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Atmospheric Chemistry and Physics
Discussions

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

Anonymous Referee #1

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This paper compared the Brewer-Dobson circulation diagnosed from four reanalysis datasets, with emphases on the contribution from unresolved gravity waves as well as the seasonal cycle. This is a useful comparison and fits well into the scope of the S-RIP project. However, I found the methodology of the analysis problematic, which may lead to most of the conclusions from the analysis incorrect. Therefore, I cannot recommend publishcation of the paper at this time.

Major comment:

My main concern is on how the contribution from Rossby waves and gravity waves to the Brewer-Dobson circulation is calculated. The decomposition was based on the fol-

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lowing equation: Psi=Psi_RW + Psi_GW + Psi_dUdt (their equation 6), where Psi_RW and Psi_dUdt were estimated by integrating the momentum equation, Psi was estimated by integrating the TEM velocity, and Psi_GW was then estimated as a residual. This is valid in theory, but in practice, because reanalysis data is not fully consistent, there should be an additional residual error term on the right-hand side of the equation. As a result, the gravity wave contribution estimated in the paper includes both true gravity wave contribution and the residual errors as well. Furthermore, based on the study by Abalos et al. (2015), a highly relevant study the authors seem to have missed, the residual errors dominate over the true gravity wave contribution.

The authors claimed that "the gravity wave contributions can be estimated only indirectly", which is incorrect. Most modern reanalysis products do explicitly provide the parameterized gravity wave drag employed in their model. Therefore, one can directly estimate the gravity wave contribution to the circulation, which is done in Abalos et al. (2015). According to Abalos et al. (2015), the gravity wave contribution is substantially smaller than the resolved waves in all three reanalysis datasets they analyzed, which are also included in this study. In addition, Abalos et al. (2015) compared the different estimations of the Brewer-Dobson circulation: one based on integration of TEM velocity (equivalent to Psi in this paper), and one based on integration of the momentum equation (equivalent to Psi_RW+Psi_GW+Psi_dUdt here). They reported a larger difference between the two estimations than the contribution from parameterized gravity waves (Fig. 3 and Fig. 4 in Abalos et al.), and larger difference among estimation methods than among datasets. Comparing result shown in this paper with those in Abalos et al. (2015), it is clear that the "gravity wave contribution" estimated here is consistent with the difference between the two estimation methods in Abalos et al., indicating that most of the "gravity wave contribution" here is actually the residual errors.

Other comments:

1. The author used the term "Rossby wave", but what they actually referred to is the resolved waves. It is true that in the extratropics, most resolved waves are indeed

Rossby waves. But in the tropics, there are also Kelvin waves and other gravity waves that are large enough to be resolved.

2. Page 8 Line 28-29: The claim about the usage of gravity wave parameterization in the reanalysis is incorrect. According to Seviour et al. (2011), ERA interim does not include non-orographic gravity wave drag. According to Gelaro et al. (2017), orographic gravity wave drag in included in MERRA2.

Reference: Abalos, M., B. Legras, F. Ploeger and W.J. Randel, 2015: Evaluating the advective Brewer-Dobson circulation in three reanalyses for the period 1979-2012. J. Geophys. Res., 120, doi:10.1002/2015JD023182

Gelaro, R., and coauthors, 2017: the Modern-Era Retrospective Analysis for Re-seaerch and Applications, Version 2 (MERRA-2), J. Clim., 30, 5419-5454.

Seviour, W. J., Butchart, N. and Hardiman, S. C., 2012: The Brewer–Dobson circulation inferred from ERAâĂŘInterim. Q.J.R. Meteorol. Soc., 138: 878-888. doi:10.1002/qj.966

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