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

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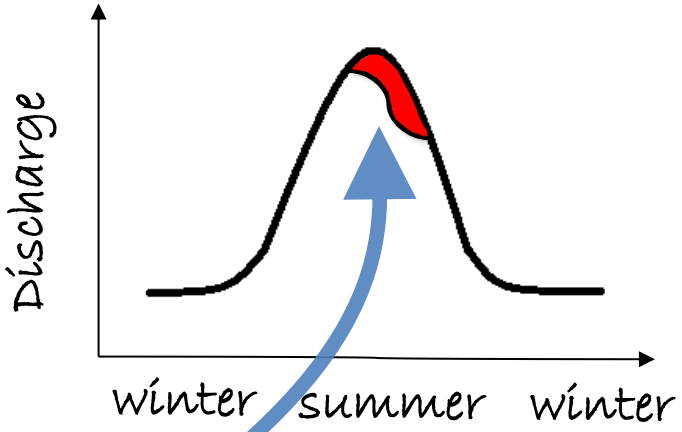
WGMS

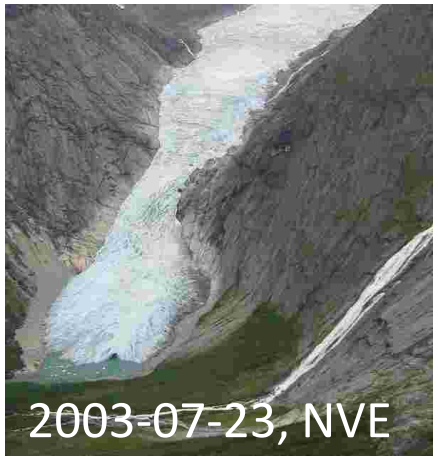
Streamflow droughts in glacierized catchments

- Hydrological reservoir
  - Annual
  - Seasonal



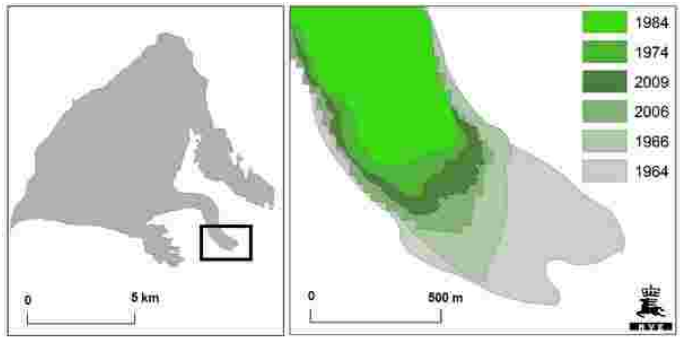
- Fluctuations in melt peak
  - Streamflow droughts
  - Hydropower, water supply

- Climate change
  - Glacier retreat
  - Changing catchments



Methodological options

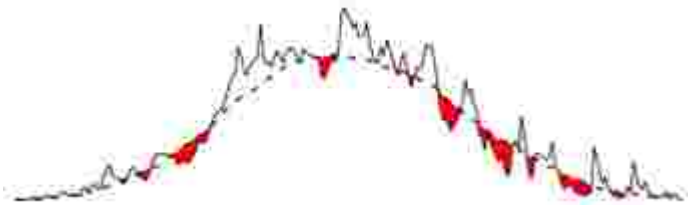
- Future projections streamflow droughts
  - Glacier modelling



