Intergovernmental Oceanographic Commission
Reports of Meetings of Experts and Equivalent Bodies

Joint GCOS-GOOS-WCRP
Ocean Observations Panel for Climate (OOPC)
Fifth Session

Bergen, Norway
20 - 23 June 2000

GOOS Report No. 98
GCOS Report No. 69
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GCOS-GOOS-WCRP/OOPC-V/3
Paris, 15 January 2002
English only

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ANNEXES

1. OPENING AND WELCOME

The Chair, Dr Neville Smith, opened the meeting and welcomed the members of the group to the 5th session of the Ocean Observations Panel for Climate (OOPC). The Chair thanked the Institute of Marine Research and the Nansen Centre, and especially Einar Svendsen, Johnny Johannessen, and Peter Haugan, for hosting the Panel and for their help with local logistics. The members of the Panel were introduced and information about local arrangements was provided by the local hosts. The full list of participants is given in Annex II.

2. REVIEW AND ADOPTION OF THE AGENDA

The Chair introduced the Agenda (given in Annex I) and noted that it would be necessary to adjust the schedule and starting times for the meeting to suit the needs of several members of the Panel and invited speakers. The Agenda was adopted without further modification.

3. REVIEW OF INTERSESSIONAL ACTIVITIES

3.1 LESSONS LEARNED FROM OCEANOBS 99

Dr Neville Smith outlined the conclusions from the First International Conference on the Ocean Observing System for Climate (OceanObs 99), which was convened jointly by OOPC and CLIVAR-Upper Ocean Panel (UOP). The conference was held in St Raphael, France, 18-22 October 1999. The conference statement can be read at:

http://www.bom.gov.au/OceanObs99/Papers/Statement.pdf

Dr Smith concluded that the conference was successful in what it set out to do; namely, to reach broad consensus on what an ocean observation system for climate should look like. He also believed that it was an educational experience for scientists to come together in a forum such as this and to be exposed to fields outside their expertise. The round-table discussions held during the conference were particularly useful for discussing the major issues facing the development of an observing system.

As outlined in the conference statement, development and implementation of the observing system will proceed by first identifying:

i. Primary Elements – fundamental and required elements without which the observing system would be weak.

ii. Critical Enhancements – component development from research through to operational phases.

iii. Critical Gaps – identifying spatial and temporal sampling problems and measurement technique limitations.

iv. Crosscutting Components – further development of data and information management systems, information technology issues, modelling and data assimilation.

Dr Smith outlined several aspects of the observing system that need further development, such as time-series stations and hydrography, and suggested that this meeting should determine what the Panel could do to make improvements in the planning of these components.

The Panel reviewed the elements of the primary network and enhancements to the observing system outlined in the conference statement, and suggested revisions or updates to the statement:

i. The tide gauge monitoring section should be modified, and concerning the issue of sea level changes, volume changes of water resulting from temperature changes (i.e. thermal expansion) should be briefly mentioned.

ii. Remote sensing and *in situ* programmes are treated separately in the statement, and these should be combined in some way to show a more unified and co-ordinated system.

iii. The *Argo* and SOOP programmes should be cross-referenced to show how Argo will take over some of the duties of SOOP.

iv. There are inconsistencies in the statement in section 4 (The Sustained Network) between components labelled as primary components and those labelled as enhanced components. In this section, it is not clear what components are required and what components are assumed to be in place from other parts of the programme.

v. There was a lengthy discussion surrounding the issue of 'bulk' temperature and 'skin' temperature. There is no definition given in the statement and often no distinctions between the two temperatures are made. Furthermore, since an accepted working definition does not exist for the time being, the discussions of sea surface temperature observations should maintain the distinctions in measurements and 'labelling' of bulk vs. skin temperatures. The members agreed that the community should be alerted to this issue.
[This issue has since been taken up by the GODAE High Resolution SST Pilot Project; see http://www.bom.gov.au/bmrc/mrlr/nrs/oopc/godae/HiResSST/].

vi. In Europe, some funding agencies have begun asking how the retrieval of the *Argo* floats will be handled, since leaving them in the ocean is seen to pose an environmental hazard, especially in high latitudes. The Chair noted that the official policy is that the floats will be retrieved whenever possible.

vii. The Panel raised the questions of how combined observations and analyses will be used to create data fields and products. Under Regional Enhancements, a section on the Southern Ocean will be added, and that possibly polar regions should be added to this section. In the Cross-Cutting Programmes section, the value of the data archaeology programmes should be mentioned.

Dr Smith and Dr Chet Koblinsky noted these comments for use in an upcoming revision of the statement. Dr Smith also announced that the OceanObs 99 papers will be peer-reviewed and published as a book by the Australian Bureau of Meteorology. The anticipated publication date is July 2001.

3.2 IOC UPDATE

Dr Maria Hood, representing the IOC, provided an update of activities at the IOC of interest to the OOPC. Janice Trotte, the former IOC Technical Officer in charge of the TAO and PIRATA programmes, has returned to Brazil to work in the Department of Hydrography and Navigation. She will continue her affiliation with IOC and GOOS from Brazil.

Over the last several months, IOC has undergone two external reviews; one for the whole of IOC and one focussing specifically on the ocean sciences programmes. The report concluded that if the IOC did not exist, it would have to be invented. The report (External Evaluation Report presented at the 33rd Session of the IOC Executive Council) highlights the necessary role the IOC plays in international ocean science programmes. Referring to the climate programmes, the external evaluation report states that:

> *"The ocean climate programmes are demanding on the IOC but critical to its future role. The direction for these programmes is largely found outside the IOC, but commitment and direct involvement of Member States are needed for their successful implementation. At the moment, the successes of recent El Nino forecasts are fresh in the minds of many governments. UNESCO and its IOC cannot afford to be absent from the debate on these critical global issues and therefore must keep Member States fully informed of, and committed to, the climate programme and its impact."*

3.2.1 Reconstituted CO_2 Panel

Dr Hood informed the Panel that the 8th Session of the Joint IOC-JGOFS CO_2 Advisory Panel in Tsukaba, Japan in January, 1999, marked the end of the work for the first CO_2 panel. The Panel had completed its main task of fostering activities leading to a high-quality, coherent ocean carbon data set from JGOFS fieldwork. The Panel has done its job well and that congratulations were in order. The CO_2 Panel now needs to be reconstituted with new Terms of Reference and a membership consistent with those terms. The Advisory Panel on Ocean CO_2 will be a joint SCOR – IOC panel, where IOC provides financing with SCOR, in-kind assistance, and stewardship for the Panel. The Panel will undertake specific tasks, such as writing white papers, convening special workshops and international ocean CO_2 conferences, and will provide ready expertise as needed to IOC and OOPC, as well as SCOR. Dr Hood presented and briefly discussed the new TORs for the Panel (given in Annex III) and noted that potential panel members have been identified and invitation letters have been sent. Dr Doug Wallace from the Institut fur Meereskunde, University of Kiel, has agreed to chair the new panel. The first meeting of the group will be held 4-6 September 2000 in Paris.

The Chair remarked that CO_2 will be a part of the long-term observing strategy, and together with the Ocean Colour Panel, GOOS will work to establish both *in situ* and satellite monitoring programmes for carbon.

3.2.2 Coastal Panel

No report was available on this item (see 3.2.3 for information on the new Coastal Ocean Observations Panel).

3.2.3 GOOS Steering Committee

Dr Neville Smith provided an update on items of interest to OOPC from the recent GOOS Steering Committee (GSC). Dr Smith noted that GOOS has matured over the last 5 years, and thus many of the advisory panels need to adjust the terms of reference according to new needs. The Steering Committee recommended (Action Item 5) that the TORs for the OOPC be changed as follows:

i. To monitor and describe the physical and biogeochemical processes that determine ocean circulation and effects on the carbon cycle and climate variability.

ii. To provide the information needed for ocean and climate prediction, including marine forecasting.

These changes must still be approved by GCOS and GTOS.

The GSC suggested that OOPC, in collaboration with CLIVAR and the SCOR-IOC CO_2 Panel, should work to develop a plan for observations needed for global hydrography to monitor the carbon inventory, carbon, heat and fresh water fluxes, thermohaline overturning, etc., (GSC Action Item 7). OOPC should continue its close ties with CLIVAR and ensure that research and operational requirements are fully integrated and consistent with GOOS and sustained research needs (GSC Action Item 8). The GSC requested the OOPC to maintain its links with the Working Group on Air-Sea Fluxes (WGASF), and to offer its assistance in the preparation and convening of a workshop in June of 2001 (GSC Action Item 9).

Dr Smith reported that in the view of the GSC, the formation of new groups focusing on waves and surges or on the polar regions is not warranted at this time. However, the GSC did request that the OOPC report to the Committee on specific actions and/or statements that arise from the OOPC V meeting, including activities in the Arctic region (see Items 5.3 and 5.6).

Other items of interest for OOPC from the Steering Committee Meeting included:

i. A new IOC office in Perth, Australia, has been opened.

ii. A new Coastal Ocean Observations Panel has been formed from the LMR, HOTO, and C-GOOS Panels.

iii. The GSC endorsed the IGOS Oceans Theme Paper, but suggested modifications to include a more comprehensive reference to *in situ* requirements.

iv. The GSC also concluded that J-DIMP is not needed at this time for issues of data and information management for the G3OS systems and recommended that the Panel be disbanded.

The GSC Executive Committee has asked OOPC to develop and evaluate a list of potential major operational centres for the GOOS Initial Observing System (IOS). The GOOS Project Office would then contact the approved centres to determine their willingness to be part of the GOOS-IOS (GSC Action 39 and Item 7, Action Items; Annex III).

3.3 GCOS STEERING COMMITTEE AND THE FOLLOW UP WITH UNFCCC

Dr Alan Thomas, director of GCOS, discussed the CoP / SBSTA decisions. The GCOS agenda in response to CoP-5 is to encourage involvement in the national reporting process, to organise regional workshops to address deficiencies in the observation systems using the available data and expert panels, to facilitate the intergovernmental process, and to develop a synthesis process with UNFCCC. The intergovernmental process for GCOS will involve using more fully the existing intergovernmental mechanisms of the GCOS sponsors, continuing to interact with the UNFCCC, especially the SBSTA, encouraging the national co-ordination of climate observations across the various disciplines and domains, and increasing representation from the national operational agencies on the GCOS Steering Committee.

Discussion

Dr Thomas asked the OOPC to list the top 3-4 priorities of the OOPC that can be sent to the GCOS Steering Committee Meeting in September 2000. The Panel outlined the following items:

- Bringing the power of UNFCCC to get nations involved and to support the Observing System. The UNFCCC can provide visibility and attention to parties not typically reached by the

G3OS systems directly. The Chair also noted that collaboration with UNFCCC would maintain the credibility of GCOS and OOPC. GCOS will be reporting to the COP on an annual basis through SBSTA.

- Focusing on regional issues of programme implementation and involvement (Argo, for example), use of data and contributions of data (historical and contemporary), involvement in the political process, especially for the developing countries, and providing access to GEF support for funding training and capacity building activities. The Chair noted that for regional workshops, attention must be paid to the use of observations and products specific to the regions.

- Fostering cross-discipline links. The Chair remarked that many cross-discipline links have not been effectively addressed, noting, for example, the links between wind, carbon, and ocean colour data that need to be dealt with in the G3OS system. The Chair suggested that GOSSP could play a unique role in this effort (the future of GOSSP is now being debated as a result of the Chair stepping down).

- Serving as an umbrella for joint activities. The Chair noted that the link between GOOS and GCOS in IGOS provides a 'global' strategy for the observing system. The director of the GOOS Project Office will attend the GCOS Steering Committee meeting in September, and Ed Harrison will continue with AOPC.

3.4 IGOS PARTNERS

Dr Neville Smith noted that for OOPC, the IGOS Oceans Theme paper (see *http://www.igospartners.org/* represents an implementation plan for remote sensing. In general, the paper is consistent with the findings of the OceanObs 99 statement. Dr Smith summarized some of the issues and challenges of long-term continuity for ocean observations, which include ocean topography, ocean vector winds, ocean biology (colour), sea surface temperature, sea ice, and salinity. In terms of knowledge challenges, the key issues are precision gravity fields, salinity measurements from space, and sea-ice thickness [See also discussion under Item 3.8.].

Discussion

The Panel noted that some of the statements in the IGOS Oceans Theme paper are not in agreement with those in the OceanObs 99 statement, and that the IGOS paper was particularly weak on fluxes and data availability. The Chair noted, however, that the IGOS paper was a useful document for OOPC and showed agreement on the major remote time-series observations needed. He also stated that OOPC should ensure that the IGOS Oceans Theme paper gets treated properly at the IOC; namely, to make it clear that the paper was not endorsed as written, since some issues are not in agreement with the OceanObs 99 statement or the recommendations of OOPC. *[The final version of the Paper was made consistent with OceanObs 99 and addresses the above issues.]*

3.5 POGO

Dr Bob Weller described the POGO programme, which consists of the directors of large oceanographic centres (i.e. SIO, WHOI, SOC) who have committed their organizations to serving the broader oceanographic community as an advocacy group capable of providing a unified voice on issues of interest to the oceanographic community. The Partnership, which currently consists of 12 nations, focuses on advocacy and securing support for important issues, promoting institutional relations (e.g. shiptime scheduling, collaborations, etc.), and strategic planning. Dr Weller directed the Panel to the web site for detailed information about POGO (http://www.sioworld.ucsd.edu/pogo.html).

The Directors of POGO agree on the priorities of a number of on-going programmes. POGO supports:

i. *Argo*, by encouraging that the research ships of the represented institutions support Argo needs whenever possible.

ii. Time-Series Stations.

iii. Establishment of a clearinghouse for sharing information among the POGO institutes.

iv. Working with the IOC and the IGOS Oceans Theme.

v. Data Exchange Pilot Programme – a programme designed to share data among the POGO institutes to see where pitfalls exist in current data and information exchange technologies, using DODS on pentium PCs or similar systems. The primary goal is to get the research community involved in data and information exchange technologies to highlight problem areas and bring intellectual expertise to the issue.

vi. Fostering communications and media outreach groups (public relations).

vii. Education and Capacity Building – POGO will work with the IOC and SCOR to support and promote these efforts.

