Intergovernmental Oceanographic Commission
Reports of Meetings of Experts and Equivalent Bodies

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

Southampton, UK
7-10 June 2004
http://ioc.unesco.org/oopc/oopc9/

GCOS Report No. 95
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GCOS-GOOS-WCRP/OOPC-IX/3
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ANNEXES

1. OPENING AND WELCOME

The Chair of the OOPC, Ed Harrison, opened the meeting and introduced Howard Roe, director of the Southampton Oceanography Centre (SOC). Roe welcomed the panel, and expressed his pleasure that this international group, whose mandate is so relevant to the work done at the SOC, was meeting at the SOC. Peter Taylor, the local host, welcomed the panel as well.

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

2. REVIEW AND ADOPTION OF THE AGENDA

The Chair introduced the provisional agenda. Dickey suggested moving the discussion of the IGBP (item 6.5.2) to the discussion of ocean carbon (item 7.4.9), which was accepted by the panel, after which the agenda in Annex I was approved. The agenda, background documents, and all of the presentations given during the meeting are available on the **meeting website**: http://ioc.unesco.org/oopc/oopc9/.

3. OOPC REVIEW 2003-2004

The chair provided an overview of the activities of the OOPC since the last meeting in September 2003. He started with the group's Terms of Reference, which he has broadly interpreted as:

- Make recommendations for the sustained global ocean observing system, including phased implementation
- Develop processes for ongoing evaluation and for the future evolution of both the systems and the recommendations
- A broad liaison responsibility with all groups interested in global ocean observations

He noted that the liaison responsibility was becoming the major task of the chair. The OOPC was well-represented at many scientific meetings, the list (completed after input from all members) can be found below. Discussions that followed distinguished the role of the OOPC in making recommendations for a global subset of measurements with broad impact, the 'sustained' network, while CLIVAR basin panels would liaise with OOPC, but have specific responsibility for process experiments.

Table 1: List of meetings with OOPC representation

Meeting	Dates	Member(s)
SAR Workshop on Ocean and Sea Ice Application, Svalbard, Norway	5-9 September 2003	Johannessen
JCOMM Expert Team on Data Management Practices (ETDMP) first session, Oostende, Belgium	15-17 September 2003	Keeley

Estuarine Research Foundation 17th Biennial Conference, Seattle, WA, USA	14 September 2003	Harrison
Expert Meeting for the writing of the GCOS Implementation Plan, Geneva, Switzerland	15-18 September 2003	Harrison
Workshop for GOOS Regional Alliance, Buenos Aires, Argentina	29-30 September 2003	Campos
Coastal Ocean Observations Panel (COOP) 5th session, Mazatlan, Mexico	30 September - 3 October 2003	Harrison
US CLIVAR Pan American Workshop, Boulder, CO, USA	16-18 September 2003	Weller
2nd meeting of the WCRP Working Group on Satellite Matters, Geneva, Switzerland	20-22 October 2003	Johannessen
Steering Group for the Global Ocean Surface Underway Data (SG-GOSUD) Pilot Project, 3rd session, Monterey, CA, USA	3-4 November 2003	Keeley
Argo Data Management Team meeting, Monterey, CA, USA	5-7 November 2003	Keeley
International GODAE Steering Team (IGST) 8th session, Miami, FL, USA	5-7 November 2003	Harrison
First Argo Science Workshop, Tokyo, Japan	12-14 November 2003	Keeley, Campos
2nd JCOMM Workshop on Advances in Marine Climatology (CLIMAR-II), Brussels, Belgium	17-22 November 2003	Reynolds
Partnership for Observation of the Global Oceans (POGO) 5th meeting, Yokohama, Japan	18-20 November 2003	Harrison, Dickey, Hood
4th GMES (Global Monitoring for Environment and Security) Forum Meeting, Baveno, Italy	26-28 November 2003	Johannessen
AGU Fall Meeting, San Francisco, CA, USA	8-12 December 2003	Weller
US CLIVAR SSC-11, Palisades, NY, USA	16-18 December 2003	Weller
The ORION Workshop, San Juan, PR, USA	4-8 January 2004	Dickey, Weller
Expert Meeting for the writing of the GCOS Implementation Plan, Geneva, Switzerland	19-22 January 2004	Harrison
Coastal Ocean Observations Panel (COOP) 6th session, Wellington, New Zealand	26-29 January 2004	Harrison
AGU Ocean Sciences Meeting, Portland, OR, USA	26-30 January 2004	Dickey, Weller, Fischer
ASLO/TOS Ocean Research Conference, Honolulu, HI, USA	15-20 February 2004	Dickey
Multi-disciplinary Ocean Sensors for Environmental Analyses and Networks (MOSEAN) Review and Planning Meeting, Honolulu, HI, USA	15 February 2004	Dickey
DEOS/ORION Moored Buoy Working Group, Santa Fe, NM, USA	5-7 February 2004	Dickey

Layered Ocean Models Annual Workshop, University of Miami, FL, USA	9-11 February 2004	Campos
WCRP Joint Steering Committee 25th session, Moscow, Russian Federation	1-5 March 2004	Harrison, Fischer
GOCE 2004 Workshop, Frascati, Italy	8-10 March 2004	Johannessen
GCOS Steering Committee 12th session, Geneva, Switzerland	15-18 March 2004	Harrison, Fischer
JCOMM Management Committee 3rd meeting, Geneva, Switzerland	17-20 March 2004	Harrison, Fischer
First CLIVAR-GSOP Data Planning Meeting on Ocean Observations, La Jolla, CA, USA	24-26 March 2004	Keeley
Mediterranean Forecast System for Environmental Prediction (MFSTEP) 2nd Annual Meeting, Brest, France	30 March - 2 April 2004	Dickey
CLIVAR VAMOS 7th Panel Meeting, Guayaquil, Ecuador	22-24 March 2004	Weller
IOCARIBE GOOS meeting, Recife, Brazil	12-13 April 2004	Campos
NOAA Climate Observation Annual System Review, Silver Spring, MD, USA	13-15 April 2004	Harrison, Hood, Reynolds, Weller
ESA Earth Explorer Mission Selection - User consultation meeting, Frascati, Italy	17-19 April 2004	Johannessen
6th WESTPAC Scientific Symposium, Hangzhou, China	18-23 April 2004	Michida
AQUARIUS Science Conference, University of Miami, FL, USA	19-23 April 2004	Campos
Atmosphere Observations Panel for Climate (AOPC) 10th session, Geneva, Switzerland	19-23 April 2004	Harrison
Expert Group for the Development of the THORPEX International Research Implementation Plan, 2nd session, Geneva, Switzerland	21-23 April 2004	Fischer
GOOS Steering Committee (GSC) 7th meeting, Brest, France	26-29 April 2004	Harrison
"Climate Variability Studies in the Ocean" Workshop at the ICTP, Trieste, Italy	26-30 April 2004	Fischer
OceanOPS '04, Toulouse, France	10-15 May 2004	Harrison, Keeley
Brazil-U.S. Workshop on Climate Variability, S. J. Campos, Brazil	19 May 2004	Campos
U.S. GOOS Steering Committee, Arlington, VA, USA	19-21 May 2004	Harrison
2nd Brazilian Symposium on Physical Oceanography, S. J. Campos, Brazil	31 May - 4 June 2004	Campos

The chair noted progress on many fronts since the last session, including advocacy of the ocean 'Next Steps', work on the GCOS implementation plan in support of the Second Adequacy Report, growth in the Argo and surface drifter networks, SOOP moving towards repeat XBT lines, GLOSS moving towards real-time reporting, progress in VOSClim and planning for the ocean time series sites, progress in ocean carbon coordination with the

IOCCP, in ocean reanalysis and analysis efforts with GODAE and the start of CLIVAR's Global Synthesis and Observations Panel (GSOP), and progress in the data system.

Later in the meeting the list of OOPC-8 action items was presented, with their present status. While many tasks were accomplished, many remain as ongoing issues.

Table 2: Summary of OOPC-8 action items

Action Item	Action	Responsible	Status
1	to submit suggestions for ocean climate indices	all including guests	ongoing
2	to develop links on the OOPC web site to existing climate index time series	Secretariat	tbd
3	to host experimental ocean climate index time series and provide process for feedback on the OOPC web site	Secretariat	tbd
4	to support development of Implementation Plan for the Second Report on the Adequacy of the Global Climate Observing System	Chair, all	done, ongoing
5	to participate in GEO architecture and implementation process as feasible	As appropriate	ongoing
6	to continue collaboration with COOP, including the development of joint COOP / OOPC pilot projects.	Chair, Dickey, Hood	ongoing
7	to prepare a report from the SACOS workshop, including observational requirements	Campos, Visbeck	done (background doc for OOPC-9)
8	to request the Southern Ocean Panel to provide suggestions for Southern Ocean sustained observing enhancements	Speer	done / ongoing
9	to prepare annual summaries of coming CLIVAR research observing activities and to provide the expected dates of termination of their present funding	CLIVAR representatives	tbd (ask for provision of this material prior to OOPC meetings)
10	to solicit input from the CLIVAR basin panels on additional observational requirements outside of the Next Steps	CLIVAR representatives	ongoing
11	to liaise with the CLIVAR Global Synthesis Observations Panel (GSOP)	as appropriate	ongoing
12	to request the Argo Science Team for analysis on how best to make the transfer from 'broadcast-mode' to 'line-mode' XBTs as Argo deployment proceeds	Chair	done, needs followup
13	to seek advice from CLIVAR and operational centers regarding barometer requirements on global drifter array	Chair, CLIVAR representatives	done (they want them, esp S. Ocean)

14	to request that JCOMM consider development of regular annual reports on variations and trends in mean sea level	Chair	done
15	to recommend (to JCOMM) that the WMO make the full historical record of VOS metadata available in electronic form as soon as possible (WMO Marine Program Publication No. 47)	Chair	done, but ongoing
16	to strongly encourage JCOMM to stress with operators of VOS fleets that data collection should meet climate quality principles and standards	Chair	done, but ongoing
17	to contact WGNE, requesting its help in coordinating establishment of an ongoing archive of operational marine surface fields and air-sea fluxes at the GODAE Server in Monterey to advance the SURFA and other projects	Chair	done, but ongoing
18	to develop a group to assess the technical feasibility of adding wave measurements to existing mooring designs, and to develop requirements specifications	Swail	to be followed up
19	to seek an overview of the state of commitments and planning for ocean satellites for report at OOPC-9	Chair, Johannessen, Secretariat	done (report by M. Drinkwater)
20	to link observing system monitoring results to the OOPC web site	Secretariat	tbd
21	to contact the CLIVAR SSG regarding the possibilities for data management for the time series stations	Weller, Keeley	done / ongoing
22	to encourage the Ocean Information Technology (OIT) project to interact with the US Data Management and Communications (DMAC) effort	Chair, Keeley	done / ongoing
23	to request GODAE and CLIVAR modeling groups to conduct observing system evaluation activities whenever feasible and to report results to OOPC	Chair	done, but ongoing
24	to request feedback from GODAE on the present and proposed initial observing system	Chair	done, but ongoing
25	to initiate observing system evaluation via estimation of uncertainties in ocean climate index value estimates	all	ongoing
26	to request the JCOMM Observations Coordination Group to develop an implementation plan for achieving and maintaining global coverage and density for Argo and surface drifting buoys	Chair, Johnson	done / ongoing (put together with OceanSITES, surface drifter, and other needs - systematic needs)

The chair also noted challenges for OOPC. These include improving the recommendations for sea ice, high latitudes, non-physical variables, and transports in particular places. Ongoing coordination efforts need to be sustained with the GEO process, and liaison with SCOR needs to be improved. The GCOS 2AR Implementation Plan needs to be completed and backing from the UNFCCC and nations solicited. The continuity of satellite missions needs to be advocated, and evaluation and feedback on the observing system, including the construction of simple ocean climate products and indices, need to be improved. How to support the implementation efforts, especially those of JCOMM, need to be addressed. And an overarching ongoing concern is the building of institutional processes and identification of resources to sustain the ocean observing system as it is being built; while the advocated *in situ* network is technically feasible, it is generally tapping research budgets, which is not sustainable.

4. SCIENCE

4.1 Ocean Climate 2003-2004

A review of the ocean climate in the last year was presented by Reynolds, Fischer, and Harrison. A detailed review of SSTs by Reynolds can be found in Annex III, and the other two presentations can be downloaded from the meeting website: http://ioc.unesco.org/oopc/oopc9/.

In large part, the ocean surface climate in the year starting in boreal summer 2003 was close to the climatological mean. The largest anomalies came outside of the tropics, associated with the European heat wave in summer 2003, and in the southern Indian and Pacific Oceans in late 2003 and early 2004, shifts in the positions of the major anticyclonic systems and the Southern Pacific Convergence Zone (SPCZ). The expected tropical dipole or zonal mode in the Indian Ocean did not materialize in the fall of 2003, interrupted by an equatorial Kelvin wave forced by the passage of an MJO event, which broke the Bjerknes thermocline-SST-wind feedback. The tropical Pacific was only slightly warmer than normal, but by the NOAA definition of an El Niño state (SSTA > 0.5 °C in the Niño 3.4 box for 3 months running), El Niño conditions were nearly reached, though there was no evidence that the coupled state of the ocean and atmosphere had changed appreciably. This points out some of the difficulties in defining and using indices.

4.2 Invited Presentation: The RAPID MOC Observing Programme

The chair introduced Harry Bryden. The presentation can be downloaded from the meeting website.

The poleward heat transport of the oceans is carried in the gyre circulation and in the meridional overturning circulation (MOC), and in the North Atlantic at 25°N, represents about 25% of the total poleward heat transport. Models of climate change mostly show a reduction in the strength of the MOC as the levels of greenhouse gases in the atmosphere increase, but vary in their estimates. The air temperature in the vicinity of the North Atlantic reduces by 6°C in a model (HadCM3) where the MOC shuts down completely.

The RAPID program, currently funded by the UK National Environmental Research Council (NERC) at GBP 20M, includes paleoclimatology studies, field experiments, modeling, and a monitoring component. Cooperation with the US (NSF and NOAA), Norway, and the Netherlands is underway. The monitoring component examines the MOC at 25-26°N. This is where the MOC is strongest, and has the operational advantage of a strong monitoring program in the Florida Straights of the Gulf Stream, which together with the Ekman flow (estimated from wind fields) and interior geostrophic flow (measured in the program) makes up the MOC. An array of 22 moorings was deployed across the Atlantic in February/March 2004, the key instrument being a profiling CTD, which along with currents, will give estimates of the interior geostrophic flow every 2 days.

The expected results of the experiment will be estimates of the Gulf Stream transport variability, the deep western boundary current, and recirculating gyre waters, including a partition waters of North and South Atlantic origin. The funding is secure for 4 years, and the vision is that this will be a pilot project, to prove the concept, on the way to becoming part of the sustained observing system.

5. HIGH-LATITUDES - STATUS, ISSUES, OPPORTUNITIES

The chair introduced this session, noting that the Next Steps recommendations do not fully cover the requirements in high latitudes.

5.1 Arctic Ocean

This presentation by Cecilie Mauritzen can be downloaded from the meeting website. An extended report can be found in Annex IV.

The dynamics of the Arctic Ocean form an important leg in the MOC, with inflow of Atlantic water into the basin and outflow of colder and fresher water. The dynamics of this region are fairly complex, with important roles for boundary currents and topographic steering, overflow mixing and large water mass transformations, fresh water input, and sea ice. The Arctic's larger role in climate variability and change is indicated in coupled variability of the ice, ocean, and atmosphere, but causal relationships and the upstream/downstream separation of events has been difficult based on the current observations and data.

Several research programs to address these uncertainties are underway or planned, including the Arctic-Subarctic Ocean Fluxes (ASOF) experiment and SEARCH, originally a US-based and now international initiative. The new CliC/CLIVAR Arctic Climate Panel (of which Mauritzen is chair) will work on requirements for an Arctic observing system of both cryosphere and ocean.

Simultaneous measures in the atmosphere, ice, and ocean domains are crucial. Some of the major challenges in this region are in observing technology for under-ice observations, in increasing deep ocean observations, in ground-truthing satellite products, particularly for sea ice, and in the provision of high-quality climate analyses and reanalyses for research.

The International Polar Year (IPY) 2007/9, coordinated through ICSU and the WMO, is likely to be a unique opportunity to build the base of an Arctic Ocean observing system, though the technology for it has to be ready now.

Discussion on the presentation focused on the many open science questions and the general lack of data in the region, partly due to technical challenges. The chair stated his view that OOPC is poorly received unless it can advocate an observing system based on proven technology with strong scientific rationale and broad consensus - the Arctic seems to need further research investment first. The OOPC viewed the IPY as an excellent opportunity to push forward with research investment, and saw the WCRP, and particularly the new CliC/CLIVAR Arctic Climate Panel, as the natural home for these activities. It also noted a fragmentation of the Arctic Ocean research into many communities, which has been an ongoing difficulty.

5.2 Cryosphere

This agenda item began with a presentation by Dick Reynolds on behalf of Nick Rayner. The presentation can be downloaded from the meeting website, and an extended report is provided in Annex V. The improvement of sea ice products faces several major challenges. These include a lack of error estimates and intercomparison activities for the different products, and uncertainties in satellite passive microwave algorithms, which can be of the order of the signals observed in the products.

The chair noted that sea ice was a high priority, and that documenting the intercomparison work that Rayner had done was critical. He questioned how to push for progress. Drinkwater noted that uncertainties, error covariances, and seasonality are necessary in the ice climatologies for their use in ocean data assimilation reanalyses. Gulev noted that high time resolution in the products was necessary for the modeling community in improving their ice models, which have a binary (ice/no ice) tendency which is not observed. The chair asked OOPC members to forward particular questions to Rayner.

Mark Drinkwater then presented the ESA's plans for remote sensing of the cryosphere, including both sea ice and land ice. The presentation can be downloaded from the meeting website. Current radar altimetry from ERS/Envisat is already providing coverage of polar sea ice thickness and drift, with the processing systems and algorithms currently in an experimental phase, undergoing improvements, as well as used in various operation products. The first satellite in ESA's Earth Explorer Missions, CryoSat, is nominally set to launch at the end of 2004, and will use a high-resolution SAR interferometric radar altimeter. The mission objectives are to improve our understanding of the thickness and mass fluctuations in polar land and marine ice, to quantify the rates of change due to climate variations, and to deliver data with uncertainty estimates, and will use extensive ground truthing from airborne laser instruments to verify algorithms. Drinkwater also presented the other Earth Explorer missions, most specifically GOCE (the Gravity field and steady-state Ocean Circulation Explorer), due for launch in 2006. The ESA will publish a number of announcements for funding opportunities associated with each of the 4 Earth Explorer missions.

Ryabinin informed the participants of a new IGOS-P Cryosphere Theme, which was approved by the IGOS Partners in 2004. The Theme was initiated by WCRP CliC and SCAR. The Theme report is expected in 2005, and should provide a basis for strengthening coordination of and generating increased support for cryospheric and high-latitude observations.

