Global Ocean Observing System

**Intergovernmental Oceanographic Commission**
*Reports of Meetings of Experts and Equivalent Bodies*

# GCOS-GOOS-WCRP
# Ocean Observations Panel for Climate (OOPC)
**Fourth Session**

# WCRP CLIVAR
# Upper Ocean Panel (UOP)
**Fourth Session**

# Special Joint Session of OOPC and UOP

**Woods Hole, USA**
**17-21 May 1999**

**GCOS Report No. 75**
**GCOS Report No. 56**
**ICPO Report No. 31**
**WCRP Report No. 11/1999**

**UNESCO**

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GCOS-GOOS-WCRP/OOPC-IV/3
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## FOREWORD

As a one-time event, the chairs of the Ocean Observations Panel for Climate (OOPC) and the CLIVAR Upper Ocean Panel (UOP) agreed to schedule their 4th sessions at a common date and place to make possible three days of a joint session of the two Panels as well as single-day separate sessions during the same week.

The joint session was scheduled to conduct a preliminary run-through of the full programme planned by the OOPC and the UOP for the OCEANOBS99 Conference. If the Conference was to succeed, it was considered vital to have this exercise to obtain feedback from the large group of members and invited guests on cohesion weaknesses, flaws, gaps, etc., with enough lead time to plan and reach agreement on revisions to the programme.

The separate sessions addressed normal Panel business. It was agreed that the separate and joint sessions would appear within a single document, appropriately titled and numbered with standard report numbers consistent with the parentage of these Panels. This document is thus the report of the 3-day joint and two separate 1-day sessions of the OOPC and the UOP, held 17-21 May 1999 at the Woods Hole Oceanographic Institution.

## TABLE OF CONTENTS

## B. SPECIAL JOINT SESSION OF OOPC AND UOP

**ANNEXES**

**A. OCEAN OBSERVATIONS PANEL FOR CLIMATE (OOPC)**
**FOURTH SESSION**
17-20 May 1999

## 1. OPENING

The Chair opened the meeting and asked Dr Weller, on behalf of the hosts to make a few remarks. Dr Weller welcomed Ocean Observations Panel for Climate (OOPC) to Woods Hole Oceanographic Institution and offered their assistance for both the OOPC and the joint OOPC-UOP meeting. The Chair thanked WHOI for hosting the Panel and, in particular, Mary Ann Lucas for the sterling work with local logistics. The Chair welcomed four new members of the Panel, Joel Picaut, Johnny Johannessen, Bob Keeley and Dick Reynolds as well as the new GCOS Director, Alan Thomas, and Mike Johnson from NOAA OGP. A full attendance list is included at Annex II.

## 2. REVIEW AND ADOPTION OF THE AGENDA

The Chair introduced the Agenda (see Annex I) noting the joint sessions with the CLIVAR Upper Ocean Panel (UOP) to prepare for the ocean observations Conference. Many of the detailed scientific discussions would be delayed until the joint session. This meant the agenda for Day 1 was very busy and some business might need to be discussed out of session. The Agenda was adopted without modification.

## 3. REVIEW OF INTERSESSIONAL ACTIVITIES

### 3.1 GOOS STEERING COMMITTEE AND OTHER OOPC REPRESENTATIONS

The Chair noted that the GOOS Steering Committee had its first two sessions since the OOPC last met (GSC-I in Paris, April 98, and GSC-II in Beijing, April 99; reports to the latter meeting had been circulated to Panel members). At those meetings the GSC were briefed on the activities of the Panel, including developments associated with the Global Ocean Data Assimilation Experiment (GODAE), Argo and plans for the 1st Conference on Ocean Observations for Climate. The Chair delivered reports to the GCOS SC (February 99) and the Joint Scientific Committee (March 99). He represented the OOPC at the second planning meeting (November 1998) for the development of the Implementation Action Plan for Existing Bodies and Mechanisms for Global Physical Ocean Observations for GOOS/GCOS (hereafter referred to as the *Action Plan*), and at an exploratory meeting for a possible Partnership for Observation of the Global Ocean (POGO; see item 3.7 ). The Chair noted that the Panel's activities were encouraged and endorsed, where appropriate. The Panel was thanked for their considerable enthusiasm and leadership and encouraged to continue their excellent work.

No major redirection of effort was suggested by the parent scientific bodies. The ever-broadening remit of the panel is, in part, due to GODAE. The lack of progress with carbon and sea-ice aspects was noted. Moreover, the GSC noted that surface waves may also have to be considered by the panel.

With respect to carbon, Art Alexiou, (IOC) stated that the members of the IOC-JGOFS Advisory Panel on Ocean $CO_2$ strongly recommended that the OOPC add a member with ocean carbon expertise. Ed Harrison added that the US is planning a Carbon Cycle Science Initiative for FY 2000 as part of the US Global Change Research Programme. The programme will integrate $CO_2$ modelling, observational and process research to identify and quantify regional to global scale sources and sinks as well as seek answers to how these will change in the future.

## 3.2 PANEL MEMBER ROTATION

The parent bodies agreed that some rotation of membership was desirable, as suggested by OOPC-III. John Field, Michel Lefebvre and Christian Le Provost subsequently stepped down from the Panel and were replaced by Richard Reynolds, Johnny Johannessen and Joël Picaut. An additional member Robert Keeley was added to strengthen links in the area of data and information management as suggested by both GCOS and GOOS.

The Chair noted that further rotation of membership was desirable over the next 18 months. However there was no immediate pressure to act (and nothing in the terms of reference to compel such action) so there was likely to be no change over the coming 12-18 months.

## 3.3 THE FOUR THEMES OF OOPC ACTIVITIES

The Chair noted the "drivers" for OOPC activities could now be broken into 4 themes:

(i) ENSO and related seasonal-to-interannual prediction;
(ii) Climate change, including elements of the carbon cycle and sea-ice;
(iii) Short-range ocean (and marine) prediction and fields for meteorology; and
(iv) General requirements for the climate database and climatologies.

Although each of these themes involved complex phenomena and interactions, there was broad agreement on the initial set of requirements and needed enhancements.

The elements of a strategy for responding to these plans/design are:

- Seek effective implementation mechanisms; e.g., the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM), and the Partnership for Observation of the Global Ocean (POGO).
- Establish integrating "frontier" pilot projects; e.g., the Global Ocean Data Assimilation Experiment, and Argo, the global array of profiling floats.
- Initiate focussed activities (work and renovation); e.g., workshops (SST, Time-Series and Sea Level), cooperative projects (reference sites and WGNE) and dedicated studies such as the Thermal Network Study.
- Exploit international "movements" using natural and other events to garner interest and involvement (1997/98 El Niño, UNFCCC COP and the Report on the Adequacy of Global Observing Systems).
- Encouraging partnerships, consensus (Cooperation with CLIVAR UOP, OCEANOBS99).

Neville Smith noted that the Initial (ocean) Observing System as recommended by GCOS/GOOS was now within reach. The prospects for implementing many of the recommended enhancements are now very good (e.g., *via* Argo). This is an opportunity that has been provided by many different events and developments. It is an unprecedented opportunity and one which we should endeavour to exploit, but to exploit in such a way that we put in place an observing system that will stand the test of time. The Conference, COP-5, JCOMM and POGO, and GODAE provide excellent avenues to ensure this is so.

## 3.4 GODAE

The Chair reported that the International GODAE Steering Team (and Patrons) had met twice within the last 12 months (a report on GODAE had been circulated prior to the meeting). The chair noted that Argo had been the main focus through the last 12 months. The objectives of GODAE had been revised to the following:

- The application of state-of-the-art ocean models and assimilation methods for short-range open-ocean forecasts, for boundary conditions to extend predictability of coastal and regional subsystems, and for initial conditions of climate forecast models.

- To provide global ocean analyses and re-analyses for developing improved understanding of the oceans, improved assessments of the predictability of ocean systems, and as a basis for improving the design and effectiveness of the global ocean observing system.

There has been good progress with national initiatives. Harrison reported that the US will establish a server dedicated to GODAE data at FNMOC. This is a significant and important commitment. It will include:

• Significant real-time capacity
• Distributed data handling capability
• Holdings of GTS and other data
• Residency time > 30 days

Other specific GODAE actions agreed were:

(i) Establish a data team for GODAE to:

- Help determine [in consultation with US GODAE scientists and "pilot projects"] data requirements for the centralized data server;

- Identify and implement resources to populate data server; establish archive of RT data; design, develop, and test data pathways; and establish/coordinate GODAE servers (satellite products,…)

- Identify resources to develop products, and derived products for GODAE.

(ii) Form a small internal task group in IGST to examine possible metrics (methods of measuring system performance) for GODAE.

(iii) Form a GODAE Linkages Action Team to assure GODAE products are defined to meet the needs of mesoscale, regional, coastal, and other non-global partners.

(iv) Form a modelling and assimilation working group to focus on generic issues from the global set of regional activities (e.g., product and data set intercomparisons).

(v) Establish a WG for high-resolution SST products. Its tasks will include:

• A feasibility and scoping analysis;
• To request a preferred methodology (data sets to use, processing, scientific issues) ;
• An implementation plan;
• To report to the IGST;
• Links to the AOPC/OOPC SST WG (see later item).

## 3.5 GCOS AND THE UNFCCC AND COP-4 AND 5

Alan Thomas, the new Director of the GCOS Project Office reported on developments with respect to GCOS and, in particular, the Report on the Adequacy of Global Observing Systems and the response from COP-4. Thomas reminded the members that GCOS received the mandate to initiate an intergovernmental process for action (probably *via* GCOS and friends). It was asked to identify funding processes using UN and other mechanisms and to identify a long-term intergovernmental mechanism for addressing observation issues. The COP-4 urged nations to support the implementation of atmospheric, oceanographic and terrestrial observing systems and to develop and report national observing plans. GCOS has prepared an initial draft of national reporting guidelines (distributed to OOPC members at the meeting). Thomas noted that the AOPC had provided detailed comments on the guidelines at their most recent meeting (these comments were copied to OOPC).

The OOPC, through the Chair, had provided significant input to the Report on the Adequacy of Global Observing Systems and, again through the Chair, had corresponded with the Chair of the GCOS SC with respect to the draft guidelines. The OOPC had no problems with the comments provided by AOPC, regarding them as sensible adjustments for consideration. Stan Thomas stated that the response from SBSTA to this draft was the next important step. He also reported that Peter Price (from BoM) had been appointed to work on the GCOS response at the GPO in Geneva.

The Chair noted that GCOS now has a level of credibility within the UNFCCC process and that it is being entrusted with developing an appropriate mechanism; initial indications are that this challenge is being met well. This process provides an additional mechanism for nations to leverage support for climate observations and so is important as part of the OOPC strategy. George Needler agreed to check the draft guidelines for consistency with the present version of the Action Plan. The OOPC, in particular Neville Smith and George Needler, would continue to work closely with the GCOS Secretariat and the GCOS Chair.

3.6 ARGO (THE GLOBAL ARRAY OF AUTONOMOUS PROFILING FLOATS)

The Chair briefly reported on progress with Argo, noting that Dean Roemmich (Scripps Institution of Oceanography, USA) would provide a more detailed report under agenda item 6. At the previous OOPC meeting, the Chair reported that GODAE had recommended a major deployment of profiling floats, ~ 3000, based on a proposal by Dean Roemmich. Subsequently, the CLIVAR Upper Ocean Panel also affirmed support, including provision for salinity measurements as promoted by the Ray Schmitt proposal GOSAMOR. The GODAE Chair prepared a prospectus on behalf of GODAE and, indirectly, OOPC and the UOP, and circulated this for community comment in May 1998. An Argo Workshop was organized as part of the IGST-II meeting in Tokyo, and supported by the OOPC Secretariat and GOOS. This Workshop concluded that Argo was most definitely worth doing and feasible. Initial estimates suggested the *per* profile cost (T and S to 2000 m) could be as low as US$100. Certain technical challenges were identified but none appeared insurmountable. The Workshop emphasized Argo was not an observing system solution in itself and that the OOPC would need to provide advice and guidance on the total balanced Observing System.

An Argo Science Team was formed, with Dean Roemmich as Chair, and requested to draft an initial plan. This draft was circulated for non-advocate review in October and drew around 30 responses. None questioned the need for Argo nor the technical feasibility. The majority of the comments targetted the scientific and operational rationales, deployment, sampling and the need for integration within the global observing system. The GODAE Office published the Initial Plan in early November. It was distributed at the CLIVAR Conference in December. There has been an energetic, parallel campaign to solicit international participation, led by NOAA. The first meeting of the Argo ST was held in Easton, MD in March 1999, again with the GODAE Steering Team. The Team concluded, based on national (informal) estimates, that it was realistic to expect on the order of 600 float deployments *per* year by around 2001. Global distribution was a top priority. The Southern Ocean was poorly subscribed in initial estimates. There had been considerable technical progress in float development and 200 cycles were now thought to be feasible. The deployment strategy was discussed in detail as was the preferred parking depth. The

OOPC agreed to formally endorse Argo as a pilot project and to endorse the present arrangements whereby the Argo Science Team is sponsored by GODAE.

## 3.7 PARTNERSHIP FOR OBSERVATION OF THE GLOBAL OCEANS (POGO)

Bob Weller reported on a recent initiative to create a partnership among world oceanographic institutions in support of, among other things, the ocean observing system for climate. An exploratory meeting was convened by WHOI, SIO and SOC to explore feasibility of, and opportunities for, such a partnership. The meeting was held at IOC in Paris (March 1999) and was attended by BobWeller and Neville Smith from OOPC. The meeting concluded that such a partnership was needed, in part because oceanography in the modern era required investments of resources that were beyond any single institution. The participants agreed that Argo and GODAE should be leading priorities for the partnership. The adopted charter states:

> *"The participants agree to proceed with the establishment of a partnership of institutions (and consortia thereof) which have demonstrated capability to undertake basin-scale oceanographic observations and research together with such associated members and affiliated entities as may subsequently be agreed. Representation will be at the level capable of committing their institutions."*

The mission statement reads as follows:

> *"A Partnership for Observation of the Global Oceans (POGO), composed of major institutions involved in research and observation in global ocean science, will work with the ocean, earth, and atmospheric science communities to promote global oceanography, including especially the development of an integrated global observing strategy. POGO will play a leading role in implementation of an international and integrated global ocean observing system."*

As a specific initiative, the meeting recognized the importance of rapidly developing a project for ocean time series/observatories. The meeting requested OOPC to develop a plan for consideration at the next meeting of the participants (scheduled for Dec 1-3 1999 at SIO). This plan should consider the effective sharing of information, technology and experience among participants in the project. Bob Weller (OOPC) and Uwe Send (CLIVAR UOP) have agreed to lead the drafting of such a plan.

The Chair noted that the participants had gone to some lengths to emphasise that they wished to work with, and within, existing structures and did not wish to create unwanted, additional mechanisms. The GOOS SC did raise some issues in relation to the mission and charter but these were not likely to diminish the resolves of the institutions to form such a partnership. The Chair suggested that the Partnership may well provide an additional, much needed implementation mechanism in areas which required high levels of scientific and/or technical expertise (e.g., hydrographic sections). The OOPC agreed that POGO offered considerable potential for enhancing the observing system. Both Smith and Weller were likely to attend the first formal POGO meeting at which time a plan for ocean time-series observatories should be ready.

## 3.8 FIRST INTERNATIONAL CONFERENCE ON THE OCEAN OBSERVING SYSTEM FOR CLIMATE

The Chair stated that much of this meeting's agenda was being devoted to this Conference, known informally as OCEANOBS99. He noted that its genesis was in several discussions that had taken place since OOPC-III concerning the balance of the observing system and, in particular, the perceived potential for Argo to distort this balance due to its high level of visibility. OOSDP had discussed a Conference at the time of publication of its report but it was thought at the time that such a Conference would not be effective.

However in recent years implementation has gathered pace to the point where it was now desirable to get broad community consensus on the blend of techniques/methods that should be adopted. This includes both remote and direct/*in situ* systems. After discussions with leading members of the community, it was decided that a conference involving all those involved with the implementation and maintenance of the system should be convened and that, in order to ensure full cooperation among the operational and research communities, the conference should be jointly convened by OOPC and the CLIVAR UOP.

All the major sponsors agreed and an initial Scientific Organizing Committee was formed with Neville Smith and Chet Koblinsky as co-Chairs. The first announcement was released in March and the second announcement in mid-May. Around 30 papers had been solicited, using the format of IPCC Assessment papers as a guide. The joint meeting of OOPC-UOP was the first chance to see just what might be covered by the papers and to adjust the programme so that the ultimate aim of the Conference, an agreed, balanced observing system for climate, was met. Further actions can be found under Item 6 which addresses the Conference in detail.

## 4. WORKSHOPS AND OOPC INITIATIVES

### 4.1 SEA SURFACE TEMPERATURE WORKSHOP

Dick Reynolds gave a brief report on the recent (Nov. 98) Sea Surface Temperature (SST) Workshop which was jointly convened by OOPC and AOPC. He referred to OOPC-III which exposed problems with analyses at high latitudes whereby different systems seemed to give different long-term trends. This seemed to be due to the way sea-ice was handled.

The Workshop concluded that climate change detection requirement is the most stringent in terms of precision and accuracy for SST (0.1°C). Differences in "global" SST can arise because of uncorrected satellite biases and the improper use of sea-ice "data". Data assembly remains a problem.

Dick Reynolds emphasized we are still hampered by data gaps, particular in southern high latitudes. There are several important issues related to skin *versus* bulk temperatures. The WS also noted the demand for high resolution (in space, time) is growing.

After consultation with the AOPC and OOPC it was decided that the excellent work of the Workshop should be built on with a Working Group, co-sponsored by OOPC and AOPC. Dick Reynolds agreed to Chair the WG. The initial terms of reference are in Annex III. The OOPC commended the Workshop participants, and its Chair Phil Arkin, for the excellent work that was done. The Workshop report identified several important issues and the OOPC believed these should be looked at as soon as possible. The OOPC thanked Dick Reynolds for agreeing to Chair the WG and endorsed the terms of reference as a suitable starting point for the group. Ed Harrison and Neville Smith would continue to provide input, as required.

Neville Smith noted that GODAE was about to initiate a working group to look at high-resolution products, nominally at around 10 km spacing and including diurnal resolution (see GODAE above.) This group would need to work closely with the climate SST WG to ensure common understanding of issues such as skin/bulk SST parameterizations and the use of data from microwave and geostationary instruments.

### 4.2 DATA MANAGEMENT ISSUES

Bob Keeley led a brief discussion on data management issues. It was noted that the formation of the JCOMM implied that guardianship for these issues would mostly transfer to that body. OOPC were reminded that, as part of the action plan, several issues related to data assembly, quality control and data and product distribution were identified. For sub-surface data, Keeley would be working the Upper Ocean Thermal data study to provide more explicit guidance on the operational requirements for assembly, etc.

The SST WS devoted considerable attention to the assembly and quality control (QC) of SST data, again an issue that was identified in the development of the Action Plan for JCOMM. Keeley noted that JDIMP had developed a "G3OS Data and Information Management Plan". They had also developed a global observing system information centre (GOSIC) through the University of Delaware which describes where information might be held. Ron Wilson has also developed a GOOS Draft Plan which was discussed at GOOS SC. Neville Smith noted that this was likely to undergo considerable revision as a result of the discussions at Beijing. He further noted that CLIVAR was developing its CLIVAR Data Information and Products Service and had formed a task team to look at issues, many of which are in common with OOPC and AOPC. There were, in addition, activities being undertaken within GODAE (e.g., the development of the GODAE server) and Argo which were presently outside these other considerations. The Conference would provide one opportunity to reach some consensus on who was doing what and how. Clearly, at the moment, there was not a good understanding of the way forward.

The OOPC concluded that a more focussed effort was going to be required, and that this would require the development of a deeper interest and involvement from the research community (research in D&IM). For high-quality data sets, involvement of research is mandatory. For the short-term, the JCOMM and other studies (SST, UOT) would provide focus for OOPC activities. The development of the GODAE server might serve as a basis for developing an Ocean Climate Data server.

## 4.3 TIME-SERIES AND OCEAN OBSERVATORIES

As noted above under POGO, OOPC have been requested to develop a plan for time-series stations/observatories and to present plans for surface reference sites to POGO. Weller noted that he and Uwe Send (Kiel) had agreed to take on this task. The mode would be similar to that taken by Argo. A draft plan would be prepared in collaboration with those with a key interest in this technology. This plan would then be circulated for non-advocate review, probably mostly from the UOP and OOPC panels. A revised plan would be presented to the OCEANOBS99 Conference. This document would then be published under the auspices of OOPC and UOP and provided to POGO for their consideration.

Weller also noted that there had been good progress with development of a joint project with the Working Group for Numerical Experimentation (WNEG) of CAS/WCRP. Weller had made a presentation at the last meeting of WGNE (November 98) and they agreed to develop a project which would use high-quality data from surface reference sites to test and improve operational numerical weather prediction models. Peter Gleckler (PCMDI) is the principle contact within WGNE. Weller agreed to continue to be the lead contact within OOPC for this project.

## 4.4 STUDY OF UPPER OCEAN THERMAL NETWORK

Smith described an initiative to examine the upper ocean thermal network and, in particular, the scientific rationale for and design of the ship-of-opportunity network. Smith noted that at the previous OOPC meeting an outline of relevant actions was presented (drafted by R. Bailey) and that, at that time, it was decided that no action would be taken until the response of the UOP was obtained. The most recent UOP meeting failed to make any progress so it was decided to initiate actions out of session. A description of the proposed study is included as Annex IV. Smith, Harrison and Keeley are the principal contacts within OOPC. Smith noted that the work programme is consistent with the Action Plan for JCOMM and the conclusions of the planning meetings in Sydney and Paris in 1998. For OOPC, it should provide a renovated/revised plan for the SOOP and provide recommendations for long-term support (or not) of frequently repeated and high-density lines. It should also give advice on how best to integrate the SOOP in the presence of altimetry, TAO and Argo (and other contributions). Smith noted that the approach was similar to that used for the sea level workshop.

A study was being undertaken at BMRC through the Joint BMRC/CMR Australian Facility for Ocean Observing Systems using a consultant and the advice of Rick Bailey. A Workshop was planned for August and the initial conclusions would be presented to OCEANOBS99.

The OOPC endorsed the work plan for the study and concluded that it would go a significant distance toward the aims of the Action Plan for JCOMM. A full discussion of the study would be included on the agenda for the next OOPC meeting.

## 5. JCOMM AND THE ACTION PLAN

Needler reported that the section of the Action Plan relating to ocean climate observational requirements had been updated and revised. The most recent version had been made available to OOPC members *via* the Web. He noted that other changes to the Plan had resulted from an Interim Action Group meeting in Paris last December. Needler noted that the Action Plan was the substantial basis for the CLIVAR Implementation Plan, enhanced as appropriate with sustained observations for the CLIVAR Principal Research Areas (PRAs). Together these plans formed the foundation for the upcoming OCEANOBS99 Conference. To the extent possible, the detailed sampling requirements reflected the most recent decisions of the OOPC. These requirements are summarized in tabular form in the Action Plan and are reproduced in Annex VI, Table A.

Needler further stated that the Joint (Technical) Commission for Oceanography and Marine Meteorology had been endorsed by the executives of both WMO and IOC and that in May and July of 1999, it would be proposed to the WMO Congress and IOC Assembly (it was endorsed by the former while OOPC was in session). A "Transition Planning Meeting for JCOMM" is scheduled for St Petersburg, 19-23 July. The Chair of OOPC will attend. Assuming successful adoption of JCOMM by IOC, this transition meeting will look at the issues relating to transition of the existing mechanisms into a Joint Commission. The task for OOPC is to ensure that requirements are well articulated and that, where doubts or uncertainty arise, that adequate scientific guidance is developed (e.g., as with SST).

The Chair further noted that many elements of the OCEANOBS99 Conference are directly related to JCOMM (e.g., Surface Waves, upper ocean thermal, SST, surface fluxes, etc.).

OOPC re-iterated the importance it attached to the formation of JCOMM and thanked George Needler for undertaking important redrafting.

## 6. OTHER INTERACTIONS AND LIAISON

### 6.1 SEA ICE ELEMENTS OF THE OCEAN OBSERVING SYSTEM (OOS)

Smith noted that little progress had been made since OOPC-III. That meeting suggested several modifications to published requirements most of which have been accommodated. However, this alone has not enhanced support for long-term measurements. The SST WS did examine several issues related to sea-ice but only in the context of SST analyses for climate. Drawing lessons from other areas of the observing system, OOPC concluded that a more substantial project would have to be developed, perhaps in cooperation with ACSYS. The Chair noted that informal discussions had taken place with the Chair of ACSYS, Howard Cattle. An ACSYS Products group had been formed and it was suggested that perhaps OOPC should try to link up with this group.

