

# ANANTHA NARAYANAN SURESH BABU

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## EDUCATION

### PhD, Massachusetts Institute of Technology

2023 - Present

Major: Computational Science & Engineering and Mechanical Engineering, GPA: 5.00/5.00

Advisor: Prof. Pierre Lermusiaux

### SM, Massachusetts Institute of Technology

2021 - 2023

Major: Mechanical Engineering, GPA: 5.00/5.00

Thesis: Stochastic Sea Ice Modeling with the Dynamically Orthogonal Equations

### B. Tech (with Hons.), Indian Institute of Technology (IIT) Madras

2016 - 2020

Major: Mechanical Engineering, GPA: 9.56/10.00

## RESEARCH INTERESTS

Scientific machine learning, Generative modeling, Nonlinear inference, Fluid & ocean dynamics, Sea ice dynamics, Closure modeling, Stochastic modeling, Reduced-order modeling, Bayesian learning, Model learning

## RESEARCH EXPERIENCE

### Generative modeling and inference of geophysical and oceanic turbulence

Massachusetts Institute of Technology

Graduate Research Project | Advisor: Prof. Pierre Lermusiaux

2025 - Ongoing

- Investigating diffusion model-based approaches for inverse problem in geophysical turbulence.
- Applied and benchmarked SDEdit, Diffusion Posterior Sampling, Conditional Diffusion and Classifier-Free Guidance for super-resolution and inpainting of highly turbulent geophysical flows from coarse, sparse and gappy observations.
- Currently working on generative data assimilation and inference of high-resolution surface ocean currents from sparse, gappy and noisy satellite data.

### Numerical modeling and closure modeling for fluid and geophysical flows

Massachusetts Institute of Technology

Graduate Research Project | Advisor: Prof. Pierre Lermusiaux

2024 - Ongoing

- Developed a GPU-based pseudo-spectral numerical solver for quasi-geostrophic turbulence in PyTorch, with extensions to fluid-structure interaction and flows past coastal boundaries.
- Working on data-driven, stochastic generative models for subgrid-scale closure of Large Eddy Simulations (LES).

### Physics-inspired scientific deep learning for multi-scale fluid and oceanic forecasts

Massachusetts Institute of Technology

Graduate Research Project | Advisor: Prof. Pierre Lermusiaux

2023 - Ongoing

- Developing novel vision transformer-based architectures incorporating concepts from numerical PDEs for multi-scale fluid and oceanic forecasts in the Gulf of Mexico.
- Implemented neural operator-based models for predicting fluid and oceanic flows in the Atlantic and Massachusetts Bay.

### Reduced-order stochastic modeling and Bayesian learning for sea ice dynamics

Massachusetts Institute of Technology

Graduate Research Project | Advisor: Prof. Pierre Lermusiaux

2021 - Ongoing

- Derived and implemented new dynamically orthogonal equations and schemes for reduced-order stochastic sea ice field modeling and uncertainty quantification.
- Implementing Bayesian model learning and data assimilation to learn and discover sea ice parameters, external forcing, model formulations, new rheologies, and their probability distributions.

### Crystal plasticity-based Finite Element Modeling of ice

Massachusetts Institute of Technology

Class Project | Course Instructor: Prof. Lallit Anand

2023

- Developed a crystal-plasticity based elasto-viscoplastic Finite Element Model for single crystal ice.
- Implemented a VUMAT in ABAQUS for simulations with varying crystal orientations.

## PUBLICATIONS

Narayanan, A., Sadam A., and Lermusiaux P.F.J. (2025) "Guided unconditional and conditional generative models for super-resolution and inference of quasi-geostrophic turbulence". Journal of Advances in Modeling Earth Systems. Sub-judice. doi:10.48550/arXiv.2507.00719

Narayanan, A., Sadam A., and Lermusiaux P.F.J. (2025) "Evaluation of analytical turbulence closures for quasi-geostrophic ocean flows with coastal boundaries". OCEANS 2025 IEEE/MTS Great Lakes, Chicago, September 2025. In press.

Narayanan, A., and Lermusiaux, P.F.J. (2025). "Physics-inspired neural architectures for forecasting fluid and oceanic flows". In preparation.

