CLOUD PROPERTIES, BRDFS, & INTER-SATELLITE CALIBRATIONS FROM TRIANA DATA

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OBJECTIVE 1

DERIVE CLOUD PROPERTIES FROM TRIANA

- PROVIDE ADDITIONAL INFORMATION FOR DERIVATION OF OZONE & OTHER PARAMETERS FROM *EPIC*

- ENABLE THE COMPUTATION OF BIDIRECTIONAL REFLECTANCE CORRECTION FACTORS FOR COMPUTING ALBEDOS FROM *NISTAR* RADIANCES

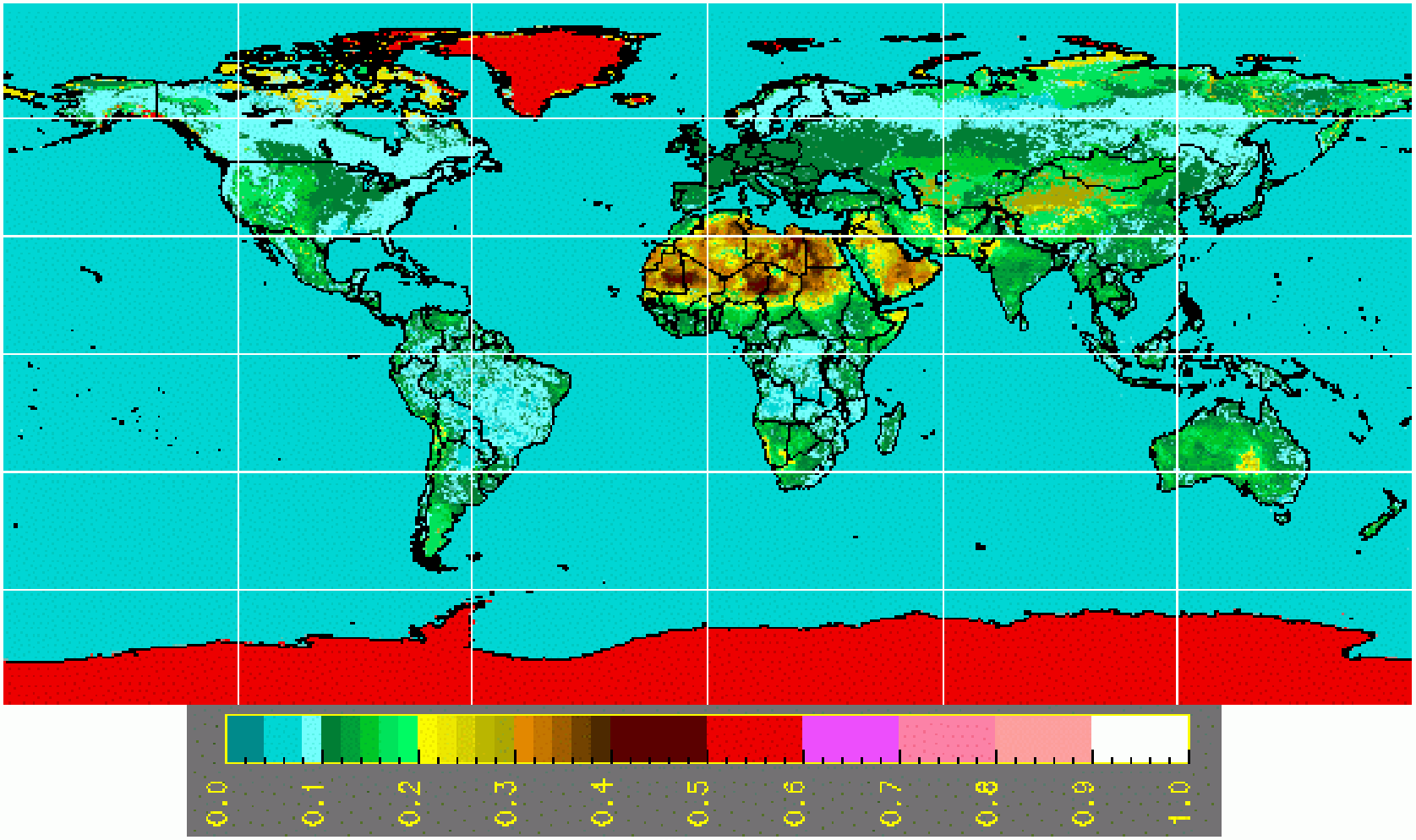
- TO STUDY ICE-CRYSTAL SHAPE & 3-D EFFECTS IN COMBINATION WITH *OTHER SATELLITES*

APPROACH FOR CLOUD RETRIEVALS

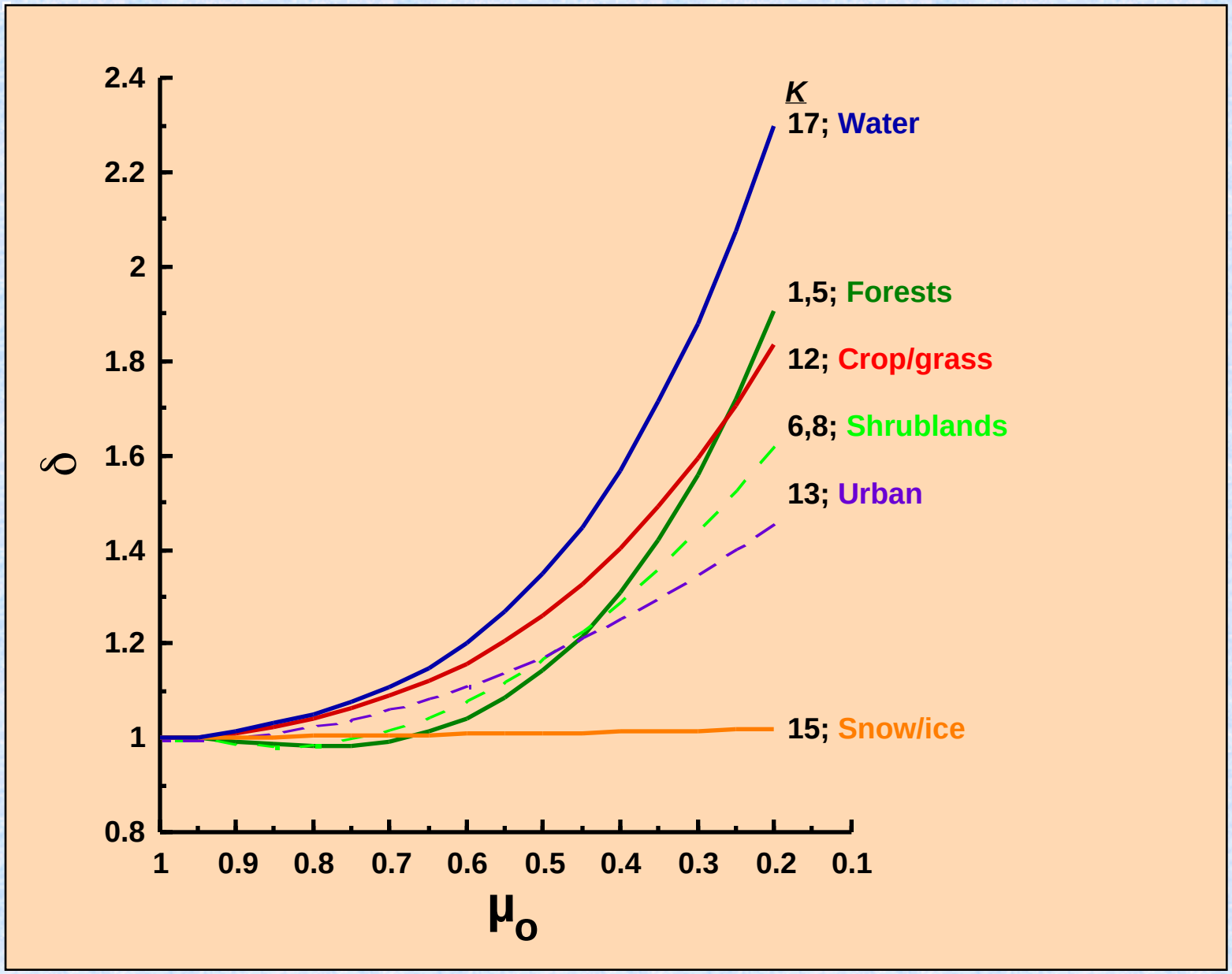
- **APPLY MULTISPECTRAL THRESHOLDS TO DETECT CLOUDS FOR EACH TRIANA PIXEL**
  - **ESTIMATE CLEAR-SKY REFLECTANCES FROM *CERES* MAPS**
  - **UPDATE REFLECTANCES FROM *TRIANA EPIC* DATA FOR OTHER CHANNELS**
  - **VERIFY WITH *CERES TRMM, TERRA, & AQUA* RETRIEVALS**
- **DERIVE CLOUD OPTICAL DEPTH USING ASSUMED PARTICLE SIZE, SHAPE, & PHASE**

