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Long-term trends in extreme significant wave height in the Northeast Pacific Ocean - an application of extreme value theory.

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Many studies reveal upward trends in the mean and higher percentiles (e.g. 95th percentile) of winter wave heights in the Northeast Pacific. However, little attention has been paid to trends in extreme wave heights. We analyse the long-term (20 years) variability of extreme significant wave heights from buoy measurements in the Northeast Pacific using an advanced non-stationary extreme value model. This statistical approach is based on a time-dependent application of the Peak-Over-Threshold (POT) method in which intensity follows the Pareto distribution and frequency to follows a non-homogeneous Poisson distribution. The model allows joint analysis of seasonality, long-term trends, and El Niño effects and is applied to significant wave height data sets (1985-2004) from twenty NOAA buoys obtaining return-level values. A new finding is the impact of El Niño variability on extreme wave heights ($>$ 99.5th percentile) along the California coast (up to 25 cm per žC NINO3 region SST anomaly). While the general relationship between wave height and El Niño is well known, such relationships generally become weaker for more extreme events, so the strength of the relationship in our results is surprising. Our results also show a general significant positive long-term trend (about 4 cm/yr) of the west coast of the US. Both the El Niño-related effects and long-term trend can be related to variations of tracks and intensities of winter storms, with some additional effects due to the details of exposure. When the modelling of extreme events takes place over a year, seasonality explains great part of the variability of data, removing noises in higher time scales analysis. Over the two decades studied, our results emphasize the close relationship between variability in extreme wave climate, interannual changes in large-scale atmospheric circulation,

and the frequency, intensity and tracks of severe storms.