B103

Beach Morphodynamic Time Scales Analysis at Hasaki Beach, Japan

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1. Introduction

Beach morphodynamic behavior can be divided into components that vary from day to year. Understanding the shoreline's behaviors and dominant forcing variants is necessary to develop a more reliable model in shoreline projection. However, studies on these time scales are rare due to the lack of high-frequency and continuous beach observation data. This study utilizes a 34-year (1986 to 2019) dataset from Hasaki Beach to analyze behavior across various time scales.

2. Dataset

Hasaki Beach is a longshore-uniform open coast located on the east coast of Japan, facing the Pacific Ocean without any shelter (Figure 1(a, b)). Bathymetric observations have been recorded in the cross-shore direction from 1986 to the present at the Hazaki Oceanographical Research Station (HORS) (Figure 1(c)). Along the 400-meter-long pier, bathymetric data has been measured every 5 meters. The measurement frequency was once per day from 1986 to 2011, and increased to once per week from 2012 onwards. This manual bathymetric technique, which does not rely on the water level as a proxy for the shoreline as image-derived techniques do, ensures high reliability of the measurements. Following previous research, this study defines the shoreline position as the horizontal position at the high water level (HWL). Wave data is determined from the atmospheric reanalysis model JRA-55 and WAVEWATCH III, which showed good agreement with in-situ wave observations.

3. Results

To understand how the beach reacts to storms and daily wave, shoreline changes are compared under storm and stable wave conditions and the criteria for identifying storm conditions is shown in Table 1. On the first day of storm arrival (Figure 2(a)), the shoreline typically experiences significant erosion, while post-storm (Figure 2(b)), accretion is more likely. However, the beach is more sensitive to a sudden increase in wave energy, leading to higher erosion than restoration. On the second day, erosion continues, with wave conditions assumed to remain at the same level as on the first day. Conversely, the shoreline variation pattern on the second post-storm day shows no significant difference compared to stable wave conditions.

Shoreline and JRA-55 hindcast significant wave height data were averaged monthly over 34 years, revealing a negative correlation between each other. From April to September, wave heights decrease as the shoreline accretes. Conversely, higher significant wave heights

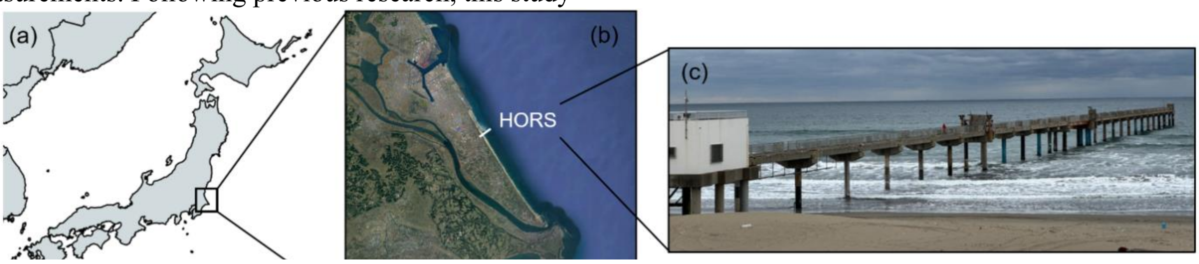

Figure 1 (a, b) Location of Hasaki beach (Google, n.d.); (c) The pier of Hasaki Oceanographical Research Station (HORS)

Table 1 Wave conditions of cases

Case	Day 1		Day2	
	ΔH_s	No. of Case	ΔH_s	No. of Case
Storm arrival	+1.0 m	253	±0.5 m	87
Post-storm	-1.0 m	187	±0.5 m	119
Stable wave	±0.5 m	5,139		

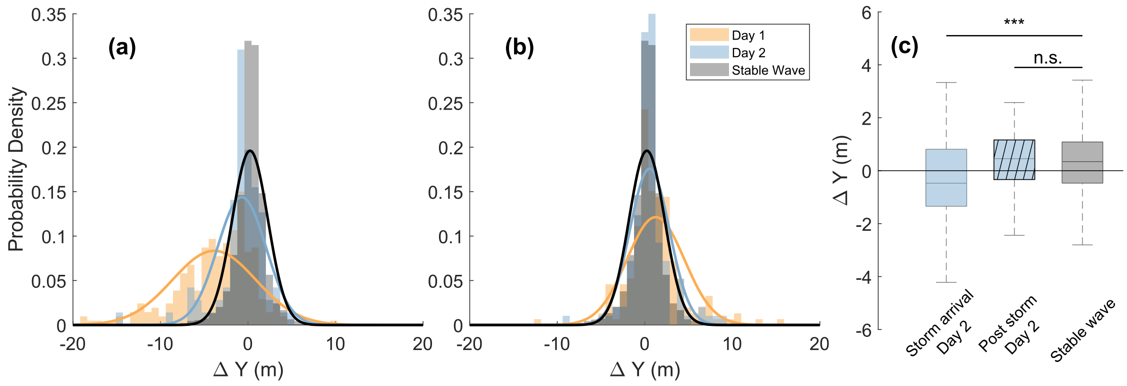

Figure 2 Histogram and probability density function of shoreline change in (a) storm arrival and (b) post-storm;(c) boxplot comparison of shoreline change.

cause shoreline erosion from October to March.

The discrete wavelet transform (DWT) is applied to the data to investigate shoreline behavior over a longer time scale. Beyond the immediate shoreline changes observed in daily comparisons, non-periodic low-frequency behavior contributes most significantly to shoreline variation. Additionally, according to DWT, shoreline variations from days to months exhibit self-affinity, meaning that variation increases as the time scale of components increases.

4. Discussion

From a two-day shoreline wave comparison, erosion and restoration exhibit vastly different magnitudes and time scales. During a storm, the first day's erosion is significant, but not all "erodible" sediment is removed immediately, and this process extends beyond two days. In contrast, accretion occurs over a shorter time scale and stabilizes more quickly under stable wave conditions. Additionally, based on stable wave patterns (Figure 2), we can infer that the shoreline undergoes slow restoration independent of wave conditions. Equilibrium shoreline models typically assign the same time scale to erosion and accretion (Splinter et al., 2014), making them ineffective for capturing short-term variations. Besides that, erosion seems more likely to be driven by disequilibrium, but accretion follows either different equilibrium states or time scales compared to erosion in this study.

5. Conclusion

The high-frequency, long-term beach morphology dataset collected at Hasaki Beach enables analysis of shoreline behavior across various time scales. Daily variations depend highly on wave conditions, with erosion and accretion occurring at different magnitudes and time scales. While long-term variation predominantly influences shoreline changes, the driving factors behind it require further study.

Reference

Splinter, K. D.; Turner, I. L.; Davidson, M. A.; Barnard, P.; Castelle, B.; Oltman-Shay, J. A Generalized Equilibrium Model for Predicting Daily to Interannual Shoreline Response. J. Geophys. Res. Earth Surf. 2014, 119 (9), 1936–1958