Hydrol. Earth Syst. Sci. Discuss., 10, C3268–C3274, 2013
www.hydrol-earth-syst-sci-discuss.net/10/C3268/2013/

Hydrology and Earth System Sciences
Open Access
Discussions

Interactive comment on "Large-sample hydrology: a need to balance depth with breadth" *by* H. V. Gupta et al.

S. Patil (Referee)

sopan.patil@gmail.com

Received and published: 18 July 2013

This is an interesting and overall well-written article. The main goal of the authors is to "provoke further discussion and participation, and to promote a potentially important theme for the upcoming IAHS Scientific Decade entitled Panta Rhei". The important theme of focus here is large sample hydrology. I especially enjoyed reading the historical context for large sample hydrology studies provided by the authors. Since this is an opinion piece, I would characterize my comments below as "reviewer's opinion". My hope is that this will lead to a stimulating discussion and an improved final paper. My comments are as follows:

1) I completely agree with the authors' main argument that using data from more places

in our research will lead to better hydrologic insight. However, I wonder if we have a problem of "latitude sampling" in catchment hydrology. For whatever socioeconomic and historical reasons, majority of the developed world (OECD countries) is located in the temperate latitudes. Not surprisingly, most of the large sample data also comes from the developed countries (as evidenced by the table shown in the supplementary material of this paper). Although a lot of climatic and physiographic variability exists within and among these countries, can we really move towards a comprehensive hydrologic understanding without having much more large sample data from the tropical regions? It would be helpful if the authors can add some perspective on this issue in the paper.

2) This paper primarily focuses on rainfall-runoff modeling issues (model structure, uncertainty, etc.) and how large sample hydrology can help resolve them. However, I believe that the scope of large sample hydrology research is (and has to be) larger than rainfall-runoff modeling alone, especially if we are to make any meaningful progress towards the "Holy Grail" of comprehensive hydrologic process understanding. Results from some recent studies suggest that synthesis of different types of data, such as numerous stream tracer experiments [Drummond et al., 2012; González-Pinzón et al., 2013] or flood events [Gaál et al., 2012], can provide equally valuable insights into catchment processes as any large sample modeling study. Most importantly, the diversity of efforts in large sample hydrology research increases the likelihood of identifying gaps in our current theories, models, and measurement techniques. I think the authors have a great opportunity to call for increasing the diversity of efforts in large sample hydrology (beyond modeling issues) in the closing sections of the paper.

3) I found some of the views expressed in "The context of current practice" (Section 1.2) to be a bit outdated. The main argument of the authors in this section is that catchment hydrology is still focused on "depth" (studying more and more about a handful of places) rather than "breadth" (including large number of places in a single study). I'm not sure if this accurately represents the current state of the field. Many of us from

the younger generation of hydrologists have fully embraced the message that large sample hydrology research is extremely valuable, partly thanks to the successful messaging of the PUB initiative [Carrillo et al., 2011; Sawicz et al., 2011; Cheng et al., 2012; Coopersmith et al., 2012; Drummond et al., 2012; Kelleher et al., 2012; Patil and Stieglitz, 2012a; Patil and Stieglitz, 2012b; Yaeger et al., 2012; Ye et al., 2012; González-Pinzón et al., 2013; Safeeq et al., 2013]. Note that the large sample hydrology papers cited in the previous sentence are: (1) in addition to the 84 papers that the authors have mentioned in their supplementary material, (2) they have been published within the last three years and by an early career scientist as first author, and (3) they are not restricted to rainfall-runoff modeling alone. Therefore, large sample hydrology research is already being conducted in a big way since the last few years. The question then becomes, how can the new IAHS initiative help channelize these diverse efforts towards a greater "decadal" goal? The authors might want to consider adding some discussion in this section that gives credit to the current (albeit diverse) efforts at large sample hydrology and also clarifies their larger goal.

4) In Section 2.2 (P9155), the authors mention MOPEX and DMIP as examples of large sample catchment datasets in the US. I think it would also be worth mentioning here the tremendous efforts of the USGS in developing large catchment datasets for research; first the HCDN database (1659 catchments)[Slack et al., 1993] developed in the nineties and its recent update called GAGES (6785 catchments)[Falcone et al., 2010].

