Progress on reducing risk of data loss for ABI using Quantitative Image Restoration

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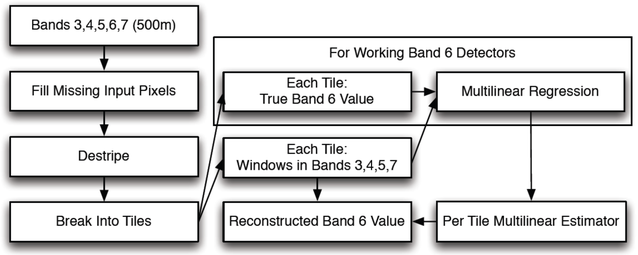
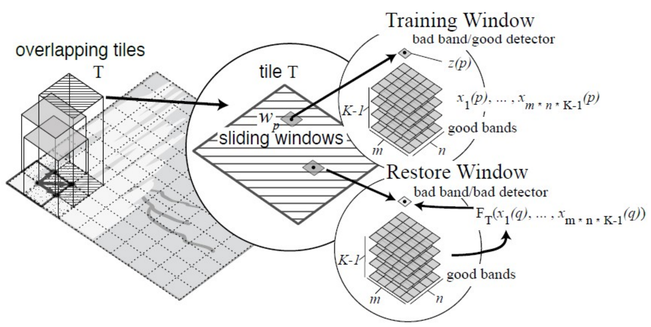
Abstract: Loss of image data due to physical instrument damage or transmission error presents a risk of data loss, potentially degrading accuracy in higher-level products. Previously, we had developed a quantitative image restoration algorithm (QIR) that uses statistical correlation across spectral bands to accurately estimate missing data due to detector damage on Aqua MODIS band 6. We present on our recent progress to adapt the QIR algorithm to work with the visible bands of the ABI simulated data.

The restoration implementation can be configured to work with any fixed set of broken detectors within the band to be restored. In addition, we adapted our current algorithm to also operate on infrared and near infrared bands. We have evaluated the restoration by simulating damage to the 0.47 micron visible and 2.1-micron infrared bands. We have performed evaluations by simulating possible damage on MODIS/Terra bands as a proxy for ABI bands. Our evaluation shows that QIR provides a better snow product then obtained using an alternate band. We have also evaluated by building a database of QIR restored reflectance images over the greater Yellowstone region. Preliminary results from that database seem to indicate that the cloud product has trouble distinguishing cloud from snow without band 6, and that restoring band 6 may provide a better cloud product.

Quantitative Restoration Algorithm

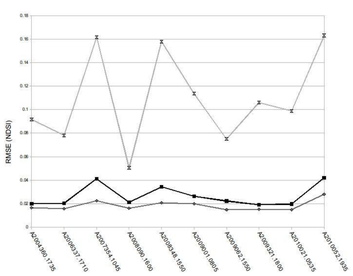


Quantitative image restoration (QIR) algorithm diagram showing the the restoration processes. It is assumed that the primary damage is in a single band, called the "bad band" and that other bands are available, called "good bands." Data is restored within overlapping tiles independently and then merged on overlaps through a weighted averaging. Within a tile there are locations where the value in the bad band is present and can be used for training (denoted p). Windows in the good band around this band provide training data. A multi-linear regression determines a restoration function F_T for the tile T. This is then applied to the windows in the good bands around a missing value in the bad band, to estimate a restored value.

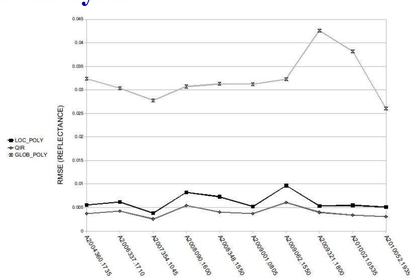


The restoration function is a composite (piecewise) function built from smaller restoration functions defined on large overlapping portions of the image, which we refer to as tiles. The tiles are defined by first partitioning the image into a grid of non-overlapping tiles. The grids of tiles are shifted horizontally by a half-tile, vertically by a half-tile, and diagonally by a half-tile, as shown at the far left of the diagram below. As a result pixels in a corner region are in only one tile, pixels near the image boundaries but not in corner regions are members of two overlapping tiles, and pixels at least a half-tile away from the boundary are covered by 4 overlapping tiles.

