Global Ocean Observing System

Intergovernmental Oceanographic Commission
Reports of Meetings of Experts and Equivalent Bodies

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

Geneva, Switzerland
9-12 May 2005
http://ioc.unesco.org/oopc/oopc-x/

GCOS • GOOS • WCRP
OOPC Ocean Observations Panel for Climate

GCOS Report No. 104
GOOS Report No. 150
WCRP Report No. 3/2006

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TABLE OF CONTENTS

1. OPENING

1.1 Opening and Welcome

The Chair of the OOPC, Ed Harrison, opened the meeting and introduced Hong Yan, Assistant Secretary-General of the WMO. Hong welcomed the panel on behalf of the Secretary-General, expressing pleasure that the group was meeting at the WMO for the first time. Hong congratulated the group in their work in the preparation of the GCOS Implementation Plan, and expressed the support of the World Meteorological Congress and the Technical Commissions of the WMO for a global ocean observing network.

The Chair thanked the local hosts, the GCOS Secretariat, for their hospitality, and welcomed the CLIVAR basin panel representatives and invited guests.

1.2 Review and Adoption of the Agenda

The Chair introduced the provisional agenda, which was approved. The agenda, background documents, and all of the presentations given during the meeting are available on the **meeting website**: ioc.unesco.org/oopc/oopc-x/.

1.3 OOPC Review 2004-2005 and Meeting Goals

The chair provided an overview of the activities of the OOPC since the last meeting in June 2004. He started with a reminder of the group's Terms of Reference, which he paraphrased as:

- Developing recommendations for a sustained global ocean observing system, in support of WCRP, GOOS, and GCOS climate objectives, including phased implementation,
- Helping to develop a process for ongoing evaluation and evolution of the system and recommendations,
- Supporting global ocean observing activities by involved parties, through liaison and advocacy for the agreed observing plans.

The goals of the system are to provide data and information products to serve climate forecasting, assessment, and research. The system is also the foundation for global operational oceanography.

A major achievement of the Panel since the last meeting was an updating, with broad input from the ocean observing community, of an implementation plan for the initial global ocean observing system for climate, written as the ocean chapter of the GCOS Implementation Plan[1] (IP). The strategy and specifics of the GCOS IP have been endorsed by GOOS, the WCRP, and the UNFCCC. However, many questions remain about how implementation will proceed—national commitments and national organizational structures to support sustained ocean observations are in many cases lacking, and current observations depend heavily on the undertakings of the research community. The Panel's short-term strategy is thus to sustain and enhance existing arrangements.

[1] *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC*, GCOS Report No. 92, WMO/TD No. 1219, available on the OOPC website http://ioc.unesco.org/oopc/

To support its second Term of Reference, the panel has focused on evaluation of the system based on uncertainty in estimates of desired ocean information, relative to the relevant ocean climate signals. Evolution of the system will be based on successful Pilot Project deployment of new sensors, results from ocean climate product sensitivity studies (conducted in cooperation with CLIVAR's GSOP panel and GODAE), and progress against the initial recommendations.

The Panel's liaison responsibilities also involved major efforts during the intersession. The OOPC was represented at a number of scientific and coordination meetings by Panel members. The list of meetings at which the Panel was represented is given as Table 1.

Table 1: List of meetings with OOPC representation since OOPC-9

Meeting	*Dates*	*Member(s)*
7th GOOS Coastal Ocean Observations Panel meeting, Tokyo, Japan	7-12 Jun 2004	Harrison
International CLIVAR Science Conference, Baltimore MD, USA	21-25 Jun 2004	Harrison
37th IOC Executive Council, Paris, France	23-29 June 2004	Fischer, Hood
CLIVAR Scientific Steering Group, Baltimore MD, USA	27-29 Jun 2004	Harrison
GCOS IP Panel Chairs' meeting, Geneva, Switzerland	5-9 Jul 2004	Harrison
9th International GODAE Steering Team meeting, Paris, France	20-22 Jul 2004	Harrison, Fischer
GCOS IP writing workshop, Geneva, Switz.	16-18 Aug 2004	Harrison, Fischer
5th GHRSST-PP Science Team meeting, Townsville, Australia	23-27 Aug 2004	Reynolds
US Integrated Ocean Observing System (IOOS) Planning meeting, Arlington, VA, USA	30 Aug - 1 Sep 2004	Harrison
US GODAE meeting, Washington DC, USA	8-9 Sep 2004	Harrison
Liverpool Challenger Society Meeting, Liverpool, UK	11-18 Sep 2004	Dickey
THORPEX Implementation Plan meeting, Beijing, China	13-15 Sep 2004	Fischer
SCOR meeting on Coordination of International Marine Research Projects, Venice, Italy	23-24 Sep 2004	Harrison, Dickey
SCOR Assembly, Venice, Italy	27-30 Sep 2004	Dickey
Ocean Optics, Freemantle, Australia	22-30 Oct 2004	Dickey
2nd GODAE Symposium, St. Petersburg FL, USA	1-3 Nov 2004	Harrison
US GOOS Steering Committee, Dallas TX, USA	3-5 Nov 2004	Harrison
CLIVAR Global Synthesis and Observations Panel meeting, Boulder CO, USA	8-12 Nov 2004	Harrison
6th meeting of the Partnership for Observation of the Global Oceans (POGO), Brest, France	29 Nov - 1 Dec 2004	Harrison
International Ocean Carbon Stakeholders meeting, Paris, France	6-7 Dec 2004	Hood, Harrison, Fischer

AGU Fall Meeting, San Francisco CA, USA	13-17 Dec 2004	Dickey
Mediterranean Forecast System - Toward Environmental Prediction, Annual Review, Bologna, Italy	5-10 Feb 2005	Dickey
4th JCOMM Management Committee meeting, Paris, France	9-12 Feb 2005	Harrison, Fischer
9th meeting of the GOOS Steering Committee, Melbourne, Australia	21-23 Feb 2005	Harrison
3rd meeting of the JCOMM Ship Observations Team (SOT), Brest, France	7-9 March 2005	Fischer, Harrison
26th meeting of the WCRP Joint Scientific Committee, Guyaquil, Ecuador	14-18 March 2005	Harrison, Fischer
11th meeting of the GCOS Atmospheric Observations Panel for Climate, Geneva, Switz.	11-15 April 2005	Harrison
NOAA Office of Climate Observations Annual Review, Silver Spring MD, USA	25-28 April 2005	Harrison, Fischer, Hood
27th meeting of the International Oceanographic Data and Information Exchange, Oostende, Belgium	26-30 April 2005	Keeley

The chair outlined the goals of the meeting, which were to decide on actions for:

- plans for the co-sponsored (w. CLIVAR) South Pacific workshop
- cooperation with the CLIVAR GSOP in pushing forward with ocean and climate information products
- issues for the upcoming JCOMM-II meeting
- subsurface indices
- advocacy for ocean satellite missions
- the ocean data system, including ID tagging and quality control
- the evolution of OOPC recommendations for the system
- the inclusion of biogeochemical and ecosystem variables
- and future directions and membership for the Panel.

Later in the meeting the list of OOPC-9 action items was revisited, with present status of each. While a number of specific tasks were accomplished, many actions remain as ongoing.

Table 2: Summary of OOPC-9 action items and status

Action Item	Action	Responsible	Status
1	to recommend that the DBCP address the undersampling of polar oceans and marginal ice zones	Chair, Secretariat	Done
2	to encourage the new CliC Arctic Ocean Panel to work towards community consensus on feasible, global-climate-motivated observing requirements	Mauritzen	See prospectus for an Arctic GOOS
3	to liaise with Martin Bergman, head of the International Arctic Scientific Committee Pacific-Arctic group, regarding Arctic	Keeley	Done

	observing plans and requirements		
4	to encourage documentation of the improvements and uncertainties in sea ice products	Reynolds	Sea Ice subgroup of SST wk gp established
5	to raise questions about sea ice products and their improvement for Rayner cc to Ryabinin for CliC	Secretariat	Done
6	to encourage the Southern Ocean panel to consider correlations of S.O. indices with wider patterns of climate variability that have societal impact, and to document these	Speer	Ongoing
7	to provide input to the draft GCOS Implementation Plan responding to the Second Adequacy report cc to Fischer, Harrison	all	Done
8	to ensure that ocean surface processes in implementation plans do not get lost between atmospheric and oceanic requirements (GCOS IP and GEO)	all	Done
9	to encourage that the WG on sea-level pressure consider improvements to real-time operational products in addition to the historical record	Chair	Done
10	to seek provision of surface flux fields from operational models for comparison with reference timeseries: a) directly through WGNE b) through a possible revitalization of SURFA via WGSF to make direct contact with Gleckler	Weller, Taylor	Done Will be coordinated via WGNE
11	to encourage GCOS and CLIVAR to renew efforts in improving data sharing for key datasets such as sea level records; consider a data policy for CLIVAR	Harrison, Weller	GSOP has proposed a data policy for CLIVAR
12	to suggest pilot projects linking global and coastal scales for suggestion to COOP; (possibly through VAMOS)	Harrison, Dickey	Done. COOP is being reformulated
13	to provide timely input into the GEO process, including current implementation plan drafting; and to emphasize role of continuing link with research/science	all	Done
14	to coordinate with the WCRP's new WG on Observations and Assimilations to avoid unnecessary duplication; and to encourage modeling feedback on observing system	Chair	Done
15	to coordinate with the CLIVAR GSOP (and CLIVAR SSG) to avoid unnecessary	Chair, Weller	Done

	duplication, to promote interaction with OOPC, and to encourage modeling feedback on the observing system		
16	to pass OOPC feedback to the IGOS-P Ocean Theme rolling review, and advocate for secretariat support for implementation	chair, GOOS director	OOPC is part of Ocean Theme review
17	to encourage coordination between the Russian Federation MERIDIAN cruises and CLIVAR Atlantic panel and JCOMM observing activities	Sokov, Marshall, Schott, Hill, Fischer	Done
18	to form a steering committee for a South Pacific Observing System workshop which will write a prospectus and suggest an organizing committee, for possible co-sponsorship by OOPC; in coordination with both the Pacific and Southern Ocean panels chairs	Weller, Hill, Speer, chair	Done
19	to find a Chinese contact for invitation to the next OOPC meeting, to improve observing strategy coordination	Chair, Secretariat, Michida	Unsuccessful
20	to encourage JCOMM or other appropriate bodies to produce data availability metrics - of data collection and data availability, as incentives for improving data sharing	Chair, Secretariat	Ongoing
21	to encourage the CLIVAR Atlantic Panel to discuss at their upcoming June meeting a potential review of PIRATA as a part of the integrated observing system; or to consider a joint OOPC/Atlantic panel review	Schott, Campos	Done
22	to encourage the release of TAO salinity data in real-time at highest frequency limited by the transmission technology (for GHRSST calibration)	Dickey, Weller, Crease	Done
23	to solicit from each of the CLIVAR panels clear requirements for SOT/SOOP XBT lines, which may differ from the current (5-year-old) recommendations	CLIVAR representatives	Done
24	to ask GLOSS to provide a real-time reporting map with finer time resolution (last year, last month, real-time, etc.) than the current map	Chair, Secretariat	Done
25	to emphasize the importance of maintaining or improving support for Port Meteorological Officers	Chair	Done
26	to emphasize the importance of the GCOS Climate Monitoring Principles to NWP centers and VOS operators (JCOMM), and their funders	Chair	Ongoing
27	to again emphasize the importance of the	Chair, Taylor,	Done

	maintenance of the ship metadata database through WMO Publication 47 (via a letter WMO SecGen and VOSClim newsletter)	Kent	
28	to review the OceanSITES whitepaper, for consideration for publication as an OOPC report	all + Sec./Weller for external rev.	ongoing
29	to encourage the NSF OOI initiative to consider ocean climate data infrastructure and observing requirements	Weller, Dickey	Done
30	to ensure JCOMM includes the VOS network in its observing system status reports and maps	Secretariat	Done
31	to suggest the WCRP WG on Surface Fluxes seek more operational met service representation / input	Chair, cc to JSC, WGNE, Taylor, Weller	Done
32	to develop on the OOPC website an information database for existing ocean biogeochemical climate observational systems (moorings, floats, VOS, etc.), including what measurements are being taken, including research-based and interdisciplinary measurements as well as sustained observations	Fischer, Dickey, Hood	ongoing
33	to liaise with GDAC concerning the availability/use of stable mooring time series for QC of Argo profiles	Weller, Keeley	Ongoing
34	to build clearly defined targets for the data system, as goals against which implementation bodies will be measured; and to regularly review observing system targets	Chair, Secretariat, Keeley, w/ contrib. from all	Ongoing
35	to comment directly on the adequacy and suitability of actions taken by JCOMM and IODE to improve the data systems	Keeley	Done
36	to actively contribute to the currently ongoing IODE evaluation with our requirements; and to encourage CLIVAR to do so	Fischer (to get survey to OOPC); all	Done
37	to encourage CLIVAR to get better observational covariance information - time and space variability of the subsurface ocean, for observing system evaluation	with Action 15	Taken to GODAE and GSOP
38	to encourage documentation of climatology comparisons, and estimation of errors in global/historical subsurface climatologies	with Action 15	Taken to GODAE and GSOP
39	to help improve estimates of quantitative requirements for VOS for fluxes	Reynolds, Weller, with Taylor, Kent	ongoing

40	to make a list of ocean climate products needing evaluation, and transmit this to the JCOMM Products & Services PA and to GSOP	chair, Weller, Keeley, Dickey, Reynolds	Pending

2. SCIENCE FOCUS

2.1 State of the Oceans 2004-2005

A review of the ocean climate in the last year was presented by Reynolds, Fischer, and Harrison. The presentations can be downloaded from the meeting website: ioc.unesco.org/oopc/oopc-x/.

Fischer showed a review of conditions in the Pacific, which showed some warming in the western central tropical Pacific, which prompted an announcement from NOAA of the "return of El Niño." Although there was a deepening of the thermocline in the eastern tropical Pacific, the SST anomaly remained neutral, and no significant eastward shift in convection was noted. The announcement of El Niño together with the lack of traditional El Niño conditions in the eastern Pacific was a cause for concern for many, and highlights the challenge in reaching a consensus on the definition of El Niño and La Niña. Other indices that showed significant excursions over the previous year included a strong drop in the NAO index in boreal winter 2004-5, and after a period of small positive PDO, a very recent strengthening of the index. A new subsurface temperature and salinity analysis for the Atlantic Ocean was now being produced on a routine basis by the Coriolis center, and could provide a source for the calculation of subsurface indices.