Clear Sky Overhead Albedo

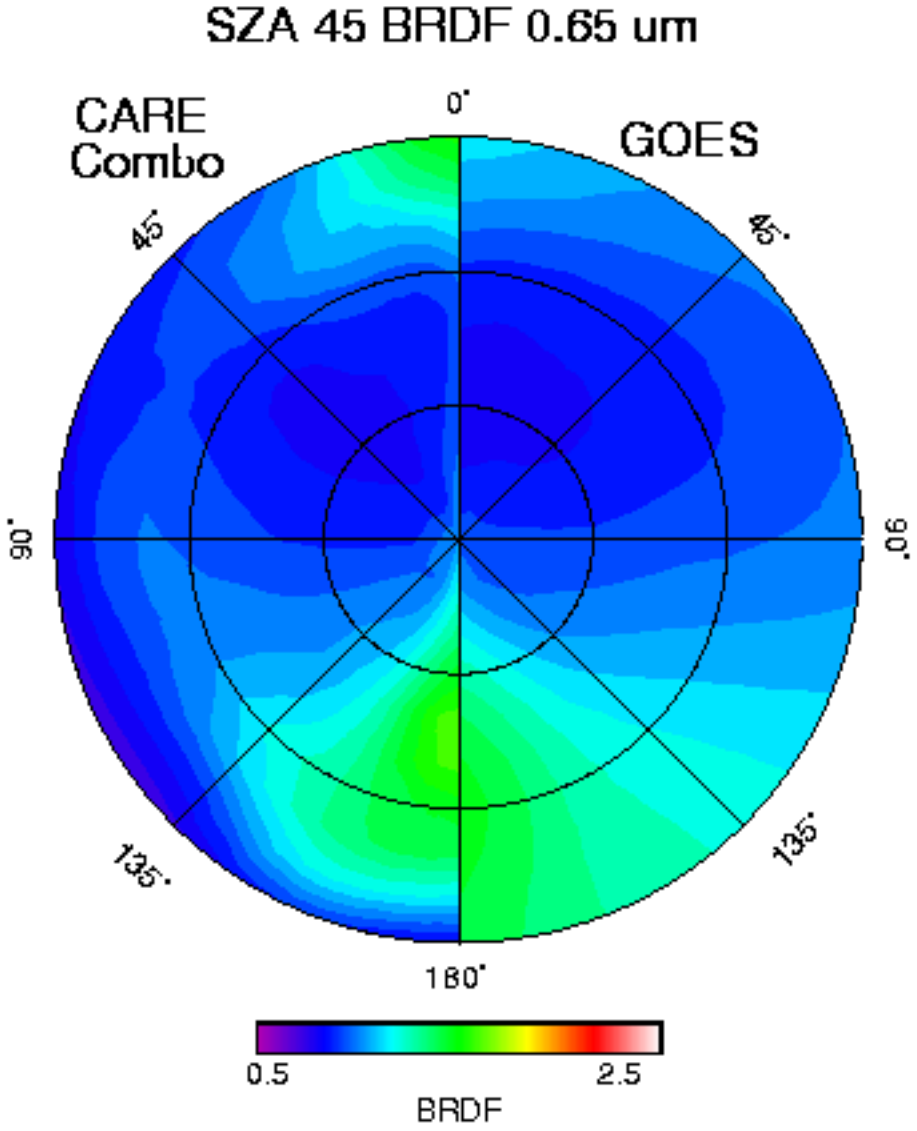
Using VIRS data and CERES MASK (April 1998)

