Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2019-657-AC1, 2019

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Vertical profiles of sub-micron aerosol single scattering albedo over Indian region immediately before monsoon onset and during its development: Research from the SWAAMI field campaign" *by* Mohanan R. Manoj et al.

Mohanan R. Manoj et al.

manojshibika@gmail.com

Received and published: 11 December 2019

At the outset, we thank the reviewer for the observation that "overall, the present work appears to be a scientifically sound exploration of this topic" and also recognizing that "Aerosol-monsoon interactions over South Asia is a very active research topic for which many open questions remain." We fully agree with this. However, while thankfully acknowledging the reviewer's overall appreciation of our paper; we disagree to some of

Printer-friendly version

Discussion paper

the comments and inferences, which apparently led to the negative recommendation. Our reasons are given below:

1. The joint INDO-UK campaign SWAAMI was conceived to address to some of the most important gaps in aerosol monsoon interactions; in which, the vertical profiles of SSA over the core Indian monsoon region (that is the Indo-Gangetic Palins, IGP) prior to the onset of Summer monsoon and its maturing phase is identified as one of the key parameters to be measured; as this information is lacking over this region, and this period, when the aerosol system of the IGP is most complex; being a mixture of advected mineral dust and local emissions (including BC, sulphates, nitrates and organics) and the meteorology is in the transformation; with moist air from the northern Indian ocean super posed over the dry air from West Asia and the intense heating of the Gangetic plains (with temperatures typically above 40°C over the entire region, leading to intense convective mixing. The time of the campaign and the type of instruments and the flight paths all were chosen accordingly, and of the several measurements of aerosols, clouds and radiation made using the FAAM aircraft of UK, we address to the specific topic of SSA and its vertical distribution just before and just after the onset of Indian Summer Monsoon to understand how the energetics changes due to change in aerosol distribution and also interaction with the monsoon system. This way, the experiment and its results are scientifically very important.

2. To our knowledge, there are no in situ measurements of SSA over this region, during the monsoon-onset phase, going as high as 6 km or above and in that way our results are the first of their kind and most relevant to the objectives of the bigger campaign. (We address to the specific issues pointed out by the reviewer, separately under other specific comments.) As such, we believe it to be apt for the reputed journal of ACP, which is bringing out a special issue on South Asian Aerosols and monsoon interaction, recognizing its topical importance. As such, we humbly disagree with the reviewers notion implying that this is 'yet another study'. In fact, this is unique, for the first time measurement of SSA over the Indian mainland up to almost mid-troposphere.

3. Further, our results very clearly have brought out the importance of the altitude resolved SSA and the large difference it makes to the vertical structure of aerosol heating rate over this region than those estimated using the currently available columnar SSA values (derived from sunphotometer networks or combination of space borne data). Such a result is also not reported so far from many places over the globe; but not at all from South Asia.

We have revised the manuscript to bring out the above aspects in focus. Responses to Specific Comments:

1) Significant variation in the SSA was observed during the campaign, with values ranging from near unity to as low as 0.7 in one region".

Yes, we agree and in fact, this itself is a very important finding; especially the low values of SSA at higher altitudes have significant implications for aerosol cloud interactions and monsoons, besides in direct atmospheric warming due to absorption of radiation, above low-level monsoon clouds. We have emphasized this aspect in the revised version of the manuscript (page 6, lines 21-22).

2) Only six different profiles are presented, and only one pair of these consists of measurements made before and during the monsoon at the same location.

Yes, we agree and also wish we had more flights from different locations. However, technical and logistical constraints and the delay in getting the aircraft readied before onset of monsoon had put a limitation on the number of sorties that could be made before onset. Nevertheless the results from the limited number of flights are quite significant

3) Many other studies have explored monsoon-aerosol interactions over India using aircraft data (see Li et al., 2016)-including an analysis of measurements from the same period as the present manuscript (Vaishya et al., 2018)-and it is not clear to me what makes the data presented in the present work particularly unique.

