Groundwater Drought under Climate Change
A Statistical Approach

UNI FREIBURG

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INTRODUCTION

BACKGROUND

Groundwater is the main natural water storage. It serves as a vital water source for public water supply and agricultural irrigation. During periods without precipitation groundwater baseflow sustains streamflow. Therefore, low groundwater storage ("groundwater drought") can affect both economy and ecosystem functioning. Climate change is expected to affect all parts of the hydrological cycle. The lack of appropriate datasets of groundwater wells impedes efforts to determine the impact of climate change on groundwater storage & drought on a scale relevant for groundwater managment.

OBJECTIVES

Regional analysis of groundwater dynamics on catchment scale

Identification of changes of groundwater drought under a climate change scenario

Comparison of past changes in groundwater drought with predicted future changes

DATA & METHODS

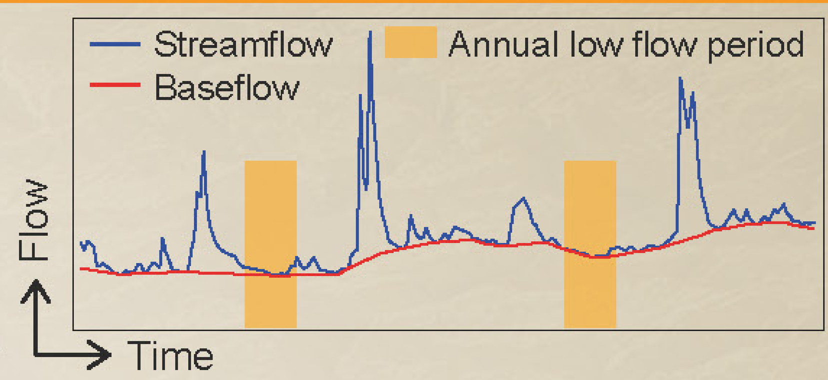
DATA

338 catchments below 200 km²

Daily timeseries for 1970-2009:

- Precipitation (E-OBS dataset)[1]
- Streamflow
- Baseflow

calculated according to WMO (2008)[2]



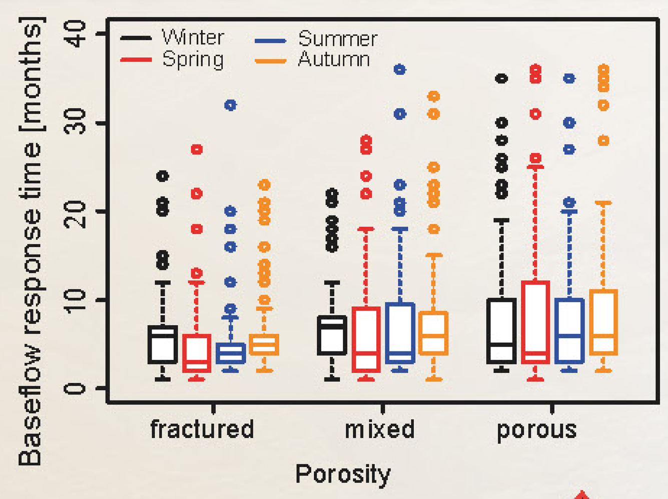
ANALYSIS

Timeseries were standardized according to the procedure of the Standardized Groundwater Index (SGI)[3]. To determine response times of streamflow and baseflow, precipitation values were accumulated for different lengths (1 - 36 months) and seasonally correlated with baseflow.

Climate Change is expected to increase precipitation in winter and decrease precipitation in summer[4, 5]. Catchment response times indicate whether these particular changes will also cause respective changes in annual low flows.

