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

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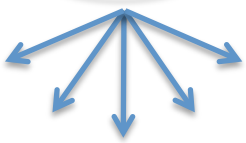
MODIS Albedo* I
Defining the Sky

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



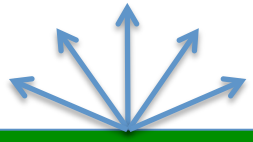
Black Sky (No Atmosphere)
Directional Radiation
$A_{BS}(\theta)$

Atmosphere Lays In Between

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

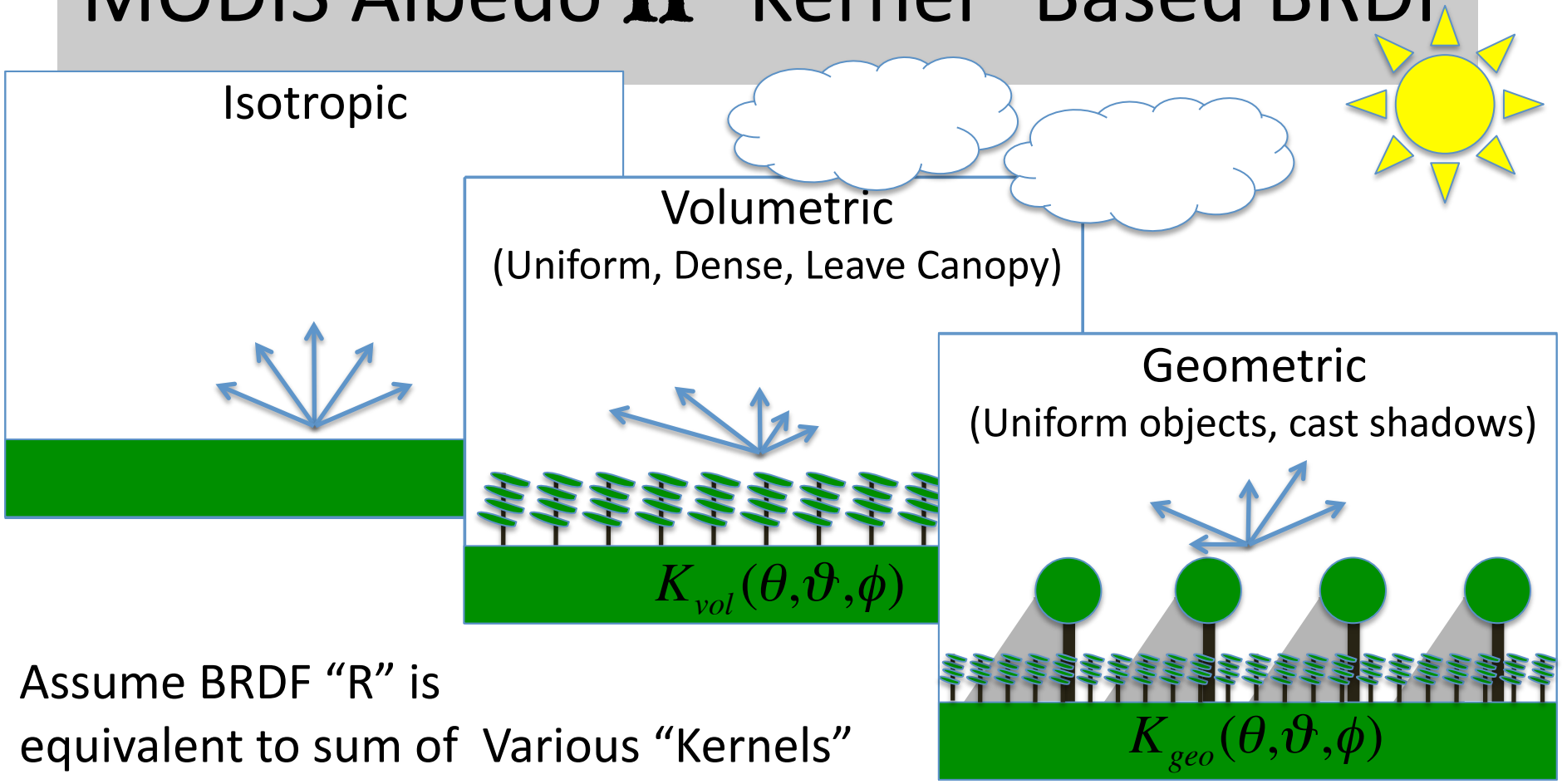
θ – Solar zenith angle

τ – Aerosol optical depth



*All MODIS albedo terms are functions of wavelength.

