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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 #3

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This study presents seasonal variations of Brewer-Dobson circulation in terms of stream function and upward mass flux for 30 years (1985-2015), using four recent reanalysis data sets (MERRA, MERRA2, ERA-Interim, and JRA55). Special emphasis is given to the contribution of gravity waves on the stream function and upward mass flux. Although this is an interesting subject that is likely to extend some previous works related to the same subject, using recent reanalysis data sets that include more recent years and, in particular, more useful variables such as gravity-wave drag (GWD), the methodology used in this paper is highly problematic, and conclusions based on the current method may lead for readers misleading. Therefore, the reviewer could not accept the current manuscript for publication in ACP.

Major Comments:

In the present study, two assumptions were made: (1) stream function calculated using Eqs. (3)-(4), so-called direct stream function (Psi), and using Eq. (5) based on downward-control principle (Psi_DC) is exactly the same. (2) stream function of Psi_DC induced by the residual term X_bar in the TEM equation represents GW contribution. Based on these two assumptions, Eq. (10) is derived. Followings are comments on the two assumptions.

1)Although the stream function Psi and Psi_DC should be equal theoretically, it is not exactly the same, likely because the governing equations used and physical processes in the GCM of each reanalysis data set are somehow different from rather simple TEM equation. Accordingly, the mass flux calculated from the two stream functions are somewhat different from each other as shown in some previous studies. Note that this is different from the case of recent work by Abalos et al. (2015) where Psi_DC is calculated using GWD rather than X_bar, which is not in momentum balance of TEM equation, and their comparison between Pai and Psi_DC stems mostly from difference between X_bar and GWD. It is curious for the reviewer why authors use Eq. (10) in calculation of stream function of GW rather than Eq. (8).

2)The major benefit of Psi_DC is to calculate the contribution of resolved planetary waves (EPD), du_bar/dt, and non-conservative term (represented by X_bar) separately. The term X_bar can be calculated from any reanalysis data set as a residual of the TEM equation. The reviewer cannot understand why the authors state " Psi_GW cannot be directly calculated because of the unknown X_bar " (Page 6, line 6). The term represents implicitly the parameterized GWD, numerical diffusion, and assimilation increment. In most recent reanalysis data sets that provide GWD variables, the magnitude of GWD is much smaller than that of X_bar. Therefore, even when GWD variables are provided from reanalysis data sets, quite large value of the residual term, say X'_bar, after excluding GWD, is required for momentum balance in the TEM equation. Therefore, the stream function calculated using Eq. (10) of the current study is not

from GWD but from X_bar, which include several sources other than GWs, in particular, assimilation increment.

3)Note that the GWD variables provided from reanalysis data are purely model output, without data assimilation, and thus high degree of uncertainties may exist. In addition, large values of X'_bar from assimilation increment may also include some parts of un-parameterized GWD, if there are. However, assimilation increment stems from various, probably all, processes in the model, including underestimation of resolved wave forcing (EDP), not exclusively from GWD. Therefore, it is not acceptable that stream function calculated using Eq. (10) of the current manuscript represent the stream function from GWs.

Minor comments: 1)GWD variables are available from all reanalysis data set used in the present study, although non-orographic GWD output is not available from ERA-Interim. This is not correctly mentioned in the manuscript.

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