

## **Comment on hess-2021-361**

Anonymous Referee #1

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Referee comment on "Unraveling the contribution of potential evaporation formulation to uncertainty under climate change" by Thibault Lemaitre-Basset et al., Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2021-361-RC1>, 2021

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The authors present an analysis of the uncertainty due to potential evaporation (PE) formulation within the GCM/RCM climate change projection chain for climate change impact assessment. Understanding how much the uncertainty in PE formulation contributes to overall climate change impact uncertainty is an important area of research. The authors find that the overall uncertainty contribution of PE formulation is low relative to the other components namely emissions scenario (RCP), RCMs and GCMs. However, some of the methodological decisions cloud the strength of this conclusion. For example, the mixture of evaporation metrics to include potential evaporation, reference crop and open water evaporation increase the variance in PE variables. Combining multiple RCPs within the analysis, rather than treating each RCP separately increased the variance due to RCPs. Also, it is unclear whether the GCM/RCMs have been bias corrected, which could also potentially increase the variance between GCM/RCM projections. All these issues may be inflating variance contributions and making it harder to see the true contribution of the PE formulation to the uncertainty. Also, the methodology behind the signal-to-noise analysis requires much more detail as it is very unclear what is being shown here. In its current form, the manuscript needs to be revised to clarify some issues identified below and to draw out more fully the implications of the interesting work presented in this manuscript. This would also help when comparing the results from this study with other studies in this area.

### Specific comments

Line 29: change "climate variables relatively to air temperature" to "climate variables relative to air temperature".

Line 32: The text “many impact models accommodate from PE amounts” is not clear – do you mean calibrated impact models can accommodate errors in PE estimates?

Line 34: remove the “s” from “formulations”.

Line 37: change “Since PE formulations is not the unique source” to “Since PE formulations are not the only source”.

Line 49: change “showed how dependent from the choice of PE formulations future streamflow anomalies can be” to “showed how future streamflow anomalies can be dependent on the choice of PE formulation”.

Line 66: change “simulated by an hydrological model” to “simulated by a hydrological model”.

Line 78: change “for the uncertainty on the unknown future greenhouse gas emissions trajectories and climate” to “for the uncertainty in future greenhouse gas emission trajectories and climate”

Line 80: delete “were collected”

Table 2: It is great that the code provides the details of how each PE formulation is calculated. However, it would be good to add a little more detail to Table 2 as some of these methods don’t have a unique formulation. For example, which Morton estimate of ET is being used? Is the Penman-Monteith reference crop (FAO56) or a different version of Penman-Monteith? Which version of Penman is being used? The formula for each method would make this clearer and or an indication of whether the formulation is open water, potential evaporation or reference crop. Also, Hamon should include sunshine hours as a variable.

Section 2.2: The seven formulations in Table 2 include estimates of potential evaporation (unlimited water availability) over land or water, reference crop (well-watered short grass) and open water evaporation. Therefore, these formulations are not expected to produce results of a similar magnitude – it would be good to indicate which formulations estimate the different types of evaporation and which produce higher to lower values (I would expect open water evaporation > potential evaporation > reference crop). While I agree that all of these seven formulations can be used to represent future atmospheric demand for climate change impact assessments, it is important to be clear about what they actually estimate and how these differences may influence the later uncertainty estimates.

Figure 2a: Much of the difference in PE between the seven formulations is likely due to them representing different evaporation variables. As mentioned previously re the seven formulations in Table 2 they include potential evaporation (unlimited water availability) from a surface, reference crop (well-watered short grass) and open water evaporation. Furthermore, most of them are estimates of evaporation from a point, whereas Morton is likely to be an estimate for a large area, which we would expect to be lower than a point estimate. If these seven formulations are kept in the analysis, then it is important to be clear that the variability is not just different formulations of a single type of evaporation metric (potential evaporation), but variability between different evaporation concepts.

Figure 5 bottom row – signal-to-noise ratio: The method used in this manuscript to calculate the signal-to-noise ratio is not clear, despite the reference to Hawkins & Sutton (2012). Table 1 does not list any pre-industrial control simulations, so it is unclear what has been used in this analysis to define the natural climatic variability against which the RCP scenarios would be compared to see if the signal-to-noise ratio is  $> 1$ . Also, it is not clear which RCP scenario is being shown in Figure 5 (bottom row) or whether the signal-to-ratio is average across the three RCP scenarios considered. The different RCPs will have different signal-to-ratios as they have very different signals, yet only one map is shown for all RCPs. It would not make sense to combine different RCPs into a single signal-to-ratio metric as they have very different signals – they should be considered one RCP at a time. More details about how the signal-to-ratio is calculated is required to understand what is being shown here and why the results are the way they are. I see that later at line 211 it appears that the different RCPs have been combined in the signal-to-ratio metric, which is not informative.

Figure 6: the x-axis is missing from the plot.

Section 4.2: The authors note that the uncertainty due the PE formulation in this study is lower than in other studies (Line 237). They suggest this may be due to other studies only considering a single RCP, which is a reasonable suggestion. I recommend only considering a single RCP at a time, rather than combining the RCPs into the one analysis as combining the RCPs will likely inflate the uncertainty in the GCM/RCM/RCP components of the analysis. However, another suggestion may be that the other studies may have bias corrected the GCM/RCM output prior to assessing the uncertainty contributions. Bias correcting the GCM/RCM projections would remove any bias between GCM/RCMs and place each GCM/RCM on a common baseline from which the difference in GCM/RCM/RCP signal would emerge. Whereas, in this study it is not clear that any bias correction of the GCM/RCM projections has occurred, so there will be increased variability in the GCM/RCM projections due this uncorrected bias.