HYDRO-METEOROLOGICAL ANALYSIS OF EXTREME WEATHER IN INDONESIA USING COUPLED ATMOSPHERIC-HYDROLOGICAL MODEL

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INTRODUCTION

In recent years, hydro-meteorological hazard in the area involving coastlines has been dominated the disaster occurrence in Indonesia. In the last 10 years, the combination of the extreme weather and the environmental capacity degradation result in more flooding vulnerability. In 11-17 January 2021, heavy flood affected South Kalimantan, Indonesia, with causing many casualties. The flood characteristics was similar with the extreme flood in Jakarta in the preceding year in 2020, and more extreme floods occurred in the following year in 2022. Our goal is to analyze the extreme weather from the hydro-meteorological perspective and identify the key factor behind the high impact flood in South Kalimantan. Two factors, sea surface temperature (SST) and soil moisture (SM) content were highlighted and the sensitivity analysis was performed to identify their influence to the flood response at the time of the event.

METHODOLOGY

The coupled atmospheric model of Weather Research and Forecasting (WRF) and the hydrological model extension (WRF-Hydro) will be used to reconstruct the flood event. The WRF model allow us to capture the process of convective rain generation simulated by the meteorological model and the feedbacks to the land surface and sub-surface flow modelled with hydrological model of WRF-Hydro. Three nested domains of 27 km, 9 km and 3 km were utilized in the atmospheric model, while hydrological model used the higher resolution of 200 m.

RESULTS AND CONCLUSIONS

The flood event was observed to be coincide with La-Nina mode of ENSO (El Nino-Southern Oscillation) with the peak relative SST decrease around -1.77 ºC (Li, et al., 2022) in the Pacific Ocean and accompanied by warmer SST in the Indian Ocean. The SST anomaly around Indonesia region appeared to generate atmosphere instability and favorable condition to the convective storm cloud generation above the warmed ocean. The hypothesis was also consistent with the WRF simulation result that the rainfall initially generated above the coastal waters in the western and southern part of Kalimantan around Java Sea. Thus, the convective cloud continuously accumulated from 11 January to 15 January resulting high anomaly rainfall compared to past historical rainfall event. Subsequently, the soil moisture content appeared to show higher than normal at the same period.

The flood response to the SST and SM content will be compared by removing the anomaly in each SST and SM. Result showed that although removing the anomaly of SST may decrease the rainfall generation above the warmed ocean (Fig 1b), runoff generation are similar to that existing condition (Fig 2). On the other hand, reducing the soil moisture content significantly reduce the runoff generation despite of anomaly rainfall occured. This phenomenon indicated that the runoff mainly generated from the saturated flow and infiltration excess. Thus, even the moderate rainfall occurrence may induce the high runoff from the infiltration excess and ground water outflow due to the high soil moisture content. Additionally, the high runoff is also coexisted with high tidal spring although the tidal range is quite insignificant.

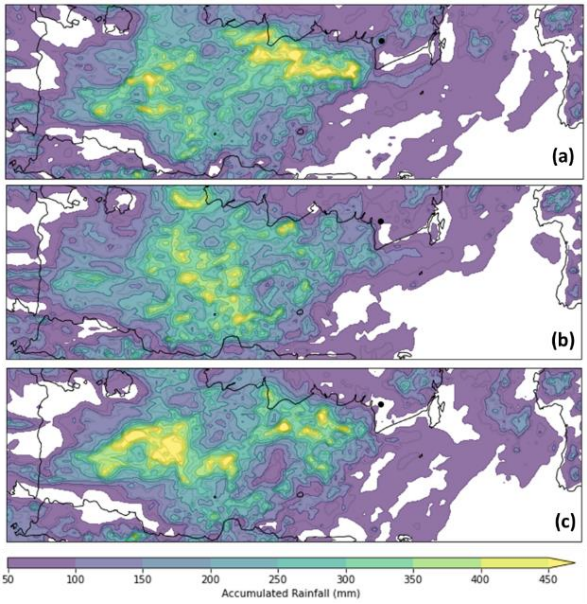

Figure 1 - The accumulated rainfall generation on 15 January 2021 for: (a) Control; (b) SST and (c) SM scenarios.

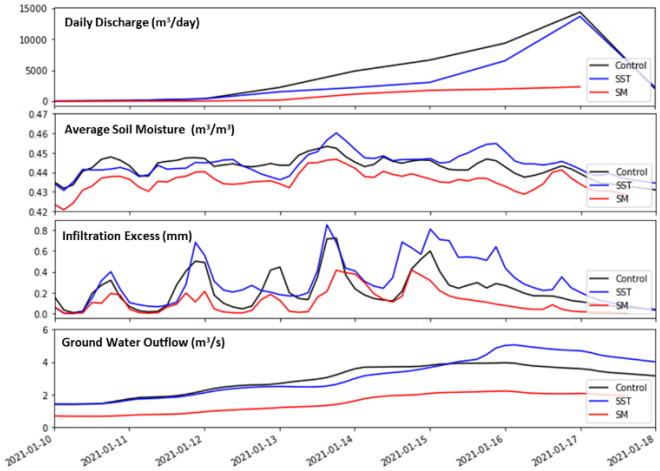

Figure 2 - Flood response to surface and sub-surface flows compared for control, SST and SM scenarios.

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