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Modelling the seasonal-to-interannual variability of extreme sea levels

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A statistical model to analyse different time scales of the variability of extreme high water levels is presented. The model uses a time-dependent generalized extreme value distribution (GEV) to fit monthly maxima series and is applied to two large and well-known historical tide gauges (San Francisco and Newlyn). The model allows the identification and estimation of the effects of several time scales - such as seasonality, interdecadal variability and secular trends - on the location, scale and shape parameters of the probability distribution of extreme sea levels. These factors are parameterized as functions of time (linear, quadratic, exponential and cosine functions) or covariates (for instance, SOI or NAO index). The inclusion of seasonal effects explains a large amount of data variability, thereby increasing the significance of the processes involved. Significant correlations with the nodal cycle, as well as with regional climate indices SOI and NAO have been detected for San Francisco and Newlyn, respectively. Specifically, in the data set for San Francisco, a positive secular trend in the location parameter is obtained (26 cm in the twentieth century) and an increase of about 20% for the secular variability of the scale parameter have been detected. Note that in the last century the sea level rise in San Francisco tide gauge was about 22 cm. That means that monthly sea level extremes in San Francisco are increasing in the mean values (4 cm in the twentieth century with respect to sea level rise) and in the variability (storminess). Results show that the model is adequate to carry out a rigorous analysis of seasonal-to-interannual sea level extremes providing time-dependent quantiles and confidence intervals. The modelling of the different time scales helps to achieve a better understanding of recent secular trends for the extreme climate events, which are one of the main concerns nowadays.