Constant glacier

Dynamical glacier

  - Variable drought threshold



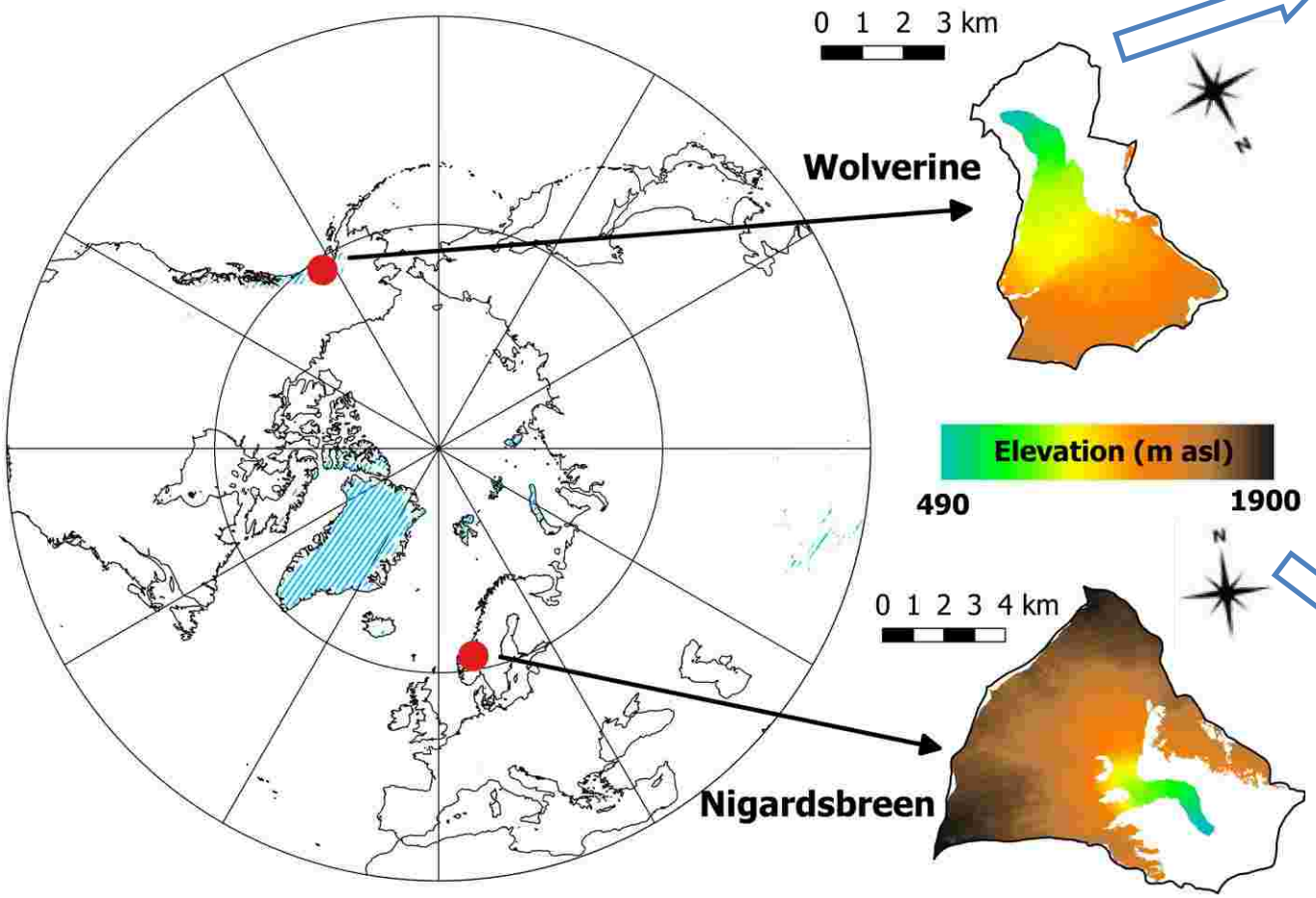
Historical threshold in future

Transient threshold

- **Objective:**

Testing effect of different methodological choices on simulating and analyzing streamflow drought in glacierized catchments

Case study catchments



Van Tiel et al. (2017, HESSD)

- Alaska
- 25 km^2
- 67% glacierized

- Norway
- 65 km^2
- 70% glacierized

Scenarios and modelling periods

Threshold definition

Historical (HistVT) Transient (TranVT)

Variable Threshold

80th percentile DOY FDC

Glacier modelling

Dynamical (Dyn) Constant (Con)

glacier area

4 scenarios

HistVT-Con, HistVT-Dyn, TranVT-Con, TranVT-Dyn

Scenarios and modelling periods

Threshold definition

Historical (HistVT) Transient (TranVT)

