Geophysical Research Abstracts
Vol. 14, EGU2012-7826, 2012
EGU General Assembly 2012

Well-controlled experimentation in artificial catchments as the key to better understand natural hydrologic systems?

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Catchments are open dynamic systems that process mass and momentum, and drive energy and entropy towards an equilibrium state of development. The formulation of equations to explain these systems results in a number of redundant variables for which constitutive relationships are required at the scale of integration. This so called "closure problem" exists due to the generally unknown relationship between hydrologic state variables and fluxes. Traditionally, we deal with two complementary approaches in hydrological research: i) experimental catchment studies and ii) physically-based hydrological modelling. The unique character of each catchment and of its eco-hydrological processes often does not allow conclusions by analogy, which would require similarity and homogeneity of catchment features. Generalised theories to cope with both the closure problem and the singularity of catchments in hydrological research have not been derived so far, and the modelling of flow processes in catchments is still impeded e. g. by scale incompatibilities of involved parameters.
One of the main questions addressed in our contribution is: How much improvement in hydrological research is possible by well-controlled experimentation fields as artificially created catchments? The definition of parameters and boundary conditions in such well-controlled experiments allows for an improvement in observation strategies and therefore a systematic learning from observed data and an enhanced understanding of the interrelation of given structures and process triggers. Also, the conditions for targeted testing of hydrological hypotheses are considered to be the best possible. In our contribution we identify examples for the determination of such processes and their description e.g. for water transport in the soil matrix, structure and dynamics of sedimentation as well as erosion in the artificial catchment Chicken Creek, Lusatia, Germany. We also show that there are still challenging aspects even in well-controlled experiments, e.g. when dealing with non-equilibrium conditions and related threshold phenomena.