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Estimating the characteristics of extreme rainfall events using a suitable precipitation product in the Garhwal Himalaya in India

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High intensity rainfall events during monsoon season causes huge damage to local people and economy in the Indian Himalaya. It is however, difficult to accurately estimate the magnitude and spatio-temporal variability of extreme rainfall because of the sparse and limited network of ground stations located within complex terrain of the Indian Himalaya, as well as the difficulty of maintaining the stations over time. Thus, secondary rainfall sources are important to hydrological and hazard studies, if they reproduce the dynamics of extreme rainfall satisfactorily. In this work, we evaluate four secondary products in the Garhwal Himalaya in India to estimate extreme rainfall, with a particular focus on the Mandakini Catchment, the site of devastating flood in 2013. The analysis included two satellite products: the TRMM and the PERSIANN, as well as two gridded products: the APHRODITE product and the IMD product. In comparing the four products against data collected at four ground stations, we determined that the IMD and TRMM products were superior to the others in detecting daily maximum monsoon rainfall. Additionally, the IMD product could document the daily extreme rainfall distribution during the June 2013 flood in the Mandakini Catchment and adjoining places better than the TRMM product. Based on these results, we selected the IMD gridded dataset with daily rainfall data from 1901 to 2013 to document the occurrence of extreme monsoon rainfall events in the Mandakini Catchment in the last century. We define extreme monsoon rainfall threshold as the 99th percentile of time series of rainfall values, and rainfall depth greater than 99th percentile is considered as extreme rainfall. The results show that extreme monsoon rainfall events occurred for 22 years out of 113 years of available data. The extreme events have increased since 2010 in the Mandakini Catchment including 4 events in 2010, 1 event in 2011, 2 events in 2012 and 3 events in 2013. Before 2010, two extreme events occurred in 1921, 3 events in 1924, and the rest of the extreme years had one extreme event each year. Further, the gap between extreme years from 1901 to 1925 ranged from 1 to 5 years, no extreme event occurred till 1948, from 1948 to 1983 extreme events occurred in intervals of more than a decade, from 1983 to 2005 the gap ranged from 1 to 9 years, and extreme events are occurring each year since 2010. The analysis also show that majority of the extreme rainfall events since 1901 have occurred towards the end of the monsoon season during August and September. Collectively, we observe an increase in the occurrence of extreme events in the Mandakini Catchment, which was recently hit by a large flood in 2013. Under the scenario of increasing extreme events, a huge disaster could happen in the future and could become more disastrous because of increasing population and rising infrastructure in the Mandakini Catchment and the Indian Himalaya.