Impact of Aqua Misregistration on MYD06 Cloud Retrieval Properties

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Introduction

Aqua MODIS bands in the Visible and Near infrared (VIS/NIR) focal planes have been found to misaligned relative to the bands located on the "cooled" short and middle wavelength and long wavelength infrared (SMIR/LWIR) focal arrays. The alignment difference ranges between .2-.35km in along scan and 0.2-0.4 km in along track direction (Xiong et al. 2006). Wang et al. 2007 assessed the impacts of this misalignment on snow index computations. In this study we examine the impact of the band-to-band misregistration on MYD06 cloud retrieval products by forcing a "misregistration" of MODIS Terra data (to simulate that of Aqua) and processing one month of Terra data. Impacts of the mis-registration on both the Level-2 and Level-3 (monthly) products are presented. For comparison, results are also presented from a method of applying a weighting correcting the 250m prior to processing the retrieval products.

Terra Deregistration

Bands 1, 2 and 7 are most important to computing the cloud optical thickness, effective radius, and retrieval fraction. Band 7 however is located on the SMIR focal plane and hence misaligned relative to bands 1 and 2. Xiong et al 2006 report the misalignment of Aqua band 7(relative to band 1) is -223 meters in the along scan direction and 409 meters along track (see Table 1 for results for Aqua bands 1-7). To investigate the effect of the misregistration on the the cloud retrieval properties, bands 1 and 2 of Terra data were deregistered to approximate the Aqua misregistration. This was accomplished by shifting 250m resolution bands 1 and 2 one pixel along scan and two pixels along track, prior to aggregation of the data to the Level-1B resolution of 1km. This will slightly overestimate the actual Aqua misregistration.

Aqua/MODIS	Along scan (m)	Along Track(m)
Band 1	0	0
Band 2	-4	0
Band 3	30	-9
Band 4	4	-38
Band 5	-246	366
Band 6	-285	382
Band 7	-223	409

Table 1. Average band-to-band registration of Aqua bands 1-7 relative to band 1 (from Table 1 of Xiong et al 2006).

Level-2 Cloud Product Impacts

The deregistered Terra Level-1B Terra data was processed to Level-2 (MYD06) cloud products and several Level-2 granules were investigated. Figure 1 a-f. are sample Level-2 imagery of cloud optical thickness and effective radius for the operational (Collection 5), deregistered, and deregistered-operational cases.

1. Missing lines in the deregistered and difference imagery are an artifact of the deregistered data processing (Because of way MODIS data is processed and the cloud mask logic, the 2 pixel along track shifting of the 250m data forces fill data for every tenth line of the 1km data, which in turn forces the adjacent 9th line to be cleared by the clear sky restoral logic).
2. Largest effective radius differences tend to occur in areas of lower optical thickness. Figure 2 (using data from the whole granule) depicts this rather well.
3. The deregistration can sometimes near cloud edge change the cloud/no cloud decision of the cloud mask (MOD35) and clear sky restoral algorithms.