Dr Weller noted that POGO has drafted the Terms of Reference for the Partnership and will hire an executive director. The terms of reference (draft) are given in Annex V. *[Dr Shubha Sathyendranath was subsequently appointed as Director.]*

3.6 JCOMM

Dr Neville Smith provided an update from the recent JCOMM-Transition Committee meeting in Paris. He noted that the organizational structure had been agreed upon and that the design was as streamlined as could be expected. There are 4 programme areas; Observations, Data and Information Management Systems, Services, and Capacity Building. Mr Etienne Charpentier will serve as the JCOMM co-ordinator for the SOOP, DBCP, and Argo programmes. The first JCOMM meeting is scheduled for 19-29 June 2001 at which time the new structure and terms of reference for the various groups will be confirmed.

Further information on JCOMM can be obtained from:

http://www.wmo.ch/web/aom/marprog/marprog.html#Joint WMO/IOC.

The Chair noted the new organizational structure (reproduced in Fig. 1). The OOPC will play its most significant role through liaison with the Observations Coordination Group (OOPC will be represented) but will also need to work with the other Programme Areas as well.

The Chair agreed to continue working with JCOMM over the next 12 months [he has been invited to deliver one of the Lectures at JCOMM I].

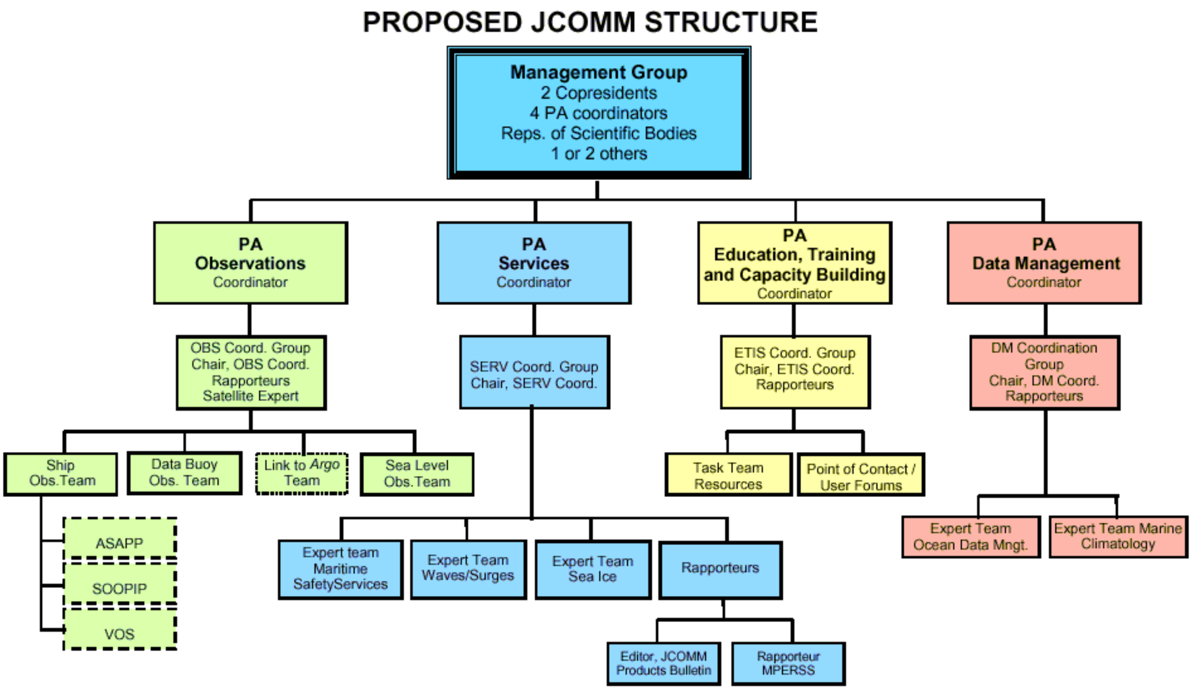

Figure 1. The proposed JCOMM organizational structure.

3.7 UPPER OCEAN PANEL AND CLIVAR IMPLEMENTATION

Dr Chet Koblinsky reported on recent developments in the UOP and CLIVAR from their May meeting. He noted that the Panel will be continued with broader terms of reference, leading to a change in name to the CLIVAR Ocean Observations Panel (COOP), with the following changes:

i. COOP will look at full-depth observations as well as surface observations. New members have been nominated for the Panel who have expertise in this area.

ii. Emphasis will be on effectiveness of the system and end-to-end management for CLIVAR, including models.

iii. CLIVAR is moving towards a basin implementation strategy rather than global implementation. The Panel must work to ensure that global science can be done within the basin implementation strategy.

iv. COOP will maintain a role in the observational requirements for seasonal-to-interannual predictions by working closely with modelling groups, like the CLIVAR Working Group on Seasonal to Interannual Prediction, to determine the observational requirements and by continuing involvement of scientists with expertise in observations on the Panel.

v. COOP will form a liaison with OOPC and GODAE for operational and quasi-operational systems.

Dr Koblinsky stated that because of its new broader terms of reference, the COOP will be fairly large in number. The Panel will consist of full-time members to focus on CLIVAR issues and ex-officio members from programmes such as TAO, GODAE, and *Argo*. The Panel will form liaisons with JCOMM groups such as GLOSS, DBCP, and SOOP, so that the Panel can contact persons within each group for co-ordinating efforts among the various programmes. These are very important connections and feedback mechanisms that allow the observation system to be responsive on a number of issues. The interactions with CLIVAR and the effectiveness of global observations will become clearer as the programmes develop.

The CLIVAR Ocean Observations Panel is scheduled to meet the week before OOPC VI, in Hobart, Tasmania.

3.8 REMOTE SENSING UPDATE

Dr Johnny Johannessen provided the following update on a number of on-going and planned remote sensing projects.

3.8.1 Ongoing Projects

IGOS Partnership Oceans Theme

In terms of the long-term continuity challenge, Dr Johannessen outlined the observations and key issues and objectives. The IGOS Ocean Theme Paper can be found and downloaded on the IOC web-site at: http://www.igospartners.org/.

Ocean Topography

Continuation of a TOPEX/POSEIDON-class high-precision satellite (i.e. Jason-1), an ERS/ENVISAT-class altimeter and the implementation of the Argo profilers. The key issues are the future funding of Jason beyond Jason-1 and of the Argo profilers. The principal data product is a 10-day global map of sea-surface height (SSH) at a resolution of 0.5°.

Ocean Vector Winds

Continuation of a morning and afternoon, ERS/QuikSCAT-type of data service, with a coverage equivalent to, or better than, a dual-sided scatterometer. The key issues here concern the closing of gaps in global coverage by two scatterometers in the 2000-2003 and 2005-2008 time periods. Principal products include 5-day averaged winds at the ocean's surface.

Ocean Biology

Continuation of global satellite missions for ocean colour, such as SeaWiFS and MODIS. The issues are to realize and help define the NASA-NPOESS bridging mission for the post-2005 time frame, refine and co-ordinate the products that can be derived from ocean colour missions, establish routine and autonomous measurements of *in situ* ocean biology and optics, and establish routine measurements of the CO_2 system. Principal products include an 8-day global composite at a resolution of 9km, and local-area coverage (on request).

Sea Surface Temperature (SST)

Continuation of the geostationary, and low-earth-orbit meteorological satellites that produce merged sea-surface temperature data products. The provision of sufficient high-quality, *in situ* data to blend with satellite data remains a key issue. A second issue is to consider how to transform ATSR-class instruments to operational systems. Principal products include 5-day, global, 0.33°x0.33° SST obtained from a variety of *in situ* sources and satellite data. These issues have been taken up by the GODAE High Resolution SST pilot Project [http://www.bom.gov.au/bmrc/mrlr/nrs/oopc/godae/HiResSST/].

Sea Ice

Continuation of the DMSP passive micro-wave systems, Radarsat and EOS Terra and post-ENVISAT systems to provide for long-term observations of ice extent and type. A key issue is the funding of Radarsat-2. Principal products include: ice drift, ice deformation and thin ice age (Radarsat), and ice extent, ice concentration, and ice drift (SSM/I).

Salinity

Continuous, large-scale, systematic collections of surface and subsurface salinity data are required but do not presently exist.

3.8.2 Planned Activities

In terms of the Knowledge Challenge the key issues and objectives are as follows:

Precision Gravity Field or Geoid

To implement the GRACE/GOCE class missions and provide a high quality Geoid.

Salinity

To develop and demonstrate space technologies (*e.g.* SMOS) that can eventually provide long-term, global data to complement the *in situ* measurement systems.

Sea Surface Temperature

To pursue the development needed to attain sea-surface temperature estimates to significantly better than ± 0.5°C on a routine and global basis.

Sea State and Atmospheric Pressure

To pursue developments in Synthetic Aperture Radar and other methods for space-based measurements.

Ocean Biology

To develop algorithms and data products to describe primary productivity and other biological processes in the ocean and in coastal seas.

Sea Ice Thickness

To develop satellite systems capable of determining ice thickness (e.g. CRYOSAT). The ERS-2 radar altimeter can provide estimates of sea ice free-board height (which in turn can be inverted to sea ice thickness) by differentiating both the shape of open water and sea ice return waveforms as well as their roundtrip travel time. The CRYOSAT mission, planned for launch in 2003 is a 3-year programme designed to estimate trends in the ice masses of the Earth. This will be achieved by measuring the change in sea ice and ice sheet thickness with a radar altimeter using interferometric and synthetic aperture techniques for resolution enhancements. CRYOSAT will go to 86ºN, filling in the gap between TOPEX / POSEIDON (66ºN) and ERS (82ºN), and the systematic focus on ice thickness will make an important addition to the observing system. The CRYOSAT programme is currently in Phase A of technical and scientific feasibility studies, and will move into Phase B, scientific and technical support studies, in July 2000.

Call for ideas for the next Earth Explorer Core Missions

As part of the Earth Observation Envelope Programme, ESA announced an opportunity for scientists from the Member States and Canada to make proposals for ideas to be assessed as potential Earth Explorer Core Missions. The four relevant themes are:

- Earth Interior
- Physical Climate
- Geosphere/Biosphere
- Atmosphere and Marine Environment

The call was released on 1 June 2000 with a submission deadline of 1 September 2000. Results will be announced on 1 December 2000. Dr Johannessen cautioned, however, that it is probably not likely that this round would include an oceanography mission given the number of ongoing missions focussing on the oceans.

Gravity Missions: Status of CHAMP, GRACE and GOCE

A common goal of these missions, in particular the latter two, is to provide a new, accurate and detailed global model of the Earth's gravity field and geoid. Whereas GOCE will aim at the static field with a 100 km spatial resolution GRACE will recover the time varying field at about 500 km resolution. The GOCE programme is scheduled for launch in 2004/2005 with a 20-month duration, and scientific and technical support studies are currently being defined. GRACE has a 2001 launch schedule with a 5-year duration, and CHAMP should be launched this year with a 2-3 year duration.

3.8.3 Sea Surface Temperature Retrievals from Passive Microwaves

Dr Johannessen focused the discussion on the satellite measurement of sea surface temperature through clouds, and provided an update on the Tropical Rainfall Measuring Mission (TRMM) microwave imager (TMI). The field of view for the TMI is 40ºN to 40ºS and has a 50 km spatial resolution. Validation tests against direct comparison with ocean buoys from December 1997 to June 1999 (F. Wentz et al., *Science*, 5 May 2000) have provide the following results:

Array	# Obs.	Mean Diff. (ºC)	SD
TAO	1479	- 0.27	0.51
NDBC	3307	0.01	0.70
PIRATA	1393	0.02	0.49

The next polar orbiting passive microwave satellite will be the joint US-Japanese ADEOS 2, which will operate the Advanced Microwave Scanning Radiometer (AMSR) with the 6.9 GHz channel that will enhance the SST retrieval. This satellite is scheduled to be launched towards the end of 2000 (see also the GODAE SST project cited above).

4. OOPC INITIATIVES

4.1 SST OBSERVATIONS

Dr Richard Reynolds presented an overview and update of SST projects and issues.

Climate Scale SST Analyses

Dr Reynolds reported on the progress of the SST Working Group. The purpose of the group is to record and evaluate the differences among historical and near-real-time SST analyses on climate time scales. The comparisons showed that there are systematic errors in SST, with the largest uncertainties resulting near the sea ice. However, there are also errors introduced by other processes including analysis assumptions, data screening and bias corrections. The group has shown that the new blended (*in situ* plus satellite) SST analyses from the United Kingdom and NOAA are in better agreement than previous products. This demonstrates that the group has been successful in improving SST products. The group has established an SST product server where data sets and data products are made available to the group. The server allows interactive mapping of the SSTs as shown in Figure 2. The server is being designed to allow public access to international *in situ* and blended SST analyses developed within NOAA as well as those developed by other US agencies and by other countries. The SST analyses will include a complete description of the individual analysis procedures. Thus, the server will be of great benefit to scientists and other users because it will allow access to different SST products at one location. Dr Reynolds stated that these SST comparisons of the Working Group are important and should continue.

Where do we need *in situ* data?

Dr Reynolds presented a method to determine where additional buoy *in situ* SST observations were needed to supplement other *in situ* and satellite observations to assure SSTs are accurate to 0.5ºC on a weekly 5º grid. If the satellite data density is adequate, *in situ* data will only be needed to correct the satellite data. In this case, the *in situ* data will be needed on a 10º grid, because it may be assumed that the satellite will give the large-scale SST gradients acceptably. The results are shown in Figure 3 for a one-year period (December 1998 through November 1999). Boxes with more than 40 weeks of data are considered to be well sampled. Boxes with fewer than 40 weeks of data require more buoy observations. If the number of boxes required was assumed be equal to the number of buoys required during the year, these results show that 200 buoys are needed (121 for the 5º boxes, 79 for the 10º boxes) for the period shown.

Corrections

Dr Reynolds gave an overview of bias corrections made for historical *in situ* SST data (1910-1941) by the UK Meteorological Office (UKMO) and by NOAA. The biases are due to instrument changes on ships. The earliest observations were made by uninsulated bucket, which are biased cold by evaporation. More recent observations are made by a various methods including insulated bucket, contact sensors and engine intake; intake temperatures are biased warm by the heat of the ship's engine. He described the two different methods, and presented a comparison of the two resulting historical corrections. The two methods show good agreement for the period 1910-1941 and suggest that uncorrected historical data were approximately 0.4ºC too warm. The two methods diverge for the period prior to 1910, however. The UKMO procedure estimates that the data are only 0.1ºC too warm in 1860, while the NOAA procedure estimates that the data are 0.4ºC too warm. This uncertainty impacts estimates of global temperature changes. Bias corrections determined by these methods need error bars, which depend on the data distribution, type of measurement and number of observations.

