

CURRICULUM VITAE

Keith Lindsay

Project Scientist III
Climate and Global Dynamics Laboratory
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Citizenship: United States of America

Education

- Ph.D., Mathematics, 1997, The University of Michigan, *Thesis: A Three-Dimensional Cartesian Tree-Code and Applications to Vortex Sheet Roll-Up*, (Dr. Robert Krasny, advisor)
- M.S., Mathematics, 1993, The University of Michigan
- B.S., Computer Science & Mathematics, 1991, Virginia Tech

Employment

- 10/2012-present: Project Scientist III, Climate and Global Dynamics Division (CGD), National Center for Atmospheric Research (NCAR), Boulder, CO
- 3/2008-9/2012: Project Scientist II, CGD, NCAR, Boulder, CO
- 8/2004-2/2008: Project Scientist I, CGD, NCAR, Boulder, CO
- 3/2003-7/2004: Associate Scientist III, CGD, NCAR, Boulder, CO
- 8/1998-3/2003: Associate Scientist II, CGD, NCAR, Boulder, CO
- 8/1997-8/1998: Visiting Assistant Professor, NSF Industrial Postdoctoral Fellowship, Claremont Graduate University, Claremont, CA, McDonnell Douglas Aerospace, Long Beach, CA

Academic Honors & Awards

- CESM Distinguished Achievement Award, 2019
- Richard C. DiPrima Prize for Best Ph.D. Thesis, Society for Industrial and Applied Mathematics, 2000
- Sumner B. Myers Prize for Best Ph.D. Thesis, Department of Mathematics, The University of Michigan, 1997
- U.S. Department of Education Fellowship, The University of Michigan, 1991-1993, 1996-1997
- Outstanding Graduating Math Major, Virginia Tech, 1991
- Phi Beta Kappa, 1991
- Hatcher Scholarship, Virginia Tech, 1989-1991

Professional Society Membership

- American Geophysical Union
- Society for Industrial and Applied Mathematics

Community Service

- CCSM Biogeochemistry Working Group Co-Chair, 2010-present
- CCSM Biogeochemistry Working Group Community Liaison
- Ph.D. Committee Member: Kristen Krumhardt (CU, graduated 2018), Natalie Freeman (CU, graduated 2017)
- Co-organizer for 2009 ASP Summer Colloquium
- CGD Seminar Coordinator, 2007-2008
- UCAR Awards Committee, 2002-2004

- Reviewer for : Geophysical Research Letters, Biogeosciences, Global Biogeochemical Cycles, Journal of Climate, Journal of Geophysical Research, Ocean Modelling, Applied Numerical Mathematics
- NCAR ASP Postdocs mentored: Shanlin Wang, 2011-2014
- NCAR ASP Graduate Student Visitors hosted: Darren Pilcher, University of Wisconsin-Madison, 2014

Research Grants Awarded

DOE, Improving CESM efficiency to study variable C:N:P stoichiometry in the oceans. July 2011-June 2014, \$82,224 (NCAR portion), Co-Principal Investigator.

NASA, Assessing the Impact of Ocean Acidification on Marine Planktonic Calcification Using Satellite Analysis and Earth System Modeling. January 2011-December 2013, \$75,858 (NCAR portion), Co-Principal Investigator.

NSF, Improved regional and decadal predictions of the carbon cycle. January 2011-December 2014, \$599,338 (NCAR portion), Co-Principal Investigator.

Publications

Refereed Publications

S. Gu, et al., 2019: Assessing the Ability of Zonal $\delta^{18}\text{O}$ Contrast in Benthic Foraminifera to Reconstruct Deglacial Evolution of Atlantic Meridional Overturning Circulation. *Paleoceanography and Paleoclimatology*, **34**, 800-812, doi:10.1029/2019PA003564.

K. M. Krumhardt, et al., 2019: Coccolithophore growth and calcification in an acidified ocean: Insights from Community Earth System Model simulations. *J. Adv. Model. Earth Syst.*, **11**, in press, doi:10.1029/2018MS001483.

