Future streamflow droughts in glacierized catchments: the impact of dynamic glacier modelling and changing thresholds

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Streamflow droughts in glacierized catchments

- Hydrological reservoir
  - Annual
  - Seasonal

- Fluctuations in melt peak
  - Streamflow droughts
  - Hydropower, water supply

- Climate change
  - Glacier retreat
  - Changing catchments

Introduction | Study area | Methods | Results | Discussion | Conclusions
Methodological options

• Future projections streamflow droughts
  – Glacier modelling
  – Variable drought threshold

• Objective:
  Testing effect of different methodological choices on simulating and analyzing streamflow drought in glacierized catchments
Case study catchments

- Alaska
  - 25 km²
  - 67% glacierized

- Norway
  - 65 km²
  - 70% glacierized

Van Tiel et al. (2017, HESSD)
Scenarios and modelling periods

Threshold definition
- Historical (HistVT)
- Transient (TranVT)
- Variable Threshold

Glacier modelling
- Dynamical (Dyn)
- Constant (Con)
- Glacier area

80th percentile DOY FDC

4 scenarios
- HistVT-Con
- HistVT-Dyn
- TranVT-Con
- TranVT-Dyn

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Scenarios and modelling periods

Threshold definition

Historical (HistVT) Transient (TranVT) Variable Threshold

Glacier modelling

Dynamical (Dyn) Constant (Con) glacier area

80th percentile DOY FDC

- HBV-light model
  Seibert and Vis (2012, HESS) & Seibert et al. (2017, HESSD)

- Modelling approach
  - Historical and future period

Introduction | Study area | Methods | Results | Discussion | Conclusions
### Kling Gupta Efficiencies

<table>
<thead>
<tr>
<th>Calibration</th>
<th>Validation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catchment</td>
<td></td>
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<tr>
<td>Nigardsbreen</td>
<td>0.94 0.94  1967-2003</td>
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<tr>
<td>Wolverine</td>
<td>0.82 0.83  2005-2014</td>
</tr>
</tbody>
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KGE ranges between –inf and 1

- **Calibration**
  - Seasonal glacier mass balances
  - Observed streamflow

Van Tiel et al. (2017, HESSD)
Glacier dynamics and drought thresholds

- Glaciers shrink → influencing hydrological regimes
- Drought thresholds based on 30 year hydrological regimes
- Changing transient thresholds for constant and dynamical glacier area

Van Tiel et al. (2017, HESSD)
Thresholds and streamflow droughts

- **HistVT-Con**: very few droughts
- **HistVT-Dyn**: major droughts every year in summer
- **TranVT-Con**: droughts more distributed over the year
- **TranVT-Dyn**: similar to TranVT-Con, but more and larger droughts due to glacier retreat

Van Tiel et al. (2017, HESSD)
Drought processes

• Comparison glacier modelling options
  – Con and Dyn
  – TranVT

• Comparison drought threshold options
  – HistVT and TranVT
  – Dyn

Van Tiel et al. (2017, HESSD)
Drought definition

• Future projections of streamflow drought $\rightarrow$ comparison needed

• Historical variable threshold
  – Severe droughts every year
  – Change in hydrological regime

• Transient variable threshold
  – Better option for changing regimes
  – No changes $\rightarrow$ benchmark itself is changing
  – Droughts results need to be put into perspective
Conclusions

• Methodological choices result in different streamflow drought characteristics

• Which options to choose?
  – Constant glacier → analyze short term climate variability effect on streamflow drought
  – Dynamical glacier → model more realistic future discharges
  – Historical Variable Threshold → assess changes between historical and future periods
  – Transient Variable Threshold → analyze drought processes in the future
Thank you!

References