Short comment on Engelmann et al. paper

This is a very interesting paper with rare lidar ratio measurements in the high Arctic near the pole. The observation of a smoke layer getting trapped in the Arctic polar vortex is also very interesting. This short comment is primarily aimed at a statement made by the authors on the CALIPSO measurements over the high latitude regions during the period of their observation. In particular in page 9 they state that "It is noteworthy to mention that the CALIPSO data base (CALIPSO, 2020a, b) does not contain clear hints on the Arctic UTLS aerosol layer observed continuously over the RV Polarstern. According to HYSPLIT (Hybrid Single-Particle Lagrangian Integrated Trajectory-Model) backward trajectories (HYSPLIT, 2020), satellite remote sensing (Kloss et al., 2020), and ground-based Raman lidar observations of the Alfred Wegener Institute at Spitsbergen (Ohneiser et al., 2021), the aerosol layer covered large parts of the Arctic and thus should have been detectable along the CALIPSO flight track (south of 81.8°N)." Contrary to this assertion, we do find clear evidence of layers detected by CALIPSO over the high latitude regions. Figure 1 shows 2 CALIPSO transects through the Arctic region on December 11, 2019 around 3:00 UTC (top panels) and 8:00 UTC (bottom panels), the same day for which smoke plume observations were presented by the authors in their Figure 3g.

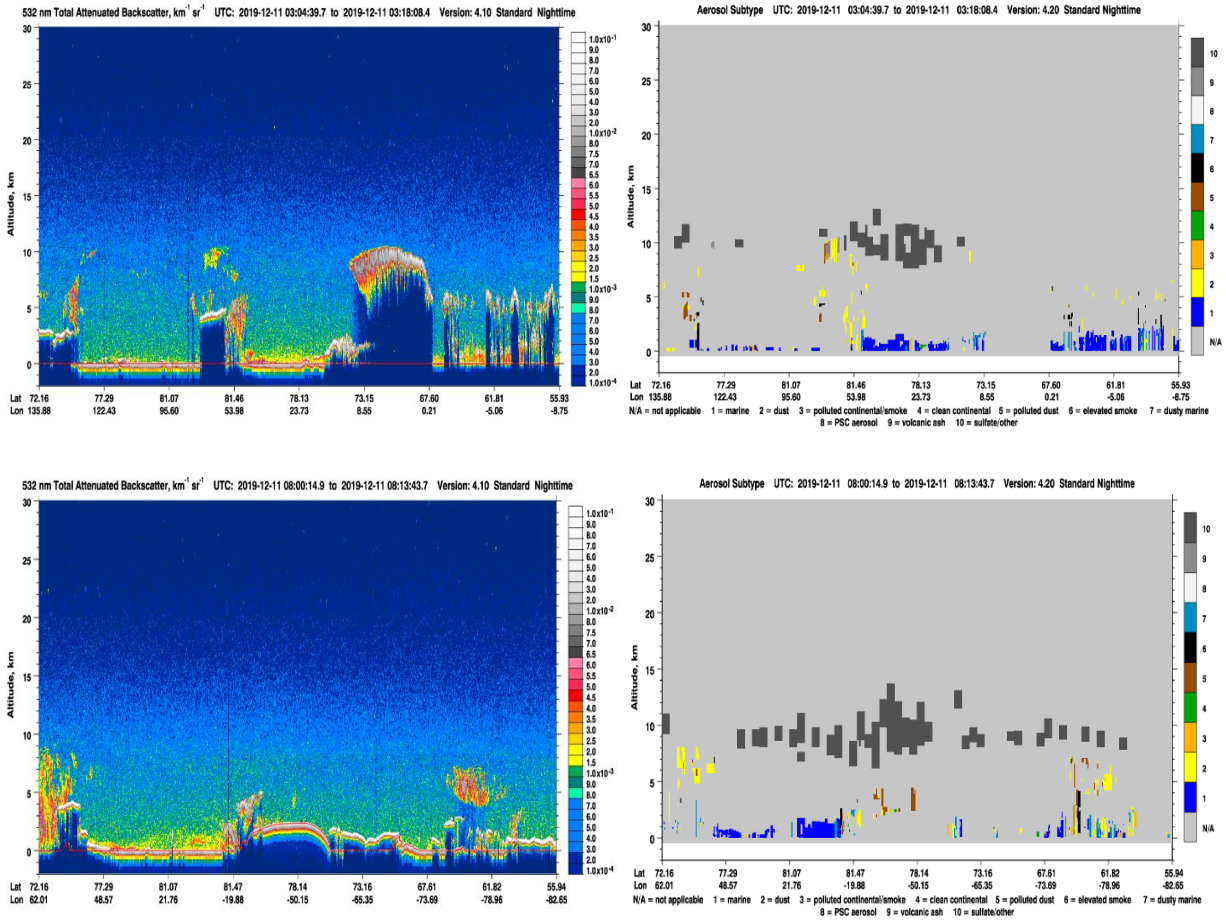

Figure 1. CALIPSO browse images of total attenuated backscatter and aerosol subtypes on December 11, 2019 near 3:00 UTC (top panels) and 8:00 UTC (bottom panels).