5.3 Southern Ocean

Mike Sparrow presented an overview of the activities and issues raised in the CLIVAR/CliC Southern Ocean (SO) Panel since the last OOPC meeting. The presentation is available on the meeting website. The major research issues in the SO are the variability and dynamics of the 'shallow' and 'deep' overturning cells, of interbasin exchange and the Antarctic circumpolar current (ACC), and teleconnections with climate variability outside the region. Coverage of the Southern Ocean by Argo floats has improved dramatically since last year, though full coverage will not be obtained until observations under sea ice can be routinely taken. A number of planned and ongoing observing projects have moved forward, these include the Good Hope project focused on Indo-Atlantic exchanges, AnSlope focused on exchanges at the Antarctic Slope Front, WECCON focused on Weddell Sea convection, and SAMFLOC focused on deep mixed layer formation processes in the southeast Pacific. Details of these and other observing programs can be found on the SO Panel's website: http://www.clivar.org/organization/southern/. Observational challenges raised at the last OOPC meeting are for the most part ongoing, apart from the progress with Argo. These include calibrating surface drifters for the high wind conditions of the SO, enhancing surface meteorological coverage including into the seasonal sea ice zone and on subantarctic islands to validate satellite observations, finding champions for surface time series stations, subsurface monitoring in the sea-ice zone, and sea-ice monitoring. Further challenges the SO Panel has identified include the need to encourage the filling of observational gaps, the extension of Argo into the seasonal sea-ice zone, and making sure data from the SO is being submitted to data centers. The SO panel also sees the IPY as an important opportunity to enhance the observing system in the polar oceans. It also supports the South Pacific Workshop proposed by the CLIVAR Pacific panel.

Kevin Speer presented some thinking the SO Panel has done in response to OOPC's request for climate indices. The presentation is available on the meeting website. Many of the well-known Antarctic climate indices are based on atmospheric data: the Southern Annular Mode, the Pacific-S. American mode, the Antarctic Dipole and Circumpolar Wave. There are connections with the ENSO pattern, though various studies taking different zones and time periods show different levels of correlation. Less work has been done on connecting ocean variability with these atmospheric modes of variability, in large part hampered by a lack of data. There are hints of covariability between the Antarctic Circumpolar Current, Ekman transport, and the major atmospheric modes, though these remain unclear. A crucial variable where available data is sparse is of course the sea ice, and particularly coastal polynas driven by katabatic winds, which are zones of new ice production and salinification that are important in driving the deep overturning cell in the SO. The various new process and sustained studies of the SO will add to the ocean data base and allow more research into the link between climate variability and the SO variability, but many holes still remain, particularly in the Pacific sector. Simultaneous transport arrays could reveal internal modes of ocean variability, and improvements in the measurements of air-sea flux fields are crucial in understanding the coupling between ocean, ice, and atmosphere.

After discussion, the OOPC panel members suggested that the SO Panel (and the other CLIVAR basin panels) should continue its work in considering ocean indices, try to link these with wider patterns of climate variability that have societal impact, and as much as possible document this work. The IPY was again mentioned as a unique opportunity to further the polar observing network, to prove value for potential transition to sustained status. The particular lack of observations in the seasonal sea-ice zone was noted.

6. SPONSORS REPORTS AND INTERSESSIONAL ACTIVITIES

The chair presented the activities of the OOPC sponsors. A general presentation on GCOS, GOOS, and JCOMM by Harrison is available on the meeting website.

6.1 Global Climate Observing System (GCOS)

The focus of GCOS has remained on the Second Adequacy Report (2AR) in response to the UN Framework Convention on Climate Change (UNFCCC), which was submitted in December 2003, and on its Implementation Plan, which is to be submitted in the fall of 2004. The GCOS framework of sparse and baseline networks, and its emphasis on treating each Essential Climate Variable (ECV) separately has been a tough fit at times to the composite ocean networks, which are made up of many different types of sensors. In preparing the Implementation Plan (IP), there has been a lot of pressure to prioritize, which has been resisted. But generally, the 'Next Steps' that emerged from the 1998 Ocean Observations conference and that are advocated by the OOPC have made it into the GCOS IP intact.

GCOS has initiated a Donor Fund for the purchase of consumables in developing the climate network in less-developed countries. Perhaps the only component of the ocean climate observing network that could benefit from this mechanism is the coastal tide gauge network. Further details of the initiative are in development.

Discussion by the OOPC focused on making sure input into the ocean part of the IP reflected the panel's concerns - surface variables had a tendency to be lost between the atmospheric and oceanic sections of the plan. The chair noted positive points of the GCOS IP: it brings attention to a number of cross-cutting issues relating to the continuity and quality of satellite observations, data sharing and standards, analysis and reanalysis, and engagement with the research community. The UNFCCC has specifically asked for a report on progress on the implementation of the ocean observing network for climate for the Spring of 2005; GOOS will take the lead in preparing this report along with GCOS.

The OOPC's twin panel for the atmosphere in GCOS, the Atmosphere Observation Panel for Climate (AOPC), shares OOPC's interest in improving real-time operational products at the air-sea interface, and has strongly supported the ocean surface components of the 'Next Steps'. The common Working Group on Sea Level Pressure has largely focused on reconstructions rather than improving operational products. The SURFA project will now fall under the WCRP's Working Group on Surface Fluxes, and OOPC panel members emphasized the importance of forward momentum in this project, which has been lacking.

6.2 Global Ocean Observing System (GOOS)

The GOOS Steering Committee (GSC) has continued its support for the basic set of recommendations on the global component of the ocean observing system advocated by the OOPC. The I-GOOS has been asked to give priority for moving forward with implementation through national efforts, and the IOC Executive Council will be asked to solicit implementation progress information. The GSC has emphasized the importance of participating in the GEO Implementation Plan.

The Coastal Ocean Observation Panel (COOP) has come far in its planning, with the basis of actions being organized around the GOOS Regional Associations (GRAs). It will be important to link global scale phenomena to local scales, and the OOPC may be able to suggest pilot projects, we should consider placing a higher priority on this activity.

National data sharing remains incomplete between nations that contribute to GOOS. This point was discussed for some time within the committee. It was pointed out that while there are many CLIVAR-relevant datasets, few of them are collected through CLIVAR.

While during WOCE, data-sharing policies were very clear, there is no CLIVAR data policy or infrastructure, making data sharing more difficult. Harrison noted that these concerns would be clearly stated in the GCOS IP. The committee thought certain key datasets might be identified where data sharing should be made a priority.

6.3 World Climate Research Programme (WCRP)

This item was presented by Vladimir Ryabinin and Sergei Gulev. An extended report by Ryabinin can be found in Annex VI, and both presentations are available on the meeting website.

The Joint Steering Committee of the WCRP, coming into its 25th year, has decided to tackle the growing scientific challenge of 'seamless prediction' - across timescales and across traditional disciplinary boundaries, by working on a new strategy on Coordinated Observation and Prediction of the Earth System (COPES). The aim is to facilitate prediction of climate and earth system variability for use in an increasing range of practical applications of direct relevance, benefit, and value to society.

Concretely, the COPES strategy has given rise to three new WCRP structural elements: the WCRP Modeling Panel, the Working Group on Observations and Assimilation (WGOA), and WCRP Task Forces, who will have limited-term focused tasks. The first was the Task Force on Seasonal Prediction. Gulev stressed the importance of ocean reanalyses for climate research, of identifying systematic errors in air-sea fluxes, and of the ocean observation system in providing the initial condition for prediction as well as observed probability density functions of climate variability.

Discussion centered on the role of the WGOA. Getting feedback from modeling groups on their requirements from the observing system, and how observations have improved predictive skill has been difficult, but is crucial for OOPC to be able to advocate for the systems.

6.4 Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM)

This item was presented by the chair. The presentation can be found on the meeting website. The JCOMM Observation Coordination Group (OCG), chaired by Mike Johnson of NOAA, has been cooperating closely with the OOPC. The OCG has adopted OOPC's Next Steps as its goals for the implementation of the global ocean observing system. These design goals use composite surface and subsurface ocean observing networks to get global coverage, climate accuracy, and to leverage existing activities. The current system is implemented to about 45% of these goals. This initial system is the ocean climate contribution to the GEOSS process, and the OCG estimates that it could be complete within 5 years, since the international logistics infrastructure is in place, and countries are already deploying and maintaining elements. Details of the global coverage and national contributions to different elements of the surface and subsurface composite systems can be found in the presentation. These statistics are also maintained in real time, in cooperation with JCOMMOPS in Toulouse, and can be found at: http://www.jcommops.org/network_status/. All real-time data streams are available from the GODAE data/product servers.

The remaining challenges are achieving global coverage, securing commitments for sustained observations, the data system and data sharing, developing a global system perspective for management and evolution, and the introduction of non-physical variables to the sustained observing system. Efforts to improve ocean analysis and reanalysis are also necessary. The OCG coordinates the work of the JCOMM SOT, DBCP, and GLOSS panels, and coordinates with the Argo project. The OCG has developed partnerships with the International Ocean Carbon Coordination Project for carbon surveys, with CLIVAR for many deployment and survey activities, and with POGO for access to research vessels and reference moorings. The priorities of the OCG are to attain real-time global coverage by the *in situ* networks, to develop system-wide monitoring and performance reporting, which will help in the commitment of funding to meet the implementation targets.

The JCOMM Management team met for the third time in March 2004. Progress was noted in monitoring the status of the global observing efforts. This will facilitate the task of the OCG, and removes this responsibility from OOPC. There was a desire for more guidance on ocean climate products for the Products and Services Program Area of JCOMM. In principle, they will be responsible for evaluations of the products. The VOS metadata concerns (WMO Publication 47) were again raised, and we were told that the situation was being addressed. There might be some benefit for OOPC from engaging with JCOMM's Expert Team on Sea Ice (ETSI). JCOMM-II will take place in September 2005, the draft agenda is now under construction. A major challenge for JCOMM remains the development of resourcing for its wide range of activities.

6.5 Other Organizations

6.5.1 Partnership for Observations of the Global Ocean (POGO)

Howard Roe, the chair of POGO, presented this item. The basic concept of POGO was to bring together the leadership of the institutions that actually have the capacity to observe the oceans, to advocate for ocean observing programs and for education-based capacity-building. POGO has received some high-level attention, including from the World Summit on Sustainable Development (WSSD) and GEO. They have also been successful at putting in place several capacity-building fellowship programs. POGO has a lean secretariat (S. Sathyendranath at the Bedford Institute of Oceanography), so little overhead in its capacity-building programs. Free and timely access of data is a POGO position, but a difficult one to advocate, as it is often tied up in national and military data release policies.

6.5.2 Group on Earth Observations (GEO)

Roe also presented this item. The GEO process grew out of the WSSD and the June 2003 G8 meeting in Evian, France, and an Earth Observations Summit in July 2003, held in Washington, DC. It is an ad-hoc group with a secretariat led by co-chairs from the US, EC, Japan, and South Africa, and is currently working on a framework document and implementation plan for the use of earth observation systems to address global environmental and economic challenges. It is a very complex and fast-moving process. The implementation plan will be written starting in July, with a review in the September timeframe, and adoption by ministers in February 2005. This strategic document is focused on 9 areas: disasters, health, energy, climate, the water cycle, weather, ecosystems, sustainable agriculture, and diversity, and ocean observations will have to fit into this framework. Two major issues facing GEO, governance and resources, have not yet been tackled, but there is some chance that major resources will be attracted, due to GEO's visibility. Also for this reason, it has the potential to move the challenges of data availability and accessibility forward. The GCOS IP is seen as an important base for the GEO Implementation Plan, and OOPC members should work to guard the importance of science as a way of advancing the societal benefits sought by GEO.

6.6 CLIMAR-II Conference

Dick Reynolds reported on the second JCOMM Workshop on Advances in Marine Climatology (CLIMAR-II). His presentation is available on the meeting website, and an extended report is in Annex VII.

The CLIMAR workshops are focused on extracting the maximum information from historical marine climatology records, and on improving the observing systems for future reference. Progress in many areas since the 1999 CLIMAR workshop was reported, and the CLIMAR-II workshop made recommendations on elements of climate monitoring quality, the collection of metadata, the homogenization of observation methods and analysis, and the improvement of data availability. The proceedings of the conference will be published in a special issue of the International Journal of Climatology, and CLIMAR-III is planned to be held in 2007. In response to a question from the panel, Reynolds pointed out that surface currents and waves were within the scope of CLIMAR, and would be added to the COADS archive, the main point of contact for this being Val Swail.

7. EXPERIMENTS, PROGRAMS, AND PROJECTS

7.1 EC/ESA Global Monitoring for Environment and Security (GMES) and MERSEA

Mark Drinkwater gave a presentation on GMES. The presentation can be downloaded from the meeting website. GMES is a joint EU and ESA initiative, is a contribution to GEO, and is designed to establish global monitoring capacity in support of sustainable development and provision of policy-relevant products, realizing benefits for markets and society. Satellite ocean monitoring is one key element of GMES, with an initial focus on fisheries and vessel monitoring, maritime traffic and safety, coastal zones and open ocean environmental monitoring, and sea ice and oil spill monitoring. The tools necessary for GMES services include operational ocean forecasting capability, so there are logical links with MERSEA and GODAE. It is now in a pre-operational stage and will be fully established by 2008.

As a complement to the Earth Explorer missions described in Section 5.2, ESA is also planning a number of Earth Watch missions, more service- rather than research-oriented. One of these is planned to be an altimeter to complement Jason after 2008. A visible-to-infrared mission is also being studied.

Drinkwater then gave a presentation on behalf of panel member Johnny Johannessen on MERSEA (Marine Environment and Security in the European Area). The presentation is available on the meeting website. MERSEA's objectives are complementary to GMES, and are to deliver information products needed by users concerned with European marine environment and security policies. MERSEA Strand-1 was an EU 5th Framework program and has just ended. It integrated satellite observations, in situ observations, and modeling, to create ocean hindcasts, nowcasts and forecasts for various user groups. The main conclusions and recommendations from the MERSEA Strand-1 project are summarized below according to requirements for satellite measurements, in-situ measurements, modeling capabilities and management.

Recommendations to meet the operational requirements for satellite measurements

- **3 altimeters beyond 2007.** A multi-satellite system for continuous high resolution altimetry is likely to involve a constellation of satellites and / or include the use of swath altimetry techniques and must urgently include a high inclination altimeter mission (post-ENVISAT) after 2007. This mesoscale altimeter mission is needed to complement Jason-2 (planned launch in 2008) and to constrain in a satisfactory way the open ocean currents and their mesoscale variability. In addition, an independent mapping of the high resolution geoid form an essential component of long term altimetry strategy. The planned launch of the GOCE mission in 2006 secures this.
- **At least 3 infrared radiometers beyond 2007.** A long-term commitment, beyond 2007, is needed to provide high quality high resolution SST measurements from combined use of passive microwave and infrared radiometers, following the multi-sensor strategy proposed for the GHRSST-PP and complemented by the view of the Eumetsat Satellite Application Facilities. Regarding GHRSST-PP this implies the need to maintain at least one sensor in orbit having measurement stability and accuracy equivalent to that of the ATSR/AATSR series of sensors.
- **3 ocean colour spectrometers beyond 2007**. There is an increasing demand for high-resolution measurements of chlorophyll derived from ocean colour data, based on at least 2-3 different concurrent missions in order to minimise the limiting effects of cloud cover effects, and served in near-real time for validation of or assimilation into marine biogeochemical models. In case 2 waters it is also important to derive reliable observations of suspended matter from satellite colour data.
- **2-3 SARs to about 2007.** Spaceborne SAR data is a highly needed source of information for detection of oil spills both from illicit vessel discharges and major accidents (e.g. Prestige case). The continuous use of multiple platforms and wide swath sensors (minimum of 2-3) is necessary to maintain sufficient temporal and spatial coverage.
- **At least 2 scatterometers to beyond 2010.** Measurement of wind vectors over the sea with 25 km resolution and global daily coverage must be made available in support of operational basin-scale ocean forecasting models. Passive radiometry and scatterometry can also be combined.

Recommendations to meet the operational requirements for In-Situ Measurements

- **Argo, VOS and Ferry-boxes:** The deployment of Argo profiling floats should be sustained, while the use of VOS and Ferry Boxes through European coastal and shelf seas should be significantly increased.
- **Rapid data transmission:** New integrated data network systems must be established for rapid transmission of very high rates of raw data to processing centres and derived products to operational users locally as well as regionally. There are both technical and policy obstacles to be tackled.
- **Sea Level:** A network of coastal and buoy stations measuring sea level must be maintained throughout European waters and the adjacent ocean.
- **Observatories:** The development and operation of integrated observatories at selected tie-points (minimum 10 sites) along the European coastal and regional seas, such as the one operating in the Irish Sea, is the only way towards routine and sustained in-situ monitoring for environment (physical, biogeochemical) and security (oil spills, red tides, toxic algal blooms).
- **HF radars:** The number of operating short and long range HF radar systems should increase to at least 10 (today 3 systems are operating) and be implemented at selected observatories.
- **Biogeochemical sensor development:** There is a developing need to be able to measure pigments, nutrients, dissolved gases and other biogeochemical properties in the sea at fine spatial and temporal resolution. This requires new chemical sensors to be developed that permit high frequency and semi-autonomous sampling from buoys as well as from VOS and ferry-boxes.
- **River discharges:** There is an urgent requirement for a routine monitoring system of river discharges (volume and nutrients) into coastal seas. The present lack of near real time dissemination of data on river discharges is a major limitation for coastal environmental monitoring.

Requirements for improving the modelling capability

- **Skill Assessment:** There is a need for systematic examinations of the performances of forecasting models which quantify their dependence on the availability, timeliness and quality of measured ocean data from satellites and in-situ systems.
- **Downscaling:** The regional high resolution forecasting systems improves with systematic and reliable information on the open boundaries from global and basin scale systems.

- **Marine GMES:** The ocean monitoring and modelling system will not be adequate for several major applications (e.g. provision of high quality and accurate 3D current field for oil spill and pollution monitoring, search and rescue applications, boundary conditions for coastal models and their applications, etc) without a high-inclination altimeter to complement Jason-2 beyond 2007.
- **Coastal Models:** Coastal models are far from being developed and operated at the adequate resolution for applications to pollution monitoring from offshore installations, ships and land sources. Moreover, the information flow from global and regional scale systems to the local coastal models have not been unified, quality controlled and nor have communication protocols been identified.
- **Ecosystem modelling:** There is a strong need to develop and advance the maturity of ecosystem modelling, in particular in the direction of species-specific properties, trophic interactions and a tighter coupling to biogeochemical cycles.
- **Emergency response services:** Oil spill combatment, search and rescue and similar services are dependent on rapid access to high-quality model prognoses and observations that are tuned to the needs of the response management applications. This requires a prepared and tested operational service chain to supply the observational and model data needed.

Management, planning and policy issues that need to be addressed

- **Inter-agency co-operation:** To secure the observational data needed for an ocean forecasting system a partnership is needed between MERSEA and the diverse agencies already making ocean observations. A comprehensive and effective forecasting system requires the various different agencies to collaborate in strategic policy decisions to install observational capacity both on *in situ* platforms and on Earth-observing satellites.
- **Additional funding:** To secure additional essential observations not already acquired by existing programmes, needs additional funds channelled through a European level agency. This will complement observing programmes that are already in place, in order to ensure that at least a minimum set of observations is in place to support a European OFS.
- **Data Policy:** The provision of both observational data and forecasting system outputs as freely available public goods will stimulate their wider application and the development of a commercial value-added sector for specialist services..
- **Diversity of observing methodology:** A balanced combination of sensor types and platforms is desirable to ensure that observations are robust to ocean and atmospheric conditions. This includes different types of satellite orbit and a combination of remote sensing and in situ instruments for measuring the same ocean parameters. A certain degree of apparent redundancy is important to guarantee adequate coverage in all conditions.
- **Space Agency Policy for monitoring missions :** The design emphasis for "Ocean Watch" or "Ocean Sentinel" Missions should be to provide follow-on sensors which deliver the same capability as their predecessors but at a much lower cost and with at least equal reliability.
- **Pre-processing of data for input to OFS:** Dialogue between satellite data providers and modellers is needed to determine an appropriate level of pre-conditioning of satellite-derived ocean variables (e.g. merging data from different sources) to optimise input to operational ocean models.

