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論文題目	Natechs and Climate Change: Wide-scale Spatial Modeling of the Occurrence Probability and Variability of Tropical Storm-Related Natech Events in the United States Under Various Climate Scenarios （Natech 災害と気候変動:多様な気候シナリオの下での米国における熱帯低気圧を引き金とした Natech 事象の発生率と変動性に関する広範囲の空間モデリング）		

（論文内容の要旨）

The overall aim of this dissertation is to determine the connection between climate change and the incidence and variability of tropical storm-related (TS) natural hazard triggered technological accident (Natech) events, by analyzing the case of the United States (U.S.), and to provide an outlook on how climate change may affect tropical storm related Natech (TSNatech) incidence in the future based on various climate scenarios. In order to achieve that aim, the thesis first developed a deep learning-based framework to retrieve Natech reports during the period of 1990 to 2017 from the National Response Center (NRC) database of the U.S. Based on the retrieved Natech events data from the NRC database, multiple statistical and spatial analysis methods were employed to analyze the temporal-spatial variation of TSNatech. Afterwards, a methodology was proposed to generate a fragility curve to estimate the probability and conditional probability of TSNatech by using wind energy. Based on the proposed estimation method and the climate data provided by the World Climate Research Programme (WCRP), the probability of TSNatech events were estimated for the periods of 1990-2017 and 2021-2100, respectively. Through the above progress, the link between climate change and the incidence of TSNatech events was determined. Climate change may be affecting the incidence of TSNatech events by affecting the activety of tropical storms. The results of this study show that the probability of TSNatech events in the U.S. may increase in the future compared to the period of 1990-2017.

The thesis contains 7 chapters described in detail below.

Chapter 1 gives a brief introduction about Natech risk and climate change. After proposing research questions, the main aim and objectives of this study are presented, including a brief summary of the methodology and dissertation structure.

Chapter 2 presents a discussion regarding previous studies related to TSNatech, climate change, and their relationships. It identifies the gaps in TSNatech research and its relationship with climate change, and proposes a pathway to fill the research gaps including the need to understand the connection between climate change and TSNatech events, and to develop a new method to analyze how TSNatech occurrence will change under future climate change.

Chapter 3 develops of a deep learning based Natech extraction framework, called the Semi-Intelligent Natech Identification Framework, and explains the procedure on how to use the developed framework to retrieve Natech events. At last, 32,841 Natech event reports were extracted from the NRC database between 1990 and 2017.

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Furthermore, the majority of those Natech reports (97.85%) were related to meteorological phenomena, with hurricanes (24.41%), heavy rains (19.27%), and storms (18.29%) identified as the main causes of these reported Natechs.

Chapter 4 analyzes the temporal-spatial variation of TSNatechs, spatially extracted from the identified Natech events in Chapter 3, based on analyzing the historical tropical storm data. A series of statistical analysis methods, spatial analysis methods, and spatial statistical analysis methods are employed to finish analyzing the temporal-spatial variation of TSNatech incidence. In order to explore the cause of such changes, this study investigates the relationships between the temporal-spatial variation of the incidence of tropical storms-related Natechs, and the accumulated cyclone energy, the North Atlantic Oscillation (NAO) index and the Oceanic Niño Index (ONI), and other variables. The results suggest there is a link between climate change and the temporal-spatial variation of the incidence of related Natechs due to its effect on tropical storm activity.

Chapter 5 proposes a spatial analysis methodology to analyze the trends of the probability/conditional probability of TSNatech on a regional basis. Based on the proposed methodology, fragility curves to describe the conditional probability of TSNatech due to the wind energy of tropical storms are estimated. The results suggest that both the probability and the conditional probability of tropical storm-related Natechs are on the rise. Wind energy of tropical storms is found to be a good estimator of the conditional probability of tropical storm-related Natechs from a regional view.

Chapter 6 proposes a methodology to estimate TSNatech probability for 1990-2017 and 2021 to 2100, respectively, based on the estimation method which is presented in Chapter 5. Through estimating TSNatech probability based on the climate Scenario MIP data which are simulated in the scenarios of shared socioeconomic pathways, this study found that TSNatech has a much higher probability of occurrence in the future. Global warming may increase the number of extreme TSNatech probability values in the future.

Chapter 7 summarizes the main findings and limitations of this study. Moreover, the recommendations of this study and future work are also discussed in this chapter.