

Landsat 5: Radiance/Reflectance Calculation Comparison

Contrary to expectations, NASA does include solar angle in its reflectance calculations. However, there are small differences between ENVI calibrated values and manually calculated values for both radiance and reflectance. The discrepancies in the reflectance values are greater than those for radiances: mostly around 1% for most bands but as high as 4% for Band 6.

The Landsat 5 image that was processed in this exercise was that of inland Sweden, north of Stockholm. A scene in the far north was chosen for its larger solar zenith angle that will make a solar angle component of reflectance calculations crucial in ensuring the accuracy of solar irradiance.

Preprocessing Step for All Files:

-Created a Mask for DN=0 on ANY band.

Landsat 5: Radiance

1. Convert DN to Radiance
2. Compare Radiance vs. ENVI Calibrated Radiance

Results:

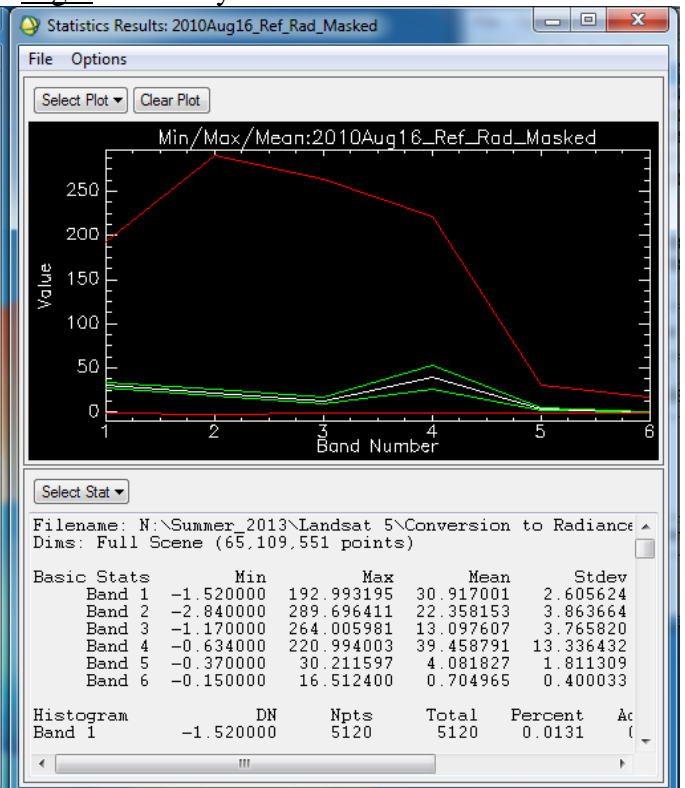
-Negative values are truncated to zero.

-Marginal average difference (~0.001 radiance) between two datasets. The biggest difference of 2.84 radiance was found for Band 2.

