How to Convert ASTER Radiance Values to Reflectance

An Online Guide

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Summary.

From reading the ever-increasing ASTER literature there are several instances when the ASTER imagery have not been converted into Top of Atmopshere reflectance. More troubling are the 'published' papers that have analyzed ASTER by using only the DN values. Therefore, in an attempt to reduce the occurence of such papers in the future, here is a brief guide that outlines how to convert the VIS-SWIR ASTER bands into TOA reflectance. For information on the ASTER sensor see the NASA-ASTER and Official ASTER Web Site.

Methodology.

Part A: DN to ASTER Spectral Radiance:

L_{rad} is calculated using the following equation:

$$L_{rad} = (DN-1)*\text{Unit Conversion Coefficient}$$

The unit conversion coefficient is different for each ASTER band. These values (Table 1) were obtained from Version 1 of the ASTER user guide (i.e. Abrams and Hook 1998). Some later user guide versions had printing errors resulting in this infromaiton being excluded.

Table 1:

Band	Coefficient ($W/m^2*sr*um$)/DN) High Gain	Normal	Low Gain 1	Low Gain 2
1	0.676	1.688	2.25	
2	0.708	1.415	1.89	
3N	0.423	0.862	1.15	
3B	0.423	0.862	1.15	
4	0.1087	0.2174	0.2900	0.2900
5	0.0348	0.0696	0.0925	0.4090
6	0.0313	0.0625	0.0830	0.3900
7	0.0299	0.0597	0.0795	0.3320
8	0.0209	0.0417	0.0556	0.2450
9	0.0159	0.0318	0.0424	0.2650

Part B: ASTER Spectral Radiance to TOA Reflectance:

R_{TOA} is calcualted using the standard Landsat equation of:

$$R_{TOA} = (pi*L_{rad}*d^2)/(ESUN_i*\cos(z))$$

Where, pi =3.14159, R_{TOA} is the planetary reflectance, L_{rad} is the spectral radiance at the sensor's aperture; $ESUN_i$ is the mean solar exoatmospheric irradiance of each band, i; z is the solar zenith angle (zenith angle = 90 – solar elevation angle), which is within the ASTER header file; and d is the earth-sun distance, in astronomical units, which is calculated using the follow EXCEL equation(Achard and D'Souza 1994; Eva and Lambin, 1998):

d = (1-0.01672*COS(RADIANS(0.9856*(Julian Day-4))))

The problem arises with the band dependent measures of $ESUN_i$, which unlike the documentation for Landsat 7 (Williams 2004) were not included within the ASTER user guides.

Thankfully the calculation of $ESUN_i$ is the same for whatever sensor you are using; as it is simply the convolution of the band's spectral response function (A) with the Extraterrestrial Solar Spectral Irradiance function (B).

A for each ASTER band can be obtained from:
http://www.science.aster.ersdac.or.jp/en/about_aster/sensor/
or download here

B can be obtained from:
http://staff.aist.go.jp/s.tsuchida/aster/cal/info/solar/
or download here

Using this standard approach the calculated $ESUN_i$ for each ASTER band is given in Table 2 (Please feel free to check for yourself and advise me if there are any mistakes):

Table 2:

ASTER Band	Smith: $ESUN_i$	Thome et al (A): $ESUN_i$	Thome et al (B): $ESUN_i$
B1	1845.99	1847	1848
B2	1555.74	1553	1549
B3N	1119.47	1118	1114
B4	231.25	232.5	225.4
B5	79.81	80.32	86.63
B6	74.99	74.92	81.85
B7	68.66	69.20	74.85
B8	59.74	59.82	66.49
B9	56.92	57.32	59.85

Notes:

Smith: Calculated by interpolating the ASTER spectral response functions to 1nm and convolving them with the 1nm step WRC data

Thome et al (A): Calcualted by convolving the ASTER spectral response functions them with the WRC data [Unknown whether these where both interpolated to 1nm or whether a subsample of WRC data values at the ASTER spectral response function step intervals were used in the convolution]

Thome et al (B): Calculated using spectral irradiance values dervied using MODTRAN.

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