The final report and a number of specific deliverables will be available from the following web site as of 15 October: http://www.nersc.no/MERSEA.S1 (user: mersea.s1, password: mer03sea). MERSEA is now continuing as an Integrated Project in the 6th Framework program, coordinated by IFREMER in France. It will build the ocean component of GMES, and federates the European contribution to GODAE, facilitating intercomparisons between systems. It builds on a number of global and regional ocean data assimilation models, capitalizes on the main conclusions and findings of MERSEA Strand-1, and will extend to biogeochemical variables.

Discussion by the OOPC focused on the relationship between satellite and in situ data as inputs into these systems. Drinkwater pointed out some key in situ variables necessary for calibration of satellite measurements: tide gauges for altimetry, point SST measurements for satellite SST, and in situ color data for carbon flux measurements. Improved relationships between the satellite and in situ communities (and between MERSEA and EuroGOOS) are necessary.

7.2 Satellites

Mark Drinkwater continued the presentations with a report on the status of ocean satellite observations. The presentation is available on the meeting website. This information was collected in the CEOS Handbook, which was last updated in October 2003. Drinkwater described the upcoming missions and overlap by variable. While in altimetry, we are currently in a 'luxury phase' with multiple platforms and sensors, there will be a gap after the end of Jason-1 in 2007 (see also above recommendations from MERSEA Strand-1), with GMES not likely to fly an altimeter before 2010. Salinity remains in research mode, and geoid missions after GRACE and GOCE need planning. For ocean vector winds, there is no successor to QuikScat planned, and the amount of swath data and whether enough coverage of the kinetic energy input to the ocean by the winds is available remains an open question. For sea ice, commitments are needed beyond 2008. The adequacy of ocean color measurements and their use for CO_2 flux estimations is also an open question. OOPC panel members discussed the best way to advance the commitments and advocacy for ocean satellite missions, and whether the IGOS-P Ocean Theme was the right mechanism. While advocacy was clearly seen as necessary, the best avenue for this remained unclear.

7.3 CLIVAR: basin perspectives

Bob Weller gave an overview of the CLIVAR program at its midpoint; the presentation is available on the meeting website. CLIVAR's goals have been to distinguish natural and anthropogenic climate variability, and to increase predictability. It has a natural intersection with OOPC, looking to it to lead action in establishing and sustaining the ocean observation system. The CLIVAR Ocean Observation Panel (OOP) has now become the Global Synthesis and Observation Panel (GSOP), which will meet for the first time in November. The first CLIVAR Science Conference will be held at the end of June, and there is an understanding that CLIVAR should focus more on its legacy in prediction and the societal benefit.

CLIVAR is organized by basin panels, charged with tracking and coordination and with advocating process studies. Weller felt that a major challenge for CLIVAR was putting into practice the knowledge gained in process studies for parameterizations, for improved modeling, for improved observing system design and requirements, and to identify further needed process studies. He cited the US example of building climate process teams, bringing together modelers, observationalists and theoreticians around single themes, as a potential example. Of particular interest to the OOPC would be trying to evaluate the utility of various elements of the observing system: for example what is our error bar on the global ocean heat budget, and what elements contribute to this?

Discussion by the OOPC focused on the question of getting feedback on the observing system, and the lack of resources devoted to these types of efforts. One difficulty is that different elements of the observing system contribute different amounts depending on the end use, on the question being asked. It is perhaps also hampered by CLIVAR's structural divisions between basin panels. OOPC felt this was a necessary and major effort, and that it should liaise with the new GSOP and others as appropriate to push this forward.

7.3.1 VAMOS

Weller then presented an overview of the activities of the Variability of the American Monsoon Systems (Panel), prepared by panel co-chairs C. Vera and W. Higgins. The presentation is available on the meeting website. The first stage (1997-2003) of VAMOS focused on the establishment of monitoring, assessment, and prediction capabilities for the monsoon regions of the Americas, and was made up of three projects, the North American Monsoon Experiment (NAME), the Monsoon Experiment South America (MESA), and the VAMOS Ocean-Cloud-Atmosphere-Land Study (VOCALS). Many questions that span the disciplinary boundaries between ocean and atmosphere are being addressed. OOPC discussion focused on possible legacies for the observing system. It was pointed out that MESA and NAME in particular might provide good pilot projects for open ocean-coastal interactions.

7.3.2 Atlantic Panel

David Marshall presented a white paper on a Tropical Atlantic Climate Experiment (TACE), the presentation and the whitepaper (as a background meeting document) are both available on the meeting website. The goal of TACE is to improve understanding of ocean and coupled processes in the tropical Atlantic on seasonal to interannual time scales, in the short term to support the AMMA (African Monsoon Multidisciplinary Analysis) project with ocean observations, and in the longer term to enhance the monitoring and determine the requirements for sustained observations in the region. The observational plan calls for maintenance of the backbone of the PIRATA array, additional surface flux moorings, subsurface current and T/S moorings, enhanced surface and profiling float arrays, XBT lines, shipboard hydrography, coastal and island stations, and satellite observations. It builds on both PIRATA and the French contribution to AMMA, EGEE. TACE also calls for ocean and coupled model studies. Discussion by OOPC focused on the need for coordination between PIRATA and TACE.

Edmo Campos gave a briefing on the results of the South Atlantic Climate Observation System (SACOS) Workshop held in Brazil in February 2003, the report of the meeting is available on the meeting website as a background document. Several cooperative projects have grown out of the workshop, including a research program on river discharge influence on shelf circulation (PLATA, Brazil, Argentina, Uruguay), Brazil and Argentina have joined the Argo program, and a GOOS regional alliance has been formed.

Alexey Sokov then presented the Russian program of MERIDIAN cruises. The presentation is available on the meeting website. The program is part of the Russian Federation National Program “World Ocean” for the years 2004-2008. This large-scale observational program in the Atlantic began in 2001, and is run with three 6000-ton displacement research vessels. Research objectives include a quantitative description of the Atlantic thermohaline circulation variability, improvements of air-sea flux estimates and new parameterizations, validation of microwave and optical satellite observations, as well as geophysical, aerosol, and biological studies. Sokov showed some early results of MERIDIAN cruises, including changes in the North Atlantic temperature and salinity fields since WOCE, and monitoring of Drake Passage circulation. OOPC welcomed the presentation and the opportunities provided. The MERIDIAN cruises could be of value to SACOS, are already part of the Good Hope experiment mentioned in Section 5.3, and provide opportunities for along-route meteorological and gas exchange measurements and validation of remotely-sensed products, thus contributing to the objectives of the WCRP Working Group on Surface

Fluxes, SOLAS and programmatic activities associated with ocean carbon. Plans for 2004 cruises have already been made, and include a MERIDIAN Ocean Radiation Experiment (MORE), further contributions to Good Hope, and cooperation with scientists from South Africa, Germany, France, Spain, and the US. Funding for the cruises are in place through 2010. Data from the cruises is available from the WOCE and Scripps data centers, and Sokov is the contact point for potential further cooperation.

7.3.3 Pacific Panel

Bob Weller and Katy Hill prepared a report on the activities of the CLIVAR Pacific Panel, given by Weller. The presentation is available on the meeting website. The research goals of the Pacific Panel are improved ENSO predictability including links with higher frequency and decadal variability, better understanding of decadal modes and tropical-extratropical exchanges, and basin-scale storage, transport, and exchange including fluxes and the effects of clouds. In terms of observational capacity, areas of concern are the South Pacific, rationalization of the evolution of the TAO array, and taking the right data to help improve numerical models, especially in the eastern tropical Pacific. The Pacific Panel has also considered a large number of process studies.

A future focus of the Pacific Panel will be the South Pacific Observing System. The panel has proposed a workshop in the spring of 2005 to address ways of improving data coverage in the region with the following objectives: to determine our current understanding of the South Pacific in interannual to decadal variability, to assess the adequacy of present models and observational networks, to propose future model experiments, and to assess the need for a dedicated South Pacific Climate Observing System. The Pacific Panel would like to do this in conjunction with OOPC and the Southern Ocean Panel. After discussion, the OOPC felt that this was a good initiative, and would provide a good opportunity to assess the data and climatologies available in the region. A new climatology from Hamburg was mentioned as having uncertainty estimates, lacking from the commonly-used Levitus climatology. Speer agreed to take the proposal to the Southern Ocean Panel, and to work with the Pacific Panel chair and Katy Hill in setting up a steering committee and prospectus for the workshop. Ryabinin pointed out the potential utility of also liaising with the Antarctic buoy program, and more generally improving links between the OOPC and the polar observing programs, which are represented by International Arctic Scientific Committee and the Arctic Council, this last one has established a Pacific-Arctic group headed by Martin Bergmann of the Department of Fisheries and Oceans, Canada. Bob Keeley agreed to talk with Bergmann.

Yutaka Michida reported on the 6th IOC/WESTPAC scientific symposium that was held in Hangzhou, China in April 2004. His presentation is available on the meeting website. WESTPAC is an IOC subcommission representing about 20 countries. Michida reported to the symposium on the state of the ocean observing system, and on the commitments required to meet the 'Next Steps' initial ocean observing network, stressing that the full participation of WESTPAC nations was required. The symposium was also an opportunity to present interesting scientific results: one being that the inclusion of Argo data in a model predicting Niño3.4 temperatures added little skill to the simulation, though this result may be biased by the already-strong sampling in the region from the TAO/TRITON array, altimetry, and XBTs. The Japanese have also had good success in a subcontract for the maintenance of TRITON moorings with Indonesian science and technology agency (BPPT). Michida reported that the Chinese have started an Argo program, and OOPC felt it would be good to liaise with the Chinese observing program, and will seek to bring someone to its next meeting for that purpose.

7.3.4 Indian Panel

Fritz Schott reported on the first meeting and activities of the new CLIVAR/IOC Indian Ocean Panel (IOP). His presentation, prepared with Gary Meyers (IOP chair), is available on the meeting website. While a CLIVAR Asian-Australian Monsoon Panel (AAMP) has existed for 8 years, the Indian Ocean Panel was formed to specifically address a sustained ocean observing system for climate variability research, and is tasked with building an implementation plan. The scientific questions that will be addressed are: monsoon and intraseasonal variability (mostly in the domain of the AAMP), shallow and deep overturning circulations, the Indian Ocean dipole/zonal mode, decadal warming trends, carbon and biogeochemistry, the Indonesian throughflow, and global linkages. The presentation includes some of the latest results from these areas.

Progress has been made in putting together an implementation plan. It will include a tropical Indian Ocean moored array including measurements in the subtropical wave regime in the southern hemisphere (to about 15 °S) and flux measurements on the equator and in the southeastern subtropics. It will also include XBT lines, carbon and standard hydrography, and throughflow monitoring. There are a few commitments to elements already, with 3 Japanese Triton moorings and a number of Indian moorings already deployed. There is a good network of tide gauges, though data availability remains a problem, and the Argo network is growing in the Indian Ocean. A modeling workshop in November/December 2004 in Hawaii will address some of the sampling questions.

Future challenges for the IOP are to complete the implementation plan, to work out the best mix of observations required by models, to build bridges between the coastal and open-ocean observing communities, and to develop an integrated research theme on the role of the Indian Ocean in climate variability and change that spans the full ocean width and depth. Another challenge would be integrating with efforts in the Southern Ocean. The OOPC welcomed the efforts of the IOP, noting the growing understanding of the influence of the Indian Ocean sector on other parts of the global climate. The OOPC was concerned with ongoing questions about data availability in the region, and urged that data availability metrics be made available alongside maps of data collection.

7.4 Other International Activities

7.4.1 Tropical Moored Arrays

Edmo Campos gave a brief presentation on the status of the tropical Atlantic PIRATA array, the presentation is available on the meeting website. Brazil services 5 moorings and 3 island stations, while France services the 5 eastern moorings, each of which is visited once per year. Brazil has proposed three additional moorings in the southwestern Atlantic. Sustained funding for all elements of PIRATA remains a challenge. The OOPC in discussions urged closer links between the TACE and PIRATA communities, and urged a review of PIRATA as it approached the end of its pilot phase. It asked the CLIVAR Atlantic Panel to take the lead on this issue.

Ed Harrison gave a brief overview of the status of the TAO array. Data returns from the array remain typical, though a problem with salinity sensors has meant that the elements of the array have needed servicing every 6 months. Some of the components of the moored systems have reached the end of their service lifetimes, and an engineering refresh will be needed in the near future. A transfer of responsibility for the TAO and PIRATA arrays to the

National Data Buoy Center (NDBC) will take place on 1 October 2004, and no impact on the scientific output or partnerships is foreseen, but will need to be surveyed.

Yutaka Michida briefed the panel on the status of the TRITON moored array. The presentation, given on behalf of Yoshifumi Kuroda of JAMSTEC, is available on the meeting website. The TRITON array, consisting of 17/18 moorings in the western Pacific and 2 in the Indian Ocean has been stable, however a level funding situation in Japan makes it difficult to maintain the full array. Improved technology with reduced cost and collaboration with the Indonesian BPPT (see Section 7.3.3) may improve the situation.

Discussion by the OOPC centered around salinity, which is not publicly released from the TAO array, and on the frequency of data transmission. The OOPC decided to urge TAO to make salinity data available, and should liaise with users including the GODAE High-Resolution Sea Surface Temperature (GHRSST) project on the necessary frequency of transmission.

7.4.2 Argo

The panel heard a report from Brian King, a member of the Argo Steering Team (the Science Team has renamed itself), his presentation is available on the meeting website. The Argo array is currently at 40% of its target, though only about 50% of the floats go to 2000 m, the rest staying closer to the surface. This is mainly a technical limitation, as penetrating the higher stratification at lower latitudes takes more energy. About 80% of the data gets onto the GTS or to data centres within 24 hours. Argo data is gradually replacing broadcast-mode XBTs. With 6000 monthly profiles, there is now enough data that in some regions of the world ocean, Argo now defines the density climatology.

Argo held its first Science Workshop in November 2003, and attracted a large number of scientists, many not traditionally thought of as part of the program, which demonstrates the value of the data. The data quality of real-time data was higher than expected, and delayed-mode quality-assured data will begin to be released in the near future. The outlook for Argo is good if countries maintain the present deployment rate and float performance continues to improve as it has. The full 3000-float array should be reached in 2006-7. The lifetime of a float should be 4 years (150 cycles), though mechanical problems have limited the life of some. Argo needs: sustained funding, continued improvements in reliability, completion of data in delayed-mode quality control, continued input of ship-based CTD profiles for quality control, an expansion of the user community, and funding for an Argo project office.

7.4.3 SOOP

Ed Harrison gave the panel an update on the Ship of Opportunity Program (SOOP) XBT observing network, his presentation is available on the meeting website. XBTs represent an important source of upper ocean temperature data, along with Argo and moored data. Argo now has reached a density where broadcast mode sampling of XBTs is unnecessary. However, repeated high-density XBT lines remain an important tool in the detection of climate variability and change. It is estimated that 5000 more XBTs per year are necessary, and since the last review of lines was more than 5 years ago, it is time again for a review of the requirements. JCOMMOPS has in place facilities to keep track of XBT sampling along lines. Data are provided by operators with a delay of approximately 3 months. The CLIVAR representatives were asked to solicit requirements by basin for high-resolution repeated XBT lines.

7.4.4 GLOSS

Ed Harrison reported on the status of the Global Sea-level Observing System (GLOSS). Mark Merrifield is the new chair of GLOSS. There is a GLOSS Core Network of 300 gauges, unfortunately the majority of them do not report in real time, and their status can be difficult to ascertain. The OOPC stressed the importance of a good relationship with GLOSS, and decided to ask GLOSS to provide a real-time reporting map and to revisit the question of time resolution in the tide gauge data, to see if it is meeting climate observing requirements.

7.4.5 VOSClim

Peter Taylor reported on the status of the VOSClim project. A full report is given in Annex VIII, and his presentation is available on the meeting website. The VOSClim project has as its goals to improve the metadata available for ships reporting meteorological data, to encourage better quality control, and to encourage better reporting. It had its last meeting in July 2003. Progress has been made on real-time monitoring on all variables, and in the preliminary scientific analyses. However, numerous challenges remain. The WMO has been slow in maintaining its metadata database of VOS ships (Publication 47). Harrison reported that progress had been reported at the February JCOMM Management Committee meeting, but this should be followed up. Support of port meteorological officers is in many cases lacking, and continuity in the face of constantly changing shipping routes was a big challenge. Strong involvement of a user community, such as the SURFA project, was also necessary. The VOSClim project is seen as a pilot project to eventually raise the standard of all the VOS observing platforms. Discussion by the OOPC focused on the numerous challenges to the program, and the need to keep advocating on behalf of the project.

7.4.6 OceanSITES

Bob Weller reported on the activities of the International Time Series Team, now known by the acronym OceanSITES. The website has been moved, and is now http://www.oceansites.org/OceanSITES/. A big effort has been made in data standards and data sharing, where Sylvie Pouliquen heads up a working group. A draft whitepaper is ready for review by the OOPC, and a brochure and new clickable web-based maps based on the JCOMM standard are forthcoming.

One new initiative in the US has been the Ocean Observatories Initiative (OOI) / ORION, which will build an observing infrastructure over the next 5 years, NSF is investing $250 million. A call for letters of intent will come out this fall. The OceanSITES group has put effort into choosing sites, taking into account disciplinary needs. Individual process studies will also have a place on the maps maintained by OceanSITES, though separated from the main sustained observations initiative. Free availability of data will be a central tenet. Moving this initiative forward will be a big challenge, however, both in terms of the resources needed to put in place the observatories (estimated at 30-40 months of ship time per year for the full system), and in supporting the coordinating mechanism and team. Discussion focused in large part on the heavy infrastructure and coordination requirements. OOPC saw the need to target the major research funding agencies to identify support for a coordination team.

7.4.7 Air-Sea Fluxes

Bob Weller then gave a report on air-sea fluxes and the new WCRP Working Group on Surface Fluxes (WGSF). His presentation is available on the meeting website. Measurements of surface fluxes face challenges in many regimes, with the effects of low and high winds and surface roughness and waves needing to be taken into account. A few high-quality reference sites exist already, and are not sent to the GTS, so provide an independent reference for comparison with model simulations. Shipboard comparisons with dedicated research cruises and with VOS ships have proved critical in calibrating these measurements. Comparisons show large differences between the measurements, climatologies, and model outputs, with different statistics as well. The SURFA project to compare surface flux fields has moved slowly due to a lack of funding. It remains critical, as some recent changes in model formulations have in fact made the surface fluxes worse.

Challenges on the horizon for improving surface fluxes include direct flux measurements, better tilt information for radiometers, and surface wave measurements, platform improvements including telecommunications and the ability to work in severe environments, and improved coordination with VOS ship operators as well as other players. The new WGSF has been formed with Chris Fairall as chair, and includes good representation from OOPC. Harrison expressed concern that there was not enough representation from the numerical weather prediction and modeling agencies, which could be an impediment to pushing SURFA forward.

