

# Ryan Patrick Abernathey

Associate Professor  
Department of Earth and Environmental Sciences  
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## Contact

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## Education

- *Sept. 2006–Feb. 2012* – **Ph.D., Climate Physics and Chemistry**, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA  
*thesis*: Mixing by Ocean Eddies, *advisor*: John Marshall
- *Sept. 2000–May 2004* – **B.A., Physics**, Middlebury College, Middlebury, Vermont, USA  
*thesis*: Phase Dynamics and Synchronization of the Van der Pol Oscillator, *advisor*: Jeffrey Dunham

## Appointments

- *July 2018–present* – **Associate Professor**, Columbia University / Lamont Doherty Earth Observatory, New York, New York, USA
- *July 2013–present* – **Assistant Professor**, Columbia University / Lamont Doherty Earth Observatory, New York, New York, USA
- *June 2012–July 2013* – **Postdoctoral Scholar**, Scripps Institution of Oceanography, La Jolla, California, USA
- *Feb. 2012–June 2012* – **Postdoctoral Scholar**, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA
- *Sept. 2006–Feb. 2012* – **Graduate Research Assistant / Ph.D. Student**, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA

## Awards

- *July 2017* – Royal Society Exchange Grant (with Laure Zanna, U. of Oxford)
- *May. 2017* – Columbia Lenfest Junior Faculty Development Grant
- *Feb. 2016* – Alfred P. Sloan Research Fellow in Ocean Sciences
- *Feb. 2016* – NSF CAREER Award
- *Apr. 2014* – NASA New Investigator Early Career Award
- *June 2011* – Student Award Winner, AMS Conference on Atmospheric and Oceanic Fluid Dynamics
- *Dec. 2010* – Outstanding Student Presentation, AGU Fall Meeting

## Publications

### In Review

1. Groeskamp, S., P. B. Barker, T. J. McDougall, R. P. Abernathey, and S. M. Griffies, 2018: A new algorithm to accurately calculate neutral tracer gradients and their impacts on vertical heat transport and water mass transformation. PDF (*Submitted to JPO*)
2. Sinha, A., D. Balwada, N. Tarshish, and R. Abernathey, 2018: Modulation of Lateral Transport by Submesoscale Flows and Inertia Gravity Waves. PDF (*Submitted to JAMES*)
3. Busecke, J., and R. P. Abernathey, 2018: Ocean Mesoscale Mixing linked to Climate Variability. PDF (*Submitted*)

