Simulated Triana-EPIC Earth Views Using MODIS

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OBJECTIVE

- To derive a EPIC-cloud mask algorithm using only visible reflectances in near backscatter geometry
- Use MODIS reflectances to simulate EPIC earth view using current bidirectional and directional models
- Determine clear-sky thresholds and validate with the CERES cloud mask
- Improve models using radiative transfer to increase backscatter and spectral resolution

TERRA-MODIS

- Polar orbiter, 10:30 LST, 1 km nominal resolution
- 362M daytime pixels available on September 7, 2000
  - 18 exabyte tapes
- Use 5 MODIS channels, 0.466 µm, 0.554 µm, 0.647 µm, 0.857µm, 0.904 µm to simulate Triana EPIC views
- Run CERES cloud mask algorithm, which is based on the 0.65µm, 1.6 µm, 3.7 µm, 11.0 µm, 12.0 µm wavelengths

CONVERT TO OVERHEAD ALBEDOS

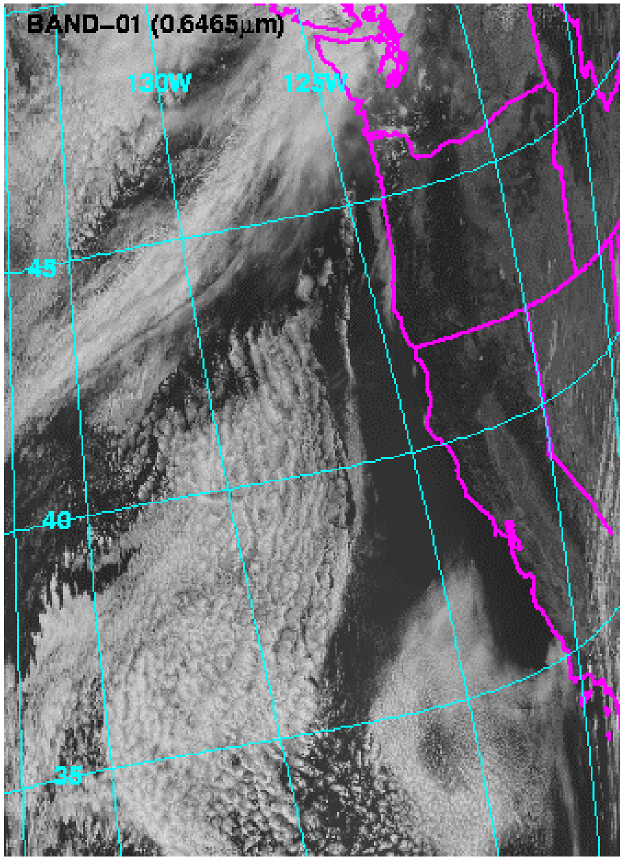
- Convert the 5 MODIS radiances to overhead albedo for each pixel using the following equation

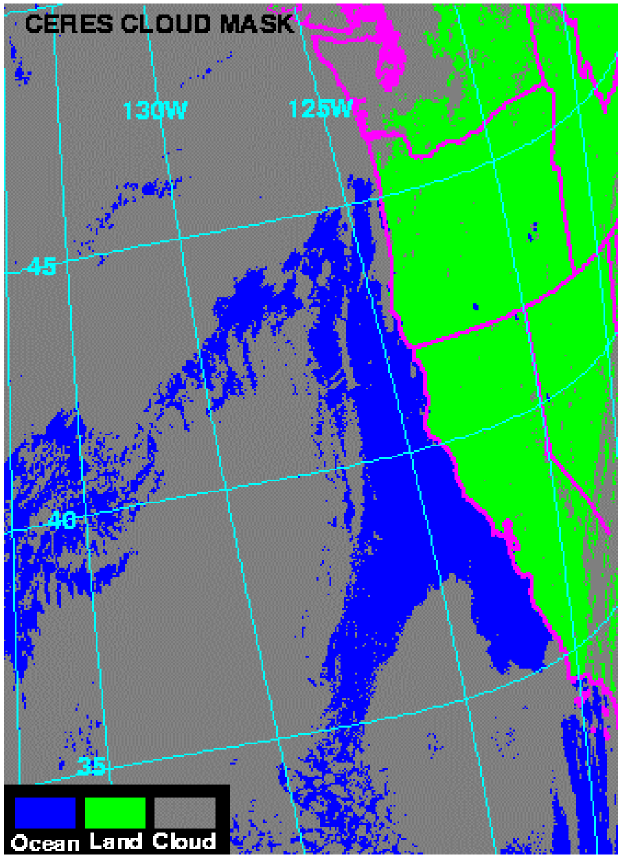
  – $\alpha_{0_v} = \pi L_v / \; [\, \delta(d)\, \mu_o\, E_v\; \chi(\mu_o, \mu, \psi, scene\,)\, \gamma\,(\mu_o\,, scene\,)$

    - L_v MODIS radiance for channel v
    - $\delta(d)$ Earth-Sun distance correction factor for Julian day d
    - E_v solar constant for channel v
    - μ_o cosine solar zenith angle, μ view angle, ψ relative azimuth angle
    - $\chi(\mu_o, \mu, \psi\,, scene\,)$ bidirectional factor
      – For ocean,land, and cloud use GOES narrowband model
      – For snow and desert use ERBE broadband model
    - $\gamma\,(\mu_o\,, scene\,)$ ERBE broadband directional factors

