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Panel on the History and Current Status of International Cooperation in the Atmospheric and Oceanic Sciences and Services

The Oceans (G.L. Holland, Panellist)

Introduction

I am no historian and I haven't researched the date when the first humans ventured out on the ocean, but I believe that it is fairly safe to say that international cooperation in ocean sciences and services is a relatively recent phenomenon. During the centuries when explorers and adventurers started to wander the ocean routes, information such as coastal maps, bathymetric charts, fishing grounds and the experience gained from knowledge of favourable winds and currents were of such commercial and economic importance that all were jealously guarded. Gradually, as trade became more multinational, the sharing of marine related knowledge became of mutual interest and cooperation began to take place in the preparation of navigational charts, tide tables etc. The exploration of the ocean depths was seen to be more of academic interest and serious exploration arrived only in the last 100 years or so. However developments in military technology, especially during the two world wars, led to an upsurge in the interest of ocean science and an awareness of the strategic importance of this knowledge for surface and subsurface ocean warfare, transportation and beach landings.

I will address international cooperation in ocean sciences and services from the period after the Second World War to the present. International cooperation in the ocean sciences covers many disciplines and many issues; but, for the most part, the paper will reflect my own views and observations of the development of cooperation between the ocean and atmospheric communities. In the same way as the World Meteorological Organization would be central to discussions of international cooperation in the atmospheric sciences, it will be no coincidence that the focus of my paper will be the establishment and progress of the Intergovernmental Oceanographic Commission of UNESCO.

The Intergovernmental Oceanographic Commission

It was the eighth session of UNESCO in 1950 that authorized the Director-General to promote the coordination of research on scientific problems relating to the oceans and marine biology. This initiative eventually led to the formation of an international advisory committee in 1955. Over the same time period, the International Council of Scientific Unions (ICSU) established a Special (later Scientific) Committee on Oceanic Research (SCOR). It was clear that cooperative efforts were needed to tackle ocean science projects, especially in areas where little regional capacity existed. The planning for one of the first major cooperative international ocean efforts, the Indian Ocean Expedition,

was begun in 1957 and co-sponsored by SCOR and UNESCO. In November of the following year, 1958, governments attending the UNESCO General Conference decided to convene an intergovernmental conference on oceanographic research.

The Intergovernmental Conference on Oceanic Research was held in Copenhagen, Denmark, in July, 1960. The principal recommendation was for an Intergovernmental Oceanographic Commission (IOC) to be established within the framework of UNESCO. A recommendation that was to be endorsed by Resolution at the UNESCO General Conference later the same year, together with approval of the initial Statutes and an Office of Oceanography to act as the IOC Secretariat. The justification for the birth of this new and valuable United Nations (UN) organization was based on the need for international cooperation in ocean research:

> *"The oceans, covering some 70 per cent of the Earth's surface, exert a profound influence on mankind and even on all forms of life on Earth ... In order to properly interpret the full value of the oceans to mankind, they must be studied from many points of view. While pioneering research and new ideas usually come from individuals and small groups, many aspects of oceanic investigations present far too formidable a task to be undertaken by any one nation or even a few nations."* (UNESCO, 1960).

The decision to place the new organization within UNESCO was undoubtedly due in part from the focus of the discussions on ocean research. Unlike its sister Specialized Agencies within the UN, the IOC did not have any immediate operational role and finding a home within UNESCO had many advantages for a fledgling science organization, providing a mature administrative base, wonderful meeting facilities and a good location. The IOC was however very different from other UNESCO science programs. It had its own autonomy, possessed its own statutes, ran its own elections and had its own Member States, nevertheless its personnel, regular budget and overall policy direction remained under the control of UNESCO.

The IOC met for the first time at the UNESCO Headquarters in Paris in October, 1961, over 100 years after the forerunner of the WMO, the International Meteorological Organization, was established in 1853. Although the emphasis of the discussions was on the societal benefits, the military implications of ocean science were still in the minds of governments and many delegations had naval representatives. For example the United States sent two Rear Admirals in their delegation of twenty eight, which also included two Senators. However, recognized international ocean scientists were also present in force, among them Roger Revelle (USA), Henry Lacombe and Jacques Cousteau (France), George Deacon (UK), K. Federov (USSR) and N. Pannikar (India). Anton Bruun from

Denmark was the first Chairman, although tragically he passed away only a few months later. The IOC secretary was Warren Wooster (USA), who also had played a large role in the Copenhagen Conference.

