Sensitivity of aerosol retrieval to surface albedo

Felix C. Seidel (a), Alexander A. Kokhanovsky (b), Michael E. Schaepman (a)

(a) felix.seidel@geo.uzh.ch, www.geo.uzh.ch/~fseidel/, Remote Sensing Laboratories (RSL), University of Zurich, Switzerland
(b) Institute of Environmental Physics, O. Hahn Allee 1, D-28334 Bremen, Germany

Abstract

Aerosol remote sensing over land is still a great challenge. The separation of the surface contribution from atmospheric effects depends often on estimated surface albedo values. It is known that surface albedo has an influence on the retrieval of the aerosol optical depth (AOD).

Aerosols above a dark surface increase the reflectance at top-of-atmosphere (TOA) and decrease it above a bright surface. In between, AOD has almost no influence on the reflectance at TOA. This critical surface albedo poses a problem to AOD retrievals.

The influence of uncertainties in surface albedo on AOD retrievals are analyzed using the radiative transfer model SMART [1] [2]. The influence is found to be very large, especially close to the critical surface albedo. 1% uncertainty can lead to approximately 0.2 AOD retrieval uncertainty.

This poster participates in **OSP**

Outstanding Student Poster Contest

Simple Model for Atmospheric Radiative Transfer

$$R_\lambda^{sensor\_space} = R_\lambda^I + T_\lambda^{\downarrow I}(R_\lambda^{II} + R_\lambda^{srf})T_\lambda^{\uparrow I}$$

where,

$$R_\lambda^I = \frac{\omega_\lambda^{mlc} P_\lambda^{mlc}(\Theta^r)}{4(\mu_0+\mu)}(1-e^{-m\tau_\lambda^I}) f_{\mu_0}^{corr}(\tau_\lambda)$$

$$T_\lambda^{\downarrow I} = e^{-\frac{\tau_\lambda^I}{\mu_0}} + \tau_\lambda^I e^{\left(-u_0 - v_0\tau^I - w_0(\tau_\lambda^I)^2\right)}$$

$$R_\lambda^{II} = R_\lambda^{mlc\,II} + \underbrace{\overbrace{\frac{\omega_\lambda^{aer} P_\lambda^{aer}(\Theta)}{4(\mu_0+\mu)}(1-e^{-m\tau_\lambda^{aer}})}^{first\ order\ scattering\ (SSA)} + \overbrace{R_\lambda^{aer\,MS}}^{second\ order}}_{R_\lambda^{aer\,II}}$$

$$R_\lambda^{sfc} = \frac{a_\lambda^{sfc} T_\lambda^{\uparrow II}}{1 - s_\lambda a_\lambda^{sfc}}$$

where,

$f_{\mu_0}^{corr}(\tau_\lambda) =$ correction factor for molecular multiple scattering

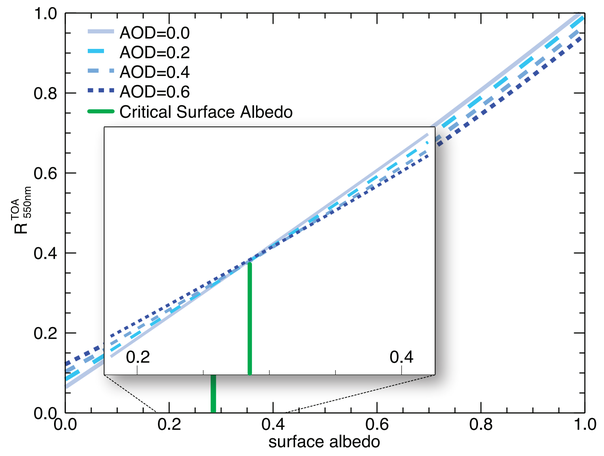
$m = (\mu_0^{-1} + \mu^{-1})$

Features:
- Analytical scalar equations
- Fast: 0.05 s per calculation
- Accuracy ø: 4%, max: 17%
- 400-800 nm, 10 nm interval
- Aerosol models: d'Almeida

Limitations:
- Two layers
- 2nd order aerosol scattering
- No gaseous absorption
- No polarization
- No terrain
- Lambertian surfaces (sfc)

