Global Ocean Observing System

Intergovernmental Oceanographic Commission
Reports of Meetings of Experts and Equivalent Bodies

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

Melbourne, Australia
2 - 5 May 2001

GOOS Report No. 113
GCOS Report No. 70
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GCOS-GOOS-WCRP/OOPC-VI/3
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ABSTRACT

This report records the discussions, conclusions, and action items resulting from the sixth session of the OOPC. The state of operational systems, experiments underway, and workshop results were a particular focus of this session. Panel members were briefed on and invited to participate in the preparation of An Assessment and Second Adequacy Report of the Climate Observing System due in 2003 being compiled by GCOS for COP-VIII. A small working Group was formed to look at mean sea level pressure with AOPC in the context of a GCOS. Individual members were assigned OOPC responsibilities for participating in workshops and working groups, namely: an International Workshop to review the Global Tropical Mooring Network; a workshop on integrating South Atlantic observations; an Indian Ocean Conference on Sustained Observations for Climate: studies on Data Identification Coding, Versions (levels) and Integration; the preparation of a paper that sets out the issues in full and complete communication of original data (e.g., broad band, 2-way, multi-disciplinary) for general consumption; and the development and use of Ocean Climate Indices.

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1. OPENING

Chairman Neville Smith opened the meeting and asked the host Michael Manton to make a few remarks. Manton, Chief, Bureau of Meteorology Research Centre in Melbourne, welcomed the participants. He noted his long continuing interest in the Panel's work which is related in many ways to the activities of his organization and to those of the GCOS Atmospheric Observations Panel which he also chairs. Smith then welcomed the Panel and guests noting the absence of Gwyn Griffiths, George Needler and Peter Haugan who had stepped down from OOPC. Among the guests present were Paul Mason, Chief Scientist of the British Met Office and incoming new Chair of the GCOS Steering Committee, and Edmo Campos and Tommy Dickey who were appointed to the OOPC shortly after the meeting. The third OOPC replacement was Peter Taylor who was unable to attend. A round of self-introductions then took place which was followed by a briefing on the facilities, and planned daily meeting schedule. A full list of participants is given in Annex II.

2. REVIEW AND ADOPTION OF THE AGENDA

Smith introduced the provisional agenda and noted that the scheduling of some items might have to be changed to accommodate the expected arrival times of certain speakers. After limited discussion the agenda in Annex I was adopted.

3. PANEL REPORTS ON INTERSESSIONAL ACTIVITY

3.1 OOPC SUMMARY

Neville Smith noted that approvals of the GSC proposed modifications to the OOPC Terms of Reference (ToR) (see Annex IV) were received from the WCRP and GCOS . He was pleased to report progress on OOPC activities on a number of fronts. The SST group are defining *in situ* requirements and analysing differences between various SST climate products. Issues raised concerning bulk and skin temperature have been taken up by the GODAE SST Group. See the report of the GODAE High Resolution SST workshop held 30 Oct - 1 Nov, Ispra, Italy (GODAE Report No. 7). The GODAE Strategic Plan has been completed and distributed (GODAE Report No. 6). Work has begun on the GODAE Implementation Plan. Argo is accumulating commitments for floats in encouraging numbers. The Surface Flux Analysis (SURFA) project, jointly with the Working Group on Numerical Experimentation (WGNE), has outlined a strategy for regular validation of model surface flux estimates. A small SURFA workshop in San Francisco (December 2000), agreed on an initial set of sites. The ToR of the TAO Implementation Panel have been revised and new members are being appointed. For assessing the present status of the tropical moorings and developing guidelines for the future, a workshop is being organized for 10-12 September 2001 at PMEL in Seattle. Piers Chapman has agreed to assist in the effort. Smith proposed the idea of a 5-year OOS plan that continues to evolve, that takes every advantage of technology development and continues to emphasize the global perspective. Data management issues are getting increasing attention but not at the in-depth level that Smith believes is required.

Co-operation with the CLIVAR OOP (the former UOP) and the Working Group on Air-Sea Fluxes (WGASF) continues to be productive. A Time Series Science Team was established, jointly sponsored by GOOS/GCOS(OOPC) and CLIVAR; the team scheduled a workshop at WHOI in May 2001.

A well attended workshop was held in Perth in November 2000 on sustained observations for climate in the Indian Ocean. William Erb, Head of the IOC Perth Regional Programme Office in Western Australia, is following up to convert the enthusiasm generated there into action. The papers for the OceanObs99 book have all been reviewed; about half are ready for publication which is scheduled for the 3rd quarter of this year. Some 750 copies will be printed.

3.2 GOOS

Smith reported that a draft policy document for regional implementation by GOOS regional bodies (e.g., EuroGOOS, MedGOOS, etc. has been developed and will be presented to I-GOOS in June for adoption. Global implementation of GOOS will be a priority of JCOMM. CEOS/IGOS-P are the focal point for remote sensing implementation issues. A strongly supported GOOS strategy for implementing capacity building has been adopted. Capacity building is a recent focus of POGO as well; together with SCOR and IOC, POGO will institute a fellowship programme for training in developing countries on implementing ocean observations and their applications.

3.2.1 GOOS Steering Committee (GSC)

Smith participated in the March meeting of the GOOS Steering Committee (GSC) and reported that GOOS is now structured around two main themes looked after by two corresponding Panels. The first, OOPC, has the global perspective and reports to the GSC on the predominantly physical climate issues. The second is coastal and non-physical oriented – this is the new Coastal Ocean Observations Panel (COOP), an amalgamation of the former C-GOOS, LMR, and HOTO Panels. New arrangements will be made to accommodate the dissolution of GOSSP and J-DIMP. A GOOS D&IM Plan has been drafted for oversight of the operational system as well as pilot projects intended for eventual enhancement of the operational system.

To deal with a growing lack of nomenclature clarity in labelling GOOS activities, the GSC decided to adopt a formal definition for GOOS Pilot Projects that reads as follows:

> "A pilot project is defined as an organized, planned set of activities with focussed objectives designed to provide an evaluation of technology, methods, or concepts within a defined schedule and having the overall goal of advancing the development of the sustained, integrated ocean observing system."

The GSC approved the OOPC work plan and considered that OOPC was making good progress in all areas; no gaps were evident and no areas were identified where activity was unsatisfactory. Discussion revealed there are emerging areas of strong interaction between the OOPC and COOP, in the coastal zone and in the open ocean (physics, biology), and with GODAE. Smith noted the commitment of the Chairs to attend each other’s meetings (Worth Nowlin will attend the next COOP for OOPC). Adding Dickey to the OOPC membership will allow OOPC to better respond to the interface issues.

3.3 GCOS

Paul Mason expressed some personal views that would underlie the directions he planned to lead GCOS when he formally assumed the position of chair of the GCOS Steering Committee. To him, JCOMM is critical to bringing together the operational and research communities. He stressed the need to improve statistics on reporting floats and other observations, to establish a GCOS Network of defined components and an agreed set of standards. He sees room for improved co-ordination in the development of remote and in situ requirements. With the termination of GOSSP, he will strive to have two experts on space observations on each science panel. Regarding IGOS, he believed that a greater measure of control was necessary to avoid duplication of effort by the Theme Teams.

Mason informed the meeting of preparations for the 2nd Report on the Adequacy of the Observing System due in the fall of 2003 to the UNFCCC. As Chair, he will oversee panel reviews and individuals participating in the exercise and will try to ensure wide community consensus including the JSC and IPCC. GCOS is preparing guidelines for National Reports due in November which will be a starting input for the Adequacy Report. Mason also alluded to regional workshops being considered for capacity building and integrating the efforts of agencies. He stated that regional workshops will be GCOS co-ordinated and seek to examine the relevance of GCOS at the regional level and to improve understanding of regional issues in terms of needs and problems. The workshops needed to involve more than the atmospheric community and links with GOOS and GTOS were necessary to encourage wider involvement. It was clear that not enough ocean-oriented people are set to attend the capacity building workshops. He believed that good metrics for observations were needed to determine if workshops resulted in improved observation reports.

Mason noted that the term G3OS was losing favour as it was confusing and might confuse and link GCOS to the atmosphere alone. He requested OOPC to assist in dropping the terminology.

Mason concluded by stressing that we need to counter the impression of funders, that we are ignoring costs when we ask for more resources. The point has to be made and remade that we are reducing costs at every opportunity as we ask for more to be more cost-effective in getting more integrated measurements. Smith added that this is in line with designing reference sites to be multi-purpose and XBT lines to be co-located with time-series stations.

3.4 AOPC

Mike Manton informed the Panel that the Atmosphere Observations Panel for Climate (AOPC) was moving forward along two streams:

1. Baseline Systems -- providing long- term, high-quality, homogeneous data sets.
2. Comprehensive Systems -- providing all available data for assimilation in models.

Components of the Baseline Systems (these are end-to-end) would be the observation network, operators, monitoring Centres, analysis Centres, etc. Ocean observations would be SST sea ice, and surface pressure. Data would come from regular reporting sources such as VOSClim, a programme to have 200 selected VOS ships to produce high-quality observations, and surface reference sites, The first step would be to get good meta data on ships and instruments, etc., and later to include enhancements like ASAP.

In the context of the Earth Radiation Mission (considered for approval by ESA in collaboration with NASDA) it would be timely that AOPC/OOPC establish a joint view on how surface reference sites (for instance) could be used for calibration-validation purposes as well.

AOPC's priorities are to generate products, to liaise with the WMO Commissions, to liaise with the meteo satellite agencies and to achieve GCOS recognition from the UNFCCC (via contribution to the Adequacy Report). Manton stressed that meta data on data sets are essential; without meta data, the satellite data are not relevant to climate.

The AOPC are creating a small Working Group to look at mean sea level pressure data in the context of a GCOS. The OOPC has agreed this is an important task and has agreed to act as a co-sponsor. DE Harrison will participate in the WG. OOPC noted the importance of good MSLP for surface air-sea interface issues and altimetry, particularly sea level change estimates.

There is a strong motivation for seeking even greater synergy with atmospheric and ocean/marine measurements for the open ocean. Surface reference sites and VOSClim are two opportunities. Both AOPC and OOPC are looking forward to improved instrumentation as a second stage of the VOSClim project. There was also agreement that better use should be made of R/V opportunities. The desirability of co-located (operated) VOS, SOOP and ASAP was highlighted.

3.5 POGO

Robert Weller reminded the Panel that POGO, a Partnership for Observations of the Global Oceans was an organization made up of oceanographic research institutions established to develop a common agenda for a common voice to their governments. He reported on the second plenary meeting held in São Paulo, 28 November to 1 December. The main focus of the meeting was on issues pertinent to the Southern Ocean and the lack of data in the southern hemisphere. The meeting adopted a declaration to promote observations in the southern hemisphere and to make a concerted effort to identify gaps and the means for addressing them in co-ordination with programmes that are active in the region. The Sao Paulo Declaration can be found on the web at: <http://www.oceanpartners.org/docSPD.pdf>.

Ways to promote capacity building in ocean observations also received much attention. Towards this end, it was decided to institute a scholarship scheme in collaboration with SCOR and IOC to provide training opportunities in developing countries on global ocean observations and their applications. POGO also decided to co-sponsor SEREAD (see 5.2.4) and to participate in training programmes initiated by other organizations such as the International Ocean Colour Co-ordinating Group (IOCCG) and the Austral Summer Institute Series initiated by WHOI and the University of Concepcion (Chile).

The next meeting is scheduled for the fall 2001 at the Bedford Institute of Oceanography, Canada. Two themes were settled on for that meeting; (1) biological observations; they are more complex and less automated than physical observations; and (2) time series observations; they are needed to complement the Argo programme which depends entirely on a free-floating array of profiling floats.

3.6 CLIVAR OCEAN OBSERVATIONS PANEL (OOP)

The first meeting of the CLIVAR Ocean Observations Panel (CLIVAR OOP) was hosted by the CSIRO Marine Research Laboratory in Hobart, Tasmania the week prior to OOPC-VI. Chet Koblinsky, the Panel chair, noted that the meeting was held in Australia to emphasize implementation in the southern hemisphere. He structured the meeting to help develop a vision for the Panel's future. The next meeting will examine heat, fresh water and momentum transport and closure of fluxes. The integrity of observations is one of his Panel's dominant interests and thus he sees a shared interest in special OOPC groups on SST and sea level. The OOPC agreed that it was appropriate for CLIVAR OOP to take the lead on heat, freshwater and momentum transports and to assess the implications for requirements and the adequacy of present and planned observing networks. The role for hydrography will also be examined within this context.

Koblinsky stated that data management was one of the great challenges and that he would also like to see a shared data management group established. Robert Keeley believed that such a group should be encouraged to provide a more precise articulation of data needs, e.g., sampling, etc. Weller added that the goal should be to seek a more modern approach than the WOCE data management system employed.

Regarding basin oversight Panels, Koblinsky reported that there is an Atlantic Panel and there is general agreement that a CLIVAR-CliC Southern Ocean Panel is needed to lead the development of a scientific programme, including observations, as there will be a significant CLIVAR focus on the Southern Ocean. The OOPC will use this group for any implementation/ oversight activities. The need for a Pacific Panel at this time was still being debated in some circles. Participants from India and China showed interest in an Indian Ocean Panel.

Argo will be the first big move to make a difference in closing the Indian Ocean budget. There is concern about the ability of manufacturers to produce the numbers of floats estimated to be purchased in the next few years. There is also considerable interest in closing the Indian Ocean budget with XBT lines.

Sensitivity experiments on the ENSO system have not been practised yet; there is insufficient data. Koblinsky agreed that the Tropical Mooring workshop was a good forum to have a needed dialogue regarding moorings and CLIVAR OOP will contribute to the review. R. Davis and D. Stammer have been nominated as two contacts for the CLIVAR OOP.

Koblinsky touched on a number of other observation issues. A WOCE-JGOFS July 2001 workshop in Southampton on transports will examine hydrographic sections needed by CLIVAR - which ones to repeat and how often. The OOPC agreed that CLIVAR OOP should take the lead on heat, freshwater and momentum transports and the implications for the Adequacy Report of present and planned observing networks. The role for hydrography should also be examined within this context. Satellite observations, surface fluxes and western boundary currents (WBCs), were also addressed. In order to develop an observing network appropriate to western boundary current regions, CLIVAR OOP has proposed a workshop be convened to a) examine our ability to monitor WBCs with existing technology, (b) evaluate emerging technology such as gliders, and (c) develop a strategy for monitoring WBCs. The OOPC agreed this was an appropriate initiative. OOPC would keep a "watching brief", in particular to ensure that relevant non-CLIVAR issues are covered.

Koblinsky encouraged the OOPC to forge an agreement on reference sites and time series stations. He noted that Toshio Sugo stated Japan would be open to a request to fund a reference site in the Kuroshio. Letters from the international community supporting such a request would be pivotal.

The CLIVAR OOP were impressed with a presentation by Uwe Send on progress with acoustic tomography and the promise of this technology to become a valuable component of an operational ocean monitoring system.

The discussion cautioned against the inflation of requirements. Weller encouraged the CLIVAR OOP to push deep hydrography. Dickie noted that JAMSTEC had agreed to moorings for physical and biogeochemical observations (for carbon sequestration, climate and fisheries applications). Harrison stated the community needs simple assessments of what we know and where we know it, based on existing data, to underpin observation strategies. A strategy for assessing the global system is also needed. CLIVAR OOP is keen to take a role in evaluation of operational products, in particular those from GODAE (e.g., reanalyses). OOPC agreed this was an important and useful role.

4. OPERATIONAL SYSTEMS

4.1 TROPICAL MOORED SYSTEMS

Joel Picaut presented a map showing the positions of the TAO, TRITON and PIRATA arrays as they are currently deployed. He divided the discussion into information about TAO/TRITON, the Pacific array and then PIRATA, the Atlantic array. [The Japanese are intending to place 2 TRITON moorings in the Indian Ocean this year at 1.5° S, 90° E and 5° S, 95° E]. Picaut noted that servicing TAO/TRITON moorings required about 380 ships days per year. The data return from the collective moorings averages about 89% although moorings in the western Pacific suffer more from vandalism. Picaut reported that a bias error was recently uncovered in the TAO wind direction instrument currently being used and it seems there is no easy solution to correct the data beyond the past three years or so. Generally, the co-operation between the US and Japan to maintain the array works well. There are unresolved problems with the NOAA budget which is causing problems for maintaining support for the TAO array.

Continuing the discussion with PIRATA moorings, Joel noted that a number of these moorings suffer frequently from vandalism which caused the data return to be only 60% over the last 2 years. The moorings at both 2° N and 2° S at 10°W were decommissioned. There is consideration of ?replacing" them with one ADCP subsurface mooring. Participants in the programme would like to expand the array to more off-equatorial locations. Picaut believed that PIRATA was at a stage where it really had to demonstrate the value of the array, and must develop a strategy to manage the vandalism. Because of problems with the ship used to service the French moorings in the array, there is talk among some French scientists about the idea of building a new, fast ship specifically for this purpose and also for deploying Argo floats.

