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Characteristics-based analysis of the hyperconcentrated peak discharge increase in the Yellow River

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Hyperconcentrated peak discharge increase often occurs in the lower Yellow River (China) aggregating the flood risk along the course. Though a few work has been done to explain this phenomenon individually, no consensus has been achieved and the similarities and differences of the underlying physics among different increasing discharge events remain unknown. Based on the concept that flood wave is a kind of disturbance whose propagation can be described by the characteristic theory, we therefore derive a compatibility equation for flow discharge along the characteristics based on the cross sectional-averaged equations of sediment-laden flow. The critical parameters for the local discharge calculation consist of the up-and down-stream discharge and sediment concentration, the cross-sectional flow area and the time scale of flood wave propagation. By applying this equation to the 18 increasing peak discharge events in the lower Yellow River over the last five decades, we aim to uncover the mechanisms of such events in a uniform way and find out their similarities and differences. The results illustrate that the most and second dominant factors for the increasing peak discharge are the temporal accumulative effect of external forces and the spatial variation of pressure energy respectively whereas the discharge increase is suppressed by the imbalanced convection. The combination of increasing upstream discharge and local flow area or that of increasing discharge and decreasing sediment concentration at the upstream may be efficient for the reduction of local discharge increase. Despite the increasing upstream discharge may raise the flood risk, there remains an opportunity to balance the prevention of discharge increase and the occurrence of floodplain inundation. All the findings could provide scientific bases for a better river regulation in the lower Yellow River.