

Timothy Smith, Ph.D.

Research Scientist

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RESEARCH INTERESTS

Coupled Data Assimilation	Ocean Modeling	Open Source Software Development
Machine Learning	Uncertainty Quantification	High Performance Computing
Probabilistic Forecasting	Ice-Ocean Interactions	Observing System Design

EDUCATION

Ph.D. in Computational Science, Engineering, and Mathematics; December 2021

The University of Texas at Austin

Thesis: *Uncertainty Quantification of Ocean Driven Melting Under the Pine Island Ice Shelf*

Overall GPA: 3.96/4.00

M.S. in Computational Science, Engineering, and Mathematics; May 2017

The University of Texas at Austin

Overall GPA: 3.96/4.00

B.S. in Mechanical Engineering with High Honors; May 2014

Certificate in Scientific Computation

Thesis: *Modeling Coupled Photovoltaic Power Plants with Compressed Air Energy Storage in Texas*

The University of Texas at Austin

Overall GPA: 3.91/4.00

RESEARCH EXPERIENCE

Research Scientist, December 2020 - present

Cooperative Institute for Research in Environmental Sciences (CIRES), CU Boulder

Physical Sciences Laboratory (PSL), NOAA Earth System Research Laboratories (ESRL)

Integrated recurrent neural network emulators with data assimilation techniques

Developed computational infrastructure for emulating large scale geophysical turbulence with echo state networks

Exploring machine learning methods to enable strongly coupled data assimilation

Graduate Research Assistant, August 2015 - December 2021

Oden Institute for Computational Engineering and Sciences; The University of Texas at Austin

Advisor: Dr. Patrick Heimbach

Developed computational framework for oceanographic uncertainty quantification

Evaluated ice shelf melt rate uncertainty reduction from sparse, in situ ocean observations

Developed and implemented anisotropic, nonstationary prior covariance model

Undergraduate Research Assistant, December 2011 - May 2014

Department of Mechanical Engineering; The University of Texas at Austin

Advisor: Dr. Mark Deinert

Developed Monte Carlo neutron transport model to better parameterize nuclear reaction rates

Implemented Monte Carlo radiation transport model in C for parameterization validation

Explored the potential solar energy cost reduction via positive feedback from economies of scale

Undergraduate Research Assistant, Summer 2013

Oden Institute for Computational Engineering and Sciences; The University of Texas at Austin

Advisor: Dr. Michael Sacks

Developed tetrahedral human heart model for mechanical deformation simulations

Established workflow for collaboration with Medtronic (industry partners)

AWARDED GRANTS AND FUNDING

- **Smith, T.A. (PI)**, J. Estep (PI). *Cloud Data Analytics Medium Range Weather Project*. Subgrant through West Virginia High Tech Foundation (HTF-22OAR-01-20230124), from prime award NOAA Community Project (NA22OAR4690670). \$212,494. March 2023-September 2024.

PUBLICATIONS

PREPRINTS AND ONGOING WORK

1. **Smith, T. A.** A Practical Formulation for an Anisotropic and Nonstationary Matérn Class Correlation Operator. (2022). Preprint: <https://www.essoar.org/doi/10.1002/essoar.10511974.1>
2. **Smith, T. A.** (2021). Flow aware parameterizations invigorate the simulated ocean circulation under the Pine Island ice shelf, West Antarctica. Preprint: <https://essopenarchive.org/doi/full/10.1002/essoar.10507839.2>
3. Chen, T.-C., Penny, S. G., **Smith, T. A.**, and Platt, J. A. 'Next Generation' Reservoir Computing: an Empirical Data-Driven Expression of Dynamical Equations in Time-Stepping Form. Preprint: <https://arxiv.org/abs/2201.05193>.
4. Abernathey, R., Busecke, J., Banihirwe, A., Zhang, C., & **Smith, T.** Xgcm: a python package for analyzing data from general circulation models. *In review at the Journal of Open Source Software*.

