

INTERNATIONAL COUNCIL
FOR SCIENCE

INTERGOVERNMENTAL
OCEANOGRAPHIC
COMMISSION

WORLD
METEOROLOGICAL
ORGANIZATION

WORLD CLIMATE RESEARCH PROGRAMME



Report of the Second Session of the Global Synthesis and Observations Panel

8 – 9 December 2006
La Jolla, CA, USA

August 2007

ICPO Publication Series No. 121
<http://eprints.soton.ac.uk/>

WCRP Informal Report No.12/2007

CLIVAR is a component of the World Climate Research Programme (WCRP). WCRP is sponsored by the World Meteorological Organisation, the International Council for Science and the Intergovernmental Oceanographic Commission of UNESCO. The scientific planning and development of CLIVAR is under the guidance of the JSC Scientific Steering Group for CLIVAR assisted by the CLIVAR International Project Office. The Joint Scientific Committee (JSC) is the main body of WMO-ICSU-IOC formulating overall WCRP scientific concepts.

Bibliographic Citation

INTERNATIONAL CLIVAR PROJECT OFFICE, 2007: Report of the 2nd Meeting of the Global Synthesis and Observations Panel. August. International CLIVAR Project Office, CLIVAR Publication Series No. 121. (not peer reviewed).

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ACTION ITEMS

ACTION: Develop data release specification, quality and timeliness for each major data stream (M. McPhaden, N. Caltabiano, D. Stammer)

ACTION: CCHDO and ICPO to strengthen contact with NODCs in order to facilitate flow of hydrographic data (ICPO, CCHDO)

ACTION: GSOP co-chairs to write to ICPO Director endorsing the JCOMMOPS Ocean Observation System Centre (GSOP co-chairs)

ACTION: Albert Fischer to circulate a JCOMM document that discusses the expansion of JCOMMOPS; GSOP co-chairs to comment on it. (A. Fischer, GSOP co-chairs)

ACTION: Produce a summary document on the needs for data streams timeliness, and submit an article to Exchanges (ICPO, GSOP co-chairs)

ACTION: White paper on CLIVAR datasets, identifying gaps and prioritise focus on data streams. Circulate to GSOP members for comments (D. Stammer, D. Roemmich, D. Behringer)

ACTION: Consult with David Anderson on his availability to be CLIVAR representative on the WOAP Task Group on data management, and report to WOAP. (D. Stammer)

RECOMENDATION: Rename the CLIVAR/Carbon Repeat Hydrography Programme to International Repeat Hydrography and Carbon Programme.

ACTION: Take the recommendation of change of name for the CLIVAR/Carbon Repeat Hydrography Programme to International Repeat Hydrography and Carbon Programme to the CLIVAR SSG via ICPO (M. Fukasawa)

ACTION: Suggested members of the International Repeat Hydrography and Carbon Advisory Group are approved by GSOP. Liaise with IOCCP (N. Caltabiano)

ACTION: Include list of ocean synthesis/re-analysis groups on the GSOP webpage, with link to their datasets (N. Caltabiano)

ACTION: Contact basin panels to review indices used in the ocean synthesis effort and encourage wider analysis (D. Stammer, ICPO)

ACTION: Start discussion of a strategy for ocean synthesis with group leads from the CLIVAR/GODAE Synthesis meeting (D. Stammer)

ACTION: GSOP to recommend to CLIVAR SSG the need of a carbon representative to GSOP (D. Stammer)

ACTION: Start plans to develop a small pilot project for joint synthesis activities between GSOP and the carbon community (D. Stammer, C. Sabine)

ACTION: Liaise with OOPC regarding a coordinated way of voicing the issues of sustainability of the ocean observing system (GSOP co-chairs)

ACTION: GSOP to start planning with ocean synthesis/reanalysis groups on the assimilation of IPY-generated datasets (D. Stammer, A. Weaver)

ACTION: Prepare a data requirements document with identification of needs and suggestion of specific tasks (D. Legler, D. Stammer)

ACTION: GSOP to endorse FSU activity of intercomparison of global fluxes (GSOP co-chairs to write to S. Smith)

ACTION: Include links to ocean heat and freshwater transport estimates on GSOP's webpage (N. Caltabiano, S. Josey)

ACTION: Forward to GSOP report of the US CLIVAR SSS Working Group (D. Legler)

ACTION: Include on GSOP webpage climate indices plots from ocean synthesis products (ICPO)

ACTION: Invite CLIVAR basin panels to provide the "top five" indices from observations and propose some new indices, in liaison with OOPC (ICPO)

ACTION: Write article to Exchanges on OOPC's State of the Ocean Climate (A. Fischer)

ACTION: Draft a white paper on the societal relevance of the ocean observing system and circulate to panel for comments (D. Roemmich, D. Stammer)

ACTION: GSOP co-chairs to write to Alex Ganachaud and Rick Lumpkin inviting them to develop the rationale for an ocean velocity workshop (GSOP co-chairs)

ACTION: Start consultation on organization of OceanObs0X with individuals identified at the meeting. Nico Caltabiano to send names list to Ed Harrison who would lead consultation. (N. Caltabiano, E. Harrison)

ACTION: Start consultation on name for GSOP co-chair as Dean Roemmich's replacement. (D. Stammer, ICPO)

1. INTRODUCTION

The Global Synthesis and Observations Panel (GSOP) was setup in 2004 with the task to oversee CLIVAR'S ocean synthesis and data management activities.

The Panel Terms of Reference are:

1. Develop, promote and seek to implement strategies for a synthesis of global ocean, atmosphere and coupled climate information through analysis and reanalysis efforts and through the use of other techniques where appropriate. Initial emphasis will be on global ocean synthesis efforts, building on previous experiences and developments.
2. Be responsible for the definition and fulfilment of CLIVAR's global needs for sustained observations (in collaboration with relevant WMO and IOC bodies, including GCOS, GTOS, GOOS, AOPC and OOPC, and JCOMM), and for the development of a strategy for their evolution/optimization based on new science and reanalysis insights, and fostering the use of resulting data sets in global synthesis efforts.
3. Promote activities to develop the surface flux data sets required by CLIVAR in liaison with the WGNE, global atmospheric reanalysis efforts and the WCRP Working Group on Surface Fluxes.
4. Provide an overview of and directions to CLIVAR data management and information activities in collaboration with other WCRP projects and in liaison with CLIVAR-relevant data centres and DACS and the ICPO.
5. Liaise and collaborate with CLIVAR Panels and Working Groups in identifying the requirements for and coordinating the development of an observing system for CLIVAR.

2. OPENING SESSION

2.1 Welcome and charge to the meeting

The Second Session of the Global Synthesis and Observations Panel was held at the Scripps Institution of Oceanography, La Jolla, USA on 8-9 December 2006. The meeting agenda can be seen in Appendix A. The panel co-chair and host, Dean Roemmich opened the meeting welcoming panel members and guests (Appendix B). Apologies were received from David Anderson, Phil Arkin, Simon Josey, Uwe Send, Neville Smith, Anthony Weaver, Susan Wijffels and Victor Zlotnicki. The panel would like to thank the Scripps Oceanography Institution for hosting this meeting, and WCRP and US CLIVAR for their financial support.

Dean Roemmich started saying that ocean observing system (OS) is evolving and perhaps there is a need for GSOP to focus on demonstrating the value of the OS. A key question to be addressed is how to increase, or at least keep, the level of funding for the ocean OS, which is at the moment, only 56% completed. Other issues to be considered: what pieces of the OS are going to continue to be developed? How do we convince funding agencies of its value and why do we need to keep it going? The statement that the coastal OS should be developed may be disadvantageous, in particular if it is detrimental to the development and maintenance of the oceanic OS. These are the issues GSOP should tackle. GSOP is not the only group that has interest in the ocean OS but it represents CLIVAR and should have a strong voice among the community.

2.2 Review of action items from GSOP-1

Detlef Stammer, GSOP co-chair, led the review of action items from GSOP's first session, which was held in Boulder (USA), on 10-12 November 2004. CLIVAR's data policy has been finalised and published (http://www.clivar.org/data/data_policy.php). Some of the ongoing actions regarding CLIVAR data, which would build on the data policy, are the development of a data release specification, quality and timeliness for each major data stream, and a data requirements white paper. These activities were revisited during the discussion on CLIVAR's data management issues.

ACTION: Develop data release specification, quality and timeliness for each major data stream (M. McPhaden, N. Caltabiano, D. Stammer)

One pressing issue concerns data release, and the existing confusion about when and where to release hydrographic data. Argo, as a partner in CLIVAR, would like to have access to good quality data in a timely fashion to be used for instrument calibration. There is a need to strongly encourage PIs to submit data quickly to their National Oceanographic Data Centres (NODCs). The CLIVAR and Carbon Hydrographic Data Office (CCHDO), with help from the International CLIVAR Project Office (ICPO), needs to make sure that a good relationship is developed with NODCs so that good quality data should flow through the system.

