令和６年度環境・社会理工学院共通経費による顕彰と研究助成　成果報告書

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研究題目	Developing Flash Flood Database and Warning System with AI Techniques: A National Approach for Japan
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研究の背景

Japan's complex topography and frequent heavy rainfall make the country highly susceptible to flash floods. Despite the large influence of this hazard, there is currently no comprehensive flash flood database in Japan. The lack of this data hampers the development of effective flash flood early warning systems. In addition, significant gaps remain in the national warning system and in responding to flash floods. Traditional methods, such as flash flood guidance systems, often require extensive hydrometeorological data and complex model development efforts. However, recent advances in artificial intelligence (AI) offer promising new methods for flash flood prediction. AI-based approaches can potentially identify flash flood occurrences rapidly and with less reliance on detailed data. Given these gaps and opportunities, this research aims to develop a comprehensive flash flood database for Japan and to explore the use of advanced AI techniques to improve the accuracy of flash flood warnings.

研究の概要と成果

(1) The flash flood database in Japan has been created.
This research created a flash flood database for Japan using observed water level data from 2000 to 2020. I proposed a threshold-based method to extract flood events from the time series of hourly water level observations. Using this method, I identified and compiled a comprehensive flood event database for approximately 1,800 stations across Japan. Each event record includes the start time, peak time, peak water level, and end time. To validate the performance of the extraction method, the results were compared with the official flood records maintained by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT). The comparison showed that 96% of the recorded flood events were successfully captured by the proposed method, indicating high reliability. Furthermore, by preliminarily defining flash floods as flood events with a rising time of less than six hours, the flash flood database was extracted from the full dataset. We found that flash floods account for around 17% of the total number of flood events.

(2) Flash Flood Warning System Development:
We developed a flash flood warning system using an advanced graph neural network (GNN) (as shown in Fig. 1). Compared to the flash flood modeling system I developed in 2022, this model incorporates river network topology into the learning process, resulting in improved predictive performance and better interpretability. To evaluate the model, we conducted tests using data from China, where a well-established flash flood database is available. The proposed GNN-based model demonstrated approximately a 15% improvement in prediction accuracy compared to baseline machine learning models. I presented this work at the Japan Geoscience Union (JpGU) Meeting 2025. In parallel, I matched the locations of flash flood events in section (1) to river networks in Japan. We also have collected and processed the key predictors—such as precipitation and terrain characteristics—as model input in Japan. I plan to extend the application of the proposed model to Japan when the flash flood database in section (1) is fixed.
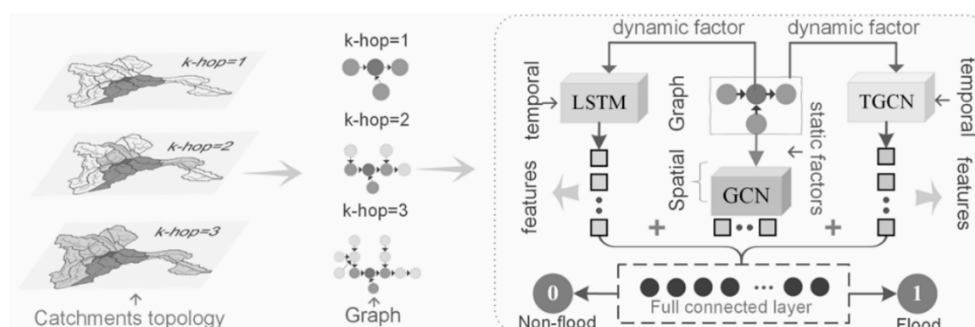

Fig. 1 The model architecture used in this research

今後の展望

Currently, a simple method is used to extract flash flood events, based on a fixed threshold of six hours for the rising time. However, this approach does not fully capture the complexity of hydrological processes in some regions of Japan. Therefore, it is important to explore more adaptive strategies that better reflect the variability of complex hydrology. Meanwhile, the proposed model has been successfully validated in China. As the next step, I plan to apply the model for flash flood warning in Japan and further refine it according to Japan's hydrological conditions.

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