Response Letter for HESS 2021-392

Dear Wouter Buytaert,

Thank you for the opportunity to submit a revised draft of “A Hydrologist’s Guide to Open Science” for publication in *Hydrology and Earth System Sciences*. Thank you also for your time and support for the manuscript during this review process. We appreciate each reviewer’s time and effort to provide feedback and insightful comments, such that we can improve our manuscript and perspectives on open science in hydrology. These changes are highlighted through track changes in the attached manuscript “A Hydrologist’s Guide to Open Science_002_Track” and are accepted (i.e., changes not tracked) in “A Hydrologist’s Guide to Open Science_002_Clean”. Below are direct point-by-point responses (in blue) to each of the reviews, with reference to our manuscript adjustments. The line numbers correspond to the manuscript with tracked changes.

Reviewer 1 Comments (R1)

R1.C1: 'Comment on hess-2021-392', Francesca Pianosi, 02 Sep 2021 reply

> *We thank the reviewer for their thoughtful and constructive comments. We are looking forward to implementing them in our final document.*

The article gives an interesting contribution to the discussion on Open Science in hydrology. I especially appreciate the practical focus on helping researchers to get started with OS, and the linking to an online repository where new materials and resources will be shared beyond the article publication.

The manuscript needs to be revised to include the section on Principle 2, which was made available as a separate file. I do not have other substantial revisions to recommend but some points for improvement and further discussion.

> *We are glad to hear that the reviewer found this manuscript interesting and that they found the online repository helpful. We apologize for not including Principle 2 in the original document. That was a misstep on our part and this section is now included in the revised manuscript posted on the HESS discussion board.*

In particular, given the "practical guide" angle of this article, one suggestion could be to complement the text with Tables listing in a very concise manner the various recommendations / tips / dos & donts for each Principle. For example, for Principle 2 (op
en software) the list may start like:

- use open-source software such as R, python or QGIS to develop your analysis

- use open-source version control system (e.g. Git) to manage changes to your code

- include documentation as comments embedded in the code as much as possible

- etc.

I think this would help reinforce key messages and help readers navigate the (numerous) points made in the text

> *We thank the reviewer for making this great suggestion. We agree that a concise table of tips, tools and resources for each principle would be a great way to summarize main takeaways for readers. We included an additional table (i.e., Table 2) in the Practical Guide section in the revised manuscript and added the table to the website as well.*

While reading the paper I noted down several other comments. I am not sure they are all worth including/addressing in the paper but I'll report them and leave to the authors to decide if they want to take them onboard.

R1.C2: L. 19 - Social challenges to embracing OS. The authors essentially mention one, the fear of being scoped, but I think others are as important. For example some researchers may be reluctant to share their software as this may bring further scrutiny and criticism of their work. Some seem to feel a sort of "jealousy" for their software, which they don't want to see modified (maybe improved!) by others. Maybe the point here is how we perceive and value intellectual ownership. If I make my software available to others so they will (unavoidably) find bugs to fix and weaknesses to improve, does this diminish or increase the value of my original contribution?

> *Thank you, this is an important addition. We modified the sentence to:*
>
> *"...and social (e.g., fear of weaknesses being exposed or ideas being scooped) challenges remain." now on Line*
>
> *We very much agree that intellectual ownership of code is a big social challenge when it comes to OS. We included a discussion of this aspect in the revised manuscript. While we cannot solve the problem within the scope of this manuscript, our hope is that it will kick-off a wider conversation on how we, as a research community, give credit for and value open software along with its benefits for advancing hydrological research. We look to work being done by the Research Software Alliance, as they aim to do this for research broadly.*

R1.C3: Line 94: "sharing the entire research process and approach (e.g., failed attempts and lessons learned that impacted research outcomes)".

I totally agree although there is a tension here between conciseness (which is needed for readability) and completeness (needed for OS). I think a good way to resolve the conflict is by having unlimited "Supplementary materials" along with a paper - as some journals now allow - so that authors can keep the main article focused on key findings, while giving detailed documentation of all the research process in the SMs.

