Changing low flow seasonality in Central European headwaters

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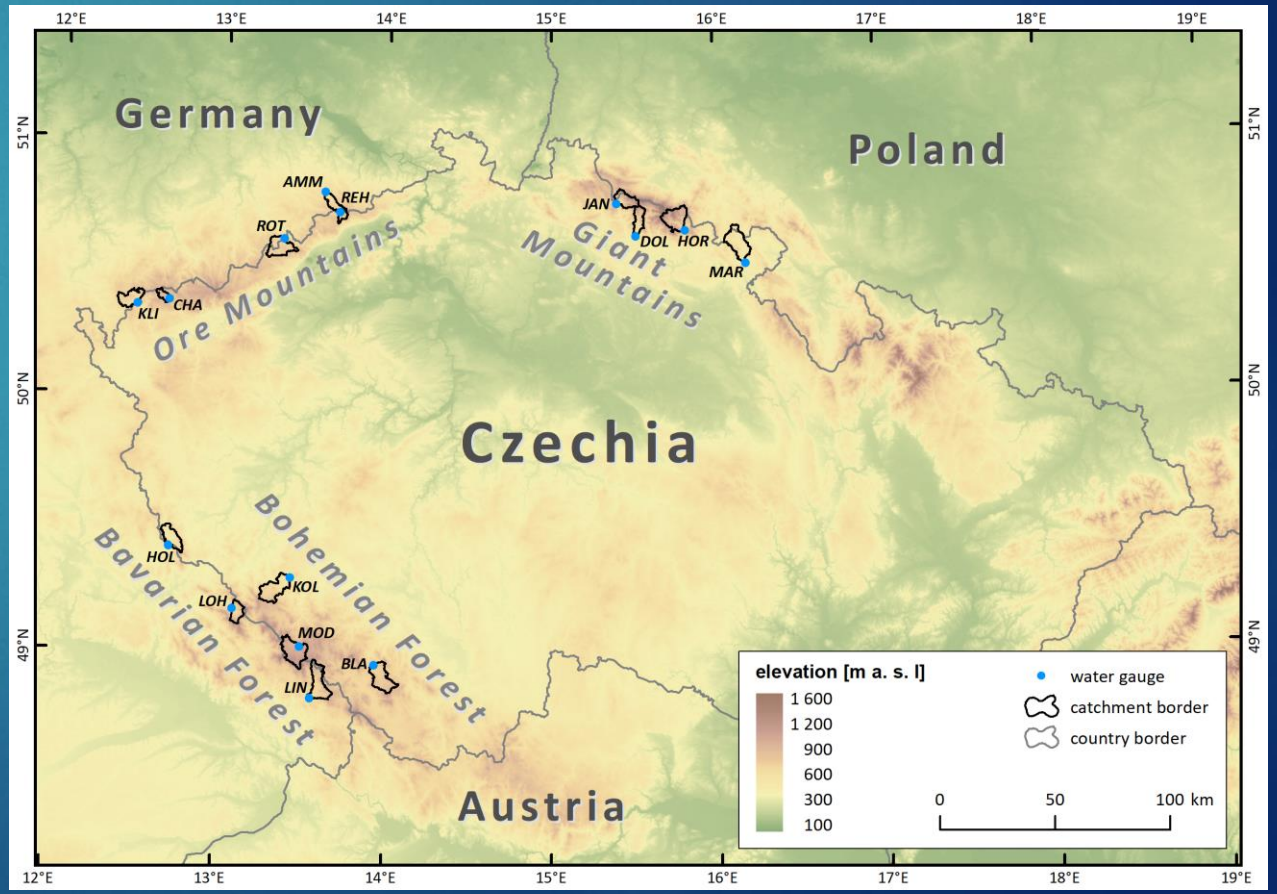
Aims + study area

