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Analyzing Uncertainty in Probable Maximum Precipitation Estimation using the Moisture Maximization Method

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Abstract

Large-scale hydraulic structures, such as dams, levees, and nuclear plants, are designed based on the probable maximum precipitation (PMP) to safely prevent failure due to inundation and overtopping in extreme flooding events. PMP is one of the most important key indices in hydrological design. This study aimed to evaluate a PMP estimation approach using a moisture-maximization method. This method enables the estimation of precipitable water (PW) using a surface dew point, under a pseudoadiabatic assumption. However, the deviation of the PW (as estimated using the surface dew point) from the actual observed PW mostly leads to an uncertain PMP estimation, as it is difficult to estimate the actual atmospheric moisture content in an air column using the surface dew point alone. In this study, to consider abundant atmospheric data spanning a long-term period, we employed the reanalysis data from "Japanese 55-year Reanalysis" (JRA-55). The data showed good reliability for the surface dew point and PW. To quantify the deviation, we estimated the errors between the actual and estimated PW values for the moisture-maximization method at 30 points across Japan. Here, the actual PW was extracted directly from JRA-55, and the estimated PW was obtained using the surface dew point extracted from JRA-55. We confirmed that the event PW was the largest source of error in the PMP estimation and that the magnitude of the errors was highly correlated with the surface dew point. We analyzed the vertical dew point profile for events with large estimation errors and confirmed that a low surface dew point showed a high deviation in the air column. Therefore, the use of PMP estimations with the moisture-maximization method should be carefully considered in rainfall events with low surface dew points (e.g., lower than 18 °C).