Editor Decision:

We have now received the new reports from both referees. They both agree that the paper has improved substantially and that most comments have been appropriately addressed. However, there are still some concerns mentioned by reviewer #1 about the bias in the results that need to be addressed and/or appropriately rebutted before a final decision.

Response:

We thank the editor and reviewers and for their comments and feedback . We believe we have addressed the comments below , and appreciate hearing back soon.

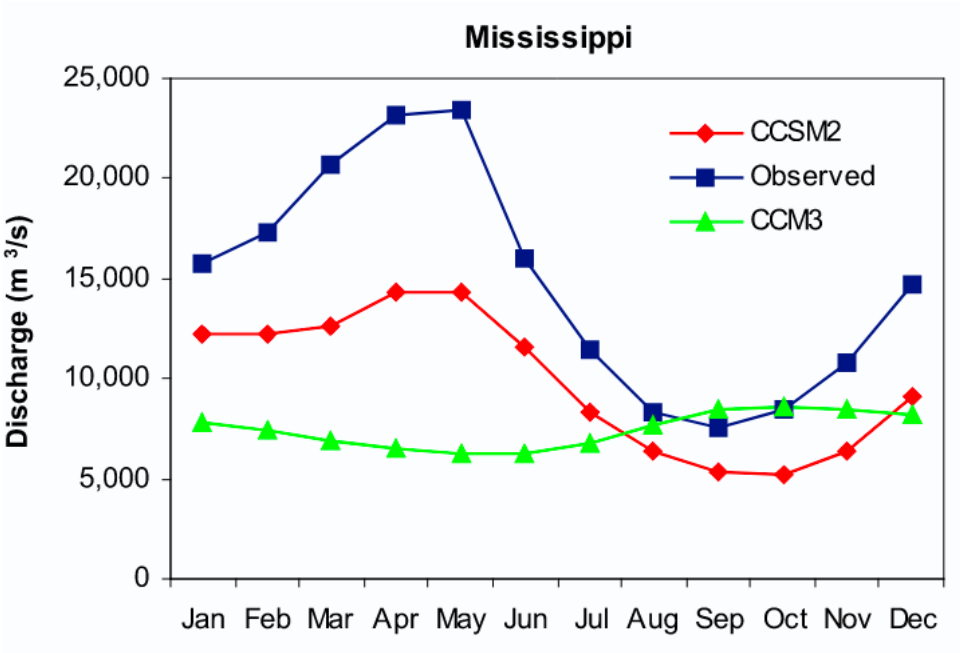
Comments from Reviewer 1

Most of my concerns have been addressed reasonably. However, although I can see that the reported runoff and snowmelt simulations become more reasonable, the overall CESM1 simulations of river discharge using the RTM routing scheme are still unexpectedly poor. Particularly, the simulations showed the timing bias for the Mississippi River that was not shown in the validation paper of the RTM scheme (Branstetter and Erickson III, 2003). The authors must carefully examine this inconsistency. Also, it would be worth to cross-check with standard CESM1 simulations to ensure that the reported bias is not an error. For example, the authors can verify their results using the ISIMIP2 CLM4.5 simulations which are also based on the RTM routing scheme and follow a well documented protocol.

Branstetter, M. L., and D. J. Erickson III (2003), Continental runoff dynamics in the Community Climate System Model 2 (CCSM2) control simulation, J. Geophys. Res., 108, 4550, doi:10.1029/2002JD003212, D17.

Response to Reviewer 1

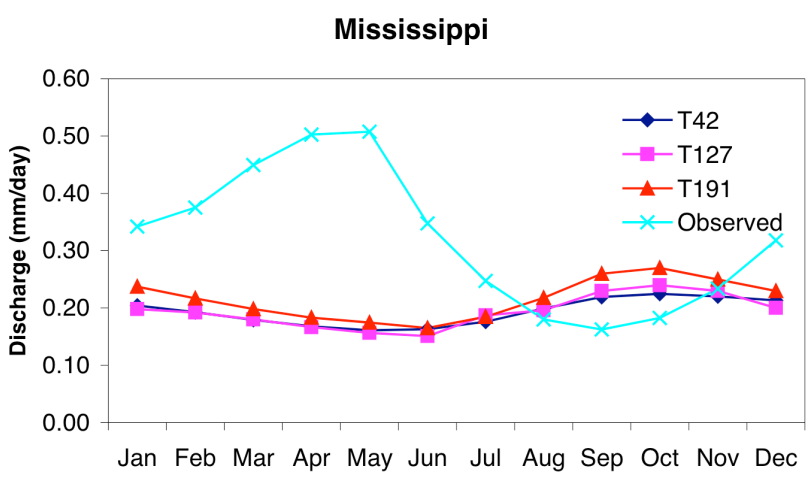
We thank Reviewer 1 for pointing out the validation in Branstetter and Erickson (2003). We have checked this again and see that our findings are consistent with these other more recent papers, as follows. CESM1, including the Last Millennium Ensemble project, uses the Community Land Model 4.0 (CLM4.0). Branstetter and Erickson III (2003) specifies using the Community Land Model 2.0 (CLM2). As noted, their results show better seasonality, specifically in Figure 1:



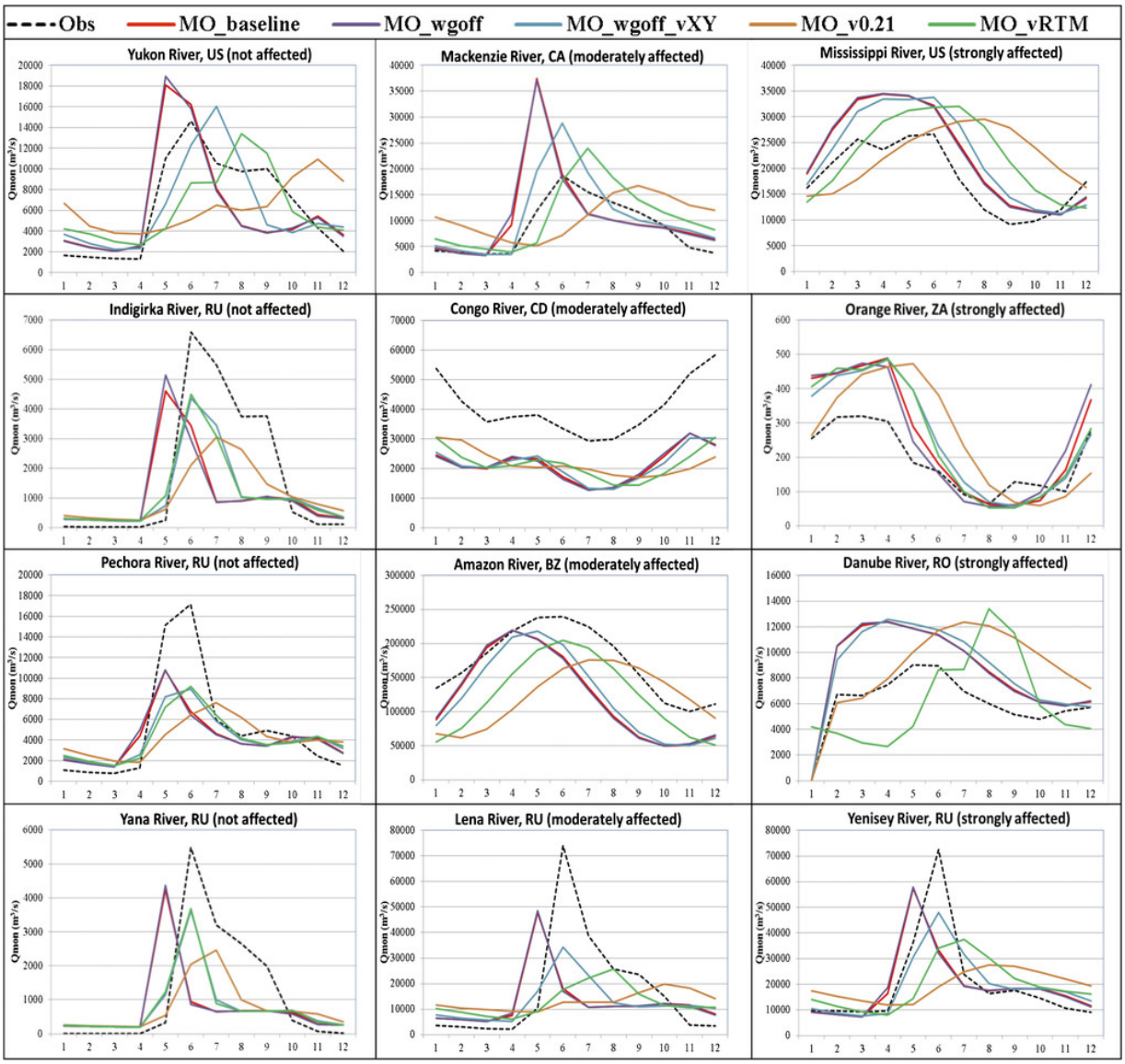
However, we find that over the years of different model iterations and in results from others, the seasonality bias is still present. For example, an earlier version from Branstetter (2001) which

uses RTM with the NCAR Land Surface Model 1.0 (LSM1.0) shows model results with peak discharge at nearly the opposite time of year of observations (Figure 2.4g):

