

## ***Interactive comment on “On the forcings of the unusual QBO structure in February 2016” by Haiyan Li et al.***

**Anonymous Referee #2**

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“On the forcings of the unusual QBO structure in February 2016”, written by Li et al.

This is very interesting manuscript, detailing the wave forcing of the unusual QBO event in 2015/2016 boreal winter. This paper attempts to investigate the responsible waves and mechanisms for 1) the reversal event at 40 hPa and 2) unusually long westerly zonal mean zonal wind at 20 hPa by separating the contributions of individual wavenumbers and different timescales, and using fields from the combined ERA-40 and ERA-Interim reanalyses.

I find a performed analysis clear and convincing, supporting main augments and findings of this manuscript. Although I am recommending major revisions, most of what I am requesting will not involve much if any in the way of new calculations, but rather requires some editing for clarity and conciseness as well as more interpretation which

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would require changes in the text and some addition of background and comparison with other studies. The results are potentially useful to the community and I think it will be a very valuable contribution to the literature once some clarifications and edits are made to both the arguments and the methodology.

General comments: First of all, this manuscript can benefit from some revisions and editing to improve for clarity and conciseness. Some recommendations are provided in the comments below. As everyone's writing style is different, those comments are by no means requirement but rather indications where writing could benefit from some editing to make your message clearer. Second, some clarifications should be done in Data and Methods section. Line by line comments are provided below. For example, I strongly recommend to rewrite “Wave filtering” subsection in a more clear way as it can be very confusing to some. In several places, your statements like “It is difficult to (do something) ” can be confusing as it is not very clear if you've applied your technique to the dataset. How did you do your filtering or any other analysis step by step? State these steps first without any unnecessary information and then provide any relevant comments regarding these techniques at the end. See more detailed comments below. Furthermore, Introduction or/and Discussions are lacking a discussion of literature on relationship between ENSO and Kelvin waves. While a role of enhanced Kelvin Wave activity due to strong 2015/2016 El Nino event in producing the extended westerly zonal wind near 20 hPa is definitely new (and very interesting) result, the enhanced Kelvin wave activity and its relation to ENSO definitely was previously looked at and documented. For instance paper by Yang and Hoskins (2013) along with others should be mentioned and cited. [Yang, G. and B. Hoskins, 2013: ENSO Impact on Kelvin Waves and Associated Tropical Convection. *J. Atmos. Sci.*, 70, 3513–3532, <https://doi.org/10.1175/JAS-D-13-081.1>]

Specific comments:

Line 95: Why is combined ERA-40 and ERA-Interim reanalyses are used instead of just using ERA-40 or ERA-Interim reanalyses by itself. It would be useful for readers

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to see a short statement explaining benefits and limitations of individual datasets vs combined one.

Line 96: Using layer averaging (30-50 hPa) to represent 40hPa level is fine if 40 hPa level is not available as an output. However, this (or other reasons for layer averaging) should be mentioned.

Line 106: "similar to U40". Is U20 also defined as a layer averaged U between two pressure levels? Please clarify.

Line 115-117: "Previous studies ..." How this sentence connects to the filtering techniques you are discussing? This seems an odd place for comparison with previous studies unless you are comparing techniques that you are using in this study with one's in previous studies.

Line 118: "following dispersion curve" Is it a part of the "kf-filter" function technique or something you performed after applying this filter. If it is unrelated to the "kf-filter" than Line 112 shouldn't be a first sentence of this paragraph.

Line 118, also line 124 A use of statements like "it is difficult ..." or "we can .." are very confusing and distracting since I am not sure if you applied the technique to your data or just speculating about it. Make sure you are clearly explaining your methods.

Line 173: "was weaker". What do you mean by this (its amplitude or persistence in time)? To my eye these three events don't stand out very well when compared to other years in this record but I could be missing something. Being specific may help.

Line 184: "However, we cannot ..." very wordy sentence. How about something like this : "Since enhanced Rossby wave behavior doesn't extend to the lower and higher levels, the observed signal less likely originated from vertical propagation." Side note: Please comment a strong signal in enhanced Rossby wave activity during October 2015.

