Drought propagation analysis using different threshold level methods

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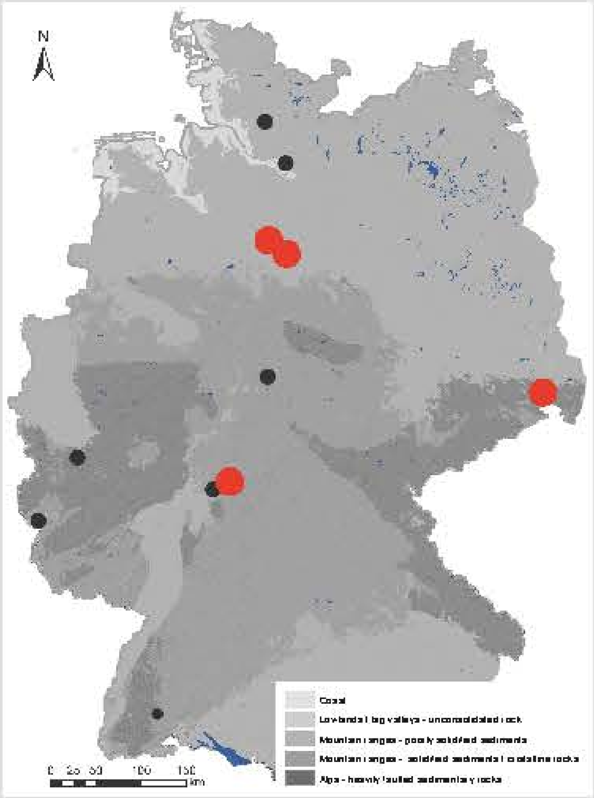
Motivation & Objective

- A variety of Threshold Level Methods is used in studies on drought propagation, but unclear impact of the choice of the threshold method.
- How would the interpretation of drought characteristics and propagation features change when another sort of threshold level method is applied?

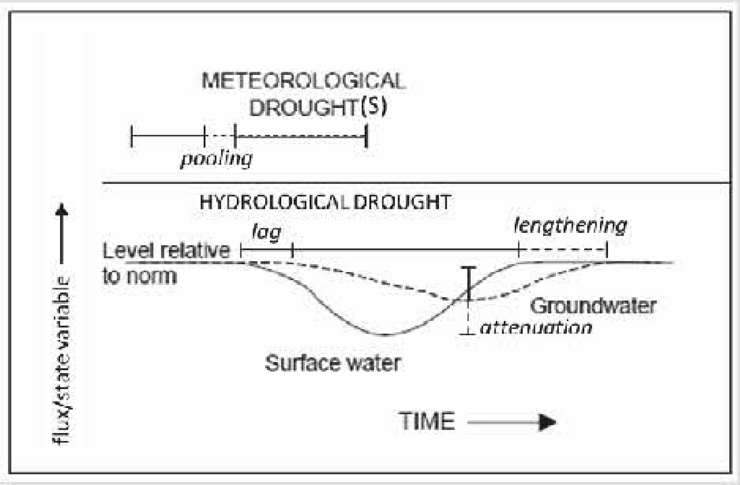
➔We aimed to evaluate the quantitative and qualitative effect of different threshold methods on drought characteristics and drought propagation features with respect to catchment controls.

Data

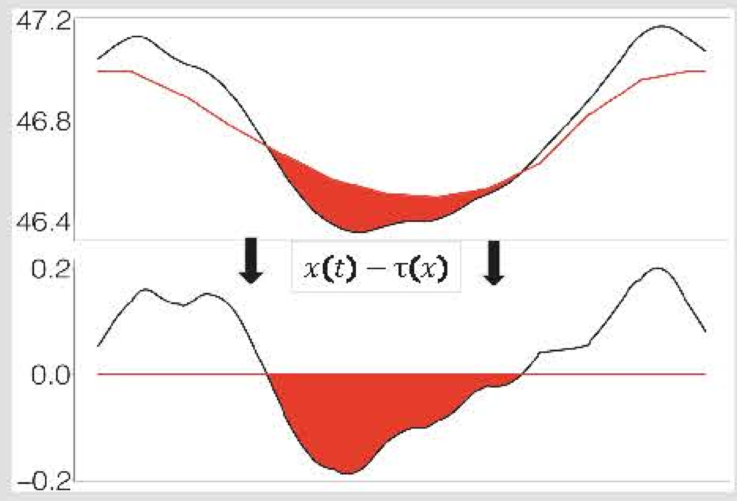


- Precipitation, streamflow and groundwater data from 10 catchments across Germany.
- Continuous daily time series 1976 to 2010.
- Located in the same climate zone (Cfb). The effect of major climate controls is minimized.
- Diverse setting of catchments accounts for a variety of catchment controls.
- Extensive use of primary (borehole & stratigraphic profiles) and secondary (mapping products) metadata to coherently link behaviour to catchment controls.