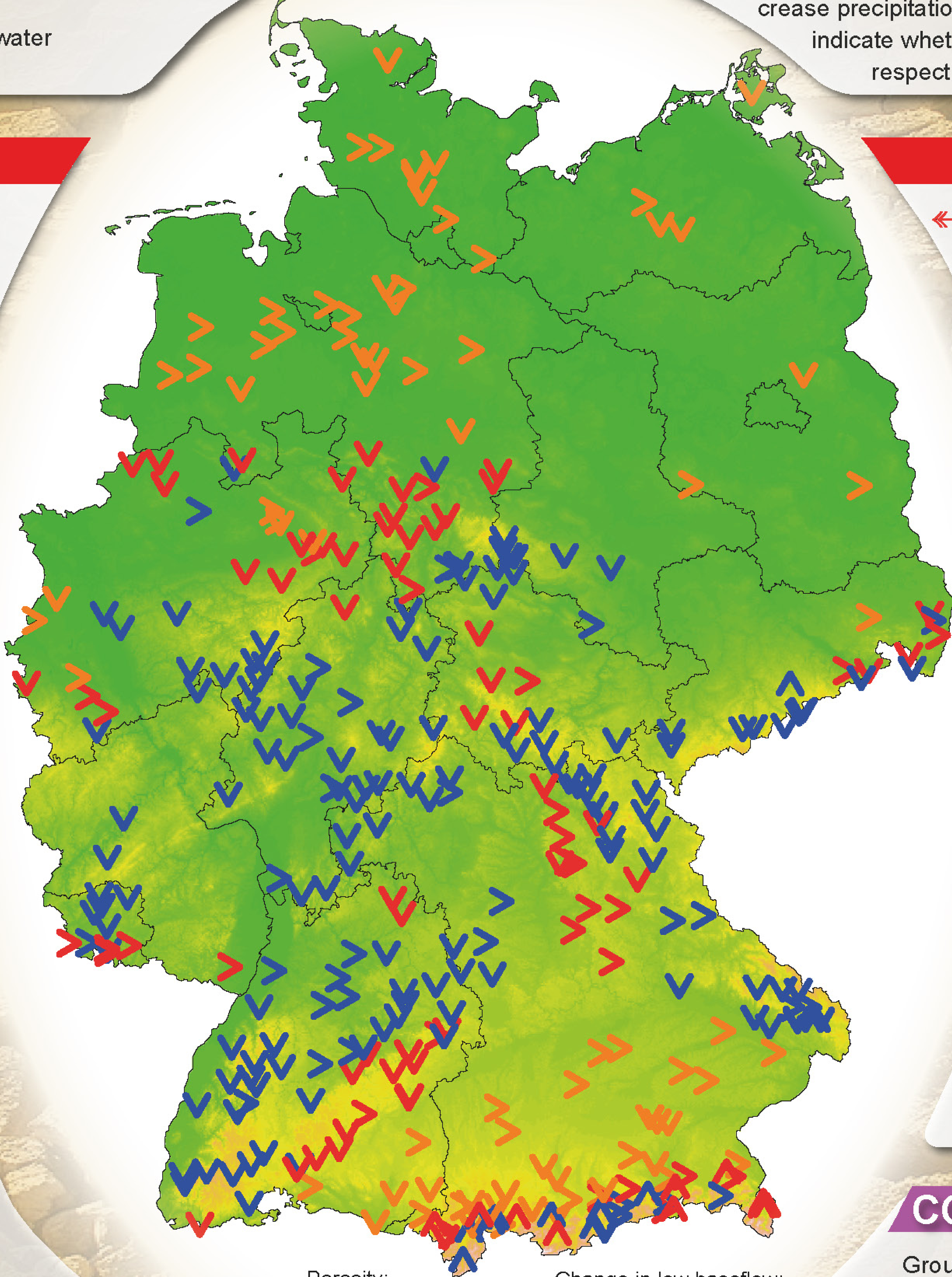
RESULTS & DISCUSSION

REGIONAL GROUNDWATER RESPONSE



The porosity of the catchment is significantly influencing the baseflow response time.

Local baseflow response times are highly variable and depend significantly on the dominating porosity class in the catchment. Additionally, there are seasonal variations for all catchments with shortest response times in spring and longest in autumn or winter. Therefore, possible changes in groundwater resources due to climate change have to be evaluated based on local conditions.



