

Community Ocean Vertical Mixing (CVMix) Status Update

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1 Background

- Current State of Mixing
- What CVMix Brings to the Table
- Parameterizations in CVMix

2 When Will CVMix Be Available?

3 Final Remarks

- Vision for the Future
- Summary
- References

Current State

- Numerous techniques for parameterizing the mixing process
- Model developers choose their favorite parameterization(s) and code them up as part of the ocean model

CVMix Project

- **Our goal:** produce an easy-to-use library containing a range of parameterizations
- **Secondary goal:** provide a stand-alone driver to test the library on its own
 - Note: we use the term “stand-alone driver” a bit loosely. CVMix can compute single-column diffusivities given proper input, but lacks the capability to see how diffusivities change over time.

Why CVMix?

Driving Force

Breckenridge 2012: MPAS-O did not have a KPP module yet and MOM5 was using an outdated implementation that GFDL wanted to improve on for their next generation model.

- CVMix is now used in development of [MPAS-O](#) and [MOM6](#), and will replace the mixing modules in [POP](#) [in CESM 1.3, November 2015].

Other Benefits

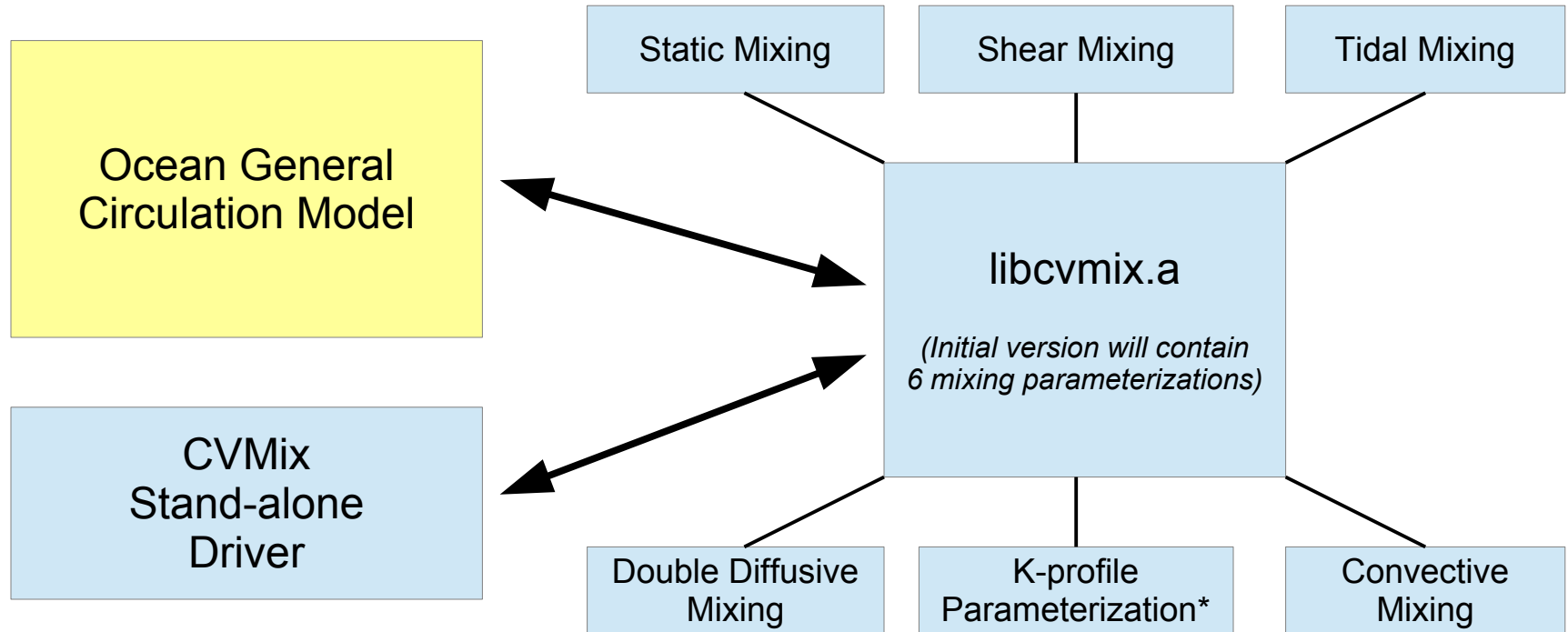
- 1 [Reduce duplicate code](#) – for example, static mixing occurs as a step in many parameterizations
- 2 CSEG is working to include non-POP / non-data ocean models in CESM
 - Vertical mixing library allows [some] physics to stay the same even if dynamics change
 - Allow more detailed [model inter-comparisons](#)

CVMix will...

- Provide a transparent, robust, flexible, well documented, open source library for use in parameterizing ocean vertical mixing processes.
- Contain a consensus of first-order closures that return a vertical diffusivity, viscosity, and possibly a non-local transport.
- Be comprised of Fortran modules that may be used in a stand-alone manner or incorporated into ocean models.
- Be developed within a community of scientists and engineers who make use of CVMix modules for a variety of research needs.

CVMix modules will be freely distributed under GPLv2 using an open source methodology.

