Comments from Reviewer 2 in italicized font.

Author response to Reviewer 2 in regular font.

Review of A. Wiacek, et al., "Absorbing aerosol radiative effects in the limb-scatter viewing geometry" General: The article examines the effects of absorbing aerosol layers upon sun-light scattered from the limb of the atmosphere and would be measured by a space based observer. The effects of the absorbing aerosol are contrasted with non-absorbing aerosol also. A dissection of the limb scattered radiance is done by looking at light that is scattered once and that which is scattered multiple times (the sum of the two being the total limb scattered radiance). This partitioning is helpful in illustrating the limitation of simple single particle scattering to understand the effect. The paper does a fairly good job of stating what the effects are and presenting the physical basis. The punch line that limb-scatter retrievals of aerosol extinction being insensitive to external information about aerosol absorption is an important statement and tends to get lost in the various comparisons, discussion and figures in the main body of the article. In addition, a bit more work would be extremely helpful in placing this recent work in context with earlier work focused on space based nadir observations of back scattered sunlight and absorbing aerosol in the atmosphere.

We thank the reviewer for a careful review. We tried to better emphasize that that limb-scatter retrievals of aerosol extinction are insensitive to external information about aerosol absorption. We have added more context about earlier work focused on space based nadir observations.

Comments:

Page 1900, line 2 & 1902, line 3: I generally think of the path length being on the order of 200 km for a 1 km thick shell. The entire path through the atmosphere can be thousands of km. Additionally, the high vertical resolution is only possible if the instrument has a small Instantaneous Field of View.

OSIRIS indeed has a small instantaneous FOV and we agree that 200 km is an appropriate path length for a 1 km shell (revision made).

Page 1904, line 3: Is 65 degrees truly a "low" solar zenith angle?

We agree, 65° is not low for nadir or zenith applications, but it is nearly the lowest angle of observation for OSIRIS. We have updated the manuscript to reflect this.

Page 1909, line 12: Herman et al., 1997 is missing from the Ref. list. I assume you mean "Global distribution of UV-absorbing aerosols from Nimbus 7/TOMS data".

Oops – change made.

You should also read Torres et al. "Derivation of aerosol properties from satellite measurements of backscattered ultraviolet radiation: Theoretical basis" (JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 103, NO. D14, PAGES 17,099-17,110, JULY 27, 1998). Especially note Fig. 3 & 6 of Torres 1998. Not all absorbing aerosol darkens the surface, for the nadir point of view. Altitude of the aerosol layer is important, as well as the total optical thickness of the layer.

Torres et al., 1998, is a clear work that guided many of our initial explorations of layer height, vertical extent, optical thickness, and even an attempt to construct an analogous AAI from OSIRIS measurements, using 35-km radiance and surface albedo instead of TOA reflectance and LER. It was the failure of this approach with limb-scatter data that lead us to careful forward model investigations of OSIRIS sensitivity (or lack thereof) to absorbing aerosols. We have revised the discussion of this point in the manuscript to acknowledge more clearly the conditions of the scene darkening observed in nadir measurements.

You need to prove that your model will produce the same results as shown by Torres for the nadir observations of lower tropospheric layers. Then transition to limb observations and gradually move the layer to larger altitudes. In addition, the optical depth of the elevated layer should be increased to see if the surface is darkened. This further analysis is needed to make an understandable connection with the nadir work.

We agree with the reviewer's suggestion that connecting our limb-scatter work with nadir backscatter work is useful, however, we believe that formally showing that SASKTRAN can reproduce the results presented in Torres et al. 1998 is beyond the scope of this work. We respectfully point out that SASKTRAN is a fully validated radiative transfer code that has been extensively documented in the peer-reviewed literature. For example, Figure 5 of Torres et al., 1998, shows a nearly linear change in the 340 nm residue as a function of optical depth, regardless of the sign of the slope. Our Table 5 shows a similar result (not graphically) with the scene darkening being linear with particle number concentration (and thus optical depth). Whether or not there is a darkening or a brightening is determined by the combination of scene albedo, particle size and complex index of refraction, with AOD further determining the magnitude of the brightening or darkening.

Page 1911, line 12: should be "Scattering phase function…"

We agree – change made.

Page 1911, line 24: What do you mean by "aerosols further down"? Down what?

Further down in the manuscript – change made.

*Page 1914 line 22: It would be helpful to include in the various tables the **vertical** optical depth for the various types of aerosols mentioned here.*

Table 3 shows vertical optical depth for absorbing dust (D1) due to scattering, absorption and extinction. We have created a new table (Table 4) that lists the vertical optical depth due to extinction in a 5-km slab due to the other modeled species.

Page 1915, line 13: What is BC?

Dropped BC midway through writing the paper in favour of "pure soot". Replaced this instance of BC with "pure soot".

Page 1921, line 11: Good point about the relationship between the aerosol layer height and the "radiance knee", but I wouldn't call a vertical optical depth of 0.01 "optically thick". It might be optically thick for the line of sight path, but not for other paths. Need to state this more specifically.

We agree that 0.01 is not "optically thick", in any observation geometry. This phrasing has been changed to "a dust layer", without reference to optical thickness.

Table 1: Why not list SAGE I, SAGE II, SAM II?

These were probably omitted because originally this table included instruments only capable of measuring limb-scattered radiation, which these three cannot do. However, since the table was expanded to include occultation instruments, they should be added. Done.

Table 5: Caption says 20 cm^-3, but the first column ranges from 0.2 to 200. Need to change caption or alter the table.

Changed caption.

Figures in general: It is hard to see the difference between circles and squares. Pick a different symbol or make them larger.

We have made the circle and square markers larger in Figures 1, 2, 3, 4, and 6. We also switched from displaying Solar Azimuth Angle to Solar Scatter Angle, as the latter is more relevant to the discussion.

In figures 7-11 it was difficult to see the difference between several of the curves. I assume that they are plotted on top of each other, but that is an assumption that the reader shouldn't have to make. The location of each curve should be more obvious.'

We have added markers to help distinguish overlapping curves in Figs 7, 8, 9, and 10. The vertical axis was also expanded. Figure 11 was labeled more consistently with the rest of the manuscript and the vertical axis was expanded.