By the end of the first session, a total of forty states had become Member States of the Commission, with most of the scientifically advanced countries represented. Another factor, in terms of the importance of the establishment of a new UN organization for ocean science, was the participation of existing UN Organizations and other international and intergovernmental bodies with related interests. Many of these organizations would become important future partners for the IOC. UN Agency representatives attended from the International Atomic Energy Agency (IAEA), Food and Agriculture Organization (FAO), World Meteorological Organization (WMO), World Health Organization (WHO), Intergovernmental Maritime Consultative Organization (IMCO, later to be renamed the International Maritime Organization (IMO)) and the International Civil Aviation Organization (ICAO). In addition delegates attended from the International Council of Scientific Unions (ICSU), International Union of Geodesy and Geophysics (IUGG), International Association of Physical Oceanography (IAPO), Special Committee on Oceanic Research (SCOR), International Hydrographic Bureau (IHB) and the International Council for the Exploration of the Sea (ICES).

How was this new organization for ocean science received by the other intergovernmental and international bodies with interests in the marine field? Certainly there were jurisdictional concerns among the interested UN Agencies. To allay fears of any duplication in responsibilities, the Acting Director-General of UNESCO, M. René Maheu stressed, at the inaugural session, that it was not the responsibility of the IOC to examine problems in meteorology, fisheries and other areas that came under the responsibilities of existing UN Agencies, although he did instruct the Commission to cooperate closely with other institutions of the United Nations family, and all other competent intergovernmental and non-governmental organizations. SCOR and its engineering ocean science counterpart Engineering Council on Ocean Resources (ECOR) became advisory bodies to the IOC and have remained so, although SCOR has been far the more active of the two.

The establishment and first session of the IOC has a distinct place in the development of international cooperation in ocean science and services. The initial discussions highlighted many issues that would recur throughout the succeeding decades. It was obvious that many Member States were looking to the new organization as being more than a meeting place to discuss ocean research and to plan cooperative oceanographic experiments. From the first meeting onwards, the IOC demonstrated an interest to evolve from cooperative science research projects towards the use of ocean knowledge and information for collectively addressing national, regional and global problems initially in areas such as ocean observing systems, coastal management, ocean health and capacity-building and later in

ocean services in climate change. The Commission moved quickly to facilitate cooperation in common objectives of governments especially those dealing with standards and formats for ocean observations, and data archive and exchange.

As the mandate for the IOC expanded, it became obvious that its ability to assume a greater role in ocean science and services was limited by its size, visibility and lack resources and staff, certainly due in part to being a small subsidiary program within a much larger organization with a very different focus. The size of the IOC budget has remained at about one per cent of its parent organization.

The UN continued to be interested in ocean matters and a possibility to re-examine the situation arose a few years later, when, in December 1966, the UN General Assembly (UNGA) requested the Secretary-General to make proposals "*…to ensure the most effective arrangements for an expanded program of international cooperation, in terms of understanding the oceans and developing its resources*". These proposals were to be made in cooperation with FAO and UNESCO, in particular with UNESCO/IOC. The 1967 IOC Assembly considered this UN directive and a related report, entitled 'International Ocean Affairs' that had been prepared by its advisory bodies. The advisory bodies recommended that the Member States of the UN and its relevant Agencies give consideration to the establishment of a central intergovernmental oceanic organization to deal with all aspects of ocean investigation and the uses of the sea. The IOC Assembly, only a few years into its existence, wasn't prepared to challenge its status within UNESCO. The IOC Member States recognized the need for additional financial support, but concluded that a major change to the existing organizational arrangement was premature.