ACTION: CCHDO and ICPO to strengthen contact with NODCs in order to facilitate flow of hydrographic data (ICPO, CCHDO)

The ocean reanalysis evaluation project is underway, with a white paper produced by D. Stammer and T. Lee. A CLIVAR/GODAE Meeting on Ocean Synthesis Evaluation was held at ECMWF, UK, in August 2006. There still a need to further develop a list of ocean synthesis/re-analysis groups on GSOP webpage, and make sure to include links to their datasets.

2.3 Report from CLIVAR SSG and CLIVAR Roadmap

Following the review of GSOP-1 action items, Detlef Stammer gave a brief report of the outcomes of the Fourteenth Session of the CLIVAR Scientific Steering Group (SSG-14), and presented the structure of the CLIVAR Roadmap as discussed during that meeting. The main issue that the CLIVAR Roadmap addresses are CLIVAR deliverables up to CLIVAR's sunset date in 2013. The Roadmap centred its discussion on the following themes: ENSO and other modes of variability, Monsoons, Decadal Variability and the Thermohaline Circulation, Anthropogenic Climate Change (ACC), Modelling, and Ocean Observations and CLIVAR Legacy.

GSOP can make significant contributions to these themes, in particular to the Decadal Variability and the Thermohaline Circulation theme, where ocean reanalysis will play an important role. A sustained OS is a message that GSOP has to voice in order to help with this theme. GSOP is clearly the lead in the Ocean Observations and CLIVAR Legacy theme. The delivery of the best quality climate dataset will be part of CLIVAR's legacy and GSOP needs to identify a way in accomplish this.

Some action items from SSG-14 were identified to be relevant to GSOP. Below a list of the SSG-14 action items and GSOP decisions:

- **Lend CLIVAR support to the campaign to create an Ocean Observation System Centre**

Albert Fischer explained the background to the creation of this centre as discussed by JCOMM. This centre would be an expansion of JCOMMOPS, and it would develop to become a real operational support centre that would help with the implementation. The panel discussed this item and agreed to endorse it. However it would also suggest that it should include some scientific management besides the oversight function. It was agreed that Albert Fischer would forward a document with details on this centre for comments to be taken to JCOMM.

ACTION: GSOP co-chairs to write to ICPO Director endorsing the JCOMMOPS Ocean Observation System Centre (GSOP co-chairs)

ACTION: Albert Fischer to circulate a JCOMM document that discusses the expansion of JCOMMOPS; GSOP co-chairs to comment on it. (A. Fischer, GSOP co-chairs)

- **Remind CLIVAR researchers of the need to submit all data in real time for model evaluation.**

The panel has agreed that this builds on GSOP's initiative on data management and agreed to follow it up with a summary of the needs for data stream timeliness.

ACTION: Produce a summary document on the needs for data streams timeliness, and submit an article to Exchanges (ICPO, GSOP co-chairs)

- **GSOP to identify and coordinate development of CLIVAR reference data sets, including error bars where possible, and develop ideas on how to make them widely accessible**

This item was the subject of recent input to the Second meeting of the WCRP Observations and Assimilation Panel (WOAP) via a paper. Detlef Stammer also reminded the panel that NCEP and ECMWF are developing fields of uncertainties for their products. During the CLIVAR/GODAE Synthesis Evaluation meeting at the ECMWF in August 2006, there was no explicit request from participants for CLIVAR reference datasets. David Legler pointed out that one of the reasons is that there is no clean dataset and the only dataset back to the 50s is the Levitus dataset. There was a lively discussion on this issue, with some participants calling attention to the fact that CLIVAR does not have the mandate to deliver datasets since it is not funded to do that. However, for CLIVAR to succeed, there is a need to identify what are the gaps on the data system and what can be done to improve this situation. Some participants also called for better entrainment of the CLIVAR Data Assembly Centres (DACs), which could facilitate this task.

ACTION: White paper on CLIVAR datasets, identifying gaps and prioritise focus on data streams. Circulate to GSOP members for comments (D. Stammer, D. Roemmich, D. Behringer)

- **GSOP to work with Atlantic Panel on Atlantic synthesis in cooperation with IOCCP**

Chris Sabine gave a brief overview of the Initial Atlantic Ocean Carbon Synthesis Meeting, sponsored by IOCCP and CARBOOCEAN, and held in 28-30 June 2006, in Laugarvatn, Iceland. He pointed out that despite this activity, the carbon community is not ready yet to assimilate of their datasets into models, however data synthesis activities are being developed. Detlef Stammer reminded the panel that physical community should entrain the carbon community in assimilation activities. One step forward was provided by Doug Wallace's participation at the last CLIVAR/GODAE Synthesis Evaluation meeting at ECMWF. The panel agreed to have a better discussion during Chris Sabine's presentation to the panel later in the meeting (see Section 4.1).

- **Develop plans for an "OceanObs 200X" and consult potential sponsors regarding sponsorship. To be seen as the CLIVAR SSG's annual workshop programme devoted to the Oceans' role in climate; include issues such as the Ocean Observations Data Centre and measurement of ocean currents and transports**

These items had a dedicated slot on the agenda and were discussed there (see Section 7).

- **Establish need for a hydrography planning and oversight group with reference to outputs from the recent Hydrography workshop. ICPO to continue its support to the international hydrography and carbon research community.**

This item had a dedicated slot on the agenda and were discussed there (see Section 3.4).

- **Ask Basin panels and other working groups to analyse ocean synthesis products and feedback to GSOP**

Detlef Stammer pointed out that following the CLIVAR/GODAE Synthesis Evaluation meeting at ECMWF, there is a vast number of datasets to be analysed, although there are several problems identified among the products. However, panels should be encouraged to make the most of these datasets and provide feedback to GSOP.

ACTION: Contact basin panels encouraging the use of ocean synthesis outputs (ICPO)

3. REPORT OF ACTIVITIES SINCE GSOP-1

3.1 Report of OOPC-11

Albert Fischer, Technical Officer for the Ocean Observation Panel for Climate (OOPC), reported on OOPC's Eleventh Session, held in Tokyo, Japan in May 2006. OOPC shaped input from the ocean research community into an ocean chapter of the GCOS Implementation Plan (GCOS-92). OOPC has also contributed to a GCOS supplement on satellite requirements (GCOS-107). Through the Committee on Earth Observation Satellites (CEOS), the world's space agencies are currently preparing a coordinated response to the needs and requirements set out by GCOS. CEOS keeps track of space agencies' plans and how they respond to GCOS

requirements/needs. However, transforming GCOS requirements into actions is a difficult task. Research funding is not sustained and there is a need to coordinate work with agencies and countries for continuation of funding streams. The development of climate products is an important step to show the value of the OS.

OOPC believes that a new strategy for XBT observations needs to be set in light of the success of the Argo programme and because changes in shipping activities have made some of the lines a challenge to be kept operational. OOPC thinking is that this Upper Ocean Review should take place after a significant period of overlap between the two systems, with some time for analysis of the dataset. A possible target is the year of 2008, but it is worth reviewing this in context of all Voluntary Observing Ships (VOS) operations (met, fluxes, pCO₂).

One of the activities that OOPC is planning for the near future is a joint OOPC/GODAE Observing System Evaluation (OSE) and Observing System Simulation Experiments (OSSE) workshop, planned initially for November 2007 in Paris. It plans to use GODAE systems to improve understanding of data utility and provide preliminary recommendations for optimization of the observing system, with the understanding that utility depends on the desired end product and on model design. A question to be addressed is whether ocean climate analyses/reanalyses would be ready to make a contribution to the workshop. David Legler asked if one of the aims is to share results of optimization of the OS for assimilation? Albert Fischer confirmed that this would be one of the aims. Mike McPhaden pointed out that the Indian Ocean Observing System is an example of a good work between modellers and observationalists. In the planning stages, models were used to show areas in that region which are over- or undersampled.

Albert Fischer also gave OOPC's thinking of the organisation of a major conference in ocean observation, a follow up to the OceanObs99 held in St. Raphael, France in 1999. The GCOS Steering Committee has strongly recommended OOPC to move forward with this activity, and it is expected that the GOOS Scientific Steering Committee will also endorse it. It also has support from the chair of the WCRP Joint Scientific Committee (JSC). Some of possible objectives of this activity would be to show the achievements of the integrated ocean observing system: observations, analysis, services, the evolution of the observing system, both in situ and satellite, major advances in scientific knowledge from the ocean OS, and achievements in ocean products and services. It could besides focus on challenges and opportunities, and reaffirm the way forward, including commitments to current plans and increasing funding for sustained observations now funded by research. This item had a dedicated slot on the agenda and the panel decided to further discuss it at the appropriate time (see Section 7).