### Published / In Press

1. Abernathey, R., J. Marshall, E. Shuckburgh, and M. Mazloff, 2010: Enhancement of Mesoscale Eddy Stirring at Steering Levels in the Southern Ocean. *J. Phys. Oceanogr.*, **40**, 170–185, doi:10.1175/2009JPO4201.1. PDF → online
2. Abernathey, R., J. Marshall, and D. Ferreira, 2011: The Dependence of Southern Ocean Meridional Overturning on Wind Stress. *J. Phys. Oceanogr.*, **41**, 2261–2278, doi:10.1175/JPO-D-11-023.1. PDF → online
3. Hill, C., D. Ferreira, J.-M. Campin, J. Marshall, R. Abernathey, and N. Barrier, 2012: Controlling Spurious Diapycnal Mixing in Eddy-Resolving Height-Coordinate Ocean Models: Insights from Virtual Deliberate Tracer Release Experiments. *Ocean Modelling*, **45–46**, 14–26, doi:10.1016/j.ocemod.2011.12.001. PDF → online
4. Abernathey, R., and J. C. Marshall, 2013: Global surface eddy diffusivities derived from satellite altimetry. *J. Geophys. Res.*, **118**, 901–916, doi:10.1002/jgrc.20066. PDF → online
5. Abernathey, R., D. Ferreira, and A. Klocker, 2013: Diagnostics of isopycnal mixing in a circumpolar channel. *Ocean Modelling*, **72**, 1–16, doi:10.1016/j.ocemod.2013.07.004. PDF → online
6. Gnanadesikan, A., R. Abernathey, and M.-A. Pradal, 2014: Exploring the isopycnal mixing and helium-heat paradoxes in a suite of Earth System Models. *Ocean Science Discussions*, **11**, 2533–2567, doi:10.5194/osd-11-2533-201. PDF → online
7. Abernathey, R. P., and P. Cessi, 2014: Topographic Enhancement of Eddy Efficiency in Baroclinic Equilibration. *J. Phys. Oceanogr.*, **44**, 2107–2126, doi:10.1175/JPO-D-14-0014.1. PDF → online
8. Klocker, A., and R. Abernathey, 2014: Global Patterns of Mesoscale Eddy Properties and Diffusivities. *J. Phys. Oceanogr.*, **44**, 1030–1047, doi:10.1175/JPO-D-13-0159.1. PDF → online
9. Abernathey, R., and D. Ferreira, 2015: Southern Ocean isopycnal mixing and ventilation changes driven by winds. *Geophysical Research Letters*, **42**, 10,357–310,365, doi:10.1002/2015GL066238. PDF → online
10. Abernathey, R. P., and C. Wortham, 2015: Phase speed cross spectra of eddy heat fluxes in the Pacific. *J. Phys. Oceanogr.*, **45**, 1285–1301, doi:10.1175/JPO-D-14-0160.1. PDF → online
11. Gnanadesikan, A., M.-A. Pradal, and R. Abernathey, 2015: Isopycnal mixing by mesoscale eddies significantly impacts oceanic anthropogenic carbon uptake. *Geophysical Research Letters*, **42**, 4249–4255, doi:10.1002/2015GL064100. PDF → online (*2015GL064100*)
12. Solomon, A., L. M. Polvani, K. L. Smith, and R. Abernathey, 2015: The impact of ozone depleting substances on the circulation, temperature and salinity of the Southern Ocean: An attribution study with CESM1 (WACCM). *Geophysical Research Letters*, **42**, 5547–5555, doi:10.1002/2015GL064744. PDF → online
13. Sinha, A., and R. Abernathey, 2016: Timescales of Southern Ocean Eddy Equilibration. *J. Phys. Oceanogr.*, **46**, 2785–2805, doi:10.1175/JPO-D-16-0041.1. PDF → online
14. Abernathey, R., I. Cerovečki, P. R. Holland, E. Newsom, M. Mazloff, and L. D. Talley, 2016: Southern Ocean Water Mass Transformation Driven by Sea Ice. *Nature Geoscience*, **9**, 596–601, doi:10.1038/ngeo2749. PDF → online
15. Wang, L., M. F. Jansen, and R. P. Abernathey, 2016: Eddy phase speeds in a two-layer model of quasigeostrophic baroclinic turbulence with applications to ocean observations. *Journal of Physical*

