Supplement of Hydrol. Earth Syst. Sci., 29, 7041–7071, 2025
https://doi.org/10.5194/hess-29-7041-2025-supplement

Hydrology and Earth System Sciences
Open Access

Supplement of

Hyper-resolution large-scale hydrological modelling benefits from improved process representation in mountain regions

Joren Janzing et al.

Correspondence to: Joren Janzing (joren.janzing@slf.ch)

S1 Variables

Table S1. List of model parameters. Sources for reference values: a: standard PCR-GLOBWB setup; b: Magnusson et al. (2014); c: Van Tiel et al. (2018).

1: Variables			
Symbol	**Variable**	**Value**	**Units**
T	Daily average temperature		°C
M	Melt rate		m day^{-1}
k	Day of the year since 21st of March		-
P	Total precipitation		m day^{-1}
P_{snowfall}	Snowfall		m day^{-1}
Q	Glacial water release		m day^{-1}
S	Glacial water storage		m
SWE	Snow water equivalent		m
2: Parameters			
Symbol	**Parameter**	**Value**	**Units**
T_{thresh}	Threshold temperature above which melt occurs	0	°C
DDF	Degree-day factor	0.0025^{a}	m°C^{-1}day^{-1}
DDF_{max}	Maximum degree-day factor, on 21st of June (NH)	0.0039^{b} or calibrated	m°C^{-1}day^{-1}
DDF_{min}	Minimum degree-day factor, on 22nd of December (NH)	0.0005^{b} or calibrated	m°C^{-1}day^{-1}
m_{m}	Parameter controlling the transition between melt and no melt	0.5^{b}	°C
T_{snowfall}	Temperature below which all precipitation is snow	1^{b}	°C
m_{p}	Parameter determining the range where snow and rainfall co-occur	1.24^{b}	°C
C_{ice}	Glacier melt correction factor	calibrated	-
f_{acc}	Ice accumulation fraction	calibrated	day^{-1}
K_{min}	Tuning parameter	0.2^{c}	day^{-1}
K_{range}	Tuning parameter	0.5^{c}	day^{-1}
A_{g}	Tuning parameter	0.003^{c}	m^{-1}

S2 Tranferability in time

We study the extent to which model performance for SWE and streamflow simulations remains stable under varying climate conditions, i.e. for periods with low vs. high average temperature. Model performance for discharge and SWE differs between the two evaluation periods representing different average temperature conditions, with performance change depending on the region (see Figure S1). The simulated average snow conditions over Switzerland still match observations very well over both evaluation periods (see Figure S1C). In contrast, simulated discharge performance differs for the calibration and evaluation periods (see Figure S1D and E). However, performance of discharge simulations can both increase and decrease during the evaluation period as compared to the calibration period depending on the catchment. These changes have slightly smaller magnitudes than the changes due to different forcing datasets (compare to Figure 4G,H, and I), suggesting that the selected evaluation period is important for model performance in individual catchments. For the domain as a whole, the warmer Evaluation II period shows a slight drop in median performance of streamflow simulations (median KGE: 0 0.26) compared to Evaluation I period (median KGE:0.27; see Figure S1F). This change is, however, small, indicating that performance remains stable over time and is only weakly influenced by changing climate conditions such as increasing temperatures. Finally, when we compare glaciers between time periods the spatial patterns of evolution seem to remain mostly constant (see Figure S1H, I, J and K).

