8.5 A globally relocatable high-resolution WRF realtime forecast system for renewable energy.

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Utopus Insights has developed a globally relocatable high-resolution WRF-based forecasting system code-named "Nostradamus" to support its time-sensitive, high-resolution atmospheric modeling applications including wind and solar energy forecasting. Nostradamus predicts meteorological variables including wind, wind gusts and solar irradiance,. and drives downstream energy applications such as Wind HyperCast, Solar HyperCast and Demand forecasting, which in turn feed a peak demand forecasting application. The downstream applications use machine learning techniques at their core to incorporate high-dimensional weather forecasting data for improved forecasting accuracy. Nostradamus is currently initialized from GFS and runs up to 4 times per day depending on the client application, assimilating available meteorological observations within a time window prior to the initialization time, using the FDDA technique. Nostradamus also has an automated on-the-fly validation system to provide the client with confidence on the forecast accuracy of relevant meteorological features. Built with high scalability across various computing platforms, Nostradamus can readily be deployed on local HPC clusters, stand-alone machines as well as in the cloud. Utopus Insights has been using Nostradamus successfully around the globe for its clients for various renewable energy applications.

For Solar HyperCast, Nostradamus predicts the direct and normal radiation components, as well as the diffused component that is an important contributor to solar power production on days of thin clouds. In addition, Nostradamus-predicted snow cover and snow fall rate were recently added to Solar HyperCast, which improves the forecasting accuracy on the days after a snowfall, when the irradiance might be high, but the snow cover on panels drives lower power production. For Wind HyperCast, Nostradamus offers various wind forecasting outputs including hub-height wind speed as well as wind gusts. Further improvement of the wind energy forecasting has been achieved based on the multi-layer feed-forward perceptron, a class of deep learning algorithms.

Based on our systematic validation for meteorology, the current Nostradamus configuration predicts wind speed and direction with reasonable overall model mean absolute errors (typically 1 m s-1 for wind speed and 30 degrees for wind direction). However, the surface air temperature prediction shows an overall cold bias (~1-2 K). In addition, compared with the temperature at the first model level, the diagnostic 2-m temperature field tends to have larger error (~2-3 K). Validation based on renewable energy production indicated improved Solar HyperCast forecasting with the added snow feature (e.g., 15% error reduction on snowy days for a group of solar farms in the North-Eastern US). Similarly, errors of Wind HyperCasts decreased from 14-16% to as low as 5-7% by also exploiting Nostradamus forecasts of temperature, air density and wind gusts in addition to those of wind speed. In this

presentation, we will introduce Nostradamus and present model validation results as well as results from use cases for both meteorology and renewable energy forecasting.