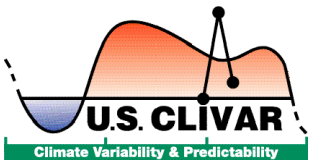

U.S. CLIVAR: Climate Variability and Predictability

U.S. CLIVAR 2008 Summit Report

February 2009

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US CLIVAR 2008 Summit Report

1 ACTION ITEMS

Action Item 1. **Finalize the decadal working group prospectus (Goddard, Vimont, Solomon). Assuming the decadal working group is approved, PPAI will co-chair the WG (Goddard) and will actively participate in the WG (Koster and Kirtman).**

Action Item 2. **Hall to determine which aspect of the prospectus to pursue, identify a co-chair for the workshop, and submit a proposal to David Legler by December 2008.**

Action Item 3. **The panel will continue working with Meg Austin, Director of the UCAR visiting scientist program, to institute this program. (Lisa Goddard, Ben Kirtman)**

Action Item 4. **Finalize BAMS seasonal prediction best practices paper (Kirtman).**

Action Item 5. **PPAI members (Goddard and Kirtman) will participate in the National Academy assessment of climate predictability on intraseasonal to interannual time scales study.**

Action Item 6. **PPAI members (Delworth, Meehl and Kirtman) will continue to contribute to white papers on seamless prediction.**

Action Item 7. **Finish writing the manuscript for Seasonal/Interannual prediction review for North America (Lisa Goddard).**

Action Item 8. **The panel will push forward on this at the 2009 summit. (Ben Kirtman)**

Action Item 9 **Continue to solicit information from and provide feedback to process studies concerning their progress toward best practices goals [process study liaisons]**

Action Item 10. **Draft essay on parameterization best practices (fall 2008) to be submitted for publication before next summit [Donner and Bryan]**

Action Item 11. **Put together a "best practices" news item (for EOS or BAMS) highlighting current NODC submission criteria, expectations for PIs, the role of NODC data advocates, how to contact NODC to get them involved early, and strategies for dealing with orphan data sets. [Donohue PSMIP lead, with POS]**

Action Item 12. **Contact PIs involved in data collection of orphan data types (e.g. turbulent dissipation) and involve them in discussion of long-term archive. [Legg]**

Action Item 13. **Communicate PSMIP feedback to each of the USCLIVAR process studies by end of summer [process study liaisons].**

Action Item 14. **Communicate PSMIP feedback to IASCLIP PIs and program managers [Xubin Zeng]**

Action Item 15. **Synthesize feedback from PSMIP and Pos into a single letter to Salinity field experiment PIs [Frank Bryan and Mike Alexander]**

Action Item 16. **Communicate feedback to PUMP2 PIs. [Ed Schneider]**

Action Item 17. **Communicate PI recommendations for instrument upgrades (upgrade R/V Ka'imimoana ADCP and enhance TAO moorings) to program managers.**

Action Item 18. **Communicate PSMIP feedback to CIOFE PIs and program managers. [Piotr Flatau]**

Action Item 19. **Finish CPT "review and recommendations" document by end of summer and forward to program managers [Legg and Flatau]**

Action Item 20. **Prepare 2-page documents summarizing PSMIP's current and future activities in the areas of drought and decadal variability by October 1st [Legg and Zuidema]**

Action Item 21. **Discuss boundary layer cloud workshop/working group with wider community by Sept. 1st [Zuidema, Flatau, Zeng]**

Action Item 22. **Explore possibilities for SWOT-related working group/workshop by next summit [Ferrari]**

Action Item 23. **Develop proposal for Tropical biases working group by next summit [Ed Schneider with members of other panels]**

Action Item 24. **Initiate contact with NASA program managers regarding future satellite missions and related process studies, before next summit [Zeng]**

Action Item 25. **Contact oceanographers/ice scientists with relevant expertise inviting them to apply for panel membership [Legg]**

Action Item 26. **POS (and PSMIP) panels will provide both scientific and logistical guidance for the field program and as the plans become more finalized the panel(s) should provide comments/suggestions. (Chris, Sirpa)**

Action Item 27. **Provide a description of the datasets to Cathy Stephens who will construct the web page (Alexey) b) A Climate Variations article highlighting the web page, including examples of the historical data, will be written once the web page is relatively complete (Alexey)**

Action Item 28. **POS should provide feedback on specific topics and names to lead the sessions. One or more topics could include using observations to better understand physics/dynamics of the oceans. (Sarah, Sirpa)**

Action Item 29. **Encourage NODC to provide a link to the DART data at NGDC and NBDC.**

Action Item 30. **US CLIVAR should recommend that the National Data Buoy Center recognize that the bottom pressure data collected by the DART moorings as valuable and that we encourage NDBC to make sure that both the real time and delayed mode data make their way to the data centers (e.g. NGDC, NODC).**

Action Item 31. **POS should make sure that those running the GRACE gravity satellite are aware of the the DART bottom pressure sensors and encourage people from the GRACE community to contact NDBC to express the value they see in the DART data.**

Action Item 32. **Put together a "best practices" news item (for EOS or BAMS) highlighting current NODC submission criteria, expectations for PIs, the role of NODC data advocates, how to contact NODC to get them involved early, and strategies for dealing with orphan data sets. (Sarah, Chris, Sonya, Margarita, others)**

Action Item 33. **Assemble a list of these orphan data sets (e.g. turbulent diffusivities, LADCP, IES, current meters), and will see if some advocates can be identified within the community. (Chris, Sarah)**

Action Item 34. **Check requirements for reporting errors, realism (can requirements be met in next 10 years) and consistency between documents b) Extend synthesis to in situ data. Recommend requirements for gravity measurements from the grace satellite. c) Report findings to Eric Lindstrom (NASA program manager), provide synthesis information directly to chairs of JCOMM and GCOS (Ed Harrison, Neville Smith and Greg Donnely).**

Action Item 35. **Explore additional ways to distribute data e.g. post on US CLIVAR web page, white paper for OceanObs'09 conference, etc. (Tony, Rong)**

Action Item 36. **POS will work with Decadal Predictability WG co-chairs (Amy Solomon, Arun Kumar, Lisa Goddard) to formulate a final prospectus and help launch the WG. (Dan)**

Action Item 37. **POS will seek input from the research community as to whether a workshop or working group is an effective way to advance research in this area, and if so, address the best way to focus this endeavor, e.g. only address physical tipping points or look at a subset of interdisciplinary problems. (Rong)**

Action Item 38. **A workshop aimed at addressing IESA definition and requirements should occur. The group needs to work towards strong involvement from major assimilation centers (Tony).**

Action Item 39. **Write a 2-3 pager describing specific Panel activities and how they relate to the major scientific questions surrounding drought. Similarly write a 2-3 pager on decadal variability/predictability (Panel co-chairs to coordinate submissions by mid-November)**

Action Item 40. **Synthesize these 2-3 pagers into material outlining major scientific questions, current activities, and possible future activities suitable for consumption by CCSP and agency planning activities (US CLIVAR SSC coordinated by USCO)**

Action Item 41. **Explore opportunities to provide high-level briefings on US CLIVAR to agency senior leadership (USCO to take up with IAG members)**

Action Item 42. **Scope out a possible US CLIVAR article (e.g., in EOS) synthesizing he benefits of the reorganized US CLIVAR, and the new science challenges we've been able to address through new frameworks (e.g. CPTs, model evaluation program, working groups,) and provide some ideas on frontiers as CLIVAR sees them (USCO to coordinate)**

Action Item 43. **Distribute guidance to Panels outlining how best to solicit agency support for workshop ideas (USCO)**

Action Item 44. **Arrange teleconferences between IAG and Panel co-chairs as required (USCO to coordinate)**

Action Item 45. **Identify and contact relevant program agency program managers of programs that interface between climate science and decisions makers to communicate CLIVAR activities and explore intersections of interest (USCO to coordinate)**

Action Item 46. **Discuss with International CLIVAR leaders how best to improve communication and coordination between the US and Int'l programs (USCO)**

2 Welcome and introductions

David Legler welcomed everyone to the U.S. CLIVAR Annual Summit. He noted the interesting discussions of the previous day on decadal variability.

3 U.S. CLIVAR Report

Marty Hoerling presented a summary of U.S. CLIVAR activities during the past year. He focused primarily on drought and decadal variability/predictability, both motivated by interactions with service and decision-making communities. He noted the differences between the U.S. CLIVAR Panels and Working Groups and the importance of taking a broad view of opportunities of the community as a whole. He spent the remainder of his presentation summarizing the goals and successes of the Panels. The Process Study Model Improvement (PSMI) Panel has developed a set of "best practices" which have been communicated to U.S. CLIVAR process studies PI's and through publication of a Bulletin of the American Meteorological Society (BAMS) Inbox article

(in press). After noting some highlights from CLIVAR Mode Water Dynamics Experiment (CLIMODE) and Kuroshio Extension System Study (KESS), he noted that the PSMI Panel will be working to shape the next phase of Climate Process Teams (CPTs). Marty emphasized the importance of field campaigns in the larger context of climate in addition to their value in the specific experimental region. For the Phenomena, Observations and Synthesis (POS) Panel, he noted the growing importance of data stewardship activities. He added that characterizing the important processes of phenomena like El Niño/Southern Oscillation (ENSO) are important to identify its global climate impacts, not just of ENSO, but on decadal variability and related SST forcing on US drought (a focus of the Drought Working Group). He noted that factors other than sea surface temperature (SST) may also be associated with Drought. The Predictability, Predictions and Applications Interface (PPAI) Panel has worked closely with International CLIVAR over the past year to produce white papers on seasonal prediction and continue to advocate for a tropical biases Working Group. They are planning to devote more time to questions regarding predictability of decadal variations (and the need for a Decadal Predictability Working Group). He noted that the US is developing a multi-model coupled ENSO prediction system, and that links between climate research and applications continues to be a point of discussion within the Panel. Marty concluded noting the opportunities for CLIVAR to coordinate activities to address key needs of information and decision-making communities with regards to drought and decadal variability/predictability. For example, CLIVAR could provide a synthesis and assessment of the known causes for, and predictability of drought, and could further motivate enable a science-based risk assessment of drought and its impacts. For decadal variability/predictability, he noted that CLIVAR could clarify observing system needs for monitoring & detecting decadal phenomena, determine predictability of decadal phenomena, assess current capabilities, gaps, opportunities with regards to possible climate changes in the upcoming decadal climate to 2018, and elucidate potential uses of decadal predictions. He noted that U.S. CLIVAR has benefited from international participation of International CLIVAR in its Working Groups and should continue its close working relationship with its supporting funding agencies.

4 Working Group Reports

4.1 Drought WG Science Report

Siegfried Schubert provided an overview of the Working Group activities, including a workshop in October 2008 joint with the Climate Diagnostics and Predictability Workshop; coordinated global model experiments addressing the role of SSTs and soil moisture in regional drought; and analysis of model-based indices of drought. He reminded everyone that the modeling experiments represent a significant investment with no new money. Analysis of the initial results from the Atmospheric Modeling Intercomparison Project (AMIP) runs exhibit good ENSO anomalies; there is strong seasonality with a lot happening in summer and fall even though the SST anomaly forcing has no seasonality. There is an interesting response over Asia that all models appear to be capturing. The Pacific shows storm tracks and the Atlantic indicates presence of Low Level Jets. Looking at precipitation difference shows that the Pacific response (cold SSTA lead to drought conditions over parts of the U.S.) is agreed upon by models, but the Atlantic response is different among the models. More analysis will be presented at the October Workshop in Lincoln, NE. Siegfried noted that one can also look at conditions conducive to hurricanes, e.g. westerly shear and tropical storm development. He concluded by announcing that the community can take advantage of the output of these drought model experiments as all of the data will be made available to the community in late October 2008. The Scientific Steering Committee (SSC) was impressed by the breadth and scope of the Drought WG activities. Siegfried noted that the

Working Group members were very enthused and engaged. He also noted plans to synthesize the findings of the Working Group experiments through several publications.

