CLIVAR Ocean Model Development Panel (OMDP)
Overview

The 12th Session of the CLIVAR Working Group on Ocean Model Development (WGOMD) was held in Kiel, Germany on 10-11 April 2014. The meeting report is available here: http://www.clivar.org/sites/default/files/documents/WGOMD12_report_final_0.pdf. The meeting followed the WGOMD Workshop on High Resolution Ocean Climate Modeling, held on April 7-9, 2014. The overarching goal of the workshop was to bring together modeling groups conducting high-resolution ocean – sea-ice and / or fully coupled earth system model simulations as well as groups working in process orientated studies, theory, and parameterizations in order to review the state-of-science, including new sensitivities and processes emerging in these high resolution simulations. A CLIVAR Exchanges Special Issue (http://www.clivar.org/sites/default/files/documents/exchanges65_0.pdf) has been produced devoted to the workshop topics, with a collection of short articles prepared by many of the invited speakers as well as an overview article led by A. M. Treguier and the Scientific Steering Committee that summarizes the workshop outcomes and recommendations.

WGOMD met in The Hague, The Netherlands on 14-15 July, preceding the Pan-CLIVAR meeting. Agenda items included reviewing the ToRs to reflect the group's transition to the Ocean Model Development Panel (OMDP), CORE updates, and WGOMD engagement in the CLIVAR Research Foci. The group held joint meetings with GSOP, AIP, and SOP and made a CORE presentation to PP. Since then, WGOMD has initiated collaborative activities with SOP, GSOP and AIP. The Action Items are provided below.

This report is intended as a summary and update of the main areas of WGOMD work since the Kiel and Pan-CLIVAR gatherings.

Ocean Model Development
WGOMD coordinates ocean model development internationally, across all ocean climate model development efforts on parameterizations, numerics, nesting, and data assimilation. The following approaches are used:

- Coordinated Ocean-ice Reference Experiments (CORE) Framework
- Workshops
- US CLIVAR Climate Process Teams (gravity current overflows, upper ocean mesoscale and submesoscale mixing, internal gravity wave mixing, sea-ice heterogeneity and oceanic vertical mixing)
- Community ocean Vertical Mixing (CVMix) Project
- Establishment / encouragement of informal collaborations both within the ocean modeling community and with other CLIVAR panels for addressing model biases, parameterization development, etc.

WGOMD endorses the CVMix project, a collaboration between NCAR, GFDL, and LANL. CVMix is a software package that aims to provide transparent, robust, flexible, well documented, shared Fortran source code for use in parameterizing vertical mixing processes in numerical ocean models. The project is focused on developing software for a consensus of closures that return a vertical diffusivity, viscosity, and possibly a non-local transport, with each quantity dependent on the tracer or velocity being mixed. CVMix modules are written as kernels designed for use in a variety of Fortran ocean model codes such as MPAS-ocean, MOM, and POP. Code development occurs within a community of scientists and engineers who make use of CVMix modules for a variety of ocean codes. CVMix has been released as a beta-code, with release of version 1.0 scheduled for early 2015. Code will be freely distributed to the open source community under GPLv2 using an open source methodology.

As of June 2014, the CVMix code includes a suite of mixing schemes, including the K-Profile Parameterization for the surface boundary layer, and rudiments of tidal mixing schemes. Significant refinement and expansion to the code, including new parameterizations, will follow as testing within MPAS-O, MOM, and POP continues.

WGOMD continues to establish and encourage collaborations both within the ocean modeling community and with other CLIVAR panels to address model biases, parameterization development, etc.

CLIVAR Research Foci engagement

WGOMD members are engaged with the following CLIVAR RFs:
Upwelling - E. Curchitser, A. Oschlies, G. Danabasoglu
Decadal - G. Danabasoglu
Sea level - S. Griffies, S. Marsland, Y. Komuro
Heat uptake - A. M. Treguier, M. Winton, G. Nurser

Coordinated Ocean-ice Reference Experiments
CORE I is a spin up experiment while CORE II is a hindcast experiment based on the CORE inter-annually varying atmospheric data sets (Large and Yeager 2009). Both are being used by modeling groups as part of their standard ocean – sea-ice and coupled model development process. There are further developments of the CORE framework (CORE III - Greenland freshwater forcing, partial coupled CORE, climate sensitivity CORE, high res CORE etc) that are being explored by the community.

The primary goal of the CORE-II experiments is to provide a framework for evaluation, understanding, and improvements of the ocean components of the earth system models. Additionally, CORE-II simulations are used for investigation of mechanisms for seasonal, inter-annual, and decadal variability; the attribution of ocean-climate events to forced and natural variability; the evaluation of robustness of mechanisms across models; and

for bridging observations and modeling, by complementing ocean reanalysis from data assimilation approaches. CORE-II experiments also provide consistent ocean and sea-ice states that can be used for initialization of climate (e.g., decadal) prediction experiments.

