IAHS2017-136
IAHS Scientific Assembly 2017
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How to assess the cumulative impacts of reservoir operation on hydrological regime

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Rivers provide numerous goods and services for humankind, including a source of water for domestic, industrial and agricultural purposes, a means of power generation and waste disposal, routes for navigation, and sites for recreation and spiritual activities. However, 60% of the world's rivers are fragmented by hydrologic alterations, with 46% of the 106 primary watersheds having been modified by the presence of large dams. The Yangtze River is one of the most important rivers in the world. Hydrological processes of the Yangtze River have been greatly changed since the end of the 20th Century due to extensive human activities. The problems of potential effects of the different climatological conditions during the two periods on flow regime are not addressed. Moreover, little is known about the flow regime changes caused by reservoir operation since 2009 in which the Three Gorges Dam (TGD) was completed. Therefore, the objectives of this study are: (1) to present a framework to assess the impacts of dam on hydrological regime; (2) to investigate the flow regime changes in the Yangtze River using the updated daily discharges and (3) to analyze the possible causes behind changes in the flow changes and the possible ecological implications in downstream reaches. We reconstructed the unregulated flow series to compare with the regulated flow series in the same period (2003 to 2013). Eco-surplus and eco-deficit and the Indicators of Hydrologic Alteration parameters were used to examine the hydrological regime change. Among 32 IHA parameters, Wilcoxon signed-rank test and Principal Components Analysis identified the October median flow, 1 and 3-days maximum flows, 1-day minimum flow, and high pulse duration as the representative indicators of hydrological alterations. Eco-surplus and eco-deficit showed that the reservoir also changed the seasonal regime of the flows, with the reduction in autumn flow and increase in winter flow. Annual extreme flows and October flows changes lead to negative ecological implications downstream from the TGD. Ecological operation for the Three Gorges Dam is necessary to mitigate the negative effects on the river ecosystem in the middle reach of Yangtze River. We hope the results of this study will be greatly beneficial to river management and restoration of eco- system in the Yangtze River characterized by intensified dam construction.