Climate change and hydrological systems in Switzerland - Which catchments are particularly sensitive?

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OESCHGER CENTRE CLIMATE CHANGE RESEARCH

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Objectives

In our study, we apply a wide range of Regional Climate Models (RCMs) to a comprehensive set of mesoscale catchments distributed over Switzerland, to quantify the impact of climate change on Swiss hydrological systems.

We determine catchments exhibiting sensitivity towards those changes in climate that are anticipated for Switzerland during the first half of the 21st centrury (OcCC 2007), e.g. changes in precipitation patterns and increasing temperatures.

We present the results of an application of 17 climate scenarios to six test regions, each of them representing a natural geographic region of Switzerland. Basic relations of catchment characteristics and climate sensitivity are specified.

Data

A total of 17 RCMs from the ENSEMBLES project (HEWITT & GRIGGS 2004) were interpolated to meteorological station locations (BOSSHARD ET AL. 2009) using the Delta Approach (PRUDHOMME ET AL. 2002). We added the daily Deltas calculated for the period 2021-2050 to the observed time series (1976-2005) of precipitation and temperature (*Fig. 2*). These scenario time series are used to force the hydrological modelling system PREVAH (VIVIROLI ET AL. 2009, *Fig. 3*) at a temporal resolution of one hour and a spatial resolution of 500 x 500 m^2.

We apply the climate scenarios to six test regions first (*Fig. 1*) to check them for hydrological plausibility. After this plausibility test, the climate scenarios will be applied to approximately 200 mesoscale catchments with an average area of 150 km^2 and a range of 30 to 2000 km^2.

