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Accuracy comparison of mesoscale model simulated offshore wind speeds between Japanese and German coastal waters

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Abstract

In the previous studies [1] [2] using the FINO met masts located in German coastal waters, numerical simulations with a mesoscale model are found to typically have a bias of ±5 % in annual mean wind speed and a root-mean-square-error (RMSE) of about 15 % through a year. On the other hand, in Japanese coastal waters, our latest study [3], which uses Japanese met mast measurements for accuracy verification, show that the bias at a hub height ranges ±5-10 % and the RMSE is around 30-40 %. To investigate the differences in detail, this study attempts to carry out the accuracy comparison of mesoscale model simulated offshore wind speeds between Japanese and German coastal waters by using the same model configuration and input data as well as by using similar kinds of surface wind speed measurements. The results indicate that German sites obviously have a better accuracy than Japanese sites. It is implied that the differences between both countries are caused by the difference in the accuracy of objective analysis used as input into WRF, as well as differences in complexity of topography and associated wind climate.

Methods

As a mesoscale model, the Advanced Research WRF (the Weather Research and Forecasting model) is used in this study. The WRF simulations are performed for Japanese and German coastal waters using domains with the same size, as shown in Figure 1. These simulations are conducted for one year from January to December 2009 for Japan and from May 2009 to April 2010 for Germany. The model configuration used in the simulation is shown in Table 1.

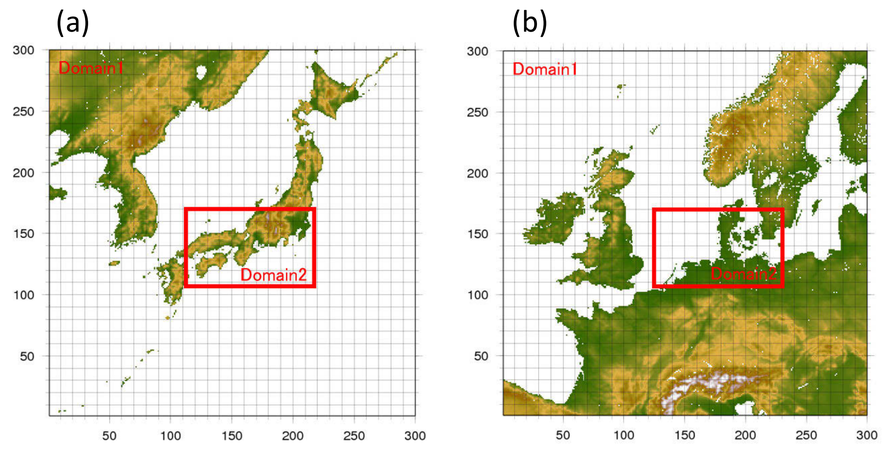

Figure 1 Domains used in the simulations for (a) Japanese and (b) German coastal waters

Table 1 Model configuration

Model	Advanced Research WRF (ARW) ver. 3.4.1	
Period	Germany : 1 May 2009 through 30 April 2010 (1 year) Japan : 1 January 2009 through 31 December 2009 (1 year)	
Input data	30 s x 30 s USGS terrain height and land use 6-hourly, 0.25° x 0.25° ECMWF Operational Analysis Daily, 0.05° x 0.05° UK Met Office OSTIA SST	
Levels	40 levels (Surface to 50 hPa) Lowest levels : 12 m, 40 m, 76 m, 116 m, 161 m, 214 m	
Domains	Domain 1	Domain 2
Grids	8km x 8km, 300 x 300 grids	2km x 2km, 420 x 260 grids
4DDA	Enabled	Enabled, but excluding below 2,000 m
Physics options	Dudhia shortwave scheme RRTM longwave scheme Eta microphysics scheme Betts-Miller-Janjic cumulus parameterization scheme Mellor-Yamada-Janjic (Eta) TKE PBL scheme Monin-Obukhov (Janjic Eta) surface-layer scheme Noah land surface scheme	

