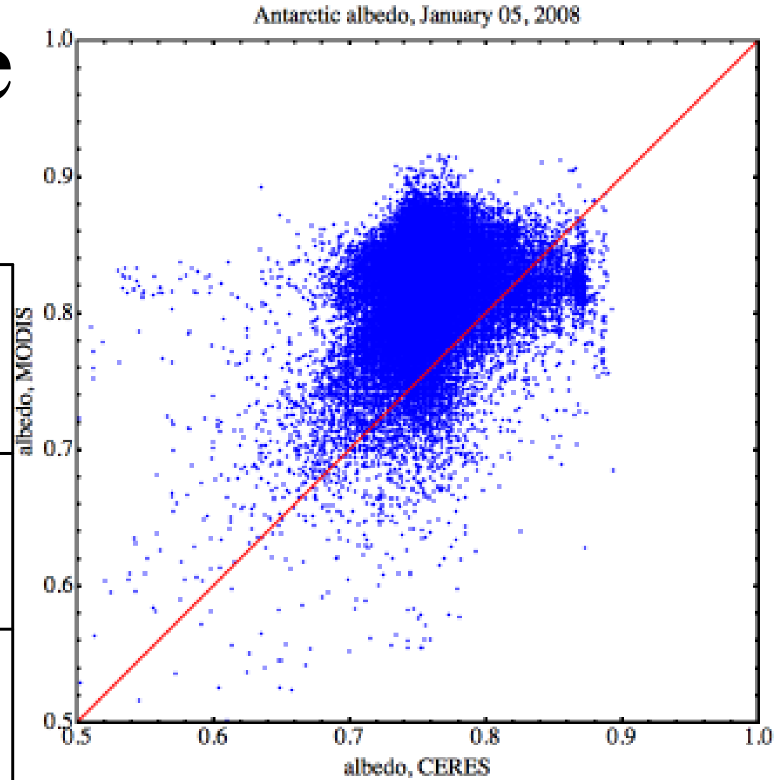
Modeling CERES TOA SW observations over the Antarctic using in-situ BRDF measurements (work in progress)