We agree. We included this as a suggestion explicitly in this line, such that it reads: "...sharing the entire research process and approach (e.g., failed attempts and lessons learned that impacted research outcomes) as appropriate in the main journal article and in more detail in the supplementary materials section of a publication. An additional option for authors is to share the entire research process associated with a publication through the Open Science Foundation's platform."

R1.C4: Line 98: I think the point about "minimising the use of jargon" is very important. We use a lot of academic writing cliches in our articles, perhaps thinking it makes them sound more technically solid, but often it only makes them more difficult to read! Another issue is the recourse to hyper-specialised terms that are only understood within our small research niche - and often take different meanings across sub-communities even within the same broad discipline (a good example: the diverse uses of the term "bottom-up approach" across sub-communities in hydrology and water resource management). Every now and then initiatives are launched to build glossaries that should help researchers navigate each other jargon, but my impression is they are quickly abandoned (for example years ago I was involved in a project on uncertainty and risk in natural hazard assessment and such glossary was one of the project outputs... I don't think it was ever delivered!). Maybe rather than building glossaries we should just do more to use a common and simpler language. This should include avoiding the creation of new terms for concepts that may be easily described with existing maths terminology. I write and review a lot of modelling/methodological papers, and I have the impression that new terms (and acronyms!) are often created under the pressure to "demonstrate novelty" - authors may be afraid that if their proposed methodology does not have a new name but is described using standard terms from a statistic textbook, reviewers will dispute its novelty. This way though we make our papers unnecessarily obscure and in the long-run we collectively contribute to fragmentation of knowledge and duplication of efforts. This links back to the general tension I find between OS and the way we reward (over-emphasise?) "novelty" of individual contributions (see also comment [1] above).

Thank you to the reviewer for their insightful thoughts on this. We agree that jargon is used as a way to demonstrate novelty, and glossaries are not a solution (rather only reduce the symptoms). We included the following a brief discussion of these two items in the text:

Jargon can be misused as a way to demonstrate novelty or describe niche details, as fundamental terms that one field uses commonly may be "jargon" to another. Further, widely used glossaries are not a sustainable solution in the long term for supporting interdisciplinary open science progress because science is ever-evolving and fields may use terms in different ways. We recommend concepts be expressed using as simple terms familiar to scientists across disciplines as possible. When this is not possible, terms should be defined to 1) describe a unique process and 2) ensure that a word with multiple interpretations is defined. (e.g., "substrate" meaning something you feed bacteria versus "substrate" meaning soil).

We have included the following discussion on line 116: "When this is not possible, jargon and niche terms should be defined to 1) describe a unique process and 2) ensure that a word with multiple interpretations is defined. (e.g., "substrate" meaning something you feed bacteria versus "substrate" meaning soil)."

R1.C5: L. 193 About green OA. Maybe this sounds naive but I really wonder what are the drawbacks of "green OA" (and how it may be sustainable in the long-term for publishing companies)? Authors do not pay publication fees, readers do not pay subscription fees (after the embargo period) as they can access the non-typeset version... sounds very convenient - but for the publishing companies! Am I missing something?

Green OA means that the review version of a manuscript (postprint) is shared with the public, while access to the final typeset version remains restricted to subscribers. Since the involved publishers only gain benefit from subscriptions, they have a strong incentive to make the final version more useful to readers than the postprint version. This is often achieved by formatting templates at the postprint stage that make a paper barely readable (e.g. figures separated from figure captions somewhere at the end of the document). So effectively, green-OA is not meant to work for publishers, it is a fall-back solution to tick the open-access box, while still maintaining a strong incentive to pay for the final typeset article for a more convenient reading experience. There are research communities (e.g., AI research) that mostly publish in a Diamond open access format, i.e., no fees for anyone, but obviously these do not follow a subscription-based business model, as green-OA does. We clarified this in the main article in line 293 as follows:

"In subscription-based green OA models, authors can self-archive the accepted, non-typeset authors' version of an article (i.e., a postprint) in a repository of the authors' choice after the journal's embargo period. However, this version may not be as accessible to read (e.g., figures separated from their reference in a paper) as the final typeset version."

R1.C6: L. 226: "For software, we suggest the authors start by declaring a permissive license because it improves transparency and reduces downstream licensing conflicts."

