Intergovernmental Oceanographic Commission
technical series

43

Original

IGOSS Plan and Implementation Programme 1996-2003

prepared jointly with the
World Meteorological Organization

UNESCO 1996

For bibliographic purposes, this document should be cited as follows:
IGOSS Plan and Implementation Programme 1996-2003
IOC Technical Series 43, UNESCO 1996
(English, French, Spanish, Russian)

Published in 1996
by the United Nations Education,
Scientific and Cultural Organization
7, place de Fontenoy, 75352 Paris 07 SP

Printed in UNESCO's Workshops

TABLE OF CONTENTS

Part A - The Plan

Part B - Implementation programme

Part A - The Plan

1. INTRODUCTION

1.1 GENERAL

The Integrated Global Ocean Services System (IGOSS) is the global operational system for collection and exchange of oceanic data and the timely preparation and dissemination of oceanic products and services. IGOSS is an international programme for real-time exchange of ocean data and is planned, developed and co-ordinated jointly by the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization UNESCO) and by the World Meteorological Organization (WMO). The system consists of national facilities and services provided by the participating Member States of IOC and Members of WMO to share ocean data for mutual benefit.

The original concept of IGOSS was that of an Integrated Global Ocean Station System. This system was started in 1967 through the establishment by IOC of a permanent Working Committee for IGOSS and by WMO through the Executive Committee Panel on Meteorological Aspects of Ocean Affairs. Since that time, the objective of the system has shifted towards ocean services and the name changed to reflect this shift Co-operation between IOC and WMO for IGOSS has increased and led to the establishment of the Joint IOC-WMO Committee for IGOSS. A series of General Plans and Implementation Programmes for IGOSS have been developed over the years and the present Plan is for the period 1996 -2003." The main IOC and WMO resolutions relating to IGOSS are listed in Annex 1.

As IGOSS develops during 1996-2003, it must take into account many recent developments, including:

(i) Expanding understanding of the importance of the ocean in global climate and ecology, particularly as a result of the UN Conference on Environment and Development (UNCED, Rio de Janeiro, 1992);

(ii) Expanding requirements for operational oceanographic data and products by several user communities and international programmes, particularly the Global Ocean Observing System (GOOS);

(iii) Progress in implementation of global ocean observing programmes, including TOGA WOCE, and others;

(iv) Large increases in the observational capabilities of environmental satellites and moored and drifting buoys;

(v) Progress in automation of oceanographic data collection and global satellite communications;

(vi) Progress in computerized data quality control procedures and product preparation using interactive graphics workstations and other devices; and

(vii) Rapid development of the global communication systems, such as Internet, for sharing environmental data between scientists and data centres in many countries.

1.2 PURPOSE AND BENEFITS

The primary purpose of IGOSS is to promote international operational exchange of ocean observations between Member States of IOC and WMO to support efficient and effective ocean monitoring and services, whether for operational applications or research. To achieve these purposes, IGOSS promotes, develops and co-ordinates the international arrangements necessary for timely global acquisition and exchange of oceanic data, provision of ocean services and dissemination of oceanic products including observations, analyses and forecasts of important ocean features to various user groups, on an operational basis.

IGOSS makes a significant contribution to the building of a global data base of oceanic and atmospheric information. Establishment of a global ocean data base is essential to understand the complex interactions within the coupled ocean-atmosphere system, to improve our ability to forecast weather and climate, to manage marine resources, and to develop GOOS and other global programmes. A primary goal of IGOSS is to improve the global coverage of observations, including presently data sparse areas of the southern oceans.

IGOSS real-time reports of ocean conditions have wide ranging socio-economic benefits. In combination with weather analyses and forecasts, IGOSS data and products can improve the economy, efficiency, and safety of naval operations. From information on marine winds, currents, surface and sub-surface temperature and salinity, the growth, decay, and movement of sea ice and icebergs can be forecast. Real-time reports of surface and sub-surface thermal structure, together with surface wind analyses and locations of ocean fronts, can improve decisions on the day-to-day movement of fishing vessels and operating depths and help develop a better understanding of the relations between ocean conditions and fish populations. Other areas that can benefit from IGOSS activities include marine exploration, disaster prevention, marine pollution, search and rescue activities, etc.

The level of our understanding of the ocean's role in weather, climate and marine resources depends directly on our ability to observe the structure and variability of the ocean in time and space. Forecasts of ocean conditions require global data gathered at closely spaced intervals in time and space and global exchange of the data in real- or near real-time. Such an effort cannot succeed without international co-operation and standardization. IGOSS enables Member States to develop this co-operation and standardization, thereby enabling the States to provide improved oceanic and related services and products for their national economies,

Although satellites have revolutionized the collection of weather data, significant gains in the accuracy of short-term forecasts and the analysis of longer term climate variations have been hampered by the scarcity of *in-situ* ocean observations. Sea surface temperature (SST) data are used operationally in atmospheric models for short-term and medium-range forecasts for periods of up to a week. Fields of SST provide a fixed boundary condition and are assumed to remain constant over the period of the forecast. Although this approach is reasonably effective, improved results may be achieved by taking into account changes in ocean variables during the forecast period. To compute such changes will require joint atmospheric/oceanic models. For effective long-range forecasting, models of the coupling between the atmosphere and ocean, and variations in both, will be required. Many real-hme reports of *in-situ ocean* conditions will be required to support these models. And as larger computers become available, higher resolution numerical ocean and atmospheric models will be developed which will require even more reports, more closely spaced in time and space.

Operational models of ocean chemical variables and pollutants will require reports of many additional types of ocean observations. These models cannot be achieved without an operational global ocean observing and data exchange system such as IGOSS.

1.3 USER REQUIREMENTS

User requirements for IGOSS data provision and services are established only in a qualitative sense. Some expressed user requirements are known, for instance from OOSDP and EuroGOOS documents. In the future, specification and quantification of user requirements will become mandatory for IGOSS and steps will be taken to harmonize on-going activities with this information.

IGOSS sea-surface data are required both by the scientific and operational communities, as well as certain sectors of marine industry. With regard to IGOSS sub-surface data, the major users are at present within the scientific community, whose requirements clearly aim at the optimum resolution and long term monitoring of large-scale physical processes of the ocean. It is foreseen that requirements will grow from future needs to forecast ocean processes on a seasonal, inter-annual and decadal basis. Other requirements may also come from fisheries and developments in marine industry.

1.4 PRINCIPLES

The basic principles under which IGOSS operates are:

(i) Member States participate in the collection and timely international exchange of IGOSS operational data. Normally surface observations should be transmitted in real-time while sub-surface data can be slightly delayed, viz within 48 hours. Nevertheless, oceanic data as old as 30 days are useful operationally and should be internationally exchanged;

(ii) IGOSS, to be effective, must be a co-ordinated system responsive to the operational and research requirements agreed upon among the participating Member States and should utilize the most modem observing, communication and processing technology available;

(iii) IGOSS must be a dynamic system, flexible enough to be adapted to scientific and technical advances;

(iv) IGOSS must be planned and implemented in conjunction with relevant systems of WMO and IOC such as GOOS, the World Weather Watch (WWW) and the International Oceanographic Data and Information Exchange (IODE);

(v) IGOSS, to be effective, must include a strong training and assistance programme to enable wider participation, particularly of developing countries in its activities;

(vi) For global consistency and uniformity, IGOSS observations of all types, their accuracy, frequency, technical characteristics, means of telecommunication, reporting codes and methods of quality control and data exchange must comply with standards and procedures defined in relevant IGOSS documentation:

(vii) IGOSS shall be used only for peaceful purposes, due account being taken of the national sovereignty and security of states, in accordance with the provisions of the Charter of the United Nations and with special attention to the United Nations Convention on the Law of the Sea.

1.5 MANAGEMENT

The Joint IOC/WMO Committee for IGOSS shall, within its terms of reference, “plan and co-ordinate the implementation of IGOSS in accordance with the purposes and principles set forth in the Plan and Implementation Programme for IGOSS.” The Joint committee is responsible to the governing bodies of IOC and WMO for all aspects of IGOSS and review progress in implementation of the Plan. During the intercessional period, IGOSS management is mainly provided though Contacs amongst the National Representatives for IGOSS, who must be active and knowledgeable in their respective fields of activity, and through the information they exchange with the Secretariats of IOC and WMO. The Joint Committee is supported by subsidiary bodies (groups of experts, task teams, etc.) which it establishes as required. The officers of these groups may meet during the intercessional period as an executive committee (“IGOSS Bureau”). The terms of reference and composition of the IGOSS subsidiary bodies are found in the document “composition of IGOSS” which is issued periodically.

1.6 STRUCTURE OF IGOSS

The essential elements of IGOSS are:

(i) IGOSS Observing System (IOS) which consists of the co-ordinated international operational observing system of various facilities and arrangements voluntarily contributed by Member States for obtaining standardized oceanic observations from various platforms (including research ships, ships-of-opportunity and voluntary observing ships, ocean weather stations, buoys, fixed platforms, aircraft and satellites);

(ii) IGOSS Data Processing and Services System (IDPSS) which consists of the international operational data processing and services system of National, Specialized and World Oceanographic Centres for the processing of operational ocean data and provision of products and services to various marine user groups;

(iii) IGOSS Telecommunication Arrangements (ITA) which consists of the international operational arrangements of telecommunication facilities of the WWW Global Telecommunication System (GTS) and other arrangements necessary for the rapid and reliable collection and international distribution of IGOSS data and processed information.

The above division of elements of IGOSS has been made as a matter of convenience; it should be understood that these are closely interdependent and should not be interpreted as completely separate entities.

For the implementation of the above elements of IGOSS, four other important supporting activities are identified:

(i) Training and assistance;
(ii) Research and development;
(iii) Monitoring of operations; and
(iv) Information exchange.

The IGOSS training and assistance programme is primarily intended to enable developing countries to participate actively in IGOSS activities. Considerable attention is given by IOC and WMO, within their relevant aid programmes, to training and assistance for IGOSS purposes. The fields of synoptic oceanography, oceanic observations, data processing and archiving, application of ocean products and services are particularly emphasized.

The IGOSS research and development programme is aimed at improving the global ocean observational network design and developing operational analyses and forecasting services. IGOSS promotes these research programmes in order to maximize its effectiveness and to make use of the latest techniques and methodologies,

The operation of IGOSS is monitored to enable Member States to locate deficiencies in the implementation of the programme and take the necessary remedial measures. The main monitoring fictions are carried out by the Member States themselves while the IOC and WMO Secretariats carry out non-real-time monitoring on a global basis.

IGOSS information exchange is aimed at providing Member States with up-to-date information on all aspects of the IGOSS structure and operations. Also included within this component are activities which publicize the objectives and achievements of IGOSS, especially within the user communities.

The structure described above is used to run the System in general and to implement various “operational programmes” and “pilot projects” more specifically. The first (in time) and still the core IGOSS operational programme is the international exchange of BATHY, TESAC and, more recently, TRACKOB data on a permanent operational basis; it was established as such to begin on 16 June 1975. The core of this core programme is the IGOSS XBT Ship-of-opportunity Programme (SOOP), implemented in close collaboration with WCRP programmes. The IGOSS Task Team on Quality Control of Automated Systems (TT/QCAS) assists the SOOP in dealing with technical issues such as error characteristics of and algorithms used for the Expendable Bathythermographs (XBTs). Other operational programmes have also been established within IGOSS, such as the IGOSS Sea-level Programme in the Pacific (ISLP-Pac) and the IGOSS Sub-surface Thermal Structure Programme (ISTP). Generally, such operational programmes are established after they have been successfully run for some time as “pilot projects”. Present IGOSS pilot projects encompass the Global Temperature and Salinity Pilot Project (GSTPP), in co-operation with IODE (see below section 1.6.3), the IGOSS Pilot Project on Altimetric Sea-surface Topography Data (IPAST) and others. Annex 2 gives some examples of the IGOSS operational programmes, pilot projects and related activities.

1.7 RELATIONSHIP BETWEEN IGOSS AND MAJOR INTERNATIONAL SYSTEMS AND PROGRAMMES

There are international activities which either support or are supported by IGOSS. IGOSS must be carefully and effectively integrated with these activities in order to be of maximum use. Described below are some major activities and interactions:

1.7.1 GLOBAL OCEAN OBSERVING SYSTEM (GOOS)

GOOS is one of several global observing systems being developed as an initiative of the IOC, WMO, the United Nations Environment Programme and the International Council of Scientific Unions. Companion global observing programmes include the Global Climate Observing System (GCOS) and the Global Terrestrial Observing System (GTOS). These programmes overlap to some extent and therefore also share elements in common. For example, the climate module of GOOS is the ocean component of GCOS.

Five "application modules" for GOOS have been identified:

(i) Climate monitoring, assessment, and prediction;
(ii) Monitoring and assessment of living marine resources;
(iii) Monitoring of the coastal zone environment and its changes;
(iv) Assessment and prediction of the health of the ocean; and
(v) Marine meteorological and operational ocean services.

A major function of GOOS will be to monitor ocean fluctuations such as the El Nino-Southern Oscillation so that timely response can be made to the events. This monitoring will require that many ocean observations be reported and analyzed in real- or near real-time. GOOS will require a large expansion of the present number of observations to provide better resolution of ocean features. Since IGOSS promotes timely reporting of observations and expanded coverage of the global ocean, IGOSS will be a vital element for development of GOOS. Although IGOSS reports will contribute to all five of the GOOS application modules, it will be particularly important to the services one.

For consistent monitoring of the earth's environment and rapid exchange of data between programmes and nations, GOOS, GCOS and GTOS will have to develop, use and share a common data management scheme. Since weather is fundamental to most environmental problems and since the meteorologists have developed a real-time system for globally sharing weather data, the common data management plan for GCOS, GOOS and GTOS must be based on that of the World Weather Watch (WWW). All three programmes will participate in the Distributed Data Bases (DDB) of WMO/GTS to share oceanic, atmospheric and terrestrial data globally, both for real-time operational applications and delayed-mode retrospective applications.

1.7.2 WORLD WEATHER WATCH (WWW)

The purpose of the World Weather Watch (WWW) Programme is to facilitate the development and operation of global systems for observing, data-processing and exchange of meteorological and related data and information and to ensure that the national Meteorological and Hydrological Service of each Member has access to the information it needs to provide effective services.

The Programme includes the frequent and regular observation of a wide range of meteorological elements from thousands of locations on land and sea. in the air and from outer space; the rapid collection and exchange of the observations; the preparation of information and charts describing the current and forecast weather; co-ordinated monitoring and quality control arrangements for observational data and products; and the dissemination of this information to all national Meteorological and Hydrological Services that require it using terrestrial and satellite-based telecommunication systems, It is based on the reality that all parts of the global weather system are always interactive and thus no one country can be fully self-sufficient in the provision of all of its meteorological and related services.

Implementation of the WWW system is through application of the concept that each Member country undertakes, according to its means, to meet certain responsibilities in the agreed globally co-operative scheme. The Programmes main functions are planning, organization and co-ordination of the facilities and arrangements at the global and regional levels, the design of observing and communications networks, the standardization of observing and measuring techniques, the development and use of common communications and data management procedures, and the presentation of both observations and processed information in a manner that is understood by all, regardless of language, and supporting activities that assist national Meteorological and Hydrological Services to obtain maximum benefits from the Programme.

The Programme embraces, in co-operation with other agencies and organizations as appropriate, meteorological programmes in extra-territorial regions and on satellites in outer space. It also includes the Tropical

Cyclone Programme that aims to provide timely warnings and to reduce the adverse impact of damaging tropical storms.

An increasingly important part of the WWW Programme provides support for developing international and related programmes such as the Global Climate Observing System (GCOS), the Global Ocean Observing System (000 S), the Integrated Global Ocean Services System (IGOS), and the Global Atmospheric Watch (GAW).

1.7.3 INTERNATIONAL OCEANOGRAPHIC DATA AND INFORMATION EXCHANGE (IODE)

The International Oceanographic Data and Information Exchange is an IOC system for global exchange of oceanographic data that is reported by mail and other media in non real-time. In IODE marine environmental data of international interest are exchanged among National Oceanographic Data Centres (NODCs), responsible NODCs (RNODCs) and three ICSU/IOC World Data Centres for Oceanography. The IODE is coordinated by the IOC Technical Committee on IODE and operates according to the procedures outlined in the Manual on IODE (IOC Manuals and Guides Series No. 9).

The functions of IGOSS and IODE are complementary: IGOSS emphasizes real-time global collection and reporting of ocean data and development of operational ocean services while IODE emphasizes archival and retrieval of oceanographic data. IGOSS and IODE share a common interest in formats for international exchange of ocean data: IODE supports the General Format 3 (GF-3) while IGOSS uses the WMO formats. IODE supports rescue of historical files of ocean data in the Global Oceanographic Data Archaeology and Rescue (GODAR) project.

IG0SS contributes to the IODE data archiving system by submitting its data to the IODE RNODCs for IGOSS and ensuring that data are easily exchanged. To improve the data flow from IGOSS to IODE, the two programmes jointly support the Global Temperature Salinity Programme (GTSP) for assembly of all available temperature and salinity measurement data, both operational as well as delayed-mode data. Further information on IGOSS/IODE data exchange is given in the Guide to Operational Procedures for the Collection and Exchange of oceanographic Data (IOC Manuals and Guides Series No. 3) and the Guide to IGOSS Data Archives and Exchange (IOC Manuals and Guides series No. 1).

1.7.4 WORLD CLIMATE PROGRAMME (WCP)

The World Climate Programme (WCP) has the following components:

(i) World Climate Data and Monitoring Programme (WCDMP);
(ii) World Climate Applications and Services Programme (WCASP);
(iii) World Climate Impact Assessment and Response Strategy Programme (WCIRP); and
(iv) World Climate Research Programme (WCRP).

Each of the WCP components relies on IGOSS support, e.g.: oceanic data are an essential part of the World Climate Data and Monitoring Programme; the World Climate Applications and Services as well as Impact Assessment and Response Strategy Programmes need oceanic products and services and the World Climate Research Programme need supporting ocean monitoring systems.

The objectives of the WCRP are to:

(i) Establish the physical basis of long-range weather prediction;

(ii) Understand the predictable aspects of global climate variations over periods of several months to several years;

(iii) Assess the response of climate to natural or man-made influences over periods of several decades.

It is understood that the first and second objectives are necessary for achieving the third: to acquire the scientific knowledge of the basic atmospheric, oceanic and ice processes which determine the mean state of climate and its response to a changing global environment. Thus WCRP projects contribute to, and-require the support of IGOSS.

1.8 RELATIONSHIP BETWEEN THE JOINT COMMITTEE IGOSS AND INTERNATIONAL ORGANIZATIONS OR GROUPS

There are many other international activities which either support, or require the support of IGOSS (or both). IGOSS must be effectively co-ordinated with these programmes to maximize benefits and avoid duplication.

1.8.1 COMMISSION FOR MARINE METEOROLOGY (CMM)

The Commission for Marine Meteorology (CMM) is the WMO constituent body with overall responsibility for the development and international co-ordination of marine meteorological data and services in support of the safety of life and property at sea and of national economic interests in the marine area. The responsibilities of the Commission also cover the operation of certain marine observing systems, in particular the WMO Voluntary Observing Ships (VOS) scheme, the collection and exchange of marine data and their quality control, archival and processing to support the requirements of all marine users. Within WMO, the work of CMM directly supports the WWW, the WCP (including the WCRP and GCOS) and other WMO programmes, and it is closely co-ordinated with them. CMM also has a general co-ordinating role in the preparation of the Marine Meteorology and Associated Oceanographic Activities Programme section of the WMO Long-Term Plan.