3.2 WOAP-2

Detlef Stammer, CLIVAR representative to WOAP, reported on WOAP's Second Session, held on 28-30 August 2006, in Ispra, Italy. WOAP has four task groups: Reanalyses, Data Management, Reprocessing and GEO Items. On GEO, WOAP-2 members made a recommendation to send a message to GEO stressing the need to use the GCOS IP and follow-on satellite supplement as the main guideline for climate tasks in the 2007-2009 GEO workplan, and include a message on funding for climate activities.

Regarding data activities, a recommendation was made that the WMO Information Systems should be publicised within the WCRP community and should be considered by all projects. A matrix on data management (policy, meta data, web site), prepared by T. Koike in preparation for WOAP-2 needs to be validated and completed. One issue is the general data management within WCRP. All existing efforts were developed independently, but these need to be homogenized to ensure synergies. A WOAP Task Group on data management has been setup, chaired by Norm McFarlane. It will review the status and management of observational data and model output archives, including web sites within WCRP, and will make recommendations for WCRP-wide overarching structure, site contents and data policy. It will be composed of one member from each of the core-projects, besides representatives from GCOS and the WCRP Modelling Panel (WMP). GSOP as the oversight group for data management in CLIVAR has been tasked with identifying a CLIVAR representative to this task team. The group discussed this issue and suggested David Anderson.

ACTION: Consult with David Anderson on his availability to be CLIVAR representative on the WOAP Task Group on data management, and report to WOAP. (D. Stammer)

On reanalysis issues, WOAP endorsed plans for the 3rd International Reanalysis Conference to be held in Tokyo, Japan, on 28th January to 1st February 2008, recommending support by WCRP and GCOS as well as GEO. A. Simmons and K. Trenberth were tasked to write an EOS article about atmospheric reanalysis workshop to publicise the benefits and importance of reanalysis for climate research. A working group, led by WCRP and GCOS will address issue of “development of improved observational data sets for reanalysis”.

3.3 WCRP Sea Level Workshop

The WCRP Workshop on Understanding Sea-level Rise & Variability was held in Paris on 6-9 June 2006, aimed at (i) identifying the uncertainties associated with sea-level rise and variability, as well as the research needed to narrow these uncertainties; and, (ii) supporting the Global Earth Observation System of Systems (GEOSS) by helping develop international scientific consensus for the observations needed to address these uncertainties. Stan Wilson, co-chair of the organising committee gave an overview of the main scientific results and recommendations made by the workshop participants, which can be found on the workshop’s Summary Statement (http://wcrp.ipsl.jussieu.fr/Workshops/SeaLevel/Reports/Summary_Statement_2006_1004.pdf).

The future of satellite missions important for monitoring sea level rise are very much dependent on the USA, and in particular NASA. The continuation of Jason-type mission could be done by a development of Jason-3 or a large swath altimetric mission. For surface vector winds, Windsat does not meet the requirements for operational data, and there is a great concern that there will be gaps in the satellite system since QuikSCAT is entering its 8th year with no follow-on identified.

The workshop showed that since 1992, global mean sea level is rising at a rate of 3.2 +/- 0.4 mm/yr based on tide gauges and satellite altimeters. For the previous century, the trend was about 1.7 +/- 0.3 mm/yr based on tide gauges. Current estimates of thermal expansion over the first decade of altimetry account for about half of the observed rise, but only about a quarter over the previous half-century.

Axel Timmermann enquired if there is really a good understanding the spatial variability of sea level rise, and the relation between patterns of sea level rise to other modes of variability. This is an important aspect since in order to separate anthropogenic impact, there is a need to understand the natural variability of sea level rise. Stan Wilson confirmed that there is a good understanding of these aspects though this remains an ongoing topic of research,. What it is important to further explore are other relative aspects of sea level rise, e.g. subsidence, occurring on a regional scale, so that impacts can be better monitored.

3.4 International Repeat Hydrography Workshop

Masao Fukasawa presented the outcomes of the International Repeat Hydrography Workshop held on 14-16 November 2006 in Shonan Village, Japan, and sponsored by CLIVAR and IOCCP. The workshop promoted an overview of the CLIVAR-Carbon Repeat Hydrography Program after 1990, in addition to the ongoing national ocean observation programmes. The workshop also assessed the current programme and plans of repeat hydrography in each ocean basin. It concluded that a new strategy is needed in light of advances in technology and linkages with other international observation programmes, e.g. Argo and GEOTRACES.

Although it is recognised that ship-based hydrography alone cannot meet the science goals, it is still remains the only means of directly measuring the full suite of water properties at high vertical resolution. A core set of measurements has been recommended, with WOCE-level of precision and accuracy. Participants, however, were aware that not every country is capable of achieving ship-based hydrography which would follow these guidelines, and therefore would be considered complementary to define the repeat hydrography programme as a global network. Also, at international level, it seems appropriate to redefine the name of the CLIVAR/Carbon Repeat Hydrography. Participants agreed and made a suggestion that and appropriate definition would be the ” International Repeat Hydrography and Carbon Programme”. GSOP members agreed with this change of name and recommend it to be taken to the CLIVAR SSG.

RECOMENDATION: Rename the CLIVAR/Carbon Repeat Hydrography Programme to International Repeat Hydrography and Carbon Programme.

ACTION: Take the recommendation of change of name for the CLIVAR/Carbon Repeat Hydrography Programme to International Repeat Hydrography and Carbon Programme to the CLIVAR SSG via ICPO (M. Fukasawa)

The workshop participants felt that there is a need to establish a small advisory group, with representatives from CLIVAR, IOCCP, the SOLAS/IMBER Carbon Implementation Group and Argo, which would develop a cohesive and comprehensive programme. Names put forward to participate on this advisory group were: Masao Fukasawa, Bernadette Sloyan, Greg Johnson, Arne Koertzinger, Niki Gruber and Chris Sabine. Roger Dargaville (IOCCP Programme coordinator) and Nico Caltabiano (ICPO Staff Scientist) would provide oversight and technical support. GSOP members agreed with these names but requested that if any additional members are invited, previous consultation with GSOP should take place.

ACTION: Suggested members of the International Repeat Hydrography and Carbon Advisory Group are approved by GSOP. Liaise with IOCCP (N. Caltabiano)

3.5 CLIVAR/GODAE Meeting on Ocean Synthesis Evaluation

Detlef Stammer gave an overview of the CLIVAR/GODAE Meeting on Ocean Synthesis Evaluation held on 31 August to 01 September 2006 at the ECMWF, Reading, UK. The main goals of this meeting were (i) to evaluate the quality and skill of available global synthesis products and determine their usefulness for CLIVAR; (ii) to identify the common strength and weakness of these systems and the differences among them, as well as to identify what application can be best served by what synthesis approach; (iii) to define and test climate-relevant indices that in the future should be provided routinely by ongoing or planned synthesis efforts in support of CLIVAR and of the wider community; and, (iv) to define climate data standards required for CLIVAR syntheses.

Individual ocean synthesis efforts were asked to compute indices from their results prior to the workshop and make them available to the project for further evaluation by theme leads chosen before the meeting. Input had been solicited from individual CLIVAR basin panels regarding metrics and indices for global reanalyses and the identification of CLIVAR reference data sets. The evaluation effort was based on results available from the period 1950 to present, including those that cover the TOPEX/JASON-1 era. During the meeting, other aspects related to ocean synthesis were discussed, such as CLIVAR Data Sets, the CLIVAR Surface Flux Reference Data, a discussion of data and error Requirements, the CLIVAR/GODAE metrics for ocean analysis, and data archiving.

Leads presented the intercomparison results of the chosen eight themes (RMS Model-Data Misfits, Meridional Transports, Heat and Salt Content, Sea Level Changes, Transports through Key Regions, Water Masses, Indices and Surface Fluxes) to the meeting participants. The main outcomes of the meeting were:

- A quantitative statement of the skill of available global synthesis products and their usefulness for CLIVAR.
- Identification of common strengths and weakness of systems and the differences among them.
- Prototype synthesis support of global and regional CLIVAR research (this will be extended as work progresses).
- A basic set of recommendations with regard to future synthesis resource planning.
- Recommendations for CLIVAR data processing and management.
- GSOP Web site to present climate indices from ocean syntheses over last 50 years (counter part to OOPC indices from data alone).
- Stimulation for WGOMD and IPCC to join in.