Methods



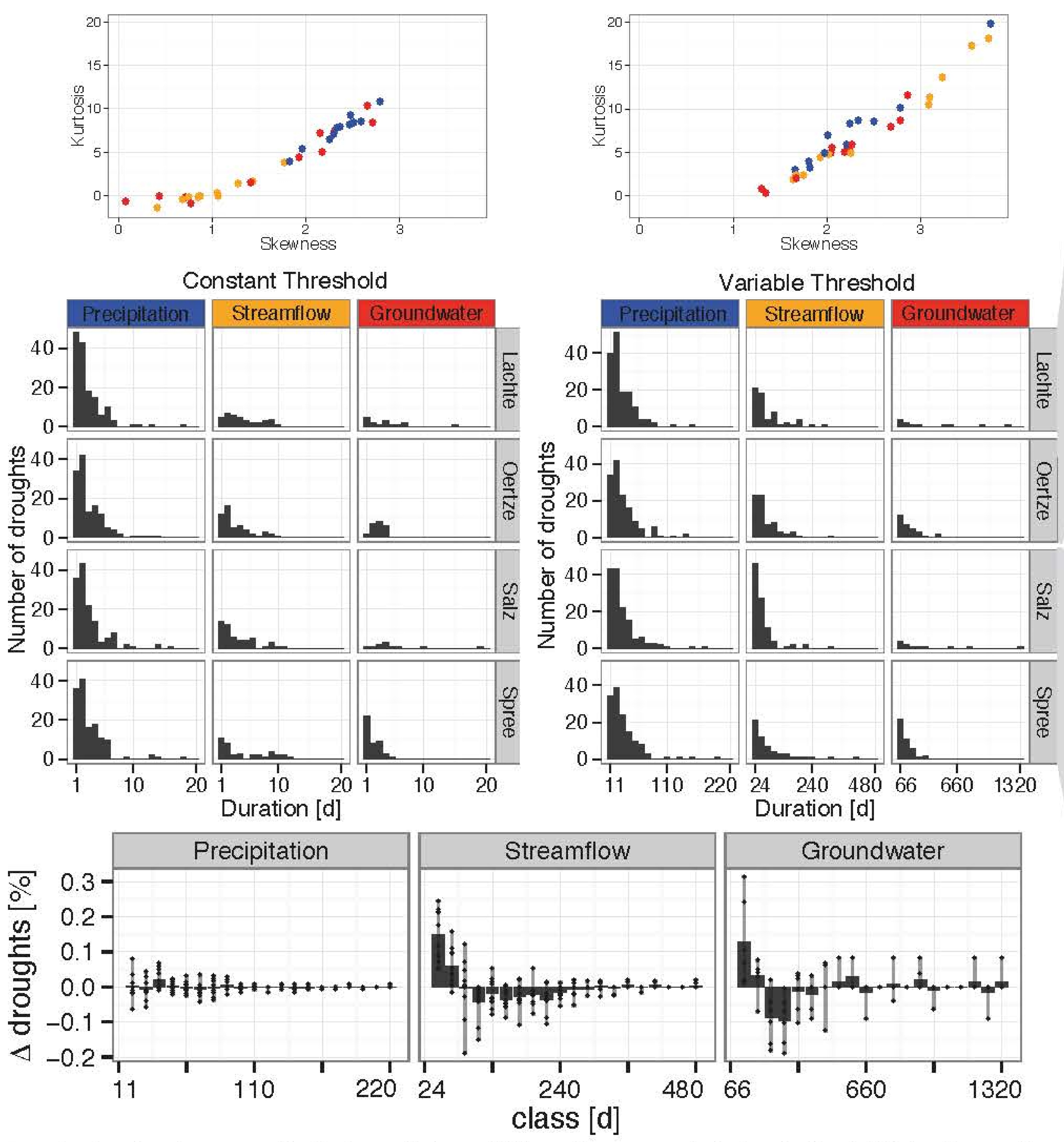
Drought propagation features.



Normalisation procedure: hydrograph minus threshold.

- Drought event identification with the Constant and the Variable Threshold Level Method (q=30%) in precipitation, streamflow and groundwater time series from case study catchments.
- Pooling procedures (inter-event time, t=5; minimum duration, t=3) and a smoothing procedure (moving average, t=30).
- DDD analysed as the replacement characteristic for reasons of straight-forward comparability.
- For a visualised analysis of drought propagation patterns (left figure), normalised hydrographs were produced by subtracting the threshold from the hydrograph (right figure).

