Hydrol. Earth Syst. Sci. Discuss., 11, C5821–C5828, 2014
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Discussions

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Interactive Comment

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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Thank you for your general comments about the papers, and in particular for the detailed review of the paper in your supplementary material. We agree with nearly all of the edits suggested there, and have updated the paper to reflect this. A modified version of the manuscript which reflects these changes, as well of those of the 2nd review, is included in the supplement file. A version which reflects the 3rd and 4th review is forthcoming.

As to the specific comments, please see the following:

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1) 12234/24-25: “present the results of the conductivity mass-balance work that were used to support the baseflow values obtained by the digital filter approach (a Figure plotting one vs. the other for the 2001-2009 period might suffice).”

Figure 1 is a plot of the values produced by the two methods at an annual timescale and figure 2 is at a monthly timescale. The y-axis is the output from the Eckhardt digital filter (EDF Baseflow) and the x-axis is the Conductivity Mass-Balance (CMB Baseflow), and the overlain black line is the one-to-one line. Both the annual and the monthly correlations were very high, with values of 0.958 and 0.956 respectively.

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 plot including all data points. 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.

2) 12239/8-9: “What are the actual values of tree densities in the plantations?”

Based on (unpublished) forest plot assessments conducted in the study watershed, the average tree density values are:

o Eucalypt, unevenly spaced (<15 yrs old): 1,600 trees/ha

o Eucalypt, evenly spaced, terraces (<5 years old): 1,500 trees/ha

o Eucalypt, flat terrain (<5 yrs old): 2,600 trees/ha

o Pines, unevenly spaced (<30 yrs old): 500 trees/ha

3) 12240/12: “In addition to more baseflow, baseflow comprised a larger fraction of total runoff.”

Edits were made to the text to reflect the increase in the proportion of baseflow.

4) 12241/6-10: “The authors could test this hypothesis (that soil hydrophobicity was responsible for the reduction in baseflow) by conducting a quickflow separation (using the Hewlett and Hibbert relation, or a similar separation method), and examining whether there has been any change in the number and magnitude of quickflow events and the ratio of quickflow to precipitation.”

Using a quickflow separation method such as the Hewlett and Hibbert relation would represent an alternative approach for assessing changes in streamflow characteristics in the study watershed. However, given that such methods are also based on division of the hydrograph data (similar to the baseflow separation we have applied), we are uncertain how this could be used to test the SWR hypothesis, as suggested by the reviewer.

It is interesting however to consider the results of this study within the context of the Hewlett and Hibbert's conceptualization of the four key factors driving the separation of quick and slow flow (McDonnell, 2009). Of the four, the average soil mantle depth or depth to a relatively impermeable layer is considered the most critical, followed by slope, and then the frequency / intensity of precipitation events. The fourth factor is land-use, which they consider to be superimposed on the effects of the other factors.

In the Agueda watershed, the first three of these factors can be considered to be relatively stable over the 75 year test period, while the fourth (land-cover) has changed substantially. Based on these factors, a corresponding change in the quick / slow flow proportion of streamflow (or as we have considered, the baseflow) would therefore be reasonable to expect. We see this impact in our baseflow trend analysis during the Eucalypt afforestation period, which we attribute to the changes in soil properties (i.e. SWR) induced by Eucalypts (as observed in the SWR field tests conducted in the study watershed).

5) 12241/12-14: "Should the order of this argument be reversed? I would have thought that a delay in breaking soil water repellency would lead to a longer recovery of soil moisture levels, since water would continue to move laterally over the surface of hydrophobic soils." This is a good point, as the two processes are certainly self-reinforcing, i.e. that a delay in soil wetting would lead to a delay in breaking SWR which would lead to a delay in soil wetting. However, it is important to note that high SWR does not entirely prevent soil wetting, and that plot studies here have shown that only part of the rainfall is converted to overland flow, regardless of how repellent the soil is. This is particularly important during large frontal storm systems, with persistent rainfall occurring over days or weeks, which will increase the soil moisture regardless of high SWR. Therefore, soil moisture is likely less impacted by SWR than the breakdown of SWR is on the soil moisture levels. However, we have modified the text to better reflect that these processes are self-reinforcing.

6) Table 2: "Include baseflow amounts." This has been added.