Variable Threshold

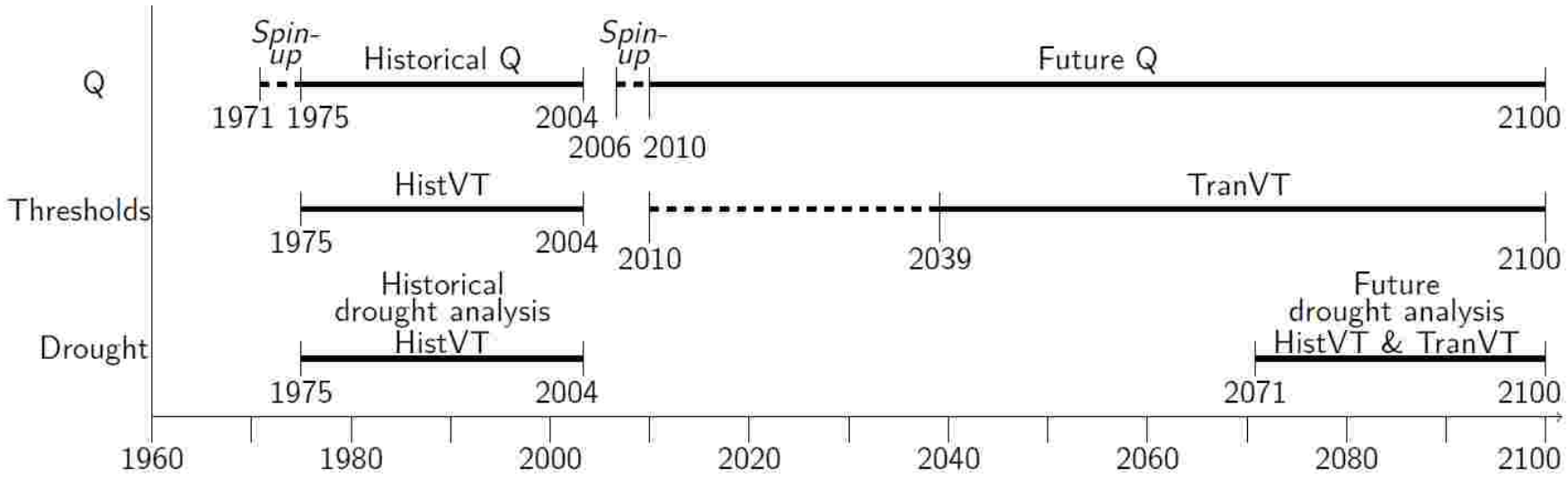
Glacier modelling

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



Calibration

Kling Gupta Efficiencies

	Calibration			Validation		
Catchment	Con	Dyn	Period	Con	Dyn	Period
Nigardsbreen	0.94	0.94	1967-2003	0.90	0.90	2004-2013
Wolverine	0.82	0.83	2005-2014	0.89	0.87	1973-1977

