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WORLD CLIMATE RESEARCH PROGRAMME (WCRP)

CLIVAR OCEAN OBSERVATIONS PANEL (OOP)
First Session
(Hobart, Australia, 27-30 March 2001)

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Meeting Highlights

The meeting considered several overarching themes:

- Sustained or quasi-sustained observations in support of CLIVAR research need to be made on a fully global basis. Realization of this goal will require special attention to Southern Hemisphere implementation. A key theme for this meeting was the objectives, requirements and plans for Southern Hemisphere observing systems

- The currently projected implementation of the Argo array will lead to significant progress in many areas of CLIVAR research.

- Expanded and improved information management and technology, such as standardized formats and improved data transmission capabilities are needed to enhance data return and increase utility of data from many observing platforms. The panel endorsed an open data policy for all sustained observations in CLIVAR. It recommended that the data be archived in a manner which is flexible and can absorb continued improvements. The OOP looks for the DTT to develop a specific plan to implement these requirements. The OOP emphasized that data management must be intrinsic to each observing element and groups organizing these elements should have a data management plan and report to the OOP on its development.

- Significant progress has been made in planning for time series observations and repeat deep hydrography in support of CLIVAR and in coordination with other disciplines. Coordination with carbon community in particular should be vigorously pursued. The panel was encouraged to hear about the formation of the Time Series Working Group, which was to meet the week of May 20, 2001, in Woods Hole.

- Planning for satellite missions is very promising. CLIVAR should encourage further investigations with the data in support of CLIVAR research.

- The panel reviewed major projects being developed by GOOS and GCOS through the OOPC and AOPC. The OOP recommended that other CLIVAR panels evaluate the utility for climate research of improved products from the OOPC SST projects and the GODAE. OOP and the DTT need to provide CLIVAR inputs to the GOOS Ocean Information Technology and Management Initiative.

- The panel reviewed plans for CLIVAR implementation in the Pacific, Indian and Southern Ocean basins. The panel was pleased to see plans developing for the Southern Ocean. This work is needed to ensure the full global implementation of the observing system. Formation of a CLIVAR Southern Ocean Panel was encouraged. The work on plans for the Indian Ocean is promising and will be reviewed annually. The OOP will review plans for the ocean observing component of AAMP projects on an annual basis, with particular attention to facilitating coordination among the participating nations. The panel discussed a report of the outcomes of the CLIVAR Pacific Workshop, held in Honolulu in February. The OOP members felt in a position to ensure the necessary coordination amongst elements which are going forward and recommended that further workshops be held to advance planning in this basin, as appropriate.

Conclusions/Recommendations

The OOP review of the global ocean observing system in light of CLIVAR requirements lead to the following conclusions and recommendations:

1. ARGO

The level of proposed and funded commitments (reported at the ARGO Science Team meeting in March, 2000) is encouraging. OOP lauded the ARGO Science Team for its success in getting international participation in the array. Global coverage at desired spacing looks possible. OOP reemphasized the need for full global distribution of the floats and urged the ARGO science team to continue pursuit of this goal with contributing nations. Additional commitments to the Southern Hemisphere are needed.

Because of the high level of national support for this project it will be necessary to expand the capacity to build floats and CTDs to meet the currently projected timetable.

The lack of an adequate telecommunication system remains a major problem.

Current plans for data management involve many national data centers and more than one central repository. The OOP asked the ARGO team to develop a means of assessing whether the data system was functioning well and report to the OOP at such a time as an assessment was possible.

2. XBT network

OOP endorsed findings of the XBT review team and expressed concern that the projected probe supply would not allow full implementation of the new high density/ high frequency network design. Once again, OOP stressed the need for coverage in all parts of the world ocean and urged the SOOPIP to implement designated lines in the Southern Hemisphere wherever possible. In particular, support for zonal sections to close the Indian and South Atlantic Ocean was encouraged.

Concern was expressed as to the effectiveness of certain aspects of the existing data quality control and archiving systems and OOP suggested that JCOMM might want to take this under review.

SOOPIP was encouraged to pursue coordination of all aspects of voluntary ship utilization. Thermosalinographs will be a particularly valuable resource given the prospects for remote sensing of salinity. Again, coordination with the carbon community needs to be explored.

3. Tropical Moored Arrays

The OOP noted with satisfaction the successful implementation of the TAO/Triton array through very fruitful cooperation between the US and Japan. It noted, in particular, that the goal of making the data flow transparent to user had been met.

OOP recommended that the continued risk of vandalism should be taken into account when developing observational strategies and that alternative technologies such as gliders or aerosondes should be considered in areas of particularly high risk.

Encouraged by Japanese pilot deployments and the interest by several other countries in Indian Ocean moorings, the OOP urged the AAMP to foster the coordination of these plans.

Concern was expressed that the long term future of the PIRATA array in the Atlantic will be too heavily based on its impact in seasonal to interannual climate prediction. The WGSIP should be involved in the evaluation of this system to estimate the array's value for CLIVAR research.

4. ENSO Observing System Review

The panel expressed concern over the discrepancy between the expectations for the ENSO review and the tools available to do the evaluation. The value of the ENSO observing system for research purposes should not be underestimated. OOP will nominate a member of research community to represent CLIVAR interests (Kessler to approach Davis). The WGSIP and, perhaps, AAMP should also identify their interests for this review and nominate a person to participate.

5. Deep Repeat Hydrography

OOP fully endorsed the requirement for deep hydrography in support of climate change detection as developed by C. Sabine et al in the informal report “The need for continuing global deep ocean ocean surveys”. Koblinsky will investigate with US agencies and other potential funders whether further coordination is needed between the carbon, geochemical tracer and physical oceanography communities to develop a coordinated implementation plan. Wijffels will continue discussion of plans at the WOCE/JGOFS transport workshop this July. OOP noted that there would be a requirement for a high quality data archive in support of this effort.

6. Satellites

Many missions, which will contribute data vital to CLIVAR science, are in space or under development. Continuity of topography, winds, and surface temperature measurements for this decade looks very promising. At future meetings OOP will discuss specific research questions of relevance to CLIVAR which could benefit from application of the resulting data. OOP will discuss these objectives with space agencies and encourage appropriate climate research opportunities in future research announcements.

OOP Chair to write to GEWEX IPO requesting an update on plans to bring ISCCP data up to date and stressing the CLIVAR requirement for this data. [DONE – NASA/Langley Research Center plans to process these data through 1995 by the end of 2001, and 1998/99 by mid-2002.]

7. Ocean Information Technology

OOP noted that current data transmission capabilities were severely limiting in many ocean observing systems. The Panel supports the concept introduced by N. Smith (OOPC) to escalate research into improved data transmission and handling systems in support of operational oceanography and CLIVAR. OOP will assist in organization of a workshop on this topic. The outstanding requirements for research applications should also be brought to the attention of JCOMM.

8. Boundary Currents

OOP underlined the requirement for determining heat and volume transports in boundary currents (WBCs) in all ocean basins. It noted encouraging results using high density XBTs in conjunction with satellite altimetry data and urged further application of this technique where feasible. OOP is looking forward to demonstrations of the "glider" instrument capabilities currently under development (Once again, telecommunications may be a critical limitation). Given promising new techniques and developing applications, OOP recommended that the interested community consider a workshop to review techniques and assess future opportunities and requirements for boundary current measurements. A “virtual workshop” on WBCs is currently underway, led by the University of Rhode Island.

9. Fluxes

OOP fully supported the need for surface reference sites as put forward in the SCOR-WCRP Fluxes WG report and the report of SURFA working group. The panel recommended that SURFA in conjunction with the Time Series Science Team determine a shortlist of the first 3-5 priority sites that they would expect to be deployed. This short list should include strong scientific justification for their selection and an indication of parties who will commit to carrying out the deployments. In light of the specific major areas of uncertainty in the heat exchange raised during the discussion, the panel suggested that the priority sites should include one deployment in each of the following key exchange regions:

a) The Gulf Stream / Kuroshio areas of maximum ocean heat loss towards the western boundaries of the Northern Hemisphere ocean basins.

b) Southern Ocean (55-65 S band). It was repeatedly noted during the panel discussions that at present no high quality in situ flux estimates exist for the Southern Ocean.

Despite technological and logistic challenges, the Time Series Science Team (TSST) should pursue deployment of one or two reference sites in the Southern Ocean, in coordination with other parties interested in instrumenting such a site. Send will carry forward in discussion at the time series workshop and discuss with Bob Weller (SURFA rep on the TSST). Josey will discuss at flux workshop in May.

The OOP encouraged efforts to include baseline ocean surface observations in the VOSClim programme for extending reference concept to VOS.

The OOP recommended that a study be undertaken to determine the impact of scatterometer winds on improving flux estimates from operational models.

10. Time series measurements

U. Send reported very encouraging progress in developing strategies for ocean observatories including flux reference sites, multi-disciplinary stations, and transport observing sites. OOP asked for a report at its next meeting on which sites were operational or planned and on recommendations arising from the workshop in May 2001.The creation and maintainance of these sites could be an important legacy from CLIVAR.

11. Monsoons

Argo floats with high resolution XBT/ XCTD lines at boundaries will allow for significant progress in closing transport estimates and should therefore constitute an important element of any observing system in the Indian Ocean.

The OOP encouraged the Indian Ocean Argo implementation meeting to consider a requirement for possible modification of float parameters for monitoring intraseasonal variability in the Indian Ocean.

Since SST is a key variable in this region, evaluation of the new SST products and SST observing systems should be carried out by the AAMP.

OOP needs to foster Ocean GCM intercomparisons in this region, including evaluation of GODAE products; perhaps a topic for future meetings.

20°S in the Indian Ocean should be a high priority for a surface flux reference site. There is also a need for improved river and rainfall data throughout the region to close the freshwater budget. (Letters of support for Global Precipitation Mission are needed).

The panel heard with interest various plans for process-oriented studies in Indian Ocean and S. China Sea. The need for development of a full column ocean observing system over the entire Indian Ocean basin to meet a variety of CLIVAR needs was discussed. The SOCIO meeting in Perth in November of 2000 was an excellent step in this direction. The AAM Panel, in cooperation with OOP, should continue to develop these plans.

12. Ocean Assimilation

OOP recognized that significant progress was being made with ocean data assimilation systems, but that presently none were sufficiently mature to take full advantage of all available observations. The OOP encouraged development in this area and noted that, in light of current capabilities, results from Observing System Simulation Experiments (OSSEs) and Observing System Experiments (OSEs) must be interpreted with care.

13. Surface Network

The panel heard a report from the Drifting Buoy Cooperation Panel and agreed to review in more detail developments in the surface network at its next meeting. The importance of surface pressure observation in the Southern Ocean was reiterated.

14. Acoustic Tomography

Impressive new results were reported which indicated that acoustic techniques could form an element of the CLIVAR observing system. The OOP supports ongoing efforts to develop common software packages for data analysis and common data formats to facilitate usage of these data by the broader CLIVAR community.

15. Monitoring

The panel recommended that the ICPO track the development of the observing system in terms of funded activity, planned activity and proposed activity. The CLIVAR web site should include a link to data sources for all CLIVAR observing elements.