## 6.2 COASTAL PANEL

The third meeting of the Coastal Panel (C-GOOS) had been held at Accra, Ghana during 13-15 April 1999 and Needler reported on the progress that had been made, on plans for the future, and on matters of joint concern for the OOPC requiring co-operation. The intention is to provide an initial implementation plan for C-GOOS after the next 2 meetings of the Panel. It is envisioned to have 2 parts; one describing a global network of required observations and the other a set of pilot projects that may on the longer term be included in the global network. An initial draft of the global network was prepared for the Accra meeting and was extensively reviewed. At present it includes satellite observations, a tide gauge network, an enhanced network of off-shore buoys and platforms (mostly focussed on surface meteorological conditions), observations on critical sections, and a coastal watch of near-shore properties allowing local input and contributions to the global data set. A revised version of the global network will be available when the Panel meets in Beijing in November.

Regarding the pilot projects, several possibilities were presented by Panel members and discussed at C-GOOS-III. Before the next meeting these will be developed further and a more comprehensive and, to some extent, prioritized list will be prepared. C-GOOS has mostly been developing a system of physical and biological observations and is working with the expectation that in the longer-term there will be an amalgamation with the LMR and HOTO modules requirements for coastal observations.

Needler also briefed the OOPC on the subject of OOPC/C-GOOS co-operation which had also been addressed at C-GOOS-III. It is well recognized by C-GOOS that the coastal observing system requires elements of the OOSC for coastal problems. These include, for example, the provision of the large-scale wind and SST fields, sea level in the context of the large-scale geocentric framework, and forcing by the ENSO/tropical wave guide of the western coast of the Americas. Interest was expressed in what GODAE might provide regarding dynamical forcing of the coastal seas and in what profile data might be provided by Argo within the EEZs.

C-GOOS can also provide benefits for the OOSC. For example, 'coastal' observations of winds and SST can provide data of higher resolution for the OOSC that will sometimes be in regions of poor global coverage because of persistent local fog. The use of coastal tide gauges for the global determination of changing ocean volume requires information on the coastal tidal regimes and the dynamical adjustment of the coastal circulation to changes in off-shore forcing; these are coastal problems. Some C-GOOS observations will likely provide higher resolution observations of importance to global climate change and variability. Examples are observations of the poleward flowing eastern boundary currents and of shelf transports such as by the Labrador Current and through the Canadian Archipelago. These are important aspects of the global climate system but they are of a higher resolution than has been included in the initial design of the OOSC.

Given the above and the fact that common mechanisms, such as JCOMM, will be used to implement both the OOSC and coastal observations, C-GOOS recognized that there is a need for consistency and co-operation in the design of the global and coastal aspects of GOOS. The OOPC concurred. OOPC noted that sea level was a high-priority requirement for the coastal community and that, for implementation, it would be sensible to extend the remit of the proposed sea level working group to examine this issue. This had been discussed by GOOS SC and was due to be raised at the GLOSS meeting in Toulouse the previous week.

## 6.3 UPDATE ON SATELLITE GRAVITY MISSIONS

Johnny Johannessen provided an update on recent developments for gravity missions, particularly for the GOCE. (Gravity Field and Steady-State Ocean Circulation Explorer) mission. He stated that the decision on whether to go with a GOCE mission would be made by 7 June. He noted that GRACE gives ocean bottom pressure variations, order of 10's of mb, which reflect the Gulf stream and Kuroshio meanders with signals of the order of 20-50 mb. This suggests that a bottom pressure sensor array would be required for validation.

Johannessen reported that a study was completed since OOPC-III that compares GOCE with two other relevant missions, CHAMP (Challenging Mini-satellite Payload for Geophysical Research and Application) and GRACE (Gravity Recovery and Climate Experiment). The study concludes that GOCE would be a unique gravity field mission that would open a completely new range of spatial scales to research. In particular, it would for the first time provide a precise reference surface at a wavelength of about 100-200 km for unification of height systems, levelling of GPS and for the determination of absolute ocean topography from data delivered by satellite altimetry. The latter is a major deficit in current knowledge which undermines estimates of absolute ocean circulation and its transport of heat and freshwater.

The study also demonstrates that GRACE is complementary to GOCE in that it will provide the temporal variations of the Earth's gravity field with high precision in the long to medium wave length range, i.e., 500 km and longer. GRACE will measure gravity changes due to mass changes or mass motion related to sea level, hydrology, glaciology and solid Earth. At intermediate scales, both missions provide relevant information to advance the knowledge of the Earth's gravity field and its reference equipotential surface, (geoid). The report of the study, titled European Views on Dedicated Gravity Field Missions: GRACE and GOCE was published by the European Space Agency (ESA) as an Earth Sciences Division Consultation Document, ESD-MAG-REP-CON-001, May 1998.

## 6.4 ATMOSPHERIC PANEL

Ed Harrison provided a brief report on the most recent AOPC meeting, noting that the discussion of the Report on the Adequacy of Global Observing Systems and the SST Workshop were significant agenda items. Harrison summarized as follows:

(i) Francis Bretherton, the new chair of GOSSP was in attendance. He is pushing for using ocean satellite observations for an end-to-end activity, including merging satellite and *in situ* observations. It is important for OOPC to review the CEOS ocean surface data requirements table and to keep it updated. CEOS uses these requirements.

(ii) With respect to the GSN (Global Surface Network) and GUAN (Global Upper Air Network), it has been decided to seek daily observations as well as monthly means. It was agreed that the GSN data should consist of the following:

- Mean daily temperature (calculated using current national practice);
- Maximum daily temperature;
- Minimum daily temperature;
- Total daily precipitation;
- Daily mean wind speed;
- Daily mean sea level and station pressure ( calculated using current national practice.

Harrison emphasized that the politics of data exchange of daily data and cost issues are non-trivial. There is a new CLIMAT format for reporting, but much remains to be done to get all nations reporting in this format. Efforts continue, to try to increase the number of GSN and GUAN stations actually reporting data. Some discussion occurred about how best to make the GSN and GUAN information available to interested users. The move to establish a US-GODAE data and products server/browser was noted; perhaps it will provide a model that could help.

(iii) Discussions took place on how best to interact/relate with SBSTA (Subsidiary Body {of the Conference of the Parties for the UNFCCC} for Scientific and Technological Advice).

(iv) The GOSIC (Global Observing Systems Information Center) at the University of Delaware **<http://www.gos.udel.edu>** serves as a central site to help people find information about the G3OS programmes, data requirements, observing systems and data sets and products. AOPC was invited to participate in GOSIC.

(v) A review of the GPCP (Global Precipitation Climatology Project) was presented. Ocean values remain quite uncertain. There is little i*n situ* information to help calibrate satellite information. Work continues to improve the processing of satellite information and to improve the quality of *in situ* ocean measurements.

(vi) A report of the jointly sponsored AOPC/OOPC workshop on global SST and sea ice was presented. Differences between different products are uncomfortably large over many regions of the ocean, relative to the climate signals of interest to GCOS. The need for more *in situ* data in data sparse regions is clear. Such data would greatly facilitate improved bias corrections of satellite IR data. There remains uncertainty about how best to process satellite sea-ice information. Questions also remain about the uncertainties in historical reconstructions of global SST and sea ice fields.

Dick Reynolds has agreed to chair a working group to carry out more detailed intercomparison of SST and sea ice products, to identify the sources of differences between them and to recommend steps to improve the quality of future analyses and of retrospective analyses.

(vii) Preliminary results about the level of uncertainty in sea level pressure analyses were presented. In the tropics and in high latitudes (especially high southern latitudes) the RMS differences between daily analyses can be a significant percentage of the signal. It was recommended that further exploration of the state of knowledge of sea level pressure be carried out and reported on at the next meeting of AOPC.

The OOPC agreed that a study of sea level pressure fields on climate scales (trends, long-term variability) was needed. Harrison volunteered to provide input. It was also noted that precipitation (net freshwater flux) was a significant issue. Discussion at AOPC suggested little progress had been made with ocean measurements.

## 6.5 GLOBAL OBSERVING SYSTEM, SPACE PANEL (GOSSP)

The Chair briefed the Panel on recent activities related to satellite requirements and the Space Panel (GOSSP), now chaired by Francis Bretherton. He noted that a report had been submitted to GOOS SC (circulated to OOPC prior to the meeting) asking for their endorsement of requirements for the oceans (principally those of OOPC and GODAE). This Report to GOOS SC is included as Annex V. The approved Table of Requirements is in Annex VII Table B. The GOOS SC, while noting that it itself does not have the expertise to judge the veracity of the stated requirements, concluded that GOSSP (with the help of GODAE and OOPC) had attended to this request in a scientifically sound manner and that it was appropriate for them to be regarded as definitive GOOS requirements.

GOSSP had raised several issues for the attention of GOOS SC, particularly with respect to ocean colour and biology, but the SC was not in a position to provide advice. Smith also noted that GOSSP, in cooperation with the IGOS Partners, were formulating a position paper for the Oceans Theme of CEOS. The priority measurements are:

(i) Surface topography/altimetry
- T/P-Jason-like quality altimetry – at least one in orbit at all times
- High-resolution altimeter (e.g., an ENVISAT or better instrument in orbit at all times)
- 3rd altimeter in orbit desirable

(ii) Sea surface irradiance
- Need improved methods for assembly, validation
- Trend toward higher resolution products (GODAE) and use of multiple platforms, including geostationary and microwave data

(iii) Surface Wind Vectors
- At least one NSCATT scatterometer (or an equivalent) is essential
- Strong multi-application case emerging for a second scatterometer

(iv) Ocean Colour
- Consensus that ocean colour is a priority measurement

The OOPC endorsed the suggested priorities but noted that the Conference would provide a more appropriate forum for endorsement. Smith also noted the need for surface short-wave radiation products. An outline for a possible project had been circulated after IGST-II and was discussed again at the last GODAE meeting. It was believed that carriage of this project was probably better done within OOPC. The Chair reported there had been some correspondence with GEWEX but that, as yet, no decision had been made on a project. This will be pursued inter-sessionally.

### 6.6 CAPACITY BUILDING

The Chair noted that a capacity building effort was to be mounted by GOOS. Bob Weller volunteered to provide input on OOPC's behalf. Needler volunteered to act as back-up. POGO also suggested it might provide some help in this area.

## 7. CLOSING AND NEXT MEETING

Johnny Johannessen and Peter Haugan volunteered to investigate locations in Norway for the next meeting, possibly early June 2000. The date and place were subsequently set as Bergen, 20-23 June 2000.

# B. SPECIAL JOINT SESSION OF OOPC AND UOP

18-20 May 1999

## INTRODUCTION

This 3-day joint session of the OOPC and the UOP, was conducted as a preliminary run-through of the programme planned by the OOPC and the UOP for the OCEANOBS99 Conference. It was essential to have this exercise to have all the speakers have a common understanding of the Conference, the objectives and the philosophy underlying its design, and the relationship sought between their papers and all the others on the programme. It also provided the only real opportunity to obtain feedback from the large group of members and invited guests on cohesion weaknesses, flaws, gaps, etc. with enough lead time to plan and reach agreement on revisions to the programme.

The session was co-chaired by N. Smith and C. Koblinsky, the respective chairs of OOPC and UOP, The co-Chairs introduced each item by briefly describing its background to the Conference. (Participants had been circulated the first and second Announcements, the annotated programme and a guideline for authors.)

The scientific basis was provided by the OOSDP Report and subsequent modifications by OOPC to the design and plans, and the CLIVAR Science Plan and Implementation Plan. A fundamental principle was that the ocean observing system (for climate) will be multiple purpose and serve a broad community. There will be just one and it will need support and consensus on its structure and the blend of observations. This First International Conference on the Ocean Observing System for Climate was conceived to get this agreement.

The Conference, otherwise known as OCEANOBS99, was sponsored by GCOS/GOOS, WCRP/CLIVAR through the OOPC + UOP. It enjoyed a wide institutional and organizational support and was held in Saint Raphaël, France, 18-22 October 1999.

Smith opened with some remarks that provided background to this joint session. OCEANOBS99 is for the ocean community rather than a showcase for individual interests. The Scientific Organizing Committee agreed on an approach. It is not unique or superior. For the purposes of the Conference, "Climate" is treated as the ensemble of environmental realizations, not average weather or everything slow and large (scale). An immediate implication is that we will consider short-range forecasts, etc.

The ocean community is moving beyond a "research *versus* operational" stance and developing the notion of sustained observing systems with broad patronage and application. The key questions to be asked for prospective elements are: Can it be sustained? Is it worth sustaining? Do we know how?

The answers are inevitably a function of resources, people, knowledge; there will be no simple definition of observations to be include in or out of the system. The primary task is reaching agreement on the rationale and the blend of observations. We are not seeking the “latest and greatest”; nor considering satellite *versus in situ*; nor surface versus upper ocean; nor mid-latitudes *versus* tropics; etc.

Smith concluded his opening remarks by stating that integration and synthesis is not just about models and data assimilation; complementarity and integration must be sought at all levels. The Conference is seeking consensus, not prescribing or imposing. Attaining this consensus cannot be done just at the Conference. We must seek it initially in specialist areas, then for broader constituencies and regions, and finally within the larger ocean community. We have an opportunity to decide on what the future will look like; to seek a robust, sustainable future for the ocean observing system; let us use this opportunity wisely.

This session discussed the papers in roughly the same order as in the 2nd Announcement. The discussion was referenced against the annotated programme for OCEANOBS99. Numbering corresponded to that draft programme. Comments, criticisms, suggestions are included here in abbreviated note form.

## 1. USERS, APPLICATIONS AND OVERVIEW (First Session)

### 1.1 INTEGRATED SYSTEM OVERVIEW (by Needler for Nowlin *et al.*)

#### 1.1.1 Outline of the Paper

<u>Start with science base</u>. What led to TOGA and WOCE, Namias, possibility of global altimeter and scatterometer, recognition of the ocean's role in climate (Stream 3 of WCRP) etc. TOGA, - first attempts at climate prediction. WOCE’s first goal was a global ocean description. WOCE had a second

goal: to leave a climate observing system behind it. Greenhouse gas concerns, leading into the IPCC, and to FCCC, and observing system requirements.

Formation of GCOS and GOOS in 1992. Describe relevant goals and objectives. Origin of OOSDP (before GCOS and GOOS in 1990). Saw opportunity of funding for systematic observations and moved goal 2 of WOCE forward. Optimism that TOGA prediction would work and need observations. Give general goals and approach of OOSDP.

The challenge of implementation. Research to implementation. Limited regions to global perspective. Reason for formation of JCOMM (integration, etc.). The need for broad international involvement (a few nations did most of the field work of WOCE and TOGA).

The most recent COP-4 push of the GEF. The recognition of the need for repeated assessments for the IPCC, by SBSTA of the OOSC for the FCCC .

The advent of CLIVAR. Climate research on decadal scale has overlapping considerations with OOSC design. But research objectives can be different than for operational systems. Also funding sources can be different.

End upbeat on future. New technologies in use (altimeter, scatterometer, Argo). Existing effort (North Atlantic profiling floats for example). Funding: example of operational funding in tropical Pacific. Improved recognition of governments and public of climate issues

### 1.1.2 Discussion/Reactions

There were no detailed concerns with the content of the paper. There was concern that the opening might be too "dry". Neither the CLIVAR IP nor the OOSDP/OOPC plans are filled with exciting schematics. Yet it is background and detail that is needed. Some expressed the view that this paper might work best after the papers dealing with specifics. Since it effectively deals with the integrated, global system – the end-point of the Conference rather than the beginning.

One option might be to take some of the background material and develop it as one or two posters – the posters at the CLIVAR Conference were one of the highlights. Many participants thought such displays might be the most effective way of providing detailed designs. If it is still to be used as a talk at the front, then we will need to develop schematic links into the rest of the programme.

## 1.2 APPLICATION OF SEASONAL-TO-INTERANNUAL PREDICTION – (by Ants Leetmaa)

### 1.2.1 Summary of the Paper

The northern hemisphere experiences climate variations on seasonal and decadal time scales. Trends are also important. A few modes, ENSO, ENSO-Decadal, Arctic Oscillation (AO), produce much of this. (This does not preclude the existence of other modes). In general, explanations for regional climate variations require consideration of several of these modes.

The next "easy plum" for adding to predictability is the ENSO-Decadal mode. There is no consensus yet that the AO is a distinct mode. It might be the sum of North Pacific and NAO contributions. A better understanding of the AO/NAO is critical for further enhancements of predictability.

### 1.2.2 Discussion/Reactions

Many participants agreed that this was exactly the sort of presentation needed to motivate subsequent presentations. It gave a nice discussion of the "fundamentals" (modes) and provided concrete examples of how a global observing system could enhance the quality and range of climate forecast products. The societal impacts figure and the discussion of relevance to the energy industry seemed to be two highlights. Leetmaa suggested the title may change because of the rather broader coverage.

The discussion on modes of variability suggested these should be used as links to subsequent talks so that the audience at the Conference was able to explicitly link back the detail to the applications.

After the presentation on 1.1 and 1.2 it was also concluded that a similar talk focused on climate change was also needed.

1.3 THE SOUTHERN HEMISPHERE PERSPECTIVE (not discussed at the meeting)

1.4 THE DIVIDEND FROM INVESTING IN OBSERVATIONS, A EUROPEAN PERSPECTIVE (Not discussed at the meeting)

1.5 OPERATIONAL OCEANOGRAPHY AND PREDICTION, GODAE (not discussed at the meeting)

1.6 THE ACTION PLAN FOR GOOS/GCOS AND SUSTAINED OBSERVATIONS FOR CLIVAR (by George Needler)

### 1.6.1 Outline of the Paper

Reference back to paper 1.1. Give OOSDP terms of reference to show design aim. Address difficulty of optimization around subgoals, or variables, or fields. Give OOSDP choice of subgoals. OOSDP set priorities, show priorities. Illustrate observation mix with one or two impact-feasibility diagrams (SST, ENSO?). Give sequence through first Action Plan draft to CLIVAR sustained observations to final Action Plan.

Increasing specification of space-time scales and accuracy of observations. Refer to detailed OOSC as given in paper. Give one or two examples, perhaps SST and upper ocean T.

Changes since OOSDP. Design may not show full impact of precision altimeter. Scatterometer yet to be routinely used. Profiling floats are in OOSDP but in a sense are a pilot project. Design will evolve with understanding of environment and new technology.

For future consideration. New technology. Acoustics (ATOC). Strategy of Argo deployment.

Autonomous underwater vehicle (Autosub).

Revised design. Changed mix of observations to optimize system based on new knowledge.

Implications of GODAE . Better techniques for *in situ* / satellite blended products.

New areas of coverage. Mediterranean. Arctic. Higher resolution for critical elements. Western boundary currents. Poleward flowing eastern undercurrents.

### 1.6.2 Discussion/Reactions

The discussion here followed that with paper 1.1; while this material was extremely important, a "dry" introduction early in the Conference may not be the best way forward. Many people favoured the development of posters which would be on display for the duration of the Conference and which could be used as a "connector" for detailed talks. If we followed this option (and also introduced a "primer" Conference talk) the first few papers would be: Conference "primer" (why the Conference, what it hopes to achieve, etc.); Leetmaa talk; Climate Change; Operational Oceanography and Prediction; The Dividend from Investment; and Gary Meyers' Southern Hemisphere Perspective. The Action Plan would be presented as 2 or 3 posters.

In the closing session we would then have Nowlin *et al.*, which could then work off all the previous talks and make the connection, finally, into GCOS, GOOS, CLIVAR and the integrated system. As an option it could be preceded by a presentation on the detail by Needler.

1.7 DECADAL-TO-CENTENNIAL VARIABILITY (by Vikram Mehta)
[This paper was shifted from its position in the announcement (6.2) to earlier in the meeting to provide further motivation and context].

**1.7.1 Outline of the Paper** (Convening authors: Mojib Latif, Vikram Mehta)

**Introduction**

Decadal-multidecadal climate variations over oceans influence climate over continents. Understanding and predictability of decadal-multidecadal climate variations very important in itself, and crucial for predicting interannual climate variations and anthropogenic climate change. A global view of ocean observations; permanence and continuity of data streams; accuracy and stability of instruments and techniques. Development of new technologies to meet challenges; data management and dissemination. Synergistic deployment of satellite-based sensors, *in situ* sensors, and satellites for data relay. Development of data assimilation systems as an integral component of the ocean observing system for decadal-centennial climate variability studies .

Observed decadal-centennial climate variability phenomena; comparison with models.
- Decadal and longer timescale variations in interannual ENSO characteristics and in interannual ENSO predictability.
- Decadal-multidecadal variations in the Pacific climate.
- Decadal variations in the tropical-subtropical Atlantic, especially South Atlantic, climate.
- "Decadal" timescale, NAO-AO-sea ice variations in the North Atlantic.
- Decadal and longer timescale variations in the Asian-Australian monsoons.
- Multidecadal-centennial timescale THC variations.

<u>Important oceanic features/processes</u>. "Red noise" response to atmospheric forcings. Subtropical and subpolar gyres. Meridional "overturning" circulations. Tropical and extratropical ocean-atmosphere interactions. Non-linear dynamics of gyres and coupled ocean-atmosphere systems. Direct and indirect response to solar variability.

<u>Data requirements</u>. Which data do we need to understand the phenomena described earlier? SST, surface stress, upper-ocean heat content, surface salinity. Subtropical gyres. Meridional 'overturning' circulations. Are the data we need to study dec-cen variability the same as those to study global warming? Perhaps yes. The major oceanographic impact of global warming is supposed to be on the THC. So, we need to measure THC-related variables for studies of both. Which data are most useful for decadal predictions? What is the role of data assimilation in understanding and predicting dec-cen and anthropogenic climate phenomena? Are accurate surface flux measurements needed? Are the fluxes produced by operational NWP centres adequate? Do we need any changes in the meteorological observing system?

Challenges. To think, plan, and implement observing systems on decadal-century timescale and 'global' space scales; to design observing systems that are flexible enough to incorporate 'course corrections'; etc.

### 1.7.2 Discussion/Reactions

This talk covered a lot of territory and provided an essential link into the coupled modelling community. The question of where it was best placed was not totally resolved; its scientific content does not fit with the opening talks (that is, it discusses specifics rather than generalities and fundamentals). It draws out the links with terrestrial and atmospheric components, e.g. precipitation, river run-off, etc. Some overlap with Leetmaa. The talk must draw out the key dependencies; long consistent records; relative value of Time Series (spot measurements) *versus* shorter global records; whether integrating measurements (e.g., sea level, thermometry) might be more useful than other measurements; whether calibration and testing of model processes is more important than testing and validation of the coupled model fields themselves.

How do we build decadal elements? Develop the right focus? It is not enough to say we need everything.

### 1.8 GENERAL DISCUSSION/REACTIONS ON SESSION 1

UNFCCC and climate change needs to be covered explicitly. Understanding and attribution need to be discussed. Dependence of trends on natural variability. Pick it up so that it directly taps into the prominent issues of today. Useful to build an image of important modes of variability and use these images (schematics) as touch-stones for later talks.

## 2. REGIONAL AND PHENOMENOLOGICAL APPROACHES (Second Session)

### 2.1 THE ENSO OBSERVING SYSTEM – AN UPDATE (by William Kessler)

### 2.1.1 Outline of the Paper

Purpose**:** Review status of ENSO observing system, with emphasis on performance during the 1997-99 El Niño/La Niña cycle. This article can be considered an addendum to the McPhaden *et al.* (1998) review article on the TOGA observing system, but with a focus primarily on the tropical Pacific.

Introduction**.** Brief review of the 1997-99 El Niño/La Niña cycle. This was the first warm/cold event that the observing system was fully in place. Definition of what we mean by the ENSO observing system: TAO, VOS/XBT, drifting buoys, tide gauges, satellites (most notably AVHRR, TOPEX/Poseidon, NSCAT, ERS, etc.). Note that since 1997, the US has been providing operational support for the *in situ* elements of the ENSO observing system based on the need for sustained support of climate forecasting efforts.

How did we benefit by having the ENSO observing system in place? Near real-time data allowed for blow-by-blow account of ENSO evolution. The 1997-1999 El Niño/La Niña cycle was the best ever documented, compared to last major El Niño in 1982-1983 which was not detected until nearly at its peak. High resolution in space and time underscored the importance of high frequency forcing associated with the Madden-Julian Oscillation (MJO) (and other synoptic forcings) on the evolution of the ENSO cycle. SST and Subsurface thermal field data were critical for initializing ENSO forecasts of tropical Pacific. SSTs, which in turn were of great value in long range weather forecasting. Real-time validation of ENSO forecasts in early 1997 built confidence in those models that were predicting a warm event (as compared to the Lamont model, heretofore the most successful forecast model, which was predicting a weak cold event in 1997). The wealth of data from the tropical Pacific greatly heightened public awareness about ENSO and its global consequences on climate and marine ecosystems. Combined with model forecasts, this awareness lead to mitigation efforts in many countries around the world.