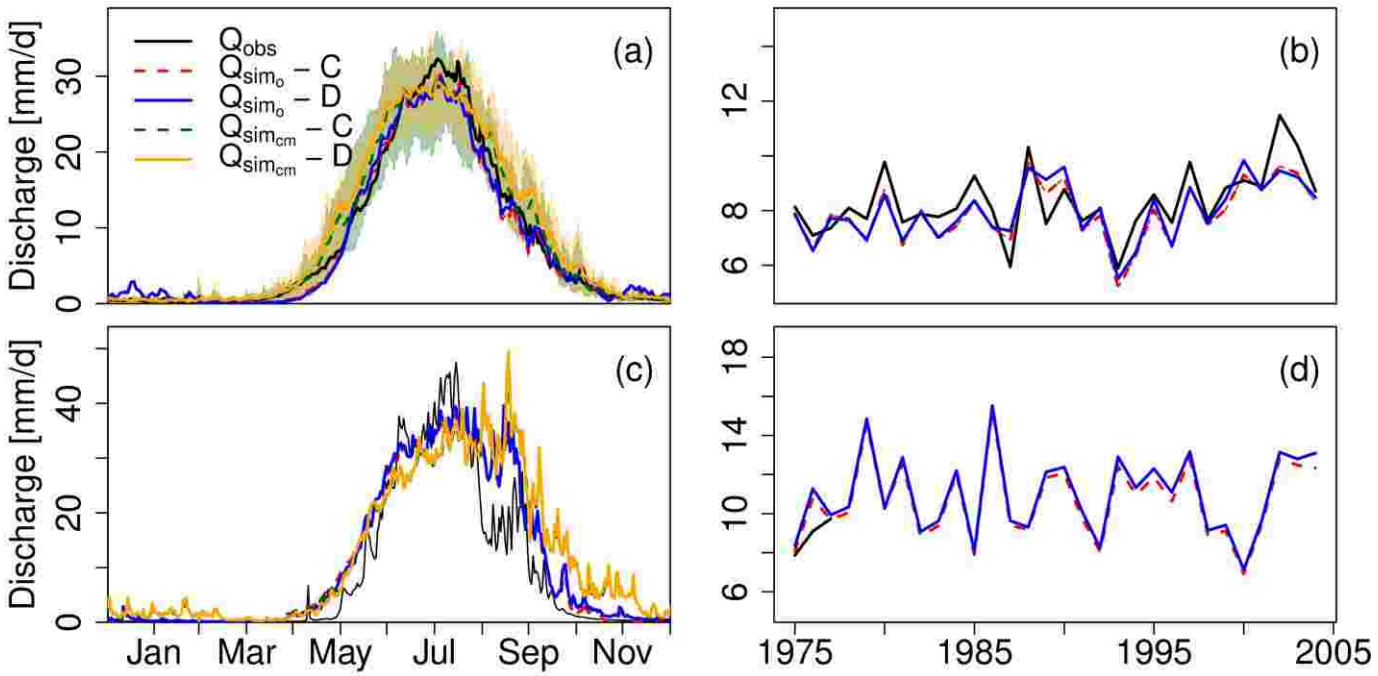
KGE ranges between –inf and 1

- Calibration
  - Seasonal glacier mass balances
  - Observed streamflow

Nigardsbreen →

Wolverine →

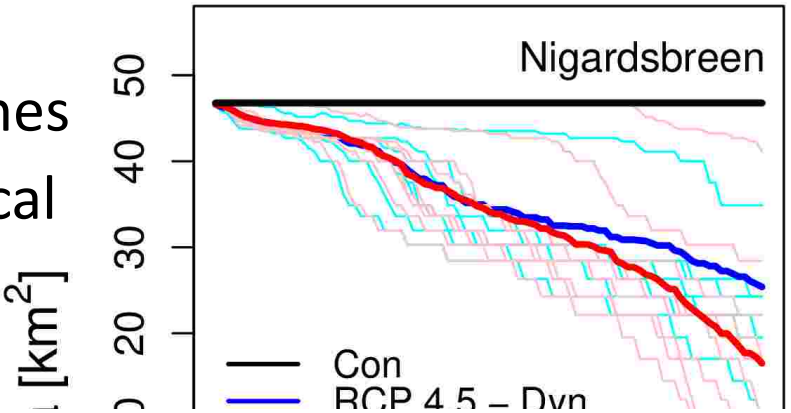
Historical period (1975-2004)



Van Tiel et al. (2017, HESSD)

