Improving the Accuracy of Wind Gust Forecasts for Power Distribution Systems

Rafael Toshio Inouye, C. Beneti, L. Calvetti, L. E. S. Oliveira, and S. Paz

Challanges in Wind Gust Forecasting

Variability

Wind gust forecasts are challenging due to their high spatio-temporal variability, making them difficult to predict accurately.

Impact on Power Infrastructure

Wind gusts affect power generation and distribution, leading to potential power outages and infrastructure damage.

Regulatory Impact

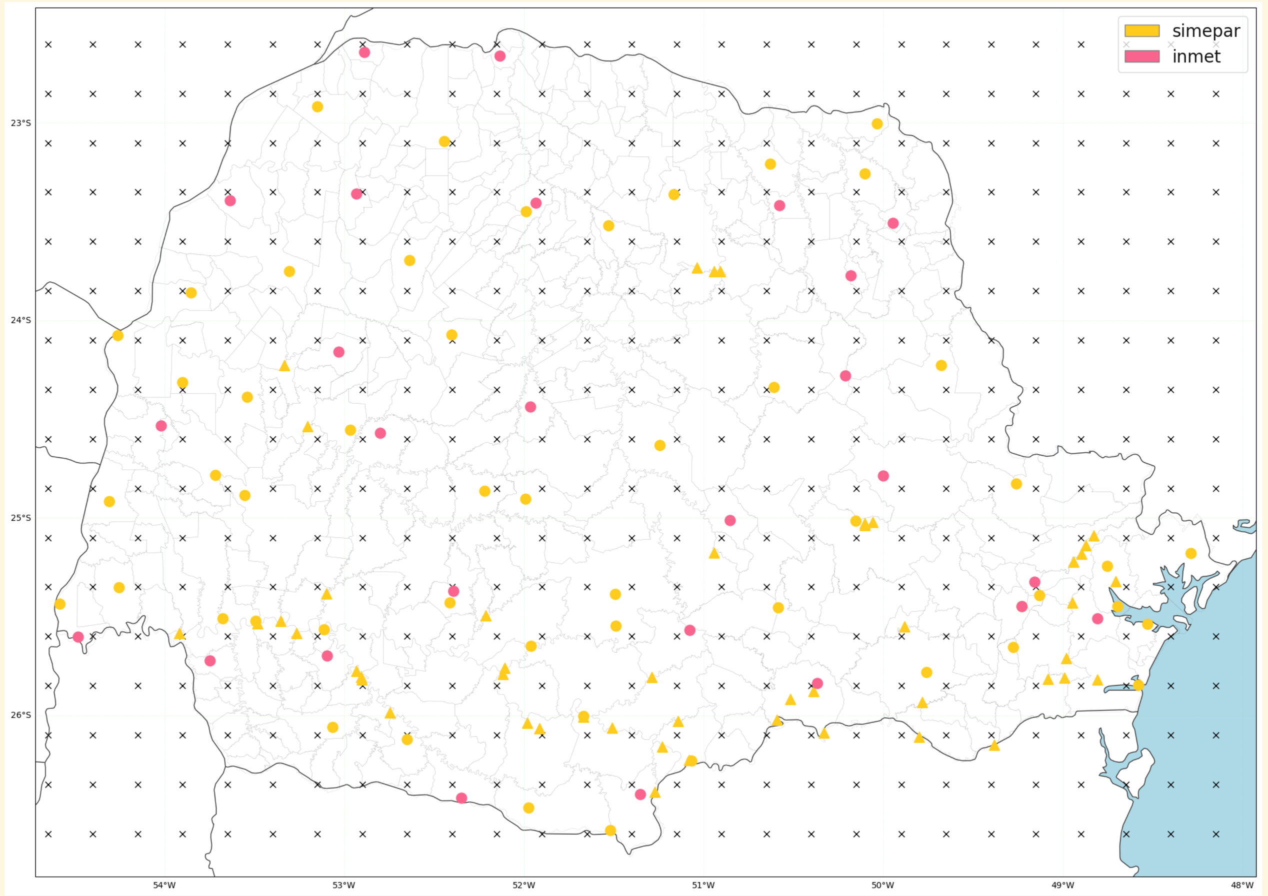
Regulatory bodies, like ANEEL in Brazil, impose penalties for power outages, emphasizing the need for accurate forecasting to maintain supply levels.

Data preparation

Surface Stations locations and Model grid points

Surface data was provided by SIMEPAR and INMET, their data were used as labels during training (figure 1).

Figure 1 - Model grid points and surface stations

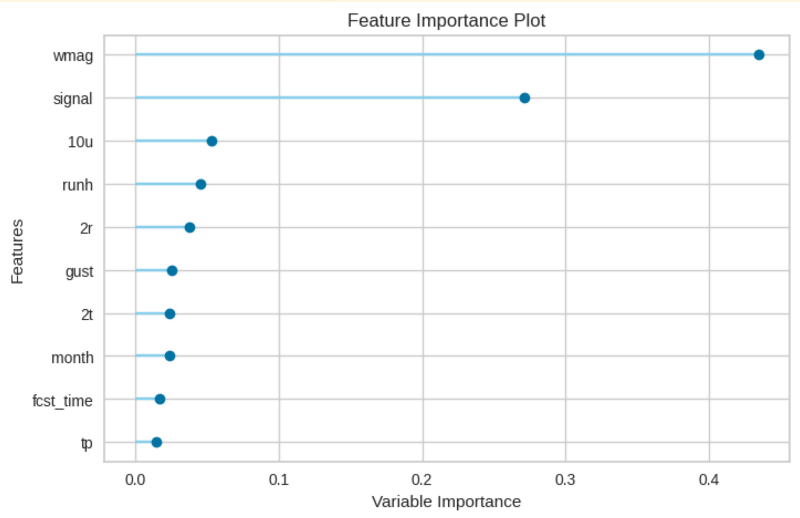


Features

Features were extracted from WRF outputs, the avaible variables were:

