The effect of averaging time and recording interval on the mean wind speed and significant wave height

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1. Introduction
To determine the $V_{ref}$ in the site assessment of wind turbine, those methods which are based on Monte Carlo Simulation of tropical cyclones[1] or mesoscale model are proposed. However, the averaging time of the maximum wind speed estimated by these methods are said to be 1 hour to 3 hours and the correction concerning the difference in the averaging time is needed. What is more, in IEC61400-3[2], 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 in Suez, and proposed a correction model, which is adopted in IEC61400-3. However, the applicability of this model to the other sites and conditions are not clarified.

Similar discussion is needed for the evaluation time of significant wave height. In addition, in Japan, historical measurement data of significant wave height is recorded every two hours. These data is needed for the estimation of significant wave height with the return period of 50 years. However, the statistical characteristic of these data is not made clear.

2. Objectives
This study first try to investigate the relationship of 10 minutes average wind speed and that of longer averaging time using the measurement during both tropical cyclone and other strong wind event, and propose a model for the correction. Then similar approach is taken for the significant wave height. Lastly, the effect of sampling frequency, especially the characteristic of the historical significant wave height data evaluated for 20 minutes recorded every two hours, are discussed and a method to utilize those historical measurement data is proposed.

3. Methodology
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. As an example of the
strong wind other than tropical cyclone, the measured wind speed from 2004 to 2005 at a natural gas platform located at offshore Iwaki [5], Japan were used. In this data, strong wind event is mostly caused by extratropical cyclones. The effect of evaluation time of the significant wave height was investigated by using the wave height measurement at Choshi Offshore test site is used.

4. Results
The difference between 10 minutes wind speed and other averaging time is investigated and an example is shown in Figure 1. Similarly, the difference between significant wave height of evaluation time of 20 minutes and other evaluation time is investigated and an example is shown in Figure 1.

Figure 1. The difference between 3 hours average wind speed and 10 minutes average wind speed for non-typhoon wind at Iwaki (left); the difference of significant wave height with the evaluation time of 3 hours and 20 minutes for non-typhoon case in Choshi (right)

The distribution of these difference assumed to follow log-normal distribution (Figure 2) and the mean value and the standard deviation of the distributions are identified empirically by using the measurement data.

Figure 2 Distribution of the differences between 3 hours average wind speed and 10 minute average wind speed for 3 hours average wind speed is between 19m/s and 20m/s (left); similar distribution for wave height (right)

Based on this modelled log-normal distribution, Monte Carlo simulation is performed to generate the wind speed and wave height with shorter averaging time and evaluation time. Then the statistical relationship between maximum values are investigated. The results shows similar characteristics to the relationship proposed by Larsen and Mann [3] for non-typhoon case. The results for typhoon will be shown in the full paper.

An correction method of historical wave data measured each two hours, is proposed as shown in the following equation. By using this equation, the historically measured data $H_{1/3}^{20}$ the evaluation time of which is 20 minutes are corrected to continuous data with the evaluation time of three hours $H_{1/3}^{180}$. 
Figure 3 shows the comparison of true continuous data and converted data from the data measured each two hours. Clearly, the wave height converted to three hours evaluation time shows good agreement with the continuous data.

\[
H_{1/3}^{180/i} = \frac{1}{6} \left[ \left( \tilde{H}_{1/3}^{20,i-1} \right)^2 + 4 \left( \tilde{H}_{1/3}^{20,i} \right)^2 + \left( \tilde{H}_{1/3}^{20,i+1} \right)^2 \right]
\]

Figure 3 comparison of historical wave height data measured each two hours and continuous data: evaluation time of 20 minutes (left); evaluation time of three hours (right)

5. Conclusions
In this study, the effect of averaging time and evaluation time of mean wind speed and significant wave height was investigated. The characteristic of the historical wave height data recorded each two hours are also investigated. Following results were obtained.

1. The characteristics of the different averaging time and evaluation time of mean wind speed and significant wave height were investigated and statistical relationship between different averaging / evaluation time is modelled. Based on the proposed model, the relationship between maximum values are investigated. The results for maximum wind speed for non-typhoon case shows similar characteristic proposed by Larsen and Mann.

2. The characteristic of the historical wave measurement data recorded every two hours are investigated and a correction method to those data is proposed. The estimated significant wave height with the evaluation time of three hours from historical data shows very good agreement with continuously recorded significant wave height with the evaluation time of three hours.

6. References