- To obtain an overview of low flow regime development in montane, **near-natural** catchments *(1968–2019)*
- Inter- and intra-regional comparison of the low-flow and hydrological drought seasonality
- Assessment of the summer hydrological droughts in the last 50 years in the context of the recent *(2014–2019)* period

- Headwaters of:
  - Giant Mountains + Broumov Highland *(NE region)*
  - Ore Mountains *(NW region)*
  - Bohemian + Bavarian Forest *(SW region)*

- 15 selected catchments:
  - Area < 100 km^2
  - Time series of daily discharge > 50 years
  - Small anthropogenic runoff influence
    - Absence of dams and large reservoirs

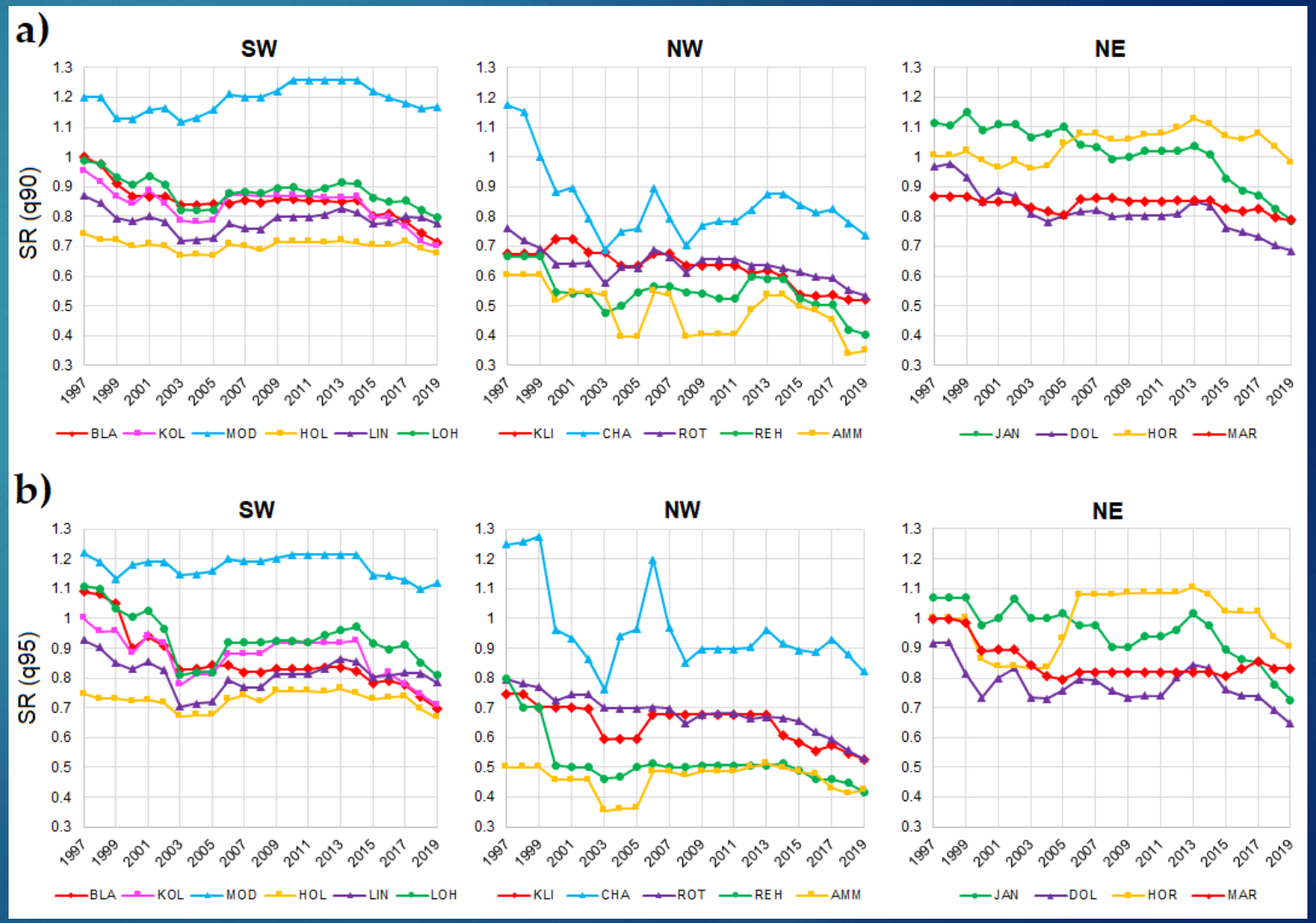


Data + Methods

- Q_d = mean daily discharge time series *(1968–2019)*
  - CHMI *(Czechia)*
  - LFULG Sachsen *(Saxony)*
  - GKD Bayern *(Bavaria)*