What measurement issues were highlighted? Salinity may be important for optimizing assimilation of temperature and altimetry data in ocean models, for initializing ENSO forecasts, and for a complete understanding of processes at work in the coupled system of the tropical Pacific. Strength of the 1997-98 El Niño raises questions about relation to decadal time scale basin-wide variations involving higher latitudes (i.e., the Pacific Decadal Oscillation (PDO); and about possible interactions with global warming trends. This argues for more systematic *in situ* observational efforts in the higher latitudes of the North and South Pacific. Responses to ENSO forcing in tropical Indian and Atlantic Oceans were pronounced, and MJO originates over the Indian Ocean, emphasizing need for more systematic measurements in other tropical oceans.

<u>Future directions</u>. More salinity data are needed in the tropical Pacific to improve skill of ENSO forecasts. Technology exists, and progress is being made on developing observational strategies (TAO/TRITON, VOS, Argo, possibly satellites in the future). Japanese TRITON buoy programme is a major new observational initiative that will help secure long-term support for the moored component of the ENSO observing system in the Pacific (complementing operational support by the US for TAO), with planned expansion into the Indian Ocean in 2000. More coverage of drifters in data sparse regions such as the Indian Ocean and Southern Ocean is being implemented for improved global SST analyses. Important for understanding both causes and consequences of ENSO. Continuation of TOPEX/Poseidon quality altimeters for ENSO studies is essential; NSCAT quality winds hold promise for future observational and forecasting efforts. Integration with efforts to develop a basin scale Pacific observing system (Niiler/Davis presentation) is essential.

### 2.1.2 Discussion/Reactions

No problems of any substance with the outline/content. It will be important to emphasise the research (understanding) requirements *versus* "operational" usage. Issue of whether and when to do this talk; it is probably good as a foundation block. Subsurface data <u>is</u> essential (reference NEG report). Salinity appears to be important (for research this is one of the key issues) .

## 2.2 A TROPICAL ATLANTIC OBSERVING SYSTEM (by Gilles Reverdin)

### 2.2.1 Outline of the Paper

- Preface
- Why the Tropical Atlantic (TA)?
- Themes
  - Theme 1: SST/Surface fluxes
  - Theme 2: Sea Level/Subsurface Thermal Structure
  - Theme 3: Circulation
  - Theme 4: Modelling and Data Assimilation
- Status of the Observing System
- Recommendation

### 2.2.2 Discussion/Reactions

The presentation was based on discussions at the recent Climate Observing System for the North Atlantic meeting in Miami (COSTA) [in practice this presentation followed both PBECS/N Pacific and

ACVE]. PIRATA have agreed to extend the "pilot" another 5 years; there has been around 80 % return of data; also discussed extensions to $20^0$S, $20^0$N. Team should be encouraged to address how they arrived at justification for various arrays.

Were Observing System Simulation Experiments conducted (PIRATA - yes, others?). How done? Utility?

The point was made that all talks need to stratify/order their requirements in terms of (a) what is going now, (b) what is a practical enhancement, and (c) extra data needed for regional interests and/or process studies. The latter are strictly speaking not of direct concern to the Conference but for presentations such as this must be included to emphasise the coherency of the plans.

This presentation emphasized the need to get generic global elements on the table early in the Conference so that subsequent talks do not need to introduce them. So, for example, it is best to get global SST, winds, etc., presented early as these are fundamental to everything. The ENSO OS is an essential element of Pacific studies. Perhaps Argo has to go early if the Pacific and Atlantic (and Southern ocean) presentations are going to depend upon it.

It will be important that the "ACVE" and TA talks are consistent. Participants agreed that a separate S. Atlantic presentation is needed to complement the TA and ACVE aspects.

2.3 OCEANIC BOUNDARY CURRENTS (by Walter Zenk, Matsui Kawabe and Dean Roemmich)

### 2.3.1 Considerations for a Paper to be Prepared

This topic was introduced by Roemmich. He noted that the path forward was far from clear. He suggested the following aspects should be considered:

Crucial: - geostrophic estimates *versus* direct; frequency (minutes, hours, days, ..).

Less Crucial: - depth; horizontal resolution; salinity; distance offshore.

Given: - narrow boundary currents are numerous; suggestion that for meridional overturning, boundary currents are high priority; enhanced measurements rapidly ramp up the cost; there remain many outstanding issues (which implies it is a major research issue but, perhaps, not yet at the point where we know what should be implemented long term); and some nations have already made significant commitments.

Roemmich added that there may be a generic, cost-effective global approach that could be agreed, but it was not going to come easily. As an example, he showed the data from the HD XBT line into Brisbane: it is relatively easy data to collect. The data provide a measure of mean and variability. The question arises as to how much should be invested in supplementary direct measurements? Harrison suggested we need to address fundamentals: what measurements do we need to get, say, the budget to within 10%? These issues would need to be considered in the context of other measurement programmes/elements.

Zenk presented a table on classification of boundary currents which quite neatly showed the diversity. It is easy to conclude that there can hardly exist a universal method for observing boundary currents in the general view of the Conference. In order to demonstrate their key role in various parts of the world ocean we may restrict ourselves, say, to one surface boundary current system like the Kuroshio and possibly one subsurface case as the Northern Intermediate Boundary Current or the Deep Western Boundary Current in the Brazil Basin.

Kawabe presented some results of research on the Kuroshio current and its transport. He noted that heat storage in the Kuroshio region was large when the volume transport was large. This in turn led to large latent and sensible heat release in winter and, perhaps, a strong Aleutian Low/PNA Pattern and small N. Pacific Index. He noted that Kuroshio meanders are decadal (typically ~ 21 years). He went on to discuss the deep flow of lower central Pacific water and the fact that northward penetration of this water mass involved deep, bathymetry controlled boundary currents.

### 2.3.2 Discussion/Reactions

It was clear from these three presentations that the issue of boundary currents was a complex one in terms of the integrated observing system. For the Conference, a reasonable target might be to come to some agreement on the preferred method and sampling rates, at least as far as transports are concerned. Global heat and volume transport is not the only issue. For places like the Kuroshio there is a strong regional interest and there is an interest in short-range ocean forecasts.

Zenk and Roemmich agreed to work with Imawaki on this paper. The meeting agreed that it was an important aspect and must be addressed at the Conference as part of the global, integrated system. The following further notes were compiled by Zenk:

There was also a high degree of consensus that the Indonesian Throughflow belongs to the class of Western Boundary Currents which deserves attention in a future sustained observational system. A discussion of methods would be helpful: repeat sections (XBT, XCTD, ADCP...) *versus* integrating methods (cable, P/IES, tomography, satellite altimetry, etc.), moored instrumentation *versus* Lagrangian methods. Minimum requirements for sustained observations in boundary currents should be discussed including the need for a cost-effective way. Also a cartoon showing the boundary current problem as an observational technique with its global impact could be very helpful for the audience of the Conference. The minimum case we need to stress is the importance of boundary current measurements for integral quantities like heat and fresh water fluxes with their long-term impact on the global climate. Also more short-term effects with respect to marine forecasting were mentioned. In summary, a primary aim of the presentation in St. Raphaël would be to suggest a cost-effective way of sustained monitoring of the most important boundary currents.

## 2.4 THE PACIFIC BASIN EXTENDED CLIMATE STUDY (by William Kessler)

### 2.4.1 Abstract of the Paper

P-BECS is directed at understanding and modelling the phenomena that are observed to constitute interannual and decadal variability of climate in the Pacific basin: the ENSO cycle (especially its decadal modulation) and other low-frequency, signals such as the Pacific Decadal Oscillation (PDO). The focus of P-BECS is the upper 1000 m of the ocean and the processes that lead to seasonal through decadal anomalies of SST, upper ocean heat, salt and freshwater transport and stratification. P-BECS grows from the success of the ENSO observing system, i.e., a broadscale sustained observing network; embedded intensive process studies and enhanced measurements in important areas (e.g., boundary/equatorial currents); closely tied to exploiting assimilating models.

P-BECS is based on the perception that the next step in understanding climate variability beyond the ENSO cycle involves more than the tropics; longer timescales imply broader meridional scales. P-BECS will make ocean and air-sea flux measurements to describe this variability, integrate these measurements with other ocean observations, satellite and meteorological data, and develop and test data-assimilating models to understand the impacts of the tropical-extratropical interaction on the climate of the Pacific.

Regarding decadal variability of the Pacific, five hypotheses are offered:

- Subtropical air-sea interaction produces ocean temperature anomalies that are advected along isopycnal surfaces to the equator, where they upwell and result in equatorial SST anomalies (years to decades). This produces a rapid negative feedback *via* atmospheric teleconnections. (Gu and Philander, 1997)

- Advection of SST anomalies from the Sub-Arctic Frontal Zone (SAFZ), (primarily in the southern hemisphere) to the equator *via* the eastern limbs of the subtropical gyres (one decade). Then a rapid negative feedback through atmospheric teleconnections. (White and Cayan, 1998).

- Excitation of Rossby waves similar in pattern to, but less equatorially-confined than, ENSO. The subsequent slow propagation of these waves to the western boundary and their reflection along the equator changes the sign of equatorial thermocline depth and thus SST (decades). Then a rapid negative feedback as atmospheric teleconnections change the sign of extra-tropical wind stress curl, forcing waves of opposite sign. (Zhang, Wallace and Battisti, 1997).

- SST meridional gradient anomalies in the North Pacific subtropical gyre alter jet stream intensity, then the gyre circulation adjusts through the propagation of wind-forced Rossby waves (decades). These change the poleward advection of heat by the Kuroshio which provides a negative feedback to the SST gradient. (Latif and Barnett, 1994. Jin, 1997).

- Or is it just noise in the tropical ENSO system?

Some issues for discussion. North *versus* South Pacific (stopping at southern sub-tropical; gyre). Improvement in OGCM thermohaline structure (will assimilation do this?). How to measure subtropical water mass formation? Winter mixed layer; effect of winter storms. Air-sea heat/water fluxes.

Takeuchi presented some information on the Frontiers research programme and observations. Floats and WBC measurements were important components. ADCP measurements were a strong interest.

### 2.4.2 Discussion/Reactions

It was emphasized that the ENSO OS is a fundamental part of the OS for Pacific decadal modes. Argo and eastern and western boundary measurements are also fundamental parts; surface flux measurements were also considered a high priority. Salinity observations are critical. What is the role for acoustic tomography? Several people commented on the fundamental need for good winds with resolution adequate to estimate curl forcing. There is faith that long time scales equate to broad space scales, but there need to be intense (process) measurements somewhere to verify this.

This discussion (along with that which followed the Atlantic presentations) convinced the meeting that the original order of the papers needed to be changed. The regional interests like PBECS have fundamental dependencies on global components and/or operational elements, like SST, ENSO OS, altimetry and Argo, so it made sense that these global components be presented first. This would simplify the task since then they would only need concentrate on the enhancements which are driven by the regional interest.

These papers also emphasized the importance of providing some level of standardization among the papers. If we are to build an image of a coherent, global integrated system we must take care that it is constructed in an orderly way (i.e., the foundations 1st), with components of agreed "standard". For OCEANOBS99 this means explicit consideration of the feasibility of an element – is it ready now? A doable enhancement, with relatively certain subscription? Or more dream like and requiring substantial research? What is the level of investment required? If the audience can seem some level of discipline through the papers they are more likely to buy into the global system with trust that it is not skewed by sectional/self/local interest.

## 2.5 ATLANTIC CLIMATE VARIABILITY EXPERIMENT (ACVE) (by Detlef Stammer)

### 2.5.1 Abstract of the Paper

ACVE Implementation Aspects. The philosophy of the ACVE is to adopt a basin wide perspective in an intensive study of climate variability in the Atlantic sector on intraseasonal to decadal time scales, closely connected with a lower level effort on the meridional overturning circulation and Arctic variability. Specific objectives include understanding of phenomena (e.g., NAO) and the processes that are involved; and determination of sensitivities and interactions of Atlantic and with other processes (e.g., ENSO) primarily through modelling and paleoclimate studies. Priority Items include:

- Further development and analysis of historical and proxy data.
- Design and process studies to design the best system.
- Modelling studies to better understand the Atlantic interaction with land, atmosphere and ice.
- Ocean state estimation through data assimilation of the time evolving ocean state.

Many technical challenges with regard to ocean observations, data flow and details as how to deal with all the new observations (e.g., PALACE data) are common to both the Atlantic and Pacific basins and should be handled in a similar manner to minimize efforts and costs. The Atlantic committee suggests that in terms of products, two levels are required:

- A near-realtime product for a seasonal-to-interannual forecast purpose: this product will be of "quick-look" quality with primary intend to provide initial conditions for climate forecast runs.

- A high-quality science product: this product is a re-analysis effort, which will be updated every couple of month and will be available with several month's delay. The purpose here is to provide a continuous estimate of the global time-evolving ocean over a 10-15 year time frame and with a spatial resolution of up to 1/4 degree. Regionally enhanced approaches will be embedded in the global estimate for the Atlantic and Pacific separately to enhance regional science and data aspects there.

### 2.5.2 Discussion/Reactions

Discussion of connection of tropical Atlantic variability to NAO: is it passive or coupled? At what time scale does the atmosphere "feel" the ocean? [Point was made again that it would be nice to have a common schematic of, say, the NAO, so that people immediately recognized when that mode was being discussed.] Presentation was based on US ACVE plan; we do not think the (International) CLIVAR focus will be much different. The comments on the readiness/feasibility of needed elements followed those of the PBECS presentation. Stammer argued they were "subscribed" but the definition here might be different from elsewhere. The mooring arrays were emerging as another "commonality". There is a strong connection to COSTA/tropical Atlantic paper. The more "established/mature" should come first.

Agreement that a separate South Atlantic paper would be useful.

## 2.6 THE INDIAN OCEAN (by Susan Wijffels)

[This paper was shifted from its first session position (1.3) in the announcement]

### 2.6.1 Outline of the Paper

<u>Characteristics of the Indian Ocean.</u> Strong hydrological cycle. Warm pool with strong barrier layers. Dominant seasonal cycle. Interannual: ENSO (ocean and atmospheric teleconnections) plus other? Strong MJO variability in both the atmosphere and ocean. Decadal variability seen in SST/SLP. Little

known about subsurface. One of strongest signatures of secular SST increase in global ocean. Large source of heat and moisture for global atmosphere

Major *in situ* observing activities now. JASMINE: intensive COARE-like work in Bay of Bengal. Extension of TRITON. XBT monitoring (France, US, Japan, Australia). T/S programme - sparse. Indian mooring programme? Subtropical gyre - not really monitored *in situ*.

Co-operative Ocean Observing Experiment (COOE) pilot projects (Australia) 1999-2001. Ten profiling STP floats at ARGO resolution: NW Australia and Java. T/S/F on VOS around Australia and to Singapore.

Observing requirements. Salinity is key. Argo - at high enough sampling frequency to average through MJO ? TRITON Array. Expand T/S network. How to monitor the subtropical gyre/WBC?

Conference for GCOS/GOOS proposed for planning/implementing an Indian Ocean observing system - 2000 Perth, WA, IOC Office.

**2.6.2 Discussion/Reaction**

Participants were happy that this paper combined the motivational part (as in Leetmaa) with some detail on requirements. This would suggest however that we should carefully arrange the programme so that it suits the rest of the talks. The image is that we are near zero, with the exception of marine and some XBT lines. There is a strong need to get regional coordination and motivation, hence the enthusiasm for an observations conference. Argo would make a relatively big impact if implemented according to plan.

Following on from the "modes" discussion, this paper will introduce intra-seasonal modes in a bigger way than they have been introduced elsewhere. We probably need to get some South American input as well *via* VAMOS.

At this point in the exercise some further consolidation of the main reactions was sought. The main conclusion that surfaced was that we needed to transfer the commonalities (cross- interests) up front. The structure might then be roughly like:

- Global sustained, long-term aspects
- Regional sustained measurements
- Sustained observing system pilot projects where we have a solid plan to fill gaps
- Then integrated systems which include all aspects of the above for a region plus selected process-oriented arrays, or, have a strong reliance on the above aspects.

So the up-front contributions might include:

- Global wind estimates (remote, NWP and *in situ*)
- Surface topography (ALT and *in situ*)
- SST (remote and direct)
- Surface waves
- Argo
- Perhaps one talk on modelling and assimilation (GODAE?)
- Perhaps a talk on the generic aspects of data management, etc.
- Perhaps surface heat flux/reference sites also

The next level would be non-global basic and sustained observations:

- The ENSO OS
- Initial time-series station/observatory arrays
- Pacific
- Atlantic
- Hydrography
- Boundary measurements, etc.

There was no conclusion on this discussion other than a change was needed to ensure all papers had the impact we desire.

2.7 HIGH-LATITUDE PROCESSES AND THE ICE-COVERED OCEAN (by Peter Haugan)

### 2.7.1 Initial Outline

Introduction. General relevance of the polar oceans to climate; differing nature of Arctic and Antarctic, including ocean circulation; great salinity anomaly; thermohaline circulation etc.

Key high latitude processes. Atmospheric driving; sea ice and its interactions with the ocean; deep convection; role of freshwater (especially Arctic); hydrographic structure; shelf processes; connectivity to the world ocean (Arctic, Antarctic), etc.

Recent climatic trends and variability. E.g., Arctic halocline 'warming' and potential link to NAO/Arctic oscillation, etc.; changes in sea ice extent (Arctic/Antarctic). Greenland Sea and Labrador Sea convection, etc. Antarctic circumpolar wave; links to ENSO.

Current observing system in high latitudes and historical datasets. Including Arctic Ocean Buoy Programme, Arctic Sea Ice Thickness Programme; monitoring of flow in key locations (e.g. VEINS); counterparts in Southern Hemisphere; hydrographic section data; satellite remote sensing ( i.e., sea ice).

Needs and key variables for measurement and monitoring. Key datasets and systems (e.g., ice extent, concentration and thickness; heat and freshwater flux into/out of Arctic; atmospheric driving, etc.); relevance to climate and operations (e.g Arctic Ocean Buoy Programme); synergy with wider global observing system (e.g., relevance to/of e.g., Argo); cost-benefit appraisal; needs for process studies; required investment. Relevant international programmes (SCAR, WCRP, ACSYS, VEINS; GOOS, etc.). Future programme developments (e.g., WCRP CLIC). Relationship to measurement needs.

### 2.7.2 Discussion/Reactions

General agreement that the direction outlined is a good one. The remit was very broad which meant: (a) there was a lot to cover and (b) there was a danger of losing the good among all the (necessary) speculation. The Atlantic paper will draw into the sub-polar gyre (Labrador Sea) so this is perhaps an area which can be down-played.

The above-mentioned primary goal of a global integrated system suggests that we should not be letting scientific maturity and level of interest (size of the community) dictate the paper distribution. The participants agreed that bundling the Southern Ocean (which was becoming everything south of the sub-tropical gyres) was not in the best interest of developing a global system. The SOC agreed to explore the options for a Southern Ocean paper. As with other papers, but perhaps even more so, it would be important to clearly state what is there now (the existing "system") for climate related observations of the high latitude and ice-covered oceans, and then state what is worth maintaining long-term. Then we want a clear statement of feasible, realistic enhancements for which there should be broad consensus. One got the impression that there may be a resource deficit for the things that needed to be done, though that was when the Southern Ocean was being included.

Will the high latitude and ice-covered oceans part of GOOS/GCOS benefit from Argo? The answer is: probably "very little" in which case careful consideration should be given to an approach that will complement the impact of Argo elsewhere. The SOC would explore the possibility of a paper just on sea-ice if the authors of this paper thought that necessary.

## 2.8 WIND WAVES AND GOOS (outline from Neville Smith)

### 2.8.1 The Topics

The topics that are planned to be addressed in this paper are:

- Operational wave forecasting
- Wave observations needed to adequately define the global wave climate
- Wave measurements and remote sensing
- Waves and regional/mesoscale oceanography and meteorology
- Waves and air-sea exchange

The approach might cover science support, observing networks, data and information flow, archives/standards, quality assurance, resources, regulatory powers, technical support, administrative structures, capacity building, affiliated drivers, products, and special issues. There are strong links to surface fluxes and wind stress papers as well as links into many other OCEANOBS99 papers. The paper will be "outed" at Marine Conference in Vancouver mid-September.

### 2.8.2 Discussion/Reactions

No one had any particular problem with the brief outline. Smith noted that only very preliminary discussion had taken place on the content of the paper. Agreement on the Convening authors was reached only recently. Weller noted that McWilliams and others (including Mark Donelan) are suggesting that modification of surface current fields by surface waves may be a significant effect, thus becoming a factor in heat and freshwater transport. The WMO Vancouver meeting would provide an opportunity to test the support for recommendations (the desired observing system). That same meeting will also look at other marine data. Because of the timing this paper may have to be fast-tracked on a delayed schedule.

## 2.9 HEAT AND WATER CYCLES (by Susan Wijffels)

### 2.9.1 Synopsis of Presentation

<u>Ocean budget approaches</u>. Transport measuring hydrographic sections: WOCE one-time survey -> decadal means, limited spatial resolution, but relatively accurate large areal integrals for heat, silica conservation is a key constraint. Example - 30$^o$S in Pacific.

<u>Results out so far</u>.Most intriguing - small net freshwater flux divergence diagnosed at 40$^0$S in the Atlantic. Historically, the Atlantic has been considered a large source of atmospheric moisture. Hemispheric asymmetry in ocean heat transport is large and is now being confirmed in some of the new flux products. Global and basin results will be available in the next year or two Aliasing errors? Transport of measuring XBT/XCTD lines - e.g., high resolution Tasman Box (Sprintall and Roemmich, 1998). Flux is a residual of advection and storage (from altimeter). Seasonal to interannual timescales? Only effective where heat flux is carried in the upper ocean (< 800 m)?

Use seasonal cycle of storage to ‘calibrate’ flux estimates [pointwise]? Moisan and Niiler (1998). Done for heat in North Pacific - can it be done elsewhere? Ignores seasonal advection of heat - where valid? What about salt storage? Seasonal freshwater fluxes?

Repeat transport-resolving hydrography. How important to measure the western boundary flow? Repeat cycle that is logistically feasible? [Monitors deep tracer storage as well.] Transport resolving XBT/XCTD - more feasible, more frequent. End point dynamic height moorings (MP). Heat flux associated with MOC - not horizontal gyre heat flux, nor freshwater fluxes. Storage monitoring for assimilation into models.

Roemmich presented some material on HDX lines and contrasted the information derived from hydrographic one-time surveys and the HDX. The former get the deep and a full suite of variables including tracers. The latter are much cheaper, can be done regularly (each season) and can resolve the variability which is likely of the same amplitude as the mean. An option would be to target deeper probes (~ 2000 m) which would be a modest additional cost for HDX and forgo the extra detail that might be afforded by hydrography: the one-time surveys need to be "registered" against HDX repeats. The priorities might be: quality, high-resolution temporal sampling, ensuring no gaps (minimizing).

### 2.9.2 Discussion/Reactions

At the time of the meeting the SOC had been unable to draw a commitment to author this paper. This was in part because it was an aspect that was extremely well covered at the WOCE Conference and not a lot could be added to that. It was noted that most of the important elements (surface fluxes, boundary HD sections, hydrography, etc.) would be covered elsewhere. For the observing system, however, it was critical that the major sources of error be targeted. There is still work to be done on existing data: are we premature in seeking a consensus on the correct approach? The strategy that seemed to be emerging was:

- Combine HDX with 1-time surveys and/or surface fluxes;
- HD sampling of the boundaries (But where? How often?);
- Do storage monitoring from models.

## 2.10 CARBON CYCLE AND TRACERS (by Ed Harrison)

### 2.10.1 Topics for Consideration

At short notice, Harrison agreed to provide some discussion points based on his knowledge of US planning. Rana Fine and Liliane Merlivat have agreed to be Convening Authors. Among the key questions are:

- What has happened to the $CO_2$ already emitted by human activity? (Global budget; spatial distribution of sources and sinks; terrestrial, ocean, atmospheric roles),

- How will atmospheric $CO_2$ concentration change in the future? (Processes, prediction).

A goal is to establish accurate estimates of the oceanic carbon sink, including understanding its interannual variability, spatial distribution and the mechanisms that regulate it. (2 Gton/year ± ?? where? Why? )

A document on the US initiative is available through OGP. It is a new initiative with FY00 startups and FY01 for first major efforts. It includes terrestrial, ocean and atmospheric components.

The *in situ* ocean needs include air-sea carbon flux (year-to-year variation); repeat hydrography (inventory change); process studies (understanding parameters); time-series stations (understanding parameters, modelling). Harrison agreed that ocean colour measurements were a key aspect of their plan. Smith noted that JGOFS intended to stimulate guidance in this area.

