MODIS SEMI-ANNUAL REPORT - July 15, 2001 – Jan 15 2002

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CONTENTS

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B. OVERVIEW OF RECENT PROGRESS

B.1 Processing and Algorithm Development

Ocean color

In September we became aware that there was a time-dependent trend in normalized water-leaving radiances (nLw) of ocean color PGE's version V3.3 and earlier. This trend was caused by a discrepancy between Level 1B and Level 2 correction procedures. The correction for Earth-Sun distance, required for the reflectance calibration, was applied twice, once to generate the m1 coefficient at MCST, and once again during Level 2 ocean color production. This discrepancy was initially masked by the ocean normalization process and was repeated for different instrument calibration epochs (A side vs. B side electronics, mirror sidedness episodes, formatter problems, etc.). Only when a consistent operationally processed time series from MODAPS became available in late summer was the obvious trend present. Once this problem was identified from the time series analysis we immediately corrected the problem and re-calibrated the visible channels and delivered V3.4 of the oceans code to correct this problem. Due to this unfortunate but unavoidable experience, during October and November the RSMAS SCF purchased additional disk storage capacity to enable local processing of selected days to facilitate rapid creation of global time series for calibration and analysis in a timely manner.

Ocean color products as derived from radiances measured by MODIS have since undergone exhaustive corrections and calibrations at the University of Miami SCF since the instrument was activated aboard the Terra satellite. These corrections have been developed and applied both at the engineering and algorithm levels. The result is a global time series of 36km and 4km resolution ocean color products.

The images were processed at the University of Miami using interim version 4 correction and calibration factors. Reprocessing of MODIS ocean color data is expected to begin in June, 2002 (Collection IV processing) and will be based on the calibration and corrections factors presented here. These Images are dramatically improved over previous versions, however, issues still remain and we expect to refine the correction factors before finalizing. Comparisons to both in situ and SeaWiFS data show good agreement, and provide uncertainty and variability estimates that remain in the MODIS data in order to aid investigators who are beginning to use MODIS data sets for oceanographic research.

Given the slow progress towards removing instrument artifacts from the L1b (RVS, mirror side difference, polarization - changes seen in time, long term and orbit) we began the following approach to limit the instrument effects in the data set to permit evaluation of derived products .

Summary of correction/calibration strategy:
Overall linear time trend removed from bands 8-12 using modal analysis
Minimum of 6 distinct epochs identified from MCST m1 coefficient times series
Bands 8-12 recalibrated to Moby in situ nlw for each epoch
Different polarizations(5a)
Remaining cross-scan dependence removed
Mirror side time dependence minimized
Inter-detector biases minimized
Remaining biases are approximately 1% for bands 8-12, RMS less than 10%

Cross scan response time dependencies

The plots below in Figure 1 row A show the before corrections time series of the average cross scan performance normalized to pixel 500 for granules over the Hawaii validation site. The continuous time coordinate on the y axis is seconds since Jan 1, 1993 (MODIS TIA time). These plots show a severe east-west bias in most bands, particularly 412nm. In addition the magnitude of these biases appear to change in time. The black lines identify the 6 epochs for which correction factors have been developed. These epochs correspond to changes in electronic state of the sensor and changes in rate of degradation in the mirror response as a function of scan angle.