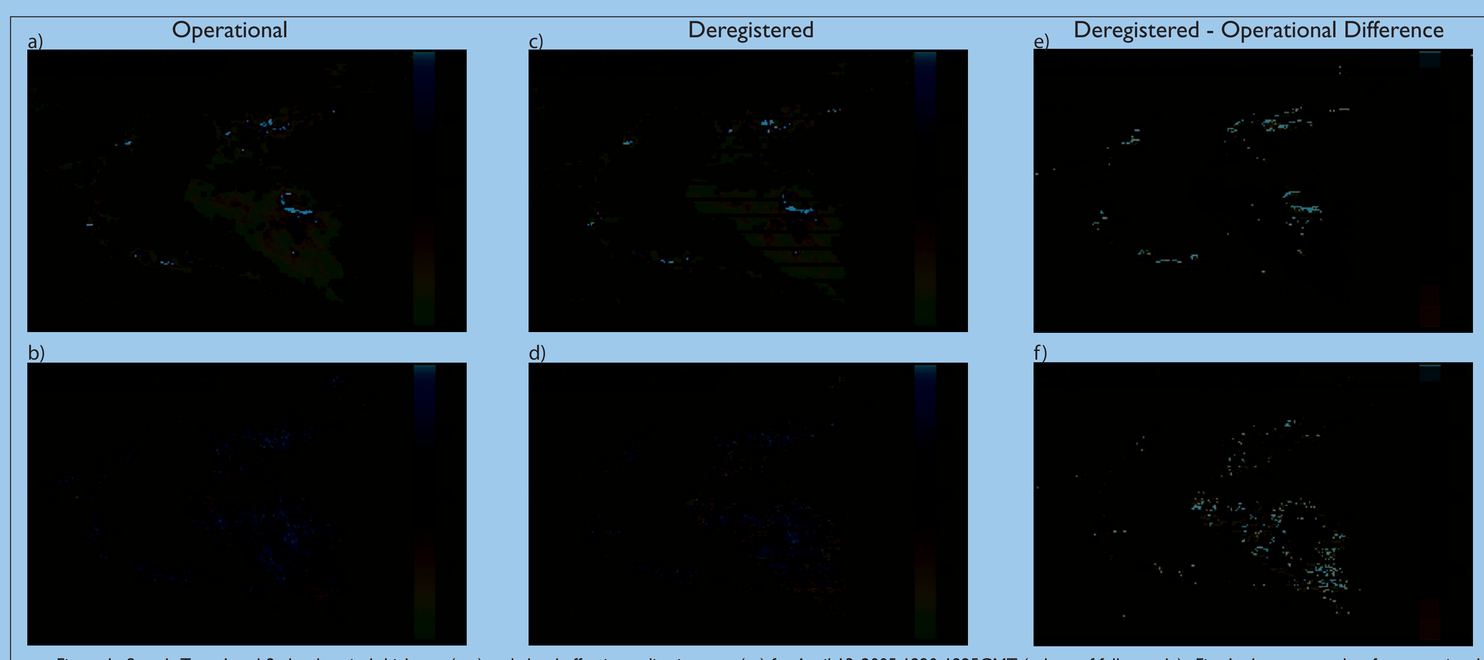

Figure 1. Sample Terra Level-2 cloud optical thickness (tau) and cloud effective radius imagery (re) for April 13, 2005 1220-1225GMT (subset of full granule). Figs.1 a,b are tau and re for operational Collection 5 data, Figs.1 c,d tau and re for deregistered Collection 5 data, and Figs.1 e,f the difference of the deregistered (tau, re) minus operational (tau, re) data.

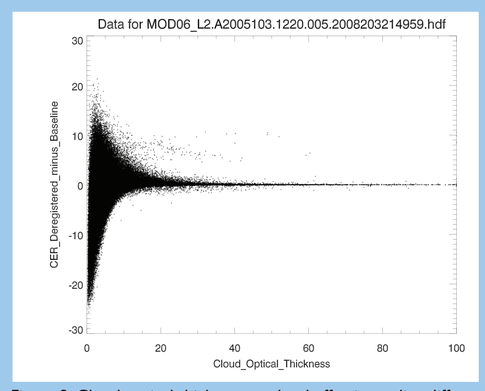

Figure 2. Cloud optical thickness vs cloud effective radius difference of the deregistered minus operational data showing the appreciable impact of the deregistration on the effective radius at lower optical thickness values. Data is from the full granule of April 13, 2005 1220-1225GMT.

Level-3 Monthly Product Impacts

One month of the deregistered Terra Level-2 data was processed to Level-3 (MYD08) and is compared here to the Collection 5 operational data. Figure 3 shows global monthly average for cloud optical thickness, effective radius, and cloud fration for the operational data, the deregisterd-operational data, and histogram of each parameter (using only Liquid water cloud data for 50N-50S over ocean). Note: due to the deregistration processing artifact noted in the L2 data discussion above, the L3 data in Figure 3 was computed from Terra detectors 3 and 8, rather than the usual operational method of using detectors 4 and 9.

1. The deregistration tends to increase optical thickness in higher optical thickness regions, and decrease optical thickness in lower optical thickness regions, but most changes are within +- 1.0 of the opertional value.
2. Largest (most variable) effective radius differences tend to occur in areas of lower optical thickness, though most differences are less than a micron from the operational value.
3. The deregistration tends to decrease more effective radii values than increase, especially in low optical thickness/ less cloudy regions.
4. Proability distribution functions comparing the optical thickness (Figure 4a) and effective radius (4b) of the operational and deregis-tered data show mostly relatively minor differences due the deregistration.