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7) Figure 6: “This should also include the baseflow quantity data and trend results.” Figure 6 includes only the precipitation, Q yield, and BFI results, as the results of the streamflow and baseflow quantity (in mm) do not add a large amount of additional data for analysis. An appendix is also included as supplementary material, which provides the results for streamflow and baseflow quantity, the values for all of the non-significant findings (which do not appear as lines in figure 6), and the lower and upper bounds of the Thiel-Sen trend. The authors decided that including additional information to figure 6 would make interpretation more difficult, without adding much value to the reader. Therefore it was decided to provide this information as a separate table.

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Cartwright, I., Gilfedder, B., and Hofmann, H. (2014). Contrasts between estimates of baseflow help discern multiple sources of water contributing to rivers. Hydrol. Earth Syst. Sci. 18, 15–30.

McDonnell, J.J. (2009). Hewlett, J.D. and Hibbert, A.R. 1967: Factors affecting the response of small watersheds to precipitation in humid areas. In Sopper, W.E. and Lull, H.W., editors, Forest hydrology, New York: Pergamon Press, 275–90. Progress in Physical Geography 33, 288–293.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/11/C5821/2014/hessd-11-C5821-2014-supplement.pdf

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

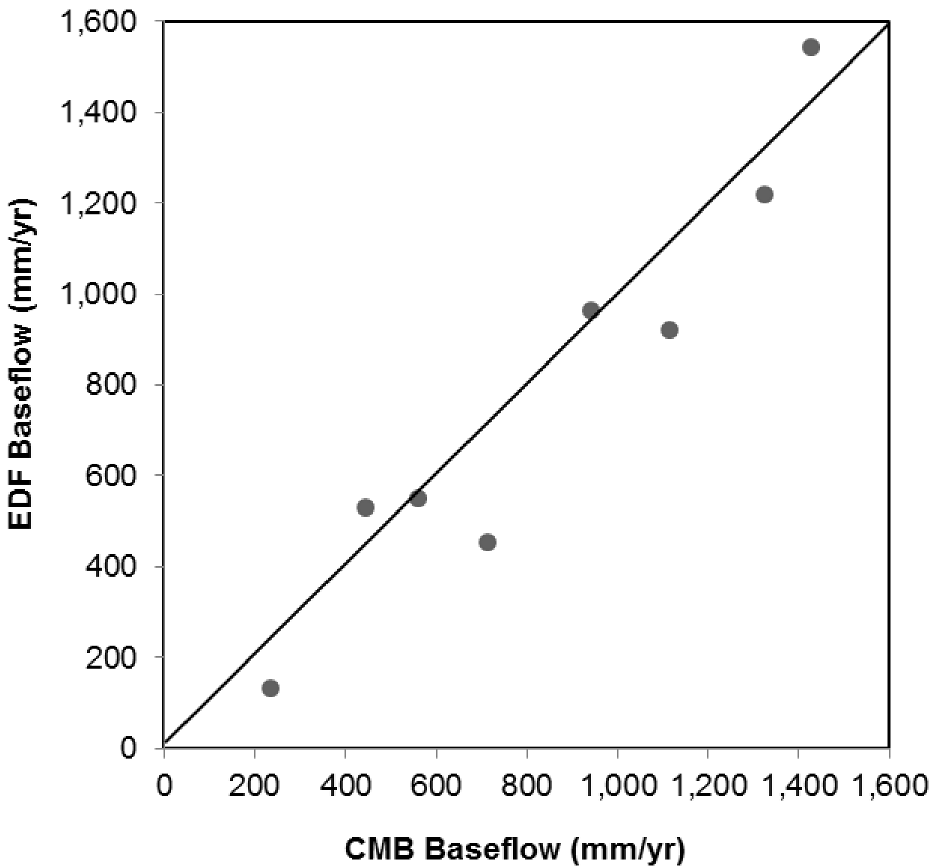

Fig. 1.

