

HESS Review of “The evolution of process-based hydrologic models: Historical challenges and the collective quest for physical realism” by M Clark et al.

This is a synthesis paper for the special HESS issue honoring Eric F Wood. The paper is structured around three modeling “challenges” posed by Freeze and Harlan: (1) define suitable model equations – i.e. process parameterizations, (2) define adequate model parameters --- i.e. the adequacy of data and the resulting uncertainty; and (3) cope with limitations in computing power – computational constraints. The paper is very successful in presenting historical modeling challenges and summarizing various approaches developed over the years to address the challenges, but less successful in offering a more comprehensive vision of moving forward.

The review of the historical progress (and literature) is very comprehensive, and a student wanting to read about land surface modeling could spend a semester reading the paper and selected references, and really learn what has been done.

I have one major comment related to areas 1: nothing is mentioned about the numerical schemes used to solve current LSM – especially those like Noah, VIC, Topmodel, mHM, etc. I think the papers by Dmitri Kavetski (e.g. WATER RESOURCES RESEARCH, VOL. 39, NO. 9, 1246, doi:10.1029/2003WR002122, 2003; or JH 320(1,SI)173-186 <arch 2006.) offers important insights that need to be included. Martyn probably know of other similar works, since he is the lead author on WRR 46, Art W10510, Oct 8, 2010 with Dmitri.

Section 5 (Summary and next steps) was rather disappointing. The three points basically says the challenges remain, without any insights as to potential pathways forward. While the majority of the paper would really help students understand LSM developments over the last 40 years, the last section would offer no idea of where new research should go. To say that the key challenge is best posed by a quote by Wood (“*What modeling experiments need to be performed to resolve the “scale” question and what is the trade-off among model complexity, the physical basis for land parameterizations and observational data for estimating model parameters?*”), given the eminence of the author list, leaves this reviewer somewhat disappointed.

I would recommend that the authors augment this last section by listing potential pathways. Does SUMMA offer a framework for the modeling experiments Wood asks for? Can one develop a virtual reality (with or without SUMMA?), as called out by Wood (Wood, Eric F, Jan Boll, Patrick Bogaart and Peter Troch 2005. The Need for a Virtual Hydrologic Laboratory for PUB, Ch 16 in *Predictions in Ungauged Basins: International Perspectives on the State of the Art and Pathways Forward*. Eds. S Franks, M Sivapalan, K Takeuchi, and Y Tachikawa, IAHS Pub 301, Wallingford, Oxon. pp189-203), to explore “*trade-off among model complexity, the physical basis for land parameterizations and observational data for estimating model parameters?*”? So I challenge the eminent authors of this synthesis paper to offer students and younger colleagues ‘hints’ on ways forward. It would make the paper much more impactful.