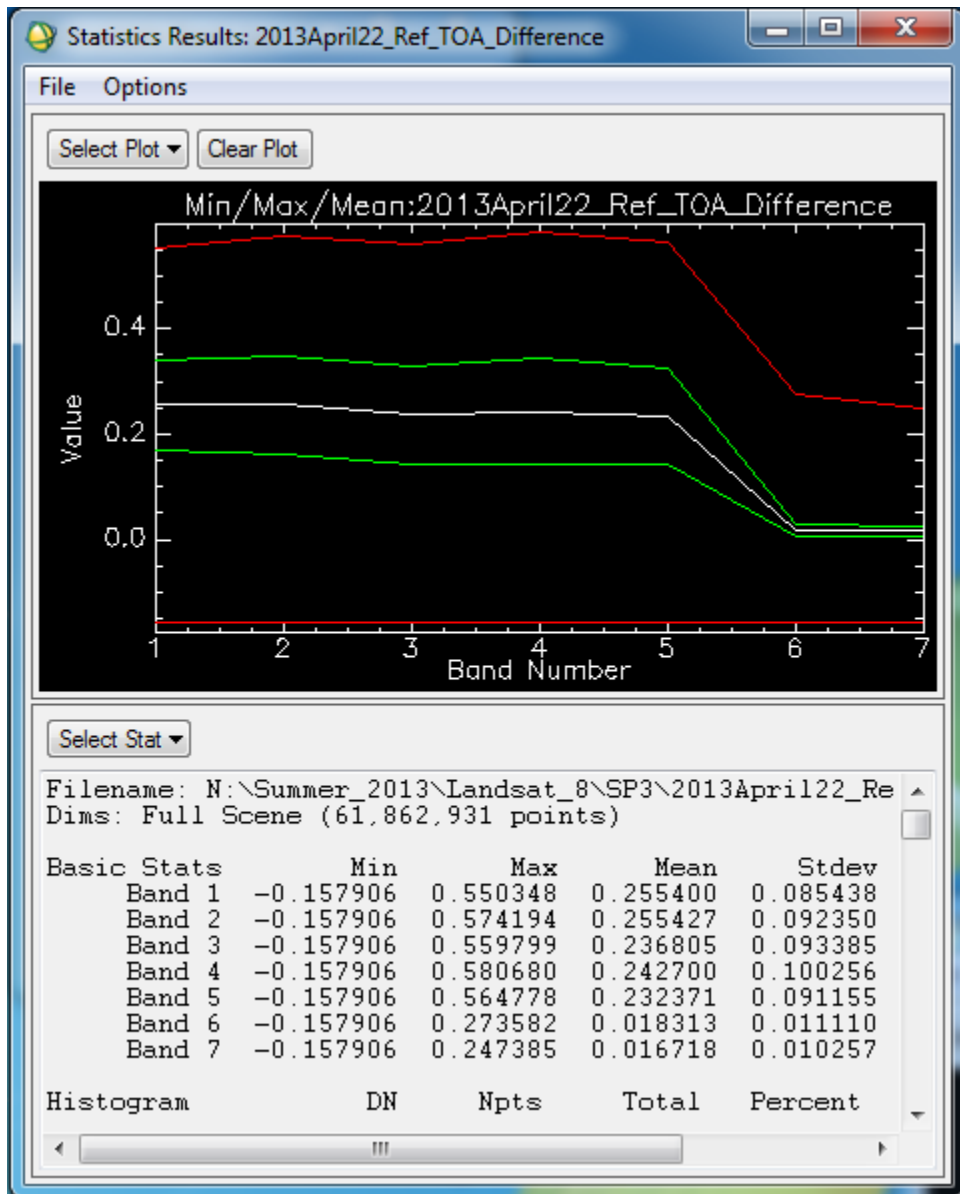


Landsat 8: Comparison of TOA Reflectance Values with SP3

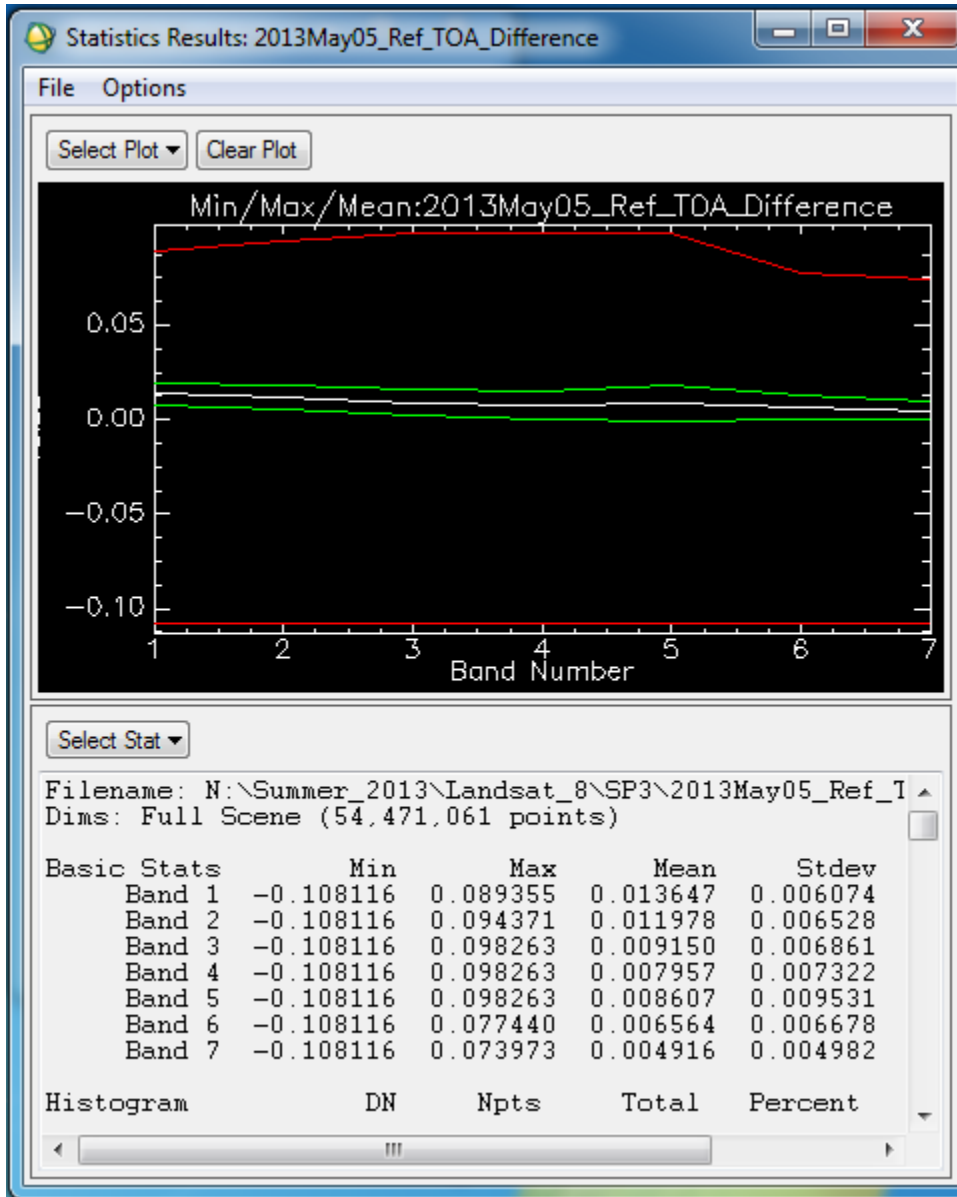
In order to see how manually calculated reflectance values compare with those that are automatically generated by the Service Pack 3, I used Band Math to map out the differences between the two: B1-B2; B1 = manually calculated TOA, B2 = SP3 generated TOA. This was done for all scenes: Alaska, Dominica, Florida and Mississippi.

