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Comment

## ***Interactive comment on “Measurement-based direct radiative effect by brown carbon over Indo-Gangetic Plain” by A. Arola et al.***

**Anonymous Referee #1**

Received and published: 7 September 2015

The manuscript “Measurement-based direct radiative effect by brown carbon over Indo-Gangetic Plain” by Arola et al. presents a novel approach to determining the total aerosol, black carbon (BC), and brown carbon (BrC) direct radiative effect (DRE) using AERONET inversion data products obtained from four AERONET sites in the Indo-Gangetic Plain region. In addition to providing valuable information regarding the sign and magnitude of the DREs, the manuscript details a unique analysis on the seasonality of the DRE for each aerosol type. Overall, the manuscript presents interesting results to a solid analysis and would make a nice contribution to ACP. However, before publication, I believe the following points should be addressed:

-Some statistics on the relevant parameters are needed. Error bars representing one standard deviation on the monthly averages should be included on all the panels in Fig.

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3. How variability in these parameters impact monthly differences in the DREs should be assessed in order to confirm the seasonal cycle.

-As suggested by Lack and Cappa (2010) and Kim et al. (2015) there may be a spectral dependence of kBC, especially those particles containing coatings. Some analysis or discussion on how a spectrally-dependent kBC would impact the calculated BrC volume fractions (and thus the BrC DREs) should be included in the text. Alternatively, if the assumption that considering only pure, uncoated BC is indeed valid for this region and/or this method, this should be stated and supported with references.

-It is my understanding the BrC refractive index (and its spectral dependence) are not well established. A reference and reason as to why the selected BrC refractive index was used would be helpful, even if this is already stated in the referenced Schuster et al. (2015a) paper.

-The results section (Section 3, starting on page 21591, line 5) was a bit confusing; as is, the discussion jumps back and forth between Fig. 4 and 5 too much. I suggest restructuring it so that the discussion and description of the more generalized relationship between BrC and BC volume fractions and the differences in  $k$  (i.e., Fig. 5) precedes the discussion of the time series in Fig. 4. Also the lines in the bottom panel of Fig. 5 are confusing. I understand each point represents the monthly average BC and BrC volume fractions starting with January at the star but it's not clear it's really showing anything valuable. I recommend only plotting April and November (the middle of the two interesting periods) or removing them all together and referring to Fig. 3.

-Two of the most interesting and important findings of this work are 1) the seasonality in BrC radiative forcing and 2) the fact assuming spectrally-invariant BrC can result in offsets upwards near a factor of 2 in BrC DRE. However, the significance of these results seems to get a bit lost in the comparison to the total aerosol DRE which appears to have no relationship seasonally or otherwise to BrC DRE. Further, because this comparison occurs at the very end of the discussion, it leaves the reader with a bit

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of “so what?” feeling. I suggest re-framing the big picture and focusing more on the potential errors introduced in the estimated positive forcing associated with carbonaceous aerosols when BrC DRE is neglected. This can be done by including a panel showing the monthly contribution of BrC DRE to total carbonaceous aerosol DRE (BrC +BC) as a ratio or percentage, either in addition to or in replacement of the BC DRE in Fig. 6 and adding some corresponding text in the discussion. This would show that, while BrC might be a minor contributor to the total aerosol effect in this region, it does contribute with some significance to uncertainties in the positive RF (upwards near 10% for some months based on Fig. 6) associated with aerosol absorption.

Other specific comments:

Title: I’m not sure if this should be considered “measurement-based” since the analysis relies on parameters obtained indirectly (retrieved) from radiance and direct-sun measurements. I would suggest removing “measurement-based” and starting the title either as “Retrieved direct-radiative...” or just “Direct-radiative...”

Page 21586, line 25 and Page 21587, lines 7-8: So are Level 1.5 or Level 2.0 size distributions used? Clarify.

Page 21589, lines 3-8: For those instances in which dust is placed in the fine mode, how is BrC distinguished from dust for k440? Do any of these instances occur in March-May? If yes, how does this impact the results shown for the pre-monsoon dust season (March-May) when BrC is noted to have a high BrC volume fraction?

Page 21589, lines 28-29: See above. If goethite and hematite were not distinguished from BrC in the fine mode, could the enhancement in BrC volume fraction be because it is really a BrC + fine-mode dust estimate?

Page 21593, lines 20-25: What are the values compared to the non-BrC DREs? A table of these values would be useful.

Minor editorial comments:

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Page 21584, line 4: Remove “those” in second sentence.

Page 21585, line 1: Need an “and” before (2).

Page 21586, line 7: AERONET does both a direct-sun and sky radiance measurements at 440, 670, 870, and 1020nm. Add “also” between “are” and “used” to make this clearer.

Page 21592, line 24: Remove “best.”

Page 21594, line 8: Add “an” between “using” and “identical.”

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Interactive comment on Atmos. Chem. Phys. Discuss., 15, 21583, 2015.

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