- GIS analysis: physiographic properties of the catchments *(slope, exposition, soils, land cover ...)*
- R package „lfstat“:
- Development of the **30-year moving averages** *(22 periods within the 1968–2019 timeframe):*
  - Seasonality ratio *(SR)* $SR_{q90} = \frac{q90_s}{q90_w}$; $SR_{q95} = \frac{q95_s}{q95_w}$
    - Ratio between summer and winter low flows / droughts
      - 0 to 1 = summer drought regime; ± 1 = indifferent drought regime; > 1 winter drought regime
  - Seasonality index *(SI)*
    - Average day of low-flow *(Q90)* and streamflow drought *(Q95)* occurrence
    - Average drought „concentration“ throughout the year *(0 = very variable; 1 = highly concentrated)*
- For summer seasons: streamflow drought duration and deficit streamflow volumes
  - Based on Q95 varying monthly threshold

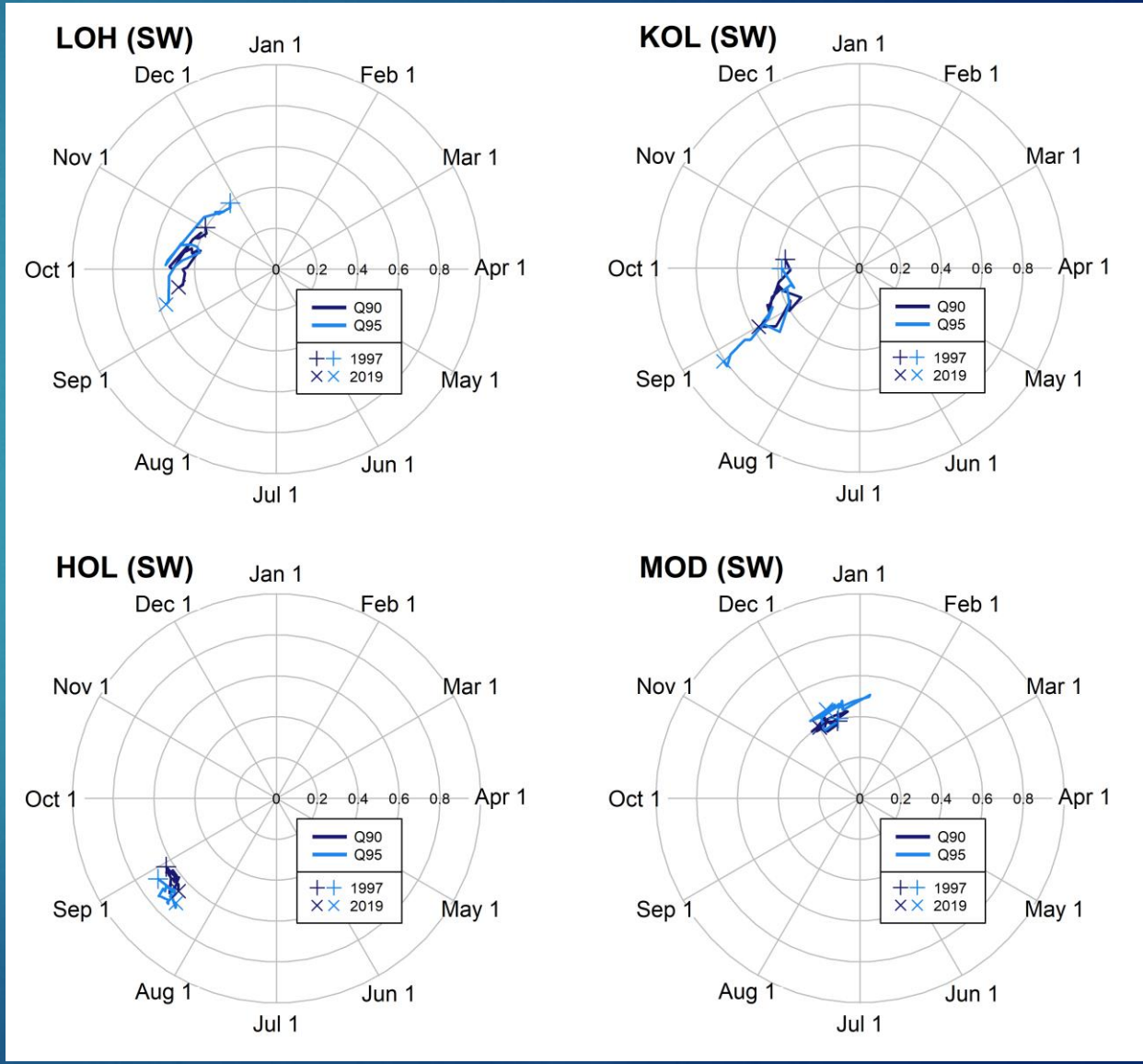
Results (seasonality ratio)