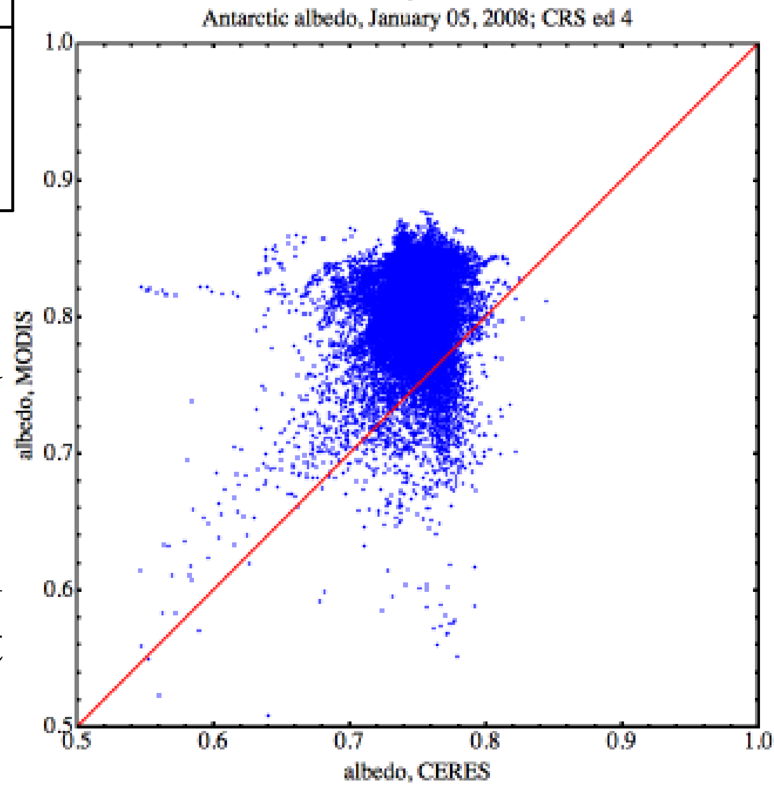
A. Radkevich

CERES underestimates surface albedo over the Antarctic

CRS ed, N_{FOV}, SZA	a_{CERES} (STD)	a_{MODIS} (STD)	$a_{MODIS} = c\, a_{CERES}$
CRS ed 2, All SZAs, $N_{FOV} = 45496$	0.758 (0.039)	0.814 (0.042)	1.0727
CRS ed 2, SZA < 70, $N_{FOV} = 26879$	0.751 (0.025)	0.806 (0.039)	1.0724
CRS ed 4, All SZAs, $N_{FOV} = 18036$	0.745 (0.026)	0.800 (0.038)	1.0719

Is MODIS a benchmark? Maybe not, but…
Grenfel *et al* (JGR 1994) reported ground measurements of clear sky albedo: a = 0.80, 0.84, 0.85. for SZA = 55º, 68º, 72º, respectively.
Possible reasons for the surface albedo underestimation is underestimation of TOA albedo over permanent snow/ice.





Solution: precise RT modeling involving accurate bottom boundary condition

RT model:

- 32 bands covering CERES SW band;
- monochromatic calculations performed by DISORT;
- accounts for Rayleigh scattering;
- gas absorption (correlated-*k*, HITRAN);
- clouds and aerosol scattering and absorption (if any);
- surface elevation.

BRDF:

$$\rho(\theta_0, \theta_v, \varphi) = \frac{I_r(\theta_0, \theta_v, \varphi)}{F_0(\theta_0)} = \alpha(\theta_0) R(\theta_0, \theta_v, \varphi) / \pi$$

Where $\alpha(\theta_0)$ – black sky albedo, cannot be measured due to Rayleigh scattering, has to be modeled; $R(\theta_0, \theta_v, \phi)$ – anisotropic reflection factor, measurable(?), an attempt to clean out directional distribution of the incident light in measurements under clear sky.

$$R(\theta_0, \theta_v, \varphi) = \frac{\pi I_r(\theta_0, \theta_v, \varphi)}{\int_0^{2\pi} d\varphi \int_0^{\pi/2} d\theta_v \sin\theta_v \cos\theta_v I_r(\theta_0, \theta_v, \varphi)}$$

