Welcome!

NASA Langley 2022 Symposium on Turbulence Modeling: Roadblocks, and the Potential for Machine Learning

Suffolk, VA

27-29 July 2022

Overview

- This in-person symposium is a follow-on to:
  - UMich/NASA Symposium on Advances in Turbulence Modeling (2017)
    - See: NASA/TM–2017–219682: “Status, Emerging Ideas and Future Directions of Turbulence Modeling Research in Aeronautics”, Duraisamy et al.
  - UMich Symposium on Model-Consistent Data-driven Turbulence Modeling (2021)
- It has 2 themes:
  - Identification of critical issues for Reynolds-averaged Navier-Stokes (RANS) models, as well as possible ways forward
  - A “Collaborative Testing Challenge” for data-driven RANS models

Overview

- 1st Theme (critical issues for RANS):
  - Discuss turbulence modeling from both academic and industrial perspectives
  - New developments in RANS, including advancements enabled by data-driven techniques
  - Synergies between turbulence theory, traditional modeling, experiments, simulations, and emergent ideas
  - Limitations and perceived stagnation of turbulence models
  - Latest developments in turbulence scale-resolving simulation capabilities
  - Transition modeling
- 2nd Theme (collaborative testing challenge):
  - Foster shared understanding of the needs of data-driven model developers, traditional CFD developers, and especially end users
- We were fairly open-ended in our specification of what participants should talk about, so you will see a wide variety
- We have roughly 80-90 attendees
- If we don't have your talk yet, please see me or MC during a break
- The slides will be made public after the meeting
- We are going to try to record the panel discussions

Agenda Day 1

Wed July 27			
7:30 - 7:45 am	Registration & refreshment/food payments		
7:45 - 8:00 am			
8:00 - 8:15 am			
8:15 - 8:30 am			
8:30 - 8:45 am	Welcome, Intro, Overview	1 hr	
8:45 - 9:00 am			
9:00 - 9:15 am	Bookend talk 1 - **SPALART**		
9:15 - 9:30 am	An Old-Fashioned Framework for Machine Learning in Turbulence Modeling		
9:30 - 9:45 am	Break		
9:45 - 10:00 am	**Knopp, T.**: A data-driven wall law for the mean velocity in adverse-pressure gradient and modification of the SSG/LRR-w model	1.75 hrs	RANS related
10:00 - 10:15 am	**Abe, H.**: Improvement on the AMM model for predicting wing-body juncture flows		
10:15 - 10:30 am	**Agarwal, R.**: Review and Potential of Wray-Agarwal Family of Turbulence and Transition Models for RANS Simulations		
10:30 - 10:45 am	**Fritsch, D.**: Measurement and Modeling of Non-Equilibrium Turbulent Boundary Layer Flows		
10:45 - 11:00 am	**Lowe, T.**: Benchmark Turbulence Modeling Validation Experiments for Three-Dimensional Flows with Separation		
11:00 - 11:15 am	Discussion		
11:15 - 11:30 am			
11:30 - 11:45 am	Lunch		
11:45 - 12:00 noon			
12:00 - 12:15 pm			
12:15 - 12:30 pm			
12:30 - 12:45 pm			
12:45 - 1:00 pm	Invited Talk - **HUANG**	2 hrs	
1:00 - 1:15 pm	The Anchor Points of Turbulence Modeling		
1:15 - 1:30 pm			
1:30 - 1:45 pm	Panel Discussion - RANS		
1:45 - 2:00 pm	**Batten, Durbin, Hirsch, Smith**		
2:00 - 2:15 pm	(Moderator: **Spalart**)		
2:15 - 2:30 pm			
2:30 -2:45 pm			
2:45 -3:00 pm	Break		
3:00 - 3:15 pm	Intro to Challenge Case (**Rumsey**)	1.75 hrs	
3:15 - 3:30 pm	**Stoellinger, M.** (talk+Challenge): V&V of DES using multiple CFD codes		Talks including ML Challenge
3:30 - 3:45 pm			
3:45 - 4:00 pm	**Cherroud, S.** (talk+Challenge): Local Bayesian Mixing of Stochastic Explicit Algebraic Reynolds Stress Models		
4:00 - 4:15 pm			
4:15 - 4:30 pm	Discussion/Day 1 wrapup		
4:40 - 4:45 pm			
4:45 - 5:00 pm			
7:00 PM	NO-HOST DINNER		

