Improved baseflow characterization in mountainous catchments

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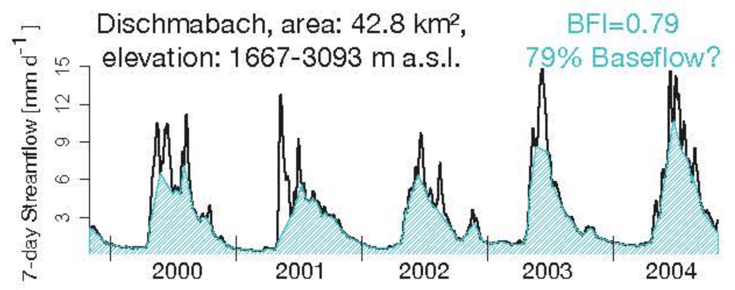
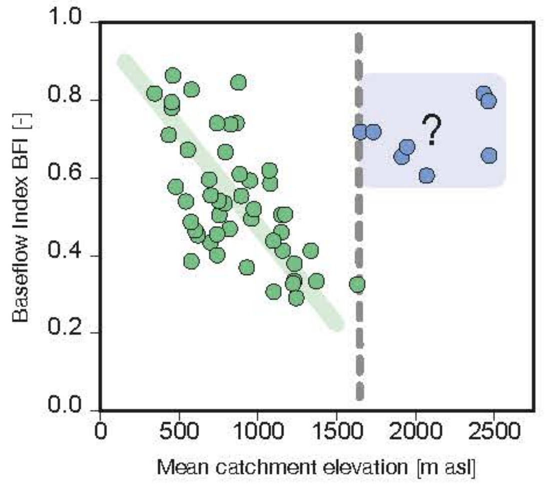
Shortcomings of conventional method

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-IH- or WMO-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!



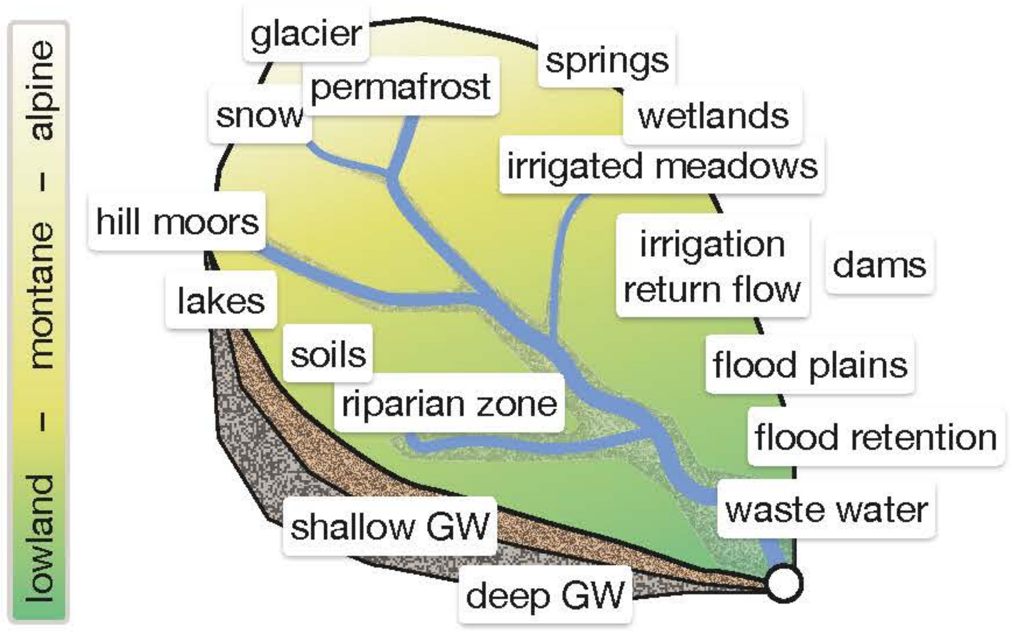


- BFI estimates are inverse to mean catchment elevation below 1600 m asl.
- Application UK-IH/WMO baseflow separation leads to an overestimation of the baseflow component in higher elevation catchments.
- Only two contributing sources are considered due to the fixed filter width of 5 days.
- Is it realistic to assume that all contributions younger than 5 days are 'quickflow'?