Drought Duration Distributions

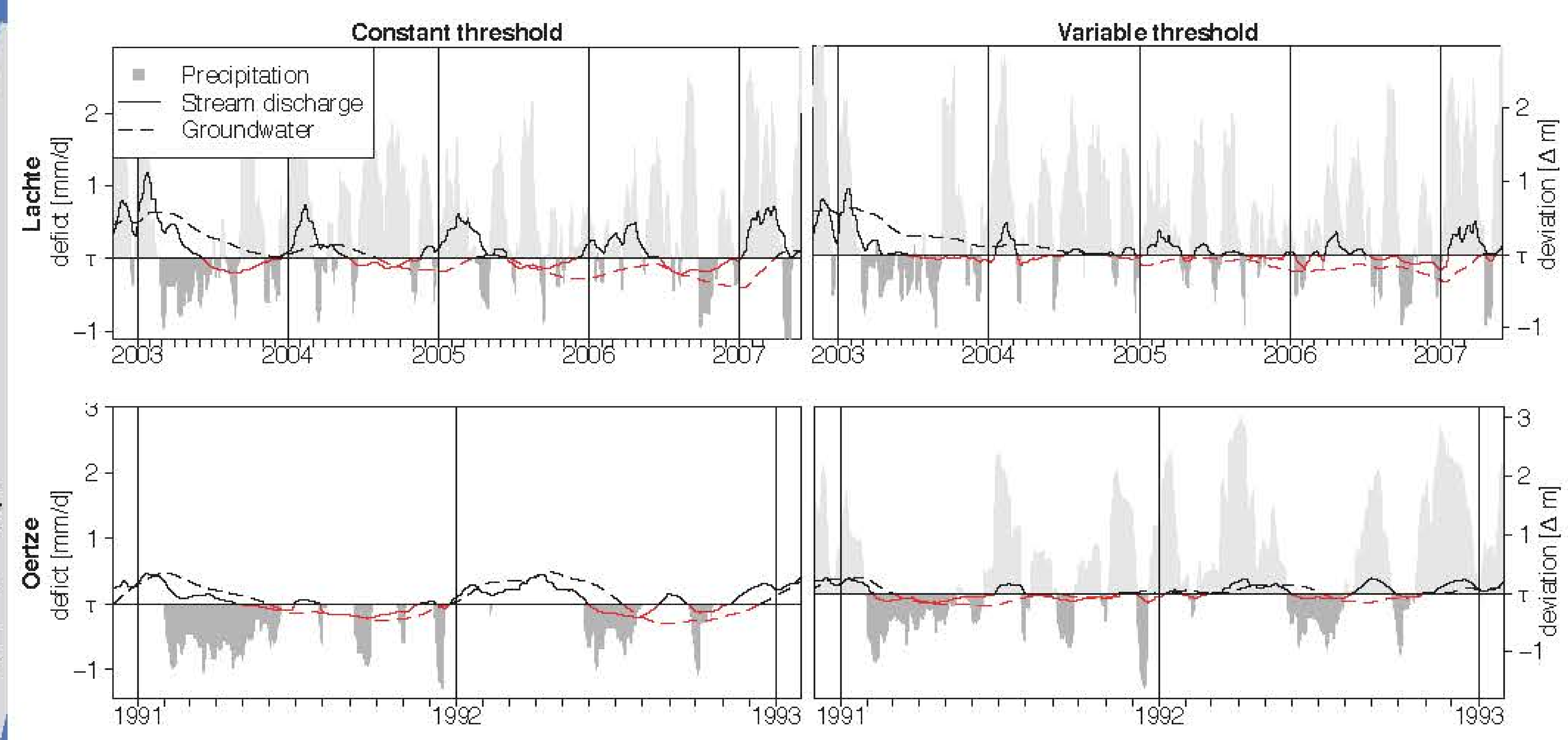


Drought duration frequency distributions of 4 out of 10 catchments for both thresholds (middle) with product moment graphs (top) and characteristic changes per drought duration class between thresholds (bottom).

- Drought duration distributions of precipitation homogeneous across all catchments and both threshold methods.
- Increasing variability in streamflow and groundwater drought duration distributions observable.
- A left-shift is visible comparing constant and variable threshold method, with a characteristic pattern of big increase in short, medium decrease in intermediate and slight increase in long droughts (not for precipitation).

