

regional_mom6: Automatic generation of regional configurations for the Modular Ocean Model 6 in Python

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DOI: [10.xxxxxx/draft](https://doi.org/10.xxxxxx/draft)

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Submitted: 01 January 1970

Published: unpublished

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Summary

The Modular Ocean Model version 6 (MOM6) is a widely-used open-source general circulation ocean-sea ice model developed mainly at the Geophysical Fluid Dynamics Laboratory (GFDL) (Adcroft et al., 2019). Among other improvements over its predecessor MOM5 (Griffies, 2014), MOM6 has more capable support for open boundary conditions and thus is becoming popular for regional ocean modeling studies (see, e.g., Ross et al. (2023), Ross et al. (2024)) in addition to global configurations. However, setting up a regional configuration for MOM6 can be challenging and time consuming and often involves using several programming languages, a few different tools, and also manually editing/tweaking some input files. The regional_mom6 python package overcomes these difficulties, automatically generating a regional MOM6 configuration.

The regional_mom6 package takes as input various datasets that containing the ocean initial condition, the boundary forcing (ocean and atmosphere) for the regional domain, and the bathymetry. The input datasets can be on the Arakawa A, B, or C grids (Arakawa & Lamb, 1977); the package performs the appropriate interpolation using xESMF (Zhuang et al., 2023) under the hood, to put the everything on the C grid required by MOM6. Thus, the package automates the re-gridding of all the required forcing input, takes care of all the metadata encoding, generates the regional grid, and deals with a few other necessary steps. This allows users to setup a regional MOM6 configurations using only Python and from a single Jupyter notebook.

regional_mom6 is continuously tested and comes with an extensive documentation that also includes documented tutorials/examples for setting up regional MOM6 configurations using publicly-available forcing and bathymetry datasets (namely, the GLORYS dataset for ocean boundary forcing (Copernicus Marine Services, 2024), the ERA5 reanalysis for atmospheric forcing (Copernicus Climate Change Service, 2024), and the GEBCO dataset for bathymetry (GEBCO Bathymetric Compilation Group 2023, 2023)).

Having the entire process for setting up a regional configuration running in a Jupyter notebook dramatically reduces the barrier to entry for first-time users, or those without a strong background in Fortran, experience in compiling and running scripts in terminals, and manipulating netCDF files. Besides making regional modelling with MOM6 more accessible, our package can automate the generation of multiple experiments (e.g., a series of perturbation experiments), saving time and effort, and improving reproducibility.

We designed regional_mom6 with automation of regional configurations in mind. However,

the package's code design and modularity makes more complex configurations possible since users can use their own custom-made grids with more complex boundaries and construct the boundary forcing terms one by one.

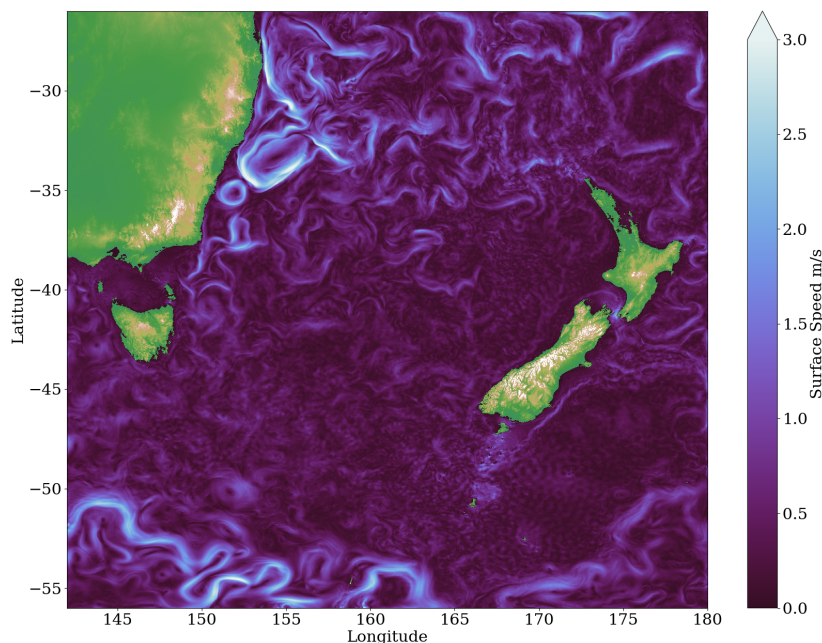


Figure 1: A snapshot of the ocean surface currents from a MOM6 regional simulation of the Tasman sea. The simulation is forced by GLORYS and ERA5 reanalysis datasets and configured with a horizontal resolution of 1/80th degree and 100 vertical levels (see Barnes (2024) for the source code).

