WORLD METEOROLOGICAL ORGANIZATION

Weather • Climate • Water

WORLD WEATHER WATCH

TWENTY-SECOND STATUS REPORT ON IMPLEMENTATION

2005

WMO-No. 986

Secretariat of the World Meteorological Organization – Geneva – Switzerland

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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, of its authorities, or concerning the delimitation of its frontiers or boundaries.

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FOREWORD

In April 1963, the Fourth World Meteorological Congress approved the concept of the World Weather Watch (WWW) Programme of the World Meteorological Organization (WMO). Since then, the WWW has grown to be the fundamental facility for almost all programmes of WMO and other relevant international agencies as regards the provision of basic meteorological data and products, telecommunication services and the management thereof.

This publication is the twenty-second in a series of biennial reports on the status of implementation of WWW. It was mainly designed to inform the senior management of the National Meteorological and Hydrological Services (NMHSs) – but also those from academia and the private sector who may be interested – of the operational status of WWW. It provides information concerning the structure, status and trends of the implementation, as well as performance of the core components of WWW, notably the Global Observing System (GOS), the Global Telecommunication System (GTS) and the Global Data-processing and Forecasting System (GDPFS).

Some parts of this publication have been compacted from detailed information and reports made available by Members to the Commission for Basic Systems (CBS) and the working groups of the regional associations (RAs) which deal with WWW.

I wish to take this opportunity to express my sincere appreciation to the Members of WMO for their continuing efforts towards the consolidated further development of WWW, as well as their collaboration in providing the information on which this report is based.

M. Jarraud
(Secretary-General)

EXECUTIVE SUMMARY

STATUS OF THE WORLD WEATHER WATCH

INTRODUCTION

1. The World Weather Watch (WWW) is an international cooperative programme that oversees the gathering and distribution of meteorological data and products to World Meteorological Organization (WMO) Members. This *Twenty-Second Status Report on Implementation* documents the progress and changes made in 2003 and 2004 within the various components of WWW.

GLOBAL OBSERVING SYSTEM

2. The Global Observing System (GOS) consists of facilities for making observations on land and at sea, from aircraft and from satellites.
3. Each WMO regional association (RA) draws up a regional network of observing stations, called a Regional Basic Synoptic Network (RBSN), to meet the collective needs of its Members. The level of implementation of the RBSN surface stations in 2004 varied from 18 per cent in Region IV to 95 per cent in Region VI, with a global average of 75 per cent. The number of SYNOP reports actually received at Main Telecommunications Network (MTN) centres on the Global Telecommunication System (GTS) varied regionally from 53 per cent of those required in the RBSN of Region I to 94 per cent in Region VI, with a global average of 77 per cent. While surpassing the 2002 level, the overall results showed that almost one quarter of expected reports were still missing in the international exchange. The main reason for this data gap continues to be either the absence of observations or telecommunication problems.
4. In addition to stations in the RBSNs, a large number of supplementary stations have been established to meet regional and national needs. Most of these stations are automated and record observations hourly. There were a total of 3 077 automated stations as of October 2004, an increase of 29 per cent since 2002.
5. The percentage of upper-air reports actually received at centres on the GTS varied from 36 per cent of those required in Region I to 86 per cent in Region IV, providing a global average of 67 per cent. As in previous years, the number of southern hemisphere stations making two observations per day is considerably less than those in the northern hemisphere. Gaps in upper-air data coverage persisted over Africa, Asia, South America and the oceans, mainly due to obsolete equipment and a lack of consumables.
6. The Regional Basic Climatological Networks (RBCNs) have been revised for each Region. As of July 2004, all Regions, including the Antarctic, comprise a total of 3 107 stations. Out of these, 2 600 stations are listed as CLIMAT stations and 507 as CLIMAT TEMP stations.
7. WMO relies on ships, moored and drifting buoys and stationary platforms for synoptic and upper-air observations over the oceans. The total number of ships recruited by WMO Members for the Voluntary Observing Ship (VOS) Programme numbered 6 651 in 2004. The number of ship reports received at MTN centres has remained fairly constant during the past eight years at about 6 000 reports daily, although slightly less than half of these are from VOS ships. In May 2004, the total number of active drifting buoys reporting data on the GTS had increased to 945, compared with 750 in 2002.
8. There were about 200 000 Aircraft Meteorological Data Relay (AMDAR) observations per day in 2004. Because about 50 per cent of the aircraft providing AMDAR data fly between Europe and North America and within those continents, there are still relatively few AMDAR observations over Regions I and II.
9. The new WMO Space Programme was initiated by the Fourteenth World Meteorological Congress in May 2003 as a cross-cutting programme to increase the effectiveness and contributions from satellite systems to the development of the GOS as well as to other WMO-supported programmes. The spaced-based component of the GOS is now composed of three satellite types: operational meteorological polar-orbiting and geostationary satellites and environmental research and development (R&D) satellites.

GLOBAL TELECOMMUNICATION SYSTEM AND DATA MANAGEMENT

10. The GTS comprises the MTN, Regional Meteorological Telecommunication Networks (RMTNs) and National Meteorological Telecommunication Networks (NMTNs). The MTN is the backbone of the GTS, connecting regions via major Regional Telecommunication Hubs (RTHs). The RMTNs connect WWW centres within a Region, and the NMTNs connect the meteorological stations or centres of a particular country.
11. All but one of the 25 MTN circuits are in operation with, or have definite plans for the migration to, transmission control protocol/Internet protocol (TCP/IP). Implementation of the Improved MTN project (IMTN) is continuing, with 12 World Meteorological Centres (WMCs) and RTHs interconnected through advanced data-communications network services.
12. Significant progress has been made in the implementation of RMTNs and connecting these to the MTN,

but serious shortcomings still exist at regional and national levels in some Regions. In Region I, several GTS circuits were upgraded via leased lines, satellite-based systems or public data networks, including the Internet. Most of Region II GTS circuits were operating at medium or high speed, but five centres still have low-speed connections. A plan for an improved RMTN based on a cluster of networks using cost-effective network services, such as Frame Relay network services, is nearly implemented. Several satellite-based data-distribution systems were operating in Region II, including meteorological data distribution (MDD) and TV-Inform-Meteo. In Region III, significant progress was made with the 64 kbit s^{-1} digital connections of RTHs Brasilia and Buenos Aires. The Regional Meteorological Data Communication Network (RMDCN) has entered its implementation phase. All 13 National Meteorological Centres (NMCs) in the Region receive World Area Forecast System (WAFS) and operational meteorological (OPMET) information via the International Satellite Communications System (ISCS). In Region V, progress was made with the implementation of Frame Relay services. Several satellite-based telecommunications systems were either expanded or upgraded. Use of the Internet also increased, particularly for linking small Pacific nations. In Region VI, the RMDCN interconnects 33 RTHs and NMCs using a shared, commercially-provided managed network service to which NMCs and RTHs connect via a national access point. The RMDCN has proven to be highly reliable and very secure.

13. Satellite-based multipoint telecommunication systems are an essential component of the GTS, and each WMO region is completely covered by at least one satellite distribution system. These systems effectively complement point-to-point circuits, particularly in the delivery of processed meteorological information to NMCs.

14. High frequency (HF) radio broadcasts have high recurrent operational costs and limited efficiency; consequently, several Members have discontinued their operation. In some instances, these have been replaced by satellite distribution systems.

15. The World Radiocommunication Conference 2003 (WRC-03) had a favourable outcome and finalized several serious issues that had been under debate for many years, including the bands 401-406 MHz, 1675-1710 MHz (radiosondes and meteorological satellites) and 2700-2900 MHz (meteorological radar). Efforts are under way to safeguard the passive frequency band 23.6-24.0 GHz. This frequency band (water vapour absorption line) is crucial to WMO operations and is under threat in some regions.

16. The table-driven code forms (TDCF) are still not widely used and many NMCs can therefore not benefit from the full range of data and products available within the WWW. A comprehensive plan for a WMO-wide migration to TDCF has been developed and was endorsed by the Fourteenth World Meteorological Congress in May 2003. The implementation and coordination of the migration to TDCF has commenced, and the start of operation exchange is planned for late 2005.

GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM

17. The Global Data-processing and Forecasting System (GDPFS) generates nearly all the numerical weather prediction (NWP) products required by Members. The GDPFS is made up of WMCs, Regional Specialized Meteorological Centres (RSMCs) and NMCs.

18. Most RSMC operations have shown sustained improvement by enhancing their forecast systems and computer facilities, although some RSMCs in Region I still need to upgrade their data-processing equipment.

19. Global models are now running at 17 GDPFS centres; 76 centres run NWP models operationally; 32 run limited area models (LAMs) (with resolution coarser than 35 km); and 46 centres run mesoscale models (resolution 35 km and finer). Most major centres are running ensemble prediction systems (EPSs) for short-, medium- and extended-range forecasts, and an increasing number of centres are using EPSs for long-range forecasting.

20. Steady progress has been made in RSMC forecasts of tropical cyclone positions. Most RSMCs apply statistical models to supplement deterministic numerical models.

21. Eight RSMCs share the responsibility for disseminating atmospheric transport model products in the framework of the international coordinated response plans for nuclear emergencies, thus achieving a global coverage.

22. The monthly exchange of forecast verification scores has continued among nine GDPFS centres. Of the seven centres whose root-mean-square (RMS) errors are reported herein, most showed a small but steady improvement in forecasting 72- and 120-hour 500-hPa heights over Asia, Europe and Australia/New Zealand.

CHAPTER I

INTRODUCTION

PURPOSE AND SCOPE OF THE WWW PROGRAMME

1. Meteorological services are required for the safety of life and property, the protection of the environment, and for the efficiency and economy of a wide range of weather-sensitive activities. Central to the provision of these services is the receipt by NMCs of observational data, analyses and forecasts. WWW is the international cooperative programme that arranges for the gathering and distribution in real time, on a worldwide scale, of meteorological information required by individual Members, by other WMO programmes and relevant programmes of other international organizations. The full description of the WWW Programme, including the implementation goals, is contained in Chapter 6.1 of the *Sixth WMO Long-term Plan 2004–2011* (WMO-No. 962).

2. The overall objectives of the WWW Programme are:

(*a*) To maintain and strengthen an efficient and economic worldwide integrated system for the generation, collection, processing and exchange of meteorological and related environmental observations, analyses, forecasts, advisories and warnings and other specialized products to meet the needs of all Members, WMO Programmes and relevant programmes of other international organizations;

(*b*) To promote and support, through capacity-building, measures for the introduction of standards, procedures and technology which enable Members to contribute to, and benefit from, the WWW system and ensure the high level of quality, reliability and compatibility of observations and forecasts needed for the delivery of services required in Member countries;

(*c*) To provide the basic infrastructure for obtaining observational data and related services needed by relevant international programmes addressing global environmental issues.

COMPONENTS OF THE WWW SYSTEM

3. The WWW operates at global, regional and national levels. It involves the design, implementation, operation and further development of the following three interconnected, and increasingly integrated, core elements:

(*a*) The GOS, consisting of facilities and arrangements for making observations at stations on land and at sea, and from aircraft, environmental observation satellites and other platforms. It is designed to provide observational data for use in both operational and research work;

(*b*) The GTS, consisting of integrated networks of telecommunication facilities and centres, especially RTHs, for the rapid, reliable collection and distribution of observational data and processed information;

(*c*) The GDPFS, consisting of World, Regional/Specialized and National Meteorological Centres to provide processed data, analyses and forecast products.

4. The implementation, integration and efficient operation of the three core elements are achieved through the following support programmes:

(*a*) The WWW Data Management (WDM) programme, which monitors and manages the information flow within the WWW system to assure quality and timely availability of data and products and the use of standard representation formats to meet the requirements of Members and other WMO Programmes;

(*b*) The WWW System Support Activities (SSA) programme, which provides specific technical guidance, training and implementation support, the WWW Operational Information Service (OIS) and supports cooperative initiatives.

ORGANIZATION OF WWW PROGRAMMES

5. The WWW core elements are managed through quasi-independent programmes, each supported by a corresponding organizational unit in the WMO Secretariat. The approved operational procedures and practices of WWW are given in the regularly updated *Manual on the Global Data-processing System* (WMO-No. 485), *Manual on the Global Observing System* (WMO-No. 544), *Manual on the Global Telecommunication System* (WMO-No. 386), *Manual on Codes* (WMO-No. 306) and the associated *Guides* (see Annex IV).

6. In addition to the core element and support function programmes, the WWW depends on critical contributions of five other programmes that complement and enhance the WWW core elements in important specific areas:

(*a*) The Instruments and Methods of Observation Programme (IMOP), which improves the accuracy and standardization of instruments and observation/measurement techniques and promotes implementation of new instrument technology; the IMOP is managed under the technical responsibility of the Commission for Instruments and Methods of Observation (CIMO);

(*b*) The WMO Space Programme, which coordinates WMO requirements for environmental satellite data and products, facilitates cooperation between WMO and the satellite operators, and strengthens Members' capabilities to receive and effectively use satellite data;

(*c*) The Tropical Cyclone Programme (TCP), which assists NMSs in minimizing loss of life and property damage caused by tropical cyclones and associated phenomena;

(*d*) The Emergency Response Activities (ERA) programme, which assists National Meteorological Services (NMSs) in responding effectively to large-scale atmospheric pollution emergencies, including nuclear accidents;

(*e*) The WMO Antarctic Activities, aimed at promoting and coordinating the implementation and operation of the core elements of the WWW in the Antarctic.

7. The WMO bodies primarily concerned with WWW are the Commission for Basic Systems (CBS), CIMO and the RAs. CBS is responsible for technical matters relating to worldwide cooperation in the planning, implementation, operation and further development of the WWW system. At regional level, working groups on the regional aspects of the WWW assist the RAs in coordinating the implementation of WWW. CIMO is responsible for the scientific and technical standards relevant to instruments and observing systems deployed within WMO programmes, primarily the WWW. The WWW also receives input and guidance from bodies that work through the WMO Space Programme, in particular the Coordination Group for Meteorological Satellites (CGMS), the Committee on Earth Observation Satellites (CEOS) and the Consultative Meetings on High-Level Policy on Satellite Matters.

RELATIONSHIP OF WWW WITH OTHER PROGRAMMES

8. The WWW provides both the common infrastructure and the meteorological database to support a broad range of WMO programmes and the related activities of international organizations. Within WMO, these include TCP, the Marine Meteorology and Oceanography Programme (MMOP), the Public Weather Services Programme (PWSP), the Aeronautical Meteorology Programme (AeMP), as well as the World Climate Programme (WCP) and the Integrated Global Ocean Services System (IGOSS). The WWW implements and operates the basic infrastructure for the atmospheric component of the Global Climate Observing System (GCOS). Of particular importance is the coordination of plans and activities between WWW and international organizations, notably the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), the International Bureau of Weights and Measures (BIPM), the Food and Agriculture Organization of the United Nations (FAO), the International Atomic Energy Agency (IAEA), the International Civil Aviation Organization (ICAO), the Intergovernmental Oceanographic Commission (IOC), the International Telecommunication Union (ITU), the United Nations Environment Programme (UNEP) and the World Health Organization (WHO).

CHAPTER I

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(*b*) To promote and support, through capacity-building, measures for the introduction of standards, procedures and technology which enable Members to contribute to, and benefit from, the WWW system and ensure the high level of quality, reliability and compatibility of observations and forecasts needed for the delivery of services required in Member countries;

(*c*) To provide the basic infrastructure for obtaining observational data and related services needed by relevant international programmes addressing global environmental issues.

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CHAPTER II

THE GLOBAL OBSERVING SYSTEM

REQUIREMENTS FOR OBSERVATIONAL DATA

1. Although GOS requirements are dictated to a large degree by the needs of numerical techniques, GOS also has the responsibility of meeting the needs of WMO programmes dealing with climatology and climate change, aviation and agricultural forecasts and environmental quality monitoring. The formulation of data requirements is an evolving process based on experience with observing systems and improvements in data assimilation techniques. The process balances user demand with the technical feasibility of data resolution. The requirements for observational data for GDPFS centres are given in the *Manual on the Global Data-processing System* (WMO-No 485). The complete set of observational requirements for other WMO-supported programmes such as GCOS can be found in the CEOS/WMO online database maintained at http://alto-stratus.wmo.ch/sat/stations/SatSystem.html.

2. The frequency and density of the observations required depend on the scale of the meteorological phenomena being analysed and forecast, whether small scale, mesoscale, large scale or planetary scale. Short-range weather forecasts require more frequent observations from a denser network over a limited area in order to detect small-scale phenomena and their development. As the length of the forecast period increases, so does the area over which observations are required.

3. The WMO requirements for synoptic observational data are generally divided into three categories: global, regional and national. The first two data types are mainly used to define the initial conditions of global weather prediction models. Individual countries use national data as supplementary observations for nowcasting, severe weather warnings and other specialized services. Each WMO RA draws up a RBSN to meet the collective needs of its Members. Together, these regional networks form the global network. Generally speaking, surface synoptic stations are expected to report every six hours for global exchange and every three hours for regional exchange, while upper-air stations are required to report at least twice per day. The details of all stations operated by Members are given in *Weather Reporting* (WMO-No. 9), Volume A, which is available on the Internet via the WMO OIS home page at http://www.wmo.ch/web/www/ois/ois-home.htm.

IMPLEMENTATION OF THE SURFACE-BASED SUBSYSTEM

Surface synoptic observations

4. The status of implementation of RBSN surface stations as of 1 October 2004, according to information provided by Members, is presented in Table II-1. The level of implementation of the RBSN surface stations in 2004 that made the full eight observations per day varied from 18 per cent in Region IV to 95 per cent in Region VI, with a global average of 70 per cent. A major change in the network design in Region IV resulted in the

Table II-1
Status of implementation of RBSN surface synoptic stations as of 1 October 2004 compared to those in 2002 (the numbers of stations expected to report every three hours, every six hours, and less frequently, as committed to by Members in *Weather Reporting* (WMO-No. 9), Volume A, are shown)

WMO Region	*Required in the RBSN*		*Making the complete observing programme, at least 8 observations per day (0000, 0300, 0600, 0900, 1200, 1500, 1800 and 2100 UTC)*			*Making observations at the main hours (0000, 0600, 1200 and 1800 UTC)*			*Making some observations daily*			*Stations not yet established or otherwise non-operational*		
	Number		*Number*		*%*	*Number*		*%*	*Number*		*%*	*Number*		*%*
	2002	2004	2002	2004	*2004*	2002	2004	*2004*	2002	2004	*2004*	2002	2004	*2004*
Region I	588	611	399	366	*60*	60	61	*10*	125	174	*21*	4	10	*2*
Region II	1 234	1 234	1 126	1 118	*91*	43	43	*3*	51	55	*4*	14	18	*1*
Region III	435	435	174	170	*39*	2	1	*0*	238	242	*55*	21	22	*5*
Region IV	512	512	394	92	*18*	32	310	*61*	70	76	*14*	16	34	*7*
Region V	394	395	303	295	*75*	41	40	*10*	39	14	*10*	11	46	*12*
Region VI	769	770	732	735	*95*	10	9	*1*	20	20	*3*	7	6	*1*
Antarctic	72	75	58	60	*80*	9	9	*12*	3	3	*4*	2	3	*4*
GLOBAL	**4 004**	**4 032**	**3 186**	**2 836**	***70***	**197**	**473**	***12***	**546**	**584**	***14***	**75**	**139**	***3***
Global 1988		4040		3 042	*75*		238	*6*		3	*0*		148	*4*

number of stations making eight observations per day dramatically decreasing from 77 per cent in 2002 to only 18 per cent in 2004. However, there was a complimentary increase in the number of stations making four observations per day in Region IV to 61 per cent in 2004 compared to only 6 per cent in 2002. All RAs have reviewed and modified their RBSN during the past two years, but most changes have been relatively minor. An exception was in Region I, where there has been a significant increase to 611 stations, up from 588 stations in 2002. All RAs, including the Antarctic, maintained or slightly increased their number of RBSN stations. Overall, there has been an increase of 28 stations in the RBSN during the period 2002–2004 to a global total of 4 032 stations. This continues the trend for the period 2000–2002 when there was an increase of 47 stations in the RBSN.

5. The 2004 Annual Global Monitoring (AGM) of the Implementation of the WWW indicates the number of SYNOP reports actually received at centres on the GTS. Highlights of that report are contained in Chapter V. Figure V-3 shows that the percentage of reports received compared to those required from the RBSNs in 2004 ranged from 53 per cent in Region I to 94 per cent in Region VI, with a global average of 77 per cent. The 2004 results show that 23 per cent of required reports are missing in the international exchange. The main reason for this data loss is that 353 stations included in the RBSNs did not report during the 2004 monitoring period. However, the majority of these so-called 'silent stations' are implemented according to *Weather Reporting* (WMO-No. 9), Volume A. Some reports are also not received because of telecommunication problems, although the proliferation of digital and high-quality circuits in recent years has resulted in telecommunication problems now being a minor cause of lost reports. Figure II-1 shows the average number of SYNOP observations received daily from RBSN stations during October monitoring periods 1994–2004. The 2004 result is the highest ever number of SYNOP reports received since the start of monitoring, and the seventh consecutive year that the number of received reports has increased. Figure II-2 gives an indication of the relative density of SYNOP observations received from each Region. This relative density is obtained from the number of SYNOP reports received in each Region divided by the Regional surface land area taken as a percentage of the global total. The average regional density is 16.6 per cent, and it is therefore apparent that Region I and Region III have a lack of coverage of SYNOP reports. Region I has 23 per cent of the global land but only 11 per cent of the observations, with a resulting density of seven per cent. Region III with 13 per cent of the global land area but only eight per cent of the global total of synoptic observations has a relative density of nine per cent. By comparison, Region VI, with eight per cent of the global land area and 23 per cent of the observations, has a very dense relative coverage of SYNOP reports of 40 per cent, more than twice the global average density.

6. In addition to stations in the RBSNs, a large number of supplementary stations have been established to meet mostly regional and national needs. Table II-2 shows the increase in the total number of stations, including RBSN and supplementary stations, established since 1988. This increase is over one per cent per year, and has been occurring regularly for the last 16 years. In 2004, the number of established stations was slightly more than 11 000, whereas in 1994 the number of stations was slightly less than 10 000. Many of the established stations are automatic stations, whose numbers are steadily increasing and reached a total of 3 077 in October 2004, compared to 2 391 stations in October 2002, a healthy increase of 29 per cent in two years. Over one quarter of all established stations are now automatic. All Regions show an increase in the number of automatic stations (Figure II-3), with a significant increase in Region IV and Region VI. Of these 3 077 automatic stations, 651 are included in the RBSN. Thus, 16 per cent of all surface synoptic stations in the RBSN are automatic stations.

Upper-air observations

7. Some 90 per cent of all established upper-air stations are included in the RBSNs. Table II-3 shows the

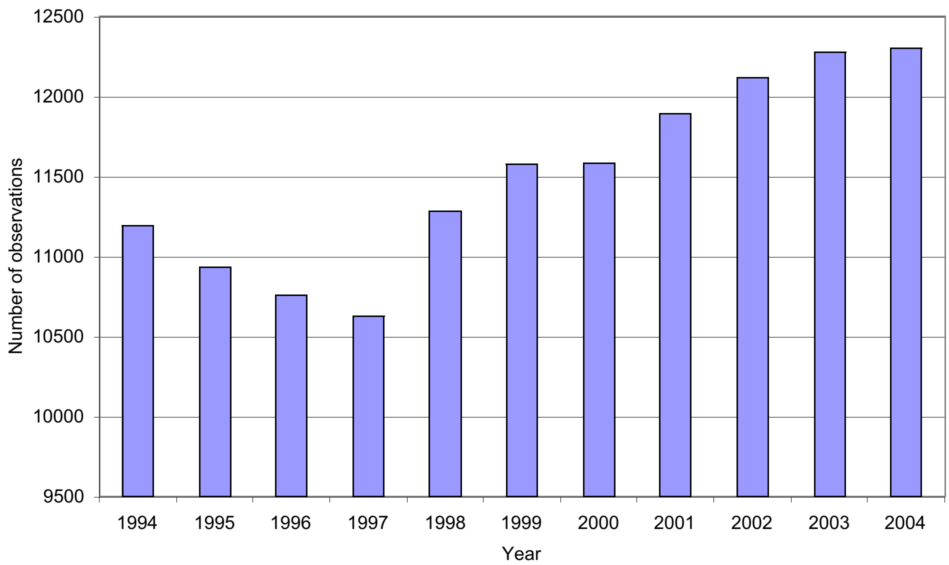


Figure II-1 — Average daily number of SYNOP reports received on the GTS from RBSN stations during the 15-day AGM period 1994–2004.

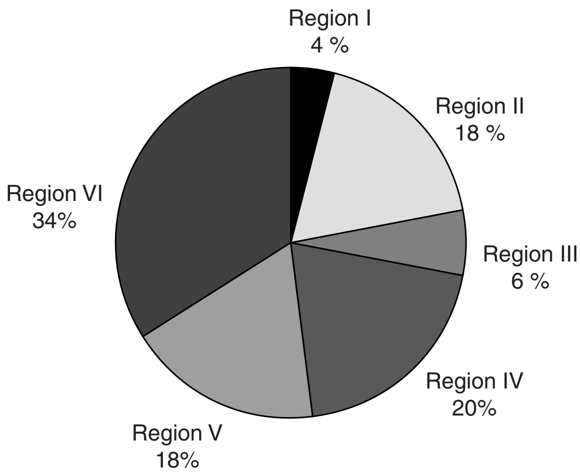


Figure II-2 — Relative surface density of SYNOP reports from RBSN stations received during the October 2004 AGM monitoring period.

status of implementation of all upper-air stations in the 2004 RBSN with comparable figures for 2002. With regard to this table, it should be noted that all upper-air stations are radiowind stations (891 stations globally), but that not all upper-air stations are radiosonde stations (820 stations globally). This means that 71 of these upper-air stations make wind observations only. Table II-3 shows that, during the two-year period 2002–2004, the number of fully operational stations (making two observation per day) again decreased, continuing the trend of the previous four-year period. The number of radiowind stations dropped slightly from 625 to 622, and the number of radiosonde stations dropped from 588 to 581. However, the implementation as a percentage of the RBSN did not change significantly, with radiosonde implementation decreasing from 72 per cent in 2002 to 71 per cent in 2004. Geographical distribution remains a concern, with the southern hemisphere having consistently lower percentages of stations proposed for making two observations a day than the northern hemisphere. There is also a persistence of data-sparse areas over some parts of Africa and South America.

8. The number of upper-air reports actually received as compared to those required from the RBSN during the 2004 monitoring period at MTN centres varied from 36 per cent in Region I to 86 per cent in Region IV, with a global average of 67 per cent (Figure V-8). For the first

Table II-2
All surface synoptic stations implemented for the period 1988–2004 (the percentage increase during the 16 years since 1988 is indicated as well as the numbers of stations making hourly and CLIMAT observations)

Year	*Total number of stations*	*Making observations at*					*Climate reporting*
		0000 UTC	*0600 UTC*	*1200 UTC*	*1800 UTC*	*Hourly*	
1988	9 525	6 958	7 390	7 904	7 255	3 849	1 830
1990	9 649	7 016	7 483	7 499	7 323	3 965	2 247
1992	9 762	7 168	7 597	8 065	7 420	4 162	2 264
1994	9 950	7 314	7 786	8 313	7 634	4 449	2 310
1996	10 106	7 469	7 898	8 460	7 776	4 585	2 528
1998	10 214	7 697	8 017	8 595	7 926	4 712	2 499
2000	10 602	8 072	8 376	8 974	8 333	5 027	2 729
2002	10 932	8 365	8 661	9 247	8 617	3 202	2 628
2004	11 205	8 677	8 951	9 537	8 918	5 636	2 881
Increase since 1988 (percentage)	18	25	21	21	23	46	57

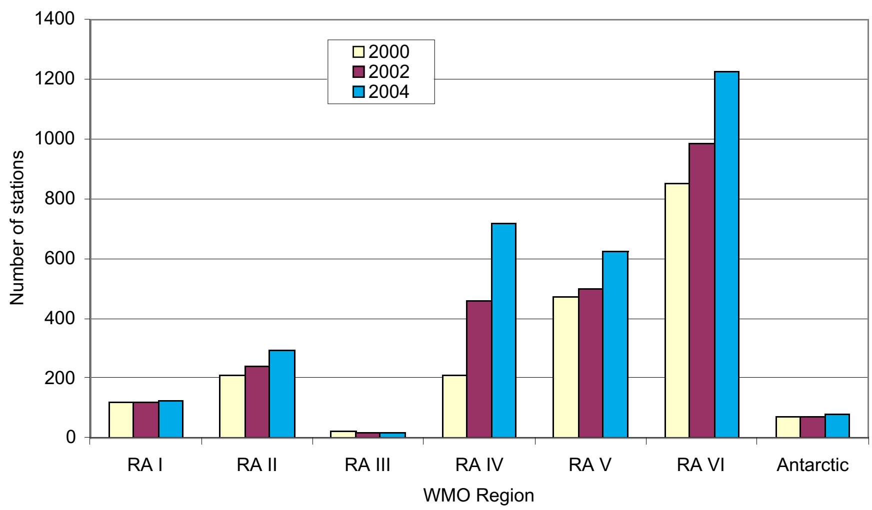


Figure II-3 — Number of automatic weather stations (AWS) operational in 2000, 2002 and 2004 according to *Weather Reporting* (WMO-No. 9), Volume A.