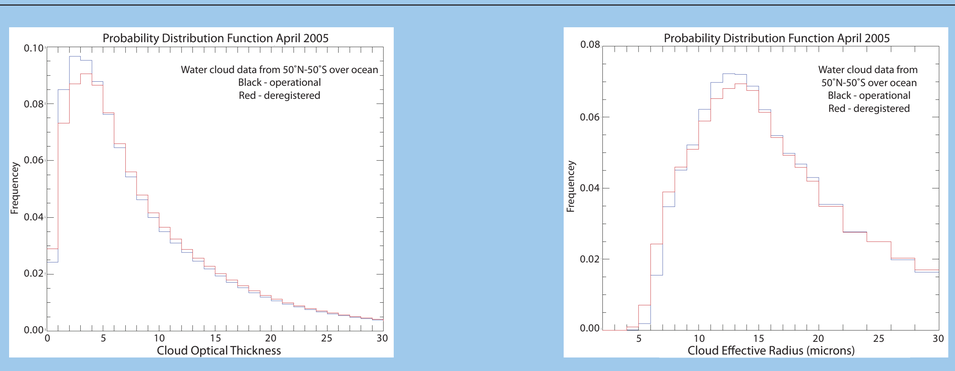

Figure 4(a,b). Probability distribution functions for optical thickness and effective radius for operational and deregistered April 2005 Terra data.

