IMPROVED DESTRIPING FOR TERRA AND AQUA MODIS DATA: ALGORITHM DESCRIPTION AND QUANTITATIVE RADIOMETRIC ASSESSMENT

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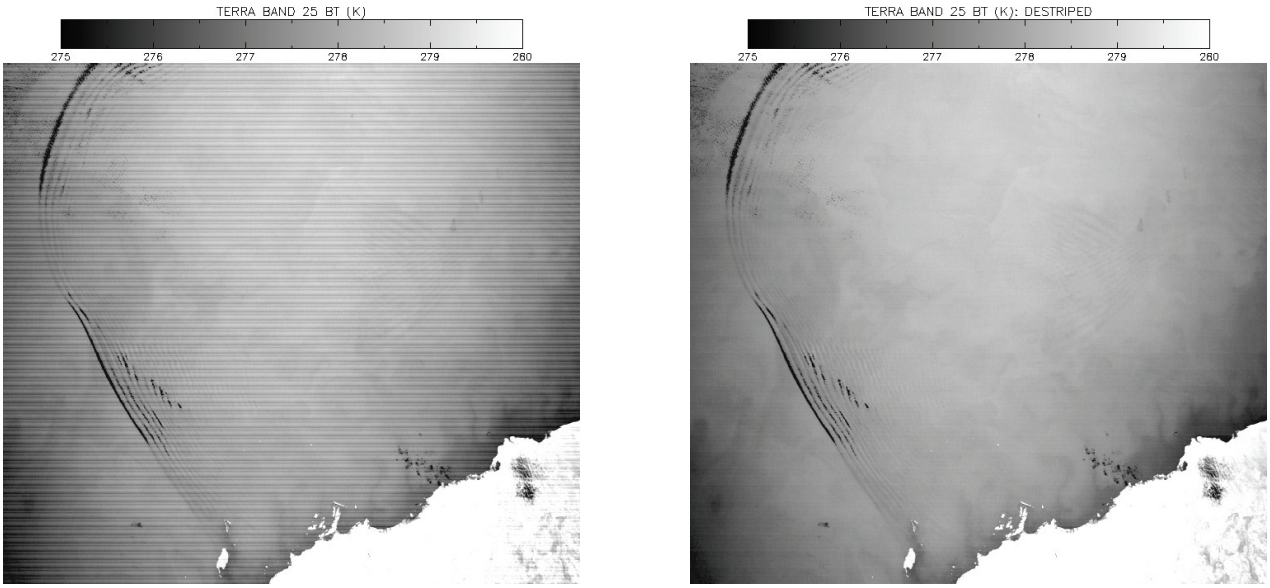
1. INTRODUCTION

The MODIS imaging sensor onboard the NASA Terra and Aqua spacecraft acquires earth imagery at 1000, 500, and 250 meter resolution. The resulting image data are used for a wide variety of land, ocean, and atmospheric applications. Due to the novel design of the MODIS optics and detector subsystems (e.g., two-sided scan mirror, multiple samples along track per earth scan), striping can be observed in the MODIS calibrated radiances at all spatial resolutions. For data integrity reasons, the MODIS Science Team decided early on that destriping would not be removed in the archived Level 1B products (i.e,. the calibrated radiances), and that it would be the responsibility of the end user to destripe the data to suit their own needs. Based on the work of Weinreb et. al. [1], the authors developed a destriping algorithm for MODIS data based on the technique of matching empirical distribution functions (EDFs). The technique assumes that for a given sample of MODIS earth view data (e.g., a 5-minute "granule"), the EDF for each "striped" detector can be adjusted to match the EDF for a reference detector in that band which is behaving normally.

