Response to Reviewer # 2

Review for "Flavor identification of the stratospheric sudden warmings based on the downward tropospheric influence" by Lu and Rao.

Summary
Using the reanalysis, this study analyzes the possible impact of the downward-propagating SSWs on the continental climate. To by best knowledge, this is the first study to classify the downward-propagating SSWs into three types: North America, Eurasia, and BOTH. This classification is established on the existing evidence that the composite SSW shows wide coldness anomalies over the Eurasia and/or North America. However, the coldness over both continents is not synchronous for all SSWs. It will improve the understanding of the diversity of the SSW in influencing the near surface. In general, this study is very interesting and worth publishing after a revision.
Response: Thank you for your positive comments.

1. The classification of downward-propagating SSWs is mainly based on the cold anomalies over both continents. Not all of cold temperature anomaly variations are caused by the stratospheric variability, and the composite might filter out the contribution of other variability if the sample size is large enough. Is there any possibility to increase the sample size if the model data are used? For example, CMIP6 provides a large model ensemble dataset, which contains much more samples than ERA5. If those data are used, the stability of the composite results can be well confirmed.
Response: This article only uses ERA5 reanalysis to compare the possible impact of NDW and DW. The sample size is relatively small for NA events. However, the composite anomalies for the NDW and each type of NW is significant (see Figures 1, 3, 4, 5, 6, 7). The sample size really can impact the robustness of the composite results, but an increase of the sample size might not change the anomaly pattern.

To well address your concern, we made several revisions this time. Firstly, we discuss the possible issue resulting from the limited sample size in reanalysis. Secondly, we provide an insight into the future study that use more sample size from CMIP5/6 models to verify our research. Namely, we expected to increase the sample size and validate the conclusions using model data. However, due to the limited scope of this study, we did not insert too many figures. We can show the figure exclusively for your reference (Fig. R1).

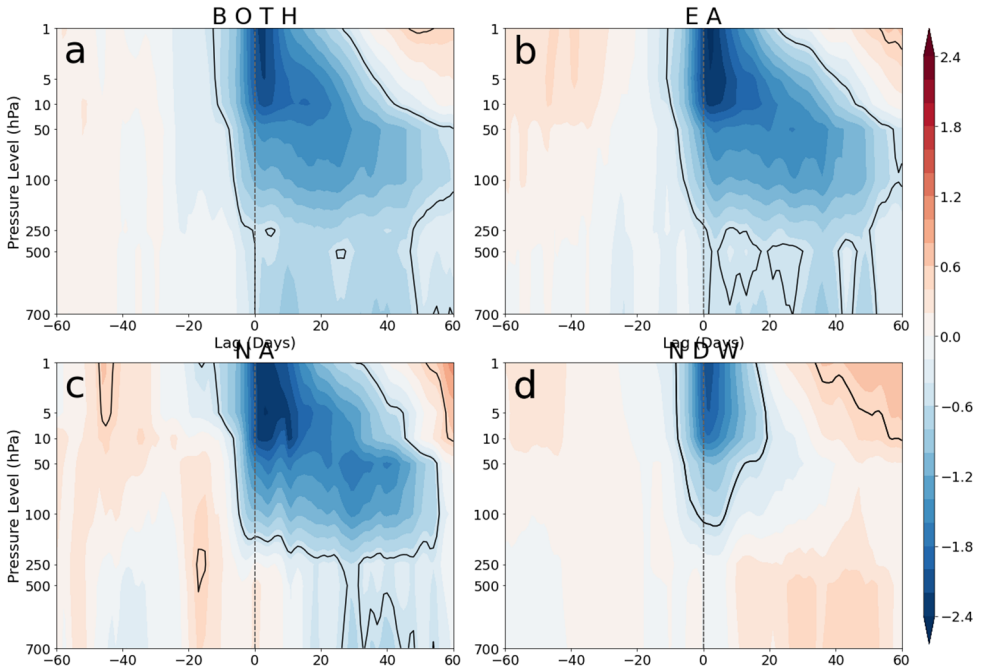

Fig. R1. Same as in Figure 1, but for model data. CESM2-WACCM historical simulations (r1i1p1f1 to r3i1p1f1) were used for composite (the sample size for each type exceeds 35).

Revision related to this comment can be found at Lines 21-22, L546-548, etc.

2. This study classifies the SSW using the t2m anomalies, which is based on the fact that major SSWs show larger and more significant t2m composite than rainfall composite. Are the zonal band of rainfall anomalies over North Atlantic sensitive to the threshold of downward-propagating SSW type?

Response: Please refer to Fig. 6 in the paper, and we can see that the rainfall anomaly pattern is very similar for the DWs, and the pattern for NDW is farther northward biased. The primary difference lies in the area coverage of significant precipitation anomalies. To well consider your concern, we also verify this conclusion using CMIP6 outputs. Please refer to Fig. R2 for more details. Due to the limited scope of this study, we only show the observational facts in this paper. The model evidence is left for future study.

To well address your concern, we made several revisions.