- Oceanography*, **46**, 1963–1985, doi:10.1175/JPO-D-15-0192.1. PDF → online
16. Newsom, E., C. Bitz, F. Bryan, R. P. Abernathey, and P. Gent, 2016: Southern Ocean Deep Circulation and Heat Uptake in a High-Resolution Climate Model. *Journal of Climate*, **29**, 2597–2619, doi:10.1175/JCLI-D-15-0513.1. PDF → online
  17. Bishop, S. P., P. R. Gent, F. O. Bryan, A. F. Thompson, M. C. Long, and R. P. Abernathey, 2016: Southern Ocean Overturning Compensation in an Eddy-Resolving Climate Simulation. *Journal of Climate*, **46**, 1575–1592, doi:10.1175/JPO-D-15-0177.1. PDF → online
  18. Groeskamp, S., R. P. Abernathey, and A. Klocker, 2016: Water Mass Transformation by Cabbeling and Thermobaricity. *Geophysical Research Letters*, doi:10.1002/2016GL070860. PDF → online (2016GL070860)
  19. Gnanadesikan, A., A. Russell, M.-A. Pradal, and R. Abernathey, 2017: Impact of Lateral Mixing in the Ocean on El Nino in a Suite of Fully Coupled Climate Models. *Journal of Advances in Modeling Earth Systems*, doi:10.1002/2017MS000917. PDF → online
  20. Uchida, T., R. P. Abernathey, and K. S. Smith, 2017: Seasonality in Ocean Mesoscale Turbulence in a High Resolution Climate Model. *Ocean Modelling*, **118**, 41–58, doi:10.1016/j.ocemod.2017.08.006. PDF → online
  21. Busecke, J., R. P. Abernathey, and A. L. Gordon, 2017: Lateral Eddy Mixing in the subtropical salinity maxima of the global Ocean. *J. Phys. Oceanogr.*, doi:10.1175/JPO-D-16-0215.1. PDF → online
  22. Balwada, D., K. S. Smith, and R. Abernathey, 2018: Submesoscale Vertical Velocities Enhance Tracer Subduction in an Idealized Antarctic Circumpolar Current. *Geophysical Research Letters*, doi:10.1029/2018GL079244. PDF → online
  23. Tesdal, J.-E., R. P. Abernathey, J. I. Goes, A. L. Gordon, and T. W. N. Haine, 2018: Salinity Trends within the Upper Layers of the Subpolar North Atlantic. *Journal of Climate*, **31**, 2675–2698, doi:10.1175/JCLI-D-17-0532.1. PDF → online
  24. Tarshish, N., R. Abernathey, C. Zhang, C. O. Dufour, I. Frenger, and S. M. Griffies, 2018: Identifying Lagrangian coherent vortices in a mesoscale ocean model. *Ocean Modelling*, **130**, 15–28, doi:10.1016/j.ocemod.2018.07.001. PDF → online
  25. Seville, E. van, and others, 2018: Lagrangian ocean analysis: fundamentals and practices. *Ocean Modelling*, **121**, 49–75, doi:10.1016/j.ocemod.2017.11.008. PDF → online
  26. Abernathey, R., and G. Haller, 2018: Transport by Lagrangian Vortices in the Eastern Pacific. *Journal of Physical Oceanography*, **48**, 667–685, doi:10.1175/JPO-D-17-0102.1. PDF → online
  27. Tamsitt, V., R. P. Abernathey, M. R. Mazloff, J. Wang, and L. D. Talley, 2018: Transformation of Deep Water Masses Along Lagrangian Upwelling Pathways in the Southern Ocean. *Journal of Geophysical Research: Oceans*, **123**, 1994–2017, doi:10.1002/2017JC013409. PDF → online

## Sponsored Projects

- *NSF OCE 13-57133* – \$101,621 (2015-01-01 - 2016-12-31), PI  
Collaborative Research: The Upper Branch of the Southern Ocean Overturning in the Southern Ocean State Estimate: Water Mass Transformation and the 3-D Residual Circulation
- *NASA NNX14AI46G* – \$259,539 (2015-05-06 - 2017-05-05), PI  
Quantifying Surface Diapycnal Mixing by Mesoscale Eddies using Satellite Observations
- *NSF OCE 15-53593* – \$762,946 (2016-02-15 - 2021-01-31), PI  
CAREER: Evolution of Ocean Mesoscale Turbulence in a Changing Climate
- *NASA NNX16AJ35G* – \$339,203 (2016-05-01 - 2020-04-03), Institutional PI  
Fluxes of heat, carbon and oxygen at SWOT scales
- *NSF OCE 1740648* – \$1.2M (\$736,713 to LDEO) (2017-09-01 - 2020-08-31), lead PI  
Collaborative Proposal: EarthCube Integration: Pangeo: An Open Source Big Data Climate Science Platform
- *NSF OAC 1835778* – \$254,103 (2018-11-01 - 2022-10-31), PI  
Collaborative Research: Framework: Data: Toward Exascale Community Ocean Circulation Modeling

## Teaching

- *Research Computing in Earth Science* – An intensive and hands-on immersion in the application of modern research computing practices to data analysis and visualization, using datasets and methods drawn from across Earth Science. (Fall 2017)
- *Ocean Dynamics* – Advanced topics in ocean circulation theory (Spring 2017)
- *Introduction to Physical Oceanography* – Physical properties of seawater, ocean water masses and their distribution, sea-air interaction, ocean general circulation, mixing processes. Co-taught with Arnold Gordon (Fall 2013, Fall 2014, Fall 2015, Fall 2017)
- *Geophysical Fluid Dynamics* – Fundamental concepts in the dynamics of rotating stratified flows. Geostrophic and hydrostatic balances, potential vorticity,  $f$  and  $\beta$  plane approximations, gravity and Rossby waves, geostrophic adjustment and quasigeostrophy, baroclinic and barotropic instabilities. (Spring 2015, Spring 2016)
- *Python for Scientific Computing* – An informal introduction to python, designed to take a novice from zero to fully functional in about eight hours. Topics include core python language, IPython notebooks, numpy, matplotlib, Basemap, pandas, and xarray. (September 2014, August 2015)

## Software

- *xgcm* – A python package for the analysis of finite-volume ocean general circulation model output. Builds on xarray and dask projects to provide parallel, out-of-core scalability.
- *xmitgcm* – A python package for reading MITgcm binary MDS files into xarray data structures.
- *xarray* – A community-driven open source project to which I contribute. Xarray provides data structures and computational methods for working with labeled multidimensional numerical array data.
- *xrft* – Fourier transforms on xarray data structures.
- *pyqg* – A python quasigeostrophic model for turbulence simulations. Well documented and easy to use—ideal for students, but fast enough for real research.

