Atmos. Meas. Tech. Discuss., 6, C341–C349, 2013
www.atmos-meas-tech-discuss.net/6/C341/2013/

Atmospheric Measurement Techniques Discussions

AMTD

6, C341–C349, 2013

Interactive Comment

Interactive comment on "Preliminary investigations toward nighttime aerosol optical depth retrievals from the VIIRS day/night band" *by* R. S. Johnson et al.

R. S. Johnson et al.

johran@bethel.edu

Received and published: 18 March 2013

This is a good paper, introducing ideas for retrieving AOD from the VIIR day/night band. The algorithm is presented as preliminary, and a more detailed analysis of the uncertainties is discussed but not performed here. This seems ok to me, but I suggest that the authors might do at least a little more digging into the performance criteria (e.g., #11 below).

We would like to thank the reviewer for the very supportive comments.

1. P590, line 23. "...there are no other available, reliable..." In the next sentence you mention CALIPSO, and although the lidar ratio is uncertain in many circumstances, I

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

think dismissing AOD derived from the instrument as ‘unreliable’ is overstated. I do understand that there might be very little coincident data, and as such, you decided not to make use of it for the purposes of this demonstration-of-concept paper.

We agree with the reviewer that this comment is overstated with regard to CALIPSO, and we would like to thank the reviewer for bringing this to our attention. In light of this, we have changed the text to state, “. . .there are no other available, reliable nighttime aerosol datasets besides CALIPSO for validation purposes. CALIPSO can provide nighttime τ, but it was decided not use this resource as a validation tool because of the very low frequency of overpasses over a given city and the high uncertainty in the CALIPSO-derived τ product (Campbell et al., 2012).”

2. P592, line 21. “. . .nighttime physical properties. . .” It seems you really mean “nighttime AOD.”

Thank you for your suggestion. The text has been changed from “. . .nighttime aerosol physical properties. . .” to “. . .nighttime τ. . .”. Also, the corresponding subsection title, “Method for estimating nighttime aerosol properties with VIIRS” has been changed to “Method for estimating nighttime aerosol optical depth with VIIRS”.

3. P592, line 23. Might be: “. . .via obscuration and horizontal diffusion of scattered Artificial . . .” It is not only horizontal diffusion, which fuzzes out the bright surface and lunar sources; backscattering and absorption of the surface-emitted light also reduce the contrast as observed from space.

We would like to thank the reviewer for the insightful comment. We have changed the parenthetical comment to state, “. . . (i.e., via backscattering, absorption, and the horizontal diffusion of scattered artificial light).”

4. P593, line 6. “. . . diffuse transmittance . . .” (typo – it is usually called the diffuse transmittance)

Thank you for bringing this mistake to our attention. “diffused” has been changed to

AMTD
6, C341–C349, 2013

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

“diffuse”. Also, other instances of this error have been sought out and corrected.

5. P593, last line. You might mention the spectral band-pass of the VIIRS channel used. I see you mention the oxygen A-band as requiring a possible correction, but depending on the band-pass, you might also need to consider ozone, etc. in the atmospheric optical depth.

We have taken the reviewer’s advice for further clarification and have accordingly changed the discussion on the top of pg. 594 to state, “Although, there will be some inherent uncertainty in this assumption since the DNB response function, full width at half maximum from 0.5 to 0.9 μm, includes the oxygen A-band. A future study should consider the impact of the oxygen A-band, as well as other absorbing bands such as water vapor, on the proposed algorithm.”

6. P594, lines 18-19. It is not clear how Ia is derived. I guess the implication here is that Ia is derived on a low-AOD night, but you would still need to somehow take account of whatever AOD was there at that time. I now see you get to this on P596, lines 23-25. How many such days did you use to estimate Ia in each case, and how repeatable a value did you obtain?

For a given artificial light source, the value of Ia was obtained using data from the whole study period. Ideally, Ia values are also functions of viewing geometry, season, time of a day, etc. We leave a more thorough analysis of Ia to a future study. Although we chose Ia as the value of Isat from the moonless night with the lowest value of estimated nighttime AERONET τ (using the average of the AERONET values from before and after the VIIRS overpass), we investigated other potential values of Ia based on all of the VIIRS DNB radiance data from moonless nights. By plotting Ia as a function of estimated AERONET τ and extrapolating to a τ of 0, we have estimated the true value of Ia for each city. Then, we compared these estimated values of Ia to the values of Ia that were actually used in the study. The percentage difference between the estimated values and the actual values that were used in our study are approximately 2%, 4%, and 2% at Cape Verde, Grand Forks, and Alta Floresta, respectively. According to Eq. 10 from the paper, this corresponds to a maximum uncertainty in τ of 0.02, 0.04, and 0.02 in AOD at Cape Verde, Grand Forks, and Alta Floresta, respectively. At Grand Forks, the radiance values were adjusted according to Eq. 8 before extrapolating to a τ of 0.