Below are the Statistics output for all scenes.

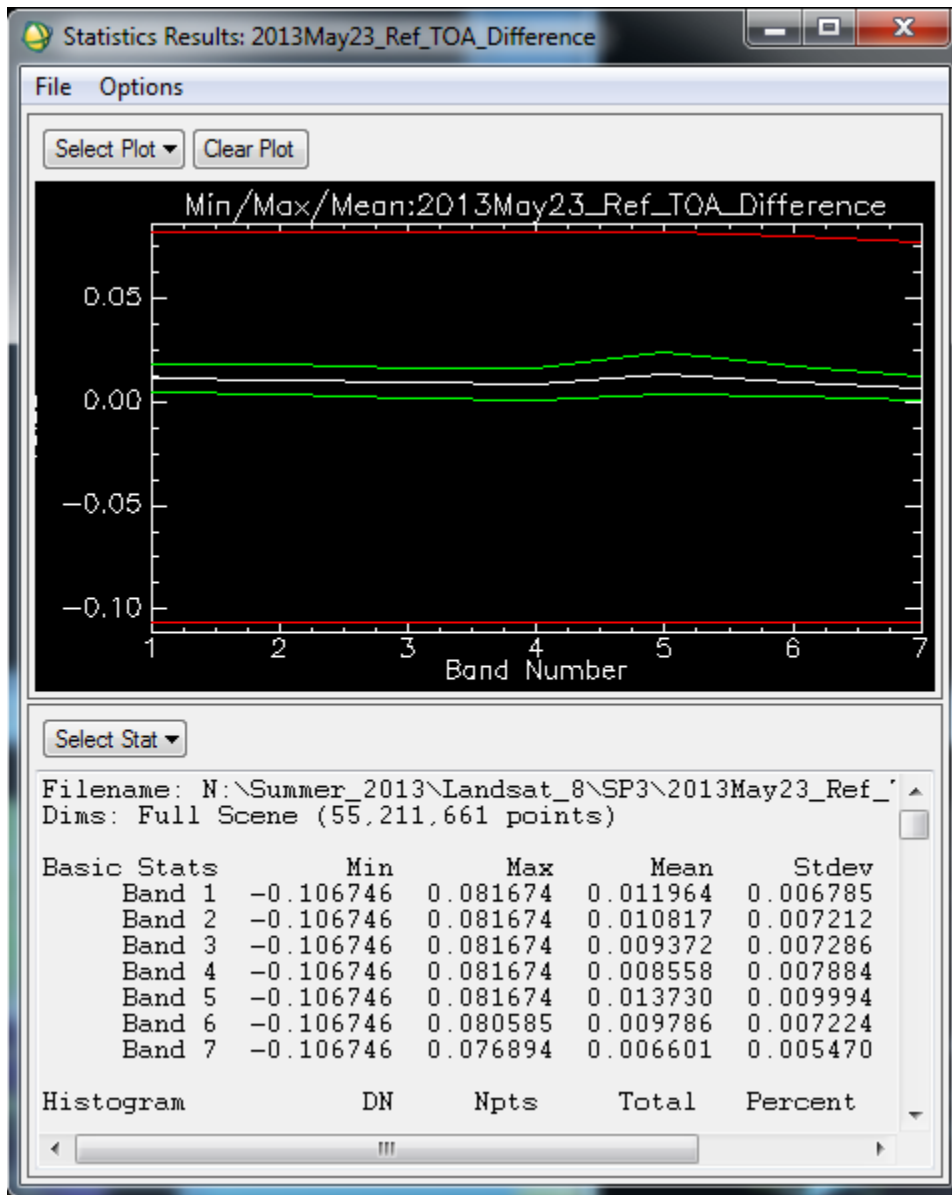
- ❖ *Alaska: 2013April22_Ref_TOA_Difference (Mask: DN=0 on ALL bands)*