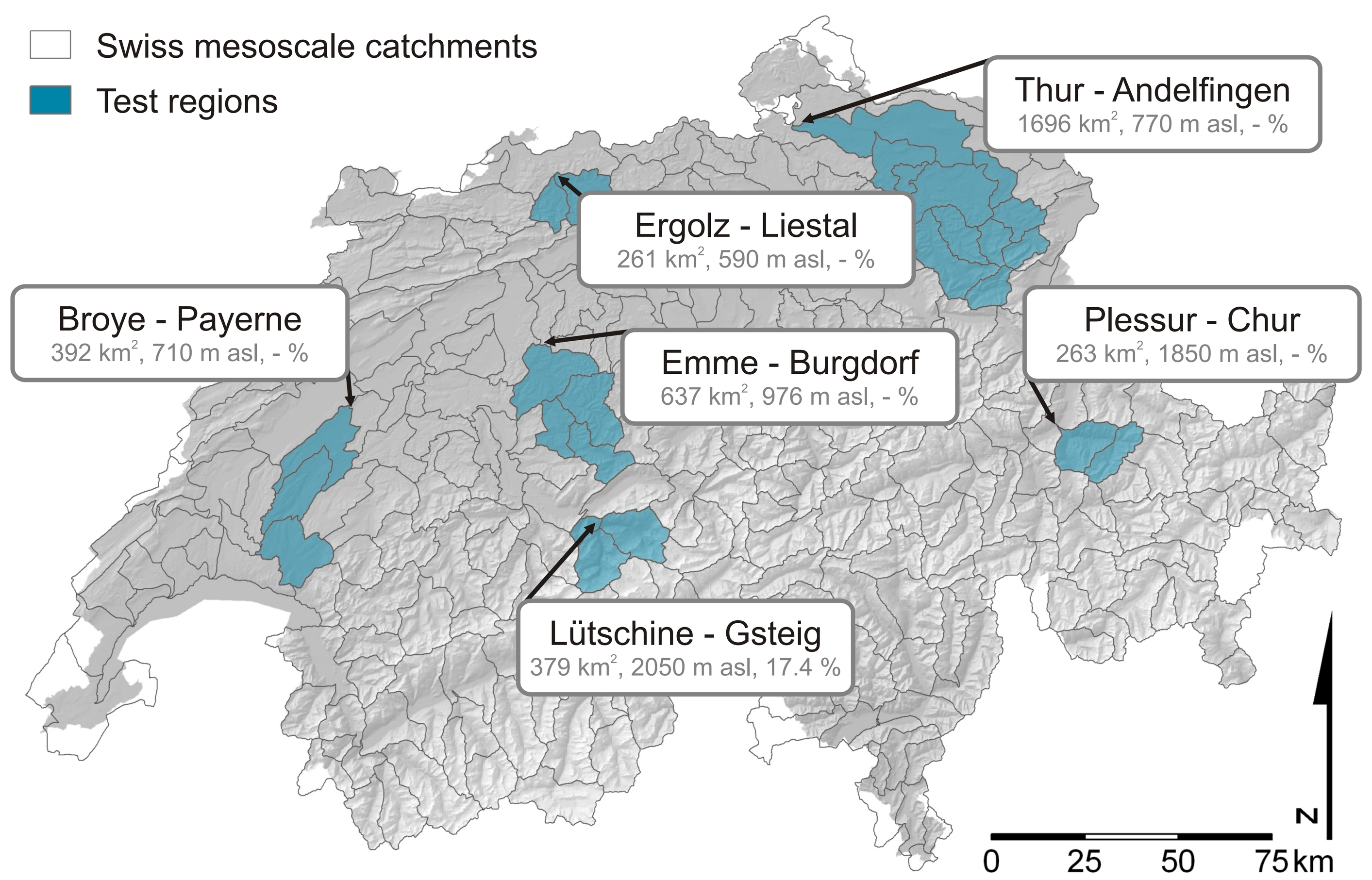

Figure 1: Six test regions out of approximately 200 Swiss mesoscale catchments. The climate scenarios are applied to these catchments to test them for hydrological plausibility. Indicated are river and gauge name, catchment size, mean elevation and percentage of glaciated area.

