

Geosci. Model Dev. Discuss., referee comment RC1
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Comment on gmd-2021-364

Anonymous Referee #1

Referee comment on "Atmospheric river representation in the Energy Exascale Earth System Model (E3SM) version 1.0" by Sol Kim et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2021-364-RC1>, 2022

The authors evaluated the simulations of atmospheric rivers in the model E3SM and explored the relevant physical and dynamical processes. However, I have some major concerns as well as many other comments listed below. Before the author solve these concerns, this manuscript might not be ready to publish.

Major Concerns:

(1) Lines 112-120: The authors compared the AR frequency between MERRA2 and E3SM. Although the authors clarified that "All % differences mentioned below ... are absolute differences, not relative difference", the description is misleading. For example, "there is a slight positive bias (1-3%) in the E3SM frequency near the edge between the tropics and subtropics ..." I do not think 1-3% (absolute difference in AR frequency) is a "slight positive bias". For example, while the AR frequency is below 10% over the southern California coastal region (Figs. 1a-b), the 1-3% bias (Fig. 1c) is large. In other words, the relative difference/bias of AR frequency over that region is larger than 10-30%. The bias in Chile is even larger (Fig. 1c). Please rewrite this part and the potential reasons for the large bias should be discussed.

(2) Line 122 and line 130: "... exhibits a close match ..." and "... in agreement with ..."
Similar to my last comment, please be careful with these vague descriptions. For example, as the authors mentioned that in NDJFM over the west coast of North America, the AR frequency difference is 3-4% (line 125). That means the relative difference is roughly > 30-40% over the US West Coast (one of the most important area that affected by ARs) during the AR season (NDJFM). These model bias should be carefully examined and described.

(3) Many statistical analyses (such as Figs 2 and 4) are conducted over the global domain. Those results are important. However, many useful information/signals might be smoothed out using the global domain. It would be helpful if the authors could conduct similar analyses for some regions with high frequency or high impacts of ARs, such as the west coast of North America in NDJFM. I believe many readers will be interested in the analysis for that kind of region (with large model bias as well as high social impacts), rather than a smoothed result for a global domain.

(4) I have some concerns and suggestions for Fig. 4. (a) In my understanding, in each panel the total probability of E3SM or MERRA2 should be 1. However, it seems like the total probability is much lower than 1. Please clarify. (b) In panel a, please put " $\times 10^4$ " closer to the unit or the numbers in X-axis. (c) Please keep consistency in the number of decimals for the values of medians in each panel. (d) In caption, "sets of line" should be "sets of lines". (e) Please extend the Y-axis in panel e since it seems like the maximum value is higher than the probability of 8×10^{-3} (is the probability values at Y-axis correct?).

(5) Lines 227-233: "A large source of general E3SM precipitation biases come from ... suggesting certain large-scale circulation biases may have larger influence on AR frequency than the frequency of non-AR storms." These sentences are important to interpret the potential mechanism responsible for the model bias in AR precipitation. However, it is difficult to follow the logic. For example, how did the authors conclude that "... certain large-scale circulation biases may have larger influence on AR frequency than the frequency of non-AR storms" without analyzing the frequency and precipitation rate of non-AR storms?

(6) Fig. 5 shows the comparison of AR precipitation rate. How about the total AR precipitation amount? For example, over the US West Coast E3SM has positive bias in both AR precipitation rate and AR frequency in NDJFM. I am curious how large the bias of total AR precipitation will be over there.

(7) I suggest the authors go through the manuscript to improve the writing. This manuscript would be easier to read if the authors could improve the writing. I listed some issues below, but there are more places that could be improved.

Other Comments:

(1) Line 58: What is "standard resolution"?

(2) Lines 58-63: These two sentences provide a general background for the E3SMv1 performance, but they are vague. Please re-write and provide more details.

(3) Line 79: is "daily data" daily mean or instantaneous?

(4) Line 80: "Five ensemble members ...". Please clarify the difference between the ensemble members, as well as the motivation to use the five ensemble members.

(5) Line 87: "AMIP", please spell out the full name when it is used for the first time.

(6) Line 88: "CMIP6 DECK simulations", please define DECK.

(7) Lines 105-106: "This means the threshold is calculated separately for MERRA2 and the E3SM simulation." Is there any large difference in the IVT threshold between MERRA2 and E3SM? The difference in the IVT threshold (85th percentile) could be a part of the model bias.

(8) Line 110: "All % differences ..." should be "All percentage differences ..."

(9) Line 152: "SDs are consistent with MERRA2." This sentence is too vague.

(10) Line 161: "... AR frequencies are well < 1.0 %." Difficult to understand.

(11) Line 162: "The seasonal SDs reveal sources of the higher annual SDs." Higher than which SDs? I saw the annual SD is obviously lower than the NDJFM and MJJAS SDs in Fig. 3.

(12) Lines 165-168: "MJJAS SDs (Fig. 3b peak for $\sim 1.5\%$ over various regions of ... " Difficult to follow. Please rewrite.

(13) Line 168: "In general, the northern hemisphere shows more internal variability." This is an interesting result, but do the authors have any idea about the potential reasons?

(14) Line 170: "... using a single historical simulation ..." Why did the authors use a single historical simulation? How did the authors select the single simulation?

(15) Line 171: "The distribution of all the ARs ..." Do the authors mean the "characteristics"?

(16) Line 172-173: "All characteristics show strong similarities in shape and peak at the same values, barring magnitude of mean IVT (4e)." I do not understand this sentence, what are the "same values"? I do not understand the logic to mention 4e (Fig. 4e?) here either?

(17) Lines 175-177: These two sentences are difficult to follow. Please rewrite.

(18) Lines 199-200: "For annual AR precipitation, E3SM reproduces the ..." Please be careful, there might be large differences in the distributions and magnitudes of AR precipitation if using different precipitation data. "Reproduce" might be too vague.

(19) Line 202, "The western coasts ... produce higher rates of AR precipitation in E3SM." "Produce" might not be suitable here.

(20) Line 226-227: "... model bias in the subtropical jet would affect precipitation ..., as both are influenced by the jet and storm tracks." Please provide reference.

(21) Lines 250-252: "Although Dong et al. (2021) looked at future projections of large-scale circulation and precipitation changes ... which can explain the sources of some of the AR biases." I do not understand the logic to use the results of future projections from Dong et al. (2021) to explain "the sources of some of the AR biases" in the historical simulations in this study. Many factors and even mechanisms may change under climate change.

(22) Fig. 8: It would be helpful if the authors could add contours to show the distribution of AR frequency in the historical simulations.

