Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2020-308-RC2, 2020

Hydrology and Earth System Sciences
Discussions
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Interactive comment on "The era of Infiltration" *by* Keith Beven

Fred Ogden (Referee)

fred.ogden@noaa.gov

Received and published: 21 July 2020

My review is written from the perspective of a hydrologic model developer who develops models to solve practical hydrograph prediction problems, firmly in the domain of "hydrologic engineering". From a practical standpoint, given that all models are falsifiable, we seek models with the smallest number of parameters that predict hourly hydrographs reasonably well on a continuous basis when driven by reasonably accurate hourly forcing data. From the public safety and welfare standpoint, we are particularly interested in the peak discharge, its timing, and the total event runoff volume, especially for larger events.

In this paper Beven makes the point that for too long, modelers have overemphasized the role of infiltration on stormflow generation. I agree with this statement. Keith does his usual excellent deep dive into historical writings to illustrate that many contemporary

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research questions were well elucidated in the first half of the last century. I found the article an enjoyable read.

As a developer of several novel infiltration solutions, I would counter that the “era of infiltration” is largely over. Few people in hydrologic science today seem to care too much about infiltration. Outside the fields of soil physics and applied mathematics it is viewed as an esoteric topic. When my co-authors and I published the work describing the steps leading to the Soil Moisture Velocity Equation (Ogden et al. 2015, 2017) one of the reviewer comments was: “Most of the people who would care about this topic are deceased.”

Beven concludes that over-reliance on falsified perceptual models related to the importance of infiltration theory in runoff generation impedes progress. Rather, I see this a symptom of our lack of detailed knowledge, not the cause. Much of the field research effort expended in hydrologic science over the past 30+ years focused on highly uncertain subsurface processes and their role in runoff generation. Studies using inferences from light stable isotopic tracers and geochemistry to infer flow path and residence times in study after study provided site-specific results, and to date no common theory has arisen.

The reason for over-emphasis on infiltration theory or the persistent use of regression-based empirical approaches (e.g. CN) or other gross conceptualizations in runoff prediction lies squarely with the lack of a comprehensive and verifiable theory of runoff generation. As Beven correctly wrote, surface runoff is seldom seen in many hydrologic landscapes. In those cases, what is the alternative to infiltration theory? Catchment scale hydrographs remain flashy, even in the absence of observed surface runoff!

Nevertheless, accurate infiltration modeling remains an important need. Infiltration has a large effect on the catchment-scale water balance, particularly as it determines the store of water that is used by shallow-rooted plants through transpiration in many locations, at least during certain times of the year. Failure to correctly model this flux, or its

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omission, destroys the ability of a model to simulate an important hydrologic process, which renders models incapable of accurately closing the water and energy budgets.

Surface runoff, defined as water that enters the stream without having ever entered the subsurface, does occur; most commonly from areas of disturbed soils associated with agriculture, construction, and urbanization. As a flux, it frequently occurs in response to heavy to extreme rainfall, independent from runoff generation mechanism. I am not aware of a many instances where subsurface stormflow alone is responsible for flash flooding and its associated risks to life and property, except perhaps in situations where karst geology is involved.

In general, the specific terms: surface runoff, interflow, return flow, and groundwater flow or base flow describe useful concepts. They connote flow paths not mechanisms. I think when applied within the bounds of the WMO definitions, these terms are valid. Is it not reasonable to assert that stormflow consists of a superposition of surface runoff and interflow atop base flow? This definition remains valid if only one of these flow paths is non-zero.

Differentiation between flow path and runoff generation mechanism is important. The infiltration-excess and saturation-excess mechanisms have clear definitions, and might be considered well-behaved end-members that do occur in some catchments, even if only rarely, intermittently, and only under precisely defined conditions. When they are known to occur, these two mechanisms are highly predictable using models with a relatively small number of parameters.

However, there exists a vast state/parameter space lying between these two runoff generation end members and it appears to be incomprehensibly complex. In this region heterogeneities dominate, as do uncertainties in processes, parameters, and difficult to identify, describe, quantify, and model unsteady bio-physiographic and anthropogenic phenomena. This complexity is bounded at the lower end by Occam's razor and the concept of model parsimony, with a nearly limitless upper bound occupied by parame-

ter estimation schemes and the concept of equifinality.

I thank Keith Beven for writing this thought provoking paper. However, after reading it I have come to a different conclusion. I believe that the lack of a general, verifiable theory of runoff generation, hampered by our inability to know what is truly going on in the subsurface is the problem. Over-reliance on infiltration theory and other empiricisms is merely a symptom caused our lack of this knowledge.

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