NWP FORECAST IN RENEWABLE ENERGY: HANDLING UNCERTAINITIES

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DISCUSSION POINTS

- Need of RE forecasting

- Methods of RE forecasting
  - Wind
  - Solar
  - Application of NWP in RE forecasting

- Usage of NWP in NIWE forecasting model

- Uncertainties in NWP
  - Ideal case
  - Practical case
  - Impact in forecasting accuracy

- Validation of NWP with actual measurements
  - Wind
  - Solar

- Handling Uncertainties in NWP to eliminate the systematic error in NWP
  - Bias correction technique
  - Using many NWP sources

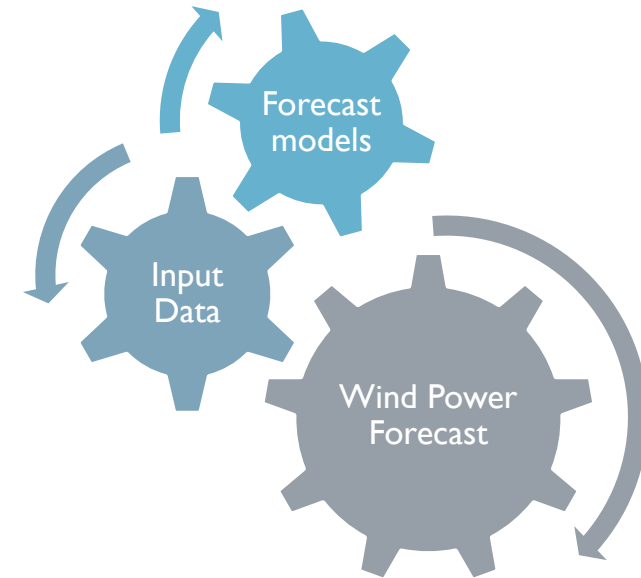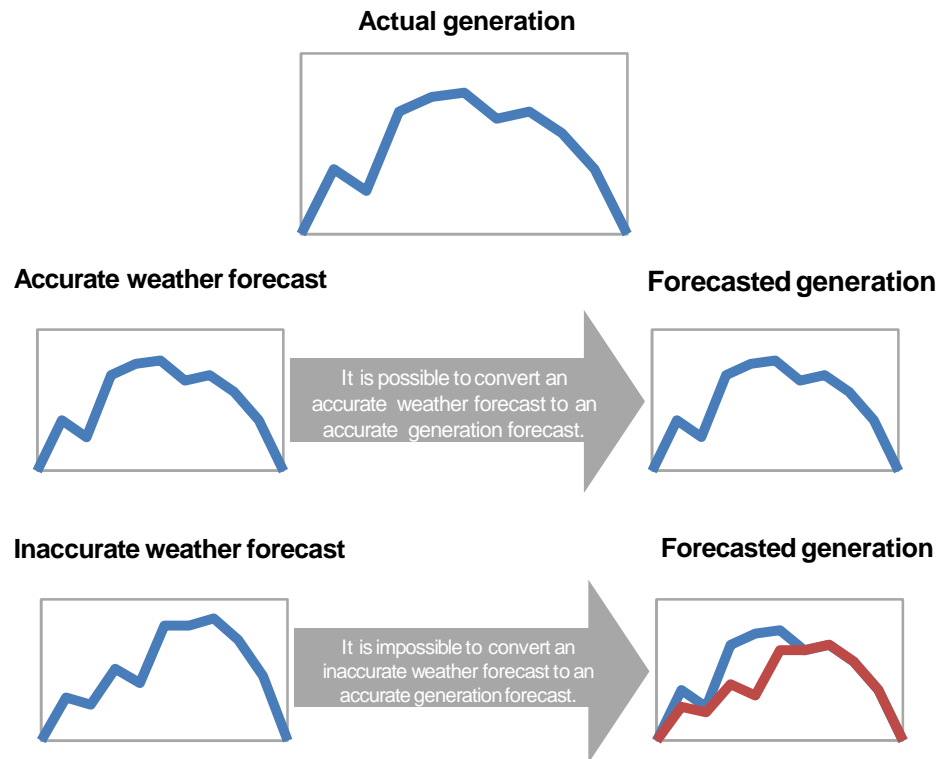# WHY WIND POWER FORECASTING IS NEEDED

Seasonal Wind Power Variation
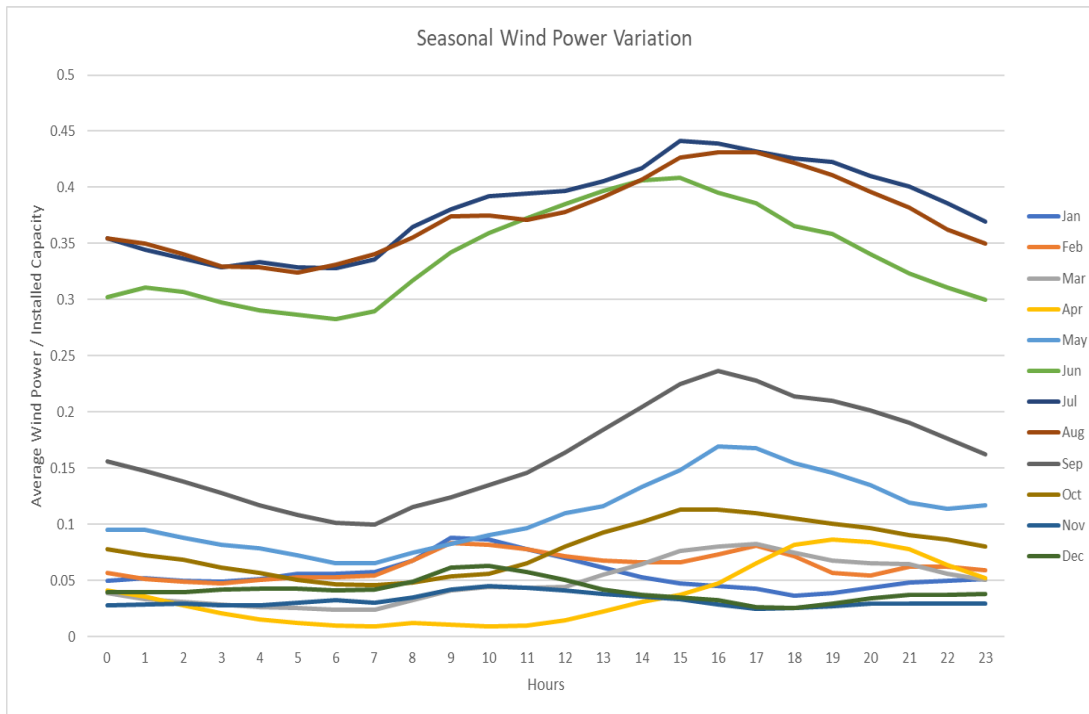
Renewable Energy forecasts in decision-making

- Definition of reserve requirements

- Unit commitment and economic dispatch

- Coordination of renewables with storage

- Design of optimal trading strategies

- Electricity Market-clearing

- Optimal maintenance planning (especially for offshore wind farm)
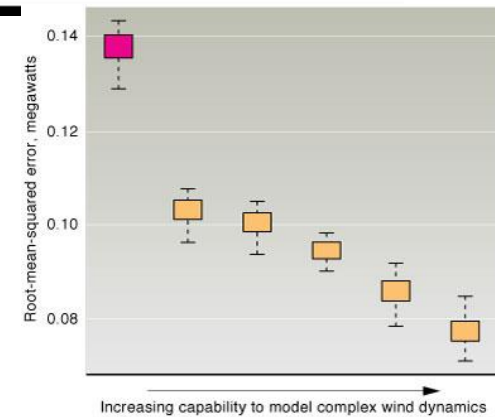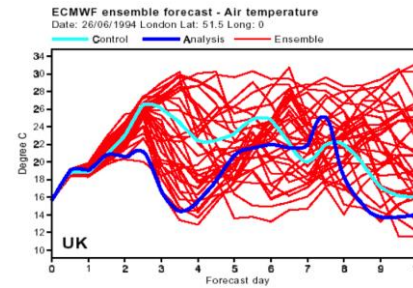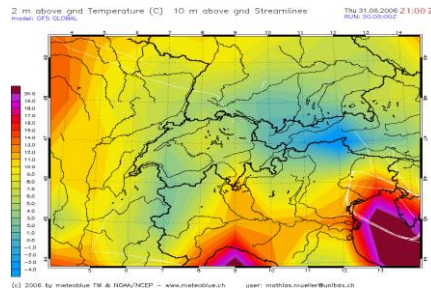
NEED FOR RELIABLE NWP DATA IN FORECASTING

Actual generation

Accurate weather forecast   **Forecasted generation**

It is possible to convert an accurate weather forecast to an accurate generation forecast.

