Calibration Tool Development for the GOES-R Solar UltraViolet Imager

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Abstract

The ability to predict, identify, and track severe space weather is growing increasingly important in our high-tech world. Serious solar events such as coronal mass ejections, geomagnetic storms, and solar flares have been known to cause serious damage to orbital installations, resulting in loss of communications and power, aberrations in instrument behavior, and even satellite faults. Improving the abilities to recognize when severe space weather will affect our sensitive installations hinges not only on how advanced the space weather instrumentation is, but also how well the hardware is characterized, understood, and the instrument performance is tracked. For the GOES-R series the Calibration Working Group led by NOAA/NESDIS/STAR will assume responsibility for technical oversight of pre-launch and post-launch calibration, as well as long-term monitoring. This presentation will focus on the recent progress in developing capabilities for prelaunch/post-launch calibration and long-term trending for the GOES-R Solar Ultra-Violet Imager (GOES-R SUVI).

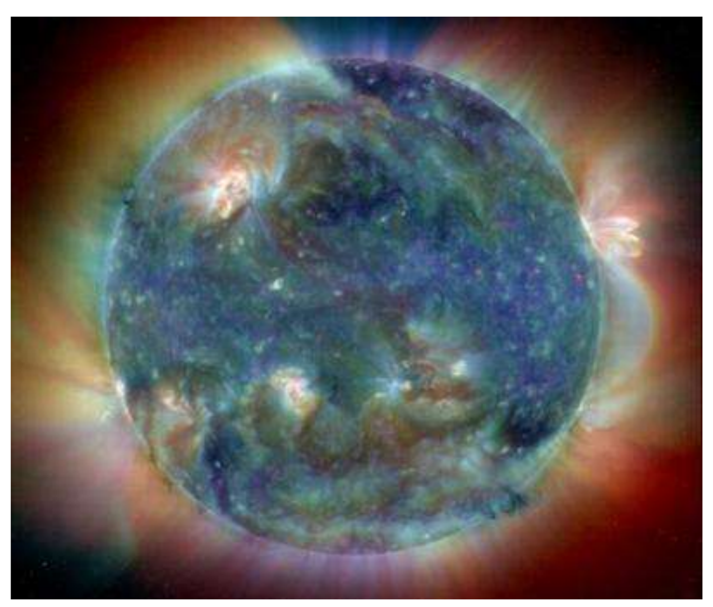

Figure 1: Multi-wavelength composite of SOHO/EIT at 30.4, 28.4, and 19.5nm. GOES-R SUVI will be capable of similar products.

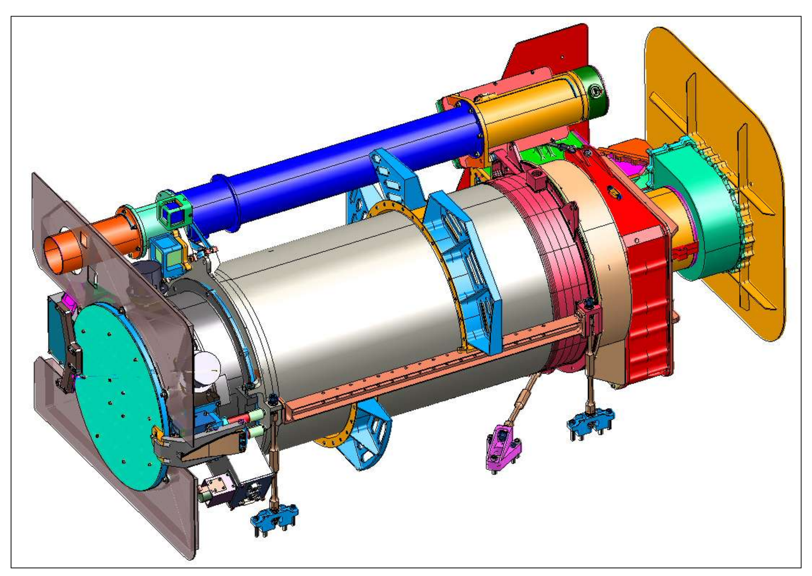

Figure 2: Illustration of SUVI (Courtesy of Lockheed Martin)

SUVI Calibration Toolkit

The CWG SUVI Toolkit that is under development will monitor the calibration and operational parameters of the SUVI instrument post-launch. Using both raw instrument and telemetry data, the Toolkit is intended to:

- Independently derive the calibration parameters:
  - Dark Current
  - SNR/CNR
  - CCD Gain & Linearity
  - Bad Pixels
  - Flat-fields for each bandpass
  - Filter Integrity
  - Relative Throughput change due to contamination
- Track and trend critical operational parameters such as:
  - Temperatures
  - Current Draw
  - Voltages

In the case that either the operational or the derived parameters are outside of normal range, a notification is sent out or a warning is generated. This will prove critical in the detection and resolution of instrument anomalies on-orbit.

