and services will be delivered;

     (*d*) Propose method(s) and procedures by which ongoing performance will be assessed (e.g. by verification);

     (*e*) Propose method(s) by which particular WWW Meteorological Centres' changing requirements could be made known and improvements in operational performance introduced by the RSMC;

     (*f*) Address the question of contingency and back-up arrangements to cover situations where the RSMC may not be able to provide the required services.

5. Demonstration of the capabilities to CBS and the constituent body or bodies referred to under (1);

   - The prospective RSMC should expect to demonstrate its general capabilities of relevance to the service to be offered (such as access to relevant data and processing capability), its ability to meet the above commitment and the suitability of its other proposals.

6. Recommendation by CBS to include in the *Manual on the GDPFS*:

   (*a*) The new function(s) of the existing centre; or

   (*b*) The identification and function(s) of the new centre.

7. Acceptance of the CBS recommendation by Congress or the Executive Council.

APPENDIX I-3

# REGIONAL AND GLOBAL ARRANGEMENTS FOR THE PROVISION OF TRANSPORT MODEL PRODUCTS FOR ENVIRONMENTAL EMERGENCY RESPONSE

## SUPPORT FOR NUCLEAR ENVIRONMENTAL EMERGENCY RESPONSE

### NOTIFICATION OF WMO

In the framework of the Convention on Early Notification of a Nuclear Accident, the International Atomic Energy Agency (IAEA) informs the WMO Secretariat and RTH Offenbach (Germany) of the status of the emergency. If needed, the IAEA will request support from the WMO RSMCs. Beginning with a site area emergency, RTH Offenbach will disseminate the EMERCON messages on the GTS in the form of an alphanumeric bulletin in plain-text English language under the abbreviated heading WNXX01 IAEA for global distribution to the NMCs/RSMCs (see also the WMO *Manual on the Global Telecommunication System*, WMO-No. 386).

When the IAEA no longer requires WMO RSMC support, the IAEA will send an EMERCON termination message to the RSMCs, the WMO Secretariat and RTH Offenbach. RTH Offenbach will disseminate the EMERCON termination message on the GTS in the form of an alphanumeric bulletin in plain-text English language under the abbreviated heading WNXX01 IAEA for global distribution to the NMCs/RSMCs.

### REGIONAL ARRANGEMENTS

**The RSMCs designated by WMO for the provision of atmospheric transport model products for nuclear environmental emergency response shall:**

**1. Provide products only when either the delegated authority[1] of any country in the RSMC region of responsibility or the IAEA requests RSMC support. Upon receipt of a request from the delegated authority[2] or from the IAEA, the RSMC shall provide basic information to the National Meteorological Service of that country or to the IAEA, respectively. If multiple requests are received, highest priority will be given to IAEA requests.**

**2. Upon receipt of a first request for products related to a nuclear incident and in the absence of a prior notification by the IAEA, inform the WMO Secretariat, all designated RSMCs and the IAEA of the request.**

**3. For an IAEA request sent to the RSMCs to produce and distribute products, the requested RSMCs will distribute the basic products to the IAEA, and all RSMCs will distribute to the National Meteorological Services in the region[3] and WMO. For a request for support from a Delegated Authority and without notification by the IAEA, basic information provided to the National Meteorological Service of the requesting country will not be disclosed to the public in that country nor distributed by RSMCs to other National Meteorological Services.**

**4. Provide, on request, support and advice to the IAEA and WMO Secretariats in the preparation of public and media statements.**

**5. Determine the standard set of basic products and the method of delivery in consultation with users and the IAEA.**

**6. Provide product interpretation guidelines to users.**

**7. Provide support and technology transfer to national and regional meteorological centres that want to become designated RSMCs.**

**8. Make arrangements to provide backup services. These would normally be between the two designated centres in a region. Interim arrangements should be made by centres in regions with a single designated RSMC.**

### GLOBAL ARRANGEMENTS

Until such time as new RSMCs have been designated, it is proposed that Regional Association VI-designated RSMCs be responsible for providing services for radiological emergencies to Regional Association I; Regional Association IV-designated RSMCs be responsible for providing services to Regional Association III; while the Regional Association V-designated RSMC, in collaboration with Regional Association IV-designated RSMCs, will be responsible for providing services to Regional Association V.

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**[1] The person authorized by the Permanent Representative of the country to request RSMC support.**

**[2] The RSMC products will be provided to the NMS Operational Contact Point designated by the Permanent Representative.**

**[3] The basic information will normally be provided by the NMS to the IAEA national contact point.**

In cases of radiological emergencies where coordination is required between RSMCs of different regions, the RSMCs of the region where the emergency has occurred will provide this coordination.

**SUPPORT FOR NON-NUCLEAR ENVIRONMENTAL EMERGENCY RESPONSE**

If support is required for response to a non-nuclear environmental emergency, related to atmospheric transport of pollutants, the Permanent Representative with WMO of the affected country may direct its request for support to the operational contact point of the designated RSMC(s) for its regional association.

1. **Due to the potentially broad range of environmental emergencies, the RSMC shall consider each request with regard to its capabilities and the suitability of its products to address the emergency requirements and will then respond accordingly.**

2. **The RSMC shall inform all other designated RSMCs and the WMO Secretariat of the request and the agreed actions.**

APPENDIX I-4

# DEFINITIONS OF METEOROLOGICAL FORECASTING RANGES

| | | |
|---|---|---|
| 1. | Nowcasting | A description of current weather parameters and 0 to 2 hours' description of forecasted weather parameters |
| 2. | Very short-range weather forecasting | Up to 12 hours' description of weather parameters |
| 3. | Short-range weather forecasting | Beyond 12 hours' and up to 72 hours' description of weather parameters |
| 4. | Medium-range weather forecasting | Beyond 72 hours' and up to 240 hours' description of weather parameters |
| 5. | Extended-range weather forecasting | Beyond 10 days' and up to 30 days' description of weather parameters, usually averaged and expressed as a departure from climate values for that period |
| 6. | Long-range forecasting | From 30 days up to two years |
| | 6.1 Monthly outlook | Description of averaged weather parameters expressed as a departure (deviation, variation, anomaly) from climate values for that month (not necessarily the coming month) |
| | 6.2 Three-month or 90-day outlook | Description of averaged weather parameters expressed as a departure from climate values for that 90-day period (not necessarily the coming 90-day period) |
| | 6.3 Seasonal outlook | Description of averaged weather parameters expressed as a departure from climate values for that season |

NOTES:

(1) In some countries, long-range forecasts are considered to be climate products.

(2) Season has been loosely defined as December/January/February = Winter; March/April/May = Spring; etc. ... in the northern hemisphere. In the tropical areas seasons may have different durations. Outlooks spanning several months such as multi-seasonal outlooks or tropical rainy season outlooks may be provided.

| | | |
|---|---|---|
| 7. | Climate forecasting | Beyond two years |
| | 7.1 Climate variability prediction | Description of the expected climate parameters associated with the variation of interannual, decadal and multi-decadal climate anomalies |
| | 7.2 Climate prediction | Description of expected future climate including the effects of both natural and human influences |

APPENDIX I-5

# ARRANGEMENTS FOR THE PROVISION OF METEOROLOGICAL ASSISTANCE TO UNITED NATIONS HUMANITARIAN MISSIONS

**The United Nations Office for the Coordination of Humanitarian Affairs (UN/OCHA) shall normally request a service from a National Meteorological Centre (NMC) of the National Meteorological Service of the country concerned. If the NMC is not operational, this fact shall be confirmed to the associated RSMC with geographical specialization when requesting a service. UN/OCHA shall also specify details of the area or location for which the service is required. The NMCs or RSMCs usually provide the products to the UN/OCHA Headquarters operation centre. The RSMCs zones of responsibility are as specified in the annex to this appendix.**

**The NMC shall:**

**Upon receipt of a request from UN/OCHA, provide to it or its designated recipient location, basic meteorological and climate information and forecasts. The products to be provided will be negotiated with UN/OCHA, but could consist of 72-hour public weather forecasts, severe weather advisories and warnings, longer-range outlooks, and may include climate information for specified areas or locations in support of humanitarian missions.**

**The WMO Secretariat shall:**

**(*a*) Upon request, from UN/OCHA, arrange guidance in the interpretation of specialized meteorological information and products made available by NMCs or RSMCs;**

**(*b*) Establish and maintain up-to-date NMCs operational contact points for assistance to United Nations humanitarian missions and make these available to UN/OCHA and RSMCs;**

**(*c*) Establish and maintain up-to-date RSMCs contact points and their backups.**

**The RSMC with geographical specialization and its backup for the relevant zone of responsibility shall:**

**(*a*) Upon receipt of a request from UN/OCHA with confirmation that the relevant NMC of the National Meteorological Service of a Member facing an emergency or in catastrophic distress and out of service, provide to UN/OCHA, basic meteorological and climate information and forecasts. The products to be provided will be negotiated with UN/OCHA, but could consist of 72-hour public weather forecasts, severe weather advisories and warnings, and longer-range outlook and may include climate information for specified areas or locations in support of humanitarian missions;**

**(*b*) For an ongoing requirement, determine in consultation with UN/OCHA the relevant set of climate information, basic forecasts, their format and methods of delivery, location of delivery, depending on the nature of the situation.**

Provision of forecasts from a remote RSMC is not an ideal arrangement and the quality of the forecasts can be expected to be reduced accordingly. The service provided should be accepted on the terms of a best effort basis and recognized as such by UN/OCHA.

## ANNEX

## ZONES OF RESPONSIBILITY OF RSMCs FOR PROVIDING BACKUP SERVICES TO UNITED NATIONS HUMANITARIAN MISSIONS

| RSMC | ZONE OF RESPONSIBILITY |
|---|---|
| **REGION I** | |
| Algiers | Algeria; Libyan Arab Jamahiriya; Tunisia |
| Cairo | Egypt; Sudan |
| Dakar | Benin; Burkina Faso; Cape Verde; Cameroon; Chad; Central African Republic; Congo; Côte d'Ivoire; Democratic Republic of the Congo; Equatorial Guinea; Gabon; Gambia; Ghana; Guinea; Guinea-Bissau; Liberia; Mali; Mauritania; Morocco; Niger; Nigeria; Sao Tome and Principe; Senegal; Sierra Leone; Togo; Ascension Islands; Spain (Canary Islands); St Helena; Portugal (Madeira); Western Sahara |

| **RSMC** | **ZONE OF RESPONSIBILITY** |
|---|---|
| Nairobi | Burundi; Djibouti; Ethiopia; Kenya; Rwanda; Somalia; Uganda; United Republic of Tanzania |
| Pretoria | Angola; Comoros; Botswana; Kerguelen and New Amsterdam; Lesotho; Madagascar; Malawi; Mauritius; Mozambique; Namibia; France (Department of La Réunion); Seychelles; South Africa; Swaziland; Zimbabwe; Zambia |
| **REGION II** | |
| Beijing | China; Democratic People's Republic of Korea; Hong Kong, China; Macao, China; Viet Nam |
| Jeddah | Bahrain; Kuwait; Oman; Qatar; Saudi Arabia; United Arab Emirates; Yemen |
| Khabarovsk | Russian Federation (in RA II) |
| New Delhi | Bangladesh; Bhutan; India; Maldives; Nepal; Pakistan; Sri Lanka |
| Novosibirsk | Mongolia; Russian Federation |
| Tashkent | Afghanistan; Iran (Islamic Republic of); Iraq; Kazakhstan; Kyrgyzstan; Tajikistan; Turkmenistan; Uzbekistan |
| Tokyo | Cambodia; Japan; Lao People's Democratic Republic; Myanmar; Philippines; Thailand; Republic of Korea |
| **REGION III** | |
| Brasilia | Brazil; Colombia; Ecuador; France (Department of French Guiana); Suriname; Venezuela |
| Buenos Aires | Argentina; Bolivia; Chile; Paraguay; Peru; Uruguay |
| **REGION IV** | |
| Washington | Bahamas; Barbados; Belize; British Caribbean Territories; Canada; Colombia; Costa Rica; Cuba; Dominica; Dominican Republic; France (Martinique, Guadeloupe, Saint Pierre and Miquelon); Guatemala; Guyana; Haiti; Honduras; Jamaica; Mexico; Netherlands Antilles; Nicaragua; Panama; Saint Lucia; Trinidad and Tobago; United States of America; Venezuela |
| Miami | El Salvador |
| **REGION V** | |
| Melbourne | Australia |
| Darwin | Brunei Darussalam; Indonesia; Malaysia; Papua New Guinea; Singapore; Solomon Islands |
| Wellington | Cook Islands; Fiji; French Polynesia; Kiribati; New Caledonia; New Zealand; Niue; Pitcairn; Tokelau; Tonga; Tuvalu; Vanuatu; Wallis and Futuna; Western Samoa |
| **REGION VI** | |
| Exeter | Gibraltar; Denmark (Greenland); Iceland; Ireland; Netherlands; United Kingdom of Great Britain and Northern Ireland |
| Moscow | Albania; Armenia; Azerbaijan; Belarus; Cyprus; Georgia; Jordan; Poland; Romania; Republic of Moldova; Russian Federation (in RA VI); Ukraine; Yugoslavia |
| Offenbach | Austria; Belgium; Bosnia and Herzegovina; Bulgaria; Czech Republic; Croatia; Denmark; Estonia; the former Yugoslav Republic of Macedonia; Germany; Hungary; Israel; Finland; France; Latvia; Lithuania; Luxembourg; Norway; Portugal; Slovakia; Slovenia; Spain; Sweden; Switzerland |
| Rome | Greece; Italy; Lebanon; Malta; Syrian Arab Republic; Turkey |

APPENDIX I-6

# REGIONAL AND GLOBAL ARRANGEMENTS FOR ATMOSPHERIC BACKTRACKING

## NOTIFICATION

In the framework of the cooperation agreement between the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) and WMO that entered into force on 11 July 2003, the Provisional Technical Secretariat (PTS) notifies the RSMCs designated for the provision of atmospheric backtracking products and the WMO Secretariat in case that anomalous radionuclide measurements occur in the International Monitoring System. The notification will be in the form of an electronic mail message that will specify the coordinates of the requested stations as well as start and stop of the measurements. The measurement scenario will not be revealed.

## GLOBAL ARRANGEMENTS FOR ALL RSMCs TO DISTRIBUTE THE PRODUCTS TO CTBTO

1. All notified RSMCs shall acknowledge the receipt of the request and deliver the requested atmospheric backtracking products in electronic form and in the predefined format to a server specified by CTBTO/PTS as part of the notification.
2. The products shall be delivered as fast as technically possible within defined timelines.
3. Every participating RSMC that is temporarily unable to honour the request should notify CTBTO/PTS and the WMO Secretariat as soon as possible, but in any case within 24 hours. The contact officer of the PTS is specified in the electronic mail message.
4. Requests for support from the PTS are considered confidential and must not be disclosed.

## REGIONAL ARRANGEMENTS FOR ONE OR MORE RSMCs TO DISTRIBUTE PRODUCTS TO AN NMHS

If support is required for response to an incident requiring backtracking using atmospheric transport models, then the Permanent Representative with WMO, or the person authorized of the requesting country may direct the request for support to the operational contact point of the designated RSMC(s) for its regional association.

1. The RSMC shall consider each request with regard to its capabilities and the suitability of its products to address the requirements and will then respond accordingly.
2. The RSMC shall inform the WMO Secretariat of the request and the agreed actions, and may inform all other designated RSMCs of the request.
3. The RSMC products will be provided to the NMS Operational Contact Point designated by the Permanent Representative.

ATTACHMENT I.1

# GUIDELINES TO REVIEW THE STATUS OF RSMCs WITH GEOGRAPHICAL SPECIALIZATION

## 1. RSMC CAPABILITIES TO BE REVIEWED

Taking into account the functions to be performed by designated RSMCs with geographical specialization, their capabilities will be examined under three aspects: their ability to communicate with other centres, their access to computing facilities to achieve specific tasks, and their ability to issue the products which are requested by the users.

*Telecommunication aspects*

In order to play fully their role, existing RSMCs have to be linked with neighbouring centres. The following type of links are necessary for the effective implementation of their assignments:

(*a*) Medium- or high-speed lines connecting the RSMC and the appropriate WMC, as well as the RSMC which is chosen to provide backup assistance;

(*b*) Lines with sufficient bandwidth to transmit the products issued by the RSMC to the users in the corresponding NMCs.

*Computing facilities aspects*

The computing facilities available in existing RSMCs with geographical specialization must have enough power to enable:

(*a*) Preprocessing of observational data including data in binary data representation forms;

(*b*) Objective analysis and NWP models over the geographical responsibility area;

(*c*) Postprocessing of data including display in the form of charts, time-series, tables, as well as the generation of products in binary data representation forms.

*Product aspects*

In order to fulfil their responsibilities, the RSMCs have to provide several products to the users, some of which are:

(*a*) Gridded fields or local forecasts in the form of maps, time-series, GRID/GRIB and BUFR messages;

(*b*) Elaborated technical guidance (maps and directives);

(*c*) Verification of the quality of the products by means of CBS approved procedures.

## 2. DOCUMENTS TO BE PRODUCED BY RSMCS

In order to demonstrate their capabilities to perform the activity related to geographical specialization, the documentation to be provided by the RSMCs should include the following:

(*a*) A description of telecommunication and data-processing facilities including contingency and backup arrangements;

(*b*) The product guide indicating the list of the products which are available and their transmission schedule;

(*c*) Monthly statistics on the availability and timeliness of the products;

(*d*) Monthly verifications of the products by means of CBS-approved procedures.

RSMCs with geographical specialization have to summarize this information in order to produce, every year, their contribution to the WWW Technical Report on the activity of the GDPFS.

## 3. PROCEDURE

A regular review of the capabilities of the RSMCs with geographical specialization should be undertaken by their regional association. In order to do so, it is suggested that regional associations request their RSMCs to produce the above-mentioned documentation. It is also suggested that regional associations obtain feedback from the users. Regional associations should inform CBS, for further action, of the results of the review of the capabilities of the RSMCs with geographical specialization in their region.

ATTACHMENT I.2

## PROCEDURES FOR THE ELABORATION OF OBSERVATIONAL DATA REQUIREMENTS

The formulation of observational data requirements is a complicated process which consists of several stages. At various levels this process involves groups of end-users, regional associations, WMO technical commissions and other bodies. In order to rationalize the formulation of the observational data requirements, the following procedures (schematically shown in Figure 1) are proposed:

1. Users present to WMO Members their needs for observational data for various applications (e.g. meteorological services for aviation, marine navigation, industry, agriculture, climate research, etc.). Meteorological data might be used in two ways: directly in the provision of meteorological services, and in the preparation of meteorological products (weather analysis and prognoses) by GDPFS centres. In the latter case, GDPFS centres are considered as users.

2. WMO technical commissions are responsible for the consolidation of data needs presented by Members and for the formulation, on their basis, of a statement on observational data requirements/goals (usually in the form of tables) in various WMO Programmes. This should include explanatory notes and a rationale for the requirements/goals and, if possible, a statement on the incremental value of partially meeting these goals (in terms of accuracy, density, frequency, etc.). Often this will include a feedback process with users to ensure that enough information and understanding about users' needs are available. If a statement on requirements/goals is addressed to the World Weather Watch, and in particular to the WWW Global Observing System, it should be presented to the Commission for Basic Systems for consideration.

3. The Commission for Basic Systems:

(*a*) Evaluates the feasibility of stated requirements/goals through expertise by appropriate working groups, particularly the Working Groups on Observations and on Satellites. The evaluation of technical and instrumental feasibility should be conducted in collaboration with the Commission for Instruments and Methods of Observation, the WMO body responsible for the Instruments and Methods of Observation Programme (IMOP). This would probably involve a feedback process between working groups and technical commissions. The evaluation process will result in the formulation (in the form of tables) of what portion of the statement of requirements/goals is feasible and can be achieved;

(*b*) Formulates system requirements to provide observational data to meet the requirements/goals defined by the technical commissions;

(*c*) Develop any amendments to the WMO mandatory and guidance publications on the basis of system requirements and submit them (in case of mandatory publications) to the Executive Council.

4. The Executive Council approves the amendments and requests the Secretary-General to incorporate them in appropriate WMO *Manuals*.

5. The Members will be advised on the performance of observing systems and programmes through updated WMO *Manuals* and *Guides* to meet users' needs for observational data.

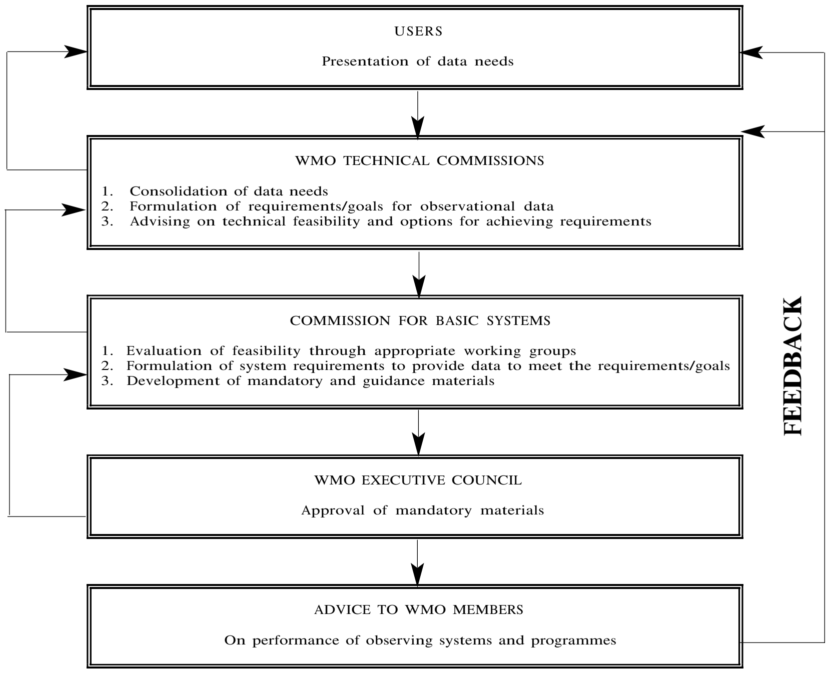


Figure 1 — Procedure for the elaboration of observational data requirements

PART II

# DATA-PROCESSING AND FORECASTING ASPECTS

## 1. FUNCTIONS OF WMCs, RSMCs AND NMCs

### 1.1 GDPFS products and services

Each Member or group of Members(s) responsible for a GDPFS Centre should ensure that its centre performs the relevant category of the following functions:

#### 1.1.1 *Real-time products and services for middle latitudes and subtropical areas*

For *middle latitudes and subtropical areas*, the GDPFS should provide the following products derived from deterministic and ensemble NWP systems and services in *real time*:

(*a*) Surface and upper-air analyses;

(*b*) Prognoses one to three days in advance, including:

(i) Surface and upper-air prognoses of pressure (geopotential), temperature, humidity and wind in map or other form;

(ii) Diagnostic interpretation of numerical weather prediction (NWP) products to give:

a. Areal distribution of cloudiness;

b. Precipitation location, occurrence, amount and type;

c. Sequences at specific locations (time diagrams), at the surface and aloft, of temperature, pressure, wind, humidity, etc., subject to agreement between Members where appropriate;

d. Vorticity advection, temperature/thickness advection, vertical motion, stability indices, moisture distribution, and other derived parameters as agreed by Members;

e. Jet-stream location and tropopause/layer of maximum wind;

f. Numerical products providing sea-state or storm-surge forecasts;

(*c*) Prognoses four to 10 days in advance, including:

(i) Surface and upper-air prognoses of pressure (geopotential), temperature, humidity and wind;

(ii) Outlooks of temperature, precipitation, humidity and wind in map or other form;

(*d*) Extended- and long-range forecasts of averaged weather parameters as appropriate, including sea-surface temperature, temperature extremes and precipitation;

(*e*) Interpretation of numerical products using relations derived by statistical or statistical/dynamical methods to produce maps or spot forecasts of probability of precipitation or precipitation type, maximum and minimum temperature, probability of thunderstorm occurrence, etc.;

(*f*) Sea-state and storm-surge forecasts using models driven by winds from global NWP models;

(*g*) Environmental quality monitoring and prediction products;

(*h*) Independent real-time quality control of the Level II and Level III data defined in Note (3) to paragraph 1.5.2.

#### 1.1.2 *Real-time products and services for tropical areas*

For tropical areas, the GDPFS should provide the following products from deterministic and ensemble NWP systems and services in real time:

(*a*) Surface and upper-air analyses;

(*b*) Prognoses one to three days in advance, including:

(i) Surface and upper-air prognoses, particularly of wind and humidity in map or other form;

(ii) Diagnostic interpretation of NWP products to give:

a. Areal distribution of cloudiness;

b. Precipitation location/occurrence/amounts;

c. Time sequence of weather parameters at specific locations, subject to agreement between Members, where appropriate;

d. Vorticity, divergence, velocity potential, vertical motion, stability indices, moisture distribution and other derived parameters as agreed by Members;

e. Jet stream and layer of maximum wind locations;

f. Numerical products providing sea-state or storm-surge forecasts;

(iii) The use of special NWP-nested models or diagnostic interpretation of fine-mesh global models to give:

a. Tropical storm positions and tracks;

b. Tropical depression and easterly wave positions and movement;

(*c*) Prognoses four to 10 days in advance, including:

(i) Surface and upper-air prognoses, particularly of wind and humidity;

(ii) Outlooks of precipitation, wind, cloudiness and wet and dry periods;

(iii) Life cycle of tropical storms;

(*d*) Extended- and long-range forecasts of averaged weather parameters, as appropriate, including sea-surface temperature, temperature range and precipitation;

(*e*) Interpretation of numerical products, using relations derived by statistical/dynamical methods to produce maps or at specific location of forecast probability of cloudiness, temperature range, precipitation, thunderstorm occurrence, tropical cyclone tracks and intensitities, etc.;

(*f*) Environmental quality monitoring and prediction products;

(*g*) Sea-state and storm-surge forecasts using models driven by winds from global NWP models;

(*h*) Independent real-time quality control of the Level II and Level III data defined in Note (3) to paragraph 1.5.2.

1.1.3 ***Non-real-time products and services***

The GDPFS should also provide the following products and services in non-real time:

(*a*) Long-range weather and climate monitoring products when operationally useful;

(*b*) Climate-related diagnoses (10- or 30-day mean charts, summaries, anomalies, etc.) particularly for the tropical/subtropical belt;

(*c*) Intercomparison of products, verification and diagnostic studies, as well as NWP model development;

(*d*) Access to data, products and intercomparison results using internationally-accepted formats and media;

(*e*) Provision of continuously updated catalogues of data and products;

(*f*) Regional and global analyses (circulated by Members or research institutions) of the atmosphere and oceans, including means and anomalies of surface and upper-air pressure, temperature, wind and humidity, ocean currents, sea-surface temperature, and ocean surface layer temperature; derived indices, including blocking and teleconnection indices;

(*g*) Satellite remote sensing products distributed by Members; including outgoing long-wave radiation, sea-surface elevation, and normalized vegetation indices;

(*h*) Monthly and annual means or totals for each year of a decade (e.g. 1971–1980, etc.) and the corresponding decadal (10-year) averages of pressure (station level and mean sea level), temperature and precipitation, principally from CLIMAT reporting stations;

(*i*) Climatological standard normals (for the periods 1931–1960, 1961–1990, etc.) of selected elements, principally from CLIMAT reporting stations;

(*j*) Guidelines on the operational use of GDPFS centre products; and

(*k*) Carrying out periodic monitoring of the operation of the WWW.

## 1.2 Functions of Members responsible for GDPFS centres

### 1.2.1 *Interpretation at NMCs*

National Meteorological Centres (NMCs) should be able to use, interpret and interact fully with GDPFS products in order to reap the benefits of the WWW system. Appropriate guidance on the methods for the interpretation of the GDPFS output to end-user products should be made available to Members, as well as methods for the verification and intercomparison of forecasts.

### 1.2.2 *Accessibility of products*

GDPFS products should be accessible through a system of World Meteorological Centres (WMCs) and Regional Specialized Meteorological Centres (RSMCs)* with functions and responsibilities as defined in the Manual and according to agreements among Members when appropriate.

### 1.2.3 *Data management*

**The WWW data management function shall be used to coordinate the real-time storage, quality control, monitoring and handling of GDPFS data and products.**

## 1.3 WMC responsibilities

### 1.3.1 *Output products*

1.3.1.1 Each WMC applying sophisticated high-resolution global NWP models including ensemble prediction systems should prepare for distribution to Members and other GDPFS centres the following products, based on the list in paragraphs 1.1 to 1.1.3 above:

(*a*) Global (hemispheric) analysis products;

(*b*) Short-, medium-, extended- and long-range weather forecasts based on deterministic and ensemble NWP system with global coverage presented separately, if required, for:

  (i) The tropical belt;

  (ii) The middle and high latitudes or any other geographical area according to Members' requirements;

(*c*) Climate-related diagnostic products, particularly for tropical regions;

(*d*) Environmental quality monitoring, analyses, forecasts and prediction products.

1.3.1.2 Global model products required to meet the needs of all WMO Programmes should be made available to national and regional centres at the highest possible resolution given technological and other constraints.

### 1.3.2 *Use of products*

WMCs should also carry out verification and intercomparison of products and make results available to all Members concerned, support the inclusion of research results into operational models and their supporting systems and provide training courses on the use of WMC products.

1.3.3 The functions of a WMC should also include the following non-real-time activities:

(*a*) Carrying out the development of research in support of large- and planetary-scale analyses and forecasting;

(*b*) Exchanging technical information with other centres;

(*c*) Providing opportunities for training personnel in data processing;

(*d*) Managing non-real-time data involving:

  (i) Collection and quality control of data not available from the GOS in real-time, via mail or other means;

  (ii) Storage and retrieval of all basic observational data and processed information needed for large- and planetary-scale research and applications;

  (iii) Making non-real-time data available to Members or research institutes upon request;

(*e*) Continuously updating and providing, on request, catalogues of available products.

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* The present structure of the GDPFS is given in Appendix I-1.

## 1.4 RSMC responsibilities

### 1.4.1 *Output products*

1.4.1.1 *Regional Specialized Meteorological Centres (RSMCs) with geographical specialization*

**Regional Specialized Meteorological Centres (RSMCs) with geographical specialization shall be designated in each Region, capable of preparing with the support of WMCs, and where applicable RSMCs outside the Region, analyses and short-, medium-, extended- and long-range weather forecasts with the highest possible quality and with meteorological content, geographical coverage and frequency required by Members and agreed for the system. Output products from RSMCs should comprise:**

**(*a*) Analyses and prognoses at the surface and/or in the free atmosphere for short, medium, extended and long ranges, for the tropical, subtropical and extratropical areas, according to the obligations of each RSMC and as agreed by the regional association;**

**(*b*) Interpreted forecasts of specific weather parameters in map form or at specific locations (e.g. precipitation amounts, temperature, wind and humidity), subject to agreement between Members, where appropriate;**

**(*c*) Guidance on storm-position and track forecasts for the areas affected by tropical storms;**

**(*d*) Climate analyses, long-range forecasts, onset, intensity and cessation of the rainy season(s);**

**(*e*) Environmental quality monitoring and predictions, such as UV-B;**

**(*f*) Results of forecast verifications and intercomparison studies.**

1.4.1.2 *Regional Specialized Meteorological Centres (RSMCs) with activity specialization*

**A Regional Specialized Meteorological Centre (RSMC) with activity specialization shall be designated, subject to the formal commitment by a Member or group of cooperating Members, to fulfil the required functions of the centre and meet the requirements for the provision of WWW products and services initiated and endorsed by the relevant WMO constituent body or bodies concerned. The centre should be capable of preparing independently or with the support of WMCs, and where appropriate, other GDPFS centres and disseminating to Members concerned:**

**(*a*) Global medium-range forecasts and related analyses;**

**(*b*) Extended- and long-range weather forecasts and related mean analysed values and anomalies;**

NOTE: Centres producing global long-range forecasts, and recognized as such by CBS, are called Global Producing Centres for Long-range forecasts (GPCs). The criteria to be recognized as a GPC and the list of official recognized GPCs can be found in Appendix II-8.

**(*c*) Tropical cyclone warnings and advisories, storm position, intensity and track forecasts for their areas;**

**(*d*) Three-dimensional atmospheric modelling products including trajectories, integrated pollutant concentration, and total deposition for environmental emergency response, atmospheric backtracking modelling procedures;**

**(*e*) Drought monitoring products such as drought indices.**

1.4.1.3 Regional model output products required to meet the needs of all WMO Programmes should be made available to national centres at the highest possible resolution given technological and other constraints.

1.4.1.4 The overall list of output products required for international exchange from GDPFS centres is given in Appendix II-6.

### 1.4.2 *Conversion capabilities for transmission of products*

In order to meet the requirements of NMCs for output products in character representation and/or graphical form, all RSMCs should have facilities for conversion of products from binary to character and/or graphical form for regional transmission.

### 1.4.3 *Constraints for adjacent centres*

To the maximum extent feasible, adjacent RSMCs with geographical specialization should be prepared to assume each other's functions. This does not necessarily mean that each RSMC should be prepared to use the analytical models employed by RSMCs adjacent to it. Each RSMC should, however, be able to issue products covering equivalent geographical areas and to give information generally similar to that contained in the products of adjacent RSMCs.

1.4.4 The functions of an RSMC should also include the following non-real-time activities:

(*a*) Assistance in the management of non-real-time data involving:

(i) Assistance to the WMC in management and maintenance of non-real-time data, in particular by obtaining late and delayed observational data for its area of responsibility;

(ii) Storage and retrieval of basic observational data and processed information needed to discharge the non-real-time responsibilities of the RSMC;

(iii) Making non-real-time data available to Members or research institutes upon request;

(*b*) Development and refinement of new techniques and applications;

(*c*) Carrying out comparative verifications of RSMC products and making results available to all Members concerned;

(*d*) Regular exchange with other centres of information on techniques and procedures used and results achieved;

(*e*) Providing opportunities for training of personnel in manual and automated techniques;

(*f*) Continuously updating and providing, on request, a catalogue of available products.

1.5 **Members' responsibilities**

Each Member shall ensure that it has a National Meteorological Centre adequately staffed and equipped to enable it to play its part in the World Weather Watch.

1.5.1 ***NMC functions***

Each Member should ensure that its National Meteorological Centre performs the functions defined in Part I, paragraph 4.1.3 and as elaborated in Part II, paragraphs 1.1 to 1.2.3.

1.5.2 ***Checking of collected information***

Each Member shall designate a National Meteorological Centre, or other appropriate centre, to be responsible for meteorological checking of information collected before transmission on the Global Telecommunication System.

NOTES:

(1) It is for each Member to decide, in the light of its own capabilities and needs, the extent to which it wishes to receive and use products of WMCs and RSMCs.

(2) The telecommunication functions of World Meteorological Centres and National Meteorological Centres are specified in the *Manual on the GTS*.

(3) Definition of data levels. In discussing the operation of the GDPFS it is convenient to use the following classification of data levels, which was introduced in connection with the data-processing system for the Global Atmospheric Research Programme (GARP):

Level I: Primary data. In general these are instrument readings expressed in appropriate physical units and referred to Earth coordinates. Examples are: radiances or positions of constant-level balloons, etc. but not raw telemetry signals. Level I data still require conversion to the meteorological parameters specified in the data requirements.

Level II: Meteorological parameters. These are obtained directly from many kinds of simple instruments, or derived from the Level I data (e.g. average winds from subsequent positions of constant-level balloons).

Level III: Initial state parameters. These are internally consistent data sets, in grid-point form obtained from Level II data by applying established initialization procedures. At those centres where manual techniques are employed, Level III data sets will consist of a set of manually-produced initial analyses.

1.5.3 The functions of an NMC should also include the following non-real-time activities:

(*a*) Support, as required, of the appropriate RSMC in managing non-real-time data, including management of its national database;

(*b*) Storage and retrieval (including quality control) of observational data and processed information to meet national and certain international requirements;

(*c*) Research concerning operations to meet national requirements.

## 2. QUALITY CONTROL OF OBSERVATIONAL DATA AND THEIR RECEPTION AT GDPFS CENTRES IN REAL- AND NON-REAL TIME

### 2.1 Quality control of observational data

#### 2.1.1 *Definitions*

2.1.1.1 Quality assurance should be taken to mean the procedures that ensure the best possible quality of the data which are used for purposes of the GDPFS.

2.1.1.2 Quality control (QC) requires that an operational entity, be it a WMC, RSMC, NMC or observing site, has the ability to select, edit, or otherwise manipulate observations according to its own set of physical or dynamical principles. Furthermore, real-time QC should carry the connotation that such a centre has the ability to feedback, or query, an observation-originating point of a responsible staff, where appropriate, on erroneous or questionable data, or on the lack of an expected report within a time sufficient to retain the synoptic usefulness of the report.

2.1.1.3 Quality monitoring, on the other hand, is the act of aggregating information on the quality of a sample of observations from the point of view of a particular application, e.g. numerical weather prediction. It is important to make a distinction between quality monitoring and delayed-time quality control. The latter needs to be clarified in terms of the actual practices of the centres producing delayed-time products.

2.1.1.4 Quantity monitoring is the act of aggregating information on the numbers of observations available, transmitted and used by a centre.

#### 2.1.2 ***Responsibility for real-time quality control***

2.1.2.1 The primary responsibility for quality control of all observational (Level II) data should rest with the national Meteorological Service from which the observation originated ensuring that when these observations enter the GTS they are as free from error as possible.

2.1.2.2 Quality control of observational data needed for real-time uses shall not introduce any significant delay in the onward transmission of the data over the GTS.

2.1.2.3 To detect errors which may escape the national quality-control system and errors introduced subsequently, RSMCs, WMCs and other GDPFS centres should also carry out appropriate quality monitoring of the observational data they receive.

#### 2.1.3 ***Minimum standards***

2.1.3.1 Members should implement minimum standards of real-time quality control at all NMCs, RSMCs and WMCs. These standards of quality control for real-time data are given in Appendix II-1.

2.1.3.2 For the NMCs not capable of implementing these standards, Members concerned should establish agreements with an appropriate RSMC or NMC to perform the necessary quality control on an interim basis.

### 2.2 Requirements for observational data

2.2.1 In determining observational data requirements for their data-processing functions, Members shall keep in mind the needs of all WMO Programmes and WMO supported programmes.

