

Article

Morphological Response of Coastal Dunes to Typhoons and Winter Monsoons on Pingtan Island, China

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Abstract: Wind plays a crucial role in the formation of coastal dunes, and in China, these dunes are shaped by the combined effects of typhoons and winter monsoons. However, the unique characteristics of Chinese coastal dunes impacted by these forces remain poorly understood, as prior research has predominantly focused on their separate impacts. This study employed RTK-GPS technology to conduct 14 high-precision morphological assessments of coastal dunes in Tannan Bay, Pingtan Island, Fujian, China, between 2014 and 2017, aiming to investigate the response patterns of coastal dunes to typhoons and winter monsoons. Our findings indicate that coastal dunes respond variably to typhoons of differing intensities, with considerable height changes across different sections; however, winter monsoons contribute to an overall increase in dune height. Both dune volume and height increased due to continuous sediment accumulation at the base of the windward slopes. Additionally, the average high-water level advanced seaward by 3.0–4.0 m. We concluded that in Tannan Bay, typhoons exert only a temporary “braking” effect on dune morphology, whereas the winter monsoon is the primary driver of its long-term evolution. These findings contribute to a comprehensive understanding of coastal dune dynamics and provide insights for effective coastal sand management and disaster prevention strategies.

Keywords: coastal dunes; morphological change; typhoon; winter monsoon; Pingtan Island



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1. Introduction

Coastal dunes serve as vital natural barriers in coastal regions, supporting significant biodiversity and contributing to the aesthetic value of tourist destinations [1–3]. Wind is the dynamic factor in the formation of coastal dunes; specifically, their development and movement are controlled by near-surface air flow and aeolian processes [4,5]. China’s coastal zone, a quintessential monsoon climate region, is profoundly influenced by the East Asian winter monsoon, experiencing frequent typhoon landfalls each year. This distinctive climatic setting imparts Chinese coastal dunes with both the common characteristics of global coastal dunes and unique features arising from their formation and evolution under the influence of typhoons and the East Asian winter monsoon [6]. Therefore, investigating the combined impact of typhoons and the winter monsoon on coastal dune morphology is essential for revealing the governing principles of their development and evolution. Such an investigation also provides a scientific foundation for accurately assessing regional characteristics, understanding the formation and evolution of coastal environments, and elucidating coastal sand geomorphological processes.

Typhoons and other high-energy events are widely recognised for their ability to induce rapid and significant alterations in coastal dune morphology [7–11]. For example, the high-energy storm Johanna in 2008 caused a retreat of up to 6.0 m in the Vougot Beach dune in Brittany, France [12]. Similarly, following the impact of Hurricane Fiona in 2022, foredunes in Brackley at Prince Edward Island National Park, Canada, experienced an

average crest retreat of 5 m, with localised peaks reaching 10 m [13]. The morphology of the coastal dunes on Pingtan Island, Fujian, China, underwent substantial changes following Typhoon Matmo in 2014, primarily due to reductions in volume and height [14]. Despite the individual impacts of typhoons on coastal dune morphology, there are no cumulative effects in response to successive typhoon events [15]. The current understanding suggests that the response mechanisms of coastal dune morphology to typhoons involve a complex interplay of factors, including typhoon parameters (i.e., intensity, duration, and frequency), storm surge wave characteristics (i.e., height and direction), dune morphology and its composite features, vegetation cover, sand supply, coastal trends, and sea-level fluctuations [6,16–18].

However, the response of coastal dune morphology to the winter monsoon has been only slightly affected by multi-year morphological changes. For example, on the Changli Gold Coast in Hebei Province, China, the coastal transverse sand ridge crest moves westward (landward) during winter, accompanied by an increase in crest elevation [19]. Similarly, the coastal transverse dunes at Mui Ne, Vietnam, exhibit oscillatory behaviour in response to seasonal wind reversals [20]. The evolution of the lateral sand ridge along the Tottori coast in Japan over the past 500 years indicates that the development of coastal dunes has been primarily driven by the East Asian winter monsoon [21]. In general, existing studies have not fully grasped the characteristics of coastal dunes in China shaped by typhoons/winter monsoons. Research that separately examines the influences of typhoons and winter monsoons is inconsistent with the formation and evolution of coastal dunes. Consequently, there is a limited understanding of the synergistic response mechanism of coastal dunes to these combined forces.

To address this gap, Pingtan Island in Fujian Province, China, characterised by significant seasonal wind direction variations, frequent typhoon activity, and typical coastal dune distribution, was selected as the primary research area for this study. Focusing on the largest coastal dunes on the island, this study investigated the morphological response to typhoons and winter monsoons using continuous high-precision morphological observation data collected before and after these weather events. The study addresses two main questions: (1) What are the response characteristics of coastal dune morphology to typhoons and winter monsoons? (2) What roles do typhoons and winter monsoons play in the morphological development and evolution of coastal dunes? The findings are intended to reveal the developmental and evolutionary patterns of coastal dunes in Tannan Bay, Pingtan Island, providing a scientific foundation for the sustainable development, utilisation, and conservation of coastal dune landscapes.

2. Materials and Methods

2.1. Study Area

Pingtán Island, the largest island in Fujian Province, is situated along the central coast of Fujian, east of the Taiwan Strait (Figure 1). The island boasts coastal dunes spanning an area of 86.6 km², exhibiting a variety of morphological types, such as coastal foredunes, climbing dunes, transverse dunes, and sand sheets [22–24]. These dunes are primarily fed by sediment from the mouth of the Minjiang River, predominantly composed of medium to fine sand [22–24]. Pingtan Island experiences a south subtropical oceanic monsoon climate characterised by an average annual temperature of 19 °C, annual precipitation of 1100 mm, and a mean annual wind speed of 4.8 m·s^{−1} (with prevailing winds from the NNE). The tidal regime on the island is semi-diurnal, with an average tidal range of approximately 4.0 m and a spring tidal range of 6.0–7.0 m.

