### OLI Standalone 60 Second Radiometric Stability Characterization

#### Background/Introduction

Both the bias and the gain instrument stability of an instrument are contributing factors to variability within a radiometrically calibrated product. The OLI has a “60 second stability,” aka short-term stability requirement specifically designed to control this within product variability. The specific requirement states: “Over any time period up to 60 seconds, after radiometric correction per 5.3.1.2, the scene-averaged OLI image data for radiometrically constant targets with radiances greater than or equal to L-typical shall not vary by more than plus or minus 0.5% (95% or 2 sigma confidence interval) of measured radiance.” The 60-sec stability characterization requires scenes of temporally uniform radiance above Ltypical[[1]](#footnote-1), e.g., long solar acquisitions. Long shutter data will also be analyzed to allow determination of the bias stability contribution to the overall stability. These datasets (L0r) at most will only be bias and non-linearity corrected. Additionally, solar data products (L1r) will allow characterization of the L1r product 60-second stability. In the processing flow, these collects should be regarded as “special” collects vs. “standard” dark or solar collects identifying the data collects types that will meet the scene(s) minimum length criteria required for this processing.

There are two options for the analyst for processing these Scenes

Option 1 – that is described in this ADD is the IAS processing that relies on Histogram statistics Characterization to collect the basic statistics on the Scenes and then populate the minimal radiometric stability metric as a standalone algorithm that is gathering information only on the 60sec stability.

Option 2 – Is the a Toolkit algorithm that operates on the datasets directly and computes the basic statistics from the image data and then populate an extended radiometric stability metric that is gathering information to any stability period up to 60sec (as selected by the analyst) The toolkit version of this stability characterization has a separate ADD and data files for validation.

The output produced by this option 1 algorithm depends on the input data provided, i.e., solar or shutter. Response and gain differences statistics across time intervals of 60 seconds are calculated from these uniform radiance scenes and stored in the characterization database. As reflected in the OLI Ops-Con special 60 seconds long solar acquisitions and related 60 seconds long dark collects will be made at the nominal integration time and their statistical characteristics calculated by Histogram Statistics Characterization at multiple level of processing will be used as input to this algorithm. This short-term stability characterization will produce five categories of outputs:

1. Dark Shutter Raw data band level change in stability
2. Solar bias and non-linearity corrected data band average stability
3. Solar product band average stability in radiance
4. Band average gain stability or L1R Product stability in %
5. Detector by detector level relative gain stability in %

The individual detector relative gain short-term stability will be used in the analysis for the non-uniformity requirement stability and track actual performance characteristics against the system engineering allocations.

Solar L1r data products histograms will be used to directly verify the 0.5% radiometric stability requirement. The solar L1r product stability metric will be converted from radiance units to % so it can be evaluated directly against the 0.5% requirement. Solar data that is bias and nonlinearity corrected will be used to characterize the 60s band mean and relative gains stabilities.

Note that the bias used for bias removal is derived from a model that is based on the pre and post solar collect event dark shutter collects which are also taken at the nominal integration time.

An additional Toolkit implementation for this characterization will exist. In that Toolkit implementation the algorithm will works directly on the image data and produce the basic Statistical information on the image or on a set of image subsets. It will generate more radiometric stability output categories for the investigating analyst.

#### Inputs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Descriptions** | **Symbol** | **Units** | **Level** | **Source** |
| Signal Mean |  | Float[DN] or [w/m2 sr um] | NBxNSxND | Histogram[[2]](#footnote-2) Stat Char |
| Signal Max |  | Float[DN] or [w/m2 sr um] | NBxNSxND | Histogram10 Stat Char *Qmax* |
| Signal Min |  | Float[DN] or [w/m2 sr um] | NBxNSxND | Histogram10 Stat Char *Qmin*  |
| Signal StDev |   | Float [DN] or [w/m2 sr um] | NBxNSxND | Histogram10 Stat Char *σ* |
| Relative gains  | r | [unitless] | NBxNSxND | CPF  |
| Scene Type (i.e O\* or D\*) | Stype | Char | NB  | DBL0Rp Image file |
| Processing Step (i.e., before or after Gain application) | Pstep | Integer | NB | Histogram Stat Char Position in processing flow (RPS Level)  |
| Impulse Noise Pixels Locations | LM1 | Integer | NBxNSxND xL | LM |
| Saturated Pixel Mask[[3]](#footnote-3)  | LM2 | Integer | NBxNSxND | LM |
| Dropped Frames Mask  | LM3 | Integer | NBxNSxND xL | LM |
| Inoperable Detector List  | Dinop | Float | NBxNS | CPF |

