Development of new forward libraries for MOD06 optical properties

Nandana Amarasinghe*, Steven Platnick and the Cloud Retrieval Group
NASA Goddard Space Flight Center, Greenbelt MD 20771
*Science Systems and Applications Inc., Lanham MD 20706

Introduction

Seven band look up tables (LUT) of the top of the atmosphere reflectance for a Lambertian surface of zero albedo were developed by radiative transfer calculations using DISORT. Based on our interpolation error investigations, the multiple scattering (MS) part of the reflectance is stored as a function of optical thickness (τ), effective particle radii (R_E), solar zenith (θ_0), sensor zenith (θ) and relative azimuth ($\Delta\phi$). The single scattering part of the reflectance can then be added dynamically to the interpolated multiple scattering part of the reflectance for a particular sun-satellite geometry. This approach significantly reduces the interpolation error.

Developing LUT over ocean with Cox-Munk surface BRDF is in progress and results from modeling clear sky radiances for sun glint scenes from Terra are very encouraging.

Method

1. Construct several LUTs with different discretizations for solar , view and azimuth angles. We followed the same method of Andy Heidinger to discretize τ. Values upto 2.0 are discretized in linear τ space and discretization in log(τ) space for values beyond 2.0
2. Linear Interpolation error estimates are calculated by choosing mid points of the pre constructed table as the truth.
3. Figure 1 shows the reflectance plotted, both multiple (blue) and full (red), in μ (=cos(θ) space and degree space
   - More linear in μ space (left hand side panel) than degree space (right hand side panel).
   - Multiple scattering part does not have sharp peaks (for example at rainbow, glory features)