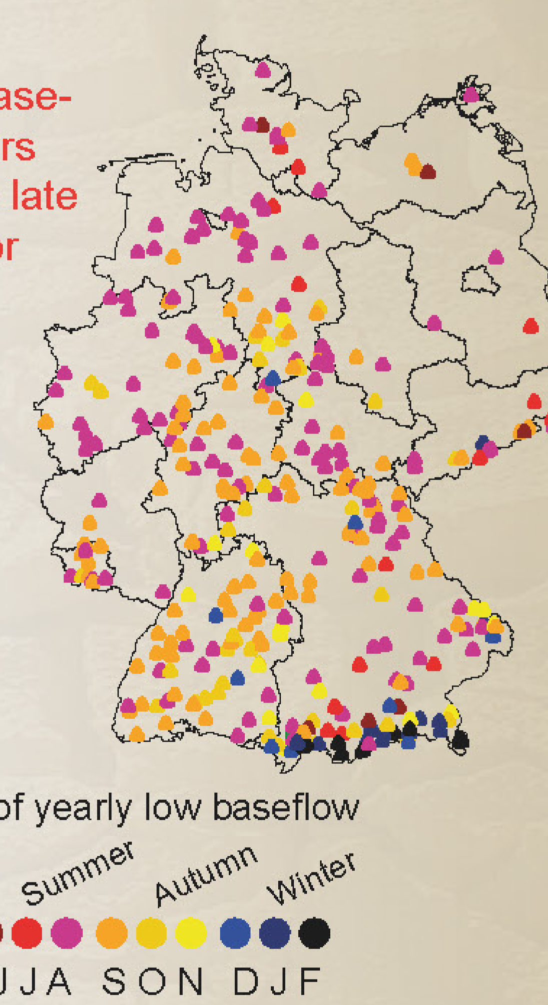
Porosity:
- porous
- mixed
- fractured

Change in low baseflow:
- increase
- no change
- decrease

GROUNDWATER DROUGHT HAZARD

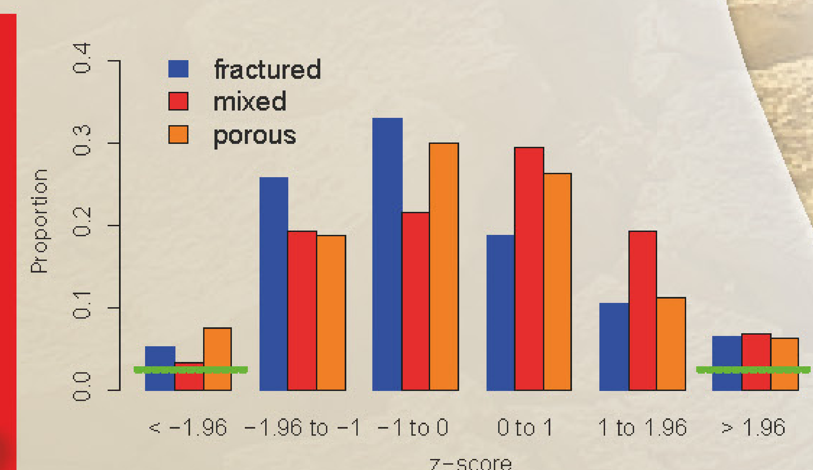
For about 2/3 of the catchments an increase in groundwater drought severity due to climate change is predicted.

Yearly low baseflow occours most often in late summer or autumn.



Porosity is a significant factor influencing the predicted change of groundwater drought hazard. Porous catchments are less likely to respond wth increases in drought hazard. Catchments with decreasing drought hazard are those with yearly low baseflow in winter. Snow storage complicates the interpretation and hence results are more uncertain.

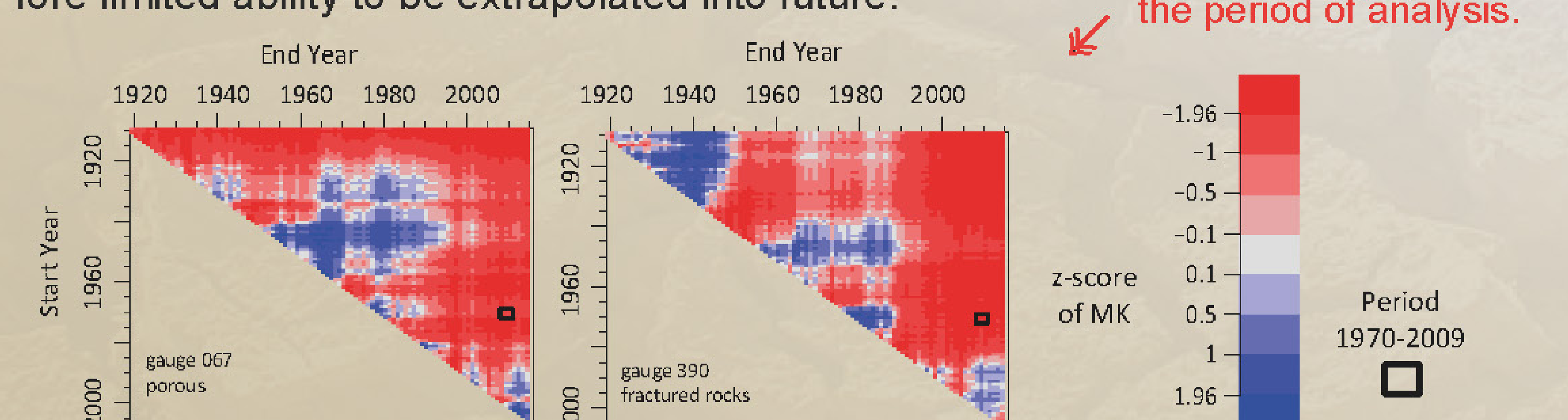
HISTORICAL TRENDS



Slightly more significant trends than expected by chance.

Past trends do not reveal a distinct pattern. For fractured rocks there is a higher proportion of catchments with decreasing trends coinciding with the predicted changes. However, trends strongly depend on the observations period and have therefore limited ability to be extrapolated into future.

Calculated trends of the Mann-Kendall Test for Trends strongly depend on the period of analysis.



CONCLUSIONS

HETEROGENEITY

Groundwater response times are heterogeneous and have to be assessed for every catchment individually. Groundwater management has to focus on local natural conditions as well as the season of yearly low-flow to assess the vulnerability of water storage to climate change.

Generally, shifts in precipitation will mainly affect catchments with short groundwater response times, i.e. most of all 'fractured rocks' catchments. For these catchments drought hazard is most likely to increase under climate change. However, past trends do not show distinct patterns yet to support these findings.

References:

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