

Interactive comment on “Vertical and horizontal distribution of sub-micron aerosol chemical composition and physical characteristics across Northern India, during the pre-monsoon and monsoon seasons” by James Brooks et al.

Anonymous Referee #1

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Manuscript title: Vertical and horizontal distribution of sub-micron aerosol chemical composition and physical characteristics across Northern India, during the pre-monsoon and monsoon seasons

Authors: James Brooks et al.

Dear Editor/Authors,

The submitted manuscript presents detailed airborne in situ measurements of aerosols

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taken during different flights over northern India covering pre-monsoon and monsoon seasons. The characteristics of aerosols over the region are presented regarding high-quality vertical and spatial measurements of optical, microphysical, and chemical composition of aerosols. The measurement dataset reveals higher concentration of organic matter followed by sulfate, ammonium, and black carbon mostly confined within the boundary layer inside the Indo-Gangetic Plain (IGP)—one of the most densely populated areas of the world. Above the boundary layer, the measurements show the dominance of coarse mode dust aerosols between 3-6 km transported from the adjacent Thar Desert. Outside the IGP, the sulfate component is found to dominate the aerosol mass followed by other species. Upon arrival of monsoon season and then onwards, the mass concentration of aerosols is found to decrease significantly, by $\sim 50\%$ and $\sim 30\%$, outside and inside the IGP region, respectively.

The results presented in the paper bring an unprecedented set of information about aerosol spatial and vertical distribution, with its chemical analysis, over northern India, which can help constraint aerosol representation in the models and satellite-based remote sensing algorithms. However, first, it was a little surprise to me that authors didn't include the CALIOP space lidar data to complement and support (or not) their findings. CALIOP lidar provides a detailed vertical structure of aerosol backscatter and extinction that can be compared with the aircraft measurements for the consistency (or lack thereof) check. Second, the ground-based AERONET aerosol measurements at a couple of sites (Kanpur and Gandhi College) located in the center of IGP can also offer another perspective and correlation to the presented measurements. Authors are strongly recommended to add these two components to the article which, in my opinion, will further enhance the content and quality of the work.

Specific suggestions on the paper are listed below. The article is mostly well-written with some attention needed to improve the presentation, e.g., long sentences, punctuations. The content highlighted in the paper certainly fits into the scope of the ACPD journal and can be published given that above two major concerns are addressed.

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Thanks.

Specific comments:

It was a little surprise to me that authors didn't include the CALIOP space lidar data to complement and support (or not) their findings. CALIOP lidar provides a detailed vertical structure of aerosol backscatter and extinction that can be compared with the aircraft measurements for the consistency (or lack thereof) check. Second, the ground-based AERONET aerosol measurements at a couple of sites (Kanpur and Gandhi College) located in the center of IGP can also offer another perspective and correlation to the presented measurements. Authors are strongly recommended to add these two components to the article which, in my opinion, will further enhance the content and quality of the work.

CALIPSO browse images https://www-calipso.larc.nasa.gov/products/lidar/browse_images/production/

Daytime CALIOP/CALIPSO overpass on the Indian subcontinent on June 11th
Night-time overpass on June 30th
Daytime and nighttime overpass on July 11th

AERONET data over Kanpur and Gandhi College: <https://aeronet.gsfc.nasa.gov/>
AERONET volume size distribution and fine-mode fraction can be compared with aircraft measurements, at least on a qualitative sense.

Title: Remove 'comma' and 'the'

Abstract: Line 4: "...high mass concentration of dust(?)" Line 11: what is 'std'? Line 20-25: Elevated concentration of dust at altitudes >1.5 is a clear indication of dust transport from the Great Indian Desert, also called the Thar Desert, in northwestern India

Introduction Page 3, line 17: "...have been subject to analysis now for nearly two decades" Jethva et al. (2005) has been one of the early research works highlighted the seasonal variability of aerosols, both natural and anthropogenic, over the Indian sub-continent using satellite and ground measurements.

Jethva, H., S. K. Satheesh, and J. Srinivasan (2005), Seasonal variability of aerosols over the Indo-Asian Gangetic basin, *J. Geophys. Res.*, 110, D21204, doi:10.1029/2005JD005938.

Page 3, line 21-22: “Much uncertainty. . .that determine the resultant climatic impact of aerosols as well as the regional air quality”

Methodology and Climatology Page 4, line 8: “A total of twenty-two science flights. . .”

Results: Page 8, line 14-15: Figure 3: The extinction profile derived from lidar measurements show peak concentration between 1.5 to 2 km for June 11th-flight B956; that for June 12th-flight B957 shows centroid of the aerosol layer at 3 km with the presence of aerosols with reduced extinction from 6 km to all the way to near-surface. The author needs to reword the interpretation of Figure 3.

Last paragraph: It is striking to me that NW region shows a minor peak in SO₄ between 4 to 6 km, but the peak is much clearer and more pronounced over IGP. There is no doubt, in my opinion, that elevated peak in concentration over IGP is a result of transported dust from NW, likely from the Thar Desert, but it is intriguing and a bit counter-intuitive that such peak isn't observed over NW!

Page 9, Figure 5: Please mention in the caption that the data belongs to the first 1000 meters of the atmosphere. Page 10, first paragraph: Bringing here the size distribution retrievals from AERONET over Kanpur and Gandhi College stations for the same dates or nearby dates is necessary here to complement and compare the aircraft observations.

Page 13, line 1: “. . .aerosol haze in and around the IGP” Page 13, line 16: “aerosol presence”

Page 14, line 16: “such as China with a ratio of”

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2018.

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