Picaut concluded by noting the TAO Implementation Panel (TIP) has been dissolved with the intent to replace it with a Tropical Moored Buoy Implementation Panel (also TIP) which would broaden the scope from the previous Pacific orientation to include PIRATA and moorings in the Indian Ocean as well. The new Panel would also focus more on implementation and servicing and less on science issues.

Masaki Kawabe explained that a problem at another TRITON mooring had delayed the deployments of the moorings in the Indian Ocean, but that these were scheduled for deployment late this year. In the western Pacific, Japan is planning to deploy 3 buoys by November, 2001 and 2 more by July, 2002.

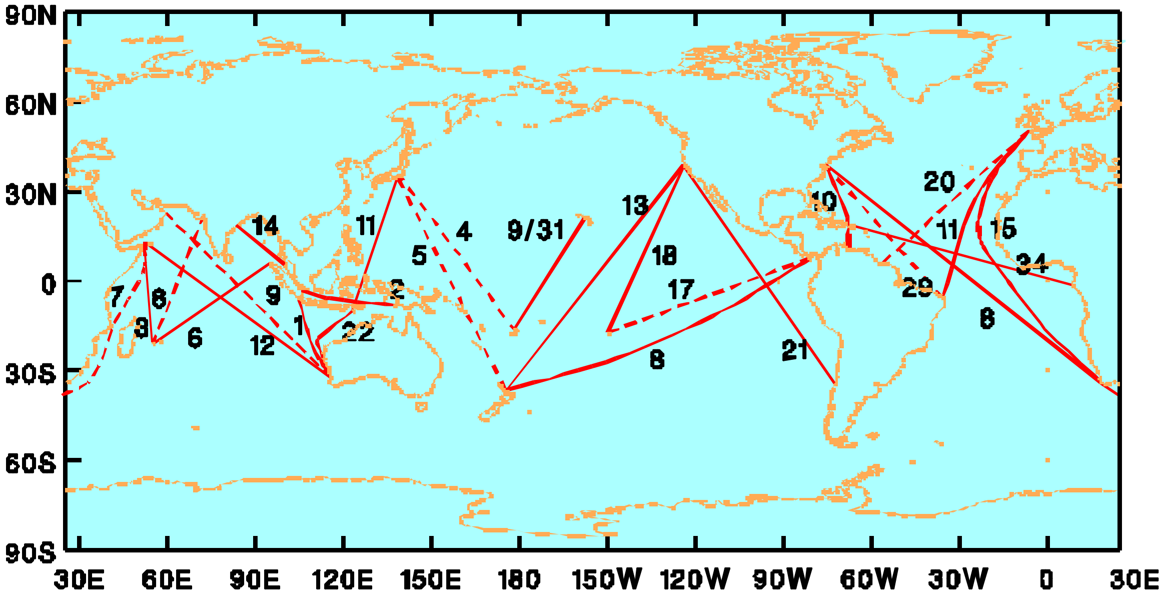
4.2 SHIP-OF-OPPORTUNITY PROGRAMME (SOOP)

Rick Bailey, chair of the JCOMM Ship-Of-Opportunity Programme Implementation Panel (SOOPIP), gave a presentation on the status and issues currently facing this programme. SOOPIP is co-ordinating the implementation of the SOOP through the operation of data sampling and tracking systems, quality control procedures, instrument evaluation studies and the ongoing development of co-ordination processes. In addition to the regular sampling of upper ocean temperature through the deployment of XBTs, the programme is developing a multi-disciplinary sampling capacity. This includes the collection of data on sea surface salinity (SSS), current profiles, CO_2, and plankton distribution. Plans were discussed for the further co-ordination of these and related activities(e.g., JCOMM VOSClim and ASAP projects) under the proposed JCOMM Ship Observations Team in the Observations Programme Area. More information on the status of SOOP can be obtained from:
< http://www.ifremer.fr/ird/soopip//>.

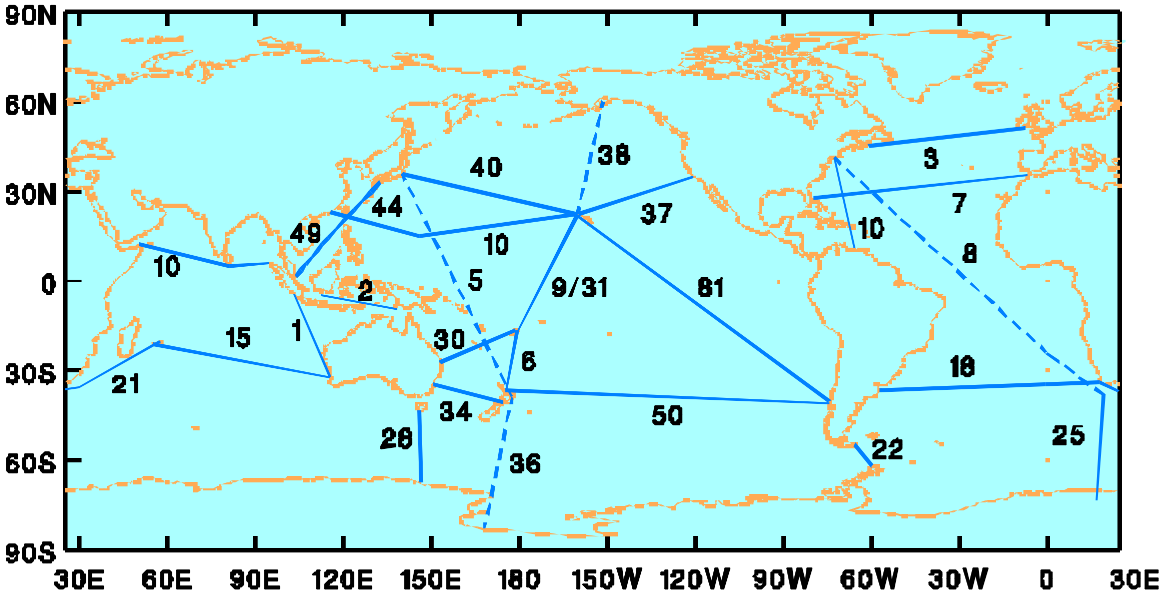
4.2.1 Upper Ocean Thermal Network

Bailey provided details on the background study and workshop to review the global upper ocean thermal network. This network is predominantly supported by the XBT SOOP. The background study was undertaken by the CSIRO/BMRC Joint Australian Facility for Ocean Observing Systems (JAFOOS) with support from NOAA's Office of Global Programmes, the Australian Bureau of Meteorology and CSIRO Marine Research. The workshop was held in Melbourne, August 1999 (see http://www.bom.gov.au/bmrc/ocean/JAFOOS/review.html). The review was sponsored by OOPC, SOOPIP and the (former) CLIVAR UOP. The extensive background study demonstrated an effective way of quantitatively assessing the performance of the programme against a set of scientific objectives using a number of selected criteria. The approach was similar to that undertaken by the Sea Level Workshop and review, but more complicated by the type of sampling involved.

The review recommended the XBT network focus on line sampling along selected frequently repeated and high-density transects, as the Argo profiling float programme came online and was demonstrated to be working efficiently (see figure 4.2-1). It was noted, however, that sampling had already tended to this form, with the broad scale sampling already in decline before Argo is implemented. With the existing limitations on resources available to achieve the complete recommended network, there is a tendency to focus on the identified high priority sampling with existing resources now, rather than later. Around 35,000 XBTs are required to implement the recommended network, whereas around 25,000 are at present available for deployment. Reallocation of resources to support the Argo programme by NOAA have resulted in the XBT support being further reduced in recent years, with around 3,000 XBTs being cut from the programme.



Recommended frequently repeated XBT network.



Recommended high-density XBT network.

The review highlighted the need for a data-tagging system to help eliminate a number of data management problems associated with different resolution, real-time and delayed mode data streams. The implementation of such a system for SOOP is being addressed by SOOPIP in conjunction with the Global Temperature Salinity Profile Programme (GTSPP) which oversees the data management issues for SOOP. The OOPC reiterated the importance it attaches to this element of the integrated observing system. The Panel members expressed satisfaction with the success of the review, and appreciation for the efforts of Bailey and Smith in ensuring its success.

5. EXPERIMENTS, PROGRAMMES AND PROJECTS

5.1 GODAE

5.1.1 General Overview

Smith summarized overall progress in GODAE. The GODAE Strategic Plan (GODAE Report No. 6) was issued in December 2000 by the International GODAE Steering Team (IGST). An outline of the GODAE Implementation Plan was agreed at the 5th IGST meeting in Noumea, February 2001. GODAE is expected to provide climate and other products that are valuable to the oil and fishing industries and for coastal managers as well (e.g., storm surges, etc). GODAE is now in what is considered the development phase (until end of 2002), during which we need to identify application Centres, establish metrics, and exercise real-time data servers. During the period 2003-2005, GODAE will be in the demonstration phase. A new phase has been added: a consolidation phase during 2006-2007. Smith believed that most functional components of GODAE were in good order and prospects for their being ready for the demonstration phase were good. NWP products, flux data from SURFA and ECMWF, and new GEBCO data are expected to be inputs. Argo data and SSTs, altimetric heights, and winds are also expected to be input from data assembly Centres. These are not yet established and have to be soon. Two GODAE data and product servers are ready: one in the US at the Fleet Numerical Meteorology and Oceanography centre (FNMOC) in Monterey, California and the other in France at Toulouse. Possibly another server site will be established at the International Pacific Research Centre (IPRC) in Hawaii. A workshop to be held at IPRC 25-27 July 2001 will undertake an intercomparison of characteristic products of GODAE that will be provided from the Atlantic prototype project and Pacific models. A 3-day GODAE Conference is scheduled for June 2002 in Biarritz France to address scientific and technical advances and to look at prototype products. A new SST pilot project is underway. Argo is going well.

Smith reminded the Panel that OOPC has the responsibility for the integration of the OOS. Harrison added that we need to assure that all data being assimilated has error bars and that climate products produced from the OOS are routinely validated.

5.1.2 GODAE in France

Picaut provided an overview of the French contribution to GODAE, namely, MERCATOR: the modelling and assimilation programme, and CORIOLIS: the *in situ* observation programme. A two-week surface-height forecast has been regularly produced since January 2001. The model uses only satellite altimeter data and CORIOLIS products near real time. Use of Argo data is planned in the future. The model has a 1/15°-resolution model for the North Atlantic and Mediterranean Sea, and a 1/4°-resolution model for the rest of the global ocean. Data assembly Centres for in-situ, altimeter, sea surface temperature (SST), and other forcing data have been established, and are providing data to the MERCATOR Assimilation Centre based in Toulouse. In 2003-2005, near real-time nowcasts (routine observation-based global monitoring and assimilation for the North and tropical Atlantic) will be operational. Products of MERCATOR are available from its website <http://www.mercator.com.fr>.

5.1.3 GODAE in Norway

Johnny Johannessen provided an overview of Norway's contribution to GODAE; namely, the DIADEM system, and its successor, TOPAZ. They are EU funded projects with additional national support and are both co-ordinated by G. Evensen. The system includes a 3-D OGCM model based on the Miami Isopycnal Co-ordinate Ocean Model (MICOM), coupled to an ice model, and an ecosystem model. The spatial resolution in the North Atlantic is about 1/4°, while the resolution gradually gets coarser in the far field areas (such as the south Atlantic) to around 1°. Near real-time observed data of SST, sea level anomalies, and ocean colour, are assimilated into the model using a Kalman filter; real-time forecasts of the ocean state are produced for the North Atlantic, the Nordic Seas and the Arctic Ocean. The atmospheric forcing field including surface pressure, air temperature and vector wind is obtained from ECMWF. Model output products include currents, temperature, sea ice concentration and distribution and bio-parameters (see the website <http://www.halo.is>). In the context of practical use of the results, oil companies, for instance, are interested in current variability and strength of current shear as produced from a high resolution (2-7 km) nested model of a smaller modelling region.

The ocean monitoring programme, DIADEM, will end this summer and will shift to TOPAZ. In TOPAZ, an upgraded system developed from DIADEM will be employed. It will incorporate improved models of the mixed layer and ecosystem dynamics. The ecosystem assimilation scheme uses satellite ocean colour observations from SeaWiFS and integrates 11 variables to produce the real time product. TOPAZ will be able to calculate ocean state variables in deeper layers and in more detail for the coastal areas.

5.1.4 GODAE Hi-Resolution SST

Smith reported briefly on the results of the GODAE Hi-Resolution SST workshop in Ispra, Italy, 30 October - 1 November 2000 (see http://www.bom.gov.au/GODAE/HiResSST/). Profile data show that the assumption of a mixed layer that is well mixed is not a good one, contributing to the ambiguities in what is meant by sea surface temperature. The workshop agreed to develop a pilot project within the framework of GODAE. Four tasks were agreed:

(1) Develop a working (strategic) plan around 4 themes:
  - o testing, proving and refining data sources,
  - o integration and assimilation: the data providers,
  - o the product line (applications) and users: the data users
  - o research and development;

(2) Form a project oversight Science Team;
  - o Craig Donlan agreed to act as chair;

(3) Have the plan critically reviewed by advocates and non-advocates;
  - o plan finalized by mid 2001;

(4) Conduct Pilot Project according to plan and schedule.

Hi-resolution at the pixel level is 1-2 km for the ATSR; 8 km for geostationary orbits; and 50 km for microwave radiometers. The pilot project will compare IR data from polar-orbiting and geostationary platforms and from microwave radiometers.

OOPC welcomed the initiative and noted the synergy with its SST, SURFA and Time- Series projects, particularly for the Dedicated Data Sites (DDS). OOPC encouraged co-location of these sites with existing and planned sites related to climate and baseline data sets. Calibrating the GHRSST data sets with existing and past "climate" data sets and products is a key issue. Richard Reynolds and Smith will provide connections to the project for OOPC.

5.2 ARGO

5.2.1 General Overview

Smith provided a general overview on the Argo programme based on recent updated information from Dean Roemmich. Currently a total of 900 floats have been committed, of which about 500 shall be deployed by 2002 including major arrays in the Atlantic and Western Pacific. In addition there is a proposal for an additional 750 per year in the next three years. 3,000 floats are therefore targeted for global implementation by 2004. Ocean basin implementation meetings to promote the Argo objectives and plans have been held in Tokyo (June and October 2000) and Paris (July, 2000). Another will come up in Hyderabad in July 2001 for the Indian Ocean.

The technical development and testing regarding the floats are going well. The Seabird CTD records show fairly long (3 years) and stable (0.01 psu) salinity measurements. In addition the data system is making good progress (see also paper by Keeley in Annex III) with near-real-time provision of the float data via the GTS. (Note that real time access to the data is also possible via internet connection to the servers in Toulouse and/or Monterey.) In addition an Argo Information Centre with a full time co-ordinator will soon come online with regular provision of float position maps and other additional float data information. Of concern is the need for improved communication capabilities; (e.g., IRIDIUM, increased Argos capacity), the need for international/national agreements on float deployment and data collection in exclusive economic zones. It is also clear that the awareness of the Argo programme needs further promotion, in particular in underdeveloped countries. The float production capacity and float sensor reliability, particular the salinity sensor, is also an issue to bear in mind. Regarding experience with operational lifetime, the French reported a float (not exactly an Argo float) loss rate in the Mediterranean of 25% after 3 years and 40% after 4 years.

Kawabe briefly reported on a recent Argo implementation workshop in Tokyo held in October 2000 and the outcome from a questionnaire survey. The survey results made it clear that half of the island countries in Oceania, Asia, and Africa are not aware of the Argo project. Contributing to this is the fact that the smaller island countries may have limited funds, limited or no oceanographic activity, and no source of support for technology and instrument development. In addition, many of these countries do not have GTS communication facilities, nor is ready access to the internet commonly available . On the other hand, they have platforms that might, for instance, be useful for float deployments. More promotional activity is therefore needed, but it was also emphasized that it is important to have the right point of contact. In this context IOC and the GOOS office in Perth might be helpful.

5.2.2 US Argo

The US Argo programme, notably phases I and II, was reviewed by Steve Piotrowicz. Under the National Ocean Partnership Programme (NOPP), 55 floats were funded by the Office of Naval Research (primary) and NOAA in 1998-1999, while 132 floats were funded by NOAA in 2000. These shall all be deployed by end of 2001 and contribute to the 500 floats in the water. For 2001 the proposal to NOAA (currently in review) is requesting US$ 3 million to support further purchase and deployment of floats. (Note that the price is approximately $18,500 - $20,000 to purchase, deploy and operate one float; of this the pure operational cost including communication and data management for one float amounts to about $1,000. per year). The US Argo programme objectives are primarily to meet the requirements for seasonal to interannual variability studies (such as associated with the ENSO) as well as the operational requirements of priority to NOAA and the US Navy. The US floats will be parked at 1000m, some with 1,500m profiling depth with other exact profiling depths to be determined. The targeted accuracy is 0.02 psu with a threshold of 0.05 psu. This seems feasible in comparison to the present stable Seabird records. The US long term plan, after 2005, calls for a continuous "life-time" involvement of 275 floats per year.

