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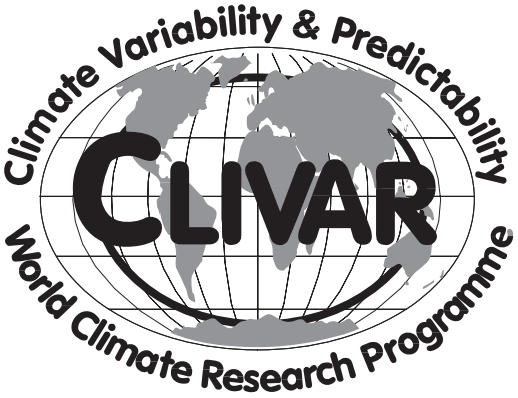

Report of the First Session of the CLIVAR Global Synthesis and Observations Panel (GSOP).

Millennium Hotel, Boulder, Colorado, 10-12 November 2004.

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Actions and Recommendations

Data management, data quality, requirements for DACs.

1 ACTION: Draft a data requirements whitepaper (3-6 months) (D. Legler, S. Wijffels, D.Stammer, N. Smith, A. Weaver, V. Zlotnicky, J. Carton, David Anderson)

2 ACTION: Develop elements of a data quality and assembly project (D. Legler, N. Smith to lead)

3 ACTION: Highlight importance of hydrographic data release at next POGO meeting (J. Gould)

4 ACTION: Write terms of reference for Ad Hoc group to address issues of Global Hydrography coordination including data release (J. Gould)

5 ACTION: Hydrography Tracking (DIU) activity is needed (also a DPM Action) - Seek resources (Ad Hoc Hydro group)

6 *RECOMMENDATION*: Revisit the suggestion of an Upper Ocean thermal review at the next meeting, based on a specific proposal (GSOP Panel)

7 ACTION: Articulate motivation, format, and source sponsorship for a meeting to review the Upper Ocean Thermal network (E. Harrison/ OOPC, N. Smith, B. Molinari)

8 *RECOMMENDATION*: Altimeter and Wind measurements are key climate measurements - their utility needs to be highlighted (sea level rise, S-I forecasting) and the need for them to be continued.

9 ACTION: Draft letter to agencies and highlight concern about the uncertain future of Altimeter and satellite wind data for climate research. (GSOP/SSG Chairs)

10 ACTION: Edit draft data principles and submit to SSG for approval and distribution (M. McPhaden, N. Smith, V. Zlotnicky, K. Richards)

11 ACTION: Develop data release specification, quality and timeliness for each major datastream - McPhaden to draft outline (GSOP members)

12 ACTION: Write guidelines for process studies and highlight relevance/importance to wider CLIVAR activities (N. Smith)

13 ACTION: Request information on data release and management specifications from process study P.I's through Basin panels (K. Richards, K. Speer, M. Visbeck, G. Meyers)

14 *RECOMMENDATION:* Ensure that information on CLIVAR data requirements, management and CLIVAR DACs is disseminated to the community.

15 ACTION: Seek ways of better informing the CLIVAR community of data management policy, DACs, and data management activities. (Article/issue of Exchanges?) (ICPO to explore)

16 ACTION: Contact Breck Owens for status of analysis of WOCE Era Ocean Circulation (D. Roemmich)

17 ACTION: Organize a workshop to articulate CLIVAR requirements for direct measurements of ocean circulation. (N. Smith and GSOP chairs to nominate WG participants in addition to P. Niiler, M. McPhaden, U. Send)

18 ACTION: Provide oceanography examples which illustrate the need for reprocessing of satellite data and submit to WOAP for advocacy (Zlotnicki)

19 ACTION: Write a letter to GLOSS to recommend that barometric pressure be included in the suite of measurements at sea level stations (GSOP Chairs)

(II) Reanalysis and intercomparison.

20 ACTION: Draft white paper on guidelines for reanalysis intercomparisons (in 3-6 months) in partnership with GODAE, Basin panels need to provide input. WGOMD needs to be a part of this. (N. Smith, Stammer, T Lee, D. Anderson, D. Behringer, A. Weaver, K. Richards, M. Visbeck, K. Speer, S. Wijffels)

21 ACTION: A representative of GSOP to sit on WGOMD (Stammer)

22 ACTION: Over next year – test out results in pilot intercomparison. (N. Smith, Stammer, T Lee, D. Anderson, D. Behringer, A. Weaver, K. Richards, M. Visbeck, K. Speer, S. Wijffels)

23 *RECOMMENDATION*: CLIVAR Reanalysis products will be available in 2009 (in time for the 5th IPCC Assessment Report)

24 ACTION: Explore subsurface Ocean Indices possibilities from observations and reanalysis products in partnership with ETCCDMI (B. Sloyan, D. Anderson, D. Stammer, T. Lee)

25 ACTION: Develop ocean reanalysis website with information on guidelines, requirements and pointers to ocean reanalysis efforts. Input required from panel members. (T. Lee, ICPO to discuss)

(III) Surface fluxes and standards

26 *RECOMMENDATION*: Evaluation of Forcing flux datasets: New flux datasets used to force ocean reanalyses should be evaluated against surface flux reference site measurements.

27 ACTION: Write to groups who develop flux fields (S. Josey, D. Stammer)

28 *RECOMMENDATION*: Ocean Reanalysis fluxes: All future ocean reanalysis fluxes should be evaluated against research quality data (flux buoys, research vessels), in addition to large scale constraints (e.g. heat transport), to determine whether reanalysis has led to improvements (individual reanalysis groups).

29 ACTION: Develop guidelines/recommendations for evaluating ocean reanalysis fluxes (Josey, S. Smith).

30 *RECOMMENDATION*: GSOP recommends that one of the activities of the recently formed WCRP WGSF should be an evaluation of flux products developed since the report of the WGASF.

31 ACTION: GSOP representative required as point of contact with WGSF to raise this issue (S. Josey).

32 ACTION: All datasets should be listed on CLIVAR data pages. Guidance is needed on high priority datasets. (ICPO)

33 ACTION: Present the need (in support of Ocean Reanalyses) for best quality wind and wind stress fields for 1950-2004 to the NASA Ocean Vector Wind Scientific Team (OVWST) and enlist their help. (D. Legler)

(IV) Other actions:

34 ACTION: Draft a paper on Socio economic relevance of GSOP, circulate to panel comment, and then submit to SSG (D. Stammer)

35 ACTION: Highlight issues associated with research/operations interface at the next POGO meeting. (D. Roemmich)

36 ACTION: Write to NASA and NOAA to highlight concern about transfer of satellites from research to operations (V. Zlotnicky, D. Stammer)

1. Introduction

The first GSOP meeting followed on immediately from the CLIVAR Reanalysis workshop held at NCAR from the 8-10th November 2004. The workshop was organized and run under GSOP and addressed various issues related to ocean reanalysis. The meeting outcomes that need to be followed up were reviewed during the GSOP meeting. Because the workshop focussed mostly on assimilation/reanalysis, the GSOP meeting spent more time on observation and data issues, including the sustained observing system and quality issues of data for reanalysis.

1.1. Welcome

To open the meeting the local host, Dr Kevin Trenberth, Head of the NCAR Climate Analysis Section and member of the WCRP JSC, welcomed the panel to Boulder, and outlined local arrangements. GSOP Co-Chair Dean Roemmich then outlined modifications to the agenda to make room for more discussion on synthesis issues in light of the outcomes of the Ocean Reanalysis Workshop. The participants in and agenda for the meeting are at Appendices 1.1 and 1.2. (All appendices will be found at www.clivar.org/organization/gsop/implementation/gsop_1.html

1.2. CLIVAR and the ICPO – News

Ms Katy Hill, CLIVAR staff support for GSOP, outlined the overall structure of CLIVAR, role of the project office and recent developments in the International CLIVAR Project. A key highlight was the 1st International CLIVAR Science Conference held in June of this year in Baltimore, titled "CLIVAR 2004: Understanding and Predicting our Climate System." This was a tremendous success with around 650 registered participants from 56 countries, and nearly 700 science posters on show. Unfortunately, this year also saw the departure of Dr Andreas Villwock from the project office, CLIVAR's longest serving staffer who has worked for the project since its conception 8 years ago. This leaves a gap in the expertise at the project office, and the Director, Dr Howard Cattle is currently focussing on securing continuing funding for the project office from the UK and US, as well as other sources.

1.3. Outcomes of the CLIVAR Assessment

Ms Katy Hill outlined the CLIVAR internal assessment that was held earlier this year in conjunction with the CLIVAR conference. Each panel was reviewed against its terms of reference and the overall CLIVAR aims by a panel of reviewers made up of previous SSG members. The reviewers then presented their findings at the 13th Session of the SSG, which was held immediately after the conference. Recommendations specific to GSOP included:

- GSOP should be the primary CLIVAR interface with the COPES WCRP Observation and Assimilation Panel (WOAP) previously the Working Group on Observations and Assimilation (WGOA). It was recognised that potential for duplication between these two groups and therefore coordination was needed. A representative of GSOP will serve on WOAP.
- GSOP should take the lead on Ocean Reanalysis for WCRP.
- GSOP should set the agenda to satisfy CLIVAR's needs for global synthesis.
- GSOP would be the primary CLIVAR link with OOPC and explore potential for cooperation and collaboration with JCOMM.
- GSOP should work closely with CLIVAR's modelling and basin panels to develop strategy on how they would interact in future.
- SSG requested a preliminary list of data requirements for Ocean Reanalysis following the workshop. A small Ad Hoc is group needed to assess how to meet requirements. Strong links to, if not a dedicated data management component will be required.
- Joint initiatives with SOLAS and WGSF should be identified.