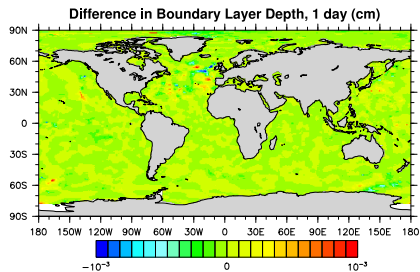
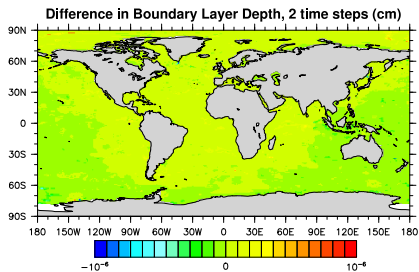
CVMix (Current State)



*Currently debugging KPP mixing, last hurdle before beta release (anticipated June 30th)

- 1 **Static background mixing**
 - Constant mixing
 - Bryan-Lewis (1979)
- 2 **Shear-induced mixing** (“Richardson number mixing”)
 - Pacanowski and Philander (1981)
 - Large et al. (1994), henceforth LMD94
- 3 **Tidal mixing** (Simmons et al. 2004)
- 4 **Double diffusion mixing** (Schmitt, 1994 / LMD94 / Danabasoglu et al., 2006)
- 5 **K-profile parameterization** (“KPP”; LMD94)
- 6 **Vertical convective mixing** (density based as well as Brunt-Väisälä)

Beta Version: Available by the end of this month

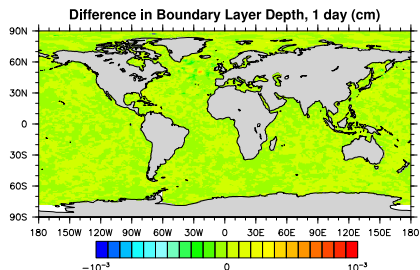
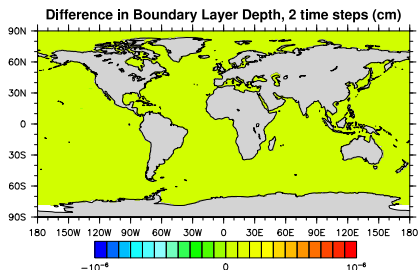


POP vs POP with CVMix for computing OBL depth

Why Aren't We In Beta Already?

- 1 **Internal testing:** the figures above compare differences in boundary layer depth after 2 time steps and after 1 day; round-off level changes grow quickly [leap-frog instability?]
- 2 **Efficiency:** calling CVMix's KPP routine from POP currently requires 10 calls to CVMix (plus POP is still doing two internal computations), goal is to 2 calls (and one internal computation)

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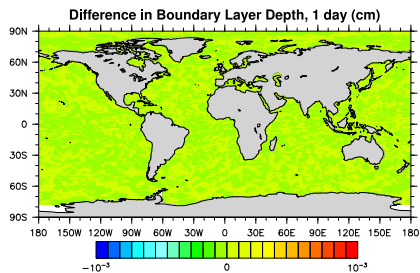
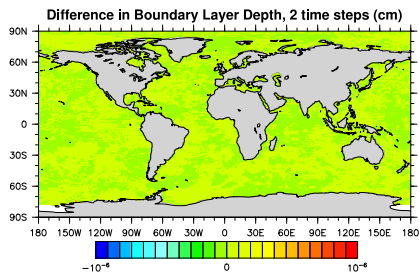


POP vs POP with order of operations change: mks (not cgs) in turbulent scales

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Out-of-the-box POP vs POP with different task count

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What to Expect from Beta Version

What We Want From Beta Testers

1 Patience:

- There will be performance issues (POP + CVMix crashes with multiple OpenMP threads per MPI task, no vectorization / tuning)

2 Feedback:

- Documentation is work in progress, both for using existing modules and adding new modules
- Use cases at GFDL, LANL, and NCAR may not exercise every branch of code \Rightarrow unknown bugs

Working to make CVMix 1.0 Available by the End of September

- Focus primarily on **performance**
 - POP + CVMix runtime is about 30% greater than standard POP
- Also will continue to improve **documentation** based on user feedback

- 1 Scientists will share code used to parameterize ocean vertical mixing
 - Provides added scrutiny to the code integrity
 - Allows for easier comparison of various parameterizations
- 2 Process modelers will incorporate new parameterizations into CVMix
 - Optimizes distribution of their ideas to the wider research community
- 3 Research will be stimulated by availability of schemes for testing in a suite of process and large-scale models

Coming Soon!

- Multi-lab collaboration to build vertical mixing library
- No change in POP interface, but changes “under the hood”
- Ability to run as a stand-alone / single-column executable
- Encouragement for the community to add mixing methods to share with others

- 1 Bryan, K. and L. J. Lewis, 1979: A water mass model of the world ocean. *Journal of Geophysical Research*, **84**, 2503-2517.
- 2 Danabasoglu, G., W. G. Large, J. J. Tribbia, P. R. Gent, B. P. Briegleb, and J. C. McWilliams, 2006: Diurnal coupling in the tropical oceans of CCSM3. *Journal of Climate*, **19**, 2347-2365.
- 3 Large, W., J. McWilliams, and S. Doney, 1994: Oceanic vertical mixing: a review and a model with a nonlocal boundary layer parameterization. *Reviews of Geophysics*, **32**, 363-403.
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- 5 Schmitt, R. W., 1994: Double diffusion in oceanography. *Annual Review of Fluid Mechanics*, **26**, 255-285.
- 6 Simmons, H. L., S. R. Jayne, L. C. St. Laurent, and A. J. Weaver, 2004: Tidally driven mixing in a numerical model of the ocean general circulation. *Ocean Modelling*, **6**, 245-263.