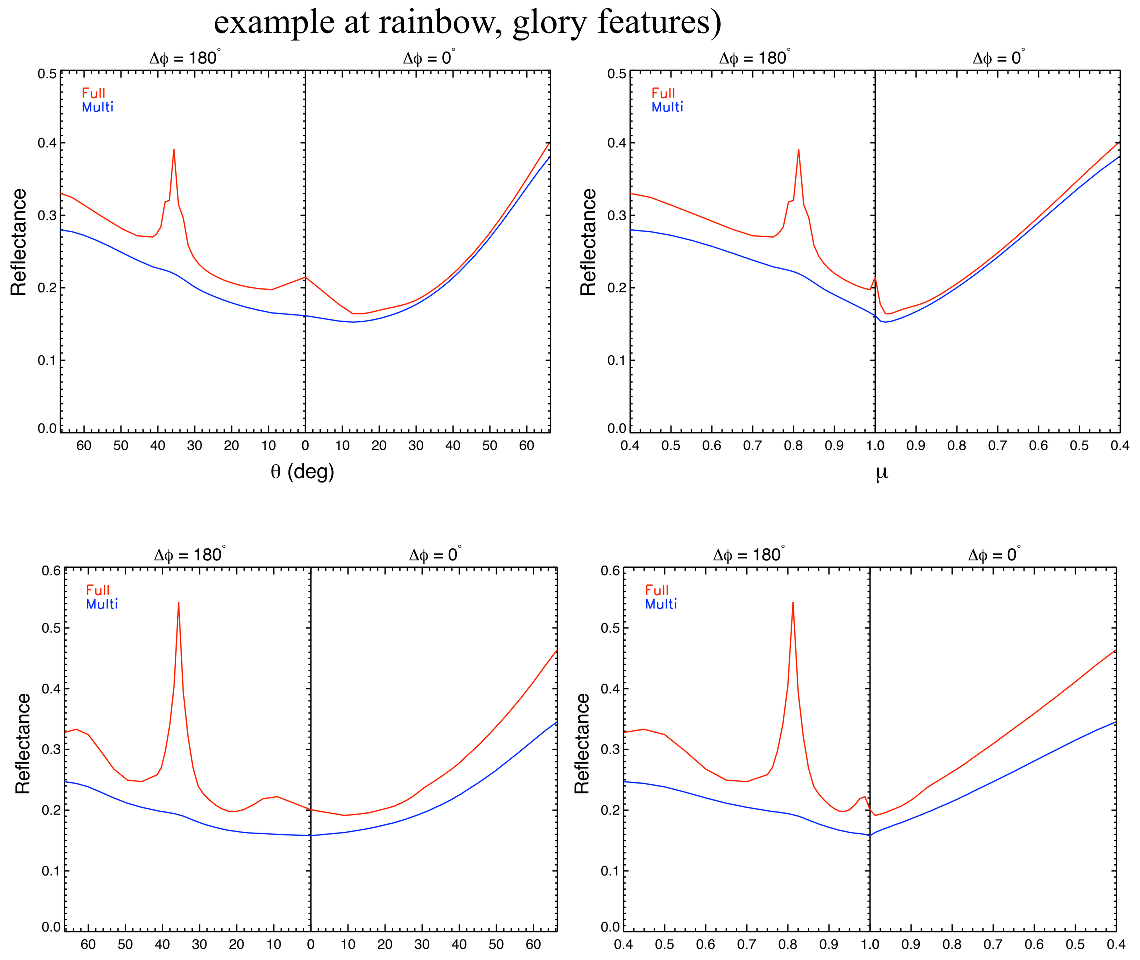


Figure 1. Top: Water cloud θ_0 = 35.7°, τ = 4.14, R_E = 10μm. Bottom: Ice cloud θ_0 = 35.7°, τ = 4.14, R_E =60μm

Linear interpolation error

- Figure 2 (ICE) and figure 3 (WATER) show the med-max interpolation error for full reflectance LUT (left panel) and multi LUT (right panel)
- Decrease in interpolation error by an order of magnitude or more was noted with MS reflectance
- Hybrid scheme ($\Delta\mu$= 0.0125 and 0.05) produces the lowest interpolation error (dash-line)
- This scheme was adapted because of large interpolation errors near μ=1.0 for $\Delta\mu$ = 0.025 and $\Delta\mu$ = 0.05 (see Figures 4 and 5, polar plots)

