

## On large scales of turbulence in the energy entrainment of wind farms

**Luciano Castillo**

Texas Tech University, USA

To understand what role large-scale motions play 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 of a 3 x 5 turbine array. Modal decomposition of the Reynolds stresses and fluxes of the MKE are constructed. From these, it is established that low order modes have large contributions to Reynolds shear stress. Additionally, it will be shown that MKE transport resulting from Reynolds shear stress and wall normal stress typically bring energy into and out of the array respectively. 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.

The concept of coherent energy transfers is employed here as means to uncover the scales responsible for entrainment of MKE into the array. Major contributions are achieved by large-scale motions associated with sums of the Reynolds shear stress modes. The sum of the first 9 modes yields 54% of the total energy entrainment, with scales given by  $L \sim 13D$  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. 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.

### Biography

Luciano Castillo has completed his Ph.D. in 1997 from the State University of New York at Buffalo. He is currently the Executive Director of the National Wind Resource Center and the Don-Kay-Clay Cash Endowed Chair at Texas Tech University. He has published many papers in journals such as J. Fluid Mechanics and Physics of Fluids on boundary layers, turbulence and aerodynamics. He has given several invited talks and has served as guest editor for journals such as J. of Turbulence and Physics of Fluids.

luciano.castillo@ttu.edu