Geeta Nain

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Career Highlights

Catastrophe Risk Modeling — Hurricane Hazard Modeling with Parametric, Numerical and Machine Learning Approaches

Research and Work Experience

- **Graduate and Predoctoral Research Appointee – Argonne National Lab , IL** 2022–Present
  Investigating ocean–wave-atmosphere interactions and reduced parametric model biases to enable more accurate, physically consistent modeling of hurricane wind, wave and storm surge risk assessments with Projects on Offshore Wind Energy in Extreme Events; Coupled Numerical Modeling (C-WFS) and Probabilistic Hazard Assessment; TC-Induced Storm Surge Risk; Offshore Wind Energy in Extreme Events
  - Investigating the influence of ocean-wave coupling on wind structure with high-resolution coupled **WRF–FVCOM–SWAN (C-WFS)** simulations using HPC systems at the Argonne Leadership Computing Facility (ALCF).
  - Developed blended parametric–numerical wind fields and implemented MPI-based parallelization to optimize storm surge simulations.
  - Evaluated tropical cyclone–induced storm surge risks using parametric and probabilistic models.
- **PhD Research collaboration with ANL at Michigan Tech University (MTU)** 2024–2026
  Hurricane Wind Modeling with Theoretical (Parametric), Coupled WRF Model (C-WFS), and Physics Informed Machine Learning (PIML) Approaches
  - Evaluated parametric hurricane wind models and their impacts on storm surge, improving understanding of model biases and hazard predictions.
  - Investigated the role of ocean–wave interactions in shaping hurricane wind structure, contributing to more physically consistent storm simulations.
  - Developing a machine learning–based wind fusion tool to integrate insights from coupled models, addressing biases in parametric wind representations.
- **Research Assistant – Purdue University** 2018–2022
  Hurricane Track Generation and Probabilistic Hazard Evaluation
  - Developed and validated track-generation models for tropical cyclones using dynamic steering flow and statistical ensembles.
  - Collaborated with NCAR RAL to evaluate and improve probabilistic hurricane hazard forecasts for the Hurricane Risk Calculator, supporting wind, storm surge, and rainfall risk assessment.
  - Integrated synthetic tracks, WRF-simulated storms, and parametric wind models with Argonne EVS to assess mid-century hurricane-induced storm surge, blending large-scale flow with vortex-resolving wind fields.
- **Senior Modeling Analyst – Moody's RMS (Risk Management Solutions), India** 2014–2018
  Projects: North Atlantic and Asia Typhoon Hazard Model
  - Calibrated hazard modules for North Atlantic and Asia-Pacific tropical cyclone models.
  - Simulated storm surge and wind fields using **MIKE21**, optimizing track selection and applying parallel processing (MPI).
  - Generated return-period inundation maps and quantified uncertainty for hazard portfolios.

Education

– **Ph.D. in Atmospheric Science** Summer 2026
Michigan Technological University (MTU), Houghton, MI
Graduate Research Fellowship, Argonne National Laboratory
Dissertation: Advancing Hurricane Wind Modeling: Parametric Evaluation, Ocean–Wave Interactions, and Machine Learning–Based Bias Correction

– **Professional Master's in Geodata Science** 2022
Purdue University, West Lafayette, IN
Certification: Computational Interdisciplinary Graduate Program (CIGP) – Computational Sciences & Engineering

– **Master of Technology in Earth System Science & Technology** 2014
Indian Institute of Technology (IIT) Kharagpur, India
Thesis: Statistical Downscalling for Indian Summer Monsoon Rainfall

– **Bachelor of Technology in Aeronautical Engineering** 2012
Babu Banarasi Das National Institute of Technology, Lucknow, India
Thesis: Modeling Trajectory of a launched vehicle considering as point mass

Technical Skills

Models: C-WFS (Coupled WRF, FVCOM, SWAN), ADCIRC, MIKE 21, CLIMADA
Programming: Python, R, Fortran, MATLAB, NCL, Bash
Machine Learning: Neural Networks, PyTorch, Tenser Flow
Software: MetPlus, AWIPS, GEMPAK, RiskLink, ArcGIS, QGIS
Database Management: SQL, NoSQL
Version Control & HPC: Git, GitHub, Visual Studio, SLURM, MPI, ALCF (Polaris)

