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## ***Interactive comment on “A multi-model evaluation of aerosols over South Asia: Common problems and possible causes” by X. Pan et al.***

### **Anonymous Referee #1**

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#### General comments:

Pan et al., 2014 discuss the multi-model evaluation of aerosol distributions over the South Asian region. The focus is on understanding the common problems in model-simulated aerosol properties and possible causes of underestimation of model-simulated aerosol properties. Even though model underestimation of aerosol properties over South Asia are previously reported in regional-scale analysis (e.g. Reddy et al., 2004; Ganguly et al., 2009), the multi-model evaluation of aerosol distributions over South Asia could be useful for the scientific community.

The paper is generally well written and the possible causes of underestimation of AOD such as relative humidity and emission amount are quite interesting. The multi-model

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simulated aerosol properties are evaluated using different observation data sets (e.g. ISRO-GBP, ICARB and satellites). Dust aerosol underestimation is previously reported as one of the possible causes in AOD underestimation especially in pre-monsoon season over South Asia. However, the inter-model differences and pre-monsoon underestimations are not well described in the manuscript. These points need to be addressed in the manuscript in context with the existing literature. The following comments should be addressed before the manuscript would be satisfactory for publication in ACP.

Specific comments:

1) In Section 4.1 and 4.2, large diversity among model-simulated AOD is visible. The possible causes of inter-model differences over IGP region are not clear from the manuscript. Varying wet /dry deposition rates and emission fluxes do cause significant variations in a single model, but these uncertainties do not explain most of the inter-model differences. Textor et al. [2007] also found that inter-model differences were only partially explained by differences in emission inventories. Bond et al., [2013] pointed out large differences in modelled horizontal and vertical transport are largely responsible for the inter-model diversity for BC distributions. It could be useful if authors highlight the most significant parameter in the model need to be focussed for improving the aerosol distributions over South Asia instead of one general sentence that mentioned the manuscript (Page 19119, lines 15-19).

2) In Section 5, different possible cause for AOD and AAOD underestimation is described. The underestimation of natural aerosols (e.g. dust) emission flux may also lead to error in total aerosol distributions. Previous studies reported that dust emission flux underestimation can lead to underestimation of model-simulated AOD over South Asia/IGP during pre-monsoon (MAM) season (e.g. Cherian et al., 2012). Few information are reported in the manuscript Section 2.2 (Page 19103, lines 1-5). In Fig.5, the pre-monsoon season (MAM) AOD is not well captured by most of models over Kanpur. The spatial distribution of AOD is also partially captured by all models during this season (Section 4.3). This could be due to missing dust transport to Kanpur from

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dust source regions. It could be useful if authors provide more informations about the inter-model differences in dust aerosol treatment and estimated model differences in dust emissions.

3) The information about aerosol refractive index for each species used in the different models is missing from the paper. For example, Black Carbon and Dust AODs are strongly depend on refractive indices used in the model. The refractive index information could be useful for understanding the inter-model differences in AODs. It could also useful for providing the future model improvements of AOD distributions over South Asia.

Technical comments:

Page 19099, line 8: aboved?? Page 19110, line15: It is interesting to see nitrate rather than dust dominate AOD over northern India in the Had Gem model. Whether this is the reason for satellite observed AOD well simulated during winter by this model over South Asia? Page 19112, Section 4.5: Moorthy et al., [2013] pointed out that improvement in the atmospheric boundary layer (ABL) parametrization in GOCART model over tropical region might improve the model-simulated BC distributions. How the authors comment about this? Page 19113, line 24: It is not clear what “low bias” means? Rewrite the sentence. Page 19114, line 7: Only BC surface concentrations are severely underestimated over IGP? All the models underestimate sulphate by 5-50% (Page 19115, line 15). Page 19114, line 17: Correct the sentence. Page 19115, line 15: What is the reason for sulphate underestimation? Is it related to the sulphate chemistry scheme used in each models? In the Conclusion section, point 2 (Page 19120): BC concentrations are better captured by models over Kharagpur. This should be mentioned in this section. In the Conclusion section, point 4 (Page 19121): Better represent nitrate in the models is not clear. Whether Nitrate emissions or chemistry scheme used in the models?

Figures 4, 5 and 6: Quality is poor. Lines and colours are not clearly visible. Figures

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7a-d: Its very difficult to compare spatial distribution of AOD in different seasons. Better provide mutli-model mean and deviation against observations and move these figures into supplementary information.

#### References:

Bond, T. C., et al. (2013), Bounding the role of black carbon in the climate system: A scientific assessment, *J. Geophys. Res. Atmos.*, 118, doi:10.1002/jgrd.50171.

Cherian, R., et al. (2012), Examination of aerosol distributions and radiative effects over the Bay of Bengal and the Arabian Sea region during ICARB using satellite data and a general circulation model, *Atmos. Chem. Phys.*, 12, 1287–1305, doi:10.5194/acp-12-1287-2012.

Textor, C., et al. (2007), The effect of harmonized emissions on aerosol properties in global models-An AeroCom experiment, *Atmos. Chem. Phys.*, 7(17), 4489–4501, doi:10.5194/acp-7-4489-2007.

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