ICE

TOTAL MULTI

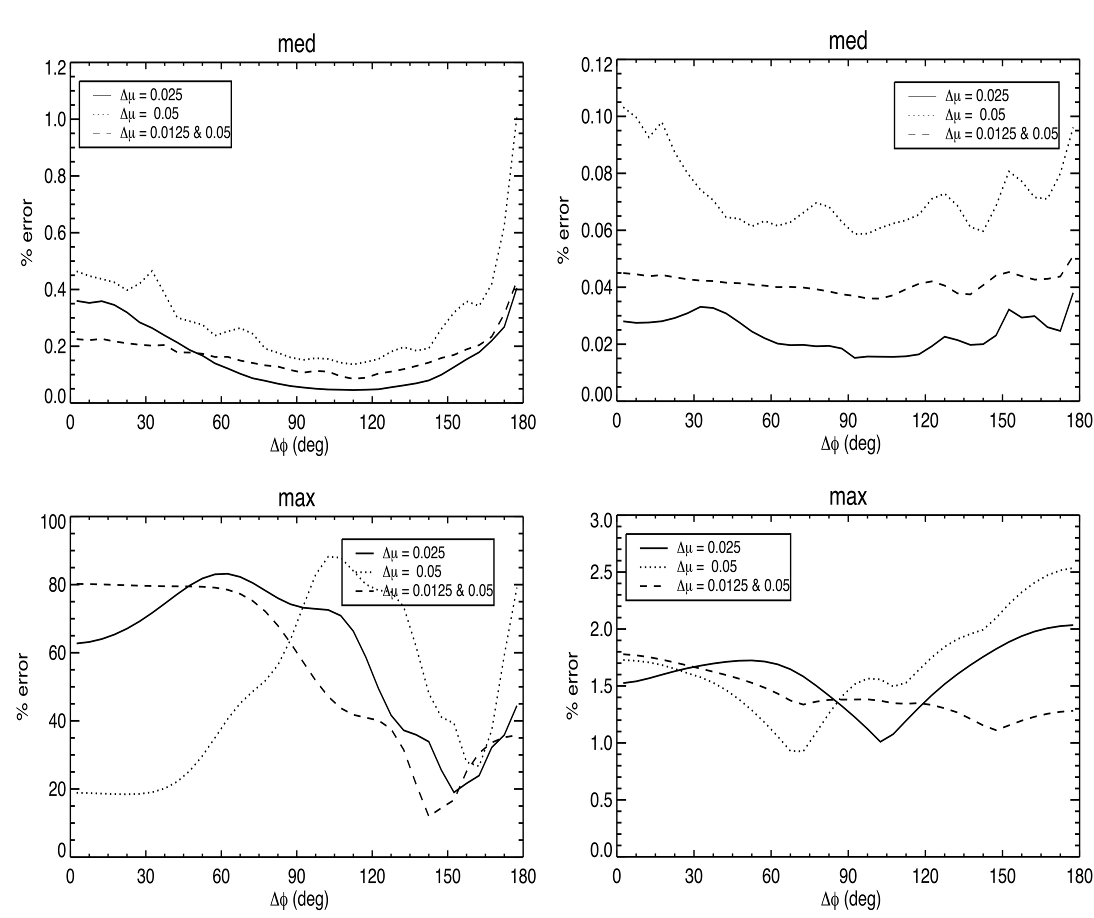


Figure 2 B01-Ice linear interpolation error for all solar angles, all view angles and all optical thickness values