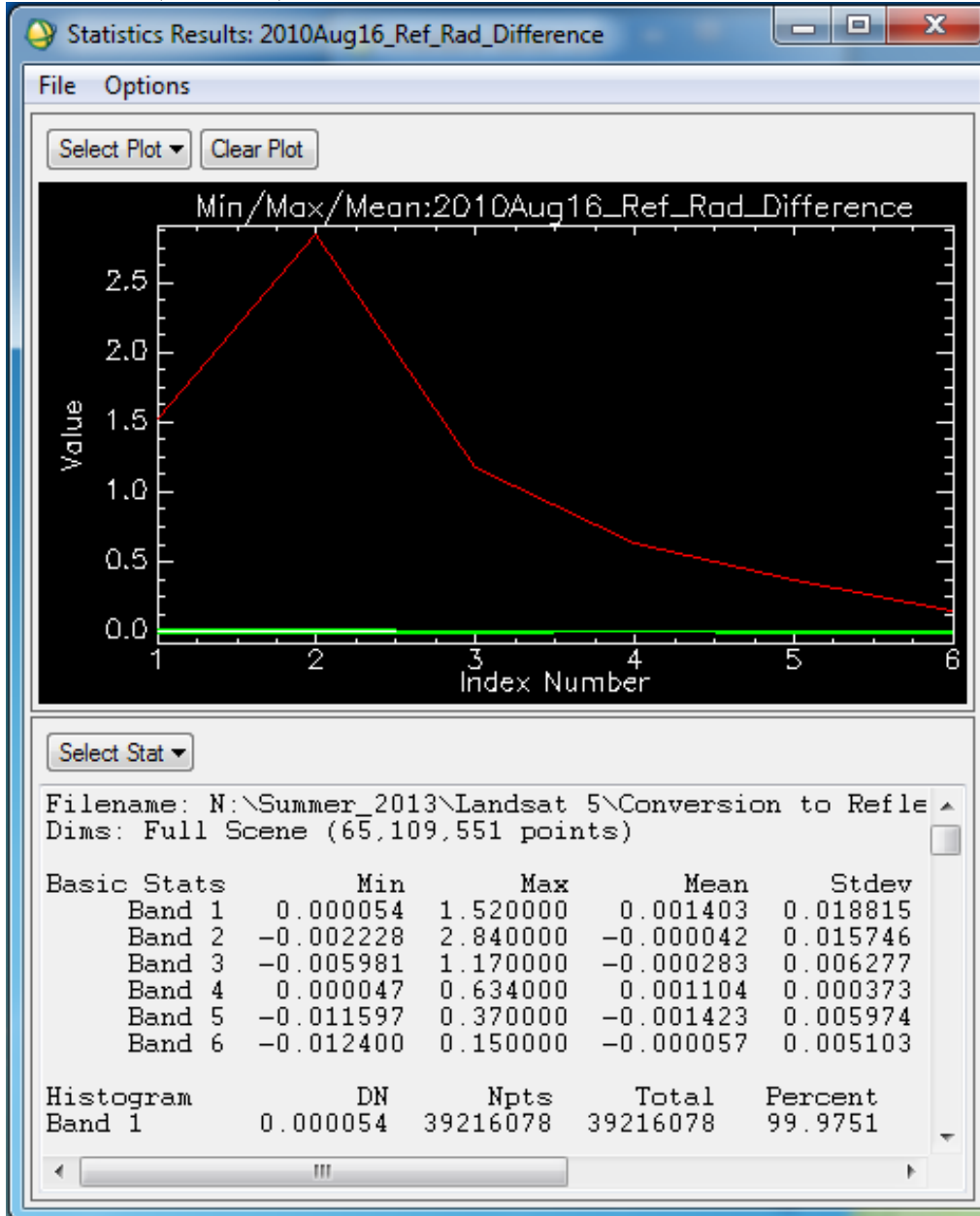
Left: ENVI Calibrated Reflectance



Right: Manually Calculated Reflectance



Band Math (Radiance): B1-B2 = ENVI – Manual



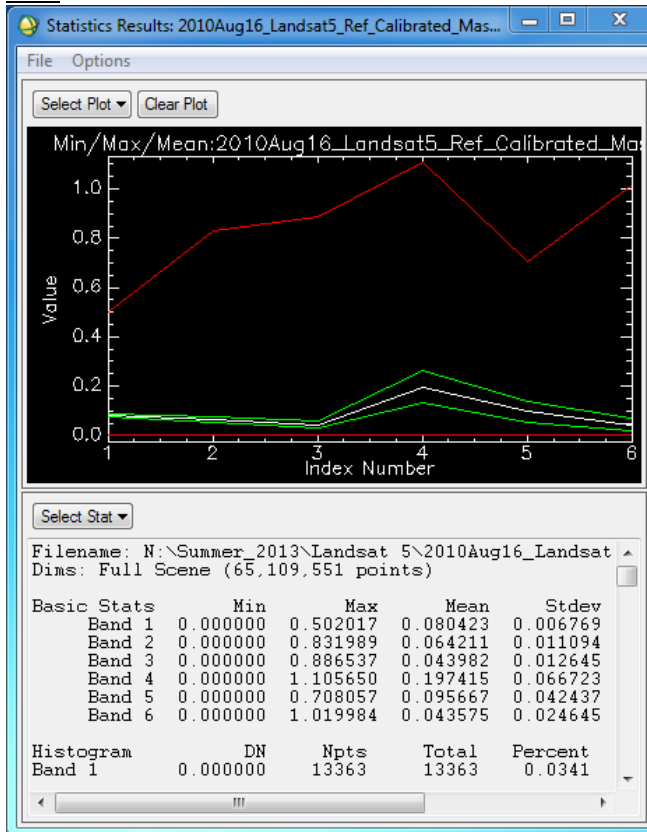
Landsat 5: Reflectance without Solar Angle

