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Temperature signal in suspended sediment export from an Alpine catchment

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S1. Sensitivity Analysis on Snow Model parameters

We apply a sensitivity analysis on the three main parameters of our Snowmelt model: snowmelt factor $\mathbf{k_{snow}}$ [mm day^{-1} °C^{-1}], threshold temperature for the onset of snow melt $\mathbf{T_{SM}}$ [°C], and the rain–snow threshold temperature $\mathbf{T_{RS}}$ [°C]. We analyze the impact of the parameters on the model results by perturbing one single parameter at the time. We compute some of the goodness of fit measures adopted during the calibration (TSS, NS RMSE) and analyze their relative change as function of the parameter perturbation (Fig. S1).

As expected, the snowmelt factor k_{snow} is the most sensitive parameter (Fig. S1). For k_{snow} between 1.6 and 5.6 mm day^{-1} °C^{-1}, the relative reduction of TSS and NS results respectively lower than 10% and 15% (Fig. S1). Although reducing the snowmelt factor k_{snow} below 2.6 mm day^{-1} °C^{-1} increases RMSE by almost 40%, it results in incrementing RMSE only by 0.06 units (SCF [0–1]). For T_{SM} varying within the range of –2 ÷ 2 °C, TSS and NS decrease less than 10%. While the change in RMSE results larger similarly to the case of k_{snow} (Fig. S1). The effect of T_{RS} is even more negligible, with relative changes of goodness of fit measures within 5.5% (Fig. S1).

We also estimated the influence of these three parameters on the trends and the jumps that we identified over the period 1975–2015 for the hydroclimatic variables simulated with the model: SM, IM, ER, SCF. For this purpose, we applied statistical tests for equality of mean annual and monthly values before and after mid–1980s after perturbing one parameter at the time within physically reasonable ranges of values.

In agreement with the results of our analysis (Sect. 5.3), a statistically significant increase of mean annual IM and ER and a statistically significant decrease of mean annual SCF after mid–1980s are detected for all selected parameter values. Similarly, mean annual SM shows a decreasing tendency after mid–1980s for all parameter selections, and in about 50% of all the parameters selections statistical tests even show a statistically significant drop in mean annual SM. The increases in mean monthly ER in June and July are identified respectively in more than 90% and in 100% of the cases. Similarly, all parameters sets show an abrupt rise of IM after mid–1980s for all spring and summer months (May–August). This confirms that by perturbing the parameters of the snow model within reasonable ranges, the overall results of our analysis do not change. This is also depicted in Fig. S2. The differences in mean monthly values of IM and ER between the period after and before mid–1980s are shown for multiple values of each of the three parameters. The confidence interval depicted in Fig. S2 is built by selecting, for each month, the highest and the lowest values of the confidence interval (5% significance level) among all parameter sets. The comparison between Fig. S2 and Fig. 8c and Fig. 8d, shows that changing parameters within reasonable ranges would not substantially change the results of our analysis.

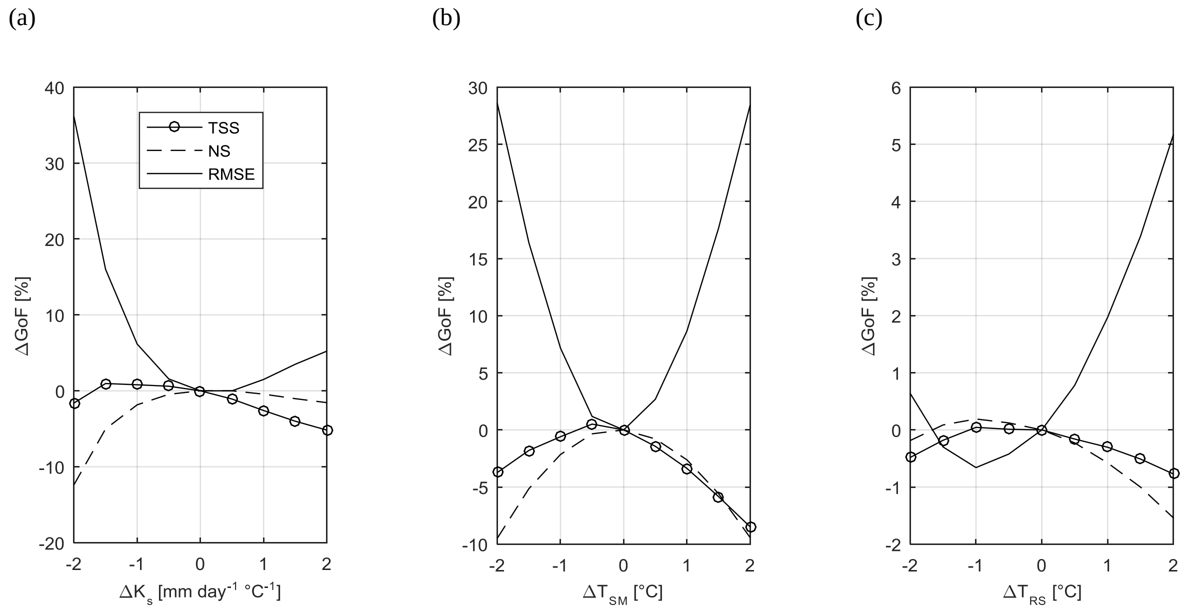

Figure S1: Parameter perturbation analysis on: (a) snowmelt factor k_{snow} , (b) threshold temperature for the onset of melt T_{SM}, (c) rain–snow threshold temperature T_{RS}. The relative change [%] of TSS, NS and RMSE are shown for each parameter.