2. ALGORITHM DETAILS AND IMPLEMENTATION

The algorithm treats the MODIS 1000 meter spectral bands as though they have 20 detectors (10 detectors on each scan mirror side). The EDF is computed for each detector in a spectral band, and subsequently the EDF for each detector is adjusted to match the EDF of the reference detector. From the "corrected" EDF, a correction lookup table (LUT) is computed for each detector in each spectral band per granule. The correction LUT is applied to the scaled integer values in MODIS Level 1B HDF4 files which represent the calibrated radiance for the earth scene. To maintain radiometric integrity, an offset is applied to the destriped scaled integer data for each band so that the median value following destriping is the same as the median value before destriping. In the case where a detector is either dead or exhibiting excessive random noise, the scaled integers for this detector are replaced with the scaled integers from the nearest neighboring detector in the along track direction. An example of the before and after impact of the algorithm is shown in Figure 1.

The algorithm was primarily designed to work with MODIS 1000 meter resolution data in spectral bands 20, 22-25, 27-30, and 33-36 because these are the bands used to create MODIS atmosphere products, and the algorithm was designed by members of the MODIS Atmosphere subgroup of the MODIS Science Team. However, the algorithm has also been adapted by the MODIS Land group to destripe bands 5, 6, and 7 before the MODIS land atmospheric correction algorithm is applied. The destriping technique described here has been applied to the complete Terra and Aqua MODIS mission records as part of the Collection 5 Atmosphere and Land retrospective and forward processing at NASA Goddard Space Flight Center. However, it should be noted that the destriped Level 1B data are not available from the NASA archive. Instead, the destriping algorithm is applied to the MODIS Level 1B data during creation of the Atmosphere and Land products, and is then discarded. Until recently, it was not possible for MODIS users outside the MODIS Science Team to utilize the algorithm for destriping Level 1B data. However, the algorithm was recently released as part of the IMAPP software package described by Huang et al. [2] and is now available to anyone who wishes to destripe MODIS 1000 meter resolution Level 1B data. The IMAPP website is available at http://cimss.ssec.wisc.edu/imapp/. The 500 meter version of the destriping algorithm is also available as part of the MOD09 atmospheric correction software package released by the NASA Direct Readout Laboratory.



Original Destriped

Figure 1: Terra MODIS Band 25 Original and Destriped Scenes over a mostly uniform surface

3. IMPROVED DESTRIPING ALGORITHM AND QUANTITATIVE ASSESSMENT

In the original implementation of the algorithm, it was observed that if the granule being destriped contained rapid radiance transitions from (e.g., from cold ocean to hot land surface), it is possible for artifacts to be introduced in the destriped image due to a discontinuities in the original EDF. These artifacts initially manifested themselves in the MODIS Level 2 Cloud Mask product, where a difference between MODIS bands 31 and 32 is one of the spectral tests used to detect clouds. The authors have shown that this effect can be mitigated by using a larger data sample (e.g., a global day) to compute the EDFs for each detector, and then using these EDFs to compute the correction LUTs. In this presentation, we demonstrate the improvement in the performance of the algorithm due to using global data samples to computer the EDFs. Furthermore, we present a set of correction LUTs which the authors have computed for every month of the Terra and Aqua missions, which can be easily applied to the scaled integers contained in the MODIS Level 1B HDF4 files.

We also present a quantitative assessment of the radiometric impact of the destriping algorithm over the lifetime of the Aqua mission by comparing MODIS original and destriped radiances to collocated Atmospheric Infrared Sounder (AIRS) hyperspectral infrared radiances. This assessment will demonstrate that the destriping algorithm does not have a negative impact on MODIS radiometric performance for climate applications.

4. REFERENCES

[1] Weinreb, M. et al., "Destriping GOES Images by Matching Empirical Distribution Functions". *Remote Sens. Environ.*, 29, pp. 185-195, 1989.

[2] Huang, H. L. et al., "International MODIS and AIRS Processing Package (IMAPP): A Direct Broadcast Software Package for the NASA Earth Observing System". *Bull. Am. Met. Soc.*, 85, pp. 159-161, 2004.