Joint retrieval of aerosol optical properties over North America using GEOS-Chem and MISR

Shen-shen Li and Yang Liu
Emory University, Rollins School of Public Health

Introduction

The assumption on aerosol models is an important factor in the retrieval of satellite aerosol optical depth (AOD). A few studies have demonstrated that GEOS-Chem data can significantly improve the Moderate Resolution Imaging Spectroradiometer (MODIS)'s capability of AOD retrieval*[e.g., Drury et al., 2008; Wang et al., 2010]*. However, the local surface visible/near infrared (2.1µm) reflectance ratio (VISvs2.12) , the assumption of Lambertian surface and transparent atmosphere at 2.1µm used in MODIS algorithm is not universally applicable over different land types and non-clear days. The Multiangle Imaging SpectroRadiometer (MISR) launched by NASA in 1999 has a unique design with 9 cameras pointed at fixed angles, which allows its aerosol retrieval to be conducted without the Lambertian surface assumption. In this study, we extended the method described in Drury et al. [2008] and Wang et al. [2010] using MISR data to minimize the uncertainties of surface bidirectional reflectance and to improve the GEOS-Chem's aerosol optical properties.

Data and Methods

Data

1. GEOS-Chem (v-8-3-2): July, 2008 , 2°×2.5° horizontal resolution, 37 vertical layers
2. MISR L1B2 Terrain-Projected Radiance product
3. MISR L2 Surface product
4. AERONET data, MISR and MODIS Aerosol product for comparison

Retrieval Algorithm

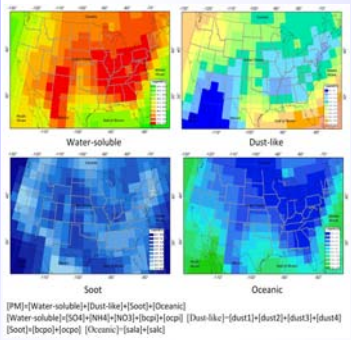
1. Initialize the algorithm with 10 AOD values at 0.47µm, between 0.01 and 2.0.
2. Simulate the Dust-like, Water-soluble, Soot and Oceanic aerosol volume percentages using GEOS-Chem mixing ratios.
3. Generate 9 groups of atmosphere parameters using 6S radiative transfer code with the input from the initial AOD (step 1), aerosol model (step 2) and geometric angles of MISR L1B2.
4. Compute 9 groups of modeled surface reflectance using:

$$\rho_s^*(\mu_s,\mu_v,\phi)=\frac{\rho_{TOA}(\mu_s,\mu_v,\phi)-\rho_o(\mu_s,\mu_v,\phi)}{T(\mu_s)T(\mu_v)+\rho_{TOA}(\mu_s,\mu_v,\phi)S-\rho_o(\mu_s,\mu_v,\phi)S}$$

where ρ_o (path reflectance), S (backscattering radio), and T (upward total transmission) are from step 3; and ρ_{TOA} is MISR TOA reflectance.

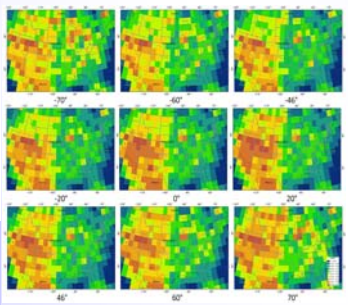
5. Calculate the object function of $y=(\rho_S^{*1}-\rho_S^1)^2+(\rho_S^{*2}-\rho_S^2)^2+\ldots+(\rho_S^{*9}-\rho_S^9)^2$ where $\rho_S^1,\rho_S^2,\ldots,\rho_S^9$ are generated from MISR L2 surface product.
6. Select the min value and interpolate the initial AOD, and repeat the Steps 1 to 5, then get the successful AOD retrievals.

Results and Discussion



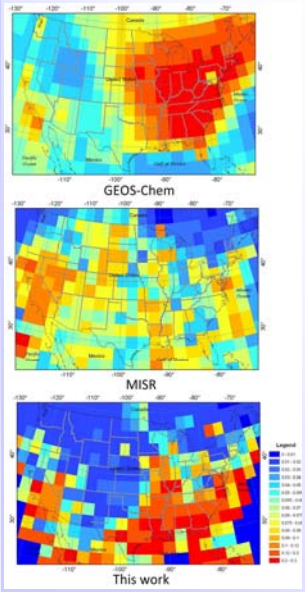
Plots on the left: monthly mean volume percentage of aerosol components

- The aerosol model in July is dominated by water-soluble particles, especially in eastern US (> 70%).
- The dust-like aerosol is high (>20%) for the semi-arid regions in the West.
- The percentage of soot and sea-salt aerosols usually show smaller values (<10%) in the continental US.



Plots on the left: monthly mean of surface reflectance

- The reflectance at blue band is smaller (<0.02) in the East than in the West.
- The bidirectional reflectance in 9 satellite zenith angles is different, though the non-Lambertian effect is reduced after averaged in 2°×2.5° GEOS-Chem grid.



Plots on the left: GEOS-Chem, MISR, and this work AOD distribution

- The GEOS-Chem simulations show high AOD values in the east and low AOD values in the west with a smooth regional gradient.
- In the MISR maps, high AOD values are more scattered regionally with high values in California. No clear spatial patterns are evident.
- Compared with the operational MISR product, AOD values retrieved by this algorithm show higher values in the high AOD regions such as the southeast, and lower values in the semi-arid regions in the Midwest.
- Further validation using AERONET data to this algorithm will be on-going work.

Summary

- We extend the joint AOD retrieval using satellite reflectance and CTM simulations developed using MODIS data to MISR, which allows us not to depend on the assumption of Lambertian surface as well as the relationship of VISvs2.12. Our approach also differ from previous work in the use of radiative transfer code and the treat of update solutions.
- The main error can be attributed to the uncertainties of MISR surface bidirectional reflectance products, which are probably retrieved using default MISR aerosol models. The applicability and validation of MISR surface product needs to be performed over different regions.
- The coarse spatial resolution of GEOS-Chem simulations may also introduce uncertainties in our AOD retrieval. We will use the higher resolutions (e.g., 1°×1°; 0.5°×0.67°) to improve the joint retrievals for future research.

References

- Drury E., Jacob D. J., Wang J. , et al., (2008), Improved algorithm for MODIS satellite retrievals of aerosol optical depths over western North America, J. Geophys. Res.-Atmos., 113(D16), Art. No. D16204
- Wang J., Xu X.G., Spurr R., et al.,(2010), Improved algorithm for MODIS satellite retrievals of aerosol optical thickness over land in dusty atmosphere: Implications for air quality monitoring in China . Remote. Sens. Environ.,114 (11) : 2575-2583

This project is funded by the MISR team led by Dr. David Diner at JPL under contract No. 1363692. Please direct your questions to Prof. Yang Liu (yang.liu@emory.edu).