GSOP members noted that differences between some of the solutions are very large. There is a need to be careful about what is useful for a particular purpose. Detlef Stammer agreed with this and informed the panel that further meetings are being planned to understand the differences so that better agreement among ocean synthesis products can be achieved. GSOP members suggested that CLIVAR basin panels be invited to review the indices used in the ocean synthesis efforts. CLIVAR basin panels should also be reminded that these datasets are available and should be encouraged to use them. The panel also suggested that the

CLIVAR/GODAE Meeting on Ocean Synthesis Evaluation group leads should start a discussion of a strategy for the future of the ocean synthesis evaluation project.

ACTION: Include list of ocean synthesis/re-analysis groups on the GSOP webpage, with link to their datasets (N. Caltabiano)

ACTION: Contact basin panels to review indices used in the ocean synthesis effort and encourage wider analysis (D. Stammer, ICPO)

ACTION: Start discussion of a strategy for ocean synthesis with group leads from the CLIVAR/GODAE Synthesis meeting (D. Stammer)

4. SCIENCE TALKS SESSION

4.1 Global Carbon and Synthesis needs

Chris Sabine, chair of the International Ocean Carbon Coordination Project (IOCCP), gave a talk on “A global ocean carbon observing network: inventories, fluxes and processes”. He noted that the carbon community, although with datasets very organised, does not use the same approach used by ocean synthesis/reanalysis efforts. There have, however, been three basic approaches: inventories, fluxes and processes. The uncertainties observed during the WOCE/JGOFS era were greatly reduced with increase of observations, and post-WOCE observations which were focused on the North Atlantic and North Pacific up to 2006. The CLIVAR/CO₂ Repeat Hydrography Program is approximately 50% complete and on schedule to finish its first global survey by 2012.

Observational synthesis activities organised by the carbon community have been initiated. The Atlantic Ocean Synthesis started in June 2006 with a meeting in Iceland, and led by CARBOOCEAN. Few CLIVAR representatives attended the Iceland meeting, but it has been recognised that there is a need for a larger synthesis meeting, which would focus on merging physical and carbon datasets. The Pacific Ocean Synthesis was initiated at the PICES meeting in October 2006, and the Indian Ocean Synthesis was discussed at the Sustained Indian Ocean Biogeochemical and Ecological Research (SIBER) workshop in October 2006. This group is moving forward and plans to transform this activity into a programme. Synthesis is clearly starting to emerge as a dominant theme in the carbon community and there is a need to know how synthesis is being organized within CLIVAR and what opportunities are there for collaboration. Detlef Stammer noted that most of the synthesis activities are being developed through assimilation of datasets and perhaps the basin panels should be more actively involved in developing observational synthesis activities. David Legler questioned if regional synthesis is the correct approach. Ideally global synthesis should be the final goal but maybe regional activities are where it should start. Martin Visbeck noted that the right approach is not necessarily regional but it is where the critical mass can be found.

Surface pCO₂ measurements have a large network (VOS, research cruises, moorings) but it has been done on an *ad hoc* basis. There are, however, plans to start a more combined approach. Existing and planned NOAA pCO₂ moorings are designed to build on the OceanSITES reference flux sites. Chris Sabine also noted that there is no assimilation of pCO₂ datasets into models, but the concept in the carbon community is to use multiple platforms to produce seasonal CO₂ flux maps. Chris Sabine also showed how successful the inclusion of an oxygen sensor on Argo floats can be in order to estimate carbon changes. A group of experts interested on this approach has been formed and is in the process of finalising a white paper which will address technical and financial aspects on the addition of an oxygen sensor on Argo floats. It is clear that adding this sensor would certainly reduce floats' lifetime and more floats would need to be deployed to cover for this reduced lifetime.

To finalise his presentation, Chris Sabine enquired if there is still need for carbon representatives on all of the CLIVAR basin panels or if it makes more sense to coordinate through a broader group, like GSOP. Some of the basin panel representatives found that members of the carbon community in the basin panels have been very effective in demonstrating the science. However, in practice, collaborations have been slow to emerge. Basin panels should be encouraged to engage carbon representatives, with list of questions and problems and identify what they in turn would need from the physical side. Perhaps a representative at

GSOP would be more appropriate if both communities aim for global synthesis, and GSOP members wish to make this a recommendation to the CLIVAR SSG.

ACTION: GSOP to recommend to CLIVAR SSG the need of a carbon representative to GSOP (D. Stammer)

However, the real question is how can proactive steps be taken to actually move possible collaborations forward? The carbon community would like to see some priority on the CLIVAR side so that these interactions could really happen. There is a need to encourage the communities to work together from the planning stages, with submission of joint proposals. Members of the carbon community should be invited and be more present during CLIVAR synthesis meetings. In the mean time, a plan for a small pilot project should be developed to encourage joint synthesis activities.

ACTION: Start plans to develop a small pilot project for joint synthesis activities between GSOP and the carbon community (D. Stammer, C. Sabine)

4.2 Global Heat Content

Josh Willis gave a presentation on “Global Ocean Heat Content”. Measuring the ocean's heat content is important for understanding sea level rise as well as the Earth's response to global climate forcing. The ocean's heat content is about 20 times larger than the atmospheric one. The historical record shows that from 1955 to 1988 there was an approximate increase of about 14.5×10^{22} J. This has clear implication for sea level, with recent rates of sea level rise being almost an order of magnitude larger than historic rates. The global mean rate of sea level rise from 1880 to the present is about 1.7 mm yr^{-1} . From 1955 to the present, the rate due to thermal expansion is about 0.4 mm yr^{-1} , which leaves about 1.3 mm yr^{-1} of sea level rise, presumably due to changes in ocean mass.

Recent studies of globally averaged upper-ocean heat content from profile data have shown that in the top 750 metres, from 1993, the warming rate is of about $0.36 \pm 0.15 \text{ Wm}^{-2}$. However, from 2003 to 2005, the trend has been negative, at about $-1.0 \pm 0.10 \text{ Wm}^{-2}$. This has indicated that the ocean cooled. This trend was initially thought to be part of natural variability as happened in the early 80s. Coupled models with prescribed historical greenhouse gas concentrations can recreate features of the most recent warming, but none of these models contain interannual variability of the magnitude observed by this cooling. Recent investigations have found that the recent cooling of the upper ocean is an artefact resulting from two different instrument biases discovered in the in situ data, rather than actual climate variability.

Assimilation runs that could reconcile processes like thermal expansion would be a great help in understanding the long term variability of the ocean heat content more. Quick availability of a high quality-controlled hydrography data is essential in order that early evaluation of the Argo data can be done.

4.3 Shallow overturning in the Pacific

Mike McPhaden gave a presentation on “Decadal Variability and Trends of the Pacific Shallow Meridional Overturning Circulation and Their Relation to Sea Surface Temperature”. This work is part of the US CLIVAR Coupled Model Evaluation Project (CMEP), which aims at diagnosing the quality of climate model simulations, and understanding and assessing the uncertainty of the future climate change projections. Its particular focus is on using existing observational datasets for evaluating 20th century simulations (20C3M).

One hypothesis for the Pacific Decadal Climate Variability is that, on decadal time scales, tropical Pacific temperature anomalies are determined by the rate at which the subtropical circulation cells transport thermocline water towards the equator. So are any observed warming trends in the Tropical Pacific induced by the increase of greenhouse gases? Some previous generation computer models suggested anthropogenic forcing of sea surface temperature trends in the tropical Pacific. However, models are sensitive to specification of poorly understood physical processes, and not all models give the same results.

In this study was observed a weakening trend of the shallow overturning (interior STC) of -11 Sv over the past 50 years, but the circulation fluctuates significantly on decadal time scales, with decade-to-decade variations of $8\text{-}12 \text{ Sv}$ about the trend. The models exhibit decadal variations in pycnocline volume transport,

but the magnitude of the variability is underestimated. As in observations, significant correlation exists between meridional transport convergence and tropical SST in the majority of the models, indicating an important role for ocean circulation in tropical Pacific SST variability on decadal time scales. Most models show no trend in transport convergence and underestimate the trend in the eastern tropical Pacific SST, and none showed a significant cooling trend. These trends are apparently not directly related to the shallow overturning. There is a suggestion that the simulated trends could be due to greenhouse gas forcing, using global air temperature trends as a proxy for that forcing.

Eddy permitting MIROC is the only model that reasonably reproduces the observed trend in transport convergence and eastern tropical Pacific SST over the last half century. Could this be because of its higher resolution? If the observed trends and those simulated in the MIROC model are ultimately related to greenhouse gas forcing, these results suggest that the changing shallow overturning may enhance warming that arises from anthropogenic forcing in the eastern tropical Pacific.

The panel noted that this work and similar studies would be very important as input for the AR5, as much as reanalysis. Maybe the next generation of models would have more correspondence.