### 2.10.2 Discussion/Reactions

In the absence of the Convening Authors or a well-qualified stand-in, the meeting was limited in what it could add. Smith noted that there had been some correspondence offline about the importance of including the tracer measurements in the hydrographic plans. The importance of tracer measurements had arisen several times.

As they stand both Sessions 2 and 1 are very diverse, perhaps too diverse, and not well enough glued together. The author guidelines will need to be fleshed out even further if the papers are to be "integrated" - that is, to reflect some of the discussion points above in the guidelines. There was unanimous agreement about turning Session 2 and 4 about (pending the presentations in Session 4); see comments above.

## GENERAL DISCUSSION/REACTIONS ON FIRST TWO SESSIONS

The most significant gaps in the first two Sessions to emerge thus far are:

- The Southern Ocean
- The South Atlantic
- Climate change.

We need to provide "standards" for proposed elements (i.e., making clear what is "now"; soon to be; and dependent on further research). Need to balance regional pull *versus* global objective. All talks in this group should address the following:

- What can we do now, and what will we be able to do with the global integrated observation system that this conference seeks? Why do we need it?
- Global background system *vs* regional enhancements, evolution, etc.
- Aspects of measurement requirements (errors, resolution): how well do we need to measure various variables to have impact on science phenomena of interest? Do we know? Would OSSE's help? Can this be articulated? If not, why not?

Evolution of the system is important so somewhere, reasonably early on, this will need to be addressed/flagged: another paper in Session 3? The lack of a commitment to the heat and water budget paper suggests we should look for alternate approaches (see later discussion with hydrography for conclusion). Need to be careful of areas where we are perhaps seeking sustained measurement networks prematurely. Should consider a (shorter) paper on Indian/W. Pacific.

Ocean intraseasonal phenomena. Temporal sampling (the inadequacy of snap-shots) is a "gap" that must be filled. New techniques: how do we anticipate? Maintain continuity? Two modes of construction: the global foundation, then sub-elements, OR, region by region. We need prioritization of the requested enhancements. At this point the role of models and assimilation has been barely touched. Should consider poster displays as a way of gluing the parts together with detail.

## 3. DATA FLOW, PROCESSING AND PRODUCTS

[Additional invited presentations here]

### 3.1 OCEAN OBSERVATIONS FOR THE NEXT MILLENNIUM: ASSEMBLY, QUALITY CONTROL, ARCHAEOLOGY, AND MANAGEMENT (by David Legler)

### 3.1.1 Outline of the Paper

Introduction (by Holliday, Bindoff): motivation; elements of a successful DM system; historical context and current capabilities; why DM is needed; what works, what does not.

Assembly: review capabilities, approaches (Freitag, Keeley, Michida, Le Traon, Gérard); models of data assembly; ocean data assembly; real-time and delayed mode and operational; climate.

Quality review (Keeley, Holliday, Legler): Why it is necessary.

Data archaeology (Levitus, Kohnke): motivation, capabilities, strategic plans.

Data access/distribution (Michida, Freitag, Zlotnicki, Legler): Issues and approaches. Current models of data access/distribution methodologies. Future approaches.

Data management (Webster, Wilson, Keeley, Legler): Information centre. Coordination. Systems monitoring. Interaction with operational and research units.

Data management model for future ocean observing systems (Legler, Bindoff): Scope, structure, management, needed resources, participants, sustainablity.

### 3.1.2 Discussion/Reactions

A view that seemed to be generally held was that cramming all the mentioned aspects into one paper was going to be too much. If the rule of thumb is that 10% of the effort needs to be devoted to this area, then we should have at least one more paper. The present structure draws greatly on WOCE experience. The operational oceanography and seasonal forecast systems which exist now (e.g., the JCOMM) need to be increased attention. Things like the GODAE server at Monterey, practices being developed for JCOMM, handling of satellite data, and "proven" systems like TAO should probably be the core since we are looking toward the sustained components, not the experimental/research components. Also the DODS-like future. Things like data flow rates versus existing capabilities, the cost of telemetry and other information transmission, etc. need to be brought out.

Just as for other papers, we are trying to show what parts we believe are invaluable and exist now; what parts should be the immediate enhancements; and what needs to be developed. This is a huge task for one paper.

Metrics, system evaluation and monitoring, etc. need to be considered also. Where are the bottlenecks? Where is investment warranted? Metrics - some specific examples should be mentioned - e.g. tide gauge data, satellites, upper ocean thermal, hydrographic, etc. Model products; satellite data. Perhaps one option is to have one focus on the preferred structure of a fast route, and one paper focus on the slow route (archaeology, scientific QC, etc.).

3.1a DISTRIBUTED OCEAN DATA SYSTEM (by Peter Cornillon) [not discussed]

## 3.2 DEVELOPING A NEW PARADIGM FOR OCEANOGRAPHY
(by Neville Smith and Chet Koblinsky)

### 3.2.1 Topics for Consideration

Smith offered the following topics around which a paper would be developed.

Oceanography is entering a new era. Seasonal-to-interannual predictions now; decadal effects being contemplated; impact of climate variability on various sectors, e.g., energy industry, acknowledged. All these suggest a maturing oceanographic sector. The ENSO OS is under sustained funding and attracts many users: operational, long-term, continuing. Research programmes are more multi-disciplinary, multi-faceted: sophisticated observational requirements. New ways are emerging for accessing information, both for research (e.g., Distributed Ocean Data System (DODS) and operations (e.g., the GODAE server). Post-WOCE, JGOFS era: Argo, Carbon initiative. New partnerships and implementation mechanisms are emerging: the JCOMM and POGO; a more effective relationship with CEO and remote sensing agencies.

Science *versus* and Applications/Operational. Science "works off" the basic plus the sustained observing system: system is there for all, not just specific projects/programmes. Science provides guidance, direction and discipline. Science and operational oceanography are foundering new partnerships of mutual benefit. All contribute to a sustained OS of wide and general benefit. The OS enjoys wide support and consensus from the community (we hope). But it is not a fixed partnership: science and operations work together and their respective roles evolve and change.

All have a role to play. Originators (of data), assemblers, processors (models, assimilation, forecasts), users, resource managers, all have important roles. It is a "classless" community: credit should be, and be seen to be, attributed to all involved in the observing system. All should feel ownership and enjoy credit, not just the last in the line. The users will often be "middlemen", groups who had value and work with the real customers. That is their business – ours is the oceanographic system.

Circulating information. Making information freely and widely available. Better and smarter data assembling strategies and interfaces, e.g., Distributed Ocean Data System (DODS). Centralized, enhanced capability data servers (e.g., the GODAE data server).

Changing modes of operation. Those agencies concerned with direct and indirect observation of the ocean are changing their mode of operation. For example, CEOS is actively trying to adjust to oceanography as a key theme. Lindstrom, Fellous and others have been looking at the likely issues for the next decade; these include:

- Developing mandates to operate and maintain long-term ocean and climate observations;
- National and international policies guiding the timeliness and necessity for transition of measurements;
- User groups for operational ocean products must be cultivated and consulted;
- Consideration of the constituency in the coastal zone;
- Technological development for ocean research *vs*. potential future as operational instruments;
- Data systems must be reconfigured to optimize delivery of data and data products;
- Every effort to enable wide availability of data;
- An operational system design to minimize single points of failure within the system;
- The relative roles of the government and commercial sectors;
- Personnel and skill requirements for maintaining an ocean observing system;
- Developing a new paradigm. Sensitivities and the history of debate about free and open exchange of data has a long, long history. WMO Resolution 40 provides one element; Principles of GOOS. History of oceanography and the new demands.

It will require unprecedented cooperation and good-will to establish a new paradigm. But, there is a rich array of examples where such a mode has been effective including TAO, the sea level network, real-time and delayed mode data from TOPEX/Poseidon.

From the product side, the examples include Reynolds' SST from NEP. ECMWF re-analyses and the Levitus analyses. Ready access to operational products suggests that the community has accepted, and enjoys, the wide benefits of working in this way.

### 3.2.2 Discussion/Reactions

The meeting participants were comfortable with this approach (with the caveat that the authors may have different emphases from those chosen by Smith and Koblinsky). The meeting agreed that this was an important paper for the Conference. Was its present scheduled location (just before the first of the round tables) appropriate? Most thought not, though the D&IM papers were probably the most relevant. With the probable rearrangement of Sessions 4 and 2 it may be this discussion will fall on Thursday anyway, which would be good.

The essential issue as far as the Conference is concerned is making data and product access as open as possible. The outline above did not discuss resource management; the new paradigm will include a change in the way resources are managed and allocated for ocean observations, e.g., on addressing conversion of some satellite systems from research to operational mode. Do we need to differentiate between public observations that are part of global integrated array and research measurements that are proprietary?

## 3.3 ROUND TABLE NO. 1 - A NEW ERA FOR OCEANOGRAPHIC DATA SHARING AND AVAILABILITY

For the participants at this joint UOP/OOPC meeting at least, the "new paradigm" was not an issue that required long debate. All agreed that cost must be addressed by the Conference. In the Guidelines "needed investment" was mentioned but all authors will need to be encouraged to treat this in a similar manner. The Conference is not after detailed costs but indicative numbers. For systems like TAO and Argo, reasonable estimates are available. Where a resource is shared, or only partly utilized (e.g., a ship for mooring service or a satellite that does more than oceanography), a *pro rata* estimate will suffice. The main purpose is NOT to target areas for cost cuts but to build up a reasonable image of the investment that is being sought. Everyone needs to appreciate that this investment is considerable and that investments large and small are all important for maintaining the global system.

The D&IM section does not bring out system evaluation very clearly, particularly intercomparison of model output. The power and value of metadata needs to be explicit. Maintenance of good meta-databases does not come free. We need to emphasise even more the power of integrated data sets. Perhaps we cannot wait until Session 6 for this to emerge.

The overall coherency remained an issue, something the SOC will just have to address. Need more attention on the products/outputs of the system and their sensitivity to the D&IM system. Errors on data – how are they to be handled?

We have greatly expanded what is being asked of the D&IM paper. Options include (a) adding a 2nd paper, (b) coordinating the presentation with demonstrations and posters, (c) splitting the paper into the "fast" and "delay/scientific" elements.

Is session 3 in the right place (probably not). Metrics/evaluation need to be there. Paradigm paper should be toward the end of the Conference.

## 3.4 PARTNERSHIP FOR OBSERVATIONS OF THE GLOBAL OCEAN (by Lisa Shaffer)

At an exploratory meeting March 8-10, 1999 in Paris at IOC, participants agreed to create a new forum, called the Partnership for Observations of the Global Oceans (POGO). The Partnership brings together major marine research institutions in the world, at the level of decision-makers who can commit resources, to join forces to ensure that implementation of global programmes is done efficiently and effectively. By considering the needs of multiple disciplines, including climate and biodiversity, and by working across international boundaries and with existing international organizations and scientific programmes, global ocean observing programmes can be implemented in a way that increases the societal return on the investment in ocean observing infrastructure.

There are many international groups and organizations that participate in oceanographic research and coordination. POGO is unique in that it brings together the implementing institutions at the level of the Director (i.e., the senior decision-making authority). POGO participants will be able to make commitments on behalf of their organizations and give new direction to their programmes in response to common needs and collaborative strategic planning. POGO is not a group of governmental institutions addressing policy matters. It is not a group of scientists debating research or establishing scientific priorities. It is a group of institutions that receive the funding and the obligation to make things happen. These institutions design sensors, invent technology, build climate models, study marine biodiversity, conduct research on the global carbon cycle, operate ships, and teach students. They deploy buoys and floats, they maintain moored platforms, they collect specimens, they operate experimental aquariums, and they operate laboratories. They are not constrained by the political processes that control formal intergovernmental deliberations in the United Nations system. POGO will be a place for informal, but structured dialog and an emphasis on decisions and actions. The group agreed to convene its first formal meeting in December 1999, at which time participants would agree on the Charter, Mission, and Terms of Reference, along with an initial plan of action. The outcome of the meeting in Saint Raphaël will be an important input for the first POGO meeting. The hope is that POGO can contribute to the efficient implementation of the observing capabilities being defined and debated within OOPC, UOP, and other groups.

As the nature of scientific inquiry and the capability for global monitoring expand and evolve, institutional structures and relationships need to change as well. POGO is meant to facilitate communication and coordination among the various participants, focusing on concerted action and implementation issues, without regard to the institutional character of the participating entities. POGO also has obtained and will continue to seek funding from non-government sources for global ocean observing. These resources can provide important support for elements not easily funded within existing governmental mechanisms. POGO offers its services to UOP and OOPC and the Saint Raphael meeting participants as well move toward achieving an integrated, sustained capability to observe and understand the world's oceans.

## 4. SPECIFIC CONTRIBUTIONS TO THE OBSERVING SYSTEM

### 4.1 CURRENTS AND OCEAN CIRCULATION (by P. Niiler)

#### 4.1.1 Topics

In Niiler's absence, Koblinksky went through the topics to be included in this paper. They fell under two categories.

Present Situation. Direct observations of basin scale circulation were made in WCRP in 1988-99 with drifters, floats and ships. ADCP and moorings – techniques are well developed. Mean sea surface currents and surface eddy energy estimates exist for about 80% of the globe. Seasonal and interannual variability for the tropical Pacific. Indian and Atlantic observations will continue. Basic assumptions of circulation theory can be tested – such as Sverdrup vorticity balance in the tropical Pacific. Absolute sea level can be estimated for the Pacific Ocean from momentum balance to 1-2 cm uncertainty with model of wind momentum convergence that is derived from vorticity balance. Eddy heat convergence on Pacific equator is comparable to mean convergence. Altimeter eddy energy is equal to observed energy only if satellite data is filtered over an increasing length scale toward the tropics.

The Future Needs. Global survey of circulation must be completed: tropical Atlantic and Indian Oceans and sub-polar Pacific not yet done. Observations of circulation, together with altimeter data, are most cost effective way for determination of the geoid or the reference level. Model testing is at infancy. Simulation of circulation is the "acid" test of models. Decadal climate phenomena are in advection-diffusion balances for conservation of energy and material. Correct advection (and diffusion) tests of models are crucial for correct climate models. Circulation observations are the basis. Circulation observations can be utilized with ancillary data. These must be part of observations of the mass and flux fields. New technology is emerging, e.g., MiniMet, Gliders. Ideal surface circulation, SST, SSS, "Flux" array is 1000 drifters. About 700 now in the global ocean.

### 4.1.2 Discussion/Reactions

The outline as presented was perhaps too focused on the surface circulation. It will be important to pick up aspects related to moorings, floats (ALACE, etc.,), indirect estimates from altimetry), and so on. There was some disquiet about emphasizing the possibility of absolute sea level determinations from surface drift 2000-3000 floats and/or gravity measurements. There would unlikely be consensus if this was floated.

Weller noted that McWilliams and others (including Mark Donelan) are suggesting that modification of surface current fields by surface waves may be a significant effect, thus becoming a factor in heat and freshwater transport. It was not immediately clear when in the Conference this topic should be covered. The surface drift part is close to a global fundamental/needed network. The subsurface measurements (advection) might be best placed next to discussion of budgets and transports. The SOC should consider this.

Where are we headed with global synthesis of ocean currents (WOCE work, potential future direction with global obs.)? Emphasize importance of circulation estimates for climate. What are errors anticipated? Highlights to emphasize: Ekman currents, tropical maps and fields; What have we learned, what will we learn on larger scale?

Short-range ocean forecasting is a significant user for upper ocean current data; this non-climate aspect could be a strong selling point. For climate, the measuring the contribution of Ekman currents in transport of heat and freshwater is a clear priority; this did not emerge strongly from the outline.

4.1a UTILIZING HISTORICAL DATA: A NEW PERSPECTIVE FOR UOT (by Syd Levitus)
[An invited presentation here]

4.2 ARGO, THE ARRAY OF PROFILING FLOATS (by Dean Roemmich)

### 4.2.1 Outline of the Paper

What is Argo? The Argo network is a global broad-scale array of profiling floats. Its primary aim is to measure the physical state of the ocean (T, S, u) on climate-relevant scales and for data assimilation and initialization of seasonal-to-interannual forecasts. All data will be reported in real-time.

The design of the Argo (Why?). Draft Plan will have salinity section enhanced. Salinity measurements are critical for understanding the climate-relevant dynamics and thermodynamics of the ocean and for assimilation of altimetric (surface topography) information.

Implementation issues and national plans. There are several outstanding deployment and technical issues. Argo is not a complete ocean observing system. It will not measure, WBCs, deep ocean, air-sea fluxes, geochemical tracers, etc.

The anticipated accomplishments of Argo**.**

Argo's role in the integrated global observing system**.** Argo is the binding glue for the global system.

### 4.2.2 Discussion/Reactions

It is clear that Argo is being considered as a fundamental aspect of regional and global plans (Pacific, Atlantic, ...). Like the ENSO OS, it should perhaps go out front to allow dependent talks to work off it.

## 4.3 TIME-SERIES STATIONS (by Robert Weller, Send *et al.)*

### 4.3.1 Outline of the Paper

What is this paper covering?
- Moorings: surface, subsurface
- Repeat occupation, shipboard AUV
- Bottom mounted (OBS, electric field, float park, ...)
- Relationship to remote sensing (satellite, acoustic)

Why are TS important?
- An essential element of a comprehensive integrated ocean observing system
- Attributes – high temporal and vertical resolution, capable of supporting many concurrent, colocated measurements
- Rationale – surface forcing, water mass transformation, transport, and the resolution, understanding and parameterization of ocean processes.
- Heritage – Ocean Weather Stations, BATS, HOTS, etc.
- Technologically mature: communication, mooring technology

How to do?
- Mooring types, moored sensors – salinity, T, V, biogeochem
- Data delivery – satellite communications, inductive modems
- Bottom mounted
- Acoustic
- Comparative costs

Where?
- CLIVAR: transport, water-mass transformation, process study, interior ocean, surface flux
- TAO, PIRATA
- GOOS
- Coastal / WBCs.

### 4.3.2 Discussion/Reactions

The biggest challenge seems to be to convince the community that such approaches are cost effective and scientifically defensible. For surface reference sites there does not appear to be any dispute.

For subsurface T-S there is some doubt. The major issue is cost, so this cannot be ducked at the Conference. The Atlantic seems to be the first priority: the integrated plan for Atlantic variability seems to mount a very appealing case for the inclusion of several time series stations. Several of these already have strong national commitments. Outside these areas there are also good cases put for particular sites: PAPA and the subtropical site in the N. Pacific. KERFIX near Kerguelen. And so on. This paper should carefully build from these solid "bases".

A critical point will be whether you can mount a convincing case for a long-time series at a single point is a good method for capturing temporal variability on long-time and large space scales. It is an approach Levitus used to good effect in his talk.

Cost of surface reference sites is an issue. Cost/benefit ratio appears to be too high (for oceanography alone). What can be done to reverse this? What studies would this team recommend?

This paper is an excellent example where we need to get the order right. The time-series presentation needs to come in after we have the global-spanning pieces in place. T-S approach the task from a very different angle so we need to ensure the complementarity is obvious and appreciated.

4.4 HYDROGRAPHIC SECTIONS (by John Toole)

### 4.4.1 Topics

Time-series data. The traditional approach was ship-based hydrographic casts. The new approach uses moored instrumentation (with ship-based measurements at times of mooring- service cruises).

Repeated sections. To complement moored instruments and profiling floats. Done by traditional, high-resolution hydrographic casts coast-to-coast and high-resolution XBT/XCTD lines from VOS.

Repeated basin-scale surveys. Full-depth hydrographic casts with extensive water sample analysis.

### 4.4.2 Discussion/Reactions

The meeting concluded that we should merge the relevant parts of the heat and freshwater cycle paper with this paper. The break-up would now be:

- Boundary current paper to cover transports in W/EBCs,
- Large-scale transports to be covered in hydrography paper which would now be grouped with the measurements papers,
- Inventories to be the focus of the carbon/tracers papers.
- Argo, TS papers also to cover important measurements of the heat and water cycles

At this point, there is not a consensus on what we should be doing now; as needed enhancements; or in the future. We have only imperfect notions of the way hydrography will contribute to the global integrated system. This is a major challenge for the authors with the time remaining before the Conference. There is also a big challenge to make the benefits of hydrography tangible; what does it bring to the sustained observing system that is important enough to demand long-term commitments? There are obvious strong links with the boundary currents and carbon/tracer inventory papers. This then raises the question of the best spot for the paper so that it is able to have greatest impact.

As has been emphasized many times before, we will only get consensus if the rationale and cost-effectiveness arguments are strong. It is in no one’s interest to over-play or under-play the role of contributions. If it is over-played we run the risk of not getting any support. If it is under-played the global system is weakened. Both OOPC or UOP are keen to have a strong hydrographic component. The climate change connection may be very important for establishing this role. George Needler has volunteered to act as a go-between for the hydrography, carbon/tracer and BC papers.

## 4.5 SAMPLING THE OCEAN WITH ACOUSTICS (by Carl Wunsch)

### 4.5.1 Main Points

- Combined with upper ocean measurements (XBTs, PALACE, etc.), tomography is exceptional in its ability to detect changes in the abyss. A danger for global oceanography is that the observation systems will by fiat declare the abyss to be either unmeasurable and/or uninteresting. It can become a self-fulfilling prophecy (as did occur in the Pacific hydrography).

- Acoustic sources become a public resource for either anyone who wishes to listen to do tomography of their own, or to track floats. The tomography community is being encouraged to try and produce an integrated strategy, e.g. with the float community.

- Tomography is not the only technology where one can anticipate that further engineering development will occur. A danger for global semi-operational systems is that they freeze their technology and are unable to take advantage of improvements as they occur.

### 4.5.2 Discussion/Reactions

Wunsch focused on the large-scale, low-frequency variability. He did not cover the many other applications of acoustics. Everyone seemed content with this focus. The Conference will open with the "primers" which will identify the important drivers as far as GCOS/GOOS and CLIVAR are concerned. The links to these goals need to be clear and easily appreciated. In the present CLIVAR IP, only links to regional arrays are given any prominence. In OOSDP it is mentioned as an emerging technology.

Both OOPC and UOP believe acoustic tomography should be considered. But how should this be done? The most likely way is to find an increment to the existing observing system that is feasible (i.e., there is likely to be someone who wishes to do it) and makes sense in terms of the overall plans. Wunsch suggested the Labrador Sea (for convection); the Indian Ocean (because of regional interest); under sea-ice (one of the few methods available).

There remains considerable skepticism about the cost-effectiveness of global sampling. Whether or not this is justified, we certainly do not wish to go to OCEANOBS99 with a stance that is not going to attract support. If the authors believe global tomography is ready, either for doing now (i.e., people are already committed to it) or as a near-term enhancement, then the cost-effectiveness will have to be addressed explicitly. Otherwise, we are better off putting strong support behind regional enhancements like, say, the Labrador Sea, and being content to get the technique operating as part of the sustained observing system (rather than risking all on the global approach).

What observations could be delivered as public data to user community? How timely/fast could these obs be made and delivered? The meeting reached no conclusions on the above – the challenge remains with the authors to provide a convincing case. This is the same challenge that faces all papers. We need to decide how acoustic methods are to be included in the network

## 4.6 UPPER OCEAN NETWORK (by Neville Smith)

### 4.6.1 Outline of an Upper Ocean Study

Smith reported on a study to be supported by OGP and BoM on behalf of OOPC, UOP and IGOSS

SOOP. He addressed the following topics.

Why measure the UOT&S? Why this study?
- The ship-of-opportunity programme was developed by TOGA, WOCE;
- Operating in the presence of TAO, altimetry and improved models and assimilation ;
- Argo;
- More mature understanding of contributions by HDX;
- It is time to renovate the design.

The approach to the study
- Compile consolidated account of UOT database;
- Produce consolidated "maps" of information content;
- Document practices: assembling, quality control and distribution;
- Document "value adding" processes;
- Provide quantitative assessment of all SOOP lines against scientific objectives;
- Provide a renovated SOOP (UOT) plan;
- Produce a Report for a Workshop (for OCEANOBS 99).

Scientific issues
- Transition of broadscale in the presence of Argo;
- Future of frequently repeated lines;
- Future of high-resolution lines;
- Altimetry and UOT sampling;
- Data for initialization, e.g. ENSO;
- Salinity;
- Data assembly, value adding, etc.;
- Retrieving and renovating the UOT and salinity database.

The objectives
- Mean and monthly climatology of heat content, upper ocean structure;
- Variability of the upper ocean;
- Initialization of operational/experimental S-to-I (seasonal to interannual) models;
- Understanding tropical variability, predictability;
- Heat and mass transport;
- Trends and climate change;
- Ocean state estimation and model testing.

