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Morphological parameters to assess the state of coastal dunes

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Coastal dunes host priority habitats that provide different ecosystem services, such as biodiversity or socio-economical resources, and they are the first line of defence against the impact of storms, providing protection to adjacent coastal communities. However, the capacity of these systems to provide such services depends on their morphological and ecological status, which may change spatially and over time. Despite the relevance of assessing to dune state, a simplified and universal approach for this purpose is lacking. The present work explores the temporal and spatial variability of a series of morphological parameters and their best combination to inform about the state and resilience of coastal dunes. For that, the morphology of one sandy peninsula and one barrier island, with contrasting exposure to meteocean conditions and anthropogenic pressure, located within the Ria Formosa in the south coast of Portugal, were analysed. The available dataset covers the period between 2008 and 2018 and consists of Digital Terrain Models (DTMs) and orthophoto mosaics. Shoreline indicators (e.g., wet/dry line, debris line, vegetation seaward limit and dune heel line) were mapped in all orthophoto mosaics and extracted each 10 m alongshore. Parallelly, cross-shore profiles were defined at each 10 m from the DTMs to automatically extract the position and the elevation of the dune crest, dune toe and berm. The extracted parameters and indicators allowed estimating the width and slope of the different segments within the beach and the dune. Results show significant differences in the dune crest height alongshore each barrier while other parameters such as the dune toe presented a rather intra-barrier homogeneous distribution intra-system. The latter parameters are significantly different from barrier to barrier while the dune crest height values partially overlapped when both barriers were compared. Observed temporal and spatial variability of the extracted parameters was tentatively compared with the historical evolution of the evaluated barrier and the incident wind and wave conditions suggesting that the parameters might be regulated by different drivers. For instance, while the dune crest height appears strongly regulated by the historical evolution of the coast, the rest of the parameters, homogeneous within each barrier, appear to be controlled by external factors associated to the variable orientation of the coast relative to the main wave and wind climate. These results might be highly relevant when assessing the adaptation capacity of these type of systems and thus to their resilience with implications on the definition of coastal barrier states and tipping points in barrier response to disturbances.