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Interactive comment on "Assessing the impacts of 1.5 °C global warming – simulation protocol of the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP2b)" *by* Katja Frieler et al.

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In the course of the ISIMIP2b simulation phase there have been some improvements of the protocol that do not directly refer to the reviewers' comments but have let to associated adjustments of the manuscript:

1. Instead of the originally suggested linear interpolation from historical land use patterns from HYDE3.2 to future projections generated by the LU model MAgPIE we have decided to apply a harmonization method that has recently been developed in the context of the CMIP6 process (Hurtt et al., in preparation). While the underlying MAgPIE simulations have not changed the main text and the SI have been adjusted to describe

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the new harmonization approach. Figure 3 of the main text now shows the areas of crop land from the historical reconstruction and the original MAgPIE simulations without interpolations. The SI contains a comparison of the harmonized crop land areas and the original data for the IPSL-CM5A-LR climate model. The patterns for the other models are currently generated. George Hurtt, Louise Chini, Ritvik Sahapal, Benjamin Bodirsky, Jan Volkholz, and Steve Frolking have been added to the list of authors as they were involved in the generation of the new harmonized LUH2-ISIMIP2b land use data set.

2. We were able to integrate a section on the simulation of climate-change effects on lakes using coupled lake-hydrodynamic and water-quality models into the ISIMIP2b protocol. Rafael Marcé, Don Pierson, and Jonas Jägermeyr have lead the development of the section and have been added to the list of co-authors.

3. Similarly, a "terrestrial biodiversity sector" has been added to the ISIMIP2b protocol. Christian Hof and Matthias Biber have worked on the development of the associated section of the protocol document (https://www.isimip.org/protocol/#isimip2b) together with Thomas Hickler and they have thus been added to the list of co-authors.

4. We now also provide spatially explicit GDP distributions as input for the ISIMIP2b simulations or to e.g. estimate damages in post-processing of bio-physical impact simulations. The new data set covers the period from 1860 to 2100 and is consistent with reported national GDP data for the historical period and future projections on national level following SSP2 (see section 6 of the main text). The development has been done by Daisuke Murakami, Yoshiki Yamagata, and Tobias Geiger who have been added to the list of co-authors.

5. We now propose a method to account for the effect of changes in Terrestrial Water Storage (TWS) e.g. due to projected changes in ground water abstraction according to SSP2 on sea level rise. The approach is designed to be consistent with projected changes in land use and irrigation patterns as provide within ISIMIP2b and will be

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applied to generate spatially explicit patterns of sea level change for the Group 3 simulations within the coastal infrastructure sector. A description of the associated addition to the Group 2 sea level projections has been added to the paper. Riccardo Riva has been involved in the development of the approach and will contribute the sea level fingerprints associated with the projected changes in TWS. He has been added to the list of co-authors. 6. The hurricane simulations are no longer considered as an additional impact sector within ISIMIP2b but as a complement to the climate input data sets provided to force the impact models. Therefore the associated description has become part of Section 3 on climate input data.

Below we provide detailed answers to the review by D. Jacob:

1. Dear All, I suggest to publish the manuscript almost as it is. It is a good paper, well written. The method explained is solid and fits to the purpose.

Answer: Thank you very much for this positive evaluation of the paper!

2. There are a few minor issues: the paper is very detailed. There is a lot of repetition of the simulations design. It is listed in many sections.

Answer: To avoid repetition and increase the readability of the paper we have moved the largest part of the sector specific scenario lists from section 8 to the new ISIMIP2b protocol document including all technical details required to set-up the model simulations within the individual sectors. We also tried to avoid repetition of the scenario design across the other sections. In particular, the introduction has been re-structured and shortened.

3. on page 4 in the middle paragraph it says that the data from ISIMPI2a will eventually be publicly available. In order to help the community in this lind of studies and for trust building - they should be made publicly available. Otherwise it is not possible for outsiders to judge on the quality of all follow up and proposed simulation results.

