Unprecedented Observations of Complex Terrain Influences on Wind Resources and Wind Turbine Wakes: An Overview of the Perdigão Field Campaign

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Abstract

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Introduction

In early 2017, the Perdigão field campaign took place in the Vale do Cobrão (Valley of the Snake) in central Portugal. This valley is nestled between two ridges approximately 150-200m higher than the center of the valley; the two ridges are separated by approximate 1500m, and the southwest ridge has one wind turbine. The field campaign, which leveraged support from several funding agencies and institutions from Europe and the US, was designed to closely observe the dynamics and thermodynamics of flow within, above, and around the valley to help understand wind energy physics and improve short-time predictability of airflow in mountainous terrain. This presentation will present an overview of the instrumentation and new measurement methods deployed in the campaign, as well as initial results from the data analysis and modeling studies.

Data and Methods

The Perdigão campaign's instrumentation array was remarkably dense with meteorological towers, remote sensors, and airborne instrumentation. While the Vale do Cobrão is only approximately 6 km along and 2 km wide, 54 flux towers with heights ranging from 10–100 m (see Figure 1) deployed 184 total sonic anemometers, along with thermistor arrays, LiCORs® for sampling carbon dioxide and water

vapor fluxes, and radiometers to sample incoming, outgoing, and net radiation. Winds in the lower boundary layer were carefully observed with 21 scanning lidars, 7 profiling lidars, two sodars, and 2 radar wind profilers. Remotely-sensed measurements of temperature and moisture were also collected with three microwave radiometers, atmospheric emitted radiation interferometers (AERIs), differential absorption (water vapor) lidar (DIAL), and ceilometers. At least 112 radiosondes were launched to measure profiles of temperature, winds and relative humidity, primarily from a site within the valley but on occasions from two sites outside the valley. Two tethered lifting systems flew turbulence probes inside and outside of the valley. Other instrumentation included microbarographs and nanobarographs to record pressure and acoustic propagation, and seismometers to assess gustiness of the flow.

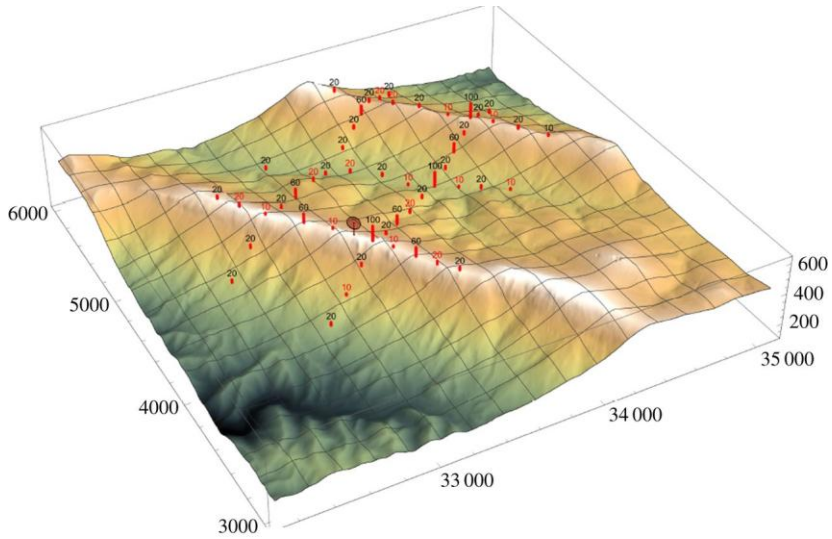

Figure 1: Terrain and planned layout of towers for the Perdigão 2017 campaign. Figure from Mann et al. 2017[1]

Results

Perdigão is a rich and extensive dataset. At this early point in the data analysis, we have observed wind turbine wakes that follow the terrain down into the valley as well as wind turbine wakes that are lofted above the valley. Several cases of recirculation of flow within the valley occurred during the intensive measurement campaign. Mesoscale-microscale modeling of these cases is underway.

Conclusions

Due to tremendous cooperation between European groups funded by the ERANET+ mechanism, European groups funded with other mechanisms, US groups funded by the National Science Foundation, and US groups funded by the US Department of Defense, a rich and extensive dataset has been collected to study flow in complex terrain. The larger scientific community is invited to access data via project websites, such as the US site at https://www.eol.ucar.edu/field_projects/perdigao, with quick-view plots at http://catalog.eol.ucar.edu/perdigao, as well as the Portuguese site at http://winds.fe.up.pt/wiki/doku.php.

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References

1. Mann, J. *et al*. Complex terrain experiments in the New European Wind Atlas. *Phil Trans R Soc A* **375,** 20160101 (2017).