5.2.3 European Commission GYROSCOPE Float Programme

Walter Zenk gave a status review of the GYROSCOPE project in which 80 floats have been funded. The project, which is jointly between Germany, France and Spain, will purchase the PROVOR and APEX float types. The deployment will take place in the northeastern North Atlantic, with the objectives to provide T and S data for assimilation together with satellite radar altimeter data in ocean models. These will form part of the so-called ?Argo-equivalent floats” as they will be deployed differently from the Argo deployment grid of 3 x 3 degrees. The project, approved by the European Commission in

January 2001, is funded for 3 years, and will therefore need additional funding to be extended beyond 2003.

5.2.4 SEREAD Project

Erb informed the Panel about a new capacity building project built around Argo. The project known as Scientific Educational Resources and Experience Associated with the Deployment (SEREAD) of Argo floats in the South Pacific Ocean began with the formation of a steering committee in January 2001. Sponsors include the IOC Perth Regional Programme Office, Western Australia, the International Ocean Institute (IOI) Headquarters, the IOI-Pacific Islands, the New Zealand based National Institute of Water and Atmospheric Research (NIWA), the UNESCO Office in Apia, Samoa, the South Pacific Applied Geoscience Commission (SOPAC), NOAA, the Scripps Institution of Oceanography and POGO.

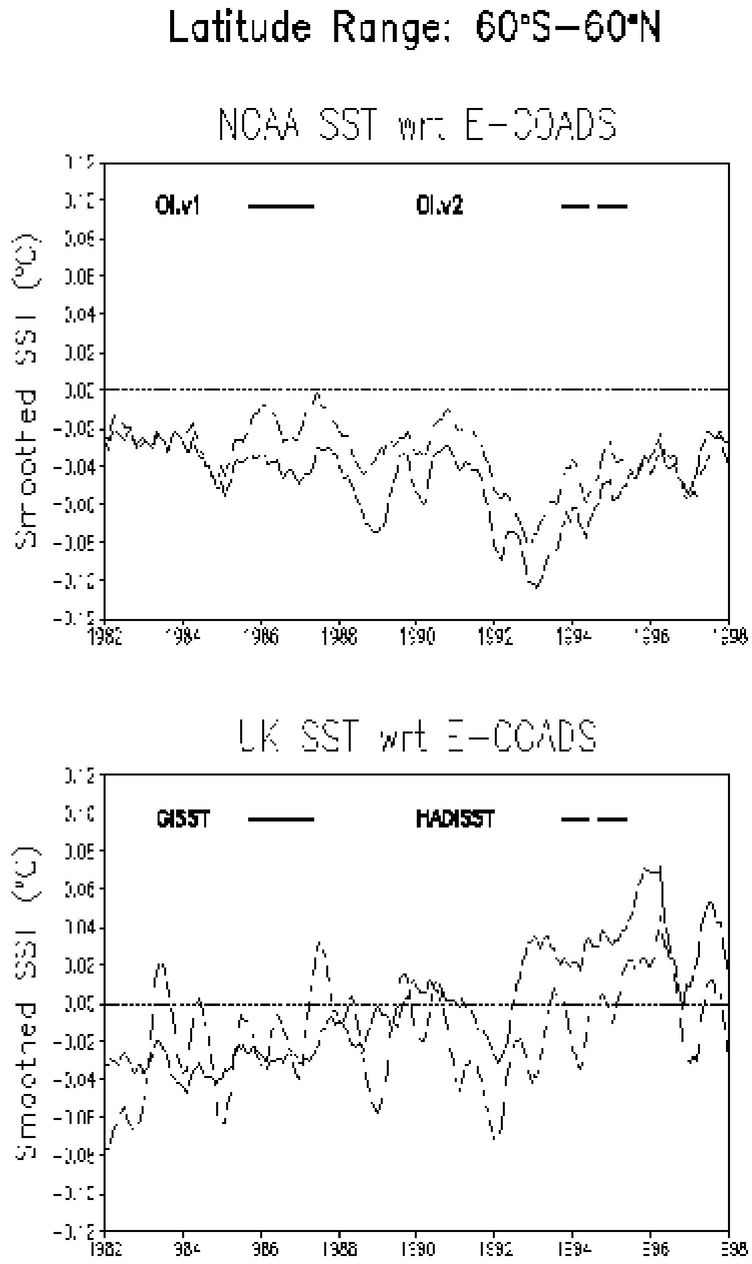
SEREAD will involve secondary school students from a number of Pacific Island countries in monitoring Argo floats. Selected schools in the region with access to the Internet will have an opportunity to "adopt" a float. The classes will be able to name and to follow the progress of their float during its lifetime. The aim is to exploit the new experience to generate heightened awareness and to promote discussion among Pacific Island students, teachers and communities in subjects such as global ocean observing systems, climate change, sea level rise, global warming and the local impacts of these dynamics. Professor Robin South of IOI-Pacific Islands is the Project Co-ordinator.

Pacific Island science teachers participating in SEREAD will be trained on the theory and purpose of float development, deployment and data gathering. The development of school curriculum materials as part of the project will be carried out by NIWA with assistance from IOI-Pacific Islands. Through scheduled visits by Argo investigators, Pacific Island students will be offered the opportunity to interact with some of the leading scientists in the world. Project co-ordinators expect that this interaction will foster a global appreciation among the students that they are not merely isolated islands. Though SEREAD is a Pacific initiative, it has potential for adoption by other regions of the world.

5.3 SST/SEA ICE (SI) WORKING GROUP

Reynolds opened his report by reviewing the terms of reference for the SST/SI Working Group for GCOS (see Annex V). The present participants include scientists from BMRC, JMA, LDEO, METEO FRANCE, NASA (GSFC), NCAR, NOAA (CDC, NCDC, NCEP, PMEL), NRL, SOC, UC, UKMO.

Progress had been made on the intercomparisons which Reynolds illustrated with results displayed in the figure below. The figure shows monthly time series of four analyses relative to the enhanced version of COADS (E-COADS). (The enhanced version uses both ship and buoy SST observations.) The time series are computed by averaging the difference between the analyses and COADS from 60°N to 60°S. Because E-COADS is defined by monthly summaries (averages) of the available *in situ* SST data within each grid box, E-COADS is not defined everywhere. Thus, the differences are only computed where E-COADS is defined. All four analyses use both *in situ* and satellite data. The two analyses in the lower panel are produced at the Met Office Hadley Centre for Climate Prediction and Research. The analysis labelled GISST is the Global Sea-Ice and SST data set, version 2.3b, of Rayner et al. (1996). The analysis labelled HadISST is the more recent Hadley Centre sea-Ice and SST data set, which is described in Parker et al. (1999). The two analyses in the upper panel are produced at NOAA using optimum interpolation (OI). The analysis labelled OI.v1 (version 1) is described by Reynolds and Smith (1994). The analysis labelled OI.v2 (version 2) uses improved *in situ* data and the same sea ice and sea-ice-to SST algorithm used in the UK.



The figure shows that both versions of the OI have a small negative bias. This is due to the under correction of the satellite negative bias from regions south of 20° S where *in situ* data are sparse. The figure also shows that the OI.v2 analysis is closer to E-COADS than the OI.v1 in almost every month. Thus, some of the residual negative bias in the OI.v1 analysis relative to E-COADS has been reduced in the OI.v2 analysis but not completely eliminated. The initial GISST differences are similar to the OI. However, the GISST differences gradually change sign with time. These differences are influenced by changes in the UK *in situ* data, which show similar differences relative to E-COADS. HadISST uses a newer version of UK *in situ* data which show smaller differences relative to E-COADS than GISST. However, the HadISST differences seem to have a stronger seasonal cycle than the other analyses. The seasonal differences primarily occur in the Northern Hemisphere middle latitudes where *in situ* data should be adequate for analysis without satellite data. Thus, the seasonal difference is difficult to explain.

Reynolds also showed differences between E-COADS and satellite data summaries. These differences are larger than the analysis differences in figure 5.3-1 and are primarily due to cloud contamination. All data (both *in situ* and satellite) are passed through nonlinear quality control (QC) procedures. Thus, even the same input data will have different statistics following QC.

Differences among analyses are a rough measure of the accuracy of the analyses (terms of reference item 4). However, the development of procedures to ensure the quality and consistency of the SST (terms of reference item 3) are difficult. To make further progress on these items, Reynolds developed a procedure to objectively examine the NOAA analyses. In this procedure new versions of the analyses were produced while holding back some of the buoy data. To attempt to avoid any selection bias, buoy data (both moored and drifting) were excluded with an ID ending in either 4 or 9. This randomly excludes approximately 20% of the buoy data. The fraction of excluded buoys was selected to exclude enough data for verification while minimizing the impact on the analysis. The withheld data can then be used as independent data to determine analysis accuracy.

Reynolds also discussed differences in sea-ice products and mentioned that sea-ice concentration is converted to SST in the UK method by determining a least-squares climatological fit between sea ice and SST. Comparisons with E-COADS show that the UK method used in GISST, HadISST and OI.v2 is clearly superior to an older method used in OI.v1. However, SST data near the ice edge are sparse; additional data are needed to improve accuracy of the method.

Funding has been obtained for a web-based Live Access Server. The server will allow users to access different SST analyses and summaries as well as sea-ice analyses. It will also allow users to display these fields and their differences. Reynolds is developing a system to better link SST data users and data providers. The initial version of this system would send regular messages to NOAA/AOML to indicate where additional buoys were needed to improve the SST analysis.

Based on the points above, Reynolds proposed the following tasks for the WG:

1. For open ocean regions:

    a. Agree upon a standard period (5-10 years).
    b. Select exactly the same data set (no QC) for the standard period.
    c. Define a subset of buoy data as independent.
    d. Compute data summaries and analyses of QC dependent observations by type (ship, buoy, satellite, etc.).
    e. Verify data summaries and analyses against independent data.

2. Gather *in situ* observations from research programmes near the sea ice to verify sea ice to SST algorithms.

3. Develop an interface between SST data users and SST data providers to indicate where future buoy deployments are needed.

4. Complete development of an SST web server to allow users to:

    a. Examine differences in SST (*in situ* and/or satellite) analyses and data summaries
    b. Examine differences in sea-ice analyses.
    c. Download part or all of the above products.

5. Maintain a link with the GODAE High-Resolution SST project (see 5.1.4).

During the ensuing discussion, several suggestions emerged. It would be beneficial to have satellite retrievals include an estimate of the cloud contamination. The development of contacts by the SST/SI Working Group with the Meteo France polar ice group and the US National Ice Centre (NIC) and some follow-up with the Climate and Cryosphere (CliC) group would be useful. The International Arctic

Buoy Programme at the University of Washington, Polar Science Centre, would be a good place to start looking for additional buoys located near the ice edge. Reynolds agreed to continue to lead the effort.

References

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5.4 EUROPEAN FIELD EXPERIMENTS

5.4.1 ANIMATE Programme

Zenk informed the Panel of a new programme called ANIMATE (Atlantic Network of Interdisciplinary Moorings and Time-Series for Europe). This is an EC-approved activity by the Kiel Institute fur Meerskunde under Uwe Send to co-ordinate a set of European repeat VOS lines and time-series measurements in the North Atlantic by making the most of existing experience from different European groups. The project provides an initial network of sustained moored time series stations equipped with key identical instrumentation (pCO_2 sensors, Seacats, and sediment traps). The T-S observations are integrated with carbon variability studies (by D. Wallace). The target areas for time series measurements are:

- the subtropical gyre (Canary Islands);
- a region west of Ireland (Porcupine Abyssal Plain);
- the subpolar gyre (Central Irminger Sea).

Zenk noted that the plan calls for:

- interfacing the time series with four approved European CAVASOO (Carbon Variability Studies by Ships of Opportunity) observation lines in the North Atlantic;
- providing appropriate access to strategic data for climate research by implementing real time telemetry of prime data;
- opening moored platforms to outside groups for enhancement with additional sensors and transmission systems of their own.

5.5 SATELLITE PROGRAMMES

Johannessen provided a status overview of the earth observation remote sensing programme in Europe.

5.5.1 Altimetry and Scatterometry

Johannessen reported that ERS-2 has lost its gyros and is currently not delivering data on a regular basis. Intensive work is being undertaken to find solutions. The goal is to get scatterometer delivered winds back in operational mode by August-September this year. Overall, one should not be too optimistic; ERS-2 is most likely nearing its end. *Johannessen reported subsequently that a solution to the attitude* *stability problem has been implemented, and, since the end of April, ERS-2 has been delivering data from all instruments according to the nominal operation plan.*

Jason-1 was scheduled for launch December 2001 which is the year of the 9th anniversary of TOPEX/POSEIDON. This will secure continuity of precision altimetry up to 2005, and together with the ENVISAT radar altimeter (scheduled for launch in December 2001) the situation looks good for the next 4 years. It may even improve further if sufficient accuracy of the height measurements from Geosat Follow-On can be achieved. NOAA is currently working on this. On the other hand, the altimeter outlook beyond 2005 is less promising. Jason-2 is not yet firm, but discussion with EUMETSAT is going on. There is no plan for a continuation of the ENVISAT radar altimeter. This situation is even more disturbing in light of the three gravity missions that will be in operation before 2006. CHAMP is currently in orbit; GRACE is scheduled for launch towards the end of 2001; and GOCE will be launched in 2005. The data on the geoid field provided by these missions, in particular from the latter two, will allow full use of the altimetric signal at wavelengths down to 100 km.

The two high resolution altimetric missions, US ICESAT and ESA CRYOSAT, dedicated for cryosphere studies including ice sheet elevation and sea ice surface roughness height (and in turn freeboard and ice thickness), will be launched in 2003/2004. ICESAT uses a beam-limited laser altimeter technique, while CRYOSAT is a dual antenna altimeter combining cross-track interferometry with along-track synthetic aperture processing. The missions are very complementary and should provide new and promising capabilities for cryosphere research.

Regarding the vector wind retrievals, it has now become clear that METOP-ASCAT c- band will not be launched until 2005. With an unclear future of the continued operation of the ERS-2 scatterometer, we have to rely on the ku-band Quickscat. Analyses of the ERS-2 c-band scatterometer data on NWP forecasts have shown good impact, notably for precise location of intense wind regimes such as hurricanes and typhoons. Testing is currently underway to determine the impact of the Quickscat winds on ECMWF forecasts. Problems are encountered with the quality of the data in the presence of rain cells. ADEOS-2, which is planned for launch for February 2002, will also carry a ku-band scatterometer (Seawinds). Good scatterometer coverage is becoming uncertain since Quickscat ends in September 2002 and we face a large gap (3-years) until METOP is launched with only one scatterometer supplemented by DMSP. The continuity of vector wind retrievals up to 2005 and beyond is by no means assured.. Scatterometer-derived winds may be augmented with passive microwave retrievals of wind speed from AM SR on ADEOS-2.

5.5.2 Salinity

ESA 's Soil Moisture and Ocean Salinity (SMOS) mission is planned for launch in 2005/2006. It employs an L-band passive microwave radiometer and can recover sea surface salinity (SSS) from a single pass observation with a precision of 1 psu in 30 km resolution cells. This might be useful in areas with high-salinity gradients and strong variability. On the other hand, better radiometric accuracy can be achieved by averaging pixels in space and time. By assuming random distribution of the radiometric signal noise, the retrieval accuracy will improve, but it will still be a challenge to get to the GODAE requirement of 0.1 psu at 200 km squares for an averaging time of 10 days. This will be particularly problematic in cold water areas where the radiometric sensitivity to SSS is lower. In addition, it will also be necessary to have reliable removal of other effects influencing the brightness temperature signal, wind-induced surface-roughness variability including breaking waves, presence of foam and rain cells as well as spatial temperature variations within individual pixels. So far, preliminary results (obtained by Sobieski [UCL] and Boutin [LODYC] in an ESA study) suggest that for low to moderate winds below 7 m/s the surface roughness and foam effect can be removed. In comparison, it will become a big problem for winds above 15 m/s. Further development and improvement of emissivity modelling is a must in this context.

An ongoing ESA-initiated study is addressing this emissivity problem, in addition to regional application of SMOS SSS retrievals. Regarding the latter, preliminary results for high-latitude applications provide interesting results. Based on a newly released Russian hydrographic data set from the Nordic Seas, the SSS field is analysed and compared to the output from the MICOM ocean model. The comparison is promising and shows very small SSS gradients and variations on seasonal and inter-annual time scales, except during the presence of great salinity (fresh water) anomalies as in 1970 and 1985 with anomalies of 0.3 and 0.5 psu. Detection of the latter therefore seems feasible from SMOS. Moreover, from simulation of SSS variability within 200 km squares averaged over 10 and 30 days, it appears that the standard deviation during the winter seasons is typically less than 0.1 - 0.2 psu except in the Fram Strait. This is also promising in the context of future SMOS observation capabilities in high-latitude, cold-water regions, provided the assumption on random noise distribution is reliable and the emissivity modelling development for removal of wind effects proceeds favourably.

Similar studies are being undertaken for other regions. A-priori, one may argue that applications of SMOS in moderate and low-latitude regions should be equally (or more) feasible from the fact that the sensor sensitivity increases with SST. Notably, these applications include seasonal to interannual SSS variations important for climate predictions, equatorial rain pool dynamics, steric effect versus salinity on sea surface topography, thermohaline circulation and importance of SSS. Note that a special session in the Journal of Geophysical Research - Ocean is currently in preparation on ocean salinity and importance of observations from satellites. It is being co-ordinated by G. Lagerloef.