Objectives

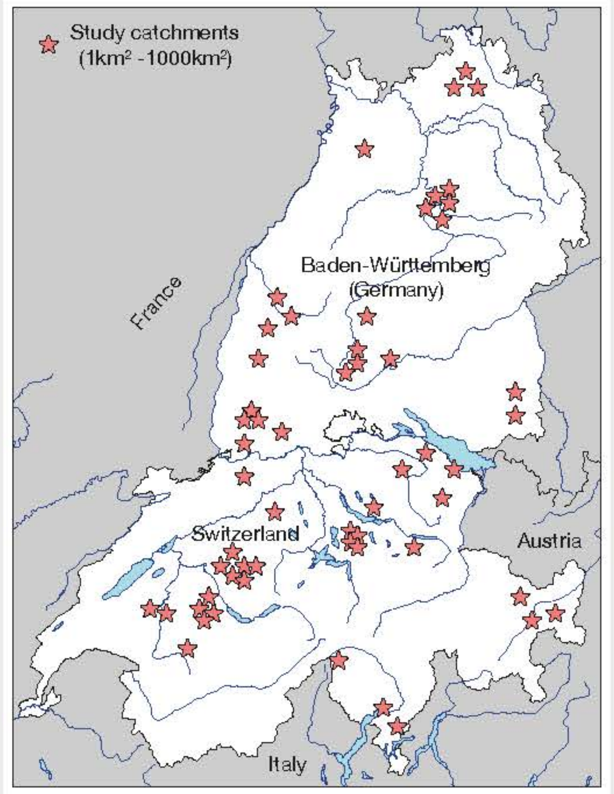
1) To implement a baseflow separation procedure that considers multiple contributing sources with specific delays.
2) To classify contributing sources in order to determine their origins with measures of constancy and seasonality (*Collwell's Predictability*).
3) To test whether a simple classification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

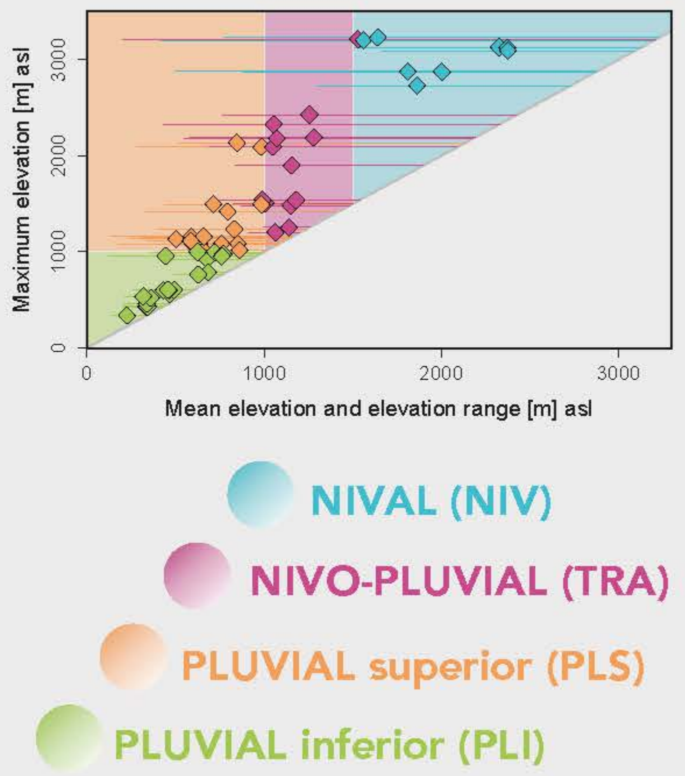
Multiple delayed contributions to streamflow



