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Conversion of Wind and Waves with Reference Periods for the Donghae Gas Field

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In this study, wind and waves are studied for offshore wind power at the Donghae gas field in South Korea. Two kinds of data sets are compared: one set contains 39-year National Oceanic and Atmospheric Administration (NOAA) hindcast data and the other 3-year buoy-measured data obtained by the Korea Meteorological Administration in South Korea (KMA). The NOAA and KMA data sets for different reference periods, recording intervals, and measuring altitudes are compared. Furthermore, data from 2.7-year (2 years and 8 months) in situ measured waves at the end of a jetty and wind at a height of 100 m in the shipyard of Samsung Heavy Industries Co., Ltd. (hereafter referred to as the SHI yard) are used in advance to investigate the feasibility of these conversions. This study proposes the conversion relations between different conditions for wind and waves. For waves, an uncertainty correction factor with different reference periods is suggested to convert and compare the significant wave heights for the data sets in the Donghae gas field and the SHI yard. For wind, the traditional Norwegian Petroleum Directorate (NPD) wind profile optimized for open sea as recommended by DNV GL is directly used to convert the wind speed in the Donghae gas field with different reference periods. However, because of significantly complex terrain conditions in the SHI yard, a newly modified NPD wind profile is suggested to adjust the turbulence intensity. Then it is applied to convert and compare the wind speed in the SHI yard. This modified NPD wind profile shows a good match, but it requires further study because of the limited data length used in this study.

INTRODUCTION

There is a growing interest in renewable energy around the world to reduce gas emissions from the combustion of fossil fuels. The Korean government has also developed offshore wind power as an alternative. Reliable design environment conditions such as wind and waves are highly desired in applications of offshore structures or floating offshore wind turbines (FOWTs). Unfortunately, there are several different reference periods of duration of wind and waves with different recording intervals, including idling times. For example, the National Oceanic and Atmospheric Administration (NOAA) hindcast wave data typically provide 3 hr-Hs and 10 m-1 hr-Vw every 3 hr as an offshore standard, where 3 hr-Hs denotes significant wave height (Hs) in a 3 hr reference period, and 10 m-1 hr-Vw denotes the 1 hr average wind speed (Vw) at an average water level of 10 m in a 1 hr reference period. Meanwhile, the Korea Meteorological Administration (KMA) in South Korea provides measurement data recorded by an offshore wave buoy composed of 17 min-Hs for wave heights and 5 m-10 min-Vw for wind speeds. Their recording interval is 30 min or 1 hr. Waves are sampled at 1 Hz. Every one of the 1,024 samples is analyzed by Fourier transform to get spectral quantities of Hs and the spectral peak wave period in seconds (Tp). The height of an anemometer on the buoy is about 5 m from its draft. Therefore, the conversion relations of magnitudes of wind and waves with different reference periods should be considered to compare them with different sources of data sets of wind and waves.

First, in this study, in situ measured wind speeds and waves at the shipyard of Samsung Heavy Industries Co., Ltd. (SHI yard) were used to study the conversion factor of Hs and Vw. The wind was measured at a height of 100 m, where the top of the Goliath crane is located. Waves were measured at the end of the K-jetty. The measurement period is about 2.7 years (2 years and 8 months). A conversion factor for waves with different reference periods and recording intervals are newly derived in this study based on analytical relations assuming a narrow-banded Gaussian random process of wave elevations with an additional uncertainty correction coefficient. For wind speeds, a modified Norwegian Petroleum Directorate (NPD) profile is newly introduced to obtain a conversion factor according to different reference periods based on the traditional NPD wind profiles (Frøya, ISO, and NORSOK) in open sea as recommended by DNVGL-RP-C205 (DNV GL, 2019) and API RP 2SK (American Petroleum Institute, 2005), with an additional correction factor to adjust the turbulence intensity (TI) as a result of complex terrain conditions (e.g., the SHI yard).

Then, two data sets of Hs and Vw in the Donghae gas field—one comprising 39-year long-term NOAA hindcast data and the other 3-year buoy-measured KMA data—are investigated. For waves, the wave conversion factor as described above is applied to convert 17 min-Hs of the KMA data into 3 hr-Hs, and it will be compared with 3 hr-Hs of the NOAA data. The traditional NPD wind profile with no TI correction is directly applied to convert 5 m-10 min-Vw of the KMA data into 10 m-1 hr-Vw, and then it will be compared with 10 m-1 hr-Vw of the NOAA data.

SHI YARD DATA

Measurements of Wind and Waves at SHI Yard

Since June 2018, waves have been measured at the end of a K-jetty as shown in Fig. 1, supported by several thin columns with a diameter of about 0.2 m in the SHI yard. The mean water level is within the height of these columns to avoid the reflected waves. An ultrasound-type LOG_aLevel has been measuring wave elevations with 5 Hz of sampling rate. Every one of the 4,096

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KEY WORDS: Modified NPD wind profile, conversion relation (factor), reference period of duration, recording interval, turbulence intensity (TI) correction factor, floating offshore wind turbine (FOWT), inverse first-order reliability method (IFORM).