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)
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1. OPENING

1.1 Opening and Welcome

The Chair of the OOPC, Ed Harrison, opened the session at 9:30 on Tuesday 16 May 2006. He welcomed the participants including the those from the region, and thanked the local hosts, the Ocean Research Institute of The University of Tokyo, for their good will and hospitality. Introductions around the room were made. Yutaka Michida advised the participants of local arrangements. Harrison then reminded participants of the OOPC'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 providing most of the data for global operational oceanography. The plan for the observing system is written with differing national priorities in mind.

1.2 Review and Adoption of the Agenda

The Chair introduced the provisional agenda, which was approved (see Appendix I). The agenda, background documents, and all of the presentations given during the meeting are available on the **meeting website**: ioc.unesco.org/oopc/oopc-11/. Hyperlinks directly to the meeting presentations are also given below.

1.3 OOPC activities 2005-2006 and Meeting Goals

Harrison noted that plans for the initial ocean observing system for climate, embodied in the GCOS Implementation Plan[1] (GCOS-92), received high-level acceptance in the past year, from GOOS, the WCRP, JCOMM, GEO, the UNFCCC, and the G8 Gleneagles meeting. Turning these high-level endorsements into action remains a challenge. The plan emphasized the need for global coverage, integrating a variety of different sensor systems, data systems, and the production of climate information products.

A number of issues remained pressing. These included gaps in continuity in ocean satellite missions, the transition from research funding to sustained funding for some observing networks, and the priority of the global module within GOOS.

Liaison between groups implementing or using part of the global system that OOPC advocates was an important activity to maintain support for sustained ocean observations, and the members of the Panel attended a large number of meetings last year to support that goal of the Panel.

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[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/

Harrison shared his goals for the meeting, which were to define actions that could be taken regarding:

- organizing an OOPC review of the PIRATA moored array
- Ocean reanalysis issues: how to move from ocean data to information, and communicated with the sponsors of such activities
- Questions and issues from JCOMM (see 1.4 immediately following)
- Ocean satellite continuity issues
- Ocean data systems issues
- global observations of ocean biogeochemical and ecosystems variables

1.4 Overview of observing system status and issues from the JCOMM Observations Coordination Group

Harrison presented a report from Mike Johnson[2], chair of the JCOMM Observations Coordination Group (OCG).

The JCOMM OCG uses the ocean chapter of GCOS-92 as its implementation plan. Overall, the *in situ* networks are about 56% towards those goals. Coordination of the various networks is becoming more of a challenge. A special roundtable on this issue focusing on JCOMMOPS, held in May 2006 in Washington DC, recommended that over the next five years JCOMMOPS should evolve towards an observing program support center for all international global ocean observing networks.

The OCG asked OOPC for a scientific review of requirements for VOS observations for use in Numerical Weather Prediction (NWP) and climate studies, stemming from a request from the second session of JCOMM (September 2005), and for input on the need for barometers on surface drifters.

The Panel noted that it would need to get input from WGNE or THORPEX in order to respond to the request about the requirements for VOS and barometers for NWP (***Action*** for chair/secretariat). The **Panel discussed** the timeliness and necessity of a review of upper ocean measurements (including the SOOP program and VOS measurements) in light of the now nearly complete deployment of Argo floats, and **decided** that the right time frame would be in about 2008, to allow for a period of overlap between systems. Such a review should evaluate all volunteer measurements (not just temperature), and account for the value in having a ship-board observer for the breadth of observations that made possible. It should also involve the use of Observing System Experiments (OSE) and Observing System Simulation Experiments (OSSE), although taking into account their limitations in answering only the question asked, while composite networks were designed to answer multiple questions and observing requirements.

2. REGIONAL FOCUS: EAST ASIA

A large part of the first day of the meeting was devoted to a regional symposium on contributions to the sustained ocean observing system by East Asian countries (including the host Japan, South Korea, and China).

Presentations were given by:

- Korean sustained ocean observations (Chang)

[2] all talks are available at: http://ioc.unesco.org/oopc/oopc-11/ or by clicking the hyperlink.

- Chinese sustained ocean observations (Wang)
- SOLAS Japan (Uematsu)
- Forecasting system for Kuroshio variability (Yamagata)
- Observational studies of mode waters, and basin-scale observations in the Pacific (Suga)
- Japanese Argo (Shikama)
- Japanese observational plans in the Indian Ocean and Indonesian Throughflow (Masumoto)
- Japanese GODAE (Awaji)
- NEAR-GOOS and Japanese operational observations (Yoshida)

Each of these presentations is available on the meeting website or directly from the hyperlinks above.

In the roundtable discussion that followed the Panel **expressed its appreciation** to all the speakers, and also the fact that it was **impressed** at the great level of activity in the region. It discussed the need for regional coordination, and **noted** the growing level of research ship time that would be provided by China. Specific endorsement of the Japanese Argo program from the Panel was sought, and it **agreed** to draft a letter to the sponsors (***Action*** for chair/secretariat).

3. SCIENCE FOCUS

3.1 State of the Ocean 2005-6

3.1.1 Sea Surface Temperature

Reynolds presented a report on the sea surface temperature (SST) anomalies in 2005-6. Some notable signals were persistent warm SSTs in the northern North Atlantic, recurring since the 2003 heat wave, a larger extent of warm water in the north tropical Atlantic hurricane generation region, a long-term warming trend in the northern hemisphere (from 20°S to 80°N), and clearer evidence in a composite Pathfinder and AMSR SST analysis of anomalies associated with the passage of Hurricane Katrina.

3.1.2 State of the Ocean web site compilation of ocean climate indices

Fischer presented a new section of the OOPC website that highlights the current state of the ocean climate[3] using climate indices. This was called for in the 2003 OOPC-8 meeting, and has three goals: using uncertainty estimates to provide a simple tool for evaluation of the observing system, to provide a tool for communication about the ocean observing system, and to provide a quick overview of the state of the ocean.

The site was used to present an overview of the ocean climate in the past year, which shoed a mild Niña-like cooling in the tropical Pacific, a peak in North Atlantic SST anomalies with a recent reduction, high intraseasonal variability in the tropical Indian Ocean, and a reduction in the last few years of the North Atlantic current index, due mostly to changes in the subpolar gyre.

The **Panel decided** to solicit input from the CLIVAR basin panels on the most important indices, to coordinate with the CLIVAR GSOP panel in order to extend this work to ocean reanalyses, and to coordinate with GODAE on their metrics and perhaps include them

[3] http://ioc.unesco.org/oopc/state_of_the_ocean/

in the page (***Actions*** for Secretariat). The Panel also **decided** to write a semestrial overview of the state of the ocean climate to guide non-experts in interpreting the information (***Action*** for Reynolds with review by Panel). An expert/working area of the website might be made available to test new indices while not revealing them to the general public. Discussion of the appropriate timescale for updating particular indices, and interest in global trends, also took place. Some further indices of interest would be recent research work on global upper ocean thermal changes (showing a global cooling in the last few years) and reconciling that with continued observations of sea level rise (***Action*** for Secretariat, to put some of these indices on the page).

3.2 Role of the Indonesian Throughflow in climate variability, and sustained observing strategies

Gordon presented a report on the Indonesian Seas and its throughflow (ITF), focused on their role in climate variability and observing strategies. He emphasized that processes in the Indonesian Seas—notably surface heat and freshwater fluxes, Ekman upwelling and tidal mixing—modify the Pacific water flowing through them into the Indian Ocean, that the ITF is not a simple outflow from the Pacific into the Indian.

The ITF modifies the circulation in both the Pacific and Indian Oceans. Uncertainty in the size of the ITF is a dominant source of error in basin-wide Pacific and Indian heat and freshwater budgets. Heat and freshwater fluxes into the Indian Ocean affect the coupling, with potential impacts on ENSO and the Asian monsoon. Models show that the ITF strongly affects the upper layer heat storage and SST in both the Indian and Pacific oceans, through differ in their prediction of its effect. The Indian Ocean is more strongly affected, as the ITF cools the thermocline, flushing the tropical waters of the Indian Ocean to the Agulhas Current, as well as moving northward through the Somali current, upwelling, and exiting in the southward Ekman flow. This modifies the meridional overturning of the Indian Ocean (as well as the Pacific), and cools the tropical Indian Ocean.

Many processes affect the ITF. The surface winds over the Indonesian seas reverse with the Asian monsoon, favoring upwelling in boreal summer and downwelling in boreal winter, with strong associated air-sea fluxes. The complex coastal geometries and bottom topography create complex and high levels of tidal mixing. This complex topography also creates multiple inflow and outflow points, some with sill overflows contributing to the mixing. The shallower thermocline in the western Pacific during El Niño events exposes the thermocline to wind mixing, also affected by a reduced ITF.

Studies of water masses indicate that the Makassar Straight (between Borneo and Sulawesi) is the primary ITF pathway (maybe >80%). The cool transport-weighted average temperature of the ITF (about 15°C) comes from a restricted contribution from the warm surface layer. Seasonal storage in the Banda Sea due to seasonally-reversing Ekman convergence means that the flow into the Indian Ocean is highly modified Pacific water: Indonesian water.

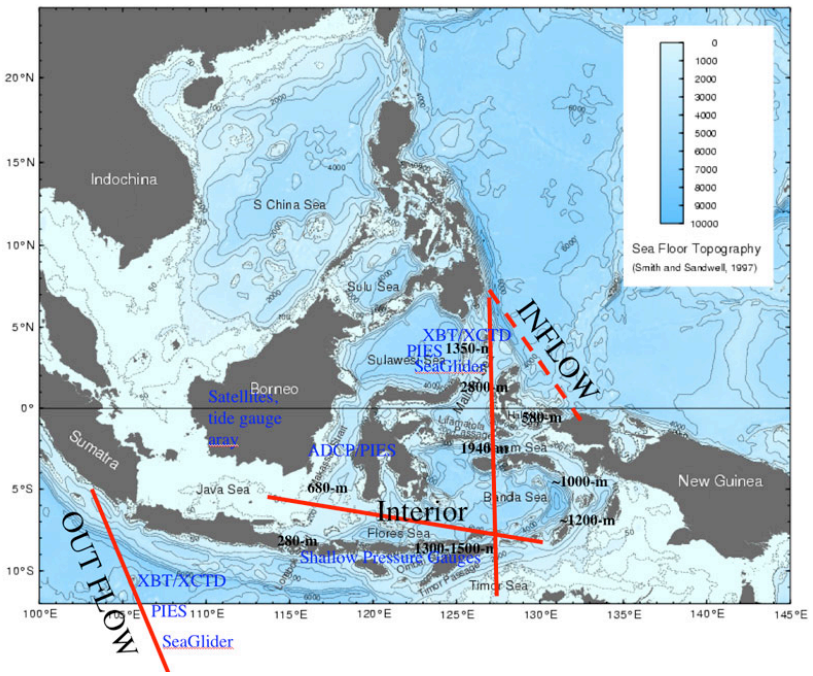
The vertical profile of the ITF heat and freshwater input into the Indian Ocean appears important in regulating the stratification and surface heat fluxes in that ocean. This profile depends on the regional freshwater input and its distribution, which is modified by the phase of ENSO, the Asian monsoon, and longer time scale variability. There are strong potential feedbacks on these processes and on the Indian Ocean dipole, making for an implied highly-coupled system.

Direct observations of the transport in the Makassar Straight correlate well with a 100 day lag with XBT data across the IX1 XBT line, giving confidence in the XBT data as a tool for detecting ITF variability over a long record.

The INSTANT (International Nusantara Stratification and Transport) program is measuring velocity, temperature, and salinity of the Indonesian Throughflow with simultaneous mooring deployments in the inflow and outflow passages over 2004-2006. This program is providing a wealth of data to look at physical processes and compare with models. A developing research program for 2008 will focus on the Lombok Straight.

Sustained observations of the ITF must be cost-effective and compatible with Indonesian government concerns (primarily about satellite transmission of data out of Indonesian waters). The ITF data stream should be assimilated into models to anchor the models in reality.