2.2.2 To determine the minimum overall area of data coverage required, Members shall consider the area for which they are preparing analyses and forecasts, the scale of phenomena being dealt with, and the needs of the actual analysis/forecast process in use.

NOTES:

(1) Requirements of GDPFS centres for national, regional and global exchange of observational data needed, including in particular those of large-scale advanced NWP, are given in Appendix II-2.

(2) Intra- and inter-regional exchange programmes of observational data for large-scale and mesoscale analysis are set up by the regional associations concerned.

### 2.3 Times of receipt of observational data

2.3.1 The observational data required for real-time purposes shall reach the national Meteorological Services sufficiently quickly to be used effectively.

2.3.2 The observational data shall therefore be handled rapidly during pre-processing by the GDPFS and during transmission by the GTS.

NOTE: Target times for the receipt of observational data are given in Appendix II-3.

## 3. ANALYSIS AND FORECASTING PRACTICES

NOTE: In addition to the regulations contained in this chapter, detailed guidance is given in the *Guide on the Global Data-processing and Forecasting System* (WMO-No. 305) and in the *International Meteorological Tables* (WMO-No. 188).

### 3.1 Reference surfaces for upper-air analysis

3.1.1 The principal type of reference surface for representing and analysing the conditions in the free atmosphere over large areas shall be isobaric.

3.1.2 **The standard isobaric surfaces for representing and analysing the conditions in the lower atmosphere shall be the 1 000 hPa, 850 hPa, 700 hPa, 500 hPa, 400 hPa, 300 hPa, 250 hPa, 200 hPa, 150 hPa and 100 hPa surfaces.**

3.1.3 The standard isobaric surfaces for representing and analysing the conditions in the atmosphere above 100 hPa should be the 70 hPa, 50 hPa, 30 hPa, 20 hPa and 10 hPa surfaces.

### 3.2 Preparation of upper-air charts

3.2.1 Members should either prepare or have available upper-air charts for at least four of the six following standard isobaric surfaces: 850 hPa, 700 hPa, 500 hPa, 300 hPa, 250 hPa and 200 hPa.

### 3.3 Short-range weather forecasting

In the short-range weather forecasting process, Members should:

- Evaluate the present meteorological situation;
- Examine the quality and relevance of the analysis;
- Indentify the key elements of the meteorological situation, according to the accepted conceptual models and/or guidance or tools;
- Examine the various guidance products and choose the most likely scenario;
- Describe the evolution of the atmosphere corresponding to the chosen scenario;
- Deduce the consequences for smaller scale and specific areas;
- Describe the expected weather in terms of weather elements, including automated production techniques when applicable;
- Decide on the opportunity or necessity to issue or end warnings;
- Distribute the various products to users;
- Evaluate according to performance measurements or verify forecasts.

## 4. PRACTICES FOR PICTORIAL REPRESENTATION OF INFORMATION ON METEOROLOGICAL CHARTS AND DIAGRAMS

### 4.1 Scales and projections of meteorological charts

4.1.1 The following projections, as appropriate, should be used for weather charts:

(*a*) The stereographic projection on a plane cutting the sphere at the standard parallel of latitude 60°;

(*b*) Lambert's conformal conic projection, the cone cutting the sphere at the standard parallels of latitude 10° and 40° or 30° and 60°;

(*c*) Mercator's projection with true-scale standard parallel of latitude 22$^1/_2$°.

4.1.2 The scales along the standard parallels should be as follows for weather charts:

| | | | |
|---|---|---|---|
| (*a*) | Covering the world: | | 1 : 40 000 000 |
| | | Alternative: | 1 : 60 000 000 |
| (*b*) | Covering a hemisphere: | | 1 : 40 000 000 |
| | | Alternatives: | 1 : 30 000 000 |
| | | | 1 : 60 000 000 |
| (*c*) | Covering a large part of a hemisphere or hemispheres: | | 1 : 20 000 000 |
| | | Alternatives: | 1 : 25 000 000 |
| | | | 1 : 30 000 000 |
| | | | 1 : 40 000 000 |
| (*d*) | Covering a portion of a continent or an ocean or both | | 1 : 10 000 000 |
| | | Alternatives: | 1 : 25 000 000 |
| | | | 1 : 20 000 000 |
| | | | 1 : 15 000 000 |
| | | | 1 : 7 500 000 |

4.1.3 The name of the projection, the scale at the standard parallels and the scales for other latitudes should be indicated on every weather chart.

4.2 **Symbols used on meteorological charts**

4.2.1 A standard set of symbols and models should be used for plotting data on meteorological charts.

4.2.2 A standard set of symbols should be used for representing analyses and forecasts on meteorological charts.

NOTE: The symbols used for the pictorial representation of observational data, analyses and forecasts on meteorological charts are those given in Appendix II-4.

4.3 **Construction of aerological diagrams**

4.3.1 Diagrams used for representation and analysis of upper-air observations of pressure, temperature and humidity should:

(*a*) Be constructed on the basis of:

(i) The values of the physical constants and parameters given in the *Technical Regulations* (WMO-No. 49), Volume I, Appendix A;

(ii) The assumption of ideal gas properties, except for the values of both saturation vapour pressure and heats of transformation of phases of water, at specific temperatures;

(*b*) Bear a legend stating the principles used in their construction.

4.3.2 Diagrams used for the accurate computation of geopotential from upper-air observations of pressure, temperature and humidity should possess the following features:

(*a*) Equal-area transformation of pressure-volume diagram;

(*b*) Straight and parallel isobars;

(*c*) A scale such that the errors involved in computation are significantly smaller than those arising from instrumental errors.

4.4 **Preparation of charts and diagrams for facsimile transmission**

4.4.1 ***Preparation of charts***

4.4.1.1 When preparing charts for facsimile transmission, the following basic considerations in the preparation of the original copy should be followed:

(*a*) The minimum line thickness should be sufficiently large to ensure clear reproduction;

(*b*) Lines which are required to be reproduced uniformly should be of uniform width and intensity;

(*c*) The minimum separations of detail in letters, figures, symbols, etc. should be sufficient to avoid filling-in of the spaces in the reproduction;

(*d*) Letters, figures, symbols, etc. should be drawn as simply as possible;

(*e*) Models employed in plotting should be as simple as possible.

4.4.2 ***Standardization of maps for facsimile transmission***

4.4.2.1 The standard projections and scales in paragraphs 4.1.1 and 4.1.2 should also apply to documents prepared for facsimile transmission.

4.4.3 ***Colours and features***

4.4.3.1 Since the reproduced chart or diagram may show little, if any, colour differentiation between the different elements plotted on the original copy, the original should be prepared either using a monochromatic system or, if a polychromatic system is employed, in such a way that the reproduction conforms to a monochromatic system. For example, on the original copy, fronts should be entered in their appropriate colours, providing the symbols used to draw the fronts conform to the frontal symbols of the monochromatic system given in Appendix II-4.

4.4.3.2 Synoptic weather maps and charts prepared for transmission by facsimile should include the following features:

(*a*) Geographical outlines of minimum detail necessary for orientation purposes with coastlines interrupted where station data are to be plotted;

(*b*) Selected meridians and parallels printed in double thickness (bold-face) for orientation purposes;

(*c*) Map references required only for convenience in the entering of data, e.g. index numbers, 1° intersections of latitude and longitude, station circles, etc., to be printed in non-photo blue;

(*d*) Letter and figures of a size compatible with resolution characteristics of the transmission system(s) over which the charts are to be transmitted.

4.4.4 ***Legend***

4.4.4.1 All charts and diagrams transmitted by facsimile should bear a bold legend including:

(*a*) The type of chart or diagram;

(*b*) The date and time to which the data refer or, in the case of forecast charts, the time to which the forecast applies;

(*c*) An explanation of the plotted symbols or isopleths if these are not obvious from the style of the chart.

NOTE: Minimum requirements for identification of charts transmitted in pictorial form are also given in the *Manual on the Global Telecommunication System* (WMO-No. 386) (see Volume I, Part II, paragraph 3.1).

4.4.5 ***Plotted data***

4.4.5.1 Entries on the original copy should conform to the basic principles outlined in Appendix II-4.

4.4.6 ***Analysed data***

4.4.6.1 Isopleths, frontal symbols, areas of precipitation, etc. should be entered, as appropriate, in the manner laid down in Attachment II.4. Care should be taken not to obliterate one set of plotted data by another.

## 5. EXCHANGE OF PRODUCTS BETWEEN CENTRES

### 5.1 Times of availability of products

5.1.1 **Processed data (products) required for real-time and non-real time purposes shall reach the national Meteorological Service sufficiently quickly to be of effective use in its associated timescale.**

5.1.2 **Both observational and processed data shall therefore be handled rapidly by both the GDPFS and the GTS (see also paragraph 2.3.2).**

NOTE: Target times for the availability of processed information are given in Appendix II-5.

### 5.2 Programmes of output products

5.2.1 **Members shall establish programmes of output products for general distribution by their WMCs and/or RSMCs, taking into account requirements of other Members and the capability of the GTS to handle these products.**

NOTE: Overall lists of products, to be used as general guidance by Members in establishing output programmes for their WMCs and RSMCs, are found in Appendix II-6.

5.2.2 Each Member should state which products its NMC, RSMC or WMC wishes to receive from other centres.

5.2.3 In order to avoid overloading the GTS, Members should limit requests by their NMCs for products, taking into account the following considerations:

(*a*) Members should require output products from RSMCs with geographic specialization normally from one RSMC located in the same WMO Region (exceptions should be restricted to cases where the area, for which a Member needs to receive RSMC output products, is not covered by the products from one RSMC in the same Region);

(*b*) If there is an urgent need for a Member to receive the same product from more than one geographically specialized RSMC or WMC for special operational purposes, these requirements should be limited to a selection of two levels of analyses and prognoses;

(*c*) Members should request processed information from the centres most readily accessible on the GTS.

NOTE: The lists of global and regional model products, to which the highest priority should be given by WMCs and RSMCs for preparation, are given in Attachments II.1 and II.2.

5.2.4 Globally specialized RSMCs should tailor their products to regions to meet regional requirements and, if possible, to limit their size to avoid overloading the GTS.

## 5.3 Transmission priorities for GDPFS products

NOTE: The priorities listed in this section are intended as guidance to GDPFS centres on providing observational data and output products to the GTS in the proper sequence. As regards the relay of information by automated telecommunication centres, the provisions of the *Manual on the Global Telecommunication System* apply.

### 5.3.1 *Transmission priorities for global model products from WMCs and RSMCs*

5.3.1.1 Priorities for the transmission of global model output products should be used when several such WMC and RSMC products are available at the same time.

NOTE: Transmission priorities for global model output products are given in Attachment II.3.

### 5.3.2 *Transmission priorities for regional model products from RSMCs*

5.3.2.1 Priorities for transmission of regional model products should be based on the requirements for interregional exchange of RSMC products on the MTN and its branches.

NOTE: Transmission priorities for regional model products, from RSMCs which have the highest priority for transmission on the MTN and its branches (without indication of order of preference), is given in Attachment II.4.

### 5.3.3 *Transmission priorities after transmission outages on the MTN and its branches*

(*a*) Normal transmission schedules of observational data should be resumed no later than the first main standard time of observation following the cessation of the outage;

(*b*) Procedures for the transmission of accumulated meteorological data should not interfere with the resumption of normal transmission schedules. If these data are redundant, they should not be transmitted.

NOTES:

(1) Although new automatic rerouting procedures provide a capability for routing traffic when a segment of the MTN is disrupted, there is still a need for a system of priorities which can be used for the transmission of meteorological data when the rerouting procedures cannot be used.

(2) Priorities for transmission of observational data on the MTN and its branches are given in Attachment II.5 (Part 1).

### 5.3.4 *Transmission priorities for global model products from WMCs and RSMCs after outages*

5.3.4.1 Global model products accumulated due to circuit disruption should be transmitted with the least possible delay.

NOTE: A list of transmission priorities for global model products, from WMCs and RSMCs after outages on the MTN and its branches, is given in Attachment II.5 (Part 2).

### 5.3.5 *Transmission priorities for regional model products from RSMCs after outages*

5.3.5.1 Regional model products from RSMCs accumulated due to circuit disruptions on the MTN and its branches should be transmitted with the least possible delay.

5.3.5.2 The regional model products should have a higher priority than global model products for transmission after outages on the MTN and its branches.

NOTE: A list of transmission priorities for regional model products, from RSMCs after outages on the MTN and its branches, is given in Attachment II.5 (Part 3).

### 5.3.6 *Priority of observational data over processed data*

5.3.6.1 **On the MTN and its branches, transmission of observational data shall have priority over the transmission of processed data (in both analogue and digital form).**

### 5.3.7 *Transmission of products in binary, alphanumeric and pictorial form*

5.3.7.1 Until such time as all centres are in a position to convert output products in GRIB and/or GRID code form into pictorial form, Members should transmit certain of their WMC and RSMC products also in pictorial form in addition to alphanumeric and/or binary form.

5.3.7.2 A list of such products for transmission on the MTN and its branches should provide guidance to members for triple transmissions.

NOTES:

(1) Members are encouraged to transmit processed information in the GRID and/or GRIB code forms.

(2) A minimum list for transmission of products in binary, alphanumeric and pictorial form is given in Attachment II.6.

(3) As Members develop the capability at their RSMCs for transforming these products from GRID and/or GRIB to pictorial form, the pictorial transmission will be discontinued, where appropriate.

### 5.3.8 *Plan for monitoring the operation of the World Weather Watch*

5.3.8.1 Members should implement the plan for monitoring the operation of the World Weather Watch, in particular the real-time monitoring.

NOTE: The plan for monitoring the operation of the World Weather Watch is given in Attachment II.7.

### 5.3.9 *Procedures and formats for the exchange of monitoring results*

5.3.9.1 GDPFS centres participating in the exchange of monitoring results should implement standard procedures and use the agreed formats.

NOTE: Procedures and formats for the exchange of monitoring results are given in Attachment II.9.

### 5.3.10 *Standards in the provision of international services by Regional Specialized Meteorological Centres (RSMCs) for atmospheric transport modelling in radiological environmental emergency response*

5.3.10.1 **The designated RSMCs with activity specialization in this field shall implement agreed standard procedures and products.**

NOTE: Standards in the provision of international services by RSMCs for atmospheric transport modelling, for radiological environmental emergency response are given in Appendix II-7.

### 5.3.11 *Standards in the provision of international services by Regional Specialized Meteorological Centres (RSMCs) for atmospheric transport modelling in backtracking*

5.3.11.1 The designated RSMCs with activity specialization in this field shall implement agreed standard procedures and products.

NOTE: Standards in the provision of international services by RSMCs for CTBT Verification support are given in Appendix II-9.

## 5.4 Responsibilities of Members for providing information on their real-time data-processing activities

5.4.1 **Members shall provide the Secretariat annually, at the end of January, with information on equipment in use at their centre, usage of data and products from the GTS, analysis and prediction techniques, real-time quality control and verification procedures, and results obtained at their centre(s) for inclusion in an Annual WWW Technical Progress Report on the Global Data-processing and Forecasting System.**

5.4.2 Members should provide the Secretariat, at stated intervals, with current information on appropriate routine computer programs used in their centres, which they are willing to make available, or their requirements and requests for software support for inclusion in the WMO Secretariat Software Registry.

APPENDIX II-1

# MINIMUM STANDARDS FOR QUALITY CONTROL OF DATA FOR USE IN THE GDPFS (BOTH REAL-TIME AND NON-REAL-TIME)

## INTRODUCTION

1. According to the WWW plan the Commission for Basic Systems was required to develop minimum standards for quality control of data in the GDPFS. The Plan for Monitoring the Operation of the WWW, developed by CBS (as presently published in the *Manual on the GTS*, WMO–No. 386, Attachment I-5), also includes reference to the fact that minimum standards should be defined in the *Manual on the GDPFS*.

## OBJECTIVES

2. The objectives of the GDPFS quality control are:

(*a*) To ensure the best possible quality of the data which are used in the real-time operations of the GDPFS;

(*b*) In non-real time, to protect and improve the quality and integrity of data destined for storage and retrieval within the GDPFS;

(*c*) To provide the basis for feedback of information on errors and questionable data to the source of the data.

## BASIC COMPONENTS

3. The minimum standards for quality control of data apply to all WWW centres: NMCs, RSMCs, WMCs. They include quality control at various stages of processing. They apply to both real-time and non-real-time processing and should lead to various records of quality-control actions.

## ASPECTS OF IMPLEMENTATION

4. Quality-control standards may be introduced progressively at a GDPFS centre using a modular approach. The general priorities for implementation of the minimum standards under the modular concept concern quality control of data, according to:

(*a*) Sources (e.g. stations);

(*b*) Type (e.g. SYNOP, TEMP);

(*c*) Time (e.g. 00 UTC, 12 UTC);

(*d*) Parameters and characteristics (e.g. pressure, wind, temperature, amount of precipitation).

5. WMCs having multiple responsibilities as an RSMC and/or an NMC, and RSMCs also having a responsibility as an NMC, should assume the minimum standards pertinent to all levels at which the centre operates.

6. Table I of this Appendix lists the minimum standards for real-time and non-real-time quality control at NMCs, RSMCs and WMCs. Where applicable, regional associations and national Meteorological Services will set up similar quality-control standards for data exchanges only at regional or national levels.

## RESPONSIBILITIES

7. General principles for the application and administration of GDPFS minimum standards for quality control of data are given in the following paragraphs.

8. The basic responsibilities for implementing minimum standards for quality control of the GDPFS rest with Members.

9. An essential part of the quality-control plan includes an exchange of information about data deficiencies between GDPFS centres and observation points in order to resolve those deficiencies and minimize their recurrence.

10. The frequency with which information is exchanged in order to improve the quality of data and products should correspond to the frequency with which monitoring reports are exchanged. These are given in the Plan for Monitoring the Operation of the WWW, as given in Attachment II.7, in particular, paragraph 22.

11. The minimum standards specify which data are to be quality-controlled and how often. The detailed methods for performing the quality control are left to the Members to develop, but should conform to the minimum standards.*

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* Methods for real-time and non-real-time quality control are given in the *Guide on the GDPFS*, WMO–No. 305.

# Table I

## GDPFS MINIMUM STANDARDS FOR QUALITY CONTROL OF INCOMING DATA (RECEIVED VIA THE GTS OR OTHER MEANS)

| (1) | *Station list*<br>(2) | *Types of report*<br>(3) | *Times of observations**<br>(4) | *Parameters to be quality-controlled*<br>(5) | *Procedures for quality control*<br>(6) | *Records to be maintained*<br>(7) | *Minimum frequency for performing quality control*<br>(8) |
|---|---|---|---|---|---|---|---|
| REAL TIME | WMCs, RSMCs and NMCs: Global exchange list of RBSNs in Volume A, WMO-No. 9, *Observing Stations* | SYNOP | 00, 06, 12, 18 | FM 12:<br>All mandatory groups | *Checking*<br>• Detection of mission data at centres<br>• Adherence to prescribed coding formats<br>• Internal consistency<br>• Time consistency<br>• Space consistency<br>• Physical and climatological limits<br><br>*Remedial Action*<br>Before further processing, correct or flag erroneous or suspect data<br><br>*Notification:*<br>Discrepancies and missing data should be made known to the appropriate centre or station<br><br>NOTE: It is recognized that notification of not all errors or doubtful data can be done in real time by a processing centre. Thus when it becomes feasible binary data representation should be used to exchange together with observations:<br>• Instruments<br>• Information on data correction applied<br>• Information on quality control | • Information to identify source of data such as station, aircraft, ship<br><br>• Type of deficiency (non-receipt, incomplete or incorrect reports, etc.)<br><br>• Identification of deficient element (whole report, specific group, specific parameter, etc.)<br><br>• Frequency of occurrence of data deficiencies (according to station type and element) | Preferably with each operational cycle; otherwise, with sufficient frequency to establish representative records |
| | | SHIP | 00, 06, 12, 18 | FM 13:<br>All mandatory groups | | | |
| | | PILOT<br>Parts A and B<br>C and D | 00, 06, 12, 18 | FM 32:<br>Sections 1, 2, 3, 4 | | | |
| | | PILOT SHIP<br>Parts A and B<br>C and D | 00, 06, 12, 18 | FM 33:<br>Sections 1, 2, 3, 4 | | | |
| | | TEMP<br>Parts A and B<br>C and D | 00, 06, 12, 18 | FM 35:<br>Sections 1, 2, 3, 4, 5, 6 | | | |
| | | TEMP SHIP<br>Parts A and B<br>C and D | 00, 06, 12, 18 | FM 36:<br>Sections 1, 2, 3, 4, 5, 6 | | | |
| | | PILOT MOBIL<br>Parts A and B<br>C and D | | FM 34:<br>Sections 1, 2, 3, 4 | | | |
| | | TEMP MOBIL<br>Parts A and B<br>C and D | | FM 38:<br>Sections 1, 2, 3, 4, 5, 6 | | | |
| | | SATEM<br>SATOB | Asynoptic | FM 86:<br>Mean temperatures<br>FM 88:<br>Cloud-motion winds | | | |
| | | Aircraft meteorological observations | Asynoptic | • Time and position<br>• Wind<br>• Temperature<br>• Flight level | | | |
| | | BUOY | Asynoptic | FM 18:<br>Sections 1, 2 | | | |

*(continued)*

## GDPFS MINIMUM STANDARDS FOR QUALITY CONTROL OF INCOMING DATA (RECEIVED VIA THE GTS OR OTHER MEANS) *(contd.)*

| (1) | Station list (2) | Types of report (3) | Times of observations* (4) | Parameters to be quality-controlled (5) | Procedures for quality control (6) | Records to be maintained (7) | Minimum frequency for performing quality control (8) |
|---|---|---|---|---|---|---|---|
| | | CLIMAT** | Monthly | FM 71: Section 1 | | | |
| | | CLIMAT SHIP** | Monthly | FM 72: Section 1 | | | |
| | | CLIMAT TEMP** | Monthly | FM 75 | | | |
| | | CLIMAT TEMP SHIP** | Monthly | FM 76 | | | |
| | | BUFR | As defined within the message | FM 94: Section 4 | | | |
| NON REAL TIME | WMCs, RSMCs and NMCs: Global exchange list of RBSNs in Volume A, WMO-No. 9, *Observing Stations* | Same as for real time plus: | Same as for real time plus: | Same as for real time plus: | *Checking*<br>Same as for real time and in addition:<br>• Review of recorded data in comparison with observations taken before and after<br>• Inter-comparison of parameters and calculations<br>• Check of supplementary data<br>• Check of extreme values<br><br>*Remedial Action*<br>Correct errors and flag data as appropriate<br><br>*Notification*<br>Refer discrepancies to observing stations or WWW centre as follows:<br>• Once per month from NMCs<br>• Once every three months from RSMCs<br>• Once every six months from WMCs and lead centres | *Summarize records developed in real time to include:*<br>Same as for real-time with all data deficiencies found in real time combined with additional ones found in non-real time | With sufficient frequency to establish representative records |
| | | ROCOB | Asynoptic | FM 39: Sections 1, 2 | | | |

* Use observation time nearest to maintain synoptic hours when observation not taken at main synoptic hours.

** Monthly on receipt and prior to initial distribution or use.

NOTES: (1) Any of the observational data types, described in column (3) in terms of their alphanumeric code forms, may also be transmitted in BUFR code. If so, they should be subject to the same minimum standards of quality control as their alphanumeric counterpart. New data (in BUFR) should have quality-control standards developed as appropriate.

(2) Lead centres for data-quality monitoring are given in WMO-No. 488, *Guide on the Global Observing System*, Part VII, paragraph 7.2.2.1.

The geographic area (zone) of responsibility for application of the minimum standards will correspond to that undertaken by each WWW centre for data processing and forecasting, as laid down in Attachment III.2.

**ADVANCED STANDARDS**

12. The primary purpose of quality control is to detect data deficiencies and to attempt to correct them in real time. Thus, the WWW centres should perform quality-control operations as these are developed and as their technical capabilities allow. Centres which have high-speed computers can apply standards for quality control which are far beyond the minimum standards. These advanced standards should involve more real-time quality control, including correcting or flagging of more reports, parameters and levels than listed in Table I. The *WWW Guides* give information on methods for more advanced quality control.*

13. It is also the responsibility of automated centres to perform nearly continuous inspection and quality control of processing programmes that enable computers to identify, decode, process and array data properly.

**MINIMUM STANDARDS FOR PROCESSED DATA**

14. Minimum standards for quality control of processed data should include:

(*a*) Standards for presentation of processed data as they are given in Appendix II-4;

(*b*) Spatial and temporal coherence in the meteorological structure of the product (that is, no impossible or contradictory atmospheric states).

* Methods for real-time and non-real-time quality control are given in the *Guide on the GDPFS*, WMO-No. 305.

APPENDIX II-2

# OBSERVATIONAL DATA REQUIREMENTS FOR GDPFS CENTRES FOR GLOBAL AND REGIONAL EXCHANGE

The following paragraphs 1, 2 and 3 state the observations required to operate all GDPFS centres at national, regional and global levels. Paragraph 4 addresses the data requirements for NWP operations only.

1. The types of observation networks and platforms providing data required at data-processing and forecasting centres are as follows:

(*a*) All stations included in the Regional Basic Synoptic Networks;

(*b*) The network of supplementary synoptic stations, including automatic stations;

(*c*) Automatic marine stations (drifting buoy and moored buoys);

(*d*) Mobile sea stations;

(*e*) All other stations making radiowind, radiosonde/radiowind and pilot balloon observations;

(*f*) Meteorological rocket stations;

(*g*) Aircraft meteorological observations;

(*h*) Wind profilers;

(*i*) Doppler and weather watch radar systems and networks;

(*j*) Space-based systems producing:

- (i) Imagery (including both analogue and digital imagery);
- (ii) Radiance data;
- (iii) Vertical temperature and humidity profiles;
- (iv) Cloud and water vapor motion winds;
- (v) Cloud height, temperature, type and amount;
- (vi) Digital information about clouds (liquid water or ice (total));
- (vii) Surface wind, precipitation rate and precipitable water;
- (viii) Land temperature;
- (ix) Sea-surface temperature;
- (x) Ocean surface wind vector;
- (xi) Albedo;
- (xii) Ocean wave spectra;
- (xiii) Sea ice cover;
- (xiv) Snow cover, depth and water equivalent;
- (xv) Earth radiation fluxes;
- (xvi) Aerosols and trace gases;
- (xvii) Volcanic ash;
- (xviii) Other meteorological and environmental products;

(*k*) Radiological data reporting stations in case of nuclear accidents (required for GDPFS centres running transport models for environmental emergency response);

(*l*) Selected climatological/agrometeorological/hydrological stations;

(*m*) Lightning detection and location systems network;

(*n*) Global Atmosphere Watch (GAW) network.

The observational data which will be needed to obtain optimum results from NWP systems by the year 2000 and meet the needs of all WMO Programmes and WMO supported Programmes are elaborated in paragraph 4 below and its related three tables.

2. The report code types which carry the data provided by the platforms listed in paragraph 1 above are given below:

(*a*) BUFR and GRIB;

(*b*) TEMP — Parts A, B, C and D;

(*c*) PILOT — Parts A, B, C and D;

(*d*) TEMP SHIP — Parts A, B, C and D;

(*e*) PILOT SHIP — Parts A, B, C and D;

(*f*) TEMP MOBIL — Parts A, B, C and D;

(*g*) PILOT MOBIL — Parts A, B, C and D;

(*h*) COLBA;

(*i*) TEMP DROP;

(*j*) ROCOB;

(*k*) SYNOP;

(*l*) SHIP;

(*m*) Reports from automatic stations on land and at sea;

(*n*) CODAR/AIREP/AMDAR;

(*o*) Selected satellite data, such as cloud images, SATEM, SAREP, SARAD, SATOB;

(*p*) BUOY;

(*q*) CLIMAT, CLIMAT SHIP;

(*r*) CLIMAT TEMP, CLIMAT TEMP SHIP;

(*s*) BATHY, TESAC, TRACKOB;

(*t*) WAVEOB;

(*u*) RADOB;

(*v*) RADREP.

NOTES:

(1) Items (*a*) to (*v*) do not indicate priorities.

(2) BUFR and CREX can encode any of the other above data forms and many more. If BUFR or CREX is used to represent any of these data forms, in lieu of the specific alphanumeric code form, the same data requirements apply.

3. The frequency of observational reports required is as follows:

(*a*) BUFR and GRIB, as available;

(*b*) TEMP, PILOT, TEMP SHIP, PILOT SHIP, TEMP MOBIL, PILOT MOBIL, ROCOB, COLBA and TEMP DROP, as available;

(*c*) SYNOP, SHIP and reports from automatic stations on land and at sea — 0000, 0300, 0600, 0900, 1200, 1500, 1800, 2100 UTC and hourly whenever possible;

(*d*) CODAR/AIREP/AMDAR reports, as available;

(*e*) Selected satellite data, such as cloud images, SATEM, SAREP, SARAD and SATOB and digital cloud data, as available;

(*f*) BUOY, as available;

(*g*) CLIMAT, CLIMAT SHIP, CLIMAT TEMP and CLIMAT TEMP SHIP — once per month;

(*h*) BATHY, TESAC, TRACKOB and WAVEOB, as available;

(*i*) RADOB and RADREP, as available.

4. Data needed for advanced NWP by the year 2000 is as follows:

**GENERAL CONSIDERATIONS**

The following tables list the observational data which will be needed for advanced NWP systems by the year 2000. They include the needs for data assimilation and for analysis and model validation for global short- and medium-range forecasting (excluding long-range forecasting).

Requirements for regional modelling have also been considered. They have been mentioned in the explanatory text, where appropriate, but they have not been listed in the tables. Mesoscale modelling has not been considered.

It is most likely that data of the given specifications would benefit global NWP, if available; however, it does not mean that NWP could not be carried out without such data, as NWP models produce useful products even with the observational data set currently available. It does not mean either that data of higher specification would not be useful; on the contrary, when and where such data are produced they should be made available.

The problem of the feasibility of observing all the variables listed in these tables is not addressed. Most of the requirements stated here could only be met by satellite-borne observing systems. However, in many cases a combination of satellite and *in situ* data is needed to obtain adequate resolution and to ensure stability of calibration of remote sensing systems.

**CONTENTS OF THE TABLES**

The following notes provide some explanation of how the lists were prepared and some provisos on their use:

*Variables*

Following past convention, the observational requirements for data assimilation are stated in terms of geophysical variables. This is thought to be useful since, from a user's perspective, these are the variables on which information is required. However, it is important to note that these variables are not always observed directly (satellite systems observe none of them directly, with the exception of top-of-the-atmosphere radiation and a Doppler wind lidar). Also, it is no longer true that the users need their data exclusively in the form of geophysical parameters; recent developments in data assimilation have demonstrated the potential and the benefits of using data at the engineering level (e.g. radiances, brightness temperatures).

*Horizontal resolution*

(*a*) In general (and with some oversimplification), data are useful for assimilation and validation on spatial scales which the models are attempting to represent. One hundred kilometres are given as the requirement for the variables listed in the tables. However, it is possible to benefit from higher resolution data, considering the current developments towards global models with a grid length of less than 50 km;

(*b*) Regional models attempt to represent spatial scales above the mesoscale. Observational data are required at a resolution of 10 km.

*Vertical resolution*

(*a*) The same rationale is applied here: global NWP models are expected to have a resolution of less than one kilometre throughout the troposphere and lower stratosphere, with considerably higher resolution in the planetary boundary layer. In the mid- and upper stratosphere, a resolution of two kilometres is likely to be sufficient. The requirements for observations should be comparable;

(*b*) For regional models, observations are required at a resolution of 100 m (50 m in the planetary boundary layer).

*Temporal resolution*

(*a*) Just as with spatial resolution, data will be useful for assimilation and validation on temporal scales, which the models are attempting to represent. In the past, this has not been the case; so-called "four-dimensional" assimilation systems would more appropriately be described as "intermittent three-dimensional" systems, and they have not been able to make proper use of observations more frequently than the period of the data assimilation cycle (typically six hours). However, continued progress towards truly four-dimensional data assimilation is making it possible to extract useful information from observations at higher temporal frequency. With such systems, higher temporal resolution can compensate, to some extent, for poor horizontal resolution when the atmosphere is moving. A requirement of three hours for upper-air data and one hour for surface data has been specified. However, like in the case of spatial resolution, upper-air data of higher specification (up to one hour) should also be made available (e.g. cloud motion wind data from geostationary satellites, wind profiles from wind profilers);

(*b*) For regional models, both upper-air and surface data are required at a resolution of one hour.

*Accuracy*

The values given are intended to represent the RMS of the observation errors. The assessment of accuracy should include not only the true instrumental error but also the representativeness error (i.e. the characteristics of some observing systems, particularly *in situ* systems, which sample spatial and temporal scales that are not represented by the models). For NWP applications, such effects appear as though they were observation errors.

*Timeliness*

In NWP, the value of data degrades with time, and it does so particularly rapidly for variables which change quickly. Operational assimilation systems are usually run with a cut-off time of about three hours for global models and one and a half hours for regional models (although data received with longer delays remain useful). Therefore, the timeliness of data delivery must take into account the advertized initiation time of any operational model that uses that data. For observations which are expected to be used for validation, and not for analysis/assimilation in near-real-time, the timeliness is less critical.

## TABLE 1
### Three-dimensional fields

| | *Horizontal resolution (km)* | *Vertical resolution (km)* | *Temporal resolution (hours)* | *Accuracy (RMS error)* | *Notes* |
|---|---|---|---|---|---|
| Wind (horizontal) | 100 | .1 up to 2 km<br>.5 up to 16<br>2 up to 30 | 3 | 2 m $s^{-1}$ in the troposphere<br>3 m $s^{-1}$ in the stratosphere | (1)<br>(2) |
| Temperature | 100 | .1 up to 2 km<br>.5 up to 16<br>2 up to 30 | 3 | .5 K in the troposphere<br>1K in the stratosphere | (3) |
| Relative humidity (RH) | 100 | .1 up to 2 km<br>.5 up to tropopause | 3 | 5% (RH) | |
| Turbulence | 100 | .3 | 1 | – | |
| Ozone | Variable | Variable | Variable | 5% | |
| Greenhouse gases | Variable | Variable | Variable | 2–10% (1pptv–1ppmv) | |
| Reactive gases | Variable | Variable | Variable | 2–10% (1pptv–1ppbv) | |
| Aerosols-chemical and physical properties | Variable | Variable | Variable | – | |
| Salinity | 250 | Variable | 6h | 1% | |
| Sub-sea surface temperature | 250 | Variable | 6h | 0.5 K | |
| Sub-sea surface current | 250 | Variable | 6h | 2 cm $s^{-1}$ | |
| Soil moisture 0–10 cm | 100 | – | 1 day | 0.02 $m^3$ $m^{-3}$ | |
| Soil moisture 10–100 cm | 100 | – | 1 week | 0.02 $m^3$ $m^{-3}$ | |

NOTES:

(1) Accuracy specified as RMS vector error.

(2) Hourly wind data from geostationary satellites and from wind profilers are also required. Tropospheric horizontal and vertical resolution and accuracy can be met by a space-based Doppler wind lidar in a Sun-synchronous orbit.

(3) Geopotential height can be retrieved from specified T and RH with sufficient accuracy.

## TABLE 2

## Surface fields

| | *Horizontal resolution (km)* | *Temporal resolution* | *Accuracy (RMS error)* | *Notes* |
|---|---|---|---|---|
| Pressure | 100 | 1h | 0.5 hPa | |
| Wind | 100 | 1h | 2 m $s^{-1}$ | (1) |
| Temperature | 100 | 1h | 1 K | |
| Relative humidity | 100 | 1h | 5% | |
| Visibility | 100 | | | |
| Accumulated precipitation | 100 | 1h | 0.1 mm | (2) |
| Precipitation rate | 100 | 1h | 0.1 mm $h^{-1}$ | |
| Sea and lake surface temperature | 100 | 1 day | 0.5 K | |
| Soil temperature | 100 | 3h | 0.5 K | |
| Sea-ice and lake ice cover | 100 | 1 day | 10% | |
| Snow cover | 100 | 1 day | 10% | |
| Snow equivalent-water depth | 100 | 1 day | 5 mm | |
| River runoff | 250 | 1 week | | |
| Lake water level | Variable | 1 week | | |
| Water quality | 250 | 1 week | | |
| Sediments | 250 | 1 week | | |
| Percentage of vegetation | 100 | 1 week | 10% (relative) | |
| Phenomological data | Variable | 10 days | | |
| Soil temperature, 20 cm | 100 | 6h | 0.5 K | |
| Deep soil temperature, 100 cm | 100 | 1 day | 0.5 K | |
| Surface roughness | 50 | 1 month | | |
| Albedo, visible | 100 | 1 day | 1% | |
| Albedo, near infrared | 100 | 1 day | 1% | |
| Long-wave emissivity | 100 | 1 day | 1% | |
| Multipurpose imagery | 1 or 4 | 6h | – | |
| Surface net radiation | 50 | 6h | 1% | |
| UV incoming | 50 | 1h | 1–5% | |
| Waves spectra | 100 | 1h | 0.01 m | |
| Salinity | 100 | 6h | 1% | |
| Sea level | 50 | 12h | 0.01m | |
| Ocean current | 100 | 6h | 2 cm $s^{-1}$ | |
| Greenhouse gas concentrations | Variable | Variable | 2–10% (1pptv–1ppmv) | (3) |
| Ozone | Variable | Variable | 1–5% | |
| Precipitation chemistry | Variable | Variable | – | |
| Aerosols-chemical and physical properties | Variable | Variable | – | |
| Reactive gases | Variable | Variable | 2–10% (1pptv–1ppmv) | |
| Radionuclides | Variable | Variable | | |
| Volcanic activity | Variable | Variable | | (3) |

NOTES:

(1) Wind at 10 metres over land;
Over sea, height in the range 1 to 40 metres (to be transmitted with the observation).

(2) Required principally for model validation, not time critical.

(3) For some programmes, e.g. environmental monitoring, environmental emergency response and public weather services, much higher resolution data is needed operationally.

