Wind Power Forecasting using WRF and ANN enhanced with Statistical Capabilities

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Introduction

The significance of wind power is at its peak with ever increasing energy demand and environmental concerns associated with fossil fuel based power generation. Integrating the available wind power capacity to the grid is a challenging task because of its intermittent nature. Wind power penetration to the grid can be improved and grid stability can be attained by enforcing accurate wind power forecasting. Forecasting gives an estimate of wind power that can be generated at any given instance, with which power generation at conventional power stations can be properly planned and scheduled.

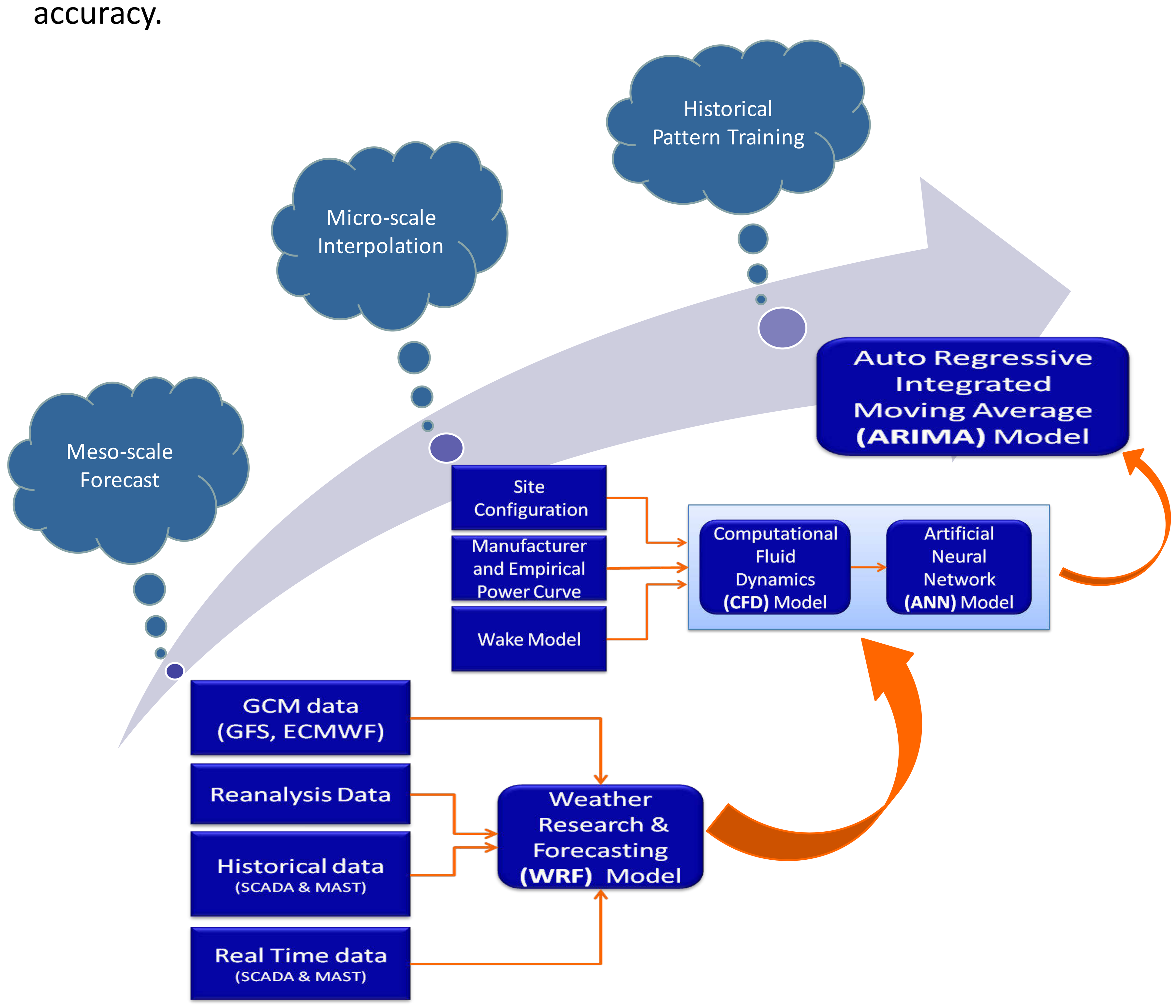
Objectives

Improving wind power forecasting accuracy with hybrid model approach combining,

- Numerical Weather Prediction based Weather Research and Forecasting (WRF) model.
- Computational Fluid Dynamics (CFD) along with Artificial Neural Network (ANN) technique.
- Statistical method based Auto Regressive Integrated Moving Average (ARIMA) model.

Approach

➢Physical conditions of the atmosphere are clearly represented with the help of WRF. Global Forecast data from different global models are used to specify the boundary conditions for a limited area of interest using nesting. Site specific data from turbine SCADA and weather monitoring stations are incorporated in WRF to specify the local atmospheric and physical conditions with greater accuracy.