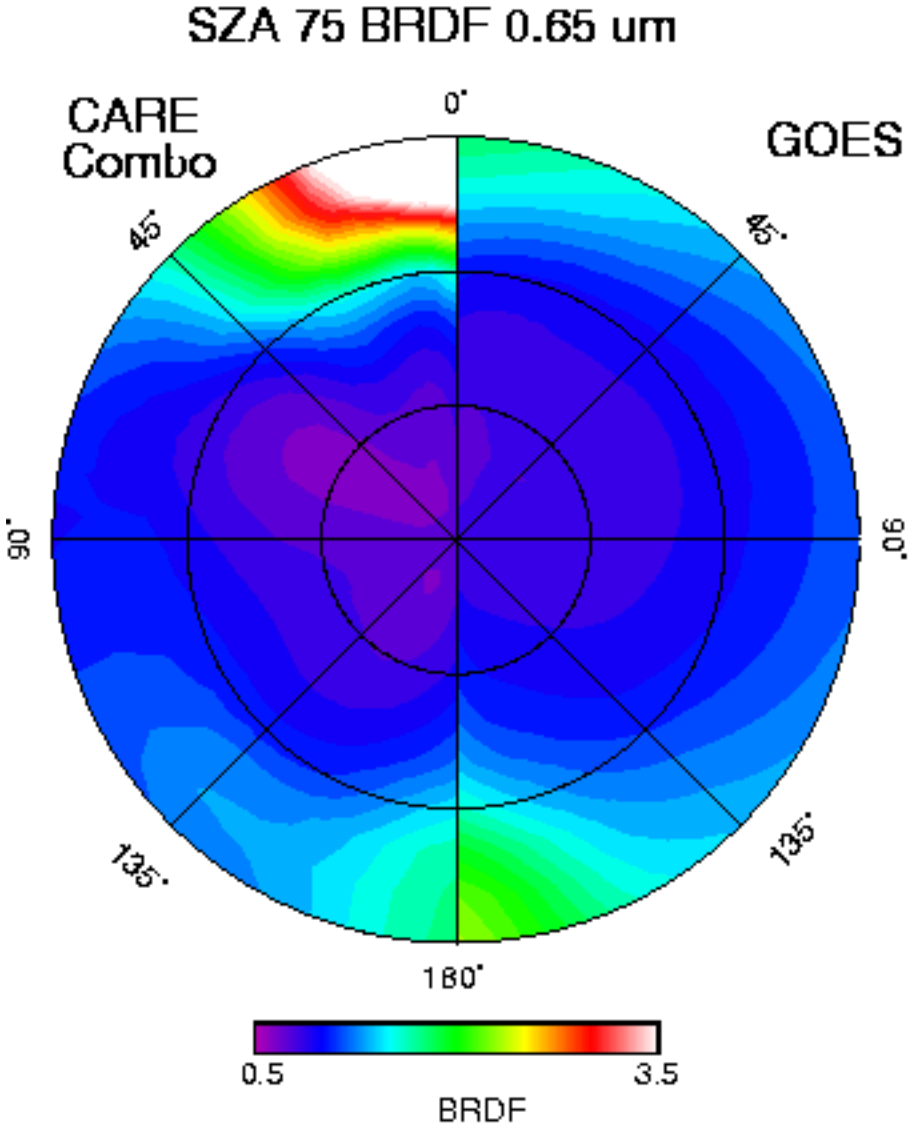


DIRECTIONAL 0.65-μm ALBEDO MODELS FROM *CERES/VIRS* DATA

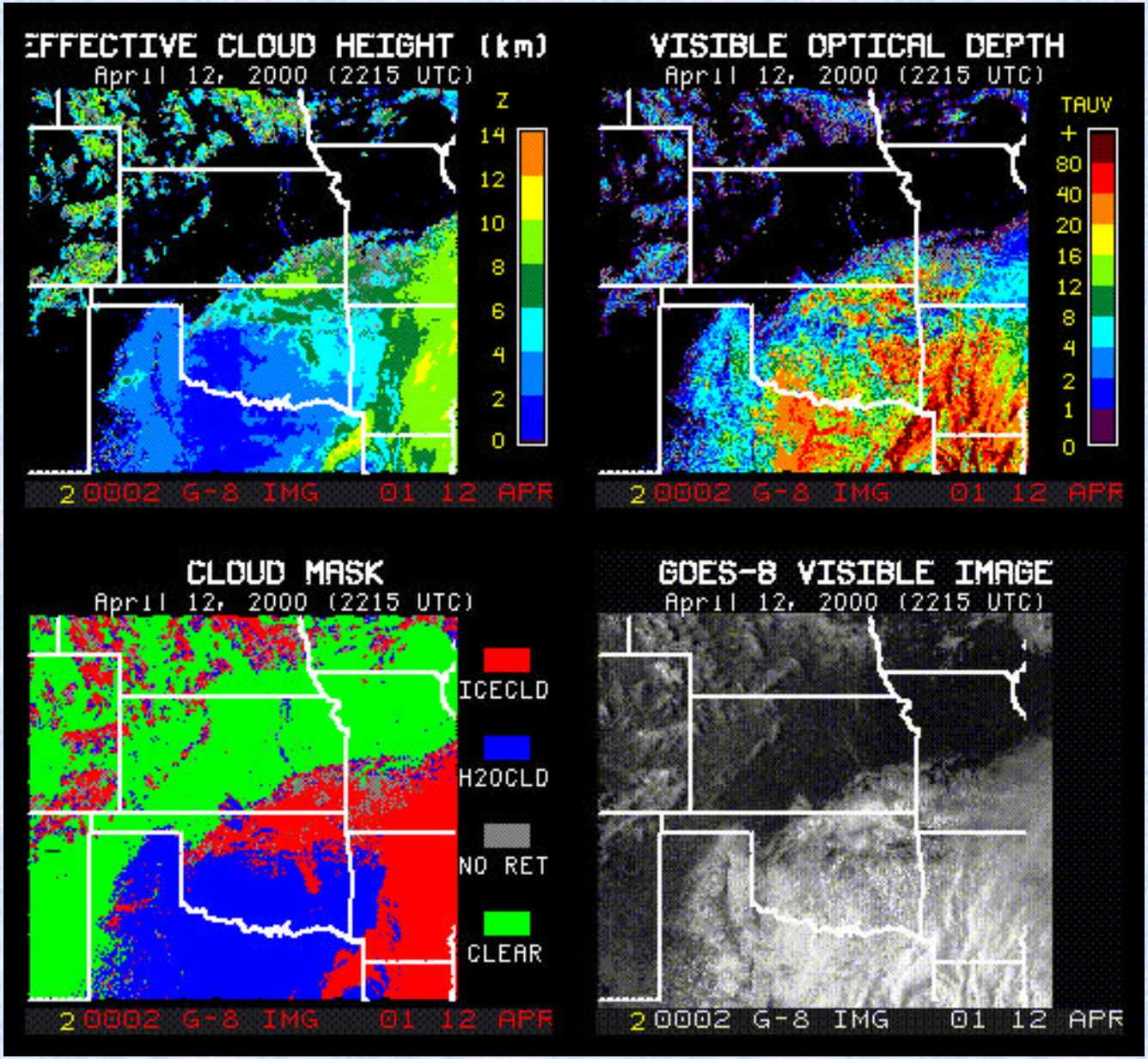


EXAMPLE OF BRDFs FOR CLEAR-SKY VEGETATION TO CONVERT ALBEDO TO REFLECTANCE





EXAMPLE OF SOME OF THE CLOUD PRODUCTS CURRENTLY DERIVED FROM GOES DATA



PROPOSED SIMULATIONS & TEST DATASET FOR CLOUD DETECTION & RETRIEVAL ALGORITHMS

THEORETICAL

Adding-doubling code calculations using the *EPIC* wavelengths > 400 nm.

Simulate reflectances at *Triana* scattering angles (various combos of SZA& VZA with small range of RAZ) for

1) range of cloud droplet/crystal size, altitude, optical depth, layering and background, atmosphere, and aerosol

- **a) re = 2 -32, De = 10 - 150 µm**
- **b) tau = 0.1 - 256**
- **c) alt = 1000mb to 100mb**
- **d) 1 and 2 cloud layers, thin over thick for two layer**
- **e) aerosol loading from 0.02 to 2 for smoke, dust, and generic aerosols**

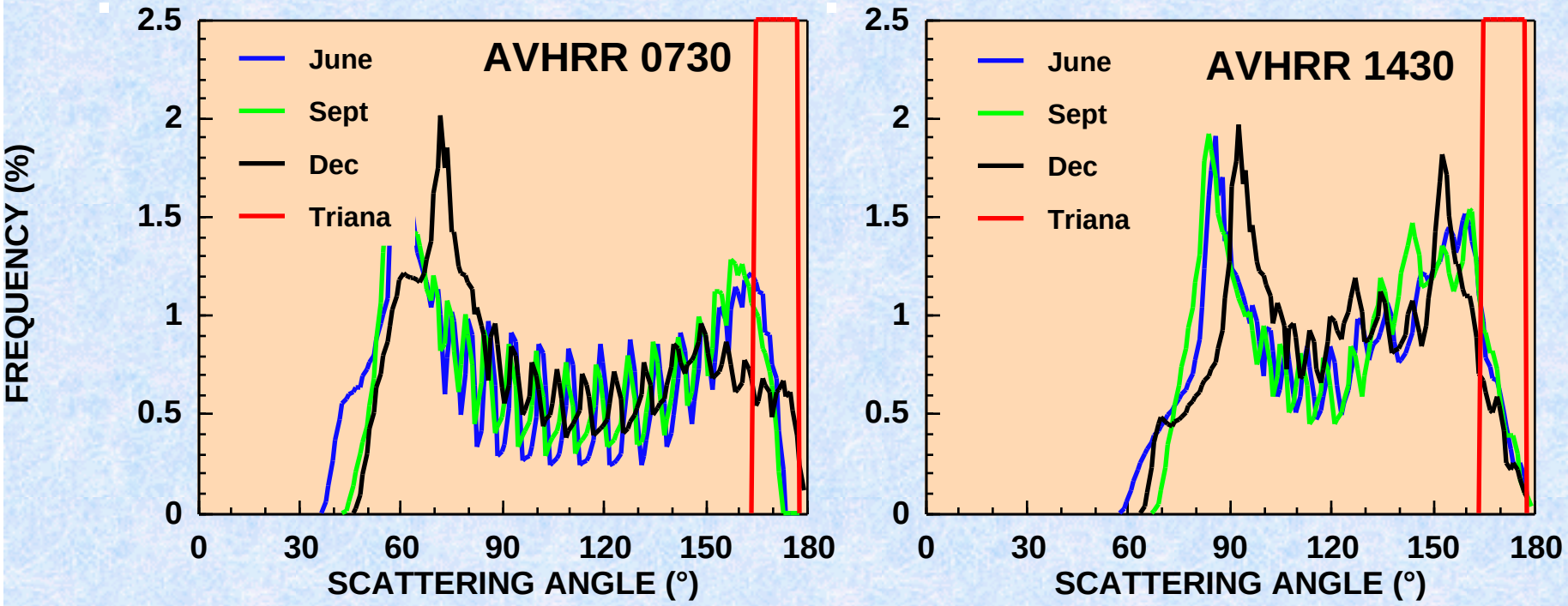
2) surface background: ocean (3 wind speeds), land (grass, crop, forest, shrub, marsh), desert, snow, ice

(will use *Kriebel and CARE full hemisphere BRDF data for land, plus inverted CERES/GOES models for desert, snow, ocean, and theoretical ocean models for wind speed variation)

