Geophysical Research Abstracts
Vol. 18, EGU2016-8440, 2016
EGU General Assembly 2016

The Evolution of Root Zone Storage Capacity after Land Use Change

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Root zone storage capacity forms a crucial parameter in ecosystem functioning as it is the key parameter that determines the partitioning between runoff and transpiration. There is increasing evidence from several case studies for specific plants that vegetation adapts to the critical situation of droughts. For example, trees will, on the long term, try to improve their internal hydraulic conductivity after droughts, for example by allocating more biomass for roots.
In spite of this understanding, the water storage capacity in the root zone is often treated as constant in hydrological models. In this study, it was hypothesized that root zone storage capacities are altered by deforestation and the regrowth of the ecosystem. Three deforested sub catchments as well as not affected, nearby control catchments of the experimental forests of HJ Andrews and Hubbard Brook were selected for this purpose. Root zone storage capacities were on the one hand estimated by a climate-based approach similar to Gao et al. (2014), making use of simple water balance considerations to determine the evaporative demand of the system. In this way, the maximum deficit between evaporative demand and precipitation allows a robust estimation of the root zone storage capacity. On the other hand, three conceptual hydrological models (FLEX, HYPE, HYMOD) were calibrated in a moving window approach for all catchments. The obtained model parameter values representing the root zone storage capacities of the individual catchments for each moving window period were then compared to the estimates derived from climate data for the same periods.

Model- and climate-derived estimates of root zone storage capacities both showed a similar evolution. In the deforested catchments, considerable reductions of the root zone storage capacities, compared to the pre-treatment situation and control catchments, were observed. In addition, the years after forest clearing were characterized by a gradual recovery of the root zone storage capacities, converging to new equilibrium conditions and linked to forest regrowth. Further trend analysis suggested a relatively quick hydrological recovery between 5 and 15 years in the study catchments. The results lend evidence to the role of both, climate and vegetation dynamics for the development of root zone systems and their controlling influence on hydrological response dynamics.