Different observing methods have different advantages and disadvantages. For *sea level*, variability can be observed from tide gauges, shallow pressure gauges, and satellite altimetry. Indonesia has an extensive tide gauge network, and discussions are ongoing to put in place collaborations that would allow timely access to the data. Shallow pressure gauges can estimate the surface flow in straights. Sea surface slope reveals information about the surface flow, but thermocline information is needed in a number of places. For *stratification*, variability can be observed using repeat XBT/XCTD lines, gliders, pressure sensor-equipped inverted echo sounders (PIES), or Argo floats. For *circulation*, variability can be observed using Argo floats, gliders, ADCP moorings, or surface drifters. Few surface drifters or Argo floats make it through the Indonesian Seas, and their direct satellite reporting poses a problem with the Indonesian government. Gliders pose the same problem, however it is planned that the 2008 program will use them, reporting data to a local site and via satellite at the same time. XBT/XCTD lines remain a very effective tool for monitoring the ITF. A mooring with deep ADCPs (below the reach of fishermen) could provide time series in key passages such as the Makassar Straight.



Gordon proposed an ITF observing system (draft schematic above) that was composed of the following components:

- **Makassar Straight**: ADCP mooring and PIES
- **Inflow**: Startup of a XBT/XCTD high-frequency (2-week) line extending from Mindanao (Philippines) to northwestern Irian Jaya (Indonesia)
- **Outflow**: Continuation of the IX1 XBT/XCTD high-frequency (2-week) line; as well as shallow pressure gauges in the outflow straights
- **Interior**: Continuation of the IX22/PX11 (north-south) and PX02 (east-west) XBT/XCTD lines across the Indonesian Seas at 2-week frequency
- **Overview**: Satellite altimetry and frequent reporting from the GLOSS tide gauge array

Each of the four XBT/XCTD lines (three currently done and one proposed) could eventually be replaced by PIES and gliders, which are a less wasteful technology. Gordon noted that this entire plan was now being done as a part of INSTANT, but that it was scheduled to come out of the water in December 2006.

The **Panel noted** that recent inverse models compared fairly well to the direct observations of about 10±2 Sv for the ITF transport. The ITF heat flux was thought to be mostly dependent on the variability in current, as the profile in temperature changes mostly with ENSO and not seasonally. The Panel noted that many models did not represent the transformation of the Pacific water in the Indonesian Seas before the outflow into the Indian Ocean, and that specific parameterizations for mixing in the ITF region should be investigated in models. The **Panel highlighted** the potential importance of the ITF in feedbacks leading to decadal modulations of ENSO, the Asian monsoon, and the Indian dipole, as well as the current uncertainty about the reliability of models and analyses for decadal estimations of ITF variability, as the main reasons for sustaining observations of the ITF, and **endorsed** the plan outlined by Gordon (***Action*** for chair/secretariat, to include these recommendations in the next revision of the GCOS Implementation Plan, and to communicate endorsement to potential sponsors).

The Panel also noted that although the ITF region falls between the CLIVAR Pacific and Indian panels, it was being well-addressed by the Indian Ocean panel. The Panel was quite hopeful that a large number of these observing activities could be taken on by Indonesian scientists and institutions in the future, and that a transition through the 2012-2015 time frame would take place. Weller asked Gordon for short written input to a 'CLIVAR legacy' white paper (***Action*** for Gordon).

3.3 The Atlantic MOC: a northern perspective

Schott presented a report on the Atlantic Meridional Overturning Circulation (MOC). Recently it has been suggested from conventional hydrographic analysis across the subtropical North Atlantic that the MOC might have slowed down compared to earlier observations (Bryden et al., Nature 2005). The presumed decrease of southward Deep Water flow was mostly said to occur between 3000-5000m depth. Schott reviewed other evidence from observations in the subpolar North Atlantic and from assimilation output results (SODA and ECCO) regarding the evolution of MOC elements during the past decade.

At the exit of the subpolar North Atlantic, east of the Grand Banks, the Deep Western Boundary Current (DWBC) was measured during WOCE in 1993-95 and again during 1999-2005 by the IFM-GEOMAR group, Kiel. No change in current intensity and transport of the cold water branch of the MOC over that decade could be detected (Schott et al., JPO 2004; and submitted 2006). Related measurements at the exit of the Labrador Sea, at 53N, during 1996-2005 also fail to show a decrease in the DWBC currents (Dengler et al., subm.). One possible cause that appears attractive for an MOC slowdown is the decadal freshening of the northern overflows and entire deep subpolar North Atlantic. It had been argued (e.g.,

Hansen, Science 2004) that this freshening would reduce the meridional density gradient driving the MOC. However, as shown by S. Lozier (pers. comm. 2006) the decadal freshening of the deep basin, below 2500m, was mostly compensated by cooling, i.e. the deep northern freshening cannot serve as a driver for the "slowdown" of lower Deep Water flow. Furthermore, different model simulations yield an MOC reduction of less than 10% for all possible northern density gradients of the observed past (Latif et al., subm.). Assimilation model output fields show that for the exit of the subpolar basin, at 43N, no decadal slowdown of the MOC was obtained, in the SODA-POP run of 1958-2002 and for the 50-year ECCO run (D. Stammer, pers. comm.). Additional evidence against a slowdown was presented by Schmittner et al. (GRL 2006). They used an ensemble analysis of a number of IPCC models and found for the ensemble average MOC that it had even slightly increased in past decades and would only decrease into the year 2100 under GH forcing scenarios. The overall conclusion of Schott's OOPC presentation was that the available evidence, both observational and modelling, strongly indicates that no detectable changes and trends of the Atlantic MOC have occurred in recent decades.

3.4 Requirements for an MOC monitoring network and MOC indices

Visbeck presented ideas for monitoring the MOC and for creating indices from observations. An ideal observing system would include measurements of MOC *forcing*: surface stress and heat flux, freshwater forcing from the Arctic, and overflows (which could also be considered part of the MOC itself; *observations* of the MOC itself: integrated mass flux measurements (like the RAPID array), measurements of isopycnal slope/potential energy at specific points, measurements of boundary currents (both measures of just portions of the MOC), and measurements of SSH and SST variability (for associated impacts); and finally *synthesis*: using both forward and assimilating models. Visbeck recalled his OOPC-10 presentation[4] on sustained observations in the Atlantic that support the capturing of decadal signals, none of which were truly 'operational.'

Visbeck then explored a number of proxy 'indices' using guidance from forced ocean models. Subpolar gyre transports are fairly well correlated with high-latitude MOC anomalies in the FLAME and ORCA05 models, as were changes in the overflow density in the Denmark Straight. Direct observations of boundary current transport in the Labrador Sea were also found to be highly correlated with the MOC in an ocean model.

Direct observations of transport across a section can be aliased by recirculations, and a ocean models show that a significant part of the section needs to be observed before the transport anomalies become representative. The warm upper limb of the MOC near the equator is carried in North Brazil Current (NBC) rings. The DWBC at 10°S breaks up into eddies at about 8°S, and carry the southward transport of NADW into the South Atlantic, forming the return limb of the MOC. Counting these NBC and DWBC eddies could be a simple index of the MOC, although the DWBC eddies do not appear in altimetry because they are deep and density-compensated.

In global warming simulations, a dipole SST index between North and South Atlantic between 40-60° in latitude, respectively, is strongly correlated with MOC weakening. Since 1975 this difference has indicated an MOC strengthening, supported in the ORCA-LIM model. Visbeck noted a proposal to continue the RAPID array across 24°N, since the two years of data expected were too short, and Japanese and British plans to revisit 30°S.

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[4] available from: http://ioc.unesco.org/oopc/oopc-x/

The Panel discussed the representativity of the ocean models used in the guidance studies cited by Visbeck, both in terms of model error, and potential changes in the index/MOC relationships with evolution in the ocean dynamics with global change, and **agreed** that further research into these relationships was necessary. The Panel **suggested** that the dipole SST indices for the MOC should be an experimental index on the OOPC site (***Action*** for secretariat).

4. OCEAN PRODUCTS: ANALYSES AND REANALYSES

4.1 CLIVAR GSOP actions and requirements

Stammer presented a report from the CLIVAR Global Synthesis and Observations Panel (GSOP), which he co-chairs. He reminded the Panel that synthesis was required by CLIVAR for a wide range of climate studies, including of the planetary heat balance, the global hydrological cycle, sea level changes, and other global-scale climate variability, and including the initialization of coupled models. There are a number of prototype synthesis efforts, but only a few sustained activities for climate-quality hindcasts.

Early results from the 50-year German ECCO (GECCO) run were promising, and GSOP was engaged with GODAE to a reanalysis evaluation effort, with the goal of identifying the best possible estimates and approaches for different types of climate studies. GSOP had polled the CLIVAR basin panels for climate indices that should be routinely computed by the reanalysis efforts. It also identified a need for CLIVAR reference data sets for evaluation and as input into the reanalysis efforts.

CLIVAR had also been active in repeat hydrography, co-sponsoring a workshop with IOCCP in November 2005. The workshop advocated the creation of a small oversight group for international repeat hydrography, the development of synthesis activities around particular scientific activities, using workshops and an integrated approach for each basin, and improvement of the data management component of the hydrography program.

WCRP had high interest in data reprocessing efforts, and GSOP was cooperating with the WCRP Observation and Assimilation Panel (WOAP) in their efforts.

Weller asked GSOP if it could provide guidance to the time series observing community on what types of instrumentation in the subsurface would be helpful in testing reanalyses, particularly whether certain vertical modes needed to be resolved (***Action*** for GSOP). The Panel **discussed** the use of the reanalyses for OSSEs, and again **noted** that the answers could be useful, but could depend on the model, and would depend highly on the question asked.

4.2 GODAE

Harrison presented a report by P.-Y. Le Traon and M. Bell, new co-chairs of GODAE. They reported good progress in GODAE national activities, and the transition of the project office to Exeter. GODAE is scheduled to end by the end of 2008, but some international coordination activities will transition to JCOMM.

The major goals for GODAE through the final period were to: develop demonstrations of the utility and impact of GODAE prediction models, continue with error characterization and product standardization work, use the models for observing system experiments, work with JCOMM to define a transition to operational systems, and to develop new efforts in ecosystems prediction and between large-scale and coastal systems.

The Panel discussed the balance between national activity under GODAE and the international coordination effort, and **encouraged** the intercomparison effort. It also **noted** the importance of publicity about the availability of products, and for the research community, the availability of stable products for evaluation and feedback.

4.3 Working Group of Surface Fluxes

Weller presented a report on the Working Group on Surface Fluxes (WGSF), drawing on material from Chris Fairall. This group was established by the WCRP to review requirements of WCRP programs for air-sea fluxes, to develop links to IGBP research initiatives, such as SOLAS, in the area of air-sea fluxes, to encourage research and activities to improve knowledge of air-sea fluxes, and to keep the community and the JSC informed on progress through reports, web presence, and, as needed, workshops. The goal also is to work toward better observing systems, to better accounting for the role of air-sea fluxes in climate prediction and anthropogenic change, to better coordination of flux programs, to better funding for air-sea interaction research, and to engaging more young scientists in air-sea interaction research. Initial WCRP foci that require consideration of air-sea fluxes include seasonal prediction, sea level, monsoons, climate change, and extreme events.

The community had in the 1980s and 1990s used VOS-based air-sea flux products and fluxes from NWP reanalyses, typically those of NCEP and ECMWF. Such products have large differences. Recent efforts have focused on synthesizing flux fields from satellite, NWP, and in-situ inputs in ways that minimize error. Yu and Weller at WHOI, Cronin and colleagues at NOAA PMEL, Smith and colleagues at FSU have developed such fields. There are also efforts underway to blend satellite data sets for better coverage and resolution and to get better resolution for forcing ocean models by using higher resolution surface fields from NWP models. Ocean data assimilation efforts can also be used to infer surface flux fields, as, for example, done by the ECCO project.