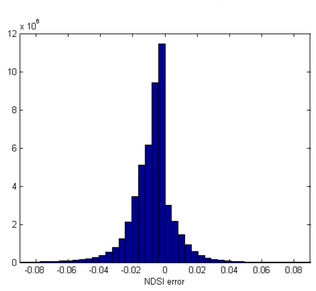
Error Analysis



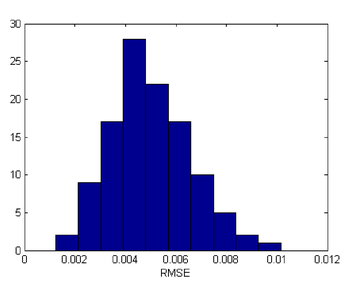
RMSE of NDSI for 10 test granules.



RMSE, in reflectances for 10 test granules



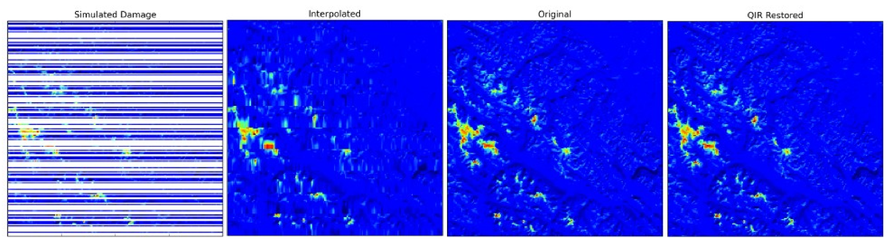
Histogram of NDSI errors using restored band 6 over 10 test granules.



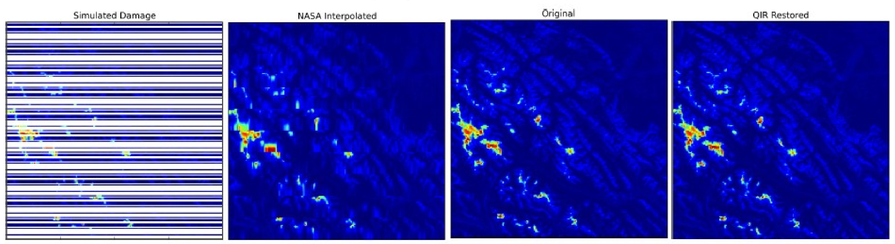
Distribution over 113 granules of the QIR RMSEsin reflectances.

Simulation of possible damage and restoration using Terra granule

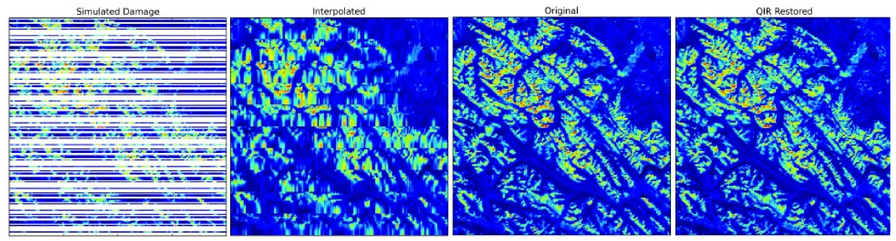
500m resolution acquired on day 273, 2010 at 19:05 UTC



Band 2 (proxy for 0.86 micron ABI)



Band 3 (proxy for 0.47 micron ABI)



Band 7 (proxy for 2.25 micron ABI)

Planned Work

1. Investigate improvements by integrating spatial interpolation within the damaged channel with cross band interpolation.
2. Investigate fusing information from full disk and CONUS high resolution for restoration.

Publications

1. I. Gladkova, M. Grossberg, F. Shahriar, G. Bonev, P. Romanov, Quantitative Restoration for MODIS Band 6 on Aqua, IEEE Transactions on Geoscience and Remote Sensing, vol.50, no. 6, Jun. 2012. to be published. [Online]. Available: doi:10.1109/TGRS.2011.2173499.
2. I. Gladkova, M. Grossberg, G. Bonev, P. Romanov, F. Shahriar, Increasing the Accuracy of MODIS/Aqua Snow Product Using Quantitative Image Restoration Technique, IEEE Geoscience and Remote Sensing Letters, to be published
3. I. Gladkova, M. Grossberg, G. Bonev, P. Romanov, G. Riggs, D. Hall, A full snow season in Yellowstone: a database of restored Aqua Band 6, submitted to IEEE Geoscience and Remote Sensing Letters

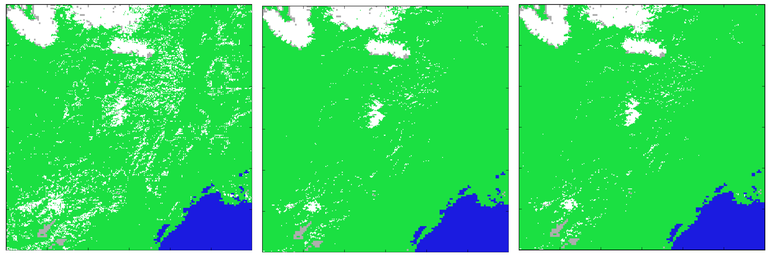
Presentations

I. Gladkova, M. Grossberg, G. Bonev, P. Romanov, Seasonal snow cover of Yellowstone estimated with restored MODIS Aqua, and MODIS Terra snow cover maps, AGU Chapman Conference on Remote Sensing of the Terrestrial Water Cycle in Kona, Hawaii

