IMPACT ASSESSMENTS OF CLIMATE CHANGE ON BEACH TOPOGRAPHY IN TOSA BAY, JAPAN

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INTRODUCTION

For coastal zone management, it is important to predict future changes in external forces and beach topography due to climate change. In particular, as wave direction is one of the dominant factors in the longshore sediment transport, changes in wave direction exert significant impacts on future beach topography. Despite many studies carried out on the future projection of wave climate, there are few examples of studies on future beach topography due to climate change. This study aims to assess future changes in wave direction by wave simulation considering climate change, and to clarify the effect on beach topography on actual beaches.

METHODOLOGY

The target area is the Tosa Bay coast, located on the Pacific coast of Japan (Figure 1), where sediment transport during typhoons is predominant. First, using global warming simulation results (d4PDF) by a global atmospheric model calculated by Mizuta et al. (2017) and others (Figure 2), typhoon characteristics in the present (historical) climate and future climate scenario (+2-K and +4-K) is analyzed, and wave simulation by a wave model (SWAN ver.41.31) is conducted for 100 typhoons affecting the target area. From these results, spectrum analysis of wave climate is performed, and future changes in energy-averaged mean wave direction during typhoons due to climate change are estimated.

Next, the longshore sediment transport model that can reproduce the actual beach topography of the last 15 years from 2006 to 2020 in the target area is developed. Using this model, numerical simulation of beach topography is carried out, and the characteristics of future changes in sediment transport and beach topography due to the estimated future changes in wave direction is analysed.

RESULTS

The estimated mean wave direction during typhoons in the present climate is 175° for offshore locations (water depth of about 100 m, point B) and 174° for coastal location (water depth of about 25 m, point A). In +4-K future climate, mean wave direction at the offshore location is 165°, resulting in anti-clockwise change of about 10°, while mean wave direction at the coastal location is 168°, resulting in anti-clockwise change of about 6° (Figure 3, 4). At other sites, mean wave direction also would be changed anti-clockwise in the future.

The sediment transport model shows that the direction of the longshore transport is predominantly westward even in the present climate. Calculations of beach topography using future changes in wave direction at the coastal location further demonstrate an increase in sediment transport in the westward direction, resulting in an increase in the amount of westward longshore sediment transport (depth-integrated) of about 1000 m^3 / year (about 130%) (Figure 5). These changes in sediment transport processes result in shoreline erosion of up to 10 m. These results indicate that beach erosion will be more severe, especially on the east side of the target area (Figure 6).

CONCLUSIONS

Future changes in wave direction due to climate change are estimated and the impact assessments on actual beach topography are conducted. The results show that mean wave direction would be changed anti-clockwise in the future in the target area with increasing westward sediment transport. This demonstrates that sediment transport processes will change significantly with climate change, making future coastal management difficult in the way it has been done in the past.

REFERENCES

Mizuta et al. (2017): Over 5000 years of ensemble future climate simulations by 60km global and 20km regional atmospheric models, B. A. M. S, pp. 1383-1398.

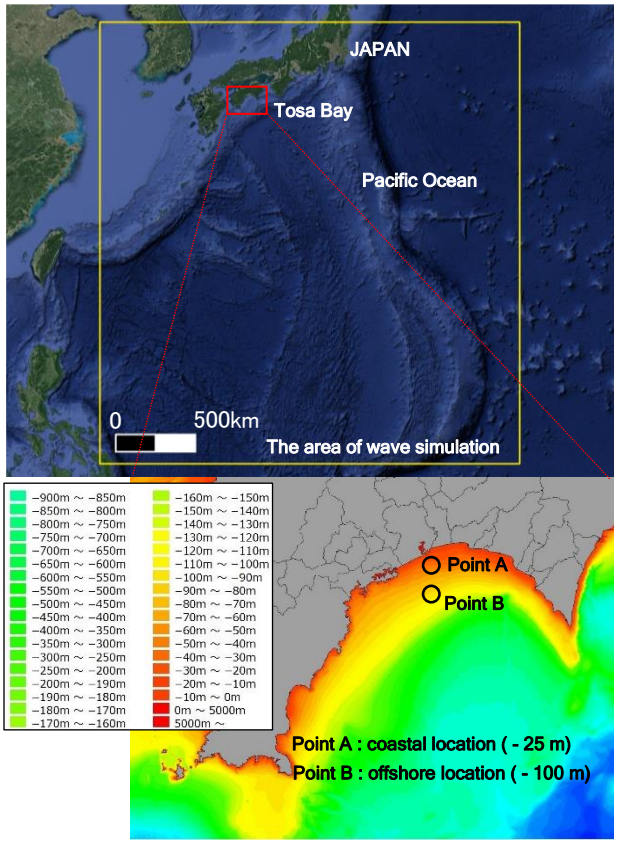

Figure 1 – Target location map (Tosa Bay, Japan). Yellow line is the area of wave simulation.

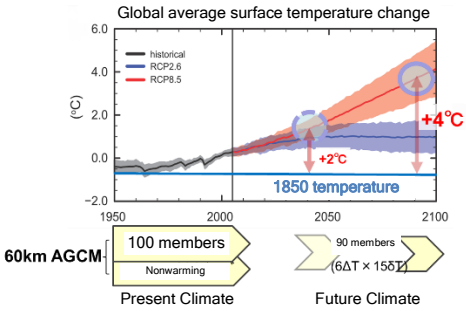

Figure 2 – Overview of d4PDF. (https://www.miroc-gcm.jp/d4PDF/index_en.html)

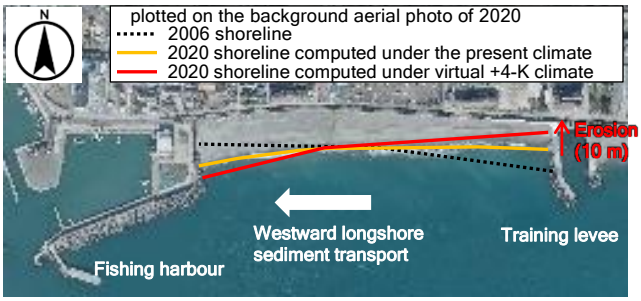

Figure 6 – Calculation results for shoreline in the present climate and +4-K future climate on the east side of Tosa Bay. Background aerial photo is 2020.

