

# Muralikrishnan Gopalakrishnan Meena

Oak Ridge, Tennessee, USA

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## CURRENT AFFILIATION

### Computational Scientist - Fundamental Turbulence

Oak Ridge Leadership Computing Facility  
Oak Ridge National Laboratory, Tennessee, USA

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## EDUCATION

### University of California, Los Angeles, USA

*January 2019 - June 2020*

Ph.D., Mechanical Engineering, minor in Applied Mathematics  
Dissertation: Network community-based analysis of complex vortical flows: Laminar & turbulent flows  
Advisor: Prof. Kunihiko Taira

### Florida State University, U.S.A

*August 2015 - December 2018*

Master of Science, Mechanical Engineering

### Cochin University of Science & Technology, India

*June 2010 - May 2014*

Bachelor of Technology, Mechanical Engineering

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## RESEARCH AREAS OF INTEREST

**Fluid Dynamics:** • Turbulence • Atmospheric turbulence & climate modeling • Vortex interaction • Unsteady aerodynamics • Flow control

**Data Science:** • Network science (graph theory) • Machine learning (regression, clustering, interpretability) • Clustering • Reduced-order modeling

**Biological Sciences:** • Fungal community interactions & metabolic networks

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## TECHNICAL SKILLS

### Scientific Computing:

- *CFD solvers:* DNS & LES solvers (based on immersed boundary method, finite difference & volume, spectral) in HPC environment; Basic user of OpenFOAM & ANSYS FLUENT
- *Parallel computation & HPC:* MPI, bash scripting, HPCToolkit for profiling (basic user), various HPC systems of US-DOE (OLCF-Summit, Andes), US-DOD (Gordon & Conrad), and academia (UCLA & FSU)
- *Machine learning & Data Science:* Packages - PyTorch (Python & C++ with GPU), TensorFlow (Keras), Scikit-learn, NetworkX, Matlab BCT for graphs; ML Models - mainly using MLP, CNN, LSTM
- *Performance portability:* Basic user of YAKL ([github.com/mrnorman/YAKL](https://github.com/mrnorman/YAKL)) & HIP (including ROCm profiler & debugger)
- *Distributed version-control:* Git, Github

### Programming Languages:

- Fortran, C++ (basic user of `gdb` & `valgrind` debuggers), Python (including Jupyter Lab), Matlab

### Design:

- *Scientific modeling:* Solidworks, Pointwise
- *Visualization:* Matlab, Python, Ncview, Tecplot, ParaView, OmniGraffle, Draw.io

### Other:

- *Academic mentoring:* NSF-REU

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Last updated: March 11, 2022

## WORK EXPERIENCE

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<b>Oak Ridge National Laboratory</b> Computational Scientist	<i>2022 - Present</i>
<b>Oak Ridge National Laboratory</b> Postdoctoral Research Associate	<i>2020 - 2022</i>
<b>University of California, Los Angeles</b> Graduate Research Assistant	<i>2019 - 2020</i>
<b>Florida State University</b> Graduate Research Assistant Teaching Assistant: Numerical Methods for Engineers (Spring 2016, 2017)	<i>2015 - 2018</i>

## PUBLICATION

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Google Scholar: [scholar.google.com/citations?user=2yNLfcsAAAAJhl=en](https://scholar.google.com/citations?user=2yNLfcsAAAAJhl=en)

