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Assessing Possible Climatic Impacts of Large Wind Farms Using Satellite Data

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This is an invited talk.

A growing number of numerical simulations with hypothetical wind farms generally agree that large wind farms might affect local to regional weather and climate. Here we present observational evidence for such impacts based on analyses of satellite derived land surface temperature (LST) data at ∼1.1 km for the period of 2003-2011 over a region in West-Central Texas, where four of the world's largest wind farms are located. A warming effect is observed at nighttime over wind farms relative to nearby non-wind-farm regions while the effect at daytime is small. Its spatial pattern couples very well with wind turbines geographically, particularly at nighttime in summer, and its magnitude exhibits a persistent upward trend, corresponding to the increase of operating wind turbines with time. There are no evident changes in land surface properties over the wind farm region. No warming effects are seen for a nearby non-wind-farm region with similar topography, particularly over high elevation ridges where the wind turbines are mostly built. Together, these results suggest that the warming effect observed in MODIS over wind farms are very likely attributable to the development of wind farms. This inference is also consistent with the diurnal and seasonal variations in the frequency of wind speed and direction distribution and the changes in near-surface atmospheric boundary layer (ABL) conditions due to wind farm operations. The nocturnal ABL is typically stable and much thinner than the daytime ABL and hence the turbine enhanced vertical mixing produces a stronger nighttime effect. The stronger wind speed and the higher frequency of the wind speed within the optimal power generation range in summer than winter and at nighttime than daytime likely drives wind turbines to generate more electricity and turbulence and consequently results in the strongest warming effect at nighttime in summer. Overall, the warming effect reported here is local and small compared to the strong background year-to-year LST changes.