Table II-3
Status of implementation of RBSN upper-air stations, showing the number of stations requested and the number and percentage implemented as of 1 October 2004, compared to 2002
(W = Radiowind R = Radiosonde)

WMO Region	*Stations in the RBSN*				*Making observations at 0000 and 1200 UTC*						*Making one observation per day*						*Stations not yet established or otherwise non-operational*					
	Number				*Number*				*%*		*Number*				*%*		*Number*				*%*	
	2002		2004		2002		2004		2004		2002		2004		2004		2002		2002		2004	
	W	R	W	R	W	R	W	R	W	R	W	R	W	R	W	R	W	R	W	R	W	R
Region I	106	91	105	92	24	24	24	23	23	25	53	48	53	46	50	50	29	19	29	22	28	24
Region II	327	294	328	295	250	241	251	242	77	82	37	42	37	42	11	14	40	11	40	11	12	4
Region III	58	58	58	58	15	15	15	15	26	26	34	34	34	34	59	59	9	9	9	9	16	16
Region IV	143	142	143	142	126	126	126	126	88	89	11	11	12	11	8	8	6	5	5	5	3	4
Region V	118	87	109	87	81	54	76	46	70	53	34	38	30	27	28	31	3	5	3	4	3	5
Region VI	136	136	135	135	123	122	124	123	92	91	9	10	9	10	7	7	4	4	2	2	1	1
Antarctic	13	12	13	13	6	6	6	6	46	46	6	6	6	6	46	46	1	0	1	1	8	8
GLOBAL	**901**	**820**	**891**	**822**	**625**	**588**	**622**	**581**	**70**	**71**	**184**	**189**	**181**	**176**	**20**	**21**	**92**	**53**	**89**	**54**	**10**	**7**
GLOBAL 1988			988	855			720	642	73	72			147	166	15	19			121	87	12	10

time in several years, the total number of TEMP reports received daily has increased. However, nine per cent of the radiosonde network (92 stations) included in the RBSNs did not report during the 2004 monitoring period, even though the majority of these 'silent stations' are implemented according to *Weather Reporting* (WMO-No.9), Volume A.

9. Figure II-4 shows the average number of RBSN TEMP observations received daily during October monitoring periods 1994–2004. From this figure, it can be seen that the number of TEMP reports received is now almost back to the number of observations received a decade ago. In fact, the number of reports received in 2004 was the highest number received since 1995. However, large gaps in upper-air reports still persist in certain regions of Africa, South America, and Central and Northern Asia, mainly due to lack of consumables and obsolete equipment. Figure II-5 shows the relative surface density of TEMP observations received from each Region, a value arrived at by taking the number of TEMP reports received in each Region divided by the surface area of each Region and compared to the global total. The average regional density is 16.6 per cent. As is the case with SYNOP observations, it is apparent that there is a definite lack of coverage of TEMP observations in Regions I and III. This compares with Region VI, which has twice the density of TEMP reports compared to the global average.

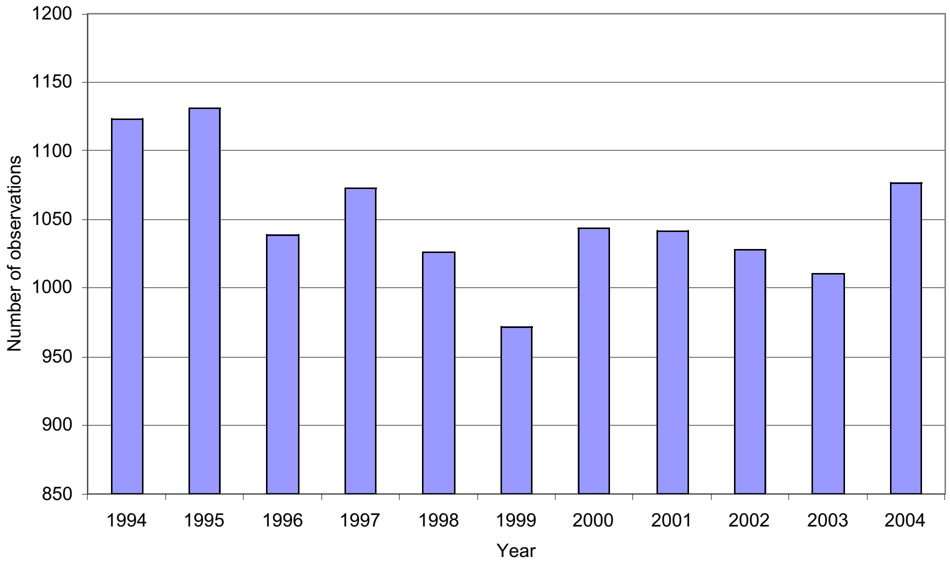


Figure II-4 — Average daily number of TEMP reports received on the GTS from RBSN stations during the 15-day AGM period 1994–2004.

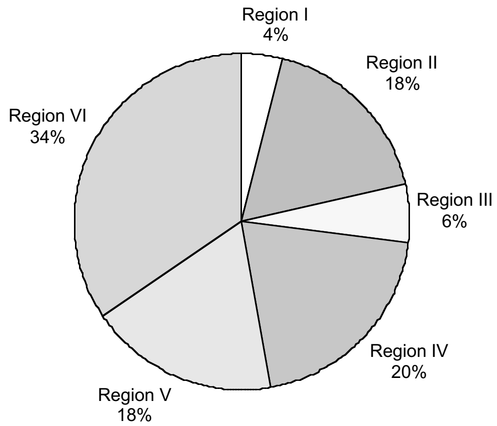


Figure II-5 — Relative surface density of TEMP reports from RBSN stations received during the October 2004 AGM monitoring period.

Table II-4
Status of RBCN as of October 2004, compared to that of October 2002

RSBN	*CLIMAT*		*CLIMAT TEMP*	
WMO Region	*2002*	*2004*	*2002*	*2004*
Region I	616	637	19	28
Region II	593	593	194	194
Region III	344	325	49	49
Region IV	242	298	72	58
Region V	188	192	74	77
Region VI	520	526	91	88
Antarctic	72	29	12	13
Global	2 575	2 600	511	507

Climatological observations

10. RBCNs have been established for each Region. This network includes the stations in the GCOS Surface Network (GSN) and the GCOS Upper-air Network (GUAN) stations, supplemented by other CLIMAT and CLIMAT TEMP reporting stations needed to meet national and regional requirements. These RBCN stations now serve as the target list for WWW monitoring. As of October 2004, these networks comprised a total of 3 107 stations, of which 2 600 are CLIMAT stations and 507 are CLIMAT TEMP stations. The regional breakdown is shown in Table II-4.

11. The number of CLIMAT and CLIMAT TEMP reports available during the last decade was far from an ideal network and reached only about 40 per cent of the total number of expected stations. In addition, about 20 per cent of stations initially selected for the GSN were not in the RBSNs and consequently were not monitored during WWW monitoring. The establishment of the RBCNs is aimed at increasing the availability of CLIMAT and CLIMAT TEMP reports, both overall and for GSN and GUAN requirements. Monitoring conducted during the 2004 AGM of the number of reports received compared to the number of reports expected from the RBCNs showed that 62 per cent of the CLIMAT reports and 71 per cent of the CLIMAT TEMP reports had been received. This is still not considered satisfactory, and several initiatives have been taken to rectify the deficiencies. To improve the generation and dissemination of CLIMAT and CLIMAT TEMP data, a series of regional training seminars has been organized, with the first one held in Moscow in November 2004. Additionally, a special handbook on operational procedures and practices to be used by observers in compiling and transmitting CLIMAT and CLIMAT TEMP reports over the GTS was prepared and distributed in 2004.

12. The GUAN, composed of 152 stations, and the GSN, composed of 981 stations, were established in 1996 and 1999, respectively, to provide a global backbone network of homogeneous, long-term and high-quality climate data. For both networks, monitoring centres have been established. GUAN performance is monitored by the United Kingdom Met Office (UKMO) Hadley Centre with respect to monthly CLIMAT TEMP reports and by the National Climatic Data Center (NCDC) in Asheville, United States, with respect to TEMP reports (see http://www.guanweb.com). The GSN is monitored jointly by the Japan Meteorological Agency (JMA) with an emphasis on temperature and the *Deutscher Wetterdienst* (*DWD*) with an emphasis on precipitation (see http://www.gsnmc.dwd.de). With regard to GUAN, a slight decrease in the availability of CLIMAT TEMP reports was reported, dropping from 77 per cent in June 2002 to 74 per cent in June 2004. Figure II-6 shows the reception of CLIMAT TEMP reports during 2004, as monitored by the Hadley Centre. With regard to the availability of CLIMAT reports from GSN stations, since the beginning of monitoring in January 2000, there has been a continuous improvement in the performance of the GSN, from 60 per cent in December 2001, to 63 per cent in December 2002 and 67 per cent in December 2003. Figure II-7 shows the availability of CLIMAT messages on a regional basis for the period 2000–2003, where big differences in the performance between the Regions are evident. However, it is apparent that the number of reports received is increasing from all Regions, with some Regions showing very significant gains of over 20 per cent in the availability of CLIMAT reports over the three-year monitoring period.

Marine meteorological observations

13. WMO relies on ships, moored and drifting buoys and stationary platforms for synoptic surface and upper-air observations over ocean areas, and profiling floats for data through the ocean depths. Observations from ships adequately cover the major shipping lanes. Moored and drifting buoys play a very important role in providing observations from the large data-void ocean areas.

14. The total number of ships recruited by Members for the WMO VOS programme and actively reporting observations has decreased in recent years. At present, 52 Members operate VOS, with the total number of active ships at the end of 2003 being 6 651. The number of ship

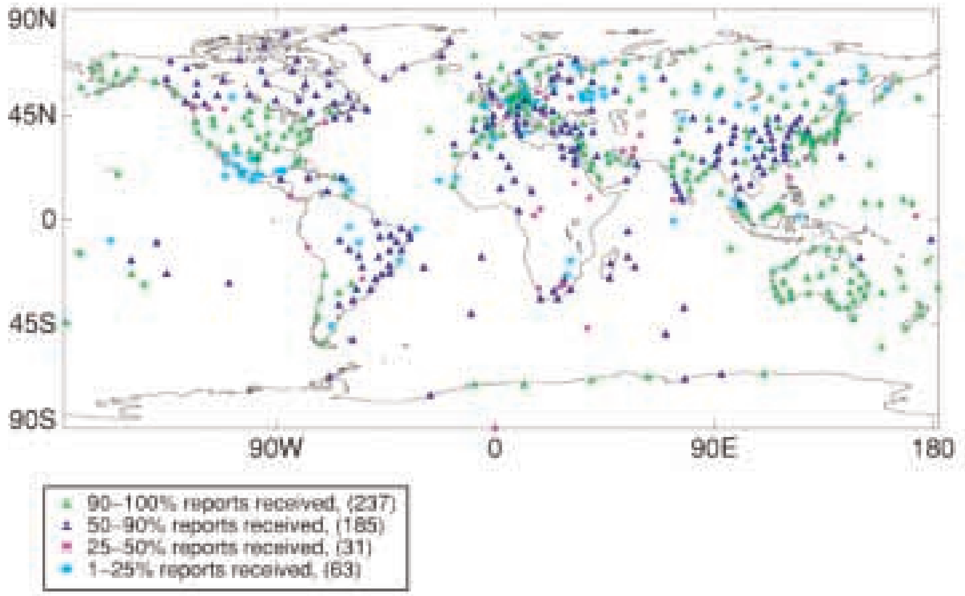


Figure II-6 — CLIMAT TEMP reports received during 2004 (from UKMO — Hadley Centre).

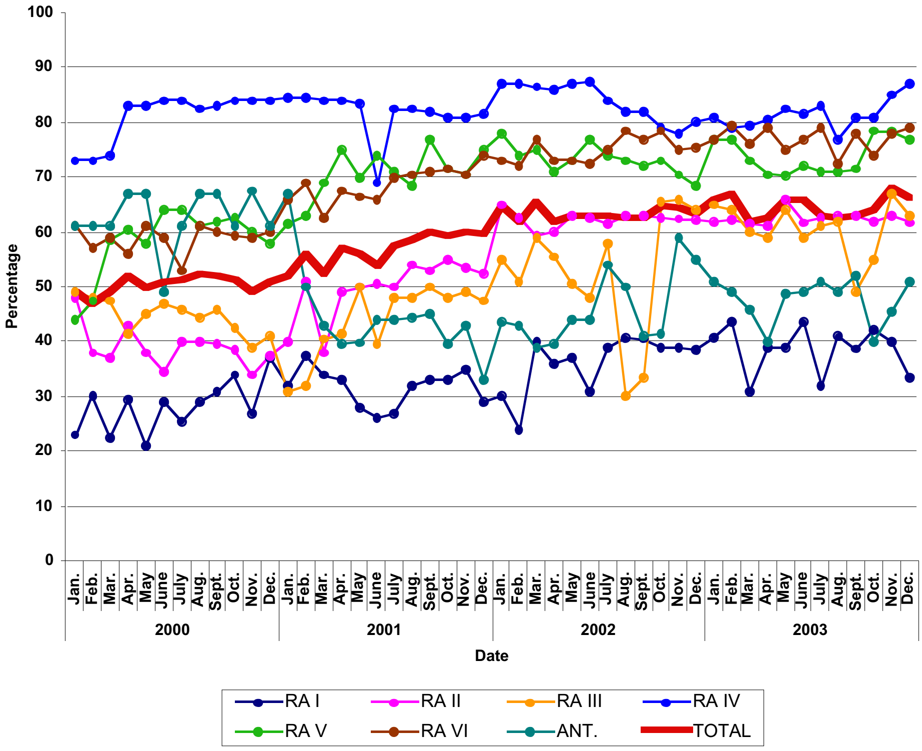


Figure II-7 — Percentage of CLIMAT reports received from GSN stations during the period 2000–2003 (from GSNMC, Germany).

reports received at MTN centres has not changed significantly over recent years, and during the last eight years has remained fairly constant at about 6 000 reports per day. It should be noted, however, that less than half (43 per cent in July 2004) of all ship reports received at MTN centres originate from VOS ships. The remainder (and majority) come from moored buoys, oil rigs and fixed platforms. Figure V-16 shows that during the period October 1996 to October 2004 there was a fairly constant reception of about 2 700 ship reports per day from VOS ships. During this same monitoring period, the daily receipt of SHIP TEMP reports has remained essentially constant at 15 to 20 reports per day (Figure V-16).

15. There has been a continuing increase in the deployment of other types of sea stations. By June 2004, the total number of active drifting buoys deployed globally and reporting data to the GTS was around 945, compared with 750 in 2002. Coverage of buoy reports during the October 2004 monitoring period can be seen in Figure V-13. During the past 10 years, the number of air-pressure reports from drifting buoys increased five-fold, from approximately 50 000 to around 250 000 per month in mid-2004. Since July 2003, all drifting buoy reports are encoded and transmitted in BUFR code format. The collection of buoy data via satellite is carried out mostly through the Argos System, a cooperative undertaking between the National Centre for Space Studies (CNES) of France and the National Oceanic and Atmospheric Administration (NOAA) of the United States.

16. Automated marine stations on moored buoys, fixed platforms and oil rigs supplement the GOS to an increasing extent. In addition to meteorological parameters, these stations provide oceanographic and other environmental data, including wave height and direction, sea temperature, water and air pollution data, and surface and underwater currents. In July 2004, there were 221 such supplementary platforms, contributing 53 per cent of all available ship reports transmitted in SHIP format. A total of 20 fully automated systems under the Automated Shipboard Aerological Programme (ASAP) were operated during 2003 by nine countries, primarily in the North Atlantic, although there were some observations from all ocean basins. ASAP provides valuable upper-air data from the data-sparse ocean areas. The number of radio-soundings has averaged at around 5 500 soundings annually in the period 1995–2003. In addition to oceanic surface and upper-air observations, two other marine programmes contribute subsurface temperature, salinity and current data. The Ship-of-Opportunity Programme (SOOP) committed 19 000 expendable bathytheromograph (XBT) drops during 2003, providing important subsurface data over specific ship tracks. A complementary programme is Argo, a network of 3000 profiling floats distributed over the entire ocean and planned to be fully implemented in 2006/7. In November 2004, Argo reached an important milestone, with half of its planned network implemented. Eighteen countries participate in Argo. Each float provides a monthly report of the complete profile of temperature and salinity to a depth of 2 000 m. In July 2004, Argo provided about 110 profiles daily. Figure II-8 shows the Argo network as of January 2005. See http://www-argo.ucsd.edu for more details.

Aircraft meteorological observations

17. Conventional aircraft weather reports (AIREP) have continued to decline (Figure V-16) as automated reporting of meteorological data from aircraft has been increasing. Monitoring in 2004 showed that less than 4 000 AIREP reports were exchanged daily on the GTS. The volume of AMDAR data increased from about 140 000 in 2002 to nearly 200 000 in 2004. Over 50 per cent of the aircraft providing AMDAR data fly between Europe and North America and within these continents. They mostly transmit their observations in BUFR code. Reports in BUFR code, which outnumber reports in character code, have only recently begun to be counted during the monitoring periods. There is a smaller, but significant, number of AMDAR reports over Australasia, Asia and South Africa. The aircraft to satellite data acquisition and relay (ASDAR) programme had been producing less data in recent years, and it was formally terminated in December 2003. Automated air reporting from the North Atlantic and Pacific regions carried out in association with the ICAO automatic dependent surveillance (ADS) transmitted about 6 000 meteorological reports per month to the World Area Forecast Centres (WAFCs) in London and Washington. The AMDAR programme in the United States received over 100 000 reports per day. Over half of these reports were obtained at level flights, but an increasing number of reports were being obtained during the ascent and descent phases of flights. These data were distributed via the GTS in WMO standard BUFR format. New AMDAR programmes have become operational in Saudi Arabia and Hong Kong, China. In mid-2004, two Saudi aircraft were operational, but the number of aircraft is planned to increase to 29. Hong Kong, China, is producing data from one aircraft, but this number is anticipated to increase. Japan has a fully operational system producing 10 000 reports per day in the Japan area. These data have been exchanged since August 2004. The Canadian AMDAR programme is semi-operational, and in late 2004 was producing about 10 000 reports daily. Work is continuing on new AMDAR systems in China, Argentina and the Arab Emirates. India has commenced planning an AMDAR system, and several other countries are planning to join, including Hungary, Poland, Morocco and the Russian Federation. The United States Tropospheric Airborne Meteorological Data Reporting (TAMDAR) system uses its own unique sensor package. During 2004, the system was undergoing evaluation trials. Sensors have been installed on two Canadian aircraft and 60 American regional aircraft. A number of countries have indicated interest in using the TAMDAR system once the system is established and becomes operational. The WMO Executive Council in 2004 approved the integration of AMDAR into WWW and its

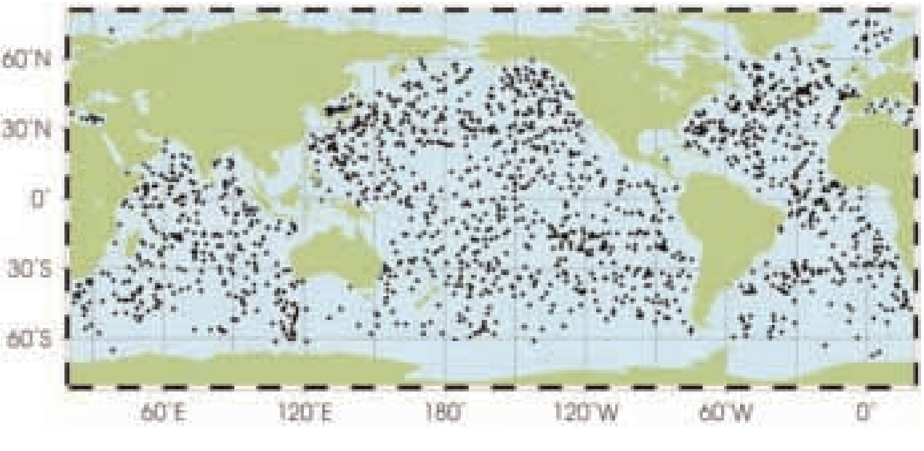


Figure II-8 — Argo network as of January 2005.

coordination mechanisms. Steps have been taken to further integrate AMDAR into the GOS, and to this end several AMDAR training workshops were held in 2003 and 2004.

Other observation stations/systems

18. Observations from weather radar stations, along with geostationary satellite data, constitute one of the best means of studying small-scale and mesoscale cloud precipitation systems. They are essential for the effective and reliable detection, tracking and forecasting/warning of dangerous weather phenomena such as tropical cyclones and tornadoes. In some countries, systems combining the output of radar networks and the information received from geostationary meteorological satellites are in operational use, or are at an advanced stage of development. Combined systems such as these now number in the low thousands. In addition, some Members have indicated that they are operating spherics detection systems for the detection and location of lightning flashes. The increasing skill of forecasters, along with the availability of radar, satellite and now spherics data, both in situ and through the GTS and the Internet, has enhanced the quality of severe weather prediction and warning whenever these data are made available. Wind-profiling and Doppler radars are proving to be extremely valuable in providing data of high resolution in both space and time, especially in the lower layers of the atmosphere. Wind profilers are especially useful in making observations at times between balloon-borne soundings, and have great potential as a part of integrated networks. Doppler radars are used extensively as part of national and, increasingly, regional networks, mainly for short-range forecasting of severe weather phenomena. The Doppler radar capability of making wind measurements and estimates of rainfall amounts is particularly useful.

19. The GOS also comprises stations intended for purposes such as the Global Atmosphere Watch (GAW), radiation measurements, meteorological rocket soundings, climatological and agricultural observations, radioactivity measurements and tide-gauge measurements. Because these stations mainly provide specialized information for WMO programmes outside WWW, details are not included here.

THE SPACE-BASED SUBSYSTEM

20. The Fourteenth World Meteorological Congress (Geneva, May 2003) recognized the critical and fast growing importance of data, products and services provided by the WWW's expanding space-based component of the GOS to WMO Programmes and WMO-supported programmes. Congress decided to initiate a new major WMO Space Programme as a cross-cutting programme to increase the effectiveness and contributions from satellite systems to the development of WWW's GOS, as well as to other WMO-supported programmes and associated observing systems (GAW, GCOS, the World Climate Research Programme (WCRP), the World Hydrological Cycle Observing System (WHYCOS) and the Global Ocean Observing System (GOOS)).

21. The space-based component the GOS now comprises three types of satellites: operational meteorological polar-orbiting and geostationary satellites and environmental R&D satellites (see Figure II-9). With regard to meteorological satellites, both polar-orbiting and geostationary, they continue to be invaluable to WMO National Meteorological and Hydrological Services (NMHSs) through the provision of many services, including imagery, soundings, data collection and data distribution. The current constellation of operational meteorological satellites includes GOES-9, GOES-10,

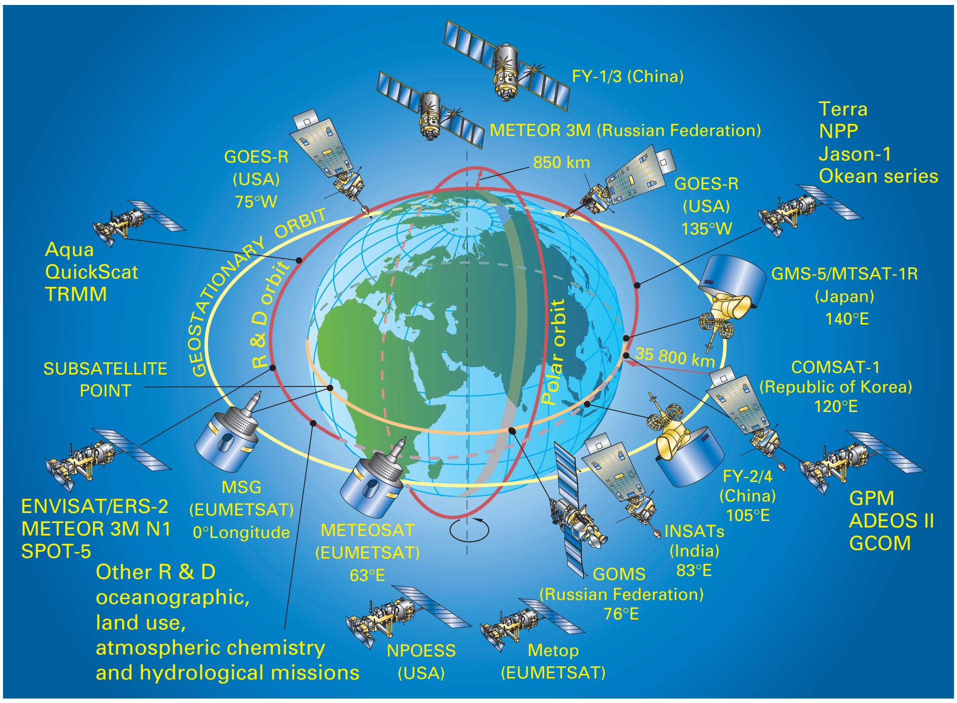


Figure II-9 — Satellite systems comprising the space-based component of the Global Observing System.

GOES-12, NOAA-16 and NOAA-17 operated by the United States; GMS 5 operated by Japan; METEOR-3M N1 operated by the Russian Federation; Meteosat-5, Meteosat-7 and Meteosat-8 operated by EUMETSAT; and FY-2B and FY-1D operated by China. Additional satellites in orbit or in commissioning included GOES-11, NOAA-11, NOAA-12, NOAA-14 and NOAA-15 operated by the United States; GOMS/Electro N1 operated by the Russian Federation; Meteosat-6 operated by EUMETSAT; and FY-2A and FY-1C operated by China. In order to complement and further improve the space-based subsystem of WWW's GOS, R&D satellites are also incorporated into the GOS. They include the National Aeronautics and Space Administration (NASA) Aqua, Terra, NPP, TRMM, QuikSCAT and GPM missions; the European Space Agency (ESA) Envisat, ERS-1 and ERS-2 missions; the Japanese Aerospace Exploration Agency (JAXA) GCOM series; the Russian Federal Space Agency (Roskosmos) research instruments on board the Russian Federal Service for Hydrometeorology and Environmental Monitoring (ROSHYDROMET) operational METEOR 3M N1 satellite, as well as on its future ocean series; and the CNES JASON-1 and SPOT-5.

22. Current information related to satellite status, broadcast schedules and future plans can be found on the WMO home page at http://www.wmo.ch by selecting "WMO Space Programme" from its drop-down menu. The current status of polar-orbiting and geostationary satellites is shown in Table II-5 and Table II-6, respectively. The future plans for polar-orbiting and geostationary satellites are shown in Table II-7 and Table II-8, respectively.

IMPLEMENTATION GOALS FOR SATELLITE RECEIVERS

23. Both polar-orbiting and geostationary satellites provide visible and infrared cloud images. Geostationary satellites also provide water vapour images and indications of wind structure, the latter being of particular value in the tropics. Polar-orbiting satellites are equipped with vertical profile radiometers for temperature and humidity soundings. Both types of satellites operate data collection and dissemination services. It should be noted that the goals for WMO Members are 100 per cent for polar-orbiting satellite data receivers, either automatic picture transmission (APT) or high-resolution picture transmission (HRPT), and 100 per cent for geostationary satellite receivers, either weather facsimile (WEFAX) or high resolution (HR). This means that each WMO Member should be equipped with at least one polar-orbiting satellite data receiver and one geostationary satellite data receiver. In this regard, WMO Members have achieved an overall implementation of 88 per cent, 89 per cent, 100 per cent, 76 per cent, 86 per cent and 84 per cent for polar-orbiting and geostationary satellite receivers in WMO Regions I, II, III, IV, V and VI, respectively. It should also be noted that access to satellite data and products by Members could be through a composite data access service comprising both direct broadcast from satellite systems and advanced dissemination methods (ADM). ADM are the baseline, while direct broadcast reception serves as back-up, as well as for those WMO Members unable to take advantage of ADM. Thus, the number of receiving stations may not increase if the use of ADM increases. Over the coming years, low rate picture transmission (LRPT)/low rate information transmission (LRIT) will replace the present APT/WEFAX receivers. The transition will have a direct and potentially large impact on existing and planned ground receiving equipment belonging to WMO Members. The transition schedule can be found on the web page of WMO Space Programme as mentioned above.

QUALITY OF OBSERVATIONAL DATA

24. The quality of observational data is regularly monitored and reported on under the guidelines in Part V—Quality control of the *Manual on the Global Observing System* (WMO-No. 544). The monitoring is carried out by designated lead centres (Table II-9). The procedures and formats for the exchange of monitoring results are published in Attachment II-10 of the *Manual on the Global Data-processing System* (WMO-No 485). These include selection criteria for the determination of 'suspect' stations. These standardized criteria assist in the intercomparison of the various lead centres. The lead centres produce six-monthly reports on the results of data quality monitoring. These reports are distributed to Members so that they can take remedial action, as required. These Members/agencies then report to lead centres and the Secretariat on their remedial efforts. A WMO web site to support data quality monitoring is available at http://www.wmo.ch/web/www/DPS/Monitoring-home/mon-index.htm.

Upper-air data quality

25. As well as regular monthly monitoring of the quality of upper-air data conducted by several monitoring centres, detailed six-monthly reports are prepared by the European Centre for Medium-Range Weather Forecasts (ECMWF) and the designated lead centre for monitoring upper-air data. Each report includes details of stations reporting 'suspect' geopotential heights and 'suspect' wind speed and wind direction and 'suspect' temperature. In addition to monitoring radiosonde data, wind-profiler data is also included in the monitoring.