7.4.8 SST Working Group

Dick Reynolds reported on progress in improving SST products. A full report is given in Annex IX, and the presentation is available on the meeting website. Reynolds reported that much of the progress was happening outside of the formal working group. The GHRSST pilot project has been producing operational results, which have been available since 2002 for areas around Japan, and are now available for the Atlantic and Mediterranean, and will shortly be available for the region around Australia, and a global product from the US. Work on intercomparisons and verification of subjective decisions made in the analyses needs to continue.

Advances have also been made in the historical climatological record, which were reported at CLIMAR-II, these are notably a reexamination of historical biases and the inclusion of uncertainties in the analyses. The requirements for the in situ observing system for satellite calibration in SST have been refined in studies at NOAA/NCDC. Discussion of this analysis revealed some assumptions, such as the maintenance of the ship temperature network, that may need revisiting. OOPC welcomed the progress reported, and encouraged the group, which it saw as having a distinct mission focused on operational products, to continue its work, as has provided a valuable platform on which to advocate for improvements in systems producing SST products.

7.4.9 Ocean Carbon

Maria Hood provided an update on ocean carbon observations being coordinated through the International Ocean Carbon Coordination Project (http://ioc.unesco.org/ioccp). Her presentation is available on the meeting website. The IOCCP is a pilot project of the SCOR-IOC Advisory Panel on Ocean CO_2 and the IGBP-IHDP-WCRP Global Carbon Project that began in January 2003 in response to the need for a single, international, program-independent coordination mechanism for the numerous ocean carbon observation activities being carried out and planned as part of national, regional, and global research programs. The mission of the IOCCP is to provide a global view of ocean carbon by:

- Developing a compilation and synthesis of ocean carbon activities and plans;
- Working with international research programs to fully integrate carbon studies into planning activities;
- Standardizing methods, qc/qa procedures, data formats, and use of certified reference materials;
- Promote regional and global data integration and synthesis activities.

These coordination activities are laying the foundation of a global ocean carbon observing system. Hood provided a brief status of the initial ocean carbon observing system, summarized in the following table, which includes an inventory of existing activities, sampling resolution requirements, the coordinating organizations for each system element, the data products and centers managing the data, and the next steps for development of the system. A full status report of IOCCP activities for 2003 and plans for 2004 are available at the following website: http://ioc.unesco.org/iocweb/co2panel/Publications.htm.

The Global Ocean Carbon Observing System – April 2004

Element	Inventory	Coordinating Bodies	Data Centers / Products	Next Steps (2004-2005)
Repeat Sections	31 funded / 7 pending 2003-2008 86% of WOCE / JGOFS Survey	IOCCP & CLIVAR IPO	CDIAC Ocean CO_2 + CLIVAR Products: synthesis groups *via OCCC, Carbo-Ocean, PICES, IMBER, with coordination by IOCCP where needed.*	Develop implementation strategy: 2004 workshop to reach agreements on Global Survey lines, and core and ancillary variables. Establish data synthesis projects: Agreements pending funding decision of Carbo-Ocean, 7/2004.
Carbon SOOP	18 lines operating / 4 start 2004	IOCCP	CDIAC Ocean CO_2[1] Products: *synthesis activities via SOLAS WG3.*	Develop implementation strategy: pending re-analysis of sampling requirements, establish small working / writing group (2005 finish). Develop synthesis activities: agreements pending funding decision of Carbo-Ocean, 7/2004. Develop common formats for uncertainty estimates: late 2004, establish small working group to develop common format for estimating uncertainty from SOOP systems.
Time Series	~9 operating	OTS, Research Programs, (*IOCCP to collate information for carbon*)	OTS (Ifremer-Coriolis)[1]	Initiate analysis of gaps and duplications: pending approval of global science plans and national projects (end 2004), perform an analysis of ocean carbon TS activities within each project. Ensure that ocean carbon systems are

				operating on "GCOS" reference stations where appropriate.
Ocean-Colour	Satellite missions adequate for medium-term	IOCCG	IOCCG serves as data portal.	Coordinate in situ observing needs with developing ocean carbon observing system: where appropriate, enhance SOOP and TS activities with required measurements as prioritized by IOCCG. (2004/2005)

Italicized text indicates that actions are under discussion.
[1.] Ocean carbon data management activities for SOOP and time series are also coordinated with the IFREMER Coriolis data projects (Argo, GOSUD, OTS) through a common expert, Thierry Carval, at Ifremer. Coordination as of April 2004 includes Carval participation at data workshop with input to Carbon SOOP data formats and exchange agreements, and communication links to GOSUD project.
For more information and national / international planning documents, visit http://ioc.unesco.org/ioccp.

There is now reasonably comprehensive information about ocean carbon activities and plans, and the ocean carbon community is in agreement about the goals for an ocean carbon observing system. The major next step for the system elements is to develop an agreed strategy for the system that would provide a metric for gauging the progress in the creation of a system capable of meeting the product goals. The strategy for the global carbon survey from repeat hydrographic sections and the core and ancillary measurements required on each line will be developed within the year. The strategy for the surface ocean pCO_2 network will begin with a re-analysis of the sampling requirements needed for surface pCO_2 to be able to make annual global air-sea flux estimates to +/- 10% (0.2 Pg C / yr). This network will undoubtedly require a multi-system approach that includes VOS operations, drifters, and time series measurements, and the development of an implementation strategy for a sustained system from a variety of platforms will be challenging.

Hood noted that previous OOPC sessions have called for the development of a pilot effort for ocean carbon, and that the IOCCP has already been working closely with the OOCP this past year in the development of the adequacy report and implementation plans for GCOS, as well as similar efforts for the IGOS-P Integrated Global Carbon Observations Theme and GEO. While it has been agreed informally that the IOCCP is "GOOS Carbon" and is a pilot effort of OOPC, this has never been officially agreed or documented.

The OOPC thanked Hood for her presentation and expressed enthusiasm about the developing ocean carbon network. The Panel discussed some of the technical difficulties of the underway pCO_2 systems and how these are currently hindering expansion of the number and spatial coverage of the lines and integration with the VOSClim program. The Panel agreed that the IOCCP should be considered as a pilot effort of the OOPC and that ocean carbon issues for GOOS and GCOS should be coordinated through the IOCCP in cooperation with OOPC.

7.4.10 Biogeochemistry

Tommy Dickey provided a brief introduction to the International Geosphere-Biosphere Program (IGBP). His full presentation is available on the meeting website. IGBP programs of relevance to OOPC activities include: Land-Ocean Interactions in the Coastal Zone (LOICZ-2), Surface Ocean-Lower Atmosphere Study (SOLAS), and Integrated Marine Biogeochemistry and Ecosystem Research (IMBER). IMBER builds upon and extends research conducted during the Joint Global Ocean Flux Study (JGOFS) and the Global

Ecosystem and Dynamics (GLOBEC) program. These programs provide critical links for observing systems to science needs and research-based observations. They are interdisciplinary and involve good connections to the OOPC concerning carbon and other interdisciplinary variables. In particular, OOPC interests are matched in terms of forcing and feedbacks for biogeochemistry, ecosystems, and climate variability.

SOLAS research areas include: 1) air-sea interaction, 2) CO_2, DMS, and other radiatively active gases and their effects, 3) the penetrative component of solar radiation and its modulation, and 4) pH as it is decreasing and its effects on coral reefs and their ecosystems. The IMBER program concerns: 1) global change, natural and anthropogenic forcings and impacts on biogeochemical cycles and ecosystem dynamics, 2) questions that involve impacts and alterations of relations between elemental cycling and ecosystem dynamics, and 3) feedback mechanisms of the Earth system from these changes.

The discussion then focused on interdisciplinary sensors and platforms. Some of the variables that are now accessible using different interdisciplinary sensors with various platforms are listed below:

- CO_2 / O_2 – ships (underway), moorings, drifters
- Macronutrients (nitrate, phosphate, silicate, ammonia) – ships (underway), moorings, drifters, AUVs, gliders
- Micronutrients/Trace elements (iron) – ships, moorings
- Optics – PAR, Spectral to hyperspectral inherent and apparent optical properties for quantifying variables including penetrative component of solar radiation, particle size distributions, phytoplankton biomass, primary productivity, phytoplankton by groups/species (i.e., HABs, etc.), particulate organic carbon, bioluminescence – most platforms including profiling floats, color satellites (hyperspectral coming) [see *Oceanography* June 2004]
- Fluorescence - phytoplankton biomass, carbon assimilation rates – most platforms for fluorometers
- Optical plankton counters (sheet optics) – ships, moorings, AUVs, cables
- Video systems for identifying plankton – ships, moorings
- Acoustic backscatter (single and multi-frequency) for zooplankton biomass and distributions – ships, moorings

There are several emerging sampling capabilities as well. These include: DNA samplers on ships and moorings, mass specs and flow cytometers on moorings and large AUVs, and chemistry and biology on a chip, emerging micro and nano technologies. The platforms that can be used for deploying these instrumentation systems are evolving as well. These include improved autonomous and remotely operated vehicles, cable-serviced observatories, moored and drifting profilers, and gliders.

There remain several important challenges for interdisciplinary sampling of the ocean. These include endurance under adverse conditions, biofouling, integration of systems, cost and resource identification, optimal strategies for sampling, and for some systems, power and bandwidth requirements. Synthesis of the data with models remains a challenge, though there is growing interest. International cooperation, coordination, and capacity-building remain challenges as well, but have been helped by the efforts of POGO. The transfer of technology from outside oceanography might provide an important way forward.

Dickey described some of the advances in interdisciplinary oceanography that have been enabled via new interdisciplinary sensors and improved platform capabilities. Biogeochemical and ecosystem problems involving extreme and/or episodic events including upper ocean response to hurricanes and typhoons, mesoscale eddies, and internal solitary waves have been studied during the past decade.

Dickey recommended OOPC compile a short technical paper, a living document, outlining key climate-relevant biogeochemical processes, sensors and systems, and observational programs in place. The website could also include links to research observations and programs.

Maria Hood led a brief discussion about the concerns of some of the global research programs that the observing systems are not sufficiently coordinated or integrated with research programs and their needs, especially for biogeochemical variables. These concerns are expressed in the recent ICSU review, and will be discussed in detail at an upcoming meeting in September 2004 between representatives of the global research programs and the observing systems. Hood outlined some of the major concerns that had been relayed to her through personal communications with representatives of the global research programs. The global research programs feel that they have no access to "GOOS data streams" and no access to "GOOS infrastructure" for use as research platforms. This highlights a serious communication failure in getting across the message that the climate observing system is, in fact, a system of systems and that, at present, most systems (e.g., TAO/TRITON array, Argo Program, VOSClim, etc) are managing their own planning, implementation, and data products, following agreed strategies and principles. Hood suggested that the time is right (and the need critical) to make a major effort at the GOOS level to develop a professional Web-site (as well as print material, such as an informational brochure) that is informative and useful for the general public, system managers, and scientists. It should be made clear, at a glance, what the observing system is and how it works:

- What are the components of the observing system, who operates them, and what do they measure?
- How to obtain the data?
- Who are the Advisory Groups, Science Teams, SSCs, etc, for each component and how can they be contacted?
- How can the research community use the infrastructure of the observing system?
- What is the status of the system and what's next?

The Web should include GOOS, OOPC, and COOP activities within a single and integrated framework that does not require outside users to understand the administrative structure of the panels in order to find the information they want. The Web should contain basic information about the observing system, document and image libraries, standardized maps and tables showing the status of the systems, and a clearing-house of information about technology developments, best practices, and standards. This has been an outstanding issue for both GOOS and OOPC for several years, and it is time to mark the beginning of a new phase of GOOS management with a concerted effort on communications and outreach at the international project office level.

The OOPC had a discussion of ecosystems observations, and their place in GOOS and in climate observations. There is not currently a natural home under the GOOS structure. There are interesting potential points of liaison in different communities including the fisheries communities, and indications that some ecological indicators could be strong indicators of physical processes, more difficult to observe. A workshop uniting key players could be clarifying for GOOS.

7.4 The Global Ocean Data Assimilation Experiment (GODAE)

GODAE has entered its demonstration period (2003-2005), and products are now available on the GODAE servers. Feedback from users is needed, and a training process to introduce users to the products may be necessary to get this started. Systematic comparison of products in the North Atlantic is underway, but needs to be extended. There will be a GODAE summer school in September, and a Symposium in November. GODAE has 3 streams - high resolution near real-time, seasonal-to-interannual forecasting, and climate reanalysis, all of these groups will be involved in the new CLIVAR GSOP, and the latter two have links to the WCRP. The OOPC felt that it should try to tap the GODAE community for help in computing routine climate indices.

7.5 Data management Issues

Keeley presented a summary of the developments in international data systems that impact the global observing system. His presentation is available on the meeting website. He spoke about a number of diverse issues including those surrounding metadata, data dictionaries, xml, the themes of the Ocean Information Technology project, measuring the success of the observing program in meeting global climate observational targets, developments in new observational systems of Argo and surface salinity, and contributions to CLIVAR and GODAE.

The JCOMM ETDMP has taken on 3 pilot projects that address some of the issues of the Ocean Information Technology Pilot Project. One pilot is concerned with standardizing the way available data sets are described. Presently groups use forms promoted by FGDC, and other diverse descriptions. There is a group to work towards a convergence to ISO 19115 which seems to be able to accommodate the information found in other forms. A second project is addressing issues related to developing standards for quality control. Members of this pilot are working both with members of ETDMP, but also with GODAE to converge towards standards. There is also a component that is working towards a standard data dictionary that is used commonly by a wide group of data centres. At present this is in early days, but progress is encouraging. Finally, there is a pilot to show how diverse data distributed at different physical locations can be integrated to produce composites. All of these OIT related activities have targets to show results by the next JCOMM meeting in Sep, 2005.

There have been developments in the use of xml for both metadata and data. A joint working group of ICES and IODE have made progress towards xml structures that can be used to exchange both data and metadata. Results of this work will be presented on the Marine XML web site. This working group has completed its work and it is expected that continuing efforts will be picked up by both IODE and JCOMM.

The Global Ocean Surface Underway Data Project has progressed so that there is now a global data centre at Coriolis, and some data are starting to appear. There have been agreements made between the High Resolution Marine Meteorology project to acquire the TSG data collected by US ships in conjunction with meteorological observations. There will also be a comparison of the data sent on the GTS and those that arrive at the global data centre.

The Observations Programme Area of JCOMM is proposing to produce summaries that show the degree to which global observations meet the targets set by OOPC for climate measurements. These summaries will be produced by different centres but with a common form. The first ones will be prepared for the last quarter of 2004 and will be made available early in 2005.

The data system for Argo is progressing well. This year it is expected that the delayed mode data will become available at the global data centres. In addition, it is expected that regional data centres will begin limited operations. There will be some common statistics produced by the data system that will allow a composite performance of floats to be made. Some proposals are under consideration now.

Keeley described the implementation of a technique for the unique identification of original XBT profiles and records delivered in real-time. This has started in April with all of the data coming through the US SEAS system. The Australians have part of their software in place to contribute and they hope to come on-line in a few months. An analysis of the effectiveness of this procedure will be presented to both JCOMM and IODE next year.

Keeley showed sample data collected using CTDs that had been mounted on marine mammals. When the mammals come to the surface, the data are sent through the ARGOS system. Some of these mammals dive to 1000 m and the resulting profiles are typically 10-20 points. Some of these data are collected from regions close to or even within ice-infested waters. There is a growing interest by the PIs in making these data available even in real-time.

8. ADEQUACY, NEXT STEPS, AND STATUS

8.1 Observing System Evaluation

This item was introduced by the Chair, and a presentation is available on the meeting website. The OOPC has proposed an initial evaluation strategy based on estimating the uncertainty in ocean climate indices, but questions remain on how to move forward with this. How will the indices be selected? Should they be computed from products or from data alone? These indices have not been routinely calculated for the subsurface ocean, partly due to a lack of data. Who can we get interested in this problem?

An alternative strategy would be to decide a priori on the necessary space and time accuracy, and try to estimate the local uncertainty of analyses, the approach taken with SST. However, the poor sampling of the subsurface ocean makes this difficult since there is a lack of statistical information. With assumed correlation functions and amplitudes, much could be done from the perspective of optimal interpolation.

The estimation of uncertainties in existing ocean climatologies is another critical evaluation strategy. If rigorous comparisons between the various global and regional climatologies have not been made and documented, how can we encourage this work to go further?

The contribution of different observing elements to the overall system also needs to be addressed. The tropical upper Pacific, with the moored arrays, XBT lines, Argo, VOS, repeat hydrographic sections, altimeter, vector satellite winds, and microwave SST has been cited as a region meriting such a study. The forecasting community is in a position to carry out such studies, but are not funded to do so. It is also possible that different forecast systems will give different outcomes.

A major challenge remains dealing with the different needs of different applications of the global ocean observing system.

Liz Kent presented a report on sampling requirements for VOS surface fluxes, her presentation is available on the meeting website. Poor knowledge of the space and time decorrelation timescales of surface fluxes has made determining the required level of measurements for a fixed uncertainty of 15 W m^{-2} per 5°x5° box (5°x2° in the tropics) difficult to ascertain. The OOPC was encourage to provide their input to improve this calculation.

8.2 Ocean Product Evaluation

This item was introduced by the Chair. In principle, the evaluation of ocean products is the responsibility of the JCOMM Products and Services Program Area. The Panel was not sure that this JCOMM program area had much focus on the global climate products of interest here.

The OOPC decided to provide a list of products it would like to see to the JCOMM Products and Services group, and to liaise with GSOP on this matter.