4.2 Madden Julian Oscillation (MJO) WG Science Report

Duane Waliser reported on several recent accomplishments. MJO simulation diagnostics were motivated by the lack of consistent assessment of metrics/diagnostics in previous studies. The MJO WG developed a number of these diagnostics, a volunteer computed them for a number of products, coupled and uncoupled models, and posted them on a website. Several papers are in preparation for the Journal of Climate. The WG then focused on MJO Forecast Metrics based on work of Wheeler and Hendon (2004). The operational (including NCEP, Canada, Australia, Japan, and ECMWF) are all on board community has adopted these with the help of the Working Group on Numerical Experment (WGNE). A paper on this effort is in preparation. Duane indicated the successful MJO Workshop in November 2007 made these recommendations:

- Where possible, develop scalar metrics of MJO model skill for use in multi-model comparisons and for tracking model fidelity.
- Work with the observation, model-development, and theoretical communities to develop process-oriented diagnostics to improve our insight into the physical mechanisms for robust MJO simulation.
- Continue to explore multi-scale interactions & convectively-coupled equatorial waves, both in observations and high resolution modeling frameworks, with particular emphasis on vertical structure and diabatic processes
- Expand efforts to develop and implement MJO forecast metrics under operational conditions
- Develop an experimental modeling framework to assess MJO predictability and forecast skill from contemporary/operational models

Lastly, Duane suggested some opportunities to continue the efforts of the MJO WG including working through the international CLIVAR Monsoon Panels, upcoming Monsoon workshops, the NSF-sponsored Center for Multi-scale Modeling of Atmosphere Processes (CMMAP) at Colorado State University (CSU), or the nascent Years of Tropical Convection (YOTC) activity. He noted there is value in keeping the MJO Working Group remaining active even though it is formally ending.

During the discussion there was agreement the Working Group set a high bar of activity and impact. It was noted that the diagnostics did develop some scalar diagnostics for operational use. There was a suggestion to reach out to operational/training programs (like COMET) and the Hazard Assessment effort at NOAA. Wayne noted impacts and relevance of the MJO in hurricane genesis and outside the tropics, e.g. along the west coast of the US and in Asia – see the MJO WG web pages. Wayne concluded that the answer to the question of why some models made better MJOs is not clear. The Workshop tried to address this, but some future work from the WG is still necessary.

4.3 Western Boundary Current WG Science Report

Mike Alexander started his presentation with the overriding scientific motivation for the Working Group:

- How does air-sea interaction compare in the western North Atlantic and North Pacific?
- What is the nature (temporal and spatial scales, predictability) of atmosphere-ocean interaction in WBC regions?
- To what extent are coupled models getting the interaction right?
- To what extent does air-sea interaction extend beyond the boundary layer and influence broader climate variability in both the atmosphere and ocean?

The WG is developing an assessment of current knowledge addressing these questions organized into two papers: 1) small frontal scale and 2) large basin scale. New analyses will also be

conducted in support of these papers to be submitted to Journal of Climate in 2009. Mike also showed depictions of frontal scale air-sea interactions over the Gulf Stream-GS and Kurioshio Extension-KE regions. Net heat flux anomalies and sea surface height (SSH) variability are large in these regions. Fluctuations of both the KE and GS may affect storm tracks. A recent paper by Minobe (2008) indicated remarkable signatures of the GS extending up through atmosphere to 300mb. He described how changes in the convection over these regions impact atmospheric circulation leading to changes in the number of storms and their meridional position depending on how the GS SST fronts are treated. In the Pacific, Earth simulator runs indicate decadal-scale cooling through the west and central Pacific are concentrated along the KE SST frontal boundaries at ~42N, and that these decadal changes of SSTA may be related to the meridional migration of these fronts. The WG is also synthesizing findings about how the air-sea coupling in these regions plays a role in decadal variability, to what extent the SST patterns are simulated in models, and if there is any predictability originating from these regions and mechanisms. Mike showed results of a heuristic model based on observations suggesting that air-sea coupling enhances and improves decadal signals. Mike concluded with a description of an upcoming 3-day open workshop in January 2009 (Phoenix) when more of the science and Working Group assessment will be completed.

4.4 High Latitude Surface Fluxes WG Science Report

See Appendix A.

4.5 Atlantic Meridional Overturning Circulation (AMOC) report

See Appendix B.

5 Ocean data stewardship plans for climate – Margarita Gregg (NOAA-NODC)

Margarita Gregg (National Oceanographic Data Center - NODC) provided an update on the products and vision for NODC over the next 5-10 years. She reminded the audience that NODC's mission is to provide stewardship of marine environmental and ecosystems data and information. She emphasized the importance of data access and that the success of NODC's efforts will rely on national and international partnerships. She views NODC as the portal to obtain any ocean information and data, but indicates that NODC doesn't have to physically house all the data (e.g. satellite). The success of their efforts is judged by the usefulness of their services to a diverse set of users. She reviewed a number of data sets (e.g. profile data base), activities (e.g. data archeology) and products (e.g. World Ocean Database) of interest to CLIVAR. NODC is working to establish end-to-end management - from acquiring the data, preserving it, assuring quality, and providing open access to the information. NODC is increasingly working with the ecosystems community (and NOAA NMFS) to integrate their data into NODC systems. She noted the importance of metadata and quality assurance as two important areas of interest for climate records. NODC is also active in developing authoritative products such as ocean heat and freshwater content estimates. These efforts further exercise NODC data holdings and, more importantly, provides checks on metadata, data quality flagging, and data completeness. NODC has been working with international partners to address/correct temperature biases introduced in use/flagging of fall-rate equations in the XBT databases. She went on to describe several NODC products:

- Global ocean heat content and freshwater influx – updated every 3 months
- AVHRR Pathfinder SST, Argo Global Data Repository
- GCOS SST intercomparison activities
- Joint archive for sea level

She also described NODC's wide array of activities to provide comprehensive end-to-end data management for coastal environment. This includes efforts to provide data via geospatial visualizations (e.g. through Google)

She then outlined the challenges facing NODC. She noted increasing expectations and costs are forcing prioritization within NODC and welcomed CLIVAR's input. She concluded by posing questions on the relevant roles of NODC, CLIVAR, and the PI; CLIVAR requirements for ocean data and information; NODC's expectations of CLIVAR, and CLIVAR's expectations of NODC.

A lengthy discussion ensued. The first topic addressed ocean-atmosphere process-study data. These data are archived at NOAA (NODC for ocean data and NCDC for surface and atmospheric data). NOAA is working to establish metadata links across their systems and centers to enable retrieval of both. CLIVAR suggested that a co-located data product would be helpful. CLIVAR expressed concern that data from such process experiments is not sufficiently labeled (e.g. as CLIMODE) and thus difficult to find and retrieve (sometimes data are lost at NODC). Margarita responded that, at present project names (e.g. JGOFs or WOCE) are not an NODC search field, but it could be done at the request of the research community. One part of the solution is to have proper reporting standards whereby metadata such as an experiment name are properly reported and included in NODC catalogs. Moving forward will require we look at the critical parts of the submission process and how metadata are stored. This will require cooperation across agencies to insure information such as experimental tags are reported, stored, and retained. An effort to recover metadata may be required. Further on this topic, the PSMI Panel provided a vision of how data can be searched and retrieved, such as by experiment or by measuring platforms. Additionally, for variables such as velocity gradients, researchers need to know something about the instruments used and would additionally like to be able to access all data and synthesis products from a field experiment in a simple way, e.g. storing air-sea fluxes in conjunction with raw oceanographic data. For long-term needs CLIVAR sees a demand for someone not associated with the data to be able to access, understand, and use experimental data. Margarita indicated that NODC has not provided links to synthesis data sets. NODC could do more, but it must weigh all new demands for new services against other needs. Another question addressed NODC development of consistent products to facilitate analysis and use, e.g. is NODC working on global time series? Margarita responded that the World Ocean Atlas is a time series and that additional time series can be put together with current data, but lack sufficient data to make global products. Some satellite time series data such as AVHRR and GHRSST exist for SST, but in some other areas there are no time series products yet. NODC is updating some products quarterly so they can interact better with scientists. CLIVAR asked also about the many efforts within the research community (e.g. NCAR and COLA), and within government labs (e.g. NODC, NCDC) to develop visualization and data manipulation tools – is there concern that there is duplication of effort? Should more sharing of tools be pursued, perhaps as guided by the data management sub-committee within US CLIVAR? Margarita felt that the agencies, as opposed to a PI-lead activity, are a better place to encourage coordination of these efforts. Another asked about formal partnerships between NODC and other data centers, NASA data archives? Margarita responded that NODC is currently focusing on intra-NOAA collaboration right now, especially between fisheries. CLIVAR also commented that facilitating access and providing quality data are important, but does NODC see working with CLIVAR to set up specifics and guidelines for data quality? NODC indicated yes that would be helpful and asked for specific recommendations on how to proceed. CLIVAR also asked about how best to communicate (informally? formally?) requirements for ocean data and information and that activities underway such as reanalysis and process studies are thinking more about this at the moment. Should CLIVAR develop a requirements document and in what kind of time frame? Margarita responded that as process

studies get going, knowing the metadata requirements and having a data management plan at the very beginning would be helpful. Further discussion is required on the need for a requirements document.

6 International CLIVAR, Prospects for 2009-2013

Jim Hurrell, co-chair of International CLIVAR reminded the audience of the broad remit of CLIVAR. He described the CLIVAR Organization and briefly discussed how U.S. CLIVAR ties into the structure, e.g. through U.S. CLIVAR Panel members sitting on International CLIVAR Panels and though the efforts of the US and International Project Offices. He also noted that Martin Visbeck is now a CLIVAR co-chair. Jim then proceeded to highlight some key activities of CLIVAR organized across four cross-cutting themes. In Anthropogenic Climate Change, Jim noted the leadership of CLIVAR scientists in contributing to IPCC AR4, planning for AR5 model runs, and the role of Global Synthesis and Observations Panel (GSOP) working with the ocean carbon community. In Decadal Prediction, Jim noted the Working Group on Coupled Models – and the Working Group on Seasonal to Interannual Prediction (WGCM-WGSIP) efforts to organize (with IGBP) the recent Aspen workshop on decadal prediction experiments as well as the Atlantic Panel's effort to coordinate monitoring/predictability of AMOC, and of GSOP to coordinate intercomparisons of ocean data assimilation/synthesis products. WGSIP organized a major international Workshop on Seasonal Prediction (which noted that maximum predictability has not yet been achieved in seasonal prediction) and is coordinating a World Climate Research Programme (WCRP) Historical Forecast Project. The Monson cross-cut is being led by the various CLIVAR monsoon Panels, with activities in Asia (AMY and IMS) and South America (VAMOS-VOCALS and modeling plans). In the area of extremes, CLIVAR is sponsoring the Expert Team of Climate Change Data Indices (e.g. nice web site and software on how indices are constructed) and the U.S. CLIVAR-lead effort on drought. Jim then noted a number of plans for future activities by the various CLIVAR Panels (see the presentation for more details). Jim informed the audience about the upcoming third World Climate Conference (Theme: Climate Prediction and Information for Decision Making) in 2009 and noted the strong relevance to CLIVAR activities. Planning is beginning for a 2nd CLIVAR Conference in 3-4 years. Finally, Jim invited discussion about the future evolution of WCRP noting the urgent need for a vision and how the core projects would focus and evolve. There was a productive discussion at the last JSC meeting about this evolution, agreeing that the core activities are working well now, and that there is no need to reinvent them at the present. But, WCRP needs to identify outstanding scientific issues and formulate a way for WCRP to address them in the future. He strongly noted that this is an opportunity for CLIVAR to provide input and noted that the U.S. CLIVAR organizational structure is being considered by some as an organizational template.