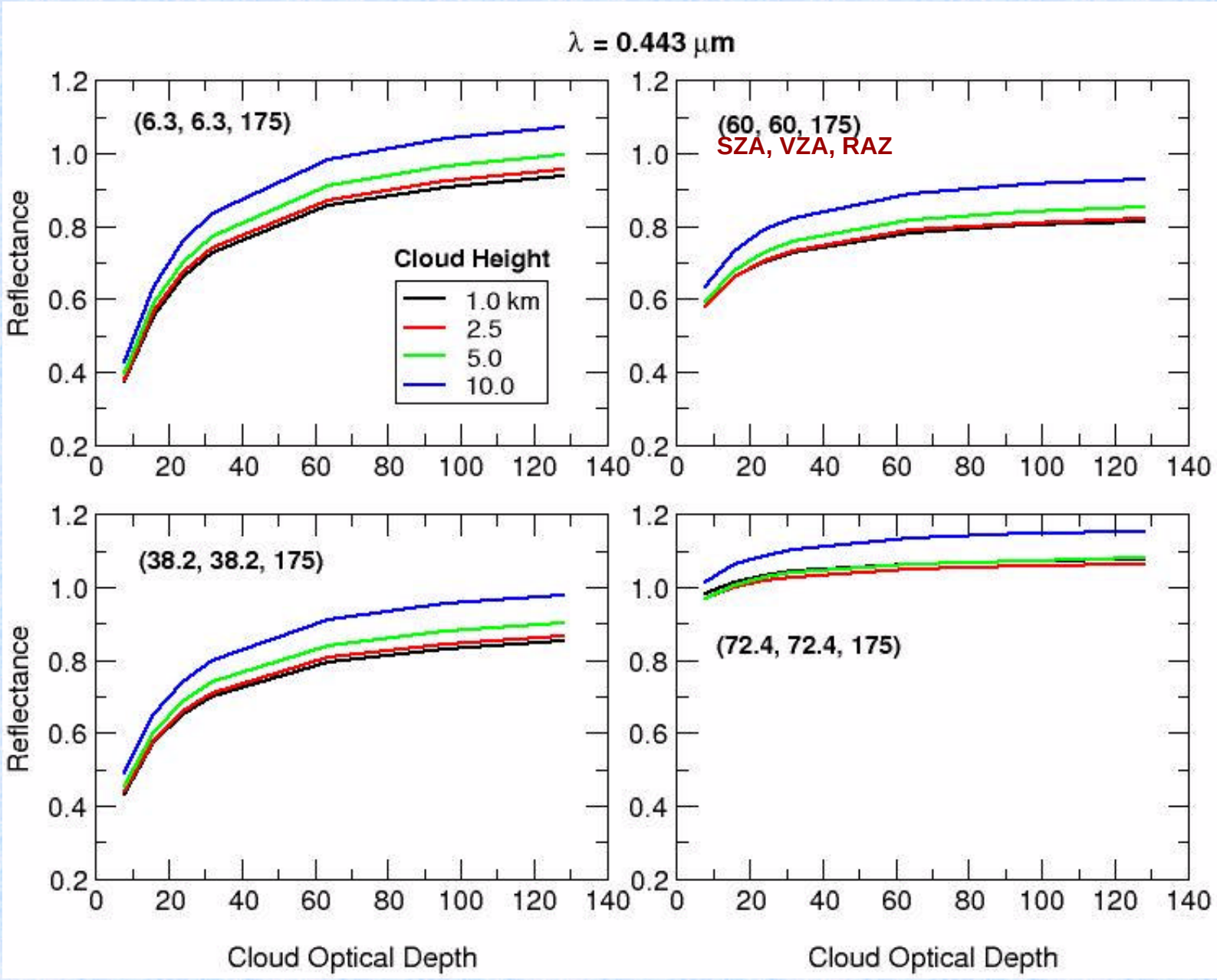
3) surface elevation up to himalyas

4) standard atmospheres, plus an assortment of soundings we often use to test RTMs at LaRC

SCATTERING ANGLES FOR REMOTE SENSING SATELLITES



EXAMPLE A-D CALCULATION FOR TROPICAL ATMOSPHERE, TOA REFLECTANCE FOR WATER CLOUD OVER OCEAN



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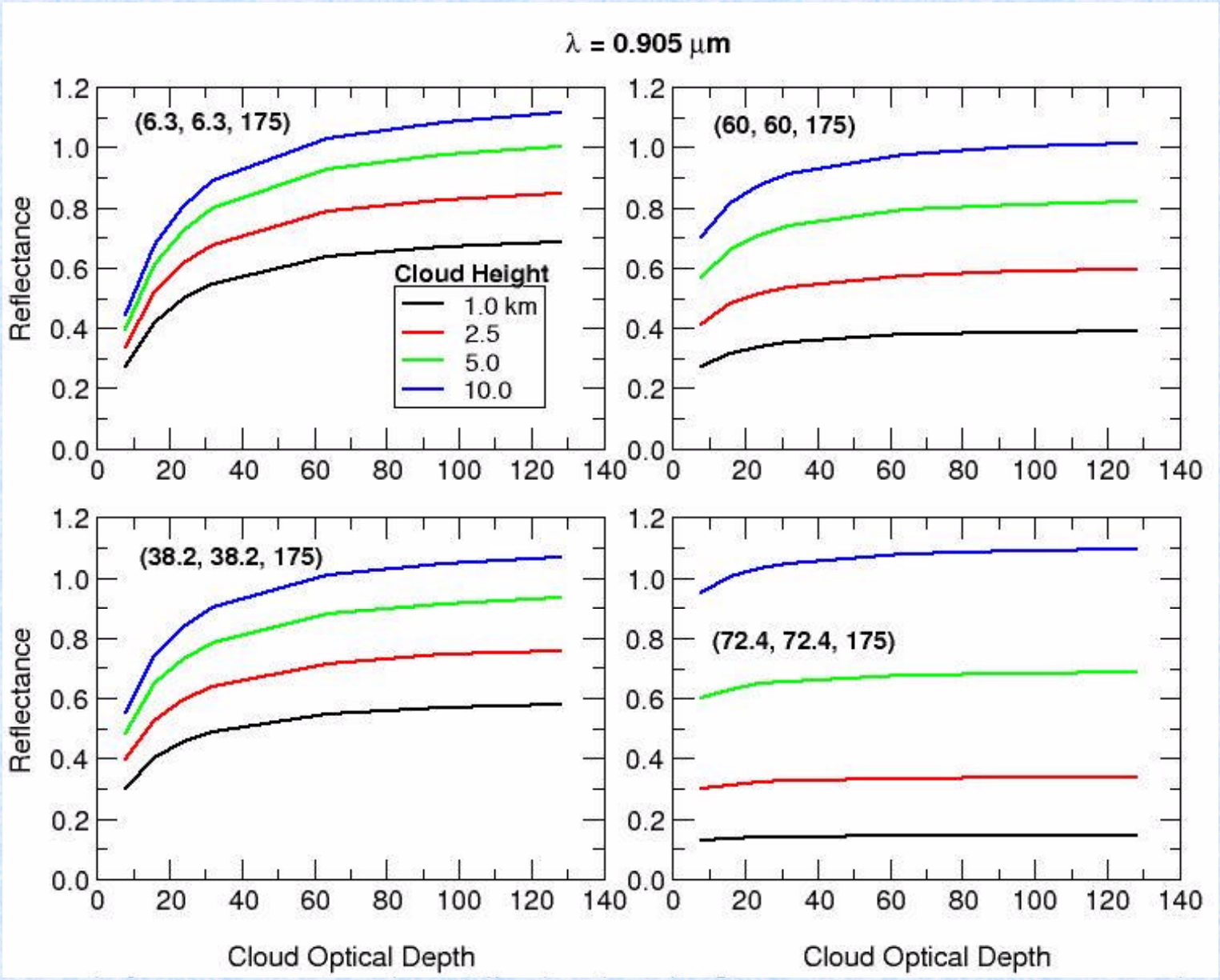
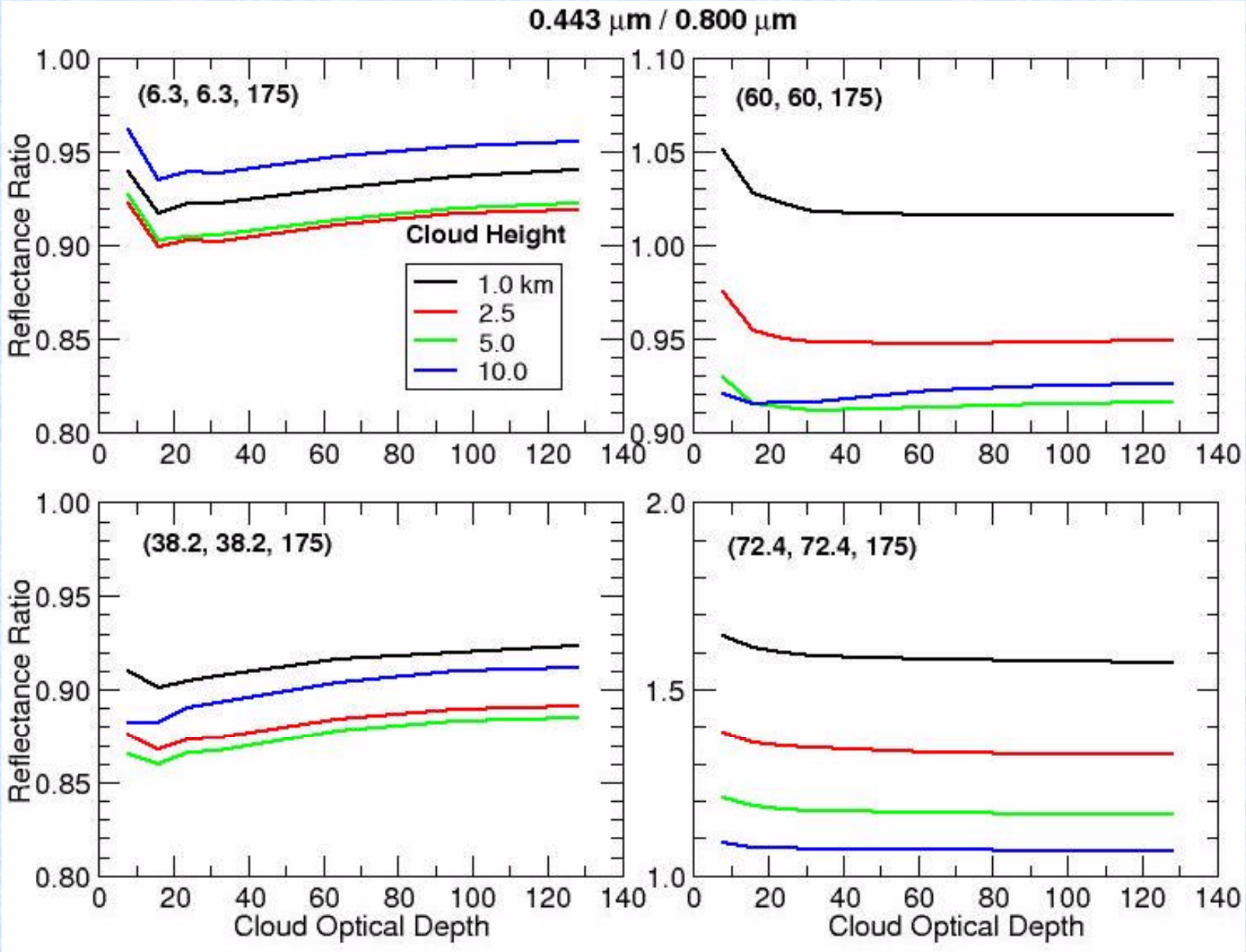