3. Convert Radiance to Reflectance with Solar Angle
4. Compare Reflectance with Solar Angle vs. ENVI Calibrated Reflectance

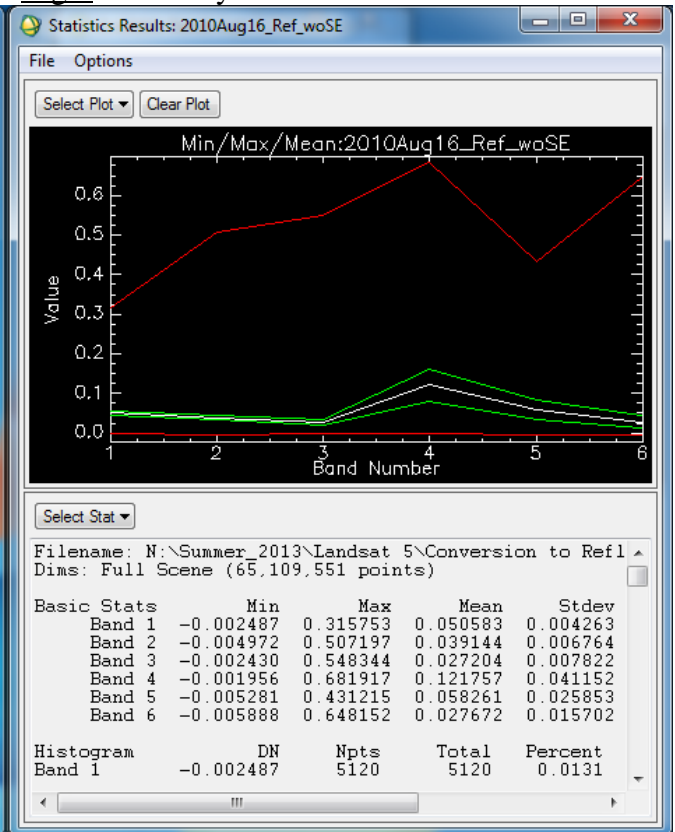
Results:

- Negative values are truncated to zero.
- The two histogram curves for two types of calculations have the same shape, but not the same values.
- The average difference is smaller than the calculations without solar angle at ~0.02 radiance.
- The difference histogram curve has the same shape as the input data, which indicates the difference is due to a constant offset factor across all bands.

