Geomorphological patterns observed in foredunes under storm and fair-weather conditions revealed by UAV images

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Coastal sandy barriers form a typical environment in wave-dominated coasts. Not rarely, the surface morphology of these features should be interpreted by aeolian sediments, fixed by vegetation, forming foredunes. The morphology observed in the foredunes depends from different processes, related for example the wind speed, wind direction, different types and density of vegetation, variation of wave energy and beach morphodynamics. In this case, some specific geomorphological patterns can be observed in the foredunes, such as blowouts and erosive scarps or even different types of dunes, describe for example by nebkas and parabolic. In the last ten years, the geomorphology experiences a truly revolution by the use of digital photographs obtained by Unmanned Air Vehicles (UAV), where details from the surface were revealed by structure from motion (SfM) photogrammetry. The low-cost and effective results from UAV and SfM provide a high-resolution (centimeters-scale) digital elevation models (DEMs), which allow a more accurate analyses in geomorphology. Using these techniques, the aim of this study is analyzing the morphological characteristics of foredunes submitted by high-energy waves and winds from different directions along Massambaba Beach, southeast Brazil. Massambaba Beach present a more than 50 km of continuous Holocene barrier, classified as stationary barrier. The beach morphodynamic varies from intermediated/reflective on the west side, to intermediated/dissipative in the east. To evaluate the morphological patterns observed by hydrodynamics and aerodynamics effect along the foredunes, we determine changes in the vegetation density by remote sensing, and found that the density decrease from west to the east. After, we select four different areas to survey by UAV. The results showed that the area 1 located in the west Massambaba, the foredunes present disconnected blowouts from the beach, forming a bi-directional parabolic dune, where fair-weather (northeast) and storm winds (south) play an important role. In the central Massambaba the blowouts increase not only in terms of area, but some parabolic dunes can be observed directly connect from the beach, formed by off-shore and onshore winds. In some specific sites, beach scarps eroded the precipitation ridges that reach the berms, and create good conditions for overwash deposits, formed by high-energy waves. The east Massambaba, where we observe the decrease in vegetation density, different types of dunes coexist such as nebkas and parabolic, and the parabolic can be orientated by northeast or southwest depending of prevailed wind. The foredunes in the east Massambaba experience overwash process, which favor overwash deposits. We conclude that the morphological complexity observed in the foredunes, revealed by DEM, indicates the importance of these techniques to investigate different process caused by wind and waves.