### OLI Bias Determination

#### Background

Removing the detector’s bias from each detector’s data is a necessary first step in the conversion from the raw detector signal to radiance (and reflectance) as part of product generation. The bias determination algorithm estimates the bias to remove from each pixel. There are several ways in which the bias can be estimated. One way uses a per-detector bias estimated by averaging shutter data on a per detector basis. Another way uses a pair of coefficients *a1* and *C1* to relate the average per-SCA VRP response to the average per-imaging detector dark response. These coefficients are then applied to the per-SCA VRP response to estimate the average per-detector dark response. Frame to frame variation in the bias can also be estimated by using the VRP data and a coefficient *a0* that relates the per-frame behavior of the VRPs to the per frame behavior of the detector dark response within a scene.

The selection of bias model parameters used to derive the bias to be applied is specified via parameters/flags set in the processing work order. These flags are defined as options below.

#### Input

| **Description** | **Level** | **Source**  | **Type**  |
| --- | --- | --- | --- |
| VRP cross track averages corresponding to the scene (AVRP) | NBands x NSCAs x Ndetectors x Nframes | Calculated from image data | Float |
| Dropped frames in VRP data | Nbands x NSCAs x Ndetectors x Nframes | Mask | Integer |
| Impulse noise in VRP data | Nbands x NSCAs x Ndetectors x Nframes | Mask | Integer |
| Saturated pixels in VRP data | Nbands x NSCAs x Ndetectors x Nframes | Mask | Integer |
| VRP operability list | Nbands x NSCAs x Ndetectors x Nframes | CPF | Integer |
| Pre-acquisition shutter average (Sa) | Nbands x NSCAs x Ndetectors | BPF | Float |
| Post-acquisition shutter average (Sb) | Nbands x NSCAs x Ndetectors | BPF | Float |
| Bias model parameter (a0) | Nbands x NSCAs | BPF | Float |
| Bias model parameter (a1) | Nbands x NSCAs x Ndetectors | BPF | Float |
| Bias model parameter (C1) | Nbands x NSCAs x Ndetectors | BPF | Float |
| CPF Bias (bCPF) | Nbands x NSCAs x Ndetectors | CPF | Float |

**Output**

|  |  |  |  |
| --- | --- | --- | --- |
| **Description** | **Level** | **Target**  | **Type**  |
| Bias | Nbands x NSCAs x Ndetectors x Nframes | Bias Removal or file | Float |

#### Options

* Output bias values to file (default off)
* bias selection
	+ Per-detector bias (no estimate of per frame variation included)
		1. Pre-acquisition shutter average (*Sa*)
		2. Post-acquisition shutter average (*Sb*)
		3. Average of pre- and post-acquisition shutter averages (*Sab*, default)
		4. CPF bias (bCPF)
		5. Estimate using a1, C1, and the per-SCA VRP averages
	+ Per-frame bias (estimate of per frame variation included)
		- Source of *a0, a1,* and *C1*
			1. Current BPF
			2. Selected date/time for alternate BPF
		- Five options for calculating *C*
			1. Pre-acquisition shutter average (*Sa*)
			2. Post-acquisition shutter average (*Sb*)
			3. Average of pre- and post-acquisition shutter averages (*Sab*, default for the per frame bias)
			4. CPF bias (bCPF)
			5. Estimate using *a1*, *C1*, and the per-SCA VRP averages

#### Procedure

If a per-detector bias is selected where the option number is included in 1-4, then retrieve the selected bias values from the BPF. If option 3 has been selected, then calculate *SAB*, the average of *SA* and *SB*.

 (1) where *d* is detector, *s* is SCA, and *b* is band.

If a per-detector bias using option 5 is selected, then retrieve *a1* and *C1* from the BPF. Calculate the per-detector bias estimate with these parameters.

For each band excluding the pan band

* + For each SCA
		- Find the cross-track average of all of the VRP detectors.  (1) where *f* is line, *QVRP* is the VRP detector response for the specific band, *Nd* is the number of VRP detectors in a band, and *AVRP* is the VRP average for frame *f*. Note that any anomalous pixels will be excluded from calculations.
		- Calculate the per-SCA average of the VRP data across all frames.

 (2)

* For each detector
	+ Calculate the per-detector estimate of the bias mean.

 (3)

Where *Eavg* is the estimate of the bias average.

* For the pan band, follow the procedure for the other bands, only treat the odd and even frames separately. Note again that all anomalous pixels are excluded from calculations.

 (3)

 (5)

 (4)

 (5)

 (6)

 (7)

* Write the per-SCA VRP cross track averages to the database.

The result of any of these options should be an array containing a single value for every detector of every band, with the exception being the Pan band where for every detector there is an odd frame estimate and an even frame estimate. Expand this array such that there is one bias value for every frame of the image to be corrected, except for in the case of the Pan band where the even frame estimate should be expanded to only the number of even frames, and the odd frame estimates expanded to only then number of odd frames. The result will be a single value for every pixel in the image to be corrected where every frame belonging to the same detector is identical. **Note** that 1.5 DN should have been added to non-barrel-shifted data during convert to float. This is to account for the average error due subtracting the lower 12 of 14-bit data from the upper 12 of 14-bit data.

If the selected option is to have the bias include an estimate of the per-frame variation, calculate the per-frame bias based on bias model parameters from the specified BPF.

* For each band excluding the pan band
* For each SCA
	+ Retrieve the bias model parameters (*a0*) from the specified BPF.
	+ Calculate the per-SCA average of the VRP data across all frames.  (8) where is the VRP data average and *N* is the number of frames.
* For each SCA, detector, and frame
	+ If one of the options 1-4 for calculating *C* is selected
		- Retrieve the values of S, where S is per detector bias values from the source selected from the previous list.
		- Calculate the constant value *C*.  (9) where *S* is the selected per detector bias. Note that no pixels marked as bad or anomalous are included in this calculation.
	+ Otherwise, if option 5 is chosen, then *C* is calculated in exactly the same way as in (9) except S is Eavg, as written in (10).  (10)
	+ Calculate the per frame bias estimate.  (11) where *bias* is the bias estimate.
* For the pan band, follow the procedure for the other bands, only treat the odd and the even frames separately.  (12)  (13)  (14)  (15)  (16)  (17)

Note that dropped frames will be excluded from calculations and will be set to zero in *bias*.

Send the bias to Bias Removal, and if the option is selected, to file.

#### Maturity

Level 3, although portions of this algorithm originated from ALIAS and the L7 IAS before that, the per-frame bias calculation is new.

The coefficients *a0*, *a1*, and *C1* may be stable enough from collect to collect that it would be possible to calculate it less often than every interval.

There may be enough similarity between using the pre- and post- shutter acquisition averages that we may be able to not use the post shutter acquisition averages.

Instead of a simple average of pre- and post-acquisition shutter averages, an interpolation function could be used so that either a per-frame or per-scene bias would be used. This would only occur if there was a significant drift in the pre-to-post-acquisition shutter averages.