### Peer-reviewed Articles

1. T.A. Rush, J. Tannous, M.J. Lane, **M. Gopalakrishnan Meena**, A. Carrell, J.J. Golan, S. Cottaz, S. Fort, J.M. Ané, N.P. Keller, D. A. Pelletier, D.A. Jacobson, D. Kainer, P. Abraham, R.J. Giannone, J.L. Labbé, “Fungal LCOs: Modulators of metabolite production and bacterial development”, *revised manuscript in-preperation*, 2022
2. **M. Gopalakrishnan Meena**, M. J. Lane, J. Tannous, A. A. Carrell, P. E. Abraham, R. J. Giannone, J-M Ané, N. P. Keller, J. L. Labbé, D. Kainer, D. A. Jacobson, and T. A. Rush, “A light into the fungal metabolomic abyss: Network analysis for revealing relationships between exogenous compounds & their outputs”, *in review*, 2022
3. **M. Gopalakrishnan Meena**, M. R. Norman, and D. M. Hall, “Subgrid-scale surrogate modeling of atmospheric flows: A deep learned approach using high-resolution simulation data,” *in review*, 2022
4. T. A. Rush, H. K. Shrestha, **M. Gopalakrishnan Meena**, M. K. Spangler, J. C. Ellis, J. L. Labbé, and P. Abraham, “Bioprospecting Trichoderma: A systematic roadmap to screen genomes and natural products for biocontrol applications”, *Frontiers in Fungal Biology*, 2:716511, 2021
5. S. Mahajan, L. S. Passarella, F. M. Hoffman, **M. Gopalakrishnan Meena**, and M. Xu, “Assessing teleconnections-induced predictability of regional water cycle on seasonal to decadal timescales using machine learning approaches”, DOE BER AI4ESP, No. AI4ESP1086, 2021
6. **M. Gopalakrishnan Meena** and K. Taira, “Identifying vortical network connectors for turbulent flow modification”, *Journal of Fluid Mechanics*, 915, A10, 2021
7. C.-A. Yeh, **M. Gopalakrishnan Meena**, and K. Taira, “Network broadcast analysis and control of turbulent flows”, *Journal of Fluid Mechanics*, 910, A15, 2021
8. Z. Bai, N. B. Erichson, **M. Gopalakrishnan Meena**, K. Taira, and S. L. Brunton, “Randomized methods to characterize large-scale vortical flow network”, *PLOS One*, 14(11), e0225265, 2019
9. **M. Gopalakrishnan Meena**, A. G. Nair, and K. Taira, “Network community-based model reduction for vortical flows”, *Physical Review E*, 97, 063103, 2018
10. **M. Gopalakrishnan Meena**, K. Taira, and K. Asai, “Airfoil wake modification with Gurney flap at low-Reynolds number”, *AIAA Journal*, 56(4), 1348-1359, 2018

### Peer-reviewed Conference Proceedings

1. **M. Gopalakrishnan Meena**, M. R. Norman, and D. M. Hall, “Deep learned subgrid-scale surrogate modeling of atmospheric flows using high-resolution simulation data,” 12th International Symposium on Turbulence and Shear Flow Phenomena, Osaka, Japan, July 19 - 22 (Online), 2022 (TSFP 12 229)
2. M. R. Norman and **M. Gopalakrishnan Meena**, “Confident, adaptable, and robust machine learning to augment traditional modeling and simulation,” Position Papers for the ASCR Workshop on Reimagining Codesign, USDOE Office of Science (United States), 2021

3. **M. Gopalakrishnan Meena** and K. Taira, “Characterizing influential networked structures in isotropic turbulence,” 11th International Symposium on Turbulence and Shear Flow Phenomena, Southampton, UK, July 30 - Aug. 2, 2019 (TSFP 11 235)
4. **M. Gopalakrishnan Meena**, K. Taira, and K. Asai, “Low Reynolds number wake modification using a Gurney flap,” 55th AIAA Aerospace Sciences Meeting, Grapevine, TX, Jan. 9-13, 2017 (AIAA 2017-0543)
5. **M. Gopalakrishnan Meena**, A. Anandakrishnan, and M. A. Kavumcheril. “Numerical study on heat transfer and fluid flow in pin fin-dimple channels with fillet on dimple edge”, ASME Gas Turbine India Conference, New Delhi, India, Dec. 15-17, 2014 (GTINDIA2014-8103)

## PRESENTATIONS

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Underlined: Invited presentation

