TOWARDS AN IMPROVED GLOBAL OBSERVING SYSTEM

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ABSTRACT

The advent of new observing systems during the past two decades, their partial introduction into operation (e.g. meteorological satellites) or early testing during the field phase of FGGE (e.g. ASDAR and drifting buoys), and at the same time the increasing difficulties of the Meteorological Services to implement and maintain the conventional observing system call for an improved composite global observing system. The planning of such a composite observing system has to be based on observational requirements, a sound network design, technical feasibility and operational availability of the individual observing system components and the ability of meteorological services to implement and maintain parts of the overall system. The present status of the individual planning stages for an improved global observing system within WMO is shown and an outlook on the implementation will be presented.

1 INTRODUCTION

Remarkable progress has been made during the twenty years since the mid-sixties, when WMO adopted the concept of the World Weather

Watch (WWW). The results are obvious in all three sub-systems of the WWW: The Global Observing System (GOS), the Global Data Processing System (GDPS) and the Global Telecommunication System (GTS). As the GOS is concerned a comprehensive world-wide space-based system is now in routine use, filling many observational gaps over the vast extra-territorial regions and the sparcely populated and less developed land areas. Automated observing systems to supplement other surface-based systems and satellite techniques have been developed and thoroughly tested during FGGE. At the same time Meteorological Services have been faced with increasing financial difficulties entailing great problems in implementing and maintaining the conventional surface-based observing system, and in connection with the build-up of the space-based component decisions in favour of the latter have been taken.

The only way out of the present dilemma is the establishment of composite observing systems. There is a general consensus that such composite observing systems are required not only on a global but also on a regional and national level. There exists, however, no experience in designing and implementing composite observing systems. The following sequence of steps would be a logical approach to solve the problems:

- establishment of observational requirements
- present status of the GOS
- available or potential new observing system components
- network design taking into account the ability of Meteorological Services to implement and maintain parts of the overall system
- operational system evaluation in specific areas which might result in a modified network design
- final deployment of observing system components and implementation of the improved composite GOS.

Right from the beginning it should be noted that especially the items

- establishment of observational requirements and
- network design

are problem areas, and most likely no firm and common answers will be found.

2 OBSERVATIONAL REQUIREMENTS FOR THE IMPROVED GOS

Before establishing the observational requirements for the improved GOS, the agreed purpose of the GOS as sub-system of the WWW has to be recalled. In the Manual on the GOS (WMO-No 544) the following is stated: "The purpose of the Global Observing System (GOS) shall be to provide the meteorological and related environmental observations from all parts of the globe that are required by Members for operational and research purposes." If this statement is taken seriously, the GOS would have to provide the observational data on several space scales for describing all the different scale phenomena from the planetary to the small scale and for the various applications. It should be clear that the GOS will never meet this general requirement. So at present, the main emphasis is placed on obtaining an improved global data base and by this servicing the needs of the Meteorological Services in the following three general areas:

- time and space coverage commensurate with
  - global and hemispheric models
  - large-scale synoptic analysis and forecasting
  - mesoscale analysis and forecasting

- representative depiction of the meteorological variables and defined parameters required for service programmes (e.g. aviation and marine services)

- increased quality of the data.

The present agreed requirements for observational data for the global network and regional networks are contained in the "Manual on the GOS (WMO Publication No 544)" and are in Tab. 1

A - OBSERVATIONAL REQUIREMENTS FOR THE GLOBAL NETWORK IN THE MIDDLE AND HIGH LATITUDES

The following specifications have been taken from the observational requirements set forth for the First Global GARP Experiment and should be considered as minimum WWW requirements for providing input to numerical models dealing with the atmosphere on a planetary or large scale.

Temperature

Horizontal resolution	500 km
Vertical resolution	4 tropospheric levels 3 stratospheric levels
Accuracy	± 1°C

Wind

Horizontal resolution	500 km
Vertical resolution	4 tropospheric levels 3 stratospheric levels
Accuracy	± 3 m s^{-1}

Wind is of lower priority than temperature, since it can be derived from temperature with the help of the balance equations.

Relative humidity

Horizontal resolution	500 km
Vertical resolution	2° of freedom in the troposphere*
Accuracy	±30%**

Sea-surface temperature

Horizontal resolution	500 km
Accuracy	± 1°C

Pressure

Horizontal resolution	500 km
Accuracy	± 0.3%

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* Vertical humidity distribution should be described with the help of a tropospheric model profile with two independent parameters, which should be specified by means of observations.