JOURNAL ARTICLES

1. **Smith, T. A.**, Penny, S. G., Platt, J. A., & Chen, T.-C. (2023). Temporal Subsampling Diminishes Small Spatial Scales in Recurrent Neural Network Emulators of Geophysical Turbulence. *Journal of Advances in Modeling Earth Systems*, 15(12), e2023MS003792. <https://doi.org/10.1029/2023MS003792>
2. Halpern, D., Le, M. K., **Smith, T. A.**, & Heimbach, P. (2023). Comparison of ADCP and ECCOv4r4 Currents in the Pacific Equatorial Undercurrent. *Journal of Atmospheric and Oceanic Technology*, 40(12), 1369-1381. <https://doi.org/10.1175/JTECH-D-23-0013.1>
3. Platt, J. A., Penny, S. G., **Smith, T. A.**, Chen, T.-C., & Abarbanel, H. D. I. (2023). Constraining chaos: Enforcing dynamical invariants in the training of reservoir computers. *Chaos: An Interdisciplinary Journal of Nonlinear Science*, 33(10), 103107. <https://doi.org/10.1063/5.0156999>
4. Platt, J. A., Penny, S. G., **Smith, T. A.**, Chen, T.-C., and Abarbanel, H. D. I. (2022). A systematic exploration of reservoir computing for forecasting complex spatiotemporal dynamics. *Neural Networks*, 153, 530–552. <https://doi.org/10.1016/j.neunet.2022.06.025>
5. Penny, S. G., **Smith, T. A.**, Chen, T.-C., Platt, J. A., Lin, H.-Y., Goodliff, M., and Abarbanel, H.D.I. (2022). Integrating Recurrent Neural Networks with Data Assimilation for Scalable Data-Driven State Estimation. *Journal of Advances in Modeling Earth Systems*. 14, e2021MS002843. <https://doi.org/10.1029/2021MS002843>
6. Kostov, Y., Johnson, H., Marshall, D., Forget, G., Heimbach, P., Holliday, P., Li, F., Lozier, S., Pillar, H., & **Smith, T.** Contrasting sources of variability in subtropical and subpolar Atlantic overturning. *Nature Geosciences*. <https://doi.org/10.1038/s41561-021-00759-4>

7. Nguyen, A. T., Pillar, H., Ocaña, V., Bigdeli, A., **Smith, T. A.**, & Heimbach, P. (2021). The Arctic Subpolar gyre sTate Estimate (ASTE): Description and assessment of a data-constrained, dynamically consistent ocean-sea ice estimate for 2002–2017. *Journal of Advances in Modeling Earth Systems*, 13, e2020MS002398. <https://doi.org/10.1029/2020MS002398>
8. Laguë, M. M., Pietschnig, M., Ragen, S., **Smith, T. A.**, & Battisti, D. S. (2021). Terrestrial Evaporation and Global Climate: Lessons from Northland, a Planet with a Hemispheric Continent. *Journal of Climate*, 34(6), 2253–2276. <https://doi.org/10.1175/JCLI-D-20-0452.1>
9. Goldberg, D. N., **Smith, T. A.**, Narayanan, S. H. K., Heimbach, P., & Morlighem, M. (2020). Bathymetric Influences on Antarctic Ice-Shelf Melt Rates. *Journal of Geophysical Research: Oceans*, 125(11), e2020JC016370. <https://doi.org/10.1029/2020JC016370>
10. **Smith, T.** & Heimbach, P. (2019). Atmospheric Origins of Variability in the South Atlantic Meridional Overturning Circulation. *Journal of Climate*, 32(5), 1483–1500. <https://doi.org/10.1175/JCLI-D-18-0311.1>
11. Stoll, B. L., **Smith, T. A.**, & Deinert, M. R. (2013). Potential for rooftop photovoltaics in Tokyo to replace nuclear capacity. *Environmental Research Letters*, 8(1), 014042. <https://doi.org/10.1088/1748-9326/8/1/014042>

PEER REVIEWED CONFERENCE PROCEEDINGS

1. Osborne, A. G., **Smith, T. A.**, & Deinert, M. R. (2013). Comparison of actinide production in traveling wave and pressurized water reactors. In *Proceedings of GLOBAL 2013: International Nuclear Fuel Cycle Conference-Nuclear Energy at a Crossroads*.

