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A comparison study on the estimation of extreme structural response from different environmental contour methods

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ABSTRACT

Environmental contours are often applied in probabilistic structural reliability analysis of marine structures in order to identify extreme environmental conditions that may give rise to extreme loads and responses. The perhaps most common way of establishing such environmental contours is based on the IFORM approximation (Inverse First Order Reliability Method), but recently an approach based on direct Monte Carlo simulations with importance sampling has been proposed as an alternative. Even though these contours should be used in the same way and address the same problem, there might be rather large differences between such contours in certain cases. In particular, the alternative contour method will always yield convex contours, whereas the traditional contours may be either convex or non-convex.

In this paper, recent comparison studies are extended to include applications on simplified response examples. The contours are applied to simple response problems with known response surfaces in order to study how large the differences between the methods may be in terms of estimated maximum response and associated return periods. These case studies clearly illustrate the influence of the environmental contour method on the estimated extreme structural response. Whereas the different methods yield comparable results for some structural problems, they may give very different estimates of the extreme response for other. The estimated extreme responses and associated return periods from either method will also be compared to the correct extreme response, as estimated by simulation studies, for the desired return period. It is demonstrated that in certain cases, the estimates from some of the contour methods are highly conservative, whereas they in other cases might be very optimistic. The reason for these results are discussed and some requirements on the response functions for obtaining conservative estimates will be stated.

1. Introduction and background

Probabilistic structural reliability analysis is performed to ensure that a structure is able to withstand the required design loads. A realistic description of the environmental loads and structural response is a crucial prerequisite for structural reliability analysis of structures exposed to environmental forces. In principle, full long-term response analyses should be considered [1], but this is normally very time-consuming and computational intensive.

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Fig. 1. Approximate locations for the fitted wave height- and period distributions.