I personally agree with this suggestion but I think many (including some at the R&D team of the University I work at!) would find it controversial. A permissive license (say for example the MIT license) implies that the software developed by publicly-funded researchers will be freely available also to users that may make a commercial use of it - and hence may be willing to pay for a licence. So, should universities "give away" a potential source of revenues? Is this fair to tax-payers who funded the research and related software development?

We agree with the reviewer that a discussion on ownership of software created with public funds was lacking from our paper. We added more discussion on this. In short, we think that software created by universities should be available for the entire public, including companies. Leaving distribution of this software in the hands of university valorization departments severely limits adoption to the lucky few that can afford the licensing fees and time needed to negotiate access, which are usually large corporations.

“Developers should consider the impact of charging licensing fees or using closed licenses which may lead to a lack of access for those that cannot afford licensing fees or time to negotiate access.” on line 325.

Some more general thoughts:

R1.C7: A lot of the activities for OS mentioned in this paper take time - for self-learning and training and to make data/software accessible to others. For example, documentation is key for open software to be meaningfully used by others but developing good documentation is very time-consuming (this was a key lesson I learnt in my own projects - see Pianosi et al 2020). So I think there is a tension here between OS and the general "publish or perish" attitude. I wonder if Open Science is necessarily also Slow Science (e.g. Frith, 2019)?

We thank the reviewer for bringing up this important point about the time it takes to learn new skills, attend training, and make data/software open and accessible. We agree there is a tension between the academic pressure to increase the pace of research while ensuring research is transparent and well documented. This again highlights the tension between quality and quantity, inherent in any productive environment. OS effectively shifts the balance from quantity to quality, and it necessitates new approaches of research assessment, as e.g. formulated in the SF DORA declaration (https://sfdora.org/). As a result of these changes in value and its inherent transparency, OS can help improve public trust in science. This also means that PIs, their institutions, funders and organizations need to better value OS by providing support and time to implement OS standards that go beyond publishing open access.

That said, we included a discussion of this balance between social pressures and open science and will refer to the paper on slow science that was suggested by the reviewer. We added the importance to set up future generations of hydrologists by suggesting incorporating OS courses into curriculum, such that they are set up for success to work in an OS manner. We appreciate them pointing this paper out.

“Open science shifts the focus to improving research’s reproducibility, transparency, collaboration and source acknowledgement, and long-term impact, not unlike calls for “slow science” (Frith, 2019). These shifts in priorities necessitate new approaches of assessing one’s own research, like using DORA, and adapting accordingly. However, time and effort required to adjust one’s research practice and learn new techniques may seem daunting and in conflict with academia’s current drive to increase their productivity and output quantity (i.e., the “publish or perish mentality”).” was included on Line 64.

R1.C8: Open teaching. I am all in favour for it - like most of us last year I developed lots of materials for on-line learning and I am keen to make it open access (as soon as I find out what's my University policy on this!). This said, I wonder what the long-term implications of open teaching will be for university life. If excellent study materials become available online to

all and for all subjects, then what is the reason for enrolling in a university programme instead of self-learning? Will students only attend university to clarify doubts and get assessed - or, in other words, will the main role of universities become accreditation rather than delivering contents? I am not saying this is necessarily a bad thing (maybe it'll give academics more time for research or other type of engagement with students, such as mentoring or research-based teaching) - just highlighting it would be a very substantial change to the way higher education works today.

> *We thank the reviewer for bringing up open education as an important part of open science. The same arguments used to argue for open science can (and should in our opinion) be used for open education. We recognize that making teaching material openly available will change the way academic knowledge is translated to students and will result in growing pains for those. As teachers ourselves we know, both from literature on education as well as from our experiences, that the roles of the teacher and peer interaction is essential in the learning process and cannot be 'completely replaced' by online available open education material. For example, networking, lab experiments, interpersonal development, etc. cannot be replicated solely by open education material. Rather, the availability of open education material offers the teacher the possibility to focus their attention on developing learning activities that reinforce concepts provided by open education material and addressing different learning styles to have the most impact on the students.*
>
> *While the above answer to the reviewer shows our thoughts on Open Education, we are hesitant to add too much of an emphasis on it in the manuscript under review. The focus of the manuscript is on Open Science for hydrological researchers. We do think a separate publication (or maybe even series of publications in a special issue) on Open Education in Hydrology is timely and of great value to the hydrological teaching community. We added the following sentence to section 1. Motivation for Open Hydrology:*
>
> *"In education, open science makes research outcomes and processes available to teachers of hydrology courses for inclusion in their teaching. A movement parallel to open science, but not the focus of this manuscript, is open education, which argues for and provides tools to share education materials and best practices freely and openly." was included on like 362.*