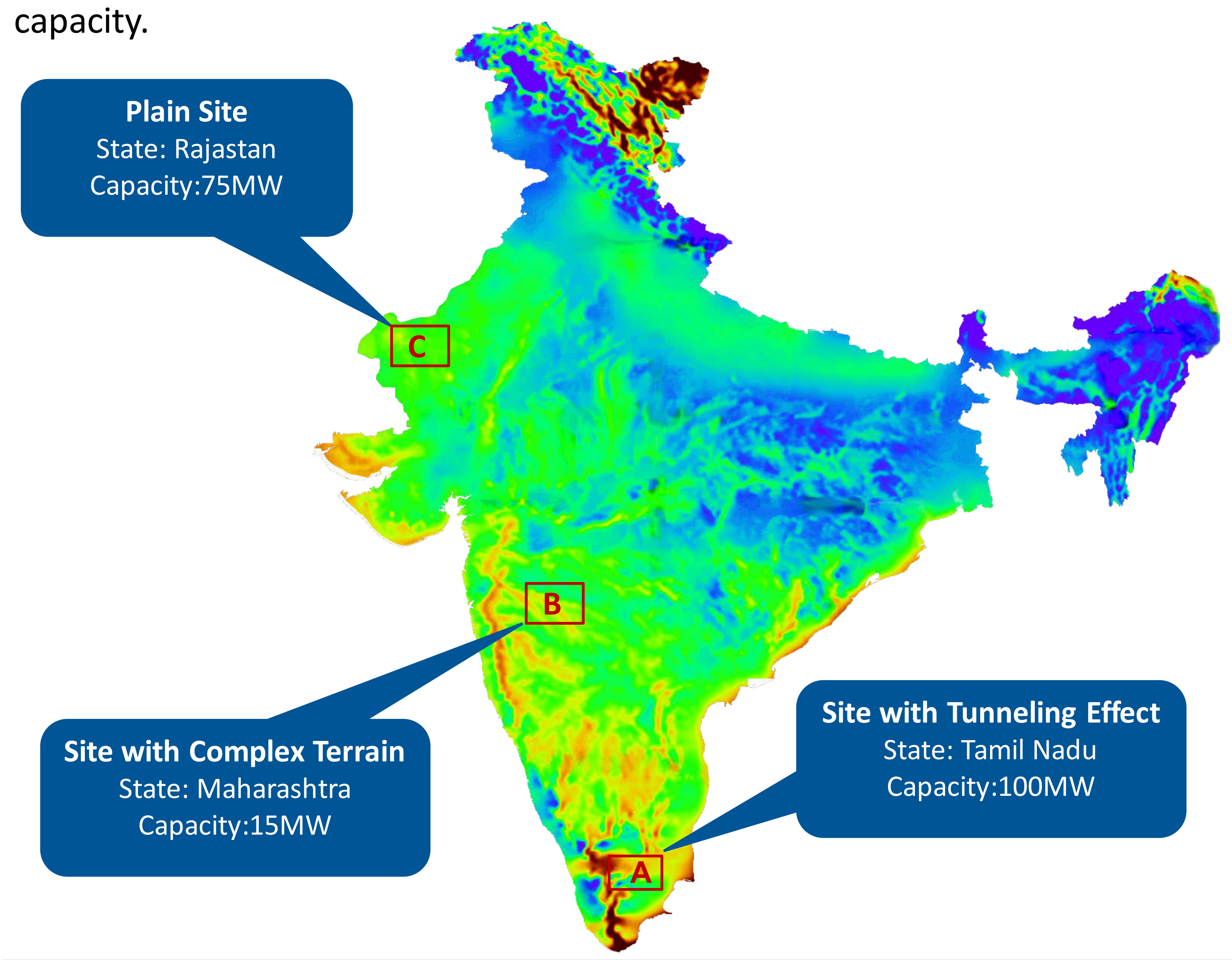
Block Diagram of Hybrid Model Methodology

➢Forecasted wind speed output of WRF is fed into CFD based ANN solution and meso-scale wind speed output of WRF is interpolated to micro-scale level using its built-in downscaling technique. Forecast tool, using its ANN feature, train the model with the actual wind speed obtained at site and forecasted wind speed obtained from WRF and calibrates the model accordingly to adjust itself to the error between forecasted and actual wind speed. CFD along with forecast tool is used to forecast the wind power at site level.

➢Univariate statistical model based ARIMA is used in the final stage to improve the wind power accuracy by training the model with historical data to follow the trend or pattern associated with wind power generation.