CERES CLOUD MASK EXAMPLE

MODIS VIS Image and Cloud Mask, 1940GMT, Sep 07, 2000

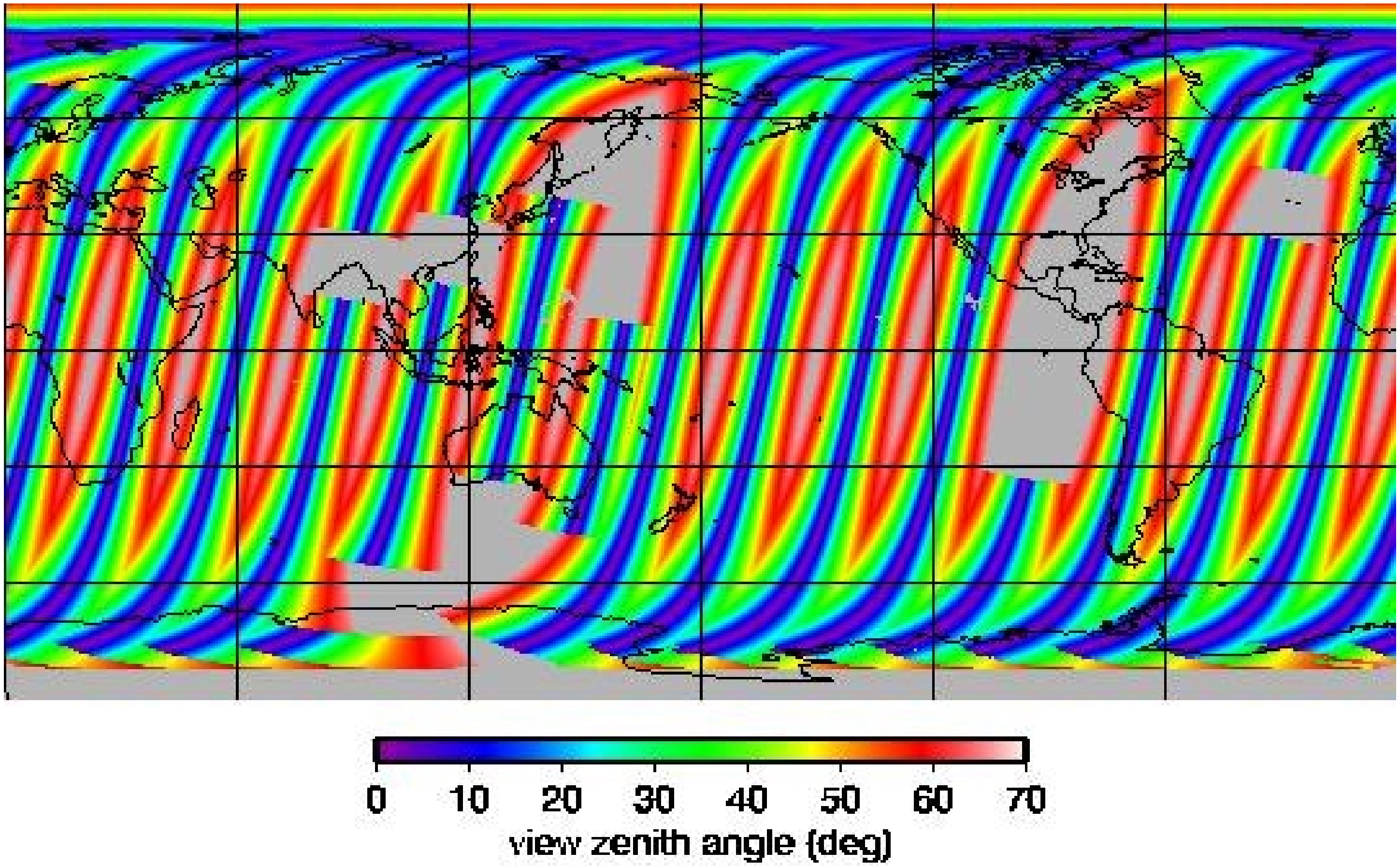




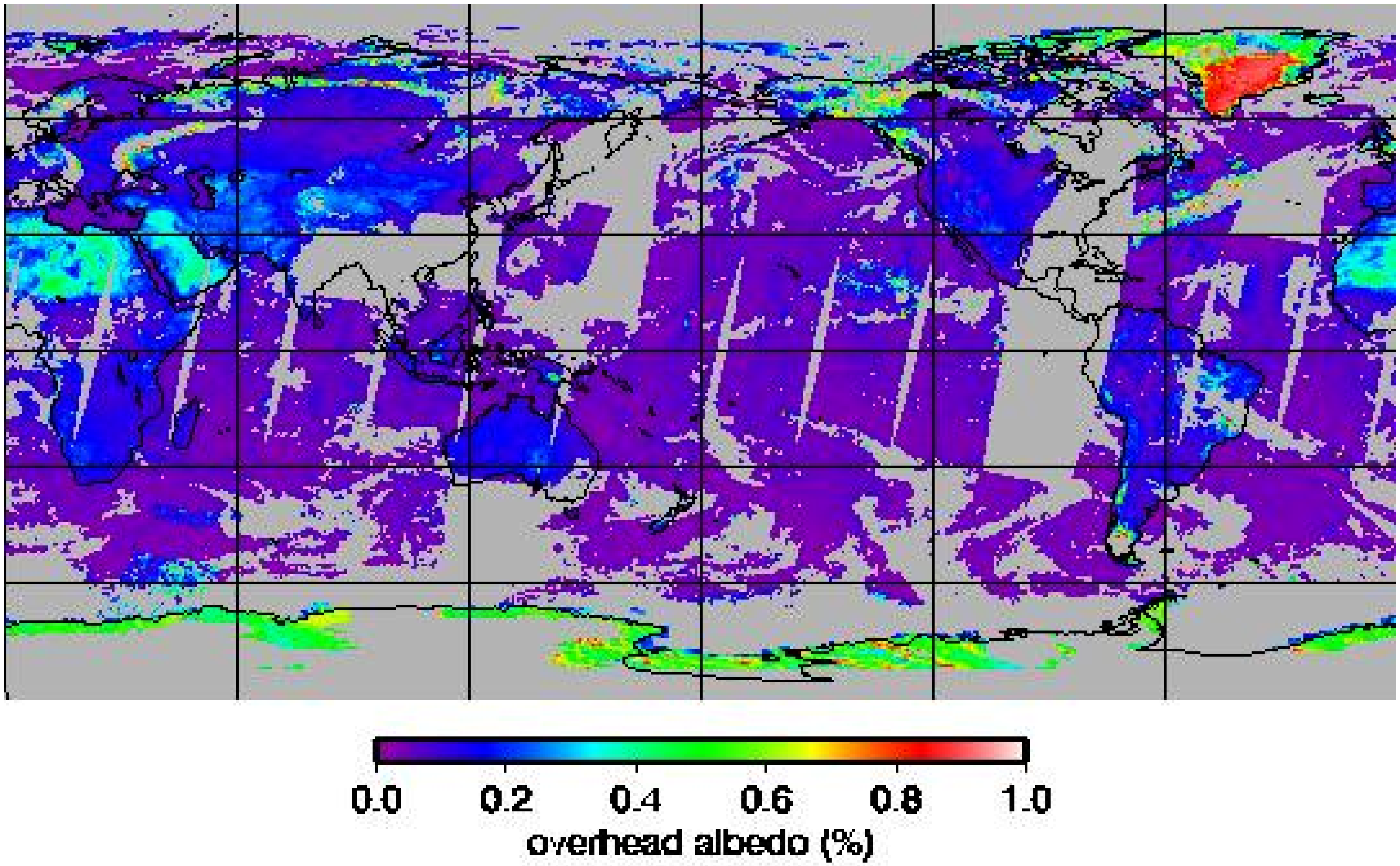
EPIC-Triana View

- Grid MODIS pixels into EPIC 8 km nominal footprints
- Take means of overhead cloudy and clear-sky albedos
- Footprints with multiple MODIS overpasses select the GMT with the lowest view angle
- Convert EPIC overhead albedos to reflectances using EPIC angles using the following equation
  - $\rho_v = \alpha_{0v}(cld)\,\chi(\mu_o, \mu, \psi, cld)\,\gamma(\mu_o, cld)\,F_{cld}$ +
  - $\alpha_{0v}(clr)\,\chi(\mu_o, \mu, \psi, clr)\,\gamma(\mu_o, clr)\,F_{clr}$
    - *clr* the dominant clear scene type, *cld* cloudy scene
    - F scene fraction

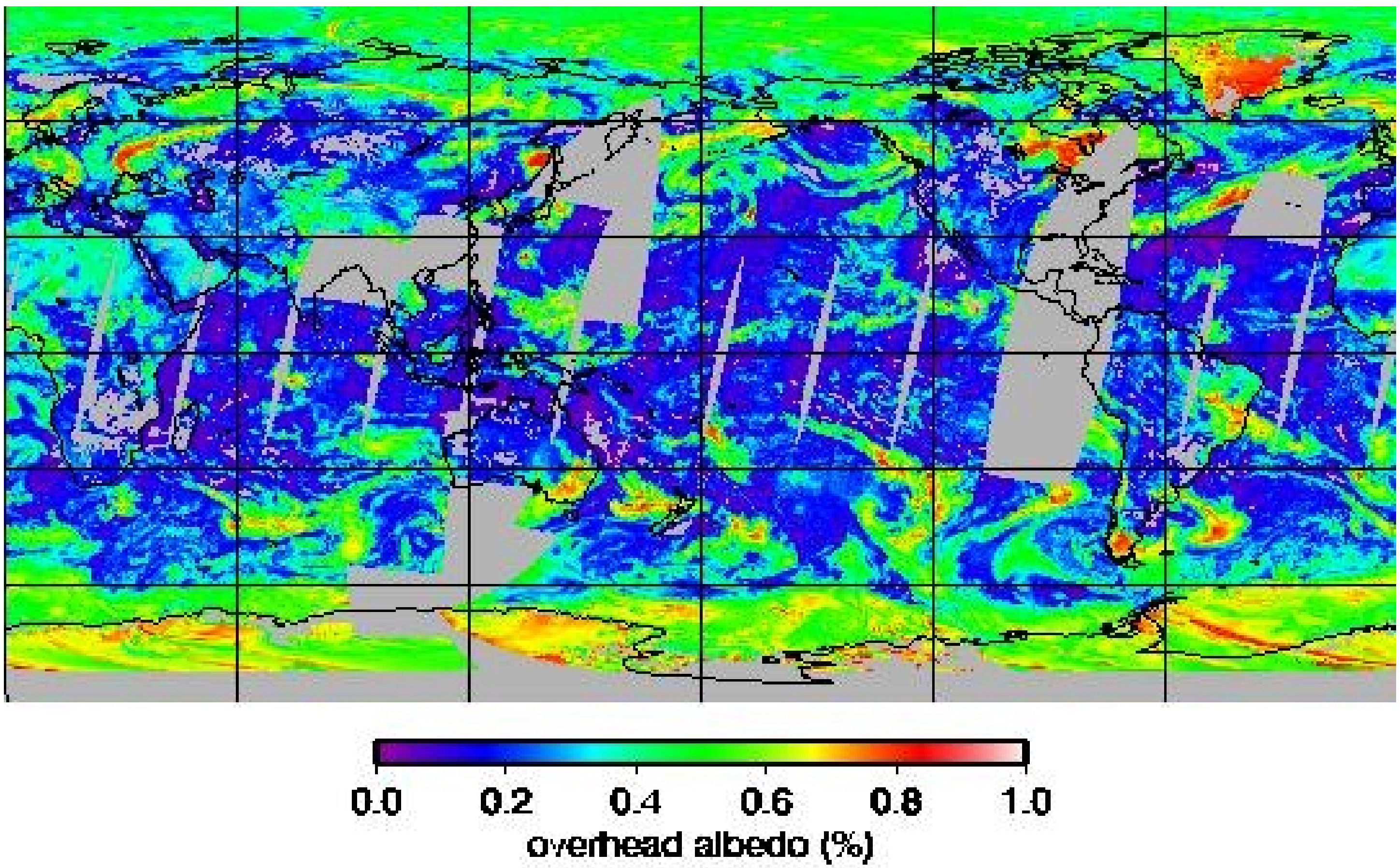
MODIS VIEW ZENITH ANGLES, SEP. 7, 2000



0.65 µm CLEAR SKY ALBEDO, SEP. 7, 2000



0.65 µm CLOUDY SKY ALBEDO, SEP. 7, 2000



EXAMPLE OF TRIANA EPIC VIEW SIMULATION

- **MODIS DATA FROM SEPTEMBER 7, 2000**

- **TRIANA GEOMETRY**

  - **3°N of L1**

- **RGB IMAGERY FROM 22 HOURS**

  - **JPEGS shown -> 400 x 400 pixels (32 km)**

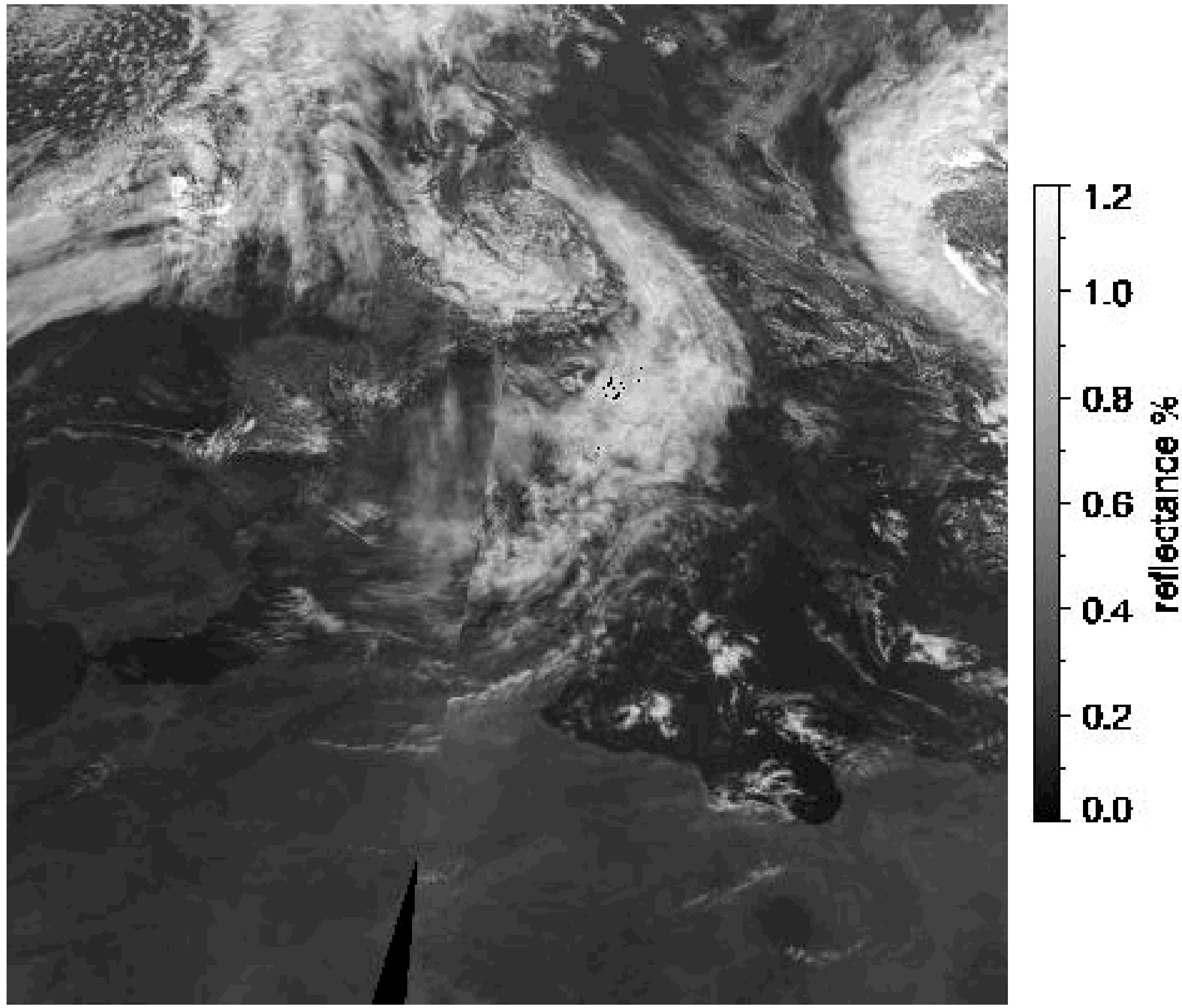
  - **Histogram equalization for viewing purposes**

