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How wave runup can suppress the amplification of extreme coastal water levels due to sea-level rise

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Sea-level rise will amplify the occurrence frequency of extreme coastal water levels along nearly all inhabited coastlines. A good understanding of how this amplification will develop over the 21st century can help communicating the benefits of mitigation and aid decision-makers in the planning of adaptation strategies. The frequency amplification of extremes is strongly modulated by the variance in extreme coastal water levels, driven by astronomical tides, storm surges and waves. However, wave effects, and particularly wave runup, are rarely incorporated in the analysis of extremes. In this study, we quantify the influence of wave runup on extremes at a number of coastal sites which span a wide range of coastal climates and tidal regimes. Using a joint probability method following Heffernan and Tawn (2004), we simulate a large number of extreme coastal water levels, considering the potential covariance in extreme storm surges and waves. Wave runup is derived from reanalysis wave data using a range of five parametrizations which vary in their complexity and their specific applicability to sandy or gravel beaches. By combining the simulated extremes with projected mean sea-level rise, we compute the frequency amplification of extremes and the influence of wave runup thereon. We conclude that studies which neglect wave runup underestimate the variance in extreme coastal water levels, and may therefore overestimate the frequency amplification of these extremes due to mean sea-level rise.