Geophysical Research Abstracts
Vol. 15, EGU2013-13185, 2013
EGU General Assembly 2013

Experimental study of the impact of large-scale wind farms on land-atmosphere exchanges

wei Zhang (1), Corey Markfort (1), Fernando Porté-Agel (2,1)

(1) Saint Anthony Falls Laboratory, Department of Civil Engineering, University of Minnesota, Minneapolis, USA (wzhang@umn.edu, mark0340@umn.edu), (2) Wind Engineering and Renewable Energy Laboratory (WIRE), École Polytechnique Fédérale de Lausanne (EPFL), ENAC-IIE-WIRE, Switzerland(fernando.porte-agel@epfl.ch)

Wind energy is one of the fastest growing sources of renewable energy world-wide, and it is expected that many more large-scale wind farms will be built and cover a significant portion of land and ocean surfaces. By extracting kinetic energy from the atmospheric boundary layer and converting it to electricity, wind farms may affect the transport of momentum, heat, moisture and trace gases (e.g. CO_2) between the atmosphere and the land surface locally and globally. Understanding wind farm-atmosphere interactions and subsequent environmental impacts are complicated by the effects of turbine array configuration, wind farm size, land-surface characteristics and atmospheric thermal stability. In particular, surface scalar flux is influenced by wind farms and needs to be appropriately parameterized in meso-scale and/or high-resolution numerical models.

Wind-tunnel experiments of model wind farms with perfectly aligned and staggered configurations, having the same turbine distribution density, were conducted in a neutral turbulent boundary layer with a surface heat source. Turbulent flow and fluxes over and through the wind farm were measured using a custom x-wire/cold-wire anemometer; and surface scalar flux was measured with an array of surface-mounted heat flux sensors within the quasi-developed flow regime. Although the overall surface heat flux change produced by the wind farms was found to be small, with a net reduction of 4% for the staggered wind farm and nearly zero for the aligned wind farm, the highly heterogeneous spatial distribution of the surface heat flux, dependent on wind farm layout, is significant. The difference between the minimum and maximum surface heat fluxes could be up to 12% and 7% in aligned and staggered wind farms, respectively. This finding is important for planning intensive agriculture practices and optimizing agricultural land use with regard to wind energy project development. The well-controlled wind-tunnel experiments presented here also provide a first comprehensive dataset on turbulent flow and scalar transport in wind farms, which can be further used to develop and validate new parameterizations for surface scalar fluxes in numerical models.