Clearly, CMM and the Joint Committee for IGOSS have many common areas of interest and even overlap, covering marine observing systems, data collection and exchange, data management and the provision of meteorological and oceanographic services to marine users. Close co-ordination is therefore essential, to ensure that there is no duplication of effort and that wherever possible common systems, formats and procedures arc employed for marine data and services, At present, co-ordination is achieved through reciprocal representation at relevant meetings, including the Commission/Committee themselves, their Advisory Working Group/Bureau and various subsidiary bodies. A joint CMM-IGOSS-IODE Sub-group on Ocean Satellites and Remote Sensing has been established, to serve the interests of all three parent bodies in this important field, This successful body may serve as a model for the future co-ordination and even integration of CMM and IGOSS activities which are of mutual and direct concern.

1.8.2 GLOBAL SEA LEVEL OBSERVING SYSTEM (GLOSS)

The implementation of the Global Sea-Level Observing System (GLOSS) as a main activity of IOC in developing a global ocean observing system was decided by the IOC Assembly at its Thirteenth Session (March 1985) “as a basis for an extension under the auspices of IOC of the existing sea-level network”. GLOSS is based on an international global network of permanent sea-level measuring stations. It includes near real-time data collection, data analysis and product preparation for international exchange with unified formats and procedures, as required for scientific and practical applications.

GLOSS is a multi-purpose system which covers the entire sea-level spectrum, from short-lived tsunami to changes related to tectonic processes. Monthly mean averages from GLOSS stations are to be reported to the Permanent Senke for Mean Sea-Level (PSMSL). Operational sea-level data are reported in near-real-time within IGOSS to centres concerned, including the IGOSS Specialized Oceanographic Centre (SOC) for the IGOSS Sea-Level Project in the Pacific Ocean (ISLP-Pac) and the SOC for the IGOSS Sea-Level Pilot Project in the North and Tropical Atlantic (ISLPP-NTA). A full description of GLOSS objectives, scope and major elements is given in the Implementation Plan for GLOSS.

By decision of the IOC Executive Council at its twenty-fifth session (Paris, March 1992), the Group of Experts on GLOSS became a subsidiary body of the (then) IOC Committee for GOOS (paragraph 139 of the summary report of the session). GLOSS can therefore be considered as part of GOOS.

1.8.3 DATA BUOY CO-OPERATION PANEL (DBCP)

The Data Buoy Co-operation Panel (DBCP) was established by WMO and IOC to achieve optimum use of buoy deployments and to increase in the amount of drifting and moored buoy data available. These tasks are of direct concern to IGOSS because buoys are a major source of real-time ocean reports, especially in areas with sparse coverage by ships, The Joint IOC/WMO Committee for IGOSS has agreed to provide both information and assistance in support of the DBCP and its work, wherever possible and appropriate. The DBCP in turn takes IGOSS requirements into consideration in performing its tasks.

1.8.4 REGIONAL ACTIVITIES

There is a variety of regional bodies or programmes which arc implemented by Member States in different regions of the world and which have a substantial ocean monitoring component and thus can contribute to the development of the global IGOSS programme and at the same time, receive support from IGOSS. These regional activities include the WESTPAC and IOCARIBE of IOC, the WMO regional associations, and the Joint IOC-WMO--CPPS Working Group on the Investigation of "El Nino". Development and linking of such regional bodies and programmes will be a fundamental means of developing and supporting the Global Ocean Observing Programmes (GOOS),

1.8.5 OTHER INTERNATIONAL ORGANIZATIONS AND SUBSIDIARY BODIES

Many other international organizations and related subsidiary bodies also interact with IGOSS at various levels. Among these may be mentioned the Scientific Committee on Oceanic Research (SCOR) and the Scientific Committee on Antarctic Research (SCAR), both part of the International Council of Scientific Unions (ICSU), the Engineering Committee on Ocean Research (ECOR), the International Council for the Exploration of the Sea (ICES) and the Pacific Marine Science Organization (PICES), All these bodies may contribute to various aspects of IGOSS, as well as requiring the support of IGOSS in their own activities.

1.9 PRESENT STATUS OF IGOSS

IGOSS was started in the 1960's to provide a way for ocean scientists to relay data from research vessels to shore. Since then the programme has expanded to include XBT probe drops from ships-of-opportunity and measurements from drifting and moored buoys. Today the main focus of IGOSS remains vertical profile data (BATHY and TESAC) but the programme now includes underway surface temperature, salinity and currents (TRACKOB) and other data sources. The numbers of BATHY and TESAC reports made in the IGOSS programme are shown on a year-by-year basis in Annex 3.

In spite of the sustained growth of observations in IGOSS. many problems still exist. First, the number of real-thnc reports is still inadequate for monitoring the global ocean and to satisfy the demand for ocean data, both from scientific programmes and other users, The present sampling is adequate for monitoring large scale thermal changes of the ocean for support of ENSO and other climate predictions but is not adequate for smaller scale applications, such as prediction of location of fish stocks, drift of pollutants, or effect of ocean currents on ships or oil drilling platforms, Present sampling is very sparse in the south Atlantic, Indian, Southern and Arctic Oceans,

Second. in spite of the efforts of IGOSS. probably less than a fourth of the surface and sub-surface ocean measurements that arc made are reported in real-time and exchanged internationally. Automation of XBT observations from ships-of-opportunity and real-time reporting via satellite is now common but automated reporting is still not implemented for CTDs. ADCPs and other profilers on most research and other survey vessels. Also real-time reports of additional types of ocean observations are needed, including chemical and biological variables.

Third, IGOSS quality control procedures have improved as a result of co-operative efforts with IODE, TOGA, WOCE and other programmes to standardize the algorithms for data correction but much remains to be done. Automated quality control of all types of ocean observations will be required to meet data needs of GOOS and other programmes. The GTSP is supported by IGOSS and IODE and is a major advance in the assembly and quality control of ocean profile data.

Finally, the ultimate objective of IGOSS is to prepare usefull ocean products but present IGOSS products are still of relatively low resolution. slow in delivery (often by mail) and not as useful as they might be. IGOSS has established several Pilot Projects to develop new products and some of these are issued on an operational basis by ocean data centres. Additional efforts are needed to make more IGOSS products, improve their resolution, and make them available electronically on demand to all ocean laboratories in all countries. The IGOSS Products Bulletin (IPB) designated in 1991 compiles and publishes quarterly IGOSS global and regional products as a valuable service to the scientific and operational oceanographic community and international programmes. During 1996-2003 the IPB should be published monthly rather than quarterly, and also be made available via Internet and other electronic networks for timely access to oceanographic products, issued by different countries.

1.10 MAIN AREAS FOR IGOSS DEVELOPMENT DURING THE PERIOD 1996-2003

An efficient global ocean services system encompassing observational activities, telecommunications, data processing, storage and retrieval, and product formulation and dissemination is a vast undertaking that can only be achieved through multi-national efforts. Emphasis will be placed on increasing Member States' contributions to IGOSS and improving co-operation with other oceanographic sampling programmes. The specific objectives are to increase the number of oceanic observations, improve their quality and timeliness, assimilate the data into operational models, and prepare useful ocean products. IGOSS observations are time-critical and major efforts arc required to make ocean data collection and transmission more operational. Efforts are necessary build on GTSP to further integrate reporting and processing of real-time and delayed-mode ocean data to meet the objectives of IGOSS and IODE. In addition, economic analyses of the benefits of IGOSS should be undertaken for use by Member States.

The principal areas in which efforts must be directed during 1996-2003 are the following:

Observations

(i) During the period 1996 to 2003, the number of real-time reports of surface and sub-surface ocean measurements must be increased by an order of magnitude or more to meet the operational objectives of GOOS and other global observing programmes. Although the present number of temperature profiles is adequate to resolve the largest scale ocean climate changes, the number should be increased for greater resolution of ocean features.

(ii) The present number of real-time reports of salinity profiles is inadequate to resolve even global scale salinity changes. To meet the demands for ocean data during 1996-2003, the number of salinity reports must be greatly increased to monitor the distribution of ocean density (and hence circulation and stratification).

(iii) Attention must be given to improving the geographical distribution of IGOSS reports. In particular, increased reporting is needed in the Southern Oceans, the Arctic and in coastal areas,

(iv) Additional types of ocean observations. such as observations of dissolved gases (e.g. carbon dioxide) and chlorophyll concentration, are needed to meet demands of global change programmes such as (GOOS and GCOS. Means to bring these observations into operational use (in a sense to be defined by GOOS) are required and may impact IGOSS.

(v) Increased automation is needed to increase the number of ocean observations, improve their accuracy, and reduce the labour required for their collection and reporting in real-time.

(vi) Many existing IGOSS data arc collected and disseminated as part of observing systems established for major international research programmes, Efforts must be made to ensure that these observing systems are maintained operationally following the termination of the research programmes. A major challenge for IGOSS during 1996-2003 will be to take over operation of the TOGA ship-of-opportunity XBT programme, find sustainable funding for the programme, expand it to additional ships and lines, and make the programme globally operational.

(vii) Additional sources of real-time reports of ocean conditions must be identified through involvement of more researchers, fisheries biologists, fishermen, pollution control experts and others in IGOSS programmes. In particular, efforts must be made to obtain the co-operation of oil companies and others actively involved in offshore commercial activities for the purpose of:

a) Accessing marine meteorological and oceanographic data currently obtained from their platforms;

b) Seeking their assistance in carrying out additional marine and oceanographic measurements.

(viii) Regional ocean and coastal programmes which do not presently make real-time reports of ocean obsrvations must be identified and co-operative programmes developed with them to share data for mutual benefit.

(ix) Access to operational satellite data must be improved to improve integration of *in-situ* and satellite data in ocean models.

(x) Satellite-derived data, such as SST or sea-ice drift, are increasingly being used to generate analyss. Improved use and distribution of such analyses will reduce the need for more costly *in situ* measurements.

Communication Techniques and Codes

(i) A much greater proportion of existing ocean observations must be reported in real-time than at present. This will require increased automation of digitizing ocean observations, encoding the data in suitable codes, and transmission of the data to shore analysis centres for processing and development of products.

(ii) Efforts should be made to improve the reliability of IGOSS communications so that fewer data are lost from system failures, communications problems, and data handling. Considering the substantial investment made for obtaining IGOSS data, improvements in the reliability of IGOSS communications are very cost effective.

Reporting, Quality Control and Archive

(i) Greater effort must be made to improve the quality control procedures for IGOSS reports. Consistent quality control procedures are being developed by the GTSP to ensure that IGOSS reports are suitable for most purposes.

(ii) Data processing and archive of IGOSS data must be closely linked and eventually merged with that of IODE so that the data can be processed and made available to all users, irrespective of when the data were originally received (in real-time or delayed-mode). The GTSP provides an excellent prototype for expanded co-operation between IGOSS and IODE.

(iii) Efforts must be made to improve analysis techniques to improve the quality, timeliness and availability of products developed from IGOSS data.

Products

Products that are of use and of economic benefit to Member States must be identified, developed and distributed. Economic applications of IGOSS data must be underscored through, for example, improvements in forecasts and analyses based on IGOSS products which describe ocean features such as sea-surface temperature, ocean current and heat flux. The enhanced realization of economic importance of the data will encourage the participation of more countries in IGOSS,

TEMA

(i) In order to increase the participation of developing countries in IGOSS, appropriate training and concurrent provision of equipment must be arranged.

(ii) Specialized Iong-term training courses in marine meteorology and physical oceanography, in particular as they relate to IGOSS. must be established at appropriate institutions to train scientists from developing countries.

2. IGOSS OBSERVING SYSTEM

2.1 PURPOSE AND PRINCIPLES

The purpose of the IGOSS Observing System (IOS) is to provide an appropriate global mechanism for the timely collection and exchange of standardized oceanic and related meteorological data for synoptic analysis. The IOS consists of voluntary observations by participating countries using ships, buoys and other platforms. The objective is to provide an internationally co-ordinated observing system which proves more efficient than the simple addition of its components. Wherever possible, platforms will be used for multiple purposes for cost effective use of facilities.

2.2 **OBSERVATIONAL REQUIREMENTS**

2.2.1 TIME AND SPACE SCALES

IGOSS is an international programme for global, real-time exchange of ocean observations and relies upon sampling by Member countries which are often dictated by scientific, economic, industrial and social needs at the national level. Although IGOSS attempts to provide global coverage on a variety of time and space scales, it can exchange no more observations than are provided by Member countries. As a result, the level of IGOSS reports is insufficient to provide the levels of sampling needed for all applications.

IGOSS attempts to monitor the ocean on three space scales: global, basin-scale and mesoscale. This classification is somewhat arbitrary as ocean phenomena and processes occur on a much wider range of time and space scales and phenomena at different scales interact with each other. Global coverage is needed to support global analysis and general circulation models which at present have typical resolutions of 1 or 2 degrees of longitude and latitude and days to weeks and months. Higher resolution sampling is needed to support basin and mesoscale models, such as of coastal areas. Ideally one observation is needed for each grid point at each time interval of an ocean model. High resolution observations are also needed to prevent aliasing in process studies.

2.2.2 RELEVANT VARIABLES

The following sub-sections describe the principal variables that are observed by the IOS.

2.2.2.1 Sea-surface temperature

Sea surface temperature (SST) is widely observed as part of surface marine weather reports, sub-surface thermal profiles and by satellites. SST data are fundamental to many numerical ocean models and forecasts. Due to the many ways of observing SST, care must be taken to indicate the method of measurement to permit intercomparison of data sets,

2.2.2.2 Sub-surface temperature profiles

Profiles of sub-surface temperature are the most common sub-surface ocean measurements. The profiles are usually made at predetermined depths or as continuous casts. Newer profilers are being developed to provide profiles at closely spaced intervals, The temperature profiles are normally reported in real-time in BATHY code.

2.2.2.3 Surface and sub-surface salinity

Salinity observations are essential for description of the density structure of the ocean. Salinity is not as easily measured as temperature and thus salinity data are not as common in the IOS as temperature. A major objective for IGOSS in the period 1996-2003 will be to increase global real-time exchange of salinity reports. This will require much greater participation in IOS of research and other vessels which observe salinity than hitherto. These vessels encode their CTD profiles in TESAC messages and underway surface salinometer data in TRACKOB messages for real-time reporting and global exchange. Care must be taken to ensure that the salinity sensors are properly calibrated and maintained.

2.2.2.4 Near surface currents

Velocities of near surface, wind-driven currents maybe deduced from observation of ships' set and drift and reported in TRACKOB code. Near surface currents are also observed from position reports of drifting buoys and exchanged in BUOY code. Set and drift of buoys should continue to be reported with meteorological observations as at present. Wind stress, which is the driving force of drift, can be estimated by satellite-borne microwave sensors: separate arrangements are being made for exchange of these results.

2.2.2.5 Sub-surface current profiles

Whilst a knowledge of sub-surface ocean currents and their variability is essential in marine research, the spatial and temporal scales of the data collected by commonly used moored current meters is inappropriate for the IOS. However Acoustic Doppler Current Profilers (ADCP) are now widely used on research vessels and observe on scales appropriate for IOS. ADCP data are collected by research programmes and it is expected that these data will become a major source of IGOSS current observations. A number of issues remain to be resolved for global ocean current monitoring, including the time averaging and vertical spatial sampling intervals which should be used,

2.2.2.6 Sea level

Sea-level observations are handled by the GLOSS: see paragraph 1.8.2 above.

2.2.2.7 Waves

Wave observations are made by visual estimation from ships, by ship-borne and moored wave-recorders and by satellite sensors, Wave observations from ships are reported as part of surface marine weather reports while ship-borne and moored wave recorder observations are reported in WAVEOB code. The number of reports is inadequate however and additional efforts are required to report more of the data in real-time.

2.2.2.8 Other variables

IGOSS *in-situ* ocean observations are often made in concert with measurements of surface marine weather conditions, including wind direction and speed, air temperature and dew point, atmospheric pressure, sea-ice cover, cloud cover, solar radiation and precipitation on WMO voluntary observing ships. The data are reported to shore together and provide a very valuable companion data set to the IGOSS data.

2.3 OBSERVATIONAL STRATEGY

IGOSS relies on observational strategies developed by the scientific community through programmes such as the WCRP. The general goal of IGOSS has been to obtain global XBT coverage at a coarse resolution with finer resolution coverage in selected regions where there is increased interest and support for sampling. This goal has been developed in several IGOSS Ship-of-opportunity meetings and, with a co-operative effort by many countries, are now nearly being reached. Exceptions are that sampling remains sparse in the southern oceans and many coastal regions. To fill these gaps, IGOSS is totally dependent on the sampling programmes of the Member countries and can suggest ways that the gaps might be filled but cannot provide funds for such sampling.

When formulating plans for measuring a particular oceanic variable, several factors must be considered:

(i) The distribution and variability of the variable in time and space;

(ii) Available methods of measurement of the variable;

(iii) The purpose of the observation and the preparation and use of products derived therefrom;

(iv) Accuracy of sensors for the variable;

(v) Available communication links between the observing system and the GTS; and

(vi) Availability of automated systems for reporting and processing the data.

In selected areas where sufficient ship traffic exists and where there is sufficient interest by scientists and others, it is possible that increased measurements can be made near a specified location. Such locations could be designated as special observing areas.

2.3.1 NETWORK DESIGN

In planning a system for ocean monitoring such as IGOSS, it is important that optimum choices be made for the locations, platforms, sensors and frequency of observations. To conserve scarce resources, the sampling pattern should provide adequate resolution of ocean features without wasteful, duplicate observations. A common method of designing an optimum sampling pattern is network design. Network design can be interpreted as determining the density of observing stations and the frequency of observations which are required to achieve the desired resolution of the variable and the physical process of interest. The relative merits of the spatial and temporal coverage provided by satellites against the more accurate but restricted *in-situ* measurements from vessels must be weighed and co-ordinated effectively.

Network design has been approached in a number of ways. The method developed by the meteorological community requires a knowledge of the variability of the variables over a variety of scales given as correlation or structure functions. This approach provides an estimate of the accuracy with which the value of the variable can be interpolated on a grid-point system in relation to:

(i) Signal-to-noise ratio of the region; and

(ii) Spatial and temporal correlation of the variable at a given location.

Diagnostic studies with numerical models can be very useful in defining the position of the most sensitive areas with respect to the measurement of a specific oceanic variable.

2.3.1.1 Global network

The IGOSS global programme for XBT drops from ships-of-opportunity is based upon network design analyses of the variability of ocean conditions. The present ship-of-opportunity XBT network was developed by the TOGA and WOCE research programmes and in the future, will be determined by GOOS and other global observing systems.

2.3.1,2 Regional networks

The development of regional programmes will make it possible to collect additional data in coastal and other areas of local interest and will form an important part of the IOS. Regional networks will tend to be denser than the global network and more closely focused on processes under consideration. Data collected in regional programmes will contribute greatly to the global coverage.

The participating Member States w-ill establish the requirements for the regional networks based upon user needs, ocean characteristics and compatibility with national and global scale networks. Use of WMO and IGOSS standards for data communications will be vital to insure that the regional data can be easily exchanged internationally and contribute to the global effort.

2.3.2 SUMMARY

To the maximum extent possible, national, regional and global networks should complement one another to permit the most effective use of resources. The IGOSS Observing System will continue to operate as a global system within which basin-scale, regional, and national sampling networks will operate as IGOSS components utilizing IOC-WMO standards, recommended procedures and guidelines.

2.4 COMPONENTS OF THE IGOSS OBSERVING SYSTEM

The observing components of IGOSS can be categorized into surface-based, space-based and sub-surface-based sub-systems, Each system has different abilities and data from the systems complement one another to provide a more complete total sampling. Surface- and sub-surface-based observations provide water chemistry data and details of the interior of the ocean but have poor spatial and temporal resolution of changing conditions. Space-based observations have more complete spatial and temporal coverage but only limited ability to measure conditions within the water column. Surface-based observations are vital for calibration or “ground truth” of space-based observations.

2.4.1 SURFACE-BASED SUB-SYSTEM

Surface-based observing platforms, such as ships, drilling platforms, buoys and coastal stations are the primary source of IGOSS data.