4.4 Trends in mid-latitude ocean circulation

Wenju Cai gave a presentation on the circulation trends of the Southern Hemisphere Ocean, and presented a set of results linking them with the increasing CO₂, Antarctic ozone depletion, and anthropogenic aerosols. He showed that although increasing CO₂ and Antarctic ozone depletion over the past decades have induced similar changes in circulation, ozone depletion appears to be the major forcing, particularly in the summer season. These changes feature a strengthening of the circumpolar westerlies and a weakening of the midlatitude westerlies extending from the stratosphere to Earth's surface. The surface wind changes forced a southward shift and spin-up of the super-gyre, which links the subtropical South Pacific, Indian and Atlantic Ocean circulation, advecting more warm water southward. The circulation change includes a strengthening of the East Australian Current (EAC) flow passing through the Tasman Sea. The southward shift of the EAC represents a strong mechanism for the observed unusually large warming in the Tasman Sea and may contribute to the reported range extension to the south of many marine species in the South West Pacific (for more details, see Cai, W. (2006), Antarctic ozone depletion causes an intensification of the Southern Ocean super-gyre circulation, *Geophys. Res. Lett.*, 33, L03712, doi:10.1029/2005GL024911.) The role of Antarctic ozone depletion on the Southern Hemisphere subtropical gyre circulation was further highlighted through an analysis of more than 70 20th century simulations from the WCRP/Intergovernmental Panel of Climate Change (IPCC) Fourth Assessment (AR4) model archive at PCMDI (Cai, W. J., and Cowan T. (2007). Trends in Southern Hemisphere circulation in IPCC AR4 models over 1950-99: Ozone-depletion vs. greenhouse forcing. *Journal of Climate*, 20 (4), 681-693).

The concept of a subtropical super-gyre in the Southern Hemisphere was discussed and Wenju Cai presented evidence that it plays an important role in the global conveyor, which is the large-scale oceanic current associated with the North Atlantic overturning. A quantitative reconstruction of the conveyor using a Lagrangian diagnosis based on hundreds of thousands of water parcel trajectories clearly shows that the supergyre is involved in organizing the path of the return-flow to the North Atlantic.

Although manmade aerosols are mainly concentrated in the Northern Hemisphere, they strongly affect the Southern Hemisphere ocean circulation. Aerosols (fine particles) tend to have a mitigating effect on greenhouse gas-induced climate warming because they scatter incoming solar radiation. Through global climate model experiments forced with and without manmade aerosols, Wenju Cai and colleagues showed that, although aerosol cooling at the surface is greater in the Northern Hemisphere, the increasing level of aerosols in the 20th century induced a pan-oceanic heat redistribution. This involved a reduction in Southern Hemisphere oceanic heat content as heat was transported to Northern Hemisphere oceans. In this way, manmade aerosols suppressed sea level rise in the Southern Hemisphere as much as that in the Northern Hemisphere, including a strengthening in northward cross-equatorial heat transport in the Atlantic and Pacific oceans, with Atlantic currents associated with global oceanic overturning playing a major role. The implication is that as manmade emissions of aerosols decrease due to environmental regulations, the mitigating effect of this oceanic heat transport will decrease, exacerbating expected slowdowns of Atlantic Ocean overturning, and acceleration of sea level rise in the Southern Hemisphere (for more details, see Cai,

W., D. Bi, J. Church, T. Cowan, M. Dix, and L. Rotstayn (2006), Pan-oceanic response to increasing anthropogenic aerosols: Impacts on the Southern Hemisphere oceanic circulation, *Geophys. Res. Lett.*, 33, L21707, doi:10.1029/2006GL027513.)

4.5 Climate Impacts of Subantarctic Mode Water (SAMW) and Antarctic Intermediate Water (AAIW): Pathways to a better understanding

Bernadette Sloyan showed results concerning the simulation of Subantarctic Mode Water and Antarctic Intermediate Water in climate models. The eight climate models considered by this study include GFDL-CM2.1, CCSM3, CNRM-CM3, MIROC3.2(medres), MIROC3.2(hires), MRI-CGCM2.3.2, CSIRO-Mk3.0, and UKMOHadCM3. All provided their output in support of the Intergovernmental Panel on Climate Change's Fourth Assessment report (IPCC AR4) and have been compared to the Commonwealth Scientific and Industrial Research Organization (CSIRO) Atlas of Regional Seas. The climate models, except for UKMO-HadCM3, CSIRO-Mk3.0 and MRI-CGCM2.3.2, provide a reasonable simulation of SAMW and AAIW isopycnal temperature and salinity in the Southern Ocean. Many models simulate the potential vorticity minimum layer and salinity minimum layer of SAMW and AAIW, respectively. However, the simulated SAMW layer is generally thinner and at lighter densities than observed. All climate models display a limited equatorward extension of the SAMW and AAIW north of the Antarctic Circumpolar Current. Errors in the simulation of SAMW and AAIW property characteristics are likely to be due to a combination of many errors in the climate models including simulation of wind and buoyancy forcing, inadequate representation of sub-grid scale mixing processes in the Southern Ocean, and mid-latitude diapycnal mixing parameterizations.

Finally initial results of Thorpe scale based mixing estimates were presented for the Southeast Pacific. Antarctic Intermediate Water is formed near the Subantarctic Front predominantly in the Pacific sector of the Southern Ocean. While air-sea fluxes, Ekman transport and cross-frontal mixing are suggested to set the characteristic properties of Antarctic Intermediate Water, the relative importance of any one process on the formation of the water mass is still poorly understood. During austral spring (2005) and summer (2006) hydrographic surveys in the southeast Pacific observed the formation of Antarctic Intermediate Water and subsequent restratification of the water column, respectively. The vertical and spatial distribution of turbulent eddy diffusivity, estimated from density inversion in the CTD and XCTD profiles has been examined, to investigate the importance of mixing on the formation of Antarctic Intermediate Water and compare this formation process with convection driven by air-sea fluxes. Significant density overturns and diffusivity determined from Thorpe scales are confined to the Antarctic Intermediate Water mass layer in both the winter and summer survey, and are much more energetic during the austral spring.

5. BASIN PANEL UPDATES ON THE OBSERVING SYSTEM

5.1 Atlantic Panel

Martin Visbeck gave an overview of the present situation of the observing system in the Atlantic region. These observations will help the Atlantic Panel to address some of the CLIVAR science topics, such as the North Atlantic Oscillation, the Tropical Atlantic Variability and the Meridional Overturning Circulation. The panel's strategy is to have a coordinated approach for observation, modelling and synthesis, all in association with other programmes and CLIVAR panels.

XBT profiles have been taken in most of the repeat lines with data are probably released in real time. The surface drifter network has a good coverage of the region, with exception to the Tropical Atlantic. This issue has been taken to OOPC who will communicate it to DBCP. The number of Argo floats has increased rapidly in the region, which now seems to have a complete appropriate coverage. Repeat Hydrography proceeds in a coordinated fashion between CLIVAR and CARBON needs. A major survey was done in 2003-05 but there is an issue of estimating what would be the "right" frequency of repeat. This is an issue that the Atlantic Panel is encouraged to investigate. The Carina dataset has been released, with appropriate quality control but it is not completely publicly available.

One of the Panel's major activities is the coordination of the Tropical Atlantic Climate Experiment (TACE), which aims to advance understanding of coupled ocean-atmosphere processes and improve climate prediction for the Tropical Atlantic region. The TACE core period spans for six years, from 2006/7 to 2011/12. The PIRATA array also plans enhancements, which include a northeast extension, the Brazilian southwest extension, and a southeast extension in the Benguela Current area. A significant number of research and sustained fixed point measurements exist but their continuity for the lifetime of CLIVAR is not guaranteed. GSOP could help in voicing the issues of sustainability of the ocean observing system, in a coordinated way with OOPC. The proposal for RAPID-WATCH (a follow up of the RAPID Programme) has also been submitted to the UK Natural Environment Research Council (NERC) with a funding period to cover 2007 to 2014. Several activities are also being developed in the Arctic region, mainly the development of iAOOS (international Arctic Ocean Observing System). Perhaps one issue for GSOP is to engage with the coordination of IPY and provide a voice for the continuity of funding for the Arctic Ocean observing system after IPY.

ACTION: Liaise with OOPC regarding a coordinated way of voicing the issues of sustainability of the ocean observing system (GSOP co-chairs)

5.2 Indian Ocean

Mike McPhaden reported on the development of the Indian Ocean Observing System (IndOOS) which the international CLIVAR and GOOS communities have developed plans for. The CLIVAR/GOOS Indian Ocean Panel (IOP) was established for 3 years in 2004 with a key objective to develop an implementation strategy for an Indian Ocean Observing System to support climate analysis and forecasting. Following the CLIVAR SSG-14 in April 2006, the IOP was established as a permanent CLIVAR basin panel to continue guiding implementation of the observing system. It subsequently published "The role of the Indian Ocean in the climate system: an implementation plan for sustained observations" (http://eprints.soton.ac.uk/20357/01/IOP_Impl_Plan.pdf).

