Dear Reviewer,

Thank you very much for your time and efforts on reviewing our manuscript. We considered all comments and suggestions, and provided our detailed point-by-point responses below.

Reviewer #2

General Comments

> This well-written article presents a good analysis of stratospheric cirrus clouds above North America, and provides convincing explanations for the mechanisms responsible for the presence of these clouds. The data is well described, the figures support the results and the discussion is interesting. I am in favour of its publication in ACP, once the minor comments below will be addressed.
>
> A semantic issue I'd like to see addressed is the fact that the clouds described as "SCC" in the present article appear to be most often than not, according to the results presented, overshoots of convective systems. Labelling them as "stratospheric cirrus clouds" makes me a bit uneasy, as they are most frequently not independent clouds but rather a small part of a larger system, that happens to reach above the tropopause. Depending on the nature of a stratospheric cloud (independent cirrus or upper part of a convective system), I suppose the formation processes involved should be very different, as should be the impact on stratospheric water vapour. It would be useful if the authors could address this issue, either by proposing a way to avoid confusing independent cirrus with upper parts of convective systems, or by demonstrating that the distinction is not important.

Answer: Thank you very much for your positive comments.

Yes, we considered the term "stratospheric ice clouds (SICs)" would be more appropriate in this work as it includes also the stratospheric part of deep convection. We have revised them all in the revised manuscript.

Minor Comments

Comment $*$ 1

> Introduction: this section is very good. The authors summarised very well the existing literature on stratospheric cirrus clouds, the observational evidence for their existence, and the mechanisms that might lead to their formation. It is an enjoyable read. L. 59: It is unclear to me what you mean by "kind of controversial". Are you suggesting the results from the previously cited works are incorrect, inconclusive, or unreliable? Maybe you mean that existing evidence for stratospheric cirrus is circumstantial and imprecise by definition (there are multiple definitions of the tropopause, etc). If that is the case, the presented results could also be labelled controversial. Please be more explicit in your statement.

Answer: In this sentence, we intend to mention that even though the specific statistics of occurrence frequencies of ice clouds in midlatitudes are different from study to study, the existence of those high altitude ice clouds is well accepted. We have rephrased it in the revised manuscript.

"Even though the actual numbers of occurrence frequency are different from study to study, the occurrence of SICs at midlatitudes is generally notable"

Comment ∗ 2

L. 192: "The example adds a further aspect... over North America" I'm not sure I understand this sentence.

Answer: We have revised it in manuscript.

"Figure.1 shows a typical example of co-located stratospheric ice clouds and deep convection, a situation which can be frequently observed over the Great Plains during the thunderstorm season."

Comment ∗ 3

Figure 4: A visual inspection of the time series presented here does not suggest to me a good correlation between them. Spikes in N_{SCC} (orange) are frequently paired with flat N_{DC} or BT_{min} curves, and vice versa. The text does not attempt to discuss short-scale variability of these time series or of the correlation between the time series. The text does not really discuss the contents of that figure. Because of this, I do not think this figure really brings anything to support the paper's argument. I would actually be more interested in a visual representation of the annual evolution of the various indicators, NOD_{SCC}, NOD_{DC}, N_{SCC}, $R_{SCC\ DC}$, etc. This would make a more interesting discussion in my opinion.

Comment ∗ 4

L. 233: "Despite large day-to-day variations, the occurrences of SCC and deep convection are generally correlated." Again, looking at Figure 4, I'm not sure I see such a good correlation. The correlation coefficient between SCC and convection is sometimes as low as 0.3. Do the authors consider a 0.5 correlation coefficient high or low? I would be interested in seeing a lengthier discussion of these parameters, hopefully helped with a figure.

Answer: Thanks, we would like to answer comment 3 and 4 together. Figure 4 and corresponding texts have been revised in the revised manuscript.

In Fig.4, we want to show the high correlations between occurrence of stratospheric ice cloud and deep convection. As the rate at which SICs are formed depends on several parameters, such as the intensity, the spatial extent, and the duration of the deep convection events, the simple linear correlation coefficient of the observation numbers of SICs and deep convection is not necessarily the best indicator for correlation. Additionally, we considered the number of days with SICs and deep convection detections as a proxy for identifying possible correlations. And it is the method we used to calculate the fraction of SICs related to deep convection in Section 3.3. Please find details below.

Yes, the annual evolution of deep convection and SICs is very interesting. But the long-term variation analysis seems out of scope of this study, and we will investigate it in our future work.

"The temporal correlations between SCCs and deep convection are further analyzed based on time-series of daily detection numbers (n_{obs}) over the Midwest United States (35°N – 45°N, 90°W – 100°W) from May to August (Fig. 4). Data from three years, 2010, 2013, 2015, which have Pearson linear correlation coefficients (r_{SIC-DC}) of 0.66, 0.52, and 0.3, respectively, between the number of CALIPSO SIC observations and AIRS deep convection observations, are shown here as representative examples to illustrate the temporal correlation between SICs and deep convection. A visual inspection of the time series in Fig. 4 shows that individual events or episodes of SICs and deep convection often occur simultaneously.