Land-surface data quality

26. The quality of land-surface reporting continues to improve. For some Regions, the number of 'suspect' stations remained effectively constant, but for others this number decreased. To assist with consistency, and to allow easy comparison of results from all monitoring centres, a revised set of monitoring rejection criteria has been adopted to overcome the discrepancies caused by centres using disparate selection criteria. Some examples of the types of errors that have been documented are the use of a wrong station elevation, errors in the reduction to mean sea level, use of

Table II-5
Polar-orbiting satellites coordinated within CGMS in orbit as of November 2004

Orbit type (equatorial crossing times)	*Satellites (+ operation mode)*	*Operator*	*Crossing time (+ altitude)*	*Launch date*	*Status*
Sun-synchronous 'Morning' (0600–1200) (1800–2400)	NOAA-17 (Op)	USA/NOAA	1002 (D) 833 km	06/02	Functional
	NOAA-15 (B)	USA/NOAA	0708 (D) 813 km	05/98	Functional (problems with AVHRR + HIRS)
	NOAA-14 (B)	USA/NOAA	1752 (A), 850 km	12/94	Functional. One OBP is not functioning.
	NOAA-12 (L)	USA/NOAA	0449 (D), 850 km	05/91	Functional (except sounding)
	NOAA-11 (L)	USA/NOAA	2237 (A), 845 km	09/88	Functional. SBUV instrument data limited.
	DMSP F-15 (Op)	USA/NOAA	2029 (A), 833 km	12/99	Defence satellite. Data available to civilian users through NOAA.
	DMSP F-14 (B)	USA/NOAA	2029 (A), 833 km	04/97	Defence satellite. Data available to civilian users through NOAA.
	FY-1D (Op)	China	0900 (D), 863 km	05/02	Functional
	FY-1C (B)	China	0850 (D), 863 km	05/99	Functional
	SPOT-5 (R)	CNES	1030 (D), 800 km	05/02	Functional
	Envisat (R)	ESA	1030 (D), 782 km	03/02	Functional
	ERS-1 (R)	ESA	1030 (D), 782 km	07/91	Replaced by ERS-2 in 03/00 after an overlapping period
	ERS-2 (R)	ESA	1030 (D), 782km	04/95	Owing to OB recorder problems in 06/03, the LBR mission is ensured over ESA acquisition station only
	QuikSCAT (R)	USA/NASA	0600 (A), 803 km	06/99	Functional
	Terra (R)	USA/NASA	1030 (D), 705 km	12/99	Functional
Sun-synchronous 'Afternoon' (1200–1600) (0000–0400)	NOAA-16 (Op)	USA/NOAA	1354 (A) 870 km	09/00	Funtional
	Aqua (R)	USA/NASA	1330 (A), 705 km	05/02	Functional
Sun-synchronous 'Early morning' (0400–0600) (1600–1800)	DMSP-F13 (Op)	USA/NOAA	1812 (A) 833 km	03/97	Defence satellite. Data partly available to civilian users through NOAA
Non sun-synchronous or unspecified orbits	METEOR-3M N1 (Op)	Russian Federation	1 018 km (A)	12/01	Functional
	METEOR-3 N5 (Op)	Russian Federation	1 200 km (A)	08/91	Functional (APT transmissions of visible images)
	TRMM (R)	USA/NASA	350 km	11/97	Functional
	Jason-1 (R)	CNES	1 336 km	12/01	Functional

R = R&D B = Back-up A = North
Op = Operational L = limited availability D = South

incorrect station pressure, and problems with consistency of barometer readings. Standardization and quality control for automatic weather stations (AWSs) are becoming more important with the introduction of new more sophisticated sensors and processing algorithms. Basic quality control procedures are applied at the AWS. More extended quality control is applied at national data-processing centres.

Marine surface data quality

27. RSMC Exeter, the lead centre for quality monitoring of surface marine data, collects statistics on all ship call signs and buoy identifiers, from which a list of 'suspect' platforms is produced. Currently, the six-monthly lead centre report includes mean sea-level

Table II-6
Geostationary satellites coordinated within CGMS in orbit as of November 2004

Sector	*Satellite (+ type)*		*Operator*	*Location*	*Launch date*	*Status*
East Pacific (180°W–108°W)	GOES-10	(Op)	USA/NOAA	135°W	04/97	Inverted, solar array anomaly, DCP interrogator on backup
West Atlantic (108°W–36°W)	GOES-12	(Op)	USA/NOAA	75°W	07/01	Functional
	GOES-11	(B)	USA/NOAA	103°W	05/00	In orbit backup to GOES-10, -12
East Atlantic (36°W–36°E)	METEOSAT-7	(Op)	EUMETSAT	0°	09/97	Functional
	METEOSAT-8	(Op)	EUMETSAT	3°W	08/02	Functional
	METEOSAT-6	(B)	EUMETSAT	9°E	11/93	Rapid Scanning Service minor gain anomaly on IR imager
Indian Ocean (36°E–108°E)	METEOSAT-5	(Op)	EUMETSAT	63°E	03/91	IODC, functional but high inclination mode
	FY-2B	(Op, L)	China	105°E	06/00	Only hemispheric scanning since 06/03. Image transmission stops in eclipse periods
	FY-2A	(B, L)	China	87°E	06/97	
	FY-2C	(P)	China	105°E	10/04	
	INSAT-2E	(Op)	India	83°E	04/99	Operational multipurpose satellite
	INSAT-3A	(Op)	India	94°E	04/03	Operational multipurpose satellite
	KALAPANA	(Op)	India	83°E	12/02	Dedicated meteorological satellite
	GOMS/Electro N1	(B)	Russian Federation	76°E	11/94	Since 09/98 in standby
West Pacific (108°E–180°E)	GOES-9	(Op)	USA/NOAA	155°E	05/95	Poviding data to Japan
	GOES-8	(B, L)	USA/NOAA	165°E	04/94	Back-up to GOES-9
	GMS-5	(Op, L)	Japan	140°E	03/95	Back-up to GMS-5 with GOES-9 started 05/03

P = Pre-operational B = Back-up
Op = Operational L = Limited availability

pressure (MSLP), wind speed, wind direction and sea-surface temperature (SST). There are plans to expand this list to include air temperature and relative humidity (which are required for the VOS Climate project (VOSClim)). An example of the ship monitoring conducted by RSMC Exeter is the monitoring of the quality of surface pressure from ships. Monitoring allows the identification of those ships which consistently report low-quality (RMS deviations above a certain level compared with first-guess field) pressure observations over a period of time. The six-monthly monitoring reports are distributed to port meteorological officers at the NMSs which recruited the identified ships, along with a request to undertake remedial action. The effectiveness of both the monitoring and follow-up actions was confirmed by the fact that the number of ships making consistently bad pressure observations fell from 50 to 60 ships per month several years ago to a reasonably constant current level of 20 to 25 ships per month. This number would undoubtedly rise again if the monitoring and follow-up were to be discontinued.

28. A number of major meteorological centres undertake real-time monitoring of the quality (compared with the first-guess model fields) of variables reported by drifting buoys and received via the GTS. The monitoring results are relayed to buoy operators through an Internet mailing list, in accordance with the Quality Control Guidelines recommended by the Data Buoy Cooperation Panel (DBCP). An example of the positive results of the operation of these guidelines is seen in the RMS difference between buoy air-pressure observations and the first-guess model field, which has decreased from around 2.0 hPa in 1994 to near 1.0 hPa in 2004 (Figure II-10). The mean difference is now probably close to the uncertainty in the model. The improved quality of these observations over the past 12 years is significant and due primarily to improvements in the quality of the pressure sensors.

AMDAR data quality

29. AMDAR data quality remains very high, with frequent exchange of monitoring reports. Operational experience continues to show that this constant vigilance on a daily basis is essential to ensure that erroneous data are detected and their distribution inhibited.

30. The monitoring of the quality of AMDAR data on a real- or near real-time basis is carried out by several major centres such as National Centers for Environmental Protection (NCEP), ECMWF, UKMO, the Royal Netherlands Meteorological Institute (KNMI), the Canadian Meteorological Centre (CMC), Australia's National Meteorological Operations Centre (NMOC) and the United

Table II-7
Future polar-orbiting satellites coordinated within CGMS

Orbit type (equatorial crossing times)	*Satellite*	*Operator*	*Planned launch date*	*Other information*
Sun-synchronous	METOP-1	EUMETSAT	12/2005	(840 km) (0930 D) AHRPT
'Morning'	METOP-2	EUMETSAT	12/2009	(840 km) (0930 D) AHRPT
(0600–1200)	METOP-3	EUMETSAT	06/2014	(840 km) (0930 D) AHRPT
(1800–2400)	FY-3A	China	01/2006	(0930) Series of seven satellites
	FY-3B	China	12/2006	(0930)
	METEOR 3M-2	Russian Federation	12/2005	(1 024 km) (0915, 1030 or 1630 A)
	DMSP F-16	USA/NOAA	10/2003	(833 km) (2132 A)
	DMSP F-18	USA/NOAA	10/2007	(850 km) (A)
	NPP	USA/NOAA	10/2006	(833 km) (1030 D)
	NPOESS-1	USA/NOAA	11/2009	(833 km) (2130 D)
	NPOESS-4	USA/NOAA	11/2015	(833 km) (2130 D)
	Monitor-E	Russian Federation	04/2005	(540 km) (0540)
	GOCE	ESA	02/2006	(250 km) (dawn-dusk)
	SMOS	ESA	02/2007	(756 km) (0600 A)
	ADM-Aeolus	ESA	10/2007	(408 km) (1800 A)
Sun-synchronous	NOAA-N	USA/NOAA	02/2005	(870 km) (1400 A)
'Afternoon'	NOAA-N'	USA/NOAA	11/2008	(870 km) (1400 A)
(1200–1600)	NPOESS-2	USA/NOAA	06/2011	(833 km) (1330 A)
(0000–0400)	NPOESS-5	USA/NOAA	01/2018	(833 km) (1330 A)
	GCOM-C	Japan	01/2010	(800 km) (1330 D)
	GCOM-W	Japan	01/2009	(800 km) (1330 D)
Sun-synchronous	DMSP-F17	USA/NOAA	04/2005	(850 km) (A)
'Early morning'	DMSP-F19	USA/NOAA	04/2009	(850 km) (A)
(0400–0600)	DMSP-F20	USA/NOAA	10/2011	(850 km) (A)
(1600–1800)	NPOESS-3	USA/NOAA	06/2013	(833 km) (1730 A)
	NPOESS-6	USA/NOAA	05/2019	(833 km) (1730 A)
Non sun-synchronous	CRYOSAT	ESA	03/2005	(717 km)
	Resurs-01 N5	Russian Federation	01/2005	(680 km)
	Resurs DK	Russian Federation	06/2005	(480 km)
	Sich-1M	Russian Federation/ Ukraine	12/2004	(650 km)
	GPM Constellation	USA/NASA	11/2010	(600 km)

A = North
D = South

States Navy's Fleet Numerical Meteorology and Oceanography Center (FNMOC). These monitoring centres provide statistics and routine reports in non real time. Errors in wind speed and direction and temperature observations are identified by the monitoring centres and traced for corrective action. Inter-aircraft comparisons for ascent and descent data are performed in some areas, providing a powerful means for the identification of aircraft that produce erroneous data. A web-based reporting system has been developed by NCEP, the agency responsible for monitoring aircraft reports (see http://www.nco.ncep.noaa.gov/dmqab/qap/amdar). This web site provides routine public access to monitoring information. A set of uniform monitoring rejection criteria has been adopted to overcome the wide range of criteria previously in use by the various participating centres.

Table II-8
Future geostationary satellites coordinated within CGMS

Sector	*satellite*	*Operator*	*Planned launch*	*Other remarks (planned location)*
East Pacific (180°W–108°W) and West Atlantic (180°W–36°W)	GOES-N GOES-O GOES-P GOES-R	USA/NOAA USA/NOAA USA/NOAA USA/NOAA	02/2005 04/2007 10/2008 10/2012	75°W 75°W 135°W 135°W
(East Atlantic (36°W–36°E)	MSG-2 MSG-3 MSG-4	EUMETSAT EUMETSAT EUMETSAT	06/2005 06/2008 12/2011	0°, METEOSAT-9 when operational 0°, METEOSAT-10 when operational 0°, METEOSAT-11 when operational
Indian Ocean (36°E–108°E)	Elektro-L INSAT-3D FY-2D FY-2E	Russian Federation India China China	12/2006 07/2006 12/2006 12/2009	76°E 83°E, dedicated meteorological mission 105°E, improved FY-2 series 105°E, improved FY-2 series
West Pacific (108°E–180°E)	MTSAT-1R MTSAT-2	Japan Japan	02/2005 02/2006	140°E, multifunctional transport satellite 140°E, back-up to MTSAT-1R until 2009

Table II-9
Lead centres for monitoring observation data quality

Centre	*Data type*	*Area of responsibility*
WMC Washington	Aircraft and satellite data	Global
RSMC/ECMWF	Upper-air data	Global
RSMC Exeter	Surface marine data	Global
RSMC Nairobi	Land-surface observations	RA I
RSMC Tokyo	Land-surface observations	RA II
RSMC Buenos Aires	Land-surface observations	RA III
RSMC Montreal	Land-surface observations	RA IV
WMC Melbourne	Land-surface observations	RA V
RSMC Offenbach	Land-surface observations	RA VI

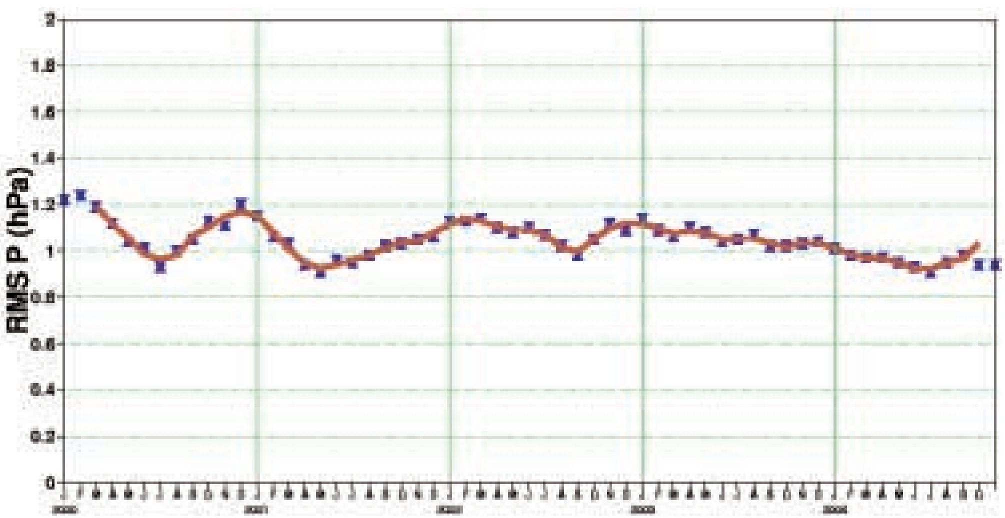


Figure II-10 — RMS difference between buoy air-pressure observations and the first-guess model field for the period 2000–2004 (from ECMWF).

CHAPTER III

THE GLOBAL TELECOMMUNICATION SYSTEM AND WWW DATA MANAGEMENT: INFORMATION SYSTEMS AND SERVICES

GLOBAL TELECOMMUNICATION SYSTEM

1. The GTS is organized into three levels — the MTN (global), the RMTNs (regional) and the NMTNs (national). The structure of the GTS is depicted in Figure III-1. The MTN is the backbone of the GTS, interconnecting the six Regions; the RMTNs interconnect the various regional and national WWW centres within a Region; and the NMTNs connect the meteorological stations or centres to the NMCs of each country.

MAIN TELECOMMUNICATION NETWORK

2. The MTN interconnects the three WMCs and 18 major RTHs. All but one of the 25 MTN circuits are in operation with TCP/IP or had a firm plan for the migration to TCP/IP. Seventeen MTN circuits are implemented through data-communications network services in the framework of the IMTN; five circuits are operating at 64 kbit s^{-1} and two at 9.6 kbit s^{-1}. However, one circuit (New Delhi–Cairo) still uses very low speed characteristics and is not capable of meeting MTN requirements. All MTN centres are equipped with computer-based message-switching and data-communication systems, and particular progress was made through the introduction of cost-effective PC-based message-switching and data-processing systems in several developing countries.

IMPROVED MTN PROJECT

3. The project to implement the MTN with data-communications network services is almost completed. The IMTN, as depicted in Figure III-2, aims at the full implementation of the MTN through these advanced network services. Implementation started in early 2003, and at present 17 MTN circuits have been implemented. The IMTN consists of two interconnected managed data-communications networks, called ‘clouds’. ‘Cloud I’ provides the interconnectivity between RTH/WMCs Washington and Melbourne and RTHs Tokyo, Exeter, Brasilia and Buenos Aires. ‘Cloud II’ is an extension of the RA VI-RMDCN and provides the interconnectivity between RTHs Exeter, Toulouse and Offenbach, RTH/WMC Moscow and adjacent RTHs Nairobi, Dakar, Algiers, Cairo, Jeddah, New Delhi and Beijing. The IMTN has proven to be a cost-effective way to implement the GTS, with very high reliability, full security, a guaranteed quality of service and an easy connectivity and scalability of service.

REGIONAL METEOROLOGICAL TELECOMMUNICATION NETWORKS

4. Significant progress was made in the implementation of RMTNs, although serious shortcomings still exist in some Regions at regional and national levels. Figures III-3 to III-8 show details of the status of implementation of the RMTNs in the six Regions.

Region I

5. There are eight RTHs in Region I — Cairo, Nairobi, Lusaka, Pretoria, Dakar, Algiers, Brazzaville and Niamey. Despite serious economic difficulties, continuous effort has

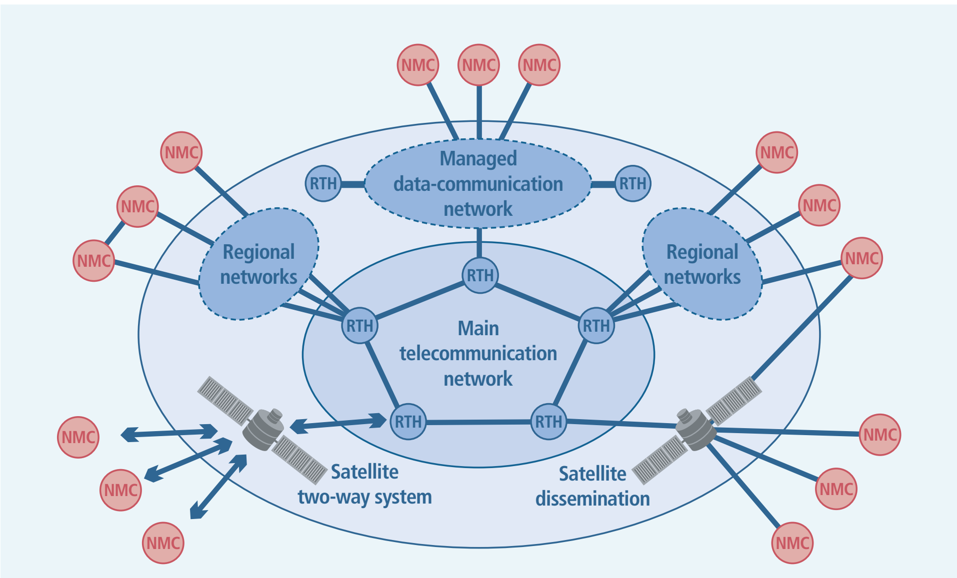


Figure III-1 — Structure of the Global Telecommunication System.

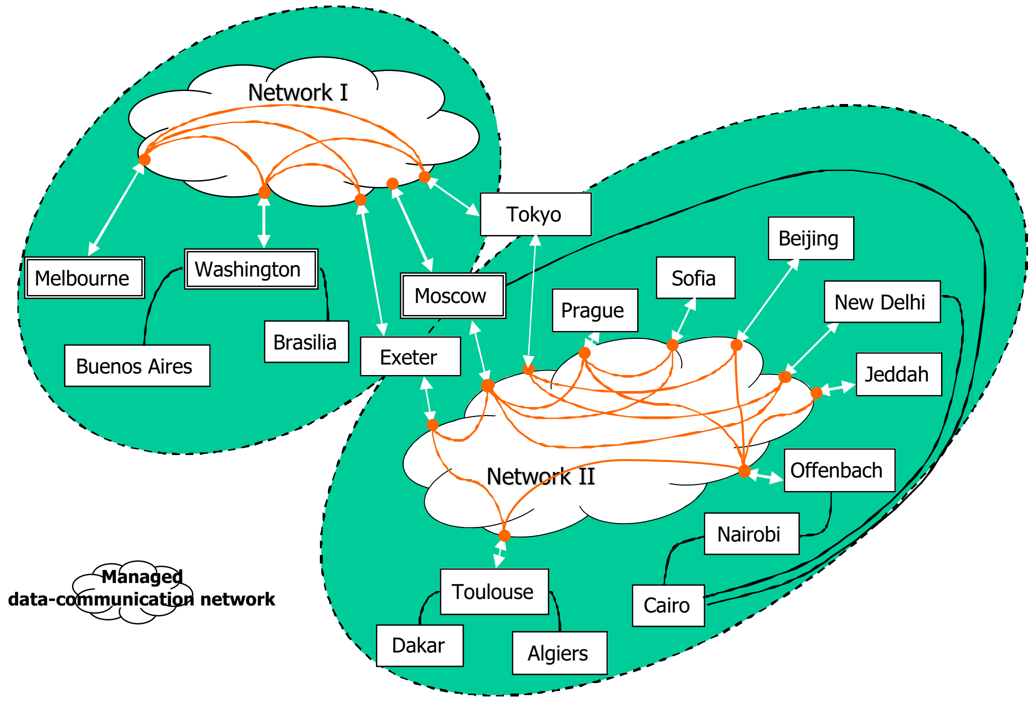


Figure III-2 — The Improved Main Telecommunication Network (IMTN) as of January 2005.

enabled some improvement in GTS circuits via leased lines, satellite-based telecommunications, in particular SATCOM, or public data networks, including the Internet. The RMTN plan comprises 88 circuits, of which 69 are in operation. Twenty GTS circuits (interregional and regional) are now operating at 19.2 to 128 kbit s^{-1}, and eighteen at 2.4 to 9.6 kbit s^{-1}. Satellite-based data-distribution systems (MDD, RETIM Africa and the satellite distribution system for information relating to air navigation (SADIS) as part of the ICAO aeronautical fixed service (AFS)) and the data-collection system METEOSAT/DCS continued to play a crucial role. There are still some serious shortcomings, in particular at national level. To address these shortcomings and to enable sustainable development, particularly in meteorological data communications, the RA I strategy plan for enhancing WWW basic systems has been developed. The PUMA project for the implementation of METEOSAT second general (MSG) receiving stations, funded by the European Commission, and the RETIM Africa system have entered the implementation stage.

Region II

6. Region II has nine RTHs — Tehran, Tashkent, Novosibirsk, Khabarovsk, Tokyo, Bangkok, New Delhi, Beijing and Jeddah. Most Region II GTS circuits are operating at medium or high speed, but there are still five centres with low-speed connections, and four centres – Baghdad, Kabul, Dushanbe and Phnom Penh – that are not connected. Twenty-four centres are connected by circuits operating at 64 kbit s^{-1} with TCP/IP, double the number of two years ago. The plan for an improved RMTN in Region II is nearly implemented. The RMTN, particularly in its eastern and southern parts, has been improved by the continuing implementation of advanced data-communication systems, including Frame Relay services and digital circuits. This has been complemented by satellite-based distribution systems such as METEOSAT MDD, TV-Inform-Meteo and the satellite systems operated by China and India and by the use of the Internet. The exchange of data and products on point-to-point circuits is complemented by satellite-distribution systems operating in at least 16 centres.

Region III

7. In South America there are three RTHs — Brasilia, Buenos Aires and Maracay. The 64 kbit s^{-1} digital connections of Brasilia and Buenos Aires are operational and a high speed TCP/IP link has been established between Brasilia and Porto-Alegre. However, shortcomings persist at several NMCs which lack automation and have low speed telecommunication circuits. Six NMCs are reliant on low-speed connections. The RA III RMDCN project aims at radical modernization of the RMTN for Region III and has entered its implementation phase. The upgrades provided by this project will enable NMHSs to considerably enhance their reception and use of data and products. All 13 NMCs are also equipped with systems for receiving WAFS and OPMET information via the ISCS operated by the United States.

Region IV

8. There is only one RTH in the Region — Washington. The two-way ISCS operated by the United States which provides for the RMTN was upgraded during 2004 to TCP/IP procedures with increased capacity. The ISCS upgrade also led to the replacement of all NMC workstations. The ISCS is complemented by the GOES Satellite Data Collection Platforms system and the GOES Emergency Managers Weather Information Network (EMWIN) for small islands.

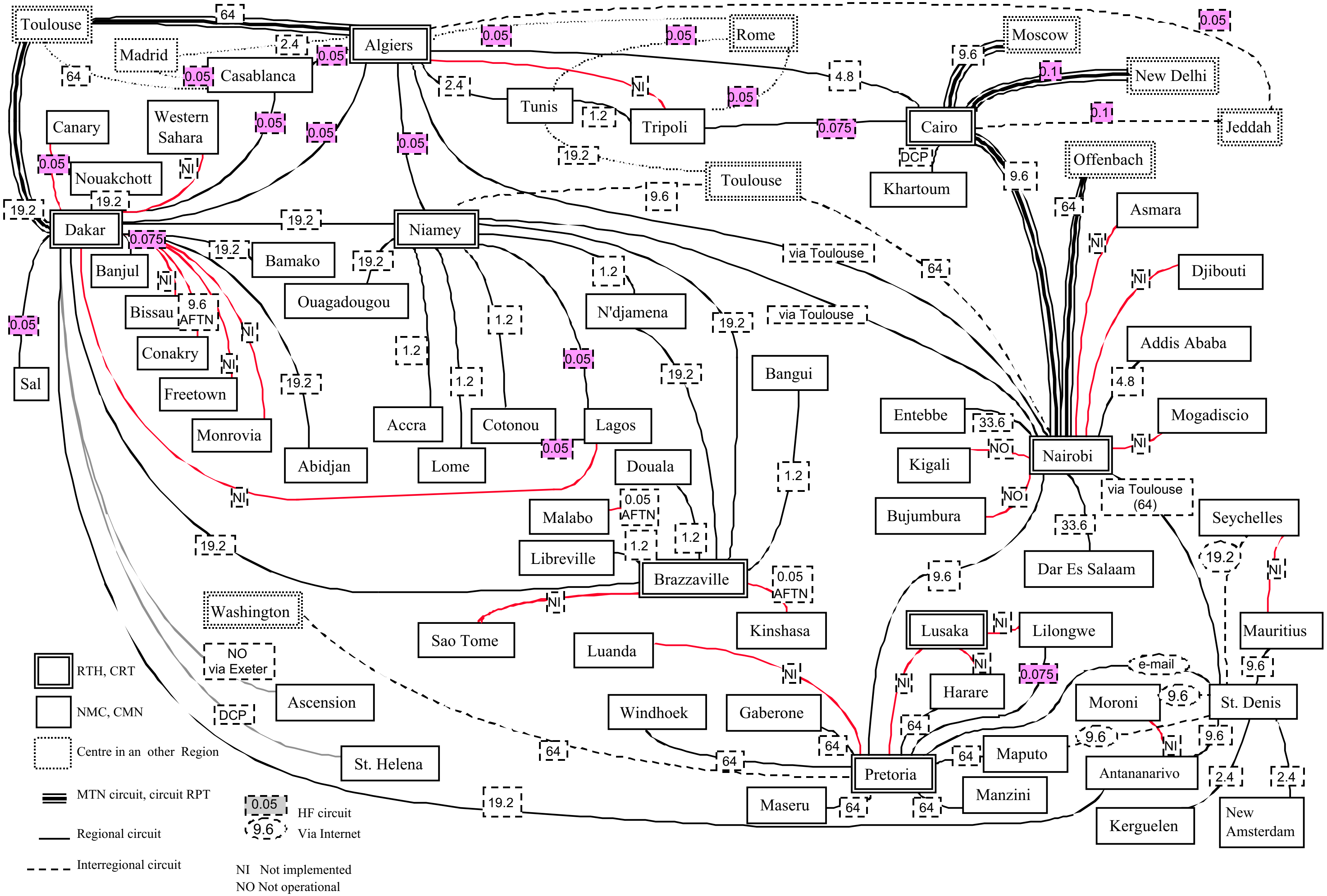


Figure III-3 — Regional Meteorological Telecommunication Network for Region I (Africa)
Point-to-point circuits implementation (kbit s⁻¹).

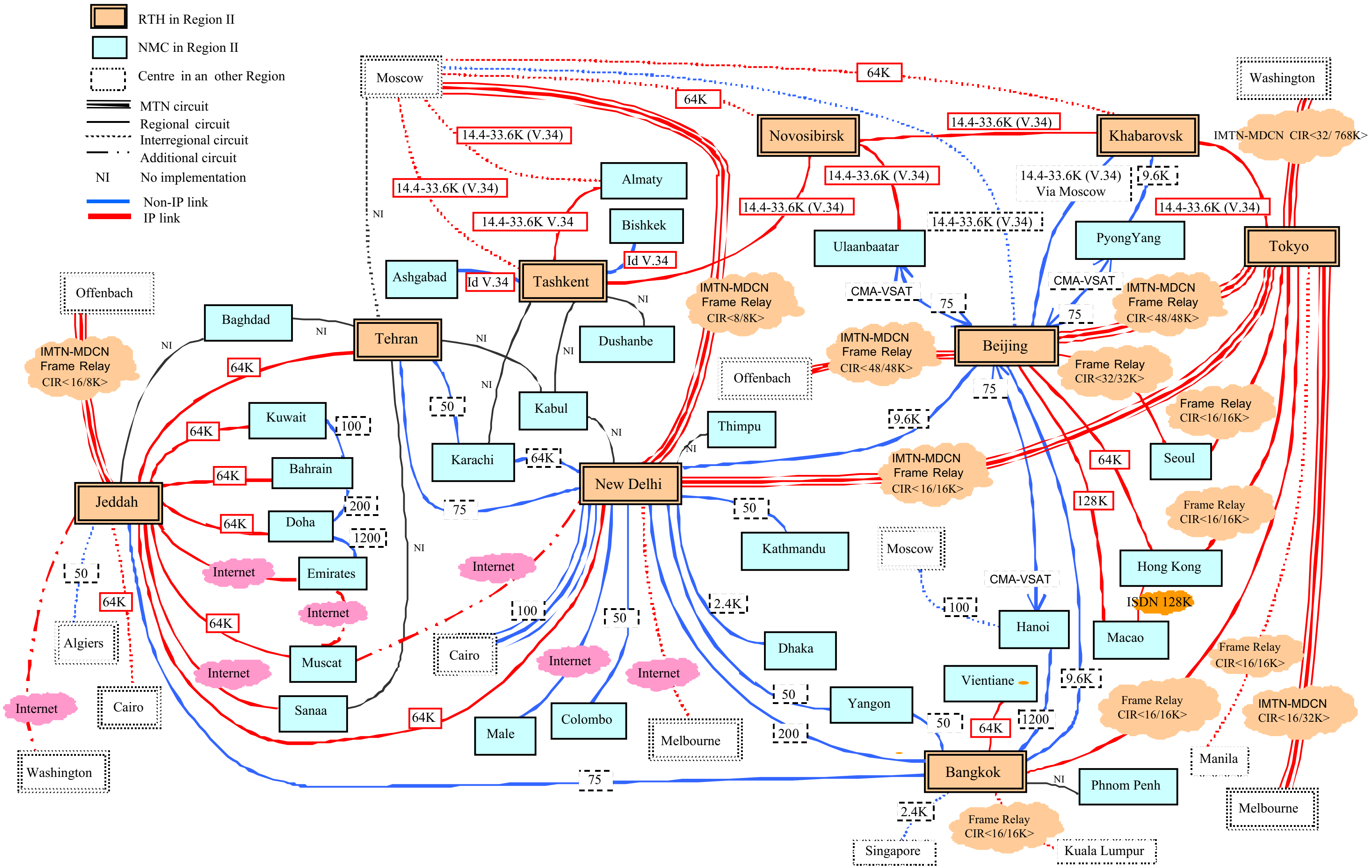


Figure III-4 — Regional Meteorological Telecommunication Network for Region II (Asia)
Point-to-point circuits implementation (kbit s-1).