The array design is based on observing, understanding, and predicting key ocean and climate phenomena that have significant socio-economics impacts on countries surrounding the basin and that affect global climate variability, and works as an integrated, sustained and multi-platform network. Emphasis of the array is on the ocean, but will provide surface met data as well, and implementation is underway with contributions from several nations. Two process studies in the region that are taking place in 2006-07 (MISMO and CIRENE) will both benefit from and contribute to the array. Argo floats are on target for full implementation of the required 480 floats in the region, and XBT lines are likely to have full implementation, with exception to IX10. The newest component of the observing system is a basin scale moored buoy array, which had its design supported by numerical model observing system studies. The moored array has initial investments from the U.S., India, Japan, Indonesia, and France.

There are however many challenges to full implementation (fishing vandalism, ship time, funding, etc.) but success promises significant scientific and societal benefits. There are opportunities for cooperative interdisciplinary studies leveraging investments from both physical and biogeochemical research communities, and in particular between CLIVAR and SIBER. Discussions are also ongoing with the tsunami warning system community to develop multi-hazard platforms and coordination of logistics.

5.3 Pacific Ocean

Axel Timmermann, chair of the Pacific Implementation Panel presented a report on the activities of the panel, as well as plans for observations and processes studies in the region. The panel has identified some key scientific thrusts such as the tropical Pacific cold tongue, westerly wind bursts and its interactions with ENSO, the variations of ENSO and interaction with the annual cycle, Pacific multidecadal variability, vulnerabilities of present observing systems and model biases. The panel has also contributed with an extensive list of metrics, which was requested from CLIVAR Basin Panels prior to the CLIVAR/GODAE Meeting on Ocean Synthesis Evaluation.

Several countries in the region have made large contribution to the development of the OS in the region, with extensive plans for the coming years. China has deployed about 100 Argo floats in Western Pacific and Eastern Indian Ocean during 2002-2006. Then in each following year, about 20 floats are to be deployed for

the network's operation in normal conditions. China will also have a complete coastal hydrographic mapping during 2006 to 2008. Japan is redesigning and developing a prototype of a new Argo float, besides inclusion of biochemical sensors in some of the floats.

Two large process studies are being developed in the region. First, in the Southeastern Pacific, VOCALS (VAMOS Ocean-Cloud-Atmosphere-Land Study) has been funded and will start with its field activities in October 2007. VOCALS has been endorsed by the CLIVAR Pacific panel and aims at targeting some questions regarding different hypotheses for the origin of warm model biases in the Southeastern Pacific. These warm biases might be due to under-represented stratus cloud-SST feedbacks, lack of ocean eddies, or problems in simulating the strength of oceanic Tsuchiya jets that upwell near the Peruvian coast. Second, in the Southwestern Pacific, SPICE (Southwest Pacific Ocean Circulation and Climate Experiment) is in its planning stages. It aims at understanding the dynamics of the southwestern boundary currents as well as their influence on climate. It will have a large field experiments component as well as a modelling component. GSOP could make a contribution to these two programmes in providing guidance on what would be the best way to feed their datasets to the international stream.

Axel Timmermann also suggested that GSOP encourages experts on process studies to evaluate the different ocean synthesis products, focusing on ENSO instability, ENSO-annual cycle interactions, tropical instability waves and heat transports. Also, it would be interesting if the GSOP ocean synthesis evaluation activity could encourage the assimilation of climate paleo-proxies. Detlef Stammer reminded the panel that there is already an action item that all basin panels will be invited to evaluate the synthesis products and feedback to GSOP.

5.4 Southern Ocean

Sarah Gille reported activities of the CLIVAR/CliC/SCAR Southern Ocean Panel on behalf of the panel's co-chairs. The Southern Ocean Panel aims to design a strategy to assess climate variability and predictability of the coupled ocean-atmosphere-ice system in the Southern Ocean region, and to develop and refine an implementation plan for the Southern Ocean region which defines the process studies, sustained observations, and model experiments needed to meet the objectives of CLIVAR, CliC and SCAR. The Panel is actively involved with the observing system in the Southern Ocean during IPY, and several process studies are underway, some with a sustained effort.

Based on an assessment of IPCC runs, the Southern Ocean panel has identified that some indices, such as total Drake Passage transport, are of limited use. However stratification and watermass indices (e.g. north-south density differences) will be key for the region, and watermass benchmarks for climate models are needed. The panel has also identified other key indices. Detlef Stammer noted that all panels will be invited to review indices as suggested previously to the CLIVAR/GODAE Meeting on Ocean Synthesis Evaluation. The Southern Ocean Panel has also identified several problems with ocean synthesis and reanalysis products regarding air-sea fluxes. A better assessment is needed of fluxes and errors in the Southern Ocean region. Atmospheric reanalysis has also several problems in the region, and there are some efforts for development of regional atmospheric reanalysis products, with a boundary layer component to improve fluxes. These efforts also plan to produce a validation and assessment of the quality of air-sea flux products in the Southern Ocean region. Although some components already exist, international efforts are not coordinated.

IPY will provide a data-intensive period during 2008-2009 and regional analyses are planned but a synthesis of global scope is needed to address heat and freshwater transports at the largest scales. The Southern Ocean Panel would request GSOP to support a focused effort to produce a global ocean synthesis that incorporates IPY period data. This of course would need support of IPY related groups such as SCAR to create data archives and access. Detlef Stammer again reminded the panel that there is already an action item that all basin panels will be invited to evaluate the synthesis products and feedback to GSOP. However, synthesis and reanalysis groups should be encouraged to assimilate the IPY-generated dataset and extend their product availability.

ACTION: GSOP to start planning with ocean synthesis/reanalysis groups on the assimilation of IPY-generated datasets (D. Stammer, A. Weaver)

5.5 Arctic Ocean/IPY

Vladimir Ryabinin, from the Joint Planning Staff for WCRP, gave an overview of observations in the Arctic Ocean and plans for IPY. There are several programmes developing activities in the Arctic Region, and good research is being done. However, there is a strong need for a better coordination of those activities, as well as better data sharing. CliC has developed its Data and Information Service for CliC (DISC) and is seeking to encourage submission of data to appropriate data centres, but most of the data still resides with PIs.

In September 2006, GOOS, in cooperation with GCOS and WCRP has setup a Memorandum of Understanding on an Arctic GOOS Regional Alliance, which will be led by EuroGOOS. The Secretariat will be held at the Nansen Centre and the main objectives will be the development of an Arctic sustained observing and climate product plan, and the implementation of this plan during IPY. One of the first steps will be the establishment of a Portal for Arctic Ocean data and products. The US and Europe have also set up the Arctic Observing Network and DAMOCLES programmes, respectively, which will make a contribution towards the observing system in the Arctic during IPY. The International Arctic Buoy Programme continues to be developed and data will be held and MEDS, Canada.

Vladimir Ryabinin stressed that there is a continuing need to establish a distributed data archive with an inventory of existing oceanographic data for the Arctic Ocean. The panel discussed this issue but felt that this would be a task for CliC since it is the most appropriate body in WCRP to deal with this issue.

6. INDICES AND DATASETS SESSION

6.1 Review of CLIVAR data sets and data centres

David Legler gave an overview of the present status of the CLIVAR Data Assembly Centres (DACs) and CLIVAR datasets. In any programme, the objectives of data management are to enhance data flow from to the community, to perform quality control checks in order to remove biases, to add metadata to aid in climate signal detection, and to develop products, which would be useful to the scientific community. In CLIVAR, 12 DACs can be identified, responsible for 9-10 streams of data. Outside CLIVAR, another large number of activities with data management components can be identified, e.g. Argo, OceanSITES, Marinemetaddata.org, etc. Some of these activities have finite lifetime, others have funding secured for longer with momentum.

Regarding data management planning, several plans and strategies are being developed, such as the US IOOS/DMAC Data Management strategy, JCOMM Data Management strategy, and the IOC Data Management strategy. Within the WCRP, WOAP has established a Task Group on data management. However, implementation of these strategies remains unclear at the moment.

David Legler reported that he had contacted all the CLIVAR DACs and requested that they sent a brief summary of their status of activities. Most of the DACs replied to this request confirming that they continue to operate as data assembly centres. However, some of these centres are not conducting data quality control activities, or only focus on their country's datasets, mainly due to funding policies. Data flow from PIs or NODCs to some of these centres is slow. Some comments received were based on the perception that CLIVAR seems to be little interested in the operation of DACs. In some of the centres, progress on their activities is not a priority within the institutional host due to a perceived lack of interest in data management by CLIVAR. Most of the CLIVAR DACs commented that they do need support and commitment from CLIVAR for their data management activities, including setup of regular meetings between DACs representatives.

