



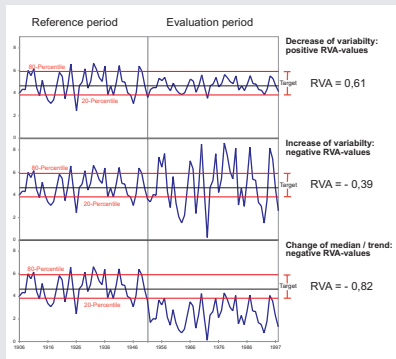
Assessment of Impacts on Stream Flow Magnitude and Variability based on the Natural Flow Paradigm

Objectives

The integrity of river ecosystems is related to the natural intra- and interannual variation of stream flow. Environmental flow requirements therefore have to consider different aspects of the hydrological regime instead of focusing on specific thresholds. The assessment system "Hydrological Quality" is based on the "Natural Flow Paradigm" and therefore quantifies alterations in stream flow in relation to the natural or semi-natural hydrological regime of the catchment.

Quantification of hydrological alteration

Comparison of IHA-variables in evaluation and reference periods



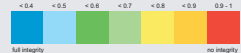
Range of Variability Approach (RVA), (Richter et al. 1997):

$$RVA = \frac{(n(n+Target) E / n E) - (n(n+Target) R / n R)}{(n(n+Target) R / n R)}$$

Ecological flow requirements:

The reference period represents stream flow under natural conditions or conditions prior to investigated impacts. Ecological integrity is maintained if the RVA remains in certain limits close to zero

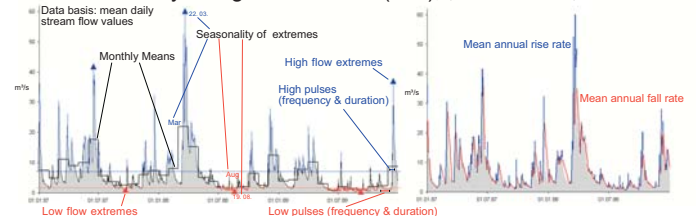
Classification based on absolute RVA-values:



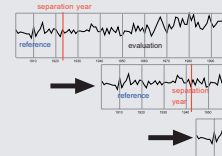
The reference period can either be a measured time series or a simulation result. Usually natural conditions of stream flow have to be simulated using water-balance models.

Parameterization of stream flow variability:

Indicators of Hydrological Alteration (IHA), (Richter et al. 1996)



Quantification of gradual alteration



Moving separation of the time series:

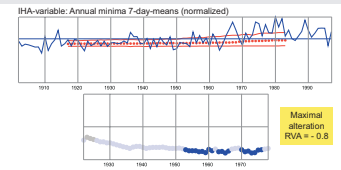
RVA-values are calculated for all possible separation years resulting in a time series of RVA values.

The minimal length of each period (reference or evaluation) is 20 years.

The degree of the alteration is given by the maximal / minimal RVA-value.

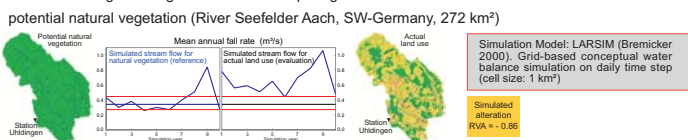
Example: Gradual alteration of low flows (River Inn, Austria / S-Germany, 9712 km², Station Oberaudorf)

- IHA-variable: Annual minima 7-day-means (normalized)
- Median
- Moving median (30 years)
- Percentiles (30 years)
- RVA < -0.7
- 0.7 < RVA < -0.4
- 0.4 < RVA < 0.4
- 0.4 < RVA < 0.7
- RVA > 0.7

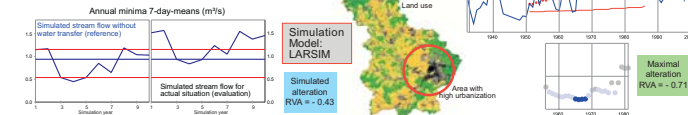


Alterations resulting from human impacts

Land use change: Change of rise rates comparing simulated stream flow for actual land use and potential natural vegetation (River Seefelder Aach, SW-Germany, 272 km²)



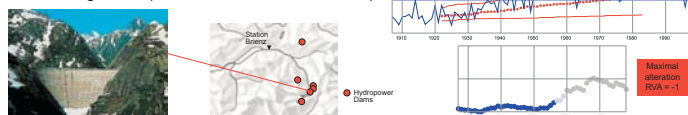
Urbanization: Change of low flows due to water transfer (River Würm, SW-Germany, 417 km²)



Flood protection: Change of high flows due to dam building between 1957 and 1982 (River Lein, SW-Germany, 246 km²)



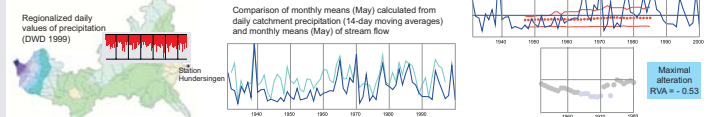
Hydropower: Change of complete hydrological regime due to storage dams (River Aare, Switzerland, 554 km²)



Alterations resulting from climatic impacts

Climatic impacts on hydrological alterations are analysed using daily values of catchment precipitation

Precipitation input: Change of monthly means in May due to increased precipitation (River Danube, SW-Germany, 2639 km²)



Discussion and conclusion

- A central element of the assessment procedure is the reference to individual flow conditions of specific rivers. Ecological flow requirements are represented by the IHA-variables which describe magnitude and variability of stream flow. The assessment of ecological integrity is based on the quantification of hydrological alteration resulting from human or climatic impacts.

- A prerequisite of the assessment are time series of daily stream flow which cover periods prior and after the investigated impact. Alternatively stream flow simulations can be used to quantify alterations which are not documented by station measurements.

References:

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- DWD (Deutscher Wetterdienst) (1999): Bereitstellung von langen Reihen interpolierter Gitterpunkte des Niederschlages (Tageswerte) mit Hilfe des Verfahrens BONIE für Baden-Württemberg. Bericht des KLWA-Projektes (Klimawandel und Konsequenzen für die Wasserwirtschaft), A1.1.1/BW.
- Richter, B.D., Baumgartner, J.V., Powell, J., Braun, D.P. (1996): A Method for Assessing Hydrologic Alteration within Ecosystems. Conservation Biology, 10, 4, 1163-1174.
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