Presentations, Publications & Collaborations

– Nain, G., et al. (2026). **Bias Propagation from Parametric Wind Models to Storm Surge Estimates in Tropical Cyclones** *(Manuscript prepared for GRL)*
– Nain, G., et al. (2026). **Coupled Ocean–Wave–Atmosphere Feedbacks Shaping Wind Structure of Hurricane Delta (2020),** *Poster Presentation, 37th Conference on Hurricanes and Tropical Meteorology, San Diego, CA, March 30-April 3*
– Nain, G., et al. (2026). **Leveraging Synthetic Aperture Radar and ML to Refine Tropical Cyclone Surface Winds,** *Oral Presentation, 37th Conference on Hurricanes and Tropical Meteorology, San Diego, CA, March 30-April 3*
– Nain, G., et al. (2025). **Ocean and Wave-Induced Feedback on Hurricane Wind Structure: Multi-Storm Insights on Wind Hazards,** *Oral Presentation, NAWEA/WindTech 2025, Dallas, TX, Oct 15-17*
– Nain, G., et al. (2025). **Fully Coupled High-Resolution Atmosphere–Ocean–Wave Simulations of Hurricane Henri (2021): Implications for Offshore Load Assessments,** *Collaboration with Argonne National Lab team (EVS), Wind Energy Sci. Discuss*
– Nain, G., et al. (2025). **Updates on the Hurricane Risk Calculator: APP Capabilities, Risk Messaging and Pilot Testing,** *Collaboration with NCAR team (RAL), UCAR report*
– Nain, G., et al. (2025). **Large-Scale Control of Seasons with Extreme Tropical Cyclone Activity in the North Atlantic,** *Poster,105th AMS Annual Meeting, New Orleans, LA, Jan 12-16*
– Nain, G., et al. (2024). **Implication on Modeled Storm Surge with Different Parametric Wind Forcing for Different Storm Characteristics,** *Oral Presentation, AGU Fall Meeting (2024), Washington D.C, Dec 9-13*

- Nain, G., et al. (2024). **Hurricane-Induced Extreme Winds at Turbine Hub Height for Offshore Wind Farms,** *Poster Presentation, AGU Fall Meeting (2024), Washington D.C, Dec 9-13*
- Nain, G., et al. (2024). **A Data-Based Method with Dynamic Steering Flow to Represent Track Uncertainty** *Poster Presentation, 24th Conference on Atmospheric & Oceanic Fluid Dynamics, Burlington, VT, Jun 20*
- Nain, G., et al. (2024). **Adequacy of Parametric Hurricane Models and need to utilize Machine Learning approaches for describing Hurricane Offshore Wind Over US North East Outer Continental Self,** *Poster Presentation, Symposium on Hurricane Risk in a Changing Climate, Honolulu, HI, June 2-6*
- Nain, G., et al. (2024). **Parametric and Machine Learning Approach for describing Hurricane Offshore Winds over the US Northeast Outer Continental Shelf,** *Poster Presentation, 36th Conference on Hurricanes and Tropical Meteorology, Long Beach, CA, May 5-10*
- Nain, G., et al. (2023). **Physically consistent synthetic tracks and wind field modeling for Tropical cyclone,** *Poster Presentation, AGU Fall Meeting (2023), San Francisco, CA, Dec 11-15*
- Nain, G., et al. (2023). **Investigating Physical Consistency of Synthetic Hurricane Tracks for Surge Risk,** *Poster Presentation, 103rd Annual Meeting, Denver, CO, Jan 8-12*
- Nain, G., et al. (2022). **Role of Background Flow in Hurricane Induced Surge Risk,** *Oral Presentation, AGU Fall Meeting (2022), Chicago, IL, Dec 12-16*
- Nain, G., et al. (2022). **The HurricaneRiskCalculator web app: Enhancing public safety, resilience, and adaptation through actionable assessments of structure-specific wind risks,** *Collaboration with NCAR team (RAL), NCAR Report*
- Nain, G., et al. (2022). **Sensitivity of Verification Metrics to Sharpness and Correlation,** *Oral Presentation, 102nd Annual AMS Meeting (2022), Houston, TX, Jan 23-27*

Professional Development, Communication & Leadership

- **Professional Development Chair**, Graduate Student Government, Michigan Tech (2025-2026)
- **Top 10 Semi Finalist**, 3MT Thesis Competition, Michigan Tech (2025, 2024)
- **First Place**, Graduate Research Colloquium Poster Competition, Michigan Tech (March 2025)
- **Outstanding Graduate Award**, Geo Data Science, Purdue University (Dec 2022)
- **First Place**, One Min Thesis Department Competition, Earth, Atmosphere and Planetary Sciences (EAPS), Purdue University (2019)
- **Distinguished Toastmaster (DTM)**, Toastmasters International (2018)