"Adopting relative continental cold anomalies as the criterion for classifying SSWs, changes in precipitation anomalies are not so sensitive to the DW type as t2m anomalies." (L502-503)

"Using more samples from model outputs, a deeper understanding of different types of DW events is possible, left for future investigation." (L57-548)

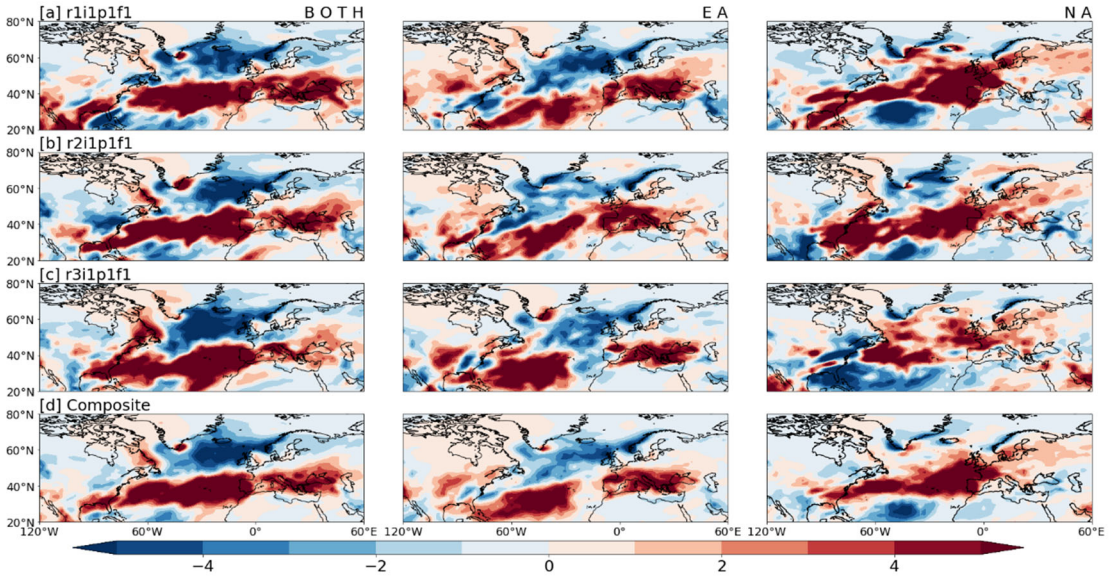

Fig. R2. Composite rainfall anomalies for BOTH, EA, and NA using model outputs from (a) CESM2-WACCM r1i1p1f1, (b) CESM2-WACCM r2i1p1f1, (c) CESM2-WACCM r3i1p1f1; and (d) all historical simulation members.

Other comments

L38: determine => determines; Butler et al., => remove ","

Response: Revised. (L40)

L44: lead => leads

Response: Revised. (L45)

L46: mechanism => mechanisms

Response: Revised. (L46)

L56: and have => remove

Response: Revised. (L57)

L64: populated => growing ; extreme extreme => remove one

Response: Revised. (L65)

L101-102: Reviesed as "The isobaric levels extend from 1000 hPa to 1 hPa, and the horizontal resolution of the data is 0.25° latitude by 0.25° longitude."

Response: Revised. (L104-105)

L105: SSW => SSWs; All => all

Response: Revised. (L110)

L107: The 1 November => 1 November

Response: Revised. (L112)

L111: using => used; do => does
Response: Revised. (116)

L113: twice => more than once
Response: Revised. (L117-119)

L117: ERA => remove
Response: Revised. (L122)

L120: the cosine => cosine
Response: Revised. (L125)

L125: Natarajan et al., => Natarajan et al.
Response: Revised. (L130)

L130: White et al., (2019) => White et al. (2019)
Response: Revised. (L135)

L147, 151: Esler et al., (2009) => Esler et al. (2009)
Response: Revised. (L153, 155)

L174: Characterize => characterizes
Response: Revised. (L181)

L186: return => returns
Response: Revised. (L192)

L188: are present => is present
Response: Revised. (L194)

L198: persist => persists
Response: The original sentence has been modified.

L231: interval => intervals
Response: Revised. (L252)

L232: region => regions
Response: Revised. (L253)

L243: move => moves
Response: Revised. (L269)

L259:stable moderately warm state => moderately warm stable state

Response: Revised. (L292)

L267: Lu and Ding, 2015; => Lu and Ding, 2015
Response: Revised. (L306)

L309: the circulation structured is different => the circulation structure is differently organized
Response: Revised. (L361)

L330: amplitude .. are => amplitude is
Response: Revised. (L383)

L337: cut => cuts
Response: Revised. (L391)

L342: midlatitude => midlatitudes
Response: Revised. (L395)

L364: all for => for all
Response: Revised. (L431)

L385: reverse => reverses
Response: Revised. (L458)

L392: elongate => elongates
Response: Revised. (L465)

L409: finding => findings
Response: Revised. (L483)

L412: weaker smaller => weaker
Response: Revised. (L486)

L421: ocean regions =>oceanic regions
Response: Revised. (L494)

L424: 0-10 day => 0-10 days
Response: Revised. (L497)

L431: show => shows
Response: Revised. (L504)

L440: show => shows
Response: Revised. (L513)