Response to reviewers

We would like to thank both reviewers for taking the time to review our manuscript and provide valuable comments. These comments will, without any doubt, help us improve our analysis and discussion. In the following, we describe how we intend to revise our manuscript to address these comments. This response will be followed by a more detailed point-by-point response to all the reviewer's comments.

1) **Choice of the SST domain in the SVD analysis**

Both reviewers have noted that the current SST domain used for the SVD analysis, which extends over most of the equatorial and northern sectors of the Pacific Ocean, is likely too broad to adequately capture ENSO's relationship with North American subseasonal variability. One issue is the possible contamination by other timescales of variability affecting the North-Pacific sector. In response to these comments, we will limit the SST domain to 20°S - 20°N. Our results are, however, found rather insensitive to this change of domain, and thus our conclusions on the earlier version all remain valid.

2) **Purpose of using the SVD analysis**

Reviewer #2 also expressed doubts about the practicality of using the SVD analysis over the use of classical ENSO indices. We believe however that the SVD analysis is useful for objectively assessing which flavor of ENSO is optimally related to subseasonal variability over North America through the maximization of the covariance. Starting from the classical ENSO indices would require repeating the analysis for each index, and it does not necessarily guarantee that these indices could uncover a parcicular SST pattern having the optimal connection with the subseasonal variability. Identifying this optimal connection via the SVD anlaysis thus also contributes to improving the significance of our subsequent analyses by providing time series that are the most representative of the relationship between equatorial SST variability and subseasonal variability over North America.

3) **The implication for North American weather predictability**

Reviewer # 1 suggested discussing the implications of our results for weather predictability over North America. Since we agree this would add value to the manuscript, we will add the following discussion to our conclusion section to the revised manuscript: "Our results suggest that predictive skill over North America may be deteriorated during La Niña due to enhanced baroclinic energy conversion to SSV and, as a consequence, increased atmospheric internal variability over the sector. This is in agreement with the overall less skillful predictions achieved during the negative phase of the PNA (Lin and Derome 1996; Sheng 2002) which, in terms of extratropical mean flow changes, is to some extent similar to the extratropical response to La Niña."

4) **The sensitivity of wave train structures to reference locations**

In response to a comment from reviewer # 1, it will be added to the revised manuscript that the locations are chosen because the identified mode of covariability has a large impact on SSV over these sectors (Fig. 2) and atmospheric circulation patterns associated with localized SAT variability are quite sensitive to a parcicular choice of the reference locations. It will also be noted in the revised manuscript that these patterns share similar features, such as their spatial scale and meandering, with the circulation anomalies associated with the leading modes of SAT variability (Lin 2015) although the exact location of their cyclonic and anticyclonic centres of action are not the same. We consider that they may correspond to modes of lesser importance or combinations of the leading modes.

