English Summary

Wind Variability Database in Hokkaido District

The 2011 off the Pacific coast of Tohoku Earthquake has necessitated our nation to implement the use of renewable energy from both global warming and energy policy perspectives. In this context, this work aims to develop and make available a database containing assessments of wind variation risks within the Hokkaido area, which is consistent with the previously built Tohoku-district database. Moreover, variation characteristics in wind direction, not considered in the previous work, were evaluated for Hokkaido and Tohoku districts. This database is intended to aid those considering wind power generation in the area. This report describes the work concerning creation of the database and discusses the assessment results obtained.

(１) Creation of detailed wind state data of the Hokkaido district over the past 20 years

Understanding of long-term annual wind variation is an important factor in wind power generation business because 15-20 year time span is usually considered for carrying on this type of business. Although meteorological stations across the country continuously record observation data necessary to carry out such long-term wind variation assessments, there exist problems. First, the number of these meteorological stations is far from sufficient. Furthermore, various changes are made in, for example locations of the offices and observation apparatus, which make understanding of long-term annual wind trends difficult. Therefore, essential long-term annual wind data is still lacking and is posing the industry a great risk in judging startup and continuance of wind power generation business.

In order to overcome such difficulties and to grasp the trends in long term wind states, numerical weather simulations over the past 20 years in the Hokkaido region were carried out in this study. The implementation of numerical weather simulations allows for reproduction of the climate states over the past 20 years in any spatial range. The numerical simulations implemented in this study are based on the patented technologies developed collaboratively between the ITOCHU Techno-Solutions Corporation (CTC) and the Tohoku Electric Power Co., Inc. (patent no. 3226031). High-resolution numerical simulations, 1 hour and 500m in time and spatial mesh respectively, of the Hokkaido district were carried out, and detailed wind states for the region over the past 20 years were reproduced and created. A CTC-original software LOCALS™, incorporating numerical weather prediction (NWP) model, was implemented into a zooming-style simulation as illustrated in Figure 1. The computational domain and the time period considered are, areas within services of the Hokkaido Electric Power Co. and 20 years: 1991~2010, respectively. Since execution of thousands of cases must be completed within a given time frame, the simulations reported in this work were carried out in distributed computing style, specifically 60 cases in parallel per each execution.

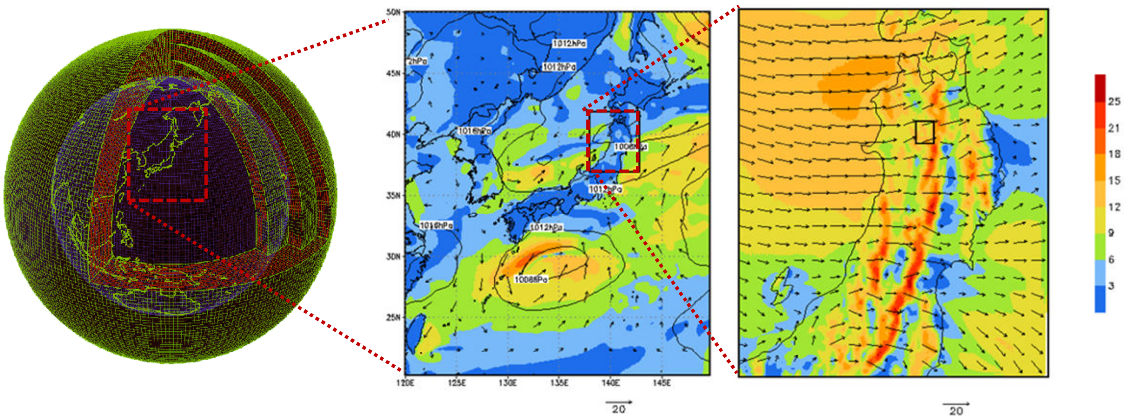

Fig. 1 A conceptual illustration of the numerical weather simulation

(2) Creation of wind-state variation database

Usually, wind energy developers, lenders and investors estimate the expected annual gross power of electricity to be generated to evaluate the continuance of the wind energy businesses. Since the gross annual power generation is an important factor, its variation risks must be evaluated adequately, which require information on variation of annual wind speed.