The OOPC reiterated its support for the development of salinity observations both remotely and *in situ*.

5.6 EVALUATION /SENSITIVITY EXPERIMENTS

5.6.1 Evaluation of Tropical Moorings

Smith discussed the planned review of the moored tropical buoy arrays and an associated workshop scheduled for September 10-12 of this year at PMEL. The general framework of the review would be similar to that employed for the upper ocean network and for sea level except that a number of stakeholders would be canvassed for their input on the value and function of the array. The review process will be guided by a Scientific Organising Committee chaired by Smith. Piers Chapman has agreed to work as a special consultant for this review; he will consolidate the written submissions and compile applicable inputs from the OceanObs99 papers, the CLIVAR Atlantic meeting, and other background materials. Chapman will also assist in the drafting and the production of the Workshop Report. The organizing committee will decide on the scope of the review (TAO, TRITON, PIRATA or something less), the invitees, the methodology to be used and how to handle remote sensing in the review. OOPC agreed that:

- The focus should be the global tropical mooring arrays (not just the Pacific), and that the impact should be assessed against the global, broad objectives and not restricted to ENSO.
- Development of metrics was important.
- OSSEs should be done and the review should take advantage of existing OSSEs.
- Dick Feeley and/or Chavez could provide input on multi-disciplinary aspects, and Paulo Nobre should be a contact and a workshop invitee.
- The ToR should be altered to explicitly pick out the use of moorings for validation of satellites directly.
- Logistics and vandalism should be considered and strategies developed for dealing with this issue.
- the review should be constructive and positive.
- The possibility should be considered of using the PIRATA and the CLIVAR Tropical Atlantic Variability (TAV) Workshop as a venue for assessing the importance of PIRATA for Tropical problems and for assessing the importance of other components of the global mooring array.

Smith will lead OOPC contributions to the workshop with Picaut, Harrison and Weller participating.

In subsequent discussion, Smith remarked that if there was not enough time before the review, perhaps a study could be carried out afterwards to look at the relative importance of certain of the moorings compared to the others in influencing model results. Whereas the discussion seemed to be focusing on using the review to forestall reductions in the array, it was noted that CLIVAR would have additional funds which could permit enhancements. It was also noted that the review was going to look at the array in the context of the other measurement programmes (Argo, SOOP, remote sensing, etc.) to identify the properties of the array that complement the other systems. Such a process could provide a way to deal with the effects of vandalism, and provide a measure of the cost effectiveness of the component parts of the array.

The TAV Workshop scheduled 3-7 September in Paris offers an opportunity to solicit and entertain other views for the evaluation process. Other suggestions for the PMEL workshop were to identify which moorings might be least damaging to give up in a future budget crunch and which should carry biogeochemical sensors; to include consideration of satellite observations, and to apply a global tropical perspective to the study.

5.6.2 Observing System Evaluation

OOPC needs to provide a framework for objectively evaluating the performance of the OOS. Towards this end. Harrison introduced a discussion on OOS sensitivity and evaluation experiments with a presentation on the potential approaches and the potential pitfalls to be avoided in undertaking such experiments. To have a useful result (i.e., that provides revealing feedback that can be acted on), experiments have to be done relative to specific objectives. There are two classes: (a) to address one or two aspects of the OS, or (b) to cover lots of aspects at once. They involve real costs and the customer has to believe it's worth the trouble, that he needs the feedback to improve his product. Customers can be research programmes (doing climate assessment, making climate forecasts), operational centers delivering products, etc.

Harrison provided an example using the evaluation of single field performance for illustrative purposes. To start with, one needs scale information (amplitude, location, space scales, time scales). Objective analysis tools can be used if we know the scales well enough. For most fields this is rarely the case; our scale information is incomplete. Field by field (or region by region) this information must be gathered. Harrison cautioned that modest changes in scale information can lead to large changes in the effectiveness of the OS. Not many fields have been thoroughly evaluated. It is not easy to get funds to over-sample which is very much needed for confidence in results.

Harrison cautioned that we cannot expect definitive results in the short run but believed we must try. He stated that research programme evaluations should be a responsibility of each programme within the context of its objectives. This would probably require a ?culture change” in research programme management.

There are very few instances where we have realistic high-resolution models available and truly comprehensive ocean model data sets to undertake experiments. With a consistent data set assembled from all the available observations, a variety of sub-sampling can be done. We do not know how many such data sets exist. Can we get them prepared if needed? How much infrastructure is needed to do the OS work? Would the community benefit if this work were done? Done right, the answer is probably yes. But the other side of the equation is it would take teams of people to do; the work is intrusive; and it takes a long time to do.

As an example for evaluation of ocean forecasts, Harrison noted that data on CO_2 inventory change and CFC invasion are obviously crucial evaluation information for forecast models. Major challenges in conducting an experiment include developing the metrics for evaluation of forecast skill, and holding funds together. Harrison offered a preliminary list of items that need consideration in a plan:

- Evaluate community support;
- Review knowledge of scales and uncertainties;
- Set up metrics (indices and/or. ..);
- Identify qualified data sets and/or invite preparation of new ones;
- Improve connection to ENSO community;
- Remind/educate climate change community of importance of OS - get their endorsement.

In the ensuing discussion, several telling points were made. The range of possible choices to initiate this work is large and the Panel needs to carefully consider where it can be most effective. Delays in starting must consider that within about five years CFC ocean penetration data will be contaminated by horizontal advection. This is a broad front task beyond the OOPC remit; it should be done in partnership with JCOMM and CLIVAR OOP with JCOMM taking on the metrics and CLIVAR OOP taking on large scale ocean circulation and inventories. Skill scores have been very successful in motivating improvements in Numerical Weather Prediction, but we did not spell out a clear objective of the observing system, so an objective quantitative evaluation turns out to be difficult. OOPC agreed work was needed to develop an action plan for a monitoring and system evaluation within the JCOMM framework

5.6.3 The Second Adequacy Report

Undertaking an assessment of the OS for the GCOS Adequacy Report is going to force OOPC back to its roots and to evaluate the OS against the broad objectives established by the OOSDP that we function with -- and these are now broader than those of direct relevance to Climate Change. The Chair concluded this will need to be developed as an action item. First, we wish to develop an outline of how we could implement an assessment system through the JCOMM framework, doing some gathering of simple information statistics, (e.g., number of obs per unit area/volume per month) but also, where possible, providing information on indices of the state of the ocean and its observation. Second, we need to start considering the process we will use for the GCOS UNFCCC ?adequacy assessment", going from a synthesis of the National Reports, through to statements on the adequacy of the present observing system. We probably need to keep broad perspectives in both cases, consistent with our terms of reference (Annex IV), and recognizing (and working with) sister groups (e.g., AOPC). OOPC will:

- Develop an action plan for a monitoring/evaluation system within the JCOMM framework, referring to indices and other "summaries";
- Begin developing a process within the GCOS/UNFCCC framework targeted at the synthesis of National Reports on ocean observations, keeping a broad perspective;
- Following the above, develop a strategy for assessment of the OS (Adequacy Report #2);
- Encourage some OSSEs; work with CLIVAR WGSIP; with GODAE; with CLIVAR OOP; and with the WGCM.

5.7 Ocean Climate Indices

Harrison led a discussion on ocean climate indices. His motivation was to use them in fashioning a way to better communicate with the press, the electorate, etc., on why we need an OOS. The concept is that reliable physical or biological indices exist for indications of climate change and variability that are rather easily observed and that serve as integrative representations for the complex processes of the ocean climate system that are behind the change. Such simple indices have well known shortcomings but they have distinct advantages in conveying and maintaining relevancy to funding agencies and the general public. The Southern Oscillation Index, the NINO-3 index, the annual mean SST and the North Atlantic (Arctic) Oscillation Index all provide a simple representation of variability on climate scales, in a form that non-specialists can appreciate and understand. The objective is to develop a comprehensive suite of indices that would convey to the educated laymen the richness of temporal and spatial variability in the ocean and thus provide a broadly accepted rationale for the evolution of an OOS.

Indiscriminate use of indices without appreciation of all their normally associated caveats carries some risk. Even those cited above, though they are widely used, are not well defined and their usage can cause confusion. So consideration should be given to reaching consensus on definitions. Harrison gave examples of other ocean features that might have value as indices of climate scale variability and/or climate change:

Sea level variability and change
Arctic, Antarctic ice
Oceanic gyres -strength, location
Intermediate waters, deep waters ("the state")
Meridional overturning circulation
Meridional transports
Inter-basin exchanges
Carbon inventories and other biogeochemical fluxes
Hydrological state/cycle (e.g., river flow, ...)

The discussion brought general agreement on several points. OOPC needs to pursue the indices concept because of their high degree of societal relevance as well as their scientific relevance in the sense that we believe they are good proxies for certain phenomena that are important. The present list is missing indices of surface exchange (e.g., the number of eddies, north-south movement, east-west movement). The preparation of a Primer for Indices also may help when searching for consensus. This would necessitate agreeing on the audience for the Primer; some indices have direct societal relevance, like river flow, and others are more representative of the adequacy of the OOS. That suggests 3 types of metrics will be required: (1) for performance and completeness of the OOS, (2) for societal engagement, and (3) for scientific purposes.

As a first step OOPC members were tasked with providing Harrison with a list of three important indices which may have potential relevance to assessing the ocean state, or the state of the OOS, or the effective influence of a publicity campaign. Phenomena are preferred over a single numerical value. OOPC will work with the community to develop a set of ocean state indices which can be part of an annual state of the ocean report to WMO, IOC and the UNFCCC.

6. WORKSHOPS

6.1 INDIAN OCEAN WORKSHOP (SOCIO)

Smith summarized the workshop on Sustained Ocean Observations for Climate in the Indian Ocean (SOCIO) held in Perth in November 1999. The goals were to form a consortium of countries with common science and societal interests in the Indian Ocean and to initiate the development of a multinational action plan for an Indian Ocean Observation System that can be used to garner support. There were 61 participants from 11 countries with solicited discussion papers in the same framework as the OCEANOBS 99 Conference.

The societal drivers, e.g., defense, fishing, transport, tourism, agriculture, land use, etc., were well discussed. The main science issue that emerged related to intra-seasonal oscillations of the ocean state and their societal impacts. Participants discussed how to build an integrated observing system, containing a number of components and how these components would interconnect. Because of the dearth of in-situ observations it was clear that remote sensing would play a major role in the observing system. The data management component was offered by NIO. A straw man of a mooring design was presented which included TRITON moorings (from the Japanese), current meters, time-series stations, etc.

The conclusion was that a sustained observing system was not only desirable but doable. A pilot project is under consideration to spin up from 2001 to 2005 in an attempt to exploit other programmes that would be working in the Indian Ocean in that time frame, including GEWEX, a JGOFS follow on, GODAE, GOOS and the network of 90 Argo floats that would be the backbone of the system. Results of the meeting plus the invited papers were being assembled into a report for CLIVAR. Smith emphasized that there was a need to attract more people to the planned programme and to sustain the level of interest generated at the SOCIO workshop.

Erb worked closely with the people from CSIRO Marine Research in Hobart (Gary Meyers, et al) in organizing the SOCIO Conference. To follow up and continue the momentum generated by the Conference, Erb is trying to organizing a workshop for 2002 to develop an integrated multi-disciplinary plan for implementing an ocean observing plan for the Indian Ocean. This plan would be written to accommodate the needs of GOOS, GCOS, CLIVAR and GODAE. He was seeking assistance from the OOPC in assembling an organizing committee and finding a chair. Several names were suggested of individuals who were prominent in the open discussions at SOCIO,. e.g., Peter Hacker, that would probably be willing to help and perhaps act as chair. The OOPC agreed to name two individuals to assist Erb in providing some additional impetus for moving the Conference planning along.

The SOCIO follow-up is proceeding along two fronts. The Perth Office will seek to engage high-level representatives from relevant Indian Ocean agencies in order to develop a consensus on the rationale and requirements. This is being done through a meeting that will take place in New Delhi during November 8-9, 2001. Second, the Workshop itself should be structured as an implementation meeting in the sense that it should explicitly focus on action rather than ideas or proposals. The Workshop should seek conformation of commitments and develop a strategy to garner further investment. Note should be taken of the following in the planning of the Workshop:

- An Argo Implementation Meeting is scheduled for Hyderabad in July 2001.
- GCOS is involved in convening a regional workshop for the western Indian Ocean region.
- There is a WIOMAP initiative to enhance marine services in the western Indian Ocean.
- There is a proposal from Mark Jury (S Africa) to establish a mooring network in the western Indian Ocean.

6.2 SOUTH ATLANTIC

Campos led a discussion on the South Atlantic and a possible strategy for initiating action on sustained observations for climate for the South Atlantic. The basis was the paper by Campos and his co-workers portrayed at the OceanObs99 Conference. The pertinent manuscript currently is undergoing peer review for the Conference Volume. It describes key features of the South Atlantic influencing climate including the following:

- upper ocean wind-driven circulation [according to Peterson and Stramma's work (Progr. Oceanogr., vol. 26(1), 1991)],
- the deep thermohaline circulation as part of the global oceanic circulation [according to Schmitz (Woods Hole Oceanogr. Inst., Tech. Rep. 96-04, 08)],
- the Brazil Current [carries warm saline tropical water to the south],
- dynamics and variability of the Brazil/Malvinas Confluence [may affect the atmosphere],
- Algulhas retroflection and Benguela Current, [carries Indian Ocean water into the S. Atlantic]
- deep meridional overturning cell (MOC) [results in heat transport moving equatorward],
- the possibility that the MOC may be stopping,
- Subduction and generation of intermediate waters in the subantarctic zone [as recently summarized by Schmid *et al.* (J. Phys. Oceanogr., vol. 30(12), 2000)],
- bifurcation of the upper and intermediate circulation off Northern Brazil,
- position of the ITCZ [its position is likely to be affected by the ocean],

- Antarctic intermediate water transport [the numbers are in debate],
- air-land-sea interaction as manifested by SST modulated rainfall over South America [several studies show correlation],
- El Nino and rainfall along the Atlantic seaboard [relation not clear],
- warming in the Vema Channel at 30°S off South America.

Campos further reported on the following ongoing projects in the region that were developed between Brazil, the United States and other partners:

- ISEC/CLIVAR: co-ordinated field work in the western boundary zone between 5° N - 10° S, focused on surface and intermediate levels (partners in Sao Paulo, Narragansett, Kiel),
- SALPLATA: tracing the low-salinity tongue of the Rio de la Plata delta in the shelf regions of Brazil, Uruguay and Argentina (partners in Sao Paulo, Montevideo, Buenos Aires) and,
- VARIAS: analysis of 130 years of MICOM data output with respect to interannual variability (Sao Paulo in co-operation with RSMAS, Miami).

In the follow-on discussion, it was agreed the initial OceanObs99 paper lacked a section on a strategy for implementing sustained observations. It was further agreed that the final draft should provide a sharper focus on the role of the S. Atlantic on regional and global climate, improved definitions and terms for a sustained observing system and a clearer identification of the societal sustained reasons for pursuing an observation programme in the South Atlantic. Though a rationale has been developed in specific areas through, for example, VAMOS, it has not been done for the South Atlantic as a whole. Clearly, for Brazil, climate issues are important, such as relationships with rainfall. We seem to be at the stage of searching for understanding of the variability in many cases rather than knowing what we want to do in terms of sustained observations. Where it is clear, it is difficult. The South America - Africa 30° S XBT line was given up by Germany after a few years. A revival of that line as part of the proposed VOSClim Project was explicitly recommended. For this and other reasons, the VOSClim group needs a South American representative.

In the absence of such knowledge, the OOPC concluded that implementation of some "safe" options might be the best strategy, i.e., relying on currently planned Argo, SOOP and VOSClim operations to enhance our knowledge of the upper ocean dynamics and perhaps adding one fixed site that does surface reference tasks and tastes temperature and salinity variability. The rationale for a South Atlantic surface reference site is clear. Brazil is in a position to provide the logistical support.

An alternative strategy might be to develop some consensus through a process similar to SOCIO for the Indian Ocean. Such a workshop would require broad co-operation and a broad base of support (multi-use, multi-purpose, from NWP to climate change). Emphasis should be placed on bringing members from the scientific community and sociological specialists together. Advantage could be taken of planned scientific meetings this year to get people together to start some small scale work in the background to prepare for planning a workshop next year.

Conclusions

OOPC favoured the SOCIO approach, i.e., organize a Sustained Observations for Climate for the South Atlantic (SOCSA) Conference. Picaut noted that the TAV workshop could be a good opportunity for starting some early planning (VAMOS is more GEWEX than CLIVAR, or ocean). Another opportunity is the WOCE South Atlantic Workshop. Weller noted that POGO also identified a lot of things that were happening which need to be brought together. Alexiou cautioned that we need motivated "leaders" to make this happen, otherwise it becomes a round-robin of meetings. Geoff Brundrit and Janice Trotte might play leadership roles. Weller suggested it may be timely to go beyond PIRATA for Brazil.

