

Ouarda et al: Change detection in the Great Lakes hydro-climatic variables Part III

General Comments

This is a very thorough set of analyses, and generally well presented. It does suffer from a lack of interpretation. The statistical methods are well presented and these reflect the state of current practice. The introduction would benefit from a statement of the objectives and the problem that these statistics are meant to address.

I found it odd that in several places the text refer to data contributed by Alain Pietroniro who is also listed as a co-author. Alain is actually with Environment Canada and not the IJC as indicated on the title page.

Some addition text that helps guide the reader through the analysis would be a benefit. If you are not used to reading trends analysis statistics this is going to be heavy going. What might be the physical [or observational] changes that result in these points of change? The fact that many of them are simultaneous suggests that this could be mechanistic but some attribution, even speculative would be interesting. One would hope that potential methodological changes have been eliminated. These are not random series, and these change points can be expected to have some explanation.

While this is a very good presentation with respect to the analysis, one would like to see some summary of all the change points, and some interpretation of what these might mean. At times it is hard not to feel that there were a bunch of plots generated and someone wrote one or two sentences about each and then strung them into a sequence and wasn't as selective as they might be. In many places, improvements to the figures could result is as many tables not being necessary.

The paper clearly describes where each of the time series comes from and the sources. It does not address whether these data are suitable for the type of analysis that is being conducted which could have strong bearing and there is no discussion of data quality and how that might be affected by the derivations involved. As I read this, almost none of the series are original observations; rather they are derived from other series. This has some addition repercussions that are dealt with in the detailed comments below.

While these are good analyses of the annual and monthly time series, one wonders if there would not be some merit is looking at the complete series of monthly values in at least some of the cases. Some of the changes in monthly series are likely timing shifts related to the climate system with earlier snowmelt in warmer periods.

Specific Comments

Page 2 paragraph 1 line 10 - Precipitation should be precipitation

Page 3. section 2 2nd sentence – unusual to note in the text that one of the co-authors supplied the data.

Last sentence – a cleared definition of ‘water falls’ is needed. One can see that there are water levels, differences in water levels, but ‘falls’ are apparently differences in differences.

Page 4 line 4 should not “... Great Lakes responsibilities.” Be something like “... Great Lakes Authorities.”?

Line 5 insert ‘only’ between “is one”

Line 8 again – Pietroniro as source and as co-author.

Figure 1. Labels should include all those used in the text. See the following partial list of place names used in the text without a location in this figure:

- Text refers to Fermi – but Figure shows Fermi Power Plant
- St. Mary River
- Georgian Bay
- Detroit River
- St. Clair River
- Niagara Falls
- Niagara River

Page 7 there is something wrong with the calculation of change in storage:

A change in one meter should be multiplied by the areas of the lake to give a volume [which is the typical measure of storage] to convert to an equivalent flow one would then divide by the number of seconds in a month [days*24*60*60]. As this volume is critical in the analysis was this applied to every month as having about 30.4 days in it as in the following table? And what was the source of the areas that was used? the following are from Wikipedia.

	sq miles	km2	m/km2	seconds	factor
Superior	31820	82400	1000000	2626560	31372
Huron	23010	59600	1000000	2626560	22691
Michigan	22400	58000	1000000	2626560	22082
Erie	9940	25700	1000000	2626560	9785
Ontario	7450	19500	1000000	2626560	7424
St Clair	430	1100	1000000	2626560	419

Page 12. line 6 spacing and punctuation “... component .On”

Page 14 line 2nd from end of page. The equation seems to have been overprinted...

Page 19

Comment: did the authors consider using the MK with covariates as another approach?

2nd paragraph Lines 4-6:

This text:

“Table 7 also shows that water levels experienced upward trends in St-Clair Shore and Gibraltar stations whereas they showed downward trend in Harbour Beach. However, observed trends were not significant in any of mentioned water level stations.” is technically not correct. If the trends are not significant they are not trends.

Page 21 Table 9

How much of these differences could be attributed to differences in degrees of freedom?

Also line 1 of the table the time series label should be Erie not ERI.

Comment: can it be true that a series x has no trend, and a series y has not trend, but a series z [where $z_i = x_i - y_i$] could have a trend given that the uncertainty around z is greater than either of x or y since $SD_z = \sqrt{(SD_x^2 + SD_y^2)}$?

