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
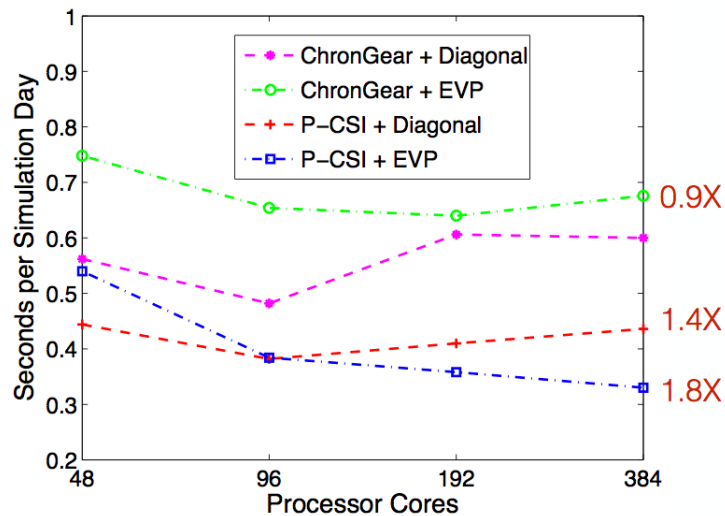# (A Scalable Barotropic Solver)

Hu & Huang

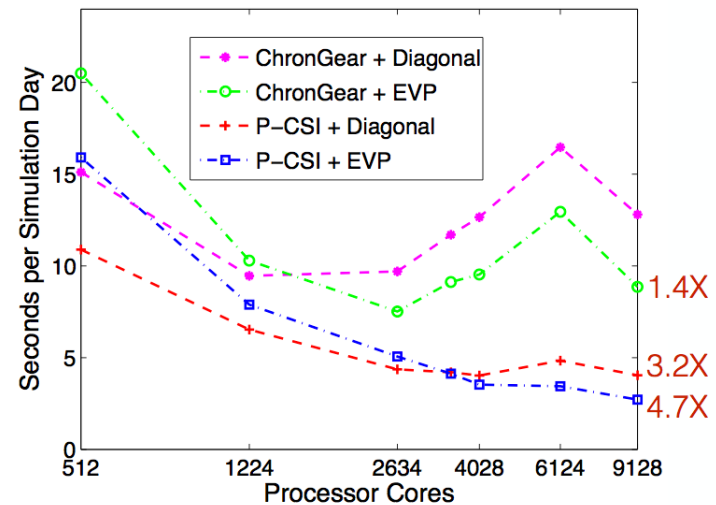Tsinghua University, China

Tseng, Baker, Bryan, & Dennis

NCAR

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

On Yellowstone; EVP: Error Vector Propagation Preconditioning

Sea Surface Diurnal Cycling (SSDC) Parameterization

Large & Caron
NCAR

- Parameterization for diurnal cycling of temperature, salinity, and velocity

- Flux calculations make use of T_{bulk} and T_{skin}, rather then T_f (default)

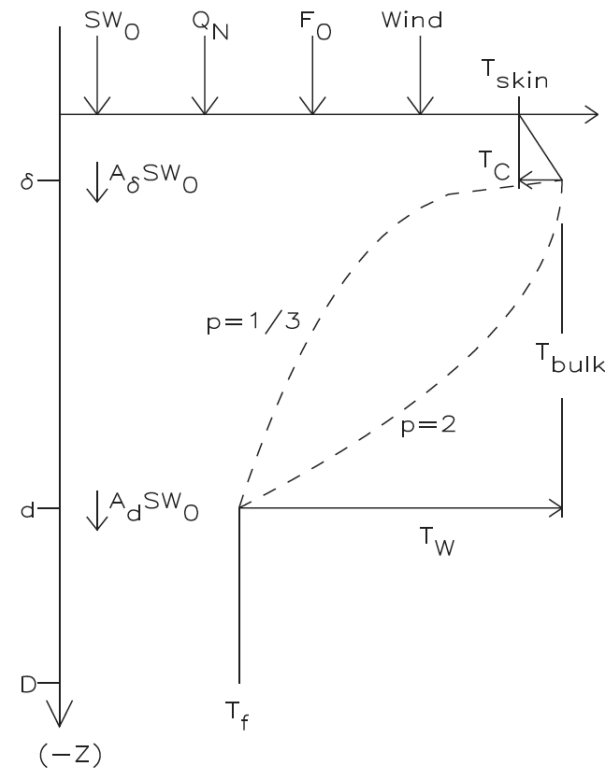- Fluxes are calculated and accumulated at the coupling frequency of the atmospheric model

