Verification of 1D and 2D wave spectral formulations against measured data

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ABSTRACT

The paper presents a verification of 1D and 2D wave spectral formulations against measured data, aiming at validating and possibly improving the empirical formulas used in the definition of spectral parameters. Jonswap spectral formulation has been employed, with Mitsuyasu-like directional spreading function. The verifications of the empirical formulations commonly used in engineering practice, have highlighted a reasonable agreement with measured data, although extremely dispersed.

KEY WORDS: Wave spectra; directional spreading function; spreading parameter; spectral width; peak enhancement factor; Goda and Suzuki.

INTRODUCTION

In the engineering application, a sea state is generally completely described using spectral forms. The most common spectral forms for describing the frequency distribution of the energy of a sea state are usually the Jonswap and Ochi-Hubble formulations. Their efficacy has been demonstrated by numerous studies and publications related to various world locations such as the one by Gao et al. (2020) and Piscopia et al. (2003). To describe the directional distribution, equations such as the one proposed by Mitsuyasu et al. (1975) or the Wrapped Normal one, are generally used. The parameters of these relationships would require calibration based on spectral measured data at the site of interest. However, measurements of spectral data are rarely available, and, for this reason, empirical correlations from literature are often used.

In this study, Jonswap spectral formulation have been employed, with Mitsuyasu-like directional spreading function. For Jonswap spectrum, the relationships for spectral parameters proposed by DNVGL-RP-C205 and the HYPA relation for spectral amplitude have been considered. The aim of this paper is to use a series of measured spectral data from Mediterranean Sea and Barents Sea, to verify how these empirical relationships correctly estimate the measured spectra. In particular, as for 1D spectra, the reconstructed spectra from measured data will be compared with the Jonswap formulations while, as regards 2D spectra, the results obtained using the directional spreading function reconstructed from measure data, will be compared with those obtained using the empirical spreading function of Mitsuyasu et al. (1975) and the expression of Goda and Suzuki (1975) for the spreading parameter which can be improved by a slight modification of coefficients. The measured data have however shown high dispersion. It can therefore be said that any empirical relationship does not always provide an exhaustive description of the spectrum. These uncertainties should be considered in engineering practice by introducing appropriate precautions into design.

Finally, measured data have been used to check the Goda relationship between maximum directional spreading parameter and wave steepness. Since this correlation is the only one proposed by the literature to link these two parameters, it is easy to use it in engineering practice. The measured data, although extremely dispersed, show that the relationship provides an upper limit to the observed data and does not seem applicable for standard design conditions.

BASIC DATA

The measured data used in this paper have been taken from measurement campaigns at 2 locations. The first of these measuring points, named H1, is in the Mediterranean Sea, offshore the Egyptian coast at the Nile Delta. The measurement campaign lasted from February 1999 to February 2000. The second measuring point, named W1, is in the Barents Sea offshore the northern Norwegian coast. The measurement campaign lasted from November 2006 to December 2007. For these locations, the features in terms of position, water depth, instrument type and start/end measuring date and time, have been reported in Tables 1~2, whereas Figs. 1~2 show the measuring points geographical overview. The measuring points provide both synthetic data like significant weight height ($H_s$), peak wave period ($T_p$), mean zero crossing period ($T_c$), maximum wave height ($H_{max}$) and associated period ($T_{max}$), maximum crest elevation ($C_{max}$), mean wave direction ($\theta$), and spectral data like reference frequency range (or bin) in which the spectral parameters are recorded, spectral energy density associated to a fixed frequency bin, mean wave direction, directional spreading...