In his assessment of data management issues in CLIVAR, David Legler noted that many groups are now involved in data management activities and CLIVAR is not in a position to lead progress in those practices. The CLIVAR SSG and CLIVAR panels are not in position to oversee global data management activities at a working level, thus any proposed activities will need to be clearly tied to CLIVAR science goals. CLIVAR must recognize that many groups must participate in data management activities to address CLIVAR needs. Therefore, CLIVAR needs to identify and focus support on a few clearly defined products and objectives. One of these activities could be 50-yr integrated database, comprising quality-controlled data from several sources, e.g., XBT, CTD, Argo, with specified attributes for purposes of producing 50-yr ocean reanalyses

suitable for detecting changes or initializing coupled climate forecasts. CLIVAR'S role could also be in helping data streams that are non operational or routine and supported through research programs (e.g. hydrography, salinity) to follow a set of best practices and perhaps, when appropriate, to move towards becoming operational eventually.

The proposed recommended actions concerning CLIVAR's data management are:

- Clarify and communicate CLIVAR's level of commitment to coordinating and supporting data management activities;
- Identify a GSOP member, or request help from ICPO, who has the time, knowledge, and interest to take an the active role for data management issues;
- Identity a few desired products/needs, which would be part of the CLIVAR legacy, and include these in the "data requirements" document (GSOP-1 action item - to be completed)
- Develop a resource that lists observation deployments (short-term and long-term) and encourage PIs to forward the data from these efforts to national and international centres
- Identify how/when some mature DACs should move to the care of another group or programme involved with data management.

The panel discussed on this issue extensively. It is clear that CLIVAR's commitment and support need to be transmitted to the DACs. The "Data Requirements" whiter paper would certainly give some feedback to the DACs. There is resource problem, which makes it important that a focused activity, with identification of gaps, should be defined. GSOP needs to put a case to the CLIVAR SSG or ICPO that there is a need for increased manpower effort on data management since it is an important activity. Once a focus activity (e.g., 50-year reanalysis) is identified with its associated needs, a request should be made to the DACs in order that they could identify their contribution to that particular activity.

ACTION: Prepare a data requirements document with identification of needs and suggestion of specific tasks (D. Legler, D. Stammer)

6.2 Flux evaluation guidelines

Following a recommendation from the first GSOP meeting, a white paper entitled "Guidelines for Evaluation of Air-Sea Heat, Freshwater and Momentum Flux Datasets" was completed. Shawn Smith, who co-authored this white paper with Simon Josey, reported on the motivation and recommendation made within the white paper.

Since there is a wide range of flux datasets currently available from ship, satellites, atmospheric reanalyses, a certain degree of confusion has arisen. It is unclear which dataset provides the most accurate representation of air-sea exchanges. Since the advent of ocean synthesis/reanalyses products, another class of flux data have been added to this mixture. Some of the flux datasets currently available have very limited evaluation (Large and Yeager, 2004) while others (NOC Climatology; OAFflux) have adopted a range of measures in order to evaluate the product. However, a standard flux evaluation method is still needed for common comparison of flux fields and identification of biases. Several sources provide data that can be used for flux evaluation. Research buoy data come primarily from moored buoys providing flux time series from 4 months to 2-3 years. There are a limited number of moorings to date but a global array of surface flux reference sites is planned under OceanSITES. Research vessel data can provide shorter time series (1-2 months) of the same variables as measured by buoys plus some direct turbulent flux measurements. Research vessel data are not so heavily used as buoys due to short time series and inhomogeneous data management, but the SAMOS project aims to improve data access. Also, for the Southern Ocean, research vessels are the best platform for getting flux data. A catalogue of flux products is available under "Related products" at <http://www.coaps.fsu.edu/RVSMDC/FSUFluxes/>

The mooring and vessel data allow several flux evaluation methods to be used which combine techniques developed in a range of previous studies. Local evaluation compares co-located research quality data to identify biases in gridded fields. This method needs to consider both meteorological variables (SST, air temperature and humidity, wind speed) as well as the heat flux components. Regional evaluation uses reference data provided by hydrographic estimates of the heat and freshwater transport across typically zonal

sections within a basin. The main problem is that there is no central archive of heat and freshwater transport estimates and this would be highly desirable. Global evaluation relies on the understanding that the global mean net heat flux must be close to zero on long timescales. Other evaluation methods are possible but some would require more development, e.g. rain gauges, Argo.

The white paper makes the following recommendations:

- All gridded flux products should provide fields of meteorological parameters (Q, T, SST, winds) to facilitate product comparison
- Products should document turbulent flux algorithms used
- Create a single resource (on-line archive) of ocean heat and freshwater transport estimates
- Develop 6-hourly and monthly averages of in-situ meteorological and flux observations from reference data sets

The panel discussed these recommendations. It is clear that a standard dataset is needed but its generation is difficult and require funding. Florida State University (FSU) is developing an activity on intercomparison of global fluxes and the panel agreed to endorse it. Another very important item is the development of an on-line archive of ocean heat and freshwater transport estimates. Perhaps it would be useful to start with links to these estimates from the GSOP webpage and develop from there once a data centre is identified to hold the archive.

ACTION: GSOP to endorse FSU activity of intercomparison of global fluxes (GSOP co-chairs to write to S. Smith)

ACTION: Include links to ocean heat and freshwater transport estimates on GSOP's webpage (N. Caltabiano, S. Josey)

6.3 Sea Surface Salinity

The panel briefly discussed the issue of Sea Surface Salinity (SSS) in light of the planned launch of two satellite missions dedicated to measuring SSS. GSOP could coordinate some activities and track data availability. Some of the scientific questions that have been asked are: How does SSS affect climate? Why is it an important variable? In order to address these questions properly, a global, long-term network is needed. To date, there is no science programme aimed to answer these climate questions. However there are no identified global observations that could support such programme. Argo observations have had a large impact on products originating from data assimilation and is a very good start. Chris Sabine also noted that salinity directly impacts how much CO₂ the ocean can take up. One technical issue is the accuracy that those satellite missions will deliver. The SMOS objective is to have accuracy better than 0.1 PSU, with 10 days to monthly grid scale (200 km). Knowing that single measurement will be less accurate (~1 PSU), spatial and temporal averages will be needed to reduce the noise. Aquarius accuracy is 0.2 PSU in monthly averages at 100 km resolution.

The US CLIVAR Program has started a SSS Working Group, and organised a workshop at Woods Hole on 8-10 May 2006. A report is being prepared and will be forwarded to GSOP when ready.

ACTION: Forward to GSOP report of the US CLIVAR SSS Working Group (D. Legler)

6.4 OOPC/CLIVAR climate indices

Albert Fischer presented an overview on the OOPC's State of the Ocean Climate website (http://ioc3.unesco.org/oopc/state_of_the_ocean/). This tool serves as an evaluation of the observing system, by estimating the uncertainty in the measure of climate indices or quantities that act as indicators of climate variability, and working towards a measure of our ability to observe. In the long term, the development of ocean forecasting and ocean reanalyses, and observing system simulation experiments (OSSEs) will provide specific feedback. Another objective of this activity is to serve as a way to communicate information about the ocean observing system and the ocean's role in climate and climate variability to the community. It also acts as a one-stop-shop for users to obtain the datasets linked to those indices.

The indices presented on the webpage are surface ocean indices, atmospheric teleconnection indices and subsurface indices. They are updated every two weeks and include the current value of the indices, as well their monthly tendency. Some sea-ice indices presented are from external websites that have sea ice products, based on a variety of data sources and algorithms. The website has had an increasing visibility, and has links from the IOC and CLIVAR websites.

Albert Fischer noted that there is considerable scope for developing the website, including:

- Information about the impacts associated with the index - patterns of climate variability, links between indices, changes in rainfall, even historical examples; with references
- more subsurface indices: upper ocean heat content, mixed layer / thermocline depth, MOC, transports like ITF, mode waters, salinity changes, taking advantage of time series (mooring, repeat XBT) with improved uncertainty estimates
- sea level indices (including dynamic indices from altimetry)
- composite indices (ex: hurricane index - combination of ocean heat content and atmospheric conditions)
- sea ice indices
- indices specific to the polar regions
- more information/better links about the observing networks contributing to the calculation of the indices

Following the CLIVAR/GODAE Meeting on Ocean Synthesis Evaluation, there is a good momentum for this work to be done in closer collaboration with GSOP. It would be a good opportunity to see real-time indices compared with the long record of past variability, and also the calculation of indices based on quantities difficult or impossible to calculate from data alone. CLIVAR basin panels have already previously provided a list of indices which was used during the CLIVAR/GODAE Meeting on Ocean Synthesis Evaluation. This list reflects different approaches taken by each basin panel. It would be useful to get CLIVAR basin panel input on the ‘top 5’ indices which could be used for public consumption. If information about the impacts associated with the index is displayed, there will also be a need to reach a consensus on the wording, with appropriate references.

