Using the USGS Landsat 8 Product

Background
The standard Landsat 8 products provided by the USGS EROS Center consist of quantized and calibrated scaled Digital Numbers (DN) representing multispectral image data acquired by both the Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS).

The products are delivered in 16-bit unsigned integer format and can be rescaled to the Top Of Atmosphere (TOA) reflectance and/or radiance using radiometric rescaling coefficients provided in the product metadata file (MTL file), as briefly described below. The MTL file also contains the thermal constants needed to convert TIRS data to the at-satellite brightness temperature. Further details can be found in the LDCM Cal/Val Algorithm Description Document and the Landsat 8 Science Users' Handbook available from the Landsat website (location coming soon).

Conversion to TOA Radiance
OLI and TIRS band data can be converted to TOA spectral radiance using the radiance rescaling factors provided in the metadata file:

$$L_\lambda = M_L Q_{cal} + A_L$$

where:

L_λ = TOA spectral radiance (Watts/(m2 * srad * μm))
M_L = Band-specific multiplicative rescaling factor from the metadata (RADIANCE_MULT_BAND_x, where x is the band number)
A_L = Band-specific additive rescaling factor from the metadata (RADIANCE_ADD_BAND_x, where x is the band number)
Q_{cal} = Quantized and calibrated standard product pixel values (DN)

Conversion to TOA Reflectance
OLI band data can also be converted to TOA planetary reflectance using reflectance rescaling coefficients provided in the product metadata file (MTL file). The following equation is used to convert DN values to TOA reflectance for OLI data as follows:

$$\rho\lambda' = M_\rho Q_{cal} + A_\rho$$

where:

$\rho\lambda'$ = TOA planetary reflectance, without correction for solar angle. Note that $\rho\lambda'$ does not contain a correction for the sun 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)

TOA reflectance with a correction for the sun angle is then:

$$\rho\lambda = \frac{\rho\lambda'}{\cos(\theta_{SZ})} = \frac{\rho\lambda'}{\sin(\theta_{SE})}$$

where:

$\rho\lambda$ = TOA planetary reflectance
θ_{SE} = Local sun elevation angle. The scene center sun elevation angle in degrees is provided in the metadata (SUN_ELEVATION).
θ_{SZ} = Local solar zenith angle; $\theta_{SZ} = 90° - \theta_{SE}$

For more accurate reflectance calculations, per pixel solar angles could be used instead of the scene center solar angle, but per pixel solar zenith angles are not currently provided with the Landsat 8 products.

Conversion to At-Satellite Brightness Temperature
TIRS band data can be converted from spectral radiance to brightness temperature using the thermal constants provided in the metadata file:

$$T = \frac{K_2}{ln(\frac{K_1}{L_\lambda}+1)}$$

where:

T = At-satellite brightness temperature (K)
L_λ = TOA spectral radiance (Watts/(m2 * srad * μm))
K_1 = Band-specific thermal conversion constant from the metadata (K1_CONSTANT_BAND_x, where x is the band number, 10 or 11)
K_2 = Band-specific thermal conversion constant from the metadata (K2_CONSTANT_BAND_x, where x is the band number, 10 or 11)