Which SST?

Dr Reynolds reminded the Panel that there is still a debate about the use and definition of 'bulk' temperature and 'skin' temperature. He presented a time series of buoy SST measurements (Anderson et al., 2000[1]) at four different depths as shown in Figure 4. The figure shows a typical daytime heating on March 11, 1998, and a night time cooling due to precipitation (which lowered the

[1] Anderson, S. P., Huang, K., N. J. Brink, M. F. Baumgartner, R. A. Weller. 2000: Pan American Climate Study (PACS) Data Report, UOPT Technical Report 00-01,Woods Hole Oceanographic Institute, 145pp.

local surface salinity) on March 12. The figure illustrates the uncertainty in obtaining bulk SST observations with unspecified depth. There are also differences in the depth of skin measured from IR and from microwave satellite instruments. All these problems must be resolved in a high-resolution SST analysis (see the GODAE HiResSST Workshop report at:

http://www.bom.gov.au/bmrc/mrlr/nrs/oopc/godae/HiResSST/Workshop/.

Discussion

The Panel discussed whether Argo data could resolve the near surface SST given the limitations in the sampling rate, rate of rise, and depth accuracy. Dr Weller believed that the FSI (Falmouth Scientific Instruments) sensors could handle the sampling rate required for this type of measurement. Dr Keeley noted that he has seen surface temperature spikes in the Argo data. In a subsequent private communication, the Chair of the *Argo* Science Team noted that the pumps on profiling floats were usually stopped prior to reaching the surface in order to avoid fouling. This then limits the near-surface measurements. However, he did note that this procedure could be changed if a strong case were mounted. The Panel agreed that it would be best to have information on the near-surface SST variability (skin and bulk SST measurements) by having the floats sample at various times during the diurnal cycle rather than sampling only at night.

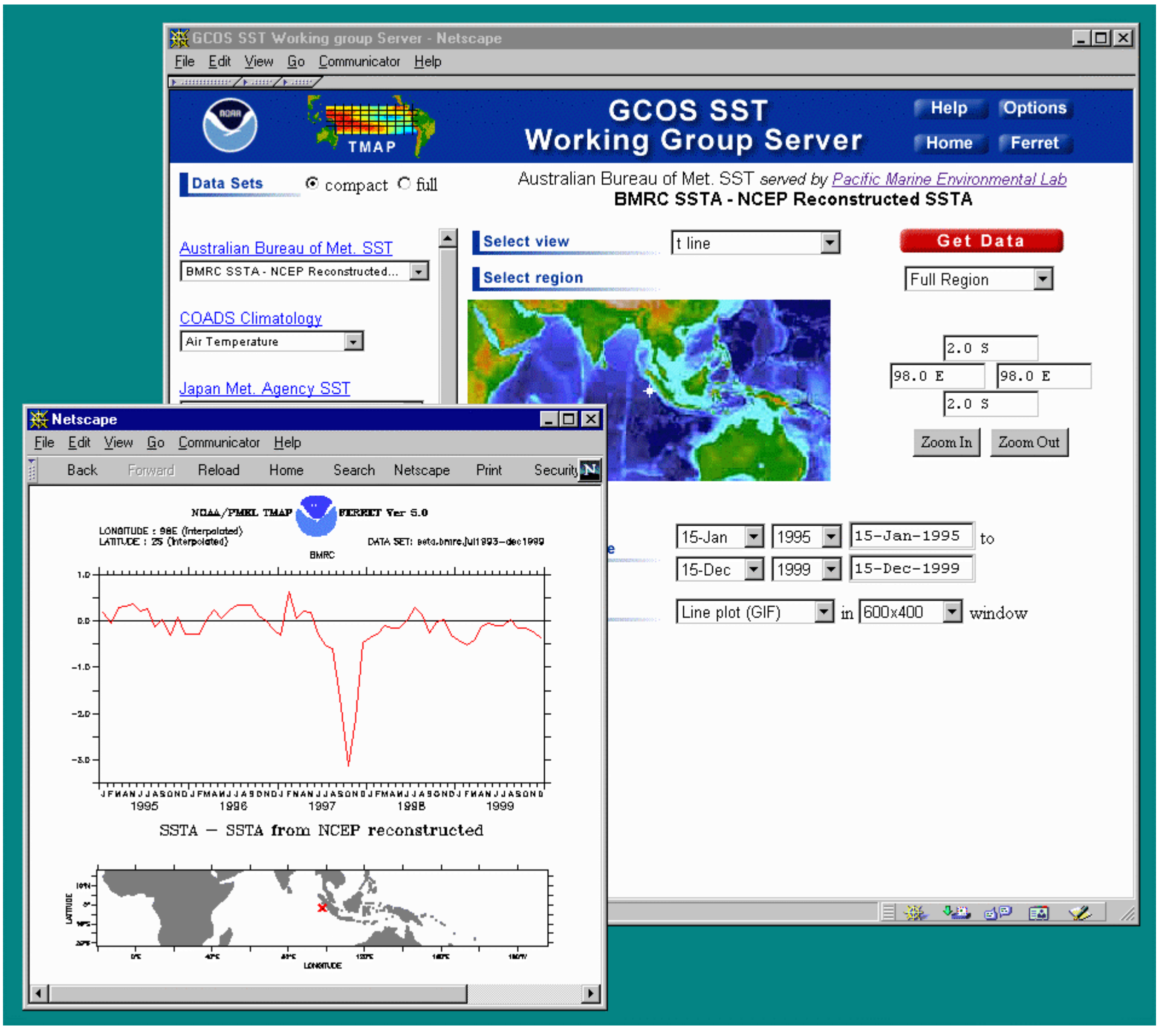

Figure 2

Example of the GCOS SST server developed at PMEL/NOAA. A user can select part or all of a data set to display (see display in smaller window) or to download.

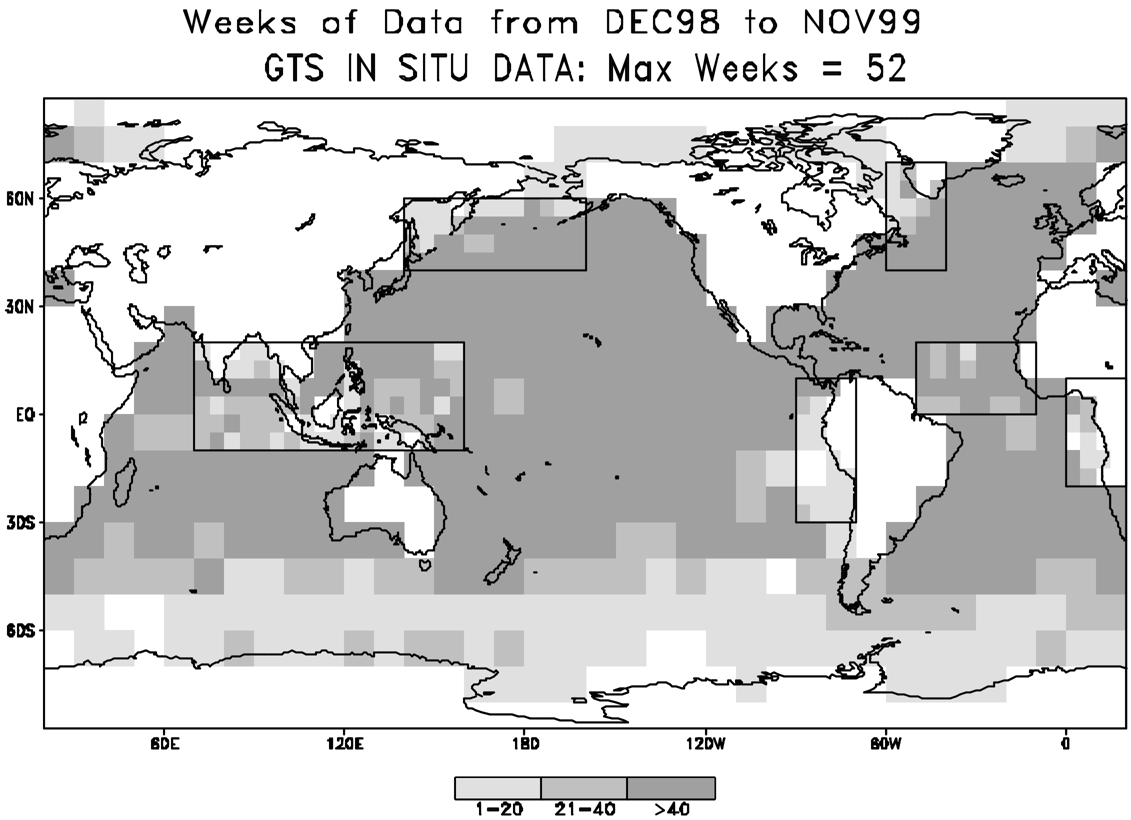

Figure 3

Number of weeks with adequate *in situ* observations on a 5° and 10° grid. The 5° grid is required when the satellite observations are not adequate. The period is December 1998 through November 1999.

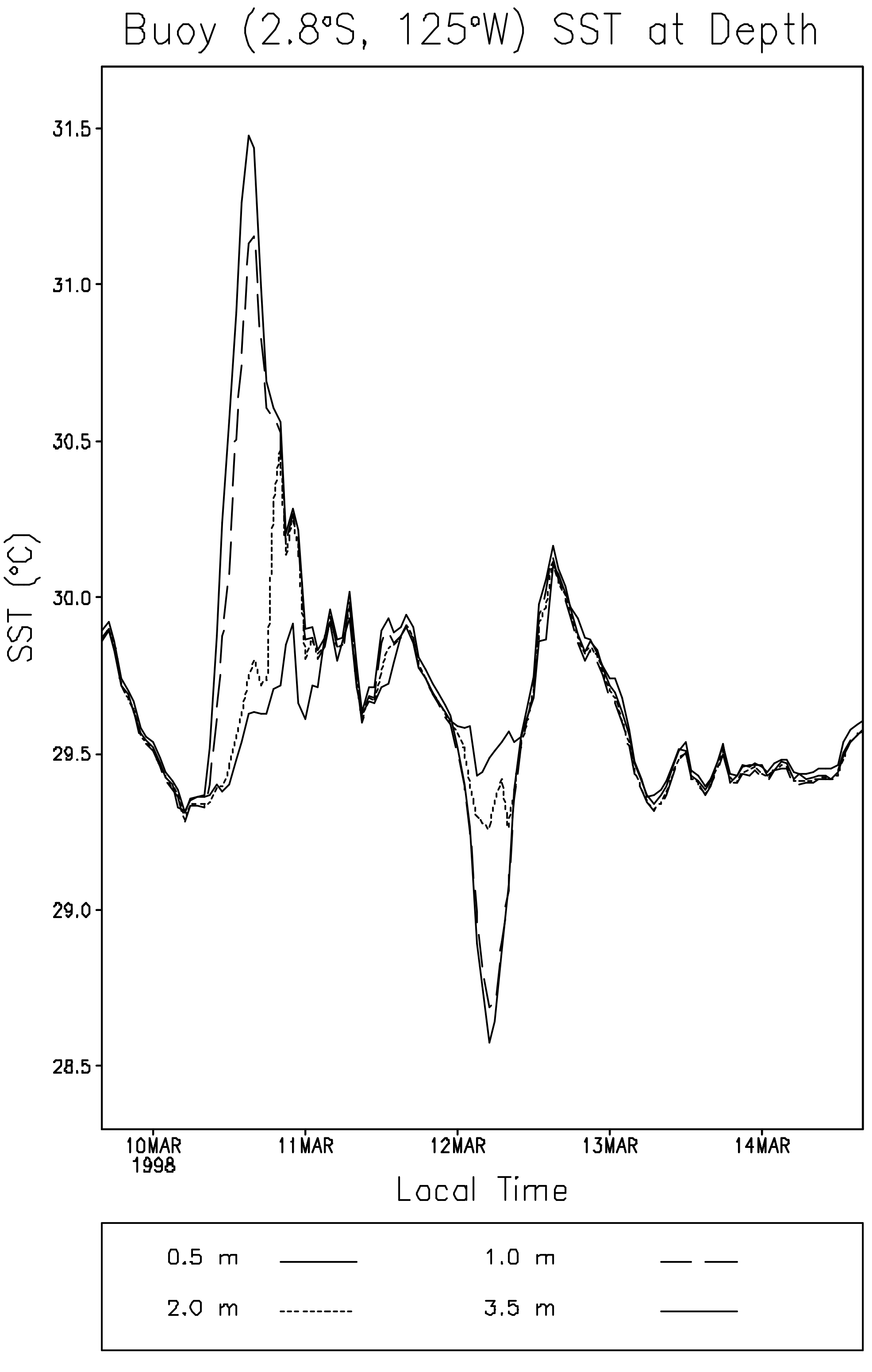

Figure 4

Bulk SSTs from a buoy in March 1998. The figure shows the variability in SST at four different depths. The labels on the time -axis are centered on midnight local time.

4.2 GODAE HIGH-RESOLUTION SST PRODUCTS

Dr Neville Smith briefly discussed the GODAE high-resolution SST project goals:

i. Develop high-resolution SST products;

ii. Provide data for broad utility – meet requirements of climate research and coastal NWP services;

iii. Provide SST data with high temporal and spatial resolution – 10 km spatial resolution and at least daily measurements with attention to the diurnal cycle;

iv. Inputs will include:

- Raw SST from satellites in near-real time and delayed mode;
- Analysed SST from satellite and *in situ* data;
- Properly accounted-for and defined skin, bulk, “thin” sea surface temperature measurements.

A workshop is planned for November 2000 (see document on web-site at:

http://www.bom.gov.au/bmrc/mrlr/nrs/oopc/godae/HiResSST/).

4.3 SURFACE REFERENCE SITES/SURFA

Dr Bob Weller discussed the Surface Flux Analysis Project (SURFA) and the need for surface reference sites and reference data sets with high-quality, continuous data from established reference locations. As discussed at the OceanObs 99 Conference, these data are necessary for calibrating and testing weather prediction, re-analysis and coupled climate models. He discussed possible flux calculation locations and told the panel that OOPC should aid in determining the most critical sites. He suggested that OOPC should act on this soon because the community needs to ensure long-term support for the sites, and to work together with the modelling , *in situ*, and remote sensing communities.

