Update on Ocean Model Developments and Simulations towards CESM2

OMWG Overarching Development Themes:

• **Addressing persistent model biases** (including related to BCG) via inclusion of new (missing) physics as well as improvements of existing parameterizations

• **Advancing our modeling capabilities** via model (numerical) improvements
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• Completed
  ✓ Barotropic solver enhancements
  ✓ Sea Surface Diurnal Cycling (SSDC) parameterization (in coupler)
  ✓ Community ocean Vertical Mixing (CVMix) framework

• In Progress (implemented, but testing)
  ➢ Langmuir mixing parameterization & WaveWatch III
  ➢ Robert – Asselin time filter
  ➢ Enhanced mesoscale eddy diffusivities at depth
  ➢ Specification of mesoscale eddy diffusivities via steering level approach
  ➢ Anisotropic mesoscale eddy diffusivities
  ➢ Tidal mixing parameterizations
  ➢ Estuary parameterization
Barotropic Solver Enhancements
(A Scalable Barotropic Solver)

Hu & Huang
Tsinghua University, China

Tseng, Baker, Bryan, & Dennis
NCAR

Replacement of Preconditioned Chronopoulous-Gear (ChronGear) Solver with Preconditioned Stiefel Iteration (P-CSI) Solver which requires no global reductions

On Yellowstone; EVP: Error Vector Propagation Preconditioning
- Parameterization for diurnal cycling of temperature, salinity, and velocity
- Flux calculations make use of $T_{\text{bulk}}$ and $T_{\text{skin}}$, rather than $T_f$ (default)
- Fluxes are calculated and accumulated at the coupling frequency of the atmospheric model

*Figure 1.* Schematic of diurnal warming of the near-surface ocean. Inputs to SSDC from the atmosphere, $SW_0$, $Q_N$, $F_0$, and wind stress, and from the ocean $T_f$ and $A_d$ are defined in the text, as are the outputs, $T_C$, $T_W$, $T_{\text{skin}}$, and $T_{\text{bulk}}$. The dashed curves show equation (6) for $p = 1/3$ and $p = 2$. With the latter, more heat is required to warm $T_W$ a given amount and there is a larger gradient, and hence cooling flux, at $-z = d$. 
Community ocean Vertical Mixing (CVMix) Framework

Levy, Danabasoglu, & Large (NCAR); Griffies, Adcroft, & Hallberg (GFDL); Ringler & Jacobsen (LANL)

- CVMix is a software package that aims to provide transparent, robust, flexible, well-documented, and shared Fortran source codes for use in parameterizing vertical mixing processes in ocean models.
- CVMix modules are used in POP2, MPAS-O, and MOM6.
- In POP2, K-Profile Parameterization (KPP) is enabled via CVMix.
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Enhanced mixing within the oceanic boundary layer through Langmuir turbulence
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NCAR
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH
Specification of Mesoscale Eddy Diffusivities via Steering Level Approach

Truesdale & Danabasoglu
NCAR
Marshall
MIT

Steering levels: Surfaces / regions at which the propagation speed of mesoscale eddies approach that of the mean flow;

Maximum mixing occurs at the steering levels;

Mixing is strongly suppressed away from the steering levels, e.g., in strong flows where the mean flow and propagation speed of eddies differ significantly.
New Tidal Mixing Parameterizations / Approaches
Norton & Danabasoglu (NCAR); Schmittner & Ullman (Oregon SU)

• New dissipation energy flux fields,
• Inclusion of subgrid-scale bathymetry in the energy flux field,
• Separation of semi-diurnal and diurnal tides with different local dissipation efficiency,
• Algebraic decay of dissipation energy in the vertical,
• Incorporation of the 18.6-year Lunar Nodal Cycle
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Summary and Plans

• Evaluation of new / improved physics is in progress;

• Initial assessments show mixed results in general, i.e., some improvements and some degradations, but there some outstanding science questions as well;

• Our plan is to continue our assessment of these new developments, considering some select parameterizations together in fully-coupled simulations;

• OMWG will make a final evaluation / recommendation for the ocean model version to be used in CESM2 following the 21st Annual CESM Workshop