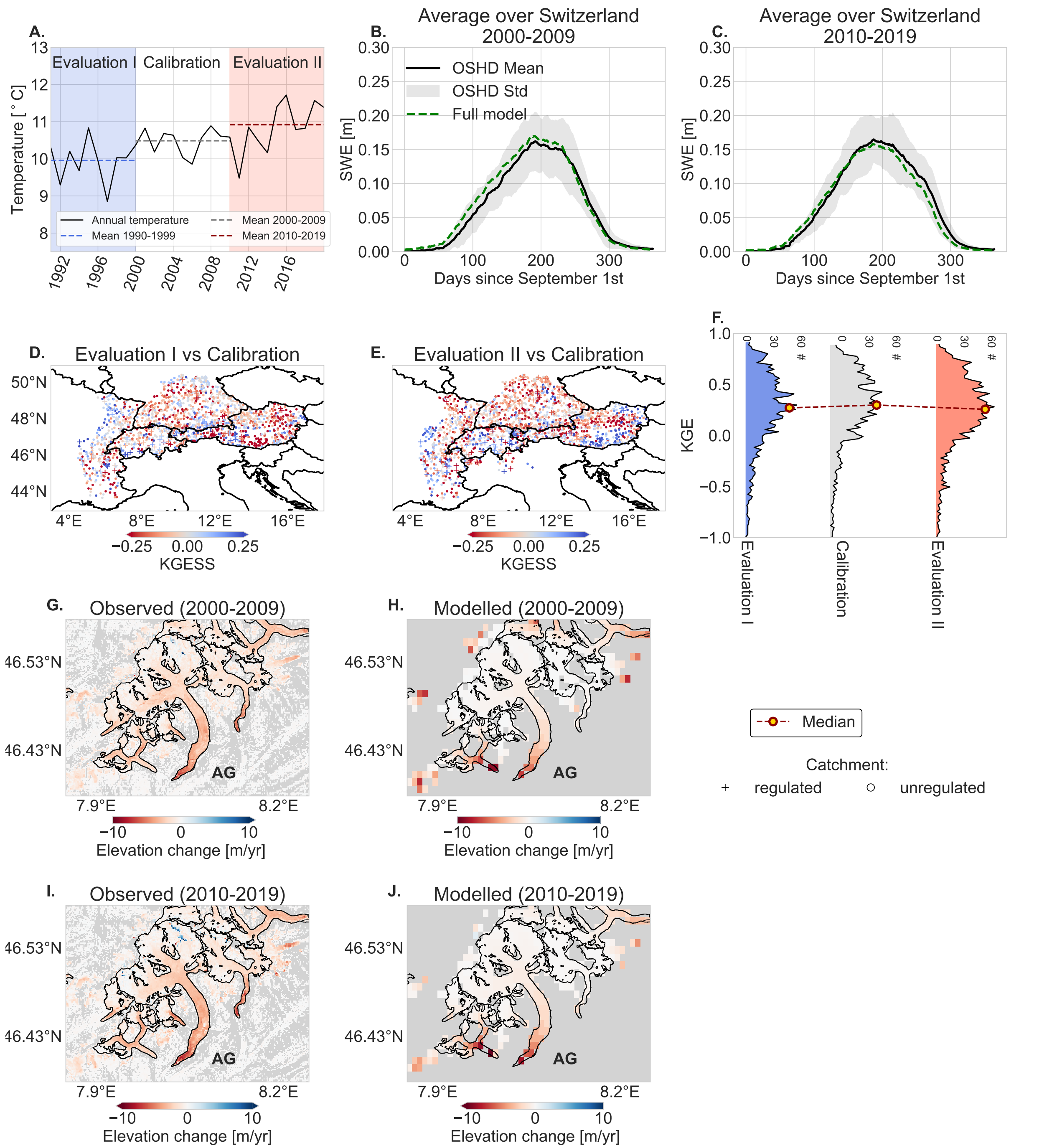

Figure S1. Dependence of model performance of the Full model run on time period and average temperature climatology. (A) Mean annual air temperature during the two evaluation and the calibration periods. Average climatology of snow over Switzerland for (B) 2000–2010 and (C) 2010–2019. Comparison of the performance of discharge simulations (KGESS) for (D) Evaluation period I and (E) Evaluation period II against the one in the calibration period. (F) Distribution of KGE scores over the three periods across the evaluation catchments. Changes in glacier elevation around the Aletsch glacier for the Calibration Period (Observations: G; Simulations: H) and Evaluation Period II; (Observations: I; Simulations; J). Observations from Hugonnet et al. (2021), AG indicates the Aletsch glacier.