Results

Table 2 shows the accuracies of WRF-simulated wind speed at Japanese and German observation sites. It is found that an annual bias of within ±5 % at a hub height is achieved even at lower heights in the German coastal waters, while it exceeds ±5 % at five of nine sites in the Japanese coastal waters. As for a relative RMSE (Figure 2), including the values at the 100m-height of FINO met masts (cited from [1]), the value is around 20 % at the German sites, whereas it is 30 to 45 % at the Japanese sites. Figure 3 shows wind speed correlation charts for representative site of Japan (KBB10) and Germany (Arkona Becken). Comparing the two charts, Arkona Becken clearly exhibits a smaller dispersion of wind speed, having a higher CC (0.93) than KBB10 (0.74).

Table 2 Accuracies of WRF-simulated wind speed at Japanese and German observation sites

No.	Country	Site name	Measure. Height	Mean wind speed (OBS)	WRF-simulated wind speed		
					Bias	RMSE	CC
1	Japan	Hazaki	10 m	5.94 m/s	0.12 m/s (2.1 %)	2.23 m/s (36.8 %)	0.76
2	Japan	Hiratsuka	24 m	5.58 m/s	0.32 m/s (5.9 %)	2.01 m/s (37.4 %)	0.75
3	Japan	Omaezaki	7 m	6.67 m/s	0.47 m/s (6.6 %)	2.17 m/s (30.4 %)	0.85
4	Japan	Owase	7 m	4.64 m/s	0.51 m/s (10.0 %)	2.31 m/s (44.8 %)	0.72
5	Japan	Shirahama	23 m	5.06 m/s	0.45 m/s (8.2 %)	2.05 m/s (37.2 %)	0.77
6	Japan	Nansei-Buoy	10 m	6.95 m/s	0.32 m/s (4.4 %)	2.17 m/s (29.8 %)	0.83
7	Japan	KBB10	10 m	7.71 m/s	-0.34 m/s (-4.6 %)	2.80 m/s (38.0 %)	0.74
8	Japan	KBB13	10 m	8.44 m/s	-0.88 m/s (-11.6 %)	2.86 m/s (37.8 %)	0.77
9	Japan	Kochinishi	7 m	6.28 m/s	0.34 m/s (5.1 %)	1.99 m/s (30.0 %)	0.82
10	Germany	Arkona Becken	10 m	7.75 m/s	-0.37 m/s (-5.1 %)	1.38 m/s (18.7 %)	0.93
11	Germany	Darßer Schwelle	9 m	7.47 m/s	-0.23 m/s (-3.2 %)	1.37 m/s (19.0 %)	0.92
12	Germany	Fehmarn Belt	8 m	7.38 m/s	-0.31 m/s (-4.4 %)	1.62 m/s (23.0 %)	0.89
13	Germany	Ober Bank	9 m	6.79 m/s	-0.24 m/s (-3.7 %)	1.33 m/s (20.3 %)	0.92

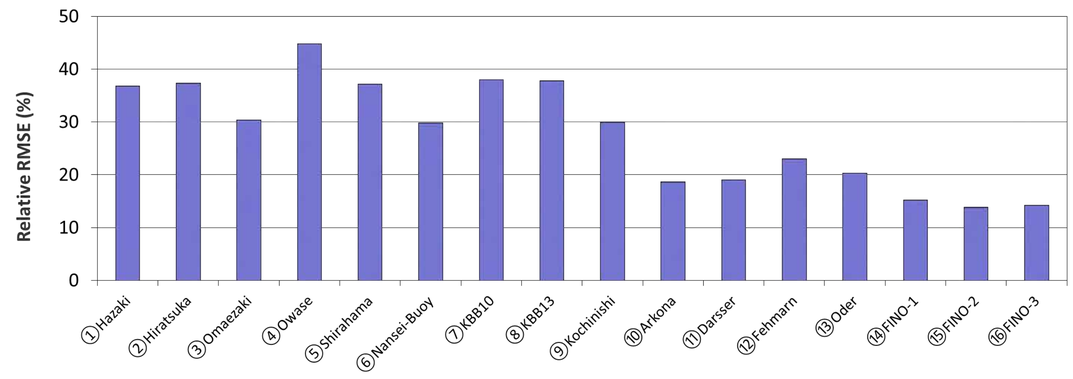

Figure 2 Relative RMSE for all sites of Japan and Germany (%)