## TABLE 3

## Other two-dimensional fields

| | *Horizontal resolution (km)* | *Temporal resolution* | *Accuracy (RMS error)* | *Notes* |
|---|---|---|---|---|
| Cloud fractional cover | 100 | 3h | 10% | |
| Cloud top height | 100 | 3h | 0.5 km | (1) |
| Cloud base height | 100 | 3h | 0.5 km | (1) |
| Total liquid water content | 100 | 3h | 20% | |
| Cloud phase/particle size | 50 | 6h | – | |
| TOA net short-wave radiation | 100 | 3h | 5 W $m^{-2}$ | (2) |
| TOA net long-wave radiation | 100 | 3h | 5 W $m^{-2}$ | (2) |
| Multipurpose IR/VIS imagery Radiance | 5 | 30 min | – | (3) |
| Column ozone | Variable | Variable | 1% | |
| Optical depth/turbidity | Variable | Variable | – | |
| Column greenhouse and reactive gases | Variable | Variable | – | |

NOTES:

(1) Accuracy is higher in planetary boundary layer.

(2) Required principally for model validation; not time critical.

(3) Required to assist real-time observation monitoring and analysis/forecast validation.

## APPENDIX II-3

# TIMES OF RECEIPT OF OBSERVATIONAL DATA

<table>
<tr><td colspan="3">Receiving centre / Received data</td><td>WMC</td><td>RSMC (RTH)</td><td>NMC</td></tr>
<tr><td rowspan="3">Time of receipt of observational data</td><td>Global network</td><td>Surface + Upper</td><td>H + 3 (6)</td><td>H + 3 (6)</td><td>H + 3 (6)</td></tr>
<tr><td rowspan="2">Regional network</td><td>Surface</td><td rowspan="2">X</td><td>H + 2 (3)</td><td>H + 2 (3)</td></tr>
<tr><td>Upper</td><td>H + 3 (4)</td><td>H + 3 (4)</td></tr>
<tr><td colspan="2" rowspan="2">Minimum storage time of observational data for transmission purposes</td><td>Surface</td><td>H + 24</td><td>H + 24</td><td rowspan="2">X</td></tr>
<tr><td>Upper</td><td>H + 24</td><td>H + 24</td></tr>
</table>

NOTES:

(1) This table states times, e.g. H + 3 (6) hours, within which different categories of data should normally be transmitted to the different centres. H is the time of observation. The first figure is the time necessary for collection of data in regions where telecommunication systems and receiving centres make full use of modern technical equipment. The figure in brackets is applicable where the Global Telecommunication System operates under most difficult conditions.

(2) Time of receipt of observational data is the time at which an adequate amount of data needed for analyses has been received.

APPENDIX II-4

# GRAPHICAL REPRESENTATION OF DATA, ANALYSES AND FORECASTS

## 1. THE SURFACE PLOTTING MODEL

If it is required to plot the elements shown in the model, they should be placed in the relative positions shown. Any of the elements may be omitted.

| | | | | |
|---|---|---|---|---|
| $T_gT_g$ | $T_xT_xT_x$<br>or<br>$T_nT_nT_n$ | $C_H$ | E<br>or<br>E'sss | |
| | TTT | $C_M$ | $PPPP/P_oP_oP_o$<br>or $a_3hhh/$<br>$P_oP_oP_oP_o$ | |
| V V | $ww/w_1w_1$<br>or<br>$w_aw_a/w_1w_1$ | N | PPP | a |
| | $T_dT_dT_d$ | $C_LN_h$<br><br>h or hh | $W_1W_2/w_1w_1$<br>or<br>$W_{a1}W_{a2}/w_1w_1$ | GG<br>or<br>GGgg |
| | $T_wT_wT_w$ | $P_{wa}P_{wa}H_{wa}H_{wa}$<br>or<br>$P_wP_wH_wH_w$ | $RRR/t_R$<br><br>$D_sv_s$ | |

| |
|---|
| $d_{w1}d_{w1}P_{w1}P_{w1}H_{w1}H_{w1}$<br><br>$d_{w2}d_{w2}P_{w2}P_{w2}H_{w2}H_{w2}$ |

The "boxes" are included in the diagram simply to fix the relative positions of the elements and are not included in the actual plot. The wind plot is not shown in the model. Ship identification letters or buoy identifiers should be plotted above the model. In the case of automatic weather stations, an equilateral triangle should be plotted round the station circle so that the apex of the triangle (△) points towards the position of the medium-cloud symbol.

## 2. GRAPHIC REPRESENTATION OF DATA ON WEATHER CHARTS

2.1 The following rules concern the symbols to be used for the plotting of various elements figuring in a surface observation:

N — Total cloud cover

| *Code* | *Symbol* |
|---|---|
| 0 = 0 |  |
| 1 = 1 okta or 1/10 or less, but not zero |  |
| 2 = 2 oktas or 2/10–3/10 |  |
| 3 = 3 oktas or 4/10 |  |
| 4 = 4 oktas or 5/10 |  |
| 5 = 5 oktas or 6/10 |  |
| 6 = 6 oktas or 7/10-8/10 |  |
| 7 = 7 oktas or 9/10 or more, but not 8 oktas or 10/10 |  |
| 8 = 8 oktas or 10/10 |  |
| 9 = 9 Sky obscured, or cloud amount cannot be estimated |  |
| / = No measurements made |  |

ddff — True direction, in tens of degrees, from which wind is blowing (dd) and wind speed in units indicated by $i_w$ (ff)

Wind is represented by barbs and solid pennants in black, the full barbs representing 5 m $s^{-1}$ or 10 knots, the half barbs representing 2.5 m $s^{-1}$ or 5 knots and the solid pennant representing 25 m $s^{-1}$ or 50 knots.

The wind shaft in black is directed along the axis of the wind towards the centre of the station circle and stops at its circumference.

All pennants and barbs lie to the left of the wind shaft in the northern hemisphere and to the right of the wind shaft in the southern hemisphere.

Barbs are at an angle of approximately 120° from the wind shaft. Pennants are triangles with their bases on the wind shaft.

A calm should be indicated by a circle drawn around the station circle:

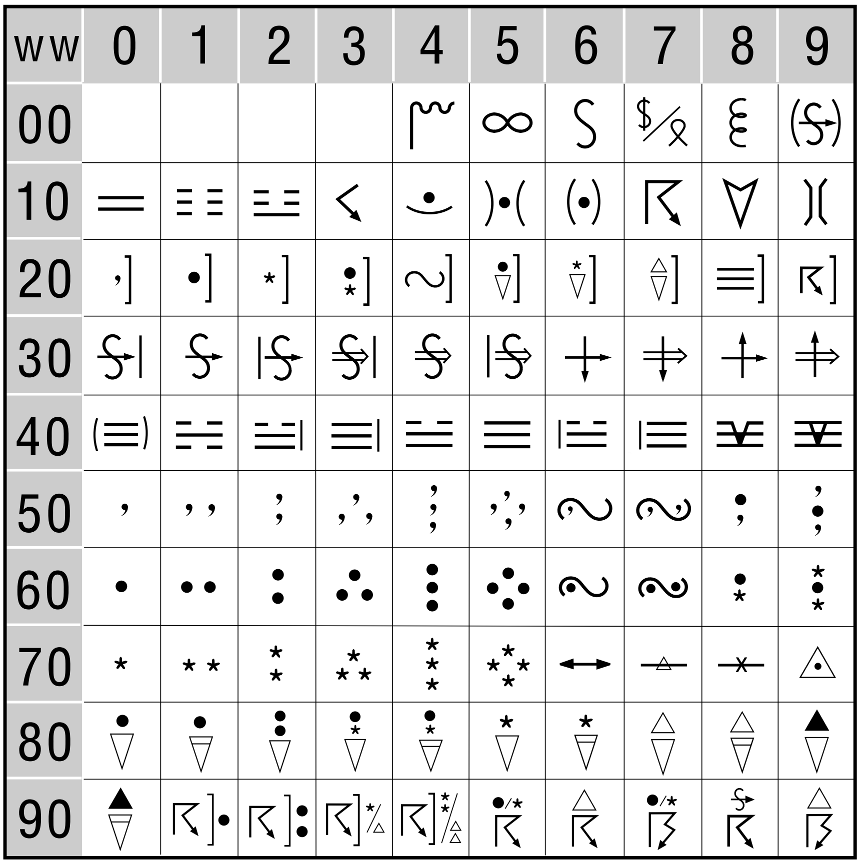
Missing wind speed should be indicated by placing an "X" at the end of the wind shaft in lieu of the wind barbs. Wind direction is indicated in the usual manner, e.g. X——O. When the wind direction is missing, no wind should be plotted.

VV — Horizontal visibility at surface

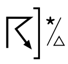
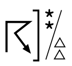
The code figures are plotted.

ww Present weather reported from a manned weather station (see Note 1)

The symbols for the appropriate code figures are given in the following table:




In the polychromatic method, black is used.

In the symbols  and  , Δ or * are alternatives, according to the observation.

In the symbols  and , the rain symbol and the snow symbol are alternatives, either • or * being used, except in cases of doubt.

NOTES: (1) The meanings of the code figures for present weather are given in Code table 4677 in the *Manual on Codes* (Publication No. 306) (Annex II to the *Technical Regulations*).

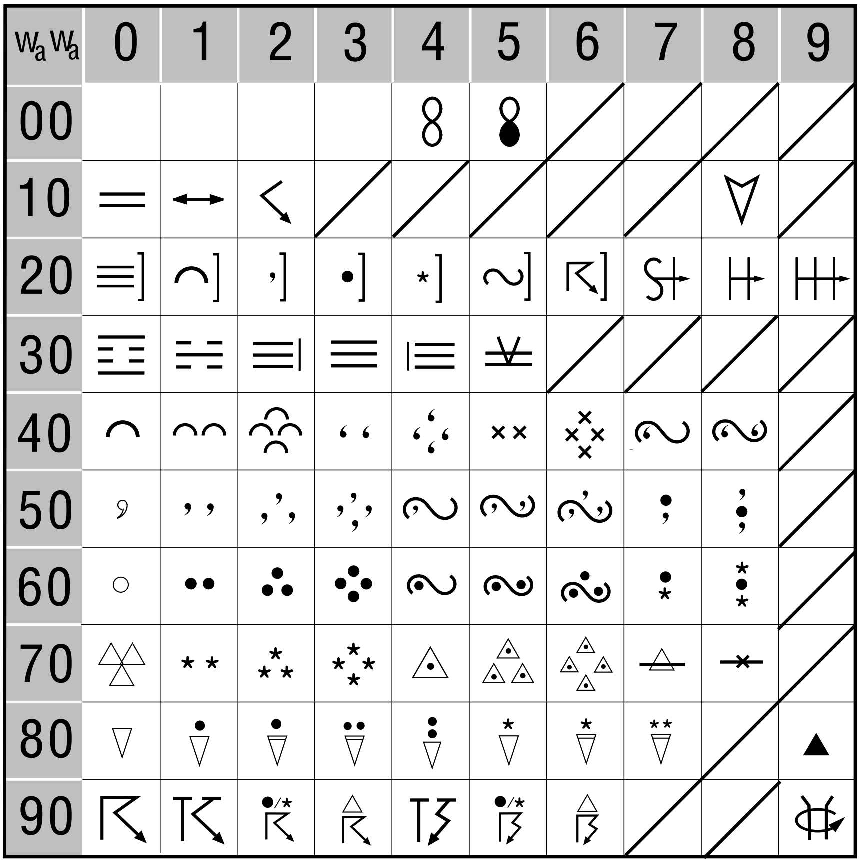
(2) When present and past weather are not included because:

(*a*) They are not significant ($i_x$ = 2 or 5), the spaces for ww and $W_1W_2$ are left blank;

(*b*) No observation was made ($i_x$ = 3 or 6) or the data are missing ($i_x$ = 1 or 4, but no 7-group in the message), ww and $W_1W_2$ are both plotted as //.

$w_a w_a$ Present weather reported from an automatic weather station (see Note 2)

The symbols for the appropriate code figures are given in the following table:




The symbols 30, 50, 60 and 70 represent the generic form of weather phenomena and may be plotted in an enlarged form.

The symbol ⌒ can specify any form of precipitation. ‘ specifies rain or drizzle. X specifies solid precipitation.

The symbols in row 80 represent intermittent precipitation, including showers.

NOTES: (1) The meaning of the code figures for present weather reported from an automatic station are given in Code table 4680 in the *Manual on Codes* (WMO-No. 306) (Annex II to the *Technical Regulations*).

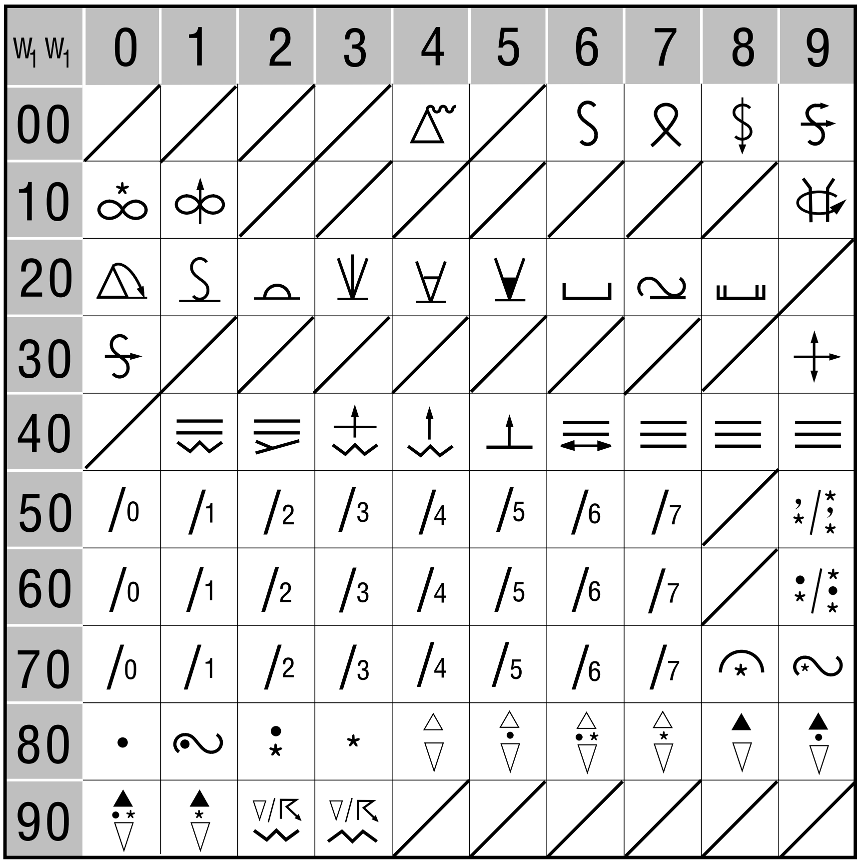
(2) When present weather and past weather are not included because:

(*a*) They are not significant ($i_x$ = 5), the squares for $w_a w_a$ and $W_{a1} W_{a2}$ are left blank;

(*b*) No observation was made ($i_x$ = 6) or the data are missing ($i_x$ = 7 but no 7-group in the message), $w_a w_a$ and $W_{a1} W_{a2}$ are both plotted as //.

$w_1w_1$ Present weather (in addition to ww or $w_a$ $w_a$)

The symbols for the appropriate code figures are given in the following table:




The pairs of symbols ∇/⇖ , ;/* or :/* are alternatives according to the observation.

The symbol /2 means drizzle, rain or snow whose rates of fall are indicated by code figures 52, 62, and 72 respectively. The symbols are plotted in conjunction with ww, present weather, or $w_aw_a$ or $W_1W_2$ or $W_{a1}W_{a2}$. (e.g. , ,/2).

Symbol ⁀⁀ means over sea, lake or river (over water).

Symbol ‿‿ means on or over mountains.

Symbol ≻ means in or over valleys.

NOTE: The meanings of code figures for present weather are given in Code table 4687 in the *Manual on Codes* (Publication No. 306) (Annex II to the *Technical Regulations*).

$W_1W_2$ Past weather reported from a manned station

The symbols to be plotted for both $W_1$ and $W_2$ are taken from the following list:

| *Code figure* | | *Symbol* |
|---|---|---|
| 3 | Sandstorm or dust storm |  |
| 3 | Blowing snow |  |
| 4 | Fog or ice fog or thick haze | ≡ |
| 5 | Drizzle | , |
| 6 | Rain | • |
| 7 | Snow or rain and snow mixed | * |
| 8 | Shower(s) | ▽ |
| 9 | Thunderstorms |  |

The two symbols are plotted as $W_1W_2$.

In the polychromatic method, red is used.

NOTE: See Note (2) under ww.

$W_{a1}W_{a2}$ Past weather reported from an automatic station

| *Code figure* | | *Symbol* |
|---|---|---|
| 1 | VISIBILITY REDUCED |  |
| 2 | Blowing phenomena, visibility reduced |  |
| 3 | FOG | ≡ |
| 4 | PRECIPITATION | ◠ |
| 5 | Drizzle | , |
| 6 | Rain | • |
| 7 | Snow or ice pellets | */△ |
| 8 | Snow shower(s) or intermittent precipitation | ▽ |
| 9 | Thunderstorm |  |

NOTE: The meanings of code figures for past weather reported from an automatic station are given in Code table 4531 in the *Manual on Codes* (Publication No. 306) (Annex II to the *Technical Regulations*).

PPPP or $a_3$hhh — Pressure at mean sea-level in tenths of a hectopascal omitting thousands digit of hectopascal of the pressure value or geopotential of the standard “constant pressure level” given by $a_3$ in standard geopotential metres omitting the thousands digit

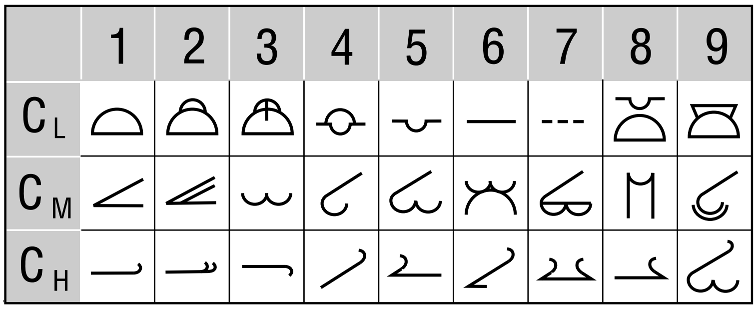
Normally the pressure is that which has been reduced to mean sea-level. It may be plotted as reported in four figures or alternatively in three figures by plotting the last three figures only of the group. If $a_3$hhh has been reported instead of pressure reduced to mean sea-level and it is to be plotted on the same chart as mean sea-level pressure observations then it is plotted in four figures and the first figure ($a_3$) can be used to indicate the datum plane, other than mean sea-level, to which the plotted value refers.

TTT — Air temperature in tenths of a degree Celsius, its sign given by $s_n$

The actual value of this temperature may be plotted in degrees and tenths of a degree Celsius, the tenths figure being separated by a decimal point , or it may be plotted in whole degrees Celsius, having first been rounded to the nearest degree. Negative values are preceded by a minus sign.

$C_L C_M C_H$ — Cloud of the genera Stratocumulus, Stratus, Cumulus and Cumulonimbus ($C_L$); Altocumulus, Altostratus and Nimbostratus ($C_M$); and Cirrus, Cirrocumulus and Cirrostratus ($C_H$)

The symbols for the appropriate code figure are given in the following table:




In the polychromatic method, black is used. However, the use of red for plotting $C_H$ symbols is optional.

NOTES: (1) The meanings of the code figures for type of cloud are given in Codes tables 0509, 0513 and 0515 in the *Manual on Codes* (Publication No. 306) (Annex II to the *Technical Regulations*).

(2) If, with $C_L$ = 8, it is known that the base of the Sc is below the base of the Cu, the symbol  is used.

$N_h$ — Amount of all $C_L$ cloud(s) present or, if no $C_L$ cloud is present, the amount of all the $C_M$ cloud(s) present

The code figure for $N_h$ is entered to the right of the position allotted to $C_L$.

h or hh — Height, above ground, of the base of the lowest cloud seen. The cloud figure for h is entered below the position allotted to $C_L$. If hh is reported, the two code figures for hh may be entered in lieu of h.

$8N_sCh_sh_s$ — Genus of cloud (C)

| *Code figure* | | *Monochromatic* |
|---|---|---|
| 0 | Cirrus Ci |  |
| 1 | Cirrocumulus Cc |  |
| 2 | Cirrostratus Cs |  |

| *Code figure* | | *Monochromatic* |
|---|---|---|
| 3 | Altocumulus Ac |  |
| 4 | Altostratus As |  |
| 5 | Nimbostratus Ns |  |
| 6 | Stratocumulus Sc |  |
| 7 | Stratus St |  |
| 8 | Cumulus Cu |  |
| 9 | Comulonimbus Cb |  |

The symbols corresponding to code figures 6 to 9 will be plotted in the position allotted to $C_L$, those corresponding to code figures 3 to 5 in the position allotted to $C_M$ and those corresponding to code figures 0 to 2 in the position allotted to $C_H$. The symbols should be arranged in ascending order of height of cloud base, i.e. the lowest cloud will be at the bottom.

The code figures for $N_s$ and $h_sh_s$ relating to the lowest cloud layer should normally be plotted in the positions reserved for $N_h$ and h. If the purpose of the chart requires it, the code figures for $N_s$ and $h_sh_s$ for each cloud layer may be plotted against the corresponding cloud symbol in the same manner as are $N_h$ and h for $C_L$.

$T_dT_dT_d$ Dew-point temperature in tenths of a degree Celsius, its sign being given by $s_n$

The actual value of this temperature may be plotted in degrees and tenths of a degree Celsius, the tenths figure being separated by by a decimal point, or it may be plotted in whole degrees Celsius, having first been rounded to the nearest degree. Negative values are preceded by a minus sign.

a Characteristic of pressure tendency during the three hours preceding the time of observation

| *Code figure* | | *Monochromatic* |
|---|---|---|
| 0 | Increasing, then decreasing; atmospheric pressure the same as or higher than three hours ago |  |
| 1 | Increasing, then steady; or increasing, then increasing more slowly; atmospheric pressure now higher than three hours ago |  |
| 2 | Increasing (steadily or unsteadily); atmospheric pressure now higher than three hours ago |  |
| 3 | Decreasing or steady, then increasing; or increasing, then increasing more rapidly; atmospheric pressure now higher than three hours ago |  |
| 4 | Steady; atmospheric pressure the same as three hours ago |  |
| 5 | Decreasing, then increasing; atmospheric pressure the same as or lower than three hours ago |  |
| 6 | Decreasing, then steady; or decreasing, then decreasing more slowly; atmospheric pressure now lower than three hours ago |  |
| 7 | Decreasing (steadily or unsteadily); atmospheric pressure now lower than three hours ago |  |
| 8 | Steady or increasing, then decreasing; or decreasing, the decreasing more rapidly; atmospheric pressure now lower than three hours ago |  |

$ppp$ Amount of pressure tendency at station level during the three hours preceding the time of observation, expressed in tenths of a hectopascal

The pressure change is plotted in two figures by plotting only the last figures of $ppp$ unless the first figure of $ppp$ is other than zero, in which case the pressure change is plotted as reported in three figures. The plotting figures may be preceded by a plus sign when $a$ = 0, 1, 2 or 3 and by a minus sign when a = 5, 6, 7 or 8. In this case the symbol for $a$ = 2, 4 (if used) or 7 may be omitted.

$D_s v_s$ Direction (true) of resultant displacement of the ship ($D_s$) and ship's average speed made good ($v_s$) during the three hours preceding the time of observation

The direction $D_s$ is plotted by means of an arrow pointing in the direction towards which the ship is moving and the code figure for the speed $v_s$ is entered to the right of the arrow.

$T_w T_w T_w$ Sea-surface temperature in tenths of a degree Celsius, its sign given by $s_n$

The actual value of this temperature is plotted in degrees and tenths of a degree Celsius, the tenths figure being separated by a decimal point, or it may be plotted in whole degrees Celsius, having first been rounded to the nearest degree. Negative values are preceded by a minus sign.

$d_{w1}d_{w1}$ $d_{w2}d_{w2}$ True direction, in tens of degrees, from which swell waves are coming

This is represented by an arrow with a wavy shaft; the arrow-heads point in the direction towards which the waves are moving. If $d_{w1}d_{w1}$ is reported as 00, a wavy line without an arrow-head is drawn in a north-south direction.

If $d_{w1}d_{w1}$ is reported as 99, crossed arrows with wavy shafts are drawn one from south-west to north-east and the other from south-east to north-west, thus .

If $d_{w1}d_{w1}$ is missing, it is plotted as for $d_{w1}d_{w1}$ 99 but the arrowheads are omitted.

When there is a second swell system reported by $d_{w2}d_{w2}$, this is plotted below the first.

$P_{w1}P_{w1}$ $P_{w2}P_{w2}$ Period of swell waves in seconds

The code figures for $P_{w1}P_{w1}$ and $P_{w2}P_{w2}$ are plotted immediately to the right of the symbol for $d_{w1}d_{w1}$ and $d_{w2}d_{w2}$.

When there are no swell waves $P_{w1}P_{w1}$ and $P_{w2}P_{w2}$ are not plotted.

$H_{wa}H_{wa}$ $H_wH_w$ $H_{w1}H_{w1}$ $H_{w2}H_{w2}$ Height of waves, obtained by instrumental methods ($H_{wa}H_{wa}$), wind waves ($H_wH_w$) or swell waves ($H_{w1}H_{w1}$ and $H_{w2}H_{w2}$), respectively in units of 0.5 metre

These code figures are plotted immediately to the right of the symbols for $P_{wa}P_{wa}$, $P_wP_w$, $P_{w1}P_{w1}$ or $P_{w2}P_{w2}$ respectively.

When there are no swell waves $H_{w1}$ and $H_{w2}$ are not plotted.

NOTE: If instrumental wave data, as reported in group $1P_{wa}P_{wa}H_{wa}H_{wa}$, are plotted, they should be underlined.

$P_{wa}P_{wa}$ $P_wP_w$ Period of waves, obtained by instrumental methods ($P_{wa}P_{wa}$) or period of wind waves ($P_wP_w$), in seconds

The code figure either for $P_{wa}P_{wa}$ or for $P_wP_w$ is plotted under the symbol for low clouds.

NOTE: If instrumental wave data, as reported in group $1P_{wa}P_{wa}H_{wa}H_{wa}$, are plotted, they should be underlined.

$RRR$ Amount of precipitation which has fallen during the period preceding the time of observation, as indicated by $t_R$

If following a national decision this element is to be plotted, the following cases may occur:

(a) Precipitation amount is reported ($i_R$ = 1 or 2), the figures of $RRR$ are entered at the appropriate place in the plotting model (see paragraph 1 of this Appendix);

(*b*) Precipitation amount is zero ($i_R$ = 3), RRR is not entered on the map;

(*c*) No observation was made ($i_R$ = 4), RRR is entered as ///.

$t_R$ Duration of period of reference for amount of precipitation, expressed in units of six hours, and ending at the time of the report

The code figure for $t_R$ is entered, except in cases where precipitation is not reported ($i_R$ = 3 or 4).

$T_xT_xT_x$ or $T_nT_nT_n$ Maximum ($T_xT_xT_x$) or minimum ($T_nT_nT_n$) temperature in degrees Celsius and tenths, its sign given by $s_n$

The actual maximum or minimum temperature is entered in degrees and tenths of a degree Celsius, the tenths figure being separated by a decimal point and negative values being preceded by a minus sign.

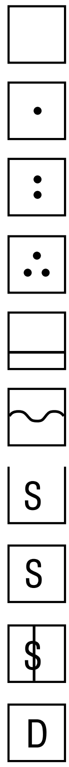
$T_gT_g$ Ground (grass) minimum temperature of the preceding night in whole degrees Celsius, its sign given by $s_n$

The actual value is entered in degrees Celsius, negative values being preceded by a minus sign.

E or E' State of the ground without (E) or with (E') snow or measurable ice cover

One of these is plotted using the appropriate symbol from the following tables:

*Code figure for* E



0 Surface of ground dry (without cracks and no appreciable amount of dust or loose sand)

1 Surface of ground moist

2 Surface of ground wet (standing water in small or large pools on surface)

3 Flooded

4 Surface of ground frozen

5 Glaze on ground

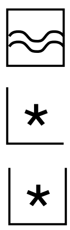
6 Loose dry dust or sand not covering ground completely

7 Thin cover of loose dry dust or sand covering ground completely

8 Moderate or thick cover of loose dry dust or sand covering ground completely

9 Extremely dry with cracks

*Code figure for* E'



0 Ground predominantly covered by ice

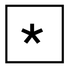
1 Compact or wet snow (with or without ice) covering less than one-half of the ground

2 Compact or wet snow (with or without ice) covering at least

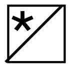
one-half of the ground but ground not completely covered

*Code figure for* E' (continued)

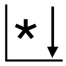
3 Even layer of compact or wet snow covering ground completely



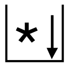
4 Uneven layer of compact or wet snow covering ground completely



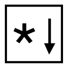
5 Loose dry snow covering less than one-half of the ground



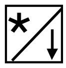
6 Loose dry snow covering at least one-half of the ground (but not completely)



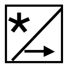
7 Even layer of loose dry snow covering ground completely



8 Uneven layer of loose dry snow covering ground completely



9 Snow covering ground completely; deep drifts



sss Total depth of snow in centimetres

This is plotted in code figures or actual depths in accordance with national or regional decisions.

GG Actual time of observation to the nearest hour UTC

GG is plotted only if it is different from the reference hour of the chart.

2.2 The following rules determine the symbols to be used for the plotting of the various upper-air observation elements which appear on the constant pressure charts.

(*a*) The wind at the level of the chart should be plotted with a solid shaft touching the station circle, the barbs and solid pennants flying to the left of the wind shaft in the northern hemisphere and to the right of the wind shaft in the southern hemisphere. The full barbs represent 5 m $s^{-1}$ or 10 knots, the half-barbs represent 2.5 m $s^{-1}$ or 5 knots, and the solid pennant represents 25 m $s^{-1}$ or 50 knots.

Derived winds should be plotted with the shaft touching the station circle and the barbs and solid pennants flying towards the side of higher pressure. If one derived wind is plotted, the shaft should be a solid line. If two derived winds are plotted, one of them should be plotted with a broken shaft.

Colour separation between the observed and derived winds is recommended. In wind field analyses code figures may replace the barbs and pennants.

(*b*) Clouds should be plotted with the same symbols as used on surface charts.

## 3. ANALYSES AND FORECASTS ON WEATHER CHARTS

### 3.1 General rules

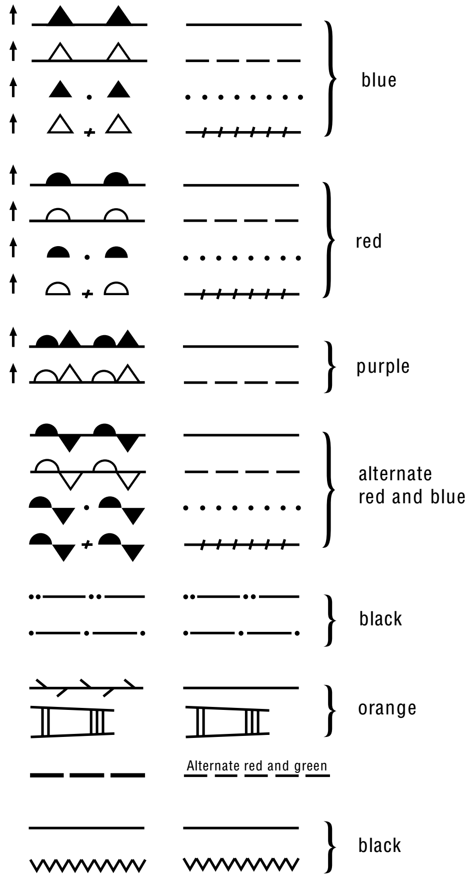
(*a*) The basic symbol shown in the table below is placed on the chart along the line of the phenomenon and it is repeated as necessary to indicate the extent of the phenomenon;

(*b*) The arrows on items 1 to 10 of the table are not part of the symbol but are entered to indicate the orientation of the symbol with respect to the direction of motion of the phenomenon.

## 3.2 Symbols

*Term* — *Symbol* (*Monochromatic*, *Polychromatic*)

1. Cold front at the surface
2. Cold front above the surface
3. Cold front frontogenesis
4. Cold front frontolysis
5. Warm front at the surface
6. Warm front above the surface
7. Warm front frontogenesis
8. Warm front frontolysis
9. Occluded front at the surface
10. Occluded front above the surface
11. Quasi-stationary front at the surface
12. Quasi-stationary front above the surface
13. Quasi-stationary front frontogenesis
14. Quasi-stationary front frontolysis
15. Instability line
16. Shear line
17. Convergence line
18. Intertropical convergence zone
19. Intertropical discontinuity
20. Axis of trough
21. Axis of ridge




NOTE: The separation of the two lines gives a qualitative representation of the width of the zone; the hatched lines may be added to indicate areas of activity.

## 3.3 Representation of weather features

Weather features on charts may be shown in the manner indicated below:

*Feature* — *Monochromatic* — *Polychromatic*

(*a*) Zones of continuous precipitation


Monochromatic: Solid shading or cross-hatching

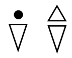
Polychromatic: Solid shading or cross-hatching in green

(*b*) Zones of intermittent precipitation

Monochromatic: Single hatching

Polychromatic: Single hatching in green

The appropriate weather symbol may be distributed over the zone.

| Feature | | Monochromatic | Polychromatic |
|---|---|---|---|
| (*c*) | Areas of showers | Large shower symbols distributed over the area with the symbol for rain, snow or hail added as appropriate, e.g.  | As monochromatic system but in green |
| (*d*) | Areas of thunderstorms | Large thunderstorm symbols distributed over the area with the symbol for rain, snow or hail added as appropriate, e.g.  | As monochromatic system but in red |
| (*e*) | Areas of fog | Large fog symbols distributed over the area |  Solid shading in yellow |
| (*f*) | Areas of duststorm, sandstorm or dust haze | Large symbols for the appropriate phenomenon distributed over the area |  Solid brown shading with the appropriate weather symbol distributed over the area |

NOTE: In all cases, the extent of the area affected by the phenomena may be delineated by a thin boundary line of the same colour. The shading, hatching or superimposed symbols should not obliterate the plotted data.

## 4. REPRESENTATION OF THE ANALYSIS AND FORECAST ON SPECIFIC CHARTS

### 4.1 Surface charts

#### 4.1.1 *Fronts*

Fronts will be shown using the symbols given in paragraph 3.2.

#### 4.1.2 *Isobars*

It is recommended that isobars be drawn at intervals of 4 or 5 hPa. Multiples or sub-multiples of these basic intervals may be used depending on the scale and purposes of the chart but, whatever the intervals, the 1 000 hPa isobar should always be included in the series.

#### 4.1.3 *Pressure centres*

(*a*) The location of a pressure centre may be indicated by a cross. To indicate the nature of the centre, a capital letter appropriate to the language of the country is entered above the symbol marking the centre.

(*b*) In the case of tropical cyclonic circulations the centre is marked by a special symbol as shown below:

 For a tropical cyclonic circulation with observed or estimated maximum winds of 17 to 63 kt (29 to 117 km/h);

 For a tropical cyclonic circulation with observed or estimated maximum winds of 64 kt (118 km/h) or more.

(*c*) The letter or the symbol for a tropical cyclonic circulation should be aligned parallel to the adjacent meridian.

(*d*) Pressure centres may be given an identifying letter to assist in their tracking from chart to chart. This should be written as a suffix to the letter or symbol defining the pressure centre. A tropical cyclonic circulation may have a name assigned to it. This may be entered in block letters near to the centre.

(*e*) The value of the pressure at the centre should be entered in whole hectopascals immediately below the symbol marking the centre, the number being parallel to the adjacent line of latitude.

#### 4.1.4 ***Tracks of pressure centres***

The previous positions of a pressure centre may be entered by means of symbols in the same way as the present position. Above each symbol may be entered the corresponding time in hours (two figures) and below it the pressure of the centre at that time in hectopascals. The symbols should be joined by a thick broken line. The forecast position of a pressure centre may also be indicated by a symbol in the same way as the present position, the time and the estimated pressure being entered above and below the symbol respectively. The present position and the forecast position should be joined by a solid arrow drawn along the track the centre is forecast to take.

#### 4.1.5 ***Isallobars***

Isallobars of three-hour change should normally be drawn for intervals of single hectopascals. Large intervals may be used if the scale of the chart is small or if the period is longer than three hours. The "no change" line will be numbered with a zero and the numbers on the other lines will be preceded by a plus sign if the pressure has risen and a minus sign if it has fallen.

### 4.2 **Charts of isobaric surfaces**

#### 4.2.1 ***Fronts***

If fronts are entered, the symbols given in paragraph 3.2 should be used.

#### 4.2.2 ***Isohypses of absolute topography or contour lines***

It is recommended that contour lines be drawn at intervals of either 40 gpm (80, 20 and 10 when appropriate) or 60 gpm (120, 30, 15 when appropriate). The lines should be numbered in geopotential decametres, e.g. 5280 gpm should be labelled 528.

#### 4.2.3 ***Height centres***

The positions present, past and forecast of high and low centres in the contours may be indicated in the same way as for pressure centres on surface charts (see paragraphs 4.1.3 and 4.1.4). Above the symbol marking a centre may be entered a capital letter appropriate to the language of the country. The value of the height at the centre should be entered immediately below the symbol marking the centre to the nearest ten metres, e.g. 5280. The number should be entered parallel to the adjacent line of latitude.

#### 4.2.4 ***Isotachs***

Isotachs should normally be drawn at intervals of 20 kt (40, 10 and 5 when appropriate). Centres of regions of minimum and maximum speed may be marked according to national practices. On the maximum wind charts, however, the maximum should be marked by a "J" followed by the estimated maximum speed, e.g. J 120.

#### 4.2.5 ***Jet streams***

A jet stream should be marked by a heavy, solid line with arrow-heads placed at intervals along it pointing in the direction of the flow in the stream.

#### 4.2.6 ***Isohypses of relative topography or thickness lines***

If thickness lines are drawn, the following intervals are recommended: either 40 gpm (80, 20 and 10 when appropriate) or 60 gpm (120, 30, 15 when appropriate).

