NCMRWF Data Product for Offshore Wind Energy Applications

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Abstract

This study, first of its kind evaluates the suitability of Indian Monsoon Data Assimilation and Analysis (IMDAA) reanalysis data products for offshore wind resource assessment. IMDAA is a high resolution (12km) reanalysis data over Indian region spanning 1979-2018. Near surface (at 50m) wind speed and direction from IMDAA have been validated against measurement and MERRA-2 over a location proposed for offshore wind power project in India. Wind speed distribution in IMDAA shows better accordance with measurement than MERRA-2.

1 Introduction

In view of global warming and fossil fuel depletion there is a need for a paradigm shift towards sustainable development with renewable energy solutions. Wind and Solar energy form suitable (inevitable??) alternatives. Wind power is a promising renewable energy technology that has proved to be commercially viable. A total capacity of around 38 GW from wind and 34 GW from solar energy (till 2019) have been installed, bringing India among top five countries in the world in terms of power generation from renewable sources. The Indian government has set a target of 60 GW of wind power and 100 GW of solar power installation by 2022. Through competitive bidding and aggressive mechanism the wind and solar power tariffs have dropped significantly. There is a need of better wind and solar resource assessment and exploration of offshore wind power potential to achieve this aggressive target set by the Government of India.

India has an offshore wind power potential of around 70 GW along the coast of Gujarat and Tamil Nadu. First Offshore Wind Project of India (FOWPI) is a project funded by European Union (EU) and it aims to support Ministry of New and Renewable Energy (MNRE) and National Institute of Wind Energy (NIWE) in strengthening the country's offshore wind energy sector and provide technical assistance in preliminary implementation of first off-shore wind farm project of India, on a sea bed area of 70 sq. km. with a tentative capacity sizing of 200 MW near the Gulf of Khambat, approximately 25 km off the coast of Gujarat (https://www.fowpi.in/).

2 Data and Methodology

2.1 Measured Data:

The measured wind data from National Institute of Wind Energy (NIWE) over a location near Gulf of Khambat (Latitude = 20°45'19.100"N, Longitude = 71°41'10.930"E) has been obtained from data portal of NIWE. This data has been measured using a Lidar installed for assessing the wind power potential of this region for a proposed offshore wind power project. The dataset spans from 01-Nov-2017 to 30-Dec-2018 and has wind speed and direction at many levels from 40m to 200m above the surface. The quality controlled wind speed and direction data at 50m for nearly 12 months have been considered in this study.

2.2 MERRA-2

The first version of MERRA, the "Modern-Era Retrospective Analysis for Research and Applications", was released in 2009. In early 2016 the production stopped and was replaced by MERRA-2 which is now updated in "near real-time", i.e. data is available with a couple of months lag. This datasets are widely used in the wind energy industry at different levels of wind resource assessment. It provides winds at 50m at an hourly interval and assumed to be one of the best reanalysis for this purpose. Required wind data for the study period at hourly interval has been taken.

2.3 IMDAA

The Indian Monsoon Data Assimilation and Analysis (IMDAA) is a regional high-resolution atmospheric reanalysis over the Indian subcontinent. This regional reanalysis over India is the first of its kind and is produced by the National Centre for Medium Range Weather Forecasting (NCMRWF) and Met Office (MO), U.K, in collaboration with the India Meteorological Department (IMD) under the National Monsoon Mission (NMM) project of the Ministry of Earth Sciences, Government of India. The reanalysis runs from 1979 to 2018, to span the era of modern meteorological satellites. This dataset like MERRA-2 has hourly temporal resolution and wind parameters at 50m. It has very fine grid resolution of approximately 12km. Details of this data and its usefulness in wind resource assessment can be found at [1] and [2].

3 Results and Discussion

As all the three datasets have winds at 50m this height has been selected for comparison. Nearest grid points from gridded datasets MERRA-2 and IMDAA have been considered for getting u and v components of wind for the study location. Wind speed and direction have been calculated from these components. In figure 1 a time-series comparison of MERRA-2 and IMDAA shows that two reanalysis datasets are in good agreement. The time-serial correlation coeffiiceient (R) with hourly measured wind speed for both datasets are 0.75. This figure further depicts the monthly variation of wind speed. May-July months have higher wind speed where power generation will be higher and reanalysis datasets have well reproduced this behaviour. Wind Rose is generally used to represent the wind direction. It tells the predominant wind direction, means; the direcation from which wind will be blowing maximum of the time. This parameter is useful for minimizing wake losses and maximizing the energy yield by putting optimal turbine layout.