References

Pianosi et al (2020) How successfully is open-source research software adopted? Results and implications of surveying the users of a sensitivity analysis toolbox, EMS.

Available at:https://research-information.bris.ac.uk/ws/portalfiles/portal/215604556/Paper_SAFE_Survey_accepted.pdf

We have incorporated this reference throughout the document, including "Documenting the workflow of software, from how to input data to how to interpret results, help lower barriers for users (Pianosi et al., 2020)." in Principle 3 on software on Line 245.

Frith (2019) Fast Lane to Slow Science, Trends in Cognitive Sciences.

Available at:
https://discovery.ucl.ac.uk/id/eprint/10091940/1/Frith_Fast%20Lane%20to%20Slow%20Science%20Prefinal.pdf
Citation: https://doi.org/10.5194/hess-2021-392-RC1

We have incorporated this reference as "Open science shifts the focus to improving research's reproducibility, transparency, collaboration and source acknowledgement, and long-term impact, not unlike calls for "slow science" (Frith, 2019). These shifts in priorities necessitate new approaches of assessing one's own research, like using DORA, and adapting accordingly." in Section 1 on Line 64.

Reviewer 2 Comments (R2)

I enjoyed reading this manuscript. The manuscript argues for the use of open science practices in hydrology and does this admirably in a very structured and transparent way. This makes for a helpful document, as are reference for practisioners but also for teaching purpose. It should facilitate discussions surrounding open science both in hydrology but also in other fields (where similar issues exist).

The manuscript is structured along four principles, addressing various stages of research and their potential to be more open. Although there is overlap between them I think this approach works well to address some of the discussions surrounding open science. Further "scenarios" as listed at the end of the manuscript help put some of these principles in context.

As such I'm willing to accept the manuscript as is, as most comments are minor and deal with very nuanced language. Comments listed below should be considered if possible.

General comments:

R2.C1: When looking at the larger picture, it might be very important to note somewhere that open access is not a technical challenge anymore but mostly a socio-cultural one. When looking at table A1 and the challenges discussed only 3 out of 13 are technological, while the remaining are mostly political / socio-cultural. Despite the tools listed in the manuscript, I fear open science practices are not governed by the lack of these tools, the access to them (most of them are free), or even the use of them by some.

We thank the reviewer for this observation. We agree that most challenges are not technical in nature. With this paper we want to contribute to removing the sentiment that open science is a technical problem by exemplifying many tools and resources via the practical guide in Section 2. Furthermore, we provide suggestions on how individual scientists can work on removing the remaining challenges. Hopefully we can contribute to overcoming some of the socio-cultural challenges listed. To this end we added the following to the appendix discussion: "Note that only three out of thirteen challenges are of a technical nature. This shows that the adoption of Open Science is (no longer) a primarily technical challenge." on line 603.

Detailed comments:

R2.C2: [Line 83] "Open hydrologists intentionally plan for, describe, and share the entire research process and approach from motivation to the final product"

I would be careful about leaning too strongly on either defining output as products or the fact that a pre-defined motivation should be provided in order to keep things open. From a very practical point of view dealing with science output as products is often very efficient, as it sets clear expectations. However, language matters and managerial language creep is sometimes very toxic as it often debases research (favouring short term returns, products, over slow generation of bodies of knowledge). I would suggest to shy away from defining research as products, and use research outputs / research results instead.

We fully agree that thinking of research as products is counter-productive, and may be one of the contributing factors to non open source research being the norm. We willre-phrase this principle from "product" to "output" throughout the manuscript as well as in the figure and the tables.