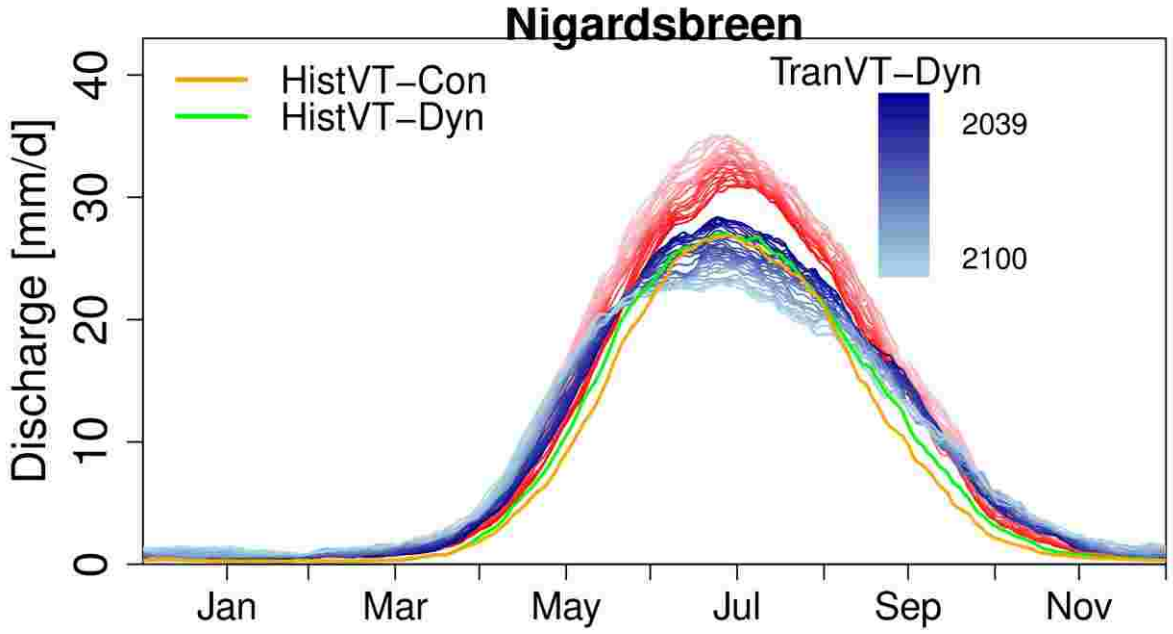
Glacier dynamics and drought thresholds

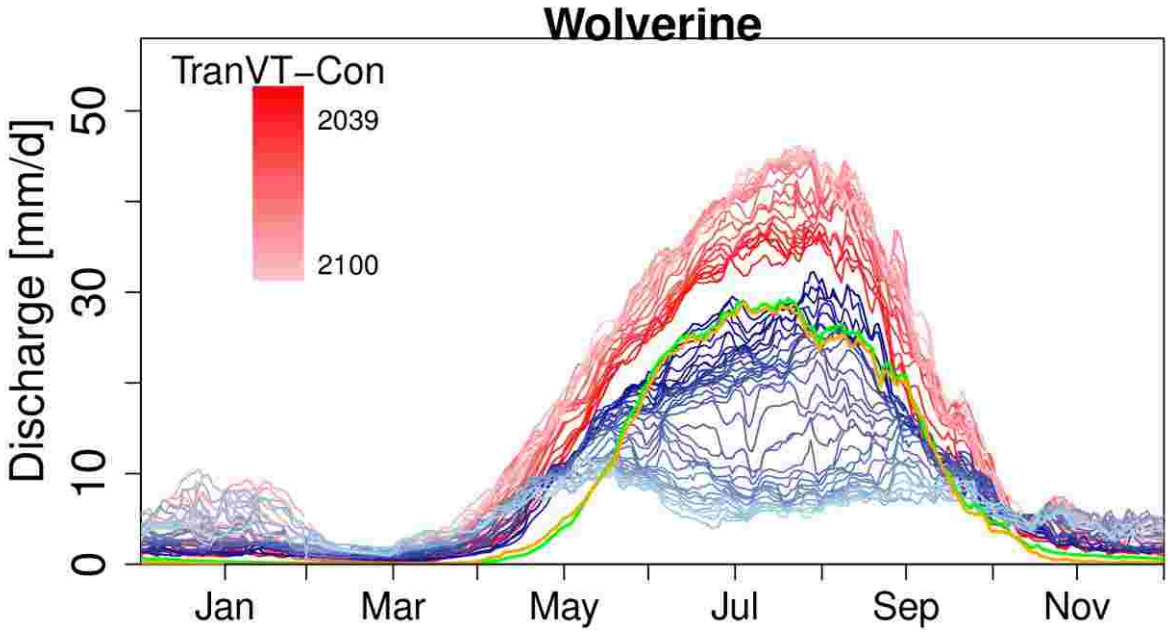
- Glaciers shrink → influencing hydrological regimes
- Drought thresholds based on 30 year hydrological regimes
- Changing transient thresholds for constant and dynamical glacier area



Van Tiel et al. (2017, HESSD)