Methods

Adding the Delta to the observed time series

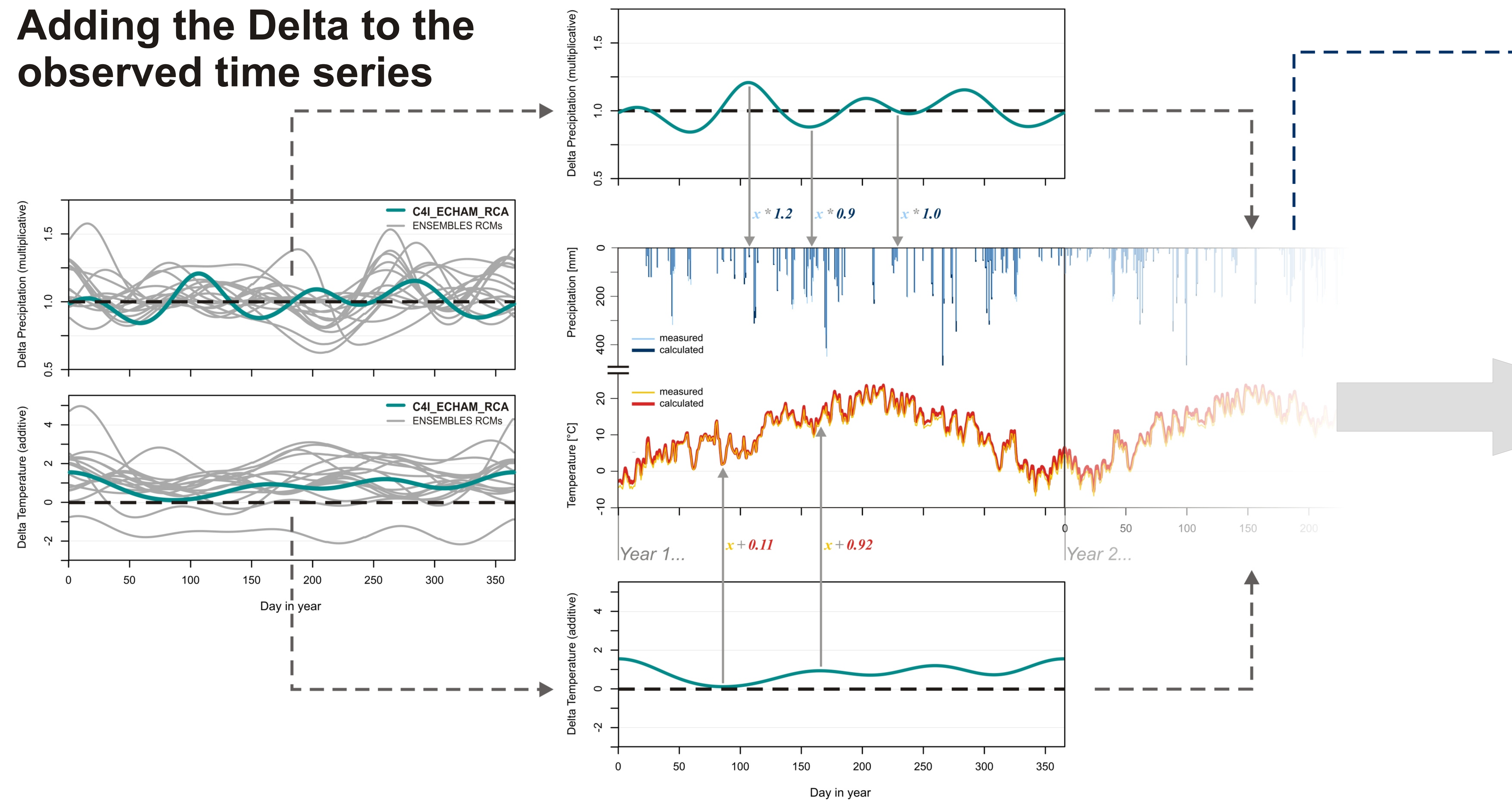

Figure 2: Schematic representation of the calculation of climate scenarios using Delta Change signals, exemplified through the RCM model chain C4I_ECHAM_RCA (Institution_GCM_RCM). Left side: Mean annual cycle of Delta Change signals for temperature (additive) and precipitation (multiplicative) at Bern-Liebefeld, 565 m asl, 46.93 °N, 7.42 °E. The Delta Change signals are calculated for the scenario period 2021-2050 relative to the reference period 1976-2005 .The driving emmission scenario (SRES) is A1B (BOSSHARD ET AL. 2009).

