Planetary reflectance ($\rho_p$) is sometimes used with earth imagery to reduce the image-to-image illumination differences by normalizing for solar irradiance. The following equation for band-dependant planetary reflectance was taken from the *Landsat 7 Science Data User’s Handbook*\(^1\). Note that planetary reflectance is an exoatmospheric correction and does not correct for atmospheric effects such as absorption or scattering.

Planetary reflectance is defined as,

$$\rho_p = \frac{\pi \cdot L_\lambda \cdot d^2}{E_{\text{SUN}, \lambda} \cdot \cos \theta_S},$$

where,

- $\rho_p$ = Unitless planetary reflectance,
- $L_\lambda$ = Radiance for spectral band $\lambda$ at the sensor’s aperture (W/m\(^2\)/\(\mu\)m/sr),
- $d$ = Earth-Sun distance in astronomical units from Table 1,
- $E_{\text{SUN}, \lambda}$ = Mean solar exoatmospheric irradiances from Table 2 (W/m\(^2\)/\(\mu\)m),
- $\theta_S$ = Solar zenith angle.

$L_\lambda$ can be obtained in the correct units from the IKONOS image product by converting from digital values ($DN_\lambda$) using the equation,

$$L_\lambda = \frac{10^4 \cdot DN_\lambda}{\text{CalCoef}_\lambda \cdot \text{Bandwidth}_\lambda}$$

where,

- $\text{CalCoef}_\lambda$ = Radiometric calibration coefficient [DN/(mW/cm\(^2\)-sr)]
- $\text{Bandwidth}_\lambda$ = Bandwidth of spectral band $\lambda$ (nm)

Both $\text{CalCoef}_\lambda$ and $\text{Bandwidth}_\lambda$ for the IKONOS bands are given in Table 2. Further information on the calibration coefficients can be found in Reference 2 and the bandwidth in Reference 3.
The earth-sun distance \((d)\) in astronomical units can be obtained from any nautical handbook or interpolated from the values listed in Table 1.

Table 1. Earth-Sun Distance in Astronomical Units

<table>
<thead>
<tr>
<th>Julian Day</th>
<th>Distance</th>
<th>Julian Day</th>
<th>Distance</th>
<th>Julian Day</th>
<th>Distance</th>
<th>Julian Day</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.9832</td>
<td>74</td>
<td>0.9945</td>
<td>152</td>
<td>1.0140</td>
<td>227</td>
<td>1.0128</td>
</tr>
<tr>
<td>15</td>
<td>0.9836</td>
<td>91</td>
<td>0.9993</td>
<td>166</td>
<td>1.0158</td>
<td>242</td>
<td>1.0092</td>
</tr>
<tr>
<td>32</td>
<td>0.9853</td>
<td>106</td>
<td>1.0033</td>
<td>182</td>
<td>1.0167</td>
<td>258</td>
<td>1.0057</td>
</tr>
<tr>
<td>46</td>
<td>0.9878</td>
<td>121</td>
<td>1.0076</td>
<td>196</td>
<td>1.0165</td>
<td>274</td>
<td>1.0011</td>
</tr>
<tr>
<td>60</td>
<td>0.9909</td>
<td>135</td>
<td>1.0109</td>
<td>213</td>
<td>1.0149</td>
<td>288</td>
<td>0.9972</td>
</tr>
</tbody>
</table>

The IKONOS mean solar exoatmospheric irradiance \((E_{\text{SUN}})\) is calculated for each of the IKONOS bands by integrating the relative spectral response of each band \((RSR,\) see Figure 1 and Reference 4) and the solar irradiance over wavelength,

\[
E_{\text{SUN}_{\lambda}} = \frac{\int RSR_{\lambda} \cdot \text{SolarIrradiance} d\lambda}{\int RSR_{\lambda} d\lambda}.
\]

The solar irradiance used to calculate the \(E_{\text{SUN}}\) values listed in Table 2 was obtained from the 2000 American Society for Testing & Materials (ASTM) Standard Extraterrestrial Solar Spectrum Reference E-490-00 (Figure 1 and Reference 5).

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**Figure 1. IKONOS Relative Spectral Response and Solar Spectrum**

*IKONOS Planetary Reflectance, Q5OL Rev. 2*
Table 2. IKONOS Band-dependent Parameters

<table>
<thead>
<tr>
<th>IKONOS Band (λ)</th>
<th>CalCoefλ Pre 2/22/01* (DN/(mW/cm²-sr))</th>
<th>CalCoefλ Post 2/22/01* (DN/(mW/cm²-sr))</th>
<th>Bandwidthλ (nm)</th>
<th>Esunλ (W/m²/μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pan (TDI-13)</td>
<td>161</td>
<td>161</td>
<td>403</td>
<td>1375.8</td>
</tr>
<tr>
<td>Blue</td>
<td>633</td>
<td>728</td>
<td>71.3</td>
<td>1930.9</td>
</tr>
<tr>
<td>Green</td>
<td>649</td>
<td>727</td>
<td>88.6</td>
<td>1854.8</td>
</tr>
<tr>
<td>Red</td>
<td>840</td>
<td>949</td>
<td>65.8</td>
<td>1556.5</td>
</tr>
<tr>
<td>NIR</td>
<td>746</td>
<td>843</td>
<td>95.4</td>
<td>1156.9</td>
</tr>
</tbody>
</table>

* - Image production date. Coefficients are for the 11-bit products. See References 2 & 3.

The final variable used in calculating ρₚ is the solar zenith angle,

\[ \theta_s = 90^\circ - \text{SolarElevationAngle}. \]

For any IKONOS image product, the Solar Elevation Angle is available from the image metadata.

References

1. Landsat 7 Science Data User’s Handbook:  


4. IKONOS Relative Spectral Response:  

5. 2000 American Society for Testing & Materials (ASTM) Standard Extraterrestrial Solar Spectrum Reference E-490-00:  
   [http://rredc.nrel.gov/solar/spectra/am0/](http://rredc.nrel.gov/solar/spectra/am0/)

*IKONOS Planetary Reflectance, QSOL Rev. 2*