N. S. Lovenduski, S. G. Yeager, K. Lindsay, M. C. Long, 2019: Predicting near-term variability in ocean carbon uptake, *Earth Syst. Dynam.*, **10**, 45-57, doi:10.5194/esd-10-45-2019.

S. G. Yeager, et al., 2018: Predicting Near-Term Changes in the Earth System: A Large Ensemble of Initialized Decadal Prediction Simulations Using the Community Earth System Model, *Bull. Amer. Meteor. Soc.*, **99**, 1867–1886, doi:10.1175/BAMS-D-17-0098.1.

G. J. Kooperman, et al., 2018: Plant physiological responses to rising CO_2 modify simulated daily runoff intensity with implications for global-scale flood risk assessment, *Geophys. Res. Lett.*, **45**, 12457-12466, doi:10.1029/2018GL079901.

N. M. Freeman, et al., 2018: The Variable and Changing Southern Ocean Silicate Front: Insights From the CESM Large Ensemble, *Global Biogeochem. Cycles*, **32**, 752-768, doi:10.1029/2017GB005816.

W. Fu, F. Primeau, J. K. Moore, K. Lindsay, J. T. Randerson, 2018: Reversal of Increasing Tropical Ocean Hypoxia Trends With Sustained Climate Warming, *Global Biogeochem. Cycles*, **32**, 551-564, doi:10.1002/2017GB005788.

G. J. Kooperman, et al., 2018: Forest response to rising CO_2 drives zonally asymmetric rainfall change over tropical land, *Nat. Clim. Change*, **8**, 434-440, doi:10.1038/s41558-018-0144-7.

- J. K. Moore, et al., 2018: Sustained climate warming drives declining marine biological productivity, *Science*, **359**, 1139-1143, doi:10.1126/science.aao6379.
- J. Zhang, et al., 2017: Asynchronous warming and $\delta^{18}\text{O}$ evolution of deep Atlantic water masses during the last deglaciation, *Proc. Natl. Acad. Sci. USA*, **114**, 11075-11080, doi:10.1073/pnas.1704512114.
- J. C. Orr, et al., 2017: Biogeochemical protocols and diagnostics for the CMIP6 Ocean Model Intercomparison Project (OMIP), *Geosci. Model Dev.*, **10**, 2169-2199, doi:10.5194/gmd-10-2169-2017.
- T. Rohr, M. C. Long, M. T. Kavanaugh, K. Lindsay, S. C. Doney, 2017: Variability in the mechanisms controlling Southern Ocean phytoplankton bloom phenology in an ocean model and satellite observations, *Global Biogeochem. Cycles*, **31**, 922-940, doi:10.1002/2016GB005615.
- J. Liptak, G. Keppel-Aleks, K. Lindsay, 2017: Drivers of Multicentury Trends in the Atmospheric CO_2 Mean Annual Cycle in a Prognostic ESM, *Biogeosciences*, **14**, 1383-1401, doi:10.5194/bg-14-1383-2017.
- K. M. Krumhardt, N. S. Lovenduski, M. C. Long, K. Lindsay, 2017: Avoidable impacts of ocean warming on marine primary production: Insights from the CESM ensembles, *Global Biogeochem. Cycles*, **31**, 114-133, doi:10.1002/2016GB005528.
- N. Mahowald, et al., 2017: Interactions between land use change and carbon cycle feedbacks, *Global Biogeochem. Cycles*, **31**, 96-113, doi:10.1002/2016GB005374.
- K. Lindsay, 2017: A Newton-Krylov solver for fast spin-up of online ocean tracers, *Ocean Model.*, **109**, 33-43, doi:10.1016/j.ocemod.2016.12.001.
- N. S. Lovenduski, G. A. McKinley, A. R. Fay, K. Lindsay, M. C. Long, 2016: Partitioning uncertainty in ocean carbon uptake projections: Internal variability, emission scenario, and model structure, *Global Biogeochem. Cycles*, **30**, 1276-1287, doi:10.1002/2016GB005426.
- A. Bardin, F. Primeau, K. Lindsay, A. Bradley, 2016: Evaluation of the accuracy of an offline seasonally-varying matrix transport model for simulating ideal age, *Ocean Model.*, **105**, 25-33, doi:10.1016/j.ocemod.2016.07.003.
- R. S  ferian, et al., 2016: Inconsistent strategies to spin up models in CMIP5: implications for ocean biogeochemical model performance assessment, *Geosci. Model Dev.*, **9**, 1827-1851, doi:10.5194/gmd-9-1827-2016.
- G. A. McKinley, D. J. Pilcher, A. R. Fay, K. Lindsay, M. C. Long, N. S. Lovenduski, 2016: Timescales for detection of trends in the ocean carbon sink, *Nature*, **530**, 469-472, doi:10.1038/nature16958.
- N. S. Lovenduski, M. C. Long, K. Lindsay, 2015: Natural variability in the surface ocean carbonate ion concentration, *Biogeosciences*, **12**, 6321-6335, doi:10.5194/bg-12-6321-2015.
- A. Jahn, et al., 2015: Carbon isotopes in the ocean model of the Community Earth System Model (CESM1), *Geosci. Model Dev.*, **8**, 2419-2434, doi:10.5194/gmd-8-2419-2015.
- M. C. Long, K. Lindsay, M. M. Holland, 2015: Modeling photosynthesis in sea ice-covered waters, *J. Adv. Model. Earth Syst.*, **7**, 1189-1206, doi:10.1002/2015MS000436.