  - **Digital images at 1600 x 1600 (8 km)**

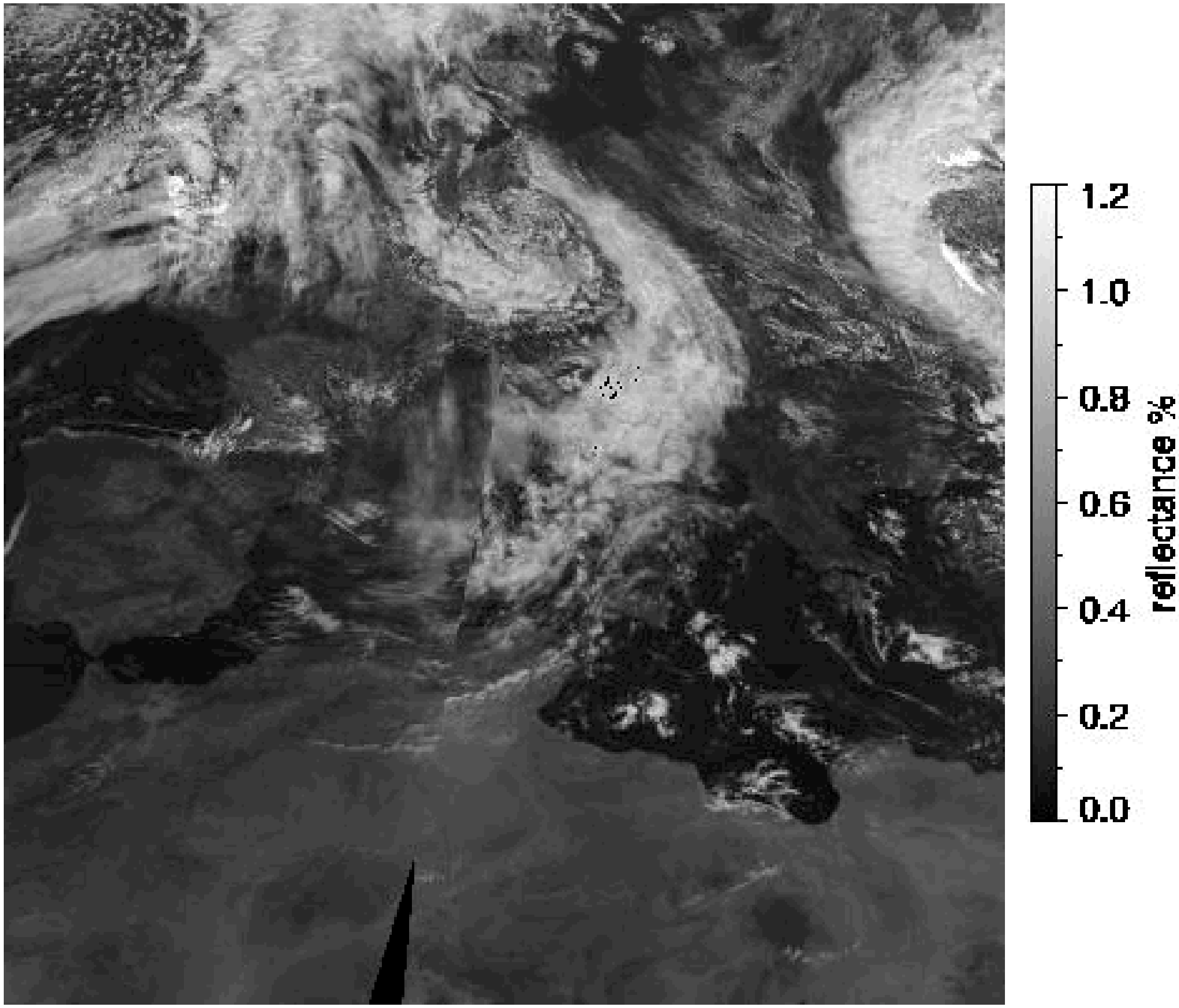
- **FUTURE SIMULATIONS:**

  - **fill gaps, use more days, derive cloud properties, test various L1 positions, apply other BRDFs**

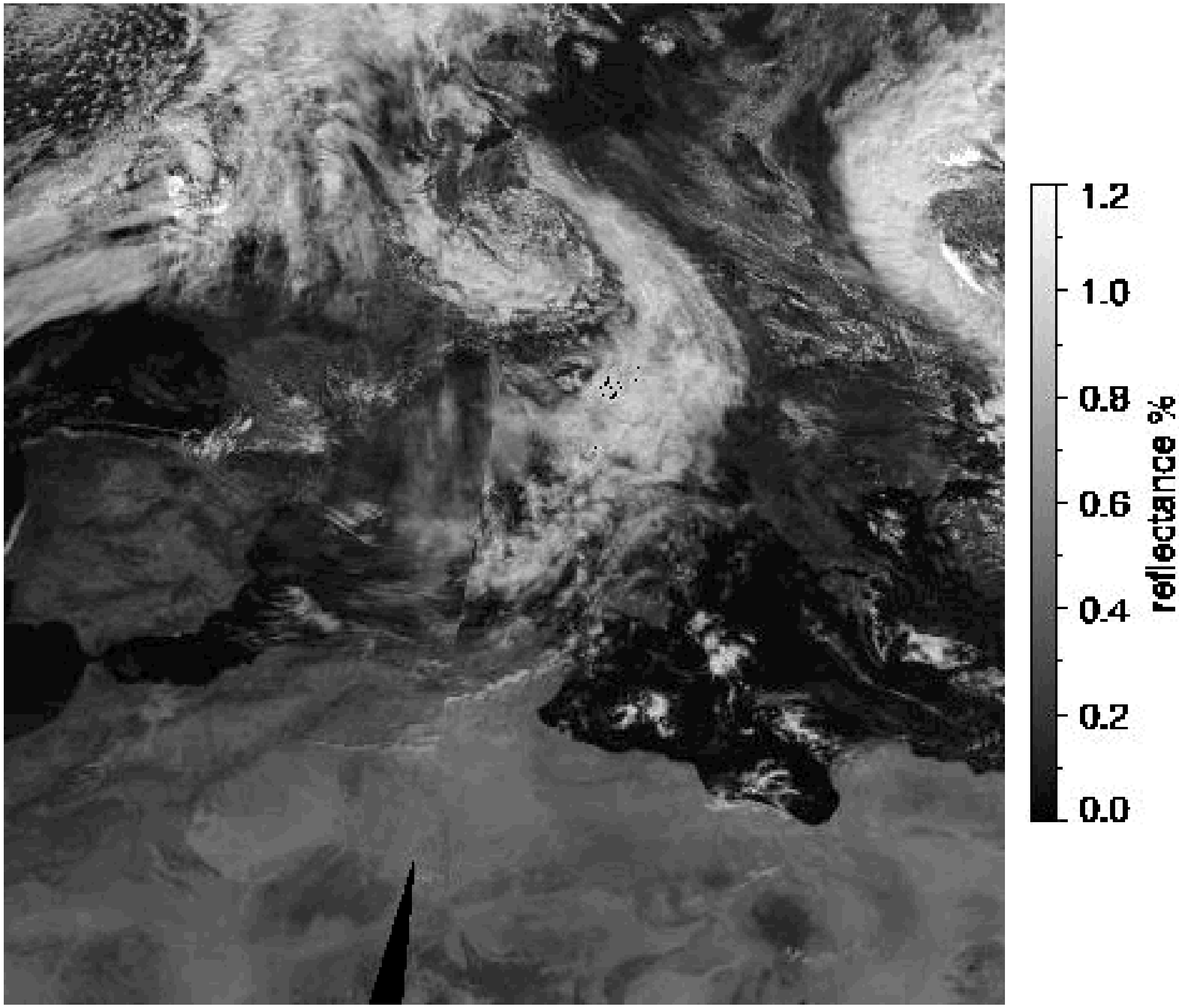
CLOSE UP VIEW OF ORBIT STITCHING OVER EUROPE 0.466 µm