Narayanan, A., and Lermusiaux, P.F.J. (2025). "Generative closure modeling for 2D fluid dynamical systems and geophysical flows". In preparation.

Narayanan, A., and Lermusiaux, P.F.J. (2025). "Stochastic sea ice modeling with the Dynamically Orthogonal equations: Theory and applications". In preparation.

Rajagopal, E., Narayanan, A., Ryu, T., Haley, Jr., Mirabito, C., and Lermusiaux, P.F.J. (2023). "Evaluation of deep learning models towards ocean forecasting". OCEANS '23 IEEE/MTS Gulf Coast, 25–28 September 2023. 10.23919/OCEANS52994.2023.10337380

**Narayanan, A.,** Rajan, A., Pramanik, R., and Arockiarajan, A. (2019). "A thermodynamically-consistent phenomenological viscoplastic model for hydrogels". Materials Research Express, 6(8), 085418. DOI: 10.1088/2053-1591/ab2a49

Pramanik, R., **Narayanan, A.,** Rajan, A., et al. (2019). "Theoretical modeling and experimental characterization of transversely isotropic hydrogels". International Journal of Engineering Science, 144, 103144. DOI: 10.1016/j.ijengsci.2019.103144

Rajan, A., Pramanik, R., **Narayanan, A.,** and Arockiarajan, A. (2019). "Mechanics of viscoelastic buckling in slender hydrogels". Materials Research Express, 6(5), 055320. DOI: 10.1088/2053-1591/abo691

**FELLOWSHIPS & AWARDS**

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**MathWorks Mechanical Engineering Fellowship (2023-2024), (2024-2025), MIT,** awarded to graduate students who actively use MathWorks software in their research

**Travel Award (2025), USACM,** awarded to attend the 18th U. S. National Congress on Computational Mechanics in Chicago, Illinois

**Travel Award in Ocean Engineering (2025), MIT,** awarded to attend the 18th U. S. National Congress on Computational Mechanics in Chicago, Illinois

**Martin A. Abkowitz International Travel Fellowship in Ocean Engineering (2023), MIT,** awarded to attend the SIAM Geosciences conference in Bergen, Norway

**Homer A. Burnell Presidential Graduate Fellowship (2021), School of Engineering, MIT,** awarded to outstanding incoming graduate students at MIT

**MITACS Globalink Summer Research Fellowship (2019),** awarded to pursue a fully funded 12-week research internship at the University of British Columbia, Vancouver

**CONFERENCES**

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**Presentations**

"Physics-inspired neural architectures for forecasting fluid and oceanic flows", 18th U. S. National Congress on Computational Mechanics, Chicago, Illinois

"Stochastic modeling & learning for sea ice dynamics", 2024 SIAM Conference on Mathematics of Planet Earth, Portland, Oregon

"Probabilistic modeling & Bayesian learning for coupled sea ice-ocean dynamics", 17th U. S. National Congress on Computational Mechanics, Albuquerque, New Mexico

"Bayesian data assimilation & learning for coupled sea ice-ocean systems", 2023 SIAM Conference on Mathematical & Computational Issues in the Geosciences, Bergen, Norway

**Posters**

"Probabilistic modeling and Bayesian learning for sea ice dynamics", 2024 Ocean Sciences Meeting, New Orleans, Louisiana

**SOFTWARE AND SKILLS**

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PyTorch, Python, Shell scripting (Bash, Linux command line), HPC, MATLAB, ABAQUS (UMAT, VUMAT), Git

**PROFESSIONAL SERVICE**

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Reviewer - NeurIPS Workshop on Structured Probabilistic Inference & Generative Modeling (SPIGM)	2025
Reviewer - Ocean Modelling, Journal of Physics D: Applied Physics, Physica Scripta, Materials Research Express	since 2024

**PROFESSIONAL EXPERIENCE**

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<b>Boston Consulting Group (BCG)</b>	<b>Chennai, India</b>
Associate	Nov. 2020 - Aug. 2021
<ul style="list-style-type: none"><li>• Worked across industrial goods &amp; public sectors.</li><li>• Designed and facilitated investments of over \$ 200 Million for the largest sector-specific industrial park of an Asian government.</li><li>• Developed growth &amp; product expansion strategies for a large Indian tractor manufacturer.</li></ul>	