** The accuracy referred to for relative humidity is an absolute value and is derived from satellite data.

Tab. 1 a: Observational requirements for the global network in the middle and high latitudes (Manual on the GOS (1))

B - OBSERVATIONAL REQUIREMENTS FOR THE GLOBAL NETWORK IN THE TROPICS

Wind

Horizontal resolution	500 km over land 1 000 km over ocean
Vertical resolution	4 tropospheric levels 3 stratopsheric levels
Accuracy	$\pm$ 2 m s^{-1}

Wind is considered the main parameter in the tropics, since it is characterized by a weak relation with the mass field and cannot be derived satisfactorily from other parameters. Complete vertical resolution is a critical requirement in the near-Equator zone.

Temperature

Horizontal resolution	The same as for wind
Vertical resolution	4 tropospheric levels 3 stratospheric levels
Accuracy	$\pm$ 1°C

Relative humidity

Horizontal resolution	The same as for wind
Vertical resolution	2° of freedom in the toposphere*
Accuracy	$\pm$ 30%**

Sea-surface temperature

Horizontal resolution	1 000 km
Accuracy	$\pm$ 1°C

Data from the global network should be obtained at least twice a day. Observations from the ordinary upper-air and surface stations should be carried out at standard synoptic times 0000 and 1200 GMT. If, due to local conditions, observations are to be conducted at other times, such observations can also be useful to meet global requirements.

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* Vertical humidity distribution should be described with the help of a tropospheric model profile with two independent parameters, which should be specified by means of observations.

** The accuracy referred to for relative humdity is an absolute value and is derived from satellite data.

Tab. 1 b: Observational requirements for the global network in the tropics (Manual on the GOS (1))

ATTACHMENT II.3

REQUIREMENTS FOR HORIZONTAL SPACING AND FREQUENCY OF REPORTING FROM THE REGIONAL NETWORKS

Type of observation	Density		Frequency
	Adequate	Minimum for sparsely-populated and oceanic areas	
Land surface	≤150 km	500 km	8 per day, at the main and the immediate standard times
Oceanic surface	≤300 km	500 km	4 per day, at the main standard times
Surface-based upper air	≤300 km	1 000 km	4 per day, at the standard times (if not possible, at least at 0000 and 1200 GMT)

Tab. 1 c: Observational requirements for horizontal spacing and frequency of reporting from the regional networks (Manual on the GOS (1))

It is worth mentioning that the above specifications have been taken from the observational requirements set forth for the FGGE and are considered as minimum WWW requirements for providing input to numerical models dealing with the atmosphere on a planetary or large scale. Neither these requirements nor those for improved horizontal spacing and frequency of reporting from the regional networks do satisfy the various needs described above.

The requirements for the improved global data base are forced by the recent developments in the field of numerical weather prediction as well as increasing demands for global and specialized products by a variety of end users.

As it is well known, numerical weather prediction is both an initial data and a modelling problem. Error budget analysis suggests that, locally, analysis errors are more important than modelling errors for forecasts to about 2 days; this short-range forecasting is particularly affected by data inadequacies. The same studies also indicate that the errors in the forecast are dominated by analysis errors at forecast ranges beyond 5 days, too.

Several proposals for a new set of requirements are existing. Recent proposals have been formulated by a study group of the WMO Working Group on the GOS (1983) and another one by J. A. Woods (ECMWF, 1984), see Tab. 2 and 3.

It will be necessary to consolidate the proposals and agree on a proposal which can be used for planning and implementation purposes, and which will serve as basis for the next 10 years or so. It is hoped that at the next session of the Commission for Basic Systems (CBS), scheduled for the end of 1985, an agreement will be reached within the framework of WMO.

3 PRESENT STATUS OF THE GOS

The status of the GOS is monitored on a yearly basis. The last monitoring was carried out in October 1983 and demonstrated for instance that the flow of global data reached only a level of 75 %

	Horizontal Resolution	Vertical Resolution	Accuracy (RMS)	Frequency of Observation
i. Temperature (T)	250 km*	10 layers in troposphere 5 layers in stratosphere	±0.5-1.0°C trop. ±1.0-2.0°C strat.	Preferred: 4 per day Required: 2 per day
ii. Wind (V)	250 km	10 layers in troposphere 5 layers in stratosphere	±1-2 m s^{-1}trop. ±2-3 m s^{-1}strat	Preferred: 4 per day Required: 2 per day
iii. Relative Humidity (RH)	250 km	4 layers	better than ±30%	Preferred: 4 per day Required: 2 per day
iv. Sea-surface Temperature (T_s)	250 km 50-100 km desirable in areas of boundary currents, upwelling and near the equator	-	±0.5°C with systematic differences among observing systems eliminated on 3 day averages	Instantaneous measurements averaged over three days
v. Surface Pressure (P)	250 km	-	±0.2%	Preferred: 4 per day Required: 2 per day
vi. Satellite Imagery**	250 km	At least 3 layers (low, middle, high) and cloud top height	To be determined (expected to be a function of latitude)	Required: 8 per day

* Tropics: Horizontal resolution of temperature is 500 km. All other elements remain the same for the tropics.