Pingtán Island is distinguished by significant seasonal wind direction, frequent typhoons, and typical and representative coastal dunes. Owing to its prolonged isolation from the mainland and minimal human interference due to its underdeveloped economy, the coastal dunes on Pingtan Island are relatively well preserved compared to many other locations in China, showcasing the natural state of wind-blown sand landforms. This unique characteristic positions Pingtan Island as an exemplary target area for researching the coordinated response of coastal dune morphology to monsoons and typhoons [22–24].

Among these features, Tannan Bay stands out as one of the five major wind inlets on Pingtan Island. It hosts a dissipative beach where the largest coastal dune has formed. The dunes here are typical coastal foredunes, comprising multiple nabkhas (shadow dunes). This coastal dune complex is dominated by *Spinifex littoreus* (Burm. f), with the trailing edges of the dunes supported by planted *Casuarina equisetifolia*, forming a protective forest.

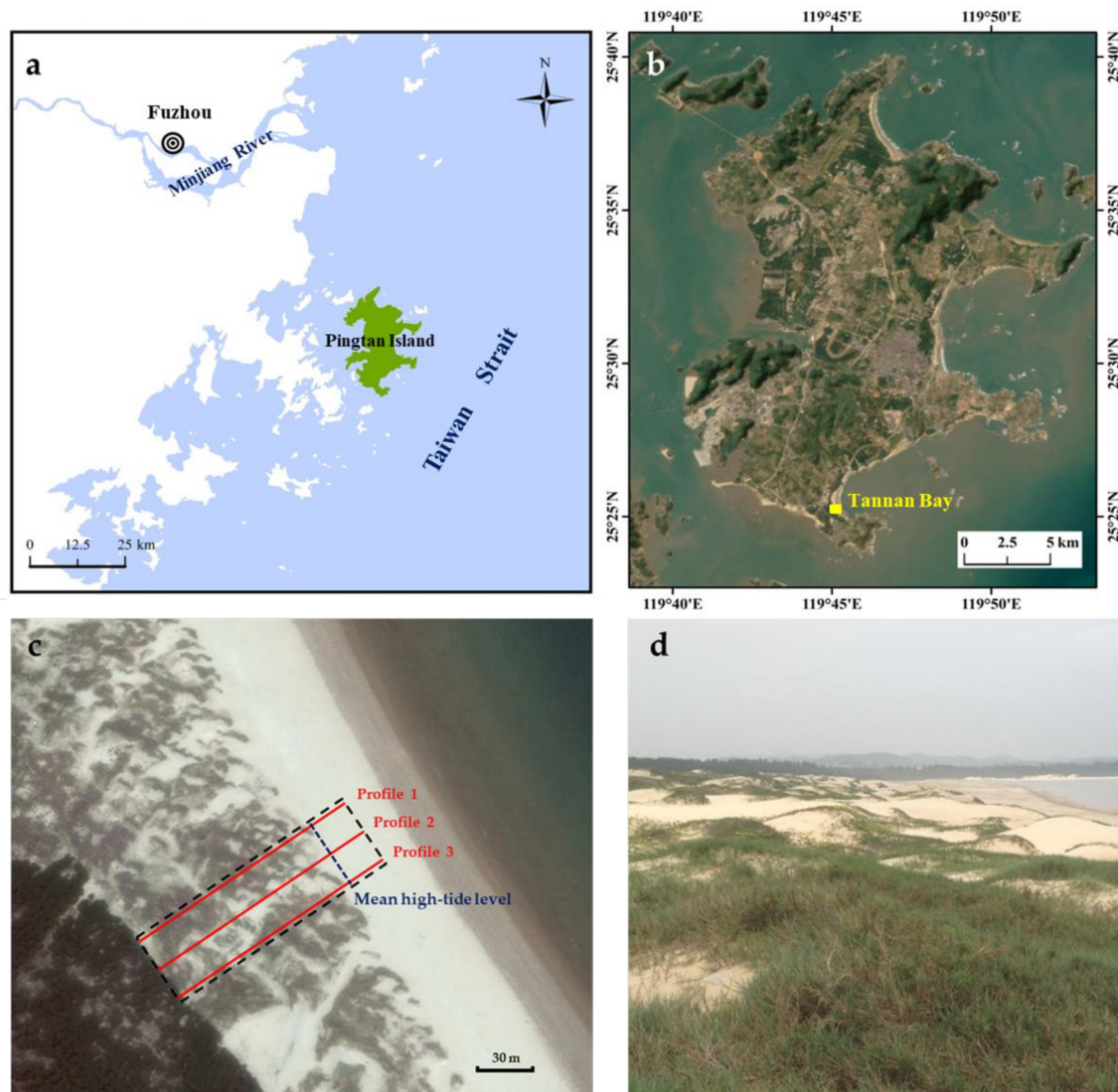


Figure 1. Observation area of coastal dunes in Tannan Bay, Pingtan Island: (a–c), landscape photo (d) taken in May 2016.

