SPATIAL AND TEMPORAL CLUSTERING ANALYSIS OF EXTREME WAVE EVENTS AROUND THE UK COASTLINE

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MOTIVATION

In northern Europe and the UK in particular, a remarkable series of storms occurred over the winter of 2013/14, with large waves which led to considerable damage to coastal infrastructure. The most significant features of this storm season were the length of coastline affected by flooding (i.e., 'spatial footprints') and the short inter-arrival times between extreme events (i.e., 'temporal clustering') (Haigh et al., 2016). These extreme wave event characteristics had a large contribution to the devastating consequences along the coast, yet little attention has been paid to them in previous studies. The main aim of this study is to assess the spatial footprints and the temporal clustering of extreme wave events around the UK to facilitate the inclusion of such information into coastal management.

DATA AND METHODOLOGY

We use three types of data: observations from 18 wave buoys around the UK, gridded mean sea level pressure and wind fields to digitize storm tracks, and climate indices that affect the wave climate in the North Atlantic. We then follow the same methodological approach developed by Haigh et al. (2016) for storm surge analyses. First, we extract significant wave heights that exceeded the 1 in 1-year return levels at all sites. Second, we identify the distinct, extra-tropical storms that produced the extreme wave events. This involves a two-step procedure: first, we use the 3-day storm window to find all wave buoy sites that were affected by each event; second, we digitize the storm tracks associated with each extreme wave event. Based on the results, we examine the number of study sites affected by each event and their spatial distributions to assess spatial footprints. We investigate the temporal clustering of events by looking at the days between event occurrences, and assess correlations between the variability in the number of events and climate indices.

RESULTS

First, we compare the dates and return periods of extreme events. In total, 165 significant wave heights were found that exceeded the 1 in 1-year return level across the 18 sites. These high wave occurrences were generated by 92 distinct storms. Second, we examine the spatial characteristics of waves for the 92 storm events. A significant correlation (95% confidence) of 0.55 is found between the number of sites affected by a specific event and the maximum return period (Figure 1).

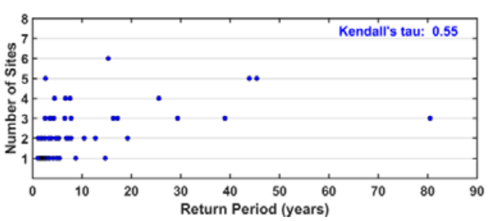

Figure 1 – Maximum return period against number of sites where the 1 in 1-year threshold was exceeded.

We selected the most significant events to find spatial patterns. Overall, our results suggest there are six categories of spatial footprints, with some overlap: Southwest (SW); West (W); Northwest (NW); Northeast (NE); East (E); and Southeast (SE) (Figure 2).

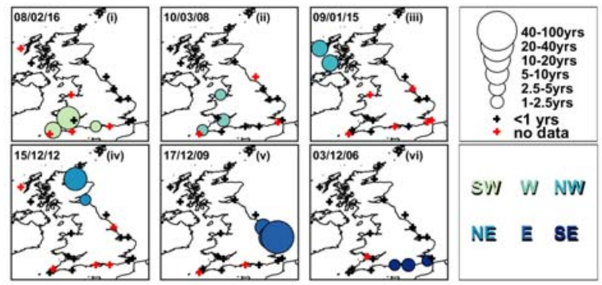

Figure 2 – Examples of extreme event spatial patterns for each of the identified regions.

The tracks of storms leading to extreme wave events in each region were also assessed. Storm track patterns are similar within the SE, SW, W, and NW regions, whereas no regular patterns were found for the eastern regions. Finally, from assessing temporal trends and event clustering we find that 90% of all events occurred between October and March, as well as those with the highest return period and shortest inter-arrival times. Large inter-annual changes in the number of events and their characteristics are found. Overall, the West Europe Pressure Anomaly (WEPA; Castelle et al., 2017) is the atmospheric oscillation index that best explains such variability, although correlations vary spatially depending on the considered index.

DISCUSSION

Our results identify the dependence between return periods and spatial footprint sizes, regions of high wave occurrences, and the spatial and temporal variability linked to atmospheric oscillations. However, caution must be taken in the results interpretation given the uneven spatial resolution of study sites, short records and data gaps. Advancements in wave data consistency both temporally and spatially are essential to achieve more reliable results, especially in the light of climate change and potential increase in storminess.

REFERENCES

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