We partly agree and partly disagree. Firstly, there are not 'many other studies' over this region. In fact, there were none before SWAAMI; as has been said in out general response #2. A few aircraft measurements that are available over the IGP pertained to winter and early spring, when the meteorology is different, convection is weak and long-range transport is subdued. Even the paper mentioned by the reviewer (Vaishya et al 2018, which itself was part of the SWAAMI campaign) had limitations in its vertical extent (covering only up to 3 km above ground level) and also pertained only to the scenario prior to onset of monsoon. It did not examine the changes as the monsoon progressed. Our measurements yielded SSA profiles as high as 5 km in its vertical coverage and covered the pre-onset and main phases of the monsoon (page 3, lines 8-13). Presence of absorbing aerosols at higher altitudes (below low-level monsoon clouds) are very important due to two processes; one amplification of absorption due to the reflective clouds underneath and two, the higher warming for same amount of radiation absorbed, due to the thinner air at higher altitudes. These are the uniqueness of our results and we have better focused on these in the revised manuscript (page 10, lines 11-13).

The other measurements available (on which Ramanathan et al 2007 relied upon greatly) are the ones during the Indian Ocean Experiment airborne measurements (Ramanathan et al 2001), and by Corrigan et al 2008; both of which were confined to the south Asian outflow over the Indian Ocean and Southeast Asia, during late winter to early spring when the synoptic meteorology was different. It did not cover any part of the Indian landmass; not even the southern peninsula and thus did not provide the information prior to onset of monsoon, especially over the IGP with its unique characteristics.

On the other hand, the Li et al. (2016) paper is a sort of overview paper, based primarily on modelling and past observational data. The paper did not use any realistic SSA profile over Indian / South Asian landmass (for any season) and this vindicates the absence of this critical information and the dire need for it. This is the knowledge-gap

SWAAMI aimed to bridge. We are revising the ms to bring these novelties to clear focus of the reader.

References

Corrigan, C.E., Roberts, G.C., Ramana, M.V., Kim, D., Ramanathan, V., 2008. Capturing vertical profiles of aerosols and black carbon over the Indian Ocean using autonomous unmanned aerial vehicles. Atmos. Chem. Phys. 8, 737-747.

Li, Z., Lau, W.M., Ramanathan, V., Wu, G., Ding, Y., Manoj, M.G., Liu, J., Qian, Y., Li, J., Zhou, T., 2016. Aerosol and monsoon climate interactions over Asia. Reviews of Geophysics 54, 866-929.

Ramanathan, V., Crutzen, P.J., Lelieveld, J., Althausen, D., Anderson, J., Andreae, M.O., Cantrell, W., Cass, G., Chung, C.E., Clarke, A.D., Collins, W.D., Coakley, J.A., Dulac, F., Heintzenberg, J., Heymsfield, A.J., Holben, B., Hudson, J., Jayaraman, A., Kiehl, J.T., Krishnamurti, T.N., Lubin, D., Mitra, A.P., MacFarquhar, G., Novakov, T., Ogren, J.A., Podgorny, I.A., Prather, K., Prospero, J.M., Priestley, K., Quinn, P.K., Rajeev, K., Rasch, P., Rupert, S., Sadourny, R., Satheesh, S.K., Sheridan, P., Shaw, G.E., Valero, F.P.J., 2001. Indian Ocean Experiment: An integrated analysis of the climate forcing and effects of the great Indo-Asian haze. Journal of Geophysical Research 106, 28,371 - 328,398.

Ramanathan, V., Ramana, M.V., Roberts, G., Kim, D., Corrigan, C., Chung, C., Winker, D., 2007. Warming trends in Asia amplified by brown cloud solar absorption. Nature 448, 575-578.

Vaishya, A., Babu, S.N.S., Jayachandran, V., Gogoi, M.M., Lakshmi, N.B., Moorthy, K.K., Satheesh, S.K., 2018. Large contrast in the vertical distribution of aerosol optical properties and radiative effects across the Indo-Gangetic Plain during the SWAAMI–RAWEX campaign. Atmospheric Chemistry and Physics 18, 17669-17685.

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2019-657,

2019.

Printer-friendly version

Discussion paper