

US CLIVAR Program Brief on Climate Process Teams
Prepared by the Process Study Model Improvement Panel
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For over fifteen years, Climate Process Teams (CPTs) have played a pivotal role in enhancing the accuracy of climate models by targeting specific processes affecting their fidelity via fostering collaboration between observational scientists, process experts, theoreticians, and model developers. First introduced by US CLIVAR, CPTs fund multi-institution projects bridging the gap between process-level understanding and large-scale climate model development.

The most recent round of CPT projects followed a 2016 review by the US CLIVAR Process Study and Model Improvement (PSMI) Panel. It assessed their effectiveness, identified ongoing challenges, and recommended strategies for future model improvements. In 2022, the PSMI panel convened a session about CPTs at their bi-annual panel meeting in Norfolk, Virginia. Three PIs who were funded following the 2016 review were invited to provide updates on the scientific progress and for the panel to gather feedback on the strengths and weaknesses of the CPT funding model, given their mission. A fourth CPT PI was invited to give a virtual seminar to the PSMI panel in 2023. A synthesis of the strengths and successes of the CPT model is:

1. **Advances in Parameterizations and Model Improvements:** Each CPT made significant progress in refining parameterizations and improving model representations of key processes, such as mesoscale eddies in ocean models, unified convection parameterization, and vertical momentum flux in the atmospheric boundary layer. These developments contributed to reducing long-standing biases, improving the fidelity of climate models, and advancing our fundamental understanding of the processes involved.
2. **Empowering Early Career Scientists (ECS):** CPTs effectively engaged early career scientists, allowing them to lead efforts and focus on developing code and diagnostic tools that benefit the broader scientific community. Many ECS who have participated in CPTs have gone on to be important contributors to the US climate modeling enterprise following the completion of the CPT. This demonstrates the value of CPTs in maintaining this pipeline and strengthening the United States' position as a world leader in Earth system prediction and projection.
3. **Collaboration between U.S. Modeling Centers:** The CPT mechanism is unique in fostering collaboration across research groups, observation teams, and modeling centers. It develops formal connections between centers that may otherwise rely on less structured partnerships. CPT PIs emphasized the importance of cross-center collaboration in enhancing model development efficiency. This was achieved through both code sharing and knowledge transfer, including the exchange of unpublished findings (e.g., evidence suggesting that a specific parameterization implementation was unstable or unlikely to yield improvements).

Based on these successes, the PSMI Panel believes that CPTs provide important value to the U.S. modeling enterprise.

The PSMI Panel also identified several potential enhancements for future iterations of CPTs:

1. **Standardizing and Sharing Code and Results:** The panel observed that actively sharing tools, datasets, etc., has contributed significantly to the success of particular CPT efforts. More consistent and transparent sharing of tools, datasets, evaluation metrics, and process-oriented model outputs—particularly for larger initiatives like large eddy simulations—could benefit the broader scientific community and facilitate more widespread application of parameterization advancements.
2. **Facilitating Cross-CPT Collaboration:** The panel noted the potential for greater collaboration between different CPTs. Mechanisms to foster more frequent and structured interactions between teams could lead to breakthroughs by leveraging the strengths and insights of each CPT and creating synergy across different areas of climate modeling research.
3. **Enhancing Collaboration between U.S. Modeling Centers:** The PSMI Panel appreciates the CPT mechanism's success in fostering collaboration across diverse research groups and U.S. modeling centers. Building on this, the panel sees an opportunity to further enhance communication and knowledge sharing by organizing regular, organized forums bringing together all supported CPTs. Such forums could significantly enhance communication and knowledge sharing and accelerate model advancements by exchanging experiences and lessons learned.

The topic of CPTs was discussed at both the 2023 and 2024 SSC meetings for which PSMI Panel co-chairs Clayton (2023), Wenegrat (2024), and Zarzycki (2023 and 2024) were present. It was agreed upon that the PSMI Panel would hold another session at their 2024 bi-annual meeting in Princeton, New Jersey, to provide feedback to both the CLIVAR SSC and the IAG regarding future CPTs. At this meeting, the panel reviewed:

- The previous CPT funding solicitation and information sheet.
- The CPT white paper entitled "Translating Process Understanding to Improve Climate Models," which was written by members of the PSMI Panel and U.S. CLIVAR following a community workshop in October 2015.
- The CPT "best practices" document, which was written following a 2018 AGU Town Hall sponsored by the PSMI Panel.
- The previous PSMI Panel notes regarding CPTs from relevant meetings in 2022, 2023, and 2024.

In summary, the PSMI Panel agrees with the utility of CPTs and emphasizes that they represent a unique opportunity for U.S. modeling centers, university researchers, and funding agencies.

Anecdotally, other modeling centers around the globe have expressed support for the CPT funding mechanism and have suggested similar approaches through their funding agencies. CPTs provide a critical collaboration pathway between U.S. modeling centers and foster long-term retention of expertise at these centers to support the U.S. climate modeling enterprise. These projects have also resulted in targeted parameterization improvements, and numerous examples of parameterizations have been implemented or improved in U.S. climate models as a result of previous CPTs.

The panel agrees that the previous solicitation and documentation serve as a useful starting point and that a wholesale reevaluation of the CPT model is not necessary at this time. **The panel offers the following points for consideration of future funding opportunities or CPT evaluation:**

- Future CPT solicitations could avoid listing specific climate processes and instead permit flexibility for PIs to justify processes' importance. The panel agreed that the white paper commissioned in 2016 remains relevant in the next 1-3 years and could be referenced in any solicitation.
- The panel suggests that coupled and interface processes among key climate model components be included explicitly in the scope of potential projects, in addition to processes traditionally focused on a single model component.
- Communication between a CPT and the broader scientific community can be further improved, including across CPTs (both current and recently concluded). A suggestion is for projects to include support for either CPT "PI" meetings (bringing together PIs across CPT projects) and/or CPT "workshops" that will include external scientific community members, not just CPT scientists.
- One underappreciated success of the recent CPTs has been the development of process-oriented diagnostics and other metrics that improve modeling centers' capacity to address the fidelity of model parameterizations. The panel suggests specifically encouraging these deliverables as open-source tools that can foster collaboration with other modeling centers and improvement in their component models.
- Some panel members advocated for CPTs to serve as "leaders" in data curation, documentation, and accessibility. All CPTs were noted to have acquired, synthesized, and generated observational and simulation data as well as process-oriented climate model output that could be of use to other lab or university researchers. A suggestion would be to request teams to provide more detailed data management plans that "go above and beyond" a standard FOA including the sharing of data management contributions across team members and that proposal reviewers are requested to give particular focus to this proposal component.
- The panel agreed that one of the challenges with CPT hiring is the necessity to involve researchers with theoretical knowledge of processes and technical and computational skills that allow them to work on the "nuts and bolts" of climate models. No universal solution was agreed upon, but two primary suggestions emerged: one was for projects to include additional support to hire software engineering support specifically for the CPTs or, in the absence of that, CPT proposals could be required to discuss how they would specifically target these scientists – who tend to be early career – during the hiring process.
- There was some concern that the mention of specific NOAA-funded field campaigns in the previous call may have caused some researchers to eschew equally suitable datasets in their CPT proposals. Two recommendations emerged: one suggestion was to eliminate such text entirely, and the other suggestion noted that agencies could promote US-funded fieldwork but emphasize that other observational data sources should be used where applicable and beneficial.