Review of the manuscript *"Air quality and radiative impacts of downward propagating sudden stratospheric warmings (SSWs)"* (No. egusphere-2023-1175) by Williams et al.

General comments:

This paper investigated anomalous ozone and water vapor perturbations in both the stratosphere and the troposphere following stratospheric sudden warming events (SSWs), with specifically emphasis on the Polar-night Jet Oscillation (PJO) events and on the upper troposphere-lower stratosphere (UTLS) and surface regions. The capability of the EMAC chemistry-climate model in simulating historical ozone and water vapor anomalies was first evaluated compared to the CAMS atmospheric composition reanalysis dataset. A longer simulation from the EMAC model with a stratospheric origin ozone tracer (O_3S) was later used to investigate the ozone and water vapor anomalies and their corresponding radiative impacts for the PJO and non-PJO SSWs. The main finding are that significantly prolonged ozone anomalies and vertical water vapor dipole can be addressed in the lower most stratosphere (LMS) following PJO-type SSWs. SSW composites of the O_3S further indicate pronounced increases of ozone in the troposphere and a higher frequency for the exceedance of WMO air quality standard at the surface over specific extratropical continental areas. Overall, the paper is well organized and written, and I see the merit of this study in addressing the potential influence of stratospheric ozone on the troposphere and the surface air quality based on model simulations, albeit SSW-related ozone anomalies in the stratosphere have been widely investigated in previous studies. I would recommend publication of this paper after the following comments are fully addressed.

Specific comments:

1. Figure 1b: I'm concerned about the lags used to perform the ozone statistics associated with SSWs. According to previous studies (e.g., de la Cámara et al., 2018, Hong and Reichler, 2021), negative ozone anomalies were found before the onset of SSWs. Therefore, including ozone perturbation at negative lags (i.e., -20 to -5 day) may reduce the significance of SSW composite for ozone. I suggest to modified the analysis of Figure 1b by performing the SSW composite after lag 0.

   Reference

   de la Cámara, A., Abalos, M., Hitchcock, P., Calvo, N., and Garcia, R. R.: Response of Arctic ozone to sudden stratospheric warmings, Atmos. Chem. Phys., 18, 16499–16513, https://doi.org/10.5194/acp-18-16499-2018, 2018b.

   Hong, H.-J. and Reichler, T.: Local and remote response of ozone to Arctic stratospheric

circulation extremes, Atmos. Chem. Phys., 21, 1159–1171, https://doi.org/10.5194/acp-21-1159-2021, 2021.

2. Ln 279-281: Why the PJO-type SSW in February 2010 was excluded?
3. Ln 327-330: The persistent ozone anomalies in the lower stratosphere after the PJO-type SSWs can be attribute to the weakening planetary wave influence and the longer chemical relaxation time scale. Is there an explanation for the long-lasting O_3S or O_3F in the troposphere as the dynamical time scale becomes relatively short toward the lower troposphere?
4. Ln 380-382: As indicated by Figure S3a and Table S5, significant increases in the frequency of grid point incidences can also be found over the LMS (100-300hPa) region from the full O_3 tracer. I'm wondering whether this result can also be verified using the CAMS dataset. Could you repeat the analysis of Figure S3a but use the CAMS dataset instead?
5. Ln 483-485: Why an increase of ozone between 1-100hPa leads to cooling temperature anomalies (Figure 8a) while ozone mostly absorbs shortwave radiation on the layer?

Technical corrections:

1. Ln 371: *"... in all cases pertaining to the mean, 90^{th} and 95^{th} ..."* should be *"median, 90^{th} and 95^{th} ..."* according to Table S1. The same correction should be applied to Ln 553, too.
2. Ln 432: *"... when using the O_3 tracer with the O_3S amount for ..."* should be corrected as *"... when using the O_3 tracer with the O_3 amount for ..."* if I understand the methodology for performing the 'pseudo' climatology correctly.