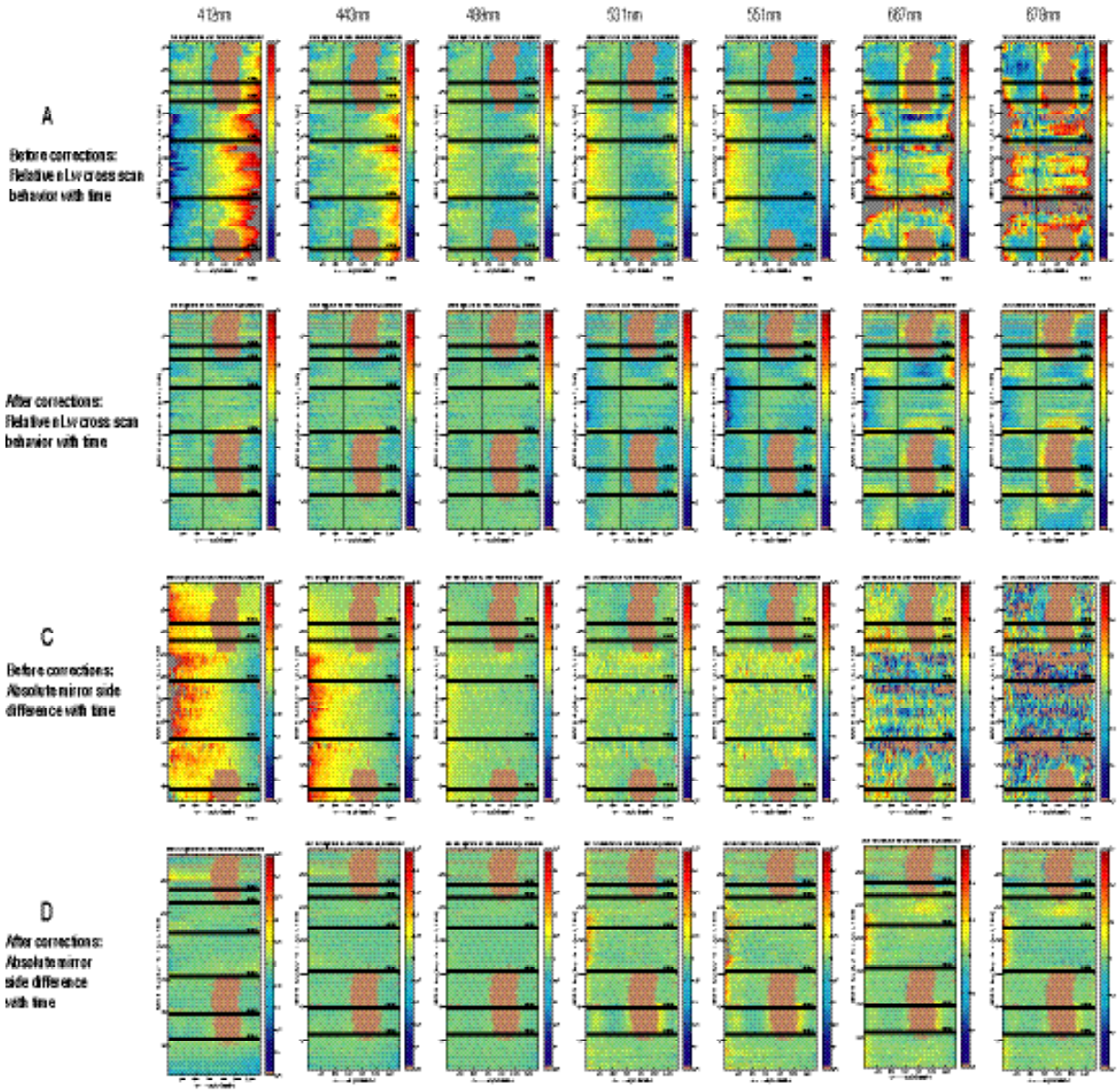
The plots in Figure 1 row B are the results after cross scan corrections are applied to each epoch. The normalized cross scan performance in space and time is much more uniform and removes most of the east-west bias previously present.

Mirror side response time dependencies

The MODIS instrument has a rotating mirror such that every 10 scan lines are from opposite sides of the mirror. The plots in Figure 1 row C show the before correction time series of the average absolute difference between the two mirror sides for all Hawaii granules. The plots indicate that the response of the two mirror sides changes as a function of time and scan angle, increasing the severity of the striping in images

The plots in Figure 1 row D are the results after mirror side corrections were applied to each epoch. Both the cross scan and time dependencies of mirror side differences are dramatically reduced, although the early and current epochs (a-side electronics) require further refinement,

Figure 1 Waterfall time series plots, Row A: Before corrections average cross scan performance, Row B; After corrections cross scan performance, Row C: Before corrections average absolute difference between the two mirror sides, Row D: After correction mirror side performance.