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_{-z} are defined in the text, as are the outputs, T_C, T_W, T_{skin}, and T_{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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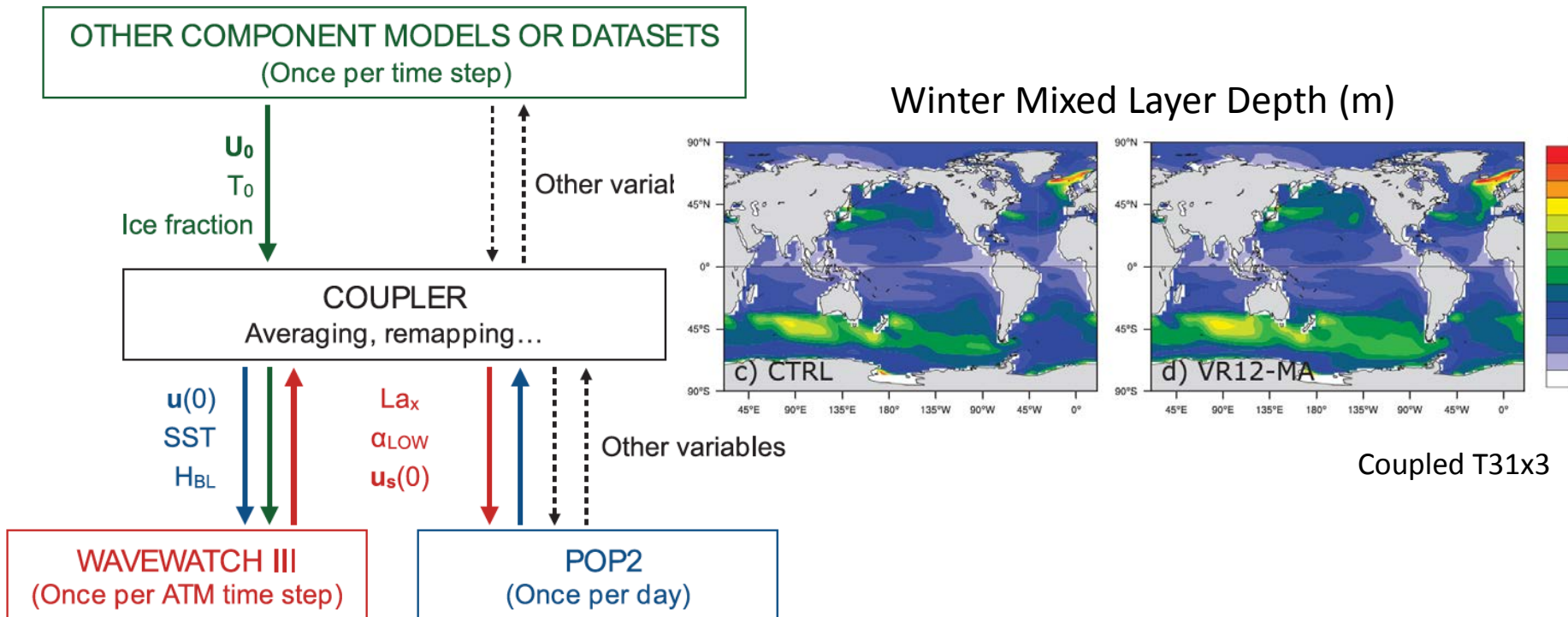
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Langmuir Mixing Parameterization & WaveWatch III

Li, Webb, & Fox-Kemper

Brown University

Craig, Danabasoglu, Large, & Vertenstein

NCAR

Enhanced mixing within the oceanic boundary layer through Langmuir turbulence

Winter Mixed Layer Depth (m)