1. Introduction

The first meeting of the CLIVAR Ocean Observations Panel was held March 27 to 30, 2001 at the CSIRO Marine Laboratory in Hobart, Australia. The Chair, C. Koblinsky, briefly reviewed the Panel's mandate and history noting that it was to fill the role previously held by the CLIVAR Upper Ocean Panel, but with a purview which extended throughout the water column. Close consideration would be required with individual ocean basin panels in formation and with the Ocean Observations Panel for Climate which was meeting the following week in Melbourne, Australia. C. Koblinsky welcomed Panel members and guests (see Appendix 2 for List of Participants) and thanked in particular N. Bray, G. Meyers, A. Schillar, and B. Marshall of CSIRO for providing excellent hospitality and support for this meeting. The agenda, as given in Appendix 1, was adopted.

2. Ocean Observations Panel for Climate (OOPC) Report (*N. Smith*)

The GODAE Strategic Plan

The International GODAE Steering Team (GIGST) had met twice over the last year (GODAE IV, Southampton, May 2000 and GODAE V, Noumea, February 2001). The GODAE homepage is: http://www.bom.gov.au/GODAE/ and the GODAE Strategic Plan has been published at: http://www.bom.gov.au/GODAE/Strategic_Plan.pdf

The Strategic Plan presents the approach GODAE is taking to the development of needed components. In several cases GODAE does not have the lead and is encouraging enhancements and adaptations to meet its requirements. In other cases, GODAE is being pro-active to ensure the needed capacity is in place.

The Plan discusses the rationale and scope for GODAE including the vision and objectives. The reasons for acting now are presented. Perceived benefits and prospective users are noted and a list of specific outcomes given. The legacies of GODAE will include a better, integrated sustained ocean observing system and global operational oceanographic systems maintained by several nations.

GODAE is being guided by a set of principles and guidelines. The concept of a GODAE Common is being used to foster free and open exchange among the GODAE Partners. The Common comprises data, products, servers, and the accumulated knowledge base. The essential elements of GODAE are observational networks, models and estimation tools. The generation of globally consistent fields of the ocean state through the synthesis of multivariate satellite and in situ data streams with models is an identifying characteristic of GODAE. The unique nature of GODAE includes:

- The development of coherent, organized data sets
- Synoptic ocean analyses and hindcasts
- Short-range ocean forecasts
- Reanalyses and initial conditions for climate forecasts
- Statistical Characterization of Products
- A Dedicated Improvement Cycle

The Plan also discusses implementation concepts, the GODAE functional components (servers, centres, etc.) and GODAE phases. A transition phase (2006-2007) has been added to accommodate the transition of GODAE systems to operational support. The Plan recognizes the importance of developing both objective and subjective metrics to measure the success or otherwise of GODAE.

GODAE High-Resolution SST Project

On the basis of the Prospectus issued in April 2000, around 28 scientists were invited to a Workshop in Ispra, Italy to debate the prospects for a Pilot Project. The participants unanimously agreed to develop a Pilot Project within the framework of GODAE (see http://www.bom.gov.au/GODAE/HiResSST/ for a full report). The aim of the project is to develop high-resolution SST data sets and products using all available remote and in situ measurements and scientifically defensible definitions of SST.

A strategic plan will be developed focussed around 4 themes.

(i) Testing, proving and refining the data sources
- Distinguish (a) Skin SST; (b) sub-skin SST; and (c) Bulk SST
- Diagnostic Data Sets (DDSs)
- Regional gathering and assembly
- Global intercomparisons

(ii) Integration and assimilation: the data providers

(iii) Users and application: the data users

(iv) Research and Development
- e.g, shallow profilers
- Radiometers on VOS/SOOP

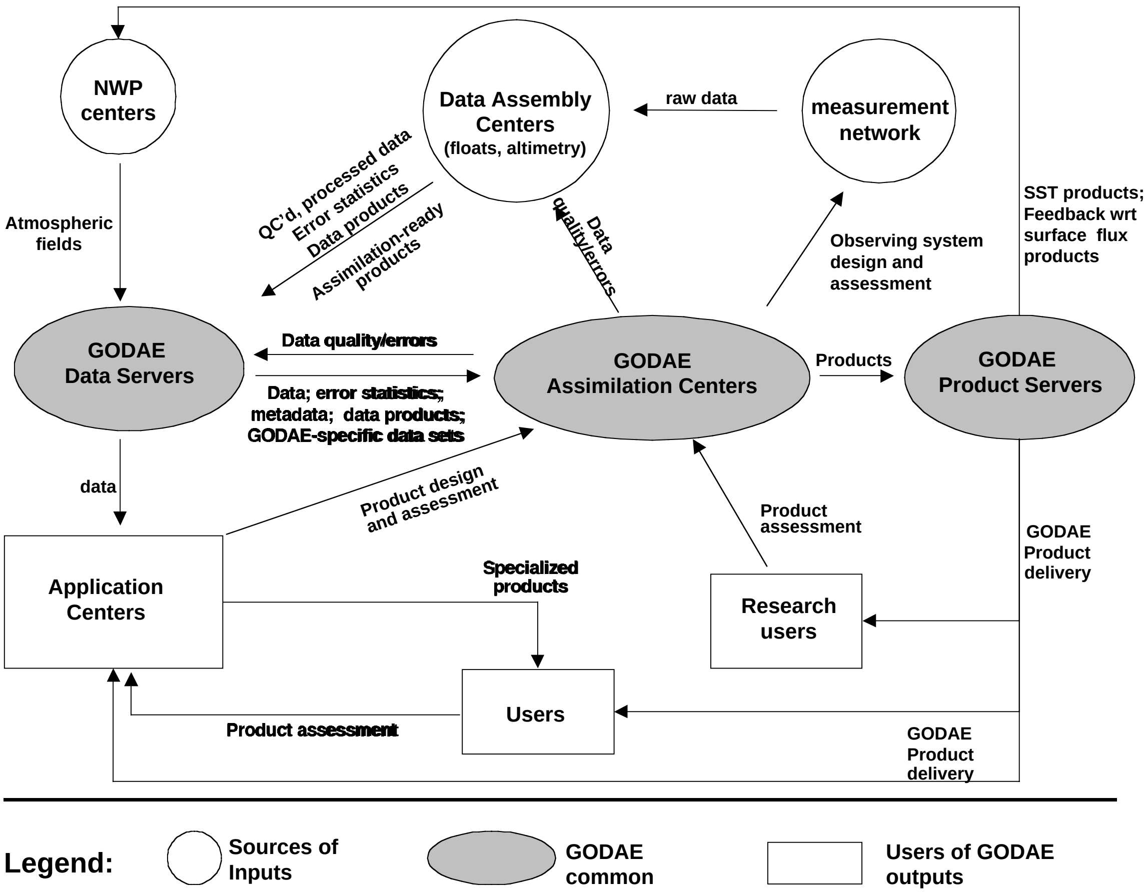
A project Science Team has been approved for oversight of the Project (C. Donlon, Joint Research Centre (JRC), is the Chair). The development of the project will follow the method used for Argo and Terms-of-Reference follow the guidelines developed by GODAE for Pilot Projects. The Strategic Plan will be reviewed by advocates and non-advocates with a tentative data for the first draft of mid-2001.

The IGST believes this Project will make a valuable contribution in several areas. For example, it will exploit synergy with the SURFA project and the assembly and data serving will be used for other parts of GODAE.

The GODAE Implementation Plan

The GODAE Implementation Plan (IP) is being constructed around the functional components diagram shown in Figure 1 (from the Strategic Plan). The Plan will discuss each of the elements (inputs, servers, assimilation centers, users/application centers) as well as the interfaces between these elements. Substantial plans have been provided as the basis for the GODAE Common. As is noted in the following section, considerable progress has already been made toward implementation, though the IGST also recognizes that much work remains to be done.

A first draft of the Implementation Plan was produced for GODAE V. The overall structure was endorsed and commitments gained for all the sections of the Implementation Plan. It is hoped that by around July a second, more complete draft can be circulated. The first full draft will be available by around November and will be reviewed at GODAE VI (to be hosted by the Navy Oceanographic Office, Stennis, Dec 4-7).



Specific GODAE Activities

Figure 1. A schematic showing the functional components of GODAE. The shaded components are within the GODAE Common and their development is primarily the responsibility of GODAE.

National Contributions. Descriptions of national activities have been received from Australia, Japan, France, Norway, the U.K. and the U.S.A. While in most cases there is no specific budget line for GODAE, commitments have been built on existing activities and, in some cases, enhanced operational center activity. A list of existing related sites is given in Table 1.

Some prototype systems are now available though in several cases they are in the early stages of development. What is clear is that high-quality, interesting and potentially valuable products are now emerging. Further investment is required but, based on the existing and potential contributions, it would seem GODAE is not greatly off schedule.

Table 1: List of GODAE Product / Activity Sites

GODAE Home Page	http://www.bom.gov.au/GODAE/
MERCATOR Ocean Bulletin	http://www.mercator.com.fr/

Argo Home	http://www.argo.ucsd.edu/
HiResSST Project	http://www.bom.gov.au/bmrc/mrlr/nrs/oopc/godae/HiResSST/
HICOM	http://hycom.rsmas.miami.edu/
DIADEM	http://www.theyr.com/diadem/
TOPAZ	http://www.halo.is/
NAVOCEANO	http://www.navo.navy.mil/
FNMOC	http://www.fnmoc.navy.mil/
NRL Modelling	http://www7320.nrlssc.navy.mil/global_nlom/
US GODAE	http://www.usgodae.fnmoc.navy.mil/
Bathymetry (BODC)	http://www.bodc.ac.uk/
UK Met Office	http://www.met-office.gov.uk/
UK Met Office European Shelf Seas Data Assimilation and Forecast Experiment (ESODAE)	http://www.met-office.gov.uk/sec5/ESODAE/ESOHOME2.html
Met Office Met Office Forecasting Ocean Atmosphere Model (FOAM)	http://www.met-office.gov.uk/sec5/OA/FOAM/FOAM.html

NWP Products and fluxes. To some extent, GODAE must work with what is available. However, because of the relationship between several of the national activities and existing operational entities, it is hoped some actions can be taken to enhance products (e.g., through the SURFA project). A letter has been drafted for the attention of ECMWF requesting access to operational surface products, in real-time, for GODAE Partners.

Data Assembly Centers. The SST and *Argo* project provide good examples of the demands being placed for good data set assembly. Specific actions are taking place for altimetry, SST and surface winds (also *Argo*). It remains unclear whether adequate radiation products will be available. New bathymetric data should be available mid-year from GEBCO (GODAE will probably use this as a standard product). GODAE is recommending the establishment of an ocean current data assembly centre, operating in real-time. No such entity exists now.

Data and Product Servers. The establishment of the US GODAE Monterey Server is the most significant recent development. This site will provide access to all GODAE data (either directly or via distributed access) as well as providing a range of products. A similar facility is being established in France. It is likely a project will be established around this theme as there are many interesting new developments that GODAE wishes to promulgate through its community. There are significant issues concerning coordination of the sites and ordered arrangements
and access to information. The likely establishment of a further site at the IPRC (Honolulu) may provide an orderly procedure for migrating data from the Monterey site to climate servers.

