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Atmospheric Measurement Techniques
Discussions

Interactive comment on "Stratospheric aerosol particle size information in Odin-OSIRIS limb scatter spectra" *by* L. A. Rieger et al.

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Thank you for the reply, we have performed some additional analysis that hopefully addresses some of your concerns regarding information in the short wavelengths. We think other concerns have been answered in more detail in our previous reply, but have tried to address them briefly here as well.

A few points: (1) you yourself conclude that getting size distribution from OSIRIS multi-angle observations is fruitless. Note that it may work for a different Limb Scatter (LS) sensor with a wider range of Single Scatter Angles (SSA), but OSIRIS has a limited range (SSA=90+-30 degrees)

We believe that the this is not a trivial conclusion. The idea of retrieving particle size information based on both different wavelengths and measurements at different scattering angles seemed plausible and the result that both measurements contained very similar information was certainly a surprise to us. Yes, geometries outside of OSIRIS range may prove beneficial in adding additional particle size information. However, OSIRIS does provide a fairly wide range of scattering angles (60-120 degrees), and the fact that comparing geometries does not improve the size information across this range (when wavelength information is also used) is a valuable result, applicable at least to a large subset of the other LS sensor measurements.

(2) It is indeed unfortunate that the imager is "noisy". If it was not noisy, then your methodology would have improved OSIRIS aerosol product and that would have been quite valuable to the community, who as you surely know, is in dire needs for information on global stratospheric aerosol data.

We have traded some precision for an improvement in accuracy, and while both would certainly be ideal, in the end it was a trade-off we believe was worth making. As you say, we are in dire need of global stratospheric aerosol data, and a more accurate product is certainly beneficial - particularly when the excellent sampling of LS measurements helps to minimize the effects of decreased precision.

(3) you central point that no size information can be retrieved from visible and NIR wavelengths is fundamentally flawed. The method has been used by SAGE and POAM to infer valuable information on aerosol microphysics. While LS sensors may be blind to shorter wavelengths, aerosol extinctions can be retrieved independently at a series of wavelengths over a wide spectral range, the range depending on SSA. As SSA is decreased, the forward peak of the aerosol phase function ensures that aerosol scattering dominates over Rayleigh, even at shorter wavelengths (450 nm), and even more at longer wavelengths (NIR). So, your point (which I believe is not valid even

for OSIRIS), is definitely not valid for LS sensors in a sun-synchronous orbit, such as OMPS or SCIAMACHY.

It is not that no information is available from shorter wavelengths, but that the information is highly case dependent, and at least for OSIRIS geometries, an unreliable source. We have attached figure 1 below to help highlight this point. Here measurement vectors were simulated for a variety of geometries and particle sizes. During forward scatter conditions (SSA=60), it is possible to distinguish cases with a mode radii less than 0.08 microns using visible wavelengths. However, distributions with a mode radius greater than 0.08 microns look essentially the same (at least for a measurement with 1% error in measured radiance). As the scattering angle is increased these differences become increasingly difficult to distinguish. Conversely, the longer wavelengths always provide a good measure of particle size, even for noisier measurements. This will be more clearly explained in the revised paper, in particular the point that it is still theoretically possible to obtain size information from vis/NIR wavelengths under some conditions.

(4) While I would agree that there is as yet no definite method to retrieve aerosol particle size from LS measurements, I want to make two points:

(a) What you propose here will not help the field: your first method (angular) has failed and your second cannot be used by present or future LS sensors since they do not have a 1.5 micron imager

(b) It is obvious (from SAGE/POAM) that spectral data can yield some information on particle size. You do not need to "prove" that point. What the community needs is to determine what (how much) size information can be retrieved. Probably only one piece of information, such as one moment of the size distribution, or one of the two parameters defining the lognormal distribution: Mean radius if you confine mode width to a constant value, or vice versa. It may be that SCIAMACHY data can yield even

more information than OSIRIS or OMPS since SCIAMACHY spectral coverage is very large and extend well into the IR where Rayleigh scattering is relatively small.

