Review of “Exploring river-aquifer interactions and hydrological system response….. Lu et al

Franklin Schwartz
The Ohio State University

The paper by Lu et al examines surface water groundwater interactions in lowland catchments in Belgium. The purpose of the study was to fill a gap in knowledge related to these catchments (Line 61). Their approach relied on an impulse response modeling to establish baseflow from knowledge of water table fluctuations. Those baseflow estimates would then be employed to evaluate methods of hydrograph separation and to learn something about the hydrology of these lowland basins.

Study Design

Intuitively, I question the motivations for study, discussed in the introduction. There are many different kinds of watersheds worldwide and it is not clear why the knowledge gap in this case was worthy of the time spent. Another question is the apparent need for another study designed to evaluate the efficacy of various baseflow separation techniques. The paper itself identified the key problem (Line 216) “Limitations for these hydrograph separation methods are their intrinsic difficulty to validate the separated baseflow and the lack of any representation of the physical processes of the river-aquifer exchange”. This problem is well known and has been widely explored (e.g., Partington et al., 2012). The positive aspects mentioned in the paper “fast”, “efficient”, “widely used” and quantitative (line 218) really don’t justify techniques know to be little more than guesses in most applications. The choices to address this problem in my opinion are to minimize this aspect of the study in the paper, demonstrate with field data that one of the approaches does work well enough to be useful, or to use a modelling approach like SWOT that might be useful.

The study in my opinion suffers from an over-reliance on theoretically based approaches. On line 48, the paper mentions several field-based approaches, but suggested that these were scale-inappropriate. There are other techniques not mentioned that have been used in other studies, e.g., isotope tracers and geochemical hydrograph separation. These of course come along with their own problems but have been applied to basins of this scale, which are small in area. The paper would be helped by field-based data/observations that could validate any of the empirical conclusions.

The decision to forego a rigorous physically based modeling, approach e.g., HydroGeoSphere, in the study design was surprising. That model was used in various baseflow application e.g., Olsthoorn et al. (2012) – an application looking at the efficacy of hydrograph separation methods (cited in the paper), and with geochemical approaches (Jones et al., 2006). Even if the study was focused on refinement of the impulse-response approach, it would have been prudent to start with a simple well constrained model-based proxy (like Olsthoorn et al. 2012).

What is Baseflow?

I think it is important for the authors to explain their concept of baseflow. The implicit definition in the paper is that stream baseflow is due to groundwater. For developed watersheds, baseflow is flow in the

stream between storm-runoff events. That water could be groundwater, but it also might include slow surface-water discharge from impoundments, storm-water ponds, dewatering, or discharges of treated sewage, etc (Liu et al. 2013). With this expanded definition in mind, the authors need additional field data to support their assumption that baseflow is groundwater.

Development of a watershed (farming, cities etc.) also has the potential to reduce baseflows by decreasing natural groundwater recharge due to tile drains, stormwater collection systems and fast runoff from pavements and altered land cover. To provide context for this study of low land basin these possibilities need to be explored with additional field data and observations.

Questions Concerning the Data

The descriptions of these study watershed appear relatively meager in terms of hydrologic data. First, in looking at the stream hydrographs, it seemed that that discharges were unusually constrained in a narrow range of discharges. I think that for the two smaller basins at least mean daily discharges do not provide adequate temporal resolution of discharge conditions.

In most watersheds, groundwater-level hydrographs are relatively uncommon. The record shown in the paper appears to have combined bits-and-pieces of hydrographs from different wells. But I could be mistaken. The assertion that forcing from precipitation provides a single simulated water-level fluctuation for an entire catchment is a serious simplification that has not really been appropriately justified and is not appropriate. The job of the land-surface component of hydrologic models is to redistribute water on the land surface due to topography, land cover, and soil conditions, which together provide for huge variability in local infiltration rates. Similarly, the hydrologic response of shallower wells could be substantially different than deeper wells because of local variability in hydrogeologic parameters. For example, there are no indication as to whether aquifers are fractured at shallow depth etc.

It is also noticeable that the locations of groundwater observation wells are biased to specific parts of watersheds, and to locations close to streams. Are these completed in alluvial aquifers adjacent to the stream or at what depths? Are these wells special to have water-level records, what kind of records exist etc.? How often are water levels measured in these wells.

Publication Strategy

With 23 Figures and 45 pages, this paper is overly long with several uncoordinated threads. Yet even at this size, there are major gaps in the description of the hydrogeological setting and data deficiencies that are concerning. My recommendations would be for the authors to rethink their publication strategy to create several papers with different purposes.

With modest effort, there might be a first paper to examine unique features of the hydrologic settings, especially basin morphology, elevation, land use land cover, in predicting hydrographs. It might be necessary to find an approach to reconstruct (downscale) hydrographs to improve resolution. Also, high-resolution water sampling of one storm – with specific conductance etc. together with a few groundwater samples could provide a better understanding of where inter-storm water is coming from.

A second paper might be designed to develop a more sophisticated understanding of water-level behaviors in a model system with a uniform rainfall to begin exploration of the impulse response modeling of the first link – precipitation groundwater.

Finally, a third paper might extend to modeling baseflow as you have done in this paper. But with a much better concept of how everything is working. I would also recommend that you only return to hydrograph separation with a tunable scheme that would integrate basic approaches with some kind of observational approach.

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