IAPSO (October, Argentina), the next International Symposium on Remote Sensing of the Environment (also S. America), the TAV Workshop, the connection to the proposed Southern Ocean Panel, VAMOS, GOOS Africa, and others, provide opportunities to develop this idea. There are many different potential players.

Campos and Zenk agreed to provide OOPC focal points. Johannessen will explore opportunities at ISRSE. The target is an integrated sustained OOS for the South Atlantic consisting of Argo floats, repeat hydrography (particularly along 30°S), surface drifters, moored boundary current arrays, inverted echo sounders, XBT SOOP and VOSClim lines and satellite observations. The optimal blend of these methods will help to better understand the variability of the South Atlantic and its impact on climate both regionally and globally.

6.3 SURFA - SURFACE REFERENCE SITES WORKSHOP

Weller reported on progress with the WGNE-OOPC Surface Reference Site (SURFA) project. The goals are to formalize the incorporation of high quality *in situ* data (surface meteorology and air-sea fluxes) in the NWP and climate model intercomparison process to validate and verify models. The goal of the OOPC is to determine the source of the model errors and to work with the modelling centres to fix them. The strategy is to use data from fixed surface reference sites (SURFA) in critical locations and high quality VOS data (VOSClim) to expand the comparisons in space and time.

Peter Gleckler maintains a web site which shows fluxes from models and from buoy data. The results from the site show clear model biases. Weller mentioned that he too found the high-quality VOS fluxes produced by Taylor were also proving to be very helpful in indicating model flux biases. However, these results are sensitive to the flux parameterization used for the VOS data.

Although the comparisons reveal model biases, the NWP centres want additional buoy sites in different regions (e.g., regions with high stratus clouds, high tropical humidity, western boundary currents, etc.) before they are willing to make corrections. There are 31 sites planned of which 5 to 8 are now operational. Weller noted that flux measurements are impacted by variations of the instrument package found on the buoys. Because these differences can be large, careful intercomparisons of the buoy instruments must also be carried out.

A small workshop on these issues was held in San Francisco in December 2000. The following items were agreed:

- Identification of products and formats needed for reference sites and for VOSClim to be resolved by March 2001. Differences between WHOI and TAO products should be aligned by May 2001.
- NWP data streams to be set up so that data flows automatically to SURFA to permit inter-comparisons of the historical and existing site flux data by the 2001 session of WGNE.
- VOSClim data to be available from NCDC by the end of 2001; some data available earlier.
- Establishment of funding for targeted buoy reference sites will be a long term ongoing effort.

In addition, the following action items were agreed at the meeting:

- Peter Gleckler will focus on establishing a steady NWP data stream from just one or two centres, probably JMA and FNMOC. Mark Swenson and Takeshi Uji will serve as centre contacts for this effort.
- Gleckler will work with Weller and Mike McPhaden to ensure that data from operational moorings will be made available for the NWP comparisons. Winds will be provided at 10 m and temperatures at 2 m.
- To ascertain the utility of historical buoys Gleckler will evaluate interannual variability in the

NCEP and ERA reanalysis and the 10-year SCO monthly data.
- William Emery will serve as liaison to the SEAFLUX and GODAE projects.
- Taylor, as an OOPC representative for the VOSClim Project, will present SURFA requirements to the VOSClim data assembly centre being established at NCDC in Asheville.
- Weller will present to CLIVAR and GOOS the recommended future reference sites.
- Frank Bradley and Taylor will work with Weller to ensure that error estimates are properly represented in reference site.

Some thought was given to roving moorings as an optional strategy to overcome costs and the criticism that fixed point data have problems. The lesson learned from using research vessels for purposes like this is that without a professional ?mentor" on board both the instrument and the data lose out. If the data are reported in real time, then it wouldn't have to be manned to know when the data are bad.

The OOPC agreed that it is critical that it be proved that the establishment of surface reference sites in various places will improve model results. So far there are no globally applicative formulae that are good for radiative parameters. Coupled with VOSClim observations, the reference sites will have increased value. Weller noted that ECMWF would be very pleased to have a site in stratus prone areas to check cloud prediction in real time. A site near 20^{o} S off Chile would be welcomed.

6.4 TIME SERIES WORKSHOP

Weller informed the Panel about his plans to form a Time Series Science Team to examine the multi-disciplinary requirements for time series stations. The terms of reference have been drafted (Annex VII) and a meeting has been scheduled for 21-23 May 2001 at WHOI. He and Uwe Send will co-chair the Team. Maria Hood will be the CO_2 link. Weller stated that there was a clear link between the time series project and both the SURFA Project and the biological projects (through of Dickey). He suggested that there needed to be a procedure established to link the time-series *in situ* data to those provided by satellite. OOPC believed the Space Agencies should accept these sites for satellite calibration. Costs for real time surface met data alone were estimated at >$40K and for subsurface data at >$100K per year. The Panel agreed the T-S science team needs to provide a clean document outlining communications needs, bandwidth, etc. The T-S science team should adhere to the GSC guides on pilot projects in preparing the document.

Weller stated that we have to partner with the community involved with Dynamics of the Earth and Ocean Systems (DEOS) programme; DEOS is still alive. (For further information on DEOS see: www.deos.org). The US NSF and the Ocean Sciences Board of the National Academy of Sciences approved a US Ocean Observatories major equipment proposal arising out of DEOS planning. A total of $120 million was forwarded to the Congress for consideration in the new Bush administration budget. British DEOS is planning to submit a major equipment proposal to NERC in the fall. Accordingly, it was agreed that an effort should be made to have NSF and DEOS represented at the workshop. It was further agreed that the science team would benefit from having representatives from Canada and India on the science team.

6.4.1 Biogeochemical Observations

Dickey reported on the work of his University of California, Santa Barbara (UCSB) Ocean Physics Laboratory (OPL) group and collaborators concerning autonomous biogeochemical measurements and emerging technologies. This work has direct relevance to designing multi-disciplinary time series sites. Solutions to problems such as global climate change, carbon cycling, variability in biomass and fish abundances, and ocean prediction are primarily limited by undersampling. Ocean data sets need to be interdisciplinary, collected simultaneously, and span up to ten orders of magnitude in time and space scales in order to observe the relevant processes. We need to massively increase the variety and quantity of ocean measurements. Present capabilities for obtaining needed physical data are relatively advanced.

Recently, however, new technologies have also enabled interdisciplinary sampling of the ocean at unprecedented time and space scales. Many innovative technologies involving sensors, computing, robotics, and data telemetry are being developed. Autonomous sampling of interdisciplinary variables using platforms including moorings, drifters, profiling floats, gliders, and autonomous underwater vehicles (AUVs) is becoming a major emphasis of observational oceanography. The types of autonomous measurements now include several key chemical, bio-optical, and biological variables.

Moorings have been used to test many of the sensors and systems, which have been or likely will be transitioned to other autonomous sampling platforms. Dickey's group and collaborators are making observations of dissolved oxygen, partial pressure of carbon dioxide, chlorophyll, apparent and inherent optical properties, primary production using *in situ* incubation systems, macro- and micro-nutrients, and trace elements such as lead, iron and manganese. Dickey described interdisciplinary sensor packages that have been deployed from several different moorings (TAO array, WHOI, and UCSB) in several different regions: the North Atlantic (north of and near Bermuda, south of Iceland, sites off coast of US), the Pacific (off Hawaii, in the equatorial Pacific at 0, 140W, OWS "P", sites off west coast of the U.S), the Arabian Sea and the Mediterranean Sea. Record lengths of multi-disciplinary observations from moorings are generally less than 1 ½ years with a few exceptions (e.g., Bermuda Testbed Mooring is now in its seventh year). Processes which have been studied using mooring time series include: internal solitary waves and their role in sediment resuspension and bio-optical variability, ocean response and sediment resuspension in the wakes of hurricanes, and primary productivity variability associated with eddies, tropical instability waves, Kelvin waves, ENSO, seasonal and monsoonal phenomena. Also, early results obtained from AUVs equipped with interdisciplinary sensors suggest new observational approaches and strategies.

Endurance of bio-optical and chemical sensors has been primarily limited by bio-fouling; however, considerable progress has been made and deployments of 6-months in oligotrophic waters have proven feasible. The multi-platform approach using a variety of strategically deployed platforms is critical. Dickey envisioned the development of 4-dimensional test beds that use models plus observations for "data" where performance of instruments can be evaluated. A grand goal is to obtain truly 3-dimensional global time series of interdisciplinary variables. There is considerable international interest and some efforts are already underway in interdisciplinary autonomous measurements. It is well accepted that climate studies need instruments in the water observing physical variables for a long time. However, chemical and biological observations likely have value as proxies as well for climate purposes. Zenk indicated that fish and whales have potential as proxies too.

This raises design questions for the time series science team. Do we go for fewer enhanced suites of time series instrument packages, or more of the standard ones? Should we embrace process studies sites that are used for validating new methods as well as providing surface reference data for satellite calibration and time series data for detecting variability and climate change?

7. CARBON SYSTEM OBSERVATIONS

Prior to the meeting the Panel Members had been supplied with two background documents for this agenda item. One was a short paper by Douglas Wallace (Chair of the SCOR-IOC Ocean Carbon Panel and member of GSC) prepared for the GSC titled: *Observing Systems for Biogeochemistry: the Importance of Volunteer Observing Ships*; it is included in Annex VI. The second was a more comprehensive paper prepared by M. Hood, S. Doney and others as the ocean component for the IGOS-P Carbon Theme titled: *A Global Ocean Carbon Observation System – A Background Report*. A Alexiou introduced the Hood-Doney paper and noted the considerable consultation that had taken place in the development of the paper including with several OOPC members. It provides an in-depth review of the rationale for an ocean carbon observing system, the available technologies, the modes of measurement (time series moorings, VOS surface obs, hydrographic sections, satellite sensors etc.) that lead to a recommendation for implementing a prototype system now.

Roger Francey (CSIRO Atmospheric Research) described a new, portable, low-flow rate, infrared pCO_2 analyser system suitable for remote operation. Operating costs are <20% of a conventional high-precision system. Initial applications are for background atmospheric monitoring and as a diagnostic tool. One prototype is intended for shipboard use. The anticipated precision in spatial CO_2 differences is a few ppb, some 10-20 times more precise than conventional system capability. It can maintain very direct links to primary WMO CO_2 standards. There is potential to monitor for small, slow, integrated atmospheric changes associated with Southern Ocean circulation changes forced by climate.

Francey provided some perspectives from his work. He stated that we are looking at a chemical system that is way out of equilibrium with regard to CO_2, CH_4, delta ^{13}C (fossil fuel is depleted in ^{13}C). He demonstrated that getting the interannual variation in terrestrial biosphere fluxes right would provide a constraint on interannual variations in ocean uptake (and vice versa). Francey identified a number of improvements in atmospheric methods that would reduce uncertainties in surface fluxes determined by inverse methods. He concluded that ocean, terrestrial and atmosphere communities need to move toward closer planning within a “multiple-constraint” modelling framework, if a consistent story of the global carbon cycle is to be achieved.

Bronte Tilbrook described work he is doing in connection with IGBP, IHDP and WCRP, and plans under development on ocean carbon. The results of the JGOFS/WOCE Ocean CO_2 survey in the 1990's have provided high quality data to estimate excess carbon inventories in all the major ocean basins. The excess carbon results from the uptake of anthropogenic CO_2. Its estimate therefore is a major constraint on the partitioning of carbon dioxide into the ocean and terrestrial biosphere since pre-industrial times. Repeat hydrographic sections every 5 to 10 years through the ocean basins are being planned by a number of countries to determine decadal-scale changes in the ocean carbon inventory. When combined with atmospheric data, the ocean observations will provide more rigorous estimates of terrestrial and ocean carbon uptake than have previously been possible. These data will also be a key parameter used to develop and validate models that attempt to project future ocean uptake.

Tilbrook noted that the 1990's have also seen a dramatic increase in the amount of surface carbon data used to estimate surface air-sea fluxes of CO_2. Taro Takahashi from the Lamont Doherty Earth Observatory has collated much of the available pCO_2 data and the general pattern of air-sea fluxes on large regional scales is now evident for the oceans. However, data used by Takahashi were collected over about 30 years and corrected to 1995 using a variety of assumptions. While these data do provide general patterns of sources and sinks for the surface ocean, they are insufficient to resolve temporal changes on interannual and longer scales, and the magnitude of the net ocean exchange is still controversial. For example, regional uptake estimates based on ocean observations in the Southern Ocean show more uptake than estimates derived from atmospheric inversions. Moreover, the sign of net CO_2 fluxes in the continental margins is still unknown.

Tilbrook emphasized there is also a sparsity of time series stations in the ocean where carbon and other biogeochemical tracers are sufficiently well sampled for the development of ocean carbon models. The success of the past decade of research on ocean carbon cycling has shown clear observational and modelling strategies for improving regional and global carbon budgets. A co-ordinated effort for ocean carbon and other biogeochemical measurements on repeat sections, time series and volunteer observing ships will be a major step to developing robust understanding of the current and future role of the ocean in the carbon cycle.

Zenk informed the Panel about hydrographic sections that were firmly scheduled. He also mentioned that some of the yachts participating in the Volvo Ocean Race will be equipped with a suite of instruments measuring ocean variables. The race will begin in Southampton 23 September 2001 and end in Kiel in June 2002.

The following points were developed:

- There is a real need for the terrestrial-ocean-atmosphere communities to work together to come to grips with the various contributions to carbon cycle variability and change.
- The main game (for carbon cycle measurements and implementation) is to fully exploit synergy and intersections with other components of the system.
- One of the primary principles is that we are seeking synergy and integration within the OOS and that, wherever and whenever possible, any extension to include carbon measurements should exploit synergy with existing VOS/SOOP/ASAP lines.
- Systematic, repeated line sampling is preferred to *ad hoc*, random (broadcast mode) sampling.
- There is general agreement that specialist time-series sites are a useful (very useful) contribution to the OOS, not through routine ingestion of data, but through the influence on testing and proving of parameterizations and calibrating satellite retrievals.
- Real-time transmission is emerging for ocean carbon measurements.
- The Hood-Doney et al. paper largely skips data issues and standards; this will need to be addressed at some stage.
- With respect to hydrography (discussion of full-column sampling), there was little to be gained by curtailing sampling depth (cf discussion at OceanObs99). There was agreement with the general approach of (rolling) 5-7 year repeats.

The OOPC drew the following conclusions:

- An appropriate approach for carbon measurements is to treat it as a “Pilot Project” activity. It would be a finite length activity with specific objectives; it would aim to test and evaluate candidate systems, test and evaluate routine operation and data delivery mechanisms, develop standards and formats for data exchange, etc.
- It is timely to begin implementation of routine VOS observations for pCO_2. The Ship Observation Team of the JCOMM should begin a process for embracing such measurements.
- There are several candidate lines (e.g., Germany EC funded programme CAVASOO, the Australian lines).
- There is strong support for the time-series approach.
- The 3rd component is a hydrographic programme. Consistent with the comments above, this needs to be integrated with other programmes (e.g., CLIVAR, etc.).
- OOPC will entrust development of a detailed plan to the process initiated by Doney et al, with due consideration of issues for integrating the ocean part with other elements, development of the Carbon Cycle programme, etc.
- The “drifter” element perhaps needs to be seen in a more general context (e.g., surface and subsurface drifters, gliders); the feeling is that emphasis should be given now to exploiting profiler capability (e.g., O2 sensors); the surface drifter approach seems less effective for now.

8. DATA AND INFORMATION MANAGEMENT

Smith opened the discussion of this agenda item by providing a brief introduction to the Ocean Data and Information Technology Project. The issues are many; the list starts with too little telemetry capacity, lack of common standards and practices, no agreed formats for coastal and biological observations, or non-conventional ocean data, and so on. Smith is proposing to tackle the issues on a broad (GOOS-wide) front with the following approach:

- agree on a suite of studies to evaluate capability and functionality of existing systems;
- properly scope the utility: look at the total requirement for all aspects of D&IM (the What and the Why);
- evaluate technologies, methodologies: availability/suitability (the How);
- set a work schedule for studies ,workshops;

- convene an international conference to review the studies and seek consensus on implementation for improved D&IM

The Panel then turned its attention to a paper distributed prior to the meeting that was prepared by Keeley (see Annex III). It uses the Argo data system as a model to discuss the requirements of an end-to-end data system. It describes the Argo real-time system, identifies gaps and weaknesses, and examines issues not yet addressed by the system. Argo meta data, data versions (e.g., original, QC'd, etc.), properties of data tags/identifiers, archiving and system monitoring are treated in considerable detail.

The OOPC agreed with the strategy being adopted for Argo data management and the intent to use this approach as a model for broader application including GODAE. OOPC should also bring the paper to the attention of JCOMM. The concept of self-describing "data packets" was found particularly attractive and the Panel recommended they be independent of platform. The unique tag identifier developed for Argo is a good development; an even more general approach (i.e., independent of the ocean/met community) would get over issues related to non-Argo (non-ocean community) data sets. The Panel concluded that data versions must not be arbitrary and self-assigned, there must be an accreditation system. Johannessen suggested using the same definitions for the data levels as those used by the satellite community. Zenk cautioned that the system must be able to evolve with the improvement of the present data transmission capability and be compatible with the next generation of data transmission systems.

