IPID4all Doctorate Research Exchange with Carl von Ossietzky University Oldenburg
Feedback report

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Analysis of the result of WRF simulations on the choice of the driving objective analysis dataset

Introduction

The Weather Research and Forecasting model (WRF) is the most widespread model, used for offshore wind resource assessment. WRF can calculate a lot of weather elements by inputting meteorological and geographical data from different sources. Configurations of the WRF calculations can be changed freely and easily according to a needed accuracy, time-step, or domain. Actually, NeoWins (http://app10.infoc.nedo.go.jp/Nedo_Webgis/top.html), the wind atlas in Japan, was made from WRF simulation. Although assessments of wind resources can be done with less money by using WRF instead of a met mast, an improvement of the accuracy in the model is essential. An improvement of an input data for WRF is a possibility to do that. For this reason, this study focuses on objective analysis datasets used for the initial and boundary conditions for WRF simulations.

Research Undertaken

At first, a comparison of four objective analysis datasets is carried out in Japanese and German coastal waters. The details of these datasets are described in table 1. MANAL is a dataset made for complex Japanese terrain features and was used to make NeoWins (described in the former section). Figure 1 shows the location of in-situ observations in German and Japanese coastal waters. To derive wind speeds at each site from the information provided at the grid points of the objective analysis, the horizontal bilinear interpolation is used. Moreover, a liner interpolation using logarithmic height is used to adjust wind speeds to each different height of observations. The Verifications are conducted for a year (low height observation: 2014, hub height in Germany: 2014, and hub height in Japan: depending on those observation periods). To compare all datasets with different temporal resolutions and samples, relative bias and RMSE are used. These statistics are derived by dividing bias and RMSE (Root Mean Square Error) by mean wind speed.

Figure 2 and 3 show the result at low height and hub height observations respectively. At Choshi (a hub height observation in Japan), only monthly averaged mean wind speeds are available. Thus, relative RMSE cannot be calculated.

Table 1: Details of Objective analysis datasets

	ECMWF Operational	ERA interim	ERA5	MANAL
Source	ECMWF	ECMWF	ECMWF	JMA
Spatial resolution	0.25°x0.25°	0.25°x0.26°	0.3°x0.3°	0.05°x0.05°
Temppral resolution	6-hourly	6-hourly	hourly	3-hourly
Coverage	Global	Global	Global	Japan

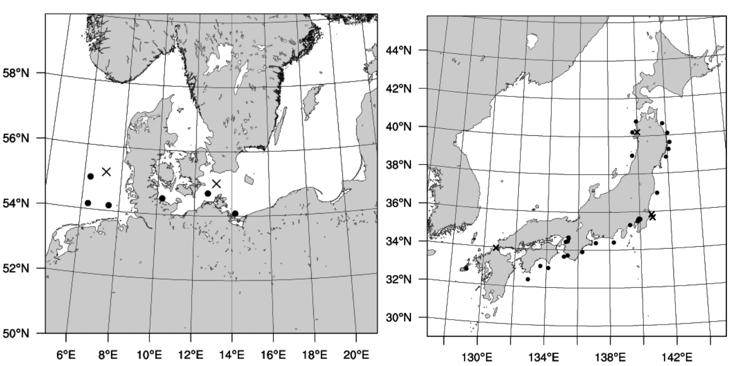

Figure 1: In-situ observations in Germany and Japan (dots: low height, crosses: hub height)

In terms of a comparison between two countries without MANAL, which is unavailable in Germany, all datasets have better accuracies at German sites. This implies that the accuracy of the same dataset varies from country to country.

In terms of a comparison between four datasets, EC-Oper seems to be the most accurate of three datasets in Germany, taking both bias and RMSE into account. In Japan, MANAL has high accuracies as well as EC-Oper. However, MANAL seems to be a more accurate dataset than EC-Oper considering them at hub height. This result implies MANAL is suitable for input data for WRF simulation.

