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Hydrometeorological Nowcasting Methods for Flash Flood Early Warning Systems in the Chugoku Region of Japan

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Introduction

As a result of climate change, unprecedented disasters associated with extremely heavy rainfall, intense typhoons and associated coastal sea disasters are now occurring every year. To mitigate the negative impacts of unprecedented rainfall-induced disasters and contribute to the development of Early Warning Systems (EWS), real-time forecasting or nowcasting models are needed to predict extreme river water levels and discharges, but such models have not yet been accurately developed nor implemented in Japan.

This study introduces hydrometeorological tools and methods for the future development of real-time forecasting of river water levels and discharges for use in early warning systems and associated flash flood disaster prevention in the Chugoku region of Japan.

Methods

The Cell Distributed Runoff Model version 3.1.1 (CDRM) hydrological model calibrated by the Shuffled Complex Evolution optimization method developed at the University of Arizona (SCE-UA) was applied for the river mouth hydrograph calculations (Figure 1) using two methods, 5 Calibrated Parameters Method (5-CPM, Troselj et al., 2017, Trošelj and Lee, 2021) and newly introduced 7 Calibrated Parameters Method (7-CPM). The hydrological parameter calibration was conducted for seven first-class rivers on seven the most extreme historical heavy rainfall events (JMA) in the Chugoku region of Japan. Then, the calibrated parameter sets from the six past events were applied with observed rainfall data from the Heavy Rainfall Event of July

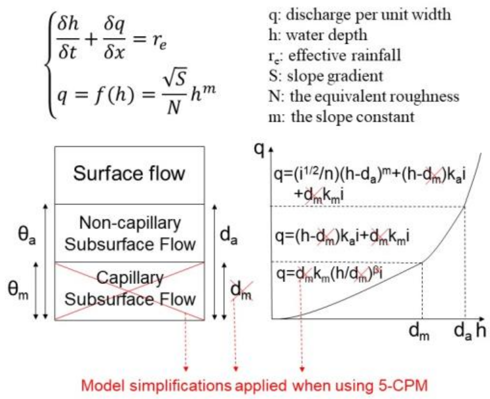

Figure 1: CDRM Model configurations.

2018 (HRE18) to project and validate river mouth hydrographs of all seven rivers. The mean ensembles of river discharges were compared for validation. These ensembles were calculated as averaged values of the six validation cases of river discharges for every 168 hourly time steps from 3rd to 9th July 2018 (Eq. 1).

$$P_t = \frac{1}{n}\sum_{i=1}^{n} Q_s^t(i) \qquad (1)$$

Finally, the hydrometeorological forecasting was conducted with different lead-times using rainfall data from the high-resolution deterministic 3-hourly Meso-Scale Model (MSM) meteorological forecasts with lead-times from 4 to 22 hours before occurrence of the peak river discharge. The forecasts were used as inputs into the calibrated CDRM model instead of the observed rainfall. On this way, reproducibility of river mouth hydrographs was analyzed using seven meteorological forecasts with various lead-times, which can similarly be used for future nowcasting.

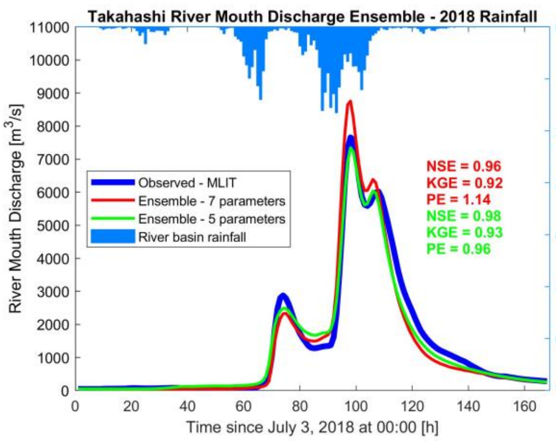

Figure 2. Takahashi River validation discharge results with the HRE18 rainfall expressed as mean ensembles of all six calibrated parameter sets with two methods (red: 7-CPM; green: 5-CPM) using observed rainfall.

