Validation and bias correction techniques to improve Numerical Weather Prediction wind speed data

-Krithika V, Project Engineer

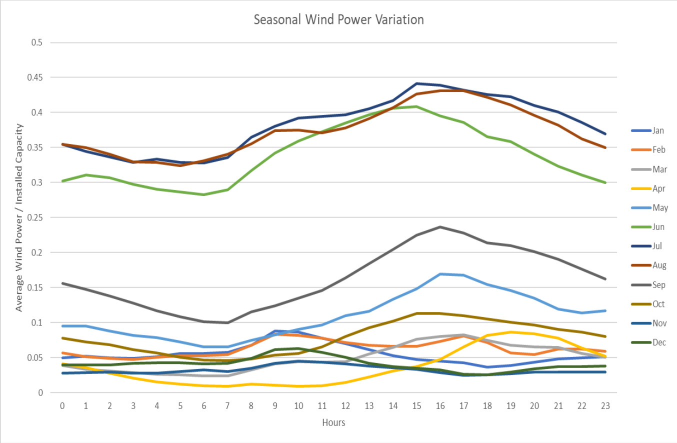
Picture courtesy: Energyjobline

A.G Rangaraj, Krithika.V, Y.Srinath, K.Boopathi and N Sheelarani, K.Balaraman
National Institute of Wind Energy (NIWE)

Sushant Kumar
National Centre for Medium range Weather Forecasting (NCMRWF)

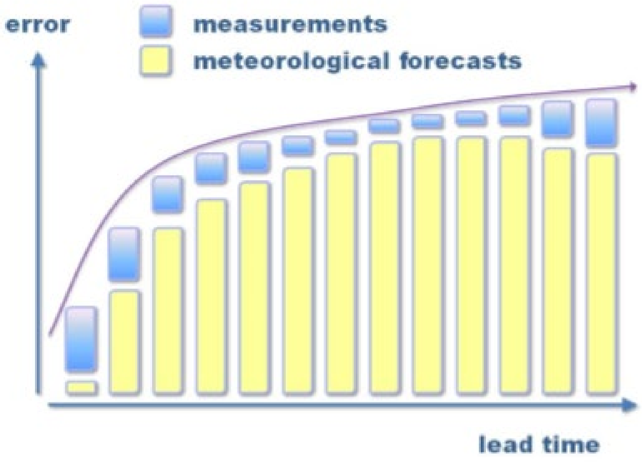
Outline

- Introduction
- Methodology
- Case Study
- Results
- Future Scope



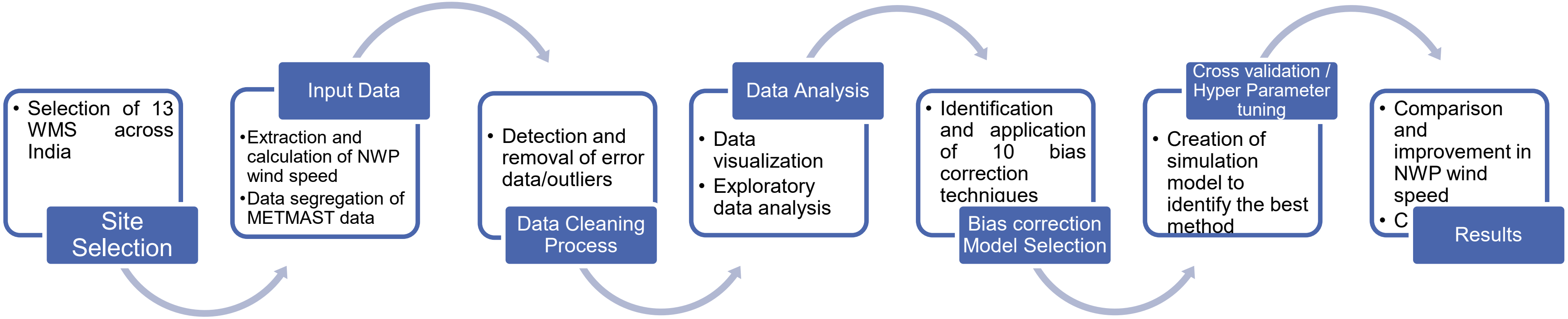
Introduction

- Necessary inputs for wind power forecasting
- Issues in the NWP model
- Need for Bias correction model