2.2. Typhoon

During the observation period from 2014 to 2017, several typhoons impacted Fujian Province. Typhoons were selected for study based on the criteria of a maximum wind speed exceeding 24.5 m/s on Pingtan Island and making landfall within 100 km of the island. Specifically, Typhoon Matmo in 2014, Super Typhoon Soudelor in 2015, Super Typhoon Megi in 2016, and Typhoon Nesat in 2017 recorded maximum wind speeds of 24.9 m/s, 36.3 m/s, 35.5 m/s, and 29.7 m/s, respectively, at the Pingtan Island meteorological station. Furthermore, the prevailing wind direction during these events was northward, with all typhoons initially making landfall on Taiwan Island before proceeding to a secondary landfall along the Fujian coastline (Table 1).

Table 1. Overview of the four typhoons from 2014 to 2017 on Pingtan Island.

Typhoon	Typhoon Genesis	Landfall			
		Landfall Date	Landfall Place	Classification	Dissipated Time
Typhoon Matmo (T201410)	Formed at 02:00 on 18 July in the northwest Pacific Ocean east of the Philippines	23 July 2014	Taitung, Taiwan Fuqing, Fujian	Severe typhoon Tropical storm	25 July 2014
Typhoon Soudelor (T201510)	Strengthened from tropical storm to severe tropical storm at 02:00 on 2 August	8 August 8 2015	Hualien, Taiwan Putian, Fujian	Severe typhoon Typhoon	10 August 2015
Typhoon Megi (T201617)	Formed as a tropical depression on 23 September	27 September 2016	Hualien, Taiwan	Severe typhoon	29 September 2016
Typhoon Nesat (T201709)	Formed on 21 July off the coast of Palau	28 September 2016 29 July 2017 30 July 2017	Huian, Fujian Yilan, Taiwan Fuqing, Fujian	Typhoon Typhoon Typhoon	30 July 2017

2.3. Methods

To investigate the morphological characteristics of coastal dunes, a sample observation area measuring approximately 120.0 m by 40.0 m was established in a typical section of the coastal dunes in Tannan Bay, Pingtan Island (Figure 1c). To ensure consistency across observation sites and to account for the representative distribution of coastal dunes, 291 high-precision observation points were strategically positioned within the sample area. These included 275 observation points located on the coastal dunes and an additional 16 points situated on the beach, which served as reference markers for dune changes, although these reference points were not included in the statistical calculations and analyses. Furthermore, three sampling profiles (P1, P2, and P3) were designated within the sample area to monitor morphological changes along typical cross-sections of the coastal dunes.

Multi-station differential RTK-GPS technology was employed to measure the morphological changes at the observation points within the dune sample area. This technology ensures the measurement accuracy at the centimetre or even millimetre level, making it an invaluable tool for coastal dune studies, as demonstrated in previous research [25,26]. To leverage the precise navigation capabilities of the RTK-GPS, a series of 14 repeated point measurements were conducted between 14 July 2014 and 30 July 2017. These measurements encompassed the periods before and after various typhoons and winter monsoon, enabling a comprehensive analysis of the coordinated response of coastal dune morphology to these environmental factors on Pingtan Island. Unfortunately, our observation sample area began to suffer damage in October 2017 due to local management interventions, including the installation of a sand barrier net at the back of the coastal dunes and the construction of a recreational walkway. Therefore, we were unable to continue observing the natural state of coastal dune morphology changes beyond this period.