To date, CORE-II simulations have been performed worldwide by over twenty modeling groups. The simulations are being analyzed in about ten separate studies, each focusing on a specific aspect of the solutions. These projects include analysis of mean states in the North Atlantic with a focus on the Atlantic Meridional Overturning Circulation (AMOC; Danabasoglu et al. 2014) and an assessment of global and regional sea level changes (Griffies et al. 2014). The manuscripts are being submitted to a Special Issue of *Ocean Modelling*.

Forced ocean (CORE-II) and reanalysis product intercomparison
WGOMD and GSOP have initiated an effort to compare low-frequency variability in AMOC from a set of ocean reanalysis products and from ocean hindcast simulations. These products are used for initialization of decadal prediction experiments for CMIPs. Currently, five reanalysis products and a few hindcast solutions are included in this inter-comparison. Initial investigation of the ocean state reanalyses suggests that there is *no consensus* on the sign of the AMOC trend since the 1960's. In part, these differences can be understood through examination of the northward geostrophic shear flow induced by the zonal density differences across the Atlantic basin. While low frequency changes (decadal and longer) in the temperature and salinity in the upper 250 m of these reanalyses are in general agreement, below 250 m the reanalyses products do not show consistent trends. Analysis of hindcast solutions and detailed comparisons with available observations are ongoing. The findings from this joint study will be included in a Climate Dynamics Special Issue on inter-comparison of reanalysis products.

Ocean Model Inter-comparison Project (OMIP) in CMIP6
WGOMD has recently proposed an OMIP for endorsement by the CMIP panel. The primary goal of the OMIP is to provide a framework for evaluation, understanding, and improvements of ocean components of the physical and earth system models that contribute to CMIPs. The first phase of the OMIP will be based on our existing CORE-II framework.

CMIP6 Ocean Model Output
WGOMD and collaborators have produced an updated version of the CMIP6 Ocean Model Output request document (Griffies et al. 2009; Griffies et al. 2014). This document presents recommendations for sampling physical ocean fields for CMIP6 and its MIPs, including the OMIP. The goal is to precisely define a suite of ocean model diagnostics related to physical properties and processes within the simulated ocean and associated boundary fluxes.

Atmospheric states for forcing ocean-ice climate simulations
Perhaps the main challenge faced by WGOMD - seen as a *grand challenge* -
is that the ocean modeling community needs a concerted effort from the
relevant communities within WCRP to produce atmospheric states suitable for
forcing ocean – sea-ice climate simulations. Until now, an effort volunteered
by NCAR for the community has produced the dataset currently used (Large
and Yeager, 2009). This approach is not sustainable since there is now a
widespread level of community interest in CORE (around 20 modeling groups
with more expressing interest), and the planned contribution of CORE forcing
to OMIP. This growing use of and interest in CORE requires the atmospheric
forcing dataset to be regularly updated and maintained. Furthermore, there is
a scientific need to provide more than a single atmospheric state in order to
examine the robustness of simulations, and to help refine the forcing
products.

WGOMD has proposed that the First Session of OMDP in 2015 is organized
as a mini workshop on the state-of-science of forcing ocean and sea-ice
models to review of recent developments, new methods, and data sets

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Pan-CLIVAR Action Items
July 2014

GSOP-OMDP
1. Forced ocean and reanalysis product intercomparison with a focus on the North Atlantic and Atlantic meridional overturning circulation.

2. Recommend joint extension and development of REOS.

3. Explore the establishment of a 'CLIVAR' repository at Hamburg for CORE and reanalysis products, with consistent data storage and delivery, including the adoption of ESGF/CMIP conventions.

4. Joint effort towards the design of the sustained and future ocean observing system, in collaboration with GCOS.

SOP-OMDP
1. SOP to pursue accurate AABW production numbers to assist assessment of ocean models (Talley).

2. OMDP/SOP to explore new CORE experimental protocol for a common simulation of CORE-II with Ice Shelf Water forcing component representing loss of Antarctic Ice.

3. OMDP/SOP to explore new CORE experimental protocol for a common simulation of CORE-II with shifted Southern Ocean winds strength and/or latitude (This was a follow up to proposals of Winton (OMDP) and Paul Spence (UNSW Australia) as presented by England (SOP)).

AIP-OMDP
1. Recommend that OMDP and AIP holds a joint future meeting on areas of mutual interest - upwelling, AMOC, Gulf Stream separation, tropical cyclones ocean-climate impact.

PP-OMDP
1. Support development of multiple forcing datasets for CORE-II.