Forcing the hydrological model with scenario data as climate input

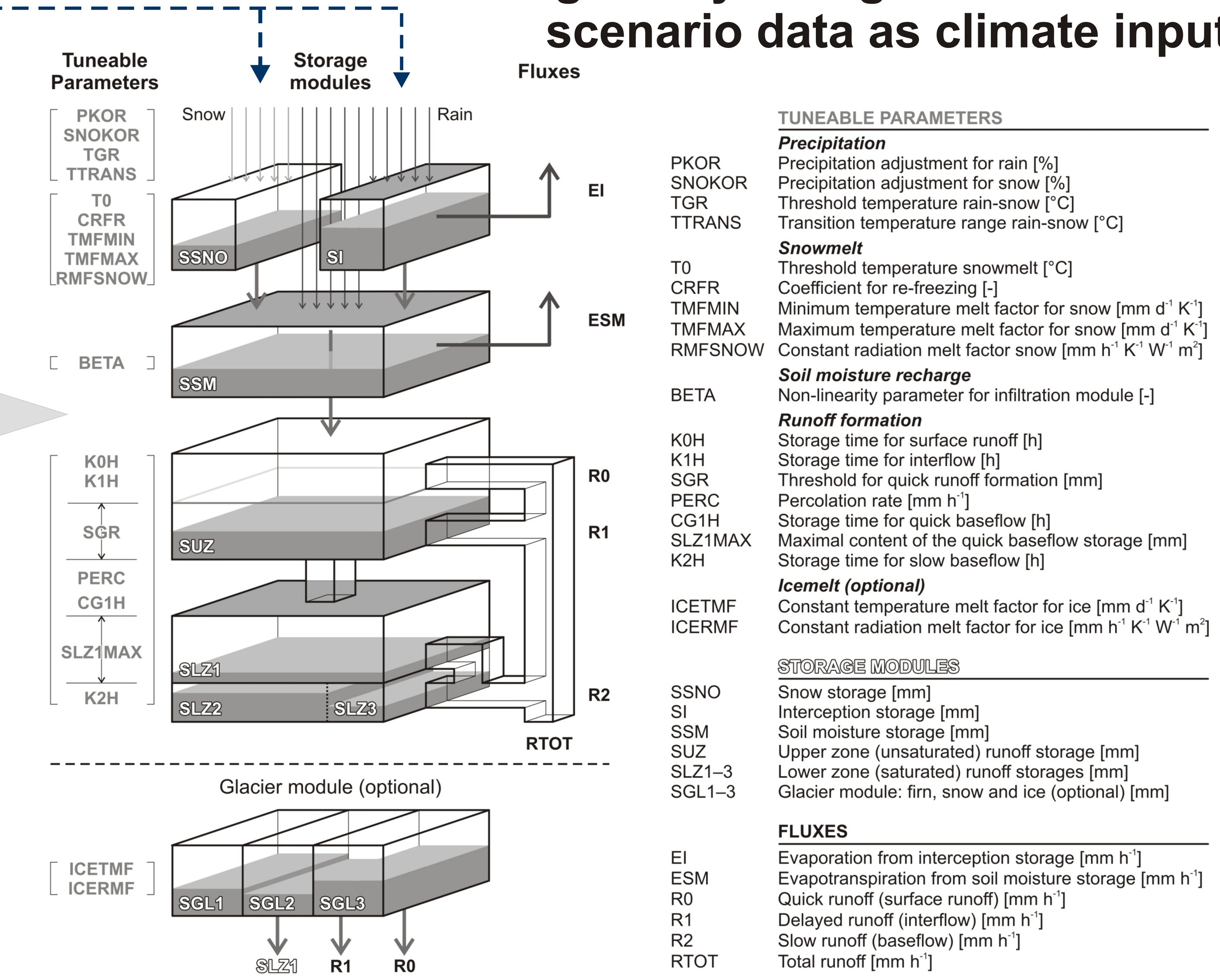

Figure 3: Schematic visualization of the hydrological modelling system PREVAH (VIVIROLI ET AL. 2009)

Results

The results of the hydrological modelling with observed and scenario data are visualized in *Figure 4*, shown as runoff regimes and seasonal differences in discharge quantity for control and scenario runs .