2.4.1.1 Ships

2.4.1.1.1 Types of ships

(i) Research ships will continue to be an important element for IOS because of the versatility, dependability and accuracy of their observations. Rapid and easy access to research vessel data must be ensured. Laboratories are interested in regional oceanographic problems and can obtain and transmit data quickly using modem observing and reporting systems, including those on fishery research vessels. But the number of research vessels is relatively small and their operating costs are high and increasing;

(ii) Ships-of-opportunity are merchant or fishing vessels which make and transmit oceanographic observations for international exchange, These ships will continue to be an important component of the IOS during 1996-2003. The expanding use of automatic observing and reporting systems has led to an increase in numbers of ships-of-opportunity in IGOSS because of reduced requirements for manpower both on board the vessels and for real-time reporting of the data.

Ships-of-opportunity should be used to satisfy both meteorological and oceanographic requirements as far as possible. It is expected that many of the ships in the WMO Voluntary Observing Ships (VOS) scheme which now make weather observations can be recruited to make oceanographic observations. The VOS port meteorological officers area unique asset and will continue to encourage oceanographic observations on these ships and ensure that ships’ masters are approached in a co-ordinated fashion.

2.4.1.1.2 Criteria for selecting ships

The general criteria which are considered important for selecting ships should include the following:

(i) In terms of programmatic consideration:

a) Projected route to cover data sparse areas;
b) Specific programme needs;
c) Support to GOOS and other global observing systems;
d) Potential applications of the data for fisheries, pollution control and oceanographic research;

(ii) In terms of ships-of-opportunity:

a) Ships’ experience in observing programmes, such as that acquired by WMO’s Voluntary Observing Ships;
b) Adequate communication facilities aboard ships;
c) Easy contact with ships’ owners and the vessels to permit good communication and ease of servicing;
d) Favourable working relationship with the ship’s crew.

2.4.1.1.3 Shipboard equipment

(i) XBTs: expendable bathythermograph probes observe continuous profiles of sub-surface temperature from ships while underway. XBT drops from ships-of-opportunity are the primary sampling technique in IGOSS. Automated shipboard observing systems are being developed to electronically digitize XBT data, encode the data as BATHY messages and report the data to shore in real-time by satellite. The systems are low cost, small in size, easily installed on ships, and provide good quality control of the data. Many automated observing systems have interfaces to Global Positioning Systems (GPS) for automated entry and reporting of position data. During 1996-2003 these systems will be further developed for greater compatibility, better quality control, and greater standardization to reduce operator training and system maintenance and repair;

(ii) Sampling bottles: mechanical water sampling bottles arc the traditional sub-surface sampling device from oceanographic research vessels, Bottles are simple, inexpensive and provide water samples for salinity and chemical analyses but they are labour intensive, require that the ship stop on station and do not provide continuous profile data.

(iii) CTDs: Conductivity-Temperature-Depth profilers provide continuous profiles of sub-surface temperature and salinity and have replace sampling bottles on many research and other vessels. CTD profile data are reported in TESAC code. Because CTD profilers require that the ship must be stopped to take a profile, undulator and other towed devices are being developed to allow sampling from a ship while underway. Although the resolution and accuracy in temperature of a CTD is generally better than for an XBT, both temperature and conductivity sensors are subject to calibration shills:

(iv) XCTDs: expendable CTD profilers have been under development for many years to improve their accuracy and reliability. Although XCTD probes cost several times more than XBT probes, XCTDs are expected to become widely used in IGOSS during 1996-2003 to increase the real-time reporting of salinity profiles;

(v) ADCPs: sub-surface current profilers, particularly Acoustic Doppler Current Profilers, can produce real-time profiles of relative horizontal velocity continuously in time throughout the upper several hundred meters of the water column. ADCPs use existing Doppler speed log devices that are installed on several hundred vessels world-wide. Measurements are made while the ship is underway using back scattered signals from particles in the water column to deteemine a profile of water velocity;

(vi) Surface observations: many research and other vessels have surface underway salinometer for recording surface temperature and salinity while underway, During the period 1996-2003, many of these systems will be interfaced to satellite transmitters for real-time reporting of the data in TRACKOB code. Surface current measurements will become common using ship drift and other techniques, based on GPS-type positioning systems.

2.4.1.2 Buoys

Real-time reports of sub-surface temperature, salinity and currents from moored and drifting buoys have become a major component of IGOSS. Buoy data are an essential component of the IOS in that they report data frequently at relatively low cost and obtain data from ocean areas which cannot be conventionally observed by other means, such as in areas of bad weather and the Southern Oceans. Buoy observations are essential to the calibration and validation of satellite-borne sensors in data sparse areas and to the quality control of satellite derived ocean observations for operational applications. Rapid and easy access to buoy data must be ensured.

Moored buoys have provided a reliable suite of routine ocean surface and sub-surface obseevations and measure a number of variables. Improvements in buoy hardware, logistics and durability in recent years have resulted in a variety of buoy hull sizes and configurations that can economically observe and report real-time temperature and wave measurements. The observations from the TOGA buoys in the tropical Pacific are increasingly vital to the IOS.

Drifting buoys are tracked by polar orbiting satellites while taking wind, pressure, air and sea temperature measurements. Many of the buoys are tracked with the Argos system which locate and collect data from drifting buoys to provide low-cost measurements over the globe. Drifting buoys capable of supporting a sub-surface string of thermistors to measure temperature at several depths have been developed and will be widely deployed in the period 1996-2003.

2.4.1.3 Coastal stations and offshore platforms

Coastal stations and offshore platforms should be considered as part of IOS, because they can measure variables such as SST, sea level, and surface salinity. Oil drilling platforms often observe sub-surface temperature and salinity. Data from these stations and platforms are relatively inexpensive to collect and useful for long-term monitoring coastal ocean conditions. As part of GOOS. the global network of sea level stations of GLOSS will be expanded to better monitor variations in sea level.

2.4.1.4 Other platforms and sensors

Many ocean observing systems already exist and new ones are being developed and will be implemented during 1996-2003. The challenge for IGOSS will be to encourage real-time reporting of obseevations from these systems to support global monitoring programmes.

2.4.2 SPACE-BASED SUB-SYSTEM

Satellite data are regularly assimilated into ocean models and many new sensors are in a developmental stage which have much potential for the improvement of operational ocean forecasts, Access to satellite data has also improved dramatically permitting many developed and developing countries to make use of it in national and regional activities. Space-borne sensors which currently provide important ocean measurements include, for example:

(i) The Advanced Very High Resolution Radiometer (AVHRR) on polar orbiting satellites routinely provides sea-surface temperature (SST) observations. The collection, processing, analysis and distribution of these SST retrievals is highly refined and the ground processing system operates efficiently on an operational basis. The retrievals are routinely utilized to prepare operational products;

(ii) The radar altimeter operating from polar orbiting satellites provides altimetric measurements of the sea surface topography, TOPEX/POSEIDON and ERS-1 are currently providing observations of wave heights, surface wind speed, ice edge and ocean topography. These observations are undergoing operational evaluations at national centres and are experiencing a growing, but still limited, application in operational ocean forecasts;

(iii) The Synthetic aperture mapping radars like the one on ERS-1 operating from polar orbiting satellites measure back scatter from the ocean. Measurements from these platforms are used to infer sea ice texture, leads, edges and motion and ocean wave patterns, Measurements from these sensors can also provide information on oil spills. These observations are undergoing operational evaluations at national centres and arc experiencing a growing, but still limited, application in operational ocean forecasts:

(iv) The multiple beam microwave scatterometer observations from near-polar-orbiting satellites are used to infer sea surface wind vector and sea surface wind stress. Measurements from these instruments are routinely used in the operational data assimilation process of numerical weather prediction models,

In the near future, Ocean Colour Radiometers will be deployed. These sensors operate from a sun-synchronous polar orbit and will be used to infer marine productivity, suspended matter, chlorophyll, marine pollution and coastal zone water dynamics (eddies. current, etc.). The operational use of these data will expand the user community for operational ocean data and result in increased demand for product development and data distribution, A smaller element of the observing system, but still of significance, is the use of fixed wing and rotating wing aircraft. Aircraft are used as platforms for remote-sensors, as vehicles for XBT and XCTD sampling and for delivery of surface and sub-surface systems such as drifting buoys.

2.4.3 SUB-SURFACE SUB-SYSTEM

Sensors on the sea floor, tethered and freely floating neutrally buoyant instruments carried by submersibles or maintained in underwater habitats could provide useful data to IGOSS. Other systems include manned submersibles and habitats which may become common in the future. During 1996-2003 new techniques will be developed to allow international exchange of data taken by sub-surface observing systems.

3. IGOSS TELECOMMUNICATION ARRANGEMENTS

3.1 PURPOSE AND PRINCIPLES

The purpose of the IGOSS Telecommunication Arrangements (ITA) is to ensure the rapid and reliable collection, exchange and distribution of ocean data originating from the IGOSS Observing System and of processed information available from the IGOSS Data Processing and Services System. The ITA are based on the following principles:

(i) The basic element of the ITA is the Global Telecommunication System (GTS) of the World Weather Watch of WMO, The GTS was originally based on telex technology but is being upgraded to modern, high speed, packet switching circuits (such as X.25 and other error checking and correcting protocols),

In order to effectively forecast ocean features, Member States will encourage GTS transmission of all ocean data. For this purpose:

a) The National Meteorological Service responsible for the operation of a telecommunication centre of the GTS, whether it be a World Meteorological Centre (WMC), a Regional Telecommunication Hub (RTH) or a National Meteorological Centre (NMC), is responsible for both transmission to and reception from the GTS of IGOSS observational data;

b) The WMO standard telecommunication procedures are applied for the handling of IGOSS observational data; where non-GTS circuits are used, procedures applicable to those circuits should be followed.

(ii) A variety of methods are used to transmit IGOSS data to shore analysis centres:

a) international Maritime Mobile Service;
b) radio communication using exclusive HF bands;
c) geostationary and polar-orbiting environmental satellites;
d) communication satellites;
e) very high frequency (VHF) transmissions, including cellular telephones.

3.2 ENCODING, COLLECTION AND EXCHANGE OF IGOSS DATA

IGOSS observations were manually encoded into WMO formats and sent to coastal radio stations. These methods were laboursome and caused errors and delays in transmission. Automatic of encoding and reporting of the data by satellite is now common and will become standard practice during 1996-2003.

Collection and exchange of IGOSS data can be handled by many different routes. A common route is as follows:

(i) Collection platform to coastal radio station or satellite Earth station;

(ii) Coastal radio station or Earth station to National Meteorological Centre (NMC) or National Oceanographic Centre (NOC);

(iii) NMC or NOC to an appropriate GTS Centre for data insertion on the GTS;

(iv) Relay from a GTS Centre to National Oceanographic or Meteorological Centres.

Where possible, IGOSS data are exchanged following the procedures specified in the Guide to operational Procedures for the Collection and Exchange of Oceanographic Data (IOC Manuals and Guides Series No. 3, prepared jointly with WMO) and the Manual on the GTS (WMO-No. 386). In the preparation of bulletins for insertion onto the GTS, allowance is made within the WMO Regulations for the exchange of operational oceanographic data that are older than 48 hours. Operational data are defined within IGOSS as data up to 30 days old. Older data are processed in the IODE system. During 1996-2003 the IGOSS and IODE systems will be more closely linked to reduce any delays and duplication of effort between the two systems.

3.3 METHODS OF DATA COLLECTION

3,3,1 SURFACE-BASED SYSTEMS

(i) International Maritime Mobile Service: High frequency radio is a common communication system for reporting surface marine weather and IGOSS ocean data, Use of HF radio will decrease during 1996-2003 as satellite communications become available on all ships;

(ii) Radio communication using exclusive HF bands: The World Administrative Radio Conference (WARC) allocated six HF bands for the transmission of ocean data. These frequencies were used in the past for specialized coastal applications but, like HF radio, their use is decreasing and being replaced by satellite transmission;

(iii) Very high frequency (VHF) transmission: VHF transmissions are used for short-distance, line of sight communications for collection of data from moored buoys situated close to a coastline. Cellular and other VHF and UHF telephone systems will become common during 1996-2003.

3,3.2 SATELLITE-BASED SYSTEMS

Data collection from ships and automated oceanic data acquisition systems is now routine via geostationary and polar-orbiting satellites:

(i) The International Maritime Satellite (INMARSAT) system provides an effective and reliable mechanism for the collection and distribution of navigational, meteorological, hydrographic and oceanographic information, including transmission of binary and facsimile data. INMARSAT provides two services of wide use in oceanography: Standard A service for voice and modem communications and Standard C service for low data rate digital applications. During 1996-2003 Standard C systems will be installed on most vessels under the Global Maritime Distress and Safety System (GMDSS) and thus Standard C will become a dominant means for reporting IGOSS data;

(ii) The Argos system is flown on-board polar-orbiting meteorological satellites and has demonstrated its efficiency in the collection of environmental data since 1978. Its platform location capability makes it the most efficient system for operating automated ODAS that need to be located, such as drifting buoys. The annual Argos Joint Tariff Agreement Meeting, co-sponsored by IOC and WMO, defines the privileged conditions under which govemmcnt-sponsored programmes may access the system;

(iii) The Data Collection System (DCS) of the geostationary meteorological satellites provides an efficient system for transmission from Data Collection Platforms (DCP) which do not need to be located. Conditions for access to the system arc determined by satellite operating agencies

(EUMETSAT, India, Japan, Russia, USA) under the auspices of the Co-ordination on Geostationary Meteorological Satellites (CGMS).

3.4 DISSEMINATION OF OPERATIONAL PRODUCTS TO USERS

Marine data products are prepared and distributed operationally in both analog and digital formats. Many nations prepare marine products in analog formats, including weather maps sent as facsimiles over HF radio to ships and oceanographic products distributed by mail to research laboratories.

Although analog formats are useful and widely used, they suffer from several problems:

(i) HF radio facsimile maps can be distorted by HF noise;
(ii) mailed products are not available in a timely fashion; and
(iii) all analog products can only be viewed and must be digitized before the data can be used in numerical models.

Increasingly, products are being distributed in digital formats to avoid these problems. Gridded numerical fields can be transmitted to users by radio, Internet or other media (in WMO GRID or GRIB or other format), contoured by the user on a microcomputer or workstation and input to numerical models.

Operational IGOSS products are distributed to users (including users at sea) on a national basis using appropriate telecommunication circuits. International dissemination is through the GTS and Internet. During 1996-2003 broadcast of marine products in analog facsimile form by HF radio will be supplemented by digital broadcasts of gridded numeric fields via INMARSAT Standard C and other satellite systems. Also an evolving “Ocean Network” on Internet will supplement the GTS for distribution of operational ocean data and products.

4. IGOSS DATA PROCESSING AND SERVICES SYSTEM

4.1 PURPOSE AND PRINCIPLES

The IGOSS Data Processing and Services System (IDPSS) serves as an international operational ocean data processing and services system. The purpose of the IDPSS is to make available to users quality controlled and processed observational data, analyses and forecasts needed for marine activities. The IDPSS is intended to provide a common basis for the operation of the IGOSS ocean data processing centres, provide for the standardization of ocean products when necessary, ensure that the requirements for ocean products of all Member States are recognized and minimize duplication.

4.2 **ORGANIZATION**

The IDPSS is a product formulation and data management system using telecommunicated data. The main elements of the IDPSS are as follows:

(i) National Oceanographic Centres (NOCs) or National Meteorological Centres (NMCs) are the basic element of the system. These are the sole responsibility of Member States and provide services in response to national priorities. Member States that do not have an NOC are encouraged to establish one and participate in the IDPSS;

(ii) At the request of several Member States, or in response to the requirements of international programmes, Specialized Oceanographic Centres (SOCs) may be established to provide products for specific regions or projects. Member States are invited to establish SOCs and designate their areas of responsibility. Operations of SOCs are described in the Guide to SOCs (IOC Manuals and Guides Series No. 19, prepared jointly with WMO);

(iii) World Oceanographic Centres (WOCs) are specific SOCs to provide products on the global scale. WOCs have highly automated facilities that can deal with large volumes of data and use numerical techniques to analyze and forecast large- and planetary-scale phenomena. WOC products are usually available to other centres via the GTS and Internet. Three WOCs have been established (in China, Russia, and the USA).

Many of the SOCs and WOCs also participate in the IODE programme for processing non-operational ocean data. During 1996-2003 IGOSS will cooperate with IODE to link the IGOSS SOCs and WOCs with the IODE World Data Centres and WMO NMCs to manage data collected by the GOOS and to develop an operational "Ocean Network" on Internet for timely global exchange of ocean data and products.

During 1996-2003, the IDPSS will become a component of a larger system of Distributed Data Bases (DDB) being developed by WMO to support GOOS and other global observing systems, including GCOS and GTOS. In the DDB, each centre will be able to share data with other centres by browsing files at other centres and downloading data of interest over Internet. Browse and download services will also be provided to scientists and other users over Internet for global exchange of all types of environmental data.

4.3 FUNCTIONS

4.3.1 OVERVIEW

The IDPSS Centres are established in response to national and international requirements. The Centres follow standard procedures to process ocean data, including the following:

(i) quality control of ocean data;
(ii) preparation of edited collections of observations in standard formats for users;
(iii) production and dissemination of oceanic analyses and forecasts;
(iv) fully documenting and distributing data processing and analytical methods for other participants in the IDPSS; and
(v) monitoring the flow of data through the Centres.

The Centres participating in the IDPSS provide a variety of products, some of which are routine in nature whilst others support specific oceanographic and meteorological projects.

4.3.2 SPECIFIC FUNCTIONS

National Oceanographic Centres (NOCs) perform quality control, transmit data and prepare products in accordance with national priorities. NOCs also monitor data exchange and specify data requirements for analyses and forecasts.

Specialized Oceanographic Centres (SOCs) collect and process data from the GTS and/or other sources, perform quality control and prepare specialized products. SOCs also monitor data exchange, develop and document procedures and specifications and provide training.

World Oceanographic Centres (WOCs) receive data from the GTS, perform quality control and prepare global products. WOCs also work closely with NOCs and SOCs in performing non-operational fictions.

4.3.3 QUALITY CONTROL

The quality of IGOSS data is a primary criteria by which users judge the utility and efficiency of IGOSS. Therefore, data must be continually monitored and steps taken to improve data quality. The basic elements of quality control of IGOSS data are the detection and elimination of errors that occur during the observation and coding of the data and transmission. The most serious errors are ship identification (call sign), position and time errors (who? where? when?). Thus, quality control of the data must begin while the data are still aboard ship.

Consistent quality control tests must be performed throughout the routing of the data from the observer to the user. As a minimum for data collected on board ships, quality control procedures are to be applied at the following points in the data flow scheme:

(i) On board the vessel prior to transmission, often using automated observing systems;

(ii) At NOCs or NMCs as a real-time activity prior to the insertion of the data into the GTS;

(iii) At SOCs after receiving the data set from the GTS and before use of the data in scientific analyses; and

(iv) At WOCs before the data are archived and distributed in global data sets.

The sophistication of the quality control techniques increases in the later stages of the process after the gross errors are detected and corrected in earlier stages. Many of the NOCs, SOCs and WOCs now use interactive graphics workstations to speed and improve quality control of the data.

Quality control procedures for drifting buoy data are also important, since poor quality data detract from the potential of drifting buoys to provide observations in data sparse areas. Real-time gross error checks are required prior to dissemination of the data via the GTS. In addition, the DBCP has implemented a set of guidelines for slightly delayed-mode quality control of buoy data, which allows to correct erroneous data or suppress them from GTS distribution.

It is the responsibility of the data originator to make sure, to the extent possible, that the data submitted for circulation on the GTS do not contain large and obvious errors. NMCs or NOCs, before insertion of operational data onto the GTS, shall apply only the “minimum quality control procedures” described in IOC Manuals and Guides No. 3. SOCs shall carry out quality control in accordance with IGOSS standard procedures (Manuals and Guides No, 3). The final data set will then be provided on a regular basis to the RNODCs for IGOSS.