MODIS Albedo II "Kernel" Based BRDF



Assume BRDF "R" is equivalent to sum of Various "Kernels"

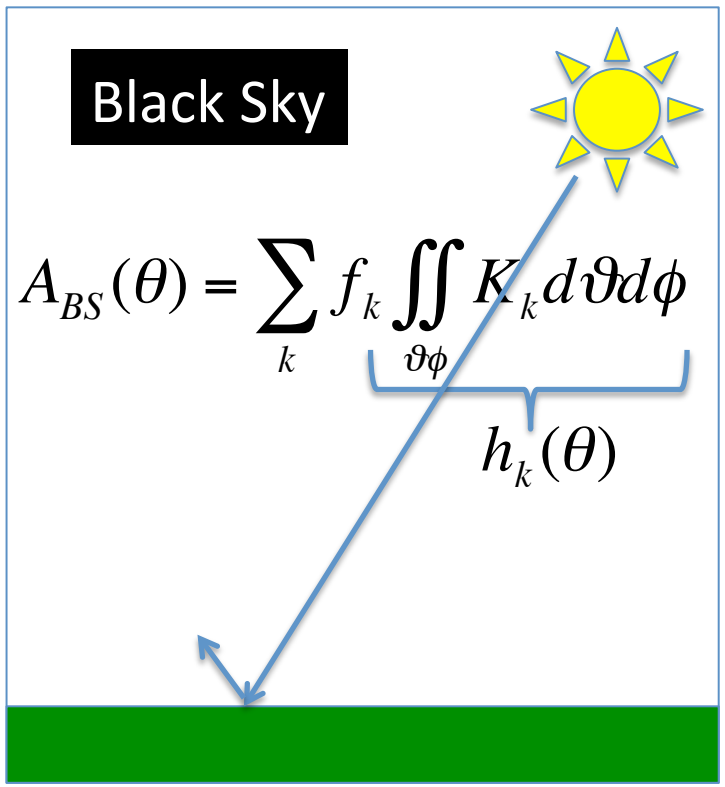
$$R(\theta,\vartheta,\phi,\Lambda) = f_{iso}(\Lambda) + f_{vol}(\Lambda)K_{vol} + f_{geo}(\Lambda)K_{geo}$$

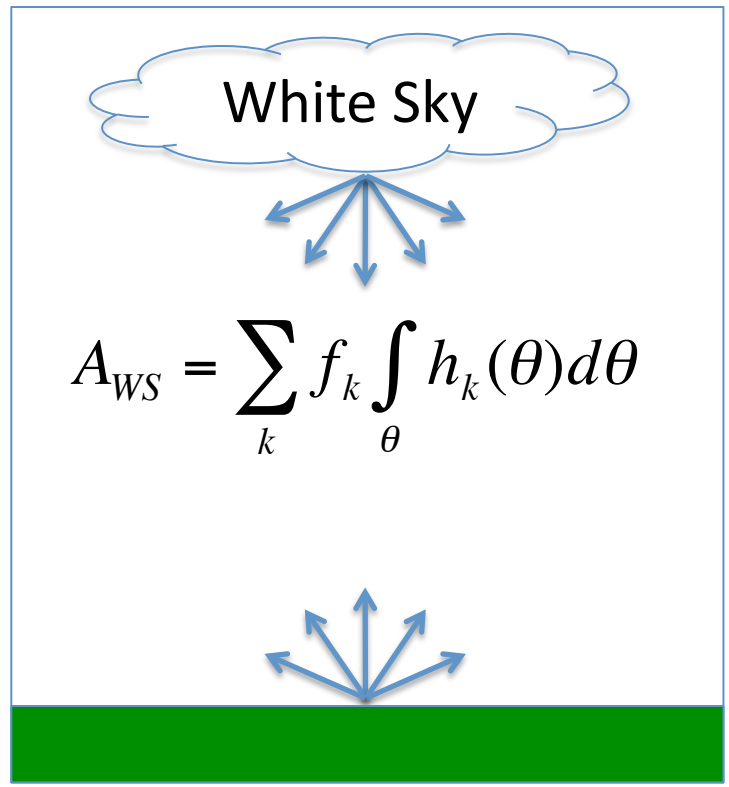
$f_k(\Lambda)$ – Derived from MODIS radiance observations.