1. **M. Gopalakrishnan Meena**, M. R. Norman, and D. M. Hall, “Deep learned subgrid-scale surrogate modeling of atmospheric flows using high-resolution simulation data,” 12th International Symposium on Turbulence and Shear Flow Phenomena, Osaka, Japan, July 19 - 22 (Online), 2022 (TSFP 12 229)
2. **M. Gopalakrishnan Meena**, M. J. Lane , J. Tannous , T. A. Rush, “Predicting production of known, putative, and unknown microbial metabolites through network analysis,” 31st Fungal Genetics Conference, March 15-20, 2022 (Biotechnology-331V)
3. **M. Gopalakrishnan Meena**, “Data-driven modeling of turbulent flows: Approaches using graph theory & AI,” *Data Sciences & Machine Intelligence Group Seminar*, Pacific Northwest National Laboratory, March 7, 2022
4. **M. Gopalakrishnan Meena**, M. R. Norman, and D. M. Hall, “Subgrid-scale surrogate modeling of cloud-like flows: An AI-based approach using high-resolution simulation data,” AMS 102nd Annual Meeting, Virtual Conference, January 23-27, 2022 (paper # 13A.5)
5. **M. Gopalakrishnan Meena**, M. R. Norman, and D. M. Hall, “A deep learned subgrid-scale surrogate model for cloud-like flows from high-resolution simulation data,” AGU Fall Meeting, Virtual Conference, December 13-17, 2021 (A15E-1689)
6. C.-A. Yeh, **M. Gopalakrishnan Meena**, and K. Taira, “Network-based resolvent analysis for modification of isotropic turbulence,” 25th International Congress of Theoretical and Applied Mechanics, Milan, Italy, Aug. 2021
7. T. A. Rush, H. K. Shrestha, **M. Gopalakrishnan Meena**, M. K. Spangler, J. C. Ellis, J. Labbé, and P. E. Abraham, “Bioprospecting Trichoderma: A systematic roadmap to screen genomes and natural products for biocontrol applications”, 9th Annual Oak Ridge Postdoctoral Association Research Symposium, July 29, 2021
8. M. R. Norman, C. Eldred, I. Lyngaas, **M. Gopalakrishnan Meena**, K. Pressel, M. Taylor, “Recent Developments for a New Cloud Resolving Model on the A-Grid,” *PDEs on the Sphere*, Virtual Meeting, May 17-21, 2021
9. M. R. Norman, C. Eldred, W. Hannah, I. Lyngaas, **M. Gopalakrishnan Meena**, K. Pressel, M. Taylor, X. Yuan, “Developing a New Cloud Resolving Model for the E3SM-MMF ECP AD Project,” *ECP Annual Meeting*, Virtual Meeting, April 12-16, 2021
10. **M. Gopalakrishnan Meena**, “Identifying vortical network connectors for turbulent flow modification,” *Network Science for Fluid Mechanics Seminar Series*, Virtual Seminar Series, March 19, 2021
11. M. R. Norman and **M. Gopalakrishnan Meena**, “Confident, adaptable, and robust machine learning to augment traditional modeling and simulation,” *ASCR Workshop on Reimagining Codesign*, Virtual Workshop, Mar. 16-18, 2021
12. C.-A. Yeh, **M. Gopalakrishnan Meena**, and K. Taira, “Network broadcast mode analysis and control of 2D decaying isotropic turbulence,” *SIAM Conference on Computational Science and Engineering*, Virtual Conference, Mar.1-5, 2021 (MS275)
13. **M. Gopalakrishnan Meena** and K. Taira, “Modeling and modifying fluid flows using network-community-based techniques: laminar and turbulent flows,” *SIAM Conference on Computational Science and Engineering*, Virtual Conference, Mar.1-5, 2021 (MS190)

