Reducing the Size and Complexity of Full-Aperture Radiometric Calibrators on Thermal Imaging Satellites
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Although moderate to high resolution (100 m or less GSD) satellite-based thermal imaging from sensors like ASTER and Landsat ETM+ and TIRS have shown great utility, there are a limited number of these sensors currently flying and a limited number planned. Important thermal applications like fire detection, volcano monitoring, water management, water quality monitoring, urban heat island mapping, and climate change assessments would benefit from enhanced thermal imaging data streams taken at increased frequency (shorter repeat times) and higher spatial resolution (smaller GSD). One of the factors limiting thermal imaging growth is the size and complexity of traditional on-board full-aperture radiometric calibrators. As an imaging system’s resolution increases (GSD decreases), both the aperture and full-aperture black body calibrator grow, limiting the scalability of this approach. Finding ways to reduce the size and complexity of the on-board calibrator therefore could enable higher resolution thermal imaging sensors. It could also lead to an increase in the number of thermal imaging satellites by lowering their cost, thereby improving (reducing) repeat times. This paper outlines an alternative radiometric calibration approach that could significantly reduce the size, power, complexity and cost of the overall thermal imaging payload. The proposed approach uses a small on-board imaging transfer radiometer bore-sighted with a primary instrument. It is similar to a traditional cross calibration approach but instead incorporates the second calibrated transfer sensor on-board the same spacecraft. By simultaneously acquiring data from both the transfer radiometer and primary instrument on the same spacecraft, the geometry and temporal differences associated with cross calibration are virtually eliminated and the overall accuracy of the approach improves. This type of calibrator could also serve to monitor a primary sensor’s radiometric stability during image acquisition without the primary sensor having to regularly look at a calibration source. An analysis of the transfer radiometer characteristics and the accuracy needed to meet Landsat requirements are provided based on TIRS Landsat 8 Band 10 simulations. Initial analyses indicate that the calibrator aperture diameter of a Landsat TIRS-like instrument’s transfer radiometer could be less than 15 mm, a small fraction of the current calibrator. This approach could also eliminate the need for a primary instrument scene selector mechanism or simplify its implementation. Trades between uncooled and cooled detector implementations are provided. The overall expected uncertainties of this approach and expected error as a function of the ratio of the primary sensor and transfer radiometer GSD are shown.