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Hydrology and Earth System Sciences
Discussions

Interactive comment on "HESS Opinions: A Planetary Boundary on Freshwater Use is Misleading" *by* Maik Heistermann

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Introduction

After the interactive discussion has closed, I would like to use the opportunity to provide a brief (and certainly subjective) synopsis, and to suggest some changes for a potential revision of the manuscript.

I take it that the number of three referee and five short comments is comparatively high, so it might be helpful to sum up some major issues. Before that, I would like to thank, again, all commentators for their contributions. Most notably, I would like to thank Prof. Gerten and Prof. Rockström for taking a stand to defend the freshwater PB. I had the feeling that the tone of the discussion became a bit harsh towards the end, and I might not be entirely blameless in that matter. All the more, I honestly hope that no hard

feelings will remain.

Everyone who had the perserverance to follow through the interactive discussion might directly jump to the section on *"suggested changes in a potentially revised version"* because the following text will mostly repeat what has been said before.

When I originally wrote the manuscript of the opinion paper, I was kind of concerned. To me, the idea of a planetary freshwater boundary appeared so obviously flawed that I suspected I had missed any important aspects. And indeed, people have been repeatedly suggesting that I "misunderstood", "misconceived" or "misinterpreted" the concept - not only in this interactive discussion.

At this point, I am confident that this is not the case. I would not object, however, if someone said that the PB on freshwater use provided ample opportunity for misunderstanding and confusion. To me, that is a direct consequence of its lack in scientific underpinning. The PB proponents will probably continue to disagree, but it should trouble them, too, if their supposedly clear "dashboard for global sustainability" (Clift et al. 2017) creates so much confusion.

So what has been said so far?

- SC1 by Prof. Sivapalan mostly shared the concerns voiced in the opinion paper, but demanded an "alternative way forward", e.g. to adjust the idea of a "safe operating space" to the basin scale.
- RC1 by an anonymous referee basically welcomed the opinion paper as *"an important and timely piece of work, which will stimulate further discussion among academics"* which I perceive as mostly neutral.
- Dr Christof Lorenz, in SC2, also agreed with the criticism towards the freshwater PB, and demonstrated, in addition, that we did not understand the global water

cycle at a level that warrented such far reaching claims as implied by the freshwater PB.

- Fernando Jaramillo, in SC3, pointed out a reference to his criticism of the estimate of the current level of the control variable related to the freshwater PB (Jaramillo and Destouni, 2015).
- Prof. Savenije, in RC2, did not explitely take a stand with regard to the planetary boundary on freshwater use, but most insightfully elaborated on the role of terrestrial moisture recycling as a feedback mechanism that could potentially reach far beyond the river basin scale.
- Prof. Gerten, in RC3, demanded that *"the author should reflect [some points] as otherwise the concept of PBs and also the concept of water footprints is partly misrepresented."* I will pick up some of these points below.
- Dr. Perry, in SC4, mainly supported the opinion paper. He pointed out that *"PBs for water are perhaps useful to raise awareness among unscientific readers, but [...] as soon as the surface is scratched, the concept produces more confusion than insights."*. He also provided a simplified representation of the global water cycle in order to highlight the planetary role of agricultural freshwater consumption in terrestrial evapotranspiration.
- Finally in SC5, Prof. Rockström argued that the critique voiced in the opinion paper was "unsubstantiated" as it was built on two "fundamental misunderstandings" of the freshwater PB. I will also try to pick up his points below.

All comments have been extensively addressed. In my view, the interactive discussion did not produce any new evidence as to the existence or quantification of a planetary freshwater boundary. So I do not see any cause to budge from my statement that *"as long as Earth system science does not present compelling evidence, the exercise of*

assigning actual numbers to such a boundary is arbitrary, premature and misleading." (p. 7, ll. 3-5 of the manuscript). Still, the discussion was helpful to shed some light on the motives and reasoning behind the freshwater PB. In the following, I will try to recap some of those arguments, mainly introduced by RC2, RC3 and SC5.