Another ocean resolution was passed by UNGA in 1968, endorsing the concept of a long-term and expanded program of oceanographic research. This resolution also urged Member States at the UN and relevant UN Agencies to agree, as a matter of urgency, to broaden the base of the IOC so as to enable it to formulate and coordinate such an expanded program. At the same session, the UN General Assembly welcomed the concept of an International Decade of Ocean Exploration (IDOE) and requested the IOC to coordinate this activity in cooperation with other organizations. Subsequently, the IOC Member States requested the Director-General of UNESCO to negotiate a formal basis of cooperation with other UN Specialized Agencies with interest in matters related to ocean science. The result of these negotiations was the establishment of a unique committee, called the Inter-Secretariat Committee on Scientific Programs Related to Oceanography (ICSPRO). It consisted of the Executive Heads of FAO, WMO and IMCO. Membership was open to other UN Agencies, and the UN Environment Program (UNEP) joined in 1972. The members of this high-level committee, chaired by the Director-General of UNESCO, agreed to support the IOC activities through cooperation, provision of staff and assistance with publications and meeting facilities. A staff member was seconded from FAO, WMO and IMCO to facilitate the cooperation. In

1974, approximately one-quarter of the IOC staff salaries and operational funds were provided by the ICSPRO Agencies. Unfortunately, by the mid-1970s, the financial constraints throughout the UN System became more apparent, and the ICSPRO arrangement faltered. Staff members were recalled to their parent organizations, with the one exception of the staff officer position from WMO. ICSPRO continued to meet into the 1990s, but the level of representation was not kept at the executive head level and although not formally disbanded, has fallen into disuse.

Many external forces would prove to have an influence upon the ocean community during the last fifty years and many of them directly linked to the development of international and intergovernmental cooperation in ocean sciences and services. The political recognition of the importance of the environment and its place alongside the economy and health in dealing with human development led to a series of global environmental Conferences. In 1972, the UN Conference on the Human Environment was held in Stockholm, Sweden, to draw attention to the planetary environment and the global issues that needed to be addressed by society. The oceans were not a large part of the agenda, but one of the Working Groups set up in preparation for the Conference was a Working Group on Monitoring and Surveillance, chaired by Richard Hallgren. Several recommendations focused on ocean pollution and the Conference requested the IOC to create a program for the investigation of pollution in the marine environment.

In 1992, the second global conference on the environment was held in Rio de Janeiro, Brazil – the UN Conference on the Environment and Development (UNCED). This was an historic meeting, which would influence the evolution of most international environmental programs over the succeeding years. In Rio, the oceans were to have more prominence. The conference produced Agenda 21, an environmental program, which included a chapter (Chapter 17) specifically dealing with oceans. In particular it was proposed that an integrated and comprehensive global ocean observing and information system be created to provide the information needed for oceanic and atmospheric forecasting, for ocean and coastal zone management by coastal nations, and for global environmental change research. The influence of Agenda 21 on the IOC and on other UN organizations concerned with the environment was substantial.

The latest global conference was the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg, which reviewed progress in the implementation of Agenda 21. The WSSD endorsed the work taking place on climate and observation and underlined the need for collaboration and cooperation in planetary issues.

Another huge change in ocean affairs that has had significant impact on the programs and policies of the IOC was the coming into force of the UN Convention on the Law of the Sea in 1994. Negotiations began in earnest with the third UN Conference on the Law of the Sea, held in Caracas (Venezuela) in 1974. Despite the enormity of the task, governments

reached agreement on the greater part of the text in Caracas, although the final Articles on seabed resources were to take several more years of negotiations. Many of the Articles that concerned the IOC, however, were already in their final form, for example those on scientific research, marine pollution and technology transfer. The IOC is recognized within the Law of the Sea Articles as a 'competent international body'. The legal regime laid out in UNCLOS is of importance in the conduct of scientific research and observations, jurisdictional issues and national responsibilities. To date, most attention has been focused on seabed resources and Articles dealing with responsibilities on the transfer of technology and capacity building have been largely ignored.

The Early Years in the Development of Ocean Services

In terms of the expansion of international cooperation in the ocean and atmosphere sciences, the next big challenge came as the ocean community started to turn its attention to real-time observations and the related information services that could follow. By the mid-sixties, the IOC had established a Working Committee called the Integrated Global Ocean Stations System (IGOSS), formed initially to protect frequency channels for communicating ocean data from moored and drifting buoys. At the same time there was a growing appreciation of the importance of ocean data to improve marine forecasts and extend weather predictions. The more sophisticated models for weather forecasting needed information on ocean–atmosphere exchanges, and longer-term forecasts needed data on the heat content of the ocean surface layers. The WMO had an Executive Committee Panel of Meteorological ~~Marine~~ Aspects of Ocean Affairs (MAOA) and, by 1970, these two bodies were holding mutual planning meetings. Initially, the two communities were very hesitant to work together, and the Secretariats in the two organizations were quite jealous of their respective mandates and responsibilities. Nevertheless the cooperation proceeded slowly. ~~IGOSS recognizing the need for operational ocean data, kept its acronym, but changed its name to the Integrated Global Ocean Services System.~~ In 1977, IGOSS became a joint IOC-WMO Working Committee.

