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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Estimating the effects of aerosol, cloud, and water vapor on the recent brightening in India during the monsoon season" *by* Feiyue Mao et al.

Anonymous Referee #1

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The authors examine changes in surface solar radiation (SSR) in the region of India during the monsoon period (June to September) from 2006 to 2015. They relate the SSR changes to changes in aerosol optical depth (AOD), in clouds, and in water vapor. The study relies mostly on satellite products, notably CloudSat, CALIPSO, CERES, and MODIS. The authors find SSR to increase with time, which they ascribe to a decrease in clouds that overcompensate the effect of increasing AOD.

The overall topic of the study - changing SSR in India and its causes - is of interest and suitable for ACP. However, in its present form the study suffers from various shortcomings and a general lack of precision, as detailed below under major (and minor)

comments. In particular, the data presented looks, at least in parts, as if it were not a June-September average but rather representative for a specific time of the day. This casts doubt on the entire analysis. Therefore, I recommend rejection of the manuscript in its present form.

Major comments:

1) SSR magnitude / averaging period. The study deals (see its title) with recent SSR brightening in India. Looking at figure 1b, which shows corresponding key quantities (short-wave radiation at TOA and surface), two thoughts / questions come to mind. First, the radiative fluxes shown are very high, e.g. "TOA Incoming Solar" is around 1230 Wm-2 whereas one would expect for a June mean for India something more on the order of 400 to 500 Wm-2. Why? See also the next two major comments. Second, the SSR trend shown in the figure has a p-value of 0.42, thus the SSR brightening the authors aim to explain is not statistically significant.

2) A-train data. A-train has a small footprint, what then is the overpass statistics over the domain of interest? What is the statistical uncertainty of an individual June to September data point, e.g. CloudSat vertical cloud frequency? Is overpass time (A-train equator crossing around 1:30 am and 1:30pm local time) an issue for the presented analysis? The "TOA Incoming Solar" in Figure 1b may suggest so, as its value is around 1230 Wm-2, whereas a June mean for India is more on the order of 400 to 500 Wm-2. If the data is instantaneous, how representative is it for the entire monsoon season?

3) Products used. It would be helpful if the authors stated more clearly, in Sections 2 and 3 as well as in the figure captions, which variable they take from which satellite / model product and what the intrinsic uncertainty is of the product and why. Also, it should be discussed to what degree different products (satellite and model) can be inter-compared / combined.

4) Season chosen. The authors focus on the monsoon season, June to September, when AOD tends to be lowest over India and cloud cover tends to be particularly pronounced (e.g. Raja et al., Atmos.Env. 142, (2016), p. 238-250; or Nair et al., Clim.Dyn. 49, (2017), p.1411-1428). Why this choice? And how do results for this season compare with, for example, results based on annual means?

5) Averaging region. I assume that line plots, as e.g. in Figure 2 or in Figure 3a, are averages taken over the region shown in the maps, e.g. in Figure 3c. If so, the average includes a substantial amount of sea and of the Himalaya. So the averages shown are not actually averages over India. The authors should comment on how this affects their results.

6) Statistical significance. While the authors give p-values in some of the figures, they do not address them in the text. Given that many p-values exceed 0.05 or even 0.1 the authors should comment on them. Also, there is no statistical significance given for any of the maps.

Minor comments:

a) p.6, l.6: What do you mean by "... with the scene that the lidar penetrates the entire atmosphere to exclude the effect of un-penetrated profile for lidar. "?

b) p.6, l.10: What do you mean by "The low significant level occur in the line trend of AOD detected by MODIS, and mainly result from the disturbance of widespread cloud during monsoon season. "?

c) p.6, l.12: What do you mean by "Moreover, aerosols mostly consist of dust, smoke, and polluted dust. These aerosols all present distinct absorbing effects on solar radiation, thereby attenuating the incoming solar radiation more intensively than do other types of aerosols in the surface. " What other types of aerosols? And why should aerosol mostly consist of dust, smoke (black carbon?), and polluted dust?

d) p.7, l.21: "...the change of LW vertical heating rate is insignificant and similar to that in SW." However, for SW you claimed that it is significant. How then can it be similar?

e) p.7, l.23: "...but cooling by 0.1 - 0.2 Kd-1 within the cloud..." Looking at Figure 4, cooling seems rather on the order of 1 - 2 Kd-1.

f) p.7, l.24: What do you mean by "In general, the net vertical heating rate weakens consistently, indicating that the changes of clouds physical characteristics shift the vertical heating and cooling, and weakening the vertical radiative effect of clouds. "?

g) p.8, l.1: "particle number concentration", do you mean "cloud droplet number concentration"?

h) Section 3.3: How is clear sky defined? I assume via 'few clouds in the pixel', but a) what is few and b) how many pixels remain / what is the statistics?

i) p.8, l.22: "Notably, high concentration of water vapor is favorable to generate more or stronger clouds and thus less radiation in surface and vice versa." One may debate this statement as clouds depend on two parameters: water vapor and temperature. The latter changes as well in your data, I assume, as SSR and heating rates change.

j) p.9, l.14: "However, the conclusion of this study is significant even when overestimated factors are considered." Why should this be so?

k) Figure 1a: Where does the line for "Dust, Smoke, Polluted Dust" come from? Which satellite / model data?

l) Figure 1b: y-axes should read "Radiative Fluxes" (not Fluxs).

m) Figure 7a: As for Figure 1b, the values are way too high to be monthly means. Colors in the figure and in the figure caption do not match.

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