Lyne-Hollick Filter

The Lyne-Hollick digital filter technique was first suggested in 1979 (Lyne and Hollick 1979). The technique is derived from signal analysis, namely high-pass filters where the signal (streamflow) is separated into high-frequency (quick flow) and low-frequency (base flow) components.

This recursive digital filter[1] that uses a single parameter, alpha (α) , to control the separation between base flow and quick flow. The filter is applied in both forward and backward directions to minimize phase distortion.

The equations for the Lyne-Hollick filter are as follows:

$$b = \alpha b_{k-1} + \frac{1-\alpha}{2}(Q_k + Q_{k-1})$$

where b is base flow, α is the filter parameter, Q is the total streamflow, and k is the time step.

Parameters

α

The filter parameter, α, controls the attenuation of base-flow separation from the streamflow record.

The α is typically set between 0.90 and 0.95 [Nathan and McMahon (1990);]. A higher value of α results in greater signal attenuation (lower base flow estimate), while a lower value allows for less signal attenuation (greater base flow estimate).

[1] In signal processing, a recursive filter is a type of filter which reuses one or more of its outputs as an input (eg. streamflow)

Number of passes

The Lyne-Hollick filter can be applied in both forward and backward directions to minimize phase distortion[2]. Often, the filter passes over the streamflow data three times: forward, backwards, and forwards again.The number of passes determines the smoothness of the base flow estimate, with more passes resulting in a smoother base flow.

Considerations

- The Lyne-Hollick filter is sensitive to the choice of α, and it is recommended to test different values to find the most appropriate one for a given dataset.
  - Commonly used values are between 0.90 and 0.95, but the optimal value may vary depending on the hydrological characteristics of the watershed being studied (Nathan and McMahon 1990).
- The Lyne-Hollick filter is best suited for continuous streamflow records and may not perform well with datasets that have significant gaps or irregular sampling intervals
- The filter may not accurately capture base flow during extreme hydrological events, such as floods or droughts, where the assumptions of slow base flow changes may be violated. (Lyne and Hollick 1979)
- The filter does not have a physical basis and is purely a mathematical construct, which may limit its applicability in certain hydrological studies (Eckhardt 2008, 2023)
  - However, the technique does provide objective, repeatable base-flow separation that is easily automated (Nathan and McMahon 1990).

References

Eckhardt, K. 2008. "A Comparison of Baseflow Indices, Which Were Calculated with Seven Different Baseflow Separation Methods." *Journal of Hydrology* 352 (1-2): 168–73. https://doi.org/10.1016/j.jhydrol.2008.01.005.

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Nathan, R. J., and T. A. McMahon. 1990. "Evaluation of Automated Techniques for Base Flow and Recession Analyses." *Water Resources Research* 26 (7): 1465–73. https://doi.org/10.1029/WR026i007p01465.

[2]Alteration of the signal's shape by a filter modulating different frequencies by different amounts.