

## ***Interactive comment on “Time-series analysis of the long-term hydrologic impacts of afforestation in the Águeda watershed of North-Central Portugal” by D. Hawtree et al.***

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Received and published: 31 December 2014

Thank you for your detailed and thoughtful review of the paper. Please see our response to your specific comments below.

1. “The authors adopted the ratio of annual runoff to annual precipitation to do this. However, this is a crude approach because any change in precipitation/runoff relationship will occur at a much shorter time-step and the effect will be largely masked at an annual level. Therefore, for the study to provide credible results, I would have expected the effect of precipitation on runoff to be removed in a more credible way.”

We certainly agree that changes in this ratio may be masked at the annual time scale. However, this ratio was not only tested at the annual time scale, but also over 4-month periods (selected to represent the seasonal dynamic of the watershed), which should better reflect the shorter time-periods where the runoff ratio may have changed. Monthly time periods were considered in the preliminary analysis as well, however due to the temporal lag between precipitation events and streamflow response the ratios did not have much utility (i.e. many months had more streamflow than precipitation, due to the carry-over from the previous month). Therefore, we selected the 4-month periods for analysis as a temporal period which is long enough to provide stable precipitation/streamflow ratios, while being able to capture sub-annual streamflow dynamics. However, if the reviewer has suggestions for additional methods of analysis which would be more credible, then we are open to the suggestion.

2. “The interpretation of the baseflow trends needs further consideration. A recent paper in HESS by Cartright et al. (2014) is pertinent. For the watershed analysed by Cartright et al., they showed that estimates of baseflow from the local minimum and recursive digital filters (including the Eckhardt filter adopted by the authors) are higher than those based on chemical mass balance using CI calculated from continuous electrical conductivity measurements. This suggests that baseflow computed using a digital filter is made up of local riparian groundwater (including bank storage) that has a short storage delay time plus the more regionally based groundwater with a much longer storage delay time. The interplay between these two baseflow components may explain some of the features of the BFI trends observed in Figure 6. I would suggest the authors examine this aspect in relation to the Agueda watershed.”

Thank you for the reference to the Cartright paper; this is an interesting comparison of the different methods of estimating baseflow. As indicated by the paper, it is possible that the recursive digital filter method provides an over-estimate of baseflow, due to the aggregation of different sources of delayed flow.

To assess this over there period where we have data for both sources, figures 1 -

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3 can be considered, where the y-axis is the output from the Eckhardt digital filter (EDF Baseflow) and the x-axis is the Conductivity Mass-Balance (CMB Baseflow). The overlain black line is the one-to-one line. For the annual time scale the correlation 0.958 (figure 1), the monthly was 0.956 (figure 2).

In the monthly plot there are a large number of months where the values were less than 100 mm, which are difficult to visualize in the first plot. Figure 3 includes only the months where both values were less than 100 mm, to better show the relationship during drier months.

This plot reveals that there is a greater difference in the estimates during the drier months (as compared to all months) although the Pearson's correlation coefficient of 0.83 still indicates a high level of correlation. As can be seen in the plot, the reduced correlation appears to be primarily due the higher estimates produced by the CMB method.

We are not certain what may account for these higher estimates with the CMB, as this aspect of the BFI estimates was not explored in depth (which is outside the objective of the study). However, a potential explanation could relate to the findings of Cartwright et al. (2014), which found over estimation from baseflow estimated by the chemical mass balance method during the early stages of high-discharge events, which they attribute to the flushing of saline (and therefore more chemically similar) water at the start of an event. A similar flushing impact could account for some of the higher estimates here, although this is speculative, and may be accounted for by another factor which the authors are not aware of. The current study also did not find systematically higher annual estimations from the EDF method, which contrasts with the findings of Cartwright et al. (2014). This may indicate that there are different dominant hydrologic factors at work between the two sites, notably that there may be less transient sources of water in the Agueda watershed when compared to the Cartwright study.

These figures do indicate that there is a difference between the BFI estimates of the

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two methods, and there are indications of a positive bias of the CMB method during low months, and from this analysis, we cannot assess which method provides a more accurate estimate of BFI. However, for the purposes of this study, the accuracy of the method of estimating the BFI is a secondary consideration to the data availability to utilize an approach, and the stability of the estimations from the method selected. As the CMB data is only available for a short period of time, relative to the 75 year period being considered, it is not a viable method for conducting the trend tests needed for this study. By contrast, the EDF method provides a consistent method of estimating the baseflow across the entire 75 year period, since it is strictly based on the hydrograph data. Therefore, while a chemical mass balance approach (such as that tested by Cartright) may provide a more accurate baseflow ratio, there is no data available to support this method over the data period considered in this study.

3. P12224, L6: I think 7 should read 70. This seems to have been a type-setting error, as we have 75 written in the submission draft (1936 to 2010).

4. P12226, Ls28 - 29: After “20%” add ‘of total rainfall’. Delete “of total rainfall” from the next line. Change made as suggested.

5. P12226, L28 -12227, L6: "These percentages are not useful unless the mean annual precipitation is provided for each case."

