M3 Level 2 Reflectance Conversion

This routine is designed to provide users a method for converting M3 Level 1B Radiance data into Level 2 Reflectance data. This help file is divided into two sections; the first section provides details for the use of the routine itself, and the second section provides information on the algorithm that the routine implements.

Program Use

Notes: The Level 2 conversion routines do not support spatial or spectral subsetting. The user may create spatial subsets of M3 L1B data as desired before running the Level 2 conversion. Spectral subsets, however, cannot be made because the Level 2 conversion routine is expecting a full set of M3 wavelengths (at either Target or Global resolution).

Because M3 files are large, output to memory is not supported.

Call the routine by going to the ENVI main menu and choosing *M3 Tools -> Data Analysis -> Convert L1b to L2*. This will launch a small dialog that asks the user to pick one of three choices:

1. **Do complete Level 2 conversion.** This will be the user's normal choice. All of the individual correction factors necessary to convert radiance data to reflectance are applied within a single routine. See the section below for details on the individual correction factors.
2. **Pick a single correction factor to apply.** This choice is designed to allow the user maximum flexibility in their use and understanding of M3's reflectance conversion. It allows the user to apply a single one of the individual reflectance conversion factors (terms in the conversion equation given in the next section). The main purpose of this is so that the team can experiment with improvements to the reflectance conversion, but it also gives users the ability to better investigate unexpected results.
3. **Get help on the Level 2 Creation process.** Launches this help file.

Files used by the program

Data files accessed by the reflectance conversion routines are stored under the MAT application folder in the level2_creation subdirectory to the resources directory (mat/resources/level2_creation). Currently, these files are used (there should be one version of each file for both target and global data):

1. **solar_spectrum_*mode*.sli –** (*mode* = target or global) An ENVI spectral library that contains the solar spectrum currently used.
2. **ground_truth_*mode*.sli** - An ENVI spectral library file that contains the Apollo 16 ground truth correction factor that is applied per wavelength to each pixel in a L1B file.
3. **photometry_correction_*mode*.sli** – This file is also formatted as an ENVI spectral library, but it is read by the reflection conversion routines as a 2D lookup table. It contains the per-wavelength factor that normalizes the phase angle of the L1B data to the Apollo 16 phase angle.

The lookup table contains normalization factors ("spectra") for each whole number phase angle between 0 -90°. Actual M3 L1b phase angles are interpolated between values in this table.

Algorithm

The equation that converts L1B radiance to L2 reflectance is the following:

Reflectance = ((radiance/solar_spectrum)*limb_darkening)*phase_angle/ground_truth

Each of the four terms that convert the input data (radiance) into reflectance are described below:

1. **solar_spectrum –** the solar spectrum is read from an ENVI spectral library file as described above, and each pixel's radiance spectrum is divided by this solar spectrum. Each radiance spectrum is divided by the same solar spectrum.
2. **limb_darkening** – This is the first of the two terms that make up the M3 photometry correction. The correction factor is [{cos(i) – cos(e)}/cos(i)], where i and e are the incident and emission angles, respectively. Incident and emission angles are stored for each pixel in the L1B "Observation" file, in the "To-Sun zenith angle" and "To-M3 zenith angle" bands. The reflectance conversion routine reads these data for each pixel in the input radiance data, converts the data in these bands from degrees to radians, and computes the limb darkening term.
3. **phase_angle** – This is the second term comprising the M3 photometry correction. In the Observation file that accompanies each L1b radiance image cube, there is a band that contains the phase angle for each pixel in the input radiance image cube. The program reads in this information for each pixel in the image, so that each pixel has its own resulting phase angle correction. The phase angle correction's purpose is to normalize the input radiance to ROLO-based Apollo 16 measurements at 30° phase. A lookup table has been created that contains pre-computed normalization factors at each M3 wavelength for all integer phase angles between 0 -90°. The program interpolates the values in this table to achieve a specific correction for each input pixel's observed phase angle.
4. **ground_truth** – A per-wavelength ground truth correction is read from an ENVI spectral library file (see above) and this single correction factor is applied to each pixel in the input radiance data. Currently the correction factor is 1.0 at each wavelength (so it is really not being applied), but once mission data is acquired the correction factor will be updated and applied.