기후 분과 [P-153]

The Multi-Column Ocean Model (MCOM): A New 1-D Ocean Model in CESM2

Jongsoo Shin[1], Young-Oh Kwon[1], Gokhan Danabasoglu[2], Ivan Lima[1], Yu-Chiao Liang[3], Glenn Liu[1], Yu-Heng Tseng[3], and Michael Levy[2]

[1]Physical Oceanography Department, Woods Hole Oceanographic Institution
[2]Climate and Global Dynamics Laboratory, National Center for Atmospheric Research
[3]Department of Atmospheric Sciences, National Taiwan University

We introduce the Multi-Column Ocean Model (MCOM), a new one-dimensional (1-D) ocean column model that extends the hierarchy of ocean components in the Community Earth System Model version 2 (CESM2). MCOM is designed to bridge the gap between the slab ocean model (SOM) and the full three-dimensional ocean general circulation model (FOM). Built on the framework of the Parallel Ocean Program version 2 (POP2), MCOM disables lateral ocean processes while retaining key vertical processes such as vertical mixing and entrainment. Its multi-layer vertical structure enables MCOM to realistically provide seasonal and interannual variability in the mixed layer depth—a feature missing in SOM—while remaining simpler than FOM. To assess its performance, we conducted 500-year preindustrial (PI) control simulations with CESM2 coupled to MCOM and compared the results with the simulations using FOM and SOM. The findings highlight the distinct roles of 1-D vertical processes (e.g., vertical mixing, interannual mixed layer depth variability, and entrainment) relative to 3-D ocean dynamics (e.g., wind- and buoyancy-driven circulation) in climate variability and predictability on interannual to decadal timescales. This study advances understanding of how atmospheric forcing, 1-D vertical ocean processes, and 3-D ocean dynamics interact, offering new insights into the ocean's role in modulating atmospheric circulation.

Keywords: Ocean model hierarchy, Multi-column ocean model, Vertical processes, Lateral processes

※ This work was supported by the National Science Foundation (NSF) Climate and Large-scale Dynamics Program (AGS-2040073) and the NSF Physical Oceanography Program (OCE-2219436). The authors gratefully acknowledge the support from Research Growth Donations to WHOI. The model experiments were supported by the CESM Climate Variability and Change Working Group (CVCWG) and were performed using high-performance computing support from the Derecho system (doi:10.5065/qx9a-pg09), provided by the NSF National Center for Atmospheric Research (NCAR), sponsored by the National Science Foundation.