MATTHEW J. CHURCHFIELD

National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80501
720-355-6001
matt.churchfield@nrel.gov

EDUCATION:

Purdue University – West Lafayette, Indiana: 5/2006 to 7/2009

- Doctor of Philosophy in Aeronautical Engineering
  - Major: Aerodynamics
  - Minor: Dynamics and Control
  - Specialization: Computational Science and Engineering

Purdue University – West Lafayette, Indiana: 8/2003 to 5/2006

- Master of Science in Aeronautical Engineering
  - Major: Aerodynamics
  - Minor: Computational Science and Engineering

University of Nevada – Reno, Nevada: 8/1998 to 5/2002

- Bachelor of Science in Mechanical Engineering (summa cum laude)

RESEARCH EXPERIENCE:

National Renewable Energy Laboratory (NREL)

8/2013 to current – Senior Researcher
5/2011 to 8/2013 – Research Engineer
8/2009 to 5/2011 – Postdoctoral Researcher

- Research focus: To better understand complex wind-plant physics using large-eddy simulation (LES)
  - wind-turbine wake behavior
  - effect of atmospheric stability, terrain, and mesoscale weather on wind-plant performance
  - wind-plant control
- Role: Provide technical leadership in the area of wind plant simulation
  - PI for DOE-funded mesoscale-microscale weather coupling project
  - Actively involved in DOE-funded projects on high-fidelity wind-plant modeling and wake characterization
  - Team member of DOE-funded exascale-computing project with wind-plant physics as the application
- Collaborate with researchers at the University of Colorado, Boulder; Penn State University; Johns Hopkins University; Cornell University; The National Center for Atmospheric Research; Lawrence Livermore National Laboratory, Sandia National Laboratory; Pacific Northwest National Laboratory; and Argonne National Laboratory; Boeing Commercial Airplanes; and various turbine manufacturers
- Provide mentorship to visiting/intern students at undergraduate to doctoral level
- Supervised by Dr. Patrick Moriarty

RESEARCH EXPERIENCE (CONTINUED):

Purdue University School of Aeronautics and Astronautics

8/2003 to 7/2009 - Graduate Research Assistant

- Research focus: To compute a wingtip vortex flow for the purpose of assessing Reynolds-averaged Navier-Stokes (RANS) turbulence model performance in this type of highly rotational flow. That work, which comprised my masters degree research, led to my doctoral research in examining a proposed turbulence model's performance in predicting turbulence in vortical flows
- Collaborated with researchers at NASA
- Advised by Dr. Gregory Blaisdell

PROFESSIONAL AFFILIATION/SERVICE:

- Member of the American Institute of Aeronautics and Astronautics (AIAA).
- Technical Discipline Chair for Wind Energy Symposium at AIAA SciTech 2016 – 2018.
- Member of the American Meteorological Society.

STUDENT MENTORING:

- Hosted/mentored visiting Ph.D. students and professors on visits ranging from a week to a year.
- Served/serving as graduate committee member for students at the Technical University of Denmark; Johns Hopkins University; Cornell University; University of Colorado, Boulder; and University of Puerto Rico.
- Department of Energy Science Undergraduate Laboratory Internship Program: Mentored undergraduate students in wind energy simulation and data analysis at the NREL, 2010, 2012, 2015.

AWARDS & HONORS:

- 2017: NREL Chairman's Award for Exceptional Performance
- 2015: NREL Technology Transfer Award for development of the Simulator for Wind Farm Applications
- 2018: NREL National Wind Technology Center Outstanding Individual Award
- 2013: NREL President's Award for outstanding service in the development of NREL's wind plant simulation capability
- 2010: NREL Outstanding Mentor Award for mentorship of a summer student

First-Author Journal Publications

Churchfield, M. and Blaisdell, G. "Reynolds Stress Relaxation Turbulence Modeling Applied to a Wingtip Vortex Flow". In: *AIAA Journal* 51.11 (2013), pp. 2643–2655. DOI: 10.2514/1.J052265.