Issues and needs raised that require further deliberation and study included the following:

- a robust totally automated 24-hours/day, 7-days/week system,
- a data tracking system of who did what to data where and when,
- a method of rejecting data that doesn't have all the required tags,
- a data label identifying the kind of salinity sensor used in obtaining TESAC data,
- a system that is capable of functioning with the future possibility of two-way communication,
- a system that can deal with gliders, autosubs, and other platforms,
- a monitoring system with appropriate metrics to prove the system is delivering as advertised,
- a better system for assignment of float ID numbers than by block distribution to countries,
- a procedure for assigning meta data,
- a data-version-labelling approach coupled with an accreditation system,
- a code that allows changes to be made or to add identifiers in the future,
- a system for handling delayed mode data,
- a long-term home for Argo data that is integrated with other data,
- a consistent uniform way of estimating speed from floats, and
- a study of what must be included in bio meta data.

S. Piotrowitz discussed the costs involved for telemetering data from an ocean platform (float, mooring, etc.) to the satellite, to Service Argos, to the National Weather Service. The costs are not negligible and will grow with the introduction of gliders and 2-way communication. He reminded the Panel that global capability is the goal and that Iridium is the best bet at present to achieve this (ORBCOM is not global, it goes from 70°N to 70°S). Iridium was recently saved from going out of existence by a Navy contract to make it possible to maintain the system.

Panel members were very interested to learn of the US Navy's efforts to salvage the previously bankrupt Iridium satellite communication system for future use in data transmission mode. The potential cost benefits (costs cheaper by 2 orders of magnitude) and enhanced capabilities (two-way communication, increased bandwidth), when compared to systems like Service Argos, were extremely promising. In general, the community must move to total communication of original data; the complications and indirect cost and loss of value are unbearable. Two-way communication would facilitate the more optimal use of platforms (modified sampling, status evaluation, etc.). Existing satellite systems, such as Argos, should be encouraged to pursue similar capabilities to enable suitable competition. Argos has already expressed an interest in being informed of the functional requirements so they can address such user needs if possible. The Panel noted that additional users, not presently considered under the scope of the Iridium project, should include TAO, VOS and SOOP as well as SURFA and Time-Series sites. Concerning the costing for the accompanying data delivery system in the US, the Panel suggested considerable savings could be made by having users dial into a service centre, rather than having the data distributed directly. There is a growing need to develop the capability for transmitting multi-disciplinary data as demands increase for this data.

The Panel supported the efforts of Chairman Smith in preparing an in-detail issues paper and an initiative on data management, which have gone to heads of oceanographic agencies, data centres, stakeholders, international organizations and panels concerned with the problems currently plaguing oceanographic data management. It is not too early to be undertaking such an effort. Additional areas suggested by the Panel to be investigated include the development of quantitative QC measures, data security issues, data exchange policies (not all present national "free- exchange" policies are actually "free"), and standardization of research data formats through funding proposal requirements. A data accreditation system has to be invoked. Advice should be sought from other industries who have already tackled similar problems (e.g., finance industry).

At a minimum, the initiative for an Ocean Data and Technology Project needs to be undertaken in partnership with the satellite community. It was proposed that GOOS take guardianship of the initiative, with GODAE to take the lead in issues concerning products and data exchange. Smith envisioned a target of 2-3 years from now to develop the architecture for the system after which time the engineers could take over to design the working system. He believed the design should incorporate ?xml" data standards. Mason added that the design should address both science and operational data needs. Weller urged caution against science loopholes that allow exceptions to free exchange that result in data getting lost. Johannessen stated that EUMETSAT is fully involved in these issues in preparation for the EPS/NPOESS ground segment and that their experience and plans could be relevant and should be considered in this context. Dickey agreed that taking a step back to take a fresh look is a good and necessary approach but the process should entrain existing WOCE DACS and SACS experience.

Keeley urged quick action regarding the data version issue and deciding on a scheme to be implemented. He believes the scheme must distinguish between levels of QC, data resolution and state of processing. The scheme used by the satellite community will be a good place to start. If this could be done quickly, it could be implemented in the Argo data system.

Other data systems, including JCOMM and IODE would also benefit from implementing a useful data version indicator as well as unique data tags. Greater thought will be needed for these, since these data systems often deal with data that although collected at the same time, are split into different data streams (i.e. surface meteorological and subsurface temperature data from a ship). The data undergo different processing and QC, and some way must be found that can usefully report these differences. In recombining these data, a user must be able to recognize that the data originated together.

Keeley also noted that there must be metrics devised to monitor if the data systems are meeting the goals. These monitoring tools would be used to identify weakness and to improve performance. He concluded that because the Argo data management system was just forming, it was an opportune time to incorporate some of these ideas and to test their utility.

The Panel recommended that Argo data be integrated into the Upper Ocean Thermal UOT (and Salinity) data systems, with JCOMM taking the role in this integration. It was recommended that the UOT community (including Argo) utilize this opportunity of a new platform with specific data management requirements to revise the present data management system. Unique tagging, for instance, is not an issue solely related to Argo but one that the broader community could benefit from if addressed together. The same could be said with regard to developing an accreditation system and developing performance metrics. These are all urgent for Argo, and accordingly progress must be made soon. It was suggested the proposed initial Argo Data Management System Workshop later in the year be expanded to also include other elements of the UOT(S) system.

Keeley noted that the development of the Argo data system, has some new, useful ideas embodied in it. These are relevant to GTSPP and it is his intention that they be carried forward into GTSPP as well. He also noted an IODE project for managing surface salinity data in formation and that he would be promoting these ideas in that project as well.

Smith concluded that some of the issues listed above need further development in the near future. OOPC agreed that two studies need to be undertaken now, one on data IDs and data version assignments, the other on integrating data sets, upper ocean data sets for example. A third could focus on metrics and statistics. Keeley and Dickey agreed to work with Smith in fleshing out the needs related to maintaining data integrity.

9. NATIONAL ACTIVITIES

Where National activities are pertinent to specific agenda items and therefore described under other sections, they are not repeated here. Accordingly, reports by those countries may not be listed in this section.

9.1 CANADA

Keeley reported that Canada has purchased about 50 Argo floats for deployment in the Northeast Pacific and elsewhere as required. The first deployments will take place in late May, with others scheduled for September and later.

At a GTSPP (the chair being from Canada) meeting held in March, representatives from the US SEAS programme explained that they were in the process of changing the system so that the full resolution profiles from XBTs would be sent ashore and then converted to BATHY messages for distribution on the GTS. Included will also be a system for tagging each profile uniquely as had been advocated by OOPC. This change can have a profound impact on GTSPP operations and therefore on the SOOP as well. GTSPP will be discussing the impacts and how to re-align its operations in light of this.

The idea of a surface salinity programme to manage data from thermosalinographs was discussed and accepted as part of an IODE meeting. This will also be raised at the upcoming JCOMM meeting. Organization of an initial meeting to plan the programme is scheduled for the last quarter of 2001. Canada, because of its data management experience in GTSPP, will be contributing to this meeting.

9.2 FRANCE

Picaut informed the Panel that the French effort is currently focussed on the Atlantic to provide sustained and improved observing systems for the CORIOLIS Project. The development of an operational profiler is proceeding with efforts devoted to making the PROVOR float smaller and cheaper and air-deployable, perfecting sea operations in its deployment and examining the data validation and real time processing procedures. France is also involved with aspects of the XBT, XCTD, R/V, VOS, thermistor chains, CTD, thermosalinograph, hull-mounted ADCP and moored surface buoys. A Eulerian probe is also under development. Picaut provided the following schedule relating to float commitments:

2001 -- 2002 Project Pommier will employ 20 profilers.
2001 -- 2002 Gyroscope Project will employ 80 European profilers
(40 from France and 40 from Germany).

2001 -- 100 are funded already.
2002 -- 135 more planned for procurement.
2003 -- plans call for an additional 65-90.

9.3 GERMANY

Zenk stated that about 150 floats will be procured; some will be deployed in the Drake Passage. Project ANIMATE has been approved for funding (see 5.4.1). The proposal to the EU for obtaining CO_2 observations aboard the *FS Polarstern* was not approved. Some hydrographic sections have been funded. The ESTOC site will be equipped with CO_2 sensors. Zenk recommended that a reference site mooring be considered for a location North of the Denmark Straits.

9.4 JAPAN

Kawabe described the Japanese Boundary Current Monitoring Project. The aim is to establish methods to measure the Kuroshio's variability and to be able to monitor it via the Internet. He mentioned that he was concerned that the preliminary agreed list of surface reference sites did not include a site in the region of the Kuroshio and the Kuroshio Extension. The EOFs show that the Kuroshio needs monitoring at two points: 29° N 135° E (south of Japan), and 35° N 155° - 160° E. JAMSTEC has 2 TRITON buoys which it is willing to be used for the Kuroshio Extension study. Kawabe is proposing these be used for air-sea flux reference sites, but so far JAMSTEC has shown no interest in fluxes. He will continue his efforts at persuasion. The southern site has the advantage of having a record of more than 20 years of data. These data were obtained by the Japan Meteorological Agency up until last year.

9.5 UNITED STATES OF AMERICA

Harrison reported that US sustained observations are being planned and implemented via CLIVAR, NOPP and various NOAA activities, the latter being done through operational directorates. The Office of Global Programmes (OGP) supports CLIVAR and ENSO activities. An integrated observation system budget was prepared by all the groups. Argo ended up with the highest priority with some separate additional funds for GODAE. Harrison did not see even in the distant horizon the development of an Initial Ocean Observing System initiative happening in the US What is another and more likely way to accomplish nearly the same thing is to do it through a research package that would ramp up say over 10 years. OOPC agreed to keep pushing for the OCEANOBS99 vision of an integrated ocean observing system, recognizing that countries hate to commit funds indefinitely into the future.

10. SUMMARY OF ACTION ITEMS

This Report's Action Items are compiled here for convenience.

(1) *The 2nd Observing System Adequacy Report*. The National Reports on Climate Observations requested by GCOS are due for COP VI in November 2001. The synthesis of this information will take place during 2002. The Adequacy Report will be due mid-2003 for COP VIII.. The OOPC will need to play a role on the synthesis process (2002) and a leading role (within GCOS) of the Assessment of the measurement network The OOPC must develop a strategy for assessment of the OS for the GCOS Adequacy Report. OOPC agreed to work with GCOS and to begin by developing a process within the GCOS/UNFCCC framework targeted at the synthesis of the National Reports.

(2) *Coastal OOP (COOP)*. There are emerging areas of strong interaction between the OOPC and COOP in the coastal zone and in the open ocean (physics, biology), and for GODAE. The Chairs have

committed to attend each other's meetings (W. Nowlin will attend the next COOP for OOPC). Dickey will respond to the interface issues as required.

(3) *AOPC*. The AOPC are creating a small Working Group to look at mean sea level pressure data in the context of a GCOS. The OOPC has agreed to act as a cosponsor. Harrison will participate in the WG. Surface reference sites and VOSClim are two immediate opportunities for collaboration between AOPC and OOPC . There was also agreement that better use should be made of R/V opportunities and that VOS, SOOP and ASAP be co-located (operated).

(4) *CLIVAR.* CLIVAR OOP will develop a global perspective for ocean observations, using a WOCE-JGOFS workshop on Transports to be held in Southampton 26-29 June 2001. The OOPC agreed that CLIVAR OOP should take the lead on heat, freshwater and momentum transports and the implications for the Adequacy Report of present and planned observing networks. The role for hydrography will also be examined within this context.

A joint CliC/CLIVAR group will be formed to lead the development of a scientific programme in the Southern Ocean, including observations. The OOPC will use this group for any implementation/oversight activities.

CLIVAR OOP has proposed a Workshop be convened to examine our ability to monitor western boundary currents (WBCs). OOPC agreed this would be an appropriate initiative and would keep a "watching brief", in particular to ensure that relevant non-CLIVAR issues are covered.

(5) *GODAE*. OOPC acknowledges responsibility for integration issues of the OOS. The OOPC needs to assure that error bars are put on all data being assimilated.. Reynolds and Smith will provide liaison to the GODAE Hi-Resolution SST Pilot Project for OOPC.

(6) *SST/SI Project.* Follow-up by the SST/SI WG with Clic is required on sea ice data sources. Reynolds agreed to continue leading this working group.

(7) *Tropical Moorings*. OOPC will lead an International Workshop to review the Global Tropical Mooring Network. CLIVAR OOP will contribute to the review. Russel Davis and Detleff Stammer have been nominated as two contacts. Smith will lead OOPC contributions to the workshop with Picaut, Harrison and Weller participating.

(8) *South Atlantic*. Campos and Zenk agreed to provide OOPC focal points for stimulating discussion sessions on integrating South Atlantic observations at already scheduled meetings (e.g., IAPSO, COSTA-2). Johannessen will explore opportunities at ISRSE. The target is an integrated sustained OOS for the South Atlantic.

(9) *Indian Ocean.* OOPC agreed to name two individuals to assist Erb in organizing an Indian Ocean Conference on Sustained Observations for Climate

(10) *Ocean Climate Indices*. OOPC members were tasked with providing Harrison with a list of three important indices which may have potential relevance to assessing the ocean state, or the state of the OOS, or the effective influence of a publicity campaign.

(11) *Data Identification Coding, Versions (levels) and Integration*. OOPC agreed that two studies need to be undertaken now, one on data IDs and data version assignments, the other on integrating data sets, upper ocean data sets for example. A third could focus on metrics and statistics. Keeley and Dickey agreed to work with Smith in fleshing out the needs related to maintaining data integrity.

(12) *Data Telemetry*. OOPC must draft a paper that sets out the issues in total communication of original data (e.g., broad band, 2-way, multi-disciplinary) for general consumption.

11. NEXT MEETING

At the kind invitation of Walter Zenk, the Seventh Session of the OOPC will be held in Kiel, 5-8 June 2002.

ANNEX I

AGENDA

1. OPENING

2. REVIEW AND ADOPTION OF THE AGENDA

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3.6 CLIVAR OCEAN OBSERVATIONS PANEL (OOP)

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5.1.3 GODAE in Norway
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5.5.1 Altimetry and Scatterometry
5.5.2 Salinity
5.6 EVALUATION/SENSITIVITY EXPERIMENTS
5.6.1 Evaluation of Tropical Moorings
5.6.2 Observing System Evaluation
5.6.3 The Second Adequacy Report
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6. WORKSHOPS

6.1 INDIAN OCEAN WORKSHOP (SOCIO)
6.2 SOUTH ATLANTIC
6.3 SURFA - SURFACE REFERENCE SITES WORKSHOP
6.4 TIME SERIES WORKSHOP
6.4.1 Biogeochemical Observations

7. CARBON SYSTEM OBSERVATIONS

8. DATA AND INFORMATION MANAGEMENT

9. NATIONAL ACTIVITIES

9.1 CANADA
9.2 FRANCE
9.3 GERMANY
9.4 JAPAN
9.5 UNITED STATES OF AMERICA

10. SUMMARY OF ACTIONS ITEMS

11. NEXT MEETING

ANNEX II

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ANNEX III

AN END-TO-END DATA SYSTEM

by Bob Keeley

Introduction

This paper discusses the requirements and features of an end-to-end data system; that is a system that handles data provided by collectors to data and products delivered to clients. The Argo data system, currently under development, is used as the immediate focus. This is done for two reasons. First, the Argo system has certain features built in to manage problems encountered by older data systems. Second, since it is not mature, there is still the opportunity to modify what is being built.

After reviewing the Argo system, the paper looks at gaps and weaknesses that are present. Some of these are due to the system being immature, but others are due to more far reaching issues not yet addressed. In the last section of the paper, these broader issues are examined in more detail.

The object of the paper is to generate comments about how an end-to-end system should function and what kind of information must be maintained to meet the needs of clients. Suggestions and comments that can influence the Argo data management will be considered and implemented to the extent possible. All comments are valuable in helping to design future systems and retrofit existing ones.

The Argo Data System

A number of countries or groups of countries are buying and deploying profiling floats. Each country and group is either building their own data assembly centre, DAC, or having another centre manage the data from the floats. These DACs are responsible for getting the data from Service Argos, carrying out preliminary processing and QC and sending the results to the GTS, to the float PI and to an Argo server. The DACs are also responsible for getting the data back from the PIs (called delayed mode data) in 90 days and sending these data to an Argo server.

There are two Argo servers planned. One will operate on the GODAE server in Monterey, and another will operate at IFREMER in Brest. These servers will function as mirrors of each other and will coordinate their holdings. The Argo servers act as data warehouses and will support data and product distribution. Clients can go either to the Argo servers, or to their local DACs to get data or products from the program.

When the float is configured for deployment by the PI, the information about its duty cycle, type of sensors, float type, etc., is sent to its associated DAC. Some of this information is required to process the data received and some is metadata that is valuable in interpreting the data in subsequent years. Each DAC, at present, is responsible for securing and maintaining this information. The Aro servers will archive the metadata files for all floats.