Inaccurate weather forecast   **Forecasted generation**

It is impossible to convert an inaccurate weather forecast to an accurate generation forecast.
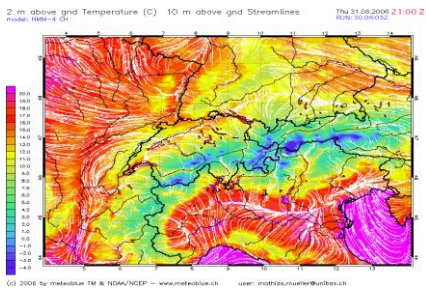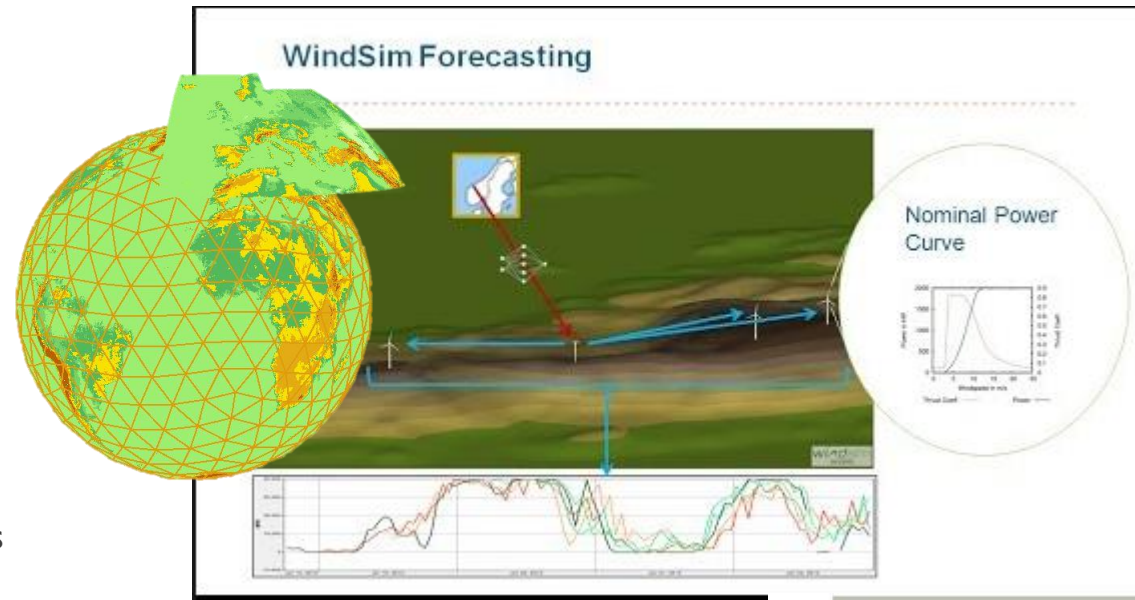
Forecast models

Input Data

Wind Power Forecast

Without accurate weather forecast, a generator cannot submit accurate schedules

METHODS OF WIND POWER FORECASTING
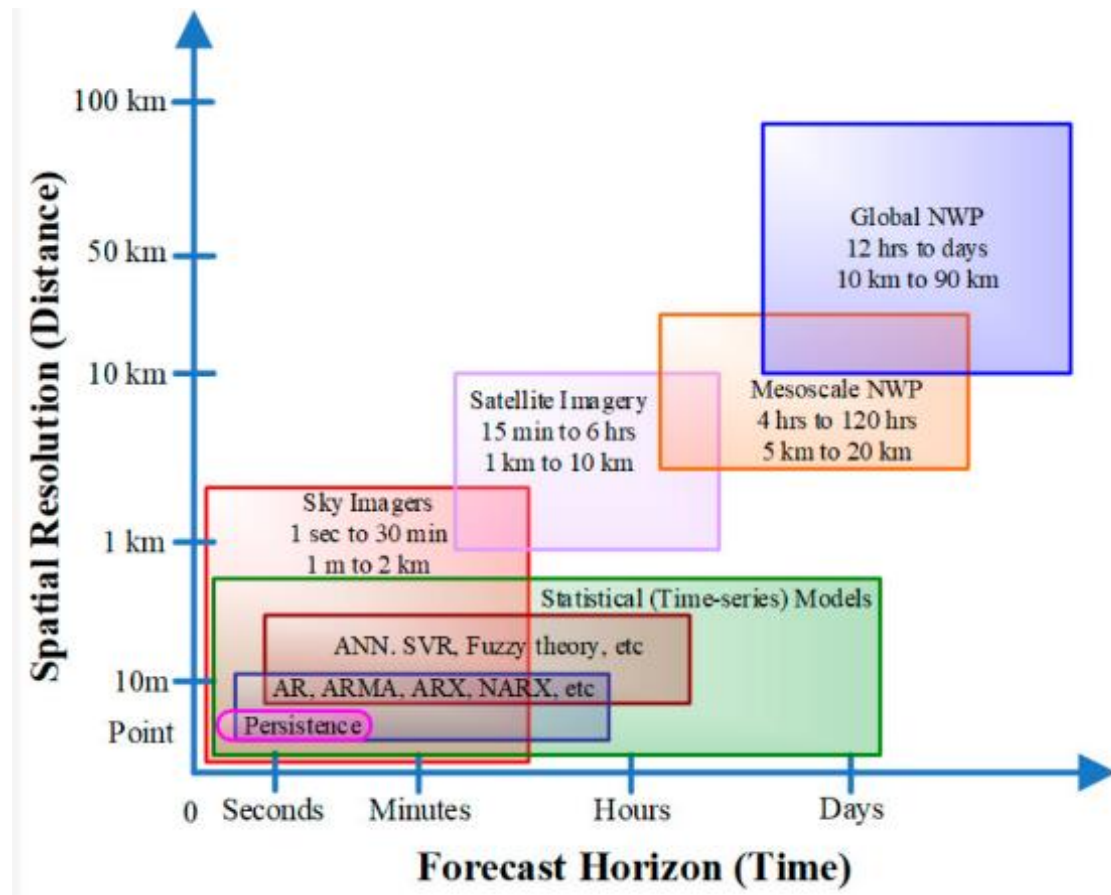
- Physical Approach
  - Using Numerical Weather Prediction
    - Power Curve to convert power
  - Using Wind Flow Modeling
    - Computational Fluid Dynamics
    - Linear wind flow modeling
- Statistical Approach
  - Using Statistical Models
  - Using Machine Learning / Artificial Neural Networks
- Mixed Physical – Statistical Approach