Where might we be headed?
- More selective SOOP; it remains an effective tool;
- Extra focus on frequently repeated lines in boundary regions and across zones of greater variability;
- Build in HDX as a strategy for transports; consider making frequently repeated HDX;
- De-emphasize broadcast in regions of expected good Argo coverage;
- Streamlined data assembly, QC, .. System;
- Put case for high level of scientific QC for climate change applications;
- Be conservative to preserve integrity of climate data set.

### 4.6.2 Discussion/Reactions

Some thought the study was (too) ambitious; others thought not. This paper was one of the first to begin addressing the integration and complementarity explicitly. It had been positioned in the programme next to the round-table with this in mind. Several people emphasized how critical it was that the Conference be seen to address such issues. There are obvious strong links through the HDX lines to boundary currents (BCs) and heat and freshwater transport. The Argo and T-S papers are also important. Use the thermal study to indicate how SOOP might be adjusted in the presence of TAO, Argo and other measurements.

## 4.7 ROUND TABLE NO. 2 - TOWARDS AN INTEGRATED *IN SITU* NETWORK

The theme of this round table is integrated *in situ* networks with a focus on upper ocean measurements (the papers above) and emerging technologies.

To assure an appropriate focus for this round table, it is extremely important that this session convey the benefits of integration and the global system: satellites (for x and y); Argo, TAO, etc. give us T, S(z); other elements cover the edges (BC arrays), deep (hydrography), etc. We must explain the benefits of complementary systems; not just gaps, but the fact that the sum (benefit) of x and y together is greater than the sum of the benefits of x and y alone. We must encourage inclusiveness and allow for important redundancy where resources permit. Models and assimilation are a critical "glue"; without the assimilation papers the round table here might lack key information. Cartoons were suggested to show the global system before and after each "part". Summarizing, the preferred structure for papers is:

- Short introduction on WHAT this paper is and is not concerned with;
- For global (cross-cutting) need explicit links into a subset of the "drivers"; try to avoid representing the same driver in different ways;
- A discussion of WHY this element/area/perspective is relevant and important;
- HOW this area/element/perspective is going to be done/enacted/implemented;
- Specifics of WHERE/WHEN observations will be taken;
- SCHEDULE: what to be done now; enhancements; future needs and evolution (the latter is the link into the evolution session);
- Links into system: what does this part do for the global system; what dependencies does it have on other parts of the global system;
- Focus on contribution to global network; integrated; sustained;
- Forego comprehensiveness to increase focus on the "winners"/gems.

## 4.8 SURFACE TOPOGRAPHY AND SEA LEVEL

### 4.8.1 Outline

The outline for this paper will be a product of the sea level workshop.

### 4.8.1 Discussion

Sea level pressure is needed to get the best out of altimetry. G. Mitchum is likely to use the sea level workshop as the starting point. Where remote sensing is concerned, we need to have very clear statements on the preferred initial system (e.g., Jason, + ENVISAT), the desired enhancements (e.g., ERS-like + B/U Jason?), and, most importantly, the future evolution.

## 4.9 SURFACE WINDS AND SURFACE STRESS (by David Legler)

### 4.9.1 Outline - Mike Freilich

<u>Brief summary of required data characteristics</u>**.** Emphasis on space-time resolution and classes of climate phenomena problems that can (or cannot) be addressed given various resolutions/accuracies.

<u>Potential remote sensing approaches</u>. Active *vs* passive. C-band scatterometers and Ku-band. Scalar (magnitude) *vs* vector wind.

Overview of entire suite of planned missions.

Point measurement accuracies. Neutral wind velocity and direct stress from scatterometers. Basic accuracies, magnitude and direction. Subsidiary effects and associated errors (e.g., waves and rain). Validation Techniques.

Sampling errors and effective resolution. Individual mission capabilities. Joint mission capabilities - multiple co-orbiting instruments are required to produce statistically valid, accurate fields with required high space-time resolution.

Real and potential roles of international operational agencies.

### 4.9.2 Discussion

Remember to fold *in situ* considerations, e.g., TAO.

## 4.10 SEA SURFACE TEMPERATURE AND SALINITY (by Richard Reynolds and Gilles Reverdin)

### 4.10.1 Topics to be covered

Present *In Situ* Data. VOS, Drifting and Moored Buoy (does NOT report SSTs each synoptic period to save ARGOS costs).

Present Satellite Data. NOAA-14 - satellite-skin tuned to buoy-bulk temperature. Separate algorithm for day and night.

Seasonal/Interannual SST Analyses (operational) (Analyses included in OOPC/AOPC SST working group). Resolution: time: weekly, space: 1$^o$; accuracy in tropics: 0.3 - 0.5$^o$C. Present Status: (1) requires continuation of buoy network (especially TAO); (2) bulk-tuned satellite data with real-time bias correction needed to maintain full 1$^o$ resolution.

Decadal/Centennial SST Analyses (operational) (Analyses included in OOPC/AOPC SST working group). Resolution: time: monthly, space1 to 5$^o$; accuracy: 0.1$^o$C on 10$^o$ grid. Present Status: observational system has gradually improved over the historic period; accuracy problems with system in extratropics. Limited *in situ* data in Southern Hemisphere extratropics. Uncertainties in the processing procedure for *in situ* data. Difficult to correct bulk-tuned satellite data due to sparse *in situ* data. Improved satellite bias correction procedure being computed at NEP. Inadequate accuracy in high latitudes. Limited *in situ* data and satellite data in high latitudes. Augmentation of SST obs using sea ice concentrations has problems because ice concentrations are uncertain and the model for climatological conversions is statistical and based on climatology.

Daily SST Analyses (under development at NEP). Resolution: time: daily, space: ½ $^o$; accuracy: 0.5 - 1.0$^o$C. Present Status: diurnal signal is noise. Differences in depth of bulk SSTs is ignored. Daytime satellite data can show strong diurnal signal. Tuning between bulk and skin T breaks down. One satellite cannot properly resolve daily diurnal signal. Daytime satellite Ts are eliminated when wind speed < 3 m/s. Present satellite bias correction must be computed on a minimum of a weekly time scale. Future Improvements: Add morning polar orbiter (NOAA-15); add US GOES satellites (coverage much better, diurnal signals can be resolved, diurnal biases, present), future versions will not have required dual channels. Add additional satellites: ATSR (dual look can eliminate biases, algorithm is skin not bulk), TRMM (microwave, low latitude orbit), and other planned satellites.

GODAE SST Analyses (planned). Resolution: time: 3 hours, space:10 km; accuracy 0.1 - 0.2° C. Present Status (not operational). Future Improvements: Diurnal signal is CRITICAL; *In situ* data: all *in situ* data (especially buoys) must reports at least 8 times daily and metadata (including error characteristics) must be available. Satellites: all geostationary satellite needed; multiple Polar-orbit data needed (IR + microwave). Conversions: accurate global SST algorithm needed to convert between bulk and skin; bulk conversions needed [i.e., ship (2m) and buoy (0.5m)]. Additional procedures: work directly with satellite radiances. Use model for skin *vs*. bulk, aerosols dynamics.

#### 4.10.2 Discussion/Reactions

We wish to focus on the positive contributions from SST measurements to a whole range of climate and other oceanographic problems; we should not take for granted that SST will be given high priority. This is probably not the forum to leave a whole lot of technical issues on the table (they will not be resolved by the Conference) nor to discuss in detail future plans, like GODAE. The GODAE SST Analyses and the Daily SST Analyses sections (above) can probably be combined and have only the really clear (and most promising) developments alluded to. Conversely, where the issues have to do with the "system" they should be discussed in the mode of "opportunities for collaboration or integration”. The remote sensing of sea-ice is an important link.

### 4.11 ROUND TABLE NO. 3 - TOWARDS AN INTEGRATED LONG-TERM REMOTE NETWORK

Should we consider inserting an integrating (model) paper to encourage consideration of (focus on) the whole rather than the parts? Re: cost: what is the most effective way to incorporate consideration of needed investment without diverting attention away from the value delivered? Do not need precise accounting but should provide something indicative. For the SOC: Do we have the right balance? The contributed papers give us an opportunity to increase the focus in certain areas. How do we ensure that focused/process work is advertised as a critical element of the evolution of the sustained system.

How do we ensure continuity with the technology sessions and the main business? How should we position the discussion of regional implementation relative to measurement discussions, e.g., ENSO OS, PBECS, ACVE, etc.? How should we position satellite observations relative to *in situ*, again to ensure we are presenting the global system as the target, not the individual bits?

## 5. EVOLUTION AND THE FUTURE – EMERGING TECHNOLOGIES

Presentations considered here consist of potential papers -- papers to be encouraged.

### 5.1 NEW PLATFORM TECHNOLOGY FOR SUSTAINED OBSERVATIONS (by Gwyn Griffiths *et al*.)

#### 5.1.1 Topics

The topics covered in this presentation are:

- Moore’s Law applied to AUVs?
- 2D - 4D AUVs - a family of platforms
- Industry drivers for low cost observations
- Science Drivers: Long sections
- Process studies
- Polar oceanography
- Observatories
- Sensors

- Communications, Energy
- Costs and Legal Issues

**Summary**: Rapid pace of technological advance in vehicles & communications; sensor development slower. Propelled vehicles energy cost *per* km of order $0.50 likely to be achievable in next decade. Glider cost-*per*-profile similar to XBT if amortized over 5000 profiles. Jury still out on the reliability of vehicles, feasibility of commercial builds, operational overheads, long-term data quality. Continuing engineering trials and process study experiments will provide more experience. By 2003: powered AUV range > 2000 km; depth > 3000 m; gliders proven to 5000 km; docking routine.

### 5.1.2 Discussion/Reactions

The meeting participants seemed happy with the content. It did focus on Autonomous Underwater Vehicles (AUVs) rather than some other areas such as moorings, acoustics, marine measurements, etc. But AUVs do seem to represent the new direction. At the end of his talk Griffiths mentioned the float-park idea presently pursued by the float group in Kiel. They have developed and successfully tested RAFOS floats that can be preliminarily moored at the bottom where they "hibernate" until their mission starts by release from the anchor and the ascend to their observational depth. The principle, featuring dual-release floats, allows individually delayed starts of Lagrangian observations at identical sites. This cost-effective method can build up Lagrangian time-series of temperature and currents at remote or temporarily ice-covered regions, if adequate insonification is available.

Computing and infrastructure are missing. It is important that the technology discussion does not start too far away from the proposed sustained elements. That is, the Conference is looking for an indication of where the next generation enhancements might come from. Griffiths' own view was that gliders might provide this which does connect nicely with the Argo presentation.

Referring to the research ship fleet: is this a strategy that is disappearing or is it emerging (e.g., for sustained hydrographic sections). At present a single session on emerging technologies is scheduled. This is going to limit what can be presented. Yet it is an area of immense interest. Can demonstrations and posters fill the gap? The SOC should consider options.

## 5.2 EMERGING EARTH OBSERVATION FOR SUSTAINED APPLICATION
(by Johnny Johannessen)

### 5.2.1 Overview of the Paper

The presentation started with an overview of Earth Observation capabilities divided into the following categories: kinetic, thermal, hydrological, biological and cryospheric. It pointed to strengths and weaknesses within each of the categories. Some examples:

<u>Thermal</u>. The lack of passive microwave observations of SST at relatively high spatial resolution (i.e., 25 to 50 km) with the advantage of being cloud independent;

<u>Hydrological</u>. The lack of surface salinity observation as well as precipitation at higher latitudes and subsequent possibility to better constrain the evaporation minus precipitation budget;

<u>Kinetic</u>**.** The lack of knowledge of a precise and high resolution marine geoid that would lead to new and advanced opportunities for utilizing satellite altimetry to estimate the "steady-state" mean sea-surface topography as well as the time varying component, and in turn provide better ways for determining the ocean mass and heat transports;

Cryosphere. The lack of sea-ice thickness retrievals which would allow more accurate estimates of the sea-ice-volume fluxes and associated importance of the fresh water flux for the thermohaline circulation at higher latitudes.

Disregarding the above limitations of the currently operating satellites and those which are approved for the next 5-7 years, continuity seems likely for observations of some fundamental quantities such as:

- sea surface topography from altimeter;
- near surface vector wind and associated wind stress;
- sea surface temperature;
- sea-ice extent and concentration;
- ocean color (and surface Chlorophyll A);
- surface wave spectra.

As Earth observations from satellites are limited to surface observations, the importance for integration with *in situ* (surface and sub-surface) observations and coupling with models and assimilation tools was EMPHASISE in the context of the Ocean Observing System. The presentation continued with some review of future plans for new Earth Observation methods. In particular, this included the complementary gravity field observing satellites (ESA-GOCE, and NASA/German GRACE). These could provide new and important observations of the marine geoid to 100 km resolution and 1 cm accuracy, as well as temporal changes of the bottom pressure over about 500 km regions at 30-60 days time intervals. Ice thickness retrievals from radar altimetry may prove practical using along track synthetic aperture processing and across track interferometry (two antennas) aiming at vertical precision of about 5-10 cm averaged over 50 km cells. An interesting opportunity for complementarity, between NASA's ICESAT (GLAS) to fly in 2001 and ESA's CRYOSAT to fly in 2003, was also addressed. Efforts toward sea surface salinity retrievals using passive microwave L-band (1.2 GHz) are aiming at an accuracy of 0.1 to 0.2 psu over 200 km cells at 10-20 days interval. As such, this would meet the requirements specified in GODAE. Such a system now seems feasible (ESA's SMOS mission), although there are challenges associated with corrections for SST diurnal variations as well as diurnal and daily wind speed variations.

In this context it was also mentioned that the Indian Space Agency is about to launch Oceansat 1 flying a passive microwave system (6.6, 10, 18 and 23 GHz both V- and H- polarization). As this gives very important data for SST observations (as discussed above), it would be very timely if the Indians would allow the scientific community to access these data. It was therefore suggested that perhaps an official request for regular access to these data should come *via* OOPC to CEO.

In closing, the continuity aspect of Earth observations was again EMPHASISE. In this context the importance of the collaboration of EUMETSAT and NOAA with ESA and NASA was mentioned as they are responsible for the transfer from an experimental satellite system to an operational system. The observations of the quantities or parameters such SST, sea surface topography, vector wind, ocean colour and sea-ice extent and concentration seems to be secured with regard to the continuity aspect (for about the next 10 years). However, the scientific community have an important role in near future to come up with precise requirements for the minimum numbers of satellites and sensors and their corresponding repeat orbits and choice of coverage. As correctly pointed out by the workshop participants, this should also include redundancy issues as well as plans and strategies for inter-calibration and drift monitoring.

### 5.2.2 Discussion/Reactions

In terms of enhancements, the comments above for *in situ* are equally applicable here; we need to focus on the most likely next generation of enhancements. Smith noted that the Conference Statement (conclusions) did not directly depend on the papers in the "emerging" session. The important role they played was to convey an image of where the system might be evolving to.

## 6. SYSTEM-WIDE PERSPECTIVES AND SYNTHESIS

### 6.1 GLOBAL OCEAN MODELLING AND STATE ESTIMATION IN SUPPORT OF CLIMATE RESEARCH (By Detlef Stammer )

#### 6.1.1 Outline of the paper

Introduction. Why do we need ocean state estimation? Is it feasible now? What can we expect to learn? What is needed for climate research?
Global Modelling Efforts**.** Process-oriented Studies. Model development. Surface forcing.
Status of Ocean State Estimation**.** Model-Data Synthesis. Error Evaluations.
Coupled Ocean-Atmosphere Models**.** Model Initializations. Towards Coupled Estimates.
Outlook**.** What are the gaps in our knowledge? What is required for the future? How will we fit all pieces together?

#### 6.1.2. Discussion/Reactions

The participants unanimously agreed that this type of paper was critical for the goals of the Conference. It demonstrated how an integrated, global system could be exploited. Enhanced estimates of the ocean state were obtained by interpreting the combined data set within the framework of a model, ensuring a level of dynamic and physical consistency through the field estimates. This immediately posed the question: Do we have enough of this type of paper spread through the programme? Most people thought NO! Need to emphasize the importance of starting the global integrated observing system early to benefit future more sophisticated models.

The covariance matrices contain the recipe for using the observed information: the weights and estimates of influence spread. There is thus an immediate and crucial need to work on the development of these parameterizations. This cannot be done by modellers or data gatherers or assemblers in isolation. There is also an immediate connection to the metrics of the observing system. Insofar as the influence of data on model field estimates, initial conditions and forecasts is used as a guide for the importance of data, decisions on covariance matrix parameterizations and/or weights will directly impact the metrics.

Smith commented that, as with other papers, the assimilation synthesis papers have a "Why, What, How, Where/When" characteristic. These need to be very clear so that the links through to the observational elements are fully appreciated. Treating modelling and assimilation as such a system component, there are several reasons for such use:

Integration and understanding. Learning about the dynamics and physics; understanding modes.
As a component of the "operating" system for:

- Producing an initial condition and forecast (ENSO, short-range ocean, wave forecast);
- Producing consistent ocean estimates (climate assessments; commercial users; science);
- Inferring the un-observed information (e.g., salinity from ALT, T; heat flux);
- Filling gaps in space-time (re-analyses; using dynamics to transfer information in EWG);
- Observing system design/sensitivity studies.

This paper focuses on the consistent estimation aspect and contributes to the integration and understanding part. It also has good measures of the gap filling aspects. The following Stockdale, Anderson paper is an example of the forecasting aspect. The Latif, Mehta *et al.* paper picks up the understanding part for longer time scales. But we do not have a paper focused on observing system design/sensitivity studies and we are probably lacking in papers demonstrating how the integrated data set is exploited. (The GODAE paper in session 1 will do this to some extent; perhaps it should be moved to another place in the programme?)

Smith added that, as with other papers, we want the modelling aspects to produce clear images of what is available now, what are likely or needed enhancements, etc. We also want clear images of which data are ready to be used now in real-time (in delayed mode; in climate assessment); what data might be used in the enhanced system, and so on. If we do not know how to use, say, subsurface salinity, it is better to say so explicitly and encourage research.

## 6.2 ENSO FORECAST SYSTEMS (by Tim Stockdale for D. Anderson *et al.)*

### 6.2.1 Outline of the Paper

Where we are now**.** ECMWF/NEP. data usage. Data requirements for accurate analyses (very large). Forecast skill versus data (poorly understood).

Where we expect to be in 10 years. Incremental improvements in seasonal forecasts – model errors reduce only slowly. Not just seasonal – e.g., 30-day forecasting. Improvement and change in data assimilation. "Optimum" data requirements will change. Rate of improvement unknown. Calibration of seasonal forecasts in the presence of decadal/long-term variability. 30 year + reference periods.

**Data issues**. Forcing fields, esp. Wind stress (model/data interaction). Global picture of T, S important, accurate SST. High accuracy in equatorial wave-guide. High frequency/synoptic view important (NWP forcing, altimeter, *in situ* data). Long period analyses, historical data.

### 6.2.2 Discussion/Reactions

The intra-seasonal aspects are emerging as a gap in the Conference papers. The Meyers *et al* paper does have this as a remit in part but this will not pick up issues of data assimilation and short-range (1-3 month) climate forecasts. It is not immediately obvious whether the data are needed for improved ocean estimates (initial conditions) or to improve models so that they make better use of present class of estimates. The fact that models such as ECMWF have significant bias suggests it may be more of the former.

## 6.3 ROUND TABLE NO. 4 - OVERALL DISCUSSION OF PROGRAMME

This discussion was relatively brief and concentrated on the form the Conference Statement would take (the last Round Table is intended to focus on endorsement of the Conference Statement). What we want conveyed is a strong vision: it's global, it's integrated, it's a system, it serves a broad operational and scientific community.

*Why a global ocean observing system?* The jewels and gems; the dominant modes:
- ENSO forecasts;
- Tropical Atlantic Dipole; Indian equatorial Dipole;
- Short-range ocean and marine forecasts;
- Climate change and carbon inventory;
- Understanding decadal models and mining useful predictability (Arctic Osc., PDO, NAO, ACW).

*What are the primary elements of the system?* What exists now + enhancements.

**The global fundamental elements:**
- Sea surface temperature measurements from space and direct;
- Wind measurement from space, direct and from NWP;
- Surface topography/sea level from altimetry and gauges;
- An integrated upper ocean temperature (and salinity) network comprising:
  - Argo, the global array of profiling floats,

- Ship-of-Opportunity measurements focused in the perimeters and with increased effort on HDX and frequently repeated,
- Selected time-series stations.

**Surface wave and other global marine measurements including surface drift.**
**Specific phenomenological and/or regional enhancements:**
- The ENSO OS;
- Tropical Atlantic measurements;
- Hydrography and other deep measurements;
- Regional tomography (?);
- Boundary Current monitoring.

**The glue: assembly centres, processing, models, assimilation**:
- Centres active in data assembly and distribution, including operational centres;
- Facilities for data serving (e.g., GODAE data server);
- Operational and other centres providing regular model products (for CLIVAR these are not necessarily at operational centres).

*How to make it happen?* The needs:
- Evaluation: metrics, monitoring data and product flow ;
- Investment existing and required;

*Where/When?* – The schedule:
- Image of where we are intending to measure;
- Summary of what exists now;
- Immediate enhancements (many are underway/planned);
- Major issues and challenges; major gaps;
- Major issues for consideration by research community.

*Integration and implementation* - The strategy:
- How to turn it into an integrated system;
- The role of models and assimilation;
- Regional/basin actions;
- Key partnerships;
- The new paradigm;
- Science as a guardian;
- Reporting;
- Evolution.

## SUMMARY DISCUSSION

With this type of format it seems more logical to shift the Nowlin *et al.* paper toward the end. It is going to address the integrated system and give the big picture view.

Wijffels noted that it would be extremely useful if authors could see the Conference Statement outline. (Done!) We do not have a paper developing a view from the resource side. Speakers should try to emphasize connections to other papers that will be presented during the conference. Especially, regarding the integrated observing system. The Statement might grow into a lengthy executive summary; perhaps it should comprise a paper outline like the above and a 1-page statement? Need to consider the audience carefully.

The SOC would be asked to consider the major conclusions from this meeting and adjust the programme accordingly. These include:

- One paper has been dropped (heat, water cycles), to be covered by BC, hydrography and inventory papers.
- The overview and plan papers from Session 1 are likely to be moved (and perhaps combined) to the concluding session.
- A 15-minute "motivational" primer likely to be inserted at start; a paper on climate change needs to be added.
- The programme flow now may more closely resemble the outline given under section 3 of the Conference Statement outline.
- Papers on the South Atlantic and Southern Ocean are needed (perhaps shorter).
- Extra attention is needed for D&IM and for observing system studies, perhaps also for sea-ice.

[Implication for programme is probably an extra hour in all for these additional papers, if they are shorter. Will they go through the same review process?]

- Make use of posters (as at CLIVAR Conference) to add additional "glue" between presentations.
- Consider using visual and short cameo presentations to retain focus on the global, integrated characteristics of the observing system, e.g., maintain images of the global system, incremented as each paper is presented, so that the construction/building is evident to all.
- Consider establishing a web page with summary of costs.
- Need for simple cartoons of process studies/basin experiments - role of each observation system, background *vs.* regional, e.g., ENSO Observing System diagram. Same needed for observation components. Plan was to ask CNES/Toulouse artists to work on this.

**C. CLIVAR Upper Ocean Panel (UOP)**
**Fourth Session**
21 May 1999

# 1. INTRODUCTION

## 1.1 WELCOMING

The CLIVAR Upper Ocean Panel (UOP) met at the Woods Hole Oceanographic Institution in Woods Hole, Massachusetts from May 18 to 21, 1999. Dr. Robert Weller, a member of both the CLIVAR Scientific Steering Group (SSG) and the OOPC hosted the meeting. The UOP wishes to thank Dr Weller and his staff for providing excellent facilities and support for this meeting.

## 1.2 OCEANOBS99

From May 18 to 20, the UOP and the OOPC met jointly to discuss in detail the co-sponsored conference that will be held this fall, October 18-22, in Saint Raphael, France. This conference, entitled: "The First International Conference on Ocean Observations for Climate" (OCEANOBS99) will seek to establish a consensus on the global ocean observing system for climate research and applications. The conference is described further at the following Web sites: **http://www.bom.gov.au/oceanobs99/, http://www.oceanobs99.cls.fr**/ . The agenda, participants, and minutes from the joint meeting are attached.

## 1.3 CLIVAR-UOP Meeting Participants

On May 21, the UOP met in a short session to conduct CLIVAR business. Panel members in attendance included: Chet Koblinsky, chair; Tim Stockdale, Billy Kessler, Susan Wijffels, Neville Smith, Gilles Reverdin, Kensuke Takeuchi, and Andreas Villwock (IOPC). Ants Leetmaa and Dean Roemmich were unable to attend. Invitees included: Dave Behringer (NOAA/NCEP), Brech Owens (WHOI), Ray Schmitt (WHOI), and Bob Weller (WHOI). The topics covered in the abbreviated agenda are addressed in the following sections.