The panel acknowledged this important task led by OOPC and discussed how GSOP could work closely with and build on this activity. Following the CLIVAR/GODAE Meeting on Ocean Synthesis Evaluation, GSOP should provide on its webpage, plots showing comparisons of data and synthesis, and information on the products. GSOP should also invite the basin panels to provide “top-5” indices to be used for public consumption. Basin panels could also be invited to propose some indices which would be placed on an “expert page”. Comments would be accepted before being placed on the “public page”. In order to increase the visibility of the OOPC’s State of the Ocean Climate to the CLIVAR community, it was suggested that Albert Fischer write an article to CLIVAR Exchanges.

ACTION: Include on GSOP webpage climate indices plots from ocean synthesis products (ICPO)

ACTION: Invite CLIVAR basin panels to provide the “top five” indices from observations and propose some new indices, in liaison with OOPC (ICPO)

ACTION: Write article to Exchanges on OOPC’s State of the Ocean Climate (A. Fischer)

6.5 Ocean observations and societal relevance

Dean Roemmich led a discussion on ocean observations and their societal relevance. Should GSOP take the initiative and put an argument of the value of the OS for society? There was an action item from First GSOP Meeting to draft a white paper on the Socio-economic relevance of ocean observations and opportunity was taken to discuss the structure this paper should take. A possible structure could be to demonstrate the value of the observing system to global observations of climate generally, attribution of climate change signals, subseasonal-to-decadal prediction, and rapid climate change detection. Stan Wilson noted that one of the goals of such a paper should be to demonstrate to funding agencies how important the actual observing system is, and that without it, most of the actual understanding in climate would not be achieved.

Axel Timmermann noted that the CLIVAR Pacific Panel has produced a document on societal impacts and that it could start the discussion. Detlef Stammer highlighted that one of the motivations is that with a large number of ocean synthesis products available, it is now possible to describe the impacts of the ocean on climate. This could help to stimulate the community to discuss the topic. Wenju Cai pointed out that in Australia, the justification for the observing system is to improve predictability and as input to policy, therefore GSOP should use this paper to show that the climate problem as an economic one.

GSOP should aim to publish this paper in EOS, where the audience is the scientific community. But the end goal would be to capture the support of large organisations that can fund observing system initiatives.

ACTION: Draft a white paper on the societal relevance of the ocean observing system and circulate to panel for comments (D. Roemmich, D. Stammer)

7. FUTURE PANEL ACTIVITIES SESSION

The panel has previously discussed the possibility in organising a workshop on Ocean Velocity. The rationale behind this workshop would be to bring the community together review and further develop requirements for this measurements. Some of the panel members noted that perhaps this issue is not a high priority on the list of basin panels, asking if GSOP should focus on ocean boundary currents and gather the interest of the community before committing to a workshop on large-scale ocean velocity.

A design of an observing system for the western boundary currents is very dependent on the regional details, and therefore it would be very difficult to have a generic design. It can be done but GSOP would need to identify experts and what is needed in all these areas. The panel identified Alex Ganachaud and Rick Lumpkin as two experts that could develop the rationale for such a workshop. It should be stated that initially, this workshop should be organised without the need of financial support from CLIVAR, i.e. organisers should try to attract external sources of funding. If not possible, it should be organised jointly with next GSOP meeting.

ACTION: GSOP co-chairs to write to Alex Ganachaud and Rick Lumpkin inviting them to develop the rationale for an ocean velocity workshop (GSOP co-chairs)

Another future activity that the panel considered was the proposal for a follow on conference to the OceanObs99 one.

The participants had an extensive discussion on the plans for such an international conference on Ocean Observations. The discussion centred in identifying the focus for such event. It was recognised that it is time to demonstrate to society the real value of ocean observations, in addition to monitoring ocean biogeochemistry, ecosystem and fisheries. Such conference should also focus on challenges and opportunities, reaffirming commitments to current plans, with a view to seeking increasing funding for sustained observations now funded by research.

The panel suggested a list of potential scientists who should be consulted before foundations for such large event are laid out. Suggested names are: Dean Roemmich, Detlef Stammer, Chris Sabine, Richard Lampitt, Pete Strutton, Lisa Goddard, Bob Weller, John Church, Satish Shetye, Pierre-Yves Le Traon, Tommy Dickey, Toshio Sanyo. It was suggested that OOPC should take the lead on the organisation, with closer support from CLIVAR. The panel agreed therefore that Ed Harrison, OOPC's chair should make the initial contact with these individuals. A potential timeframe for the conference would be end of 2009, with some workshops, e.g. UOT review, Velocity workshop, in the run up for it.

ACTION: Start consultation on organization of OceanObs0X with individuals identified at the meeting. Nico Caltabiano to send names list to Ed Harrison who would lead consultation. (N. Caltabiano, E. Harrison)

8. PANEL BUSINESS

The panel discussed its membership and noted that Dean Roemmich is due to rotate off as co-chair on 31st December 2007 but would be willing to continue as a panel member. A process will be initiated by Detlef Stammer and the ICPO Director to identify a new name for co-chair.

ACTION: Start consultation on name for GSOP co-chair as Dean Roemmich's replacement. (D. Stammer, ICPO)

APPENDIX A

Second Global Synthesis and Observations Panel meeting, La Jolla, CA, USA., 08 - 09 December 2006

AGENDA

FRIDAY, DECEMBER, 8:

- 8:00 Reception, coffee
- 8:30 Welcome and charge to the meeting (Dean. Roemmich)
- 8:45 Review of action items from GSOP-1 (Detlef Stammer)
- 9:15 Report from CLIVAR SSG and CLIVAR Roadmap (Detlef Stammer)
- 9:45 Discussion

10:15 COFFE BREAK

REVIEW OF ACTIVITIES SINCE GSOP-1

- 10:40 OOPC-11 (Albert Fischer)
- 11:00 WOAP-2 (Detlef Stammer)
- 11:20 WCRP/COPES Sea Level Workshop (Stan Wilson)
- 11:40 Repeat Hydrography Workshop (Masao Fukasawa)

12:00 LUNCH BREAK

- 13:00 CLIVAR Synthesis Workshop (Detlef Stammer)
- 13:20 Discussion

SCIENCE DISCUSSIONS

- 14:00 Global Carbon and Synthesis needs (Chris Sabine)
- 14:30 Global heat content (Josh Willis)
- 15:00 Discussion

15:30 COFFE BREAK

- 16:00 Shallow overturning in the Pacific (Mike McPhaden)
- 16:30 Trends in mid-latitude ocean circulation (Wenju Cai)
- 17:00 Climate Impacts of Subantarctic Mode Water and Antarctic Intermediate Water: Pathways to a better understanding (Bernadette Sloyan)
- 17:30 Discussion
- 18:00 Adjourn

SATURDAY, DECEMBER, 9

- 8:00 Reception, coffee

BASIN PANELS UPDATE OF THE OBSERVING SYSTEM

- 08:30 Atlantic (Martin Visbeck)
- 08:50 Indian (Mike McPhaden)
- 09:10 Pacific (Axel Timmermann)
- 09:30 Southern Ocean (Sarah Gille)
- 09:50 Arctic Ocean / IPY (Vladimir Ryabinin)

10:10 COFFE BREAK

- 10:40 Review of CLIVAR data sets and data centres (David Legler)
- 11:10 Flux evaluation guidelines (Shawn Smith)
- 11:40 Discussion

12:00 **LUNCH BREAK**

13:00 Sea Surface Salinity (Detlef Stammer)
13:30 OOPC/CLIVAR climate indices (Albert Fischer)
14:00 Ocean observations and societal relevance (Dean Roemmich)
14:30 Discussion

15:00 **COFFE BREAK**

15:30 Future activities
Velocity workshop
Upper Ocean Thermal Review
OceanObs0X

16:30 Review of final actions
17:00 Panel business (future meetings, membership)
17:30 End of meeting

APPENDIX B

LIST OF ATTENDEES

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APPENDIX C

PANEL MEMBERS

| NAME | AFFILIATION |
|---------------------------|---|
| Dean Roemmich (co-chair) | Scripps Inst. of Oceanography, La Jolla, USA |
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| Phil Arkin | University of Maryland, USA |
| David Behringer | NOAA NCEP, Camp Springs, USA |
| Masao Fukasawa | JAMSTEC, Yokosuka, Japan |
| Simon Josey | National Oceanography Centre, Southampton, UK |
| Mike McPhaden | NOAA PMEL, Seattle, USA |
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| Neville Smith | Bureau of Meteorology, Melbourne, Australia |
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