We agree that providing more information about the comparison sites would give greater context to these reported findings. We are putting this together now, and will add it to the paper shortly.

6. P12228, Ls16-17: Delete “analyzes” and add after Value ‘are analysed’. Change made as suggested.

7. P12230, L26: “Corine Land Cover” requires an appropriate reference. Citation added.

8. P12233, L15: “streamflow/precipitation”. Should this not be ‘annual stream-

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flow/annual precipitation”.

These values are not necessarily annual, since this refers to both the annual and the seasonal time periods (the 4-month data period used for analysis in addition to the annual values). Actually, the (mm/yr) designation after the other values is not correct in this case, because this also refers to the seasonal data.

This section has been re-written as: “Over the time periods shown in Fig. 4, the trend testing was conducted for aggregated “annual” and “seasonal” values of precipitation (mm), streamflow quantity (mm), streamflow yield (streamflow/precipitation), baseflow quantity (mm), and baseflow index (baseflow/streamflow).”

9. P12238, L5: Reword – replace “well below” with ‘less than’. Change made as suggested.

10. P12238, Ls15-23: It would be helpful if the authors had compared their results with those from similar catchments elsewhere. There are approximately 190 separate land use impact studies reported in Bosch & Hewlett (1982), Brown et al. (2005) and Farley et al. (2005). It is likely that some of these would be from catchments that have similar climate and physical features as in the Agueda watershed.

We agree the it would be useful to draw attention to some catchments from these studies which are similar to the current study. We will add this to the manuscript shortly.

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 12223, 2014.

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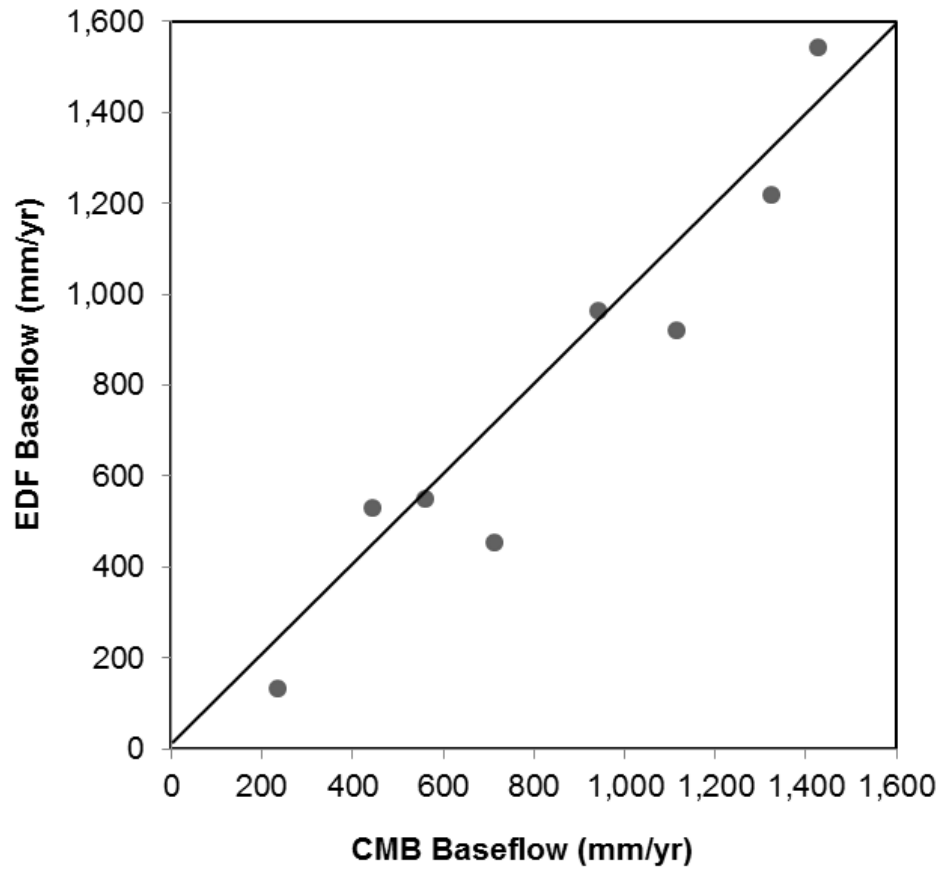


Fig. 1.

