

Md Badrul Hasan

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RESEARCH SUMMARY

My research advances physics-informed machine learning methods for turbulence modeling in rotating atmospheric boundary layers, with a focus on ML-enhanced subgrid-scale (SGS) closures for hurricane simulations in WRF. I combine LES data, invariance-aware neural networks, and large-scale HPC simulations to address over-dissipation and turbulence suppression in strongly rotating flows.

EDUCATION

University Of Maryland, Baltimore County (UMBC)

Ph.D. in Mechanical Engineering
Department of Mechanical Engineering

2022 - May, 2026 (Expected)

University Of Maryland, Baltimore County (UMBC)

M.S. in Mechanical Engineering
Department of Mechanical Engineering

2019 - 2022

Bangladesh University of Engineering and Technology (BUET)

B.Sc. in Mechanical Engineering
Department of Mechanical Engineering

2013 - 2017

WORK EXPERIENCE

Computational Mechanics Laboratory, UMBC

January, 2022 - Present

Graduate Research Assistant

- Conducting *a posteriori* and *a priori* evaluations of invariance-embedded machine learning SGS closures for rotating hurricane boundary layers, integrating ML-based stress and eddy-viscosity models into WRF. (**UMBC 2025 COEIT Interdisciplinary Proposal Award**)
- Developing machine-learning-based models of backscatter-admitting sub-grid-scale (SGS) processes to improve hurricane boundary layer simulations.
- Advancing methods for detecting stealthy, long-term cyber-attacks on wind energy assets using physics-informed neural networks. (**UMBC 2024 Cybersecurity Leadership Exploratory Grant**)

Joint Centre for Earth Systems Technology (JCET), UMBC

January, 2020 - June, 2022

Graduate Research Assistant

- Compared the numerical dissipation of different weather prediction models like WRF and NUMA with Dr. Stephen Guimond supported by the National Science Foundation (NSF) under grant AGS-2121366.
- Visualized and Compared the remote sensing radar data from Imaging Wind and Rain Airborne Profiler (IWRAP) with Dr. Stephen Guimond for NOAA/AOML/HRD Hurricane Field Program.

University Of Maryland, Baltimore County (UMBC)

January, 2019 - May, 2024

Graduate Teaching Assistant

- Conducted the lab demonstrations and grading on ENME-432L, Fluids/Energy Lab with Dr. Meilin Yu.
- Assisted Dr. James Baughan on teaching and grading on the ENME-423, HVAC Design.

PUBLICATIONS

Journals

- **Hasan, M. B.**, Guimond, S. R., Yu, M., Reddy, S., & Giraldo, F. X. (2022). The Effects of Numerical Dissipation on Hurricane Rapid Intensification with Observational Heating. *Journal of Advances in Modeling Earth Systems*, 14, e2021MS002897. [DOI]
- **Hasan, M. B.**, Yu, M., & Oates, T. (2025), Invariance-embedded Machine Learning Sub-grid-scale Stress Models for Meso-scale Hurricane Boundary Layer Flow Simulation I: Model Development and *a priori* Studies. (2025) [DOI]. (*Under Review*)

Conference Proceedings

- **Hasan, M. B.**, Yu, M., Xiao, H. (2023). Sub-grid Scale Modeling of Meso-scale Hurricane Boundary Layer Flows using Machine Learning. In *AIAA SciTech 2023 Forum*, p. 2487. [DOI]
Presented at AIAA SciTech 2023, National Harbor, MD.
- **Hasan, M. B.**, Yu, M., Oates, T. (2025). Comparison of Several Machine-Learning-Enhanced Sub-grid Scale Stress Models for Meso-scale Hurricane Boundary Layer Flow Simulation. In *AIAA SciTech 2025 Forum*, p. 2212. [DOI]
Presented at AIAA SciTech 2025, Orlando, FL.
- **Hasan, M. B.**, Yu, M., Oates, T. (2025). Evaluating Machine Learning-Enhanced Sub-Grid Scale Stress Models With Invariance Embedding for Meso-Scale Hurricane Boundary Layer Flows. In *Proceedings of the ASME 2025 Fluids Engineering Division Summer Meeting, V001T01A001.*, [DOI]
Presented at ASME FEDSM 2025, Philadelphia, PA.
- Kalwani, S., **Hasan, M. B.**, Chen, Z., Yu, M. (2025). Physics-Informed Machine Learning for Detecting Stealthy Long-Term Cyber Attacks on Wind Energy Systems. In *8th Workshop on Big Data for CyberSecurity (BigCyber-2025)* , 2025 IEEE International Conference on Big Data, 8-11 December, 2025, Macau SAR, China. [Video Presentation]
- **Hasan, M. B.**, Yu, M., Oates, T. (2026). Semi-A Priori Evaluation of Backscatter-Admitting Machine Learning Sub-Grid Scale Models in WRF Hurricane Simulations. In *AIAA Aviation 2026 Forum*. (*Under Review*)
- **Hasan, M. B.**, Yu, M., Oates, T. (2026). A Baseline A Posteriori Evaluation of Machine-Learning-Predicted Eddy Viscosity Fields in Mesoscale Hurricane Boundary Layer Simulations. In *ASME Fluids Engineering Division Summer Meeting (FEDSM)*, 2026. (*Under Review*)