#### 4.2.7 ***Isotherms***

Isotherms will not normally be drawn on charts on which thickness lines are entered. Isotherms should be drawn at intervals of either 5°C (10°C and 2.5°C when appropriate) or 2°C (1°C when appropriate).

#### 4.2.8 ***Moisture lines***

If lines of equal dew point are drawn, the same intervals as for isotherms may be used.

APPENDIX II-5

# TIMES OF AVAILABILITY OF PRODUCTS WITH HIGH OPERATIONAL PRIORITY

| | *Short-range 00–72 hours | Medium-range 72–120 hours | Medium-range 120–240 hours |
|---|---|---|---|
| Global model products (digital) | H + 5 (9) | H + 6 (10) | H + 11 (13) |
| Global model products (graphic) | H + 6 (10) | H + 7 (11) | H + 12 (14) |
| Regional model products (digital) | H + 4 (5) | | |
| Regional model products (graphic) | H + 5 (6) | | |

* 00 denotes analyses.

Notes:

(1) This table states, e.g. H + 5 (9) hours, within which different categories of products should normally be transmitted to the different centres. H is the time of basic observations. The first figure is the time necessary for collection of data, for processing and transmission of products in regions where telecommunication systems, processing and receiving centres make full use of modern technical equipment. The figure in brackets is applicable where the GDPFS operates under most difficult conditions.

(2) Charts of high operational priority normally mean surface and 500 hPa analyses and forecasts. High priority may also be given to other products, if based on regional requirements and agreements.

(3) Concerning forecasts, high priority is given to regional forecasts up to one or three days, and to global forecasts up to five days or even more, if these forecasts will have reached an acceptable degree of reliability.

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APPENDIX II-6

# OVERALL LIST OF OUTPUT PRODUCTS REQUIRED FOR INTERNATIONAL EXCHANGE FROM GDPFS CENTRES

Within the constraints of technology and programme requirements, model output should be supplied at the highest possible resolution.

1. **ANALYSES**

Surface (including synoptic features)

925 hPa
850 hPa
700 hPa
500 hPa
400 hPa
300 hPa
250 hPa
200 hPa
150 hPa
100 hPa
70 hPa
50 hPa
30 hPa
20 hPa
10 hPa

} Parameters: Pressure (P)/geopotential height (H), temperature (T), wind (W) and humidity (R), as appropriate and applicable

Tropopause and maximum wind or tropopause and vertical wind shear
Relative topography, in particular the thickness 500/1 000 hPa
Jet streams
Digitized cloud mosaics
Mapped radiometric data
Stability
Precipitable water
Snow depth
Changes to 500 hPa, 24 hours
Changes to relative topography, thickness 500/1 000 hPa, 24 hours
Freezing level
Pressure changes, three hours
Pressure changes, 12 and/or 24 hours
Precipitation areas, six hours
Precipitation areas, 24 hours
Sferics
Radar echoes
Nephanalyses
Sea-surface temperature
Land-surface temperature
Snow and ice cover
Storm alerts
Sea ice
State of sea
Storm surge
Thermoclines
Superstructure icing
Top of Ekman layer
Surface air trajectories

850 hPa air trajectories
700 hPa air trajectories
500 hPa air trajectories
Health risk index for travellers
Stratospheric ozone bulletins
Assessments of satellite ground-truthing radiation experiments
Climate-related analyses (e.g. climate system monitoring and climate normals)

## 2. FIVE-DAY, 15-DAY AND 30-DAY MEAN ANALYSED VALUES AND ANOMALIES

Surface, 850 hPa, 500 hPa } Parameters: P/H, T, W and R, as appropriate and applicable
Sea-surface temperature anomaly

## 3. PLOTTED DATA

Plotted surface data (three-hourly)
Plotted upper-air data (850, 700, ..., 100 hPa)
Tabulated winds
Aerological diagrams

## 4. FORECASTS

Surface (including synoptic features), 925 hPa, 850 hPa, 700 hPa, 500 hPa, 400 hPa, 300 hPa, 250 hPa, 200 hPa, 150 hPa, 100 hPa, 70, 50, 30, 20 10 hPa } Parameters: P/H, T, W and R, as appropriate and applicable
Jet-stream location and tropopause/layer of maximum wind
Significant weather
Relative topography, thickness 500/1 000 hPa

NOTE: The above list includes products which are required as part of the ICAO World Area Forecast System in accordance with requirements determined by ICAO.

Freezing level
Vorticity
Vertical motion
Areal distribution of cloudiness
Precipitation location, occurrence, amount and type
Sequences at specific locations (time diagrams) at the surface and aloft of T, P, W and R
Vorticity advection, temperature/thickness advection, vertical motion, stability indices, moisture distribution and other derived parameters
Tropical storm positions and intensities
River stage, discharge and ice phenomena
Tropical depression and easterly wave positions and movement
Four-to-10-day outlook for T, W, R and precipitation
Forecasts of probability of precipitation and temperature extremes for mid-latitudes and subtropical areas or forecasts of cloudiness, temperature range and precipitation probability for tropical areas
State of sea

Storm surge
Sea-surface temperature
Thermoclines
Sea ice
Superstructure icing
Three-dimensional trajectories with particle locations at synoptic hours for EER
Time integrated pollutant concentration within the 500 m layer above ground in three time periods up to 72 hours for EER
Total deposition up to 72 hours

## 4.1 Ensemble prediction system products

4.1.1 Products for short range and medium range

(*a*) GLOBAL PRODUCTS FOR ROUTINE DISSEMINATION
*(Period for all fields: forecast D+0 to D+10 (12-hour intervals) at highest resolution possible)*
Probabilities of:
(i) Precipitation exceeding thresholds 1, 5, 10, 25 and 50 mm/24 hours
(ii) 10 m sustained wind and gusts exceeding thresholds 10, 15 and 25 m $s^{-1}$
(iii) T850 anomalies with thresholds -4, -8, +4 and +8 K with respect to a reanalysis climatology specified by the producing Centre
Ensemble mean (EM) + spread (standard deviation) of Z500, PMSL, Z1000, vector wind at 850 and 250 hPa
Tropical storm tracks (lat/long locations from EPS members)

(*b*) MODEL FIELDS
Full set or subset of EPS members' variables and levels for requesting WMO Members for specific applications.

(*c*) OTHER GRAPHICAL PRODUCTS
Location-specific time series of temperature, precipitation, wind speed, depicting the most likely solution and an estimation of uncertainty ("EPSgrams"). The definition, method of calculation and the locations should be documented.

4.1.2 Products for extended range

ENSEMBLE MEANS ANOMALIES/SPREAD
One-week averages and the monthly mean (all anomalies with respect to model climate):
Tropical SST
Standard ENSO/indices
Z500 and Z1000, precipitation, T850 and surface temperature

Probabilities:
Terciles: above, below, normal (with respect to model climate)
Precipitation
Z500
Z1000
T850 and surface temperature

Model fields:
(*a*) Full set or subset of EPS members' variables and levels for requesting WMO Members for specific applications.
(*b*) Relevant post-processed fields from sequence of daily output (e.g. indices of monsoon onset, droughts, tropical storm activity, extratropical storm track activity)
(*c*) Extended-range forecasts (levels and parameters as appropriate with 5-, 10-, 15- or 30-day mean values as applicable)

## 4.2 Long-range forecast products

Minimum list of LRF products to be made available by Global Producing Centres (GPCs):

FORECAST PRODUCTS

NOTE: It is recognized that some centres may provide more information than the list including, for example, daily data or hindcast data.

Basic properties:

Temporal resolution: Averages, accumulations or frequencies over 1-month or longer periods (seasons)

Spatial resolution: 2.5° × 2.5°

NOTE: Selected to match resolution of current verification data.

Spatial coverage: Global
(Separate areas of interest to users, down to subregions of a continent or ocean basin, may be provided on special request from Members.)

Lead time: Any lead times between 0 and 4 months
(Definition of lead time: for example, a three-monthly forecast issued on 31 December has a lead time of 0 months for a January-to-March forecast, and a lead time of 1 month for a February-to-April forecast.)

Issue frequency: Monthly or at least quarterly

Output types: Either rendered images (e.g. forecast maps and diagrams) or digital data. GRIB-2 format should be used for products posted on FTP sites or disseminated through the GTS.

Indications of skill including hindcast should be provided in accordance with recommendations from CBS on the Standardized Verification System (Attachment II-8). The minimum required is level 1 and level 2 verification. The verification of the Niño3.4 index will only apply to those centres producing such indices. However, GPCs are encouraged to provide level 3 verification. Verification results over the hindcast period are mandatory.

Content of basic forecast output:
(Some products are intended as directly meeting NMS requirements with regard to information needed for end-user applications (direct or further processed); others are to assist the contributing global centres in product comparison and in the development of multimodel ensembles. These products are regarded as feasible from current systems.)

(*a*) Calibrated outputs from ensemble prediction systems showing the mean and spread of the distribution for:
- 2-metre temperature over land;
- Sea-surface temperature;
- Precipitation;
- Z500, MSLP, T850.

NOTE: These fields are to be expressed as departures from normal model climate.

(*b*) Calibrated probability information for forecast categories for:
- 2-metre temperature over land;
- SST (atmospheric coupled models only);
- Precipitation.

NOTES:
1. The minimum requirement is (b); (a) should be provided, at least, by request.
2. Tercile categories should be provided, consistent with present capabilities. Information for larger numbers of categories (e.g. deciles) is foreseen, however, as capabilities increase and to match better the anticipated end-user requirements. These targets are implied also for forecasts from statistical/empirical models.
3. Information on how category boundaries are defined should be made available.
4 "Calibrated" implies correction based on systematic errors in model climatology, using at least 15 years of retrospective forecasts.

APPENDIX II-7

# USERS' INTERPRETATION GUIDE FOR ATMOSPHERIC TRANSPORT MODEL PRODUCTS PROVIDED BY RSMCs

**Standards in the provision of international services by RSMCs for nuclear environmental emergency response**

The Delegated Authority requests support from WMO Regional Specialized Meteorological Centres (RSMC) for atmospheric transport modelling products by using the form entitled "Environmental Emergency Response — Request for WMO RSMC Support by Delegated Authority". The Delegated Authority then sends the completed form immediately to the RSMCs as per the regional and global arrangements and ensures receipt of the form by phone. This will initiate a joint response from the RSMCs in their region of responsibility.

The International Atomic Energy Agency (IAEA) requests support from WMO RSMCs for atmospheric transport modelling products by using the form agreed between WMO and IAEA. The IAEA then sends the completed form immediately, by fax and by e-mail (preferred), to the RSMCs as per the regional and global arrangements and ensures receipt of the form by phone. The lead RSMCs shall confirm receipt of the IAEA request by fax or e-mail (preferred) to IAEA. This will initiate a joint response from the RSMCs in their region of responsibility. The IAEA sends an information copy of its Request Form by fax or by e-mail (preferred) to RTH Offenbach. When the lead RSMCs' products become available, the lead RSMCs shall send an announcement to the IAEA that their respective products are available and the products' location (RSMC's dedicated website), by fax or by e-mail (preferred).

The designated RSMCs shall implement agreed standard procedures and products by:

(*a*) The provision of the following standard set of basic products within two to three hours of reception of a request and according to the general rules for displaying results;

(*b*) The adoption of the following forecast periods for the numerical calculations;

(*c*) The adoption of a joint response approach;

(*d*) The adoption of the general rules for displaying results.

1. Default values to be used in response to a request for products for the unspecified source parameters[1]

(*a*) Uniform vertical distribution up to 500 m above the ground;

(*b*) Uniform emission rate during six hours;

(*c*) Starting date/time: date/time specified at "START OF RELEASE" on request form or, if not available, then the "date/time of request" specified at the top of the request form;

(*d*) Total pollutant release 1 Bq (Becquerel) over six hours;

(*e*) Type of radionuclide $^{137}$Cs.

2. Basic set of products

Five maps consisting of:

(*a*) Three-dimensional trajectories starting at 500, 1 500 and 3 000 m above the ground, with particle locations at six-hour intervals (main synoptic hours up to the end of the dispersion model forecast);

(*b*) Time-integrated airborne concentrations within the layer 500 m above the ground, in Bq s $m^{-3}$ for each of the three forecast periods;

(*c*) Total deposition (wet + dry) in Bq $m^{-2}$ from the release time to the end of the dispersion model forecast.

A joint statement that will be issued as soon as available.

3. Forecast periods for numerical calculations

The initial set of products will cover the period from T, the start time of the release, through a forecast of 72 hours from t, the start time of the current output from the operational NWP model.

1 The adoption of default values is based on the understanding that some runs of the transport/dispersion models need to be carried out with default parameters because little or no information (except location) will be available to the RSMC at an early stage. RSMCs are, however, requested to conduct and propose subsequent model runs with more realistic parameters as they become available (products based upon updated parameters will be provided on request only or confirmed from IAEA or a Delegated Authority). This may, for example, refer to a more precise assumption of the vertical distribution or the need to conduct a model run for the release of noble gases.

The first 24-hour period for integrated exposures in the dispersion model will start at the nearest ynoptic time (0000 or 1200 UTC) prior to or equal to T. Subsequent 24-hour integrations of the dispersion model will be made up to, but not exceeding, the synoptic time nearest to t+72.

If T is earlier than t, the first response will use hindcasts to cover the period up to t.

4. Joint response and joint statements

A joint response means that the collaborating RSMCs shall immediately inform each other of any request received; initially both should produce and send the basic set of products (charts) independently and then move rapidly towards providing fully coordinated response and services for the duration of the response. Following the initial response, the RSMCs shall develop and provide, and update as required, a "joint statement" to describe a synopsis of the current and forecast meteorological conditions over the area of concern, and the results from the transport models, their differences and similarities and how they apply to the event.

5. General rules for displaying results

In order to make the interpretation of the maps easier, the producing centres should adopt the following guidelines:

General guidelines for all maps:

(a) Provide labelled latitude and longitude lines at 10° intervals and sufficient geographic map background (shore lines, country borders, etc.) to be able to locate precisely the trajectories and contours;

(b) Indicate the source location with a highly visible symbol (●, ▲, ✖, ✻, ■, etc.);

(c) Indicate the source location in decimal degrees (latitude — N or S specified, longitude — E or W specified, plotting symbol used), date/time of release (UTC), and the meteorological model initialization date/time (UTC);

(d) Each set of maps should be uniquely identified by at least product issue date and time (UTC) and issuing centre;

(e) Previously transmitted products from the dispersion model need not be re-transmitted;

(f) Indicate with a legend if this is an exercise, requested services, or an IAEA notified emergency.

Specific guidelines for trajectory maps:

(a) Distinguish each trajectory (500, 1 500, 3 000 m) with a symbol (▲, ●, ■, etc.) at synoptic hours (UTC);

(b) Use solid lines (darker than map background lines) for each trajectory;

(c) Provide a time-height (m or hPa) diagram, preferably directly below the trajectory map, to indicate vertical movement of trajectory parcels.

Specific guidelines for concentration and deposition maps:

(a) Adopt a maximum of four concentration/deposition contours corresponding to powers of 10;

(b) A legend should indicate that contours are identified as powers of 10 (i.e. $-12 = 10^{-12}$). If grey-shading is used between contours, then the individual contours must be clearly distinguishable after facsimile transmission and a legend provided on the chart;

(c) Use solid dark lines (darker than map background lines) for each contour;

(d) Indicate the following input characteristics: (i) source assumption (height, duration, isotope, amount released); (ii) the units of time integrated concentration (Bq s $m^{-3}$) or deposition (Bq $m^{-2}$). In addition, charts should specify: (i) "Time integrated surface to 500 m layer concentrations"; (ii) "Contour values may change from chart to chart", and if the default source is used; (iii) "Results based on default initial values";

(e) Indicate, if possible, the location of the maximum concentration/deposition with a symbol on the map and include a legend indicating the symbol used and the maximum numerical value;

(f) Indicate the time integration starting and ending date/time (UTC).

The RSMCs will normally provide the products in the ITU-T T4 format suitable for both group 3 facsimile machines and transmission on parts of the GTS. The RSMC may also make use of other appropriate technologies.

**ENVIRONMENTAL EMERGENCY RESPONSE ALERT**

**REQUEST FOR WMO RSMC SUPPORT BY DELEGATED AUTHORITY**

*This form should be sent by fax to the RSMC. At the same time, the Delegated Authority must immediately call the RSMC to confirm the transmission of this request for RSMC support.*

*(This section must be completed in full)*

STATUS: . . . . . . . . . . . . . . . . . . . . . . . . . . . .(EVENT OR EXERCISE) Date/time of request: .......................................(UTC)

NAME OF DELEGATED AUTHORITY: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

COUNTRY: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

DELEGATED AUTHORITY TELEPHONE/FAX NUMBERS: (......) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .(Tel.)

(......) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .(Fax)

REPLY TELEPHONE/FAX NUMBERS FOR NMS OF

REQUESTING COUNTRY: (......) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . (Tel.)

(......) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .(Fax)

NAME OF RELEASE SITE: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .(facility and place)

GEOGRAPHICAL LOCATION OF RELEASE: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .(lat./long. decimal degrees N or S; E or W)

*(essential accident information for model simulation — if not available, model will execute with standard default values)*

RELEASE CHARACTERISTICS:

START OF RELEASE: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .(date/time, UTC)

DURATION: . . . . . . . . . . . . . . .(hours), or end of release . . . . . . . . . . . . . . . . . . . . . . .(date/time, UTC)

RADIONUCLIDE SPECIES: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

TOTAL RELEASE QUANTITY: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .(Becquerel)

OR POLLUTANT RELEASE RATE: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .(Becquerel/hour)

EFFECTIVE HEIGHT OF RELEASE: Surface: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .or

Stack height: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .(m), or

Aloft: top . . . . . . . . . . . . . . . . . . . . . . .(m), base . . . . . . . . . . . . . . . . .(m)

*(helpful information for improved simulation)*

SITE ELEVATION: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .(m)

LOCAL METEOROLOGICAL CONDITIONS NEAR ACCIDENT: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .(wind speed and direction/weather/cloudiness, etc.)

OTHER INFORMATION: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .(nature of accident, cause, fire explosion, controlled release, foreseeable development, normal activity, projected conditions, etc.)

*(to be completed by RSMC)*

DATE/TIME OF RECEIPT OF REQUEST: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .(UTC)

DATE/TIME OF RETURN CONFIRMATION OF RECEIPT: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .(UTC)

NOTE: All times in UTC.

**ENVIRONMENTAL EMERGENCY RESPONSE**

**REQUEST FOR WMO RSMC SUPPORT BY IAEA**

*The IAEA sends the completed form by fax to all RSMCs and RTH Offenbach. At the same time the IAEA calls the 'Lead' RSMCs (selected on the form) to ensure receipt of this form.*

**STATUS:** ☐ **EMERGENCY** ☐ **EXERCISE** Date/time of request: yyyy-MM-dd/HH:mm (UTC)

REQUESTED RSMCs: (indicate the lead RSMCs by a checkmark below)

☐ EXETER ☐ TOULOUSE ☐ MELBOURNE ☐ MONTREAL ☐ WASHINGTON

☐ BEIJING ☐ TOKYO ☐ OBNINSK ☒ RTH Offenbach

SENDER'S NAME: **INTERNATIONAL ATOMIC ENERGY AGENCY**

| | | |
|---|---|---|
| COMMUNICATION DETAILS: | Tel.: +43 1 2600 22023 | Use to confirm receipt of request |
| | Fax: +43 1 26007 29309 | Use to confirm receipt of request |
| | E-mail: eru3@iaea.org | Use to confirm receipt of request |

NAME OF RELEASE SITE AND COUNTRY: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . (facility and place)

GEOGRAPHICAL LOCATION OF RELEASE:
(MUST BE COMPLETED) . Decimal degrees ☐ N ☐ S
. Decimal degrees ☐ E ☐ W

DECLARED EMERGENCY CLASS:
☐ NONE ☐ Other, specify: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

ACTION REQUIRED:
- ☐ NONE
- ☐ GO ON STANDBY (request for products or for assistance on weather conditions is to be expected)
- ☐ GENERATE STANDARD PRODUCTS AND SEND TO IAEA ONLY
- ☐ GENERATE STANDARD PRODUCTS FOR THE IAEA AND REGIONAL DISTRIBUTION
- ☐ OTHER ACTION: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

*(essential accident information for model simulation — if not available, model will execute with standard default values)*

RELEASE CHARACTERISTICS:

START OF RELEASE: Date/time: – – / : (UTC)

DURATION: . . . . . . . . . . . . . . . (hours) or END OF RELEASE: Date/time: – – / : (UTC)

RADIONUCLIDE SPECIES: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

TOTAL RELEASE QUANTITY: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .(Becquerel)

OR POLLUTANT RELEASE RATE: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .(Becquerel/hour)

EFFECTIVE HEIGHT OF RELEASE:
☐ Surface or
☐ Stack height: . . . . . . . . . . . . (m), or
☐ Aloft: top: . . . . . . . . . . . . (m), base: . . . . . . . . . . . . . .(m)

*(helpful information for improved simulation)*

SITE ELEVATION: . . . . . . . . . . . .(m)

LOCAL METEOROLOGICAL CONDITIONS NEAR ACCIDENT: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
(wind speed and direction/weather/cloudiness, etc.)

OTHER INFORMATION: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
(nature of accident, cause, fire explosion, controlled release, foreseeable development, normal activity, projected conditions, etc.)

*(to be completed by RSMC)*

DATE/TIME OF RECEIPT OF REQUEST: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .(UTC)

FOR LEAD RSMC(s) ONLY

DATE/TIME OF RETURN CONFIRMATION OF RECEIPT: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .(UTC)

NOTE: All times in UTC.

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APPENDIX II-8

## DESIGNATED GLOBAL PRODUCING CENTRES FOR LONG-RANGE FORECASTS AND DESIGNATION CRITERIA

1. Centres that are designated as Global Producing Centres for Long-range Forecasts (GPCs) are as follows: Melbourne, Montreal, Beijing, Toulouse, Tokyo, Seoul, Washington, Exeter and ECMWF.

2. In order to be officially recognized as a Global Producing Centre for Long-range Forecasts, a centre must as a minimum adhere to the following criteria:
   - Have fixed production cycles and time of issuance;
   - Provide a limited set of products as determined by Appendix II-6 of this Manual;
   - Provide verifications as per the WMO SVSLRF;
   - Provide up-to-date information on methodology used by the GPC;
   - Make products accessible through the GPC website and/or disseminated through the GTS and/or the Internet.

APPENDIX II-9

## PRODUCTS PROVIDED BY RSMCs WITH ACTIVITY SPECIALIZATION IN ATMOSPHERIC TRANSPORT MODELLING (BACKTRACKING FOR CTBT VERIFICATION SUPPORT)

The CTBTO Provisional Technical Secretariat (PTS) requests support from WMO Regional Specialized Meteorological Centres (RSMCs) for atmospheric transport modelling (backtracking) products by using an electronic mail message with the subject line "====== PTS REQUEST FOR SUPPORT =====" to all RSMCs. This will initiate a response from all RSMCs.

The designated RSMCs shall:

(*a*) Mail back the response form to the responsible officer at the PTS within 3 hours;

(*b*) Conduct standardized backtracking computations according to the specifications listed below for all measurements included in the notification message;

(*c*) Upload the results on a secured ftp server, as defined in the notification message, within 24 hours of reception and according to the format as defined below.

The specifications for the backtracking are as follows:

- Simulate a release of 1.3 $10^{15}$ Bq of a tracer integrated backward in time (no deposition, no decay) at a constant rate at the point of the station location from surface to 30 m from measurement stop to measurement start.
- Calculate the respective (backward) tracer concentrations [in $Bq/m^3$] at a global 1 x 1 degree grid, output frequency 3 hours, time average of output 3 hours, from surface to 30 m.
- Simulate backwards in time to the requested ending date/time (usually 6–14 days from sample collection stop).

The PTS shall:

(*a*) Restrict requests to cases of anomalous radionuclide measurements or system tests;

(*b*) Contact the RSMCs in case no confirmation of a request was received within 3 hours;

(*c*) Conduct regular announced and/or unannounced system tests;

(*d*) Share the results of tests with the other RSMCs at a website.

The PTS will not request any graphical products or products other than those specified above. Customized end-user products will be produced by the PTS for submission to the National Authorities, along with RSMC model output. Measurements and end-user products will not be shared by the PTS with the RSMCs or the WMO Secretariat for reasons of confidentiality.

**NOTIFICATION MAIL MESSAGE SENT OUT BY THE PTS TO WMO RSMCs**

```
====== PTS REQUEST FOR SUPPORT =====
Date issued: YYYYMMDD hhmm
Responsible officer: NAME

Point of contact:
NAME
Tel. ....................
Fax. .....................
name@****.***

Secure website (location/user/password)
--------------
Download of information:
****://*************
username
Password
--------------
Data upload:
****://*************
Username
Password
--------------

For authentication purposes, this mail message is also available
on the website:
****://*************************************.txt
==============================================================
Source-receptor matrix results are requested for
005
stations
#    LON    LAT    ID    Measurement Start/stop time (YYYYMMDD hh)
001 -70.90 -53.10 CLP18 20050328 15 20050329 15
002 -70.90 -53.10 CLP18 20050329 15 20050330 15
003 -71.25 -41.10 ARP03 20050329 12 20050330 12
004 -58.47 -34.54 ARP01 20050329 18 20050330 18
005 -70.90 -53.10 CLP18 20050330 15 20050331 15
==============================================================
Please calculate backward to
YYYYMMDD hh
==============================================================
Please upload data within
24
hours

==RESPONSE FORM================================================
=== WMO Centre response form ===
=== Please send back this form ===
=== to the sender of the request as ===
=== soon as possible ===
==============================================================
(x) We will send our contributions within the time limit (default)
( ) We will send our contributions kkk hours later then the time limit
( ) We got your request but are not able to perform computations
==============================================================
====== PTS REQUEST FOR SUPPORT =====
```

**FORMAT OF THE MODEL RESULTS AS DELIVERED BY THE RSMCs**

Line 1: Header line (station longitude, latitude, start of measurement interval (YYYYMMDD hh), end of measurement interval (YYYYMMDD hh), release strength (Bq), number of hours backward, output every “k” hours, time average of output, station name)

Line 2-k: data lines (latitude, longitude, time step number, value)

17.57 59.23 20030106 09 20030107 09 0.13E+16 144 3 3 1.00 1.00 “SEP63”
58.00 15.00 1 0.1209120E-01
59.00 15.00 1 0.6446140E-01
60.00 15.00 1 0.3212887E-02
58.00 16.00 1 0.2649441E+01
59.00 16.00 1 0.9029172E+01
60.00 16.00 1 0.7616042E-01
58.00 17.00 1 0.1073919E+02
59.00 17.00 1 0.3082339E+02
60.00 17.00 1 0.1408468E-01
58.00 18.00 1 0.2643455E+00
59.00 18.00 1 0.7357535E+00
58.00 14.00 2 0.7759376E-02
59.00 14.00 2 0.6508716E-01
60.00 14.00 2 0.2403110E-01
61.00 14.00 2 0.6662516E-03
62.00 14.00 2 0.2838572E-04
58.00 15.00 2 0.1015775E+01
59.00 15.00 2 0.5030275E+01
60.00 15.00 2 0.8239139E+00
61.00 15.00 2 0.6797127E-02
62.00 15.00 2 0.6521360E-04
58.00 16.00 2 0.8181147E+01
59.00 16.00 2 0.2503959E+02
60.00 16.00 2 0.5937406E+00
61.00 16.00 2 0.1784474E-02
58.00 17.00 2 0.1403705E+02
59.00 17.00 2 0.3715418E+02
60.00 17.00 2 0.1306086E-01
58.00 18.00 2 0.2718492E+00
59.00 18.00 2 0.7555131E+00
……

ATTACHMENT II.1

# LIST OF GLOBAL MODEL OUTPUT PRODUCTS WHOSE PREPARATION SHOULD BE GIVEN HIGHEST PRIORITY BY WMCs AND RSMCs

## 1. ANALYSES

| Level | Time | |
|---|---|---|
| Surface | 00, 12 UTC | Parameters: Pressure (P)/geopotential height (H), temperature (T), wind (W) and humidity (R), as appropriate and applicable |
| 850 hPa | " | |
| 700 hPa | " | |
| 500 hPa | " | |
| 300 hPa | " | |
| 200 hPa | " | |
| 100 hPa | " | |
| 50 hPa* | " | |
| ***or*** | | |
| 70 hPa* | " | |

Nephanalyses or digitized cloud mosaics
Storm alerts
} As applicable

Area coverage: northern hemisphere, southern hemisphere and the tropical areas

Five-day, 15-day and 30-day mean analysed values and anomalies
Surface
850 hPa
500 hPa
Sea-surface temperature anomaly
} Parameters P/H, T, W and R as appropriate and applicable

## 2. FORECASTS

| | |
|---|---|
| Surface | H+24 (00, 12 UTC), H+48 (00, 12 UTC), H+72, beyond H+72, beyond 240 |
| 850 hPa | “ “ “ “ “ “ “ |
| 700 hPa | “ “ “ “ “ “ |
| 500 hPa | “ “ “ “ “ “ , beyond 240 |
| 300 hPa | H+24 (00, 12 UTC), H+48 (00, 12 UTC) |
| 250/200 hPa | H+24 (00, 12 UTC), H+48 (00, 12 UTC), H+72, beyond H+72, beyond 240 |
| 100 hPa | H+24 (00, 12 UTC), H+48 (00, 12 UTC), H+72 |

Precipitation and vertical motion (twice per day)
Tropical storm position and intensity
Sea-surface temperature anomaly
Transport model products for EER (as required)
Extended-range forecasts
Five-, 10-, 15- or 30-day mean surface
Five-, 10-, 15- or 30-day mean 850 hPa
Five-, 10-, 15- or 30-day mean 500 hPa
} Parameters as appropriate and applicable
Long-range forecasts (monthly, three-month or 90-day, seasonal to multi-seasonal outlook)
Area coverage: northern hemisphere and southern hemisphere, middle latitude and subtropical areas, and products for the tropical areas
Parameters: P/H, T, W and R, as appropriate and applicable

* In accordance with any requirements expressed by regional associations

ATTACHMENT II.2

# LIST OF REGIONAL MODEL OUTPUT PRODUCTS WHOSE PREPARATION SHOULD BE GIVEN HIGHEST PRIORITY BY RSMCs

1. **ANALYSES**

| | | |
|---|---|---|
| Surface | 00, 06, 12, 18 UTC | Parameters: Pressure (P)/ geopotential height (H), temperature (T), wind (W) and humidity (R), as appropriate and applicable |
| 925 hPa | 00, 12 UTC | |
| 850 hPa | 00, 12 UTC | |
| 700 hPa | 00, 12 UTC | |
| 500 hPa | 00, 12 UTC | |
| 400 hPa | 00, 12 UTC | |
| 300 hPa ***or*** 250 hPa | 00, 12 UTC | |
| 200 hPa | 00, 12 UTC | |
| 150 hPa | 00, 12 UTC | |
| 100 hPa | 00, 12 UTC | |
| 50 hPa* ***or*** 70 hPa* | 00, 12 UTC* | |

Tropopause and maximum wind or tropopause and vertical wind shear 00, 12 UTC

Sea-surface temperature as appropriate, but not more than once daily

Nephanalyses

Sea-ice distribution as appropriate, but not more than once daily

2. **FORECASTS**

| | |
|---|---|
| Surface | 00, 06, 12, 18 UTC, H+24 (once daily), H+48 or H+36 (once daily) |
| 850 hPa | H+18 (00, 12 UTC)*, H+24 (00, 12 UTC), H+48 or H+36 (00, 12 UTC) |
| 700 hPa | H+18 (00, 12 UTC)*, H+24 (00, 12 UTC) |
| 500 hPa | H+18 (00, 12 UTC)*, H+24 (00, 12 UTC), H+48 or H+36 (00, 12 UTC) |
| 400 hPa | H+18 (00, 12 UTC)*, H+24 (00, 12 UTC), H+36 (00, 12 UTC) |
| 300 hPa ***or*** 250 hPa ***or*** 200 hPa | H+18 (00, 12 UTC)*, H+24 (00, 12 UTC), H+48 or H+36 (00, 12 UTC) |
| 150 hPa | H+18 (00, 12 UTC)*, H+24 (00, 12 UTC), H+48 or H+36 (00, 12 UTC) |
| 100 hPa** | H+24 (00, 12 UTC)**, H+24 (00, 12 UTC), H+48 or H+36 (00, 12 UTC) |

Parameters: P/H, T, W and R as appropriate and applicable

Precipitation location, occurrence, amount and type

* In accordance with any requirements expressed by regional associations

** To meet aviation demands in accordance with requirements expressed by regional associations

Tropopause and maximum wind or tropopause and vertical wind shear: H+18 (00, 12 UTC), H+24 (00, 12 UTC)

Significant weather: four times per day*

State of sea: at least once daily

Vertical motion or vorticity: H+24 (00, 12 UTC), H+48 or H+36 (00, 12 UTC)

Tropical storm position and intensity

Tropical depression and coastal wave position and movement

Transport model products for EER (as required)

Four- to-10-day outlook for surface T, W, R and precipitation

Forecasts of probability of precipitation and temperature extremes for middle latitude and subtropical areas or forecasts of cloudiness, temperature range and precipitation probability for tropical areas

* In accordance with any requirements expressed by regional associations

ATTACHMENT II.3

# TRANSMISSION PRIORITIES FOR GLOBAL MODEL PRODUCTS FROM WMCs AND RSMCs

1. **FORECASTS BASED ON 00 AND 12 UTC DATA**

| | |
|---|---|
| 24 h | 500 hPa |
| 24 h | surface |
| 48 h | 500 hPa |
| 48 h | surface |
| 72 h | 500 hPa |
| 72 h | surface |
| 300 hPa *or* 250 hPa *or* 200 hPa | 24 h, 48 h and 72 h |

Medium-range products (beyond H+72):

surface
850 hPa
500 hPa
250/200 hPa

Larger-range products (beyond H + 240):

| | |
|---|---|
| surface, 850 hPa, 500 hPa, 200/250 hPa | Parameters, as appropriate |

2. **ANALYSES**

| | |
|---|---|
| Surface | 00 and 12 UTC |
| 500 hPa | 00 and 12 UTC |
| 300 hPa *or* 250 hPa *or* 200 hPa | 00 and 12 UTC |
| 100 hPa | 00 and 12 UTC* |
| 50 hPa | 00 UTC* |

Nephanalyses, as available

3. **FORECASTS**

24 h 100 hPa, based on 00 and 12 UTC data*
Parameters: P/H, T, W and R, as appropriate and applicable
Precipitation and vertical motion
Tropical storm position and intensity
Sea-surface temperature anomaly
Transport model products for EER (as required)
Extended-range forecasts five-, 10-, 15- or 30-day mean values (level surface, 500 hPa and parameters as applicable)
Long-range forecasts (monthly, three-month or 90-day, seasonal to multi-seasonal outlook)

* In accordance with any requirements expressed by regional associations

ATTACHMENT II.4

## TRANSMISSION PRIORITIES FOR REGIONAL MODEL PRODUCTS FROM RSMCs

| | |
|---|---|
| Surface | Analyses: 00 and 12 UTC<br>Forecasts: 24 h, based on 00 and 12 UTC data |
| 850 hPa, 700 hPa, 500 hPa | Analyses: 00 and 12 UTC<br>Forecasts: 24 h, based on 00 and 12 UTC data |
| Either 300, 250 or 200 hPa* | Analyses: 00 and 12 UTC<br>Forecasts: 24 h, based on 00 and 12 UTC data |
| 100 hPa** and 50 hPa** | Analyses: 00 and 12 UTC<br>Forecasts: 24 h, based on 00 and 12 UTC data |
| Products beyond H+36 up to and including H+72 | Surface<br>850 hPa<br>700 hPa<br>500 hPa<br>250/200 hPa<br>100 hPa |
| Medium-range products (beyond H+72) | Surface<br>850 hPa<br>500 hPa<br>250/200 hPa |
| Significant weather | Forecasts: 00/06/12/18 UTC<br>Requirements established regionally |
| Nephanalyses | One per day as available |
| State of sea | Forecasts: 24 h, based on 00 and 12 UTC data |
| Tropopause/maximum wind<br>***or***<br>Tropopause/vertical wind-shear analysis | 00 and 12 UTC |
| Precipitation location, occurence, amount and type | As available |

Parameters: PH, T, W and R as appropriate and applicable

Tropical storm position and intensity

Tropical depression and easterly wave position and movement

Transport model products for EER (as required)

Four-to-five-day or four-to-10-day outlook for surface T, W, R and precipitation

Forecasts of probability of precipitation and temperature extremes for middle latitude and subtropical areas or forecasts of cloudiness, temperature range and precipitation probability for tropical areas

* The use of 300 hPa, 250 hPa or 200 hPa to be decided by regional associations

** In accordance with any requirements expressed by regional associations

ATTACHMENT II.5

# TRANSMISSION PRIORITIES AFTER OUTAGES

1. **OBSERVATIONAL DATA**

| | |
|---|---|
| Storm alerts<br>TEMP, TEMP SHIP (Part A)<br>Soundings derived from satellite data | Not more than 12 hours after the time of observation |

SYNOP and SHIP – Not more than six hours for the 06 and 18 UTC observations or 12 hours for the 00 and 12 UTC observations

2. **GLOBAL MODEL PRODUCTS FROM WMCS AND RSMCS**

| | |
|---|---|
| 48 h surface, 850, 700 and 500 hPa forecasts, 00 or 12 UTC<br>72 h surface, 850, 700 and 500 hPa forecasts, 00 or 12 UTC | Until new products are available |

3. **REGIONAL MODEL PRODUCTS FROM RSMCS**

| | |
|---|---|
| 24 h surface forecasts, 00 or 12 UTC<br>24 h 850, 700 and 500 hPa forecasts, 00 or 12 UTC<br>24 h forecasts of the 300 ***or*** 250 ***or*** 200 hPa level<br>24 h 100 hPa forecasts, 00 or 12 UTC*<br>24 h 50 hPa forecasts, 00 or 12 UTC* | Until new products are available |

Parameters: P/H, T, W and R as appropriate and applicable

* In accordance with any requirements expressed by regional associations

ATTACHMENT II.6

## MINIMUM PRODUCT LIST FOR TRANSMISSION IN BINARY, ALPHANUMERIC AND PICTORIAL FORM

1. **FORECASTS**

| | |
|---|---|
| 24 h 500 hPa<br>24 h 700 hPa<br>24 h 850 hPa<br>24 h surface<br>48 h 500 hPa<br>48 h 700 hPa<br>48 h 850 hPa<br>48 h surface | Based on 00 and 12 UTC data |
| 72 h 500 hPa<br>72 h 700 hPa<br>72 h 850 hPa<br>72 h surface | Based on 00 *or* 12 UTC data |
| 300 hPa<br>***or***<br>250 hPa<br>***or***<br>200 hPa | 24 h, based on 00 and 12 UTC data |

2. **ANALYSES**

| | |
|---|---|
| Surface<br>850 hPa<br>700 hPa<br>500 hPa<br>300 hPa ***or*** 250 hPa ***or*** 200 hPa | Based on 00 or 12 UTC data |

Nephanalyses, as available

Parameters: P/H, T, W and R as, appropriate and applicable

ATTACHMENT II.7

# PLAN FOR MONITORING THE OPERATION OF THE WORLD WEATHER WATCH

## OBJECTIVES

1. The objectives of the monitoring effort are to improve the performance of the World Weather Watch (WWW), in particular the efficiency and effectiveness of the operation of the WWW Global Observing System (GOS), the Global Data-processing and Forecasting System (GDPFS) and the Global Telecommunication System (GTS) on a national, regional and global level. As the operation of these three elements of the WWW (GOS, GDPFS, and GTS) is so interrelated, each element cannot be monitored independently; therefore, for efficient monitoring of the operation of the WWW as an integrated system, close coordination between all centres concerned, as well as with the WMO Secretariat, is essential in order to identify the deficiencies and initiate corrective action as quickly as possible.

