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Experimental study of the horizontally averaged flow structure in a model wind-turbine array boundary layer[1] RAUL BAYOAN CAL, Portland State University, JOSE LEBRON-BOSQUES, Rensselaer Polytechnic Institute, HYUNG-SUK KANG, Johns Hopkins University, LUCIANO CASTILLO, Rensselaer Polytechnic Institute, CHARLES MENEVEAU, Johns Hopkins University — Wind-tunnel measurements are performed in order to quantify the vertical transport of momentum and kinetic energy across a boundary layer that includes a three-by-three array of model wind turbines. The data are obtained using stereo-PIV, on 18 planes surrounding a wind turbine. The data are used to compute mean velocity and turbulence properties averaged on horizontal planes. We compare the effects of turbulence stresses with those arising from the averaging of spatially varying mean flow distributions ("canopy stresses"). Results are compared with simple momentum theory and with models for effective roughness length scales that are often used to model wind turbine arrays in computer models for the large scales of the atmosphere. The impact of vertical transport of kinetic energy due to turbulence and mean flow correlations is quantified. It is found that the fluxes of kinetic energy associated with the Reynolds shear stresses are of the same order of magnitude as the power extracted by the wind turbines, highlighting the importance of vertical transport.

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