ISIMIP3b paper review comments

Reviewer 1

This paper describes the setup of the scenario and the climate-related forcings for ISIMIP3b. I truly appreciate the significant efforts made by the authors. The paper is important, interesting, and well written. I have a few comments.

Major comment

L511-525: The five representative ESMs include a hot model (UKESM1-0-LL). It has been suggested that the "hot model" issue of the CMIP6 ensemble can cause overestimation of impact assessments (Hausfather et al. 2022), Shiogama et al. 2022a). It depends on the variables and regions whether the hot model overestimates future change projections (Tokarska et al. 2020, Paik et al. 2023, McDonnell et al. 2024, Swaminathan et al. 2024, Li et al. 2024, Shiogama et al. 2022b, 2024, 2025). Although the internal variability component of the tropical Pacific surface warming pattern can affect the evaluation of "hot models" (Liang, Gillett, and Monahan 2024), the relative contributions of forced changes and internal variability to the observed tropical Pacific surface warming pattern are highly uncertain (Watanabe et al. 2024). Therefore, at least, please discuss the possible influence of the "hot model" issue on impact assessments of ISIMIP3b.

Reply:

Thanks so much for this very valid comment. To address the issue (and a related comment by reviewer 2), we added the following discussion to the relevant section:

"The five GCMs provide a good representation of both the mean and the range of the full CMIP6 multi-model ensemble ECS. According to (Meehl et al. 2020), the CMIP6 multi-model mean ECS is 3.7°C, which is precisely met by the mean ECS of the five ISIMIP3b GCMs. The transient climate response (TCR) of 2.0°C is also precisely met. This provides an improvement over ISIMIP2b, in the sense of the selected GCM subset reflecting the statistics of the larger CMIP ensemble. In ISIMIP2b the mean ECS for the full CMIP5 was 3.2°C compared with a mean ECS of 3.72°C for the four ISMIP2b GCMs (see Table S1 and S2 in (Jägermeyr et al. 2021)). The ISIMIP3b ensemble includes three models with below-average ECS (GFDL-ESM4, MPI-ESM1-2-HR, MRI-ESM2-0) and two models with above-average ECS (IPSL-CM6A-LR, UKESM1-0-LL) (see **Table 4**). In line with their ECS values, we find GFDL-ESM4 and UKESM1-0-LL to project the weakest and strongest global warming, respectively, under any future scenario considered (see **Figure 3**). Under SSP5-8.5, the global mean near-surface temperature in 2100 is about 3°C larger in UKESM1-0-LL than in GFDL-ESM4. Under SSP1-2.6, the projections are about 1.5°C apart. The ensemble mean warming of the ISIMIP3b CMIP6 models is significantly higher than the warming of the ISIMIP2b CMIP5 models, across global land area by an average of 0.3°C, but over the main breadbasket cropland regions by more than 0.5°C between 1983–2013 and 2069–2099, under both SSP1-2.6 and SSP5-8.5 (Table S1 in (Jägermeyr et al. 2021). This is in line with the higher median ECS in CMIP6 compared to CMIP5; indeed, some CMIP6 models have an ECS above the assessed likely (2.5°C to 4°C) and very likely (2°C to 5°C) ranges in the IPCC's sixth assessment report (AR6) (Forster et al. 2021). The reasons for these higher estimates of ECS are complex, with cloud feedback processes playing an important role (Zelinka et al. 2020). While the plausibility of the very high ECS estimates has been questioned, recent studies indicate CMIP6 models with high ECS tend to simulate cloud properties better than low ECS models (Bock and Lauer 2024); also, unaccounted natural variability may have biased the IPCC's assessed ranges somewhat low (Watanabe et al. 2024; Liang, Gillett, and Monahan 2024)

The ISIMIP3b ensemble reflects the spread in ECS of the overall CMIP6 ensemble, with two models above the AR6 likely range and one of these (UKESM1-0-LL) above the very likely range. The strong warming response of these models should be kept in mind when conducting ISIMIP3b-based impacts studies. However, depending on the region and variable of interest, the high ECS does not necessarily have any bearing on the magnitude or realism of projected regional impacts, and any further selection of models should not be based solely on ECS but on the models' suitability for the impacts variables in question (Swaminathan et al. 2024)). In many applications, results can be harmonized by describing the simulated impacts in terms of global mean temperature changes instead of time for the different emission scenarios."