R2.C3: [Line 96] I think asking for a reasonable explanation of methods is ok. However, more often than not the answer might come down to a lack of funding. I wonder to what extent such a motivation will be accepted in review, and if this will stigmatize those who have less resources if there is the expectation that you are really explicit about these methodological choices (limited by funding). This dynamic already exists, but at least the expectation doesn't exist that it is written in full.

We thank the reviewer for pointing this out. However, we believe that making science open is not an activity that comes on top or after "science has been done", but should be an intrinsic part of the scientific method. This is why we advocate for following the open science approach from the start and throughout the process or to incorporate open science in the stage of research one is currently in (even post-publication). This way, promises in terms of quantity of results per amount of funding may need to be scaled down in favour of improved quality of results, i.e. more reproducible results.

In Line 108 (previously 96), we will clarify that this should be done as is possible.

Further, we clarified this in the Summary and Outlook, on Line 344, as such:

"Funding agencies, publishers, and hydrologic organizations are increasingly requiring hydrologists to adopt open science practices, but not all are aware of the additional effort and time needed. Adopting open science practices can be a major lift for researchers, as these practices need to be implemented throughout the process from the project design and budget generation to the final outputs and post-publication curation of data."

R2.C4: [Line 135] Requirements for version control shouldn't be grounded in the ability to peruse through previous in silico experiments. It is a tall order to ask people to use version control in the first place, it is another barrier to do this consistently in the way of a lab notebook. I heavily use git and to be honest my commits aren't clean. It is important that people save the state of the software used in particular experiments (either through a release/checkpoint on zenodo, github or similar). Actual commits or even branches probably have less value, and make things difficult if not less transparent. i.e. I would stress the deposition of code in repositories, rather than front loading additional computational skills (which are for some hard to acquire - saving data/code in a repo isn't). In general, I will take dirty code over no code and a static release tied to a manuscript over a dynamic repo (with recent changes).

We fully agree that ensuring the exact version of an experiment used for a publication is available is more important than tracking all intermediate versions. We found that without consistently using version tracking it becomes almost impossible to track exactly what version of the software was used for what experiment. Deposition of code in repositories is mentioned in Principle 4 as well, but we agree some additional emphasis will be helpful. We added the following sentence to address this aspect:

Following Line 219, we added the following: "Even more important than version tracking is depositing the code used for each publication in a repository such as zenodo for safe keeping, and this is explained in Principle 4".

R2.C5: [Line 159] This section focusses on software documentation, mostly for the end user. However, true open development is often hampered by not only the lack of user end documentation but proper code comments in the software itself. The lack of clear documentation of the code functioning (not the code use) by inline comments is something that is often forgotten and limits code re-use within different contexts. It also limits learning opportunities by seeing how computational problems are solved within a real world situation, not a classroom setting. A line on this could go a long way.

Thank you for this observation. We agree that comments in the software itself are very important. We added some clarifications in the text that documentation should also be for developers, not only users. We added additional text on the importance of inline and developer documentation of code.

Specifically, we added the following in line 249: "In addition to documenting the use of code, open hydrologists developing software can include inline comments to document the expected function of their code, which improves code reuse in different contexts and provides students a deeper look into real-world coding applications and software development."

R2.C6: [Line 160] Include a link to ReadTheDocs, people might not be familiar

With the many technical terms used in the section we fear that addings links to all would clutter the paper too much. But we agree that some of the less common ones could use a link rather than letting the reader search the Internet for the term. We incorporated links in our new table (i.e., Table 2), as suggested by the first reviewer within each section of the summary table that includes tips, tools, and resources that complement the practical guide.

R2.C7: [Line 179 (and the section below)] I would suggest an open license. Permissive is the perogative of the researcher. It must be acknowledged that permissive licenses, on open software and data, in the past have been abused by industry by offloading tasks to OSS volunteers while not giving back proportionally to the gains made (e.g. recent more restrictive licensing on the openstreetmap data) and this risk is to be assessed by researchers. I think this is echoed by some other reviewers as well. However, the spirit of open science would suggest a permissive license and I value the sentiment.