EXAMPLE A-D CALCULATION FOR TROPICAL ATMOSPHERE, TOA REFLECTANCE RATIOS FOR WATER CLOUD OVER OCEAN



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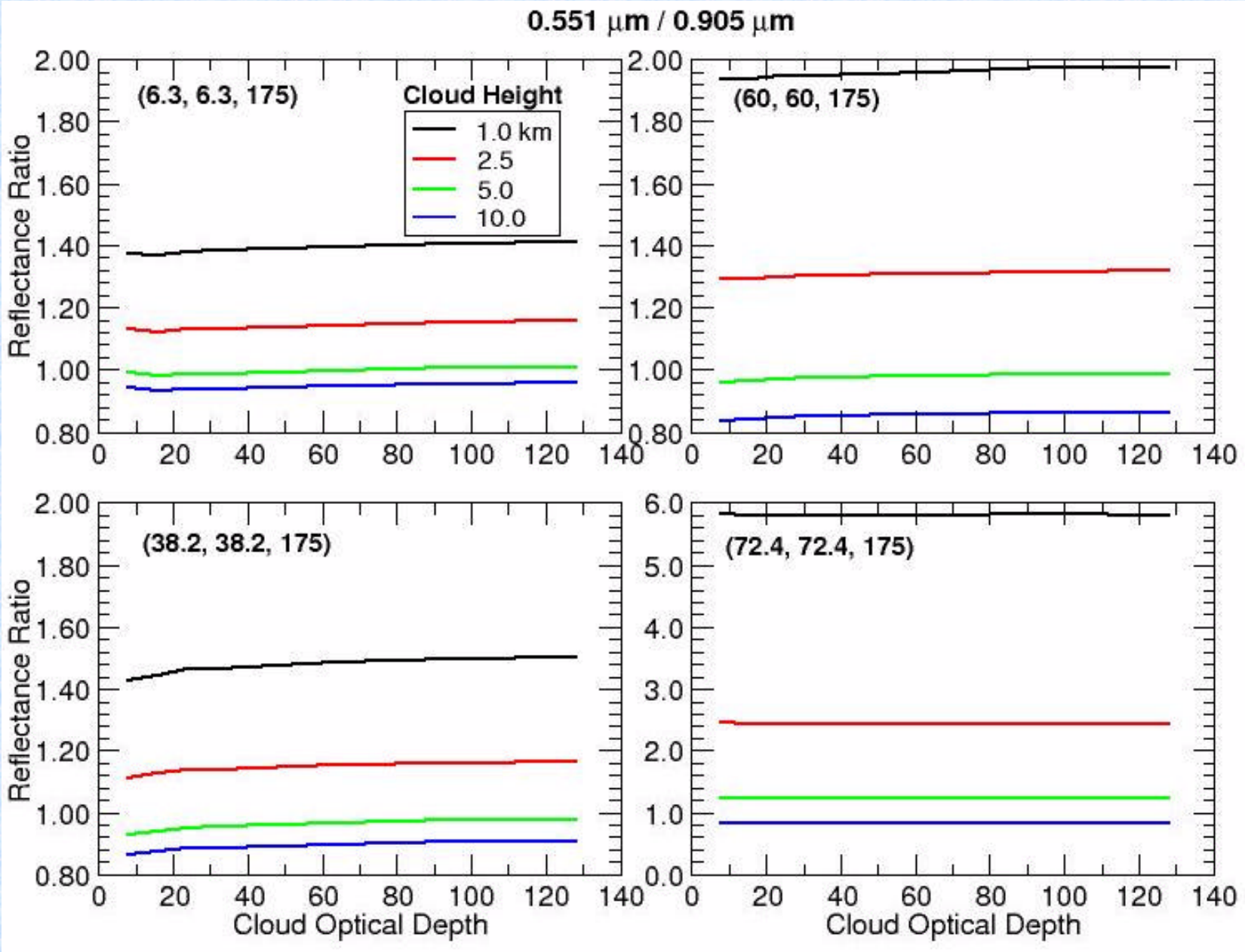


ALGORITHM DEVELOPMENT

Examine combinations of simulated spectral *EPIC* reflectances to determine cloud properties

a) Determine cloud/no cloud thresholds

b) examine ratios for height info

c) retrieve optical depths matching reflectances to models

TESTING & VALIDATION

- **Create realistic datasets from MODIS and SeaWifs**

a) Initially select only those pixels satisfying the Triana angular constraints; apply CERES cloud algorithm to determine "true" cloud properties

b) Develop full-fledged dataset by "moving" and"turning" raw MODIS pixels after analysis with CERES cloud algorithm;

- apply relevant BRDF models to compute reflectances for SZA = 0° and retain CERES cloud info for each pixel

- move pixels to desired SZA using directional models based on CERES and theory

- turn albedo into Triana reflectance using the BRDFs

c) Data from both (b) and (c) are then convolved to simulate Triana pixel size so that reflectance and "true" cloud information for each "Triana" pixel are known

- Create albedo background map for each month

  a) Begin with CERES VIRS, AVHRR, MODIS derived 10' overhead-sun albedos for relevant wavelengths; supplement with surface spectral databases (e.g., CARE, ASTER)

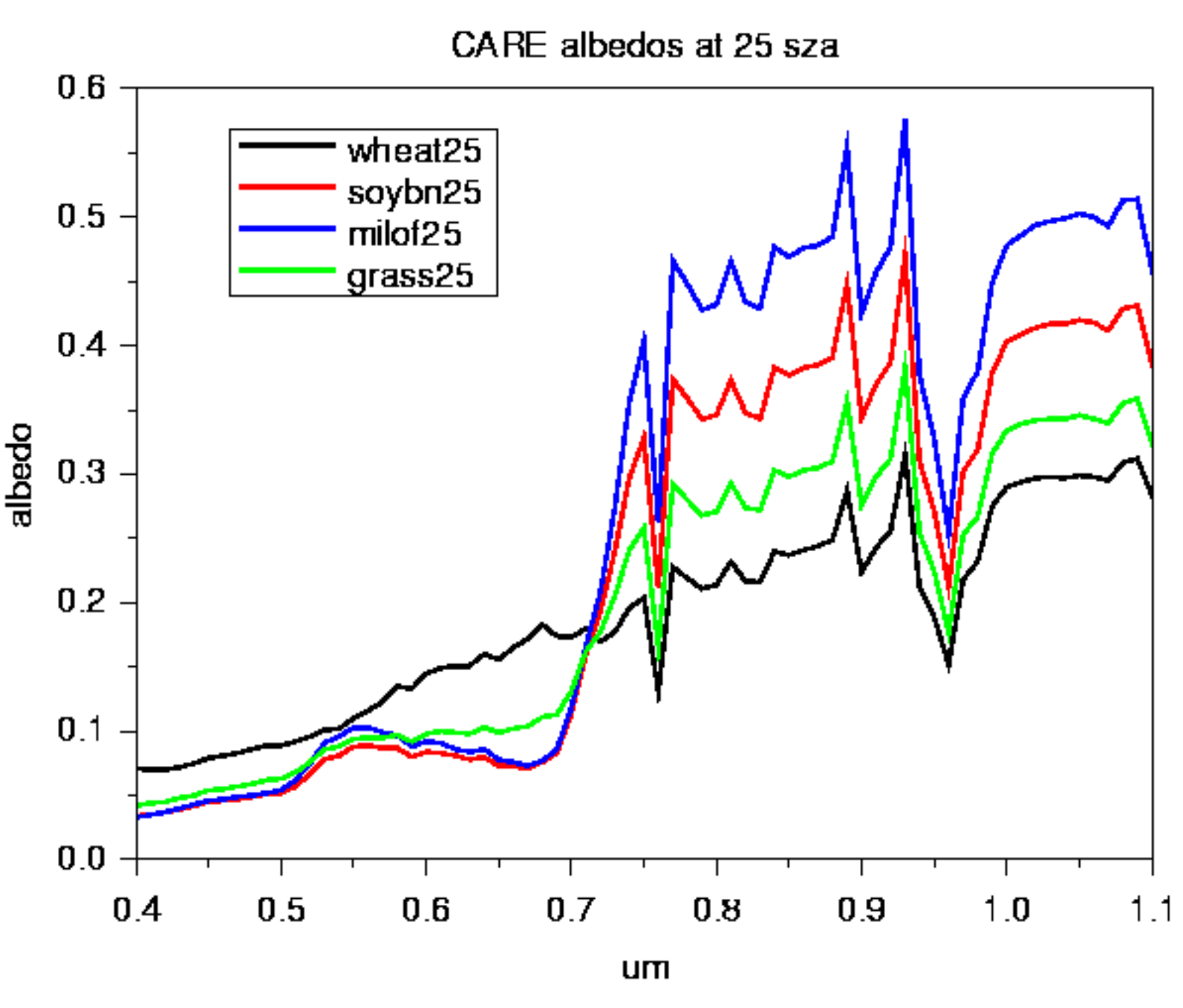
  b) Update as additional data become available

