THE COMMUNITY OCEAN VERTICAL MIXING (CVMIX) PROJECT

The Community Ocean Vertical Mixing (CVMix) project is a broadly used computational modeling framework to calculate the small-scale transport of heat and gases between the ocean surface and the deeper ocean. Because water covers 70 percent of the planet's surface, these calculations are important for representing atmosphere-ocean interactions.

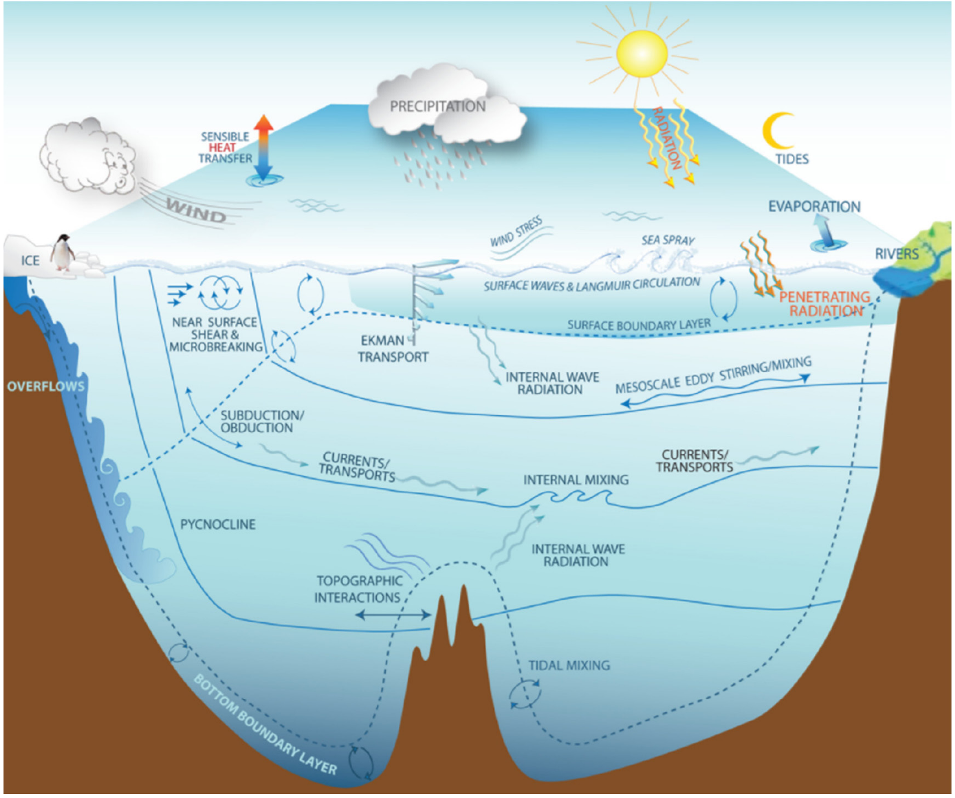
Sea surface temperature (SST) plays a major role in the atmosphere-ocean energy exchange, and vertical mixing in the ocean boundary layer (the upper 100 meters of the ocean) is one of many processes that affect SST. Vertical mixing transports atmospheric heat and carbon dioxide from the atmospheric boundary layer to the abyssal ocean.

The magnitude of vertical mixing in the ocean is dependent on vertical and horizontal processes that range in size from a kilometer to a few meters. Small-scale mixing processes strongly influence water temperature, salinity, and density, and have an important influence on the coupled climate system.

Earth system models cannot represent this critical transport between the atmosphere and deep ocean due to coarse model resolution.

While there are numerous techniques to represent vertical mixing processes, the developers of the CVMix project chose simpler, more computationally efficient schemes for use in earth system models. The goals are to provide the ocean modeling community:

- An easy-to-use library containing a range of parameterizations
- A stand-alone driver to test the library on its own.



The ocean boundary layer is a critical earth system interface between the atmosphere and ocean. Oceans are big, and they absorb vast amounts of heat and carbon. Knowing how heat and carbon move through the upper levels of the ocean is essential to integrating the ocean into the rest of the climate system. Illustrated here is a schematic of the small-scale mixing processes in the ocean.