Main findings

low elevations: decreasing runoff in general, highest in spring and summer

high elevations: strong increase in winter runoff

snow-fed regimes: lower runoff in summer compensated by higher runoff in winter

ice-fed regimes: increasing runoff and earlier peak

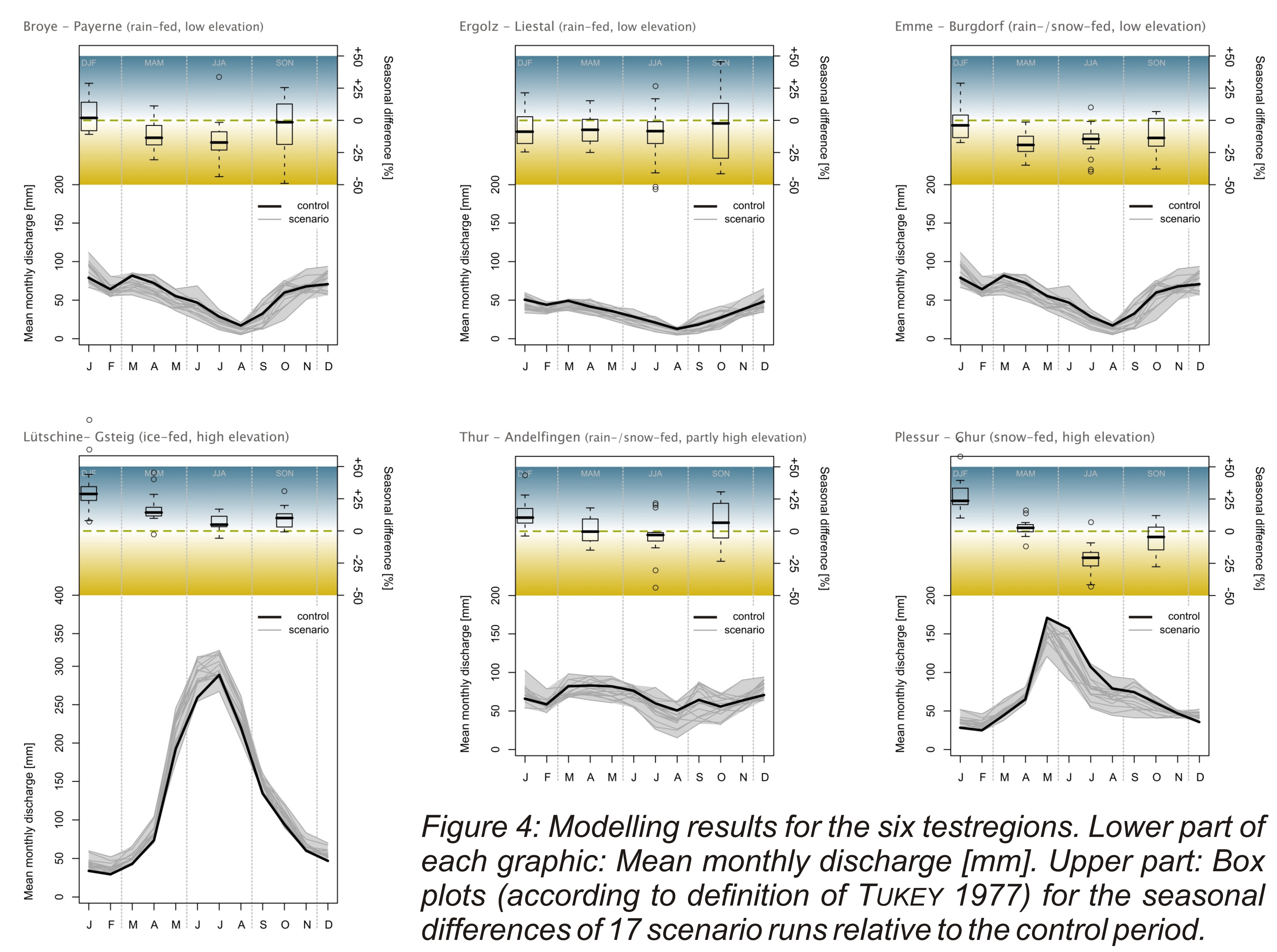

Figure 4: Modelling results for the six testregions. Lower part of each graphic: Mean monthly discharge [mm]. Upper part: Box plots (according to definition of TUKEY 1977) for the seasonal differences of 17 scenario runs relative to the control period.

Conclusion

We showed an application of 17 highly resolved climate scenarios to six mesoscale test catchments in Switzerland for the period 2021-2050.

The majority of scenarios result in decreasing runoff for catchments in lower elevations, with a most distinct decrease in spring and summer.

Snow-fed catchments show higher runoff in winter (increasing percentage of rain) and less runoff in summer (reduced snow pack).

Ice-fed catchments show increasing runoff during the whole year with an earlier peak due to increasing temperatures and earlier glacier melt.

We will apply the climate scenarios to a comprehensive set of approximately 200 mesoscale catchments to determine the climate sensitivity of hydrological systems in Switzerland.

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