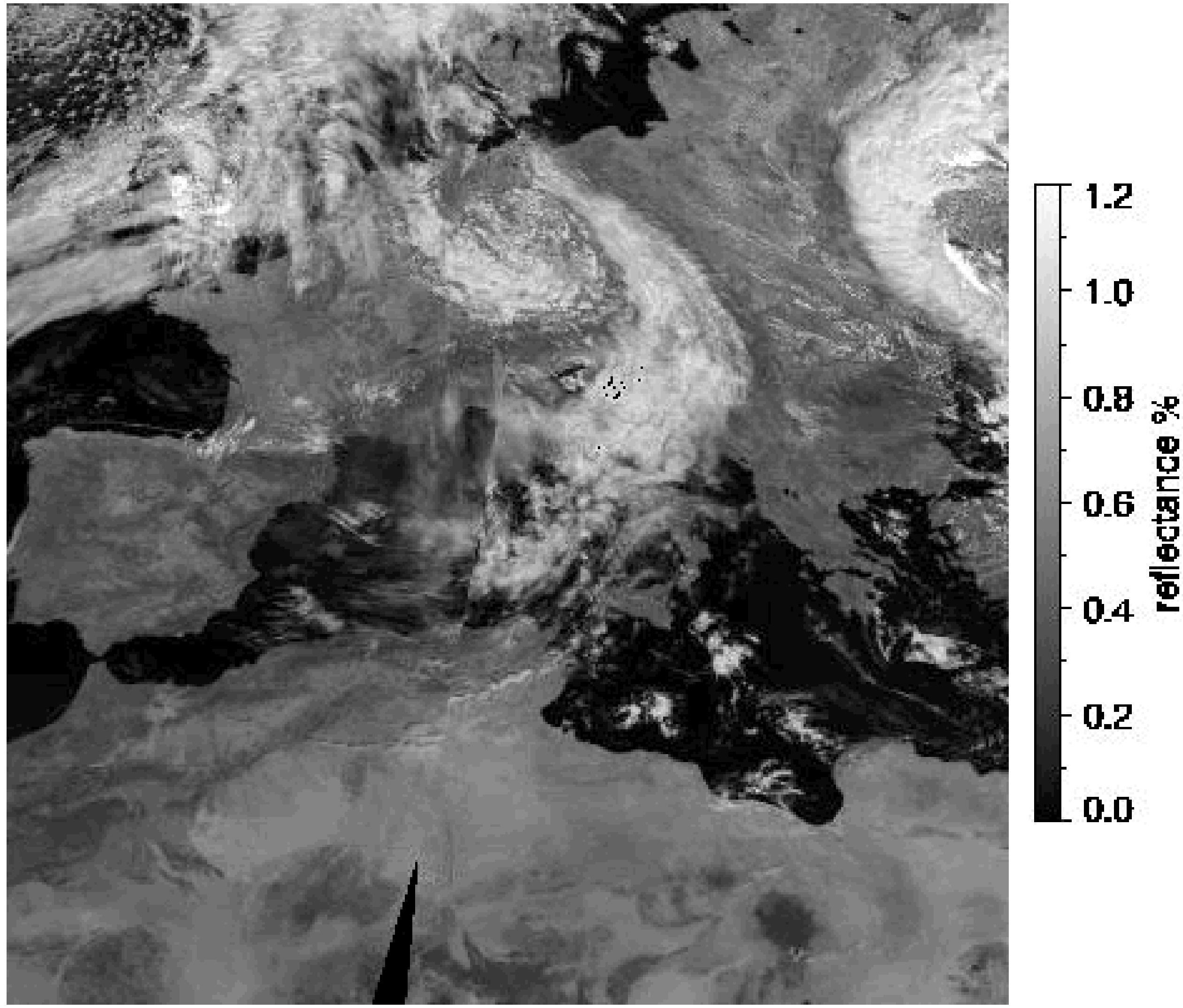
CLOSE UP VIEW OF ORBIT STITCHING OVER EUROPE 0.554 µm



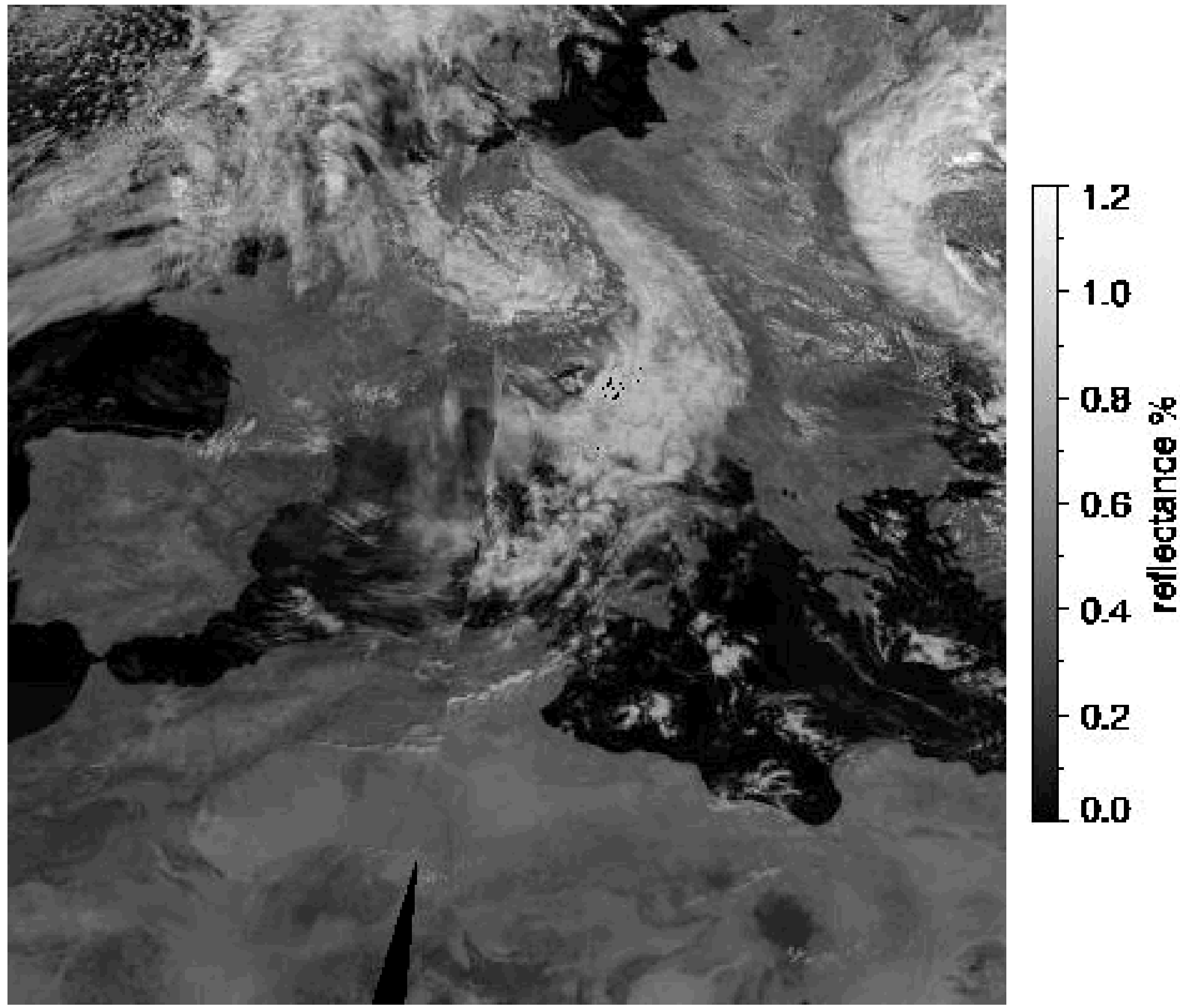
CLOSE UP VIEW OF ORBIT STITCHING OVER EUROPE 0.647 μm