Figure 1 shows the surface currents from a regional ocean simulation of the Tasman sea that was configured using the regional_mom6 package.

Statement of need

The learning curve for setting up a regional ocean model can be quite steep. In the case of MOM6, there are several tools scattered in Github repositories, for example those collected in ESMG's grid tools (Cermak et al., 2021). Also, there exist several regional configuration examples but they are hardcoded for particular domains, specific input files, and work only on specific high-performance computing machines.

Until now there has been no one-stop-shop for users to learn how to get a regional MOM6 configuration up and running. Users are required to use several tools in several programming languages and then modify –sometimes by hand– some of the input metadata to bring everything into the format that MOM6 expects. Many parts of this process are not documented, requiring users to consult the MOM6 Fortran source code. Other ocean models have packages to aid in regional configuration setup, for example Pyroms (Hedstrom & contributors, 2023) for the Regional Oceanic Modelling System (ROMS; Shchepetkin & McWilliams (2005)) and MITgcm_python (Naughten & Jones, 2023) for the Massachusetts Institute of Technology General Circulation Model (MITgcm; Marshall et al. (1997)). With MOM6's growing user base for regional applications, there is a need for a platform that walks users through regional domain configuration from start to finish and, ideally, automates the process on the way. regional_mom6 fills precisely this need.

By having a shared set of tools that the community can work with and contribute to, this package also facilitates collaboration and knowledge-sharing between different research groups.

67 Using a shared framework for setting up regional models, it is easier to compare and contrast
68 examples of different experiments and allows for users to gain intuition for generating their
69 chosen domain.

70 Another potential advantage of a package that allows users to automatically obtain regional
71 configurations of MOM6 is in education. With the technically-challenging aspects of setting
72 up a regional configuration now being automated by the `regional_mom6` package, students
73 can set up and run simple MOM6 regional configurations and also change parameters like
74 resolution or forcing, run again, and see how these parameters affect the ocean flow.

75 Acknowledgements

76 We thank the Consortium for Ocean–Sea Ice Modeling in Australia (cosima.org.au) for useful
77 discussions during the development of this package. We acknowledge support from the
78 Australian Research Council under DECRA Fellowship DE210100749 (N.C.C.) and grant
79 LP200100406 (A.E.K.). We would also like to acknowledge the code and notes by James
80 Simkins, Andrew Ross, and Rob Cermak, which helped us to troubleshoot and improve the
81 algorithms in our package.

