

Response to the comments of the referee 1

### **Notes on the correlation between SSWs and solar activity**

By Ekaterina Vorobeva

Dear Referee,

Thank you a lot for your constructive suggestions. We tried to follow your comments and suggestions.

Specific comments.

*Referee writes: "There are, of course, further proxies for solar activity."*

In order to satisfy the referee and to enlarge an area of paper's application, we add four proxies (solar 3.2 cm, 8 cm, 15 cm, and 30 cm fluxes) in Table 1.

*Referee note: "A positive correlation between MSSW and F10.7 is a statistical result which does nothing state about the mechanism of connection."*

We have similar notation in the Summary section, i. e.: "Note that the correlation is necessary but not a sufficient condition for a relationship between the two phenomena".

*Referee notes: " There occurs a possible bias due to decreasing strength of the solar cycles (from cycle 21 to cycle 24 now) and the simultaneous increasing cooling of the middle atmosphere due to growing CO2 concentration (e.g. Berger and Lübken, 2011) and a general trend in stratospheric ozone by increase of the concentration of some minor constituents such as methane, N2O and other greenhouse gases. This entails a trend in the composition independent of solar activity"*

The separation of the effects of long-term changes in solar cycle and long-term changes of anthropogenic greenhouse gases (GHGs) and ozone-depleting substances (ODSs) on the middle atmosphere still remains unsolved problem. Yes, generally speaking, joint declining of solar cycle and growth of GHGs and ODSs may produce bias in correlation. But according with current knowledge, there is no statistically significant impact of anthropogenic changes on frequency of SSWs (e. g. Butchart et al., 2000; SPARC CCMVal, 2010; Mitchell et al., 2012; Hansen et al., 2014, Ayarzagüena et al., 2018). Moreover, some of recent works show increase of the SSWs frequency (e.g., Huebener et al., 2007; Charlton-Perez et al., 2008; Bell et al., 2009; Schimanke et al., 2013; Ayarzagüena et al., 2013). Thus, in last case, the join effect of negative

trend in solar cycle strength and positive trend of GHGs may just reduce positive correlation, but cannot be its cause.

We add similar notation into the section Discussion.

*Referee writes: "Please define and explain in more detail the expression "normalized" (line 109)."*

We rewrote line 109 in order to explain the expression "normalized" used in the text. Due to the limitation of paper size, we do not describe in detail a process of using a norm factor but we present the reference where one can find it.

*Referee writes: "Chapter 2 should be split inserting Chapter 3 "Discussion" after line 123. Summary is then Chapter 4."*

Chapter 2 was split into Chapter 2 "Data, Method, and Result" and Chapter 3 "Discussion". In addition, we expanded Chapter 3 "Discussion" according to the referee's comments and suggestions.

*Referee writes: "However, it should be mentioned that already the step from Figure 1b to 1c entails a statistical uncertainty which decreases with the number of solar cycles."*

We noted this fact right after the equation (1).

*Referee writes: "The references ... are missing in the Text. (It is not necessary to quote Labitzke so often, your paper deals with the influence of the F10.7 flux upon the occurrence rate of MSSW, not with the connection between the occurrence rate of MSSW and the phase of the QBO.)"*

Thank you for this remark. We removed the references missing in the text.

*Referee writes: "Authors beginning with Sh... should be quoted after Sc... in the list of references (e.g. Shepherd after Scherhag )."*

Thank you for this remark. We rewrote the list of references in alphabetical order.

*Referee writes: "The reference Charlton et al., 2007 is double. Line 91: Charlton et al., 2007."*

The reference in Line 91 was changed to Charlton et al., 2007.

*Referee writes: "Line 24/25: A corresponding mesospheric cooling has been found shortly after. The SSW starts with a mesospheric cooling before the SSW occurs in the stratosphere."*

Currently, there are no unique opinion on time delay between SSW and mesopause cooling. Some authors state that they coincide (e. g. Zülicke et al., 2018). We do not touch this question in our short note and do not want make any strong statements on this subject.

*Referee writes: "Line 72 What is meant with: "One of the strongest effects on the nature of Earth comes from the sun..."?"*

The author wanted to notice the solar influence on the Earth's atmosphere. Line 72 was rewritten to clarify the point.

*Referee writes: "Line 78/80...without to consider a relation to QBO..."*

Corrected according to the reviewer's comment.

*Referee writes: "Line 123 Not only: "different periods", but also different bins, different solar proxies."*

We added other possible reasons for the difference of correlation coefficients.

Thank you a lot for taking the time to review the manuscript.

With respect,

Ekaterina Vorobeva.