Recent Initiative of Solar and Wind forecasting using a high resolution cloud resolving model

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Abstract:

Although significant progress has been made in dynamical weather forecast in India, attempts to generate wind and solar energy forecast using dynamical weather forecast, remain elusive. An attempts has been made to generate the wind and solar forecast over a selected location in Maharashtra. In this initiative, the high resolution (12 km) global model forecast has been particularly utilised along with cloud resolving forecast from a non-hydrostatic model. Initial results are promising. The model forecast along with systematic bias correction enhances the forecast skill with correlation higher than 0.9. This initiative will further be extended to ther location as well.

1. Introduction:

The increasing demand of energy and rapidly decreasing conventional fossil fuels are the main drivers for the increasing interest in renewable energy resources (RES). Wind -, Hydro-, Biomass -, Solar Energy are some of the renewable energy sources. Out of these RES, Wind energy is considered to be one of the attractive solution for the power generation due to its lowest cost. In India, after Solar Power (62%), Wind Energy (34%) has the higher potential of renewable power. As wind is inherently variable, wind power is also a fluctuating source of energy. Short-term forecast such as from 1hr upto 72 hrs, are useful in power system planning. Medium Range forecasts from 3 days to 7days are needed for maintaining the wind farms and energy storage operations. Accurate wind power forecasting reduces the

risk of uncertainty and allows for better grid planning and integration of wind into power systems.

In recent years, with increased computational efficiency, NWP is the most important component in the wind power prediction because it represents the first input to any wind power prediction system that uses NWP model output. Understanding the uncertainty in the model wind forecast will ultimately help to understand the uncertainty in the wind power forecast. Thus the main objective of the present study is to check the fidelity of the model for wind power forecasting at a site in complex topographical region. The model is evaluated on the basis of different skill scores.

2. Methodology:

2.1 Model Configuration and Physical Options:

Weather Research and Forecasting (WRF) version 3.7.1 is used in the present study (Skamarock et al. 2008). Model is run in four domains with 27-, 9-, 3-, 1 km as horizontal resolution (Figure 1a). The model's initial and boundary conditions are supplied from GFST1534 (~12.5km). Details of model experiment are summarized in Table 1. Based on different sensitivity experiments, the best model configuration is denoted in bold letters (Table 1) and same is used for rest of the experiments.

Table 1. WRF Model Configuration based on different physical parameterization sensitivity experiments over 'Agaswadi' site in Maharashtra.

Domains & Resolution	**4 domains** with 27km, 9km, 3km and 1km resolution (Based on domain sensitivity Expts.)
Initial Conditions	**GFS T1534 00 UTC** (Based on IC sensitivity)
Model Integration Time	48 h
Model Output	At **2 min** interval for inner domain of 1km
Vertical Levels	**45** (Based on vertical level sensitivity)
Landuse Landcover Data	**MODIS** (Based on Landuse and Landcover data sensitivity)

Cumulus Parameterization	**KF Scheme** (Based on Cu sensitivity)
Microphysics	**Morrison Scheme** (Based on Microphysics sensitivity)
Planetary Boundary Layer	**Yonsei University (YSU) Scheme** (Based on PBL sensitivity)
Radiation Scheme	RRTM for Long Wave and Dhudhia for Short Wave

2.2 Site Details:

In the present study, we have chosen a site 'Agaswadi' which is in Maharashtra state of India. This site is hilly terrain with elevations ranging between 700 and 900 m above mean sea level (Figure 1b). There are total 33 wind mills spread over this region with each mill separated by ~ 200m from each other. All these wind mills are located at 90m height above the surface and thus observations of wind are available at 90m height from surface.

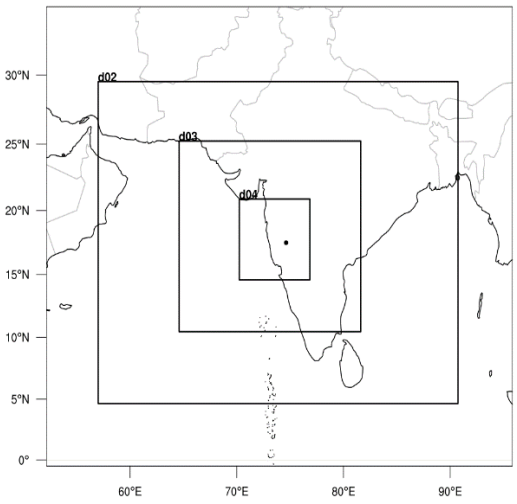

Figure 1a Domain of integration for WRF model. First Domain's horizontal resolution is 27km, Second domain 9km, 3rd domain 3km and innermost 4th domain 1km.

