Improved baseflow characterization in mountainous catchments

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Shortcomings of conventional method

Global change adversely affects contributions of groundwater aquifers and other delayed sources to streamflow (e.g., snowmelt, outflow from wetlands or lakes). Based on frequency filtering of hydrographs, conventional graphical baseflow separation methods separate quickflow and baseflow from streamflow (UK-H- or WMH-method [1,2]). The method was developed in humid, lowland catchments where groundwater is the dominant control of baseflow and quickflow is assumed to disappear after 5 days. These assumptions are not appropriate for higher elevation catchments!

Methods

DATA & CLASSIFICATION

- BFI estimates are inverse to mean catchment elevation below 1000 m a.s.l.
- Application UK-H/WMH baseflow separation leads to an overestimation of the baseflow component in higher elevation catchments.
- Only two contributing basins are considered due to the fixed filter width of 5 days.
- It is realistic to assume that all contributions younger than 5 days are ‘quickflow’.

OBJECTIVES

1) To implement a baseflow separation procedure that considers multiple contributing sources with specific delays.
2) To classify contributing sources in order to determine their origin with measures of constancy and seasonality (Colwell’s predictability).
3) To test whether a simple classification scheme based on catchment elevation is able to predict similarity of catchments according to relative contributions in different delay classes.

Multiple delayed contributions to streamflow

- Colwell’s [4] developed a simple measure based on information theory to assess the uncertainty of a periodically fluctuating variable (here: mean monthly streamflow).
- Inverse uncertainty can be seen as Predictability P (pl-1), which is additive component of Contancy C and Contingency M (Desoer’s [5]).

- Delayed contributions to streamflow

- Shape, slope, derivation and base level of CDOs are important descriptors of delayed source.
- Short delayed contributions ( ≤ quickflow) diminish after 3 days (breakpoint 1).
- Intermediate delays vary strongly among different catchment groups (breakpoint 3).
- Strong relationship (R²) is found between flow mean (MAMMARQ) and BFI60 (maximum filter width of 60 days).
- BFI60 characterizes sustainability of baseflow.
- Delay-patterns vary among catchment groups and elevation.
- Longer delays in lowland (PLU), shorter delays in montane (PLS-TRA), more intermediate delays in alpine catchments (NIU).

Baseflow characterization with constancy and seasonality of streamflow regimes

- The U-shaped relationship between “Mean Elevation” and “Predictability P” suggests more short-delayed contributions and smaller water storages in catchments between 600-1500 m a.s.l.
- Higher Contancy C indicates stronger groundwater-control and is correlated with contributions in the “baseline delay” (PLU, PLS, TRA, NIU).
- Higher Contingency M - as a measure for seasonality - indicates stronger control of transient, seasonal contributions and is correlated with intermediate delay class (NIU > TRA/PLS/PLU in class X2).
- Only weak correlations between Predictability P and other catchment characteristics (e.g. area, mean slope, drainage density) were found.

Conclusions

- Graphical baseflow separation with variable filter widths allow to consider and identify multiple delayed contributions to streamflow.
- An elevation-based classification scheme is feasible to distinguish streamflow contribution in different delay classes.
- Origin of delayed sources can be identified by Colwell’s Predictability (e.g. stormflow, snowmelt or groundwater depletion), which also show lowest water storage capacity in montane catchments.
- Delays shorter than 60 days are associated with constancy (pluvial regime and/or seasonality) (pluvial regime), delays longer than 60 days characteristic the sustainability of baseflow.

References


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