- Maximum gust at 10m
- Total precipitation
- Surface pressure
- Temperature at 2m
- Relative humidity at 2m
- Wind direction at 10m
- Mean wind speed at 10m

Figure 2 - Feature Importance



An XGBoost model was setup to classify whether the error would be very negative, less than -2m/s, neutral, or positive, greater than 2m/s. This output was used as an additional feature. Other features like initialization hour, month and forecast time were also passed as features to the regression model.

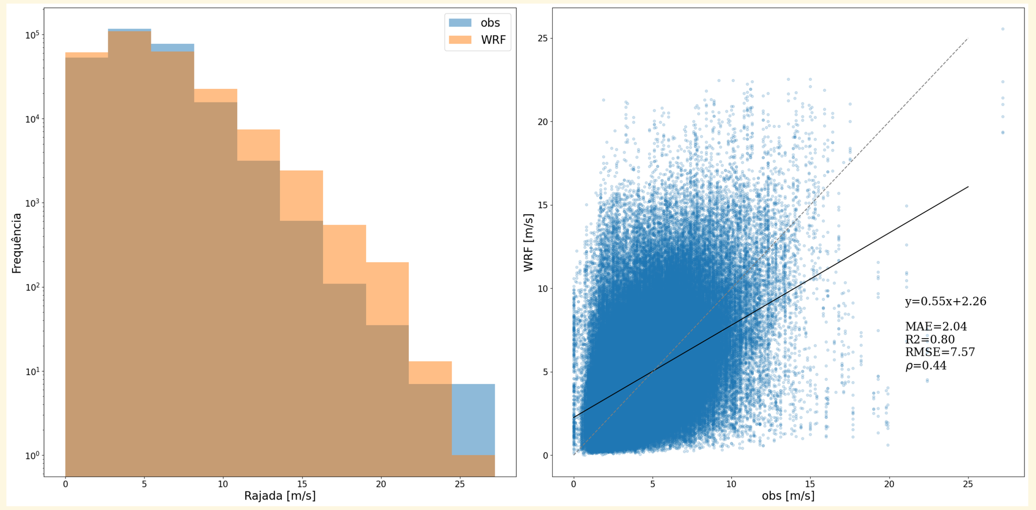
Results

An experiment was conducted to test the feasibility of correcting predicted gust data. Curitiba was chosen as a case study because it is the capital of Paraná and has a large population.

After adjusting the machine learning model, it was found that the two most important features were the wind magnitude at 10 meters and the error signal classification. Unexpectedly, the actual gust prediction originally given by the numerical model was only the sixth most important information for the ML model (figure 2).

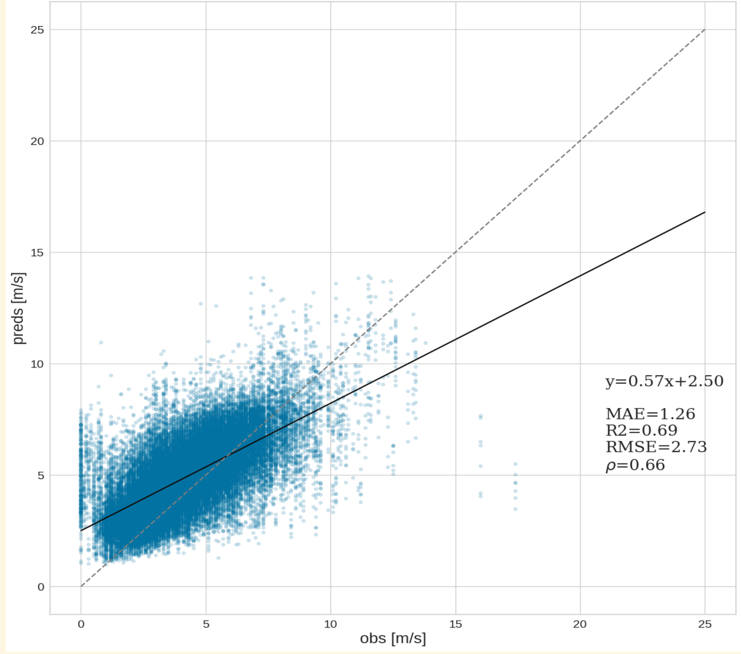
Observing the numerical model predictions for the wind gust variable at the Curitiba (figure 3) station, it can be seen that there is a similarity in the distribution, but with a tendency to overestimate less intense gusts and underestimate more intense gusts.

Figure 3 - Gust observation compared to WRF forecasting



Using the corrected predictions by the ML model, an improvement in the prediction can be seen, mainly from the point of view of the RMSE, which shows that the forecasts are less dispersed in relation to the observations. There was also an improvement in the Pearson correlation, but the R2 score indicates that the current model explains less of the gust variance.

Figure 4 - Gust observation compared to corrected WRF forecasting



Conclusions

A simple machine learning model was proposed to verify the feasibility of the work. The results for the municipality of Curitiba indicate that machine learning architectures are possible solutions for the problem of post-processing of gust predictions. The grid point approach has the major disadvantage of disregarding the spatial and temporal correlation of meteorological events. To address this problem, it is intended to apply other architectures such as CNN.