Minor comments

L98: ISIMIP3 -> ISIMIP3b?

Reply: indeed, thanks!

Table 2 (page 13, pre-industrial control, 2015soc, 1st priority): Please omit "ensi".

Reply: Done!

Figure 4: Can you add the plot of bias correction data of the historical simulation? It would be a good example to show hot bias-correction reduced the bias.

Reply: Thanks for the great suggestion, we revised the figure and added the bias-adjusted historical simulation data, showing the agreement with the observational data (see Figure below, brown line vs. thick black line). While doing so we also discovered that the uncorrected climate model data (blue and green lines) was not correctly displayed, and corrected it.

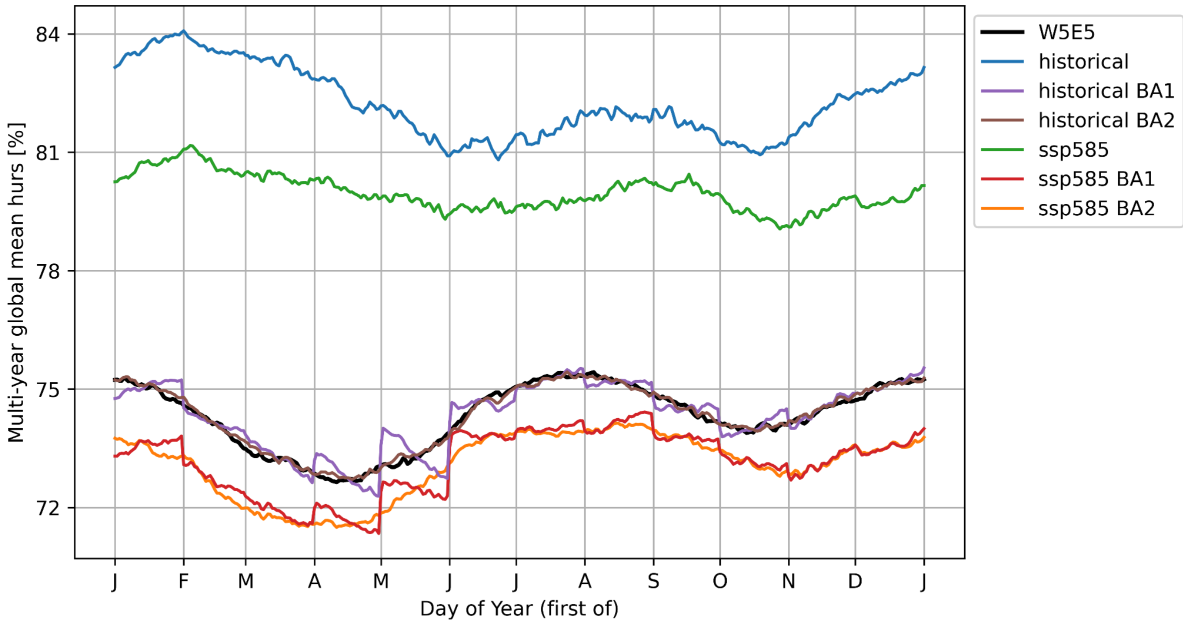

Figure 4: Global multi-year daily mean near-surface relative humidity for UKESM1-0-LL historical (1979-2014) and SSP5-8.5 (2065-2100), with uncorrected historical simulated data in blue, uncorrected future simulated data in green, historical bias-adjusted data in purple and brown, future bias-adjusted data in red and orange, and observational reference data in black. The bias is effectively reduced throughout all days of the year (brown line closely matching the black line) when ISIMIP3BASD v2.5 is applied in running-window mode in steps of one day (BA2). In contrast, a month-by-month application, which was the only option in ISIMIP3BASD v1.0, generates discontinuities at each turn of the month (BA1).

L808: "the Global Surge and Tide Model (GTSM) model" -> the Global Surge and Tide Model (GSTM)"?

Reply: We have adjusted the text. The correct name is Global Tide and Surge Model (GTSM).

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