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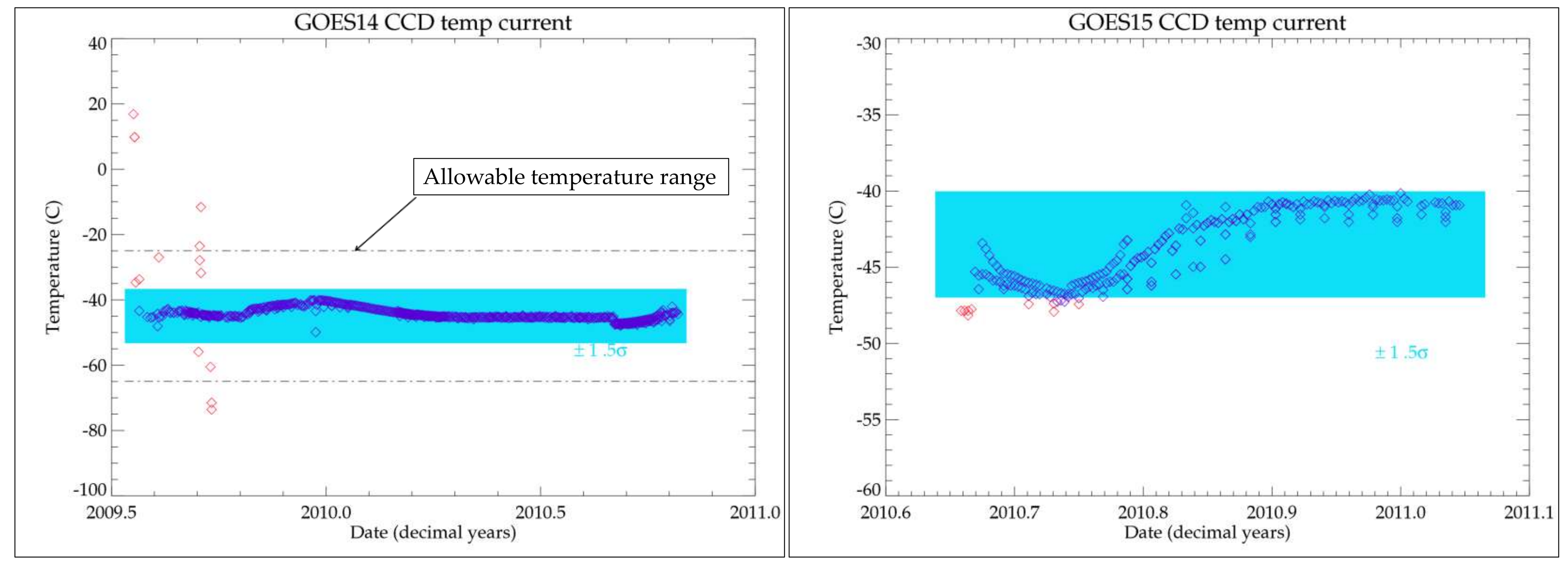
Operational parameters