Churchfield, M., Li, Y., and Moriarty, P. "A Large-Eddy Simulation Study of Wake Propagation and Power Production in an Array of Tidal-Current Turbines". In: *Philosophical Transactions of the Royal Society A* 371.1985 (2013), p. 20120421. DOI: 10.1098/rsta.2012.0421.

Churchfield, M. et al. "A Numerical Study of the Effects of Atmospheric and Wake Turbulence on Wind Turbine Dynamics". In: *Journal of Turbulence* 13.14 (2012), pp. 1–32. DOI: 10.1080/14685248.2012.668191.

Churchfield, M. and Blaisdell, G. "Numerical Simulations of a Wingtip Vortex in the Near Field". In: *Journal of Aircraft* 46.1 (2009), pp. 230–243. DOI: 10.2514/1.38086.

Other Select Journal Publications

Martínez-Tossas, L., Churchfield, M., and Meneveau, C. "Optimal Smoothing Length Scale for Actuator Line Models of Wind Turbine Blades Based on Gaussian Body Force Distribution". In: *Wind Energy* (2017).

Sanz Rodrigo, J., Churchfield, M., and Kosović, B. "A Methodology for the Design and Testing of Atmospheric Boundary Layer Models for Wind Energy Applications". In: *Wind Energy Science* 2.1 (2017), p. 35.

Doubrawa, P. et al. "A Stochastic Wind Turbine Wake Model Based on New Metrics for Wake Characterization". In: *Wind Energy* (2016). DOI: 10.1002/we.2015.

Doubrawa, P. et al. "Wind Turbine Wake Characterization from Temporally Disjunct 3-D Measurements". In: *Remote Sensing* (2016). DOI: 10.3390/rs8110939.

Sanz Rodrigo, J. et al. "Mesoscale to Microscale Wind Farm Flow Modeling and Evaluation". In: *Wiley Interdisciplinary Reviews: Energy and Environment* 2.6 (2016). DOI: 10.1002/wene.214.

Keck, R.-E. et al. "Two Improvements to the Dynamic Wake Meandering Model: Including the Effects of Atmospheric Shear on Wake Turbulence and Incorporating Turbulence Build-Up in a Row of Wind Turbines". In: *Wind Energy* 18.1 (2015), pp. 111–132. DOI: 10.1002/we.1686.

Lundquist, J. K. et al. "Quantifying Error of Lidar and Sodar Doppler Beam Swinging Measurements of Wind Turbine Wakes Using Computational Fluid Dynamics". In: *Atmospheric Measurement Technology* 8 (2015), pp. 907–920. DOI: 10.5194/amt-8-907-2015.

Martínez-Tossas, L., Churchfield, M., and Leonardi, S. "Large Eddy Simulations of the Flow Past Wind Turbines: Actuator Line and Disk Modeling". In: *Wind Energy* 18 (2015), pp. 1047–1060. DOI: 10.1002/we.1747.

Mirocha, J. et al. "Investigating Wind Turbine Impacts on Near-Wake Flow Using Profiling Lidar Data and Large-Eddy Simulations with an Actuator Disk Model". In: *Journal of Renewable and Sustainable Energy* 7.043143 (2015). DOI: 10.1063/1.4928873.

Fleming, P. et al. "Evaluating Techniques for Redirecting Turbine Wakes Using SOWFA". In: *Renewable Energy* 70 (2014), pp. 211–218. DOI: 10.1016/j.renene.2014.02.015.

Fleming, P. et al. "Simulation Comparison of Wake Mitigation Control Strategies for a Two-Turbine Case". In: *Wind Energy* (2014). published online. DOI: 10.1002/we.1810.

Jha, P. et al. "Guidelines for Volume Force Distribution Within Actuator Line Modeling of Wind Turbines on Large-Eddy Simulation-Type Grids". In: *Journal of Solar Energy Engineering* 136.3 (2014), p. 031003. DOI: 10.1115/1.4026252.

Keck, R.-E. et al. "On Atmospheric Stability in the Dynamic Wake Meandering Model". In: *Wind Energy* 17.11 (2014), pp. 1689–1710. DOI: 10.1002/we.1662.

