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(都市イノベーション学府 Graduate School of Urban Innovation)

論 文 要 旨
Summary of Dissertation

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専 攻 Department	Graduate School of Urban Innovation
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論文題目 Title	Response of Hypoxia Development in A Semi Enclosed Water Body to Global Climate Change Under Moderate to Worst Case Scenario
和訳または英訳 Translation (J->E, or E->J)	複数シナリオに基づいた将来の気候変動に対する閉鎖性海域での貧酸素化の応答

To simulate the coastal environment, regional ocean models require accurate weather data for atmospheric boundary conditions such as air temperature, wind speed, and direction. In the first phase of this study, a numerical framework was developed to simulate different physical, chemical, and biological processes in a semi-enclosed coastal ecosystem by integrating the Weather Research and Forecasting (WRF) model with a 3D hydrodynamic and ecosystem model (Ise Bay Simulator). The final analytic data of the global forecast system released by the National Centers for Environmental Prediction with a 0.25° horizontal resolution was used as an atmospheric boundary condition for the WRF model to dynamically downscale the weather information to a spatial and temporal fine resolution. This modeling framework proved to be a good tool to simulate the physical and biogeochemical processes in a semi-enclosed coastal embayment, and its simulation results were further compared with recorded Automated Meteorological Data Acquisition System (AMeDAS)-driven ecosystem simulations and observed data. The performance of both the AMeDAS and WRF datasets was equally good, and more than 80% of the variation in bottom dissolved oxygen for shallow water and more than 90% of the variation in dissolved oxygen for deep water was reproduced. This well-developed framework was utilized in the second phase of this study to assess the response of hypoxia development in a semi-enclosed water body to global climate change under moderate to the worst-case scenario. Differentiating from other researches in which authors made their pseudo climate change scenarios by changing few metrological parameters. In this study, the weather research and forecasting (WRF) model was used to dynamically downscale future climate change projections generated by the Global Climate Model (GCM). The downscaled high-resolution future weather products were further utilized to drive the 3D hydrodynamic and ecosystem model to simulate the bottom dissolved oxygen. The three climate projections under moderate to worst-case RCP scenario (RCP 4.5, RCP 6.0 & RCP 8.5) were simulated for six end century years (2095-2100), and weather and ecosystem results were compared with the six present baseline years (2011-2016). The weather simulation results indicated that in the future annual average air temperature will increase by 15%, 19%, and 29% under moderate to worst-case RCPs respectively. Similarly, the higher precipitation events in the future caused an increase in annual average river discharge by 10%, 17%, and 26%. The typical wind pattern in Ise Bay will also change in the future, the overall and summer winds will slow down and a 10% decline in southeast wind events and a 10% increase in the northwest wind will propagate. The change in meteorological parameters greatly affected the paraments directly associated with hypoxia development such as increased nutrients loading, enhanced stratification, and oxygen consumption. The ecosystem simulations in the shallower region were affected more than the deeper region and a significant decline in the annual average bottom dissolved oxygen was pointed out. The results suggest that the future hypoxic response in Ise Bay is severe and the annual average bottom oxygen will decline by 17%, 21%, and 26% under moderate to worst-case scenarios respectively. It's not only the decline in bottom oxygen which will prevail in the future, but the duration of hypoxia will also increase by more than 20% owning to hypoxia prone conditions.

Keywords: Weather Research and Forecasting (WRF) Model, Dynamic Downscaling, Climate Change, Hypoxia, Ise Bay.