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A Bayesian hierarchical model for wind speeds in the North Atlantic Ocean

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Extreme weather conditions represent serious natural hazards to ship operations and may be direct causes or contributing factors to maritime accidents. Such severe environmental conditions can be taken into account in ship design and operational windows can be defined that limits hazardous operations to less extreme conditions. Nevertheless, possible changes in the statistics of extreme weather conditions, possibly due to anthropogenic climate change, represent an additional hazard to ship operations that is less straightforward to account for in a consistent way. Obviously, there are large uncertainties as to how future climate change will affect the extreme weather conditions at sea and there is a need for stochastic models that can describe the variability in both space and time at various scales of the environmental conditions.

Previously, Bayesian hierarchical space-time models have been developed to describe the variability and complex dependence structures of significant wave height in space and time. These models were found to perform reasonably well and provided some interesting results, in particular pertaining to long-term trends in the wave climate. Significantly increasing trends were detected in significant wave height for an area in the North Atlantic Ocean, indicating that the future wave climate may be rougher than the current and recent wave climate. Previous studies have also demonstrated that such trends in the wave climate may have the potential to influence the structural reliability of ocean going ships and recommended to consider such effects in marine structural design.

In this presentation, a similar probabilistic framework is applied to oceanic windiness and the spatial and temporal variability of the 10-meter wind speed over an overlapping area in the North Atlantic Ocean is investigated. When the results from the model for North Atlantic windiness is compared to the results for significant wave height over the same area, it is interesting to observe that whereas an increasing trend in significant wave height was identified, no statistically significant long-term trend was estimated in windiness. This may indicate that the increase in significant wave height is not due to an increase in locally generated wind waves, but rather to increased swell. This observation is also consistent with other studies that have suggested a pole-ward shift of the main storm tracks.

The stochastic model presented herein is provided as an alternative, complementary approach to physical models for modeling the impacts of climate change on environmental processes such as the significant wave height and the windiness, with a more direct approach to modeling uncertainties.