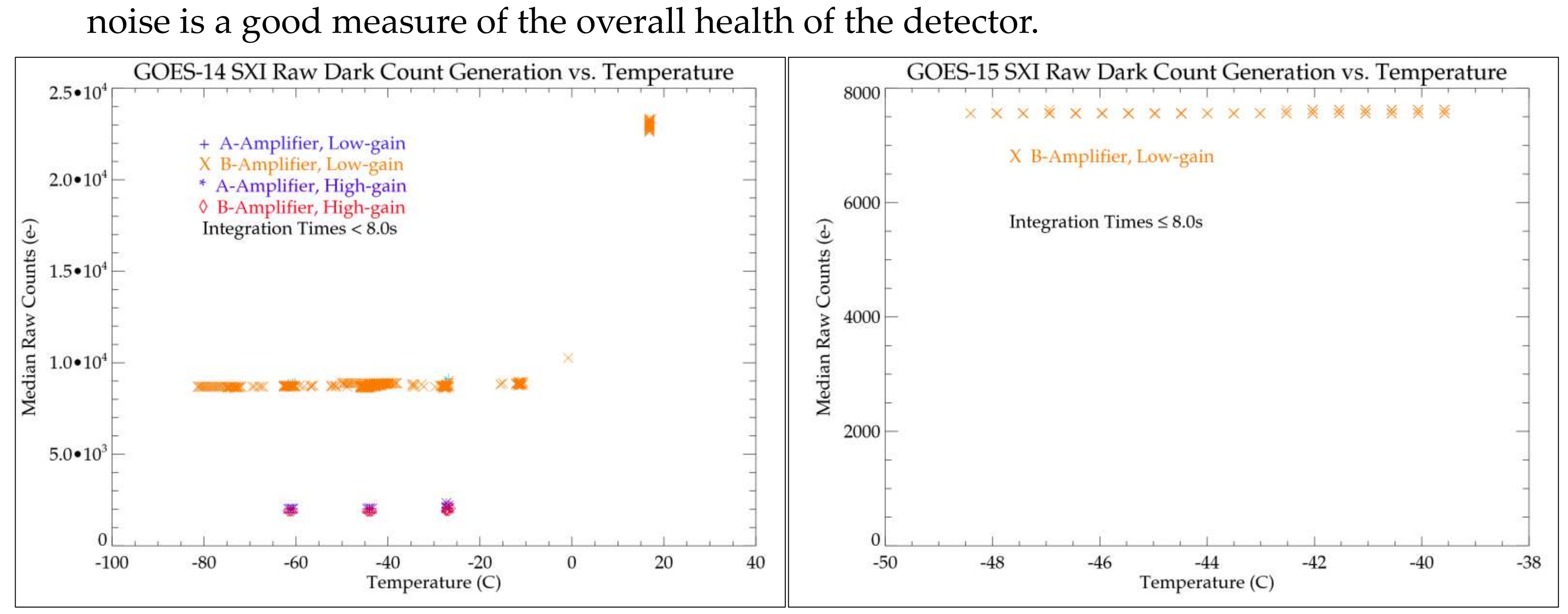


Figures 3 & 4: SUVI temperature trending using GOES-14 & 15 SXI temperature data.

Since factors like the CCD (detector) temperature can greatly affect the data quality from an instrument, the SUVI Calibration Toolkit will monitor quantities such as temperatures, voltages, and current readings recorded in the SUVI T&C packets. When and if these quantities fall outside allowable ranges, alerts and warnings will be generated.

Calibration parameters

Detector Noise: Noise from the electronics and thermal electrons from the detector both contribute to the detector noise. As satellite instruments age, it will be expected that the detector will suffer from particle and other damage. Trending and tracking the detector noise is a good measure of the overall health of the detector.



Figures 5 & 6: Analysis of the GOES-14 & 15 Detector Noise as a function of Temperature.

The two figures above demonstrate the median of the raw detector noise from GOES-14/15 SXI instruments as a function of temperature. As can be seen from the figures, the GOES-14 SXI went through rigorous post-launch testing for all amplifiers and multiple temperatures, whereas the GOES-15 SXI immediately entered an operational state after the on-orbit checkout phase. Both instruments demonstrate a very low rate of thermal electron generation in the operational temperature range (around -43C). For all temperatures that within the allowable operational range, the detector noise will be tracked and trended so that changes can be discerned (see figure 7).

