Geophysical Research Abstracts
Vol. 13, EGU2011-5947-1, 2011
EGU General Assembly 2011

Semi-distributed rainfall rates inferred from discharge observation networks

Robert Krier (1,2), Patrick Matgen (1), Klaus Görgen (1), Laurent Pfister (1), Lucien Hoffmann (1), Stefan Uhlenbrook (2,3), Hubert Savenije (2), James Kirchner (4,5,6)

(1) CRP Gabriel Lippmann, Environnement et Agro-biotechnologies (EVA), Luxembourg (rkrier@lippmann.lu), (2) Water Resources Section, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, The Netherlands, (3) Department of Water Engineering, UNESCO-IHE, Delft, The Netherlands, (4) Department of Environmental Sciences, Swiss Federal Institute of Technology, ETH Zurich, Switzerland., (5) Department of Earth and Planetary Science, University of California, Berkeley, USA, (6) Swiss Federal Institute for Forest, Snow, and Landscape Research WSL, Birmensdorf, Switzerland.

The high spatial and temporal uncertainties that are inherent to the measurements of catchment precipitation have a large impact on hydrological simulations. Quantitative precipitation estimates remain a major challenge, especially for small-scale heavy rainfall events for which such forecasts are most urgently needed due to the risk of rapid hydrological responses. Hence, there is still a need for developing new ways of directly or indirectly determining incoming rainfall and its spatial and temporal variability. In this context Kirchner [2009] recently advocated a new approach for inferring rainfall and evaporation from discharge fluctuations by "doing hydrology backwards". This approach is essentially based on the assumption that catchment behaviour can be conceptualized with a single storage-discharge relationship.

Our work is based on Kirchner's study by testing an alternative and yet complementary way for inferring semi-distributed rainfall estimates by using an operational discharge measurement network. The main objectives are:
1) to extend Kirchner's [2009] methodology by including a threshold parameter based on soil moisture measurements. Our fundamental working hypothesis is that we expect catchments to behave as simple dynamical systems with unambiguous storage-discharge relationships only if critical soil moisture thresholds are exceeded. We use measurements of the soil wetness index (SWI) as a proxy for the catchment storage status. We validate the inferred rainfall rates against spatially distributed weather radar data instead of rain gauge point measurements;
2) to evaluate the potential of Kirchner's method for inferring semi-distributed precipitation fields using streamflow fluctuations extracted from an operational hydrological measurement network. We calculated catchment rainfall time series of 24 nested subbasins to generate a semi-distributed catchment rainfall data set in our study area; and
3) to discuss the potential of the approach for assessing and diagnosing the functioning of hydrological systems.

The test area for this study is the mesoscale Alzette catchment (1253 km2) in the Grand-Duchy of Luxembourg. The dense networks of rain gauges, discharge measurements and the presence of weather radar, on the one hand, and a very diverse lithology, on the other hand, provide ideal testing conditions for the purposes of this work.
Our study showed that the approach could clearly be extended by taking a soil wetness index threshold into account. In almost all subbasins Kirchner's sensitivity function g(Q) expressing the sensitivity of discharge to changes in storage becomes markedly better as tool for inferring catchment-scale precipitation rates. Our investigations show that it is possible to generate a distributed rainfall data set by applying Kirchner's 'hydrology backwards' model to different nested subcatchments.

Kirchner, J.W. (2009), Catchments as simple dynamical systems: Catchment characterization, rainfall-runoff modeling, and doing hydrology backward, Water Resour. Res. 45, doi:10.1029/2008WR006912