1 Answers to Reviewer 1

First we want to thank Reviewer#1 for the encouraging review and especially for the tedious inspection of formatting the bibliography.

We changed all mentioned points according the suggestions.

2 Answers to Reviewer 2

First we want to thank Ref#2 for the valuable suggestions how the paper can be improved. Rev#2 raises three specific concerns:

1) Missing comparison with previous studies, here especially with Sukhodolov etal. (S2017):

In contrast to S2017, the current paper includes also a contribution from a geomagnetic storm to the solar particle forcing and evaluates its possible impact. The maximum ionization of the geomagnetic storm is here in the MLT region. NOy transported from the lower thermosphere into the middle atmosphere dominates the NOy input and can reach the stratosphere under favourable dynamical conditions during an elevated stratopause event. This cannot be studied with the setup of S2017, as for such a study a model with a top height reaching in the lower thermosphere is necessary (SOCOL has an upper boundary of about 80 km). To our knowledge, such an experiment has not been performed before. A sentence emphasizing this new aspect has been added in section 2 and the wording in the abstract has been changed slightly to make that clearer.

In the discussion section we now comment especially on the GMS results. In addition, we performed an GMS only experiment with 10x strength of the extreme scenario to clarify the role of GMSs. We only note this experiment in the text without showing a figure as the drawn conclusions are confirmed, i.e. that the impact of the GMS is small compared to the SPE.

We now also compare explicitly with the the results of S2017 (new subsection NOy, ozone).

A direct comparison with the results of S2017 as suggested by the reviewer seems to us not meaningful (besides the practical difficulties): S2017 focus on dynamical feedbacks. They look for strong ozone changes in the early winter in order to maximize radiative feedbacks and are finally searching for surface effects. Here, only an ensemble is capable to yield meaningful results. Our setup is more suited to analyze the direct chemical effects as we are using specified dynamics and can compare with a chemical reference run. As a result, our comparisons show higher impacts for composition but not the most probable impacts as S2017. With respect to total ozone, S2017 show in their Fig. S4 of the supplement the ozone loss in DU. We reach about the same initial ozone loss (with the date of the event in January first higher in SH), but lasting much longer in the NH compared to S2017. (S2017 give a maximum global decrease of total ozone of 8.5% which we cannot reproduce from the latitudinal distribution of the total ozone differences shown in their Fig. S4. Assuming a global mean of 300 DU we estimate a reduction of only between 1 - 2 %). See also answer to 3).

2) Scaling property

This is a valid point which we now answer with a short subsection in the context of the ozone response. We added an experiment with a strength of 1/5 of the EXT and discuss the result.

3) Present day vs historic conditions:

This is related essentially with 1): a full comparison with a historic simulation like S2017 can only be accomplished by the model performing these simulations. From a chemical point of view, the flux of source gases like N2O into the stratosphere and their mean residence time determine the concentrations of tracers and the composition. Therefore, an analysis of the mean dynamical and chemical states under historic and present-day conditions would be necessary. There is no discussion in S2017 how the model results of the background state differ from present-day conditions. Even the simple fact that we expect the relative increase of NOy to be higher in S2017 just by the smaller pre-industrial concentration of N2O is only a guess as the N2O oxidation depends on the mean residence time and on ozone which depends itself also on the circulation.

Minor issues:

We followed the reviewer's suggestions, see the tracked changes and changed figures. Only with regard to 'NOy input' we would stay with this term as it describes the general case independent of local production or transport from the thermosphere.