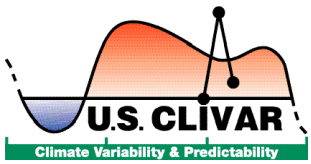

U.S. CLIVAR: Climate Variability and Predictability

Review of U.S. CLIVAR pilot Climate Process Teams, and recommendations for future Climate Process Teams

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Review of USCLIVAR pilot Climate Process Teams, and recommendations for future Climate Process Teams.

Prepared by the USCLIVAR Process Studies and Model Improvement Panel, September 2008.

Introduction

Climate Process Teams were initiated by USCLIVAR in 2003 with funding from NSF and NOAA in order to facilitate the transfer of new understanding gained through field experiments and process modeling into improvements in climate models. The combination of NOAA and NSF funding ensured the participation of both academic scientists and scientists at climate modeling centers. This cross-institutional participation was deemed to be important since it is rare to find institutions with sufficient expertise in all the areas of field measurements, process modeling and climate model development. The CPT program was specifically designed to bridge this gap to accelerate transfer of field experiment findings to parameterizations leading to improved climate model simulations.

The first round of pilot CPTs began with 3 years of funding for 3 different CPTs, an atmospheric CPT focused on low-latitude cloud feedbacks (CPT-clouds), and 2 smaller ocean CPTs focused on different aspects of ocean mixing – eddy-mixed layer interactions (CPT-Emilie), and gravity current entrainment (CPT-GCE). During the 3rd year of funding, each team applied for an extension for a further 2 years, and the ocean CPTs were successful in obtaining this extension, while the atmospheric CPT was not. The ocean CPTs therefore come to an end in August 2008, while the atmospheric CPT ended in 2006.

The purpose of this document is to review the achievements, legacies and challenges of the 3 pilot CPTs, and provide guidelines for a future round of CPTs.

The bulk of the funding for the CPTs went toward postdoctoral fellows and research staff salaries, with smaller amounts for senior researchers. No new observations were funded. A significant component of each CPT was a quasi-annual workshop organized to facilitate exchange of ideas.

In the pilot CPTs, the ocean CPTs were competitive, with 2 CPTs funded out of a total of 10 proposals. The atmospheric CPT was less competitive, with 1 CPT funded out of 2 proposals.

Review of past CPTs

Achievements The over-arching goal of the 3 pilot CPTs was improvement of climate models through enhanced parameterized representation of physical processes. The two ocean CPTs have successfully developed several new parameterizations. CPT-Emilie developed new parameterizations for both the mesoscale and submesoscale eddies in the upper ocean and CPT-GCE developed parameterizations for the shear-driven mixing in overflows, the mixing in the frictional bottom boundary layer, and representations of the dense water transport through the straits and down the slope. These parameterizations were implemented in the NCAR CCSM ocean component, the GFDL ocean models and, in the case of CPT-GCE, also in HYCOM. The new parameterizations in CCSM and in the GFDL models will be included in the AR5 IPCC assessment simulations.

In order to create these new parameterizations strong collaboration between the model developers, theoreticians, process modelers and observationalists was necessary, and would not have occurred without the CPT framework. In the case of CPT-Emilie, theory and process modeling led to an improved understanding of the eddy processes active in the upper ocean, and analysis of upper ocean data provided key statistics to validate the theory. Finally the development and implementation of the new parameterization schemes required close interaction between the process modelers and key personnel at the modeling centers. In the case of CPT-GCE, observationalists consolidated data from several different field experiments into an easy-to-reference table, allowing a more complete and thorough understanding of the similarities and differences between different overflows and facilitating comparison with model simulations. The development of several of the parameterizations was initiated by interactions which took place between team members from different institutions at the workshops.

The achievements of the atmospheric CPT were related to improvements in understanding of the response of the climate model physics to applied forcing, through use of diagnostics and aqua-planet models. A shallow convection and planetary boundary layer scheme from UW is now being tested at NCAR and GFDL.

An important achievement of the CPTs has been the formation of teams comprising observationalists, theoreticians, process modelers and climate model developers. One hopes, that such interactions, now established, will continue even after the CPT funding ends.

Both ocean CPTs agreed that having a single coordinating PI as the team leader was the key to their success.

Legacies The principal legacies of the CPTs are the improved general circulation models and the parameterizations they contain. CPT-GCE also includes benchmark high-resolution simulations,

idealized overflow scenarios and regional configurations for model intercomparison. CPT-Emilie initiated planning of several new field experiments, including CLIMODE, ONR-funded studies of submesoscale eddies, and the future SWOT mission. Both ocean CPTs have helped to train high-quality young scientists. Finally a large number of publications have resulted from each CPT, including several synthesis and review articles. Continued interaction between the team members from diverse fields are another lasting, but perhaps less tangible, legacy.

Challenges The major challenge identified by both ocean CPTs is the manpower resources available at the modeling centers. Each modeling center had a research staff member or postdoctoral researcher assigned full-time for the CPT work, but the implementation of highly sophisticated parameterizations into the global models required significant effort on the part of the more experienced modelers at both GFDL and NCAR. It proved important to have someone at the modeling centers who was committed to the problem at hand, a difficult task given the competing demands such as IPCC assessments.

CPT-Emilie also listed the integration of the observationalists as a challenge because the absence of any new funded field campaigns did not provide an immediate return to the observationalists.

The main challenge faced by the atmospheric CPT was that the goal of the CPT was more ambitious than could be addressed by the resources available. Therefore, the effort was too diffuse with the entire team not focusing on a single problem.

