Volume changes on a coarse-grained beach in relationship with wave data

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ABSTRACT

San Felipe is a mixed beach located in the northern coast of Gran Canaria Island. This study of volume changes over time has been carried out using elevation models which have been obtained from topographic data. Eighteen surveys were performed where data were taken from the entire beach with a total station. Wave data is the main factor involved in the volumetric changes of the beach. The most relevant parameter is the maximum significant wave height, which relates very well to the volume changes in the beach throughout the study period (R^2=0.73). On the other hand, wave direction determines if the beach accumulates or erodes. Storm events are often from the NW and are associated with high wave heights, which are responsible for the largest accumulations of cobbles and pebbles that have occurred throughout the study period. Conversely, in periods of calm prevail NE wave that cause erosions of up to 450m^3 between two consecutive surveys. However, this last factor also depends on the maximum significant wave height since the results shows that with small changes both positive and negative values have the same direction wave.

INTRODUCTION

In the two last decades, the scientific interest by coarse-grained beaches or mixed beaches has increased and therefore the number of morphodynamics studies available is considerable. Recent studies have determined that this type of beaches have a high degree of stability and it makes them less vulnerable against strong waves [1].

However, on Gran Canaria Island there are not previous studies in this type of environments even though there is a large number of them. Gaining a better understanding of how these beaches evolve, and which factors determine its volume changes may help to take appropriate management measurements designed to preserve the coast in the mid-term against future stormy events and sea level rise.

The aim of this study is to analyse the evolution of the volume of the coarse-grained particles on a certain beach, putting it in relationship with wave data.

MATERIALS & METHODS

San Felipe is a mixed beach located on the north coast of the island of Gran Canaria (Spain) (Fig. 1). It is 200m long and variable width depending on the season. The upper part of the beach is covered all year with basaltic and phonolitic cobbles and pebbles, while the lower profile shows a great seasonality.

During the winter, a sand bar is completely submerged, and it is not until the beginning of the summer when it moves onshore, covering the coarse-grained particles located on the lower foreshore. These situations last for the end of the autumn, when northwestern swells pull the sand again offshore.

Wave climate in the area shows that dominant waves are from N-NNE. Nevertheless it shows a clear seasonality between periods with or without storm events. During storm events, dominant waves have a NNW component while in calm periods they are from NNE. Tidal range of the study period, from October 2013 until March 2015, is 2.95m.

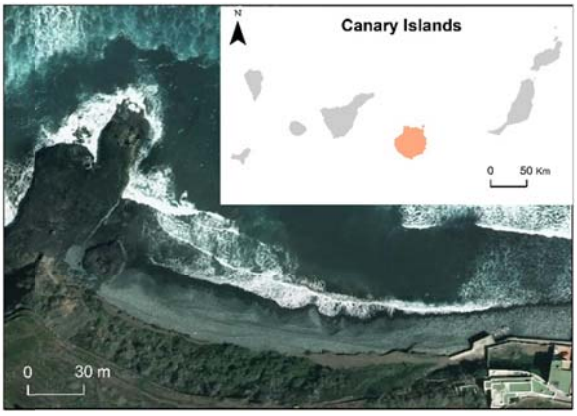

Fig. 1. Location map of San Felipe beach which is in the north of Gran Canaria Island (orange).

Eighteen surveys were carried out from October 2013 to March 2015. Topographic data for the whole beach were collected with a Leica total station TCR307. Data obtained in every survey were filtered and elevation models, using *Surfer 11*, were performed. The interpolation method used to generate the elevation models was *Kriging* with a spatial resolution of 0.1m.

Since San Felipe is a mixed beach and we only want to focus on the portion covered by pebbles and cobbles, the boundary between coarse-grained particles and sand was measured in four of the summer surveys. The average height was established at Z=2m. Considering this height as a lower limit, the volume of the cobble and pebbles was accurately calculated for each survey.

Wave data recorded at Gran Canaria buoy were analyzed to determine the wave regime at the study area.

RESULTS & DISCUSSION

The volume of coarse-grained particles shows a clear seasonality, with higher volumes corresponding to the winter months (from December to April), while the lowest values take place during the summer and autumn period (Fig. 2). It clearly shows that higher waves pile-up the particles in the upper part of the beach, while smaller waves are responsible of eroding that accumulation.

To include wave data, we have used the highest significant wave height that was recorded between two consecutive surveys (H_s max). Two wave data were discarded because the wave buoy was inoperative during more that 60% of considered period.

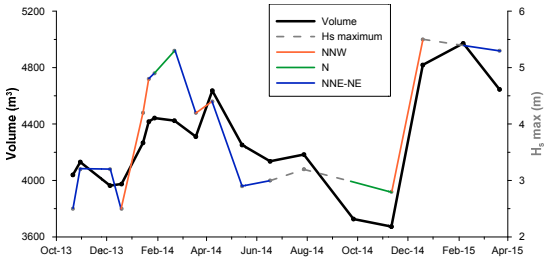

Fig. 2. Volume of coarse grained particles (black line) and maximum significant wave height (grey dots). The different colours of lines, connecting dots, indicate the direction of the highest waves for the period. No data (dash line).

Fig. 2 shows that the volume of coarse-grained particles shows the same pattern than that of H_s max (R^2=0.73). However, wave height is not the only factor responsible for volume changes, but also the direction of waves is involved. Positive changes in volume correspond to periods where the waves with higher wave height are from the NNW, and conversely the most significant negative changes are associated with waves from the NNE. On the other hand, when H_s max shows small values there is not a clear pattern between wave direction and the sign of the volume change.

Previous studies have identified cyclic or seasonal patterns of beach changes in response to incident processes. [2] observed temporal variations that indicate erosion in coarse clastic under storm conditions. Also [3] provides a conceptual model for low-energy mixed beaches in which more energetic waves move sediment offshore and less energetic waves move sediment onshore. However, the results presented here determine the opposite pattern, since under strong waves the beach has more volume of cobbles and pebbles while weaker waves erodes the beach. Our results perfectly agrees with [4], who determined that onshore transport take place during storms, that throws material landwards, as well as with [5], who obtained that the larges responses occur during the winter months when wave energy levels increase.

There are two wave factors which determine the volume changes of cobbles and pebbles in San Felipe beach. The highest significant wave height recorded between consecutive surveys shows a good correlation with volume changes. Likewise, the wave approaching direction determines whether the changes are positive or negative, indicating onshore or offshore transport.

ACKNOWLEDGMENTS

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