RCP 4.5

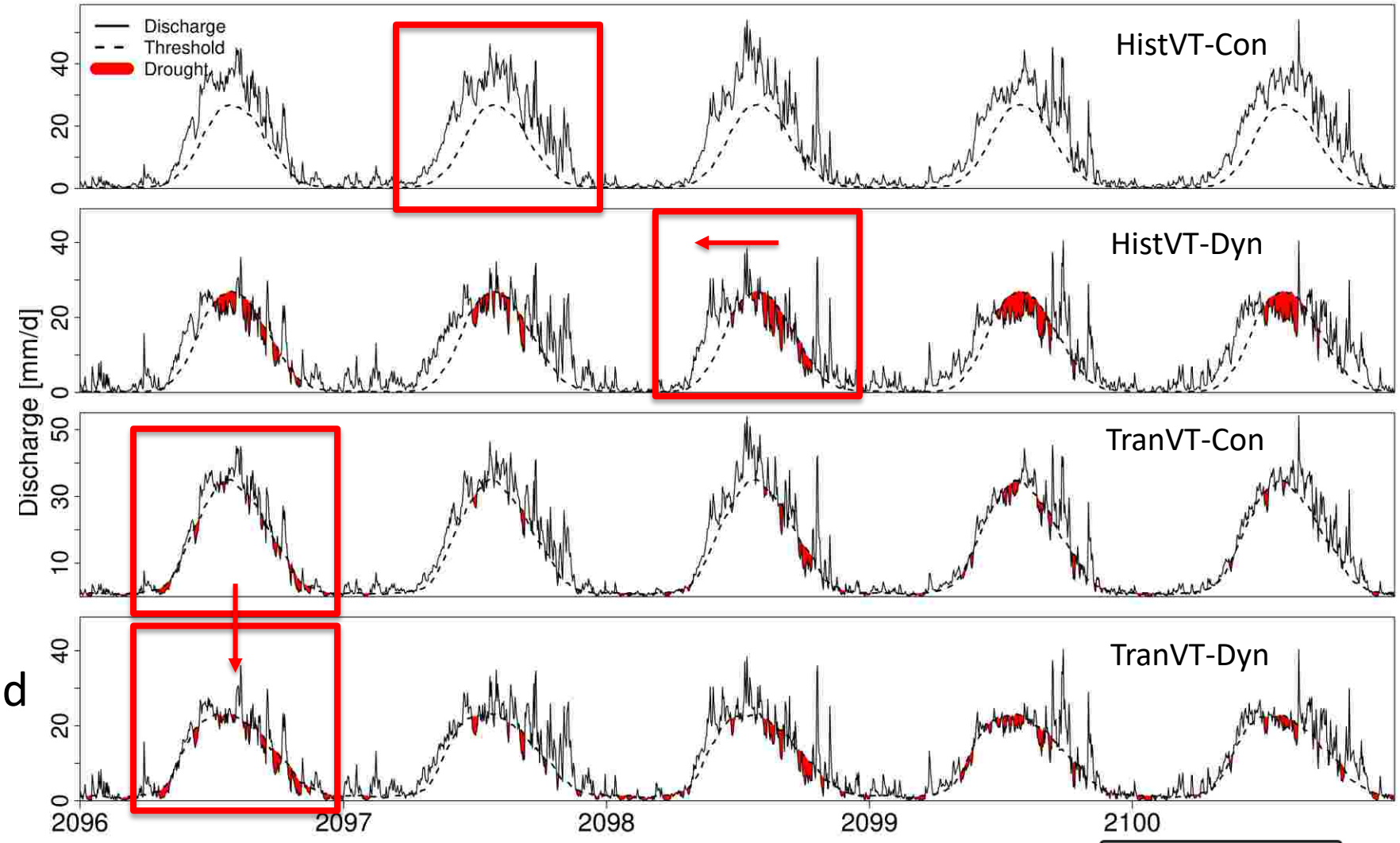




Thresholds and streamflow droughts

- 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