SELECTED PRESENTATIONS

ORAL PRESENTATIONS

1. *Recurrent Neural Network Emulation for High Resolution Forecasting*. ECMWF-ESA Workshop on Machine Learning for Earth Observation and Prediction. Reading, UK. November 21–24, 2022.
2. *Toward Recurrent Neural Network Emulation of High Resolution Sea Surface Temperatures*. Ocean Sciences Meeting. Virtual Conference. February 24 – March 4, 2022.
3. *Quantifying uncertainties in ocean driven melting under the Pine Island ice shelf*. SIAM Conference on Mathematical and Computational Issues in the Geosciences. Virtual Conference. June 21–24, 2021.
4. *ecco_v4_py demo: analysis tools for the ECCO state estimate in python with xarray and dask*. ECCO Townhall, Ocean Sciences Meeting 2020. San Diego, California. February, 2020.
5. *Atmospheric origins of variability in the South Atlantic meridional overturning circulation*. Workshop on Sensitivity Analysis and Data Assimilation in Meteorology and Oceanography. Aveiro, Portugal. July, 2018.
6. *A dynamical reconstruction of AMOC variability at the mouth of the South Atlantic*. US AMOC Science Team Meeting. Santa Fe, New Mexico. May, 2017.

POSTER PRESENTATIONS

1. *Recurrent Neural Network Emulation of Turbulent Geophysical Fluids*. AGU Fall Meeting 2022. Chicago, IL. December, 2022.
2. *Uncertainty Quantification of Ocean Driven Melting Under the Pine Island Ice Shelf, West Antarctica*. Invited Poster at Ocean Sciences Meeting. February – March, 2022. See it [here](#).
3. *Atmospheric origins of variability in the South Atlantic meridional overturning circulation*. Ocean Sciences Meeting. February, 2020.

4. *Informing bathymetry through an ocean model*. Workshop on UQ for inverse problems in complex systems. Cambridge, UK. April, 2018.
5. *A dynamical reconstruction of AMOC variability at the mouth of the South Atlantic*. SIAM Conference on Mathematical and Computational Issues in the Geosciences. Erlangen, Germany. September, 2017.

HONORS AND AWARDS

- **Certificate of Recognition**, UT Austin SIAM Student Chapter. 2018.
- **Poster Presentation Award**, SIAM Conference for Mathematical and Computational Issues in the Geosciences. September, 2017
- **Professional Development Award for Travel**, UT Office of Graduate Studies. Fall, 2017.
- **CSEM Fellowship**, Oden Institute, UT Austin. 2014 - 2018
- **Graham F. Carey Undergraduate Scholarship in Computational Science**, Oden Institute, UT Austin. 2014
- **Fuel Cycle Research Award**, US DOE Office of Fuel Cycle Technologies. 2013
- **Nuclear Energy University Program Scholarship**, US DOE Integrated University Program. 2012
- **Undergraduate Research Fellowship**, UT Austin, 2012