The Global Temperature and Salinity Programme (GTSP) provides a prototype for improvement of IGOSS data quality control and processing in the future, In the GTSP all available temperature and salinity profile reports are obtained from the GTS at several locations, merged with available delayed-mode data, quality checked on an interactive graphics workstation, and distributed to users on Internet and other media. The data are archived in a Continuously Updated Data Base and will be published on CD-ROM for inexpensive desktop computer access.

4.3.4 PRODUCT PREPARATION AND DISSEMINATION

A growing quantity and variety of ocean products are being prepared by NOCs, SOCs, and WOCs. These products range from simple inventories of IGOSS data to analyses and forecasts of surface and sub-surface thermal structure and sea level. Because much of the work in the past was conducted under the aegis of TOGA many products were concentrated on the tropical oceans. With the development of GOOS, more products are being prepared for global and regional coverage.

Some analyses are “blended”, using a combination of conventional *in-situ* data and satellite data. *In-situ* data are used as bench marks for temperature values in regions of sufficient data; between the bench marks satellite data are used to define the shape of the temperature field.

As the quality and quantity of IGOSS data increases and as the demands of new programmes or systems like GOOS are getting defined during 1996-2003, the variety of IGOSS products will increase. Products must be easily available, up-to-date, have sufficient spatial detail to show major ocean” fluctuations for all areas globally. In considering the preparation of new products, Member States should ensure the usefulness of products (by establishing close contact between users and SOCs) and timeliness of delivery of the products. For global compatibility of products, methods of product preparation and displays of products should use common symbols, geophysical units and, if possible, common projections and other criteria.

Development of products should be based on uniform specifications concerning accuracy and spatial and temporal resolution to meet user requirements. At present many ocean products are issued on a monthly time scale but as the number of observations increases in GOOS and other programmes or systems, more frequent analyses will be possible. Already some ocean variables such as SST are analyzed on a 12-houly basis by weather forecasting centres.

IGOSS products are distributed in many ways, including analog forms as printed maps and published journals and in gridded numerical form that are distributed by GTS and Internet. Preparation of gridded products is expected to increase in 1996-2003 as computers and communications become more powerful and widely available. It is important that all users, and potential users, of the products have access to them as quickly as possible. This will require increasing use of standards for exchange of products. In conjunction with the World Weather Watch, IGOSS products will increasingly be distributed on Internet and be available for browse and download on the Distributed Data Bases (DDB) network. Standards such as data formats and software will be required to ensure compatibility of the various data sets. Use of the standard WWW format for gridded products, GRIB, should be encouraged in IGOSS for compatibility of operational oceanic and atmospheric products.

Examples of IGOSS products are shown in Annex 4. A selection of IGOSS Products is published quarterly in the IGOSS Products Bulletin. The Bulletin is expected to be published monthly from computer graphics data. A filly interactive version of the Bulletin is available on the World Wide Web. During the period 1996-2003 many of the fields will be distributed as numeric gridded fields over the DDB and Internet for display on microcomputers and workstations.

4.3.5 DATA MANAGEMENT

As GOOS develops during 1996-2003, IGOSS real-time data will become more closely linked with IODE delayed-mode data. Close collaboration between IGOSS and IODE is required for smooth flow of the real-time IGOSS data into IODE archives and to maximize efficiency and minimize the user's task of obtaining data from two sources. SOCs will submit the operational ocean data originating from the IOS (and other operational sources) to the respective RNODCs for IGOSS in computer compatible form. The submission will occur on a monthly or more frequent basis to allow the IODE system to update archived data and provide more comprehensive data sets to users. A typical data flow from IGOSS to IODE is shown in Annex 5.

An example of IGOSS and IODE co-operation is the Global Temperature Salinity Programme (GTSP), a prototype for improved IGOSS-IODE data flow. In GTSP real-time IGOSS reports of temperature and salinity profiles are received from the GTS at several locations, assembled in a common format, quality controlled and relayed to IODE data centres. Similar data are received in non real-time through such programmes as the IODE Global Oceanographic Data Archaeology and Rescue (GODAR) project and merged with the IGOSS data in a Continuously Updated Data Set.

5. SUPPORTING ELEMENTS OF IGOSS

5.1 IGOSS TRAINING AND ASSISTANCE

To create and maintain a comprehensive global ocean services system, efforts must be made by IOC and WMO to involve as many countries as possible and to ensure that their participation is effective. In this regard the IGOSS training and assistance programme is a supporting activity for the efficient and effective implementation of the three essential elements of IGOSS, The training and assistance programme works in co-ordination with existing mechanisms in IOC and WMO, particularly the Voluntary Co-operation Programmes (VCP) of both organizations. The IOC/VCP is based on the principle of mutual assistance between developed and developing Member States of IOC and serves as a source of assistance to strengthen marine science in developing Member States and enable them to participate fully in IOC programmes. The WMO/VCP is integrated with the World Weather Watch and seeks, through UNDP and donor country funds and assistance, to improve the global synoptic network for the benefit of all Members. The IOC/VCP should put special emphasis on IGOSS activities along with the principle that IGOSS products contribute economic benefits locally, regionally and globally. Thus IGOSS may be considered as a relevant focal point around which to raise interest and participation in the IOC/VCP.

Contributions by Member States under the IOC or WMO/VCP should be based on the IGOSS priorities set forth in this Plan. Training programmes must include provision of equipment and a schedule for monitoring the value of the training to IGOSS and to Member States which receive the training.

Global expansion of Internet and the WMO DDB to all countries in 1996-2003 will allow much easier international data exchange and involvement of developing Member States in IGOSS activities. All Member States will be able to enter and receive regional and global data sets in near real-time at very low cost.

5.2 IGOSS RESEARCH AND DEVELOPMENT

5.2.1 RATIONALE

The data gathered under the auspices of IGOSS and the products generated from it benefit from a close association with ongoing and planned research programmes on both global and regional scales. Such programmes help in defining the spatial and temporal coverage that is required of the relevant variables in order to improve our understanding of the oceanic and atmospheric processes and their variability.

In order to ensure that maximum use is made of the IGOSS efforts, strong encouragement will be given to systematic development and validation of models dealing with upper-ocean dynamics, ocean/atmosphere coupling and regional meso-scale ocean prediction. Also needed is an emphasis on studies dealing with methods for data assimilation and initialization in the oceanic component of these models as, for example, is done routinely in the numerical weather prediction models. Such studies are essential to improve our ability to more accurately forecast the ocean or ocean/atmosphere environmental conditions and contribute to an enhanced utility of the IGOSS observations.

5.2.2 TECHNIQUES AND METHODOLOGY

Research priorities in techniques and methodology should be specified in relation to the desired application. Some improvements in the operation of IGOSS can be made by improvement of standardization and automation of sensors used by ships and other platforms. More effective use of the observing platforms can depend less on research than on better organization, increased funds and on engineering developments. For example, improved methods are being developed for measuring sea-surface variables by satellite. Better estimates of near-surface currents are being made by drifting buoys, Through remotely-sensed data, geostrophic currents can be calculated by using mean sea-level observations available from altimetry. New expendable devices provide accurate salinity and current measurements.

Numerical eddy-resolving ocean models are being developed in several countries to better represent marine phenomena and circulation patterns. The most important contribution of these models would be in the development of techniques and methods for the satisfactory incorporation of processes, of which the scales are smaller than the sampling grid, There will also be a need for monitoring their output, by direct comparison of observations and forecasts for suitably chosen parts of the model or by checking the simulated integrated effects against observed values.

5.2.3 APPROACH

The responsibility for the studies and experiments which would lead to the solution of the problems cited above lies with Member States. They are urged to undertake research and development programmes to improve the operations of IGOSS. In doing so, the international mechanisms already in existence within IOC, WMO and their advisory bodies, for co-ordinating and designing research programmes and data management should be used whenever possible.

5.3 IGOSS MONITORING

The IOC and WMO Secretariats regularly monitor IGOSS operations, on the basis of regular (monthly or annual) reports submitted by Member States as well as specific surveys. The monitoring covers aspects such as the quantity, reliability, accuracy and speed of exchange of oceanographic reports over the GTS, the status of ocean observing systems and the status of oceanographic products issued by national centres. The results of the monitoring are communicated to Member States in an annual report and in information service bulletins.

Monitoring of IGOSS activities is also done by the GTSP and WOCE; these have led to major improvements in the accuracy, completeness and timeliness of the monitoring statistics.

During 1996-2003 monitoring of IGOSS activities will be further improved as the IGOSS and IODE centres connect to the Internet and participate in the WMO DDB. This will allow better integration of metadata and inventories of data availability and of ocean data with climate and weather data.

5.4 IGOSS INFORMATION EXCHANGE AND PUBLICATIONS

The IOC and WMO Secretariats publish and regularly update, on behalf of IGOSS and the Member States, a variety of manuals and guides relating to the structure and operation of IGOSS. These manuals and guides are supplemented by information service bulletins, which report on the status of implementation of various aspects of IGOSS and arc based on IGOSS monitoring exercises. Finally, a variety of pamphlets and brochures are prepared, by Member States or by co-operative, programmes such as GTSP, as contributions to IGOSS as a means of publicizing the purpose and achievements of IGOSS.

Part B - Implementation programme

1. GENERAL PRINCIPLES OF IGOSS IMPLEMENTATION

Enhancement of IGOSS during 1996-2003 will depend heavily on the development of requirements under GOOS and GCOS, and will be directed as much as possible to rneeting these requirements. It is expected that IGOSS will provide the basis for the operational component of GOOS, as well as operational aspects of the oceanographic component of GCOS, Within this framework. IGOSS will be implemented according to the following basic principles:

(i) All national ocean activity connected with the implementation of IGOSS should be the responsibility of the Member states themselves and should, as far as possible, be met from national resources;

(ii) Maximum use should be made of existing facilities and arrangements in the different fields of activity involved;

(iii) No existing component or facility of IGOSS should be removed before the corresponding new component or facility can meet the requirements at least to the same extent as the old;

(iv) Coastal states should, without prejudice to their rights as determined under international law, facilitate the collection and transmission of IGOSS data from platforms in their coastal waters in addition to their own national contributions to IGOSS;

(v) Implementation of IGOSS within developing Member States should be based on the principle of the utilization of national resources but, where necessary, assistance may be in part provided by:

a) International funding mechanisms such as UNDP and GEF,

b) Contributions from IOC-VCP and/or WMO-VCP,

c) Bilateral or multilateral arrangements.

2. IMPLEMENTATION ACTIVITIES 1996-2003

2.1 GENERAL

To meet the requirements of GOOS, GCOS and other global ocean monitoring activities, more abundant and more accurate real-time reports of more types of ocean observations are needed to provide greater details of ocean fluctuations in time and space. The data will also be needed for fisheries research, commercial fishing, navigation, pollution control, weather and climate prediction. calibration of remotely-sensed observations and other applications. Since IGOSS is the international programme for coordination of real-time reporting of ocean observations, it must respond to the expanding operational and research needs for ocean data.

Co-operative projects must be developed with most, if not all, ocean monitoring and research programmes so that many more of the existing observations can be reported in real-time. This will require development of automated data encoding, transmission and processing techniques. The quality of the observations must be improved through application of new data collection techniques. Closer links must be established with IODE to report more of the existing observations in real-time. Global electronic connections via Internet and the WMO DDB are required to facilitate access to data and products by Member States' and particularly by developing countries. Contributions from the private sector, in data collection, exchange and processing, should be utilized whenever possible.

The primary specific objective of the IGOSS Implementation Programme for the period 1996-2003 will be to meet the stated requirements of GOOS and GCOS for upper ocean temperature and salinity data for climate monitoring, research and prediction. It is expected that these requirements will arise directly from the final report of the Ocean Observing System Development Panel (OOSDP).

2.2 IGOSS OBSERVING SYSTEM

2.2.1 IOS SURFACE-BASED SUB-SYSTEM

Maps in Annex 6 indicate the distribution and present level of sampling of sub-surface profile reports collected and exchanged under IGOSS. Clearly emphasis must be placed on increasing coverage in the Atlantic, Indian and Southern Oceans, whilst recognizing that the Pacific Ocean is not yet as densely sampled as is desirable. Increased reporting of observations in coastal waters is also needed.

In order to meet the requirements of GOOS, GCOS and (as much as possible) the WCRP, it will be necessary to increase the numbers of real-time reports in several ocean areas during the time scale of this plan. The following initial specific goals are therefore set, bearing in mind that these may need to be modified as more detailed requirements emerge from GOOS and GCOS:

(i) Fully implement the TOGA/WOCE low density network (42,100 probes per year and 150 ships) throughout the period. on the basis of the IGOSS Ship-of-Opportunity Implementation Plan, If possible, double the number of BATHY and TESAC reports distributed on the GTS, to attain 100,000 per annum by 2003. This implies:

a) Recruit some additional ships-of opportunity,

b) Equip as many ships as possible with automatic observing, formatting and reporting systems for automatic sub-surface data reporting through satellites, including ship drift current observations, computed by satellite navigation,

c) Supply these ships with a sufficient number of sub-surface temperature (XBT and XCTD) probes,

d) Increase the amount of real-time data transmitted from existing retrievable profiling CTD systems on research vessels and Expendable Conductivity Temperature Depth (XCTD) systems at present under development;

e) Equip ships with acoustic Doppler current profilers (ADCP) and pursuing effective means of data exchange;

(ii) Double the number of TRACKOB reports. This will be achieved through installing automated encoding and reporting systems on all available ships that have underway thermosalinographs;

(iii) Through the DBCP, progressively convert existing research-oriented to operational drifting buoy networks, primarily in data sparse areas, to provide data on surface currents, sea temperatures and atmospheric pressures. Where possible, encourage and assist in the deployment of enhanced technology drifting buoys with sub-surface temperature sensors;

(iv) Increase automation of observations and transmission of reports in order to reduce costs and handle the increase in conventional and satellite data.

2.2.2 IOS SPACE-BASED SUB-SYSTEM

Many ocean data collection satellites will be launched during the period 1996-2003. The Committee on Earth Observing Satellites (CEOS) is coordinating plans for these satellites to ensure adequate coverage of the ocean and compatibility of the data collected. IGOSS and the World Weather Watch contribute to the CEOS plans for proposed satellites. These are outlined in Annex 7.

These space systems represent a unique source of global ocean observations that have operational utility, provided the sensor-derived measurements can be delivered to operational centres in real-time and that the centres can implement techniques for proper assimilation of the data, Thus, there are incentives to develop collection, processing and global distribution mechanisms, that include developing countries, to access the data from planned satellites, on a real-time basis. This development will enhance forecasting and warning capabilities and will meet the access and archival requirements of the research community. Through IGOSS, the real-time exchange of satellite data will be facilitated.

The rapid transition of experimental/research oriented satellites to operational status has been demonstrated by the TOPEX/POSEIDON and ERS series satellites. This emphasizes the need for IGOSS to be aware of the need for follow-on missions to be planned for those experimental sensors destined for operational use. There is no longer the opportunity to test an instrument, find it provides useful data, and then wait 10 to 15 years to find another platform for the next mission, IGOSS must ensure that operational instruments are tested and operated in parallel with experimental instruments so that adequate inter-comparisons can be obtained. IGOSS must also impress upon satellite agencies the need to have an adequate back-up plan in case launches fail. This was recently demonstrated with the failure of NOAA I and LandSat 6.

Efforts continue to fly a mission to measure the geoid. This mission continues to be crucial to the refinement of the altimeter data for sea surface topography determination. Research is on-going in the development of a sensor to measure sea surface salinity.

Work in this field under IGOSS will continue to be carried out jointly with the WMO/CMM and the IODE of IOC, and in co-operation with the Working Group on Satellites of the WMO/CBS,

2.3 IGOSS TELECOMMUNICATION ARRANGEMENTS

The specific goals for the period are to fully implement the use of satellite-based communications systems such as INMARSAT for the real-time collection of IGOSS data, to ensure that binary code forms such as the WMO Binary Universal Form for the Representation of meteorological data (BUFR) are filly adapted and applied for the exchange of IGOSS data, and to ensure that communication facilities such as Internet can be used to enhance international access to IGOSS data sets. These will be achieved through:

(i) Development and global implementation of appropriate transmission formats and protocols for the usc of INMARSAT and similar satellite-based telecommunication systems for the collection of IGOSS data and the transmission of IGOSS products to ships at sea;

(ii) Full adaptation of BUFR for the global transmission of all oceanographic data on the GTS, and its progressive implementation for IGOSS data exchange.

It is expected that it will be several years before the GTS is fully capable of carrying BUFR. As a solution to the still existing constraints, a flexible, table-driven code for Character Exchange (CREX) has been established to complement BUFR, and this code will be adapted and implemented for IGOSS data;

(iii) Connections to Internet will be encouraged and assisted, to provide universal access to IGOSS data and products by ships. oceanographic institutions and other sites. Ships will be able to automatically receive data from other ships. to forward these to appropriate centres for insertion onto the GTS, and to receive analyzed products in return.

2.4 IGOSS DATA PROCESSING AND SERVICES SYSTEM

Improvements to IDPSS will need to be made during 1996-2003 to provide the products and services required by operational and research users. Specific goals for the IDPSS during the period will be:

(i) The implementation of an end-to-end IGOSS data management structure, based on the existing GTSP, in direct co-operation with IODE and in co-ordination with the WWW data management;

(ii) The development and gradual introduction of an IGOSS Distributed Data Base (DDB) structure, linked to the WWW DDB, to enhance access by all countries to IGOSS data and products;

(iii) A general improvement in the range, coverage, quality and distribution of IGOSS products available through the WOCs, SOCs and NOCs.

These goals will be achieved. inter alia through the following activities:

(i) The WOCs will produce global sea-surface temperature maps with special emphasis on the incorporation of satellite data and develop global sub-surface temperature, salinity and density field analysis, In addition, these centres should consider the possibilities for global products of currents. sea-level and wave data and for integration of the data into operational models and products;

(ii) SOCs will produce regional real-time products (analyses and forecasts) for areas where sufficient data density is available such as for the North Atlantic Ocean and serve the needs of regional projects;

(iii) Each Member State will be further encouraged to establish a National Oceanographic Centre or National Meteorological Centre with corresponding functions for IGOSS or, where such a NOC/NMC does not exist. an appropriate SOC should be available to provide the required IGOSS services;

(iv) The IGOSS Sea Level Project will gradually expand to all ocean basins;

(v) Collaboration among IGOSS, IODE, CMM and CBS will increase through joint meetings, directed specifically towards more complete linkage of operational and non-operational oceanographic and meteorological data systems, through support for and expansion of the GTSP, and joint participation in a DDB structure:

(vi) IGOSS will co-operate with IODE and others to promote global connections to Internet, especially in developing countries, for universal access to real-time ocean data;

(vii) Guidelines will be expanded for the quality control of IGOSS data and procedures will be standardized among IGOSS centrcs using real-time quality control systems to eliminate errors before distributing the data via GTS;

(viii) Common standards will. where possible. be prepared for global sharing of ocean, climate and other data as part of GOOS, GCOS and GTOS. Agreement on formats among Member States will be required. particularly' as to implementation of the WMO binary formats for ocean observations. Standards should not. howecer, restrict potential advancements as technology changes;

(ix) The number of real-time IGOSS products will be expanded to provide more climate diagnostic charts, surface salinity products and surface current products. Priority will be given to improvement of forecasts of ocean features, Products required include:

a) global sca-surface topography using a composite of in-situ and satellite observations,

b) global ocean thermal mixed-la}cr depth using observations assimilated into a global model;

(x) Standard algorithms will be developed to ease the processing of operational data and to generate data sets of comparable quality for a more reliable interpretation of the data;

(xi) IGOSS products will be more widely distributed and efforts will be made to distribute them at sea in real-time; the IGOSS Products Bulletin will continue to be prepared and distributed on a regular basis, on a variety of media;

(xii) Improvements in local and regional forecasts and analyses resulting from availability of IGOSS data will be documented, and furthcr efforts will be made to document the economic benefits of IGOSS data and products;

(xiii) IGOSS will co-ordinate with CMM and others to encourage and assist the development of co-operative regional centres for the preparation and dissemination of regional oceanographic products.

