Reply to Reviewer 1 comments

Authors thank the anonymous reviewer for taking their time to read the manuscript and for providing constructive comments. We believe the suggestions provided have helped us to improve the clarity and quality of the manuscript. Below, we address each comment in detail and describe the changes made in the revised version. Our reply is provided in blue italic font.

General statement

This research utilizes the ERA5 reanalysis data and defines the Sudden Stratospheric Warming (SSW) based on the polar-region-averaged wind field. In-depth analyses are conducted on the three major SSW events identified. The authors correctly note that the first two SSW events have relatively short durations, in contrast to the last SSW event, which persists for a substantially longer period. Additionally, they draw inferences about the relationship between the three SSW events and the tropospheric blocking pattern. The overall writing of the manuscript is commendably fluent. However, before recommending this manuscript for publication, I have several concerns that require attention.

We thank the reviewer for the positive feedback.

Major issues

1. The authors ascribe the rapid termination of the first SSW event to the westward-propagating Blocking High (BH) in the North Pacific (Lines 205-207). In reality, as evident from Figures 3b and 3c, the decline in V'T' is not solely observed in the North Pacific region; rather, the changes over the Atlantic Ocean are quite conspicuous. The authors should consider the causes of this weakening in a more comprehensive fashion and quantitatively present the contribution ratios of each BH.
   We had meant that the largest contribution to the negative heat flux (thick green contours) -in a zonal mean sense- arises from the western flank of the Pacific BH, where advection is equatorward (see Fig 4g). There is also a negative contribution from Central Eurasia, but the contribution from the North Atlantic is rather positive (purple contours in Fig 4g). This discussion was clarified along these lines.

2. Regarding the third SSW event, the authors indicate that the circulation after the outbreak is favorable for the upward propagation of planetary waves. Nevertheless, this conclusion is merely based on the average results for the 5–8 days following the outbreak and cannot represent the situation that may endure for up to one month.
   This is correct and has now been clarified:" Note that, during and after the reversal in March, descending easterlies would hinder vertical propagation of PWs high into the stratosphere, and PWs would be evanescent in the lower stratosphere (Fig2c)".

Minor issues

1. As can be seen from Figures 2 and 5, the intensities of planetary waves at 100 hPa one month after the occurrences of the second and third SSW events show minimal differences. Yet, one is a short-lived SSW event while the other is a long-lived one. What

accounts for this?
This is indeed a key question of great importance for long-range forecasting. We are not sure if it was meant "one month after" here, but the persistence of PW forcing around and briefly after the onset is a key factor determining the evolution into a long or short event (Orsolini et al., 2018, cited). This longer persistence around the onset of the March event is clearly seen on Fig 2b. It is intimately linked to the synoptic evolution of BHs, as we argued.

2. In Figure 5, it is observable that $V_a'T_c'$ is negative during the weakening phase of each SSW event. The authors need to elucidate what factors give rise to this situation.
This interference term is dominated by anomalous meridional advection of the wave-1 background temperature. In fact, this term turns negative already around onset, in the JAN and MAR events. It is difficult to draw systematic conclusions: In the decay phase, it dominates in the case of the JAN event, while the other interference term or the nonlinear term dominate for the MAR event, in late March.

3. The rapid weakening of the upward propagation of planetary waves is a necessary condition for the short duration of the SSW. I opine that quantitatively characterizing this feature could be an important research avenue.
We argued that the rapid weakening or, on the opposite, the persistence of the wave forcing is intimately linked to the synoptic evolution of BHs over the different oceanic basins. Improving our understanding of these processes and their predictability would indeed be a valuable research avenue.