#### Outputs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Descriptions** | **Symbol** | **Units** | **Level** | **Target** |
| Signal Variability, SCA average |  | Float [DN] or [w/m2 sr um] | NB x NS | DB (Bias, Gains & Solar L1R Stability) |
| Gain or L1r Product Variability, SCA average  |  | Float [%] | NB x NS | DB (Gains & Solar L1R Stability) |
| Relative gain or L1r Product Variability, per-detector [[4]](#footnote-4) |  | Float [%] | NB x NSxN D | DB (Gains & Solar L1R Stability) |
| Scene Type (i.e O\* or D\*) | Stype | Char | NB | DB |
| Processing Step | Pstep | Integer | NB | DB |

\*Note: The developer should consider splitting these outputs into 2 or more DB tables; one for bias stability and the other for Gain stabilities. It would keep the units for each table consistent.[[5]](#footnote-5)

#### Options

Trending On/Off Switch: If trending is Off, output parameters are written to a text file.

#### Prototype Code

The source code is written in IDL

IDL Version 7.0.8, Mac OS X (darwin x86\_64 m64). (c) 2009, ITT Visual Information Solutions

It was test on iMac OS-X 10.6.1 3.06 GHz Intel Core 2 Duo

Source code include three modules from which one module serves as the main program that uses the others.

The instructions how to run each test scenario are put as comments in the First page of the main module.

Data outputs and inputs to modules at times use temporary IDL .sav files to store calculated variables. – those that could be generated by the developer they are not include in the package.

For each data type the data storage of what would be the link to DB is save into a IDL .sav file formats– those output files were saved and will be attached in with the source code

For L0r Dark data the generated parameters are store in - > IAS\_Dark \_output

For L0r Solar data the generated parameters are store in - > IAS\_Solar \_output1

For L1r Solar data the generated parameters are store in - > IAS\_Solar \_output2

OUTPUT variables generated ARE not in the same data format as it should be for the fully developed system since it is only dealing with one SCA and one band therefore 2 dimensions are missing.

The list of source code modules:

IAS\_60SRS\_main.pro - > main module

Get\_stat.pro -> main stat calculation and ingesting of Histogram data module

IAS\_cal\_stab\_solar.pro -> calculate the Solar related output stability performance parameters

Data inputs: dark\_shutter\_hist , solar1\_hist , solar2\_hist , rel\_gains.sav

Dark\_shutter\_hist is the histogram data from dark shutter data (it holds information on Mean, Min, Max, and Stdev)

Solar1\_hist is the histogram data from L0rc Bias removed and linearity correct L0r Solar data (it holds information on Mean, Min, Max, and Stdev)

Solar2\_hist is the histogram data from L1r Solar Diffuser Product data (it holds information on Mean, Min, Max, and Stdev)

Data outputs:

Three folders: Test ID#1, Test ID#2, Test ID#3

Each holding the corresponding output: IAS\_Dark\_output, IAS\_Solar\_output1, IAS\_Solar\_output2 All stored in IDL .sav file formats

#### Procedure

Note that in order to characterize radiometric stability we call this algorithm at least 3 times: Once to process long dark shutter histogram data, and twice to process the histogram data for the closest long solar collect (once using the L0rc1 intermediate Cal product histogram results and once using the L1R intermediate Cal product histogram results.)

