Towards low flow risk maps

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Introduction

Extreme low flows have direct and indirect negative impacts on socio economic and ecological functions of rivers. These negative effects determine **local risk** as a function of the regional drought hazard and the river system's vulnerability. Todays recommendation for action to reduce the impacts of low flow are mostly based on hazard information.

Often only **site-specific information** (gauging stations) represents the entire catchment. Vulnerability information, especially on water uses, are only sparsely available. Hence, a comprehensive understanding of the drivers of **low flow risk along the longitudinal river profile** is often lacking.

Objectives

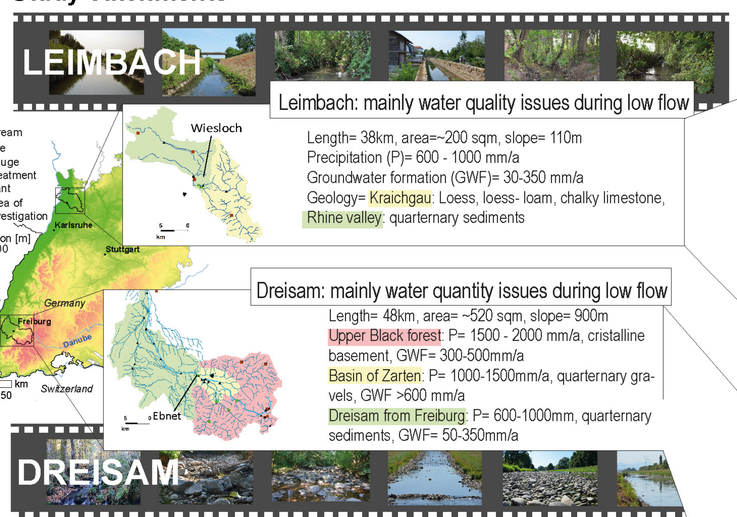
- **Develop an approach to asses low flow risk,**
- **Compare site specific vs. longitudinal analysis,**
- **Visualise the tangle of effects of water uses.**

The approach is inspired by *UNISDR drought risk definition*: **drought risk = hazard x vulnerability**

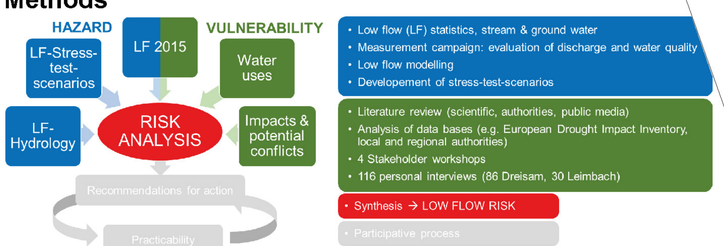
We follow the recommendations of components to be included in drought risk analysis:

- Analyse the hazard, past and future
- Visualise past impacts
- Assess the vulnerability to low flow
- Estimate potential impacts

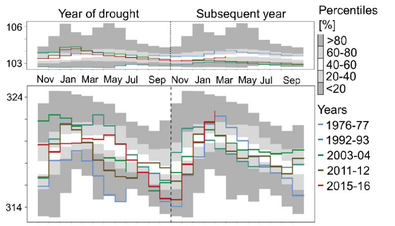
Study catchments



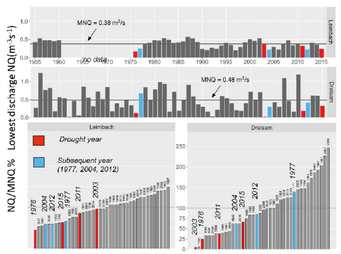
Methods



Site-specific analysis



Annual cycle of monthly groundwater levels, upper: Leimbach, lower: Dreisam, drought years & subsequent are highlighted. Annual cycles of entire period of investigation in grey.



Period of time 1976-2015 (sorted by NQ/MNQ %)

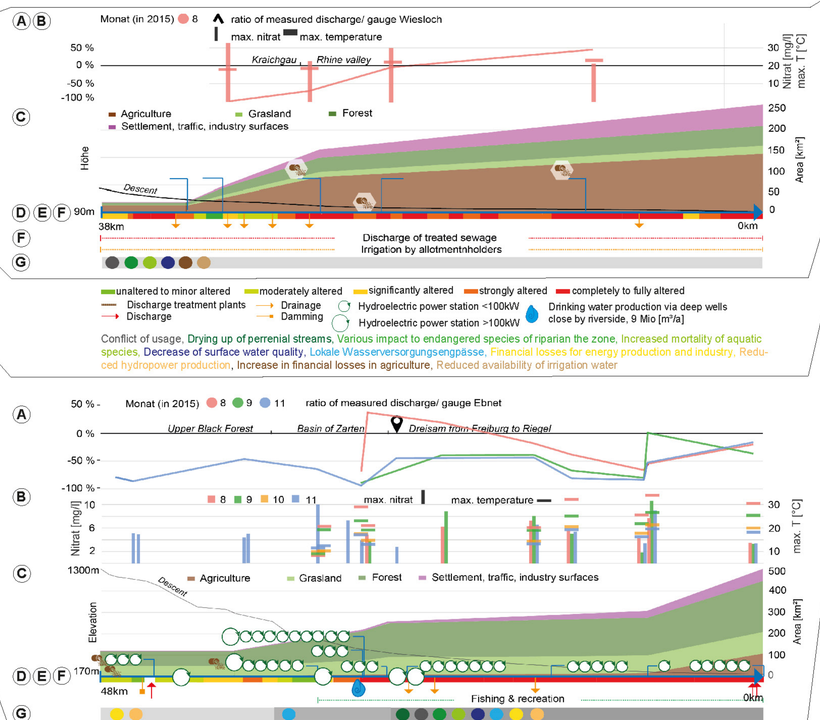
Low flow indices NQ (lowest discharge) and MNQ (mean low flow)

