*Article*

# Enhancing a Real-Time Flash Flood Predictive Accuracy Approach for the Development of Early Warning Systems: Hydrological Ensemble Hindcasts and Parameterizations

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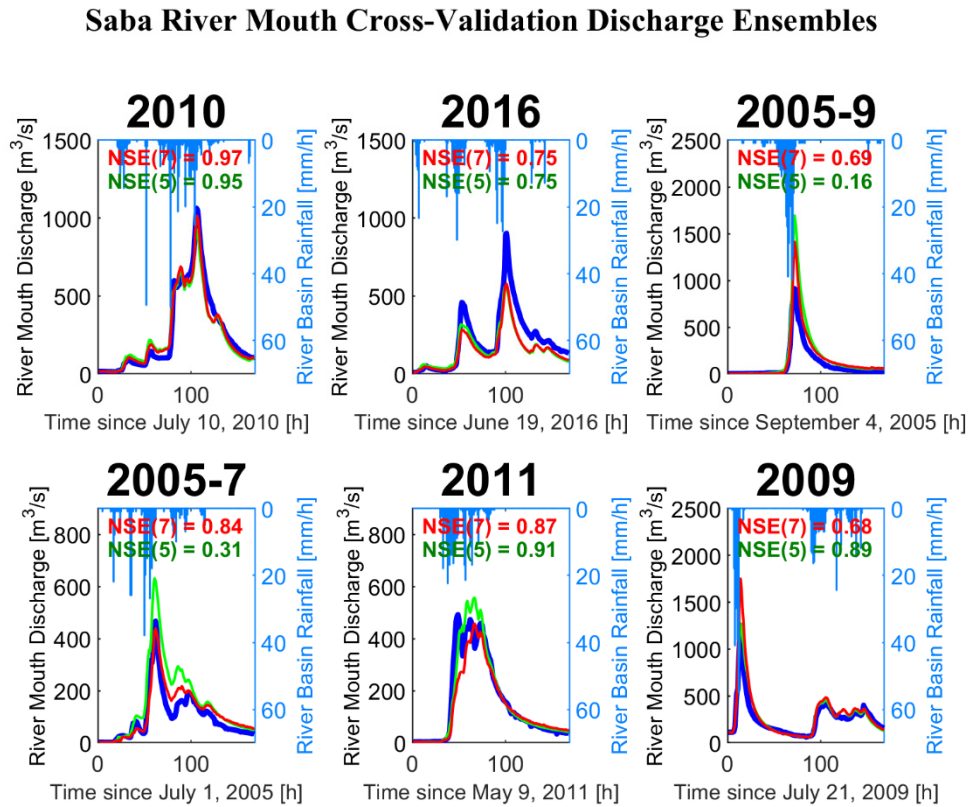
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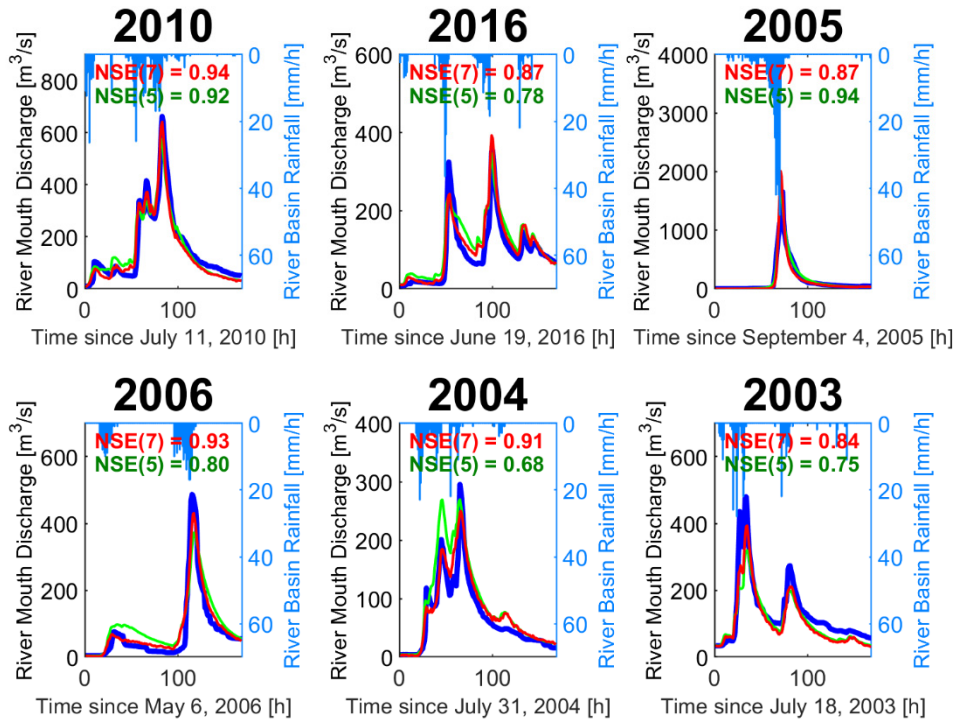
**Supplementary Material 2**

