Using computer simulations to study large wind farms

Charles Meneveau
Johns Hopkins University

Abstract:
Similar to other renewable energy sources, wind energy is characterized by low power density. Hence, in order for wind energy to make a significant contribution to our overall energy supply, large wind farms (on or off-shore) need to be envisioned. As it turns out, not much is known about the interactions between large wind farms and the atmospheric boundary layer. A case in point, as wind farms are getting larger, operators have begun to complain about the so-called "wind-farm underproduction" problem. This presentation will summarize our recent results that focus on understanding how wind turbines, when deployed in large arrays, extract kinetic energy from the atmospheric boundary layer. Large Eddy Simulations (LES) are used to improve our understanding of the vertical transport of momentum and kinetic energy across a boundary layer flow with wind turbines. The presentation will summarize the basics of LES, and showcase some applications and results to the study of large wind farms. This work is a collaboration with colleagues and students and is supported by the National Science Foundation (the WINDINSPIRE project).

BRIEF BIO-SKETCH

Charles Meneveau is the Louis M. Sardella Professor in the Department of Mechanical Engineering at Johns Hopkins University. He also has a joint appointment in the Geography and Environmental Engineering Department and as deputy director of the Institute for Data Intensive Engineering and Science (IDIES) at Johns Hopkins. He received his B.S. degree in Mechanical Engineering from the Universidad Técnica Federico Santa María in Valparaíso, Chile, in 1985 and M.S, M.Phil. and Ph.D. degrees from Yale University in 1987, 1988 and 1989, respectively. During 1989/90 he was a postdoctoral fellow at the Stanford University/NASA Ames' Center for Turbulence Research.

Professor Meneveau has been on the Johns Hopkins faculty since 1990. His area of research is focused on understanding and modeling hydrodynamic turbulence, and complexity in fluid mechanics in general. He combines experimental, computational and theoretical tools for his research. Special emphasis is placed on the multiscale aspects of turbulence, using appropriate tools such as subgrid-scale modeling, downscaling techniques, fractal geometry, wavelet analysis, and applications to Large Eddy Simulation. The insights that have emerged from Professor Meneveau's work have led to new numerical models for Computational Fluid Dynamics and applications in engineering and environmental flows. With his students and co-workers, he has authored over 140 peer-reviewed articles. In 2005 the ISI has recognized the article "Scale Invariance and Turbulence Models for LES" (2000, with J. Katz) as a "Highly Cited Article", placing it in the top 1% within its field.

Professor Meneveau is a foreign corresponding member of the Chilean Academy of Sciences, and a Fellow of the American Academy of Mechanics, the U.S. American Physical Society and the American Society of Mechanical Engineers. He received the inaugural Stanley Corrsin Award from the American Physical Society (2011), the 2011 J. Cole Award from AIAA, the 2004 UCAR Outstanding Publication award (with students and other colleagues at JHU and NCAR), the Johns Hopkins University Alumni Association's Excellence in Teaching Award (2003), and the APS' François N. Frenkiel Award for Fluid Mechanics (2001).

He is now Deputy Editor of the Journal of Fluid Mechanics, and the Editor-in-Chief of the Journal of Turbulence. In the past, he has served as Associate Editor for the Journal of Fluid Mechanics, as member of the Editorial Committee of the Annual Reviews of Fluid Mechanics and as an Associate Editor for Physics of Fluids.