Page 24

Note Table 14 dates

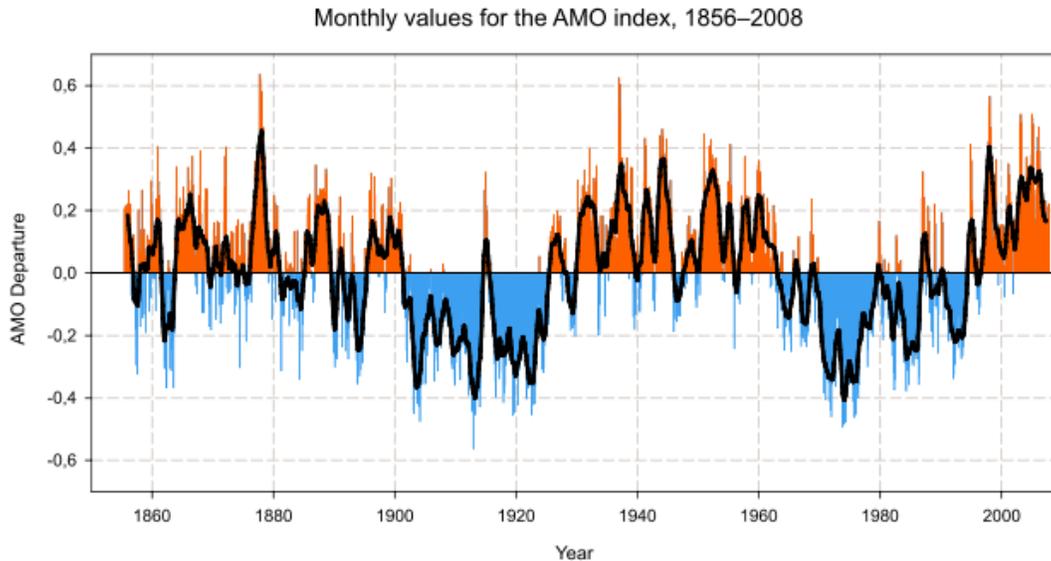
1912 / **1923** / 1935 / **1942** / **1957** / **1969** / 1988 : bold are change points in **lake levels** and italics in *WL differences*.

Page 25

Figure 2. These [and all similar figures that follow] would be better presented using consistent timescale and y axis so that the point of change similarities are easier to relate and the slopes are also comparable. I note in general that the panel labels are only marginally legible and a larger font is recommended. Some of these use the a,b,c,d,.. labelling and others do not. The reader would be much better served by a consistent format and scales.

Comment: While I expect this is not an issue these authors were asked to address, the differences in water levels are a bit difficult to compare conceptually since the Δ 's have different meanings – in some cases these are along a “river” and could be easily converted to a slope that would have some physical meaning, say for instance Lakeport-Gibraltar. However, when one differences the differences between Harbour Beach-SCS and SCS-Cleveland

Page 26. Comment: can shifts in the Atlantic Multidecadal Oscillation or the PDO be related to these points of change or are these physical changes to say – channels? Some of the data in table 14 are reminiscent of those in the following figure.



Page 28

Figure 3. These would be better presented using consistent timescale and y axis so that the point of change similarities are easier to relate and the slopes are also relatable. It is also interesting that in the bottom two panels the period post 1990 is not identified as a point of change unlike the other four cases. Did the authors consider normalizing these data to zero mean and unit variance before analysis to reduce the effects of measurement scale? When scaled similarly as they are one is struck by the similarity of panels d and f [also c and e] but with quite different change point detection.

Page 31 – same comment to figure 5 regarding scales. Labels on panels are difficult to read but do not seem to correspond or are inconsistent with the text. Did the authors consider reversing the series and performing change point detection on the reversed series? Some discussion of the effect of the series length would be useful as generally the number of pieces seems related to the record length.

Page 34 – paragraph describing Figure 6. While this is very descriptive can we be assured that it is real? Small changes in the change point could result in there being little or no slope but considerable steps in average. While the changes in the water level sites seem straight-forward, these changes in difference in water level [which would be slopes if the distance between points was used] is not so readily apparent. This is not likely due to the authors, but it would be useful to provide text that helps the reader conceptualize how these derivatives can be or should be interpreted.

Page 35

Figure 7 panel b is labelled ‘water level’ and should be more informative as these two panels are actually differences in water levels.

Page 35

The text:

Figure 7 shows that the difference between residual and component NBS in Lake Superior experienced a downward shift in 1967 where the downward trend observed before the change

point was followed by an almost stationary period in terms of mean but more variable in terms of variance.

Needs to be stated more clearly. The peak at the end of 7a is being interpreted as increased variability and not a change which is undetectable as it is at the end of the record.

Similarly,

This figure also shows that the fall between Lakes Huron and Erie experienced three decreasing shifts but the time series was characterized consistently by a downward trend for the whole observational period.