The trend IDs for long dark and long solar collects processing need to be found. Based on these trend ID’s and the processing level the correct histograms information can be imported to this algorithm.

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Calculating statistics (get it from Hits Stat)

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1. Based on the Labeled Mask and detector operability list omit those detectors when calculating SCA level averages.
2. Populate histogram statistics metric per detector in the relevant variables and calculate the average across all detectors within an SCA.
	1.  (1)
	2.  *Qmax* (2)
	3.  *Qmin* (3)
	4.  *σ* (4)
	5.  (5)
	6. Note that calculations should only include operable and in-spec detectors. (i.e., ignore pixels flagged as inoperable, saturated, dropped frame, impulse or fill.)

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Calculating Stability of Signal

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1. For each detector, calculate the 2-sigma the along-track variation in the image that is at the length of t=60sec.
2.  (6)

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Processing data to generate outputs

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1. Calculate the SCA average variability, i.e, the average across all detectors within each SCA:
2.  (7)
3. For dark data, record the SCA mean variabilities () to the database or output file (along with other specified outputs in the output table). This is the end of the algorithm for dark data.
4. For solar data also do this :
5. Calculate the per-detector variability in terms of percent change. It illustrates the impact of individual detectors on the overall radiometric stability.
6.  (8)
7. where rD is the relative gain from CPF for L0Rc data and 1.0 for L1R data.
8. Calculate the SCA average variability in terms of percent gain change:
9.  (9)
10.  should be calculated using the same list of detectors used to produce the mean signal in equation (5)
11. For L0Rc data, write the per-detector percent variability () and the SCA average variability () to the database or output file (along with other specified outputs in the output table).
12. For L1R data, write the SCA average percent variability () to the database or output file (along with other specified outputs in the output table).
13. For L1R if output to file selected also write to file the per-detector variability () and the SCA Radiance mean variability () (along with other specified outputs in the output table).

#### Maturity

Level 2 (no reuse).

Algorithm design is settled on the fact that we will have especially long solar and dark collects that are at least 60sec in length.

Equation 6 was replaced to reflect BATC 2-sigma method to asses 60-sec stability that is based on the calculation of 60sec interval Standard Deviations statistics  per detector over the entire interval of t=60sec. For that reason we elected to break this characterization into 2 flavors where the 1st is IAS standalone implementation where the statistics needed for this algorithm is calculated and passed directly from the relevant Histogram statistics Characterization DB, and the 2rd flavor is the Toolkit implementation of the algorithm where calculations of the basic statistics run directly on the data and more complicated options of trending and processing are implemented. The changes implemented for the IAS version is a simplification of original calculations.

Future direction of the algorithm is dependent on OLI performance and an overtime comparison between the basic 2-sigma based calculation stored in the IAS and the Toolkit Worst-case based calculations. It could be that after the IOC period we will find a credible need for update of the IAS algorithm implementation, in that case we will submit a CCR to this and maybe histogram statistic ADDs.

1. These will be limited to Long Solar diffuser and Long Shutter collects only. [↑](#footnote-ref-1)
2. Histogram data will be collected from different level of processing i.e., L0R for Dark Shutter data, L0Rc for Solar Diffuser and at L1R for Solar Diffuser product. [↑](#footnote-ref-2)
3. This mask should include any of the detectors that had been reported by the Saturation characteristics processing, i.e., high and low saturations in both digital and analog categories [↑](#footnote-ref-3)
4. We will not store in DB the Solar L1R calculated per detector gains 60 stabilities but it will be calculated and written to an output file if the option of trending is turned off. [↑](#footnote-ref-4)
5. Note that the new output table consolidated two solar processing outputs into a single variable that have the same dimension, while the meaning of the stored data depends on the input data. This way we store both the percent of SCA absolute gain change and the percent SCA mean radiance change into a single DB column and similarly we store the percent per detector relative gain change and radiance signal stabilities in another DB column (this is possible since both are sharing the same dimension and have nearly the same calculations). [↑](#footnote-ref-5)