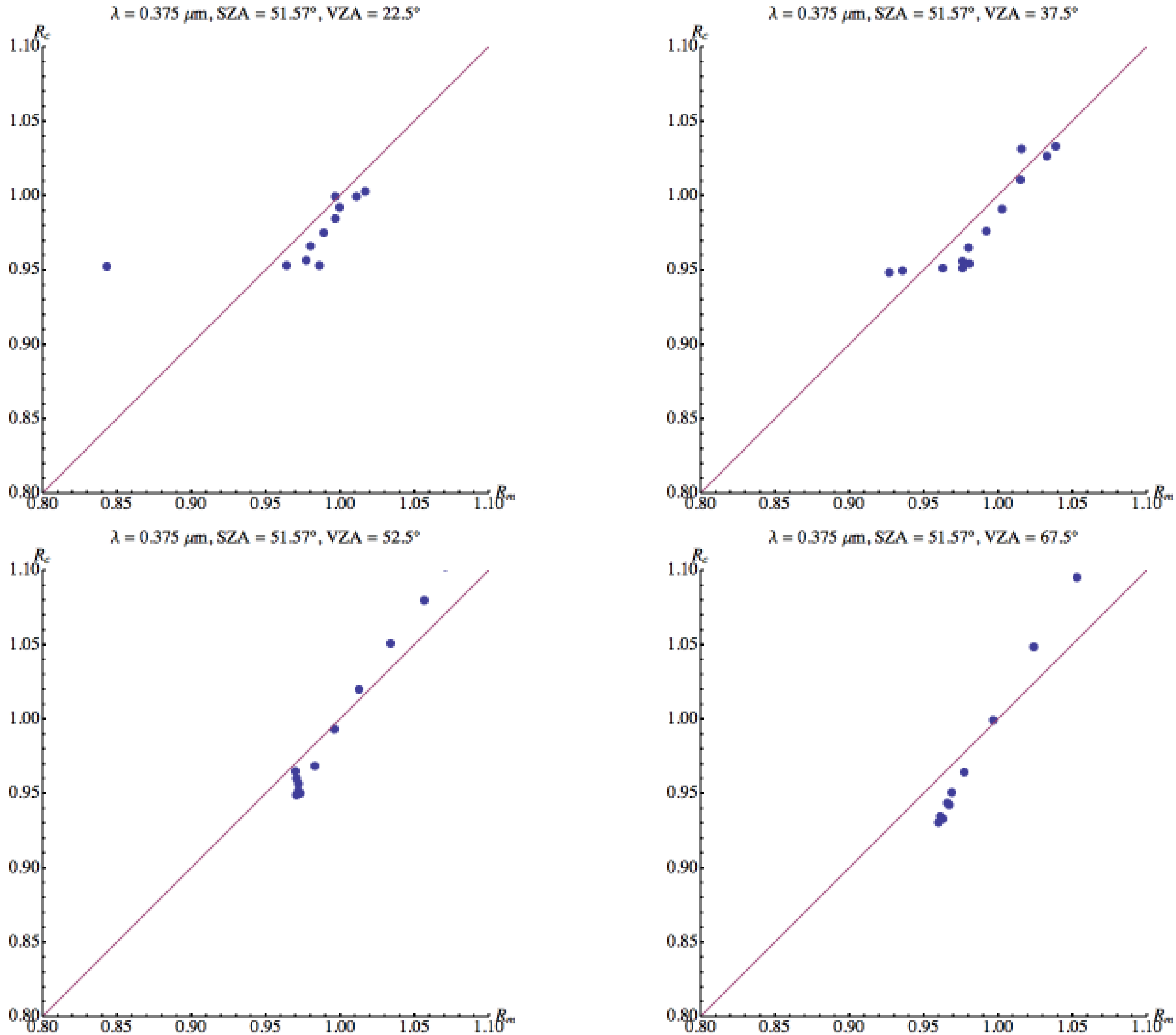
Measurements of *R* and their analytical model

Reflected radiance and flux were measured at Dome C in austral summers of 2003 – 2004 and 2004 – 2005 (Hudson et al 2006 JGR). Measurements are done at θ_v = 7.5° , 22.5° , …, 82.5° and ϕ = 150° , 165° , …, 345° , 0° , 15° , 30° and wavelength 0.35 to 2.4 μm with a step of 0.025 μm.
Matrix of all measurements can be represented as

