Geophysical Research Abstracts
Vol. 18, EGU2016-12369, 2016
EGU General Assembly 2016

On the trail of double peak hydrographs

Núria Martínez-Carreras (1), Christophe Hissler (1), Laurent Gourdol (1), Julian Klaus (1), Jérôme Juilleret (1), Jean François Iffly (1), Jeffrey J. McDonnell (2,3), and Laurent Pfister (1)

(1) Luxembourg Institute of Science and Technology, Department 'Environmental Research and Innovation' (ERIN), Belvaux, LUXEMBOURG (Email: nuria.martinez@list.lu), (2) Global Institute for Water Security, University of Saskatchewan, Saskatoon, CANADA, (3) School of Geosciences, University of Aberdeen, Aberdeen, Scotland, UK

A double peak hydrograph features two peaks as a response to a unique rainfall pulse. The first peak occurs at the same time or shortly after the precipitation has started and it corresponds to a fast catchment response to precipitation. The delayed peak normally starts during the recession of the first peak, when the precipitation has already ceased. Double peak hydrographs may occur for various reasons. They can occur (i) in large catchments when lag times in tributary responses are large, (ii) in urban catchments where the first peak is often caused by direct surface runoff on impervious land cover, and the delayed peak to slower subsurface flow, and (iii) in non-urban catchments, where the first and the delayed discharge peaks are explained by different runoff mechanisms (e.g. overland flow, subsurface flow and/or deep groundwater flow) that have different response times. Here we focus on the third case, as a formal description of the different hydrological mechanisms explaining these complex hydrological dynamics across catchments with diverse physiographic characteristics is still needed. Based on a review of studies documenting double peak events we have established a formal classification of catchments presenting double peak events based on their regolith structure (geological substratum and/or its weathered products). We describe the different hydrological mechanisms that trigger these complex hydrological dynamics across each catchment type. We then use hydrometric time series of precipitation, runoff, soil moisture and groundwater levels collected in the Weierbach (0.46 km^2) headwater catchment (Luxembourg) to better understand double peak hydrograph generation. Specifically, we aim to find out (1) if the generation of a double peak hydrograph is a threshold process, (2) if the hysteretic relationships between storage and discharge are consistent during single and double peak hydrographs, and (3) if different functional landscape units (the hillslopes and the plateau) equally contribute to the generation of delayed peaks in double peak hydrographs. We found evidence of catchment storage being a dominant control on the delayed peak activation. The amount of this storage threshold was consistent over a 3-year period. Hillslopes were connected to the stream at low discharge values, whereas the plateau contribution to discharge was significant when storage reached a certain threshold value. The latter seems to trigger the generation of the delayed peak in the double peak events. We also observed a non-linear relationship between storage and discharge, which leads to hysteretic relationships between both variables. During single peak hydrographs and first peaks in double peak hydrographs discharge increases faster and peaks before catchment storage, resulting in counter-clockwise hysteretic loops. This was explained by the fact that these runoff peaks are generated by precipitation falling directly into the stream or near stream locations, and/or by the contribution of water flowing through preferential flowpaths that quickly reached the stream network. When catchment storage exceeded the threshold for the generation of double peak hydrographs, events showed clockwise hysteretic loops. It is the stored water in the catchment that will peak first and consequently generate the delayed peak in the hydrograph as a result of the capacity exceedance of a subsurface storage.