Harrison presented some comparisons prepared by N. Rayner between the Hadley Centre and blended Global Digital Sea Ice Data Base (GDSIDB) sea ice extent datasets for the northern hemisphere, which revealed significant differences. The GDSIDB database showed much less reduction in extent over the last 50 years ending in 1990. Rayner indicated that differences in methodology were grounded in scientific choices and assumptions that are equally defensible. He then showed some ongoing work on determination of oceanic subsurface temperature trends discernible in the better sampled parts of the world ocean, based on *in situ* data over the last 50 years (World Ocean Data Base 2001). At 100 m there were some discernable (at 90% confidence) basin-scale patterns in the North Atlantic and North Pacific, and to a lesser extent in coastal regions. Some of these patterns repeated at 300 m, though there was much less data. At 500 m, the areas with significant amounts of data were confined to the western boundary current regions of the North Pacific and Atlantic, and to some coastal regions in the northern hemisphere. The noteworthy features included the presence of clear sub-basin scale patterns of trend of both positive and negative sign, with much greater amplitude (up to 3 °C) than recent estimates of world ocean averages (~0.04 °C). Evidently there are regional patterns of strong warming and cooling compared with the expected global warming signal. These pointed to the need to improve the observing system, including reanalysis efforts; estimates of the uncertainty of decadal trends over the world ocean would appear to deserve additional scrutiny.

Reynolds showed weekly SST anomalies from the NOAA OI SST anomalies relative to a 1971 - 2000 climatology. The SST anomaly mean for January 1990 - April 2005 shows long term warming in tropics and Northern Hemisphere mid-latitudes, especially in North Atlantic. During May 2004 - April 2005 the anomaly mean showed warming in 5 regions: the eastern middle and high latitude North Pacific, the high latitude North Atlantic, the tropical North Atlantic, the central equatorial Pacific and the equatorial Indian Ocean. The two regions with the strongest anomalous signals were the middle and high latitude northeastern Pacific (30ºN - 70ºN; 180 -120ºW) and the high latitude North Atlantic (50ºN-70ºN, 60ºW - 20ºE). Both of these regions showed strong boreal summer warming in 2004. In addition there was similar summer warming in 2003. These warming events in 2003 and 2004 were the ocean's response to the summer surface temperature heat waves over the land, transferred by surface fluxes.

2.2 Invited Presentation: Measuring the Meridional Overturning Circulation

Martin Visbeck's presentation can be downloaded from the meeting website.

Recently there has been considerable public interest about the possibility of 'abrupt climate change' involving changes in the thermohaline circulation of the ocean (e.g. the film, "The Day After Tomorrow"). The wind- and buoyancy-driven ocean transports carry a large amount of heat and fresh water, and play a significant role in the poleward transport of heat in the tropics, while the atmosphere is dominant further away from the equator. WOCE data allowed for a number of estimates of the heat and freshwater transport in the Meridional Overturning Circulation (MOC), but large uncertainty remains over the possibility of significant changes in the MOC due to climate change. A poll of scientific experts showed a large range of perceptions about the possibility of an Atlantic MOC shutdown with a 6 °C increase in temperature in 100 years, ranging from 0% to nearly 100%.

The MOC is estimated through the combination of a number of different types of observations: cable-based or direct moored velocity estimates, geostrophic transport measurements, and potential energy index sites. In the past decade a number of direct velocity time series have been made in the North Atlantic and in the deep overflows into the North Atlantic. The transport time series are expensive, and the adequacy of their resolution of the boundary currents is unclear, but they have provided valuable insights. For example, the transport in the Faroe Bank channel overflow[2] was observed to drop from about 1.5 to about 1 Sv from 1996 to 2000, raising concern that overflows from the Arctic were diminishing significantly; but continuation of the measurements a few years more showed a return to nearly the original value[3]. Other overflow and deep western boundary current time series show significant temporal variability on multi-year timescales. A new five-year program to measure the transport across the Atlantic (RAPID) started last year. A number of the other transport time series which were funded by thematic German research funds will end in the next three years. Decisions need to be made about which are most important to continue, so that funding can be sought. There are correlations some of the transports with the NAO. A number of studies have shown freshening of the North Atlantic in the past decades.

Forced ocean models of the MOC show some level of robustness, but again a fairly high level of natural variability and considerable ensemble spread complicates prediction. Reanalyses are promising ways of estimating recent variability, but will be underconstrained by the amount of available observations. A quantitative estimate of the sensitivity of MOC estimates to any particular set of specific observations is currently impossible. The direct

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[2] Hansen, B., W. R. Turrell and S. Østerhus, 2001: Decreasing overflow from the Nordic seas into the Atlantic Ocean through the Faroe Bank channel since 1950, *Nature* 411, 927-930, doi: 10.1038/35082034.

[3] Hansen, B., S. Østerhus , D. Quadfasel and W. R. Turrell, 2004: Already the Day After Tomorrow?, *Science* 305, 953-954, doi: 10.1126/science.1100085.

current arrays are possibly the best that can be done to obtain a basin-scale observed index of the MOC, but the cost-effectiveness needs to be agreed. Global data sets including Argo profiles of temperature and salinity need models to be converted to an MOC index, which remains a research issue.

The Panel recognized the value of the numerous studies contributing towards measurement of the Atlantic MOC, and recognized the difficulty in convincing national research agencies to fund sustained observations. The need is clearly strong for these research observational activities, coupled with a strong analysis/synthesis effort to be continued for about a decade. Only then could a 'rationalization' of which elements should be sustained be attempted, particularly in view of the decadal variability of elements of the MOC. Coupled model predictions of the effects of smaller changes (order 10-30%) in the MOC on regional climate would be important in advocating for the continuation of these efforts, as would a better understanding of the 'secondary effect' to carbon uptake and ecosystems, and **the Panel encouraged** CLIVAR and other modeling groups to aid in this effort. Maintaining time series was also seen as crucial in being able to address future research questions that would arise.

2.3 Invited Presentation: Shallow Subtropical Overturning Circulations

Fritz Schott's presentation can be downloaded from the meeting website. He reported on work carried out by a number of investigators on analyzing the circulation and variability associated with the Subtropical Cells (STCs). These are shallow overturning circulations that connect the equatorial upwelling regimes of the Pacific and Atlantic with the subtropical subduction regions by poleward Ekman transports at the surface and equatorward thermocline flows. The situation is different in the Indian Ocean, where the upwelling takes place north of the equator and subduction occurs in the southern hemisphere subtropics. The result is a cross-equatorial cell (CEC) in the Indian Ocean which connects both regimes by southward Ekman transports at the surface in the interior and by northward thermocline transports along the western boundary carried by the Somali Current. In addition, there is a hemispheric STC in the Indian Ocean, driven by the upwelling in the 5-12 °S latitude range, at the northern edge of the Trades.

The key set of observations on Pacific STC variability was presented in two papers by McPhaden and Zhang[4] (MZ). From geostrophic mass transport calculations along 9 °S and 9 °N in the Pacific they showed that the equatorward convergence of the STC thermocline flow was decreasing by about 12 Sv ($=10^6 m^3 s^{-1}$) from the 60's to the mid-90's, and increasing again since. It was suggested that in consequence of the reduction in equatorial upwelling, equatorial SST was increasing until about 1995, and then decreasing again when the STC strengthened again.

A number of assimilation and prognostic models (e.g., ECCO of U.Hamburg/MIT, SODA-POP of Texas A&M, Earth Simulator of JAMSTEC/IPRC) are presently being analyzed to better understand the mechanisms responsible for these large Pacific changes. While the models analysed in our study agree in showing a decreasing trend of interior STC convergence from the 1960s to the 1990s, they also show that much of this decrease is compensated by western boundary transports (which MZ could not evaluate for lack of

[4] McPhaden, M. J. and D. Zhang, 2002: Slowdown of the meridional overturning circulation in the upper Pacific Ocean, *Nature* 415, 603-608, doi: 10.1038/415603a, and
McPhaden, M. J. and D. Zhang, 2004: Pacific Ocean circulation rebounds, *Geophys. Res. Lett.* 31, L18301, doi:10.1029/2004GL020727.

observations). Yet, there are also significant differences among the model results as to the details of the 9 °N vs. 9 °S STC transport changes, which require further study. A main cause for these model-to-model STC transport differences appears to rest with the wind forcing used. An essential component relating Pacific STC variability with the Indian Ocean is the Indonesian Throughflow (ITF).

In the Atlantic, the database is too sparse to repeat the Pacific cross-basin STC calculation, but measurements of the western boundary transports off Brazil over the past several years and model analyses suggest that Atlantic STC variability is fairly small, and that its role in equatorial SST and climate may be dominated by other effects.

Observations in the Indian Ocean are even sparser, in particular regarding the subsurface structure of circulation features and anomalies. From the ECCO and SODA assimilation products, the variability of the cross-equatorial cell in relation to northern upwelling and heat balance variations was studied, and decadal CEC changes were found which merit further investigation. Variability of mixed-layer depth and SST over the 5-12 °S thermocline dome plays an important role in cyclogenesis and precipitation over East Africa. Therefore, improving our understanding of ocean processes determining the upwelling and thermocline variability in this region are an important objective of Indian Ocean CLIVAR studies. A decadal decrease of Ekman divergence and resulting warming in that dome region during 1992-2002 were reported by T. Lee[5]. Model studies further suggest an important role of the ITF in decadal Indian Ocean variability, by advection of Pacific anomalies related to the Pacific Decadal Variability (PDV).

As regards observational requirements, in particular concerning a sustained network, the model STC and CEC studies in the different oceans showed the following:

- The interior STC transports can reasonably well be estimated by geostrophy and it has to be evaluated how well Argo profiles may cover the zonal subtropical extent in the future to determine interior thermocline transport changes.
- At the equator, TAO-type array measurements with ADCPs are required to measure variability of equatorial circulation and of the Undercurrent.
- The low-latitude western boundary currents (LLWBCs) need to be measured because it was found that (in models) much of the interior thermocline transport variability is compensated by the LLWBCs, such that the coast-to-coast transport variability is much smaller.
- An essential requirement is continued measurement of the ITF, beyond the INSTANT period, not only for a better understanding of the shallow tropical-subtropical circulations, but also for the entire global circulation system.

For STC pathway studies, the use of Lagrangian methods is important; for example an experiment with isopycnic RAFOS floats (IFM-GEOMAR, Kiel) is underway in the Atlantic.

The Panel noted the possibility that the STCs play a part in the decadal variability of tropical interannual variability such as ENSO, and in modifying the tropical stratification, with possible effects on upwelling and ecosystems. **The Panel agreed** on the importance of sustained monitoring of the Indonesian Throughflow in understanding the variability of the pathways of heat in the tropical oceans. As for the STC measurements, a strong research observations and synthesis effort should be maintained for about 8-10 years, with a design for sustained observations coming from this effort. The LLWBCs are generally poorly observed.

[5] Lee, T., 2004: Decadal weakening of the shallow overturning circulation in the South Indian Ocean, *Geophys. Res. Lett.* 31, L18305, doi:10.1029/2004GL020884.

3. SPONSOR REPORTS AND LIAISON WITH OTHER INTERNATIONAL GROUPS

3.1 GCOS Including the Implementation Plan

Alan Thomas's presentation is available on the meeting website. He presented an overview of the *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC* (GCOS-92)[6], to which the Panel contributed. The Implementation Plan (IP) reprises the Second Adequacy Report's Essential Climate Variables (ECVs), and calls for a major satellite component emphasizing accuracy and continuity, global *in situ* observations, capacity building, sustained product generation and improved data management, and international oversight and coordination. The actions in the report represent, for the ocean domain, an estimated US$ 200 million of additional investment per year.

The IP was presented to the Subsidiary Body for Scientific and Technical Advice (SBSTA) of the Convention, and subsequently to the Tenth meeting of the Conference of the Parties (COP-10), which encouraged Parties to strengthen their efforts to address the priorities identified in the IP, invited Parties supporting Earth observation satellites to provide a coordinated response, and asked GOOS to provide a report on "progress made towards implementing the initial ocean climate observing system," which was presented in June 2005 to the 23rd meeting of SBSTA in Bonn, Germany.

The IP has also formally been adopted as the climate component of GEOSS, and the JCOMM Management Committee in February adopted GCOS-92 as the basis for the work plan of the Observations Programme Area, a proposition that will be brought to JCOMM-II in September in Halifax.

Paul Mason, the chairman of GCOS, congratulated the OOPC for its effort in pulling together a nearly universally-agreed plan for the ocean domain, and stated that the issue for the OOPC was now to find a path forward towards implementation.

The Panel agreed to consider the list of GCOS Implementation Plan actions where it is identified as an Agent for Implementation (see Annex III, and **Actions 1-9**). **The Panel also agreed** to maintain a portfolio of specific proposals for workshops or coordination activities that would help to move forward key actions, keeping in mind those projects that would be priorities of the IPCC (see **Action 10**).

3.2 GOOS Including the Coastal GOOS Implementation Plan

The Chair gave a presentation on the Global Ocean Observing System (GOOS), which is available on the meeting website. He noted that GOOS had a new director (Keith Alverson), and a new chair (John Field). He noted that the Coastal Ocean Observations Panel (COOP) had finished its implementation strategy[7] and had disbanded, with the functions of COOP to now be incorporated into the GOOS Scientific Steering Committee. The Coastal Strategic Implemenation Plan was focused on societal needs, and had a number of subsystems and interactions to interface users with data and analysis. There was a need to better identify connections between the coastal and global components of GOOS. GOOS had set up a

[6] see Footnote 1.

[7] *An Implementation Strategy for the Coastal Module of GOOS*, GOOS Report No. 148 (2005), available at http://ioc.unesco.org/goos/.

number of regional alliances (GRAs) to help implement the global and in particular the coastal modules of GOOS.

