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A stochastic model for predicting future ocean wave climate and potential impact on ship environmental loads

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This presentation will present a stochastic model in space and time for significant wave height; a Bayesian hierarchical space-time model. The model consists of different components in a hierarchical manner including in particular a component for modelling the contribution from long-term trends in the wave climate. This Bayesian hierarchical space-time model allows modelling of complex dependence structures in space and time and incorporation of physical features and prior knowledge, yet at the same time remains intuitive and easily interpreted. Including a trend component in the model is a novel feature, and different model alternatives for estimating long-term trends in the wave climate are explored. Such trends might be a result of climate change, or it may be a sign of long-term natural variability. Either way, such trends will influence the environmental hazards to ocean going ships in the future.

The presented model is fitted to significant wave height data for monthly maxima over an area in the North Atlantic ocean, and aims at describing the temporal and spatial variability of the data over a period of more than 44 years for the chosen area. In particular, the model identifies long-term trends present in the data. It is demonstrated that the models predicts an increasing expected trend in the monthly maximum significant wave height. If such trends are to persist, it means that the wave climate are expected to become rougher in the future, implying a rougher operating environment for ships and other marine structures. Extrapolations of the estimated expected trends are made in order to obtain future projections of the North Atlantic wave climate towards the year 2100.

Subsequently, it will be explored how the results from the model can be linked to structural loads and response calculations, i.e. how to take expected future trends into account in the calculations. Using the conditional modelling approach, the projected expected increases in significant wave height are incorporated by modifying the joint distribution of significant wave height and wave period. In turn, this implies modified environmental contour lines used in the load calculations. The potential impact of the estimated long-term trends of significant wave height on the wave-induced structural loads of an oil tanker will be discussed and illustrated by an example. It is found that the potential impact is not negligible and this might introduce additional hazards to future ship operations unless adequate measures are taken in design or operation.