NAVO has also announced that many of its formerly non-public models will now be made public through a server established at Stennis. The openness of the US Navy data and product systems has set a high “standard” for other GODAE partners.

Product Characterization. This will be an important aspect of GODAE activities. In effect, it is the quality assurance process for GODAE products. Two projects were approved by the IGST at GODAE V.

(i) A GODAE Atlantic Prototype Project. The objective is to use the Atlantic as a prototype to test and evaluate functionality needed for and appropriate to the global experiment (data access, assimilation and forecasting, products, …).

(ii) A Pacific Model and Product Intercomparison. This project will intercompare products in the North Pacific Ocean, principally for the mesoscale fields, and in the tropical Pacific for climate prediction. A Workshop is to be held at the IPRC in July to develop details. This workshop will also discuss applications, data assimilation issues and the potential implementation of the IPRC data server.

Applications. Several exciting applications are now emerging or proposed. For example, the Norway-led DIADEM and TOPAZ projects are providing experimental analyses and forecasts to the oil and gas industry, at resolutions of around 2 km. Most national plans include significant applications and user involvement.

GODAE Conference. GODAE V accepted a French proposal to hold a 3-day Conference, in Biarritz, France, 13-15 June 2002. Details are available at:
http://www.cnes.fr/BIARRITZ2002

Summary

- The GODAE Strategic Plan is published and a draft of the Implementation Plan is available. The Implementation Plan should be published by February 2002.
- A new Pilot Project has been initiated to develop high-quality, high-resolution SST data sets and products.
- The *Argo* Pilot Project is progressing well with the most significant unresolved issue being long-term subscription to remote areas needed for a global array.
- Significant activities in data set development, data and product servers, prototype model assimilation systems and applications have been reported.
- While progress has not been strong on all fronts, the evidence from GODAE V is that developments are on track for the intensive phase 2003-2005.

3. Atmospheric Observation Panel for Climate (AOPC) Report (*M. Manton*)

Michael Manton, Chair of AOPC, described the GCOS strategy of the development and maintenance of two types of end-to-end systems. Baseline systems provide long-term high-quality consistent homogeneous data of key elements of the climate system. These observations provide benchmarks or calibration for the comprehensive systems that use all the available data for assimilation in models.

Baseline systems for monitoring land-based surface and upper-air variations are being established in cooperation with WMO and its member National Meteorological Services. The AOPC is keen to work with other groups, such as the CLIVAR OOP, to establish similar baseline systems for observations over the ocean. Under the leadership of the WMO-IOC JCOMM, AOPC expects the VOSClim program to evolve to provide baseline surface observations over the global ocean. Eventually the 200 VOSClim ships should be carrying IMET packages to ensure the quality of their data.

Baseline upper-air observations over the ocean can be produced through increased deployment of Automated Shipboard Aerological Programme (ASAP) containers on VOSClim ships. At present the focus of ASAP containers tends to be in the North Atlantic. However, collaboration between USA, UK and Australia is leading to the introduction of an ASAP container on a ship that routinely traverses the Southern Ocean. It is expected that JCOMM will encourage further deployment of these containers.

OOPC and AOPC jointly sponsor a SST-SI Task Group. With the new focus on high-resolution SST analysis being developed in GODAE, the OOPC-AOPC Task Group is expected to have an increasing emphasis on sea-ice analysis, as a significant cause of uncertainty in global SST analyses.

The AOPC is establishing a task group, led by Rob Allan of UKMO, to focus on the analysis of surface pressure for climate purposes. In addition to the inherent relevance of the surface pressure distribution to climate, it also provides a means for estimating the distribution of surface winds away from the tropics.

The outstanding need for the satellite agencies to recognise the importance of baseline climate observations was discussed. Recent reports from the USA National Research Council highlight the need for satellite data to comply with the basic requirements for consistency, calibration and meta-data for climate purposes.

The AOPC is placing increasing emphasis on the generation of GCOS products that provide useful outputs from the program. Initial products will be indices of the state of the global climate based on point data, e.g. from the GCOS Surface Network. However, a new project is being developed, led by Ed Harrison, to develop a small number of orthogonal indicators of global climate representing broad-scale features of the general circulation.

A further activity, related to the generation of products, will be a contribution to the GCOS adequacy analysis of the global climate system being developed under the next few years for the Coastal Ocean Program (COP) to the Framework Convention on Climate Change (FCCC). The adequacy analysis is expected to be developed by the science community and accepted by policy makers, so as to provide an internationally-accepted framework for maintaining and enhancing the global climate system.

In general discussion, it was noted that pressure sensors on drifters in the Southern Ocean have a substantial impact on the analysis of pressure, and hence on the overall analysis of the meteorology of the southern hemisphere. The importance of the flux reference sites to AOPC was emphasised. In particular, there is a strong case to identify priority sites for initial implementation, where the sites are relevant to monitoring both the ocean and atmosphere. Finally it was also noted that research vessels often do not routinely report real-time meteorological data. The inclusion of research ships, such as the Antarctic supply vessels, could have a significant impact on the VOSClim program in regions that are poorly sampled by commercial ships.

4. Pacific

4.1 CLIVAR Pacific Plans and Implementation (W*. Kessler*)

An international Pacific Workshop was hosted by the IPRC in Honolulu in early February 2001. About 75 scientists from around the Pacific Rim attended and reported on work that they are doing or planning for the next few years. Recommendations from the workshop will probably result in the formation of a CLIVAR Pacific Panel this year.

Notable work reported on at the workshop included extensive studies in the eastern tropical Pacific under the aegis of EPIC (US) and VAMOS (international). An intensive set of fieldwork will occur in 2001 along 95W, focusing on the transition from the east Pacific cold tongue to the ITCZ and warm pool north of the equator. Other work in this project focusses on the stratocumulus decks off the coast of South America, including studies of the coupled ocean-atmosphere boundary layers, and the relation between the stratus decks and convection over South America. Peru, Ecuador and Chile have been granted World Bank funding for climate research, and will contribute to work in the eastern Pacific. Peru already has two TAO-type moorings in the water and Ecuador has similar plans.

Other ongoing and funded work is occurring in the Kuroshio Extension region. The Kuroshio Extension System Study (KESS) program is funded in Japan; funding for the US element of KESS was declined by NSF (proposal will be resubmitted). KESS is designed to provide a detailed look at the ocean-atmosphere heat balance over a five-year period, including advective fluxes in the Kuroshio, mixing across the front, and air-sea fluxes, especially when winter cold outbreaks blow cold dry continental air over the relatively warm Kuroshio water.

CLIVAR interests in the Pacific have three main scientific focii: ENSO, the decadal modulation of ENSO, and decadal variability in mid-latitudes. In many respects the same observations are needed for all these phenomena.

Scientists at the workshop argued that ENSO is not a solved problem, as skill in forecasting less-than-extreme events remains weak. Although many models simulate the growth and development of El Nino events reasonably well, the dynamic and thermodynamic balances in these models are different, indicating that we do not have a clear description of the factors influencing the ENSO cycle beyond the gross characteristics. The CLIVAR strategy proposes significant improvements to the observing system, including limited-duration process studies to examine the mechanisms that mix and upwell thermocline water to the surface and thereby foster ocean-atmosphere coupling. The aim of these studies is to improve the parameterization of the vertical exchange processes in models so that the sustained (sparse) ENSO observing system can provide the information needed to properly simulate these balances.

There are many theories for the decadal modulation of the ENSO cycle, and this field is wide open. A key element appears to be modulation of the mean depth of the equatorial thermocline, which determines the sensitivity of equatorial SST to changes in the equatorial winds. One set of ideas holds that slow modulation can be achieved through the slower timescales of the subtropics, and mechanisms can involve changes in the water properties subducted in the eastern subtropics that are advected on decadal timescales to the equatorial thermocline. Another possibility is that changes in the wind forcing in the subtropics modulates the strength of the circulation bringing water to the thermocline, or changes its depth because of changes in the Ekman divergence. The CLIVAR strategy is to improve observations and analyses of the basin-scale fields so the slow evolution (including property advection) can be viewed as a whole. Argo, in conjunction with altimetry, is key, as well as learning how to monitor the western boundary currents. These observations will have to be assimilated into OGCMs in order to produce the complete fields so the advective terms can be estimated.

Decadal variability of the North Pacific has important impacts on fisheries and climate, especially over the Pacific Northwest from California to Alaska. A prominent decadal signature, known as the Pacific Decadal Oscillation (PDO) has a spatial pattern resembling a broadened ENSO signature, with one sign from the eastern equatorial Pacific along the American continent to Alaska, and the opposite sign in the central North Pacific. It is unclear if the PDO is just a reflection of the low-frequency modulation of ENSO, broadened because low-frequency Rossby waves have wider meridional scales, or if it is a separate, entirely mid-latitude signal, as suggested by some coupled models. A key question is the degree to which the mid-latitude atmosphere feels changes in mid-latitude SST, which is quite controversial. Another mechanism for low-frequency variability of the North Pacific is due to the large heat fluxes in the Kuroshio Extension region, when winter cold-air outbreaks blow cold dry continental air over the warm waters of the Kuroshio. If either the Kuroshio transport or the cold outbreaks vary, then the change in latent heat flux could be very large. The CLIVAR strategy again involves taking the observations to depict the slow evolution of the gyre, including Argo and altimetry, along with process studies (e.g. KESS) to understand the ocean-atmosphere changes associated with variability along the Kuroshio Extension.

4.2 Thermocline ventilation of the North Pacific (*T. Suga*)

T. Suga presented a paper on the subduction rate for the North Pacific based on new climatology of winter mixed layer and subsurface hydrography along with Hellerman and Rosenstein wind stress data.

The most important difference of the new estimation from previous ones is the use of the new mixed layer climatology this is gridded with smoothing over fairly small spatial scale and thus retains realistic water mass structure near frontal zones and boundary regions. The subduction rate distribution in space, density and T/S domains clearly shows that the mid-latitude thermocline is ventilated primarily through intense subduction from a few locations corresponding to the formation regions of subtropical Mode Water, Central Mode Water and Eastern Subtropical Mode Water. That is, the T/S relation in the main thermocline is maintained largely by the formation of the mode waters with rather confined water properties. The new estimation also reveals difference in major mechanisms of formation among these mode waters. These features of the thermocline ventilation provide targets to be monitored by observation systems and to be reproduced by numerical models.

4.3 Sea surface salinity variability in the western tropical Pacific.(*Y. Gouriou*)

Y. Gouriou outlined two studies of sea surface salinity variability in the western tropical Pacific showing that influence of SSS on dynamical and thermo-dynamical air-sea interactions involved in the El Niño Southern Oscillation events. Here two studies are presented.