However, as the rate at which SICs are formed depends on several parameters, such as the intensity, the spatial extent, and the duration of the deep convection events, the simple linear correlation coefficient of the n_{obs} of SICs and deep convection is not necessarily the best indicator for correlation. Additionally, we considered the number of days NOD with SICs and deep convection detections as a proxy for identifying possible correlations. In Fig. 4, we see that even in 2015, which has the lowest linear correlation coefficient, 87 % of the days with SIC observations are related to days with deep convection. SICs are

generally co-occurring with deep convection (>80 % for each single year from 2007 to 2018, not shown), which indicates a high degree of correlation between deep convection and SICs on the temporal scale over the Great Plains in summertime."

In Section 3.3:

"The fraction of SICs related to deep convection is defined as the ratio of day numbers with SICs and deep convection both detected to the total number of days with SIC detections."

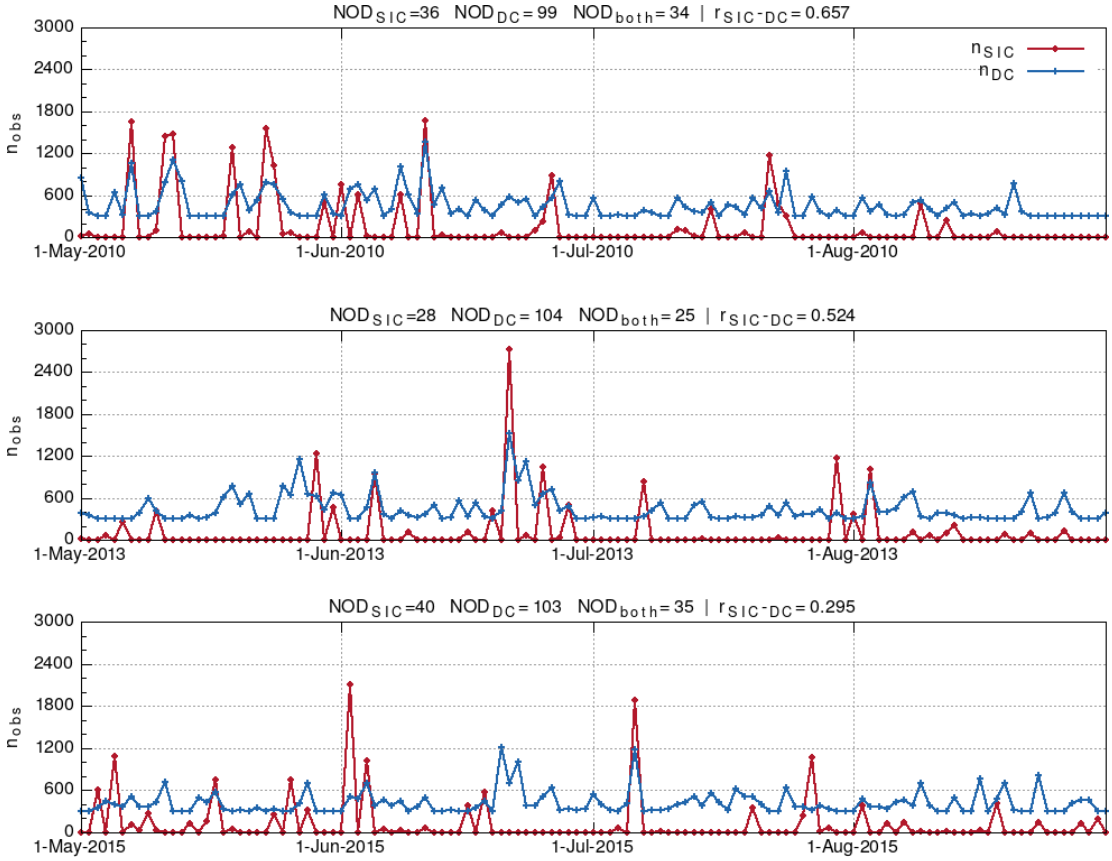

Figure 4: Daily numbers of nighttime observations of SICs (red line with no offset), deep convection (blue line with offset of 300) over the Midwest United States (35°N – 45°N, 90°W – 100°W) in MJJA in 2010, 2013 and 2015. Number of days with occurrences of SICs (NOD_{SIC}), deep convection (NOD_{DC}) and both of them (NOD_{both}) are counted. Total detection numbers of SICs (n_{SIC}), deep convection (n_{DC}) on each day and their Pearson linear correlation coefficients (r_{SIC-DC}) are also shown above the plots.