Improving Wind Ramp Forecasts by the HRRR System via Statistical Post-processing

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Abstract

Wind power forecasting is gaining international significance as more regions promote policies to increase the use of renewable energy. In this study, we compare different methods to generate probabilistic wind ramp forecasts from the High-Resolution Rapid Refresh (HRRR) numerical weather prediction model with up to twelve hours of lead time at two tall-tower locations in the United States. We validate model performance using 18 months of 80-m wind speed observations from towers in Boulder, Colorado and near the Columbia River Gorge in eastern Oregon.

Keywords: *Ramps, HRRR, Statistical post-processing, Probabilistic forecasts*

Introduction

Wind ramps, large variations in wind power production during a period of minutes to hours, challenge utilities and electrical balancing authorities. A sudden decrease in wind energy production must be balanced by other power generators to meet energy demands, while a sharp increase in unexpected production results in excess power that may not be sold to the grid, leading to a loss of potential profits. In this study, we use statistical post-processing to improve wind ramp forecasts and gain uncertainty information by turning deterministic forecasts from the HRRR model into a range of possible forecast scenarios.

Methods

We employ three statistical post-processing methodologies, two of which are not currently used in the literature for wind forecasting to correct biases in the HRRR model and to generate ensembles of short-term wind speed and power production scenarios. This probabilistic enhancement of HRRR point forecasts provides valuable uncertainty information of ramp events and improves the skill of predicting up- and down-ramp events over the raw forecasts. We illustrate how we use one of the ensemble statistical methods to generate forecasts and gain uncertainty information based on past historical wind speed scenarios in Fig. 1. We also compute Brier skill scores for each ensemble method at predicting up- and down- ramps to determine which method provides the best prediction of ramp events.

Results and conclusions

The Standard Schaake Shuffle, one of the multivariate methods we employ to generate probabilistic forecasts yields the best performance at predicting up- and down-ramps when compared to observations, but due to the complex terrain of the two sites we analyzed, it was difficult to obtain significantly positive skill scores when predicting ramps. Forecasts for wind ramps in locations with less complex terrain such as the Great Plains may yield even better results. These statistical methods can be implemented by wind farm operators to generate a range of possible wind speed and power scenarios to aid and optimize decisions before ramp events occur.

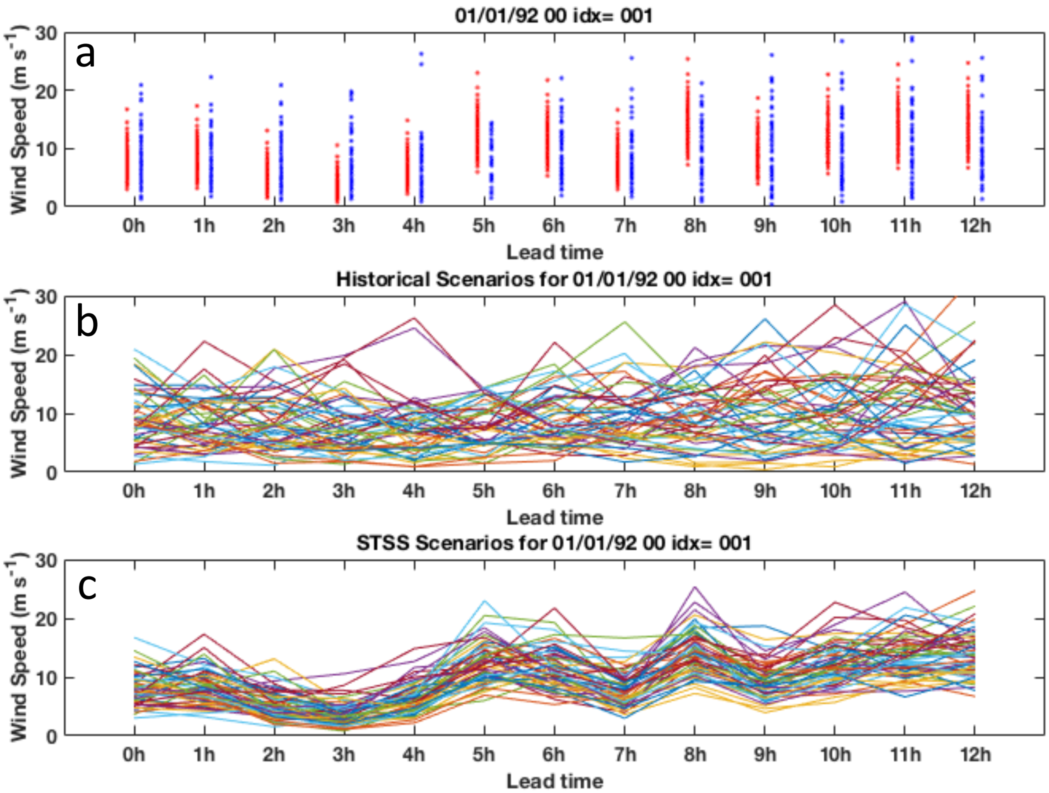

Figure 1. Illustration of how the multivariate Standard Schaake Shuffle (STSS) method uses fifty historical wind speed scenarios to remap and gain information about the uncertainty of the HRRR forecasts. Fifty quantiles (a, red dots) from a predictive distribution that defines our wind speeds and a distribution of equal size of historical wind speed scenarios (a, blue dots) show the spread of uncertainty for a given day, model initialization, and for each forecast lead time. Historical scenarios selected by the STSS (b) are then used to inform us how to connect each of the red dots in (a) across lead time to produce realistic shapes of forecast scenarios based on how past wind speeds behaved. The ensemble of forecast scenarios generated by the STSS method (c) can be used by wind farm operators to identify future ramp events and the uncertainty associated with them.