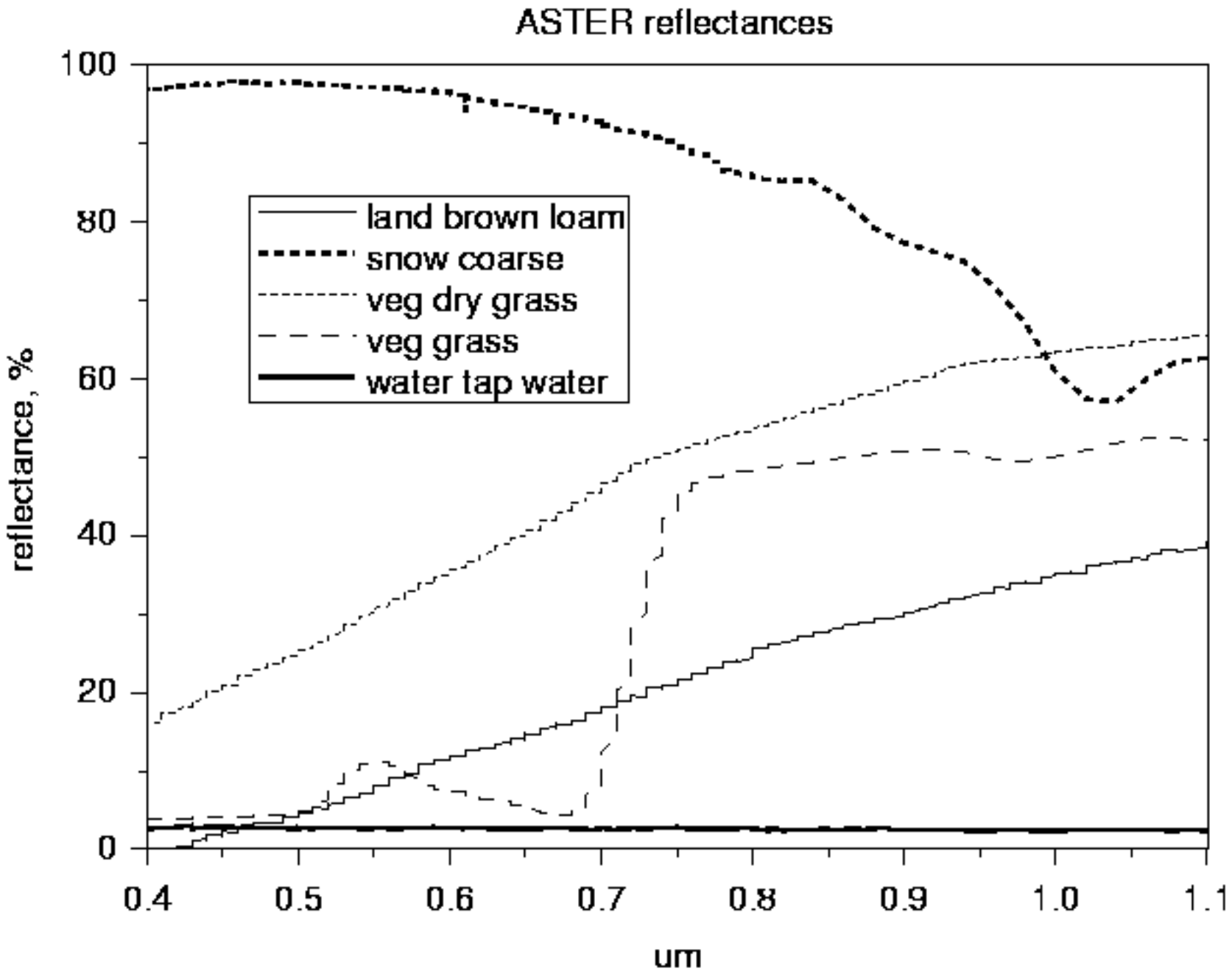
  c) Use CERES directional models to adjust albedo to relevant SZA and assortment of BRDF models to predict clear-sky reflectance (already coded in CERES software)

- Integrate NWP data & background maps to enhance retrievals (optional for processing)

- Perform retrievals with altered MODIS datasets to determine errors in cloud fraction, tau, & height for a range of Triana locations and views

- Develop improvements in algorithm to account for expanding pixel size with SZA & possibly background (type + terrain) through comparisons with "truth" data from CERES retrievals using VIS, NIR, and IR data


CARE albedos at 25 sza
wheat25
soybn25
milof25
grass25
albedo
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
um


ASTER reflectances
100
80
60
40
20
0
reflectance, %
land brown loam
snow coarse
veg dry grass
veg grass
water tap water
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
um

OBJECTIVE 2

DERIVE REFLECTANCE ANISOTROPIC & MISSING LIGHT CORRECTION FACTORS FOR EACH NISTAR RADIANCE

- **TO COMPUTE AND MONITOR THE PLANETARY ALBEDO**

BIDIRECTIONAL REFLECTANCE CORRECTION

Lambertian albedo: $a = \pi L / [E_o \cos(SZA)]$

Anisotropic albedo: $a = \pi L / [\chi E_o \cos(SZA)]$

L radiance

χ normalized bidirectional reflectance factor

E_o solar constant

SZA solar zenith angle

ANISOTROPIC REFLECTANCE FACTORS

- INITIAL VALUES FROM *ERBE* MODELS

  (12 SCENE TYPES)

- UPDATE USING *CERES* MODELS

  (100 - 200 SCENE TYPES)

SHORTWAVE ANISOTROPIC CORRECTION

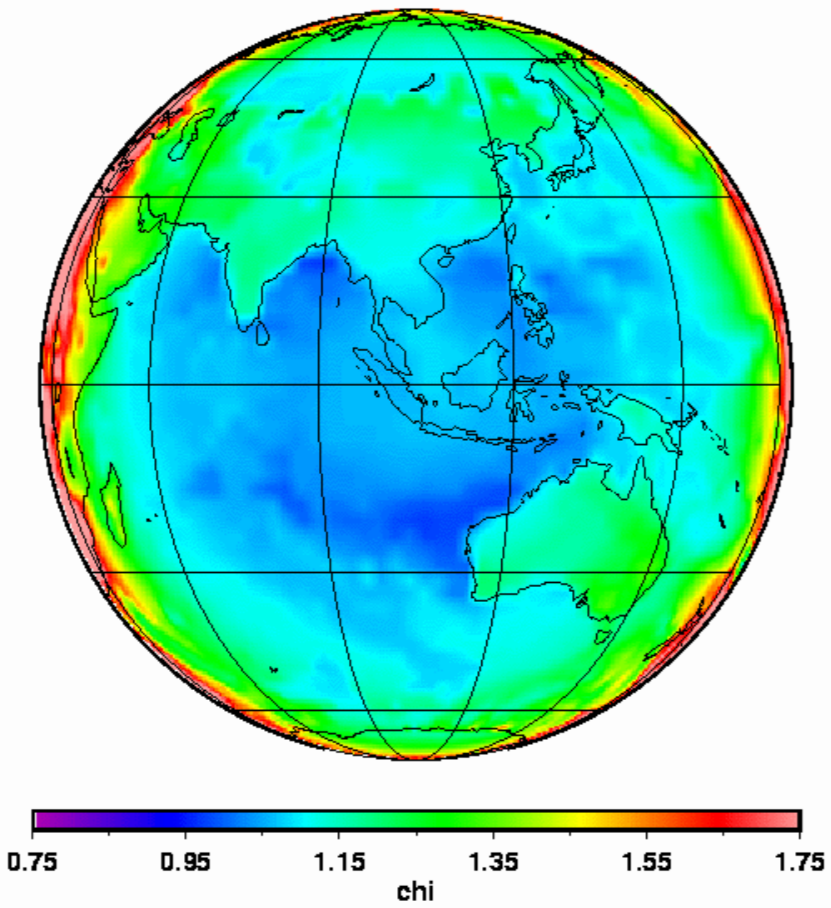
Shortwave ADM from *EPIC* data at time *t*

$$\chi_T(t) = \frac{\sum_{i=1}^{N} \mu_o R_i(t) A_i}{\sum_{i=1}^{N} \mu_o R_i(t) A_i / \chi(K_i(t), \theta_o, \theta, \phi)}$$