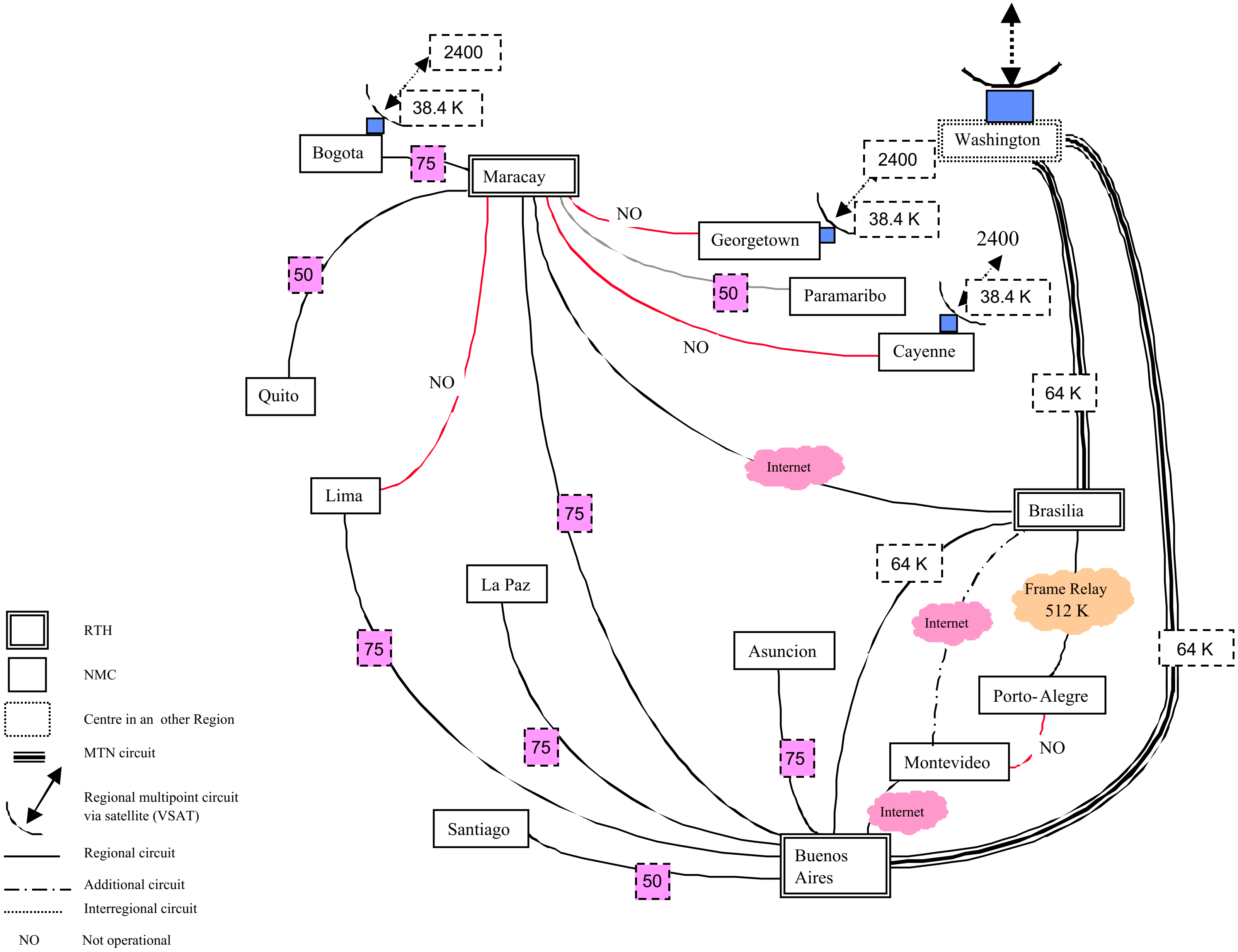


Figure III-5 — Regional Meteorological Telecommunication Network for Region III (South America)
Point-to-point circuits implementation (kbit s^{-1}).

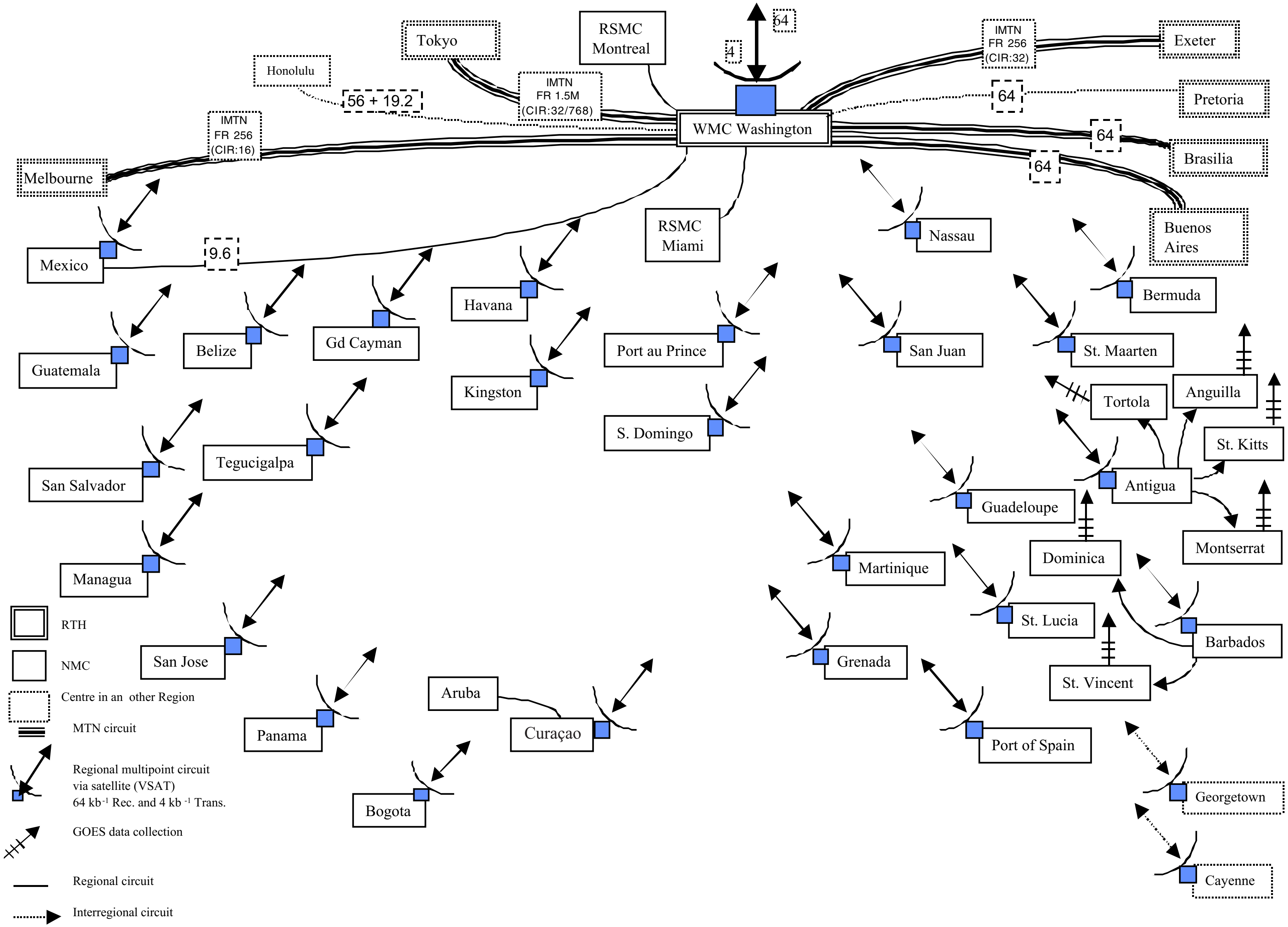


Figure III-6 — Regional Meteorological Telecommunication Network for Region IV (North and Central America)
Point-to-point circuits implementation (kbit s^{-1}).

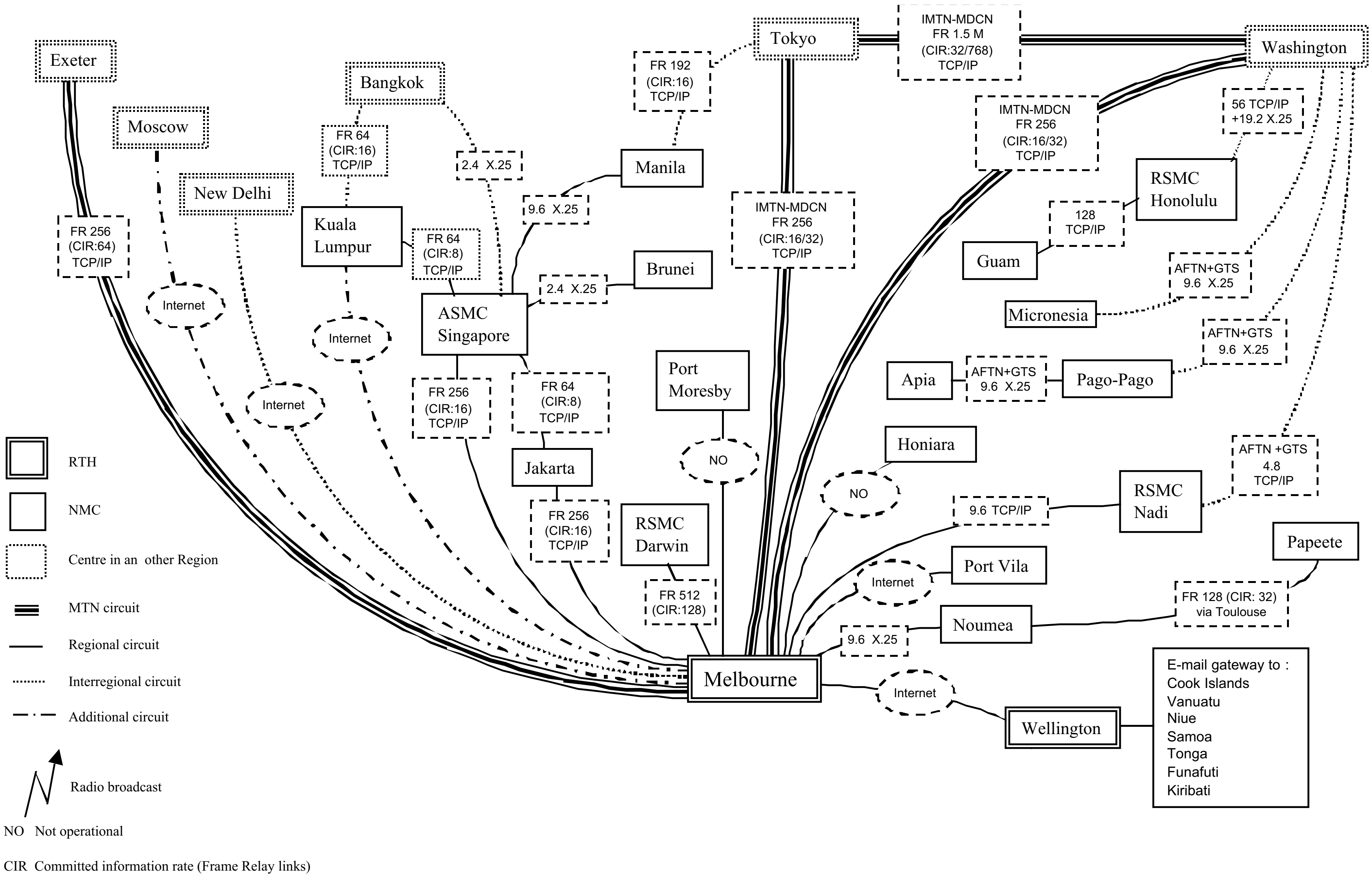


Figure III-7 — Regional Meteorological Telecommunication Network Plans for Region V (South-West Pacific)
Point-to-point circuits implementation (kbit s-1).

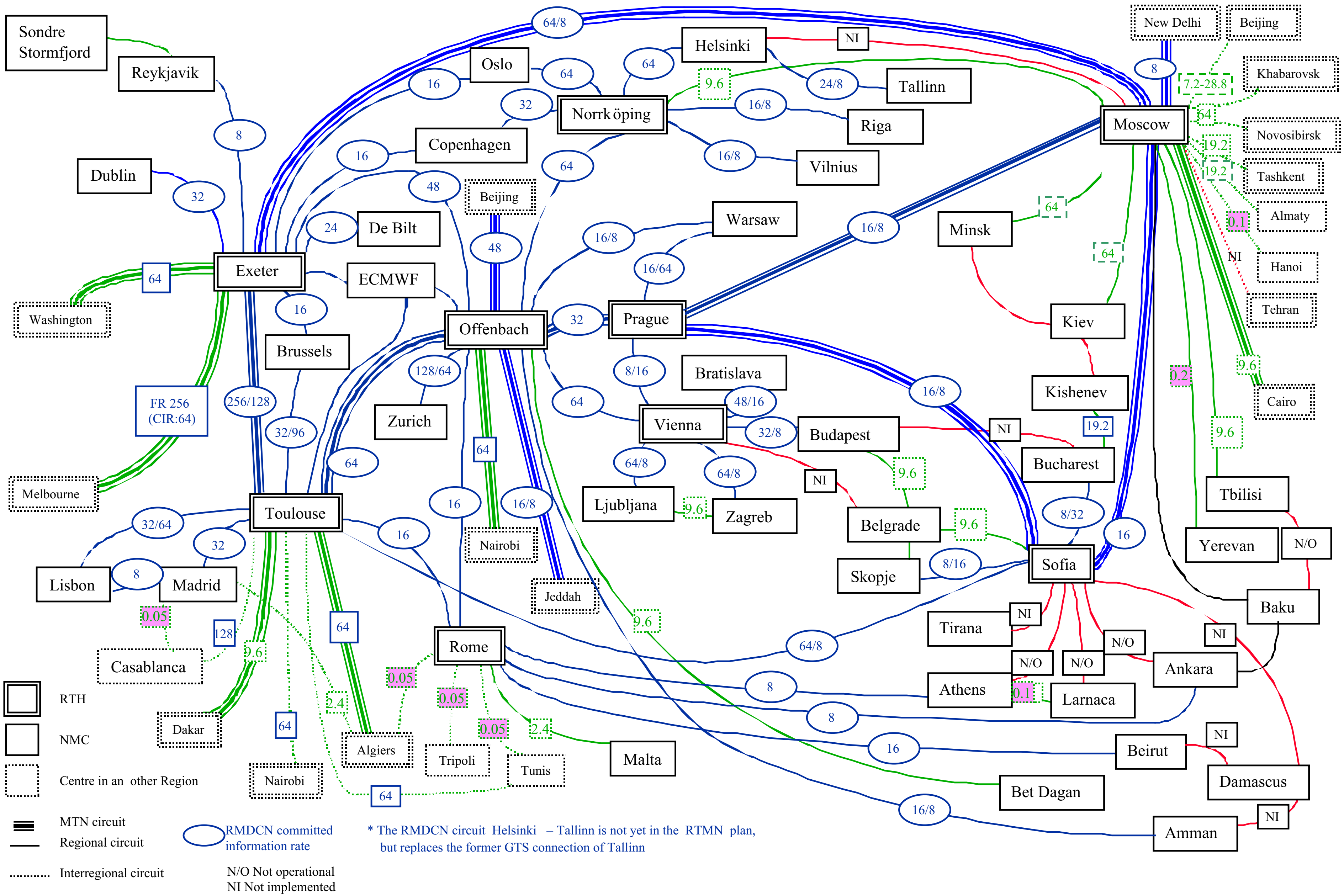


Figure III-8 — Regional Meteorological Telecommunication Network for Region VI (Europe)
Point-to-point circuits implementation (kbit s^{-1}).

Region V

9. There are two RTHs in Region V — Melbourne and Wellington. Significant progress was made in the Region V RMTN with the inclusion of several additional GTS circuits, particularly in the Pacific. Also important was the implementation of Frame Relay services and the expansion and upgrades of satellite-based communications, including the ISCS, the data-collection system (DCS) of the GMS and GOES satellites and the GOES EMWIN. Additional technical changes to EMWIN, a crucial source of data, warnings and forecasts for the Pacific, are also planned. Use of the Internet was also on the increase, in particular for the collection of observational reports and for linking small nations in the Pacific.

Region VI

10. There are nine RTHs in Region VI — Exeter, Norrköping, Toulouse, Offenbach, Moscow, Rome, Prague, Vienna and Sofia. The RA VI RMDCN, based on a shared managed network service managed by ECMWF, interconnects 33 RTHs and NMCs at speeds ranging from eight to 256 kbit s^{-1}. The RMDCN met both the RA VI GTS requirements and the data exchange requirements between ECMWF and its Member and Cooperating States. The RMDCN has proven to be an excellent cost-effective implementation of the GTS with a very high level of reliability, full security, guaranteed quality of service, easy scalability of capacity and reduced installation and maintenance costs. Some RA VI Members still operate leased point-to-point GTS circuits and Internet connections. These centres are expected to join the RMDCN once cost-effective. Satellite-based distribution systems (DWDSAT, TV-Inform, RETIM and MDD) continue to play an important role in the Region.

MULTIPOINT TELECOMMUNICATION SERVICES VIA SATELLITE AND RADIOBROADCASTS

11. There has been extensive implementation and significant technological upgrades of satellite-based multipoint telecommunication systems. These are essential integrated components of the GTS for the distribution of large volumes of information. These satellite-based data-distribution systems comprise both commercial telecommunications and environmental satellites. As shown in Table III-1, each WMO Region is completely covered by at least one satellite-based distribution system, and several systems were implemented at national or subregional level. These systems effectively complement point-to-point circuits, particularly in the delivery of processed meteorological information to NMCs. Satellite-based systems using digital video broadcasting (DVB) techniques were implemented in Region VI and extended to cover Regions I and II, including RETIM operated by France and EUMETCast operated by the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) and also supporting DWDSAT of Germany, and are also planned in other Regions.

12. Several Members discontinued their HF broadcasts because of high recurrent operational costs and limited operational effectiveness. In some centres, for example RTH New Delhi, HF broadcasts were replaced with satellite-distribution systems through digital audio broadcasting (DAB) techniques. Satellite-based systems using DAB techniques for 'data casting' were also used by the World Space Radio and Internet (RANET) experiment over Africa and the Pacific. HF broadcasts may still be required in some areas, mainly at regional level. In the maritime community, more effective distribution systems, such as the International Maritime Satellite System (INMARSAT), within the framework of the Global Maritime Distress and Safety System (GMDSS), are in rapid development.

DATA-COMMUNICATION TECHNIQUES AND PROCEDURES

13. The GTS adopts international standard data-communication services, equipment, techniques, protocols and applications to the largest extent possible, with a view to improving the cost-effectiveness of facilities. This results in reduced costs as regards equipment purchase and maintenance, as well as in reduced human resources needed for development. The TCP/IP and the file transfer protocol (FTP) have generally replaced the former X.25. New emerging advanced data-communications network services, such as MPLS (multi-protocol label switching), are expected to quickly supersede Frame Relay networks. Development in migrating the underlying network structure of the IMTN 'cloud 1' to one based on MPLS is currently under way, with a test of its implementation planned for 2005.

14. The Future WMO Information System (FWIS) is under development as an overarching approach to bring together the diverse and divergent information systems that have been developed to meet WMO requirements. The FWIS will be used for the collection and sharing of information for all WMO and related international programmes.

15. For several small NMHSs, the Internet is the only affordable telecommunications system for transmitting meteorological information, despite its possible shortcomings, such as availability, reliability, delays and security. The dramatic increase in the use of the Internet has led to a revision of the existing guidance for observational data collection using e-mail over the Internet. The revised procedures provide a simple, clear tool for small NMHSs for which e-mail, in some cases through low-capacity Internet access such as very slow dial-up lines, is the only viable option for providing observational reports. The *Guide on Internet Practices* has been revised to take into account technological developments. The *Guide* is also available on the WMO web server in English, French, Russian and Spanish. Most NMHSs, if not all, have FTP servers, but several do not have the system administration experience to configure them adequately. To overcome this deficiency, a guide on the use of FTP and FTP servers at WWW centres is being developed.

WORLD WEATHER WATCH DATA MANAGEMENT

16. The WDM provides the support functions needed for the orderly and efficient overall management of meteorological data and products of the WWW system, and

coordinates the monitoring of data and product availability and quality. WDM provides specifications for data formats, including codes and exchange formats, and guidelines for computer storage of observational data and products.

METADATA STANDARDS

17. Technical data exchange is the key to the success of WMO Programmes. As the variety and volume of data increases, it has become obvious that metadata is the key to effective data exchange. To make this a reality, a WMO core metadata standard has been developed. The WMO core profile within the context of the International Organization for Standardization (ISO) 19115 geographic information standard has been endorsed as the 'formal draft version 1.0' against which WMO Programmes will perform formal testing.

DATA REPRESENTATION AND CODES

18. There has been a continuous development of the WMO codes and code tables, in particular TDCF FM 92 GRIB Edition 2, FM 94 BUFR and FM 95 CREX, in response to new and evolving requirements, including ensemble and long-range forecasts, satellite imagery, radar data and transport model products. The Guide for GRIB Edition 2 has been published, and several centres are now exchanging data operationally in GRIB code. Regarding GRIB2 encoder/decoder software, several centres, including ECMWF, EUMETSAT, *DWD*, JMA, NCEP and UKMO, have made their software freely available. Experimental and operational exchange of BUFR data is now taking place, including buoy, BATHY and TESAC data from Service Argos, and, from various centres, ship data, wind profiler data, satellite data and AWS observations.

TABLE-DRIVEN CODE FORMS

19. TDCF, with their self-description, flexibility and expandability, are the solution to satisfy the demands of rapidly evolving science and technology. The TDCF FM 94 BUFR and FM 95 CREX offer great advantages in comparison with the traditional alphanumeric codes (TAC) like FM-12 SYNOP and FM-35 TEMP. The reliability of binary data transmission provides for an increase in the quality and quantity of data received at meteorological centres, which will lead to the generation of better products. The migration plan to move to TDCF was endorsed by the Fourteenth World Meteorogical Congress in May 2003. Congress urged Member countries to develop, as soon as possible, a national migration plan, derived from the international plan, with analysis of impacts, costs, solutions, sources of funding, training, technical planning and schedule. The implementation and coordination of the migration to TDCF have commenced, and the start of operational exchange is planned for November 2005. Several centres have made BUFR, CREX and GRIB encoder/decoder software freely available. TDCF training seminars were held in RA I, RA III and RA IV in 2003 and in RA II and RA V in 2004.

WWW OPERATION MONITORING PROCEDURES

20. A large and increasing number of WWW centres participate in the AGM of WWW operations. The special MTN monitoring (SMM) provides complementary results enabling more detailed and more frequent analysis. A project on integrated WWW monitoring (IWM) is being developed. A PC-based common monitoring application has been developed by Germany (*DWD*) and is available for use by NMHSs. The increased use of BUFR code has stressed the importance of monitoring data presented in BUFR code, and four RTHs are participating in a pilot study and testing for the monitoring of BUFR bulletins.

RADIO FREQUENCIES FOR METEOROLOGICAL ACTIVITIES

21. The current radio frequency allocations and regulatory provisions of the ITU Radio Regulations are addressing requirements for meteorological and related environmental activities, through specific radiocommunication services: meteorological aids (radiosondes); meteorological satellite; earth exploration-satellite, including passive remote sensing; and radiolocation for weather and wind profiler radars. However, the threat on the full range of radio frequency bands allocated for meteorological and related environmental systems is continuing with the increasing development and expansion of new commercial radiocommunication systems. WMO, including CBS, NMHSs, meteorological satellite agencies and the

Table III-1
Satellite-based telecommunication systems by WMO Region

Region	*System providing complete or near-complete coverage*	*System providing partial coverage*
RA I	ISCS (Atlantic) MDD*, EUMETCast UKSF/WWW RANET Experiment RETIM-Africa	RETIM-2000
RA II	UKSF/WWW**	ISCS (Pacific) TV-Inform-Meteo MDD, EUMETCast
RA III	EMWIN-E ISCS (Atlantic)	MDD ISCS (Pacific)
RA IV	EMWIN-E ISCS (Atlantic)*	MDD ISCS (Pacific)
RA V	ISCS (Pacific)*	EMWIN-W
RA VI	MDD, EUMETCast DWDSAT* ISCS (Atlantic) RETIM-2000* UKSF/WWW	

* Component of the RMTN
** Pilot project

WMO Secretariat, has continued its active participation in ITU radiocommunication and related forums to ensure that meteorological frequency issues are recognized and supported. The joint ITU/WMO *Handbook on Use of Radio Spectrum for Meteorology* is being updated; the updated information will be posted on the WMO and ITU web sites. WRC-03 had a favourable outcome and finalized several serious issues that had been under debate for many years, including the bands 401-406 MHz, 1675-1710 MHz (radiosondes and meteorological satellites) and 2700-2900 MHz (meteorological radar). These are therefore now consolidated as important allocations for meteorological operations. Utmost importance is also being attached to ensuring absolute protection of the special bands allocated to space-borne passive sensing, which are a unique natural resource for atmospheric measurements and have an increasing importance in meteorology, such as for observations, NWP and climatology. NMHSs and meteorological and environmental satellite operators have been encouraged to do their utmost to safeguard the passive frequency band 23.6-24.0 GHz. This frequency band (water vapour absorption line) is crucial to WMO operations and research and is under threat in some Regions.

CHAPTER IV

THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM

1. The GDPFS consists of WMCs, RSMCs and NMCs. The number of GDPFS centres evolved from 1992 to 2004 as shown in Table IV-1. WMCs Melbourne, Moscow and Washington continued to develop their global forecasting systems. WMCs Melbourne, Moscow and Washington run EPS for medium- and long-range forecasts. Details of the daily output of products (analyses and forecasts) of WMCs are given in the annual WWW Technical Progress Reports on the GDPFS available from the GDPFS web site at http://www.wmo.ch/web/www/DPS/GDPFS.html.

RSMCs WITH GEOGRAPHICAL SPECIALIZATION

2. There are 30 GDPFS centres implemented as RSMCs, of which 27 have geographical specialization, namely Algiers, Beijing, Exeter, Brasilia, Buenos Aires, Cairo, Casablanca, Dakar, Darwin, Exeter, Jeddah, Khabarovsk, Melbourne, Miami, Montreal, Moscow, Nairobi, New Delhi, Novosibirsk, Offenbach, Pretoria, Rome, Tashkent, Tokyo, Tunis, Washington and Wellington. The locations of the RSMCs are shown in Figure IV-1. These centres provide regional products to assist NMCs in the forecasting of small-scale, mesoscale and large-scale weather systems. They also provide, upon request, meteorological assistance to United Nations humanitarian relief missions as defined in the *Manual on the Global Data-processing System* (WMO-No. 485), Appendix I-5.

3. The location of GDPFS centres active in NWP, including RSMCs, is indicated in Figure IV-2; the types of models run at those centres are listed in Annex I. The processing equipment available at the GDPFS centres, as reported by them, is listed in Annex II. Most RSMC operations in all Regions have shown sustained improvement, with enhanced forecasting systems and computer facilities, thereby improving the accuracy of their products.

4. In Region I, for example, RSMCs Algiers, Cairo, Casablanca and Tunis now run mesoscale models on upgraded computing facilities. RSMC Pretoria currently runs a global model, a LAM and a mesoscale model, as well as an EPS for medium-range forecasts, and a general circulation model performing simulations up to eight months. Other RSMCs in Region I, however, still need to upgrade their data-processing equipment to perform more fully the functions required of them. In Region II, most centres run LAM, now including Jeddah. Several centres, including Hong Kong and Novosibirsk, have upgraded their supercomputers to run their regional models. Two RSMCs (Beijing and Tokyo) run global models. In addition, India's National Centre for Medium-Range Weather Forecasting also runs a global model. RSMC Buenos Aires in Region III now runs a mesoscale model. In Region VI, most NMCs run their own mesoscale models. Several centres in the region have made upgrades to their computing capabilities, including RSMCs Exeter, Offenbach and Toulouse. Also, ECMWF has upgraded its computing capabilities. Increased computing power at many centres has led to higher resolution models being run.

RSMCs WITH ACTIVITY SPECIALIZATION

5. RSMCs with activity specialization provide products that meet specific requirements, such as medium-range forecasting products, tropical cyclone forecasting products and transport model products for environmental emergency response.

