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Comparison of wave height interpolation with wavelet refined cubic spline and fractal methods

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ABSTRACT

This study presents two new methods for significant wave height interpolation, and compares the results from them with the cubic spline method for different durations of wave record gaps. Information about wave height is important for planning and design applications in both coastal and offshore engineering. However many gaps exist in the records and they are not necessarily small. Although a number of previous studies have attempted to fill the gaps in wave height records, most of the interpreted results are not satisfactory.

In this paper, the wavelet refined cubic spline method and fractal method are applied to improve interpolation accuracy. Results indicate that both methods show advantages over the cubic spline method, on the average, for the whole dataset. However, further analysis reveals that the methods introduced in this paper are not as effective as the cubic spline method for all gap sizes. The methods are implemented and compared at two study areas having quite different patterns of wave height.

1. Introduction

The modelling of significant wave height is important to coastal and ocean engineering applications, such as ocean resource management. It is a necessary component in the design and planning of coastal structures, harbours, waterways, and shore protection. Time series analysis of wave height provides long-term prerequisite knowledge about the local wave climate and is essential for coastal management and environmental impact studies. However, due to the complexity and uncertainty of wave generation, it is difficult to interpolate and model wave heights using deterministic equations.

Two categories of approaches have been studied before. Firstly, by using an ocean wave model to simulate wave height (physics-based approaches) and secondly, by analysing wave data patterns using interpolation methods (statistical approaches). The physics-based approaches use computer models of the equations governing wave growth, propagation and decay. These models require detailed ancillary data (Deo et al., 2001), such as wind data and bathymetry in an extended area around the site (Bouws et al., 1998; Kinsman, 2002; Janssen 2008), which may be difficult to provide (Altunkaynak and Özger, 2004). Operational wave models can provide archives of wave parameters, these include WAVEWATCH III (Tolman, 2009) at NOAA, and WAM at the ECMWF (Sterl et al., 1998) and the Australian Bureau of Meterorology (Durrant et al., 2009). Operational consensus forecast (Woodcock and Engel, 2005) is a method that combines a physics-based approach with a statistical approach. Gaps in wave height records, are interpolated by combining wave model output with in situ records (Woodcock and Greenslade, 2007; Durrant et al., 2009), successfully for deep water sites.

However, the above models do not have the appropriate physics for shallow waters (less than 25 m), as well as having insufficient spatial and bathymetric resolution. A wave model such as SWAN (Simulating Waves Near Shore, Booij et al., 1999) is needed for nearshore simulations, nested in the models described above. For these, a dedicated ensemble of SWAN runs at a nearshore site would need to be run to implement the consensual forecast method to interpolate gaps in wave height, which would require considerable computational effort.

Reikard et al. (2011) demonstrated that the statistics-based approaches perform better at short interval sizes, while physics-based approaches produce more accurate interpolation results at large scale. Although the combination of the two approaches can yield more satisfying outputs, it still relies on the individual interpolation accuracy of each technique.

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The statistics-based interpolation techniques can be more reliable and accurate (Deo and Kumar, 2000). In addition, while the interpolation of wave height data could involve randomness, in this circumstance, a statistical model could be more suitable (Deo et al., 2001). However, on the other hand, the time-series extension method is sensitive to the rule that determines the correlation

Fig. 1. Two study sites—Cottesloe and Port Hedland.