2. The implementation of the monitoring plan involves all three subsystems of the WWW. Thus, in the context of monitoring, the GOS is responsible for ensuring that the observations are made according to the prescribed standards, are encoded correctly and are presented for transmission at the times laid down; in addition, the GOS responds in timely fashion to requests for checks, corrections, etc. The GTS is responsible for ensuring the regular flow of meteorological information, both raw and processed. This involves keeping a close watch on the receipt and transmission of information, generating requests for missing bulletins and other products when necessary, checking telecommunication formats, arranging for the re-routeing of traffic in cases of outages and other difficulties, and so on. The GDPFS provides processed information for timely distribution and also has an important role in the quality control of data.

3. An important objective of any monitoring activity must include provision for the identification of deficiencies and also for corrective action to improve the efficiency and effectiveness of the WWW. Success is measured in terms of how many deficiencies are corrected.

4. In accordance with the decision of Seventh Congress, the following items should be included in the monitoring programme:

(*a*) Regularity of observations;

(*b*) Quality of observational data and correct coding;

(*c*) Completeness and timeliness of collection of observational data at the NMC concerned;

(*d*) Adherence to WMO standard codes and telecommunication procedures;

(*e*) Collection of observational data at RTHs and WMCs;

(*f*) Exchange of data and processed information on the regional meteorological telecommunication networks and the Main Telecommunication Network;

(*g*) Evaluation of the observations and processed information received at NMCs, RSMCs and WMCs in respect of their data needs.

## BASIC COMPONENTS

### 5. REAL-TIME MONITORING

Real-time monitoring is the term used to describe monitoring which is carried out quickly enough to allow remedial action to be taken in time to be of value in day-to-day meteorological work. Ideally, it should be carried out within the times specified in the appropriate *Manuals* and *Guides* as the maximum acceptable time delays for the receipt of meteorological information, but in practice it is still valuable if it can be carried out before similar subsequent information is received.

In view of the short time available, corrective action on real-time monitoring should be restricted to departures from the normal, e.g. bulletins or observations which are not received in time, obvious or suspected errors, and so on. Thus real-time monitoring requires the provision of information concerning:

- Bulletins not received by the specified time;
- Observations not received by the specified time, or which are incorrect or suspect, or cannot be interpreted with confidence;
- Inadequacies in receipt of processed information.

## 6. NON-REAL-TIME MONITORING

Non-real-time monitoring is the term used to describe monitoring which is carried out over a specific time period. The purpose of non-real-time monitoring is to keep under review the general performance of the WWW and to identify shortcomings which may persist after real-time monitoring has been carried out. Non-real-time monitoring requires the preparation of summaries and various statistics which become available after a certain time, which may vary from a few hours to several months.

## 7. FOLLOW-UP ACTION FOR COORDINATION AND ASSISTANCE

In the real-time mode, the initial corrective action will be immediate and will be taken at the centres concerned or at the point of observation. In the non-real-time mode, follow-up action will be taken by the Members concerned to remedy any deficiencies with respect to the WWW plan. In some cases, this might involve obtaining advice on the procedures for obtaining external assistance and information on the maintenance and operation of their WWW facilities. In addition, the Secretary-General will take action as indicated in paragraph 16 below.

## DEFINITIONS AND STANDARDS

8. IN THE MONITORING CONTEXT, THE TERMS USED AND THE MINIMUM STANDARDS TO BE ATTAINED SHOULD BE AS DEFINED IN THE *MANUAL ON THE GLOBAL OBSERVING SYSTEM*, THE *MANUAL ON THE GLOBAL TELECOMMUNICATION SYSTEM*, THE *MANUAL ON CODES*, THE *MANUAL ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM* AND RELEVANT PARTS OF THE *TECHNICAL REGULATIONS*.

## PRIORITIES

9. THE MONITORING SCHEME SHOULD CONCENTRATE, IN THE ORDER OF PRIORITY GIVEN BELOW, ON THE ESTABLISHMENT OF CHECKS ON THE FOLLOWING INFORMATION:

(*a*) TEMP and TEMP SHIP and TEMP MOBIL, Parts A and B;

(*b*) PILOT, PILOT SHIP and PILOT MOBIL, Parts A and B;

(*c*) SYNOP (global exchange);

(*d*) SHIP and AIREP/AMDAR (global exchange);

(*e*) CLIMAT and CLIMAT TEMP;

(*f*) All other observational data and processed information, regularly exchanged.

Monitoring of satellite data presents a special case. There are only a few operators and their standards for monitoring, including quality control of satellite data, are already high. Monitoring of satellite data bulletins and GRID-code bulletins shall be a special event for a limited time as designated by the WMO Secretariat.

10. In implementing this monitoring plan, it is important to establish the capability for quick responses at the observing points and at all centres to requests for checks and repetitions in real time. It will also be found useful to give particular attention to ensuring the following elements of the monitoring plan:

(*a*) The correct telecommunication formats of messages in the GTS;

(*b*) The correct coding of messages and reports;

(*c*) The timely availability of data;

(*d*) The quality of the meteorological content of messages.

## RESPONSIBILITIES

11. The basic responsibilities for monitoring the operation of the WWW rest with the Members.

12. The responsibilities for carrying out the real-time and non-real-time monitoring activities are given in Tables A and B. An essential part of the monitoring plan is that information should be exchanged between adjacent centres on the GTS in order that telecommunication problems in particular may be readily identified. A special aspect of the exchange of information is that procedures should be developed to ensure that no doubts exist that a bulletin contains all the observations available for inclusion in it. In the case of standard bulletins containing routine observations, the contents of the bulletins should always conform to the list included in the appropriate WMO publication, as amended. When the observations from some stations included in the publication are not available for any reason, NIL should appear in place of the coded report. As

a further check on completeness, NMCs should send messages to the associated RTH, preferably in advance, when it is known that observations from listed stations are not (or will not be) available. It is important that all WWW centres (NMCs, RSMCs, RTHs and WMCs) make a contribution to the overall monitoring effort. Obviously, centres having a multiple role will make more than one contribution. In the contributions, the following points should be taken into account:

(*a*) For the monitoring at *bulletin* level, retard (RTD) and corrected (COR) bulletins should be included;

(*b*) For the monitoring at *report* level, corrected reports should not be counted as additional reports, but retard reports should be counted;

(*c*) Duplicated reports and duplicated bulletins should be counted only once;

(*d*) The contributions should clearly indicate the database used for monitoring (telecommunications or data processing);

(*e*) The contributions should also report any outages of centres and/or circuits occurring during the monitoring period;

(*f*) In the contributions every possible effort should be made to adhere to the times included in the headings of the tables.

13. The frequency with which monitoring reports should be prepared and/or exchanged is illustrated in the following table:

| | |
|---|---|
| Every day: | Every centre carries out continuous real-time monitoring; |
| At intervals of not more than one month: | NMCs prepare a summary of relevant information on monitoring for use on a national and international level as appropriate; |
| At least once every three months: | RTHs/RSMCs send a summary of monitoring information to their associated NMCs; |
| At least once every three months: | RTHs/RSMCs send a summary of monitoring information to adjacent RTHs which supply them with data; |
| Once every six months: | WMCs send a summary of monitoring information to adjacent RTHs/RSMCs. |

Reports called for at intervals of three months or more should always be forwarded to the Secretary-General in an agreed format for further action. As regards contents, reports should include as many items for Table B as are practical and useful.

14. Members should implement the plan for monitoring the operation of the WWW at the earliest possible date, in particular the real-time monitoring.

15. In order to keep under review the efficient operation of the WWW, internationally coordinated monitoring on a non-real-time basis should be carried out periodically, once a year in October, on the full range of global observational data and with the participation of a limited number of major WWW centres. During other periods, particular problem areas should be monitored, in respect of either selected information only or limited parts of the world. The Secretary-General will arrange, in consultation with the appropriate centres, details of the special monitoring exercises and the periods during which they should be carried out, and will provide adequate notice well in advance.

16. The Secretariat will carry out the necessary analyses of the non-real-time monitoring reports from WWW centres and will make the results of the analyses available to the centres concerned. The Secretary-General will coordinate and advise on assistance necessary to rectify the deficiencies revealed from the results of the monitoring. The Secretary-General will also arrange (as required) for the specific monitoring exercises mentioned in paragraph 15 above to be carried out.

## PROCEDURES

17. As far as real-time monitoring is concerned, each centre should develop the necessary detailed procedures for this purpose. These procedures will vary from centre to centre, but should be designed to facilitate the real-time checking of the receipt of bulletins and observations as appropriate. At fully automated centres, these procedures may include the use of telecommunication system records, visual display units, special programs in telecommunication and data-processing computers, and so on. At manual centres, check lists or sheets may be developed for the same purposes using ticks, crosses or the entry of times to indicate when selected bulletins and/or reports have been received. To avoid excessive use of paper forms, it may be convenient to place transparent sheets of plastic over the check sheets and make entries using soft wax pencils. The entries can be removed very easily when a suitable period has elapsed and the sheets made ready for the checks to be repeated for a later period. Some further guidance on the operation of real-time monitoring, together with examples of the kind of forms which might be developed, is given in Table C.

18. As far as non-real-time monitoring is concerned, when special exercises are requested by the Secretariat, an indication of the

form in which contributions should be made will be provided at the time the request is made. It is important that, as far as possible, centres should follow closely the procedures indicated in order that results from various centres be directly comparable with each other. It is particularly important that this should be the case when the annual global monitoring exercise is carried out. The procedures, together with the standard forms to be used for the provision of results, are given in Table D.

19. It is emphasized that nothing in the formal monitoring procedures prescribed in the attachment is intended to replace the normal day-to-day exchange of information and advice between adjacent centres. As far as possible, all problems should be resolved in this way and, after a time, only serious difficulties will be reflected in the formal monitoring reports.

## QUALITY OF OBSERVATIONAL DATA

20. Centres with global, hemispheric or near-hemispheric models should monitor the quality of one or more of the main types of observations using techniques such as those listed in Table E. Statistics should be compiled separately for each land station by station index number, for each ship or aircraft by call sign, for each buoy by identifier, and for each satellite by identifier, and for various geographic areas and levels in the atmosphere.

21. The centres should analyse the results and produce in an agreed format lists of observations believed to be consistently of low quality, together with information on which element of the observation (pressure, temperature, etc.) is thought to be of low quality and the evidence for considering it as such. These lists should be based on data received over one month and should be exchanged monthly between participating centres.

22. For each type of observation a lead centre shall be nominated from time to time by the president of CBS. The lead centre should liaise with the participating centres to coordinate all the monitoring results of that observation type and to define common methods and criteria to be used for compiling the monthly statistics. The lead centre should draw the attention of appropriate focal points where they have been identified and of the WMO Secretariat to obvious problems as they are detected. It should also produce every six months a consolidated list of observations of the relevant observation type believed to be of consistently low quality. Information on problems with observing systems, as well as individual observations, should also be included. When compiling the consolidated lists of suspect stations the lead centres should be rigorous so as to identify only those stations where they are confident that the observations are of consistently low quality. They should state which elements of the observation are considered of low quality and provide as much information as possible identifying the problem. The list should be passed on to the participating centres and to the WMO Secretariat. Where focal points have not been identified the Secretariat should notify Members of agencies responsible for the observations which appear to be of low quality, and request them to make an investigation with a view to identifying and correcting any possible cause of error. Members should be asked to reply within a fixed period of time, reporting on any remedial action and stating if any assistance is required. Monitoring results including follow-up action should be made available to CBS, the Executive Council and Congress. In the case of enquiries made by WMO, feedback to the lead centres is requested.

## STATISTICAL VERIFICATION OF NUMERICAL WEATHER PREDICTION

23. The accuracy of forecasts of numerical weather prediction models should be monitored by objective verification procedures.

(*a*) Centres operating global, hemispheric or near-hemispheric models and regional models covering appropriate areas should compile verification statistics using the standard procedures described in Table F. The results, together with any relevant information such as improvements that have been made to their NWP systems, should be exchanged monthly between participating centres. Such information may enable centres to identify deficiencies or problems and make improvements in their NWP systems;

(*b*) Centres receiving GDPFS products over the GTS may wish to verify appropriate areas using the standardized measures listed in Table F and send the results to the producing centres.

24. The statistics of EPS verification should be exchanged. A lead centre for EPS verification should take responsibility for gathering the statistics of EPS verification and for deriving probabilistic scores such as the Brier score, the reliability score, ROC area and the economic value from the exchanged reliability table. The lead centre should make the verification scores available on a website, which is open to the NMHSs, promptly.

TABLE A

# REAL-TIME MONITORING

| *Items* | *National units* | *NMC* | *RTH/RSMC* | *RTH/WMC* |
|---|---|---|---|---|
| 1. Bulletins not received in time | ← | ↔ | ↔ | |
| 2. Observations not received in time | ← | | | |
| 3. Processed information not received in time | | → | → | |
| 4. Errors in observations | ← | (←) | | |
| 5. Special bilateral checks | ↔ | ↔ | ↔ | |

*(Items are indicative rather than mandatory)*

NOTES:

1. *Bulletins not received in time* are bulletins which appear on the transmission schedule and have not been received by a time agreed bilaterally between two adjacent centres.
2. *Observations not received in time* are observations which appear in the published contents of the bulletins listed for transmission but which have not been received by the time agreed.
3. *Processed information not received in time* refers to data not received by the time agreed but known to be in the transmission schedule.
4. Errors in observations are errors detected or suspected in the coding and/or meteorological content of messages.
5. *Special bilateral checks* are checks on any of the previous elements 1–4 or other elements which may have been arranged temporarily or on a more continuous basis by the centres concerned.

The phrase *national units* is understood in this context to mean national observing, collecting and dissemination systems.

The arrows indicate the direction in which messages concerning monitoring will normally be sent. Thus, for example, messages concerning suspected errors in observations will normally be sent to the observing network only by NMCs — unless a special bilateral agreement has been made between an NMC and an appropriate RSMC to carry out real-time quality control on its behalf. To cover this possibility, an entry in parentheses has been made under RSMC.

TABLE B

## NON-REAL-TIME MONITORING

| *Items* | *NMC* | *RTH/RSMC* | *RTH/WMC* |
|---|---|---|---|
| 1. Bulletins not received | x | x | x |
| 2. Bulletins received late | x | x | x |
| 3. Observations not received | x | x | x |
| 4. Observations received late | x | x | x |
| 5. Processed information not received | x | x | |
| 6. Processed information received late | x | x | |
| 7. Non-adherence to telecommunication format | x | x | x |
| 8. Completeness of observational data | x | x | x |
| 9. Quality of observational data | x | x | x |
| 10. Deficiencies in processed information | x | x | x |
| 11. Statistical verification of numerical weather prediction | x | x | x |
| 12. Special bilateral or multilateral checks | x | x | x |
| 13. Notes on recurrent problems | x | x | x |
| 14. Monitoring reports | x | x | x |

*(Items are indicative rather than mandatory)*

NOTES:

1. *Bulletins not received* are bulletins scheduled for transmission but not received.
2. *Bulletins received late* are bulletins received later than the time periods specified by WMO or agreed bilaterally.
3. *Observations not received* are observations scheduled for transmission but not received.
4. *Observations received late* are defined in a similar way as "bulletins received late" in Note 2 above.
5. *Processed information not received* is products in alphanumeric or pictorial form scheduled for transmission but not received.
6. *Processed information received late* is defined in a similar way as "bulletins received late" in Note 2 above.
7. *Non-adherence to telecommunication format* refers to errors made consistently or frequently by transmitting stations which interfere with the regular transmission of messages.
10. *Deficiencies in processed information* are shortcomings (e.g. data missing, messages garbled, facsimile products unreadable) which seriously interfere with the operational value of the products.
11. *Statistical verification of numerical weather prediction* would be supplied only by centres having a special interest in, and capability for, this type of information.
12. *Special bilateral or multilateral checks* means supplementary checks arranged between two or more centres by mutual agreement, on either a temporary or a continuous basis, to deal with special problems.
13. *Notes on recurrent problems* indicate areas of difficulty not covered by Notes 1–12 inclusive.
14. *Monitoring reports are reports in the format* to be developed by the Secretary-General, in consultation with the president of CBS and the chairmen of the appropriate working groups.

The crosses in the various columns indicate the centres at which these functions would normally be carried out.

TABLE C

# GUIDANCE FOR REAL-TIME MONITORING

## 1. CHECK ON THE RECEPTION OF OBSERVATIONAL REPORTS FROM LAND STATIONS

In order to implement real-time monitoring, suitable forms should be used for checking the reception of observational reports from land stations. Separate tables may be prepared for SYNOPs for global exchange, for TEMP/PILOTs for global exchange, for SYNOPs for regional exchange, and so on in order to check the availability of various types of observational data. If an observation from a particular station has not been received within the appropriate time, a request should be made to the station. Detailed procedures must be developed to meet the needs of centres of various kinds.

## 2. CHECK ON THE RECEPTION OF AIRCRAFT AND SHIPS' WEATHER REPORTS FROM COASTAL RADIO STATIONS OR AERONAUTICAL RADIO STATIONS

Each centre should ensure that all bulletins have been received, and procedures to ensure that this is the case (for example by introducing the use of channel sequence numbers and similar ideas) should be developed to meet local needs.

## 3. CHECK ON CODING OF OBSERVATIONAL REPORTS

Observational reports should be checked before transmission of bulletins, in order to eliminate coding errors. This check should be made by the observer when the observation is first made and by suitably qualified staff when the bulletins are prepared. Such checking procedures, however, must not result in appreciable delays in the transmission of bulletins.

## 4. CHECK ON THE STANDARD FORMAT OF METEOROLOGICAL MESSAGES

Meteorological messages shall be checked *to ensure that the standard format has been used and corrections shall be made as required*. In particular, the following points shall be checked:

(*a*) The starting line, the abbreviated heading and the end-of-message signal of messages shall be completely free of error;

(*b*) Reports included in a bulletin shall be separated by the report separation signal.

It is emphasized that messages which can be handled without difficulty at manual centres may still give very serious problems at automated centres, unless the procedures are scrupulously observed. Even a single incorrect character can lead to difficulties in some cases.

## 5. CHECK ON THE RECEPTION OF SCHEDULED BULLETINS WITHIN SPECIFIED TIMES

Each RTH should check the reception of bulletins from the NMCs in the zone of responsibility. For this purpose, forms such as Examples 1 and 2 may be useful. If channel sequence numbers (nnn) have not been received in sequential order, queries should be made to the centre concerned immediately. Where no channel sequence number procedures are in operation, other measures must be taken to ensure that no transmissions have been missed and no individual observations missed because of garbling, radio fading, or other causes.

EXAMPLE 1

## REAL-TIME MONITORING

(Check for individual meteorological bulletins, not received, incorrect format or mutilated)

| *CENTRE:* | *DATE:* | *CIRCUIT:* | | | *PAGE:* |
|---|---|---|---|---|---|
| *Abbreviated heading* | *Description of fault* | *Time of receipt* | *Time of request* | *Time of receipt of repeat* | *Remarks (e.g. circuit outage times)* |
| | | | | | |

EXAMPLE 2

## MONITORING OF THE RECEPTION OF SHIP/AIREP BULLETINS AND NUMBER OF REPORTS

| SHIP | | | AIREP | | |
|---|---|---|---|---|---|
| *Abbreviated heading* | *Time of receipt* | *Number of reports* | *Abbreviated heading* | *Time of receipt* | *Number of reports* |
| | | | | | |

TABLE D

# PROCEDURES FOR INTERNATIONALLY COORDINATED NON-REAL-TIME MONITORING

## 1. MONITORING PERIODS

The internationally coordinated monitoring of data for global exchange will be carried out once a year in October with a view to periodically checking the efficiency of the operation of the WWW. Statistics should be compiled by manually operated and automated centres for the periods 1–5 October and 1–15 October respectively. In order to facilitate the comparison of results between manually operated and automated centres, automated centres should also provide results for the two periods of 1–5 October and 1–15 October.

NOTE: As regards CLIMAT/CLIMAT TEMP, the monitoring period should be extended to 15 days, even if (for other observations) a return for a period of only five days is made.

## 2. TYPES OF DATA TO BE MONITORED

The types of data listed in the following table should be monitored:

| *Types of data* | *Abbreviated headings of bulletins* $T_1T_2A_1A_2$ | *Reference format for presentation of results* |
|---|---|---|
| SYNOP reports | $SMA_1A_2$ | A |
| Parts A and B of TEMP reports | $USA_1A_2/UKA_1A_2$ | $B_1/B_2$ |
| Parts A and B of PILOT reports | $UPA_1A_2/UGA_1A_2$ | $B_1/B_2$ |
| SHIP reports | $SMA_1A_2$ | $C_1/C_2$ |
| Parts A and B of TEMP SHIP reports | $USA_1A_2/UKA_1A_2$ | $D_1/D_2/D_3/D_4$ |
| Parts A and B of PILOT SHIP reports | $UPA_1A_2/UGA_1A_2$ | $D_5/D_6/D_7/D_8$ |
| DRIFTER reports | $SSA_1A_2$ | E |
| AIREP reports | $UAA_1A_2$ | F |
| AMDAR reports | $UDA_1A_2$ | G |
| BATHY/TESAC reports | $SOA_1A_2$ | H |
| CLIMAT reports | $CSA_1A_2$ | $I_1$ |
| CLIMAT TEMP reports | $CUA_1A_2$ | $I_2$ |

(*a*) *Monitoring of* SYNOP *reports*

For each monitored station identified by the station index number (IIiii), the number of SYNOP reports made at the main standard synoptic hours (00, 06, 12 and 18 UTC) and available during the monitoring period within one hour, two hours and six hours of the standard bulletin times, should be inserted in the appropriate columns of Format A;

(*b*) *Monitoring of Parts A and B of* TEMP *and* PILOT *reports*

For each monitored station identified by the station index number (IIiii), the number of Parts A and B of TEMP and PILOT reports (made by tracking a free balloon by electronic or optical means at the main standard synoptic hours (00, 06, 12 and 18 UTC) and available during the monitoring period within two hours and 12 hours of the standard bulletin times) should be inserted in the appropriate columns of Formats $B_1$ and $B_2$;

(*c*) *Monitoring of* SHIP *reports*

The number of bulletins identified by their abbreviated headings ($T_1T_2A_1A_2$ii CCCC) including SHIP reports made at the main synoptic hours (00, 06, 12 and 18 UTC) and available during the monitoring period within two hours and 12 hours of the standard bulletin times with the number of reports included in these bulletins should be inserted in the appropriate columns of Formats $C_1$ and $C_2$;

(*d*) *Monitoring of Parts A and B of* TEMP SHIP *and* PILOT SHIP *reports*

The number of bulletins identified by their abbreviated headings ($T_1T_2A_1A_2$ii CCCC) including Parts A and B of TEMP SHIP and PILOT SHIP reports made at the main synoptic hours (00, 06, 12 and 18 UTC) and available during the monitoring period within 12 hours and 24 hours of the standard bulletin times with the number of reports included in these bulletins should be inserted in the appropriate columns of Formats $D_1$ to $D_8$;

(*e*) *Monitoring of* DRIFTER, AIREP *and* AMDAR *reports*

The number of bulletins identified by their abbreviated headings ($T_1T_2A_1A_2$ii CCCC) including DRIFTER, AIREP and AMDAR reports compiled between 21 and 03 UTC, 03 and 09 UTC, 09 and 15 UTC and 21 UTC and available during the monitoring period before 05, 11, 17 and 23 UTC respectively, as well as the number of reports included in these bulletins, should be inserted in the appropriate columns of Formats E, F and G;

(*f*) *Monitoring of* BATHY/TESAC

The time of receipt of bulletins identified by their complete abbreviated headings ($T_1T_2A_1A_2$ii CCCC YYGGgg (BBB)) containing BATHY/TESAC reports as well as the number of reports included in these bulletins should be inserted in the appropriate columns of Format H;

(*g*) *Monitoring of* CLIMAT *and* CLIMAT TEMP *reports*

For each station monitored and identified by the station index number (IIiii), "1" should be inserted in the appropriate column of Format $I_1$, if the September CLIMAT report is received between 1 and 5 October or 6 and 15 October, otherwise "0" should be inserted in these columns. The same procedure should be applied to the September CLIMAT TEMP report in Format $I_2$.

## 3. GLOBAL DATA SET TO BE MONITORED

3.1 The global data set to be monitored is determined by:

(*a*) The lists of stations, the observations (SYNOP, TEMP, PILOT, CLIMAT and CLIMAT TEMP reports) of which have to be globally exchanged;

(*b*) The lists of abbreviated headings of bulletins containing SHIP, TEMP SHIP, PILOT SHIP, DRIFTER, AIREP and BATHY/TESAC reports which have to be globally exchanged according to the *Catalogue of Meteorological Bulletins*. For ease of reference, the Secretariat will compile these lists of abbreviated headings which will be attached to the relevant format for each monitoring.

3.2 The references of the lists mentioned (including the references to the relevant amendment to the *Manual on the GTS* and of the edition of the *Catalogue of Meteorological Bulletins*) are given in the formats prepared by the Secretariat for each monitoring.

## 4. GEOGRAPHICAL AREA IN WHICH DATA SHOULD BE MONITORED

GTS centres should monitor the global data set or part of it as follows:

(*a*) NMCs or centres with similar functions should monitor at least the availability of the data from the zone for which they are responsible for the data collection and their insertion into the GTS;

(*b*) RTHs not located on the MTN should monitor at least the availability of the observational data from their zone of responsibility for the collection of observational data as prescribed in Volume II of the *Manual on the GTS*. RTHs should also monitor the availability of observational data from the Region in which they are located and from any other Region to which they are linked by an interregional circuit;

(*c*) WMCs and RTHs located on the MTN should monitor the availability of the complete set of data for global exchange.

## 5. IMPLEMENTATION OF MONITORING PROCEDURES AND QUESTIONNAIRES

5.1 Questionnaires related to the procedures implemented at the centres, suspension of observing programmes at observing stations and suspension of transmission on circuits are given in Formats J, K and L respectively.

5.2 Monitoring procedures should be implemented at centres in such a way that all replies to the questions included in Format J should be positive (reply: Yes).

## 6. STANDARD FORMAT FOR STATISTICS

6.1 With a view to enabling the easy comparison of results of internationally coordinated monitoring carried out by the different centres, the standard formats attached should be used. All centres carrying out monitoring should state clearly the period covered. In each format, centres should present the results Region by Region as well as for the Antarctic and give totals of the number of bulletins or reports received within the specified time Region by Region and for the Antarctic.

6.2 If the report or bulletin indicated in the first column is not scheduled to be received, N should be inserted in the second column of the format concerned, otherwise S should be inserted.

6.3 The statistics should be sent to the adjacent centres concerned and to the WMO Secretariat at the earliest possible date after the end of the monitoring period but not later than 15 November.

## 7. ROLE OF THE WMO SECRETARIAT

The Secretariat will ensure that the Members are aware of their respective responsibilities and will collect the statistical results of internationally coordinated monitoring from the Members concerned. The Secretariat will make a summary of the statistics and will evaluate the deficiencies and effectiveness of the operation of the WWW as a whole and in part. In this connection, the Secretariat will check the observing programme of individual observing stations. The results of the monitoring will be made available to the Executive Council and CBS by correspondence or at sessions as appropriate. The Secretariat will take up the possibility of remedial action with Members concerned in order to eliminate shortcomings in the operation of the GOS and the GTS as quickly as possible.

## 8. SPECIAL TYPES OF NON-REAL-TIME MONITORING OF THE WWW

If necessary, monitoring of the WWW may be undertaken in different regions and for various types of observational data. The purpose of such monitoring is to identify, in greater detail, deficiencies in the collection and exchange of data in different parts of the GTS and the reason for such deficiencies. Special types of monitoring should be initiated by the Secretary-General or by some of the Members concerned. The dates and duration of such monitoring would have to be agreed upon by those Members.

NOTE TO FORMATS A – L

See *Weather Reporting* (WMO-No. 9), Volume C1 – Catalogue of Meteorological Bulletins, for lists of abbreviated headings for global exchange of the following bulletins: SHIP, TEMP SHIP, Parts A and B; PILOT SHIP, Parts A and B; DRIFTER; AIREP; AMDAR; and BATHY TESAC. These lists will also be included by the WMO Secretariat in the letter of invitation to participate in the monitoring.

## FORMAT A

### STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: SYNOP

*Monitoring centre*: .......................................................................... *Monitoring period*: ..........................................................................................

| *Station index number** IIiii | *S/N ** * | *Number of* SYNOP *reports received between HH (standard bulletin time) and* | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *HH (UTC) + 1 hour* | | | | | *HH (UTC) + 2 hours* | | | | | *HH (UTC) + 6 hours* | | | | |
| | | *00* | *06* | *12* | *18* | *Total* | *00* | *06* | *12* | *18* | *Total* | *00* | *06* | *12* | *18* | *Total* |
| | | | | | | | | | | | | | | | | |

* Reference for the global exchange list: *Manual on the GTS* — Amendment .....

** S = if data are scheduled to be received; N = if data are not scheduled to be received

# FORMAT $B_1$

## STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: TEMP and PILOT (PART A)

*Monitoring centre*: ..........................................................................  *Monitoring period*: ..........................................................................

| *Station index number** IIiii | *S/N *** | *Number of* TEMP *reports (Part A) received between HH (standard bulletin time) and* | | | | | | | | | | *Number of* PILOT *reports (Part A) received between HH (standard bulletin time) and* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *HH (UTC) + 2 hours* | | | | | *HH (UTC) + 12 hours* | | | | | *HH (UTC) + 2 hours* | | | | | *HH (UTC) + 12 hours* | | | | |
| | | *00* | *06* | *12* | *18* | *Total* | *00* | *06* | *12* | *18* | *Total* | *00* | *06* | *12* | *18* | *Total* | *00* | *06* | *12* | *18* | *Total* |
| | | | | | | | | | | | | | | | | | | | | | |

* Reference for the global exchange list: *Manual on the GTS* — Amendment .....

** S = if data are scheduled to be received; N = if data are not scheduled to be received

# FORMAT $B_2$

## STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: TEMP and PILOT (PART B)

*Monitoring centre*: ....................................................................... *Monitoring period*: .......................................................................

| *Station index number** IIiii | *S/N *** | *Number of* TEMP *reports (Part B) received between HH (standard bulletin time) and* | | | | | | | | | | *Number of* PILOT *reports (Part B) received between HH (standard bulletin time) and* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *HH (UTC) + 2 hours* | | | | | *HH (UTC) + 12 hours* | | | | | *HH (UTC) + 2 hours* | | | | | *HH (UTC) + 12 hours* | | | | |
| | | *00* | *06* | *12* | *18* | *Total* | *00* | *06* | *12* | *18* | *Total* | *00* | *06* | *12* | *18* | *Total* | *00* | *06* | *12* | *18* | *Total* |
| | | | | | | | | | | | | | | | | | | | | | |

* Reference for the global exchange list: *Manual on the GTS* — Amendment .....

** S = if data are scheduled to be received; N = if data are not scheduled to be received

## FORMAT $C_1$

### STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: SHIP

*Monitoring centre*: ..........................................................................  *Monitoring period*: ..........................................................................

| *Abbreviated heading** $T_1T_2A_1A_2ii$ CCCC | *S/N ** * | *Number of SHIP bulletins and reports received within 2 hours of the standard bulletin time* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *00 UTC* | | *06 UTC* | | *12 UTC* | | *18 UTC* | | *Total* | |
| | | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* |
| | | | | | | | | | | | |

* See attached list of abbreviated headings of SHIP bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference: *Catalogue of Meteorological Bulletins*—edition .....)

** S = if data are scheduled to be received; N = if data are not scheduled to be received

## FORMAT $C_2$

### STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: SHIP

*Monitoring centre*: ..................................................................... *Monitoring period*: .....................................................................

| *Abbreviated heading** $T_1T_2A_1A_2ii$ CCCC | *S/N* ** | *Number of SHIP bulletins and reports received within 12 hours of the standard bulletin time* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *00 UTC* | | *06 UTC* | | *12 UTC* | | *18 UTC* | | *Total* | |
| | | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* |
| | | | | | | | | | | | |

* See attached list of abbreviated headings of SHIP bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference: *Catalogue of Meteorological Bulletins*—edition .....)

** S = if data are scheduled to be received; N = if data are not scheduled to be received

# FORMAT $D_1$

## STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: TEMP SHIP (PART A)

*Monitoring centre*: .......................................................................... *Monitoring period*: ..........................................................................

| *Abbreviated heading** $T_1T_2A_1A_2ii$ CCCC | *S/N *** | *Number of* TEMP SHIP *bulletins and reports (Part A) received within 12 hours of the standard bulletin time* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *00 UTC* | | *06 UTC* | | *12 UTC* | | *18 UTC* | | *Total* | |
| | | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* |
| | | | | | | | | | | | |

* See attached list of abbreviated headings of TEMP SHIP (Part A) bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference: *Catalogue of Meteorological Bulletins*—edition .....)

** S = if data are scheduled to be received; N = if data are not scheduled to be received

# FORMAT $D_2$

## STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: TEMP SHIP (PART A)

*Monitoring centre*: .......................................................................... *Monitoring period*: ..........................................................................................

| *Abbreviated heading** $T_1T_2A_1A_2ii$ CCCC | *S/N *** | *Number of* TEMP SHIP *bulletins and reports (Part A) received within 24 hours of the standard bulletin time* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *00 UTC* | | *06 UTC* | | *12 UTC* | | *18 UTC* | | *Total* | |
| | | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* |
| | | | | | | | | | | | |

* See attached list of abbreviated headings of TEMP SHIP (Part A) bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference: *Catalogue of Meteorological Bulletins*—edition .....)

** S = if data are scheduled to be received; N = if data are not scheduled to be received

## FORMAT $D_3$

### STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: TEMP SHIP (PART B)

*Monitoring centre*: ..........................................................................   *Monitoring period*: ..........................................................................

| *Abbreviated heading** $T_1T_2A_1A_2ii$ CCCC | *S/N *** | *Number of* TEMP SHIP *bulletins and reports (Part B) received within 12 hours of the standard bulletin time* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *00 UTC* | | *06 UTC* | | *12 UTC* | | *18 UTC* | | *Total* | |
| | | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* |
| | | | | | | | | | | | |

* See attached list of abbreviated headings of TEMP SHIP (Part B) bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference: *Catalogue of Meteorological Bulletins*—edition .....)

** S = if data are scheduled to be received; N = if data are not scheduled to be received

# FORMAT $D_4$

## STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: TEMP SHIP (PART B)

*Monitoring centre*: ............................................................................ *Monitoring period*: ...........................................................................................

| *Abbreviated heading** $T_1T_2A_1A_2ii$ CCCC | *S/N* ** | *Number of* TEMP SHIP *bulletins and reports (Part B) received within 24 hours of the standard bulletin time* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *00 UTC* | | *06 UTC* | | *12 UTC* | | *18 UTC* | | *Total* | |
| | | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* |
| | | | | | | | | | | | |

* See attached list of abbreviated headings of TEMP SHIP (Part B) bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference: *Catalogue of Meteorological Bulletins*—edition .....)

** S = if data are scheduled to be received; N = if data are not scheduled to be received

# FORMAT $D_5$

## STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: PILOT SHIP (PART A)

*Monitoring centre:* ........................................................ *Monitoring period:* ........................................................

| *Abbreviated heading** $T_1T_2A_1A_2ii$ CCCC | *S/N ** * | *Number of* PILOT SHIP *bulletins and reports (Part A) received within 12 hours of the standard bulletin time* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *00 UTC* | | *06 UTC* | | *12 UTC* | | *18 UTC* | | *Total* | |
| | | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* |
| | | | | | | | | | | | |

* See attached list of abbreviated headings of PILOT SHIP (Part A) bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference: *Catalogue of Meteorological Bulletins*—edition .....)

** S = if data are scheduled to be received; N = if data are not scheduled to be received

## FORMAT $D_6$

### STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: PILOT SHIP (PART A)

*Monitoring centre*: ........................................................................ *Monitoring period*: ........................................................................

| *Abbreviated heading** $T_1T_2A_1A_2ii$ CCCC | *S/N *** | *Number of* PILOT SHIP *bulletins and reports (Part A) received within 24 hours of the standard bulletin time* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *00 UTC* | | *06 UTC* | | *12 UTC* | | *18 UTC* | | *Total* | |
| | | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* |
| | | | | | | | | | | | |

* See attached list of abbreviated headings of PILOT SHIP (Part A) bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference: *Catalogue of Meteorological Bulletins*—edition .....)

