Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2020-229-RC1, 2020

Hydrology and Earth System Sciences
Discussions

Interactive comment on "Impact of karst areas on runoff generation, lateral flow and interbasin groundwater flow at the storm-event timescale" *by* Martin Le Mesnil et al.

Anonymous Referee #1

Received and published: 19 July 2020

The study analyzed stream flow observations at 108 gages in three regions with varying karst area, focusing on event-scale hydrologic response to 20 large storm events. Using 15 descriptors on catchment water balance, hydrograph shape, and difference between an upstream and downstream gage, the study compared the catchment response in karst (K), middle (M) and non-karst (NK) catchments. It is concluded that (1) karst promotes high infiltration but (2) slows down flood response (both rising and falling limb), and the latter behavior is attributed to inter-basin groundwater flow (IGF).

I find the study valuable in that it selected a wide range of catchments under different climatic and geologic conditions, and that it focused on event time-scale response

Printer-friendly version

Discussion paper

of catchment runoff underlain by karst geology. However, the manuscript can benefit significantly from a clearer and sounder conceptual model, better framing of the questions (what we know and don't know) and the hypotheses to be tested with this particular dataset, how the results speak for or against the hypotheses posed, and a better overall presentation, as expanded below.

First, there are some conceptually ambiguities.

(a) My understanding is that groundwater flow, particularly trans-catchment groundwater flow, or inter-basin flow (IBF), does not follow surface drainage structure in karst terrain as depicted in Figure 1. We cannot delineate groundwater basins based on surface topography, a well-known problem in karst terrain. Figure 1 depicts the IBF as completely defined by, and in parallel with the surface drainage gradient. While this may be fine for unconsolidated materials without strong geologic structure, it is hardly the case for karst terrain, where the extensive underground conduit networks do not follow the topography. The authors' finding that the strongest lateral inflow is in intermediate catchments in NK, that is, there is more IBF in non-karst areas, is counter intuitive and confusing, and points to this conceptual flaw. The reason may well be that in NK areas the surface and subsurface drainage system are more aligned, and such an assumption is more valid, allowing the detection of IBG inflow. The authors need to clarify and justify this assumption, because it also underlies the methodology used in the study, with the analyses entirely based on streamflow.

(b) The methodology infers IBF into and out of a catchment by comparing the inflow QI and outflow Qo of a stream reach (Fig 1). The authors need to clarify to what extend one can infer IGFs from streamflow alone. The difference reflects inflow from local precipitation falling on its topographic catchment and subsequent infiltration and surface and subsurface runoff (local source), the inflow from upstream catchments via IBF (remote source), minus the loss to local aquifers (local sink, recharging local aquifers, increasing groundwater storage) which may or may not leave the catchment via IBF (remote sink). But without an explicit aquifer water balance to track all the terms during

Printer-friendly version

Discussion paper

the events, it is difficult to separate these terms. To arrive at quantitative results, the authors need to explicitly quantify these terms, incorporating aquifer water level observations, spring discharges. The diffusive wave model for surface water propagation appears to be an over-kill in comparison to a complete lack of first-order water balance in the subsurface.

Second, the authors should provide a more thorough literature review, discuss what we know and do not know in terms of event-scale catchment runoff generation in karst terrain, and pose a set of testable hypotheses. For example, it is expected that in karst area, infiltration is high, and storm flow is flashy due to the open conduits in the subsurface, but after a threshold when the groundwater builds up to the spring overflow point. Then as the results are opposite (slow hydrograph response), one can reason why this hypothesis must be rejected. For another example, one can hypothesize that in karst catchments, streamflow can be lower or higher than expected from calculations based on infiltration over the surface catchment area alone (local source), or there is mass imbalance, and thus IGF must be invoked. Then the analyses can be targeted to test these hypotheses, and the results discussed with clarity surrounding these hypotheses.

Third, in addition to the above, a few other things can be done to reduce the length, enhance focus, clarify terminology and make it easier for readers to follow the central theme and take-home messages.

(a) Move “Section 3 The Study Area” to before “Section 2 Methodology”

(b) List all variables in a table with definitions. It is hard to remember the 10s of mathematical symbols mentioned later – one has to go back and find their definitions.

(c) In presenting results, please use plain English of the meaning of the variable, rather than the ratio of 2 variables defined earlier, so the reader can grasp the meaning of the results.

(d) Is the lateral hydrograph, QL, the same as IGF? Both appeared in the text fre-

quently, and it appeared that they are used in the same context. If so, please unify the terminology. If not, please make it more clear by using a conceptual model diagram.

(e) The authors talk about losing reach vs gaining reach, in the context of losing water to other catchments via IGF. The terms “losing streams” or “gaining stream” have been understood as stream and local groundwater exchange, regardless of the source/sink is local or remote (IGF). Perhaps use “losing catchment” vs “gaining catchment” because here the authors refer to IGF?

(f) in Fig 1, catchments include headwater, intermediate, but is it intermediate between a headwater and a tailwater catchment? Is there another catchment below the intermediate?

Line 296. Is this stream loss, or simply that the infiltration over the surface catchment drained elsewhere, to neighboring catchments? IBF is not just a result of stream flow loss; infiltrated water may not go to the streams at all in its own catchment but may enter streams in other catchments.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2020-229, 2020.

Printer-friendly version

Discussion paper