Specific recommendations with regard to Data Management were also identified:

- The review concluded that CLIVAR still needs to meet the data management challenge. CLIVAR must either (a) give detailed specification of requirements to others or (b) build a management scheme to meet these.
- Data management would be explicit in TOR of each panel inc. modelling panels.
- CLIVAR will ask International Ocean Data Exchange (IODE) to review the CLIVAR DACs against CLIVAR requirements (for reanalysis and other activities).

During discussions it was agreed that the SSG had high expectations from the newly formed GSOP panel, and the panel would have to rise to the challenge. However, it was felt that there was sufficient momentum in the community to tackle these challenges.

1.4. WCRP, the Coordinated Observation and Prediction of the Earth System (COPES) initiative, and the WCRP Observations and Assimilation Panel.

Dr Kevin Trenberth gave a presentation on the new WCRP COPES initiative, and framework designed to improve synergy across the WCRP member projects including areas such as Data Management and promote activities of central importance to WCRP's aims. It also aims to bring WCRP more into line with the priorities of the funders of WCRP science. The ultimate aim is seamless prediction of the climate system from seasonal to centennial timescales. Whilst the implementation of COPES is largely based on existing infrastructure, some overarching groups have been set up to facilitate the synthesis of activities in key areas.

The group of most relevance to GSOP is the WCRP Observations and Assimilation Panel (WOAP), chaired by Kevin Trenberth. This group has terms of reference similar to those of GSOP, but will take the wider pan WCRP viewpoint. The key activities identified by WGOA are listed in appendix 1.3. A key initial focus will be the promotion of the reprocessing of satellite data streams, and feedback was requested from GSOP as to what reprocessing is needed to which data streams. Some examples would be useful to advocate the need. Dr Victor Zlotnicki agreed to provide some oceanographic examples. Key issues for WOAP will include the suitability of satellite observations for WCRP needs, and especially ensuring continuity of the climate record. WOAP will promote reprocessing of satellite data as the algorithms and processing capabilities develop, and needs arise. Such issues will be linked to in situ data and reanalysis of the climate record.

ACTION: Provide oceanographic examples to illustrate need for reprocessing of satellite data and submit to WOAP for advocacy (V. Zlotnicki).

During the discussion, it was noted that there is potential for duplication of activities between WOAP and GSOP and therefore careful coordination is needed. GSOP has been asked to nominate a member to the WOAP, and the GSOP Co-chair Dr Detlef Stammer has agreed to act in this capacity.

ACTION: Representative of GSOP to sit on WOAP (D. Stammer)

1.5. GSOP's niche among global observing initiatives

Dr John Gould gave an overview of the plethora of groups and organisations involved in the coordination of global observations, both intergovernmental and non-governmental, and where GSOP fitted in (see appendix 1.4). Dr Gould emphasised that GSOP's role is unique in that it is firmly routed within the science. In situ climate observations on which research and operations now depend were originally developed in the research community. GSOP will also provide the link from observations to analysis, synthesis, prediction and applications.

GSOP's initial focus will be on ocean reanalysis/synthesis, although GSOP must ensure that activities evolve complimentarily to meteorology. The history of analysis of the atmosphere is far more advanced than the ocean. However, ocean and atmosphere data synthesis efforts can learn from each other. Specifically, there needs to be movement towards the coupling of ocean and atmosphere reanalysis activities. The development of improved flux datasets would be a step towards this and GSOP, as a minimum, needs to advocate requirements from these and atmospheric reanalysis.

GSOP also has a unique perspective on data management. Standards need to be developed for data used in reanalysis and reanalysis activities, and their use needs to be advocated – this includes advocating for data release.

It was generally noted that GSOP's Terms of Reference are quite broad – partly because they were developed prior to the existence of WOAP. Generally the panel agreed that the role of the panel will be defined by its work plan, but it would probably be useful to revisit the Terms of Reference at some point in the future.

1.6. Ocean Observations Panel for Climate (OOPC) issues for GSOP

An overview of OOPC's activities was given by Dr Ed Harrison, who also outlined how OOPC and GSOP could work in a complimentary manner. OOPC is co-sponsored by WCRP, the Global Ocean Observing System (GOOS) and the Global Climate Observing System (GCOS). It has had a close relationship with CLIVAR historically and CLIVAR is currently represented at OOPC meetings by representatives of its ocean basin panels. Dr Harrison sees this as a mutually useful arrangement, and is keen to see this continue even now GSOP is in place (see also discussion at the end of this section).

The GCOS Implementation Plan has now been published and is available from www.wmo.ch/web/gcos/gcoshome.html. GCOS will continue to look to the Joint Commission for Oceanography and Marine Meteorology (JCOMM) and the International Ocean Carbon Coordination Project (IOCCP) for the development of standards, and coordination of implementation. In the report, GCOS calls for the completion of a first set of ocean climate reanalyses with uncertainty estimates and including the preparation of needed input datasets.

Dr Harrison then outlined what he felt were the key challenges:

- Real time data transmission – we cannot manage a climate observing system without knowing quickly where are system problems.
- Sustaining funding commitments.
- Maintenance of satellites with climate relevance.
- Development of climate indicators of wide appeal to build interest.
- Develop high latitude, transport, and sea ice pilot projects.
- Global cooperation and coordination.

OOPC sits between research and operational activities, and the definition of "operational" was discussed in depth. Generally, a system is considered operational when there is an institutional commitment to sustain it – regardless of the institution – for instance the Tropical Atmosphere Oceans (TAO) array became operational long before it was transferred to the National Data Buoy Centre (NDBC).

While JCOMM is proving effective at tracking observations and producing maps, the data alsoneed to be transferred into products and analyses so that the value of the observing system can be fully demonstrated. This is key to sustaining funding. GSOP has a role to play here. The development of indices for climate variability that have a wide public appeal will certainly help to demonstrate the utility of the observing system, and it was suggested that GSOP work with the Expert Team on Climate Change Detection Monitoring and Indices (ETCCDMI – co-sponsored by the World Climate Programme Commission for Climatology (CCl) and CLIVAR) to develop these in the subsurface ocean. Centres such as ECMWF already produce area-averaged indices, and Argo opens up opportunities for zonal averages, etc. These need to be explored more before releasing them into the public domain.

ACTION: Explore possibilities for computing subsurface ocean indices from observations and reanalysis products – in partnership with ETCCDMI (Anderson, Sloyan, Lee, Stammer)

A discussion on the division of responsibilities between OOPC and GSOP followed. CLIVAR is essentially going to rely on the real time observing system in the future. GSOP has a definite role to play in utilizing the sustained observing system and demonstrating its relevance and usefulness for ocean reanalysis, but also in reviewing it and possibly revising it. In addition delayed mode data, their availability, their quality control to produce climate quality data and use in reanalyses is still an issue, and there is an opportunity for GSOP to develop pilot projects to address this.

1.7. Outcomes of the 1st Data Planning Meeting on Ocean Observations (DPM1)

Dr David Legler presented the outcomes of DPM1, which was held at the Scripps Institute of Oceanography in March of this year. See the meeting report in appendix 1.5. Dr Legler summarised the meeting, and then provided some recommendations to GSOP.

At the meeting, it was clear that, several full time equivalents were available to engage in ocean data management for CLIVAR (climate) but since CLIVAR adopted the WOCE DACs, they have received little feedback or guidance from the CLIVAR community.

Articulating CLIVAR's data requirements should be made a high priority. CLIVAR cannot assess its needs, develop a strategy for data management, nor decide how to partner with other programs without first describing its own requirements for data management. A specific and crisply stated set of needs is required, which includes:

- Description and characterization of the desired data
- Data assembly requirements.
- Delivery time frames.
- Integration with other data types.
- Characterization and level of QC
- Error bars/uncertainty estimates.
- Need for products, search/discovery tools

To support routine reanalysis effort, CLIVAR also needs to source a data tracking capability that will allow a reliable and complete data collection for assimilation efforts. This has proven to be a problem in particular for hydrographic data, which can take considerable time to be released from Principle Investigators (P.I.'s), but also in terms of tracking the existence of new – often non-CLIVAR – measurements. Knowing that the observations were made and when would help to encourage its release. First steps to track observations should be through the basin panels. The staffers responsible for the basins have been working hard to develop databases of observations of interest to each basin. The next step will be to find out where these data reside once collected.