Line 224: What do you mean under "it's different components". What components  
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exactly do you mean? Be more specific.

Line 236: What do you mean by "weaker but similar"? These are two contradictive words. Weaker in strength (or amplitude) but similar in shape?

Line 245: "slower than 0.15 cpd, or 6-7 day frequency". Should it be day-1 ? Also, can you change these to a more familiar timescales which you are using (in days)? This will make comparison with your study easier and you'll support your argument for their study to include both, the faster and quasi-stationary Rossby waves". Otherwise it is not very obvious.

Line 325: Very confusing. Please rewrite. First sentence of the paragraph should reflect its main idea or statement.

Line 351: "50 to 20 hPa" Do you mean "50 -200 hPa" because I see a strong signal in the upper troposphere as well?

Line 384 and also 393-394: As mentioned in General Comments, this is definitely not a new result. Previous studies, discussing enhanced KW activity during El Niño events, have to be cited and also discussed. One of these studies is by Yang and Hoskins (2013). Yang, G. and B. Hoskins, 2013: ENSO Impact on Kelvin Waves and Associated Tropical Convection. *J. Atmos. Sci.*, 70, 3513–3532, <https://doi.org/10.1175/JAS-D-13-081.1>

Technical comments:

Line 136: "In order to explore" -> "To explore" (remove "In order")

Line 152: "We explore a possible ..... in section 3.1.3". -> remove this sentence

Line 130: "Figure 2 illustrates .... ." Remove entire sentence since the same information is included in Figure 2 caption.

Line 183: "Enhanced Rossby wave ... in the NH" -> remove the entire sentence (it doesn't have a logical connection with sentences before and after)

Line 202: "Figure 4 shows that the horizontal .." -> "As expected, the horizontal Rossby wave momentum fluxes peak in the ..."

Line 211: "We calculated the mean ...." -> "The mean horizontal ... in the tropics are shown in Figure 5. The maximum ..."

Line 223-224 "Their study was ..." -> "Although their study ... (35.8 hPa and 40 hPa respectively), we describe the evolution ..."

Line 229-230: Remove "As shown in Figure 5" and connect it with next sentence -> "The Rossby waves ... (red triangles in Figure 5) with horizontal momentum flux having maximum values of about ...."

Line 233: "We calculated ..." -> "To explore the sources of quasi-stationary Rossby waves, Figures 6 and 7 show the horizontal ...."

Line 234: remove entire sentence "Then we analyzed ..."

Line 235-237: Remove "Figures 6 and 7 show" and combine this sentence with a next one -> "The contribution of Rossby waves .... in November 2010, while ..."

Line 239: Put a dot after "in Figure 8", remove "which reveals that"

Line 240-242: change to : "The peaks of Rossby waves w2040 in Jan 1960, Nov 2010 and Feb 2016 at 40 hPa occurred earlier at higher latitudes, which is indicative of their extratropical origins. This is in agreement with Figures 5, 6, and 7 revealing an important contribution of quasi-stationary Rossby waves to the enhanced Rossby activity in the tropics mainly by wavenumber 1 and to a lesser degree by wavenumber 2 of extratropical origin."

Line 252-260: Need some revisions for conciseness. For example, there are few sentences that can be combined together into one and extra words have to be removed (e.g., "as shown in" (line 256), "the results reveal that in particular" and so on).

Line 284: How about : "The meridional gradients are negative in late March 2016,

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which indicates barotropic – baroclinic instability (see section 2.4). In this study, W3 maximizes one month prior to March 2016. This is consistent with Coy et al. (2017) ...

Line 341: Start this sentence with "The average period ..." and remove all words before it ("By performing ... we found that").

Line 342: Add -> "(Figure 12). However, in 2015/2016 the ..."

Line 351: Remove "Figure 13 shows that ...pertubations had" -> "from 50 to 200 hPa with maximum amplitudes ..."

Line 380: remove parenthesis around 20 hPa

Figures: It would be great if you can increase thickness of the zonal mean zonal wind contours.

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Interactive comment on Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2019-740>, 2019.

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