Manuscript Number: acp-2018-1153
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Title: Lidar observations of pyrocumulonimbus smoke plumes in the UTLS over Tomsk (Western Siberia, Russia) from 2000 to 2017

Point-by-point response to Referee 2

General comment

Comment: The contribution is an important documentation of pyrocumulonimbus-related aerosol events occurring in the upper troposphere and lower stratosphere. Long-term lidar observations taken over Tomsk, Siberia, Russia, from 2000-2017 are carefully analysed, presented, and discussed. The result is a well written paper that even may guide other lidar groups to re-analyze their own lidar observations. Nevertheless, only few stations around the world can provide such results as presented here.
I recommend: Minor revisions.

Response: We thank Referee 2 for a positive review and useful comments. Our point-by-point responses to Reviewer #1 comments and changes made are presented below.

Specific comments

Comment 1: Abstract: Remove the first lines… Start with: In this paper… The abstract should be always compact and as short as possible: Goals, methods, key results, not more. All motivating points shall be given in the Introduction (only).
Response 1: Perhaps, you are right, but we follow the manuscript preparation guidelines for authors provided by ACP. Namely: "The abstract should be intelligible to the general reader without reference to the text. After a brief introduction of the topic, the summary recapitulates the key points of the article and mentions possible directions for prospective research…"

https://www.atmospheric-chemistry-and-physics.net/for_authors/manuscript_preparation.html

Comment 2: P2, L13-15: Satellite remote sensing is not able to provide us with the top of the smoke layers, the retrieved tops are at much too low altitudes. That should be clearly mentioned. Only lidars are able to resolve smoke plumes correctly. Satellites often provide the erroneous impression that most of the smoke is in the PBL, which is contradiction with almost all lidar observations around the world (e.g., as monitored by EARLINET teams of Amiridis et al., ACP and JGR, Nicolae et al., JGR, and also Mattis et al., JGR 2008: : :). So, on a global scale, only CALIOP can do a reliable job.

Response 2: We agree and have never declared in our manuscript that satellite remote sensing provides us with the top of the smoke layers. Due to this reason, only 2 maximum pyroCb plume altitudes are known (see Table 2). We estimated the altitudes from which air masses containing pyroCb plumes arrived in Tomsk from North America based on the HYSPLIT backward trajectories. However, we now use available CALIPSO data (version 4.10) to corroborate the Tomsk observations for the 2013–2017 period. The CALIPSO data are given in the Supplement.

Comment 3: P3, L21-25: Any comment? Why not using always the tropopause as H1 in Eq.(2)? The tropopause height is always available from GDAS… And the reader (at least this reviewer) wants to obtain a clear picture of the smoke impact on stratospheric aerosol conditions.

Response 3: The use of the fixed 11-km altitude is a compulsory measure. As we noted in the manuscript, we are not able to precisely determine the tropopause altitude above the lidar site due to the absence of meteorological stations launching radiosondes in Tomsk. So, we use sonde data from the three nearest to Tomsk stations (launching sondes twice a day), which allow us to estimate the tropopause altitude more precisely (and closer in time to aerosol layer observation) than that from GDAS data. Due to an 11-km fixed altitude and, therefore, a fixed 11–30 km altitude region, we can (regardless of the real tropopause altitude) make a comparative analysis of aerosol loading over Tomsk from both volcanic eruptions and pyroCb events in the 2000– 2017 period. In addition, a fixed altitude of 11 km excludes the tropospheric aerosol sources and does not allow us to miss pyroCb plumes from North America.

Instead of

"where the lower limit H_1 = 11 km falls within either the UT or LS due to the variability of the local tropopause altitude and does not allow missing pyroCb plumes in the UTLS, and the upper limit is the calibration altitude $H_2 = H_0$ = 30 km."

We write

"where the lower limit H_1 = 11 km can fall within the UT, TR* or LS due to the variability of the local tropopause altitude and the upper limit is the calibration altitude $H_2 = H_0$ = 30 km. The use of the fixed 11-km altitude is a compulsory measure because there is a problem in determining the tropopause altitude over the lidar site due to the absence of a meteorological station launching radiosondes in Tomsk. Nevertheless, the 11-km lower limit does not allow missing pyroCb plumes from Northern America and excludes the tropospheric aerosol sources with the exception of cirrus clouds. Moreover, the fixed 11–30 km altitude region allows us (regardless of the real tropopause altitude) to make a comparative analysis of aerosol loading over Tomsk due to both volcanic eruptions and pyroCb events from 2000 to 2017."

*TR means tropopause region

[**Page 4, lines 2–8, revised manuscript**]

Comment 4: P7, P15: No event from 2003 to 2013? Can you say something about the reasons? Was it wet in western Canada, western United states? Or was the long range transport blocked?

Response 4: Several pyroCb events, the plumes from which could potentially be detected in Tomsk in the 2004–2011 period, are listed in Table 1. Section 3 reports the facts of pyroCb plume detection in the UTLS over Tomsk, whereas the reasons of the absence of detected pyroCb aftereffects in Tomsk are discussed in Sections 4 and 5. According to our findings and the conclusions provided, e.g., by Peterson et al. (2018), pyroCb aftereffects are comparable to those from volcanic eruptions with VEI ≤ 3, whereas 11 out of 12 volcanic eruptions, detected in Tomsk in the 2004–2011 period, had VEI = 4. Therefore, the main reason is that we cannot unambiguously discern the pyroCb plumes against the background of more powerful volcanic plumes through the use of only one-wavelength aerosol ground-based lidar. The use of space-based lidar measurement data to infer particle type in the 2004–2011 volcanic period is not the subject of the current research. Nevertheless, we could draw some conclusions about the pyroCb smoke impact on UTLS aerosol conditions due to two periods of volcanic quiescence (2001–2004 and 2012–2017), during which no significant volcanic eruptions (with VEI ≥ 3) occurred in the Northern Hemisphere (see Sections 4 and 5).

Peterson, D.; Campbell, J.; Hyer, E.; Fromm, M.; Kablick, G.; Cossuth, J.; DeLand, M. Wildfire-driven thunderstorms cause a volcano-like stratospheric injection of smoke. NPJ Clim. Atmos. Sci. 2018, 1. https://www.nature.com/articles/s41612-018-0039-3

Comment 5: P15, L6-24: What about bad weather conditions? … and the probability that you missed several short-term PyroCB events…? Is your lidar automated? Probably not, so the probability is at least not zero that you missed some nice events.

Response 5: You are right. Bad (cloudy) weather conditions led to the absence of lidar data for 290 out of 630 (~46%) ten-day periods from 2000 to 2017. See please "Data for Figure 10.opj" in the Supplement. To open the file, the scientific graphing and data analysis software "Origin" is required (https://www.originlab.com/), the trial version of which can be downloaded at: https://www.originlab.com/demodownload.aspx. Taking into account the 2004–2011 volcanic period, we can say that many pyroCb events could be definitely missed.

Sincerely,
Authors