WATER

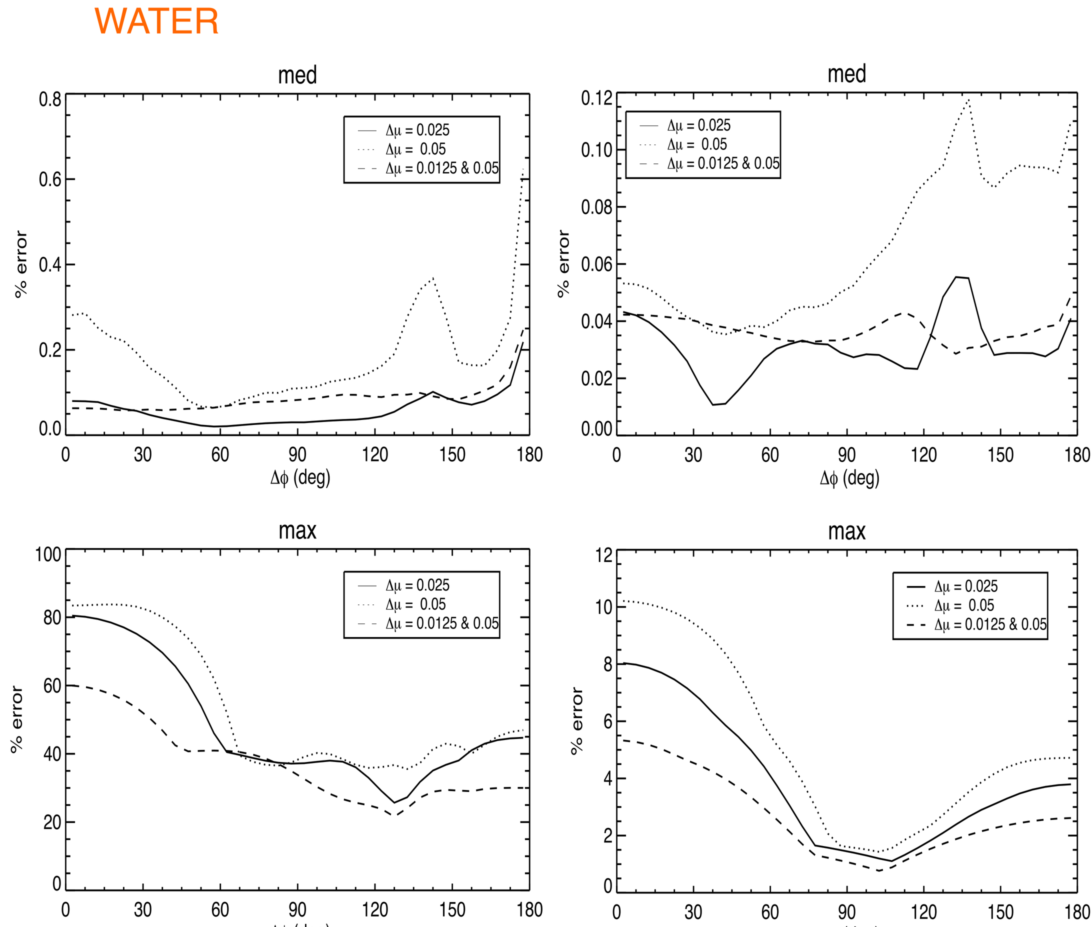


Figure 3 CH01-Water linear interpolation error for all solar angles, all view angles and all optical thickness values.