Discussion

The Chair agreed that OOPC should make recommendations regarding reference sites, and the Panel agreed that a small working group should meet in August or September before the SURFA and VOSCLIM meetings in October (subsequently scheduled for December, San Francisco). The Panel suggested that the group be composed of 6-7 principle players with perhaps some connection to US GEWEX. The Chair noted that OOPC has some funding to support this meeting. Dr Weller agreed to chair the Science Team and follow up on these proposals. See Section 7 Review Schedule of Action Items, Item 5.

4.4 MOORED BUOY ARRAYS

4.4.1 TAO/Triton

Dr Mike McPhaden reported that as of January 1, 2000, the TAO array has been called the TAO / TRITON array, and that the two buoy systems had been cross calibrated to a high degree of accuracy. This merger is an important step forward in demonstrating that JAMSTEC and PMEL can work together to provide high-quality, blended data sets for climate studies. Dr McPhaden also reported on an intercalibration experiment between 2 IMET buoys, 2 PMEL ATLAS buoys, and 1 JAMSTEC TRITON buoy at WHOI during May-June 2000. The purpose of the intercomparison is to establish the comparability of three widely used meteorological measurement systems for climate studies. The results of the experiment are being written up for publication as a technical report.

Dr McPhaden highlighted some of the problems with the mooring arrays, most notably the problem of fish aggregation around the buoys and vandalism / destruction of the buoys by fishing operations. From the TAO / TRITON array, he reported that the data return from buoys in fishing areas is 10% lower than the other parts of the array. In the PIRATA array, equipment and data return are also very poor in fishing areas. There are a number of outreach efforts in ports and with fishing agencies to try to alleviate some of these problems.

Dr McPhaden also reported that inflationary pressures and actual budget cuts effectively reduced funds for the TAO array by 10% in the past year. This reduction in funding is manageable though because of JAMSTEC's new involvement in the western Pacific. McPhaden cautioned, however, that inflationary pressures will continue, and will erode the value of available fixed levels of funding. Long-term maintenance of TAO and other elements of the ENSO observing system will be problematic with no increases in funds. This realization should serve as an impetus to set in place a process for evaluating and guiding the evolution of the system.

Discussion

The Panel discussed the need for a review process for the ENSO Observing System to determine which elements and sensors of the system are crucial. The Panel stated that a long-term vision is needed for this review and evaluation process, and that the set of recommendations and suggestions from the review process should be used as the basis for continuing reviews. Possible terms of reference for the "rolling-review" process for the ENSO Observing System are given in Annex VI. A scientific organizing committee will be formed with representation from the OOPC, JCOMM Observations Panel (i.e. SOOP, etc.), the CLIVAR Pacific Panel, COOP, and WGSIP. See Section 7, Review Schedule of Actions, Item 4.

4.4.2 PIRATA

Dr Joel Picaut provided an overview of the PIRATA array, outlining the development of the programme from the first PIRATA Steering Committee in 1995, implementation plan development in 1996, and first deployments in 1997, to the current plans to complete the original array by the end of 2000. The array presently consists of 12 ATLAS buoys, 6 in the west and 6 in the east. Dr Picaut noted that there are large data losses for both technical reasons and vandalism, and that the average data return was 66%. During the COSTA (Climate Observing System for the Tropical Atlantic) workshop in May 1999, it was argued that there is a need to establish a tropical observing system in the tropical Atlantic as part of CLIVAR. It has been recommended to consolidate PIRATA toward a sustained observing system over 2001-2005 and it has been suggested to extend the PIRATA array. A PIRATA Resources Board has been formed, consisting of members from Brazil, France, and USA to ensure a new design of the original array. In the meantime, the PIRATA Steering Committee and Resources Board encourage further development and expansion of the array in coordination with other countries (South Africa, Morocco, etc.).

Discussion

The Panel noted that PIRATA is still a research pilot project, but that it is also contributing to operational objectives. The Chair suggested that a timeline is needed to show how PIRATA is emerging as an operational component of the larger observing system. The following phases were presented:

- The pilot phase for PIRATA is very close to be completed.

- The consolidation of the research array is now happening. This will require assessment of the impact of the tropical surface and subsurface measurements, consideration of extratropical variations and their impact / priority relative to the tropical moorings, and consideration of the cost-effectiveness in the light of high losses of the eastern moorings.

- In 2001 there will be an assessment of PIRATA and decisions made for the sustained operational network.

4.4.3 EPIC

Dr McPhaden briefly mentioned the EPIC array at 95ºW (Eastern Pacific Investigation of Climate), designed to study air-sea interaction in a cold-tongue region. The array measurements include short and longwave radiation components and provide a good data set for estimating fluxes.

4.4.4 TAO Implementation Panel

The Panel also discussed the future of the TAO Implementation Panel (TIP), stating that in general, the scope of the group should be reduced to serving mainly as a technical advisory function, but that the geographical scope should be increased to a global view to reflect the larger array created by TAO/TRITON, PACS, PIRATA, and a possible Indian Ocean component. The Panel suggested that the terms of reference for the panel should be modified and new members chosen to reflect these new mandates. The proposed new terms of reference for the Tropical Moored Buoy Implementation Panel (keeping the acronym TIP) are given in Annex VII. See also Section 7, Review Schedule of Actions, Item 3. Proposed membership includes individuals representing institutions or agencies that provide resources such as ships, mooring hardware and/or technician time to maintain tropical moored buoy arrays. The likely data and location of the Review are 10-12 September 2001, in Seattle.

4.5 TIME SERIES STATIONS

Dr Weller provided the Panel with an update since the OceanObs 99 conference on discussions and development of proposed time series sites. He stated that time series stations have an important place in a global observing system, but that at present, very few exist. He also reminded the group of the unique benefits provided by eulerian time series, most notably the high vertical and temporal resolution and the possibility to employ a large suite of sensors. Some of the scientific objectives of time series sites are:

- Measure air-sea fluxes.

- Assess vertical processes.

- Measure transport and variability of major current systems.

- Determine variability / statistics on a wide range of timescales to support and validate modelling efforts.

- Study impact of physical variability on biogeochemical cycling processes and ecosystem dynamics.

Dr Weller pointed out that time series stations can provide important contributions to other programmes and also reiterated the importance of establishing links with some of these programmes. The US OCTET programme (Ocean Carbon Transport Experiment) is interested in using time series stations as an integral part of the programme. The SOLAS programme (Surface Ocean Lower Atmosphere Study) will use surface moorings as the key multi-disciplinary tool. The DEOS programme (Deep Earth Observing System) is planning a major effort to develop a global network of buoys with high-tech instrumentation, and has target dates of 2003-2007 for construction and implementation of the observing system. This programme is very ambitious. It seems likely to be funded at about US$60M. At the OceanObs 99 Conference, the time series station group developed good plans, but it needs to work fast to interact with some of these other groups. If the DEOS global observation network is endorsed by the international community, the research community may suffer, and thus it is very important to establish some links to these groups in the planning and development stages. Dr Weller also noted that the time series station group needs to establish more firm ties to the modelling community and to find some joint activity to develop this link.

Discussion

Dr Weller mentioned that the planning and development of the proposed time series stations for the North Atlantic are reported to be on schedule. Dr Walter Zenk mentioned that the ESTOC station near the Canary Islands has recently been turned down for funding by the EC, and speculated that perhaps this was because the time series station community has not provided the context and justification for these programmes. Dr Masaki Kawabe noted that JMA has recently withdrawn support for 3 met buoys, some of which have been maintained for nearly 30 years. They are instead turning towards the use of more 'cost-effective' instrumented drifting buoys to measure meteorological parameters and SST, with data retrieval in real-time (using ORBCOMM). The buoy will be un-drogued, with the idea that the buoy will stay in place more effectively over the approximate 6-month deployment.

The Panel discussed these situations and stated that the arguments and justification for time series stations has been made repeatedly and that not much more could be done in this area. Proposals may be having difficulty with funding because while much of the justification for the stations is built around biogeochemical and ecosystem science objectives, the typical mooring service periods are much shorter than the periods over which the sensors are stable (~3-4 months).

Dr Weller suggested that the time series station programme needs a working group or a committee with support from the modelling, *in situ*, and remote sensing communities to get more active in pushing ideas forward and ensuring long-term support for these sites. He stated that DEOS would most likely be a strong partner in this effort, and that the group would also benefit from partnerships with groups like JGOFS, SOLAS, and GRACE. The Chair agreed and proposed that OOPC establish a science team for the development of a set of sustained time series stations (the Chair proposed the title: 'time series experimental array', or, 'TSEX'), under the joint sponsorship of GOOS / GCOS (OOPC), research (CLIVAR, OOS, JGOFS, etc.) and the DEOS. The possible Terms of Reference for the group are given in Annex VIII. Dr Weller pointed out that some of the initial issues will be:

- Calibration: uniformity, intercalibration, pre- and post-calibration, quality and accuracy (linked to Argo and other observing system elements).
- Deployment and maintenance: document ship time, servicing needs, etc.
- Indicate the utility of select time series stations as test-beds / prototypes for the development of the program.
- Explore links to marine industries as a source of support and that might use time series sites as test-beds and / or provide instrumentation and telecommunication resources.

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The Chair will liaise with Drs Weller, Zenk and Koblinsky to establish a time-series group (a meeting is scheduled for May 2001, possibly in Washington).

4.6 SUB-SURFACE THERMAL WORKSHOP

Dr Ed Harrison introduced this topic, and provided a brief review of the XBT and Upper Ocean Thermal Sampling workshop that was held in Melbourne in August, 1999 and of the recommendations from that workshop that were presented at OceanObs99 in St Rafael in October, 1999. Despite their strong efforts, the CLIVAR requirement of monthly profiles over each 2º x 5º region, globally, cannot be met by the present SOOP / XBT programme. The Argo program of a global array of profiling floats is needed to meet the requirement. However, Argo cannot provide all of the information needed for the ocean climate observing system. Thus XBTs are still useful and will play important roles in the observing system, especially with frequently repeated lines (FRX) and high-density lines (HDX). The Melbourne workshop conducted a review of the present XBT network sampling frequency and density showed that considerable revision appears to be appropriate to optimise the XBT contribution to the observation system. Dr Harrison showed an overview of the global thermal data set in the World Ocean Atlas 98 to show the distribution of data, as it existed *circa* 1995. Observations are very sparse in some areas, with limitations on the utility of the climatology. The recommendation of the Melbourne meeting, accepted by the OceanObs99 meeting, was that a specific set of frequently repeated lines and high-density lines should given priority over 'broadcast mode' XBT sampling in the regions where Argo is deployed and operating successfully. To accomplish the research and operational communities' goals, a 'capable' thermal observation system needs input over a range of space and time scales and data synthesis procedures, including data assimilation into realistic models, is needed for evaluation the contributions of the various data streams, and to guide development of improved products.

Dr Smith provided a brief update from the working group of the SOOP Implementation Panel (SOOP information is located at http://www.ifremer.fr/ird/soopip/). He noted that there has been a 60% increase in the price of XBTs. It had been thought that high-density or frequently repeated lines would have smaller overhead costs, but this has not occurred. The network is currently 7,000-10,000 XBTs short of the plan. Dr Smith concluded that broadcast sampling is no longer effective. A revised SOOP plan has been developed to account for these recent changes. One hopeful note is that some new countries are beginning to participate in the SOOP and VOS programmes.

Discussion

The Panel discussed these issues and agreed that the XBT programme needs to be revised based on these new developments. The Chair would communicate the substance of these discussions to the Chair of the SOOP Implementation Panel who will also attend the next meeting.

4.7 INDIAN OCEAN WORKSHOP

Dr Neville Smith presented an overview of the SOCIO programme (Sustained Observations for climate of the Indian Ocean). The OOPC and CLIVAR will convene a workshop in Perth, 13-15 November 2000, with a view to forming an alliance of Indian Ocean countries, developing multi-national action plans, and reaching agreement on principles of a long-term strategy.

Details are available at http://www.marine.csiro.au/conf/socio/.

Discussion

The discussion revealed that the decadal (non-monsoon) parts of the Indian Ocean seem to be getting lost within CLIVAR. The Panel suggested that OOPC, CLIVAR and the SOCIO group need to develop this part further. Bill Erb (from the IOC Perth Office) will coordinate follow-up action which will also be an item on the 2001 meeting agendas for OOPC and CLIVAR OOP. The Chair asked Dr Maria Hood to check on funding opportunities for participants from developing countries for the Perth meeting.

4.8 GODAE – STRATEGY

Dr Pierre-Yves Le Traon reviewed the GODAE strategic plan (*http://www.bom.gov.au/bmrc/mrlr/nrs/oopc/godae/Strategic_Plan.pdf*) prepared last year and reviewed at the last GODAE meeting. He presented the strategy as defined in the plan, the rationale and scope of the GODAE programme, the benefits and users of the data, the time schedule for implementation, and the short and long-term legacy of GODAE. Dr Le Traon presented the GODAE phases:

1998-1999	Concept Development
2000-2002	Development / Pre-operational phase
2003-2005	Demonstration phase (to coincide with planned satellite missions and Argo)
2006-2007	Consolidation and transition

Dr Le Traon discussed the general strategy and guiding principles of GODAE, including data exchange issues, and the required programme components and inputs. The heart of GODAE is "assimilation" of data, and described the planned GODAE outputs: coherent, organized data sets, short-range forecasts, re-analysis, and statistical characterization of products.

The basic implementation elements are the development of the implementation plan and development and operation of the functional components, such as the data servers, assimilation centres, data sources and inputs, and user services / product development. GODAE development will proceed by way of prototype systems, task groups, and pilot programmes, such as Argo. Capacity building and outreach programmes will also be important components of GODAE. Dr Le Traon stated that there is a need to establish a means of evaluating the programme through both internal metrics (from the different data assimilation centres) and external metrics/reviews (i.e. from the end users).