Archer, C. et al. "Meteorology for Coastal/Offshore Wind Energy in the United States: Recommendations and Research Needs for the Next 10 Years". In: *Bulletin of the American Meteorological Society* (2013). DOI: 10.1175/BAMS-D-13-00108.1.

First-Author Book Chapters

Churchfield, M. J. and Moriarty, P. J. "Modeling and Simulation of Wind Farm Flows". In: *Modeling and Simulation in Wind Plant Design and Analysis*. Ed. by Veers, P. S. submitted for publication in 2019. Michael Faraday House, Six Hills Way, Stevenage, SG1 2AY, United Kingdom: IET Publishing, 2019.

Invited Talks

Churchfield, M. *An Overview of Wind Plant Aerodynamics Simulations at the National Renewable Energy Laboratory*. Kenninger Summer Institute, Purdue University, West Lafayette, Indiana. 2018.

Churchfield, M. *The Complexities of Wind Flow Through Wind Power Plants*. Geophysics Seminar, Indiana University, Bloomington, Indiana. 2018.

Churchfield, M. *An Overview of Wind Plant Aerodynamics Simulations at the National Renewable Energy Laboratory*. Mechanical Engineering Graduate Seminar Series, University of Wyoming, Laramie, Wyoming. 2017.

Churchfield, M. *An Overview of the SWiFT Wake Experiment and Supporting Computations*. Windfarms 2016, Dallas, Texas. 2016.

Spalart, P. and Churchfield, M. *The Treatment of Turbulence and Boundaries in Wind Farm Simulations*. U.S. Department of Energy Atmosphere to Electrons (A2e) High Fidelity Modeling, ModSim Environment Workshop, Denver, Colorado. 2015.

Churchfield, M. *An Overview of Wind Plant Aerodynamics Simulation Research at the National Renewable Energy Laboratory*. The Pennsylvania State University Mechanical Engineering Seminar Series, State College, Pennsylvania. 2014.

Churchfield, M. *Wind Plant Simulation Efforts at NREL and The Future of High-Fidelity Wind Plant Simulation*. Sandia Laboratories Wind Turbine Blade Workshop, Albuquerque, New Mexico. 2014.

Churchfield, M. *Adding Complex Terrain and Stable Atmospheric Condition Capability to the Simulator for On/Offshore Wind Farm Applications (SOWFA)*. The First Symposium on OpenFOAM in Wind Energy, Oldenburg, Germany. 2013.

Churchfield, M. *Initial NREL Work in Coupling Mesoscale and Microscale Flow Simulation*. Atmospheric Modeling at Large Eddy Simulation Scales: Opportunities and Challenges, Argonne National Laboratory, Illinois. 2013.

Churchfield, M. *The Challenges of Wind Plant Aerodynamics Simulation*. Boulder Fluid and Thermal Sciences Seminar Series, Boulder, Colorado. 2013.

Moriarty, P., Churchfield, M., and Robinson, M. *Modeling Atmospheric Turbulence Effects on Wind Farms*. 6th AIAA Theoretical Fluid Mechanics Conference, Honolulu, Hawaii. 2011.

First-Author Conference Papers

Churchfield, M. J. et al. "An Advanced Actuator Line Method for Wind Energy Applications and Beyond". In: *AIAA SciTech, Grapevine, Texas*. AIAA Paper 2017-1998. American Institute of Aeronautics and Astronautics, Washington D.C., 2017. DOI: 10.2514/6.2017-1998.

Churchfield, M. J. et al. "Using High-Fidelity Computational Fluid Dynamics to Help Design a Wind Turbine Wake Measurement Experiment". In: *Journal of Physics Conference Series – The Science of Making Torque from Wind, Munich, Germany* 753.3 (2016), p. 032009. DOI: 10.1088/1742-6596/753/3/032009.

Churchfield, M. J., Wang, Z., and Schmitz, S. "Modeling Wind Turbine Tower and Nacelle Effects within an Actuator Line Model". In: *AIAA SciTech, Kissimmee, Florida*. AIAA Paper 2015-0214. American Institute of Aeronautics and Astronautics, Washington D.C., 2015. DOI: 10.2514/6.2015-0214.