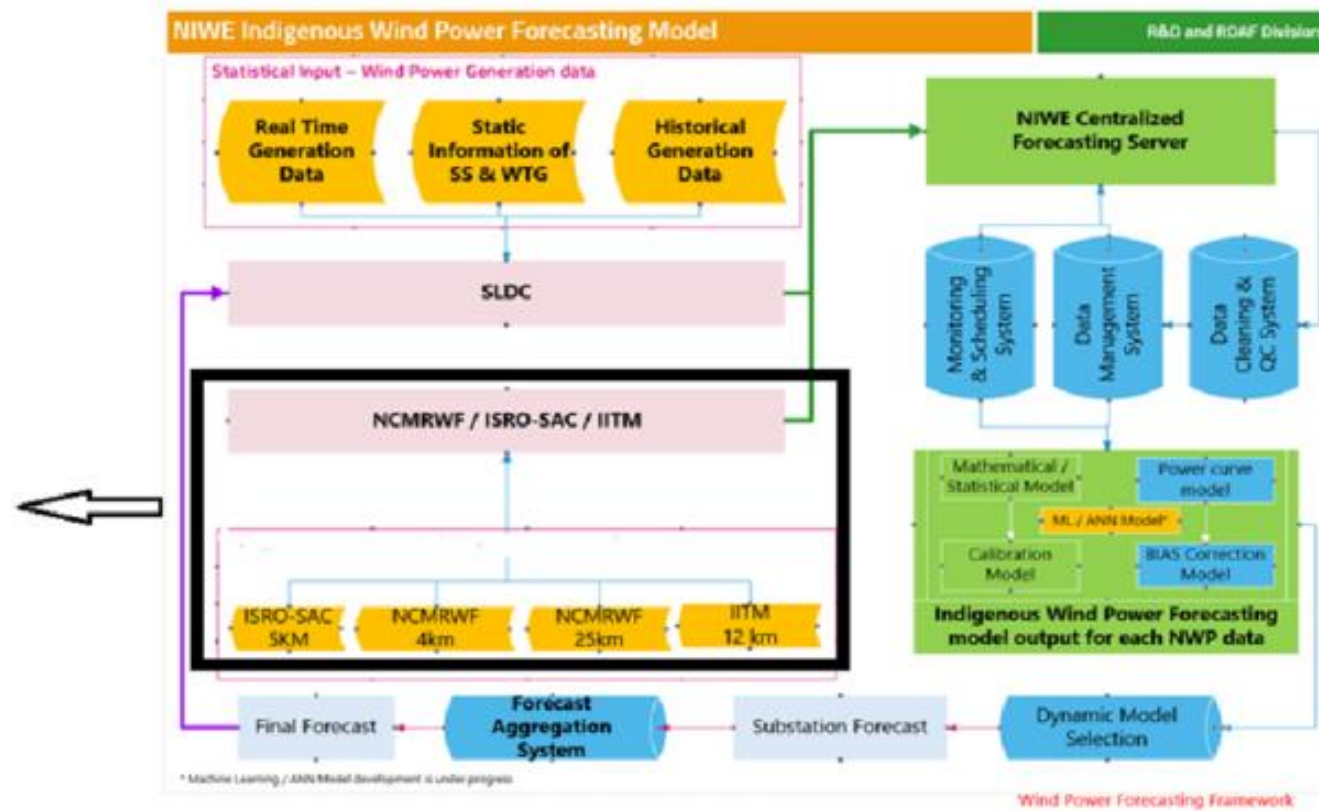A Short-Term Wind Speed Forecasting Model by Using Artificial Neural Networks with Stochastic Optimization for Renewable Energy Systems,,Chiou-Jye Huang and Ping-Huan Kuo
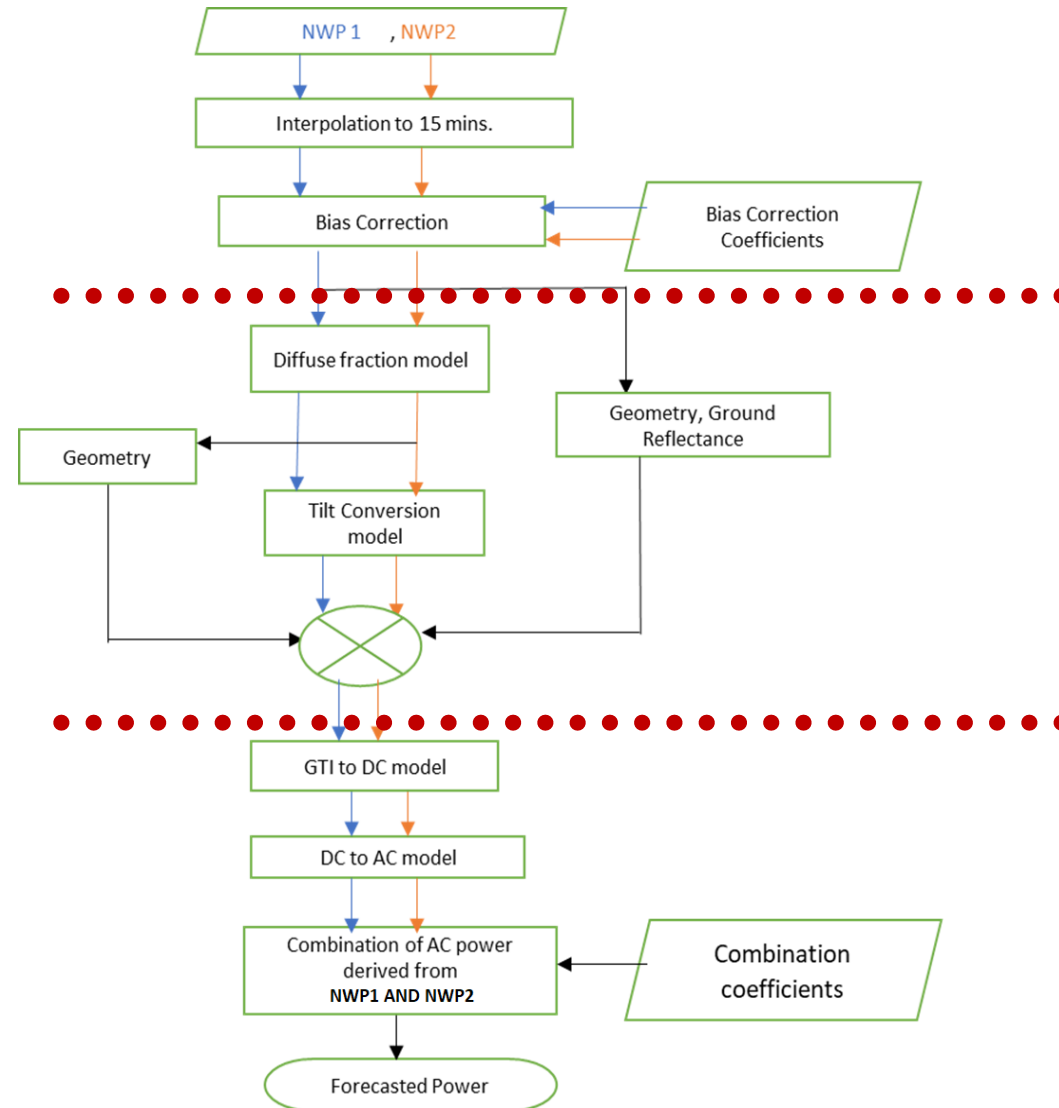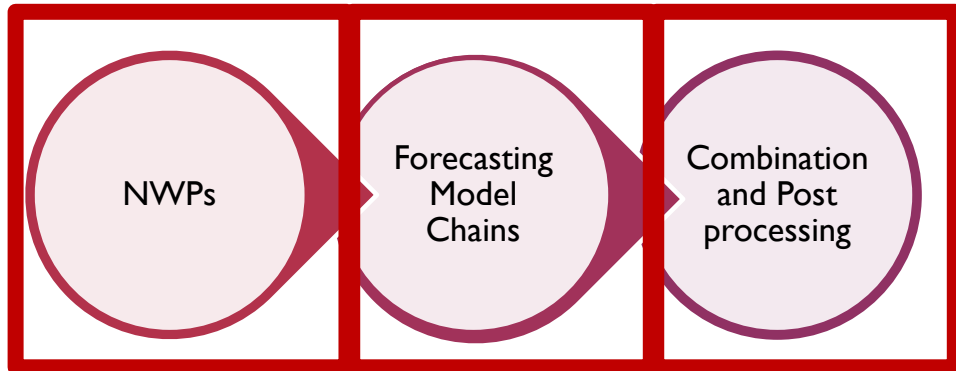
Numerical prediction data/ Physical model input

