### Non-uniformity Characterization

#### Background

Streaking, Banding, and Full Field Of View (FFOV) Uniformity characterizations provide 4 different measures of detector uniformity. All characterizations will generate metrics for uniformity and stability of uniformity assessments, both prelaunch and postlaunch. In the latter case, these will be characterizations will be used for Key Performance Requirement verification.

FFOV Uniformity: the standard deviation of all detector column average radiances across the FFOV within a band shall not exceed 0.5% of the average radiance

There are 2 methods for characterizing Banding.

Method A: The root mean square of the deviation from the average radiance across the full FOV for any 100 contiguous detector column averages of radiometrically corrected OLI image data within a band. This banding specification is met when the metric is less than or equal to 1.0% for OLI and 0.5% for TIRS of the band average radiance.

Method B: The standard deviation of the radiometrically corrected values across any 100 contiguous detector column averages of OLI image data within a band. This banding requirement is met when the metric is less than or equal to 0.25% for OLI and 0.5% for TIRS of the average radiance across the 100 detector columns.

Streaking is measured across any 3 contiguous detector column averages, across the FOV. The streaking requirement is met when the metric is less than 0.005 for OLI bands 1-7 and 9, and 0.01 for the OLI panchromatic band or 0.005 for the TIRS bands. The streaking parameter is defined below.

For OLI, this algorithm is intended to work primarily on solar scenes, though the capability to process uniform Earth scenes should be included; verification of the requirements at 2\*Ltyp will require extra analysis. For TIRS, this algorithm should be run on blackbody scenes with a temperature set point between 260 and 330K .

Based on the current process flow: These characterizations should be performed on radiance data. The Histogram Statistics Characterization module is performed on bias-corrected and linearized image data, but before the gains and relative gains have been applied. The non-uniformity characterization will not operate on the image data, but rather will use the Histogram Statistics in the database. Therefore, the algorithm will need to apply the gains from the database/CPF to convert the histogram means to radiance.

Analysis of the output data will determine whether, initially, the Non-Uniformity specification is being met and then, later, whether there are changes in uniformity across the focal plane. This algorithm requires a uniform scene or a scene of known non-uniformity. For OLI, the only target that is expected to meet this requirement is the solar diffuser. Therefore this algorithm may only be useful for characterizing the non-uniformity performance, particularly the full field of view uniformity, on one spectral target, as opposed to the three indicated in the requirement. For TIRS, the blackbody will be operated at multiple temperature set points. Each of these blackbody images should be useful in characterizing the banding and streaking over the range of typical Earth temperatures

Note: the notation in this version of the banding equations has been modified from the OLI Requirements Document for clarification.

#### Inputs

The inputs to this algorithm come from either the output of other algorithms (DB) or from a set of calibration parameters (CPF). Table 6‑39 lists the inputs of this algorithm.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Descriptions** | **Symbol** | **Units** | **Level** | **Source** | **Type** |
| Detector means (bias corrected, linearized only) | Qi | DN | Nband x NSCA x Ndet | DB (histogram statistics table) | float |
| Gains | G | DN/(w/m2 sr um) | Nband |  | float |
| Relative gains | ri | [] | Nband x NSCA x Ndet | CPF | float |
| Inoperable detectors, out-of-spec detectors |  |  | Nband x NSCA x Ndet | CPF | integer |
| Solar or blackbody non-uniformity scaling factors | i | [] | Nband x NSCA x Ndet | CPF | float |

Table 6‑39. Algorithm Inputs

#### Outputs

The outputs of this algorithm are typically stored in the characterization database. However, an option to store this data to an ASCII text file is needed to support testing. This reduces inserts into the database as well as speeding up calibration updates. Table 6‑40 lists the outputs of this algorithm.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Descriptions** | **Symbol** | **Units** | **Level** | **Target** | **Type** |
| BandingMetric\_FFOV | BFFOV\_i\_percent | % | Nband x NSCA x Ndet | Db, report | float |
| BandingMetric\_per100pix | Bper100det\_i\_percent | % | Nband x NSCA x Ndet | Db, report | float |
| Full FOV Uniformity Metric | FFOV\_metric\_percent | % | Nband | Db, report | float |
| Streaking Metric | Si | [] | Nband x NSCA x Ndet | Db, report | float |