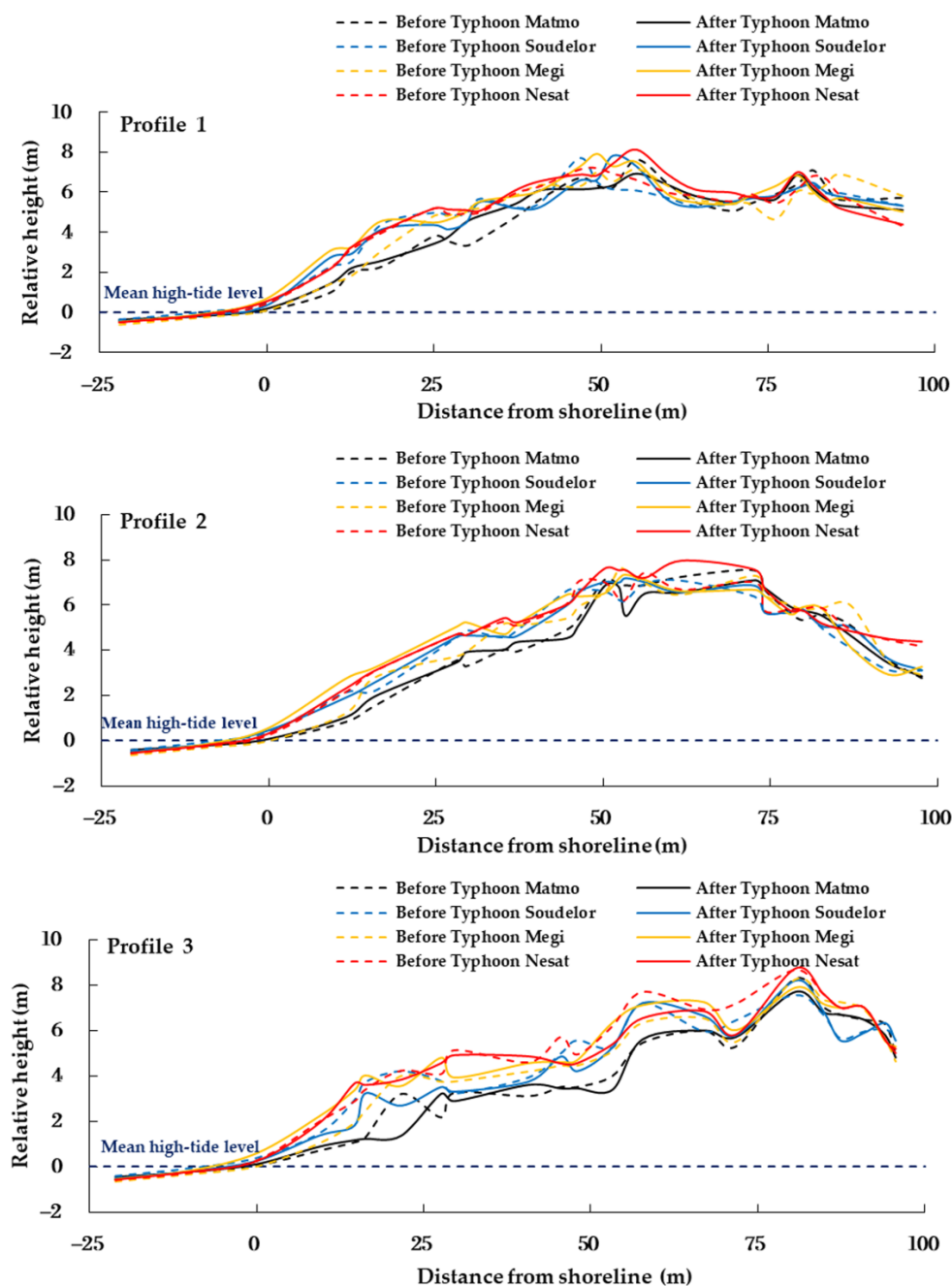
3. Results

3.1. Morphological Changes of Coastal Dunes before and after Typhoons

In 2014, following Typhoon Matmo, the observation sample area of the coastal dunes in Tannan Bay experienced a volume reduction of 42.6 m³. The average height change recorded at the 275 observation points within the sample area was 0.35 m, with the maximum height change recorded being 2.45 m (Table 2). Specifically, the average height changes at observation points P1, P2, and P3 were 0.45 m, 0.33 m, and 0.35 m, respectively. The maximum height decrease observed was 1.84 m, while the maximum height increase was 1.18 m. Spatially, coastal dune heights increased at the foot and middle of the windward slope, while the height of the slope crest decreased. However, the height changes across the coastal dunes exhibited local variations, which corresponded to the differing vegetation distributions on the dune surfaces (Figure 2).

Table 2. Height changes of observation points in the coastal dune sample area before and after typhoons.

Time	Height Change (m)	Average Height Change (m)	Height Reduction		Height Increase		Volume Change (m ³)
			Number of Points	Average Value (m)	Number of Points	Average Value (m)	
Before and after Typhoon Matmo	−2.45 ~ 1.87	0.35	126	−0.36	149	0.34	−42.6
Before and after Typhoon Soudelor	−2.28 ~ 2.12	0.29	159	−0.30	116	0.27	−201.9
Before and after Typhoon Megi	−2.34 ~ 2.47	0.67	99	−0.57	176	0.72	863.9
Before and after Typhoon Nesat	−1.43 ~ 1.51	0.28	112	−0.32	163	0.26	194.9

**Figure 2.** Height variation of observation profiles of the coastal dunes before and after typhoons.

In 2015, following Typhoon Soudelor, the volume of the observational sample area of coastal dunes in Tannan Bay decreased by 201.9 m³. The average height change across the 275 observation points in the sample area was 0.29 m, with the maximum recorded height change being 2.28 m (Table 2). The average height changes at observation points P1, P2, and P3 were 0.34 m, 0.31 m, and 0.40 m, respectively. The heights of the observation points along the sampling line showed a maximum decrease of 1.51 m and a maximum increase of 1.68 m. Spatially, the height of the coastal dunes on the windward slope decreased, whereas the height on the leeward slope increased. However, significant differences were observed in other parts of the coastal dunes. For example, the height of the middle and lower windward slopes in Profiles 1 and 2 increased by 0.38 m, while the height along transect line C decreased by 1.51 m (Figure 2).

In 2016, following Typhoon Megi, the volume of the observational sample area of coastal dunes in Tannan Bay increased by 863.9 m³. The average height change across the 275 observation points in the sample area was 0.67 m, with the maximum height change recorded at 2.47 m (Table 2). The average height changes at observation points P1, P2, and P3 were 0.85 m, 0.55 m, and 0.61 m, respectively, with a maximum height decrease of 1.84 m and a maximum height increase of 1.66 m. Spatially, the height of the coastal dunes increased on the windward slope, although significant differences were observed in other parts of the dunes (Figure 2).

In 2017, following Typhoon Nesat, the volume of the observation sample area of the coastal dunes in Tannan Bay increased by 194.9 m³. The average height change across the 275 observation points in the sample area was 0.28 m, with the maximum recorded height change being 1.51 m (Table 2). The average height change of observation points P1, P2, and P3 was 0.38 m, and the heights of the observation points along the sampling line showed a maximum decrease of 1.36 m and a maximum increase of 1.66 m. Spatially, the height of the coastal dunes increased at the middle and top of the windward slopes, while the changes in other parts of the coastal dunes showed significant variations (Figure 2).

3.2. Morphological Changes of Coastal Dunes before and after Winter Monsoons

Following the winter of 2014/2015 (December 2014 to February 2015), the volume of coastal dunes in the observation sample area of Tannan Bay increased by 450.6 m³. The average height change across the 275 observation points in the sample area was 0.5 m, with the maximum recorded height change being 3.19 m (Table 3). The average height changes at observation points P1, P2, and P3 were 0.51 m, 0.36 m, and 0.71 m, respectively, with the maximum decrease recorded at 0.97 m and the maximum increase at 2.64 m. Spatially, the height of the coastal dunes increased from the foot of the windward slope to the slope crest, while the height changes on the leeward slope varied significantly (Figure 3).

