
Katherine M. Smith

Postdoctoral Research Associate

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Education

- 2013–2017 **Ph.D. Mechanical Engineering**, *University of Colorado, Boulder, CO*.
Dissertation title: *Effects of Submesoscale Turbulence on Reactive Tracers in the Upper Ocean*.
Advisor: Dr. Peter E. Hamlington.
- 2013–2015 **M.S. Mechanical Engineering**, *University of Colorado, Boulder, CO*.
- 2007–2012 **B.S. Mechanical Engineering**, *San Francisco State University, San Francisco, CA, cum laude*.

Honors and Awards

- 2017 Best Poster Presentation, 21st Conference on Atmospheric and Oceanic Fluid Dynamics, American Meteorological Society, Portland, OR.
- 2017 CU Graduate School Summer Fellowship, University of Colorado, Boulder.
- 2016 Achievement Rewards for College Scientists Scholarship (ARCS), ARCS Foundation, Colorado Chapter.
- 2015 CU Science Communication Fellowship, University of Colorado, Boulder.
- 2013–2014 Outstanding Mechanical Engineering Research Potential Fellowship, Mechanical Engineering, University of Colorado, Boulder.
- 2013–2014 Dean's Fellowship, Mechanical Engineering, University of Colorado, Boulder.
- 2011–2012 National Science Foundation Scholarship, San Francisco State University
- 2007–2012 Dean's List, San Francisco State University.
- 2010 Tau Beta Pi Engineering Honor Society, San Francisco State University.

Professional Experience

- 2017–present **Postdoctoral Research Associate**, *Environmental and Industrial Fluid Dynamics Group*, Department of Applied Mathematics and Theoretical Physics (DAMTP), University of Cambridge, Cambridge, UK.
- Examine the dynamics and characteristics of forced stratified turbulence through the use of Direct Numerical Simulations (DNS) for the purpose of improving understanding of small-scale mixing processes in the ocean as a part of the Mathematical Underpinnings of Stratified Turbulence (MUST) Project
 - Explore the effects of submesoscale and small-scale mixed layer processes on sinking tracers such as particulate organic matter (POM) and phytoplankton seed populations in order to better understand their impacts on carbon export from the surface ocean
- 2013–2017 **Graduate Research Assistant**, *Turbulence And Energy Systems Lab (TESLa)*, Department of Mechanical Engineering, University of Colorado, Boulder, CO.
- Examine the effects of turbulence on reactive tracers that are important in the global climate cycle within the upper mixed layer of the ocean through the use of Large Eddy Simulation (LES) numerical codes and coupled global climate models for the purpose of improving understanding of bio-physical interactions and their subgrid scale parameterization
 - Develop numerical codes, in scientific programming languages such as Fortran and C++, and execute on high-performance supercomputers, for the purpose of studying both upper ocean turbulence and characterization of pulsed/rotational detonation engines
 - Use observational and experimental data along with data assimilation and optimization techniques to develop, calibrate, and test a reduced-order biogeochemical model
 - Perform analysis using statistical and spectral analysis techniques in data-analysis languages such as Matlab and Python

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- 2014–2017 **Instructor - Fluids & Flow Visualization, LEGO Robotics, CU Science Discovery Learning Summer Camps**, University of Colorado, Boulder, CO.
- Teach local and international K-12 kids science and engineering topics such as fluids, flow visualizations, programming, and robotics in a week long fun and engaging summer class
- 2013–2014 **Graduate Teaching Assistant, System Dynamics, Measurements II Lab**, Department of Mechanical Engineering, University of Colorado, Boulder, CO.
- Assist undergraduate professor by providing additional in-class support, homework and presentation grading, exam proctoring, and one-on-one interactions during office hours and labs
- 2012–2013 **Research and Design Scientist I - Thermal Fluid Scientist, Energy & Environment Department, Fuels Modeling & Simulation Department**, Idaho National Laboratory, Department of Energy, Idaho Falls, ID.
- Develop numerical code to simulate multiphase, reactive, fluid flow within porous media for INL's FALCON (Fracturing And Liquid CONvection) program, a parallel fully-coupled model of geothermal systems
- 2012 **Science Undergraduate Laboratory Intern (SULI), Energy & Environment Department**, Idaho National Laboratory, Department of Energy, Idaho Falls, ID.
- Translating Fortran equations of state code into C++, restructuring program flow, and evaluating program performance on both Mac and Linux machines
 - Generating 2D and 3D meshes and developing a test suite for code maintenance and verification
- 2011–2012 **Mechanical Engineering Design Intern, Wastewater Enterprise**, San Francisco Public Utilities Commission, San Francisco, CA.
- Prepare conceptual design reports, cost estimates, budgets, specifications and parameters on projects for Project Engineer
 - Research and gather information for environmental impact reports
 - Evaluate current conditions, take measurements, perform research, analyze and then make recommendations on needed modifications in the field
 - Coordinate visits and presentations for vendors expecting to bid on projects