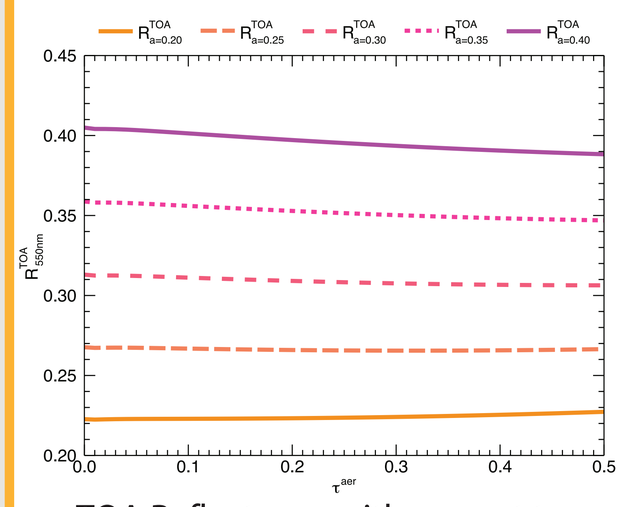
Critical Surface Albedo

- Aerosols increase TOA reflectance (R) at dark surfaces and decrease at bright surfaces.
- TOA Reflectance at the critical surface albedo has very low sensitivity to AOD.
- AOD retrieval is difficult close to the critical surface albedo using single nadir observations.

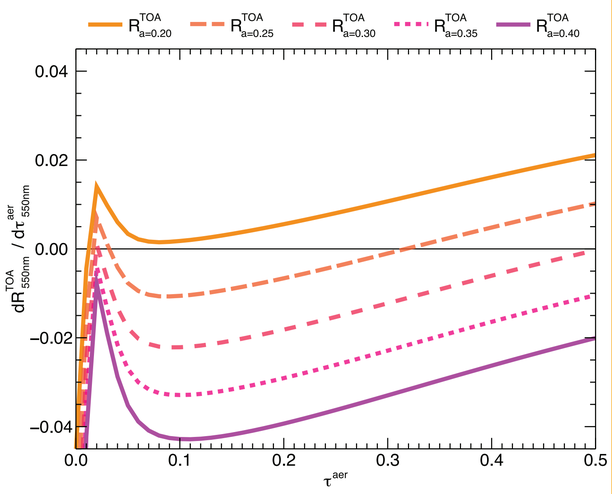


TOA Reflectance does not depend on AOD at critical surface albedo. (SZA=60°, Continental aerosols)

$$\frac{dR_\lambda^{TOA}}{d\tau_\lambda^{aer}} \begin{cases} > 0 & \text{if AOD increases reflectance} \\ = 0 & \text{if AOD has no effect on reflectance} \\ < 0 & \text{if AOD decreases reflectance} \end{cases}$$