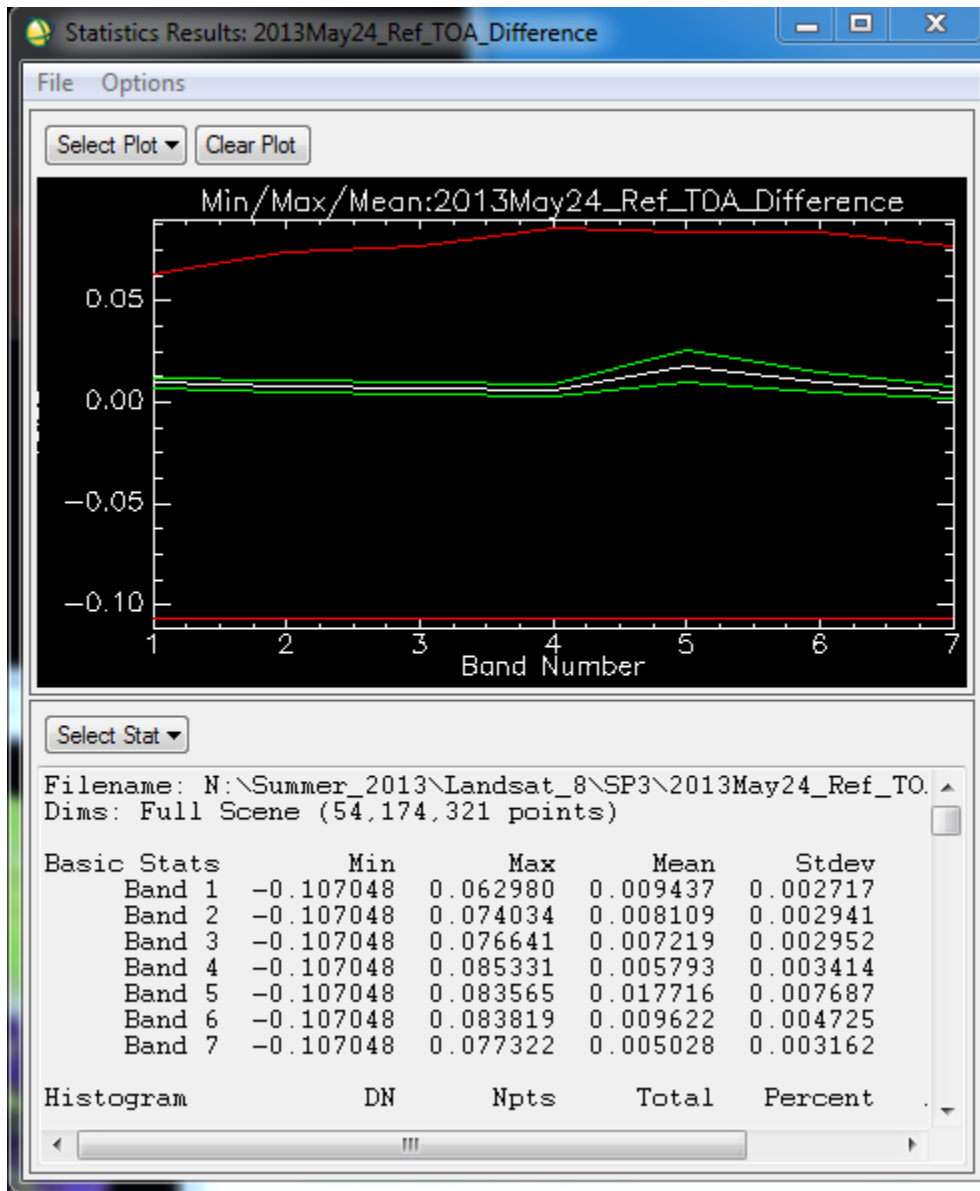
❖ *Dominica: 2013May05_Ref_TOA_Difference(Mask: DN=0 on ALL bands)*



❖ Florida: 2013May23_Ref_TOA_Difference (Mask: DN=0 on ALL bands)



❖ *Mississippi: 2013May24_Ref_TOA_Difference (Mask: DN=0 on ALL bands)*



The differences are small (~ 0.01) and pretty much uniform in their respective bands as is evidenced by small standard deviations.

Without SE in TOA Reflectance Calculations

But, once $\sin(\theta_{SE})$ is taken out of the calculations (inserted below for reference), the differences in the reflectance values are greater (~0.03) but the same across all bands (Means and StDev's are the same). This offset in the TOA reflectance values is approximately the same across different images except for Alaska. For example, in the Mississippi scene, SP3 reflectance values are about 0.03 greater than the manually calculated values. But, in the Alaska scene, SP3 reflectance values are about 0.04 greater.

These offsets disappear when the mask for DN=0 on ALL bands is applied.

Take Away Points:

- Mask for DN=0 on ANY band highly recommended before processing
- SP3 is a reliable tool for DN to reflectance conversion IF one disregards solar angle.
- For regions close to the poles where solar angles are substantially smaller, one should be cautious to use SP3 reflectance values.

DN to TOA Reflectance Formula:

$$\rho\lambda = \frac{M_{\rho}Q_{cal} + A_{\rho}}{\sin(\theta_{SE})}$$

where:

$\rho\lambda$ = TOA planetary reflectance, without correction for solar angle.

M_{ρ} = Band-specific multiplicative rescaling factor from the metadata (REFLECTANCE_MULT_BAND_x, where x is the band number)