# 2. IMPLEMENTING THE GLOBAL SYSTEM

The primary goal of the Upper Ocean Panel is to insure the implementation of a global ocean observing system. Members expressed concern that the plans for the Atlantic and Pacific are limited to the more northern parts of these oceans. Coverage of the Southern Oceans below 30º S is sparse. Methods to alleviate this problem were discussed throughout the meeting. The Panel agreed to be vigilant in encouraging projects for the implementation of Argo into the Southern Oceans.

Model sensitivity studies are needed to examine the impact of inadequate observations in the Southern Hemisphere (see below). It was pointed out that it is important for CLIVAR to have adequate global observations from the onset so that in the future more sophisticated models will have a global basis to study many scales of variability. In addition, the panel discussed methods to facilitate capacity building with Southern Hemisphere nations. Partnerships with VAMOS and AAMonsoon panels may be helpful. Invitations and support for members of Southern Hemisphere countries to OCEANOBS99 were encouraged.

## 3. CLIVAR SSG-8 ISSUES

Koblinsky noted issues from the CLIVAR SSG-8 meeting relevant to the UOP. He mentioned that the SSG was looking to the UOP to facilitate the global synthesis and data assimilation of the CLIVAR observations, in addition to the global integrated observing system. The SSG had also mentioned the need for the UOP to interact with the other panels within CLIVAR, especially the Working Group on Seasonal to Interannual Predication (WGSIP). These issues were discussed during the meeting and a few action items have been established as described below.

## 4. MODELLING ISSUES

The Panel discussed the observing system sensitivity model studies described by Dr Detlef Stammer during the preview of the OCEANOBS99 conference. It was decided to learn more about these tools at the next UOP meeting. In addition, membership with this expertise was addressed. The panel discussed how specific studies could be carried out, such as: the impact of inadequate Southern Hemisphere observations; the impact of Argo horizontal and vertical (parking depth) distribution, the impact of unobserved sub-grid scale phenomena, the impact of boundary current processes, and the role of point time series measurements. These analyses should also include an examination of the accessability of relevant data sets. A joint meeting with the GODAE SSG may be the best way to facilitate progress in these studies.

## 5. PROFILING FLOATS

Ray Schmitt of WHOI presented some early results from a profiling float deployment in the tropical Atlantic. He displayed temperature and salinity measurements from several months of data. He described some difficulties with the salinity profiles that resulted in full profile biases from time to time. Fouling of the flushing pump with organisms is thought to be the cause. Methods to correct these offsets were described.

He showed horizontal fields of T and S from interpolating the sparse float coverage. Good agreement with climatology was apparent. The impact of small-scale features in the salinity field that alias some of the maps was described. Koblinsky mentioned some of the developments in surface salinity measurements with airborne radiometers and satellites.

Future airborne mapping missions over large float deployments should be considered to examine the role of high resolution sea surface salinity observations to detect small-scale salinity structures. The apparent success of the European Space Agency Soil Moisture Ocean Salinity (SMOS) proposal was noted. It was suggested that the UOP should work with the NASA Salinity Sea Ice Working Group and Argo Science Team to develop a workshop on *in situ* salinity measurement technology.

**Action Item**: Koblinsky will discuss the potential for a UOP/SSIWG-sponsored salinity-measurement-technology workshop with Gary Lagerloef, Chair of the SSIWG, and US funding managers.

## 6. SYSTEM INTEGRATION AND CALIBRATION ISSUES

Bob Weller discussed the development of the Global Eulerian Observing (GEO) system and the surface flux reference sites. The panel discussed the various plans for these systems and how they could be relevant to CLIVAR. The panel endorsed the inter-calibration of IMET and TAO flux measurements.

## 7. TIME-SERIES MEASUREMENTS

The panel discussed the potential use and needs for long-time series measurements in the ocean for CLIVAR. A plan for specific sites was encouraged for the OCEANOBS99 conference. Documents are to be produced this year describing the plans for these systems. It was decided that the UOP and OOPC would help to vet these documents with the science community. It was agreed that the Partnership for Ocean Global Observations (POGO) should take the lead in developing these systems. The UOP will review the status of these systems at its next meeting.

## 8. INDIAN OCEAN OBSERVATIONS WORKSHOP

Susan Wijffels described a workshop on Indian Ocean Observations for Climate that will be held in Perth, Australia next year. Gary Meyers of CSIRO, and former UOP member, is a convenor. Neville Smith mentioned that an office of the IOC would be set up in Perth to facilitate the Indian Ocean observing system.

**Action Item**: The UOP agreed to get a synopsis of the conference from Meyers and discuss with him whether or not the UOP could help facilitate the conference.

## 9. UPPER OCEAN THERMAL WORKSHOP

**Action Item**: The UOP and OOPC will co-convene a special workshop on the Upper Ocean Thermal Programme in Melbourne, August 7-10, 1999. (see attached notes from joint UOP/OOPC meeting for details).

## 10. MEMBERSHIP

It was agreed at UOP-III that the nominal term of membership would be 3 years. Charter members agreed to rotate off in groups of three. This year, Leetmaa, Reverdin, and Stockdale will rotate off the panel. In addition, a slot remained open from our previous meeting because P.-Y. LeTraon was unable to accept an appointment. In selecting new members, we sought to maintain strength on the panel in model/data assimilation and near-surface observations. In addition, we sought to add members to the panel who could address arising issues in decadal variability, acoustics, time series, and polar oceanography.

The Panel acknowledges the excellent work of Ants Leetmaa as the initial chair of the UOP, we thank him for setting the tone and vision for this component of CLIVAR. The panel also acknowledges and thanks Gilles Reverdin and Tim Stockdale for their outstanding work on the Panel over the past three years.

The Panel nominated new members to replace Leetmaa, Stockdale, Reverdin and D. Luther. In addition, the panel felt that it was necessary to add two additional members to the panel who could address issues on polar oceans and decadal problems that are important to CLIVAR and the global perspective but not currently represented on the UOP. Consequently, two additional individuals were recommended to bring expertise for these aspects.

## 11. NEXT MEETING

Based on the discussions of this meeting and the interests of the SSG, the panel agreed to consider three topics for the coming year: synthesis and observing system design studies, the integrated observation of boundary currents, and the potential impact of acoustic tomography on CLIVAR.

It was agreed that the panel members attending OCEANOBS99 would meet on Saturday morning, October 23 in Saint Raphaël, France at the Bleu Marine Hotel to review the discussions at the conference. At St. Raphaël, the panel will review its plans for 1999/2000 and its agenda for the 5th meeting of the UOP. There was general agreement that the 5th meeting of the UOP would probably be most appropriate in the July-September time frame of 2000. Potential meeting sites included a joint meeting with the international GODAE SSG at a site TBD, a joint meeting with the African and AA Monsoon panels and, possibly TAO implementation panel at the Indian Ocean Observing System conference in Perth, or a separate meeting of the UOP only, probably in a European location. We will finalize these plans at OCEANOBS99.

ANNEX I

## AGENDAS

**GCOS-GOOS-WCRP Ocean Observations Panel for Climate**
**Fourth Session, 17-20 May 1999**

**1. OPENING AND INTRODUCTIONS**

**2. REVIEW AND ADOPTION OF THE AGENDA**

**3. REVIEW OF INTERSESSIONAL ACTIVITIES**

3.1 GOOS STEERING COMMITTEE AND OTHER OOPC REPRESENTATIONS
3.2 PANEL MEMBER ROTATION
3.3 THE FOUR THEMES OF OOPC ACTIVITIES
3.4 GODAE
3.5 GCOS AND THE UNFCCC AND COP IV AND V
3.6 ARGO (THE GLOBAL ARRAY OF AUTONOMOUS PROFILING FLOATS)
3.7 PARTNERSHIP FOR OBSERVATION OF THE GLOBAL OCEANS (POGO)
3.8 THE 1ST INTERNATIONAL CONFERENCE ON THE OCEAN OBSERVING SYSTEM FOR CLIMATE

**4. WORKSHOPS AND OOPC INITIATIVES**

4.1 SEA SURFACE TEMPERATURE WORKSHOP
4.2 DATA MANAGEMENT ISSUES
4.3 TIME-SERIES AND OCEAN OBSERVATORIES
4.4 STUDY OF UPPER OCEAN THERMAL NETWORK

**5. JCOMM AND THE ACTION PLAN**

**6. OTHER INTERACTIONS AND LIAISON**

6.1 THE SEA ICE ELEMENTS OF THE OCEAN OBSERVING SYSTEM (OOS)
6.2 THE COASTAL PANEL
6.3 UPDATE ON SATELLITE GRAVITY MISSIONS
6.4 THE ATMOSPHERIC PANEL
6.5 GLOBAL OBSERVING SYSTEM, SPACE PANEL (GOSSP)
6.6 CAPACITY BUILDING

**7. CLOSING AND NEXT MEETING**

**Joint Session of OOPC and UOP**
**18-20 May 1999**

## 1. USERS, APPLICATIONS AND OVERVIEW (First Session)

1.1 INTEGRATED SYSTEM OVERVIEW
1.2 APPLICATION OF SEASONAL-TO-INTERANNUAL PREDICTION
1.3 THE SOUTHERN HEMISPHERE PERSPECTIVE
1.4 THE DIVIDEND FROM INVESTING IN OBSERVATIONS, A EUROPEAN PERSPECTIVE
1.5 OPERATIONAL OCEANOGRAPHY AND PREDICTION, GODAE
1.6 THE ACTION PLAN FOR GOOS/GCOS AND SUSTAINED OBSERVATIONS FOR CLIVAR
1.7. DECADAL-TO-CENTENNIAL VARIABILITY
1.8 GENERAL DISCUSSION/REACTIONS ON SESSION 1

## 2. REGIONAL AND PHENOMENOLOGICAL APPROACHES

2.1 THE ENSO OBSERVING SYSTEM – AN UPDATE
2.2 A TROPICAL ATLANTIC OBSERVING SYSTEM
2.3 OCEANIC BOUNDARY CURRENTS
2.4 THE PACIFIC BASIN EXTENDED CLIMATE STUDY
2.5 ATLANTIC CLIMATE VARIABILITY EXPERIMENT (ACVE)
2.5 ATLANTIC CLIMATE VARIABILITY EXPERIMENT (ACVE)
2.6 THE INDIAN OCEAN
2.7 HIGH-LATITUDE PROCESSES AND THE ICE-COVERED OCEAN
2.8 WIND WAVES AND GOOS
2.9 THE HEAT AND WATER CYCLES
2.10 THE CARBON CYCLE AND TRACERS

## 3. DATA FLOW, PROCESSING AND PRODUCTS

3.1a DISTRIBUTED OCEAN DATA SYSTEM)
3.1 OCEAN OBSERVATIONS FOR THE NEXT MILLENNIUM: ASSEMBLY, QUALITY CONTROL, ARCHAEOLOGY, AND MANAGEMENT
3.1a PARTNERSHIP FOR OBSERVATIONS OF THE GLOBAL OCEAN
3.2 DEVELOPING A NEW PARADIGM FOR OCEANOGRAPHY
3.3 ROUND TABLE NO. 1 **-** A NEW ERA FOR OCEANOGRAPHIC DATA SHARING AND AVAILABILITY

## 4. SPECIFIC CONTRIBUTIONS TO THE OBSERVING SYSTEM

4.1a UTILIZING HISTORICAL DATA: A NEW PERSPECTIVE FOR UOT
4.1 CURRENTS AND OCEAN CIRCULATION
4.2 ARGO, THE ARRAY OF PROFILING FLOATS
4.3 TIME-SERIES STATIONS
4.4 HYDROGRAPHIC SECTIONS
4.5 SAMPLING THE OCEAN WITH ACOUSTICS

4.6 THE UPPER OCEAN NETWORK
4.7 ROUND TABLE NO. 2 - TOWARDS AN INTEGRATED *IN SITU* NETWORK
4.8 SURFACE TOPOGRAPHY AND SEA LEVEL
4.9 SURFACE WINDS AND SURFACE STRESS
4.10 SEA SURFACE TEMPERATURE AND SALINITY
4.11 ROUND TABLE NO. 3 - OVERALL DISCUSSION OF PROGRAMME

**5. EVOLUTION AND THE FUTURE – EMERGING TECHNOLOGIES**

5.1 NEW PLATFORM TECHNOLOGY FOR SUSTAINED OBSERVATIONS
5.2 EMERGING EARTH OBSERVATION FOR SUSTAINED APPLICATION

**6. SYSTEM-WIDE PERSPECTIVES AND SYNTHESIS**

6.1 GLOBAL OCEAN MODELLING AND STATE ESTIMATION IN SUPPORT OF CLIMATE RESEARCH
6.3 ROUND TABLE NO. 4 - (Simulation)

**CLIVAR Upper Ocean Panel (UOP)**
**Fourth Session , 21 May 1999**

**1. INTRODUCTION**

1.1 WELCOMING
1.2 OCEANOBS99
1.3 CLIVAR-UOP

**2. IMPLEMENTING THE GLOBAL SYSTEM**

**3. CLIVAR SSG-8 ISSUES**

**4. MODELLING ISSUES**

**5. PROFILING FLOATS**

**6. SYSTEM INTEGRATION AND CALIBRATION ISSUES**

**7. TIME-SERIES MEASUREMENTS**

**8. INDIAN OCEAN OBSERVATIONS WORKSHOP**

**9. UPPER OCEAN THERMAL WORKSHOP**

**10. MEMBERSHIP**

**11. NEXT MEETING**

ANNEX II

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ANNEX III

## TERMS OF REFERENCE FOR SEA SURFACE TEMPERATURE WORKING GROUP (SST WG)

1. Record and evaluate the differences among historical and near-real-time SST analyses and SST Seasonal to Interannual (SI) analyses.

   (a) Identify a standard data set for the intercomparisons of different products, e.g., COADS.

   (b) Select several standard difference products as a minimum comparison set (i.e., define regions and time periods; compute biases, standard deviations, and rms differences, etc.).

2. Identify the sources of difference in the analyses.

3. On the basis of comparison of those differences with the expected climate signals in the SST patterns, recommend actions needed to ensure the quality and consistency of SST and SST/SI analyses.

4. Establish criteria to be satisfied by SST and SST/SI analyses to ensure the quality and consistency required by GCOS.

5. Report annually to AOPC and OOPC on progress and recommendations.

ANNEX IV

# THE UPPER OCEAN THERMAL REVIEW

## BACKGROUND

The TOGA and WOCE programmes used ships-of-opportunity to deploy XBTs along selected ship routes known as SOOP XBT lines. These lines, first established in the North Pacific, and then extended to the tropics and other mid-latitude regions, provided the data for observing network design and for fundamental studies of ocean variability and predictability. The tropical network was critical for developing models of ENSO and continues to be an important contribution to the initialization of prediction models. SOOP thermal data also constitute the bulk of the global upper ocean thermal data and so represent our "knowledge" of the seasonal cycle and interannual variability.

The Tropical Atmosphere-Ocean array (TAO) was an initiative of TOGA. At present, it constitutes the core of the (operational) ENSO observing system. Until now, it has been argued that TAO and SOOP are complementary and that any redundancy that does exist could not be removed without significant effort and loss of capability.

In the early 1990's the US and France launched the TOPEX/Poseidon altimeter. This instrument delivered, and continues to deliver, estimates of sea surface topography changes to an accuracy of around 2 cm. This capability, plus the development of skillful model and data assimilation systems, has forever changed the way we gather and interpret ocean data. With such information available it does not make sense to design and evaluate networks in isolation. Networks must be considered as a contribution to a larger, integrated *in situ* and remote system, with consequences for sampling and design.

There is now also a developing plan for a future global array of profiling floats (Argo). In principle, Argo will deliver T and S profiles of the upper ocean (to around 1500-2000m) every 10 days or so from around 3000 floats. This will revolutionize traditional upper ocean observing methods and thus network design. It is timely then to re-consider the upper ocean sampling network, particularly the SOOP XBT contribution, including, where possible, salinity sampling.

The rationale for the observing network is provided by the CLIVAR Implementation Plan (IP), The OOSDP Design (1995) plus the Action Plan for the Ocean Observing System for Climate (Sydney Workshop, GOOS publ.)

## A STUDY OF THE UPPER OCEAN THERMAL NETWORK

The GCOS/GOOS/WCRP Ocean Observations Panel for Climate (OOPC), CLIVAR Upper Ocean Panel (UOP) and the Ship-of-Opportunity Programme of the IOC/WMO Integrated Global Ocean Services System (IGOSS SOOP) have agreed to convene a study of the upper ocean network with the support of NOAA and the Bureau of Meteorology. The aims of this study are to:

(i) to compile a consolidated account of the existing Upper Ocean Thermal data base, using WOCE, Levitus and whatever other data bases that are available. The attributes that we seek to quantify are:

- (a) the sampling as a function of space and time, extending back to at least the early 1980's. These statistics should be by longitude-latitude bins (2 x 2 °?) as well as by traditional lines/regions (as defined in WOCE). The statistics should give some measure of vertical sampling and depth;

(b) a measure of the continuity for specific lines/regions, including the relative information content of low-density, frequently repeated and high-density lines;

(c) a measure of the quality (level of QC that the data have been subjected to);

(d) availability - delayed mode *versus* real-time; gaps in delivery systems; public versus private; etc. permanent archives;

(e) availability of metadata;.

(f) logistical considerations with regard to particular tracks;

(g) any other political/technical attributes which might impact/qualify the attributes.

The analysis should include all forms of sampling (broadcast, high-density, frequently-repeated, *ad hoc*, etc.).

(ii) Produce consolidated "maps" of information level/content based on the dominant scales of climate signals. The raw distribution statistics do not take account of the actual information content so it is useful to seek some consolidation of the information in (1) even if it does depend on certain assumptions. The SOOP contribution should be identified.

(iii) Document the existing practices for assembling, quality control and distribution of upper ocean data, working from existing material of GTSPP, WOCE UOT/DPC and IGOSS SOOP.

(iv) Document to the extent possible the "value adding" of thermal data process chains, be they automated assimilation (e.g., NCEP, BMRC, UKMO, ECMWF), quick-look/semi-automated quality control (e.g., GTSPP, AOML), or higher-level scientific quality control and assembly (e.g., CSIRO, AOML, Levitus, NODC).

(v) Provide quantitative assessment of all SOOP lines. This should include an assessment of relevance/impact against scientific objectives including seasonal-to-interannual prediction, environmental/ocean prediction, improved climatologies and climate change monitoring, scores against key attributes (continuity, quality, etc.), notes on extenuating circumstances, and the existence of proxies in the event of gaps/discontinuities in the lines. The broad-scale sampling should also be assessed as a precursor to Argo with a view to maintaining the temporal and spatial integrity of resolved signals such as the global ENSO wave, the Antarctic Circumpolar Wave, decadal variability, etc.

(vi) Provide, on the basis of 5 (above), a renovated SOOP plan including broad cost and high-density strategies, taking account of, as far as is practical: the existence (or potential) of other direct sampling networks (e.g., TAO, Argo); the indirect information available from remote sensing, particularly altimetry; and the indirect information available from models (e.g., wind-forced, equatorial).

(vii) Produce a Report based on the above which will form the background for a workshop to be convened in the 3rd quarter of 1999. The Executive Summary from this process will constitute a key paper for the OCEANOBS 99 Conference, 18-22 October 1999. The Report will be published jointly under the joint auspices of the GCOS/GOOS/WCRP OOPC, CLIVAR UOP and IOC/WMO IGOSS SOOP IP.

**SCIENTIFIC ADVISORY COMMITTEE (SAC)**

A SAC is to be formed to oversee the study. Nominated members are:

N. Smith (BMRC Aust., Chair)
R. Molinari (AOML, USA)
E. Harrison (PMEL, USA)
T. Delcroix (IRD/ORSTOM, Fr.)
D. Roemmich (Scripps, USA)
K. Hanawa (Tohoku U., Japan)
O. Alves (ECMWF/UKMO, UK)
R. Bailey (CMR/BMRC JAFOOS)
R. Keeley (MEDS, Can.)

This committee will be supported by a consultancy led by R. Bailey with input from R. Keeley (both will be members of the SAC). In addition, several key scientists, data users and SOOP practitioners will regularly be consulted and given the opportunity to provide advice. These include:

A. Leetmaa
M. Ji
G. Meyers
G. Reverdin
W. White
S. Levitus
K. Takeuchi
P. Rual
A. Sy

S. Thurston (NOAA OGP), M. Johnson (NOAA OGP) and E. Charpentier (SOOP Coordinator) will provide organisational and technical support and be included in SAC deliberations and in other organisational matters.

**TERMS OF REFERENCE**

The Terms of Reference for the SAC are:

(i) to provide scientific advice on the conduct of the study and to the consultancy;

(ii) to provide advice and guidance on the preparation of the study Report and a solicited paper for the OCEANOBS99 Conference;

(iii) to provide guidance on the consolidation of views from the study Workshop;

(iv) to report to, and frame recommendations for the consideration of the GCOS/GOOS/WCRP OOPC, CLIVAR UOP and IOC/WMO IGOSS SOOP, as appropriate, with regard to future implementation and scientific advice.

**CONSULTANCY**

A consultancy will be contracted to gather the information for the study under the direction of R. Bailey, particularly for the study aims 1 through 5 above. To the extent possible the information will be quantitative. S. Thomas has been contracted for two months to undertake the initial collation of information, principally from existing data sources. R. Keeley will provide additional expertise and input for data management issues. The consultancy will be responsible for the drafting of the Report. Final scientific and technical judgements will come via the workshop and the SAC.

**WORKSHOP**

An international workshop will be held at BMRC in the 3rd quarter of 1999 to consider the initial report and its recommended upper ocean thermal strategy. It will be held over 3-4 days with as much of the editorial and technical amendments being undertaken on-site as is practical. The final report should be available in electronic form by the time of the OCEANOBS 99 Conference. An executive summary will be produced which will form the basis of a Conference paper. This paper should be subjected to non-advocate review prior to Conference. Members of the OOPC and UOP might be able to provide this input.

**FUNDING**

The consultancy, report preparation and publication and workshop will be sponsored by the NOAA Office of Global Programmes and BMRC.

ANNEX V

**GOSSP REPORT TO GOOS SC-II**
**(An interpretation by Neville Smith on behalf of the Chair GOSSP, Dr F. Bretherton)**

## 1. BACKGROUND

GOSSP is responsible for facilitating communications between the G3OS and the CEOS agencies. The statement of user requirements is an essential part of this interface, relied upon by the agencies to define what is expected of them. It is thus very important that these statements be clear, accurate, and up to date. However, GOSSP does not set these requirements, they are set by the G3OS's themselves.

The CEOS/WMO database is the official record of these statements. It is maintained by Don Hinsman of WMO, and is accessible by an on-line server, or on a distributed CD ROM. The existing entries raise several questions, some of which will be addressed here. More specifically, there is a need for GOOS to endorse a set of ocean requirements. In this paper, a set of requirements is given (based on drafts by OOPC and GODAE) and the GOOS SC is asked to endorse both the Table and the comments attached which directly address several key issues. The stated requirements do not fully embrace all the modules of GOOS.

The CEOS through its Strategic Implementation Team (SIT) has recommended that requirements be referenced in future against a set of Themes. The Chair of GOSSP has drafted a position paper relative to this request and this is discussed below. The CEOS have also requested updated statements of requirements and input on needed actions. A draft discussion paper has been circulated with a view toward the input to the IGOS Partners meeting in Rome this coming June.

## 2. THE REQUIREMENTS AND THE WMO DATABASE

Because of the history of GODAE as a Pilot Project of CEOS the requirements discussed here reflect, in the first instance, needs of GODAE. The more general requirements of the OOPC (i.e., the climate module) are mostly less stringent than GODAE in terms of spatial and temporal sampling but more stringent in terms of quality and continuity. There are also several requirements that must be considered jointly with those of numerical weather prediction (e.g., SST, surface winds). Whereas climate requirements are often less stringent than those for NWP (space, time), GODAE's are in general more stringent. The surface marine requirements are mostly covered by the combination of these two with the exception of surface wave measurements (these are covered in the WMO requirements ; this table entry is new).

In terms of the characteristics of the required ocean fields, we are generally interested in two types of products/requirements. For climate, mesoscale variability is generally averaged in both time and space before data are assimilated into models and/or analysis systems. Examples include SST and sea surface topography. For GODAE, where attention is on much higher resolution estimates, the plan is to resolve such variability. This variability must also be resolved for biological applications. For the coastal zone, the spatial requirements may be even more severe. In most cases we expect the relevant data to be combined within model data assimilation systems.

