Powering Up with Space-Time Wind Forecasting

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Abstract: The technology to harvest electricity from wind energy is now advanced enough to make entire cities powered by it a reality. High-quality short-term forecasts of wind speed are vital to making this a more reliable energy source. Gneiting et al. (2006) have introduced an accurate and sharp model for forecasting the average wind speed two hours ahead based on both spatial and temporal information; however, this model is split into nonunique regimes based on the wind direction at an off-site location. This work both generalizes and improves upon this model by treating wind direction as a circular variable and including it in the model. It is robust in many experiments, such as predicting at new locations and under rotations of the wind directions. We compare this with the more common approach of modeling wind speeds and directions in the Cartesian space and use a skew-t distribution for the errors. The quality of the predictions from all of these models can be more realistically assessed with a loss measure that depends upon the power curve relating wind speed to power output. This proposed loss measure yields more insight into the true worth of each model's predictions.

Keywords: Circular variables; Power curve; Skew-t distribution; Space-time modeling; Wind direction and speed.