ICTAS

NEW HORIZONS

SEMINAR SERIES

Wind Plant Aerodynamics- A Spectral Analysis for Energy Entrainment

During the first portion of this seminar, extensive PIV data collected from a scaled down 3 blade, 3 x 5 turbine array is shown. In order to understand how large-scales motions play a role in providing mean kinetic energy (MKE) to the array, low dimensional tools based on a proper orthogonal decomposition (POD) are used to analyze the spatially developing velocity field inside the scaled array. From this analysis, modal decomposition of the Reynolds stresses and fluxes of the MKE are constructed. Thus, from these modal expansions it is established that low order modes have large contributions to Reynolds shear stress regardless of analysis domain. In addition, it will be shown that mean kinetic energy transport resulting from Reynolds shear stress typically serves to bring energy into the array while transport terms associated with Reynolds wall-normal stress typically removes energy from the array. Furthermore, it will be shown that the sum of the first 13 modes for the mean fluxes contributes 75% of the total Reynolds shear stress in the domain.

The concept of coherent transfers of energy is employed here as means to uncover the scales responsible for the entrainment of mean kinetic energy into the array. The major contributions to the MKE entrainment are achieved by large-scale motions associated with sums of the Reynolds shear stress, (idiosyncratic) modes. Thus, the sum of the first 9 modes yield 54% of the total energy entrainment, with scales given by L ~ 13D associated with this sum. From these results, it is clear that scales of the order of the total wind farm size are those, which are critical in determining how much power can be extracted from the atmospheric boundary layer. In addition, during this seminar it will be shown that dispersive stresses are also important in the energy entrainment and dissipation in wind arrays with complex topography and where proximity between turbines exists.

ABOUT THE SPEAKER

Luciano Castillo is the Don-Kay-Clay Cash Distinguished Engineering Chair in Wind Energy and the Executive Director/President of the National Wind Resource Center (NWRC) at Texas Tech University. After spending 12 years at Rensselaer Polytechnic Institute he joined the ME department at TTU in 2011. His research in turbulence using experimental techniques, direct numerical simulations and multi-scale asymptotic analysis has injected new ideas in turbulent boundary layers and improved our understanding of the effects of initial conditions on large scale turbulence, particularly on wind energy performance. Some of his awards include: the NASA Faculty Fellowship, the Martin Luther King Faculty Award, and the Robert T. Knapp Award on complex flows from the ASME among others. He published over 100 articles including a seminal paper on turbulent boundary layers and scaling laws.

TUESDAY, OCTOBER 8, 2013

2:00 - 3:30 pm, Kelly Hall 310

Dr. Castillo's presentation is co-sponsored by the Virginia Tech Center for Renewable Energy and Aerodynamic Testing (CREATe). Established in the fall of 2012, CREATe brings together faculty interested in wind energy who possess expertise in related technical areas. CREATe is designed to be interdisciplinary and is coordinated with Virginia Tech's Institute for Critical Technology and Applied Science.

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