Churchfield, M. J. et al. "A Comparison of the Dynamic Wake Meandering Model, Large-Eddy Simulation, and Field Data at the Egmond aan Zee Offshore Wind Plant". In: *AIAA SciTech, Kissimmee, Florida*. AIAA Paper 2015-0724. American Institute of Aeronautics and Astronautics, Washington D.C., 2015. DOI: 10.2514/6.2015-0724.

Churchfield, M. J. et al. "Wind Turbine Wake Redirection Control at the Fishermen's Atlantic City Windfarm". In: *Offshore Technology Conference, Houston, Texas*. OTC-25644-MS. OnePetro, The Society of Petroleum Engineers, 2015. DOI: 10.4043/25644-MS.

Churchfield, M. J., Lee, S., and Moriarty, P. J. "Adding Complex Terrain and Stable Atmospheric Condition Capability to the OpenFOAM-Based Flow Solver of the Simulator for On/Offshore Wind Farm Applications (SOWFA)". In: *ITM Web of Conferences – 1st Symposium on OpenFOAM in Wind Energy, Oldenburg, Germany* 2.02001 (2014). DOI: 10.1051/itmconf/20140202001.

Churchfield, M. J. et al. "A Comparison Between Wind Turbine Aerodynamics Model Output When Using Generic Versus Actual Turbine Characterization as Input". In: *51th AIAA Aerospace Sciences Meeting including the New Horizons Forum and Aerospace Exposition, Grapevine, Texas*. AIAA Paper 2013-1206. American Institute of Aeronautics and Astronautics, Washington D.C., 2013. DOI: 10.2514/6.2013-1208.

Churchfield, M. J. et al. "Using Mesoscale Weather Model Output as Boundary Conditions for Atmospheric Large-Eddy Simulations and Wind-Plant Aerodynamics Simulations". In: *International Conference on Future Technologies for Wind Energy, Laramie, Wyoming*. 2013.

Churchfield, M. J. et al. "A Large-Eddy Simulation of Wind-Plant Aerodynamics". In: *50th AIAA Aerospace Sciences Meeting including the New Horizons Forum and Aerospace Exposition, Nashville, Tennessee*. AIAA Paper 2012-537. American Institute of Aeronautics and Astronautics, Washington D.C., 2012. DOI: 10.2514/6.2012-537.

Churchfield, M. J. and Blaisdell, G. A. "A Reynolds Stress Relaxation Turbulence Model Applied to a Wingtip Vortex Flow". In: *49th AIAA Aerospace Sciences Meeting including the New Horizons Forum and Aerospace Exposition, Orlando, Florida*. AIAA Paper 2011-663. American Institute of Aeronautics and Astronautics, Washington D.C., 2011. DOI: 10.2514/6.2011-663.

Churchfield, M. J., Li, Y., and Moriarty, P. J. "A Large-Eddy Simulation Study of Wake Propagation and Power Production in an Array of Tidal-Current Turbines". In: *9th European Wave and Tidal Energy Conference, Southhampton, England*. European Wave and Tidal Energy Conference, 2011.

Churchfield, M. J. et al. "Wind Energy-Related Atmospheric Boundary Layer Large-Eddy Simulation Using OpenFOAM". In: *AMS 19th Symposium on Boundary Layers and Turbulence, Keystone, Colorado*. Paper 1B.6. American Meteorological Society, 2010.

Churchfield, M. J. and Blaisdell, G. A. "The Lag RST Turbulence Model Applied to a Vortex Flow". In: *46th AIAA Aerospace Sciences Meeting and Exhibit, Reno, Nevada*. AIAA Paper 2008-769. American Institute of Aeronautics and Astronautics, Washington D.C., 2008. DOI: 10.2514/6.2008-769.

Churchfield, M. J. and Blaisdell, G. A. "Near Field Wingtip Vortex Computations Using the WIND Code". In: *44th AIAA Aerospace Sciences Meeting and Exhibit, Reno, Nevada*. AIAA Paper 2006-633. American Institute of Aeronautics and Astronautics, Washington D.C., 2006. DOI: 10.2514/6.2006-633.