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Earth System Dynamics
Discussions

Interactive comment on "Freshwater resources under success and failure of the Paris climate agreement" *by* Jens Heinke et al.

Anonymous Referee #1

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The following is a review of the article titled, "Freshwater resources under success and failure of the Paris climate agreement" by Heinke et al.

In this study, the authors apply a simplified impact model (LPJmL) under 152 climate scenarios (8 dT x 19 GCMs) and 5 SSP population scenarios to demonstrate the global populations at-risk of severe water crowding, which to varying degree will be exacerbated by projected changes to water availability. The authors define the following three critical thresholds: a greater than 20% decreases in mean annual discharge, an increase of 50% in the total number of drought months, and an increase in the 10-year return flood event by 30%. Under the SSP2 scenario, they report that 33% of the world's population will be living in >1000 p/fu regions and 9.1% of those affected will be in region's with severe hydrologic change, and thus, presumably the most challenging

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Discussion paper

adaptation cases. The paper is interesting and worthwhile but not carefully written nor illustrated. There are a number of ways in which this paper can be improved.

Although I am not a water manager or decision maker, I do not see that the information provided is particularly actionable. The regions are quite large. Can the authors provide a subset of the most striking examples of sub-regions under population and hydrologic change stress (i.e., map the areas of Table 1 for each degree warming?).

The authors also do not discuss regional uncertainty in the GCMs or SSPs. For example, Fig. S7 shows (white) areas where there is disagreement among models and conversely, agreement among models. I would think at least the model spread (as a surrogate for projection uncertainty) should be discussed in-hand with the water stress projections.

I also misunderstand the statistics for "ANY" hydrologic changes (e.g., Fig 2 and throughout). Take the Indian subcontinent, for example, which is colored in panel (d) but not for (a-c). How can the "ANY" affected area exceed the sum of the area for the 3 metrics of severe change?

The "majority", "more likely than not" and other terminology was introduced but not consistently or clearly applied throughout the paper.

I provide my detailed comments below.

Abstract: the fact that MAD, ND, and Q10 are used to quantify variability needs explicit mention.

Ln9 suggest something closer to the following: "by water scarcity. [Simultaneously, global warming is shifting the seasonality and overall quantity of available water. This study estimates the separate and joint effects of population growth and hydroclimate change on global water resources for a range of warming scenarios, ranging from +1.5-5C. Hydroclimate change is quantified through three metrics: mean annual discharge, number of drought months, and magnitude of the ten-year return flood event. . . .and

evaluates how climate [change] mitigation. . .hydrological change, as well as the severity of the water scarcity. The results show that without climate [change] mitigation. . .”

Pg2ln1-5 there should be discussion of changing precipitation phase (snow vs rain), earlier springs, longer growing seasons, and glacial melt (Himalayas).

Pg2ln23 it is unclear how the current approach addresses “changes in variability”

Ph2ln27 the number of drought months does not tell us about the severity of the drought. And multi-year droughts are not identified because every year is treated independently.

Pg3ln14 suggest [0.5 x 0.5 degree grid cell]

Pg3ln22-23 where does temperature come from? In cases for which GPCC and CRU precipitation are both available, which one is used, or how are the two estimates merged? These datasets revert to climatology in months for which observations are not available. So, the inter-annual variability of the random sample will be less than actual unless these years are filtered.

Pg3ln24 suggest “[random] resampling [with replacement]”

Pg3ln27 what are the inputs and parameters for LPJmL?

Pg5ln7 it should be noted that in practice the seasonality of the MAD shortfall matters, since the reservoirs (and rivers) are managed for alternative purposes including flood management and hydroelectric power generation

Pg5ln16 is this “river discharge” or “grid cell runoff”. There is no mention of a routing scheme. Is the CDM approach most needed because the analysis is on a grid-by-grid basis?

Pg5ln26 why not just use the standardized precipitation index-6months (SPI-6)?

Pg6ln14 large floods can be important “drought busters”. What is the logic for pe-

nalizing Q10 floods in a water scarcity context? Could the authors provide further justification for the 30% threshold? What is the relative frequency shift? i.e., Q10 plus 30% is what return flood on-average for each region?