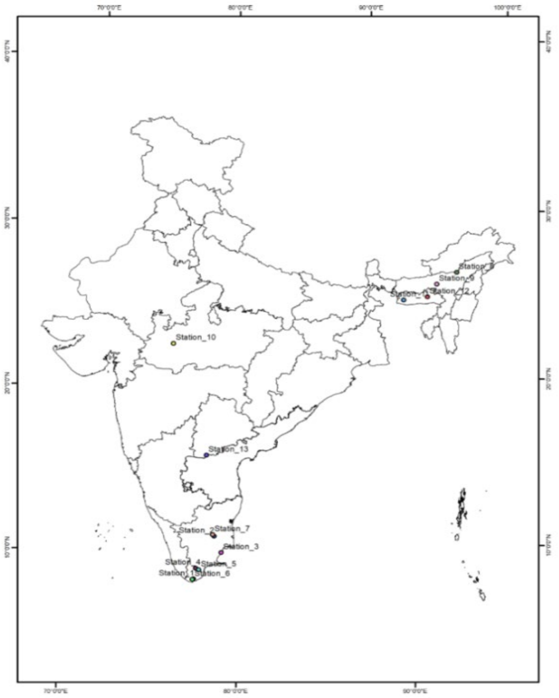
Picture courtesy: DTU pierre pinson

Methodology

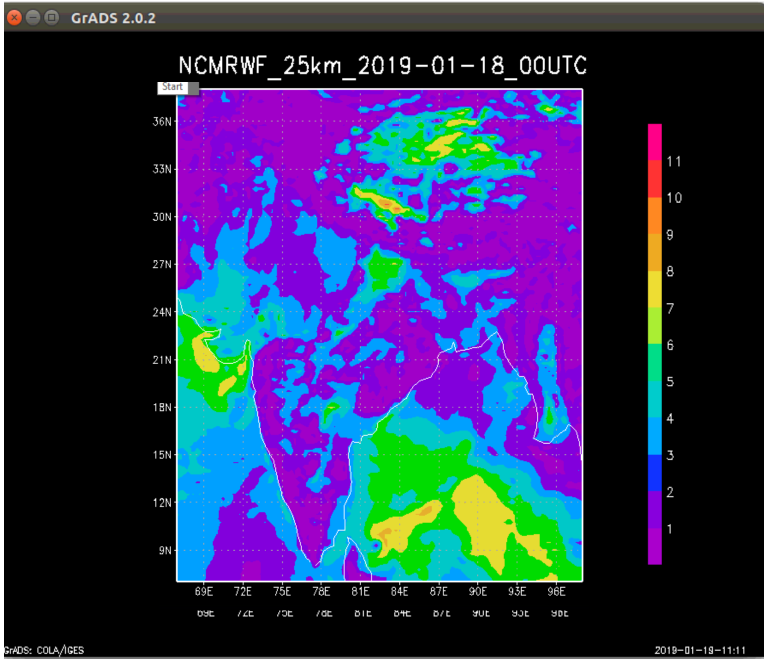


Site Selection

Station ID	State	Type of terrain	Analysis Start date	Analysis End date
1	Tamilnadu	Plain	2018-05-01	2019-05-31
2	Tamilnadu	Plain	2017-07-31	2018-07-31
3	Tamilnadu	Plain	2016-12-24	2017-12-24
4	Tamilnadu	Plain	2017-12-01	2018-12-31
5	Tamilnadu	Plain	2018-03-01	2019-03-31
6	Tamilnadu	Complex	2018-04-24	2019-05-24
7	Tamilnadu	Plain	2017-02-01	2018-02-28
8	Assam	Semi-Complex	2017-08-01	2018-08-31
9	Assam	Semi-Complex	2018-01-01	2019-01-31
10	Madya Pradesh	Plain	2016-08-01	2017-08-18
11	Meghalaya	Complex	2017-11-13	2018-11-13
12	Meghalaya	Complex	2018-01-01	2019-01-31
13	Telangana	Plain	2018-06-01	2019-06-30