Research Interests

Turbulent flows, reactive flows, geophysical flows, biogeochemistry, reduced order modeling, computational fluid dynamics, large eddy simulations, direct numerical simulations, global carbon cycle, combustion, renewable energy.

Publications

Peer-Reviewed Journal Publications (3)

- [1] K. M. Smith, P. E. Hamlington, and B. Fox-Kemper. Effects of submesoscale turbulence on ocean tracers. *Journal of Geophysical Research: Oceans*, 121(1) 3597-3624, 2016.
Citations (Google Scholar): 23, Journal Impact Factor (2015): 3.318
- Spatial distribution, temporal evolution, and calculated eddy diffusivity of idealized non-reactive tracers vary widely depending on flow regime (i.e. combined submesoscale-Langmuir vs. Langmuir only regimes)
 - Submesoscale eddies transport tracers on much slower time scales and with greater variance through intermittent jets and plumes
 - Langmuir turbulence is not always fast enough to clear out the surface layer in order to maintain a more favorable gradient for idealized passive air-sea flux tracers; saturation can occur
- [2] B. B. Stephens, M. C. Long, R. F. Keeling, E. A. Kort, C. Sweeney, E. Apel, E. Atlas, S. Beaton, J. D. Bent, N. Blake, J. Bresch, J. Casey, B. C. Daube, M. Biao, E. Diaz, H. Dierssen, V. Donets, H. Ducklow, M. Gierach, R. Green, J. Haag, M. Hayman, A. Hiils, M. S. Hoecker-Martinez, S. Honomichl, R. Hornbrook, J. Jensen, R. Lueb, I. McCubbin, K. McKain, E. Morgan, T. Newberger, S. Nolte, J. Powers, B. Rainwater, K. Randolph, A. Rockwell, M. Reeves, S. Scathffler, M. Smith, K. Smith, J. Stith, G. Stossmeister, D. Toohey, A. Watt. The O₂/N₂ Ratio and CO₂ Airborne Southern Ocean (ORCAS)

Study. *Bulletin of the American Meteorological Society*, 99 (2) 381-402, 2018. Citations (Google Scholar): 1, Journal Impact Factor (2015): 7.929

- Overview of the scientific and methodological aspects of aircraft observational campaign which collected atmospheric CO₂, O₂, and reactive gas measurements, hyperspectral ocean color images, and microphysical cloud process data over the Southern Ocean during January-February 2016
- [3] K. M. Smith, P. E. Hamlington, K. Niemeyer, B. Fox-Kemper, and N. Lovenduski. Effects of Langmuir Turbulence on Upper Ocean Carbonate Chemistry. *Journal of Advances in Modeling Earth Systems*, Accepted, 2018. <http://arxiv.org/abs/1809.02509>. Journal Impact Factor (2015): 3.970
 - Results using varying strengths of Langmuir turbulence as well as time-dependent, equilibrium, and no carbonate chemistry models are compared
 - Langmuir turbulence is fast enough to provide a favorable gradient for CO₂ flux and pulls CO₂ deeper into the mixed layer before hydration; increased Langmuir strength leads to increased CO₂ flux

Peer-Reviewed Journal Publications: Submitted and In Preparation (3)