CONFERENCE PRESENTATIONS & SEMINARS

- Physics-Informed Machine Learning for Turbulence, Hurricanes, and Wind-Energy Cybersecurity, *Mechanical Engineering Graduate Seminar*, University of Maryland, Baltimore County (UMBC), February 2026. [**Oral**]
- Invariance-Embedded Machine Learning Sub-Grid-Scale Stress Models for Meso-Scale Hurricane Boundary Layer Simulations, *2025 Research Symposium on Environmental and Applied Fluid Dynamics*, The George Washington University, Washington, DC, May 2025. [**Oral**]
- Assessment of Invariance-Embedded Machine Learning Models for Sub-Grid Scale Stress in Meso-Scale Hurricane Boundary Layer Flows, *COEIT Research Day*, UMBC, Baltimore, MD, April 2025. [**Oral**]
- Sub-grid Scale Modeling of Meso-Scale Hurricane Boundary Layer Flows using Machine Learning, *COEIT Research Day*, UMBC, Baltimore, MD, April 2024. [**Oral**]

- The Effects of Numerical Dissipation on Hurricane Rapid Intensification with Observational Heating, *AGU Fall Meeting*, New Orleans, LA, Dec 2021. [Poster]
- The Effects of Numerical Dissipation on Simulating Hurricane Intensification in a Realistic Regime, *AGU Fall Meeting*, San Francisco, CA, Dec 2020. [Poster]
- The Effects of Numerical Dissipation on Simulating Hurricane Intensification in a Realistic Regime, *Seminar Series*, Department of Mechanical Engineering, UMBC, Baltimore, MD, Nov 2020. [Oral]

AWARDS & SCHOLARSHIPS

2025 AIAA Professor Kirti “Karman” Ghia Memorial Award

Inaugural recipient for best student paper, Comparison of Several Neural Network-Enhanced Sub-grid Scale Stress Models for Meso-scale Hurricane Boundary Layer Flow Simulation, awarded by the Fluid Dynamics Technical Committee (FDTC) at AIAA SciTech 2025.

Graduate Student Association (GSA) Professional Development Grant, UMBC

Recipient in May, 2025 and December, 2024;

Provided support for professional development and thesis-related research expenses.

University Technical Scholarship (2013–2017)

Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh

GRANT & PROPOSAL EXPERIENCE

NSF Research Proposal (Submitted, 2026; Under Review)

Led technical development of the scientific methodology and contributed to writing for a multi-year NSF proposal integrating physics-informed machine learning with wind energy cyber-physical systems.

TECHNICAL STRENGTHS

Turbulence & SGS Modeling	SGS closures, eddy-viscosity models , rotating boundary layers
CFD / PDE Models	WRF, NUMA, OpenFAST, COMSOL
Scientific Machine Learning	PINNs, neural operators, neural ODEs
Deep Learning	PyTorch, CUDA
High-Performance Computing	Slurm, OpenMPI, GPU clusters
Programming	Python, MATLAB, Fortran

WORKSHOPS & TRAINING

Structure-Preserving Scientific Computing and Machine Learning: Summer School & Hackathon, University of Washington, Seattle

June, 2025

Participant

- Selected as one of **40 graduate students** from across the U.S. and Canada; program supported in part by **NSF** and **PIMS**.
- **Hackathon Project D: Neural ODEs Exploring Time Integration Methods and Training Strategies**; relevant to *weather forecasting* and *nonlinear dynamical systems*.
- Activities included lectures, hands-on computational labs, and collaborative mini-projects at the intersection of scientific computing and machine learning.

LEADERSHIP & INVOLVEMENT

Bangladesh Student Association, UMBC
Treasurer

September, 2019 -August, 2020

- Managed funds and coordinated events for Bangladeshi graduate students at UMBC, fostering community engagement.

PEER REVIEW SERVICE

- **Physics of Fluids** (AIP Publishing) - computational fluid dynamics
- **AIAA Aviation Forum 2026** - data-driven methods for CFD modeling

MEDIA COVERAGE & ONLINE FEATURES

UMBC News Feature

- **Modeling Hurricanes with Machine Learning**

Research featured in UMBC News highlighting ML-based hurricane modeling. (January 2025)