Comparing the accuracy of WRF simulation in Baltic Sea and in Japanese coastal waters using in-situ data of low height

Fuko OKAYAMA, Graduate School of Maritime Sciences, Kobe University, Japan

SUMMARY: This study aims at comparing the accuracy of WRF simulation in Baltic Sea and in Japanese coastal waters using in-situ data of low height. WRF model simulation are compared with buoy or offshore station measurements at 4 observation sites in Baltic Sea and 9 observation sites in Japanese coastal waters. It was found that WRF simulation in Baltic Sea is better than it in Japanese coastal waters. The bias, root mean square error (RMSE) and correlation coefficient (C.C.) of simulation in Baltic Sea averaged for all sites are -0.29m/s, 1.43m/s and 0.92, respectively.

INTRODUCTION

Recently, renewable energy is expected to increase in the future as aim are made to reduce greenhouse gas emissions associated with energy production in Japan. Offshore wind energy yet is to be installed, a governmental project of offshore wind power generation commenced. However, there are many kind of technical or environmental problems in developing offshore wind power generation[1].

Thus far, the accuracy for offshore WRF simulation has verified using hub-height (80~100m) in North Sea, however, it has verified using low (7~10m) height in Japan. In order to promote the development of offshore wind power generation in Japan as Northern Europe, this study aims at comparing the accuracy of mesoscale model simulation in Baltic Sea and in Japanese coastal waters using in-situ data of buoys which are similar observation height.

DATA AND METHOD

The Weather Research and Forecasting (WRF) model is used in this study. WRF was used to simulate in Japan for one year (January to December 2009) for the area shown right of Figure 1, and in North Sea and Baltic Sea for period of one year (May in 2009 to April in 2010) for the area shown left of Figure 1. The model configuration used in the WRF simulation are shown in Table 1. The characteristic of Japanese simulation is the condition which is input data, domain, and other physics option used to WRF simulation is same as it in North Sea and Baltic Sea.

The verification is carried out for one year or less of 2009. The observational locations and measurement heights are listed in Table 2. The 6 buoys (Omaezaki, Owase, Nansei-Buoy, KB10, KB13, Kochinishi) or offshore measurement station (Hasaki, Hiratsuka, Shirahama) are located in Japanese coastal waters, and 4 offshore stations (Arkona Becken, Darßer Schwelle, Fehmarn Belt, Oder Bank) are located in Baltic Sea. These are also shown Figure 1.

Table 1. Model configuration

Model	Advanced Research WRF (ARW) Ver.3.4.1
Period	Japan : 1 January 2009 through 31 December 2009 (1 year) Germany : 1 May 2009 through 30 April 2010 (1 year)
Levels	40 levels (Surface to 50 hPa)
Input data	6-hourly, 0.25°x 0.25°ECMWF Operational Analysis Daily, 0.05°x 0.05°UK Met Office OSTIA SST
4DDA	Domain 1 : Enabled Domain 2 : Enabled, but excluding below 2,000m
Physics options	Dudhia shortwave scheme RPTM longwave scheme Eta microphysics scheme Betts-Miller-Janjic (Eta) TKE PBL scheme Monin-Obukhov (Janjic Eta) surface-layer scheme Noah land surface scheme

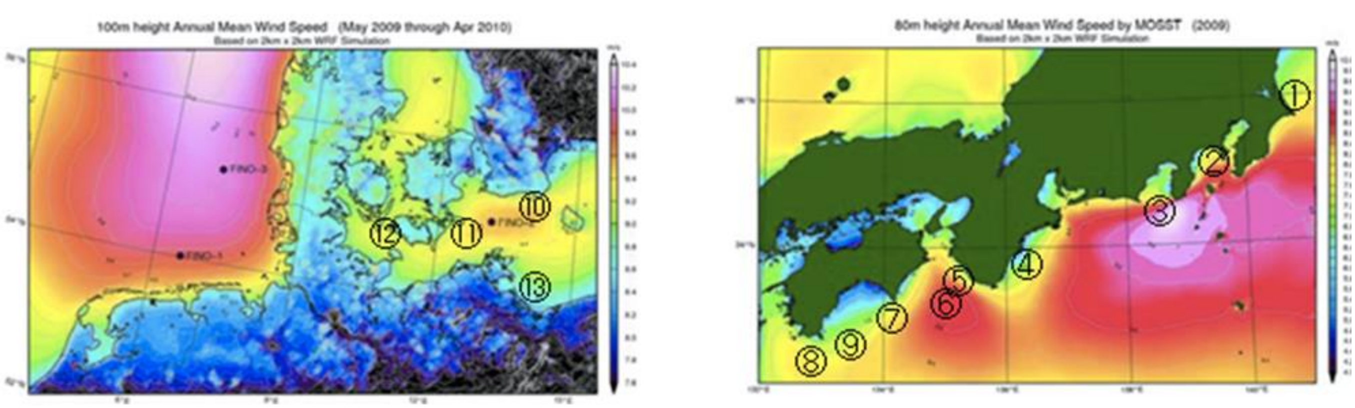

Figure1. Domain used in the simulation and location of the in-situ data
(Left is in North Sea and Baltic Sea, right is in Japanese Sea)

Table 2. Accuracy verification of WRF simulation.

