Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2020-791-RC1, 2020

Atmospheric Chemistry and Physics Discussions

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EGU

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 #1

Received and published: 3 September 2020

This paper provides quite many missing pieces of the 2016 QBO disruption puzzle. Previous literature has concentrated on the role of equatorward-propagating extratropical waves, with only a couple papers giving equatorial wave modes any focus.

Overall, the effort made by the authors is quite impressive. All equatorial wave modes are separated and their effect on the wind structure is studied in detail, and additionally parameterized convective GWs are included in the study. As the authors mention, of course the CGW parameterization has some limitations (which parameterization doesn't?), but I think the approach is physically consistent and the CGW results are, at least, qualitatively correct.

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Discussion paper

The paper is a bit lengthy, but short summaries are provided for the trickier figures, which I appreciated. Overall well written, figures are mostly good, a nice sketch in Fig. 16 to put all together, interesting discussions and definitely worthy of publication in ACP. I only have a fair amount of minor comments, mainly to make some figures or methods easier to interpret for the reader, and in some parts to request a more detailed comparison with recent QBO disruption literature.

%%% Title: strictly speaking, it's not only planetary wavenumbers that you study, I suggest something more accurate "Role of equatorial waves and convective gravity-waves in the 2015/16 QBO disruption" or similar (it's ok to use the QBO abbreviation in the title, since all your potential audience will know what it means)

%%% p.2, l.31-33: specify that this is for extratropical latitudes when you refer to polar vortex and its downward impact.

%%% p.2, l.55: 'is the prerequisite for'

I think a better wording would be '... eq. waves preconditioned the extratropical Rossby wave breaking, ...'. prerequisite implies that without the MRG, the ex. Rossby wave breaking and QBO disruption wouldn't have happened, which to my knowledge cannot be assured 100%.

%%% p.2, l.56: '... each equatorial wave mode to the QBO...'

%%% p.3, l.87-88: sentence is repetitive, can be removed

%%% p.3, l.89-93: specify subsections where each item is done, e.g. specific wave types within section 3

%%% p.6, l.178: include the GPM dataset into section 2.1

%%% p.6, l.179: Here or perhaps within the supplement, justify why the magnitude and scaling are not crucial for both datasets in Fig. S1 to match: not the exact magnitude, but rather the shape of the vertical profiles is what's important, correct?

%%% p.6, l.180: SPB –> Since this abbreviation is not used later in the manuscript, I recommend to keep the full name, and remove the abbreviation from the first time it's used

%%% Figure 1: I suggest making 1(a) the lat.-height sections and 1(b) the vertical profiles and refer to them accordingly in the text.

Also, make it clear in the caption that the climatology is for WQBO years.

Y-axis labels: for better visibility I'd keep the pressure levels only, since the numbers with height in km get mixed up in between panels.

%%% p.7, l.188: In section 2.1 you say it will be referred to as WQBO climatology, you may want to rephrase that for consistency. Here, remind the reader that when you're talking about climatology, it refers to WQBO phase.

%%% p.7, l.199-200: '... positive (negative) drag on the zonal wind in regions of positive (negative) shear, ...'

%%% p.7, l.212: February –> March

%%% p.7, l.195-213: I miss some linking of these results with recent literature in this paragraph:

–> How do these results compare to Lin et al. (2019)? Especially for MRG, IG and CGW, it should be highlighted your results build upon those by Lin et al. (2019) (their Fig. 3 is quite similar to yours), that focus mostly on MRG in their discussions. Your eq. wave differentiation is more detailed, which is a big plus.

–> Regarding your Kelvin wave forcing results, I find it really neat that it helps maintain the two westerly jets. This was suggested/hinted by Li et al. (2020), who studied the long-lasting westerly jet around 20hPa, but your results really confirm this is the case. Li et al. (2020) also showed above-average upper-tropospheric Kelvin wave activity linked to El Nino. This should be mentioned/discussed within this paragraph.

–> Also, this is a very long paragraph, could be easily split into 2-3.

%%% Fig. 3: I suggest to move the climatology plot to the supplement (as it doesn't have crucial information for the main text), and make the rest bigger. Right now this figure is too busy and it's easy to get lost within, specially with the duplicate letters for the sub-panels.

%%% p.9, l.253-254: Mention to Lin et al. (2019) needed here. Your results are in line with theirs, plus the addition of IG in the preconditioning.

%%% p.10, l.294: origination –> just 'origin'

%%% p.11, l.324: I suggest making this (dividing by density) for all figures: the vertical/horizontal arrows without scaling for pressure in the previous plots, may lead the reader to underestimate upper level wave propagation at first glance, specially if one is quickly comparing upper tropospheric and stratospheric levels without paying much attention to the legend.

However, this is not a must: the figures have the divergence in pressure-independent units, and the units of the arrows are clearly shown - more than enough to correctly interpret everything with basic knowledge about EP flux.

%%% p.12, l.369-374: This belongs in the methods section

%%% Fig. 8(c-d): I suggest to, apart from making the c-d plot smaller, put the timeseries next to each other, or even merge them into one continuous timeseries.

%%% p.13, l.379-380:You may easily add a climatology line into Fig. 8(c-d)

%%% p.13, l.381: Could the authors perhaps provide a daily timeseries of MRG EPD (in the boxed region) to compare with with the q timeseries to assess this as a source? Would be a nice addition as Fig. 8(e-f)

%%% Fig. 9: I suggest to translate the y-axis unit (mean rain rates) into something more relatable, e.g. mm/day

%%% p.14, l.417-419: This was linked by Li et al. (2020) to the El Nino event that winter. Perhaps it would be useful to add a discussion somewhere in this section, about the overall increase in eq. wave activity and precipitation together with El Nino. Also a mention to Barton and McCormack (2017) could be added.

%%% p.14, l.440-442: There is a lot of new information and little justification about the source level here, I suggest you detail more about this in the methods section, and refer to the corresponding methods section when you start with this figure.

%%% p.15, l.446: A non-expert will need more explanation about the source level to understand the attribution made in this sentence. Again, this could be already detailed in the methods section and referred to here.

%%% Figure 13 and p.15, l. 447-460: I don't doubt the validity of your results and conclusions regarding Fig. 13, but it would be much easier to interpret if you showed the same plots for He and Hw separately. Mixing both makes this figure a bit confusing. Separating He and Hw will allow the reader to identify which fraction deviates more from climatology (and gets filtered by the wind shear) in a more straightforward way.

%%% p.15, l.462-467: You discuss the Kawatani paper in the next paragraph. Barton and McCormack (2017) showed important ENSO influence on the background winds and momentum fluxes below 30hPa (see e.g. their plots 3 and 4). It would be worth to add it into your discussion.

%%% p.16, l.488-490: Please detail a bit more what convective source and WFRF mean for the non-expert. Convective source spectrum is related to the movement of convection itself, WFRF to the GWs emmited from it, correct?

%%% p.16, l.496: higher static stability at which height range? Intuitively, deeper convection is related to tropospheric instability.

%%% p.16, l.497: please use relative terms: warmer / colder

%%% p.16, l.497-499: Rephrase this sentence to make it clear that El Nino increases overall amount of convection in the tropics. There must be earlier studies (probably mentioned in the Domeisen review paper) providing this relation to say this with more certainty than 'possibly triggered by El Nino'

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