- [4] K. M. Smith, P. E. Hamlington, N. Pinardi, and M. Zavatarelli. A Reduced Order Biogeochemical Flux Model For Use In High-Resolution Multi-Scale Biophysical Simulations. In Preparation, 2018
 - Development, calibration, and validation of a new reduced-order biogeochemical flux model; includes sensitivity study of model parameters, optimization of most sensitive parameters for the Sargasso Sea, and a skill assessment and comparison to similar models
 - Demonstrates model's ability to accurately capture complexity of open ocean ecosystems by making use of chemical functional families and variable nutrient uptake ratios
- [5] K. M. Smith, C. Vreugdenhil, and J. R. Taylor. Effects of submesoscale processes on sinking tracers. In Preparation, 2018
 - The amount of tracer exported from the surface mixed layer and its effective eddy diffusivity within the mixed layer is dependent on the presence of submesoscale processes and the sinking rate of that tracer
 - Theory and the development of a reduced-order model of this process are outlined
 - Variance of tracers exported below the mixed is highly correlated to the mixed layer process present prior to its export
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- [6] K. M. Smith, C. Caulfield, and J. R. Taylor. Turbulence in Forced Stratified Exchange Flows. In Preparation, 2018
 - Direct numerical simulations of forced stratified exchange flows where the mean profiles are damped back to their initial vertically dependent profiles; the bulk Richardson number and ratio of shear layer to stratification layer heights are varied in order to understand fundamental differences in turbulence and mixing characteristics of shear thinning and shear broadening regimes

Peer-Reviewed Conference Proceedings (1)

- [7] C. A. Z. Towery, K. M. Smith, M. Van Schoor, and P. E. Hamlington. Examination of Turbulent Flow Effects in Rotating Detonation Engines. *AIAA Paper*, AIAA-2014-3031, 2014.
 - High-resolution two- and three-dimensional large eddy simulations of pulsed and rotating detonation engines

- Examines unsteady and turbulent flow effects on the operation, performance, and efficiency of the engine
- Tests the accuracy of common Reynolds averaged turbulence models

Presentations

Conference Presentations (15)

