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Regional-scale analysis of dune-beach systems using Google Earth Engine

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Coastal sand dunes provide a large variety of ecosystem services, among which the inland protection from marine floods. Nowadays, this protection is fundamental, and its importance will further increase in the future due to the rise of the sea level and storm violence induced by climate change. Despite the crucial role of coastal dunes and their potential application in mitigation strategies, the phenomenon of the coastal squeeze, which is mainly caused by the urban sprawl, is progressively reducing the extents of the areas where dune can freely undergo their dynamics, thus dramatically impairing their capability of providing ecosystem services.

Aiming to embed the use of satellite images in the study of coastal foredune and beach dynamics, we developed a classification algorithm that uses the satellite images and server-side functions of Google Earth Engine (GEE). The algorithm runs on the GEE Python API and allows the user to retrieve all the available images for the study site and the chosen time period from the selected sensor collection. The algorithm also filters the cloudy and saturated pixels and creates a percentile-composite image over which it applies a random forest classification algorithm. The classification is finally refined by defining a mask for land pixels only.

According to the provided training data and sensor selection, the algorithm can give different outcomes, ranging from sand and vegetation maps, beach width measurements, and shoreline time evolution visualization. This very versatile tool that can be used in a great variety of applications within the monitoring and understanding of the dune-beach systems and associated coastal ecosystem services. For instance, we show how this algorithm, combined with machine learning techniques and the assimilation of real data, can support the calibration of a coastal model that gives the natural extent of the beach width and that can be, therefore, used to plan restoration activities.