Pg6ln19 the authors have omitted a section introducing SSP scenarios

Pg7lns11 what are the “basins” that were used. Can these be illustrated?

Pg8ln4-5 it would be useful for the authors to provide figures that better illustrate the relative/shared contribution of both pathways named here.

Pg8ln8 define “substantial”

Pg8ln9 what is “severe”

Pg8lns17-19 are these statistics from a table or figure or not shown? Is it 108 million fewer or total impacted? 319 million fewer or total? 15 million fewer or total? Unclear if “these figures” are total affected or differences from 5C numbers is prior paragraph.

Pg8lns16-30 is there no feedback between the population scenario and water availability? Will population continue to grow as projected despite severe shortages of water?

Pg9ln2 “water supply systems” statement is vague and should be qualified by references

Pg9ln9 where regionally are these 2.99 billion people concentrated?

Pg9ln11 where geographically is this change in high crowding projected?

Pg9ln13 “occur in places”, please provide examples.

Pg9ln18 I misunderstand. How is ANY (1.94billion) larger than the sum of MAS, ND, and Q10?

Pg9ln21 it would be instructive to see the regional distribution of the projected benefit of the Paris agreement

Pg9ln22 intended reference to “remaining number of people affected by severe hydrological change” is unclear.

Pg9ln26 clarify here if “11% of total population” is of global affected population (274mil) or LAM or MEA population

Pg9ln26 is this “another 29% [of the affected global population] live in SAS and SSA, although they locally comprise only 2% of the population”?

Pg9ln28 “since substantial societal and economic efforts”. Please clarify or add a reference.

Pg9ln31-32 “reduce the costs” this may not always hold. Depending on the region and the solution, the infrastructure investment to serve 5% may be just as expensive as serving 10%.

Pg10ln3 “one quarter of the total population” I am a bit confused with this statistic following the 11% figure cited in the prior paragraph.

Pg10ln14 a version of Fig S6 should be included in the main article.

Pg11ln16 the meaning/intent of “disproportionally strong” is unclear

Pg11ln19 suggest “affect populations [already coping with water scarcity]. Since the specific affected populations have not been identified or discussed, I do not believe a statement about “room for further adaptation” can be supported here.

Pg11ln22 the phrase “more likely than not” should be italicized and applied more methodically throughout where appropriate.

Pg11ln22-23 suggest “hydrological change. [Of those affected, 1.9 billion (21.2% of global population) would have. . .”

Pg11ln23 “limited capacity to adapt”. Again, I do not believe the study supports statements about barrier to adaptation. It is unclear that population pressure [always] limits

capacity to adapt.

Pg11ln30 separate statistics should be cited for Latin America and Middle East and North Africa regions

Pg12ln1-2 Is this statement sill in reference to LA and MEA or globally, in-general?

Fig1 the flow unit should be defined in the caption. Why is SSP3 so different in terms of total population growth? I'd personally prefer a figure with panels for each region with pop. Growth and % in each water class.

Fig 2. The specific thresholds that define "critical", i.e. 20% decrease in MAD, 50% increase in ND, and 30% increase in Q10 should be noted here.

Fig3. Clarify in the caption that this data corresponds with Fig.2. Why is the population affected by the two classes unvarying? It appears to be 3billion for all cases for <1000 p/fu. Why not just limit the x-axis to 70% for readability? Big takeaways- droughts are impacted at all warming levels, MAD above 2C, and Q10 above 3C?

Table 1. What is the scale factor for the population? The map of the regions delineated should be included in the main paper. Does the 33% of global population correspond to the "any" category in Fig 2d? Does the 21.6% of global population affected at +5C correspond with the "any" category in Fig 3d? Where would the 65% from Fig 3d fall in this table, if there was an additional section? Clarify that all percentages are provided as a percentage of total global population.

Fig S1 Most differences appear in Middle East, China, South Asia, and North Africa. The discussion and supporting figures could do better to highlight this finding.

Fig S2 why does the SSP2 scenario no match what is shown in Fig.3?

Fig S3 "water [crowding]"

Fig S4 "water [crowding]"

Fig5 this belongs in the main article.

Fig S6 consider a version of this in the main article. Perhaps 10 panels covering each region? FIgS7 Why not include this plot and parallel plots for ND and Q10 in the main article?

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