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Interactive comment on "Modelling the residual mean meridional circulation at different stages of stratospheric warming events" *by* Andrey V. Koval et al.

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Reply to the Reviewer #1 of the paper by Koval et al. "Modelling the residual mean meridional circulation at different stages of stratospheric warming events"

We would like to thank the Anonymous Referee #1 for useful comments and suggestions. We considered all of them and added all the necessary edits to the revised manuscript. Our answers are given below.

Line 50. Question: SSW, major and minor, do also occur in the Southern hemisphere, e.g., https://doi.org/10.3390/atmos11101063

Answer: In the revised text the phrase is modified as "the middle atmosphere during winter"

L. 64. Q: "studied for the first time". Further in the text, authors cite other papers on the same subject, so this work is not the first of its kind. May be the "first time with this model"?

A: The phrase is modified

L. 93. Q: How the normal modes were included? By adding additional disturbances at the lower boundary? Or they were generated by the model in response to daily variations of the solar flux?

A: The MUAM involves NM parameterization by adding terms to the heat balance equation in the troposphere, which have forms of time-dependent sinusoidal components with zonal wavenumbers m = 1 - 3. For setting the latitude structures of NM components, the parameterization uses respective Hough functions. Periods of NMs are equal to the resonant periods of atmospheric reaction to the wave forcing at low boundary (about 5, 10 for m = 1; 4, 7 days m = 2; 2 days m = 3). We added respective discussion to the revised text.

L. 95-96. Q: That is, at 50, but not 30 km? This is unclear from the text. Formulas (3) and (4). For me they look precisely equal to (1) and (2). Are they just another form of the latter, or am I missing something?

A: We modified the text. Eq. (3) and (4) are just other forms of eq. (1) and (2), which are used in our calculations.

L. 206. Q: "Increased downward ... velocities". As follows from Fig. 2b, the downward velocities between 20 and 60 km weaken during SSW. Is it a typo? L. 208. Again, if the downward velocities are weaker over high latitudes, they cannot help with heating the atmosphere.

A: In Fig. 2b2 at altitudes 20-40 km near the North Pole, one can see negative add-ons

to the background downward vertical velocity shown in Fig. 3a2. This corresponds to increasing adiabatic heating of in the high-latitude stratosphere during SWs. We clarified this in the revised text.

L. 214. Q: "Parcels" rather than "particles" is more suitable word for gas elements.

A: Corrected.

L. 216. Q: "For short time intervals". Here it would be appropriate to give the characteristic chemical lifetime of ozone at these heights in comparison with 11-day intervals of interest.

A: We decided to moved from estimations of ozone transport to considerations of the residual and eddy fluxes of atmospheric mass. However, we added references showing that the photochemical lifetime of ozone exceeds 30 - 50 days below 30 km altitude, where the ozone can follow the fluxes of mass.

L. 217. Q: Specify what data the MUAM ozone model is based on.

A: We extended the MUAM description.

L. 214. Q: Is that really "monthly-mean" ozone? How good is to use monthly means for such rapid events as SSW? Or some sort of time interpolation was used?

A: We removed discussions of ozone fluxes from the revised text.

L. 245. Q: Ozone fluxes enhance the residual circulation? They just reflect it. A rewording is needed.

A: the discussion of residual and eddy mass fluxes is substantially extended and modified.

L. 248-250. Q: I would recommend to move reservations concerning the fixed ozone distribution to the beginning of the section. Readers would then understand from the beginning that this is just a rough estimate.

A: We moved from ozone to considerations of the residual fluxes of atmospheric mass in the revised text.

L. 266. Q: Aren't the fluxes decrease at this location, as Fig. 2b shows?

A: Fig. 3b2 shows negative add-ons to the residual vertical velocity at altitudes 20-50 km near the North Pole during SW. Accordingly, the downward mass fluxes are also enhancing in this region.

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