Analysis of a complex terrain effect on wind flow pattern using lidar and nacelle-mounted anemometer measurements.

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Abstract
Wind energy encounters challenges due to variability in the wind resource. Complex terrain and synoptic scale meteorological processes are contributors to this variability. The effect of complex terrain on the local wind flow is investigated using data from nacelle-mounted anemometers and Doppler lidar in the second **W**ind **F**orecast **I**mprovement **P**roject (WFIP-2) study area.

Introduction

To study the potential effects of terrain on mean wind flow patterns, sites with variable terrain, eg. hills and valleys, are selected. Two west to east transects (Figure 1), approximately 10 km in distance are identified in a region heavily utilized by wind turbines for wind power production.

Observations and Analysis

Wind speed and direction measurements are available from 55 nacelle-mounted anemometers and a Leosphere 200S Doppler lidar located near the Wasco State Airport, OR. Data are available for the time period of January 2016 – March 2017 in 1-minute intervals for the turbine data, and 15-minute intervals for the Doppler lidar. Wind speed measurements from nacelle-mounted anemometers are grouped by similar hub-heights and longitudinal position within each of the two transects. Only anemometer measurements with statistically similar wind flow (correlation > 0.98 between turbines included in the group) are used to compute a nightly group mean speed.

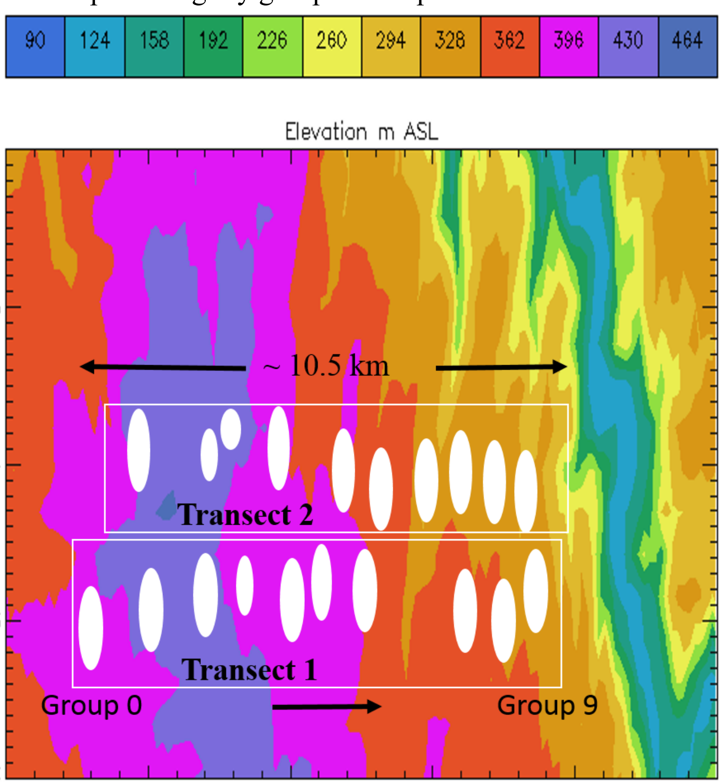

Figure 1. Map of the study area shows terrain elevations (m) according to the color scale on the top of this figure. Two white boxes indicate west to east transects of turbine groups shown by white ellipses.

Results

A terrain influence on the pattern of westerly, night-time wind speed is persistently observed over each of the two transects, independent of the magnitude of the mean wind speed, power production, or season.

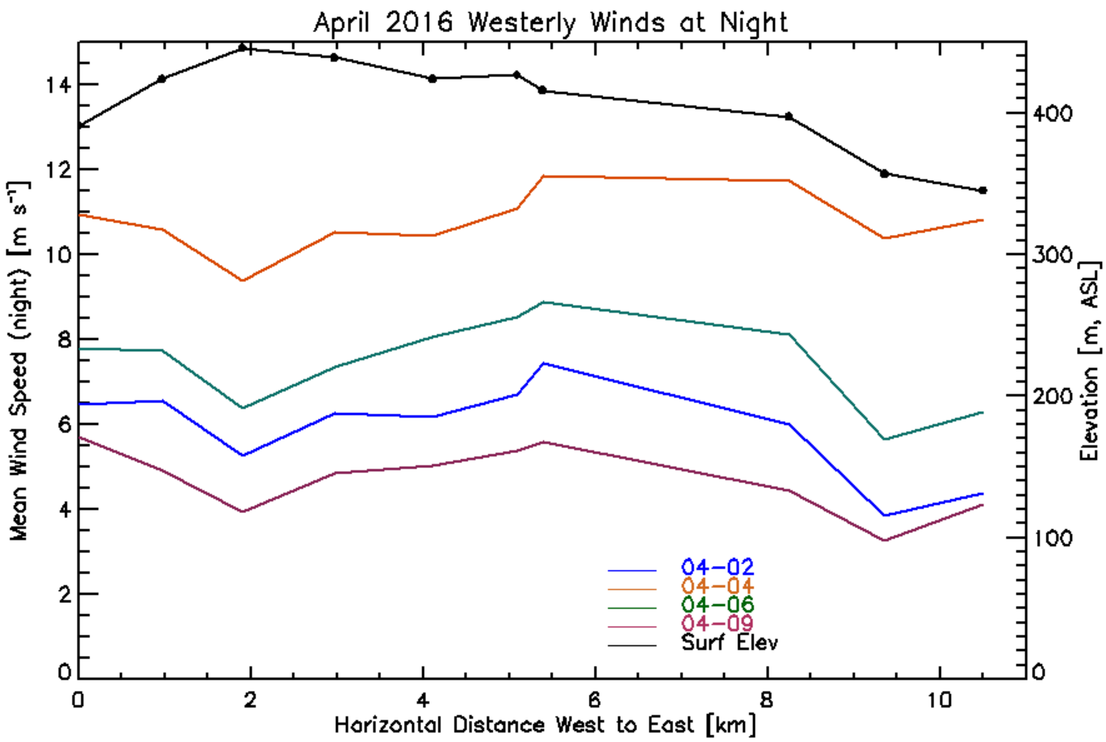

Figure 2. Nightly mean wind speeds for April and the mean terrain elevation as a function of distance (group) for transect 1. April 2 = blue, April 4 = orange, April 6 = green, April 9 = purple, terrain elevation, m, ASL = black dotted line.

Conclusions

Lidar observations of hub height winds were used to evaluate the reliability of the nacelle-mounted anemometer measurements. Data from four turbines, within the field of view of the lidar, were compared to the lidar measurements through orthogonal regression analysis. These statistical results show good agreement and indicate the nacelle measured wind speeds are representable for analysis.

Analysis of the nacelle-mounted anemometer measurements of westerly winds for the each night of the year shows clear indication of a terrain effect on mean wind speed regardless of the months or season. In addition to, the terrain effect seems to dominate any wind farm induced effects. Once the terrain influence is properly quantified, it can be removed from the wind measurements to investigate the effects of wind farms. This analysis will allow developing improved wind farm parameterizations for use in the numerical weather prediction models.

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