A discussion then ensued. An agency representative noted that there were recommendations a few years ago to International CLIVAR that they reorganize and move towards the US structure and wondered why nothing has apparently happened. Jim noted that he wasn't aware of these older recommendations but indicated the SSG discussed recently a possible reorganization. CLIVAR decided that in light of possible changes in WCRP over the next few years, that it should retain its current structure for now and reorganize after 2011 once the path of WCRP is clearer. David noted that international CLIVAR has also been more focused on the WCRP cross-cuts than U.S. CLIVAR has. Another person asked about "COPES" and how the strategy would be implemented. Jim noted that according to the JSC, COPES and the WCRP Strategic Framework should be implemented by WCRP and its core projects, and currently that implementation is in the form of WCRP cross-cuts. To the question about the merging of WCRP and IGBP efforts (following the general direction of modeling centers like NCAR), Jim noted that this was discussed by the JSC a year ago, but no strong position was advocated. The upcoming review of

WCRP may provide additional guidance. There was concern that the "applications" themes of the World Climate Conference (WCC) would not engage or encourage young investigators to focus on science issues. Jim responded by noting that Martin Visbeck is on the organizing committee and that he and CLIVAR are pressing to have the WCC recognize the importance of research. Rick Rosen added that the science/research issues will not be lost even though the WCC is bringing in users to help focus science questions. Another commented that a CLIVAR Conference in 2011 would be timely for AR5, as review papers could be marquee items making it known how CLIVAR science is contributing towards IPCC AR5.

7 Inter-Agency Group Input (from NSF, NASA, and NOAA)

David Legler proceeded to introduce input from the U.S. CLIVAR Inter-Agency Group (IAG). He noted that the IAG meets monthly to address implementation of CLIVAR in the US and that the agencies cooperate well with each other (and noted that other programs do not usually enjoy such a helpful body of federal research managers). Eric Lindstrom summarized NASA's climate goals through a set of questions (e.g. how can climate variations induce changes in the global ocean circulation?). He noted that NASA has provided support to U.S. CLIVAR for its Project Offices, as well as support of scientific research in ocean state estimation, decadal climate variability research and workshops, drought research/workshops, AMOC, and new missions such as the OSTM/Jason-2 altimetry. He indicated the top five long-range climate research areas of interest to NASA are end-to-end systems for climate prediction; understanding the role of slowly-varying components of the earth system in climate; observing system development, AMOC, and decadal climate variability. He encouraged U.S. CLIVAR Panels to address the climate/decision-support interface (PPAI), stimulate process improvement into model changes through ESMF, address need for and development of climate data records and observing system priorities, and lastly asked CLIVAR to map its ambitions onto agency goals, agendas, and priorities.

NOAA then described its climate mission which considers observations and monitoring (to describe the state of the climate system), research and modeling (for understanding and predicting climate from weeks to decades to a century), and development of a climate services component (to improve ability of society to plan for and respond to climate change). They noted the NOAA Climate Prediction Program for the Americas (CPPA) support of process studies (e.g. NAME, EPIC, VOCALS), and focuses on drought as well. CPPA is also taking up downscaling of forecasts and CFS model assessment and improvement. The NOAA CVP program has supported modeling and diagnostics studies, Coupled Model Experiment Project (CMEP) and Drought in Coupled Models Project (DRICOMP), CPTs, and AMOC as well as abrupt climate changes, and the Climate Prediction Applications Postdoctoral Program (CPAPP) initiated by U.S. CLIVAR. NOAA noted their lead in the planning activities of a climate services division. They suggested CLIVAR continue to improve representation of physical processes in climate models, improve understanding of drought and other extremes, address improvements in S-I predictability and prediction, help develop decadal prediction capabilities, and contribute to the ongoing development of the climate observing system. They also suggested CLIVAR consider and develop input for the anticipated new Climate Change Science Program (CCSP) Strategic Plan by identifying the major scientific questions that must be resolved in the next 5-10 years.

NSF conveyed its role in supporting research that advances discovery, knowledge, and understanding in all areas of climate science. They also promote teaching and training in climate science, and advancements in climate research that will bring benefits to society. They noted their support of a wide variety of research activities (in addition to the project office support), such as for CPTs, CMEP, DRICOMP, CLIMODE, VOCALS, DIMES, AMOC, and the growing Year of

Tropical Convection (YoTC). Their research interests that intersect with CLIVAR include predictability of the climate system across a range of time and space scales, process understanding, new observing techniques, improved observations and modeling of climate forcing, diagnostics and modeling improvement and evaluation, unified modeling approach (weather through decadal and longer time scales), high-resolution climate models, and climate extremes and coupling to extreme weather. They suggested U.S. CLIVAR identify a small set of questions and the facilities and research required to address them; provide feedback on long-range scientific priorities, brief NSF management on CLIVAR achievements and opportunities; engage the broader climate research community; develop activities that enhance the productivity of investigators; and provide information and iterations leading to stronger research proposals.

8 Charge to the panels

David Legler provided a template to each of the panels for reporting at the end of the Summit. In addition to discussing panel previous year activities, he asked each panel to consider their progress on the two foci identified during the 2006 U.S. CLIVAR summit: Drought and Decadal Variability/Predictability. Discussion of these foci should center around: synthesizing existing knowledge of the foci and capabilities within the panel; assessing opportunities and articulating panel goals related to the foci; and devising a plan to achieve these goals.

9 Predictions, Predictability & Applications Interface Panel Report

The panel had extensive discussion of U.S. CLIVAR contributions to decadal prediction and predictability. This discussion is particularly important given the emerging international CLIVAR activities in this regard. The panel was briefed on the results of the decadal prediction workshop in Aspen. Two member of PPAI (Goddard and Kirtman) represented U.S. CLIVAR at the workshop. A number of key issues were raised at the Aspen workshop, which were also discussed at PPAI.

9.1 Predictability

- What is the predictability? The big challenge is to make quantitative statements about the predictability of regional climatic variables that are of use to society. What is the predictability of changes in extreme weather events? What is the predictability of regional ecosystems? What is the predictability of regional hydrology? Much of the regional predictability will also depend on the predictability of known phenomena such as PDO, IPO, NPO, AMO, TAV, NAO, which we do not know.
- What are the sources of predictability? For example, with ENSO we know that the source of predictability is sub-surface thermal anomalies in the equatorial western Pacific. What are the sources of predictability for the PDO, IPO, NPO, AMO, TAV, NAO etc? Are there sources of predictability from interactions among the components of the climate system? Traditionally, we have focused on interactions among the physical component, but it is possible that there may be predictability due to interactions between the physical and biogeochemical components of the climate system.
- What are the factors that limit decadal predictability? Again with ENSO, it has been suggested that "weather noise" due to internal atmospheric dynamics limits predictability. Is this also true for decadal variability? How do model errors limit decadal predictability and how do we reduce these errors and their impact? What role does model resolution play in limiting predictability? Initialization and Data Assimilation
- What data is needed for initializing the climate system? What land-surface, ice, ocean and atmospheric data do we need?
- Multiple approaches for data assimilation are likely to be required. On the one hand, we need to develop best practices in state estimation, and on the other hand we need to develop

initialization strategies, which will use results of state estimation, but may not be the "best" observed state.

- What are the best methods for initialization? There is likely to be multiple initialization strategies – the community needs to develop a process for indentifying the best practices for initializing decadal predictions that include all the components of the climate system.

Based in these challenges the PPAI recommended modifications to the decadal working group prospectus. The revised prospectus has been submitted for consideration to the U.S. CLIVAR committee.

Action Item 1: **Finalize the decadal working group prospectus (Goddard, Vimont, Solomon). Assuming the decadal working group is approved, PPAI will co-chair the WG (Goddard) and will actively participate in the WG (Koster and Kirtman).**

9.2 Climate Impacts on Natural Resources

The panel extensive discussions of a climate impacts on natural resources and how PPAI can best facilitate progress. Hall presented a draft prospectus for a Climate Impacts on Natural Resources working group. This prospectus involved climate impacts on water resources, and marine and terrestrial ecosystems. After extended discussion, the group concluded the prospectus was not focused enough. It involved too many research communities and too many topics. The group recommended a workshop be organized instead. The workshop would be limited to just one aspect of the prospectus (i.e. either water resources, marine ecosystems, or terrestrial ecosystems). The purpose of the workshop would be to develop a still narrower narrow focus for a working group. Also relevant to this issue are parallel discussions at the summit with David Mountain (representing GLOBEC). Mountain indicated his interest in CLIVAR support for marine ecosystem applications.

Action Item 2: **Hall to determine which aspect of the prospectus to pursue, identify a co-chair for the workshop, and submit a proposal to David Legler by December 2008.**

9.3 Climate Prediction and Applications Postdoc Program (CPAPP).

Lisa Goddard provided an update on the CPAPP program, initiated by the PPAI panel. U.S. CLIVAR CPAPP program, currently supported by NOAA, is moving into its
2nd year. The announcement of opportunity is currently out for postdoctoral researchers, with 2 positions available in 2009. Our inaugural post-doc, Galina Guentchev, began her work with the U.S. Bureau of Reclamation and NOAA-ESRL this summer, where she will focus climate change projections applied to western water.

Action Item 3: **The panel will continue working with Meg Austin, Director of the UCAR visiting scientist program, to institute this program. (Lisa Goddard, Ben Kirtman)**

9.4 Best practices in prediction.

WCRP Position paper on seasonal prediction has been published. This position paper has extensive contributions from PPAI including representation at the 2007 workshop. A version of the position paper has been accepted for publication in the Bulletin of the American Meteorological Society.

Action Item 4: **Finalize BAMS seasonal prediction best practices paper (Kirtman).**

There will be a National Academies assessment of climate predictability on intraseaonal to interannual time scales. This study will review the current state of knowledge about estimates of predictability of the climate system on intraseasonal-to-interannual timescales, assess in what ways current estimates are deficient, and recommend ways to improve upon the current predictability estimates. The study will also recommend research and model development foci and efforts that will be most beneficial in narrowing the gap between the current skill of predictions and estimated predictability limits. The review of predictability estimates to be addressed will include oceanic and atmospheric variables such as sea surface temperature, surface temperature, precipitation, and soil moisture, as well as indices like Nino 3.4 sea surface temperatures or the phases of the Madden-Julian Oscillation.

Action Item 5: **PPAI members (Goddard and Kirtman) will participate in the National Academy assessment of climate predictability on intraseasonal to interannual time scales study.**

There are two white papers on seamless prediction under development to be submitted to BAMS. The first paper focuses on the seamless prediction problem from the perspective of the operational weather forecasting community, but has inputs from PPAI with respect to seasonal prediction. The second white paper focuses on the institutional and infrastructure issues associated with seamless prediction.

Action Item 6: **PPAI members (Delworth, Meehl and Kirtman) will continue to contribute to white papers on seamless prediction.**

9.5 Seasonal/Interannual prediction review for North America.

The results of this review are complete.

Action item 7: **Finish writing the manuscript for Seasonal/Interannual prediction review for North America (Lisa Goddard).**

9.6 Tropical Biases Working Group.

We concluded that a working group on tropical biases is highly desirable, but that the timing is not right for it now.

