Response to Reviewer#1 Comments

Comment 1:

The authors have appropriately addressed the issues and made substantial revisions to the manuscript, while I keep my concern on the spinup configuration of the JSBACH model. I acknowledge that the Figure B2 shows that the thermal regime has little change after 45-years of simulation till 1986. But the transient atmospheric forcing is theoretically impossible to get the soil thermal regime in equilibrium. To me the equilibrium is more likely to the consequence of the relatively cold period in the 1950s and 1960s. Since the 1970s, it is clear that the soil temperature start to increase, and the trend is close to that in the 2000s. In this way, I don't think the JSBACH is correctly spun-up. Authors should either re-conduct the spin-up simulation or give a thorough discussion on why the JSBACH model needs to be spun-up in a different way.

Response:

We thank the reviewer for this important comment. We agree that, under transient atmospheric forcing, a strict equilibrium of the soil thermal regime cannot theoretically be achieved because the forcing itself evolves over time. Our objective was therefore not to obtain a steady state equilibrium, but to ensure that the model state used for analysis is no longer influenced by the initial conditions.

To address this, we performed an additional test simulation in which the model was initialized using a substantially longer spinup period. Specifically, the model was first forced with GSWP3 atmospheric forcing from 1901 to 1940, followed by ERA5 forcing from 1941 onwards. We then compared this simulation with the original experiment, which was forced directly with ERA5 from 1941 onwards. The blue line represents the original simulation, while the green dotted line represents the simulation with the longer spinup. This gives the soil column roughly twice the equilibration time before our original analysis start date of 1986, and particularly, a different initial thermal state in 1941 than the original exp.

As shown in the figure below, the deep layer winter soil temperature, summer soil moisture (0-1 m), and winter snow depth from the extended spinup simulation (green dashed) converge to the same trajectory as the original simulation (blue solid) well before 1986, after which the two remain virtually indistinguishable for the remainder of the analysis period. The upper soil layers also show the same convergence within about 10 years. The 0-1 m soil moisture is shown here because the mean bedrock depth over the selected Siberian region in Fig. B1 is approximately 1 m.
Through this exercise, we found that, for the Siberian region, JSBACH requires only about 10 years of spin-up for the soil thermal and hydrological variables analyzed here. However, we fully agree with the reviewer that this evidence deserves to be included in the manuscript. Finally, we would like to thank the reviewer for this additional analysis. It does not change the scientific conclusions of the manuscript, but it has allowed us to better document the spinup behaviour of JSBACH and clarify all doubts regarding the spinup time, which we hope will also benefit future users of the model.

This figure has been replaced with the originally submitted Fig. B2 in the revised manuscript.

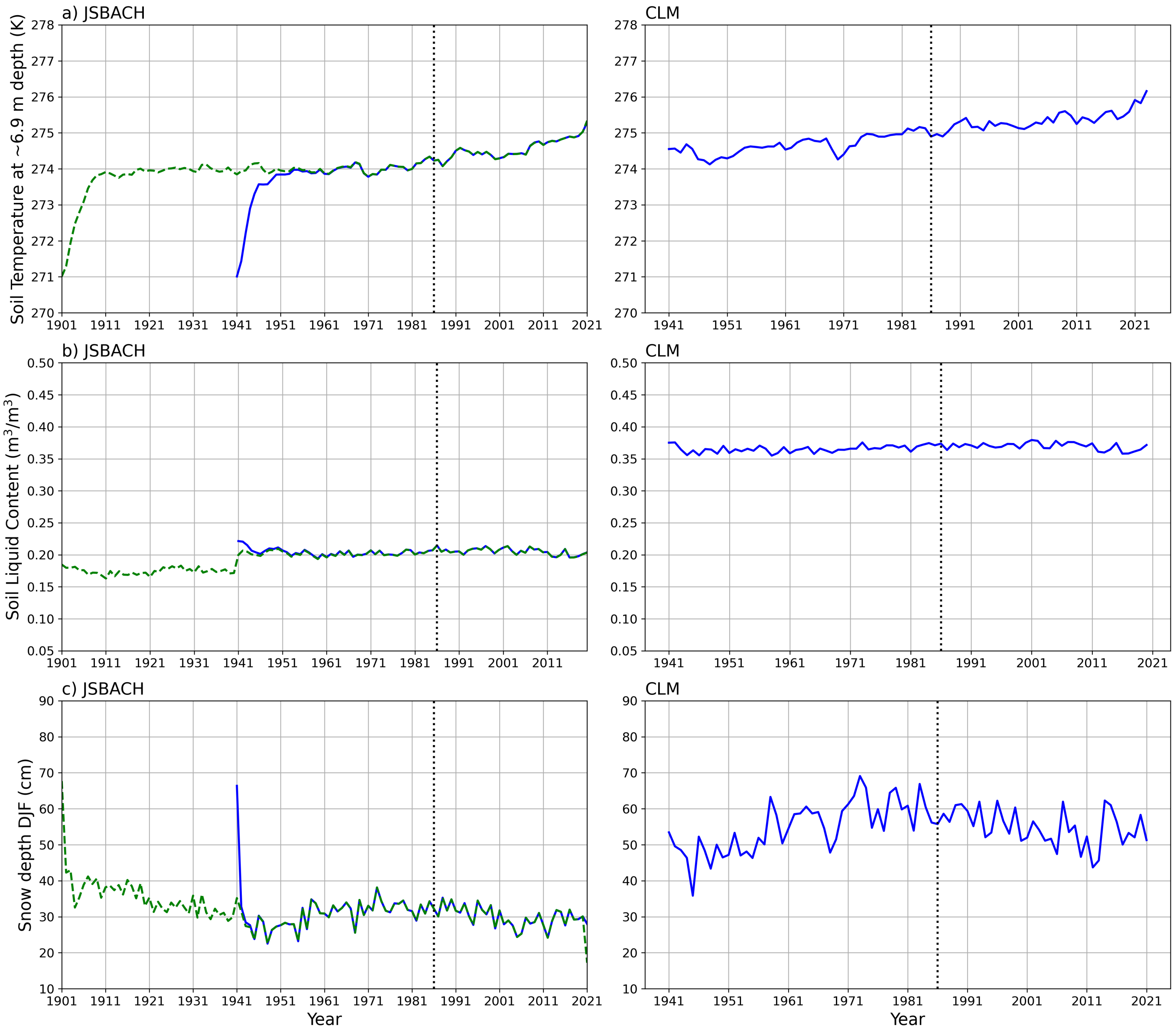

Figure 1: Time series of (a) winter mean soil temperature at 6.9 m depth, (b) summer mean volumetric soil liquid water content (0-1 m) (m^3/m^3), and (c) winter mean snow depth, averaged over the region shown in Fig. B1, simulated by JSBACH (first column) and CLM5 (second column) for the period 1941-2022 (blue solid lines). In addition, an extended JSBACH simulation forced with GSWP3 (1901-1940) and subsequently ERA5 (1941-2022) is shown (green dashed line), which converges to the same trajectory as the standard simulation well before the start of the analysis period, indicating that the soil thermal and hydrological states become effectively independent of the initial conditions before 1986.