Over the last year the WGSF worked on developing its website (http://www.etl.noaa.gov/et6/wgsf/), on a flux measurement handbook, on creating a library of flux-related computer codes, on a catalog of flux products, on a WGSF Flux Newsletter, and improving linkage to other activities. A particular effort has been to include representation from the IGBP SOLAS project and build joint WCRP-IGBP activities with foci on air-sea fluxes. Dialog with the WGNE has been re-opened about the SURFA project, where accurate in-situ surface flux times series from ocean sites are provided with the intent that they get compared with the surface meteorology and air-sea fluxes from operational NWP and climate models. The intent is to identify biases in models and motivate a common effort to reduce such model biases. There were contributions from members of the air-sea flux community to the IPCC Fourth Assessment. The flux handbook has been drafted, with Frank Bradley (CSIRO) as lead author; its title is “A Guide to Making Climate Quality Meteorological and Flux Measurements at Sea”.

Weller used the WHOI OA Flux Product (http://oaflux.whoi.edu) to illustrate differences between the recent synthetic flux products and the NCEP, ECMWF fields. The sensible and latent heat flux fields in these synthetic flux products verify well against in-situ observations and provide the basis for examining variability in sensible and latent heat flux fields. The shortwave and radiation fields now available, however, continue to have biases and other problems that limit their utility as climate quality products. Thus, developing improved surface radiation fields over the ocean remains a priority activity.

The WCRP WGSF will in time transition to include in its mandate land surface fluxes. The advice and input of OOPC on moving forward in the near term was sought in advancing

SURFA, in working with the radiation community to develop improved surface marine radiation fields, on support for continued work on developing flux products, and on a potential flux summer school and a joint WGSF-SOLAS workshop.

The Panel **discussed** the errors in the mean fields in these surface flux products: Weller noted their lack of resolution in high-gradient areas such as the Gulf Stream biased means so as to make them not very useful for that purpose, but rather in looking at variability. They were also useful in identifying areas where further *in situ* data would help constrain the estimates.

4.4 SST-Sea ice Working Group

Reynolds presented his group's new daily 0.25° optimal interpolation (OI) SST product. The presentation focused on improvements to the climate-scale sea surface temperature (SST) analysis produced at NOAA as described by Reynolds and Smith (1994) and Reynolds et al. (2002). This analysis uses infrared (IR) satellite data from the Advanced Very High Resolution Radiometer (AVHRR) and in situ data from ships and buoys. The analysis is done by optimum interpolation (OI) with a separate step to correct any large scale satellite biases relative to the in situ data. The analysis is performed weekly on a 1° spatial grid from November 1981 to present.

The 1° OI code[5] was modified to run daily on a 1/4° grid and to allow multiple satellite datasets instead of AVHRR alone. However, for this purpose the OI noise to signal and correlation scales had to be modified because these scales had been computed for weekly data. A method was devised to adjust these corrections so they could be used for daily data. The average weekly scales weekly scales were 700 km; the new averaged daily scales were 100 km. The weekly OI included a 7-day bias correction of the satellite data using in situ data. Differences between the OI analyses using the different satellite products showed that satellite bias corrections were still needed for each satellite product. Thus, a running average 7-day bias correction is carried out in the daily OI.

The daily OI codes were run for AVHRR and in situ data for January 1985 - December 2005. Advanced Microwave Scanning Radiometer - Earth Observing System EOS (AMSR-E) microwave satellite data became available in June 2002. The coverage of AMSR-E data is dramatically improved over AVHRR because microwave data can be retrieved under cloudy conditions as long as there is no precipitation. In particular, the impact of clouds greatly reduces AVHRR retrievals north of 40°N and south of 40°S compared to AMSR-E. Thus, the daily OI was also run with AVHRR, AMSR-E and in situ data from June 2002 through the end of 2005. The analyses will be made operational soon. Both sets of these daily analyses are presently available at: ftp://eclipse.ncdc.noaa.gov/pub/OI-daily/

Harrison noted plans to make real-time metadata for ocean surface temperature measurements available.

Reynolds then presented a report on the working group. Fred Singer planed to hold a Sea Surface Temperatures session at the American Geophysical Union 2006 Joint Assembly on May 25, 2006, in Baltimore, Maryland. At this session he planned to state that accurate measurement of SST is difficult. Several other authors planned to contest that point of view. Tom Smith and I prepared a presentation entitled “Analyses of SST with Uncertainty

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[5] References: Reynolds, R. W. and T. M. Smith, 1994: Improved global sea surface temperature analyses. *J. Climate*, **7**, 929-948. Reynolds, R. W., N. A. Rayner, T. M. Smith, D. C. Stokes and W. Wang, 2002: An improved in situ and satellite SST analysis for climate. *J. Climate*, **15**, 1609-1625.

Estimates" in which we showed that analyses of large-scale variations have interdecadal signals larger than the uncertainty of the analyses.

At the 7th GHRSST-PP Science Team Meeting workshop in Boulder, CO in March 2006 there were a number of important presentations. Kenneth S. Casey, NOAA National Oceanographic Data Center, reported that he is establishing a web site which will allow users to compare different SST data sets. Chris Merchant (University of Edinburgh) presented his plans to improve Along Track Scanning Radiometer (ATSR) data including the development of a common format for all the different instruments. Also, John Stark presented a new UK Met Office SST analysis which will presently be operational daily on a 1/20° grid. For sea ice there was a presentation by Florence Fetterer on the National Snow and Ice Data Center's Sea Ice Products. A presentation by Søren Andersen (Center for Ocean and Ice, Denmark) discussed his plans to lead the sea ice working sub group in a new evaluation of the different sea ice products.

The Panel discussed the need to maintain vigorous intercomparisons between ATSR data and other SST satellite measurements. Reynolds also noted that he was handing leadership of the SST working group to Nick Rayner.

Harrison presented a report from S. Andersen on the sea-ice working group, based on its written report[6]. Its core tasks will be to assemble relevant data sets into an accessible form, establish metrics for comparisons between products and between products and data, and to estimate uncertainty in existing sea ice products and observations.

The Panel **expressed** its appreciation for the spin-up of this effort. It also noted the interest in a number of various products: ice edge, ice concentration, ice volume, depending on the audience. Various members of the panel noted that there was movement in the community, and that this effort was timely. While the group would begin with sea ice concentration measurements, there was clear interest on the part of climate researchers on estimates of sea ice thickness.

Ukita presented the CliC and IGOS-P Cryosphere Theme. His goal was to enhance coordination and cooperation between CliC and OOPC with regards to sea ice observations. He gave a quick overview of CliC and reported on requirements for sea-ice observations (compiled by Mark Drinkwater of the IGOS-P Cryosphere Theme writing team). He stressed the importance of making sea-ice extent, concentration, thickness, and drift data available for a various end users and applications. He presented a view shared by many members of CliC Project Area (CPA) 3 and IGOS-P Cryosphere Theme report writing team that a provision of error estimates on sea ice parameters is a high priority. A need for inter-comparison of existing sea-ice data for key parameters such as concentration, thickness, and draft, was discussed. An exact framework, in which the above tasks are conducted, remains a future issue for involved groups. Ukita listed (i) AOPC/OOPC WG on SST and Sea Ice, (ii) CliC Project Area 3 on the marine cryosphere and its interactions with high latitude oceans and atmosphere, (iii) IGOS Cryosphere Theme/sea ice part, (iv) IGOS Ocean Theme, (v) International Ice-Charting WG, (vi) JCOMM Expert Team on Sea Ice as potential groups for future discussions, although the list is by no means exhaustive and needs a further review.

Future dialogue is needed to discuss:

- requirements for error estimates on key sea-ice parameters with GSOP
- the way to share information on sea/ice-related materials between AOPC/OOPC SI sub-WG and IGOS-P Cryosphere Sea-ice component.

[6] available as a background document on the meeting website.

Another area of potential overlap between OOPC and CliC is heat fluxes (pointed out by Weller). Future dialogue is needed to discuss requirements. Harrison noted that the Cryosphere and Ocean Themes should coordinate responsibility for sea ice.

The Panel **encouraged** the efforts of CliC in pulling together the historical data for sea ice, as well as upward-looking sonars in the Arctic and Southern Oceans, starting with the building of inventories.

5. REGIONAL OBSERVING PANELS

5.1 CLIVAR Atlantic Ocean Panel

Visbeck presented a report on the activities of the CLIVAR Atlantic panel, with input from his co-chair W. Hazeleger. The Atlantic panel has three principal research areas: the North Atlantic Oscillation, Tropical Atlantic Variability, and the Atlantic Thermohaline Circulation. It has a strategy of promoting a balanced approach to describing, understanding, and assessing the predictability of climate phenomena using observations, modeling and theory, and synthesis.

Coverage of *in situ* observing elements was examined. Most SOOP XBT lines are covered at about the expected frequency. The surface drifter network in March 2005 showed some gaps in coverage in the eastern tropical Atlantic and in the Gulf of Guinea, a degradation in coverage from 2004. The Argo profiling float network was rapidly growing, with only a few small holes left, off the coast of Brazil, in the eastern Gulf of Guinea, and east of the South Sandwich Islands (***Action*** for secretariat: to communicate to DBCP and Argo the existence of these gaps). Repeat hydrography in the Atlantic was proceeding in a coordinated fashion between CLIVAR and carbon needs, with a major survey in 2003-05. It is unclear if another survey might take place in 2010-12 during CLIVAR. A significant number of research and sustained fixed point measurements exist, but their continuity for the lifetime of CLIVAR is not guaranteed, and several arrays will not be continued.

A major initiative in the panel is the Tropical Atlantic Climate Experiment (TACE), led by B. Johns and W. Hazeleger. Its goals are to advance understanding of coupled processes and to improve climate prediction for the Tropical Atlantic. Specifically, the goals are to a) advance understanding of the key processes that control SST, interactions with the Atlantic Marine ITCZ, and related predictability in the eastern tropical Atlantic, and b) to contribute to the design of an enhanced sustained observing system for the tropical Atlantic region. The experiment will include a balance of observations and coupled predictive systems and ocean synthesis. A number of enhanced observations are planned, for both seasonal predictions and interannual and longer timescales. The core period will span six years from 2006/7 through 2011/12. Plans include enhancements to the PIRATA array, enhanced float and drifter coverage, and a glider section across the equator. They also include a time series station at the Cape Verde observatory. The PIRATA enhancements include a northeast extension, the Brazilian southwest extension (not a part of TACE), and a southeast extension in the Benguela Current area. C. Reason and M. Rouault (University of Cape Town) have some funding for this which is running out (***Action*** for chair/secretariat, to follow up on this capacity-building initiative).

Issues at the intersection of CLIVAR and OOPC were raised, including how to advocate for the maintenance of existing networks. CLIVAR is a major scientific user of the existing networks, but all users should speak with one voice when defending the observing system - this should be OOPC. But given the diversity of users, how will the overall usefulness of a particular observing element be evaluated in the context of other data?

Another crucial issue is how to transition pilot project efforts to sustained observations? CLIVAR has projects that if proven useful should be sustained. This remains an open issue. Remaining issues in synthesis and data management also remain.

The Panel discussion focused on the north Atlantic and enhanced observations for the IPY. The Panel **was encouraged** by the growing coordination of Arctic ocean observations, and **agreed** that the legacy of enhanced observations during the IPY should be a focus of a future meeting as the lessons from the IPY were being learned.