Action item 8: **The panel will push forward on this at the 2009 summit. (Ben Kirtman)**

10 Process Studies and Model Improvement Panel Report

10.1 Best Practices for Process Studies

PSMIP discussed the best practices for process studies which have been developed over the course of several years in consultation with process study PIs. An article in press in the Bulletin of the American Meteorological Society (BAMS) aims to publicize these best practices to the

wider community, and we will continue to maintain an ongoing discussion with process study PIs regarding their application of the best practices.

Action item 9 **Continue to solicit information from and provide feedback to process studies concerning their progress toward best practices goals [process study liaisons]Best Practices for Process Studies**

10.2 Best Practices for Parameterization Development

To complement the guidelines for best practices for process studies, an outline for best practices in parameterization and parameterization development was developed by Leo Donner. These practices emphasize the role of process models as the link between process studies and parameterization development and improvement, and the need to isolate and expose the most uncertain aspects of parameterizations. These guidelines impact the design of not only the parameterizations themselves, but also the design of observational process studies so that they adequately constrain the external forcing of the intermediary process models.

Action Item 10: **Draft essay on parameterization best practices (fall 2008) to be submitted for publication before next summit [Donner and Bryan]**

10.3 Data Stewardship

A subset of PSMIP (Flatau, Legg, Donohue, Joyce, Zuidema, Ferrari) met with POS and Margarita Gregg from NODC to discuss issues associated with long-term archive of climate-relevant data-sets at NODC. Of particular concern to PSMIP are issues associated with archiving data from field-experiments – one concrete suggestion was that data should be tagged by experiment name, as well as by instrument type. Another concern is that "new" data types, e.g. L-ADCP and turbulence data, are not archived at NODC. Gregg indicated that it would be most practical for NODC to work with the group associated with a field experiment as a single entity, rather than with individual PIs. Access would be facilitated by having a "champion" for the data-set, either at NODC or outside. Each field experiment needs to work with NODC from the beginning to develop the metadata and list of data to be archived. Raf Ferrari shared a list of all turbulent dissipation studies from the last 10-15 years as a starting point for improving long-term archive of this data.

Action item 11: **Put together a "best practices" news item (for EOS or BAMS) highlighting current NODC submission criteria, expectations for PIs, the role of NODC data advocates, how to contact NODC to get them involved early, and strategies for dealing with orphan data sets. [Donohue PSMIP lead, with POS]**

Action item 12: **Contact PIs involved in data collection of orphan data types (e.g. turbulent dissipation) and involve them in discussion of long-term archive. [Legg]**

10.4 Ongoing process studies

In advance of the summit, process study liaisons solicited information from process study PIs, which was shared with the full panel at the summit. The panel discussed the process study progress with regard to the best practices, summarized below for each process study.

Action item 13: **Communicate PSMIP feedback to each of the U.S. CLIVAR process studies by end of summer [process study liaisons].**

10.4.1 CLIMODE (Liaison: Terry Joyce and Frank Bryan)

The goal of the CLIvar Mode Water Dynamics Experiment is to investigate 18^0 Atlantic water formation, with the field phase lasting from 2005-2007. Analysis has begun and a BAMS article is under review. Recommendations include making revisions to the COARE air-sea flux bulk algorithm available to modeling centers, and a request to submit datasets, meta data and special value-added datasets to one central server, either EOL or NODC, in a common format such as netcdf.

10.4.2 DIMES (Liaison: Raffaele Ferrari and Kathy Donohue)

The Diapycnal and Isopycnal Mixing Experiment is a US-UK collaborative field experiment planned along the tilting isopycnals of the Antarctic Circumpolar Current for 2009-2012. The panel recommended that PIs plan early for how to share data through the DIMES website, and archive data at NODIC afterwards in a common well-documented data format such as netcdf.

10.4.3 EPIC (Liaison: Paquita Zuidema and Piotr Flatau)

The Eastern Pacific Investigation of Climate process study conducted a field experiment in 2001 that contained a focus on both the Eastern Pacific ITCZ and the southeastern Pacific stratocumulus region. Data analysis has mostly finalized. EPIC serves as a predecessor to the VOCALS process study. A stratocumulus Integrated Dataset, intended for model assessment, is available (EOL) with an eastern Pacific ITCZ IDS on the way. 2008 is the last year EPIC will be discussed by PSMIP.

10.4.4 KESS (Liaison: Terry Joyce and Kathy Donohue)

The Kuroshio Extension System Study field component has recently ended. The majority of primary datasets have been made public at NODC, with the panel recommending remaining datasets and higher-level datasets and diagnostics be archived.

10.4.5 NAME (Liaison: Wanqiu Wang and Xubin Zeng)

The North American Monsoon Experiment 2004 field campaign is now in a data analysis phase, with the NAME Forecast Forum continuing to assess the capability of current models. A data availability and updating assessment was done during the summer of 2008 by EOL. The panel recommends the NAME FF identify and document existing common deficiencies of the current numerical models in forecasting the NAM, thereby helping to better motivate further study as part of IASCLIP.

10.4.6 VOCALS (Liaison: Paquita Zuidema and Piotr Flatau)

The VAMOS Ocean-Coupled-Land-Atmosphere Study is aimed at understanding model biases for the eastern low-latitude Pacific and aerosol indirect effects as manifested in its stratocumulus deck. A regional experiment is planned for fall 2008. VOCALS is building on its predecessor EPIC, and enjoys both NOAA and NSF support and strong UK participation. A pre-experiment modeling assessment of 2006 conditions along 20 S is in progress. EOL is responsible for data management, with best practices in place.

10.5 Possible Future Process Studies

PSMIP discussed several possible future process studies. Some of these process studies are being developed by U.S. CLIVAR working groups; others are being initiated by independent PIs who are now seeking U.S. CLIVAR input and feedback.

10.5.1 Intra-Americas Study of Climate Processes - IASCLIP (Panel liaison: Xubin Zeng and Paquita Zuidema)

The Intra Americas Study of Climate Processes is a recently initiated process study focused on understanding the mechanisms for seasonal to interannual variability in the IAS and the role of IAS variability in the surrounding regions. NOAA is providing some funds for diagnostics research in their FY09 call, and an observational campaign is proposed for 2011-2012. Ben Kirtman provided a presentation on IASCLIP. The IASCLIP WG is planning for an IASCLIP Forecast Forum for 2009, expanding on the NAME FF. Plans for a process study (should it occur) are in a preliminary stage, with an initial 'virtual' field campaign a possibility. A primary PSMIP recommendation is for more permanent buoys in the IAS region, which is also congruent with hurricane research priorities. Buoy-visitation cruises, both planned and opportunistic, can be used to spur the initial model-data comparison, similar to the VOCALS experience. The justification for a field campaign still needs to be made, should invoke funding from other agencies, and thought needs to be given to available resources.

Action item 14: **Communicate PSMIP feedback to IASCLIP PIs and program managers [Xubin Zeng]**

10.5.2 SALINITY Process Study (Panel Liaison: Paquita Zuidema and Frank Bryan)

A calibration-validation field program associated with the Aquarius mission launch in 2010 has been proposed to quantify the salinity budget of the upper ocean near the salinity maximum of the subtropical North Atlantic. PSMIP recommended the PIs more clearly articulate the process study concept, remaining mindful of best practices, and evaluate how the processes are represented in current ocean climate models and re-analysis. A 2nd recommendation is for the group to work through the International CLIVAR Indian Ocean Panel to explore partnership opportunities with the Indian oceanographic community.

Action Item 15: **Synthesize feedback from PSMIP and Pos into a single letter to Salinity field experiment PIs [Frank Bryan and Mike Alexander]**

10.5.3 Surface Water Ocean Topography (SWOT)

The surface water and ocean topography mission is planned for 2016, and a field experiment to take advantage of this opportunity is under discussion. (See working groups.)

10.5.4 PUMP2 (Liaison: Ed Schneider and Sonya Legg)

The Pacific Upwelling and Mixing Physics 2 project is a revision of the PUMP project, which was not funded by NOAA. Several related small projects have been funded by NSF and NOAA. Investigators have requested PSMIP express support for the investigation of PUMP, support coupled model experiments to study the climate sensitivity of the upwelling cell and its parameterizations, and advocate for ancillary projects on NOAA TAO cruises.

Action item 16: **Communicate feedback to PUMP2 PIs. [Ed Schneider]**

Action item 17: **Communicate PI recommendations for instrument upgrades (upgrade R/V Ka'imimoana ADCP and enhance TAO moorings) to program managers.**

10.5.5 United states participation in 2011 Cooperative Indian Ocean field Experiment [Liaison: Piotr Flatau and Ed Schneider]

Duane Waliser presented a draft proposal for a US component of CIOFE. The proposed multinational field experiment, planned for 2011 and endorsed by the U.S. CLIVAR MJO working group, targets the physical processes involved in the initiation of the Madden-Julian Oscillation (MJO) over the Indian Ocean. The proposed US contribution, a radar-capable ship (e.g. R/V Ron Brown) for 50 days, will extend the total ship time (added to the Japanese component) to 100 days, optimizing the chances of capturing the MJO convective initiation. The time frame is set by the already-planned Japanese experiment, and may coincide with a proposed ARM-funded deployment to Manus. PSMIP supports the preliminary plan, while encouraging the PIs to follow the best practices for process studies. PSMIP also encourages cooperation the Joint Aerosol-Monsoon Experiment, and Atmospheric Brown Cloud project. PSMIP encourages the involvement of a radar specialist at PI level, that a survey be done of other ships capable of hosting a Doppler precipitation radar should the Ron Brown not be available, and encourages communication of the draft proposal to the NOAA climate board and NSF program managers.

Action item 18: **Communicate PSMIP feedback to CIOFE PIs and program managers. [Piotr Flatau]**

10.6 Climate Process Teams

PSMIP discussed the completed questionnaires received from the PIS of the soon-to-be-completed pilot CPTs, and reviewed the timeline for a possible new set of CPTs to begin in 2009, depending on availability of funding. Different program managers would like to see different levels of guidance for future topics, and show different levels of enthusiasm for a new round of CPTs. Program managers may request further input, in addition to the "review and recommendations'' document, before the eventual call-for-proposals.

Action item 19: **Finish CPT "review and recommendations" document by end of summer and forward to program managers [Legg and Flatau]**

10.7 Foci documents

PSMIP discussed how the process studies, working groups, CPTs and other initiatives we support form part of U.S. CLIVAR efforts focused on drought and decadal variability.

Action item 20: **Prepare 2-page documents summarizing PSMIP's current and future activities in the areas of drought and decadal variability by October 1st [Legg and Zuidema]**

10.8 Working groups

PSMIP participated in discussions for three possible future working groups, Integrated Earth System Analysis, Decadal Variability and Predictability, and Climate and Ecosystems. Of the three only the Decadal variability and predictability working group will be proposed in the coming year.

PSMIP reviewed the current working groups, e.g. the Western Boundary Current working group, with the following conclusions:

- PSMIP strongly supports the WG format. WG have gone beyond their original mandate of summarizing the state of knowledge on particular science topics. They actually generated new exciting science. This happened mostly because the WG provided a framework for scientists with a common interest to regularly discuss their results and act as a group, instead of separate individuals.
- PSMIP wants to stress that the goal of a working group is to raise awareness in the community about science topics of relevance to CLIVAR. This is typically done by producing white papers that summarize recent advances. WG should not be an instrument for scientists lobbying for a particular process study.
- PSIMIP recommends that David Legler organizes groups teleconferences using Skype to reduce costs for international participants. This has been an issue in the past, because the international collaborators were responsible for the conference call from their side.