We have changed and added the following discussions in the text: "The Ia values are considered to be emissions from artificial lights. As a first order approximation, we chose a radiance value for each city from a moonless night where the pair of temporally nearest AERONET τ values from before and after the VIIRS overpass was at a minimum. For a given artificial light source, the value of Ia was obtained using data from the whole study period. Ideally, Ia values are also functions of viewing geometry, season, time of a day, etc. We leave a more thorough analysis of Ia to a future study. Although we chose Ia as the value of Isat from the moonless night with the lowest value of estimated nighttime AERONET τ (using the average of the AERONET values from before and after the VIIRS overpass), we investigated other potential values of Ia based on all of the VIIRS DNB radiance data from moonless nights. By plotting Ia as a function of estimated AERONET τ and extrapolating to a τ of 0, we have estimated the true value of Ia for each city. Then, we compared these estimated values of Ia to the values of Ia that were actually used in the study. The percentage difference between the estimated values and the actual values that were used in our study are approximately 2%, 4%, and 2% at Cape Verde, Grand Forks, and Alta Floresta, respectively. Later in section 4.2, it is shown this corresponds to a maximum uncertainty in τ of 0.02, 0.04, and 0.02 at Cape Verde, Grand Forks, and Alta Floresta, respectively. At Grand Forks, the radiance values were adjusted according to Eq. 8 before extrapolating to a τ of 0."

7. P594, lines 15-17. What do you assume about the aerosol properties to derive the diffuse reflectance, and what uncertainty is introduced by estimating k this way?

For estimating k, we have assumed that for a given atmospheric layer the upward direct and diffuse transmittances will equal the downward direct and diffuse transmittances. No gaseous absorption is assumed and the solar zenith angle is assumed to be 0°. We also assume the 6S radiative transfer model and its desert, urban, and biomass burning aerosol models for Cape Verde, Grand Forks, and Alta Floresta, respectively, will provide a sufficient first order approximation of k. An average relative change of approximately 0.1 in k is found between the smoke and dust aerosol models. An average relative change of approximately 0.04 in k is found between the smoke and urban aerosol models.

We have added the following discussions in the text: "Aside from the theoretical uncertainty analysis, a preliminary empirical uncertainty analysis was also conducted for I 'sat (or ΔI by varying the background) and Ia as discussed in the previous sections. We have summarized the results of these average uncertainties in Table 3. In addition, we approximated k using the desert, urban, and biomass burning aerosol models from the 6S radiative transfer model for Cape Verde, Grand Forks, and Alta Floresta, respectively. We find an average relative change in k (Δk/k) of approximately 0.1 between the smoke and dust aerosol models. An average (Δk/k) of approximately 0.04 is found between the smoke and urban aerosol models. Such a change in k values corresponds to a 0.04 to 0.1 uncertainty in τ based on Eq. 10. We have included the Δk/k estimation in Table 3 as well.

Table 3 does not include an estimate for the uncertainty in τ due to the factor C because the use of C was not deemed to be necessary at Alta Floresta or Cape Verde from the results shown in Fig. 3. C was used at Grand Forks; however, C was also used to adjust the moonless night Isat values for extrapolating an estimated Ia value for determining the uncertainty in τ due to Ia. Thus, for Grand Forks the uncertainty in τ due to C is partially included in the uncertainty due to Ia. An extensive number of observations are needed to carefully study the relationship between Ia and C, which might be unique to an individual city. We leave the full study of the interaction between Ia and C to a future paper.

AMTD
6, C341–C349, 2013

We want to remind the readers that both the theoretical and empirical uncertainty analyses in this section are rather simplified approaches. Uncertainties in aerosol properties (k) and the true city signal (Ia) may vary as τ increases. For example, the wrong aerosol model may be chosen for the k correction, which would have a greater impact with larger values of τ because k may be a function of τ. With regard to Ia, a larger uncertainty may exist in estimating Ia for a region that is consistently covered with thick aerosol plumes than for a relatively clear region. Also, omitted terms such as can become less insignificant as τ increases. Therefore, the actual performance of the retrieval process needs to be further evaluated using ground based nighttime aerosol observations (e.g. Berkoff et al., 2011)."