(xiv) Sea ice is an important ocean variable for operations. research and global climate studies. IGOSS will therefore support the work of CMM in the collection and processing of sea-ice data and the preparation of sea-ice products.

2.5 SUPPORTING ELEMENTS OF IGOSS

Enhancement of IGOSS during 1996-2003 will require the introduction of new technological developments in all its components. i.e. observing, telecommunications, and data processing. To meet the increased needs for trained personnel and experts in such fields as automatic data processing, marine telecommunication, and maintenance of electronic equipment, specialized long-term training courses will need to be introduced at selected training institutes. In addition, training and equipment will need to be made available to developing countries, to enable them to participate fully in all aspects of IGOSS, while training and guidance will be required in the preparation and application of IGOSS data and products. These goals will be addressed during the period through:

(i) Enhancement in the application of the IOC-VCP and the WMO-VCP to IGOSS implementation. Member States must increase their support to the IOC-VCP and the IOC Secretariat should establish a more formalized management structure for co-ordinating assistance activities. The assistance to be provided to Member States will be based on the IGOSS development priorities contained in this Plan. as well as the potential local economic benefit to countries, e.g. fishing activities, from obtaining IGOSS products;

(ii) The IGOSS system will be well-publicized during this period with the distribution of literature describing IGOSS and other activities which expand visibility and promote Member States' involvement:

(iii) Enhanced monitoring of IGOSS data flow will be undertaken to facilitate the detection and correction of faults in the system and ensure the full availability of all data collected;

(iv) The existing set of IGOSS Manuals and Guides will be maintained and regularly updated. Information service bulletins covering aspects of IGOSS implementation and an IGOSS status report will be published annually by the Secretariats. Member States will assist, as required, in the preparation of these publications. The multilingual IGOSS Glossary will be completed and published:

(v) IGOSS will co-operate with CMM and others to encourage the implementation of specialized training courses directly related to IGOSS at selected existing universities and other training institutions:

Finally, the Joint IOC/WMO Working Committee for IGOSS will continue to meet every four years. Regular meetings (annual/biennial) will also occur of ship-of-opportunity programme managers and IGOSS/IODE representatives. Other experts meetings will be held as necessary and the IGOSS Bureau will meet as often as possible in order to keep abreast of new developments.

MAIN IOC AND WMO RESOLUTIONS RELATING TO IGOSS

IOC Res. **(dates of the session)**	WMO Res. **(dates of the session)**	Subject *(inter alia)*
V-20 (19-27 October 1967)		Establishment of a permanent IOC Working Committee for an Integrated Global Ocean Station System (IGOSS)
	17 (EC-XX) (30 May -13 June 1968)	Establishment of an Executive Committee Panel on Meteorological Aspects of Ocean Affairs (MAOA)
VI-7 (2-13 September 1969)	13 (EC-XXII) (8-16 October 1970)	Adoption of GPIP for Phase I of IGOSS
EC-V.12 (3-8 March 1975)	9 (EC-XXVII) (26-30 May 1975)	Establishment of the international exchange of BATHY/TESAC data on a permanent operational basis (beginning on 16 June 1975)
EC-VII.9 (21-26 June 1976)	6 (EC-XXVIII) (27 May -16 June 1976)	Adoption of GPIP 1977-1982
x-22 (27 Oct. -10 Nov. 1977)	8 (EC-XXIX) (26 May -15 June 1977) 6 (EC-XXX) (25 May -15 June 1978)	Establishment of the Joint IOC-WMO Working Committee for IGOSS
EC-X1.1 1 (26 Feb. -6 March 1979)	7 (EC-XXX) (28 May -1 June 1979)	RepollofIGOSS-I(18-27 September 1978)
EC-XIV.18 (22-27 June 1981)	6 (EC-XXXIII) (1-17 June 1981)	Report of IGOSS-II (20-29 October 1980), including: - adoption of GPIP 1982-1985 - "Integrated Global Ocean *Station* System" becomes "Integrated Global Ocean *Services* System"
EC-XVII.4 (31 Jan. -9 Feb. 1984)	12 (EC-XXXV) (30 May -2 June 1983)	Report of IGOSS-III (21 February -2 March 1983)
XIII-6 *(12-28* March 1985)	11 (Ec-XXXVII) (5-22 June 1985)	Approval of the *"accelerated implementation"* of IGOSS
EC-X1X.5 (6-12 March 1986)	15 (EC-XXXVIII) (2-13 June 1986)	Report ofIGOS+-IV(11 -20 November 1985), including the extension of validity of the IGOSS GPIP 1982-1985 up to the end of 1988
XV-7 (4-19 July 1989)	9 (EC-XLI) (5-17 June 1989)	Report ofIGOSS-V(14-23 November 1988), including the new PIP 1989-1995
EC-XXV.4 (10-18 March 1992)	7 (EC-XLIV) (22 June -4 July 1992)	Report of IGOSS-VI (18-27 November 1991)

Annex 2

EXAMPLES OF IGOSS OPERATIONAL programmes, PILOT PROJECTS AND RELATED ACTIVITIES

This Annex gives some examples of existing IGOSS operational programmes, pilot projects and related activities, as follows:

(i) The IGOSS Sub-surface Thermal Structure Programme (ISTP);

(ii) The IGOSS Task Team on Quality Control for Automated Systems (TT/QCAS);

(iii) The IGOSS Sea-level Programme in the Pacific (ISLP-Pac);

(iv) The IGOSS Pilot Project on Altimetric Sea-surface Topography Data (IPAST).

IGOSS Sub-surface Thermal Structure Programme (ISTP)

With the inception of the Tropical Ocean/Global Atmosphere (TOGA) Programme in 1985 and the World Ocean Circulation Experiment (WOCE) in 1990, both the university research community and governmental operational agencies have recognized the need for active scientific management of the global oceanographic database. At the same time, they have recognized that this is best conducted through collaboration between government and academic institutions. This has led to the establishment of the Joint Environmental Data Analysis (JEDA) Center at the Scripps Institution of Oceanography (SIO) in La Jolla CA, working in collaboration with the National Oceanographic Data Center (NODC) in Washington DC. The JEDA Center at SIO has been given responsibility for conducting scientific quality control on the global subsurface temperature observation set in delayed mode. This data management capability has been developed within the Global TemperatureSalinity Pilot Project (GTSPP) formed within the IGOSS-IODE consortium of operational and archival agencies.

The objective of the JEDA Center is to maintain the global subsurface temperature database in support of scientific research conducted within the TOGA and WOCE global change research programmes. This support consists of providing guidance concerning where subsurface temperature observations should be collected, actively seeking existing observations to insure their incorporation into the global database, and maintaining scientific quality control of the database to insure its utility for research purposes, The JEDA Center combines the capacity of NODC in locating, acquiring, and reformatting observations with SIO's proven abilities in providing quality control, objective analysis, and scientific investigation, An operational task of the JEDA Center is to generate operational products that aid scientists in understanding and predicting global climate change. Examples of these products are issued in the IGOSS Products Bulletin.

Within the JEDA Center concept, NODC acts as a focal point in the U.S.A. for the collection and collation of subsurface temperature observations made over the global ocean within the context of the Integrated Global Ocean Services System (IGOSS) Sub-surface Thermal Structure Programme (ISTP). These observations are relayed to NODC from the international consortium of national governmental operational agencies participating in the GTSPP. Each of these operational agencies transmits subsurface temperature observations daily to the Marine Environmental Data Service (MEDS) in Ontario, Canada. MEDS acts as the central clearing house for this global subsurface temperature observation base. At MEDS, these observations are reformatted, collated, and reviewed. The observations are then electronically forwarded via the Internet to NODC and to the JEDA Center at SIO during the first few days of each month. The JEDA Center provides scientific quality control on these observations, updates the quality-controlled subsurface temperature database, and constructs operational products.

The main task of the JEDA Center is to acquire, each year, all available delayed-mode subsurface temperature observations made two years hence. NODC actively pursues delayed-mode observations from a wide variety of national and international sources. The subsurface temperature observations are transmitted to the JEDA Center via the Internet and receive scientific quality control. These are returned to NODC via Internet for archival and for distribution to scientific and governmental user communities.

IGOSS Task Team **for Quality Control of Automated Systems (TT/QCAS)**

Noting the general concern expressed by the IGOSS community for the standardisation and improvement of the procedures to control the quality of IGOSS data, and noting further that the 2nd Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity programmes (Sidney, Canada, 5-8 August 1987) and the IGOSS Group of Experts on Operations and Technical Applications (OTA) at its frost session (Geneva, Switzerland, 30 November -4 December 1987) both envisaged to establish task teams to deal with the quality control of data obtained from automated observing systems, the Joint IOC-WMO Working Committee for IOSS decided at its 5th Session (Paris 14-23 November 1988) to establish a unique Task Team on Quality Control of Automated Systems (TT/CQAS) as a subsidiary body of the IGOSS OTA with the following terms of reference:

(i) to study both systematic and random error characteristics of each component of the automated systems in use such as:
- instrument error characteristics;
- system and software performance limitations; and
- algorithms used to calculate fall rates, temperatures at depth, etc;

(ii)) to recommend to the IGOSS OTA possible standards in equipment and software to be used for IGOSS purposes (particularly in the context of ship-to-shore communications);

(iii) to maintain a close working relationship with IODE experts in order to ensure consistency between IGOSS and IODE procedures in the field of quality control of data.

The Task Team primarily consists of, and relies on, scientists who are directly involved with the data collection and data management activities of large international research programmes such as the World Ocean Circulation Experiment (WOCE) and the Tropical Ocean Global Atmosphere (TOGA) Programme of the World Climate Research Programme (WCRP). This has proven to be a very successful combination, with considerable progress being achieved on such items as the determination and international implementation of correct fall rate equations for commonly used expendable bathythermographs (XBTs)(including preparation of a comprehensive paper for submission to a major scientific journal), instrument error characteristics (bowing problem, start of descent timing delay for some XBT recording systems), and scientific evaluations of new instrument developments such as the Sippican expendable conductivity temperature depth (XCTD) probe and Sparton XBTs. The TT/QCAS also works closely with the TOGA/WOCE XBT XCTD Progamme Planning Committee (TWXXPPC) in its activities.

IGOSS Sea-Level Programme in the Pacific (ISLP-Pac)

The IGOSS Sea Level Programme in the Pacific (ISLP-Pac) was begun as a pilot project in 1984 and provided an early, and very successful, example of operational oceanography. The ISLP-Pac provides monthly maps of the Pacific sea level deviations from the long-term mean as well as maps of the sea level anomalies from the long-term seasonal cycle that are corrected for atmospheric pressure anomalies. We also produce quarterly updates of an index of the tropical Pacific upper layer volume and annual updates of indices of the ridge-trough system and equatorial currents for the Pacific Ocean.

Since June 1984 monthly maps of the Pacific sea level topography have been produced without fail. At the end of each month we begin collecting monthly mean sea level values from 93 participating stations in over 30 countries throughout the Pacific basin. At the end of 1 month these values, which come in via telex, fax, telephone, and email, are subjected to as much quality control as possible and a map of the Pacific sea surface topography is generated. These maps are presently distributed by mail to users, including several national agencies that reproduce the maps and further distribute them. In addition, the maps are submitted to the Climate Analysis Center's bulletin and to the IGOSS Products Bulletin. The net result is that approximately five weeks after the end of a month, hundreds of users throughout the world have received an analysis of the state of the Pacific Ocean sea surface topography for that month.

We have also instituted an “anonymous ftp” system on the Internet computer network that allows users to log into one of our computers here at the UH and to obtain copies of files containing the most up to date versions of all of our IGOSS products, The Internet network is widely available throughout the United States, with connections to Europe, Asia, and Africa developing rapidly. The system typically responds within a few seconds and data transfer rates of 50 kilobytes per second are normal. By the time our maps are seen by a potential user, the digital data are available to be transferred for any additional calculations that are desired. Also, note that it is not only last month's data that are available, but the entire time series. All of the products discussed above are available for access by this method. The complete dataset is subjected to a detailed review on an annual basis.

A high priority is placed on the routine functioning of this activity. Obviously, an operational activity that does not function month in and month out without fail would be of questionable usefulness. However, the ISLP-Pac has also continued to evolve and improve each year. From the outset of the project to present, the number of stations has risen from 20 to 93 and the number of countries participating has risen from 11 to 33. During 1993, two stations have been included from Malaysia and two additional NOS stations have been added as well. There are several recently installed NOS stations in South and Central America (e.g., Naos Island and Diego Ramirez) that we will add in the coming years.

IGOSS Pilot Project on Altimetric Sea Surface Topography (IPAST)

The past year (1992-93) was the first time that two satellite altimeters have been simultaneously in operation. Topex/Poseidon completed its first year while ERS-1 ended its second year of problem-free observations. Data from both missions are being processed in near real-time at NOAA to generate the following analyses:

(i) ERS-1 Altimeter Pacific Sea Level Analysis, ERS-1 data are combined with Geosat altimeter data (using the met.hod of crossover differences) to derive sea level anomaly in the tropical Pacific relative to the l-year period, April 1985-86.

(ii) Blended ERS-1 Altimeter/Tide Gauge Analysis. Tide gauge data in the western half of the tropical Pacific are blended with the ERS-1 analysis above to yield an analysis that contains the best characteristics of each data set (the tide gauges provide large-scale accuracy, the altimetry provides complete spatial coverage).

(iii) Topex/Poseidon Altimeter Sea Level Analysis. The Topex/Poseidon data are being analysed as pure collinear differences because they are several times more accurate than either Geosat or ERS-1 data. These data are used to derive global sea level deviations and anomalies relative to the 1993 annual mean.

Each of the above analyses are published monthly in the NOAA Climate Diagnostics Bulletin and the IGOSS Products Bulletin. Because of the exceptional accuracy of the Topex data (5 cm absolute, **2** cm for monthly mean changes), a high-resolution, digital version of this global analysis is made available to the public via anonymous ftp.

Altimetric monitoring of global sea level should continue without interruption throughout the decade:

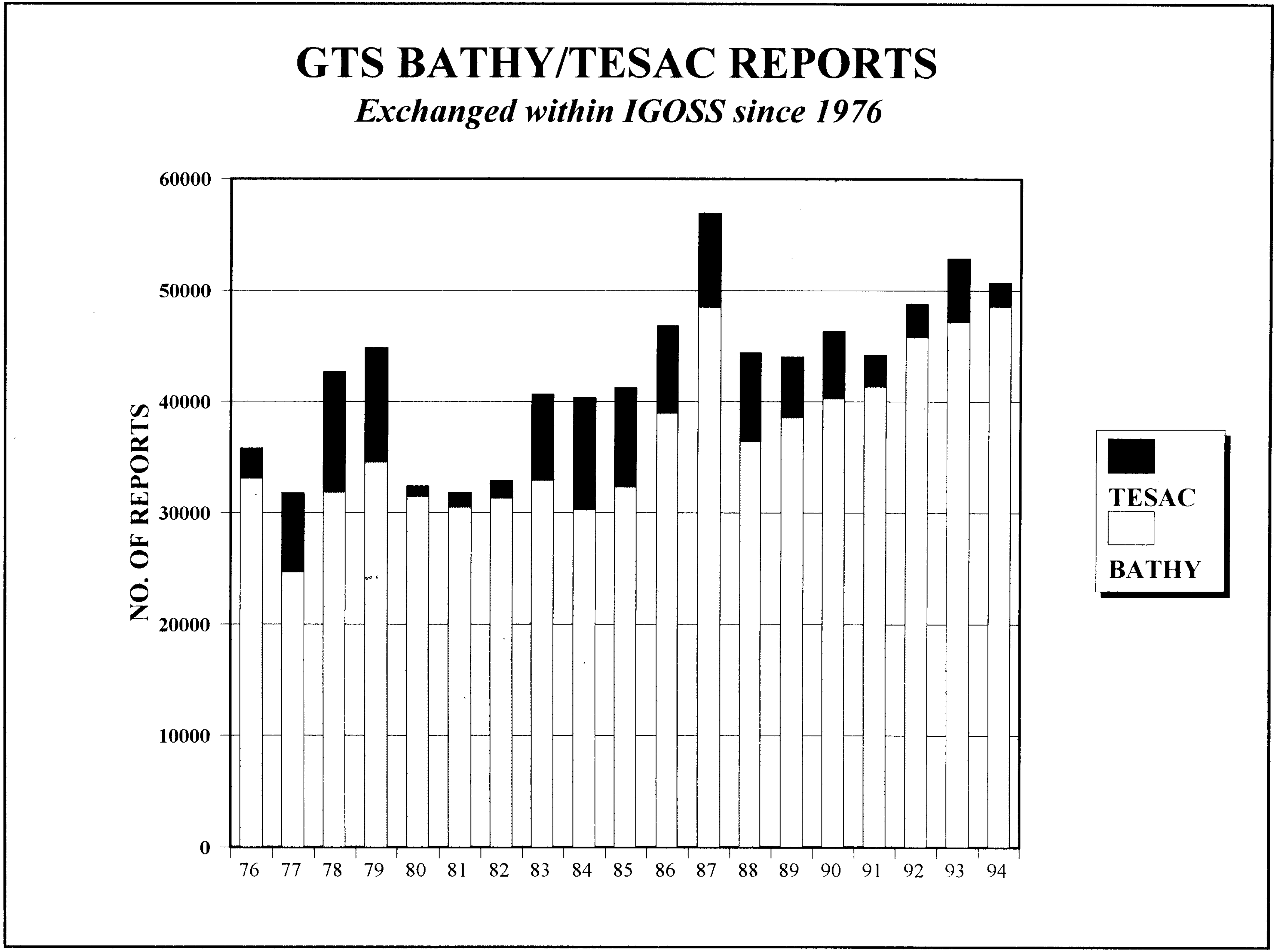
(i) It is anticipated that Topex/Poseidon will operate until 1997;

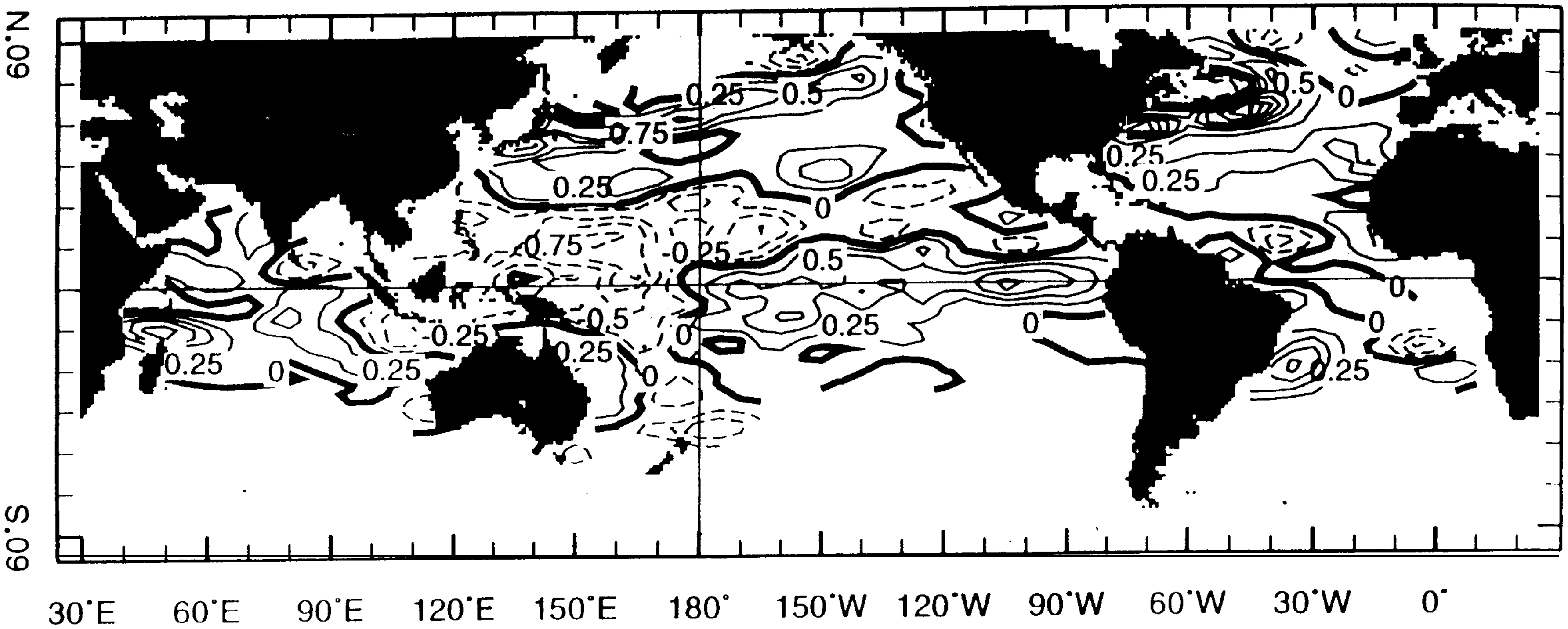
(ii) ERS-1 will be replaced by ERS-2 in 1995 which should extend to 1998;