- J. T. Randerson, et al., 2015: Multi-century changes in ocean and land contributions to climate-carbon feedbacks, *Global Biogeochem. Cycles*, **29**, 744-759, doi:10.1002/2014GB005079.
- J. E. Kay, et al., 2014: The Community Earth System Model (CESM) Large Ensemble Project: A Community Resource for Studying Climate Change in the Presence of Internal Climate Variability, *Bull. Amer. Meteor. Soc.*, **96**, 1333–1349, doi:10.1175/BAMS-D-13-00255.1.
- K. Lindsay, et al., 2014: Preindustrial-Control and Twentieth-Century Carbon Cycle Experiments with the Earth System Model CESM1(BGC), *J. Climate*, **27**, 8981-9005, doi:10.1175/JCLI-D-12-00565.1.
- S. Wang, D. Bailey, K. Lindsay, K. Moore, and M. Holland, 2014: Impacts of sea ice on the marine iron cycle and phytoplankton productivity, *Biogeosciences*, **11**, 4713-4731, doi:10.5194/bg-11-4713-2014.
- K. Misumi, et al., 2014: The iron budget in ocean surface waters in the 20th and 21st centuries: projections by the Community Earth System Model version 1, *Biogeosciences*, **11**, 33-55, doi:10.5194/bg-11-33-2014.
- F. M. Hoffman, et al., 2014: Causes and Implications of Persistent Atmospheric Carbon Dioxide Biases in Earth System Models, *J. Geophys. Res. Biogeosci.*, **119**, 141-162, doi:10.1002/2013JG002381.
- A. Bardin, F. Primeau, K. Lindsay, 2014: An offline implicit solver for simulating prebomb radiocarbon, *Ocean Model.*, **73**, 45-58, doi:10.1016/j.ocemod.2013.09.008.
- J. K. Moore, K. Lindsay, S. C. Doney, M. C. Long, K. Misumi, 2013: Marine Ecosystem Dynamics and Biogeochemical Cycling in the Community Earth System Model [CESM1(BGC)]: Comparison of the 1990s with the 2090s under the RCP4.5 and RCP8.5 Scenarios, *J. Climate*, **26**, 9291-9312, doi:10.1175/JCLI-D-12-00566.1.
- I. Marinov, S. C. Doney, I. D. Lima, K. Lindsay, J. K. Moore, N. Mahowald, 2013: North-South asymmetry in the modeled phytoplankton community response to climate change over the 21st century, *Global Biogeochem. Cycles*, **27**, 1274-1290, doi:10.1002/2013GB004599.
- K. Misumi, K. Lindsay, K. Moore, S. C. Doney, D. Tsumune, 2013: Humic substances may control dissolved iron distributions in the global ocean: Implications from numerical simulations, *Global Biogeochem. Cycles*, **27**, 450-462, doi:10.1002/gbc.20039.
- M. C. Long, K. Lindsay, S. Peacock, J. K. Moore, S. C. Doney, 2013: Twentieth-Century Oceanic Carbon Uptake and Storage in CESM1(BGC), *J. Climate*, **26**, 6775-6800, doi:10.1175/JCLI-D-12-00184.1.
- V. K. Arora, et al., 2013: Carbon-concentration and carbon-climate feedbacks in CMIP5 Earth system models, *J. Climate*, **26**, 5289–5314, doi:10.1175/JCLI-D-12-00494.1.
- C. Jones, et al., 2013: 21st Century compatible CO₂ emissions and airborne fraction simulated by CMIP5 Earth System models under 4 Representative Concentration Pathways, *J. Climate*, **26**, 4398–4413, doi:10.1175/JCLI-D-12-00554.1.
- G. Keppel-Aleks, et al., 2013: Atmospheric carbon dioxide variability in the Community Earth System Model: Evaluation and transient dynamic during the 20th and 21st centuries, *J. Climate*, **26**, 4447–4475, doi:10.1175/JCLI-D-12-00589.1.