PSMI explored some ideas for future working groups or workshops, including one, suggested by Zuidema, which aims to draw upon the recent field experiments in boundary layer cloud processes (e.g. VOCALS, EPIC) to explore the integration and application of results to boundary layer cloud modeling. Several panel members also participated in discussions towards a tropical biases working group.

Ferrari expressed interest in proposing a WG on upper ocean dynamics at the next summit. The motivation is the upcoming SWOT (Surface Water and Ocean Topography Mission) which will provide SSH and geostrophic velocities down to scales of O(10)km. The goals of the WG would be to summarize (1) what new physics can be studied at 10km global resolution, (2) what process studies should happen to provide the science basis for interpreting SWOT data, (3) how to coordinate the process studies with the biogeochemistry community which is very interested on the implications of O(10)km dynamics on surface nutrients and biology.

Action item 21:	**Discuss boundary layer cloud workshop/working group with wider community by Sept. 1st [Zuidema, Flatau, Zeng]**
Action item 22:	**Explore possibilities for SWOT-related working group/workshop by next summit [Ferrari]**
Action item 23:	**Develop proposal for Tropical biases working group by next summit [Ed Schneider with members of other panels]**

10.9 Research Gaps

PSMIP discussed the processes where greater research investment is needed, in order to improve models. We suggest sub-thermocline mixing, sea-ice processes, ice-shelf/land-ice processes, the role of aerosols in hydrologic cycle, and the role of soil-moisture processes, as processes involved in decadal prediction, AMOC and drought which need more investment.

PSMIP-monitored process studies and model improvement activities have typically received investment mainly from NSF and NOAA. We discussed the need to engage NASA, including the Modeling, Analysis and Prediction manager as well as the physical oceanography manager, more over next year, especially with regard to future process studies related to satellite missions.

Action item 24: **Initiate contact with NASA program managers regarding future satellite missions and related process studies, before next summit [Zeng]**

10.10 Discussion of CLIVAR Coordination with Policy and Decision Makers

The PSMI panel discussed the topic "explore how best to inform and interact with programs that interface directly with policy and decision makers in order to enhance the relevance of climate research coordinated by U.S. CLIVAR." The panel felt that it was appropriate that the interface between U.S. CLIVAR and the programs in question should be the Director of the CLIVAR Office (i.e. David Legler). The CLIVAR Office could provide application and sector specific advice on scientific issues relevant to the programs. Additionally, representatives of the programs could be invited to CLIVAR meetings in order to foster communication between the scientific and decision-making communities. Another suggestion was that panel chairs could participate by phone in agency meetings.

10.11 Panel Membership

Terry Joyce (WHOI) and Raf Ferrari (MIT) are due to rotate off the panel this year, so we will need 2 new members to replace them, including at least one sea-going physical oceanographer, in order to maintain expertise relevant to our process study mandate. An ice scientist would also help to fill a gap in our current expertise. Paquita Zuidema and Sonya Legg will remain co-chairs for the next year.

Action item 25: Contact oceanographers/ice scientists with relevant expertise inviting them to apply for panel membership [Legg]

11 Phenomena, Observations and Synthesis Panel Report

11.1 OBSERVATIONS

11.1.1 Salinity

While the U.S. CLIVAR Salinity working group (SWG) ended a year ago it has remained active in an official capacity and is formally recognized by NASA. Jim reported on the activities and plans of the SWG over the past year. The activities included a special session devoted to salinity at the 2007 fall AGU meeting, an Oceanography (journal) issue devoted to salinity, including a description of the upcoming Aquarius satellite mission and a SWG meeting held in Woods Hole. At the meeting, plans for a process study were initiated in support Aquarius mission for the 2011-2013 time frame. As a first step the SWG decided that a relatively "quiet" location where the salinity balance would be relatively easy to determine would be a good choice to validate the results from Aquarius. They chose the subtropical Atlantic, which has the additional benefits of being in warm water where the sensor on the satellite is more accurate, is relatively easy to service and can leverage off other resources. The SWG is planning to meet next year.

Discussion on the field program led to several suggestions:

- A protocol for data stewardship should be considered early in the planning process so early contacts with NODC would be valuable

- The northeast extension of the Pirata array would be near the process study region. Chris suggested that the salinity measurements on the northernmost buoy might be upgraded to include higher-resolution measurements of salinity as soon as possible should the SWG consider this helpful. If necessary, US CLIVAR could draft a letter of recommendation to GOOS to upgrade the instruments on the buoy.

Chris has subsequently confirmed that the International PIRATA Steering Committee (US, France, Brazil) has a standard form that any researcher wishing to augment the instruments on a mooring should complete. Any member of the SWG wanting to work on this should contact Rick Lumpkin at NOAA/AOML in Miami for more information.

Action Item 26: **POS (and PSMIP) panels will provide both scientific and logistical guidance for the field program and as the plans become more finalized the panel(s) should provide comments/suggestions. (Chris, Sirpa)**

11.1.2 Historical data set primer

At the 2007 summit Alexey presented a wide array of efforts to obtain and archive historical data. While this information would be very valuable for the research community to be aware of, it was unclear how to best provide it to the community. At this summit we decided that a web based description and links to the various data sets would be most useful. The "informed guide to data sets" by Clara Deser and Jim Hurrel may provide some ideas on how to go about this.

Action item 27: **a) Provide a description of the datasets to Cathy Stephens who will construct the web page (Alexey)**

b) A Climate Variations article highlighting the web page, including examples of the historical data, will be written once the web page is relatively complete (Alexey)

11.1.3 OceanObs'09

David Legler described the planning for the OceanObs 09 conference to be held on 21-25 September 2009, Venice, Italy. Almost a decade has passed since the OceanObs'99 symposium played a major role in consolidating the plans for a comprehensive ocean observing system able to deliver systematic global information about the physical environment of the oceans. The goals of the upcoming meeting include catalyzing the community, developing a consensus plan on where to go in the future and promoting partnerships to sustain and advance development of the observing system into the 21st century. One plan to organize the meeting is as follows:

Day 1 - high level talks, celebration of accomplishments

Day 2 – sea level including regional trends

Day 3 – societal benefits, ecosystems, extremes, tsunamis,

Day 4 – Frontier of ocean observations, e.g. oxygen sensors on Argo floats

Day 5 – Future directions

Other ways to organize meeting e.g. by basin or by variable (temperature salinity, etc.)

Action item 28: **POS should provide feedback on specific topics and names to lead the sessions. One or more topics could include using observations to better understand physics/dynamics of the oceans. (Sarah, Sirpa)**

11.1.4 Archival of DART pressure data

Meghan Cronin (NOAA/PMEL) was concerned that the pressure data from the Deep-ocean Assessment and Reporting of Tsunamis (DART) buoys was not being archived by NOAA. The data is being stored at the National Geophysical Data Center (NGDC, http://www.ngdc.noaa.gov/hazard/DARTData.shtml). It might also be useful for NODC to link to this data at NGDC. The real time data is also archived at the National Buoy data center (NBDC).

Action Item 29: **Encourage NODC to provide a link to the DART data at NGDC and NBDC.**

Action Item 30: **U.S. CLIVAR should recommend that the National Data Buoy Center recognize that the bottom pressure data collected by the DART moorings as valuable and that we encourage NDBC to make sure that both the real time and delayed mode data make their way to the data centers (e.g. NGDC, NODC).**

Action Item 31: **POS should make sure that those running the GRACE gravity satellite are aware of the the DART bottom pressure sensors and encourage people from the GRACE community to contact NDBC to express the value they see in the DART data. (Chris, Sarah)**

11.1.5 Data Stewardship Breakout

Members of all three panels met with Margarita Gregg to discuss how to improve the archival and distribution of ocean data. Several ideas were discussed including:

- Identify "orphan" data sets (e.g. Turbulence measurements)
- Coordinate group collection/submission of these data
- Data searchable by field program (e.g. all data from CLIMODE)
- Early participation of NODC in field programs to facilitate archival
- Recommend using netcdf
- Outside validation of updated or new products
- Leverage state of the art development at other institutions

Action item 32: **Put together a "best practices" news item (for EOS or BAMS) highlighting current NODC submission criteria, expectations for PIs, the role of NODC data advocates, how to contact NODC to get them involved early, and strategies for dealing with orphan data sets. (Sarah, Chris, Sonya, Margarita, others)**

Action Item 33: **Assemble a list of these orphan data sets (e.g. turbulent diffusivities, LADCP, IES, current meters), and will see if some advocates can be identified within the community. (Chris, Sarah)**

11.1.6 Synthesis of observational requirements

Tony provided an overview on his and Rong's efforts to synthesize various observational requirements including those for operations as described by the Joint WMO-IOC Technical Commission on Oceanography and Marine Meteorology (JCOMM) and those for climate monitoring and research as described by the Global Climate Observing System (GCOS) into a unified set of requirements.

Action Item 34: **(Tony, Rong) a)Check requirements for reporting errors, realism (can requirements be met in next 10 years) and consistency between documents**

b) Extend synthesis to in situ data. Recommend requirements for gravity measurements from the grace satellite.

c) Report findings to Eric Lindstrom (NASA program manager), provide synthesis information directly to chairs of JCOMM and GCOS (Ed Harrison, Neville Smith and Greg Donnely).

Action Item 35: **Explore additional ways to distribute data e.g. post on US CLIVAR web page, white paper for OceanObs'09 conference, etc.**

11.1.7 Biases in SST data

Alexey gave an overview of biases in SST data sets, including:

- Differences in 5-year averages between MODIS and COADS
- (complex structure both spatially and seasonally)
- Differences between ships and buoys
- Biases in the seasonal and diurnal cycles

Biases resulting from the diurnal drift in crossing times of instruments aboard AVHRR satellites. This has important implications for length of overlap between satellites for calibration,

11.1.8 INSTANT

Tony gave an update on INSTANT: International Nusantara Stratification and Transport program: a 3-year (2003-2006) deployment of moorings to measure the transports of the Indonesian throughflow (ITF) in key passages (Makassar, Lombok, Ombai, Timor).

A workshop was help in May 2008 at Lamont to evaluate models and interpret INSTANT data. The workshop outcome included:

Defining metrics for models

(1) Integrated transports instead of point-wise comparison.

(2) Vertical structure.

(3) Imbalance of inflow & outflow of Indonesian Seas.

Were the INSTANT observations representative of the long-term mean?

11.2 Working Groups and Science Teams

11.2.1 Drought Working Group (DWG)

Siegfried Schubert gave a brief overview of the status of the DWG (well documented in a ppt presentation available from US CLIVAR on line). We then discussed topics that still need to be addressed (which will be incorporated into the 2-page document sent to the agencies on gaps and future directions):

- Bridging current modeling studies with observations
  - Develop soil moisture fields for model initialization and validation
  - Provide guidance to NIDIS how to best use information from models
- Explore decadal prediction of drought using coupled models
- Role of deep soil moisture in providing memory and low frequency predictability
  - Improved model formulations
  - What data is available? What new measurements are needed?

11.2.2 Indian Ocean (IO) Working Group (International CLIVAR)

Tony gave an overview on the International CLIVAR working group on Indian Ocean variability and recent research on IO variability. There has been many articles published in the last year on investigations of Indian Ocean variability (see related ppt), yet several issues still remain including (to be included in write-up to the agencies)

- Cause of multidecadal surface warming and subsurface cooling
- Role of Indonesian through flow verses the subtropical cell in the Indian Ocean on decadal variability
- Role of natural verses anthropogenic forcing
- Interaction between the Indian ocean variability and the Asian monsoon

11.2.3 Atlantic Meridional Overturning Circulation science team (AMOCST)

Tony gave an overview on the goals and activities of the AMOCST formed in March of 2008. The goals OFAMOCST include design & implementation of a monitoring system, the role of AMOC in climate and the predictability of AMOC.