** S = if data are scheduled to be received; N = if data are not scheduled to be received

# FORMAT $D_7$

## STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: PILOT SHIP (PART B)

*Monitoring centre*: ..........................................................................  *Monitoring period*: ..........................................................................

| *Abbreviated heading** $T_1T_2A_1A_2ii$ CCCC | *S/N ** * | *Number of* PILOT SHIP *bulletins and reports (Part B) received within 12 hours of the standard bulletin time* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *00 UTC* | | *06 UTC* | | *12 UTC* | | *18 UTC* | | *Total* | |
| | | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* |
| | | | | | | | | | | | |

* See attached list of abbreviated headings of PILOT SHIP (Part B) bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference: *Catalogue of Meteorological Bulletins*—edition .....)

** S = if data are scheduled to be received; N = if data are not scheduled to be received

# FORMAT $D_8$

## STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: PILOT SHIP (PART B)

*Monitoring centre*: ........................................................................ *Monitoring period*: ......................................................................................

| *Abbreviated heading** $T_1T_2A_1A_2ii$ CCCC | *S/N ** * | *Number of* PILOT SHIP *bulletins and reports (Part B) received within 24 hours of the standard bulletin time* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *00 UTC* | | *06 UTC* | | *12 UTC* | | *18 UTC* | | *Total* | |
| | | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* | *Bulletins* | *Reports* |
| | | | | | | | | | | | |

* See attached list of abbreviated headings of PILOT SHIP (Part B) bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference: *Catalogue of Meteorological Bulletins*—edition .....)

** S = if data are scheduled to be received; N = if data are not scheduled to be received

## FORMAT E

### STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: DRIFTER

*Monitoring centre*: ........................................................................ *Monitoring period*: ........................................................................

| *Abbreviated heading*** $T_1T_2A_1A_2ii$ CCCC | *S/N* *** | *Bulletins compiled between 21* and 03* UTC and received before 05 UTC* | | *Bulletins compiled between 03* and 09* UTC and received before 11 UTC* | | *Bulletins compiled between 09* and 15* UTC and received before 17 UTC* | | *Bulletins compiled between 15* and 21* UTC and received before 23 UTC* | | *Total* | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Number of bulletins* | *Number of reports* | *Number of bulletins* | *Number of reports* | *Number of bulletins* | *Number of reports* | *Number of bulletins* | *Number of reports* | *Number of bulletins* | *Number of reports* |
| | | | | | | | | | | | |

* Hour of compilation = GGgg included in the abbreviation heading.

** See attached list of abbreviated headings of DRIFTER bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference: *Catalogue of Meteorological Bulletins*—edition .....)

*** S = if data are scheduled to be received; N = if data are not scheduled to be received

## FORMAT F

### STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: AIREP

*Monitoring centre*: ........................................................................ *Monitoring period*: ........................................................................

| *Abbreviated heading*** $T_1T_2A_1A_2ii$ CCCC | *S/N* *** | *Bulletins compiled between 21* and 03* UTC and received before 05 UTC* | | *Bulletins compiled between 03* and 09* UTC and received before 11 UTC* | | *Bulletins compiled between 09* and 15* UTC and received before 17 UTC* | | *Bulletins compiled between 15* and 21* UTC and received before 23 UTC* | | *Total* | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Number of bulletins* | *Number of reports* | *Number of bulletins* | *Number of reports* | *Number of bulletins* | *Number of reports* | *Number of bulletins* | *Number of reports* | *Number of bulletins* | *Number of reports* |
| | | | | | | | | | | | |

* Hour of compilation = GGgg included in the abbreviation heading.

** See attached list of abbreviated headings of AIREP bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference: *Catalogue of Meteorological Bulletins*—edition .....)

*** S = if data are scheduled to be received; N = if data are not scheduled to be received

# FORMAT G

## STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: AMDAR

*Monitoring centre*: ......................................................... *Monitoring period*: .........................................................

| *Abbreviated heading*** $T_1T_2A_1A_2ii$ CCCC | *S/N **** | *Bulletins compiled between 21* and 03* UTC and received before 05 UTC* | | *Bulletins compiled between 03* and 09* UTC and received before 11 UTC* | | *Bulletins compiled between 09* and 15* UTC and received before 17 UTC* | | *Bulletins compiled between 15* and 21* UTC and received before 23 UTC* | | *Total* | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Number of bulletins* | *Number of reports* | *Number of bulletins* | *Number of reports* | *Number of bulletins* | *Number of reports* | *Number of bulletins* | *Number of reports* | *Number of bulletins* | *Number of reports* |
| | | | | | | | | | | | |

* Hour of compilation = GGgg included in the abbreviation heading.

** See attached list of abbreviated headings of AMDAR bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference: *Catalogue of Meteorological Bulletins*—edition .....)

*** S = if data are scheduled to be received; N = if data are not scheduled to be received

## FORMAT H

### STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: BATHY/TESAC

*Monitoring centre*: ..........................................................................

*Monitoring period*: ..........................................................................

| BATHY/TESAC | | | | BATHY/TESAC | | | |
|---|---|---|---|---|---|---|---|
| *Abbreviated heading** $T_1T_2A_1A_2ii$ CCCC YYGGgg (BBB) | *S/N*** | *Date/Time of receipt* | *Number of reports* | *Abbreviated heading** $T_1T_2A_1A_2ii$ CCCC YYGGgg (BBB) | *S/N*** | *Date/Time of receipt* | *Number of reports* |
| | | | | | | | |

* See attached list of abbreviated headings of BATHY/TESAC bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference: *Catalogue of Meteorological Bulletins*—edition .....)

** S = if data are scheduled to be received; N = if data are not scheduled to be received

## FORMAT $I_1$

### STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: CLIMAT

*Monitoring centre*: ............................................................................ *Monitoring period*: ............................................................................

| CLIMAT | | | | CLIMAT | | | |
|---|---|---|---|---|---|---|---|
| *Station index number* IIiii* | *S/N*** | *Reports received 1 – 5 October* | *Reports received 6 – 15 October* | *Station index number* IIiii* | *S/N*** | *Reports received 1 – 5 October* | *Reports received 6 – 15 October* |
| | | | | | | | |

* Reference for the global exchange list: *Manual on the GTS* — Amendment .....

** S = if data are scheduled to be received; N = if data are not scheduled to be received

## FORMAT $I_2$

### STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: CLIMAT TEMP

*Monitoring centre*: ...........................................................................    *Monitoring period*: ...........................................................................

| CLIMAT TEMP | | | | CLIMAT TEMP | | | |
|---|---|---|---|---|---|---|---|
| *Station index number* IIiii* | *S/N*** | *Reports received 1 – 5 October* | *Reports received 6 – 15 October* | *Station index number* IIiii* | *S/N*** | *Reports received 1 – 5 October* | *Reports received 6 – 15 October* |
| | | | | | | | |

* Reference for the global exchange list: *Manual on the GTS* — Amendment .....

** S = if data are scheduled to be received; N = if data are not scheduled to be received

## FORMAT J

### QUESTIONNAIRE RELATED TO THE IMPLEMENTATION OF PROCEDURES AT THE MONITORING CENTRES

*Monitoring centre*: .......................................................................... *Monitoring period*: ..........................................................................

| Question: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Is the monitoring automated? | Is the counting of bulletins and reports performed before quality control? | Are bulletins and reports counted only if received or transmitted on the GTS channels? | Are duplicated bulletins disregarded? | Are bulletins including only NIL reports counted? | Are bulletins including COR or CCx counted in addition to bulletins to be corrected? | Are duplicated reports included in bulletins having the same abbreviated heading disregarded? | Are duplicated reports included in bulletins having a different abbreviated heading disregarded? | Are NIL reports disregarded? | Are reports included in in bulletins including the indicator COR or CCx disregarded in addition to reports to be corrected? | Are all AIREP/ AMDAR reports made at different positions during the flight counted as different reports? |
| Reply: (yes or no) | | | | | | | | | | | |

NOTE: Monitoring procedures should be implemented at centres in such a way that all replies to the questions included in Format J are positive (reply: yes)

Comments: ..........................................................................................................

..........................................................................................................

## FORMAT K

### SUSPENSION OF OBSERVING PROGRAMMES AT OBSERVING STATIONS

*Monitoring centre*: ..........................................................................   *Monitoring period*: ..........................................................................

| *Station index* Iliii | *Details of suspension and reasons* | *Number of reports (SYNOP, TEMP or PILOT) not made for each observation time* | | | | |
|---|---|---|---|---|---|---|
| | | *Type of report* | *00 UTC* | *06 UTC* | *12 UTC* | *18 UTC* |
| | | | | | | |

**Example of entry**:

| *Station index* Iiiii | *Details of suspension and reasons* | *Number of reports (SYNOP, TEMP or PILOT) not made for each observation time* | | | | |
|---|---|---|---|---|---|---|
| | | *Type of report* | *00 UTC* | *06 UTC* | *12 UTC* | *18 UTC* |
| Iiiii | Delayed delivery of balloons | TEMP | 2 | | 1 | |
| Iiiii | Delayed delivery of caustic soda | PILOT | 5 | 5 | 5 | 4 |
| | Lack of manpower | SYNOP | 7 | 7 | 7 | 7 |

# FORMAT L

## SUSPENSION OF TRANSMISSION ON CIRCUITS

*Monitoring centre*: ........................................................................ *Monitoring period*: ........................................................................

| *Circuit suspended* | *Duration of suspension* | *Remarks* |
|---|---|---|
| | | |

**Example of entry**:

| *Circuit suspended* | *Duration of suspension* | *Remarks* |
|---|---|---|
| (1) IIiii — NMC | 48 hours from 0645 UTC, 2 October | Failure of transmitter |
| (2) NMC —NMC<br>(NMC — RTH)<br>(RTH — RTH) | 15 hours from 0900 UTC, 3 October | Poor HF propagation |

NOTE: In cases where reasons of suspension are known, details should be given in column “Remarks”.

## TABLE E

## Techniques for monitoring the quality of observations

1. Compilation of statistics on the difference between observed values and the analysis and first-guess field;
2. Compilation of statistics on observations which fail the routine quality-control checks;
3. Examination of time series of observations from a particular station (particularly useful in data-sparse areas);
4. Compilation of statistics on the differences between reported values of geopotential height and geopotential height recalculated from significant level data for radiosonde stations, using common formulae for all stations;
5. For surface stations which report both mean sea-level pressure and station-level pressure, compilation of statistics on differences between reported mean sea-level pressure and mean sea-level pressure recomputed from reported station-level pressure and temperature and published values of station elevation;
6. Compilation of co-location statistics.

TABLE F

## Factors and methods used in standardized verification of NWP products

### I – VERIFICATION AGAINST ANALYSIS

**Area** Northern hemisphere extratropics (90°N – 20°N) (all inclusive)
Tropics (20°N – 20°S) (all inclusive)
Southern hemisphere extratropics (20°S – 90°S) (all inclusive)

**Grid** Verifying analysis is the centre's on a latitude–longitude grid 2.5° × 2.5°; origin (0°, 0°)

**Variables** Mean sea-level pressure, geopotential height, temperature, winds

**Levels** Extratropics: Mean sea-level, 500 hPa, 250 hPa
Tropics: 850 hPa, 250 hPa

**Time** 24 h, 48 h, 72 h, 96 h, 120 h, 144 h, 168 h, 192 h, 216 h, 240 h ...

**Statistics** Mean error, root-mean-square error (rmse), anomaly correlation, $S_1$ skill score, root-mean-square vector wind error ($rmse_v$)

The following definitions should be used:

mean error

$$M_{f,v} = \frac{\sum_{i=1}^{n} (x_f - x_v)_i \cos \varphi_i}{\sum_{i=1}^{n} \cos \varphi_i}$$

rms error

$$rmse = \sqrt{\frac{\sum_{i=1}^{n} (x_f - x_v)_i^2 \cos \varphi_i}{\sum_{i=1}^{n} \cos \varphi_i}}$$

correlation coefficient between observed and forecast anomalies

$$r = \frac{\sum_{i=1}^{n} (x_f - x_c - M_{f,c})_i (x_v - x_c - M_{v,c})_i \cos\varphi_i}{\sqrt{\sum_{i=1}^{n} (x_f - x_c - M_{f,c})_i^2 \cos\varphi_i} \cdot \sqrt{\sum_{i=1}^{n} (x_v - x_c - M_{v,c})_i^2 \cos\varphi_i}}$$

rms vector wind error

$$rmse_v = \sqrt{\frac{\sum_{i=1}^{n} (\vec{V}_f - \vec{V}_v)_i^2 \cos \varphi_i}{\sum_{i=1}^{n} \cos \varphi_i}}$$

$S_1$ skill score (mean sea-level pressure and geopotential height only)

$$S_1 = 100 \cdot \frac{\sum_{i=1}^{n} (e_g)_i \cos \varphi_i}{\sum_{i=1}^{n} (G_L)_i \cos \varphi_i}$$

where: $x_f$ = the forecast value of the parameter in question;

$x_v$ = the corresponding verifying value (analysed);

$n$ = the number of grid points in the verification area;

$\cos \varphi_i$ = cosine of latitude of grid point $i$;

$x_c$ = the climatological value of the parameter;

$M_{f,c}$ = the mean value over the verification area of the forecast climate anomalies;

$M_{v,c}$ = the mean value over the verification area of the analysed climate anomalies;

$\vec{V_f}$ = the forecast wind vector;

$\vec{V_v}$ = the verifying (analysed) wind vector.

$$e_g = \left\{ \left| \frac{\partial}{\partial x}(x_f - x_v) \right| + \left| \frac{\partial}{\partial y}(x_f - x_v) \right| \right\}$$

$$G_L = \max\left( \left| \frac{\partial x_f}{\partial x} \right|, \left| \frac{\partial x_v}{\partial x} \right| \right) + \max\left( \left| \frac{\partial x_f}{\partial y} \right|, \left| \frac{\partial x_v}{\partial y} \right| \right)$$

where the differentiation is approximated by differences on a 2.5° × 2.5° latitude/longitude grid.

NOTES:

(1) Values for these statistics should be computed daily (0000 UTC and 1200 UTC separately) for each specified area. Monthly averages should then be computed from the daily values of all forecasts verifying within the relevant month. For those centres not running forecasts from either 0000 or 1200 UTC, tables may alternatively be provided for 0600 UTC and 1800 UTC and should be labelled as such.

(2) The number of runs (daily statistics) forming the monthly means should be exchanged in the monthly report.

(3) Annual averages of daily verification are included in the yearly *Technical Progress Report on the Global Data-processing System.* These statistics are for the 24, 72 and 120 h forecast and include the rms vector wind error at 850 hPa (tropics area only) and 250 hPa (all three areas) as well as the rms error of geopotential heights at 500 hPa (northern and southern hemispheres).

(4) To the extent possible, horizontal and vertical interpolations from model to verifying grids should not involve multiple steps or explicit smoothing.

## II – VERIFICATION AGAINST OBSERVATIONS

**Network** The seven networks used in verification against radiosondes consist of radiosondes stations lying within the following geographical area:

| | | |
|---|---|---|
| North America | 25°N–60°N | 50°W–145°W |
| Europe/North Africa | 25°N–70°N | 10°W–28°E |
| Asia | 25°N–65°N | 60°E–145°E |
| Australia/New Zealand | 10°S–55°S | 90°E–180°E |
| Tropics | 20°S–20°N | all longitudes |
| Northern hemisphere extratropics | 20°N–90°N | all longitudes |
| Southern hemisphere extratropics | 20°S–90°S | all longitudes |

**Stations** The list of radiosonde stations to be used in each network is updated annually by the lead centre for radiosondes. The chosen stations must be available to all the centres and provide quality data on a regular basis. Consultation with all centres (usually by electronic mail) is desirable before establishing the final list. This list is published in the monthly WWW *Operational Newsletter*, as appropriate.

**Variables** Geopotential height, temperature, winds

**Levels** 850 hPa, 500 hPa, 250 hPa

**Time** 24 h, 48 h, 72 h, 96 h, 120 h, 144 h, 168 h, 192 h, 216 h, 240 h ...

**Statistics** Mean error, root-mean-square error (rmse), trend correlation, root-mean-square vector wind error ($\text{rmse}_v$)

The following definitions should be used:

mean error
$$M_{f,v} = \frac{1}{n}\sum_{i=1}^{n}(x_f - x_v)_i$$

rms error
$$rmse = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_f - x_v)_i^2}$$

correlation coefficient between observed and forecast trends
$$r = \frac{\sum_{i=1}^{n}(x_f - x_{f_o} - M_{f,f_o})_i(x_v - x_{v_o} - M_{v,v_o})_i}{\sqrt{\sum_{i=1}^{n}(x_f - x_{f_o} - M_{f,f_o})_i^2} \cdot \sqrt{\sum_{i=1}^{n}(x_v - x_{v_o} - M_{v,v_o})_i^2}}$$

rms vector wind error
$$rmse_v = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(\vec{V}_f - \vec{V}_v)_i^2}$$

where: $x_f$ = the forecast value of the parameter in question;
$x_v$ = the corresponding verifying value (observed);
$x_{f_0}, x_{v_0}$ = same as above, but for the initial time;
$n$ = the number of observations in the verification area;
$M_{f,f_0}$ = the mean value over the verification area of the forecast trends;
$M_{v,v_0}$ = the mean value over the verification area of the observed trends;
$\vec{V}_f$ = the forecast wind vector;
$\vec{V}_v$ = the verifying (observed) wind vector.

NOTES:

(1) The observations used for verification should be screened to exclude those with large errors. In order to do this, it is recommended that centres exclude values rejected by their objective analysis. Moreover, centres which apply a correction to the observations received on the GTS to remove biases (e.g. radiation correction), should use the corrected observations to compute statistics.

(2) Values for these statistics should be computed daily (0000 UTC and 1200 UTC separately) for each specified network. Monthly averages should then be computed from the daily values of all forecasts verifying within the relevant month. For those centres not running forecasts from either 0000 or 1200 UTC, tables may alternatively be provided for other base times and should be labelled as such.

(3) The number of runs (daily statistics) forming the monthly means should be exchanged in the monthly report, as well as the average number of observation points used in the computations.

(4) Annual averages of daily verification are included in the yearly *Technical Progress Report on the Global Data-processing System*. These statistics are for the 24, 72 and 120 h forecast and include the rms vector wind error at 850 hPa (tropics network only) and 250 hPa (all seven networks) as well as the rms error of geopotential heights at 500 hPa (all the networks except for tropics). A table of the number of observations per month should also be part of the yearly report.

(5) To the extent possible, horizontal and vertical interpolations from model to verifying observations should not involve multiple steps or explicit smoothing.

## III – STANDARD VERIFICATION MEASURES OF EPS

EXCHANGE OF SCORES

Monthly exchanges:

**Ensemble mean**
For verification of ensemble mean, the specifications in this table of the attachment for variables, levels, areas and verifications should be used.

**Spread**
Standard deviation of the ensemble averaged over the same regions and variables as used for the ensemble mean.

**Probabilities**

Probabilistic scores are exchanged in the form of reliability tables. Details of the format of the reliability tables are provided on the website of the Lead Centre for verification of EPS.

*List of parameters*

PMSL anomaly ± 1, ± 1.5, ± 2 standard deviation with respect to a centre-specified climatology
Verified for areas defined for verification against analysis

Z500 with thresholds as for PMSL. Verified for areas defined for verification against analysis

850 hPa wind speed with thresholds of 10, 15, 25 m $s^{-1}$. Verified for areas defined for verification against analysis

850 hPa u and v wind components with thresholds of 10th, 25th, 75th and 90th percentile points with respect to a centre-specified climatology. Verified for areas defined for verification against analysis

250 hPa u and v wind components with thresholds of 10th, 25th, 75th and 90th percentile points with respect to a centre-specified climatology. Verified for areas defined for verification against analysis

T850 anomalies with thresholds ± 1, ± 1.5, ± 2 standard deviation with respect to a centre-specified climatology. Verified for areas defined for verification against analysis

Precipitation with thresholds 1, 5, 10, and 25 mm/24 hours every 24 hours verified over areas defined for deterministic forecast verification against observations

Observations for EPS verification should be based on the GCOS list of surface network (GSN).

NOTE: Where thresholds are defined with respect to climatology, the daily climate should be estimated.

*Scores*

Brier Skill Score (with respect to climatology) (see definition below*)
Relative Operating Characteristic (ROC)
Relative economic value (C/L) diagrams
Reliability diagrams with frequency distribution

NOTE: Annual and seasonal averages of the Brier Skill Score at 24, 72, 120, 168 and 240 hours for Z500 and T850 should be included in the yearly Technical Progress Report on the Global Data-processing and Forecasting System.

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* The Brier Score (BS) is most commonly used for assessing the accuracy of binary (two-category) probability forecasts. The Brier Score is defined as:

$$BS = \frac{\sum_{ij}\left(F_{ij} - O_{ij}\right)^2}{N}$$

where the observations $O_{ij}$ are binary (0 or 1) and $N$ is the verification sample size. The Brier Score has a range from 0 to 1 and is negatively-oriented. Lower scores represent higher accuracy.

The Brier Skill Score (BSS) is in the usual skill score format, and may be defined by:

$$BSS = \frac{BS_C - BS_F}{BS_C} \times 100 = \left[1 - \frac{\sum_{ij}\left(F_{ij} - O_{ij}\right)^2}{\sum_{ij}\left(C_{ij} - O_{ij}\right)^2}\right] \times 100$$

where $C$ refers to climatology and $F$ refers to the forecast.

## ANNEX

### Content and format of monthly verification report

A report is prepared each month by the centres and exchanged electronically among the participants. The prescribed content and format have followed closely in order to facilitate the processing of verification data at the receiving end of the communication:

**Content**

**A – Verification against analysis**

Each region is represented by the table first number:

| | |
|---|---|
| TABLE 1.x | NORTHERN HEMISPHERE VERIFICATION AGAINST ANALYSIS (20–90°N) |
| TABLE 2.x | TROPICAL VERIFICATION AGAINST ANALYSIS (20°N–20°S) |
| TABLE 3.x | SOUTHERN HEMISPHERE VERIFICATION AGAINST ANALYSIS (20–90°S) |

Within each region, specific table numbers are assigned to variables and levels.

For northern and southern hemispheres (Tables 1.x and 3.x):

| | |
|---|---|
| TABLE x.1 | MEAN SEA-LEVEL PRESSURE |
| TABLE x.2 | 500 HPA GEOPOTENTIAL HEIGHT |
| TABLE x.3 | 250 HPA GEOPOTENTIAL HEIGHT |
| TABLE x.4 | 500 HPA TEMPERATURE |
| TABLE x.5 | 250 HPA TEMPERATURE |
| TABLE x.6 | 500 HPA WIND |
| TABLE x.7 | 250 HPA WIND |
| TABLE x.8 | and more reserved |

For tropics (Tables 2.x):

| | |
|---|---|
| TABLE 2.1 | 850 HPA GEOPOTENTIAL HEIGHT |
| TABLE 2.2 | 250 HPA GEOPOTENTIAL HEIGHT |
| TABLE 2.3 | 850 HPA TEMPERATURE |
| TABLE 2.4 | 250 HPA TEMPERATURE |
| TABLE 2.5 | 850 HPA WIND |
| TABLE 2.6 | 250 HPA WIND |
| TABLE 2.7 | and more reserved |

**B – Verification against observations**

Each network is represented by the table first number:

| | |
|---|---|
| TABLE 4.x | NORTH AMERICA VERIFICATION AGAINST RADIOSONDES |
| TABLE 5.x | EUROPE/NORTH AFRICA VERIFICATION AGAINST RADIOSONDES |
| TABLE 6.x | ASIA VERIFICATION AGAINST RADIOSONDES |
| TABLE 7.x | AUSTRALIA/NEW ZEALAND VERIFICATION AGAINST RADIOSONDES |
| TABLE 8.x | TROPICS VERIFICATION AGAINST RADIOSONDES |
| TABLE 9.x | NORTHERN EXTRATROPICS VERIFICATION AGAINST RADIOSONDES |
| TABLE 10.x | SOUTHERN EXTRATROPICS VERIFICATION AGAINST RADIOSONDES |

Within each region, specific table numbers are assigned to variables and levels:

| | |
|---|---|
| TABLE x.1 | 850 HPA GEOPOTENTIAL HEIGHT |
| TABLE x.2 | 500 HPA GEOPOTENTIAL HEIGHT |
| TABLE x.3 | 250 HPA GEOPOTENTIAL HEIGHT |
| TABLE x.4 | 850 HPA TEMPERATURE |
| TABLE x.5 | 500 HPA TEMPERATURE |
| TABLE x.6 | 250 HPA TEMPERATURE |
| TABLE x.7 | 850 HPA WIND |
| TABLE x.8 | 500 HPA WIND |
| TABLE x.9 | 250 HPA WIND |
| TABLE x.10 | and more reserved |

**Format**

## Format of exchange of WMO standards scores by electronic media

(Examples of a number of tables are given)

Columns

0 1 2 3 4 5 6 7 8
1234567890123456789012345678901234567890123456789012345678901234567890123456789 0

- n1 blank line see note 4

VERIFICATION TO WMO STANDARDS

CENTRE NAME MMMMMMMMM YYYY

MODEL NAME AND CHARACTERISTICS

- File header see note 1

- n2 blank line see note 4

# Comment line : missing cases must be reported here.
# Comment line

TABLE 1.1 NORTHERN HEMISPHERE VERIFICATION AGAINST ANALYSIS (20–90°N)

MEAN SEA LEVEL PRESSURE SEPTEMBER 1997

- Table header 11 lines see note 2

| FORECAST PERIOD (HOURS) | MEAN ERROR (hPa) 0000 UTC | MEAN ERROR (hPa) 1200 UTC | RMSE (hPa) 0000 UTC | RMSE (hPa) 1200 UTC | ANOM. CORR. 0000 UTC | ANOM. CORR. 1200 UTC | SKILL SCORE 0000 UTC | SKILL SCORE 1200 UTC |
|---|---|---|---|---|---|---|---|---|
| 24 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 48 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 72 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 96 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 120 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 144 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 168 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 192 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 216 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 240 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |

- m data line see note 3

- n3 blank line see note 4

TABLE 1.2 NORTHERN HEMISPHERE VERIFICATION AGAINST ANALYSIS (20–90°N)

500 HPA GEOPOTENTIAL HEIGHT SEPTEMBER 1997

| FORECAST PERIOD (HOURS) | MEAN ERROR (m) 0000 UTC | MEAN ERROR (m) 1200 UTC | RMSE (m) 0000 UTC | RMSE (m) 1200 UTC | ANOM. CORR. 0000 UTC | ANOM. CORR. 1200 UTC | SKILL SCORE 0000 UTC | SKILL SCORE 1200 UTC |
|---|---|---|---|---|---|---|---|---|
| 24 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 48 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 72 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 96 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 120 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| etc. | | | | | | | | |

0 1 2 3 4 5 6 7 8
1234567890123456789012345678901234567890123456789012345678901234567890123456789 0

Columns

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

TABLE 1.4 NORTHERN HEMISPHERE VERIFICATION AGAINST ANALYSIS (20–90°N)

500 HPA TEMPERATURE SEPTEMBER 1997

| FORECAST PERIOD (HOURS) | MEAN ERROR (K) | | RMSE (K) | | ANOM. CORR. | |
|---|---|---|---|---|---|---|
| | 0000 UTC | 1200 UTC | 0000 UTC | 1200 UTC | 0000 UTC | 1200 UTC |
| 24 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 48 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 72 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 96 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 120 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| etc. | | | | | | |

TABLE 1.6 NORTHERN HEMISPHERE VERIFICATION AGAINST ANALYSIS (20–90°N)

500 HPA WIND SEPTEMBER 1997

| FORECAST PERIOD (HOURS) | MEAN SPEED ERROR (m/s) | | RMSEV (m/s) | |
|---|---|---|---|---|
| | 0000 UTC | 1200 UTC | 0000 UTC | 1200 UTC |
| 24 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 48 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 72 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 96 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 120 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| etc. | | | | |

TABLE 4.1 NORTH AMERICA VERIFICATION AGAINST RADIOSONDES

850 HPA GEOPOTENTIAL HEIGHT SEPTEMBER 1997

| FORECAST PERIOD (HOURS) | MEAN ERROR | | RMSE | | TREND CORR. | |
|---|---|---|---|---|---|---|
| | 0000 UTC | 1200 UTC | 0000 UTC | 1200 UTC | 0000 UTC | 1200 UTC |
| 24 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 48 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 72 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 96 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 120 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| etc. | | | | | | |

TABLE 4.7 NORTH AMERICA VERIFICATION AGAINST RADIOSONDES

850 HPA WIND SEPTEMBER 1997

| FORECAST PERIOD (HOURS) | MEAN SPEED ERROR | | RMSEV | |
|---|---|---|---|---|
| | 0000 UTC | 1200 UTC | 0000 UTC | 1200 UTC |
| 24 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 48 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 72 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 96 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| 120 | xxxxxxx | xxxxxxx | xxxxxxx | xxxxxxx |
| etc. | | | | |

NUMBER OF OBSERVATIONS USED 0000 UTC = xxxx 1200 UTC = xxxx – see note 7

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

NOTE 1: (File header)

Underlining is optional.

Line 1: Fixed title (A80).

Line 4, columns 17 to 48: Centre name.

Line 4, columns 49 to 64: Month and year in full (6X, A32, AI6).

Line 7: Model name or characteristics (A80).

NOTE 2: (Table header)

Underlining is optional.

Line 1, columns 11 to 16: Table number.

Line 1, columns 17 to 80: Table name (10X, F6.0, A64).

Line 3, columns 17 to 48: Parameter name.

Line 3, columns 49 to 64: month and year in full (16X, A32, AI6).

Line 7: Score names (10X, 4 (IX, A16)).

Line 8: Units (optional) (10X, 4 (IX, A16)).

Line 9: Times (10X, 4 (2X, A7, IX, A7).

NOTE 3: (Data lines)

m depends on forecast length.

Examples of specifying data are given.

xxxxxxx represents any numeric value.

Missing data should be left blank.

Reading data: (IX, I5, 4X, 4 (2X, F7.0, IX, F7.0)).

Searching for missing data: (10X, 4 (2X, A7, 1X, A7)).

NOTE 4:

n1, n2, n3 may be variable.

NOTE 5:

A line beginning # is treated as a comment.

A comment line should not occur within the file header, table header, or between data lines.

Comment lines can be used to give information on abnormal events, and/or any significant changes introduced into the NWP system during the month.

*Missing cases must be reported in comment lines after the file header.

NOTE 6: All characters should be in ASCII representation.

*NOTE 7: (Number of observations used)

Reading data: (57X, I4, 12X, I4).

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* Proposed modification to current procedures.

ATTACHMENT II.8

# STANDARDIZED VERIFICATION SYSTEM (SVS) FOR LONG-RANGE FORECASTS (LRF)

## EXECUTIVE SUMMARY

### 1. FORMULATION

The SVS is formulated in four parts:

1.1 **Diagnostics.** Information required incorporates derived diagnostic measures and contingency tables. Estimates of the statistical significance of the scores achieved are also required. Additional diagnostic measures are suggested but are not incorporated into the core SVS as yet. Use of the additional diagnostics is optional.

1.2 **Parameters.** Key variables and regions are proposed. However producers are not limited to these key parameters, and can thus all contribute regardless of the structure of individual forecast systems. The parameters to be verified are defined on three levels:

Level 1: Diagnostic measures aggregated over regions and for indices,

Level 2: Diagnostic measures evaluated at individual grid points,

Level 3: Contingency tables provided for individual grid points.

The SVS makes provision for staggered implementation of the three levels of information and the inclusion of estimates of skill significance over a two-year period.

1.3 **Verification data sets.** Key data sets of observations against which forecasts may be verified are proposed.

1.4 **System details.** Details of forecast systems employed.

1.5 **Exchange of verification information**. The SVSLRF verification results are made available through a website maintained by the Lead Centre. The functions of the Lead Centre for SVSLRF include creating and maintaining coordinated websites for the LRF verification information so that potential users would benefit from a consistent presentation of the results. The website address is http://www.bom.gov.au/wmo/lrfvs/.

### 2. DIAGNOSTICS

Three diagnostic measures are incorporated in the core SVS: relative operating characteristics (ROC), reliability diagrams and accompanying measure of sharpness, and mean square skill scores (MSSS) with associated decomposition. Estimates of statistical significance in the diagnostic scores are also included in the core SVS. The three diagnostics permit direct intercomparison of results across different predicted variables, geographical regions, forecast ranges, etc. They may be applied in verification of most forecasts and it is proposed that, except where inappropriate, all three diagnostics be used on all occasions. Tabulated information at grid-point resolution is also part of the core SVS. The tabulated information will allow reconstruction of scores for user-defined areas and calculation of other diagnostic measures such as economic value.

2.1 **ROC.** To be used for verification of probability forecasts. For Level 1 information (measures aggregated over regions), the ROC curve and the standardized area under the curve (such that perfect forecasts give an area of 1 and a curve lying along the diagonal gives 0.5) should be provided. For Level 2 information (gridded values), the standardized area under the ROC curve should be provided.

2.2 **Reliability diagrams and frequency histograms.** To be used in the assessment of probability forecasts. They are required as part of Level 1 information only.

2.3 **MSSS and decomposition.** To be used in verification of deterministic forecasts. For Level 1, an overall bulk MSSS value is required and will provide a comparison of forecast performance relative to "forecasts" of climatology. The three terms of the MSSS decomposition provide valuable information on phase errors (through forecast/observation correlation), amplitude errors (through the ratio of the forecast to observed variances) and overall bias. For Level 2, quantities pertaining to the three decomposition terms should be provided. Additional terms relating to MSSS are required as part of Level 3 information.

2.4 **Contingency tables.** In addition to the derived diagnostic measures, contingency table information provided at grid points for both probability and categorical deterministic forecasts form part of the core SVS. This information constitutes Level 3 of the exchange and will allow RCCs and NMHSs (and in some cases end-users) to derive ROC, reliability, other probability-based diagnostics and scores for categorical deterministic forecasts for user-defined geographical areas.

A number of recommended contingency table-based diagnostics are listed. The Hanssen-Kuipers score is the deterministic equivalent to the area under the ROC curve, and thus provides a useful measure for comparing probabilistic and deterministic skill. The Gerrity score is a recommended score for overall assessment of forecasts using two or more categories.

## 3. PARAMETERS

The list of key parameters in the core SVS is provided below. Any verification for these key parameters should be assessed using the core SVS techniques wherever possible. Many long-range forecasts are produced which do not include parameters in the key list (for example, there are numerous empirical systems that predict seasonal rainfall over part or all of a country). The core SVS diagnostics should be used to assess these forecasts also, but full details of the predictions will need to be provided.

Forecasts can be made using different levels of post-processing, typically no-post-processing (raw or uncalibrated), simple correction of systematic errors (calibrated, i.e. calibration of mean and of variance) and more complex correction using hindcast skill (recalibrated, e.g. Model Output Statistics or perfect programme approaches). Most centres are currently issuing forecasts resulting from a simple calibration. Therefore, for the sake of comparison on the Lead Centre website scores for forecasts that were raw or calibrated (as specified in the respective skill score section) are to be submitted. It is preferable to exclude forecasts that were recalibrated, but GPCs are encouraged to apply the SVSLRF methodology and to display the results on their recalibrated forecasts on their website.

### 3.1 Level 1: Diagrams and scores to be produced for regions

Diagrams (e.g. ROC and reliability curves) are to be supplied in digital format as specified on the Lead Centre website.

3.1.1 Atmospheric parameters. Predictions for:

T2m screen temperature anomalies within standard regions:

- Tropics 20°N to 20°S;
- Northern extratropics ≥20°N;
- Southern extratropics ≤20°S.

Precipitation anomalies within standard regions:

- Tropics 20°N to 20°S;
- Northern extratropics ≥20°N;
- Southern extratropics ≤20°S.

3.1.2 Scores and diagrams to be produced for probabilistic forecasts:

- Reliability diagram and frequency histograms;
- ROC curve and standardized area under the curve;
- Estimations of error (significance) in the scores;

The above scores and diagrams to be produced for equiprobable tercile categories.

3.1.3 Score to be used for deterministic forecasts:

MSSS with climatology as standard reference forecast.

3.1.4 Stratification by season

Four conventional seasons: March–April–May (MAM), June–July–August (JJA), September–October–November (SON), December–January–February (DJF).

3.1.5 Lead time

Preferred minimum: two lead times, one preferably to be two weeks or more but neither greater than four months.

### 3.2 Level 2: Grid-point data for mapping

3.2.1 Grid-point verification data to be produced for each of the following variables (verification should be provided on a 2.5° × 2.5° grid):

- T2m;
- Precipitation;
- Sea-surface temperature (SST).

3.2.2 Verification parameters to be produced for deterministic forecasts

The necessary parameters for reconstructing the MSSS decomposition, the number of forecast/observation pairs, the mean square error (MSE) of the forecasts and of climatology and the MSSS are all part of the core SVS. Significance estimates for the correlation, variance, bias, MSE and MSSS terms should also be supplied.

3.2.3 Verification to be provided for probability forecasts

ROC area for three tercile categories, as well as significance of the ROC scores.

3.2.4 Stratification by season

If available, 12 rolling three-month periods (e.g. MAM, AMJ, MJJ). Otherwise, four conventional seasons (MAM, JJA, SON, DJF).

3.2.5 Lead time

Preferred minimum: two lead times, one preferably two weeks or more, but neither greater than four months.

3.2.6 Stratification according to the state of ENSO

Stratification by the state of ENSO should be provided if sufficient ENSO events are contained within the hindcast period used. Scores should be provided for each of three categories:

(*a*) All hindcast seasons;
(*b*) Seasons with *El Niño* active;
(*c*) Seasons with *La Niña* active.

### 3.3 Level 3: Tabulated information to be exchanged

Tabular information to be provided for grid points of a 2.5 × 2.5 grid.

3.3.1 Contingency tables

Contingency tables to be produced for verifying forecasts of tercile categories in each of the following variables:

T2m;
Precipitation;
SST.

3.3.2 Tables to be produced for probabilistic forecast verification

The number of forecast hits and false alarms to be recorded against each ensemble member or probability bin for each of three equiprobable categories (terciles). It is recommended that the number of bins remain between 10 and 20. The forecast providers can bin according to percentage probability or by individual ensemble members as necessary. No latitude weighting of the numbers of hits and false alarms is to be applied in the contingency tables.