MODIS Albedo 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:





MODIS Albedo IV

From Albedo to HDF Coefficients

$$A_{BS}(\theta) = \sum_k f_k \underbrace{\iint_{\vartheta\phi} K_k \, d\vartheta d\phi}$$

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

Gives:

$$\begin{aligned} A_{BS}(\theta) = \; & f_{iso}(g_{0iso} + g_{1iso}\theta^2 + g_{2iso}\theta^3) + \\ & f_{vol}(g_{0vol} + g_{1vol}\theta^2 + g_{2vol}\theta^3) + \\ & f_{geo}(g_{0geo} + g_{1geo}\theta^2 + g_{2geo}\theta^3) \end{aligned}$$

$$A_{WS} = f_{iso}g_{iso}^{ws} + f_{vol}g_{vol}^{ws} + f_{geo}g_{geo}^{ws}$$

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

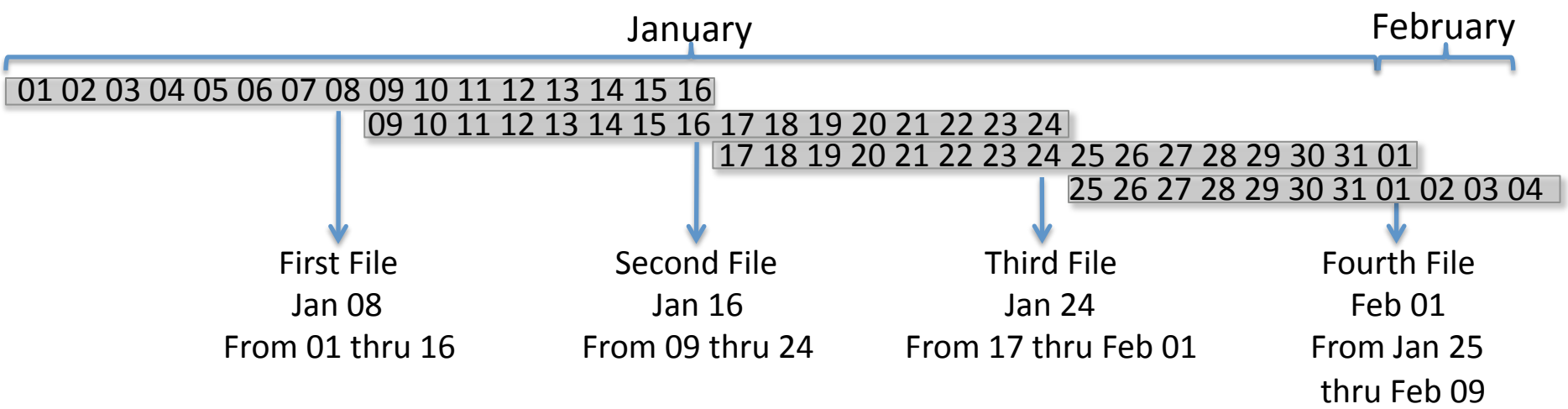
g_{jk} *and* $S(\theta,\tau)$ Pre-computed, supplied in MODIS code.

CRS & MODIS Albedo Compared at Footprint Resolution Using CCCM NEWS* data product.

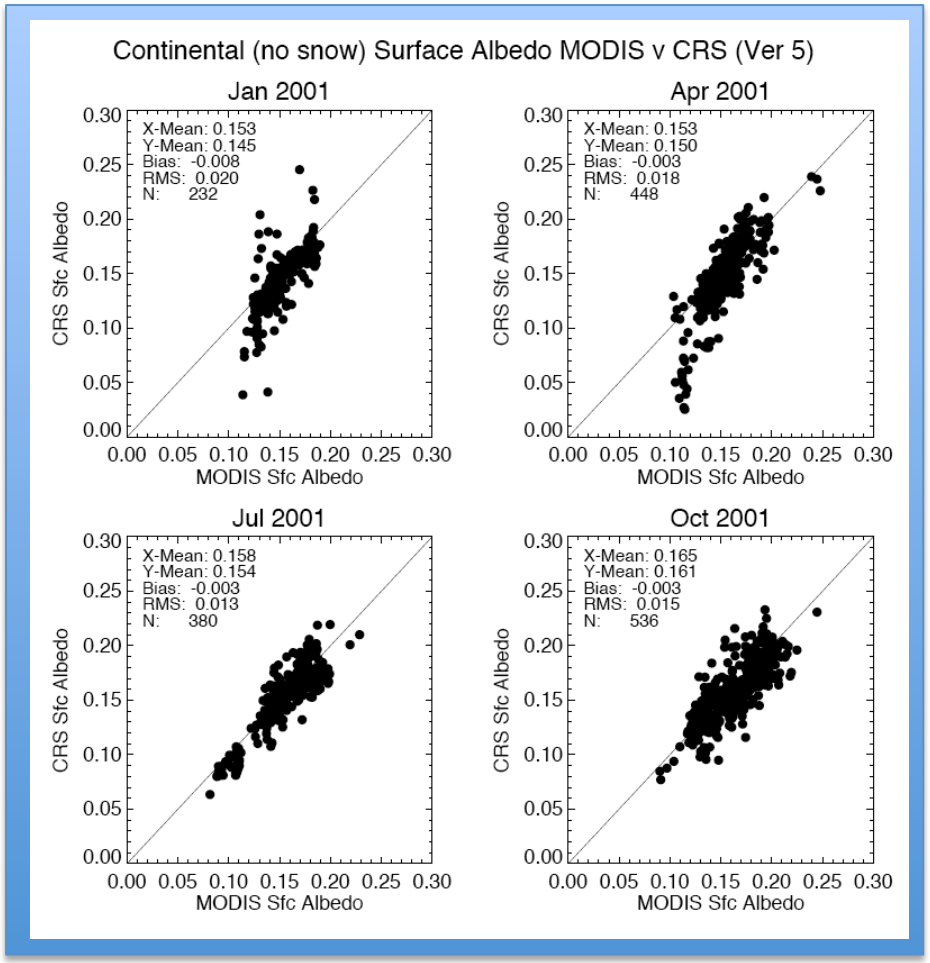
- Use Clear Sky (Minnis retrieval of all MODIS pixels inside CERES footprint.)