There is an absence in most cases of national frameworks for sustained ocean observations and analysis, which are being done in large part in the research community with research funding. The challenge of sustaining activities is ongoing, and **the Panel looked** to GOOS, amongst others, as a partner in facing this challenge.

3.3 WCRP: Overview and Focus on WOAP and GSOP

Valery Detemmerman gave the Panel a presentation focusing on the relationship between the WCRP and OOPC, touching on two new panels with some overlapping interests, and on the relationship with CLIVAR; two presentations are available on the meeting website.

The recent assessment of CLIVAR asked for a focus on four major themes: ENSO, the monsoons, decadal modes of variability and the thermohaline circulation, and anthropogenic climate change. While CLIVAR is organized around basin panels, the assessment pointed to the need for implementation with the global domain in mind. All the panels were asked to consider indices useful for ongoing monitoring of the climate system, in cooperation with the OOPC and the Expert Team on Climate Change Detection Monitoring and Indices (ETCCDMI). Data management was identified as an area with great need for development under CLIVAR.

WCRP had recently elaborated its strategic plan for 2005-2015, Coordinated Observation and Prediction of the Earth System (COPES), which was meant to respond to changes in climate research, with new large datastreams, and a closer relationship to operational centers. It envisions the development of seamless climate prediction capability across domains and timescales.

One early initiative under COPES was the organization (at IOC/UNESCO in June 2006) of a Sea Level Workshop, designed to identify and organize a systematic attack on the major terms in the uncertainty budget of sea level rise. It will identify requirements for research, for technical development, and for sustained observations.

A new panel formed under COPES is the WCRP Observations and Assimilation Panel (WOAP), whose terms of reference charge it with: definition of observational requirements for climate system analysis and prediction, assisting in the optimization of observational strategies for sustained observation, acting as a focal point for WCRP interactions with other groups and programmes, promoting and coordinating synthesis of global observations for the fully-coupled system, and promotion and coordination of WCRP information and data management activities.

A new CLIVAR Global Synthesis and Observations Panel (GSOP) will focus initially on ocean synthesis, and in WCRP has the clear lead in this area over WOAP. The actions for GSOP defined out of the first meeting were to work on:

- a data requirements white paper,
- a data quality and assembly project for ocean reanalysis,
- promotion of global hydrography coordination,
- an upper ocean thermal review,
- data release specifications,
- guidelines for process studies,
- documentation of ocean needs for reprocessing satellite data (for WOAP),
- guidelines for reanalysis intercomparison (with GODAE),

- subsurface ocean indices (with the ETCCDMI and OOPC),
- an ocean reanalysis website,
- evaluation of ocean reanalysis fluxes,
- and compilation with NASA of the best winds for 1950-2004 for reanalyses.

The Panel noted many areas of overlapping interest with GSOP, and the chairs of OOPC and GSOP agreed to cooperate to combine resources where feasible and to avoid duplication of effort. Further discussion of the relationship between the OOPC and GSOP takes place in Section 5.1.1.

3.4 JCOMM

3.4.1 Overview and preparations for JCOMM-II

Edgard Cabrera, the new head of the Ocean Affairs Division at the WMO, gave the Panel a presentation on the structure and goals of JCOMM, which is available at the meeting website. JCOMM's overall goal is the intergovernmental coordination, management, and standards-setting for operational oceanography and marine meteorology, it is an implementation mechanism for global GOOS. It is organized into four programme areas: Observations, Services, Capacity Building, and Data Management. The Observations Programme Area (OPA) is addressed in the following presentation.

The Services Programme Area is structured around the coordination and provision of services for marine safety and transport, for natural disaster prevention, and for global climate prediction and research. The Data Management Programme Area cooperates with the IODE, and is focused on providing integrated data management for the observations and services of JCOMM. JCOMM has an ambitious work programme, and the regular programme resources are insufficient to conduct them, requiring substantial extrabudgetary support. The Second Session of JCOMM will take place in September 2005 in Halifax, Canada.

3.4.2 Observations Coordination Group and Implementation

Mike Johnson's presentation is available on the meeting website. The JCOMM Observations Programme Area (OPA) coordinates the work of three implementation panels – the Data Buoy Cooperation Panel (DBCP), the Ship Observations Team (SOT), and the Global Sea Level Observing System Group of Experts (GLOSS GE). Since JCOMM was established in 2001, there has been a link to the international Argo program as well. The OPA has also been working to coordinate globally with the international OceanSITES program and with the International Ocean Carbon Coordination Project (IOCCP). These four efforts – JCOMM, Argo, OceanSITES, and IOCCP – represent major international contributions to implementation of the global ocean observing system for climate. All four are needed for sustained global ocean observation and there is opportunity for significant implementation efficiencies in working together.

Three observing system issues are common to all JCOMM implementation panels - the SOT, the DBCP, and the GLOSS GE – as well as to Argo, Ocean Sites, and the IOCCP. The OPA has chosen to give priority attention to these:

A. Achieving global coverage by the *in situ* networks,
B. System-wide monitoring and performance reporting,
C. Funding to meet implementation targets.

The first issue is the fundamental need for achieving global coverage by the *in situ* networks. There is presently significant international momentum for implementation of a composite global observing system consisting of: 1) the *in situ* networks -- moored and drifting buoy arrays, profiling floats, tide gauge stations, and ship-based networks; 2) continuous satellite missions; 3) data and assimilation subsystems; and 4) system management and product delivery.

The GCOS IP (GCOS-92) has now been endorsed by the UNFCCC and by the Global Earth Observation System of Systems (GEOSS). Although the system specified by GCOS-92 is designed to meet climate requirements, marine services in general will be improved greatly by implementation of the global coverage called for by this design. The system will support global weather prediction, global and coastal ocean prediction, marine hazard warning, marine environmental monitoring, military applications, and many other non-climate users. JCOMM is identified as the implementing agent, or a contributing implementing agent, for 21 of the specific actions listed in the GCOS-92 ocean chapter (pages 56-84). These specific actions have been accepted by the OPA as a roadmap to guide the OPA work plan for the next four years.

A major milestone will be achieved by the DBCP in September 2005[8]. The global drifting buoy array will reach its design goal of 1250 buoys in sustained service. Thus the global drifting buoy array will become the first component of the Global Ocean Observing System to be completed. This is an accomplishment worth celebrating. It has taken 10 years since the international community set out on the GOOS quest with the publication of the *Scientific Design for the Common Module of the Global Ocean Observing System and the Global Climate Observing System* by the Ocean Observing System Development Panel in 1995.

A significant milestone was achieved by Argo in December 2004. The half way mark was reached with 1500 floats being deployed globally.

The total composite *in situ* ocean system (DBCP, SOT, GLOSS, Argo, OceanSITES, IOCCP) achieved a major milestone in March 2005 by surpassing the 50% completion mark. Based on the system targets identified in GCOS-92, the ocean system has achieved 51% global coverage in May 2005.

A major challenge for the Observations Programme Area is to develop easy to understand performance reports that can help in evaluating the effectiveness of the observing system and help in efforts to convince governments to provide the funding needed to meet global implementation targets. The OPA is working to develop standard base maps showing required global coverage against what is presently in place. Much work is being done by JCOMMOPS, the implementation panels, and other partners around the world to evaluate observing system status and effectiveness. The OPA is developing summary reports illustrating how advancements toward global coverage improve the adequacy of the observational information that is essential for monitoring the state of the ocean and marine meteorology.

A standard map projection has now been accepted by the OPA for reporting system status and progress. It is an Equidistant Cylindrical Projection, 90 °N to 90 °S, broken at 30 °E. A standard set of colors indicating country contributions is used by JCOMMOPS. For indicating system performance, a progression of colors (red, orange, yellow, green, blue) is used varying from red-for-bad to blue-for-good.

A demonstration project is now underway to develop regular reports of observing system monitoring and performance metrics in cooperation with the GOOS Program Office. A

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[8] *Ed. note:* This goal was in fact achieved.

consolidated Progress Report with Contributions by Countries is available at www.jcommops.org/network_status/ which lists the 64 countries and the European Union that maintain elements of the composite ocean observing system, and the number of platforms and expendables contributed by each country. This report will allow tracking of progress toward implementation of the ocean system specified in GCOS-92.

The OPA is working to develop a real time observing system monitoring capability with live access server to provide web browser and data visualization for system analysis and evaluation. Real time data and metadata will be pulled from multiple sources, including the GTS and the web-based GODAE data servers, and will be stored on the OPA system servers for five years for display and analysis. System managers and other users will be able to generate their own customized reports for specific global and regional needs using this international observing system management infrastructure.

The JCOMM OPA is working to help convince governments to provide the funding needed to meet global implementation targets. Global coverage cannot be achieved with the resources that are presently being applied. As noted above, the baseline GCOS ocean system is only 51% complete. One way the OPA can help is to develop easy to understand statistics and reports that decision makers will be able to use to justify new funding. Efforts in this regard are summarized above.

The OPA has developed a proposal for consideration by JCOMM-II (meeting in Halifax in September 2005) to establish a trust fund for consumables. The initial thrust of this idea is XBTs but other expendables could be added in time. It is estimated by JCOMMOPS that 24000 XBT probes are needed annually to maintain the system. Presently the five counties contributing to XBT procurements provide only about 18000 probes per year. This leaves a 6000 probe gap. The OPA proposal is for establishment and management of a JCOMM Trust Fund to help encourage additional countries to join with the present five countries and contribute to filling this gap.

Johnson suggested that scientific design help was needed from the OOPC particularly in two areas.

1) First was the target number of barometers needed for the drifting buoy array. The present target value of 700 barometers is only a best guess and needs to be examined.

2) Second, it was suggested that perhaps a workshop was needed to reevaluate the design of the 51 HDX and FRX lines and the coordinated utilization of the VOS fleet as a whole. The sampling rates on north-south and east-west XBT lines needs to be clarified; some XBT lines are now very difficult to maintain because of changes in commercial shipping routes; and there has been suggestion that some low density lines need to be included in the long term system design because of the value of long time series on those historic lines. Also, in order to take a more systematic approach to implementation of VOS operations it would be valuable to have a design concept for VOS surface observations in regard to possibly applying standards similar to VOSClim more broadly across the fleet, and for a target number of VOS ships and sampling frequency/density needed for sustained global coverage.

With the priority activity in many places on building and maintaining a tsunami warning system including deep-sea buoy systems, and the availability of research ships with this servicing capability, **the Panel agreed** that coordination with climate activities was a critical need (see also Sections 5.2.2 and 7.1, and **Action 11**).

The Panel agreed to respond to the request for guidance on the targets for barometers on surface drifting buoys, as well as to revisit of the requirements tables from Needler et al, 1999, for example for the 5° surface drifter requirement for SST calibration and in particular the SOOP XBT sampling requirements (see also Sections 5.5 and 5.7, and **Actions 12-15**).

3.5 GEO

Guy Duchossois, the Work Plan Team Manager for the interim GEO Secretariat, gave the panel a presentation on GEO, which is available at the meeting website. He reviewed the major decisions made at the previous week's First GEO plenary, which largely concerned the governance of GEO. GEO has begun to assemble a Work Plan, with identifies tasks for GEO through 2007. The Work Plan will be adopted in December 2005 by the 2nd GEO Plenary. GEO was also working with the IOC, WMO, and ISDR on the Indian Ocean Tsunami Warning System.

The Panel recognized the importance of maintaining close contact with GEOSS to ensure integration of ocean observing system plans in GEO work plans and to offer expertise when needed (see **Action 11**). The Panel will maintain a prospectus of possible projects for funding from GEO (for example coordination activities for space-based products, specific workshops aimed at IPCC) and put them forward to GEO when appropriate (see **Action 16**).

3.6 Others: POGO, IGBP, IPY

The chair gave the Panel a report on the activities of the Partnership for Observation of the Global Oceans (POGO). POGO unites the directors of oceanographic research institutions, and has a new chair, Tony Haymet of CSIRO Marine Research. It has proved a useful vehicle for advocacy in the GEO process, and as a place for the OOPC to advocate for sustained global observations.

The Panel expressed its appreciation for the efforts of POGO in consolidating feedback for GEO. It also looked to POGO to help encourage the real-time reporting of ocean hydrography, and in the development of a community-wide cruise data base to identify opportunities for sensor deployment.

Maria Hood gave the panel a presentation on the evolution of IGBP programmes. Two major new programmes are growing under the IGBP. The Surface Ocean Lower Atmosphere Study (SOLAS) is focused on biogeochemical-physical interactions across the air-sea interface. The Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) Project is focused on interactions between ocean biogeochemical cycles and ecosystems, and how they respond to and force global change. A coordination meeting organized by SCOR in Venice in September 2004 was very useful in getting these two research communities to understand the benefits of, and the relationship between sustained and research observations.

The Panel agreed that it is important to develop closer communication and coordination with the IGBP scientific community. The goals of OOPC and IGBP overlap significantly in maintaining a sustained observation system in partnership with research, for both observations and analysis (see **Action 17**).

Eduard Sarukhanian presented plans for the International Polar Year (IPY) 2007-8, his presentation is available on the meeting website. The IPY will include a number of new observational initiatives in the polar regions, with some of the headline projects relating to polar oceanography being:

- an Integrated Arctic Ocean Observing System, led by the Arctic Ocean Science Board
- the role of Antarctica and the Southern Ocean in past, present, and future climate, led by the CLIVAR-CliC-SCAR Working Group on the Southern Ocean

- a synoptic Artic shelf-slope interactions study (iAnZone)
- Arctic and Antarctic Sea Level Network development and studies of polar sea level variability (GLOSS, JCOMM)

The establishment of legacy polar observational networks were a goal of the IPY, as were the development of sound data management policies and strategies. Sarukhanian invited the Panel to provide guidance to individual project steering committees, in particular to studies of the ocean in climate change, establishment of observational networks, and oceanographic data management issues.

4. SATELLITE OBSERVATIONS

4.1 Requirements for Climate Observations and Status Report, including the European GMES initiative

Johnny Johannessen presented the Panel with a status report on the requirements and satellite missions for climate monitoring and research, and on the European Global Monitoring for Environment and Security (GMES) initiative; his presentation can be downloaded from the meeting website.