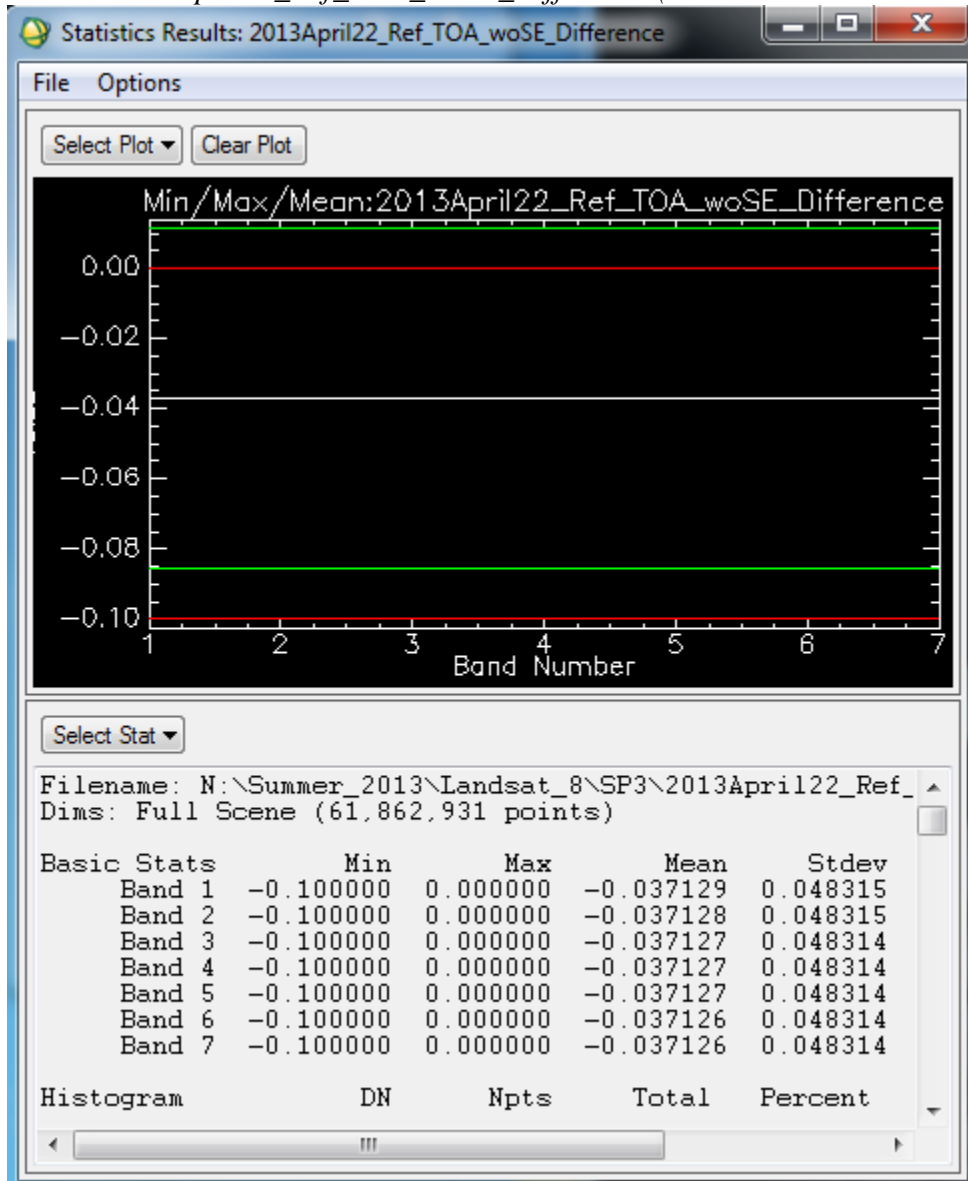
A_{ρ} = Band-specific additive rescaling factor from the metadata (REFLECTANCE_ADD_BAND_x, where x is the band number)

Q_{cal} = Quantized and calibrated standard product pixel values (DN)

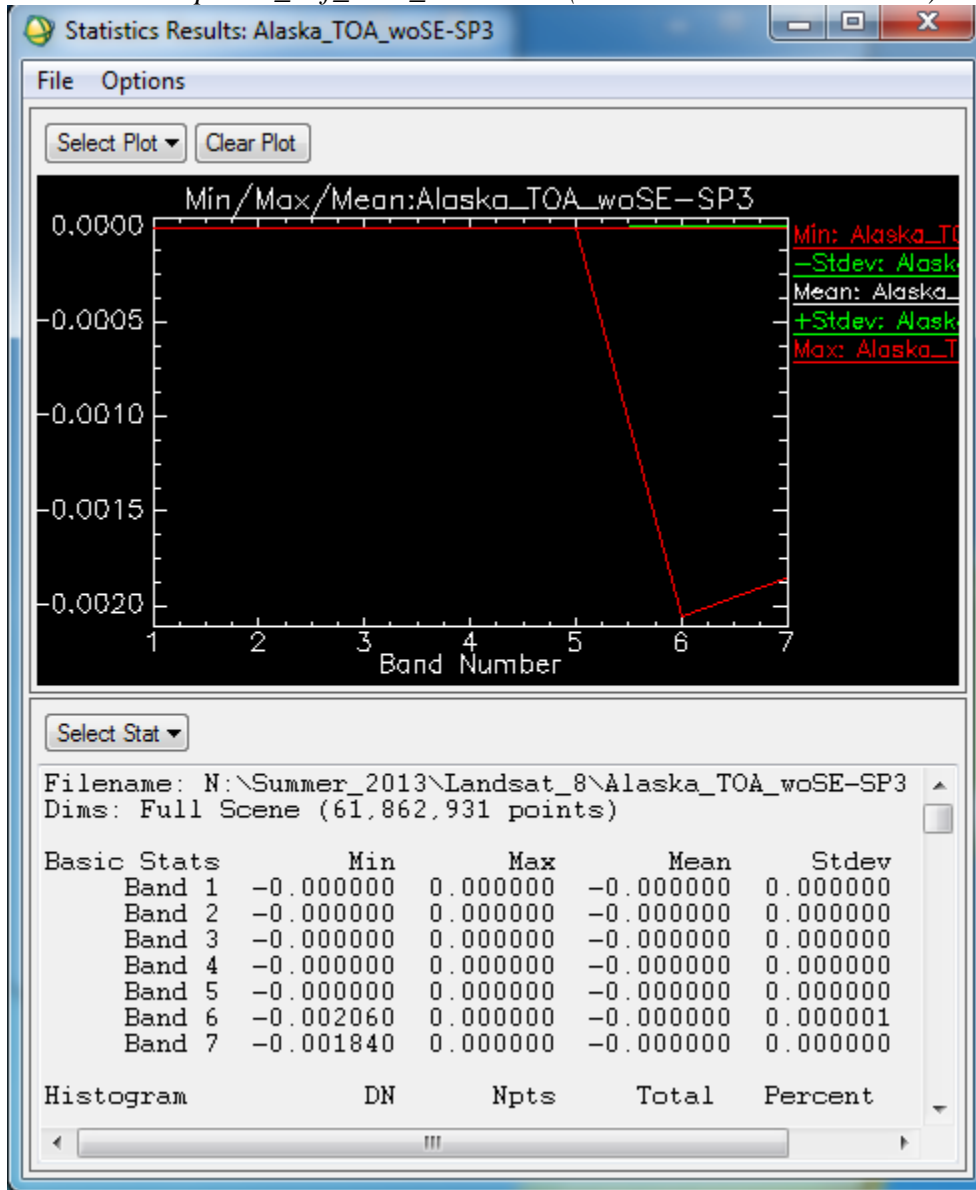
θ_{SE} = Local sun elevation angle. The scene center sun elevation angle in degrees is provided in the metadata (SUN_ELEVATION).