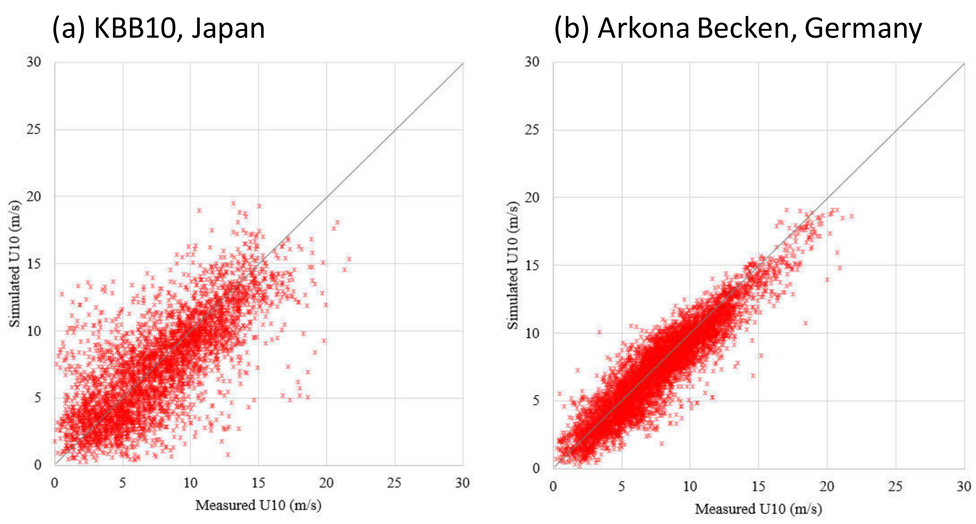

Figure 3 Wind speed correlation charts for representative sites of Japan and Germany.

Conclusions

Main conclusions in this study are summarized as follows.

1. Accuracy verifications of WRF-simulated sea surface winds show that Japanese sites have an annual bias of within ±10 %, a RMSE of 30 to 45 % and a CC of 0.72 to 0.85, while for German sites they are within ±5 %, around 20 % and 0.89 to 0.93, respectively.
2. These results indicate that even if the same model configuration, input data and verification method are used, the accuracy of mesoscale model simulated offshore wind speed is worse in the Japanese coastal waters, compared to that in the German coastal waters.

These results imply that the differences between both counties are caused by the difference in the accuracy of objective analysis used as input into WRF, as well as differences in complexity of topography and associated wind climate.

References

[1] Ohsawa, T., S. Shimada, D. Heinemann, G. Steinfeld, M. Schmidt, J. Tambke, L. Bremen, 2013 :Offshore wind resource maps in German coastal waters based on WRF simulation. Proc. of EWEA OFFSHORE 2013, Nov. 19 - 21, 2013, Frankfurt, PO.258, 10p.

[2] Olsen, B. T., A. N. Hahmann, A. M. Sempreviva, J. Badger, H. E. Jørgensen, 2015: Simulating wind energy resources with mesoscale models: Intercomparison of state-of-the-art models. Proc. of EWEA Annual Conference and Exhibition 2015, Nov. 17, 2015, Paris, France.

[3] Ohsawa, T., M. Kato, H. Uede, S. Shimada, Y. Takeyama, T. Ishihara, 2016: Investigation of WRF configuration for offshore wind resource maps in Japan, Proc. of Wind Europe Summit 2016, Sep. 27 - 29, 2016, Hamburg, Germany. (submitted)