The ocean climate requirements for satellite measurements in terms of accuracy and continuity between missions have been stated in both the GCOS IP and a report by the WCRP Satellite Working Group[9]. These are sustained observations of sea ice and SST (both in passive microwave and infrared), ocean colour, ocean surface winds, and continuous coverage from altimeters for both high precision and high resolution sea level measurements (multiple satellites in multiple orbits with different repeat periods/resolutions). Johannessen outlined some of the key areas for concern: altimetry coverage after 2008, and adequate ocean surface winds in the very near future. He also mentioned the coming launches (in 2007/2008) of GOCE, SMOS and Aquarius that would provide new data on the marine geoid and sea surface salinity.

GMES is a joint European Union (EU) and European Space Agency (ESA) initiative, with the aim of establishing an operational, sustainable, autonomous capacity for environmental monitoring. This includes space-based systems, *in situ* systems, data integration and information management, and the provision of services. It is the major European contribution to GEOSS. The implementation phase (2004-2006) will establish a dialogue between users and providers, develop services, design the space component, assess and upgrade the *in situ* component, improve the data management, and develop a long-term funding strategy and business plan. An operational phase will begin in 2007, with implementation of the space component, an expansion of the *in situ* component, and operation of a sustained data integration and information management capacity. Some of the core services identified in GMES with relevance to the ocean are: acquisition of knowledge on the state and evolution of the global environment including monitoring the global oceans, providing support to civil protection for risks associated with marine industrial activities and transport, providing support to EC common fisheries management policies, and supporting the 6th EC Environmental Action Plan for climate change, for integrated coastal zones management, and for the marine environment. More details on GMES can be found at http://www.gmes.info.

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[9] *Space Mission Requirements for WCRP*, September 2004, WCRP-119, WMO/TD-No. 123

The Panel identified the continuity and continued high quality of ocean satellite missions for SST, vector winds, altimetry, ocean colour and sea ice as a high area of concern. **It highlighted** in particular the problem area for altimetry after 2008, and concerns over continuation of adequate vector scatterometer missions. The Panel will participate in the review and revision of the IGOS-P Ocean Theme report (see **Action 5**). It also identified the intercomparison of sea ice products to improve climate quality as an important effort, and encouraged this effort to move forward under the IPY (see also Section 5.1.5 and **Action 19**).

4.2 Working with the International Satellite Planning Process

Don Hinsman gave the Panel a presentation on the WMO Space Programme, with particular emphasis on input to the planning process for satellite observations; his presentation is available on the meeting website. The WMO Space Programme was established in 2004 as a cross-cutting programme of the WMO, designed to help develop an integrated WMO Global Observing System for all the goals of the organization. This includes increasing the effectiveness and contributions from satellite systems to ocean observations for GCOS, GOOS, WCRP, and JCOMM, all programs that WMO has a stake in.

Hinsman provided a summary of the multiple groups for international coordination of space observations. At the WMO, some recent developments have been the establishment of a two new groups: the Consultative meetings on high-level policy for satellite matters, and the organization of a new WMO Expert Team on Satellite Systems under the WMO Committee for Basic Systems (CBS) Open programme Area Group (OPAG) on Integrated Observing Systems (IOS).

The Panel thanked Don Hinsman for his presentation and planned to consult with the WMO Satellite Program about how to best communicate its requirements to elements of the international satellite planning process, including to the Consultative meetings on high-level policy for satellite matters and to the CBS OPAG IOC Expert Team on Satellite Systems, also working via GCOS (see **Actions 5 and 18**).

5. EXPERIMENTS, PROGRAMS, AND PROJECTS

5.1 Ocean Analysis and Reanalysis

5.1.1 CLIVAR Global Synthesis and Observations Panel (GSOP)

Detlef Stammer, the chair of the CLIVAR Global Synthesis and Observations Panel (GSOP), gave a presentation on the scope and activities of his panel, and common points with the OOPC and GODAE. His presentation is available on the meeting website.

The reach of CLIVAR research is broad, and the need for reanalysis serves a number of purposes. These include providing improved databases and reference datasets for climate research and the study of ocean dynamics, initialization for seasonal-to-interannual (SI), decadal, and longer term climate forecasting, to bring regional and basin-scale research into a global framework, and to provide guidance on the effectiveness for climate purposes of the ocean observing system. Synthesis of CLIVAR observations and models are also needed, which requires data archiving, integration, and a hierarchy of synthesis systems.

The terms of reference of GSOP charge it with developing and promoting implementation strategies for global ocean synthesis, to help define CLIVAR's global needs for sustained observations, to promote activities to develop surface flux data sets with WGNE and WGSF, to provide directions for CLIVAR data management activities in collaboration with other WCRP projects and data centers, and to liaise with CLIVAR groups in identifying the requirements for an observing system for CLIVAR.

The first meeting of GSOP was held in conjunction with a CLIVAR ocean reanalysis workshop in November 2004. Some of the outcomes of and challenges identified at this meeting are:

- Ocean reanalyses have to address a range of user needs (describing the ocean dynamics, SI forecasting, decadal-centenial forecasting, anthropogenic climate change), and so the requirements will differ. While operational centers focus on SI, an institutionalization of ocean reanalyses for other purposes is needed,
- The data stream needs to be coordinated to support all of the requirements,
- Testing of reanalyses for each of the requirements is urgently needed, which requires involvement of a large part of the science community,
- For decadal efforts, the data stream and quality control become large efforts,
- Surface flux uncertainties remain a large issue.

GSOP will aim to make reanalysis products available in 2009, in time to contribute to the 5th IPCC Assessment Report. The meeting also identified a number of actions for GSOP (see Section 3.3).

The Panel re-emphasized that the observing system has both an observing and a synthesis component, and that the synthesis should be discussed as a part of the observing system.

The Panel agreed that the GSOP and the OOPC will continue to communicate and coordinate efforts closely. Their relationships with the CLIVAR basin panels are evolving. **The Panel encouraged** GSOP and the ocean reanalysis/analysis community to increase its publicity on available products, to build the relationship with users; and to consider other ways of doing this, including quick publishing of basic intercomparison studies. **The Panel also asked** GSOP for help in ongoing evaluation of observing system requirements and strategy for evolution, and in the development of prototype ocean climate indices.

5.1.2 WCRP Observations and Assimilation Panel (WOAP)

Gilles Sommeria provided the Panel with a report on the scope and objectives of the WCRP Observations and Assimilation Panel, which scheduled its first meeting for June 2005. He recalled that Valery Detemmerman had already described COPES and the rationale for WOAP. The main focus of the group would be on next-generation atmospheric climate reanalyses, and so would be complementary to GSOP. The ToRs of WOAP are:

- definition of the observational requirements for climate system analysis and prediction, and assisting in optimizing the observing strategy for sustained observations,
- to promote coordination and synthesis of all domains of climate across the WCRP
- to coordinate data management activities to access observational data, including satellite data, across the WCRP.

Proposed activities for the group included a workshop in 2006 on coordination of the next round of climate reanalyses, and a conference in 2007 to be led by Adrian Simmons. The group would also address the reprocessing of satellite and *in situ* data from the last 30 years in preparation for reanalyses.

The Panel encouraged the climate research community to develop decadal-to-centennial scale coupled assimilation capabilities and to plan for a first coupled reanalysis effort. **The Panel also agreed** that WOAP was a potential natural point for advocacy of satellite missions.

5.1.3 GODAE

The chair presented a report from Neville Smith on progress made in the Global Ocean Data Assimilation Experiment (GODAE) since the last OOPC session, the presentation is available on the meeting website. GODAE is in its third year of its demonstration phase, and begins a consolidation phase next year, with an end foreseen in 2008. The development of an infrastructure to continue operational ocean forecasting is needed, and the products need more user community attention.

GODAE held its second symposium (www.bom.gov.au/GODAE/Symposium II/) in November 2004, with a focus on the models in operation and demonstrating utility. The priority of providing data and information services were confirmed, with a weakness identified in the user interface. The need for benchmarks for product lines, for information delivery, and for interfaces was identified. GODAE also identified a need to improve the fora for communication between the providers (the GODAE community) and users, with improved communication on the availability of products to users, and the utility of GODAE to supporting organizations. The scientific issues raised at the symposium included the important role of the intercomparisons in estimating the uncertainty of the forecasts, the utility of forecast ensembles, and feedback for the observing system. Perspectives for the future of GODAE required a better definition of the market and business case for ocean prediction, while new scientific frontiers in global biogeochemistry and ecosystems, extended weather prediction, and coastal assimilation and predictability would require additional research and coordination.

GODAE also held a summer school (www.mediatec-dif.com/isso/ishome.htm) in September 2004 in France. The lectures are to be published by Springer in book form in January 2006.

GODAE had also made significant progress in North Atlantic intercomparison work. The comparison, led by Laurence Croznier, required significant investment, but was invaluable in quickly identifying issues with models: with model bias, and with model physics and numerical problems. The intercomparison revealed large mean sea level uncertainty, and challenges in modeling overflows.

The GODAE High-resolution Sea Surface Temperature (GHRSST) project continued to make progress, and is reported on in Section 5.1.5.

The Panel welcomed the Atlantic intercomparison exercise, finding it to be very valuable for model validation and improvement, and **encouraged** the extension of this work to other basins and globally.

5.1.4 MERSEA and Other European Initiatives

Johnny Johannessen gave the Panel a presentation on the European MERSEA Integrated Project (http://www.mersea.eu.org), his presentation is available on the meeting website. MERSEA is a European system for operational monitoring of ocean physics and biogeochemistry, with global and regional coverage, and nesting (downscaling) support to shelf sea systems and coastal systems. It is an element of GMES and a European contribution to GODAE. Building on MERSEA Strand-1, it has 14 million € of funding over 4 years (2004-2007) but has a very ambitious work programme, and is meant to become operational in 2008. It is intended to provide products for the marine environment (including oil spill and Harmful Algal Bloom monitoring), global climate, and marine safety. By integration of existing satellite observations with data from *in situ* measurement networks and ocean models, daily mean products and forecasts from four different data assimilation systems (~10 km resolution) are intercompared and distributed through an OPeNDAP server[10]. One of the targeted activities currently ongoing is the demonstration of the combined need for Argo and altimetry.

5.1.5 SST/Sea Ice WG and Marine Historical Data Workshop

Dick Reynold's presentation is available at the meeting website.

The SST sea ice working group is a loose confederation of people working on SST and sea ice analysis. Most of the work on sea ice being done by members of this group has been done by Nick Rayner at the UK Met Office. However, progress has been slowed by health problems.

The remainder of this report is on SST with a primary focus on the recent work at the National Climate Data Center on analyses of *in situ* and satellite data. Reynolds et al. (2002)[11] has been producing a weekly optimum interpolation (OI) sea surface temperature (SST) analysis on a 1-degree spatial grid from November 1981 to present. The analysis uses bias corrected Advanced Very High Resolution Radiometer (AVHRR) infrared satellite retrievals and *in situ* SST observations from ships and buoys. The analysis has been available since 1993 and is widely used for weather and climate monitoring and forecasting. Thiébaux et al. (2003)[12] produced an analysis beginning in May 2001 which used the same input data except that the analysis was produced daily on a 0.5-degree grid and used smaller spatial error e-folding scales. Chelton and Wentz (2005)[13] compared both analyses with microwave SSTs from the Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E), for 6 high gradient regions. These results showed that the gradient features in Thiébaux et al. agreed better with the AMSR-E data than Reynolds et al. This occurred even in regions with sparse AVHRR data due to cloud cover over the comparison period. This implies that many SST features evolve slowly in time. The comparisons also show that reduction in spatial e-folding scales of the Reynolds et al. analysis alone is not sufficient and that both the temporal analysis period and the spatial grid size must be reduced.

To improve the OI analysis, it is planned to produce a new daily analysis on a 0.25-degree spatial grid. The analysis would use Pathfinder AVHRR data instead of the operational AVHRR data when available. This is because the Pathfinder project is a reanalysis and has better quality control than the operational version. The OI analysis would still include a

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10 http://w3.mersea.eu.org/html/information/data_access.html

11 Reynolds, R. W., N. A. Rayner, T. M. Smith, D. C. Stokes, W. Wang, 2002: An Improved In Situ and Satellite SST Analysis for Climate, *J. Climate* 15, 1609-1625 , doi: 10.1175/1520-0442(2002)015<1609:AIISAS>2.0.CO;2.

12 Thiébaux, T., E. Rogers, W. Wang, B. Katz, 2003: A New High-Resolution Blended Real-Time Global Sea Surface Temperature Analysis, *Bull. Amer. Meteor. Soc.* 84, 645-656, doi: 10.1175/BAMS-84-5-645.

13 Chelton, D. B., and F. J. Wentz, 2005: Global High-Resolution Satellite Observations of Sea-Surface Temperature for Numerical Weather Prediction and Climate Research. *Bull. Amer. Meteor. Soc.* 86, *in press*.

weekly correction of any satellite biases using the *in situ* data. Thus, the analysis would still be useful for climate purposes but would also be useful for users requiring higher resolution such as those wishing to compute air-sea fluxes. After the new analysis is carefully tested and evaluated, an additional version would be computed using microwave data from the Tropical Rainfall Measuring Mission (TRMM) Microwave Imager (TMI) and AMSR-E. Because the microwave and infrared retrieval methods are different, the bias errors from the two different sources are independent. Thus, OI biases in regions without *in situ* data will be reduced when both types of satellite data are used as shown by Reynolds et al. (2004)[14].

The weekly OI analysis method includes a preliminary correction of the AVHRR satellite data using *in situ* data before it is used in the OI. This is necessary because the OI method assumes that the data do not contain long-term biases. Because satellite biases occur in our period of interest, a preliminary step using Poisson's Equation is carried out to remove satellite biases relative to *in situ* data before the OI analysis is begun. However, the major problem with this method is that the correction is performed independently for each week's analysis. Thus, there is no continuity of the correction between weeks. In most cases, the cause of the bias, for example the presence of volcanic aerosols, does persist in time. Because the correction is based on limited *in situ* data, this can lead to week-to-week noise in the correction. An alternative bias correction method has been designed to reduce these problems. The results show that differences between the Poisson bias correction and the OI bias correction were modest. However, the OI bias correction is superior because sea ice data are not needed to stabilize the OI at high latitudes as it is in the Poisson method. Furthermore, the OI has temporal continuity while the Poisson correction does not. This allows the OI bias correction to have the slightly stronger correction in the high latitude Southern Oceans where *in situ* data are sparse.