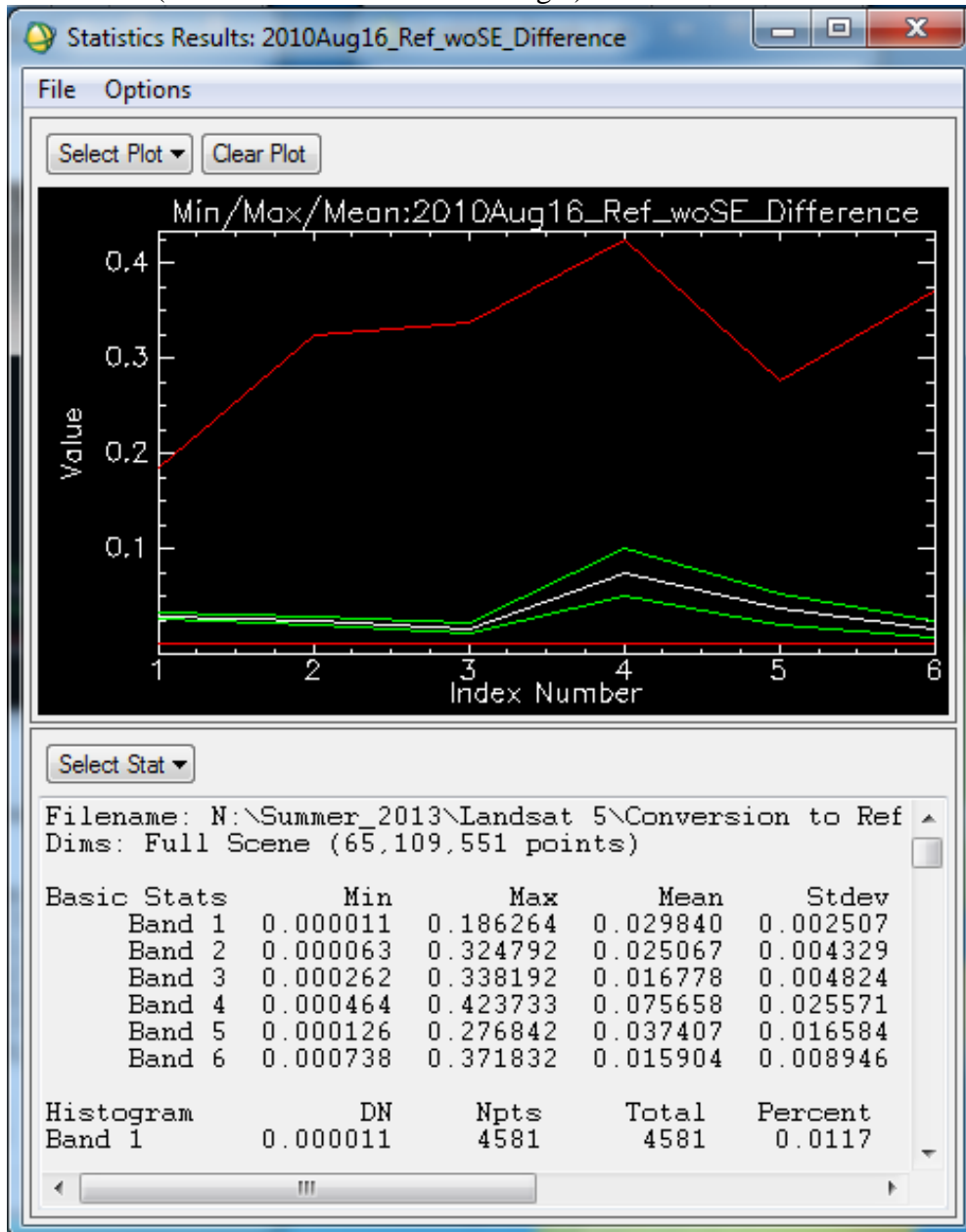
Left: ENVI Calibrated Reflectance



Right: Manually Calculated Reflectance



Band Math (Reflectance without Solar Angle): B1-B2 = ENVI – Manual



Landsat 5: Reflectance with Solar Angle

5. Convert Radiance to Reflectance without Solar Angle
6. Compare Reflectance without Solar Angle vs. ENVI Calibrated Reflectance

Results:

- Negative values are truncated to zero.
- The two histogram curves for two types of calculations have the same shape, but not the same values.
- However, the average difference is ~0.001.

Note: Solar irradiance values used to calculate reflectance here are those published for Landsat 7, which have nearly identical band designations.

Table 11.3 ETM+ Solar Spectral Irradiances

Band	watts/(meter squared * μm)
1	1969.000
2	1840.000
3	1551.000
4	1044.000
5	225.700
7	82.07
8	1368.000

Landsat 5 vs. Landsat 7 Band Wavelength Range Comparisons:

Landsat Thematic Mapper (TM) images consist of seven spectral bands with a spatial resolution of 30 meters for Bands 1 to 5 and 7. Spatial resolution for Band 6 (thermal infrared) is 120 meters, but is resampled to 30-meter pixels. Approximate scene size is 170 km north-south by 183 km east-west (106 mi by 114 mi).