MEDIUM-RANGE WEATHER FORECASTING

6. ECMWF was one of the first among the leading GDPFS centres to implement a four-dimensional variational analysis (4-DVAR) data assimilation system, making use of the massive parallel-processor technology. Currently, ECMWF runs a T511L60 global model, producing global

Table IV-1
Number of GDPFS centres grouped by type (WMCs, RSMCs and NMCs) and by forecast models for the period 1992–2004 (the categories are exclusive: the WMCs are not recounted among the RSMCs or the NMCs; RSMCs are not re-counted among the NMCs)

Type of centre	*WMC*							*RSMC*							*NMC*						
Year	92	94	96	98	00	02	04	92	94	96	98	00	02	04	92	94	96	98	00	02	04
Number of centres	3	3	3	3	3	3	3	25	25	26	28	28	29	29	141	155	155	156	156	160	162
Using computers for NWP	3	3	3	3	3	3	3	15	16	20	25	26	26	26	19	22	24	29	33	36	38
Running global model	2	2	2	3	3	3	3	7	8	10	10	10	10	10	1	1	2	2	3	3	3
Running hemispheric model	2	2	1	1	1	1	0	1	1	1	0	0	0	0	1	1	0	0	1	1	2
Running limited area model	3	3	3	3	3	3	3	14	14	20	16	14	13	11	19	20	24	18	16	16	18
Running mesoscale model	0	0	1	3	3	3	3	3	4	4	7	10	12	19	4	4	7	14	23	27	32

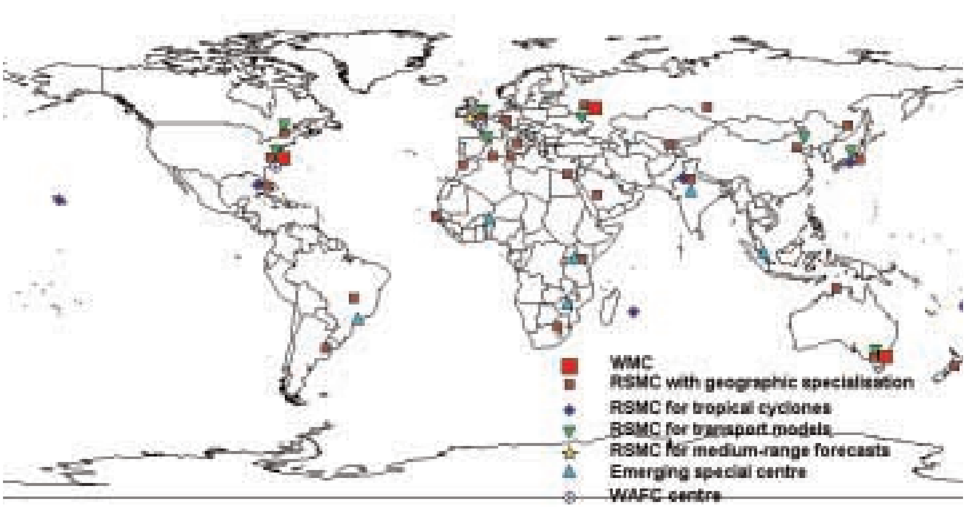


Figure IV-1 — Location and type of RSMC.

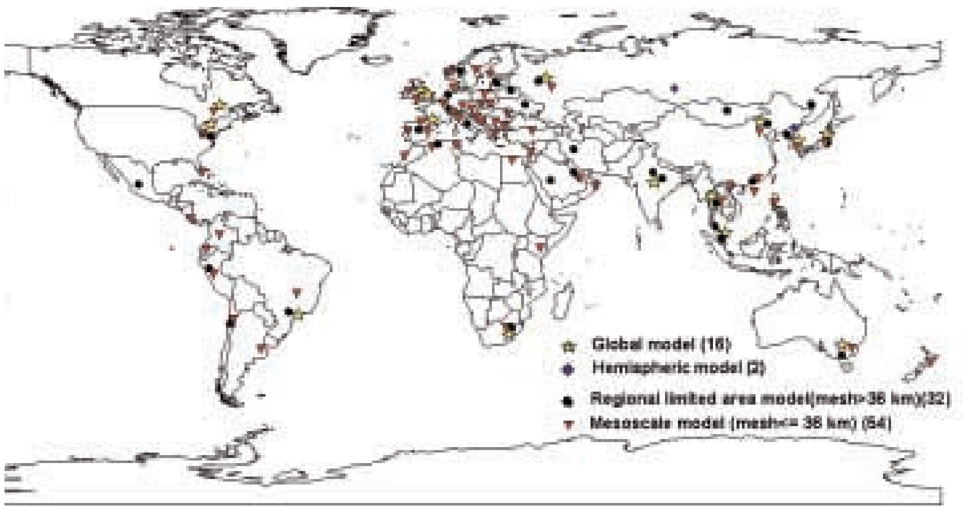


Figure IV-2 — Types of operational numerical models running at GDPFS centres.

analyses four times a day and two 10-day forecasts daily. Forecast products are disseminated on the GTS in GRIB code and are also available on the centre's web site. Table IV-2 provides a summary of these products. A 50-member (T255L40 model) EPS for medium-range forecasts (out to 10 days) is run daily, and selected results are made available on the GTS and the Internet.

TROPICAL CYCLONE FORECASTING

7. Six centres designated by WMO as RSMCs, with activity specialization in tropical cyclones and located in Honolulu, La Réunion, Miami, Nadi, New Delhi and Tokyo, monitor all tropical cyclones over their assigned areas from the early stages of formation and throughout the cyclones' lifetime using surface meteorological observations, satellite data, weather radars and computers (see Figure IV-3). These centres also provide forecasts on the behaviour of tropical cyclones, their movement and changes in intensity and on associated phenomena – principally storm surges and flash floods. The centres issue information for the international community, including the international media, in addition to providing advisory information and guidance to NMSs. The provision of tropical cyclone warnings for national territory

Table IV-2
ECMWF products on the GTS

GLOBAL DOMAIN (90°N-90°S)		
Mean sea-level pressure, 850 hPa temperature 500 hPa height, u, v (850, 700, 500, 200 hPa) Relative humidity (850, 700 hPa) Analyses and forecasts every 24 hours up to day 7 (168 hours)		
TROPICAL BELT (35°N-35°S)		
Divergence and vorticity (700 hPa) Analyses and forecasts every 24 hours up to day 6 (144 hours)		
BASED ON EPS		
Probability of precipitation	>10 mm,	NH, SH at H+72, 96, 120, 144
Probability of precipitation	>20 mm,	NH, SH at H+72, 96, 120, 144
Wind gusts	$>15\ ms^{-1}$	NH, SH at H+72, 96, 120, 144
Wind gusts	$>25\ ms^{-1}$	NH, SH at H+72, 96, 120, 144
Products are in format FM 47 GRID with 5° × 5° resolution and in format FM 92 GRIB with 2.5° × 2.5° resolution		

Figure IV-3 — Areas of responsibility of RSMCs specializing in tropical cyclone forecasting.

and coastal waters is, in essence, a national responsibility. Such official warnings are contained in advisories issued by the NMS.

8. The six Tropical Cyclone RSMCs, together with five tropical cyclone warning centres (Brisbane, Darwin, Perth, Port Moresby and Wellington) which have regional responsibility, provide advisories and bulletins with up-to-date first-level basic meteorological information on all tropical cyclones, hurricanes and typhoons throughout the world. The first-level basic information comprises reliable information from a clearly defined source on the tropical cyclone's location and size and its present and forecast movement and intensity.

9. There has been significant improvement in the monitoring and forecasting of tropical cyclones over the years as a result of development of the WWW and advances in support technology. There were scientific advances in the understanding and modelling (including NWP) of tropical cyclones and their environment. The rapid increase in computer power in recent years has enabled numerical models to attain resolutions where small-scale systems, such as tropical cyclones, are resolved. These models are displaying real skill with regard to motion prediction and have the potential to handle cylone genesis. However, only a limited number of models have attained resolutions where cyclone structure (including intensity) can be addressed. Nonetheless, current research models and programmes indicate that numerical model forecasts of tropical cyclones will continue to improve. Improvements will also come from the ability to resolve fine-scale structure as computing power and memory continue to increase and become less expensive. Position forecast verification statistics for warnings issued by RSMCs Honolulu, New Delhi, Nadi and Miami in 2003 are shown in Tables IV-3 to IV-7.

10. In 2003, RSMC Miami Hurricane Center began issuing five-day hurricane forecasts, extending the three-day forecasts issued since 1964 after going through a rigorous set of experiments during the 2001 and 2002 Atlantic and eastern and central North Pacific hurricane seasons to test this capability. These experiments were successful largely because of improved modelling techniques developed jointly by the NOAA Geophysical Fluid Dynamics Laboratory, the Environmental Modeling Center and other researchers. Experiments indicate that the five-day track forecast is as accurate as the three-day forecast was 15 years ago. The two-year trial showed that the five-day average track error for Atlantic tropical storms and hurricanes was 323 nautical miles (nm), and 191 nm in the eastern Pacific. For comparison, in 1964 to 1965 – the first two years of three-day Atlantic track forecasts – average error was 389 nm. In 2003, RSMC Miami also began to include tropical depressions in its verification. Before 2003, only cases where the cyclone was of tropical storm strength were included in the verification sample.

Table IV-3
RSMC Honolulu track forecast errors in 2003, measured in nautical miles
(values in parentheses indicate the number of forecasts)

Forecast	*12-hr*	*24-hr*	*36-hr*	*48-hr*	*72-hr*	*96-hr*	*120-hr*
RSMC	37 (25)	64 (21)	100 (18)	146 (16)	244 (12)	309 (8)	270 (4)
CLP5	49 (25)	102 (21)	179 (18)	275 (16)	404 (12)	555 (8)	636 (4)
GFDL	35 (19)	51 (15)	80 (13)	107 (10)	154 (8)	236 (8)	233 (2)
AVNI	40 (17)	83 (15)	112 (15)	91 (12)	92 (7)	129 (3)	99 (1)
AVNO	51 (17)	81 (13)	126 (9)	114 (8)	105 (5)	120(3)	--
BAMS	43 (25)	71 (21)	101 (18)	135 (16)	175 (12)	231 (8)	235 (4)
BAMM	46 (25)	69 (21)	86 (18)	120 (16)	188 (12)	277 (8)	412 (4)
BAMD	58 (25)	101 (21)	137 (18)	186 (16)	315 (12)	544 (8)	749 (4)
LBAR	48 (16)	96 (14)	137 (13)	219 (12)	293 (8)	173 (3)	--

Table IV-4
RSMC New Delhi forecast position errors in kilometres for tropical cyclones in the Bay of Bengal and the Arabian Sea in 2003

Date	*12-hr*			*24-hr*			*36-hr*			*48-hr*		
	P	*C*	*CLIP*	*P*	*C*	*CLIP*	*P*	*C*	*CLIP*	*P*	*C*	*CLIP*
10–19 May	77	73	67	188	198	176	283	370	315	367	453	388
12–15 Nov.	100	-	-	308	-	-	448	-	-	574	-	-
11–16 Dec.	126	114	114	306	263	284	415	346	379	459	373	415
Mean for 3 cases	101	93	90	267	231	230	382	358	347	466	413	401

C = Climatology, P = Persistence and CLIP = CLIPER model

Table IV-5
Nadi forecast track errors in 2003
(persistence errors in parentheses are included for comparison)

Lead-time	*0-hr*		*12-hr*		*24-hr*	
Name of tropical cyclone	*Mean error (km)*	*Number*	*Mean error (km)*	*Number*	*Mean error (km)*	*Number*
Ami	6	12	95(161)	8	293(596)	4
Beni	14	30	94(104)	26	165(304)	22
Cilla	10	11	131(130)	9	269(220)	7
Dovi	15	21	58(80)	19	76(160)	15
Erica	3	10	93(107)	10	232(308)	7
Eseta	9	16	106(147)	12	240(465)	10
Fili	20	4	-	-	-	-
Gina	32	17	153(165)	14	233(359)	12
Aggregate	14	121	100(121)	102	188(302)	76

Table IV-6
RSMC Miami forecast mean track errors in nautical miles in 2003 for the North Atlantic

Model	*Forecast period (hrs)*						
	12	24	36	48	72	96	120
CLIPER	47.3	100.7	160.4	216.8	327.8	480.6	643.8
GFDI	32.0	54.5	76.1	99.8	146.9	213.7	280.0
GFSI	37.1	62.1	86.6	109.2	155.5	199.9	274.2
NGPI	37.1	63.6	90.6	119.8	167.5	235.6	298.5
OFCL	35.1	58.0	81.6	105.5	131.9	170.3	207.0

Table IV-7
RSMC Miami forecast mean track errors in nautical miles in 2003 for the eastern North Pacific

Model	*Forecast period (hrs)*						
	12	24	36	48	72	96	120
CLIPER	39.5	81.8	132.4	175.7	255.1	416.7	687.2
GFDI	37.0	68.7	96.4	119.2	166.8	205.1	230.0
GFSI	42.0	75.3	106.7	135.6	206.1	317.1	429.6
NGPI	37.3	69.6	103.7	130.5	199.6	271.8	465.6
OFCI	32.9	61.0	88.7	112.1	161.4	248.3	385.7

PROVISION OF ATMOSPHERIC TRANSPORT MODEL PRODUCTS FOR ENVIRONMENTAL EMERGENCY RESPONSE ACTIVITIES

11. There are eight RSMCs designated for the provision of transport model products in cases of man-made and other environmental emergencies, in particular nuclear emergencies, smoke from wildland fires and airborne hazardous substances from chemical incidents. All centres have implemented the regional and global arrangements for the provision of products as defined by WMO in the *Manual on the Global Data-processing System* (WMO-No. 485). They provide, upon request, specialized transport/dispersion/deposition model products in accordance with the *Manual* (Appendices I-3 and II-7). The centres are shown in Table IV-8. The official product distribution method for exchanging transport model products and information is facsimile transmission. However, all eight transport model centres have implemented web-based technologies to exchange information and products. A designated telecommunications function is provided to switch emergency notification information from the IAEA to the WMO GTS for Members. Specialized atmospheric transport modelling products are also prepared by the nine designated Volcanic Ash Advisory Centres (VAAC) for the prediction of airborne ash distribution.

Table IV-8
Centres responsible for the provision of transport model products

RSMC	*Area of responsibility*
Exeter	RA VI and RA I
Toulouse	RA VI and RA I
Montreal	RA III and RA IV
Washington	RA III and RA IV
Beijing	RA II
Obninsk	RA II
Tokyo	RA II
Melbourne	RA V

NMCs AND CENTRES WITH SIMILAR FUNCTIONS

12. The locations of sites running numerical models at NMCs are shown in Figure IV-2. A detailed listing of these centres, the models they run and the computer equipment available are given in Annex I and Annex II. Many NMCs, particularly in Regions II, III and VI, have well-developed computer capabilities and are able to run mesoscale models with a resolution of 35 km or finer. In Region II, Hong Kong upgraded its computing capabilities. In the same region, Bangkok and Seoul run global models, and Macau runs a LAM. In Region IV, San Jose now runs a mesoscale model and Mexico City runs a LAM. In Region V, two new centres have come online, Kuala Lumpur runs a LAM and Manila runs a mesoscale model. There is still a lack of real-time data-processing capabilities in the NMCs of many developing countries. However, the GTS and satellite-based dissemination systems enable NMCs to receive products directly and reliably from WMCs and RSMCs. Most centres now have Internet access to selected products made available by the GDPFS centres.

VERIFICATION OF NUMERICAL WEATHER PREDICTION

13. The monthly exchange of verification scores using standards and procedures agreed upon by CBS has continued among the centres in Exeter, Melbourne, Montreal, Moscow, Offenbach, Tokyo, Toulouse, Washington and ECMWF.
14. A limited set of basic scores is included in the annual WWW Technical Progress Reports on the GDPFS. Mean annual RMS errors of 500 hPa height against observations for 72- and 120-hour ranges over Asia, Australia/New Zealand, Europe and North America are plotted in Figure IV-4 for the period 1992–2004. The RMS scores for global models running at ECMWF, Exeter, Montreal, Tokyo, Toulouse, Melbourne and Washington forecasting centres are shown.
15. Most forecast centres continue to show a general trend towards improved forecasts over all four areas and for both time ranges. However, the degree of improvement is not completely uniform. Most noticeable is a decrease of forecast skill over North America and Europe in 1999. Taken collectively, the degradation in scores over North America in 1999 is significant. However, forecast skills over Europe and North America have shown an improving trend since 1999.
16. In 2004, another unusual anomaly has appeared: for three regions, namely Asia, Australia/New Zealand and Europe, at both 72- and 120-hours, the forecast skill from all centres is slightly worse than for 2003. Only the North American region shows increasing skill into 2004. The reason for this worsening trend, which in general is not large but consistent, has not yet been identified.
17. Asia has traditionally shown the best verification scores from all centres, both for the 72- and 120-hour forecast ranges; however, the scores over the Australia/New Zealand area are now comparable for 120-hours over Asia in 2001. Height errors over Europe and North America, both for 72- and 120-hours, are now also very similar, with the most improvement over the past 12 years being made in the 120-hour forecasts over Europe. The spread of scores from all centres is now very similar for all forecast areas. The spread of scores over Australia/New Zealand has decreased over the past several years and is now similar to the spread of the scores over the other forecast areas.
18. Model forecasts from all centres have shown significant improvements over the 12-year period of record. It is notable that over all four areas and at both forecast times, ECMWF has for the fourth consecutive year produced the highest skilled model forecasts. Second place alternates between Exeter and Washington. However, as already noted, all centres now produce forecasts that are very similar in their skill. The increase in forecast skill by all centres over the past 12 years is very apparent, and the rate of improvement does not yet appear to be slowing down.
19. Figure IV-5 shows the RMS for tropical winds at 850 hPa and 250 hPa for 72- and 120-hour ranges. In general, forecasts of the tropical winds at 850 hPa are about the same from all centres with a spread of less than two metres per second at both 72- and 120-hour ranges.

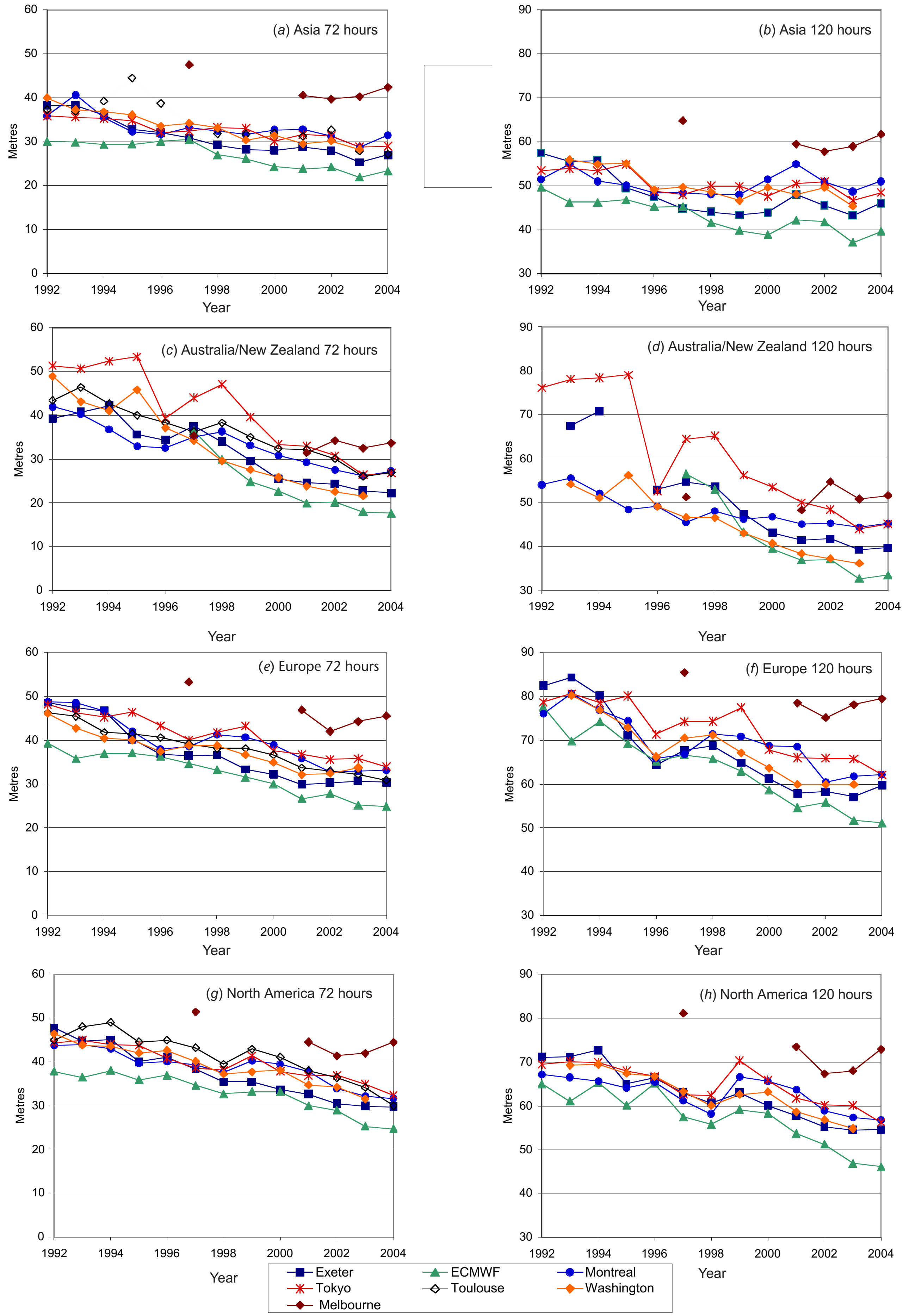


Figure IV-4 — Mean annual 500 hPa height errors over Asia, Australia/New Zealand, Europe and North America.

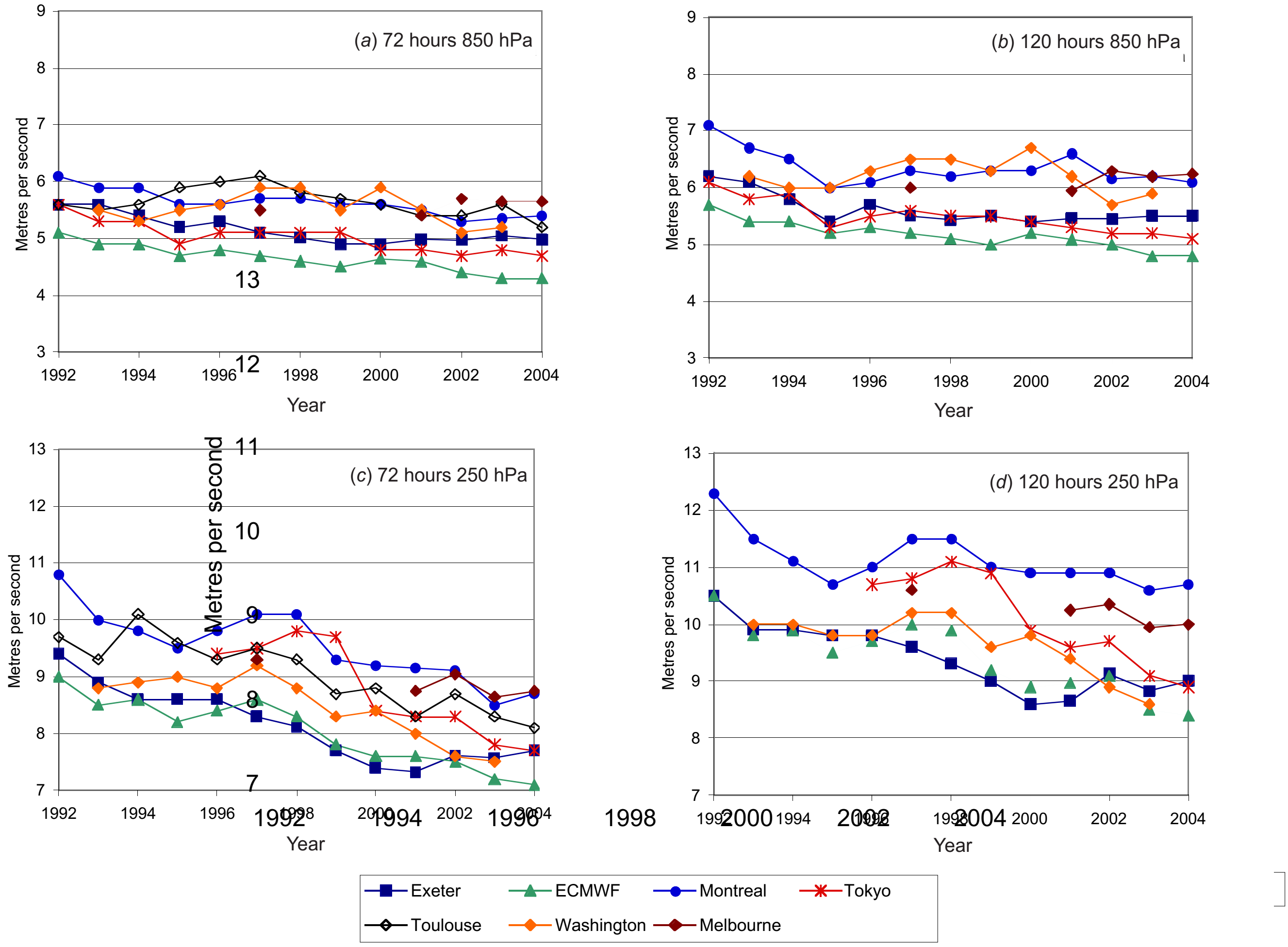


Figure IV-5 — 72- and 120-hour mean annual RMS tropical wind speed errors for 850 and 250 hPa.

The wind error at 850 hPa has decreased by an average of one metre per second over the 12-year period of record, whilst at 250 hPa the error has decreased by almost two metres per second over the same period. The spread of errors is, not surprisingly, a little larger at 250 hPa than at 850 hPa.

20. CBS has defined and recommended standard scores to be attached to long-range forecasts and to be used for quality assessment. The core standardized verification system also provides a means for GDPFS centres to exchange standardized verification statistics.

TECHNICAL DEVELOPMENT AT GDPFS CENTRES

21. Advanced GDPFS centres have implemented data assimilation systems with three-dimensional variational analysis (3-DVAR) and even some with 4-DVAR, including direct assimilation of satellite radiance and humidity data. Physical parameterization schemes (such as convection, cloud and radiation) are constantly improved, leading to better very short-range and short-range predictions, especially over the tropical regions. Global models are now run at 16 GDPFS centres and 12 of these disseminate their products on the GTS or through satellite systems. Fourteen centres now run operational EPSs, which are applied to all forecasting ranges.

22. Continuous operations are performed by the Association of South-East Asian Nations (ASEAN) Specialized Meteorological Centre (ASMC) in Singapore and by emerging centres, such as the African Centre of Meteorological Applications for Development (ACMAD), and the Drought Monitoring Centres (DMCs) in Nairobi and Harare. These centres have plans to further improve their equipment and to train staff at various levels. ACMAD provides guidance to NMCs on medium-range forecasting, monthly climate bulletins and experimental seasonal outlooks. ACMAD is also working on the development of a regional model using boundary conditions obtained from an advanced GDPFS centre. DMCs Nairobi and Harare provide decadal climate diagnosis information with seasonal outlook for East and southern Africa.

23. Seventy-four GDPFS centres currently run NWP models operationally; 32 run LAMs with resolution coarser than 35 km, and 54 run mesoscale models with a resolution of 35 km or finer. As shown in Figure IV-6, the number of centres running mesoscale models increased dramatically over the last eight years. During the last two years, the number of centres running regional or local models (either LAM or mesoscale) has increased by 10 per cent, and the number of centres running mesoscale models has increased by 20 per cent. The number of centres running global models and hemispheric models remains unchanged. Ten centres are now running high-resolution non-hydrostatic models operationally.

24. Most advanced centres now operate, or have under development, EPS for use in short-, medium- and/or

long-range forecasting. Most operational EPS use global models for medium-range predictions. A small number of regional ensembles focusing on short-range forecasts are operational or under development. Table IV-9 shows the centres producing short- or medium-rage EPS products, and Table IV-10 shows the centres producing long-range (seasonal) EPS products. Centres recently added to the list of EPS-operating centres include Beijing and Moscow, with several other centres adding additional EPS time-range products to their repertoire. A list of verification products to be exchanged between centres producing EPS data, both short-range and medium-range, has been developed. A subset of these scores is published in the annual GDPFS Technical Progress Report. A list of EPS producers and their products is available on the GDPFS web site at http://www.wmo.ch/web/www/DPS/EPS-HOME/eps-home.htm.

25. Thirteen GDPFS centres are engaged in long-range forecasting activities at global level. Ten centres now operationally use coupled ocean-atmosphere models. These produce useful long-range forecasts up to seasonal and multi-seasonal prediction periods, for both SST and some atmospheric parameters. Eleven centres are using EPS for long-range forecasting as shown in Table IV-10. ACMAD, DMCs Nairobi and Harare and several major GDPFS centres are actively using NWP results in creating long-range forecasts, including seasonal to interannual outlooks. Ensembles combined with statistical linear regression is the method used in most cases for monthly and seasonal outlooks. Several centres make available on the Internet extended and long-range forecasts, including national and even global seasonal forecasts. Some centres, such as the International Research Institute for Climate Prediction (IRI) and NOAA-NCEP, offer open access, and others, including ECMWF and the Brazilian National Institute for Space Research (INPE), restrict access by using a password. WMO Members can request the password for accessing ECMWF extended tropical belt products and ECMWF global products.

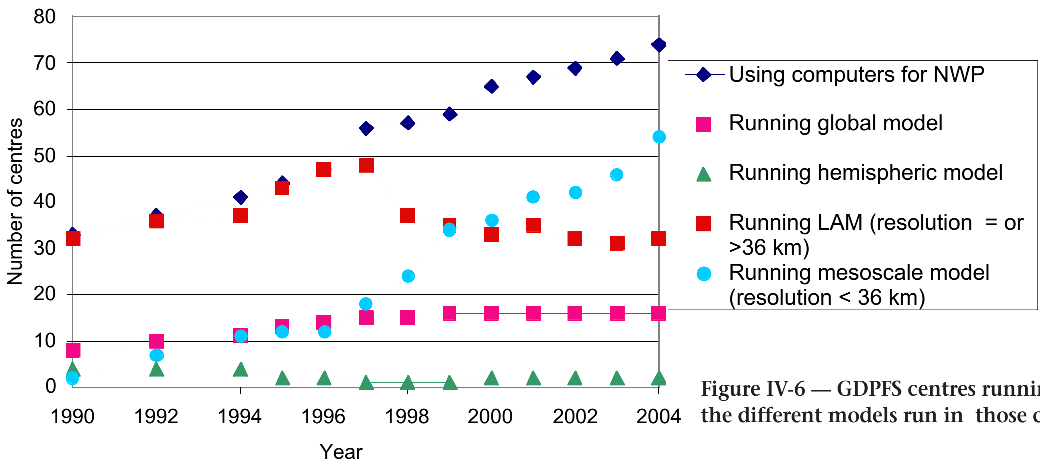


Figure IV-6 — GDPFS centres running NWP models, and the different models run in those centres.