(Source: USGS)

- ❖ Alaska: 2013April22_Ref_TOA_woSE_Difference (Mask: DN=0 on ALL bands)



❖ Alaska: 2013April22_Ref_TOA_woSE-SP3 (Mask: DN=0 on ANY band)

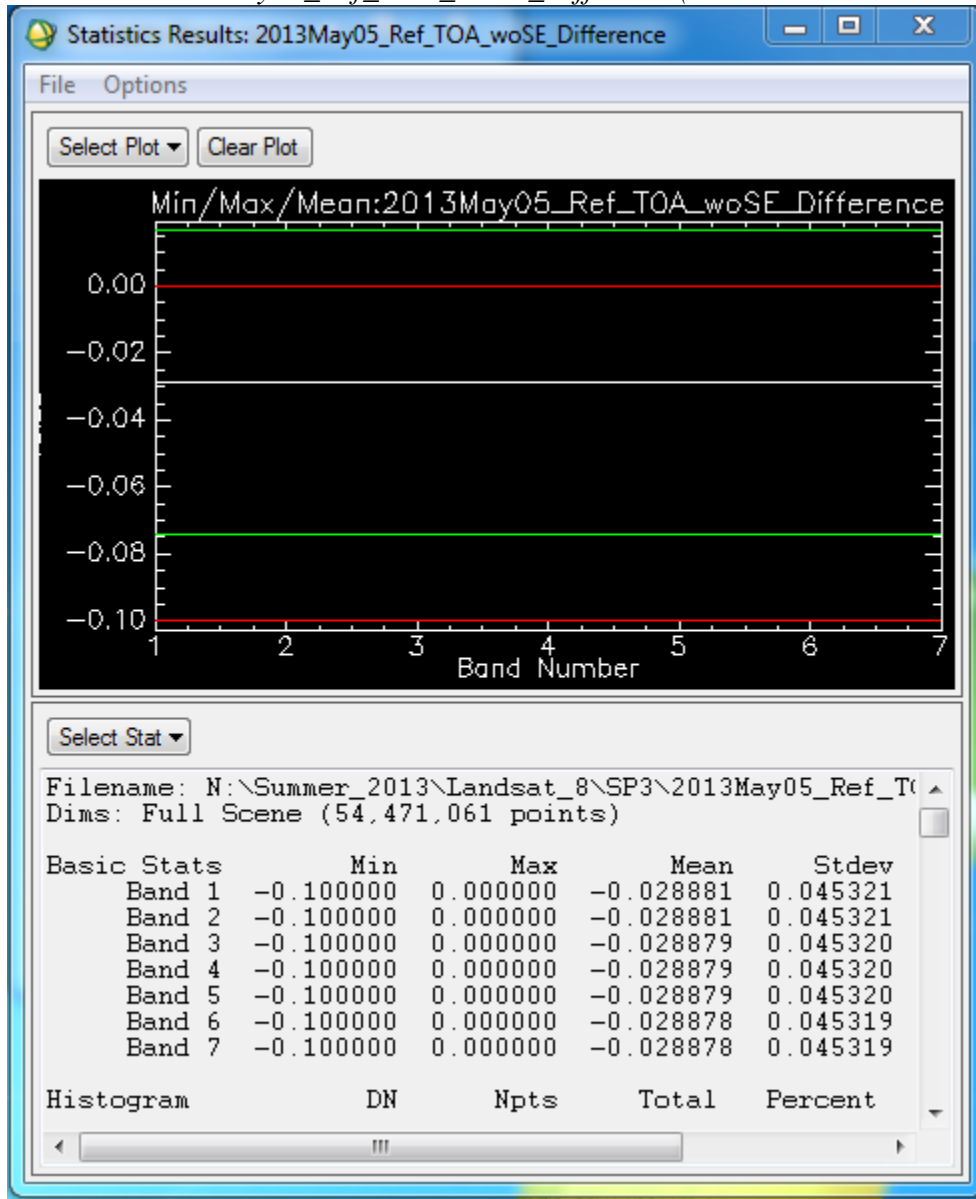


For every band, the differences between the manual and SP3 calculated reflectance values (still disregarding the solar angle) are zero.

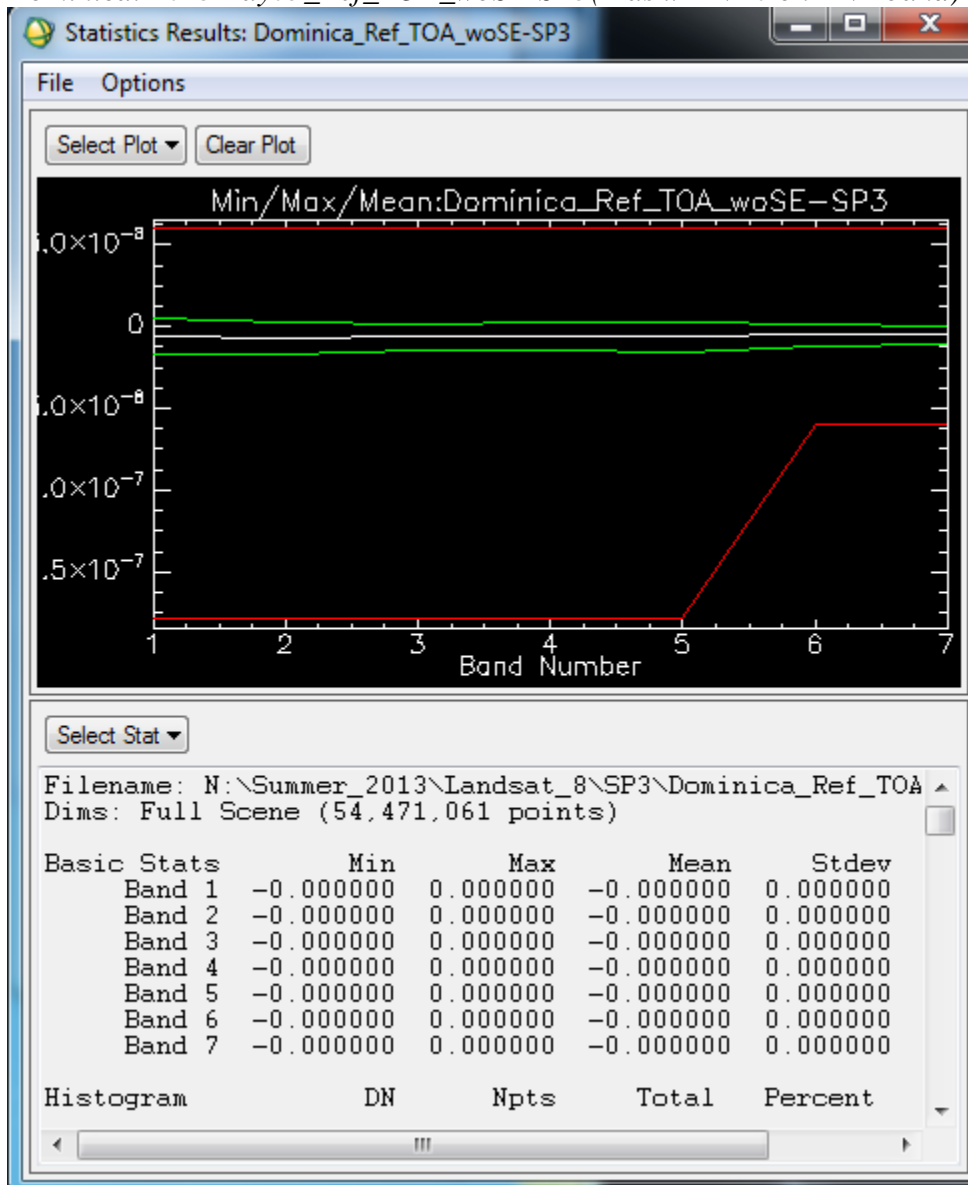
Below is a table of values deviating from zero in more than two pixels for Bands 6 and 7.