$$\mathbf{R} = \mathbf{1} + \mathbf{U}\Sigma\mathbf{V}^T$$

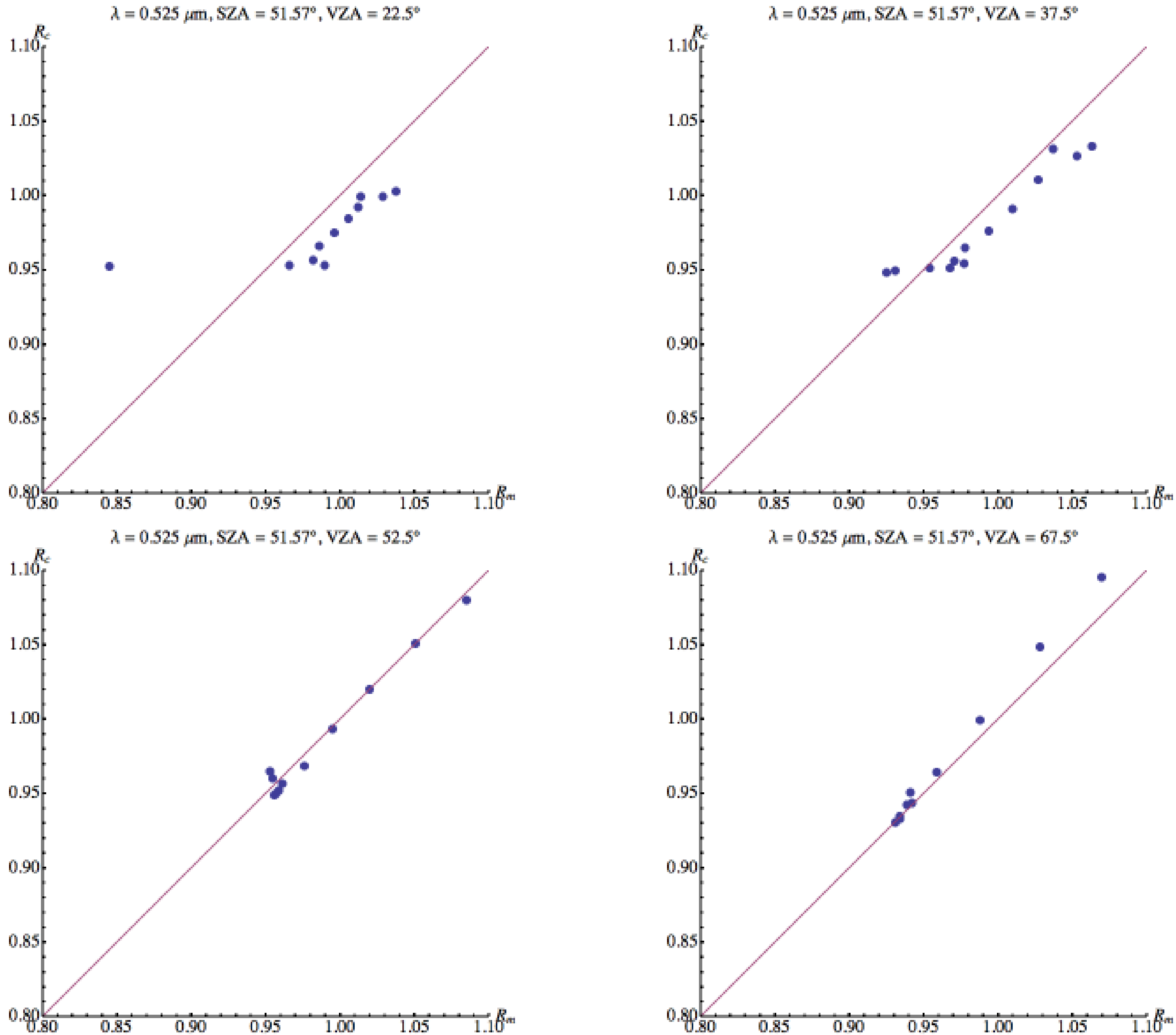
Where rows of R represent grid of SZA and RAZ while columns represent SZA values and wavelength. The representation above comes from EOF of the data. It was shown that variability of R can be described with first few columns of **U**, **Σ**, and **V**. Columns of V represent dependence on SZA and wavelength. They were parameterized.

