EasyChair Preprint

№ 10220

Visualizing NeverWorld2: a Set of Ocean Simulations to Study Mesoscale Eddies Across Resolutions

Scott Pearse and Gustavo Marques

May 21, 2023

Visualizing NeverWorld2: A set of ocean simulations to study mesoscale eddies across resolutions

Scott Pearse Gustavo Marques
National Center for Atmospheric Research, Boulder, CO 80307, USA

May 12, 2023

Abstract

NeverWorld2 is an idealized configuration implemented using the Modular Ocean Model dynamical core (MOM6) for studying mesoscale eddies. It was run at four horizontal grid spacings of 1/4°, 1/8°, 1/16°, and 1/32°. The model was configured to use adiabatic physics, which allows the solutions to achieve a quasi-equilibrium state relatively fast. This visualization shows eddies being resolved at these four resolutions. The eddies that are resolved at the highest resolutions imply significant computational cost savings because of NeverWorld2's adiabatic physics.

1 The NeverWorld2 simulation code

This visualization of NeverWorld2 [2] depicts some of the dynamics used to resolve mesoscale ocean eddies in an idealized representation of the Drake Passage. Located between South America and Antarctica, the Drake Passage is known for having some of the most turbulent waters on the planet. The non-uniform ocean depth used in the NeverWorld2 simulations has a central ridge that interacts with the ocean eddies, as well as an inlet on the western side of the domain, and an outlet on the eastern side at approximately -45° latitude.

NeverWorld2 fills a gap between two types of configurations: 1) quasi-geostrophic models that cannot span two hemispheres, and 2) idealized general circulation models that generally have diabatic processes and buoyancy forcing and, therefore, take a long time to reach equilibrium.

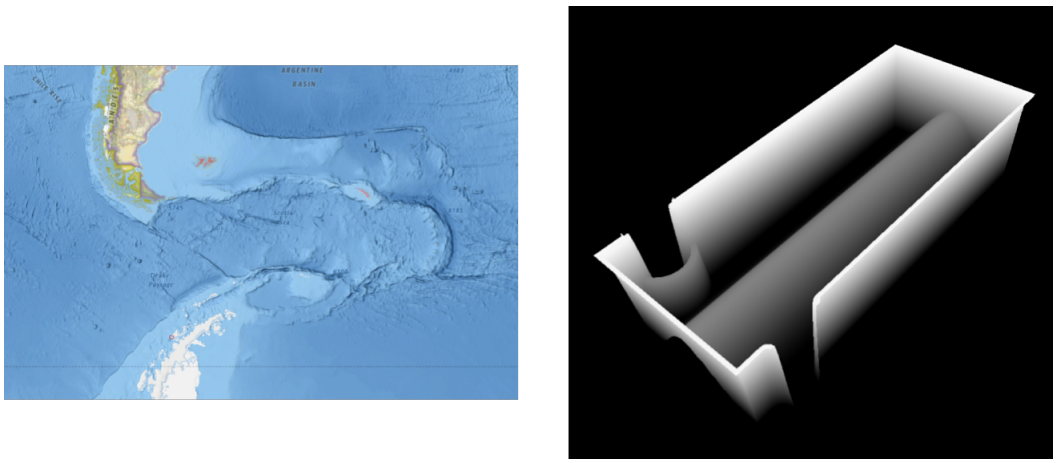

Figure 1: Imagrey of the Drake Passage[5] alongside NeverWorld2's idealized ocean floor.

2 NeverWorld2 execution environment

The NeverWorld2 simulations were executed on the Cheyenne supercomputer [4], a 5.34 petaflops system built for the National Center for Atmospheric Research in Boulder, Colorado. Cheyenne is comprised of 145,152 Intel Xeon processor cores in 4,034 dual-socket nodes, and contains 313 TB of total memory. NeverWorld2's total data footprint is approximately 3.5 TB and required approximately 266,000 CPU hours to execute.

Simulation	Discretization (XYZ)	Gridpoint Count
1/4°	240x560x50	6,720,000
1/8°	480x1120x50	26,880,000
1/16°	960x2240x50	107,520,000
1/32°	1920x4480x50	430,080,000

Table 1: NeverWorld2 grid discretization.

3 Visualization toolset

The visualization was rendered using VAPOR [1], an open-source desktop application developed at NCAR. VAPOR specializes in accessible 3D analysis of Earth System Sciences (ESS) data. The application is comprised of eleven OpenGL algorithms called Renderers, which depict scientific data in different ways according to user-defined parameters. This visualization uses VAPOR's Direct Volume Renderer (DVR) to depict ocean eddies according to the MOM6 Kinetic Energy (KE) variable, using the "thermal" colormap from matplotlib's cmocean module [6]. The ocean floor is depicted in greyscale using VAPOR's TwoDData Renderer.

Over sixteen different perspectives of the four NeverWorld2 simulations were generated using VAPOR's newly developed Python API, which allows the application to be executed through a Python script. The most compelling perspectives were chosen for the final visualization production. Visualizations were executed on NCAR's Casper data analysis and visualization cluster [3]. Casper is a heterogeneous system comprised of 100 nodes that feature either Skylake or Cascade Lake processors. For this visualization, VAPOR utilized nodes that feature NVIDIA Quadro GP100 GPUs.

4 Acknowledgements

We acknowledge the use of the Cheyenne and Casper supercomputers at the NCAR-Wyoming Supercomputing Center (NWSC), which is supported by the National Science Foundation (NSF). We thank the staff at NCAR and NWSC for their assistance and support.

References

[1] Shaomeng Li, Stanislaw Jaroszynski, Scott Pearse, Leigh Orf, and John Clyne. Vapor: A visualization package tailored to analyze simulation data in earth system science. *Atmosphere*, 10(9):488, 2019.

[2] Gustavo M Marques, Nora Loose, Elizabeth Yankovsky, Jacob M Steinberg, Chiung-Yin Chang, Neeraja Bhamidipati, Alistair Adcroft, Baylor Fox-Kemper, Stephen M Griffies, Robert W Hallberg, et al. Neverworld2: An idealized model hierarchy to investigate ocean mesoscale eddies across resolutions. *Geoscientific Model Development*, 15(17):6567–6579, 2022.

[3] National Center for Atmospheric Research (NCAR). Casper supercomputer at the ncar-wyoming supercomputing center (nwsc). accessed 2023-05-12. Boulder, CO: UCAR/NCAR/CISL.

[4] National Center for Atmospheric Research (NCAR). Cheyenne supercomputer at the ncar-wyoming supercomputing center (nwsc). accessed 2023-05-12. Boulder, CO: UCAR/NCAR/CISL.

[5] National Oceanic and Atmospheric Administration. Electronic navigational charts (encs) viewer. https://www.nauticalcharts.noaa.gov/ENCOnline/ENCOnline.html#/viewer, Accessed 12-May-2023.

[6] Kristen M Thyng, Chad A Greene, Robert D Hetland, Heather M Zimmerle, and Steven F DiMarco. True colors of oceanography: Guidelines for effective and accurate colormap selection. *Oceanography*, 29(3):9–13, 2016.