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Atmospheric Chemistry and Physics Discussions

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

Anonymous Referee #1

Received and published: 27 September 2019

General Comments: The authors present a study of Rossby and Kelvin wave activity as it relates to the 2015/16 QBO disruption. The analysis is detailed, and describes the evolution and impact of various Rossby wave modes organized by wavenumber and/or frequency. Although the wind structure was conducive to the disruption in other select cases, one particular feature marking the disruption as anomalous is reported to be a resonance between wavenumber 1 and 2 Rossby modes originating in the extratropics, which combine to generate a wave 3 mode in the subtropics that provides significant easterly acceleration near 40 hPa. The authors also studied the prolonged westerly phase near 20 hPa. They provide evidence that, in the case of the disruption, a record-strength El Nino directly increased Kelvin wave activity, which caused the prolonging.

Overall, the paper is well-written with strong scientific justifications. It provides a

uniquely detailed look at the wave activity surrounding the QBO disruption. I have just some minor concerns with specific results, which I have written below.

Specific Comments: Line 268 - All components of a Rossby wave packet do not necessarily travel together since the Rossby wave is dispersive.

Line 300 - It seems somewhat contrived to choose the 0.066/day peak to discuss the W3 being locally generated when that is not the frequency with the strongest power. Where does the power at 0.055/day come from?

Line 303 - I am also somewhat unclear on the following: you claim that a combination of the fast W2 (momentum flux Fig. 10c) and slow W1 (amplitude Fig. 10e) create the slow W3. When you say fast W2 are you talking about the w0520 Rossby wave? The 0.033/day frequency implies a period of 30 days, which is inconsistent with your "fast W2" resonance theory. Can you elaborate?

Line 350- Enhanced with respect to what? The previous winter? Of course the Kelvin wave activity depends on the wind structure. There are no Kelvin waves here until February because the winds are too strong westerly. The general tropospheric Kelvin wave activity looks to be lower than the previous winter too.

Line 356 - Again, is the Kelvin wave momentum flux "enhanced" just because Kelvin waves can propagate into this region of weak westerlies? If yes, this is not surprising.

Line 360 - This is not necessarily true. Kelvin waves can propagate through westerly flow as long as their phase speed is greater than the flow speed. So the fact that the westerlies are weak in this case allows them to do so.

Line 374 - In the standard QBO paradigm, increased Kelvin wave activity causes descent of the westerlies, because the waves accelerate the flow below their critical level, which in turn lowers the critical level, and so on. Why in this case does the increased Kelvin wave activity not promote descent?

Line 394 - There are a few studies to have linked Kelvin wave activity to El

Nino. cf. Yang and Hoskins (https://doi.org/10.1175/JAS-D-13-081.1), Das and Pan (https://doi.org/10.1016/j.scitotenv.2015.12.009), Rakhman et al (doi:10.1088/1755-1315/54/1/012035)

Technical Corrections: Figure 1 caption - Please delete the first instance of "The vertical blue lines denote the time periods..." in the first sentence (it is repeated later). In panel (a) there are no red triangles, so either add them or do not mention them in the penultimate sentence.

Figure 5 - The label should read "Total Rossby wave" (typo)

Figure 8 - Can you add a legend to this figure? Also, are the time axes correct? You mention on Line 241 different months for the peaks in each year, but these all peak in February.

Figure 10 caption - Please move the sentence about Panel (e) to the end, the descriptions that follow it all refer to the other panels so it is a little confusing.

Figure 11 caption - "February" (typo)

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