5.2 CLIVAR-GOOS Indian Ocean Panel

Schott presented a report from the CLIVAR Indian Ocean Panel (IOP), with input from G. Meyers and M. McPhaden. The IOP has finalized its implementation plan[7] which was presented to the CLIVAR SSG prior to their recent meeting (SSG-14). The presentation first focused on recent research developments that show a larger role of the Indian Ocean in climate than had been previously thought. Analysis from the SODA assimilation shows large decadal variability of the shallow cross-equatorial cell that accomplishes much of the meridional heat exchange. This could, however, not account for the puzzling difference in decadal heat storage changes between the North and the South Indian Ocean. On the interannual time scale the Indian Ocean Zonal Dipole Mode (IOZDM) plays an important role, in particular preconditioning the open-ocean upwelling dome northeast of Madagascar for intraseasonal variability. A decadal change in correlation between the IOZDM and ENSO has been found and there is a possible role of the Indonesian Throughflow (ITF) in advecting Pacific Decadal Variability and thus affecting the upwelling intensity of Sumatra and IOZDM development. An important activity of IOP members and affiliated scientists in the build-úp phase of the Panel were Ocean System Simulation Experiments (OSSEs), that specifically investigated the role of intraseasonal variability and how to best measure it with the mix of available observational methods.

The core of the Implementation Plan worked out by IOP is an array of moored stations augmented by flux measurement buoys that are urgently needed to overcome the serious deficits in the heat budget parameterizations of the Indian Ocean. Initial deployments of a 4-mooring array have already been carried out on the equator near 80E (Indian cooperation with PMEL) and first analysis by McPhaden et al. (pers. comm.) yielded strong intraseasonal variability and allowed heat budget estimates. Further east, at 90-95 E, the Japanese TRITON array is operating, again yielding large intraseasonal variability (Masumoto et al., 2005). It is now important to make the full array of 44 stations operational as quickly as possible. The IOP has proposed a five-year build-up phase for the array and OOPC was asked for its endorsement. The mooring deployments and exchanges require substantial and continued ship time commitments (estimated at approx. 6 months per year) and OOPC was asked for its support in making adjacent nations aware of these needs. There is also the issue of coordinating the Indian Ocean climate array with the logistics of the Indian Ocean Tsunami Warning System (IOTWS). A white paper on synergies among both systems is presently been worked out by the chairs of both groups.

Regarding the Argo array of profiling floats, the Indian Ocean is in reasonable shape at present with about 400 operating floats (compared to the Argo requirement of 480); but strong efforts have to be made to sustain and replenish the array. Similarly, the XBT network is considered vital by IOP and continued efforts to keep it going are required. In addition, a set of hydrographic/carbon surveys for inventory change observations is part of the

[7] available as a background document on the meeting website.

implementation plan. The expansion of the tide-gauge network is pursued in cooperation with IOWTS and others, but timely access to the data for research purposes remains a problem with some nations.

Regarding the role of the IOP in CLIVAR, this Panel, which was only created in 2004, had originally only been given a limited lifetime of three meetings. However, at SSG-14, the IOP arguments that the Indian Ocean should be treated similar to the other basins which have continuing CLIVAR basin panels was accepted and the Panel will now continue.

The Panel **agreed to endorse** the Indian Ocean moored array as a pilot project, with a later review of its lifetime and sustained elements. It **encouraged** the JCOMM Observations Coordination Group to work with the IOP to develop a deployment strategy, with the difficult issue of ship time for maintenance of the array looming (***Action*** for chair). It encouraged efforts to get mooring-based tsunami warning observations coordinated with the climate observations, for ship deployment coordination at least.

5.3 CLIVAR Pacific

Suga presented a report from the CLIVAR Pacific Panel, which was recently renewed and now led by a new chair, Axel Timmermann. The new panel members met in Honolulu (15-17 February 2006) for the first time. The Panel has identified new scientific key thrusts: the warm pool role in climate, tropical instability waves and climate, the role of eddies in Pacific climate, South Pacific boundary currents and climate, reasons for model biases, the cold tongue complex, the origin of decadal variability, the origin of ENSO irregularity, and pan-oceanic connections. The sustained ocean observations in the Pacific, including the TAO/TRITON array, Argo, XBT lines and repeat hydrography were reviewed and re-endorsed. The panel also discussed and endorsed the current process study, KESS (Kuroshio Extension System Study), and the planned process studies, PUMP (Pacific Upwelling and Mixing Physics), SPICE (Southwest Pacific Ocean Circulation and Climate Experiment) and VOCALS (VAMOS Ocean Cloud Atmosphere Land Study) in view of the above mentioned scientific focal points.

The Panel is interested in supporting following observational activities in collaboration with OOPC:

- To keep 3000 profiling floats of Argo program in the global oceans
- To develop gridded Argo products to facilitate the analysis of Argo data
- To get involved in the planning stages of newly planned field experiments in the Pacific such as SPICE, give recommendations of existing observational infrastructures and help integrate these projects internationally
- To promote long-term ocean time-series stations/sections in the Pacific and encourage the community to use these data in addition with Argo and ocean data-assimilation products
- To coordinate/initiate experiments to measure the strength and dynamics of deep equatorial jets as well as of Tsuchyia jets
- To encourage the community to continue the WOCE transect at 85W, going through the heart of the Antarctic Intermediate Water
- To seek feasibility of glider arrays to measure flows in boundary current areas
- To initiate a discussion on a piggy-back system of RFT mass spectrometers on some Argo floats to get a chemical, biogeochemical and isotopic state-estimate of the ocean

5.4 CliC-CLIVAR Southern Ocean Panel

Fukumachi presented a report from the CliC-CLIVAR Southern Ocean Panel, prepared with input from co-chairs Speer and Renfrew. Evidence for the relationship on interannual and longer timescales between an Antarctic Dipole in sea ice (east and west of the Antarctic Peninsula) and the Pacific South American Pattern (PSA) and Wave-3 patterns. The Southern Annular Mode (SAM) and Semi-Annual Oscillation (SAO) are associated with more symmetrical sea ice concentration anomalies.

The Southern Ocean Panel identified the following issues requiring further enhancements to observing networks or technology. Some of these issues will get some focus through IPY (March 2007-March 2009) projects.

- Argo
  - Maintaining and re-seeding array (need to increase the number of floats)
  - Under-sea-ice technology (4 approaches at AWI, JAMSTEC, UW, and WHOI), necessary to resolve climate modes
- Sea ice zone
  - Sea ice thickness/volume. IPY activity planned.
  - Ocean properties under sea ice – depends on under-sea-ice floats
  - Expanded met buoy network - need ships for deployment (IPY BEARDS proposal).
  - Coastal margin; onshore-offshore exchange (IPY SASSI proposals)
- Repeat hydrography, XBT, and tracer sections
  - Good plans, but not all funded (only Drake Passage approaching needed sampling rate)
- Meteorology
  - High quality ship observation (IMET on supply vessels - SAMOS)
  - Air-sea flux reference stations - one is still an ORION priority.
  - Reynolds does not yet use Argo SST in Southern Ocean
- Satellite data streams must be maintained
  - Altimeter; gravity; ice; SST; wind
  - Replacement Cryosat has been approved (launch 2009)

The International Polar Year will provide opportunities, including a quasi-synoptic circumpolar survey, monitoring of the Antarctic Slope Front, under-ice Argo, ice thickness measurements and an enhanced ice drifter array, and proof of concept of a Southern Ocean observing system. A dedicated regional reanalysis project would help to improve air-sea flux estimates. Current assimilations often reject the data that does exist.

The Panel **revisited** the issue of the sustained legacy from enhanced IPY observations. It **decided** to ask the Artic and Southern Ocean panels to help it evaluate the requirements to sustained ice drifting buoys (***Action*** for chair/secretariat). Their original requirements were based on the correlation spatial scales of atmospheric pressure, which yields a small number of buoys, but they are useful in calibrating satellite products of ice drift. It **noted** that marine mammals are now providing a large volume of useful temperature profiles, and **encouraged** experiments in assimilating this data into models. The Panel also noted its interest in time series stations in the Southern Ocean, and **offered** to work with the Southern Ocean Panel in defining requirements for sustained time series observations beyond the IPY (***Action*** for chair/secretariat, to liaise with OceanSITES and the Southern Ocean Panel).

5.5 CliC-CLIVAR Arctic Climate Panel

Fischer presented a report on the Arctic Climate Panel (ACP) with input from C. Mauritzen and B. Dickson. The panel is now co-sponsored by CLIVAR and CliC. Many Arctic Ocean observations are coordinated by the Artic Ocean Science Board and other national and regional programs, and the ACP will work with these bodies. The AOSB is coordinated an integrated Arctic Ocean Observing System (iAOOS), and EuroGOOS (Norway) has put forward an Arctic GOOS observation. A big ramp-up in observations for the IPY is expected.

The transformation of water masses in the Nordic Seas and the Arctic Ocean are important to the North Atlantic overflows, and to setting conditions in areas of deep convection in the North Atlantic. Water enters the Arctic through the Fram Straight, Barents Sea, the Bering Straight, and from freshwater runoff. It exits through the Canadian archipelago and the western Fram Straight. The residence time in the Arctic is between 1-100 years depending on the pathway. There is topographic steering and cyclonic circulation of Atlantic waters entering the Arctic, and strong interactions with sea ice and surface fluxes.

Many research questions remain on the Arctic's role in climate change, and the causal relationships can be difficult to extract. The connections to the sub-Arctic regions may not be limited to the oceans and ice, but include interactions with the NAO, which seems to have predictors in subtropical and tropical SST.

The ACP's interaction with OOPC center around the legacy of sustained observations from the IPY.

The Panel again **signaled its encouragement** at the coordination and breadth of activities planned for the IPY. It **supported** the activities of the sub-working group on sea ice, and **encouraged** the development of an Arctic GOOS (or other similar structure) to coordinate sustained observations after the IPY. It **resolved** to maintain liaison with CliC and other relevant groups including the ACP as the lessons of IPY observations were learned, and a legacy could be defined, towards the end of the IPY.

6. GLOBAL PROJECTS

6.1 Satellite Observations

6.1.1 Missions update

Johannessen presented an update on satellite ocean missions. The presentation provided an update of the satellite mission status according to the following three classes: in orbit, approved and planned. The time period focused on present to 2014. Quantities such as sea level, surface geostrophic current, sea surface temperature, sea ice extent and concentration, ocean color and near surface winds and waves are forming the backbone oceanographic quantities for climate and environmental monitoring. Currently they are routinely observed from satellites. In addition, the feasibility to observe ocean surface salinity from SMOS and Aquarius and sea ice thickness from Cryosat-2 will be explored in the time frame from late 2007 to 2012. The value of space missions for long term climate and environmental monitoring comes from the capability to systematically and consistently produce globally integrated, high quality and reliable data products from the merged analysis of measurements from the whole constellation of operational and research/ demonstration satellites. In view of the emerging operational oceanography, there is also growing demand for the continuity of near real time satellite data.

The outlook for continuity and approval of new operational and research/ demonstration satellite missions up to 2014 reveals a picture with varying degrees of promising and not-so-good outlook. In particular, the radar altimetry situation remains a concern (see timeline plot below) as 3-4 altimeters are the only plausible way to initialize the ocean mesoscale. Moreover, long term series of Jason satellites (climate reference) are needed for sea level observations.

Through 2007 the situation is fairly safe, but from then on the entire altimetry situation and guarantee for continuity lies in the extended lifetime operation of both the high accuracy, mid-inclination and medium accuracy, high-inclination altimeter orbits. On the assumption that the continuity of the high precision, mid-inclination altimeter is secured the timeline plot illustrates that we could be faced with a serious gap around 2009/2010. In that time frame the high-inclination and high-resolution altimetry of the Envisat RA-2/GFO types are expected to near their end of operation implying that we could lack adequate observations to

monitor ocean eddies and mesoscale variability. Consequently, the danger are that assimilation of such merged altimetry fields in ocean models stopped. Only at the launch of Sentinel-3 (SRAL/GMES) could it then be possible to resume such operational modeling and assimilation. Hence, the situation is very sensitive to delays in the launch of Sentinel-3 in view of the fact that the planned NPOESS launch now is postponed until 2013.