Polar plot of error: ICE

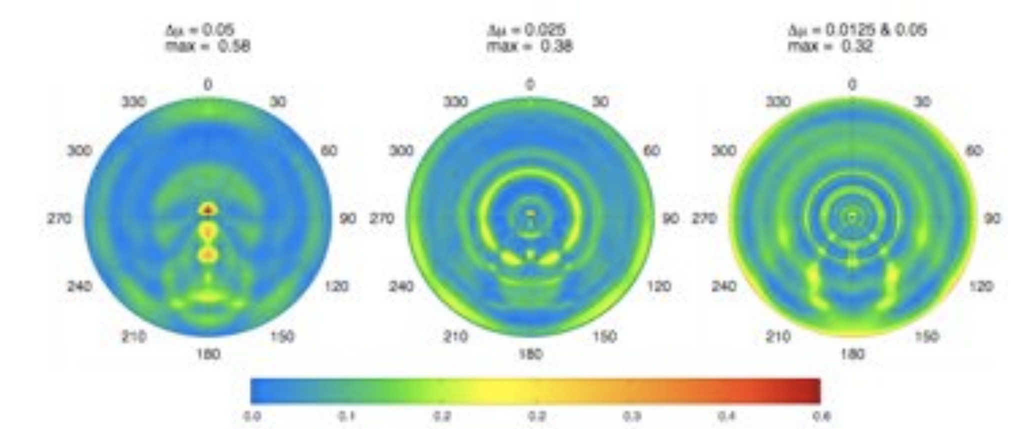


Figure 4 B01-Ice, Multi Reflectance τ = 4.14, R_E = 60.0μm, θ_0 = 35°

Polar plot of error: WATER

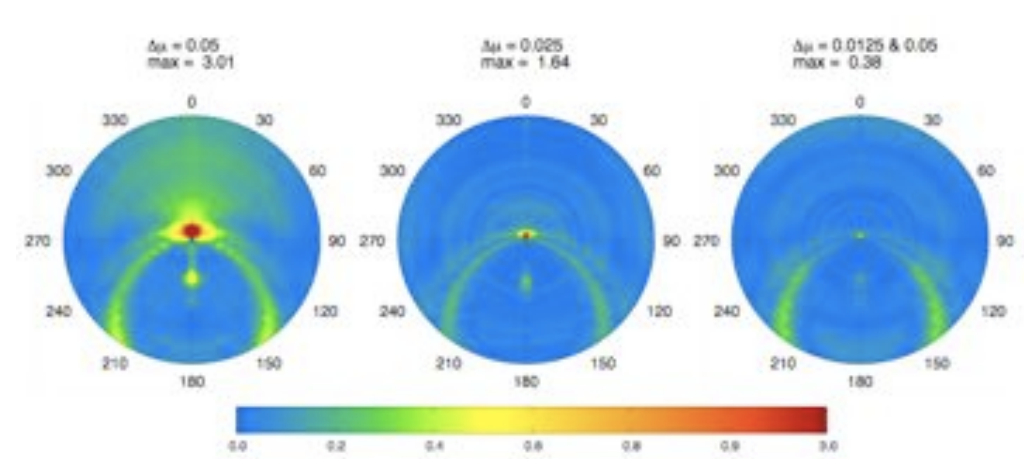


Figure 5 CH01-Water, Multi Reflectance τ = 4.14, R_E = 10.0μm, θ_0 = 35°

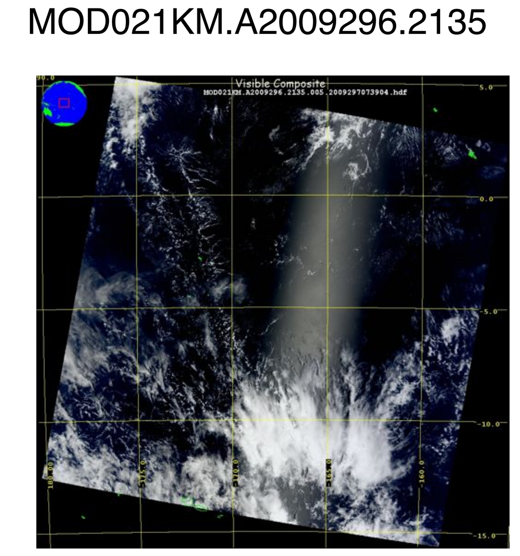
Terra Sun Glint Scenes

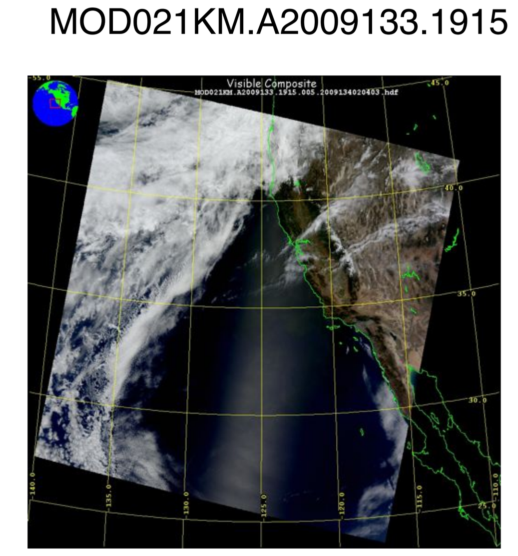
Since we are planning to create a separate ocean LUT with a Cox-Munk surface BRDF, it is useful to see how the Cox-Munk model compare with real sun glint scenes.

Radaitive transfer calculations were done to calculate clear sky radiances with

1. No Rayleigh scattering
2. With Rayleigh scattering
3. Rayleigh scattering plus a coarse mode aerosol layer with optical thickness of 0.1
4. Same as 3, but constant wind speed
5. Same as 3, different wind direction