In order to grasp such variations, wind speeds were computed over the past 20 years using wind data created from high-resolution state-of-the-art numerical weather simulations involving 1 hour and 500m mesh in time and space, respectively. Using the computed average wind speed of the past 20 years, analyses were carried out to determine the variation range and long-term trends. The assessments were made based on wind speeds at 80m above ground assuming the hub-height of 2MW-class wind turbines.

The range of variations in the wind states were evaluated using indices based on standard deviations. Currently, internationally implemented wind power generation risk assessments assume distributions of the variations concerning individual risk factors, for example yearly fluctuations and simulation errors, to be normal. These assessments superpose the standard deviations from each risk factor to evaluate total risks in wind power generation. In this investigation, wind variation risks resulting from errors in the simulations of annual wind speed were taken into consideration for analyzing the variation range of annual wind speed.

This year, in order to grasp the wind-direction traits of the Hokkaido region, frequencies of winds according to directions (16 directions) based on wind speed classification and all wind speeds, and average speeds were compiled. The wind direction frequencies based on wind speed classifications were visualized as wind-rose diagrams. As for data made open to the public, most frequent directions of winds that exceed 5.5 m/s were collected and the direction was illustrated with an arrow for each given point (mesh).

In this report, the analysis results were summarized as shown in Table 1. The averaged annual wind speed of the past 20 years and standard deviations of the Hokkdaido district are illustrated in Fig. 2. By creating a database of the Hokkdaido district, this work clarified the average annual wind speed and its wind variation risks. Furthermore, frequencies and average wind speeds for 16 directions, as well as most frequent directions from detailed 20-year simulation results were compiled and visualized as wind-rose diagrams as illustrated in Fig. 3 and Table 2.

Table 1 Specification summary of the wind-state variation database

database component	content
Average annual wind speed over 20 years	20-year average of annual wind speed [m/s] (simulation errors not considered)
Standard deviations of yearly annual wind speed	Standard deviations of yearly annual wind speed over 20 years[%] (simulation errors considered)
Maximum annual wind speed in yearly annual wind speed	Maximum annual wind speed in yearly annual wind speed [m/s] (simulation errors not considered)
Minimum annual wind speed in yearly annual wind speed	Minimum annual wind speed in yearly annual wind speed [m/s] (simulation errors not considered)
Frequencies of winds according to 16 directions	Frequencies of winds according to 16 directions over 20 years

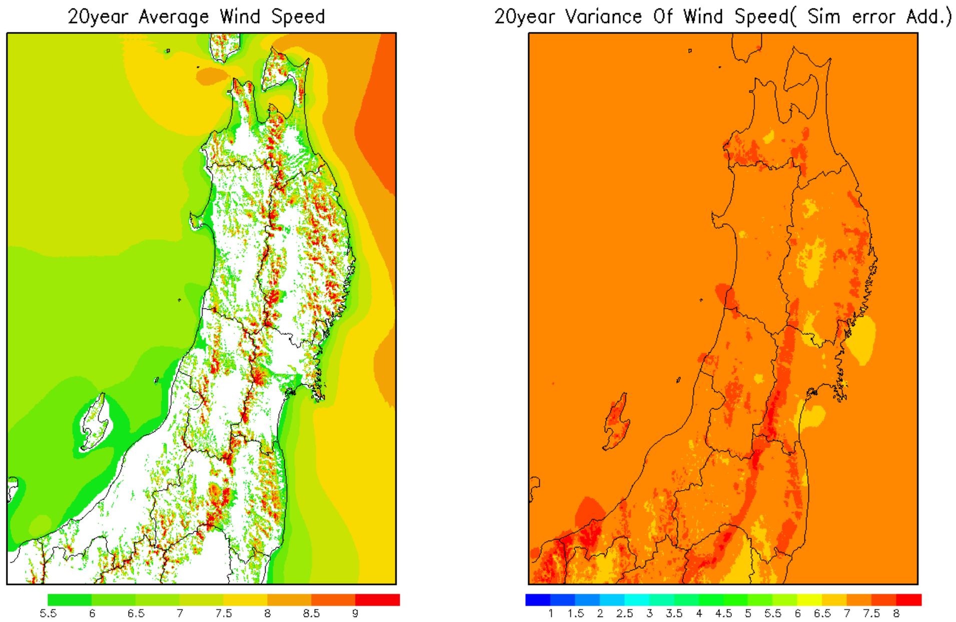

Fig. 2 Average annual wind speeds over the past 20 years in the Tohoku district[m/s] (left) , Standard deviations[%](right)