One great benefit for the IOC was the possibility of using the WMO Global Telecommunications System (GTS) for the distribution of data in real-time. A similar framework did not exist for ocean data. The shipping and fishing industries relied on atmospheric marine weather services, and the only large users of real-time subsurface data were the military, who were not anxious to share their data. The negotiations between the IOC and WMO representatives, regarding placing ocean data on the GTS, proved to be a difficult task. Objections were voiced on both sides of the table and arose from quite separate concerns.

The meteorological community and its weather services depended on an operational system of regular data collection and distribution. There was no such parallel system in the

oceanographic community. Funding of civilian ocean observations came almost entirely from the research budgets of scientists and many were afraid that the on-going costs for an ocean data collection and distribution system would erode research budgets and reduce the flexibility of generating new projects. There was a second reason for concern. For years ocean researchers had been responsible for their own observations. The difficulties associated with collecting subsurface data in an often hostile environment had led to the need for painstaking quality control, most often by the researchers themselves. Data then being withheld from others until research findings had been compiled and published. The hoarding of data was a problem to the sharing of achieved ocean data and now the suggestions for exchanging data in real-time presented an even bigger challenge.

Opponents on the atmospheric side had much different reservations. They were concerned that the GTS, which was not without its own technical challenges, could become further congested with the addition of ocean data. The temperatures versus depth (BATHY) data were the first to be considered and there was a difference between the two communities in the interpretation of "real-time". In this period, the collection of ocean data was still slow and often not available for exchange until vessels reached port. Incidentally, an associated part of this international cooperation was the use of the WMO port officer network to collect ocean data from research vessels and to submit them to the GTS. The unavoidable delay made it necessary to define real-time, for ocean data, as data transmitted within thirty days of observation. For the ocean community, the GTS service represented a huge step forward in terms of data availability. BATHY data were mostly associated with studies of large scale ocean processes and still timely after thirty days, relative to the ocean timescales involved.

Obviously the numbers of observations were small in the early years, but gradually increased over the years, also expanding to include temperature and salinity (TESAC) profiles. By the mid-1980s, the name of IGOSS was changed to the Integrated Global Ocean Services System, retaining its acronym but reflecting its growing maturity.

The Further Development of Ocean Services

By the 1980's there were many activities within the IOC that were contributing to a growing suite of ocean services, however a consensus was emerging that a more ambitious and comprehensive approach was needed. A Technical Committee on Ocean Processes and Climate (C/OPC), under the chairmanship of James Baker (USA), considered that understanding and forecasting climate change would require the existence of an ocean observing system similar to the World Weather Watch system that underpinned weather forecasting. In 1988, this vision for the future was presented to the twenty first IOC Executive Council. Additional support was received from the Second World Climate Conference, which identified the need to establish a Global Ocean Observing System as the ocean component of the proposed Global Climate Observing System.

In 1988 the IOC created an ad hoc expert group to prepare proposals for the development of an integrated global ocean observing system leading to a World Ocean Watch. In 1989 the WMO and the IOC endorsed a program to design and implement a global operational observing system and, at the sixteenth IOC Assembly (1991), governments decided to undertake the development of a Global Ocean Observing System (GOOS), broadened to include physical, chemical, biological and coastal ocean monitoring. The decision recognized that the IOC sea level program GLOSS and IGOSS were fundamental building blocks of GOOS, which of course also included the climate observations needed by GCOS. In the same year the World Meteorological Organization's 11th Congress agreed to be a co-sponsor. The Assembly agreed that GOOS would be a highly complex and sophisticated undertaking and its establishment of GOOS was considered to represent a 'new era in oceanography'. In 1992, an intergovernmental committee for GOOS (I-GOOS) was formed to coordinate the implementation of GOOS and a Scientific Advisory Panel, later to become the GOOS Scientific Steering Committee, was proposed the same year. By 1998 a GOOS strategic plan and prospectus had been published. Individual Member States would benefit from sharing data and information from existing national systems and could cooperate in the development of regional GOOS associations.