In the first one, by T. Delcroix and M. McPhaden, SSS in the Western Pacific warm pool (130°-180°E, 10°N-10°S) is analyzed for the period 1992-1999 taking advantage of complementary data from the VOS programme and the TAO array of moored buoys. Information on SST, surface wind stress, surface zonal currents, evaporation, and precipitation is also incorporated. These fields all go through large oscillations related to the ENSO events. In particular during the 1997/98 El Niño, precipitation minus evaporation increased in the equatorial band east of about 160°E, in conjunction with anomalous westerly wind, eastward surface currents, and a decrease in SSS. Opposite tendencies were evident during the subsequent strong 1998/99 La Niña. A proxy indicator for barrier layer formation is developed in terms of changes in the zonal gradient of SSS. Correlation between changes and SST changes few degrees longitude to the west is significantly non-zero, consistent with the notion that increased barrier layer thickness is related to warmer SSTs during periods of westward surface flow associated with La Niña, and vice versa during El Niño. The role of equatorial Rossby waves is examined regarding their effects in affecting barrier layer thickness west of 160°E.

In the second study, by Y. Gouriou and T. Delcroix, SSS and SST data collected from ships of opportunity (1976-1999) are analyzed in the South Western Tropical Pacific (SWTP - 10°S-24°S/160°E-140°W) for a 24 year period. This region lies below the South Pacific Convergence Zone (SPCZ), at the southern edge of the Western Pacific warm pool. Complementary data such as precipitation and pseudo-windstress are used to help in the analysis. The mean and seasonal variations of those parameters are described. An EOF analysis of the low-pass filtered time-series is then performed to extract the interannual variability.

All parameters depict an interannual signal that is well correlated with the SOI. The South Western Tropical Pacific is saltier and colder during El Niño events than during La Niña ones. There is a deficit (excess) in precipitation and northward (southward) anomalies of the meridional component of the pseudo-stress during El Niño (La Niña) events. Together with consistent precipitation changes, the interannual variability in SSS can be partly explained by the displacement of the salinity front that delimits the fresh warm-pool waters from the salty subtropical waters. Computation of geostrophic current anomalies from Topex/Poseidon indicates that significant westward anomalies of current developed during the 1997/98 El Niño, in phase with the displacement of the salinity front. The South Western Tropical Pacific salinity front moves westward (eastward), in contrast with the equatorial salinity front which moves eastward (westward) during an El Niño (La Niña) event.

5. Southern Ocean (*S. Rintoul*)

Steve Rintoul reviewed the present status of Southern Ocean CLIVAR. Substantial progress has been made in recent years in understanding the links between the Southern Ocean and climate. These advances were reviewed at a workshop held in November 2000 in Perth, Australia. The workshop was sponsored by the Climate Variability and Predictability (CLIVAR) and Climate and the Cryosphere (CliC) programmes of the World Climate Research Programme. About 35 scientists participated in the workshop, including representatives from all the major nations involved in Southern Ocean research.

The workshop highlighted significant progress in a number of areas since the Science and Implementation Plans for CLIVAR had been written. As a result of these advances, it is now possible to define a coherent set of integrated experiments targeted at Southern Ocean phenomena of direct relevance to climate. The workshop concluded that the plans must evolve to reflect the scientific progress made, and that a CLIVAR/CliC Southern Ocean Panel was needed to coordinate the revision of the plan and its implementation. Proposed terms of reference and panel membership was to be submitted to the CLIVAR SSG meeting in May 2001 for approval.

The workshop concluded it was useful to organize Southern Ocean CLIVAR into four main research themes: the "shallow" overturning cell, the "deep" overturning cell, interbasin exchange, and teleconnections and low-frequency variability. A strawman plan for the system of sustained observations and process studies needed to address these themes has been prepared.

While a perhaps surprisingly large number of commitments have been made to carry out elements of the plan, significant gaps remain. Argo is a particularly high priority in the Southern Ocean: each of the major research themes requires broad-scale measurements of upper ocean temperature and salinity - the only feasible way to attain such measurements in a remote region like the Southern Ocean is with Argo. More accurate surface fluxes are another high priority. Additional work is required to define the optimal mix of observations (reference stations, VOS measurements, drifters, ocean transport calculations, etc.) needed to improve and validate the flux products from reanalyses.

There was some discussion of the scientific questions CLIVAR would not be able to address if sustained observations were not made in the southern hemisphere oceans. These issues include: variability of the overturning circulation; decadal variability of ENSO; ocean uptake of carbon; climate change detection and attribution; variability of regional climate in the southern hemisphere; basin-scale heat and freshwater budgets; global temperature response to greenhouse forcing; centennial variability; and sea level rise. An important role for COOP is to continue to advocate strongly for a truly global observing system, so that issues of critical importance to CLIVAR can be addressed.

6. Monsoon/Indian Ocean

S. Godfrey introduced this topic with a brief review of some recent research on monsoons. He emphasized that improved understanding of monsoon predictability was a major challenge for CLIVAR and that it would require a judicious mix of modelling and process studies and enhancements to the observing system. He noted that significant progress had been made in outlining observation requirements for the Indian Ocean at the Ocean Observations 1999 meeting in San Raphael, France and at the more recent meeting on Sustained Observations for Climate in the Indian Ocean (SOCIO) held in Perth, Australia in November 2000.

6.1 Indian Climate Research Programme (*P. Vinayachandran*)

P. Vinayachandran began by noting that understanding and predicting the variability of the Indian monsoon is extremely important for the well-being of over one billion people and the diverse flora and fauna of the region. The monsoon is strongly coupled to the warm oceans surrounding the Indian subcontinent. One of the major objectives of the Indian Climate Research programme (ICRP) is to understand the oceanography of the seas around India and the nature of their coupling to the atmosphere. Towards this goal ICRP has undertaken two national experiments: namely BOBMEX and ARMEX. The BOBMEX was successfully carried out during July-August 1999. Observations of the atmosphere, ocean and air-sea interface unravelled hitherto unknown intra-seasonal variability of the ocean atmosphere system over this region. The ARMEX is planned for 2002 and its primary objective is to understand the role of the ocean on the onset of summer monsoon along the west coast of India. There are currently 12 meteorological ocean buoys in the Arabian Sea and Bay of Bengal, monitoring the seas around India (See Fig (1) for a map of ongoing committed and proposed ocean observations in the Region. Finally, the proposed ARGO floats array is expected to provide the subsurface ocean data that would help to understand the response of the north Indian ocean to monsoons.

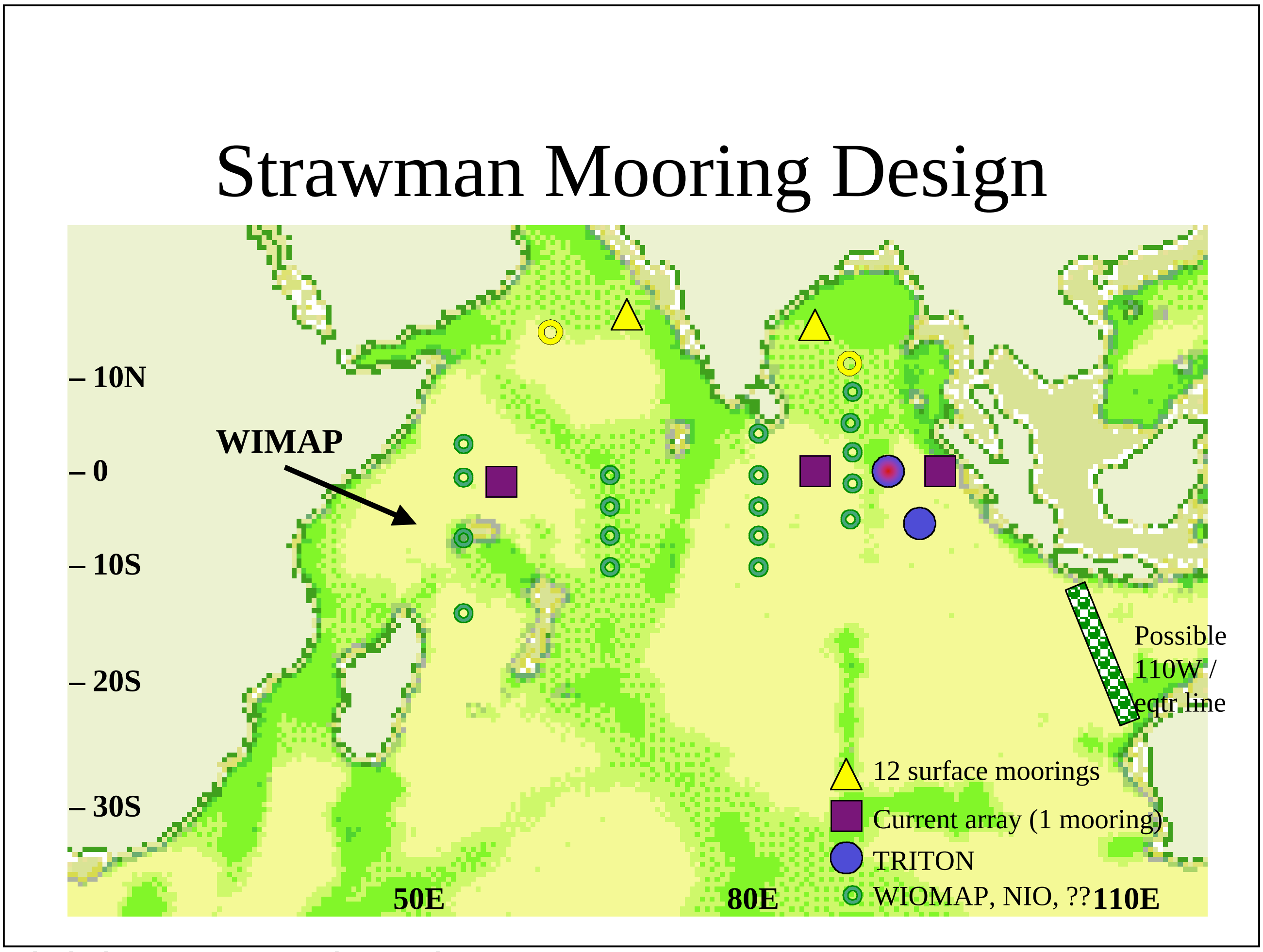


Fig (1a) Strawman-Mooring Design

Ongoing, committed or proposed observations

12 surface moorings (yellow triangle)--India (NIOT) presently operates moorings in the Bay of Bengal and Arabian Sea. The moorings measure weather variables and at some locations subsurface temperature and currents.

Triton (blue octogon)--Japan (FORSGC) will place two current meter moorings in the eastern equatorial region in November 2001.

Current array (square)--India (NIO) will deploy trial moorings at various locations in the central equatorial region for up to a year during the next few years.

Forward planning

Green dots--WIOMAP, NIO, TAO PANEL are refining a mooring design for a trial temperature and current meter array during 2001-2005.

110E--USA and Australia are discussing moorings on 110E complemented with frequently repeated XBT sections.