The user is encouraged to aggregate the tables over grid points for the region of interest and to apply methods of assessing statistical significance of the aggregated tables.

3.3.3 Tables to be produced for deterministic forecasts

3 × 3 contingency tables comparing the forecast tercile with the observed tercile, over the hindcast period.

3.3.4 Stratification by season

If available, 12 rolling three-month periods (e.g. MAM, AMJ, MJJ). Otherwise four conventional seasons (MAM, JJA, SON and DJF).

3.3.5 Lead time

Preferred minimum: two lead times, one preferably two weeks or more, but neither greater than four months.

3.3.6 Stratification according to the state of ENSO

Stratification by the state of ENSO should be provided if sufficient ENSO events are contained within the hindcast period used. Scores should be provided for each of three categories:

(*a*) All hindcast seasons;
(*b*) Seasons with *El Niño* active;
(*c*) Seasons with *La Niña* active.

### 3.4 Verification for indices (Level 1)

3.4.1 Indices to be verified

Niño3.4 region SST anomalies. Other indices may be added in due course.

3.4.2 Scores to be calculated for probabilistic forecasts

ROC area for 3 tercile categories. Where dynamical forecast models are used, the ROC scores should be calculated for the grid-point averaged SST anomaly over the Niño3.4 region. It is recommended that significance of the ROC scores should also be calculated.

3.4.3 Scores to be calculated for deterministic forecasts

The three terms of the Murphy decomposition of MSSS, produced with climatology as standard reference forecast. As a second (optional) control, it is recommended that damped persistence be used. Significance estimates should accompany each of the three terms.

Where dynamical models are used, the MSSS decomposition should be calculated for the grid-point averaged Niño3.4 anomaly.

3.4.4 Stratification by month

Verification should be provided for each calendar month.

3.4.5 Lead time

Verification for each month should be provided for six lead times. Namely zero-lead and 1-month, 2-month, 3-month, 4-month and 5-month leads. Additional lead times are encouraged if available.

## 4. STAGGERED IMPLEMENTATION

In order to ease implementation, producers may stagger the provision of the elements of the core SVS according to the following recommendation.

(*a*) Verification at Levels 1 and 2 in the first year of implementation,

(*b*) Verification at Level 3 by the middle of the year following implementation of Levels 1 and 2,

(*c*) Level of significance by the end of the year following implementation of Levels 1 and 2.

* * *

## 1. INTRODUCTION

The following sections present detailed specifications for the development of an SVS for LRF within the framework of a WMO exchange of verification scores. The SVS for LRF described herein constitutes the basis for LRF evaluation and validation, and for exchange of verification scores. It will grow as more requirements are adopted.

## 2. DEFINITIONS

### 2.1 LRF

LRF extend from 30 days up to two years and are defined in Table 1.

**Table 1**

| | |
|---|---|
| Monthly outlook | Description of averaged weather parameters expressed as a departure from climate values for that month |
| Three-month or 90-day ‘rolling season’ outlook | Description of averaged weather parameters expressed as a departure from climate values for that three-month or 90-day period |
| Seasonal outlook | Description of averaged weather parameters expressed as a departure from climate values for that season |

**Definition of LRF**

Seasons have been loosely defined in the northern hemisphere as December-January-February (DJF) for winter (summer in the southern hemisphere), March-April-May (MAM) for spring (autumn in the southern hemisphere), June-July-August (JJA) for summer (winter in the southern hemisphere) and September-October-November (SON) for autumn (spring in the southern hemisphere). Twelve rolling seasons are also defined e.g. MAM, AMJ, MJJ. In tropical areas, the seasons may have different definitions. Outlooks over longer periods such as multi-seasonal outlooks or tropical rainy season outlooks may be provided.

It is recognized that in some countries LRF are considered to be climate products.

This attachment is mostly concerned with three-month or 90-day outlooks and seasonal outlooks.

### 2.2 Deterministic LRF

Deterministic LRF provide a single expected value for the forecast variable. The forecast may be presented in terms of an expected category (referred to as categorical forecasts, e.g. equiprobable terciles) or may take predictions of the continuous variable (non-categorical forecasts). Deterministic LRF can be produced from a single run of a numerical weather prediction (NWP) model or a general circulation model (GCM), or from the grand mean of the members of an ensemble prediction system (EPS), or can be based on an empirical model.

The forecasts are either objective numerical values such as departure from normal of a given parameter or expected occurrences (or non-occurrences) of events classified into categories (above/below normal or above/near/below normal for example). Although equiprobable categories are preferred for consistency, other classifications can be used in similar fashion.

### 2.3 Probabilistic LRF

Probabilistic LRFs provide probabilities of occurrences or non-occurrences of an event or a set of fully inclusive events. Probabilistic LRFs can be generated from an empirical model, or produced from an EPS.

The events can be classified into categories (above/below normal or above/near/below normal for example). Although equiprobable categories are preferred for consistency, other classifications can be used in similar fashion.

### 2.4 Terminology

There is no universally accepted definition of forecast period and forecast lead time. However, the definition in Table 2 will be used here.

**Table 2**
**Definitions of forecast period and lead time**

| | |
|---|---|
| Forecast period | Forecast period is the validity period of a forecast. For example, LRF may be valid for a 90-day period or a season. |
| Lead time | Lead time refers to the period of time between the issue time of the forecast and the beginning of the forecast validity period. LRFs based on all data up to the beginning of the forecast validity period are said to be of lead zero. The period of time between the issue time and the beginning of the validity period will categorize the lead. For example, a winter seasonal forecast issued at the end of the preceding summer season is said to be of one-season lead. A seasonal forecast issued one month before the beginning of the validity period is said to be of one-month lead. |

Figure 1 presents the definitions of Table 2 in graphical format.

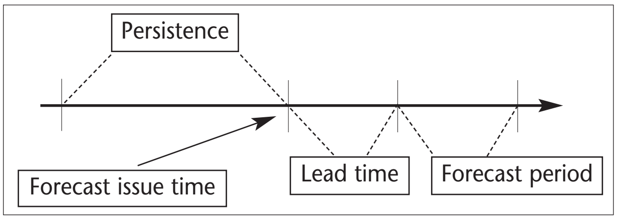


Figure 1 — Definition of forecast period, lead time and persistence as applied in a forecast verification framework

The forecast range determines how far into the future LRFs are provided; it is thus the summation of lead time and forecast period.

Persistence, for a given parameter, signifies a persisting anomaly which has been observed over the same length of time as the forecast period and immediately prior to the LRF issue time (see Figure 1). It is important to realize that only the anomaly of any given parameter can be considered in persistence. The persisting anomaly is added to the background climatology to retrieve the parameter in question. Climatology is equivalent to a uniform persisting anomaly of zero.

## 3. SVS FOR LRF

Forecasts can be made using different levels of post-processing, typically no-post-processing (raw or uncalibrated), simple correction of systematic errors (calibrated, i.e. calibration of mean and of variance) and more complex correction using hindcast skill (recalibrated, e.g. Model Output Statistics or perfect programme approaches). Most centres are currently issuing forecasts resulting from a simple calibration. Therefore, for the sake of comparison on the Lead Centre website scores for forecasts that were raw or calibrated (as specified in the respective skill score section) are to be submitted. It is preferable to exclude forecasts that were recalibrated, but GPCs are encouraged to apply the SVSLRF methodology and to display the results on their recalibrated forecasts on their website.

### 3.1 Parameters to be verified

The following parameters are to be verified:

(*a*) Surface air temperature (T2m) anomaly at screen level;

(*b*) Precipitation anomaly;

(*c*) SST anomaly.

In addition to these three parameters, the Niño3.4 index, defined as the mean SST anomaly over the Niño3.4 region from 170°W to 120°W and from 5°S to 5°N, inclusive, is also to be verified.

It is recommended that three levels of verification be done:

(*a*) Level 1: large-scale aggregated overall measures of forecast performance (see section 3.1.1).

(*b*) Level 2: verification at grid points (see section 3.1.2).

(*c*) Level 3: grid point by grid point contingency tables for more extensive verification (see section 3.1.3).

Both deterministic and probabilistic forecasts are verified if available. Level 1 is applicable to the T2m anomaly, precipitation anomaly and Niño3.4 index. Levels 2 and 3 are applicable to the T2m anomaly, precipitation anomaly and SST anomaly.

3.1.1 Aggregated verification (Level 1)

Large-scale verification statistics are required in order to evaluate the overall skill of the models and ultimately to assess their improvements. These are bulk numbers calculated by aggregating verifications at all grid points within large regions; they will not necessarily reflect skill for any subregion. This aggregated verification is performed over three regions:

(*a*) Tropics: from 20°S to 20°N, inclusive;

(*b*) Northern extratropics: from 20°N to 90°N, inclusive;

(*c*) Southern extratropics: from 20°S to 90°S, inclusive.

Verification of the Niño3.4 index is also part of Level 1 verification.

3.1.2 Grid-point verification (Level 2)

Grid-point verification is recommended for a regionalized assessment of the skill of the model, for which a 2.5° × 2.5° latitude/longitude grid is recommended, with origin at 0°N, 0°E. Verification should be supplied to the Lead Centre for visual rendering. The formats for supplying derived verification are specified on the Lead Centre's website.

3.1.3 Contingency tables (Level 3)

**Table 3**
**Summary of the core SVS**

| *Parameters* | *Verification regions* | *Deterministic forecasts* | *Probabilistic forecasts* |
|---|---|---|---|
| | | **Level 1** | |
| T2m anomaly<br>Precipitation anomaly | Tropics<br>Northern extratropics<br>Southern extratropics | MSSS (bulk number) | ROC curves<br>ROC areas<br>Reliability diagrams<br>Frequency histograms |
| | (section 3.1.1) | (section 3.3.1) | (sections 3.3.3 and 3.3.4) |
| Niño3.4 index | N/A | MSSS (bulk number) | ROC curves<br>ROC areas<br>Reliability diagrams<br>Frequency histograms |
| | | (section 3.3.1) | (sections 3.3.3 and 3.3.4) |
| | | **Level 2** | |
| T2m anomaly<br>Precipitation anomaly<br>SST anomaly | Grid-point verification on a 2.5° × 2.5° grid | MSSS and its three-term decomposition at each grid-point | ROC areas at each grid point |
| | (section 3.1.2) | (section 3.3.1) | (section 3.3.3) |
| | | **Level 3** | |
| T2m anomaly<br>Precipitation anomaly<br>SST anomaly | Grid-point verification on a 2.5° × 2.5° grid | 3 × 3 contingency tables at each grid-point | ROC reliability tables at at each grid-point |
| | (section 3.1.2) | (section 3.3.2) | (section 3.3.3) |

Contingency tables allow users to perform more detailed verifications and generate statistics that are relevant for particular regions. The content and structure of the contingency tables is defined in sections 3.3.2 and 3.3.3. Data formats for supplying the contingency tables are specified on the Lead Centre's website.

3.1.4 Summary of the core SVS

The following gives a summary of parameters, validation regions and diagnostics that form the core SVS. The required periods, lead times and stratification against the state of ENSO are given in section 3.2.

The number of LRF realizations is far smaller than in the case of short-term numerical weather prediction forecasts. Consequently it is essential as part of the core SVS to calculate and report error bars and the level of significance (see section 3.3.5).

In order to ease implementation, participating LRF producers may stage the introduction of the core SVS by prioritizing implementation of verification at levels 1 and 2.

Other parameters and indices to be verified as well as other verification scores can be added to the core SVS in future versions.

## 3.2 Verification strategy

LRF verification should be done on a latitude/longitude grid, with areas as defined in section 3.1.1. Verification can also be done at individual stations or groups of stations. Verification on a latitude-longitude grid is performed separately from that done at stations.

A 2.5° × 2.5° verification latitude-longitude grid is recommended, with origin at 0°N, 0°E. Both forecasts and the gridded verifying data sets are to be interpolated onto the same 2.5° × 2.5° grid.

In order to handle spatial forecasts, predictions for each point within the verification grid should be treated as individual forecasts but with all results combined into the final outcome. The same approach is applied when verification is done at stations. Categorical forecast verification can be performed for each category separately.

Similarly, all forecasts are treated as independent and combined together into the final outcome, when verification is done over a long period of time (several years for example).

Stratification of the verification data is based on the forecast period, lead time and verification area. Stratification by forecast period should, for T2m and precipitation, be by four conventional seasons for Level 1. For Levels 2 and 3 stratification should be on 12 rolling seasons (see section 2.1) if available, otherwise four conventional seasons should be used. Verification results for different seasons should not be mixed. Stratification by lead time should include a minimum of two lead times, with lead time not greater than four months. Forecasts with different lead times are similarly to be verified separately. Stratification according to the state of ENSO (where there are sufficient cases) should be as follows:

(*a*) All hindcast seasons;

(*b*) Seasons with El Niño active;

(*c*) Seasons with La Niña active.

For Niño3.4, SST anomaly verification should be stratified according to each calendar month and lead time. Six lead times should be provided, ranging from zero to a 5-month lead.

## 3.3 Verification scores

The verification scores to be used are: MSSS and ROC.

MSSS is applicable to deterministic forecasts only, while ROC is applicable to both deterministic and probabilistic forecasts. MSSS is applicable to non-categorical forecasts (or to forecasts of continuous variables), while ROC is applicable to categorical forecasts whether deterministic or probabilistic in nature.

The verification methodology using ROC is derived from signal detection theory and is intended to provide information on the characteristics of the systems upon which management decisions can be taken. In the case of weather/climate forecasts, the decisions may relate to the most appropriate way of using a forecast system for a given purpose. ROC is applicable to both deterministic and probabilistic categorical forecasts and is useful in contrasting the characteristics of deterministic and probabilistic systems. The ROC derivation is based on contingency tables giving the hit rate and false alarm rate for deterministic or probabilistic forecasts. The events are defined as binary, which means that only two outcomes are possible, occurrence or non-occurrence. It is recognized that ROC as applied to deterministic forecasts is equivalent to the Hanssen and Kuipers score (see section 3.3.2).

The binary event can be defined as the occurrence of one of two possible categories when the outcome of the LRF system is in two categories. When the outcome of the LRF system is in three (or more) categories, the binary event is defined in terms of occurrences of one category against the remaining ones, hence the ROC has to be calculated for each possible category.

### 3.3.1 MSSS for non-categorical deterministic forecasts

Let $x_{ij}$ and $f_{ij}$ ($i$=1, ..., $n$) denote time series of observations and continuous deterministic forecasts, respectively, for a grid point or station $j$ over the period of verification (POV). Then, their averages for the POV, $\bar{x}_j$ and $\bar{f}_j$ and their sample variances $s_{xj}^2$ and $s_{fj}^2$ are given by:

$$\bar{x}_j = \frac{1}{n}\sum_{i=1}^{n} x_{ij}, \quad \bar{f}_j = \frac{1}{n}\sum_{i=1}^{n} f_{ij}$$

$$s_{xj}^2 = \frac{1}{n-1}\sum_{i=1}^{n}\left(x_{ij} - \bar{x}_j\right)^2, \quad s_{fj}^2 = \frac{1}{n-1}\sum_{i=1}^{n}\left(f_{ij} - \bar{f}_j\right)^2$$

The MSE of the forecasts is:

$$MSE_j = \frac{1}{n}\sum_{i=1}^{n}\left(f_{ij} - x_{ij}\right)^2$$

In the case of cross-validated (see section 3.4) POV climatology forecasts where forecast/observation pairs are reasonably temporally independent of each other (so that only one year at a time is withheld), the MSE of climatology forecasts (Murphy, 1988) is:

$$MSE_{cj} = \frac{n-1}{n} s_{xj}^2$$

The MSSS for $j$ is defined as one minus the ratio of the MSE of the forecasts to the MSE for forecasts of climatology:

$$MSSS_j = 1 - \frac{MSE_j}{MSE_{cj}}$$

For the three domains described in section 3.1.1, it is recommended that an overall MSSS be provided, which is computed as:

$$MSSS = 1 - \frac{\sum_j w_j MSE_j}{\sum_j w_j MSE_{cj}}$$

where $w_j$ is unity for verifications at stations and is equal to $\cos(\theta_j)$, where $\theta_j$ is the latitude at grid point $j$, on latitude-longitude grids.

For either MSSS$j$ or MSSS, a corresponding root mean square skill score (RMSSS) can be obtained easily from:

$$RMSSS = 1 - \left(1 - MSSS\right)^{1/2}$$

MSSS$j$ for fully cross-validated forecasts (with one year at a time withheld) can be expanded (Murphy, 1988) as:

$$MSSS_j = \left\{ 2\frac{s_{fj}}{s_{xj}} r_{fxj} - \left(\frac{s_{fj}}{s_{xj}}\right)^2 - \left(\frac{\left[\bar{f}_j - \bar{x}_j\right]}{s_{xj}}\right)^2 + \frac{2n-1}{(n-1)^2} \right\} \Bigg/ \left\{ 1 + \frac{2n-1}{(n-1)^2} \right\}$$

where $r_{fxj}$ is the product moment correlation of the forecasts and observations at point or station $j$.

$$r_{fxj} = \frac{\frac{1}{n}\sum_{i=1}^{n}\left(f_{ij} - \bar{f}_j\right)\left(x_{ij} - \bar{x}_j\right)}{s_{fj} s_{xj}}$$

The first three terms of the decomposition of MSSSj are related to phase errors (through the correlation), amplitude errors (through the ratio of the forecast to observed variances) and overall bias error, respectively, of the forecasts. These terms provide the opportunity for those wishing to use the forecasts for input into regional and local forecasts to adjust or weight the forecasts as appropriate. The last term takes into account the fact that the 'climatology' forecasts are cross-validated as well.

Note that for forecasts with the same amplitude as that of observations (second term unity) and no overall bias (third term zero), MSSSj will not exceed zero (i.e. the forecasts' MSE will not be less than for 'climatology') unless $r_{fxj}$ exceeds approximately 0.5.

The core SVS for LRF requires grid-point values of the correlation, the ratio of the square roots of the variances, and the overall bias, i.e.

$$r_{fxj},\ \frac{s_{fj}}{s_{xj}},\ \left[\bar{f}_j - \bar{x}_j\right]$$

In addition, it is recommended that grid-point (j) values of the following quantities be provided:

$$n,\ \bar{f}_j,\ \bar{x}_j,\ s_{fj},\ s_{xj},\ r_{fxj},\ MSE_j,\ MSE_{cj},\ MSSS_j$$

As an additional standard against which to measure forecast performance, cross-validated damped persistence (defined below) should be considered for certain forecast sets. A forecast of ordinary persistence, for a given parameter and target period, signifies a persisting anomaly (departure from cross-validated climatology) from a period immediately preceding the start of the lead time for the forecast period (see Figure 1). This period must have the same length as the forecast period. For example, the ordinary persistence forecast for a 90-day period made 15 days in advance would be the anomaly of the 90-day period beginning 105 days before the target forecast period and ending 16 days before. Ordinary persistence forecasts are never recommended as a standard against which to measure other forecasts if the performance or skill measures are based on MSE as here, since persistence is easily surpassed in this framework.

Damped persistence is the optimal persistence forecast in a least squares error sense. Even damped persistence should not be used in the case of extratropical seasonal forecasts, because the nature of the interannual variability of seasonal means changes considerably from one season to the next in the extratropics. In all other cases, damped persistence forecasts can be made in cross-validated mode (see section 3.4) and the skill and performance diagnostics based on MSE as described above (bulk measures, grid-point values and tables) can be computed and presented for these forecasts.

Damped persistence $r^m_{\Delta,j}\left[x_{ij}(t-\Delta t)-\bar{x}^m_{ij}(t-\Delta t)\right]$ is the ordinary persistence anomaly $x_{ij}(t-\Delta t)-\bar{x}^m_{ij}(t-\Delta t)$ damped (multiplied) towards climatology by the cross-validated, lagged product moment correlation between the period of persistence and the target forecast period. Thus:

$$r^m_{\Delta,j}=\frac{\frac{1}{m}\sum_m\left[x_{ij}(t-\Delta t)-\bar{x}^m_{ij}(t-\Delta t)\right]\left[x_{ij}(t)-\bar{x}^m_{ij}(t)\right]}{s^m_{xj}(t-\Delta t)\,s^m_{xj}(t)}$$

where $t$ is the target forecast period, $t$-$\Delta t$ the persistence period (preceding the lead time), and $m$ denotes summation (for $r^m_{\Delta,j}$, $\bar{x}^m_{ij}$, $s^m_{xj}$) at each stage of the cross-validation over all $i$ except those being currently withheld (section 3.4).

⇒ MSSS, provided as a single bulk number, is mandatory for Level 1 verification in the core SVS. MSSS, together with its three-term decomposition, are also mandatory for Level 2 verification in the core SVS. For the exchange of scores via the Lead Centre website the MSSS and its decomposition term should be calculated using the raw forecasts and preferably not the calibrated ones.

### 3.3.2 Contingency tables and scores for categorical deterministic forecasts

For two- or three-category deterministic forecasts the core SVS for LRF includes full contingency tables, because it is recognized that they constitute the most informative way to evaluate the performance of the forecasts. These contingency tables then form the basis for several skill scores that are useful for comparisons between different deterministic categorical forecast sets (Gerrity, 1992) and between deterministic and probabilistic categorical forecast sets (Hanssen and Kuipers, 1965), respectively.

The contingency tables should be provided for every combination of parameter, lead time, target month or season, and ENSO stratification (when appropriate) at every verification point for both the forecasts and (when appropriate) damped persistence. The definition of ENSO events is provided on the Lead Centre's website. If $x_i$ and $f_i$ now denote an observation and corresponding forecast of category i (i = 1, ..., 3), let $n_{ij}$ be the count of those instances with forecast category i and observed category j. The full contingency table is defined as the nine $n_{ij}$. Graphically, the nine cell counts are usually arranged with the forecasts defining the table rows and the observations the table columns:

**Table 4**
**General three-by-three contingency table**

| | | *Observations* | | | |
|---|---|---|---|---|---|
| | | *Below normal* | *Near normal* | *Above normal* | |
| Forecasts | Below normal | $n_{11}$ | $n_{12}$ | $n_{13}$ | $n_1$ |
| | Near normal | $n_{21}$ | $n_{22}$ | $n_{23}$ | $n_2$ |
| | Above normal | $n_{31}$ | $n_{32}$ | $n_{33}$ | $n_3$ |
| | | $n\ _1$ | $n\ _2$ | $n\ _3$ | T |

In Table 4, $n_{i\bullet}$ and $n_{\bullet i}$ represent the sum of the rows and columns respectively; $T$ is the total number of cases. Generally at least 90 forecast/observation pairs are required to estimate properly a three-by-three contingency table. Thus it is recommended that the tables provided be aggregated by users over windows of target periods, such as several adjacent months or overlapping three-month periods, or over verification points. In the latter case, weights $W_i$ should be used in summing $n_{ij}$ over different points $i$ (see discussion on Table 5). $W_i$ is defined as:

$W_i$ = 1 when verification is done at stations or at single grid points within a limited graphical region;

$W_i$ = cos ($\theta_i$) at grid point $i$, when verification is done on a grid, $\theta_i$ being the latitude at grid point $i$.

On a 2.5 degree latitude-longitude grid, the minimum acceptable sample is easily attained, even with a record as short as $n$ = 10, by aggregating over all grid points within a 10-degree box. Alternatively, in this case, an adequate sample can be achieved by aggregation over three adjacent months or overlapping three-month periods and within a 5-degree box. Regardless of this, scores derived from any contingency table should be accompanied by error bars, confidence intervals or level of significance.

Contingency tables such as the one in Table 4 are mandatory for Level 3 verification in the core SVS.

Relative sample frequencies $p_{ij}$ are defined as the ratios of the cell counts to the total number of forecast/observation pairs $N$ ($n$ is reserved to denote the length of the POV):

$$p_{ij}=n_{ij}/N$$

The sample probability distributions of forecasts and observations, respectively, then become:

$$p(f_i) = \sum_{j=1}^{3} p_{ij} = \hat{p}_i \; ; \quad i = 1, \ldots, 3$$

$$p(x_i) = \sum_{j=1}^{3} p_{ji} = p_i \; ; \quad i = 1, \ldots, 3$$

A recommended skill score for the three-by-three table which has many desirable properties and is easy to compute is the Gerrity skill score (GSS). The definition of the GSS uses a scoring matrix $s_{ij}$ ($i$ = 1, ..., 3), which is a tabulation of the reward or penalty every forecast/observation outcome represented by the contingency table will be accorded:

$$GSS = \sum_{i=1}^{3} \sum_{j=1}^{3} p_{ij} s_{ij}$$

The scoring matrix is given by:

$$s_{ii} = \frac{1}{2}\left( \sum_{r=1}^{i-1} a_r^{-1} + \sum_{r=i}^{2} a_r \right)$$

$$s_{ij} = \frac{1}{2}\left[ \sum_{r=1}^{i-1} a_r^{-1} - (j-1) + \sum_{r=j}^{2} a_r \right]; \quad 1 \le i < 3, \; i < j \le 3$$

where: $a_i = \left( 1 - \sum_{r=1}^{i} p_r \right) \Big/ \left( \sum_{r=1}^{i} p_r \right)$

Note that the GSS is computed using the sample probabilities, not those on which the original categorizations were based (i.e. 0.33, 0.33, 0.33).

Alternatively, the GSS can be computed by the numerical average of two of the three possible two-category, unscaled Hanssen and Kuipers scores (introduced below) that can be computed from the three-by-three table. The two are computed from the two two-category contingency tables formed by combining categories on either side of the partitions between consecutive categories: (*a*) above normal and a combined near and below normal category; and (*b*) below normal and a combined near and above normal category.

The easy construction of the GSS ensures its consistency from categorization to categorization and with underlying linear correlations. The score is also equitable, does not depend on the forecast distribution, does not reward conservatism, utilizes off-diagonal information in the contingency table, and penalizes larger errors more. For a limited subset of forecast situations, it can be manipulated by the forecaster to his/her advantage (Mason and Mimmack, 2002), but this is not a problem for objective forecast models that have not been trained to take advantage of this weakness. For all these reasons it is the recommended score.

An alternative score to the GSS to be considered is LEPSCAT (Potts, et al., 1996).

Table 5 shows the general form for the three possible two-by-two contingency tables referred to above (the third is the table for the near normal category and the combined above and below normal category). In Table 5, $T$ is the grand sum of all the proper weights applied on each occurrence and non-occurrence of the events.

**Table 5**
**General ROC contingency table for deterministic forecasts**

The two-by-two table in Table 5 may be constructed from the three-by-three table described in Table 4 by summing the appropriate rows and columns.

| | | *Observations* | | |
|---|---|---|---|---|
| | | *Occurrences* | *Non-occurrences* | |
| Forecasts | Occurrences | $O_1$ | $NO_1$ | $O_1+NO_1$ |
| | Non-occurrences | $O_2$ | $NO_2$ | $O_2+NO_2$ |
| | | $O_1+O_2$ | $NO_1+NO_2$ | T |

In Table 5:

$O_1$ represents the correct forecasts or hits: $O_1 = \Sigma W_i \, (OF)_i$, (OF) being 1 when the event occurrence is observed and forecast; 0 otherwise. The summation is over all grid points or stations;

$NO_1$ represents false alarms: $NO_1 = \Sigma W_i \, (NOF)_i$, (NOF) being 1 when the event occurrence is not observed but was forecast; 0 otherwise. The summation is over all grid points or stations;

$O_2$ represents the misses: $O_2 = \Sigma W_i \, (ONF)_i$, (ONF) being 1 when the event occurrence is observed but not forecast; 0 otherwise. The summation is over all grid points or stations;

$NO_2$ represents the correct rejections: $NO_2 = \Sigma W_i\ (NONF)_i$, (NONF) being 1 when the event occurrence is not observed and not forecast; 0 otherwise. The summation is over all grid points or stations;

$W_i$ = 1 when verification is done at stations or at single grid points; $W_i = \cos(\theta_i)$ at grid point *i* when verification is done on a grid, $\theta_i$ being the latitude at grid point *i*.

When verification is done at stations, the weighting factor is one. Consequently, the number of occurrences and non-occurrences of the event are entered in the contingency table as per Table 5.

However, when verification is done on a grid, the weighting factor is $\cos(\theta_i)$, where $\theta_i$ is the latitude at grid point *i*. Consequently, each number entered in the contingency table as per Table 6, is, in fact, a summation of the weights properly assigned.

Using stratification by observations (rather than by forecast), the hit rate (HR) is defined (referring to Table 5) as:

$$HR = {}^{O_1}/(O_1 + O_2)$$

The range of values for HR goes from 0 to 1, the latter value being desirable. An HR of 1 means that all occurrences of the event were correctly forecast.

The false alarm rate (FAR) is defined as:

$$FAR = {}^{NO_1}/(NO_1 + NO_2)$$

The range of values for FAR goes from 0 to 1, the former value being desirable. A FAR of zero means that in the verification sample, no non-occurrences of the event were forecast to occur.

The Hanssen and Kuipers score (see Hanssen and Kuipers, 1965 and Stanski, *et al.*, 1989) is calculated for deterministic forecasts. The Hanssen and Kuipers score (KS) is defined as:

$$KS = HR - FAR = \frac{O_1 NO_2 - O_2 NO_1}{(O_1 + O_2)(NO_1 + NO_2)}$$

The range of values for KS goes from -1 to +1, the latter value corresponding to perfect forecasts (HR being 1 and FAR being 0). KS can be scaled so that the range of possible values goes from 0 to 1 (1 being for perfect forecasts):

$$KS_{scaled} = \frac{KS + 1}{2}$$

The advantage of scaling KS is that it becomes comparable to the area under the ROC curve for probabilistic forecasts (see section 3.3.3) where a perfect forecast system has an area of 1 and a forecast system with no information has an area of 0.5 (HR being equal to FAR).

⇒ Contingency tables for deterministic categorical forecasts (such as in Table 4) are mandatory for Level 3 verification in the core SVS. These contingency tables can provide the basis for the calculation of several scores and indices such as the GSS, the LEPSCAT or the scaled Hanssen and Kuipers score and others.

3.3.3 ROC for probabilistic forecasts

Tables 6 and 7 show contingency tables (similar to Table 5) that can be built for probabilistic forecasts of binary events.

**Table 6**

**General ROC contingency table for probabilistic forecasts of binary events with definitions of the different parameters. This contingency table applies when probability thresholds are used to define the different probability bins**

| *Bin number* | *Forecast probabilities* | *Observed occurrences* | *Observed non-occurrences* |
|---|---|---|---|
| 1 | $0–P_2$ (%) | $O_1$ | $NO_1$ |
| 2 | $P_2–P_3$ (%) | $O_2$ | $NO_2$ |
| 3 | $P_3–P_4$ (%) | $O_3$ | $NO_3$ |
| n | $P_n–P_{n+1}$ (%) | $O_n$ | $NO_n$ |
| N | $P_N$–100 (%) | $O_N$ | $NO_N$ |

In Table 6:

$n$ = the number of the $n^{th}$ probability interval or bin $n$; $n$ goes from 1 to $N$;

$P_n$ = the lower probability limit for bin $n$;

$P_{n+1}$ = the upper probability limit for bin $n$;

$N$ = the number of probability intervals or bins;

$O_n = \Sigma W_i\ (O)_i$, (O) being 1 when an event corresponding to a forecast in bin n, is observed as an occurrence; 0 otherwise. The summation is over all forecasts in bin n, at all grid points or stations;

$NO_n = \Sigma W_i\ (NO)_i$, (NO) being 1 when an event corresponding to a forecast in bin $n$, is not observed; 0 otherwise. The summation is over all forecasts in bin $n$, at all grid points $i$ or stations $i$;

$W_i$ = 1 when verification is done at stations or at single grid points; $W_i = \cos(\theta_i)$ at grid point $i$, when verification is done on a grid; $\theta_i$ being the latitude at grid point $i$.

**Table 7**

**General ROC contingency table for probabilistic forecasts of binary events with definitions of the different parameters. This contingency table applies when the different probability bins are defined as a function of the number of members in the ensemble**

| *Bin number* | *Member distribution* | *Observed occurrences* | *Observed non-occurrences* |
|---|---|---|---|
| 1 | F = 0, NF = M | $O_1$ | $NO_1$ |
| 2 | F = 1, NF = M–1 | $O_2$ | $NO_2$ |
| 3 | F = 2, NF = M–2 | $O_3$ | $NO_3$ |
| n | F = n–1, NF = M–n+1 | $O_n$ | $NO_n$ |
| N | F = M, NF = 0 | $O_N$ | $NO_N$ |

In Table 7:

$n$ = the number of the $n^{th}$ bin; $n$ goes from 1 to $N$ = M + 1;

$F$ = the number of members forecasting occurrence of the event;

$NF$ = the number of members forecasting non-occurrence of the event. The bins may be aggregated;

$O_n = \Sigma W_i\ (O)_i$, (O) being 1 when an event corresponding to a forecast in bin $n$ is observed as an occurrence; 0 otherwise. The summation is over all forecasts in bin $n$, at all grid-points $i$ or stations $i$;

$NO_n = \Sigma W_i\ (NO)_i$, (NO) being 1 when an event corresponding to a forecast in bin $n$ is not observed; 0 otherwise. The summation is over all forecasts in bin $n$, at all grid points $i$ or stations $i$;

$W_i$ = 1 when verification is done at stations or at single grid points; $W_i = \cos(\theta_i)$ at grid point $i$, when verification is done on a grid, $\theta_i$ being the latitude at grid point $i$.

To build the contingency table in Table 6, probability forecasts of the binary event are grouped in categories or bins in ascending order, from 1 to $N$, with probabilities in bin $n$-1 lower than those in bin $n$ ($n$ goes from 1 to $N$). The lower probability limit for bin $n$ is $P_n$ and the upper limit is $P_{n+1}$. The lower probability limit for bin 1 is 0%, while the upper limit in bin $N$ is 100%. The summation of the weights on the observed occurrences and non-occurrences of the event corresponding to each forecast in a given probability interval (bin $n$ for example) is entered in the contingency table.

Tables 6 and 7 outline typical contingency tables. It is recommended that the number of probability bins remain between 10 and 20. The forecast providers can bin according to per cent thresholds (Table 6) or ensemble members (Table 7) as necessary. Table 7 gives an example of a table based on ensemble members.

The HR and FAR are calculated for each probability threshold $P_n$ (see Tables 6 and 7). The HR for probability threshold $P_n$ ($HR_n$) is defined as (referring to Tables 6 and 7):

$$HR_n = \left(\sum_{i=n}^{N} O_i\right) \Big/ \left(\sum_{i=1}^{N} O_i\right)$$

and $FAR_n$ is defined as:

$$FAR_n = \left(\sum_{i=n}^{N} NO_i\right) \Big/ \left(\sum_{i=1}^{N} NO_i\right)$$

where $n$ goes from 1 to $N$. The range of values for $HR_n$ goes from 0 to 1, the latter value being desirable. The range of values for $FAR_n$ goes from 0 to 1, zero being desirable. Frequent practice is for probability intervals of 10% (10 bins, or $N = 10$) to be used. However the number of bins ($N$) should be consistent with the number of members in the EPS used to calculate the forecast probabilities. For example, intervals of 33% for a nine-member ensemble system could be more appropriate.

The HR and FAR are calculated for each probability threshold $P_n$, giving $N$ points on a graph of HR (vertical axis) against FAR (horizontal axis) to form the ROC curve. This curve, by definition, must pass through the points (0,0) and (1,1) (for events being predicted only with >100% probability (never occur) and for all probabilities exceeding 0%, respectively). No-skill forecasts are indicated by a diagonal line (where HR = FAR); the further the curve lies towards the upper left-hand corner (where HR = 1 and FAR = 0) the better.

The area under the ROC curve is a commonly used summary statistic representing the skill of the forecast system. The area is standardized against the total area of the figure such that a perfect forecast system has an area of one and a curve lying along the diagonal (no information) has an area of 0.5. The normalized ROC area has become known as the ROC score. Not only can the areas be used to contrast different curves, but they are also a basis for Monte Carlo significance tests. It is proposed that Monte Carlo testing be done within the forecast data set itself. For the core SVS for LRF, the area under the ROC curve can be calculated using the trapezium rule, although other techniques are available to calculate the ROC score (see Mason, 1982).

⇒ Contingency tables for probabilistic forecasts (such as in Tables 6 and 7) are mandatory for Level 3 verification in the core SVS. ROC curves and ROC areas are mandatory for Level 1 verification in the core SVS, while ROC areas are only mandatory for Level 2 verification in the core SVS.

3.3.4 Reliability diagrams and frequency histograms for probabilistic forecasts

It is recommended that the construction of reliability curves (including frequency histograms to provide indications of sharpness) be done for large-sample probability forecasts aggregated over the tropics and, separately, the two extratropical hemispheres. Given frequency histograms, the reliability curves are sufficient for the ROC curve, and have the advantage of indicating the reliability of the forecasts, which is a deficiency of the ROC. It is acknowledged that the ROC curve is frequently the more appropriate measure of forecast quality than the reliability diagram in the context of verification of LRF because of the sensitivity of the reliability diagram to small sample sizes. However, because measures of forecast reliability are important for modellers, forecasters and end-users, it is recommended that in exceptional cases when forecasts are spatially aggregated over the tropics and over the two extratropical hemispheres, reliability diagrams be constructed in addition to ROC curves.

The technique for constructing the reliability diagram is somewhat similar to that for the ROC. Instead of plotting the HR against the FAR for the accumulated probability bins, the HR is calculated only from the sets of forecasts for each probability bin separately, and is plotted against the corresponding forecast probabilities. The HR for each probability bin ($HR_n$) is defined as:

$$HR_n = \frac{O_n}{O_n + NO_n}$$

This equation should be contrasted with the hit rate used in constructing the ROC diagram.

Frequency histograms are constructed similarly from the same contingency tables as those used to produce reliability diagrams. Frequency histograms show the frequency of forecasts as a function of the probability bin. The frequency of forecasts for probability bin $n$ ($F_n$) is defined as:

$$F_n = \frac{O_n + NO_n}{T}$$

where $T$ is the total number of forecasts and $T = \sum_{n=1}^{N} (O_n + NO_n)$

⇒ Reliability diagrams and frequency histograms are mandatory for Level 1 verification in the core SVS.

