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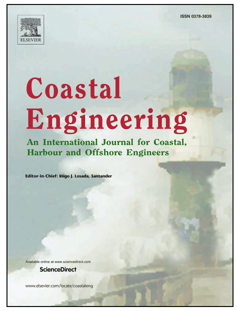

Uncertainty quantification in estimation of extreme environments

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Uncertainty quantification in estimation of extreme environments

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Abstract

We estimate uncertainties in ocean engineering design values due to imperfect knowledge of the ocean environment from physical models and observations, using Bayesian uncertainty analysis. Statistical emulators provide computationally efficient approximations to physical wind–wave environment (i.e. "hindcast") simulators and characterise simulator uncertainty. Discrepancy models describe differences between hindcast simulator outputs and the true wave environment, where the only measurements available are subject to measurement error. System models (consisting of emulator–discrepancy model combinations) are used to estimate storm peak significant wave height (henceforth H_S), spectral peak period and storm length jointly in the Danish sector of the North Sea. Using non-stationary extreme value analysis of system output H_S, we estimate its 100-year maximum distribution from two different system models, the first based on 37 years of wind–wave simulation, the second on 1200 years; estimates of distributions of 100-year maxima are found to be in good general agreement, but the influence of different sources of uncertainty is nevertheless clear. We also estimate the distribution of 100-year maximum H_S using non-stationary extreme value analysis of storm peak *wind speed*, propagating simulated extreme winds through a system model for H_S; we find estimates to be in reasonable agreement with those based on extreme value analysis of H_S itself.

Keywords: Bayesian uncertainty analysis, emulation, discrepancy, extreme, significant wave height, non-stationary.

1. Introduction

Estimation of characteristics of extreme ocean environmental variables is critical in marine and coastal structural design. This typically requires extreme value analysis of historical data from measurements and hindcasts, characterising the environment over some period of time, typically of the order of 30 to 100 years. The use of extreme value analysis is motivated by asymptotic arguments concerning the forms of tails of probability distributions (e.g. Beirlant et al. 2004). Inference involves estimating the maximum value that might be observed in a time period considerably longer than that of the historical sample, typically of the order of 1000 or 10000 years (or analogous extreme quantiles of the distribution of the annual maximum). Estimation is complicated by numerous sources of systematic and random

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