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Competing mechanisms of momentum transport in large wind farms[1] JOHAN MEYERS, Mechanical Engineering, University of Leuven, CHARLES MENEVEAU, Mechanical Engineering & CEAFM, Johns Hopkins University — In very large wind farms in the atmospheric boundary layer, energy, and momentum are on average transported from layers above the farm downward towards the turbines (Calaf, Meneveau, Meyers, Phys. Fluids 2010). In the current work, we investigate in more detail the three-dimensional flows of mass, momentum and energy towards individual turbines, based on a suite of large-eddy simulations. We find that there are two competing mechanisms which bring momentum to the turbines, i.e. a sideways flux, and a top-down flux of momentum (sideways fluxes themselves are fed by a top-down flux in regions outside the turbine wake area). For large spanwise turbine spacings, sideways momentum fluxes are dominating; for small spanwise spacings, the top-down mechanism is dominant. Inspired by these observations, we propose a new integral model for wind-farm performance, in which competing fluxes of momentum are represented by closed analytical expressions obtained by integrating momentum equations over different regions in the ABL.

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