In general, the outlook for the other quantities routinely observed from satellites is more promising, perhaps with the exception of surface temperature. To remedy this, the GODAE High Resolution SST Pilot Project (GHRSST-PP) has established an internationally accepted approach to blending SST data from different sources that complement each other. For this to work effectively, there must be an assemblage of four distinct types of satellite SST missions in place at any time. The continuity of geostationary radiometry and AVHRR type radiometers are secured. However, observations by the more accurate radiometer of the ATSR/AATSR type could be faced with a gap until Sentinel-3 and VIIRS are launched in 2011-2013 time frame. Moreover, continuous SST from microwave radiometer may also be faced with a gap in the 2009-2011 time frame.

Of the new explorer type missions the sea surface salinity observations to be tested out with SMOS and Aquarius, beginning in late 2007, are welcomed by the community. The same is true for the GOCE mission (to be launched by mid-2007) that aims to deliver a new and precise geoid at a spatial resolution of 100 km.

The MERSEA is a European contribution to GODAE and capitalize on four major data assimilation systems; notably FOAM operated at UK Met., MFS operated at INGV, Italy, MERCATOR operated by MERCATOR, France and TOPAZ operated by NERSC. The core objectives is the full integration at European level of the global to regional ocean monitoring and forecasting capacity (http://www.mersea.eu.org). MERSEA delivers *standard operational products and information* which are the indispensable inputs to further down-stream regional to coastal services. This also includes provision of standard reports aimed at policy makers and management/stakeholders, in the form of consolidated bulletins, indices and indicators. In accordance with GMES (http://www.gmes.info) implementation plan MERSEA shall enter into full marine core service operation by 2008.

Weller asked for better information on satellite missions supporting the calculation of surface fluxes, which is in the remit of the AOPC. This would help close an information gap with the WGSF (***Action*** for chair/secretariat to provide input to the AOPC meeting). The Panel **emphasized** the importance of integration of *in situ* measurements with all stages of satellite missions for calibration and validation (***Action*** for chair/secretariat, to include these issues in the revision of the IGOS-P Ocean Theme).

6.1.2 IGOS-P Ocean Theme

Harrison presented an report on the review/revision of the IGOS-P Ocean Theme report. IGOS-P calls for a five year rolling review of its Theme documents. The Ocean Theme was the first and so is the first to undergo its rolling review. The co-chairs are P. Digiacomo and K. Alverson.

The report will address: motivation, ocean observations for societal benefit, accomplishments since the first report, challenges and recommendations, plans for implementation, and conclusions. The Panel will be solicited for feedback on the draft report.

6.1.3 GCOS-CEOS report on satellite requirements

Harrison presented an update on the GCOS-CEOS report on satellite requirements. The UNFCCC, after publication of the GCOS Implementation Plan, asked the satellite agencies through CEOS to respond to the plan. CEOS then returned to the UNFCCC asking for clarification on the GCOS plan, including more information on space and timescale requirements. The result is a supplemental report to the GCOS IP. The draft is posted on the GCOS website for open comment, and will be presented to the UNFCCC in late 2006. CEOS is expected to provide a response at the same time.

6.2 Volunteer Observing Ship (VOS) and VOSClim

Fischer gave a presentation by P. Taylor and E. Kent on the Volunteer Observing Ship (VOS) program and VOSClim. While the quality of VOS observations has generally increased over the years, the general decline in numbers of VOS observations is resulting in a deterioration of the observing system for several GCOS Essential Climate Variables. This is because, especially in extra-tropical regions, the total observational error is dominated by the sampling error. Why are VOS numbers in decline? The problem is that the needs for marine data by the weather prediction component of Meteorological Services are increasingly being met by data from satellites, moored buoys and the hugely increasing number of reports from drifting buoys. VOS data is seen as unreliable and expensive, and for weather prediction purposes it probably is, as only a subset of the information provided by the ship tends to be used and little effort is taken to identify the higher quality data amongst the smaller number of unreliable reports. There is also a trend towards Automatic Weather Systems, on a smaller number of ships which don't give the full range of variables. The

transition is not being managed with climate quality in mind. To save funds, the numbers of Port Meteorological Officers (PMOs) is rapidly decreasing and the quality of the VOS system depends critically on the quality of the PMO system. A present, serious threat is the withdrawal of ship operators from the VOS system due to concerns for ship security.

Taylor and Kent had a number of suggestions for halting the decline in quality. These were to:

- provide a definition of the data requirement for surface meteorology (with JCOMM ETMC, CCI/CLIVAR ETCCMDI, perhaps at the next CLIMAR meeting?),
- start monitoring against the targets (JCOMMOPS?),
- create a brochure for educating ship crew,
- ensure membership of VOS is not a security risk by reclassifying VOS data from WMO "essential data" to restricted exchange

There was also concern about the transition to BUFR reporting codes and heterogeneity amongst ship systems, leading to potential confusion at the decoding step.

The Panel **strongly disagreed** with the suggestion to reclassify VOS data. This could lead to problems with data release (as has occurred with other non-essential data types). It also felt that this issue was best handled by JCOMM.

The Panel **noted with concern** the decline in VOS, noting that these measurements were the connection with the historical data record for many surface meteorological and flux variables. It decided to continue a conversation offline to come up with a strategy for addressing the true requirements for VOS for climate (***Action*** for chair/secretariat involving Reynolds, Visbeck, Taylor, Weller, Kent, and representatives of the pCO_2 observing community).

6.3 SOOP XBT lines and DBCP surface drifters

Fischer presented a report on the status of the Ship of Opportunity Program (SOOP) XBT lines and the Data Buoy Cooperation Program (DBCP) surface drifting buoys.

In 2004, the latest year for which the SOOP report is complete, 39 of the 51 designated lines were occupied. The SOOP Technical Coordinator at JCOMMOPS makes available on their website[8] a number of tools for monitoring the frequency of lines based on both real-time data from the GTS and operator reports. The Panel has been asked to provide updated guidance to the SOOPIP on requirements for XBT lines, coordinating feedback with the CLIVAR basin panels. Their next meeting will take place in April 2007 (***Action*** for secretariat).

The Panel thought it would be **worthwhile** to collect scientific references that use the XBT data to bring back to the SOOP panel (***Action*** for secretariat). Some members also **expressed** frustration at problems with real-time availability of XBT data, an issue they wished to refer to the JCOMM OCG (***Action*** for chair/secretariat). They **cited** the NOAA/AOML program as being exemplary in both data availability and the strong link between users and operators of XBT data.

The DBCP surface drifting buoy program passed a milestone in September 2005 with the ceremonial deployment of buoy 1250, completing the numerical target for the array. Deployment to the one buoy per 5° box standard is a constant challenge. The Panel was

[8] http://www.jcommops.org

also reminded that it had given itself some commitments under the GCOS Implementation Plan to encourage a surface current analysis/reanalysis using surface drifter data.

The Panel **noted** the availability of R. Lumpkin's tool for predicting the global surface drifter distribution 90 days out, but **expressed concerns** that it was not being properly taken advantage of in deployment opportunities. This feedback needed to be brought to both DBCP and JCOMM (***Action*** for chair/secretariat). The Panel also noted a challenge for volunteer deployments for both DBCP and Argo floats, being the acquisition of proper clearances for deployment within EEZs. It decided to ask the DBCP to consider helping (***Action*** for chair/secretariat) volunteers in obtaining these clearances. The Panel also **decided** to ask GODAE for help on the question of surface current analyses and requirements for surface drifters (***Action*** for chair/secretariat). The Panel also **decided** to communicate with WGNE for input on requirements for sea level pressure requirements on surface drifting buoys (reinforcing ***Action*** in 1.4).

6.4 Argo profiling floats

Fischer presented a report by H. Freeland on global progress towards full implementation of Argo. The array was making rapid progress towards global coverage. This was aided by improving float reliability and lifetimes. In January 2006 Argo reported 7045 profiles, the equivalent of 84,300 profiles per year. This can be compared to the 20,000 CTD profiles gathered over the more than 8 years of the WOCE program. A number of groups were working on improving Argo coverage near or under sea ice. The number of scientific research projects involving Argo data has grown.

Access to hydrographic data in near real time for salinity quality control in Argo floats remains an issue of interest for the program. The major challenge for Argo is now securing long-term funding in national programs, while maintaining a high level of technical innovation and support, as well as scientific oversight to maintain climate quality.

The Panel **reiterated** its support for GTS transmission of basic CTD profile data from research vessels, noting that operators would have to be lobbied (***Action*** for chair, to bring this issue to POGO). The Panel reviewed current knowledge about the state of national Argo funding, which in some nations is getting stuck between research and more operationally-focused agencies. It **noted** that the larger problem of lobbying research agencies to fund sustained ocean observations that could capture decadal variability had not been well-addressed. It **expressed its great satisfaction** in the progress of the Argo network.

6.5 OceanSITES

Weller presented a report on the OceanSITES network of ocean time series observations. As a reminder, this group, an ad hoc group of international participants who have formed a steering committee, act to advocate and coordinate the sustained deployment of multidisciplinary ocean time series observations. The OceanSITES group has been working on a pilot project running from 2001 to 2006 to define the need for sustained ocean time series.

Over the last year there has been progress on a new web site (http://www.oceansites.org/), updating on information about each of the sites, production of white papers for the Atlantic, Pacific, Indian, and Southern Oceans, production of new maps showing site locations, data sharing, and production of an OceanSITES brochure. The data team and steering committee met in Hawaii in February 2006.

The website presents an overview, maps (current sites, near-term sites, and sites in the vision of a global array). New maps are being developed that cut through the database by discipline: biogeochemical, carbon dioxide, geophysical, meteorological, and physical. Information can be downloaded by basin, or the documentation for the sites in a given basin can be examined on line. The website also provides archives of graphics, of documents and of meeting presentations. Links are provided to steering team members' institutions and to central contacts for the project. Progress has been made on agreeing on data formats, and select data sets have been submitted to Sylvie Pouliquen at the Coriolis data center at IFREMER. An OceanSITES brochure is under final review and will be printed soon.

The OceanSITES vision map is ambitious in its depiction of future sites in challenging locations such as the Southern Ocean. Fortunately, there is interest in advancing the technology to make sustained occupation of such sites possible in the near future. One such project is the U.S. National Science Foundation's ORION (Ocean Research Interactive Observatories Network) project. One component of ORION, the global component, seeks to develop new moorings, with improved telemetry and designed to survive in challenging regimes. A "medium bandwidth" surface mooring and also a "high bandwidth" spar buoy mooring are both planned. The ORION global effort has identified a number of high priority sites and also intends deployment at each site of at least one subsurface mooring to allow full water column sampling and possibly gliders where Lagrangian sampling would complement the moorings. ORION global deployments would be coordinated with OceanSITES and other programs.

The Ocean SITES steering committee views that it has met the goals of its pilot phase. It looks toward advice and input from OOPC on how to move forward, like Argo, as a component of sustained climate observations in the ocean.

The Panel **discussed** the difficulties in getting the funding agencies to invest in the coordination (both technical and program-level) necessary to help OceanSITES move forward. OceanSITES is different from Argo in that it is a platform, from which many different types of observations can be taken by individual PIs - Argo is a more uniform system. The second Ocean Theme report and a future ocean observations conference should push these emerging capabilities, including OceanSITES and gliders, as platforms for many different types of observations. (***Action*** for Weller raising the coordination and integration needs of the program with potential sponsors; and reinforcement of last action in 6.1.1)

6.6 GLOSS Tide Gauge observations

Aarup, Technical Secretary for the Global Sea Level Observing System (GLOSS), provided an update on the GLOSS program and the implementation of the GLOSS Core Network. GLOSS continues program implementation based on its core activities: (i) coordination of global sea level observation for science; (ii) data archiving and Quality control; (iii) training activities and provision of technical advice.

Following the 26 December 2004 tsunami several GLOSS sea level stations in the Indian Ocean are being upgraded to real time data delivery both directly by GLOSS, but also through collaborative efforts between OdinAfrica, the Indian Ocean Tsunami Warning System and GLOSS. Tsunami warning systems are also being developed for other regions, notably the Caribbean, the Mediterranean and the North East Atlantic, and GLOSS sea level station network upgrades are expected in those regions over the comming years.