"But there IS large scale feedback beyond the river basin scale"

Prof. Savenije's contribution was pivotal to focus the discussion on large scale moisture feedback. But he himself acknowledged that, in terms of anthropogenic disturbance, the efficiency of terrestrial moisture recycling would be reduced rather by land use change, namely deforestation. Consumptive freshwater use, however, *might* have the opposite effect on evapotranspiration as it can be viewed to increase terrestrial moisture recycling in regions of dominant irrigation. It might still be argued that such an increase could be counterbalanced by a decrease of evapotranspiration in downstream wetlands, estuaries or inland lakes (the Aral Sea being a textbook example). Prof. Rockström also presented some papers that highlight how irrigation might decrease or shift monsoonal precipitation in case moisture convergence is decreased by the cooling effect of evapotranspiration from irrigated areas. The net effects of such interactions on terrestrial moisture recycling and atmospheric circulation are well worth being investigated! But as of today, the idea to use "runoff depletion in the form of consumptive runoff or blue water use as a proxy for capturing the full complexity of global freshwater thresholds" (Rockström et al, 2009) is not based on any evidence. Beyond, none of the references presents a credible scenario for the collapse of regional hydrological cycles (triggered by freshwater consumption) and its propagation across scales, including a state shift away from the Holoscene state of the Earth system (the defining criterion of the PB concept).

"The freshwater PB must not be viewed in isolation"

Although the opinion paper is and remains explicitely about the planetary boundary on

freshwater use, it is insightful to consider the general approach behind the PB framework: Steffen et al. (2015) emphasize that *"the planetary boundaries framework arises from the scientific evidence that Earth is a single, complex, integrated system"*. The implicit claim is that the PB concept provides an integrated perspective on the state of the Earth system. In my opinion, it does quite the contrary: The PB concept *disintegrates* the Earth system into nine distinct boundaries. After that, it is argued that all boundaries interact and should not be viewed in isolation. The consequences of that argument are left in the dark. What does it mean regarding the interpretation of the individual boundaries? At the same time, Rockström et al. (2009) insist that *"transgressing one or more planetary boundaries may be deleterious or even catastrophic due to the risk of crossing thresholds that will trigger non-linear, abrupt environmental change within continental- to planetary-scale systems"* and that *"each proposed boundary position assumes that no other boundaries are transgressed."* That is an intrinsic contradiction, and it is symptomatic for the overall PB framework. It is closely related to my alleged misunderstanding (as raised by Prof. Rockström) according to which I *"wrongly interpreted the planetary boundaries framework as if [there were a planetary tipping point for freshwater]"*, although the PB literature never claimed such a planetary scale tipping point. That is right. The idea, however, to suggest a "planetary boundary, but no planetary tipping point" remains confusing at best.

"Planetary and basin-scale freshwater boundaries should be viewed together"

As elaborated in the opinion paper, Steffen et al. (2015) supplemented the original (2009) planetary boundary on freshwater use with a set of basin-level boundaries estimated from environmental flow requirements. Both approaches co-exist as unrelated. In RC3, Prof. Gerten admits that "it is not yet satisfactorily solved how to adequately add up the regional transgressions in many places to a global value." To me, the question is, however, not "how to add up regional transgressions", but "why"? If there were evidence of "basin/regional-level tipping points related to freshwater use" (no evidence, yet!), why should it be cast into an aggregate global number? As I see it, the call for

such an aggregate number is a classical example of circular reasoning: "We assume the existence/usefulness of a planetary boundary on freshwater use. This is why we need to aggregate regional estimates to the planetary level."

"If you disagree with the idea of a freshwater PB, what is your alternative?"