All data at present are coming through the Service Argos system. Within the Service Argos data stream is a WMO float number and a station number. The station number is incremented each time a float comes to the surface and the data are sent ashore. This number in combination with the WMO identifier constitutes a unique tag for each station. This tag is being carried throughout the Argo data system and is the way that duplications will be identified and the correspondence between real-time and delayed mode data confirmed.

The Argo program has agreed that all data from profiling floats in the program will be distributed in real-time on the GTS. Before the data from a float can be circulated on the GTS it must receive a WMO identifier. The method of assigning WMO identifiers is being changed so that as of 1 June, 2001, every deployment of a float will receive a new identifier. This helps to remove the ambiguities in data tracking that occur when identifiers were reused.

Argo participants have agreed that all data should be distributed within 24 hours of the float coming to the surface. To meet the 24 hour turnaround time, the data transfers from Service Argos to DACs will happen multiple times a day. In addition, because of the short time only automated data quality assessment will be carried out. These procedures have been agreed by participating DACs.

The QC process will result in quality flags being assigned to the individual measurements. These will be retained in the data sent to an Argo server and to the PIs. Because a TESAC does not support sending this information, they will be stripped away from the reports. Because of WMO policy, in some relatively short time, data distribution will be converted to BUFR and when BUFR comes into use, it will be possible to send QC flags and other metadata in real-time.

Floats must stay on the surface for some hours in order to send the complete profile information through the satellite system. While at the surface, a number of float positions will be determined and these all come to the DACs. There is no provision presently to circulate these surface drift measurements in real-time, though they will be sent to both PIs and an Argo server.

Data going to an Argo server will be in the netCDF format but in two different data structures. One structure will be used for profile data and a second one for surface drift data. Both structures support the inclusion of quality flags, plus additional information.

PIs will carry out whatever QC they deem appropriate and will return the data to the DAC which must then pass the data to the Argo server. Through the use of the unique tag, the Argo server will be able to recognize previously received data and match to the data they presently hold.

There is an international requirement that the float operators notify countries when floats are going to enter their territorial waters. This demand is being met by an Argo Information Centre with help from one of the DACs.

Specific Gaps and Weaknesses

There is no current strategy for the long-term preservation of the Argo data. It has been suggested that one of the data centres could take on this role. There is a need to discuss this, clarify what must be done and examine the most effective ways for this to occur.

Although there has been agreement to carry out automatic QC procedures on the real-time profile data, for operational reasons, some DACs will not be able to conform. In the one known exception, the only impact will be on the data sent to the GTS, not on the other streams. The result is that data sent to the GTS will have undergone different treatment depending on the DAC.

The form of the TESAC message does not permit carrying data quality flags, station numbers nor most of the other metadata. It has also been agreed that any observed values that fail QC tests will be removed from the TESAC report. The result is that what appears in the TESAC and what is sent to the PI and Argo server will be different with the PI and Argo server getting the data and quality flags, but the TESAC having this information missing. When this is combined with the TESAC not carrying the station number that tags each station uniquely, there is now the creation of a near duplicate record. So, if a client takes the data from the GTS and the data from the Argo server, there is no longer an exact match. If, as a result of quality assessment, a position or date changes, there will be a mismatch of some information that must be used to match the TESAC to the Argo server record.

In practice, because of the mode of operation of the floats, this mismatch should not be serious as long as a user can distinguish the origin of each record being compared. Additionally, once GTS distribution has been converted to using BUFR, all metadata can be carried and so real-time reports should match exactly those data distributed to the PIs and an Argo server.

Though QC procedures have been agreed for profile data, there is as yet no agreement on how to handle the surface drift data. The first issue of importance here is that not every data transmission has a good location, so that while each surface drift receipt will be assigned a time, it will not have an updated location. Second, there is always a time delay between when a float reaches the surface and the first location is established. There is an expressed interest to project back in time to where the float is expected to have surfaced and so to where the profile really is measured. This remains to be resolved. The impacts are only that information that explains when the location was measured compared to when the data transmission was received needs to be kept. Additionally, a standardized processing procedure should be developed for the surface drift data.

The Argos data allows attaching a unique tag to the station, but a station has multiple locations associated with it. In order to arrive at a unique tag for the surface drift data, it is necessary to combine the WMO identifier and station number with the location time. But QC procedures may alter location times and so the tag to individual drift locations is not preserved.

Surface drift data could be used in combination with other data to derive information about the surface circulation in real-time. However, there is no plan to circulate these data on the GTS. There are two code forms, TESAC and BUOY, that could be used but either form splits the surface drift information away from the profile data. The TESAC is the preferred form for the profile data because it permits the delivery of information about the float. The surface drift data are better represented in the BUOY code form.

Data sent to the Argo server are sent in two different netCDF file structures. The present plan will put every float station into a separate file, but will combine all of the surface drift data into a single file for each float. The issue is that the surface drift data has been split away from the profile information. The only way to combine them is through the unique tag on each station. The operations of the Argo servers is not well defined as yet, but unless there is a stated requirement, it is likely that a client will have to ask for both profile and surface drift files to get all of the data associated with a float.

It is likely that each PI will carry out their own particular procedures to evaluate the quality of the data returned from their floats. Within the netCDF data structure there is the ability to track both who has processed the data and what they have done. The requirement to do this has not yet been formally stated. Unless stated, there is a great potential to lose track of versions of the data, or to lose knowledge of the work carried out by others.

The Argo plan sets a target of all data being available within 24 hours of a float coming to the surface and all data should be back from PIs within 90 days. No discussions as yet have taken place to agree to how this performance will be monitored. A sensible plan would be for each DAC to monitor its own operations. However, to get a composite for the entire program, there is as yet no strategy.

It is not yet settled how the Argo servers will maintain identical holdings and what form their services will take. Suggestions have been put forward that the servers be able to support queries qualified by area, by time and by float identifier.

Generalizations

Metadata

The metadata associated with profiling floats is relatively straightforward when compared to the complexities that arise for other kinds of data, such as in chemical or biological measurements. In these latter cases, the details of water sample preparation and analysis are crucial in the interpretation of the reported measurements. While it is possible to keep the metadata separate from the measurements, this usually increases the risk of being unable to link them back together. A common strategy has been to store such data and information in relational data structures. A problem with this has been that it is often difficult or very clumsy to reproduce these relationships in some other file-oriented format and such formats are the structures that are usually used in data exchange. A solution would seem to be in the adoption of XML and appropriate supporting information (such as a data dictionary). This structure appears to have the richness necessary to preserve complex relationships and the quality of being independent of any commercial vendors, thereby avoiding issues of proprietary software.

Unique Identifiers

The desire to assign a unique tag to data has implementation issues that need to be addressed. First and foremost a unique tag is the way to remove the problem of being able to recognize several forms of the same data. The discussion above already illustrated how within the Argo data system, the same source data will produce different versions. This is compounded the more data move around.

Argo has addressed the issue by assigning a unique tag to all of the data received each time a float reaches the surface. This collection of surface drift data, one or more profiles and associated float engineering information constitutes a data packet with a single tag. More generally for other data types, the composition of the packet is strongly dependent on the type of data being collected. For example, a data packet from an instrument recording water levels every 10 minutes and running for many years, may be all information collected in each month or each day or each hour. No matter what is the choice, unless the tag is set at the individual measured value, it will be necessary to identify information at a finer scale than the packet. There is no established strategy to do this at present.

One of the properties of a tag has to be that its sole purpose and information content is a unique identifier. So, no matter how the information of the tagged packet changes, the tag never does. It will be a mistake to encode any information subject to revision in processing, such as date, position, independent or dependent variables, into a tag where it solely resides. The consequence of so doing is that changes will cause changes to the tag thereby nullifying its reliability in identifying data versions.

If unique tags are assigned, they need to be assigned as early as feasible in the data collection process. Such tags should be useful to the data originator in keeping track of the data for themselves. All subsequent processing needs to preserve these tags. Applying the tags early cuts down on the opportunity for untagged data versions to be created. Carrying the tags with the data ensures that each user has the opportunity to resolve questions of versions based on the same data.

It is desirable that the generation of unique tags can be done independently by data collectors, DACs or whoever requires them. The tag creation process cannot be completely independent since some control of the content and form of the tags is needed. However by making use of existing international lists such as country codes, or internet domains, and using perhaps creation time stamping, it should be possible to make the tag creation process functionally independent.

Original Data

Data returned from *in situ* instruments often have some processing that must be done in order to convert the data stream to reliable measurements of the environment. The required level of processing is dependent on the type of data involved. There are both individuals and organizations that carry out this role. However, at some point, the measurements are deemed fit for analysis and exchange. As soon as the data are made available for exchange, they are considered original data to the data system and should have a unique tag.

Original data should always be available despite all of the permutations and changes that may result from subsequent processing. The original values may be kept in the same physical file with the changed values or they may be kept in separate files, but with appropriate pointers. Likely the best strategy depends on the kind of data under consideration and the capabilities of the organization. There are no modern established practices for retaining original data in this way.

The simultaneous collection of different kinds of data, for example T and S profiles with water samples, means that all measured variables will not be all available at the same time. It is desirable to have an unequivocal way to link observations collected at the same place and time. Since time and space coordinates are subject to change, the linking could be through the packet tag discussed earlier.

There are two strategies that can be employed. The first simply attaches the same tag to all of the pieces as the measurements become available. So, in the example given, the first available piece contains the T and S data. Later as the water samples are analyzed the other measurements also get the same tag. This is straightforward and simple. A second strategy tries to provide more information. Each piece contains not only the measurements available, but also points to other measurements made at the same time but that appear in other pieces. So, the piece containing the T and S measurements would have information saying water samples were collected as well. Likewise as measurements were extracted from the water samples, their pieces would inform a user that T and S measurements are also available. This second strategy is more proactive in alerting users to additional coincident data, but requires more work to implement and may be complicated to maintain.

Data Versions

One thing not addressed in the above discussions, but which will become important are the issues surrounding different versions of the data. This concerns data that have passed through different stages of processing, or have been treated in different ways by users and then made available once more to others. In some sense this is similar to a duplicates issue in that the same original data is viewed at different stages and consequently may have differences.

It is useful to be able to distinguish data that have passed through certain processing stages from those that have not. This applies both at the data packet level but also at a data collection (data set) level. Many years ago NASA developed a scheme that could be attached to data sets (an image) and that described coarsely at what stage of processing the data were. Such a scheme, or a variation, could be adopted where the levels represent the major milestones in data handling, and sub levels represent finer divisions. An example would be as follows.

Level 0: Data are as from the instruments with only on board processing and QC.
Level 1: Values have been calibrated and passed operational quality assessment.
Level 2a: Data have passed data centre quality assessment
Level 2b: Data have passed PI quality assessment
Level 2c: Data have passed independent scientific quality assessment
Level 3: Product derived from observed measurements

Here the emphasis is on what level of data checking is applicable. Such a scheme works well when data are passed around within a data system. This can be applied either at the collection or packet level and gives a user a reasonable idea of the reliability and content. Of course, some other scheme may be more applicable.

As data are passed to users outside the data system, and then returned to the system, the level of detail given in the example is insufficient to permit a user to know what differences there are between one collection and another, and even between two packets. In this case, a more detailed scheme is required that could employ information such as when the collection or packet was altered and by whom.

From a DAC perspective there are also advantages to being able to record greater detail about the internal processing carried out on the data. This has proven to allow for ready recognition and correction of errors and of tracing the provenance of data received.

Replacement

This concerns the decisions to be made when data arrive at a DAC or archive centre. First of all, the archive centre keeps the master copy of the data. In the case of Argo, the DACs are continually reviewing the data either getting data from the floats, or back from PIs. As they upload the new or changed files to the Argo servers, there needs to be clear rules about replacing older copies of data. What is more, the newer copies must be easily distinguishable from the older copies, which comes back to the need for tracking versions touched on earlier. What is true for Argo is also true generally.

A more difficult problem arises when parties outside of a data system carry out some work that improves a data set they received from the system and they wish to return it. It is a desirable thing to be able to accommodate this since it is a way that the data can be looked at by many and all of the various problems identified and corrected. The challenge is to recognize these different versions and readily communicate the differences to other users.

The recognition of versions has to be at the level of the data packet. It is common for data sets to be assembled on demand, and therefore to have a customized collection of packets. While the assembled data set is being worked on, updates from the DACs may come in so that now the data set contains older copies such that the work carried out and the results obtained against the older packets may be superceded. It is necessary to have a strategy for managing this issue.

Another issue that needs attention is what to do with data that enter the data system but subsequently are identified as wrong. This is the case where bad data slipped through the initial procedures of the originator and had they been caught, would never have entered the data system at all. In this case, and assuming a unique tag is attached to the data, the tag will be used to mark all versions of the data as obsolete. It is possible to either just mark it as obsolete, or to remove the data permanently. Marking as obsolete allows one to "remember" what has happened should the obsolete data turn up again.

Processing

Every time data undergo a format conversion, the potential for loss of information occurs. This happens because of conversion error, because information is deemed unimportant or because there is no place for certain information to be carried. There have been many attempts to produce a popular and functional data format. Though there are a few formats today that are quite popular, there is no universal scheme that is accepted. Only a format that is self-describing can be at the base of any successful scheme.

Monitoring

Every data system needs to monitor its performance. In any system, there are many different measures of performance that can be watched, but it is useful only to monitor some fraction of these. For the Argo program, there are only three performance measures that are clearly stated. Presently, there is only one, notification to countries, where the exact mechanism is worked out. There should be a consideration of what other monitoring is needed to ensure the data system is meeting its goals. Some possibilities would be looking at the quality of the data on the GTS to ensure QC procedures are being uniformly done, looking for variances in data quality across programs, looking at float lifetime and sensor statistics, monitoring the distribution of the floats, and keeping statistics of data queries at the servers. In other data systems, other metrics of performance will be required. The important point is that without such measures, it is not possible to know if the data system is performing as designed.

As the quality of data is monitored, it may well be that systematic problems are found. This information has to go to the PIs and data collectors so that they can strive to fix the problems at the source. An efficient feed back mechanism is important for a data system.

Non-compliance

Data will appear to the data system missing what is considered to be mandatory information. An example would be that a data system may insist that data have unique tags or the quality of data is indicated in a certain way. This information can be missing because contributors either don't know or don't care about the mandatory information. One view is to ignore these data; that is they are treated as non-data and are rejected by the data system. Of course, it will be necessary to work with contributors to convince them of the advantages of conforming to the standards so that the volume of rejected data is low.

Another strategy is to employ some sort of accreditation. It could be simply that data handlers are either part of or not part of a data system. If users wish the official version of data, they should get the data from the accredited handlers. Other accreditation schemes could be thought of, but the advantages and rules for accreditation must be very clear.

Conclusion

This document has proceeded from a discussion of a specific data system, that for the Argo program, to more general issues. The Argo data system is still being developed and so has room for changes and improvements. The intention of this paper is to stimulate the discussions of the desirable attributes of data systems, with the goal of incorporating procedures to build these attributes into Argo, and subsequent data systems. The specific gaps noted for Argo will be addressed by the data management committee. The more general discussions of this paper have relevance to Argo, but perhaps cannot be addressed early enough to become part of the Argo data system.

Additional questions regarding Argo

1. The data exchange format between assembly centres and the Argo servers is netCDF. The same netCDF structures will be used to deliver data to users. The present proposal for the netCDF structure for the profile data does not include such things as battery voltage, surface pressure reading, piston position and so on. Is it necessary that the format include such information?

2. The present netCDF structure permits reporting of temperature, salinity, conductivity and pressure. This list is easily expanded. How soon can we expect to have to deal with other types of profiles? How soon will we have to deal with other types of surface data or subsurface data?

3. When retrieving data from an Argo server (through an ftp download initially) how important will it be to receive the metadata (PI name, calibration information, sensor make and model, duty cycles, parking pressure, etc.) at the same time?

4. The netCDF structure reports measured values as floating point numbers with no indication of the number of significant digits. Is this okay or would you want the number of significant digits reported explicitly?

5. How important is it to include the "engineering" type information, such as piston position, etc., in the long-term archives?

6. When profiling floats come to the surface, their surfacing position is not instantly reported. Instead, the first position reported through Service Argos can be some hours after. It has been suggested that the assembly centres "project back" the position of the float when it came to the surface (and where it sinks as well) and that this projected position be stored in the archives. What conditions have to be met before these projected positions would be considered reliable?

7. There is provision to report information about results of data quality tests as well as information about the tests themselves. Is it better to report which tests were passed or which tests were failed?

8. Are there occasions when there can be mistakes in the pressure measurement as opposed to mistakes in the dependent variable fields such as temperature and conductivity?

ANNEX IV

**OCEAN OBSERVATIONS PANEL FOR CLIMATE
TERMS OF REFERENCE**

(rev. adopted by the GOOS SC, the WCRP JSC and the GCOS SC,
as of May 2001)

Recognizing the need for scientific and technical advice and guidance for the common module of the Global Climate Observing System and the Global Ocean Observing System, and the need for liaison and co-ordination between these operational observing systems (e.g. systematic, long-term, global climate observations) and those of climate research (e.g. limited-life, hypothesis-validating observations), J-GOOS, JSTC for GCOS and the JSC for the WCRP hereby establish an Ocean Observations Panel for Climate (OOPC) with the following terms of reference:

1. To evaluate, modify and update, as necessary, the design of the observing system for the common module of GOOS and GCOS whose goals are:

(i) to monitor, describe, and understand 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.