The upcoming International Polar Year (IPY) may also provide an opportunity to upgrade the GLOSS network in the Polar regions. GLOSS is involved in several sea level

observation proposals that have been submitted to the IPY Joint Committee and received tentative endorsements.

The workshop Understanding Sea Level Rise and Variability will be hosted by IOC in Paris from 6-9 June 2006. The Workshop is organized under the World Climate Research Programme (WCRP) to bring together all relevant scientific expertise with a view toward identifying the uncertainties associated with past and future sea-level rise and the research and observational activities needed for narrowing these uncertainties. The Workshop is also conducted in support of the Global Earth Observation System of Systems (GEOSS) 10-Year Implementation Plan; as such, it will help develop international and interdisciplinary scientific consensus for those observational requirements needed to address sea-level rise and its variability. More information about that workshop is available on its website[9].

Based on the recommendations from the workshop some adjustments to the GCOS/GLOSS core station network are envisioned.

The Panel expressed support for GLOSS activities, notably the training and technical advice activities, and encouraged wide dissemination of GLOSS manuals (***Action*** for Aarup: to electronically distribute the proceedings of the GLOSS workshop on tide gauges in harsh conditions to the Panel; to send status report on Indonesian tide gauges to Gordon). The Panel **reiterated** the importance of co-located GPS referencing with the tide gauge, on the tide gauge itself if possible to minimize relative movements between the gauge and geo-reference point (***Action*** for chair/secretariat bring this message back to the GLOSS GE). It **commended** the GLOSS free and open data policy for new gauges, and the large recent increase in real-time transmission of data. It **looked forward** to more information about potential modifications of the GCOS/GLOSS station network.

6.7 Repeat hydrography

Dargaville presented a report on the CLIVAR-IOCCP International Repeat Hydrography workshop. In November 2005 49 scientists from 11 countries met in Shonan Village, Japan covering areas of expertise of ocean carbon cycle, hydrography, tracers, modelling, data assimilation, the Argo float program and information management. The goals of the meeting were to review the post-WOCE hydrography activities and the extent to which the resulting data are available, to identify the priorities for ship based hydrography in light of the expansion of the Argo program, and to establish mechanisms to improved data sharing.

Scientific presentations highlighted that the WOCE and post-WOCE hydrography programs have resulted in an inventory of the total sink of anthropogenic CO_2 to within ±20%, and a detailed picture of the structure of the distribution with depth. However the frequency of the hydrographic cruises makes estimates of the trends and variability in the carbon fluxes into the ocean difficult. The carbon fluxes vary significantly with, for example, the NAO, and with decadal 'snapshot' sampling, the long-term trends can be misdiagnosed depending on the phase on the NAO.

Reviews of the completed and planned cruises show that half of the decadal survey has been completed and that with continued support the reminder of the survey should be completed. Hydrography remains the backbone of the ocean observing system, but with the expansion and success of the Argo system, it is becoming more difficult to justify maintaining the current level of repeat hydrography for physical hydrography alone. Repeat hydrography is still necessary for accessing the deep ocean, for resolution of boundary currents, and for

[9] http://copes.ipsl.jussieu.fr/Workshops/SeaLevel/

data quality checking as the Argo floats are not re-calibrated at the end of their lifespan, but as a research tool it is becoming superseded in some areas by Argo. A key driver for continuing the program is the carbon measurements, as these are not covered by the Argo program, and thus the physical hydrography community appears to be looking to the carbon community to act as the main driver for spearheading the repeat hydrography program.

An important project currently underway is the development of a technical white paper on the feasibility of adding oxygen sensors to the Argo float array. Adding extra sensors to the floats is difficult as the space available in limited, and the extra power requirements reduce the lifespan of the float. Therefore it needs to be shown very clearly that the technology available is robust and that the benefits of adding sensors outweigh the increased cost.

The current direction of the international repeat hydrography program is currently unclear, with multiple data centres and different data policies among the different data collection nations making data sharing an issue. The US-CLIVAR hydrography program has operated with some success, developing core variables lists, and US data policy has made data availability for US cruises very quick. However it is not clear if this model could work for other nations or as an international policy. A key recommendation from the meeting was to form an ad hoc advisory group to discuss and develop a strategy for forming and guiding a true international community of physical hydrographers and ocean carbon cycle scientists. The role of this group has been queried by CLIVAR who believe the goals are too vague, and the formation of this group is currently on hold until after the North Atlantic synthesis planning meeting being held in Iceland in June 2006.

Finally, to ensure success synthesis efforts, they need to be designed around key scientific questions to facilitate data sharing as opposed to simply collating all available datasets to create an updated atlas. The North Atlantic synthesis planning meeting will address the issues of what are the processed that need to be better understood, and how to best organise and execute a basin synthesis for the North Atlantic.

The Panel **emphasized** a need at the international level for a group that would work on calibration, standards, data exchange and coordination issues for repeat hydrography; building on currently-existing efforts, including national efforts and the relevant CLIVAR panels (while recognizing the CLIVAR sunset date); building on the relationship to other ocean observing networks; and taking advantage of climate reanalysis activities to address issues about decadal variability.

7. CARBON AND BIOGEOCHEMISTRY

7.1 International Ocean Carbon Coordination Project

Dargaville presented a report on the International Ocean Carbon Coordination Project (IOCCP). It provides a communication and coordination service for the international ocean carbon community, maintaining a website and quarterly newsletter, supporting observing programs in repeat hydrography, VOS underway pCO_2, timeseries pCO_2, and ocean colour measurements. It supports pilot projects in oxygen measurements on Argo, and atmospheric CO2 on VOS. It promotes the development and use of standards and best methods for carbon measurements.

Plans for repeat hydrography work are coordinated through the community and followed by the IOCCP. The community has developed a web-accessible visualization and

extraction system for ocean carbon data based at CDIAC - WAVES[10]. The underway pCO2 network is well-developed in the Atlantic and the tropical and northern Pacific, with coverage in the Indian and Southern oceans as well. A workshop on surface CO2 measurements will be held in Paris in April 2007, which will address global synthesis of surface carbon measurements. It will also address future plans for observing networks and synthesis activities.

The 'Friends of Oxygen' on Argo group is working on subsurface autonomous measurements of oxygen, and working with the Argo Steering Team. Subsurface oxygen is both a transport tracer and a biological indicator, and part of proxy measurements of dissolved inorganic carbon. They are addressing issues of sensor design, power and communications requirements, and the distribution requirements for the network. A number of Argo oxygen sensors are already deployed in the Pacific and North Atlantic. Another pilot project addresses high-precision atmospheric CO2 measurements from VOS ships, which will focus on the Southern Ocean.

OceanSITES and the Ocean Research Interactive Observatory Network (ORION) are developing an online sensor catalog of biogeochemical sensors. IOCCP has agreed to coordinate input on the carbon-related instruments. This is addressed further in the following section.

A number of enhanced observations of ocean carbon will take place during the IPY in both polar regions.

Several other ocean carbon-related activities of note are the continuing series of 'Oceans in a high-CO2 World' symposia addressing ocean acidification, a potential conference on ocean vulnerabilities co-sponsored by the Global Carbon Project (GCP), current co-siting the IOCCP and support for the IGOS-P Carbon Theme, and work on developing standards for DOIs for datasets, making them citable in scientific publications.

The Panel **thanked** the IOCCP for their exemplary work in coordination for the ocean carbon community. The idea of developing DOIs for datasets was particularly supported.

7.2 Development of global biogeochemical monitoring tools

Dickey presented a report on the development of global biogeochemical monitoring tools, focusing the first part on a report of the EurOceans Eulerian Observatory Workshop, and the second part on the development of interdisciplinary sensors.

7.2.1 EurOceans Eulerian Observatory Workshop

The EurOceans Eulerian Observatory Workshop was convened in Monaco, April 2006. The following synopsis is intended provide a flavor of the meeting; details of the discussions and deliberations may be found at the meeting ftp site[11]. The Eulerian workshop was devoted to information exchange and organization of collaborations of European interests for developing a coherent network of Eulerian measurement systems. Existing time series activities in the North Atlantic, North Sea, Baltic Sea, Mediterranean Sea, and Adriatic Sea were reviewed. Working groups focused on 1) scientific drivers, 2) emerging sensors and sampling, and 3) outreach activities. One of the programs of focus for the workshop was the Atlantic Network of Interdisciplinary Moorings and Time-series for Europe (ANIMATE), which was initiated in 2002. The initial three ANIMATE sites included moorings in the Central

[10] http://cdiac3.ornl.gov/waves/

[11] ftp://ftpocean:Atlant!que@euroceans.univ-brest.fr

Irminger Sea (CIS) off Greenland, the Porcupine Abyssal Plain (PAP) off the United Kingdom, and Estación Europea de Series Temporales del Oceano, Islas Canarias (ESTOC) off the Canary Islands. Plans are proceeding for the development of another time series site off Cape Verde. The first three of these sites have been used to successfully obtain data for 3 years. ANIMATE utilizes autonomous sampling via deep sea moorings to obtain high temporal resolution, long-term interdisciplinary data. Data that may be used to model future climate change are of particular interest. Specific ANIMATE goals (from ANIMATE website) have included:

- Development of a European carbon cycle time-series infrastructure at 3 key sites in the northeast Atlantic.
- Provide focus for European ship-based and moored repeat measurements in the 3 target areas.
- Make maximum usage of existing infrastructure, instrumentation, hardware and expertise from different European groups, and share/transfer the existing and new elements of the system for joint implementation and operation.
- Implement real-time telemetry of subsets of the prime data to be collected, for immediate dissemination to the general public using the internet.
- Extend to the wider community the use of the data obtained and the mooring infrastructure.
- Interface with the the global carbon cycle observing system.

The Eulerian Workshop also benefited from experience from the mooring technologies being developed in other European programs including the Mediterranean Forecast System - Toward Environmental Prediction and others off Norway and in the North and Baltic Seas. Some of the interesting complementary measurements that have been utilized during the past few years include glider and Argo observations. Both platform modes provide spatial context for the mooring data sets. Time series based on Argo measurements (temperature profiles) and satellite ocean color within a few degrees of the PAP site have been compared with PAP mooring data by Richard Lampitt and collaborators.

7.2.2 Interdisciplinary Sensors

A variety of sensor issues were considered during the Eulerian Workshop. Topics included: technical readiness levels of ocean sensors, needs for new interdisciplinary sensors and profiled moored packages, biofouling, vandalism of moorings, increased power capabilities, potential for linking to electrical and optical cable nodes, strategies for commercializing sensors to increase quantities of observations and to drive cost per sensors down, interfacing of sensors to systems, data telemetry capabilities, embedding calibration information into measurement systems, and formation of partnerships among academics, government and private sector to develop, test, and proliferates new sensors.

One of the major workshop recommendations was to convene an international workshop on sensors. Below are summarized some of the recommendations of such a workshop that would presumably be co-sponsored and co-funded by several organizations. The International Workshop on Sensors and Moorings for Eulerian Observatories would take place in mid 2007. This 5-day workshop would be focussed on key issues and would provide solid outcomes in areas that could include:

- Devolop a Catalog and Website for interdisciplinary sensors (including carbon)
- Moored Profiling: via physical packages, via new profiling *in situ* technologies (e.g. profiling fluorescence), via virtual moorings.

- Mooring Testbeds: designated moorings / sites for testing, evaluating and raising the Technical Readiness Levels (TRLs) of sensors and instruments, including related platforms such as gliders and autonomous vehicles.
- "Things that do not work – extracting the know-how from the High Priests"
- "Things that do not exist" – what will still be needed
- Practical classes and tutorials on sensors or procedures that people have trouble with
- Making Eulerian Observatories multifunctional: Links to satellite information – calibration validation – land air sea interactions – links to GMES. Shared functions at the sites.