Following the instructions to build on existing systems, GOOS promoted the development of regional GOOS organizations. In Europe, the establishment of a EuroGOOS was spearheading the involvement of governments and industry in the provision of regional ocean services, while, on a smaller scale, the North-East Asia Regional GOOS (NEAR-GOOS) was also making progress. These successes spawned interest in other regions of the world and a large number of regional programs now exist or are in an advanced state of planning.

On the global scale GOOS continues to be the ocean observing arm of GCOS and GCOS itself is the climate component of the Global Earth Observation System of Systems (GEOSS). To complete the cycle, the Assembly of the IOC in 2005 noted that GOOS should be considered as the marine component of GEOSS.

The obvious synergy between the IOC ocean services developments under GOOS and the climate and atmospheric services programs under WMO led to a closer association of the two organizations. In 1999, the governing bodies of the two organizations, recognizing the increasing demand for integrated marine meteorological and oceanographic data and services, and the efficiencies achieved by combining the expertise and technological capabilities of the WMO and IOC systems, decided to establish the WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM).

JCOMM is an intergovernmental body of experts providing the international, intergovernmental coordination, regulation and management mechanism for an operational oceanographic and marine meteorological observing, data management and services system. Thus

the marine meteorological and oceanographic observations, data management and service provision programs, previously managed separately by the WMO and IOC were coordinated internationally by a joint decision of their respective Member States in 1999.

One other collaborative achievement that has been especially pleasing has been the collaboration between the ocean and marine meteorological data programs. The Data Management Program Area (DMPA) of JCOMM works closely with the International Oceanographic Data and Information Exchange (IODE). The primary objective of DMPA is to implement and maintain a fully integrated end-to-end data management system across the entire marine meteorology and oceanographic community. Additionally the program area offers its expertise to assist other groups to specify and implement their own data management requirements.

Weather and Climate

It is impossible to separate the physical processes governing the atmosphere and the oceans. Oceanographers and atmospheric scientists are now well aware of the need to work together on weather and climate issues. The IOC recognized the importance of this from early in its existence and in 1965, established a Working Group on Ocean–Atmosphere Interaction. The need to involve the meteorological community was soon recognized and in 1967 the working group was dissolved in order to negotiate collaborative arrangements with the WMO. The result was a collaborative Panel on Ocean–Atmospheric Interaction, within the framework of the Global Atmospheric Research Program (GARP), co-sponsored by the IOC, WMO and the International Council of Scientific Unions (ICSU). The relationship between the IOC and WMO in terms of ocean observations (discussed above) was recognized as an integral part of this collaboration.

The IOC agreed to arrange for oceanographic participation in the GARP Atlantic Tropical Experiment (GATE) in cooperation with its scientific advisory body, SCOR. GATE was successfully carried out in the summer and autumn of 1974, with the participation of about forty research vessels, and large numbers of buoys, moorings and aircraft. This initial success was followed by an observational phase of the First GARP Global Experiment (FGGE), extending from December 1978 to November 1979. Again the IOC and SCOR agreed to provide the scientific guidance and IGOSS was used to manage the real time ocean data flow. The global experiment resulted in a large increase in the number of ocean messages exchanged, and further demonstrated the usefulness of the collection and availability of real time ocean data.

In 1979, recognizing the importance of the ocean's role in global climate change, IOC and SCOR formed the Committee on Climate Change and the Ocean (CCCO), with one of the pioneers of global warming studies, Roger Revelle, as its chairman. The CCCO was to provide significant guidance to the Commission as its climate-related programs evolved over the next few years, of course in cooperation with the

meteorological community. In 1980, WMO organized an intergovernmental and interagency planning meeting on the World Climate Program and established the World Climate Research Program (WCRP).

The need for large-scale ocean experiments to complement the programs of the WCRP was the subject of an intergovernmental conference in Tokyo, which recommended, *inter alia*, two major programs: the Tropical Oceans and Global Atmosphere (TOGA) program and the World Ocean Circulation Experiment (WOCE), with the IOC being a major sponsor. TOGA (1985–95) would be the forerunner to the development of the monitoring program for the prediction of the El Niño and its recognition as a driver of the seasonal global climate. The TOGA Working Committee was made up of scientists and managers from governments and universities representing both the atmospheric and ocean disciplines. WOCE (1990–97) would be the largest ocean experiment ever seen, involving the efforts of thirty countries, and yielding a data set essential for climate research.