(iii) The U.S. Navy will launch the Geosat Follow-On altimeter in 1996;

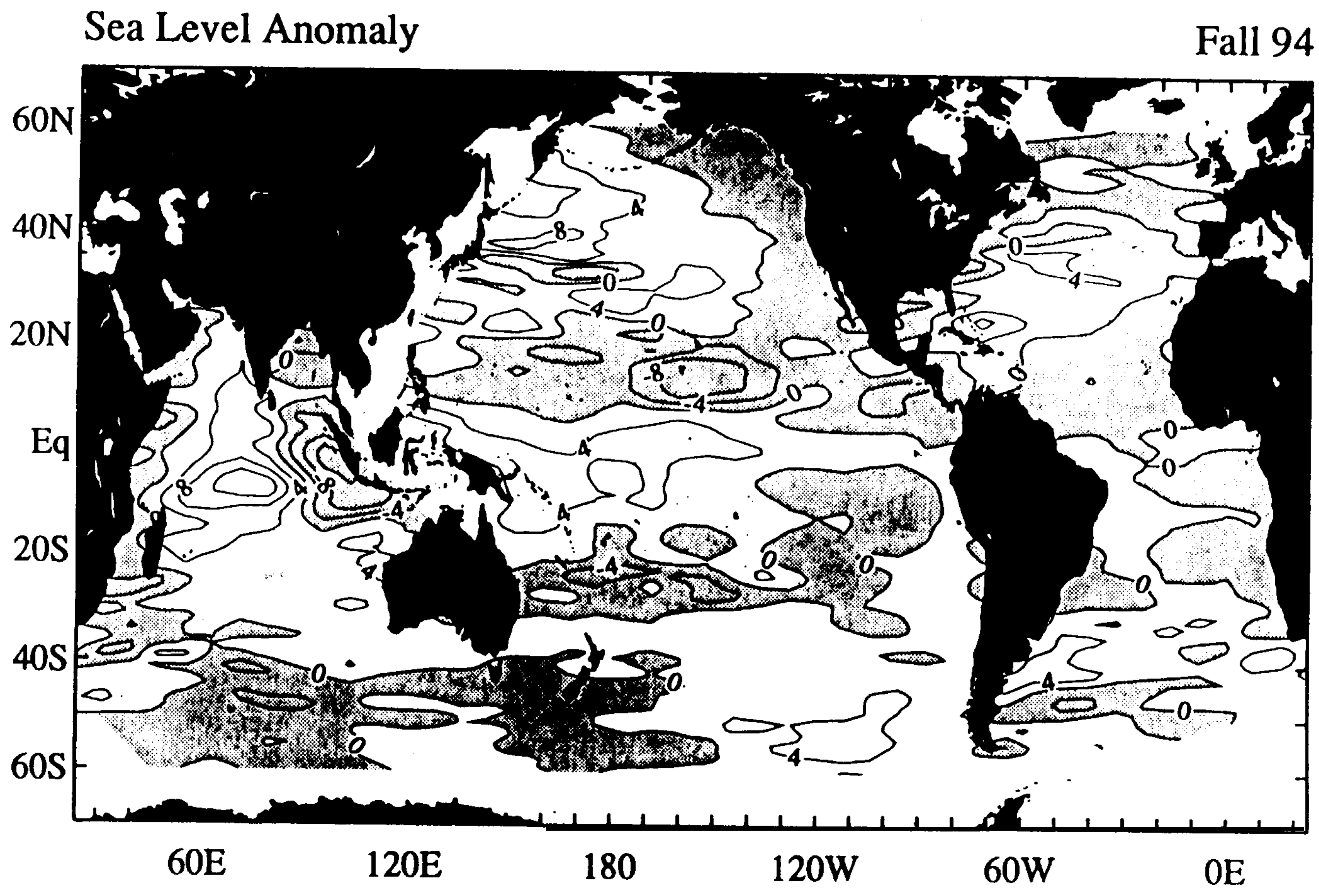
(iv) ESA will launch the Emisat altimeter in approximately”1 998.

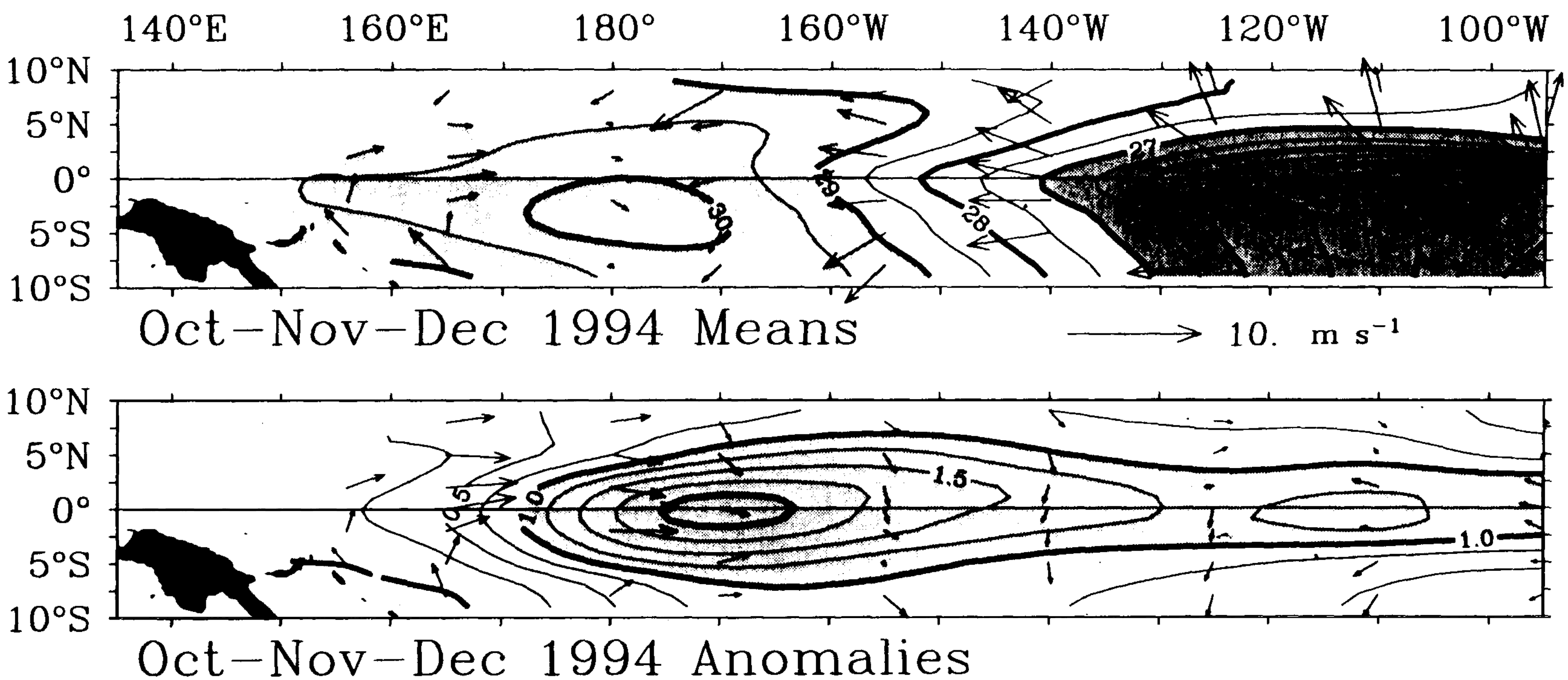
BATHY AND TESAC REPORTS EXCHANGED WITHIN IGOSS





HEAT STORAGE (0/400m) NOVEMBER-DECEMBER 1994


Sea Level Anomaly
Fall 94
60N
40N
20N
Eq
20S
40S
60S
60E
120E
180
120W
60W
0E



QUATERLY MEANS AND ANOMALIES OF SST AND WINDS, TAO ARRAY

Annex **5**

IGOSS-IODE DATA FLOW

The system shown in Figure 1 consists of an IGOSS and an IODE component. The system is complex. Data can enter the system and reach the user by a number of different routes. The route chosen by a particular user will be selected on the basis of a compromise between the urgency of the need and the quality and completeness of data needed to meet the requirement. If the data are required in a few days then only the telecommunicated data of IGOSS will be available and there may not be time to determine and apply the final most accurate instrument calibrations. On the other hand, if the data are not required for a few months or even a year or two, a higher quality and more complete dataset can be compiled.

The IGOSS component is based on an operational data flow using telecommunication facilities. This component contains in general data which have been transmitted via satellites or radio. The time-frame in which data and products are available extends from one day to one/two months. The operational dataset accumulated by the IGOSS SOCs is forwarded to the RNODCs-IGOSS at the end of each month.

The IODE component is based on a non-operational data flow. The IODE system deals with all types of oceanographic data including high resolution datasets from research cruises and monitoring exercises. IGOSS data enter the IODE system via two routes: an operational dataset is forwarded to the RNODCs-IGOSS at the end of each month; the original data accompanied by additional information are forwarded to national oceanographic agencies and then handled by IODE centres. The time-frame in which datasets and products are available from the IODE system ranges from two months, for simple datasets and products, to several months or years for complex integrated multi-disciplinary datasets from long-term variability studies. Further details on IODE mechanisms and procedures can be obtained from the *IOC-ICSU Manual on International Oceanographic Data Exchange, 1991 (IOC Manuals & Guides NO 9).*

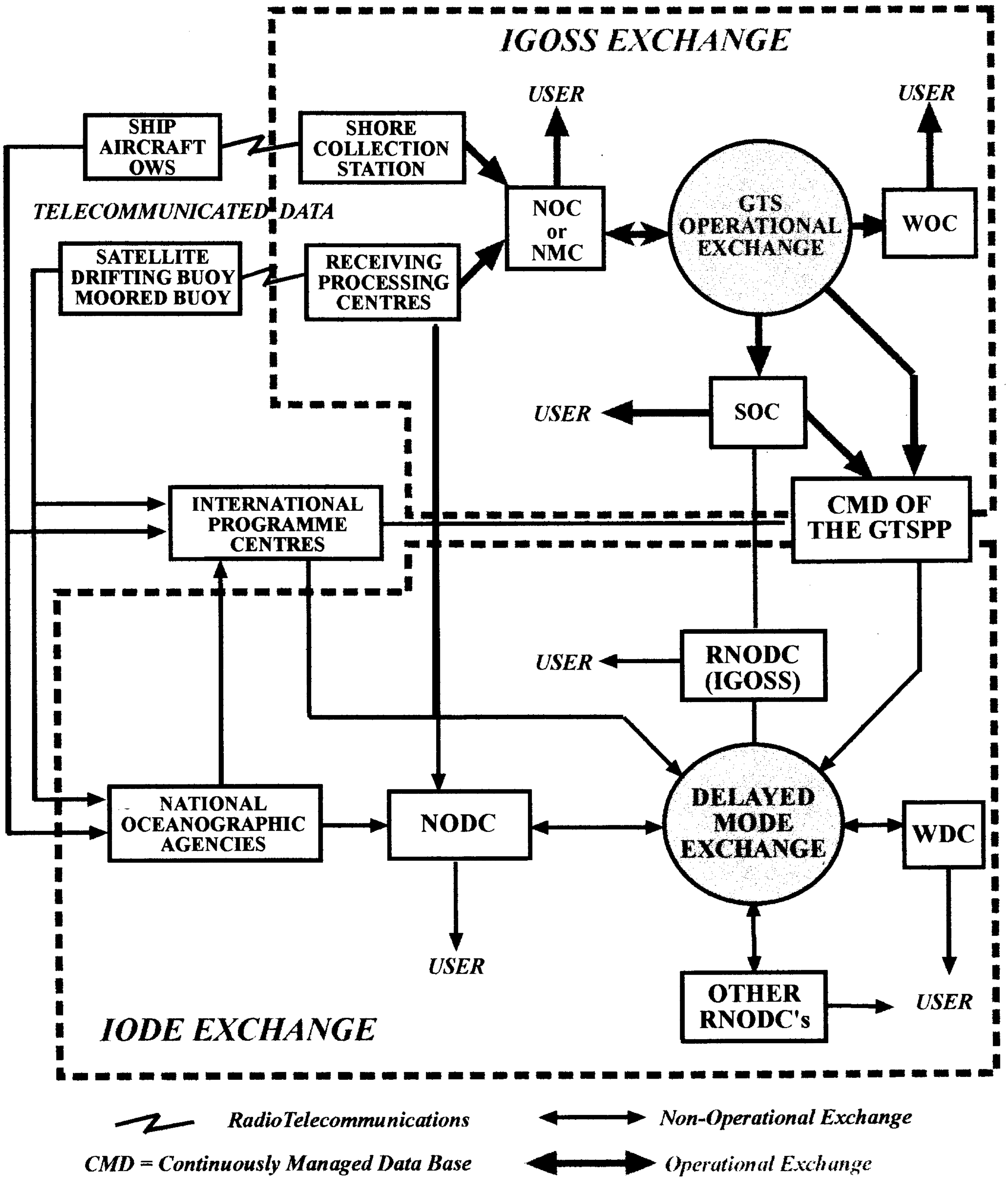
Another component of the IGOSS-IODE data management system is represented by the box *"INTERNATIONAL PROGRAMME CENTRES"* in Figure 1. This box shows data flows between IGOSS-IODE centres and centres established in other programmes. For example the Tropical Ocean and Global Atmosphere (TOGA) and World Ocean Circulation Experiment (WOCE) programmes established data centres in scientific organizations that perform functions complementary to the data management activities of IGOSS and IODE, particularly in regard to quality control of data. Thus complex systems can be built up that incorporate the strengths of IODE & IGOSS and the strengths of these other programme centres to provide the best possible and most economic data management.

As far as the IGOSS-IODE data flow is concerned, the essential point to keep in mind is therefore the following:

> The IGOSS operational datasets are forwarded by the IGOSS SOCs to the RNODCs-IGOSS in digital form on a monthly basis. It is the responsibility of the RNODCs-IGOSS to process the data and be prepared to make the data and data inventories available to users on request within one month following receipt of an operational dataset. This ensures that the data are available from the IODE system two months after the observation date.

IGOSS-IODE XBT/CTD DATA FLOW

(from IOC Manuals & Guides, Series 1, 1993)



