Review of revised B19.

B19 have revised the text, some figures, and given greater advocacy to the Brewer Dobson Circulation (BDC) as the pathway for what they interpret as ascending aerosol structures observed in autumn 2017 over Mediterranean Europe. To their credit, B19 added more data to the analysis and depicted these data in a fuller manner than the original manuscript. They bolstered their BDC argument by referring to the now published Kloss et al. (2019) (K19) paper and invoking Jäger (2005), in which the impact of El Chichon and Pinatubo on a mid-latitude lidar station were emphasized. Jaeger implicated the BDC for lidar-based aerosol structures after the El Chichon and Pinatubo eruptions that resembled the ascending aerosol structures B19 report and discuss.

Unfortunately I found none of the BDC-related revisions convincing, and in fact concluded that the new content served to weaken the case for BDC influence in 2017. Considering that my original assessment was that this was a major issue, and that B19 have placed even greater advocacy on BDC in the revised manuscript, my assessment is that this is still a major concern that needs to be dealt with. B19 have responded satisfactorily to the additional concerns brought up by bother reviewers. Hence I would consider this paper worthy of publication after defensible revisions regarding the BDC attribution are made.

Below I elaborate on the BDC concern.

For reference, B19 state that meridional transport from the tropical stratospheric reservoir ensued n mid-September 2017. “However, during the autumn and winter season (from mid September to end of December) a northward transport of aerosols from the tropical stratospheric reservoir (TSR) towards the mid latitudes must be considered.” This means that within about 1 month of the pyroCb injection (mid-August) in British Columbia (52°N), large abundances of stratospheric smoke completed a movement into the TSR and a subsequent movement to 32-35°N by way of the characteristically slow BDC. On its face this seems meteorologically improbable. As will be mentioned below, there is also no evidence of smoke at the required time and altitude observed in the TSR.

B19 have cited Kloss et al (K19) who claimed a BDC influence on tropical smoke they reported. Even if that point is conceded, K19’s results are irreconcilable with those of B19. The only evidence K19 give for BDC-driven tropical ascent is a time series of vertically resolved aerosol data wherein the first hint of tropical stratospheric smoke is discerned in late October 2017. The images below, from B119 and K19, synchronized, illustrate the irreconcilability. The K19 aerosol ascent begins after the onset of perceived Mediterranean (extratropical) ascending structure (September 2017). Moreover, the K19 tropical layer never reaches the altitude of the B19 structure during the B19 time frame (“18-19 km to 22-23 km height from the beginning of October to the beginning of December”). Given the expected lag between the tropics and extratropics due to the characteristically slow BDC transport, there is no information available in K19 to support the argument that B19’s earlier, higher structures come from the tropics.

The scenarios of Jäger (2005) and B19 are wholly different. The 2017 pyroCb eruption event was at 52°N; the smoke plume is entirely at high latitudes as late as mid-August. Even if it is acknowledged that some fraction of the pyroCb stratospheric smoke eventually got into the TSR, it is surely a small proportion of the source term (Bourassa et al., 2019). The Pintaubo and El Chichon aerosol source terms

were massive relative to the 2017 pyroCb event and exclusively tropical at source. Hence all meridional aerosol spread started from these massive source terms. Even so it took more than one month for the Pinatubo aerosol to arrive over central Europe (Jäger, 1992). It is noted here that the original Garmisch-Pinatubo timeline has been reinterpreted (Fromm et al., 2010) such that the earliest Pinatubo aerosols to reach Garmisch were~1 month later than reported by Jäger (1992), 2 months post eruption. According to Reiter et al. (1982) the onset of El Chichon aerosol at Garmisch was ~1 month after the eruption. So even under the relatively favorable situations of the two volcanoes, the impact on Europe lagged by one or more months from the injection date.

If indeed some of the Canadian pyroCb stratospheric smoke got into the TSR, then got lofted by the BDC, then got spread back to the extratropics, one might hypothesize that the residual concentration of aerosols would be much smaller than the "main" smoke over Europe transported there more directly. However, the particulate extinction plots in B19 do not suggest a systematic difference between these two populations. Hence it would have to be argued that the BDC-transported smoke would have a heritage of even greater concentrations (translated as extinction). Neither K19 nor any other published works on the Canadian pyroCb smoke expressly or implicitly show that the tropics contained such relatively large smoke concentrations.

The replaced figure in B19 on which they focus the BDC discussion (Figure 8) has a variety of structures. B19 acknowledge that fact. However, the newly constructed figure hinders their argumentation. There are very high layers earl on and what can be interpreted as descending structures within. With smoke aerosols at and above 22 km in September in the Mediterranean zone, it is difficult to sort out the reasons for all of the variations in altitude that are evident. Given the co-existence of structures with positive slope, negative slope, no slope, and even multiple simultaneous layers, attention to just the positive-slope structure seems to be artificially limited, in my opinion.