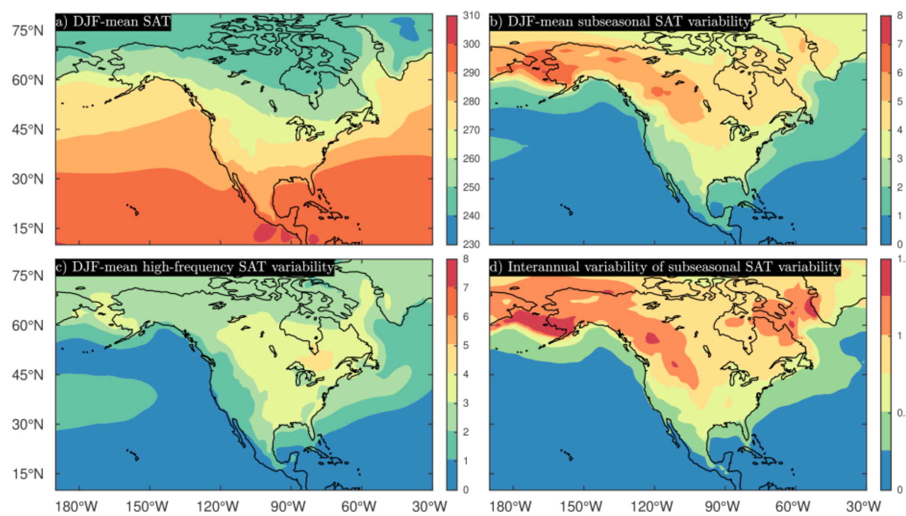
5) Relationship with the PNA

Reviewer # 2 inquired whether the extratropical response is the one associated with the well-known PNA pattern. The observed winter-mean response is in fact more similar to the extratropical response forced by ENSO than the one associated with the purely internally-generated PNA (Straus and Shukla 2002). It is also known, for instance, to project onto the Tropical Northern Hemisphere (TNH) pattern (Trenberth et al. 1998; Soulard et al. 2019). It remains unclear whether the modulation of baroclinic energy conversion is achieved through the projection of the extratropical response on the internally-driven PNA or TNH, but we speculate that it may be achieved through the PNA since important modulations of baroclinic energy conversion take place over the western North Pacific where the PNA has a greater influence on the mean flow. We believe this is an important point, and the relevant discussions will be added to the revised manuscript.

It is, however, out of the scope of the present study to assess quantitatively whether this impact is achieved through a projection on natural modes of variability. It should be the topic of our future standalone paper on internally-generated variability, in which the PNA, the TNH, and other teleconnections affecting the North Pacific sector should be investigated.

6) Importance of ENSO's influence on SSV

Reviewer # 2 has proposed to discuss the importance of ENSO's influence on SSV. To this end, we will add a new figure (Fig.1) to show the climatology of SSV and its interannual modulations. We will also illustrate the fraction of this variability modulated by ENSO on our Fig. 2 showing the result of the SVD analysis.



New Figure 1: *Climatological features of SAT variability (1958-2015). The a) DJF-mean SAT, b) DJF-mean subseasonal SAT variability, or SSV, c) DJF-mean high-frequency SAT variability, and d) interannual modulation of subseasonal SAT variability are shown with colour shadings. All variables are in units of K. Variability is illustrated with the standard deviation.*

7) **Improving the focus of the introduction**

Reviewer # 2 noted that one of our introductory paragraphs, where we discuss blocking events and weather extremes, seems off-topic. The reason we discuss blocking there is to illustrate, with a specific event of subseasonal time scale, how ENSO can modulate subseasonal variability and associated weather impacts. Such influence has rarely been discussed for general subseasonal variability, but abundant literature investigated this influence in the context of atmospheric blockings. We believe that our discussion with linkage to extreme events in referring to blocking is relevant to subseasonal variability, because extremes are, by definition, associated with highly anomalous, and thus variable, weather. We nevertheless agree that this discussion could be connected better with the preceding part of the introduction, and we will modify the text to improve this connection.

Also, we believe that the section about the impact of ENSO on extremes, although brief, may be of interest to some readers. We consider it important to illustrate that subseasonal variability is not the only factor controlling the occurrence of extremes. The winter-mean changes in temperature associated with ENSO play a very important role. Nonetheless, we will de-emphasize this aspect by removing the last paragraph of the introduction that summarizes this finding.

8) **Assessing modulations of the vertical structure of subseasonal eddies**

Reviewer # 2 expressed doubts about the utility of our analysis of the vertical structure of eddies and thus suggested looking at all cyclonic/anticyclonic anomaly centers associated with subseasonal eddies instead of focusing on the circulation near the reference grid points. The reason we keep our focus close to the reference grid points is that it is where we have greater confidence about the structure of the subseasonal eddies. Farther away from the reference grid points, where remote anticyclonic and cyclonic anomalies could be located, correlation and regression values decrease substantially, which means we do not have as much confidence in the identified structure under the low signal to noise ratio. This is why we have chosen a reference grid point located in a region of large modulations of CP, but not over North America, for this analysis. We will revise the manuscript to better justify this approach.

We greatly appreciate the reviewer's suggestion to illustrate how structural changes of subseasonal eddies affect baroclinic energy conversion. To this end, we will add panels showing the heat fluxes associated with subseasonal eddies to illustrate how the overall contributions to poleward heat fluxes tend to increase in $SVD1_{SST} > 1$, especially to the west of the reference longitude due to the enhanced baroclinic structure of the eddies.