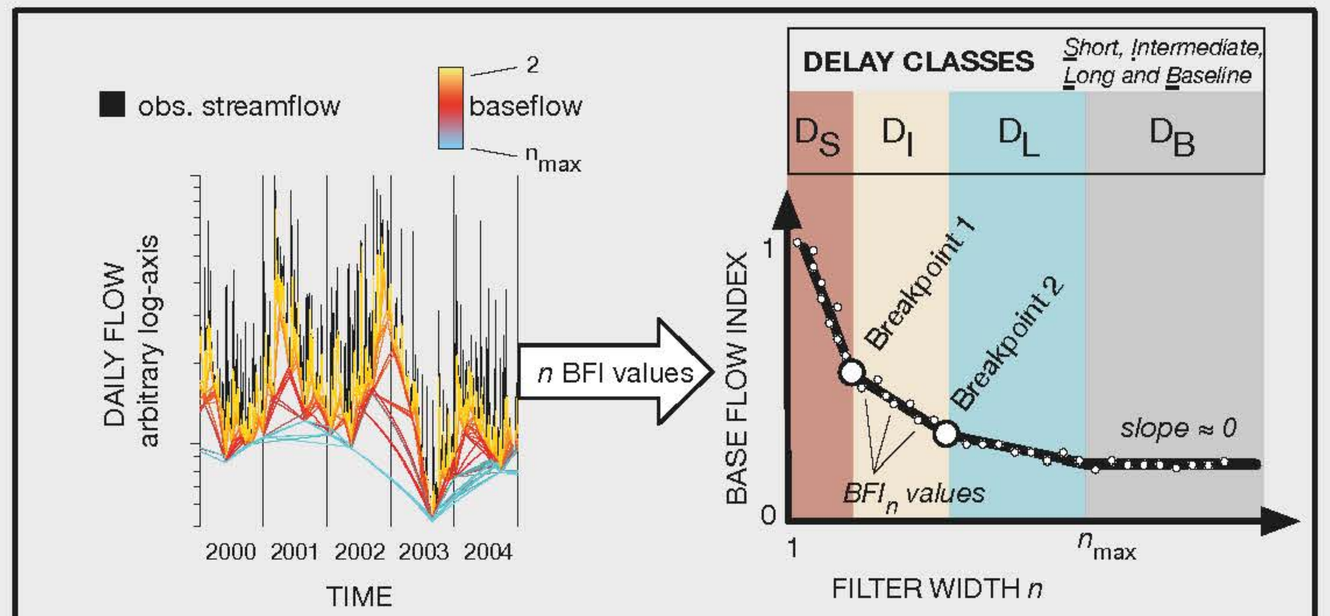
Methods

DATA & CLASSIFICATION





NEW BASEFLOW SEPARATION



- Baseflow separation is based on minima streamflow values of every *n*-day period. For each filter width *n* a BFI (baseflow / streamflow) is calculated.
- Relationship between BFI values and filter widths *n* is piecewise linear and the two breakpoints indicate a characteristic change of slope between segmented linear regressions [3].
- Maximum filter width *n.max* is identified when BFI is almost equal to a low flow metric (*mean annual minimum flow / mean flow*) for all catchments.