-Summary Plots of Correction factors

The plots below provide a summary of the interdetector, cross-scan, and mirror side correction factors developed for each epoch to date.

Figure 2a, epochs starting 2000 001 and 2000216

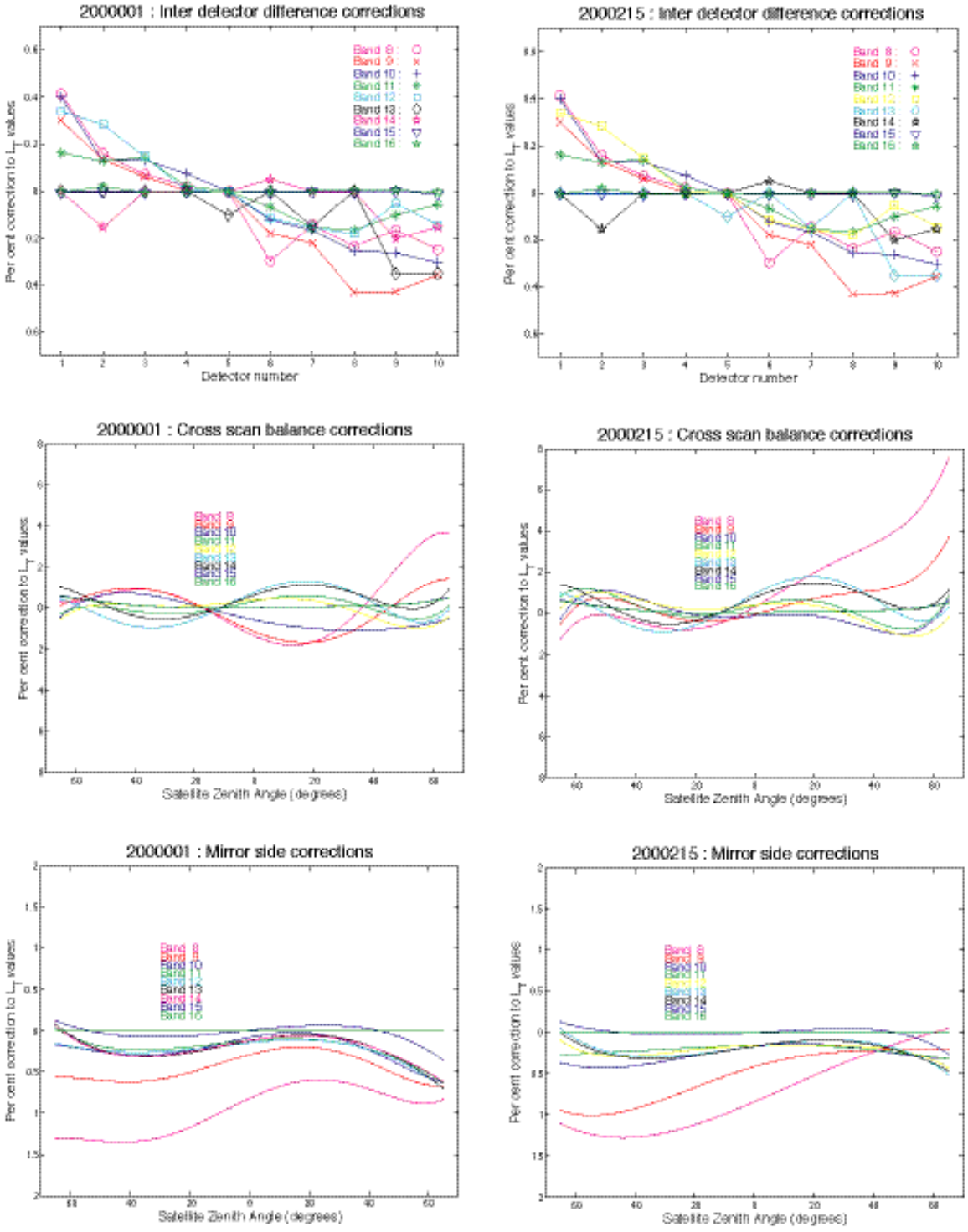
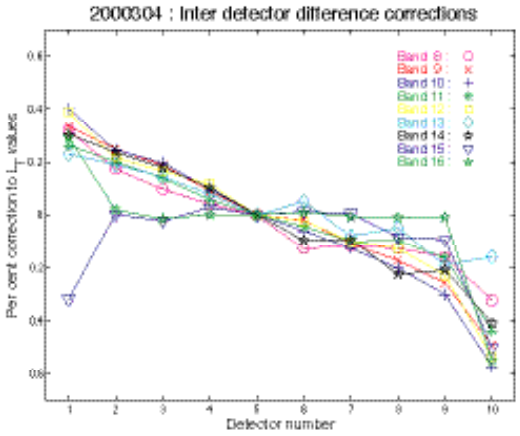
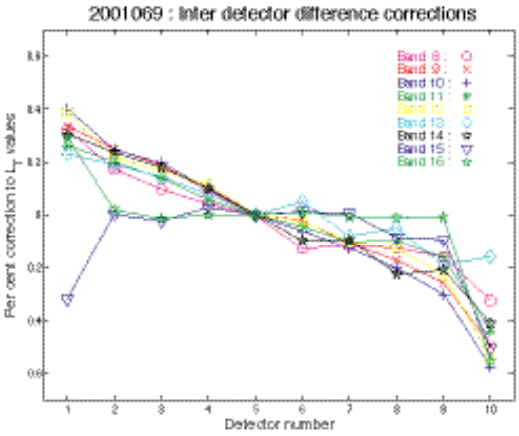
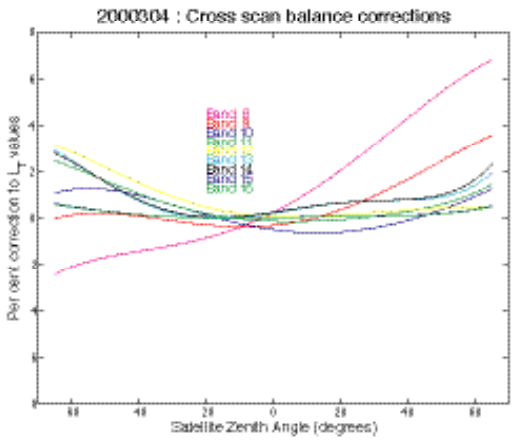
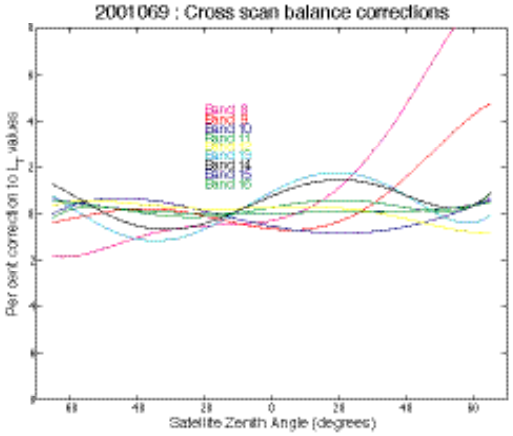