MOD021KM.A2009296.2135 MOD021KM.A2009133.1915

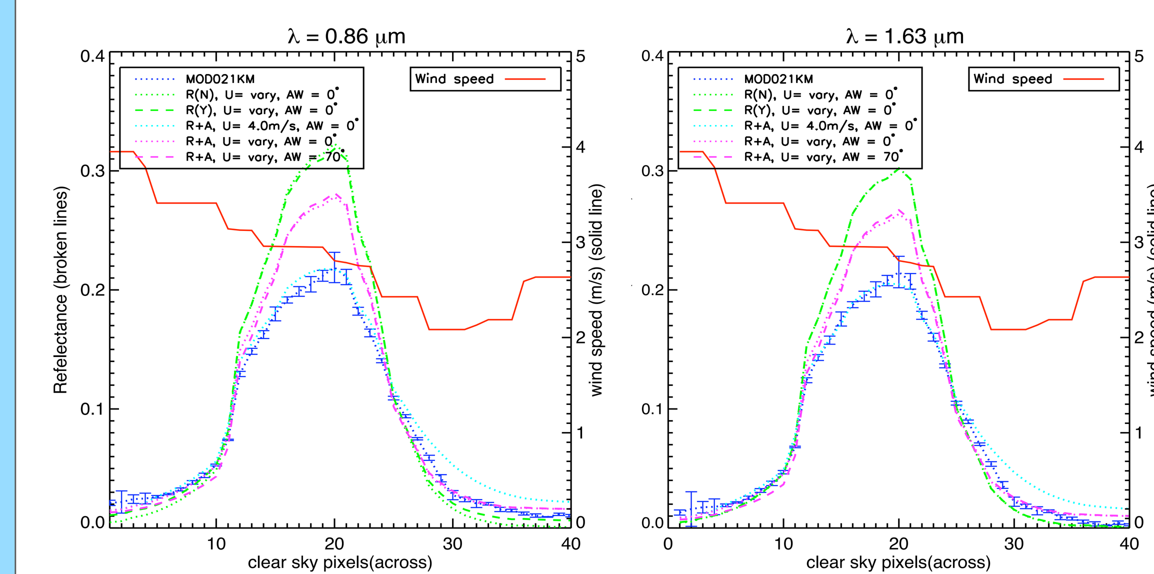




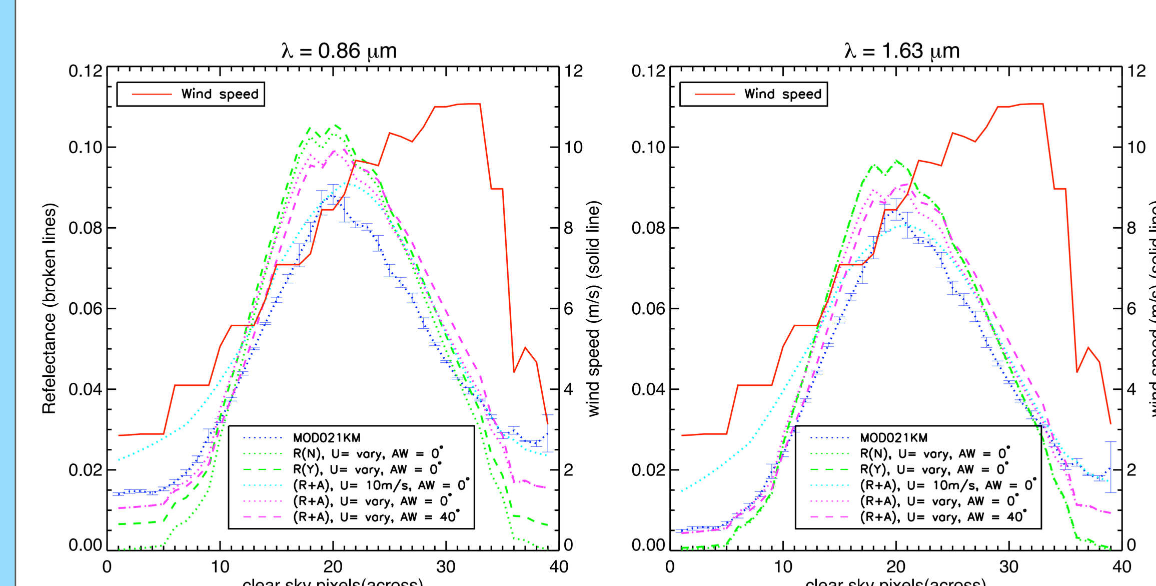
Comparison of MODIS clear sky reflectances

- Clear sky reflectance of two MODIS glint scenes, average of five, every 10 scan lines, compared well with that calculated from DISORT with Cox-Munk surface BRDF away from the glint (λ = 0.86 μm, left panels and λ = 1.63 μm, right panels). Significant differences can be seen for one of the sun glint scenes, MOD021KM.A2009296.2135, near the glint.

MOD021KM.A2009296.2135



MOD021KM.A2009133.1915



Summary

Constructed 6-parameter (λ, τ, θ_0, θ, $\Delta\phi$, R_E) look up tables of the multiple scattering part of the reflectance by discretizing solar and view angles in μ space, with Δμ of 0.0125 for μ in [0.75, 1.0] and Δμ of 0.05 for μ ≤ 0.75, and relative azimuth in degree space with a Δϕ of 5°. These new look up tables, used in C6, are in the process of being integrated into the retrieval code. Multi month sensitivity tests are planned.