Coupled T31x3

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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;
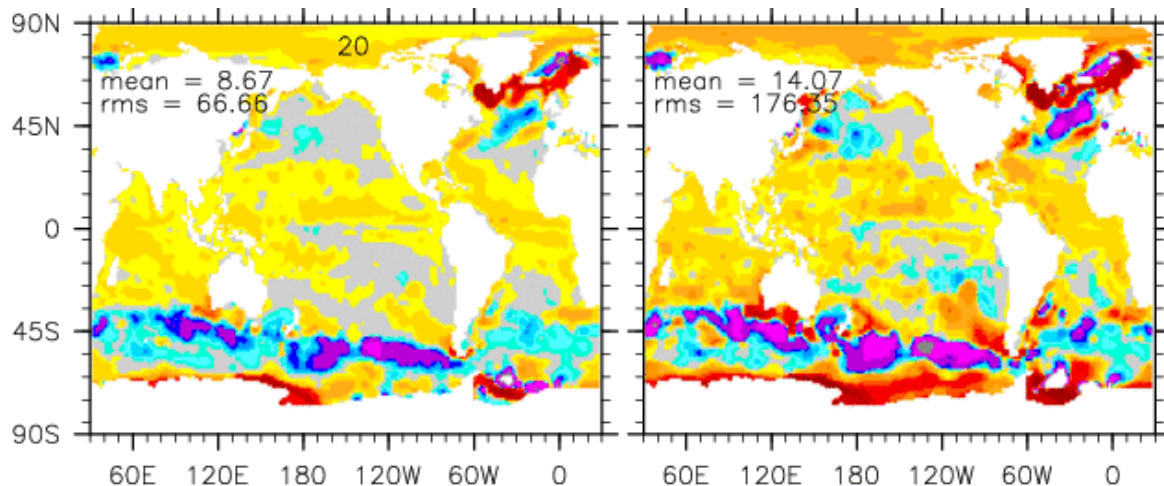
Maximum mixing occurs at the steering levels;