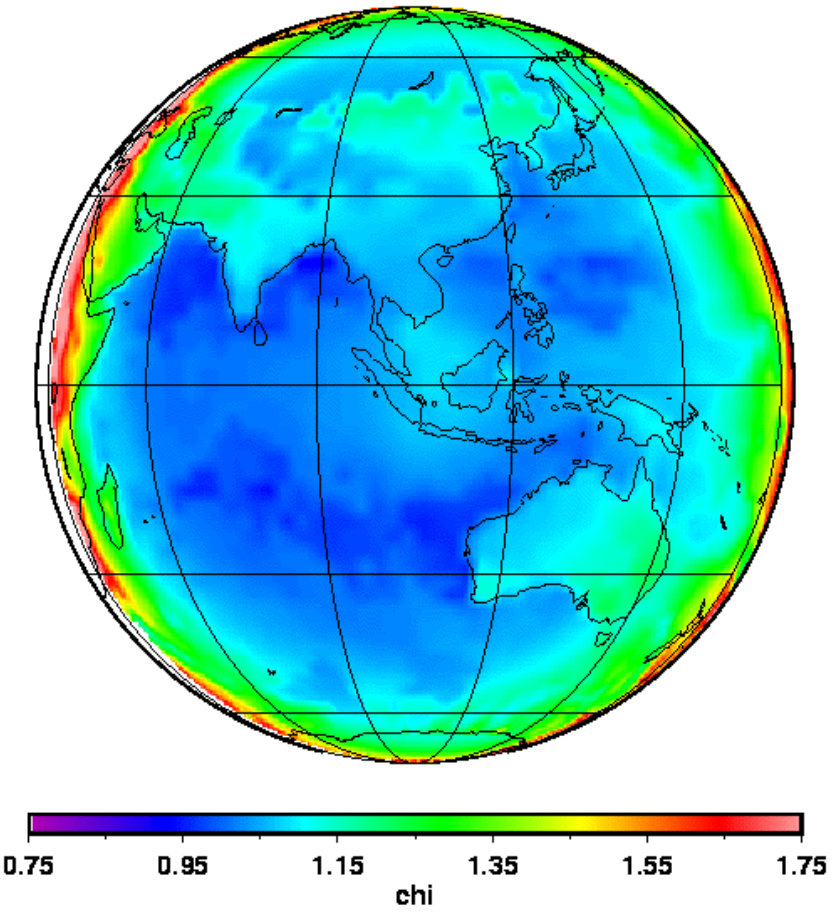
- R_i mean weighted reflectance for 443, 645, 870, & 905-µm
- A pixel area
- μ_o cos*(SZA)*
- N total number of pixels used
- χ normalized bidirectional reflectance factor
- K scene type from cloud screening

• **NEAR-IR ALBEDO TO BE COMPUTED FASHION SIMILAR TO SW**

BIDIRECTIONAL REFLECTANCE FACTOR
FOR TRIANA VIEW
March 21 3˚ West of center (L1)

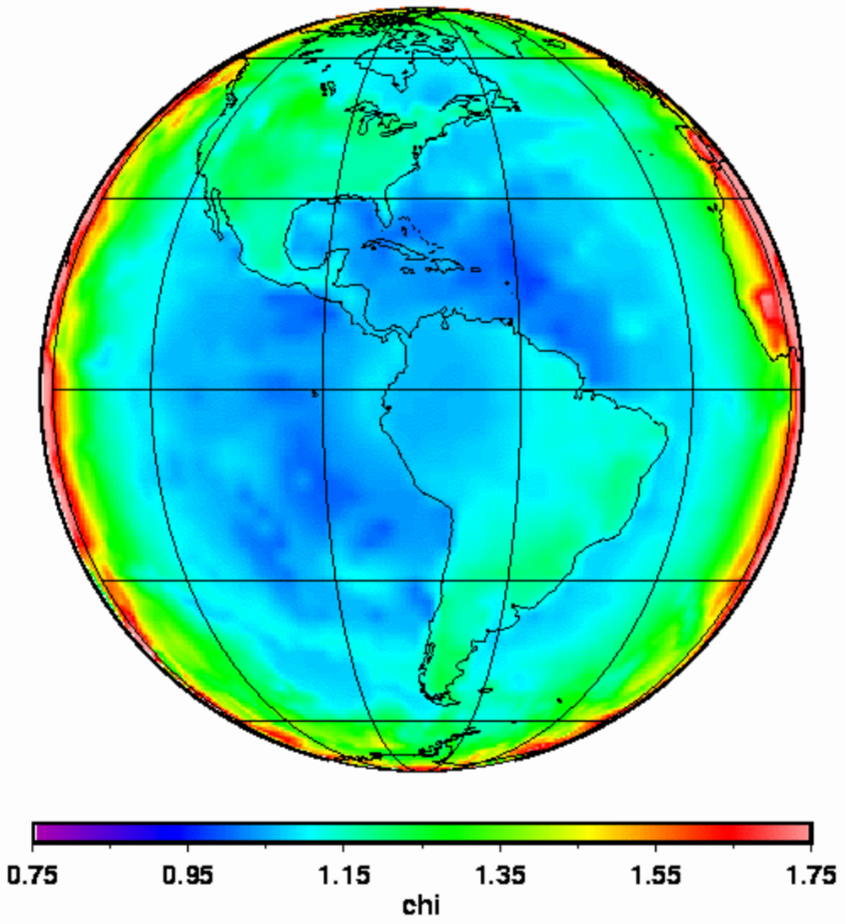


BIDIRECTIONAL REFLECTANCE FACTOR
FOR TRIANA VIEW
March 21 15˚ West of center (L1)



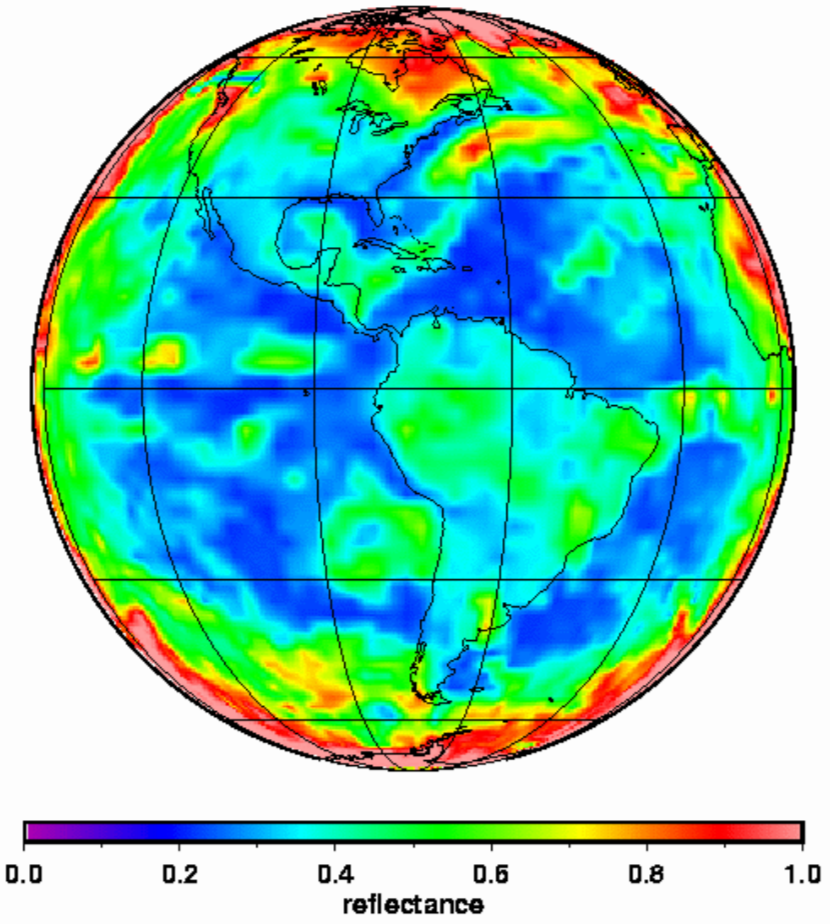
BIDIRECTIONAL REFLECTANCE FACTOR
FOR TRIANA VIEW