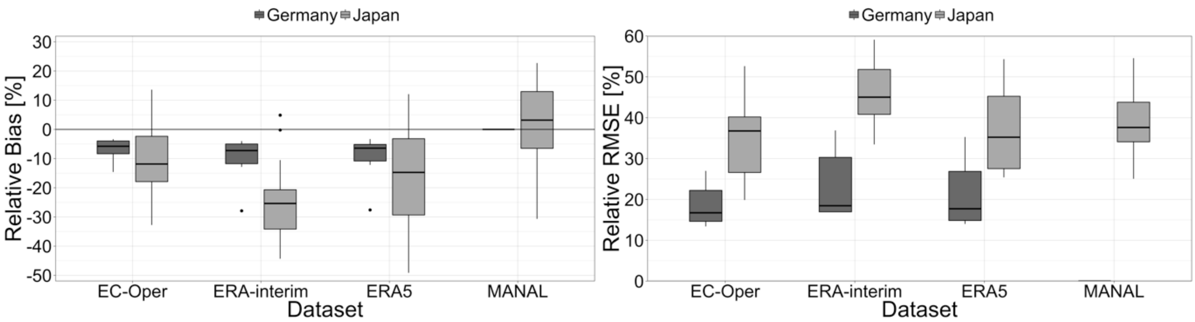

Figure 2: Result of the comparison at low height observations (left: relative bias and right: relative RMSE)

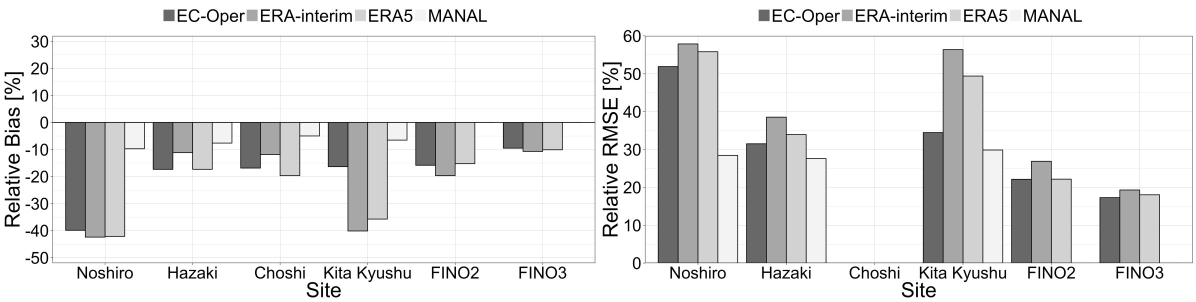

Figure 3: Result of the comparison at hub height observations (left: relative bias and right: relative RMSE)

After that, WRF simulations for hub height observations in both countries are carried out, in order to look at the effect of input data on the WRF result. In these simulations, EC-Oper is used as an input dataset for WRF. Moreover, most of physical options are similar to those used for making NeoWins, Japanese wind atlas. Table 2 shows these configurations. Figure 4 shows two example of domain settings. These similar configurations enable us to compare between MANAL (used for making NeoWins) and EC-Oper (used in this study). In this report, the accuracy comparison of WRF simulations using EC-Oper as an input data is described. Figure 5 shows the result at six hub height observations. According to this figure, there's no large difference about these biases, which are approximately within plus or minus 5% except Noshiro. However, RMSEs in Japan are twice as large as those in Germany. All thing considered, WRF simulations for Germany have better accuracy than Japan. Through this study, the fact that the accuracy in WRF simulation depends on an accuracy of input datasets is confirmed. Moreover, another comparison between MANAL and EC-Oper, as an input for WRF, will be carried out after this exchange.

Finally, I would like to acknowledge BMWi (Bundesministerium für Wirtschaft und Energie), PTJ (Projektträger Jülich) and BSH (Bundesamt für Seeschifffahrt und Hydrographie) for FINO2, FINO3 and other buoy data in Germany. For Japanese hub height and low height observations, I would also like to appreciate NEDO (New Energy and Industrial Technology Development Organization) project for making offshore wind resource map.

