Introduction

To determine the $V_{m}$ on the site assessment of wind turbine, those methods which are based on Monte Carlo Simulation of tropical cyclones [3] or mesoscale model are proposed. However, the averaging time of the maximum wind speed estimated by these methods is 1 hour to 3 hours and the correction concerning the difference in the averaging time is needed. In IEC61400-3, an international standard for design of offshore wind turbine, 1 hour average wind speed is needed to calculate the extreme load under extreme wind and wave situation, which have to be estimated from 10 minutes average wind speed.

Larsen and Mann [3] investigated the relationship between 10 minutes average maximum wind speed and that of longer averaging time based on the measurement during strong wind event at five sites in Denmark and three sites along the coast of Gulf of Suez, and proposed a model for the correction, which is adopted in IEC61400-3. However, as the variations of wind speed during tropical cyclones are usually larger than that during the other strong wind event, the estimated 10 minutes average wind speed based on this model may underestimate the 10 minutes average maximum wind speed.

Yasui et al. [4] modeled the standard deviation of the difference between 10 minutes average wind speed and 3 hours average wind speed based on the measurement data during tropical cyclones. However, the properties of maximum wind speed with the averaging time of 3 hours and 10 minutes were not discussed and no model was proposed for the averaging time other than three hours.

This study try to investigate the relationship of 10 minutes average wind speed and that of longer averaging time based on this model may underestimate the 10 minutes average maximum wind speed.

The difference of Wind Speed for Different Averaging Time

To clarify the effect of difference in the averaging time on the maximum wind speed, the distribution of the difference in wind speed is investigated by using the measurement data.

- Extratropical cyclones: Measurement data at Iwaki [5]
- Tropical cyclones: Measurement data at Miyako-Jima Island

Moving average for M minutes average wind speed

If $M$ is an even number

$$u_{M,i} = \frac{1}{2} (u_{i} + u_{i+1})$$

$$m = \frac{1}{2} \frac{M}{10}$$

If $M$ is an odd number

$$u_{M,i} = \frac{1}{2} (u_{i-1} + u_{i+1})$$

$$m = \frac{1}{2} \frac{M}{10} - \frac{1}{2}$$

The difference of 10 minutes average wind speed and 10 minutes average wind speed

- The average value of $u_{M,i}$ is independent of wind speed and almost always equal to 0.
- The variance becomes larger as the $M$/10 minutes average wind speed becomes larger.
- The variance is larger for the case of tropical cyclone.

Distribution of the differences between 3 hours average wind speed and 10 minute average wind speed: Extratropical cyclone at offshore Iwaki, b) Tropical cyclone at Miyako-Jima.

- The average value of $u_{M,i}$ is independent of wind speed and almost always equal to 0.
- The variance becomes larger as the $M$/10 minutes average wind speed becomes larger.
- The variance is larger for the case of tropical cyclone.

Modeling of the Standard Deviation of $\Delta u$

As log-normal distribution can be characterized by standard deviation, for both the case of tropical cyclone and extratropical cyclone, the standard deviation $\sigma_{\Delta u}$ of $\Delta u_{M,i}$ is plotted against $M$ minutes average wind speed $u_{M,i}$.

$$\sigma_{\Delta u_{M,i}} = a(M) u_{M,i}$$

For extratropical cyclones, the standard deviation can be modeled as:

$$\sigma_{\Delta u_{M,i}} = b(M) u_{M,i} + c(M)$$

Where, $a(M)$, $b(M)$ and $c(M)$ are the functions of averaging time $M$ and estimated for each $M$ by using least square method.

- By multiplying the coefficient proposed in this study, the maximum value of 10 minutes average wind speed can be captured.

Conclusions

In this study, the measurement data of wind speed during tropical cyclone and extratropical cyclone are analyzed and a method to estimate the maximum value of 10 minutes average wind speed from minutes average wind speed are proposed.

References