Stakeholders for the workshop would include, among others: EurOceans, Carbocean ESONET, OceansSITES, IOC, IOCCP (Maria Hood), International Ocean Colour Coordinating Group (IOCCG), ACT, EuroACT, the FerryBox project, ORION/OOI, IOOS, private companies, and trade associations. Sponsors for the workshop could include all of the aforementioned stakeholders plus others such as the EU, POGO, and GEOSS.

Finally, a brief review of technologies was provided. A host of new developments have taken place during the past year. Some of the areas illustrating the progress were presented to the OOPC. These include several new chemical, dust and aerosol samplers, trace element samplers, video systems, and optical sensors, new methods for reducing the effects of biofouling, increased testing and utilization of platforms for interdisciplinary measurements. Looking forward, microelectromechanical (MEMS), nanotechnologies, and genomic technologies show great promise and some researchers are beginning to develop oceanographic measurement systems capitalizing upon these. Data telemetry capacity is still very constrained and stps need to be taken to improve bandwidth capabilities for all in situ platforms. There is increasing thrust toward cabled measurement systems along with buoy platforms that can be deployed in harsh ocean and ice conditions. Please see the powerpoint presentation for examples. A few recent reviews that bear on interdisciplinary observations are provided as a starting point for those interested in more details.

The Panel was **encouraged** by the development of observing techniques and regional coordination activities in biogeochemical measurements of the oceans, and **supported** the idea of a sensor workshop, focused on developments in open-ocean measurements. It **asked** Dickey to lead the development of a concept for the workshop (***Action*** for Dickey), and would contribute to the development of an organizing committee and the scoping of the workshop (***Action*** for chair, secretariat, Dargaville and others). The Panel **noted** the need to build momentum for global observations of ecosystem variables, as the technology was beginning to be ready, and the sponsors of the observing system needed to be made aware of this.

8. DATA MANAGEMENT

Harrison presented a report by Keeley on data management issues for global ocean climate observations. Developments since OOPC-X have included: continued development of JCOMM data metrics for data coverage and availability; and a review of IODE, which recommended a more streamlined structure and a distributed system, continued developments of ODINs, a reassessment of the groups of experts, and moving towards an international metadata system. Further work was necessary in developing standards (for QC and other issues), and in clarifying the roles of the World Data Centers and the National Oceanographic Data Centers.

The presentation to OOPC-X[12] reviewed the components needed for successful data management, including: data assembly, quality control, duplicates management, version control, the application of standards, and the development of tools for data discovery, browsing, and delivery.

In *data archiving*, a number of developments have taken place, including:

- The GHRSST-PP has decided on definitions for SST observations. This is being incorporated into information to be sent with the data.
- JCOMM DMPA will host a meeting to look at commonalities across JCOMM activities to begin convergence in solutions (read adoption of standards).
- There is more urgency to getting real-time data reporting in BUFR.
- Development of cooperation to GOOS Coastal Module.
- GOSUD & SAMOS are working towards an integrated data handling system.

In terms of *data access*, developments over the past year have included: i) as part of the WIS, meteorological and oceanographic metadata profiles (ISO19115) are being finalized; ii) the JCOMM DMPA is working with WIS to show how ocean archives can contribute; iii) ocean carbon data still available only to project participants; and iv) OceanSITES has data system under construction.

Other activities of note include the development of other data system performance metrics, the production of an IOC and JCOMM Data Management Strategies, funding for SeaDataNet, and continued development of the U.S. DMAC initiative.

Keeley suggested that the OOPC continue to voice its desire for convergence to a few solutions and encourage the use of standards, that it remind groups like JCOMM and IODE of their responsibility to find solutions, and to push for improved data system performance by highlighting good and bad practices from the point of view of OOPC. It should also continue to advocate for the near real-time transmission of all observations and metadata in support of operational oceanography, status monitoring, and data management; interactive data and product access from data centers; historical data release; and development of agreed QC procedures.

The Panel **noted** the heterogeneity of quality control procedures across the observing networks, and the crucial need to maintain high levels of communications between the data users in the scientific community and the data managers. Clear actions to move this forward, however, remained elusive.

9. SPONSOR REPORTS AND LIAISON WITH OTHER INTERNATIONAL GROUPS

9.1 Global Climate Observing System

Harrison presented a report on the OOPC relationship to GCOS. He reviewed the UNFCCC COP-10 decision on the GCOS Implementation Plan, the GCOS/CEOS report on satellite requirements, and new draft national reporting requirements for implementation of the ocean observing system. The UNFCCC and GCOS's relationship with it are for the moment the major intergovernmental push for sustained ocean observations for climate. COP-10 invited the GCOS secretariat to revise the national reporting guidelines to include observations of the Essential Climate Variables, and asked for a comprehensive report on progress in the GCOS Implementation Plan for the 30th meeting of the Subsidiary Body on

[12] available at http://ioc.unesco.org/oopc/oopc-x/

Scientific and Technical Advice (SBSTA) in 2009. Harrison already reported on the GCOS/CEOS supplemental report on satellite data requirements in Section 6.1.3.

The Panel **welcomed** the new chair and director of GCOS, and looked forward to continuing its productive role as a panel of GCOS. It directed the Panel secretariat to liaise with the GCOS secretariat as revised guidelines for GCOS national and GOOS national reporting were prepared (***Action*** for secretariat). It also looked forward to working with the new chair of the AOPC (A. Simmons) on surface flux issues (***Action*** for chair, to emphasize the surface flux working group at the next AOPC meeting).

9.2 Global Ocean Observing System

Fischer presented a report on the OOPC relationship with GOOS. He recalled that GOOS had two modules, a global climate module overseen by the OOPC, and a coastal module designed by COOP, but now overseen for the moment directly by the GSSC. JCOMM was a major tool for implementation of the global module, and the GOOS Regional Alliances a major tool for the implementation of the coastal module.

The new leadership of GOOS was now in place, with a new chair (F. Gérard) and vice-chairs of the Integovernmental panel for GOOS (I-GOOS), a new chair (J. Field) for the GSSC, and a new director of the GOOS project office (K. Alverson). The stated goals for GOOS for 2006-7 are to: i) increase national commitments to and investment in the global component of GOOS, and ii) establish clear principles and guidelines for GOOS Regional Alliances.

GOOS planned to focus on: i) communications and outreach, ii) raising the level of national involvement in I-GOOS, iii) two task teams, on joint with JCOMM on Industry, and another joint with JCOMM and the GRAs on the implementation of coastal GOOS, iv) developing the GRAS, and v) a GSSC focus on a chlorophyll-a pilot project. The resources dedicated to these tasks were quite limited.

Coastal GOOS may in the future have a dedicated panel (Panel for Integrated Coastal Observations PICO), perhaps co-sponsored by GTOS.

The Panel **expressed** some concern that GOOS was largely focusing on the coastal module, and on the need to collect clear examples of the interaction between open ocean and coastal regions for prediction (***Action*** for secretariat, to solicit these examples from Johannessen, Chang, Visbeck and others). It also looked forward to working with the task team on coastal observations and a potential PICO panel on joint activities of relevance to both the global and coastal modules.

9.3 World Climate Research Programme

Harrison gave an oral presentation on the OOPC relationship with the WCRP. Here also, new leadership has been put into place recently. John Church is now the chair of the JSC, and Ann Hendersen-Sellers the director of the Secretariat. The director is quite focused on climate impacts on society. The relationship with OOPC has been quite cordial.

The Panel discussion **focused** on the OOPC-CLIVAR relationship. It **noted** that climate research was its main customer, but that it was difficult to sell the system based on that rationale alone. This had led to the panel's approach to serve a larger number of communities with one composite system. Regarding the basin panels, OOPC viewed them as **critical** to moving the implementation forward and sustaining parts of the ocean observing system, as it provided the close link to the scientific research community necessary to maintain momentum and quality. The OOPC on the other hand had access to the JSC, the

UNFCCC, and I-GOOS, and served a role of taking CLIVAR basin panel requirements to higher levels. Some of the panels were more focused than others on sustained observations, but input from GSOP and invited experts to the OOPC could compensate for this varied focus.

9.4 JCOMM

Fischer presented a report on the Panel's relationship with JCOMM. The OOPC is formally recognized by JCOMM as an adviser on the requirements for the global ocean climate observing system. JCOMM-II (September 2005) accepted the ocean chapter of the GCOS Implementation Plan as their implementation plan for ocean observations. M. Johnson remained as Coordinator for observations, while Panel member R. Keeley now headed Data Management and C. Donlon headed Services. JCOMM-II also marked the beginning of the tenure of two new co-presidents (P. Dexter and J.-L. Fellous).

The Panel **discussed** the role of JCOMM, its Management Committee (MAN), and Observations Coordination Group, in taking on biogeochemical measurements. It decided that further offline discussions should take place in order to decide whether the Panel should recommend MAN take up biogeochemical variables (***Action*** for chair with Dickey, Weller to consult with community).

9.5 GEO/GEOSS

Harrison presented a report on the Group on Earth Observations (GEO), and the Global Earth Observation System of Systems (GEOSS). He noted that ocean data and information are needed to meet most of the GEO Societal Benefit Areas, yet the ocean observing system is not very visible within GEO documentation. "Oceans United" had formed as a collection of ocean groups (international and intergovernmental) to ensure that the importance of the ocean is clear within the GEO planning and actions process.

The Panel **noted** that in Japan GEO had been useful in the planning and allocation process for ocean data management, and **expressed hope** that the GEO process could help with some of the satellite ocean observation issues.

9.6 POGO

Harrison gave an oral presentation on the OOPC relationship to the Partnership for Observation of the Global Oceans (POGO). It was very active on behalf of Oceans United in the GEO process, worked with SCOR in capacity-building activities, and was moving forward with a project to improve ship schedule sharing.

The Panel **expressed its appreciation** for the work that POGO was doing on behalf of global ocean observations for climate.

9.7 IGBP, SCOR, IMBER, SOLAS

Harrison gave an oral presentation on OOPC relationship with other global scientific programs involving the oceans. He noted that SCOR had been sponsoring coordination meetings for international marine programs, and another meeting would take place in December 2006 in London. The Panel **noted** the importance of remaining connected to these other international research programs, through WGSF for SOLAS and other more direct means for the others, especially as global sustained ocean biogeochemical and ecosystems observations may take center stage for future OOPC work.

10. ROUNDTABLE ON FUTURE INITIATIVES

The Panel held a roundtable discussion on the role of the OOPC, the status of its recommendations, relationships with other bodies, and what it saw as its central goals and actions in the near future.

On OOPC's terms of reference and focus on physical variables for climate

The Panel **recognized** some pressure to extend its work into providing recommendations on global ocean biogeochemical and ecosystems observations, and further recognized that the current panel membership was i) not equipped to deal with this issue, and ii) in need of some refreshing. It **noted** however that no other group had a long-term mandate to follow up on the global networks for which it provided recommendations and evaluation, and that the **core liaison and advocacy activities** for the physical observing system for climate **needed to be carried forward** in order to maintain forward momentum for the system. It felt that its vision at least in the medium term (the next 3-5 years) should stay in part focused on the sustained global observations, in service of as many communities as possible that could benefit from the data.

One area that the Panel decided it would like to move forward with was better **linkages** between the global/open-ocean measurements it advocated and coastal ocean problems (reinforcing ***Action*** in 9.2).

It also **reiterated** the importance of the sustained observations it oversaw to understanding **decadal variability** in the climate system, and resolved to continue its work in developing appropriate ocean indices of this variability (see ***Actions*** in 3.1.2).

On the need to refresh the current recommendations

The Panel was **satisfied** with the state of its recommendations in general, though it noted the outstanding issues brought to it from JCOMM regarding the VOS and particular SOOP lines, and resolved to work with the **GLOSS** Group of Experts in refining its recommendations for the GCOS subset of the GLOSS Core Network (***Action*** for chair/secretariat).