9. SUMMARY OF ACTIONS

Action Item	Report Ref	Action	Responsible	Date
1	5.1	to recommend that the DBCP address the undersampling of polar oceans and marginal ice zones	Chair, Secretariat	Oct DBCP mtg
2	5.1	to encourage the new CliC Arctic Ocean Panel to work towards community consensus on feasible, global-climate-motivated observing requirements	Mauritzen	ongoing
3	5.1	to liaise with Martin Bergman, head of the International Arctic Scientific Committee Pacific-Arctic group, regarding Arctic observing plans and requirements	Keeley	ASAP
4	5.2	to encourage documentation of the improvements and uncertainties in sea ice products	Reynolds	ongoing
5	5.2	to raise questions about sea ice products and their improvement for Rayner cc to Ryabinin for CliC	Secretariat	ASAP
6	5.3	to encourage the Southern Ocean panel to consider correlations of S.O. indices with wider patterns of climate variability that have societal impact, and to document these	Speer	ongoing
7	6.1	to provide input to the draft GCOS	all	9 July

		Implementation Plan responding to the Second Adequacy report cc to Fischer, Harrison		2004
8	6.1	to ensure that ocean surface processes in implementation plans do not get lost between atmospheric and oceanic requirements (GCOS IP and GEO)	all	ASAP
9	6.1	to encourage that the WG on sea-level pressure consider improvements to real-time operational products in addition to the historical record	Chair	OOPC-X
10	6.1/ 7.4.7	to seek provision of surface flux fields from operational models for comparison with reference timeseries: a) directly through WGNE b) through a possible revitalization of SURFA via WGSF to make direct contact with Gleckler	Weller, Taylor	OOPC-X
11	6.2	to encourage GCOS and CLIVAR to renew efforts in improving data sharing for key datasets such as sea level records; consider a data policy for CLIVAR	Harrison, Weller	ASAP
12	6.2	to suggest pilot projects linking global and coastal scales for suggestion to COOP; (possibly through VAMOS)	Harrison, Dickey	
13	6.5.3	to provide timely input into the GEO process, including current implementation plan drafting; and to emphasize role of continuing link with research/science	all	ASAP
14	6.3	to coordinate with the WCRP's new WG on Observations and Assimilations to avoid unnecessary duplication; and to encourage modeling feedback on observing system	Chair	
15	7.3	to coordinate with the CLIVAR GSOP (and CLIVAR SSG) to avoid unnecessary duplication, to promote interaction with OOPC, and to encourage modeling feedback on the observing system	Chair, Weller	
16	7.2.1	to pass OOPC feedback to the IGOS-P Ocean Theme rolling review, and advocate for secretariat support for implementation	chair, GOOS director	
17	7.3.1	to encourage coordination between the Russian Federation MERIDIAN cruises and CLIVAR Atlantic panel and JCOMM observing activities	Sokov, Marshall, Schott, Hill, Fischer	
18	7.3.2	to form a steering committee for a South Pacific Observing System workshop	Weller, Hill, Speer, chair	

		which will write a prospectus and suggest an organizing committee, for possible co-sponsorship by OOPC; in coordination with both the Pacific and Southern Ocean panels chairs		
19	7.3.2	to find a Chinese contact for invitation to the next OOPC meeting, to improve observing strategy coordination	Chair, Secretariat, Michida	OOPC-X
20	7.3.3	to encourage JCOMM or other appropriate bodies to produce data availability metrics - of data collection and data availability, as incentives for improving data sharing	Chair, Secretariat	
21	7.4.1	to encourage the CLIVAR Atlantic Panel to discuss at their upcoming June meeting a potential review of PIRATA as a part of the integrated observing system; or to consider a joint OOPC/Atlantic panel review	Schott, Campos	ASAP / 20 June 2004
22		to encourage the release of TAO salinity data in real-time at highest frequency limited by the transmission technology (for GHRSST calibration)	Dickey, Weller, Crease	ASAP
23	7.4.3	to solicit from each of the CLIVAR panels clear requirements for SOT/SOOP XBT lines, which may differ from the current (5-year-old) recommendations	CLIVAR representatives	SOT-III (March 2005)
24	7.4.4	to ask GLOSS to provide a real-time reporting map with finer time resolution (last year, last month, real-time, etc.) than the current map	Chair, Secretariat	
25	7.4.5	to emphasize the importance of maintaining or improving support for Port Meteorological Officers	Chair	
26	7.4.5	to emphasize the importance of the GCOS Climate Monitoring Principles to NWP centers and VOS operators (JCOMM), and their funders	Chair	
27	7.4.5	to again emphasize the importance of the maintenance of the ship metadata database through WMO Publication 47 (via a letter WMO SecGen and VOSClim newsletter)	Chair, Taylor, Kent	
28	7.4.6	to review the OceanSITES whitepaper, for consideration for publication as an OOPC report	all + Sec./Weller for external rev.	
29	7.4.6	to encourage the NSF OOI initiative to consider ocean climate data infrastructure and observing requirements	Weller, Dickey	
30	7.4.5/6	to ensure JCOMM includes the VOS network in its observing system status	Secretariat	

		reports and maps		
31	7.4.7	to suggest the WCRP WG on Surface Fluxes seek more operational met service representation / input	Chair, cc to JSC, WGNE, Taylor, Weller	
32	7.4.10	to develop on the OOPC website an information database for existing ocean biogeochemical climate observational systems (moorings, floats, VOS, etc.), including what measurements are being taken, including research-based and interdisciplinary measurements as well as sustained observations	Fischer, Dickey, Hood	
33	7.5	to liaise with GDAC concerning the availability/use of stable mooring time series for QC of Argo profiles	Weller, Keeley	ASAP
34	7.5	to build clearly defined targets for the data system, as goals against which implementation bodies will be measured; and to regularly review observing system targets	Chair, Secretariat, Keeley, w/ contrib. from all	
35	7.5	to comment directly on the adequacy and suitability of actions taken by JCOMM and IODE to improve the data systems	Keeley	
36	7.5	to actively contribute to the currently ongoing IODE evaluation with our requirements; and to encourage CLIVAR to do so	Fischer (to get survey to OOPC); all	ASAP
37	8.1	to encourage CLIVAR to get better observational covariance information - time and space variability of the subsurface ocean, for observing system evaluation	with Action 15	
38	8.1	to encourage documentation of climatology comparisons, and estimation of errors in global/historical subsurface climatologies	with Action 15	
39	8.1	to help improve estimates of quantitative requirements for VOS for fluxes	Reynolds, Weller, with Taylor, Kent	summer 2004
40	8.2	to make a list of ocean climate products needing evaluation, and transmit this to the JCOMM Products & Services PA and to GSOP	chair, Weller, Keeley, Dickey, Reynolds	ASAP

10. DATE AND LOCATION OF NEXT SESSION

The chair suggested meeting at the WMO, site of two of OOPC's sponsors (GCOS and the WCRP), and where the OOPC has never met. After discussion, OOPC-X was set for 9-12 May 2005, at the WMO, Geneva, Switzerland.

ANNEX I
AGENDA

The Ninth Session of the GCOS-GOOS-WCRP
Ocean Observations Panel for Climate
7-10 June 2004
Southampton Oceanography Centre,
Southampton, UK
http://ioc.unesco.org/oopc/oopc9/

Agenda (v.5, 7 June 2004)

Monday, 7 June	
0900 - 1700 *break* *1030 - 1045* *lunch* *1230 - 1330* *break* *1500 - 1515*	**1. Opening and welcome** (15 min) **2. Review and adoption of the agenda & OOPC-8 report** (15 min) **3. OOPC review 2003-2004 & Meeting Goals** (30 min - *Harrison*) **4. Science** 4.1 Ocean Climate 2003-2004 (40 min) SST anomalies (10 min - *Reynolds*) Other surface anomaly indices (20 min – *Fischer*) ENSO (10 min – *Harrison*) 4.2 Invited Talk: Dr. Harry Bryden, The RAPID MOC Observing Programme (60 min) **5. High-latitudes – Status, Issues, Opportunities** 5.1 Arctic Ocean (60 min - *Mauritzen*) 5.2 Cryosphere (60 min - *Reynolds for Sparrow, Drinkwater*) 5.3 Southern Ocean (60 min - *Sparrow, Speer, Cunningham*)
1700	**Reception** SOC restaurant (hosted by Peter Taylor)
Tuesday, 8 June	
0900 - 1700 *break* *1030 - 1045* *lunch* *1230 - 1330* *break* *1530 - 1545*	**6. Sponsors Reports and Intersessional Activities** 6.1 Global Climate Observing System (GCOS) including review of the Implementation Plan for the 2AR (60 min) 6.2 Global Ocean Observing System (GOOS) (15 min - *Harrison*) 6.3 World Climate Research Program (WCRP) (20 min - *Ryabinin, Gulev*) 6.4 Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) (15 min - *Harrison*) 6.5 Other Organizations 6.5.1 Partnership for Observations of the Global Ocean (POGO) (15 min - *Roe*) 6.5.2 IGBP (15 min - *Dickey*) 6.5.3 Group on Earth Observations (GEO) (15 min - *Roe*) 6.6 CLIMAR-II Conference (15 min - *Reynolds*) (continues...)

Tuesday, 8 June (cont'd)	
	7. Experiments, Programs, and Projects 7.1 EC/ESA Global Monitoring for Environment and Security (GMES) and MERSEA (45 min - *Drinkwater*) 7.2 Satellites (45 min - *Drinkwater*) 7.2.1 Status & future of missions - salinity, sea ice, microwave SST, surface vector winds, sea surface height, color 7.3 CLIVAR: basin perspectives (overview, 15 min - *Weller*) 7.3.1 VAMOS (15 min - *Weller for Higgins/Vera)* 7.3.1 Atlantic TACE whitepaper (30 min - *Marshall, Schott*) SACOS workshop (30 min - *Campo*) Russian Atlantic observational prog. (20 min - *Sokov*) 7.3.2 Pacific CLIVAR panel activities (30 min - *Weller/Hill*) WESTPAC meeting (15 min - *Michida*)
Wednesday, 9 June	
0900 - 1700 *break* *1030 - 1045* *lunch* *1230 - 1330* *break* *1530 - 1545*	**7. Continued…** 7.3.3 Indian (60 min - *Schott*) 7.4 Other International Activities 7.4.1 Tropical Moored Arrays (30 min – *Campo, Harrison, Michida*) 7.4.2 Argo (20 min - *King*) 7.4.3 SOOP (15 min – *Harrison?*) 7.4.4 GLOSS Tide Gauge Network (15 min – from *Johnson*) 7.4.5 VOSClim (15 min - *Taylor*) 7.4.6 Time Series Stations (30 min - *Weller*) 7.4.7 Air-Sea Fluxes & new Flux group (15 min - *Weller*) 7.4.8 Sea Surface Temperature Working Group (30 min - *Reynolds*) 7.4.9 Ocean Carbon (30 min - *Hood*) 7.4.10 Biogeochemistry (60 min - *Dickey, Hood*) 7.4 GODAE (20 min - *Harrison*) 7.5 Data Management Issues (60 min - *Keeley*)
Thursday, 10 June	
0900 – 1500 *break* *1030 - 1045* *lunch* *1230 - 1330*	**8. Adequacy, Next Steps, and Status for Ocean Climate - Discussion** 8.1 Observing system evaluation process 8.2 Ocean product evaluation process 8.3 Potential workshops/meetings **9. Summary of Action Items** **10. Date and Location of Next Session**

ANNEX II
PARTICIPANTS

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ANNEX III
SEA SURFACE TEMPERATURE VARIABILITY FOR 29 MAY 2003 THROUGH 26 MAY 2004

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The sea surface temperature (SST) variability is based on the weekly optimum interpolation (OI) analyses of Reynolds et al. (2002) and is shown as anomalies with respect to a1971-2002 climatological base period. To best demonstrate the changes between 2003 and a more typical period, figure 1 shows the mean and standard deviation of the weekly anomaly for the 14 year period beginning in 1990 and including 2003. The top panel in figure 1 shows the mean anomaly. This field is very flat with indications of small positive anomalies occurring primarily in the tropics and in the North Atlantic. These anomalies are primarily due to the overall global warming of SSTs that has been occurring since the 1970s. The lower panel shows strong SST anomaly variability in the eastern and central tropical Pacific due to ENSO events. This period includes the strong El Niño event of 1997-1998. In addition, there is indication of important variability in middle latitudes, especially in the Northern Hemisphere.

The mean and standard deviation of the anomaly for 29 May 2003 through 26 May 2004 is shown in figure 2. The upper panel of figure 2 shows that the mean anomaly has stronger signals than the same panel in figure 1. There are positive anomalies greater than 0.6ºC in the central and western Pacific tropical Pacific and in most of the Atlantic north of 30ºS. The positive anomalies are even stronger between 50ºN and 70ºN with some regions with anomalies above 1.8ºC. The lower panel of Figure 2 shows the anomaly standard deviation. Here the major variability occurs in northern middle latitudes with little tropical Pacific variability because the weak El Niño event which ended in March 2003. The ENSO signal is much clearly much weaker than the signal shown in figure 1.

Time series of the SST anomalies are now examined in two regions from January 1997 through 28 May 2004. The upper panel in figure 3 shows the time series of the SST anomaly averaged over most the North Atlantic between 50ºN and 70ºN. This time series shows a strong positive anomaly >1ºC which lasted from July 2003 through the end of October 2003. This warming is the oceanic signature of the heat wave which occurred in Europe in the summer of 2003. During this period the Climate Prediction Center's North Atlantic Oscillation (NAO) Index, which is defined from sea level pressure, showed a positive NAO signal which is associated with a European climate which is cooler and wetter than normal. However, the NAO link with climate is primarily for the winter season. Please note that there is a drop in the SST anomaly at the end of May 2004. This drop is over 1ºC from the highest value in the summer of 2003. However, this drop brings the SSTs closer to normal and is and clearly suggests that the 7ºC drop depicted in the movie "The Day After Tomorrow" is not occurring.

The lower panel of figure 3 shows a time series of SST anomalies in the tropical eastern Pacific between 10ºS and 10ºN for a region often referred to as the Niño-3 region. Here the strong El Niño warming of 1997 is clearly evident. In 2002-2003 there was a weak El Niño which ended in March 2003. The Climate Prediction center has predicted normal, non-ENSO, conditions for 1994. The time series in Figure 2 was begun in January 1997 so the difference between strong and weak ENSOs could be shown.

Reference

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.

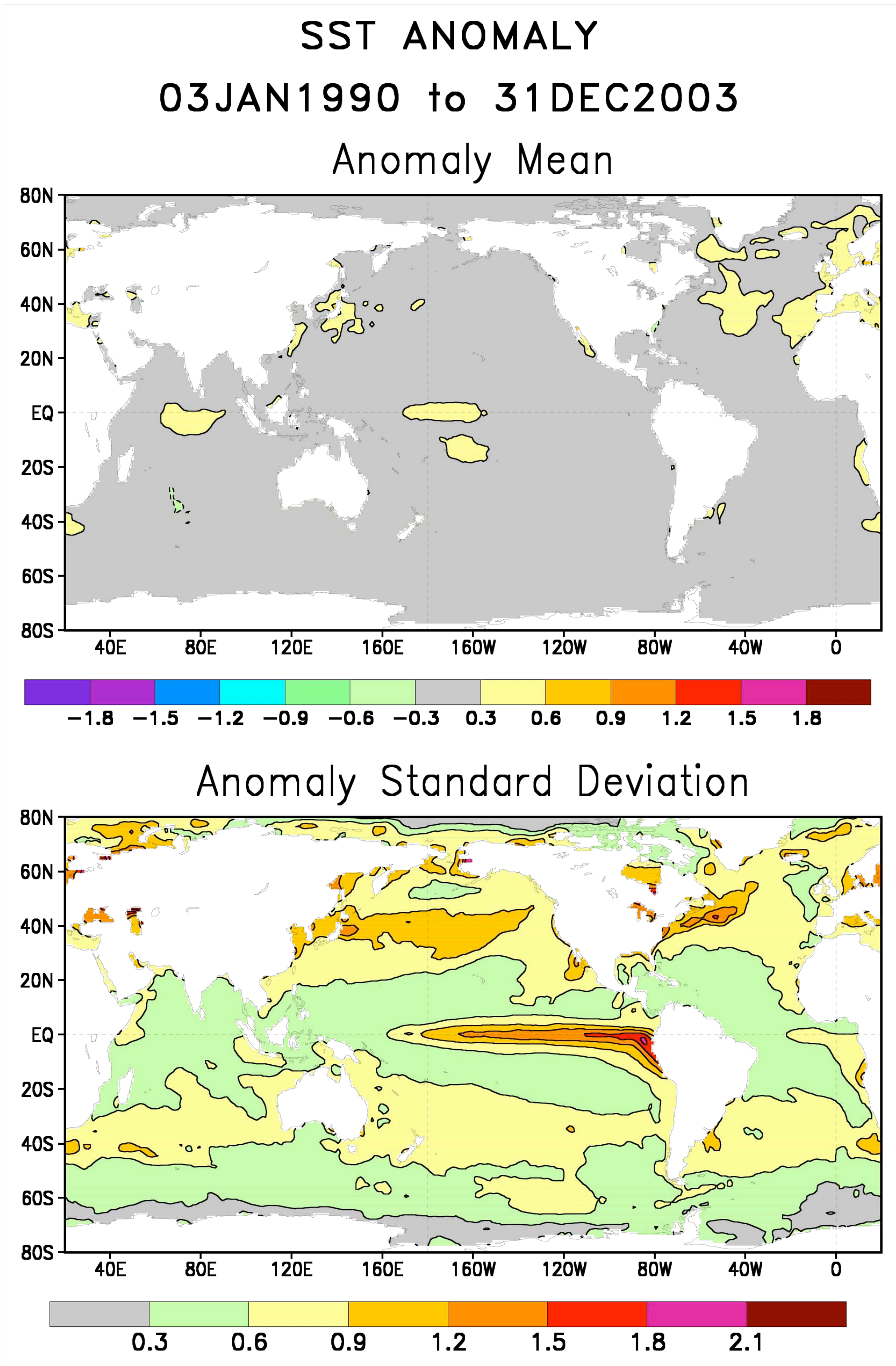

Figure 1. Mean and standard deviation of weekly SST anomalies for the period January 1990 through December 2003. The anomalies are computed relative to a 1971-2000 base period. The contour interval is 0.3°C; the 0 contour is not shown.

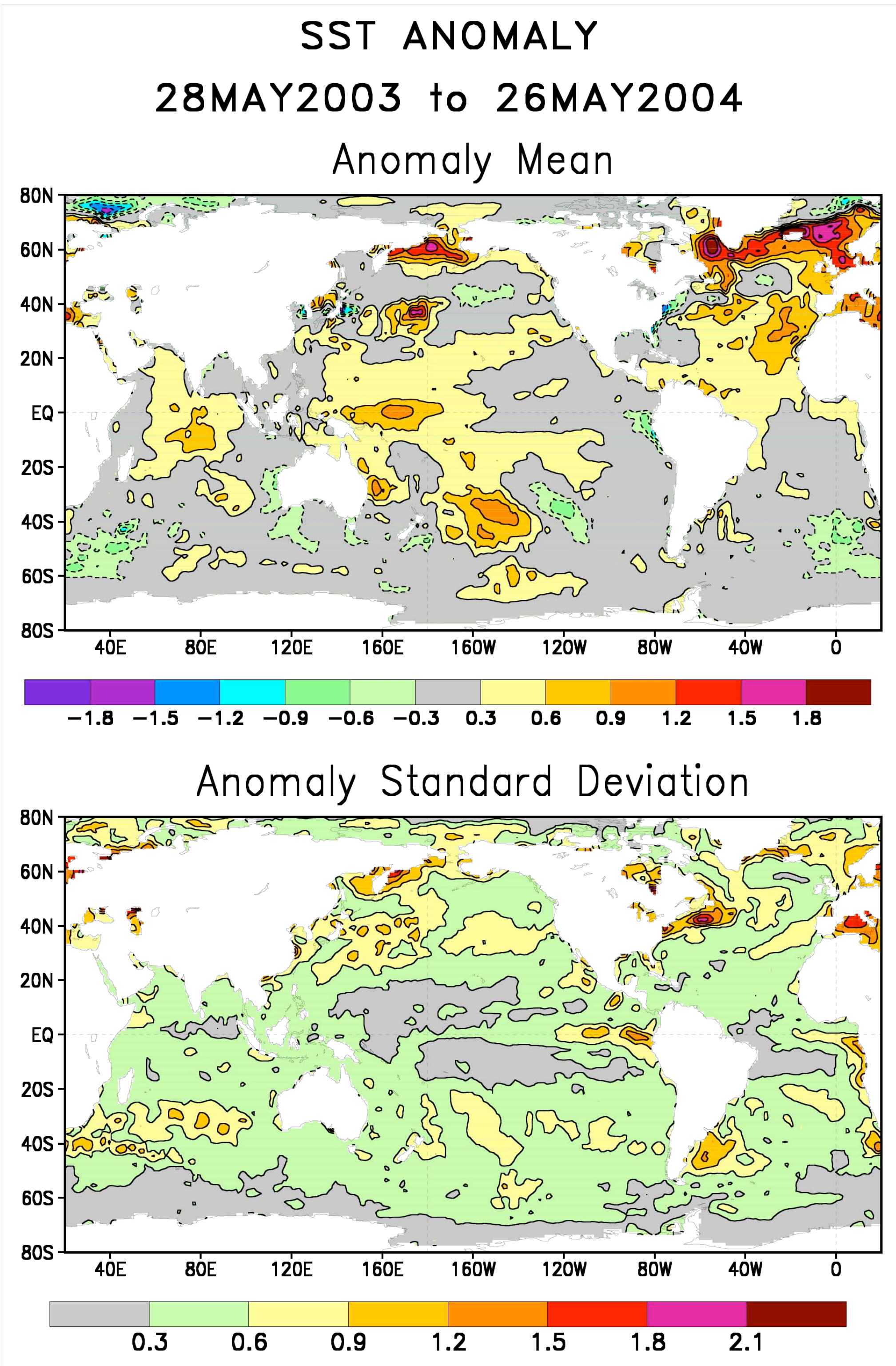

Figure 2. Mean and standard deviation of weekly SST anomalies for the period 29 May 2003 through 26 May 2004. The anomalies are computed relative to a 1971-2000 base period. The contour interval is 0.3°C; the 0 contour is not shown.

