Landsat5 and Landsat7 Geometric Corrections Updates

In this document are described the changes to the geometric correction algorithms, required to successfully process both Bumper Mode (Landsat5) and SLC off (Landsat7) data. Moreover a procedure to import in the system the L5 Bumper Mode Calibration Parameters File (CPF) files are described.

Enhanced Thematic Mapper Scan Line Corrector Off

Background

On May 31, 2003 the scan line corrector (SLC) halted to work properly. The SLC device displace the ETM+ line of sight in the fore-to-aft direction during the active scan at a constant rate designed to compensate the spacecraft motion. If uncompensated, the spacecraft motion adds an along-track component to the scan mirror's cross-track trajectory, leading to a zigzag scanning pattern. This zigzag produces an overlap where one scan end and the *next* scan start, and leave a gap where one scan end the *previous* scan start. The maximum gap at the end of the scan is approximately 420 meters, which corresponds to nearly 13 multispectral pixels.
The changes to the ETM+ geometric correction algorithms, required to successfully process SLC off data, are described in the following section.

Scan Line Corrector Geometric Model

The first step is to identify the operating state of the scan line corrector. This is accomplished by reading the serial word G of the payload correction data (PCD).

In the Landsat 7 ETM+ geometric model, the SLC contributes only to the across-scan viewing angle computations. The SLC parameters are retrieved from the CPF file as usual, but for unpowered SLC an extra parameters are required: the pointing angle of the SLC at its rest (unpowered) position. In this case both the slc_angle and the SLC non-linearity fifth-order polynomial coefficients are set to zero.

The most challenging algorithm change is about the scan gap resampling algorithm. Normal ETM+ imagery contains scan gaps that vary in size with latitude , but these gaps are typically small, no more than 1 or 2 pixels, and relatively uniform along-scan. The gaps induced in the SLC-off data vary in width from approximately 13-14 multispectral pixels at the beginning of one scan, to near zero at mid-scan, to an overlap of nearly 13 multispectral pixels at the end of the scan. The gap asymmetry requires to make the interpolation strategy flexible to adjust its behavior to the local scan gap. Where the local scan gap exceed a defined MAX_GAP we populate the corresponding points with fill value (radiometric value set to zero). This strategy is performed for both Nearest-Neighbor (NN) and Cubic Convolution (CC) resampling.

Thematic Mapper Bumper Mode Scan Mirror Correction

Background

Over the life of the Thematic Mapper instruments the mechanical device used to reverse the mirror direction have been found to wear, resulting in gradual turnaround time growth. That produces an

increase of the total scan time, which is not monitored by the scan angle device (SAM), that provides a monitoring only of the active scan time. This gradual growth in the time between scan can produce synchronization problems between scan mirror and other TM components (e.g. calibration shutter, scan line corrector, etc.). During 2002 the synchronization threshold was exceeded for the Landsat 5 mission. Now the Landsat 5 operates with an alternate scan mirror operating mode called "bumper mode", which monitors and controls the total, rather than the active, scan time. Controlling the total scan time resolves the internal synchronization issues in the TM devices.

Bumper Mode Correction Models

USGS has defined two distinct models of the Bumper Mode correction models.
The first is a "physical" model which reflects the actual physical behavior of the scan mirror device.
The second model is simplified version of the physical bumper mode which emulates the conventional SAM model. Instead of working directly with the specific bumper parameters, they are converted to equivalent conventional SAM parameters. This parameters are computed by USGS and collected in the Landsat 5 Calibration Parameters File (CPF).
USGS asserts that the SAM emulation model gives slightly better results compared to the physical model, thus ACS has chosen to implement the SAM emulation model.

SAM Mode Emulation Model

In the following the main processing steps are described:

- ✓ Identify the operating mode state in the serial words E and L of the payload correction data (PCD).
- ✓ Using the acquisition date of the data being processed, select the applicable bumper mode calibration parameter file (CPF). Merge the CPF with the conventional fixed Landsat5 CPF.
- ✓ Load the merged CPF file (new format: same field are added).
- ✓ Populate the SAM mode scan field angles with the bumper mode values retrieved from the CPF file.
- ✓ Populate the SAM mode scan mirror profile polynomial coefficients with the bumper mode values retrieved from the CPF file.
- ✓ For each scan in the image data set, replace the MSCD first half scan time value and second half scan time value (forward and reverse) with the relative bumper mode values retrieved from the CPF file.
- ✓ Continue with the conventional SAM mode algorithm.

Procedure to import CPF files

As described above, the specific bumper mode parameters are converted to equivalent SAM parameters by USGS and collected in the L5 CPF files. These files are updated continuously by USGS with a frequency of one month and stored at the following web address:

http://landsat7.usgs.gov/cpf/l5/cpf.php

In order to successfully import a new CPF file in the processing system the following procedure is required:

- Download the CPF file from the URL above, saving it in HTML format and with extension *.html* or *.htm*

- Put the new CPF file to the **/usr/tmp/** directory of the Catalog machine.
- From the **Toolchest** select: **Import -> Merging L5 CPF (Bumper Mode)** . A **Winterm** will appear showing the list of Landsat 5 CPF files currently present in the **/usr/tmp/** directory.
- Select the CPF file to merge and press Enter. A new shell will appear showing the standard output of the merging program. The CPF file is now imported.