Calculated based on yearly averaged wind speeds at 80m above ground over the past 20 years. Simulation errors were taken into consideration for calculating the standard deviations.

Table 2 Example of frequencies and average wind speeds for 16 directions, as well as most frequent direction

most frequent direction	WNW

	0.3[m/s] ～ 4.0[m/s]	4.0[m/s] ～ 6.0[m/s]	6.0[m/s] ～ 9.0[m/s]	9.0[m/s] ～ 12.0[m/s]	12.0[m/s] ～ 15.0[m/s]	15.0[m/s] ～	**all wind speeds**	**average speed**
NNE	0.75	0.73	0.88	0.44	0.29	0.26	3.34	7.63
NE	0.73	0.68	0.81	0.46	0.2	0.22	3.09	7.41
ENE	0.83	0.65	0.79	0.4	0.22	0.24	3.14	7.35
E	0.81	0.71	0.87	0.44	0.21	0.24	3.29	7.34
ESE	0.74	0.69	0.97	0.56	0.29	0.29	3.53	7.85
SE	0.77	0.85	1.08	0.6	0.39	0.48	4.18	8.39
SSE	0.9	0.94	1.4	0.98	0.57	0.62	5.41	8.67
S	1.06	1.14	2.08	1.52	0.9	0.86	7.57	8.96
SSW	0.95	1.24	2.27	2.02	1.16	0.93	8.56	9.23
SW	0.94	1.29	2.21	1.79	0.97	0.66	7.86	8.75
WSW	1.01	1.33	2.24	2.06	1.08	0.48	8.18	8.61
WSW	0.97	1.22	2.83	2.94	1.99	2.5	12.44	10.8
WNW	0.9	1.11	2.45	3.31	3.36	4.33	15.45	12.07
NW	0.75	0.85	1.38	1.33	0.97	0.72	6.01	9.36
NNW	0.73	0.72	1.04	0.7	0.43	0.35	3.98	8.31
N	0.77	0.74	1.12	0.6	0.35	0.39	3.97	8.21

