SUMMARY

1. Despite some significant recent achievements in developing methods and obtaining suitable data for the estimation of extreme wave parameters, the problem of their determination in terms of statistical analysis techniques is still far from having a completely satisfactory theoretical and practical solution. Existing reference books on waves focus mostly on information related to regular features of the wave field, not the extremes.

2. User requirements in terms of data nomenclature, accuracy and reliability are steadily becoming more stringent. The increase in sophistication of marine platforms and the expansion of offshore activities to new regions mean that increasingly expensive property is at risk of being damaged by high waves. Modern offshore operators require not only estimates of extreme wave heights. They need also complementary estimates of parameters associated with extreme waves, starting from the period and direction of the waves and ending with their spectra, associated currents, and estimates of forces acting on the structure. What they are looking for is, rather often, not simple estimates, but informative and authoritative support in their decision-making. That is why the subject of this study reflects only one stage in the development of full-range services for offshore operators and coastal management.

3. Significant recent changes in the area of extreme wave height analysis are related to the availability of new data types and models. At present, we have access to 10-20-year long data series of instrumental wave observations at automatic moored buoys and fixed platforms. Almost all of them are located in coastal areas. The contribution of satellite observations is becoming increasingly valuable in this area of research. Remotely sensed data still require some verification and bias correction. The efficient use of wave observations from polar-orbiting satellites requires data assimilation that produces a continuous field of wave spectrum parameters.

4. Numerical simulation of the wave spectrum by the most sophisticated models, driven by multi-year times series of meteorological fields, now represents the main source of data for wave climate studies, including studies of extreme waves. While most of the wave models are well tuned for forecasting and hindcasting of routine situations, both the models and their meteorological forcing, the analysis of near surface wind, may need additional verification and adjustment for studying extreme waves. There are some very successful examples of producing wind fields in individual severe storms using a combination of objective and subjective methods.

5. The results of the recent meteorological re-analysis project provide, for the first time in the history of marine meteorology, a forcing field that is continuous in time and space and is sufficiently long. Using this data, it is possible to numerically simulate a 40-year long wave series, and detect with considerable accuracy all significant storms affecting any area of interest. Trends of global wave statistics can be determined as well.

6. Wind waves are a complicated poli-modulated, poli-cyclic random process. They are poli-cyclic because of the simultaneous existence in the wave field of wind seas and swell, sometimes including more than one swell system. Poli-modulation is associated with the synoptic, seasonal, and inter-annual variability of wave parameters. Both features must be taken into account in studying extreme waves. The highest possible waves in many locations are often associated with the contribution of swell to the combined wave field. Their occurrence is most likely to occur during a certain season of a year. One should also consider the possible effect of trends associated with climate variations or long-term variability.

7. Two methods of estimating extreme wave heights, namely AMS and BOLIVAR, can take into account multiple variability scales in the extreme waves. The AMS method has the most solid theoretical foundation. The BOLIVAR method represents a further development that includes consideration of the second, third and, potentially other maxima in a year. If one is interested in further breakdown of extreme wave height estimates with respect to wave directions and seasonal variability, this requires adjustment of the corresponding absolute and conditional distributions.

8. Estimates of the highest waves, which are obtained using long time series at individual locations, are random values. This review

mostly focuses on methods available for evaluation of different quantiles of wave height distribution. Each of the considered methods has its advantages and shortcomings and must be used accordingly. In order to compare the methods, it important to examine not only point estimates of the extreme wave heights but also corresponding probabilistic ranges.

9. In order to efficiently use the described methods in practice, it is very important to define the measure of acceptable risk. This involves a very delicate balance of factors where the consequences of the damage, the cost of construction, and the cost of mitigating consequences of a possible accident are major considerations.

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