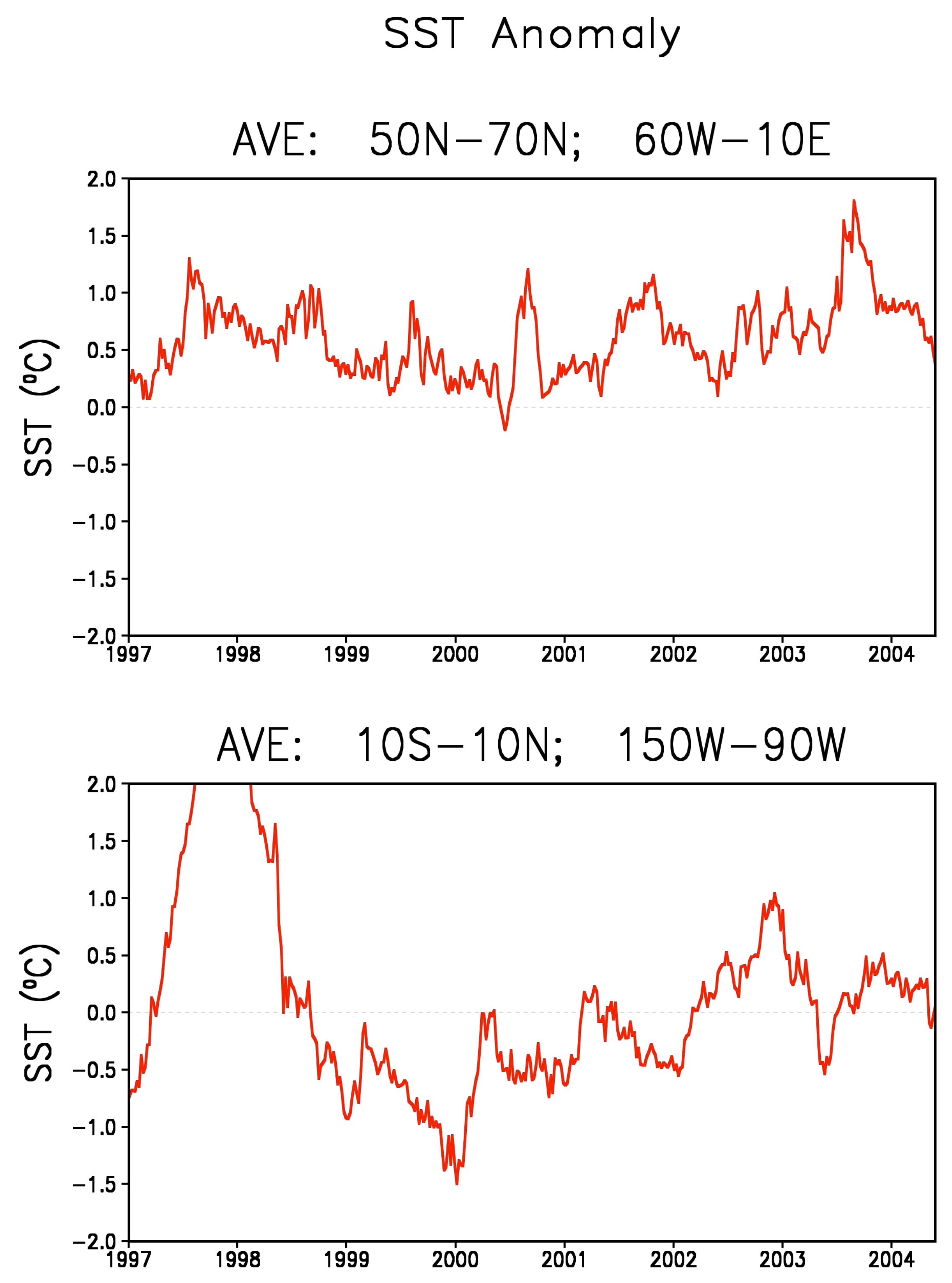

Figure 3. Time series of weekly SST anomalies for the period January 1997 through May 2004. The anomalies are computed relative to a 1971-2000 base period.

ANNEX IV
ARCTIC OCEAN – STATUS, ISSUES, OPPORTUNITIES

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An Ocean Observing System for the Arctic does not exist at present. Based on the Arctic's importance for global climate, and the high cost and high risk involved in developing such a system for a partly ice-covered ocean, this omission should be taken seriously. Not only would climate research be improved by information in the Arctic – so would numerical weather prediction and calibration of remote sensing data in general, so an efficient observing system demands coordination across fields.

A timely opportunity arises with the upcoming International Polar Year 2007-2009 (IPY; http://www.ipy.org/), co-sponsored by ICSU and WMO.

In the current implementation plan it is stated that the activities of IPY will consist of:

- A synoptic set of multidisciplinary observations to establish the status of the polar environment in 2007-2008
- The acquisition of key data sets necessary to understand factors controlling change in the polar environment
- The establishment of a legacy of multidisciplinary observational networks
- The launch of internationally coordinated, multidisciplinary expeditions into new scientific frontiers
- The implementation of polar observatories to study important facets of Planet Earth and beyond

The IPY planning process is still underway, but there is a grassroot movement to make the establishment of an AOOS a *core activity*, or *theme*, of IPY.

Scientific requirements for an AOOS

- The Arctic Ocean cannot dynamically be considered separately from the ice and atmosphere above. Similarly the Arctic cannot be considered separately from the rest of the globe. An observing system for the Arctic should recognize these facts, and ensure simultaneous, coordinated observations of the first-order variables.
- Oceanic variables of first-order importance to be monitored include
    - Strength of the boundary currents. Requires current meter arrays across sloping topography at select sites and gliders.
    - Modification of water masses. Requires full-depth repeated CTD profiles, for instance from bottom-moored and/or ice-anchored profiling CTDs and gliders.
    - Thickness of ice. Requires upward looking sonars for in situ measurements.
    - Pathways of water masses. Requires subsurface free-drifting floats.

Technical issues for an AOOS

Some of the necessary instrumentation is proven even in ice-covered oceans. These include bottom-anchored moorings, which naturally will provide the backbone for an AOOS. For other parts of the system technological developments are needed (and underway): especially the navigation and continual data recovery for subsurface floats. Ice-anchored platforms provide an interesting means for obtaining the desired coordination of atmospheric, cryospheric and oceanic data, and an international US-NSF-sponsored workshop took place in Woods Hole 06/2004 to explore the possibility of using such platforms for multidisciplinary monitoring during IPY. The recommendations from this meeting will be found at http://www.whoi.edu/science/PO/arcticgroup/projects/ipworkshop.html.

ANNEX V
SEA ICE CONCENTRATION AND EXTENT FOR CLIMATE RESEARCH: STATUS, ISSUES AND OPPORTUNITIES

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The GCOS climate monitoring principles provide a useful check list of requirements which should be satisfied by any data sets used to monitor climatic changes. The most relevant of these requirements can be summarized in terms of: stability, homogeneity and continuity. GCOS has recommended that high priority should be given to making measurements in data-sparse or climatically sensitive regions. In particular, the needs of climate assessments like those of the IPCC should be integrated into the plans from the start. In addition, users should be given easy access to data and uncertainties and any biases in the data should be quantified and published.

There are a bewildering number of sea ice data sets apparently available for climate studies. Many of these data sets are available from the National Snow and Ice Data Center (NSIDC) in the U.S. They also provide helpful data summaries describing the strengths and weaknesses of the most popular data sets. This archive contains different data sets based on passive microwave retrievals from the ESMR, SSMR, SSM/I and AMSR-E instruments on various satellites, digitized chart collections and some field measurements. The passive microwave data sets differ in the algorithms used to retrieve sea ice concentration by combination of brightness temperatures sensed by different frequency channels of the instrument. None are universally applicable and most have been validated over limited regions or times. Fields of passive microwave retrieved sea ice concentration are not presented with accompanying error estimates. Digitized chart collections include the Russian charts from the Arctic and Antarctic Research Institute (AARI), Chapman and Walsh data, plus charts for Alaska, Canadian Arctic and the Bering Sea and other Arctic regions

Other data sets are also referred to on, but not accessible from, the NSIDC web pages. The Hadley Centre SST and sea ice analysis (HadISST1) is our attempt (see Rayner, et al., 2003) at creating a more-homogeneous sea ice concentration data set by blending chart-derived data from Walsh and Chapman and the National Ice Center with passive microwave data. The Global Digital Sea Ice Data Bank (GDSIDB) was collected by JCOMM and comprises operational ice charts from various countries. An analysis of these latter data combined with data from Walsh and Chapman and climatology (where no actual data was available) was recently created by Vasily Smolyanitsky during a visit to the Hadley Centre. We hope to incorporate these into the next version of HadISST. Other operational charts have not yet been collected into the GDSIDB, but there are plans for expansion. The ACSYS Historical Ice Chart Archive contains historical sea-ice observations in the Arctic region between 30W and 70E in the form of digitized maps. It was created at the Norwegian Polar Institute. The earliest chart dates from 1553, and the most recent is from December 2002. We also hope to include these in the next version of HadISST.

To improve sea-ice fields, it is necessary to identify the “best” passive microwave algorithm (or combination of algorithms) for retrieval of sea ice concentration. Often algorithms and brightness temperature fields are worked up into sea ice concentration data sets for only a limited period, but algorithms are simple enough to apply to the whole

SMMR/SSM/I brightness temperature record with some care. The tricky part is comprehensive inter-comparison and validation. Few groups appear to have the motivation or resources to perform truly comprehensive inter-comparison and validation studies, which would be a necessary part of deciding which one algorithm (or combination of algorithms) is best for climate monitoring purposes.

It is also necessary to critically assess the passive microwave record in the context of extended GCOS climate monitoring principles (in terms of its stability, homogeneity and continuity). Given that I have had trouble finding out whether or not there are stability issues with the passive microwave data, I suggest this sort of information could be better presented. Climatically speaking, the 25 years of the passive microwave is insufficient by itself to study decadal variability, so homogeneity over the whole data record must also be assessed. In order to do this, we need a good understanding of how charts are and were created and exactly how this relates to a passive microwave concentration field.

A lot of historical chart data for the Arctic have become available over the last five years or so, which is a major step forward. There has been less improvement in the Antarctic, but there are fewer data to find and those that are around are likely point observations which will need digging out of archives and assembling or reconstructing. The first meeting of the JCOMM Expert Team on Sea Ice agreed to prepare historical information for the Southern Ocean and a report is due this autumn. In the meantime, AARI have useable data in their archives for the 1950s and 1960s and I believe NSIDC plan to digitise these shortly. Assuming the Expert Team survey identifies some potentially fruitful data sources, OOPC should encourage funding for digitization of historical Southern Ocean sea ice.

The usefulness of passive microwave retrievals in summer time is seriously limited by the instruments' inability to see through melt water and wet snow on top of the ice. More work on finding ways around this should be encouraged (by approaching funding bodies). This research is best done by remote sensing experts. However, the OOPC should first check the status of the EUMETSAT Ocean and Sea Ice SAF project as they appeared to be intending to go in the right direction in this regard.

Uncertainties in passive microwave sea ice concentration retrievals are estimated in a limited fashion for some algorithms and given in the literature, so encouragement should be given to derive comprehensive fields of uncertainty. The inability of most algorithms to retrieve thin ice should also be reflected in these estimates, as this is important for monitoring of total ice extent. However, complete and meaningful uncertainty estimates will not be available until a "best" (combination of) algorithm(s) is identified, the stability and homogeneity of the record is assessed and we can retrieve more-accurate concentrations at times of melt. It is also necessary to encourage production of error estimates for historical chart data sets, so these can be meaningfully compared with satellite retrievals and their differences understood.

Progress will likely be best made by liaising with the lead author team on the Observed Cryosphere chapter of IPCC 4AR when it is announced. OOPC/IPCC could use their combined influence to try and encourage focused work (aimed at solving the aforementioned problems, which I see as the main challenges facing any progress in being able to say anything new about sea ice change in the next IPCC report) from data set providers.

It would be useful to include a focused session on sea ice in the next scheduled marine climate data meeting. Contributions should be invited aimed at answering these remaining questions, rather than providing general presentations about sea ice. Alternatively, the IPCC team may be planning to hold such a meeting, or the OOPC might like to suggest they hold a specific meeting (although it would probably not fit into the IPCC schedule at this late stage).

In addition it is important to continue liaisons with other groups including CLiC so that information can be shared on future and impending developments.

Reference

Rayner, N. A., D. E. Parker, E. B. Horton, C. K. Folland, L. V. Alexander, D. P. Rowell, E. C. Kent, and A. Kaplan, 2003: Global analyses of sea surface temperature, sea ice, and night marine air temperature since the late nineteenth century. *J. Geoghys. Res.***, 108 (D14)**, 4407, doi:10.1029/2002JD002670.

ANNEX VI
WCRP

Dr V. Ryabinin gave a review of the WCRP status. The 25th Session of the WCRP Joint Scientific Committee (JSC-XXV) took place in Moscow on 1-6 March 2004. It discussed the status of the WCRP and also met with the Scientific Committee of the IGBP. One of the most important issues on the JSC's agenda was a new WCRP initiative called COPES, "Coordinated Observation and Prediction of the Earth System". COPES is a new overarching activity that builds on all WCRP projects and provides a context in which they and other activities and scientists will be able to perform their research, and that will help show the relevance of this research. Dr Ryabinin presented COPES to the meeting.

The COPES initiative results from realisation of several challenges that the WCRP is currently facing including, among others, the need to convert the achievements accumulated in many WCRP sectors into more comprehensive and skilful prediction of the climate system, a need to address the seamless prediction/projection problem spanning days, weeks, seasons, years, decades, centuries, and bridging with climate assessments, a growing demand to consider predictions of the broader climate / Earth System and to demonstrate the use to society of WCRP-enabled predictions. COPES will facilitate prediction of the climate/earth system variability and change for use in an increasing range of practical applications of direct relevance, benefit and value to society. It will be achieved through determination of aspects of the climate/earth system that are and are not predictable, at weekly, seasonal, interannual and decadal through to century time-scales and improvement of observing systems, data assimilation techniques and models of the climate/earth system. Close cooperation with IGBP, GCOS, NWP centres, and other partners in all aspects of COPES is foreseen.

The aims of COPES require WCRP to study how the observations of important climate variables contribute to the increased predictability of climate at various time- and space-scales. The observational issues of COPES will require the coordinated collection and reanalysis of climate observations to describe the structure and variability of the climate system, and to generate dynamically-balanced and internally-consistent states of the coupled climate system for the numerical prediction of climate. Special efforts will be required to obtain and assimilate data from the new generation of environmental satellites to meet the scientific objectives embedded in COPES. An urgent task under COPES will be to define the *in-situ* and space observing systems for the next decade required to address the aims and objectives of WCRP, and for the implementation of the COPES strategy. In particular, consideration will need to be given to identifying gaps and deficiencies in existing observing systems, which may have resulted in reduced predictability.

Under COPES, the new observational data, particularly those from the new generation of satellites, will be exploited to the maximum possible extent in pursuit of the aims and objectives of WCRP and in particular to determine what can be predicted and how it can be done. The Coordinated Enhanced Observing Period (CEOP) led by the WCRP Global Energy and Water Cycle Experiment (GEWEX) is viewed as an example of coordinated global observational activity in support of COPES.

Climate observations need to be tailored for specific purposes and set in a framework that will achieve best value. A commitment is needed to create a comprehensive, reliable, end-to-end, 'Global Climate Observational System', which will produce long-term, high-quality, temporally homogeneous data sets and products. Observations should adhere to the

Global Climate Observing System (GCOS) observing principles, thereby ensuring that they are useful for multiple purposes, including climate change. A strategic plan is required for the progressive, coordinated, periodic analyses and reanalyses of observations, which are necessary to incorporate lessons from new measurements and research, and also for the stewardship, archival and access of data, as well as the support to enable institutions to do these tasks. Increased resources are needed to achieve more effective exploitation of current and planned observations (especially for satellites) through increased international cooperation on developing integrated analyses and products. The transition from research to operational systems is also an important practical issue. It will be a task within COPES to work closely with GCOS, GOOS, GTOS, GEO, IGOS-P to specify with more precision the observations needed to improve the realisable predictability of climate at various temporal and spatial scales.

COPES modelling strategy has been proposed and will be refined in future.

The three new WCRP structural elements responding to the needs of COPES are the WCRP Modelling Panel, Working Group on Observations and Assimilation (WGOA), and WCRP Task Forces. The prime role of the Modelling Panel will be to coordinate and integrate modelling activities across WCRP with the purpose of meeting the WCRP objectives, especially in the context of COPES.

The WGOA is expected:

a. to foster, promote and coordinate synthesis of global observations from the atmosphere, oceans, land and cryosphere, and for the fully-coupled system, through analysis, reanalysis and assimilation activities across WCRP, including the Modelling Panel;
b. to act as a focal point for WCRP interactions with other groups and programmes (e.g. WMO, IOC, GCOS, GOOS, GTOS, AOPC, OOPC, TOPC, JCOMM, IGBP, IGOS-P, CEOS, IPCC, etc) on observational requirements for WCRP and assist in optimization of observational strategies for sustained observations;
c. to promote and coordinate WCRP information and data management activities, including development of web sites, in liaison with WCRP projects.

Following a decision at JSC-XXIV (March 2003), which recognised the importance of seasonal prediction as a specific objective under COPES, a limited-term WCRP Task Force on Seasonal Prediction (TFSP) was established. The prime aim of the TFSP is to determine the extent to which seasonal prediction of the global climate system is possible and useful in all regions of the globe with currently available models and data. JSC-XXV also decided to establish a Task Force for the further development of the COPES strategic framework for the WCRP for the period 2005-2015. The Task Force is expected to elaborate and detail the organisation and initial objectives of COPES so as to exploit to the full the expertise of the WCRP projects and other activities.

The COPES initiative is intended to provide a stimulus for the science of the WCRP community, and to widen the recognition of its relevance for a sustainable future. All past and existing WCRP activities have been conceived and developed with the help of a wide community of climate scientists. Comments and suggestions on COPES are welcomed.