- J. W. Hurrell, et al., 2013: The Community Earth System Model: A Framework for Collaborative Research, *Bull. Amer. Meteor. Soc.*, **94**, 1339–1360, doi:10.1175/BAMS-D-12-00121.1.
- N. S. Lovenduski, M. C. Long, P. R. Gent, K. Lindsay, 2013: Multi-decadal trends in the advection and mixing of natural carbon in the Southern Ocean, *Geophys. Res. Lett.*, **40**, 139-142, doi:10.1029/2012GL054483.
- D. Rothenberg, N. Mahowald, K. Lindsay, S. C. Doney, K. Moore, P. E. Thornton, 2012: Volcano impacts on climate and biogeochemistry in a coupled carbon-climate model, *Earth Syst. Dynam.*, **3**, 121-136, doi:10.5194/esd-3-121-2012.
- P. J. Lawrence, et al., 2012: Simulating the Biogeochemical and Biogeophysical Impacts of Transient Land Cover Change and Wood Harvest in the Community Climate System Model (CCSM4) from 1850 to 2100, *J. Climate*, **25**, 3071-3095, doi:10.1175/JCLI-D-11-u00256.1.
- K. Misumi, et al., 2011: Mechanisms controlling dissolved iron distribution in the North Pacific: A model study, *J. Geophys. Res. Biogeosci.*, **116**, G03005, doi:10.1029/2010JG001541.
- D. Tsumune, et al., 2011: Transport of ¹³⁷Cs to the Southern Hemisphere in an ocean general circulation model, *Prog. Oceanogr.*, **89**, 38-48, doi:10.1016/j.pocean.2010.12.006.
- N. Mahowald, et al., 2011: Desert dust and anthropogenic aerosol interactions in the Community Climate System Model coupled-carbon-climate model, *Biogeosciences*, **8**, 387-414, doi:10.5194/bg-8-387-2011.
- N. M. Mahowald, et al., 2010: Observed 20th Century Desert Dust Variability: Impact on Climate and Biogeochemistry, *Atmos. Chem. Phys.*, **10**, 10875-10893, doi:10.5194/acp-10-10875-2010.
- Jochum, M., S. Peacock, K. Moore, and K. Lindsay, 2010: Response of carbon fluxes and climate to orbital forcing changes in the Community Climate System Model, *Paleoceanography*, **25**, PA3201, doi:10.1029/2009PA001856.
- Jochum, M., S. Yeager, K. Lindsay, K. Moore, R. Murtugudde, 2010: Quantification of the feedback between phytoplankton and ENSO in the Community Climate System Model, *J. Climate*, **23**, 2916-2925, doi:10.1175/2010JCLI3254.1.
- Steinacher, M., et al., 2010: Projected 21st century decrease in marine productivity: a multi-model analysis, *Biogeosciences*, **7**, 979-1005, doi:10.5194/bg-7-979-2010.
- Thornton, P. E., et al., 2009: Carbon-nitrogen interactions regulate climate-carbon cycle feedbacks: results from an atmosphere-ocean general circulation model, *Biogeosciences*, **6**, 2099-2120, doi:10.5194/bg-6-2099-2009.
- Randerson, J. T., et al., 2009: Systematic assessment of terrestrial biogeochemistry in coupled climate-carbon models, *Global Change Biol.*, **15**, 2462-2484, doi:10.1111/j.1365-2486.2009.01912.x.
- Danabasoglu, G., S. Peacock, K. Lindsay, D. Tsumune, 2009: Sensitivity of CFC-11 uptake to physical initial conditions and interannually varying surface forcing in a global ocean model, *Ocean Model.*, **29**, 58-65, doi:10.1016/j.ocemod.2009.02.011.
- Krishnamurthy, A., et al., 2009: Impacts of Increasing Anthropogenic Soluble Iron and Nitrogen Deposition on Ocean Biogeochemistry, *Global Biogeochem. Cycles*, **23**, GB3016, doi:10.1029/2008GB003440.