In my first review I described (but did not show) a back-trajectory analysis from a certain location within the suspected BDC-affected smoke structure, to see where it came from. The example I provided was from an Iberian aerosol layer observation not expressly reported in B19. Understandably, B19 did not comment on this suggestion. So with this review I chose two B19-reported observations from which to run back trajectories. They were chosen because they were both similarly high layers: ~22 km. One was from Limassol in the 2nd half of September. The other was from Evora in late October. The results, shown below, reveal paths almost 180° opposed. Neither indicates a path toward the tropics; both reveal a path into an area of observed extratropical smoke at the same altitude but outside the European sector analyzed by B19. The Limassol back trajectory was consistent with a stream of smoke reported by Bourassa et al. (2019). The Evora path also provided a direct connection with upstream smoke observations by CALIPSO (see the link in both examples). These connections provide fairly strong proof that a residual meridional circulation from the tropics was not in play and that direct, quasi-isoentropic extra-tropical dynamics was the more plausible pathway.

Given the above comments and analysis, I think it is exceedingly difficult to conclude that the BDC was responsible for the disposition of the apparently ascending structures reported by B19. Given the publication of K19 it is appropriate to acknowledge this preceding paper, and the potential for alternate

explanations. But the evidence leading to the firm conclusion of the primary role of BDC is not present, in my view.

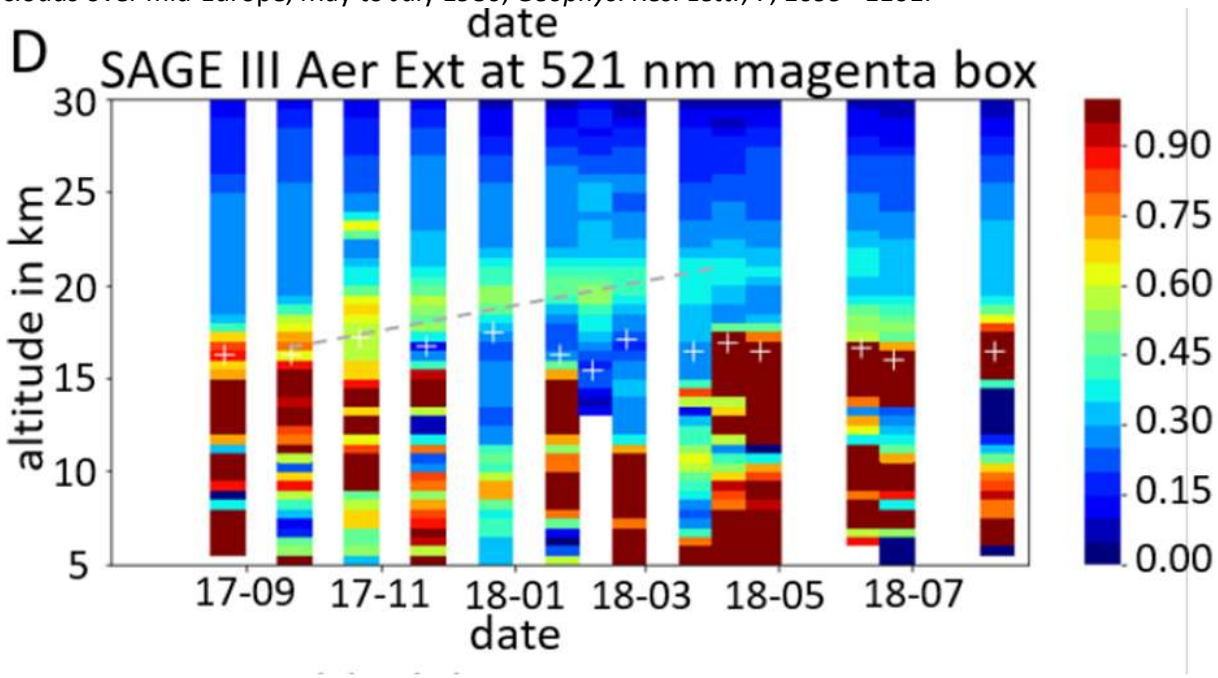
References

Bourassa, A. E., Rieger, L. A., Zawada, D. J., Khaykin, S., Thomason, L. W., & Degenstein, D. A. (2019). Satellite limb observations of unprecedented forest
fire aerosol in the stratosphere. Journal of Geophysical Research: Atmospheres, 124, 9510–9519. https://doi.org/ 10.1029/2019JD030607

Jäger, H., 1992: The Pinatubo eruption cloud observed by lidar at Garmisch Partenkirchen. *Geophys. Res. Lett.,* **19**, 191–194.