The change of the analysis spatial and temporal resolution and the change in the bias correction will not impact the buoy requirements defined by Zhang et al. (2005). However, the addition of microwave satellite data will have an impact. This is because a potential satellite bias error of 2 °C was assumed when there were no *in situ* data available. This was based on worst case estimates of satellite biases which occurred during the period of record from large volcanic eruptions and from the deteriorations of the satellite instrument with time. With the addition of microwave data, it is unlikely that both types of satellite data would suffer the same magnitude of bias at the same time. Thus, if both types of satellite data were available, the potential satellite bias error would be reduced to roughly 1 °C when there were no *in situ* data. For the current *in situ* network of ships and buoys, the average potential satellite bias error is 0.6 °C using 1 infrared satellite instrument. If both infrared and microwave satellite instruments were available, the average potential satellite bias error would be only 0.4 °C.

Other SST projects include work by Lisa Goddard and Dave DeWitt (IRI) who are going to analyze the impact of ENSO forecasts based on GCM simulations using different SST analyses. Liz Kent (NOCS) and Alexey Kaplan (LDEO) are working to carefully define errors from *in situ* observations. In addition, Alexey Kaplan is designing a statistical method to increase analysis resolution in regions of sparse data.

The GODAE High Resolution SST (GHRSST) pilot project met the week following the OOPC meeting. The US Team is a subgroup of GHRSST and is leading a project called

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[14] Reynolds, R. W., C. L. Gentemann, F. Wentz, 2004: Impact of TRMM SSTs on a Climate-Scale SST Analysis, *J. Climate* 17, 2938-2952, doi:10.1175/1520-0442(2004)017<2938:IOTSOA>2.0.CO;2.

Multi-sensor Improved SST for GODAE. A meeting was held in Miami, Florida, 5-6 April 2005. At the meeting progress was discussed on calculating single sensor error statistics (SSES) for AVHRR, TMI, AMSR-E, MODIS, and GOES satellite SSTs. In addition, efforts were discussed to model the diurnal cycle including skin-bulk effects. During the next year it is planned to improve the error characterization of the satellite data and to improve the diurnal cycle and skin-bulk modeling. It is also planned to compute better OI analyses with improvements in blending infrared and microwave SST data.

The Panel recognized the importance of making progress on the evaluation of current and historical sea ice products (see **Action 19**). GHRSST was recognized as a model project that could be emulated for other variables such as sea ice and ocean colour. Efforts are to be made to seek the establishment of a sea ice subgroup of the SST-SI working group.

5.2 CLIVAR

5.2.1 Atlantic Ocean Panel

Martin Visbeck gave the Panel a presentation on behalf of himself and Wilco Hazeleger, co-chairs of the Atlantic Panel. His presentation is available on the meeting website. He reminded the panel of the Atlantic Panel's mission, which was to recommend and oversee the implementation of observations in the Atlantic Ocean, in order to meet the objectives of CLIVAR's science plans, in particular with respect to the principal research areas: the North Atlantic Oscillation, tropical Atlantic variability, and Atlantic thermohaline circulation; and liaison with modeling and observational groups.

The strategy of the group has been to promote a balanced approach to describe, understand, and assess predictability of climate phenomena using observations, modeling and theory, and synthesis. Visbeck reported on observations in the Atlantic sector, and in particular, reported that the recommended XBT lines seem to get covered at about the expected frequency. He identified gaps in the Gulf of Guinea and in the northeastern tropical Atlantic in drifter coverage, as well as some smaller gaps in the South Atlantic in the Argo array, reflecting the tremendous growth in coverage.

The Atlantic panel has promoted a Tropical Atlantic Climate Experiment (TACE) to advance the understanding of coupled ocean-atmosphere processes and to improve climate prediction in the tropical Atlantic, focusing both on an enhanced observing system and improved coupled predictive systems (with a view towards operational activities) and ocean synthesis. The core period of the programme would be 2006/7 - 2011/12.

Visbeck reported on a number of issues that the Atlantic Panel faced regarding observations. Maintaining existing networks, in particular evaluating the utility of a particular array in the context of other data and a variety of users remained a challenge. Transitioning pilot efforts to sustained observations would be a challenge to accomplish. CLIVAR data management was fractured, and could perhaps be built on emerging data centers in support of "operational" oceanography and meteorology. The Atlantic Panel supported a CLIVAR-wide strategy for model-based synthesis, with the data streams available for other more empirical studies.

The Panel welcomed the early emphasis on analysis and synthesis of observations in the TACE program. It also **recognized**, in the general sense, that sustained observations would in many cases be conducted in the research community rather than by an "operational" entity, and that this could be beneficial for quality, and since the users of the observations were closer to the providers.

5.2.2 Indian Ocean Panel

Fritz Schott's presentation is available from the meeting website. The Indian Ocean Panel (IOP) is a subpanel of the Austral Asian Monsoon Panel (AAMP). As charged by the CLIVAR SSG and IOC, its TORs are to:

- provide scientific and technical oversight for a sustained Indian Ocean observing system needed for climate variability research,
- develop an implementation plan to meet the goals of CLIVAR and of GOOS and its modules.

At its inaugural meeting in February 2004 (in Pune, India), the foundations for the Implementation Plan were laid. The second meeting of the IOP took place 30 March – 2 April 2005 in Hobart. The IOP also contributed to the Indian Ocean Modeling Workshop (with AAMP), held at IPRC/U. Hawaii in early December 2004. The lifetime of the IOP, as given by the CLIVAR SSG, is for three meetings (i.e. is expected to end in 2006), but there are ongoing discussions with IOC on the role of the IOP. Regarding the membership, expertise in air-sea fluxes had been identified as a need at the first meeting, and Lisan Yu from WHOI was brought on board and gave an overview over the differences among different Indian Ocean flux climatologies.

The report *Understanding the role of the Indian Ocean in the climate system—implementation plan for sustained observations*, which was the focus of the second meeting, is available[15]. The science and implementation chapters were available as drafts at the meeting and changes approved. The elements of the observing system were reviewed with the following results:

- The main implementation issue discussed was the Moored Array. Following L. Yu's advice, the flux mooring off Madagascar was relocated, but the Panel confirmed the basic structure of the array as decided at the 1st meeting. The potential for combining some of the sites with a proposed Tsunami warning system was taken up and needs further study. The logistical and budgetary problems associated with establishing and maintaining the array were highlighted; 6 months of ship time per year will be needed to turn the moored array around annually.
- The Argo deployments are well under way, with about 300 active floats at present and about 100 deployments expected for 2005. Data processing and availability was judged to be in good shape (INCOIS and CORIOLIS centers). A main conclusion was that 5-day sampling to better-resolve intraseasonal variability would not be a valid option to pursue (see below). The INCOIS Argo Center will announce deployment opportunities on its web site.
- The XBT lines were reviewed individually as to their scientific need and feasibility and lines of high priority of the IOP objectives were highlighted,
- The need for full implementation of the international drifter plan (i.e. 5°x5° sampling) was stressed,
- The present void in the northern IO was lamented, and
- Re-seeding of northern (upwelling) areas was considered a priority item (for SST due to summer cloud coverage). At this opportunity, the difficulties of shipping drifters through India were brought up.

Three Observing System Simulation Experiments (OSSEs) were carried out (by G. Vecchi/M. Harrison, T. Lee and A. Schiller/P. Oke) to study the efficiency of the mix of

15 http://www.clivar.org/organization/indian/docs/92_IOP2.pdf

proposed observations. One of the conclusions (from the Vecchi/Harrison study) was that 5-day sampling in Argo profiling would have more disadvantages (halving the lifetime, divergences when surfacing more frequently in upwelling regions) than advantages compared to 10-day sampling.

Under the auspices of the IOP, the following publications are forthcoming or planned:

- BAMS article (A. Schiller et al.) on OSSEs;
- BAMS article (J. Slingo et al.) on Hawaii IO modeling workshop results;
- CLIVAR Exchanges article (M. McPhaden et al.) on Moored Array strategy
- IO Implementation Plan (see Footnote 15)
- Further, the G. Vecchi/M. Harrison OSSE paper is submitted to *J. Climate*.

The Panel welcomed the progress the Indian Ocean Panel has made in planning an ocean observing system for the Indian Ocean, and the Observing System Simulation Experiments (OSSEs) which informed the decisions of the panel, citing them as an example that should be followed in more cases. **It also reiterated** its view of the importance of sustained monitoring of the Indonesian Throughflow (see Section 2.3).

The Panel noted concern over the adequacy of ship availability to support the planned sustained observations in the Indian Ocean, in particular the equatorial moored array, and given the planned deployment and support of tsunami warning buoys. It identified a strong opportunity for coordination between natural hazard warning systems and climate observing system plans (see also Section 3.4.2, and **Action 11**).

5.2.3 Southern Ocean Panel

Albert Fischer gave the Panel a presentation on behalf of Kevin Speer and Steve Rintoul, which is available for download at the meeting website. A number of research questions of interest to the Southern Ocean (S.O.) Panel have a sustained observing component. These have to do with Antarctic Circumpolar Current (ACC) transport variations and links to large-scale patterns of climate variability, the vertical structure of water mass anomalies and transport processes, dense water formation and boundary currents, the balances in the ocean-ice system, the role of the Southern Ocean and ice system in setting the global ocean background state and mean seasonal cycle, intrinsic modes of variability and teleconnections including links to ENSO, carbon uptake, biogeochemistry, and the CO_2 feedback, and support of process studies and model development.

Sustained observations in the Southern Ocean come from a number of networks. Since the last OOPC meeting, Argo coverage has improved, though is limited by the seasonal sea ice extent, with some experimental floats in the Weddell Sea under the sea ice. The S.O. Panel would like to see transport monitoring of the ACC at choke points including the Drake Passage, south of Africa, and south of Australia. Currently, only the Drake passage has something approaching adequate sampling. The S.O. Panel also would like outflow arrays to measure bottom water formation in the Weddell and Ross Seas, in the P. Elizabeth trough, and in the Adelie region. Coverage of the Weddell and Ross Seas is planned as part of process experiments. Other sustained observations in the Southern Ocean come from:

- Repeat XBT sampling: which given the limitation of ship tracks has good sampling
- Repeat hydrography, which is in good shape largely due to the carbon community
- Bottom Pressure Recorders to monitor the ACC, covering the Drake Passage since 1988

- Tide gauges, which have gaps in the Ross Sea area and on the Antarctic Peninsula, limited by logistical challenges
- Limited progress in determining sea-ice thickness in a sustained manner
- Surface drifting buoys, where sea ice zone and deployment challenges continue to limit coverage
- International Programme for Antarctic Buoys (IPAB) marginal ice zone buoys, which are currently limited by resources (about 50 of the desired 100 per year)
- developing time series stations, which are limited by survivability in the Southern Ocean.

The Southern Ocean Panel saw the IPY as an opportunity to improve observational coverage, though it was unclear what would get funded, as well as an opportunity to improve data management and analysis and synthesis efforts.

The Panel saw opportunities to improve coordination with the operational community in the Southern Ocean, and **encouraged** the Southern Ocean Panel to pursue these. It also **encouraged** the panel to document in a white paper scientific objectives and what sustained observations are required to support these, as a base behind which to build support for these observations.

5.2.4 Pacific Ocean Panel and the South Pacific Workshop

The Panel received a presentation from Nico Caltabiano, with input from Bob Weller. It is available on the meeting website.

The CLIVAR Pacific Panel, as one of the basin Panels in the CLIVAR structure, is directly involved in two of the CLIVAR's Principal Research Areas (PRA), "ENSO: Extending and improving predictions" and "Pacific and Indian Ocean Decadal Variability". These two PRAs are the core of the panel's Terms of Reference. However, after CLIVAR's assessment in July 2004, the panel was asked to review its TORs, and conduct its activities in order to focus efforts on them. The panel membership is being reviewed, and the panel will be chaired by trans-Pacific co-chairs. Axel Timmermann (Hawaii) has been identified as one of the new co-chairs, the second one still in process of initial contact.

One of the main activities of the Pacific Panel for this year is the CLIVAR/OOPC/GOOS/Argo Workshop on the South Pacific, which will take place on 11-14 October 2005 at the Universidad de Concepción, Concepción, Chile. The objectives of the workshop are:

- To review our present understanding of the role of the South Pacific in seasonal to decadal variability of the climate system.
- To assess the adequacy of present day climate models to capture the essential physics and observational networks to monitor climate variability and change, and propose the needs of future numerical experimentation
- To assess the influence of the South Pacific on the South American and Australasian climate
- To support and help coordinate existing and beginning climate observing efforts, and build associated partnerships
- To identify deployment opportunities for the observing network, e.g. Argo floats
- To identify where the existing observing network spanning the South Pacific needs to be supplemented (such as the location of GLOSS tide gauges)
- To look for coordination of CLIVAR activities with other programmes in the South Pacific, such as Carbon, SOLAS and IMBER

A large number of scientists have demonstrated their interest in taking part in the workshop. Despite this interest, the organising committee has had problems in identifying key people at the regional and international levels who could be involved in provide guidance on the aspects of a possible sustained observational system for this region.

The Panel expressed concern on the state of planning for the October 2005 South Pacific workshop. It felt that it was important to involve the groups in South America likely to sustain observations along with the science, but that given the current state of knowledge about climate variability in the South Pacific, the workshop should focus on the outstanding science questions. The Panel will continue to participate in planning for the workshop and will be represented there.

5.3 Carbon Hydrography and Carbon Fluxes

Maria Hood, project coordinator of the International Ocean Carbon Coordination Project (IOCCP), provided an overview of ocean carbon and climate issues, and the expansion of the IOCCP to provide observation support and coordination services for ocean carbon cycle observations (rather than only for large-scale CO_2 observations). Her presentation is available on the meeting website.

Carbon and tracer measurements on the repeat hydrographic sections of CLIVAR are a priority for the community and the IOCCP was planning a joint workshop with CLIVAR for early November to agree on strategies and implementation for each basin for the rest of this decade and to reach international agreements on a data management system and center to deal with hydrographic data for all variables measured from hydrographic sections.