2. To provide a procedural plan and prioritization for an integrated set of requirements consistent with the observing system design criteria and in a form that enables timely and effective implementation. This will entail drawing from findings of WOCE, TOGA, JGOFS and CLIVAR, and particularly close interaction with the CLIVAR Ocean Observations Pane (OOP).

3. To liaise and provide advice, assessment and feedback to other panels in task groups of GCOS, GOOS and WCRP as requested, concerning ocean observing for climate in order to ensure that the designs and implementation schedules are consistent and mutually supportive.

4. To establish the necessary links with scientific and technical groups to ensure that they are cognizant of, and can take advantage of the recommended system, and that, in turn, the Panel can benefit from research and technical advances.

5. To carry out agreed assignments from and to report regularly to the JSTC, J-GOOS and the JSC for the WCRP.

ANNEX V

TERMS OF REFERENCE
FOR SEA SURFACE TEMPERATURE/SEA ICE WORKING GROUP

1. Record and evaluate the differences among historical and near-real-time SST and SST/SI analyses:

(a) Identify a standard data set for the intercomparisons of different products, e.g., COADS.
(b) Select several standard difference products as a minimum comparison set (i.e., define regions and time periods; compute biases, standard deviations, and RMS differences).

2. Identify the sources of differences in the analyses.

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

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

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

ANNEX VI

OBSERVING SYSTEMS FOR BIOGEOCHEMISTRY: THE IMPORTANCE OF VOLUNTEER OBSERVING SHIPS

by Douglas Wallace

In the context of global environmental change there is a steadily increasing need to observe our global environment for both its physical climate system but also, increasingly, for parameters relating to biodiversity and biogeochemistry (e.g. the carbon cycle). Motivations for such observations are emerging from concern over climate change but also as a result of international agreements concerning controlling future atmospheric CO2 levels (Kyoto), ozone levels (Montreal and subsequent protocols) and biodiversity (Rio treaty?).

Observations of the ocean or over the oceans are central to most such international agreements.

For example:

- the ocean plays a major role for the fate of anthropogenic CO2 emissions to the atmosphere,
- the biodiversity of the oceans is threatened as a result of pollution, climate change, fishing pressure, changes in surface water pH resulting from increased pCO2, etc.
- measurements of properties within the marine atmosphere are important for issues relating to tropospheric and stratospheric ozone.
- the ocean is a major component of the physical climate system.

There is great progress being made in establishing a global observing system suited to examining the role of the ocean in the climate system. The soon-to-be-realised combination of real-time observing systems based on autonomous profiling floats that measure temperature and salinity, when combined with satellite altimetry and other satellite observations in the context of global data assimilation models, represents a quantum leap in our ability to observe the ocean. Unfortunately our ability to observe the biological and biogeochemical state of the ocean lags very far behind. This means that major political and legal issues of great consequence for mankind are being addressed in the absence of meaningful observations to assess the global effectiveness of any remediative measures proposed.

The problem is partly one of history and culture of the respective scientific communities, but also fundamentally a technological problem. There is a long history of global-scale observation of the physical state of the atmosphere and, at least, the upper ocean, associated with the need to make weather forecasts and also military-oriented research. A need to extend this to biological and chemical properties has only recently (and rapidly) emerged in the context of human-induced global environmental change. The technological problem is related to this: sensors and techniques designed to measure oceanic physical properties (including salinity) have a long history of development. The development of chemical and biological measurements lags behind partly because of this history. However the range and variety of parameters that could be measured is orders of magnitudes greater (many different species, many different chemicals) and many key measurements are too complex to allow in-situ measurement.

How should we move forward in this area?

I take as given that:

- there is a rapidly emerging need to monitor the ocean for chemical and biological parameters (as stressed in many planning documents).
- the rate of sensor and technology development in this area is disappointingly slow (despite the urging of many planning documents).

Satellite missions are an exception: our ability to monitor biomass in ocean surface waters has rapidly improved over the past 20 years, and new sensor packages capable of measuring a variety of trace gases (including $CO2$) in the marine atmosphere are now emerging. However in-situ measurement of biogeochemical properties from autonomous platforms is still not straightforward: even for such very basic properties as dissolved oxygen and nutrients. The deployment of a suite of chemical and biological sensors on platforms such as the ARGO floats, though highly desirable, appears a long way off. And realistically, many critical biological and chemical parameters (e.g. measurements of stable isotope distributions) can never be measured from such platforms.

Planning documents constantly stress the need to develop new sensors for biological and chemical properties. Chemical oceanographers have dreamt for decades of micro-gas-chromatographs that can be deployed on CTDs. Marine molecular biologists may now dream of in-situ DNA-extraction and PCR systems! Dreaming is good, however one should not pretend that such development will be easy, or cheap, or that the resulting sensors will be suitable for deployment at the scales envisioned for physical measurements. Once again: many important biogeochemical quantities simply will never be measurable with *in situ* sensors.

Here I want to establish three premises and make a simple recommendation:

The first premise is that a great deal of the ocean's biological activity is focussed in the surface layers, and much of the scientific interest in ocean biogeochemistry focusses on issues related to atmosphere-ocean exchanges and surface layer processes (carbon fixation, Fe, N2-fixation, DMS, phytoplankton species succession, etc.). Further, the effects of global environmental change (temperature, pH, salinity, light, etc.) will be felt first and most strongly in the ocean's surface layers.

The second premise is that remote sensing of biogeochemical properties has drastically altered the spatial and temporal scales that our scientific research can address in the surface ocean and the marine atmosphere. A need to measure additional related parameters that cannot be remotely sensed on similar scales will inevitably emerge, as well as a growing need for ground-truthing of the remotely-sensed parameters themselves.

The third premise is that almost all of the present-suite of biogeochemical measurements can (potentially) be made from surface vessels. Many of the technological challenges associated with development of fundamentally new technologies required of in-situ measurements are relaxed when surface vessels are available as the platform (e.g. issues relating to power requirements, maintenance cycles, etc). The trend towards using complex laboratory instrumentation (e.g. flow cytometers, mass spectrometers, etc) on board research vessels confirms this.

Based on these three premises, I consider that the potential of making biogeochemical measurements from surface vessels has been drastically underutilized and underappreciated. The only success story is the Continuous Plankton Recorder (CPR) surveys operated by the Sir Alister Hardy Foundation for the Ocean Sciences: this is parhaps the only observing system suited to long-term, wide-scale measurement of biogeochemical parameters in existence. It is now reaching its 70th anniversary! The resulting data are proving invaluable for understanding the interaction between climate change and ocean productivity. The success of this effort is, of course, mainly a reflection of the dedication of the people involved (including the volunteer ships' officers and crew) but also reflects the success of an elegantly simple, standardised installation. Importantly, the CPR, as a towed body, does not interfere significantly with the ships operations, for example. Apart from this one excellent example, there is practically no history of long-term, basin-scale observations of biogeochemical properties in the ocean. A recent exception may be a ship-of-opportunity study of pCO2 and related properties in the North Pacific coordinated by Japan and Canada which has been operated now for about 5 years.

The use of commercial vessels (VOS) offers many potential advantages due to their scope for sampling the surface ocean with regular and fast crossings of whole ocean basins or marginal seas. I identify the following general advantages of such platforms for biogeochemical research. In this I am considering the potential of "within-ship" installations rather than semi-autonomous towed packages such as the CPR.

ADVANTAGES

1. Many/most existing measurement technologies can be readily adapted to surface vessels due to the availability of power, limited exposure to weather and seawater, etc.
2. Regular shipping routes allow relatively high-frequency repeat measurements at large spatial scales which are reasonably well matched to satellite observations. On basin scales measurements can at minimum resolve seasonal cycles. In marginal seas, up to diurnal cycles and the effects of individual storms, might be resolvable.
3. Regular port calls gives the possibility to replace failed measurement system components, or components that are subject to biofouling at <monthly intervals.
4. Transmission of data to shore in real time is relatively straightforward. Equipment problems requiring maintenance can potentially be identified prior to port calls.
5. Water samples can be collected (automatically?), stored and shipped back to laboratories during port-calls for analysis of parameters that cannot readily be measured at sea (e.g. samples for biodiversity analysis, 14C analysis).
6. Risk of equipment loss is minimal.

DISADVANTAGES

1. VOS measurements rely on the goodwill of shipping companies that have to operate in an increasingly competitive commercial environment. Goodwill alone is not a strong basis for long-term observations.
2. Although the record of VOS utilization for weather and climate-related measurements is good, one has to expect that shipping companies, officers and crew will have less direct interest in biogeochemical measurements such as surface pCO2 than they do in measurements that help them receive accurate weather forecasts.
3. Within-ship installations, which I consider essential for modern measurements, require a reliable source of pumped seawater and the means to dispose of this water easily and safely. On many ships this is a non-trivial issue.
4. Within-ship installations of biogeochemical measurement systems require space to establish equipment. Modern ships tend to have little free space.
5. Modern biogeochemical measurements may require expensive and elaborate installations. (The CPR requires only a davit and cable).
6. Commercial vessels tend to be re-assigned to alternative routes at short notice. This may require dismantling and re-installation of measurement systems on a frequent basis.This is a particular problem in the light of points 3,4 and 5 above.
7. Maintenance of such systems may require scientists to travel with the ship or service the equipment during short port-calls. Shipping company managers may worry that such arrangements could jeopardize their schedules. The possibility of crew members or officers helping with maintenance is small given the trend towards smaller, more efficient staffing of modern vessels.
8. Their may be a risk of clearance issues related to collection of scientific data in foreign waters that might jeopardize ships operations.

and so on…

RECOMMENDATIONS:

- A major effort should be made to utilize the commercial shipping fleet as a platform for making a suite of biogeochemical measurements of the surface ocean and also the atmosphere. The platforms are there, they can be used with existing measurement technologies, and the measurements are relevant to a wide-array of important scientific issues.
- Such an effort will have major repercussions for our ability to monitor and assess the consequences of global environmental change and the effectiveness of international measures taken to reduce such impacts.
- The difficulties facing better utilization of such platforms relate primarily to the ,volunteer' nature of the arrangement and recognition of the realities of the modern commercial shipping industry and their vessels.

I see a particular need to pursue the following 'big issues', starting now, if we are to be in the position to make extensive use of such platforms in the future.

- Effort must go into making small, modular, versions of modern analytical equipment that is capable of operating automatically for periods of up to several weeks. The modularity is essential for allowing failed units to be rapidly switched during short port-calls.
- The commercial shipping industry or international maritime organizations should be (carefully) approached concerning the possibility of designing "science capability" into the next generations of large commercial vessels. A standardized "science compartment" with standardized installations, including a reliable pumped water supply, would be a major step forward and allow for the flexibility of dealing with sudden routing changes. Similar facilities for making atmospheric measurements may be useful.
- The willingness of commercial companies to support science that is not in their direct interest should be recognized and even rewarded. Almost inevitably, some limited financial cost will be borne by the companies somewhere and somehow and this may jeopardize long-term operations. The possibility of such companies receiving some financial incentive to cooperate with observation programs should be investigated. Possibilities include tax benefits for the use of their vessels for research, direct payment, reductions in port fees, etc.

ANNEX VII

TIME-SERIES WORKING GROUP
TERMS OF REFERENCE

1. Define an initial set of locations for a global array of long-term time series stations for multi-disciplinary observations.

2. Develop the rationale for establishing and maintaining each element of the array including recommended minimum required measurements.

3. Complete a critical review of current and important previous sites. This includes identifying network gaps.

4. Continually review the set of locations in terms of new requirements.

5. Consider resources, logistics, data delivery.

6. Coordinate the implementation.

7. Coordinate the data transmission, formats, etc.

8. Carry out a liaison with complementary groups (e.g., ARGO) to ensure integration into the overall observing system.

9. Consider funding mechanisms for sustained observations.

ANNEX VIII

LIST OF ACRONYMS

ACSYS	Arctic Climate System Study
ACVE	Atlantic Climate Variability Experiment
ADCP	Acoustic Doppler Current Profiler
ADEOS	Advanced Earth Observing Satellite (Japan)
ALACE	Autonomous Lagrangian Circulation Explorer
ANIMATE	Atlantic Network of Interdisciplinary Moorings and Time-Series for Europe
AOML	Atlantic Oceanographic and Meteorological Lab (NOAA)
AOPC	Atmospheric Observing Panel for Climate
ASCAT	Advanced Scatterometer
ATOC	Acoustic Thermometry of Ocean Climate
ATSR	Along Track Scanning Radiometer
AUV	Autonomous Underwater Vehicle
AVHRR	Advanced Very High Resolution Radiometer
BC	Boundary Current
BECS	Basin-Wide Extended Climate Study
BMRC	Bureau of Meteorology Research Center (Australia)
BODC	British Oceanographic Data Center
BSH	Bundesamt fur Seerschiffahrt and Hydrographie (Germany)
CAS	Commission for Atmospheric Sciences
CAVASOO	Carbon Variaibility Studies by Ships of Opportunity
CDS	Computerized Documentation System
CLIC	Climate and Cryosphere
CTD	Conductivity, Temperature, Depth
DODS	Distributed Ocean Data System
CEOS	Committee for Earth Observation Satellites
CGOM	IOC Consultative Group on Ocean Mapping
CLIMAT	Report of Monthly Means and Totals from Land Stations
CLIVAR	Climate Variability and Predictability Program
CMR	Centre Meteorologico Regional
CNES	Centre Nationale d'Etudes Spatiales (France)
CRYOSAT	Ice Observing Satellite (ESA)
CSIRO	Commonwealth Scientific and Industrial Research Organization (Australia)
ECMWF	European Center for Medium-Range Weather Forecasting
EEZ	Exclusive Economic Zone
ENSO	El Nino Southern Oscillation
ENVISAT	Environmental Satellite
EOS	Earth Observation Satellite (US)
ERS	Earth Resources Satellite
ESA	European Space Agency
ESD	Earth Sciences Division
EUMETSAT	European Organization for Exploitation of Meteorological Satellites
FNMOC	Fleet Numerical Meteorology and Oceanography Center (US NAVT)
GCOS	Global Climate Observing System
GEBCO	General Bathymetric Chart of the Oceans

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

MERIS	Medium Resolution Imaging Spectrometer
METOP	Meteorological Operational Satellite
MJO	Madden-Julian Oscillation
MOC	Meridional Overturning Circulation
NAO	North Atlantic Oscillation
NASDA	National Japanese Space Development Agency
NCEP	National Center for Environmental Prediction (US)
NEG	Numerical Experimentation group
NIWA	National Institute of Water and Atmospheric Research (New Zealand)
NOAA	National Oceanic and Atmospheric Administration (US)
NPOESS	National Polar-Orbiting Operational Environmental Satellite System (US)
NPP	NPOESS Preparatory Program
NSCATT	NASA Scatterometer
NWP	Numerical Weather Prediction
OCTS	Ocean Color and Temperature Scanner
OGCM	Ocean General Circulation Model
OGP	Office of Global Programs (US)
OOP	Ocean Observations Panel
OOPC	GOOS-GCOS-WCRP Ocean Observations Panel for Climate
OOS	Ocean Observing System
OSSE	Observing System Simulation Experiment
PBECS	Pacific BECS
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 Oceans
PRA	Principle Research Area
QC	Quality Control
QSCAT	Version of Scatterometer
RMS	Root Mean Square
SAFZ	Sub-Arctic Frontal Zone
SBSTA	Subsidiary Body for Scientific and Technological Advice {of the COP for the UNFCCC}
SCOR	Scientific Committee for Oceanic Research
SIO	Scripps Institution of Oceanography
SLP	Sea Level Pressure
SMOS	Soil Moisture Ocean Salinity Satellite (ESA)
SOC	Specialized Oceanographic Centre
SOCIO	Sustained Observations for Climate of the Indian Ocean
SOCSA	Sustained Observations for Climate for the South Atlantic
SOOP	Ship-of-Opportunity Programme
SSIWG	Salinity - Sea Ice Working Group
SSS	Sea Surface Salinity
SST	Sea Surface Temperature
SURFA	Surface Reference Site
TAO	Tropical Atmosphere - Ocean (buoy array)
TEMA	Training Education and Mutual Assistance
TRMM	Tropical Rainfall Measuring Mission
TS	Temperature Salinity

UKMO	UK Met Office
UNFCCC	United Nations Framework Convention on Climate Change
UOP	Upper ocean Panel
UOT	Upper Ocean Thermal
VAMOS	Variability of the American Monsoon Systems
VIIRS	Visible and Infra-red Sensor (NPOESS Sensor)
VOS	Voluntary Observing Ship
WBC	Western Boundary Current
WCRP	World Climate Research Programme
WDB	WMO Data Base
WGASF	Working Group on Air-Sea Fluxes
WGNE	Working Group on Numerical Experimentation
WGSIP	Working Group on Seasonal to Interannual Predication
WHOI	Woods Hole Oceanographic Institution
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
WS	Workshop
XBT	Expendable Bathythermograph
XCTD	Expendable Conductivity Temperature Depth Instrument