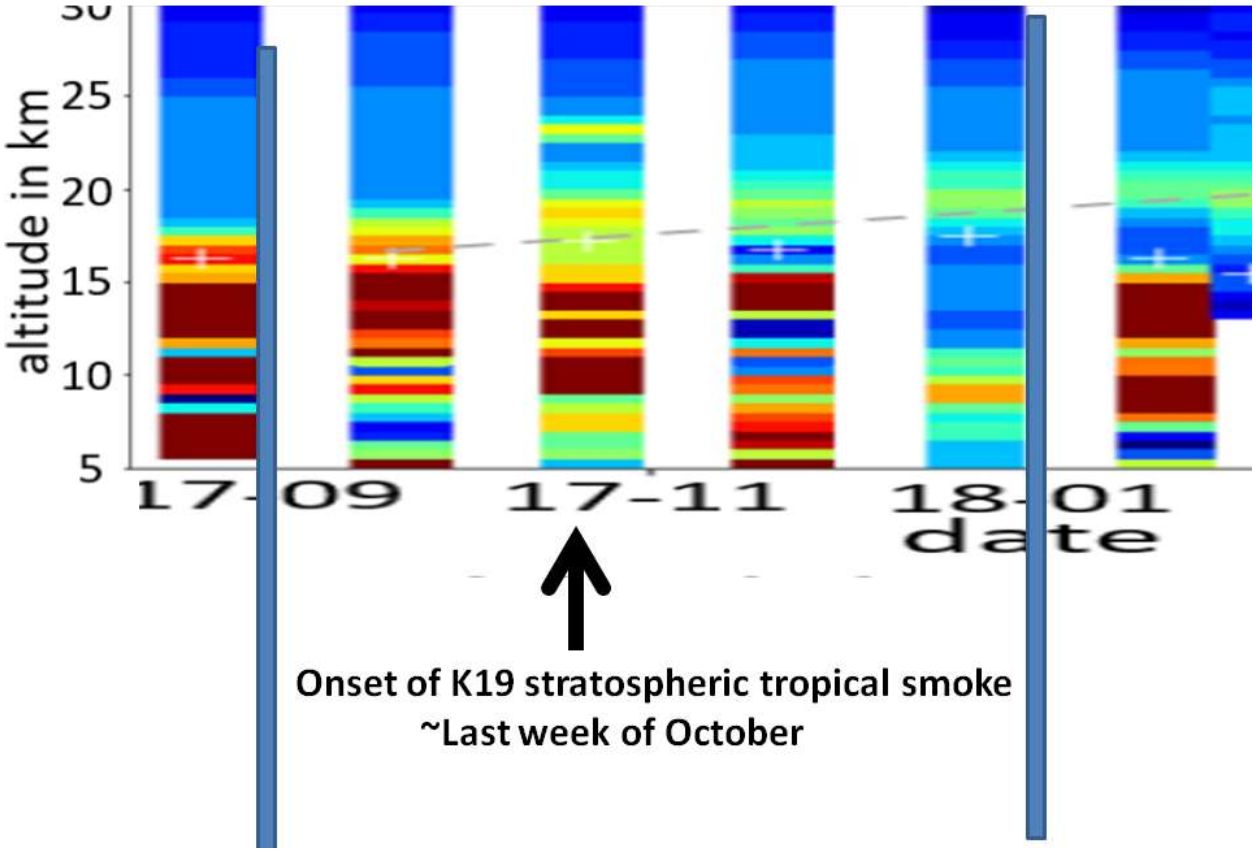
Kloss, C., Berthet, G., Sellitto, P., Ploeger, F., Bucci, S., Khaykin, S., Jègou, F., Taha, G., Thomason, L.W., Barret, B., Le Flochmoen, E., von Hobe, M., Bossolasco, A., Bègue, N., and Legras, B.: Transport of the 2017 Canadian wildfire plume to the tropics and global stratosphere 35 via the Asian monsoon circulation, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2019-204, FINAL!!!...in review, 2019. ...accepted 7 Oct 2019