Parameterization of *R* vs. actual measurements



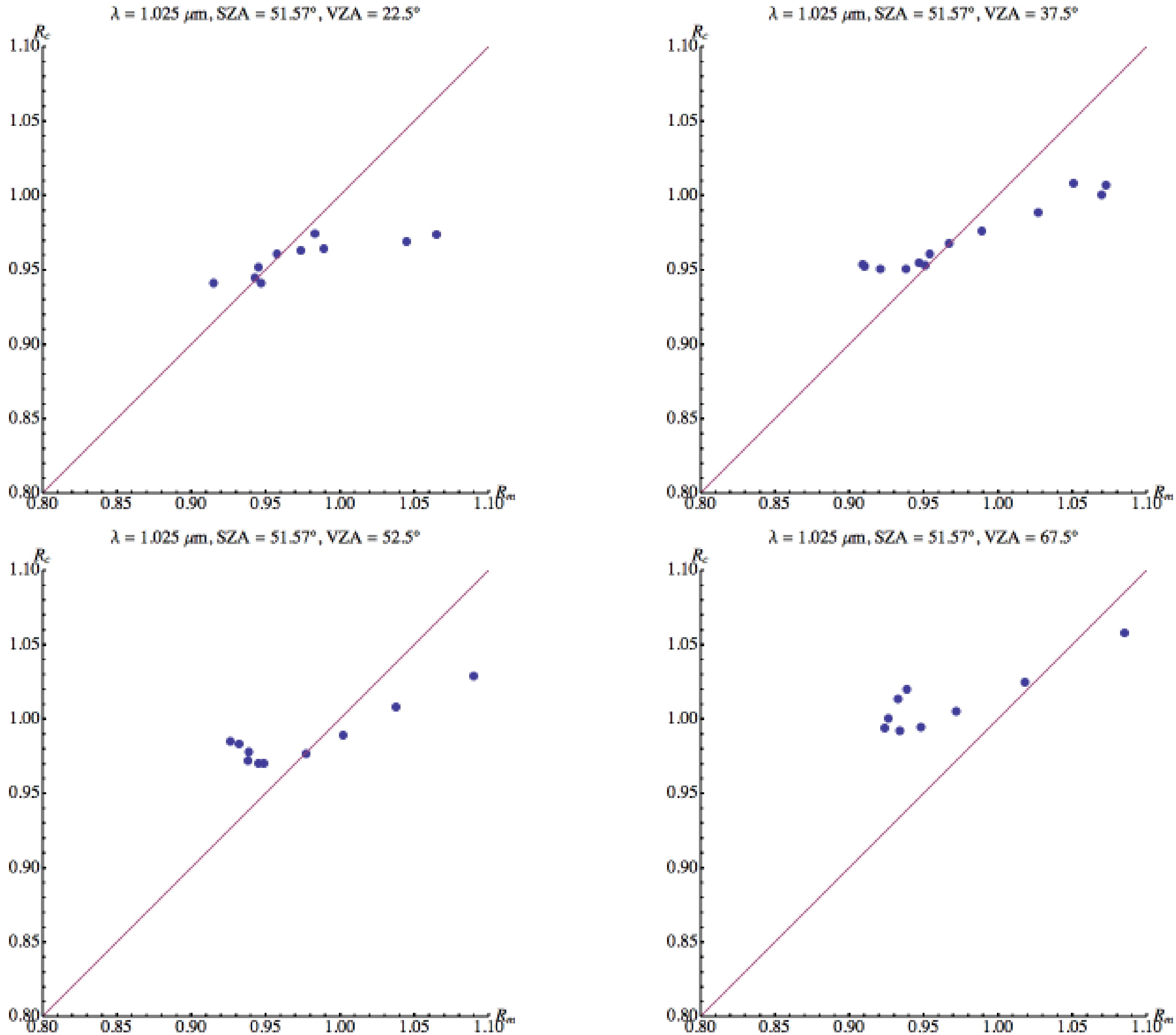
Band 6

Parameterization of *R* vs. actual measurements



Band 9

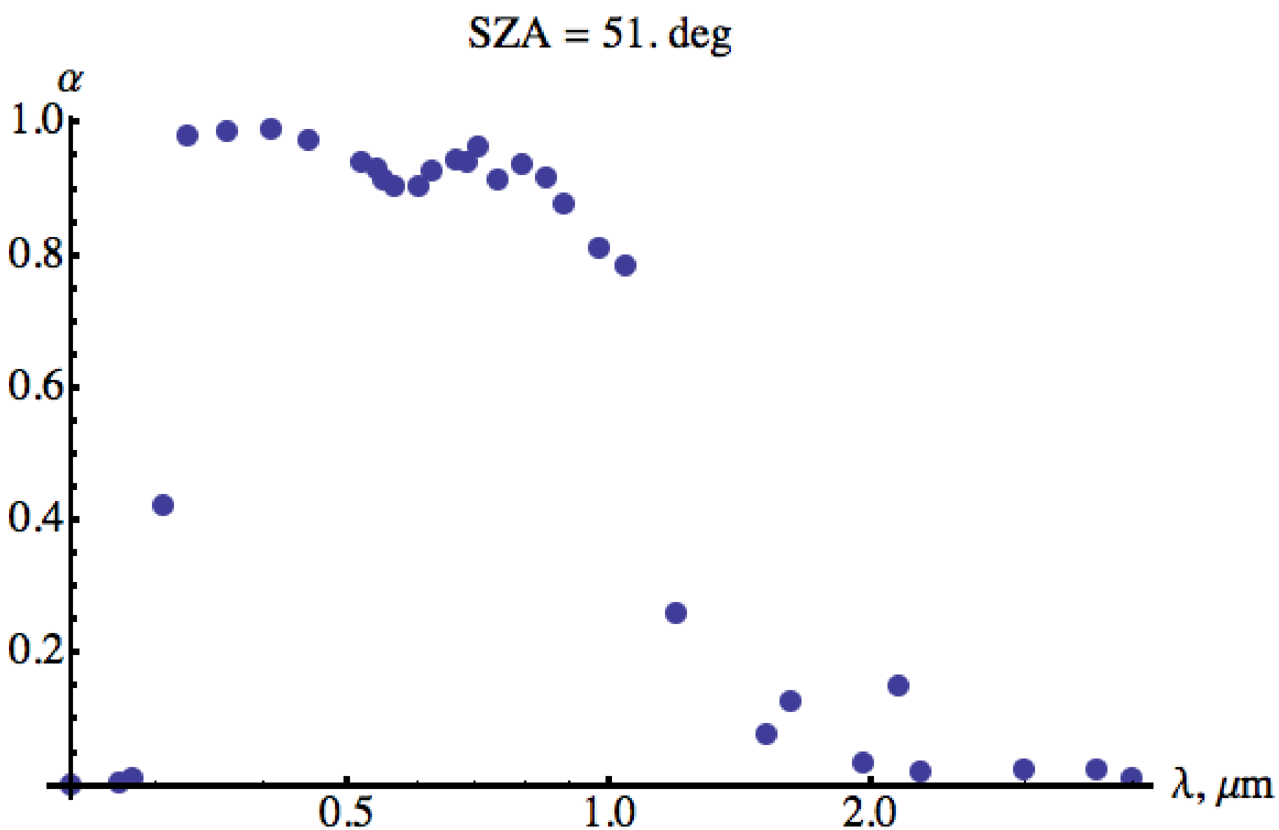
Parameterization of *R* vs. actual measurements



Band 22

Modeling black sky albedo

Snowpack was modeled as 2 layers of ice spheres. Top layer is 0.25 mm thick consisting of 40 μm (radius) spheres. Bottom layer is infinite of 90 μm spheres. The same RT model was used to calculate reflected radiances and fluxes.



Scene selection algorithm

- Clear sky as recognized by CERES CWG;
- Clear sky snow/ice as recognized by SARB algorithm (Radkevich *et al* 2013 *J Tech*);
- Center of a FOV is within 15 km from Dome C (75° 06’ S, 123° 18’ E);
- Additional check for clear sky surrounding environment has to be done by analysis of simultaneous MODIS image;
- CALIPSO cloud screening may be used for AQUA observations.