CLOSE UP VIEW OF ORBIT STITCHING OVER EUROPE 0.857 µm



CLOSE UP VIEW OF ORBIT STITCHING OVER EUROPE 0.904 µm

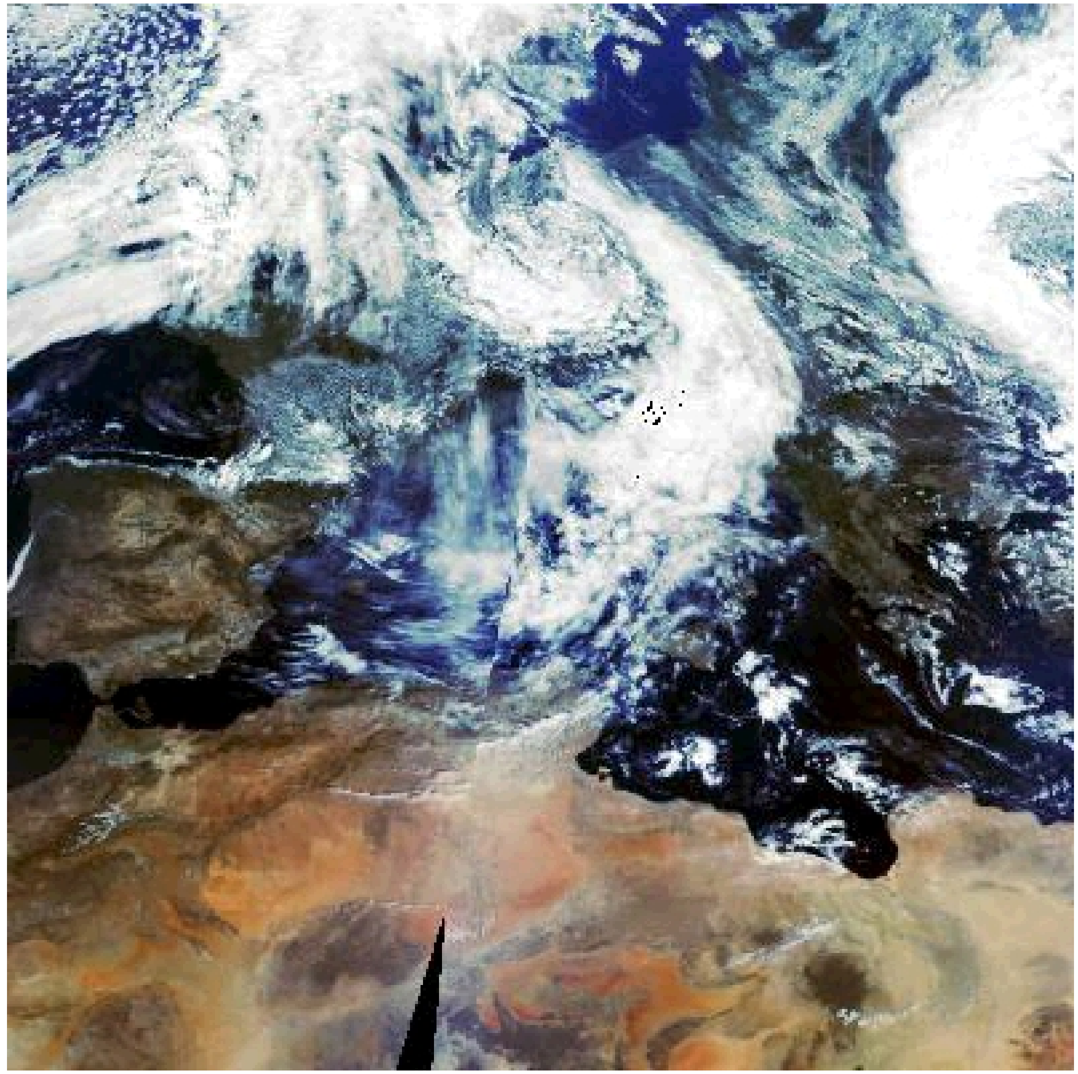


CLOSE UP VIEW OF ORBIT STITCHING OVER EUROPE RGB

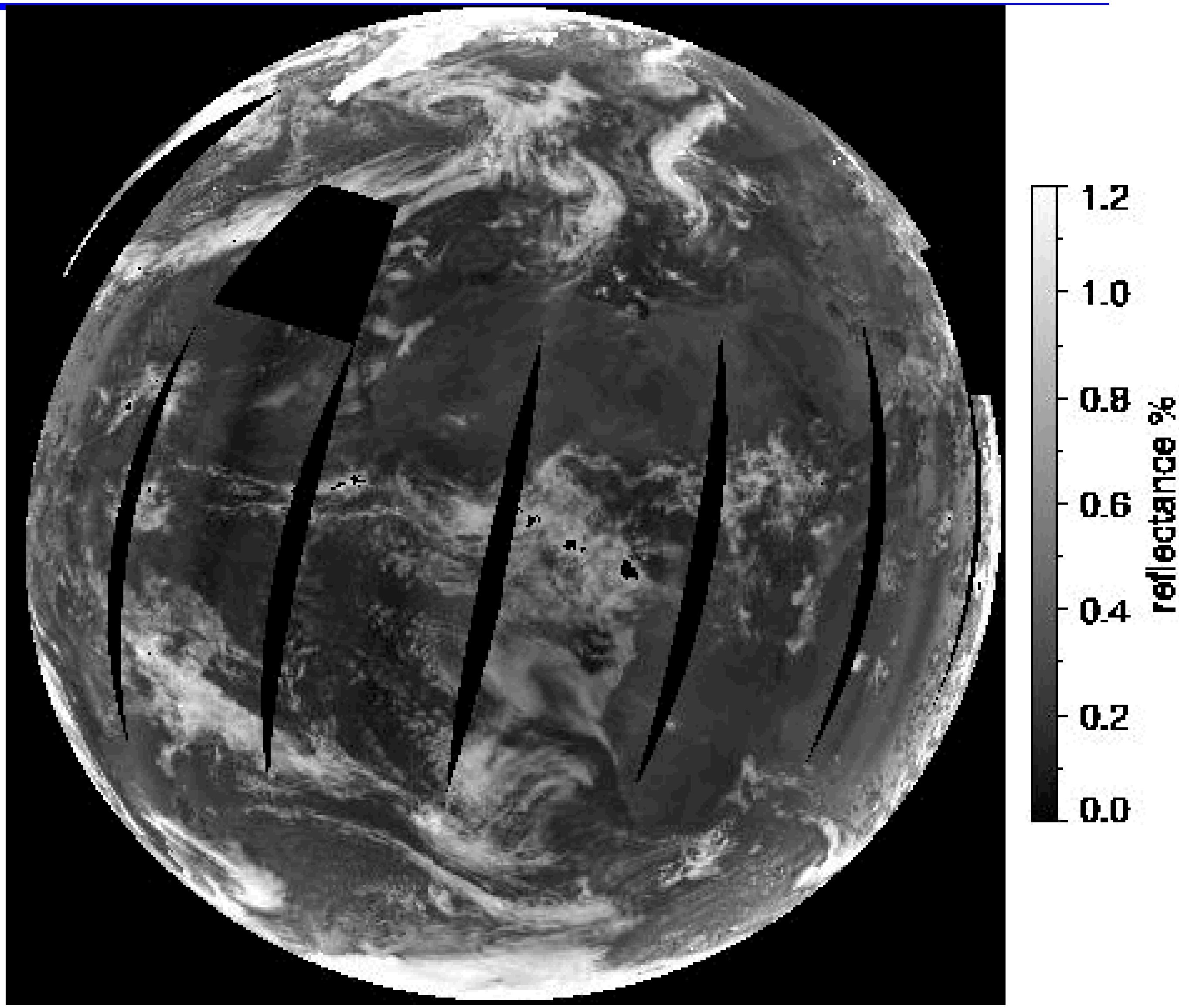
R - 0.647 µm

G - 0.554 µm

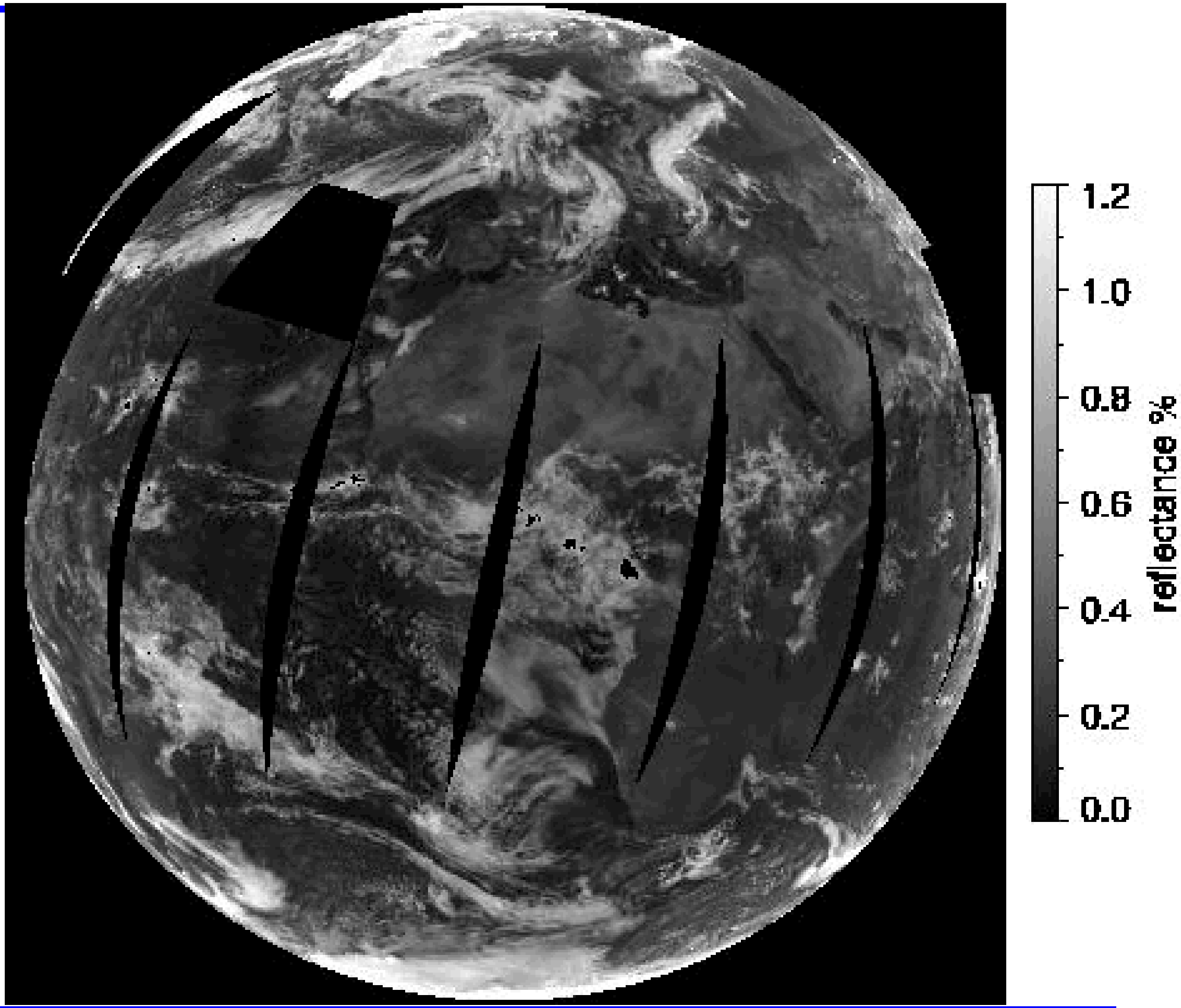
B - 0.466 µm



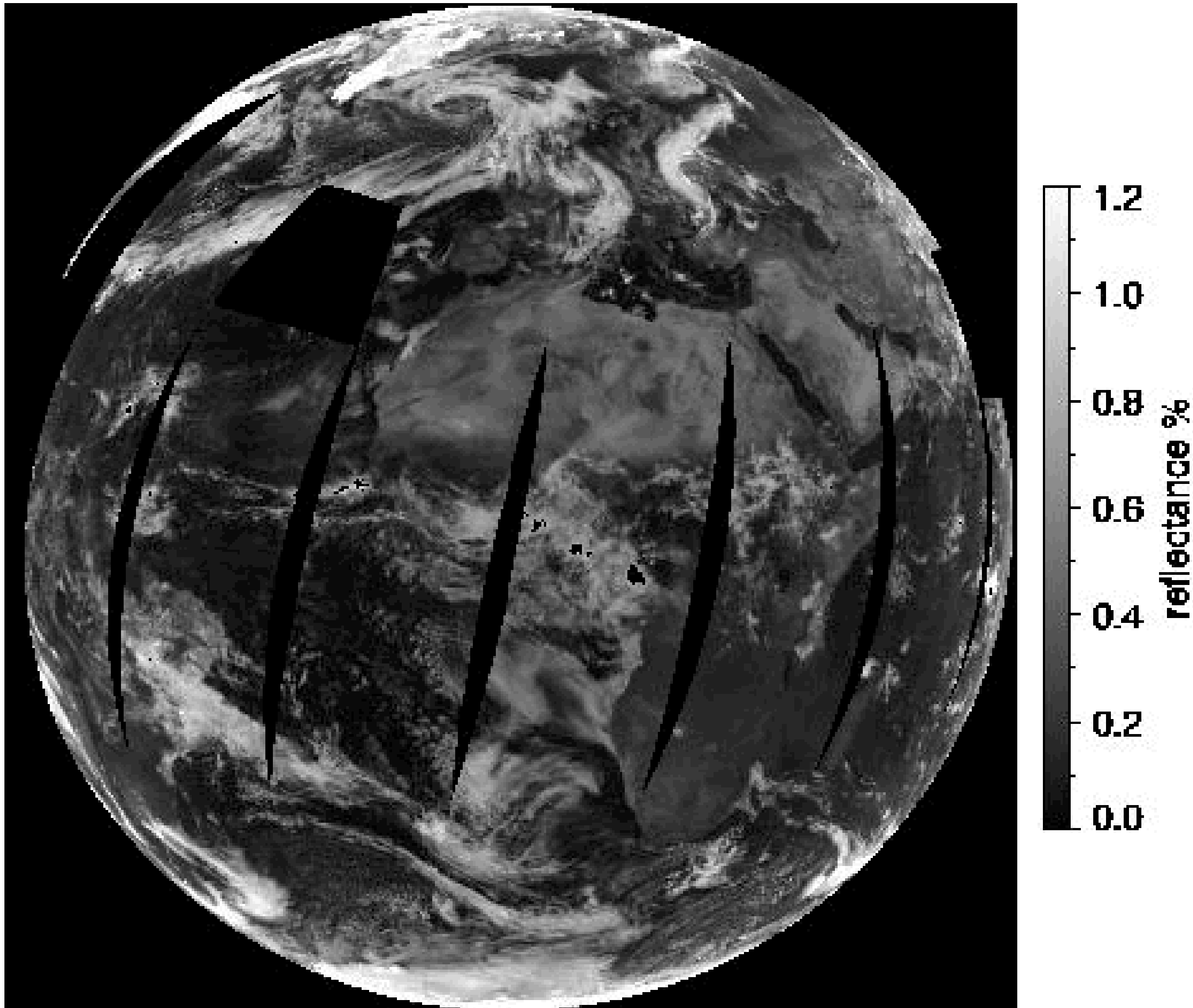
GLOBAL VIEW OF ORBIT STITCHING OVER AFRICA 0.466 µm



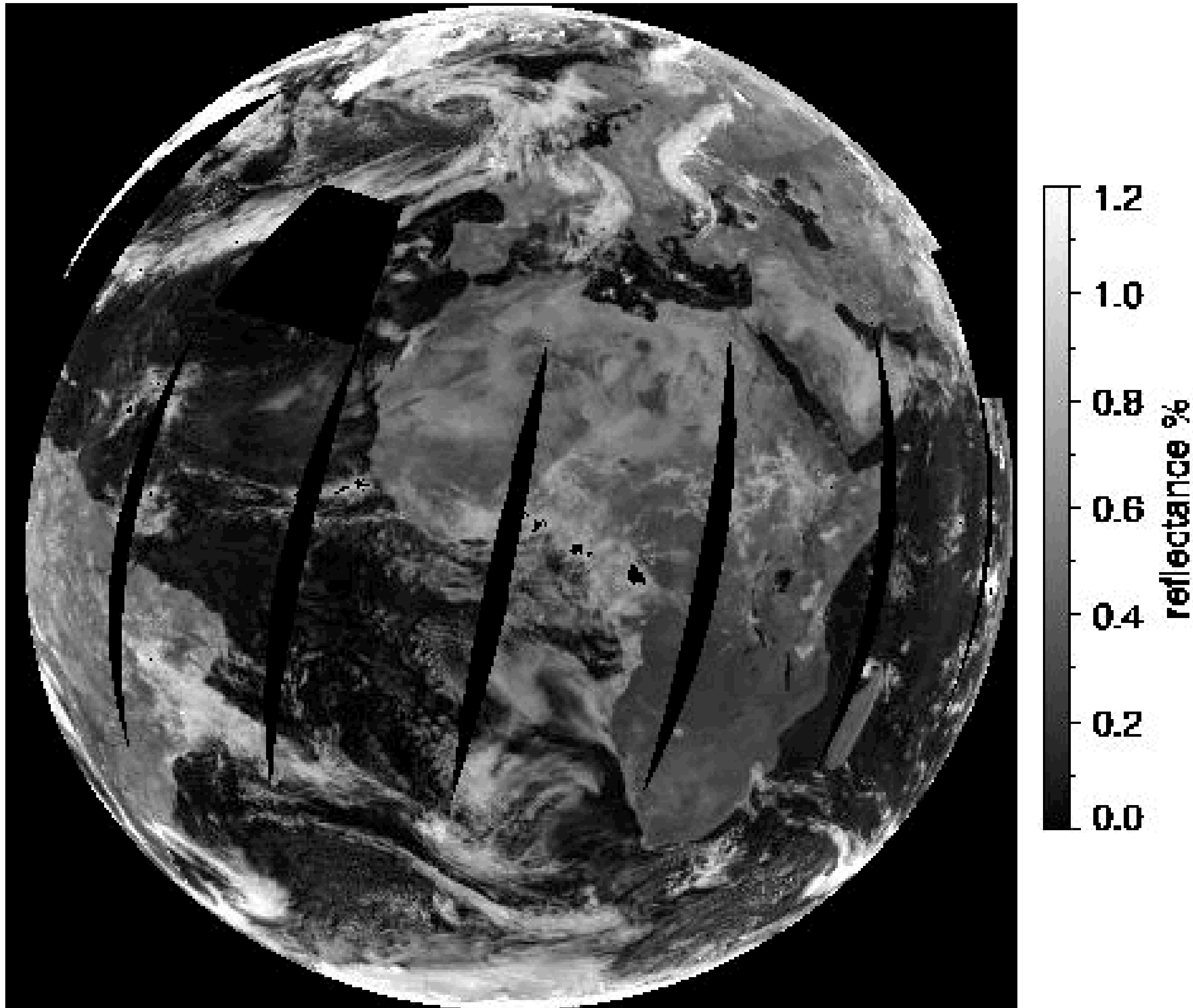
