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Performance assessment of wave measurements of wave buoys

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ABSTRACT

Long term wave measurement is of vital importance for assessing the wave power resources, optimizing the productivity of wave energy devices, and determining the largest waves for the survivability of the wave energy device during its life time in sea. Among the technologies developed for measuring ocean waves, wave buoys may be one of the most popular used devices for long-term wave measurement. In order to investigate whether the wave characteristics can be accurately measured using the wave buoys, an experimental study was carried out on the performance of three wave buoy models, that is, Wavescan buoys and one ODAS buoy, in a wave tank using the European FP7-MARINET facilities. The wave measurements using the wave buoys are compared to the measured waves using the reference wave gauges in the tank so the accuracy of the wave measurements can be examined. This paper presents the analyzed results in both time and frequency domains and the comparison between the measurements by the wave buoys and wave gauges. The analysis results reveal that the wave buoys are reliable for measuring the scaled wave conditions, for both regular and irregular waves. Besides, the Wavescan buoys have better performances than the ODAS buoy in terms of accuracy and the correlation with the wave gauges.

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1. Introduction

As fossil energy is being blamed as the main source of global warming associated with the problem of energy depletion, more projects are in process to exploit the power from the ocean taking advantage of various wave or tidal energy devices. Various wave, tidal and current energy converters have been developed to exploit the huge potential marine power, especially wave energy. Relatively, wave energy development is still at an early stage though the potential is quite considerable. Among the existing problems within the exploit of wave energy, a variety of wave energy resources assessments have been conducted around the world by deploying different wave buoys and other wave measuring technologies [1–5], while long-term measurements are still under investigation. For example, for the survivability of wave energy converters, the largest waves must be determined for the life cycle of the wave energy converter. So far, the real largest waves in 50- or 100-year return periods can be only obtained from the theoretical calculation, which themselves need validations using the long term wave measurements.

According to Smith et al. [6,7], in developing wave energy, three stages of resource assessment should be carried out: resource characterization, site assessment and resource and energy monitoring. During the processes above-mentioned, the measurements of different wave characteristics in various sea states are important and necessary for assessing the energy resources and the productivity of the energy devices. Besides, researchers will be able to evaluate the survivability and reliability of the energy devices more convincingly if the extreme waves can be measured accurately.

So far, several technologies for wave measurements have been developed and used for observations and measurements of waves around the world for many years, such as the popular wave buoys (for instance, WaveRider, Wavescan and ocean data acquisition system (ODAS) buoy), ADCP (Acoustic Doppler Current Profiler), high frequency (HF) radar and even satellite imaging. All the measuring technologies differ fundamentally in their physical working principles. More details about the measuring technologies mentioned can be found in Ref. [8–15]. Pandian et al. [16] have overviewed the recent technologies on wave and current measurement in details. The overview showed that different instruments have their own advantages and disadvantages mainly related with the applications and needs. Table 1 shows the pros and cons for the three type of measuring technologies. The high frequency radar is able to provide data for a wider area, and ADCP can provide real-time current information. However, for long-term (months or years) wave measurements, wave buoys are the most popular and cost effective technology due to its relatively easy installation/retrieval for different water depths, its measurement reliability and the continuous data transmission to onshore stations, and they are frequently referred by many countries as the principal instrument for national wave measurement projects [16].

Conventionally, the wave buoys are designed to have a short resonance period in heave so that the buoys move in phase with the waves interested, such as wave riders. In the wave measurement, the wave buoys are moored in the single point mooring system, which allows the wave buoy to match the different wind, tide and wave conditions. However, the large flexibility may also induce a problem whether the wave buoys are measuring the actual waves, especially for those large short-crested waves, for which the wave buoys may move around and hence miss to record the largest waves. It

Table 1
Pros and Cons of different measuring technologies.

Technologies	Pros	Cons
Wave buoys	Real-time telemetry applied, simple deployment and maintenance, cost effective	Vulnerable to vessel or debris, mooring system needs servicing, not accurate in extreme situations
ADCP	Robust real-time measurement for short duration, can be facilitated on ships	Long term measurement is expensive and difficult, air frequency greater than 1 Hz required
HF	Provide data for large area, no contact with sea water, easy to deploy and maintain	Disturbed by objections on sea surface, affected by salinity and sea ice, resolution decreases with the expand of target area