S3 SWE Stations

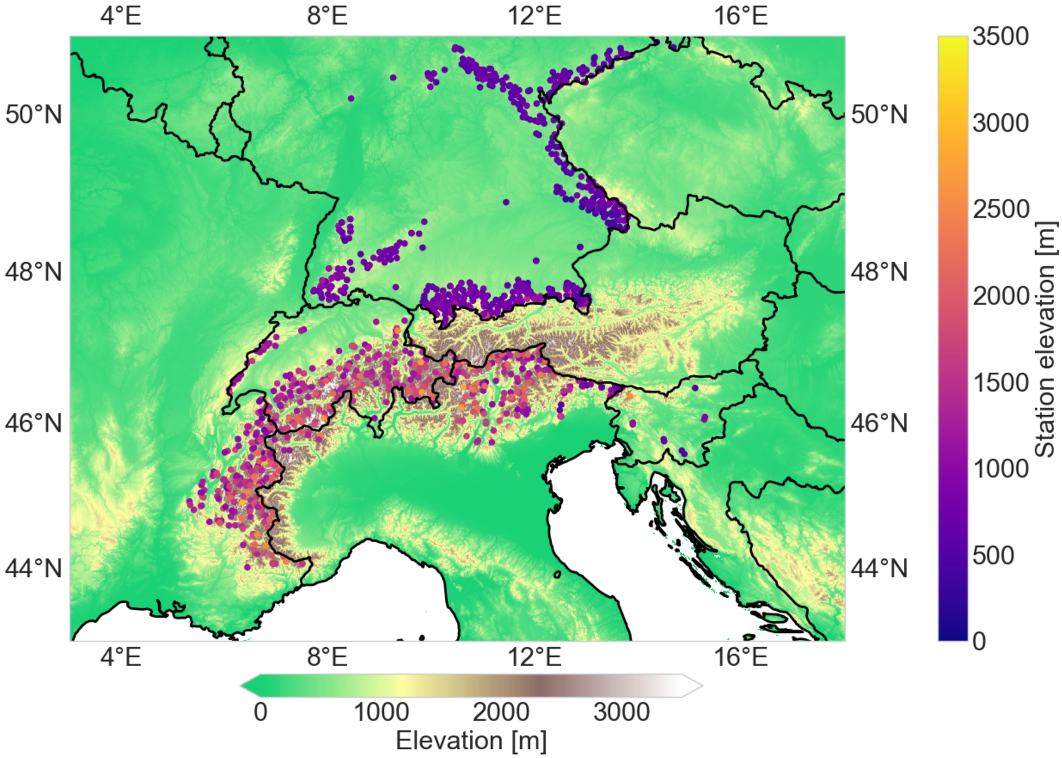

Figure S2. Location of the snow stations from Fontrodona-Bach et al. (2023) included in the analysis.

