

Reviewer Comments on the paper entitled “**A long-term observational analysis of aerosol-cloud-rainfall associations over Indian Summer Monsoon region**” by Chandan Sarangi et al., 2016.

This paper examines the relationship that exists between aerosols and precipitation through aerosol-cloud-interaction. In general the paper is written well, analysed with all the available techniques for separation from meteorological effects, and necessary references have been cited properly, but it can be improved further by correcting the comments and concerns. Though the authors have taken efforts in doing such a laborious analysis, the anticipated results are more qualitative in nature due to the complexity with decoupling the meteorology. Hence, I suggest the reviewers to take up a major revision of the same by considering the comments given below. The detailed review comments are provided below.

### Major Comments

1. Page 4, Line 4: For a comprehensive review, discuss briefly on other studies which report evidences for increase in rainfall as a result of enhanced warming over IGP region due to aerosol radiative effects and associated dynamical feedbacks (Lau et al, 2006; Manoj et al., 2011 etc.).
2. Page 9, line 5: Why 25<sup>th</sup> and 75<sup>th</sup> percentile between high and low AOD conditions were used? In section 2.3, the authors had adopted 33 and 67 percentiles. Why are these cut offs different, and what is the condition which these limits have been based up on?
3. Page 11, Line 3: Since the authors have all the relevant meteorological profiles at hand from CAIPEEX experiment, why the assumption regarding exponentially decreasing temperature pulse of 3° C was used?
4. Page 13, Lines 20-23: ‘The height above the LCL where the theoretical temperature of a buoyantly rising moist parcel (following wet adiabatic lapse rate) becomes equal to the temperature of the environment is referred to as equilibrium level’. This statement is not exactly correct. The Level of Free Convection (LFC) also satisfies the above criteria. Hence it is correct to change as: ‘The height above the **LFC**.... to as equilibrium level’.
5. Page 17, Lines 5-6: (a) ‘Thus, the aerosol indirect effect could be twice as high as aerosol direct effect over ISMR’. How did the authors estimate the indirect radiative effect? The Reviewer is doubtful about this statement here. Cloud formation is not simply as a result of aerosol indirect effect alone; however, it requires conducive thermodynamical and dynamical atmospheric processes too. Hence, the reported cooling by 30 Wm<sup>-2</sup> cannot be attributed to aerosol indirect effect alone, if the authors estimate the indirect effect by simply sorting AODs under cloudy conditions, and estimate the indirect forcing. (b) Reported cut-off values of AOD ≈ 0.3 illustrates that up to 0.3 AODs, the indirect effect dominates and beyond this limit the aerosol-radiation interaction effect dominates. No mention about this cut off is mentioned in this paper.
6. Figure 6. Each line colour in Figure Caption given for Ex1 is wrong compared with those given in the Figure itself. Please correct. Same for other figures too (e.g. Figure 8)

7. Page 21, Line 5: Is the vertical updraft velocity only 0.2 cm/s, when the convection is strong? Or is it in the unit of meter/second (instead of cm/s)?
8. Page 26, Lines 15-19: Give a discussion on whether aerosol invigoration leads to increase in total rainfall averaged over all grids and time, or if it leads to a redistribution of rain with suppressed rain at initial time, and enhanced precipitation at a later stage so that total surface precipitation is nearly conserved.
9. Figure 10 needs precise description for a general reader to comprehend the basic idea, especially about the x-axis, and the shaded region.
10. Page 26, Lines 22-25: A major drawback of the correlation analysis here is that it represents simultaneous correlation. However, aerosol build up might have taken place prior to cloud maturity and rain initiation, and subsequently could have reduced due to cloud scavenging and wet removal. A lag correlation analysis at cloud formation time scales could have been more meaningful here.
11. Section 3.4 could be merged with an earlier description of AOD retrieval errors associated with contamination due to RH. This section is a repetition.

#### Minor Comments

1. Title: 'Association' instead of 'Associations'.
2. Abstract, Line 31: Change to 'Simulated microphysics also illustrated *that* the...'
3. Abstract, Line 36: Correct as: 'While the meteorological variability influences'
4. Abstract, Line 37: Change to 'association' instead of 'associations'.
5. Page 2, Line 9: Remove comma (,) after 'cloud base'.
6. Page 3, Lines 4 & 15; Page 9, Line 20, and many places: Correct 'AP Khain et al.' to 'Khain et al.'.
7. Page 4, Line 2: Replace 'as well as' by 'and'.
8. Reference required: '...lower available spatial resolution (i.e. 0.25<sub>o</sub>×0.25<sub>o</sub>) was in general biased to smaller clouds..'
9. Page 9, line 1: Correct: 'CLOUD-aerosol Lidar and infrared pathfinder SATellite (not *CloudSat*, but *CALIPSO*)'.
10. Page 22, line 18: Correct: 'droplet spectral'.
11. Page 30, Lines 5: Remove 'other'.
12. Page 33, Lines 5: Change to 'found *to be* in-line...'