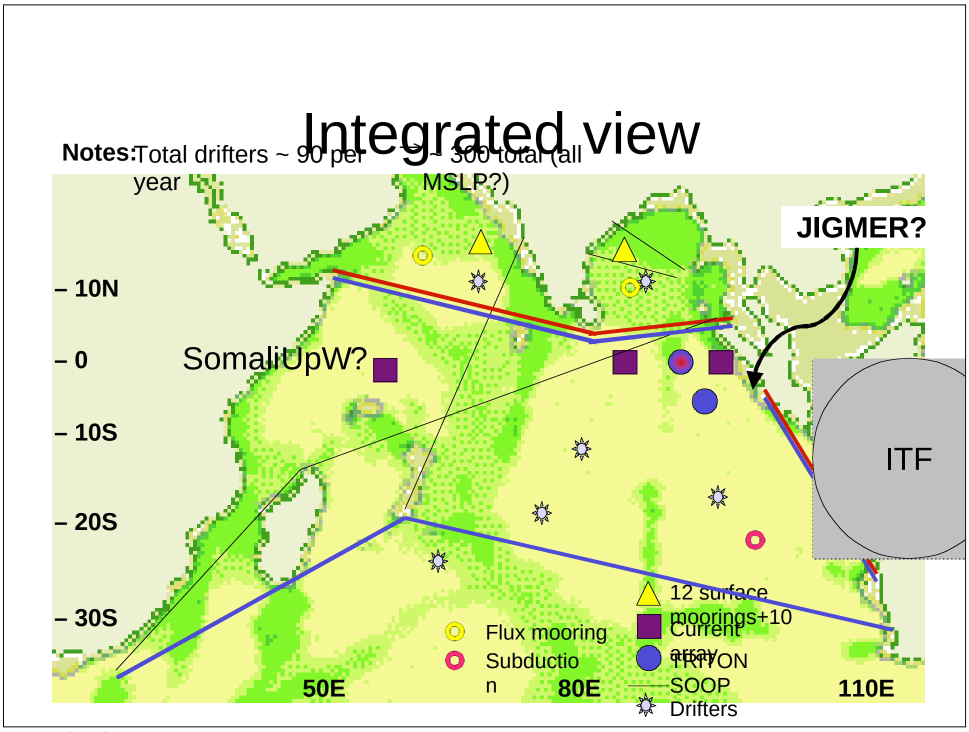


Fig (1b) Integrated View

Ongoing observations

- Ongoing drifters--currently about 120 active in the region north of 50S.
- Ongoing XBT lines:IX1*, 12 and 22 Australia, IX6 Japan, IX7 USA, IX8, 14 India, IX10 Japan (*Frequently Repeated line).
- Process study--JIGMER Joint Indonesian German study of eastern boundary processes, upwelling

Proposed:

- High Density lines IX1 (USA/Australia), IX15/21 (USA), IX10 (?) with Argo floats in enclosed areas for mass, heat, freshwater fluxes.

Forward planning and discussions:

Process studies:

- Repeat BOBMEX (India) and JASMIN (USA) air-sea interaction experiments in the Bay of Bengal;
- Subtropical/tropical overturning cells, subduction mooring (red dot), heat and freshwater fluxes in thermocline ridge 5-12S (Germany?)

- Argo floats--a surprising result was that interested nations are proposing enough floats to complete the Indian Ocean array. A workshop to refine plans and identify commitments will be held in India in mid-2001.
- Flux moorings (yellow dots) Bay of Bengal, Findlater jet, SE Indian mode water

6.2 Chinese Plan for Ocean Observations in support of CLIVAR *(J. Zhao)*

In recent years, many climate disasters have occurred in the central part of China. For example, in 1997, a serious flood in central China caused the direct loss of 7 billion US dollars. In 1998, another major flood struck China again and brought serious economic loss. In 2000, a severe drought affected most part of north and central China and caused huge economic loss. Forecasting these climate events is currently impossible, because the mechanisms causing them are not clear. Therefore, the main thrust in following years for China is to improve the accuracy of long-term climate forecasting.

The variation of the east Asian monsoon is one of the main causes of change in precipitation in central China. The Monsoon brings wet and warm air from equatorial region affects the rainfall by a complex process. China is conducting a monsoon study which includes investigations of two aspects: the variation of monsoon and the variation of tropical ocean conditions. As the warm pool system in west Pacific Ocean and east Indian Ocean is the key climate condition to affect the evaporation, it is considered to be the basis for improving climate forecasting.

A new project has been proposed by China entitled “Warm pool and circulation system and ocean-atmosphere interaction in Pacific and Indian Oceans”. The project will be started from 2002, and a pilot study about this topic will be started from 2001. Professor Jiping Chao, an academician of Chinese Academy of Sciences, will chair this project which involves 30 PIs from 6 ocean institutions.

For studying the variation of Warm Pool system in the different phase of ENSO cycle, the following aspects are emphasized

- Large range and fine vertical structure observations for warm pool water
- A whole El Nino cycle needs to be covered
- Synchronous observations In Pacific and Indian Ocean.

Major scientific issues are:

- Mechanism of the variation of warm pool
- Current system in West Pacific, East Indian Ocean and through-flow
- Variation of heat flux by west boundary current
- Response of atmosphere to variation of warm pool

Specific investigations include:

- Observations in Indo-Pacific system
- Maintaining mechanism of warm pool
- Circulation dynamics
- Matter flux over warm pool
- Observations in Indo-Pacific system
- Maintaining mechanism of warm pool
- Circulation dynamics
- Matter flux over warm pool
- Relations of warm pool to ENSO etc.
- Ocean-Atmosphere interactions
- Modeling and forecasting of warm pool

Observations and methods to be used:

- Vessel observations (6-8 cruises)
- Remote sensing
- Argo (20-30)
- Argos drifters(20-40)
- Mooring buoys(4-6)
- Numerical models

International collaboration and bilateral projects are being encouraged.

6.3 Indian Ocean and Australian Climate Impacts (*G. Meyers*)

Climate variations associated with the oceans have a large impact on Australia affecting many sectors of the economy. Impacts on agriculture have been extensively documented during the past 30 years. Typically the total value of Australian crops fluctuates from one year to the next on the order of $2 billion. Farm management practices can be altered to ameliorate climate-impacts if reliable seasonal climate predictions are available. While ENSO predictions (e.g. NINO3) are available, they alone do not provide the required information because the pattern of rainfall over Australia is quite different from one episode to another. For example, the 1982/83 episode produced severe drought over a large area of the country and it lasted a long time, well into 1983. In contrast, the 1997/98 episode produced mild drought and was short lived.

Similarly, Australia experienced years of good rainfall and good agricultural production in 1992 and 1993, but a devastating drought in 1994. None of these years were extremely La Niña (high SOI) and all of them were on the El Niño'ish side (weakly low SOI). Our hypothesis is that seasonal climatic conditions in Australia are very sensitive to small changes in the pattern of SST around the continent, in particular in the eastern tropical Indian Ocean. Along with ENSO, the recently discovered Indian Ocean Dipole seems to be related to agricultural production in Australia. CSIRO has undertaken a project aimed at making optimum use of climatic information and predictions to aid farm management. The project will take an end to end approach considering the full system-ocean, atmosphere, climate, farms, market, taxation and policy and the relationships between these elements. Purely statistical hindcast experiments have so far indicated increased productivity on the order of 14% in some industries (e.g. grazing, wheat cropping). This sets a benchmark for evaluating benefit to society. The onus is on oceanographers and modellers to demonstrate that an ocean observing system and numerical climate prediction can provide a greater benefit to agriculture than the statistical approach.

7. Air - Sea Fluxes (*S.A. Josey*)

S. Josey presented a brief overview of the current state of air-sea flux studies with the focus on recent research results and the need for a surface flux reference site network. The work of the WCRP/SCOR Working Group on Air-sea Fluxes (WGASF) was highlighted. The WGASF has recently produced a report on Intercomparison and Validation of Ocean-Atmosphere Energy Flux Fields which presently serves as the primary source of reference on this topic. The report will form the focus of a workshop to be held in Washington DC from 21-25 May 2001.

The presentation of recent science results centered on evaluations of the reliability of air-sea fluxes from the atmospheric model reanalyses at NCEPINCAR and ECMWF, and the use of hydrographic ocean heat transport estimates to constrain the ship-based SOC surface flux climatology. The reanalysis evaluations have employed high quality flux estimates from buoys and ships and have revealed that significant biases exist in reanalysis estimates of the net heat exchange as a result of biases in both the surface meteorological variables and the bulk formula schemes used to estimate the fluxes. The evaluation of ship-based surface fields using hydrographic data shows that correction of these fields to satisfy the constraint of global heat budget closure must be achieved via regional corrections in order to avoid the introduction of further biases in the corrected fields. Significant biases in the unadjusted SOC fields are found towards the Western boundaries of the Northern Hemisphere ocean basins at mid-latitudes.

The results discussed above reinforce the need for high quality estimates of the air-sea fluxes at key locations globally to serve as validation datasets for such studies. Plans for a surface flux reference site network that have been formulated as part of the Surface Flux Analysis (SURFA) project, supported by the WGNE, were presented.

8. Argo (*D. Roemmoch*)

An Implementation Planning Meeting for Argo in the Atlantic Ocean was held in Paris on July 10 and 11, 2000 (http://www.argo.ucsd.edu/rapport-final.html). A similar meeting for the Indian Ocean has been postponed until around mid-2001 though the SOCIO meeting (see OOPC Report) provided an opportunity to consider interest and commitments for the region. The Southern Ocean Workshop which followed provided similar opportunities for that region. The first meeting of the ad hoc committee addressing data management issues for the international Argo experiment was held at the IFREMER Center in Brest, France from 3 to 5 October 2000 (http://www.argo.ucsd.edu/report1.html). A full-time employee, Mathieu Belbeoch, has been hired to be Argo Technical Coordinator at the Argo Information Center (http://argo.jcommops.org/).

Table 1 provides a summary of the present status for Argo implementation.

Table 1. International Commitments for Argo Floats (15 Feb 2001)

The existing commitments to Argo are good as is the multi-national spread of interest. Taking note of the delay from funding to deployment, the Argo Science Team (AST) anticipates around 1,500 floats in the water by the beginning of GODAE and a reasonable prospect of near full implementation by the end of 2005. There is considerable uncertainty in some of the numbers and efforts are still being made to encourage more investment.

Nation	***Already Funded***	***Proposed Over Next 3 Years***
Australia	***20***	***90***
Canada	***56***	***90+***
EuropeanCommission		***80***
France	***140***	***210***
Germany		***100+***
India		***150***
Japan	***20***	***300***
NewZealand	***2***	***10***
SouthKorea	***20***	***90***
Spain		***24***
U.K.	***17***	***150***
U.S.A.	***428***	***980***
Totals	***783***	***2194***

The principal issue concerns global coverage. This will require nations to free some of their resources for use in remote regions, and the AST continues to work to this end. A second issue concerns deployment of floats in national EEZs. *Argo* took advantage of the GOOS/GCOS Regional Workshop for the Pacific Islands in August of 2000 to develop an approach with the Pacific Island nations to address this issue. This is particularly severe given the desire to adequately cover the ENSO 'warm pool', an area included within the EEZs of many island nations. The South Pacific Geosciences

Commission (SOPAC) is making progress working with its member nations to secure permission to deploy floats within their collective EEZ. Deployment within EEZs will continue to be an issue until such time as Argo and various nations are able to come to an adequate resolution.