Table IV-9
Centres producing short- and medium-range EPS products

Centre	*No. of members*	*Range*	*Comment*
ECMWF	50	10 days	SV+StoP
Montreal	16	10 days	24h LAF
	5	1 month	24h LAF
Pretoria	16	14 days	BGM
Beijing	32	10 days	SV
	12	1 month	LAF over 3 days
Seoul	17	10 days	BGM
	20	4 months	BGM
Sao Paulo	15	7 days	Random OP
INPE/CPTEC	15	1 month	Random OP
Tokyo	25	9 days	BGM
	26	1 month	BGM
	31	4 months	SV
Washington	10	3 days	BGM
	20	16 days	BGM
Moscow	10	1 month	-
Exeter	9	4 months	Random OP
Melbourne	32	10 days	SV

Table IV-10
Centres producing long-range EPS products

Centre	*No. of members*	*Range*	*Comment*
ECMWF	30	6 months	OP+StoP
Montreal	12	100 days	24 LAF, two models
Beijing	8	6 months	LAF
Seoul	32	6 months	BGM
Sao Paulo INPE/CPTEC	25	6 months	Random OP
Tokyo	31	18 months	SV
Lima	12	6 months	Perturbed SST
Toulouse	10	4 months	LAF
Washington	20	6 months	BGM
Exeter	9	2 years	Random OP
Melbourne	10	8 months	LAF

SV = Sigular vectors StoP = stochastic physics LAF = Lagged average forecasts BGM = Breeding of growing models
OP = Observation perturbations

ANNEX I

STATUS OF NUMERICAL MODELS RUNNING AT RSMCs AND NMCs

(Based on latest information available in January 2005)

REGION I

Centre	*Status*	*Model*	*Resolution*	*Level*	*Range*	*Boundary*	*Dissemination*
ACMAD	Special Centre	Access to GM					Fax, special
		LAM (regional spectral model)	50 km	28	36 h	NCEP	
HARARE	Special Centre						Special
LA RÉUNION	Tropical Cyclone (T.C.) RSMC	Full access to GM Full access to MSM					GTS, fax, sat, special
ALGIERS	Geographical RSMC	LAM (ETA)	36 km	24	72 h	GFS (NCEP)	
		MSM (ETA)	11 km	24	48 h	GFS (NCEP)	
CAIRO	Geo. RSMC	MSM (ETA)	35 km	32	120 h	GFS (NCEP)	Fax
		MSM nested non-hydro. (MM5)	63/21/7 km	36	48 h	GFS (NCEP)	
CASABLANCA	Geo. RSMC	MSM (ALADIN-NORAF)	28 km	31	72 h	ARPEGE	GTS, special
		MSM (ALADIN/ Morocco) 3D-VAR	12 km	41	72 h	ALADIN-NORAF	
		MSM (ALADIN/ Morocco local)	5 km	41	36 h	ALADIN	
DAKAR	Geo. RSMC						GTS, fax
NAIROBI	Geo. RSMC	Access to GM					GTS, fax
		MSM (HRM)	28 km	40	24 h	GME	
PRETORIA	Geo. RSMC	GM (NCEP Anal.)	T126	L28	7 days		GTS, fax
		GM Ens. 16 members (BGM)	T62	L28	14 days		
		GM (COLA)	T30	L28	8 months		
		LAM (ETA)	48 km	38	48 h	GFS (NCEP)	
		MSM (MM5)					
TUNIS	Geo. RSMC	MSM (ALADIN)	12.5 km	L41	48 h	ARPEGE	

REGION II

Centre	*Status*	*Model*	*Resolution*	*Level*	*Range*	*Boundary*	*Dissemination*
ABU DHABI	NMC	LAM (NCEP-ETA)	0.3°	42	72 h	GFS (NCEP)	
		MSM (NCEP-ETA-non-hydrostatic)	0.09°	42	72 h	GFS (NCEP)	
		LAM (HRM)				GME	
BANGKOK	NMC	GM (unified UKMO)	100 km	19	168 h		
		LAM	48 km	19	72 h		
		MSM	17 km	31	36 h		
HANOI	NMC	MSM (HRM)	28 km	20	72 h	GME	
HONG-KONG	NMC	LAM-(ORSM)	60 km	36	72 h	GSM	
		3 D-VAR	20 km	40	42 h	GSM	
		MPI-ORSM 4D-VAR	5 km	45	12 h	MSM (ORSM)	
		NHM – non-hydrostatic – Wind RADAR data assimilated					

GM = Global model
LAM = Limited area model (resolution coarser or equal to 36 km)
MSM = Mesoscale model (resolution finer than 36 km)
Perturbation technique for ensemble prediction systems: SV = Singular vectors; BGM = Breeding of growing modes; LAF = Lagged average forecasts; StoP = Stochastic physics; OP = Observation perturbations

REGION II (continued)							
Centre	*Status*	*Model*	*Resolution*	*Level*	*Range*	*Boundary*	*Dissemination*
MACAO	NMC	MSM	54/18 km	22	60 h		
OMAN	NMC	MSM (ORM28)	28 km	40	78 h	GME	
		MSM (ORM07)	7 km	40	78 h	GME	
PYONGYANG	NMC	Hemispheric model (HM)	T42	14	96 h		
		LAM – regional spectral model	100 km	14	48 h		
		LAM	50 km	18	24 h		
SEOUL	NMC	GM (GDAPS)	T213	L31	240 h		
		MSM (RDAPS)	30 km	43	48 h	GDAPS	
		MSM (RDAPS)	10 km	43	24 h	GDAPS	
		MSM (RDAPS)	5 km	43	24 h	GDAPS	
		Typhoon (KTM)	1/6 °	18	72 h	GDAPS	
		GM Ens. 32 members, BGM	T106	L21	10 days		
		GM Ens. 20 members, BGM	T106	L21	7 months		
TEHRAN	NMC	LAM (MM5)	40	23	96 h		
ULAANBATAR	NMC	LAM (MM5)					
NCMRWF	Special Centre	GM	T80	L18	5 days		
-INDIA		LAM	50 km	18	5 days		
BEIJING	Geo. and transport model (T.M.) RSMC	GM (3 D-VAR)	T213	L31	10 days		GTS, fax, sat
		LAM-(HLAFS)	0.5°	20	48 h	GM	
		GM-(MTTP). Typhoon track	T213	L31	96 h		
		MSM (NMC-MM5) nested, D.A. = nudging method	27/9/3 km	36	48 h		
		AGCM/OGCM	T106	30	30 days		
		GM Ens. 32 members SV	T106	L19	10 days		
		GM Ens. 32 members 16 SV, 16 LAF coupled	T63	L16	1 month		
		GM Ens. 8 members LAF coupled	T63	L16	Season		
JEDDAH	Geo. RSMC	LAM	48 km	48	48 h		Fax
KHABAROVSK	Geo. RSMC	LAM	75 km	11	48 h		Fax
NOVOSIBIRSK	Geo. RSMC	Hemispheric (OI)	T40	15	48 h		Fax
TASHKENT	Geo. RSMC						Fax
NEW DELHI	Geo. and T.C. RSMC	Full access to GM (NCMRWF)					GTS, fax
		LAM (LAFS) 3-DVAR	0.75°	16	48 h	NCMRWF	
		For TC: quasi-lagrangian model 3 D-VAR	40 km	16	36 h		
TOKYO	Geo.- T.M. and T.C. RSMC	GM (GSM0305) 3 D-VAR	T213	40	216 h		GTS, fax, special
		GM Ens. 25 members BGM	T106	40	9 days		
		GM Ens. 26 members BGM (13 members and LAF on 2 days)	T106	40	34 days		
		GM Ens. 31 members, SV	T63	40	120/210 days		
		MSM (RSM0103) 4D-VAR	20 km	40	51 h	GSM	
		MSM (MSM0103) 4 D-VAR	10 km	40	18 h	RSM	
		GM Coupled (AGCM/OGCM) Ens. 31 members, SV	T63	21	18 months		
		Typhoon (TYM0103)	24 km	25	84 h	GSM	

REGION III

Centre	*Status*	*Model*	*Resolution*	*Level*	*Range*	*Boundary*	*Dissemination*
BOGOTA	NMC	MSM (MM5)	25 km				
LIMA	NMC	LAM (ETA)	48 km	36	120 h	GFS (NCEP)	
		MSM (ETA-SENAMHI))	25 km	38	120 h	GFS (NCEP)	
		CCM3 Coupled En. 12 members, perturbed SST			6 months	SST	
QUITO	NMC	MSM (MM5)	25 km				
SANTIAGO	NMC	LAM (MM5)	60 km		60 h	GFS (NCEP)	
		MSM (MM5)	20 km			GFS (NCEP)	
INPE/CPTEC-SAO PAULO	Special Centre	GM AGCM CPTEC/COLA	T170	42	7 days	GFS (NCEP)	Special
		GM AGCM Ens. 15 members (random OP)	T62	28	7 days	GFS (NCEP)	
		LAM (ETA)	40 km	38	60 h	GFS (NCEP)	
		GM Coupled, Ens. 30 members (random OP) Fixed and predicted SST	T62	28	Six months	GFS (NCEP)	
BRASILIA	Geo. RSMC	Full access to GM					GTS
		MSM (MBAR-HRM)	25 km	35	48 h	GME	
BUENOS AIRES	Geo. RSMC	MSM (ETA SMN)	25 km	38	132 h	GFS (NCEP)	GTS, fax

REGION IV

Centre	*Status*	*Model*	*Resolution*	*Level*	*Range*	*Boundary*	*Dissemination*
SAN JOSE	NMC	MSM (ETA)	10 km		36 h	GFS (NCEP)	
		MM5				GFS (NCEP)	
IRI (United States)	Special Centre	Ens. multi-models, over 30 members, LAF			6 months		
MEXICO	NMC	LAM (MM5) non-hydrostatic	45 km	20	72 h	GFS (NCEP)	
MONTREAL	Geo. and T.M. RSMC	GM (GEM) 3 D-VAR	0.9° (~ 100 km)	28	240 h and 360 h		GTS
		GM Ens. 16 members (random OP and two models modifed 8 times)	T149 and 1.2°	28	240 h		
		GM (GEM Regional)	Variable mesh 0.22° (~ 24 km) over North America	28	48 h		
		MSM (HIMAP)	10 km	35	30 h		
		GM Ens. 5 members (24 h LAF)	T63	23	1 month		
		GM Ens. 12 members (24 h LAF, two models)	T63 T32	23 10	100 days		
MIAMI	Geo. and T.C. RSMC	Full access to GM and LAM					Sat
		HCN (hurricane)	0.16°	18	72 h		

REGION IV (continued)

Centre	*Status*	*Model*	*Resolution*	*Level*	*Range*	*Boundary*	*Dissemination*
WASHINGTON	WMC/ Geo. and T.M. RSMC	GFS (3D-VAR)	T254	64	84 h		GTS, ISCS, special
			T170	42	84 to 180 h		
			T126	28	180 to 384 h		
		LAM (RUC)	40 km	40	12 h	GFS	
		LAM (NGM)	90 km	16	48 h	GFS	
		MSM (HiRes) 3D-VAR (Meso-ETA) over Alaska	12 km	60	84 h	GFS	
		MSM ((HiRes) 3D-VAR (Meso-ETA) over Hawaii	10 km	28	48 h	GFS	
		Hurricane	0.5°	42	120 h	GFS	
		Regional Ens. 15 members (10 ETA + 5 RSM) (SREF) (North America) (BGM)	48 km	60	63 h		
		Global Ens. 20 members (BGM)	T126 T62	28	85 h to 16 days		
		Ens. 20 members, (CFS) MOM 3 Coupled	T62	64	7 months		

REGION V

Centre	*Status*	*Model*	*Resolution*	*Level*	*Range*	*Boundary*	*Dissemination*
KUALA-LUMPUR	NMC	LAM (MM5-RAPS)	0.5°	20	48 h	CMA	
MANILA	NMC	MSM (MM5)	20 km	36	72 h	GFS (NCEP)	
SINGAPORE	NMC and ASEAN Specialized Meteorological Centre (ASMC)	GSM	1.875°	16	240 h		Special
		LAM (FLM)	127 km	12	72 h	GSM	
		LAM (VFM)	63.5 km	13	72 h	GSM	
DARWIN	Geo. RSMC	Full access to GM					
		LAM-(TLAPS)	0.375°	19	48 h		GTS, fax, sat, special
NADI	T.C. RSMC	Access to GM					GTS, fax
WELLINGTON	Geo. RSMC	MSM					Fax
MELBOURNE	WMC, Geo. and T.M. RSMC	GM (GASP) OI-1D-VAR	T239	29	240 h		GTS, fax, sat, special
		LAM (LAPS)	0.375°	29	72 h	GASP	
		LAM (TLAPS)	0.375°	29	72 h	GASP	
		MSM (MESO-LAPS)	0.125°	29	36 h	LAPS	
		MSM (Sydney and Melbourne)	0.05°	29	36 h	LAPS	
		TCLAPS	0.15°	29	72 h	GASP	
		Ens. GM, 32 members, SV	T119	19	10 days		
		Ens. 10 members, GM coupled (ACOML), LAF	T47	17	8 months		

REGION VI

Centre	*Status*	*Model*	*Resolution*	*Level*	*Range*	*Boundary*	*Dissemination*
ANKARA	NMC	Full access to GM (ECMWF)					
		MM5V3	27 km	32	48 h		
		MM5V3	9 km	32	48 h	Nested	
ATHENS	NMC	Full access to GM (ECMWF)					
		MSM (ETA-NMC)	0.21°	32	48 h		
		MSM (nested)	0.07°	32	24 h		
BELGRADE	NMC	LAM-(ETA 95) 3D-VAR	52 km	32	120 h	GME	
		MSM (ETA)	18 km	64	48 h	ECMWF	
BET DAGAN	NMC	MSM (HRM)	13 km	38	78 h	GME	
BRATISLAVA	NMC	MSM (ALADIN)	7.18 km	31	48 h		
BRUSSELS	NMC	Full access to GM (ECMWF)					
		MSM (ALADIN)				ALADIN	
BUCAREST	NMC	MSM (HRM)	20 km	20	78 h	GME	
		MSM (MM5)	15 km	25	24 h	GFS (NCEP)	
		MSM (ALADIN)	10 km	41	48 h	ARPEGE	
BUDAPEST	NMC	MSM (ALADIN/HU) – 3 D-VAR	6.5 km	37	48 h	ARPEGE	
COPENHAGEN	NMC	Full access to GM (ECMWF)					
		MSM (DMI-HIRLAM-T15) 3D-VAR		0.15°	40	60 h	ECMWF
		MSM (DMI-HIRLAM-S05)		0.05°	40	54 h	T15
DE BILT	NMC	Full access to GM (ECMWF)					
		HIRLAM	0.5°	31	48 h		
DUBLIN	NMC	Full access to GM (ECMWF)					
		MSM (HIRLAM) 3D-VAR	0.3°	31	48 h	ECMWF	
HELSINKI	NMC	Full access to GM (ECMWF)					
		MSM (RCR-HIRLAM)	0.2° (22 km) 3 D-VAR	40	54 h	ECMWF	
		MSM (MBE)	0.08° (9 km)	40	54 h	RCR	
KIEV	NMC	LAM					
LISBON	NMC	MSM (ALADIN-Portugal)	12.7 km	31	48 h	ARPEGE	
LJUBLJANA	NMC	MSM (ALADIN)	11.2 km	37	48 h	ALADIN/ LACE	
MADRID	NMC	Full access to GM (ECMWF)					
		LAM (HIRLAM)	0.5°	31	48 h		
		MSM (HIRLAM)	0.2°	31	24 h		
		MSM (HRM)				GME	
MINSK	NMC	LAM	300 km	6	36 h		
NORRKOPING	NMC	Full access to GM (ECMWF)					
		MSM (HIRLAM) 3 D-VAR (C-22)	22 km	40	48 h		
		MSM (HIRLAM) D-11	11 km	60	24 h	C-22	
OSLO	NMC	Full access to GM (ECMWF)					
		LAM	0.5°	31	48 h		
		MSM	0.1°	31	48 h		
PRAGUE	NMC	MSM (ALADIN)	9 km	43	54 h	ARPEGE	

REGION VI (Continued)

Centre	*Status*	*Model*	*Resolution*	*Level*	*Range*	*Boundary*	*Dissemination*
RIGA	NMC	LAM (HIRLAM 2)	55 km	16	36 h		
SKOPJE	NMC	MSM (NMM) non-hydrostatic					NCEP
SOFIA	NMC	MSM (HRM)	9 km	31	48 h	GME	
WARSAW	NMC	MSM (COSMO-LM)	14 km	35	78 h	ECMWF	
		MSM (ALADIN)	13.5 km	31	48 h	ARPEGE	
ZURICH	NMC	Full access to GM (ECMWF)					
		MSM (LM – COSMO consortium) non-hydrostatic, nudging	7 km	45	72 h	IFS	
ECMWF	RSMC for medium-range	GM (IFS)	T511	60	240 h		GTS, special
		GM (IFS) Ens.- 50 members SV+StoP	T255	40	240 h		Special
		GM (IFS) Ens.- 50 members SV+StoP; coupled ocean (29 levels) Hamburg ocean primitive equation (HOPE)	T159	40	10 days to 1 month		Special
		GM (IFS) Ens.- 40 members OP+StoP, coupled ocean (29 levels) HOPE, 5 ocean analyses with SST perturbations	T95	40	6 months		GTS, SST available in GRIB 2
OBNINSK	T.M. RSMC (for RA II)	Full access to GM – HM and LAM					
TOULOUSE	T.M. RSMC	GM (ARPEGE) (4 D-VAR)	Variable mesh T358C2. 4 23 km to 133 km	41	102 h		Sat, special
		GM (ARPEGE-Tropics-Indian Ocean)	T358	41	72 h		
		MSM (ALADIN)	9 km	41	54 h	ARPEGE	
		MSM (ALADIN Tropical Cyclone- Indian Ocean)	31 km	41	72 h	ARPEGE	
		GM (ARPEGE-Climat) Ens. 10 members – LAF	T63	31	129 days		
EXETER	Geo. and T.M. RSMC	GM (unified model) 4D-VAR non-hydrostatic	0.556 lat. × 0.833 long.	38	144 h		GTS, fax, SADIS
		NAE -North Atlantic European 3 D-VAR	0.18°	38	48 h	GM	
		MSM 3D-VAR non-hydrostatic. Some RADAR data nudging	0.11°	38	48 h	GM	
		GM Ens. 41 members, coupled, OI ocean, 40 random OP of SST	Atmo: 2.5° Ocean: 1.25	19 40	6 months		
OFFENBACH	Geo. RSMC	GM (GME) 3 D-VAR	60 km	31	174 h		Sat, special
		MSM (LM – non-hydrostatic)	0.0625° (7 km)	35	48 h		
ROME	Geo. RSMC	Full access to GM (ECMWF)					Fax
		LAM (EuroHRM 3 D-VAR)	28 km	31	72 h	BC ECMWF	
		MSM (Med-HRM)	14 km	31	48 h	Euro-HRM	
		MSM (LAMI) non-hydrostatic (run in Bologna) nudging	7 km	35	72 h	GME	

REGION VI (Continued)

Centre	*Status*	*Model*	*Resolution*	*Level*	*Range*	*Boundary*	*Dissemination*
MOSCOW	WMC, Geo. RSMC	GSM 3D-VAR LAM MSM (non-hydrostatic) GM Ens. 10 members	T85 75 km 10 km T40	31 30 15 15	240 h 48 h 36 h 1 month	 GSM LAM	GTS, fax
Group of countries (ALADIN consortium): Austria, Belgium, Bulgaria, Croatia, Czech Republic, Hungary, Morocco, Poland, Portugal, Romania, Slovakia, Slovenia and Tunisia		MSM (ALADIN)	12 km	31	48 h	ARPEGE	
HIRLAM (high resolution limited area model): Denmark, Finland, Iceland, Ireland, the Netherlands, Norway, Spain and Sweden		MSM (HIRLAM)				ECMWF	
Group of countries (COSMO_LEPS): Germany, Greece, Italy, Poland, Romania and Switzerland		MSM non-hydrostatic nested in ECMWF EPS model, 10 Ens. members selected from 50 ECMWF ens. members	10 km	32	120 h		

ANNEX II

COMPUTERS USED FOR DATA PROCESSING AT RSMCs AND NMCs

(Based on latest information available in January 2005)

REGION I			
Centre	*Mainframe (number cruncher)*	*Secondary computer(s)*	*Workstations*
ACMAD		INTEL-based servers (AMEDIS system) – SUN SPARC	PCs
LAGOS			PCs (AFDOS system)
HARARE			IBM PSs – PCs
ALGIERS		PC Pentium IV	19 PCs
CAIRO	IBM S/390	4 HP 750C	12 IBM PC 300 GL, 18 PC Pentium
CASABLANCA	IBM SP	SUNSPARK 1000	SGI – 3 DEC ALPHA – MOTOROLA
DAKAR			PCs
NAIROBI		PCs, VAX3900 – VAX 11/750	SGI – PCs
LA RÉUNION			Workstations
PRETORIA	CRAY J916, CRAY SV1	2 SGI Origin 200, 2 SGI Indigo – SUN Enterprise 3000	PCs
TUNIS	Super calculator	2 DELL Xeon, HP715/80, HP 755/80	

REGION II			
Centre	*Mainframe (number cruncher)*	*Secondary computer(s)*	*Workstations*
ALMATY			PCs
BANGKOK	IBM RS/6000SP 12.96 GFlops	2 RS 6000 595	WKs
HANOI		MINCOMP ROBOTRON	MICRO PS
HONG-KONG	IBP p630 cluster (16 processors) 76.8 GFlops, IBM p690 (20 processors) 88GFlops, IBM RS/6000 SP (44 processors) 66 GFlops	CRAY SV1-1A (16 processors), SGI Origin 2000, 2 SUN E450, 2 SGI O2	WSs
KARACHI			PCs
OMAN	SUN E4500 12 processors and E4504 processors		
PYONGYANG		Pentium III	PC/AT – PS/2
SEOUL	CRAY X1-3/192-L (2.1 TFlops) NEC SX-5/28M2, SX-4/2A	HP V2500 (48PE)	SUN 2000
TEHRAN	ES9000	IBM 370 (2x 4381)	PCs
ULAANBATAR			MICRO VAX 3400
NCMRWF-INDIA	CRAY XMP/216		DEC Alpha WSs, SUN Ultra Sparc II WSs, SGI ORIGIN 200 and O2 WSs
BEIJING	IBM CLUSTER 1600 (20 TFLOPS) IBM SP RS6000 NH1 SP (71 GFLOPS)	IBM SP2/32	WSs
JEDDAH		CDC CYBER 962 – 2 CDC 910	3 SG – 4 VAX – 3 CDC
KHABAROVSK		COMPAREX, COMPLEX GIS Meteo	PC Pentium IV, PCs
NOVOSIBIRSK	CRAY EL		PCs
TASHKENT		HP 9000	PCs
NEW DELHI	CDC CYBER 2000U	SGI ORIGIN 200, 2CDC 4680	2 VAX 11/730, WS: 4 CYBER 910-485, VAX 3400, 5 Pentium II
TOKYO	HITACHI SR8000 E1/80	3 HITACHI 3500	HITACHIs

REGION III

Centre	*Mainframe (number cruncher)*	*Secondary computer(s)*	*Workstations*
LIMA	Clúster Beowulf 30 nodes, Pentium IV , IBM XP 1000	3 COMPAQ Alpha ES 40, 3 Alpha DS20, Alpha XP100	
SANTIAGO		HP E800	8 Sun Ultra 1/40
INPE(CPTEC- SAO PAULO	NEC SX 6/32M4, NEC SX 4/8A	2 SUN 280 R, 1 SUN FIRE 6800	62 WSs (DEC, Compaq), 41 PCs
BRASILIA	SGIs	2 DEC Alpha 3000-300	WSs (10): DECs, SGIs
BUENOS AIRES		SGI Origin 2002 and SGI Impact 10000	3 SGI Challenge S SGI INDIGO IMPACT – WSs

REGION IV

Centre	*Mainframe (number cruncher)*	*Secondary computer(s)*	*Workstations*
MEXICO		SGI Origin 2000	
MIAMI			WSs
MONTREAL	IBM P Series 690 (936 CPU)	5 SGI Origin 3000, 1 TANDEM Himalaya	10 SGI Origin 200, 27 HP9000, 9 HP K200, 4 SGI Indigo, 35 SGI 230, 20 Compaq DL
WASHINGTON	IBM 44 Regatta (power=about 8 × IBM/SP) (1408 processors)	2 SGI Origin 2000/32, SGI ORIGIN 3000/16	

REGION V

Centre	*Mainframe (number cruncher)*	*Secondary computer(s)*	*Workstations*
KUALA-LUMPUR		Hp J5600	
MANILA		SGI ORIGIN 2000	
SINGAPORE	NEC SX-6	2 FUJITSU M1600, FUJITSU DS90s, 8 SGI Origin 2000	WKs SGI Octane/O2/Indy, PCs
DARWIN			WSs
NADI		2 IBM RS6000/J50	WSs, PCs
WELLINGTON		ALPHA-9 PARALLEL PROCESSORS.	WSs
MELBOURNE	2 NEC SX-5	14 HP, 4 IBM RS6000 SP, 2 SGI	

REGION VI			
Centre	*Mainframe (number cruncher)*	*Secondary computer(s)*	*Workstations*
ANKARA	IBM pSeries 690	SGI Onyx 2, SGI 2200, 3 IBM p630	INTEL P4, PCs
ATHENS		CONVEX SPP1600-8	SGI: 2 INDIGO – 3 INDY – 1 ULTRA 8 WSs – 1 HP WS – PCs
BELGRADE		Beowulf Cluster	37 PC Pentium
BET DAGAN		SGI Origin O300 2000, 2xSGI Origin 200	8 SGI WSs
BRATISLAVA		HP 9000/720, SUN Sparc HS21	HPs
BRUSSELS	CRAY J916	HP servers	WSs
BUCAREST	SUN: E4500-8 processors, SUN E3500 – 4 processors, Blade1000 – 1 processor	DEC-ALPHA 5004 SUN-ULTRA (2 processors), HP servers	PCs
BUDAPEST	IBM Regatta p690 (32 processors)	SGI Origin 2000 (16 procesors) HP L3000 K250, K200, C200, D280, B180, J210, 755, 715, 710, DEC 600	SUN WS – PCs
COPENHAGEN	NEC-SX6 (8 nodes × 8 processors) 2 NEC TX 7	4 SGI Origin 200	WSs
DE BILT		SGI Power Challenge, SGI Origin 2000	Compaq clusters – WSs
DUBLIN	IBM RS/6000 SP	2 SGI Origin 200, SGI CHALLENGE L – 2 VAX 4200 – VAX 3100	
HELSINKI	IBM p690 (32 × 4 processors) (shared) – SGI Origin 2000	VAX 6240	VAX Clusters – WSs
KIEV		EC-1061	PCs
LISBON		2 DEC Alpha 2000 4/275, 2 DEC Alpha XP1000	
LJUBLJANA	14 dual processors nodes		PCs
MADRID	CRAY C-94	VAX – HP/HPUX and SUN/SOLARIS	SUN WSs
MINSK		2 Intel Celeron 600	3 Intel PIII, 2 Intel P-II
NORRKOPING	CRAY T3E (232 processors) (shared)	SGI 3800 DEC Alpha servers	29 VAX (Clusters) - 7 DEC – SUN WSs
OSLO	CRAY T3E	2 IBM RS6000 3 SGI Origin 2000, 200	VAX 4000-200/3300 DEC3100 Alpha-200
PRAGUE	NEC SX-6/4B-32	Fujitsu/ICL DRS6000	SUN SPARC 10/512, 2 TWO , 10 ONE WSs
RIGA		VAX 3100-40	Pentium 90
SOFIA		MOTOROLA SYSTEM	
WARSAW	SGI Origin 3800	SGI 3200	PCs
ZURICH	NEC SX-5 (shared)	8 processors SGI O3000	WSs
ECMWF	2 IBM P690+ Clusters, 2 × 2240 processors (1.9GHz Power4+)	5 IBM p660, 5 IBM Nighthawk, 3 HP K580, 4 SGI Origin 2000	SGIs indigo – indy, PCs
EXETER	NEC 2 × 15 SX6 + 2 × 2 TX7	IBM Z990, IBM Z800	HP WKs
TOULOUSE	FUJITSU VPP 5000 (124 processors)	HP N4000, HP T600, HP D370, HP C180	
OFFENBACH	IBM RS/6000 (80 × 16 processors)	4 SGI ORIGIN 2000	WSs
ROME	ECMWF service computer type: IBM-P690 1-4 nodes 30/120 processors.	COMPAQ ES 45, DS 10, GS 60E, 4 HP Alpha server	HP WSs
MOSCOW	CRAY Y-MP8E	CRAY Y-MPEL 98 – COMPAREX 8/83	2 HP 735 WSs

CHAPTER V

STATUS OF THE AVAILABILITY OF OBSERVATIONAL DATA FROM WWW

1. The availability of data on the MTN of the GTS is monitored through two types of exercises:

(*a*) The AGM of the operation of the WWW is carried out from 1 to 15 October. Seventeen RTHs located on the MTN provided global statistics for the 2004 AGM;

(*b*) The SMM is carried out from 1 to 15 January, April, July and October. Several RTHs located on the MTN participate in the SMM.

2. The reports from fixed stations (SYNOP and Part A of TEMP) given in this chapter result from the analysis of the AGM statistics. The reports from mobile stations (SHIP, TEMP SHIP, BUOY, AIREP, AMDAR and BUFR (aircraft)) result from the analysis of the SMM statistics.