- 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.)

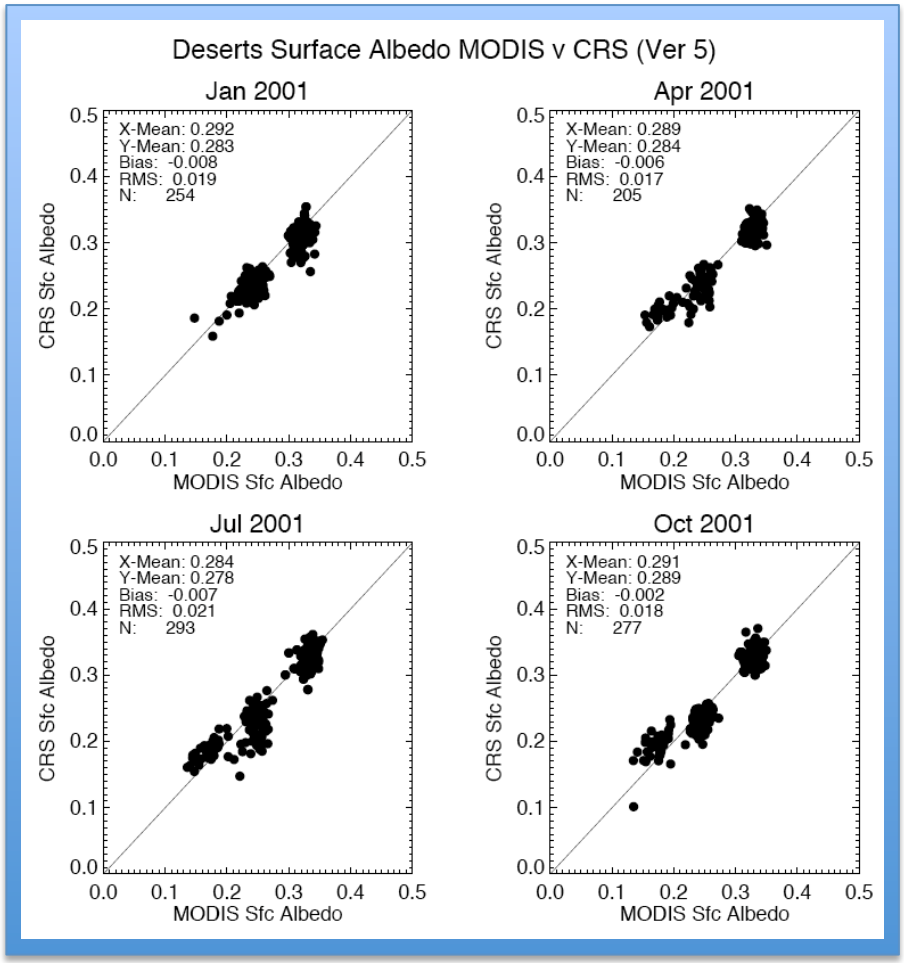
- CRS surface albedo retrieved from nadir observed CERES TOA albedo.
- MCD43C1 surface albedo developed 16-days; product every 8-days.



CRS & MODIS Compared at Footprint Resolution* Using CRS and MCD43C1 (From Terra, July 2001)



