Predicting persistent cold pool events

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Wind turbines along the Columbia River Gorge. Credit: Paytsar Muradyan / Argonne National Laboratory.

Hot air rises, cold air sinks. It's a basic tenet of nature.

Because it sinks, cold air often finds depressions or low-lying terrain, like a valley or basin, in which to collect, particularly at night as temperatures decrease. As the sun rises and temperatures rise, the cold air warms and mixes with the surrounding air. But during winter, and

even into spring, this cold air can linger—often for several days—in a phenomenon known as a "cold pool event."

Cold pools can trap pollutants that would normally mix and disperse with larger air currents, causing serious health risks in heavily populated urban areas. Known to reduce wind speeds and produce freezing rain, they also can negatively impact wind turbines in the area, diminishing electricity production in the short term and potentially damaging turbines.

Researchers at the U.S. Department of Energy's (DOE) Argonne National Laboratory recently collaborated in an 18-month, multi-institutional field campaign with the National Oceanic and Atmospheric Administration and other DOE-sponsored laboratories to study cold pool events in the Columbia River Gorge, along the Oregon-Washington border. The goal of the research is to better understand and forecast cold pool events, as part of DOE's Wind Forecast Improvement Project. Their findings were recently published in the Journal of Applied Meteorology and Climatology.

"As it stands, cold pool events are not well characterized for numerical weather prediction (NWP) models," explained assistant atmospheric scientist Paytsar Muradyan of Argonne's Environmental Science division. "Without accurate forecasting of these events, it becomes very difficult to prepare for them, particularly for energy producers."

Inclement weather caused by cold pool events can decrease the longevity of wind turbines, particularly if the turbines are still active during these poor conditions. Freezing rain, for example, will still damage turbines at rest, but will cause more damage the faster they are moving, leading to issues with the overall production of electricity and the stability of the electrical grid.

"If you cannot predict these events, you can't plan for and accommodate changes in your production of electricity," said Muradyan. "You think you will be producing a certain amount of electricity one day, but with sudden low winds caused by a cold pool event, you won't be."

The unpredictable effects of cold pool events on electricity generation can continue even after the event has subsided. When the cold air finally does mix with and disperse into warmer air, it can cause sudden and dramatic shifts in wind speed and direction, referred to as "ramp-ups" or "wind ramps."

"Improving the prediction of these wind ramps can lead to a more stable electrical grid and an overall lower cost of electricity," Muradyan explained.

To get to those predictions, the researchers collected large amounts of data to characterize cold pool events. These data can then be used to improve parametrization in NWP models. The researchers were primarily interested in collocated vertical profiles of wind speed, wind direction, temperature and humidity to develop criteria for cold pool identification.

Argonne provided two of the radar wind profilers and two of the sodar wind profilers; both were used to analyze the depth of the cold pools and the wind speed distribution. Two radio acoustic sounding systems were used for temperature profiling.

"The idea was to use these measurements, gathered in a complex terrain like the Columbia River Gorge, to develop criteria to determine whether a cold pool event is taking place," said Muradyan. "Factoring in temporal continuity, or the length of the events, we developed an algorithm to identify all of the cold pool events during the 18 months of the study."

The algorithm, Muradyan continued, could potentially be applied to other locations to improve NWP forecasting of inclement weather caused by cold pool events.

"Getting advance notice to the average citizen, as well as energy companies, is what we're striving for," she added, "because this research has the potential to improve health and reduce energy costs."

An article describing the research, "Identification and Characterization of Persistent Cold Pool Events from Temperature and Wind Profilers in the Columbia River Basin" was published in the *Journal of Applied Meteorology and Climatology* in November.

More information: Katherine McCaffrey et al. Identification and Characterization of Persistent Cold Pool Events from Temperature and Wind Profilers in the Columbia River Basin, *Journal of Applied Meteorology and Climatology* (2019). DOI: 10.1175/JAMC-D-19-0046.1

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