Dr Sergey Gulev, a member of the WCRP JSC, complemented Dr Ryabinin's presentation by a condensed review of activities in the WCRP projects and the Working

Group on Surface Fluxes. He highlighted a need for CLIVAR to support further development of ocean reanalyses, for GEWEX – to establish the WCRP-wide precipitation panel, for WGNE and WGCM – to address convection schemes in atmospheric models, systematic errors, operational fluxes. He indicated that adequate description of model initial state in terms of statistical moments and knowledge of essential climate variable probability densities from observations are relevant problems for the OOPC.

ANNEX VII
THE SECOND JCOMM WORKSHOP ON ADVANCES IN MARINE CLIMATOLOGY (CLIMAR-II)

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Background

Increasing concerns regarding regional and global climate variability and trends underscore the crucial importance of extracting the maximum information from the historical marine record, as well as improving the Global Climate Observing System (GCOS) so that future results will not suffer the uncertainty of historical ones. Accordingly, the Second Joint Commission for Oceanography and Marine Meteorology (JCOMM) Workshop on Advances in Marine Climatology (CLIMAR-II) was held at the Résidence Palace, Brussels, Belgium on 17-22 November 2003, at the kind invitation of the government of Belgium. Poster presentations started on 17 November and oral presentations took place from 19 to 22 November. A wrap-up session took place on 22 November. More than 80 people from 20 Member nations from all the WMO Regional Associations attended the workshop. Overall, 46 oral presentations and 28 poster presentations were given.

As recommended by JCOMM-I (Akureyri, Iceland, June 2001), CLIMAR-II was linked to, and immediately followed, the two-day celebration (17-18 November) of the 150th anniversary of the International Maritime Conference held in Brussels in 1853, which was convened by USA Navy Lt. Matthew Fontaine Maury and chaired by Belgian Observatory Director Dr Adolphe Quételet. The 150th anniversary ceremony was opened by His Majesty King Albert II of Belgium. CLIMAR-II was organized jointly by JCOMM and the Royal Meteorological Institute of Belgium, and sponsored by the Belgian Federal Science Policy Office, Environment Canada, the Japan Meteorological Agency and the US National Oceanic and Atmospheric Administration. The international Organizing Committee was composed of members from Belgium, Canada, Poland, the United Kingdom, USA and WMO, chaired by Scott Woodruff (USA).

CLIMAR-II was the direct successor to CLIMAR99 (Vancouver, Canada, September 1999; JCOMM, 2003a) and to the Workshop on Advances in the Use of Historical Marine Climate Data held in Boulder, USA, in January - February 2002. The latter Workshop made a range of recommendations for activities in marine climatological data development and research (Diaz *et al*., 2002). CLIMAR-II was organized partly in the light of these recommendations, and this report summarizes our progress in fulfilling them so far.

Proceedings

Like the Boulder workshop, CLIMAR-II was divided into three main sessions. In Session I, on cross-cutting issues, presentations included databases, metadata, quality control (QC), homogeneity, biases, statistical analysis techniques, reanalyses, and user products. Presentations in Session II concentrated on sea level pressure (SLP), wind and waves; and those in Session III dealt with marine temperatures and sea ice. Estimation of uncertainty was a common theme in all the sessions. Many of the presentations in each session were based on the International Comprehensive Ocean-Atmosphere Data Set (ICOADS) named I-COADS at the Boulder workshop but now re-named to ease citation and web paging. ICOADS is an upgrade of COADS, created by blending COADS with the Met Office's Marine Data Bank and millions of newly digitized logbook records, with careful elimination of duplicates (Diaz *et al*., 2002). A final summary session reviewed progress since the 2002 Boulder workshop, and discussed future activities.

Comparison with the Boulder recommendations (Diaz *et al.,* 2002) revealed good progress on :

1) Increased coverage of data, especially for data-sparse times and places.
2) Understanding and reduction of biases, e.g. in *in situ* marine air temperature (MAT) and in satellite-based sea surface temperature (SST) data.
3) Specification of uncertainties and their inclusion in analyses.
4) Comparison of QC techniques.
5) Availability of additional land-station SLP data to support marine analysis.
6) Development of techniques for reanalysis of atmospheric circulation in the pre-radiosonde era.

There has also been some progress in:

1) Approval by the WMO Executive Council of a format for metadata from Ocean Data Acquisition Systems (ODAS) including buoys.
2) Analysis of diurnal cycles in SST using geostationary satellite data.
3) Availability of satellite-based temperatures for inland seas and large lakes.
4) Research to improve the specification of SST in marginal ice zones.
5) Assembly of the first version of a blended sea-ice dataset for the Arctic for 1950-98 by the JCOMM Expert Team on Sea Ice.
6) Improvement of cloud-clearing techniques for satellite-based SST. For example, the SSTs from the Tropical Rainfall Measuring Mission (TRMM) have yielded substantial improvements in cloudy and poorly sampled tropical regions.
7) Assessment of biases in the Maury SLP data.

Furthermore, we note the substantial international effort to prepare recommendations for enhancements to GCOS (GCOS, 2003).

However, none of these advances is complete! For example:

- Millions of marine observations remain to be located and digitized from logbooks (e.g., Fig. 1), and millions that are already digitized remain to be blended into ICOADS.
- The biases in marine temperatures around 1939-45 are still poorly understood. Daytime MAT data need to be made useable. Our knowledge of biases for as much of the past as possible needs to be complemented by inclusion of appropriate metadata in data sets, so that proxy and historical data can be made compatible with modern data; also enabling future data to be made compatible with current data. This is an application of the GCOS Climate Monitoring Principles (Appendix 2 of GCOS, 2003). However, it is recognised that finding some of the required metadata will be difficult and may need augmenting by special studies of the character of the data to make deductions about some of the observational practices.
- We are still improving our assessments of uncertainties and need to compare techniques for making these assessments; we also need to specify our target accuracies.
- The global observing system still leaves large areas unobserved at the ocean surface and – especially – below.

Other Boulder recommendations, such as creation of sub-monthly analyses of SST and sea-ice, and adjustment of historical wind-speed data, are still at an early stage. CLIMAR-II supported the need for sub-monthly (pentad) analyses because they provide useful ground-truth even though they may be noisy or even impossible over most of the globe and most of the instrumental record because of the sparsity of observations. Pentad SST analyses based on satellite data (e.g. Reynolds et al., 2002) are very valuable but require in situ data for validation and often for calibration also. Adjustment of historical wind speeds is particularly difficult without metadata. Some useful work has been done for the post Second World War period (e.g. Ward and Hoskins, 1996), which showed that the problems in the raw data are indeed serious, but this needs extending throughout the ICOADS period. QC techniques for all parameters need to be fully and consistently documented; if possible, QC methods used throughout ICOADS should be homogeneous.

There were seen to be shortcomings in the access to ICOADS data. Do we have optimal methods for collecting, preparing and providing information? There are many, overlapping sources of data and products, and the problem of optimising data provision is complex. Many users are working with outdated versions of COADS. Often data are available, but it is difficult for the uninitiated to discover what is there. There should be a web-based "route map" to the best available data which should be widely advertised to all the various user communities.

The Boulder workshop recommended that the Voluntary Observing Ships Climate (VOSClim) Project be extended, or a parallel project be initiated, to include buoys. CLIMAR-II discarded this recommendation. With the planned availability of buoy metadata, buoy versus model comparison will be possible from existing datasets. Operationally the monitoring of buoy data already takes place.

Recommendations by CLIMAR-II

CLIMAR-II made the following recommendations which, except for the first under "Metadata", are not explicitly in the Boulder list. Within each subsection, recommendations are in order of priority. Ideally, all (except CLIMAR-III) should be implemented within 2 years. The consolidated Boulder and CLIMAR-II recommendations are available at http://www.cdc.noaa.gov/coads/climar2/recs.html. Throughout, the need to improve GCOS, and to adhere to the GCOS Climate Monitoring Principles, is implicit.

Climate Monitoring

1) All observations should be taken following the GCOS Climate Monitoring Principles, remembering that any distinction between "operational" and "climate" observations is artificial.
2) Because remotely sensed data are an important part of the climate record, it is recommended that the continuity and overlap of satellite missions should be planned in line with the GCOS Climate Monitoring Principles.
3) It is important that we improve dialogue between Numerical Weather Prediction, climate and data-generation communities, through for example the GCOS Panels. Some CLIMAR-II participants should attend the JCOMM Products Workshop (OCEAN OPS04) (Toulouse, 10-15 May 2004) to broaden its scope.
4) To ensure the extension of adequate climate observations into the future, it is necessary to define target accuracies for fields of each of the basic meteorological variables (SST, MAT, SLP, humidity, wind speed and direction, waves, cloud cover) and for their combination into flux fields (sensible heat, latent heat, longwave radiation, shortwave radiation, precipitation, atmospheric moisture, momentum). The adequacy of the observations collected, as measured against these requirements, should be regularly assessed. The Second Adequacy Report on the GCOS (GCOS, 2003) has already given an overall assessment, but the Statements of Guidance on observing requirements for climate need to be completed and regularly updated through the GCOS Panels.
5) Consider devising recommended standards for the location and design of meteorological masts on new ships. Instruments should be stable in severe conditions. Continuity should be maintained through any improvements and automation of *in situ* observations, following the GCOS Climate Monitoring Principles.
6) Develop, through JCOMM and its Expert Team on Marine Climatology (ETMC), a list of appropriate climate indices for winds, waves and SLP. Indices are a logical update in technology to marine meteorological summaries under MCSS. Development of climate indices should be done in liaison with the WMO/CLIVAR/CCl Expert Team on Climate Change Detection and Indices, and with the GCOS Panels.
7) The Global Ocean Observing System (GOOS) should support extra spectral ocean wave measurements at existing sites in the Southern Ocean and tropics.
8) Investigate the inclusion of wave information in ICOADS summaries.

Metadata

1) Digital availability of the entire record of the WMO ship catalogue (WMO, 1955-), in a format suitable for use in association with both operational and climate data, should be made a priority. Editions for 1955-72 and 1999 onwards are not yet available in digital form.

2) Observing practice literature, both national and international, is an important aspect of climate metadata. Two of the more important decisions recorded in this literature were the historical WMO/Commission for Marine Meteorology (CMM) decisions which improved VOS data and the Marine Climatological Summaries Scheme (MCSS). To document the evolution of observing practice, a procedure for identifying, archiving and distributing this type of metadata should be developed. The archive should be updated through JCOMM and its ETMC, without destroying the older entries, when observational practice is updated. Eventually, the archive could also link to the results of instrument validations and comparison studies.
3) An archive of metadata for moored and drifting buoys, and other ODAS (e.g. offshore platforms), should be filled by Members, with WMO coordination, as soon as possible with information on both current and historical deployments.
4) If possible, a given buoy should have a unique identifier. The re-use of identifiers (buoy numbers) for different buoys can cause erroneous application of metadata. If buoy numbers must be reused, the metadata should include sufficient features (e.g., timestamps) so that they can be correctly applied.
5) Metadata, including information on homogeneity adjustments applied, should be clearly linked to data.

Homogenisation

1) It remains essential to acquire data from independent platforms (e.g. VOS, buoys, research vessels, satellites), to allow independent validation and homogenisation of records. The important VOSClim data validation and improvement project should be continued.
2) There is a need to investigate the best way of applying wind homogenization techniques in the absence of adequate metadata.
3) Proxy data (e.g. coral-based SST estimates) should be carefully matched with instrumental data, following the GCOS Climate Monitoring Principles. Error-adjusted annual fields may help in this process.
4) Continue efforts to make QC of data more consistent and effective, including documenting and homogenising the methods used as much as possible.

Uncertainties

1) Consider forming a working group on uncertainties in climate data and analyses. This should include all climate data, not just marine, and the group could appropriately work with, and report to, the GCOS Panels and IPCC.

Data availability

1) We need to simplify and accelerate data access to users, especially new comers to the field. There should be a “route map” to the best available data. JCOMM should work with the GCOS Panels and appropriate research groups to identify operational, and experimental, integrated climate information products and put them on their web portal.
2) The successful International Marine Meteorological Archive (IMMA) format developed under the ETMC should continue to be used.
3) Support should be given to initiatives to improve the quality of research vessel surface meteorological and oceanographic data and to widen access to these data and associated metadata.

4) Investigate the inclusion of relative humidity (RH) data into ICOADS when RH is the only available moisture parameter.
5) Consider developing links to sources of coastal and island data.

Future workshops

CLIMAR-II saw the need to continue to monitor and assess progress in marine climate data analysis by bringing together the global data-development and research communities approximately every two years. Accordingly:

1) A sequel to the Boulder workshop should be held in 1-2 years' time.
2) CLIMAR-III should be held in 2007.

Conclusions

An important outcome of CLIMAR99 was the Dynamic Part of the *WMO Guide to the Applications of Marine Climatology (WMO-No.781)* (JCOMM, 2003b). Accordingly, presentations made at CLIMAR-II will be incorporated into a further JCOMM Technical Report, and a selection of papers from CLIMAR-II will be published in a special issue of the *International Journal of Climatology*, which will form an update of the Dynamic Part of the *Guide*. Through these publications and the participation of the delegates, CLIMAR-II will provide guidance and technical support to National Meteorological Services in their acquisition, processing, analysis and application of marine meteorological data.

CLIMAR-II was an outstanding success and the progress made since CLIMAR99 was clearly evident. We look forward to reporting further major advances by the time of CLIMAR-III.

Acknowledgements

We are grateful to His Majesty King Albert II, the Belgian Federal Government and to the Royal Meteorological Institute of Belgium for hosting this important event. We thank Chris Folland and Dick Reynolds for useful comments on this paper.

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Figures

Figure 1. Abstract log of the US Frigate Constitution, 1854-1855: Naval Observatory volume #345; Deutscher Wetterdienst Registration #8148 (reprinted from Braun, 2000).

Figure 2 (left to right):
- US steam frigate Mississippi, in the Gulf of Mexico, March 1847: Library of Congress, Prints & Photographs Division [reproduction number LC-USZC2-3129] (originally published by N. Currier, New York, 1848).
- Florida peninsula, January 1985: NASA Space Shuttle Earth Observations Photography database [photo STS51C-44-0026].
- TAO (Tropical Ocean Atmosphere) buoy and anemometers on NOAA ship Ka'Imimoana. Photo by Jason Poe, courtesy of TAO Project Office.

ANNEX VIII
VOSCLIM STATUS UPDATE JUNE 2004: REPORT TO OOPC9

The present status of the VOS Climate project, VOSClim, was summarised in a report to the AOPC by Elizabeth Kent and Sarah North, reproduced below (with footnotes added with regard to progress, or lack of progress, since April 2004).

—Peter K. Taylor, June 2004.

VOSCLIM STATUS UPDATE APRIL 2004: REPORT TO THE AOPC

Elizabeth Kent[*] and Sarah North[+]
[*]Southampton Oceanography Centre, VOSClim Scientific Advisor
[+]Met Office, VOSClim Project Leader

VOSClim Status

The objective of the Voluntary Observing Ship (VOS) subset envisaged by the WMO VOS Climate project (VOSClim) is to provide a source of high-quality marine meteorological data and associated metadata, suitable for a number of applications, including global climate monitoring, research and prediction. The VOSClim project held its fourth meeting at the IMO headquarters in London in July 2003 (VOSClim-IV, JCOMM 2003a). Important progress was reported including the full implementation of ship monitoring for all variables (by the Met Office acting as VOSClim Real Time Monitoring Center), the agreement of Marine Climatological Summaries Scheme (MCSS) quality assurance limits for variables in the VOSClim attachment (by Deutscher Wetterdienst for the Global Collecting Centres) and the results of a preliminary scientific analysis (by the Scientific Advisors). A decision was made to relax the recruitment criteria for VOSClim ships so that any ship with a good reporting record could participate regardless of instrumentation used. The operational side of VOSClim is beginning to work well with many Port Meteorological Officers (PMOs) recruiting ships, training the officers on the importance of VOSClim and how to make the additional observations, collecting metadata, photographing the ship and instrument sites and making repeat visits where possible. VOSClim real-time data[1] is available from the project website[2] but delayed-mode observations containing the VOSClim attachment of extra variables designed to aid scientific analysis are not yet available[3]. The first journal paper analysing the dataset will shortly be submitted (Berry and Kent 2004).

Metadata

The success of VOSClim relies heavily on the availability of good-quality metadata. VOSClim has adopted the normal VOS route for metadata delivery, through the WMO Marine Program Publication No. 47 (List of Selected, Supplementary and Auxiliary Ships).

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1 Presently (June 2004) from 111 ships.

2 http://www.ncdc.noaa.gov/oa/climate/vosclim/vosclim.html

3 As of June 2004, delayed mode data is still not available from NCDC - although they say that they will do it soon (following pressure from the VOSClim Project Manager).

The metadata contained within Publication No. 47 has in the past been made available in electronic format and has been used both operationally (for example enabling PMOs to efficiently service foreign VOS visiting their ports) and for climate research (for example allowing the height correction of marine air temperatures, Rayner et al. 2003). Electronic files are available for the period 1973 to 1998 and the first quarter of 1999. Since then, only one file has been made available (the last quarter of 2001). In 2002 an extended metadata format was introduced and later adopted by the VOSClim project as its metadata standard. Unfortunately, the WMO have not yet been able to provide electronic data in this new format. The lack of current and recent historical metadata is a serious problem both operationally for VOS and VOSClim and for climate research. Current estimates are that the missing metadata should become available during April 2004[4], perhaps prompted by the meeting of the JCOMM Expert Team on Marine Climatology (ETMC) in July 2004. The importance of historical VOS metadata to the climate community is demonstrated by a current US project to digitize Publication No. 47 for the period 1955 to 1972 to allow its wider dissemination and use by climate researchers.

It should be noted that SOT-II set up a task team on metadata to asses the need for change in WMO Publication No. 47 metadata format which will report to the ETMC in July 2004. Some changes will be easy to implement (such as adding codes for new types of instrument) but the task team will also suggest further modifications to the metadata format. It is essential that the implementation of any new format is properly resourced as the result of the last format change was that the metadata became unavailable.

Action: Recommend that the WMO make the full historical record of VOS metadata available in electronic form as soon as possible to meet the requirements of climate researchers along with current metadata to support operators and forecasters. Resources for maintenance of the VOS metadatabase and implementation of any code changes should be a priority.

Operational Support

VOSClim requires a healthy VOS system for successful operation, the support systems for both are the same. The second meeting of the WMO Ship Observations Team (SOT-II, WMO, 2003b) heard consistent reports of pressure on ship operations within National Meteorological Agencies running the VOS program. An example was the recent reduction by two thirds of the number of UK PMOs. There is also an increasing demand on their time for support for other functions, such as the drifting buoy program. Experience has shown that the enthusiasm of ships' officers participating in the VOS program (and hence the quality and frequency of their observations) depends crucially on frequent visits from PMOs providing links to the National Meteorological Agencies.

Action: The role of the Port Meteorological Officer network in improving VOS data quality should be recognised and NWP centres should be encouraged to maintain or increase resources for PMO activity.

[4] As of June 2004 we still don't have recent WMO Pub 47 metadata.

