

Review of Manuscript

'Participatory Digital Earth Twin Hydrology systems (DARTHs) for everyone: a blueprint for hydrologists'

by R. Rigon et al.

Dear Editor, dear Authors,

I have reviewed the aforementioned work. My conclusions and comments are as follows:

1. Scope

The article is well within the scope of HESS.

2. Summary

In their opinion article, the authors describe both the necessity and the key aspects of moving hydrological modeling from their current state towards Participatory Digital Earth Twin Hydrology Systems (DARTHs). Key aspects of such systems include i) flexible coupling to many sources of data available in standardized formats, ii) platform- and language-independent implementation, iii) modular design facilitating recombination of model components. Each such aspect is explained in detail in a separate section and briefly summarized in the conclusions.

3. Evaluation

Overall, this article is a relevant and timely contribution to the discussion about the future of earth system modeling in general and hydrological modeling in particular. It discusses many current hindrances towards efficient, integrated and collaborative modeling and names key elements of a framework to overcome these hindrances. So I welcome the article for its content, but I do have several suggestions to improve its presentation:

- Key messages: For a reader not strongly familiar with the current state of development of Digital Earth (DE) and Digital Twin Earth Models (DT), only after reading the entire manuscript it becomes clear what the differences to current hydrological modeling practice are, and consequently what the authors aim at with their article. A reader will be able to follow the arguments in the paper much better if this is made clear from the beginning. I therefore suggest the following changes to the manuscript:
 - Include in the introduction a clear definition (purpose, key structural and organizational elements) of DE's, DT's, DARTH's and current hydrological models. Make clear where the latter fall short of qualifying as DARTHs, why it is necessary to elevate them towards becoming DARTHs, and what it takes to do so. A comparative list, or an explanatory chart can support this (maybe directly pointing to the sections in which the individual topics will be discussed in detail). From such an introduction which provides the overall picture, it will be easier for the reader to connect to the individual sections.
 - At the beginning of each topical section (sections 2-9), include a very short overview of the section content.
- Abstract: From reading the abstract only, I did not have an idea about what to expect from the article, and what its key messages are. For example, I did not know how to interpret the term "model as commodity", which is not standard terminology in hydrology. Please rewrite, taking into consideration my previous comment about key messages.
- L271: I partly agree to the statement "The peer review process is ineffective at sniffing out poor model validation", but while it may be far from perfect, I'd say it is still the best we have. Please

explain how in a DE/DT/DARTH world quality standards are maintained better than by peer control.

- Section 7: The section header just mentions “reliability”, but in the text more aspects of model performance are discussed. I suggest widening the section header, and discussing robustness, reliability, reproducibility and realism (as mentioned in L260).
- Section 10: The conclusions are written in a rather hasty and bullet-point style, which devaluates the otherwise interesting and comprehensive paper. Please spend some more effort in writing a coherent and standalone summary and conclusion.
- Appendix A: Reading Appendix A, it was not clear to me why this section was moved to the appendix rather than being another section in the main text. I’d say the topic of proper coding is just as relevant for developing DARTHS as the other topics in sections 2-9. I suggest moving it to the main text.

Minor points

- L72: What is meant by “reasonable colour maps”?
- L82-84: It is unclear at this point what is meant by “tight, black-box models”, or rather how they differ from the previously mentioned models. Please clarify.
- L89-90: The meaning of the sentence (“At present, ...”) is not clear to me. What is meant by “modeling panorama” here? Please clarify.
- L203: For me, the user’s names are unfortunately not self-explanatory. Please add a short explanation similar to the explanation of roles.
- L353: Please explain the “information hiding principle”, because it seems to contradict the general paradigm of openness and accessibility advocated throughout the paper.
- Caption of Fig. 5: What is meant by “IT”? Also, please add the channel network to the upper map for better connection to the lower map.
- Table B1 is very helpful. Please mention it already in the introduction, such that the reader can make use of it while reading the paper.
- Overall, there are many typos in the manuscript. Please check and remove.

I have another question to the authors related to current hydrological modeling and hydrological modeling in a DARTH environment. There is no need to address this in the manuscript, but I am interested in the authors opinion. The question is related to emergence as larger-scale phenomena arising from strong interactions on smaller scales. Current models build for a specific purpose and a specific scale/resolution often either make implicit use of emergence (by taking emergence as a given, directly representing the emerged phenomenon) or, because it may be relevant, setting the model up in a way that emergence may actually happen as the model runs (e.g. emergence of convective thunderstorm cells in convection-permitting atmospheric models). The latter often requires a well-attuned choice of time-stepping, spatial resolution, numerical scheme, variable precision, processes represented, etc. With a free and modular combination of model components in a DARTH environment, we may miss such well-attuned combinations, which may lead to not only incrementally but fundamentally different model behavior. How can this be taken care of in DARTH environments?

Yours sincerely,
Uwe Ehret