Input Data



NWP

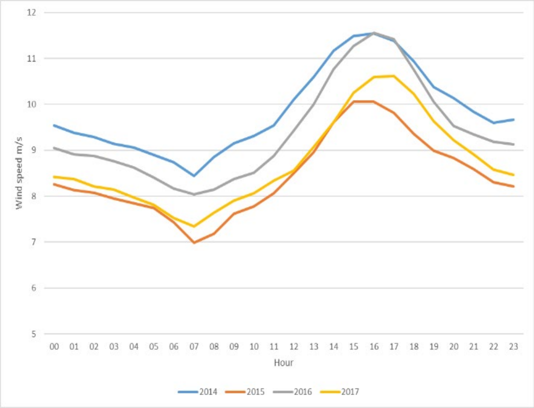
MET MAST

Data Cleaning Process

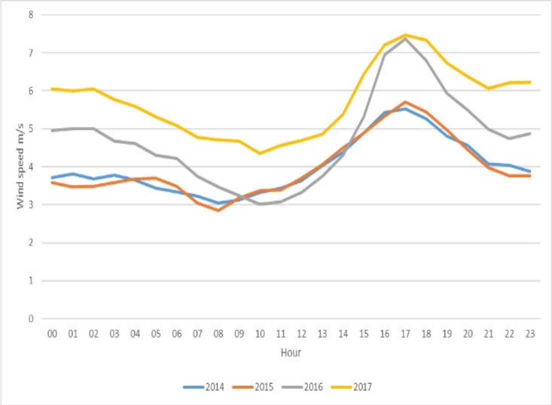
- Constant value test
- Detection and removal of outliers/anomaly
- Range test
- Detection and removal of gaps/repetition
- Visual Inspection

Bias Correction Techniques

- *Short term bias correction(STB)*
- *Diurnal Cycle forecast correction(DRL)*
- *Directional-Bias forecast (DIR)*
- *Univariate linear regression (LR)*



Diurnal pattern during windy season



Diurnal pattern during non-windy season

Combinational Techniques

- *Inverse RMSE weighted average (IRMSE)*
- *Multivariate Linear Regression (MLR)*
- *Combinational – Random Forecast model (C-RF)*
- *Combinational – Gradient Boost (C-GB)*
- *Combinational – Extreme Gradient Boost (C-XGB)*
- *Combinational – K-Nearest neighbour (C-KNN)*

Cross validation / Hyper Parameter tuning

- Determination of Window Length – Sliding Window Technique
- Simulation Model
- Methodology
- Advantage

Overview: Case Study

Site: Station_1

Objective: Validation and application of bias correction techniques to improve the NWP wind speed data

Analysis Period: 2018-05-01 to 2019-05-31

Validation Period: 2018-06-01 to 2019-05-31

Parameter of Study: Wind speed

State and Type of terrain: Tamil Nadu, Plain Terrain

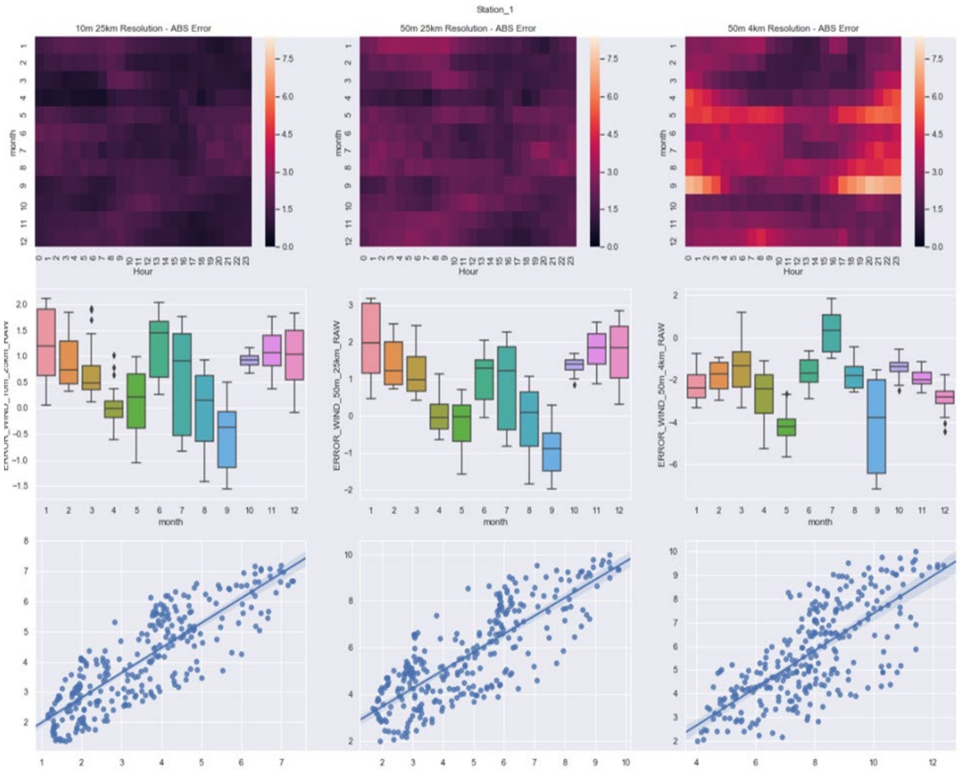
NWP Models: NCMRWF Global Model and NCMRWF Regional Model

