

# Md Badrul Hasan

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## RESEARCH SUMMARY

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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

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**University Of Maryland, Baltimore County (UMBC)** 2022 - May, 2026 (Expected)

Ph.D. in Mechanical Engineering

Department of Mechanical Engineering

**University Of Maryland, Baltimore County (UMBC)** 2019 - 2022

M.S. in Mechanical Engineering

Department of Mechanical Engineering

**Bangladesh University of Engineering and Technology (BUET)** 2013 - 2017

B.Sc. in Mechanical Engineering

Department of Mechanical Engineering

## WORK EXPERIENCE

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**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

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### 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

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- 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

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### 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

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### 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

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

## WORKSHOPS & TRAINING

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### 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

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**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

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

## MEDIA COVERAGE & ONLINE FEATURES

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### **UMBC News Feature**

- **Modeling Hurricanes with Machine Learning**  
Research featured in UMBC News highlighting ML-based hurricane modeling. (January 2025)