- Significant changes in 30-year averages of the seasonality ratio of low flows and streamflow drought in 11 out of 15 catchments
- Decreasing importance of winter droughts, transition to summer drought regime
- Most pronounced changes in catchments around **800–1000 m a. s. l.**
- Almost stable low flow regime in catchments above 1000 m a. s. l.
  - SW region: Vydra *(Modrava – MOD)*
  - NE region: Úpa *(Horní Maršov – HOR)*
- Similar for catchments under 750 m a. s. l.
  - SW region: Schwarzach *(Höll – HOL)*
  - NW region: Wilde Weißeritz *(AMM)*
  - NE region: Metuje *(Maršov n. M – MAR)*



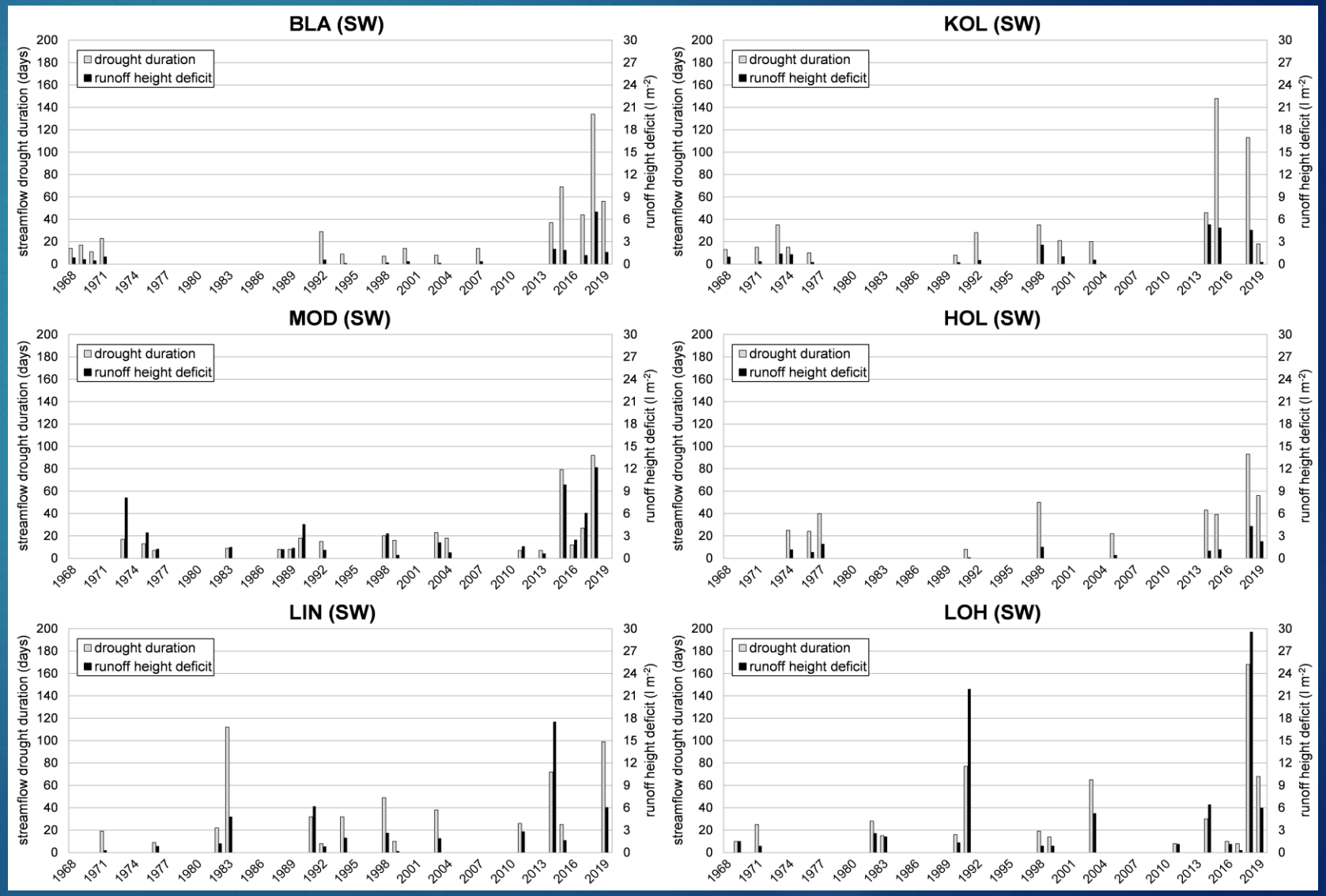
Results (seasonality index)

- Significant shifts in 30-year averages of low flows and streamflow drought occurrence in 13 out of 15 catchments
- Earlier occurrence of low flow or drought
- Most pronounced shifts of drought occurrence towards the start of the year in catchments around **800–1000 m a. s. l.**
  - SW region: Weißer Regen *(Lohberg – LOH)*: **74 days**
  - NE region: Mumlava *(Janov – JAN)*: **71 days**
- Negligible shifts in catchments above 1000 m a. s. l.
  - SW region: Vydra *(Modrava – MOD)*: **6 days**
  - NE region: Úpa *(Horní Maršov – HOR)*: **9 days**
- Similar for catchments under 750 m a. s. l.
  - SW region: Schwarzach *(Höll – HOL)*: 11 days
  - NE region: Metuje *(Maršov nad Metují – MAR)*: 11 days
- Overall increased concentration of droughts
  - BLA, KOL: 0.25–0.35 *(1968–1997)* -> 0.7–0.8 *(1990–2019)*



Results (drought duration, magnitude)

- Magnitude and duration of summer droughts were much more variable than expected
  - In some catchments, the strongest drought events were detected before 2000
- The 2014–2019 period was extremely dry in 9 of 15 catchments throughout all regions
- Most significant increases in duration and magnitude of streamflow drought events were detected in catchments oriented to S, SW and W.
  - Regardless catchment regional location