	Reflectance	# of Pixels	Total	Percent	Acc. Percent
Band 6	-0.000008	38,893,187	38,893,204	99.9999	100
	0.000000	5	38,893,209	0.0000	100
Band 7	-0.000007	38,892,151	38,892,159	99.99973	99.9973
	0.000000	1,050	38,893,209	0.0027	100

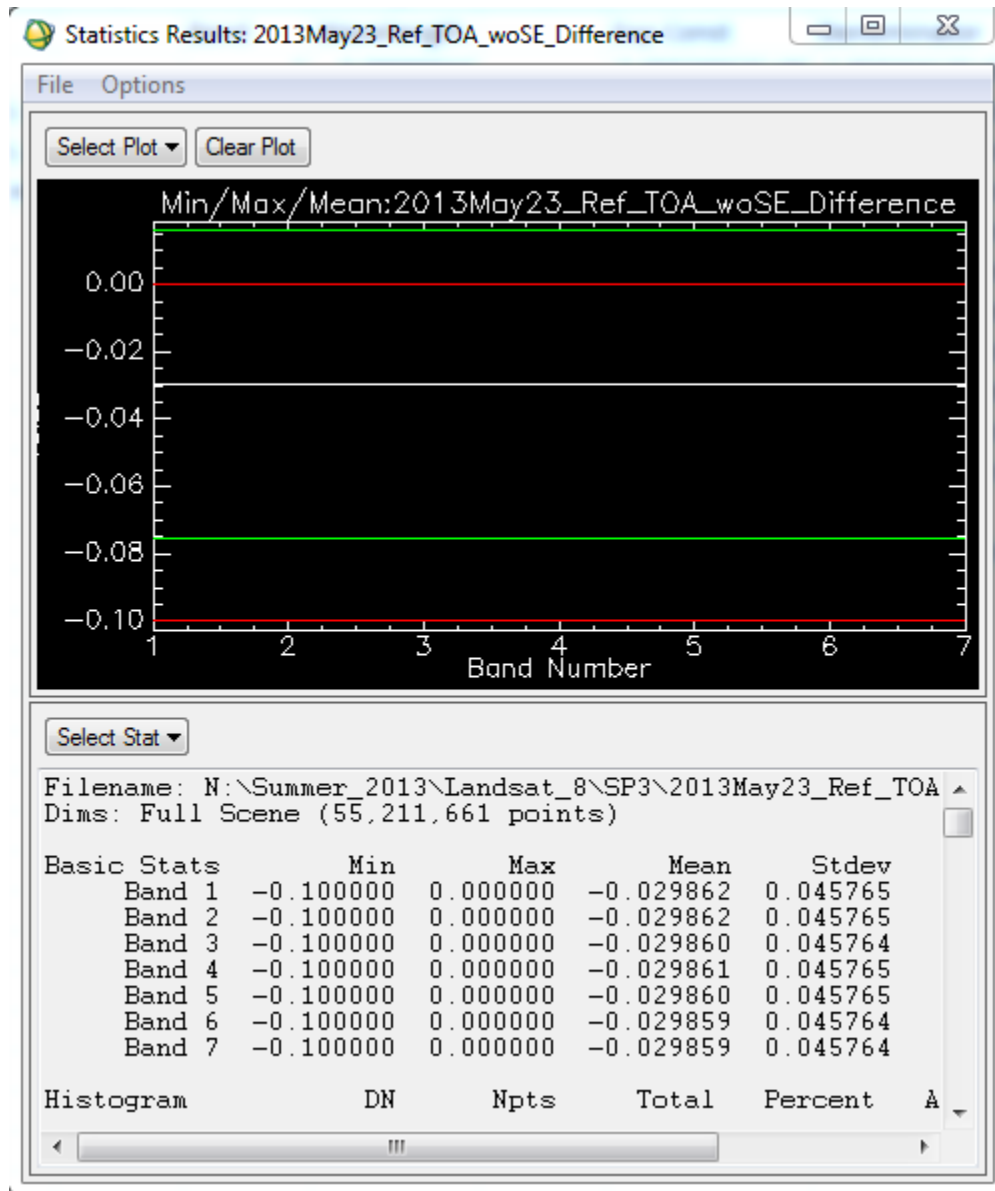
- ❖ *Dominica: 2013May05_Ref_TOA_woSE_Difference(Mask: DN=0 on ALL bands)*