The initial deployments are in the Atlantic and eastern Pacific . A strategy for assembling, quality controlling and distributing *Argo* data has been developed. All will be distributed in real-time via the GTS for the benefit of operational users who demand immediate access. A second, high-quality near-real-time stream will also be distributed.

There is also a plan to produce high-quality delayed-mode data sets which will be available via the internet within 90 days. France and the US have agreed to establish international *Argo* Data Centers through which all *Argo* data will be available.

The third meeting of the Argo Science Team (AST-3) was held in Sidney, British Columbia, Canada from March 20-22, 2001. The substantial progress in international commitments over the past year was considered (Table 1). Committed floats now total over 900, with proposals for an average of 750 per year in the next 3 years. The geographic distribution of targeted floats was also addressed (Fig 1). Early Argo deployments seek to quickly demonstrate the value and success of the project, while leading to global implementation as the highest priority. Early deployments are very sparse in the southern subtropics and the Southern Ocean (Fig 1), so this must be a strong focus of subsequent efforts. Basin Implementation Meetings have been held for the Pacific Ocean (Tokyo, April 2000) and Atlantic Ocean (Paris, July 2000), with an Indian Ocean Implementation Meeting scheduled for Hyderabad, India in late July 2001.

Progress in development of the Argo Data System was reported, following a meeting of Argo data managers in Brest in October, 2000. A standing subcommittee of the AST was formed to oversee the Data System. Immediate issues for this group are: to ensure that all Argo data are being released in near real-time via the GTS, development of a common format to allow rapid exchange and dissemination of Argo data, and establishment of a timetable with milestones for implementation of the data system.

Technical issues relevant to the Argo array were reviewed. The most significant finding has been that of multi-year stable salinity records using Seabird CTDs, although there are not yet enough records of long duration to characterize the performance reliably. The most notable technical concern is for the viability of improved communications options that could provide fast, reliable two-way communications. While improvements are required for transmission of high quality data, the improved commercial systems presently lack financial stability. An online Argo technical forum will facilitate technical exchanges and information transfer.

Number of Floats by Country	Argo Funded FY99	Float Equiv's FY99	Argo Funded FY00	Float Equiv's FY00	Argo Funded FY01	Float Equiv's FY01	Proposed over next 3 years	Prop Float Equiv's over 3 yrs
Australia			10		10		90	
Canada			10		42		90	
China					10		80	
Denmark						5		
European Commission					80			
France		8	70		65		200	
Germany				18		22	100	35
India					6		150	
Japan			20		90		300	
New Zealand					2		10	
Republic of Korea					20		90	
Spain							24	
United Kingdom			13		50	5	150	40
U.S.A.	55		132	51	150	40	825	60
TOTALS	55	8	255	69	525	72	2109	135
TOTALS BY YEAR	FY99 =	63	FY00 =	324	FY01 =	597	Ave/Yr =	748

Table 1: International Commitments for Argo floats. ***This table reflects the year in which funds are provided for floats; it takes on the order of a year until such floats are available for deployment. To achieve the global array of 3,000 Argo floats, it is necessary to provide floats at a sustained rate of 750 per year, given an average float lifetime of 4 years.***

A "Float Equivalent" is defined as a float—while not funded under the Argo Program— whose data are available consistent with the Argo Data Policy and provides the information equivalent to one Argo float.

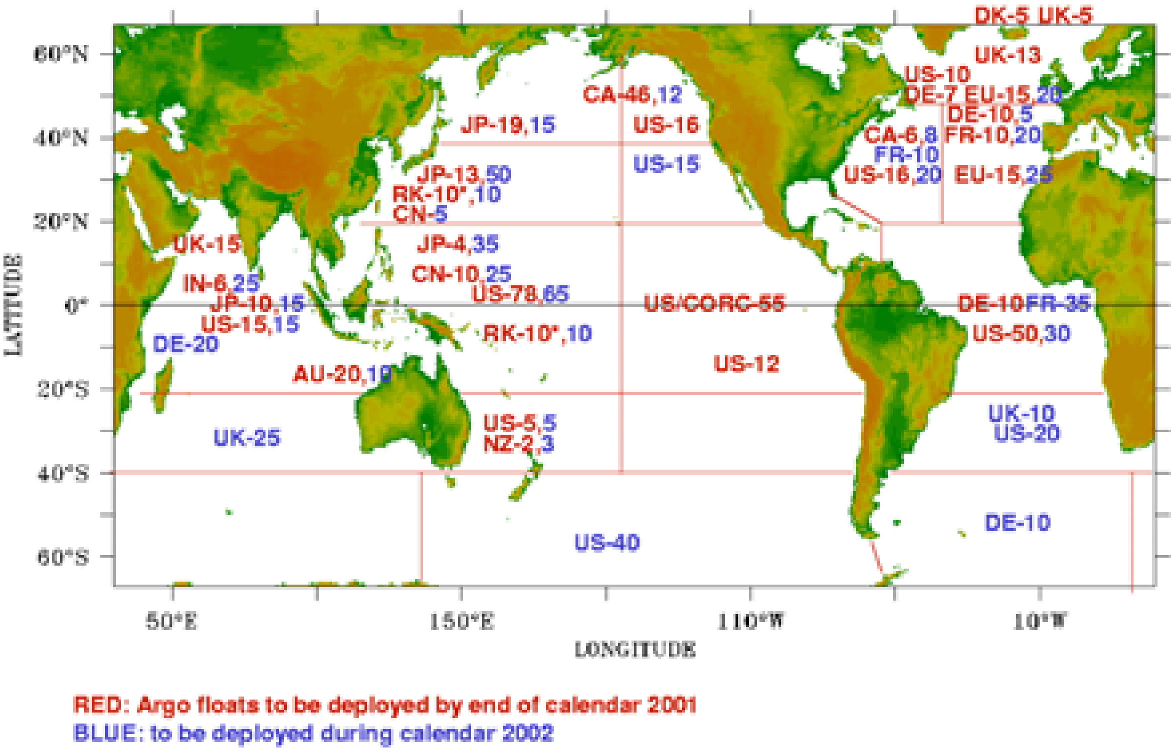


Figure 1: Target regions for funded floats planned for deployment by the end of calendar year 2002. National plans shown are Australia (AU), Canada (CA), China (CN), Denmark (DK), France (FR), Germany (DE), India (IN), Japan (JP), Korea (RK), United Kingdom (UK), United States (US), and European Union (EU). Some additional floats are funded but not yet targeted and some deployment plans are tentative.

9. Upper Ocean Thermal Network (*R. Bailey)*

R. Bailey reported on the SOOPIP, which is now an implementation panel of the Joint IOC/WMO Technical Commission for Oceanography and Marine Meteorology (JCOMM). SOOPIP, along with VOSClim and ASAP panels are sub-panels of the Ship Observations Team in the Observations Programme Area. The objectives of this arrangement include the enhanced coordination of projects involving the installation and operation of recording equipment on commercial vessels, whilst also realising the value of joint measurements (e.g. joint utilisation of vessels for surface flux and subsurface heat content measurements to close heat budgets). Recent years has shown a marked increase in the use of commercial vessels for a number of applications (including pCO2, plankton distributions, IMET, SSS, etc).

Results were presented on the review of the global Upper Ocean Thermal (UOT) network, which was jointly sponsored by OOPC, SOOPIP and CLIVAR UOP. A background study for this review was prepared by the CSIRO/BMRC Joint Australian Facility for Ocean Observing System (JAFOOS) and supported by NOAA's Office of Global Programs (see http://www.marine.csiro.au/JAFOOS). An international workshop was hosted by JAFOOS in Melbourne during July 1999. The workshop identified the unique roles of the global network in an integrated observing system (including Argo, altimeters, moorings), and recommended the focusing of sampling along lines (frequently repeated and high-density) and reducing broadcast sampling as Argo comes on line and is proven. Increasing bandwidth to enable the real-time transmission of full-resolution data, along with a data tagging system to identify unique data, were also recommended. Some problems were identified with the data management system, but which will have to be addressed in a follow up review. These recommendations were presented to and endorsed by the international community at the OceanObs'99 Conference in St.Raphael.

Implementation of the global UOT network continues to be coordinated by SOOPIP to meet (wherever possible) the sampling requirements as originally outlined by the OOSDP, and now recommended by the network review. Tools are in place to monitor programme implementation (see SOOPIP web-site at http://www.brest.ird.fr/soopip/), facilitated by the Technical Coordinator position at the JCOMM Observations Programme Support (JCOMMOPS) Centre. Many of the lines are being maintained at or close to required sampling. However, significant reduction in the support of XBT supplies by the US in 2000 has seen decreased sampling in some regions, especially in the Indian Ocean, and including the ENSO Observing System region in the Pacific. Although the support was predicted to be further decreased in 2001, lobbying by the SOOPIP Chairman and international community (including CLIVAR) has seen the situation at least stabilise for now. It is estimated that 35,000 XBTs are required to implement the recommended global network, whereas order 25,000 XBTs are being contributed by all countries at the moment. The increasing "volatility" of commercial shipping continues to create problems for the installation of equipment, as ships are being frequently taken off-line.

The COOP expressed strong support for activities aimed at better coordination and utilisation of joint measurements from commercial vessels (including pCO2, phytoplankton, IMET, SSS, etc). It also endorsed the recommendations of the global UOT review.

The COOP expressed concern that the broadcast XBT sampling is being reduced before implementation of Argo as a result of the reduced programme funding.

10. TAO/PIRATA (W*. Kessler*)

TAO

R. Kessler reported that the Tropical Atmospheric and Ocean(TAO) Array in the Pacific is facing a funding crisis this year which will likely lead to reductions in the array and degradation of the data stream. TAO funding in the USA has been flat since 1996, which translates to a compounding 3-4% annual funding cut. The effects of this reduction were offset at first as Japan took over operation of the array west of the Dateline (TRITON array), but now that that has been completed the downward trend resumes. In addition, this year there have been further direct cuts and changes in NOAA budgetary policies that appear to be producing a crisis this year. The amount of the cuts this year are uncertain but may be severe. Money can be saved in several ways, either by decommisioning moorings or by increasing the servicing interval (now 1 year for replacement and 6 months for visits/checks). Increasing these intervals would mean that if a buoy was vandalized there might be a much longer time until it could be repaired. The TAO project is now studying how to reduce the impact of such changes on the data stream and integrity of the ENSO

Observing System, and negotiations are going on within NOAA to ameliorate the funding situation.

The TAO Implementation Panel (TIP) has been dissolved, and will be replaced by a new Tropical Moored Buoy Panel. The TIP had the purpose of providing scientific advice to the project, but as the array has become mature the need is rather for a focus on logistic and technical issues.

The Japan-US collaboration has been working well with the growth of the TRITON array west of the Dateline. The data stream is transparent to the user.

10.2 PIRATA

PIRATA is transitioning from the pilot phase to a 5-year "consolidation" phase, with a new US/Brazil/France Memorandum of Understanding (MOU). Although there is much enthusiasm among the scientific community for the PIRATA data, the array must prove its worth for prediction, which is the principal justification for its funding. The forecast centers (ECMWF/NCEP) will study the impact of the PIRATA data on their seasonal forecasts during the 5-year continuation.