This is a good point, and we agree with the reviewer that it is a philosophical question what open license best represents the interests of the stakeholders. We have expanded on permissive licensing and open licensing with the addition and clarification of the following on line 320:

"Besides the article itself, it is important to ensure that data and code are licensed (i.e., a copyleft or non-copyleft license). A copyleft license type mandates that derivatives of the software and code apply the same licensing restrictions as the original work (Open Source FAQ). A non-copyleft license, or permissive license, allows for derivatives of the software to be licensed under other types (Open Source Initiative FAQ; Creative Commons FAQ)."

Further we added references and clarifications throughout the rest of the paragraph, which starts on Line 316.

Reviewer 3 Comments (R3)

We are thankful for the reviewer's supportive comments on the manuscript's scope and objective. We sincerely hope that our manuscript, which is the outcome of an inspiring

collaboration between early and mid-career hydrologists actively involved in science and research, will motivate and empower many others to engage in open hydrology.

R3.C1: I really enjoyed this paper. I think it could be a handy product to help guide groups working in hydrology that might not be familiar with all the cutting edge open science tools and general open access principles. I like that it is generally written as "here's what we're trying to do...sometimes that's not possible". The language when that's not the case concerns version control. As a researcher, I do heavily rely on it, but I might tone down the language from "critical" to "desireable" or something like that. The text mentions Travis CI with github, I would consider removing that and replace it with GitHub Actions.

*Thank you to the reviewer for their reflection on this and we will change critical to "ideal". Furthermore, we added GitHub Actions to the list with Travis CI with **Github** on line 264.*

R3.C2: As a reviewer, it was a challenge to find principle #2...but presumably that will be fixed by the final production.

We included it as a comment to the original submission, and it will be incorporated into our current version that reflects all reviewer comments.

R3.C3: The authors mention analysis pipelines several times, I was a little surprised to find no mention for some of the "make" based tools (make, targets, probably others). Not critical to add, but might be worth considering.

We agree that these are important aspects to discuss and we added in a short discussion about tools to help make analysis more easy and reproducible by automating multiple steps of a workflow. Specifically, we added: "Open hydrologists should also incorporate the use of open source, reusable, and reproducible data analysis pipeline tools (e.g. renkulab.io, ropensci.org), which facilitate collaboration for data producers, analysts, and stakeholders." on Line 188.

I liked the senerios! All in all, I'm in approval of having this paper published. The authors did a great job. I generally agreed with many of the smaller comments made by the other reviewers in the open forum, but I don't think anything rises to a "major" or required revision from my perspective. Great job!

Reviewer 4 Comments (R4)

R4.C1: The article gives a summary of the current open science movement and advice how to advance the open hydrology movement specifically. The authors present a list of guiding principles and useful resources how open science can and should be pursued. I want to thank the authors for this well written contribution to open science. I only have some minor comments that I hope the authors will take into consideration.

> *We thank the reviewer for their comments and thoughts on our article. Community feedback is highly appreciated and below we respond to your comments.*

R4.C2: Section: Motivation for Open Hydrology: A not so noble, but potentially convincing reason to adhere to open science standards would be that accessible articles/data/code see more citations. You briefly mention this for the 4th Principle. It might be worth mentioning this connection already in the Introduction.

> *We fully agree that mentioning increased citation of Open Science papers in the introduction helps the manuscript and have thus added "An additional benefit lies in increased citation numbers for articles embracing open science, as they contain useful assets on top of the scientific insights offered in the main text (Piwowar et al., 2007)" on line 42.*

R4.C3: L47-51: The explanatory sentence "specifically referred to as open hydrology" is a bit confusing, especially with the several citations coming after, it is difficult to connect "research projects" as a continuation of the list started with "open science".

> *We agree that the sentence length may lead to confusion. We re-phrased it for clarity and to reduce clutter within this sentence. (Now this is line 49-57).*

R4.C4: L116: I think it would be better to separate researchers and other stakeholders as interest groups. Co-development with other research is much more common. Ideas are discussed and shared at conferences. Carrying the same collaborative effort outside the research community is more of a problem.