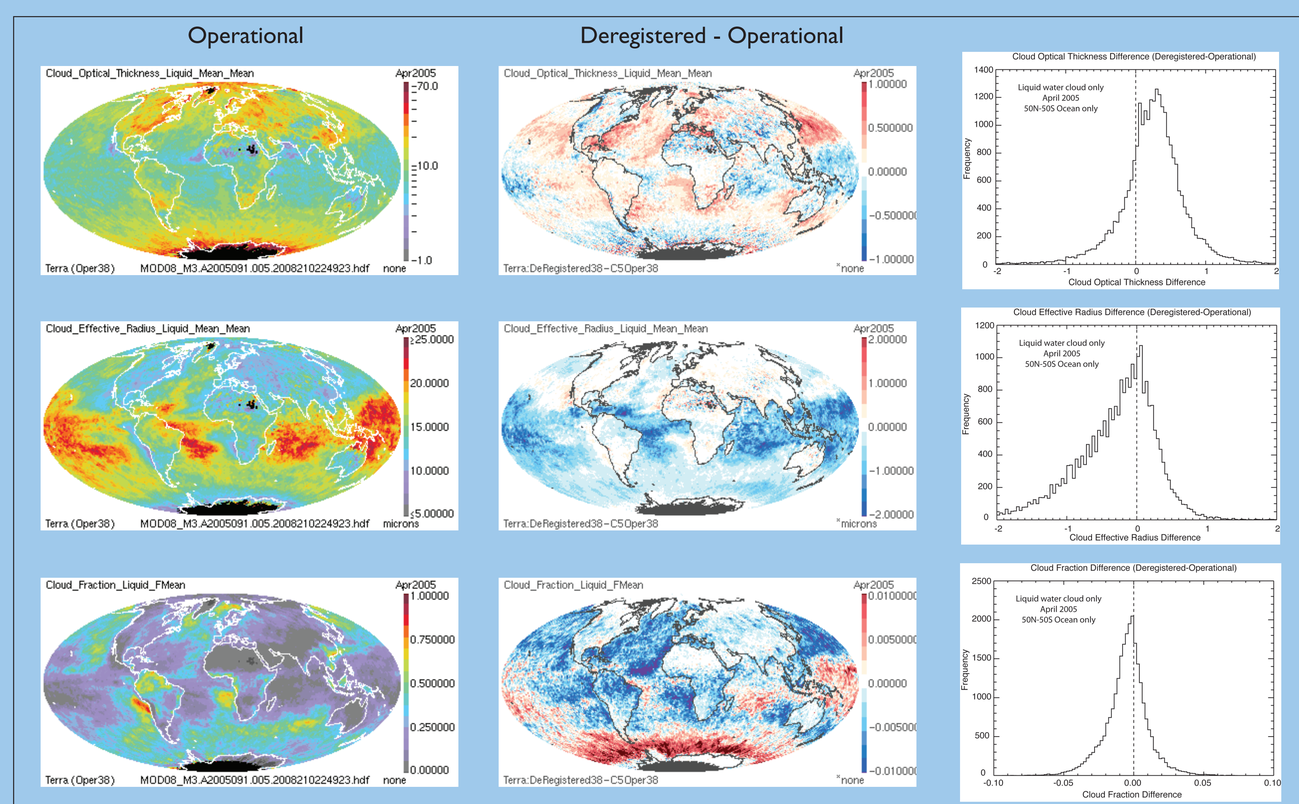

Figure 3. Terra Level-3 global cloud optical thickness, cloud effective radius, and cloud fraction imagery and histograms for liquid water cloud only on April 13, 2005 1220-1225GMT. Column 1 is the operational data, column 2 the deregistered-operational data, and column 3 historgams of deregistered minus operational difference for each cloud parameter for data 50°N - 50°S over ocean.

Comparison to a Misregisration Correction Method

Bennartz et al (personal communication) applied the following procedure to "correct" the Aqua 250m data to align the data with the SMIR and LWIR focal planes:

1. Weights were derived accordingly for the 250m data to align the focal plane mismatch. (This was done through a cross-correlation minimization of the aggregated VIS versus NIR channels for se-lected scenes using Levenberg-Marquardt minimization.)
2. The weighted 250m data was then accumulated to 1 km resolution and replaced in the Level-1b data files.
3. Revised Level-1b data was then processed (globally) to the MYD06 product for one full day
4. Global 1x1 degree (Level-3 equivalent) fields were then generated from the MYD06 products.

Difference imagery and histograms of optical thickness and effective radius for the one day generated are shown in Figure 5. Note that the red-blue color scheme in the differene imagery is reverse of that in Figure 3. The "New" data in Figure 5 refers to the corrected data (in effect the properly registered operational data in Fig. 3), and the "Old" the misregistered (deregistered) data. Interestingly the general trends of the "New-Old" data (shape, skewing, and magnitude) are reasonably similar to the difference imagery/histograms shown in columns 2 and 3 of Figure 3.

Summary

The histograms and imagery from the deregistered test compared to the operational data suggest that while the global averages of differences in optical thickness, effective radius, and retrieval fraction are near zero, significant difference can exist regionally and at smaller time/spatial scales, particularly in more heterogenous/ less cloudy regions. Similar effects can also be seen in the Bernartz et al. imagery/histograms that compares a day of global processed Aqua misregistered data with data corrected for the misregistraion. Results are also consistent with Wang et al 2007, who found that Aqua NDVI snow mapping index is improved by shifting Aqua 250m data two pixels along track and one pixel across track.

References

Xiong, X., N. Che, W. L. Barnes, Y. Xie, L. Wang and J. Qu, 2006: "Status of Aqua MODIS spatial characterization and performance," in *Sensors, Systems, and Next-Generation Satellites*, X, R. Meynart, S. P. Neeck and H. Shimoda, Eds., Proc. SPIE 6361.

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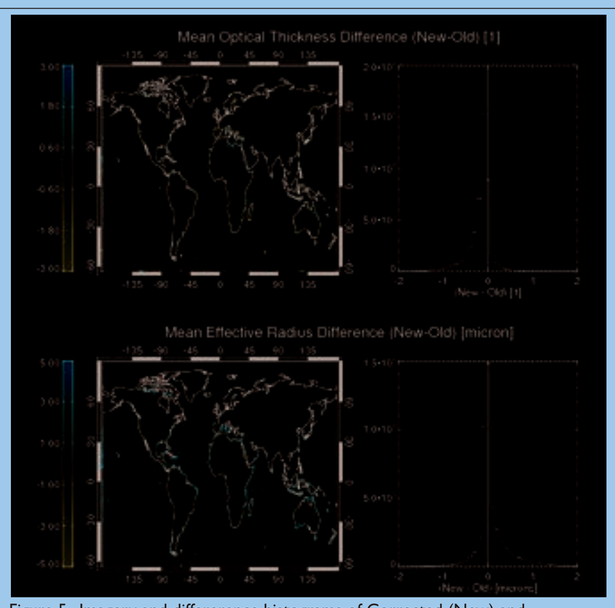

Figure 5. Imagery and differerence histograms of Corrected (New) and operational (Old) Aqua data(for one day of data), similar to the monthly average difference imagery and histograms in Figure 3. Note however the difference computation in Figure 5 (and thus color scheme and historgram direction) is reverse of the convention used in Figure 3.