HESS-2022-186
Reply to the comments of referee 2

Generic comments

1 Lines 27 to 29 could be reworded to:

Several such recursive digital low-pass filters were subsequently presented. In the following, the filter developed by Eckhardt (2005) is considered in particular. It is now one of the established methods of hydrograph separation, for example it is part of the U.S. Geological Survey Hydrologic Toolbox (Barlow et al., 2022).
The “Eckhardt filter”, as it is oftentimes called, is usually counted among the non-physical or "purely empirical" (Healy, 2010, p. 87) methods of hydrograph separation.

2 As I already wrote in my reply to RC1, I intend to reword section 3.1 as follows:

Furey and Gupta (2001) introduced the parameter *d* in Eq. (5) as the number of time steps between precipitation and groundwater recharge. A sensitivity analysis they conducted showed that the filter performance was "relatively insensitive to changes in *d*" so that *d* = 0 seemed to be an acceptable choice. Furthermore, when using Eq. (1), it is assumed that not only the groundwater recharge but also the generation of baseflow still occurs in the same time step as precipitation. When assessing these prerequisites, two aspects should be considered:
(1) The streamflow component calculated with Eq. (1) is usually likely to consist not only of groundwater, but also of transient water sources, including interflow (Cartwright et al., 2014; Yang et al., 2021).
(2) In this publication, the algorithm of Eckhardt (2005) is compared to the model ideas of Furey and Gupta (2001) on the formation of baseflow. It is not compared to the reality. If the baseflow calculated with Eq. (1) occurs in Furey and Gupta's model world at the same time step as precipitation, this does not necessarily mean that it also corresponds to a runoff component in the real world that occurs without a relevant time lag to precipitation.

3 It is right that “using groundwater recharge to estimate such a parameter is just moving the problem to another problem”. I indicated this by putting quotation marks around the word ‘only’ in the phrase “Consequently, “only” a method for estimating mean groundwater recharge is needed to approximate BFI_{max}.” (lines 135 - 136).

Specific comments

- Lines 21-22: As I already wrote in my reply to CC2, I intend to reword the first paragraph of section 1 as follows:

  A catchment can be understood as a signal converter. The precipitation is the input signal that is converted into the output signal, streamflow. In the course of this signal conversion, the water takes different paths through the catchment and is subject to different hydrological processes. This results in streamflow components that are attenuated and delayed to varying degrees compared to the input signal, the precipitation. Usually, two components are distinguished: on the one hand, the so-called baseflow as a low-frequency signal component and, on the other hand, higher-frequency signal components that are generated more quickly and less attenuated in response to precipitation events, the so-called direct runoff. From this idea, it is obvious to low-pass filter streamflow hydrographs to identify these components.

- Equation (2): I intend to add the following to lines 59 to 62:

  (a) The information about the baseflow b_k of the current time step k lies in the baseflow b_{k-1} of the preceding time step $k-1$ and in the total streamflow y_k of the current time step:

  $$b_k = A\, b_{k-1} + B\, y_k \quad (2)$$

  with parameters A and B that are functions of the filter parameter a and for which $A > 0$ and $B > 0$ is assumed (Eckhardt, 2005, Eq. (8)).

- Line 147: I would like to explain the mentioned estimate by adding the following to the text:

Since the results of Eckhardt's filter are less sensitive to the parameter BFI_{max} than to the parameter a (Eckhardt, 2012), the estimate for BFI_{max} would not even have to be particularly accurate. The sensitivity of the baseflow index BFI to the parameter BFI_{max} can be described by the sensitivity index

$$S(BFI|BFI_{max}) = \frac{(a-1)(a\,BFI-1)}{(1-a\,BFI_{max})^2}\,\frac{BFI_{max}}{BFI} \quad (12)$$

(Eckhardt, 2012, Eq. (15)). For sixty perennial streams with porous aquifers, Eckhardt (2012) has found a mean sensitivity index of 0.26. That is, a relative error of X percent in BFI_{max} would result in a relative error of 0.26 times X percent in BFI. Thus, even if BFI_{max} had an uncertainty of up to about 40 %, this would probably produce an uncertainty of less than 10 % in the calculated baseflow index.

- In the references it would be necessary to add:

Barlow, P. M., McHugh, A. R., Kiang, J. E., Zhai, T., Hummel, P., Duda, P., and Hinz, S.: U.S. Geological Survey Hydrologic Toolbox - A graphical and mapping interface for analysis of hydrologic data: U.S. Geological Survey Techniques and Methods, book 4, chap. D3, 23 p., https://doi.org/10.3133/tm4D3, 2022.