Several questions for discussion were posed about the future of hydrographic sections, post-CLIVAR, and how this activity could be sustained and implemented after the end of CLIVAR.

The Panel emphasized that ongoing (rather than end-of-program) synthesis of the carbon survey data was important; and that observing system experiments of the data from the WOCE/JGOFS era focused on both heat transport and ocean carbon (in cooperation with the CLIVAR GSOP) could be used to rationalize a recommended network and frequency for repeat hydrography. The Panel anticipates that the physical oceanography community will also develop an international repeat hydrography program.

Hood provided an overview of surface pCO_2 activities and highlighted recent advances in technology development for underway pCO_2 systems and a number of other autonomous instruments being developed that will be important contributions to the network in the coming years. Because the temporal and spatial variability of surface CO_2 is so high, designing a sustained observing system requires an integrated approach tailored to each basin or region and employing many types of platforms, including underway ships, surface time series stations, drifters, ship-board time series sections, and other new tools. This has led to the development of a more regional and basin-scale approach, rather than a global one, to developing an initial observing system. Hotspot regions for ocean carbon uptake and flux such as the North Atlantic, Equatorial Pacific, and Southern Ocean are being targeted for coordinated pilot project experiments. The EU Carbo-Ocean program has initiated a surface pCO_2 observing system for the North Atlantic to operate between 2005-2010, and the US NOAA has initiated a Seasonal CO_2 Flux Map program focused on the Equatorial Pacific. Carbo-Oceans also has a strong component of surface pCO_2 observations in the Southern Ocean, although a coordinated pilot project for an integrated observing system for the whole region will require a very large and multi-national effort.

The Panel thought that underway pCO_2 temperature and salinity data were valuable outside of the context of the pCO_2 measurements, and **asked** the IOCCP to coordinate with GOSUD on the collection of this data (see **Action 20**). The importance of a well-functioning process for underway observations was again emphasized, as it is anticipated that other variables will be feasible soon and coordination amongst all parties will be increasingly important.

5.4 Sea Level

Mike Johnson gave the Panel a presentation on global sea level change and the observing system, with input from Laury Miller and Mark Merrifield. His presentation is available on the meeting website.

Tide gauge measurements over the last century show a global rate of sea level rise of about 1.5-2 mm / year, with mass changes dominating volume changes. Altimetry over the last decade largely agrees with this, but shows strong regional patterns of sea level change. GLOSS is implementing a network of reference sea level stations, and forecasts of improvements in the network are hopeful, with a number of projects bringing more gauges online.

The network necessary to monitor and understand regional and global sea level changes includes satellite altimetry, GPS controlled tide gauges for calibration, Argo to measure global thermosteric and halosteric change, and sea and continental ice monitoring.

The Panel identified the adequacy of GPS sensors for tide gauges in accurately measuring regional and global sea level changes as an open issue, and will request that this question be taken up at the upcoming WCRP Sea Level Rise workshop.

5.5 JCOMM Ship Observations Team

Albert Fischer gave a presentation to the Panel reporting on the last meeting of the JCOMM Ship Observations Team (SOT), his presentation is available on the meeting website. The SOT has a number of subpanels. Issues raised at the Volunteer Observing Ship (VOS) implementation panel of relevance to the OOPC include difficulties in both VOS and VOSClim recruitment, problems with security with the real-time release of ship positions leading to the loss of some ships, and maintaining and updating the database of metadata (WMO Publication 47) on the VOS fleet. The Ship of Opportunity (SOOP) implementation panel identified focal points for recruitment on undersampled lines, but reported that routes from Valparaiso to New Zealand and to California were no longer in operation. The route from the Flores Sea to Japan (PX11) was not being sampled due to a resource issue for Australia. JCOMMOPS was to improve the reporting of the total number of XBTs, separating identified lines from other drops. The SOOP asked OOPC for clarification of stated discrepancy in requirements on the spatial resolution of frequently-repeated XBT lines between north-south and east-west lines, and indicated their readiness to respond to updated line requirements identified by OOPC and CLIVAR. The SOT had compiled a draft standard design for a ship science area to bring to ship-builders and the International Maritime Organization (IMO), but required further input, particularly from the non-physical observing community. It was working on ongoing efforts to identify buoy deployment opportunities.

The Panel expressed its appreciation of the work of the VOS and SOOP implementation panels, and their cooperation with the DBCP in drifter deployment. More direct feedback between the CLIVAR basin panels and the SOOP XBT operators could be useful , and a standardized form/questionnaire should be directed at the basin panel chairs (see Section 3.4.2 and **Action 14**), with feedback from the XBT operators to the panels on the feasibility and prospects of particular lines. This should also include feedback from panels to JCOMM OCG/SOT/DBCP about holes in drifter coverage.

The Panel agreed that clarification on the SOOP perceived spacing requirement for frequently repeated lines (5° for east-west lines, 150 km for north-south) was needed (see **Action 21**). **The Panel agreed** that the draft SOT specification for a ship science room should be circulated for comments and improvement (see **Action 22**).

5.6 Argo

The chair gave a presentation, prepared by John Gould, on progress with the Argo profiling float network, the presentation is available on the meeting website. Argo had made tremendous progress in the last year, with increased density in the Indian, South Pacific, and South Atlantic Oceans, and over 1800 active floats in April 2005. Since the end of 2003, Argo has been the dominant source of real-time ocean profile data. Progress has been made in float reliability by reducing deployment failures, prolonging battery life, and reducing sensor and float manufacturing errors.

The Argo data distributed in real time have basic data integrity checks, but delayed-mode calibration of salinity depends on comparison with recent climatologies, float-to-float intercomparisons, and integration of float data into regional analyses. About 20% of Argo profiles have undergone delayed-mode quality control (DMQC), and all DMQC profiles will be re-examined by the end of 2005.

Argo is now a key ocean profiling system, and will potentially change the strategy for other observing system elements such as hydrography and the XBT network. The Argo networks needs regular and rapidly-available ship-based CTD data for quality control.

The Panel noted with pleasure the great increase in coverage of the Argo array, and the efforts to address delayed-mode quality control. The Argo program was praised for its many accomplishments toward its ambitious objectives.

In accordance with the GCOS Climate Monitoring Principles, which call for a period of overlap between systems, **the Panel agreed** that it was not yet appropriate to revisit requirements for XBTs or hydrography. Deep hydrography also observes below the reach of the Argo network, and the recommendations developed in 1999 included information from OSSEs including the future Argo network. **The Panel recognized** the need to make hydrographic data quickly available for Argo calibration, and thought that assurances that the data would be used for this purpose only would help increase the rapidity of its availability. **It encouraged** Argo address this directly with the hydrographic community.

5.7 VOSClim and VOS Status

Peter Taylor's report on VOS and VOSClim is available on the meeting website.

VOSClim Status: The objective of the Voluntary Observing Ship (VOS) subset defined by the JCOMM VOS Climate project (VOSClim) is to provide a source of high-quality marine meteorological data and associated metadata, suitable for a number of applications, including global climate monitoring, research and prediction. The VOSClim project is now managed by the JCOMM Ship Observations Team (SOT) and the 5th VOSClim meeting (VOSClim-V) was held in Brest as part of the 3rd SOT meeting (SOT-III, 7-13 March 2005, Brest, France).

VOSClim Realtime Data: There have been several problems with the real time data delivery (by the NCDC acting as the VOSClim Data Assembly Centre, DAC) that were highlighted at SOT-III. There have been difficulties with the DAC web data server and it was agreed that at this time delivery of the datasets by ftp would be more effective. This has not yet been implemented. An improved system for delivery of data to the DAC requires development and implementation following discussions between the DAC and the Met Office (acting as the VOSClim Real Time Monitoring Centre, RTMC).

VOSClim Delayed Mode Data: Difficulties with the delivery of delayed mode data have also been encountered. Most delayed mode VOS and VOSClim data are stored electronically on the ships and downloaded by Port Meteorological Officers every few months. These data are returned to the National Meteorological Centres who are tasked with applying Minimum Quality Control Standards (MQCS) to the data and sending them on to the Global Collecting Centres (GCCs) in Edinburgh and Hamburg. The introduction of new formats (IMMT-2 and IMMT-3) to accommodate the VOSClim additional parameters has caused problems. Only one country had managed to implement MQCS for the new format and successfully passed delayed mode VOSClim data with additional parameters to the GCCs. Other countries have either not yet passed data to the GCCs or have applied the MQCS to data in IMMT-1 format with the VOSClim additional parameters stripped off. The result is that presently too few reports containing the extra parameters are available to determine their usefulness.

Metadata: After a considerable delay, VOS metadata (WMO Publication No. 47) is now available up to the end of 2004; there is presently a 2 month delay in delivery of the 1st quarter of 2005 metadata. This represents a significant recent improvement in metadata availability. However it was highlighted at SOT-III that the content of the metadata itself may be out of date and an urgent request was made to VOS operators to submit current metadata to the WMO.

The SOT Metadata Task Team made recommendations for the revision of the Publication No. 47 format (Annex VII in JCOMM 2005) which will be sent to JCOMM-II in September 2005. It is essential that the implementation of any changes to the metadata are properly resourced at the WMO. This includes the provision of digital data.

Scientific Analysis: Analysis aimed at demonstrating the usefulness of the VOSClim project has been hampered by the data delivery problems. However, using an *ad hoc* VOSClim data set, a paper on the effect of sensor exposure on air temperature observations is in press (Berry and Kent, 2005)[16]. There is an urgent need to extend the scientific usage of the VOSClim dataset. A presentation is planned for the Second International Workshop on Advances in the Use of Historical Marine Climate Data (MARCDAT-II, Hadley Centre, Met Office, Exeter, UK, 17-20 October 2005), to describe plans for wider data availability and stimulate discussion of the dataset amongst the marine climate community. SOT-III recommended that an informal VOSClim Scientific Users Group should be set up.

VOSClim Evaluation: VOSClim has been operating for 4 years and it was agreed at SOT-III that it was now appropriate for VOSClim to enter an evaluation phase. VOSClim has not yet recruited the estimated minimum number of ships required, just over 100 rather than the minimum initial target of 200. Recruitment has proved more difficult than expected. This may be compounded by a perception amongst some operators that VOSClim is not achieving its goals with a resultant lack of enthusiasm to increase participation and recruit more ships. It

[16] Berry, D. I., E. C. Kent, 2005: The effect of instrument exposure on marine air temperatures: an assessment using VOSClim Data, *Int. J. Climatology* 25, 1007-1022, doi: 10.1002/joc.1178.

is therefore important that, despite the small amount of data so far collected, the effectiveness of VOSClim is evaluated. Recommendations for development of VOSClim, based on analysis of the data collected in the project and from other sources, are required before the next SOT meeting in 2007.

VOS and GCOS: There was a welcome increased awareness at SOT-III of the importance of VOS observations for climate and oceanographic applications and the importance of taking observations according to the GCOS climate monitoring principles. However it is yet to be seen whether this improved awareness will halt the decline in the number of observations containing the complete range of variables required for turbulent flux calculation. A particular concern is the effect of initiatives to produce the optimum observing system design for NWP purposes. This has led, for example to the deployment of AWS systems which do not measure the full range of climate variables.

The Panel agreed on the need to develop guidance on rational targets in terms of numbers and accuracy for the entire VOS fleet (see Section 3.4.2 and **Action 15**). These should then be included in JCOMM tracking. **The Panel expressed concern** over the resources WMO was investing in keeping Publication 47 current, and **encouraged** the Ocean Affairs Division to address this issue. **The Panel agreed** that a handbook of protocols for mounting AWS systems on ships should be produced, and **encouraged** the calling of a short workshop to address this need (see **Action 23**).

5.8 OceanSITES Reference Sites

An update on the activities of the OceanSITES effort was presented by Robert Weller, and his presentation is available on the meeting website. This group advocates long-term time series sites in the global ocean and provides a forum for discussion of planning, coordination, evolution, research and operational applications, and data management issues associated with long time series observations. More information is available at the OceanSITES website: www.oceansites.org/OceanSITES/.

The time series science team met last in January 2004 following the ORION Workshop in San Juan Puerto Rico. ORION (Ocean Research Interactive Observatory Networks, www.orionprogram.org) is a U.S. National Science Foundation effort to develop next generation observing hardware for ocean sciences, including a new generation of surface moorings characterized by provision of more power and higher bandwidth two-way communication and by the capabilities needed to be deployed in more severe environments than now routinely occupied. OceanSITES sees collaboration with ORION is a path to the capabilities required to occupy sought-after sites such as those in the Southern Ocean and to provide more data in real time. OceanSITES encourages fully multidisciplinary instrumentation of the long-term time series sites. The future availability of more power and bandwidth will facilitate addition of more instrumentation as well as near real time data availability. The identification of sites of interest to diverse disciplines is being done in the ORION effort and confirms the OceanSITES view that there are a number of global sites of high value because of their value to several disciplines at once. For ORION the disciplinary perspectives are: ocean bottom/seismic, water column physics, water column biogeochemical, and air-sea fluxes.

The OceanSITES group has focused their efforts since January 2004 on: revision and updating system maps, revision and updating of a database of site information, a white paper and a brochure describing OceanSITES, and a pilot data management program. The present maps conform to the JCOMM basemap. There are three maps: 1) the presently occupied sites, 2) the present sites plus those for which funding has been obtained and will soon be in the water, and 3) the map of all recommended as well as operating sites. On maps 1 and 2, the data availability is displayed by use of a color code: red - at least some data available to all in real time, 2) yellow – data available in delayed mode (as from subsurface instrumentation that must be recovered to access data), and 3) black – data not available.

The OceanSITES effort advocates free and open access to all data where possible and is working to develop a data format and data server with Sylvie Pouliquen (IFREMER/Coriolis) taking the lead. The goal is to have an OceanSITES website showing the maps of the locations where each site can be clicked which then leads you not only to the metadata about the site but also to where the data can be downloaded.