Table 3. Height changes of observation points in the coastal dune sample area before and after winter monsoons.

Time	Height Change (m)	Average Height Change (m)	Height Reduction		Height Increase		Volume Change (m ³)
			Number of Points	Average Value (m)	Number of Points	Average Value (m)	
Before and after Winter 2014/2015	−2.26 ~ 3.19	0.50	125	−0.41	150	0.58	450.6
Before and after Winter 2015/2016	−1.20 ~ 1.23	0.29	117	−0.27	158	0.31	−226.9
Before and after Winter 2016/2017	−2.61 ~ 2.77	0.71	84	−0.51	191	0.80	50.5

Following the winter of 2015/2016 (December 2015 to February 2016), the volume of sand dunes in the observation sample area of the Tannan Bay decreased by 226.9 m³. The average height change across the 275 observation points in the sample area was 0.29 m, with a maximum height change of 1.23 m (Table 3). The average height changes at observation points P1, P2, and P3 were 0.22 m, 0.36 m, and 0.35 m, respectively. The heights of the measurement points along the sampling line showed a maximum decrease of 0.91 m and

a maximum increase of 1.07 m. Spatially, the height of the coastal dune decreased at the foot and the middle and lower parts of the windward slope, whereas the height from the middle to the slope crest increased. The height changes on different leeward slopes also varied slightly (Figure 3).

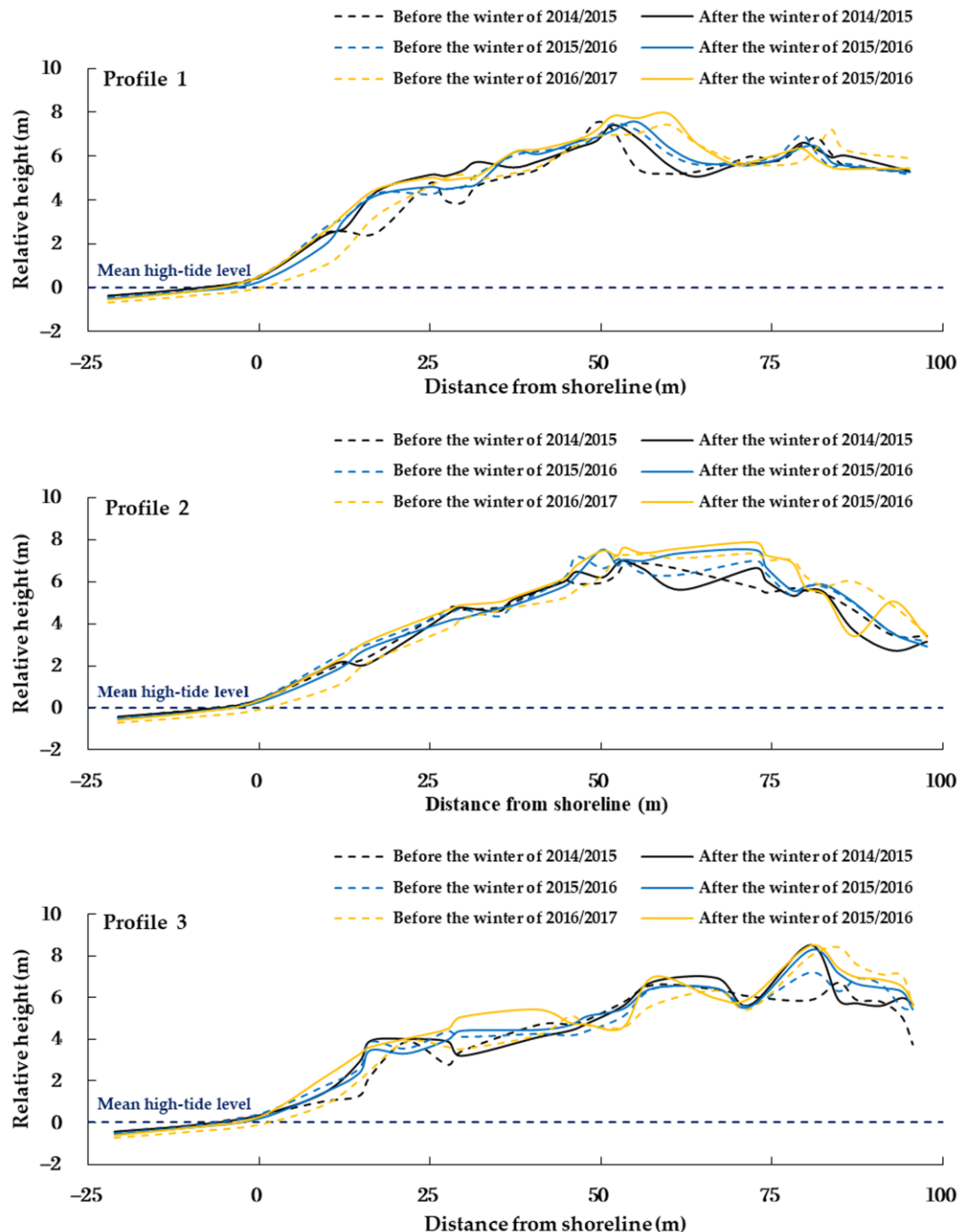


Figure 3. Height variation of observation profiles of the coastal dunes before and after winter monsoons.