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.
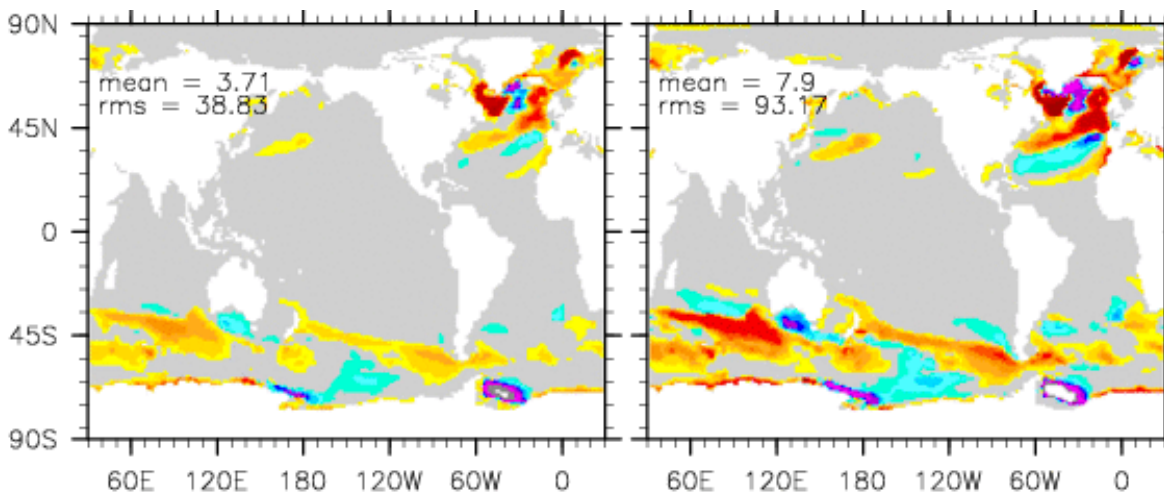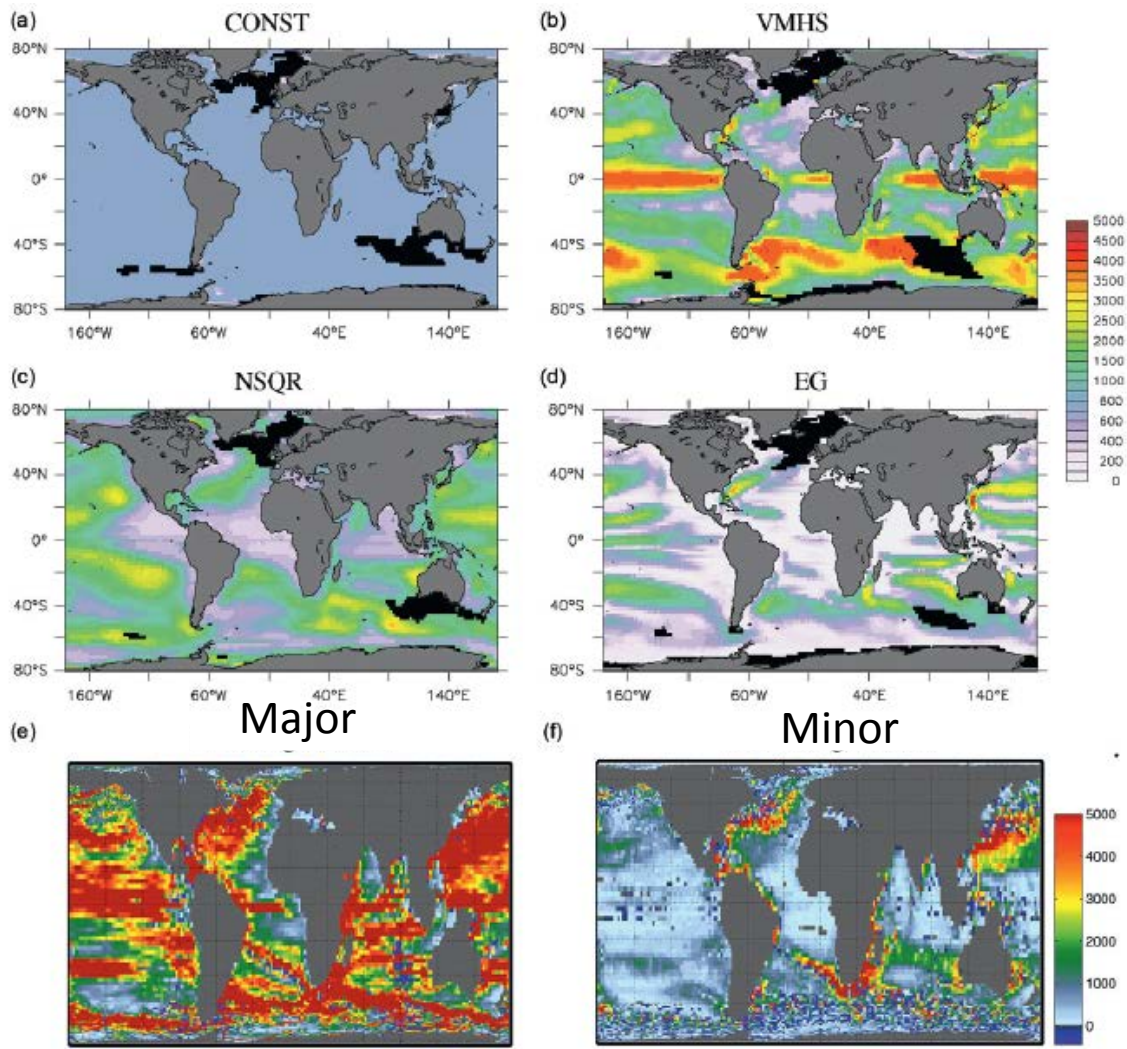
Mixed Layer Depth (m)

Anisotropic Mesoscale Eddy Diffusivities

Reckinger, Fox-Kemper, & Bachman
Brown University

Danabasoglu, Truesdale, & Bryan
NCAR

(a) CONST (b) VMHS (c) NSQR (d) EG (e) Major (f) Minor

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
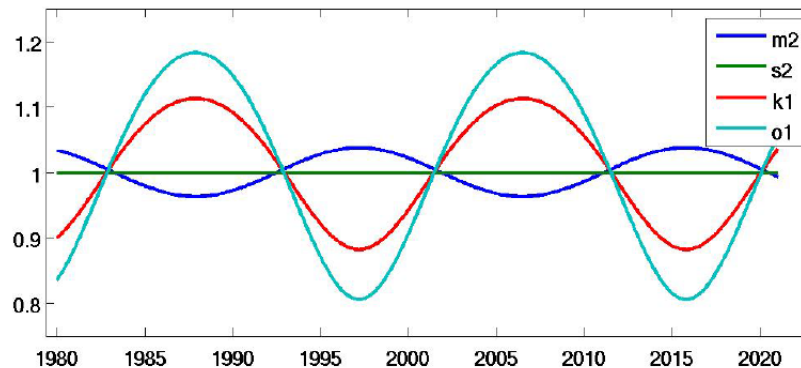
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Summary and Plans

- 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