- [P.1] Smith, K. M., Plummer, M. Bradford, J. and Podgorney, R. (2013) Adaptive Mesh Refinement Strategies for Incorporating Discrete Fracture Networks into a High Performance Computing Framework for Geothermal Reservoir Simulations. Geothermal Resource Council Meeting, October 2013, Las Vegas, NV.
- [P.2] Towery, C., Smith, K. M., Van Schoor, M., and Hamlington, P. (2014) Modeling the Effects of Turbulence in Rotating Detonation Engines. American Physical Society March Meeting, 3-7 March 2014, Denver, CO.
- [P.3] Towery, C., Smith, K. M., Van Schoor, M., and Hamlington, P. (2014) Examination of Turbulent Flow Effects in Rotating Detonation Engines. 44th AIAA Fluid Dynamics Conference, 16-20 June 2014, Atlanta, GA.
- [P.4] Smith, K. M., Alexander, S. R., Van Roekel, L. P., Fox-Kemper, B., and Hamlington, P. E. (2014) Effects of Submesoscale Turbulence on Tracer Evolution in the Oceanic Mixed Layer. 67th Annual meeting, Division of Fluid Dynamics, American Physical Society, 23-25 November 2014, San Francisco, CA.
- [P.5] Smith, K. M., Hamlington, P. E., Lovenduski, N. S., and Fox-Kemper, B. (2015) Characteristics and Evolution of Reactive Tracers in the Oceanic Mixed Layer. 20th AMS Conference on Atmospheric and Oceanic Fluid Dynamics, 14-19 June 2015, Minneapolis, MN.
- [P.6] Hamlington, P. E., Smith, K. M., Lovenduski, N. S., and Fox-Kemper, B. (2015) Large Eddy Simulations of Reactive Tracers in the Oceanic Mixed Layer. 13th U.S. National Congress on Computational Mechanics, 27-30 July 2015, San Diego, CA.
- [P.7] Smith, K. M., Hamlington, P. E., and Fox-Kemper, B. (2015) Characteristics and Evolution of Passive Tracers in the Oceanic Mixed Layer. 68th Annual meeting, Division of Fluid Dynamics, American Physical Society, 22-24 November 2015, Boston, MA.
- [P.8] Smith, K. M., Hamlington, P. E., and Fox-Kemper, B. (2016) Submesoscale Tracer Evolution in the Oceanic Mixed Layer. Submesoscale Processes: Mechanisms, Implications, and New Frontiers, University of Liege, 23-27 May 2016, Liege, Belgium.
- [P.9] Smith, K. M., Lovenduski, N. S., Fox-Kemper, B., and Hamlington, P. E. (2016) Effects of Langmuir Turbulence on Upper Ocean Carbonate Chemistry. Rocky Mountain Fluid Mechanics Research Symposium, University of Colorado, Boulder, 9 August, 2016, Boulder, CO.
- [P.10] Smith, K. M., Hamlington, P. E., Zavatarelli, M., Pinardi, N. (2016) A Reduced Order Biogeochemical Flux Model For Use in High-Resolution Multi-Scale Biophysical Simulations. American Geophysical Union Fall Meeting, 12-16 December 2016, San Francisco, CA.
- [P.11] Hamlington, P. E., Smith, K. M., Van Roekel, L. P., Fox-Kemper, B., Suzuki, N., Sullivan, P. P. (2016) Large-Scale Numerical Simulations of Ocean and Tidal Channel Boundary Layers. American Geophysical Union Fall Meeting, 12-16 December 2016, San Francisco, CA.
- [P.12] Smith, K. M., Hamlington, P. E., Niemeyer, K., Lovenduski, N. S., and Fox-Kemper, B. (2017) Effects of Langmuir Turbulence on Upper Ocean Carbonate Chemistry. Graduate Engineering Annual Research and Recruitment Symposium, University of Colorado, Boulder, 2 March, 2017, Boulder, CO.
- [P.13] Smith, K. M., Hamlington, P. E., Niemeyer, K., Lovenduski, N. S., and Fox-Kemper, B. (2018) The Global Impact of Sub-Grid Scale Langmuir Turbulence and Upper Ocean Carbonate Chemistry.

Modeling Imbalances in the Atmosphere and Ocean, Banff International Research Station, 22 February, 2018, Banff, Alberta, Canada.

- [P.14] Smith, K. M., Vreugdenhil, C., Taylor, J. R. (2018) Effects of Submesoscale Processes on Negatively Buoyant Tracers. The 18th Biennial Conference of the Challenger Society for Marine Science, Newcastle University, 12 September, 2018, Newcastle, UK.
- [P.15] Smith, K. M., Hamlington, P. E., Niemeyer, K., Lovenduski, N. S., and Fox-Kemper, B., Zavatarelli, M., Pinardi, N. (2018) Effects of Submesoscale Turbulence on Reactive Tracers. Physical Oceanography Dissertation Symposium X (PODS), University of Hawaii, , 2018, Kona, HI.

Conference Posters (3)

- [P.16] Smith, K., Hamlington, P., and Fox-Kemper, B. (2015) Effects of Submesoscale Turbulence on Oceanic Air-Sea Flux Tracers. 13th U.S. National Congress on Computational Mechanics, 27-30 July 2015, San Diego, CA.
- [P.17] Smith, K., Hamlington, P., Pinardi, N., and Zavatarelli, M. (2017) Reduced-Order Biogeochemical Flux Model for High-Resolution Multi-Scale Biophysical Simulations. European Geosciences Union General Assembly, 23-28 April 2017, Vienna, Austria.
- [P.18] Smith, K., Hamlington, P., Niemeyer, K., Fox-Kemper, B., and Lovenduski, N. (2017) Effects of Langmuir Turbulence on Upper Ocean Carbonate Chemistry. 21st AMS Conference on Atmospheric and Oceanic Fluid Dynamics, 26-30 June 2017, Portland, OR.