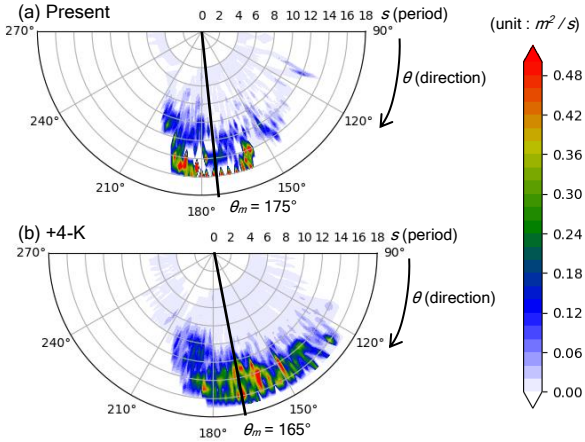

Figure 3 – Temporal average of spectra and energy-averaged mean wave direction (clockwise) in the present climate and +4-K future climate at the offshore location (point B). Semicircles lines indicate wave periods (two second intervals).

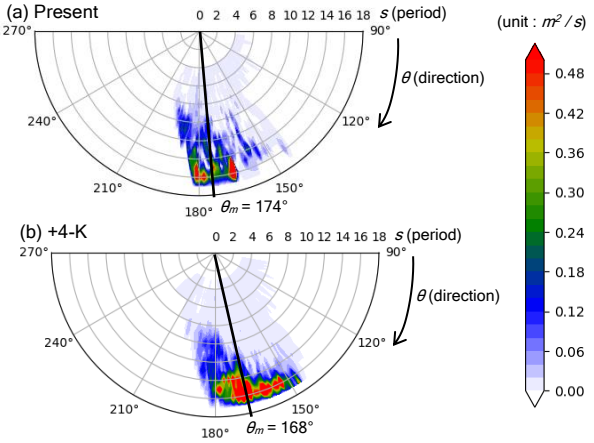

Figure 4 – Temporal average of spectra and energy-averaged mean wave direction (clockwise) in the present climate and +4-K future climate at the coastal location (point A). Semicircles lines indicate wave periods (two second intervals).

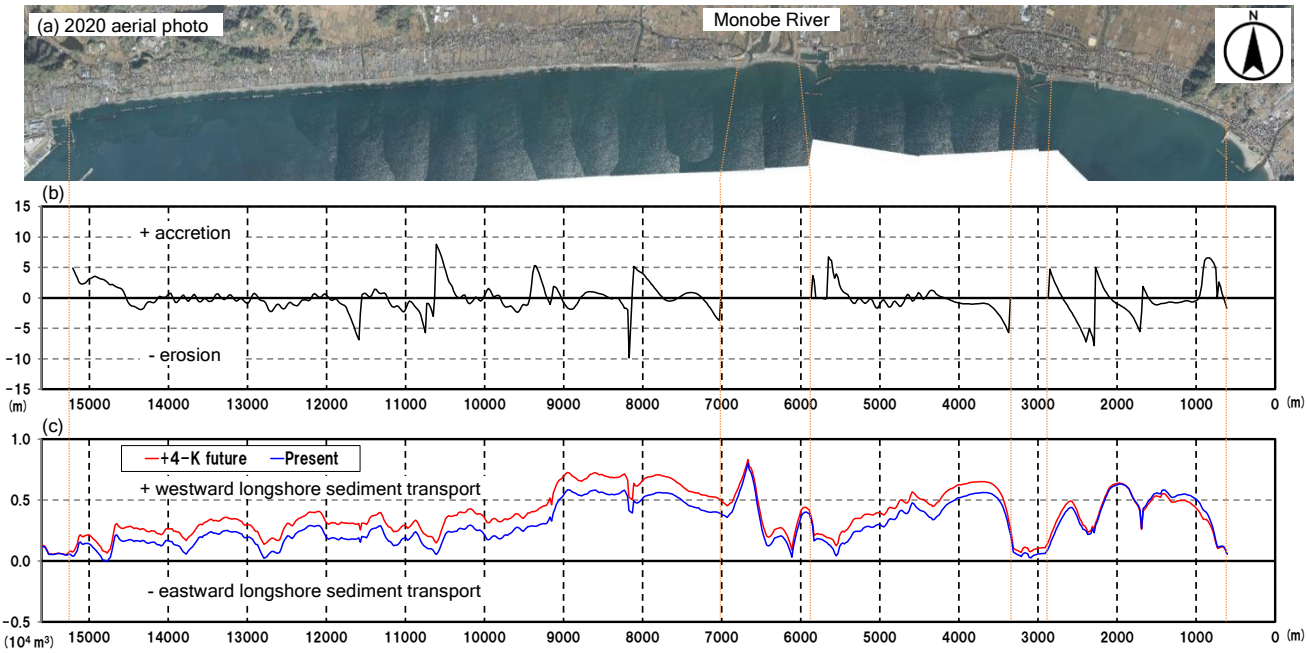

Figure 5 – Calculations of beach topography from 2006 to 2020. (a) target location map, (b) 2020 shoreline change between +4-K climate and present climate, (c) the annual averaged amount of longshore sediment transport (depth-integrated).