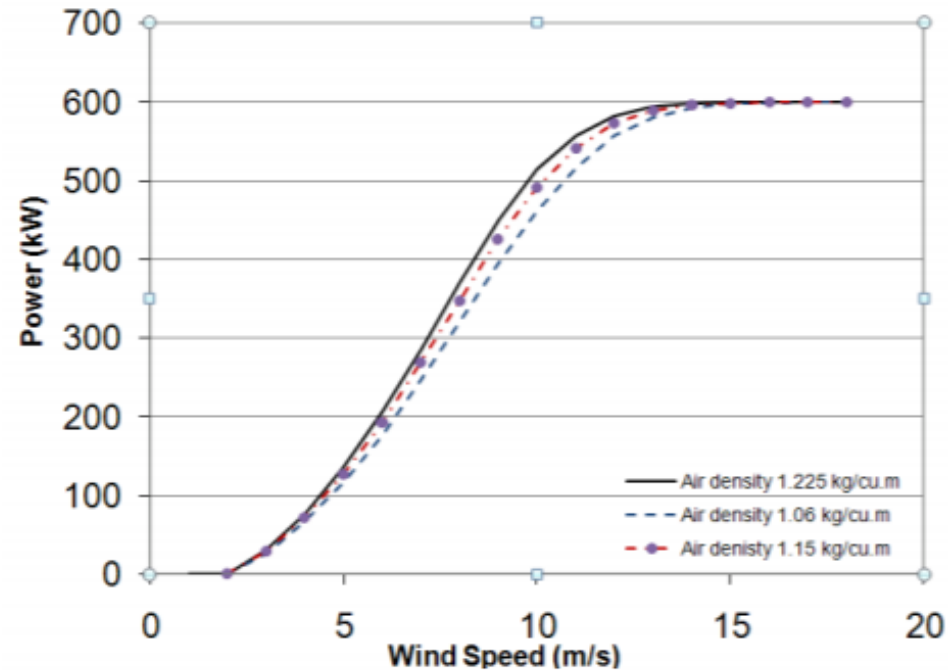# ROLE OF NWP in SOLAR POWER FORECAST MODEL CHAIN

MAJOR CHALLENGES IN NWP DATA

- NWP model error

- Time interpolation

- Vertical Height Interpolation

- Spatial Interpolation

- Frequency of model updates (00/12)

Ideal power curve
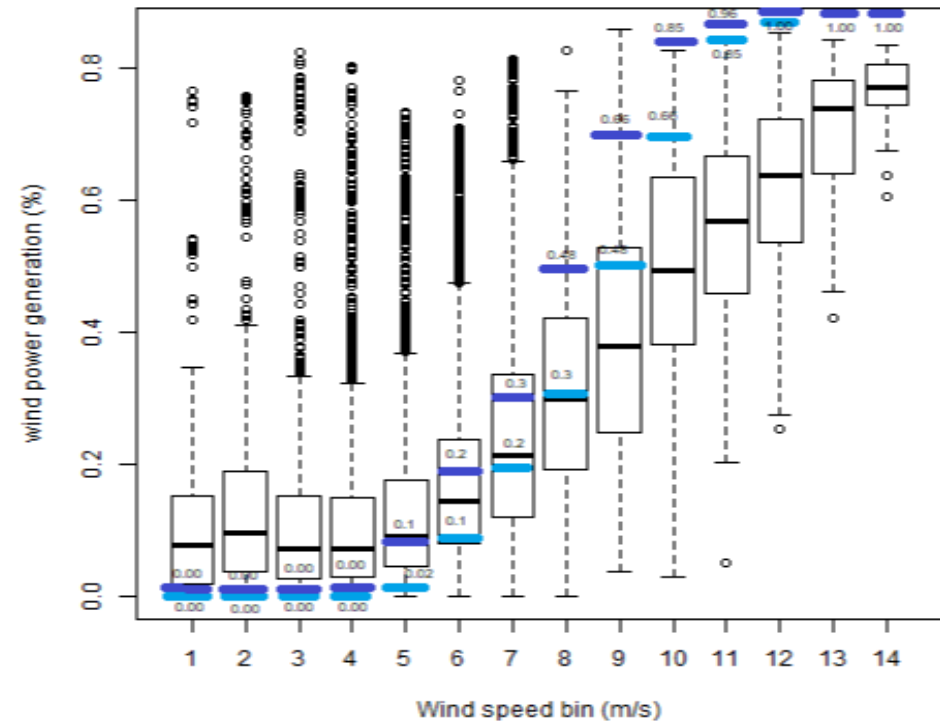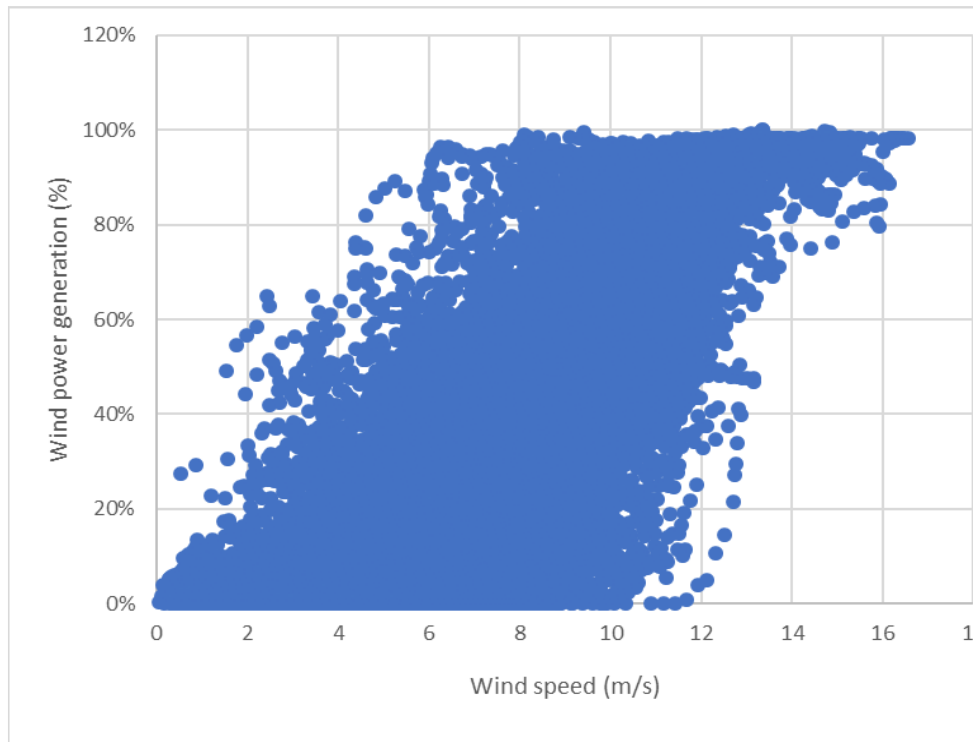
Scatter plot and box plot of the actual generation with respect to rated capacity versus the wind speed from global model output