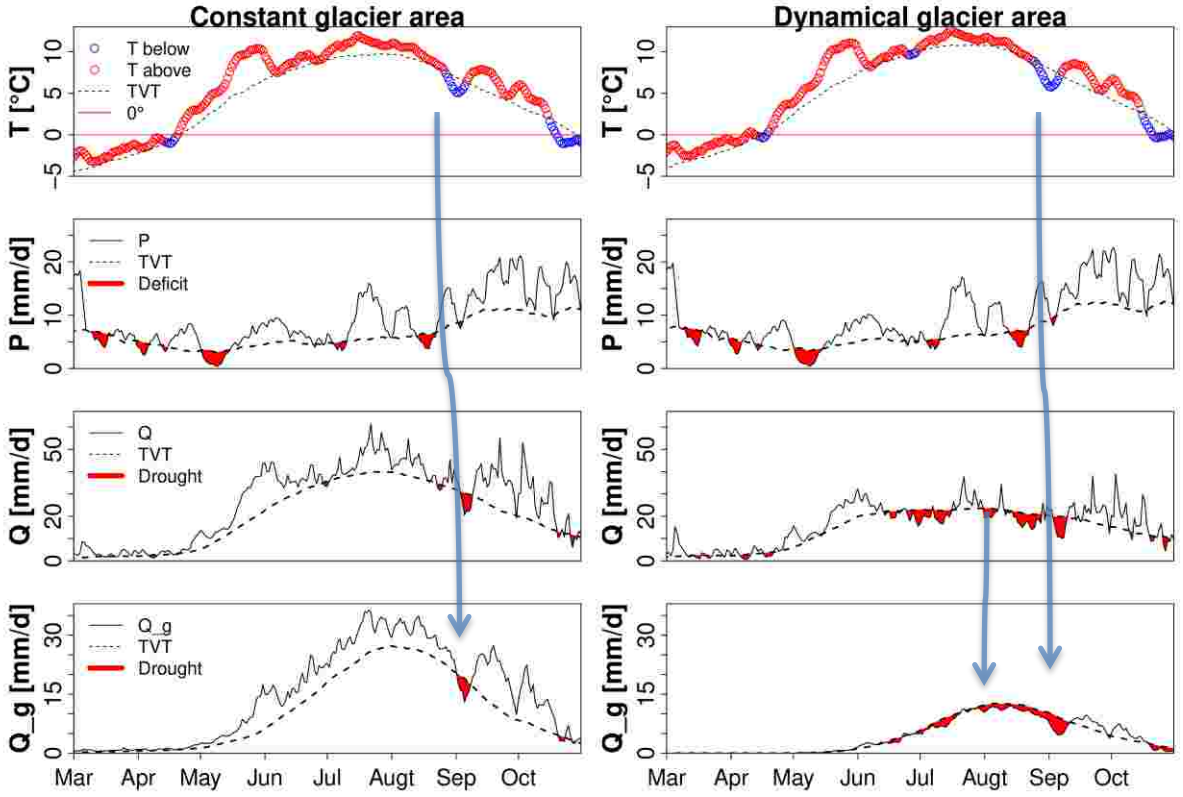
Nigardsbreen catchment



Van Tiel et al. (2017, HESSD)