The integration of key data streams is also needed. It is important to think beyond platform specific streams, and more towards parameters if we are to capitalise on the strengths of the multiplatform observing system that is in place and thereby improve quality control. In particular, the integration across the upper ocean thermal data streams should be a priority. Dr Legler identified Ocean reanalysis as a target customer for CLIVAR's data management, as this would be an opportunity to develop focussed requirements in conjunction with a targeted user community, and provide a tangible focus to efforts. Therefore the product that CLIVAR's data management efforts will produce needs to be articulated, then CLIVAR/GSOP needs to identify and participate in small manageable projects jointly with others, such as pilot efforts to evaluate/inter-compare Quality Control efforts, and the integration of profile data.

Other specific issues were raised, including a recommendation that pre-Argo profiler data should undergo Argo quality control and it was agreed that this suggestion be taken to the Argo Steering Team. It was also highlighted that the CLIVAR Data Policy is still posted on the website in draft form, and should be updated and finalised as a priority.

To conclude, Dr Legler outlined a recommended way forward:

1 Requirements document should be written (by Spring 2005)
2 Articulate the vision for CLIVAR data management. Identify where CLIVAR will take lead role, where it will partner, where it cannot/will not contribute (by Spring 2005)
3 Pilot experiments should be initiated, targeting reanalysis (Autumn 2005)
    a Quality control pilot study
    b Integrating profile data pilot study
4 Develop a plan to assess ability of current DACs to contribute needed elements (by Autumn 2005)
5 Consider other CLIVAR data management challenges:
    a Field experiment data - are current practices sufficient?
    b Is access to model products sufficient? (i.e. NOMADS)
    c Access to RT data is currently provided by GODAE servers – will this continue at the end of GODAE? If not, CLIVAR will need to source another means of access. Should CLIVAR be moving towards a real time – centric data system?
    d Development of web–based query tools.

In the discussion that followed, it was unanimously agreed that CLIVAR cannot move on and develop the necessary data management and reanalysis infrastructure, without first articulating its data requirements. Dr. David Legler volunteered to lead the effort to draft a data requirements whitepaper in the next 3-6months.

ACTION: Draft a data requirements whitepaper (3-6 months) (D. Legler, S. Wijffels, D. Stammer, N. Smith, A. Weaver, V. Zlotnicki, J. Carton, D. Anderson)

There was a vigorous discussion on quality control (QC). Targets for data quality and release need to be articulated, and there needs to be some control on data with a number of versions in circulation. It was generally agreed that the QC of data was the responsibility of the P.I., as it needs to be done by experts who work with the data. However, not all data collected on a particular cruise will be of interest to the P.I., or within their particular expertise. Large data centres such as NODC, often strip off QC provided by the data originators, and add their own automated QC routines, which reject a lot more data. For such "parented" datasets, we need to ensure that the value added that comes from the originators is not lost. For "orphaned" data such as those from many XBT programmes or under-way ship data, it is not clear what can be done to clean it up. This is a complex topic, and discussions will be ongoing.

It terms of data release, real time data are not such a problem as they are transmitted on the GTS. However, it is not immediately obvious where to go for delayed mode data. CLIVAR could seek to provide a complete list of existing data sets and data sources (e.g., one stop shopping for datasets needed) for reanalysis. Once CLIVAR's data requirements have been articulated, then a data assembly project should be initiated to collate the necessary datasets needed for Ocean Reanalysis. The CLIVAR DACs need to be included in these discussions, and this could be a joint effort with GODAE, and Dr Legler and Dr N. Smith volunteered to lead this.

ACTION: Develop elements of a data quality and assembly project (D. Legler, N. Smith to lead)

1.8. Outcomes of the Ocean Reanalysis Workshop

Dr Detlef Stammer, chair of the workshop steering committee and co-chair of GSOP outlined the outcomes of the CLIVAR Ocean Reanalysis workshop, held at the NCAR Mesa Lab earlier that week. A workshop agenda can be found in appendix 1.6.

Dr Stammer started with a summary of the workshop outcome and the identified issues and challenges that need to be addressed. CLIVAR Reanalyses need to address all the specific CLIVAR timescales: Seasonal to Interannual (GOALS), Decadal to Centennial (Dec-Cen) and Anthropogenic Climate Change (ACC). There are quite different needs and requirements specific to these applications.

In general terms, CLIVAR needs reanalysis efforts:

1 To develop more coherent, better organized, more widely available and more useful ocean datasets and reference datasets for the climate community.
2 To generate comprehensive syntheses of the state of ocean for the purposes of monitoring and understanding climate variability and change, including the interaction of the ocean with the atmosphere and cryosphere and testing models.
3 To provide a basis for the initialization of coupled models on seasonal-to-interannual and decadal and longer time scales.
4 To provide a global framework for basin scale and regional scale climate research and for research in related disciplines.
5 To provide guidance on the effectiveness of the ocean observing system for monitoring and understanding climate variability and change, including feedback on the impact of specific networks.

CLIVAR reanalyses need to be able to:
1 Describe the dynamics of climate change in the ocean (plus coupling with atmosphere, cryosphere, etc)
2 Initialise seasonal to interannual predictions
3 Initialise decadal to centennial predictions

Operational centres tend to focus on seasonal to interannual timescales and therefore it was concluded that no GSOP action was needed to support or coordinate activities on these timescales. However, there is not yet a comparable sustained activity for addressing climate-quality hind casts/reanalyses as well as decadal to centennial initialization and anthropogenic prediction problems. This needs to be developed for CLIVAR.

There seems to be a well-organized data stream for seasonal to interannual efforts that are partially also used by other reanalyses efforts. It is possible that this could be capitalised on for other efforts.

Testing the existing reanalyses in terms of their quality for each of the above requirements is urgently needed. This includes determining uncertainties. This needs to be done in close collaboration with WGOMD, GODAE and the basin panels (model-model; model-data; prediction, residuals).

ACTION: Draft white paper on guidelines for reanalysis intercomparisons (in 3-6 months) in partnership with GODAE; basin panels, and WGOMD also need to provide input. (N. Smith, D. Stammer, T. Lee, D. Anderson, D. Behringer, A. Weaver, K. Richards, M. Visbeck, K. Speer, S. Wijffels)

ACTION: Over the next year, test out results in a pilot intercomparison project. (N. Smith, D. Stammer, T. Lee, D. Anderson, D. Behringer, A. Weaver, K. Richards, M. Visbeck, K. Speer, S. Wijffels)

Testing the goodness of results requires entrainment of the science community, but will also depend on the nature of the application. GSOP should promote a wider use of reanalysis results for science and societal needs (see Section 4.4), such as downscaling for regional applications, and engage users in the feedback loop. This can help maintain the observing network. WGSIP has been involved in discussions of societal benefit, but there is a need to initiate discussions for Decadal to Centennial and Anthropogenic Climate Change activities.

Challenges exist for some reanalyses in view of the changing observing system quite similar to problems identified in atmospheric reanalyses. The ocean reanalysis community could learn a lot from the challenges experienced during the development of atmospheric reanalysis products. No immediate action is needed but users and developers need to be aware.

Data stream and data QC is a large issue for decadal reanalyses efforts. A working group needs to define existing problems of ongoing reanalyses and needs and work with DACs on implementing the needs for reanalyses.

There was a discussion on the cleaning up datasets to meet the needs of reanalysis activities. There are many efforts to clean up datasets, such as those being carried out in Susan Wijffels group, who work on Indian Ocean XBT data. But it is not clear how these disparate efforts should be coordinated. The Upper Ocean Thermal (UOT) data, in particular, are essential for reanalysis due to the historical wealth of data. A significant and coordinated effort would be needed to clean these data up. However, feedback from reanalysis activities will constantly help to improve these datasets. As noted above, discussions on the QC and clean up of UOT data will be ongoing.

Surface flux (plus run off and ice volume advection) uncertainties remain a large issue. Reanalyses efforts need to work with WGOMD on identifying the best surface flux products to utilise for ocean reanalyses. Further discussion on Surface fluxes can be found in section 2.3.

Several elements of reanalysis need to be coordinated. GSOP should maintain an overview of ongoing efforts and provide links to available data sets.

ACTION: Develop an ocean reanalysis website with information on guidelines, requirements, and pointers to datasets and ocean reanalysis efforts. Input required from panel members (T. Lee, ICPO)

CLIVAR - relevant applications of ocean reanalysis include:

1 Understanding climate dynamics from reanalyses.
2 Sea level rise and 5th IPCC assessment.
3 CO_2 sequestering.
4 Regional impacts.
5 Initializing coupled models from ocean reanalyses.
6 Observing System Experiments (OSE's): these need to be carefully prepared and evaluated.

During discussions it was suggested that CLIVAR should improve links with the IPCC process. While many scientists are involved in the IPCC, this link is not as visible or formal as it could be. It was unanimously agreed that CLIVAR should aim to make CLIVAR reanalysis products available in time to contribute to the 5th IPCC Assessment. This would also help to demonstrate the utility of reanalysis products.

RECOMMENDATION: CLIVAR reanalysis products should be available in 2009 in time for the 5th IPCC Assessment Report.

