Effects of climate change on the extreme wave climate in Espírito Santo (Brazil). Implications to erosion in coastal protected areas.

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Introduction

Changes in atmospheric conditions may alter wave characteristics, since ocean waves are generated by energy transfer from wind to the ocean surface. The ocean wave climate is highly variable and the importance of its temporal changes and extreme waves patterns extends from coastal ecosystems to beach morphodynamics. The Espírito Santo (ES) coast (southeastern Brazil) is 410 kilometers long and has diverse natural environments, such as the Paulo César Vinha State Park (a Permanent Marine Protected Area). This park presents land use conflicts which may be worsened by an increase in local coastal erosion events. This fact stresses the importance of estimate the long term variations in erosion induced by wave storms in this type of environment.

Objectives

The main goal of this work is to estimate the long term variation in coastal erosion at the Paulo César Vinha State Park (Fig. 1) due to long term variations in local extreme wave climate. In order to achieve this goal two specific objectives were established: i) Characterize storms that occurred offshore from the study area and provide a trend analysis of the storms during the period 1949–2008. ii) Analyze the variations of the potential amount of dune erosion in three different sites of the park due to long-term variations in wave storm patterns.

Methodology

Study Area

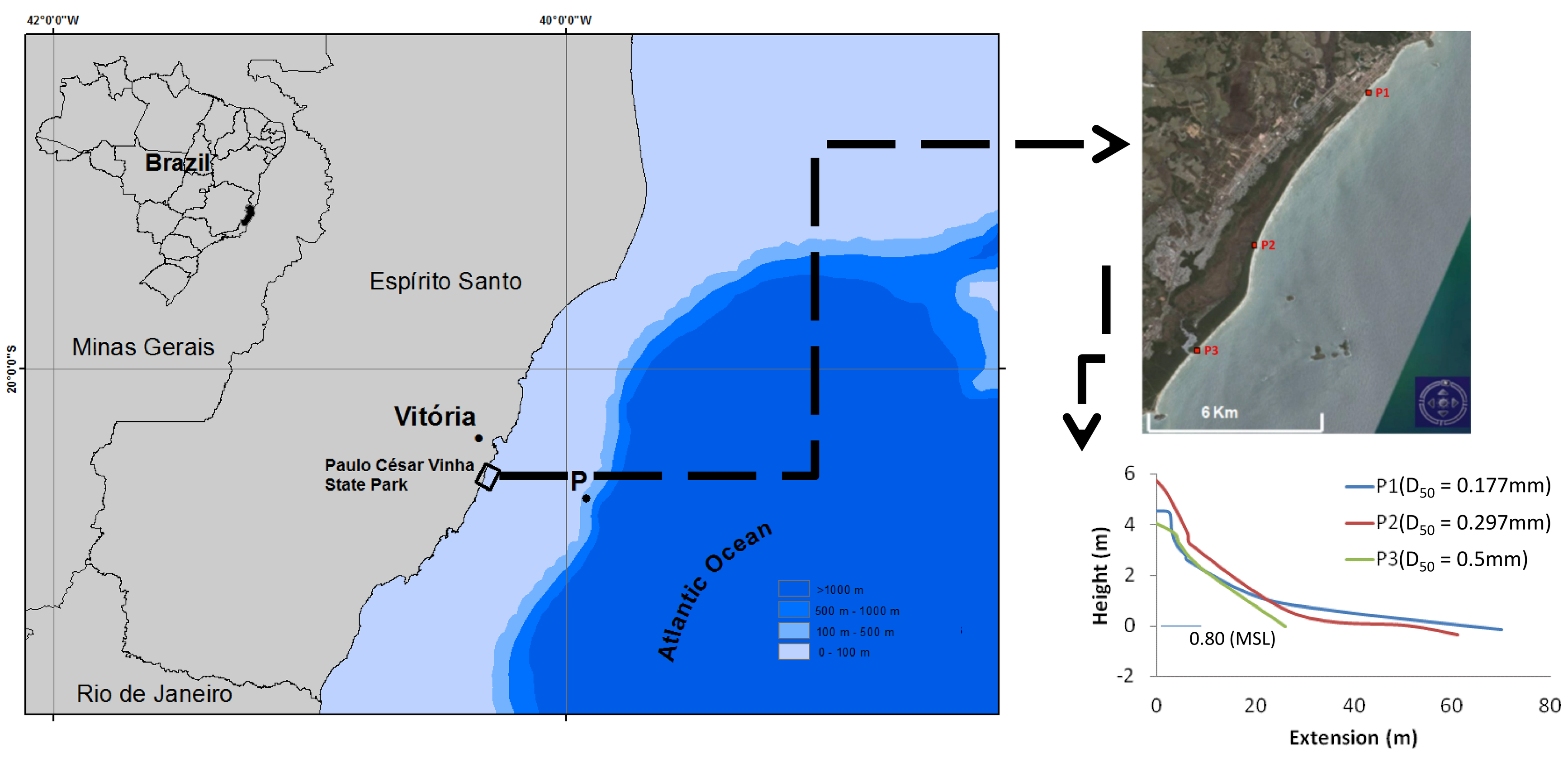


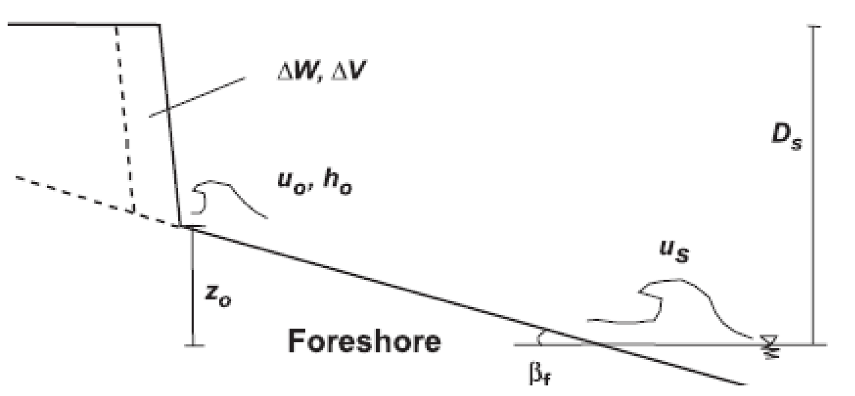
Fig 1. Location of Espírito Santo, wave point (P), Natural Park and the stations analysed with their respective profiles and D_{50} classification. Morphodynamic beach state ranges from dissipative (P1) to reflective (P3).

Wave Data

As a consequence of the lack of visual and instrumental data in the study area, data from the Global Ocean Wave model (Reguero et al., 2012), which consists of a reanalysis of global waves were used.

Dune erosion

The methodology that was used to estimate dune erosion volume (ΔVE in m³/m of beach) induced by each storm wave event, was a simplified model proposed by Larson et al. (2004):



$$\Delta VE = 4Cs(R - z_0)^2 \frac{t}{T}$$

CS - transport empirical coefficient
R - runup height (m)
t is the wave storm duration (s)
T is the wave period (s).

Fig 2. Definition sketch for modeling dune erosion due to the impact of runup waves. (from: Larson et al., 2004)

Results

Wave Data

Two different sets of storms were analyzed. The wave height threshold of the storms type 1 (T1) is H_s>2xmeanH_s and the storms type 2 (T2) is H_s>1,5xmeanH_s. Both types of storms have a minimum duration of 6 hours. For the mean wave climate the dominant wave direction was east, while the for the wave storm T1 and T2 the main direction was south and southeast (Fig. 3). However T2 presented storms from northeast direction.