GLOBAL VIEW OF ORBIT STITCHING OVER AFRICA 0.554 µm



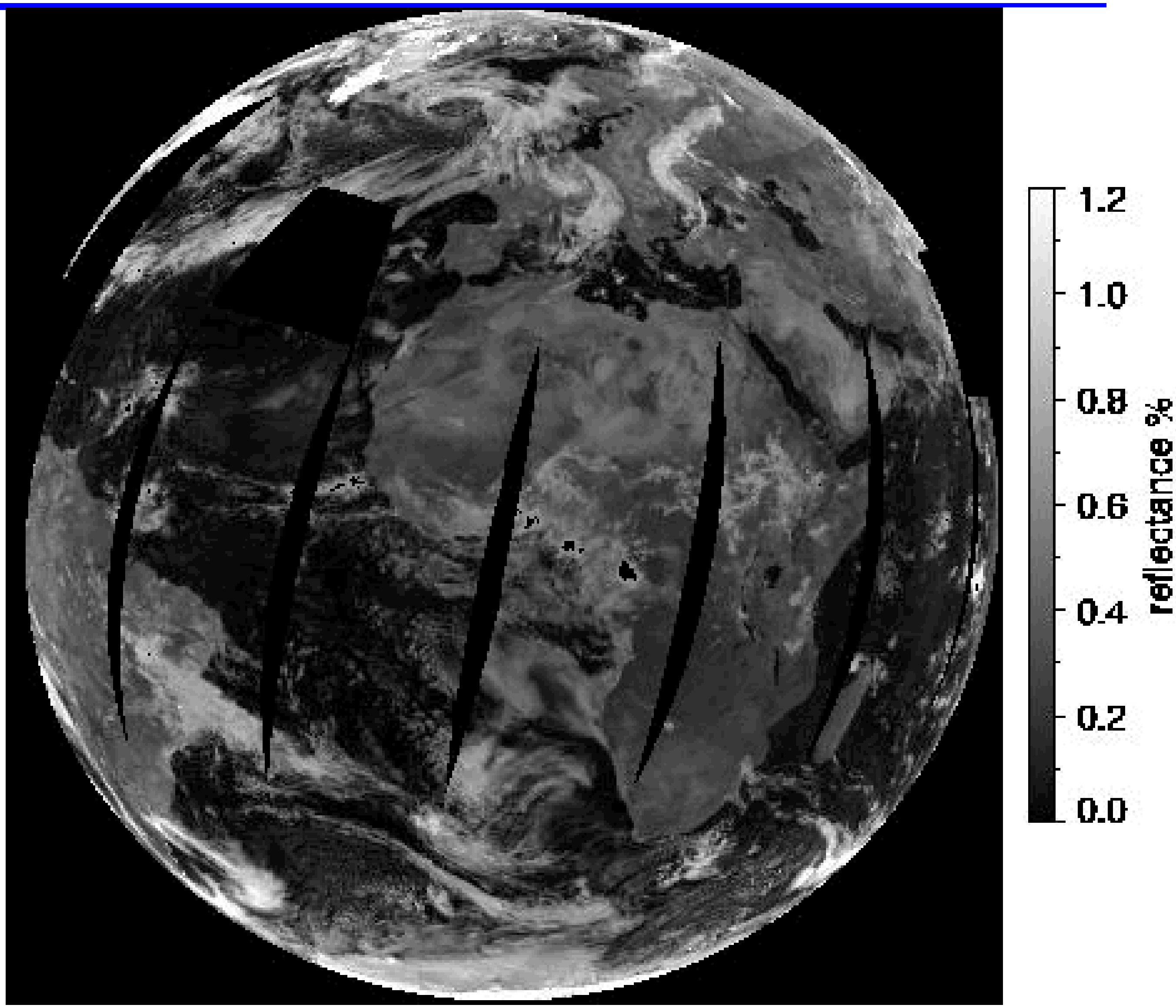
GLOBAL VIEW OF ORBIT STITCHING OVER AFRICA 0.647 µm



GLOBAL VIEW OF ORBIT STITCHING OVER AFRICA 0.857 µm



GLOBAL VIEW OF ORBIT STITCHING OVER AFRICA 0.904 µm



GLOBAL VIEW OF ORBIT STITCHING OVER AFRICA RGB

DEVELOPMENT OF CLOUD ID ALGORITHM

- **Develop theoretical database of spectral reflectances for variety of cases over various backgrounds using RTM**