## Presentations

### Invited

- *May 2018* – *Transport by Coherent Lagrangian Vortices*, MIT PAOC Colloquium, Cambridge, MA
- *Jan. 2018* – *Pangeo: An Open Source Platform for Big Data Geoscience*, Earth System Information Partners Conference, Washington, DC
- *Nov. 2017* – *Transport by Coherent Lagrangian Vortices*, Duke University, Durham, NC
- *Oct. 2017* – *Transport by Coherent Lagrangian Vortices*, University of Washington, Seattle, WA
- *Apr. 2017* – *Southern Ocean Water Mass Transformation Driven by Sea Ice*, Southern Ocean Workshop, NCAR, Boulder, CO
- *Jan. 2017* – *Eulerian eddy fluxes by coherent Lagrangian eddies in the ocean*, Transport in Unsteady Flows: from Deterministic Structures to Stochastic Models and Back Again, Banff International Research Station, Banff, CA
- *Oct. 2016* – *What are Ocean Eddies?*, Rutgers University, New Brunswick, NJ
- *Oct. 2016* – *Southern Ocean Water Mass Transformation Driven by Sea Ice*, SUNY Stony Brook, Stony Brook, NY

- *Jan. 2016 – Southern Ocean Water Mass Transformation Driven by Sea Ice*, Workshop on thermodynamic analysis for atmospheric and oceanic flows, NYU Abu Dhabi, Abu Dhabi, UAE
- *Jan. 2016 – Southern Ocean Water Mass Transformation Driven by Sea Ice*, Southern Ocean Carbon and Climate Observations and Modeling Webinar
- *Sept. 2015 – Identifying Lagrangian Coherent Structures on a Basin Scale using MITgcm and PyTables*, Workshop on the Future of Lagrangian Ocean Modeling, Imperial College, London, UK
- *Feb. 2015 – The Upwelling Branch of the Southern Ocean Overturning Circulation*, Southern Ocean Dynamics and Biogeochemistry Workshop, California Institute of Technology, Pasadena, CA
- *Dec. 2014 – The Phase Speed Signature of Mesoscale Eddy Fluxes in the Pacific*, Harvard University, Cambridge, MA
- *July 2014 – The Phase Speed Signature of Mesoscale Eddy Fluxes in the Pacific*, Woods Hole Oceanographic Institution, Woods Hole, MA
- *July 2014 – The Phase Speed Signature of Mesoscale Eddy Fluxes in the Pacific*, Geophysical Fluid Dynamics Laboratory, Princeton, NJ
- *May 2014 – Topographic Enhancement of Eddy Efficiency in Baroclinic Equilibration*, Johns Hopkins University, Baltimore, MD
- *Apr. 2014 – Topographic Enhancement of Eddy Efficiency in Baroclinic Equilibration*, Courant Institute at New York University, New York, NY
- *March 2014 – Topographic Enhancement of Eddy Efficiency in Baroclinic Equilibration*, University of Rhode Island, Narragansett, RI
- *April 2013 – Mixing By Ocean Eddies*, National Center for Atmospheric Research, Boulder, CO
- *March 2013 – Mixing By Ocean Eddies*, Scripps Institution of Oceanography, La Jolla, CA
- *Feb. 2013 – Equilibration of Circumpolar Currents with and without Topography*, California Institute of Technology, Pasadena, CA
- *Oct. 2012 – Mixing By Ocean Eddies*, Physical Oceanography Dissertation Symposium, Lihue, Kaua'i, HI
- *April 2012 – Mixing By Ocean Eddies*, Lamont Doherty Earth Observatory, Palisades, NY
- *March 2012 – Mixing By Ocean Eddies*, University of Chicago, Chicago, IL