March 21 3˚ West of center (L1)



SIMULATED SHORTWAVE REFLECTANCE
TRIANA VIEW FROM 1986 ERBE DATA

March 21 3˚ West of center (L1)



TRIANA BRDF EXAMPLE

MARCH 21

ORBIT POSITION	SUBSAT LONGITUDE 105°E	75°W
L1 + 15°	1.139	1.145
L1 + 3°	1.194	1.196

< 0.5% DIFFERENCE WITH VIEW

> 5.0% VARIATION WITH POSITION

MISSING LIGHT CORRECTION

- DERIVE CORRECTION FACTORS FROM *ERBE/CERES* DATABASES
  - SIMULATE TRIANA VIEWED ALBEDO/RADIANCE WITH YEARS OF ERBE DATA FOR *TRIANA* CYCLE SCENARIOS
  - INTEGRATE MISSING RADIANCE/ALBEDO TO SIMULATE EXACT L1 VIEW
  - COMPUTE MEAN CORRECTION FACTORS WITH ESTIMATE OF VARIANCE
  - FIT TO ANALYTICAL FUNCTION FOR APPLICATION TO *TRIANA* VIEW AND POSITION

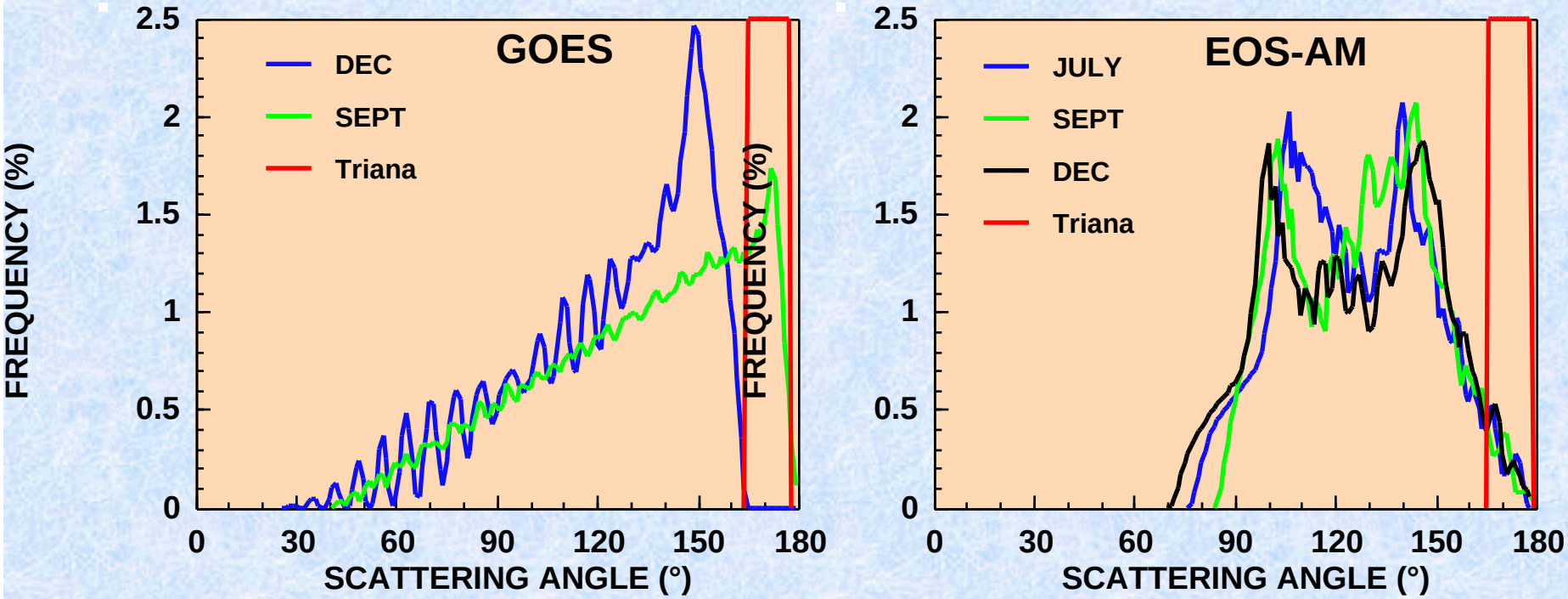
OBJECTIVE 3

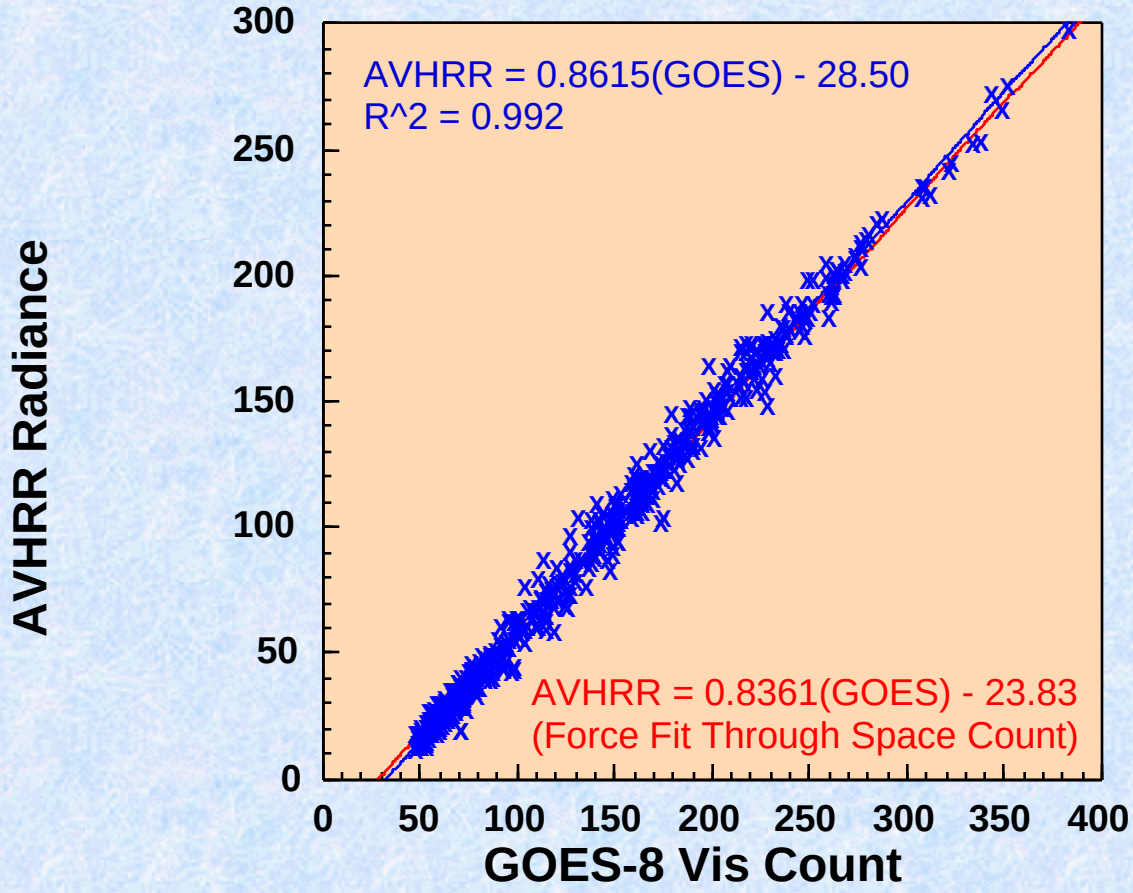
INTERCALIBRATE LIKE CHANNELS ON *EPIC* AND OTHER SATELLIES

- *CHECK & MONITOR* EPIC *CALIBRATIONS*

- *PROVIDE NORMALIZATION FACTORS TO FACILITATE MULTIANGLE VIEW STUDIES USING* TRIANA *& OTHER SATELLITES*

SCATTERING ANGLES FOR REMOTE SENSING SATELLITES



GOES-8 Visible Calibration Using NOAA-14 AVHRR

(October 1998)