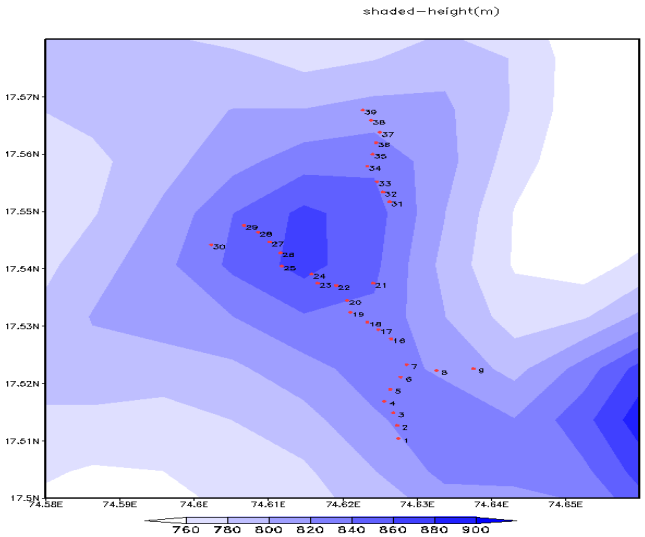

Figure 1b. Terrain Height in meter (shaded) at Agaswadi (Maharashtra state) wind Farm site in India. The dots represents the location of each wind turbine over the topographically complex site of Agaswadi. wind turbines are notes as T1-T9 and T16 to T39.

3. Results and Discussions:

Different verification measure and skill score calculations such as correlation coefficient, percentage error, bias etc. suggest that there is improvement in the skill with the

combination MODIS45-KF-Morrison-YSU (Vertical_levels-Cumulus-Microphysics-PBL) and same is further used for different cases e.g. 00UTC26Dec 2016 (Initial Condition). It is found that the best combination underestimates as well as overestimates at few instances of time at Agaswadi location. To overcome this difficulty, we applied a simple bias correction method and the improved results are presented in Figure 2. With the linear bias correction, the correlation coefficient is ~0.93 as well as the percentage error is significantly dropped below 1.5 % and it is less than 1% for first 24hrs of forecast (Figure not shown).

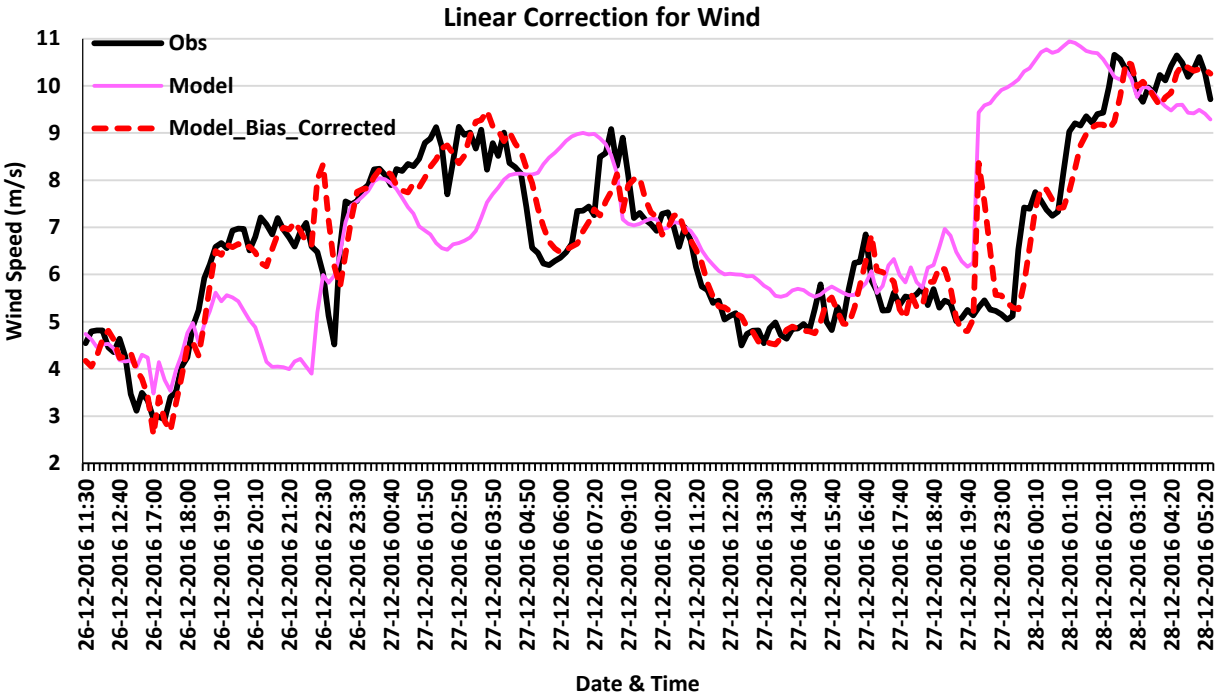

Figure 2. Time series of observed wind plotted with forecast using best model configuration (Pink color) and using linear bias correction (Red).

4. Conclusions:

With the best combination of model configuration i.e. MODIS45-KF-Morrison-YSU, and linear bias correction method the wind forecast is significantly improved over the topographically complex region.

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