International Upper Great Lakes Study – Sub-Product Review

Manuscript: *Change Detection in the Great Lakes – Hydroclimatic Variables – Part III – A complementary data analysis*

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Name of Reviewer: Richard M. Vogel
Date of Review: April 24, 2009

1. Are the objectives of the work clearly stated? 3

2. Are the methods employed valid, appropriate and sufficient to address the questions, hypotheses or the problem? 1

3. Are the observations, conclusions and recommendations supported by the material presented in the manuscript (e.g., data, model and analyses)? 3

4. Are the assumptions used valid and are the mathematics presented correct? 1

5. Is the manuscript well organized, material precise and to the point, and clearly written using correct grammar and syntax? 2

6. Are all of the figures and tables useful, clear, and necessary? 1

7. What is the quality of the overall work? 2

Recommendation (please circle your response)

B - acceptable with suggestions for revision

Rating (Circle the rating you would like to give this manuscript. Unacceptable work should be given a score of 40 or less.)

80

Comments

A. What is the best/most unique part of the analysis?

Overall the study is quite sensible and uses up-to-date statistical methods to evaluate trends and abrupt changes in various hydrologic series. The blending of these two approaches leads to a rich and complete understanding of the trends observed in various hydrologic and climatic series. Importantly the authors correct for potential autocorrelation when testing for trends. It is always a challenge to distinguish between trends and serial correlation, and the authors have used results from recent literature to apply an appropriate nonparametric Mann Kendall trend test with corrections for serial correlation. They have also applied tests which attempt to evaluate whether or not the serial correlation present is due to short or long term persistence processes. Furthermore, the authors have used the most up-to-date theory on 'change point detection' developed by the senior author Taha Ouarda and his colleagues and others. This analysis appropriately uses a Bayesian framework to inform us about the likelihood of both the number of changes and their corresponding dates, thus enabling correct probabilistic statements to be made regarding the most likely number and dates of changes to have occurred during the historical period.

B. What is the most critical aspect of the study/analysis? Why?

Of critical interest is how the authors blend the use of 'change point analyses' with 'trend detection analyses' showing that an understanding of such change points can have a dramatic influence on resulting inference on trend detection. Their analysis is quite compelling because it uses the results of the change point detection analysis to document a relatively common change point near the end of the 1960's and the beginning of the 1970's. That result is then used to determine whether significant trends occurred before or after this change point, for all data series. This resulted in very significant downward trends observed in nearly all series after 1972 and this result would likely not have been obtained had the investigators not employed the change point detection analyses. Furthermore, that analysis reveals the rather marked difference in the behavior of the time series corresponding to the hydrologic inputs to Michigan - Huron and Erie.

C. Which aspect of the analysis/modeling is weakest? Why? How can it be improved?

The weakest aspects of the study involve the lack of a meaningful introduction and the omission of a section summarizing the results. The introduction section should include the overall goals of the study. At the top of page 2 in the introduction section, the change analyses to be performed are outlined, yet the overall goal of these analyses is never made clear? It is unclear to the reader what the purpose of the various types of change analyses are. Is your goal simply to detect changes or to attribute them as well to particular causes. This issue is particularly confusing to me because the June 2008 report of the Hydroclimatic Working Group titled "Hydrology and Climate Modeling Strategy" describes Tasks 4.1-4.2 as:

Bayesian change point and trend analyses and teleconnection studies will be performed to assist in identifying the causative factors related to any changes in the Upper Lakes water supplies.

I could not find any discussion in the report relating to identification of causative factors, nor could I find any discussion concerning the purpose of the trend detection analyses. I read the report assuming that the goal of this study was related to improving our understanding of the stochastic structure of the various time series to enable a more thorough understanding and evaluation of previous stochastic analyses of NBS and other time series. However, this was never stated.

My only concern with the 'abrupt change point' analyses is that an arbitrary 10-year moving window is used in the analyses. The question arises as to whether a different length moving window, say a 5-year or a 12-year moving window would lead to different conclusions than are drawn in this study.

Serial correlation influences ones ability to detect significant trends and this is captured in the study. Cross correlation among the hydroclimatic records will have a similar impact yet this 'effect' is not accounted for in the analysis. Is this because you computed cross correlations among the various series and found them to be negligible, or did you simply ignore this issue. Some mention of this issue may be appropriate

D. Are there any other suggestions that are related to how this analysis may be used more effectively or the results explicated in a more understandable manner?

The most important omission relates to the lack of a section summarizing the results of all the various trend and change-point analyses. There are dozens of interesting results scattered throughout the manuscript, yet in the end, the reader is left wondering what the final conclusions are. In particular, the reader is left wondering how the results of the various trend and change-point detection analyses will be used in subsequent reports and studies. What are the implications of this report? I could find no discussion of this and such issues should not be left for the reader's imagination.

Please indicate any confidential comments to the Co-Chair(s) of the Independent Peer Review Group in the space below. Comments for transmission to the author(s) should be on a separate sheet attached.

No confidential comments are needed. Comments for transmission to the authors include the above comments as well the detailed comments below.

Signature: _____ Date: April 24, 2009

Additional Detailed Comments for Transmission to Authors

All of the following comments are relatively minor, none requiring major revisions, though addressing these comments and the comments discussed above should improve the manuscript considerably.

Detailed Comments

Why are you introducing the new variable net total supply (NTS) in equation (1)? An explanation would help the reader appreciate the importance of this new variable, because most previous studies have focused on NBS.

After equation (1) it might be helpful to either define residual net basin supply *RNBS* more fully or provide a reference to later sections of the report which cover this concept in more detail.

At top of page 15, why is a non-informative prior appropriate here? Don't you know the sampling distribution of the variance and couldn't one use that knowledge to develop an informative prior which would in turn improve our ability to discern change-points and trends? Perhaps such prior information is not really available in the form needed.

Last sentence, first paragraph, page 20, states:

> " As it can be seen from Table 7, the difference between water level falls for different stations ((HB - SCS) - (SCS-CLV) and (HB - SCS) - (SCS-GLB)) were also tested for trends and it was observed that theses time series were characterized by significant downward trends under the LTP assumption."

I do not see how the Mann-Kendall TFPW trend test assumes LTP because it only handles lag-one serial correlation.

Page 46 'tow' should read 'two', and 'sires' should read 'series'

Page 47 'run' should read 'runoff'

Page 47 – A greater discussion could be provided to help the reader understand how you evaluated trends under the assumption of LTP. Earlier, on page 13, in equations (14) and (15) you clearly outline how you evaluate trends using the MK statistic adjusting for short term persistence (using the lag-1 serial correlation), however, you never really show you perform the analogous tests under LTP.