S4 Degree of regulation

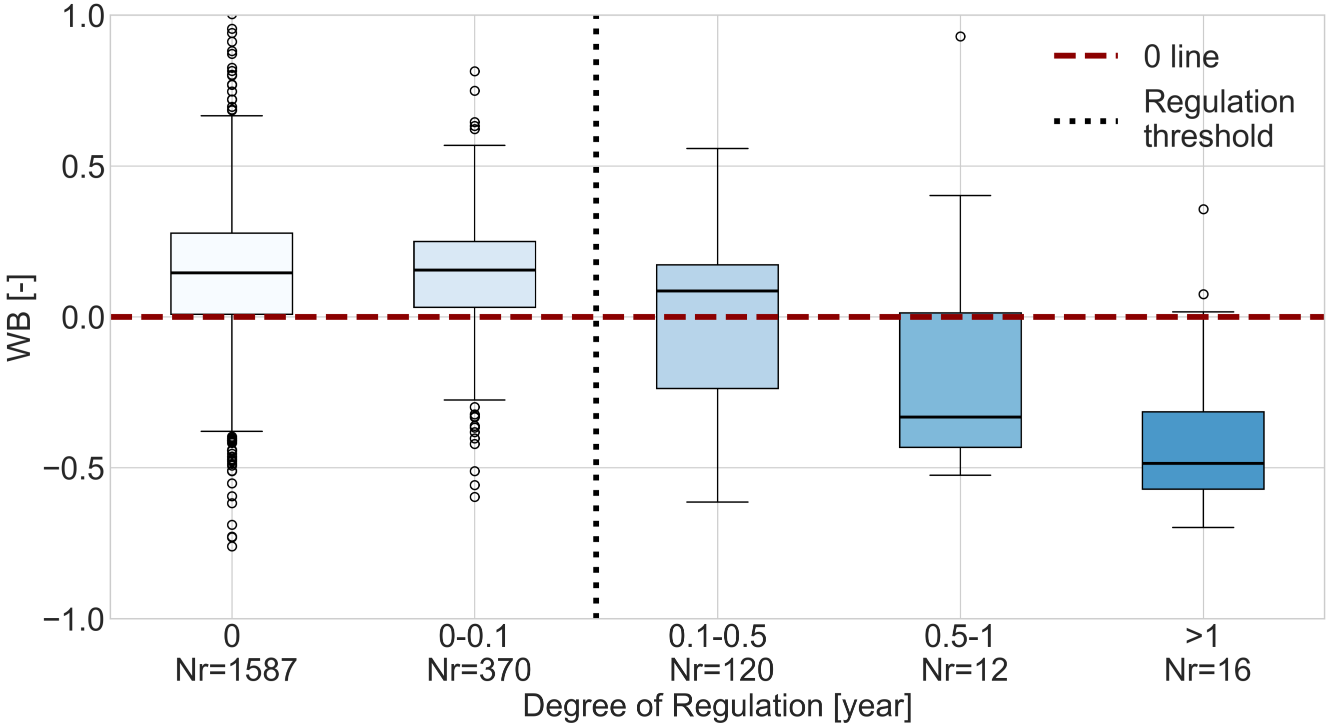

Figure S3. Relationship between the degree of reservoir regulation and the WB signature. The degree of reservoir regulation is here defined as the total reservoir volume over the catchment divided by the mean annual discharge..

References

Fontrodona-Bach, A., Schaefli, B., Woods, R., Teuling, A. J., and Larsen, J. R.: NH-SWE: Northern Hemisphere Snow Water Equivalent dataset based on in situ snow depth time series, Earth System Science Data, 15, 2577–2599, https://doi.org/10.5194/essd-15-2577-2023, 2023.

Hugonnet, R., McNabb, R., Berthier, E., Menounos, B., Nuth, C., Girod, L., Farinotti, D., Huss, M., Dussaillant, I., Brun, F., and Kääb, A.: Accelerated global glacier mass loss in the early twenty-first century, Nature, 592, 726–731, https://doi.org/10.1038/s41586-021-03436-z, 2021.

Magnusson, J., Gustafsson, D., Hüsler, F., and Jonas, T.: Assimilation of point SWE data into a distributed snow cover model comparing two contrasting methods, Water Resources Research, 50, 7816–7835, https://doi.org/10.1002/2014WR015302, 2014.

Van Tiel, M., Teuling, A. J., Wanders, N., Vis, M. J. P., Stahl, K., and Van Loon, A. F.: The role of glacier changes and threshold definition in the characterisation of future streamflow droughts in glacierised catchments, Hydrology and Earth System Sciences, 22, 463–485, https://doi.org/10.5194/hess-22-463-2018, 2018.