Table 1 provides a revised version of the requirements originally developed by GODAE and OOPC for the CEOS Analysis Group and GOSSP. Some attempts were made to take account of known requirements beyond the climate module of GOOS. In the present version the "optimal" requirement for precise altimetry has been reduced to 1 cm in accordance with comments from GOSSP members and the recent SIT meeting. Gravity measurements have been included explicitly, noting that OOPC (OOPC III, Grasse) concluded that one-off missions like GRACE and GOCE could well satisfy the long-term requirements. The original sea surface temperature entry has been renamed "Sea Surface Radiative" for two reasons. First, a new entry for net downward short-wave radiation has been included. Second, there is considerable debate about defining the relationship between the measured signal (a radiance) and the required field (SST) - either bulk or skin translations can be used.

With regard to the data in the existing WMO data base (WDB), the Chairman of GOSSP has raised several issues which need clarification. There is also the issue of ownership of and responsibility for the numbers in the data base.

First, I expected to find the GODAE requirements under the AG Projects. This is not so. Second, the database contains a group of entries attributed to IOC and GOOS. These entries were tabled at GCOS JSTC VII (Eindhoven) I believe and rejected in the strongest possible terms. Unless they can be traced back to one of the GOOS Module Panels (which I believe they cannot) they should be removed immediately and the Panel Chairs requested to make specific suggestions. [Some of these requirements do not make sense and some are clearly undoable for the global domain.] Some requirements may originate from the IGOS Long-Term Marine Biology Pilot Project (I think labelled Marine Biology - Open Ocean in my database) but I could not verify the credentials. There are also entries attributed to AOPC for ocean fields. GCOS has formally requested that OOPC take responsibility for sea-ice so this entry against AOPC should be removed in favour of entries under GOOS. A similar remark applies to SST though in this case OOPC and AOPC are sharing scientific oversight. Surface wind vectors should also be the responsibility of OOPC in the first instance.

It remains then to clarify the OOPC (GCOS) and GOOS Climate entries. (I am ignoring all the entries attributed to IOC with the exception of one JGOOS III entry for the geoid).

Ocean topography/sea level. Table 1 attempts to give some « texture » to this requirement since there are very distinct drivers (A, B and C). An entry for sea level (change) should be added (Application). The cycle time entries under OOPC/GCOS are silly. There are errors in the « Time » entry for large-scale applications and the Accuracy details should be 1 cm and 2 cm respectively for optimal and threshold.

Geoid. This was missing from the original GODAE submission. An entry under «JGOOS-III / IOC» exists. I would leave out the cycle time since it is providing a base measurement rather than a field that varies with time (this aspect though is under consideration). OOPC III is the definitive reference in our literature. The accuracy and resolution entries should be amended. Surface wind vectors. As with other aspects, there are nuances and subtleties that are just not captured in the WDB. Table 1 does little better. The entry labelled « Wind vector over the sea-surface (horizontal) » by GOOS is consistent with Table 1; the others should be discarded. Note that the direction requirements for accuracy are missing.

Sea surface radiative/SST. We do have to begin being more careful about these entries, not only because of the many different applications, but also because there is not a unique definition of SST in the context of these requirements. There may be a good case for having several application entries (including within Table 1; in the Action Plan the climate requirements are discussed in more detail). The OOPC/AOPC SST Workshop suggests 0.1o K as the bias and rms target for climate products. The 2.0o K figure would seem useless for most climate and GODAE applications. I would suggest a bias (absolute) range of 0.1o - 0.5o. The entries under GCOS Climate/GOOS are closest to those of Table 1. There are regional and non-physical applications that may influence the requirements in a significant way.

Sea surface radiative/shortwave. This is a new identification of a requirement. OOPC will probably take lead responsibility among OOPC, AOPC and GODAE.

Sea surface salinity. This is a requirement for the future. The OOPC/GODAE (and GOSSP) position has been to encourage exploration of the possibilities for remote measurements. The entry under GOOS Climate is correct.

Sea-ice cover. This requirement has not received the same attention as some of the others, at least by OOPC. OOPC III did not find any reason to make substantial changes. The Table reflects what I believe are agreed optimal and threshold requirements. Both entries are close to this.

Ocean Colour. The ocean colour Pilot Project has had prime responsibility for developing these requirements. The GOOS SC should decide how it wishes to coordinate that input with that of the modules. GOSSP has noted discrepancies between the chlorophyll and yellow-substance entries in terms of space sampling. The GODAE/OOPC requirements are similar to those for surface short-wave radiation since ocean colour (transparency) information will be used with surface radiation data.

Surface Waves. Oversight for this aspect is not clear. J-GOOS requested a background paper (Komen and Smith) but this did not look at requirements in detail. The Table entry reflects some published requirements but should be considered preliminary for the time being. OCEANOBS99 intends to look at this in more detail.

Summary. We ask the GOOS SC to endorse the requirements as given in Table 1 and request that the WDB be updated to reflect this. Some expansion of the Application entries in the data base is warranted particularly for SST. All entries should be attributable (sourced back) to GOOS and its Scientific Committee. Perhaps the relevant field value is now « Oceans Theme ». It is GOSSP's responsibility to see that the wishes of the GOOS SC are reflected in published requirements. It is the responsibility of the Panels and Projects to ensure that entries for particular applications are current and accurate. There should be a table reflecting these lines of responsibility. No other entries should appear under IOC or GCOS Ocean. For fields/applications where there is shared guidance (e.g., AOPC, OOPC) the relevant oversight body (e.g., GCOS SC) should endorse a line of responsibility. The present format cannot easily account for regional nuances, e.g., coastal or El Niño. This needs attention.

## 3. PRIORITIES AND SCIENTIFIC AND TECHNICAL ISSUES

Some of these have been noted in Section 2 and in the Table. However some further discussion is warranted. For climate applications and GODAE, remotely sensed (inferred) SST, surface topography and surface wind vector capabilities are considered mandatory. Key applications will be severely compromised in the absence of any one of these data streams. Surface wave information and sea ice extent are at a similar level of priority though the rationale is more to do with weather and marine forecasting than oceanography. There is also general agreement that remotely sensed ocean colour should be given a high level of priority. However, with respect to detail, there remain several outstanding issues and these are expanded upon below.
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Surface topography/Altimetry. TOPEX/Poseidon has demonstrated in the 1990's that precision satellite altimetry may be utilized in a wide body of ocean research (planetary waves, tides, global sea level change, etc.) and practical allocations (e.g., seasonal-to-interannual climate prediction). The follow-on mission Jason-1 aims to further demonstrate and insinuate altimetry's operational potential and utility. Jason-1 will strive to meet the challenge of a 1 cm RMS error budget.

It had been hoped that T/P would allow the complete description of ocean tides, such that they could be removed completely from future altimetric measurements. The orbit for the satellite was carefully chosen to enable this goal. Unfortunately, it has been found that a random component of the tides (RMS 2 cm) remains unresolvable in models (e.g., from solar tides) and would be aliased into the mean sea level signal from altimeters in polar orbit. This suggests at least one non-sun synchronous orbit altimeter is required.

It is the view of the scientific community that the T/P-Jason-like precision altimetry mission will be required indefinitely to monitor and understand global sea level variability. Other altimetry missions in polar orbit (ERS, ENVISAT, GEOSAT) are needed to provide operational altimetry coverage for mesoscale ocean circulation applications. The community judgement at this time is that 2 altimeters are essential. A third is deemed highly desirable but, as yet, there is no consensus on what is best for long-term applications.

The complementarity between the proposed global profiling float array Argo (and other sources of *in situ* information) and altimetry is only now being explored. It is difficult to be definitive without good data records and, for the subsurface ocean, these do not exist. The results of this research will in time impact the case for multiple altimeters.

Surface wind vectors. High resolution vector winds at the sea surface are required to force ocean models and as constraints in atmospheric and surface wave applications. The best methodology of remotely estimating vector winds remains a matter of scientific debate. The need for and utility of accurate, high-resolution winds is, however, widely recognized. One proven method to estimate wind vectors is scatterometry (Ku or C band). Examples include NSCAT on ADEOS-1, Sea winds on ADEOS-2, and ASCAT on METOP. Polarimetric radiometry also shows some promise as a less expensive alternative and has been extensively tested in airborne experiments. The spaceborne test of such an instrument is to be flown by the US Navy/NPOESS "Windsat" mission in 2002. Its simultaneity with the Sea winds scatterometer on ADEOS-2 will allow a direct comparison of the different methods.

OOPC and GODAE have concluded that at least one scatterometer (or an equivalent) is essential. The case for a second is strong, particularly if the broad range of likely applications is considered. For just GODAE and climate applications alone the case is difficult to make simply because the existing records are short (e.g., 9 months of NSCAT) though more data clearly will deliver higher quality climate products. A sustained (operational) commitment to a 2nd instrument needs more justification. This I believe comes from regional/mesoscale oceanographic, marine and weather applications. Wave prediction at both global and regional /local scales is moving toward coupled (wave-NWP) configurations. Predictions of storm and cyclone/hurricane movements are increasingly utilizing coupled atmospheric-marine-ocean models. Several recent events (e.g., the Sydney-Hobart yacht race tragedy of Boxing Day 1998) highlighted the need for high-resolution (at least 25 km), frequent (daily) wind samples. Good NWP models can fill part of this gap but present configurations do not come close to delivering wind fields at this resolution.

There are several other sources of information for surface winds including direct measurements from arrays like TAO and estimates of wind speed from radars, passive microwave and other instruments. NWP, at both global and regional levels, also provides important proxy information. It remains unclear at this time just how significant these other contributions are in terms of the case for a 2nd instrument. The launch of QSCAT may begin to give some answers.

Sea surface temperature. GODAE at least has clearly stated that the present suite of operational global SST products is inadequate for future operational applications. Both spatial and temporal resolution is lacking. Under the GODAE agenda item a project for developing high resolution products is discussed. One of the issues that must be faced (and this is a major concern for climate) is the definition of SST. Satellites actually measure surface irradiance and an algorithm is used to derive an estimate of sea temperature. The most directly-related sea temperature is that of the surface skin since it is this temperature which determines the long-wave irradiance. However for many applications, including atmospheric boundary layer parameterizations, the bulk SST has been used. The algorithms for AVHRR, then, are attuned to bulk sea (surface) temperature rather than the skin. Just how this issue should be approached is undergoing considerable debate at this time. The need (or not) to resolve the diurnal cycle is intimately connected to this debate. Many operational products work off night-time data to minimize this problem. However such strategies are biasing the climate record to some extent.

The recent OOPC/AOPC SST Workshop also highlighted the need for improved collaboration between the (operational) sea-ice and SST communities. Improved standards for the utilization of sea-ice data to infer SST need to be developed.

SST requirements beyond GODAE and OOPC can stretch the requirements further both in terms of spatial resolution and temporal resolution. The coastal community needs are likely more stringent than those of GODAE but they are also likely to be more regional. This may also be true of the biological/LMR community. The present WDB contains requirements for 0.1o K accuracy which seems an order of magnitude too severe for biological applications. Again, unless a reliable scientific source can be identified for these entries they should be omitted.

Table 1 and the discussion above make a start at identifying these issues. The WMO DB is probably not well-suited to take account of these nuances, and likely never will be. The GOOS SC should consider where the top priority issues lay and make appropriate recommendations to GOOSP and the module Panels.

Ocean Colour. Since the start of the OCTS and POLDER missions on ADEOS-1 in November 1997, there has been a nearly uninterrupted data stream of global ocean colour measurements. After a brief interruption, measurements were resumed in September 1997 by the SeaWiFS instrument on the OrbView-2 satellite. Within the next 3-5 years, ocean colour measurements will be provided by MODIS instruments on the EOS Terra satellite and EOS-PM1, MERIS on ENVISAT, and GLI on ADEOS-2. Beyond these research missions, the U.S. NPOESS Programme Office has plans to develop a visible and infrared sensor (VIIRS) that could fulfill the observation needs of both scientific and operational users. An NPOESS preparatory programme (NPP) is being planned to deploy prototypes of this and other future operational NPOESS sensors on a joint NASA- NPOESS bridging mission that will be launched in the 2004-2005 time frame to ensure continuity of moderate resolution global productivity measurements.

The Long-Term Ocean Biology Project initiated by the CEOS SIT is being coordinated by the International Ocean Colour Coordinating Committee (IOCCG), an affiliate of SCOR. Its goal is to implement a strategy for understanding ocean biogeochemical and ecosystem processes by combining long-term ocean colour and other remote sensing satellite data with in-situ measurements. While there may still be some debate about how ocean colour measurements are translated into useful fields, there is a strong consensus that ocean colour is the preferred strategy for building an image of spatial and temporal global variability and change related to upper ocean biology.

The requirements in the WDB which may have in fact originated from this project need to be considered by the GOOS SC and relevant module Panels. For example, there is a disparity in required spatial scale for yellow substance and chlorophyll. There is also a listed requirement for specific humidity which seems unjustified; we recommend its removal or reference to an appropriate expert panel. Other entries for SST and surface winds, both of which went beyond those supported in Table 1, need to be clarified. The existence of such unsubstantiated entries can be harmful.

General. As GOOS moves to applications where the emphasis is regional (even though the approach is global) the case for « local » remote sensing becomes an issue. Even in the case of global SST, it is clear that geostationary satellites stand a better chance of avoiding diurnal aliasing and capturing windows of opportunity to view the sea surface. For mesoscale applications one might also consider whether high-resolution geostationary systems might be of greater utility.

We ask that the GOOS SC make a statement on these general issues and consider appropriate strategies to address them. The GOSSP Chair undertakes to convey these messages to the Partnership meeting in June and, later, to the CEOS Assembly.

## 4. CEOS AND THE OCEAN THEME

At the January meeting of the CEOS CIT it was agreed that a more coherent focus for defining the space component of an IGOS would be to adopt "Themes" in place of the existing 6 "pilot" projects. The "Oceans" were adopted as one of the Themes with the intention of subsuming GODAE, IOCCG and GOOS/GCOS requirements. Because of the progress made with GODAE it was decided that the Oceans Theme should be given priority in terms of the development of specific requirements and needed actions. Three tasks were assigned at that meeting:

(i) A restatement of the requirements derived in the first instance from those of GODAE (undertaken by P. Bahurel on behalf of GODAE);
(ii) A list of themes to be drafted by the GOSSP Chair (attached);
(iii) A discussion of needed actions (E. Lindstrom/NASA to lead).

The input from (i) is incorporated in the discussion above as is the preamble/background from (iii) (provided in draft form by E. Lindstrom). In their wisdom CEOS have decide to retain the term "Themes" for the purposes of their discussion (GCOS SC endorsed the ideas put forward by Bretherton). While CEOS recognize the desirability of addressing a broad range of themes, it also sees that it is only practical to address a subset, where there is a visible political will to exploit global observations or where there is already a strong core of activity. The list as it stands at present is :

Domain Themes
- Oceans;
- Terrestrial (including global NPP);
- Atmospheric chemistry and climate;
- Weather predictions;
- Coastal zones; and
- Disaster management.

Cross-Cutting Themes
- Carbon storage and cycling (sources and sinks) ;
- Climate variability and change ;
- Climate inputs ; and
- Water Cycle.

There has been general agreement that the Oceans work should start at once, with the aim of completing the IGOS component by the end of 1999. In order to facilitate progress, the Chairman of GOSSP has agreed to hold an early meeting of this group devoted primarily to Oceans. The Oceans team will be led by NASA, supported by CNES, ESA, ISRO, NASDA, and NOAA with GOOS as co-leader. It is clear that the team will be able to take advantage of several on-going initiatives with high political profile. This theme will be able to incorporate the work of the ocean biology and GODAE projects begun as IGOS pilot projects under SIT. The NASA team leader has already started to make contacts and an action plan will be completed in time to share at the June IGOS Partners Meeting.

## 5. ACTIONS TO BE CONSIDERED BY CEOS

Eric Lindstrom (NASA) has produced a nice paper leading to a recommended set of actions that might be considered by IGOS partners and CEOS. A substantial part of the background to that paper is incorporated in the above. However to round out this discussion, I have provided below a copy of the actions put forward in that paper. There is no formal action requested of GOOS SC but I think feedback would be appreciated.

Excerpted from Lindstrom's paper:

*It is the intention of (the) action plan to provide some critical ideas for an ocean strategy and actionable items for the IGOS Partners. These ideas and actions will need to be developed further by the global observing community and carried forward to the highest levels of government. Oceans Theme activities in the context of an IGOS will benefit from linkage to dedicated meetings on the oceans topic planned in the summer and fall of 1999 by GOSSP, the CEOS SIT, the Ocean Observations Panel for Climate (OOPC) and other sponsors, with a potential linkage also to the 5th meeting of the Conference of the Parties for the Framework Convention on Climate Change.*

The following are ten specific items that must be addressed en route to realization of an operational oceanography capability. Their priority order has not been established. Each could be expanded into a "white paper" by a small group and discussed internationally.

(i) To enable operational oceanography, governments must provide where needed, within the charter of environmental monitoring, research and space agencies, the mandate to operate and maintain long-term ocean and climate observations.

(ii) National and international policies guiding the timeliness and necessity for transition of measurements from development as research tools to operational longevity for practical benefit must be derived and implemented. [Useful section in US IOOS report discussing transition could be used here]

(iii) User groups for operational ocean products must be cultivated and consulted. User "pull" and research "push" will both be necessary and equal partners in development of operational oceanographic capabilities. A "needs assessment" is required as well as a "capabilities assessment."

(iv) The existing strengths in ocean observing from space and in global *in situ* observing systems are in the open ocean. However the constituency for ocean products and a significant fraction of humanity live in the coastal zone. The issue of how best to use the existing global observational capabilities to address coastal problems must be the subject of focussed study.

(v) Technological development of instruments for ocean research aimed at delivery of data of premium quality need to also take account of their potential future as operational instruments. The need is to target development of capable, cost-effective, sensors for future operational deployment.

(vi) Data systems must be reconfigured to optimize delivery of data and data products in a timely manner. The data latency for required products must be defined.

(vii) Every effort must be made to enable wide availability of data for development of superior products. An assessment of restrictions to data access and its impact on oceanography is required.

(viii) An operational oceanography system should be built so as to minimize single points of failure within the system. This aspect of design has yet to be considered and will likely require unprecedented international cooperation to be realized.

(ix) What will be the relative roles of the government and commercial sectors in global operational oceanography? Products of an operational oceanographic system should be assessed for their commercial value and for their value as a public good.

(x) What will be the ongoing personnel and skill requirements for maintaining an ocean observing system and delivering products derived from it? Education, training and outreach requirements should be assessed as a long-lead time element needed to successfully implement the system.

# ANNEX VI
## TABULATED OBSERVATIONAL DATA REQUIREMENTS FOR GOOS/GCOS
## TABLE A

A summary of the sampling requirements for the global ocean, based largely on OOSDP (1995), but with revisions as appropriate. These are a statement of the required *measurement network* characteristics, not the characteristics of the derived field. The field estimates must factor in geophysical noise and unsampled signal. Some projections (largely unverified) have been included for GODAE.

**SAMPLING REQUIREMENTS FOR THE GLOBAL OCEAN**

| Code | Application | Variable | Hor. Res. | Vert. Res. | Time Res. | No. of samples | Accuracy |
|---|---|---|---|---|---|---|---|
| A | NWP, climate, mesoscale ocean | Remote SST | 10 km | - | 6 hours | 1 | 0.1-0.3°C |
| B | Bias correction, trends | *In situ* SST | 500 km | - | weekly | 25 | 0.2-0.5°C |
| C | Climate variability | Sea surface salinity | 200 km | - | 10 days | 1 | 0.1 |
| D | Climate prediction and variability | Surface wind | 2° | - | 1-2 days | 1-4 | 0.5-1.0 m/s in the components |
| E | Mesoscale, coastal | Surface wind | 50 km | - | daily | 1 | 1-2 m/s |
| F | Climate | Heat flux | 2° x 5° | - | monthly | 50 | Net: 10 W/$^{M2}$ |
| G | Climate | Precis. | 2° x 5° | - | daily | Several | 5 cm/month |
| H | Climate change trends | Sea level | 30-50 gauges + GPS with altimetry, or several 100 gauges +GPS | - | monthly means | | 1 cm, giving 0.1 mm/yr accuracy trends over 1-2 decades |
| I | Climate variability | Sea level anomalies | 100-200 km | - | 10-30 days | ~ 10 | 2 cm |
| J | Mesoscale variability | Sea level anomalies | 25-50 km | - | 2 days | 1 | 2-4 cm |
| K | Climate, short-range prediction | sea ice extent, concentration | ~ 30 km | - | daily | 1 | 10-30 km<br>2-5% |
| L | Climate, short-range prediction | sea ice velocity | ~ 200 km | - | daily | 1 | ~ cm/s |
| M | Climate | sea ice volume, thickness | 500 km | - | monthly | 1 | ~ 30 cm |
| N | Climate | surface $pCO_2$ | 25-100 km | - | daily | 1 | 0.2-0.3 atm. |
| O | ENSO prediction | T(z) | 1.5° x 15° | 15 m over 500 m | 5 days | 4 | 0.2°C |
| P | Climate variability | T(z) | 1.5° x 5° | ~ 5 vertical modes | monthly | 1 | 0.2°C |
| Q | Mesoscale ocean | T(z) | 50 km | ~ 5 modes | 10 days | 1 | 0.2°C |
| R | Climate | S(z) | large-scale | ~ 30 m | monthly | 1 | 0.01 |
| S | Climate, short-range prediction | U (Surface) | 600 km | - | monthly | 1 | 2 cm/s |
| T | Climate model validation | U(z) | a few places | 30 m | monthly means | 30 | 2 cm/s |

# ANNEX VII

## OCEAN REMOTE SENSING REQUIREMENTS

### TABLE B

| OBSERVATIONS | | | | OPTIMIZED REQUIREMENTS | | | | THRESHOLD REQUIREMENTS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Code** | **Application** | **Variable** | **Type** | **Horizontal sal e (km)** | **Cycle** | **Time** | **Accuracy** | **Horizontal scale (km)** | **Cycle** | **Time** | **Accuracy** |
| **ALTIMETRY** | | | | | | | | | | | |
| A | Mesoscale Variability | Sea Surface Topography | input | 25 | 7 days | 2 days | 2 cm | 100 | 30 days | 15 days | 10 cm |
| B | Large- scale Variability (seasonal, tides, gyres) | Sea Surface Topography | input | 100 | 10 days | 2 days | 1 cm | 300 | 10 days | 10 days | 2 cm |
| C | Mean Sea Level Variations | Sea Surface Topography | input | 200 | decades | 10 days | 1 mm/year | 1000 | decades | 10 days | 5 mm/year |
| D | Absolute Circulation Heat transport | Sea Surface Topography | input | 100 | N/A | N/A | 1 cm | 500 | N/A | N/A | 5 - 10 cm |
| E | Geoid Estimation | Geoid | Base | 100 | N/A | N/A | 2 cm | 500 | N/A | N/A | ~1 cm |
| **SURFACE WIND VECTORS** | | | | | | | | | | | |
| F | Wind-forced Circulation | Wind Field | input | 25 | 1 day | 1 day | 1-2 m/second 20º | 100 | 7 days | 7 days | 2 m/second 30º |

**Footnotes:**

A requires wave height + wind (EM bias correction) measured from altimeter,
water vapor content measured from on board radiometer, and
ionospheric content / measured from 2 frequencies altimeter.

B requires, in addition, precise positioning system: accuracy 1-2 cm for a spatial resolution of 100 km.; need to address aliasing from solar tides with non-sun- synchronous orbits.

C requires, in addition precise monitoring of transit time in the radar altimeter.

A, B, C require repeat track at + 1 km to filter out unknowns on geoid.

A requires adequate sampling: at least 2, and better 3, satellites simultaneously.

A, B, C require long lifetime, continuity, cross calibration.

D requires absolute calibration.

E requires *one-off* missions with both high- and broad-resolution determination.

F Wind field requirements for sea state determination normally exceed sampling requirements for wind forcing.