TEACHING EXPERIENCE, SERVICE, AND LEADERSHIP ROLES

TEACHING

- **Computing Mentor**, [Significant Opportunities in Atmospheric Research and Science \(SOARS\)](#). May - July, 2022.
Assisting protégé with computing needs, mostly establishing a consistent and efficient, python-based workflow for analyzing atmospheric data and model output.
- **Instructor and Co-Organizer**, [ECCO Summer School](#). May, 2019.
Presented [Jupyter notebook tutorials](#), demonstrating [ECCO state estimate](#) analysis in python
Taught students to use Git and GitHub
Organized computational resources for remote analysis via the [Texas Advanced Computing Center](#)
- **Mentor**, for Andrew Xiao (undergraduate), UT Austin. Spring, 2019.
Mentored undergraduate student during his final thesis project, titled:
Comparing Volumetric Transport from the Arctic with Estimated Transport using ECCO and ASTE
- **Teaching Assistant**, Descriptive Physical Oceanography, UT Austin. Spring, 2019.
Presented lecture and provided course notes on air-sea interactions at undergraduate & graduate level
- **K-12 Outreach Tutor & Committee Chair**, Tau Beta Pi Engineering Honor Society. 2013-2014.
Tutored students in high school mathematics
Organized supplemental Saturday tutoring sessions
- **Undergraduate Tutor**, Mechanical Engineering, UT Austin. 2011-2012.
Tutored undergraduate level thermodynamics, fluid mechanics, dynamics, & computational methods

PROFESSIONAL SERVICE AND LEADERSHIP

- **Reviewer:** Artificial Intelligence for the Earth Systems, Journal of Advances in Modeling Earth Systems, Quarterly Journal of the Royal Meteorological Society, Journal of Climate, Frontiers in Oceanography

- **Co-Organizer**, [Texas Applied Mathematics and Engineering Symposium](#). September, 2017.
Helped organize and run a 3 day, student led conference, initiated by the UT Austin Chapter of SIAM
- **Industry Liaison**, UT Austin Chapter of SIAM. 2016-2018.
Invited speakers from industry and national laboratories to give talks aimed at graduate students
Organized one-on-one meetings between representatives and students

OUTREACH AND VOLUNTEERING

- **Zero Waste Volunteer**, Oden Institute, UT Austin. January 2020 - January 2021.
Co-leading institute initiative to curtail landfill waste, implement composting, and reduce carbon footprint
- **Volunteer**, [UT Girl Day](#). February, 2020.
Organized and demonstrated Arctic-Ocean themed scientific experiments for girls in grades K-12

COURSEWORK AND SUMMER SCHOOLS

SELECTED GRADUATE COURSEWORK

Mathematics: Variational Methods for Inverse Problems, Functional Analysis, Multiscale Modeling, Statistical Estimation Theory

Computational Science: Parallel Algorithms, Validation and Uncertainty Quantification in Computational Models, Numerical Methods for Differential Equations

Fluid Mechanics & Oceanography: Dynamics of Turbulent Flows, Fluid Dynamics of the Atmosphere and Ocean, Computational Ocean Modeling, Observational Physical Oceanography

SUMMER SCHOOLS

[Advanced Climate Dynamics Course](#), September 2018

[Global Ocean Data Assimilation Experiment \(GODAE\) Ocean View International School](#), October 2017

[Statistical and Applied Mathematical Sciences Institute \(SAMSI\) Optimization Summer School](#), August 2016

SOFTWARE CONTRIBUTIONS AND COMPUTATIONAL SKILLS

SELECTED SOFTWARE CONTRIBUTIONS

- **ecco_v4_py**: python package for analyzing ECCOv4 output with [xarray](#), [dask](#), [xgcm](#), & [xmitgcm](#)
- **MITgcm**: general circulation model largely for oceanographic applications in Fortran
- **xgcm**: python package for analyzing general circulation model output
- **xmitgcm**: python package to read MITgcm binary output to [xarray](#)
- **sparc**: educational tool for solving the sparse page rank problem in C++ on multicore (KNL) architecture

COMPUTATIONAL SKILLS

Python, with experience using [Dask](#) for parallel computing, [CuPy](#) for GPU acceleration, & [xarray](#) because it's more fun to use than raw [NumPy](#)

Fortran, C/C++ with experience using MPI and OpenMP

Git/Mercurial, \LaTeX , Matlab

Check out my Git and GitHub tutorial slides for a recent team meeting [here](#)