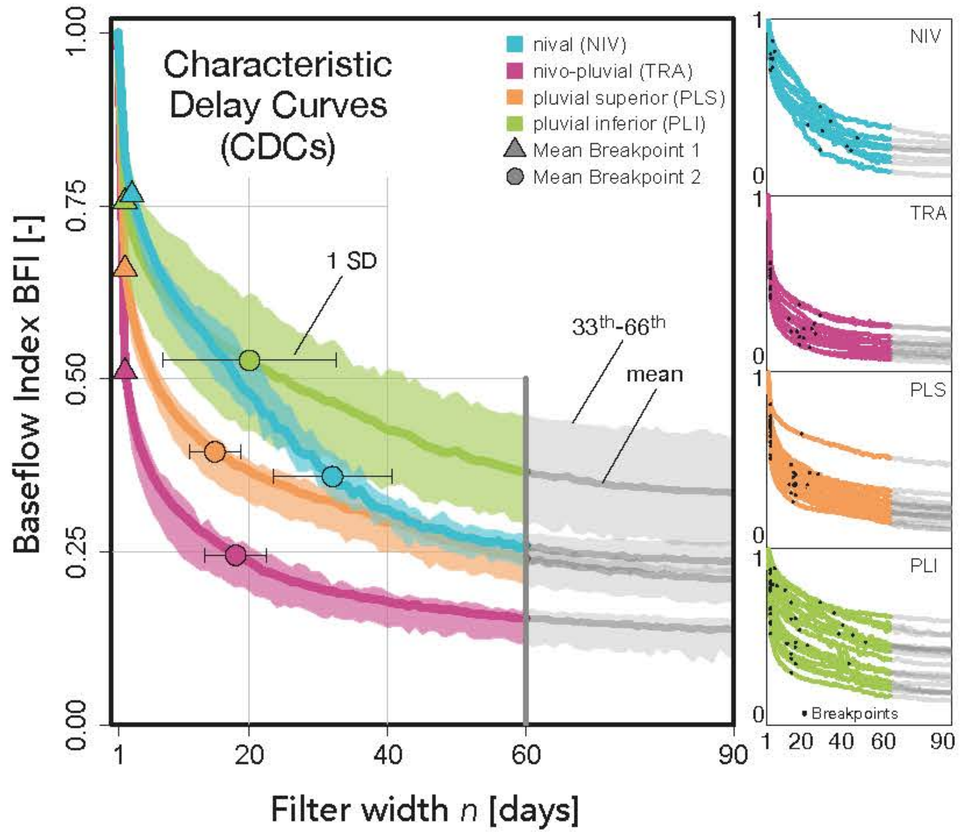
COLWELL'S PREDICTABILITY

- Colwell [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 [0-1] which is additive composed of Constancy C and Contingency M (*Seasonality*).

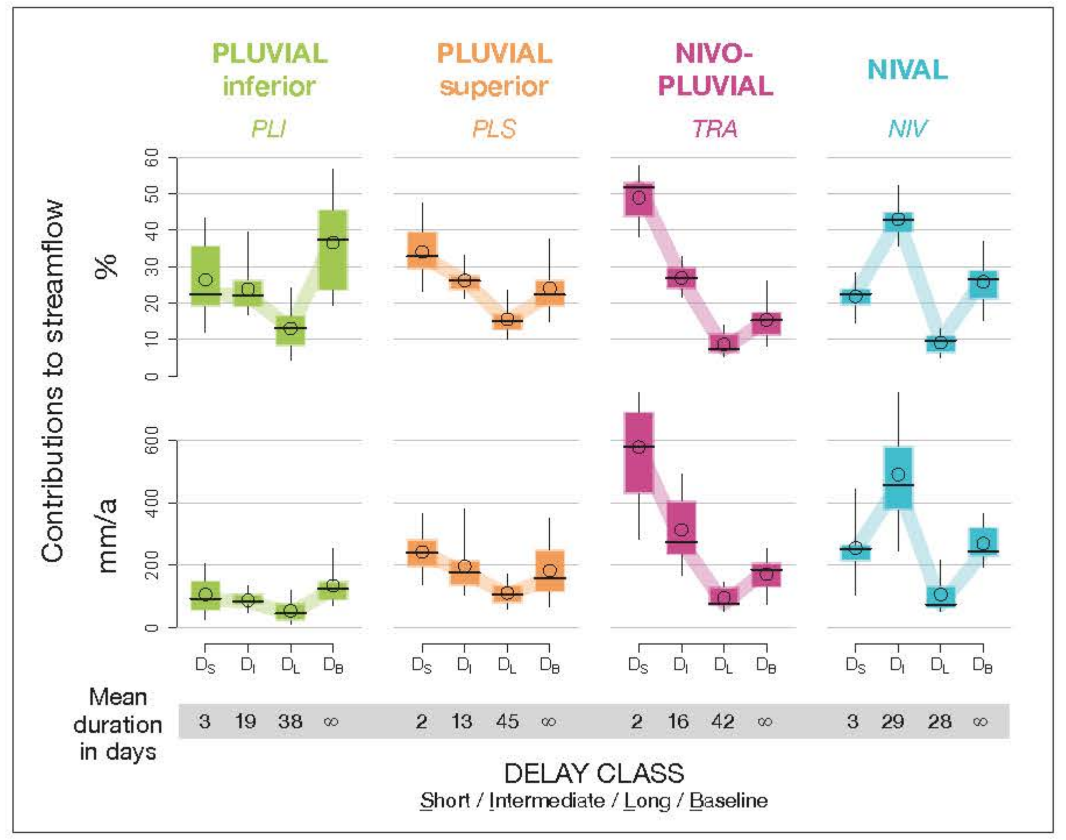
2 Examples: Regime stage in different seasons in 30 years of data.

