General comments:

The research presented here explores the relationship between cloud fraction (fc) and aerosol optical depth using multiple datasets to determine the causes for the persistent positive slopes derived using satellite data. This is an intriguing problem that points to the challenges inherent in remote sensing applications and in the implications of using this data for understanding the climate response to anthropogenic aerosol. The potential mechanisms of the positive relationships are listed clearly, and different tools and methods are applied to investigate these possibilities. A novel approach is used to examine this response, however, statistical rigor and an assessment of the uncertainty with the fc-tau relationship derived from space and its comparison to the models is lacking. It remains unclear under what conditions can the satellite retrievals be trusted and, what options do the users have in reducing the biases (of the satellite data) described here. This paper could be a useful guide to the many scientists who use satellite retrievals to investigate aerosol indirect effects. With additional statistical tests and clarification, this paper would be suitable for publication.

It has been suggested (e.g., Penner et al., 2011, PNAS) that AI (Aerosol Index, or the optical depth times angstrom exponent) is a better proxy of cloud drop number concentration than AOD as the estimated aerosol indirect forcing using AI are closer to the values predicted by the model. Thus it would be beneficial to apply AI to discuss how it would affect the results, as also indicated by Referee #1.

Specific points:

Pg 30806 L10: What is meant by *residual*?

Pg 30806 L13: Isn't wet scavenging also an important process in the mid-latitudes?

Pg 30806 L14 – 17: Explain why wet scavenging events are "likely" poorly sampled in satellite data? I can name several instruments that have the capacity to accurately measure precipitation, such as CloudSat, TRIMM, AMSR-E, to name a few.

Abstract: The main point of this paper is aiming to understand the fc-tau relationship and all of the factors that influence the response. Is it possible to include an uncertainty or error assessment on this relationship and include this in the abstract? Such as, the average slopes (and errors on the slopes) of the Fc-tau relationships derived using each method.

Pg 30807, L2: The assumption that cloud coverage increases with aerosol is not a very good assumption. Increasing aerosol concentrations can also decrease cloud coverage via the "semi-direct effect" through absorbing aerosol (Ackerman et al., 2000; Wilcox 2010, ACP), through increasing giant cloud condensation nuclei (Feingold et al., 1999, JAS), and negative responses (such as lower liquid water path and cloud albedo) have also been observed in ship tracks (e.g.,

Christensen et al., 2012, JGR; Chen et al., 2012, ACP). For completeness, these aspects about the general science should be incorporated into the discussion.

Pg 30807, L6-7: define “large regional scales”

Pg 30807, L22-24: Explain how cloud processing affects the optical properties of the aerosol? The point of this sentence in relating the slope of fc-tau is not clear.

Pg 30807, L25: the word “additional” is unclear. How many tools prior to this are being used?

Pg 30809, L6, Are points 1 and 7 being explored? If not, explain why. This aspect is mentioned again in L3-4 of pg 30814. Why are these not tested in the paper?

Pg 30811, L20 – 26: ‘a surface albedo of 0’. It is not a very good assumption. This “back of the envelope calculation” would be more insightful if a more representative surface albedo was used, I would suggest a value closer to 0.1. Also, please clarify that increasing the cloudiness, “increases” the upwelling shortwave radiation at the top of the atmosphere, not “decreases” it! In addition, more clouds are going to “decrease” outgoing longwave radiation at the top of the atmosphere. Perhaps the authors are referring to the changes at the surface, if so, please correct the terminology.

Pg 30812 L1-3: CERES does not measure low-level cloudiness, it actually ingests MODIS cloud data to infer cloud coverage over the relatively large CERES footprint of 20 km. What information from CERES was actually used in this study to derive the fc-tau relationships? And please explain why the relationship was presumably weaker in the CERES/globAerosol product compared to MODIS derived fc-tau. Was it an artifact of the retrieval? Resolution, instrument sensitivity, differences, please explain, if this dataset is to be discussed in the paper.

Pg 30813 line 29: relativity humidity → relative humidity.

Pg 30816 L12: I would add the word “aerosol optical depth” after the words “low and high.”

Pg 30816 L18: It has been commented concerning the possible model errors and bias. What kind of retrieval errors are being referred to here? Is it the “residual” cloud contamination aerosol retrieval? It would be useful if the model uncertainties and bias analysis can be provided and discussed.