No	Site name	Period of data	Measuring height	Annual mean wind speed(m/s)	Bias(m/s)	RMSE(m/s)	C.C.
1	Hasaki	1/1～12/31	10m	5.94	0.12 (2.1)	2.23 (36.8)	0.76
2	Hiratsuka	1/1～6/30	24m	5.58	0.32 (5.9)	2.01 (37.4)	0.75
3	Omaezaki	2/12～12/4	7m	6.67	0.47 (6.6)	2.17 (30.4)	0.85
4	Owase	1/1～12/31	7m	4.64	0.51 (10.0)	2.31 (44.8)	0.72
5	Shirahama	1/1～12/31	23m	5.06	0.45 (8.2)	2.05 (37.2)	0.77
6	Nansei-Buoy	1/1～12/31	10m	6.95	0.32 (4.4)	2.17 (29.8)	0.83
7	KB10	1/1～5/31	10m	7.71	-0.34 (-4.6)	2.80 (38.0)	0.74
8	KB13	1/1～5/31	10m	8.44	-0.88 (-11.6)	2.86 (37.8)	0.77
9	Kochinishi	1/1～12/31	7m	6.28	0.34 (5.1)	1.99 (30.0)	0.82
10	Arkona	5/1～12/31	10m	7.75	-0.37 (-10.1)	1.38 (18.7)	0.93
11	Darsser	5/1～12/31	9m	7.47	-0.23 (-3.2)	1.37 (19.0)	0.92
12	Fehmarn	5/1～12/31	8m	7.38	-0.31 (-4.4)	1.62 (23.0)	0.89
13	Oder	5/1～12/31	9m	6.79	-0.24 (-3.7)	1.33 (20.3)	0.92

RESULTS

Table 2 also shows bias, RMSE, and correlation coefficient (C.C.) at each observation site for WRF simulation. It is found that simulation in Baltic Sea has smaller bias and RMSE than in Japanese coastal waters, respectively, and more higher C.C.. Moreover, Figure 2 and Figure 3 are annual bias and RMSE at each observation site for WRF simulation. The bias and RMSE are expressed as relative values to the annual mean wind speed. Red line is the aim of achievement which is necessary to profit by Offshore wind energy in Japan. This study indicates that the simulation at low height in Baltic Sea has better accuracy than in Japanese coastal waters as well as it at hub-height. As the reason for this, in North Sea and Baltic Sea, it can be considered a high reproducibility of the meteorological field by mesoscale model, because the terrain is flat and the wind situation is also relatively simple. And more, since the dense high-rise meteorological observation network in Europe, there is a fact that the high accuracy of the objective analysis, ECMWF, to be input as the initial value and the boundary value to mesoscale model. The observation data in Japanese Sea is worth quality than in Europe, because they are influenced strong winds caused by various kind of disturbance as well as terrain–induced winds.

In addition, Figure 2 shows that bias in Baltic Sea is underestimation. It is seen a similar underestimation is at KB10 and KB13 with a relatively distance from nearest coastal line in Japanese Sea. However, this time, the reason could not be apparent.

CONCLUSION

This study proved that, the accuracy of WRF simulation at low-height in Baltic Sea is better than in Japanese coastal waters as well as at hub-height. Because the objective analysis, ECMWF, as input data has high accuracy. I think it is necessary to use high resolution and accurate data set as input data for simulating offshore wind speed and making wind atlas for offshore wind resource assessment in Japan. Since the accuracy of simulation in Japanese coastal waters is large different from in North Sea and Baltic Sea even though subjected to the same simulation with mesoscale model.

Acknowledgement

I would like to express my gratitude to all members of ForWind, especially Dr. Gerald Steinfeld ans Mr. Michael Schmidt who suppported me not only in doing researches but also life in Oldenburg. I also thank Dr. Martin Dörenkämper who gave me precious offshore observation data within Baltic Sea from BSH. I would also like to express my supervisor who gave me a chance to study in Oldenburg and many advices for research.

This research was supported by the project of IPID4all – Mobile Doctorates in System Integration of Renewable Energy in PPRE of Oldenburg University.

Reference

[1] T. Ohsawa, "Offshore Wind Resource Assessment and its Technical Challenges", *Environmental technology*. 2012

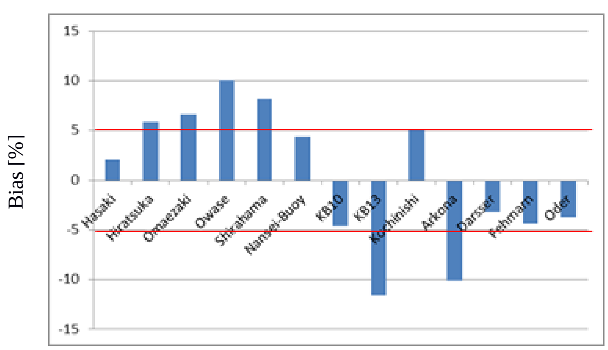

Figure 2. Comparison of annual biases at each observation site

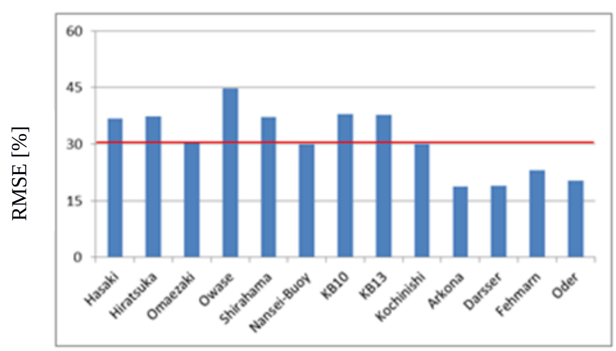

Figure 3. Comparison of annual RMSEs at each observation site