But the figure shows a stationary or even rising period prior to 1890.

Page 36. end of paragraph

Is the detectability of points of change at the beginning and the end of the record equivalent?

Figure 8. Can the source of these data be described? My understanding is that the first three are not based upon stage discharge relationships but water levels.

Page 38.

Two sentences from this paragraph need to be improved:

A visual inspection of RNBS time series in Lake St-Clair revealed that the majority of detected change points were due to the local short term variability in RNBS except the change point in 1990 which was due to **an abrupt upward change in monthly scale.**

A visual inspection of the Lake Ontario RNBS shows that there is a shift in the time series around 2000 which **in most of the cases is downward followed by an increasing trend.**

Page 39 Figure 9 is mostly not legible.

Page 40 Figure 10 is mostly not legible.

Comment: so one has to ask why the change point detection that worked so well in the previous section[s] does not work as well here? Is it because the type of change point is more difficult to detect, but all four of these panels show a pattern like $\backslash\Delta\Delta$. Is the problem series variability or pattern?

Page 41 paragraph 1.

This really seems illogical – the point of detection work described earlier clearly showed change points at 1912 / **1923** / 1935 / **1942** / **1957** / **1969** / 1988 : but this section uses 1972 which was only evident in Figure 9e for Ontario NBS. Given that I cannot read the other 4 panels can this point of change really be supported? A similar step was not detected in Figure 9d [at some unknown date]. Would it not be better to rely on the point of change shown earlier for lake levels?

Page 43

The text:

While the NTS time series of Lake Erie showed upward trends (at 10% significance level) for the whole record period, it showed no significant trend for the first segment but a significant downward trend for the second segment of observational period.

Seems strangely inconsistent, particularly since n is so much smaller in the later case.

Page 44 Paragraph 2

Here the authors use 1965, 1975, and 1980 and attribute that to the exploratory Bayesian change point detection results. These are again different years to those in Table 14, and one could expect this is from graphs that are not shown for NBS?

Tables 20-22

The footnoting in these tables is inconsistent. When describing these tables is counting the annual change and the monthly change points as equivalent appropriate?

Page 46 paragraph 2

Line 3 change “tow” to “two”

Line 4 change “sires” to “series”

Page 50 line 1 change ‘particularly in a monthly scale’ to particularly on a monthly scale’.

Paragraph 2 – line 7. link text to the appropriate table; quantify “great” agreement or delete “great”.

Page 51.

A short summary of the results is needed. The report stops almost mid-sentence. Some text that helped guide the reader would be useful.

Appendix A. page 54 - should start on a new page.

A short textual explanation of what the appendix contains would be useful. The figures in general are not very readable, but the right hand column panels are particularly uninformative, partly because they illegible. A simple explanation of how to interpret these is needed. It appears that these are in pairs but are misaligned? I believe those on the right are interpreted as there being no point of change, but one has to wonder if this could be done more effectively. Captions might be useful as well. My guess is that these are monthly results in all the appendices that are not included or discussed in the text. Appendix A is referenced at the end of page 36. *For detailed results of change detection in the Great Lakes monthly connecting channel discharges see Appendix A.*

Appendix B page 75.

Similarly, a short textual explanation of what the appendix contains would be useful. The figures in general are not very readable, but they appear to be in groups of four but the relationship seems to change from page to page. I am unsure how to interpret the first panel titled “Residual NBS Lake St Clair”. A simple explanation of how to interpret these is needed. Perhaps these could be formatted into tables with captions?

The pattern of 4 breaks down on page 81 and shifts to a pattern of 6. Then it changes again on page 83, and again on 84 and 85. If these are to be informative some effort needs to improve the presentation.

Appendix B is referenced on page 38. *For a full description of obtained results for change detection in the RNBS see Appendix B.* This appendix is not a “full description of obtained results”

Appendix C – is not found in the document

The text refers to Appendix C as follows on page 39/40. *The obtained results for annual data are shown in Figure 10 and monthly change point detection results for different lakes are presented in Appendix C.*

Appendix D. p 105 – is not referred to in the text of the document – perhaps it is Appendix C?

A short textual explanation of what the appendix contains would be useful. The figures in general are not very readable, but the left hand column panels are uninformative, partly because they are illegible. These seem to be the same pairings as in Appendix B but with the order switched. On page 110 the order switches – likely because of a panel “ST CLAIR – NTS” and then the left hand and right hand figures are now misaligned. It switched back on page 115 and become aligned. A simple explanation of how to interpret these is needed.