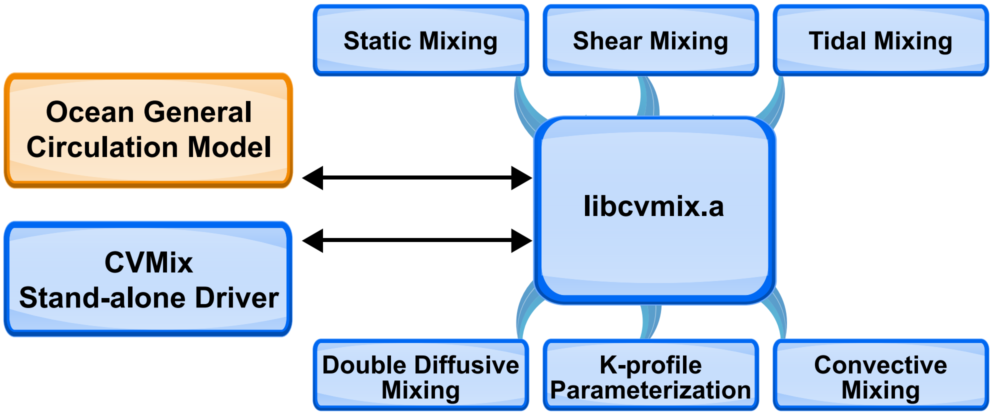
A COMMON FRAMEWORK FOR BOUNDARY-LAYER MIXING MODELS

Most ocean models use similar representations of vertical mixing, and each implements this representation differently. These small differences can make a dramatic impact on the solution. To address this challenge, CVMix—a collaborative project by scientists at DOE's Los Alamos National Laboratory, NSF's National Center for Atmospheric Research, and NOAA's Geophysical Fluid Dynamics Laboratory—is unifying a diverse set of approaches for vertical ocean mixing into a stand-alone library that can be implemented and used by all other current ocean models.

Get CVMix

Download the Community Ocean Vertical Mixing Project code:

- https://github.com/CVMix/CVMix-src
- http://doi.org/10.5281/zenodo.1000801
- Software documentation – https://github.com/CVMix/CVMix-description/blob/master/cvmix.pdf



CVMix FORTRAN modules are freely distributed using an open source GitHub repository.

The development team chose to focus on a subset of vertical mixing models to address another key challenge for researchers—computational cost. As compared with the more precise but complex General Ocean Turbulence Model (GOTM), CVMix focuses on more computationally efficient models of vertical mixing so that it can be used in more complex earth system models. This reduces computational cost.

In broad terms, CVMix can eliminate a key source of inter-model variability for vertical ocean mixing models. Combined with lower computational cost and a central library of models, CVMix can be a nexus for continual improvement in representations of vertical mixing.

MEETING THE NEEDS OF THE OCEAN MODELING COMMUNITY

The CVMix project addresses the needs of the various ocean-modeling groups to code, test, tune, and document simplified representations, or parameterizations, of ocean vertical mixing for numerical ocean simulations.

Researchers wrote CVMix modules as kernels for use in a variety of FORTRAN ocean model codes, such as Model for Prediction Across Scales-Ocean (MPAS-O), Modular Ocean Model (MOM), and Parallel Ocean Program (POP).

Notably, CVMix does not determine time-stepping for the model prognostic fields. Rather, it focuses on first-order turbulence closures for vertical-mixing processes. Future development may consider higher-order schemes. For projects desiring high-order turbulence approaches, GOTM is often used in specific cases. GOTM is widely accepted in the coastal community, but has fewer users in the global ocean modeling community.

As CVMix begins to develop high-order turbulence closures, code sharing and collaboration with GOTM will be possible. CVMix includes the following vertical mixing parameterizations:

- Static background mixing (including a spatially variable option)
- Shear-induced mixing (two options)
- Tidally driven mixing parameterization
- Double Diffusive convection
- K-Profile Parameterization (KPP) of boundary-layer mixing
- Convective mixing.

Every scheme available in CVMix computes parameterized fluxes, including non-local contributions, based on a series of inputs from the calling model. Examples include surface buoyancy and momentum fluxes, vertical stratification, and vertical shear.

FLEXIBILITY AND ADAPTABILITY

Depending on the chosen parameterization, information regarding unresolved tide speeds and bottom roughness may be required. In addition to returning diffusivities and non-local transport, various diagnostic fields can be returned to help understand the internal workings of each parameterization.

While CVMix offers a set of community accepted vertical mixing parameterizations for use in large-scale ocean models, it also provides a flexible and robust interface for implementing new first-order turbulence closures.

Given that each vertical mixing parameterization within CVMix is a unique module, many can be invoked from the calling model. This allows a flexible benchmarking interface of new and existing vertical-mixing models.

For further reading on the CVMix project, see Griffies et al. (2015), *"Theory and Numerics of the Community Ocean Vertical Mixing (CVMix) Project."*

SUPPORT

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