- **Test detection thresholds for the database**
  -> Initial algorithm

- **Apply initial algorithms to MODIS-based simulation dataset**

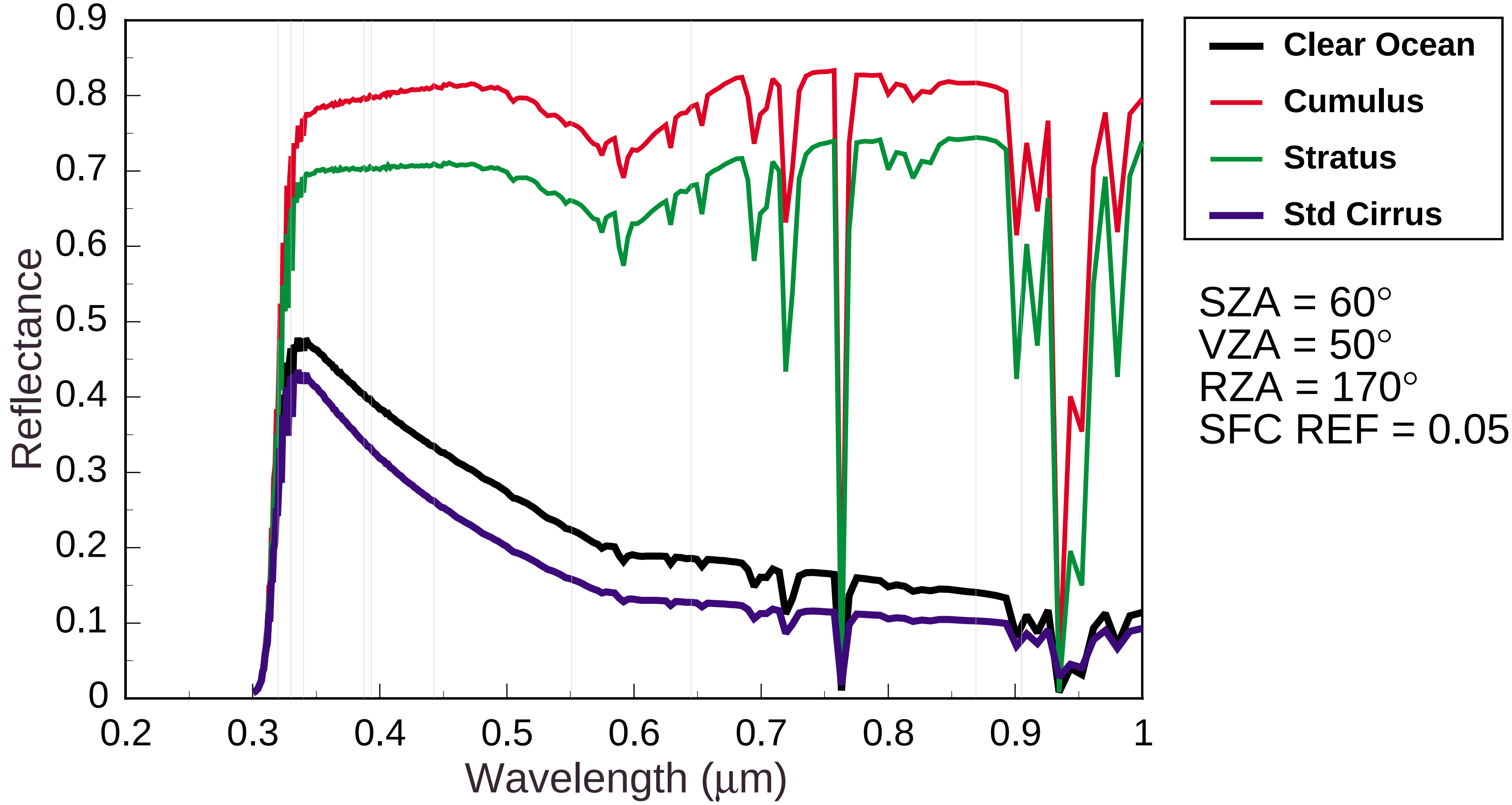
  - compare results to CERES cloud mask
  - refine algorithm
  - repeat process

*** Apply same process to first EPIC data and refine**

MODTRAN 3.5 TOA SPECTRAL RESULTS

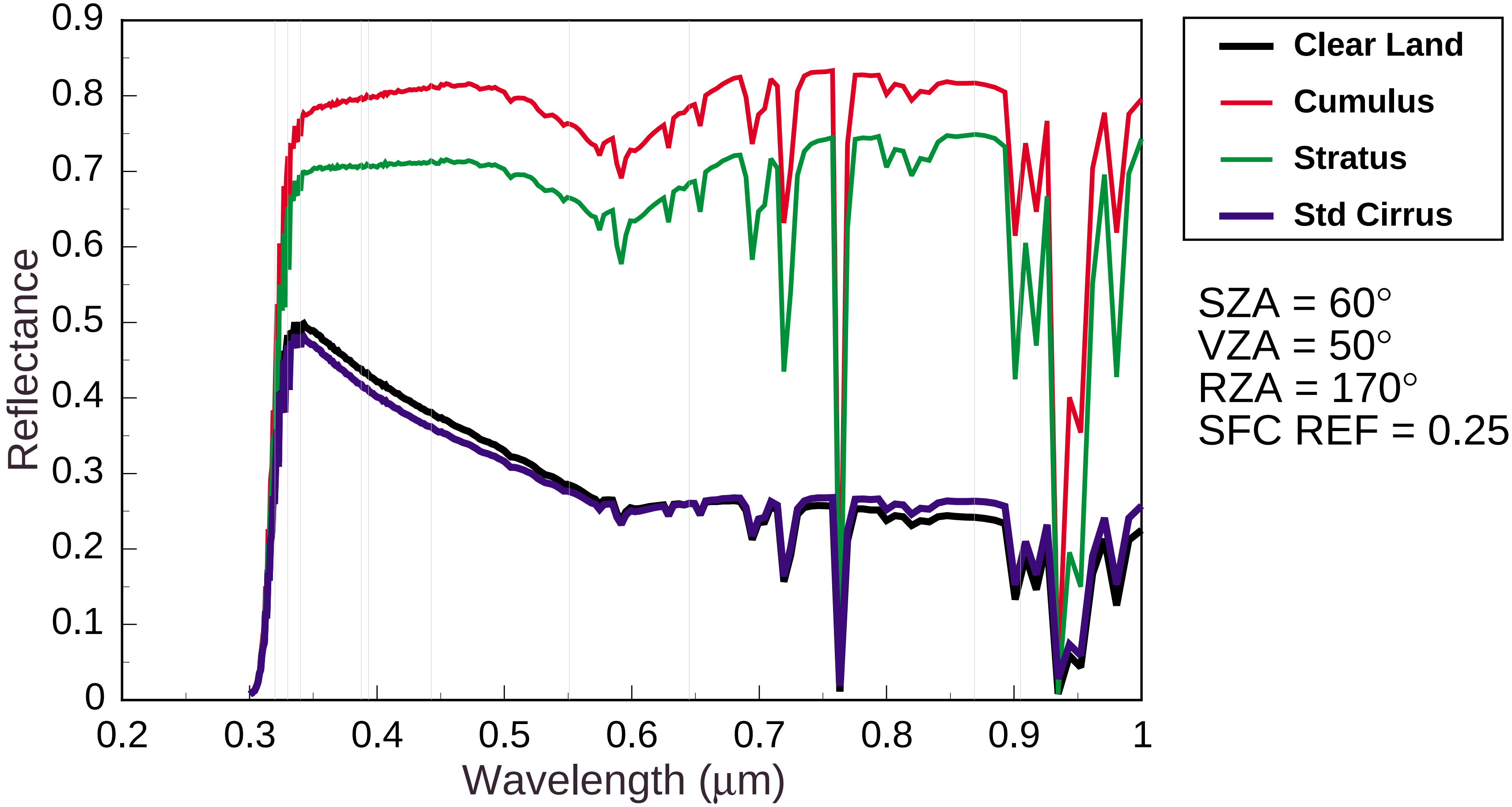
- Define surface reflectance
  - Ocean 0.05
  - Land 0.25
  - Snow 0.60
- Use standard MODTRAN clouds
  - CUMULUS, base 0.7 km, top 3.0 km
  - STRATUS, base 0.3 km, top 1.0 km
  - CIRRUS, base 10 km, top 11 km
- Use US standard atmosphere
- Use backscatter angles
- Determine which EPIC channels are best in discriminating clear and cloudy condtions