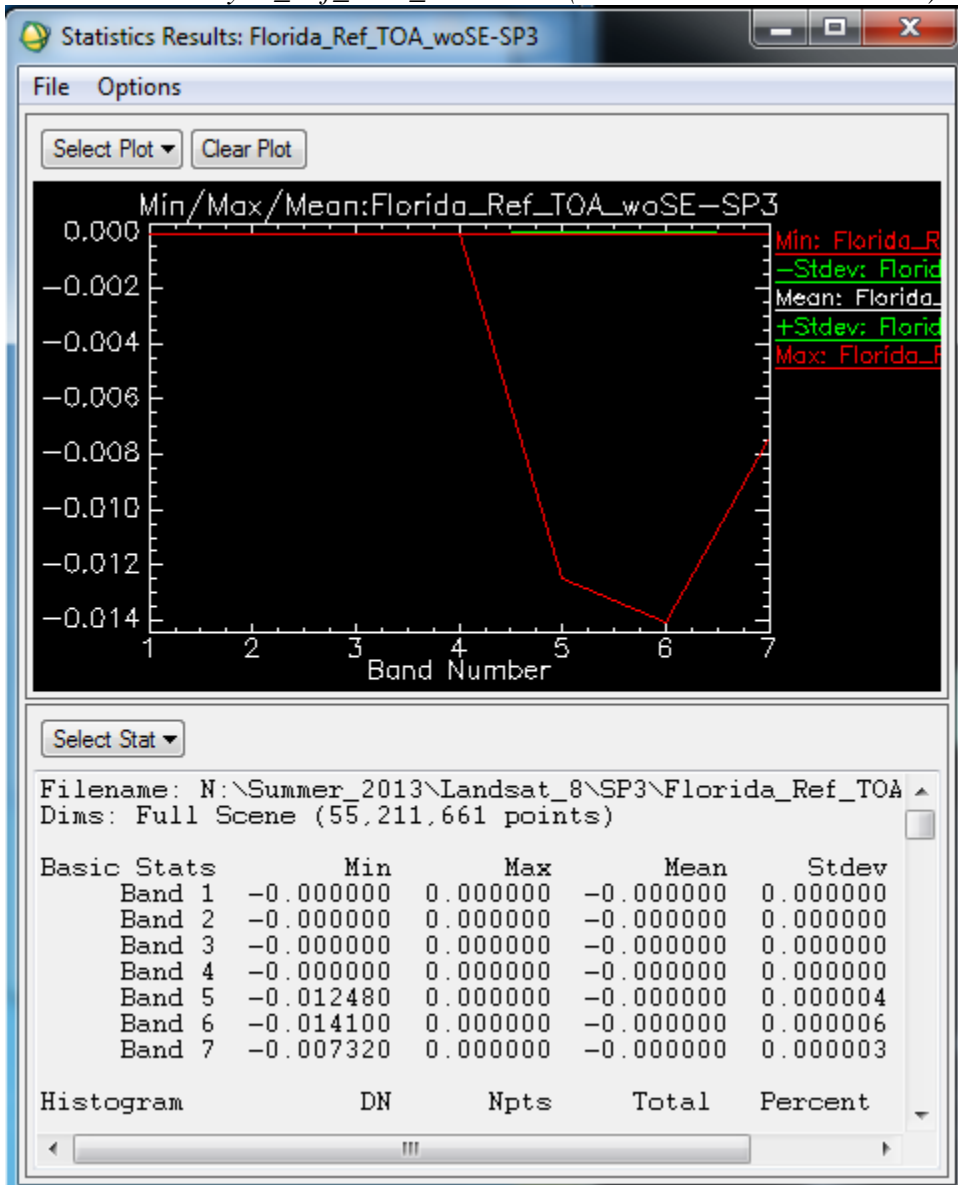
❖ *Dominica: 2013May05_Ref_TOA_woSE-SP3(Mask: DN=0 on ANY band)*



❖ Florida: 2013May23_Ref_TOA_woSE_Difference (Mask: DN=0 on ALL bands)



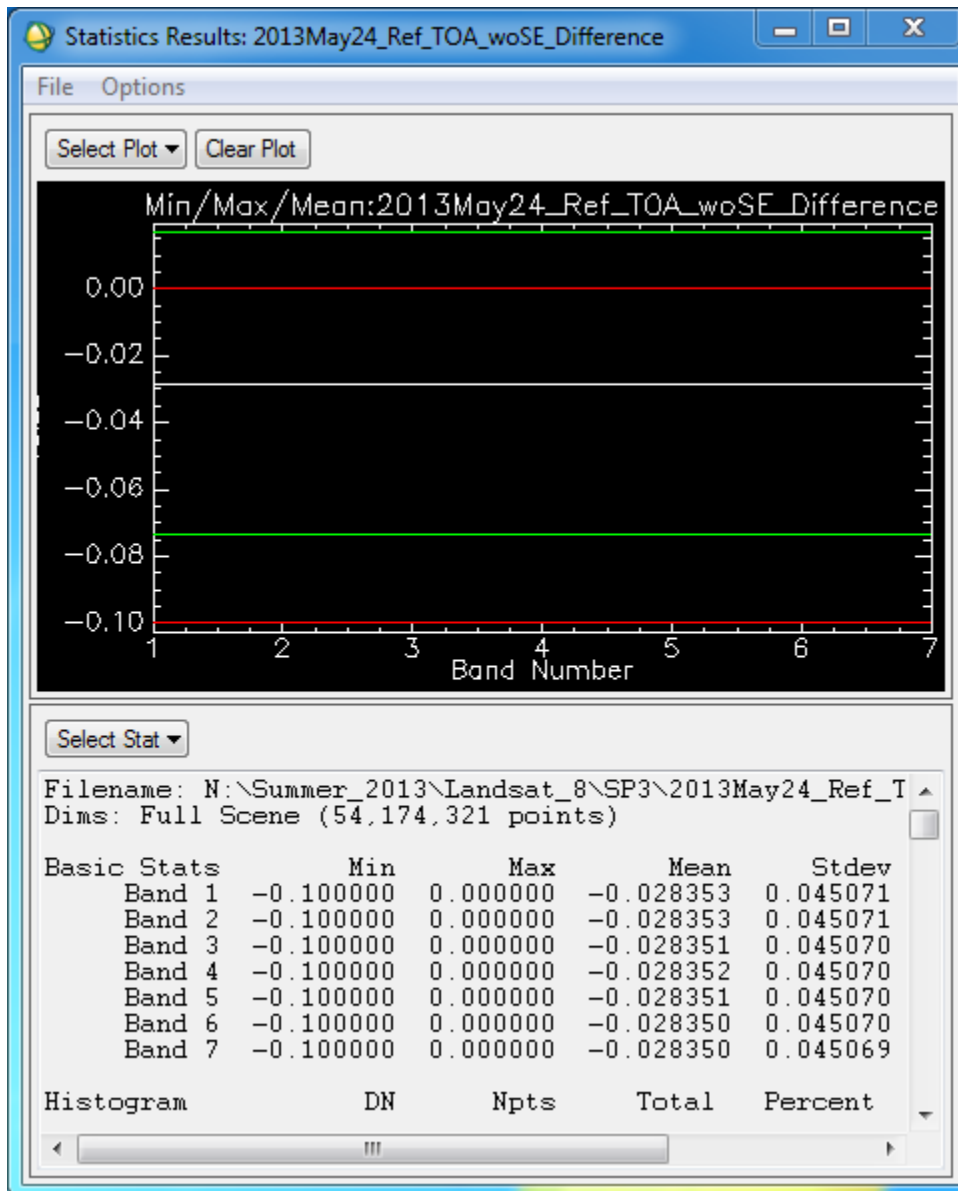
- ❖ Florida: 2013May23_Ref_TOA_woSE-SP3 (Mask: DN=0 on ANY band)