Agenda Day 2

Thu July 28			
8:00 - 8:15 am	Announcements, Coffee		
8:15 - 8:30 am			
8:30 - 8:45 am	Invited Talk - **SANDBERG**	1.5 hrs	
8:45 - 9:00 am	Evolution of Gene Expression Programming for Turbulence Modelling		
9:00 - 9:15 am			
9:15 - 9:30 am	**Fang, Y.** (Challenge): Towards more accurate and general turbulence models using CFD-driven training on multiple flows		Talks including ML challenge
9:30 - 9:45 am	**Parish, E.** (talk+Challenge): A data-driven turbulence modeling framework for the Reynolds-averaged Navier-Stokes equations via discrepancy-based tensor-basis neural networks		
9:45 - 10:00 am			
10:00 - 10:15 am	Break		
10:15 - 10:30 am	**Bin, Y. and Li, J.** (talk+Challenge): Progressive, extrapolative machine learning in turbulence modeling	1.5 hrs	Talks including ML challenge
10:30 - 10:45 am			
10:45 - 11:00 am	**Viswanathan, V.** (talk+Challenge): Differentiable Physics for Turbulence Modeling		
11:00 - 11:15 am			
11:15 - 11:30 am	**Marepally, K.** (Challenge): Field-Inversion Machine Learning Approach for Improved Turbulence and Transition Predictions of Flows Over Airfoils		
11:30 - 11:45 am	**Dwight, R.** (Challenge): SpaRTA with classification		
11:45 - 12:00 noon	**Lunch**		
12:00 - 12:15 pm			
12:15 - 12:30 pm			
12:30 - 12:45 pm			
12:45 - 1:00 pm			
1:00 - 1:15 pm	**Discussion of Challenge**	1 hr	
1:15 - 1:30 pm			
1:30 - 1:45 pm			
1:45 - 2:00 pm			
2:00 - 2:15 pm	Break		
2:15 - 2:30 pm	Invited Talk - **HIRSCH**	0.75 hrs	
2:30 - 2:45 pm	The HiFi-TURB EU project: vision and progress of ML-based turbulence modeling		
2:45 - 3:00 pm			
3:00 - 3:15 pm	Break		
3:15 - 3:30 pm	**Srivastava, V.**: Developing hierarchical augmentations via the Learning and Inference assisted by Feature-space Engineering (LIFE) framework	1.25 hrs	ML
3:30 - 3:45 pm	**Orkwis, P.:** Using LES/DNS data for Neural Network-based Improvement of Existing Turbulence Models		
3:45 - 4:00 pm	**Romano, J.:** Towards use of convolutional neural networks as a post processing enhancement to RANS modeled turbulence		
4:00 - 4:15 pm	**Discussion/Day 2 wrapup**		
4:15 - 4:30 pm			
4:30 - 4:45 pm			
4:45 - 5:00 pm			

Agenda Day 3

Fri July 29			
8:00 - 8:15 am	Announcements, Coffee		
8:15 - 8:30 am			
8:30 - 8:45am	**Eisfeld, B.** (presented by **Knopp**): Potential of Data Driven Methods for Reynolds Stress Modeling - A Fundamental View	1.5 hrs	ML
8:45 - 9:00 am	**Girimaji, S.**: Machine Learning, Scale Resolving Simulations and the Future of Predictive Computations of Engineering Flows		
9:00 - 9:15 am	**Miller, N.**: Data-Driven Calibration of RANS Closure Models with PIV		
9:15 - 9:30 am	**Evans, J.**: Data-Driven Construction of Iterative Algebraic Reynolds Stress Models using Model-Derived Turbulence Variables		
9:30 - 9:45 am	**Banko, A.**: Lessons from data-driven Reynolds stress and turbulent scalar flux closures: the roles of anisotropy, auxiliary turbulence equations, and model extrapolation		
9:45 - 10:00 am	**Volpiani, P.**: Improvement of RANS models by machine learning for a bump configuration		
10:00 - 10:15 am	Break		
10:15 - 10:30 am	Panel Discussion - MACHINE LEARNING	1.5 hrs	
10:30 - 10:45 am	**Banko, Cinnella, Dwight, Girimaji, Moser**		
10:45 - 11:00 am	(Moderator: **Duraisamy**)		
11:00 - 11:15 am			
11:15 - 11:30 am			
11:30 - 11:45 am			
11:45 - 12:00 noon	Lunch		
12:00 - 12:15 pm			
12:15 - 12:30 pm			
12:30 - 12:45 pm			
12:45 - 1:00 pm			
1:00 - 1:15 pm	Bookend talk 2 - **SPALART**	1 hr	
1:15 - 1:30 pm	Conjectures of a Generalized Law of the Wall and a Structural Limitation for Classical Turbulence Models		
1:30 - 1:45 pm	Discussion		
1:45 - 2:00 pm			
2:00 - 2:15 pm	Break		
2:15 - 2:30 pm	**Coder, J.**: Current Status of PDE-Based Transition Modeling for Aerodynamics Applications	1.75 hrs	Transition
2:30 -2:45 pm	**Durbin, P.**: Hybrid closure modeling with laminar to turbulent transition		
2:45 -3:00 pm	**Jee, S.**: High-fidelity computational data of transitional boundary layers for a data-driven approach		
3:00 - 3:15 pm	Panel Discussion - TRANSITION		
3:15 - 3:30 pm	**Xiao, Duraisamy**		
3:30 - 3:45 pm	(Moderator: **Durbin**)		
3:45 - 4:00 pm			
4:00 - 4:15 pm	Break		
4:15 - 4:30 pm	Final Discussion & Wrapup	0.5 hr	
4:40 - 4:45 pm			
4:45 - 5:00 pm			

Social

- **Group Photo:** Will be taken at our first break today; please remove your name tags and leave all personal belongings at your seat; masks can come off for the photo
- **Lunches:** If you signed up ahead of time, a boxed lunch will be available for you
- **No-host dinner Wed night:**
  - Gianna's (7386 Harbour Towne Parkway)
  - Event begins @ 6:30pm – enjoy a drink and socialize
  - Dinner will be served at 7:00pm
  - We have the area of the restaurant by the bar all to ourselves. You will be given a place card with your name & meal choice. You are welcome to sit anywhere you like in our area of the restaurant.
- **Drivers/Rides for dinner:** Sign-up sheets will be with MC

If you have not signed up for dinner or have changed any of your meal plans, please see MC at the break

Philippe R. Spalart (PRS)

- This Symposium was also originally conceived as a way to honor Philippe R. Spalart's contributions to the turbulence modeling field

- He is delivering both our first and last plenary talks

- PRS Introduction