Results and discussion

Projection and forecasting of the HRE18 river mouth hydrographs was conducted for all first-class rivers in Chugoku region of Japan but hereafter we present Takahashi River results for discussions. The six the most extreme recorded historical heavy rainfall events in terms of combination of 5-Day, 3-Day 2-Day and 1-Day rainfall amounts which have occurred in the Takahashi River basin and used for calibration of the CDRM model parameter sets are from September/October 2018, September 2013, July 2012, September 2011, July 2010 and July 2006. Figure 2 shows comparisons of our modelled results and observed data (MLIT) for the two methods when using observed rainfall, while Figures 3 (7-CPM) and 4 (5-CPM) show the same but when using seven MSM rainfall forecasts. We emphasize that accuracy metrics (NSE) of the river mouth hydrograph are very high when using observed rainfall (0.96 and 0.98 for 7-CPM and 5-CPM, respectively) whereas with forecasted rainfall the metrics are from 0.83-0.88 (7-CPM) and 0.79-0.95 (5-CPM) for forecasts of 4 to 16 hours before the peak discharge, which is in the satisfactory range of NSE (>0.7). With longer lead-times the accuracy becomes lower. Based on these results and discussions, we conclude that our

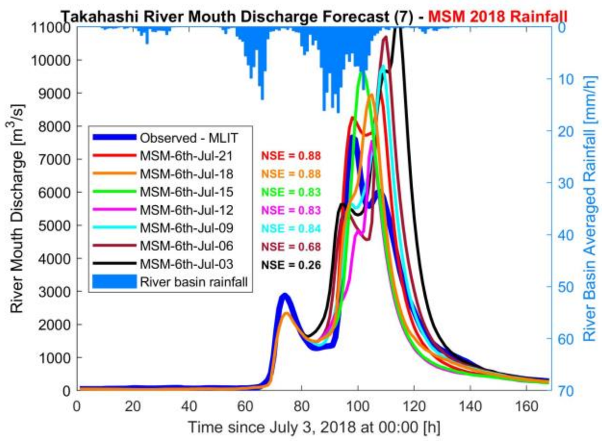

Figure 3. The same as Figure 2, but with the 7-CPM method using MSM forecasted rainfall.

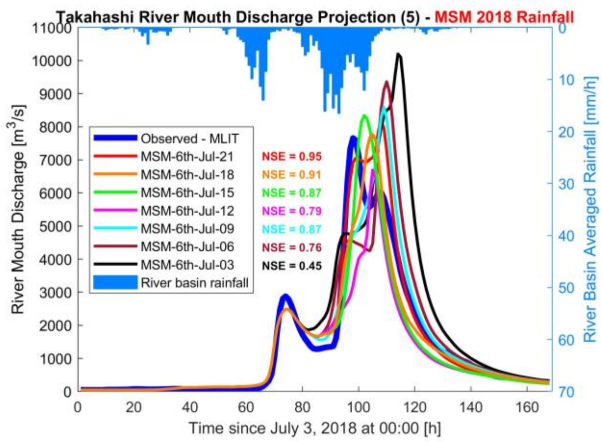

Figure 4. The same as Figure 2, but with the

5-CPM method using MSM forecasted rainfall.

proposed methodology can be used for accurate future hydrometeorological nowcasting of river discharge hydrographs in the region ahead of flash flood events.

Keywords: flash floods, CDRM, nowcasting, EWS

References

(1) Trošelj J., Lee HS. Modelling Typhoon-Induced Extreme River Discharges: A Case Study of Typhoon Hagibis in Japan, Journal of Hydrology: Regional Studies, In Press. Accepted 5 January 2021.

(2) Troselj J., Sayama T., Varlamov SM., Sasaki T., Racault M-F., Takara K., Miyazawa Y., Kuroki R., Yamagata T., Yamashiki Y. Modeling of extreme freshwater outflow from the north-eastern Japanese river basins to western Pacific Ocean, Journal of Hydrology, Vol. 555, pp. 956-970.