Activities:

- Call for proposals: NOAA, NOPP (outcome recently released); more AMOCST members after outcome of recent proposals are released.
- Jerry Miller appointed as project scientist for AMOCST
- First meeting in March 2008
- 3 AMOC-related sessions in March's Ocean Sciences Meeting.
- RAPID PI meeting in June in UK (some US AMOCST members attended).
- Enhanced interaction with European program/scientists (joint meeting with International CLIVAR Atlantic Panel in September).
- Performed detailed intercomparison of the strength of AMOC in seven ocean reanalysis products

POS also discussed potential research questions for the funding agencies to consider including:

- Predictability of the AMOC and the role of the AMOC in the predictability of the climate system
- Connection between the AMOC and SSTs
- Scale of MOC variability and the meridional connectivity. For example, to what extent are the high latitudes, subtropics and tropics interconnected? Can we trace the source(s) of changes at the Rapid/Mocha array (located at 26.5°N)?

11.2.4 Decadal Predictability Working Group (DPWG)

Dan briefed us on the evolution of the working group prospectus

Lessons from 2007 Summit:

- Lack of consensus on what a "Decadal Prediction" is or could be
- Disagreement about the focus: Pacific, or Global?
- What are the specific deliverables that the WG would provide?
- What role do user communities play?

2008 Prospectus Objectives

- Develop a global framework for understanding decadal variability that can be used as a strategy to validate and initialize climate models
    - Define frameworks for decadal prediction

    - Identify metrics to assess the simulation of decadal variability in climate models, and to evaluate *quality*, *usefulness*, or *value* of decadal predictions (some user input necessary)
    - Identify what limits our ability to simulate and predict decadal variability in climate models, with potential focus on the Pacific (ongoing efforts in other basins)
- Define a mechanistic framework to distinguish natural variability from anthropogenically forced variability on decadal time

Suggest a call from funding agencies (similar to DRICOMP) to evaluate decadal predictability in short-term AR5 model archive.

The direction of the DPWG became better defined over the course of the summit in PPAI and in a break out session. Amy Solomon, Lisa Goddard and Arun Kumar have been identified as WG co-chairs.

Action item 36: **POS will work with DPWG co-chairs (Amy Solomon, Arun Kumar, Lisa Goddard) to formulate a final prospectus and help launch the WG. (Dan)**

11.2.5 Abrupt change and Tipping points

Rong lead a discussion on the feasibility of forming a working group or having a workshop to address abrupt change and potential tipping points in the climate system during the 21st century. The motivation for such research is clear, abrupt changes could tip regional and global climate toward different climate states, thus have disproportional large societal impacts. Consequently, there is a strong interest from the climate community and public in addressing this issue, as demonstrated by enthusiastic response to the special session on abrupt change at the 2007 AGU Fall Conference and to a planned special issue of PNAS on this topic. There is also strong policy implication, e.g., the limit for global atmospheric CO_2 concentration to avoid pushing the climate system beyond the tipping point. Questions to be addressed include

- Define and identify potential tipping points;
- Assess the likelihood for tipping point to occur for different emission scenarios using CMIP model simulations;
- Identify climate variables, especially those not included in the standard model outputs, that are needed to assess abrupt change and tipping points;
- Assess our ability and the observations needed to detect the precursors and to predict abrupt change.
- Relation to decadal variability and extreme events
- Impact on ecosystems (e.g. Amazon rain forests)
-

While the panel liked the idea of this research focus, it was concerned that the topic may too broad and too interdisciplinary for a working group with a limited term to make significant progress.

Action Item 37: **POS will seek input from the research community as to whether a workshop or working group is an effective way to advance research in this area, and if so, address the best way to focus this endeavor, e.g. only address physical tipping points or look at a subset of interdisciplinary problems. (Rong)**

11.2.6 Integrated Earth System Analysis (IESA)

Tony lead the discussion incorporating information from potential working group members and suggestions provided on last years prospectus. Reasons for IESA include, to improve our

understanding of the coupled system which is limited by inconsistent state estimates among analysis systems for individual components and the need to initialize climate predictions.

Why should IESA WG be considered now:

- Advances in individual component analysis, emerging efforts towards IESA (e.g., NCEP, GFDL, NASA Goddard, ECMWF, JPL).
- Agency interests: a series of workshops on related subjects in the past few years sponsored by various agencies (e.g., coupled assimilation workshop in 2003 sponsored; IESA workshop in 2006 sponsored by the National Academies).
- The U.S. Climate Change Science Program identified IESA as one of the top priorities.

What needs to be addressed:

- Goals of IESA effort.
- Metrics (e.g. standards, error tolerance) of IESA products.
- Identification of data source & determination of error characteristics.
- Data quality control.
- Tradeoff between the sophistication of assimilation methods & required computational resources.
- Merit of "loosely" (one component can influence the other but error covariance matrices do not include information from other components) versus "fully" coupled assimilation.
- Treatment of bias for models & data.
- Error covariance of model & data.
- Strategy to deal with the difference in dominant time scales among different components.
- Non-linearity in the coupled system & implications to assimilation methods.
- Resources need.

Potential working group tasks

- Define the goals of IESA effort (esp. the targeted period of assimilation and the targeted temporal and spatial scales and phenomena).
- Develop a metrics for IESA products.
- Determine data sets for assimilation and assess status of the data (data serving, format, meta data information, and availability of error characteristics) (an example for a similar effort for atmospheric reanalysis is described by Schubert et al. 2006).
- Design a strategy to coordinate data preparation & (QC) so as to avoid duplicate efforts.

Alternative scenario: Describe all major issues for IESA, identify the corresponding technical & scientific challenges, and provide recommendation in terms of priorities.

POS also noted that there might be value to a working group arising out of the workshop or focused on a very specific topic, perhaps related to the current NCEP and NASA reanalysis efforts.

As new high resolution reanalysis become available in the next year or two compare uncoupled (NASA I) to "loosely" coupled (NCEP, NASA II)

Evaluate Potential Programmatic WG activities

- Assessment of data error characteristics
- Define metrics
- Identify scientific challenges

Then provide recommendations in terms of priorities.

Action Item 37: **POS will seek input from the research community as to whether a workshop or working group is an effective way to advance research in this area, and if so, address the best way to focus this endeavor, e.g. only address physical tipping points or look at a subset of interdisciplinary problems. (Rong)**

Action item 38: **A workshop aimed at addressing IESA definition and requirements should occur. The group needs to work towards strong involvement from major assimilation centers (Tony).**

11.2.7 Working group ideas

Extreme events (Rong, Mike, Gudrun)

- Link statistical & climate communities
  - Fitting extreme events with modeled distributions
- Ecosystem impacts
- Benefit from large ensembles and high resolution models
- Consider recently released CCSP document first

Storm track variability (Gabriel)

- Decadal variability and change
- Relation to extreme events
- Causes
- Driving of AMOC especially in SH

These ideas will be fleshed out and discussed in more detail by POS to see if they warrant a working group or other high level activity.

11.3 Small DRICOMP-like Grant Call

11.3.1 Intercomparison of new Reanalysis from NCEP, NASA, EC, JMA

Small grant call – dricomp-like activity

- Focus on interface (e.g surface fluxes)
  - Preparation for IESA
  - Compare loosely coupled (NCEP, NASA II) vs atmosphere only (NASA I)
- Best practices
  - Define metrics
  - Identifying independent data sources
  - Exploration of error covariance estimates
  - Verification Methods
- Evaluation of accuracy as a function of scale

Extreme events (could be within Reanalysis)

Marty also suggested looking at drought related variables.

12 Synthesizing and Future Plans for CLIVAR

David Legler provided some thoughts on plans for future CLIVAR activities. In addition to the Summit report from each Panel, he suggested each Panel prepare a 2-3 pager on Drought and another on Decadal Variability/Predictability summarizing the activities of the Panel as they related to these foci. He also indicated the U.S. CLIVAR Office will explore opportunities to

provide high-level briefings to agency senior leadership. There was also a suggestion that U.S. CLIVAR publish an article (e.g., in EOS) synthesizing he benefits of the reorganized U.S. CLIVAR, and the new science challenges we've been able to address through new frameworks (e.g. CPTs, model evaluation program, working groups,) and provide some ideas on frontiers as we see them. He also indicated that with the increased interest in workshop planning that some guidance be distributed to the Panels outlining how best to solicit agency support for workshop ideas. There is a need for the agencies and the Panels to increase their communications, so the U.S. CLIVAR Office (USCO) will set up teleconferences to facilitate more regular communications. The USCO will also contact relevant program managers for the Regional Integrated Science Assessments (RISAs), BLM, etc., to communicate CLIVAR activities and explore intersections of interest. There was some discussion of how best to coordinate US and international CLIVAR activities. Suggestions included seeking common membership (through U.S. CLIVAR Panel representation on International Panels and vice-versa). David closed by noting there are still research areas (e.g. observing system evaluation and design) that fall between the Panels and indicated these should receive some attention in the coming year.

Action Item 39:	**Write a 2-3 pager describing specific Panel activities and how they relate to the major scientific questions surrounding drought. Similarly write a 2-3 pager on decadal variability/predictability (Panel co-chairs to coordinate submissions by mid-November)**
Action Item 40:	**Synthesize these 2-3 pagers into material outlining major scientific questions, current activities, and possible future activities suitable for consumption by CCSP and agency planning activities (U.S. CLIVAR SSC coordinated by USCO)**
Action Item 41:	**Explore opportunities to provide high-level briefings on US CLIVAR to agency senior leadership (USCO to take up with IAG members)**
Action Item 42:	**Scope out a possible U.S. CLIVAR article (e.g., in EOS) synthesizing he benefits of the reorganized U.S. CLIVAR, and the new science challenges we've been able to address through new frameworks (e.g. CPTs, model evaluation program, working groups,) and provide some ideas on frontiers as CLIVAR sees them (USCO to coordinate)**
Action Item 43:	**Distribute guidance to Panels outlining how best to solicit agency support for workshop ideas (USCO)**
Action Item 44:	**Arrange teleconferences between IAG and Panel co-chairs as required (USCO to coordinate)**
Action Item 45:	**Identify and contact relevant program agency program managers of programs that interface between climate science and decisions makers to communicate CLIVAR activities and explore intersections of interest (USCO to coordinate)**
Action Item 46:	**Discuss with International CLIVAR leaders how best to improve communication and coordination between the U.S and Int'l programs (USCO)**

13 Closing remarks

Marty Hoerling closed the Summit by thanking all the participants for their time and energy.