VOSClim Analysis

The VOSClim dataset is a valuable resource for climate researchers. Its wide use must be encouraged. There are three distinct phases in the scientific analysis for VOSClim. Firstly, the data collected must be thoroughly assessed, using the metadata to determine bias and scatter in the observations and how they depend on observational practice and environmental conditions. The second phase will use this information to develop a strategy for the production of a high-quality dataset from the data collected by the VOSClim ships and promote good practice amongst the VOS by feeding back the results to the VOS operators. Only then can the third stage, the use of high-quality data for climate science, begin. At present, the only scientific input has come from the VOSClim Scientific Advisors at the UK Southampton Oceanography Centre. It is desirable that a wider range of scientists have input at each stage. Expanding the user base should be actively encouraged to promote a diversity of research and ensure that this dataset is used to its full potential[5]. It is further desirable to promote the wider analysis of error and bias in historical VOS datasets such as ICOADS (Diaz et al. 2002, see Section 7.3 of GCOS 2003).

Action: AOPC should encourage the wider scientific exploitation of VOSClim dataset.

VOS Development

In recent years the practice of making observations has been made easier by the introduction of automated reporting software such as TurboWin, SEAS or OBSJMA. This has reduced the burden of coding reports on the ships officers and provides help, for example, with making cloud reports by including pictures of different types of cloud. This type of software should have reduced errors due to the incorrect calculation of true winds from ship relative winds. However the use of TurboWin logging software has resulted for the first time in the implementation of a WMO directive to correct winds to 10 metres height at source (Shearman and Zelenko, 1989). SOT-II recognised this as a problem, particularly for climate research, as there is no metadata to show which reports have been corrected to 10 metres and which have not. SOT-II has set in motion the process to revoke the WMO height correction directive, and in the shorter term the TurboWin developers will remove the height correction from the next version (although leaving height correction for fixed platforms reporting in ship code following consultation with representatives of NWP centres). An interim mechanism using footnotes in WMO Publication 47 should allow the identification of some of the reports that have been height corrected at source from metadata. With pressure of time on ships' officers, there has been a move towards fully automated systems by some countries, notably Canada and France. A good quality automated system, with the facility for manual input of some parameters such as cloud types, has the potential to produce climate-quality reports. A further advantage is the reliable delivery of frequent observations in severe weather conditions. However, care needs to be taken that automatic systems are introduced in line with the GCOS Climate Monitoring Principles[6] (GCOS, 2003) and ensure that enough ships still record the full range of variables required for surface flux calculation.

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[5] Note for the OOSDP: the lack of progress on the SURFA project has removed one potential early customer for the data set.

[6] (attached)

Action: NWP centres and VOS operators should be reminded of the importance of collecting data in line with the GCOS Climate monitoring principles. The importance of VOS observations for the calculation of surface fluxes in regions away from flux reference sites should be stressed in revisions to the GCOS Draft Implementation Plan.

Convergence of VOS and VOSClim

Ideally all VOS observations would be of the quality aspired to by the VOSClim project. However, a significant minority of VOS observations are of poor quality and to some extent this undermines the usefulness of the remainder of the better quality observations. For example, SST observations from VOS are assimilated into SST analyses with a relatively low weight. This is partly because some VOS SST reports contain gross errors that could have a serious adverse effect on the analysis. Numerical Weather Prediction (NWP) centres therefore prefer to rely on SST reports from drifting buoys, which contain fewer gross errors but are prone to drift with time (potentially causing problems with large quantities of biased data in data-sparse regions). VOS reports are therefore given a low priority by NWP centres and there is little incentive to improve the quality as little use is made of the reports. Demand from the NWP community is therefore shifting from VOS to alternative data sources. In the past the requirements of the NWP and climate researchers have to a large extent coincided, but more recently there have been moves by NWP centres to develop methods of targeting observations in 'sensitive areas' for forecasting in order to reduce costs and improve forecasts. In addition new initiatives such as the Network of European Meteorological Services (EUMETNET) Composite Observing System (EUCOS) (http://www.eucos.net/) and its surface marine programme (E-SURFMAR) are addressing their efforts to producing better quality NWP forecasts over Europe. As a consequence National Met Services are likely to re-focus their VOS and buoy resources to meet the demands of NWP, possibly at the expense of climatological requirements[7]. The importance of VOS for climate is that ships provide a wide range of parameters from which the four components of the heat budget can be calculated (long and shortwave radiation, sensible and latent heat flux). Whilst some moored buoys provide similar information, typically alternative systems provide a subset of the information required for climate studies, concentrating on the variables most important for NWP, such as pressure and SST and possibly winds and air temperature. Limited automatic systems have been installed on VOS providing similar information to that obtained from a drifting buoy. The needs of the NWP and climate researchers for VOS data appear to be diverging. However, both communities would be well served by a smaller number of reliably high-quality VOS providing a full range of meteorological variables. This would be supplemented for NWP by information from other systems such as the buoy network, satellites and radiosondes. The VOSClim project, although much smaller in size, provides a possible model for a future transition to make the VOS a high-quality data system. Dialogue between the NWP and climate communities is limited, especially when one considers that many National Meteorological Agencies have both NWP and climate responsibility. Improving this dialogue

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[7] The UK Met Office held a "User forum for observations" in May at which participants were invited to present their requirements and priorities for observations collected by the Met Office. We are now invited to submit our requirements for VOS sampling, and we urgently need to define requirements in terms of numbers of observations and target accuracies for basic meteorological variables rather than mean flux values. Until this is done our requirements cannot easily be incorporated into observing system design either by the Met Office or other Meteorological Agencies.
Action: OOPC should urgently convene a small taskgroup to define VOS sampling and accuracy requirements for basic meteorological variables to meet surface flux uncertainty targets. ????? to report by end July ??????

is essential if we are to move towards a system which can meet the required range of objectives.

We need to avoid the perception that VOSClim with its minimum target of 200 ships will replace the full functionality of the VOS. Both VOS and VOSClim form part of the draft implementation of the Global Climate Observing System (GCOS, 2004). Monitoring the VOS from a climate perspective urgently needs to begin. The monitoring of VOS that is presently undertaken by NWP centres is designed to measure the quantity of observations and to identify gross errors in the data. Climate monitoring would require different information, for example the number and distribution of reports containing the variables required to calculate the four components of the heat flux to good accuracy (compared to the output of NWP models). In the past it has been possible to identify errors in models using VOS fluxes. We need to ensure that as models improve, the fluxes from VOS are of good enough quality for validation in regions away from dedicated surface flux reference sites.

Action: Encourage JCOMM to begin a dialogue with the operators of VOS fleets to ensure that the data collected continues to meet the requirements of the global climate observing system for high quality data from which the ocean surface exchanges of heat, moisture and momentum can be calculated. It is necessary to build on current monitoring of VOS weather reports to include assessment against the requirements of the global climate observing system alongside the monitoring for numerical weather prediction. This monitoring for climate is the essential first step towards raising the number of VOS that make climate quality observations.

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[8] June 2004: Now submitted

[9] Latest draft available from http://www.wmo.ch/web/gcos/GIP_Introduction.htm

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ANNEX IX
SST AND SEA ICE WORKING GROUP (WG) PROGRESS REPORT

Richard W. Reynolds
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NESDIS, NOAA, Asheville, NC, USA

The presentation summarized SST progress in several areas. However, this progress is no longer coming from the work directed by the WG. It is coming from associated groups such as the International Comprehensive Ocean-Atmosphere Data Set (I-COADS), the Workshops on Advances in Marine Climatology (CLIMAR) and the GODAE High Resolution SST Pilot Project (GHRSST-PP). It was suggested that it may be time to dissolve the WG. However, the OOPC stated that the goals of the WG differed from the other groups and that the WG should continue. In the sections which follow, SST progress is grouped under four topics. The work on sea ice was covered in a companion talk by Nick Rayner, UK Met Office.

1. GODAE High Resolution SST Pilot Project (GHRSST-PP)

Reynolds and Nick Rayner attended the Fourth Workshop in Pasadena, CA, USA, 22-26 September 2003. Reynolds will attend the next workshop in Townsville, Australia, 26-31 July 2004. The purpose of the group is to produce global, multi-sensor, high-resolution SST analyses. The Japanese (New Generation SST) project has been producing operational GHRSST analyses for ocean regions near Japan since 2002. Beginning in January 2004 a European (Medspiration project) GHRSST analysis has been available for the Atlantic and Mediterranean Sea. In addition an Australian (blueLINK project) has been funded for the ocean regions near Australia and a US (National Oceanic Partnership Program) proposal has been funded for global ocean GHRSST analyses. At present no intercomparison of analyses and in input data has been done. Furthermore there has been little verification of subjective decisions such as those needed to best balance high resolution infrared satellite SSTs with lower resolution microwave satellite SSTs.

2. SST results from the Second Joint Commission for Oceanography and Marine Meteorology (JCOMM) Workshop on Advances in Marine Climatology (CLIMAR-II), Brussels, Belgium on 17-22 November 2003.

The CLIMAR-II presentations on SST often satisfied recommendations from the Workshop on Advances in the Use of Historical Marine Climate Data held in Boulder, USA, in January - February 2002. One of the most important recommendations was to re-examine the historic bias corrections to SST, especially for the late 1930s through the end of the 1940s, and to include error uncertainties in analyses. Presentations at CLIMAR-II showed that bias corrections have been done for both the UK HadISST analysis and the NOAA/NCDC Extended Reconstruction SST version 2 (ERSST.v2) analyses. Error statistics are included in ERSST.v2 and are being added to the next version of HadISST.

3. Objective Evaluation of an In Situ Observing System for Climate SST

A method was developed at NOAA/NCDC to evaluate the adequacy of the current in situ (ship and buoy) network for climate SST analyses which use in situ and satellite observations. Because of the high spatial and temporal coverage of satellite data, in situ data are only necessary to correct any large-scale satellite biases. Simulations were used to define a potential satellite bias error as a function of in situ data density. Buoy data were simulated at different grid resolutions to show their ability to correct the satellite biases. The goal of this study was to define the in situ network which would reduce simulated satellite biases of 2C below 0.5C. Results of the simulations showed that a buoy density of two buoys on a 10º spatial grid was required. The present in situ SST observing system was evaluated to define an equivalent buoy density, which allows ships to contribute along with the buoys. Seasonal maps of the equivalent buoy density were computed to determine where additional buoys were needed. The results will influence future buoy deployments. In addition, average potential satellite bias errors could be computed from the equivalent buoy density. This allows the evaluation of the present in situ observing system for climate SST.

4. Other SST products

An Integrated SST and Land-Surface Temperatures (LST) analysis has been developed by NOAA/NCDC. This analysis combines separate analyses of SST and LST. The analysis of SST is ERSST.v2. The land analyses are derived from the NCDC Global Historical Climate Network (GHCN) temperature data. Global analyses with error estimates are produced on a global 5º grid beginning in 1880. The ERSST.v2 paper has been published as Smith, T. M., and R. W. Reynolds, 2004: Improved Extended Reconstruction of SST (1854-1997). *J. Climate*, **17**, 2466-247. The combined SST and LST paper has been submitted to the Journal of Climate as: Smith, T. M., and R. W. Reynolds, 2004: A global merged land and sea surface temperature reconstruction based on historical observations (1880-1997).

The UK Met office is producing new analyses using a more flexible gridding system with improved bias corrections. These analyses include sampling, measurement and bias-correction uncertainties at each grid value. A journal paper on these results is being prepared.

ANNEX X
LIST OF ACRONYMS

ACSYS	Arctic Climate System Study
ACVE	Atlantic Climate Variability Experiment
ADCP	Acoustic Doppler Current Profiler
ADEOS	Advanced Earth Observing Satellite (Japan)
ANIMATE	Atlantic Network of Interdisciplinary Moorings and Time
AOML	Atlantic Oceanographic and Meteorological Lab (NOAA)
AOPC	Atmospheric Observing Panel for Climate
Argo	profiling fleet network (not an acronym)
ASCAT	Advanced Scatterometer
ATOC	Acoustic Thermometry of Ocean Climate
ATSR	Along Track Scanning Radiometer
AUV	Autonomous Underwater Vehicle
AVHRR	Advanced Very High Resolution Radiometer
BC	Boundary Current
BECS	Basin-Wide Extended Climate Study
BMRC	Bureau of Meteorology Research Center (Australia)
BODC	British Oceanographic Data Center
BSH	Bundesamt fur Seerschiffahrt and Hydrographie (Germany)
CAS	Commission for Atmospheric Sciences
CAVASOO	Carbon Variaibility Studies by Ships of Opportunity
CDS	Computerized Documentation System
CLIC	Climate and Cryosphere
CEOS	Committee for Earth Observation Satellites
CGOM	IOC Consultative Group on Ocean Mapping
CLIMAT	Report of Monthly Means and Totals from Land Stations
CLIVAR	Climate Variability and Predictability Program
CMR	Centre Meteorologico Regional
CNES	Centre National d'Etudes Spatiales (France)
CRYOSAT	Ice Observing Satellite (ESA)
CSIRO	Commonwealth Scientific and Industrial Research Organization (Australia)
CTD	Conductivity, Temperature, Depth
DAC	Data Assembly Centre
DM	Data Management
DODS	Distributed Ocean Data System
ECMWF	European Center for Medium-Range Weather Forecasting
EEZ	Exclusive Economic Zone
ENSO	El Nino Southern Oscillation
ENVISAT	Environmental Satellite
EOS	Earth Observation Satellite (US)
ERS	Earth Resources Satellite
ESA	European Space Agency
ESD	Earth Sciences Division
EUMETSAT	European Organization for Exploitation of Meteorological Satellites
FNMOC	Fleet Numerical Meteorology and Oceanography Center (US NAVY)
GCOS	Global Climate Observing System
GDACS	Global Data Assembly Centres

GEBCO	General Bathymetric Chart of the Oceans
GEF	Global Environmental Facility
GEO	Global Eulerian Observing System
GEOSAT	Geodetic Satellite (US)
GEWEX	Global Energy and Water Cycle Experiment
GLAS	Goddard Laboratory of Atmospheric Sciences (US)
GLI	Global Imager
GMT	Greenwich Mean Time
GOCE	Gravity field and steady state Ocean Circulation Experiment
GODAE	Global Ocean Data Assimilation Experiment
GOOS	Global Ocean Observing System
COP	Conference of the Parties (to the UN FCCC)
GOSIC	Global Observation System Information Center
GOSSP	Global Observing Systems Space Panel
GPCP	Global Precipitation Climate Project
GPO	GCOS Project Office
GPS	Global Positioning System
GRACE	Gravity Recovery and Climate Experiment
GSC	GOOS Steering Committee
GTS	Global Telecommunications System
GTSPP	Global Temperature Salinity Profile Program
GUAN	Global Upper Air Network
G3OS	Shorthand for GOOS, GCOS, GTOS
HDX	High Density XBT Line
HOTO	Health of the Ocean Panel (of GOOS)
HOTS	Hawaii Ocean Time Series Station
IBCCA	International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico
IBCEA	International Bathymetric Chart of the Central Atlantic
IBCM	Int'l Bathymetric Chart of the Mediterranean
IBCWIO	International Bathymetric Chart of the Western Indian Ocean
ICESAT	Ice Satellite (NASA)
ICPO	International CLIVAR Project Office
IGOS	Integrated Global Observing Strategy
IGOSS	Integrated Global Ocean Services System
IGST	International GODAE Science Team
IHB	International Hydrographic Bureau
IHO	International Hydrographic Organization
IMO	International Maritime Organization
IOC	Intergovernmental Oceanographic Commission
IOCCG	International Ocean Color Coordinating Group
IOOS	Integrated Ocean Observing System (US)
IP	Implementation Plan
IPCC	Intergovernmental Panel on Climate Change
IR	Infrared
ISRO	Indian Satellite Research Organization
JAMSTEC	Japan Marine Science and Technology Centre
JCOMM	Joint Technical Commission On Oceanography and Marine Meteorology
JDIMP	Joint Data and Information Management Panel

JGOFS	Joint Global Ocean Fluxes Study
JMA	Japan Meteorological Agency
JSTC	Joint Scientific and Technical Committee
KERFIX	Kerguelan Time series Station
LMR	GOOS Living Marine Resources Panel
MERIS	Medium Resolution Imaging Spectrometer
METOP	Meteorological Operational Satellite
MJO	Madden-Julian Oscillation
MOC	Meridional Overturning Circulation
NAO	North Atlantic Oscillation
NASDA	National Japanese Space Development Agency
NCDC	National Climatic Data Centre
NCEP	National Center for Environmental Prediction (US)
NEG	Numerical Experimentation Group
NIWA	National Institute of Water and Atmospheric Research (New Zealand)
NOAA	National Oceanic and Atmospheric Administration (US)
NPOESS	National Polar-Orbiting Operational Environmental Satellite System (US)
NPP	NPOESS Preparatory Program
NSCATT	NASA Scatterometer
NWP	Numerical Weather Prediction
OCTS	Ocean Color and Temperature Scanner
OGCM	Ocean General Circulation Model
OGP	Office of Global Programs (US)
OOP	Ocean Observations Panel
OOPC	GOOS-GCOS-WCRP Ocean Observations Panel for Climate
OOS	Ocean Observing System
OSSE	Observing System Simulation Experiment
PBECS	Pacific BECS
PICES	Pacific ICES
PDO	Pacific Decadal Oscillation
PIRATA	Pilot Research Array in the Tropical Atlantic
PMEL	Pacific Marine Environmental Laboratory (of NOAA)
PMO	Port Meteorological Officer
POGO	Partnership for Observations of the Global Oceans
PRA	Principle Research Area (of CLIVAR)
QC	Quality Control
QSCAT	Version of Scatterometer
RMS	Root Mean Square
SAFZ	Sub-Arctic Frontal Zone
SBSTA	Subsidiary Body for Scientific and Technological Advice {of the COP for the UNFCCC}
SCOR	Scientific Committee for Oceanic Research
SIO	Scripps Institution of Oceanography
SLP	Sea Level Pressure
SMOS	Soil Moisture Ocean Salinity Satellite (ESA)
SOC	Southampton Oceanography Centre
SOC	Specialized Oceanographic Centre
SOCIO	Sustained Observations for Climate of the Indian Ocean
SOCSA	Sustained Observations for Climate for the South Atlantic

SOOP	Ship-of-Opportunity Programme
SSIWG	Salinity - Sea Ice Working Group
SSS	Sea Surface Salinity
SST	Sea Surface Temperature
SURFA	Surface Reference Sites Project
TAO	Tropical Atmosphere - Ocean (buoy array)
TEMA	Training Education and Mutual Assistance
TRITON	Japanese Moored Buoy in TMBN
TRMM	Tropical Rainfall Measuring Mission
TS	Temperature Salinity
UKMO	UK Met Office
UNFCCC	United Nations Framework Convention on Climate Change
UOP	Upper Ocean Panel
UOT	Upper Ocean Thermal
VAMOS	Variability of the American Monsoon Systems
VIIRS	Visible and Infra-red Sensor (NPOESS Sensor)
VOS	Voluntary Observing Ship
WBC	Western Boundary Current
WCRP	World Climate Research Program
WDB	WMO Data Base
WGASF	Working Group on Air-Sea Fluxes
WGNE	Working Group on Numerical Experimentation
WGSIP	Working Group on Seasonal to Interannual Predication
WHOI	Woods Hole Oceanographic Institution
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
WS	Workshop
XBT	Expendable Bathythermograph
XCTD	Expendable Conductivity Temperature Depth Instrument