Following the winter of 2016/2017 (December 2016 to February 2017), the volume of the observation sample area of the coastal dunes in Tannan Bay increased by 50.5 m^3 . The average height change across the 275 observation points in the observation sample area was 0.71 m, with a maximum height change of 2.77 m (Table 3). The average height changes at observation points P1, P2, and P3 were 0.63 m, 0.58 m, and 0.67 m, respectively, with a

maximum height decrease of 2.61 m and a maximum height increase of 1.66 m. Spatially, the height of the coastal dunes increased from the foot of the windward slope to the slope crest, while the height of the leeward slope decreased (Figure 3).

Between 16 July 2014 and 30 July 2017, the volume of the observed sample area of coastal dunes in Tannan Bay increased by 1058.7 m³. The average height change across the 275 observation points in the sample area was 0.96 m, with the maximum height change reaching 2.75 (Table 4). The average height changes at observation points P1, P2, and P3 were 0.90 m, 0.79 m, and 1.06 m, respectively, with the maximum height decrease being 1.34 m and the maximum height increase recorded at 2.59 m. Spatially, the height of the coastal dunes increased, particularly on the windward slope, with an average increase of 0.91 m. Furthermore, during the three-year observation period, the mean high-water level advanced seaward by a maximum distance of 3.0 to 4.0 m (Figure 4).

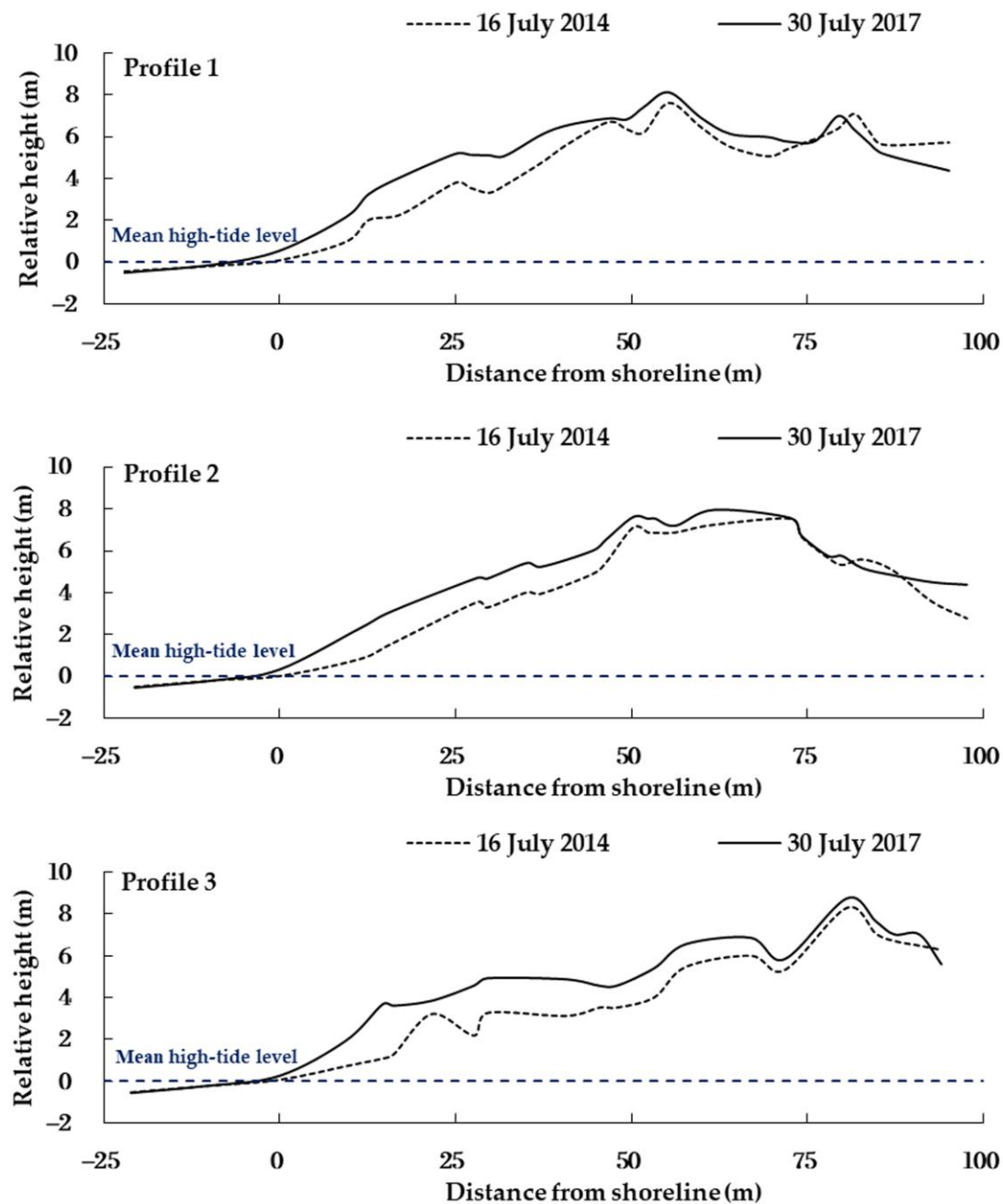


Figure 4. Height variations of observation profiles of the coastal dunes from 2014 to 2017.

Table 4. Height changes of observation points in the coastal dune sample area from 2014 to 2017.