10.3 General

A wind direction bias in all ATLAS moorings was uncovered this year. The bias error arose because of engineering mistakes made during calibration of the wind vanes. The question is still being studied, but the best present estimate is a (clockwise) bias of about 6.7 degrees. The error has been fixed for the future, but retrospective correction may not be possible in all cases because it is not clear exactly when the erroneous calibration jigs began to be used. However, all next-generation ATLAS moorings will be retrospectively correctable, which includes all PIRATA moorings. In any case, the error remains less than the claimed accuracy of TAO winds (10 degrees). For the future, a careful reexamination of the sources of error indicates that we can expect a near-zero bias error, an RMS 3 degree vane error and 4 degree compass error, for a net 5 degree overall RMS error. A NOAA Technical Report is being prepared that will describe the situation in detail.

Vandalism continues to be a severe problem in certain areas, especially near coastlines and in heavily-fished areas. Buoys are damaged both deliberately, or inadvertently in the course of fishing operations. No solution has been found for this, except to recognize that some mooring sites with heavy fishing activity (in the cold tongues of both the Atlantic and Pacific) may not be sustainable. As a result, this year the PIRATA moorings at 10W, 2S and 2N were decommissioned and will not be replaced.

11. Ocean Time Series (*U. Send*)

As a modern replacement for the historical ocean weather ships, a network of moored, autonomous time series stations can make unique contributions to a climate observing system. These include the provision of air-sea flux reference sites, the observation of water mass formation (including the forcing and the consequences like CO2 subduction), the monitoring of transports of boundary currents, overflows/passages, and the meridional overturning circulation, the collection of statistical information over a very wide range of time scales, and the ability to observe the impact of physical variability on geochemical properties (nutrients, CO2, etc) and the ecosystem. There are also a number of unique methodological benefits of fixed time series observations, in particular the ability to provide high temporal and vertical resolution over a wide range of scales, for many linked variables at one location. Also in confined regions of significant currents, fixed-point systems are the only option. These properties make such observatories an ideal complement to other elements of an integrated observing system.

Various types of technology are available or are in a prototype stage, including different options for telemetry (with/without meteorological buoy) and wire-mooring or glider-based approaches. Also autonomous moored sensors are becoming increasingly available for various biogeochemical variables. Currently most multi-year moored time series stations are operated by individual projects/PI´s with little coordination, the major exception being the tropical TAO/Triton and PIRATA arrays. Efforts are under way now to start working toward a global plan and implementation of a network of sustained moored time series observatories, addressing varying observing needs such as air-sea fluxes, transports of current systems, and physical and biogeochemical water column properties (including CO2 concentrations).

To this end, a steering/science group has been formed under the sponsorship of the COOP, OOPC and POGO, which brings together different disciplinary and regional interests/representation. This group will start its activity at the end of May 2001.

Every effort will be made to collect much of the data in real-time and to distribute them freely to the community to assure wide-spread usage. The COOP emphasized the need to interact closely with the air-sea flux site working group (SURFA), and also to coordinate across nations and disciplines to implement at least 2 Southern Ocean observatories by sharing logistics, technology and funding.

12. Hydrography (*S. Wijffels*)

Susan Wiffels briefly reviewed the requirements for deep hydrography in support of CLIVAR, including

- climate change detection, by monitoring deep ocean storage of heat, freshwater, nutrients, carbon, cfcs, etc.

- to test climate change models

- to assess changes in deep and shallow water-mass formation and overturning

- to provide calibration data for autonomous sensors, in particular salinity data for the Argo project.

She made reference to a recent "white paper" entitled "The need for continuing global deep-ocean surveys" prepared by Sabine et al.

Wiffels reported that plans to reoccupy quite a few sections were already in place, but that very little coordination had taken place amongst those planning or proposing these lines. She emphasized the need for a strategy which included global coverage, noting that much of the world's oceans was ventilated by the Southern Ocean and hence this region must be surveyed. She also called for coordination with the carbon and biogeochemical tracer communities who, it was reported, were also planning significant surveys.

The Panel concurred with the finding in the Sabine et al. white paper and recommended that at least informal discussions take place during the upcoming WOCE JGOFS transport workshop to encourage coordination and planning for section reoccupations in cooperation with the carbon and tracer communities and that further opportunities should be explored to increase dialogue amongst these groups and to ensure global coordination.

13. Acoustic Tomography (*U. Send*)

Ocean acoustic tomography has a number of properties that may be useful for contributing to an ocean observing system. These include the ability to collect large-scale integral data, to sample rapidly in time, and to remotely sense adverse/inaccessible environments.

There are also synergies with other elements of the observing system. E.g., satellites remotely sense only the ocean surface while tomography senses the interior; profiling float networks have broad spatial coverage and cover the upper 1500-2000m while the acoustics reach deep and are useable in strong currents, under the ice, in confined regions; and Eulerian observatories have excellent sampling at one location while tomography can add averages between the stations.

Potential applications of tomograpy include: convection/water mass formation, Arctic monitoring under the ice, transports through some straits and passages, heat content and transport on some reference sections, boundary current transports/dynamics, large-scale weak ocean currents, and basin-scale modes of variability/constraints.

Some recent results from past tomographic experiments were presented to exemplify the potential contributions to a climate observing system. A 9-month long experiment covering the western Mediterranean on cross-basin scales of 600km (7 stations and 13 paths) allowed 3-D basin-average estimates of total heat content evolution, and of intermediate and deep water average temperatures. The total heat content agreed to within errors with the ECMWF surface heat fluxes, both on seasonal and shorter time scales. The intermediate water integrals implied seasonal changes in volume by a factor of 2 for this water mass, while the deep water estimates had errors small enough to allow detection of a potential decadal warming trend in 2-3 years. Data from a pilot experiment in the Strait of Gibraltar using shore-to-shore acoustic transmissions demonstrated high skill in observing the deep outflow transports from the Mediterranean. A future permanent observing system could employ a cabled network of such instruments. In the Labrador Sea water mass formation regime, a 3-year record of tomographic observations now exists. The 0-1300m heat content averaged acoustically along one section tracks the NCEP surface heat fluxes very closely for the entire period if 70W/m2 are added to account for horizontal advection of heat. Comparison with data at the end point moorings shows a horizontal homogenization and thus mixing of convected water into the boundary current. Two acoustic pilot experiments over 1500km under the Arctic Sea Ice have demonstrated a climatic warming of the Atlantic Water layer there and the sensitivity of such measurements to changes in this layer. A long-term network for acoustic thermometry of the Arctic Ocean is being planned presently.

It is further proposed to explore the contribution of basin-scale acoustic thermometry to an integrated observing system through pilot deployments embedded in other observations. One possibility may be to use the expected dense network of fixed-point stations in the north Atlantic as "moorings of opportunity" to which tomography equipment can be added at small incremental effort. The discussion emphasized the need to make tomography experiments and equipment lower cost and their data easier to exploit. It was pointed out that efforts are under way to address all those issues, including a data base (server) and a standardized data format for tomography data of different processing levels (e.g. travel times along ray paths, or inverted heat content along sections), in order to make results from the experiments more widely used in, and openly available to, the community.

14. Modelling, Assimilation and Synthesis

14.1 Ocean Modelling at CSIRO Marine Research (CMR) (*A. Schiller*)

Ocean modelling at CMR covers a wide range of spatial and temporal scales to serve different applications. Customers of output from CMR models include regional fishery communities, government institutions dealing with marine ecosystems, defense forces, as well as scientists interested in regional-to-global oceanography.

On the coastal-to-regional scale two models are in use at CMR. The first one is based on the Rutgers University σ-coordinate ocean model (ROMS). The second regional model is an in-house built primitive equation model with vertical levels, called Model of Estuaries and Coastal Oceans (MECO). The regional models are used, e.g., for investigations of Rock Lobster Larvae movement off Western Australia, sediment transport, discharge in estuaries etc.

For climate applications two global models exist: a coarse resolution version and an eddy-permitting version. Both models are based on GFDL's MOM code and include some improvements by the Australian modelling community. The global, eddy-permitting model is ACOM3 (Australian Community Ocean Model, version 3; www.marine.csiro.au/~acom). Model resolution is 0.5° zonally, 0.33° meridionally and 36 vertical levels (24 levels in the upper 1000 m). All models include or will soon include data assimilation techniques based on Optimum Interpolation and/or nudging. Sea surface height (SSH), temperature and salinity are interpolated to the models grids. Observations of satellite-based sea-surface height and sea surface temperature are converted to gridded subsurface signals using statistical techniques ("Synthetic XBTs").

CMR's global models are used by the Australian Bureau of Meteorology and by CSIRO Atmospheric Research as component models in their respective seasonal-to-interannual prediction systems. Work with global ocean models within CMR focuses on the understanding of physical processes that create and maintain SST anomalies. A. Schiller presented two examples that relate to interannual and intraseasonal variability in the Indian Ocean. The heat balance during intraseasonal events agrees well with observations and other model simulations. An open question with respect to interannual variability in the equatorial Indian Ocean is the amount of water transformed during so-called "Dipole-Mode" events. Numerical results are presented which suggest that Dipole Mode events cause significant anomalies in water mass formation rates even in the deep Indian Ocean. Despite encouraging results, lack of observations in the Indian Ocean (both surface meteorology and sub-surface hydrography) prevents a more detailed model validation with observations. To overcome this problem in the short-term, even a few permanent moorings in the western, central and eastern Indian Ocean would greatly improve model validation and improvements. Additional moorings in the Arabian Sea and Bay of Bengal would improve analysis of model results on intraseasonal timescales.

The Bureau of Meteorology, CSIRO (CMR and CAR) and the Royal Australian Navy are currently negotiating a partnership agreement for the development of a global ocean analysis and prediction system. The ultimate goal of the 2.5 year project will be the implementation of an operational, regional-to-global short-term ocean forecasting system.

14.2 Coupled modelling work at CSIRO (*A. Hirst*)

There is an extensive range of climate system modelling work conducted at CSIRO (primarily at the Marine Research and Atmospheric Research divisions). The major foci of this work are climate change research, climate variability research and climate predictability and seasonal forecasting. The models used for climate change and long time scale variability are the CSIRO Mk 2 and Mk 3 coupled global GCMs. The latter model features much enhanced resolution (0.9 latitude by 1.8 longitude in the oceanic component), and enhanced physical parameterisations. The model currently used for semi-operational seasonal prediction work is the COCA coupled GCM, which has an enhanced near-equatorial grid of 0.5 latitude.

T. Hirst discussed four issues arising from this work. Firstly, the simulation of ENSO in the Mk 3 model is examined. The amplitude, episodic nature and rainfall teleconnections over Australia and India characteristic of ENSO are broadly simulated, though some quantitative differences between the observed and modelled SST anomaly patterns are noted. Secondly, the six month predictability of SST was shown for the COCA model. The model shows significant predictability in the central/eastern equatorial Pacific (as is common for such models) , and seasonally in regions both to the east and west of Australia.

