Geophysical Research Abstracts
Vol. 14, EGU2012-13238, 2012
EGU General Assembly 2012

Turbulent flow and scalar flux through and over aligned and staggered wind farms

C.D. Markfort (1), W. Zhang (1), F. Porté-Agel (2,1)

(1) Saint Anthony Falls Laboratory, Department of Civil Engineering, University of Minnesota - Twin Cities, USA , (2) Wind Engineering and Renewable Energy Laboratory (WIRE), École Polytechnique Fédérale de Lausanne (EPFL), Switzerland

Wind farm-atmosphere interaction is complicated by the effect of turbine array configuration on momentum, scalar and kinetic energy fluxes. Wind turbine arrays are often arranged in rectilinear grids and, depending on the wind direction, may be perfectly aligned or perfectly staggered. The two extreme configurations make up the end members of a spectrum of infinite possible layouts. A wind farm of finite length may be modeled as an added roughness or as a canopy in large-scale weather and climate models. However, it is not clear which analogy is physically more appropriate. Also, surface scalar flux, including heat, evaporation and trace gas (e.g. CO_2) fluxes affected by wind farms, need to be properly parameterized in large-scale models. Experiments involving model wind farms in aligned and staggered configurations, consisting of 13 rows with equivalent turbine density, were conducted in a thermally-controlled boundary-layer wind tunnel. Measurements of the turbulent flow were made using a custom x-wire/cold wire within and over the wind farms. Particular focus was placed on studying the effect of wind farm layout on flow adjustment, momentum and scalar fluxes, and turbulent kinetic energy distribution. Results show that the turbulence statistics of the flow exhibit similar turbulent transport properties to those of canopy flows, but retain some characteristic surface layer properties in a limited region above the wind farms as well. The initial wake growth over columns of turbines in the aligned wind farm is faster. However, the overall wake adjusts within and grows more rapidly over the staggered farm. The effective roughness of the staggered farm was found to be significantly larger than that of the aligned farm. The flow equilibrates faster, and the overall momentum absorption is higher for the staggered compared to the aligned farm, which is consistent with canopy scaling. Lower surface heat flux was found for the wind farms compared to the boundary-layer flow without turbines, with a greater reduction in the staggered case.