Land Sites

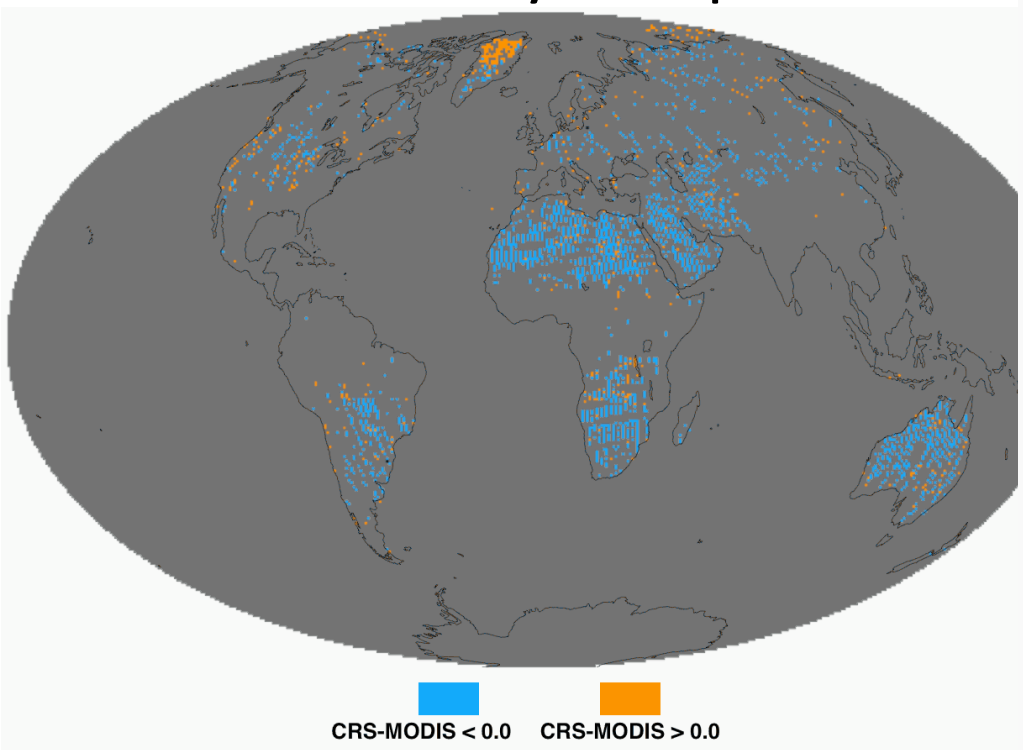


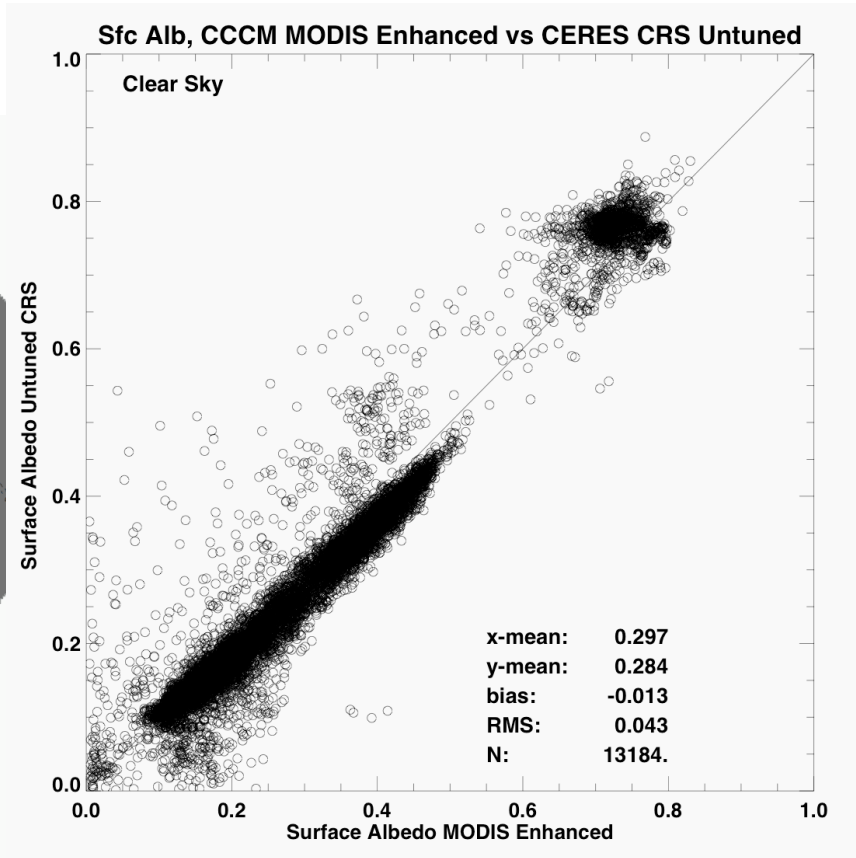
Desert Sites

*From Rutan et al. JGR 2009

CRS & MODIS Compared at Footprint Resolution Using CCCM NEWS* data product.