This question has been brought up by both critics (SC1) and proponents (RC3) of a freshwater PB. I would like to reiterate that the opinion paper intends to demonstrate that the present concept of a freshwater PB is flawed, and that it lacks scientific corroboration. I have been repeatedly confronted with the argument that *"water is of such paramount importance in the functioning of the Earth system, and that such importance must be reflected in a water-related planetary boundary"*. That is a fallacy. The water cycle is an inherent part of the climate system, and it is an agent that mediates the transport and the conversion of energy and matter. The importance of water cannot be highlighted by just putting it into an isolated PB. While that corresponds to *"the freshwater PB should not be viewed in isolation"* (see above), it merely demonstrates that the boundary is ill-defined. Its current form does neither capture the functional relevance of water in the Earth system, nor does it reflect the urgency of sustainable water resources management.

But maybe there is an alternative. It might be based on my response to Prof. Rockström, who claimed, in SC5, that I misunderstood the "planetary boundary on freshwater use" to be about "human water use". My constructive suggestion to the PB community is to be *explicit* instead of *implicit* (Peters, 2004): explicit about the processes that are considered to regulate the water cycle at large scales, and explicit about the corresponding knowledge gaps. If you think that human freshwater consumption affected terrestrial moisture recycling or atmospheric circulation patterns to a level that destabilizes the entire Earth system, than follow that thought and collect the evidence. And if you honestly think that *"the freshwater PB has nothing to do with human water use"* (as argued by Prof. Rockström in SC5), you should seriously consider to rethink the

definition of the PB on freshwater use. And until credible mechanisms acting "across scales" are identified and quantitatively understood, the PB community should resist the temptation to (expert) guess numbers. Why not mark the freshwater PB (or maybe you need to split it into different processes as the biodiversity PB?) with a big question mark as you did for "functional diversity", "atmospheric aerosol loading" or "novel entities". Any of these steps would underscore the willingness of the PB community to continuously question and scrutinize the scientific basis of their concept. And other boundaries are still waiting to be challenged.

Closely related to that issue is the argument that the concept has already increased *"awareness among policy-makers and business people that integrated and increasingly global perspectives on environmental issues including water issues are needed"* (RC3). I would like to quote Dr Perry (SC4) as a response: *"As soon as the surface is scratched, the concept produces more confusion than insights."* This interactive discussion is the living proof for that hypothesis. The confusion is a direct result of the lack in scientific underpinning, and it is the reason why, in my opinion, any attempt of "operationalization" is bound to fail. Even worse: The notion that a lack of scientific evidence is "acceptable" as long as the concept "raises awareness" makes us - as a scientific community, and as a society - vulnerable to those who actually don't want to see environmental action on the political agenda.

Suggested changes in an revised version

As to a revision of the manuscript, I suggest the following list of modifications. These suggestions are based on my responses to the specific referee and short comments. For details with regard to the underlying discussion, please see the specific comments (RC1-3, SC1-5) and my corresponding responses.

1. In response to RC1 (anonymous referee 1) and RC3 (Prof Gerten): I will remove the statement that *"the intellectual fathers of the water footprint and the planetary*

boundaries, Arjen Hoekstra and Johan Rockström, did not yet publish a single paper together". Although I still find it interesting, I agree that the statement could be conceived as "not to the point".

2. In response to RC1 (anonymous referee 1): I will replace "can't" by "cannot" (p. 4, l. 33) and "It'll" by "It will" (p. 6, l. 19). Where necessary, I will use a more neutral style, although I agree with Prof. Savenije (RC3) that the style of an opinion paper could and should be different from that typically used in a research paper. In order to avoid hard feelings, I will also try to make some statements less provocative, in cases where that is scientifically warranted.

3. In response to SC3 (Dr Jaramillo): I will include the reference to Jaramillo and Destouni (2015) in the references that are listed on p. 3, l. 3 of the manuscript under discussion.