- Doney, S. C., et al., 2009: Mechanisms governing interannual variability in upper-ocean inorganic carbon system and air-sea CO₂ fluxes: Physical climate and atmospheric dust, *Deep-Sea Res. II*, **56**, 640-655, doi:10.1016/j.dsr2.2008.12.006.
- Gruber, N., et al., 2009: Oceanic sources, sinks, and transport of atmospheric CO₂, *Global Biogeochem. Cycles*, **23**, GB1005, doi:10.1029/2008GB003349.
- Doney, S. C., et al., 2009: Skill metrics for confronting global upper ocean ecosystem-biogeochemistry models against field and remote sensing data, *J. Mar. Syst.*, **76**, 95-112, doi:10.1016/j.jmarsys.2008.05.015.
- Boyd, P. W., S. C. Doney, R. Strzeppek, J. Dusenberry, K. Lindsay, I. Fung, 2008: Climate-mediated changes to mixed-layer properties in the Southern Ocean: assessing the phytoplankton response, *Biogeosciences*, **5**, 847-864, doi:10.5194/bg-5-847-2008.
- Levine, N. M., S. C. Doney, R. Wanninkhof, K. Lindsay, I. Y. Fung, 2008: Impact of Ocean Carbon System Variability on the Detection of Temporal Increases in Anthropogenic CO₂, *J. Geophys. Res.*, **113**, C03019, doi:10.1029/2007JC004153.
- Najjar, R. G., et al., 2007: Impact of circulation on export production, dissolved organic matter, and dissolved oxygen in the ocean: Results from Phase II of the Ocean Carbon-cycle Model Intercomparison Project (OCMIP-2), *Global Biogeochem. Cycles*, **21**, GB3007, doi:10.1029/2006GB002857.
- Mikaloff Fletcher, S. E., et al., 2007: Inverse estimates of the oceanic sources and sinks of natural CO₂ and the implied oceanic carbon transport, *Global Biogeochem. Cycles*, **21**, GB1010, doi:10.1029/2006GB002751.
- Bryan, F. O., G. Danabasoglu, P. R. Gent, and K. Lindsay, 2006: Changes in Ocean Ventilation during the 21st Century in the CCSM3, *Ocean Model.*, **15**, 141-156, doi:10.1016/j.ocemod.2006.01.002.
- Moore, J. K., S. C. Doney, K. Lindsay, N. Mahowald, A. F. Michaels, 2006: Nitrogen fixation amplifies the ocean biogeochemical response to decadal timescale variations in mineral dust deposition, *Tellus*, **58B**, 560-572, doi:10.1111/j.1600-0889.2006.00209.x.
- Friedlingstein, P., et al., 2006: Climate-Carbon Cycle Feedback Analysis: Results from the C⁴MIP Model Intercomparison, *J. Climate*, **19**, 3337-3353, doi:10.1175/JCLI3800.1.
- McKinley, G. A., et al., 2006: North Pacific carbon cycle response to climate variability on seasonal to decadal timescales, *J. Geophys. Res.*, **111**, C07S06, doi:10.1029/2005JC003173.
- Doney, S. C., K. Lindsay, I. Fung, and J. John, 2006: Natural Variability in a Stable, 1000-Yr Global Coupled Climate-Carbon Cycle Simulation, *J. Climate*, **19**, 3033-3054, doi:10.1175/JCLI3783.1.
- Gent, P. R., F. O. Bryan, G. Danabasoglu, K. Lindsay, D. Tsumune, M. W. Hecht and S. C. Doney, 2006: Ocean chlorofluorocarbon and heat uptake during the 20th Century in the CCSM3, *J. Climate*, **19**, 2366-2381, doi:10.1175/JCLI3758.1.
- Mikaloff Fletcher, S. E., et al., 2006: Inverse estimates of anthropogenic CO₂ uptake, transport, and storage by the ocean, *Global Biogeochem. Cycles*, **20**, GB2002, doi:10.1029/2005GB002530.