Answer: Yes, it is the clear purpose of ISIMIP to make the impacts simulations of each

individual simulations round publically available. The quality checks of the ISIMIP2a data are nearly finished and a first package of the data is already listed on the ESGF server (https://esg.pik-potsdam.de) and will be released and freely available very soon. The others will follow soon after finalizing the doi assignment. For ISIMIP2b we even agreed with the modelers to forgo the usual "embargo period" of the archive and release the data as soon as possible to provide the opportunity to other researchers to work on the data and potentially provide additional input for the IPCC Special Report. Publication rules for the ISIMIP data in general and the ISIMIP2b output in particular are described in the "How to join ISIMIP" document (https://www.isimip.org/protocol/terms-of-use/) underlining the clear intention of providing open access to the simulation data comparable to e.g. the CMIP data. The associated reference is now included in the paper.

4. At the end, the paper is too detailed and hard to read.

Answer: We hope that we could solve this issue by moving large parts of the sector specific more technical information to the protocol document.

5. In chapter 3 it is unclear if the chosen GCMs are representative for a spread on possibilities. How do they compare to the full set of CMPI5 simulations.

Answer: To illustrate to what extent the 4 selected GCMs cover the range of projections provided by CMIP5 the SI now includes two additional plots. They show regional changes in annual temperatures and precipitation plotted against global mean temperature change for the considered 4 GCMs and the range of other models from CMIP5. As the bias-adjustment only preserves relative changes in precipitation on the grid level changes in the bias-adjusted input data cannot be directly compared to the non-bias-adjusted CMIP5 projections. Due to this problem, the comparison is based on the raw CMIP5 data. The selected regions cover the ISIMIP focus regions (river basins + oceanic regions) and global land and ocean temperatures. Regional changes are plotted against global mean temperature changes as ISIMIP2b is intended to quan-

tify impacts at different levels of global warming, in particular the difference between impacts at 1.5°C and 2°C of global mean temperature change. In order to measure how well the ISIMIP2b set covers the ranges of regional climate change projections, we have added an analysis of the Fractional Range Coverage (FRC) as proposed by (McSweeney and Jones, 2016) to the SI. In sum the 4 GCMs (originally chosen on the basis of climate input data requirements) provide an FRC close to the mean FRC across randomly chosen four-member sets of CMIP5 GCMs.

6. What is the role of the bias correction (which by the way should be named bias-adjustment, since the bias will only be reduced but not corrected!!!) on the final results?

Answer: We have adjusted the naming throughout the manuscript. The bias-adjustment is critical for the impact simulations as the represented processes may show a non-linear response to changes in temperatures or other variables. So e.g. US crop yields have been shown to drop strongly as soon as temperature exceed a critical threshold of about 30°C, dams provide flood protections as long as water levels do not exceed a certain threshold, or mortality non-linearly depends on temperatures showing a strong increase beyond site-specific threshold. In many cases these temperature dependencies are implemented in absolute terms and biases in the input data could lead to a quite different historical distribution in impacts variables than the observed ones and changes in terms of global mean temperature are expected to depend on these starting conditions. To this end we decided in favor a bias-adjustment although it comes at the cost of losing full physical consistency of the climate variables.

7. Since all impact models are so different and the input sets are also very different, I did not understand, how comparable the final results will be.

Answer: ISIMIP is designed to allow for model intercomparison within sectors but also for an aggregation or integration of impacts across sectors. To this end climate and socio-economic inputs are harmonized and all modeling groups within a given sector are asked to provide the same list of output variables. Nevertheless, different decisions

about processes to implement (e.g. inclusion of direct human interferences or not), different ways of representing these processes, different parameter settings etc. may lead to strong differences between models. This is partly accounted for by considering different scenarios within the sectors (e.g. naturalized simulation (nosoc), simulations with constant present day management (pressoc) and simulations accounting for changes in management (varsoc)). So even models not accounting for the influences of direct (human) disturbances could be compared to others in a basic naturalized setting. In general ISIMIP is an ongoing process improving the mutual understanding of the models that may lead to improvements of the protocols and models in further rounds. In general, it has turned out that it is extremely helpful to start from a very basic intercomparison only building on a common climate input and identical socio-economic storylines avoiding too much harmonization.

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