82 References

- 83 Adcroft, A., Anderson, W., Balaji, V., Blanton, C., Bushuk, M., Dufour, C. O., Dunne, J.
84 P., Griffies, S. M., Hallberg, R., Harrison, M. J., Held, I. M., Jansen, M. F., John, J. G.,
85 Krasting, J. P., Langenhorst, A. R., Legg, S., Liang, Z., McHugh, C., Radhakrishnan,
86 A., ... Zhang, R. (2019). The GFDL global ocean and sea ice model OM4.0: Model
87 description and simulation features. *Journal of Advances in Modeling Earth Systems*,
88 11(10), 3167–3211. <https://doi.org/10.1029/2019MS001726>
- 89 Arakawa, A., & Lamb, V. R. (1977). Computational design of the basic dynamical processes
90 of the UCLA general circulation model. *Methods in Computational Physics: Advances*
91 *in Research and Applications*, 17(Supplement C), 173–265. [https://doi.org/10.1016/](https://doi.org/10.1016/B978-0-12-460817-7.50009-4)
92 [B978-0-12-460817-7.50009-4](https://doi.org/10.1016/B978-0-12-460817-7.50009-4)
- 93 Barnes, A. J. (2024). Tasman-tides. In *GitHub repository*. [https://github.com/ashjbarnes/](https://github.com/ashjbarnes/tasman-tides)
94 [tasman-tides](https://github.com/ashjbarnes/tasman-tides)
- 95 Cermak, R., Simkins, J., Hedstrom, K., & Gibson, A. (2021). ESMG gridtools. In *GitHub*
96 *repository*. Github. <https://github.com/ESMG/gridtools>
- 97 Copernicus Climate Change Service. (2024). *ECMWF Reanalysis v5*. European Centre for
98 Medium-Range Weather Forecasts. <https://doi.org/10.48670/moi-00021>
- 99 Copernicus Marine Services. (2024). *Global ocean physics reanalysis*. Mercator Ocean
100 International. <https://doi.org/10.48670/moi-00021>
- 101 GEBCO Bathymetric Compilation Group 2023. (2023). *The GEBCO_2023 Grid - a continuous*
102 *terrain model of the global oceans and land*. NERC EDS British Oceanographic Data
103 Centre NOC. <https://doi.org/10.5285/f98b053b-0cbc-6c23-e053-6c86abc0af7b>
- 104 Griffies, S. M. (2014). Elements of the modular ocean model (MOM). *GFDL Ocean Group*
105 *Tech. Rep.*, 7, 47. https://mom-ocean.github.io/assets/pdfs/MOM5_manual.pdf
- 106 Hedstrom, K., & contributors. (2023). Pyroms. In *GitHub repository*. Github. [https://](https://github.com/ESMG/pyroms)
107 github.com/ESMG/pyroms
- 108 Marshall, J., Adcroft, A., Hill, C., Perelman, L., & Heisey, C. (1997). A finite-volume,
109 incompressible Navier Stokes model for studies of the ocean on parallel computers. *Journal of*
110 *Geophysical Research: Oceans*, 102(C3), 5753–5766. <https://doi.org/10.1029/96JC02775>

- 111 Naughten, K., & Jones, D. (2023). MITgcm_python. In *GitHub repository*. Github. https://github.com/knaughten/mitgcm_python
- 112
- 113 Ross, A. C., Stock, C. A., Adcroft, A., Curchitser, E., Hallberg, R., Harrison, M. J., Hedstrom,
114 K., Zadeh, N., Alexander, M., Chen, W., Drenkard, E. J., Pontavice, H. du, Dussin, R.,
115 Gomez, F., John, J. G., Kang, D., Lavoie, D., Resplandy, L., Roobaert, A., ... Simkins, J.
116 (2023). A high-resolution physical–biogeochemical model for marine resource applications in
117 the northwest Atlantic (MOM6-COBALT-NWA12 v1.0). *Geoscientific Model Development*,
118 16(23), 6943–6985. <https://doi.org/10.5194/gmd-16-6943-2023>
- 119 Ross, A. C., Stock, C. A., Koul, V., Delworth, T. L., Lu, F., Wittenberg, A., & Alexander,
120 M. A. (2024). Dynamically downscaled seasonal ocean forecasts for North American East
121 Coast ecosystems. *EGUsphere*, 2024, 1–40. <https://doi.org/10.5194/egusphere-2024-394>
- 122 Shchepetkin, A. F., & McWilliams, J. C. (2005). The regional oceanic modeling system
123 (ROMS): A split-explicit, free-surface, topography-following-coordinate oceanic model.
124 *Ocean Modelling*, 9(4), 347–404. <https://doi.org/10.1016/j.ocemod.2004.08.002>
- 125 Zhuang, J., Dussin, R., Huard, D., Bourgault, P., Banihirwe, A., Raynaud, S., Malevich,
126 B., Schupfner, M., Filipe, Levang, S., Gauthier, C., Jüling, A., Almansi, M., Scott,
127 R., RondeauG, Rasp, S., Smith, T. J., Stachelek, J., Plough, M., & Li, X. (2023).
128 xESMF: Universal regridding for geospatial data. In *GitHub repository*. Zenodo. <https://github.com/pangeo-data/xESMF>
- 129

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