**Supplementary Figure S1** shows the Saba River ensemble average cross-validation discharge results for 6 historical events selected for calibration at Shimbashi station, located 8 km upstream from the river mouth, using the 7-CPM and 5-CPM parameter sets and rainfall data input from the 2010, 2016, 2005-9, 2005-7, 2011 and 2009 events compared with observed data.



**Supplementary Figure S1.** Saba River ensemble average cross-validation discharge results for 6 historical events selected for calibration when using the 7-CPM (red) and 5-CPM (green) compared with the observed river discharges (blue—60) at a site 8 km upstream from the river mouth.
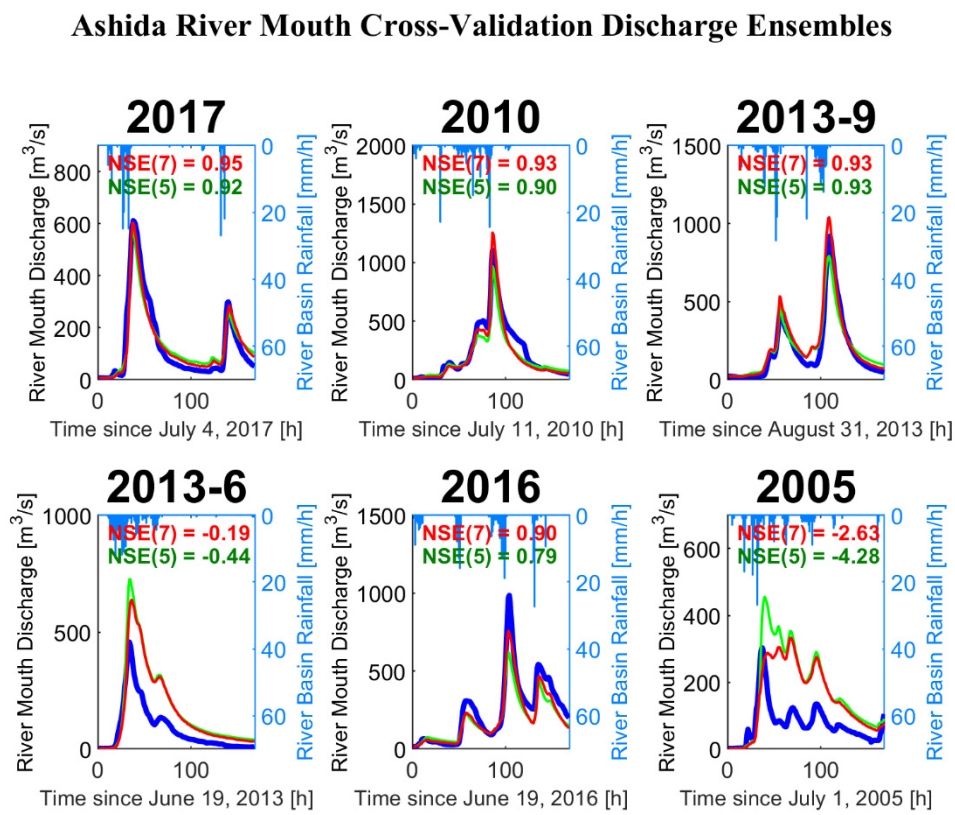
**Supplementary Figure S2** shows the Oze River ensemble average cross-validation discharge results for 6 historical events selected for calibration at Shimogahara station, located just upstream from Yasaka Lake, using the 7-CPM and 5-CPM sets with the HRE18 rainfall data and ensemble average validation of all 6 calibrated parameter sets with the 7-CPM and 5-CPM sets and rainfall data input from the 2010, 2016, 2005, 2006, 2004 and 2003 events compared with observed data. The Oze River has a flood control dam system at Yasaka Lake located less than 20 km upstream from the river mouth.