Orr, J. C., et al., 2005: Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms, *Nature*, **437**, 681-686, doi:10.1038/nature04095.

Fung, I., S. C. Doney, K. Lindsay, and J. John, 2005: Evolution of carbon sinks in a changing climate, *Proc. Natl. Acad. Sci. USA*, **102**, 11201-11206, doi:10.1073/pnas.0504949102.

Moore, J. K., S. C. Doney, and K. Lindsay, 2004: Upper ocean ecosystems dynamics and iron cycling in a global 3D model, *Global Biogeochem. Cycles*, **18**, GB4028, doi:10.1029/2004GB002220.

Doney, S. C., et al., 2004: Evaluating global ocean carbon models: The importance of realistic physics, *Global Biogeochem. Cycles*, **18**, GB3017, doi:10.1029/2003GB002150.

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Doney, S. C., K. Lindsay, J.K. Moore, 2003: Global ocean carbon cycle modeling, *Ocean Biogeochemistry*, ed. M. Fasham, Springer-Verlag, doi:10.1007/978-3-642-55844-3_10.

Dutay, J.-C., et al., 2002: Evaluation of ocean model ventilation with CFC-11: comparison of 13 global ocean models. *Ocean Model.*, **4**, 89-120, doi:10.1016/S1463-5003(01)00013-0.

Doney, S. C., I. Lima, K. Lindsay, J.K. Moore, S. Dutkiewicz, M.A.M. Friedrichs, and R.J. Matear, 2001: Marine biogeochemical modeling, *Oceanography*, **14-4**, 93-107, doi:10.5670/oceanog.2001.10.

K. Lindsay, R. Krasny, 2001: A particle method and adaptive treecode for vortex sheet motion in three-dimensional flow, *J. Comput. Phys.*, **172**, 879-907, doi:10.1006/jcph.2001.6862.

Other Publications

R. Krasny, K. Lindsay, M. Nitsche (2002) Simulation of vortex sheet roll-up: chaos, azimuthal waves, ring merger, Proceedings of the *NATO ARW and IUTAM Symposium on Tubes, Sheets and Singularities in Fluid Dynamics*, Zakopane, Poland, *Fluid Mechanics and its Applications* 71, 3-12, Kluwer.