Weather Clim. Dynam. Discuss.,
https://doi.org/10.5194/wcd-2020-56-RC3, 2020

Interactive comment on "Origins of Multi-decadal Variability in Sudden Stratospheric Warmings" *by* Oscar Dimdore-Miles et al.

Anonymous Referee #3

Received and published: 21 December 2020

The present manuscript analyzes the sources of multi-decadal variability in major Sudden Stratospheric Warmings (SSWs). To do so, the authors apply a wavelet spectral decomposition method to the output of a 1000-yr pre-industrial control simulation of the UKESM model. The results reveal a periodicity of SSWs variability of approximately 60-90 years during 450 years of the simulation. Among the studied phenomena, long-term variability of the (deep) QBO amplitude seems to be the most important. In contrast, variability in tropical sea surface temperatures and Aleutian low do not seem relevant to explain long-term SSW variability.

The analysis of multidecadal variability is a very interesting topic that is recently receiving increasing attention. However, only a few papers have addressed it due to the unavailability of long observational data record and the relatively low number of

Printer-friendly version

Discussion paper

very long model simulations with daily output. Thus, a 1000-yr pre-industrial control simulation as that used in this paper provides a good opportunity to perform such a type of analysis. The findings identified in this study, in particular, the connection between long-term variability of QBO and SSWs, are certainly promising. However, they are mainly focused on the results provided by the wavelet analysis, and I miss an attempt to explain the detected relationships. Based on this and my following specific comments, I think there are major corrections that the authors should address before recommending its publication.

Specific comments:

L21: There are earlier papers that relate the occurrence of SSWs to cold air outbreaks in mid-latitudes such as Tomassini et al. (2012) or Lehtonen and Karpechko (2016).

L130-131: The historical simulation might be better for model validation than the pre-industrial one. Changes in GHGs concentrations may affect the distribution of SSWs.

L214-216 and L339: In the first sentences the authors indicate that the Aleutian low index is computed for September-November, but along Section 3.4 it is written that it is computed for December-March. From my point of view the later would be more accurate, as it will be simultaneous to the months considered for the occurrence of SSWs.

L221-229: I am surprised that the frequency of SSWs in November does not appear in the figure. Moreover, the sum of the monthly frequency of SSWs for December-March in the model does not give 0.54 events/winter but approximately 0.1 events/winter less. Is it possible that November shows a frequency of around 0.1 SSWs/winter? If so, that means that UKESM is one of those models that presents a too weak vortex in November and an artificially high frequency of SSWs in that month. I was wondering if this is the reason why the authors restrict the analysis to the period between December-March. I would agree that SSWs in November are unrealistic but I have some concerns about not considering them. The occurrence of SSWs in November

will precondition the state of the vortex in December-January as it will be recovering and probably anomalously strong. In that case, it will prevent the occurrence of an SSW. This might distort the results for the whole winter. I think it might be worthy to repeat the analysis considering the November SSWs to check if conclusions remain the same.

L 315-318: The mature phase of El Niño events is reached from November to January (Wang 2002). I agree with the authors that it will likely remain in the same state between early and mid-winter but I think it will be important to check it.

L318-321: Some authors have related PDO and ENSO (Verdon and Franks, 2006). Is the low frequency of ENSO related to the PDO in this case?

L337-353: I was wondering if the lack of correlation between the variability of Aleutian Low and SSW can be explained by the fact that the region selected for the Aleutian Low does not coincide with that associated with precursors of SSWs. In this sense, Garfinkel et al (2012) investigate the reason why the SSW frequency in El Niño and La Niña winters is similar in observations. The find that both La Niña and El Niño lead to circulation anomalies of the same sign in the area associated with SSW precursors. I think it would be important to identify the areas of precursors of SSWs following Garfinkel et al. (2012) or Garfinkel et al (2010) and compare with the spatial pattern of the Aleutian Low that the authors compute.

Technical comments: L44: north –> North In some figures such as Figure 11 or 5, the authors use lower case a), b) and so on to refer to the different panels of a figure and in other figures such as 8 or 9 the authors use upper case A) and B) for the same purpose.

L404: figure 12 b

L409: please include (not shown) at the end of the sentence.

References: Garfinkel, C. I., D. L. Hartmann and F. Sassi, 2010: Tropospheric precur-

sors of anomalous Northern Hemisphere stratospheric polar vortices. J. Climate, 23, 3282-3299.

Garfinkel, C. I, A. H. Butler, D. W. Waugh, M. M. Hurwitz and L. M. Polvani, 2012: Why might stratospheric sudden warmings occur with similar frequency in El Niño and La Niña winters? J. Geophys. Res., 117, D19106, doi:10.1029/2012JD017777.

Lehtonen, I. and A. Y. Karpechko, 2016: Observed and modeled tropospheric cold anomalies associated with sudden stratospheric warmings, J. Geophys. Res. Atm., 121, 1591-1610, doi:10.1002/2015JD023860

Tomassini, L., E. P. Gerber, M. P. Baldwin, F. Bunzel and M. Giorgetta, 2012: The role of strastosphere-troposphere coupling in the occurrence of extreme winter cold spells over northern Europe, J. Adv. Mod. Ear. Sys., 4, M00A03. doi:10.1029/2012MS000177.

Verdon, D. C and S. Franks, 2006: Long-term behavior of ENSO: Interactions with the PDO over the past 400 years inferred from paleoclimate records, Geophys. Res. Lett.,33, L06712, doi:10.1029/2005GL025052.

Waugh, C., 2002: Atmospheric circulation cells associated with the El Niño-Southern Oscillation, J. Climate, 15, 399-419.

Interactive comment on Weather Clim. Dynam. Discuss., https://doi.org/10.5194/wcd-2020-56, 2020.

Printer-friendly version

Discussion paper