14 U.S. CLIVAR Summit Agenda

U.S. CLIVAR Science Symposium and Summit Agenda:
14-17 July 2008
Climate Predictions for 2018: What can we say now and with what fidelity/uncertainty? What is our plan to develop predictions of climate 10 years into the future?
Hyatt Regency, Irvine, CA (Conference Theatre)

Monday July 14 (Day 1)

Time	Title		Speaker
Use and Value of Decadal Predictions for 2018 (Why do decision-makers need 2018 projections? What will they be used for? (we know decision-makers *want* accurate high resolution regional projections at sub-monthly time scales – we cannot provide those at present. What attributes are most important? What other products/information *would* be of value?) (David Legler – Moderator)			
0800 - 0830	Refreshments, Registration (Conf Rm Foyer)		
0830 - 0845	Welcome and Symposium Overview		
0845 - 0915	What climate information do water managers need to make robust, long-term plans? Some experience with Southern California's Inland Empire Utilities Agency	23 min + 7 Q&A	Robert Lempert (Rand Corp)
0915 - 0945	Needs of water resources decision-makers for decadal climate predictions	23 min + 7 Q&A	Andrea J. Ray (NOAA Earth Systems Research Lab & NOAA-CIRES Western Water Assessment)
0945 - 1015	Effects of Climate Change on Marine Ecosystems	23 min + 7 Q&A	David Mountain (Univ Arizona)
Developing Decadal Prediction Capability (Martin Hoerling – Moderator)			
1045 - 1115	Decadal Climate Prediction: Challenges and Opportunities	23 min + 7 Q&A	Jim Hurrell (NCAR)
1115 - 1145	Model predictions/projections for 2018 – what is being planned and what could they tell us [Summary of AGCI workshop]	23 min + 7 Q&A	Lisa Goddard (IRI)
1145 - 1215	Consideration of climate in water resources planning: requirements, expectations, and current reality	23 min + 7 Q&A	Soroosh Sorooshian (University of California, Irvine)

Observations (Jay McCreary – Moderator)			
1345 - 1415	When the ocean speaks, who listens? Observing climate change in the oceans for the decade(s) to come.	23 min + 7 Q&A	Josh Willis (JPL)
Poster Session (Crystal Cove Room)			
1420 - 1610	Poster Session on decadal variability and predictability • Processes important in decadal variability? • How do we estimate decadal predictability? • How well are models simulating decadal variations? • Observing and detecting changes • General contributions		Refreshments
Discussion (Martin Hoerling – Moderator)			
1610 - 1715	Discussion • What can we say now about climate in 2018? and with what reliability? • What is our plan to develop predictions of climate 10 years into the future? What are some essential activities to get there?		Speakers form a panel and provide responses to prompts

Symposium Posters

Author	Title
Annmarie Eldering, Jinwon Kim and Alex Hall	A Projection of the Impact of Climate Change on the Hydroclimate in California Based on CCSM3 and JIFRESSE RESM: A Joint UCLA-JPL Research Effort on Modeling and Observing the Earth System on Regional Scales
Ben Kirtman	The Role of Weather Noise in Pacific Decadal Variability
Benjamin R. Lintner and J. David Neelin	Understanding the controls on tropical convective margins and their variability
Chris Fairall	Ship observations over the southeast tropical Pacific Ocean for climate model evaluation
Christopher S. Meinen, Molly O. Baringer, and Rigoberto F. Garcia	Florida Current Transport Variability: An Analysis of Annual and Longer-Period Signals
Fengpeng Sun	A 10-15 year modulation Cycle of ENSO Intensity and its ENSO Asymmetry- Basic State Interaction Mechanism
Gudrun Magnusdottir	Winter sea ice projected to decrease but remain sensitive to North Atlantic Oscillation
Hailan Wang, Siegfried Schubert, Max Suarez, Junye Chen, Martin Hoerling, Arun Kumar and Philip Pegion	Attribution of the seasonality and regionality in climate trends over the United States during 1950-2000
Hsun-Ying Kao	Contrasting Eastern-Pacific and Central Pacific Types of ENSO
Jin-Yi Yu	A Two-Oscillator View of ENSO and Its Interaction with Pacific Mean Climate
Lynne Talley	
Mingfang Ting, Yochanan Kushnir, Richard Seager, Cuihua Li	Forced and Internal 20th Century SST Trends in the North Atlantic

Ning Zeng, Jin-Ho Yoon, Augustin Vinzileos, G. James Collatz, Eugenia Kalnay, Annarita Mariotti, Arun Kumar, Antonio Busalacchi, Stephen Lord	Dynamical Prediction of Terrestrial Ecosystems and the Global Carbon Cycle: a 25-year Hindcast Experiment
Paquita Zuidema	Southeastern Pacific Stratocumulus Cloud Top Heights
Sirpa Hakkinen	Shifting surface currents in the northern North Atlantic Ocean
Terry Joyce	On prospects for prediction of changes in mid-latitude storm tracks
Xubin Zeng, Xiaodong Zeng, Mike Barlage	Development of the Shrub Submodel for the Community Land Model-Dynamic Global Vegetation Model (CLM-DGVM)

1730 - 1830	US CLIVAR SSC Meets with program managers	Monday, July 14

U.S. CLIVAR Summit Tuesday July 15 (Day 2)				
Time	**Agenda**		**Speaker**	**Room**
0730 – 0815	Refreshments			
0815 – 0830	Welcome and introductions	15 min		Conference Theatre
0830 - 0845	U.S. CLIVAR Report	15 min		
0845 - 1000	WG Reports Drought (Siegfried Schubert) MJO (Duane Waliser) Western Boundary Current (Mike Alexander) High-latitude Fluxes (written) & AMOC (written)	15 min talks, 30 mins disc		
1000 - 1020	**Morning Break**			
1020 - 1055	Ocean data stewardship plans for climate	20 min talk, 15 min Q&A	M. Gregg (NODC)	
1055 - 1155	International CLIVAR, prospects for 2009-2013	25 min talk, 35 min disc.	Jim Hurrell	
1155 – 1230	Inter-Agency Group Input	15 min talk, 15 min disc	Agency Reps	
1230 - 1240	Charge to the panels	10 min		
1240 - 1400	**Lunch** (on your own)			
1400 - 1730	Panel Breakouts (break from 1545-1600)	195 min		
1730 - 1830	Executive session – Joint panel topics			
1830 - 2030	Reception			

Wednesday 16 July (Day 3)				
0800 - 0830	Refreshments			
0830 - 1000	Panel Breakouts	90 min		
1000 – 1030	**Morning Break**			
1030 – 1230	Panel Breakouts	120 min		
1230 – 1400	**Lunch** (on your own)			
1400 - 1530	Panel Breakouts	90 min		
1530 - 1600	**Afternoon break**			
1600 - 1730	Panel Breakouts	90 min		

1730 – 1830	Executive session – Joint panel topics			

Thu 17 July (Day 4)				
0800 – 0830	Refreshments			
0830 - 0915	Panel reporting – 15 min per Panel	45 min		
0915 - 1000	Plans and timeline for synthesizing US CLIVAR activities into strategic plans for CCSP, agencies, etc	45 min		
1000	**END of SUMMIT**			
1015 - 1045	Executive Session	30 min		

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16 APPENDIX A. U.S. CLIVAR Working Group on High Latitude Surface Fluxes

Members: Cecelia Bitz, Mark Bourassa (co-chair), Dave Carlson, Will Drennan, Chris Fairall, Sarah Gille (co-chair), Gudrun Magnusdottir, Ross Hoffman, Rachel Pinker (associate), Ian Renfrew (associate), Mark Serreze, Kevin Speer, Lynne Talley

U.S. CLIVAR has established a Working Group on High Latitude Surface Fluxes this year, with the particular goal of addressing some of the myriad challenges associated with air-sea and air-ice-ocean exchanges in Arctic, Antarctic, and Southern Ocean regions. The working group activities are motivated by several identified deficiencies in estimates of high latitude surface fluxes (e.g., sensible and latent heat, radiative fluxes, stress, and gas fluxes).

First, in situ observations of fluxes are difficult to obtain because high latitude regions are remote and require instrumentation able to withstand high winds, extremely rough seas, and cold temperatures. Such observations are vital for satellite calibration, which is one approach to filling the void of traditional observations.

Second, the unique conditions in high latitude regions mean that lessons learned in equatorial and subtropical regions do not necessarily translate into improvements in high latitude fluxes. For example, winds over the Southern Ocean are among the strongest in the world, both in magnitude and frequency of occurrence, and can exceed the speeds for which scatterometer wind retrieval algorithms have been tested and the range of validity for standard drag coefficients. Northern Hemisphere, high-latitude, extreme marine storms occur less often, but tend to strengthen much more rapidly. Ocean and atmospheric stratification in high latitude regions can be extremely weak, resulting in deep mixed layers, and it can be extremely strong, pushing the limits of existing stability parameterizations. High latitude regions are also characterized by ice and ice/water mixes, which add additional complexity to calculating and applying fluxes.

Third, since high latitude regions are under-going rapid climate change, marked by rapidly diminishing ice cover, we expect that the character of high latitude fluxes is also changing. That is, flux climatologies are evolving in regions where the characteristics of either the overlying atmosphere or the upper ocean are changing. Fluxes through an ice-free Arctic Ocean, for example, are distinctly different from fluxes through a high-albedo, ice-covered Arctic Ocean. A substantial reduction in the extent of an ice sheet will modify the fluxes in a wider area than that of the changing ice sheet, due to modification of the overlying air mass. These fluxes are expected to have a large influence on both atmospheric and oceanographic circulation and meridional energy transfer, which will impact global climate in fundamental ways: as examples, high latitude surface fluxes control meridional overturning circulation in the ocean, ocean uptake of CO_2, and meridional transport of heat in the atmosphere.

Flux products that include high latitudes can differ substantially, even in their climatological annual averages, and they do not resolve small-scale features that are present in sea surface temperature or wind fields. For example, monthly averaged sensible and latent heat fluxes were compared for nine research quality products, and found to differ by $>40 Wm^{-2}$ in both sensible (Fig. 1) and latent (Fig. 2) heat fluxes for the high latitude (ice free) southern and northern portions of the Atlantic basin. In particular, sensible heat fluxes in the Southern Ocean have a relatively large spread among products compared to the rest of the Atlantic basin (for at least the 5^{th} through 75^{th} percentiles of fluxes over what is considered to be year-around open water). Latent heat fluxes have a relatively small spread in the high southern latitudes due to the relatively small values of this flux; however, the spread in the high northern latitudes is rather wide for the stronger events. The wide range of values for these fluxes is a major issue for high

latitude energy budgets. In contrast, monthly stress products are in relatively good agreement; however, synoptic scale (and finer) variability in reanalysis products is highly suspect in the Southern Ocean (Hilburn et al. 2003). This finding appears to be partially related to a very strong dependence on rawindsonde data in these products (Langland et al. 2008). The strengths and weaknesses of flux products differ from product to product, and are not sufficiently well described.

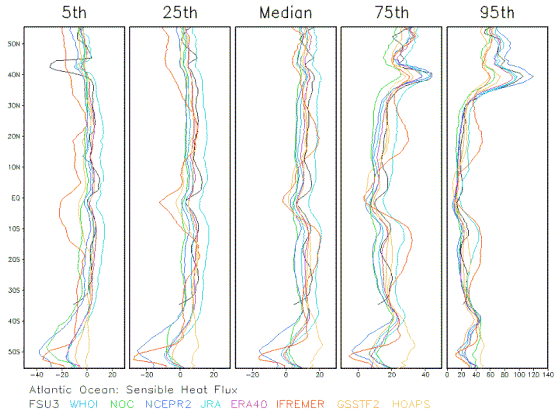

Fig. 1. Distributions (5^{th}, 25^{th}, 50^{th}, 75^{th}, and 95^{th} percentiles) of contributions to zonally averaged Atlantic sensible heat fluxes. Reanalysis products include NCEPR2 (Kanamitsu et al. 2002), JRA25 (Onogi et al. 2007), and ERA40 (Uppalla et al. 2005). Satellite derived products include IFREMER and HOAPS2 (based on method of Grassl et al. 2000). The HOAPS2 variables examined herein are identical in the HOAPS3 product. Products based on ship and buoy observations include FSU3 (adapted from the method of Bourassa et al. 2005) and NOC1.1 (formerly SOC; Josey et al. 1998). Hybrid NWP model and satellite products include WHOI (Yu and Weller 2007) and GSSTF2 (Chou et al. 2003). These products were chosen because they are freely available, reasonably easy to obtain, and reasonably homogeneous throughout a common comparison period. The common period of March 1993 through December 2000 is examined.

