Geophysical Research Abstracts
Vol. 17, EGU2015-5661, 2015
EGU General Assembly 2015

Quantifying the contribution of land use and climate change to stream flow alteration in tropical catchments

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A new approach is introduced to measure the quantitative contribution of land use and climate change to stream flow alteration based on the changes in the proportion of excess water relative to changes in the proportion of excess energy. The quantitative contribution is estimated based on three measures: (1) the resultant length (R) which indicates the magnitude of the changes in the proportion of excess water and energy with a higher resultant indicating a higher magnitude; (2) the slope of change (θ in arc degree) which indicates the magnitude of the contribution of land use and climate changes with a higher slope reflecting a higher contribution of climate change; and (3) the relative contribution of land use and climate changes to stream flow alteration (C in %). In this study, we applied our approach to five catchments (Pidekso, Keduang, Samin, Madiun and Kening) ranging in size from 234 to 3759 km2 on Java, Indonesia. The hydro-climatic data cover the period 1975 - 2012 and the land use maps acquired from multi-temporal satellite imageries (i.e. for the years 1972, 1994, 2002 and 2013) were used and analyzed. The approach consists of four steps: (1) performing abrupt change detection on annual stream flow using Pettitt's test; (2) calculating the proportion of excess water and the proportion of excess energy for the period before and after the abrupt change of the stream flow; (3) calculating the quantitative contribution of land use and climate change to stream flow changes; (4) comparing the results with the Mann-Kendall trend analysis of variability in precipitation and potential evapotranspiration, and the land use change analysis. The results show that all catchments have a simultaneous increase of the proportion of excess water and energy for the period after the abrupt change compared to the period before the abrupt change. The Samin catchment gives the highest R value with a value of 0.9 followed by Pidekso catchment (0.7), Keduang catchment (0.6), Madiun catchment (0.4) and Kening catchment (0.1). The highest θ value occurred in the Kening catchment with a value of 58.9 followed by Pidekso catchment (7.8), Samin catchment (7.6), Madiun catchment (3.1) and Keduang catchment (0.15). The quantitative contribution of land use change to stream flow alteration is 99.7% for the Keduang catchment followed by Madiun catchment (95.0%), Samin catchment (88.2%), Pidekso catchment (88.0%) and Kening catchment (37.6%). The results are in line with the results of the Mann-Kendall trend analysis for climate variability, where the precipitation has significantly changed only for Keduang (a positive trend) and Samin catchment (a negative trend) and the potential evapotranspiration has not significantly changed for all catchments. On the other hand, land use has significantly changed for all catchments particularly during the period 1994 – 2002 when the abrupt changes in stream flow were also found. We conclude that land use change has a more dominant contribution to changes in annual stream flow than climate change for the study catchments except in the Kening catchment.