## Conference

- *June 2018 – Pangeo: An Open Source Platform for Big Data Geoscience*, Earthcube All Hand Meeting, Washington, DC
- *Feb. 2018 – Pangeo: An Open Source Platform for Big Data Geoscience*, AGU Ocean Sciences Meeting, Portland, OR
- *Feb. 2018 – Transport by Coherent Lagrangian Vortices*, AGU Ocean Sciences Meeting, Portland, OR
- *June 2017 – Transport by Coherent Lagrangian Vortices*, AMS Atmosphere Ocean Fluid Dynamics Meeting, Portland, OR
- *May 2016 – Lagrangian Coherent Structures and Eulerian Eddy Fluxes in the East Pacific*, AmeriMech Symposium on Fluid Transport and Nonlinear Dynamics, WHOI, Woods Hole, MA
- *May 2016 – Online Diagnostics of Water Mass Transformation in MITgcm*, ECCO Production meeting, MIT, Cambridge, MA

- *Oct. 2015 – Isopycnal Mixing and Ventilation Controlled by Winds*, CLIVAR Workshop on Translating Process Understanding to Improve Climate Models, Princeton, NJ
- *June 2015 – Phase Speed Spectra of Ocean Mesoscale Eddies*, AMS Conference on Atmosphere Ocean Fluid Dynamics, Minneapolis, MN
- *Dec. 2014 – Surface Water Mass Transformation by Mesoscale Eddy Stirring*, AGU Fall Meeting, San Francisco, CA
- *Feb. 2014 – Evaluating Theories for Mesoscale Eddy Diffusivity Using Satellite Observations*, AGU Ocean Sciences Meeting, Honolulu, HI
- *June 2013 – Macroturbulent Equilibration of Circumpolar Currents with and without Topography*, Ocean Turbulence Conference, Center for Nonlinear Science, Santa Fe, NM
- *Feb. 2013 – Equilibration of Circumpolar Currents with and without Topography*, Southern Ocean Workshop, Massachusetts Institute of Technology, Cambridge, MA
- *Dec. 2012 – Equilibration of Circumpolar Currents with and without Topography*, AGU Fall Meeting, San Francisco, CA
- *April 2012 – European Geosciences Union General Assembly*, Vienna, Austria
- *Feb. 2012 – AGU Ocean Sciences Meeting*, Salt Lake City, UT
- *June 2011 – AMS Conference on Atmospheric and Oceanic Fluid Dynamics*, Spokane, WA
- *Oct. 2011 – Graduate Climate Conference*, Woods Hole Oceanographic Institution, Woods Hole, MA
- *Dec. 2010 – AGU Fall Meeting*, San Francisco, CA
- *Feb. 2010 – AGU Ocean Sciences Meeting*, Portland, OR
- *June 2009 – AMS Conference on Atmospheric and Oceanic Fluid Dynamics*, Stowe, VT

## Service

### Community

- Session Chair, Transport and Coherent Structures: New and Traditional Approaches for Studying Ocean Stirring and Mixing, 2018 Ocean Sciences Meetings, Portland, OR
- Faculty Member, 2014 Geophysical Fluid Dynamics Summer School, Woods Hole Oceanographic Institution, Woods Hole, MA
- Session Chair, The Southern Ocean and Its Role in the Climate System; Observations and Modeling of Physical and Biogeochemical Processes, 2014 Ocean Sciences Meeting, Honolulu, HI
- Member, EarthCube Science Committee
- Member, American Geophysical Union
- Member, European Geophysical Union
- Member, American Meteorological Society
- Reviewer for Journal of Physical Oceanography
- Reviewer for Journal of Geophysical Research Oceans
- Reviewer for Geophysical Research Letters
- Reviewer for Ocean Modelling
- Reviewer for Nature Communications

- Reviewer for National Science Foundation

## **Univeristy**

- Leader, LDEO Real Time Earth Strategic Initiative (2015 - present)
- Board Member, Center for Climate and Life (2015 - present)
- Member, Columbia Data Science Institute Working Group on Frontiers in Computing Systems (2016 - present)
- SRCPAC Education Committee (2017)
- DEES Curriculum Committee (2016)
- DEES Broad Search Committee (2016)
- DEES Cryosphere Search Committee (2015)
- Yeti High Performance Computing Executive Committe (2015-2016)