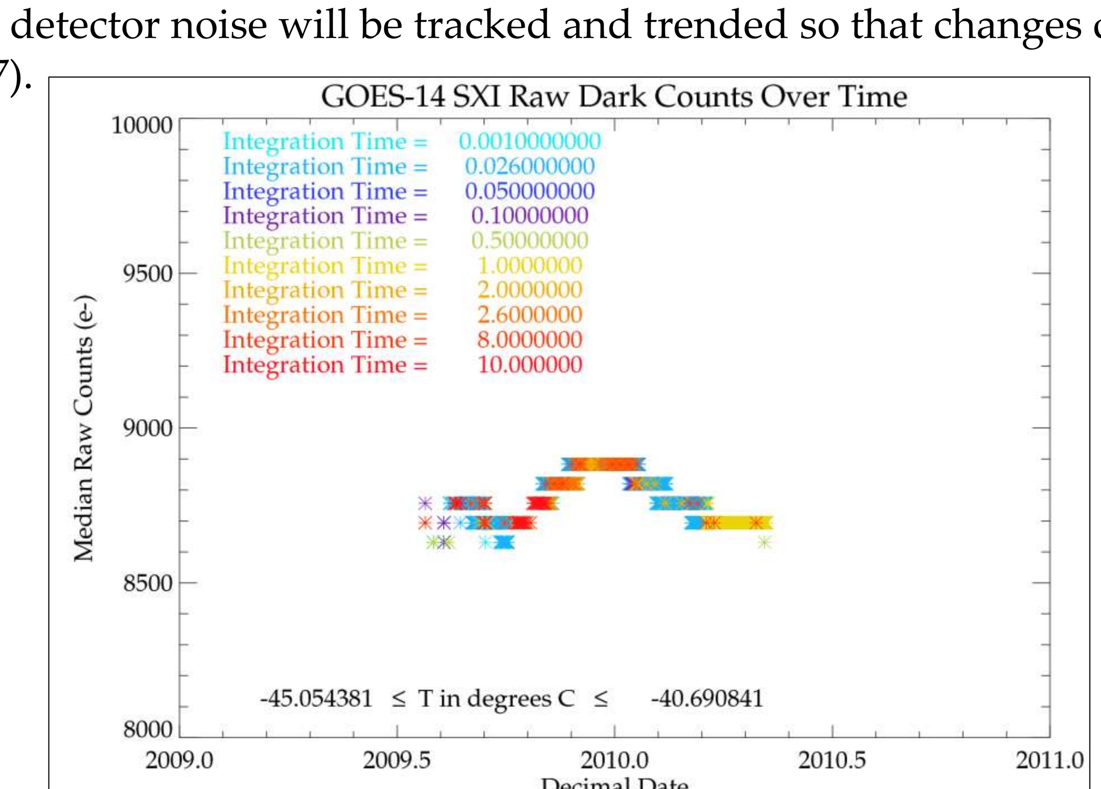


Figure 7: Trending of the GOES-14 SXI Median Detector Noise

Bad Detector Pixels: Particle damage from the harsh geostationary orbital environment that the GOES-R SUVI will inhabit is likely to cause detector elements that consistently give erroneous data. It is therefore necessary to have the capability to detect both "dead" pixels (zero signal) and pixels that consistently read "hot" (high signal). This can be done with regular data (as seen in figure 8), but will be simpler to implement with the flat frames created using the SUVI on-board LED. The CWG, operating under NOAA/NESDIS/STAR, will keep an up-to-date database of the bad pixels, also known as a bad pixel map, for all of the GOES-R series SUVI instruments .

