Analysis of MODIS-MISR Calibration Difference over Land

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Introduction

MODIS and MISR are two major instruments of the Earth Observing System producing global information about aerosol, cloud and land surface parameters. Each instrument has its advantages, such as a large number of spectral bands and daily global coverage of MODIS, or unique multi-view-angle capabilities of MISR. An optimal synergy of MODIS-MISR products could greatly benefit the broad user's community by ensuring the global view of the Earth's land, ocean and atmosphere, in combination with the best quality of products.

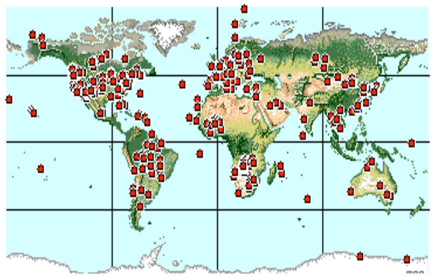
At present, systematic biases are known to exist in the AOT and Vis-NIR land reflectance between MODIS and MISR. In this work, we study one possible source of this difference, the relative calibration of MISR vs MODIS Vis-NIR land bands (B1-B4) using the AERONET-based Surface Reflectance Validation Network (ASRVN). The ASRVN is an operational processing system that receives MODIS and MISR TOA measurements around AERONET sites globally, and uses AERONET well-calibrated aerosol and water vapor information to independently derive surface BRF and albedo with the unified atmospheric correction algorithm. The ASRVN retrievals show a systematic bias in the surface albedo (0.02-0.04) in the Vis bands with higher MISR values.

For this work, we augmented ASRVN for the TOA calibration analysis. The new function regresses the calibrated TOA measurements of nadir MISR camera (An, VZA<15°) against TERRA MODIS measurements averaged over an area of 32×32 km^2. The regression accumulates data for over 170 AERONET sites, and provides a slope (A) and offset (B) for each of bands B1-B4. The slope coefficient from real data can deviate from 1 because the band-pass functions of the respective MODIS-MISR bands are different. In order to account for this difference, we have derived theoretical values A and B based on the radiative transfer simulations. The residue between experimental and theoretical values A and B can be attributed to the calibration difference of the two instruments.

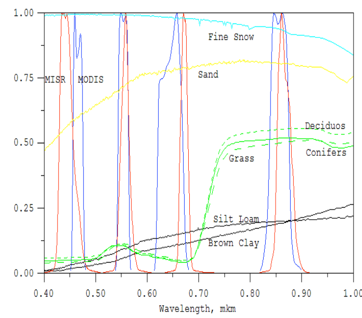
The Concept of ASRVN

Main Functions

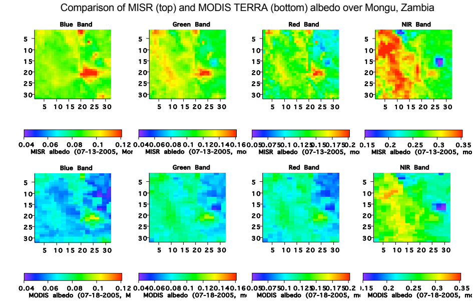
Daily Data Collection	Ancillary Data	Automatic AC
MODIS, MISR ... (area ~ 32x32 km2)	AERONET aerosol and WV, NCEP ozone	(single validated RT, unified algorithm)

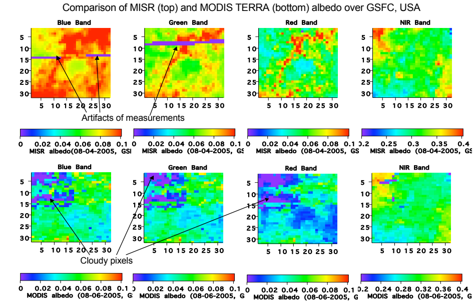


Band-pass functions of MODIS and MISR



Comparison of MODIS and MISR albedo over AERONET Sites (ASRVN product)





Simulation Model: $L = \int_{\Delta\lambda} F_\lambda I_\lambda h_\lambda d\lambda \Big/ \int_{\Delta\lambda} F_\lambda h_\lambda d\lambda$

➢**SHARM_IPC_Mie code**:
- arbitrary band-pass function;
- absorption of 7 major atmospheric gases (H_2O, CO_2, O_3, CH_4, NO_2, CO, N_2O): LBL absorption is modeled using HITRAN-2000 database and Voigt profile, continuum absorption model of AER (Clough et al.);
- atmospheric profiles of Standard Models (MODTRAN3.0)
- spectral resolution 0.01 – 1 cm^{-1};
- solar irradiance model of Kurucz (MODTRAN3.0);
- full multiple scattering RT (code SHARM) with exactly calculated single scattering, Delta-M method for clouds;

➢**Aerosol (Mie) model**:
- bi-modal log-normal size distribution,
- used urban-industrial, biomass burning, and dust/maritime models from Dubovik et al., 2002.