Seminars and Lectures (7)

- [P.19] “Phases, Ideal Gas Law, Cavitation.” Lecture, Undergraduate Fluid Mechanics (MCEN 3021), University of Colorado, Boulder, February 2015.
- [P.20] “Effects of Submesoscale Turbulence on Tracer Evolution in the Oceanic Mixed Layer.” Seminar, Boulder Fluid and Thermal Sciences Seminar Series, University of Colorado, Boulder, February 2015.
- [P.21] “Characteristics and Evolution of Tracers in the Ocean Mixed Layer.” Seminar, Laboratorio di Simulazioni Numeriche del Clima e degli Ecosistemi Marini (SiNCEM), Ravenna, Italy, March 2016.
- [P.22] “Effects of Submesoscale and Small-Scale Turbulence on Ocean Tracers.” Seminar, University of Bologna, Bologna, Italy, April 2016.
- [P.23] “Effects of Turbulence on Upper Ocean Passive Tracers.” Seminar, National Center for Atmospheric Research (NCAR), Boulder, CO, October 2016.
- [P.24] “Effects of Submesoscale Turbulence on Reactive Tracers in the Upper Ocean.” Seminar, Los Alamos National Laboratory (LANL), Los Alamos, NM, January 2017.
- [P.25] “Effects of Submesoscale Turbulence on Reactive Tracers.” Seminar, BP Institute, Cambridge, UK, October 2017.

Research Supervision

Graduate (1)

2013 **Jacob Bradford**, Department of Energy - Idaho National Laboratory, Idaho Falls.

Undergraduate (3)

2014–2015 **Christine Martini**, Department of Mechanical Engineering, University of Colorado, Boulder.

2015 **Sean Harrison**, Department of Mechanical Engineering, University of Colorado, Boulder.

2016 **Skyler Kern**, *Summer Multicultural Access to Research Training (SMART) Program*, University of Colorado, Boulder.

High School (1)

2013–2014 **Allison Leonard**, Broomfield High School, Broomfield, CO.

Undergraduate Teaching

Fall 2013 **MCEN 4043: System Dynamics**, Graduate Teaching Assistant, Department of Mechanical Engineering, University of Colorado, Boulder.

Fall 2013 **MCEN 4047: Measurements II Lab**, Graduate Teaching Assistant, Department of Mechanical Engineering, University of Colorado, Boulder.

Conference, Symposium, and Workshop Participation

2013–Present **Committee Member and Organizer**, *Graduate Engineering Annual Research & Recruitment Symposium (GEARRS)*, University of Colorado, Boulder, CO.

2013–Present **Committee Member and Organizer**, *Boulder Fluid and Thermal Sciences Seminar Series*, University of Colorado, Boulder, CO.

2015 **Committee Member and Organizer**, 1st Annual Rocky Mountain Fluid Mechanics Research Symposium, 4 August 2015, Boulder, CO.

2016 **Committee Member and Organizer**, 2nd Annual Rocky Mountain Fluid Mechanics Research Symposium, 9 August 2016, Boulder, CO.

Guest Research

Spring 2016, Fall 2016 **Laboratorio di Simulazioni Numeriche del Clima e degli Ecosistemi Marini (SiNCEM)**, University of Bologna, Ravenna, Italy.

Outreach

2011–2012 **Corresponding Secretary**, *Tau Beta Pi - Engineering Honors Society*, San Francisco State University.

2014 **Judge**, *FIRST Lego League Teamwork Judge*, Monarch Qualifier, Monarch High School, Louisville, CO.

2015 **Flow Visualization Workshop Presenter**, *American Association of University Women - Expanding Your Horizons*, University of Colorado, Boulder, March 2015.

2015 **Presenter**, *Meet a CU Scientist - CU Science Communication Fellowship*, Boulder Public Library, November 2015.

2016 **Graduate Student Scientist**, *O₂/N₂ Ratio and CO₂ Airborne Southern Ocean Study (ORCAS) Aerial Campaign*, Punta Arenas, Chile, February 2016.

2016 **Mentor**, *Summer Multicultural Access to Research Training (SMART) Program*, University of Colorado, Boulder, Student: Skyler Kern.