Measurement Data: Wind Speed and Wind Direction from MET MAST/WMS

Measurement Data temporal resolution: 15minutes

Vertical levels: 50m and 10m

Data Analysis



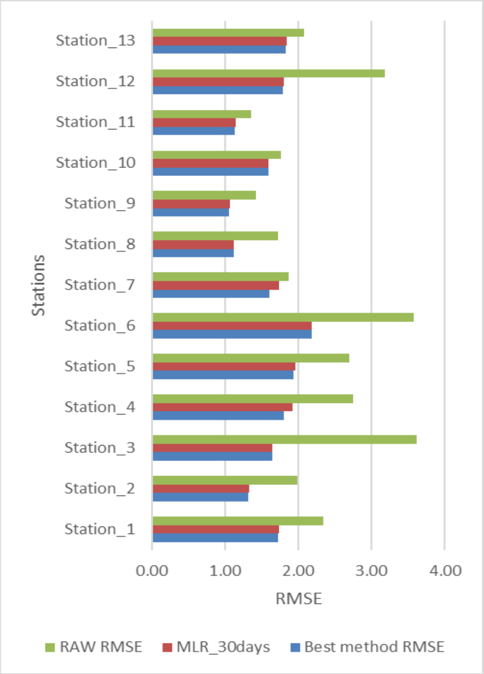
Results- Station_1

4km resolution (50m)			25km resolution (50m)			25km resolution (10m)		
Methods	RMSE	WL	Methods	RMSE	WL	Methods	RMSE	WL
RAW	3.86	Average	RAW	2.4	Average	RAW	1.62	Average
STB	2.37	3	STB	1.91	3	STB	1.36	3
DIR	2.4	3	DIR	1.82	3	DIR	1.29	3
DRL	2.3	3	DRL	1.94	3	DRL	1.36	3
IRMSE	2.05	3	**IRMSE**	**1.73**	**3**	**IRMSE**	**1.23**	**3**
LR	**1.92**	**3**	LR	1.78	3	LR	1.28	3
MLR	1.97	16	MLR	1.74	26	MLR	1.24	27
C-GB	2.07	15	C-GB	1.79	29	C-GB	1.27	30
C-KNN	1.94	3	C-KNN	1.82	3	C-KNN	1.3	24
C-XGB	2.05	22	C-XGB	1.78	30	C-XGB	1.25	30
C-RF	1.97	3	C-RF	1.77	WL	C-RF	1.3	24