Discussion

The Panel concluded that there needs to be some mechanism of interfacing and coordinating GODAE and CLIVAR measurements (time, space, and depth scales of specific fields, etc) to outline how to wisely sample in the sustained mode for both programmes and to ensure that climate observations and data quality are maintained. There was also discussion of how to link the GODAE data centres with existing centres, and how to consolidate and assemble a server for use by the community. It was suggested that GODAE should create a 'one-stop shopping' service on the server and that the focus will be on research-quality data sets. However, GODAE will also have real-time and near-real time data streams, and will draw on the expertise that exists in other programmes (for example, from the TAO programme). The Panel also agreed that the GODAE programme data will be kept within the programme rather than sent to existing national oceanographic data centres, noting the serious problems many of these centres have with QC practices.

The Panel suggested that perhaps OOPC should form a small *ad hoc* working group to draft a paper on what might be done to aid the development of the observing system, including lists of specific requirements and experiments, modelling exercises, and data assimilation experiments. Some of the initial suggestions were:

Ed Harrison:

- Sub-sampling and sensitivity studies using the most realistic ocean (and coupled, if they exist) models to characterize the 'oceanic signal' of the various 'recurring climate patterns' that we seek to observe, understand and (if predictability exists) predict. E.g., the PDO, NAO, AO, 'decadal ENSO', and other, more regional, phenomena of interest.

- Test whether present models, forced with the available surface fields, are capable of giving us realistic subsurface patterns. This would add greatly to the level of 'confidence' we assign to subsampling studies.

- Test the ability of our envisaged UOT system (altimeter, XBT, ARGO, etc/) to determine the low frequency climate patterns in the presence of vigorous short-scale variability. If there are not suitable ocean model runs in hand to carry out such studies, we might influence others to get such runs made up and their data sets stored in such a way that a range of subsampling studies could be carried out.

Bob Keeley (related to D&IM issues):

- How useful is QC of XBT data stream? What difference does it make to use GTS, MEDS, UOT data?

- The GTS data stream from any one RTH is missing data. MEDS recovers about 5% now, although this loss was higher in the past. What impact does this have? Use sample streams from different RTHs.

- What are the timeliness sensitivities? We know 50% of XBTs get onto GTS in 1 day, 80% in 3 days. If first QC is done, this lengthens to 3 and 5 days. What is the timeliness / QC tradeoff?

- Duplication rates are variable. What is the sensitivity to this?

- What is the sensitivity to errors in position or time of ship data? The error rate can be quite variable?

- What is impact of using or not using drifters with positions determined on the current orbit?

- What impact does poor or good vertical resolution of T, S have?

Neville Smith:

- The "observing system studies" should be related to individual contributions to the observing system. For example, if we were to move toward glider technology for western boundary currents, how often should we be sampling across the currents, and at what rate. In principle, we could do such sampling studies with models.

- Another example might be the (provocative) statement that we do not need to pay special attention to the WBCs for the climate problem. What errors might we expect?

Ed Harrison (with help from Bob Keeley and Neville Smith) would develop a paper on Observing System Sensitivity Experiments for the next OOPC meeting (Action Item 8). The Chair noted that CLIVAR OOP will also give greater emphasis to such work.

5. SPECIFIC AREAS NEEDING ACTION

5.1 CARBON

Dr Peter Haugan gave a presentation of the Global Carbon Cycle status with respect to the role of the oceans. He noted that there was consensus emerging among different methods and models for estimating the inventory of oceanic carbon. Based on global, multi-year averages, the inventory of DIC is estimated to be increasing by 2 Gt C y^{-1} (Gigatons Carbon per year, where 1 Gt = 10^{15} grams) based on average over the period from 1980-1989, and the oceanic uptake is estimated to be 2.4 Gt C y^{-1} over the period from 1990-97. There is, however, less consensus on a number of important issues, such as:

- Average net imbalance of carbon release and uptake on land.

- Terrestrial carbon sinks – what, where, why, how.

- Air-sea CO_2 and O_2 flux and interannual variability.

- CO_2 storage in the oceans – where.
- Excess CO_2 – where is it entering.
- Sensitivity of ocean uptake to future changes.

Dr Haugan discussed some of the imminent needs for a carbon component to the global observing system. The field work phases of both JGOFS and WOCE had come to an end, and SOLAS, which is seen as the 'successor' programme to JGOFS for carbon studies is not yet operational. In addition, this programme will only focus on upper ocean processes. The Kyoto Protocol requires nations to monitor their 'national' carbon sources and sinks, and that interannual and seasonal resolution is required to constrain both oceanic and terrestrial budgets versus emissions. The issue of deep-ocean storage of carbon has gained much attention in the last few years and this is a development that the OOPC and new CO_2 panel must watch.

In terms of observation requirements, the overall need is for improvement in measurement methods for the various components of the oceanic CO_2 system. There is a strong need to characterize the seasonal and interannual variability of CO_2, and methods must be developed further to determine pre-industrial and anthropogenic components of the CO_2 flux. The role of biological processes in regulating the distribution and flux of CO_2 is also a major focus of research. Dr Haugan discussed briefly the reconstitution of the CO_2 panel (see section 3.2.1 of this report) and stated that the most important new tasks for the panel are to advise on the measurement and observation strategy and to advise on the issue of deep-ocean carbon storage. The new CO_2 Panel Chair, Dr Doug Wallace, will lead the development of an overall strategy for the carbon observing system, combining surface pCO_2 and related observations from the VOS programme, carbon component measurements from repeat hydrographic sections, and time series of vertical profiles at key locations. There is currently an EU proposal to put CO_2 sensors on a VOS ship between Norway and Greenland, which may serve as a pilot programme for further observing lines.

Dr Haugan reported that at the April meeting of the JGOFS Scientific Steering Committee, several issues of interest for the CO_2 community were discussed. A pCO_2 observing system was proposed by Dr Andrew Watson. The JGOFS SSC gave its full support to the IOC Ocean Color Group and the ongoing GAIM model intercomparison project. Dr Haugan reported that the earlier tendency in the ocean biogeochemical community towards scepticism of GOOS was easing and that the group gave its full support to the new CO_2 panel with its new TORs.

Regarding the future of the IGBP and CO_2 issues, Dr Haugan believed that the terrestrial carbon community is well organized in comparison with the oceanic community. The discussions at JGOFS Science Conference in April highlighted some problems within the oceanic CO_2 community and suggested alternative ways forward for ocean carbon research and observations. Several meetings of the ocean carbon community are planned for the near future; SOLAS planning meeting(s), a meeting in Plymouth in September 2000 to discuss future ocean biogeochemical research, and the IGBP conference scheduled for July 2001 in Amsterdam will be important for definition of the research. The first new CO_2 Panel meeting in September is expected to address observing systems in particular.

Discussion

The Panel discussed these issues and stated that OOPC can help in the development of the observing system needed for oceanic carbon through the new CO_2 advisory panel. Based on the above meetings and initiatives within IGBP and WCRP, several papers are being prepared on a possible Global Carbon Project. OOPC will review this document at the next meeting (Harrison, Haugan). The Chair would also invite one of the Australian carbon scientists to OOPC VI.

5.2 DEEP OCEAN OBSERVATIONS

Dr George Needler introduced this section by first presenting feasibility versus impact diagrams of the recommended observing system hydrosection elements that were proposed by OOSDP. In addition, he presented plans from CLIVAR and discussed two papers from the OceanObs 99 Conference (*http://www.bom.gov.au/OceanObs99/Papers/Gould_Toule.pdf*, and *Fine.pdf*) dealing with hydrographic sections and deep ocean observations, and noted that all depend on repeating WOCE sections. He discussed at length the rationale and carbon-sampling plan from the US draft paper by P. Chapman, 'The Need for Continuing Global Deep-Ocean Surveys'.

Discussion

The panel members detected no real enthusiasm or advocacy for repeating WOCE hydrographic sections, and that it may be seen as a low priority for the observing system. It was also noted that *Argo* will provide deep survey information. The Chair, Dr Smith, noted that the global climate-ocean observing system does not match one-to-one with the CLIVAR 'global' observing system, and that there is no research programme that will provide advocacy for such deep observations. He posed the question, 'should the OOPC / GCOS fulfil this role?' He further noted that a similar conclusion might be made for non-physical observations until such a time as there is a global carbon research programme. While *Argo* does need associated deep measurements both to expand the context of 2000 m profiles and to validate the methodology, the *Argo* programme cannot be the justification for the deep repeat sections. He highlighted other possible justifications, such as:

- The thermal expansion part of the IPCC Sea Level chapter relies on those few repeat sections that exist.
- The time series strategy, like Argo, depends in part on associated hydrographic surveys.
- The non-physical research programmes need such surveys.

The Chair suggested that one option for action is that the Panel use the Chapman paper as the basis for justification, and in concert with COOP and the CO_2 panel, begin to develop a strategy with a view to involvement in discussions at a suitable future forum. See Section 7, Review Schedule of Actions, Item 2. The Panel concluded that OOPC does not have enough information on these issues to take a position at this time, and that it would look to the development of a Global Carbon Project and discussions at meetings such as the Southern Ocean Workshop (see the SOCIO Web page above) to provide recommendations and justifications for continuing the surveys.

5.3 ICE-COVERED OCEAN DISCUSSION ON FUTURE DIRECTION

Based on the previous discussion, the Panel outlined several statements regarding the future direction for ice monitoring:

- The critical importance of the polar regions for climate is evidenced by Arctic ice volume changes, NAO / AMO, etc.
- The SSM/I is essential for sea ice extent, and the importance of overlap for intercalibration (approximately 1 year) cannot be overstated. The Drinkwater et al. paper from OceanObs showed the scatterometer data were also extremely useful.
- Ice thickness (ice volume) is a key parameter and it is now feasible to measure. Experimental missions (CRYOSAT and NASA IceSAT) should be supported by a range of *in situ* measurements. Release of sonar data from submarines should be continued as they represent an important time series and an independent source. In addition, the 10-15 existing upward-looking sonar sensors in the Arctic provide an important data set for validation.

- The strategy for the Antarctic must be different for ice thickness.

5.4 MONITORING BOUNDARY CURRENTS

Dr Walter Zenk provided the following update of this topic since the OceanObs 99 Conference.

The meridional overturning circulation (MOC) and its variability are primary foci of all climate-relevant studies in oceanography. Boundary currents as integral parts of the general circulation will be part of the sustained observations and co-ordinated with persistent modelling and assimilation efforts (e.g. GODAE). There exists a variety of regional to sub-basin long boundary currents each affected by different dynamics in ocean-atmosphere coupled systems. Different physics in forcing, friction and interaction make different methodologies for the monitoring of boundary currents essential.

The Imawaki paper presented at OceanObs 99 discusses four arbitrarily selected boundary currents, all of which have a direct and global impact on climate fluctuations: Kuroshio, East Austral Current, Indonesian Throughflow and the North Brazil Undercurrent as one part of the interhemispheric exchange in the Atlantic.

In the case of the Kuroshio as a surface boundary current of the northern hemisphere, long-standing transport observations are derived from *geostrophic* shear measurements referenced to *moored current meters, acoustic Doppler current profilers* on ferry boats, and more recently from *altimeter* satellite data. Observations are supplemented by *tide-gauge records* and monitoring electro-magnetic induction in *underwater cables* due to ocean water movement.

Monitoring results from East Australian Current are also discussed. They are based on *repeat XBT observations* distributed on a triangular course between Australia, Fiji and New Zealand. As before, transport estimates are referenced to TOPEX/ POSEIDON data. In this project, XBT transects extend far offshore, enabling calculations of net transport of mass and heat for the combination of western boundary and interior ocean circulation.

The third example, i.e. the Indonesian Throughflow, comprises the only major low-latitude interbasin exchange. Observations include an XBT line between West Australia and Indonesia as part of the SOOP network. In addition *bottom pressure* recorders and *inverted echo sounders* (*P/IES*) in the Makasser Strait and moored current meters were installed.

The fourth case deals with the intermediate North Brazil Undercurrent, which has been monitored in the past by occasional hydrographic sections, moored current meters and *subsurface floats*. This boundary current plays an important role in the Atlantic asymmetric poleward heat flux with its complex equatorial three-dimensional current system. The Climate Observing System for the Tropical Atlantic (COSTA) underscores the need to establish a tropical observing system as part of CLIVAR. The COSTA consortium recommends to maintain and enhance the present moored array, *surface drifters*, XBT observations from volunteer observing ships and the current *profiling float* (PALACE) programme.

Though north of the North Brazil Undercurrent, but still at low latitudes where deep recirculation cells play a decisive role in the general circulation, "*geostrophic moorings*" presently are on position east of Guadeloupe (16°N) to monitor the baroclinic variability of the cold limb of the overturning cell. The technique is to use three moorings with numerous self-contained CTD records combined with bottom pressure gauges to estimate the averaged deep baroclinic current distributions and its variability.

Other means for the observation of boundary currents include repeated tracer surveys and the new promising glider (float) technique. Neither were discussed in the St. Raphael paper.

Discussion

The Panel noted that this is a high priority for CLIVAR, and that this programme is driving the investigations and promotion of techniques that will eventually lead to a monitoring system. Dr Zenk noted, however, that there is no unique solution for monitoring, and this is a work-in-progress These investigations are being driven mostly by basin panels and regional research initiatives rather than global climate issues. GODAE does require data for both model initialisation and prediction in the Kuroshio region. At present, however, these applications are not seen as a driving force for boundary current measurements, although ADCP data are seen as very useful validation data sets. The Panel agreed that it is also clear that moorings have a role in coastal applications.

It was suggested that the CLIVAR take the lead through its Ocean Observations Panel to define the most promising and useful techniques. The Chair stated that there was no follow-up needed by OOPC at this time, but that CLIVAR and GODAE should be encouraged to interact on this.

5.5 SALINITY FROM SPACE

Dr Johnny Johannessen provided an overview of the Soil Moisture Ocean Salinity Satellite programme to look at large scale salinity events (coarse scale). This is an ESA mission with a launch date of 2005 and duration of 3 years. The current phase of the programme focuses on technical and scientific feasibility studies and scientific support studies. An ESA Ocean Salinity Study, headed by Dr Helge Drange, is looking at SSS retrieval accuracy over incidence angles ranging from 15º to 50º, with goals of examining and quantifying the effects of roughness, foam coverage, precipitation, and SST variations on SSS retrieval accuracy. It will also examine and quantify the impact of SSS on modelling for different regions.

Dr Johannessen assessed the spatial and temporal resolution and accuracy of SMOS and stated that SMOS will be able to meet the horizontal resolution requirements for OOPC programmes very well.