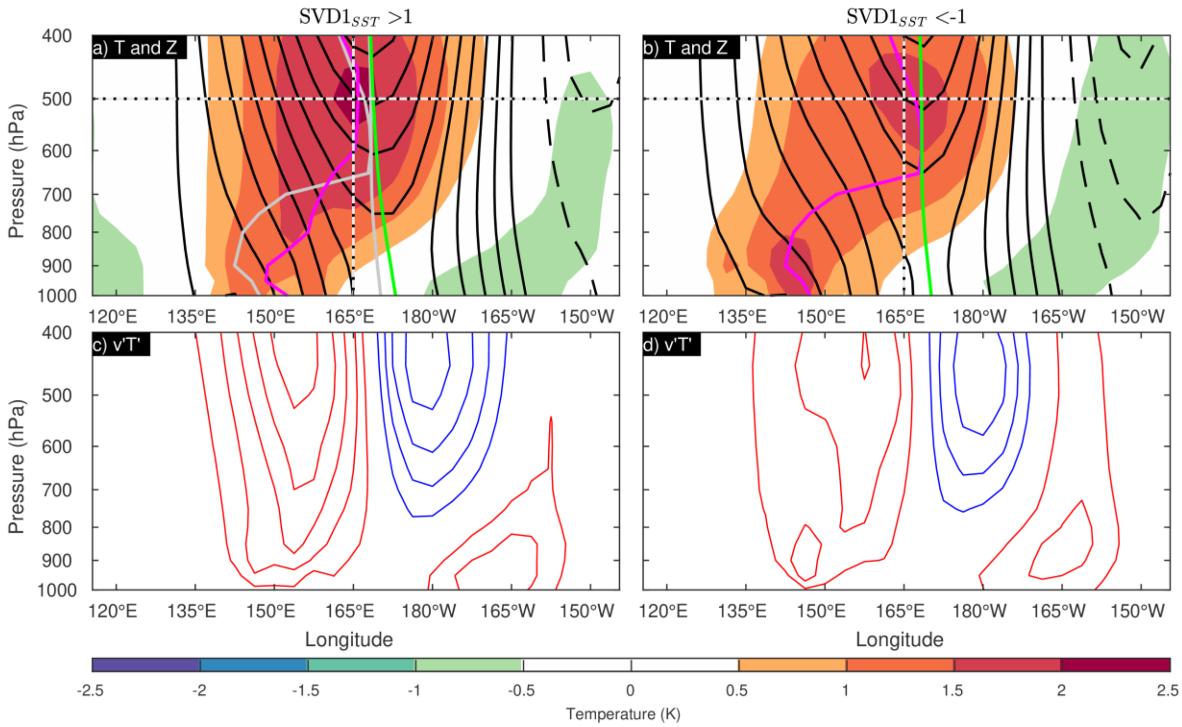


Figure 9: (a, b) Zonal sections of subseasonal anomalies in geopotential height (black contours with intervals of 10 m; solid and dashed lines are used for positive and negative values, respectively) and temperature (shadings) both regressed onto the reference time series of geopotential height at [53°N, 165.5°W] (green circles on Figs. 3c and 6), for winters when (a; left) $SVD1_{SST} > 1$ and (b, right) $SVD1_{SST} < -1$. The maxima of the height and temperature anomalies at individual pressure levels are connected verticvally with green and magenta lines, respectively. The lines shown in b) are also repeated in grey in a) for comparison. (c, d) The associated meridional heat fluxes ($v'T'$) are contoured at intervals of 1 m K s^{-1} with red and blue lines for positive (northward) and negative (southward) values, respectively.

9) Statistical significance

We will follow Reviewer # 2's suggestion to add statistical significance to Figs. 5 and 6. Statistical significance will be assessed through a bootstrapping approach with randomly resampled (1500 times) composites of the same sample sizes as those shown in Figs. 5 and 6.