** Satellite imagery has been included here because of its increasing use for the computation of vertical motion and horizontal divergence fields, as well as for the determination of the synoptic distribution of water vapor, precipitable water and cloudiness.

Tab. 2: Basic observational requirements needed to provide the global data set (Working Group on the GOS (2))

REQUIREMENTS	GLOBAL MODELS	LIMITED AREA MODELS
Data coverage	Global	c.10° to 50° lat/long
Horizontal resolution	50 - 100 km	10 - 100 km
Vertical resolution	500 m resolution to 2 km height and 1 km resolution to 15 km height and 3 km resolution to 30 km height	
Time resolution	3 - 6 hourly	hourly - 3 hourly
Parameters required:		
To specify initial state		
Free atmosphere	temperature, wind, relative humidity	
Surface	surface (or msl) pressure, temperature, soil wetness, snow (depth, ground cover) sea surface temperature (to 1 m depth) sea ice information	
For verification	precipitation	
model development } model validation }	short and long wave radiation, albedo, clouds	
Accuracy required	Temperature 0.5°C -2.0°C*	
	Wind 2 - 5 m/sec*	
	Surface pressure 0.5 mb	
	Relative humidity 10 %	

*The upper limit refers to data given at very high horizontal resolution

Tab. 3: Data requirements for global and limited area models within the coming decade (J. A. Woods (3)) of the total number of reports (SYNOP, TEMP) expected to be received. The relevant figures for SYNOP, TEMP, SHIP and AIREP reports are:

SYNOP reports:7535
TEMP reports:1070
SHIP reports:4915
AIREP reports:2928

Compared with 1982 figures, again a slight decrease in the number of TEMP and SHIP reports is noticed. The horizontal distribution of observational data on a global scale can easily be derived from the well known six panel figure of ECMWF. Figure 1 shows the large data gaps especially over the land areas of the southern hemisphere and over the vast extra-territorial regions.

4 AVAILABLE OR POTENTIAL NEW OBSERVING SYSTEM COMPONENTS

Based on the quasi-operational tests during the FGGE and the subsequent years, the following new observing systems have proven their technical feasibility and operational availability:

- ASDAR (Aircraft to Satellite Data Relay) units
- DCPs (Data Collection Platforms) on ships and other ocean platforms (e.g. oil riggs)
- ASAP (Automated Ship-board Aerological Programme)
- drifting buoys

All these new components rely on the availability of polar orbiting and geostationary meteorological satellites.

The current status of implementation is the following:

4.1 ASDAR

The work and financial support of nine WMO Member States (Con

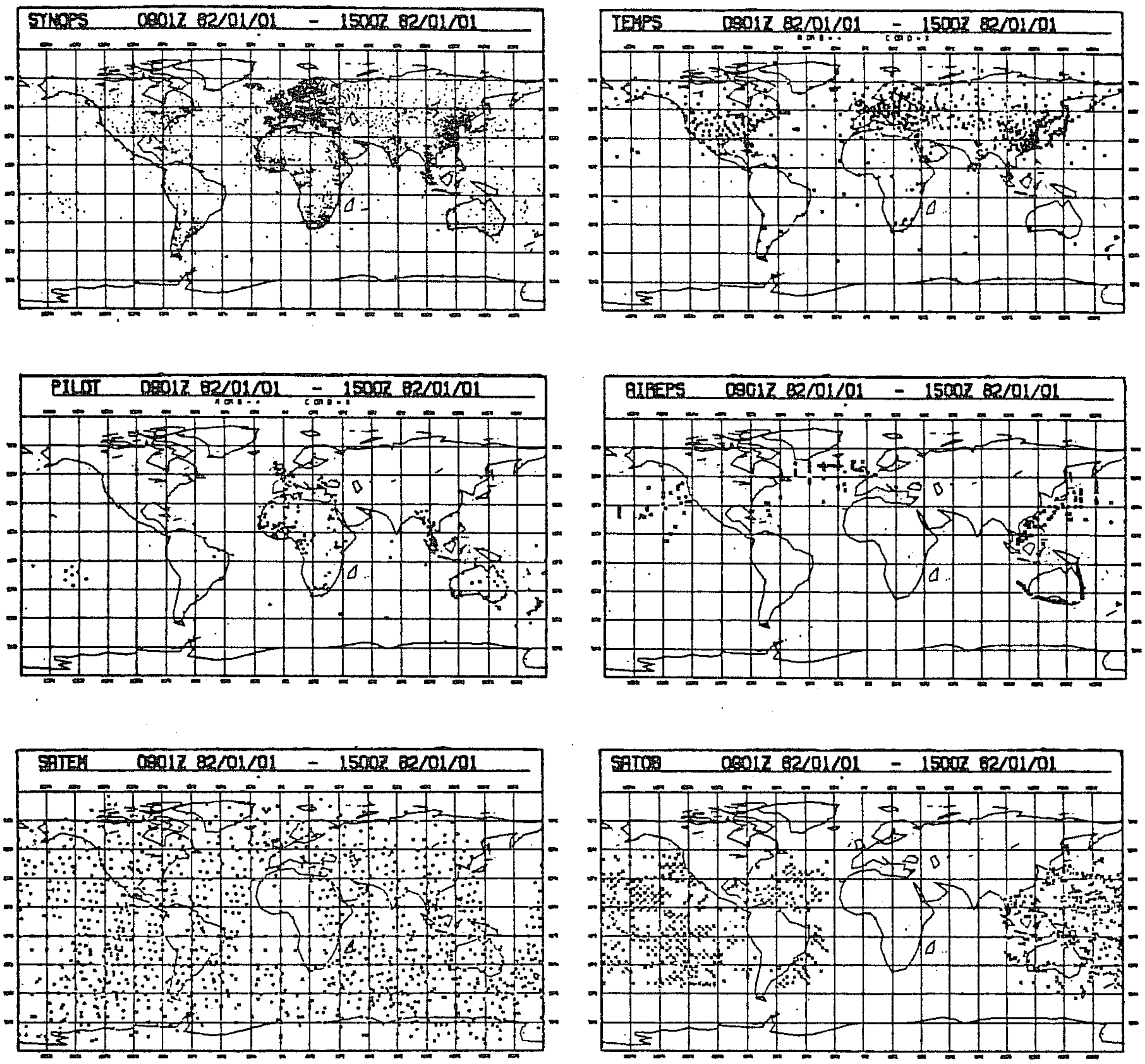

Fig. 1 : GOS data received at the European Centre for Medium Range Weather Forecasts (ECMWF) on 1 January 1982 within 3 hours of 12oo GMT

SYNOPS : Surface observations (land and ship)

TEMPS : Radiosonde observations (land and ship)

PILOT : Upper-wind observations (land and ship)

AIREPS : Aircraft weather reports including ASDAR

SATEM : Satellite remote upper-air soundings of pressure, temperature and humidity

SATOB : Satellite observations of wind, surface temperature, cloud, humidity and radiation sortium for ASDAR Development, CAD) had led to the signing of a contract to complete the development of the operational ASDAR flight unit and to certify that unit on DC-10, L-1011 and B-747 aircraft. This contract will be completed in mid-1985, however, initial procurement orders will be arranged some six months earlier. In response to a survey by the WMO Secretariat, various WMO Member States have indicated to purchase up to 50 operational units during 1985 and 1986. Actions are under way which are needed to support the early phases of the implementation and operation of the ASDAR Programme.

The co-operative activities include:

- financial and operational arrangements with satellite operators, airlines, aviation authorities and WMO Member States
- data transmission on the Global Telecommunication System (GTS)
- quality control
- fault finding, maintenance and repair services.

The first fully operational ASDAR units will be in service during the later half of 1985.

4.2 DCP

Data Collection Platforms aboard ships and other ocean platforms are installed in an increasing number. At present 15 international DCPs are registered, and it is expected that the number will reach 60 in the year 1990.

4.3 ASAP

Substantial progress has been made in recent years to develop operational procedures for obtaining aerological soundings from merchant ships. Trials during the FGGE have led to development programmes by different countries. National or joint programmes, like the Canadian/US/Japan on the North Pacific, and those by the UK, France, the Federal Republic of Germany on the North Atlantic are well advanced, and it can be assumed that up to 10 operational ASAP units will be in use by 1987 - 88. Due to this favourable situation, the Executive Council of WMO agreed in June 1984 to establish a co-operative operational Automated Shipboard Aerological Programme as soon as possible.