RESULTS OF THE ANALYSIS

3. The analysis of the AGM statistics for SYNOP reports and Part A of TEMP reports, together with the analysis of the SMM statistics for mobile stations, is given in the following figures and tables:

(*a*) SYNOP and Part A of TEMP reports received during the 10-year period 1994–2004 are shown in Figure V-1 as a percentage of the number of reports required from the RBSNs;

(*b*) Five figures provide detailed information on SYNOP reports:

   (i) The number of SYNOP reports received during the October 2004 AGM, along with the number of reports required from RBSNs and reports expected according to *Weather Reporting* (WMO No. 9), Volume A, is shown in Figure V-2;

   (ii) The percentages of SYNOP reports received and percentages expected according to WMO No. 9, Volume A, with reference to reports required from RBSNs are shown in Figure V-3;

   (iii) The number of SYNOP reports received during the October AGM for the period 2000–2004 by WMO Region is shown in Figure V-4;

   (iv) A global map showing the locations from which SYNOP reports from RBSN stations were received for 0000, 0600, 1200 and 1800 UTC during the October 2004 AGM is shown in Figure V-5;

   (v) Figure V-6 provides information on the number of surface stations (SYNOP) in the RBSNs for the period 2000–2004;

(*c*) The following five figures provide detailed information on Part A of TEMP reports:

   (i) The number of Part A of TEMP reports received during the October 2004 AGM, along with the number of reports required from RBSNs and reports expected according to WMO No. 9, Volume A, is shown in Figure V-7;

   (ii) The percentages of Part A of TEMP reports received and percentages expected according to WMO No. 9, Volume A, with reference to reports required from TEMP stations in RBSNs are shown in Figure V-8;

   (iii) The number of Part A of TEMP reports received during the October AGM for the period 2000–2004 by WMO Region is shown in Figure V-9;

   (iv) A global map showing the locations from which Part A of TEMP reports from RBSN stations were received for 0000 and 1200 UTC during the October 2004 AGM is shown in Figure V-10;

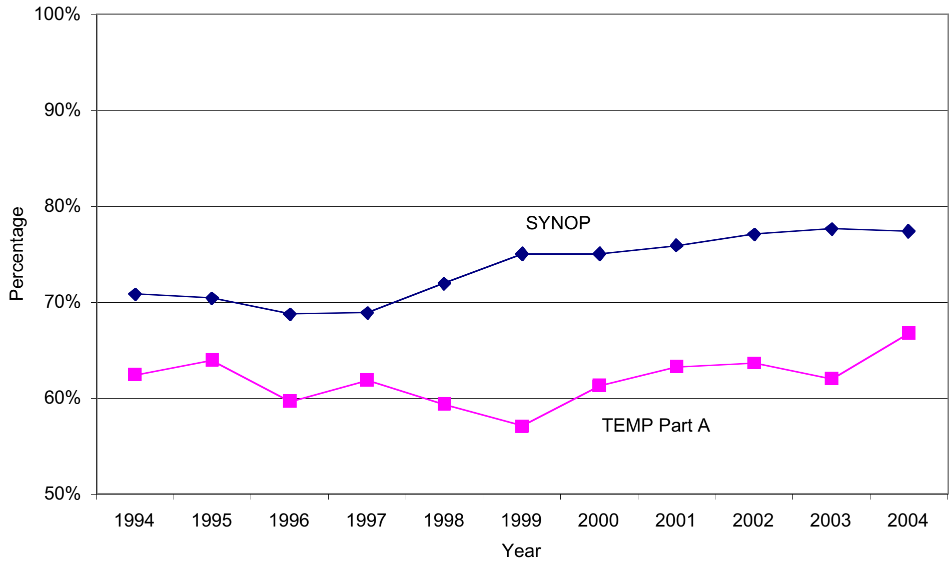
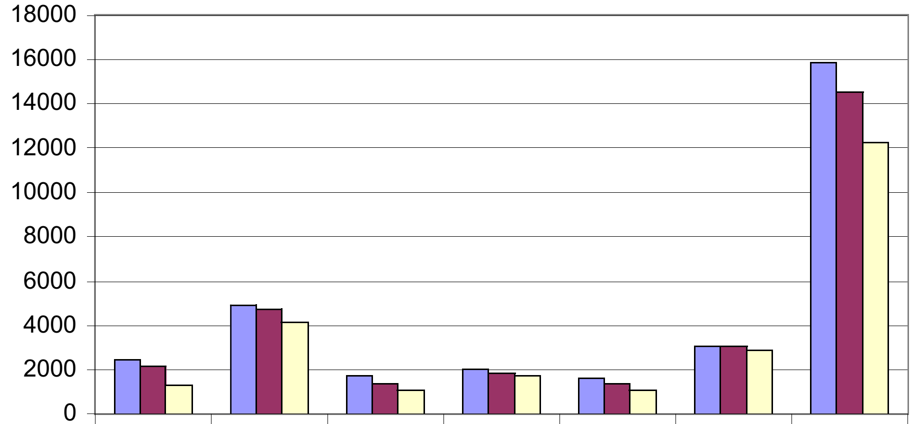


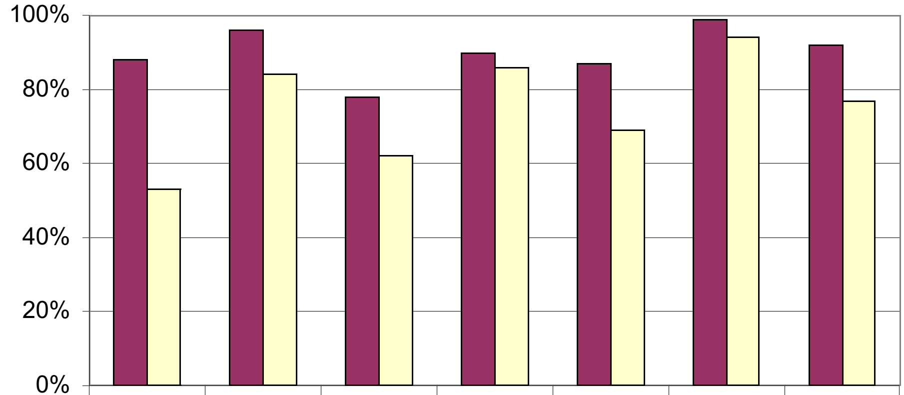
Figure V-1 — Percentage of SYNOP and Part A of TEMP reports received during October AGM periods with reference to reports required from RBSNs.

Figure V-2 — Number of SYNOP reports received during the 2004 AGM, showing also the number of reports required from RBSNs and reports expected according to *Weather Reporting* (WMO-No. 9), Volume A.

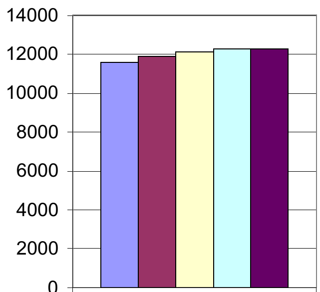


	RA I	RA II	RA III	RA IV	RA V	RA VI	Total
Required	2444	4936	1740	2048	1580	3080	15828
Expected	2158	4758	1349	1841	1379	3039	14524
Received	1294	4154	1073	1752	1083	2892	12248

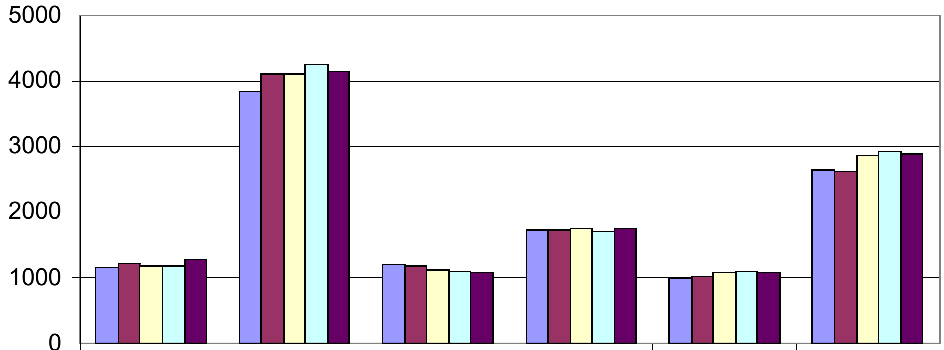
Figure V-3 — Percentages of SYNOP reports received and percentages expected according to *Weather Reporting* (WMO-No. 9), Volume A, with reference to reports required from RBSNs.



	RA I	RA II	RA III	RA IV	RA V	RA VI	Total
Expected	88%	96%	78%	90%	87%	99%	92%
Received	53%	84%	62%	86%	69%	94%	77%



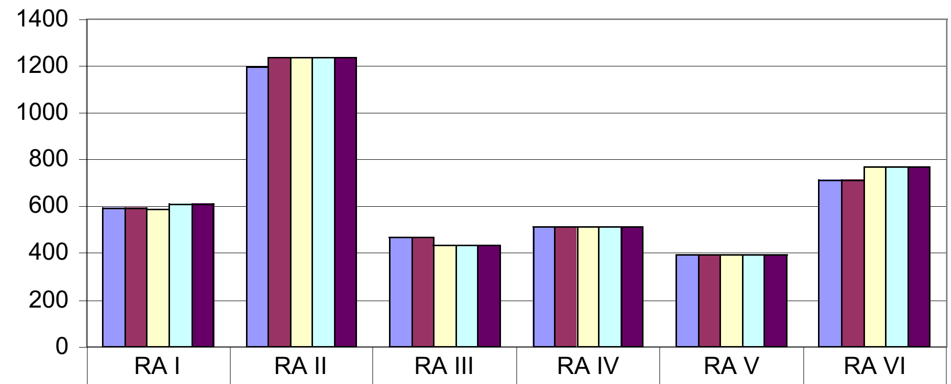
	All Regions
2000	11583
2001	11888
2002	12117
2003	12277
2004	12248



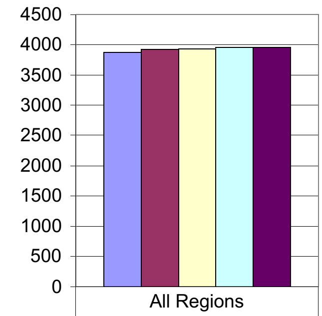
	RA I	RA II	RA III	RA IV	RA V	RA VI
2000	1167	3848	1193	1728	1001	2647
2001	1221	4110	1191	1722	1023	2622
2002	1179	4118	1110	1746	1089	2876
2003	1191	4247	1102	1709	1100	2927
2004	1294	4154	1073	1752	1083	2892

Figure V-4 — Number of SYNOP reports received during October AGMs for the period 2000–2004.

Figure V-5 — Availability of SYNOP reports from RBSN stations during the 1–15 October 2004 AGM monitoring period (the percentage of reports received is based on the main synoptic hours 0000, 0600, 1200 and 1800 UTC).



	RA I	RA II	RA III	RA IV	RA V	RA VI
2000	593	1195	467	511	396	714
2001	593	1234	467	512	396	714
2002	588	1234	435	512	394	769
2003	610	1234	435	512	395	770
2004	611	1234	435	512	395	770



	All Regions
2000	3876
2001	3916
2002	3932
2003	3956
2004	3957

Figure V-6 — Number of surface stations (SYNOP) comprising the RBSNs for the period 2000–2004 by WMO Region and globally.

(v) Figure V-11 provides information on the number of upper-air stations (TEMP) in the RBSNs for the period 2000–2004;

(*d*) A global map showing the locations from which SHIP reports were received for 0000, 0600, 1200 and 1800 UTC during the October 2004 SMM is shown in Figure V-12;

(*e*) A global map showing the locations from which BUOY reports were received during the October 2004 SMM is shown in Figure V-13;

(*f*) A global map showing the locations from which TEMP SHIP reports were received during the October 2004 SMM is shown in Figure V-14;

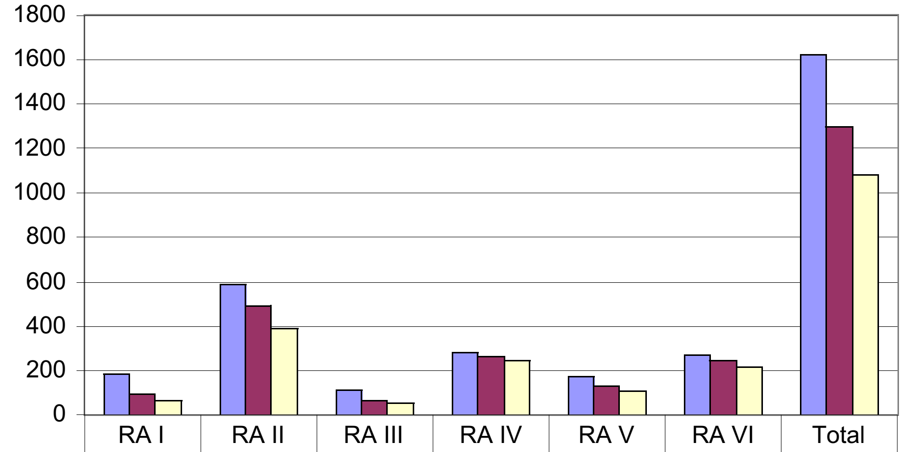
(*g*) A global map showing the locations from which AIREP and AMDAR reports were received during the October 2004 SMM is shown in Figure V-15;

(*h*) The daily average number of mobile station reports received by SMM centres during the period 2000–2004 is shown in Figure V-16;

(*i*) The timeliness of reception of reports for SYNOP and Part A of TEMP is given in Tables V-1 and V-2, respectively;

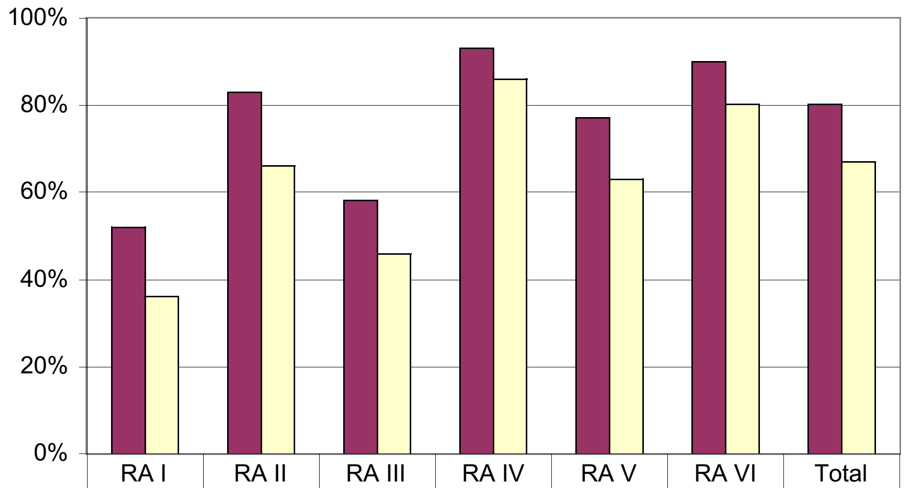
(*j*) Table V-3 provides information on the silent stations, both for SYNOP and Part A of TEMP reports.

Figure V-7 — Number of TEMP Part A reports received during the 2004 AGM, showing also the number of reports required from RBSNs and reports expected according to *Weather Reporting* (WMO-No. 9), Volume A.

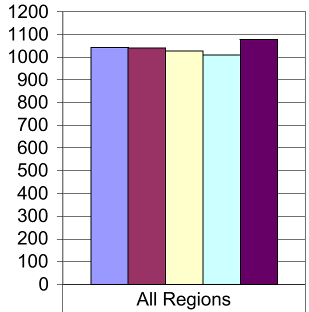


	RA I	RA II	RA III	RA IV	RA V	RA VI	Total
Required	184	590	116	284	174	270	1618
Expected	96	491	67	263	134	243	1294
Received	65	390	54	244	110	215	1079

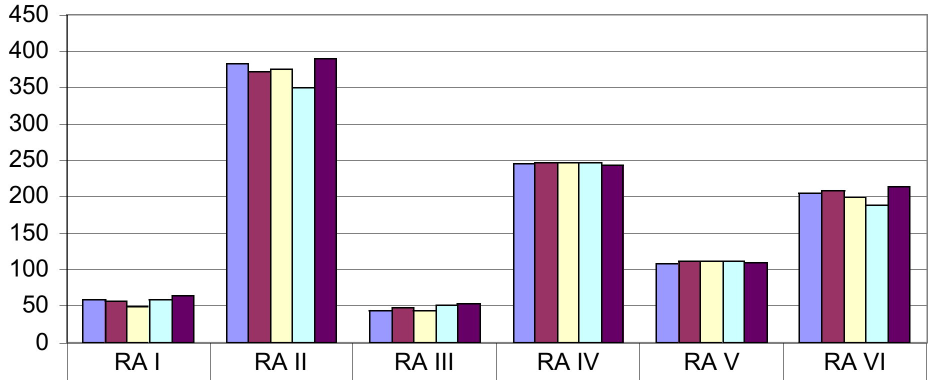
Figure V-8 — Percentages of TEMP Part A reports received and percentages expected according to *Weather Reporting* (WMO-No. 9), Volume A, with reference to reports required from RBSNs.



	RA I	RA II	RA III	RA IV	RA V	RA VI	Total
Expected	52%	83%	58%	93%	77%	90%	80%
Received	36%	66%	46%	86%	63%	80%	67%



	All Regions
2000	1043
2001	1041
2002	1028
2003	1010
2004	1079



	RA I	RA II	RA III	RA IV	RA V	RA VI
2000	59	382	44	245	108	206
2001	56	371	48	247	111	208
2002	50	376	44	247	112	199
2003	59	350	52	248	112	189
2004	65	390	54	244	110	215

Figure V-9 — Number of TEMP Part A reports received during October AGMs for the period 2000–2004.

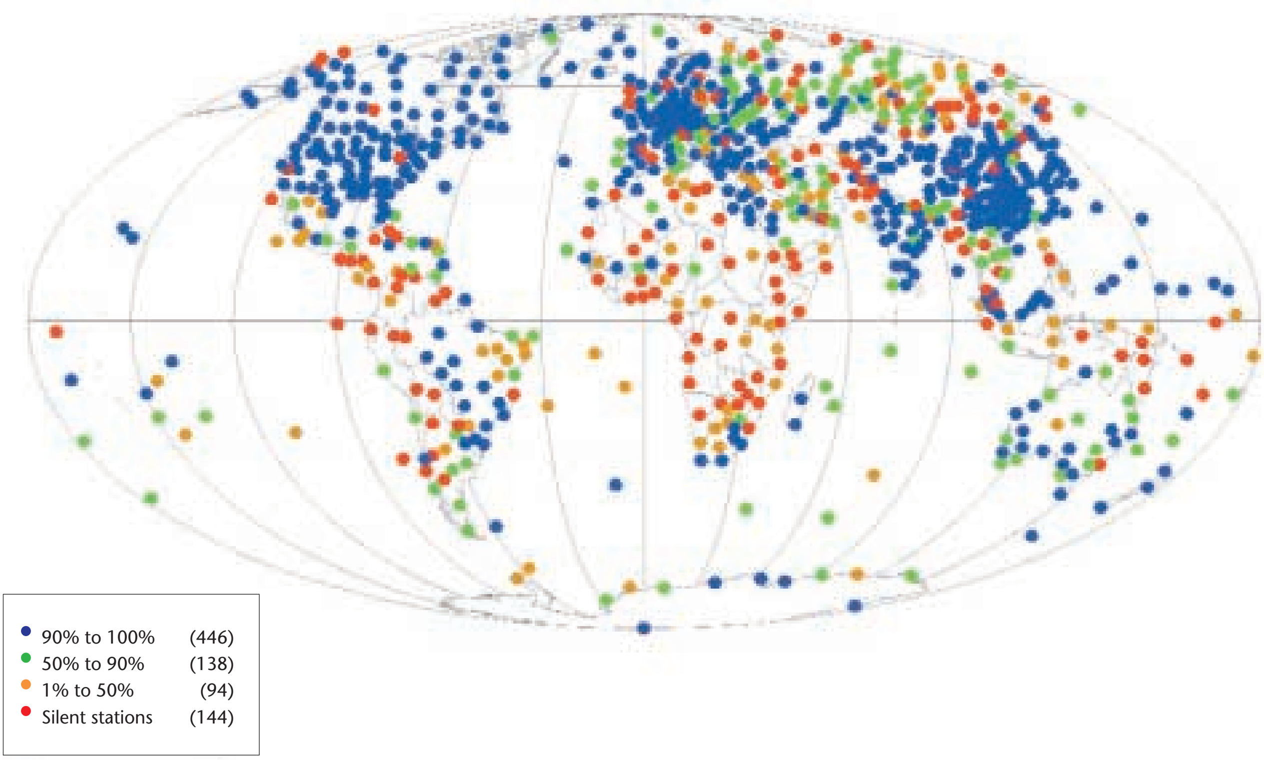
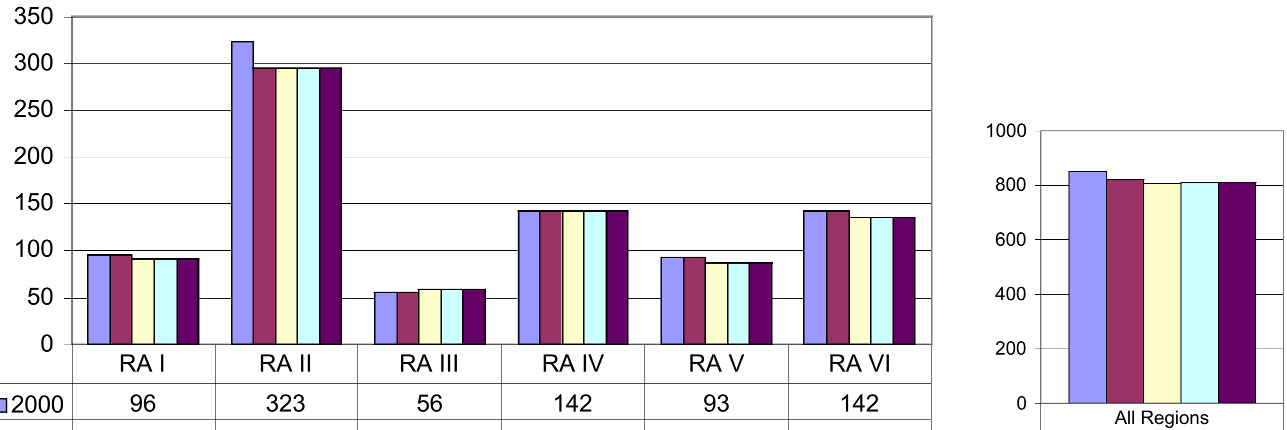


Figure V-10 — Availability of TEMP Part A reports from RBSN stations during the 1–15 October 2004 AGM monitoring period (the percentage of reports received is based on the reporting hours 0000 and 1200 UTC).



	RA I	RA II	RA III	RA IV	RA V	RA VI
2000	96	323	56	142	93	142
2001	96	294	56	142	93	142
2002	91	294	58	142	87	136
2003	92	295	58	142	87	136
2004	92	295	58	142	87	135

	All Regions
2000	852
2001	823
2002	808
2003	810
2004	809

Figure V-11 — Number of upper-air stations (TEMP) comprising the RBSNs for the period 2000–2004 by WMO Region and globally.

ANALYSIS OF THE AVAILABILITY OF SYNOP REPORTS

4. The daily average number of SYNOP reports has increased from 11 583 in 2000 to 12 248 in 2004, an increase from 75 per cent to 77 per cent of the reports required from the RBSNs (Figures V-2 to V-4). The increase was particularly significant for stations located in Regions III and V; however, there were still deficiencies in the availability of SYNOP reports, particularly in Region I (53 per cent), Region III (62 per cent) and Region V (69 per cent), as shown in Figure V-3.

5. Table V-1 shows that the availability of SYNOP reports was particularly low in Region I for 0000 UTC (41 per cent) and in Region III for 0600 UTC (30 per cent). This shows deficiencies in the preparation and collection of surface reports during the night in these Regions.

6. The increase in the number of SYNOP reports from Region I is particularly pleasing, but, at 53 per cent of the RBSN requirement, it is still not satisfactory. There is also a small decrease in the number of SYNOP reports received

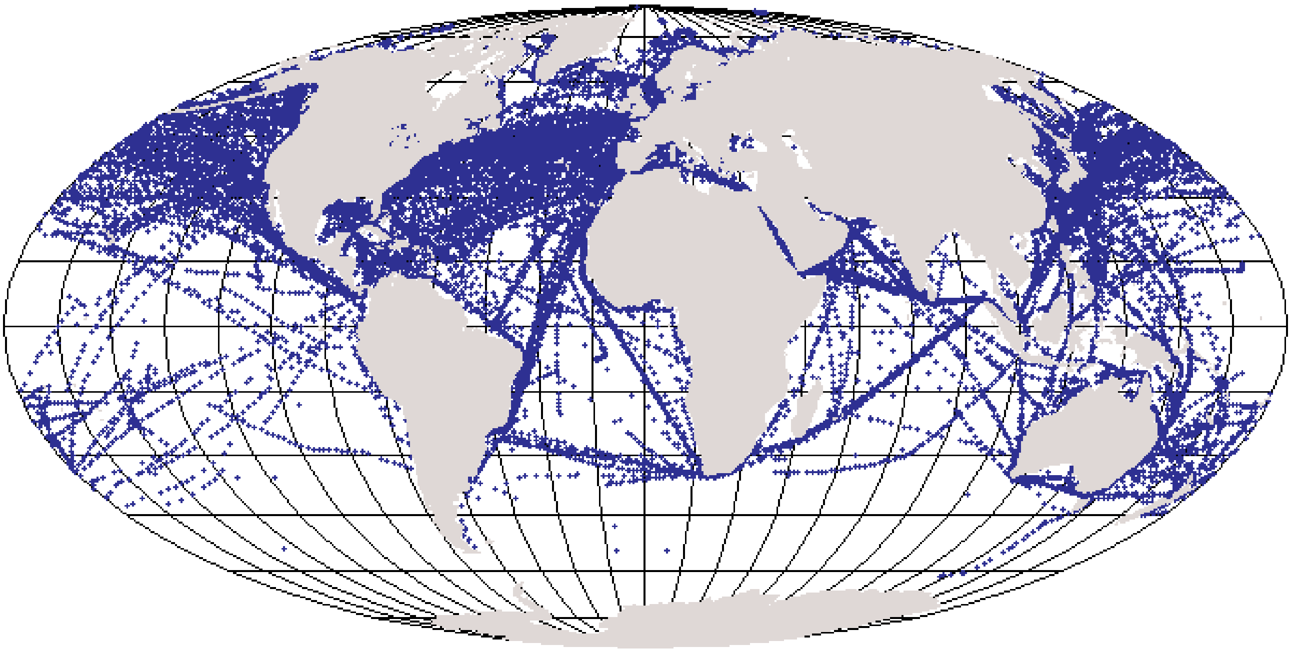


Figure V-12 — SHIP reports made at 0000, 0600, 1200 and 1800 UTC on 1–15 October 2004.

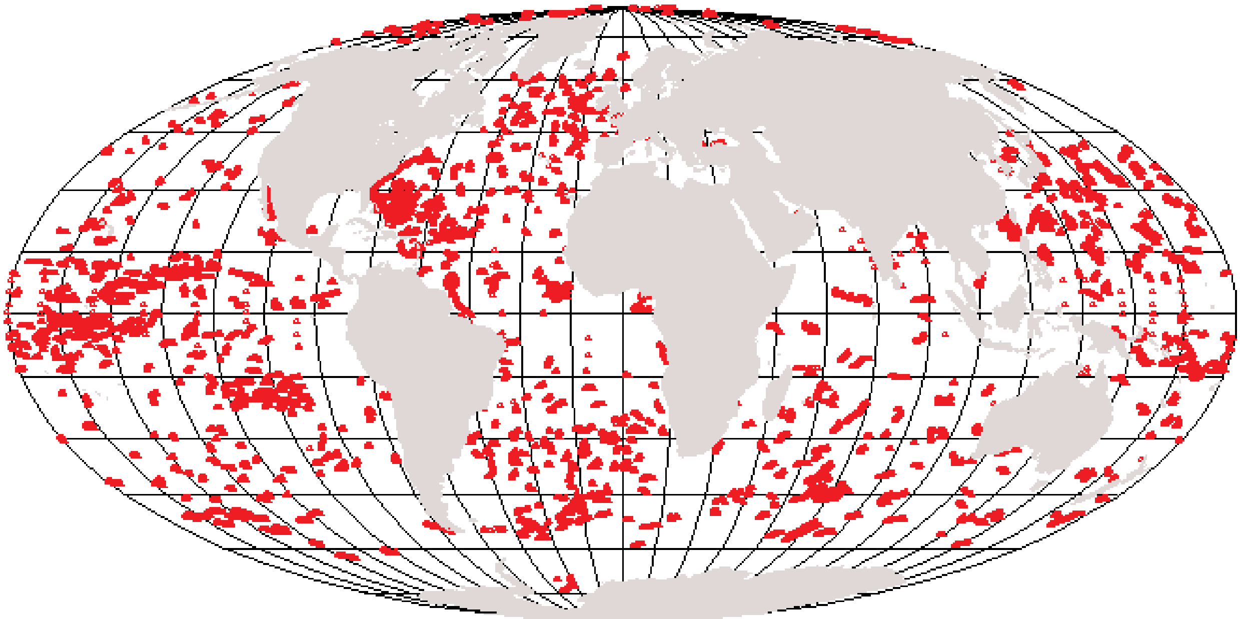


Figure V-13 — BUOY reports made on 1–15 October 2004.

from Region III. While not yet a cause for concern, any decreases need to be monitored and investigated.

7. During the 2004 AGM period, 72 per cent of the required SYNOP reports were received within one hour after the observation time, and an additional four per cent were received between one hour and six hours after the observation time (Table V-1). The most worrying delays in the reception of SYNOP reports were found for reports issued from Region I and the Antarctic. One of the reasons for these delays is the limitations of the techniques used for the data collection systems, in particular HF radio systems (SSB) in Region I and ARGOS systems in the Antarctic.

8. In 2004, 353 stations (9 per cent of the RBSN stations) were silent for SYNOP reports required from RBSNs, down from 438 in 2000 (Table V-3). The reports missing from these silent stations represent almost half of the total missing reports from the RBSN stations.