➢**Surface models**:
- spectrally invariant albedo;
- spectral albedo for 7 LC types from ASTER and USGS spectral libraries (conifers, deciduous, grass, brown clay, brown silt loam, sand, fresh snow);

➢**Water cloud models**:
- log-normal size distribution, r=6, 10, 15, 20 μm, σ=0.1 μm; τ_c=3.7 – 130;
- optical properties of water from Hale and Querry [1973].

Sensitivity of the simulation results

In simulations, we have separately analyzed clear-skies and cloudy conditions. Simulations show that clouds are the best target for computing the theoretical regression coefficients, with the summary of benefits given below. The clear-skies conditions show significant dependence of the regression coefficients on the solar zenith angle, and a considerable uncertainty due to spectral variability of different land cover types.

Water Clouds:
- Regression does not depend on SZA;
- Dependence of regression on the effective droplet size is weak, so this approach can be applied universally (for the liquid water clouds);
- The regression slope for the Blue band is moderately sensitive to the cloud top height;
- The regression slope for the Red, and to a less extent, for the Nir band depends on the column water vapor.

Simulated Regression

Water Clouds

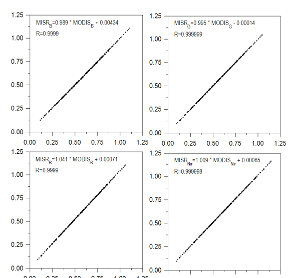


Table 1. Dependence of slope on droplet size. Simulations were done with H_c=2km, RH=2cm, 1976 US Standard Atmospheric Profile.

r_c	6	10	15	20	All
A_B	0.993	0.988	0.982	0.978	0.989
A_R	1.038	1.044	1.045	1.046	1.041

Table 2. Effect of cloud top height and column water vapor on the slope of regression.

	H_c (1-5km, 0.4 cm RH)	RH (0.4-2-5 cm, H_c=2 km)
A_B	0.980-0.987	-
A_G	-	-
A_R	1.036-1.039	1.042-1.046-1.061
A_{Nir}	-	1.002-1.008-1.017

Observed (ASRVN) Regression

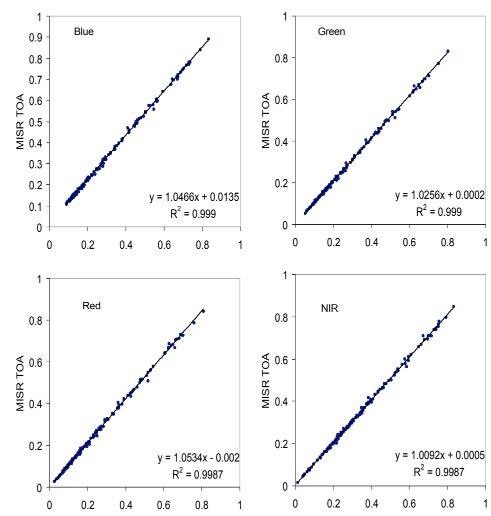


Table 3. Summary of regression coefficients

	A_B	B_B	A_G	B_G	A_R	B_R	A_{Nir}	B_{Nir}
1. Measured (151 points)	1.0466	0.0135	1.0256	0.002	1.0534	-0.0002	1.0092	0.0005
2. Simulated	0.989	0.0043	0.995	-0.0001	1.041	0.0007	1.009	0.0007
3. Difference	0.0577	0.0092	0.0306	0.002	0.0124	0.000	0.000	0.000

Conclusions

In this work, we developed two independent methods to evaluate calibration bias between MODIS and MISR. The first one derives bias as a difference between observed and theoretical regression coefficients. The second one evaluates bias based on statistical matching of the ASRVN albedo products from MODIS and from MISR over a large number of AERONET sites. The estimates from both methods agree well, except in the red band, where the albedo matching technique predicts about twice as high difference. Conclusions for the first methods are following:
- Clouds prove to be a reliable stable target for the cross-calibration analysis.
- Comparison of MODIS-MISR regression lines obtained from measurements and from simulations allows to evaluate the difference in the gain coefficient.

3. Our analysis suggests the following band gain difference:

Blue – 5.6%, Green – 3.1%, Red – 1.2%.