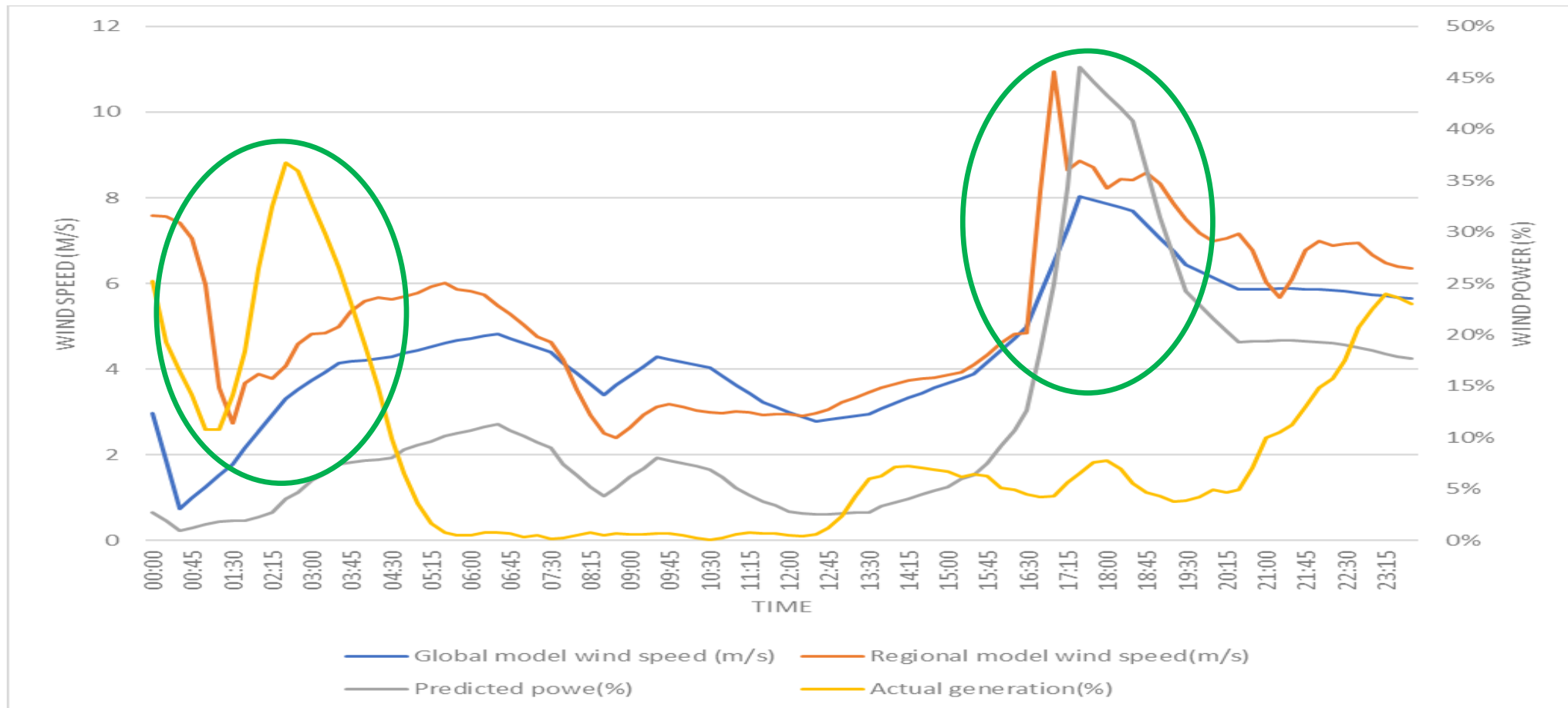Source: Operational Challenges in wind power forecasting and scheduling, AG rangaraj, K.Boopathi and Sushanth Kumar
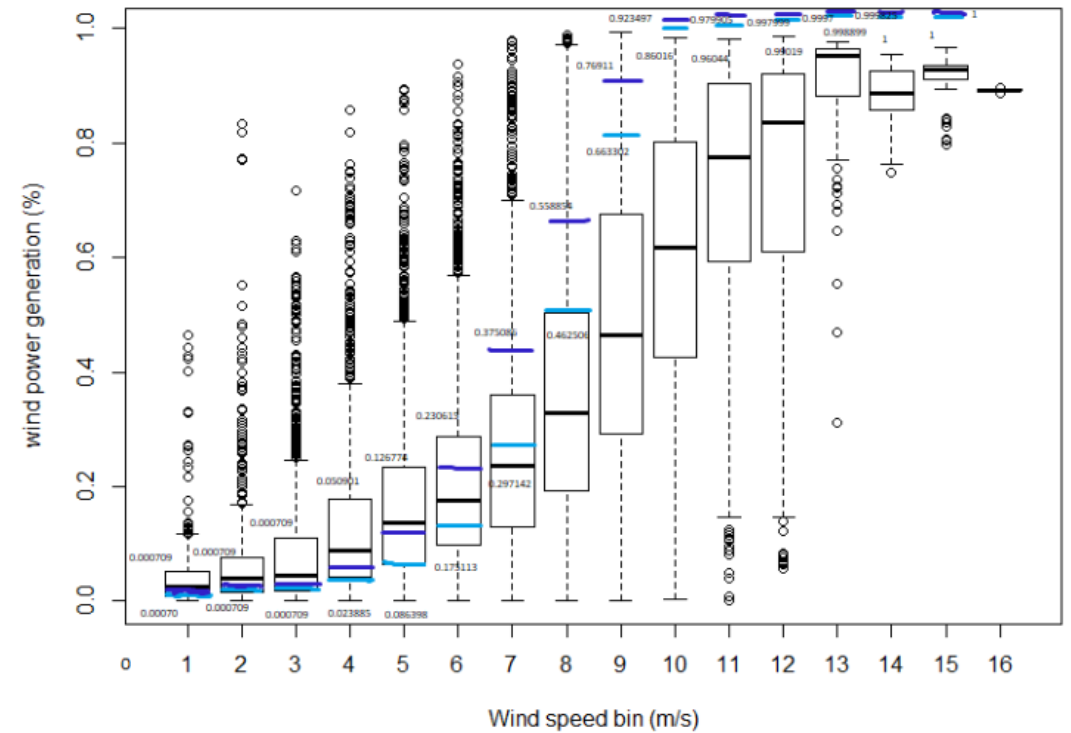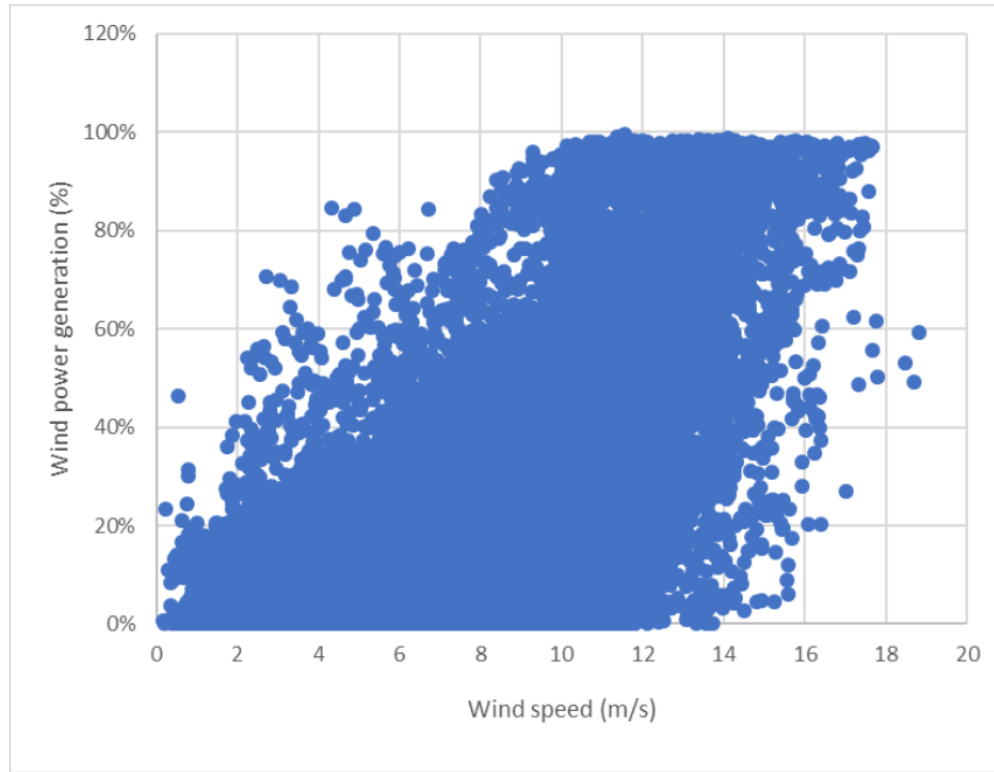
Scatter plot and box plot of the actual generation with respect to rated capacity versus the wind speed from regional model output