3.3.5 Level of significance

Because of the increasing uncertainty in verification statistics with decreasing sample size, significance levels and error bars should be calculated for all verification statistics. Recommended procedures for estimating these uncertainties are detailed below.

ROC AREA

In certain special cases, the statistical significance of the ROC area can be obtained from its relationship to the Mann–Whitney U statistic. The distribution properties of the U statistic can be used only if the samples are independent. This assumption of independence will be invalid when the ROC is constructed from forecasts sampled in space because of the strong spatial (cross) correlation between forecasts (and observations) at nearby grid points or stations. However, because of the weakness of serial correlation of seasonal climate anomalies from one year to the next, an assumption of sequential independence may frequently be valid for LRF, so the Mann–Whitney U statistic may be used for calculating the significance of the ROC area for a set of forecasts from a single point in space. An additional assumption for using the Mann–Whitney U test is that the variance of the forecast probabilities (not that of the individual ensemble predictions per se) for when non-events occurred is the same as for when events occurred. The Mann–Whitney U test is, however, reasonably robust to violations of homoscedasticity, which means that the variance of the error term is constant across the range of the variable, hence significance tests in cases of unequal variance are likely to be only slightly conservative.

If the assumptions for the Mann–Whitney U test cannot be held, the significance of the ROC area should be calculated using randomization procedures. Because the assumptions of permutation procedures are the same as those of the Mann–Whitney U test, and because standard bootstrap procedures assume independence of samples, alternative procedures such as moving block bootstrap procedures (Wilks, 1997) should be conducted to ensure that the cross- and/or serial-correlation structure of the data is retained.

ROC CURVES

Confidence bands for the ROC curve should be indicated, and can be obtained either by appropriate bootstrap procedures, as discussed above, or, if the assumption of independent forecasts is valid, from confidence bands derived from a two-sample Kolmogorov-Smirnov test comparing the empirical ROC with the diagonal.

MSSS

Appropriate significance tests for the MSSS and the individual components of the decomposition again depend upon the validity of the assumption of independent forecasts. If the assumption is valid, significance tests could be conducted using standard procedures (namely the F ratio for the correlation and for the variance ratio, and the t test for the difference in means), otherwise bootstrap procedures are recommended.

⇒ Level of significance will be mandatory in the core SVS once guidelines for calculation have been established for the complete suite of scores. A phased-in introduction of level of significance in the SVS may be used (see section 3.1.4).

### 3.4 Hindcasts

In contrast to short- and medium-range dynamical numerical weather prediction (NWP) forecasts, LRF are produced relatively few times a year (for example, one forecast for each season or one forecast for the following 90-day period, issued every month). Therefore the verification sampling for LRF may be limited, possibly to the point where the validity and significance of the verification results may be questionable. Providing verification for a few seasons or even over a few years only may be misleading and may not give a fair assessment of the skill of any LRF system. LRF systems should be verified over as long a period as possible in hindcast mode. Although there are limitations on the availability of verification data sets and in spite of the fact that validating numerical forecast systems in hindcast mode requires large computer resources, the hindcast period should be as long as possible. The recommended period for the exchange of scores is advertised on the Lead Centre website (http://www.bom.gov.au/wmo/lrfvs/).

Verification in hindcast mode should be achieved in a form as close as possible to the real-time operating mode in terms of resolution, ensemble size and parameters. In particular, dynamical/empirical models must not make any use of future data. Validation of empirical models and dynamical models with postprocessors (including bias corrections), and calculation of period of verification means, standard deviations, class limits, etc. must be done in a cross-validation framework. Cross-validation allows the entire sample to be used for validation (assessing performance, developing confidence intervals, etc.) and almost the entire sample for model and postprocessor building and for estimation of the period of verification climatology. Cross-validation procedures are as follows:

1. Delete 1, 3, 5, or more years from the complete sample;
2. Build the statistical model or compute the climatology;
3. Apply the model (e.g. make statistical forecasts or postprocess the dynamical forecasts) or the climatology for one (usually the middle) year of those deleted and verify;
4. Replace the deleted years and repeat 1–3 for a different group of years;
5. Repeat 4 until the hindcast verification sample is exhausted.

Ground rules for cross-validation are that every detail of the statistical calculations be repeated, including redefinition of climatology and anomalies, and that the forecast year predictors and predictands are not serially correlated with their counterparts in the years reserved for model building. For example, if adjacent years are correlated but every other year is effectively not, three years must be set aside and forecasts made only on the middle year (see Livezey, 1999 for estimation of the reserved window width).

The hindcast verification statistics should be updated once a year based on accumulated forecasts.

⇒ Verification results over the hindcast period are mandatory for the exchange of LRF verification scores. Producing centres have to send new hindcast verification results as soon as their forecast system is changed.

### 3.5 Real-time monitoring of forecasts

It is recommended that there be regular monitoring of real-time LRF. It is acknowledged that this real-time monitoring is neither as rigorous nor as sophisticated as hindcast verification; nevertheless it is necessary for forecast production and dissemination. It is also acknowledged that the sample size for this real-time monitoring may be too small to assess the overall skill of the models. However, it is recommended that the forecast and the observed verification for the previous forecast period be presented in visual format to the extent possible given the restrictions on availability of verification data.

Real-time monitoring of forecast performance is an activity for the GPCs rather than the Lead Centre. GPCs are free to choose the format and content of real-time monitoring information.

## 4. VERIFICATION DATA SETS

The same data should be used to generate both climatology and verification data sets, although the forecast issuing Centres/Institutes own analyses or reanalyses and subsequent operational analyses may be used when other data are not available.

Many LRF are produced that are applicable to limited or local areas. It may not be possible to use the data in either the recommended climatology or verification data sets for validation or verification purposes in these cases. Appropriate data sets should then be used with full details provided.

Verification should be done using the recommended data sets as listed on the Lead Centre website (http://www.bom.gov.au/wmo/lrfvs/).

## 5. SYSTEM DETAILS

Information must be provided on the system being verified. This information should include (but is not restricted to):

1. Whether the system is numerical, empirical or hybrid,
2. Whether the system is deterministic or probabilistic,
3. Model type and resolution,
4. Ensemble size,
5. Specifications of boundary conditions,
6. List of parameters being assessed,
7. List of regions for each parameter,
8. List of forecast ranges (lead times) and periods for each parameter,
9. Period of verification,
10. The number of hindcasts or predictions incorporated in the assessment and the dates of these hindcasts or predictions,
11. Details of climatological and verification data sets used (with details on quality control when these are not published),
12. If appropriate, resolution of fields used for climatologies and verification.

Verification data for the aggregated statistics and the grid-point data should be provided on the Web. The contingency tables should be made available on the Web or by anonymous FTP. Real-time monitoring should be done as soon as possible and made available on the Web.

## 6. SVS FOR LRF LEAD CENTRE

The Fourteenth WMO Congress endorsed the designation by CBS–Ext.(02) of WMC Melbourne and the Canadian Meteorological Centre in Montreal as Co-Lead Centres for verification of long-range and SI forecast activities. The Co-Lead Centre functions include creating and maintaining coordinated websites for LRF verification information, so that potential users will benefit from a consistent presentation of the results. The goal is to help the RCCs and NMHSs to have a tool for improving the long-range forecasts delivered to the public. Congress urged all Members to actively participate in that activity as either users or producers of LRF verification information to assure the use of the best available products.

### 6.1 Role of the Lead Centre

6.1.1 The purpose of the Lead Centre is to create, develop and maintain the website (the "SVSLRF website") to provide access to the LRF verification information. The address of the website is http://www.bom.gov.au/wmo/lrfvs/. The website will:

(*a*) Provide access to standardized software for calculating scoring information (ROC curves, areas, contingency table scores, hit rates, ...).

(*b*) Provide consistent graphical displays of the verification results from participating centres through processing of digital versions of the results;

(*c*) Contain relevant documentation and links to the websites of global-scale producing centres;

(*d*) Provide some means for the collection of feedback from NMHSs and RCCs on the usefulness of the verification information;

(*e*) Contain information and, preferably, provide access to available verification data sets;

6.1.2 The Centre will also:

(*a*) Produce monthly verification data sets in common format on 2.5° x 2.5° grids where appropriate;

(*b*) Liaise with other groups involved in verification (e.g. WGSIP and CCl) on the effectiveness of the current standardized verification system (SVS) and identify areas for future development and improvement;

(*c*) Provide periodic reports to CBS and other relevant commissions assessing the effectiveness of the SVS;

(*d*) Facilitate the availability of information to assess the skill of long-range forecasts but not to provide a direct intercomparison between the GPCs' models.

6.1.3 Detailed tasks of the Lead Centre

6.1.3.1 The Lead Centre will provide access to verification data sets on the SVSLRF website. The verification data sets will be in GRIB Edition 1 format. They will be translated to GRIB Edition 2 format when the encoder/decoder becomes widely available. RSMC Montreal will be responsible for preparing the verification data sets. These will be updated on the SVSLRF website on a yearly basis provided that new data are available. The choice of verification data sets will be revised as new ones become available and as recommended by the appropriate CBS expert team.

6.1.3.2 The Lead Centre will develop and provide specifications defining the format of the data to be sent to the Lead Centre for graphics preparation. There is no need to specify standards for graphics to be sent to the SVSLRF website because all graphics will be generated by the Lead Centre. WMC Melbourne will develop the infrastructure to generate all graphics posted on the SVSLRF website.

6.1.3.3 The Lead Centre will be responsible for making available the digital verification information as specified at Levels 1, 2 and 3 (see section 3.1).

6.1.3.4 The Lead Centre will ensure that clear and concise information explaining the verification scores, graphics and data is available and kept up to date on the SVSLRF website. The production of this documentation will be shared between the two Co-Lead Centres. Links to the participating GPCs will be listed on the SVSLRF website. The content of the documentation and information on interpretation and use of the verification data will be determined in consultation with the appropriate CBS expert team.

6.1.3.5 The Lead Centre will consult with the GPCs to make sure that the verification data are correctly displayed before making available their verification results on the SVSLRF website.

6.1.3.6 The Lead Centre will ensure that the verification results placed on the SVSLRF website come from GPCs (officially recognized by CBS) with operational LRF commitments.

6.1.3.7 The Lead Centre will provide and maintain software to calculate the verification scores. Development of the software will be the responsibility of RSMC Montreal. The software code will be available on the SVSLRF website, and will be in FORTRAN language. However, it is recognized that the use of this software is not mandatory.

6.1.3.8 The Lead Centre will publicize the SVSLRF website to other bodies involved in verification (such as WGSIP and CCl) and establish contacts in order to receive feedback and facilitate discussion for further development and improvement.

6.1.3.9 Once the SVSLRF website is operational, the Lead Centre will provide progress reports every two years to CBS, prior to its sessions.

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ATTACHMENT II.9

# PROCEDURES AND FORMATS FOR THE EXCHANGE OF MONITORING RESULTS

## 1. GENERAL REMARKS

1.1 Centres participating in the exchange of monitoring results will implement standard procedures and use agreed formats for communicating the information both to other centres and to the data providers. The following list is incomplete and requires further development in the light of practical experience. Guidance will be given through the initiative of the lead centres in their corresponding fields of responsibility.

1.2 Lead centres that are informed of remedial actions being taken should provide this information to all participating centres. The WMO Secretariat shall forward, every six months, the information it receives to the relevant lead centres. All lead centres shall produce for the WMO Secretariat a yearly summary of information made available to them and/or of those actions taken within their area of responsibility.

## 2. UPPER-AIR OBSERVATIONS

2.1 Monthly exchange for upper-air observations should include lists of stations/ships with the following information.

2.1.1 List 1: GEOPOTENTIAL HEIGHT

Month/year
Monitoring centre
Standard of comparison (first-guess/background field)

Selection criteria: FOR 0000 AND 1200 UTC SEPARATELY, AT LEAST THREE LEVELS WITH 10 OBSERVATIONS DURING THE MONTH AND 100 M WEIGHTED RMS DEPARTURE FROM THE FIELD USED FOR COMPARISON BETWEEN 1 000 hPa AND 30 hPa.

The gross error limits to be used for observed minus reference field are as follows:

| Level | Geop |
|---|---|
| 1 000 hPa | 100 m |
| 925 hPa | 100 m |
| 850 hPa | 100 m |
| 700 hPa | 100 m |
| 500 hPa | 150 m |
| 400 hPa | 175 m |
| 300 hPa | 200 m |
| 250 hPa | 225 m |
| 200 hPa | 250 m |
| 150 hPa | 275 m |
| 100 hPa | 300 m |
| 70 hPa | 375 m |
| 50 hPa | 400 m |
| 30 hPa | 450 m |

Weights to be used at each level are as follows:

| Level | Weight |
|---|---|
| 1 000 hPa | 3.70 |
| 925 hPa | 3.55 |
| 850 hPa | 3.40 |
| 700 hPa | 2.90 |
| 500 hPa | 2.20 |
| 400 hPa | 1.90 |
| 300 hPa | 1.60 |
| 250 hPa | 1.50 |
| 200 hPa | 1.37 |
| 150 hPa | 1.19 |
| 100 hPa | 1.00 |
| 70 hPa | 0.87 |
| 50 hPa | 0.80 |
| 30 hPa | 0.64 |

Data to be listed for each station/ship should include:

WMO identifier
Observation time
Latitude/longitude (for land stations)
Pressure of the level with largest weighted RMS departure
Number of observations received (including gross errors)
Number of gross errors
Percentage of observations rejected by the data assimilation
Mean departure from reference field
RMS departure from reference field (unweighted)

Gross errors should be excluded from the calculation of the mean and RMS departures. They should not be taken into account in the percentage of rejected data (neither the numerator nor denominator).

2.1.2 List 2: TEMPERATURE

Besides the geopotential height, temperature monitoring should be included at standard levels. As an initial criteria, the gross error thresholds to be considered could be:

15 (K) for p > 700 hPa
10 (K) for 700 > = 50 hPa
15 (K) for p < = 50 hPa

2.1.3 List 3: WIND

Month/year
Monitoring centre
Standard of comparison (first-guess/background field)

Selection criteria: FOR 0000 AND 1200 UTC SEPARATELY, AT LEAST ONE LEVEL WITH 10 OBSERVATIONS DURING THE MONTH AND 15 m $s^{-1}$ RMS VECTOR DEPARTURE FROM THE FIELD USED FOR COMPARISON, BETWEEN 1 000 hPa AND 100 hPa.

The gross error limits to be used are as follows:

| **Level** | **Wind** |
|---|---|
| 1 000 hPa | 35 m $s^{-1}$ |
| 925 hPa | 35 m $s^{-1}$ |
| 850 hPa | 35 m $s^{-1}$ |
| 700 hPa | 40 m $s^{-1}$ |
| 500 hPa | 45 m $s^{-1}$ |
| 400 hPa | 50 m $s^{-1}$ |
| 300 hPa | 60 m $s^{-1}$ |
| 250 hPa | 60 m $s^{-1}$ |
| 200 hPa | 50 m $s^{-1}$ |
| 150 hPa | 50 m $s^{-1}$ |
| 100 hPa | 45 m $s^{-1}$ |

Data to be listed for each selected station/ship should include:

WMO identifier
Observation time
Latitude/longitude (for land stations)
Pressure of the level with largest RMS departure
Number of observations received (including gross errors)
Number of gross errors
Percentage of observations rejected by the data assimilation
Mean departure from reference field for u-component
Mean departure from reference field for v-component
RMS vector departure from reference field

Gross errors should be handled in the same way as for List 1.

2.1.4 List 4: WIND DIRECTION

The method used for computing the wind direction bias should be included in the reports (clockwise or anticlockwise)

Month/year
Monitoring centre
Standard of comparison (first-guess/background field)

Selection criteria: FOR 0000 AND 1200 UTC SEPARATELY, AT LEAST FIVE OBSERVATIONS AT EACH STANDARD LEVEL FROM 500 hPa TO 150 hPa, FOR THE AVERAGE OVER THAT LAYER, MEAN DEPARTURE FROM REFERENCE FIELD AT LEAST ± 10 DEGREES, STANDARD DEVIATION LESS THAN 30 DEGREES, MAXIMUM VERTICAL SPREAD LESS THAN 10 DEGREES.

Same limits for gross errors as above. Data for which the wind speed is less than 5 m $s^{-1}$, either observed or calculated, should also be excluded from the statistics.

Data to be listed for each selected station/ship should include:

WMO identifier
Observation time
Latitude/longitude (for land stations)
Minimum number of observations at each level from 500 hPa to 150 hPa (excluding gross errors and data with low wind speed)
Mean departure from reference field for wind direction, averaged over the layer
Maximum spread of the mean departure at each level around the average
Standard deviation of the departure from reference field, averaged over the layer

(To be completed with information from other lead centres)

NOTES:

(1) The responsibility for updating this attachment rests with the lead centres.

(2) Urgent changes to this attachment recommended by the lead centres shall be approved, on behalf of the Commission for Basic Systems, by the president of the Commission.

2.1.5 The profilers should be monitored (suspect platforms) using the same criteria as for the radiosondes.

## 3. LAND SURFACE OBSERVATIONS

3.1 The criteria for the production of a monthly list of suspect stations are as follows:

3.1.1 List 1: MSL PRESSURE

Element: MSL pressure, surface synoptic observations at 0000, 0600, 1200 or 1800 UTC compared with the first-guess field of a data assimilation model (usually a six-hour forecast).

Number of observations: at least 20 for at least one observation time, without distinguishing between observation times.

One or more of the following:

Absolute value of the mean bias ≥ 4 hPa
Standard deviation ≥ 6 hPa
Percentage gross error ≥≥ 25 per cent (gross error limit: 15 hPa).

3.1.2 List 2: STATION-LEVEL PRESSURE

The criteria for station-level pressure monitoring is the same as for MSL pressure above.

3.1.3 List 3: GEOPOTENTIAL HEIGHT

Element: geopotential height, from surface synoptic observations or derived from station-level pressure, temperature and published station elevations at 0000, 0600, 1200 or 1800 UTC compared with the first-guess field of a data assimilation model (usually a six-hour forecast).

Number of observations: at least five for at least one observation time, without distinguishing between observation times.

One or more of the following:

Absolute value of the mean bias ≥30 m
Standard deviation ≥40 m
Percentage gross error ≥25 per cent (gross error limit: 100 m).

3.1.4 PRECIPITATION

General guidance reflecting Global Precipitation Climatology Centre (GPCC) procedures for precipitation quality monitoring is given in section 6.3.3.2 of the *Guide on the Global Data-processing System*.

NOTES:

(1) All monitoring centres are asked to conform to the above specified criteria. These monthly lists should be prepared for at least the regional association of the lead centres and, if possible, for other regional associations. Consolidated lists of suspect stations should be produced every six months by the lead centres (January–June and July–December) and forwarded to the WMO Secretariat for further action.

(2) The stations on these consolidated lists should be those appearing on all six-monthly lists of the lead centres. Other stations could be added to the consolidated list if the lead centres judge that there is sufficient evidence for their inclusion. Each centre should send its proposed consolidated list to all participating monitoring centres for comment. The final list would then be forwarded to the WMO Secretariat.

## 4. SURFACE MARINE OBSERVATIONS

4.1 Monthly exchange for surface marine observations should include lists of "suspect" ships/buoys/platforms with the following additional information:

Month/year
Monitoring centre
Standard of comparison: first-guess/background field of a global data assimilation model, often a six-hour forecast, but the background values may be valid at the observation time for non-main hour data using 4-D VAR or time-interpolation of T+3, T+6, T+9 forecasts; for SST, the first-guess/background filed may be from a previous analysis.

All surface marine data may be included, not just observations at the main hours of 0000, 0600, 1200, 1800 UTC.

4.2 The elements to be monitored should include:

Mean sea-level pressure
Wind speed
Wind direction
and, where possible:
Air temperature
Relative humidity
Sea-surface temperature

4.3 Data to be listed for each ship/buoy/platform and each element should include:

WMO identifier observation time (if not all times latitude/longitude for buoys and platforms)
Number of observations received (including gross errors)
Number of gross errors
Percentage of observations rejected by the data assimilation quality control
Mean departure from reference field (bias)
RMS departure from reference field

Gross errors should be excluded from the calculation of the mean and RMS departures. They should not be taken into account in the percentage of rejected data (neither the numerator nor denominator).

4.4 The criteria for the production of the monthly list of suspect stations are as follows:

4.4.1 List 1: MEAN SEA-LEVEL PRESSURE

Number of observations: at least 20
One or more of the following:
Absolute value of the mean bias ≥4 hPa
Standard deviation ≥6 hPa
Percentage gross error ≥25 per cent (gross error limit: 15 hPa)

4.4.2 List 2: WIND SPEED

Number of observations: at least 20
One or more of the following:
Absolute value of the mean bias ≥ 5 m $s^{-1}$
Percentage gross error ≥ 25 per cent (25 m $s^{-1}$ vector wind)

4.4.3 List 3: WIND DIRECTION

Data for which the wind speed is less than 5 m $s^{-1}$, either observed or calculated, should be excluded from the statistics.
Number of observations: at least 20
One or more of the following:
Absolute value of the mean bias ≥ 30°
Standard deviation ≥ 80°
Percentage gross error ≥ 25 per cent (gross error limit: 25 m $s^{-1}$ vector wind)

4.4.4 List 4: AIR TEMPERATURE

Number of observations: at least 20
One or more of the following:
Absolute value of the mean bias > 4°C
Standard deviation > 6°C
Percentage gross error > 25 per cent (gross error limit: 15°C)

4.4.5 List 5: RELATIVE HUMIDITY

Number of observations: at least 20
One or more of the following:
Absolute value of the mean bias > 30 per cent
Standard deviation > 40 per cent
Percentage gross error > 25 per cent (gross error limit: 80 per cent)

4.4.6 List 6: SEA-SURFACE TEMPERATURE

Number of observations: at least 20
One or more of the following:
Absolute value of the mean bias > 3°C
Standard deviation > 5°C
Percentage gross error > 25 per cent (gross error limit: 10°C)

## 5. AIRCRAFT DATA

5.1 The criteria for the production of the monthly list of suspect aircraft temperatures and winds observations are as follows:

5.1.1 Automated aircraft observations, both AMDAR and ACARS, will separately be listed as suspect for temperatures and winds in three pressure categories if the data statistics exceed the criteria defined in paragraph 5.1.2. The three pressure categories are: low surface to 701 hPa; mid to 700 to 301 hPa; and high to 300 hPa and above. To be considered suspect, the number of observations must meet minimal counts and the data statistics versus the guess must exceed at least one criterion or the gross rejection rate must exceed 2 per cent. Thus, if the magnitude of the temperature or speed bias exceed the criterion or the RMS differences to the guess exceed the limit for the pressure category, then the aircraft is listed as suspect for that pressure category. Observations differing from the guess by amounts larger than gross check limits will be considered gross and not used in computing bias and RMS differences. If the number of gross observations (NG) for a pressure category exceeds 2 per cent of the total number of checked observations, then the aircraft will be listed as suspect. After data thinning for assimilation, the remaining number of observations is NT. The number of rejected observations excluding thinning (NR) is an optional statistic for information, and for which operational practice should be documented.

List: Temperature and wind

Month/year
Monitoring centre
Standard of comparison (first guess/background field)

Each aircraft that is suspect will be listed as follows in one line:

Aircraft ID
Pressure category
Total number of available observations (NA)
NG
NT
NR
Bias
RMS difference to the guess
For wind reports, the number of exactly calm winds (NC).

5.1.2 Suspect automated aircraft temperatures and winds observations criteria

| *Variable* | *Low* | *Mid* | *High* |
|---|---|---|---|
| Gross temperature (K) | 15.0 | 10.0 | 10.0 |
| Temperature bias (K) | 3.0 | 2.0 | 2.0 |
| Temperature RMS (K) | 4.0 | 3.0 | 3.0 |
| Minimum count | 20 | 50 | 50 |
| Gross wind (m $s^{-1}$) | 30.0 | 30.0 | 40.0 |
| Wind speed bias (m $s^{-1}$) | 3.0 | 2.5 | 2.5 |
| Wind RMS (m $s^{-1}$) | 10.0 | 8.0 | 10.0 |
| Minimum count | 20 | 50 | 50 |

5.1.3 AIREP

Monthly exchange for AIREP observations should include lists of airlines with the following information:

Month/year
Monitoring centre
Standard of comparison (first guess/background field)
Selection criteria
  Number of observations > = 20
Levels monitored
  300 hPa and above
Elements monitored
  Wind and temperature
Data to be listed for each airline
  Airline ID
  Number of observations
  Number of rejected observations
  Number of gross errors
  Number of calm winds (<5 m $s^{-1}$)
  RMS excluding gross errors
  Bias excluding gross errors (wind speed and temperature)
  Gross error limits are:
    Wind 40 m $s^{-1}$
    Temperature 10 degrees °C

## 6. SATELLITE DATA

Satellite data monitoring criteria are as specified in the following table

| *Geostationary satellite wind (SATOB or BUFR code, as assimilated, centres must clarify this and channels shown)* | *Recommended criteria* |
|---|---|
| Monitoring satellites | Current operational satellites |
| Monitoring layers | Upper (101–400 hPa)<br>Middle (401–700 hPa)<br>Lower (701–1 000 hPa) |
| Minimum observation count | 20 (in 10 deg box), 10 (in 5 deg box) |
| Gross error limit (m $s^{-1}$) | 60 |
| Availability map (averaged observation number in 24 hours) | 10deg×10deg OR 5deg×5deg for all levels |
| Map: wind observed value | 10deg×10deg OR 5deg×5deg for each layer |
| Map: O-FG wind vector difference (bias) | 10deg×10deg OR 5deg×5deg for each layer |
| Map: O-FG wind speed difference (bias) | 10deg×10deg OR 5deg×5deg for each layer |
| Map: O-FG RMS of wind vector difference | 10deg×10deg OR 5deg×5deg for each layer |
| Table: Statistics as defined in the *Proceedings of the Third International Winds Workshop* (1996), Menzel, p. 17. EUMETSAT, Darmstadt, EUMP18, with reference to the first guess | The following statistics for all levels, high, medium and low in all regions, N and S extratropics and tropics for satellite in use and selected channels:<br><br>MVD = Mean vector difference<br>RMSVD = Vector difference RMS<br>BIAS = Speed bias<br>SPD = FG/background wind speed<br>NCMV = Number of disseminated SATOB winds |
| *Orbital satellite SATEM* | *Recommended criteria* |
| Monitoring satellites | Current operational satellites |
| Monitoring parameters | Thickness layers<br>(850–1 000, 100–300, 30–50) hPa |
| Gross error limit (m) | 150 (1 000–850), 400 (300–100), 500 (50–30) hPa |
| Availability map (averaged observation number in 24h) | 5deg×5deg OR 10deg×10deg for each layer |
| Map: O-FG thickness difference (bias) | 5deg×5deg OR 10deg×10deg for each layer |
| Map: O-FG RMS of thickness difference | 5deg×5deg OR 10deg×10deg for each layer |
| *Orbital satellite Atmospheric soundings* | *Recommended criteria* |
| Monitoring satellites | Current operational satellites |
| Monitoring parameters | Uncorrected brightness temperatures primarily, plus corrected |
| Monitoring channels | The lead centre will recommend a selection of channels to be monitored |
| Availability map (averaged observation number in 24 hours) | 5deg×5deg OR 10deg×10deg for each satellite |
| Map: O-FG difference (bias) | 5deg×5deg OR 10deg×10deg for each satellite |
| Map: O-FG SD of difference | 5deg×5deg OR 10deg×10deg for each satellite |

| | |
|---|---|
| *Sea-surface wind (e.g. scatterometers, SSM/I)* | *Recommended criteria*<br>Follow guidelines as above for satellite winds where possible, but applied to surface only |
| *Any other satellite product* | *Recommended criteria*<br>The pioneering centre can set the initial standard, based on the above guidelines for similar parameters, or a new standard for a new product. Report back to the lead centre for information |

PART III

# DATA MANAGEMENT ASPECTS

## 1. STORAGE OF DATA

1.1 Data (observations, analysis and forecast fields) should be organized as much as possible in database structures for easy cataloguing and preparing inventories, in order to facilitate exchange of data and request-reply processing.

1.2 Where possible the storage of data for non-real-time users should be within a database structure with the following characteristics:

(*a*) There should be a table structure present within the database which provides users with the ability to identify easily the contents of the database (some form of automatic cataloguing system);

(*b*) The database should facilitate the easy intercomparison of diverse elements contained within it;

(*c*) The ability to store a wide variety of data with flexibility in adding new types;

(*d*) Easy access from application programmes to the stored data.

## 2. COLLECTION, ARCHIVING AND RETRIEVAL OF DATA IN THE GDPFS

### 2.1 Data to be stored for non-real-time uses

**2.1.1 The following operational data shall be stored within the GDPFS:**

**(*a*) All direct observations or values calculated from these observations by simple methods;**

**(*b*) Selected derived data which cannot be easily reconstituted from observed data;**

**(*c*) Selections of analyses and forecasts including verification results.**

2.1.2 The types of material to be stored at WMCs and RSMCs should correspond broadly to those required by investigators of problems on the planetary, large, meso and small scales, respectively.

NOTE: Responsibilities for storage of data at WMCs and RSMCs are given in Attachments III.1 and III.2, respectively. Guidelines for storage and retrieval of satellite data at RSMCs and NMCs are given in Attachment III.4. In meeting these responsibilities, Members should ensure that their centres observe necessary coordination with existing archiving systems for marine, aeronautical and satellite data to avoid unnecessary duplication of stored data.

2.1.3 Members should ensure that their NMCs archive and retrieve all data originating from their national observing networks and facilities.

NOTE: Members may wish their NMCs to store additional data of regional, or even global, coverage to satisfy national requirements.

### 2.2 National arrangements for storage of climatological data

2.2.1 Each Member should collect all its climatological records in its appropriate meteorological archives.

2.2.2 Each Member should maintain an up-to-date inventory of the climatological data available in its archives and also of any other climatological data available in its territory.

2.2.3 Each Member should arrange for the transfer of climatological data from its stations to media capable of being processed by automatic methods.

### 2.3 Collection of data to be stored

2.3.1 Where urgency for immediate processing of non-real-time data exists, data collection should be by the GTS, subject to available capacity.

2.3.2 Where such urgency, or sufficient capacity, does not exist, collection should be by the safest most economical means or media available.

2.3.3 Where data are available completely through the GTS, the resulting collection should serve research or non-real-time requirements as well as real-time requirements. Collection of the same data by other methods should, in this case, not be necessary if adequate standards of quality control are achieved for the data collected by the GTS.

## 3. NON-REAL-TIME QUALITY CONTROL

### 3.1 Quality control of data to be stored

3.1.1 In addition to the real-time quality control, but prior to their storage for retrieval purposes, all data should be subject to the quality control necessary to ensure a satisfactory standard of accuracy for users.

NOTE: Minimum standards for non-real-time quality control of data to be stored by WWW centres are given in Attachment III.3.

3.1.2 The primary responsibility for non-real-time quality control should rest with Members which operate the centres that store the data. This control should be performed on a routine basis and should begin as soon as possible after the data have been received at the centre.

3.1.3 Prior to placing data in storage, all suspect values and proposed corrections should be appropriately marked for future users of data.

3.1.4 Where possible, Members should employ, and constantly improve, computerized methods used at their centres for re-examination of real-time data to detect and correct errors before storage of data.

## 4. CLASSIFICATION AND CATALOGUING OF STORED DATA

### 4.1 Catalogue of stored data

4.1.1 All Members should publish and keep up-to-date catalogues of the data which they store at their centres. A descriptive list of such catalogues should be compiled and disseminated to all Members who request it.

4.1.2 The classification and cataloguing scheme for WWW data should be made as compatible as possible with methods used by data centres of related disciplines.

## 5. MEDIA AND FORMATS FOR THE EXCHANGE OF STORED DATA

### 5.1 Media for exchange

5.1.1 To the extent possible, all data should be stored in digital form on technical carriers. When this is not possible they should be stored in the most convenient form until such time as they can be transferred to technical carriers.

5.1.2 WMCs should provide for the exchange of data in media set forth in paragraph 5.1.1 above. RSMCs and NMCs should provide for the exchange of data on at least one of the standard media set forth in paragraph 5.1.1 above. The desires of the recipient should be considered to the extent possible.

5.1.3 Members operating meteorological satellites should make available, through the WMO Secretariat, information on media and formats used to store data from their satellites.

### 5.2 Formats

5.2.1 Exchange of stored data by physical media should be in the standard formats recommended by WMO. The data records should be based on GRIB (FM 92) and BUFR (FM 94) codes wherever possible.

### 5.3 Responsibilities of Members for the exchange of non-real-time data

5.3.1 **Each Member shall be responsible for meeting requests from other Members for non-real-time data stored in its national Service in accordance with the functions laid down in Part II of this *Manual*.**

5.3.2 Members should exchange non-real-time data in the standard media given in paragraph 5.1 above and in the standard formats given in paragraph 5.2 above.

NOTE: Each Member should make appropriate financial arrangements with other Members who wish to obtain copies of non-real-time data stored within its national Service.

ATTACHMENT III.1

## DATA TO BE STORED AT WMCs

1. Members operating WMCs have responsibility for collecting data from areas as indicated:

| | | |
|---|---|---|
| Melbourne | – | southern hemisphere |
| Moscow | – | northern hemisphere |
| Washington | – | northern hemisphere |

This in no way prohibits a WMC from collecting and archiving data from a larger area.

2. The types and frequency of basic meteorological data that should be stored by the WMCs are:

| *Type* | *Frequency* |
|---|---|
| Synoptic surface observations | 00, 06, 12, 18 UTC |
| Ship reports | 00, 06, 12, 18 UTC |
| Reports from fixed ocean stations | 00, 06, 12, 18 UTC |
| Arctic floating stations | 00, 06, 12, 18 UTC |
| Buoys | 00, 06, 12, 18 UTC |
| PILOT/TEMP | 00, 12 UTC |
| PILOT SHIP/TEMP SHIP | 00, 12 UTC |
| Selected aircraft reports | |
| Selected satellite data | |
| Meteor trail winds | |
| Rocketsonde data | |

3. Members operating WMCs should archive surface and upper-air meteorological analyses of sufficient vertical resolution, at least two times a day for the assigned hemisphere and at least once a day for as much of the globe as practicable.

## ATTACHMENT III.2

## DATA TO BE STORED AT RSMCs

1. Members should ensure that their RSMCs provide for the storage and retrieval of basic observational data received through the GTS and/or other means for the zones of responsibility as indicated below:

| RSMC | ZONE OF RESPONSIBILITY |
|---|---|
| **Region I** | |
| Antananarivo | To be decided later |
| Algiers | The zone of responsibility of RTH Algiers for collection of observational data |
| Cairo | The zone of responsibility of RTH Cairo for collection of observational data |
| Dakar | The zone of responsibility of RTH Dakar for collection of observational data |
| Lagos | To be decided later |
| Nairobi | The zone of responsibility of RTH Nairobi for collection of observational data |
| Tunis/Casablanca | To be decided later |

NOTE: Certain RSMCs are not proposed for any specific zone of responsibility because of the need to avoid unwarranted duplication and to achieve the best compatibility of RSMC zones with RTH zones, considering the capabilities and arrangements of the GTS.

| RSMC | ZONE OF RESPONSIBILITY |
|---|---|
| **Region II** | |
| Beijing | The zone of responsibility of RTH Beijing for collection of observational data |
| Jeddah | The zone of responsibility of RTH Jeddah for collection of observational data |
| Khabarovsk | The zone of responsibility of RTH Khabarovsk for collection of observational data |
| New Delhi | The zone of responsibility of RTH New Delhi for collection of observational data |
| Novosibirsk | The zone of responsibility of RTH Novosibirsk for collection of observational data |
| Tashkent | The zones of responsibility of RTHs Tashkent and Tehran for collection of observational data |
| Tokyo | The zones of responsibility of RTHs Tokyo and Bangkok for collection of observational data |
| **Region III** | |
| Brasilia | The zones of responsibility of RTHs Brasilia and Maracay for collection of observational data |
| Buenos Aires | The zone of responsibility of RTH Buenos Aires for collection of observational data |
| **Region IV** | |
| Washington | All Region IV (acting for RSMCs Miami and Montreal) |
| **Region V** | |
| Melbourne | The zone of responsibility of WMC/RTH Melbourne for collection of observational data (acting for RSMC Darwin) |
| Wellington | The zone of responsibility of RTH Wellington for collection of observational data |
| **Region VI** | |
| Exeter | The zone of responsibility of RTH Exeter for collection of observational data |
| Moscow | The zones of responsibility of WMC/RTH Moscow and RTHs Prague and Sofia for collection of observational data |
| Norrköping | The zone of responsibility of RTH Norrköping for collection of observational data |
| Offenbach | The zone of responsibility of RTHs Offenbach, Vienna and Paris for collection of observational data |
| Rome | The zone of responsibility of RTH Rome for collection of observational data |

2. The types and frequency of basic meteorological data to be stored by the RSMCs are as indicated below:

| *Type* | *Frequency* |
|---|---|
| SYNOP | 3-hourly |
| SHIP | 6-hourly |
| PILOT/TEMP | 6- or 12-hourly |
| PILOT SHIP/TEMP SHIP | 6- or 12-hourly |
| Selected aircraft reports | |
| Selected satellite data | |
| DRIFTER | |

3. Members should ensure that their RSMCs archive the following analyses for their zones of responsibility:

(*a*) Surface analyses twice per day;

(*b*) Upper-air analyses for at least four of the standard isobaric surfaces listed in paragraph 3.2.1 of Part II of this Manual.

ATTACHMENT III.3

# MINIMUM STANDARDS FOR NON-REAL-TIME QUALITY CONTROL

(See Appendix II-1)

ATTACHMENT III.4

## GUIDELINES FOR STORAGE AND RETRIEVAL OF SATELLITE DATA

(*a*) RSMCs and NMCs should store a representative set of satellite observations and derived products which they are able to receive and process with their available facilities.

NOTE: Some duplication with the data stored in the larger archives of the satellite operators may be necessary.

(*b*) Data stored at RSMCs and NMCs should include imagery (digital or photos), raw radiance data for SATEM or SATOB messages and high-resolution sounding data.

(*c*) Media for exchange of satellite data should be standardized in so far as possible.

(*d*) The catalogue of archived satellite data should be published and updated by the Meteorological Service operating the centre.