Drought Propagation – Selected Events

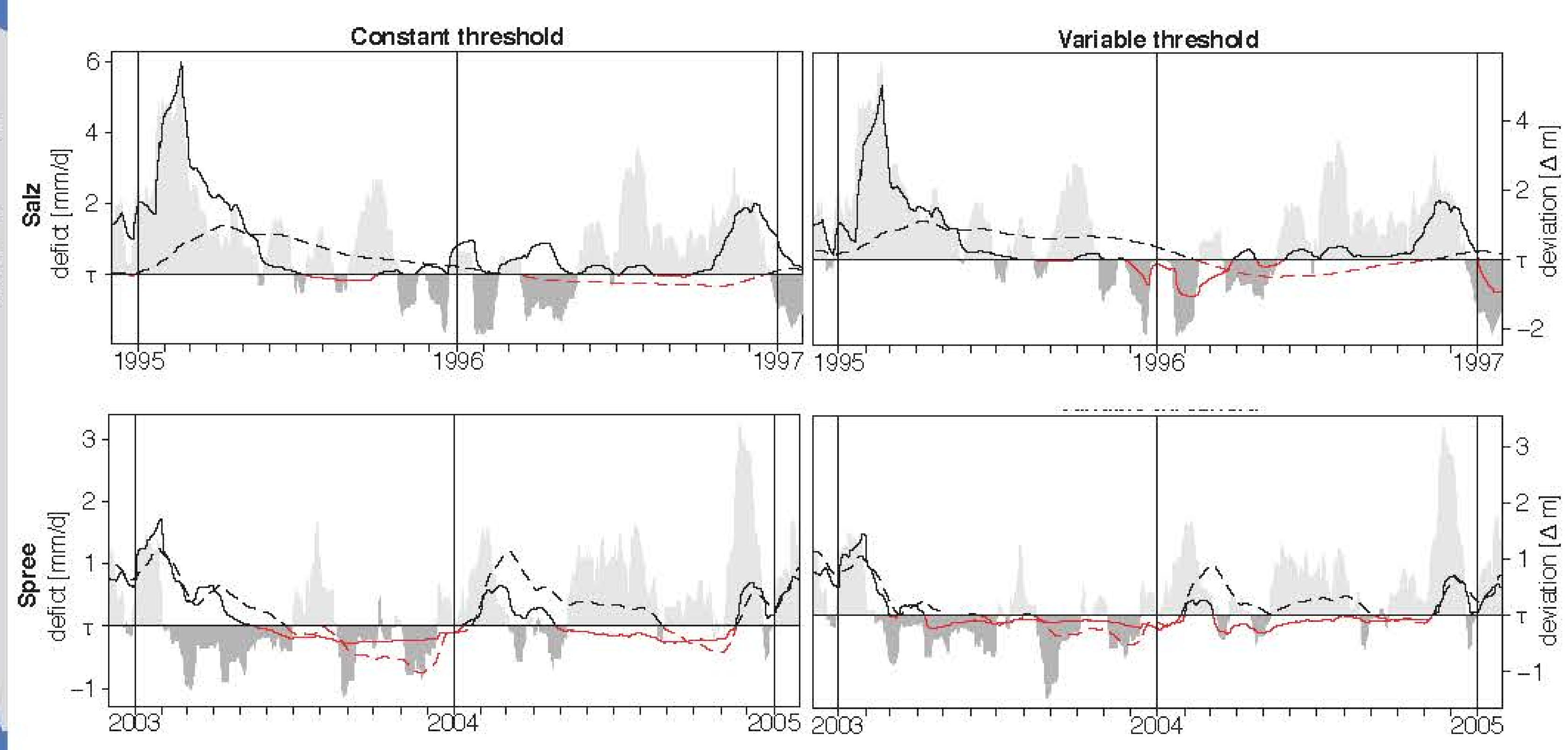
LOWLANDS



Standardised hydrographs of selected events of two lowland catchments Oertze (top) and Lachte (bottom).

- Two lowland catchments with extensive aquifers Lachte and Oertze (top).
- Long-memory groundwater triggering streamflow droughts in Lachte.
- All theoretic propagation patterns visible and hold for both thresholds despite some changes in drought characteristics.

UPLANDS



Standardised hydrographs of selected events of two mountainous catchments Salz (top) and Spree (bottom).

- Two mountainous catchments Salz and Spree.
- Spree groundwater is faster reacting than streamflow – no prolonging of droughts in groundwater – propagation pattern still holds for both threshold despite major changes in drought characteristics.
- Salz groundwater very slow reacting despite mountainous setting – major changes in streamflow from constant to variable threshold – completely different propagation patterns under constant and variable threshold – leads to different result.

Conclusion

- Drought duration characteristics are more variable for lower hydrological levels, indicating higher impact of catchment controls.
- Characteristic changes for streamflow and groundwater when moving from constant to variable threshold: massive increase in short droughts, medium decrease in intermediate droughts, and slight increase in long droughts.
- Accordance to theoretical drought propagation features is good in lowland catchments. Deviances in propagation patterns can be observed in smaller mountainous catchments. Contrasting results are possible in these settings when using a different sort of threshold.

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