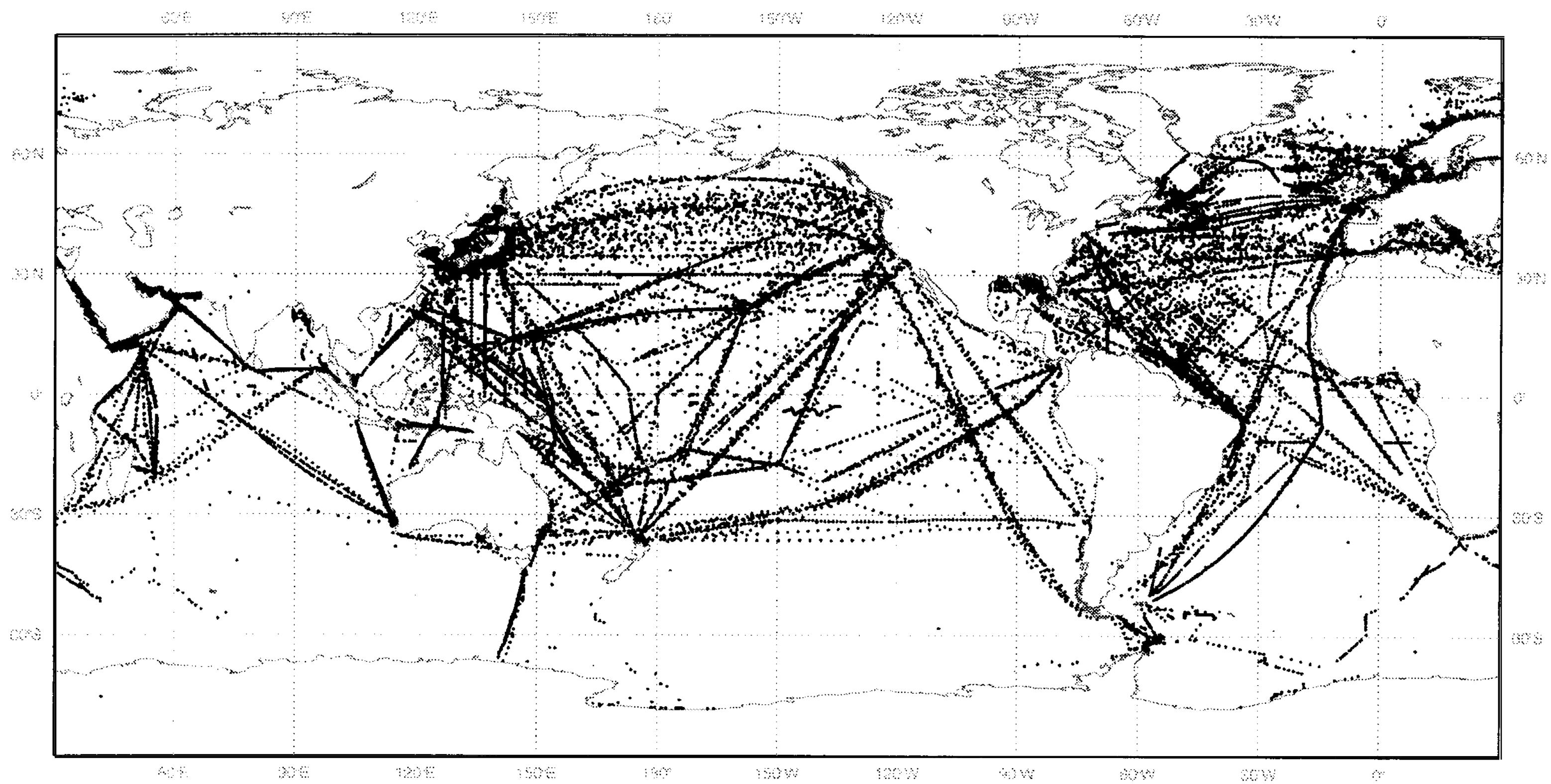
METEO FRANCE

METEO-FRANCE/SMISO   FRENCH MET OFFICE/IGOSS

Carte de pointage des observations recues en 1994

Mapping position plot chart of data received during 1994

Messages : BATHY   **Total : 54759**



MAGICS 4.2 Solaris - smiso - 4 May 1995 16:47:14

METEO FRANCE

METEO-FRANCE/SMISO

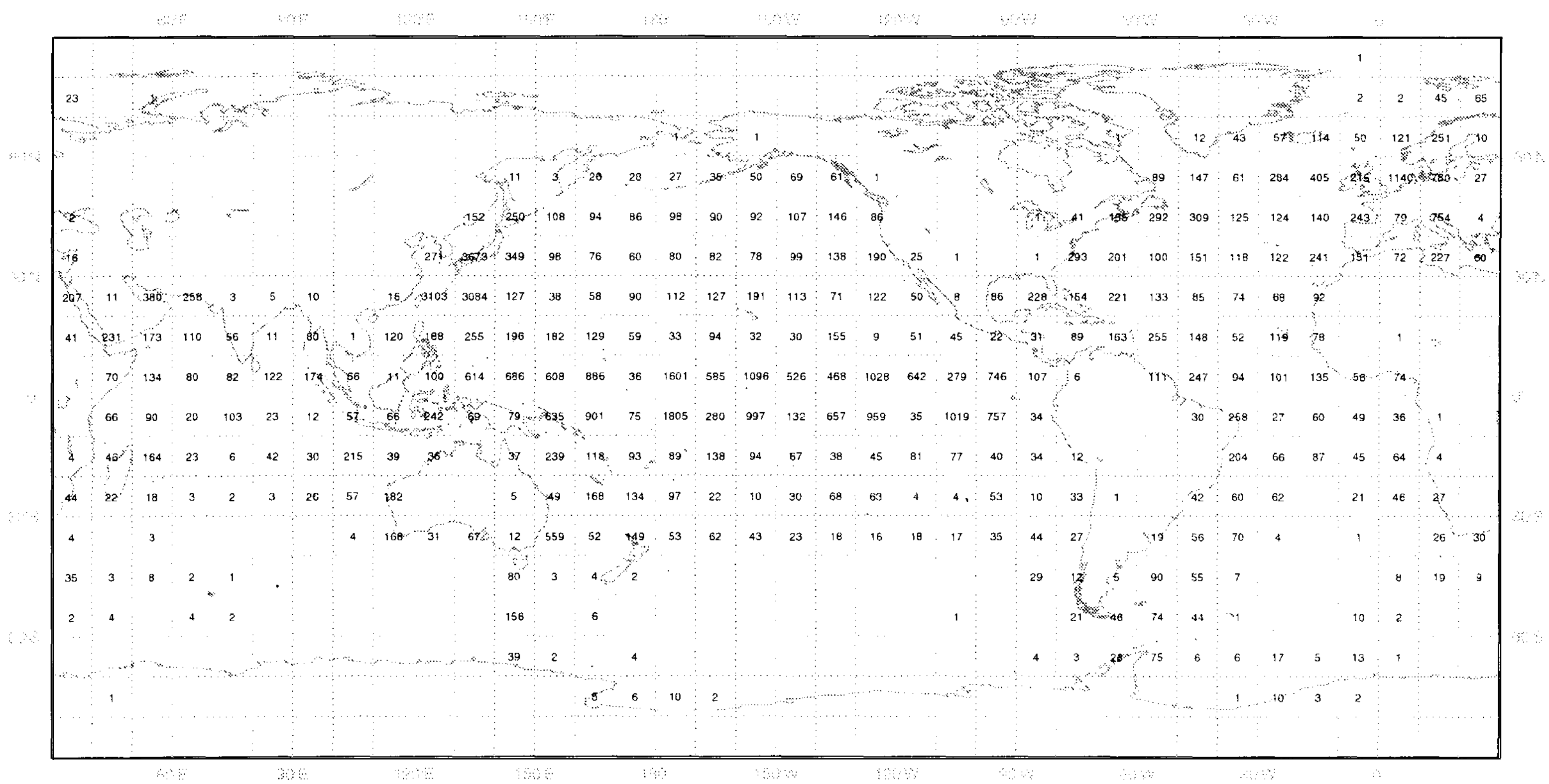
FRENCH MET OFFICE/IGOSS

Repartition par carre Marsden des observations recues en 1994

Marsden square distribution chart of data received during 1994

Messages : BATHY

Total : 54759



MAGICS 4.2 Solaris - smiso - 4 May 1995 16:47:38

METEO FRANCE

METEO-FRANCE/SMISO

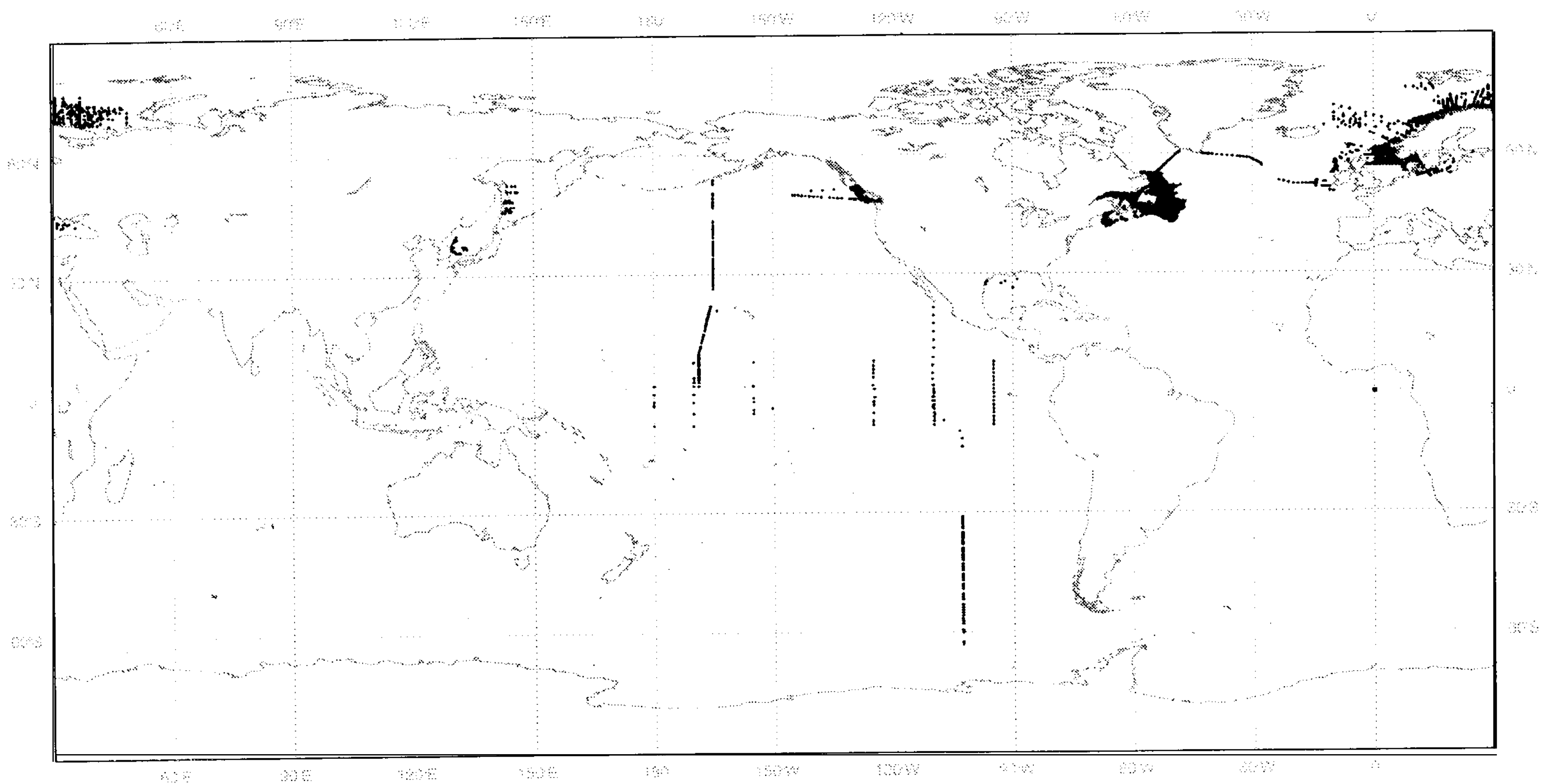
FRENCH MET OFFICE/IGOSS

Carte de pointage des observations recues en 1994

Mapping position plot chart of data received during 1994

Messages : TESAC

Total : 3873



MAGICS 4.2 Solaris - smiso - 4 May 1995 17:06:39

METEO FRANCE

METEO-FRANCE/SMISO

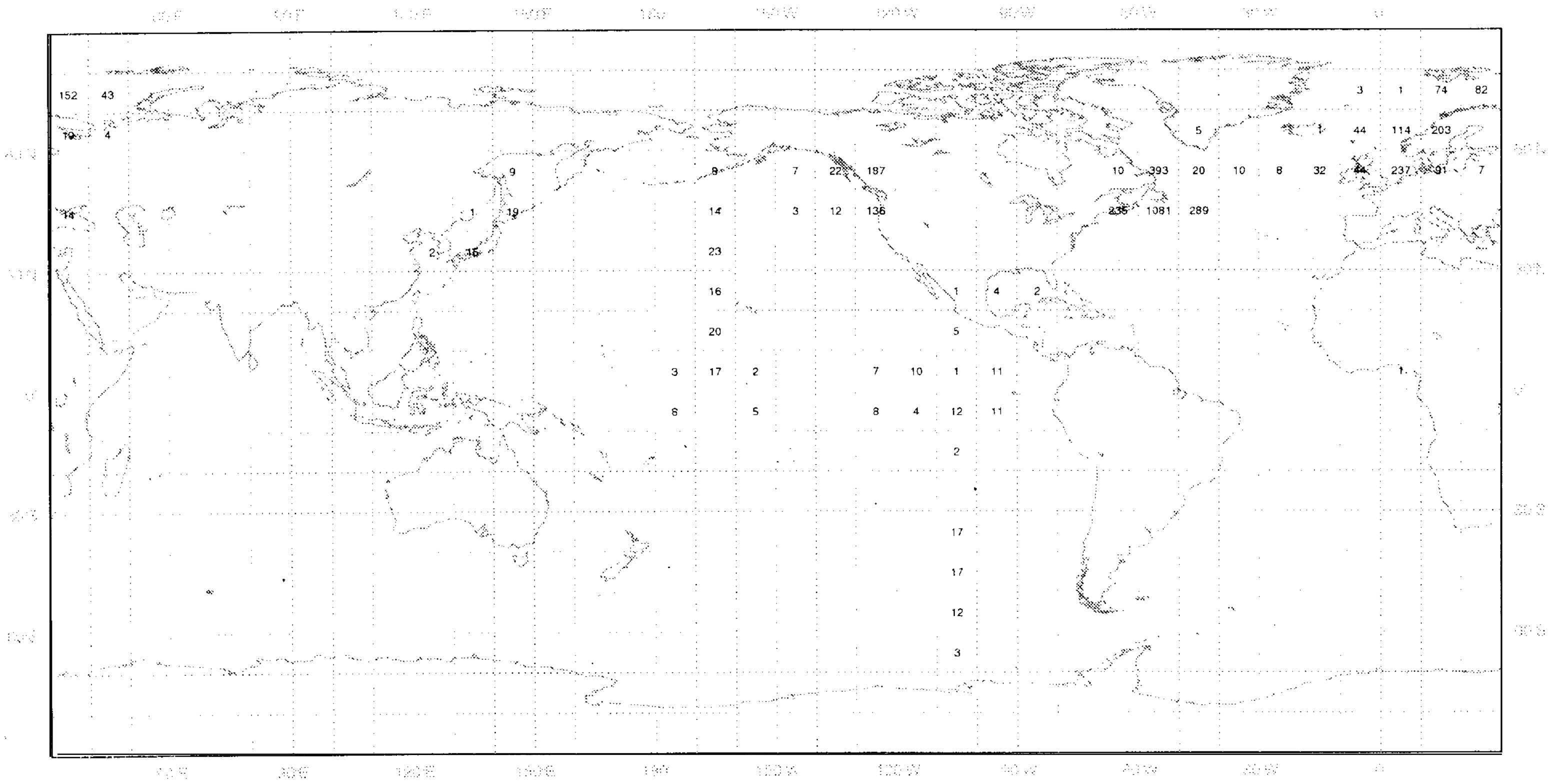
FRENCH MET OFFICE/IGOSS

Repartition par carre Marsden des observations recues en 1994

Marsden square distribution chart of data received during 1994

Messages : TESAC

Total : 3873



MAGICS 4.2 Solaris - smiso - 4 May 1995 17:06:47

EXISTING AND PROPOSED SATELLITE MISSIONS OF POTENTIAL INTEREST TO IGOSS UP TO 2013 (as on 1 January 1995)

Mission (Agency)	Status	Launch date/ Duration	Orbit details	Instruments	Primary application areas
LANDSAT 4 (NOAA)	In service	Ju1.1982 12 years 6 months	Near polar, sun synchr. crossing 0930 LST, 705 km, 99 rein, 16 days	MSS, TM	Land surface, earth resources
LANDSAT 5 (NOAA)	- id -	Mar. 1984 10 years 9 months	- id -	- id -	- id -
NOAA 9 (NOAA)	- id -	Dec. 1984 10 years	Polar, sun synchr., pm crossing, 850 km	Argos, AVHRR/2, ERBE, HIRS/2, MSU, S&R (NOAA), SBUV/2, SEM, SSU	Meteorology, climatology, physical oceanography, environmental monitoring, etc.
SPOT 1 (CNES)	- id -	Feb.1986 9 years	Sun synchr., 830 km> 101 rein, 26 days	HRV	Cartography, land surface, environmental monitoring, etc.
NOAA 10 (NOAA)	- id -	Sep.1986 8 years 3 months	Polar, sun synchr., am crossing, 820 km	Argos, AVHRR/2, ERBE, HIRS/2, MSU, S&R (NOAA), SEM	(see NOAA 9)
GOES 7 (NOAA)	- id -	Feb.1987 8 years	Geostationary	DCS, S&R (GOES), SEM, VAS, WEFAX	Meteorology, atmospheric dynamics, etc.
METEOSAT 3 (EUMETSAT)	- id -	Jun. 1988 6 years 6 months	- id -	MVIRI	Meteorology, climatology
NOAA 11 (NOAA)	- id -	Sep. 1988 6 years 3 months	Polar, sun synchr., pm crossing, 850 km	Argos, AVHRR/2, HIRS/2, MSU, SSU, S&R (NOAA), SBUV/2	(see NOAA 9)
METEOSAT 4 (EUMETSAT)	- id -	Mar. 1989 5 years 9 months	Geostationary	MVIRI	(see METEOSAT 3)
GMS 4 (NASDA)	- id -	Sep. 1989 5 years 3 months	- id -	VISSR (GMS4)	Meteorology
SPOT 2 (CNES)	- id -	Jan.1990 5 years	Sun synchr., 830 km, 101 rein, 26 days	DORIS, HRV	(see SPOT 1)
MOS lb (NASDA)	- id -	Feb.1990 5 years	Sun synchr., 909 km, 103 min, 17 days	DCS, MESSR, MSR, VTIR	Earth resources (ocean), etc.

Mission (Agency)	status	Launch date/ Duration	Orbit details	Instruments	Primary application areas.
METEOSAT 5 5EUMETSAT)	- id -	Mar, 1991 5 years	Geostationary	MVIRI	(see METEOSAT 3)
NOAA 12 (NOAA)	- id -	May 1991 3years 7 months	Polar, sun synchr., am crossing, 820 km	Argos, AVHRR/2, HIRS/2, MSU, SEM	(see NOAA 9)
ERS-1 (ESA)	- id -	Ju1.1991 3 years 6 months	Near circular, polar, sun synchr., 782-785krn, 100 min, 3 days, 35 days, 176 days	AMI - SAR image& wave & scatterometer modes, ATSR, RA	Earth resources, physical oceanography, ice & snow, meteorology, environmental monitoring, etc.
METEOR-3 N5 (Russia)	- id -	Aug. 1991 3 years 4 months	Near polar, 81-83°, 1200 km, 110 min	174-K, BUFS-2, Chaika, Klimat, MR-2000M, MR-900B, RMK-2, SFM-2, TOMS	Physical oceanography, atmospheric dynamics/water & energy cycles
UARS (NASA)	- id -	Sep. 1991 3 years 3 months	57° inclination, 600km, 97 min, 36 days	ACRIM II, CLAES, HALOE, HRDI, ISAMS, MLS (UARS), SOLSTICE, SUSIM, WINDII	Atmospheric chemistry & dynamics/water & energy cycles
INSAT IIa (ISRO)	- id -	Ju1.1992 7 years	Geostationary	BSS & FSS transponders, DRT-S&R, VHRR	Meteorology, data col. & comm., etc.
TOPEX/ POSEIDON (NASA/CNES)	- id -	Aug.1992 5 years	Non synchr., 66°, circular, 1336 km, 112 min, 10 days, ground track repeatability within 1 km	ALT, DORIS, GPSDR, LRA, SSALT, TMR	Physical oceanography, geodesy/gravity
INSAT IIb (ISRO)	Firm/ approved	Jul. 1993 7 Years	Geostationary	(see INSAT IIa)	(see INSAT IIa)
METEOR-2 N24 **(Russia)**	In service	Aug. 1993 1 year	82.5° inclination, 900 km, 102.5 min	174-K, Chaika, MR-2000, MR-900, RMK-2	(see METEOR-3 N5)
SPOT 3 (CNES)	- id -	Sep.1993 3 years	Sun synchr., 830 km, 101 min, 26 days	DORIS, HRV	(see SPOT 1)
METEOSAT 6 (EUMETSAT)	- id -	Nov.1993 5 years	Geostationary	MVIRI	(see METEOSAT 3)
Electro-GOMS N1 (Russia)	Firm/ approved	1994 2 years	Geostationary over 98°E	BRK, BTVK, RMS	Meteorology, atmospheric dynamics/water & energy cycles, etc.
FY-2 (China)	- id -	1994 3 years	Geostationary over 105°E	Multispectral Visible& IR Scan Radiometer (3 channels)	Meteorology & environmental monitoring, data coll. etc.

Mission (Agency)	Status	Launch date/ Duration	Orbit details	Instruments	Primary application areas
Resources-F1M series (Russia)	In service	1994	82.3° (1,2: near-circ., 3: ellip.), 1: 235 km, 2: 285 km, 3: 180-305 km, 89.16 rein, 14 days	KFA-1OOO, KFA- 200	Land surface, physical oceanography, geodesy/gravity
Resource-F2 series (Russia)	- id -	1994	82.3°, 240 km, 89.22 min, 16 days	MK-4	Land surface, physical oceanography
METEOR-3 N7 (Russia)	- id -	Jan.1994 2 years	Near polar, 81 -83°, 1200 km,110 min	174-K, ISP, Klimat, MR-2000M, MR-900B, PRARE, RMK-2, ScaRaB	(see METEOR-3 N5)
GOES I (NOAA)	- id -	Apr. 1994 5 years	Geostationary	DCS, IMAGER, S&R (GOES), SEM, SOUNDER, WEFAX	Meteorology
NOAA J (NOAA)	Firm/ approved	Nov. 1994 2 years 6 months	Near polar, sun synchr., am crossing, 850 km, 101.5 min	Argos, AVHRR/2, HIRS/2, MSU, S&R (NOAA), SBUV/2, SEM, SSU	(see NOAA 9)
ERS-2 (ESA)	- id -	Dec.1994 3 years	Sun synchr., 785 km	AMI - SAR image & wave & scatterometer modes, ATSR-2, GOME, PRARE, RA	(see ERS-1)
Ocean-01 (Russia)	- id -	Dec. 1994 1 year	Near polar 82.6°, 650 km, 98 min	KONDOR-2, MSU-M, MSU-S, RLSBO, RM-0.8	Land surface, physical oceanographv
PRIRODA (Russia)	- id -	1995 3 years	MIR space station, 51 .6°, 380-420 km	ALISSA, DOPI, Greben, IKAR-D, IKAR-P, ISTOK-1, MOMS-2P, MOS, MSU-E2, MSU-SK, Ozon-M, R-400, Travers SAR, TV camera	Physical oceanography, atmospheric dynamics/water & energy cycles, ice & snow, land surface
GMS 5 (NASDA)	- id -	Feb. 1995 5 years	Geostationary	VISSR (GMS5)	Meteorology
SeaStar (NASA)	- id -	Feb.1995 5 years	Polar, sun synchr., crossing 1200 h, descending, 705 km, 99 rein, 2 days	SeaWiFS	Ocean biology/ ocean colour, physical oceanography
RADARSAT (CSA)	- id -	Mar. 1995 5 years	Dawn-dusk, 98.6° inclination, ascending crossing 1800 h, 793-821 km, 7 & 17 days subcycles, 24 days	SAR	Environmental monitoring, physical oceanography, ice & snow, land surface
GOES J (NOAA)	- id -	Apr.1995 5 years	Geostationary	(see GOES I)	Meteorology
SICH-1 (NSAU)	- id -	Jul. 1995 1 year	82.5° inclination, 650 km, 98 min	(see Ocean-1)	Physical oceanography, hydrometeo.

