Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2020-791-RC3, 2020

Atmospheric Chemistry and Physics Discussions

ACPD

Interactive comment

Interactive comment on "Role of equatorial planetary and gravity waves in the 2015–16 quasi-biennial oscillation disruption" *by* Min-Jee Kang et al.

Anonymous Referee #3

Received and published: 18 September 2020

Summary: This paper provides a detailed examination of the equatorial wave structures and their evolution during October 2015 through February 2016, a time when the quasi-biennial oscillation experienced a significant disruption. This investigation, based on MERRA-2, a global assimilation system, breaks down the wind, temperature, and precipitation fields into Rossby, Mixed Rossby Gravity (MRG), inertia-Gravity (IG), and Convective Gravity (CG) waves. A novel aspect of this work is the use of a convective gravity wave parameterization to calculate the CG wave effects. The different Eliassen Palm (EP) fluxes and their divergences are evaluated. Quantities calculated for the QBO disruption are compared to their corresponding climate signatures. The results show how during October-November of 2015 MRG and IG waves acted to precondition

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Discussion paper

the QBO winds before the strong Rossby waves that occurred in 2016 and created the anomalous QBO easterlies. Why these waves were stronger than usual during this time is still unknown.

Strengths: This work provides a comprehensive view of the UT/LS equatorial waves during the QBO disruption. It expands on the work of Lin et al. (2019) by including aspects of the tropospheric forcing by precipitation and the addition of CG wave model and also differs in the choice of assimilation system from Lin et al. (2019). Figure 16 provides an especially useful summary of the changes roles played by the different waves.

Weaknesses: No major weaknesses. There are a few points that could be improved for clarity that are detailed below. There are a large number of figures. These provide a comprehensive record but it can be difficult for readers to locate the features of interest as described in the text.

Recommendation: Publish after minor revisions noted below. This is a well written, well organized, manuscript. The figures are appropriately captioned and the abstract accurately summaries the work. The topic should be of interest to many readers of ACP interested the the QBO and equatorial waves.

Comments:

Line 44: "El Nino" Coy et al. (2017) only mentioned a possibility of an ENSO connect. The terms El Nino or ENSO are not found in Osprey et al. (2016) so this sentence should be rewritten.

Line 58: Should be "Coy et al. (2017)". There is a Coy et al. (2016) describing the MERRA-2 QBO before the disruption that could probably be mentioned somewhere in the data section: Coy, L., K. Wargan, A. M. Molod, W. R. McCarty, and S. Pawson. 2016. "Structure and Dynamics of the Quasi-Biennial Oscillation in MERRA-2." J. Climate, 29:14: 5339-5354 [10.1175/jcli-d-15-0809.1]

Line 67: Each MERRA-2 data set has a DOI number that researchers are encouraged to reference and clarifies exactly what data set was used. For example from https://disc.gsfc.nasa.gov/datasets/M2I3NVASM_5.12.4/summary?keywords=%22MERRA-2%22 To cite the data in publications: Global Modeling and Assimilation Office (GMAO) (2015), MERRA-2 inst3_3d_asm_Nv: 3d,3-Hourly,Instantaneous,Model-Level,Assimilation,Assimilated Meteorological Fields V5.12.4, Greenbelt, MD, USA, Goddard Earth Sciences Data and Information Services Center (GES DISC), Accessed: [Data Access Date], 10.5067/WWQSXQ8IVFW8

Lines 248-249: How is the budget formulated so that resolved MRG and IG wave forcing acts to "enhance" the momentum budget residual, REQ? Maybe this could be rewritten for clarity.

Lines 277-287: This is a good discussion of the CGWD. It would help to see the vertical zonal mean zonal wind shear at 40 hPa as a part of Fig. 4 as that should determined in large part the GWD forcing. In addition the meridional shear of the zonal mean zonal wind across the equator might correspond to the changes in the Rossby wave forcing and be helpful to see plotted.

Lines 357-362: Figures 3, 4, and 7 all illustrate aspects of MRG waves, however it is difficult to put together a consistent picture of support for the mid-jet easterly acceleration described here. Most of the easterly acceleration appears to take place in the regions of strong wind shear, not mid-jet. In particular the contribution from MRG waves in Fig. 4 at 40 hPa is small and appears nearly constant in time. The mid-jet should be identified more quantitatively and MRG wave aspects calculated with respect to the jet at each month, at least for the earlier months, to justify this conclusion.

Lines 375-392: This instability analysis is based on zonal mean winds. A stronger case for instability might be possible with non-zonally average winds, especially when the focus is on the relatively small region defined by the box in Figure 8.

Lines 443-485: The "...apparent positive wind shear..." Is difficult to find in Fig. 14a.

The specific levels should be specified in the text.

Lines 499-502: The white and gray curves described in the text appear to be different from the Fig. 15 caption description.

Minor Comments:

Line 375: The units in Fig. 8 suggest that q_y is plotted not q_phi. This is a small point. Perhaps the units could be described in the figure caption.

Lines 732-733: The year is missing from the reference.

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