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Mapping coastal overtopping in the shadow of large ebb-tidal deltas with XBeach surfbeat: insights from the western coast of Portugal

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The exposure to wave overtopping is growing worldwide which forces coastal communities to adopt methodologies for anticipating the risks associated with it. In areas with shallow foreshores, like those created by extended ebb-tidal deltas, at the entrance of estuaries or harbours for instance, infragravity waves play an important, if not dominant, role. Therefore, hydrodynamic and topographic data collected on the downdrift side of the entrance to Figueira da Foz harbour, along the wave exposed western coast of Portugal, were used to calibrate a local XBbeach 2DH-surfbeat model to (1) investigate the role of infragravity waves and (2) the ability of a phase average model to account for the main drivers of coastal overtopping in similar locations. The local model was forced on its open boundary by water levels and 2D wave spectra dynamically downscaled using an operational model workflow developed for providing near real-time forecasts. The local dissipation of short-waves in the surf zone was calibrated based on the hydrodynamic data. This data, collected under a moderate swell, was also used to ensure the model's resolution and numerical scheme were correctly setup to reproduce the energy and shape of the infragravity wave's frequency spectrum. Lastly, the model's option to use an unconventional breaking criterion was found useful to improve the model's ability to reproduce an overtopping event. For this event, which was observed and surveyed during slightly energetic waves combined with high tides, results from the surfbeat mode were compared to results from the non-hydrostatic phase-resolving mode of XBeach (applied with a resolution four times thinner in both horizontal directions). In both cases, the modelled overtopping extents were similar and matched the data. However, it was found that the wave-induced setup was much larger in the surfbeat model. Furthermore, the extra energy brought in by accounting a fraction of the instantaneous wave height into the equation of the wave breaking criterion allowed the water to overtop the dune crest in similar proportion as in the phase-resolving case. So, the finely tuned surfbeat model was run for scenarios of a storm surge with a return period of ~70 years, combined with present day sea level and projections for 2050 and 2100. Like in the calibration runs, in these three scenarios the wave spectra for the chosen 2014's Hercules storm were dynamically downscaled. Again, the inundation maps produced with this methodology were compared to those created with the phase-resolving version of XBeach. It transpired that, for those scenarios, the wave-induced setup and the runup of the infragravity waves were the dominant drivers of overtopping along the waterfront in the shadow of the large ebb-tidal delta from the harbour's entrance. Our study therefore suggests that with minimal observation data it was possible to calibrate the phase-averaged version of XBeach to reproduce and map overtopping. Moreover, for similar coastal

zones, where wave-setup and infragravity waves dominate, the inundation maps may be more accurate that those produced with its phase-resolving counterpart, and this at a lower computational cost.