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Interactive comment on "Decomposing the response of the stratospheric Brewer–Dobson circulation to an abrupt quadrupling in CO_2" *by* Andreas Chrysanthou et al.

Anonymous Referee #2

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This study is on the changes in the stratospheric Brewer-Dobson circulation in response to a quadrupling of CO2 concentration. Utilizing the HadGEM3-A model, the authors separate out the fast response to CO2 increase from the effect of uniform SST warming as well as the SST warming pattern. It is found that the uniform warming dominates the circulation changes in the lower stratosphere, but the rapid adjustment makes comparable contribution to the uniform warming at the 10 hPa. This is a useful study in understanding the climate changes in the stratosphere. The manuscript is generally well written and logically organized. I have some relatively minor comments on some of the results and discussion, and would recommend publication after the authors address these comments.

Main comments:

1. The mechanism for the rapid adjustment of the BDC. Can the authors elaborate a little more on how the rapid adjustment affect the BDC? The authors briefly mentioned the radiative cooling in the stratosphere. One possibility is that the radiative cooling then affect the strength of the polar night jet via thermal wind balance, which then affect wave dissipation and the BDC. However, the rapid adjustment of the zonal wind shows weak decrease in the NH upper stratosphere and moderate increase in the SH upper stratosphere (Fig. 3b). Such wind changes seem to be inconsistent with the changes in w* (Fig. 4b), which shows large strengthening of the downwelling over the Arctic and small strengthening over the Antarctic.

2. The EP flux divergence plots seem to be inconsistent with the changes in stream function. The downward control principle indicates that the latitudinal distribution of Psi* anomalies should be roughly consistent with those of EP flux divergence anomalies. However, the EP flux divergence anomalies seems to locate much poleward than Psi* anomalies, especially in DJF over the Southern Hemisphere (Fig. 6 vs. Fig. S1, Fig. 7 vs. Fig. S2). Based on the argument that stronger subtropical jets following warming allow more waves penetrate into the stratosphere, one would expect the anomalous wave dissipation to occur at the subtropics. This also seems to disagree with the pattern shown in Fig. 6 and 7, where maximum wave dissipation occurs around 50-60 degrees.

3. Model bias in climatology. The model simulated turn-around latitude in piControl climatology seems to be too poleward compared to reanalysis or other models (e.g., Fig. 1 in Hardiman et al. (2014)). At around 20 hPa, there are multiple turn-around latitude in the Nothern Hemisphere, indicating more than one cell of the circulation, which seems unreasonable. Such bias in the mean circulation structure reflects bias in the waves forcing and/or other background condition. Would such model bias affect the model's ability to simulate the circulation changes in response to CO2 increase?

Other minor comments and typos:

Line 152-155: experiment “A, C, B, D” should be “B, D, C, E”.

Line 281-282: It is hard to compare the three components over NH extratropical middle and upper stratosphere in Fig. 5, as they all seem to be less than the contour interval. On the other hand, the w* changes shown in Fig. 4 seem to suggest that the SST pattern effect is much weaker than the uniform warming or the rapid adjustment.

Line 330: Fig. 7b should be Fig. 7c.

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