Assessment of Nearshore Wave Energy Resource Using Offshore Hindcast Data

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ABSTRACT

The hindcast wave data is widely used to assess the wave energy for the offshore region. In order to obtain the wave climates for nearshore region, numerical simulations were conducted for the representative waves or every wave climates conditions. While the former have a tendency to underestimate the wave energy, the latter needs enormous computational efforts. In this study, we suggest the simplified method to correct the nearshore wave power obtained by the numerical simulation with respect to representative wave by multiplying the correction factor. The correction factor is derived explicitly in terms of cross-correlation and the coefficients of variation.

KEY WORDS: hindcast data, numerical modeling, correction factor, wave power

INTRODUCTION

With limited domestic energy resources, South Korea is almost entirely dependent on imports to meet its energy consumption needs. South Korea is one of the largest net importers of oil in the world and a major importer of liquefied natural gas (LNG). Recently, global warming, the Kyoto Protocol, and the rising cost of electricity generation have aroused interest in renewable ocean energy in South Korea.

Wave energy is a renewable energy source with high power density, low visual impact, and presumed low impact on the environment compared to other renewable sources. In particular, the wave energy is being increasingly regarded as a major and promising resource in South Korea because the Korean peninsula is surrounded on all sides by Yellow Sea, East China Sea and East Sea. Until now, the wave energy potential of South Korea has only been evaluated by global wave modeling. Details on the wave energy resources around the Korean peninsula remain poorly defined.

An assessment of the wave energy resources is not only a basic prerequisite for the planning of its utilization and the selection of available sites but also an important requirement for choosing the most appropriate wave energy converter for the area and designing the converter’s capacity. The offshore wave energy can be assessed by hindcast wave data, which provide the temporally consistent and full spatial coverage required for wave energy assessment. In this study, the significant wave height, peak period, and wave direction hindcast for the period of 1979 – 2003 were used to calculate the offshore wave power densities around the Korean peninsula.

Along with offshore wave energy assessment, the wave energy around Hongdo Island was also investigated as it has the highest wave energy in the vicinity of the Korean peninsula. In general, waves propagating to nearshore sites undergo various forms of transformations such as shoaling, refraction, diffraction, and reflection. In order to consider these wave transformations at the nearshore sites, an appropriate wave transformation model should be applied. Among the various kinds of wave transformation models, SWAN (Simulating WAves Nearshore) model is widely used to simulate the waves from offshore to nearshore. Previously, many researchers performed numerical simulations of wave transformation in two ways to assess the nearshore wave energy. The first is a simulation with respect to the offshore wave time series to validate the wave buoy data and the wave model results, and the other is to simulate the representative waves of typical seasonal wave conditions. The former requires enormous computational time and effort. The latter yields inspection on the patterns for the spatial and temporal distribution of nearshore wave energy but tends to underestimate the amount of wave energy in the nearshore region owing to the correlation between the significant wave height and wave period. Özger et al.(2004) derived the stochastic wave energy formulation by introducing a correction factor explicitly in terms of the covariance of the wave energy and significant wave height. In this study, a correction factor was applied for the assessment of nearshore wave energy obtained by numerical simulation of wave transformation with respect to representative waves.

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Hindcast wave data recently established by Lee and Jun (2006) were used for this study; the data contain the significant wave height, peak period and direction for each grid point of the regional seas in northeast Asia with a grid size of 1/6° (approximately 18 km) covering a longitude of 117–143°E and latitude of 20–50°N with a frequency of 1 hour. Fig. 1 shows a map of the Korean peninsula and the resolution for the hindcast data.

The wind field used in the continuous wave simulation was the reanalyzed wind data conducted by European Centre for Midium-Range Weather Forecasts (ECMWF), which was interpolated to the grid points and time steps of the wave simulation model. However, winds induced by typhoons vary rapidly in space and time during the passage of the typhoon; which cannot be properly modeled by large scale wind data such as ECMWF data. The simulation of the waves for typhoon was separately carried out by using typhoon winds calculated by typhoon

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