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Comment on acp-2021-85

Anonymous Referee #2

Referee comment on "Contributions of equatorial waves and small-scale convective gravity waves to the 2019/20 quasi-biennial oscillation (QBO) disruption" by Min-Jee Kang and Hye-Yeong Chun, Atmos. Chem. Phys. Discuss.,
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The paper "Contributions of equatorial planetary waves and small-scale convective gravity waves to the 2019/20 QBO disruption" by Kang et al. investigates which waves contribute to the 2019/20 QBO disruption during the different stages of the disruption. It turns out that in the first phase Rossby waves from the Southern Hemisphere are the leading contribution, and in the later stage tropical MRG waves and Rossby waves from the Northern Hemisphere are the main contributions. The paper is a follow-up work of a previous paper on the 2015/16 QBO disruption and structured in a similar way for better comparability. The paper is well written and fits in the scope of ACP and is therefore recommended for publication in ACP after minor revisions.

Minor Comments:

(1) At the beginning of the introduction you should mention the papers by Ebdon (1960) and Reed et al. (1961), who independently discovered the QBO.

Ebdon, R. A.:

Notes on the wind flow at 50 mb in tropical and subtropical regions in January 1957 and in 1958,
Q. J. R. Meteorol. Soc., 86, 540-542, 1960.

Reed, R. J., Campbell, W. J., Rasmussen, L. A., and Rogers, R. G.:

Evidence of a downward propagating annual wind reversal in the equatorial stratosphere,
J. Geophys. Res., 66, 813-818, 1961.

(2) Most parameters in Eq.(1) and Eq.(2) are not explained.

(3) I.95-104: please describe briefly how the k-omega spectra are calculated

(4) I.129/Fig.1b: The positive wind shear anomaly compared to the climatology at pressures 150-100hPa does no longer hold for January 2020 - in January 2020 the wind shear has a negative anomaly.

And for the other months July-December 2019 at pressures 150-100hPa the wind anomaly is easterly, not westerly, compared to the climatology!

(5) I.145/146 (Fig.2e): Not clear which Rossby wave forcing you exactly mean. There are no anomalously strong negative values of EPFD at 0-5N in magenta stippled regions. There are several anomalies (magenta stippled regions) which, however, do not really fit to your statement:

5S/50hPa - medium strong EPFD, -2...-4 m/s/month

5N/30hPa - there is only very weak EPFD of -1...-2 m/s/month

10-20N/50-80hPa - very strong EPFD, stronger than -10 m/s/month

Do you mean strong negative, but not anomalously strong EPFD?

If yes, why would this be relevant?

Please explain in more detail.

(6) I.243 / Fig.7:

The MRG waves are deduced from antisymmetric k-omega spectra, and in Fig.7 symmetry relative to the equator would be expected. Nevertheless, the EPF and EPFD in Fig.7 are asymmetric. Where does this come from? Because zonal wind and stability are different in the different hemispheres?

(7) I.265/266: Your statement is not correct!

The barotropic term is only the second term in Eq.(3), not the first two terms.

The first term in Eq.(3) is "beta", which is always positive and acts to stabilize the zonal flow.

The second term is the barotropic term. If this term dominates and leads to negative $dQ/d\phi$, this is an indication for barotropic instability.

(8) I.268-271 / Fig.9: You should mention that the largest difference relative to the climatology is in September 2019!

In this month at 5S-5N precipitation is much weaker (by 2...3 sigma!) than the climatology.

Do you think this strong anomaly plays a role in the QBO disruption?

(9) In Fig.10 there are many regions that are above the climatology by more than 1 sigma (blue stippled), but that are at the same time in the light blue range of the color code that

is considered insignificant by the t-test.
Still, these enhancements are discussed as "widening of the spectrum" in December (I.278/279).
Can you comment on this?

Technical Comments:

I.74:

The 2019/20 QBO disruption was originally in the westerly QBO phase.

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The QBO was originally in the westerly phase when the 2019/20 QBO disruption happened.

I.76: is greater than -> is more westerly than

I.79: downward QBO phase transition -> downward QBO phase progression ??

I.92-94: in I.92 Fz consists of three terms! Please check definitions of Fz1 and Fz2!
Probably one pair of parentheses is missing in I.92

Fig.4a: the dotted line is hard to distinguish from the solid line

Fig.7: for consistency, please add the multiplication factors to the respective panels in Fig.7, similar as in Fig.5d.

caption of Fig.8: barotropic instability -> meridional potential vorticity gradient

I.278:

The spectrum more than 1sigma stronger than the climatology

->

The areas of the spectrum where values are more than 1sigma stronger than the climatology

I.280:

the strong power is evident in the spectrum related

->

areas of strong power that are evident in the spectrum are related

I.314: slightly strong -> slightly stronger

I.319/320:

The maximum negative CGWD

->

At pressures above 40hPa the maximum negative CGWD

I.369:

oval structure of the zonal wind was ...

->

the oval-shaped structure of the QBO westerlies that is seen in latitude-altitude cross sections was ...