Note the clear detection of many layers around 10-12 km between 78°N and 81°N in both cases. The layers have been classified as sulfate/other by the CALIPSO stratospheric aerosol subtyping algorithm because of the low backscatter (Kim et al., 2018). Figure 2 shows another example of aerosol layers detected on November 14, 2019.

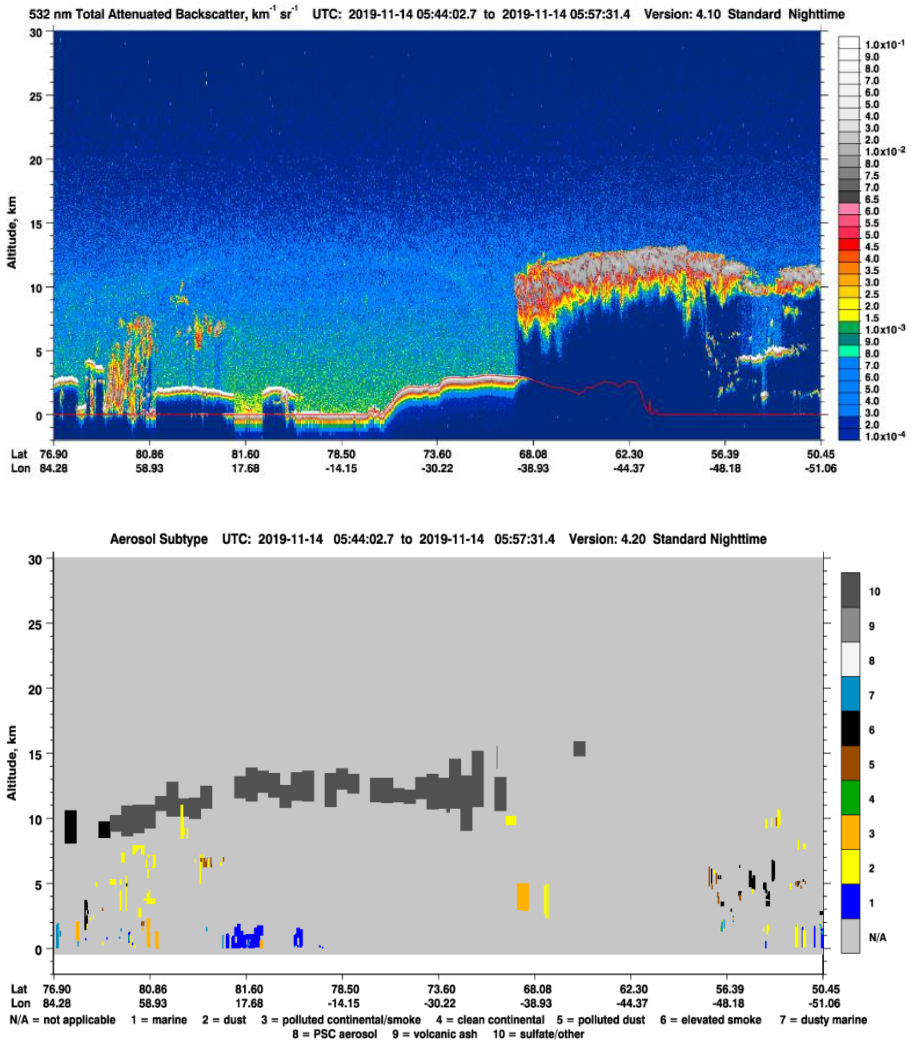

Figure 2. CALIPSO browse images of total attenuated backscatter and aerosol subtypes on November 14, 2019.

Once again a very extended and coherent plume can be observed between ~70°N-80°N as detected by the CALIPSO layer detection algorithm on November 14, 2019. As in Figure 1 the layers are mostly classified as sulfate/other, but note the 2 layers near 77°N which are actually classified as smoke.

It is therefore rather surprising that the authors chose to make the statement about the lack of layer detection by CALIPSO at high latitude UTLS region during the period of their observation.

On another point, in page 8, lines 12-15, the authors try to explain the low depolarization ratio (~0.01) in the aged smoke in terms of the core-shell structure collapsing and the particles becoming more spherical. This seems to contradict the results of Ohneiser et al. (2020) who found high depolarization ratio (up to 0.2 at 532 nm) for aged pyroCb plumes transported from Australia over Argentina in January 2020. In fact, as shown by Christian et al. (2020), the depolarization ratio in the pyroCb plumes from the Canadian pyroCb in August 2017 continued to increase with time for several weeks.

Adding latitude/longitude information on Figures 3 and 4 may be useful.

References:

Kim, M. H., et al., CALIPSO version 4 automated aerosol classification and lidar ratio selection algorithm, Atmos. Meas. Tech., 11, 6107-6135, 2018, 2018.

Christian, K. et al., Differences in the evolution of pyrocumulonimbus and volcanic stratospheric plumes as observed by CATS and CALIOP space-based lidars, Atmosphere, 11, 1035, 2020.