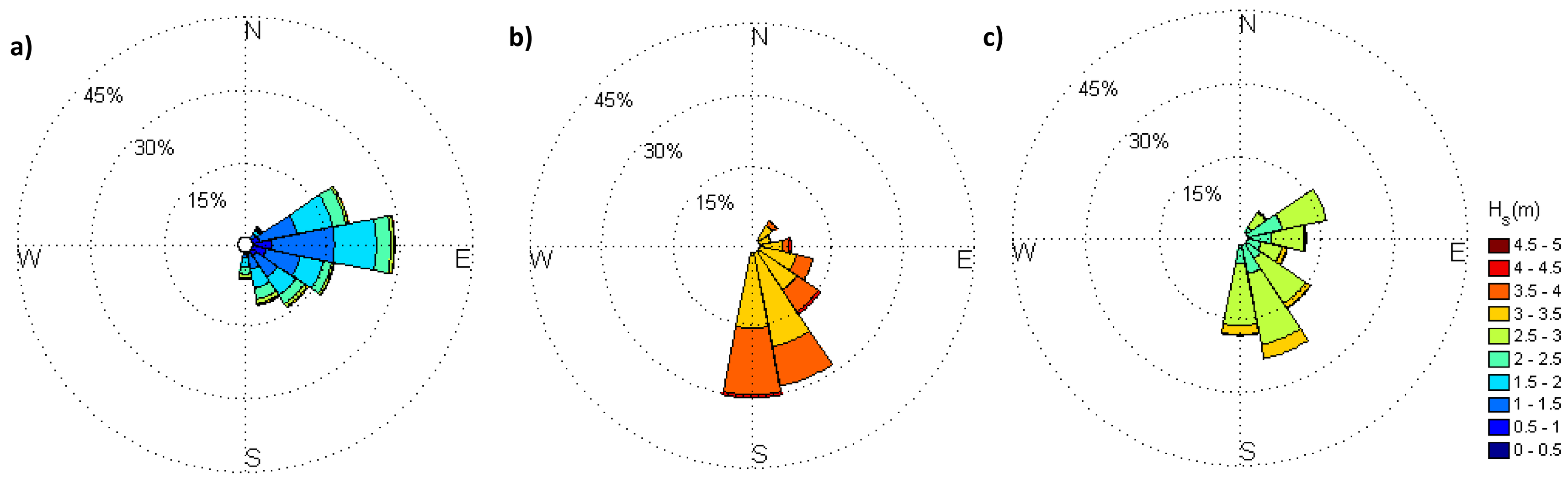


Fig 3. Roses of mean significant wave height (H_s)
for a)mean wave climate; b)wave storms type 1 and c)wave storms type 2.

Results indicated a trend for an increase in the number of storms T1 and T2 with an average rate of *O*(0.6) and *O*(1,5) storms/year, respectively (Fig. 4). No significant trends were found for storm duration, mean storm H_s and maximum storm H_s.

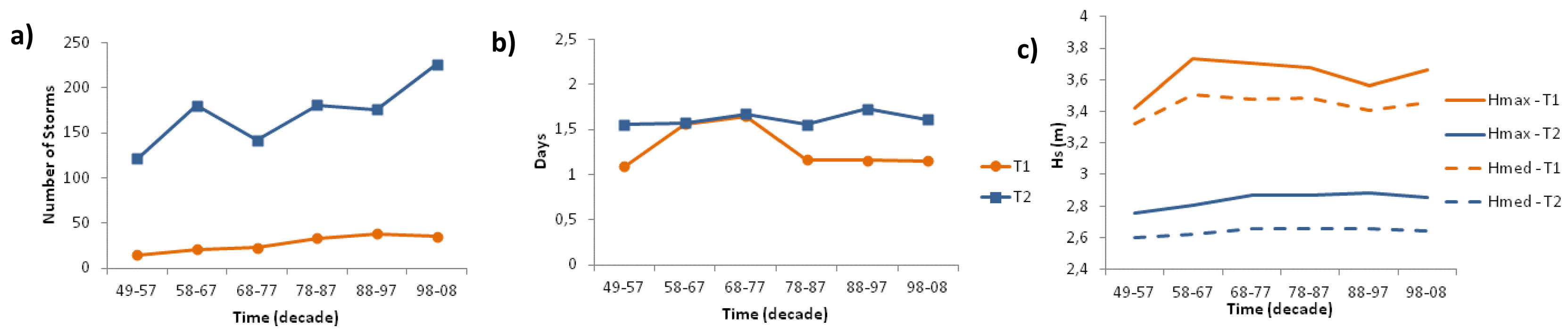


Fig 4. Decadal storm evolution a)number of storms; b)mean storm duration and c)mean of H_s (maximum and average).

