

## ***Interactive comment on “The Climatology of Brewer-Dobson Circulation and the Contribution of Gravity Waves” by Kaoru Sato and Soichiro Hirano***

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The paper examines the climatology and the Rossby and gravity wave forcing of the residual circulation in four modern reanalyses. The topic is certainly of interest for ACP and the analysis of the forcing of the residual circulation (RC) would make a noteworthy contribution to the S-RIP special issue. Unfortunately, in my opinion the current version of the paper does not provide an accurate description of the RC forcing because it lacks important considerations regarding the balances in the reanalyses, which lead to misinterpretation of the results. While the paper presents some interesting analyses of the RC forcing and seasonality, I consider that it will only be suitable for publication

C1

in ACP after the following major issues are addressed. I included suggestions on how the raised issues could be addressed.

Major issues

- The paper methodology is at present based on the assumption that the difference between the RC computed from the TEM definition (Eqs. 3 and 4) and that estimated from momentum balance (i.e. downward control plus  $du/dt$  term) is attributed exclusively to the gravity wave (GW) drag parameterized in the reanalysis. However this assumption is not necessarily valid because it does not take into account that assimilation increments can play a key role in the momentum balance of the reanalyses.
- In contrast with what is stated in the paper, GW drag is provided for all the reanalyses considered here and thus the GW contribution to the RC can be directly computed using Eq. 8. Also, all the reanalyses considered include orographic gravity wave parameterizations, and only ERA-Interim does not include non-orographic gravity waves. This information is found in the reanalysis description papers cited but is wrongly stated in the paper.

Suggestions

In my opinion the paper would notably improve and make a useful contribution to S-RIP if the authors include an analysis of the GW drag (and perhaps the zonal wind assimilation increment) provided by the reanalyses.

This would allow direct evaluation of the contribution of the parameterized GW drag in the reanalysis models to the RC using Eq. 8, without need of the assumption pointed out in the first comment. This calculation was already done in Abalos et al. (2015 JGR) for ERA-Interim, MERRA and JRA-55. However in that paper the GW contribution is not examined in detail for the different seasons and their analysis extends only to 10 hPa, so it will be interesting to present extended results here.

Moreover, analysis of the difference between the total RC computed by explicitly includ-

C2

ing the forcing by resolved and parameterized GW (Eq. 6) versus the RC computed from the TEM definition (Eqs. 3 and 4) will provide useful information on the momentum budget in the reanalyses. In particular, based on the results of Abalos et al. (2015 JGR) the two estimates of the RC are significantly different (even including the parameterized GW term). This could imply that the GW parameterizations in the reanalyses are insufficiently capturing the role of GW on the RC. In that sense it could be argued that most of the difference is attributed to the GW drag in the real atmosphere but absent in the parameterizations. This important point is not discussed in the paper, and as a result there is a confusion between the GW drag that is parameterized in the reanalyses and the real GW drag assumed to equal the residual of the momentum balance.

Explicitly computing the GW contribution and clearly explaining these issues would substantially strengthen the current discussion in the paper on the role of the different waves on the RC in reanalyses, and on the limitations of current reanalyses GW parameterizations. In addition, consideration of the assimilation increments provided by the reanalyses can help interpret the momentum balance and further clarify these issues.

#### Other general comments

- Literature citation: The previous studies Iwasaki et al. (2010 R. Met. Soc. Japan), Abalos et al. (2015 JGR) and Miyazaki et al. (2016 ACP) have already examined and compared the residual circulation in modern reanalyses and should be cited accordingly.
- Acknowledgement of the reanalysis centers for providing the data should be included.
- I recommend carefully reading the draft before submitting the new version to improve the wording in several parts.
- I find interesting the analysis of the  $du/dt$  term contribution to the RC seasonality. This

C3

term is key for the subseasonal tropical upwelling variability (Abalos et al. 2014 JAS), consistent with the downward control principle (Haynes et al. 1991 JAS), but its role for the seasonal cycle is not fully understood. For instance Kim et al. (2016 JAS) argue that it is negligible for the seasonality in tropical upwelling.

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C4