Virtual Tower Measurements during AWAKEN

Introduction

The American Wake experiment (AWAKEN) is an international, multi-institutional wind energy field campaign which is currently underway in the vicinity of the King Plains wind farm, south of the ARM Southern Great Plains (SGP) Central Facility. The goal of AWAKEN is to provide observations to better understand interactions between wind turbines in a wind farm as well as the overall impact of the wind farm on the lower atmospheric boundary layer.

One component of AWAKEN involves the use of dual-Doppler lidar measurement techniques to observe inflow and outflow (wakes) from individual turbines. In this paper we present preliminary results from the deployment two (ARM) scanning Doppler lidars that were used to measure profiles of wind speed and direction using the so-called virtual tower technique.

Methods

An asynchronous dual-Doppler scanning method is used to create a linear array of three virtual towers extending southward from the leading row of turbines in the King Plains wind farm. Virtual towers are formed at the intersection of two Range-Height-Indicator (RHI) scans, where radial velocity measurements from both lidars are used to compute profiles of wind speed and direction, as well as estimates of uncertainty.

Results

In contrast to traditional single-Doppler ground-based wind profiling, the virtual tower method 1) makes no assumption of horizontal homogeneity, 2) enables much finer vertical resolution, and 3) enables profiling very close to the surface. The examples below show time-height displays of wind speed and direction retrieved from three virtual towers for December 5, 2022 (left) and January 7, 2023 (right). Comparing winds from three virtual towers on a given day reveals the impact of the H05 turbine on “283_326” tower. In the examples below, the wake from the H05 turbine significantly reduces the wind speeds at “283_326”. The example on the left (5 Dec 2022) also shows a strong deflection of the winds in the wake of the turbine.

Raw and processed data will be made available through the A2E Data archive and portal @https://a2e.energy.gov/data#.