8. P595, lines 1-4. How big an uncertainty does assuming r_s * r_bar is negligible introduce?

The reflectance of an aerosol layer is typically low (< 0.2). However, for an optically thick plume (optical depth > 1), the reflectance of an aerosol layer could reach 0.3 or 0.4. Given a typical surface reflectance value of 0.3, the r_s * r_bar value is approximated to be 0-0.1. This introduces an approximated uncertainty in Isat and I 'sat of up to approximately 10% for thick aerosol plumes.

9. P595, lines 18-20. Were the background pixels chosen as the darkest pixels in the surroundings, or was some other criterion used?

The location of the background pixels was chosen randomly as long as the chosen pixels were distanced from the artificial light sources. Also, once the location had been randomly chosen, the location was kept constant from night to night.

10. P597, lines 9-14. I guess you are assuming that the primary factor determining the relationship in figure 3a is viewing zenith, and that the linearity of the plot is your justification. If this is the case, perhaps it would be worth mentioning.

Thank you for your suggestion. We do believe, based on the linearity of this plot, that the CVZA is a significant factor affecting the apparent strength of the observed signal, Isat, at Grand Forks. Other factors will also affect Isat, such as lunar fraction and lunar zenith angle. However, no adjustments are needed for these two factors because Ia was chosen from a moonless night and lunar lighting effects should be canceled out by taking the difference between the city radiance and the background radiance: Isat – I'sat . Therefore, only the relationship between radiance and CVZA is mentioned in Figure 3.

We have added to pg 597 line 9: "In addition to satellite viewing zenith angle, the observed VIIRS DNB radiance will also be affected by other factors such as lunar fraction and lunar zenith angle. However, no adjustments to Ia are needed for these factors for two reasons. First, Ia was chosen from a moonless night when lunar geometry should not affect the observed radiance. Second, any lunar illumination effects should be canceled out each night according to Eq. 7 by taking the difference between the city and the background radiances: Isat – I'sat. Therefore, only the relationship between radiance and satellite viewing zenith angle needs to be investigated."

And on pg 597 line 14, "The strong linear trend between radiance values from artificial light sources and CVZA from the Grand Forks region shows the importance of this relationship and the need for the adjustment factor C." has been changed to "The strong linear trend between radiance values from artificial light sources and CVZA from the Grand Forks region shows the importance of this relationship and justifies the need for determining the adjustment factor C with regard to CVZA."

11. P597, end. You might also plot the final, estimated I_a vs. exp (-tau/mu), and compare the value of I_a extrapolated to zero with the value estimated from the moonless night. I see now that you mention something like this later in the paper, but it does not seem to be a lot of extra work, and could be helpful in revealing a number of aspects of the technique's uncertainty, which is one of the main focuses of the paper.

Thank you for this suggestion. We plotted all radiance values from moonless nights as a function of estimated nighttime AERONET τ at each location. We fit a linear line to these plots and found values of Ia extrapolated to an estimated nighttime AERONET τ of 0 for each location and compared these values with the actual values of Ia used in this study. The absolute values of the relative changes in Ia were 0.02, 0.04, and 0.02 at Cape Verde, Grand Forks, and Alta Floresta, respectively. At Grand Forks, the radiance values were adjusted according to Eq. 8 before the linear line was fitted to the plot. Please see the response to comment 6 for discussion that was added to the text.

12. P599, line 20. Unlike the standard MODIS and VIIRS daytime retrievals, which rely on aerosol scattering, this is basically an aerosol absorption technique, so the increased light unaccounted for at the detector produces an underestimation in retrieved AOD. This might be worth mentioning explicitly, for those less familiar with retrieval methods.

Thanks for the suggestion. We have added "It should also be noted that the intensity of an artificial light source (Ia) may vary with respect to time of day, viewing geometry, season, and city growth. Therefore, any unaccounted increase in radiance at the detector will result in an underestimation of retrieved τ. The variation of Ia will explored in a future paper."

13. P601, line 3. Typo. ". . . VIIRS DNB is presented."

Thank you for pointing out this mistake. We have made the correction to this sentence.

"To demonstrate a new concept in this paper, a new method for retrieving nighttime τ using observations from the VIIRS DNB is presented."

14. P601, line 21. ". . . applied to nighttime thin cloud optical depth . . ." Two notes here: I'd expect this to work only with thin cloud, and rather than properties in general, this seems it would just be optical depth.

Thank you for your insight and helpful comments. We have changed this line according to your suggestion.

We have changed the relevant text to: “Alternatively, the method illustrated in this study for aerosol property retrievals can be directly applied to nighttime thin cloud optical depth retrievals.”

Please also note the supplement to this comment:
http://www.atmos-meas-tech-discuss.net/6/C341/2013/amtd-6-C341-2013-supplement.pdf

---

Interactive comment on Atmos. Meas. Tech. Discuss., 6, 587, 2013.