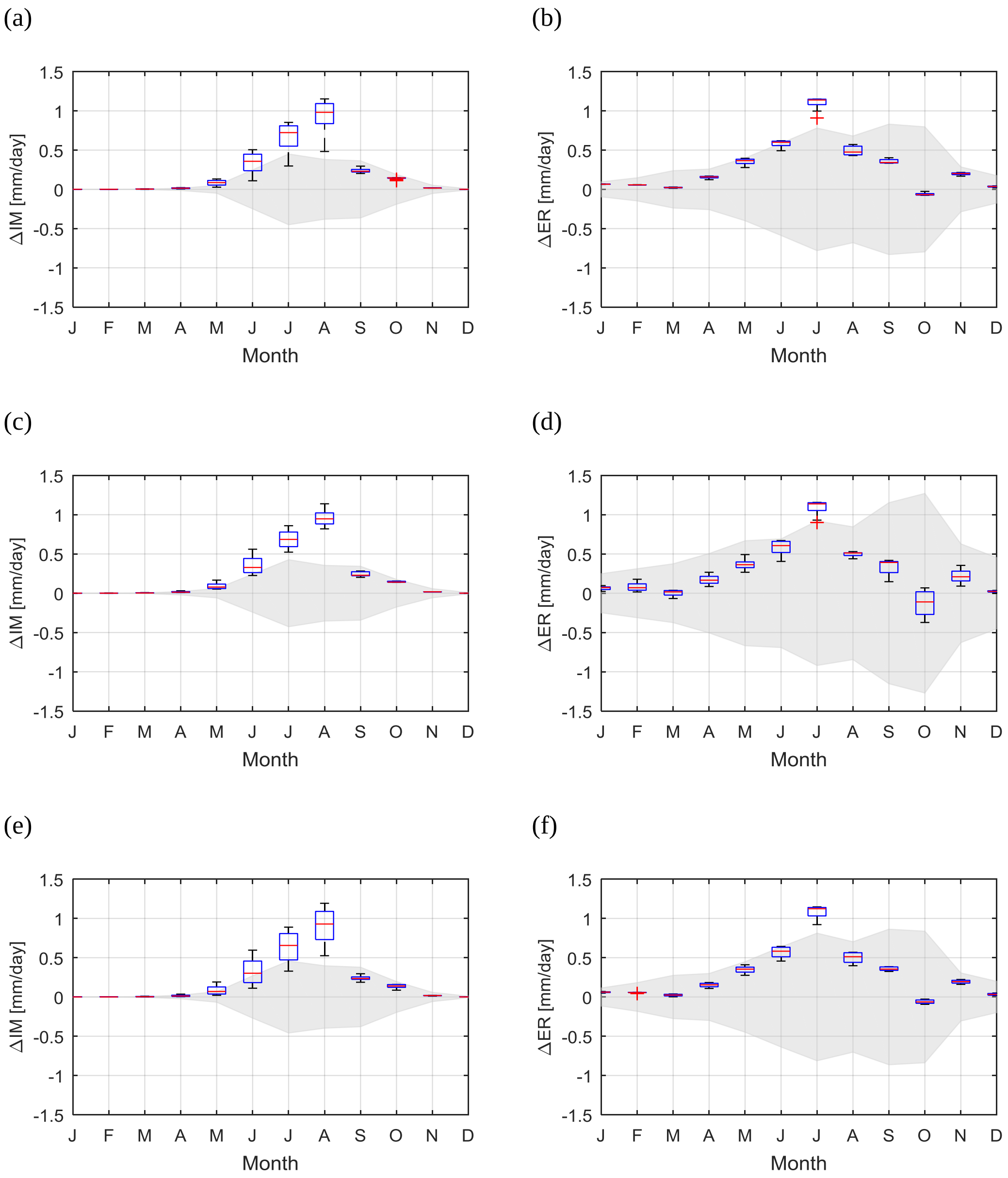

Figure S2: Sensitivity analysis on monthly differences between the periods after and before the year–of–change (1987–2015 and 1975–1986) for IM (left) and ER (right). Box plots represent monthly differences for all selections of parameters within given ranges of values: 1.6 mm day^{-1} °C^{-1} ≤ k_{snow}≤ 5.6 mm day^{-1} °C^{-1} (a,b); –2°C ≤ T_{SM}≤ 2 °C (e,f); –1 °C ≤ T_{RS} ≤ 3 °C (c,d). Grey shaded areas represent the widest confidence interval among all selections of the parameters.