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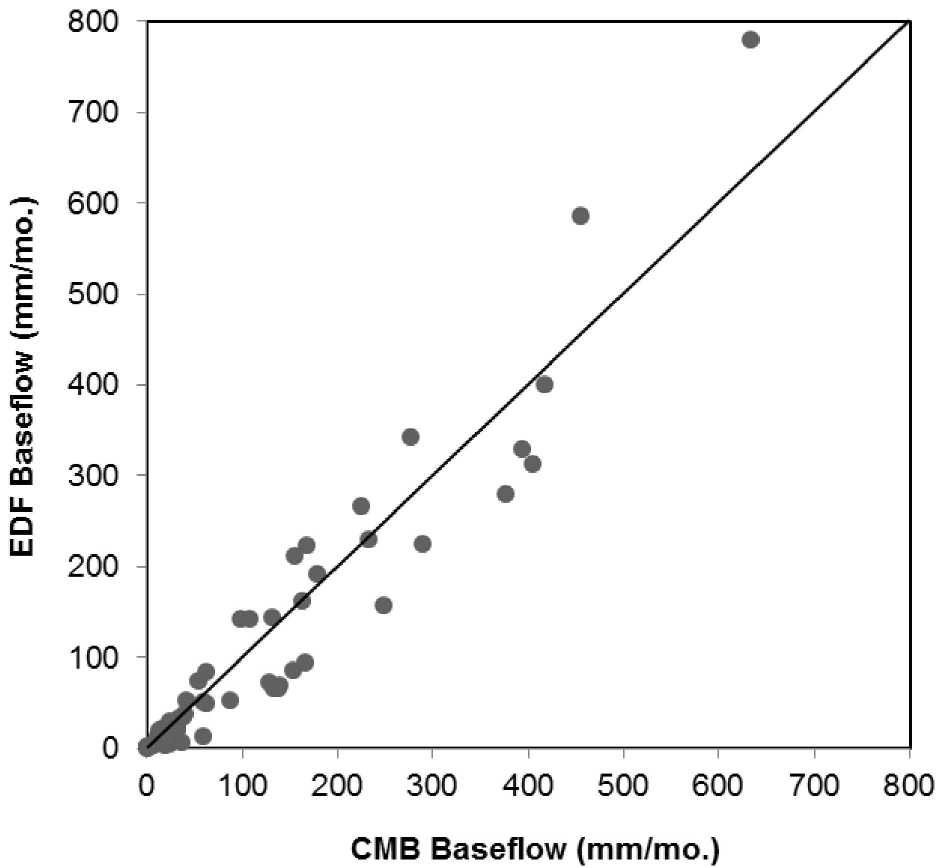

Fig. 2.

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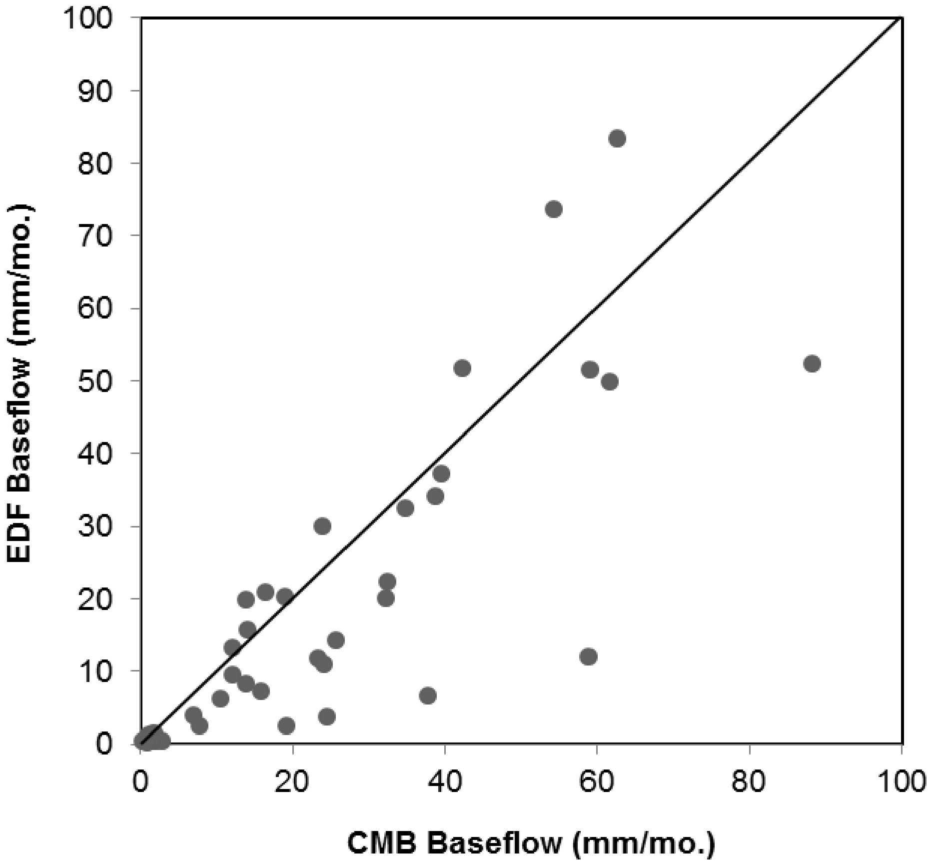

Fig. 3.

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