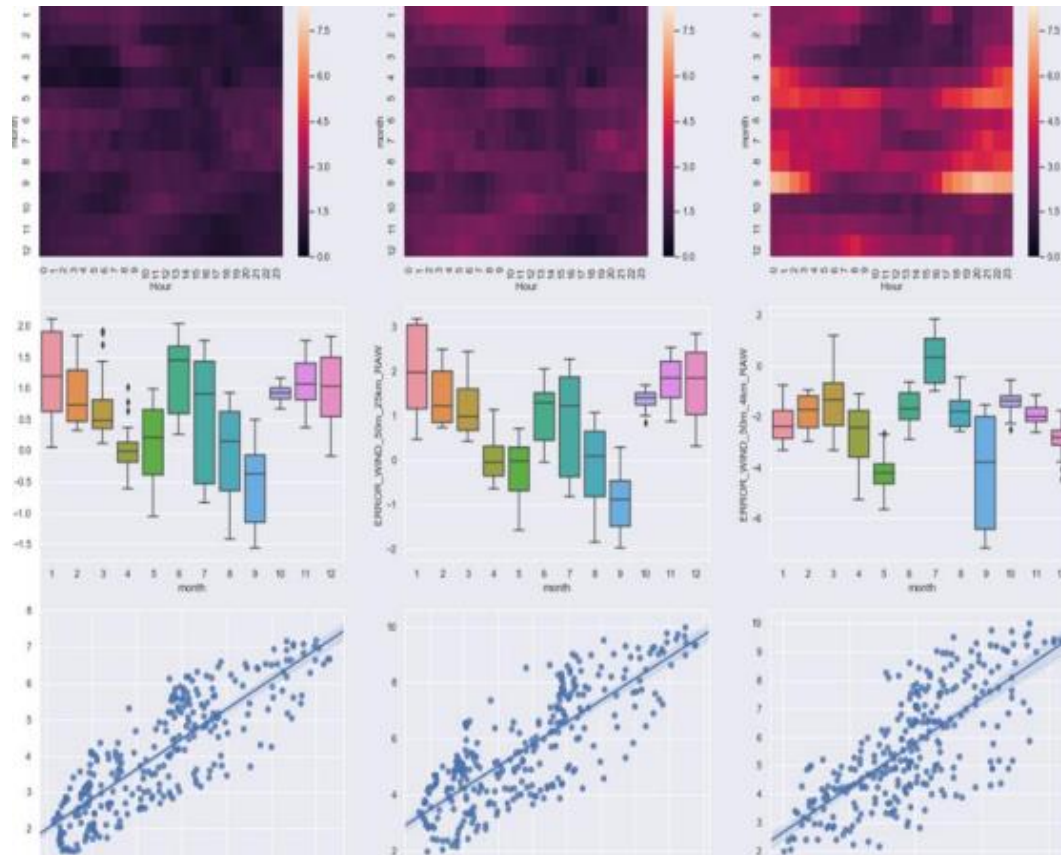Source: Operational Challenges in wind power forecasting and scheduling, AG rangaraj, K.Boopathi and Sushanth Kumar

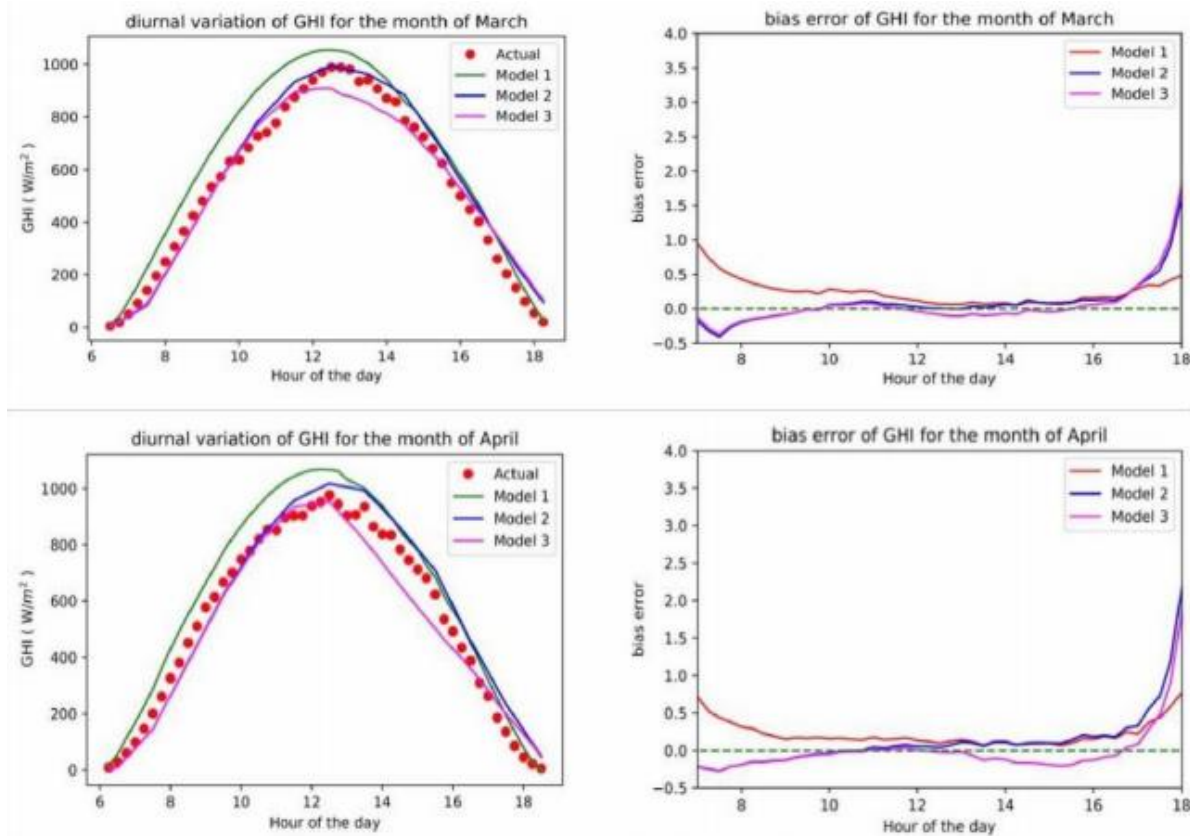Graph of Actual wind power generation and wind speed from different NWP sources
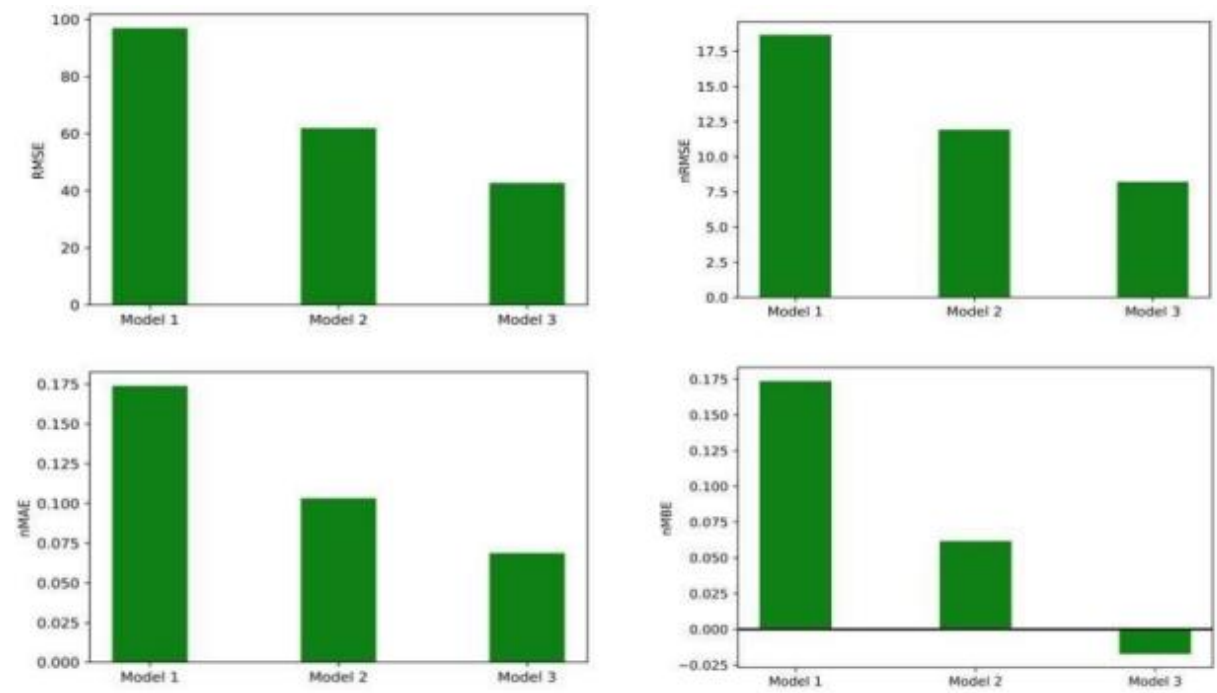
VALIDATION OF MEASURED WIND SPEED VS NWP DATA