*(Table B continues on following page)*

## TABLE B OF OCEAN REMOTE SENSING REQUIREMENTS (continued)

| OBSERVATIONS | | | | OPTIMIZED REQUIREMENTS | | | | THRESHOLD REQUIREMENTS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Code** | **Application** | **Variable** | **Type input** | **Horizontal (km)** | **Cycle** | **Time** | **Accuracy** | **horizontal (km)** | **Cycle** | **Time** | **Accuracy** |
| **SEA SURFACE RADIATIVE** | | | | | | | | | | | |
| G | Ocean/ Atmospher e coupling | Sea Surface Temperature (Radiometer) | input | 10 | 6 hours | 6 hours | 0.1º K (relative) | 300 | 30 days | 30 days | 1º K |
| H | Ocean Forcing | Short wave irradiance | input | 200 | 1 day | 1 day | 15 W/$^{M2}$ | 500 | 7 days | 7 days | 20-30 W/$^{M2}$ |
| **REMOTE SALINITY** | | | | | | | | | | | |
| I | Circulation and Water Transport | Salinity | input | 200 | 10 days | 10 days | 0.1 PSU | 500 | 10 days | 10 days | 1 PSU |
| **SEA ICE** | | | | | | | | | | | |
| J | Ice-Ocean Coupling | Sea Ice Cover | input | 10 | 1 day | 3 hours | 2 % | 100 | 7 days | 1 day | 10 % |
| **OCEAN COLOR** | | | | | | | | | | | |
| K | Unwilling to Recirculatio n | Ocean Color Signal | input | 25 | 1 day | 1 day | 2 % | 100 | 1 day | 1 day | 10 % |
| **SURFACE WAVES** | | | | | | | | | | | |
| L | Sea State Prediction | Significant wave height | input | 100 | 3 hours | 3 hours | 0.5 meters | 250 | 7 days | 12 hours | 1 meter |
| M | Sea State Prediction | Period and Direction | input | 10 | 1 hour | 2 hours | ½ second 10º | 30 | 6 hours | 4 hours | 1 second 20º |

**Footnotes:** G requires high resolution sea surface temperature: new geostationary satellite + combination with low satellite.

The requirements include consideration of climate applications as determined by the OOPC and ocean forecasting/estimation as determined by GODAE.

The requirements beyond the climate module have not been detailed here.

ANNEX VIII

## LIST OF ACRONYMS

| | |
|---|---|
| **ACSYS** | Arctic Climate System Study |
| **ACVE** | Atlantic Climate Variability Experiment |
| **ADCP** | Acoustic Doppler Current Profiler |
| **ADEOS** | Advanced Earth Observing Satellite (Japan) |
| **ALACE** | Autonomous Lagrangian Circulation Explorer |
| **AOML** | Atlantic Oceanographic and Meteorological Lab (NOAA) |
| **AOPC** | Atmospheric Observing Panel for Climate |
| **ASCAT** | Advanced Scatterometer |
| **ATOC** | Acoustic Thermometry of Ocean Climate |
| **ATSR** | Along Track Scanning Radiometer |
| **AUV** | Autonomous Underwater Vehicle |
| **AVHRR** | Advanced Very High Resolution Radiometer |
| **BC** | Boundary Current |
| **BECS** | Basin-Wide Extended Climate Study |
| **BMRC** | Bureau of Meteorology Research Center (Australia) |
| **BODC** | British Oceanographic Data Centre |
| **BSH** | Bundesamt für Seerschiffahrt und Hydrographie (Germany) |
| **CAS** | Commission for Atmospheric Sciences |
| **CDS** | Computerized Documentation System |
| **CLIC** | Climate and Cryosphere |
| **DODS** | Distributed Ocean Data System |
| **CEOS** | Committee for Earth Observation Satellites |
| **CGOM** | IOC Consultative Group on Ocean Mapping |
| **CLIMAT** | Report of Monthly Means and Totals from Land Stations |
| **CLIVAR** | Climate Variability and Predictability Programme |
| **CMR** | Centre Météorologique Regional |
| **CNES** | Centre Nationale d'Etudes Spatiales (France) |
| **COOE** | Co-operative Ocean Observing Experiment |
| **COP** | Conference of the Parties for the UN FCCC |
| **CRYOSAT** | Ice Observing Satellite (ESA) |
| **CSIRO** | Commonwealth Scientific and Industrial Research Organization (Australia) |
| **DODS** | Distributed Ocean Data System |
| **ECMWF** | European Centre for Medium-Range Weather Forecasting |
| **EEZ** | Exclusive Economic Zone |
| **ENSO** | El Niño-Southern Oscillation |
| **ENVISAT** | Environmental Satellite |
| **EOS** | Earth Observation Satellite (US) |
| **ERS** | Earth Resources Satellite |
| **ESA** | European Space Agency |
| **ESD** | Earth Sciences Division |
| **EUMETSAT** | European Organization for Exploitation of Meteorological Satellites |
| **FNMOC** | Fleet Numerical Meteorology and Oceanography Center (US NAVT) |
| **GCOS** | Global Climate Observing System |
| **GEBCO** | General Bathymetric Chart of the Oceans |
| **GEF** | Global Environmental Facility (World Bank-UNEP-UNDP) |

| | |
|---|---|
| **GEO** | Global Eulerian Observing System |
| **GEOSAT** | Geodetic Satellite (US) |
| **GEWEX** | Global Energy and Water Cycle Experiment |
| **GLAS** | Goddard Laboratory of Atmospheric Sciences (US) |
| **GLI** | Global Imager |
| **GMT** | Greenwich Mean Time |
| **GOCE** | Gravity Field and Steady State Ocean Circulation Explorer |
| **GODAE** | Global Ocean Data Assimilation Experiment |
| **GOOS** | Global Ocean Observing System (IOC-WMO-UNEP-ICSU) |
| **GOSIC** | Global Observation System Information Centre |
| **GOSSP** | Global Observing Systems Space Panel |
| **GPCP** | Global Precipitation Climate Project |
| **GPO** | GOOS Project Office |
| **GPS** | Global Positioning System |
| **GSC** | GOOS Steering Committee |
| **GTS** | Global Telecommunications System |
| **GTSPP** | Global Temperature Salinity Profile Programme |
| **GUAN** | Global Upper Air Network |
| **G3OS** | Shorthand for GOOS, GCOS, GTOS |
| **HDX** | High Density XBT Line |
| **HOTO** | Health of the Ocean Panel (of GOOS) |
| **HOTS** | Hawaii Ocean Time Series Station |
| **IBCCA** | International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico |
| **IBCEA** | International Bathymetric Chart of the Central Atlantic |
| **IBCM** | Int’l Bathymetric Chart of the Mediterranean and its Geological/Geophysical Series |
| **IBCWIO** | International Bathymetric Chart of the Western Indian Ocean |
| **ICESAT** | Ice Satellite (NASA) |
| **ICPO** | International CLIVAR Project Office |
| **IGOS** | Integrated Global Observing Strategy |
| **IGOSS** | Integrated Global Ocean Services System |
| **IGST** | International GODAE Science Team |
| **IHB** | International Hydrographic Bureau |
| **IHO** | International Hydrographic Organization |
| **IMO** | International Maritime Organization |
| **IOC** | Intergovernmental Oceanographic Commission (UNESCO) |
| **IOCCG** | International Ocean Colour Coordinating Group |
| **IOOS** | Integrated Ocean Observing System (US) |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **IR** | Infrared |
| **ISRO** | Indian Satellite Research organization |
| **JCOMM** | Joint Technical Commission for Oceanography and Marine Meteorology (WMO-IOC) |
| **JDIMP** | Joint Data and Information Management Panel |
| **JGOFS** | Joint Global Ocean Fluxes Study (IGBP) |
| **JSTC** | Joint Scientific and Technical Committee |
| **KERFIX** | Kerguelan Time series Station |
| **LMR** | Living Marine Resources Panel (of GOOS) |
| **MERIS** | Medium Resolution Imaging Spectrometer |
| **METOP** | Meteorological Operational Satellite |

| | |
|---|---|
| **MJO** | Madden-Julian Oscillation |
| **MOC** | Meridional Overturning Circulation |
| **NAO** | North Atlantic Oscillation |
| **NASDA** | National Japanese Space Development Agency |
| **NCEP** | National Center for Environmental Prediction (US) |
| **NEG** | Numerical Experimentation group |
| **NOAA** | National Oceanic and Atmospheric Administration (US) |
| **NPOESS** | National Polar-Orbiting Operational Environmental Satellite System (US) |
| **NPP** | NPOESS Preparatory Programme |
| **NSCATT** | NASA Scatterometer |
| **NWP** | Numerical Weather Prediction |
| **OCTS** | Ocean Colour and Temperature Scanner |
| **OGCM** | Ocean General Circulation Model |
| **OGP** | Office of Global Programmes (US) |
| **OOPC** | GOOS-GCOS-WCRP Ocean Observations Panel for Climate |
| **OOS** | Ocean Observing System |
| **ORSTOM** | Institut Francais de recherche scientifique pour le developpement en cooperation |
| **OSSE** | Observing System Simulation Experiment |
| **PALACE** | Profiling Autonomous Lagrangian Circulation Explorer |
| **PBECS** | Pacific BECS |
| **PDO** | Pacific Decadal Oscillation |
| **PIRATA** | Pilot Research Array in the Tropical Atlantic |
| **POGO** | Partnership for Observations of the Global Oceans |
| **PRA** | Principle Research Area |
| **QC** | Quality Control |
| **QSCAT** | Version of Scatterometer |
| **RMS** | Root Mean Square |
| **SAFZ** | Sub-Arctic Frontal Zone |
| **SBSTA** | Subsidiary Body for Scientific and Technological Advice {of the COP for the UNFCCC} |
| **SCOR** | Scientific Committee for Oceanic Research |
| **SIO** | Scripps Institution of Oceanography |
| **SLP** | Sea level Pressure |
| **SMOS** | Soil Moisture Ocean Salinity Satellite (ESA) |
| **SOC** | Specialized Oceanographic Centre |
| **SOOP** | Ship of Opportunity Programme |
| **SSIWG** | Salinity - Sea Ice Working Group |
| **SSS** | Sea Surface Salinity |
| **TBD** | To be Decided |
| **TEMA** | Training Education and Mutual Assistance (IOC) |
| **TRMM** | Tropical Rainfall Measuring Mission |
| **TS** | Temperature Salinity |
| **UKMO** | UK Met Office |
| **UNFCCC** | United Nations Framework Convention on Climate Change |
| **UOP** | Upper ocean Panel |
| **UOT** | Upper Ocean Thermal |
| **VAMOS** | Variability of the American Monsoon Systems |
| **VIIRS** | Visible and Infra-red Sensor (NPOESS Sensor) |
| **VOS** | Voluntary Observing Ship |
| **WBC** | Western Boundary Current |

| | |
|---|---|
| **WCRP** | World Climate Research Programme |
| **WDB** | WMO Data Base |
| **WGNE** | Working Group on Numerical Experimentation |
| **WGSIP** | Working Group on Seasonal to Interannual Predication |
| **WHOI** | Woods Hole Oceanographic Institution |
| **WMO** | World Meteorological Organization |
| **WOCE** | World Ocean Circulation Experiment |
| **WS** | Workshop |
| **XBT** | Expendable Bathythermograph |
| **XCTD** | Expendable Conductivity Temperature Depth Instrument |

In this Series, entitled

**Reports of Meetings of Experts and Equivalent Bodies**, which was initiated in 1984 and which is published in English only, unless otherwise specified, the reports of the following meetings have already been issued:

1. Third Meeting of the Central Editorial Board for the Geological/Geophysical Atlases of the Atlantic and Pacific Oceans
2. Fourth Meeting of the Central Editorial Board for the Geological/Geophysical Atlases of the Atlantic and Pacific Oceans
3. Fourth Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of 'El Niño' *(Also printed in Spanish)*
4. First Session of the IOC-FAO Guiding Group of Experts on the Programme of Ocean Science in Relation to Living Resources
5. First Session of the IOC-UN(OETB) Guiding Group of Experts on the Programme of Ocean Science in Relation to Non-Living Resources
6. First Session of the Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
7. First Session of the Joint CCOP(SOPAC)-IOC Working Group on South Pacific Tectonics and Resources
8. First Session of the IODE Group of Experts on Marine Information Management
9. Tenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies in East Asian Tectonics and Resources
10. Sixth Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
11. First Session of the IOC Consultative Group on Ocean Mapping ***(Also printed in French and Spanish)***
12. Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ships-of-Opportunity Programmes
13. Second Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
14. Third Session of the Group of Experts on Format Development
15. Eleventh Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of South-East Asian Tectonics and Resources
16. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
17. Seventh Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration, Monaco, 1985
18. Second Session of the IOC Group of Experts on Effects of Pollutants
19. Primera Reunión del Comité Editorial de la COI para la Carta Batimétrica Internacional del Mar Caribe y Parte del Océano Pacífico frente a Centroamérica, Aguascalientes, 1986 ***(Spanish only)***
20. Third Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
21. Twelfth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of South-East Asian Tectonics and Resources
22. Second Session of the IODE Group of Experts on Marine Information Management, Moscow, 1986
23. First Session of the IOC Group of Experts on Marine Geology and Geophysics in the Western Pacific
24. Second Session of the IOC-UN(OETB) Guiding Group of Experts on the Programme of Ocean Science in Relation to Non-Living Resources, Paris, 1987 ***(Also printed in French and Spanish)***
25. Third Session of the IOC Group of Experts on Effects of Pollutants, Oslo, 1986
26. Eighth Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration, Paris, 1987
27. Eleventh Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans, Paris, 1987 ***(Also printed in French)***
28. Second Session of the IOC-FAO Guiding Group of Experts on the Programme of Ocean Science in Relation to Living Resources, Rome, 1987
29. First Session of the IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials, Paris, 1987
30. First Session of the IOCARIBE Group of Experts on Recruitment in Tropical Coastal Demersal Communities, Cartagena de Indias, 1987 ***(Also printed in Spanish)***
31. Second IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
32. Thirteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asia Tectonics and Resources, Bangkok, 1987
33. Second Session of the IOC Task Team on the Global Sea-Level Observing System
34. Third Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets, Paris, 1987
35. Fourth Session of the IOC-UNEP-IMO Group of Experts on Effects of Pollutants, Paris, 1987
36. First Consultative Meeting on RNODCs and Climate Data Services, Wormley, 1988
37. Second Joint IOC-WMO Meeting of Experts on IGOSS-IODE Data Flow, Ottawa, 1988
38. Fourth Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources, Suva, 1988
39. Fourth Session of the IODE Group of Experts on Technical Aspects of Data Exchange, Ottawa, 1988
40. Fourteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asian Tectonics and Resources, Baguio City, 1988
41. Third Session of the IOC Consultative Group on Ocean Mapping, Bremerhaven, 1988
42. Sixth Session of the Joint IOC-WMO-CCPS Working Group on the Investigations of 'El Niño', Viña del Mar, 1988 ***(Also printed in Spanish)***
43. First Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean
44. Third Session of the IOC-UN(OALOS) Guiding Group of Experts on the Programme of Ocean Science in Relation to Non-Living Resources, Bordeaux, 1989
45. Ninth Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration, Villefranche-sur-Mer, 1988
46. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico
47. Cancelled
48. Twelfth Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans, Boulder, CO, 1989
49. Fifteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asian Tectonics and Resources, Bangkok, 1989
50. Third Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes, Hamburg, 1989
51. First Session of the IOC Group of Experts on the Global Sea-Level Observing System, Bidston, 1989
52. Fourth Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean, Paris, 1989
53. First Session of the IOC Editorial Board for the International Chart of the Central Eastern Atlantic, Lagos, 1989 ***(Also printed in French)***
54. Third Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico, Caracas, 1990 ***(Also printed in Spanish)***
55. Fifth Session of the IOC-UNEP-IMO Group of Experts on Effects of Pollutants, London
56. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean
57. First Meeting of the IOC *ad hoc* Group of Experts on Ocean Mapping in the WESTPAC Area
58. Fourth Session of the IOC Consultative Group on Ocean Mapping
59. Second Session of the IOC-WMO/IGOSS Group of Experts on Operations and Technical Applications
60. Second Session of the IOC Group of Experts on the Global Sea-Level Observing System
61. UNEP-IOC-WMO Meeting of Experts on Long-Term Global Monitoring System of Coastal and Near-Shore Phenomena Related to Climate Change
62. Third Session of the IOC-FAO Group of Experts on the Programme of Ocean Science in Relation to Living Resources
63. Second Session of the IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials
64. Joint Meeting of the Group of Experts on Pollutants and the Group of Experts on Methods, Standards and Intercalibration
65. First Meeting of the Working Group on Oceanographic Co-operation in the ROPME Sea Area
66. Fifth Session of the Editorial Board for the International Bathymetric Chart of the Mediterranean and its Geological/Geophysical Series
67. Thirteenth Session of the IOC-IHO Joint Guiding Committee for the General Bathymetric Chart of the Oceans ***(Also printed in French)***
68. International Meeting of Scientific and Technical Experts on Climate Change and Oceans
69. UNEP-IOC-WMO-IUCN Meeting of Experts on a Long-Term Global Monitoring System
70. Fourth Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
71. ROPME-IOC Meeting of the Steering Committee on Oceanographic Co-operation in the ROPME Sea Area
72. Seventh Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of 'El Niño' ***(Spanish only)***
73. Fourth Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico ***(Also printed in Spanish)***
74. UNEP-IOC-ASPEI Global Task Team on the Implications of Climate Change on Coral Reefs
75. Third Session of the IODE Group of Experts on Marine Information Management
76. Fifth Session of the IODE Group of Experts on Technical Aspects of Data Exchange
77. ROPME-IOC Meeting of the Steering Committee for the Integrated Project Plan for the Coastal and Marine Environment of the ROPME Sea Area
78. Third Session of the IOC Group of Experts on the Global Sea-level Observing System
79. Third Session of the IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials

*CONTINUED ON INSIDE OF BACK COVER*

**80.** Fourteenth Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans
**81.** Fifth Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
**82.** Second Meeting of the UNEP-IOC-ASPEI Global Task Team on the Implications of climate Change on Coral Reefs, Miami, FL, 1993
**83.** Seventh Session of the JSC Ocean Observing System Development Panel, Lisbon, 1993
**84.** Fourth Session of the IODE Group of Experts on Marine Information Management, Washington, D.C., 1993
**85.** Sixth Session of the IOC Editorial Board for the International Bathymetric chart of the Mediterranean and its Geological/Geophysical Series, Jerusalem, 1993
**86.** Fourth Session of the Joint IOC-JGOFS Panel on Carbon Dioxide, Plymouth, 1993
**87.** First Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Pacific, Tianjin, 1993
**88.** Eighth Session of the JSC Ocean Observing System Development Panel, Dartmouth, NS, 1993
**89.** Ninth Session of the JSC Ocean Observing System Development Panel, Melbourne, 1994
**90.** Sixth Session of the IODE Group of Experts on Technical Aspects of Data Exchange, Geneva, 1994
**91.** First Session of the IOC-FAO Group of Experts on OSLR for the IOCINCWIO Region, Mombasa, 1994
**92.** Fifth Session of the Joint IOC-JGOFS $CO_2$ Advisory Panel Meeting
**93.** Tenth Session of the JSC Ocean Observing System Development Panel, Paradise, TX, 1994
**94.** First Session of the Joint CMM-IGOSS-IODE Sub-group on Ocean Satellites and Remote Sensing, Paris, 1994
**95.** Third Session of the IOC Editorial Board for the International Chart of the Western Indian Ocean, Zanzibar, 1994
**96.** Fourth Session of the IOC Group of Experts on the Global Sea Level Observing System, Bordeaux, 1995
**97.** Joint Meeting of GEMSI and GEEP Core Groups, Bermuda, 1993
**98.** First Session of the Joint Scientific and Technical Committee for Global Ocean Observing System, Nantes, 1994
**99.** Second International Meeting of Scientific and Technical Experts on Climate Change and the Oceans, Valletta, 1994
**100.** First Meeting of the Officers of the Editorial Board for the International Bathymetric Chart of the Western Pacific, Bali, 1994
**101.** Fifth Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico, San José, 1994
**102.** Second Session of the Joint Scientific and Technical Committee for Global Ocean Observing System, Paris, 1995
**103.** Fifteenth Session of the Joint IOC-IHO Committee for the General Bathymetric Chart of the Oceans, Monaco, 1995
**104.** Fifth Session of the IOC Consultative Group on Ocean Mapping, Bremerhaven, 1995
**105.** Fifth Session of the IODE Group of Experts on Marine Information Management, Athens, 1996
**106.** IOC-NOAA *Ad hoc* Consultation on Marine Biodiversity, Paris, 1995
**107.** Sixth Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes, Ottawa, 1995
**108.** Third Session of the Health of the Oceans (HOTO) Panel of the Joint Scientific and Technical Committee for GOOS, Bangkok, 1995
**109.** Second Session of the Strategy Subcommittee (SSC) of the IOC-WMO-UNEP Intergovernmental Committee for the Global Ocean Observing System
**110.** Third Session of the Joint Scientific and Technical Committee for Global Ocean Observing System
**111.** First Session of the Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate, Baltimore, Md, 1997
**112.** Sixth Session of the Joint IOC-JGOFS $CO_2$ Advisory Panel Meeting, Mayaguez, 1996
**113.** First Meeting of the IOC/WESTPAC Co-ordinating Committee for the North-East Asian Regional - Global Ocean Observing System (NEAR-GOOS)
**114.** Eighth Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of "El Niño", Concepción, 1996 ***(Spanish only)***
**115.** Second Session of the IOC Editorial Board of the International Bathymetric Chart of the Central Eastern Atlantic, Paris, 1996 ***(Also printed in French)***
**116.** Tenth Session of the Offices Committee for the Joint IOC-IHO General Bathymetric Chart of the Oceans (GEBCO), USA, 1996
**117.** IOC Group of Experts on the Global Sea Level Observing System (GLOSS), Fifth Session, USA, 1997
**118.** Joint Scientific Technical Committee for Global Ocean Observing System (J-GOOS), Fourth Session, USA, 1997
**119.** First Session of the Joint IOC-WMO IGOSS Ship-of-Opportunity Programme Implementation Panel, South Africa, 1997
**120.** Report of Ocean Climate Time-Series Workshop, Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate, USA, 1997
**121.** IOC/WESTPAC Co-ordinating Committee for the North-East Asian Regional Global Ocean Observing System (NEAR-GOOS), Second Session, Thailand, 1997
**122.** First Session of the IOC-IUCN-NOAA *Ad hoc* Consultative Meeting on Large Marine Ecosystems (LME), France, 1997
**123.** Second Session of the Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC), South Africa, 1997
**124.** Sixth Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico, Colombia, 1996 ***(Also printed in Spanish)***
**125.** Seventh Session of the IODE Group of Experts on Technical Aspects of Data Exchange, Ireland, 1997
**126.** IOC-WMO-UNEP-ICSU Coastal Panel of the Global Ocean Observing System (GOOS), First Session, France, 1997
**127.** Second Session of the IOC-IUCN-NOAA Consultative Meeting on Large Marine Ecosystems (LME), France, 1998
**128.** Sixth Session of the IOC Consultative Group on Ocean Mapping (CGOM), Monaco, 1997
**129.** Sixth Session of the Tropical Atmosphere - Ocean Array (TAO) Implementation Panel, United Kingdom, 1997
**130.** First Session of the IOC-WMO-UNEP-ICSU Steering Committee of the Global Ocean Observing System (GOOS), France, 1998
**131.** Fourth Session of the Health of the Oceans (HOTO) Panel of the Global Ocean Observing System (GOOS), Singapore, 1997
**132.** Sixteenth Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans (GEBCO), United Kingdom, 1997
**133.** First Session of the IOC-WMO-UNEP-ICSU-FAO Living Marine Resources Panel of the Global Ocean Observing System (GOOS), France, 1998
**134.** Fourth Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean (IOC/EB-IBCWIO-IV/3), South Africa, 1997
**135.** Third Session of the Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC), France, 1998
**136.** Seventh Session of the Joint IOC-JGOFS $CO_2$ Advisory Panel Meeting, Germany, 1997
**137.** Implementation of Global Ocean Observations for GOOS/GCOS, First Session, Australia, 1998
**138.** Implementation of Global Ocean Observations for GOOS/GCOS, Second Session, France, 1998
**139.** Second Session of the IOC-WMO-UNEP-ICSU Coastal Panel of the Global Ocean Observing System (GOOS), Brazil, 1998
**140.** Third Session of IOC/WESTPAC Co-ordinating Committee for the North-East Asian Regional – Global Ocean Observing System (NEAR-GOOS), China, 1998
**141.** Ninth Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of 'El Niño', Ecuador, 1998 ***(Spanish only)***
**142.** Seventh Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and its Geological/Geophysical Series, Croatia, 1998
**143.** Seventh Session of the Tropical Atmosphere-Ocean Array (TAO) Implementation Panel, Abidjan, Côte d'Ivoire, 1998
**144.** Sixth Session of the IODE Group of Experts on Marine Information Management (GEMIM), USA, 1999
**145.** Second Session of the IOC-WMO-UNEP-ICSU Steering Committee of the Global Ocean Observing System (GOOS), China, 1999
**146.** Third Session of the IOC-WMO-UNEP-ICSU Coastal Panel of the Global Ocean Observing System (GOOS), Ghana, 1999
**147.** Fourth Session of the GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC); Fourth Session of the WCRP CLIVAR Upper Ocean Panel (UOP); Special Joint Session of OOPC and UOP, USA, 1999