In 1990, the CCCO, together with the WCRP, established an Ocean Observation System Development Panel (OOSDP) to develop the scientific basis for an ocean observing system for climate. The GCOS Steering Committee incorporated the recommendations of the OOSDP report into GCOS plans as the ocean component of GCOS, and agreed to implement the system in cooperation with the Global Ocean Observing System (GOOS). The current sustained global ocean observing system for climate is both the global component of GOOS and the ocean component of GCOS**.** The OOSDP was disbanded once it completed its comprehensive design for an Ocean Observing System for Climate, which was published in March 1995.

The follow-up work to the OOSDP report was continued by a new group, the Ocean Observations Panel for Climate (OOPC), which is a scientific expert advisory group, charged with making recommendations for a sustained global ocean observing system for climate in support of the goals of its sponsors, namely the programs WCRP, GCOS and GOOS. These programs in turn are the responsibility of the intergovernmental organizations of the IOC/UNESCO, WMO and UNEP together with ICSU. The mandate of the OOPC includes recommendations for phased implementation. The Panel also aids in the development of strategies for evaluation and evolution of the system and of its recommendations, and supports global ocean observing activities by interested parties through liaison and advocacy for the agreed observing plans.

The OOPC first met in 1996 and by this time, in fact in 1993, the IOC had joined the WMO and ICSU as a sponsor of the WCRP. The IOC was invited to be represented on the Joint Steering Committee (JSC) and the CCCO had been replaced by this more cooperative approach. International cooperation is essential if governments are to address global issues effectively. The WCRP encompasses studies of the global atmosphere, oceans, sea and land ice, and the land surface and requires the comprehensive effort of scientists from all disciplines.

The OOPC and the JCOMM Observations Programme Area have identified a need to develop tools for system evaluation of the sustained global ocean observing system. Eventually, an important tool for this evaluation will be the use of ocean forecast models and reanalysis models in Observing System Experiments (OSSE). Ocean climate indices are a more immediate tool, developed experimentally, that can be linked to major patterns of climate variability with significant social impact, and give estimations of their uncertainty and thus an indication of our ability to measure the ocean. These indices have been calculated using observational analyses sourced from different operational centers, and are updated on a weekly or monthly basis. The experimental work is being carried out with the input of many partners, again showing the depth of interaction in the international community.

Instrumentation and Modeling

Ocean observations have come a long way from the time when individual measurements were taken laboriously one at a time. Driven by an ever increasing demand for more timely and accurate information, there is now a steady flow of ocean data. Researchers share data with operational users interested in climatology, extended and seasonal weather predictions, ice and wind forecasts, marine transportation and offshore resource management. Automated readings of surface and sub-surface data are now commonplace. One of the exciting programs undertaken during the past few years is the Argo program and its suite of robotic floats. These floats spend most of their life drifting below the ocean surface, some as deep as 2,000 m. and every ten days, they rise to the surface, taking measurements on their ascent and descent and communicating data and position to a satellite. The goal is to have a continuous network of 3,000 floats, producing 100,000 temperature/salinity profiles per year, covering the world's oceans. That goal is nearing reality. Other systems of satellites, underwater observatories, ocean gliders, automated underwater vehicles are also being used and developed to improve our knowledge of the ocean and its interaction with the atmosphere and land boundaries.

Ocean observations on this scale cannot be implemented and maintained without the global participation of governments.

Conclusions

My treatment of international collaboration and cooperation in ocean science and services is coloured largely by my own experience in the area and therefore should not be regarded as a comprehensive history. Nevertheless, the changes that I have seen in the last forty years have been tremendous. The distribution of real time ocean data has grown from 1000 a year to a hundred times that number. Technological advances have improved the quantity and quality of available data. Greater attention to complex global issues has brought scientists of all nationalities and disciplines together.

I see no reason why the successful cooperation achieved by the atmospheric and oceanographic communities in climate and ocean and marine services over the past forty years should not continue to strengthen and improve.