Geophysical Research Abstracts
Vol. 21, EGU2019-10222, 2019
EGU General Assembly 2019

Separating effects of rainfall variability and typhoon disturbance on the runoff response of a tropical 'reforest' using a data-based mechanistic modeling approach

Jun Zhang (1,2), Wlodzimierz (Wlodek) Tych (3), Nick A Chappell (3), H.J. (Ilja) van Meerveld (4), L. Adrian (Sampurno) Bruijnzeel (5,6)

(1) Faculty of Science, VU University Amsterdam, Amsterdam, Netherlands (j.zhang@vu.nl), (2) College of Hydrology and Water Resources, Hohai University, Nanjing, P.R.China (jzg290@outlook.com), (3) Lancaster Environment Centre, Lancaster University, Lancaster, United Kingdom (w.tych@lancaster.ac.uk; n.chappell@lancaster.ac.uk), (4) Department of Geography, University of Zurich, Zurich, Switzerland (ilja.vanmeerveld@geo.uzh.ch), (5) King's College London, London, United Kingdom (sampurno.bruijnzeel@kcl.ac.uk), (6) Tropical Forests and People Research Centre, University of the Sunshine Coast, Maroochydore, Australia (sampurno.bruijnzeel@kcl.ac.uk)

Global oceanic warming increases the frequency of especially the stronger categories of tropical cyclones. This, in turn, may greatly increase the runoff response of forested tropical catchments due to the wetter (and therefore more responsive) soil conditions typically associated with a (temporarily) defoliated canopy after cyclone passage. The Philippines is located in one of the world's premier tropical cyclone-generating areas and about 30% of the annual precipitation is received during the passage of tropical cyclones (typhoons) and depressions. We instrumented the 8.75 ha reforested Manobo headwater catchment near Tacloban (Leyte Island, Philippines) in June 2013 to monitor rainfall inputs, streamflow outputs, plus mid-slope soil water- and foot-slope groundwater dynamics on a 5-minute basis over a full seasonal cycle. Leaf Area Index (LAI) was also measured at approximately weekly intervals. This broad set of finely sampled multivariable measurements over a full seasonal cycle allowed identification of the main dynamic characteristics of the catchment's behaviour and changes therein over time.

The study area was struck by super-typhoon Haiyan on 8 November 2013, causing major damage to the forest and an initial reduction in LAI from an average pre-typhoon value of 5.1±0.65 to 2.9±0.9 four weeks after typhoon passage. LAI recovered more or less to pre-disturbance values by early March 2014 (i.e. four months after Haiyan). Trends in rainfall interception losses (I) followed those in LAI, with average values of 18% (I/P) before disturbance, 12% during the period of maximum defoliation, and 17.5% after re-foliation.

Overall pre- and post-typhoon quickflow runoff coefficients (Qq/P) were 16% and 44%, but pre-Haiyan values of Qq/P increased with rainfall size class from 0.2±0.1% for small storms (5–10 mm of rain) to 11–19% for intermediate storms (20–50 mm) up to 55% for a very large event (tropical storm Rumbia, 174 mm). Pertinently, corresponding post-Haiyan values of Qq/P were 2–3 times larger for events up to 100 mm.

To investigate whether the observed increase in post-typhoon runoff response was due to lower evapotranspiration, higher rainfall, or both, changes in the rainfall-to-runoff transformation over time were quantified using the data-based mechanistic (DBM) approach to modeling. DBM, in this case using basic non-linear rainfall-runoff transfer functions, allows to largely deconvolve the effects of rainfall pattern from catchment characteristics, thereby helping to identify possible changes in the dominant processes before and after typhoon disturbance, including potential defoliation effects. The rainfall- to runoff transformation for pre-disturbance conditions was described best by a first-order dynamic model, but that after passage of Haiyan by a third-order model (implying three dynamic flow components ranging from slow to fast and instantaneous – the latter likely being foot-slope saturation overland flow), both during the largely defoliated period and after recovery of LAI. Amounts of quickflow were not related to variations in mid-slope soil water storage (0–110 cm), but exhibited a strong correlation with foot-slope groundwater dynamics. The results suggest catchment response at Manobo is governed mostly by foot-slope groundwater levels that are, in turn, determined primarily by rainfall inputs.