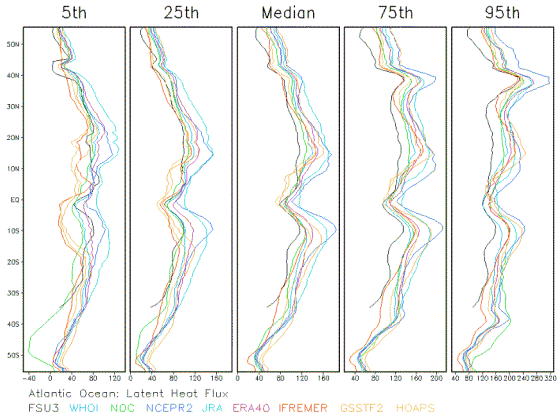

Fig. 2. As for Fig. 1, except for the latent heat flux.

At this point, it is not clear to the developers of flux products what accuracies and resolutions are required to study key processes in high latitudes. While concerns about fluxes are common, there has not always been extensive communication between the users of flux products, who hope for accurate gridded fields, and the observers of fluxes, who concern themselves with the details of turbulent boundary layer physics. The physics considered in flux parameterizations also changes

the distribution of extreme forcing events (Fig. 3), which have a disproportionately large impact on some atmosphere and ocean processes.

Furthermore, there is often a disconnect with the producers of gridded flux fields and large segments of the user community. Similarly, Arctic and Antarctic specialists rely on somewhat different funding streams and have tended not to interact; analogous issues apply for meteorologists and oceanographers. However, there appears to be much common ground.

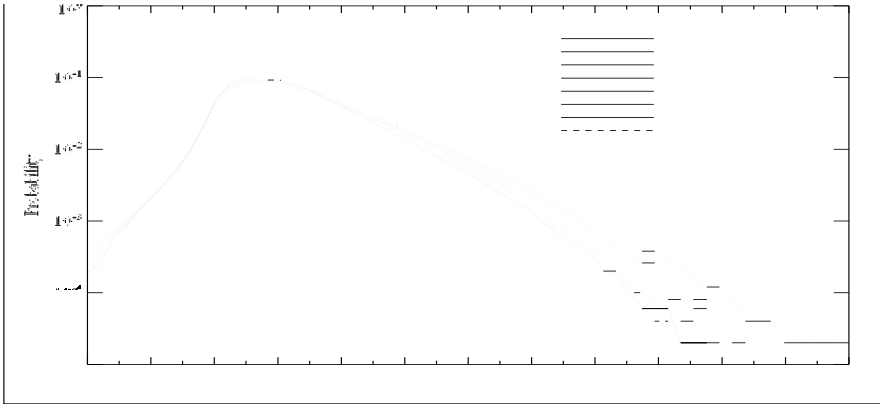

Fig. 3. Latent heat flux probability distributions for various models. Six of the models (Large and Pone 1981; Smith 1988, Large et al. 1994; HEXOS: Smith et al. 1992; Taylor and Yelland 2001; and Bourassa 2006) have been coded to differ only in their stress related parameterization (drag coefficient or roughness length). Two models are used as coded: COAREv3 (Fairall et al. 2003) and Kara et al. (2005).

The International Polar Year (IPY) intensive observing period (2007-09) is now underway, and several high latitude flux programs are just beginning. Spurred by IPY, planning is starting for Arctic and Southern Ocean observing systems. While IPY has drawn the attention of a large number of international committees, there has been comparatively little focused effort on high latitude fluxes. These fluxes are of interest for a wide range of oceanographic, atmospheric, and over-ice applications. This provides a particular impetus for the US CLIVAR working group.

16.1 Objectives

The High Latitude Surface Flux Working Group has a largely scientific focus, aimed at evaluating the current state of knowledge for high latitude fluxes, disseminating our evaluation to the broader scientific community, and laying groundwork for improved flux estimates. The working group will consider air-sea fluxes of momentum, heat, radiation, freshwater, and gas. It will also evaluate fluxes through open ocean, ice covered regimes as well as transition zones, and will consider both Arctic and Antarctic/Southern Ocean regions.

The group has two specific goals that it intends to address in its two-year lifetime:

A. Assess status of flux products for momentum and heat in high-latitude regimes, providing an honest assessment of the state of flux products; evaluate commonalities between Arctic and Antarctic. These will be assessed on a variety of spatial/temporal scales that are important to the user community.

B. On the basis of the flux assessment, identify priorities for continued flux observations, parameterizations, and requirements for updated reanalyses and gridded flux products.

The working group is beginning to make plans for a workshop focused on high latitude surface fluxes. A key goal for this workshop is to engage a broader range of perspectives.

16.2 Participation

The co-chairs are Mark Bourassa (Florida State University, FSU) and Sarah Gille (Scripps Institution of Oceanography, SIO). The other members of the working group are Cecilia Bitz (University of Washington), Dave Carlson (IPY, British Antarctic Survey), Will Drennan (University of Miami), Chris Fairall (NOAA, Boulder), Ross Hoffman (Atmospheric and Environmental Research, Inc.), Gudrun Magnusdottir (University of California, Irvine), Mark Serreze (University of Colorado), Kevin Speer (FSU), Lynne Talley (SIO), Gary Wick (NOAA, Boulder). Additional participants are Ian Renfrew (University of East Anglia) and Rachel Pinker (University of Maryland).

The working group welcomes input from others and expects to coordinate with programmatic groups focused both on surface fluxes and on the Arctic and Antarctic regions, including IPY, the Study of Environmental Arctic Change (SEARCH), the Climate and Cryosphere Project (CliC), the CliC/International CLIVAR Arctic Climate Panel, the International CLIVAR Southern Ocean Panel, the Arctic Ocean Model Intercomparison Project (AOMIP), the Southern Ice-Ocean Model Intercomparison Project (SIOMIP), the Global Energy and Water Cycle Experiment (GEWEX), the Arctic Observing Network, the Southern Ocean Observing System, SEAFLUX, Shipboard Automated Meteorological and Oceanographic Systems (SAMOS), the World Climate Research Program Working Group on Surface Fluxes, the Surface Ocean—Lower Atmosphere Study (SOLAS), and the Southern Ocean Gas Exchange Experiment (GasEx).

Further information about the working group is available on the web:
http://www.usclivar.org/Organization/hlatwg.html

16.3 Summary of Initial Findings

The working group has begun by carrying out a detailed assessment of the current status of high latitude fluxes. We have reviewed user requirements for fluxes and have considered the state of turbulent flux models used to evaluate observations and of numerical weather prediction of fluxes.

The required accuracy of fluxes depends greatly on the application, with the temporal and spatial scales of the application largely dictating the accuracy requirements. A very rough estimate of desired accuracy (bias) in the net heat flux is $10 Wm^{-2}$ when averaged over perhaps a season or a year. On the other hand, to evaluate long-term trends in ocean heat content, an accuracy of $0.3 Wm^{-2}$ might be required (Levitus 2005); however, such estimates are unlikely to be achievable with any available measurement systems. There are a wide range of spatial and temporal scales associated with high latitude applications. On the finer scales, the applications are consistent with resolving the inertial cycle. On larger scales, monthly fluxes on basin wide are useful. Fluxes are not measured on any of these scales: they are estimated through bulk formulas and estimates of pressure, sea surface temperature, water wave characteristics, near surface wind, temperatures, and humidity. These variables are also not well observed in high latitudes, except for satellite observations of wind and sea surface temperature, and even these do not meet the finest desired sampling. Variability on the largest mesoscale, and perhaps finer scales, makes substantial contributions to monthly average fluxes, particularly near shorelines and ocean fronts.

We have found that recent surface turbulent flux models have much more similar results than older models. One area of difference is the manner in which wave data are used to modify the fluxes: this subject is an active area of debate within the flux community and is an important matter for high latitude surface turbulent fluxes. These different parameterizations result in substantial differences in fluxes, particularly stress, for wind speeds greater than roughly 16 ms^{-1}. The model-to-model differences in turbulent heat fluxes are smaller in a percentage sense. The influence of atmospheric stability on surface turbulent fluxes is typically (but not always) small over the open ocean; however, stability is a very important consideration near oceanic fronts and

near shorelines or ice edges, particularly in winter when relatively cold air is rapidly transported over much warmer water. The paucity of flux observations for such conditions is a key limiting factor in the improvements of models and budgets for these fluxes. Improved satellite sampling, and satellite observations of fluxes or flux related variables would be of great help in improving the accuracy of high latitude fluxes.

Numerical weather prediction (NWP) provides an alternative to satellite observations; however, NWP accuracy would clearly benefit from improved observations. One of the disadvantages of NWP-based surface fluxes is that the accuracy of these fluxes is a low priority for weather forecasting, since weather forecasts are relatively insensitive to surface fluxes. Recently, it has been found with several atmospheric models that increased vertical resolution near the surface (e.g., adding one layer) results in much stronger coupling of the surface to the free atmosphere. This finding bodes well for the improvement of surface fluxes in future NWP models; however, for the time being NWP-based fluxes (particularly reanalyses) have large biases. These biases can be reduced by using any of the modern flux algorithms on bias adjusted winds, temperatures, and humidities. The SURFA project is currently making operational NWP data available for examination.

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17 APPENDIX B. U.S. Atlantic Meridional Overturning Circulation (AMOC) Update

Under the guidance and support of relevant federal agencies, the US ocean research community has launched a focused effort to address the 4th near-term priority of the Ocean Research Priorities Plan, the Atlantic Meridional Overturning Circulation (AMOC). Here we report significant events resulting from that effort during the past year:

- The U.S. CLIVAR office facilitated the formation of an AMOC Planning Team consisting of experts drawn from academic institutions and government laboratories with research specialties spanning ocean and atmosphere observations and modeling. These experts, including some already engaged in AMOC-relevant projects brought their experience to bear in the preparation of an Implementation Strategy for future AMOC research activities. The principal stated objectives are: **1) design and implementation of an AMOC monitoring system; 2) assessment of AMOC's role in the global climate; and, 3) assessment of AMOC predictability.** The Implementation Strategy is available as U.S. CLIVAR Report no. 2007-2.
- As recommended in the Implementation Strategy, the federal agencies engaged in funding AMOC research formed an AMOC Science Team (AMOCST) consisting initially of 12 leading investigators who are funded to pursue AMOC-relevant topics. The role of the AMOCST is to help accelerate integration across agencies and disciplines, establish splinter groups to work on subtopics, assist the agencies in building the AMOC case and updating the Office of Management and Budget, organize a regular (e.g., yearly) AMOC meeting, and develop opportunities to leverage U.S. investments through international collaborations. The AMOCST held it inaugural meeting in March 2008.
- The AMOCST engaged the international community at the 30 June – 2 July meeting of the U.K.'s RAPID program. RAPID will reach its planned conclusion later this year, but the U.K. has already committed funds for a follow-on program (RAPID-WATCH). RAPID-WATCH will deemphasize paleoclimate and increase investment in modeling and forecasting while maintaining a substantial focus on observations of the AMOC. Thus, RAPID-WATCH will constitute a continued opportunity for international collaboration. The AMOCST will be represented at the upcoming July 2008 CLIVAR Summit and will engage the international CLIVAR Atlantic Implementation Panel at its September 2008 meeting where AMOC will be a special focus topic.
- A community-wide AMOC Science Meeting is planned for Spring 2009. It will be open to all interested parties, both U.S. and international. It will be timed to closely coincide with a major cruise involving European scientists, and a goal is to develop initial input to a white paper describing U.S. AMOC observing plans in advance of the OceanObs'09 meeting.

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