Report from the CLIVAR Working Group on Ocean Model Development (WGOMD)

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The 7th Session of the CLIVAR Working Group on Ocean Model Development (WGOMD) was held on the 25-26 August 2007, generously hosted by H. Drange of the Nansen Centre (NERSC) and the Bjerknes Centre (BCCR) in Bergen Norway. This meeting focused on the major issues that the panel needs to make progress on, namely the CORE experiments and ocean model evaluation metrics. Reports on regional and institutional activities from individual WGOMD members are available on the meeting web page (http://www.clivar.org/organization/wgomd/wgomd7/wgomd_bergen.php).

The WGOMD meeting was preceded by the Layered Ocean Model Workshop (see the following web page for details: http://oceanmodelling.rsmas.miami.edu/lom/index.html) and the CLIVAR Workshop on Numerical Methods in Ocean Models (http://www.clivar.org/organization/wgomd/nmw/nmw_main.php), that is summarised below. The WGOMD meeting coincided with the Inaugural Meeting: Southern Ocean Physical Oceanography and Cryosphere Linkages (SOPHOCLES) (http://clic.npolar.no/theme/sophocles.php). WGOMD joined part of a session of the SOPHOCLES meeting and contributed some presentations outlining the CORE experiments. The SOPHOCLES community is interested in the CORE-II framework, particularly run at high resolution, though processes of interest such as water mass formation, are sensitive to details of the experimental protocol, in particular salinity restoring and coastal run-off. The question was raised of how restoring is applied under sea ice.

Review of WGOMD activities

The terms of reference of WGOMD have been updated through the removal of the qualifier on the first term of reference that previously limited WGOMD activities in stimulating the development of ocean models for research in climate and related fields to decadal and longer timescales at global scales. This focus on longer, global timescales originated from WGOMD's original role as support for WGCM. WGOMD will extend its activities to shorter and smaller spatial scales including regional and coastal problems, as well as involvement in ENSO-related issues.

A central mission of WGOMD is to facilitate the maturation of ocean models, and the use of ocean models in well defined and reproducible ocean modelling simulations. WGOMD aims to realize this mission by (a) providing pedagogical peer-review survey papers that document models and the experimental design of simulations, see for example Griffies et al. (2000), and (b) by organizing topical workshops that bring elements of the oceanography community together to discuss research and development areas relevant to increasing the scientific integrity of models and their simulations.

Attendees of the WGOMD Panel Meeting, Bergen, Norway.

Realizing this mission (or some aspect of it) allows WGOMD to provide scientifically based advice to other CLIVAR panels and to WGCM.

Summary of Workshop on Numerical Methods in Ocean Models

Prior to the WGOMD panel meeting, the WGOMD, with assistance from the Layered Ocean Model (LOM) group, organized the workshop "Numerical Methods in Ocean Models" on August 23-24, 2007 in Bergen, Norway.

The evolution of ocean models is prompted by a growing range of high profile scientific and engineering applications. These applications range from refined resolution coastal and regional modelling forecast systems, to centennial-millenial global earth system models projecting future climate. Groups worldwide are working to improve the integrity of ocean models for use as tools for science research and engineering applications. This work involves a significant number of fundamental questions, such as what equations to solve, which coordinate system to solve the equations in, what horizontal and vertical mesh is appropriate, what physical parameterizations are required, and what numerical algorithms allow for computational efficiency without sacrificing scientific integrity. Furthermore, given the increasing size of many applications, as well as difficulties of doing everything in just one group, there is a growing level of collaboration between diverse groups. This collaboration spans the spectrum of algorithm sharing to the merger of previously disparate code bases.

The numerical methods workshop aimed to foster the maturation of ocean models by supporting enhanced collaboration between model developers. It did so by bringing together nearly 100 of the world's top ocean model developers and theoreticians. Presentations were given throughout each day, with plenty of opportunity for interactions, debate, and networking. The workshop emphasized fundamentals of ocean model numerical methods and physical parametrizations. The relevance of a particular approach gauged by its ability to satisfy the needs of various applications. This workshop provided a venue for participants to educate one another on the latest advances in ocean model development.

Coordinated Ocean-ice Reference Experiments (COREs) Overview

COREs provide benchmark experiments for global ocean-ice models, and a step towards developing an Ocean Model Intercomparison Project (OMIP). The CORE-I proof of concept project includes seven international modelling groups and consists of three ocean model coordinate classes (geopotential, isopycnal and hybrid). A peer-review paper is currently in preparation illustrating CORE-I (see below) results with the seven ocean-ice models each run for 500 years (Griffies et al., 2008).

Attendees at the Layered Ocean Model Group Workshop "Numerical Methods in Ocean Models" August 23-24th, Bergen, Norway

The current COREs do not constitute Ocean Model Intercomparison Projects (OMIPs) as WGOMD is not prepared to formally sanction the present forcing dataset protocols until the community has had time to provide feedback. This means that the set of COREs outlined below are research projects that are voluntarily conducted by interested scientists and there is no formal oversight committee or data repository arrangement in place. This does not prevent the project from eventually evolving into an OMIP.

Ocean-ice model experiments are useful since they are less costly than fully coupled experiments, they can be used in hindcast mode to reproduce the history of ocean and ice variables and hence help in the interpretation of observations, they allow for the understanding of processes in the absence of biases introduced by the atmospheric model and hence potentially give superior representations (compared to the ocean component of a coupled model) of key physical, chemical and biological processes and so help in model development.

The question of the usefulness of CORE relative to coupled experiments received considerable attention. On the one hand, running CORE-type experiments facilitates testing ocean parameterisations in a framework that is isolated from the sensitivities generated by running in coupled mode. On the other hand, there is the view that testing multiple ocean models is less beneficial than assessing changes in the context of coupling to an atmosphere model.