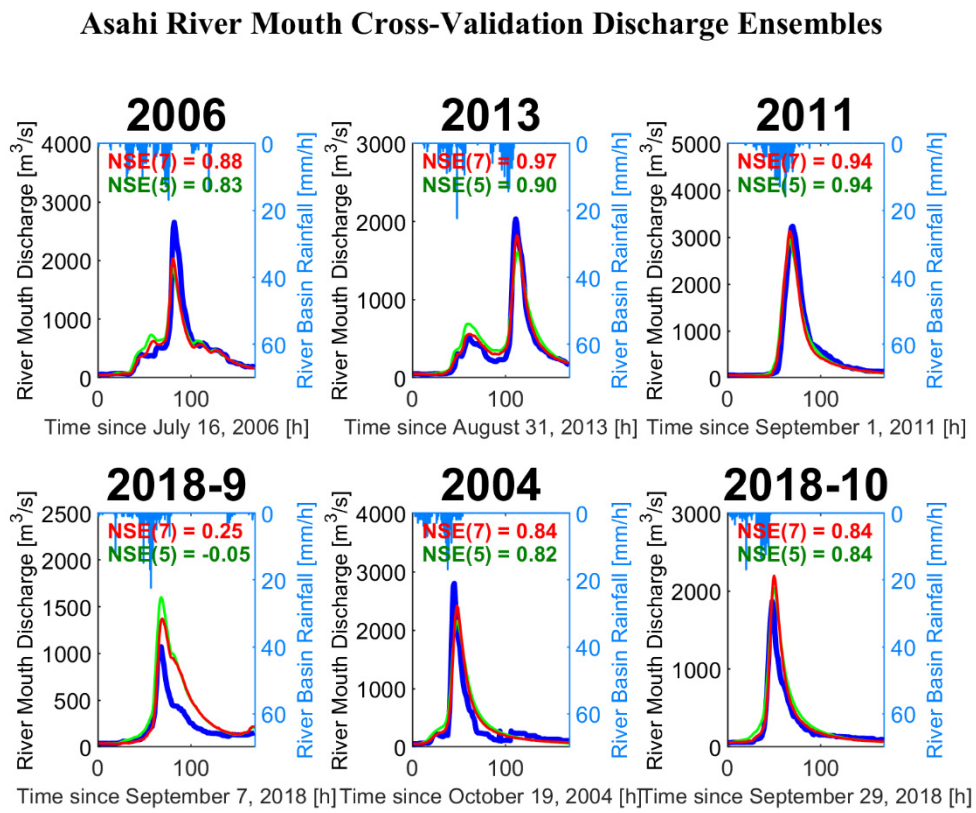**Oze River Mouth Cross-Validation Discharge Ensembles**

**Supplementary Figure S2.** Oze River ensemble average cross-validation discharge results for 6 historical events selected for calibration when using the 7-CPM (red) and 5-CPM (green) compared with the observed river discharges (blue—60) at a site located just upstream from Yasaka Lake.

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**Supplementary Figure S3** shows the Ashida River ensemble average cross-validation discharge results for 6 historical events selected for calibration at Yamate station, located 9.53 km upstream from the river mouth, using the 7-CPM and 5-CPM parameter sets and rainfall data input from the 2017, 2010, 2013-9, 2013-6, 2016 and 2005 events.