MODTRAN 3.5 Ocean

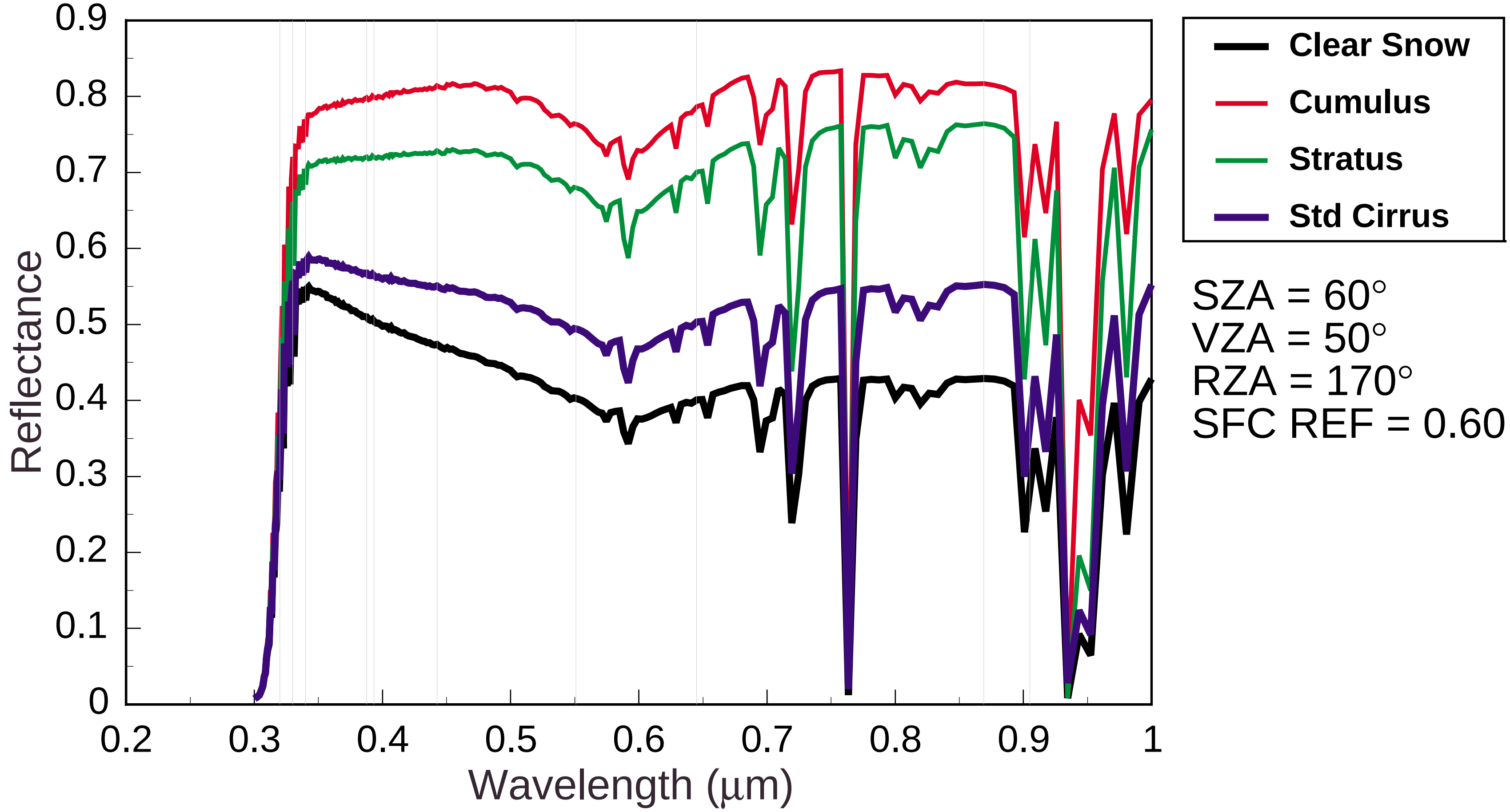


SZA = 60°
VZA = 50°
RZA = 170°
SFC REF = 0.05

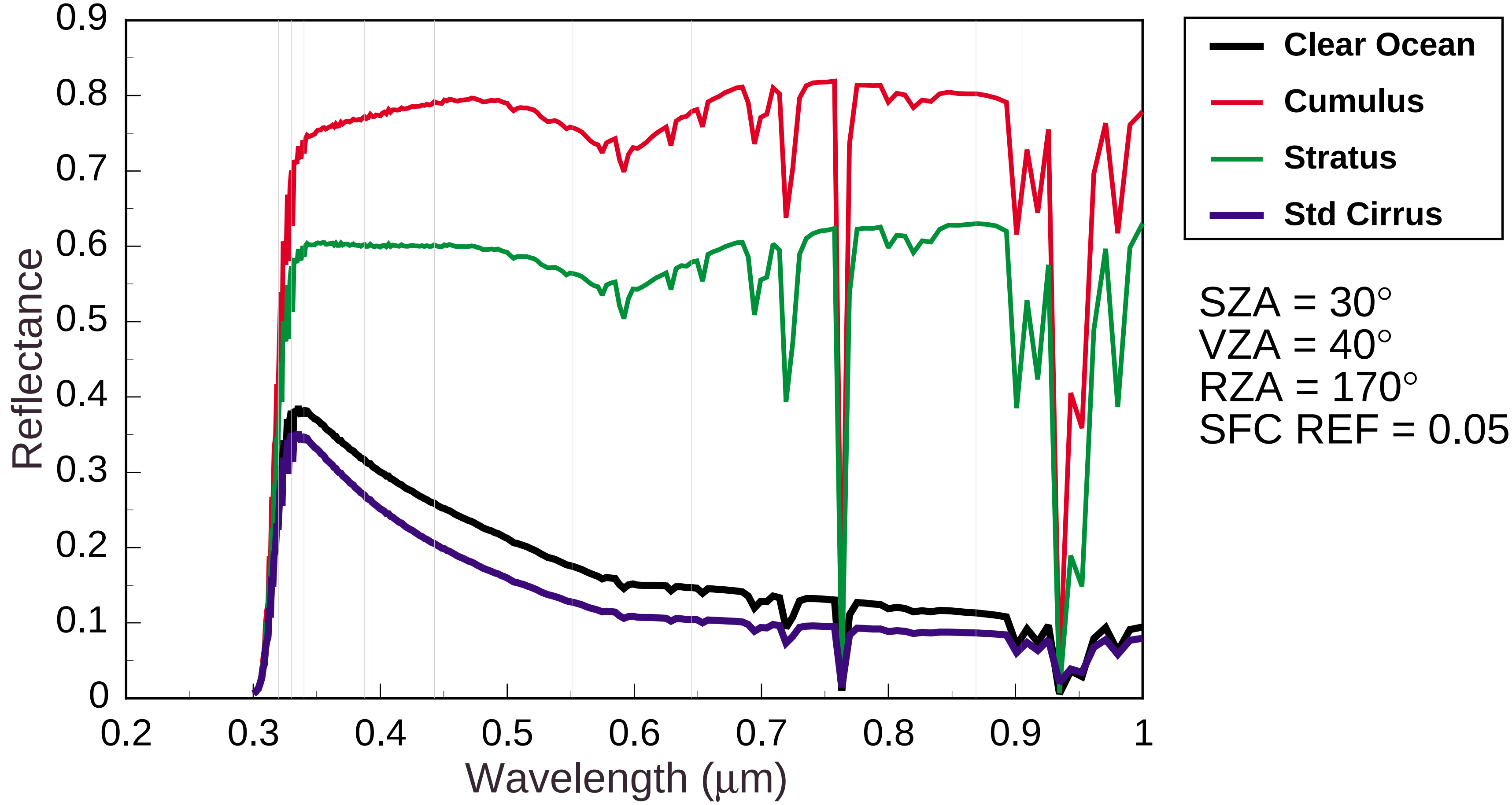
MODTRAN 3.5 Land



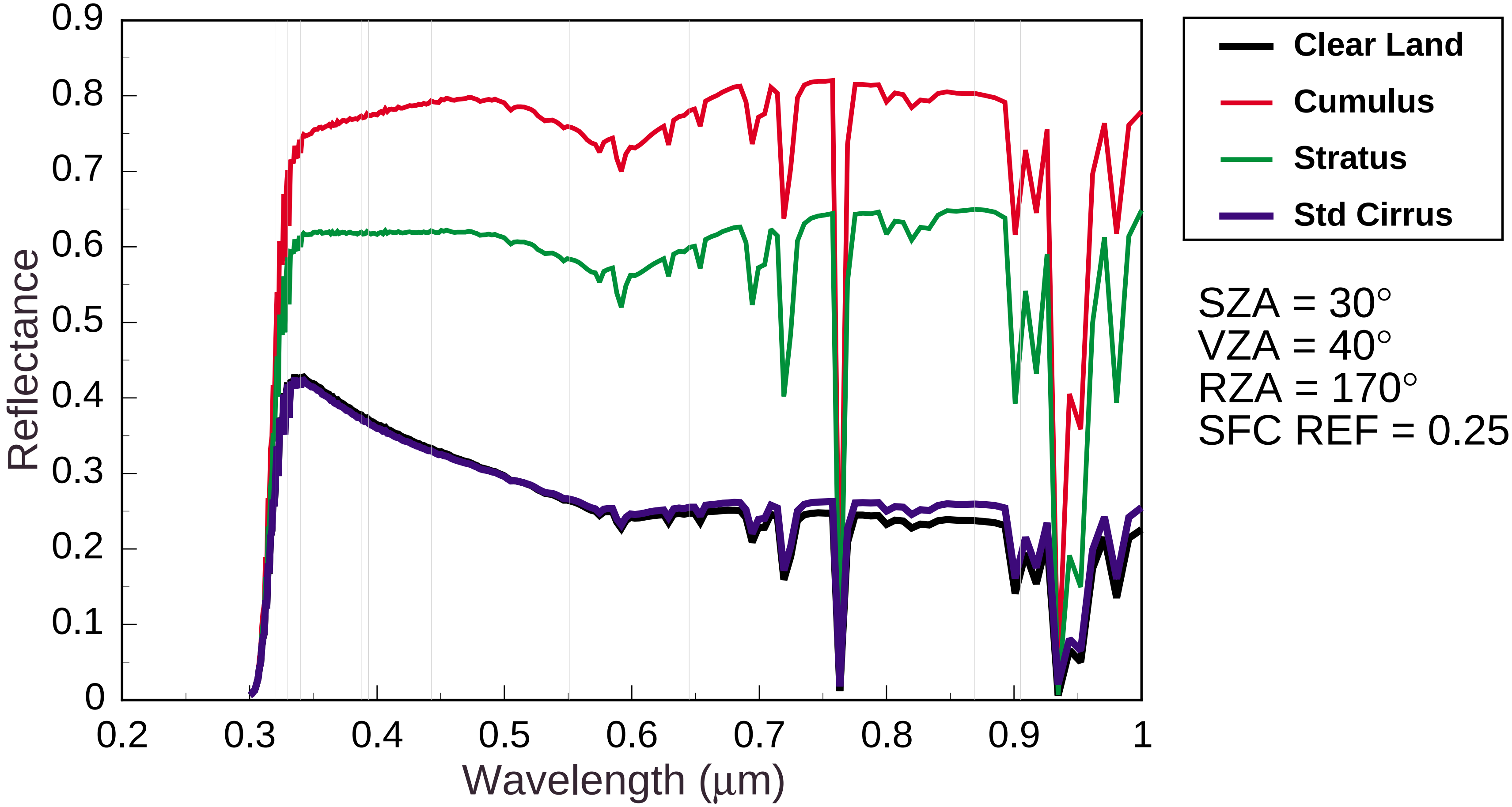
MODTRAN 3.5 Snow



MODTRAN 3.5 Ocean



MODTRAN 3.5 Land



FUTURE PLANS

- improve directional & brdf models for different wavelengths
- automate procedures for simulating with MODIS
- establish range of perturbations to BRDF models
- examine relationships between cloud fraction & reflectance ratios
- continue theoretical calculations for determining thresholds