MODIS Broadband Surface Albedo Retrieval Methodology and Comparison with CRS Surface Albedo Over Greenland

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MODIS Albedo* I
Defining the Sky

White Sky (Think Cloud)
Isotropic Radiation
$A_{WS}$

Black Sky (No Atmosphere)
Directional Radiation
$A_{BS}(\theta)$

Atmosphere Lays In Between
$A_{sfc}(\theta) = \{1 - S(\theta, \tau)\} A_{BS}(\theta) + S(\theta, \tau) A_{WS}$

$\theta$ – Solar zenith angle
$\tau$ – Aerosol optical depth

*All MODIS albedo terms are functions of wavelength.
MODIS Albedo II “Kernel” Based BRDF

Isotropic

Volumetric (Uniform, Dense, Leave Canopy)

Geometric (Uniform objects, cast shadows)

Assume BRDF “R” is equivalent to sum of Various “Kernels”

\[ R(\theta, \vartheta, \phi, \Lambda) = f_{iso}(\Lambda) + f_{vol}(\Lambda)K_{vol} + f_{geo}(\Lambda)K_{geo} \]

\[ f_k(\Lambda) \] – Derived from MODIS radiance observations.
MODIS Albedo \(\text{III}\)

From BRDF to Albedo

\[ R = f_{iso} + f_{vol}K_{vol} + f_{geo}K_{geo} \]

Integrate each “K” over azimuth & view zenith, then solar zenith:

Black Sky

\[ A_{BS}(\theta) = \sum_k f_k \int \int K_k d\theta d\phi \]

White Sky

\[ A_{WS} = \sum_k f_k \int h_k(\theta) d\theta \]
MODIS Albedo IV

From Albedo to HDF Coefficients

\[ A_{BS}(\theta) = \sum_k f_k \int \int K_k d\theta d\phi \]

Assume: \[ h_k(\theta) = g_{0k} + g_{1k} \theta^2 + g_{2k} \theta^3 \]

Gives: \[ A_{BS}(\theta) = f_{iso}(g_{0iso} + g_{1iso} \theta^2 + g_{2iso} \theta^3) + f_{vol}(g_{0vol} + g_{1vol} \theta^2 + g_{2vol} \theta^3) + f_{geo}(g_{0geo} + g_{1geo} \theta^2 + g_{2geo} \theta^3) \]

\[ A_{WS} = f_{iso} g_{iso}^{ws} + f_{vol} g_{vol}^{ws} + f_{geo} g_{geo}^{ws} \]

Finally: \[ A_{sfc}(\theta) = \{1 - S(\theta,\tau)\} A_{BS}(\theta) + S(\theta,\tau) A_{WS} \]

Where: \( f_{iso}, f_{vol}, f_{geo} \) Come from MODIS HDF files \( g_{jk} \) and \( S(\theta,\tau) \) Pre-computed, supplied in MODIS code.
CRS & MODIS Albedo Compared at Footprint Resolution Using CCCM NEWS* data product.

- Use Clear Sky (Minnis retrieval of all MODIS pixels inside CERES footprint.)

- Albedos are based on ratio of up/down flux at the surface using:
  1) CRS Edition2B algorithm
  2) “Enhanced CRS calculation” (uses MODIS MCD43C1 surface albedo.)

- CRS surface albedo retrieved from nadir observed CERES TOA albedo.
- MCD43C1 surface albedo developed 16-days; product every 8-days.
CRS & MODIS Compared at Footprint Resolution*
Using CRS and MCD43C1 (From Terra, July 2001)

*From Rutan et al. JGR 2009
CRS & MODIS Compared at Footprint Resolution Using CCCM NEWS* data product.

CRS-MODIS Albedo
All Clear Sky Footprints

*From Aqua July, 2006
CRS & MODIS Compared at Footprint Resolution Using CCCM NEWS data product.

Footprints with Snow

Snow Scenes
- x-mean: 0.719
- y-mean: 0.753
- bias: 0.034
- RMS: 0.053
- N: 1423.
Possibilities:
MODIS collects over multiple view zenith angle, CERES is nadir only in NEWS data.
Polarization error in MODIS radiances over snow.
Extra 1: CRS Aerosol Opt Depth

Clear Sky Surface Albedo Delta (CRS-MODIS): 2006/07 (CCCM Aqua)

Delta Sfc Albedo (CRS-Modis Enh), Snow Scenes

x-mean: 0.022
y-mean: 0.034
bias: 0.012
RMS: 0.055
N: 1423.