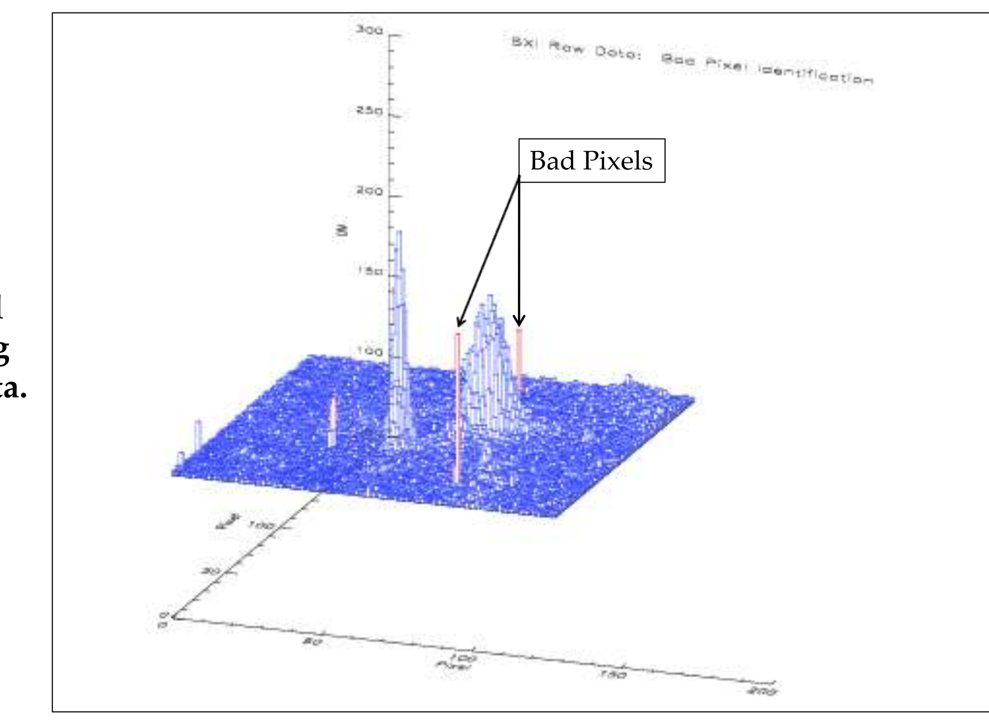
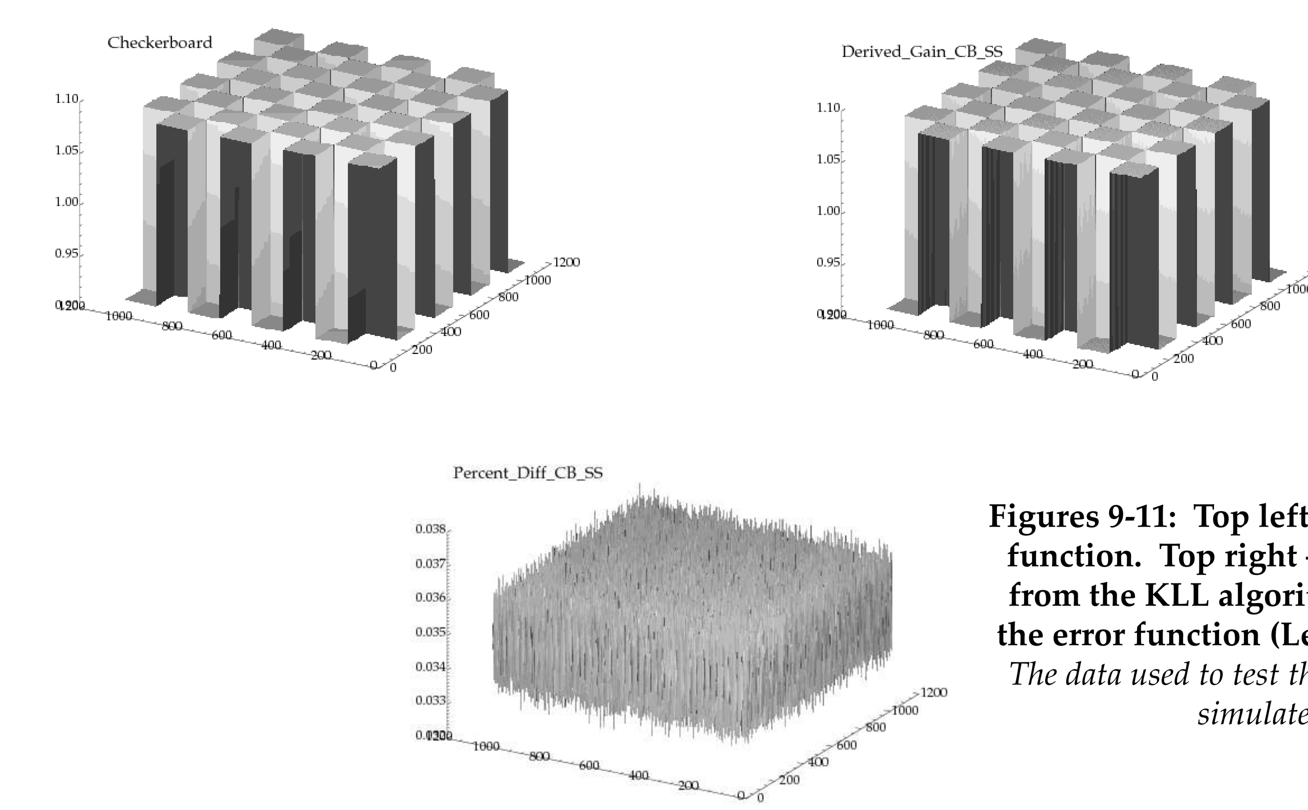


Figure 8: Bad Pixel Identification using GOES-14 science data.

Algorithm for In-band Flat Fields: The GOES-R CWG has developed a working implementation of the Kuhn-Lin-Loranz flat-field algorithm that can utilize instrument data at different offsets to obtain the flat-field. This is especially useful for space-based telescopes such as SUVI which do not have standard in-band reference sources available. Any flat-fields determined prior to launch are bound to introduce error due to the launch environment itself.



Figures 9-11: Top left – Original gain function. Top right – Derived gain from the KLL algorithm. Bottom – the error function (Less than 0.04%). *The data used to test the algorithm was simulated.*

References & Acknowledgements

GOES Series-R Program, 2009: GOES Calibration and Product Strategy Document. Baseline Version 1, NOAA/NESDIS, June, 2009, 31 pp.

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