CRS-MODIS Albedo
All Clear Sky Footprints

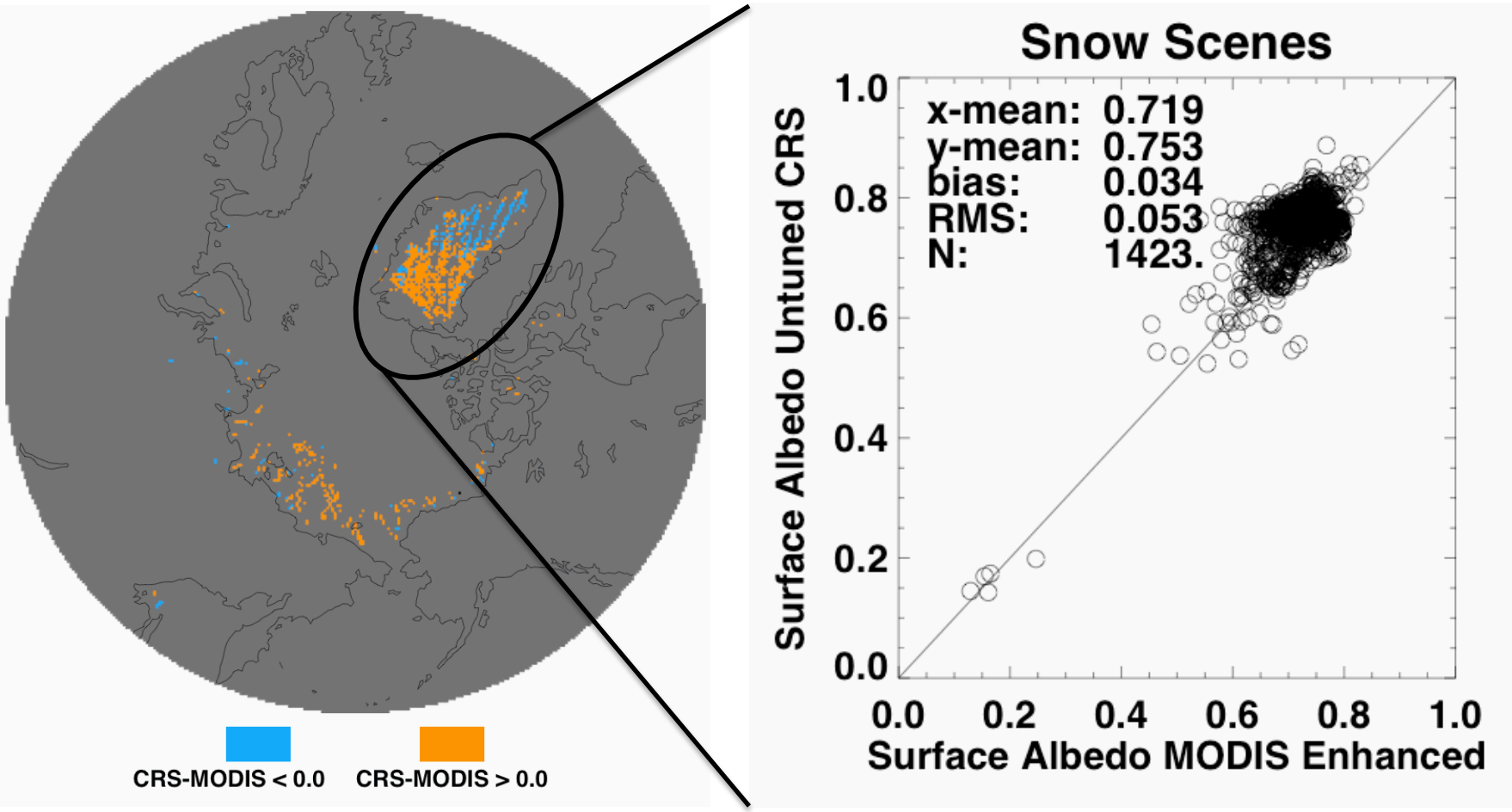




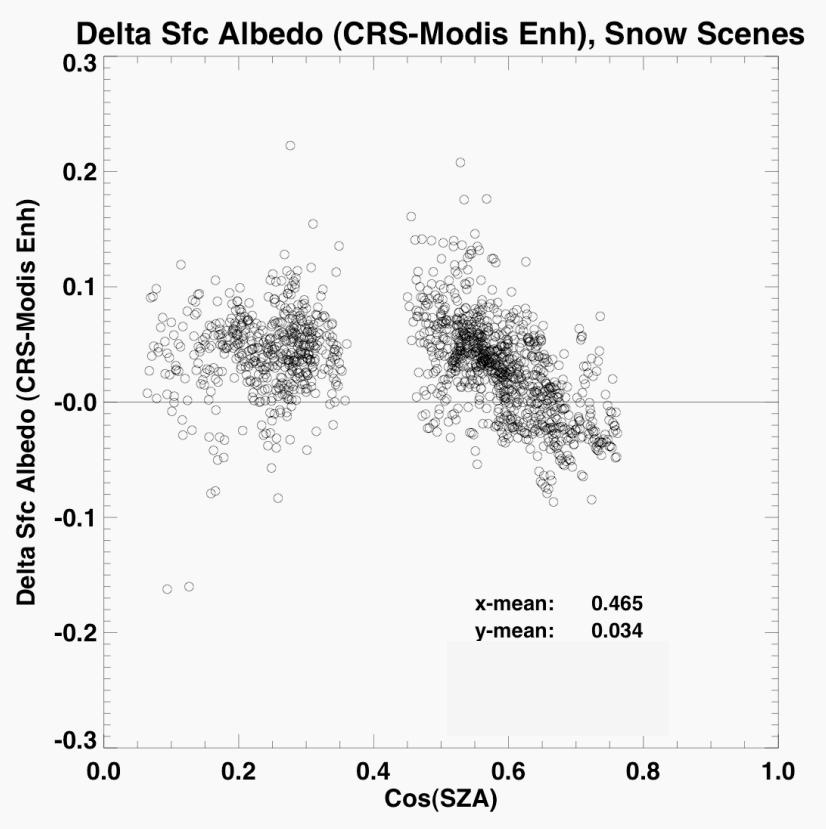