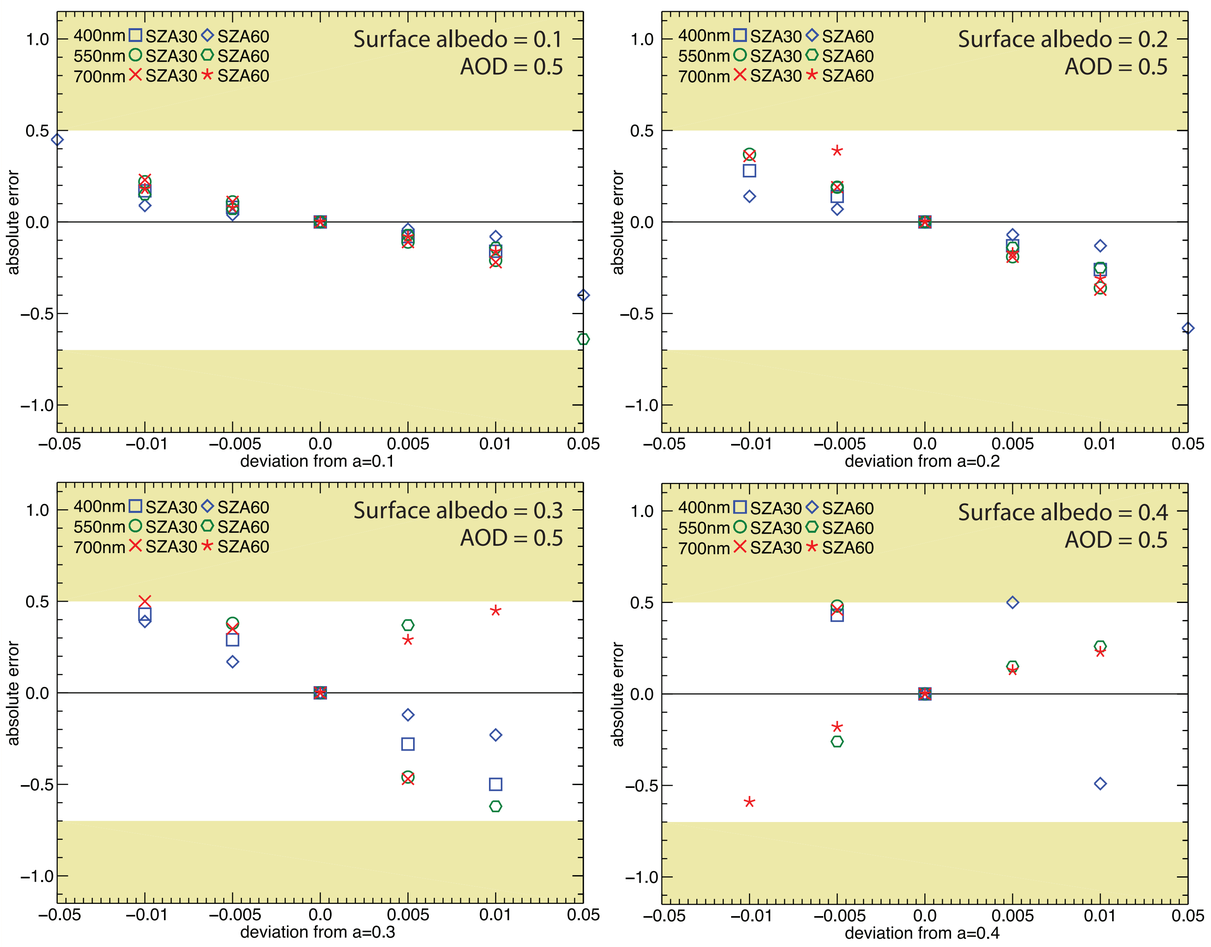
TOA Reflectance with respect to AOD for surface albedo a ∈ [0.2 - 0.4]. (SZA=60°, Marine aerosols)



Derivative of R with respect to AOD according Equation above. (SZA=60°, Marine aerosols)

Influence of surface albedo uncertainty on AOD retrieval

- Small uncertainties in surface albedo are leading to large AOD retrieval errors, especially close to the critical surface albedo.



Absolute error of AOD retrieval as a function of uncertainties in surface albedo. The uncertainties are simulated by a deviation from the true surface albedo. A deviation of ±0.01 corresponds to ±1% uncertainty in surface albedo. (SZA=Solar Zenith Angle, Marine aerosols)

Conclusions

- Reflectance at TOA is a very weak function of AOD at the critical surface albedo, posing a problem for AOD retrieval.
- Uncertainties in surface albedo lead to large AOD retrieval errors for single nadir observations.
- Multi-directional, polarized and spectral observations would reduce the influence of the surface and enhance the AOD retrieval [3].

References

[1] Seidel F. C., Kokhanovsky A. A., and Schaepman M. E.: Fast and simple model for atmospheric radiative transfer, *Atmos. Meas. Tech.* 3 (4), 1129–1141, doi:10.5194/amt-3-1129-2010, 2010.
[2] Seidel, F.C., Kokhanovsky, A.A., Schaepman, M.E.: Fast retrieval of aerosol optical depth and its sensitivity to surface albedo using remote sensing data. *Atmos. Res.*, doi: 10.1016/j.atmosres.2011.03.006, 2011(in press).
[3] Dubovik, O., et al.: Statistically optimized inversion algorithm for enhanced retrieval of aerosol properties from spectral multi-angle polarimetric satellite observations, Atmos. Meas. Tech. Discuss., 3, 4967-5077, 2010.

University of Zurich[UZH]

RSL measurements | products | policy

Universität Bremen