THERMAL INFRARED SENSOR (TIRS) STRAY LIGHT

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KEY WORDS: Landsat-8, LDCM, TIRS, Thermal Infrared Sensor, Stray Light, Ghosting, Radiometric Calibration, Radiometric Accuracy

ABSTRACT:

During the early orbit checkout period of the Landsat-8 satellite in the spring of 2013, the Thermal Infrared Sensor (TIRS) exhibited unexpected behavior. While some striping and banding was expected due to changes in calibration since launch, attempts to eliminate banding produced mixed results. Using information from a limited set of scenes improved some of those scenes, while others worsened. This indicated issues with the stability of the instrument. However, the detectors were shown to be extremely stable based on deep space and on-board black body collects.

After several months of acquiring Earth data, vicarious calibration measurements became available to estimate the absolute radiometric accuracy of the TIRS imagery. All of the vicarious measurements indicated the TIRS imagery radiance measurements were too high. The band 11 (12.0 μm) data were significantly higher than the band 10 (10.8 μm) data, but both bands were spurious enough to warrant a calibration update. Incidentally, vicarious measurements of night imagery indicated that TIRS radiances were also higher, but to a lesser extent. Temperatures at night, generally lower than during the day for a given site, indicated the error in calibration wasnt due to miscalibration. However, with a simple bias of the calibration parameters, the product accuracy was improved in February 2014 to within 1.2% (1σ) for band 10 and 2.2% (1σ) for band 11 for 300K sources.

An explanation for the errors seen in the TIRS imagery is stray light. Since the Landsat-8 satellite is capable of pointing at the moon for lunar calibration maneuvers, the TIRS instrument team worked with the flight operations team to develop a modification to the normal lunar calibration maneuver so it would image while maneuvering to point to the moon. These special lunar scans provided data to show if any stray light was being reflected into the instrument from outside its field-of-view (FOV). Stray light effects were seen in these scans, but they were small considering the moon is extremely bright in the long-wave infrared (LWIR) spectral region. Additional special lunar scans were acquired showing more ghosts at different angles. Expanding the special lunar scans even more provided a broader view of the stray light issues and a rough model of the effect was developed. This rough model indicated the calibration errors observed could be explained by the stray light from outside the FOV of the instrument.

With empirical data to support the theory of stray light corrupting TIRS imagery, a higher fidelity optical model was developed to investigate further. This newly developed optical model enabled simulations to be performed to evaluate whether the troublesome banding could be caused by this stray light. This model enables the stray light to be estimated on a single detector basis, but requires concurrent acquisition of imagery far outside the TIRS FOV (GOES, MODIS or other LWIR imagery). Initial results using GOES imagery show a significant correlation between the banding and the modeled stray light.

While this optical model could be implemented into the ground processing system, it would require significant processing and concurrent LWIR imagery from another satellite which complicates the implementation of this correction. Additional methods are being investigated to reduce the heavy processing need as well as eliminate the need for concurrent LWIR imagery.

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