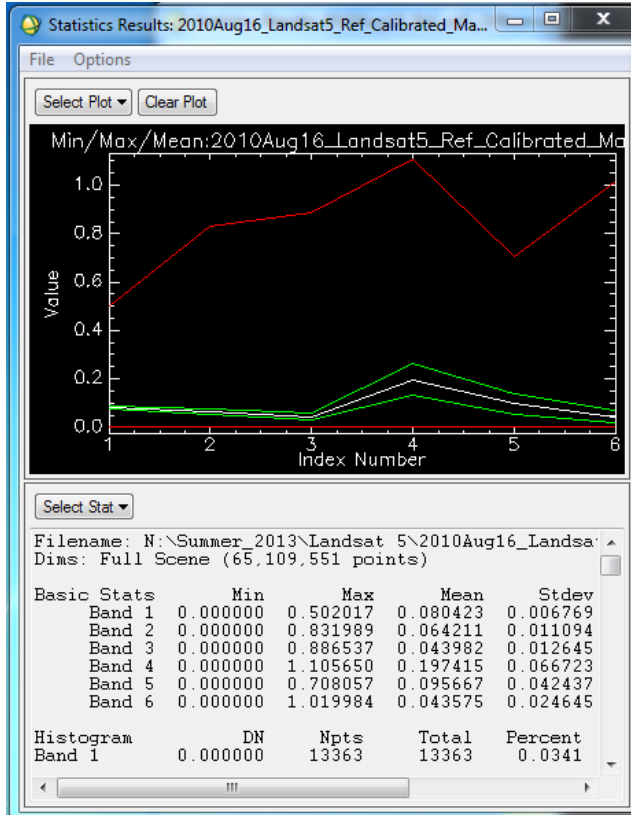
Thematic Mapper (TM)	Landsat 4-5	Wavelength (micrometers)	Resolution (meters)
	Band 1	0.45-0.52	30
	Band 2	0.52-0.60	30
	Band 3	0.63-0.69	30
	Band 4	0.76-0.90	30
	Band 5	1.55-1.75	30
	Band 6	10.40-12.50	120* (30)
	Band 7	2.08-2.35	30

* TM Band 6 was acquired at 120-meter resolution, but products processed before February 25, 2010 are resampled to 60-meter pixels. Products processed after February 25, 2010 are resampled to 30-meter pixels.

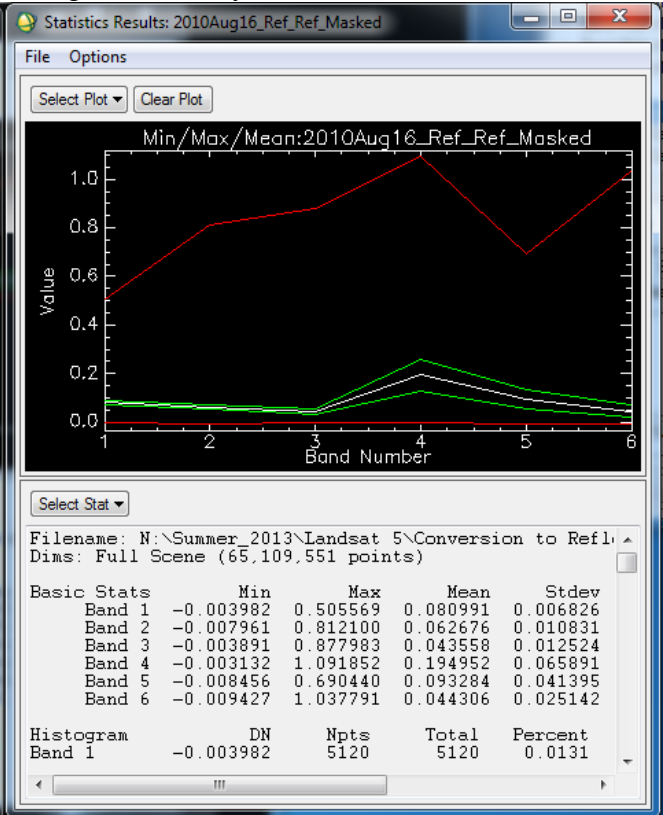
Landsat Enhanced Thematic Mapper Plus (ETM+) images consist of eight spectral bands with a spatial resolution of 30 meters for Bands 1 to 7. The resolution for Band 8 (panchromatic) is 15 meters. All bands can collect one of two gain settings (high or low) for increased radiometric sensitivity and dynamic range, while Band 6 collects both high and low gain for all scenes. Approximate scene size is 170 km north-south by 183 km east-west (106 mi by 114 mi).

Enhanced Thematic Mapper Plus (ETM+)	Landsat 7	Wavelength (micrometers)	Resolution (meters)
	Band 1	0.45-0.52	30
	Band 2	0.52-0.60	30
	Band 3	0.63-0.69	30
	Band 4	0.77-0.90	30
	Band 5	1.55-1.75	30
	Band 6	10.40-12.50	60 * (30)
	Band 7	2.09-2.35	30
	Band 8	.52-.90	15