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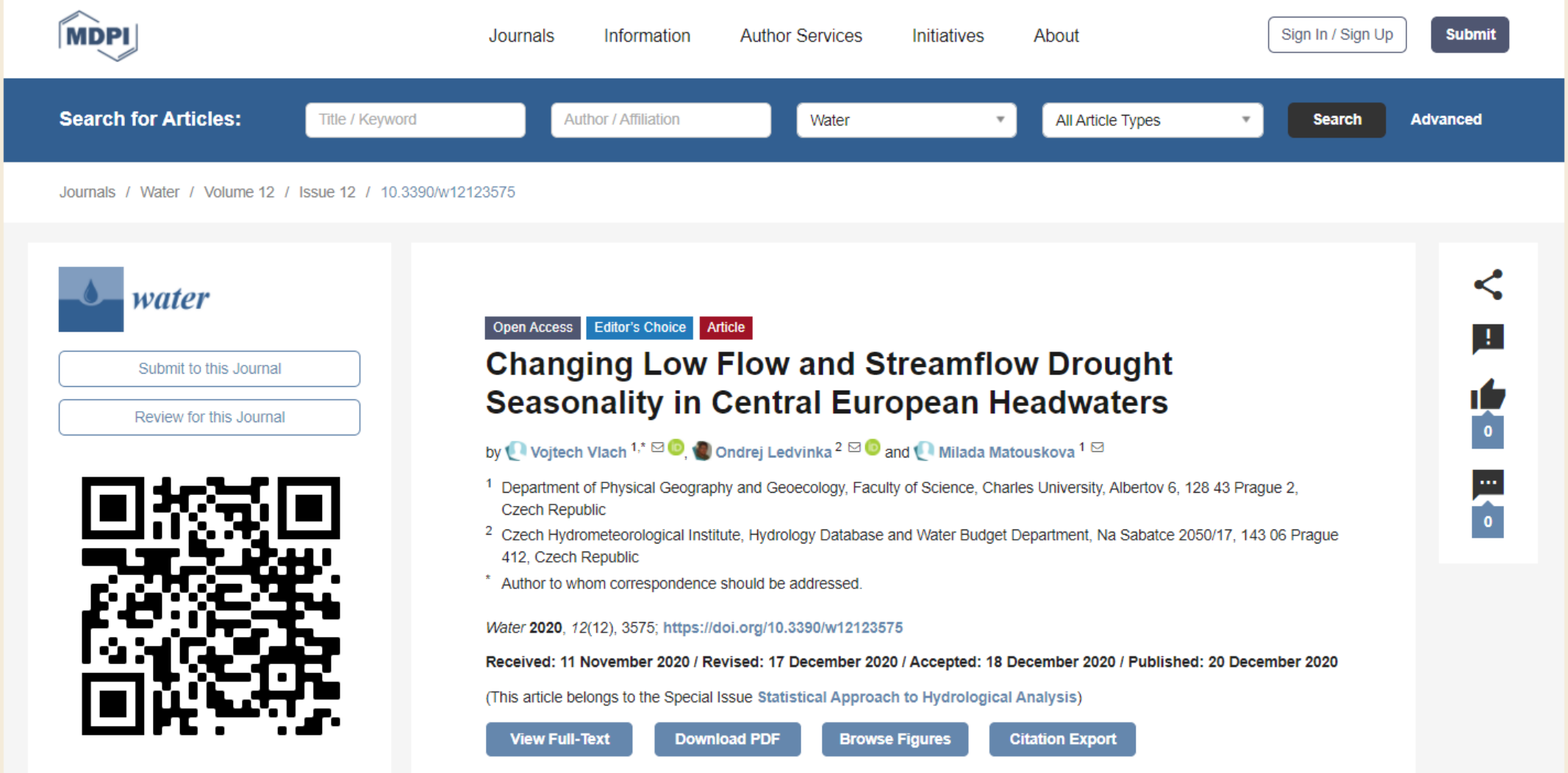

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