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Relative importance of precipitation frequency and intensity in inter-annual variation of precipitation in Singapore during 1980-2013

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Observed studies on inter-annual variation of precipitation provide insight into the response of precipitation to anthropogenic climate change and natural climate variability. Inter-annual variation of precipitation results from the concurrent variations of precipitation frequency and intensity, understanding of the relative importance of frequency and intensity in the variability of precipitation can help fathom its changing properties. Investigation of the long-term changes of precipitation schemes has been extensively carried out in many regions across the world, however, detailed studies of the relative importance of precipitation frequency and intensity in inter-annual variation of precipitation are still limited, especially in the tropics. Therefore, this study presents a comprehensive framework to investigate the inter-annual variation of precipitation and the dominance of precipitation frequency and intensity in a tropical urban city-state, Singapore, based on long-term (1980-2013) daily precipitation series from 22 rain gauges. First, an iterative Mann-Kendall trend test method is applied to detect long-term trends in precipitation total, frequency and intensity at both annual and seasonal time scales. Then, the relative importance of precipitation frequency and intensity in inducing the inter-annual variation of wet-day precipitation total is analyzed using a dominance analysis method based on linear regression. The results show statistically significant upward trends in wet-day precipitation total, frequency and intensity at annual time scale, however, these trends are not evident during the monsoon seasons. The inter-annual variation of wet-day precipitation is mainly dominated by precipitation intensity for most of the stations at annual time scale and during the Northeast monsoon season. However, during the Southwest monsoon season, the inter-annual variation of wet-day precipitation is mainly dominated by precipitation frequency. These results have implications for water resources management practices in Singapore.