The benefits and pitfalls of Observing System Experiments (OSE's) and Observing System Simulation Experiments (OSSE's) were discussed. The most useful approach is the use of experiments that degrade the observing system (OSE's), i.e. remove observations to simulate the observing system of the 1950's-1960's, and see how it impacts model simulations and forecasts. Care needs to be taken, as results are strongly model dependant. OSSE's can also be used to determine where additional observations are needed. They also help to improve understanding of how the observing system is working. However, results need to be interpreted with caution and used in context. For instance, a paper was recently published suggesting that the TAO array did not make a difference to the characterisation and prediction of ENSO. This is highly unlikely to be true!

2. Elements of the Sustained Observing System

Reports from each component of the observing system were submitted prior to the meeting. These can be found in section 2 of the appendices.

2.1. Tropical Mooring Buoys

Dr Mike McPhaden gave an overview of the status of the tropical moored buoys observing system, and issues that needed to be address by the GSOP Panel (see appendix 2.1 for more detail). The tropical moored buoys are the TAO/TRITON array in the Pacific, a US/Japan initiative, and the PIRATA array in the Atlantic, supported by the US, France and Brazil. The TAO/TRITON array is the most mature mooring buoy array, and it is without doubt a very important component to the climate observing system. It has been found for example that analyses of Pacific warm water volume in the 5°N-5°S band, which are strongly constrained by TAO/TRITON data, are a useful predictor of both El Niño SST anomalies and Indian Monsoon rainfall anomalies. Data from the TAO/TRITON array also have been valuable in tracking the development of moderate El Niño conditions this year and for use in initializing many current El Nino forecasting schemes.

PIRATA is nearing the end of its consolidation phase (2001-2005), and a decision has yet to be made as to whether it will continue operating afterwards. Continuation requires that the case be made for the utility of PIRATA in support of climate research and forecasting. There is confidence that a case can be made though and a formal evaluation of the array is planned for sometime in late 2005. Experiments such as the Tropical Atlantic Climate Experiment (TACE) are also being developed around the PIRATA array and there are proposals for extensions to the array for regional applications.

Dr McPhaden also highlighted problems experienced with fishing vandalism on the moorings close to the coasts, and it was questioned whether the moorings most affected were essential to the effectiveness/utility of the array. However, in the Pacific, the eastern-most moorings are required to characterize variations in the equatorial cold tongue, while the western-most moorings are needed to determine the wind forcing (i.e. monitor westerly wind burst activity) and ocean responses to that forcing. For PIRATA, an array with far fewer moorings than TAO/TRITON, the problem is relatively more acute, with the area experiencing most problems due to fishing vandalism in the Gulf of Guinea.

Some enhancements to the arrays are planned in the future, including adding surface salinity sensors to all TAO moorings (all TRITON moorings have this capability already, but only half of the TAO moorings are instrumented for surface salinity sensors at present). In conjunction with the OceanSites program, there are plans to add flux instruments to selected existing platforms in the Pacific (5 sites) and Atlantic (3 sites). The transition of management of the TAO array from the Pacific Marine Laboratory (PMEL) to the operational National Data Buoy Centre (NDBC) is underway, and will take 3 years to complete (Oct 2004 – Sept 2007).

An Indian Ocean Array is also currently under development to support monsoon research and forecasting. With a large proportion of the world's population dependant on the Asian monsoon, the potential utility of

such a system is clear. The first of the ATLAS moorings as part of this array were being deployed as we met, and Dr McPhaden was able to show real-time data received from these new moorings and some of the striking variability they revealed!

The Tropical Moored Buoy Implementation Panel (TIP) plays an important role in coordinating the discussion of technical, logistic, and scientific issues of relevance to mooring programmes in all three basins. Most of the panel's business is conducted by email, with informal ad hoc meetings scheduled in conjunction with other CLIVAR related meetings. The TIP web page (http://www.pmel.noaa.gov/tao/proj_over/tip/newpanel.html) contains recent reports to the CLIVAR SSG, CLIVAR GSOP and the OOPC.

2.2 The Argo Array

Dr Dean Roemmich reported on recent developments of the Argo profiling float network, and the upcoming challenges. For a full report, please see appendix 2.2 At the time of the meeting, the array was approaching 50% of its target 3000 float array, with 1471 floats in the water. Dr Roemmich was also able to announce the new interactive Argo website at http://www.argo.net. In terms of deployment strategy, floats were initially deployed in high priority regions. As the density reached 50% of target in those regions, the domain of the regional array expanded. The array is now approaching global coverage, although float deployment opportunities in remote regions remain a challenge. Efforts will be focussed on the tropical oceans and the Southern Ocean in the coming months.

Argo has a unique niche in the observing systems. It complements satellites, as it measures below the surface, the line oriented measurements from hydrography and XBT's, and the high temporal resolution of moorings. Dr Roemmich identified a number of challenges for the near future:

1 Technical evolution – improving the lifetime of the floats, which needs to approach 4 years if the complete array is to be attained with 800 deployments a year.
2 Developing better communication – i.e. by switching to iridium communication, the float needs to spend less time at the surface, when the float is most vulnerable.
3 Increasing buoyancy range of floats – currently about 60% of floats reach 2000 metres. Tropical floats have shallower range.
4 Demonstrating stability of salinity measurements on long-term deployments.
5 Integrating new sensors without compromising float lifetime (i.e. biogeochemical sensors).

The Argo array is an extremely useful tool for looking at the continual evolving state of the ocean, and is central to CLIVAR attaining its aims. A bibliography of Argo publications is maintained on the web site (www.argo.net). A successful first Argo Science Workshop was held in Tokyo in late 2003, and Argo research has been presented at many international conferences. The Argo Steering Team solicits feedback on how well the array is serving CLIVAR's needs. It should be emphasised that Argo is only one element in an integrated observing system whose full value is much greater value than the individual elements.

During the discussion, issues at the research/operations interface were highlighted. Dr Roemmich noted that the profiling float is a complex instrument that continues to evolve for better performance as noted above. It requires considerable technical expertise in support of successful large-scale deployments. Argo national programs encompass a broad range of technical approaches, but those programs providing technical expertise from the research community are generally having the greatest success.

It was generally agreed that research groups need to maintain influence and traction in the management of observing networks, but not at the expense of support from operational agencies. To this end, it is important to engage the operational community in the research-led discussions and plans. The Argo Steering Team has representation from countries that have operational involvement in Argo. It is essential to ensure that Argo and other observing system elements continue to satisfy both the research and operational requirements for these programs.

2.3. Surface (Air-Sea) Fluxes

Dr Simon Josey outlined what he felt were the main surface flux issues that GSOP needs to address. For the full surface fluxes report, see appendix 2.3. A key challenge for the flux community is how to make use of the increasing number of high quality reference sites to determine the errors in flux products. Currently there are 4 sites, and preliminary evaluations of reanalysis products show strong differences compared to heat

fluxes measured at these buoys. Further measurements are needed in a broader range of climate regions to enable correction of the various flux products and the OceanSITES program should lead to a greater range of flux reference moorings at key sites globally (see section 2.4 and appendix 2.4). In addition, the VOSClim project is now producing a high quality subset of Voluntary Observing Ship (VOS) observations with associated metadata that can potentially be used to reduce uncertainty in model based fluxes. The aim is to include a minimum of 200 ships in the project. Currently, 111 ships from 7 countries are involved, compared with 6600 for the VOS program. At OceanObs99, it was also recommended that automated flux packages should be routinely mounted on research ships. Prototypes have been developed but this goal has yet to be attained. Stand alone flux packages have been mounted on several research cruises but this is not yet a routine procedure. At present there is no formal international scientific program or data management program for flux package measurements, although one suggestion would be to internationalise SAMOS (Shipboard Automated Meteorological and Oceanographic System).

Dr Josey then gave an overview of the available flux products, and issues that need GSOP's attention. Flux products have been determined from a.) atmospheric model reanalyses, b.) synthesis of satellite and reanalysis fields and c.) ship meteorological reports. Examples of widely used flux datasets are:

1 NCEP/NCAR reanalysis,
2 ERA40 reanalysis,
3 SOC flux dataset (ship based, Josey et al. 1999).

In addition, products are now being developed through synthesis of different datasets (WHOI, Yu et al 2003) and modification of the reanalysis fields (Large and Yeager, 2004).

The WHOI dataset is formed through the synthesis of satellite and reanalysis meteorological fields but is at present only available for the Atlantic Ocean. Local evaluations of this dataset show improved agreement with reference buoys.

The Large and Yeager dataset is often referred to as an NCEP corrected flux product. However, it should be emphasised that Large and Yeager correct their method of determining the fluxes from NCEP meteorological fields, rather than correcting the NCEP fluxes themselves. Their corrections to the basic fields are not fully supported, as in some cases coefficients from unpublished manuscripts are used. In addition, the fields have not been evaluated against high quality flux measurements. Thus, it is not possible to say whether they represent an advance on the original NCEP fluxes.