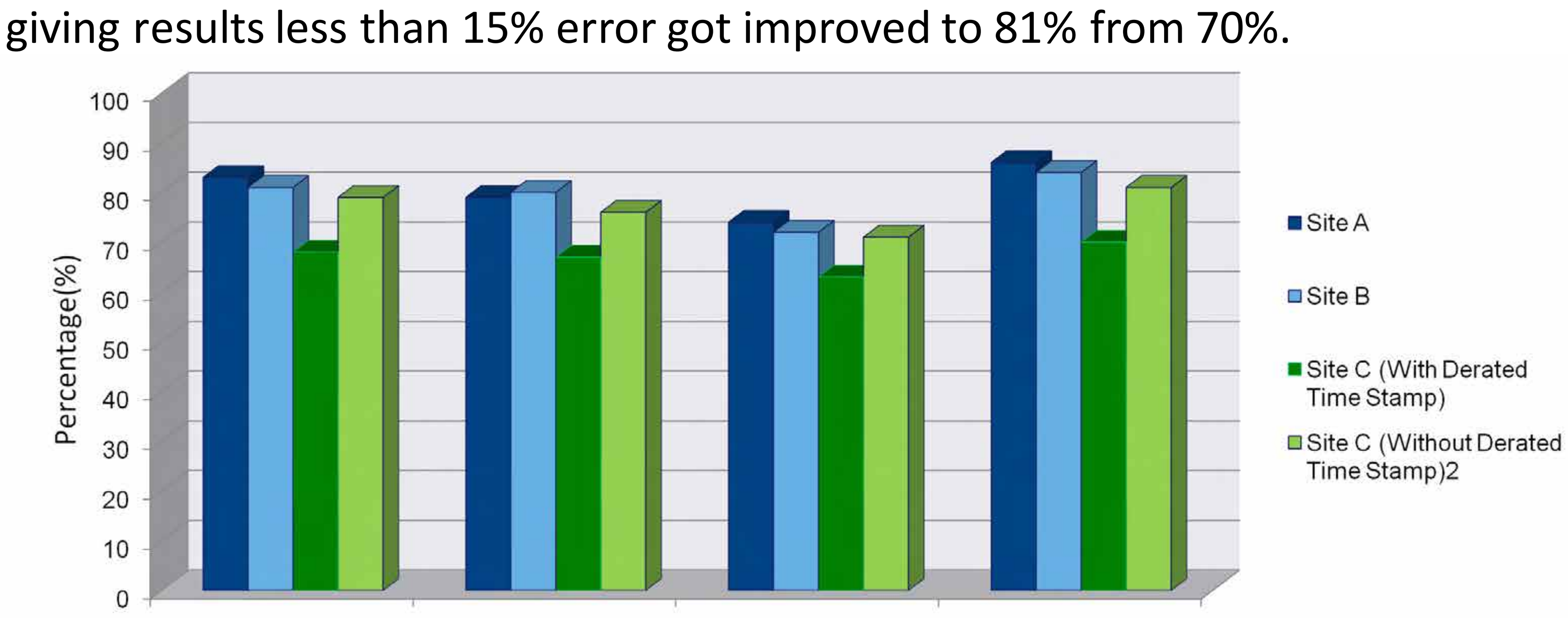
Investigation

Performance of the developed wind power forecasting system is tested at three different sites in India, each having different levels of terrain complexities. Site A is in a location where tunneling effect prevails, Site B is a complex site and Site C is a plain site in the desert area. Absolute Percentage Error (APE) is used as evaluation criteria to validate the result with actual data. Validation is done by calculating APE for forecasted wind power with respect to the available capacity.



Results

Validation is done by calculating APE for forecasted wind power with respect to the available capacity. For a period of six months with 15 minutes time stamp, the validation result shows, in two out of three sites, 86% and 84% of time the results were within the forecasting error band of 15% and in third site it was around 70%. On investigation, curtailment (de-rating) due to grid constraints was found to be the reason for a low 70% here. When the curtailment affected time stamps were removed from calculation, the percentage of time the model giving results less than 15% error got improved to 81% from 70%.



Percentage of Time Period Wind Power Forecasting Error less than 15% Error Band

Conclusion

Hybrid model developed using WRF, CFD based ANN and ARIMA improves the accuracy of wind power forecasting and it also proves to be suitable for different terrain conditions with varying complexities.

References

1. Wang, Wei, et al., "ARW Version 3 Modeling System User's Guide," *Mesoscale and Microscale Meteorology Division-National Center for Atmospheric Research (MMM-NCAR)*, 2016.
2. Zhao, Weigang, Yi-Ming Wei, and Zhongyue Su. "One day ahead wind speed forecasting: A resampling-based approach." *Applied Energy 178* (2016): 886-901.
3. Xu, Qianyao, et al. "A short-term wind power forecasting approach with adjustment of numerical weather prediction input by data mining." *IEEE Transactions on Sustainable Energy* 6.4 (2015): 1283-1291.
4. Zhao, Erdong, et al. "Hybrid Wind Speed Prediction Based on a Self-Adaptive ARIMAX Model with an Exogenous WRF Simulation." *Energies* 9.1 (2015): 7.
5. Shukur, Osamah Basheer, and Muhammad Hisyam Lee. "Daily wind speed forecasting through hybrid KF-ANN model based on ARIMA." *Renewable Energy* 76 (2015): 637-647.
6. Okumus, Inci, and Ali Dinler. "Current status of wind energy forecasting and a hybrid method for hourly predictions." *Energy Conversion and Management* 123 (2016): 362-371.