14. **M. Gopalakrishnan Meena** and M. R. Norman, "Towards a Deep Learned Subgrid-scale Surrogate Model for Cloud Resolving Models from High-resolution Simulation Data," AMS 101st Annual Meeting, Virtual Conference, January 10-15, 2021 (paper # 6.9)
15. **M. Gopalakrishnan Meena** and M. R. Norman, "Towards a deep learned subgrid-scale surrogate model for stratified turbulence from high-resolution simulation data," AGU Fall Meeting, Virtual Conference, December 1-17, 2020 (A068-0013)
16. T. A. Rush, **M. Gopalakrishnan Meena**, J. Tannous, P. Abraham, R. Giannone, and J. Labbé, "Lipochitooligosaccharides (LCOs) are biotic stress factors in *Aspergillus fumigatus*," *14th Annual Vanderbilt Postdoctoral Association Symposium*, virtual symposium, October 29, 2020
17. **M. Gopalakrishnan Meena** and K. Taira, "Network-based identification of influential structures to modify turbulent flows," *Network Science for Fluid Dynamics*, virtual workshop, June 24-25, 2020
18. C.-A. Yeh, **M. Gopalakrishnan Meena**, and K. Taira "Broadcasting Mode Analysis for Turbulent Flow Modification," *Network Science for Fluid Dynamics*, virtual workshop, June 24-25, 2020
19. **M. Gopalakrishnan Meena** and K. Taira, "Network-based identification of influential structures to modify turbulent flows," *72th Annual Meeting of the APS Division of Fluid Dynamics*, Seattle, WA, Nov. 23-26, 2019 (H10.00010)
20. C.-A. Yeh, **M. Gopalakrishnan Meena**, and K. Taira, "Time-evolving network analysis of two-dimensional turbulence," IUTAM Symposium on Laminar-Turbulent Transition, London, UK, Sep. 2-6, 2019
21. **M. Gopalakrishnan Meena** and K. Taira, "Characterizing influential networked structures in isotropic turbulence," 11th International Symposium on Turbulence and Shear Flow Phenomena, Southampton, UK, July 30 - Aug. 2, 2019 (TSFP 11 235)
22. **M. Gopalakrishnan Meena** and K. Taira, "Characterizing three-dimensional homogenous isotropic turbulence network", *SoCal Fluids XIII*, UC Santa Barbara, 20 April, 2019
23. Z. Bai, N. B. Erichson, **M. Gopalakrishnan Meena**, K. Taira, and S. L. Brunton, "Sparse and randomized sampling methods for scalable turbulent flow networks," *71th Annual Meeting of the APS Division of Fluid Dynamics*, Atlanta, GA, Nov. 18-20, 2018 (G01.00004)
24. **M. Gopalakrishnan Meena** and K. Taira, "High-dimensional turbulence network characterization and modeling", *NetSci Conference*, Paris, France, June 13-15, 2018 (140)
25. K. Taira, **M. Gopalakrishnan Meena**, and A. G. Nair, "Community-based model reduction of unsteady vortical flows", *NetSci Conference*, Paris, France, June 13-15, 2018 (135)
26. **M. Gopalakrishnan Meena**, A. G. Nair, and K. Taira, "Vortex network community based reduced-order force model," *70th Annual Meeting of the APS Division of Fluid Dynamics*, Denver, CO, Nov. 19-21, 2017 (M1.00005)
27. **M. Gopalakrishnan Meena**, A. G. Nair, and K. Taira, "Network representation and analysis of bluff body wake," *SIAM Conference on Computational Science and Engineering*, Atlanta, GA, Feb. 27-Mar. 3, 2017 (MS110)
28. **M. Gopalakrishnan Meena**, K. Taira, and K. Asai, "Low Reynolds number wake modification using a Gurney flap," *55th AIAA Aerospace Sciences Meeting*, Grapevine, TX, Jan. 9-13, 2017 (AIAA 2017-0543)
29. A. G. Nair, **M. Gopalakrishnan Meena**, and K. Taira, "Vortical and modal network analysis of unsteady cylinder wake," *69th Annual Meeting of the APS Division of Fluid Dynamics*, Portland, OR, Nov. 20-22, 2016 (E8.00004)
30. **M. Gopalakrishnan Meena**, A. Anandkrishnan, and M. A. Kavumcheril. "Numerical study on heat transfer and fluid flow in pin fin-dimple channels with fillet on dimple edge", ASME Gas Turbine India Conference, New Delhi, India, Dec. 15-17, 2014 (GTINDIA2014-8103)

## PROFESSIONAL & COMMUNITY SERVICES

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### Journal & Proposal Referee

- Journal of Fluid Mechanics    • AIAA Journal    • Physica D    • Physics Letters A
- Progress in Computational Fluid Dynamics    • Partial Differential Equations in Applied Mathematics
- INCITE - Computational Readiness    • ORNL Director's Discretionary Allocation

## Workshop Organization

- AMS Annual Meeting, January 2022: (1) Session chair - “AI in Weather and Climate Modeling: Bridging the Gap Between Theoretical Advances and Production Use” and (2) Session co-chair for 2 sessions ([annual.ametsoc.org/index.cfm/2022/](https://annual.ametsoc.org/index.cfm/2022/))
- AGU Fall Meeting, December 2021: Session chair - “AI in Weather and Climate Modeling: From Theoretical Advances to Operational Use” ([www.agu.org/Fall-Meeting](https://www.agu.org/Fall-Meeting))
- Network Science for Fluid Mechanics Seminar Series (virtual), once every month, Nov. 2020 - present: Organizer (with Aditya Nair and Kunihiro Taira) ([sites.google.com/g.ucla.edu/nsfm/](https://sites.google.com/g.ucla.edu/nsfm/))

## Training Events

- Mentor at GPU Hackathons ([www.gpuhackathons.org](https://www.gpuhackathons.org))
  1. Princeton Hackathon, June 2, 8-10, 2021 (Team SLEAP)
  2. OLCF Hackathon, October 18, 25-27, 2021 (Team 3d3n\_h4ck3r2)

## Outreach & Volunteering

- Youth Outreach in STEM, Knoxville TN ([www.yostem.org](https://www.yostem.org)) (2021 - present)
- Oak Ridge Computer Science Girls, Oak Ridge TN ([www.orcsgirls.org](https://www.orcsgirls.org)) (2021 - present)
- Buck Lake Elementary School, Tallahassee FL (2016, 2017)
- FSU AME Building Open House for public, Tallahassee FL (2016, 2017)