The SOC flux dataset provides global air sea flux fields for 1980-1997 determined from COADS ship meteorological reports. These fields are affected by sampling problems inherent in ship based products but have shown good agreement in several cases with reference buoy measurements. The original SOC flux dataset has a global net heat flux imbalance of 30 Wm-2 (Josey et al., 1999) and recent work has led an adjusted version in which this bias has been removed using inverse analysis (Grist and Josey 2003). The SOC fields are currently being extended through to the end of 2002.

There is an urgent need for a standard evaluation of all new flux datasets plus reanalysis flux fields in order to realise the full potential of the flux observing system. Newly developed datasets should be compared against high quality buoy measurements, in addition to the more widely used evaluations of large scale quantities such as ocean heat transport, and the results published in a peer-reviewed journal.

RECOMMENDATION: Evaluation of forcing flux datasets: New flux datasets used to force ocean reanalyses should be evaluated against surface flux reference site measurements.

ACTION: Write to groups who develop flux fields (S. Josey, D. Stammer)

RECOMMENDATION: Ocean Reanalysis fluxes: All future ocean reanalysis fluxes should be evaluated against research quality data (flux buoys, research vessels), in addition to large scale constraints (e.g. heat transport), to determine whether reanalysis has led to improvements (individual reanalysis groups).

ACTION: Develop guidelines/recommendations for evaluating ocean reanalysis fluxes (S. Josey, S. Smith).

RECOMMENDATION: GSOP recommends that one of the activities of the recently formed WCRP WGSF should be an evaluation of flux products developed since the report of the WGASF.

ACTION: GSOP representative required as point of contact with WGSF to raise this issue (S. Josey).

CLIVAR also needs to provide information to the community on available flux datasets. This information can be posted on the CLIVAR data pages.

ACTION: Flux datasets should be listed on the CLIVAR data pages. Guidance is needed on high priority datasets. (ICPO, S. Josey)

Repeatedly it has been shown that ocean reanalyses are very sensitive to the quality and availability of quality surface wind forcing fields. Wind products used for this purpose include those from forecast centres, as well as those that utilize SSM/I, scatterometer, and/or in-situ observations. Additionally, there are a number of approaches to developing high quality wind fields. Consequently, there are a number of wind products of varying spatial and temporal resolutions, qualities, and suitability over varying time periods.
However, there needs to be more careful consideration of what product(s) should be used and/or which approach should be used to develop a consistent and highest quality wind forcing data set suitable for ocean reanalyses. The remote sensing community could be helpful in providing expertise and products that could advance reanalysis efforts.

ACTION: Present the need (in support of Ocean Reanalyses) for best quality wind and wind stress fields for 1950-2004 to the NASA Ocean Vector Wind Scientific Team (OVWST) and enlist their help. (D. Legler)

2.4. The OceanSITES moored time series programme
Dr Uwe Send presented the OceanSITES moored time series plans (see appendix 2.4) and their role in the global observing system. The platforms are intended to be multidisciplinary, with many carrying biochemistry sensors. There are 29 sites identified. They are either representative of a larger ocean region, or are sited in areas of important or critical processes.

Dr Send requested guidance and support from CLIVAR on the following issues:

- We need to assure that data are openly available and delivered in a timely manner, and CLIVAR could help with advocating this. Pressure needs to be exerted on the community – OceanSITES currently has a policy of removing sites from the map if data release isn't open and timely.
- What is the most effective use for time series data in models and assimilation activities?
  - Understanding of processes and implementation in models?
  - Testing of models?
  - How to best use temporal statistics provided?
  - Can point data be usefully assimilated?
  - What about "integral data", like transports, heat content, etc?
  - Validating forecasts?
- Time series data are VERY important for ecosystem model development (biogeochemical model results also provide sensitive tests for physical processes). Can GSOP take this into account?
- Technological challenges: provide guidance on CLIVAR's needs and possible solutions.
  - Fouling, vandalism, etc
- Novel sensors
  - Endurance (mechanical, power)
  - Mix of high-end and simpler technologies
  - What role can gliders play? They would be complimentary to time series observations.

The use of time series in assimilation activities was discussed. ECCO doesn't assimilate time series, as there are often technical difficulties. . However, they are useful as an independent reference data set, and long time series could help constrain low frequency large-scale variability because buoys are often measuring changes that are happening upstream. It was generally agreed that they were best used as reference sites.

There are plans to assimilate the tropical array into the OceanSITES dataset, and the potential for problems with the availability of multiple datasets was highlighted. Dr Send acknowledged that this would need to be considered.

2.5. Deep Hydrography

Dr Masao Fukasawa provided an overview of the status of repeat hydrography implementation relative to the plans developed at OceanObs99 (see full report in appendix 2.5). The North Atlantic, Indian and North Pacific are covered relatively well, with occupations planned or already completed for most of the proposed lines. Most of the cruises since OceanObs99 have included carbon measurements, with around half the cruises at the target repeat frequency.

The responsibility for data management is shared between the CLIVAR-Carbon Hydrographic Data Office (CCHDO) at Scripps and the Carbon Dioxide Information Analysis Center (CDIAC) at the World Data Center. The CCHDO relies on experts in the community for QC.

There is an increasing need for real time data delivery of hydrography data (for instance by Argo for calibration and validation) as well as the traditional delayed mode hydrography data stream. However, some scientists are reluctant to release data in real time.

Only a few groups/PIs are capable of deep ocean hydrography, and a renewed effort is needed to lobby for real time data availability (TESAC transmission). The number of technical groups is smaller than the number of PIs involved in deep hydrography, therefore when technical groups provide data to the PIs, they should also be able to send it to CCHDO. The Partnership for the Observation of the Global Oceans (POGO) also has a role to play here. POGO members are the heads of major oceanographic institutions, and represent the majority of groups involved in deep hydrography. This could be a forum for lobbying for data release at an institutional level. A POGO meeting was planned for just after the meeting, and John Gould agreed to highlight this issue.

ACTION: Highlight the importance of hydrographic data release at the next POGO meeting (J. Gould).

Dr Fukasawa identified as a key issue the need for an international coordination system for hydrography. All other components of the observing system have a coordination mechanism. Therefore Dr Fukasawa recommended that the community needed to find resources for an international hydrography office, where strategy and implementation for repeat hydrography could be co-ordinated. Such an office would carry out the following activities:

- Coordinate the development of the hydrography observing system in light of changing scientific priorities.
- Develop communication with other components of the sustained observing system
- Improve the data archiving/distribution for both delayed mode and real time data
- Seek sustainability

Such an office should be supported by the community and while CLIVAR would have an interest in this activity it needs to be broader based, so that the activity continues beyond the end of CLIVAR. Hydrography will not become operational, unless coordinated centrally as individual groups have a regional focus.

There was a detailed discussion of hydrography issues post-WOCE. Many felt that the WOCE One Time Survey constrained our thinking in terms of further developing hydrography requirements. The driver is now coming from the carbon community rather than CLIVAR. Specifically, there is a requirement for high quality temperature and salinity data in their own right. A continuous source of shipboard CTD observations from the whole of the ocean is needed for Argo calibration and validation, not restricted to the WOCE repeat lines. However, hydrography cannot be sustained on the basis of the needs for calibration of Argo alone, and GSOP has a role to put the case forward, and articulate CLIVAR's needs for global hydrography in support of wider CLIVAR activities.

ACTION: Write terms of reference for a CLIVAR Ad Hoc Hydrography group to address issues of global hydrography coordination including data release (J. Gould).

There was general agreement that some sort of infrastructure was needed to keep track of what hydrography is being carried out, what is planned and to direct data to the CCHDO. The current infrastructure does not have the capacity for this activity. The International Ocean Carbon Coordination Project (IOCCP) coordinate the carbon repeat lines, but would not be able to coordinate the entire hydrography programme. The CCHDO has offered to process additional CTD data, but they cannot press individuals to provide information on activities and release their data.

ACTION: Hydrography tracking activity is needed, outside of the CLIVAR structure – seek resources (Ad Hoc Hydrography group)

2.6. Global Sea Level Observing System (GLOSS)

Dr Mark Merrifield gave a status report on the Global Sea Level Observing System (GLOSS), which comes under JCOMM (see full report in appendix 2.6). Sea level data provide the longest records of decadal variability, with many tide gauge sites having a time series of around 100 years. Tide gauges also have an advantage over altimetry, as they give the sea level rise at the coast, which has applications in coastal management. GLOSS has 170 recommended stations (many others exist), of which, 140 are transmitting data. However, there are many political issues regarding data release. For instance, many European sites are not transmitting data due to liability and data recovery issues. Half of those identified as needing to improve data release should be doing so in the next few years.

Dr Merrifield identified the following as key issues for GSOP:

- Stronger ties with GSOP are needed
- Feedback from CLIVAR community on the CLIVAR Sea Level DACs is needed.
- There are opportunities for additional data – barometric pressure, winds, what would best service CLIVAR's needs?