Thirdly, issues confronting ocean modellers are discussed. The forcing of uncoupled ocean models in the Southern Ocean is problematic because the surface flux data are so poor, with the flux reanalyses actually implying strong northward heat transport over the Southern Ocean which is inconsistent with the limited direct heat transport measurements and with a range of model results. The deep overturning in ocean models is typically weaker than observed in the Pacific and , especially, the Indian Ocean, representing an unsolved problem in ocean modelling.

Fourthly, T. Hirst discussed model consistency in the response of the Southern Ocean to global warming, based on the ongoing work of Sarmiento et al. (in prep). Surface salinity and density decline, subsurface salinity and temperature tend to increase, upper ocean stratification increases, the surface winter mixed layer shoals, and Antarctic deep overturning slows (at least in those models where there is a clearly discernable Antarctic overturning cell). These changes tend to be “progressive”, not “chaotic”, that is they are reproducible with similar timing in all ensemble members for a given model and emissions scenario. However, models diverge widely on the rate of progression of these changes in the Southern Ocean, even under a common emissions scenario. It is finally noted the biogeochemical models suggest significant changes in dissolved oxygen concentrations in the Southern Ocean under climate change, and an example of a model/observational comparison was presented which highlights the possibility of using this widely measured variable in detection/attribution work.

14.3 Seasonal to Interannual Prediction at NCEP (*D. Behringer*)

D. Behringer reported on recent study prepared for the Working Group on Seasonal-to-Interannual Prediction (WGSIP) which serves to assess the current state of Seasonal to Interannual Prediction (SIP). The comparison is based on the skill of the models to predict the mean SST anomaly in Niño 3 (150-90W, 5S-5N). This minimalist comparison is dictated by the diversity of models included in the study and justified, in part, by the fact that simple measures such as this are used to establish official forecasts. The seven models included in the study range from the purely statistical, through simple dynamics-only models to full general circulation models.

The general conclusions of the study are the following:

- All models included in the study produce useful forecasts of the peak phase of extreme events up to two seasons in advance.
- None do well at capturing the full course of events and, in particular, none do well at predicting the time of onset.
- Given the size of the sample, it is not possible to distinguish among the models.
- A composite forecast based on all systems appears to be superior to any individual system.

Therefore, while the NCEP system produces useful forecasts, it appears unable to take advantage of the added sophistication of the general circulation models it employs (at least with respect to the simple measure used in this study). This result suggests that work remains to be done to improve basic model performance (e.g. reduction of model biases and improvement of the model boundary layer). Some improvements in the NCEP forecast are anticipated with the next generation system which will include a global ocean with improved physics and improved ocean-atmosphere coupling.

As assimilation systems used for initializing SI forecasts become more sophisticated they will become better tools for evaluating the ENSO observing system. While that point has not yet been reached, it is already clear that improvements being made now to ocean assimilation systems will benefit from the routine availability of salinity profile data. Also, as the ocean components of coupled forecast systems expand beyond the Pacific basin to become global models, these data should be available (minimally) throughout the global tropics.

14.4 Variational data assimilation with the OPA *OGCM (A. Weaver and J. Vialard ECMWF, Reading*)

CERFACS is developing, in collaboration with LODYC (Paris) and the seasonal forecasting group at ECMWF, an ocean data assimilation system based on an incremental variational (Var) method. The system is being designed for the OPA OGCM (LODYC). OPA is the operational ocean forecasting model used by the French MERCATOR project. OPA is also the ocean component in three coupled ocean-atmosphere models being developed for seasonal-to-interannual prediction as part of the EC-funded DEMETER project. One of the main objectives for developing the Var system is to produce global ocean analyses for initialising the coupled model forecasts. For this purpose, both a 3D- and 4D-Var method are being explored. The two systems are complementary since the basic elements used in 3D-Var are also needed in 4D-Var. The 3D-Var is computationally less expensive than 4D-Var and therefore, though less sophisticated, is potentially more practical for high resolution global applications. 3D-Var also provides a useful reference for evaluating (the more costly) 4D-Var.

A prototype 3D- and 4D-Var system has been developed for a tropical Pacific version of OPA. The current system assimilates *in situ* temperature observations from TAO buoys and XBTs. The current 3D-Var is a univariate scheme that computes an analysis increment of the 3D temperature field using observations collected over a 10-day window.

The temperature increment is then applied gradually through a constant forcing term in the prognostic model temperature equation. In 4D-Var, the model state trajectory is adjusted to fit the observations distributed over a given time window. In particular, in the incremental version of 4D-Var used here, the analysis increment is constrained to satisfy the dynamics of the tangent-linear model over a 30-day window. As such, 4D-Var is multivariate: from the temperature observations alone, 4D-Var computes an analysis increment of the 3D fields of temperature, salinity and velocity.

Both the 3D- and 4D-Var systems have been cycled over the period 1993-98. The Var analyses have been compared to analyses produced using a univariate OI scheme and to (control) analyses produced without data assimilation. An example for mean temperature along a section at 140°W shows that, relative to the control, both 4D-Var and OI produce a large mean correction in the upper ocean thermal field (e.g., the 15^{o}C isotherm has been lifted 100m) which results in a much tighter thermocline. The mean correction is largest in the 4D-Var and occurs primarily during the first assimilation cycle which is a strong indication that the assimilation initially corrects for a large bias in the model state. The correction averaged over the TAO region (160^{o}E - 99^{o}W, 10^{o}S - 10^{o}N, 0 - 500m) is about 1^{o}C compared to about 0.05^{o}C on cycles thereafter. Also, the meridional tilt of the thermocline is much more pronounced, particularly in the 4D-Var. This results in a much stronger North Equatorial Counter Current, with mean surface velocities of 0.3 m/s compared to 0.1 m/s in the control. Comparison with independent surface velocity measurements from TAO at 0^{o}/140^{o}W shows, respectively, a correlation and mean bias of 0.83 and -0.09 m/s for 4D-Var, compared to 0.75 (0.75) and 0.33 (0.03) for the OI (control). The large bias in the surface currents in the OI analysis is a problem that arises from the model fields being corrected with unbalanced analysis increments (in the OI the temperature increment is applied as a constant forcing term as in the 3D-Var). In contrast, there is a clear positive impact from the 4D-Var, not only on the assimilated variable (temperature) but also on surface currents, thus illustrating the benefit of a multivariate-based assimilation scheme. Sea-level variability is also best reproduced in 4D-Var when compared with independent measurements from TOPEX/Poseidon (correlation greater than 0.93).

The relative impact of the 3D- and 4D-Var analyses on seasonal forecasts remains to be tested. Work is ongoing to implement the Var system in the global model where these tests will be performed. In addition, several aspects of the assimilation system need further development and refinement. Important ones include the use of new observations (e.g., sea-level from altimetry and T/S from ARGO) and the development of a multivariate background error covariance model. The latter is important even in 4D-Var for ensuring that the analysis increments are properly balanced. For example, our experiments have shown that the salinity field is only weakly constrained by the dynamics in 4D-Var when assimilating temperature observations alone over a limited period. Extra constraints on salinity, based on T/S relationships for example, must be built in to the analysis system, and ideally this should be done through the background error covariance model. The problem of assimilating temperature observations without making corresponding adjustments to salinity can be particularly dramatic in a static scheme such as 3D-Var or OI where spurious strong vertical mixing or convection can be induced in regions of weak static stability. Another issue worth further investigation is that of model bias, which, unless treated explicitly in the analysis problem, can be another source of imbalance in the analysed fields. A better use of the observations within the analysis problem would be to partition the information judiciously between correcting biases on the one hand, and random errors on the other. Moreover, explicit bias estimates would provide very useful indicators of ocean model deficiencies and hence could be of great potential interest to ocean model developers.

15. Future Directions

Finally, the panel decided on plans for future meetings and membership. The panel agreed to examine mean and variable ocean transports of momentum, heat and freshwater using synthesis techniques in conjunction with surface flux observations as a major focus for its next meeting in order to evaluate the integrated capabilities of the CLIVAR ocean observing system. The steady state transports to be discussed at the WOCE/JGOFS July, 2001 workshop will be the starting point for this discussion. It is likely that the next meeting will occur during autumn 2002. No change in membership is recommended for the coming year. The Chair, on behalf of the Panel, again thanked the local hosts for the excellent arrangements and for their significant scientific contributions to the meeting.

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Annex 1

Agenda for CLIVAR Ocean Observations Panel (COOP)
CSIRO Marine Laboratory, Hobart, Australia
(March 27-30, 2001)

1.	**Opening**	Andreas Schiller et al
2.	**Status reports**	
	CLIVAR	Chet Koblinsky, Valery Detemmerman
	OCEAN OBS99 – CLIVAR Issues	Chet Koblinsky, Neville Smith
	OOPC/GODAE	Neville Smith
	GOOS Information Technology and Management Initiative	Neville Smith
	ENSO Observing System Review	Robert. Kessler
	AOPC	Mike Manton
	IOC issues	Art Alexiou
3.	**CLIVAR Science Development**	
3.1	**Pacific Ocean**	
	The thermocline ventilation of the North Pacific	Toshio Suga
	Tropical Pacific variability	Yves Gouriou
	Pacific Science and Implementation report	Kessler, Roemmich
3.2	**Southern Ocean**	
	Southern Ocean research	Steve Rintoull
	Southern Ocean Planning Meeting	Steve Rintoull
3.3	**Indian Ocean**	
	Monsoon research	Stuart Godfrey
	Bay of Bengal and Indian climate observations	P.N. Vinayachandran
	Chinese plans for ocean observations in the Indo-Pacific region	Jinping Zhao
	Indian Ocean and Australian Climate Impacts	Gary Meyers
	Indian Ocean Planning Meeting	Gary Meyers, Bill Erb
	Role of Ocean Obs in CLIVAR Austral Asian Monsoon studies	Stuart Godfrey

4. CLIVAR Ocean Observations Implementation

4.1 Surface Observations

Surface Fluxes	Simon Josey
Data Buoy Cooperation Panel	Graeme Brough
Tide Gauges, GLOSS, Altimetry, Gravity satellites, GPS	Chet Koblinsky
Other Satellite (Winds, color, salinity, Precip,.)	Chet Koblinsky

4.2 Boundary Currents

Monitoring of East Australian Current	Rick Bailey
Recent results and plans in Indonesian Throughflow	Susan Wijffels

4.3 Upper Ocean:

ARGO	Dean Roemmich
Upper Ocean Thermal Program, SOOP, VOS, etc	Rick Bailey
TAO, PIRATA, Indian Ocean	Kessler, Meyers

4.4 The Deep Ocean:

Ocean Time Series Activity	Uwe Send
Hydrographic Sections	Susan Wijffels
Acoustic Thermometry	Uwe Send

5. Modeling, assimilation and synthesis

CSIRO Ocean Modelling	Andreas Schiller
CSIRO Coupled Modelling	Anthony Hirst
Seasonal-Interannual Prediction at NCEP	David Behringer
The Variational Data Assimilation Project	Anthony Weaver

6. Executive Session

Strategy for next few years	
Summary of Issues and Actions	Panel
Membership	
Next Meeting	

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