**Ashida River Mouth Cross-Validation Discharge Ensembles**

**Supplementary Figure S3.** Ashida River ensemble average cross-validation discharge results for 6 historical events selected for calibration when using the 7-CPM (red) and 5-CPM (green) compared with the observed river discharges (blue—60) at a site 9.53 km upstream from the river mouth.
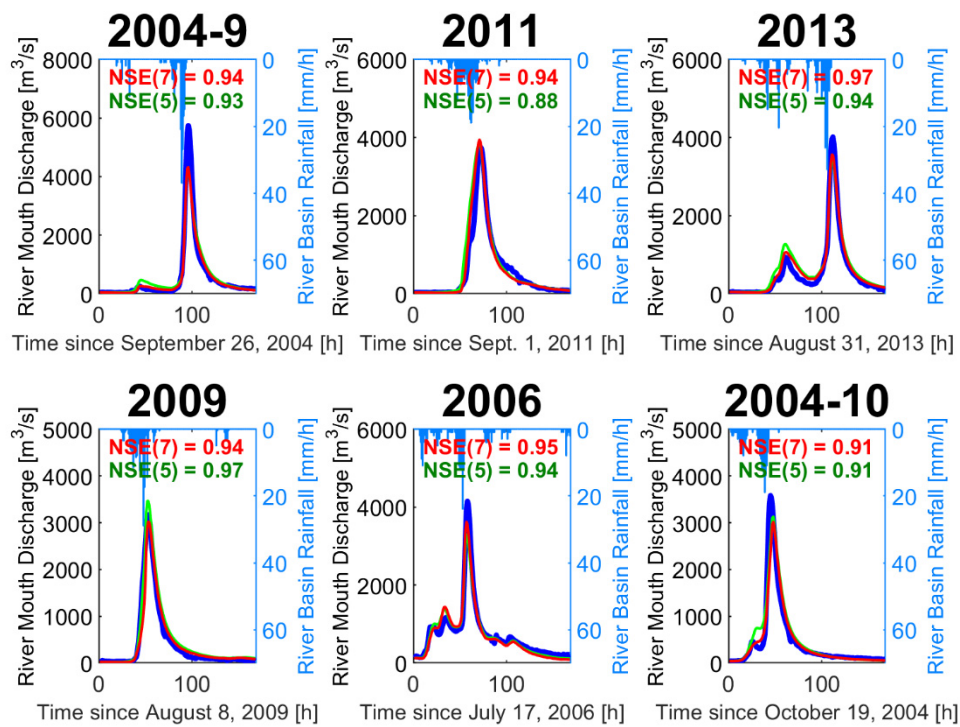
**Supplementary Figure S4** shows the Asahi River ensemble average cross-validation discharge results for 6 historical events selected for calibration at Makiyama station, located 20.4 km upstream from the river mouth, using the 7-CPM and 5-CPM parameter sets and rainfall data input from the 2006, 2013, 2011, 2018-9, 2004 and 2018-10 events.



**Asahi River Mouth Cross-Validation Discharge Ensembles**

**Supplementary Figure S4.** Asahi River ensemble average cross-validation discharge results for 6 historical events selected for calibration when using the 7-CPM (red) and 5-CPM (green) compared with the observed river discharges (blue—60) at a site 20.4 km upstream from the river mouth.

**Supplementary Figure S5** shows the Yoshii River ensemble average cross-validation discharge results for 6 historical events selected for calibration at Miyasu station, located 14.05 km upstream from the river mouth, using the 7-CPM and 5-CPM parameter sets and rainfall data input from the 2004-9, 2011, 2013, 2009, 2006 and 2004-10 events.

### Yoshii River Mouth Cross-Validation Discharge Ensembles



**Supplementary Figure S5.** Yoshii River ensemble average cross-validation discharge results for 6 historical events selected for calibration when using the 7-CPM (red) and 5-CPM (green) compared with the observed river discharges (blue—60) at a site 14.05 km upstream from the river mouth.