Dr Chet Koblinsky provided an update on the NASA salinity programme. Within NASA, the development of a salinity mission has been identified as mission "EX-4b" within the catalog of missions recommended for the follow-on programme to the Earth Observing System. Over the past year a mission design study has been the focus of a NASA JPL / Goddard SFC partnership. An alternative design to SMOS has been considered. The SMOS and NASA groups are exchanging information with each other. The NASA mission design will be proposed to the NASA Earth System Pathfinder announcement of opportunity with submission in fall of 2000 and selection in 2001. The mission has goals of 0.1 psu, 100 km resolution, and temporal resolution of 7-30 days. A number of aircraft missions are in progress to provide the foundation for this development. Two successful missions were completed last summer in the North Atlantic and demonstrated a precision of 0.25 psu. This summer an aircraft mission will be carried out off the coast of California and will attempt to achieve a precision of 0.1 psu. He further reported that the Japanese are interested in developing salinity monitoring capability and expanding the AMSR microwave instrument to low-frequency measurements for the GCOM2b programme (post 2010 date)

Dr Koblinsky asserted that for these programmes, complementary *in situ* programmes such as time series stations, ships of opportunity programs, surface drifters, and Argo are needed. While there is a "skin vs bulk" measurement issue, it may be less severe than for temperature. The radiometric measurement of salinity from space requires routine calibration and validation because of radiometer stability issues, so a well-coordinated *in situ*/satellite measurement program may be more critical for salinity than for SST. There will be a SSS workshop at Scripps Institution of Oceanography, 26-27 September. The meeting will refine the science objectives, as well as the specifications and requirements for the mission proposal. He also mentioned the need for this team to understand future operational-customer and potential requirements for near real time and delayed mode data. He concluded by stating that in this decade, there should be a launch for SSS.

Discussion

The Chair commented that OOPC should support and advocate field programmes required to provide the necessary *in situ* measurements to develop the SSS technique. The Panel discussed the various *in situ* techniques and programmes available, and concluded that the order of priority in terms of usefulness for SSS validation is time series programmes such as TAO / TRITON, then ships, then drifters. Although the drifters may have better spatial and temporal coverage than the other methods, the salinity sensors still have drift problems and the data quality will probably be less than that available from other techniques.

5.6 WIND WAVES

Dr Vladimir Ryabinin provided an update on the wind-wave observation strategy since the OceanObs 99 conference (*http://www.bom.gov.au/OceanObs99/Papers/Swail.pdf*).

5.6.1 Wave Observation

Dr Ryabinin outlined the OceanObs 99 recommendations on wind wave observations:

- Wherever possible, new measurement systems should have an overlapping period with the systems they replace.

- 2-D wave spectrum data are considerably more useful than simple wave heights. It is desirable to combine flux and other routine measurements with observations of the 2-D wave spectrum. 2-D wave spectrum observations should be made at the Surface Reference Sites because they are instrumental in analysing/studying surface fluxes. Wave observations should be conducted (as a rule) in parallel with other surface observations.

- Co-locations of altimeter wave heights and moored buoy data are needed, along with co-location of satellite waves and winds, calibration and validation of satellite winds and waves in extreme storm seas (winds > 20 m/s; waves > 8 m). Wind wave observations at TAO, TRITON, PIRATA arrays should be considered based on estimates of their cost / benefit ratio and feasibility.

- There is a need for designating the radar altimeter "operational" on polar-orbiting satellites and a need for operational spectral wave observations from wave-mode SAR. A study on optimal balance of data from scatterometer, altimeter, SAR, radiometer is required.

- It is also recommended to continue VOS wave observations because they constitute mariners' feedback on services and are useful in studies of wave climate. At the same time, as proposed by Dr Weller, some alternative methods of wave measurements including the use of bow-mounted sensors should be considered.

5.6.2 Data issues

In the area of data management the following recommendations were made:

- Enforcement of standards for wave data transmission is needed.

- Real-time transmission of the remotely sensed and buoy wave data should be facilitated.

- Modern standards for instrumented data archiving should be established that would ensure easy data retrieval and its multi-disciplinary use. Each data set should be accompanied with metadata describing the instrumentation, its characteristics, processing, calibration, and changes in those elements (e.g. sensor drift). There is a need for archiving gridded (level III) wave parameter fields.

- A project aimed at wave data rescue may be needed.

- All observing centres should be encouraged to distribute real-time data via the WMO GTS.

5.6.3 Modelling and Forecasting

Further, Dr Ryabinin discussed evolution and the current state of wind wave modelling and numerical forecasting. The focus of the discussion was on implications of the specific predictability of wind waves (as a field, which is basically forced by wind action) on the way wind waves are observed. For a well-tuned wind wave model the forecast errors are caused by errors in the meteorological forcing and in the initial conditions, but the effect of the latter is limited due to wave energy propagation, particularly in the closed seas. Existence of swell in the open seas changes wave field predictability considerably. Only a multivariate objective analysis scheme that jointly constrains the wave and wind field is capable of providing fully corrected data on wind, wind sea and swell. This fact emphasises the need for having more scatterometer data on winds, as well as direct measurements of waves (2-D spectrum and wave-height). Dr Ryabinin stressed the importance of co-located measurements and more sophisticated treatment of sea surface roughness, which is dependent not only on wind profile and stability but on the wind wave spectrum as well. The ultimate goal is to develop fully coupled models of atmosphere and wind waves, and the positive effect of such interactions has already been shown in several experiments (e.g. by Doyle or by Lionello et al.). It has been also acknowledged in the operational practice of the ECMWF. Dr Ryabinin discussed the relation between waves and generation of turbulent mixing in the ocean upper layer and the fact that wind wave effects that are fundamentally non-local can be improperly accounted for in most turbulent parameterizations. Dr Ryabinin made the following recommendations regarding the impact of wave modelling and forecasting activities on wave observations:

- Future re-analyses of surface variables and re-constructions of instantaneous fluxes between ocean and atmosphere can be insufficiently accurate for future requirements without proper instrumented observations on surface wave spectrum.

- R&D is needed into 4D variational assimilation systems to effectively handle assimilation of SAR spectra and winds, altimeter and scatterometer data, for future (re-) analysis systems and NWP forecasting.

- Waves and GODAE - Wave data are important for improved physical description of upper-ocean mixing and there is a need for a better-defined role of wind wave data in GODAE. A consistent description of fluxes in the lower atmosphere, the upper ocean and through the interface is needed.

- Research and Development needs to be enhanced on coupling a wave model with ocean/atmosphere models both in the data assimilation cycle and forecast modes and on benefit of using wave data in a multivariate objective analysis of observations of the atmosphere, the upper ocean and their interface.

5.6.4 Organization issues

Dr Ryabinin offered some recommendations on organizational matters in relation to wind wave observation, modelling, forecasting, and related services:

- Co-ordination of wave-related GOOS implementation activities should be included in the Terms of Reference for the Team of Experts (TE) on Wind Waves and Storm Surges of JCOMM.

- Both operational and scientific considerations need to be considered in developing an optimum wave programme. While all practical aspects of the wave data service provision will be mostly covered by the TE on Wind Waves and Storm Surges, a scientific support group (possibly under SCOR or OOPC) is also highly desirable.

- Capacity Building activities should focus on technical support for establishing an *in situ* monitoring network, making wave observations available to the GTS in near real time, and development of national systems for wave forecasting.

- Reviewing of wind wave observations and data services, as a part of the GOOS activities, should be continued in future on a quasi-permanent basis.

Discussion

The discussion brought out the need to predict and monitor conditions for extreme waves, and that this is not possible to do from space. In discussing measurements from VOS bow-mounted sensors, concerns were raised that the present technology can be quite expensive (about $20K), but the panel also recognized the weakness of visual observations. Robert Weller suggested that a pilot-project should be developed to put bow-mounted sensors on VOS ships to get wave information over the high-density XBT tracks. The Chair stated that perhaps OOPC should be looking at co-located tests next to TAO / TRITON and/or PIRATA, though there is an energy consideration. The goals for the ONR air-sea interaction programme and the rationale were mentioned:

- Validation and improvement of models.

- Providing the type of measurements that ship operators want.

- Improved quantification of the role of waves in air-sea fluxes.

- Improved knowledge of open ocean environment waves.

The Chair will liase with Dr Ryabinin and SCOR on the possibility of establishing a scientific working group [Action 10].

5.7 DATA SERVERS AND DATA MANAGEMENT

Dr Maria Hood presented an overview of the IOC – GOOS directions for data management. The initial implementation strategy of GOOS data and information management will be accomplished iteratively by linking existing ocean observation programmes. This decision was based on a number of considerations:

- GOOS will be a highly distributed system with contributions from many organizations, data centres, and agencies using different data and information systems.

- Programmes will include physical, chemical, and biological observations from both *in situ* measurements and satellites.

- The requirements for additional measurements and supporting information cannot be foreseen in detail at the present time.

- Because of the diversity of the existing systems and the lack of specific detail in regard to future requirements, a centralized data management system with strict control of formats, QA/QC procedures, accuracy and precision standards, and data products "certification" is not feasible for GOOS in the near future.

Dr Hood noted that the data and information management plan will outline a set of guiding principles on data management practices for the programmes contributing to GOOS. The initial goal is to connect the IOS programmes and the participating data and science centres under a unified and centralized information services system, where information about the programmes and observations may be obtained from a single source and where access to the data holdings or holder is provided. To begin to construct this type of information system, a partnership has been formed between GOSIC (Global Observing System Information Center), NASA-GCMD (Global Change Master Directory), and the IOC / IODE-MEDI (Marine Environmental Data Inventory) programme.

Dr Hood outlined the structure of the planned information system and the general role each group will play:

- GOSIC (Global Observing Systems Information Center) provides a directory-level searchable on-line metadata directory for databases that are part of the observing systems.

- The metadata directory is compatible with the NASA Global Change Master Directory (GCMD) and will be hosted by NASA on behalf of GOSIC. This will provide access to the broader community of both GCMD and GOSIC users. NASA will provide a GOSIC "view" by limiting GOSIC queries to G3OS entries.

- The system is being coordinated with the IODE-MEDI directory, which is an inventory-level metadata system based on the NASA GCMD format and standards. MEDI can be used by data centres as an offline input tool into the system or as a stand-alone metadata system that is fully compatible with the GOOS system. MEDI is web-based and provides inventory-level searches and interactive map displays of monitoring systems and stations.

- Co-ordination between the systems: NASA-GCMD contains a GOSIC window, limiting queries and information displays to the G3OS database. Within the GOSIC window, users can search across all G3OS systems at the directory level, or access IODE-MEDI to search and display inventory-level metadata from GOOS. These three systems should be nested in a manner that is transparent to the user.

Dr Hood also briefly described plans by the IODE to establish an international consortium to develop a marine version of XML (extensible mark-up language). XML is not a single, predefined markup language, but rather a meta-language - "*a language for describing other languages*". It is a set of rules for creating semantic tags used to describe data. She explained that XML is fast becoming the standard for data representation and exchange on the Internet in many areas of science. XML provides many advantages for the exchange, processing and management of marine data and can provide a generic platform for data centres to share data in a common syntax. Data can be stored in the originators' format and yet still be available for exchange over the Internet by using pre-defined tags to describe the data. XML has the potential to provide format independent data exchange and processing. Dr Hood provided the group with a paper about Marine XML and the status of the consortium (available in the report of the 8th Session of the Group of Experts on Technical Aspects of Data Exchange, available at the IOC e-library: http://ioc.unesco.org/iocpub/), and encouraged the Panel to support these developments.

Mr Bob Keeley provided an overview of the GOOS Data and Information Management Plan developed by Ron Wilson for the GOOS Steering Committee.
(http://ioc.unesco.org/goos/GOOSdm_v2_rewrite.doc)

The basic premise of the plan revolves around the end-to-end data management system, which links tasks of the data management system through to the end product development. He discussed the attributes required to accomplish these tasks for each application category of GOOS, and noted that it is the responsibility of the GOOS Science Panels to specify the required elements of data flow.

Mr Keeley posed the question, ‘what can OOPC do to encourage progress?’ and offered the following suggestions:

i. Look for a mechanism that suits operational centres, research and other data gatherers / assemblers, and non-ocean climate community that retains the integrity of data sets and in particular ensures original data are not lost and are easily recognized.

ii. Examine methods for recording value-adding procedures (from technical calibration through to scientific evaluation) that recognizes in some simple way the “value” that has been added (no judgements) and allows users to either exploit this value adding or take some quick route to the most up-to-date information.

iii. A few selected data sets / streams should be identified as a test bed for the project.

Discussion

The Chair noted that OOPC needs to provide the functional specifications for the climate components of the observing system in as much detail as possible as soon as possible. He also suggested that OOPC should review categories 1-3 of the plan (namely; Operational Marine Coastal and Ocean Short Range Forecasting and Analyses, Seasonal-to-Interannual Climate Prediction, and Numerical Weather Prediction) to see if they look reasonable. Mr Bob Keeley agreed to develop a discussion paper.

6. SCIENCE LECTURES

6.1. FISHERIES LECTURE

Dr Harold Loeng presented a special lecture to the group entitled, ‘Climate variability and the effects on fish populations in the North Atlantic’. He stated that climate variations are clearly evident in fisheries data, and that clear changes in herring, capelin, and cod abundances have been related to many physical factors, such as the location of the Icelandic front. These periods of high abundance are as much as an order of magnitude higher than the mean, with warmer years leading to better growth statistics. He noted that there is a strong correlation between the inflow of the Atlantic water in the North Sea and horse-mackerel abundances with a 6 month lag. In addition, herring recruitment is very sensitive to climate, and migration patterns follow warm water circulation. This is particularly important because herring form the basis for other fisheries in the region, and correlations between other fish populations and climate may be the result of herring sensitivity to climate rather than direct links between climate and these other fisheries. Dr Loeng noted that these effects are not simply related to temperature, but also to circulation changes. He noted that nowcasts of conditions in these regions were of particular interest.

