Large-sample hydrology: a need to balance depth with breadth

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Comments to Author

In this manuscript the authors call for an increase in large-sample studies within hydrology. This call is a timely reminder of the benefits available from analysis of large datasets drawn from a wide range of "geo-eco-hydro-climatic" conditions. They outline four main benefits of large-sample hydrology: (1) improved understanding; (2) robustness of generalizations; (3) classification, regionalization and model transfer; and (4) estimation of uncertainty. These benefits are well presented and argued. Large-sample hydrology offers much too modern hydrology and will be critical for developing a more complete understanding of how hydrologic processes change in space and time. As a reviewer I agree with the sentiment of this manuscript.

However, as a reviewer I found the historical perspective presented very narrow. By focusing on large-sample hydrology in the context of hydrologic models the authors missed the significant literature related to Comparative Hydrology. Although they refer to the book 'Comparative Hydrology: An ecological approach to land and water resources' edited by Falkenmark and Chapman (1989), the reference is toward the end of the manuscript and not in any way central to their overall argument. In my opinion the argument presented for large-sample hydrology is very similar to the purpose of Comparative Hydrology.

Falkenmark and Chapman (1989, page 12) defined Comparative Hydrology as

> *"the study of the character of hydrological processes as influenced by climate and the nature of the earth's surface and subsurface. Emphasis is placed on understanding the interactions between hydrology and the ecosystem, and determining to what extent hydrologic predictions may be transferred from one area to another."*

G Kovacs in chapter six of Falkenmark and Chapman (1989) presents the purpose of comparative hydrology as:

> *"- to delineate regions where sufficient hydrological similarity can be assumed to justify the application of techniques for characterizing hydrological processes;*

- *to compare the hydrological processes occurring in different regions in order to determine how the various elements of the water balance depend on geographical conditions;*
- *to summarize the various methods suitable for the simulation of hydrological processes and to quantify hydrological variables in different regions under different conditions."*

These three purposes of comparative hydrology are broadly similar to three main benefits for large-sample hydrology presented by the authors (improved understanding, robustness of generalizations, and classification, regionalization and model transfer).

A primary concern of Falkenmark and Chapman (1989) was developing an improved understanding of differences in hydrologic processes and conditions to facilitate transferal of hydrologic knowledge between regions for successful water resource management. Here the authors present large-sample hydrology as step toward the "Holy Grail" of hydrology, which is to "*understand catchment processes well enough that models can provide detailed simulations across a variety of hydrologic settings at multiple spatio-temporal scales, and under changing environmental conditions*". Although the paths trodden to reach large-sample hydrology and Comparative Hydrology are different, there are striking similarities between the expected benefits of large-sample hydrology and the purposes of Comparative Hydrology.

Since the authors seek to "*promote a potentially important theme for the upcoming IAHS Scientific Decade entitled "Panta Rhei"*", this manuscript is likely to frame this theme and be a significant contribution that will be widely read and cited. Therefore, I believe it is incumbent upon the authors to revise the manuscript to fully reflect the history of this topic and acknowledge the contribution(s) of Comparative Hydrology to their argument. To this end I think the manuscript would benefit from broadening the discussion of large-sample hydrology beyond hydrologic modelling.

Broadening the manuscript beyond hydrologic modelling would allow inclusion of contributions from Comparative Hydrology. For example, large-sample hydrology has contributed to understanding the influence of catchment vegetation on hydrology through comparative analyses of large samples of paired catchment studies (see Andréassian, 2004, Bosch and Hewlett, 1982; Brown et al., 2005; Sahin and Hall, 1996; and Zhang et al., 2001; 2004) and unpaired catchments (Peel et al., 2010). Haines et al (1988) provided a classification of monthly streamflow regime based on analysis of 969 global catchments. McMahon et al (1992) and Peel et al (2004) sought to understand differences in inter-annual runoff variability via analysis of a large sample of global catchments. Woo and Liu (1994) provided a case study of comparative hydrology for mountainous regions in Canada and China. Gaál et al (2012) sought to understand the controls on flood duration via analysis of annual flood events from a large sample of Austrian catchments. I believe the case for large sample hydrology would be strengthened by broadening the discussion beyond hydrologic modelling as is currently presented in the manuscript.

Another useful contribution to add to this manuscript would be a summary of freely available large samples of catchment data that could form the basis of large-sample hydrology (perhaps as an appendix). This summary should not be based solely on data sets related to hydrologic modelling. As part of the International Hydrological Decade (1965-1974) significant work on Experimental and Representative basins was conducted and significant effort was spent on collating and making available streamflow data. For example, UNESCO published a series of reports titled "Discharge of selected rivers of the world", which provided monthly and annual streamflow data for many catchments globally. These UNESCO reports were part of the seed data set for the Global Runoff Data Centre (http://www.bafg.de/GRDC/EN/Home/homepage_node.html) established by the WMO. Dai et al (2009) has collated a monthly streamflow dataset of stations closest to ocean for large exorheic rivers (http://www.cgd.ucar.edu/cas/catalog/surface/dai-runoff/index.html). Numerous national data sets have been published over the years. For example, the Hydro-Climatic Data Network (HCDN) in the USA (http://pubs.usgs.gov/wri/wri934076/1st_page.html) and the Hydrologic Reference Stations in Australia (http://www.bom.gov.au/water/hrs/index.shtml). This summary would be a significant contribution to large-sample hydrology as it would point the reader to readily available data.

Other than the above concern about the lack of historical context the manuscript is well written. However, I found it repetitive in places and recommend the authors remove repeated material and concepts. I also found figures 2, 3, 4 & 5 added very little to the argument and were not discussed by the authors. I recommend removing these figures as they are generally reproduced from earlier papers and add little insight to the argument.

Minor comments / clarifications

Page 9149, line 8: Linsley (1969) is not listed in the reference list.

Page 9156, line 12: Merz and Blöschl (2006) is not listed in the reference list. There is a Merz et al (2006) listed, but not a Merz and Blöschl (2006).

Page 9164, line 10 and other occasions: Viglione et al (2010) is not listed in the reference list. It is listed as 2011.

Page 9166, line 10: Koren (2000) is not listed in the reference list. There is a Koren et al (2000) listed, but not a Koren (2000).

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