Three CORE experiments have been endorsed by WGOMD, and these are outlined below. The CORE framework is not limited to these three experiments.

CORE-I

This experiment aims to investigate the climatological ocean and sea-ice states realised through multi-centennial simulations forced by idealised repeating normal year forcing that has been derived from 43 years of interannually varying forcing, retaining synoptic variability with a seamless transition from 31 December to 1 January (Large and Yeager, 2004).

After being initially proposed in 2004, CORE-I has reached a critical mass with a community-wide proof of concept approval and seven ocean-ice models (including geopotential, isopycnal and hybrid coordinate models) that have been run for 500 years with the repeat 'normal year forcing' of Large and Yeager (2004). The experiment has yielded a wide variety of results, with as many questions raised as answered. Broad comparison projects such as this achieve much in this way by raising questions, which then motivate further research. Without such a comparison, questions would remain unasked, and thus unanswered. A peer-review paper with 24 authors (Griffies et al., 2008) is under review at Ocean Modelling.

Performing 500 year runs highlighted that the stability of Atlantic MOC was an issue for some models in CORE-I, causing the project to falter for sometime. Some groups were not able to maintain a quasi-stable MOC for the CORE-I multi-centennial simulations without applying a non-trivial salinity restoring, also necessary to damp drifts in deep water mass properties. The participating groups were given the freedom to choose their own salinity restoring depending on each model's sensitivity. Initial results on the sensitivity of the MOC solution to model resolution indicate that models with a finer horizontal resolution (in the North Atlantic Ocean) appear to be less sensitive to details of the SSS restoring.

CORE-II

This experiment aims to investigate the forced response of the ocean in hindcast mode. The experiment will be forced by the interannually varying dataset from 1958-2004 (soon to be updated to 2006) of Large and Yeager (2004).

The initalisation of the CORE-II hindcast simulation is the key issue that needs to be addressed by the CORE-II protocol, particularly if more than the evolution of the upper ocean is to be analysed. Models can be initiated sub-optimally from the existing reanalysis period starting in the 1950s and cycling through the simulation multiple times, though still having to ignore the analysis of the first few years of the final realisation because of adjustment. An additional limitation of this approach is that the existing reanalysis period is biased to the steady increase in the NAO index between the mid-1960s and mid-1990s.

Model drift, particularly below 400m, can be removed by subtracting the trend from a climatologically forced control simulation, assuming that the system is linear.

CORE-III

This experiment aims to investigate the response of an ocean forced with normal year forcing (as in CORE-I) to a freshwater perturbation resulting from increased melt water run-off distributed around the Greenland coast. This experimental design with a hosing perturbation of 0.1Sv, proposed by Gerdes et al. (2005, 2006), is motivated by possible increases in Greenland melt water that could occur as a result of anthropogenic global warming. This runoff prescription contrasts to the practice of applying a freshwater perturbation uniformly over a North Atlantic box, as done with the Coupled Model Intercomparison Project (CMIP) for use in paleo-studies. The alternative runoff prescription from CORE-III provides a more realistic distribution of a water flux anomaly relative to the pathways of the North Atlantic meridional overturning circulation, and so can be useful to understand transient responses of the ocean. The proposed perturbation is slightly stronger than the average increase in meltwater flux from Greenland estimated over the next 500 years and it is kept constant during the 100 year experiment, which is unlikely to be the case in reality.

The experiment would be spun up with CORE-I normal year forcing, with the last 100 years repeated with the freshwater perturbation. Continuing the simulation for a recovery period would be optional. The choice of surface boundary condition remains open and could be coupled or partially-coupled, for example by an anomaly-EBM. WGOMD members are interested in exploring the CORE-III design.

Ocean Model Evaluation

The fourth term of reference of WGOMD states that one of the responsibilities of this working group is "to stimulate the validation of ocean models when used in stand alone mode and as part of a coupled ocean-atmosphere model, using oceanographic data and other methods." There is a need for a community-wide comprehensive best practice for the overall comparison and evaluation of models that is not solely based on 'favourable' diagnostics.

WGOMD Repository for the Evaluation of Ocean Simulations (REOS): WGOMD is planning to develop a website hosting a peer-reviewed clearing house on how ocean models can be systematically assessed with respect to observed datasets to monitor simulation skill, characterize the structure of model biases, assess the impact of numerical/physical choices and guide further investigations. The website will share methods, views on best practices and observational dataset quality with the wider modelling and data assimilation community. Different modelling groups already have extensive model evaluation practices and experience with comparing model simulations to observed data. The CLIVAR GSOP data synthesis community is also in the process of organizing the evaluation of synthesis products and PCMDI has plans to develop a website on climate model evaluation.

Metrics can only be defined as being useful if they are relevant for application, for example, as benchmarks to compare model development or to help understand ocean variability and mechanisms in models. There are different requirements depending on the focus of the assessment. Metrics will be classified according to priority and complexity. Metrics need to be adaptable to cope with differences that arise from analyzing different model resolutions, such as calculating transports through straits in models with different degrees of resolution. Quantitative methods (space-time collocation, filtering, statistical analyses, etc.) will be identified.

WGOMD Future Direction

WGOMD has previously focused mainly on the science of ocean models. It will now broaden this emphasis towards applying ocean modelling to scientific questions including topics such as decadal prediction and high resolution models. WGOMD continues to support WGCM in understanding climate change, while also supporting the CLIVAR regional basin panels and GSOP. WGOMD also plans to develop links with the WCRP Working Group on Numerical Experimentation (WGNE), having expertise to contribute, particularly in terms of setting model standards for decadal prediction, ocean data assimilation, regional modelling and modelling biogeochemical cycles.

References

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