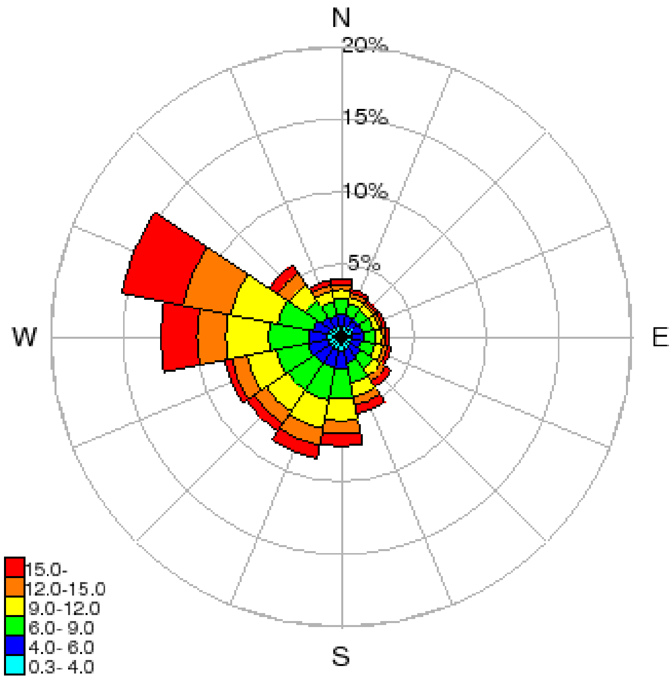

Fig. 3 Example of wind rose

(3) Upgrading of wind-state variation database of the Tohoku region

In the previous year, databse was created for 4 elements such as 'Average annual wind speed over 20 years', 'Standard deviations of yearly annual wind speed', 'Maximum annual wind speed in yearly annual wind speed' and 'Minimum annual wind speed in yearly annual wind speed'. This year, as done in the Hokkaido region, frequencies of winds and average wind speeds for 16 directions were added to the Tohoku region database to aid in better understanding of the wind direction traits. The frequencies of winds direction-wise according to speed classifications and all winds, and average wind speeds were compiled. Again, most frequent directions based on speed classification were illustrated by wind-rose diagrams. As for publicly opened data, most frequent directions of winds that exceed 5.5 m/s were collected and the direction was illustrated with an arrow for each given point (mesh).

(4) Creation of public database

Since all data in the wind database carry geographical information, this makes visualization on maps and atlases possible. In this work, Google Earth, a freeware open to public, was chosen for this purpose. Through the creation of such data, wind energy developers, lenders and investors can visually associate wind data with maps and atlases in a geometric sense. Average wind speeds and variations (standard deviations, max/min speeds) and frequencies of winds according to 16 directions were added to the database.

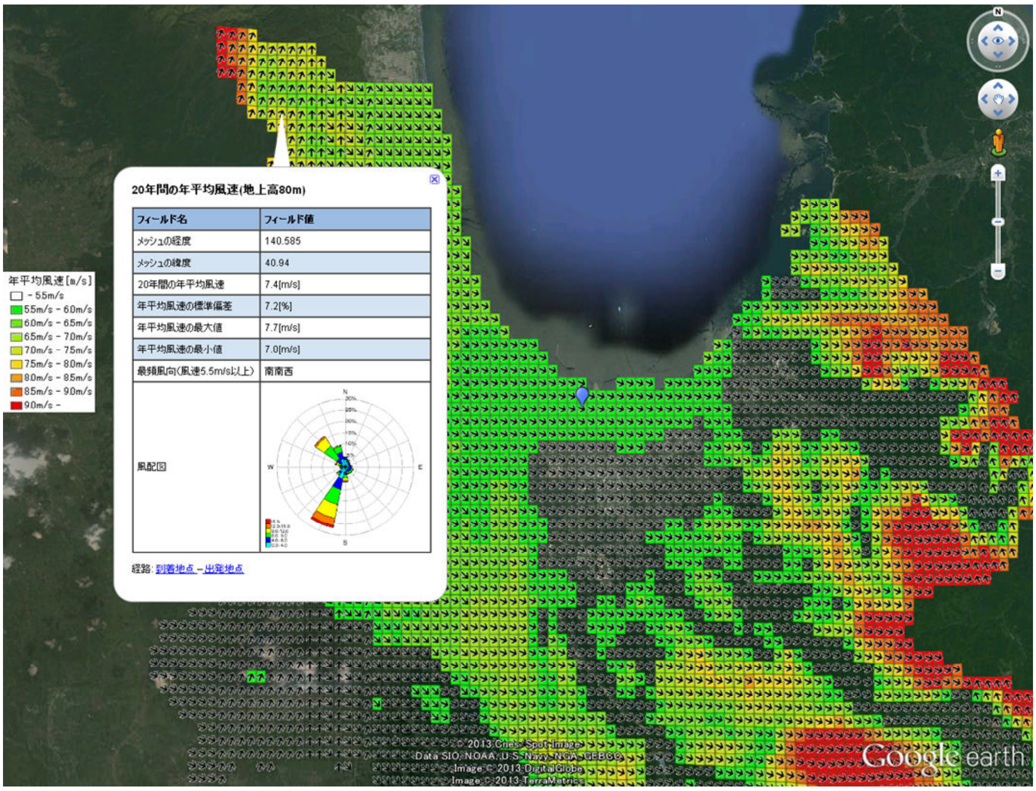

Fig. 4 Image of viewing data