(a) We are a little confused by this statement. It is currently being used by OSIRIS, has the possibility of being used by SCIAMACHY (you note they have very wide spectral coverage which includes 1.5 microns) and could certainly be used by future missions.

(b) We agree that the question of how much size information is available to LS sensors is of importance to limb scatter community, however we disagree that this question can be answered by looking at SAGE/POAM retrievals. While they provide an excellent benchmark for validation, the difference in measurement techniques is substantial, with LS retrievals at an inherent disadvantage (in terms of extinction measurements) without prior microphysical knowledge. We have attempted to address this with figure 3 and 4 in the paper, and also figure 1 included here.

(5) The Angstrom parameter can be retrieved directly from analysis of the extinction spectral shape. The spectral shape is a "strong and unambiguous" parameter if you have sufficient spectral range (wavelength ratio of 2 or more). So your analysis may be better behaved (less sensitive to noise) if you were to derive the Angstrom parameter from your derived extinction at 770 and 1550nm, and subsequently derive a mean mode radius from Mie theory. Rather than derive a mean mode radius through a non-linear method to then compute the Angstrom coefficient.

The Angstrom parameter cannot be directly retrieved from the extinction spectral shape because the shape is dependent on the assumed Angstrom parameter. Iterative procedures may help this and are certainly worth exploring in future work, however this is simply another way of searching the solution space - and not one that is substantially simpler.

Tie particle size distribution (with uncertainty on mode radius, mode width, uni-modal, *bi-modal, refractive index, particle shape...) directly to the Angstrom coefficient, which is a macro parameter which can be derived from the spectral shape of either the extinction (thru iterative process) or even the raw radiances. That is a difficult task, but a necessary one Incidentally, in LS, the extinction retrieval has to be done at same time as retrieval of size: the LS needs a combined retrieval. The problem is Non-linear, and probably necessitates some initial a priori size/extinction, and an iterative process which must converge. Not an easy problem. That is why I am concerned with the rather complex formalism described in the paper. Not because the problem is complex, but rather because the described method is unnecessarily convoluted.*

We simply disagree that the Levenberg-Marquardt technique is a convoluted way of solving multi-dimensional, non-linear problems.

Interactive comment on Atmos. Meas. Tech. Discuss., 6, 5065, 2013.

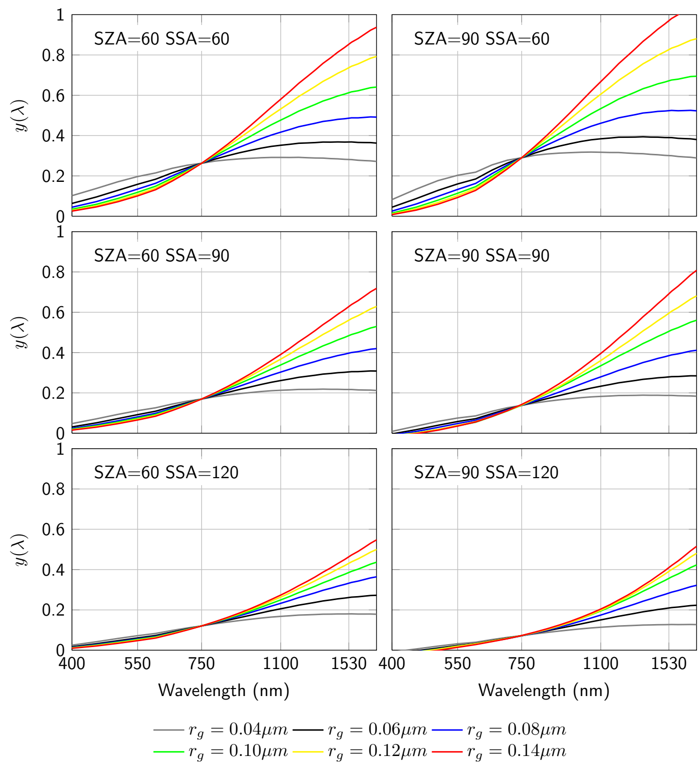

Fig. 1. Measurement vectors as a function of wavelength for a variety of OSIRIS geometries and typical particle sizes at 24.5 km. All distributions tested here have a mode width of 1.6.