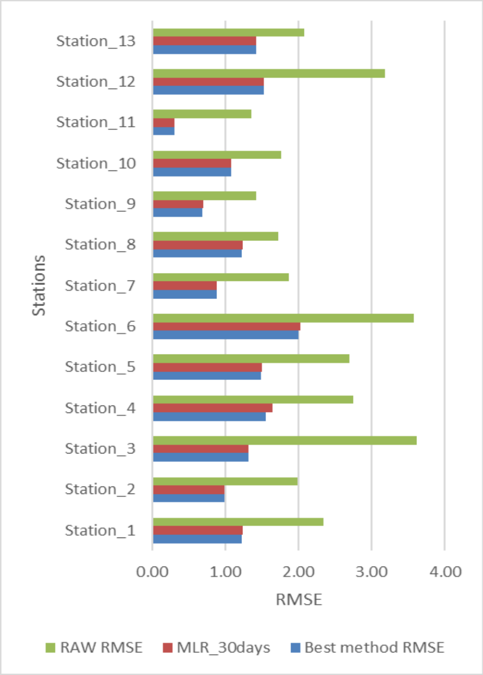
Comparison of models Station wise

	4km resolution (50m)				25k resolution (10m)				25km resolution (50m)			
SS_ID	BM	WL	IMP% - BM	IMP% - MLR_30D	BM	WL	IMP% -BM	IMP% - MLR_30D	BM	WL	IMP% -BM	IMP% - MLR_30D
1	LR	3	45.8%	42.2%	IRMSE	3	22.3%	21.1%	IRMSE	3	26.2%	25.7%
2	LR	5	30.5%	29.6%	MLR	30	35.7%	35.7%	LR	24	33.5%	32.9%
3	MLR	22	52.7%	52.6%	MLR	30	60.2%	60.2%	MLR	30	54.5%	54.5%
4	LR	3	41.0%	39.2%	LR	3	30.7%	26.4%	LR	3	34.8%	30.0%
5	LR	3	15.8%	12.2%	C-RF	30	33.4%	32.9%	C-XGB	30	28.3%	27.2%
6	IRMSE	3	20.7%	18.1%	IRMSE	3	45.6%	45.1%	MLR	30	39.0%	39.0%
7	LR	7	15.6%	20.3%	MLR	29	36.8%	36.7%	MLR	22	13.7%	6.9%
8	MLR	30	32.0%	32.0%	IRMSE	5	15.3%	14.2%	MLR	29	34.9%	34.9%
9	LR	30	34.5%	34.5%	MLR	25	29.3%	28.7%	LR	25	25.7%	24.8%
10	MLR	27	11.9%	11.7%	MLR	20	11.7%	11.6%	MLR	30	10.0%	10.0%
11	LR	22	55.0%	54.6%	MLR	30	70.0%	70.0%	LR	23	16.3%	15.8%
12	MLR	29	24.2%	23.8%	MLR	30	43.4%	43.4%	MLR	23	43.6%	43.1%
13	MLR	28	9.0%	8.7%	MLR	27	11.6%	11.4%	MLR	21	12.0%	11.7%

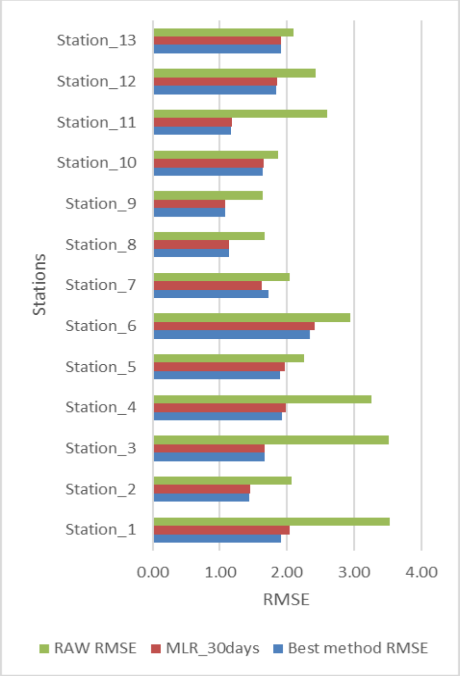
Results



25km resolution (50m)



25km resolution (10m)



4km resolution(50m)

Conclusion

- Validation of global model with two heights 50m and 10m and regional model with 50m height with actual measurements for 13 different locations in India. However, Global model 10m has better accuracy
- Identified the optimum window length for all the methods
- All the 10 bias correction techniques are improving the accuracy of the NWP models. It is also observed that for each site different bias forecast methods with different window length are performing better
- Multivariate linear regression (MLR_30D) -Benchmark model, the variation in the accuracy between the best method and MLR is less than 1% on an average for all the resolutions
- However, multivariate linear regression (MLR) combinational model with 30days window length is always performing at optimum level in all considered stations and average reduction of RMSE of 30% is noted

Future Scope

- Study the effect in accuracy of forecast when 10m wind speed is interpolated to various heights.
- Hyper parameter tuning of machine learning algorithms
- Study the effect of bias corrected wind speed in wind power forecasting

Thank you