Assessment of the short-term radiometric stability between Terra MODIS and Landsat 7 ETM+ sensors

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The Landsat 7 (L7) Enhanced Thematic Mapper (ETM+) sensor was launched on April 15th, 1999 and has been in operation for over nine years. It has six reflective solar spectral bands located in the visible and shortwave infrared part of the electromagnetic spectrum (0.5 – 2.5 μm) at a spatial resolution of 30 m. The on-board calibrators are used to monitor the on-orbit sensor system changes. The ETM+ performs solar calibrations using on-board Full Aperture Solar Calibrator (FASC) and the Partial Aperture Solar Calibrator (PASC). The Internal Calibrator Lamp (IC) lamps, a blackbody and shutter optics constitute the on-orbit calibration mechanism for ETM+. On 31 May 2003, a malfunction of the scan-line corrector (SLC) mirror assembly resulted in the loss of approximately 22% of the normal scene area. The missing data affects most of the image with scan gaps varying in width from one pixel or less near the centre of the image to 14 pixels along the east and west edges of the image, creating a wedge-shaped pattern. However, the SLC failure has no impacts on the radiometric performance of the valid pixels. On December 18, 1999, the Moderate Resolution Imaging Spectroradiometer (MODIS) Proto-Flight Model (PFM) was launched on-board the NASA's EOS Terra spacecraft. Terra MODIS has 36 spectral bands with wavelengths ranging from 0.41 to 14.5 μm and collects data over a wide filed of view angle (±55°) at three nadir spatial resolutions of 250 m, 500 m and 1 km for bands 1 to 2, 3 to 7, and 8 to 36, respectively. It has 20 reflective solar bands (RSB) with spectral wavelengths from 0.41 to 2.1 μm. The RSB radiometric calibration is performed by using on-board solar diffuser (SD), solar diffuser stability monitor (SDSM), space-view (SV), and spectro-radiometric calibration assembly (SRCA). Through the SV port, periodic lunar observations are used to track radiometric response changes at different angles of incidence (AOI) of the scan mirror.

As a part of the AM Constellation satellites, Terra MODIS flies approximately 30 minutes behind L7 ETM+ in the same orbit. The orbit of L7 is repetitive, circular, sun-synchronous, and near polar at a nominal altitude of 705 km (438 miles) at the Equator. The spacecraft crosses the Equator from north to south on a descending node between 10:00 AM and 10:15 AM. Circling the Earth at 7.5 km/sec, each orbit takes nearly 99 minutes. The spacecraft completes just over 14 orbits per day, covering the entire Earth between 81 degrees north and south latitude every 16 days. The longest continuous imaging swath that L7 sensor can collect is for a 14-minute subinterval contact period which is equivalent to 35 full WRS-2 scenes. On the other hand, Terra can provide the entire corresponding orbit with wider swath at any given ETM+ collection without contact time limitation.

There are six spectral matching band pairs between MODIS (bands 3, 4, 1, 2, 6, 7) and ETM+ (bands 1, 2, 3, 4, 5, 7) sensor. MODIS has narrower spectral responses than ETM+ in all the bands. A short-term radiometric stability was evaluated using continuous ETM+ scenes within the contact period and the corresponding half orbit MODIS scenes. The near simultaneous earth observations (SNO) were limited by the smaller swath size of ETM+ (187 km) as compared to MODIS (2330 km). Two sets of continuous granules for MODIS and ETM+ were selected and mosaiced based on pixel geolocation information for non cloudy pixels over the North American continent. The Top-of-Atmosphere (TOA) reflectances were computed for the spectrally matching bands between ETM+ and MODIS over the regions of interest (ROI). The matching pixel pairs were aggregated from a finer to a coarser pixel resolution and the TOA reflectance values covering a wide dynamic range of the sensors were compared and analyzed. Considering the uncertainties of the absolute calibration of the both sensors, radiometric stability was verified for the band pairs. The Railroad Valley Playa, Nevada (RVPN) was included in the path of this continuous orbit, which served as a verification point between the short-term and the long-term trending results from previous studies. This work focuses on monitoring the short-term on-orbit stability of MODIS and the ETM+ RSB. It also provides an assessment of the absolute calibration differences between the two sensors over their wide dynamic ranges.

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