Are global changes in wave and storm surge conditions correlated with coastal erosion/accretion?

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INTRODUCTION

Both satellite and reanalysis model data have shown statistically significant changes in global wave height in recent decades. It is often speculated that, if such changes continue in the future, they may have an impact on coastal erosion. A global study to investigate whether the observed changes in significant wave height have had a measurable impact on beach stability has, not however, previously been attempted. This presentation will bring together global datasets of changes in wave height, storm surge and coastal erosion over the last 30 years, to investigate possible links.

As a result of climate change, changes in storm and wave conditions, may impact coastal erosion and potentially representing a significant threat to coastal communities. In this study, the relative contributions of changes in a range of the physical processes affecting coastal erosion are explored for the period of 1984-2016. For this purpose, we use global datasets of wave parameters form Liu et al. (2021)[1], storm surge from GTSR[2] and coastal erosion/accretion from the data of Mentaschi et al. (2018)[3]. The datasets are used to assess whether trends in wave and storm surge properties have impacted coastal erosion/accretion over this period.

RESULTS

As an example, Figure 1 shows data from the various datasets as a function of latitude for the west coast of South America. The data shows: (a) the shoreline change rate of sandy shorelines (C_L), where red is erosion and blue is accretion. Possible wave parameters which may be correlated to the rates of erosion are shown as: (b) wave energy flux ($C_g E$), (c) trend of yearly average significant wave height (H_s), (d) trend of 95th percentile (H_s^{95}), (e) trend of number of extreme event above the 95th percentile threshold ($N_{H_s^{95}}$), (f) trend of yearly average wave period (T_m), (g) trend of yearly average of wave Direction (θ_m) (red is clockwise and blue is counter clockwise). The storm surge parameters: (h) trend of extreme surge level (95th percentile) ($\eta 95$), and (i) trend of number of storm surge events (95th percentile threshold) ($N_{\eta 95}$) are also shown.

According to Figure 1a "bursts" of erosion/accretion is happening in West coast of South America, potentially related to non-equilibrium longshore drift. As illustrated in Figure1b, c,d, as a result of increases in wave climate of southern Ocean[4,5] wave energy flux and significant wave height are increasing along most of the western coastline of South America while The trend magnitude of these parameters ($\Delta C_g E$, ΔH_s, and ΔH_s^{95}) decreases towards the north. Mean wave period (ΔT_m) (Figure 1f) show a decrease in the north of -25^0 and an increase in in south of -25^0. Also a counter clockwise rotation of the mean wave direction ($\Delta\theta_m$) is visible in Figure 1g, south of approximately 0^0, which is a result of the increases in Southern Ocean swell and the southward movement of Southern Ocean low pressure systems in recent decades[6]. Storm surge changes are less uniform (Figure 1h) showing an increases in the extreme south (Patagonia complex region) and north in the equatorial regions ($\Delta\eta^{95}$).

In general, these results indicate that there is no obvious correlation between increasing trends of waves and storm surges, and the "bursts" of longshore drift evident in the coastal shoreline dataset. This may be because the magnitudes of changes in these parameters are too small to result in clear changes in beach properties. However, the results may also indicate that the accuracy of the global coastal erosion/accretion data is insufficient to show clear links. However, a consistent increase in wave climate, as shown in Figure 1, can be a driver of non-equilibrium longshore drift as evident along sections of this and other coastlines.

The same process has been applied for other geographical locations, including: The East and West coasts of North America, Africa and Australia and Western Europe. None of these coastlines show clear links between changes in wave and surge properties and coastal erosion/accretion. Table 1 shows the percentages of coastlines around the world showing positive trends in wave and surge parameters, and sandy shoreline facing erosion. These statistics in one hand shows a quantitative comparison between East and West coast state of each of these continents and on the other hand investigate any meaningful correlation between surge and wave parameters and coastal state.

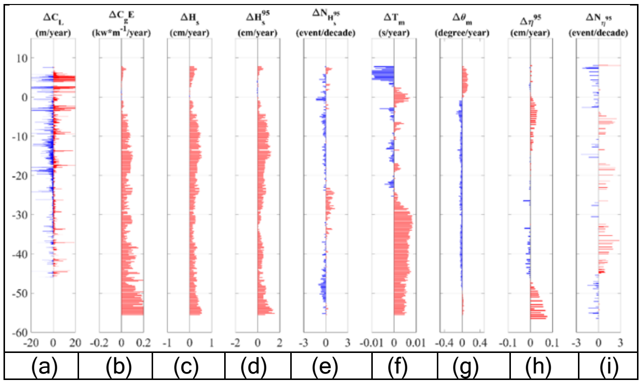

Figure 1. Latitudinal distribution of: (a) shoreline erosion/accretion ΔC_L, for sandy beaches (red is erosion and blue is accretion),(b) wave energy flux trend ($\Delta C_g E$), (c) significant wave height trend (ΔH_s), (d) 95th percentile significant wave height trend (ΔH_s^{95}), (e) number of extreme wave events above the 95th percentile trend ($\Delta N_{H_s^{95}}$), (f) mean wave period trend (ΔT_m), (g) mean wave direction trend ($\Delta \theta_m$), (h) storm surge trend ($\Delta \eta 95$) and (i)number of storm surges events tend ($\Delta N_{\eta 95}$) for the West coast of South America.

Table 1 Percentages of global coastlines showing positive trends in wave and surge parameters, and sandy shorelines showing erosion.

		Eroding sandy shoreline (Cl)	Positive trend of $C_g E$	Positive trend of H_s	Positive trend of H_s^{95}	Positive trend of $N_{H_s^{95}}$	Positive trend of T_m	Positive trend of η^{95}	Positive trend of $N_{\eta 95}$
World coastline		47%	73%	74%	71%	61%	76%	70%	42%
South America coastline	West	43%	93%	97%	93%	39%	75%	63%	46%
	East	48%	86%	77%	85%	68%	82%	86%	35%
North America coastline	West	60%	68%	82%	76%	55%	53%	86%	25%
	East	51%	87%	82%	81%	63%	87%	84%	54%
Africa coastline	West	53%	92%	89%	79%	64%	80%	49%	45%
	East	46%	99%	100%	93%	78%	99%	36%	36%
Australia coastline	West	46%	35%	20%	73%	16%	89%	79%	28%
	East	48%	99%	99%	98%	56%	99%	36%	29%
Western Europe	West	50%	63%	50%	26%	63%	69%	51%	68%

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