Analysis for various NWP models and resolution for a typical site in India

VALIDATION OF GHI MEASUREMENT DATA VS NWP DATA

The diurnal variation and bias error of GHI for the months of March and April

Error metrics of NWP datasets

HANDLING UNCERTAINTIES

- Implementation of various bias correction techniques/post processing techniques before feeding into the forecast model

- Using combination of various NWP sources

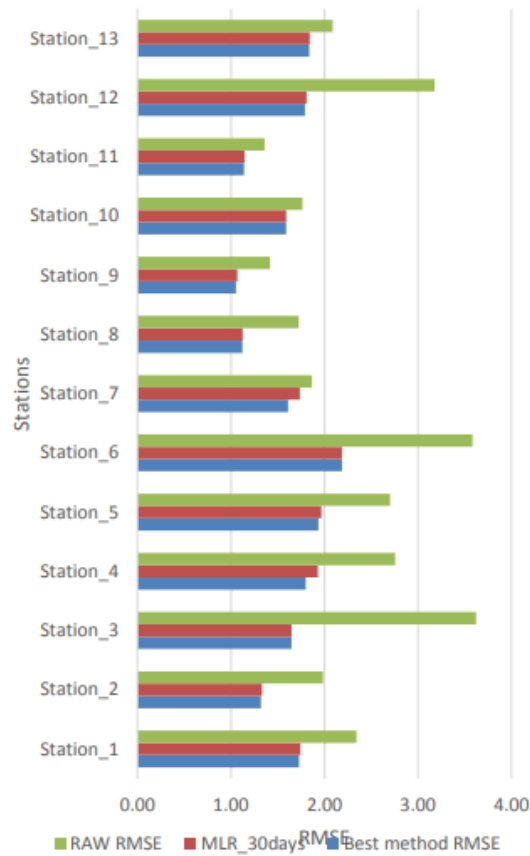# BIAS CORRECTION TECHNIQUES USED ON NWP WIND SPEED DATA

- Short term bias correction (STB)

- Diurnal cycle forecast correction (DRL)

- Directional-Bias forecast (DIR)

- Univariate linear regression (LR)

- Combinational techniques

1. Inverse RMSE weighted average

2. Multivariate linear regression (MLR)

3. Combinational – Gradient boost

4. Combinational Extreme Gradient boost
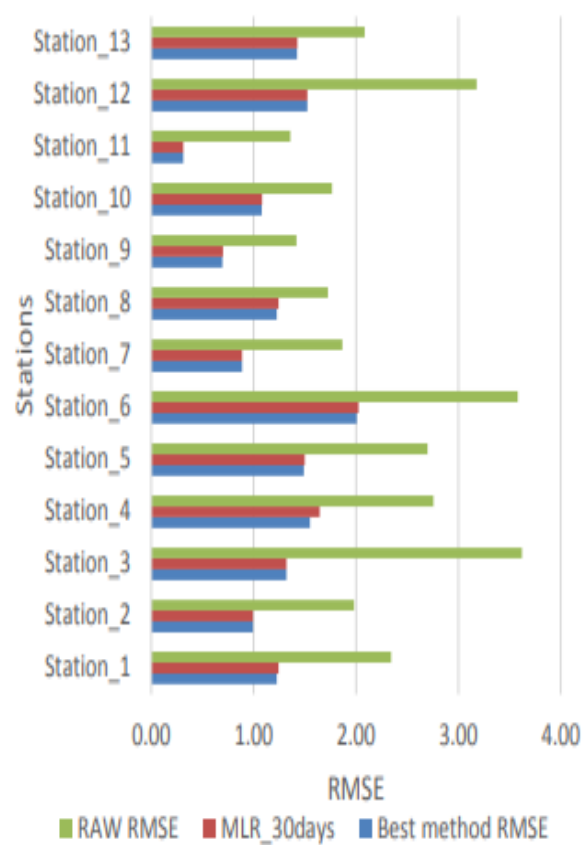
5. Combinational – K- Nearest neighbour

Source: Validation and bias correction techniques to improve numerical weather prediction wind speed data., AG Rangaraj, Krithika V , Y Srinath , K.Boopathi and N.Sheelarani,Sushant Kumar, K.Balaraman