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Table 2: Configuration used in WRF simulations

Model	Advanced Research WRF (ARW) Ver. 3.6.1
Period	Japan: Depending on obs., Germany: 2014 (Annual)
Input data	ECMWF Operational Analysis Japan: MOSST, Germany: OSTIA NCEP FNL (for Soil)
Domain	Domain 1 : 12.5km grids, 100 x 100 Domain 2 : 2.5km grids, 100 x 100 Domain 3 : 0.5km grids, Approx. 1° x 1°
Level	40 levels (surface to 50hPa)
4DDA	Domain 1 : Enable Domain 2 : Enable Domain 3 : Enable, but excluding below PBL height
Physical Option	Dudhia shortwave scheme RRTM longwave scheme Ferrier (new Eta) microphysics scheme Mellor-Yamada-Janjic (Eta) TKE PBL scheme Monin-Obukhov (Janjic Eta) surface-layer scheme Noah land surface scheme

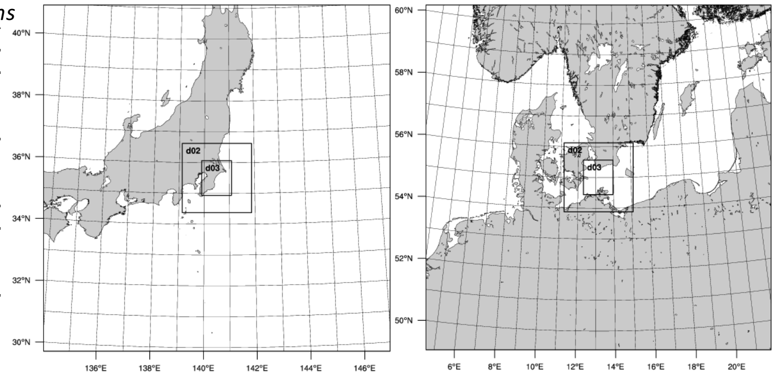

Figure 4: Examples of domains used in the simulations (left: for Hazaki and Choshi, right: for FINO2)

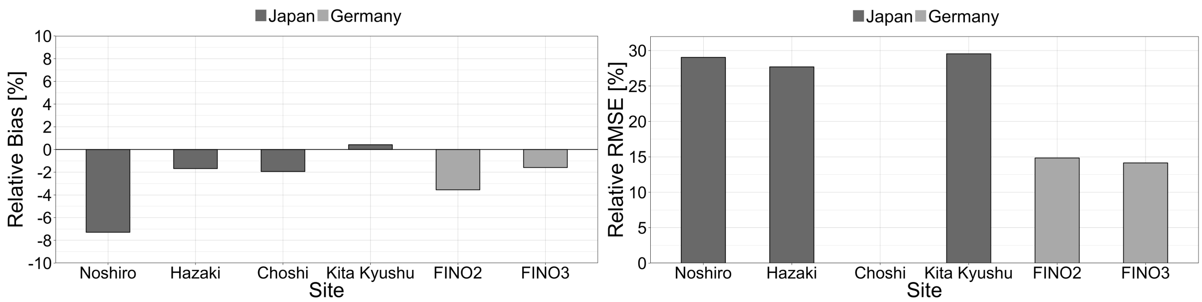

Figure 5: Result of the comparison of WRF simulations (left: relative bias and right: relative RMSE)

Personal Experience

In this program, I stayed in Germany for the first time. It was always challenging for me to communicate with all people and live alone in different country. However, it was also exciting days. I learned a lot of things related to Germany. Especially, I was surprised at a number of onshore and offshore wind turbines, which is one of the biggest differences between Japan and Germany.

ForWind is a nice place for me to concentrate on my study. I was happy to be in such an awesome environment. During free time, I was able to enjoy everything with the members of ForWind. This enabled me to learn not only the study, but also the lifestyle, culture, and people's kindness.

Conclusions

The IPID4all program gave me a great opportunity to stay in Carl von Ossietzky University Oldenburg. I spent a nice time here, thanks to this program. I would like to express my gratitude to everyone concerned my stay, especially Dr. Gerald Steinfeld, who kindly supported my study and life in Oldenburg.

Outlook

- Publications related to the results with Dr. Gerald Steinfeld

DAAD

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