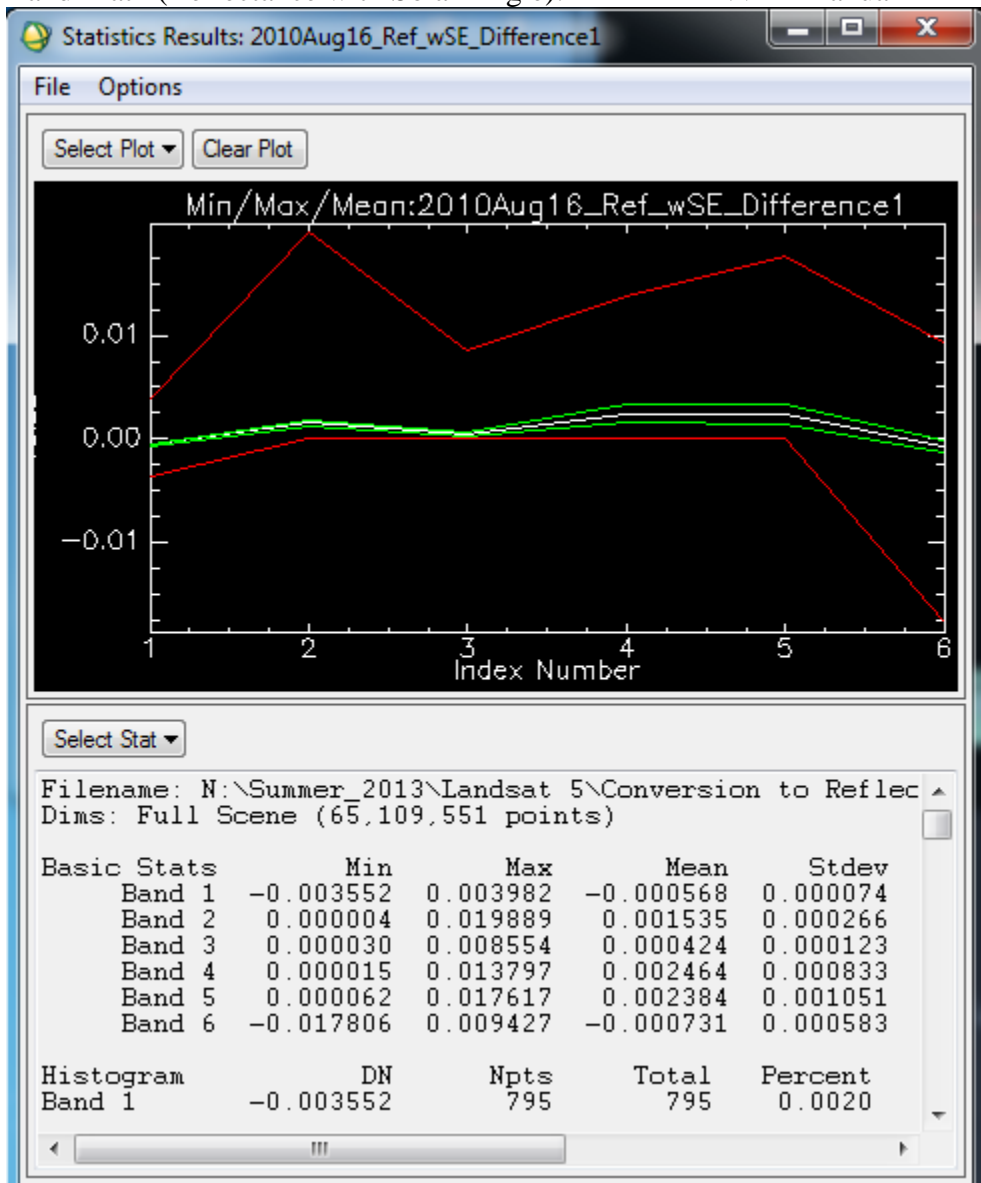
Left: ENVI Calibrated Reflectance



Right: Manually Calculated Reflectance



Band Math (Reflectance with Solar Angle): B1-B2 = ENVI – Manual



I cannot say with certainty what is responsible for slight discrepancies in both radiance and reflectance (with solar angle) calculations despite working with the same datasets and using the same algorithms.

I have included the ratio of the ENVI calibrated and manually calculated reflectance values (with solar angle accounted for) here to highlight the small degree of discrepancy between the two methods.

Band Math (Reflectance with Solar Angle Ratio): $B1/B2 = ENVI/Manual$