4.4 DRIFTING BUOYS

At present, deployment of drifting buoys for operations and research is carried out by about 15 countries mainly within national programmes. The collection of data and location of drifting buoys is carried out by the Argos system. According to information supplied by Service Argos, 225 drifting buoys were operating in October 1983. From the operational point of view, the main problem is the small number of drifting buoy reports inserted into the GTS. In October 1983 only data from 40 drifting buoys (18 %) were transmitted on the GTS.

Besides these deficiencies, the national programmes have reached a stage where the establishment of an international programme seems to be justified and the Executive Council of WMO agreed to set up co-operative drifting buoy programmes.

5 NETWORK DESIGN

Based on the preliminary results of observing system experiments (OSEs) and studies presented at the Exeter conference (April 1982) and further results available up to now the improved composite observing system is expected to include

- the conventional network of synoptic and upper-air stations
- polar orbiting and geostationary satellites
- aircraft equipped with ASDAR units
- ships participating in ASAP
- voluntary observing ships and other ocean platforms
- buoys

Taking these general results as a provisional basis the following steps for defining a final network configuration are

- development of proposals for a few network configurations based on network studies, OSEs, and observing system simulation experiments (OSSEs)
- operational system evaluations of suitable configurations for specific areas and objectives to provide the realistic input for the final design and implementation of the improved composite GOS.

5.1 DEVELOPMENT OF PROPOSALS FOR NETWORK CONFIGURATIONS

The work organized by JSC, ECMWF and WMO and carried out by several scientific groups and namely presented in Exeter 1982 and Reading 1984 provides and will give general guidelines for the development of a few network configurations. These network configurations will specify the number of individual observing system components necessary (e.g. 150 ASDAR units, 90 ASAP ships, 400 buoys etc.) on a global or regional scale, and thus will allow for the preparation of operational system evaluations.

5.2 OPERATIONAL SYSTEM EVALUATIONS

Scientific studies like network studies, OSEs and OSSEs are effective in the early design stage to examine the potential consequences of various network configurations. The development of operational procedures to accomodate improvements in the GOS, however, also needs a base of operational experience. Such a base is especially important if it can be obtained on a limited scale with resources reasonably expected to be available and then extrapolated to other parts of the world.

Past experience has shown that the employment of new components results in overall system questions which are not possible to address by studies alone. Operational demonstrations and evaluations are needed to answer realistically questions relating to subjects such as

- efficiency of field operations
- management and reporting services required
- procedures for equipment maintenance
- data quality control
- loads on the GTS
- archiving of data
- co-ordination procedures.

Each of these items has important impacts on the cost of implementation and operation of the improved GOS.

Based on these considerations, prepared at a meeting in Bracknell, April 1984, the Executive Council (EC) of WMO decided that prior to a global implementation of new system components of the WWW carefully constructed and well focused operational evaluations should be conducted. EC accepted the concept of Operational WWW System Evaluations (OWSEs) and agreed that

- the first OWSEs should concentrate on the GOS and

- the following areas for the first GOS-OWSEs should be selected
  - o North Pacific and North Atlantic including the Caribbean
  - o land areas of Africa and adjacent oceans.

Based on this formal agreement, WMO is now in a position to proceed with the implementation. The first GOS-OWSE will be the North Atlantic OWSE called COSNA (Composite Observing System for the North Atlantic) due to the rather advanced stage and the favourable conditions in that area.

It is anticipated that the preparatory phase will be initiated by an informal meeting scheduled for 8 - 10 October 1984 at ECMWF and will include an organizing meeting and a subsequent intergovernmental conference which will take place in the first half of 1985. The build-up will start 1985/86, the operational test will be conducted in 1987 and 1988, and the first results of the evaluations will be available in 1988/89.

6 IMPLEMENTATION

Based on the results of COSNA as prototype OWSE and other GOS-OWSEs, the design phase for the overall improved GOS will hopefully be finalized in 1989, and a gradual implementation could follow from 1990 onward. The philosophy of regional and by this gradual implementation using the vehicle of OWSEs seems to be the only realistic solution towards an improved GOS without further deterioration resulting from a too rapid transition from the present GOS to the improved system.

REFERENCES:

(1) Manual on the Global Observing System, WMO No 544, 1981

(2) Final report, Study Group on Study Area 1 - Optimized Observing System, Working Group on the GOS, Geneva, 19 - 23 Sept. 1983

(3) Woods, J.A., Specification of requirements for extra obser- observational data, ECMWF, 1984