Review of A Hydrological Emulator for Global Applications – HE v1.0.0, gmd-2017-113-manuscript-version2

This paper presents a hydrologic emulator (HE), built upon the pre-existing "abcd" model, designed for use in global modeling applications such as IAMs. Both a distributed, gridded version and a lumped, water basin scale version are described and evaluated. The HE is tested against a baseline model of climatological monthly mean runoff. The HE is calibrated and validated against the VIC model, and its computational efficiency is assessed. The development of a computationally efficient, open-source global hydrologic model emulator is timely and useful to the modeling community, as many inter-disciplinary multi-modeling studies are utilizing global hydrologic models. While this paper is well-written and will add a valuable model to the hydrology literature, there are some improvements that should be made before publication. These are described below, in addition to some suggestions.

Criticism related to previous reviewer's comments:

The current manuscript has successfully addressed most of the concerns of the previous reviews, but some improvements are still needed, and some concerns still need to be addressed.

1. The comparison of VIC runoff to GRDC data (Fig. S1) addresses the concern raised by a previous reviewer that VIC may not be an accurate model of global runoff. However, there needs to be a few improvements to this assessment:

- The acronyms GRDC and UNH/GRDC need their full names spelled out, and the GRDC needs to be properly cited.
- The top three panels of Fig. S1 look as though they are comparing UNH-GRDC (y-axis) to GRDC (x-axis). Such a comparison is not needed, and irrelevant, as the model UNH-GRDC product is calibrated to the GRDC data. Likely the figure is supposed to show VIC runoff vs GRDC runoff. Either the axis labels must be corrected, or the comparison needs to be redone.
- Why are these three basins chosen? The authors do not provide sufficient evidence that these basins are representative of global runoff patterns. The authors should either make this argument, or provide analysis of more basins. A map showing the r^2 values of monthly runoff in VIC vs GRDC or UNH-GRDC would be most informative, as it would show regions in which VIC is most (and least) accurate.
- Why is the comparison only made for the period 1986-1995? GRDC data now has observations through the year 2016.
- Suggestion: the authors could include a brief discussion of the limitations of the VIC model. This is not necessary, but could be helpful to readers.

2. The authors should assess the computational efficiency of the calibration processes. This would inform other users of the HE how difficult it is to re-calibrate

the model to other GHMs. While not necessary for publication, it would improve the paper to re-calibrate the HE to another GHM, demonstrating the HE's flexibility and broad applicability.

3. There is no analysis of daily runoff simulations. Even if the model is not intended to be used for daily simulations, this should be explained explicitly in the text. Line 342 states that distributed models such as the distributed HE presented here are better than lumped models for flood peak prediction. However, flood peak prediction is only accurate at daily time steps, so this statement should either be removed, or the daily accuracy of the distributed HE assessed.

4. For context, the authors could add a brief description of the type of work that IAMs coupled with (or including) GHMs have been used for.

Major criticisms: must be addressed before publication

1. This model is intended to be fully open-source and user-friendly. To accomplish this goal, the authors should include in the source package a user manual. A good example of such a model user manual is the open source CaMa-Flood manual, available here: http://hydro.iis.u-tokyo.ac.jp/~yamadai/cama-flood/Manual_CaMa-Flood_v362.pdf
2. Line 107: Where does the baseline model's climatology runoff come from? Is this based on data, or a model simulation? It needs to be described and cited.
3. Lines 226 – 229: Provide data or a citation to back up the claim that discrepancies between VIC runoff and observed streamflow products are due to human activities.
4. If the VIC simulation did not include human activities, then can the HE model be used to emulate GHMs that do include human activities such as water extractions from rivers and reservoir operation?
5. Section 2.4: Please describe the runoff range over which the model is calibrated. Does it include a good representation of extreme events? How does the distribution of runoff in the calibration period compare to potential future runoff under climate change? If there is a significant difference in these distributions, the applicability of the HE to climate change studies should be discussed.
6. Figure S4: Only the correlation coefficient for calibration on runoff is shown. The correlation for calibration with runoff and BFI should be included, as it is discussed in the text.
7. Lines 318-325, and Fig. S5: While Fig. S5 shows maps of ET, there is no quantitative assessment of ET. I suggest either a correlation analysis, or showing a difference map along with the other maps. A difference map would be very informative, showing regions of good agreement and regions of poor agreement.
8. Lines 322 – 325, and Fig.4: Figure 4 shows a good match in seasonal variation of the calibration period. It is more important to show the seasonal

variation in the validation period. The text claims that the seasonal variation in ET is good, but there is no quantitative evidence of this.

Minor criticisms: suggestions that are not essential for publication

1. Figure 4: The color scheme is good, as blue and black are similar, and the light green is hard to see. Choosing different colors, or even using some dashed lines or other symbols would improve this figure.
2. Figure 5: Showing a difference map, especially between VIC and the distributed model, would be very informative.
3. While the citation for the PET calculation is given in the text, it would be useful to either cite this again within Appendix A, and/or provide the full equation for PET within Appendix A.
4. Line 257: The objective function equation needs an equation number.
5. While the paper is mostly well-written, the authors should have a copy editor review the paper for detailed grammatical issues, as there are several sprinkled throughout the text. In a few places, these grammatical issues hinder the clarity of the text and should be revised. These places are:
    a. Lines 164 – 166, sentence beginning with "For the baseline model…"
    b. Lines 211 – 215, sentence beginning with "Second, since we have not…"
6. Lastly, the open source code is written in Matlab, a proprietary and costly computing software package. While most large U.S. and European universities have Matlab licenses, this platform may be cost prohibitive to some researchers, limiting the global usability of the open source model. While this is not required for publication, I would highly recommend that the authors translate this model into a fully open-source coding language such as R, Python, or C.