

## ***Interactive comment on “Assessment of Regional Aerosol Radiative Effects under SWAAMI Campaign – PART 2: Clear-sky Direct Shortwave Radiative Forcing using Multi-year Assimilated Data” by Harshavardhana Sunil Pathak et al.***

### **Anonymous Referee #2**

Received and published: 2 July 2020

#### General Comments:

This manuscript presents spatial variations of seasonal mean shortwave aerosol direct radiative forcing (ARF) at surface, atmosphere and TOA over the Indian region based on satellite observations and statistical assimilation of data from a network of ground-based observatories and multi-satellite products (methodology described in an earlier paper - Part-I). These are also compared with direct estimations of shortwave fluxes from satellite (CERES) observations. The results clearly show the superiority and reliability of ARF estimated using the assimilated data.

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The topic of research is highly relevant, the manuscript is well written, the data is reliable and adequate, the analysis and estimates are robust and the results provide significant advancement to the present understanding on the impact (direct radiative effect) of aerosols over the Indian region. I recommend publication of this manuscript in ACP after considering the following suggestions, which are primarily to provide better clarity on the results presented.

#### Specific Comments:

1. Page-3, Lines 26-30: Clarify on any seasonal variation of the externally mixed continental aerosol model used here (from which the phase function is obtained). Is it seasonally and spatially varying (as the aerosol type undergoes a significant spatio-seasonal variations, which is also stated in Page-4, Lines 6-14). If same phase function is used in all seasons, what is the sensitivity (typical values, preferably in percentage) of the estimated ARF to any expected variations in the assumed phase function? SSA and AOD are already described in the manuscript.
2. Clarify on the altitude profile of aerosols used in the RT simulations. Discussion of the results and some of the inferences drawn (e.g. Page-11; Lines 13-18) are based on the altitude profile of aerosols. While the statements in Page-11, Lines 13-18 are valid, it is to be seen if they are the result of the altitude variation of aerosol profiles used in the present RT calculations.
3. Statement on the uncertainty in the CERES-derived instantaneous TOA Shortwave radiative fluxes should be included.
4. Clarity on the estimation of diurnal mean ARF may be provided (like the integration of instantaneous ARF from sunrise to sunset or in terms of solar zenith angle, or otherwise). Equations (1-3) are local time dependent at any given location.
5. Figure-8; Pages 15-16: This needs to be clearly understood.  $\Delta_{AS}$  represents the difference between instantaneous  $AS_{RAD\_TOA}$  and  $CERES\_TOA$  (Eq.7). Ide-

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ally, this difference would be zero as the CERES fluxes as well as the assimilated AS\_RAD\_TOA are highly reliable (the former is directly estimated from the observed radiances through appropriate ADMs – which is pivotal in the global radiation budget estimates - while the later account for surface albedo and observed aerosol properties). Any biases in either of them would be very small or insignificant. Hence the RMS differences in Delta\_AS (having magnitude of 40-60 Wm<sup>-2</sup>) would arise from the uncertainties (random errors rather than bias) in CERES fluxes and estimated AS\_RAD\_TOA. In order to understand this properly, please provide the following: (i) mean of CERES\_TOA fluxes for different seasons and annual mean, (ii) corresponding mean differences between instantaneous AS\_RAD\_TOA and CERES\_TOA, (iii) typical uncertainties in AS\_RAD\_TOA and CERES\_TOA and (iv) statement on which factors contributed to Delta\_AS shown in Fig.8.

6. Figure 2a; Page 7, Lines 21-23: What led to the positive values of TOA ARF over the east Peninsular India? Low SSA? Over Himalayas, it might be because of high surface reflectance. Over NW India, surface reflectance and low SSA might have contributed. State clearly.

7. Page-7, Line-8: Can the month 'May' be treated as representative of summer and pre-monsoon? See the other parts of the manuscript where summer (JJA) and pre-monsoon (March-May) are clearly discriminated (e.g., Line 27, Page-15).

8. Page-4, Lines-7, 12: Add Figure number (Fig.1)

9. Proper usage of brackets while citing reference (e.g., Page-2, Lines 13, 15).

10. Page-7, Line-10: Change "... atmosphere As..." to "... atmosphere. As..."

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Interactive comment on Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2020-454>, 2020.