Time	Height Change (m)	Average Height Change (m)	Height Reduction		Height Increase		Volume Change (m ³)
			Number of Points	Average Value (m)	Number of Points	Average Value (m)	
16 July 2014–30 July 2017	−1.34 ~ 2.75	0.96	34	−0.39	241	1.03	1058.7

4. Discussion

4.1. Morphological Response of Coastal Dunes to Typhoons

The morphological response of coastal dunes to typhoons of varying intensities exhibited significant variability, with inconsistent changes in dune height observed across different sections. This finding is consistent with previous studies on the response of coastal dunes to hurricanes, such as Juliette (2001), Ivan (2004), Dennis (2005), and Irma (2017) [1,27–29], yet the finding contrasts with other studies suggesting a uniform morphological response to storms across different parts of coastal dunes [30–33]. On Pingtan Island, the strong wind erosion and sand-transport capacities during typhoons resulted in predominantly non-selective erosion and transport accumulation effects on the coastal dunes, leading to substantial morphological alterations [15]. The erosion and accumulation of coastal dunes in Tannan Bay will vary due to the differing wind strengths of the various typhoons affecting Pingtan Island. For instance, following typhoons Matmo and Soudelor, the sand dune volume in Tannan Bay decreased by 42.3 m³ and 201.9 m³, respectively, with average height reductions of 0.36 m and 0.30 m. Conversely, under the influence of Typhoons Megi and Nesat, the coastal dune volume increased by 863.9 m³ and 194.9 m³, respectively, with corresponding average height increases of 0.72 m and 0.26 m. Typhoon intensity emerges as a pivotal factor driving morphological changes in coastal dunes, with higher-intensity typhoons inducing more pronounced alterations due to their increased erosion and transport capacities. For example, despite Typhoon Nesat making landfall farther from Pingtan (95 km) than the more intense Typhoon Megi in 2016, the latter's high wind speeds and intensity resulted in a maximum dune height change of 2.47 m along the Tannan Bay coast, surpassing the 1.51 m height change induced by Typhoon Nesat in 2017.

The windward slope base and midsection of the coastal dunes in Tannan Bay are particularly susceptible to sediment accumulation caused by typhoons and storm surges, leading to increases in their height. Wind erosion typically occurs beyond a certain dune height, particularly near the slope crest [14]. However, due to variations in microtopography and vegetation cover across the coastal dunes, the primary characteristics of the different parts of the coastal dune are the distribution of erosion and accumulation post-typhoon (Figure 5). The presence of *Spinifex littoreus* vegetation on the coastal dunes in Tannan Bay acts as a protective barrier, enhancing local moisture conditions, altering near-surface flow dynamics, and mitigating erosion during typhoon events [34]. Field observations indicate that the exposed dune slopes are more prone to wind or storm surge erosion under typhoon conditions (Figure 6a), whereas vegetated slopes predominantly experienced sediment deposition (Figure 6b).

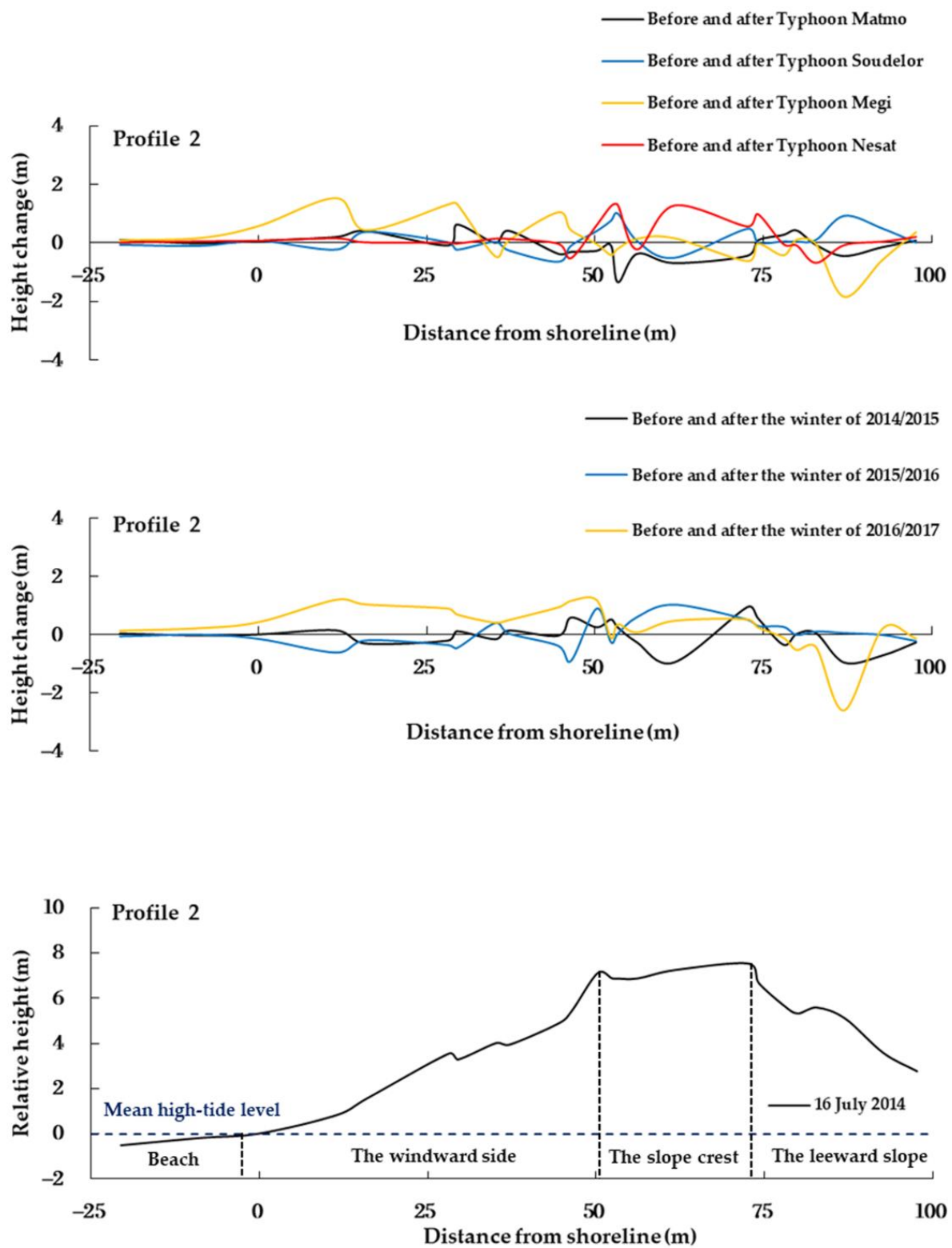


Figure 5. Height changes of different parts of coastal dunes in profile 2.