> *This is a good point. We modified the sentence to:*
>
> *"Stakeholders usually include fellow researchers, but they may also include industry professionals, non-profit organizations, government officials, communities, members of the public, and other parties that have an interest in hydrologic research." on what is now Line 130.*

***R4.*C5:** L119-124: This transition is a bit sudden. Can you elaborate what FAIR is and what it has to do with stakeholders? I would even recommend mentioning the FAIR standards already further up in the paper. Maybe you can elaborate what FAIR has to do with data management plans (L113).

Additionally, please spell out the acronyms FAIR and CARE at least once.

We feel that introducing FAIR in L113 would disturb the flow, but we pointed out more clearly that FAIR aims mainly at fellow researchers as stakeholders, while CARE encompasses a greater variety of stakeholders. We modified Line 135 to:

"Consequently, we suggest incorporating Findable, Accessible, Interoperable and Reusable (FAIR - Wilkinson et al., 2016; Garcia et al., 2020) and, where applicable, Collective Benefit, Authority to Control, Responsibility, and Ethics (CARE - Carroll et al., 2020; Walter et al., 2020) data standards into open hydrology research. While FAIR data standards were developed to improves access to and machine readability of data mainly to advance further research, thus aimed mainly at fellow researchers as stakeholders, CARE data standards encompass a greater variety of stakeholders as they were developed by Indigenous scholars to consider the interests of indigenous people whenever they are connected with a given dataset (The Global Indigenous Data Alliance, 2019) "

R4.C6: L140: Maybe "trustworthy" is a better word than "reliable"? They might still be reliable outputs when not open, but would not be trusted by others.

We agree and changed it appropriately (now Line 225).

R4.C7: L156 and Principle 3: An explanatory half-sentence what "Carpentries" is, would be helpful. Alternatively, I would follow the advice given by Reviewer 1, Francesca Pianosi, and include overview tables. These can include links to the individual resources, which makes it easier for other researchers to access them. A similar, up-to-date table would be useful for the open hydrology project website as well. While a list of articles relating to open hydrology is a useful resource, a table with direct links would be more easily accessible.

We agree that a short description of "Carpentries" is indeed necessary. We changed this line to now read: "Various courses are available through the Carpentries, a community of instructors committed to teaching foundational data science skills. The Carpentries can help you get started using Git and online Git collaboration platforms like GitHub and GitLab on topics including version control with Git (The Carpentries, 2021)." on Line 240.

In line with Reviewer 1's suggestion we now present a comprehensive table summarizing tips, tools and resources on four open hydrology principles that the manuscript introduces. We sincerely hope that this table will help hydrologists to adopt open hydrology principles at a practical level.

R4.C8: L459: Can you briefly mention Table 2 here, since in the order the document is now, it appears before the scenarios.

We added the mention to this table in Line 75 and elsewhere in the document.

R4.C9: L461: There is no Table 3. Please check your Table references in general and in the scenarios specifically. There probably has been a mishap in numbering.

We apologize for the inconvenience this has created to the reviewers. We checked out Table references throughout the manuscript and corrected all table labels in the text.

R4.C10: L508: Any advice on how to address the fear of being scooped? Since you mention this worry already in the abstract it would be good to address this in the main article as well.

We thank the community reviewer for pointing out that the fear of being scooped was not mentioned in the main body of the article. It is certainly one of the factors that prevent people from openly sharing their work. We modified the sentence in L598 to:.

"One point to address can be highlighting the potential long-term impact of open hydrology on your career (Allen and Mehler, 2019) and also the fact that early publication in an official repository is a protection against being scooped, as your contribution is then documented with a date attached to it."

We also added an additional sentence in the main text, after line 45:

"Another benefit of embracing open science practice is a vastly improved collaboration practice, as intermediate scientific results and ideas are placed in the public domain with clear authorship and date, reducing the potential for being "scooped", i.e. for seeing your results or ideas published by someone else without proper acknowledgement of the origin (Laine, 2017)."

***R4.*C11:** Principle 2: Is "Water Metadata Language" a fixed term? If it is, I do not know it and further explanation and reference would be helpful.

We thank the community reviewer for pointing this out and we adjusted this to say "...metadata formats following metadata standards based on application and topic, and…". On line 206.