Longitudinal analysis

Longitudinal profiles provide local information along the stream: hazard or vulnerability components of low flow risk.

Data sources: Governmental reports, public statistics, field surveys and questionnaires etc...

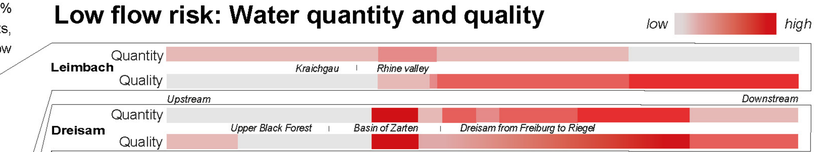
A: water quantity: ratio of own discharge measurements and gauge discharge, **B:** water quality: Nitrate concentration and water temperature (monthly) **C:** elevation profile and land use (% area), **D:** structural quality of the stream, **E:** Inlets, Outlets, discharge of treatment plants (ratio %), **F:** water usage **G**: low flow impacts (European Drought Impact Inventory).



Synthesis: Site-specific vs. Longitudinal

Punctual aspects (gauge data)	Leimbach	Dreisam
Relevant groundwater formation periods	~ 17 month	~ 3.5 month
Most extreme low flow events (sorted)	1976, 1997, 1991	2003, 1992, 1976
Impact on runoff & groundwater level of short meteorological droughts	small	strong
Impact runoff & groundwater level of lasting meteorological droughts	strong	strong
Regeneration of runoff	slowly	fast
Susceptability to climate changes following COSMO CLM	small	strong
Temporal horizon for low flow management	long-term	short-term
Longitudinal aspects (downstream)	**Leimbach**	**Dreisam**
Discharge during low flow	Increase	high variability
Water quality	Decrease	Fluctuating, Decrease
Landuse	Agriculture, Settlements	Forestry, Grasland, Agriculture, Settlements
Increasing water demand	Yes	Yes
Usage of water ressources in catchment	few springs, groundwater	Springs (upper black forest), public water supply, groundwater
Water uses (stream)	Sewage water inlet, tourism (water park), private irrigation	Public water supply (indirect: usage of near stream wells), Energy production, industry, tourism, recreation, aquaculture, private irrigation, ecology
Impacts due to low flow	Ecology	Public water supply, energy production, industry, ecology
Outlet restrictions during low flow	No	Yes
Low flow / drought management	No	No

Low flow risk: Water quantity and quality



Discussion

This study analysed **low flow risk** as a function of the **hazard** and **vulnerability** in a qualitative manner.

Applying a transdisciplinary approach:

- hazard component is assessed by hydro-climatic analysis
- vulnerability component is estimated by a combination of impact assessment and vulnerability estimation.

Both approaches are needed to gather a comprehensive understanding of local low flow risk!

Site-specific analysis have the advantage of long time series (major low flow events and long term trends) in combination with catchment properties.

The new **longitudinal profiles** are merely based on qualitative data, not time series. The presented results gave insights on local drivers of drought risk along the rivers. Hazard is not distributed uniformly and thus questions the representativity of commonly used gauges.

The analysed vulnerability illustrated the variety of water use interests along the river, and highlighted **hot spots** of potential user conflicts.

The results show **distinct patterns in low flow risk** between the catchments and along the river.

Reasons for these patterns are:

- hydrogeological characteristics that govern groundwater-surface water interaction,
- catchment-specific anthropogenic stimuli such as low flow decrease by near-stream groundwater pumping for public water supply or low flow augmentation by treatment plant discharges.

This work calls for a **comprehensive spatially variable consideration of flow characteristics and human influences** to analyse low flow risk. Highlighting these, this work is a first step towards **low flow risk maps**.

Conclusion

- Low flow risk = network of climate, catchment characteristics and anthropogenic usage
- Site-specific analysis are insufficient to assess low flow risk for entire catchments
- Low flow hazard should be analysed seperately for water quantity and water quality
- Water uses and past impacts are keys to understand local vulnerability
- Stakeholder information are essential to obtain a comprehensive understanding of local and sector specific drivers of risk

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UNISDR: Drought Risk Reduction, Framework and Practices, Contributing to the Implementation of the Hyogo Framework for Action, Geneva: United Nations secretariat of the International Strategy for Disaster Reduction (UNISDR), 2009.

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