6.2. SEA ICE LECTURE

Dr Ola Johannessen of the Geophysical Institute, University of Bergen and director of the Nansen Environmental and Remote Sensing Center, presented a lecture entitled, ‘Arctic sea ice and climate change – will the ice disappear in this century?’, based on Johannessen *et al.*, ‘Satellite evidence for an Arctic sea ice cover in transformation, (*Science*, **286**, 1937-1939, 1999) and Johannessen and Miles, ‘Arctic sea ice and climate change – will the ice disappear in this century ?’ (in press, *Science Progress*). Dr Johannessen began by noting that the Earth’s climate system responds on a variety of timescales, from global warming (centuries), to the North Atlantic Oscillation (decadal), to the Atlantic Multi-decadal Oscillation (AMO). Climate models predict arctic warming and retreating sea ice cover as a result of increased greenhouse gases and a warming climate, and quantitative observations of changes in sea ice cover may be obtained from satellite sensors measuring low-frequency microwave radiation. Time series records of sea ice obtained from the SMMR (Nimbus-7 Scanning Multi-channel Microwave Radiometer) and SSM/I (Special Sensor Microwave / Imagers now extend over two decades. The consensus from this 20-year record, corroborated in other analyses, is that there is a 3% per decade decrease in ice extent. From the data, it is possible to distinguish between first-year ice and multi-year ice, and these data suggest a 7% per decade decrease in the multi-year ice. Analyses of submarine upward-looking sonar data by Rothrock *et al.* (Geophys. Res. Lett., 26, 3469-3472, 1999) provide an estimate of a decrease in mean ice thickness of 1.3 meters over a 30 year period, corresponding to a decrease of 15% per decade, or 4 cm y^{-1}. Another technique gives an estimate of 1 cm y^{-1} decrease. Although the submarine data are spatially and temporally fragmented, the exact reasons for the large discrepancies between the studies are not fully understood. Dr Johannessen stated that the main point from these studies is that the ice cover is decreasing, and the lack of corroboration between the studies highlights the need for integrated data sets.

Dr Johannessen described several techniques currently used to measure ice thickness, such as measuring the wave period from SAR images, or from altimeter elevation profiles. He also briefly described several ice monitoring programmes. The European Space Agency programme, CRYOSAT, will look at trends in the Greenland and Antarctic ice sheets. The AMOC programme (Acoustic Monitoring of Ocean Climate in the Arctic Ocean) is an acoustic system for long-term monitoring of ocean temperature and ice thickness in the Arctic for climate variability studies. This programme involves data analysis and modelling. Dr Johannessen remarked that the 20MHz signal used to estimate the ice-thickness is not ideal, and that the optimum frequency is 250-300 MHz, although this would require more sources and receivers. He also stated that while the model is okay, the albedo used seems to lead to an under-prediction. The AICSEX programme (Arctic Ice Cover Simulation Experiment) is a modelling programme to address the questions of the effects that a diminishing ice cover would have on CO_2 levels and circulation.

Dr Johannessen concluded by stating that while the combination of evidence shows that Arctic sea ice is decreasing, understanding what is leading these changes and quantification of the processes are made difficult because of the large natural variability of NAO and AMO.

Discussion

The Chair asked what OOPC and GOOS can do to help with sustained monitoring of the polar regions and sea-ice. Clearly, ice thickness is a critical climate parameter and SSM/I and SAR are key features of the sustained observation system. The Panel emphasized the need for an overlap between these two systems of at least 1 year for intercalibration studies. The Panel also noted the importance of continued monitoring by submarines and timely release of the data. The Panel believed that the acoustic technologies seemed very promising for temperature and ice thickness monitoring. [See Item 5.3 for an OOPC Statement.]

6.3 ARGO LECTURE

Dr Pierre-Yves Le Traon presented a lecture entitled ‘*Argo*: Conception and Progress’. He briefly described the ENSO observing system, and noted that there are other phenomena than ENSO that influence climate. CLIVAR and GODAE will focus on global climate phenomena, and while the remote sensing components of these programmes are adequate for the first few years of these programmes, the existing *in situ* observation network is not sufficient to meet the full programme requirements. This, he stated, is the main driving force behind *Argo*. He provided some background information about Argo, stating that this is a joint GODAE-CLIVAR programme endorsed by the WMO and IOC. The Argo programme will provide a cost-effective observation system based on proven technology, and the full array of 3,000 floats on a 3º grid is scheduled to be in place by 2005. Data will be available in real time, with open access via the GTS and Internet (e.g., the Monterey Server). Dr Le Traon provided an assessment of the usefulness of the Argo observing system for the mesoscale descriptions needed for GODAE, and stated that the combination of Argo and high-density XBT lines will be able to resolve the statistics of the mesoscale (horizontal and vertical structure).

The real strength of the GODAE programme is the combination of remote sensing and *in situ* measurements, with Argo being the major *in situ* component.

Dr Le Traon provided a status report on *Argo* implementation. A total of 270 floats for year 2000 have already been funded, and 2,270 floats have been proposed over the next 3 years. Half of the global array should be in place at the start of GODAE in 2003, and the array should be completed by 2005, assuming a float lifetime of 4 years, with the limiting factor considered to be the salinity sensor. Although it would be possible to have more floats if the salinity sensors were not included (owing to the high cost of the sensors), CLIVAR and GODAE needs salinity data and *Argo* would be a much less effective programme without salinity measurements.

For the *Argo* data system, the US, France, and Canada have different prototype systems under development. Several centers are thus likely to exist but users should be able to get all the data from any of them. The format will be a self-documenting, platform independent binary format (NetCdf) both for real time and delayed mode. Data will be also available in near real time via the GTS (less than 12 hours). Real time and delayed mode QC and data flagging issues are still under discussion. Real time data will use automated QC and data distributed in delayed mode (approximately 3 months) will use thorough QC (e.g. salinity drift, use of results from GODAE assimilation systems). An *Argo* data system team led by Dr Bob Molinari (NOAA/AOML) is working on these issues. Mr Keeley is also a participant.

Regarding implementation planning, the Pacific basin implementation panel met in Tokyo in April 2000 and produced a statement outlining the commitments and strategy. The Atlantic implementation panel will meet in Paris in July 2000. These meetings focus on national contributions and how to coordinate the distribution of floats for global coverage. The Southern Ocean will be the most difficult for planning and implementation.

Discussion

Dr Walter Zenk briefly discussed the German contribution to the Atlantic implementation of Argo. The ministry has agreed to pay for 50 floats if they contain biological and chemical sensors (un-specified). The European Community float programme, Gyroscope, plans to contribute to Argo by launching floats in the Labrador Sea, the Irminger Sea, the Western subtropics, and the Northeast Atlantic. The Gyroscope participants will meet after the Argo Atlantic Implementation Meeting in July.

Some CLIVAR scientists have indicated a preference for a basin-scale focus for *Argo* with over-sampling rather than a coarser, global array. Dr Le Traon reiterated that the official 'statement' of the CLIVAR programme supports the global array. Several members noted that the Argo programme cuts off at 65°N and 65°S, and suggested that the high latitude seas need coverage as well. The Panel discussed the need for high-latitude work versus the difficulties and obstacles (notably sea ice) encountered in the regions. The Chair noted that OceanObs '99 supported development of acoustic methods in the Arctic.

Dr Le Traon mentioned that as agreed and endorsed by the last IOC Assembly, there will be an Argo Information Centre in Toulouse (joint with the DBCP and SOOP programme information and data centres) to provide information to official contact points in each country when floats are likely to enter an EEZ. The Panel agreed that it should work to encourage the participation of more countries in the programme. Over the next year, the GCOS Pacific regional Workshop, the SOCIO meeting, the Southern Ocean Workshop and the POGO meeting all provide opportunities to encourage participation.

The Panel discussed some of the lingering technical issues with the floats, such as the salinity sensor stability, the energy budget and lifetime of the floats, communications (Argos versus ORBCOMM), profiling and parking depth (e.g. in some areas, floats cannot reach 2000 m), performance standards, and different float types and intercalibration issues. Dr Le Traon mentioned that *Argo* would make use of existing data from other programmes for validation experiments.

The Chair listed the roles the OOPC has in Argo:

- OOPC is the 'keeper' of the integrated operational climate ocean observing system, of which Argo is a pilot contribution, and that we should work to ensure balance, quality, continuity, and availability of data from the programme. The new SOOP is the first contribution from OOPC and its Partners to encourage proper balance.

- The salinity part should most likely be the focus of the CLIVAR Ocean Observing Panel.

- OOPC is using GODAE as the path to operational assimilation take-up, but *Argo* also has a role in ENSO prediction efforts. OOPC will play a major role in the review of the ENSO observing system, which will affect the evolving scientific requirements of the Argo programme.

- OOPC must look forward to the integration of Argo in the operational observing system and data system, working with JCOMM. A single data stream, for example, is a potential goal, as well as supporting efforts to ensure consistency and quality [R Keeley will lead action under action item 11.].

- OOPC should work to promote the idea to nations and groups that they can participate in the programme without becoming float providers (e.g. at the GCOS Pacific Regional Workshop).

- OOPC should encourage continuous value-adding to the Argo data set through re-analysis and intercomparison with other observing system data. The OSSEs mentioned under 4.8 provide an opportunity.

7. REVIEW SCHEDULE OF ACTIONS

The Chair suggested that the following list of action items be circulated to the Panel after the meeting to give members another opportunity to refine the actions and time schedules:

Action Items	Who	When
1.Time Series Station Science Team, Terms of Reference: Establish a science team on time series stations to advocate time series programmes and push the programmes forward. This should be a multi-disciplinary approach including interaction with the modelling community. The team should reduce the list of time series stations to key locations, and establish partnerships with other organizations and agencies to start pushing for a concise list of justifiable stations.	Weller and Zenk (Send)	At meeting: Draft TORs (Annex VIII) At POGO: agree on Workshop
2.Strategy for Deep Measurements: Draft an appraisal of the rationale for deep ocean observations.	Needler	Robbins Carbon Transport Conference, 2001
3.Tropical Moored Buoy Implementation Panel, Terms of Reference: Propose new TORs for TIP to include other moored buoy arrays.	McPhaden, Chair	At meeting: Draft TORs (Annex VII)

4.ENSO Observing System Review Process, Terms of Reference: Draft TORs for a rolling-review process of the ENSO observing system.	Chair, McPhaden	At meeting: Draft TORs (Annex VI)
5.SURFA Experiments: Set up a meeting to make recommendations on long-term support for surface reference sites; determine critical regions, make connections with modelling, *in situ*, and remote sensing communities.	Weller, Chair Alexiou / Hood	December 2000, San Francisco. Also WGNE, Melbourne
6.Sustained monitoring of the polar regions: Advocate importance of the polar regions for climate; state support for SSM/I measurements for ice extent as well as strong support for experimental missions supported by a range of *in situ* measurements, such as the continued release of ULS data from submarines.	Chair	GSC IV
7.List of Operations Data Centres: Develop and evaluate a list of potential major operational centres for the GOOS Initial Observing System.	Chair	Annex III
8.Develop paper on Observing System Sensitivity Experiments	Harrison	For OOPC VI
9.Review of Global Carbon Project documents	Haugan, Harrison	For OOPC VI
10.Establish science WG for waves	Chair, Ryabinin	December 2000
11.Discussion paper on data integrity/identity issues	Keeley	For OOPC VI

8. OOPC MEMBERSHIP

The Panel expressed its thanks to Peter Haugan, George Needler and Gwyn Griffiths, who will be rotating off the OOPC this year. The Panel discussed nominations of new members to replace the outgoing members, noting also the need for members with expertise in deep measurements and sea ice / polar regions. It was noted that any changes to the composition of the panel must be approved by the GCOS/GOOS/WCRP parent groups.

9. CLOSING AND NEXT MEETING

The next meeting will tentatively be held in Melbourne, Australia, 2-6 April 2001.

ANNEX I

AGENDA

1. OPENING AND WELCOME

2. REVIEW AND ADOPTION OF THE AGENDA

3. REVIEW OF INTERSESSIONAL ACTIVITIES

3.1 LESSONS LEARNED FROM OCEANOBS 99

3.2 IOC UPDATE

3.2.1 Reconstituted CO_2 Panel
3.2.2 Coastal Panel
3.2.3 GOOS Steering Committee

3.3 GCOS STEERING COMMITTEE AND THE FOLLOW-UP WITH UNFCCC

3.4 IGOS PARTNERS

3.5 POGO

3.6 JCOMM

3.7 UPPER OCEAN PANEL AND CLIVAR IMPLEMENTATION

3.8 REMOTE SENSING UPDATE

3.8.1 Ongoing Projects
3.8.2 Planned Activities
3.8.3 Sea Surface Temperature Retrievals from Passive Microwaves

4. OOPC INITIATIVES

4.1 SST OBSERVATIONS

4.2 GODAE HIGH-RESOLUTION SST PRODUCTS

4.3 SURFACE REFERENCE SITES/SURFA

4.4 MOORED BUOY ARRAYS

4.4.1 TAO / Triton
4.4.2 PIRATA
4.4.3 EPIC
4.4.4 TAO Implementation Panel

4.5 TIME SERIES STATIONS

4.6 SUB-SURFACE THERMAL WORKSHOP

4.7 INDIAN OCEAN WORKSHOP

4.8 GODAE STRATEGY

5. SPECIFIC AREAS NEEDING ACTION

5.1 CARBON

5.2 DEEP OCEAN OBSERVATIONS

5.3 ICE-COVERED OCEAN DISCUSSION ON FUTURE DIRECTION

5.4 MONITORING BOUNDARY CURRENTS

5.5 SALINITY FROM SPACE

5.6 WIND WAVES

5.6.1 Wave Observation
5.6.2 Data Issues
5.6.3 Modelling and Forecasting
5.6.4 Organization Issues

5.7 DATA SERVERS & DATA MANAGEMENT

6. SCIENCE LECTURES

6.1 FISHERIES LECTURE

6.2 SEA ICE LECTURE

6.3 ARGO LECTURE

7. REVIEW SCHEDULE OF ACTIONS

8. OOPC MEMBERSHIP

9. CLOSING AND NEXT MEETING

ANNEX II

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ANNEX III

LIST OF POSSIBLE OPERATIONAL CENTRES FOR GOOS

NOAA/NCEP (marine, coastal and climate products)
NOAA/NESDIS (range of ocean data and data products, particularly satellite)
NOAA/PMEL (TAO array)
NOAA/AOML GOOS Centre
U.Hawaii Sea Level Centre
NODC (data archive and exchange)
FNMOC and NAVOCEANO (a wide range of marine and ocean forecasts and services, including GODAE Server)

ECMWF (climate and surface flux fields)

UKMO (marine and ocean forecasts (FOAM), climate products and forecasts, sea-ice warnings, etc.)
Bidston (sea level data and PSMSL)

JMA (similar range to UKMO and including many data sets)
Hydrographic dept of JMST (sea level data)
JAMSTEC (TAO/TRITON and Argo)

BoM (as UKMO; also Joint CSIRO/BMRC Australian Facility for Ocean Observing Systems for SOOP, QC data and Argo)
National Tidal Facility (sea level)

Korean MA (more limited, but certainly coastal and marine)

Meteo France (as UKMO)
Ifremer (Coriolis Project, etc.)
CLS Argos

Canadian Met Agency
MEDS (data exchange and archives)

Brazilian Navy (not certain but it seems to have broad responsibilities; PIRATA)

ANNEX IV

SCOR-IOC ADVISORY PANEL ON OCEAN CO_2
TERMS OF REFERENCE

General Terms of Reference:

1. Advise SCOR / JGOFS, GOOS, and OOPC on CO_2 observations, data management and modelling needed for studies of the global carbon cycle,

2. Provide an international forum for initiatives to promote high-quality observations of CO_2 in the oceans.

Specific Terms of Reference:

1. To identify gaps and weak links in the present CO_2 observation system needed for understanding and predicting global change;

2. To identify opportunities that can be used to further develop the observing system (e.g. piggy-backing on the climate observing system);

3. To aid the synthesis of JGOFS and IGBP results with respect to marine CO_2 observations, data management and modelling by:

   3.1 Initiating and facilitating the assembly of CO_2 data bases;
   3.2 Interacting with ocean modelers with respect to the weaknesses and appropriate uses of CO_2 data;
   3.3 Encouraging and facilitating the collaborative analysis of CO_2 data sets and supporting data.