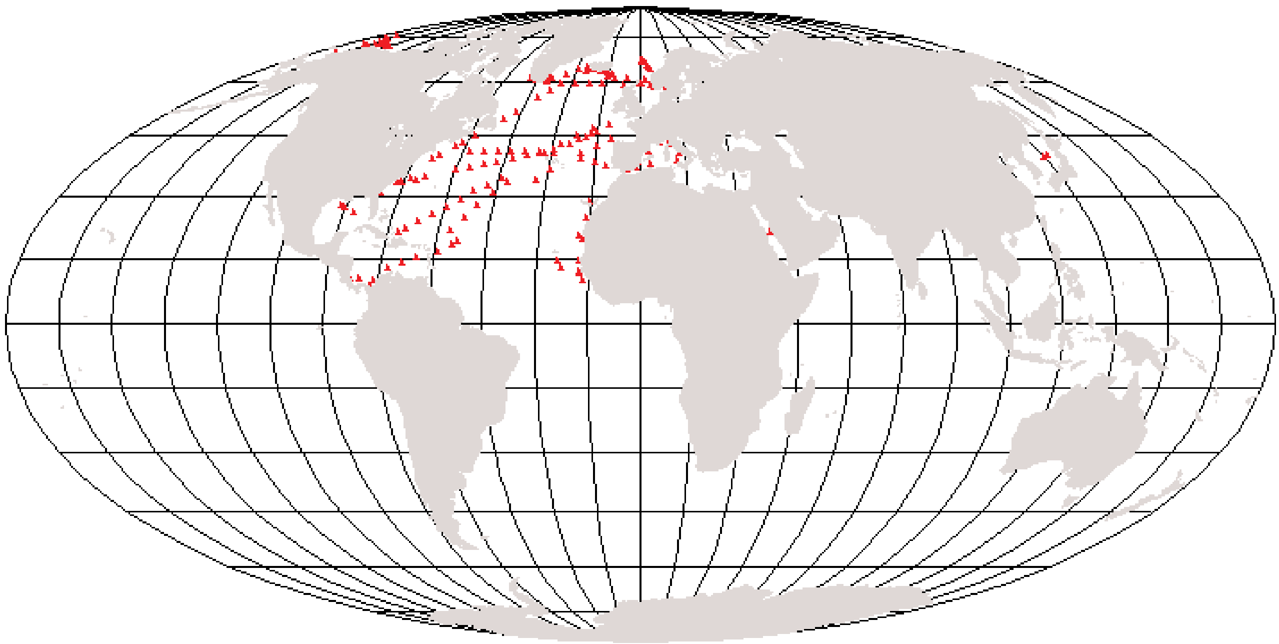


Figure V-14 — SHIP TEMP reports made on 1–15 October 2004.

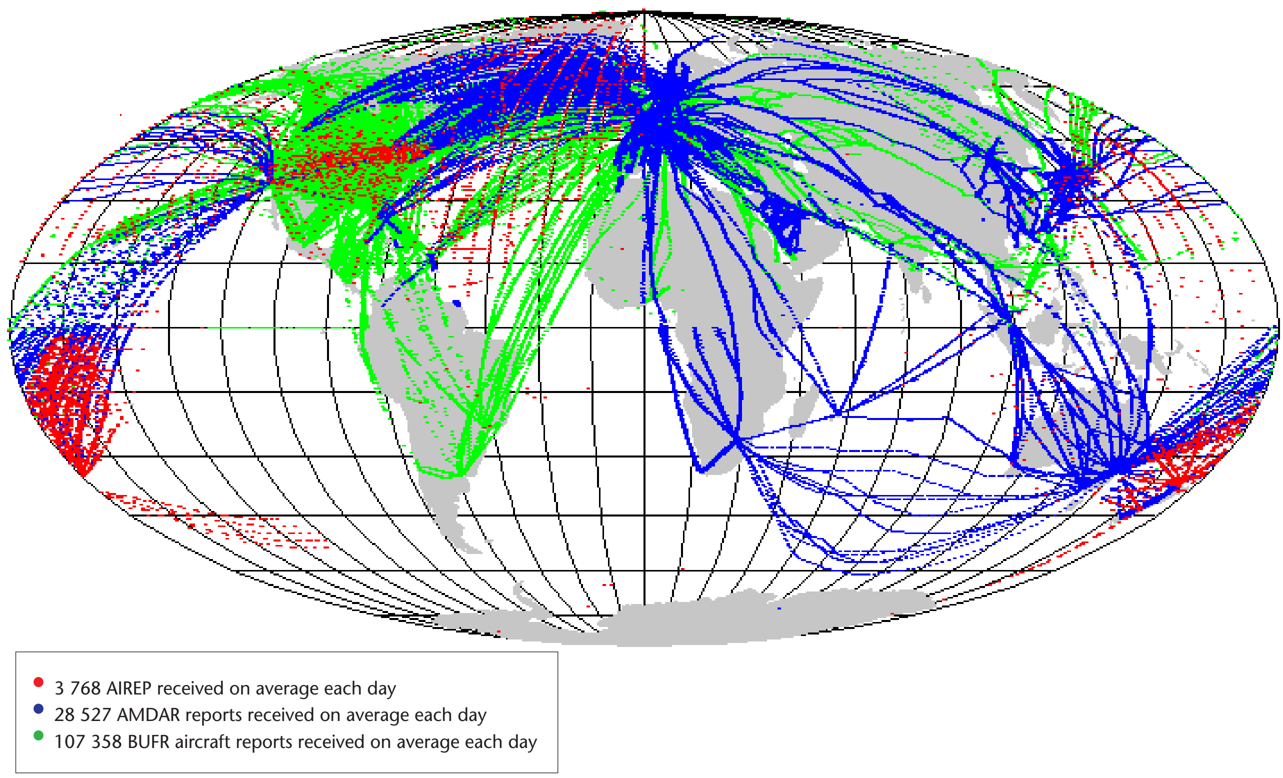
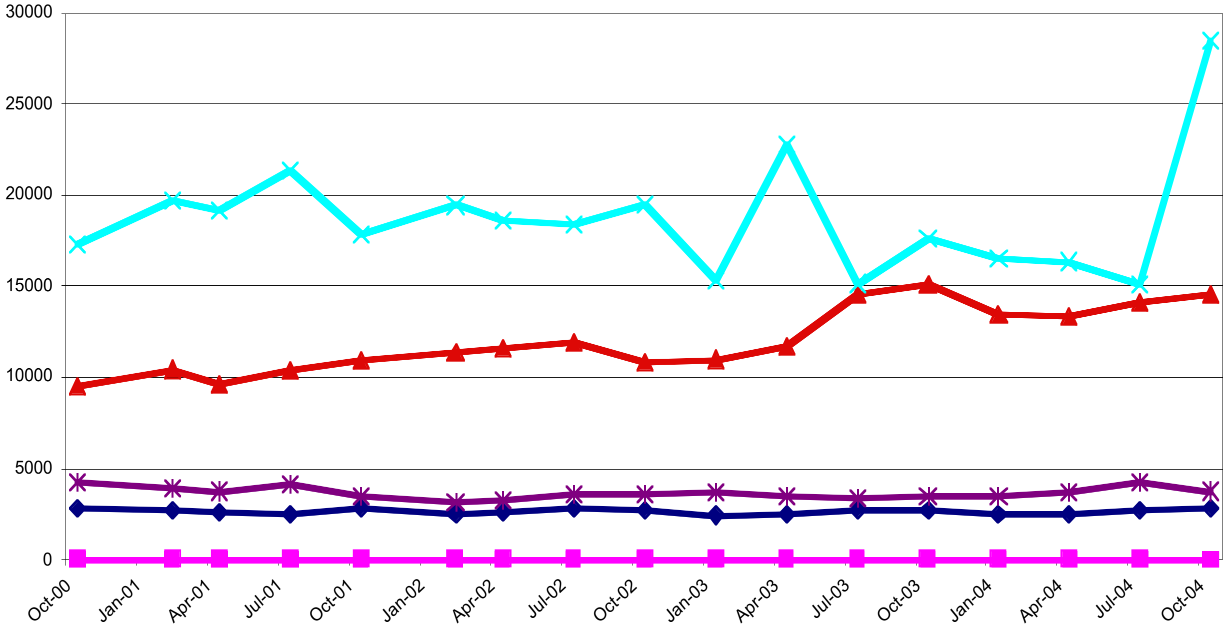


Figure V-15 — Aircraft reports (AIREP, AMDAR and BUFR) made on 1–15 October 2004.

ANALYSIS OF THE AVAILABILITY OF PART A OF TEMP REPORTS

9. The daily average number of Part A of TEMP reports received during AGM periods continues to increase from 1 028 in 2002 to 1 079 in 2004, an increase from 64 per cent to 67 per cent of the reports required from the RBSNs (Figure V-1). This increase is particularly due to improvements in the implementation and operation of the upper-air observation network in Region II, as well as improvements in Region VI. The availability of TEMP reports has now completely recovered from the slump of the mid-1990s. The availability of TEMP reports is relatively satisfactory for the eastern and southern parts of Region II, the western part of Region III, the northern part of Region IV, some countries in Region V and the western part of



	Oct-00	Feb-01	Apr-01	Jul-01	Oct-01	Feb-02	Apr-02	Jul-02	Oct-02	Jan-03	Apr-03	Jul-03	Oct-03	Jan-04	Apr-04	Jul-04	Oct-04
SHIP	2793	2691	2631	2513	2870	2549	2603	2797	2742	2446	2499	2765	2696	2464	2518	2746	2845
TEMP SHIP	14	19	19	17	18	18	17	19	16	15	14	21	19	15	18	23	13
BUOY	9542	10436	9613	10374	10919	11337	11620	11924	10841	11012	11706	14549	15100	13421	13351	14079	14541
AMDAR	17252	19728	19164	21385	17886	19441	18651	18358	19514	15334	22804	15147	17611	16567	16367	15101	28527
AIREP	4278	3935	3751	4128	3475	3149	3270	3561	3592	3680	3491	3407	3438	3452	3679	4287	3768

Figure V-16 — Daily average number of mobile station reports received by SMM centres during the period 2000–2004.

Table V-1
Timeliness of reception of SYNOP reports at MTN centres — monitoring period 1–15 October 2004

WMO Region	*Number of stations comprising the RBSN*	*Percentage of SYNOP reports received in comparison with the reports required from the RBSNs*														
		Observation: 0000 UTC received within			*Observation: 0600 UTC received within*			*Observation: 1200 UTC received within*			*Observation: 1800 UTC received within*			*Total received within*		
		1 h	*2 h*	*6 h*	*1 h*	*2 h*	*6 h*	*1 h*	*2 h*	*6 h*	*1 h*	*2 h*	*6 h*	*1 h*	*2 h*	*6 h*
Region I	611	34	37	41	47	55	59	53	58	60	48	51	52	46	50	53
Region II	1 234	81	83	85	84	85	86	83	84	85	78	79	82	81	83	84
Region III	435	64	65	66	27	29	30	75	76	77	73	74	74	60	61	62
Region IV	512	86	86	87	79	79	81	86	86	87	87	88	88	84	85	86
Region V	395	67	71	72	69	71	72	64	66	67	57	60	62	64	67	69
Region VI	770	88	90	90	93	95	95	93	95	95	93	95	95	92	93	94
Antarctic	75	42	66	69	42	61	62	44	62	70	46	61	67	44	63	67
Total	**4 032**	**72**	**74**	**76**	**71**	**74**	**75**	**77**	**79**	**80**	**74**	**76**	**78**	**74**	**76**	**77**

Region VI. The availability of TEMP reports is generally insufficient for most of the other parts of the world.

10. As can be seen in Table V-2, the availability of Part A of TEMP reports for 0000 UTC was particularly low for Region 1 (31 per cent) and for Region III (32 per cent).

11. During the October 2004 AGM period, 63 per cent of the required Part A of TEMP reports were received within two hours after the observation time, and an additional 4 per cent were received between two and 12 hours after the observation time (Table V-2).

12. In 2004, 92 stations (11 per cent of the RBSN stations) were silent for Part A of TEMP reports required from RBSNs, down significantly from 181 in 2000 and 156 in 2002 (Table V-3). The reports missing from these silent stations represent about half of the total missing TEMP reports from the RBSN stations.

ANALYSIS OF THE AVAILABILITY OF REPORTS FROM MOBILE STATIONS

13. During the October 2004 SMM, centres received on average 2 845 SHIP reports each day. The availability of SHIP reports has not significantly changed during the last four years (Figure V-16). The distribution of SHIP reports was not

Table V-2
Timeliness of reception of TEMP (Part A) reports at MTN centres — monitoring period 1–15 October 2004

WMO Region	*Number of stations comprising the RBSN*	*Percentage of TEMP reports received in comparison with the reports required from the RBSNs*					
		Observation: 0000 UTC received within		*Observation: 1200 UTC received within*		*Total received within*	
		2 h	*12 h*	*2 h*	*12 h*	*2 h*	*12 h*
Region I	92	27	31	36	40	32	36
Region II	295	61	69	60	64	61	66
Region III	58	29	32	58	61	44	46
Region IV	142	82	82	89	90	85	86
Region V	87	75	77	49	49	62	63
Region VI	135	80	82	77	78	78	80
Antarctic	13	68	69	53	54	60	61
Total	**822**	**63**	**67**	**64**	**66**	**64**	**67**

Table V-3
Number of stations included in the RBSNs from which no SYNOP or TEMP (Part A) reports were received at MTN centres — monitoring period 1–15 October 2004

WMO Region	*SYNOP*		*TEMP (Part A)*	
	Silent stations included in the RBSN	*Silent stations (implemented) (reference: WMO-No. 9, Volume A)*	*Silent stations included in the RBSN*	*Silent stations (implemented) (reference: WMO-No. 9, Volume A)*
Region I	111	7	22	14
Region II	90	21	34	20
Region III	58	6	13	5
Region IV	26	6	7	4
Region V	45	25	8	5
Region VI	10	1	8	4
Antarctic	13	1	0	0
Total	**353**	**67**	**92**	**52**

balanced between the hemispheres (Figure V-12); during the October 2004 SMM, 2 532 SHIP reports were issued on average each day from the northern hemisphere, while only 312 reports were issued from the southern hemisphere.

14. During the October 2004 SMM, centres received on average 14 541 BUOY reports each day. The availability of BUOY reports has been increasing regularly since 1996 and has almost doubled during the past six years (Figure V-16). The distribution of BUOY reports (Figure V-13) is more balanced between the hemispheres than for SHIP reports, with 7 693 BUOY reports issued on average each day from the northern hemisphere and 6 848 reports issued from the southern hemisphere.

15. During the February, April, July and October 2004 SMM exercises, SMM centres received on average each day 17 TEMP SHIP reports (Figure V-16). Most of the TEMP SHIP reports were issued from the Atlantic Ocean (Figure V-14).

16. During the October 2004 SMM, centres received daily on average 3 768 AIREP and 28 527 AMDAR reports (Figure V-16). The daily average number of AIREP reports has remained fairly static during the last four years. The daily average number of AMDAR reports has been around 15 000 to 20 000 reports during the past four years, up to and including the SMM monitoring in July 2004. The October 2004 SMM monitoring showed a significant increase up to about 30 000 AMDAR reports as a result of the AMDAR programmes in the eastern parts of Region II. Approximately two-thirds of the AMDAR reports continue to be issued from Europe (Figures V-15). Aircraft reports prepared in BUFR code started to be monitored by the SMM centres in January 2004. There are about 110 000 BUFR aircraft reports available daily, mostly from North America and Europe (Figure V-16).

CHAPTER VI

OPERATIONAL INFORMATION SERVICE

CURRENT STATUS

1. The purpose of the WWW OIS is to collect from, and distribute to, WMO Members and WWW centres detailed and up-to-date information on observing stations and programmes, facilities, services and products made available in the day-to-day operation of the WWW. OIS publishes this information in printed form, on diskettes, on CD-ROM and increasingly on the Internet, where it can be accessed on the OIS home page at http://www.wmo.ch/web/www/ois/ois-home.htm. Table VI-1 shows the information currently available on this web page.

2. Updated versions of Volumes A, C1, C2 and D of *Weather Reporting* (WMO-No. 9) were prepared and dispatched on CD-ROM, as well as being posted on the OIS home page. Additionally, the *International List of Selected, Supplementary and Auxiliary Ships* (WMO-No. 47) was also posted on the OIS home page. It has proven to be more cost-effective to produce CD-ROMs and to post the information on the WMO server than to produce paper versions of the updated information. This format is also becoming popular with Members. However, hard copies are available to Members if so required. It is anticipated that paper format distribution of many publications will be superseded by distribution on CD-ROM and particularly with interactive online access.

3. Most changes to Volume A—Observing stations are currently sent to the Secretariat on paper and entered manually. This is not efficient and is a possible source of errors. Revised procedures for updating and distributing Volume A in quasi real-time by using electronic media are under investigation.

Table VI-1
Information available on the OIS home page

Weather Reporting (WMO-No. 9), Volume A—Observing stations
Catalogue of radiosondes and upper-air wind systems in use by Members
Regional Basic Synoptic Network (RBSN) and Regional Basic Climatological Network (RBCN)
Weather Reporting (WMO-No. 9), Volume C1—Catalogue of meteorological bulletins
Weather Reporting (WMO-No. 9), Volume C2—Transmission programmes
Routeing catalogues of bulletins
Monitoring reports
Weather Reporting (WMO-No. 9), Volume D—Information for shipping
International List of Selected, Supplementary and Auxiliary Ships (WMO-No. 47)
Operational Newsletter on the World Weather Watch and Marine Meteorological Services
Additional data and products as defined in Resolution 40 (Cg-XII)

4. Information on data-processing and forecasting systems is provided on a yearly basis in the WWW Technical Progress Report on the GDPFS on the WMO server. Further information on the processed information exchanged on the GTS is available in Volume C1—Catalogue of meteorological bulletins.

5. Fourteenth Congress in May 2003 agreed to delete Volume B—Data Processing, of WMO-No. 9 from the list of WMO mandatory publications.

6. With respect to Volume C1—Catalogue of meteorological bulletins, twelve MTN centres, namely Algiers, Beijing, Exeter, Brasilia, Buenos Aires, Melbourne, Moscow, Offenbach, Prague, Sofia, Tokyo and Toulouse, are using database procedures for maintenance of their own parts of Volume C1. When all MTN centres implement these procedures, there will be a complete real-time online catalogue of bulletins.

7. Volume C2—Transmission schedules contains the transmission programmes of the distribution systems of the GTS (satellite distribution systems, and radioteletype (RTT) and radio-facsimile broadcasts). In order to avoid unnecessary duplication of information, in particular with regard to Volume D—Information for shipping, and routeing catalogues of RTHs, it has been recommended that Volume C2 should contain the identification and technical specifications of each data-distribution system and a summary of the transmission programmes.

8. All the MTN centres, except for Buenos Aires and Dakar, have made their routeing catalogues available on the Internet.

9. A data quality monitoring index page has been established on the WMO server (http://www.wmo.int/web/www/DPS/Monitoring-home/mon-index.htm) with links to web sites containing quality monitoring information. All the quality monitoring centres have been asked to provide the relevant URL addresses of their web sites and their subsequent updates.

10. Fourteenth Congress in May 2003 agreed that an important goal was to facilitate access to the information through interactive online access services. A project for the interactive online access to Volume C1 is being developed by the Secretariat. A demonstration of the application is available from http://alto-stratus.wmo.ch/WWWOIS/. Further development of interactive online services to access operational information is planned.

AVAILABLE INFORMATION

Weather Reporting (WMO-No. 9), Volume A—Observing stations

11. Volume A contains a list of 11 000 surface and 1 000 upper-air stations, which are used for synoptic purposes. The

following information for each station is kept on record: WMO index number, latitude and longitude, elevation, pressure level, surface synoptic observations, hourly and half-hourly observations, upper-air observations and other observations and remarks. It is published twice a year.

Weather Reporting (WMO-No. 9), Volume C1—Catalogue of meteorological bulletins

12. Volume C1 contains the list of meteorological bulletins being transmitted for global, interregional and regional exchange. An abbreviated heading (TTAAII CCCC) uniquely identifies each bulletin. Each bulletin records the code form used, time group, contents of bulletins and remarks. New editions are published twice a year.

Weather Reporting (WMO-No. 9), Volume C2—Transmission programmes

13. Volume C2 contains the transmission programmes of data-distribution systems of the GTS. The transmission content and transmission schedule are included. Supplements are published four times a year.

Weather Reporting (WMO-No. 9), Volume D—Information for shipping

14. Volume D comprises information on meteorological broadcasts by radiotelegraphy, radiotelephony and radiofacsimile; the global Maritime Distress and Safety System; coastal radio stations and INMARSAT land earth stations accepting ships' weather and oceanographic reports; marine meteorological services available for main ports; ship weather routeing services; and visual storm warning signals. Supplements are published twice a month.

International List of Selected, Supplementary and Auxiliary Ships (WMO-No. 47)

15. This list contains information about the approximately 7 000 ships participating in the WMO VOS programme. Information is provided on vessels and their routes and technical information is given on meteorological equipment and methods used on board, including exposure, location and instrument height/depth. The countries that recruit the ships supply this information. Updates are issued quarterly and a new consolidated edition is published annually.

Catalogue of radiosondes and upper-air wind systems in use by Members

16. This catalogue provides information on the types of radiosondes, windfinding equipment, ground systems, radiation corrections applied to temperature observations and other local practices for radiosondes and upper-air stations. It is updated annually.

Regional Basic Synoptic Network and Regional Basic Climatological Network

17. These lists contain the observing stations of the regional basic observing networks. The WMO RAs define regional basic networks of surface and upper-air stations that meet the requirements of Members and the WWW. The RAs also define the regional basic climatological networks required to provide a good representation of climate on the regional and global scale. The WMO Executive Council Working Group on Antarctic Meteorology is responsible for reviewing the Antarctic basic synoptic network. These lists are updated regularly, as required.

Routeing catalogues of bulletins

18. The routeing catalogues of the GTS centres provide information on the relay of bulletins on the GTS point-to-point circuits and their distribution on the point-to-multipoint circuits, such as the satellite-distribution systems. The routeing catalogue of a GTS centre comprises the following information for each bulletin received or transmitted by the GTS centre: the GTS circuit on which the bulletin is received by the GTS centre and the list of the GTS circuits on which the bulletin is sent by the GTS centre. They are regularly updated and accessible on the OIS home page.

Monitoring reports

19. Three types of quantity monitoring exercises are coordinated by the Secretariat within the framework of the WWW Programme: AGM, SMM and the specific monitoring on the exchange of Antarctic data. The reports are distributed on the OIS home page.

Monthly Operational Newsletter on the Operation of the WWW and Maritime Meteorological Services

20. The operational Newsletter provides a summary of the latest operational information on GOS, GTS, GDPFS, data management, including WMO code forms, and the Marine Meteorological Services Programme. It is published twice a month and distributed electronically.

Additional data and products according to Resolution 40 (Cg-XII)

21. This is a regularly updated list of additional data and products according to Resolution 40 (Cg-XII)—WMO policy and practice for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological activities. According to the practice adopted by Congress, all meteorological and related data and products required to fulfil Members' obligations under WMO Programmes should be encompassed by the combination of essential and additional data and products exchanged by Members. Members are urged to make known to all Members, through the WMO Secretariat, those additional meteorological and related data and products which have conditions related to their re-export for commercial purposes outside of the receiving country (or group of countries forming a single economic group).

METNO messages

22. The weekly METNO (Volume A and Volume C1) notifications transmitted on the GTS carry the most up-to-date information on operational changes.

ANNEX III

ACRONYMS

ACMAD	African Centre of Meteorological Applications for Development
ADM	Advanced Dissemination Methods
ADS	Automatic Dependent Surveillance
AeMP	Aeronautical Meteorology Programme
AFS	Aeronautical Fixed Service (ICAO)
AGM	Annual Global Monitoring
AIREP	Aircraft Weather Report
AMDAR	Aircraft Meteorological Data Relay
APT	Automatic Picture Transmission
ARGOS	Data Relay and Platform Location System
ASAP	Automated Shipboard Aerological Programme
ASDAR	Aircraft to satellite data acquisition and relay (aircraft report)
ASEAN	Association of South-East Asian Nations
ASMC	ASEAN Specialized Meteorological Centre
AWS	Automatic Weather Station
BIPM	International Bureau of Weights and Measures
CBS	Commission for Basic Systems
CEOS	Committee on Earth Observation Satellites
CGMS	Coordination Group for Meteorological Satellites
CIMO	Commission for Instruments and Methods of Observation
CMC	Canadian Meteorological Centre
CNES	National Centre for Space Studies (France)
CTBTO	Comprehensive Nuclear-Test-Ban Treaty Organization
DAB	Digital Audio Broadcasting
DBCP	Data Buoy Cooperation Panel
DCS	Data-Collection System
DMC	Drought Monitoring Centre
DVB	Digital Video Broadcasting
DWD	*Deutscher Wetterdienst*
ECMWF	European Centre for Medium-Range Weather Forecasts
EMWIN	Emergency Managers Weather Information Network
EPS	Ensemble Prediction System
ESA	European Space Agency
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
4-DVAR	Four-dimensional Variational Analysis
FAO	Food and Agriculture Organization of the United Nations
FNMOC	Fleet Numerical Meteorology and Oceanography Center (United States)
FTP	File Transfer Protocol
FWIS	Future WMO Information System
FY-1, -2, etc.	Meteorological Satellites (China)
GAW	Global Atmosphere Watch
GCOS	Global Climate Observing System
GDPFS	Global Data-processing and Forecasting System
GMDSS	Global Maritime Distress and Safety System
GMS	Geostationary Meteorological Satellite (Japan)
GOES	Geostationary Operational Environmental Satellite (United States)
GOMS	Geostationary Operational Meteorological Satellite (Russian Federation)
GOOS	Global Ocean Observing System
GOS	Global Observing System
GPS	Global Positioning System
GSM	Global Spectral Model
GSN	GCOS Surface Network
GSNMC	GSN Monitoring Centre
GTOS	Global Terrestrial Observing System
GTS	Global Telecommunication System
GUAN	GCOS Upper-air Network
HF	High Frequency
HR	High Resolution
HRPT	High-Resolution Picture Transmission
IAEA	International Atomic Energy Agency
ICAO	International Civil Aviation Organization
IGOSS	Integrated Global Ocean Services System
IMOP	Instruments and Methods of Observation Programme
IMTN	Improved MTN project
INMARSAT	International Maritime Satellite System
INPE	National Institute for Space Research (Brazil)
INSAT	Indian National Satellite
IOC	Intergovernmental Oceanographic Commission
IRI	International Research Institute for Climate Prediction (United States)
ISCS	International Satellite Communications System
ISO	International Organization for Standardization
ITU	International Telecommunication Union
IWM	Integrated WWW Monitoring
JAXA	Japanese Aerospace Exploration Agency
JMA	Japan Meteorological Agency
KNMI	Royal Netherlands Meteorological Institute (Utrecht)

LAM	Limited Area Model
LRIT	Low Rate Information Transmission
LRPT	Low Rate Picture Transmission
MDD	Meteorological Data Distribution
METEOR	Meteorological Satellite (Russian Federation)
METNO	Advance telegraphic notification relating to the operation of WWW (code form)
METOP	Meteorological Operational Satellite (EUMETSAT)
MMOP	Marine Meteorology and Oceanography Programme
MPLS	Multi-Protocol Label Switching
MSG	METEOSAT Second Generation
MSLP	Mean Sea-Level Pressure
MTN	Main Telecommunication Network
MTSAT	Multifunctional Transport Satellite (Japan)
NASA	National Aeronautics and Space Administration (United States)
NCDC	National Climatic Data Center (United States)
NCEP	National Centres for Environmental Protection (United States)
NMC	National Meteorological Centre
NMHS	National Meteorological and Hydrological Service
NMOC	National Meteorological Operations Centre (Australia)
NMS	National Meteorological or Hydrometeorological Service
NMTN	National Meteorological Telecommunication Network
NOAA	National Oceanic and Atmospheric Administration (United States)
NWP	Numerical Weather Prediction
OIS	Operational Information Service
OPMET	Operational Meteorological Information
PUMA	Preparation for use of MSG in Africa
PWSP	Public Weather Services Programme
RA	Regional Association
RANET	Radio and Internet
RBCN	Regional Basic Climatological Network
RBSN	Regional Basic Synoptic Network
R&D	Research and Development
RETIM	Réseau européen de transmission d'information météorologique (par satellite)
RMDCN	Regional Meteorological Data Communication Network
RMS	Root-mean-square
RMTN	Regional Meteorological Telecommunication Network
ROSHYDRO-MET	Russian Federal Service for Hydrometeorology and Environmental Monitoring
Roskosmos	Russian Federal Space Agency
RSMC	Regional Specialized Meteorological Centre
RTH	Regional Telecommunication Hub
RTT	Radioteletype Broadcasts
SADIS	Satellite Distribution System (ICAO)
SMM	Special MTN Monitoring
SOOP	Ship-of-Opportunity Programme
SSA	System Support Activities (WWW)
SSB	Single Sideband (transceivers)
SST	Sea-Surface Temperature
3-DVAR	Three-dimensional Variational Analysis
TAC	Traditional Alphanumeric Codes
TAMDAR	Tropospheric Airborne Meteorological Data Reporting
TCP	Tropical Cyclone Programme
TCP/IP	Transmission Control Protocol/Internet Protocol
TDCF	Table-driven Code Forms
UKMO	United Kingdom Met Office
UNEP	United Nations Environment Programme
UTC	Universal Time Coordinated
VAAC	Volcanic Ash Advisory Centres
VOS	Voluntary Observing Ship
VOSClim	VOS Climate Project
WAFC	World Area Forecast Centre
WAFS	World Area Forecast System
WCP	World Climate Programme
WCRP	World Climate Research Programme
WDM	WWW Data Management
WEFAX	Weather Facsimile
WHO	World Health Organization
WHYCOS	World Hydrological Cycle Observing System
WMC	World Meteorological Centre
WMO	World Meteorological Organization
WRC	World Radiocommunication Conference
WWW	World Weather Watch
XBT	Expendable bathythermograph

ANNEX IV

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