*From Aqua July, 2006

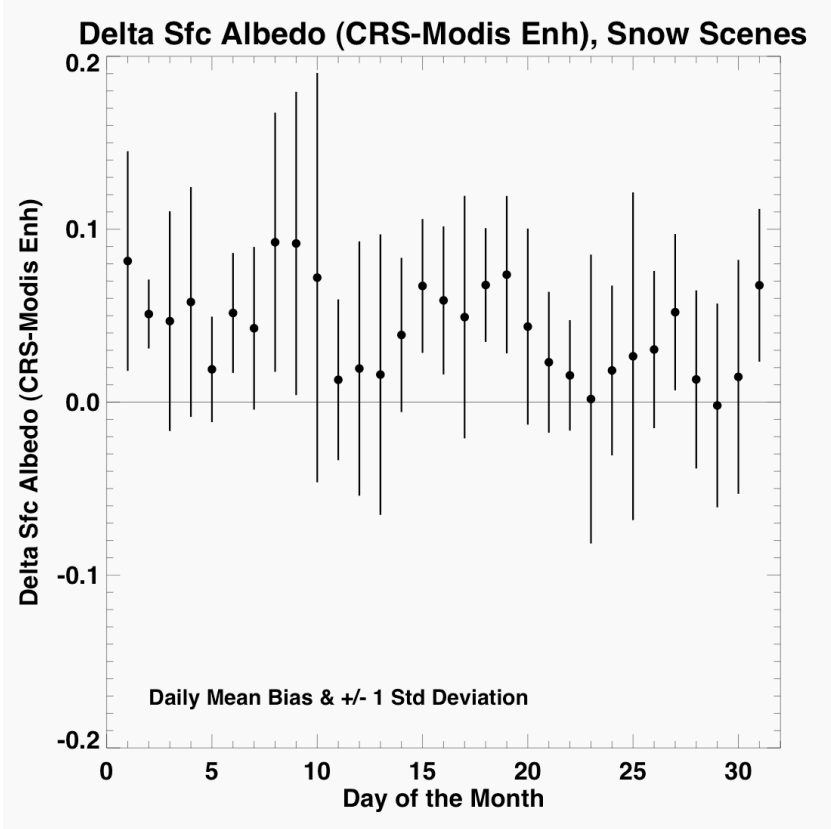
CRS & MODIS Compared at Footprint Resolution Using CCCM NEWS data product.