4. In response to RC2 (Prof Savenije) and SC5 (Prof. Rockström): I will more specifically address the issue of terrestrial moisture recycling and potential changes in atmospheric circulation patterns in the paragraph on p. 4, ll. 14-29. I will refer to Van der Ent et al. (2010) and some of the more recent literature on the topic in order to highlight the role of moisture recycling and land evapotransporation for downwind precipitation. I will also include the papers on the effects of irrigation on monsoonal rainfall, as suggested by Prof. Rockström in SC5. Furthermore, I will emphasize that the coupled effects of changes in land evapotranspiration and the general atmospheric circulation, as well as that the net effects on the water cycle, are yet to be understood (see e.g. Goessling and Reick, 2013).

5. In response to RC3 (Prof Gerten): On p. 6, I will rephrase the sentences from ll. 19-23. As pointed out above, I will drop the remark on "co-authorships between A. Hoekstra and J. Rockström", and I will adopt the wording suggested by Prof Gerten in that "the PB concept is about critical environmental limits to water use while the water footprint concept is about the actual magnitudes of that use."

6. I will try to specify a "constructive" perspective of fundamentally revising the PB on freshwater use as outlined above (i.e. being explicit about processes, admitting knowledge gaps instead of expert guessing numbers).

Concluding remarks

On April 24, I had the chance to attend one day of the two-day planetary boundary conference on "Making the Planetary Boundaries Concept Work". My impression was that the overall PB concept (including the set of specific planetary boundaries) was, by many attendees considered to be robust and beyond the need for further fundamental inquiry. Consistent with the conference title, the more pressing question was considered to be about the operationalisation of the concept. This is illustrated by a choice of planery speeches, parallel sessions and side-events (not exhaustive):

- Planetary Boundaries today: Taking Stock on the Status and Application in Societies
- Towards putting planetary boundaries in practice in the EU
- Planetary Boundaries and the Green Economy: Switzerland
- Planetary Boundaries and Transformative Policies in the German Integrated Environment Programme
- Introducing Planetary Boundaries in the Economy and Society
- Planetary Boundaries for Environmental Communication: Opportunities
- Building a Global Alliance for a Sustainable Anthropocene: Making Use of Safe Operating Space Opportunities

- Building a Coalition for the Operationalization of Planetary Boundaries: Starting Points
- Building on Experience: Lessons learned from initial operationalizations
- Planetary Boundaries for SMEs: Starting points and added value
- Planetary Boundaries for large Companies: Existing experiences, further potential
- Planetary Boundaries for the Civil Society: Existing experiences, potential for socio-ecological transformation
- The Planetary Boundaries – Added Value for the Finance Sector
- Sustainable Investments in DBU Asset Management and Ways Forward: Planetary Boundaries for the Financial Sector
- Operationalizing Environmental Risks for the Finance Sector using the Planetary Boundaries Concept

There was *one* parallel session (80 minutes) on the "Legitimization of Setting Planetary Boundaries: Scientific Findings and Normative Choices". "Democratic legitimisation" was in interesting, though somewhat diffuse topic in that session. Scientific evidence, however, as a precondition for "scientific legitimacy", remained a marginal issue at best.

As I already pointed out above, the diffuse and confusing implications of the freshwater PB are, to me, a direct consequence of its lack in underpinning. In my view, it is thus too convenient to claim that there is no way to prevent misuse of the concept. A planetary boundary on freshwater use is a point-blank invitation to sell concepts such as "water neutrality" or "water offsetting". Therefore, I would like to encourage the PB community to take a step back and rethink planetary boundaries framework. To those who are

concerned that will be lost time for action, and who think that "operationalisation" should start now: it already has!

If you want the PB framework to support that process, the science behind it should be robust. That is one of the lessons learned from the success of the IPCC. Prematurity risks to discredit the ideas which the PB framework tries to set forth. If the scientific PB community thinks that a "co-creative" procedure involving stakeholders can be helpful in revising the scientific concept: sure, why not! But that should not lead to a situation in that the current PB concept is presented to policy makers, NGOs or the private sector as "well-founded, robustly, in the international Earth system science community" (as claimed by Prof. Rockström in his video message to the recent PB conference).

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