4. To maintain a watching brief to advise IOC and SCOR on CO_2 sequestration in the ocean;

5. To advise GOOS and OOPC on appropriate technology development for CO_2 monitoring;

6. To advise GOOS and OOPC on the observational strategies needed to assess, model, and predict global ocean CO_2 fluxes.

ANNEX V

PARTNERSHIP FOR OBSERVATION OF THE GLOBAL OCEANS (POGO) TERMS OF REFERENCE

Preamble

A group of marine research institutions met in Paris in March 1999 to discuss ways in which they could work together more effectively in support of global oceanography. The result was a proposal to establish the Partnership for Observation of the Global Oceans (POGO), whose terms of reference are provided below.

Objectives

The objective of POGO is to make a major contribution to the attainment of sustained *in situ* observations of the global ocean that meet the requirements of international research and operational programs.

As a means of attaining this objective POGO will:

- Initiate key actions to enable effective coordination, integration, and implementation of international ocean observing strategies in close collaboration with the Global Ocean Observing System (GOOS);
- Establish collective agreements among institutions to promote timely developments in ocean science;
- Develop and promote coordinated views of ocean institutions concerning ocean observation and science to governments, international bodies, and others;
- Facilitate linkages between oceanographic research and operational institutions in relation to their goals, plans, and programs;
- Exchange policy and technical information;
- Coordinate the education and outreach programs of its Members;
- Encourage responsiveness to user communities;
- Promote capacity building;
- Promote sharing of facilities and infrastructure;
- Encourage interdisciplinary use of observing infrastructure.

The Partnership will actively work to inform and communicate with the broader community interested in global oceanographic observations and research.

Individual Members of POGO will use their best efforts to implement POGO recommendations in their respective programs.

ANNEX VI

ENSO ROLLING – REVIEW
TERMS OF REFERENCE

i. To review the scientific basis for an observing system in support of seasonal-to-interannual forecasting, in particular predictions of ENSO, and the study of related variability and predictability. This review should take account of experimental and operational applications as well as the science themes of CLIVAR;

ii. To document characteristics of the current data from the ENSO OS including spatial (horizontal and vertical) and temporal sampling characteristics, logistical factors, data delivery, assembly and quality;

iii. To document the accumulated data related to the ENSO OS including sampling, quality of delayed-mode data banks, length of records, integrity of data sets (including quality of metadata), and availability;

iv. Assess the impact and relative priority of elements of the ENSO observing system for operational and routine experimental ENSO forecasts;

v. Assess the impact and relative priority of elements of the ENSO OS for research, in particular issues associated with Pacific variability and predictability, research on seasonal-to-interannual prediction, and research related to intra-seasonal variability;

vi. Establish a set of metrics that can be used for ongoing assessment of the effectiveness of the ENSO observing system such as:

  a. Number of marine measurements
  b. Number of subsurface measurements
  c. Timeliness (delivery to operational users and to research)
  d. Satisfaction of research requirements in design and strategy
  e. Utility in operational forecasts
  f. Utility for research (number of papers; dependence of projects)
  g. Measuring redundancy with other systems (operational missions)

vii. To establish a process for guiding the evolution of the ENSO OS;

viii. To report to and frame recommendations for the consideration of the GCOS / GOOS / WCRP / OOPC, to the CLIVAR SSG through the COOP, WGSIP and Pacific Panel, and to JCOMM via the TAO Implementation Panel.

ANNEX VII

TROPICAL MOORED BUOY IMPLEMENTATION PANEL
PROPOSED TERMS OF REFERENCE

i. To assist in the preparation of annual operating plans for the TAO/TRITON array, PIRATA array, and related moored buoy arrays in the tropical oceans;

ii. To promote and coordinate the exchange of technical and logistic information between institutions participating in the maintenance of these arrays;

iii. To encourage the rapid dissemination of moored buoy data in real-time via the Global Telecommunications System and other mechanisms;

iv. To advise CLIVAR, GOOS, and GCOS on the technical feasibility of expansions and enhancements to existing programmes, or the implementation of new moored buoy programmes, in the tropics;

v. To ensure that organizations actively involved in moored buoy data use are informed of the workings of the panel and encourage, as appropriate, their participation in the panel deliberations;

vi. To promote an integrated approach to observing the climate system in the tropics, through development of common calibration standards, sampling and reporting procedures and through coordination with other CLIVAR, GOOS, and GCOS panels involved with observing system maintenance and development;

vii. To report annually to the CLIVAR Ocean Observations Panel (COOP), the GOOS/GCOS/WCRP Ocean Observations Panel for Climate (OOPC), to the WMO/IOC Data Buoy Cooperation Panel (DBCP);

viii. To facilitate capacity building at institutions seeking involvement in the deployment and maintenance of moored buoy arrays in support of CLIVAR, GOOS, and GCOS.

ANNEX VIII

TIME SERIES GROUP - TERMS OF REFERENCE

i. Define a global array of long-term time series stations for multi-disciplinary observations at the sea surface, in the ocean, and on the sea bottom, and develop the rationale for establishing and maintaining the array;

ii. Identify the specific locations and state the rationale for occupying them, including the discussion of continuity of existing sites and re-establishment of previously occupied sites, and indicate the sampling and highest priority measurements, including a minimum suite, for each site. This process should include consideration of resources and logistic;

iii. Consider and recommend mechanisms for real-time and delayed-mode data delivery and assembly, taking into account the nature of the observed parameters;

iv. Liase with other relevant groups, such as the Argo Science Team, the TIP, and hydrographic section program, satellite remote sensing programs, and interdisciplinary groups to ensure the time series stations are integrated with other observing system elements;

v. Develop an implementation schedule, including a pilot phase and timing for fully sustained support.

ANNEX IX

LIST OF ACRONYMS

ADCP	Acoustic Doppler Current Profiler
ADEOS	Advanced Earth Observing Satellite (Japan)
ALACE	Autonomous Lagrangian Circulation Explorer
AMO	Atlantic Multidecadal Oscillation
AMSR	Advanced Microwave Scanning Radiometer
AO	Antarctic Oscillation
AOML	Atlantic Oceanographic and Meteorological Laboratory (NOAA)
AOPC	Atmospheric Observing Panel for Climate
ASCAT	Advanced Scatterometer
ATOC	Acoustic Thermometry of Ocean Climate
ATSR	Along Track Scanning Radiometer
AVHRR	Advanced Very High Resolution Radiometer
BC	Boundary Current
BMRC	Bureau of Meteorology Research Center (Australia)
BSH	Bundesmat fur Seerschiffahrt and Hydrographi.e. (Germany)
C-GOOS	Coastal GOOS
CEOS	Committee for Earth Observation Satellites
CHAMP	Challenging Many Satellite Payload for Geophysical Research and Applications (Germany)
CLIC	Climate and Cryosphere
CLIVAR	Climate Variability and Predictability Program
CNES	Centre Nationale d'Etudes Spatiales (France)
COOP	CLIVAR Ocean Observing Panel; Coastal Ocean Observations Panel
CoP	Conference of the Parties (UNFCCC)
COSTA	Climate Observing System for the Tropical Atlantic
CRYOSAT	Ice Observing Satellite (ESA)
CTD	Conductivity, Temperature, Depth
DBCP	Data Buoy Co-operation Panel
DEOS	Deep Earth Observing System
DIC	Dissolved Inorganic Carbon
DMSP	Defence Meteorological Programme
DODS	Distributed Ocean Data System
EC	European Commission
ECMWF	European Center for Medium-Range Weather Forecasting
ENSO	El Nino Southern Oscillation
ENVISAT	Environmental Satellite
EOS	Earth Observation Satellite (US)
EPIC	Eastern Pacific Investigation of Climate
ERS-2	European Remote Sensing Satellite - 2
ESA	European Space Agency
ESTOC	Estaci¢n de Series Temporales Oce nicas de Canarias
EU	European Union
EUMETSAT	European Organization for Exploitation of Meteorological Satellites
FSI	Falmuth Scientific Instruments
GAIM	Global Analysis, Integration and Modelling (IGBP)
GCOS	Global Climate Observing System
GCMD	Global Change Master Directory (of NASA)
GEF	Global Environmental Facility
GEWEX	Global Energy and Water Cycle Experiment
GLOSS	Global Level of the Sea Surface

GMT	Greenwich Mean Time
GOCE	Gravity Field and Steady State Ocean Circulation Explorer
GODAE	Global Ocean Data Assimilation Experiment
GOOS	Global Ocean Observing System
GOSIC	Global Observation System Information Center
GOSSP	Global Observing Systems Space panel
GPO	GCOS Project Office
GPS	Global Positioning System
GRACE	Gravity, Recovery, and Climate Experiment (NASA, Germany)
GSC	GOOS Steering Committee
GTOS	Global Terrestrial Observing System
GTS	Global Telecommunications System
G3OS	Shorthand for GOOS, GCOS, GTOS
HOTO	Health of the Ocean Panel (of GOOS)
HOTS	Hawaii Ocean Time Series Station
ICESAT	Ice Satellite (NASA)
IGBP	International Geosphere – Biosphere Programme
IGOS	Integrated Global Observing Strategy
IGOSS	Integrate Global Ocean Services System
IMET	Improved Meteorology
IOC	Intergovernmental Oceanographic Commission
IOCCG	International Ocean Color Coordinating Group
IODE	IOC International Oceanographic Data and Information Exchange network
IOS	Initial Observing System
IPCC	Intergovernmental Panel on Climate Change
IR	Infrared
JCOMM	Joint Technical Commission On Oceanography and Marine Meteorology
JAMSTEC	Japanese Marine Science and Technology Centre
JDIMP	Joint Data and Information Management Panel
JGOFS	Joint Global Ocean Fluxes Study
JMA	Japanese Meteorological Agency
LMR	Living Marine Resources Panel (GOOS)
MEDI	Marine Environmental Data and Information Project (IODE)
MEDS	Marine Environmental Data Services
MOC	Meridional Overturning Circulation
MODIS	Moderate Resolution Imaging Spectroradiometer
NAO	North Atlantic Oscillation
NASA	National Aeronautics and Space Administration
NDBC	National Data Buoy Centre
NOAA	National Oceanic and Atmospheric Administration (US)
NPOESS	National Polar-Orbiting Operational Environmental Satellite System (US)
NSCATT	NASA Scatterometer
NWP	Numerical Weather Prediction
OceanObs99	The Ocean Observing System for Climate Meeting, St Raphael, France, October 1999
OCTET	Ocean Carbon Transport Experiment
ONR	Office of Naval Research (USA)
OOP	Ocean Observations Panel
OOPC	GOOS-GCOS-WCRP Ocean Observations Panel for Climate
OOS	Ocean Observing System
OOSDP	Ocean Observing System Development Panel
ORBCOMM	Name of a Satellite and a Satellite Communications System
OSSE	Observing System Sensitivity Experiments
PACS	Pan American Climate Study
PALACE	Profiling Autonomous Lagrangian Circulation Explorer
PDO	Pacific Decadal Oscillation
PIRATA	Pilot Research Array in the Tropical Atlantic
PMEL	Pacific Marine Environmental Laboratory (of NOAA)

POGO	Partnership for Observations of the Global Ocean
QA	Quality Assessment
QC	Quality Control
RTH	Regional Telecommunication Hub
SBSTA	Subsidiary Body for Scientific and Technological Advice {of the CoP for the UNFCCC}
SCOR	Scientific Committee for Oceanic Research
SeaWIFS	Sea-viewing Wide Field-of-view Sensor
SIO	Scripps Institution of Oceanography
SLP	Sea Level Pressure
SMOS	Soil Moisture Ocean Salinity Satellite (ESA)
SOC	Southampton Oceanography Centre
SOCIO	Sustained Observations for Climate of the Indian Ocean
SOLAS	Surface Ocean Lower Atmosphere Study
SOOP	Ship of Opportunity Programme
SSH	Sea Surface Height
SSIWG	Salinity - Sea Ice Working Group
SSM / I	Special Sensor Microwave / Imager
SSS	Sea Surface Salinity
SST	Sea Surface Temperature
SURFA	Surface Reference Site
TAO	Tropical Atmosphere – Ocean (buoy array)
TIP	Tropical Moored Buoy Implementation Panel
TOPEX	Ocean Topographic Experiment
TRMM / TMI	Tropical Rainfall Measuring Mission (TRMM) microwave imager (TMI).
TS	Temperature Salinity
UKMO	UK Met Office
ULS	Upward Looking Sonar
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UOP	Upper Ocean Panel
UOT	Upper Ocean Thermal Project
VOS	Voluntary Observing Ship
VOSCLIM	VOS for Climate
WBC	Western Boundary Current
WCRP	World Climate Research Programme
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
XML	Extensible Mark-up Language