The OceanSITES activity is in a 5-year pilot phase with the intention of demonstrating the ability to collect and share data from key locations around the globe and the utility of long time series data. It would be timely to work with OOPC, JCOMM, and DBCP to move the sustained time series component toward a more visible status within the sustained global ocean observations effort. OceanSITES will make efforts to improve their website and data access toward that goal and welcomes the support and guidance of OOPC.

The Panel noted the progress made and **encouraged** the OceanSITES group to increase planned efforts for wide dissemination of comparisons between data and climatology, of the variability of anomalies, and increased publicity for the availability of data, as a way to increase interest in and support for the time series stations.

5.9 WCRP Working Group on Surface Fluxes and SURFA

Bob Weller's presentation is available on the meeting website. The WCRP Working Group on Surface Fluxes met for the first time in Halifax in October 2004 in conjunction with a SOLAS meeting. This group is charged with supporting WCRP and IGBP projects' needs for surface fluxes, to encourage research and operational activities at improving knowledge of air-sea fluxes, and to communicate with the scientific community and the JSC through regular reports. The initial focus is on air-sea fluxes, then later on air-land fluxes as well. Specific objectives include developing flux data sets, improving measurement techniques, parameterizations, and algorithms, and assessing sensitivity of climate models and limits of predictability associated with uncertainties in surface fluxes.

Activities identified at the Halifax meeting to receive immediate attention included the SURFA project in which high quality Ocean Reference Station moored time series and shipboard surface meteorological and air-sea flux data are compared with those quantities from current weather and climate atmospheric general circulation models. Some difficulties remain in getting this project on track. There was also discussion of a symposium or other activities to review the state of knowledge of particle and gas flux parameterizations, preparation of a handbook on *in situ* methods for VOS and research ship, buoy, and tower flux observations, a summer school for air-sea fluxes, improvements to radiative flux observations including links to the Baseline Surface Radiation Network, the continuation of the SEAFLUX effort to archive and facilitate comparison of *in situ* and remote-sensing based flux products, and of how to support diverse community needs, including those of WCRP initiatives, for flux products.

There has been progress on developing blended flux products, where *in situ* data is used to guide selection of data from among the fields available from NWP reanalysis fields and satellite fields. Jiang and colleagues[17] and Yu and Weller[18] have, for example, prepared blended flux fields that show promise and compare well with *in situ* observations and the SOC fluxes. Yu used such fields to examine where in the Indian Ocean flux reference sites should be sited to improve present large discrepancies between these blended fluxes and reanalysis flux fields.

Improving radiative fluxes for all uses, including in assembly of these blended products, is a high priority. A dialog has been established with a new Ocean Observations Working Group of the Baseline Surface Radiation Network (BSRN) about the accuracy of ocean surface radiation observations, improving that accuracy, and selection of ocean sites at which to establish time series sites for observing surface radiation.

The Panel welcomed the commitment of the GODAE servers and of WGNE to provide fields, and would act to facilitate the setup of this archiving (see **Action 24**). It also **endorsed** the continuation of the SEAFLUX database.

The Panel welcomed the creation of the Baseline Surface Radiation Network Ocean Observations Working Group (BSRN OOWG), and agreed to provide input (see **Action 25**).

5.10 Japanese Sustained Ocean Observing Programs

Yutaka Michida reported an update of sustained ocean observation activities by Japan; his presentation is available at the meeting website. These observations include Argo, moored buoys, hydrographic sections, sea levels, and drifters. Japanese Argo activities had been supported by a national 'millennium' project: *Development of an Integrated Ocean Observation System* (2000-2005). It came to an end in March 2005, having deployed 80-100 floats per year. In April 2005, the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) started the succeeding project as its own programme for 4 years, and Japan's contribution to the Argo global array will be kept at the present level. The tropical buoy array, TRITON (Triangle Trans-Ocean buoy Network), has been maintained by JAMSTEC, with 15 buoys in the Pacific and 2 in the Indian Ocean. Yukio Masumoto of the University of Tokyo submitted a proposal to deploy and maintain 6 moored buoys in the Eastern Tropical Indian Ocean using newly designed 'mini-TRITON' design. With regard to hydrographic sections, JAMSTEC successfully completed a circumpolar cruise called BEAGLE (Blue Earth Global Experiment) from July 2003 to February 2004. The Japan Meteorological agency (JMA) maintains several regular hydrographic sections in the Northwestern Pacific that includes a long time series along 137 °E over the last 40 years. Local fisheries research laboratories have coastal monitoring lines in which CTD casts have been carried out 4-12 times a year. Most of these historical data have been made available recently through the Japan Oceanographic Data Center (JODC) data rescue activities. As an example of the activities of the research community, the Ocean Research Institute (ORI) of the University of Tokyo plans a research cruise (PI: Prof. Kawabe), in which 9 moorings deployed in September 2004 in an area southwest of the Shatsky Rise in the northwestern Pacific will all be recovered for analysis of the pathways of deep water circulation.

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[17] Jiang, C., M. F. Cronin, K. A. Kelly and L. Thompson, 2005: Evaluation of a hybrid satellite- and NWP-based turbulent heat flux product using Tropical Atmosphere-Ocean (TAO) buoys, *J. Geophys. Res.* 110, C09007, doi:10.1029/2004JC002824.

[18] Yu, L., R. A. Weller and B. Sun, 2004: Improving Latent and Sensible Heat Flux Estimates for the Atlantic Ocean (1988–99) by a Synthesis Approach, *J. Climate* 17, 373-393, doi:10.1175/1520-0442(2004)017<0373:ILASHF>2.0.CO;2.

Michida also reported that Japan maintained more than 100 sea level stations operated by JMA, the Japan Coast Guard (JCG) and Geographical Survey Institute, 15 of them were GLOSS stations, and almost all of them were available online in a real-time basis through web servers (e.g., Syowa Station, Antarctica is also listed in GLOSS network). He presented an example of sea level data analysis at Syowa Station, showing that a steady falling trend, probably due to glacial rebound, was observed in the last 20 years. He mentioned that the present activities regarding surface drifters in Japan had been limited, and that only 5-6 drifters were deployed around Japan by JMA and JCG. He informed the Panel that the MTSAT-1R (a Meteorological Satellite) was launched successfully in Feb 2005 and would be in operation in May 2005, and that ALOS was scheduled to be launched in summer 2005. He further informed the Panel of other related activities including GODAR-WESTPAC, GEOSS, the SOLAS-SSC meeting, the present data system of NEAR-GOOS, and the National CLIVAR Committee.

The Panel welcomed the Japanese contributions to the global ocean observing system and analysis, including the tropical moored arrays and their extension into the Indian Ocean, and in particular congratulated the performance of the TRITON moorings.

5.11 Towards Routine Biogeochemical/Ecosystems Measurements

Tommy Dickey's presentation is available from the meeting website.

The numbers of disciplinary variables that are necessary to solve interdisciplinary oceanographic problems are large and increasing with new discoveries. In addition, the time and space scales of key interdisciplinary processes span over ten orders of magnitude; presently, there remain major spectral gaps in our sampling. Thus, undersampling presents the main limitation to our understanding of global climate change; variability in fish biomass and regime shifts; and episodic and extreme events. However, recent advances in ocean platforms and *in situ* autonomous sampling systems and satellite sensors are enabling unprecedented rates of data acquisition as well as the expansion of temporal and spatial coverage. Consequently, improved sampling strategies will lead to a reduction in ocean forecasting error for predictions of interdisciplinary oceanic processes. Major challenges remain to massively increase the variety and quantity of ocean measurements and to effectively coordinate, synthesize, and distribute oceanographic data sets. In particular, numbers of interdisciplinary measurements are limited by the costs of instruments and their deployment as well as data processing and production of useful data products and visualizations.

Dickey highlighted some recent technological progress for solving a few key interdisciplinary oceanographic problems and outlined a few challenges and opportunities of ocean science technologies and their applications. He focused on several new biogeochemical and bio-optical measurement systems. Relevant science areas include biogeochemistry, climate, ecology, harmful algal blooms (HABs), and pollution. The sampling systems are generally capable of recording episodic and extreme events as well as long-term variability. Clearly, emerging autonomous sampling platforms and telemetry for new interdisciplinary instruments are essential for fielding these systems. Optically-based systems are used to measure inherent optical properties (e.g., using instruments' light sources) and apparent optical properties (e.g., using natural sunlight). Some optical systems use fluorescence methodologies (i.e., chlorophyll) while others use flow cytometeric and imaging methodologies (flowcams and video plankton recorders). Several autonomous chemical measurements are being used; these are made possible with wet chemical, electrical, and optical devices. In addition, automated samplers are being utilized to measure micro- and macro-nutrients, carbon, and primary productivity. Challenges remain in the form of needs for greater numbers of biological and chemical variables, signal-to-noise ratios, biofouling, reagent storage and aging, and platform constraints of size, weight, drag, and power (easiest for moorings; harder for mobile platforms).

Looking forward, many novel and innovative technologies involving computing, nanotechnology, robotics, information and telemetry technologies, space sciences, and molecular biology are being developed at a fast pace for numerous applications. It is anticipated that several of these will be transitioned to the ocean sciences and will prove to be extremely beneficial for oceanographers in the next few decades. Already, autonomous, 'robotic' *in situ* sampling, high spectral resolution optical and chemical instrumentation, multi-frequency acoustics, and biomolecular and genomic techniques are being utilized by a limited number of oceanographers. Data networks coupled with internet connectivity are rapidly increasing access to and utilization of ocean data sets.

The Panel was encouraged by developments in the diversity and lifetime of autonomous biogeochemical sensors, and emphasized that further developments were needed for routine inclusion in the sustained observing system, particularly as servicing intervals for the platforms are increasing. **The Panel believed** that the development and testing of biogeochemical sensors and their interfacing with various autonomous sampling platforms, particularly OceanSITES moorings, remains an appropriate strategy, and should proceed with high priority.

6. DATA MANAGEMENT

6.1 Progress from the Point of View of the OOPC and a Vision for the Future

Bob Keeley's report on a number of aspects of data management is available on the meeting website.

JCOMM Metrics: A project to demonstrate the performance of various observing networks against JCOMM OPA goals in a simple one-page display, in order to demonstrate to funding agencies what remains to be done, was started in late 2004. It shows the stated goal, a map of coverage, a map of density, and time series of the performance of the system. These are being produced at MEDS for temperature and salinity profiles, and for surface salinity.

IODE Review: The recently completed International Oceanographic Data and Information Exchange (IODE) review examined the mandate and mission, structure and operations, network, and effectiveness of groups. It published a number of recommendations, touching on streamlining the structure and encouraging a more distributed data system, and improving the international metadata system. The OOPC can encourage closer coordination of JCOMM and IODE activities, and greater cooperation between National Ocean Data Centers (NODCs) and IODE and the science research community.

Data Systems: From the client/user point of view, there are four functions that a data system must perform: archiving, discovery, exploration, and delivery. The data manager's role encompasses assembly of the data, its transformation into local structures, quality control and the suppression of duplicates, version control, naming standards, integrating data structures, allowing for data exposure and data and information delivery.

In order to archive data, data systems must accept numerous formats, should transcribe to a common data structure, apply consistent and accepted processing procedures while maintaining the originals, must migrate data and information through technology changes, and provide access.

Discovery tools are needed for users to find what data and information are available. Available tools include: web pages, which are haphazard; system performance indicators, of which few exist; and catalogues, of which a number exist. Catalogues have standard, controlled content and web-accessible search engines, but too few provide content, and due to a lack of automatic generation of entries, are not complete.

Exploration tools are necessary for a client to determine what data are needed. These include: web pages, which again are haphazard and lack detail; inventories, which lack detail; and visualizations, of which a few exist. Visualization tools provide searchability to some level of detail, and some allow direct viewing of data. They also allow a combination of disparate data. But they may have too many ways to see data, too few data are available using such tools, and these tools have difficulty showing full vertical and time dimensions.

Delivery tools are needed for clients to acquire the data of interest. These include web pages, inventories and ftp servers, OPeNDAP and Live Access Servers (LAS), DIGIR, and subscription services. The latest generation of services are the most valuable, as they allow subsetting before delivery, a number of receiving tools exist, and they are compatible with a number of different archive formats. Some problems remain in improving their usability, their handling of data and information, improved tools to handle the received data, and problems with security and firewalls.

Improvements in quality control, duplicates suppression through unique tags, in version control, common naming standards and vocabulary, and integrated data structures can be envisioned and are in many cases moving forward.

The OOPC can help move data management forward by continuing to voice its desire for convergence to a few solution and encouraging the use of standards, by reminding groups like JCOMM and the IODE of their responsibility in finding solutions, and pushing for improved data system performance by highlighting practices they like and dislike.

The Panel welcomed, from the user's perspective, the increasing convergence in data formats, and **encouraged** the further development of standards. **The Panel also encouraged** efforts by IODE to reach out to research scientists to facilitate archiving of research data. **It encouraged** IODE and JCOMM to work to improve the common provision of real-time and delayed mode data for ocean analysis and reanalysis systems, including through the virtual integration of various data repositories.

6.2 WMO Information System and Metadata Standard

Jean-Michel Rainer, chief of the WMO Information System (WIS), gave the Panel a presentation on the WIS, which is available on the meeting website. The current model for information management and exchange for meteorological data had a multiplicity of procedures in real-time and delayed mode, and a multiplicity of data formats, with uncoordinated metadata and catalogs. A few encouraging examples of interoperability exist, and the WMO in 2003 approved the concept of a Future WMO Information System, providing a single coordinated global infrastructure for the collection and sharing of information in support of all WMO and related international programmes.

The WIS will be common to all WMO programmes, include interdisciplinary location, retrieval, and exchange of information in real and non-real time, and will be based on ISO and industry standards, using off-the-shelf hardware and software systems. It is structured around a hierarchy of centers and data communication networks. It will build on the most successful components of WMO systems, using pilot projects and prototype solutions in the transition.

A major challenge is to develop interoperability through active involvement of all WMO Programmes and Technical Commissions. An improved GTS, based on cost-effective networks and TCP/IP protocols will be the WIS core network. It will touch only on the information exchange and data management functions, leaving data processing components to the programmes, and will bring benefits in cross-programme standardization. An Inter-commission Coordination Group on WIS was established in 2004.