Recommendations for future CPTs

The over-arching goal for future CPTs is continued transfer of new understanding gained through field experiments and process modeling into improvements in climate models and recognition that such transitions are difficult to achieve due to lack of proper funding mechanisms. We note that for the CPT to lead to improvements in climate models within the duration of the funding, several criteria must be satisfied by existing knowledge of the physical process which is the focus of the CPT. These are:

Relevance: The process must be one which is currently poorly represented in climate models, but where improvement in representation could lead to better and more credible climate simulations. Since the climate modeling centers have to heavily invest in the CPTs in terms of both manpower and computer resources, they need to have a vested interest in the CPT success. A process which is relevant to improved climate simulations should help to ensure that the climate modeling centers are engaged and interested in the CPT. It should also ensure that the effort expended in the CPT has societal benefit.

Readiness: The CPT process should be one where recent theoretical developments, process modeling, and observations are readily transferable into climate models. Because of the short timeline of the CPT it is not feasible to conduct lengthy new investigations of physical processes and expect those to transition to parameterizations. One measure of readiness is whether at the onset of the CPT there are already existing ideas for parameterizations which can be implemented in GCMs. This was the case for both pilot ocean CPTs, so that implementation, refinement, and climate assessment could be achieved during the CPT lifetime. New parameterizations can also be developed by testing and examination of the existing parameterizations, but success of the CPTs should not solely depend on developing new parameterizations.

Focus: The CPT topic needs to be focused and narrowly-defined to lead to concrete results within the short duration of the CPT. Having a narrow focus enables a somewhat smaller team to make headway, increasing the chances that everyone will be working closely together.

Model independence: The CPT topic should be of interest to multiple climate model development teams. Having several model development teams involved, at climate modeling centers or in academia, allows different solutions to be explored simultaneously and assures that several climate models benefit from such development. Conceivably it also indicates that the process is of general interest to the climate modeling community.

The choice of a topic suitable for transfer of new understanding gained through field experiments/process studies to climate models is the most important consideration for a future CPT. Any group of PIs proposing a CPT needs to show clearly how their choice of topic will satisfy all the above criteria. Some topics may appear to be the most relevant in terms of their impact on climate, yet not be ready for a CPT if more understanding through field programs and process modeling is required before parameterizations can be developed. Therefore, we recommend that the choice of topic be addressed through the peer review process. Open competition, allowing the PIs to assemble the best team, investigate the topic which best satisfies the above criteria, and rally the support of the climate model developers, appears to be the best and fairest way to ensure the funded CPTs have the necessary focus and achievable goals.

There are many possibilities for topics for future CPTs. A partial, but by no means exclusive list of topics were suggested by modeling centers in the questionnaire leading to this report: tropical convection, radiative transfer processes, aerosol indirect effects, cloud microphysics, land surface processes including soil moisture and ice, ocean mesoscale eddy processes, sea ice processes, equatorial ocean upwelling and mixing, Southern Ocean ventilation and deep water formation, and air-sea fluxes.

These topics, as specified, are too general to be a CPT, and we envision that the PIs will identify specific processes within one of these broad headings for a CPT focus. For example, tropical convection-related studies may include incorporation of convective vertical velocity distributions for improving representation of cloud-aerosol interactions and scavenging; incorporation of mesoscale processes in convective parameterizations; closure and triggers for cumulus parameterizations.

An important contributor to the success of a CPT is the commitment of the modeling centers – without the work of modeling center personnel to implement and test new parameterizations, the CPT cannot succeed. We therefore encourage any CPT proposal to clearly describe the work which will be undertaken by the modeling centers, and identify modeling center co-PIs.

To encourage competitive proposals, drawing on an extensive range of topics, while ensuring clear modeling center involvement, we suggest short pre-proposals should be requested (modeling center co-PIs encouraged). These pre-proposals would outline the proposed topic and ideas for tackling it, as well as indicating the participants and estimated budget. The pre-proposals would allow the modeling center personnel to see how they can become more involved in the development of the full proposals. Initial feedback can be provided on the pre-proposals by both modeling centers and program managers to allow the development of the best possible final proposals with the appropriate amount of detail and focus. We suggest that, to ensure fairness, there be no binding selection made on the basis of the pre-proposals.

The successful pilot CPTs agreed that annual workshops were an essential aspect of the organization which allowed the scientists to exchange ideas and focus on a common goal. Web-pages could be used to help interaction, although the somewhat limited success of these for the pilot CPTs suggests that technical assistance is needed for such a development. Furthermore, new communication methods such as wikis and google groups might prove beneficial and could be proposed. Any successful proposal should identify how communication between geographically separated members will be established and should budget for technical assistance if needed.

We suggest that a significant portion of the budget goes towards researchers who will focus fulltime on the CPT. Having fulltime CPT-funded researchers based at the modeling centers will ensure that the CPT receives continuous attention.

A single coordinating PI should be identified as the team leader. This person should be someone fully committed to guiding the project, and responsible for team coordination and synthesis. Ideally this person should not have too many other commitments, and should be at a career stage that would benefit from the responsibility of managing a successful CPT.

Observationalists are important participants in a CPT because they provide expertise which is otherwise lacking in modeling centers. However, because we envision that no new observations are funded through a CPT, we recommend that CPT proposals clearly consider the tasks of the observationalists. Such tasks may include synthesizing data from several different field programs, producing diagnostic quantities suitable for comparison with models, and evaluating parameterizations against existing data.

The size of the proposed CPTs, both in terms of number of participants and budget, needs to be considered carefully. The team should be large enough that participants from multiple institutions, involved in observations, process studies and climate model development are represented, but not so large that the focus is lost. The budget should be large enough that several junior scientists can be devoted fulltime to the CPT, and senior scientists' commitment can be ensured, as well as allowing for annual workshops.

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