

Interactive comment on “HESS Opinions: Advocating process modeling and de-emphasizing parameter estimation” by A. Bahremand

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Author's reply to Prof. Sheikh's comments

I would like to thank a lot Prof. Sheikh from Gorgan University of Agricultural Sciences and Natural Resources (Iran) for supporting the opinions of my paper with his nice words and constructive comments. He has mentioned several important points that I am going to address them here, and for a particular case in my opinion paper.

1. On the importance of measurements

Prof. Sheikh's comment stresses on the importance of improvements on measurements and monitoring techniques and tools. I agree with him that the opinion paper should pay more attention to this. Here, I would like to quote Paniconi and Putti (2015)

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that "no one would disagree that scientific progress requires a constant dialogue between measurement, analysis, and simulation". If we want to make a real progress and dramatic improvements in our physics based conceptualization we must apply all involved factors including the improvement on measurement techniques and tools for obtaining more accurate data to build/revise our formulas and test/verify our models.

2. On the importance of parameter estimation

Although, I also believe we are not yet free from calibration and parameter estimation, my paper is a plea for more physics in modeling and less focus on parameter fitting. Therefore, the word "de-emphasizing" in the title plays a good role in attracting attention to this call for shifting our focus. The intention of this opinion paper is provoking a fruitful discussion hoping to accelerate the shift which I personally think it has already begun but it needs to push for a widespread struggle. As I have mentioned in the opinion paper : "this comes at a time when enhanced computational power and sophisticated monitoring techniques now enable hydrologists to pursue deeper investigations of hydrologic processes, and to thereby simulate watershed hydrology in ever more detail."

3. On uncertainties of determination of some parameters

The comment makes some important points on difficulties of dealing with parameters such as soil saturated hydraulic conductivity, Manning roughness coefficient and the importance of high spatio-temporal variability of soil moisture content. I fully agree with Prof. Sheikh in these issues. In particular, I would like to emphasize on the two soil related parameters. There, we need more works on soil hydrology and pores media flow. The recent attention to preferential flow and unstable flow (fingering) is just because they have been so challenging from both measurement and modeling point of view (Beven and Germann, 2013; Paniconi and Putti, 2015). Beven and Germann (2013) gives a thoughtful discussion on the misuse of physics in pores media, in particular, the limitations of Dary and Richards equations. It also mentions the advances

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in measurement techniques as well as their errors, difficulties and limitations. Hence, I can conclude that the physics/process based modeling faces uncertainties from such basic matters. Therefore, we have to try more by focusing deeper and going into more details to incorporate more realistic and explicit methods for subsurface processes. Beven and Germann have suggested the reconsideration of the representation of preferential flows as a Stokes flow for profile scale and multiple interacting pathways model (Davies et al., 2011) for hillslope scale. Some alternative novel ideas such as the thermodynamic approach proposed by Zehe et al. (2013) for catchment scale preferential flow are the new directions, which in my opinion such energy-centred approaches can be more helpful as the catchment hydrology enters interdisciplinary era.

4. On the HAND and the topographic index

I agree with the comment that these indices can not cover the effects of slope aspect on soil moisture variation across the watershed. However, the opinion paper has not mentioned the HAND and the topographic index as promising techniques. I have stated the HAND and the topographic index application in hydrology as very good examples which "embody interesting revisions in the perceptual and conceptual model stages". In particular, in the classrooms whenever I talk about revisions in our perceptual and conceptual model stages, as the best example, I describe the application of HAND (Height Above Nearest Drainage) in semi lumped conceptual hydrological modeling (here, I preferred to use semi lumped instead of semi distributed). The opinion paper of Prof. Savenije (2010) elaborates on how HAND-based landscape classification can be used for conceptual hydrological modeling. Using HAND and slope, the catchment can be divided into hydrological response units (i.e. wetland, hillslope and plateau). In each HAND and slope based unit a certain runoff generation mechanism is dominant. Prof. Savenije has emphasized the intention of the proposed framework as a right level of simplification of the complex and heterogeneous hydrological world. Additionally, I would like to note about simplification in hydrology by analogy with the same concept in cartography. When teaching cartography at our university, simplification and

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generalization concepts are my best examples for cartography being as an art. Similarly in hydrology, I always see such wise simplifications as "the art of hydrology" (see Savenije, 2009). However, my opinion paper advocates more physics, more details and less conceptual. This view and opinion comes at a time that computational power and new sophisticated monitoring techniques allows us to characterizing heterogeneity and quantifying its effects (Montanari et al., 2015) and we can practice the art of hydrology by handling much more complexity and hopefully by building such a white box model which can confidently be applied for predictions with the least calibrations.

At the end, again I thank Prof. Sheikh for his constructive comments and for supporting the opinions mentioned in my article.

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