Footprints with Snow



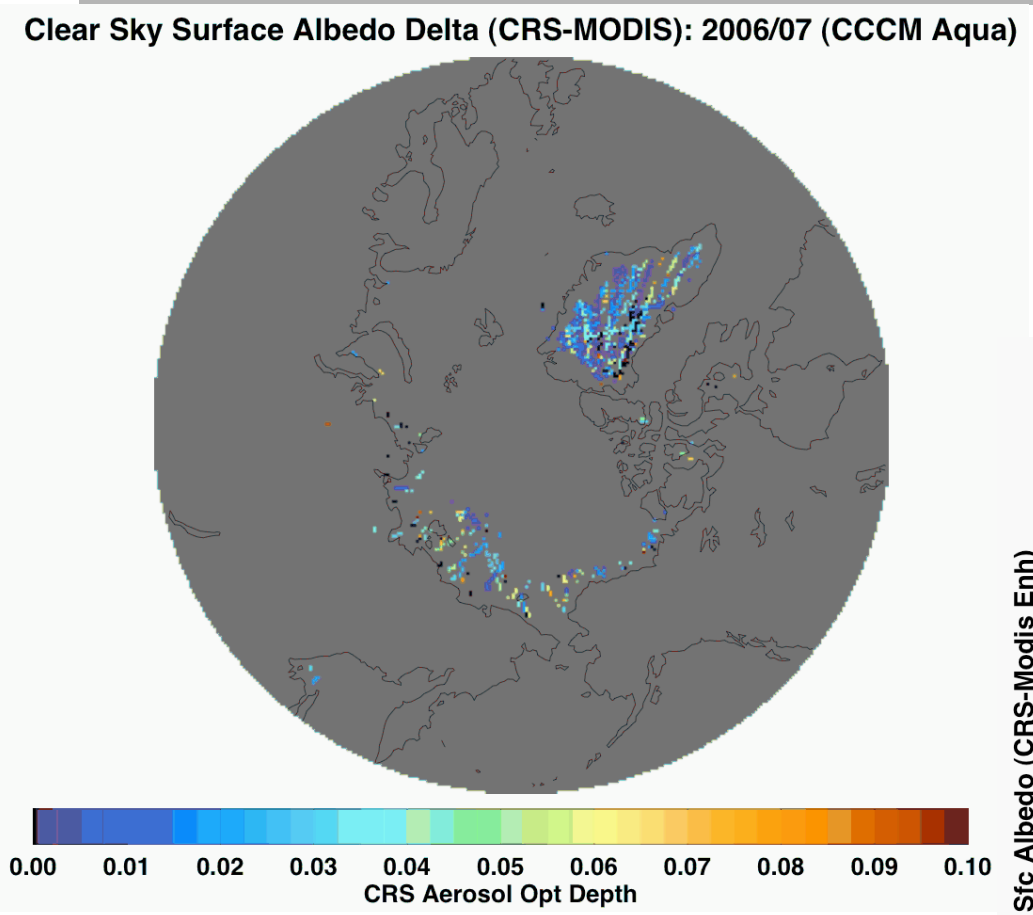
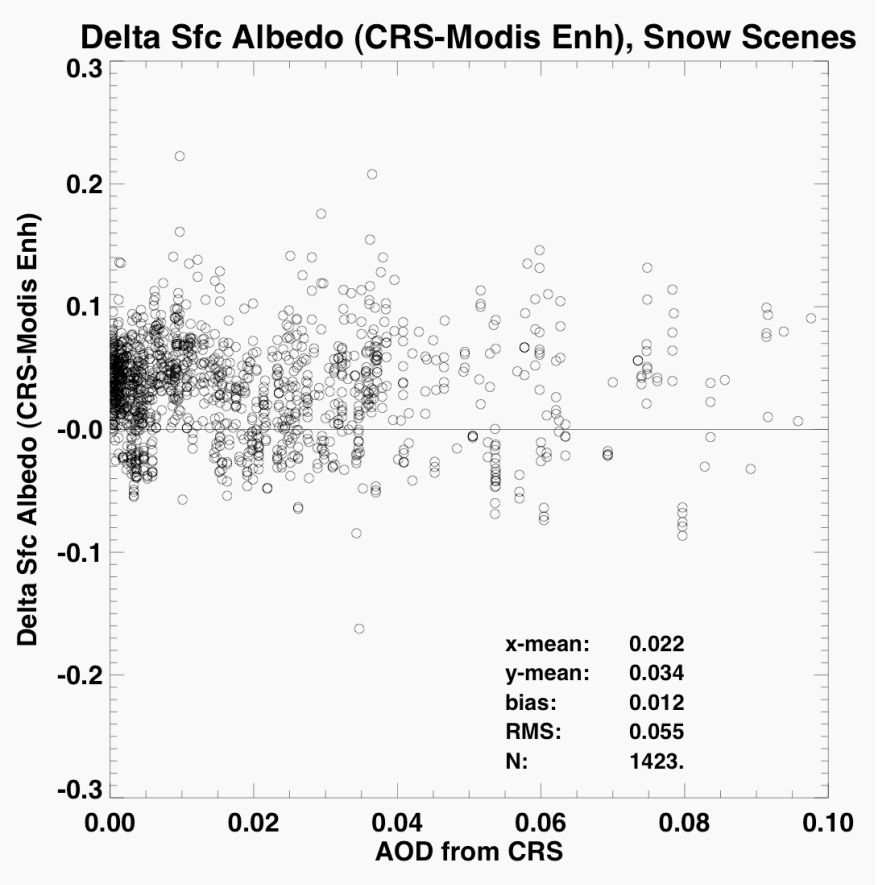
CRS & MODIS Compared at Footprint Resolution Using CCCM NEWS data product.





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