Mission (Agency)	status	Launch date/ Duration	Orbit details	Instruments	Primary application areas
METEOR-3 N8 (Russia)	Proposed	1996 2 years	Near polar, 81 -83°, 1200 km, 110 min	174-k, ISP, Klimat, MIVZA, MR-2000M, MR-900b, RMK-2, ScaRaB	(see METEOR-3 N5)
Resource-02 (Russia)	- id -	- id -	Near polar; sun synchr., 98°, 670 km	MIVZA-M, MSU-E1 , MSU-SK	Land surface, physical oceanography
Resource-F2M series (Russia)	Firm/ approved	1996	82.3°, 240 km, 89.22 min, 16 days	MK-4M	- id -
ADEOS (NASDA)	- id -	Feb.1996 3 years	Sun synchr., 796,75 km, 100.92 min, 41 days	AVNIR, ILAS, IMG, NSCAT, OCTS, POLDER, RIS, TOMS	Physical oceanography, atmospheric dynamics/water & energy cycles, atmospheric chemistry
NOAA K (NOAA)	- id -	Jun. 1996 2 years 6 months	Near polar, sun synchr., pm crossing, 825-850 km	AMSU-A, AMSU-B, Argos, AVHRR/3, HIRS/3, S&R (NOAA), SBUV/2, SEM	Meteorology
METEOR-3M N1 (Russia)	Proposed	1997 3 years	Near polar, sun synchr., 98°, 900 km	174-K, BUFS-4, ISP, KGI-4, Klimat-2, MIVZA-M, MTZA, MZOAS, ScaRaB, TOMS	(see METEOR-3 N5)
NOAAL (NOAA)	Firm/ approved	May 1997 2 years 6 months	Near polar, sun synchr., am crossing, 825-850 km	AMSU-A, AMSU-B, Argos, AVHRR/3, HIRS/3, S&R (NOAA), SEM	Meteorology
METEOSAT 7 (EUMETSAT)	- id -	Jun. 1997 5 years	Geostationary	MVIRI	Meteorology, climatology
TRMM (NASA)	- id -	Aug. 1997 3 years	35° inclination, 350 km	CERES, LIS, PR, TMI, VIRS	Atmospheric dynamics/water & energy cycles
FY-lC (China)	Proposed	Sep.4997 1 year	Polar, sun synchr., 901 km	Multispectral visible & IR scan radiometer (10 channels)	Meteorology, environmental monitoring
ENVISAT 1 (ESA)	Firm/ approved	1998 5 years	Polar, 780-820 km, 100.59 rein, 35 days	AATSR, ASAR, DORIS, GOMOS, MERIS, MIPAS, MWR, RA-2, ScaRaB, SCIAMACHY	Physical oceanography, ice & snow, atmospheric dynamics/water & energy cycles
LANDSAT 7 (NASA)	- id -	1998 5 years	Polar, sun synchr., crossing 0945-1015h, 705 km, 98 min, 233 orbits/cycle, 16 days	ETM+	Land surface, earth resources

Mission (Agency)	status	Launch date/ Duration	Orbit details	Instruments	Primary application areas
METEOR-3M N2 (Russia)	Proposed	1998 3 years	Near polar, sun synchr., 98°, 900 km	(see METEOR-3 N5)	(see METEOR-3 N5)
TOPEX/ POSEIDON follow-on (CNES)	- id -	1998 3 years	Non synchr., 66°, 1336 km, 10 days	DORIS-NG, LRA, SSALT-2, TMR	Physical oceanography, geodesy/gravity
EOS-AM 1 NASA)	Firm/ approved	Jun. 1998 5 years	Polar sun, synchr., crossing 1030, descending, 705 km, 99 min, 16 days	ASTRE, CERES, MISR, MODIS, MOPITT	Atmospheric dynamics/water & energy cycles, etc.
EOS-COLOR (NASA)	- id -	Oct.1998 3 years	Near polar, sun synchr., crossing 1200, descending, 705 km, 99 min, 2 days	Ocean colour	Ocean biology, role of oceans in global carbon & biogeochemical cycles
METEOR-3M N3 (Russia)	Proposed	1999 3 years	Near polar, sun synchr., 98°, 900 km	(see METEOR-3 N5)	(see METEOR-3 N5)
ADEOS II (NASDA)	Firm/ approved	Feb. 1999 3 years	Circular, sun synchr. recurrent, approx 802.92 km, approx 101 min, 4 days (57 revisit)	AMSR, DCS, GLI, ILAS-2, POLDER, Sea Winds	Atmospheric dynamics/water & energy cycles, physical oceanography
GOES K (NOAA)	- id -	Apr. 1999 5 years	Geostationary	(see GOES 1)	Meteorology
NOAA M (NOAA)	- id -	Jun. 1999 2 years 6 months	Near polar, sun synchr., pm crossing, 825-850 km	(see NOAA K)	Meteorology
FY-lD (China)	Proposed	Sep.1999 1 year	Polar, sun synchr., 901 km	(see FY-lC)	(see FY-lC)
METEOR-3M N4 (Russia)	- id -	2000 3 years	Near polar, sun synchr., 98°, 900 km	(see METEOR-3 N5)	(see METEOR-3 N5)
METOP 1 (EUMETSAT)	- id -	2000 5 years	Polar, sun synchr., approx 800km	AATSR, AMSU-A, ASCAT, AVHRR/3, GOMI, HIRS/3, IASI, MHS, MIMR, ScaRaB, SEM	Meteorology, climatology
MSG 1 (EUMETSAT)	Firm/ approved	2000 6 years	Geostationary	GERBI, SEVIRI	Meteorology, climatology, atmospheric dynamics/water & energy cycles
NOAA N (NOAA)	- id -	2000 2 years 6 months	Near polar, sun synchr., 825-850 km	AMSU-A, Argos, AVHRR/3, HIRS/3, MHS, S&R (NOAA), SBUV/2, SEM	Meteorology

Mission (Agency)	Status	Launch date/ Duration	Orbit details	Instruments	Primary application areas
GOES L (NOAA)	- id -	Apr.2000 5 years	Geostationary	DCL, IMAGER, S&R (GOES), SEM, SOUNDER, SXI, WEFAX	Meteorology
EOS-PM 1 (NASA)	- id -	Dec.2001 5 years	Polar, sun synchr., crossing 1330, ascending, 705 km, 99 min	AIRS, AMSU, CERES, MIMR, MODIS	(see EOS-AM)
EOS-ALT 1 (NASA)	- id -	2002 5 years	Polar, sun synchr., 1300 km	DORIS, GLAS, SSALT, TMR	Physical oceanography, geodesy/gravity, ocean altimetry & circulation, ice sheet mass balance, etc.
MSG 2 (EUMETSAT)	- id -	2002 6 years	Geostationary	(see MSG 1)	(see MSG 1)
NOAA N' (NOAA)	- id -	2002 2 years 6 months	Near polar, sun synchr., pm crossing, 825-850 km	(see NOAA N)	Meteorology
ESA Future Missions (ESA)	Proposed	2003 10 years	Polar & possibly other LEOs	AATSR, ALADIN, AMSU-A, ASAR, ASCAT, ATLID, AVHRR/3, cloud radar, DORIS, GOMI, GOMOS, HIRS/3, IASI, MASTER, MERIS, MHS, MIMR, MIPAS, MWR, PRISM, RA-2, rain radar, ScaRaB, SCIAMACHY, SEM, SOPRANO	Physical oceanography, ice & snow, atmospheric dynamics/water & energy cycles, atmospheric chemistry, land surface
EOS-AM 2 (NASA)	Firm/ approved	Jun.2003 5 years	(see EOS-AM 1)	RES, EOSDP, MISR, MODIS, MOPITT, TES	(see EOS-AM 1)
First Converged Spacecraft (NOAA)	- id -	2004 5 years	Near polar, sun synchr, pm crossing, 825-850 km	AMSU-A, Argos, AVHRR/3, HIRS/3, MHS, S&R (NOAA), SBUV/3, SEM	Meteorology, climatology, environmental applications
GOES M (NOAA)	- id -	Apr.2004 5 years	Geostationary	DCS, IMAGER, S&R (GOES), SEM, SOUNDER, WEFAX	Meteorology
METOP 2 (EUMETSAT)	Proposed	2005 5 years	(see METOP 1)	(see METOP 1)	(see METOP 1)
MSG 3 (EUMETSAT)	Firm/ approved	2006 6 years	Geostationary	(see MSG 1)	(see MSG 1)
EOS-PM 2 (NASA)	- id -	Dec.2006 5 years	(see EOS-PM1)	(see EOS-PM1)	(see EOS-PM1)
EOS-ALT 2 (NASA)	- id -	2007 5 years	(see EOS-ALT1)	(see EOS-ALT 1)	(see EOS-ALT 1)

Mission (Agency)	Status	Launch date/ Duration	Orbit details	Instruments	Primary application areas
EOS-AM 3 (NASA)	- id -	Jun.2008 5 years	(see EOS-AM 1)	CERES, EOSP, MISR, MODIS, TES	(see EOS-AM 1)
EOS-PM 3 (NASA)	- id -	Dec.2011 5 years	(see EOS-PM 1)	(see EOS-PM 1)	(see EOS-PM 1)
EOS-ALT 3 (NASA)	- id -	2012 5 years	(see EOS-ALT 1)	(see EOS-ALT 1)	(see EOS-ALT 1)

LIST OF ACRONYMS AND ABBREVIATIONS

[Note: This list does not encompass all the acronyms used in Annex 7]

ADCP	Acoustic Doppler Current Profiler
ADEOS	Advanced Earth Observing Satellite (Japan)
AMI	Advanced Microwave Instrument
ASI	Italian Space Agency
AVHRR	Advanced Very High Resolution Radiometer
BATHY	Report of bathythermal observation (WMO code form FM 63-IX)
BUFR	Binary Universal Form for Representation of Meteorological Data (WMO binary code FM 9-LX)
BUOY	Report of a buoy observation (WMO code form FM 18-X)
CBS	Commission for Basic Systems
CD-ROM	Compact Disk with a Read-Only Memory
CEOS	Committee on Earth Observation Satellites
CGMS	Co-ordination on Geostationary Meteorological Satellites
CMM	Commission for Marine Meteorology
CNES	Centre National d'Etudes Spatiales (France)
CPPS	Permanent Commission for the South Pacific
CREX	Flexible, Table-driven Code for Character Exchange
CSA	Canadian Space Agency
CTD	Conducti\ih'-Tenlpcrahue-Depth probe
DARA	[German Space Agency]
DBCP	Data Buoy co-operation Panel
DCS	Data Collection System
DDB	Distributed Data Base
ECOR	Engineering Committee on Oceanic Resources
ENSO	El Niño and the Southern Oscillation
ERFEN	Regional Study of the Phenomenon known as 'El Niño'
ERS-1	European Remote Sensing Satellite
ESA	European Space Agency

EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
GCOS	Global Climate Observing System
GDPS	Global Data Processing System
GEF	Global Environment Facility
GF-3	General Format No 3
GLOSS	Global Sea-Level Observing System
GMDSS	Global Maritime Distress and Safety System
GODAR	Global Oceanographic Data Archaeology and Rescue Project
GOOS	Global Ocean Observing System
GOS	Global Observing System
GPS	Global Positioning System
GTOS	Global Terrestrial Observing System
GTS	Global Telecommunication System
GTSP	Global Temperature-Salinity Programme
HF	High Frequency
I-GOOS	IOC-WMO-UNEP Committee for GOOS
ICES	International Council for the Exploration of the Sea
ICSU	International Council of Scientific Unions
IDPSS	IGOSS Data-Processing and Services System
IGOSS	Integrated Global Ocean Services System
INMARSAT	International Maritime Satellite Organization
INPE	Brazilian Agency for Space Research
IOC	Intergovernmental Oceanographic Commission (of UNESCO)
IOCARIBE	IOC Sub-Commission for the Caribbean and Adjacent Regions
IODE	International Oceanographic Data and Information Exchange
IOS	IGOSS Observing System
IPB	IGOSS Products Bulletin
ISLP-Pac	IGOSS Sea-Level Programme in the Pacific
ISLPP-NTA	IGOSS Sea-Level Pilot Project In the North and Tropical Atlantic
ISRO	Indian Space Research Organization

ITA	IGOSS Telecommunication Arrangements
JSTC	Joint Scientific and Technical Committee (GCOS)
NASA	National Aeronautics and Space Administration (USA)
NASDA	National Space Development Agency (Japan)
NMC	National Meteorological Centre
NOAA	National Oceanic and Atmospheric Administration (USA)
NOC	National Oceanographic Centre
NODC	National Oceanographic Data Centre (IODE)
NSAU	[Ukrainian Space Agency]
NSCAT	NASA Advanced Scatterometer
OCTS	Ocean Colour and Temperature Scanner
ODAS	Ocean Data Acquisition Systems, Aids and Devices
PC	Personal Computer
PICES	North Pacific Marine Science Organization
POSEIDON	Altimetric Mission; Altimetry Research in Ocean Circulation (NASA-CNES) [full acronym: TOPEX-POSEIDON]
PSMSL	Permanent Service for Mean Sea-Level
RNODC	Responsible National Oceanographic Data Centre (IODE)
RTH	Regional Telecommunication Hub
SAR	Synthetic Aperture Radar
SCAR	Scientific Committee on Antarctic Research
SCOR	Scientific Committee on Oceanic Research
SEAWifs	Sea-Viewing, Wide-Field-of-View Sensor
SOC	Specialized Oceanographic Centre
SST	Sea Surface Temperature
TESAC	Temperature, Salinity and Currents Report from a Sea Station (WMO code form FM 64-IX)
TOGA	Tropical Ocean and Global Atmosphere
TOPEX	Ocean Topography Experiment
TRACKOB	Report of Marine Surface Observations along a Ship's Track (WMO code form FM 62-VIII Ext.)
UHF	Ultra-High Frequency

UN	United Nations
UNCED	United Nations Conference on Environment and Development (Rio de Janeiro, 1992)
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
VCP	Voluntary Co-operation Programme
VHF	Very High Frequency
VOS	Voluntary Observing Ship
WARC	World Administrative Radio Conference
WAVEOB	Report of Spectral Wave Information from a Sea Station or from a Remote Platform (aircraft or satellite) (WMO code form FM 65-IX)
WCASP	World Climate Applications and Services Programme
WCDMP	World Climate Data and Monitoring Programme
WCIRP	World Climate Impact Assessment and Response Strategies
WCP	World Climate Programme
WCRP	World Climate Research Programme
WESTPAC	IOC Sub-Commission for the Western Pacific
WMC	World Meteorological Centre
WMO	World Meteorological Organization
WOC	World Data Centre
WOCE	World Ocean Circulation Experiment
WWW	World Weather Watch
WWWDM	WWW Data Management
XBT	Expendable Bathythermograph
XCTD	Expendable conducti~rity'-temperahlre-dcpth probe

IOC Technical Series

No.	Title	Languages
1	**Manual on International Oceanographic Data Exchange**	(out of stock)
2	**Intergovernmental Oceanographic Commission** (Five years of work)	(out of stock)
3	Radio Communication Requirements of Oceanography	(out of stock)
4	Manual on International Oceanographic Data Exchange - Second revised edition	(out of stock)
5	Legal Problems Associated with Ocean Data Acquisition Systems (ODAS)	(out of stock)
6	Perspectives in Oceanography, 1968	(out of stock)
7	Comprehensive Outline of the Scope of the Long-term and Expanded Programme of Oceanic Exploration and Research	(out of stock)
8	IGOSS (Integrated Global Ocean Station System) – General Plan Implementation Programme for Phase 1	(out of stock)
9	Manual on International Oceanographic Data Exchange - Third Revised Edition	(out of stock)
10	Bruun Memorial Lectures, 1971	E, F, S, R
11	Bruun Memorial Lectures, 1973	(out of stock)
12	Oceanographic Products and Methods of Analysis and Prediction	E only
13	International Decade of Ocean Exploration (IDOE), 1971-1980	(out of stock)
14	A Comprehensive Plan for the Global Investigation of Pollution in the Marine Environment and Baseline Study Guidelines	E, F, S, R
15	Bruun Memorial Lectures, 1975- Co-operative Study of the Kuroshio and Adjacent Regions	(out of stock)
16	Integrated Ocean Global Station System (IGOSS) General Plan and Implementation Programme 1977-1982	E, F, S, R
17	Oceanographic Components of the Global Atmospheric Research Programme (GARP)	(out of stock)
18	Global Ocean Pollution: An Overview	(out of stock)
19	Bruun Memorial Lectures – The Importance and Application of Satellite and Remotely Sensed Data to Oceanography	(out of stock)
20	A Focus for Ocean Research: The Intergovernmental Oceanographic Commission - History, Functions, Achievements	(out of stock)
21	Bruun Memorial Lectures, 1979: Marine Environment and Ocean Resources	E, F, S, R

(continued on inside back cover)

No.	Title	Languages
22	Scientific Report of the Intercalibration Exercise of the IOC-WMO-UNEP Pilot Project on Monitoring Background Levels of Selected Pollutants in Open Ocean Waters	(out of stock)
23	Operational Sea-Level Stations	E, F, S, R
24	Time-Series of Ocean Measurements. Vol. 1	E, F, S, R
25	A Framework for the Implementation of the Comprehensive Plan for the Global Investigation of Pollution in the Marine Environment	(out of stock)
26	The Determination of Polychlorinated Biphenyls in Open-ocean Waters	E only
27	Ocean Observing System Development Programme	E, F, S, R
28	Bruun Memorial Lectures, 1982: ocean Science for the Year 2000	E, F, S, R
29	Catalogue of Tide Gauges in the Pacific	E only
30	Time-Series of Ocean Measurements. Vol. 2	E only
31	Time-Series of Ocean Measurements. Vol. 3	E only
32	Summary of Radiometric Ages from the Pacific	E only
33	Time-Series of Ocean Measurements. Vol. 4	E only
34	Bruun Memorial Lectures, 1987: Recent Advances in Selected Areas in the Regions of the Caribbean, Indian Ocean and the Western Pacific	Composite E, F, S
35	Global Sea-Level Observing System (GLOSS) Implementation Plan	E only
36	Bruun Memorial Lectures 1989: Impact of New Technology on Marine Scientific Research	Composite E, F, S
37	Tsunami Glossary – A Glossary of Terms and Acronyms Used in the Tsunami Literature	E only
38	The Oceans and Climate: A Guide to Present Needs	E only
39	Bruun Memorial Lectures, 1991: Modelling and Prediction in Marine Science	E only
40	Oceanic Interdecadal Climate Variability	E only
41	Marine Debris: Solid Waste Management Action for the Wider Caribbean	E only
42	Calculation of New Depth Equations for Expendable Bathymerographs Using a Temperature-Error-Free Method (Application to Sippican/TSK T-7, T-6 and T-4 XBTs)	E only
43	IGOSS Plan and Implementation Programme 1996-2003	E, F, S, R