Figure 6. The impact of vegetation on morphological variations of dunes following a typhoon. Panel (a) displays the southeastern view of the dunes following Typhoon Megi, while panel (b) presents the northeastern view following Typhoon Megi in September 2016.

4.2. Morphological Response of Coastal Dunes to Winter Monsoons

The morphology of coastal dunes in Tannan Bay underwent significant changes before and after the winter monsoon, which were primarily attributed to the increase in coastal dune height. For instance, during the winters of 2014/2015 and 2016/2017, the coastal dunes in Tannan Bay generally experienced increases in both volume and height, with the most pronounced increase observed on the windward slope. However, in the winter of 2015/2016, despite a notable increase in dune height, there was a significant decrease in volume (Figure 5). This outcome mirrors the variation in coastal transverse dunes at Changjiangao [22], but differs from the variations in coastal sand sheets at Shanqigong on Pingtan Island [23]. The beach at Tannan Bay has abundant sand sources, and under the influence of strong NNE winds during winter, beach sediments migrate towards the shore, accumulating on coastal dunes and increasing their volume and height, particularly from the base of the windward slope to the slope crest (Figure 7). Conversely, when intense shore-driving winds are not synchronised with beach tides, leading to a disruption in the beach sand supply, the sand source of the coastal dune becomes insufficient. Consequently, the windward slope of the coastal dune shifts from accumulating sediment to experiencing erosion, resulting in decreased height, inland migration of the dune's primary body, and a reduction in dune volume within the sampled area, as observed in the morphological transformations during the winter of 2015/2016.



Figure 7. Winter landscape of coastal dunes in Tannan Bay (a,b). The photo was taken in February 2016.

4.3. Morphological Response of Coastal Dunes to Typhoons and Winter Monsoons

The coastal dunes in Tannan Bay exhibited distinct morphological responses to both typhoons and winter monsoons. Low-frequency, high-energy typhoons and high-frequency, low-energy winter monsoons can significantly alter the morphology of these coastal dunes. However, in Tannan Bay, where beach sand resources are abundant, typhoons only exert a temporary “braking” effect on the morphological evolution of the dunes, with normal sand-carrying winds being the primary driving force. This result is similar to the variation observed in the coastal transverse dunes at Changjiangao, Pingtan Island. The morphological characteristics of these coastal dunes result from the interplay between numerous beach sand resources, robust prevailing shoreline winds, dune morphology, and vegetation coverage, with ample beach sand resources and strong prevailing shoreline winds being pivotal factors [22]. In contrast, despite the lack of sand sources, typhoons play a prominent role in shaping the morphology of the coastal sand sheet in Shantigao, which is dominated by offshore wind [23]. This result is inconsistent with the understanding that wind is the primary driver of dune morphology and evolution [35]. The key to this discrepancy lies in the wind events associated with typhoons, which selectively erode and transport coastal dunes, leading to the disruption of their original morphology and noticeable changes. Nevertheless, in Tannan Bay, where the beach terrain is flat and expansive, and sand sources are abundant, coastal dunes can revert to their pre-typhoon state under the influence of shore-driving winds at speeds of 6.0 to 10 m/s during a single winter season. Thus, low-frequency, high-energy typhoons act as temporary impediments to the morphological development of coastal dunes, with the winter monsoon as the principal driving force.

Consequently, over the three-year observation period, the coastal dunes in Tannan Bay predominantly increased in both volume and height. This growth can be attributed to continuous sediment accumulation at the base of the windward slopes, leading to a seaward advancement of the average high-water level by up to 3.0–4.0 m. In summary, both typhoons and winter monsoons play crucial roles in the morphological development and evolutionary mechanisms of coastal dunes in China. Therefore, establishing a robust scientific basis is essential for effectively preventing and managing coastal sand-related disasters in the country. In our follow-up study, we aim to further explore the relationship between wind dynamics and dune morphology, integrating wind–sand flow observations to deepen our understanding of these processes.

5. Conclusions

The response of coastal dune morphology to typhoons of differing intensities on Pingtan Island shows considerable variation, with inconsistent changes in height observed across different sections of the dunes. The primary factor driving changes in coastal dune morphology in response to the winter monsoon is the increase in dune height.

Over the three-year observation period, the coastal dunes in Tannan Bay, Pingtan Island, predominantly experienced increases in both volume and height. This growth was particularly notable due to continuous sediment accumulation at the base of the windward slope, leading to the seaward advancement of the average high-water level by 3.0 to 4.0 m.

The coastal dune morphology of Tannan Bay exhibits the distinct characteristics of a coordinated response to typhoons and winter monsoons. While both low-frequency, high-energy typhoons and high-frequency, low-energy winter monsoons can lead to significant alterations in coastal dune morphology, typhoons tend to exert only a temporary “braking” effect on the morphological evolution of the coastal dunes in Tannan Bay, where abundant beach sand resources are available. The primary dynamic factor driving these changes is the winter monsoon.

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Conflicts of Interest: The authors declare no conflicts of interest.

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