COMPARISON OF BEST MODELS WITH NWP MODELS

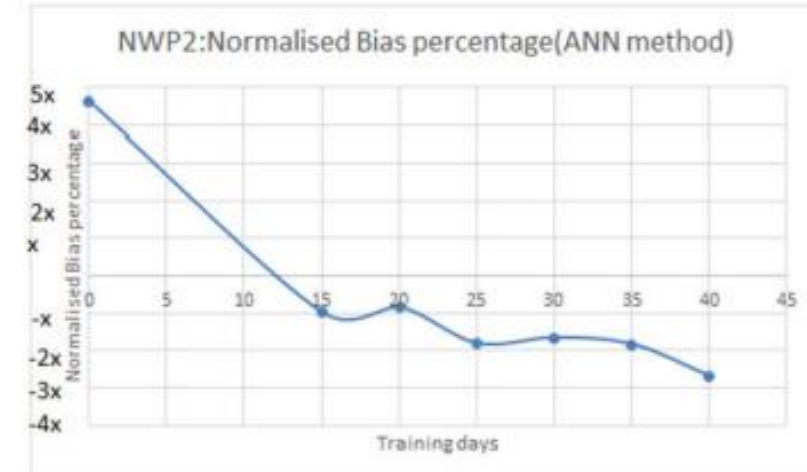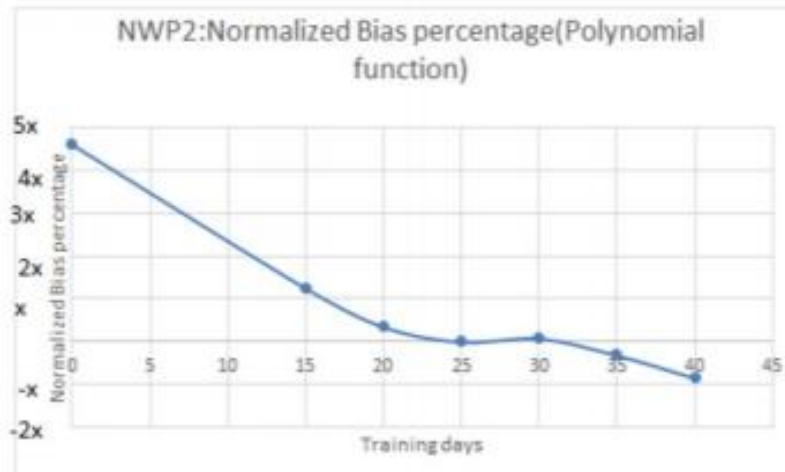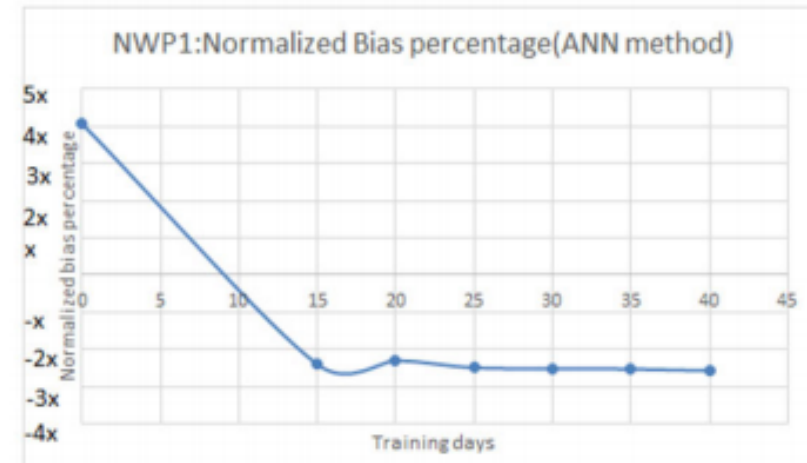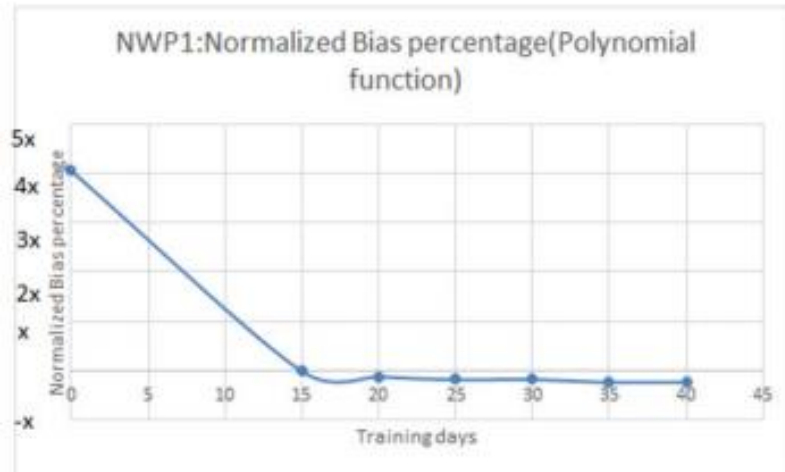Raw model 1 resolution(50m)

Raw model 1 resolution(10m)
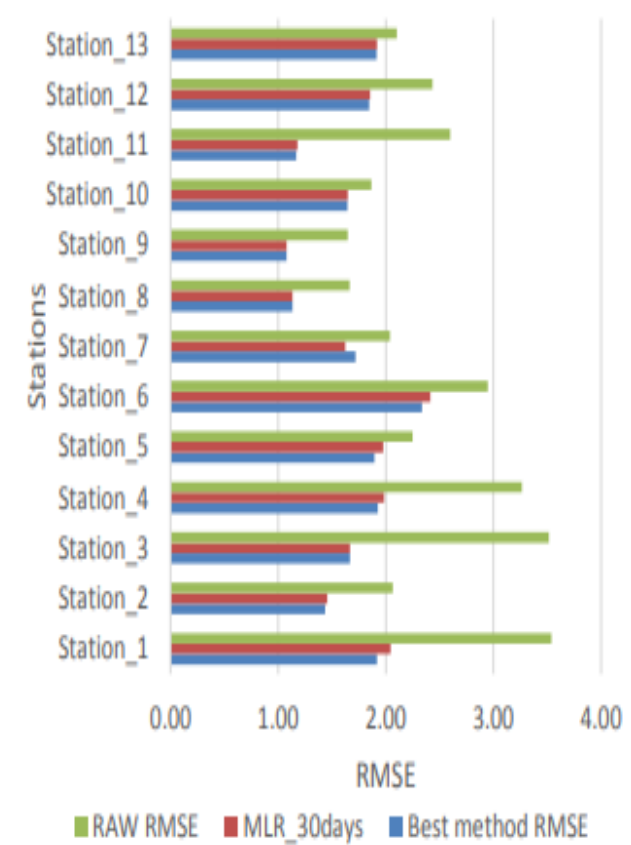
Raw model 11 resolution(50m)

BIAS CORRECTION TECHNIQUES IMPLEMENTED IN SOLAR FORECAST MODEL CHAIN

Source: Dayahead solar pv power forecasting based on combination of statistical and physical modelling NWP data for solar parks in India, Arindam Roy, Aravindakshan, Barun, Naveen, Chris, Anette, Elena, Detlev, Hans Peter Waldl, Indradip Mitra, Prasun, Karthik and Balaraman Kanna

COMBINATION OF VARIOUS NWP SOURCES

MODEL	NCMRWF AC FORECAST			ECMWF AC FORECAST		COMBINATION OF NCMRWF & ECMWF AT POWER END			
	nRMSE (%)	nMAE (%)	nMBE (%)	nRMSE (%)	nMAE (%)	nMBE (%)	nRMSE (%)	nMAE (%)	nMBE (%)
BEYER	X1	Y1	Z1	0.908 X1	1.088 Y1	-0.314 Z1	0.861 X1	0.955 Y1	1.04 Z1
HULD	1.014 X1	1.13 Y1	-1.064 Z1	0.895 X1	1.025 Y1	0.232 Z1	0.866 X1	0.955 Y1	1.17 Z1

The results for validation of AC power forecasts with individual NWP's
and combination for a typical solar park in India
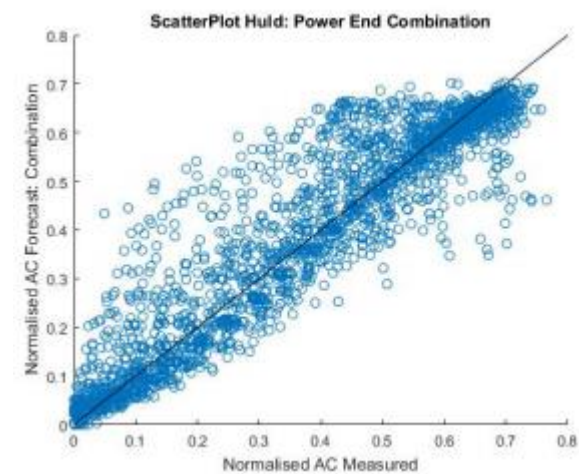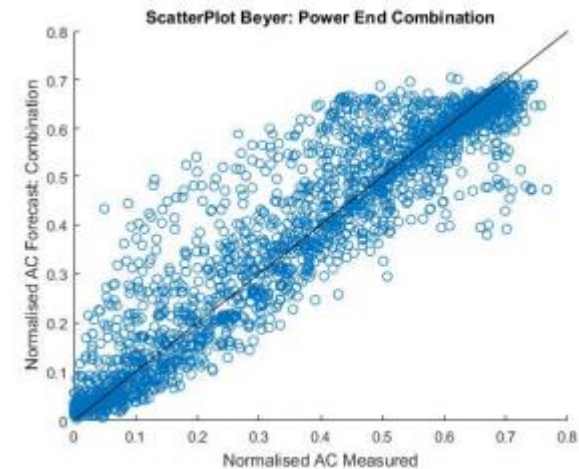
The scatter plot of combined AC power forecast and measured AC power

THANK YOU

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