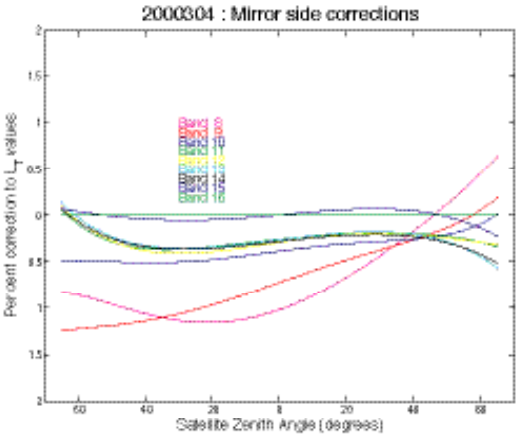
Figure 2b epoch starting 2000 304 and 2001 060











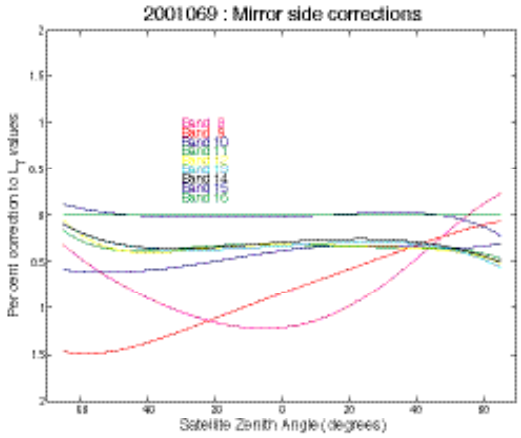


