**Atmospheric
Chemistry
and Physics
Discussions**

Interactive comment on "A unified approach to aerosol remote sensing and type specification in the infrared" *by* L. Clarisse et al.

Anonymous Referee #3

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Overall, this is a very well written and interesting paper. It provides background information about approaches that have been used for aerosol retrievals, and discusses how the different approaches relate to one another. After providing background information, aerosol analysis is applied to IASI data, and results are reported for sulfuric acid aerosols, volcanic ash, sand, ash, smoke, and ammonium sulfate.

major comments

major comment 1: The paper begins with a section that talks about techniques that have been applied to the problem of detecting clouds and aerosols in remote sensing data, with an emphasis on the infrared. This is a very good survey of the literature and a well written section. The authors have taken care to show the connections between the techniques and how the equations relate to one another. I think the paper needs

an additional paragraph or two, that ties the wide range of methods described to the actual techniques that are employed in the paper. One can try to infer it, based on the data that is needed (covariance matrices, etc), but it would be a much clearer paper if the authors simply add a paragraph that says, we apply the following technique for aerosol analysis.

In addition, there are two topics that need to be addressed in relation to the interpretation. There are when are the values of Rn meaningful, and how to apply error analysis.

major comment 2: The authors present most of the results in terms of R sub N, a distance quantity. Due to the noise on the measurement spectra, it seems there is a distance quantity that is meaningful, and some level below which the aerosols can not be differentiated from noise. This issue of when species are detectable and when they are masked in the noise is not directly addressed, and the maps and timeseries present data over a wide range of R sub N values. The maps tend not to have color bars below 0.5, but the sulfuric acid aerosol timeseries (figure 3) shows values that appear to be negative. If I understand equation 14 correctly, these are normalized values, and for clean spectra there is a mean of 0 and a std dev of 1. But most of the maps typically R sub N values of 0.5 to 2.5 or 3. Please add a few sentences to help the reader understand the expected values and how to interpret them,

major comment 3: Many of us are used to remote sensed quantities that are in physical units - optical depths, DU, or total columns. I realize that R_n is a different type of quantity, but it would be helpful to know how it relates to these other quantities - can the authors provide some indication of sensitivity - how does R_n change with optical depth for a particular species of interest. I would hope that this has been assessed some simulations analysis. This is also important because other data sources are used in comparison, so it is helpful to know how R_n relates to AOD or DU or other commonly reported quantities.

major comment 4: In a paper that reports the results of techniques for identi-

fying aerosols in infrared spectra, it is critically important that comparison data is also presented. In this paper, the authors present detections of ice crystals, sulfuric acid droplets, windblown sand, volcanic ash, ammonium sulfate, and smoke. In some cases, other data sources are cited. for example, the discussion of sulfuric acid aerosols, papers about OSIRIS measurements and ACE measurements are cited, and claimed to be consistent. For ammonium sulfate, some AOD (not species specific) is referred to as correlative data. The sand case does not talk about any other measurements data - was MODIS and MISR data looked at - if so, was there evidence of the same dust storms, or no evidence of dust? The authors claim there is no global dust product to compare to, but certainly MISR reported large, non-spherical particles are relevant to this problem. A quick look at MISR maps suggests that they see similar patterns (see http://eosweb.larc.nasa.gov/PRODOCS/misr/level3/level3_CGAS_small.html) The ice crystal case is also problematic. It may be simply an issue of graphics - when I look at Figure 1, the large swaths of IASI data appear as red and mostly gray blocks. Some of the regions that are more gray, indicating a higher cloud fraction in EUMETSAT data, also have some hints of color that indicate a range of Rn values above 1. As I asked earlier, if the Rn value is low, are these meaningful detections? Perhaps this figure would be easier to read if only data above a certain value is shown. Alternatively, perhaps only show data if Rn is above a certain value when the EUMETSAT cloud fraction is above a certain threshold?? The volcanic ash data are also shown alone, with no other correlative data. Is there any information from the volcanic ash advisory that could be used to compare and contrast with the IASI results? Again, for the smoke case, there must be some MODIS or MISR data, at least close to the source, that could be used to help corroborate the IASI measurement.

For all of these cases, a long paragraph is not required - just a couple of sentences to provide context and indicate that other data sources were thoroughly examined and compared to the IASI measurements.