During the discussion it was suggested additional variables would be particularly useful in the Southern Ocean. In Australia, it has already been decided to couple tide gauges with automated meteorological stations. The need for sea level pressure fields along with sea level data was highlighted, and GSOP would certainly recommend the inclusion of barometric pressure records for tide gauge platforms together with tide gauge data. However, it was acknowledged that pressure cannot be measured very accurately due to local effects and models actually recreate the pressure fields very well – to an accuracy of 0.5mb.

ACTION: Write a letter to GLOSS to recommend that barometric pressure be included in the suite of measurements at sea level stations (GSOP Chairs)

2.7. Velocity measurements

On behalf of Dr. Peter Niller, Dr Dean Roemmich communicated what Dr. Niller identified key issues for CLIVAR in terms of surface velocity measurements from drifters (see full report in appendix 2.7). Firstly, there was some concern that CLIVAR has not identified the utility of the direct measurement of surface velocity, preferring indirect measurements and modelling. Dr Niller requested that CLIVAR identifies/reviews the importance of the velocity field for CLIVAR research.

A discussion followed on CLIVAR's requirements for surface as well as subsurface velocity data. It was suggested that perhaps a different approach is needed to demonstrate that we need to sustain the global observing system, by demonstrating how little we know, rather than how much we know. There is currently little archiving or processing of velocity measurements, and CLIVAR appears to be dependant on models and altimetry for velocity fields rather than direct measurements: this includes boundary current and subsurface measurements.

The measurement of boundary currents is a clear gap in the present observing system. They are important to constrain meridional heat and freshwater flux calculations for example. Western boundary currents, in particular, prove a challenging environment for obtaining measurements due to the velocities involved. Boundary currents flow over deep trenches, providing an added challenge for designing an observing system. New Glider technology, currently being developed by a number of groups, could provide a solution to this.

However, some of these groups are reluctant to get involved in sustained observations programmes, as they are unsure of their long-term role as the system becomes increasingly operational.

For surface velocity measurements, it needs to be determined whether the surface circulation is adequately covered by drifters and CLIVAR simply needs to recognise the value of these measurements, or whether the observing system needs to be improved. Dr Breck Owens undertook an analysis of ocean circulation from WOCE data, and should be able to provide a status report.

ACTION: Contact Breck Owens for status of analysis of WOCE era ocean circulation (D. Roemmich)

Subsurface velocities can be obtained by Argo 1000m reference velocities. CLIVAR's requirements for subsurface velocities have also not been articulated, although they would be useful for validation of reanalysis products. It was suggested that CLIVAR should organise a small workshop to articulate its requirements for observations of ocean circulation to evaluate the adequacy of the system and next steps in terms of observations. This could involve the use of Observing System Experiments (OSE's) and Observing System Simulation Experiments (OSSE's).

ACTION: Organise a small workshop to articulate CLVIAR requirements for direct measurement of ocean circulation. (N. Smith and GSOP chairs to nominate WG participants in addition to P. Niller, M. McPhaden, U. Send)

2.8. Expendable Bathythermograph (XBT) Observing System.

On behalf of Dr Bob Molinari, Neville Smith outlined recommendations to GSOP for the XBT observing system:

1 Begin a phased reduction in low-density sampling and an enhanced effort in frequently repeated and high-density sampling.
2 Base the phased reduction on the implementation of Argo with sufficient overlap to ensure there are no systematic differences – detailed studies are required in all basins with co-existing Argo and XBT data.
3 Perform delayed mode QC

For a full report on the status of the XBT observing system, see appendix 2.8.

Dr Smith commented that delayed mode QC was proving increasingly problematic. Scientific guardianship of XBT data was being lost, for instance Pacific XBT data were no longer being QC'd.

The issues highlighted by Dr Molinari were discussed in detail. It was suggested that it was timely to have another review of the XBT observing system, and the panel agreed that this would be a useful exercise, in the context of the Upper Ocean Thermal (UOT) network (XBT, Argo, moorings, and altimetry). The aims would be to:

- Review specific lines in areas where Argo density is more than 50%
- Review and assess volatility of the shipping industry
- Report issues to JCOMMOPS
- Discuss development of a comprehensive upper ocean dataset.

Historical QC issues would probably need to be included in the review, but historical QC of hydrography needs to be treated as a separate issue. In particular, the review should address what sorts of products are needed, and whether measurements are being made in a way that is optimal to obtain these products. It would help if a more holistic approach were taken, moving away from the platform-oriented perspective. The aim could be to develop an Upper Ocean Thermal dataset. With this in mind, it was decided that such a review should be discussed further at the next GSOP panel meeting. In the meantime Ed Harrison and OOPC, along with Dr Neville Smith and Dr Bob Molinari agreed to develop a proposal for holding a UOT review.

RECOMMENDATION: Revisit the suggestion of an Upper Ocean Thermal review at the next meeting, based on a specific proposal (GSOP panel)

ACTION: Articulate motivation, format and source sponsorship for a meeting to review the UOT network (E. Harrison/OOPC, N. Smith, B. Molinari)

The quality control of data, in particular upper ocean thermal data was also a topic of considerable discussion. For instance, the quality control of XBT data should be the responsibility of the relevant P.I.'s or "parents" of the data. There is an acute problem with a considerable amount of orphan XBT data, i.e. without parents. The importance of data guardianship needs to be impressed on JCOMM. There is no quick fix for this issue, and discussions on this topic are likely to be ongoing (over the coming months) and it should be revisited at the next panel meeting.

2.9. Satellite Ocean Observations

Dr Victor Zlotnicki outlined the status of satellite ocean observations, and some specific issues that needed to be considered by GSOP for each type of data stream. For the full report, see appendix 2.9.

SEA SURFACE HEIGHT (SSH):

Satellite altimetry (sea surface topography, SSH) has proven to be the most successful satellite measurement in terms of retrieving ocean circulation properties. Nadir altimetry (which samples just a footprint 6-12 km average at the nadir point) has now become standard. TOPEX-POSEIDON has been measuring since late 1992, Jason-1 since December 2001, and the launch date for the Ocean Surface Topography Mission (OSTM) is still to be determined, all sampling the same ground track for an expected 20+ year time series. The ERS-1, 2 and Envisat altimeters (on a different ground track) as well as the US Navy's Geosat Follow-On (GFO) have added spatial resolution.

Concerns: In the US, altimetry is now moving to the National Polar-orbiting Operational Environmental Satellite System (NPOESS), the operational constellation that satisfies the operational needs of NOAA and the Department of Defence. The concern there is that it might be one more instrument in a platform not optimized for the measurement (attitude control, orbit determination, etc). A consequence of the above is a lack of interest by NASA in continuous improvement of the altimetric datasets (NASA's and other agencies) for a consistent time series, while NOAA has not picked up this responsibility.

The ability to measure SSH over a wider swath (~200 km across track with a narrow gap around nadir) promises the next revolutionary improvement of this measurement. Although an experimental instrument was ready to fly on OSTM, it was removed in March 2005 for financial reasons.

The possibility of measuring SSH by GPS reflections is being explored. This has been demonstrated in principle, but there are significant technical issues to overcome.

A special altimetry mission optimized to measure the shortest wavelengths of the oceanic geoid, which are directly tied to bathymetry by a linear transfer function, has been repeatedly presented to the community. It needs to fly. There are no technical issues to overcome.

NASA has now adopted a concept of 'Mission Senior Reviews' for all Earth missions, whereby missions have to justify why NASA should not cease their continued operations in order to use their limited funds for other priorities. A proposal has been submitted to justify the continuation of the Jason mission. The danger here is that NASA concludes that missions such as Jason are 'operational' enough that they should fall outside NASA's purview, while NOAA will not pick them up because it takes 3 years or more to add them to their budget, after NOAA becomes convinced that they add cost-effective value to weather prediction.

A fifteen-year continuous time series of altimeter measurements is now available, and proving invaluable for many climate investigations, including regional and global sea level rise. Never the less, it is clear that the future of SSH measurements remains uncertain.

WIND VECTOR OVER THE OCEANS:

Satellite scatterometry from the European ERS-1 and 2 scatterometers measured wind vectors nearly continuously in time over the 1990s, and NASA's Quikscat continuously since August 1999 to date (other NASA scatterometers, SASS, NSCAT, Seawinds on ADEOS-II, all worked flawlessly but the spacecraft that hosted them suffered unrelated premature failures). ESA/EUMETSAT will fly an ASCAT scatterometer

later in 2006. Winds from QuikSCAT are routinely assimilated into atmospheric models (NCEP and ECMWF since January 2002, FNMOC since Nov. 2004, UK Met Office since Dec. 2002, and the Japanese Meteorological Agency since May 2003. There are technical differences between the NASA and ESA/Eumetsat scatterometers: ESA uses C-band, which penetrates rain better than NASA's K-band, but ASCAT will have 50% less coverage and a factor of 2 worse resolution than QuikSCAT currently has.