On the role of OOPC in relation to CLIVAR

The Panel noted CLIVAR's sunset date of 2012, and CLIVAR's need to articulate a legacy observing system (***Action*** for Weller, preparing a white paper for the CLIVAR SSG on the observing legacy of CLIVAR, see also last action in 3.2). It was also critical, along with GSOP, in advocating sustained measurements for the capture of decadal signals.

On the relationship of the OOPC with other bodies

Some members of the panel thought that improved interaction with bodies concerned with coupling across the air-sea interface (e.g. THORPEX, SOLAS, WGNM) could help identify additional users for ocean observations (***Action***, for Weller/secretariat, to identify some points of contact and/or potential speakers at next OOPC meeting)

The Panel also noted that the WCRP was starting to get involved in a number of interdisciplinary projects with the IGBP, and that the WCRP chair and director should be kept abreast of OOPC thinking on how to tackle new opportunities in ocean observations (gliders, new sensors on Argo, other biogeochemical observations), as well as on how it and CLIVAR interacted (***Action*** for chair).

On the need for a large ocean observations conference in 2008/9

The Panel felt that such a meeting could provide some exciting opportunities, but should only be planned if it was felt that the time was right to sell a new generation of emerging observing systems and technology, in a tight coupling with emerging products. It did not come to a clear conclusion on moving forward with the meeting, but decided to continue consultations within the Panel and with other groups in the following year (***Action*** for chair/secretariat)

11. REVIEW OF ACTIONS

Action Item	Report Ref.	Action	Responsible
1	1.4, 6.3	to get input from WGNE or THORPEX on the requirements for VOS and surface drifter barometers for NWP	chair, secretariat
2	2	to draft a letter supporting the Japanese Argo program	chair, secretariat
3	3.1.2, 10	to solicit input from the CLIVAR basin panels on the most important climate indices, and to coordinate with CLIVAR GSOP and GODAE on ocean climate indices	secretariat
4	3.1.2, 10	to add indices of global upper ocean thermal change and sea level rise to the OOPC site	secretariat
5	3.2	to include the specific recommendation for a transport mooring in the Makassar Straight for monitoring of the ITF in the next revision of the GCOS Implementation Plan, and to communicate endorsement to potential sponsors	chair, secretariat
6	3.2	to provide short written input on the importance of and observing strategy for the ITF, for a white paper on the CLIVAR observing legacy	Gordon (to give to Weller)
7	3.4	to add the Atlantic MOC dipole SST index to the OOPC site	secretariat
8	4.1	to request GSOP to provide guidance on the requirements for vertical resolution in time series observations, in particular for deep observations, necessary for comparison with reanalyses	Weller, chair, secretariat
9	5.1	to communicate to DBCP and Argo the gaps in coverage in the Atlantic	secretariat
10	5.1	to follow up on the funding situation for the SE extension of the PIRATA array	secretariat
11	5.2	to encourage the JCOMM OCG to work with the IOP on a deployment strategy for the Indian Ocean moored array	chair

12	5.4	to seek input on requirements for ice drifting buoys from the Southern Ocean and Arctic panels	chair, secretariat
13	5.4	to maintain communications with OceanSITES and the Southern Ocean panel regarding requirements for sustained time series observations in the S.O.	chair, secretariat
14	6.1.1	to request information from AOPC on plans and gaps in satellite missions supporting the calculation of ocean surface fluxes	chair (to provide information to WGSF)
15	6.1.1, 6.5	to emphasize the importance of the integration of *in situ* measurements in planning and execution of satellite missions for calibration and validation, in the IGOS Ocean Theme report	chair
16	6.2	to start a conversation with Reynolds, Visbeck, Taylor, Weller, Kent, and representatives of VOS pCO_2 observing community on developing a strategy for defining VOS climate requirements	chair
17	6.3	to solicit from CLIVAR basin panels scientific references that use XBT data, for the SOOP panel	secretariat
18	6.3	to raise the problems with real-time XBT availability with the JCOMM OCG and SOOP	chair, secretariat
19	6.3	to liaise with DBCP on the use of the Lumpkin drifter density prediction tool in deployment strategy	chair, secretariat
20	6.3	to raise the issue of permitting for surface drifter deployment in national waters by volunteer deployers with the DBCP and JCOMM OCG	chair, secretariat
21	6.3	to ask GODAE for input on the requirements for surface drifters for surface current prediction	chair, secretariat
22	6.4	to raise the requirement for real-time transmission of basic CTD profiles from the research fleet with POGO	chair
23	6.5	to raise OceanSITES needs for coordination and integration activities with potential sponsors	Weller
24	6.6	to distribute the guidelines for GLOSS in harsh conditions to the Panel and to provide Gordon with a status report on Indonesian tide gauges	Aarup
25	7.2.2	to develop a sensor workshop proposal, scoping, and help form an organizing committee	led by Dickey with input from others
26	9.1	to liaise with GCOS and GOOS in harmonizing national reporting guidelines	secretariat
27	9.2, 10	to solicit examples of open-ocean influence on coastal predictions	secretariat, targeting Johannessen, Chang, Visbeck

28	9.4	to continue consultations on a recommendation to JCOMM MAN on biogeochemical variables	chair, with Panel members
29	10	to liaise with the GLOSS GE on an updated list of the GCOS subset of the GLOSS Core Network	chair, secretariat
30	10	to provide input for a CLIVAR white paper on the observing legacy of CLIVAR	all, with Weller lead
31	10	to identify points of contact for groups concerned with air-sea coupling (THORPEX, SOLAS, WGNM) and potential speakers/input to next OOPC meeting	Weller, secretariat
32	10	to maintain communications with WCRP chair and director regarding new opportunities in ocean observations including new technology, potential for new variables	chair, secretariat

12. NEXT MEETING

The Panel decided to hold its next meeting in the first week in May 2007, and it was later decided that it would be held 2-5 May 2007 at IOC/UNESCO in Paris, France.

Appendix I. Agenda

GCOS • GOOS • WCRP OOPC Ocean Observations Panel for Climate	Eleventh session of the GCOS-GOOS-WCRP Ocean Observations Panel for Climate Meeting room '001' -1 level of the Sanjo-kaikan Conference Hall The University of Tokyo 16-20 May 2006 http://ioc.unesco.org/oopc/oopc-11/

v.2.2 (11 May 2006)

Name indicates speaker or author/speaker, and the indicated length of time for each item includes time for discussion. The session will run from 9:00-17:30 (9:30-17:50 on the first day), with a 1-hour lunch break, and morning and afternoon coffee breaks, and will close at lunchtime Saturday 20 May 2006.

Tuesday 16 May morning **9:30 (note revised start time)**

1 Opening

1.1 Opening and welcome *(Harrison, local hosts, secretariat, 20 min)*
1.2 Review and adoption of the agenda and OOPC-10 report *(Harrison, 10 min, background doc.: OOPC-10 report)*
1.3 OOPC activities 2005-6 and meeting goals *(Harrison, 20 min)*
1.4 Overview of observing system status and issues from the JCOMM Observations Coordination Group (*Johnson/Harrison, 20 min*)

2 Regional focus: East Asia

2.1 Korean sustained ocean observations *(Chang, 40 min)*
2.2 Chinese sustained ocean observations *(Wang, 40 min)*
2.3 SOLAS Japan *(Uematsu, 30 min)*

Tuesday 16 May afternoon

2.4 Forecasting system for Kuroshio variability *(Yamagata, 30 min)*
2.5 Observational studies of mode waters, and basin-scale observations in the Pacific *(Suga, 30 min)*
2.6 Japanese Argo *(Shikama, 30 min)*
2.7 Japanese observational plans in the Indian Ocean and Indonesian Throughflow *(Masumoto, 30 min)*
2.8 Japanese GODAE *(Awaji, 30 min)*
2.9 NEAR-GOOS and Japanese operational observations *(Yoshida, 30 min)*
2.10 Roundtable discussion on coordination issues *(led by Harrison, 30 min)*

Tuesday 16 May evening

18:00-20:00 **Reception** hosted by the Ocean Research Institute of the University of Tokyo

Wednesday 17 May morning 9:00

3 Science focus

3.1 State of the Ocean 2005-6
- 3.1.1 Sea Surface Temperature *(Reynolds, 30 min)*
- 3.1.2 OOPC compilation of ocean climate indices/indicators, and discussion of ocean indices of interest, including state of ENSO and forecasts *(Fischer, 60 min, background site: "State of the Ocean" at ioc.unesco.org/oopc/)*

3.2 The role of the Indonesian Throughflow in climate variability, and sustained observing strategies *(Gordon, 90 min)*

Wednesday 17 May afternoon

3.3 The Atlantic MOC: variability at interannual to multi-decadal time scales *(Schott, 40 min)*

3.4 Requirements for an MOC monitoring network and derivation of MOC indices *(Visbeck, 40 min)*

4 Ocean products: analyses and reanalyses

4.1 CLIVAR GSOP actions and requirements *(Stammer, 45 min)*

4.2 GODAE *(Le Traon/Harrison, 30 min)*

4.3 Working group on surface fluxes *(Weller, 20 min)*

Thursday 18 May morning 9:00

4.4 SST-Sea Ice working group *(Reynolds, 20 min, Soren/Harrison, 20 min, background doc.: Sea Ice Working Group report)*

5 Regional observing panels

5.1 CLIVAR Atlantic, including PIRATA review *(Visbeck, 45 min, background doc.: PIRATA Review)*

5.2 CLIVAR Indian *(Schott, 40 min, background doc.: IOP Implementation Plan)*

5.3 CLIVAR Pacific *(Suga, 30 min)*

5.4 CliC-CLIVAR Southern Ocean *(Fukumachi, 30 min)*

Thursday 18 May afternoon

5.5 update on Arctic and potential IPY legacies for the observing system *(Mauritzen/Fischer, 20 min)*

6 Global projects

6.1 Satellite observations
- 6.1.1 missions update *(Johannessen, 30 min)*
- 6.1.2 IGOS-P Ocean Theme report *(Harrison, Fischer, 20 min)*
- 6.1.3 CEOS-GCOS report *(Harrison, 30 min, background doc.: GCOS-CEOS observational requirements draft document)*

6.2 VOS and VOSClim *(Taylor/Fischer, 30 min, background docs: VOS report and VOS CLIVAR Exchanges article)*

6.3 SOOP XBT *(Fischer, 20 min)*

6.4 Argo profiling floats *(Gould/Fischer, 20 min)*

Friday 19 May morning 9:00

6.5 OceanSITES time series observations *(Weller, 40 min)*
6.6 GLOSS sea level including contributions to the tsunami network *(Aarup, 20 min)*
6.7 International repeat hydrography *(Dargaville, 30 min, background doc.: International repeat hydrography and carbon workshop report)*

7 Carbon and biogeochemistry

7.1 IOCCP *(Dargaville, 30 min)*
7.2 Development of global biogeochemical monitoring tools, including potential pilot projects, report on the Eulerian Observations workshop, and sensor catalogs *(Dickey, 60 min)*

Friday 19 May afternoon

8 Data management *(Keeley/Harrison, 60 min)*
including discussion of real-time metadata pilot project

9 Sponsor reports and liaison with other international groups *(total 70 min)*

9.1 GCOS *(Harrison)*
9.2 GOOS *(Fischer)*
9.3 WCRP *(Harrison)*
9.4 JCOMM *(Fischer)*
9.5 GEO *(Fischer)*
9.6 POGO *(Harrison)*
9.7 IGBP, SCOR, including IMBER, SOLAS *(Harrison)*

Saturday 20 May morning 9:00

10 Roundtable discussion on the role of the OOPC and future initiatives *(90 min)*
including discussion of a potential OceanObs08, ecosystem variables workshop

11 Overview of decisions, recommendations and actions from the meeting *(60 min)*

12 Next meeting: when and where *(10 min)*

close of meeting Saturday 20 May lunchtime

Appendix II. Participants list

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