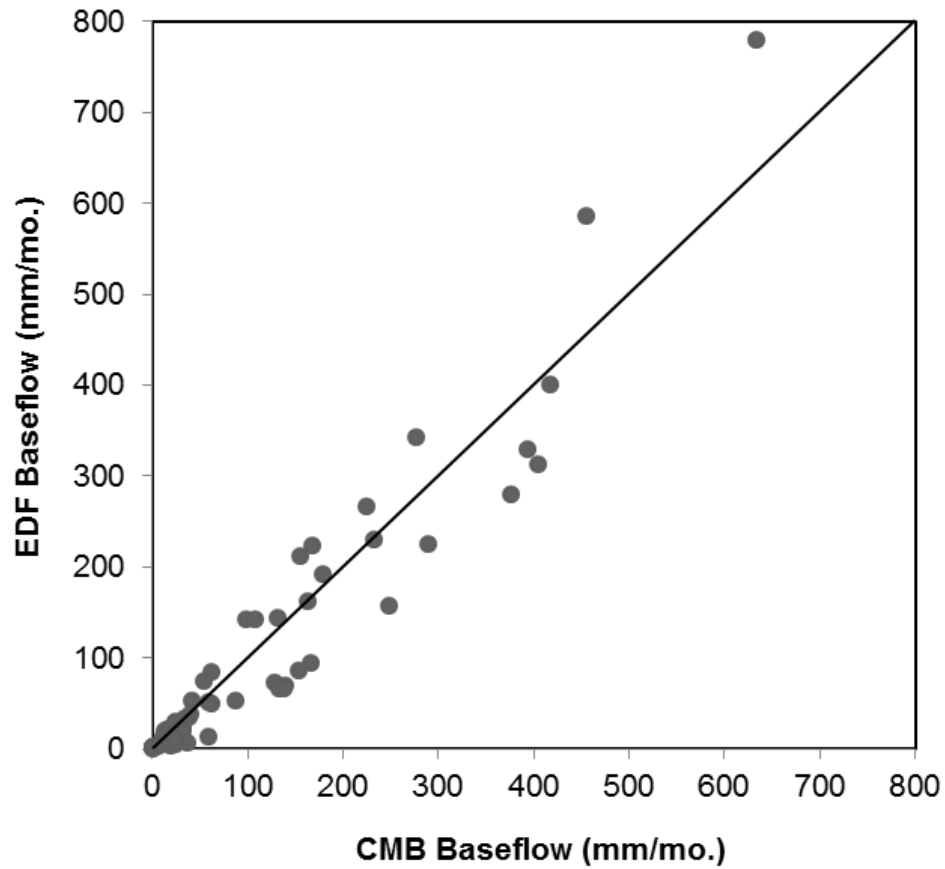


Fig. 2.

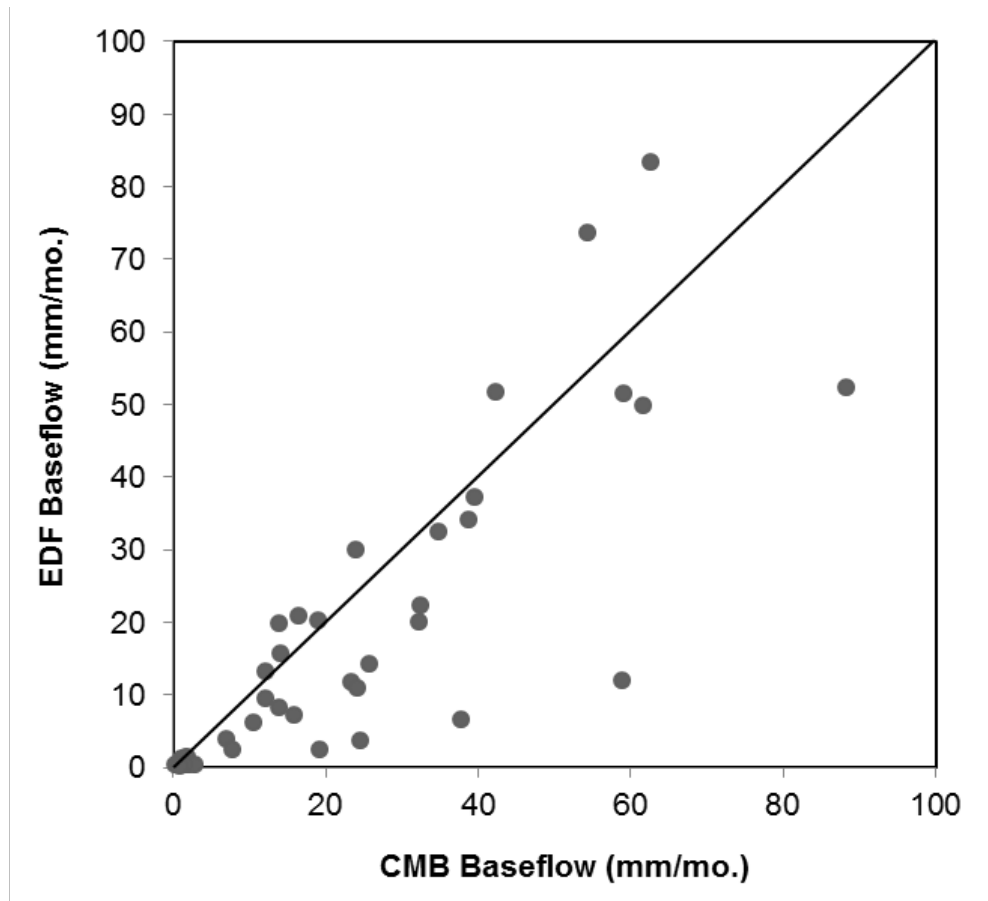


Fig. 3.