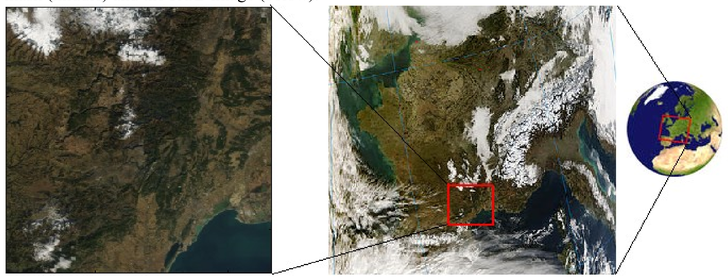
Impact of QIR on Snow Product

Current NASA-utilized solution for snow mask from Aqua is to use 2.1 micron (Band 7) measurements instead of damaged band 6

Example of snow masks for the 150 x 150 km sub image taken from the 2007354.1045 swath. White - snow, green - snow free land, blue - water, gray - clouds.

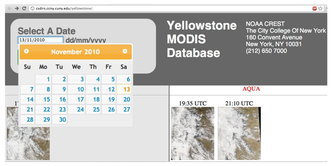


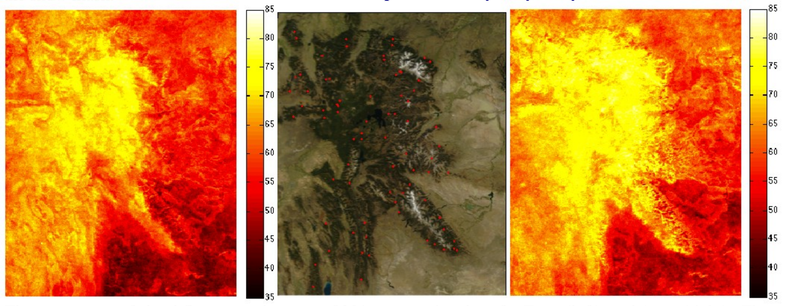
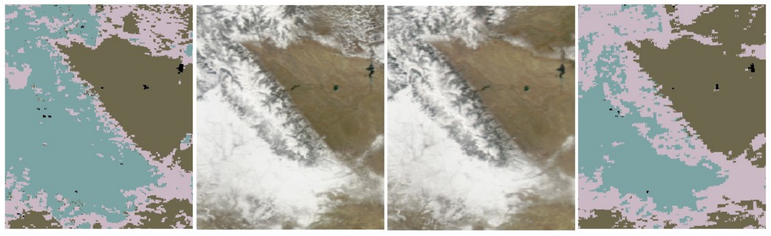
The NASA snow mask algorithm using band 7 (left) tends to overestimate the amount of snow. The snow mask based on the restored band 6 (right) clearly is in much closer agreement with the original NASA snow mask (middle) and the RGB image (below).



QIR Data Base: Full snow season, Yellowstone Region

In order to evaluate benefits of the restoration, we have created a database containing information from the restored Aqua band 6 over the Yellowstone region for the 2010-2011 snow season. Database includes restored radiances (swath and remapped), NDVI, thermal data, NDSI and band 6 based snow mask products. Even though the Database contains a limited region and spans a single season, it is possible to see potential application of QIR to the cloud mask in addition to the snow mask. The Data Base is available from: **http://csdirs.ccny.cuny.edu/yellowstone/**





The percentage of cloud flags over the span of 281 consecutive days for Terra (left) and Aqua (right). The cloud coverage over the mountains is much higher than for other regions. There is also a significantly higher percentage of cloud pixels for Aqua than for Terra, even though the passes are roughly only 2 hours apart. One possible explanation is that snow is sometimes misclassified as cloud, especially for Aqua because band 6 is a particularly valuable asset in distinguishing cloud from snow due to the fact that snow is darker than clouds in this band. To further clarify this, an apparently clear sky day, March 23, 2011, is shown below. On the far left, the Terra based snow mask shows snow on the mountains with clouds along the boundary between snow and snow free land. Despite apparently nearly identical and largely cloud free RGB images for Terra and Aqua, acquired 2 hours apart, the number of pixels identified as cloud in the Aqua cloud mask has dramatically increased.