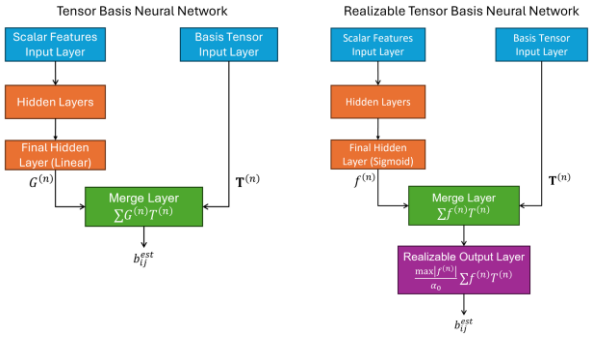
American Institute of Aeronautics and Astronautics
Dayton-Cincinnati Section

Lunch 'n' Learn
26 June 2026
Implicitly Realizable Data-driven Turbulence Modeling
Guest Speaker: Dr. James Wnek
Air Force Research Laboratory



Abstract: Machine learning (ML) provides a promising means to improve Reynolds-Averaged Navier-Stokes (RANS) turbulence modeling, but efficiently enforcing realizability, or the non-negativity of turbulent kinetic energy, has remained a challenge. Current approaches rely on costly post-processing corrections or inexact penalty methods that can suffer from ill-conditioning and fail in out-of-distribution scenarios.

Here, we introduce the first realizable tensor basis neural network (RTBNN) architecture that implicitly enforces realizability without eigendecomposition, extra hyperparameters, or penalty terms during training. First, a polar invariant map is constructed to provide a physically meaningful framework to represent realizability as a scaling problem instead of an eigenvalue constraint. This is used to develop an architecture that predicts the normalized anisotropy magnitude relative to its maximum realizable value. A proof-of-concept model was implemented and compared to the standard tensor basis neural network (TBNN) and realizability-informed (RI-TBNN) architectures using square duct data.

All models achieved an overall accuracy of $R^2 \approx 0.95$, but the RTBNN showed 32% lower training cost than the RI-TBNN while eliminating all non-realizable predictions. Compared to an OpenFOAM time step over the same number of points, the RTBNN was competitive with the RI-TBNN at 35% the cost of a timestep, and 81% lower than the cost of standard post-processing corrections. The results demonstrate the potential of the RTBNN as an efficient and robust method of realizability enforcement to support further advancements in machine learning-assisted turbulence modeling.

Biography: James Wnek is a postdoctoral researcher focusing on machine learning for computational fluid dynamics. He graduated from Wright State University in 2026 with his Ph.D. in Engineering after defending his dissertation, 'An Implicitly Realizable Tensor Basis Neural Network for Data-driven Turbulence Modeling'. James conducted his dissertation research under a DAGSI fellowship with his faculty advisor, Dr. Mitch Wolff, and AFRL sponsor, Dr. Christopher Schrock. He previously graduated from the same university with a combined B.S./M.S. Degree in Mechanical Engineering.

Time: *11:45 am*

Location:
China Garden Buffet
112 Woodman Dr.
Dayton, OH 45431

Lunch:
You will be able to purchase the buffet