Concerns: In the US, ocean vector wind measurements (OVW) will also migrate to NPOESS. The first such satellite will not fly until at least 2010, perhaps later. Furthermore, the IPO (the program office responsible for the NPOESS satellites) has decided to use a new technique, passive polarimetric radiometry (scatterometers are active instruments), and they are flying a risk-reduction mission called Windsat with one such instrument. WindSat data are not yet widely available (being a new mission, most of the effort goes to calibrating the observables to accurate winds), are less accurate than QuikSCAT measurements (even in theory, direction at speeds < ~7m/s cannot be determined), and have lower coverage and resolution (by a factor of 2 in each). The same concern over NASA Mission Senior Reviews expressed for Jason affects QuikSCAT.

SEA SURFACE TEMPERATURE:
AVHRR, a visible and infrared radiometer provides the longest time series of satellite-based observations of the ocean. Newer instruments (microwave radiometer such as ESA's ATSR on board the ERS satellites, and the TMI onboard NASA's Tropical Rainfall Mapping Mission (TRMM), provide better coverage through the clouds and stable calibration, but sample a different depth, at different spatial resolution. The current GHRSST international project aims at combining, cross-calibrating and delivering near real time SST with well understood properties and accuracies. This topic is well under control.

OCEAN COLOUR:
Presently, the MODIS colour sensor on NASA's AQUA is the only high quality, global sensor. It provides very good global estimates, but a striping problem affects high-resolution results. MODIS data from Terrais are not used to produce ocean colour data; there are serious calibration issues. From late 1997 to the end of 2004, the SeaWiFS mission provided excellent data. There are many other missions (of mixed quality) and these are listed at www.ioccg.org. One key challenge is in the calibration of the sensors, the in-situ campaigns needed to ensure that what is measured is related to physical and biological ocean properties.

Concerns: Unless significant steps are made immediately, it appears that VIIRS data on NPP will be of doubtful quality due to calibration issues. There are similar issues with NPOESS.

GRAVITY
This parameter has two applications, depending on whether the time-averaged gravity field, or the time variability is concerned. For the time averaged field, first DLR's (the German space agency) CHAMP, then the NASA/DLR GRACE missions have provided a quantum improvement in the estimate of the gravity field at wavelengths longer than ~ 200km. This helps compute the absolute geostrophic, time-averaged, ocean circulation when combined with time-averaged altimetry. For the time varying gravity field only GRACE (monthly estimates, with useful resolution of order 1,000 km or longer for oceanographic applications) is likely to contribute to high-latitude barotropically-adjusted time variability, since the measurement is approximately equivalent to time changes in ocean bottom pressure gradients. Future missions are being discussed (but are not yet proposed) in expectation that these measurements prove successful.

SEA SURFACE SALINITY
This parameter has never been measured from space. By the end of the decade, two missions, NASA's Aquarius and ESA's SMOSS will be on orbit. These exploratory missions will provide the first global, continuous coverage of seasonal and interannual changes in sea surface salinity.

Dr Zlotnicki suggested that scatterometer and altimeter observations were most at risk. GSOP has a role in advocating for them to continue.

RECOMMENDATION: Altimeter and wind measurements are key climate measurements – their utility needs to be highlighted (sea level rise, S-I forecasting) and the need for them to be continued.

ACTION: Draft a letter to agencies and highlight concern about the uncertain future of altimeter and satellite wind data for climate research (GSOP/SSG Chairs).

ACTION: Write to NASA and highlight concern about transfer of satellites from research to operations. (Zlotnicki)

2.10. Status of Support for Ocean Observations

Dr Mike Johnson, director of NOAA's Office of Climate Observations outlined the status of funding support for sustained ocean observations, and how these activities need to be justified in order for support to continue. Dr Johnson emphasised the need for a systems approach to Ocean Observations, so that the component platforms compliment each other and, as a system, provide the information needed for both research and operational needs. In this way, no single component is given precedence for funding over another, and funding is channelled to improve the performance of the system as a whole. The US contribution to ocean observations is coordinated through the Office of Climate Observations (OCO), and activities are co-funded by NOAA and NSF. The system being promoted was that set out during OceanObs99.

While the US contribution to the global ocean observing system is a significant one, the overall objectives can only be achieved through international collaboration. To this end, OCO works closely with international coordination activities such as JCOMM, OOPC, IOCCP, and CLIVAR, and Dr Johnson is keen for such relationships to develop. A discussion followed as to whether a repeat of the OceanObs99 conference was needed in order to assess the status of implementation of the observing system, but Dr Johnson felt that there was plenty of momentum to finish the proposed array in the next 5 years.

A discussion on CLIVAR's Data Policy followed, which is currently available on the CLIVAR website, but it is still in draft form, and probably needs to be revised in the context of the GCOS principles, as well as the IOC data policy. It also needs to cover products as well as raw data. The panel felt that this policy should be finalised and endorsed before CLIVAR can exert pressure for data release, and further articulate its data requirements. Dr McPhaden offered to lead an effort to update the data policy and submit it for approval by the SSG.

ACTION: Edit draft data policy and submit to the SSG for approval and distribution. (M. McPhaden to lead)

Pressure also needs to be exerted on the community to expedite data release. As the timeframe with which data can be released varies from platform to platform (depending on the amount of processing and quality control required), specifications for data release for each data stream need to be developed. The representatives at the GSOP meeting for the principle data streams were charged with developing a data release specification. Dr McPhaden offered to lead by providing a draft document for the tropical mooring array as a template.

ACTION: Develop data release specifications and timelines for each major data stream (GSOP Members – M. McPhaden to lead).

3. Ocean Basins – CLIVAR science priorities and observation strategies

3.1. The Atlantic Basin

Dr Detlef Stammer outlined the status of observations in the Atlantic Basin on behalf of CLIVAR Atlantic panel chair, Dr Martin Visbeck. A full report can be found in appendix 3.1. After giving an overview of the Atlantic panel's main science themes, Dr Stammer outlined the observing system, which is very comprehensive, but funded on a temporary basis with programmes such as RAPID, and ASOF. The tropical mooring array, PIRATA, still has problems with securing adequate ship time. In terms of data tracking, Ms Roberta Boscolo at the CLIVAR project office has worked hard to develop a database (http://www.clivar.org/organization/atlantic/IMPL/index.htm). This is a very work intensive activity, and is still incomplete as groups are still reluctant to inform the community of their activities.

During the discussion, the challenge of data tracking was noted, and it was suggested that this is something that GSOP could address. Discussions on this topic are ongoing. Gaps in the coverage of Argo in the tropical

Atlantic were also noted. Dr Roemmich mentioned that tropical regions were a priority for deployments in the coming year.

3.2. The Pacific Basin

Dr Kelvin Richards, chair of the CLIVAR Pacific panel presented outlined Pacific science issues (see appendix 3.2) and highlighted the issue of the adequacy of observations. Is the observing system adequate to constrain key physical processes needed for accurate model predictions? It is difficult to assess the adequacy of an observing system with inadequate models, and this will not be solved by planning more process studies.

Dr Richards then outlined key activities of the Pacific panel. Firstly, the panel are proposing a South Pacific Workshop, which would be jointly sponsored by CLIVAR, GOOS, OOPC and Argo and held in Concepcion, Chile towards the end of 2005. The proposal has been submitted to the SSG for approval.

The Pacific panel is also helping to initiate an assessment of the ocean component of coupled models used in climate research and prediction, specifically seasonal to interannual prediction. This activity will need a close dialogue between the basin panels, GSOP reanalysis activities, and the modelling panels to define the necessary metrics. The Pacific panel are already in discussion with WGSIP to focus on the tropical Pacific initially.

Dr Richards also outlined planned Western Boundary Current (WBC) studies. In the Pacific, the North Equatorial Current splits into the Kuroshio and Mindanao Currents, and its behaviour is related to the Southern Oscillation. There are two activities being discussed. Firstly, a study of the Mindanao Current, involving the US, Japan, China and the Philippines, although this is in the very early planning stages. Secondly, a study of the New Guinea coastal and East Australian Currents, which is a partnership between France and Australia. Both of these activities would benefit from the use of new Glider technology, especially as the Mindanao sits over a deep trench, and therefore would not be appropriate for mooring deployment.

The need to justify new observations was discussed, in terms of their societal importance. This will be addressed at the South Pacific workshop, as South American countries are likely to benefit significantly from improved understanding of South Pacific variability. The Indian Ocean Panel has been extremely successful in identifying the observations needed to improve the understanding of variability in the Asian monsoon. The panel discussed key groups and agencies that should be engaged in the South Pacific workshop. Dr McPhaden and Dr Stan Wilson offered to follow up on some local contacts. It is clear that many outreach activities are working at a regional level, and somehow they need to be linked up.

3.3. The Southern Ocean Basin.

Dr Kevin Speer provided an overview of the key observational activities in the Southern Ocean. For the full report see appendix 3.3. Dr Speer highlighted some key high latitude observational challenges, such as obtaining observations in the sea ice zone. This is an area where Argo cannot operate, but floats are being developed which can operate under ice, and moored buoys with sound sources can be used for acoustic tracking of floats. Moorings that attach to the ice are also being developed.

