Review of manuscript *Five satellite sensor study of the rapid decline of wildfire smoke in the stratosphere* (acp-2021-1015) by Martinsson et al.

Summary

This manuscript utilizes data from five satellite sensors to document the lifetime of the August 2017 Pacific Norwest pyroCb event and suggest photolysis as the mechanism responsible for the rapid aerosol mass decrease observed by satellite observations. Aerosol extinction measurements by CALIPSO-CALIOP, S-NPP OMPS Limb Profiler, and ISS-SAGE III are used in the analysis.

The paper is suitable for publication in ACP after the authors address the minor issues discussed below.

General Comments

Most of the manuscript is dedicated to the analysis of CALIOP's level1b data. No specific reason is given as to why the authors decided not to use the standard CALIOP level2 products but to develop their own interpretation of CALIOP measured backscattered radiances.

It should be emphasized that CALIOP's main advantage over SAGE III and LP observations is the availability of nighttime observations that, unlike SAGE III and LP, allowed for aerosol measurements during polar night. The usefulness of CALIOP's nighttime observational capability clearly comes across in this work where 29 out of 32 analyzed CALIOP profiles were nighttime observations.

The OMPS-LP - CALIOP AOD comparison yields no meaningful information on the accuracy of either measurement because of their implicit dependence on assumed aerosol properties.

Although photolytic destruction is a reasonable aerosol removal mechanism, the authors should address other possible mechanisms such gravitational settling. It could be argued that the initial massive injection included a variety of aerosol types and sizes some of which would have been removed by gravitational settling on time scales similar to that of photolysis.

Specific Comments

A key step in the retrieval of aerosol properties from lidar observations is the selection of the lidar ratio. The choice of lidar ratio involves specific assumptions on the polydispersion particle size distribution, particle shape and complex refractive index. Although, not explicitly stated in the manuscript, one can assume that the authors considered the implicit lidar ratio assumptions (and the associated aerosol model) in the standard CALIOP level 2 product (Omar et al., 2009) to be inadequate for the interpretation of CALIOP observations in the presence of stratospheric carbonaceous aerosols and, therefore, decided to carry out their own inversion of CALIOP's Level 1b data making use of an improved aerosol model. A brief description of both the standard and adopted aerosol properties should be presented along with the rationale leading to the re-interpretation of CALIOP level1b data.

The authors discuss the evolution of the lidar, color and depolarization ratios in detail. Although the technical definitions of these terms are well known to the lidar community, the manuscript fails to connect the variability of those parameters with the variability on the actual microphysical and optical properties of the aerosol layer of great interest to readers beyond the lidar the community. A discussion of results in terms of practically meaningful aerosol properties will enhance the science value of this contribution.

The manuscript includes several statements on assumed numerical values of parameters without any references. No doubt most lidar experts are familiar with those values, but references may be important for the at large aerosol community. Please provide references and/or a rationale for the quoted numerical values in the statements below

Line 135. ….When the depolarization ratio is less than *0.05* the data is considered background and the lidar ratio is set to *50* sr.

Line 137. Ice-clouds were removed in the lowest 3 km of the stratosphere by identifying them in stratospheric layers where the backscattering was high (attenuated backscattering larger than *0.0025* km-1 sr-1).

Line 138-139 Data in these layers were classified as probable clouds if their δv was higher than *0.20*, or smoke if δv was between *0.05-0.20*..

Line 164 …..very dense with layer AODs exceeding 1.

Detailed observations of the rapid evolution of the stratospheric AOD during the first two weeks following the onset of the pyroCb were carried out by the DSCOVR-EPIC mapper and AERONET ground-based observations (Torres et al., 2020). Both measurements reported stratospheric AOD's significantly larger than 1.0.

Line 333. The UV aerosol index is available from a variety of UV-capable sensors on several platforms (Aura-OMI, SNPP-OMPS, DSCOVR-EPIC, S5P-TROPOMI). It should be pointed out that, when data on height of absorbing aerosol layers is available, the UVAI information content can be quantified in terms of the physically meaningful aerosol optical depth (AOD) and single scattering albedo (SSA) parameters. DSCOVR-EPIC near UV observations (Torres et al., 2020) were used to quantitatively (380 nm AOD and SSA) describe the 2017 Pacific Norwest pyroCb-triggered stratospheric aerosol layer on the first week following the injection using CALIPSO-provided aerosol layer height information.

Line 382. An objective evaluation of the accuracy of OMPS-LP -CALIOP measured aerosol extinction should be done using SAGE III as standard reference. Unlike CALIOP and OMPS LP aerosol extinction, SAGE III solar occultation observations require no aerosol model assumptions whatsoever. Although SAGE III measurements are spatially and temporally sparse, just a few collocations would be sufficient to assess the accuracy of the reported aerosol extinction products.