Pierre Kerhervé gave the Panel a presentation on the interoperability of information systems and the WMO Information System, describing in more detail the application of the ISO 19100 series of metadata standards. His presentation is available on the meeting website.

The Panel identified many points of common interest between the data management systems that support the OOPC (IODE, JCOMM, research systems) and the WMO Information System initiative. **The Panel suggested** that a representative of IODE and of the JCOMM Data Management Program Area be included on the Inter-Commission Coordination Group on the WIS.

7. COOPERATION IN OBSERVATIONAL STRATEGY WITH OTHER PROGRAMS

7.1 Natural Hazard Warnings, Including Tsunami

Maryam Golnaraghi was unfortunately unable to give her scheduled presentation to the Panel. The Panel, however, touched on the issue of needed coordination between natural hazard warning systems and the climate observing system (see Sections 3.4.2 and 5.2.2).

7.2 THORPEX Weather Prediction

Jim Caughey, responsible for observational aspects of The Observing System Research and Predictability Experiment (THORPEX), gave a presentation to the Panel, which is available at the meeting website. Its goal is to improve the preditability of 1-15 day weather forecasts and to prove their societal impact. It is a project of the World Weather Research Programme (WWRP) with a implementation envisioned from 2005-2015. It will address improvements in predictability and dynamical processes, observing systems, data assimilation and observing strategies, and societal and economic applications.

The WCRP and THORPEX had identified points of common interest for coordination, envisaging a convergence in weather and climate forecasting which would require closer collaboration between these communities. Caughey signaled that the THORPEX community had a common need with the climate forecasting community for upper ocean observations, and was willing to work with the climate observing system. One approach could be to consider performance measures for both applications that could be used in optimizing the observing network, including exploration of different techniques such as adaptive observations, and requiring an improved timeliness of the availability of ocean data. A common approach for modeling could also be envisioned, with high resolution integrations for weather forecasting being switched to faster low resolution forecasts for climate forecasting after a few weeks of integration. THORPEX would be organized around a number of demonstration projects.

The Panel identified many points of common interest with THORPEX:

- a challenge for the ocean community in improving real-time data transmission

- opportunities to support THORPEX demonstration projects through enhanced ocean data
- demonstration of value of ocean data via OSEs and OSSEs
- potential future provision of highly-capable ocean platforms for atmospheric measurements (ORION)

The Panel agreed that its Secretariat will be the focal point for interfacing between THORPEX and ocean observing teams and groups (see **Action 26**). **The Panel expressed concern** that optimizing observations for NWP may not yield an optimum network for climate observations, which may be a challenge for the implementation of GCOS (see **Action 27**).

8. OOPC FUTURE DIRECTIONS

The chair presented a number of issues he believed the Panel would need to address over the coming years:

- developing recommendations for sustained observations for ocean ecosystems
- working together with CLIVAR GSOP to encourage ocean climate reanalysis efforts
- developing ocean climate indices with relevance to coupled climate variability
- developing links between the open-ocean and coastal modules of GOOS
- maintaining strong relationships with GEO, and IGBP and SCOR ocean research programmes.

The Panel agreed that the agendas of future meetings should be constructed with the advancement of these issues in mind.

9. REVIEW OF ACTIONS FOR THE NEXT INTERSESSIONAL PERIOD

Action Item	**Report Ref**	**Action**	**Responsible**	**When**
1	3.1	to seek cooperation from operators of drifting buoys to incorporate atmospheric pressure sensors	Chair, Secretariat	ongoing
2	3.1	to seek coordination of the deployment of precipitation-measuring instruments on the OceanSITES reference mooring network	Chair, Weller	ongoing
3	3.1	to review the relevance and effect of the GCOS IP, and revise the oceanic section	all	by 2009
4	3.1	to promote partnerships with ocean research institutions and science teams	Chair, all	ongoing
5	3.1, 4.1	to contribute to the updating of the IGOS-P Ocean Theme (including identifying clear demonstrations of the need for multiple altimeter missions, in cooperation with GODAE and GSOP)	Chair, Secretariat, Stammer, input from all	by OOPC-11
6	3.1	to provide input for an IOCCP-led implementation strategy for measuring	Hood	2005

		surface pCO_2		
7	3.1	to assist JCOMM and WCRP in the establishment of an international group focused on integrated analyses of the surface current field	Chair, Secretariat	by 2008
8	3.1	to encourage CLIVAR and the IOCCP to coordinate global hydrographic observations	Chair, Hood	ongoing (Nov. meeting)
9	3.1	to encourage coordination of pilot projects of reanalysis of ocean data, with CLIVAR GSOP	Chair, Stammer	ongoing
10	3.1	to maintain and promote a portfolio of specific workshops that would move forward key IP actions	Chair, Secretariat	ongoing
11	3.4.2, 5.2.2, 7.1	to promote coordination between climate observations and observations for natural disaster warning systems, in platform support and ship time, in sharing platforms and telecommunications, and in data management	Chair, Secretariat, Weller, all	ongoing
12	3.4.2	to provide updated guidance, via the OOPC-AOPC working group on SLP, on requirements for surface drifting barometers	Chair, Reynolds	OOPC-11
13	3.4.2	to provide updated guidance, via the working group on SST, on the 5° spacing surface drifter requirement for satellite SST calibration	Reynolds	OOPC-11
14	3.4.2, 5.5	to provide updated guidance, in consultation with the CLIVAR basin panels and the SOOPIP, on requirements for XBT lines (including resolution requirements and specifically on lines that cannot be maintained due to changes in shipping patterns) with a standardized form/questionnaire for the basin panel chairs, and feedback to the panel chairs	Secretariat, CLIVAR basin panels, JCOMMOPS	OOPC-11
15	3.4.2, 5.7	to provide updated guidance on the requirements for VOS and the extension of VOSClim to the VOS fleet	Taylor, Weller	OOPC-11
16	3.5	to provide input, as necessary, into the developing GEO Work Plan	Chair, Secretariat	by Dec. 2005
17	3.6	to maintain communication with IGBP SOLAS and IMBER communities, including identifying appropriate representation to the next OOPC meeting	Chair, Secretariat	OOPC-11
18	4.2	to work with Don Hinsman and GCOS on presenting ocean satellite requirements for climate to the appropriate planning groups	Chair, Secretariat	ongoing

19	5.1.5	to encourage intercomparison of operational and historical sea ice products, via the WG on SST and Sea Ice	Reynolds, Chair	Oct 2005 marine workshop
20	5.3	to coordinate the archiving of underway pCO_2 temperature and salinity data between IOCCP and GOSUD	Hood	OOPC-11
21	5.5	to clarify the frequently-repeated XBT line spacing requirement for SOOP	Chair, Secretariat, JCOMMOPS	OOPC-11
22	5.5	to disseminate the draft SOT science room proposal and gather comments	Secretariat and SOOP chair	OOPC-11
23	5.7	to encourage a short workshop in cooperation with WGSF and JCOMM VOSP on AWS technical standards and best practices, with the publication of a technical guide	Taylor, Chair, Secretariat	OOPC-11
24	5.9	to facilitate the archiving of WGNE-provided surface flux fields on the GODAE servers, and to seek strategies to perform the comparisons	Chair, Weller	OOPC-11
25	5.9	to provide input to the BSRN OOWG	Weller	ongoing
26	7.2	to act as a focal point between THORPEX and ocean observing teams and groups regarding requirements and opportunities for coordination	Secretariat	ongoing
27	7.2	to ensure coordination of ocean observing network optimization for both weather forecasting and climate goals through liaison with appropriate THORPEX groups	Secretariat	ongoing

10. NEXT MEETING

The Panel decided to meet during the week of 15 May 2006, hosted by Yutaka Michida, at the University of Tokyo, Japan, with a focus on Indonesian Throughflow monitoring and Indo-Pacific connections, the Pacific Decadal Oscillation, sustained Japanese ocean observations and coupled data assimilation efforts.

ANNEX I
AGENDA

Tenth session of the
GCOS-GOOS-WCRP Ocean Observations
Panel for Climate

WMO, Geneva, Switzerland
9-12 May 2005

http://ioc.unesco.org/oopc/oopc-x/

OOPC-X Agenda
v.4.1 (4 May 2005)

1 Opening

- 1.1 Opening and welcome
- 1.2 Review and adoption of the agenda and OOPC-9 report
- 1.3 OOPC review 2004-2005 and meeting goals (*E. Harrison*)

2 Science focus

- 2.1 State of the Oceans 2004-2005
  - 2.1.1 SST and sea ice (*D. Reynolds, N. Rayner/Reynolds*)
  - 2.1.2 Climate indices (*E. Harrison, A. Fischer*)
- 2.2 Measuring the Meridional Overturning Circulation (MOC), *Martin Visbeck*
- 2.3 Shallow equatorial overturning circulations, *Fritz Schott*

3 Sponsor reports and liaison with other international groups

- 3.1 GCOS including the Implementation Plan (*A. Thomas*)
- 3.2 GOOS including the coastal GOOS implementation plan (*E. Harrison*)
- 3.3 WCRP: overview and focus on WOAP (*D. Carson*) and GSOP (*V. Detemmerman*)
- 3.4 JCOMM
  - 3.4.1 Overview and preparations for JCOMM-II (*E. Cabrera*)
  - 3.4.2 Observations Coordination Group and implementation (*M. Johnson*)
- 3.5 GEO (*G. Duchossois*)
- 3.6 Others: POGO, IGBP, IPY (*E. Harrison, M. Hood, E. Sarukhanian*)

4 Satellite observations

- 4.1 Requirements for climate observations and status report (*J. Johannessen*)
- 4.2 The European GMES initiative (*J. Johannessen*)
- 4.3 Working with the international satellite planning process (*D. Hinsman / discussion*)

5 Experiments, Programs, and Projects

- 5.1 Ocean analysis and reanalysis
  - 5.1.1 CLIVAR Global Synthesis and Observations Panel (*D. Stammer*)
  - 5.1.2 WCRP Observations and Assimilation Panel (WOAP) (*E. Harrison*)
  - 5.1.3 GODAE (*N. Smith/Harrison*)
  - 5.1.4 MERSEA (*J. Johannessen*) and other European initiatives
  - 5.1.5 SST/Sea ice WG and marine historical data workshop (*R. Reynolds, N. Raynor/Reynolds*)
- 5.2 CLIVAR (basin reports to incl. issues for specific observing networks)
  - 5.2.1 overview
  - 5.2.2 Atlantic (*M. Visbeck*)
  - 5.2.3 Indian (*F. Schott*)
  - 5.2.4 Southern Ocean (*K. Speer/Fischer*)

- 5.2.5 Pacific including South Pacific Workshop (*R. Weller, N. Caltabiano*)
- 5.3 Carbon (*M. Hood*)
  - 5.3.1 Carbon inventory and repeat hydrography
  - 5.3.2 Carbon surface flux measurements and data exchange
- 5.4 Sea level (*M. Johnson*)
- 5.5 SOOP XBT and followup (*A. Fischer*)
- 5.6 Argo (*Harrison*)
- 5.7 VOSClim surface ship observations and fluxes (*P. Taylor*)
- 5.8 OceanSITES reference sites (*R. Weller*)
- 5.9 WCRP Working Group on Surface Fluxes and SURFA (*R. Weller and E. Harrison*)
- 5.10 Japanese sustained ocean observing programs (*Y. Michida*)
- 5.11 Towards routine biogeochemical/ecosystem measurements (*T. Dickey*)

6 Data Management (*R. Keeley*)

- 6.1 IODE review
- 6.2 Metrics (link with JCOMM OPA)
- 6.3 Future WMO Information System and Metadata standard (*J-M Rainer, P. Kerhervé*)
- 6.4 Specific initiatives (US DMAC and EU initiative, unique tag, and data dictionary)
- 6.5 A vision for the future of data

7 Cooperation in observational strategy with other programs

- 7.1 Natural hazard warnings, including tsunami (*M. Golnaraghi*)
- 7.2 THORPEX weather prediction (*J. Caughey / E. Manaenkova*)

8 OOPC future directions (*discussion*)

9 Review of Actions for the next intersessional period

10 Next meeting: when and where

ANNEX II
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ANNEX III
EXTRACT FROM GCOS-92:
ACTIONS WITH OOPC AS A NAMED AGENT FOR IMPLEMENTATION

A5: Seek cooperation from organizations operating drifting buoy programmes to incorporate atmospheric pressure sensors.
Who: Parties deploying drifting buoys and buoy-operating organizations, coordinated through JCOMM with OOPC and AOPC. Time-Frame: Continuous.

A8: Develop and deploy precipitation-measuring instruments on the Ocean Reference Mooring Network.
Who: Parties deploying moorings in cooperation with JCOMM and OOPC. Time-Frame: Coordination finalized by 2005, implementation complete by 2009.

O2: Review relevance and effect of Plan, and revise the Oceanic Section of the Plan every 5 years.
Who: OOPC, in cooperation with participating partners. Time-Frame: Report by 2009.

O4: Promote and build partnerships with ocean research institutions and science teams.
Who: OOPC with WCRP and SCOR science programmes, and with POGO and other marine research institutions. Time-Frame: Continuing.

O7: IGOS-P Ocean Theme Team to publish update of the Ocean Theme and, as appropriate, restating the satellite requirements and explicitly noting requirements for climate.
Who: IGOS-P through WMO Space Programme, CGMS, CEOS in consultation with OOPC and GCOS. Time-Frame: Continuous.

O17: Develop and implement an internationally-agreed strategy for measuring surface pCO_2.
Who: IOCCP in consultation with OOPC, implementation through national services and research programmes. Time-Frame: Implementation strategy for mid-2005; initial pilot network to begin early 2006.

O20: Establish an international group to assemble surface drifting buoy motion data, ship drift current estimates, current estimates based on wind stress and surface topography fields and to prepare an integrated analyses of the surface current field.
Who: OOPC will work with JCOMM and WCRP. Time-Frame: 2008.

O25: Perform the systematic global full-depth water column sampling of 30 sections repeated every 10 years.
Who: National research programmes in cooperation with OOPC and CLIVAR and the IOCCP. Time-Frame: Continuing.

O41: Undertake pilot projects of reanalysis of ocean data.
Who: Parties' national research programmes coordinated through OOPC and WCRP. Time-Frame: 2010.