The challenges associated with observing processes in this region, and the complexity of processes themselves (for instance the atmosphere/ocean/ice boundary layers) mean that fundamental improvements could be made in surface fluxes and reanalysis products. Dr Speer advocated a Southern Ocean regional reanalysis. Higher spatial resolution is needed, particularly around the ice edge in models. The GSOP panel will be developing global reanalyses first, but may spin up regional high-resolution activities in collaboration with basin panels. A group lead by Dr John Calder at NOAA already planning an Arctic regional reanalysis, and many groups are undertaking such regional activities. These groups have begun to interact and further discussion is expected this summer at the CLIVAR Southern Ocean Panel meeting.

Dr Speer suggested that enhancements to observations in the Southern Ocean should be a priority, specifically for sea ice, surface meteorology, drifters, transport arrays and XBT's. Planning for the International Polar Year is well underway, and this could be an opportunity to push for these enhanced measurements. The costs of observations in the Southern Ocean were discussed, in particular the acoustic

tracking system for floats, and the difficulty in justifying such an expensive system. However, it was argued that observations are poor in this region; estimates of circulation and hence heat and freshwater transports cannot be obtained from the usual thermal wind methods since barotropic flows are so strong. An investment in observations is needed to determine whether the additional measurements are needed.

3.4. Indian Ocean Basin.
Dr Susan Wijffels presented an outline of the status of observations in the Indian Ocean Basin, on behalf of Dr Gary Meyers, chair of the Indian Ocean panel (see appendix 3.4 for full report). The observation system in the region has been poor up to now, despite the strong inter-seasonal variability seen in the Asian – Australasian monsoon, and the role the Indian Ocean plays in the initialisation of ENSO. A joint CLIVAR-IOC Indian Ocean panel was set up to develop an integrated observing system, and an implementation plan is currently being prepared.

In terms of implementation, there is already a comprehensive mooring buoy system in place around India, but there is an issue with data retrieval. There are efforts to engage the Indian agencies in the process and encourage data release. Data from tide gauges, in particular would be extremely useful as there is a large coastal population, extremely vulnerable to storm surges and other extreme climatic events. It would help to get the operational centres together and demonstrate the benefit of gaining access to observations within the Exclusive Economic Zones (EEZ's).

Meanwhile, India is investing significant amounts in the Indian Ocean observing system, and the Indian Ocean Panel are confident that its data release record will improve. INCOIS, the national data centre, have the capacity to provide some services, and are keen to support the CLIVAR community. India are also investing in new technologies and building new ships.

In terms of the sustained observing system, Dr Meyers feels that the XBT line strategy needs to be revisited in the context of the science issues it is used to address, and the existence of the Argo array. Process study activities are less advanced in the Indian Ocean, as the sustained observations aren't adequate enough to provide the necessary context.

It was discussed whether CLIVAR had influence with regional bodies that contribute to the observing system. General awareness of CLIVAR at a regional or national level is pretty poor, and perhaps CLIVAR should consider partnering with GOOS regional alliances more. Needs for data tracking, data availability and data quality were also discussed. CLIVAR DACs were brought onboard 2 years ago to manage specific ocean data streams, and it was questioned whether a platform specific organisation was still the best approach. It was concluded that it was still appropriate, but that work needed to be done so that it was easier for reanalysis groups to access the data in the format that they need. It was also pointed out that awareness of the DACs is poor in the community, and CLIVAR needs to put a concerted effort to building awareness of the systems we have in place, and encourage groups to submit their data.

4. Concluding discussions on outstanding issues

4.1. CLIVAR data policy and operators input.
Dr McPhaden lead an effort to revise the data policy overnight (see previous discussion in section 2.10) and this was circulated to the panel for further discussion. The meaning of "CLIVAR endorsed data" was discussed, and it was identified as data from projects that have requested CLIVAR endorsement. For instance, the tropical moored buoy array has benefited from CLIVAR endorsement. Timeliness issues were also discussed further. The panel have already requested a definition of timeliness from each of the major data streams (see section 2.10). However, the management and dissemination of data from process studies also needs to be addressed. Information on data release and management specifications should be requested from process study P.I.'s through the basin panels, so that any issues can be discussed at the next GSOP panel meeting.

ACTION: Request information on data release and management specifications from Process Study P.I.'s through basin panels (Richards, Speer, Visbeck, Meyers).

For the future, some guideline studies need to be articulated such as CLIVAR requirements for data archival, QC, metadata etc. and the role of process studies in wider CLIVAR science. This would assist CLIVAR endorsement of process studies, which comply and encourage long term archival of process study data as a key CLIVAR requirement.

ACTION: Write guidelines for process studies and highlight relevance / importance to wider CLIVAR activities (N. Smith)

Concern was raised that CLIVAR data management was not receiving enough exposure (see section 3.4.). CLIVAR DACs have been up and running for 2 years, but much of the community is unaware of their existence.

RECOMMENDATION: Ensure that information on CLIVAR data requirements, management and CLIVAR DACs is disseminated to the community.

ACTION: Seek ways of better informing the CLIVAR community of data related activities and requirements (Article/issue of Exchanges?) (ICPO to explore).

4.2. Basin Panels, GSOP and OOPC

The need for improved observations in the Southern Ocean were discussed, and how to capitalise on the International Polar Year (IPY) in 2007. Agencies need to be alerted to the IPY. OOPC have already written to Dr. Colin Summerhayes, director of the Scientific Committee for Antarctic Research (SCAR), encouraging them to capitalise on the IPY for improving observations. Dr Chet Koblinsky, director of the NOAA Climate Office, should be contacted as he is focussing his efforts on the Arctic. GSOP, with the help of the Southern Ocean Panel, can help to articulate the role of the Southern Ocean in climate and highlight its importance. Reanalysis activities will be of help here. If CLIVAR wants to deliver high quality reanalyses in 2009, weaknesses in the high latitudes will make this difficult. The role of the high latitudes needs to be clear when the reanalysis strategy is developed. Anthropogenic Climate Change is a strong justification for improved high latitude observations during the IPY due to the acute high latitude impacts.

There are a number of proposed process studies in the Southern Ocean, and it was suggested that their data could be used in reanalyses. However, it was concluded that it was best to keep them out of reanalysis products, so they could be used to test the products. Guidance is needed from process study groups on best metrics for testing the performance of reanalysis products.

ACTION: Request metrics from process study groups for testing reanalyses (Richards, Speer, Visbeck, Meyers).

There was a lively discussion about the relationship between the basin panels, OOPC and the new GSOP panel. As a rule, OOPC are responsible for the sustained observing system, and GSOP are responsible for the research enhancements to the sustained observing system. The OOPC are keen to maintain the strong link with the basin panels as they see significant added value from their involvement. However, basin panels should certainly be represented at GSOP panel meetings, and there is a risk that lines of communication could become complicated, and the burden of travel for key members would increase if the basin panels needed to send representation to both GSOP and OOPC meetings. The initial idea was that GSOP acted to integrate and prioritise issues globally, and act as the link with OOPC, therefore the basin panels should certainly be represented at GSOP meetings. However, OOPC feels that the biggest challenge is the development and maintenance of the sustained observing system, and therefore interaction between the basin panels and OOPC should be a priority to help develop scientific justification for improving observations. It was suggested that attendance at both GSOP and OOPC meetings would be assessed on a case-by-case basis, depending on the priorities of the basin panels, and agendas of the meetings. Discussion on this topic will be ongoing.

4.3. Socio – Economic Relevance of GSOP.

While the societal importance of seasonal to interannual prediction is well established through WGSIP and monsoon activities, in many other areas of CLIVAR we have been slower to articulate the societal relevance

of activities. A 50-year reanalysis product, for instance, would help us to further understand climate change and sea level rise, and variability in the context of climate change.

ACTION: Draft a paper on the socio-economic relevance of GSOP activities, circulate to the panel for comment, and submit to the SSG. (Stammer).

4.4. The Research/Operations interface.

The operationalisation of ocean observations will help ensure the longevity of the sustained observing system. However, the operational community may have different slightly priorities to the research community, and care needs to be taken to ensure that the observing system continues to meet the needs of both the research and operational communities. For instance, research groups tend to put more emphasis on the development of new technologies, new and more accurate sensors, and more efficient systems than the operational community, who tend to focus more on producing long consistent datasets. The research community also take more of an interest in the quality control of data, whereas operational groups tend to focus on real-time data delivery.

Both the research and operational communities can benefit from working together, and research groups need to ensure that they articulate what role they can play in the long-term observation of the ocean. GSOP can help make the case as to what the scientific community to bring to these measurements. POGO also have a role to play.

ACTION: Highlight the issues associated with research/ operations interface at the next POGO meeting (Roemmich)

4.5. Date and Location of Next GSOP Meeting

Appropriate timing and locations for the next meeting were discussed, but the panel were mindful of funding constraints for holding meetings. The meeting had identified a number of targeted small and ad hoc meetings, and Ms Valery Detemmerman from WCRP recommended that these should be funded first. Timing for the next meeting would be discussed dependant on progress made on the actions set during this meeting. Dr Roemmich suggested that the next meeting should be held somewhere where the societal importance of CLIVAR activities would hit home.

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