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comment 5: page 26884, lines 5 through 8 I'm confused by the sentence "For increasing aerosol loadings the covariance matrix will have a component due to aerosol covariance, but no problems are expected here, since these are easier to detect anyway" Are the authors saying that high aerosol loading cases are not consistent with the assumptions. But, this is not a problem because they can be easily detected? If that is the message, does it imply that a different approach will be needed for high aerosol loadings? Overall, this sentence is not clear or convincing.

comment 6: page 26886, lines 8-14 The authors describe a technique where they perform a detection test for number of subgroups, and design the subgroups based on spectral clustering. Since this paper has a focus of describing a wide range of techniques and showing how they relate to one another, I am interested to know if this approach is related to the discrimination analysis approach described earlier.

comment 7: page 26889 line 24 in addition to ISAMS observations of sulfuric acid - water drops, the ATMOS high-resolution solar occultation spectra were used to identify sulfuric acid aerosols and their composition (see papers by Steele et al, and Eldering et al.)

comment 8: page 26891, lines 7 to 14 This paragraph talks about the detection of SO2 and H2SO4. Related to my earlier comment - the discussion says that the sulfuric acid aerosol continues to be detectable for many more months. When it the signal considered to be not detectable? Is there an Rn value that corresponds to fitting the noise, so levels below that are considered not detectable? I would like to see some quantitative information in that comment.

Minor comments: page 26877, line 11 The authors write "With these caveats in mind, the discovery of the pseudo-retrieval method....." I don't think 'discovery' is the right word here, it is implies a new understanding or revealing something that was previously hidden. I would suggest they replace 'discovery' with 'development'

page 26880, line 7 - the use of matrix I is slightly confusing, as it is regularly used as

the identity matrix, and I don't think that is the intention here. I would suggest that a different letter be selected, perhaps P, since this is related to the pollutant.

equation 10 - the subscript d is never defined.

page 26883, line 17 correct grammer current sentence: "We will not use any of techniques of mulitclass discrimination here" suggest " We will not use any multiclass discrimination techniques here" or "We will not use any of the techniques of multiclass discrimination here"

page 26884, line 1 correct grammer now 'except to the specific', should read 'except the specific'

page 26885, line 10. correct grammar - currently reads "to have a better grip on the quantities" suggested rewrite "to more easily interpret the quantities" or "to make the quantities more useful"

page 26889, line 16 correct grammer: currently reads "were long enough in orbit" change to "were in orbit long enough"

page 26890, line 22 correct grammer currently reads "we must be careful for potential spectral interference" I suggest "we must be careful of potential spectral interference"

page 26891, lines 15 - 20. Have the authors verified that the other peaks in SO2 correspond to volcanic eruptions? A sentence or two explaining what the other peaks are caused by would be helpful.

page 26892, line 11 A map from OMI is included in as an inset in Figure 4. First of all, what is the relationship of the DU values reported by OMI and the Rn reported here (this relates to the earlier question of how Rn changes with increasing optical depth or loading….) Secondly, the extend of the OMI signal is much smaller than the IASI map. Is this because of the different sensitivity of the UV and the IR, or because less data is included? A sentence or two describing the relationship or connections of these two datasets are needed if the OMI data is to be introduced.

page 26893, line 11 correct grammer currently reads "were selected directly over, and transported from the….." I would suggest "were selected directly over, and over the region where the dust is transported from the….."

page 26893, line 24 correct grammer currently reads "as a better sand detection allows constructing a better…" I would suggest either "as a better sand detection allows us to construct a better…" or "as a better sand detection allow for constructing a better…."

page 26893, line 25 correct grammer currently reads "to better accommodate for surface emissivity effects for the detection" I would suggest "to better accommodate for surface emissivity effects in the detection" or to better accommodate surface emissivity effects in the detection"

page 26894, line 11 change 'in case of detection' to 'in cases of detection'

page 26897 line 3 the grammar needs to be corrected - currently reads "The corresponding detection thresholds were chosen quite relaxed" I suggest : The corresponding detection thresholds were chosen to be quite relaxed"

Figure 5: The grayed out bands (which I assume are the ozone absorption band) are not explained in the text or the figure caption.

Figure 7: The label of the color bar of the upper panel is missing a ')' - currently only has: Sand (%

Title: I would suggest "A unified approach to infrared aerosol remote sensing and type specification" because the fact that this work is using infrared wavelengths makes it unique, so that should be brought out earlier in the title.