LONG-TERM PROJECTION OF EXTREME STORM SURGE IN JAPAN USING MAXIMUM POTENTIAL STORM SURGE HEIGHT MODEL BASED ON HIGHRESMIP EXPERIMENT

Shun Ito, Kyoto University, Japan, ito.shun.24z@st.kyoto-u.ac.jp
Nobuhito Mori, Kyoto University, Japan, mori.nobuhito.8a@kyoto-u.ac.jp
Tomoya Shimura, Kyoto University, Japan, shimura.tomoya.2v@kyoto-u.ac.jp
Takuya Miyashita, Kyoto University, Japan, miyashita.takuya.4w@kyoto-u.ac.jp

INTRODUCTION

The recent IPCC report indicated that the ratio of strong tropical cyclones (TCs) can increase due to climate change, and there is concern that the intensified TCs would increase the risk of storm surges. However, a storm surge is an extreme event with a lower frequency compared to strong winds and heavy precipitation. Thus, it is difficult to estimate storm surge risk under climate change considering future changes in intensity, path, and speed of TCs. This study estimates future changes in the worst class of TCs using the MPI (Maximum Potential Intensity) theory and future changes in the worst class of storm surge height along major bays in Japan using the MPS (Maximum Potential Storm surge height) model.

METHODOLOGY AND DATA

We estimated the maximum potential intensity in a given environmental field using E-MPI (Emanuel et al., 2002). Using the estimated MPI, we estimated the theoretical upper limit of storm surge height for each bay. In the MPS model (Mori et al., 2021), wind-induced and pressure-induced storm surge heights were individually calculated, assuming the worst-case TC track, a steady-state, and the TC translation speeds with the long-wave velocity in the bay. When calculating MPI and MPS, the climate data on HighResMIP (High-Resolution Model Intercomparison Project) experiment, which was evaluated specifically for TCs in CMIP6, IPCC AR6, were used. In the HighResMIP experiment, the intercomparison of TC projections with AGCM (Atmospheric Global Climate Model) and AOGCM (Atmosphere-Ocean Global Climate Model) was performed under the RCP8.5 scenario. The differences in projection between the AGCM and the AOGCM for MPI and MPS were analyzed in detail.

FUTURE CHANGES IN THE INTENSITY OF TROPICAL CYCLONES AND STORM SURGE HEIGHTS

The spatial-temporal distribution of monthly MPI in the Northwestern Pacific was investigated. Future MPI changes were the greatest in the 30-40°N latitude band in September. Then, the time-series of monthly MPI in September were analyzed by AGCM (16 models) and AOGCM (14 models) around Japan (Figure 1). Future changes in MPI from 2020 are -4.3 hPa in AGCM and -6.1 hPa in AOGCM by 2050, showing a consistent, clear TC intensified trend. In addition, using the MPI-MPS model along the Japanese coast, maximum potential storm surge heights in each bay were investigated (Figure 2). In Osaka Bay, where the largest future change was seen, the change from the present climate (1950-2014) was +0.56 m in AGCM and +0.47 m in AOGCM, which showed a consistent result between the two different climate models.

The future TC intensity shows the significant increasing trend around Japan, and the related storm surge height of major bays in Japan is also clearly projected. This result highlights importance of adaptation measures to consider storm surge changes in addition to sea level rise.

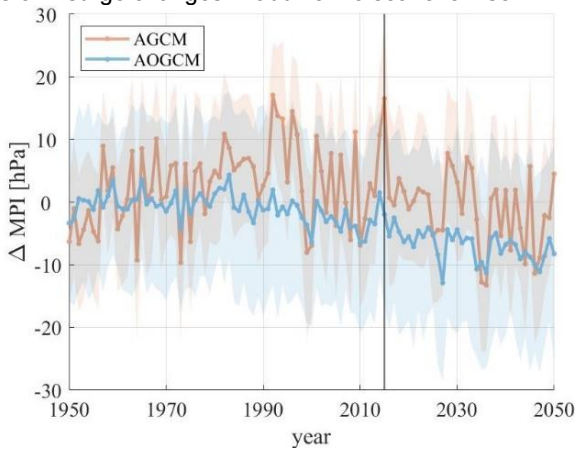

Figure 1: Time series of MPI in September around Japan (25-40°N) (red: AGCM, blue: AOGCM, background color indicates inter-model variations)

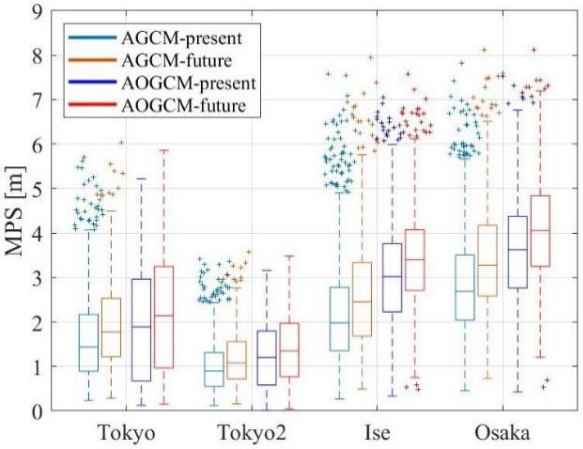

Figure 2: Boxplot of MPS in September three major bays in Japan (green and blue: present climate, brown and red: climate in 2050, green and brown: AGCM, blue and red: AOGCM)

REFERENCES

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