

# Timothy Smith, Ph.D.

## Research Physical Scientist

 [timothyas](https://github.com/timothyas)  
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### RESEARCH INTERESTS

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

### EDUCATION

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#### **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

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#### **Research Physical Scientist Scientist,** February 2024 - present

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

*Developing machine learning based weather emulators to enable strongly coupled data assimilation*

#### **Research Scientist,** December 2020 - February 2024

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*

*Explored 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)*

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**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.

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**PUBLICATIONS**

PREPRINTS AND ONGOING WORK

1. **Smith, T. A.** A Practical Formulation for an Anisotropic and Nonstationary Matérn Class Correlation Operator. (2022). Preprint: <https://essopenarchive.org/doi/full/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

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- **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

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### 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.

## PROFESSIONAL SERVICE AND LEADERSHIP

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

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### 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

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### 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,  $\text{\LaTeX}$ , Matlab

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