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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Climate change and sectors of the surface water cycle in CMIP5 projections" *by* P. A. Dirmeyer et al.

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General comments

This is a clearly presented, straightforward analysis of future water resource availability and extremes as simulated by the mean behavior of ten CMIP5 models. Some of the details of the analysis require further explanation, but in general, this is an interesting assessment of the likelihood of future changes in extremes of precipitation, soil moisture, and river discharge for two future scenarios (RCP4.5 and RCP8.5). I believe this manuscript should be ready for publication with only minor changes. I also think it is great that it grew out of a class project: those are some lucky students!!!

> We thank the reviewer for the supportive and constructive comments. We have

responded to the specific comments below point-by-point.

Specific comments

1. Section 2 a. Page 4, Line 15: "Only multi-model statistics are shown". I do not believe you ever discuss how the different native grids of the ten models are dealt with in generating the multi-model statistics.

> In the 3rd paragraph of Sec 2 we describe the interpolation and averaging process. We have expanded the discussion at the behest of Reviewer 1, regarding the motivation for interpolating all models to a much higher resolution grid. Dirmeyer et al. (2013) gives a detailed description of the process. A critical detail we should have repeated here is that we mask each model with its native land-sea mask, average only land data, and retain data on the high resolution grid only where at least 8 of the 10 models have land. This detail has been added to the text.

b. 90 years from both the historical case and the future scenarios are likely to have a large amount of change within these time frames. For the historical, are the 90 years 1921-2010? Do you find a disproportionate percentage of the extremes are from the more recent part of that 90 year period? Are the 90 years in the future already underway: 2010-2100? Wouldn't control runs reflecting fixed time periods produce more reliable statistics than these time-varying runs? I know there is a practical problem here with the availability of model data fitting that requirement, but I wonder how different your results would be if you used only the last 50 years of these runs. . .. Would they show larger impacts?

> Indeed, the climate is not stationary during the runs, and we are constrained by data availability. The last 90 years are used in each case, which is usually 1916-2005 for the historical case. For the RCP cases the last 90 years are used – our rationale was the assumption that they would contain the least trend and greatest signal (difference from the historical run in each model), but those runs vary from 94-295 years for different models and cases, so they may be from different simulated centuries

for different models. That is why we do not refer to "21st century climate" – this is mainly a sensitivity study based on CMIP5 data. Finally, we have examined the transience in the historical and 21st century parts of RCP scenarios in the most recent class project from the spring 2014 class – those results are being written up now for a separate paper.

2. Section 3: a. Page 5, Line 16 wording is inaccurate: “exceeded in at least 50% . . . of the years” would mean 45 years. I believe you mean the threshold is exceeded in 50% more years than in the control time period.

> We have rephrased the sentence: "Shading indicates where the 20th century thresholds are exceeded in at least 50, 100 (double), 200 (triple) and 300% (quadruple) more often than in the historical case (effectively 13.5, 18, 27 and 36 out of 90 years).

b. Page 5, Line 20-21: I cannot see any overlapping color scales in Figure 1. Could you make this clearer in the figure?

> The clearest example in the figure is over the south-central Amazon during JJA – this is now pointed out in the text as an example.

c. Page 6, Line 20-21: “consequences would likely depend on the location and crops grown.” And also on the nature of the wet extremes: are they a result of many more light rains or a few more intense rains? You discuss this in the next paragraph, but it is relevant here, as well.

> We have added "character of the precipitation" at this point.

3. Section 4: a. Page 7, Line 24: “the high-resolution grid used for multi-model results.” I do not believe you discuss this grid. (Also mentioned in comment 1a.)

> The last paragraph of Section 2 described the high-resolution grids to which the individual model output were interpolated.

b. Section 4.2 is written in a misleading way. You mention at the beginning that you are

discussing “the projected changes in soil moisture in areas where crops are grown,” but language like “yams and cassava also show a strong trend toward increased variability” give the reader the impression that the crops themselves are being modelled. You discuss this in the Caveats section, but I do think the language in this section has to more carefully reflect this important difference.

> We have added to the sentence: "Planting and harvest date data, and thus growing season definitions, are primarily defined within political boundaries in this data set" the phrase: "for contemporary conditions (see Section 5 for a thorough discussion of caveats)." We have also added the words "soil moisture" in several places in the subsection, including the sentence cited by the reviewer, so it will be clear we are not discussing changes in the crops themselves.

c. Discussion of Figure 10: Page 13, Line 2-3: This line makes it sound like there are lots of basins with increased variability and decreased mean runoff, but I can only see the Amazon in this category in Figure 10, and Figure 11 confirms this.

> Among the 100 largest rivers beside the Amazon in this category are the Orinoco, Magdalena, Essequibo, Paranaiba and Tocantins in South America; the Zambezi, Limpopo and Senegal in Africa; and the Amu Darya and Ili in Asia. These are the other points seen in the upper left quadrant of Fig 11. We have rephrased the sentence to say: "Most regions show an increase in variability, including in the RCP8.5 case a number of basins in South America, Africa and Asia that show a decrease in annual runoff."

4. Figure 4: This is a neat figure, though its appearance is influenced by the order that the colors are laid down. There seems to be blue buried under the yellows and browns, particularly in the top plot. I don’t have a better solution yet. . ..

> Reviewer 1 suggested inverting the color scale, which we have done.

5. Figure 6: Are all subplots necessary? The crop coverage one is useful, but I’m not

sure about the others. . .

> The local planting and harvest dates determine which months' data are used in the calculation of growing-season statistics. We suggest this is an informative subplot as it shows the global variety and suggests the degree of data convolution involved in our calculations. The length of growing season plot is probably not useful, as the reviewer suggests. We have removed it from the revised figure.

6. Figure 7-9: It would make more sense to me to have the y-axes constant for all the crops across these three figures. Then we would have a sense of the differential soil moisture changes for these different crop cover types. I recognize that the range of changes is large, so some barcharts would look very small with a larger y-maximum, but isn't that the point that you want to make? It could help emphasize that while wheat, oats, sweet potatoes, potatoes, maize and winter rye all have large vulnerable areas in the RCP8.5 scenario, only sweet potatoes is broadly impacted in the RCP4.5 scenario, though the changes in IASD of soil moisture are substantial for large regions where all six of these crops are grown. This might be hard to implement, but it would facilitate easier interpretation of these charts.

> The Y-axis in each plot is in units of area, and the range of total areas of crop coverage span nearly 2 orders of magnitude from wheat to yams. The crops listed in the lower part of Table 2, which is sorted by crop coverage, would be unreadable. The goal of Figs 7-9 is to convey a sense of the variations within the areas where each crop is grown, displayed as a sort of probability distribution for each crop; such information is not evident when a single number is given for an entire crop (as in Table 2). Table 3 also tries to convey this intra-crop variation, focusing on the extremes. Per the recommendation of Reviewer 1, we have enlarged all the labels in Figs 7-9. Hopefully this makes clearer this important information, e.g. the exponents in the units of area for the Y-axis labels.