Drought processes

Nigardsbreen catchment

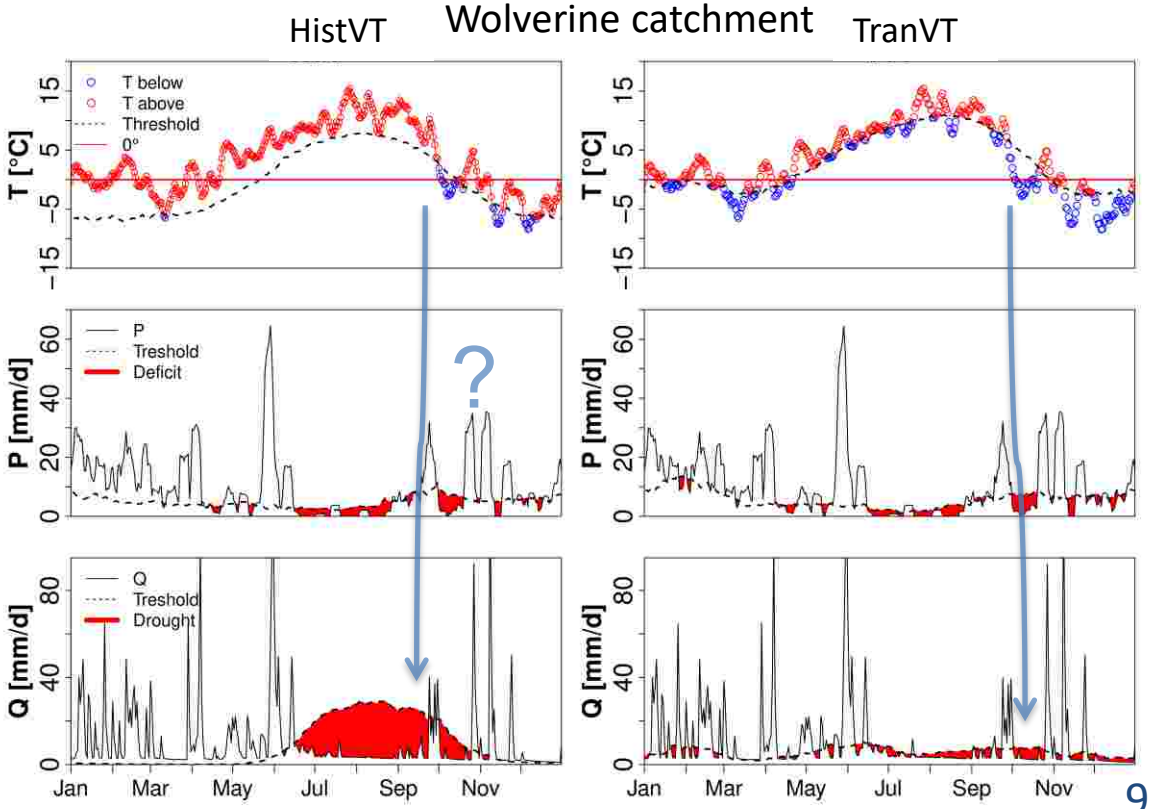


Van Tiel et al. (2017, HESSD)

- Comparison drought threshold options
  - HistVT and TranVT
  - Dyn

- Comparison glacier modelling options
  - Con and Dyn
  - TranVT

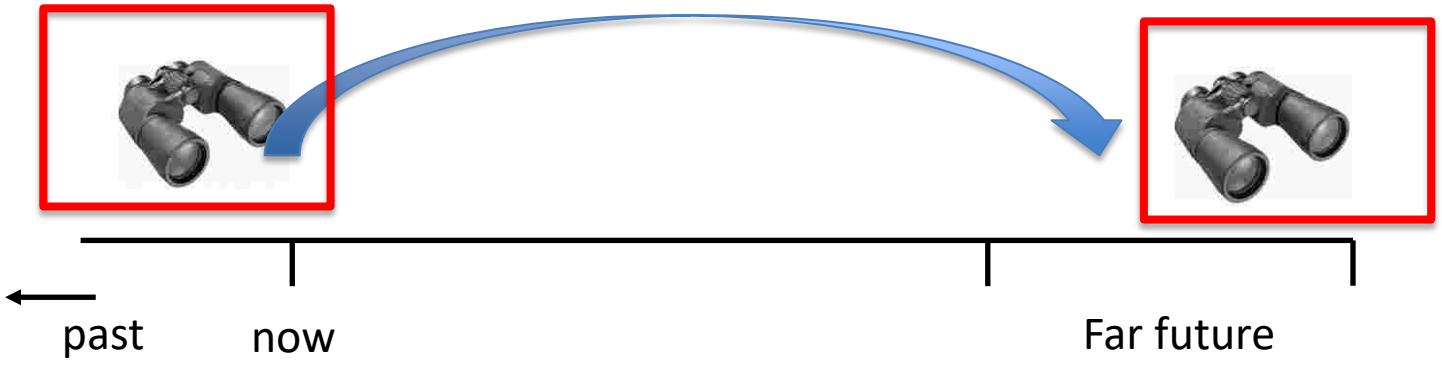
Wolverine catchment



Van Tiel et al. (2017, HESSD)

Drought definition

- Future projections of streamflow drought → comparison needed



- Historical variable threshold
  - Severe droughts every year
  - Change in hydrological regime

- Transient variable threshold
  - Better option for changing regimes
  - No changes → 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

- Seibert, J. and Vis, M. J. P.: Teaching hydrological modeling with a user-friendly catchment-runoff-model software package, Hydrol. Earth Syst. Sci., 16, 3315-3325, doi:10.5194/hess-16-3315-2012, 2012.
- Seibert, J., Vis, M. J. P., Kohn, I., Weiler, M., and Stahl, K.: Technical Note: Representing glacier dynamics in a semi-distributed hydrological model, Hydrol. Earth Syst. Sci. Discuss., doi:10.5194/hess-2017-158, in review, 2017.
- Van Tiel, M., Teuling, A. J., Wanders, N., Vis, M. J. P., Stahl, K., and Van Loon, A. F.: The role of glacier dynamics and threshold definition in the characterisation of future streamflow droughts in glacierised catchments, Hydrol. Earth Syst. Sci. Discuss., doi:10.5194/hess-2017-119, in review, 2017.