Dune Erosion

Results indicated that estimated volume of dune erosion (ΔVE) at P1 and P3 presented a increasing trend and ΔE(P3)>ΔE(P1)> ΔE(P2) ((Fig. 5).

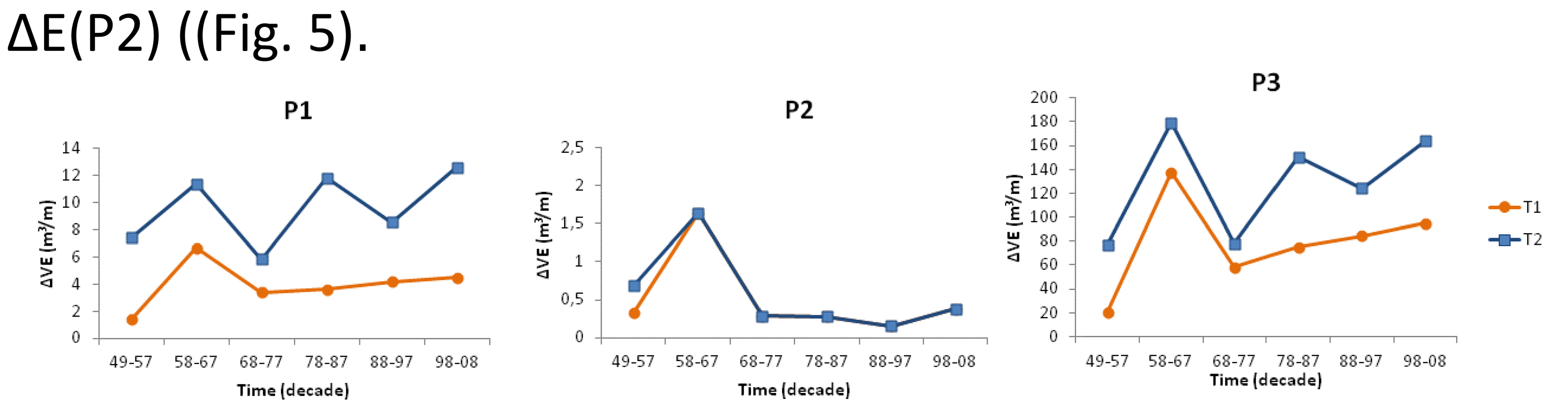


Fig 5. Potential dune erosion volume between 1949-2008 in P1, P2 and P3.

Conclusions

As a consequence of climate change, results indicated a positive trend for the number of extreme wave events between 1949-2008. This variation is higher during the last three decades. The verified growth in the number of storms was the cause for an increase of potential dune erosion in the study area.

Results indicate that the potential dune erosion volume is more intense in dissipative (P1) morphodynamic conditions than in reflective (P3) conditions. The long term variation in the ΔVE in dissipative beach conditions seems to be more influenced by storm duration, while in reflective beach conditions it seems to be more influenced by the number of storms. As dune erosion in P2 is only induced by storms with higher H_s values, a non trend in maximum storm H_s means a non trend in potential dune erosion.

References

Larson, M., Erikson, L. & Hanson, H., 2004. An analytical model to predict dune erosion due to wave impact. *Coastal Engineering*, 51(8-9), pp.675–696.

Reguero, B.G., Menéndez, M., Méndez, F.Z., Mínguez, R., Losada, I.J. 2012 A Global Ocean Wave (GOW) calibrated reanalysis from 1948 onwards. Coastal Engineering 65, 38-55.