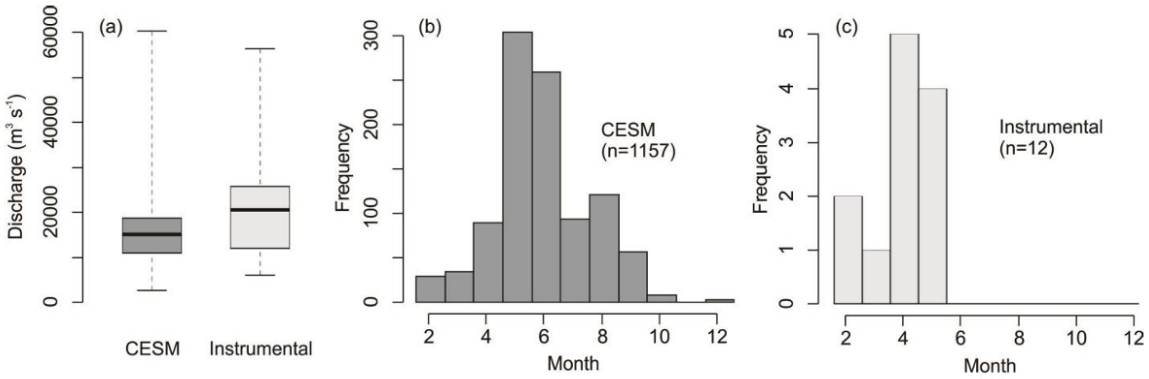
g)



Brandstetter and Erickson III (2003) is a clear improvement over these early results. In 2015, Li et al investigates the skill of the MOSART and includes RTM in comparisons of skill; both are paired with CLM4.0. In Figure 6, RTM timing, shape, and magnitude are not aligned with observations:

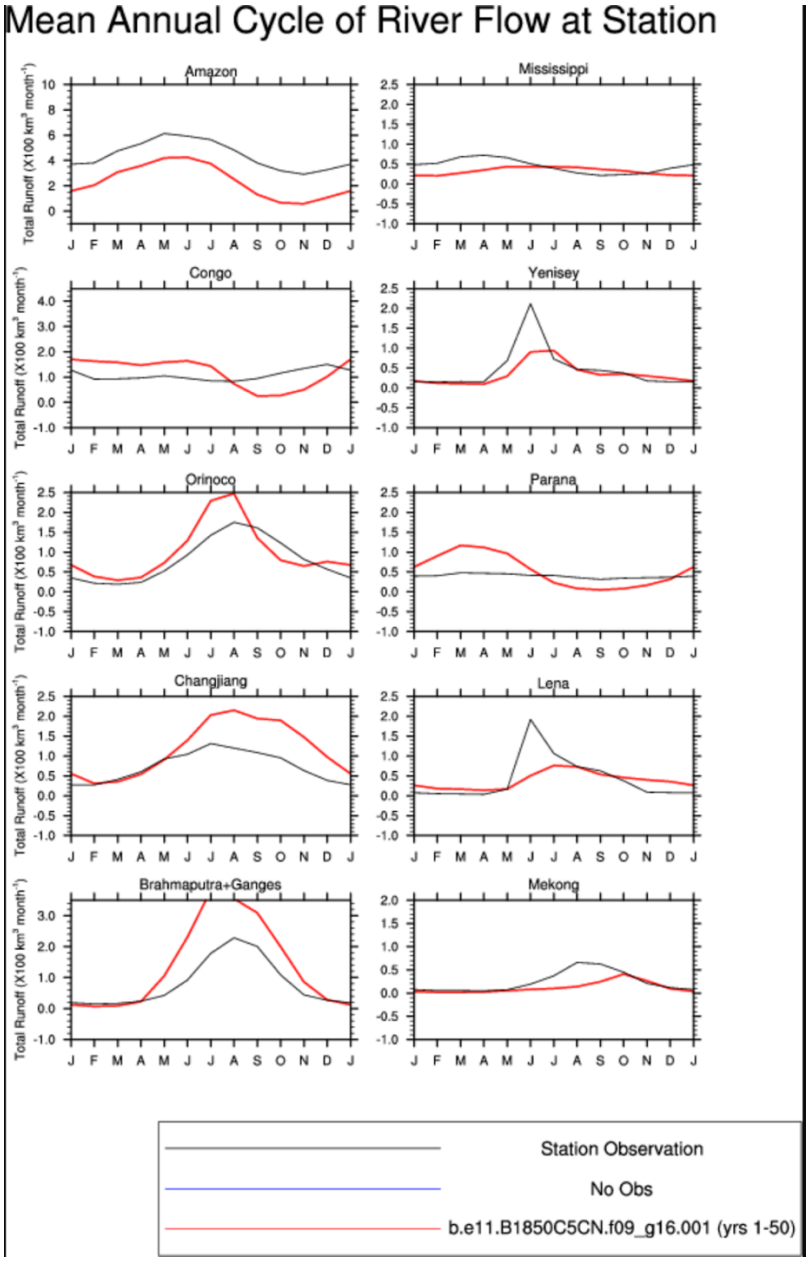


In 2017, Munoz and Dee used CESM1 LME to investigate high flows on the Mississippi. While Supplemental Figure 1 shows overlap in the timing of the largest 10% of events, there again is a mismatch in the distribution where CESM has peak events later and through the year.



Supplemental Figure 1. Comparison of lower Mississippi River discharge simulated in the CESM–LME with instrumental data from the gauging station at Vicksburg, Mississippi (USGS station no. 7289000); (a) simulated and instrumental (2008-2015) mean monthly discharge, and month of peak annual discharge for the largest 10% of events in (b) simulated and (c) observed (1897-2015) floods.

Lastly, a previously accessed NCAR CESM1.1 validation resource for “River Flow at Station” for 10 rivers shows a mismatch in timing for the Mississippi. However, the original link (in citations) seems to be temporarily unavailable, likely due to the NCAR migration of CESM data.



The variation between results shows the need for further validation and explanation of the causes of shifted seasonality in the model. While we discuss in the paper that the MOSART routing model, used in CESM2, is a substantial improvement to RTM, this validation of CESM1 discharge and investigation of causes of shifted seasonality is significant for those who still rely on CESM1 for its Last Millenium Ensemble experiments and to point to the ongoing need for hydrology to be accurately represented in Earth System models.

Citations

Marcia Brandstetter: Development of a Parallel River Transport Algorithm and Applications to Climate Studies, The University of Texas at Austin, 2001.

Branstetter, M. L. and Erickson III, D. J.: Continental runoff dynamics in the Community Climate System Model 2 (CCSM2) control simulation, Journal of Geophysical Research: Atmospheres, 108, https://doi.org/10.1029/2002JD003212, 2003.

Li, H.-Y., Leung, L. R., Getirana, A., Huang, M., Wu, H., Xu, Y., Guo, J., and Voisin, N.: Evaluating Global Streamflow Simulations by a Physically Based Routing Model Coupled with the Community Land Model, Journal of Hydrometeorology, 16, 948–971, https://doi.org/10.1175/JHM-D-14-0079.1, 2015.

Munoz, S. E. and Dee, S. G.: El Niño increases the risk of lower Mississippi River flooding, Scientific Reports, 7, https://doi.org/10.1038/s41598-017-01919-6, 2017.

CESM1.1 Diagnostics: set7_mon_stndisch_10riv.gif (577×912): https://www2.cesm.ucar.edu/experiments/cesm1.1/diagnostics/b.e11.B1850C5CN.f09_g16.001/lnd_1-50-obs/set7/set7_mon_stndisch_10riv.gif, last access: 17 April 2024.

Comments from Reviewer 2

The authors have addressed my comments in this revision. However, I have one concern regarding the use of USGS gauge for the Lower Mississippi River:
Figure 1: I cannot agree with using USGS gauge 07295100 Mississippi River at Tarbert Landing to represent the Lower Mississippi River. This is because this gauge is located downstream of the Old River Control Structure (completed in 1963) and heavily influenced by flow regulations (30% of the Mississippi river flow goes into the Atchafalaya River before reaching this gauge). Neither CESM1 nor CESM2 cannot simulate such flow separation in their model settings. I suggest the authors should still use the gauge at Vicksburg in the analysis.

Response to Reviewer 2

We thank Reviewer 2 for this point about the choice of gages. We have updated Figure 2 again, and it now includes both the USGS Mississippi at Vicksburg (07289000) and USACE Mississippi at Tarbert Landing (01100Q), which shows that the seasonality remains an issue between CESM1 and both gages, while also showing the difference in magnitude of discharge. We have also updated Tables 1 and 2 to reflect the change.