		Season A	Season B	Season C	
"Constant regime in all years" – Streamflow	high	0	0	0	C=1
	mean	30	30	30	M=0
	low	0	0	0	P=1
"Strong seasonality in all years" – Streamflow	high	30	0	0	C=0
	mean	0	0	30	M=1
	low	0	30	0	P=1

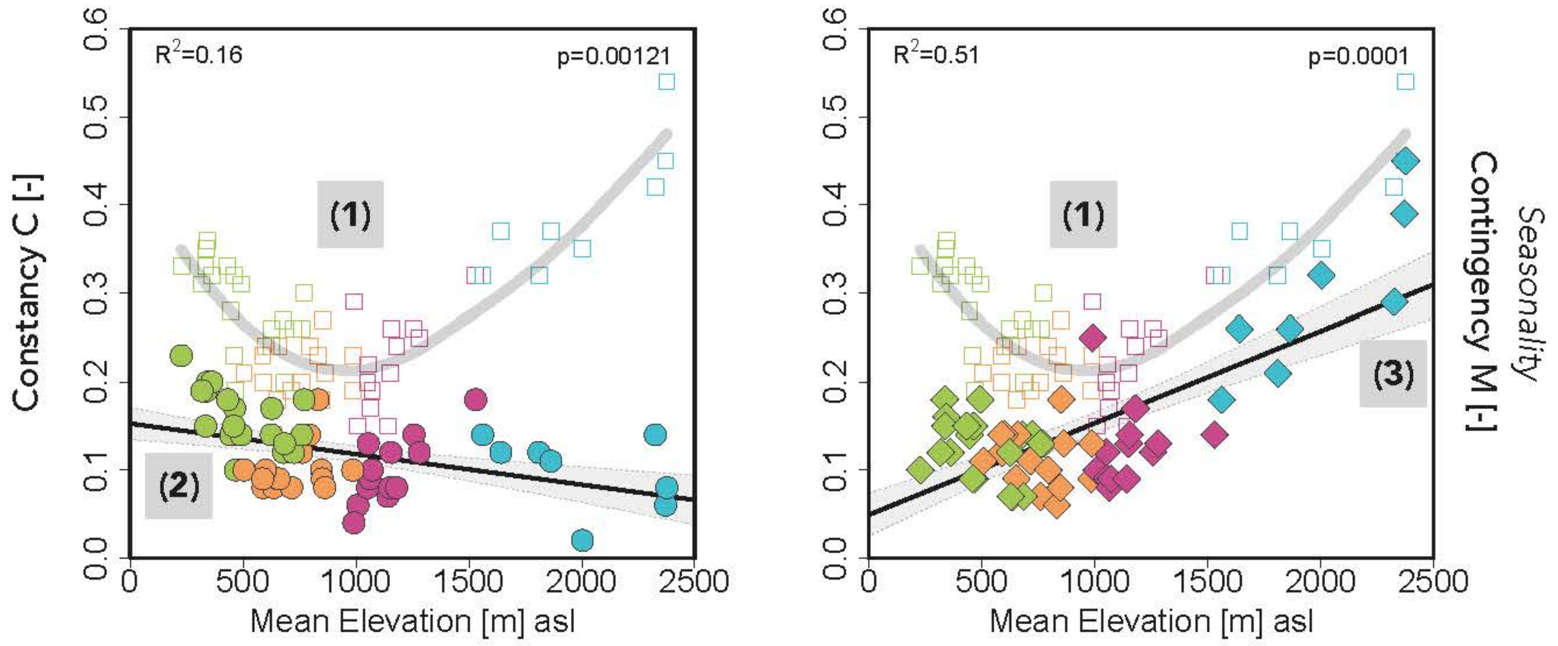
Delayed contributions to streamflow



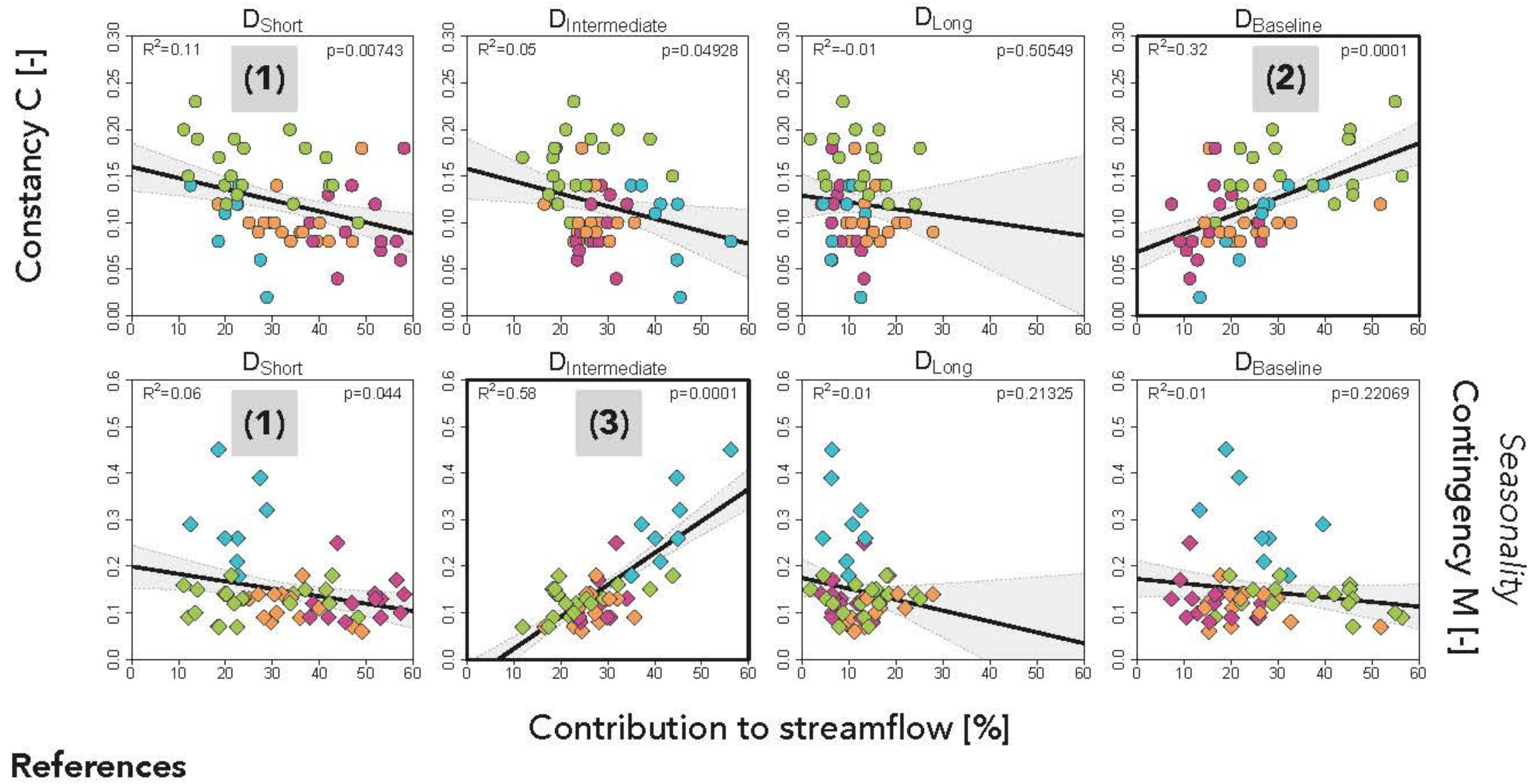
- << Shape, slope, derivation and baseline level of CDCs are important descriptors of delayed sources.
- << Short delayed contributions (=quickflow) diminish after 3 days (Breakpoint 1).
- << Intermediate delays vary strongly among different catchment groups (Breakpoint 2).
- << Strong relationship (R^2>0.99) is found between low flow metric (MAM/MQ) and BFI60 (maximum filter width of 60 days).
- << BFI60 characterizes sustainability of baseflow.
- >> Delay-patterns varied among catchment groups and elevation.
- >> Longer delays in lowland (PLI), shorter delays in montane (PLS+TRA), more intermediate delays in alpine catchments (NIV).



Baseflow characterization with constancy and seasonality of streamflow regimes



- **(1)** The *U-shaped* relationship between "Mean Elevation" and "Predictability P" suggests more short-delayed contributions and smaller water storages in catchments between 800-1500 m asl.
- **(2)** Higher Constancy C indicates stronger groundwater-control and is correlated with contributions in the "baseline delay" (PLI > PLS > TRA/ NIV in $D_{Baseline}$).
- **(3)** Higher Contingency M - as a measure for seasonality - indicates stronger control of transient, seasonal contributions and is correlated with intermediate delay class (NIV > TRA/PLS/PLI in class $D_{Intermediate}$).
- **(4)** 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** allows to consider and identify multiple delayed contributions to streamflow.
- An **elevation-based classification scheme** is feasible to distingush 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 indicates lowest water storage capacity in montane catchments.
- Delays shorter than 60 days are associated with **constancy** (pluvial regimes) and/or **seasonality** (nival regimes), delays longer than 60 days characterize the **sustainability** of baseflow.

References

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