

## ***Interactive comment on “A novel retrieval of daytime atmospheric dust and volcanic ash heights through a synergy of AIRS infrared radiances and MODIS L2 optical depths” by S. DeSouza-Machado et al.***

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- 1. Introduction should focus on the importance and current status of satellite retrieval of dust/ash particles, and give an introduction/review on progress of current techniques

Agreed, we have significantly expanded the relevant paragraphs in the introduction, as well as included more references.

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- 2. If new impact here is the use of MODIS data, please discuss the advantage over traditional chi-square retrieval, eg does it agree with MODIS for all cases?

We have added a number of subsections to the revised manuscript, which should help elucidate the use of MODIS data. One subsection uses a simple physical based model that explains the method and should make clear the advantage over the  $\chi^2$  retrieval. As also pointed out by Referee 2, more figures could be added to improve the paper. We rewrote the retrieval so that instead of finding the nearest height at which MODIS/AIRS optical depths = 4, we interpolate the retrievals at the coarse 1.5:0.5:6 km grid to a finer grid, allowing us to more accurately find the crossing point when MODIS/AIRS = 4. From this, a subsection with 2d histograms that compare retrieved AIRS optical depths to MODIS optical depths, and AIRS/MODIS retrieved heights to CALIOP heights has been added. The sub-section also compares the  $\chi^2$  retrievals and GOCART climatology for the Atlantic region, while an appendix covers the Pacific, Mediterranean and Asia/Africa regions.

- 3. Inaccuracies include "though less sensitive .. is this true for an infrared instrument (cf ice cloud)?

The paper describes the co-relationship between height and optical depth versus IR signal, but as pointed out by the referee(s), did not explicitly lay out the sensitivity to scatterers present at high altitudes. Just as for dust/ash, infrared instruments are sensitive to thin cirrus since the cold temperatures associated with the high altitude at which the scatterers are located, would significantly impact the absorption and re-emission, and hence measured radiances in the thermal infrared window. The revised manuscript now contains this description.

- 4. How can more accurate height determination improve UV retrievals, which is

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sensitive to aerosol height?

As with IR/VIS instruments, a synergy of IR/UV instruments would improve the optical depth retrievals in the UV. We have added "by co-locating the IR-retrieved heights to the UV-radiances" for clarification.

- 4. Sensitivity to scattering parameters and micro-physical parameters need to be shown

The focus of the paper is the retrieval of height and loading, and we choose not to investigate the effects of particle size or refractive index here. A number of papers have already shown how sensitive the infrared instruments are to variations in refractive indices (which impact the scattering parameters), and other micro-physical parameters. A paragraph has been added that explains their findings, and the papers have been added as references.

- 5. Comparisons amongst different instruments : please add strength and limitation of these techniques and why they are different

We hope the revised manuscript more clearly compares the two methods of determining heights using AIRS radiances. The daytime synergy using MODIS L2 optical depths has the strength that it is a strong constraint on the retrieved IR optical depth, which varies with height. The weaknesses include lack of MODIS L2 in sun glint regions or at high winter latitudes (and nighttime), and also inaccuracies in the MODIS L2 product (such as ash in the presence of broken cloud). The minimization of AIRS biases is sensitive to the underlying geophysical state, scattering parameters, and other macro-physical considerations such as dust layer thickness. Without additional information to constrain the retrieval,

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this results in a greater uncertainty in the retrieved height, but conversely can be done day or night.

- 6. Volcanic ash retrieval : high altitude peaks

We have examined many of the retrievals, and come to the conclusion that those peaks arise from a combination of circumstances. In particular, when MODIS ODs are very low, the IR height retrieval gets pushed to higher altitudes even if the IR signal is significant. The low MODIS ODs could arise because for example the ash is being retrieved in the presence of cloud, or as mentioned in the paper, no MODIS L2 retrieval was done for the pixels in question, and so the MODIS OD was filled in from adjoining regions. Most importantly, AATSR and AIRS were on different orbits, which meant the ash seen by our dust flag was not coincident in space with the AATSR data - for example the AIRS dust flag often triggered over land while the AATSR retrievals could have been over ocean and vice versa, making the evaluation of the peaks very difficult. This is now discussed more fully in the revised manuscript.