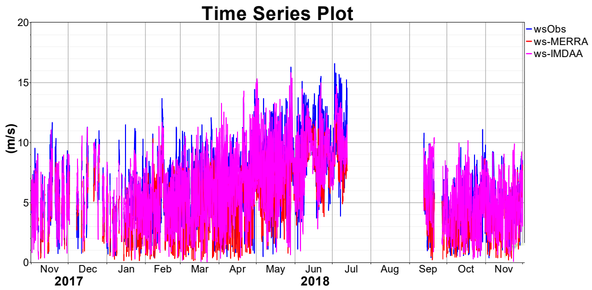

Figure 1 Time series comparison of hourly wind speed from Obs, MERRA-2 and IMDAA

Wind rose in figure 2 represents comparison of wind direction from the three datasets. The measured predominant wind direction shown in blue is south-west but reanlysis datsests show the w-sw wind direction from which majority of wind are coming.

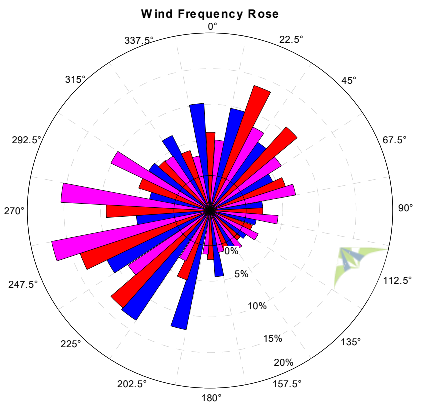

Figure 2 Wind rose diagram from measurement, MERRA-2 and IMDAA

Wind speed being chaotic in nature does not blow at same speed throuout the day. In figure 3 the mean diuranal wind speed have been plotted. Wind speeds are relatively higher in the eveing and show the peak in the night. The diurnal variabilty of wind speed has been well depicted by reanalysis datasets. However IMDAA data shows an edge over IMDAA.

Probabilty Distribution and Weibull fit curve of wind speed tell the details of wind speed in terms of mean and standard deviation. The Weibull parameters k and c represent the variabilty and mean of wind speed. In figure 4 wind speed distribution of three datasets have been plotted.

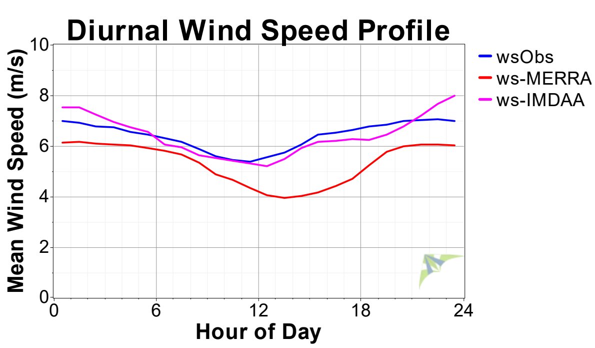

Figure 3 Mean diurnal wind speed profile

The bar lines represent the measurement while the two line plots represent reanalysis datasets.

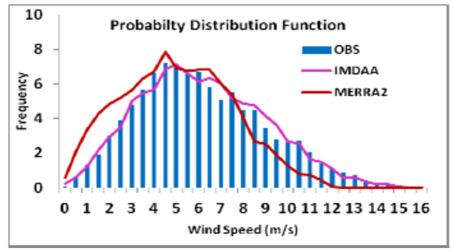

Figure 4 Probability distribution from different datasets

The mean wind speed from measurement is 6.42 m/s whereas MERRA-2 and IMDAA mean wind speeds are 5.29 and 6.42 m/s. Median wind speed, Weibull parameters k and c from IMDAA are closer to the respective statistical parameters calculated from measured wind speed. IMDAA has also picked-up the maximum wind speed better than MERRA-2.

4 Summary

Wind speed from IMDAA has been assessed first time over an offshore wind power project location near Gulf of Khambat. Near surface wind speed and direction data from IMDAA when compared with MERRA-2 and Lidar shows

Variable	Measurement	MERRA	IMDAA
Mean wind speed (m/s)	6.42	5.29	6.424
Median wind speed (m/s)	6.1	5.21	6.2
Max wind speed (m/s)	16.59	12.11	15.82
Weibull k	2.38	2.25	2.44
Weibull c (m/s)	7.25	5.97	7.25
Mean power density (W/m²)	266	152	260

that high resolution regional reanalysis IMDAA has an advantage over MERRA-2. Wind speed distribution is relatively better in IMDAA. Percentage error of IMDAA (MERRA-2) in mean wind speed, median wind speed, maximum wind speed, Weibull k and Weibull c are 0.06 (17.5), 1.64 (14.6), 4.64 (27.0), 2.65 (5.21) and 0.04 (17.7) respectively. Thus IMDAA reanalysis can be a better source of data used for offshore wind resource assessment over other coastal regions of India.

References:

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[2] Mahmood, S., Davie, J., Jermey, P., Richard, R., John, P. G., Rajagopal, E. N. and Indira Rani, S., (2018): Indian monsoon data assimilation and analysis regional reanalysis: Configuration and performance, Atmos. Sci. Lett. 2018; 19:e808, https://doi.org/10.1002/asl.808

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