5) The call for classification made in this paper is not new. However, the authors did not acknowledge that a lot of work has already been conducted over the last few years in the fields of catchment, stream, and landscape classification (all of which are highly relevant to large sample hydrology research)[Wolock et al., 2004; Kennard et al., 2010; Mücher et al., 2010; Poff et al., 2010; Ley et al., 2011; Reidy Liermann et al., 2011; Sawicz et al., 2011; Coopersmith et al., 2012; Olden et al., 2012; Wigington et al., 2012]. It would be much more informative to the readers if the authors mention (and

briefly summarize if possible) the classification-related research that already exists, and then discuss their views on what is still missing, whether previous studies have been wrong (or incomplete) in their assumptions, and what further steps should be taken to make progress in classification. Simply describing how a classification system will provide insight into a lot of unresolved issues is not enough in my opinion. That has already been mentioned in older opinion articles [McDonnell and Woods, 2004; Blöschl, 2006; McDonnell et al., 2007].

References

Blöschl, G. (2006), Hydrologic synthesis: Across processes, places, and scales, Water Resources Research, 42(3), W03S02, doi: 10.1029/2005WR004319.

Carrillo, G., P. A. Troch, M. Sivapalan, T. Wagener, C. Harman, and K. Sawicz (2011), Catchment classification: hydrological analysis of catchment behavior through process-based modeling along a climate gradient, Hydrology and Earth System Sciences, 15(11), 3411-3430, doi: 10.5194/hess-15-3411-2011.

Cheng, L., M. Yaeger, A. Viglione, E. Coopersmith, S. Ye, and M. Sivapalan (2012), Exploring the physical controls of regional patterns of flow duration curves - Part 1: Insights from statistical analyses, Hydrology and Earth System Sciences, 16(11), 4435-4446, doi: 10.5194/hess-16-4435-2012.

Coopersmith, E., M. A. Yaeger, S. Ye, L. Cheng, and M. Sivapalan (2012), Exploring the physical controls of regional patterns of flow duration curves - Part 3: A catchment classification system based on regime curve indicators, Hydrology and Earth System Sciences, 16(11), 4467-4482, doi: 10.5194/hess-16-4467-2012.

Drummond, J. D., T. P. Covino, A. F. Aubeneau, D. Leong, S. Patil, R. Schumer, and A. I. Packman (2012), Effects of solute breakthrough curve tail truncation on residence time estimates: A synthesis of solute tracer injection studies, Journal of Geophysical Research, 117, G00N08, doi: 10.1029/2012jg002019.

Falcone, J. A., D. M. Carlisle, D. M. Wolock, and M. R. Meador (2010), GAGES: A stream gage database for evaluating natural and altered flow conditions in the conterminous United States, Ecology, 91(2), 621-621, doi: 10.1890/09-0889.1.

Gaál, L., J. Szolgay, S. Kohnová, J. Parajka, R. Merz, A. Viglione, and G. Blöschl (2012), Flood timescales: Understanding the interplay of climate and catchment processes through comparative hydrology, Water Resources Research, 48(4), W04511, doi: 10.1029/2011WR011509.

González-Pinzón, R., R. Haggerty, and M. Dentz (2013), Scaling and predicting solute transport processes in streams, Water Resources Research, n/a-n/a, doi: 10.1002/wrcr.20280.

Kelleher, C., T. Wagener, M. Gooseff, B. McGlynn, K. McGuire, and L. Marshall (2012), Investigating controls on the thermal sensitivity of Pennsylvania streams, Hydrological Processes, 26(5), 771-785, doi: 10.1002/hyp.8186.

Kennard, M. J., B. J. Pusey, J. D. Olden, S. J. Mackay, J. L. Stein, and N. Marsh (2010), Classification of natural flow regimes in Australia to support environmental flow management, Freshwater Biology, 55(1), 171-193, doi: 10.1111/j.1365-2427.2009.02307.x.

Ley, R., M. C. Casper, H. Hellebrand, and R. Merz (2011), Catchment classification by runoff behaviour with self-organizing maps (SOM), Hydrology and Earth System Sciences, 15(9), 2947-2962, doi: 10.5194/hess-15-2947-2011.

McDonnell, J. J., and R. Woods (2004), On the need for catchment classification, Journal of Hydrology, 299(1–2), 2-3, doi: 10.1016/j.jhydrol.2004.09.003.

McDonnell, J. J., M. Sivapalan, K. Vaché, S. Dunn, G. Grant, R. Haggerty, C. Hinz, R. Hooper, J. Kirchner, M. L. Roderick, J. Selker, and M. Weiler (2007), Moving beyond heterogeneity and process complexity: A new vision for watershed hydrology, Water Resources Research, 43(7), W07301, doi: 10.1029/2006wr005467.