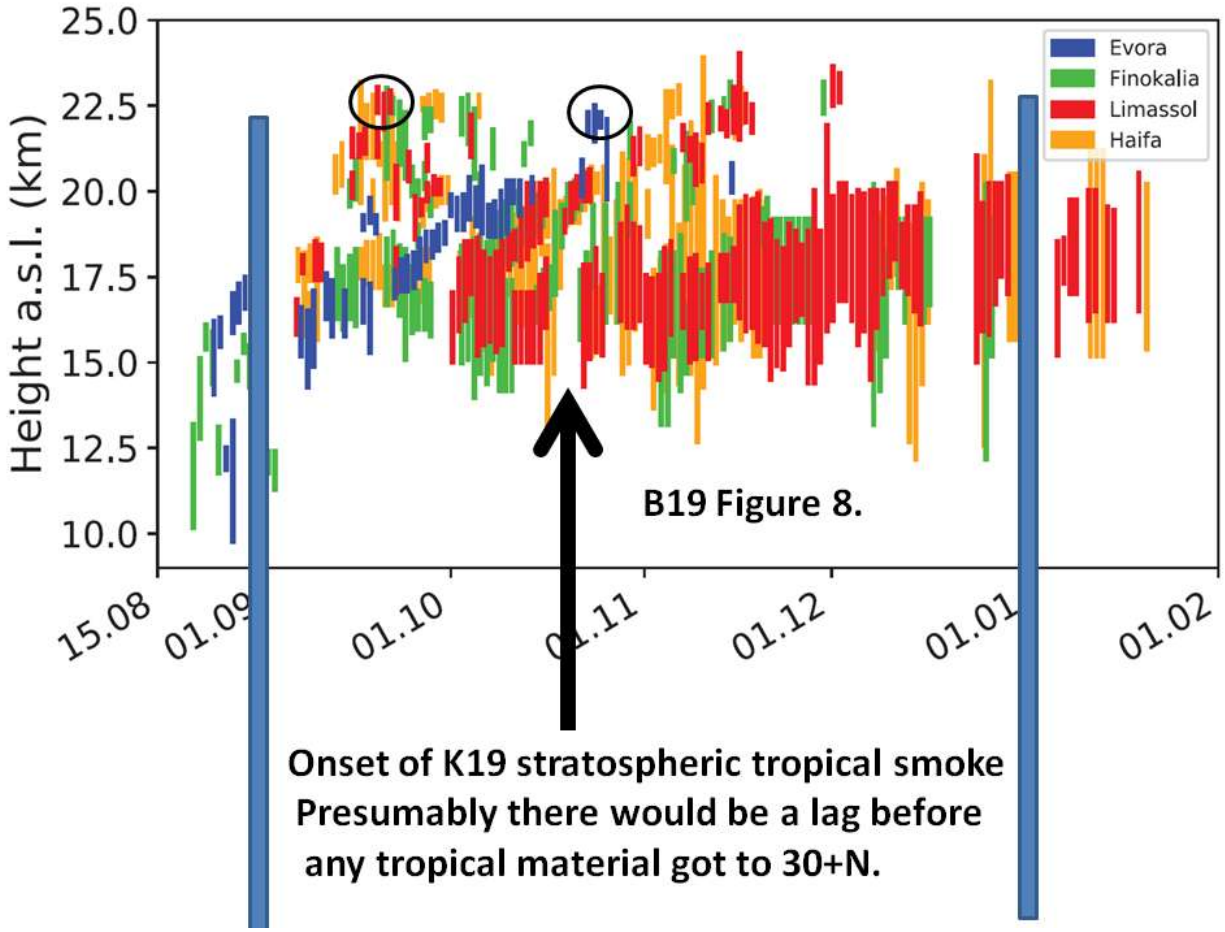
Reiter, R., H. Jäger, W. Carnuth, and W. Funk (1980), Lidar observations of the Mount St. Helens eruption clouds over mid-Europe, May to July 1980, *Geophys. Res. Lett.*, 7, 1099– 1101.

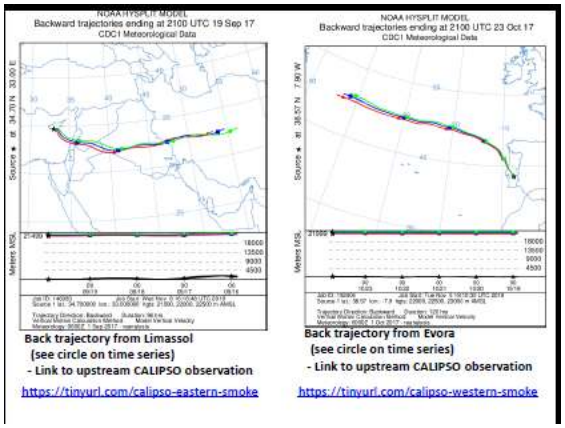


K19 Figure 1D.

K19 Fig. 1D resized to match B19 Fig. 8.







https://tinyurl.com/calipso-eastern-smoke

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