Table 6‑40. Algorithm Outputs

#### Options

* Apply non-uniformity scaling factors
* Output ASCII text file summary in addition to reporting data to the database

#### Procedure

For each solar collect, for each band:

1. Determine per-detector radiances (Li’) as given in Equation 1 for selected scene by applying the per-detector gains to the per-detector scene means (Qi). .
   1.  (1)
      1. where *G* is the band-average gain, *ri* is the per-detector relative gain and *i* is the detector counter. In this algorithm, it is meant to count across the entire focal plane, not just across a single SCA.
   2. An option would be to calculate radiance straight out of the database operation. For example *select histogram\_mean / detector\_gain from hist\_stats, cpf where cpf.date=now() and hist\_stats.detector = cpf.detector*
2. For solar and blackbody data: Correct per-detector radiance for non-uniformity (Equation 2) of the solar panel or the blackbody using the per-detector scaling factor (i). For non-solar, non-blackbody data, the scaling factors are set to 1.0 for all detectors.
   1.  (2)
   2. Note: the solar uniformity values in the CPF may be in terms of per-detector reflectance. If that is the case, the reflectances should be normalized to the average before applying them to the radiance.
   3. Note: it is unclear what form the non-uniformity scaling factors will take in the CPF. Once these are defined, we will be able to specify whether the radiances are multiplied or divided by the scaling factors.
3. Stitch the radiance data together in order across the focal plane. Include all imaging detectors. Include overlap detectors. Do not include dark or redundant detectors.
   1. *Each SCA will have several detectors that image the same portion of the ground as the adjacent SCA. For example, say the SCAs each have 500 detectors and the last 10 detectors of SCA1 image the same ground as the first 10 detectors of SCA2. The radiance array should include both SCA1 detectors 491-500 and SCA2 detectors 1-10.*
   2. The redundancy of the overlap detectors should not affect the banding and streaking results of the solar data though it means that we are not measuring the image SCA-to-SCA discontinuity.
4. Calculate Full FOV Uniformity Metric as given below in Equation 3 for the band. Do not include detectors flagged as inoperable or out-of-spec in the calculation.
   1. FFOV\_metric\_percent = stdev() / mean(L)\*100 (3)
   2. Record FFOV\_metric\_percent to the database or optionally to a file.
5. Calculate banding metrics as given below in Equations 4 and 6 for each imaging detector (i). Do not include detectors flagged as inoperable or out-of-spec in the calculation for operable detectors. Skip the banding calculation for inoperable and out-of-spec detectors.
   1. Method 1)

 (4)

 (5)

Where:

 is the radiance of detector i

 is the scene average radiance: 

* 1. Method 2)

 (6)

 (7)

Where:

 is the radiance of detector i

 is the average radiance across 100 detectors

 (8)

* 1. Record per-detector banding arrays to database or optionally to a file.
  2. In both of these calculations, the calculation cannot be performed for the detectors at the final edge (i.e., the last 99 detectors). As a result of the banding metrics not being associated with the center detector of the window, it is really the first 50 and last 50 detectors that are not characterized. However, it is the banding entries for the last 99 detectors that are left blank.
  3. In the case where i…i+99 includes inoperable and/or out-of-spec detectors, the summation should be taken for fewer detectors rather than increasing maintaining the 100 detector average.

1. Calculate streaking metric (Equation 9) for each imaging detector. Do not calculate the streaking metric for detectors flagged as inoperable and out-of-spec. Also, do not calculate streaking metric for detectors adjacent to inoperable or out-of-spec detectors.

 (9)

Where:

 is the radiance of detector i;

 and  are similarly defined for the (i-1)th and (i+1)th detector columns.

* 1. Record per-detector streaking array to database or optionally to a file.