REQUEST FOR INFORMATION (RFI)

5 May 2016

Purpose of this RFI: At the behest of the Community Earth System Model (CESM) Science Steering Committee (SSC) we, the co-chairs of the CESM Ocean Model Working Group (OMWG), would like to request specific information and broader input from ocean model development groups to guide the choice of the next ocean component of the CESM. Of particular importance is your group's view on the possibility of replacing the current Parallel Ocean Program (POP) by your ocean model as the base model code of the next generation CESM ocean component. In your response, we would appreciate your assessment of the degree to which your model code and the collaboration with your development community can meet the criteria below. Other comments and feedback, for example on the technical requirements below, indication of near to intermediate term plans for model developments, or your views on possible synergies between your existing efforts and CESM, would also be welcome.

Motivation for this RFI: As we look beyond CESM2, it is necessary to formulate a plan for the next generation ocean model component. The POP model has been used as the base code of the ocean component of CESM for more than a decade. Despite many desirable attributes and advances in its physics over the years, aspects of the current dynamical formulation of POP are an impediment to improving the model skill and addressing cutting-edge climate research questions. POP will not be developed further by the Los Alamos National Laboratory, and progress on development of the dynamical core aspects of POP within the CESM community has stagnated. This RFI is one response to the Climate and Global Dynamics (CGD) Laboratory Advisory Panel (CAP) call for a reevaluation of the development path for the CESM ocean model – a path also supported in the latest letter from the CESM Advisory Board (CAB).

Strategy: A different ocean dynamical core will need to be adopted by the time CESM3 is released in 5 to 6 years. Therefore, the final choice will need to be made in about three years, but the situation to be avoided is to reach that point with CESM only capable of running with the POP code. Therefore, by the end of 2019 a provisional CESM3 ocean component based on the selected model code will be implemented, configured, and exercised at least to the point of demonstrating its additional science capabilities. The new base model code will be selected in 2016, and implementation will begin in earnest by January 2017 when a new ocean modeler and support scientists and software engineers are in place at NCAR.

The challenges in moving to a new base model are accompanied by an opportunity to re-examine the scientific requirements for ocean modeling within the CESM community. Such input from the CESM community was solicited through an e-mail survey early in 2016, and through extended discussions at the 2016 CESM OMWG winter meeting and the 2016 AGU/TOS/ASLO Ocean Sciences Meeting.

The high-priority technical requirements for CESM3 identified through this process will ideally include:

- Advanced dynamical core technical capabilities, including flexible vertical coordinates and resolution, advanced tracer advection schemes, natural boundary conditions on freshwater and tracers, and support for non-Boussinesq configurations;

- Model infrastructure and a development environment that provides strong support for collaborative model development with the university-based CESM community. This includes both structured programs such as Climate Process Teams and small group entrepreneurial projects;
- Strong support for both regional and climate modeling applications;
- Support for a wide range of resolutions and grids, and accompanying scale aware parameterizations;
- Ability to configure and run simpler idealized configurations for process modeling and educational applications;
- Compatibility with the CESM sea-ice model;
- Ability to interface with CESM coupled data assimilation system;
- Familiar post-processing and analysis capabilities (akin to CESM workflow tools).

Furthermore, the CAP report indicated that collaboration on ocean model development is essential, and having CESM rely on a 'handed-off' model for its ocean component is not a viable option. Instead, a strong collaborative relationship with a partner institution or consortium is favored. An ideal partner will possess strong expertise in ocean dynamical core development. It will also have both the capability and desire to actively collaborate with the CESM enterprise and its community to advance a community ocean model. In addition, it is expected that the partner group will have a strong and ongoing commitment from its "home" institution and/or agency sponsors to sustain the collaboration over the long term.

Criteria: Within the overarching goal of keeping the ocean component of CESM at the forefront, the ocean model should at least have the potential to satisfy the technical requirements listed above and its published solutions should be comparable to those of the present POP in the context of the Coordinated Ocean-ice Reference Experiments (CORE). Additional desirable features include a modern code base that adheres to software engineering best practices; scalability and computational performance on modern architectures that is comparable to, or better than, POP; a commitment to comprehensive model documentation; and state-of-the-science parameterizations (comparable to those in the present POP) suitable for use in coarse resolution climate models. An expectation would then be that a configuration of the chosen model could satisfy CESM science requirements for CESM3.

In summary, it is hoped that an ocean component of the CESM would satisfy most of the following criteria to some degree:

- *A strong partnership between the developers of the model and the CESM community;*
- *A strong commitment to sustained collaboration in model development from the model's institutional home or consortium;*
- *Timely and unfettered access to new developments;*
- *Meet or have the potential to satisfy the technical requirements listed above;*
- *State-of-the-science parameterizations (comparable to those in the present POP) suitable for use in coarse resolution climate models;*
- *Published solutions showing a model version that is comparable to POP in the context of Coordinated Ocean-ice Reference Experiments (CORE);*
- *A realistic expectation that a configuration of the model would satisfy CESM3 science requirements in a timely manner;*

- *A modern code base that adheres to software engineering best practices with scalability and computational performance on modern architectures comparable to, or better than, POP;*
- *A commitment to comprehensive model documentation.*

Process and Timeline: The SSC will choose a model base code that will become the provisional replacement for POP based on the recommendations of a small independent advisory panel (AP, to be led by F. Bryan) and the OMWG. The AP will present a preliminary evaluation of the responses to this RFI at the 21st Annual CESM Workshop in Breckenridge on 21 June 2016. Therefore, responses to this RFI would be most helpful if received by June 3, 2016. During this meeting, responders can choose to take the opportunity, or not, to provide additional information and to answer emerging questions, either in person or remotely. Starting with this meeting, the AP will solicit input from the other CESM communities, particularly from the sea-ice, biogeochemistry, land-ice, and paleo-climate communities.

Following the Breckenridge meeting, the AP is likely to initiate direct discussions with responders, the OMWG, and other relevant parties, before submitting its recommendation to the SSC on 2 September 2016. The SSC and current OMWG co-chairs will jointly make a decision by early October 2016.

Community and Partnership: As a community modeling enterprise, CESM development relies on partnerships that, ideally, build on a strong desire or willingness for mutually beneficial collaboration of scientists and software engineers; joint decision-making in relevant model developments; timely and unfettered access to new developments; open lines of communication at all levels; responsiveness to the needs of the CESM community as expressed through the OMWG. The CESM community consists primarily of scientists and software engineers from NCAR, national universities, and government labs (especially DOE). Access to such community might provide the partner institution with a broader group of developers and users than it currently has.

Resources: There will be an additional ocean modeler as well as science and software engineering support at NCAR for the transition to the new ocean model, starting in January 2017. These resources will be directed, as needed, to facilitate scientific collaborations with the partner group; to design and build the interfaces between the new ocean dynamical core and other CESM components; to assist in the porting of parameterizations from POP to the new dynamical core and configuring of a CESM3 provisional ocean component; to adapt the new model to the evolving high-performance computing landscape; to interface with CESM data assimilation infrastructure; to address emerging challenges with pre- and post-processing of grids and topographies for paleo-climate; and to provide general help with, e.g., biogeochemical tracer interfaces and sea-ice coupling.

Additional available resources will be dedicated to engaging the university community in all aspects of ocean model development.