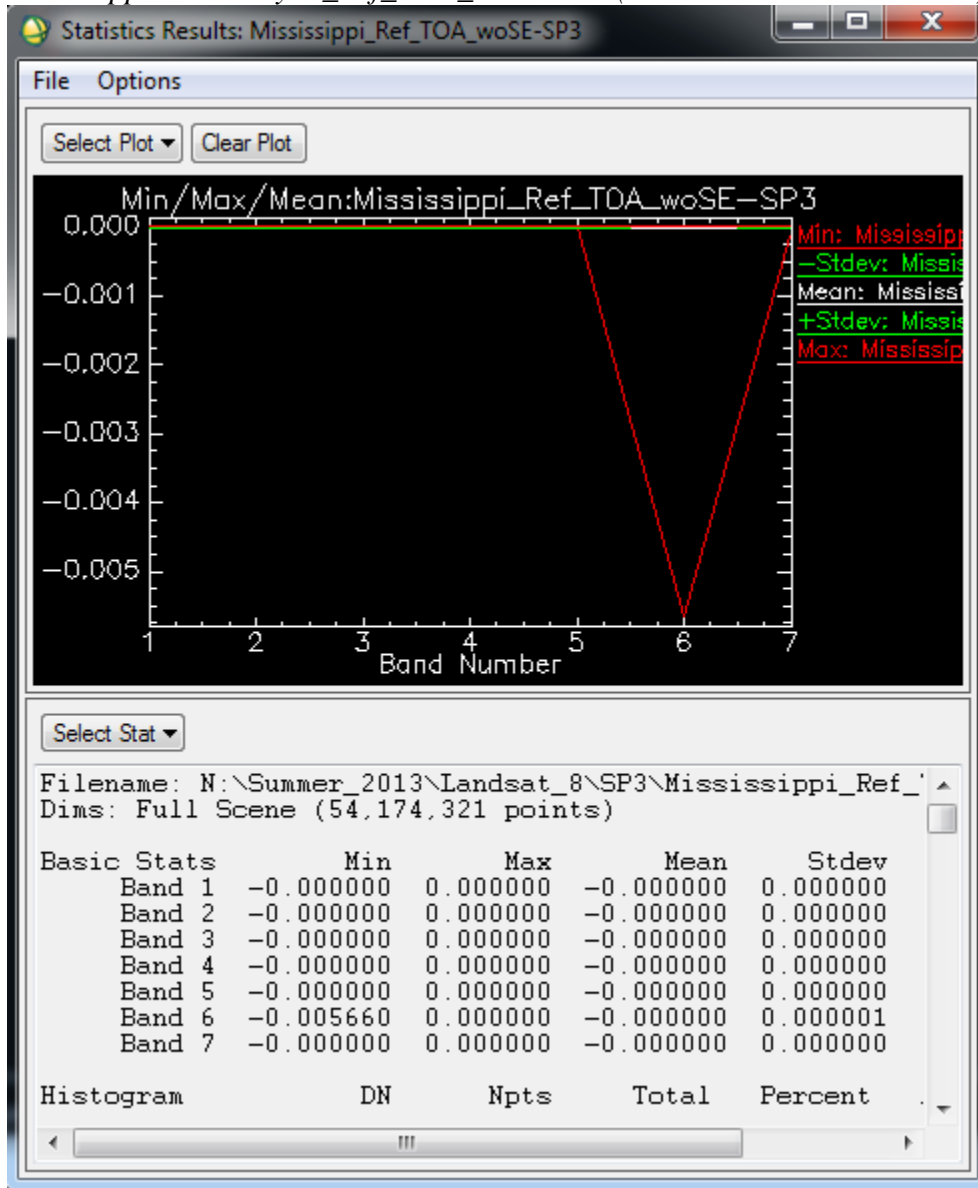
Below is a table of values deviating from zero in more than one pixel for Bands 5, 6 and 7.

	Reflectance	# of Pixels	Total	Percent	Acc. Percent
Band 5	-0.000049	38,712,314	38,712,340	99.9714	99.9715
	0.000000	11,032	38,723,372	0.0285	100
Band 6	-0.000055	38,716,716	38,716,783	99.9828	99.9830
	0.000000	6,589	38,716,783	0.0170	100
Band 7	-0.000029	38,722,490	38,722,524	99.9977	99.9978
	0.000000	848	98,723,372	0.0022	100

❖ *Mississippi: 2013May24_Ref_TOA_woSE_Difference (Mask: DN=0 on ALL bands)*



- ❖ *Mississippi: 2013May24_Ref_TOA_woSE-SP3 (Mask: DN=0 on ANY band)*



Below is a table of values deviating from zero in more than one pixel for Band 6.

	Reflectance	# of Pixels	Total	Percent	Acc. Percent
Band 6	-0.000022	38,812,221	38,812,222	99.9973	99.9973
	0.000000	1,046	38,813,268	0.0027	100