Mücher, C. A., J. A. Klijn, D. M. Wascher, and J. H. J. Schaminée (2010), A new European Landscape Classification (LANMAP): A transparent, flexible and user-oriented methodology to distinguish landscapes, Ecological Indicators, 10(1), 87-103, doi: http://dx.doi.org/10.1016/j.ecolind.2009.03.018.

Olden, J. D., M. J. Kennard, and B. J. Pusey (2012), A framework for hydrologic classification with a review of methodologies and applications in ecohydrology, Ecohydrology, 5(4), 503-518, doi: 10.1002/eco.251.

Patil, S., and M. Stieglitz (2012a), Controls on hydrologic similarity: role of nearby gauged catchments for prediction at an ungauged catchment, Hydrology and Earth System Sciences, 16(2), 551-562, doi: 10.5194/hess-16-551-2012.

Patil, S., and M. Stieglitz (2012b), Modelling daily streamflow at ungauged catchments: what information is necessary?, Hydrological Processes, doi: 10.1002/hyp.9660.

Poff, N. L., B. D. Richter, A. H. Arthington, S. E. Bunn, R. J. Naiman, E. Kendy, M. Acreman, C. Apse, B. P. Bledsoe, M. C. Freeman, J. Henriksen, R. B. Jacobson, J. G. Kennen, D. M. Merritt, J. H. O'Keeffe, J. D. Olden, K. Rogers, R. E. Tharme, and A. Warner (2010), The ecological limits of hydrologic alteration (ELOHA): a new framework for developing regional environmental flow standards, Freshwater Biology, 55(1), 147-170, doi: 10.1111/j.1365-2427.2009.02204.x.

Reidy Liermann, C. A., J. D. Olden, T. J. Beechie, M. J. Kennard, P. B. Skidmore, C. P. Konrad, and H. Imaki (2011), Hydrogeomorphic classification of Washington state rivers to support emerging environmental flow management strategies, River Research and Applications, n/a-n/a, doi: 10.1002/rra.1541.

Safeeq, M., G. E. Grant, S. L. Lewis, and C. L. Tague (2013), Coupling snowpack and groundwater dynamics to interpret historical streamflow trends in the western United States, Hydrological Processes, 27(5), 655-668, doi: 10.1002/hyp.9628.

Sawicz, K., T. Wagener, M. Sivapalan, P. A. Troch, and G. Carrillo (2011), Catchment classification: empirical analysis of hydrologic similarity based on catchment function in the eastern USA, Hydrology and Earth System Sciences, 15(9), 2895-2911, doi: 10.5194/hess-15-2895-2011.

Slack, J. R., A. Lumb, and J. M. Landwehr (1993), Hydro-Climatic Data Network (HCDN) Streamflow Data Set, 1874-1988: USGS Water-Resources Investigations Report 93-4076, U.S. Geological Survey, Reston, VA.

Wigington, P. J., S. G. Leibowitz, R. L. Comeleo, and J. L. Ebersole (2012), Oregon Hydrologic Landscapes: A Classification Framework, JAWRA Journal of the American Water Resources Association, 49(1), 163-182, doi: 10.1111/jawr.12009.

Wolock, D. M., T. C. Winter, and G. McMahon (2004), Delineation and Evaluation of Hydrologic-Landscape Regions in the United States Using Geographic Information System Tools and Multivariate Statistical Analyses, Environmental Management, 34(0), S71-S88, doi: 10.1007/s00267-003-5077-9.

Yaeger, M., E. Coopersmith, S. Ye, L. Cheng, A. Viglione, and M. Sivapalan (2012), Exploring the physical controls of regional patterns of flow duration curves - Part 4: A synthesis of empirical analysis, process modeling and catchment classification, Hydrology and Earth System Sciences, 16(11), 4483-4498, doi: 10.5194/hess-16-4483-2012.

Ye, S., M. Yaeger, E. Coopersmith, L. Cheng, and M. Sivapalan (2012), Exploring the physical controls of regional patterns of flow duration curves - Part 2: Role of seasonality, the regime curve, and associated process controls, Hydrology and Earth System Sciences, 16(11), 4447-4465, doi: 10.5194/hess-16-4447-2012.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 9147, 2013.