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Land-Surface Temperature Impact from Large Scale Structure

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Abstract

Wind industry has experienced a rapid expansion of capacity after 2009, especially in India. Based on the analysis from Moderate Resolution Imaging Spectroradiometer (MODIS) land surface temperature (LST) data for period of 2005–2012, the potential LST impacts from the large-scale wind farms are investigated in this paper. It shows the noticeable night time warming trends on LST over the wind farm areas relative to the nearby non-wind-farm regions and that the night time LST warming is strongest in summer, followed by autumn and weakest in winter with no warming trend observed in spring.

Keywords: Land-surface-temperature; Large-scale wind farm; Impact; Heat effect

Introduction

Wind power installed capacity was significantly below the potential by the end of 2007, large-scale wind farms are being built at a rapid rate in recent years. Gaining the advantages of the abundant wind resources there, the ground-breaking ceremony of first 10 GW-level wind power projects, wind Power Base, took place on 8 August 2009 [1-2]. Since then, the capacity of the wind farms in known as the "World Wind Library" expanded dramatically. Records show that the installed wind capacity in hit 1.12 GW at the end of 2009, 3.0 GW at August 2010, 3.8 GW by the end of 2010, and 4.0 GW at May 2013 with a relatively low expansion speed from 2011 to 2012. Since the wind turbines convert wind kinetic energy into electricity, some efforts have been dedicated to the impacts from the installation and operation phases of wind farms on local climate. Wind turbines could modify the surface-atmosphere exchanges by increasing surface roughness, changing the stability of atmospheric boundary layer (ABL), enhancing turbulence in the rotor wakes, and interrupting the low-level-jet in stable ABL. A few studies show that the large-scale deployment of wind farms alters the local temperature by up to a few degrees, reduces precipitation by up to 20 per cent, and even mitigates extreme weather.

The possible impacts of wind farms on surface temperature, to date only a few studies have used the observed data from operational wind farms, such as the measurements in California and in the Midwestern US. The warming effect from wind farms at night was firstly revealed and was attributed to the turbulence generated by the rotors enhancing the vertical mixing [3]. In the stable atmosphere when a warm layer overlies a cool layer, enhanced vertical mixing mixes warm air down and cold air up, leading to a warming near the surface. Then, in situ observations from a large onshore wind farm show that there is little impact on the potential temperature structure during day, but at night the presence of the wind farm does significantly decrease the vertical gradients of potential temperature, largely by increasing the 2-m temperature.

The analysis from MODIS LST data, we further the recent work carried in (2012) through investigating the potential LST impacts from the large-scale wind farms where the topography and climate conditions are significantly different from those in USA. Our analysis shows significant warming trends at night time during summer, autumn, and winter for the period 2005–2012, but no noticeable impact is detected during daytime. In terms of the seasonal magnitude of the warming trend, it shows that the night time LST warming is strongest in summer, followed by autumn and weakest in winter with no warming trend observed in spring. The night time warming trends of LST compared to LST with the magnitude of years show that the LST impacts from wind farms are less than those from the urban area [4]. These warming signals are important for the development of wind project in , since the spatial pattern couples well with the geographic layouts of wind turbines, which provides further observational evidence for the WF-induced surface warming at night time proposed by in (2012). However, analysis of seasonal variations in wind speed suggest that the seasonal variations in the magnitude of the warming trends in do not correspond to the magnitude of wind speeds, which is totally different from the work carried [5]. Further understanding about the complex processes in this question will rely on more and longer observations in the future.

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