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Do current and near-term future wind turbine deployments have a substantial impact on regional climate?

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Electricity from wind turbines (WT) currently supplies 6% of the U.S. national supply, and is projected to exceed 20% of electricity consumption by 2030. Achieving this target would require a quadrupling of installed wind energy capacity (of 84 GW, July 2017). However, questions remain about possible impacts of harnessing "the power of the wind" on the local to regional environment (i.e. 'inadvertent weather/climate modification'). Previous research on this issue has produced somewhat dichotomous results. Most observational studies have found robust statistical signature of WT wakes only at relatively short downwind distances from land-based WT arrays. While more substantial effects were manifest in early numerical research that represented the action of WT arrays as large roughness perturbations, more recent numerical simulations at both the global and regional scale that represent the action of wind turbines in a more realistic (though still parameterized) fashion and employ realistic WT densities indicate effects that are of modest magnitude. However, very few numerical studies have used realistic distributions of WT, explicit description of the WT rotor dynamics and/or have conducted simulations at high-resolution over at least a full seasonal cycle.

Year-long simulations of 2008 and 2015 are conducted using the WRF model applied at convection permitting resolution (4 km) over the eastern US to determine the impact of wind turbines on the mesoscale to regional climate. In the first simulation no WT effect is included, then a second simulation is undertaken using actual WT locations as of the end of 2014 along with their rated capacity, dimensions, thrust and power curves are employed along with the Fitch parameterization of the aerodynamics of the WT rotor. Two additional simulations are then undertaken for each year using doubled and quadrupled WT rated capacity to examine the scaling of impacts on likely future expansion of installed capacity.

On the basis of the first two simulations it is shown that while the presence of WT changes wind speeds and near-surface air temperature in 4 km grid cells in which WT are located, the impact at the regional scale on near-surface air temperature, specific humidity, the fluxes of latent and sensible heat, boundary layer heights and precipitation is not significant in any season other than summer. During summer, the maximum pairwise difference in grid cell mean temperatures is 0.5 K and the maximum increase in near-surface specific humidity is 0.4 g Kg-1. However, a spatial average of the mean seasonal perturbation of air temperature gives a net impact of < 0.1 K. Precipitation probability is also not significantly impacted in any season other than summer. In the summer the presence of WT is associated with a small decrease in precipitation probability and a decrease in season total precipitation of -2.6%. The finding of minor magnitude, but significant impacts, during summer can be used to contextualize results from previous analyses that have extrapolated inferences of substantial climate impacts from WT arrays deployed in the US Central Plains based on short-term simulations conducted for the summer season.