Figure 2c Epoch starting 2001 174 and 2001 084

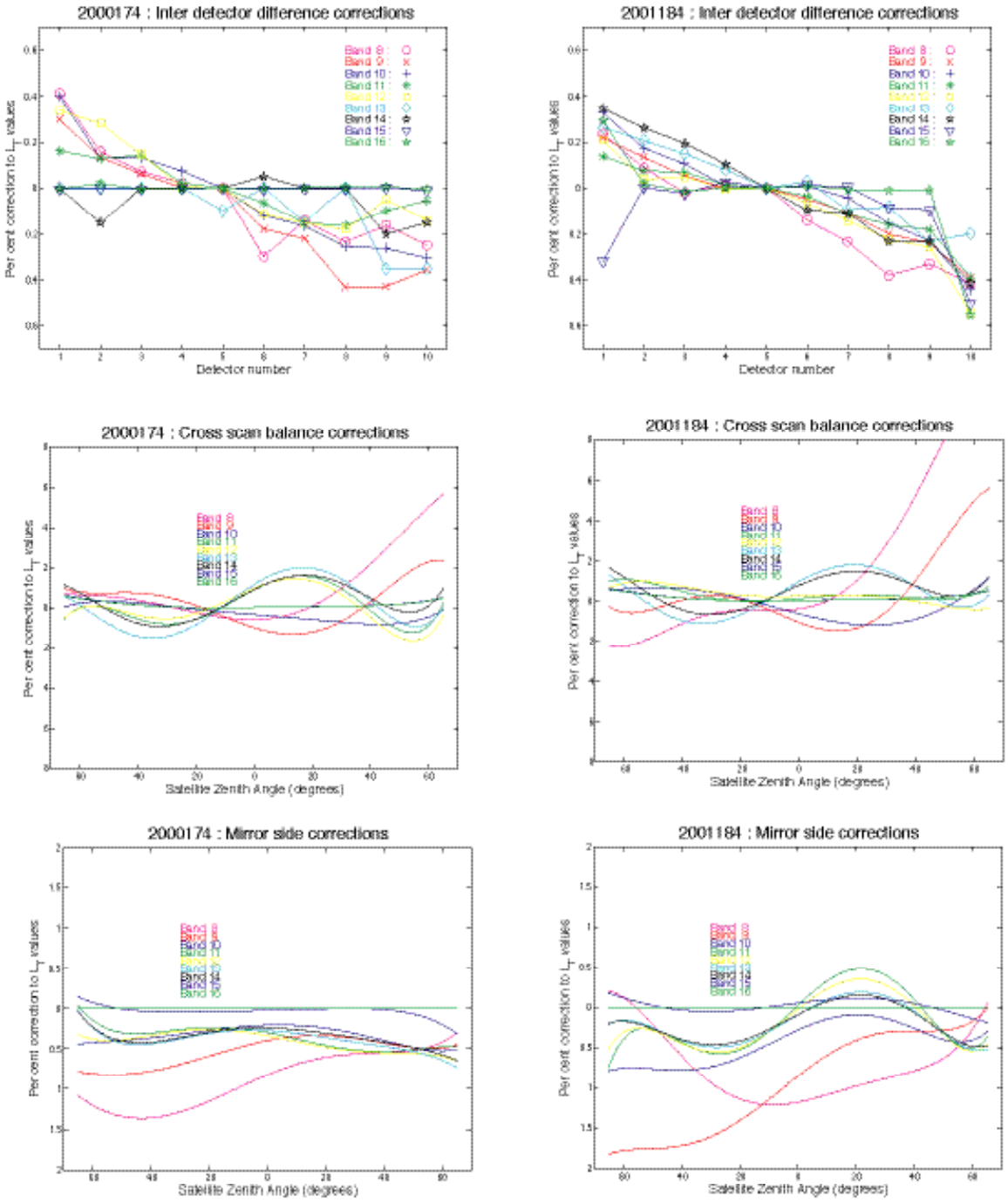
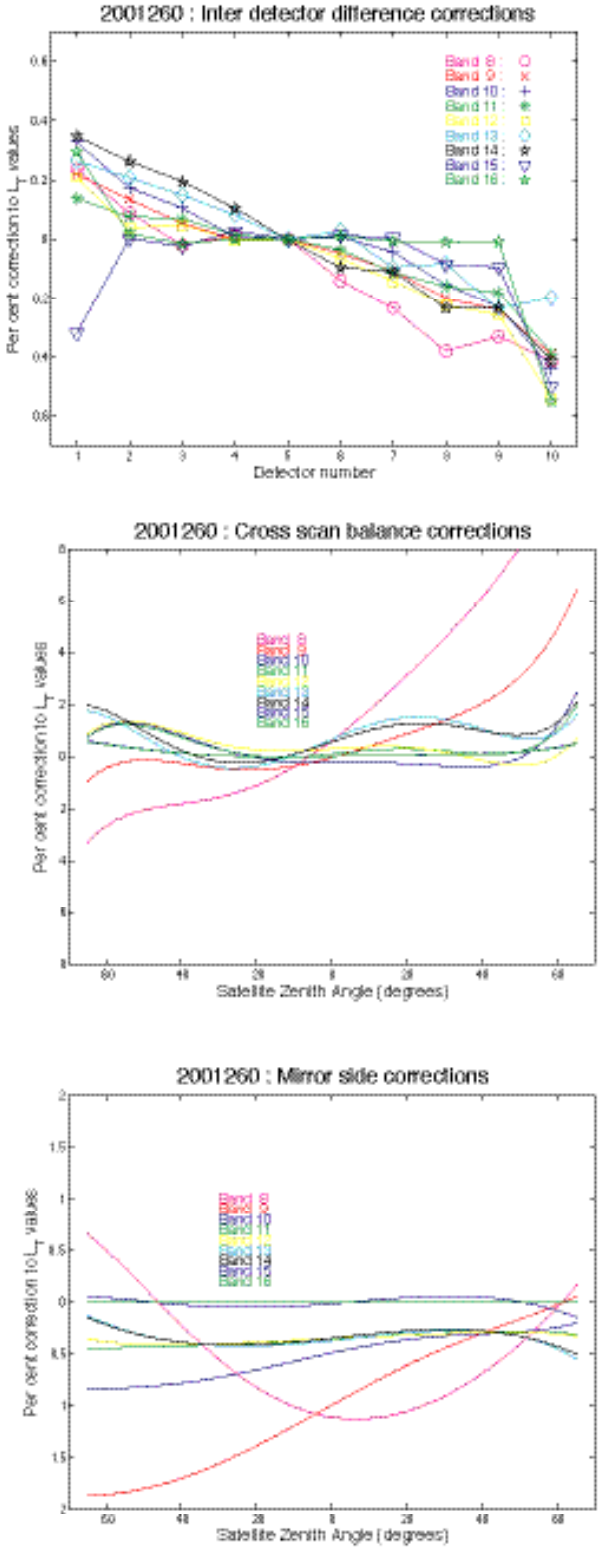


Figure 2d Epoch starting 2001 260

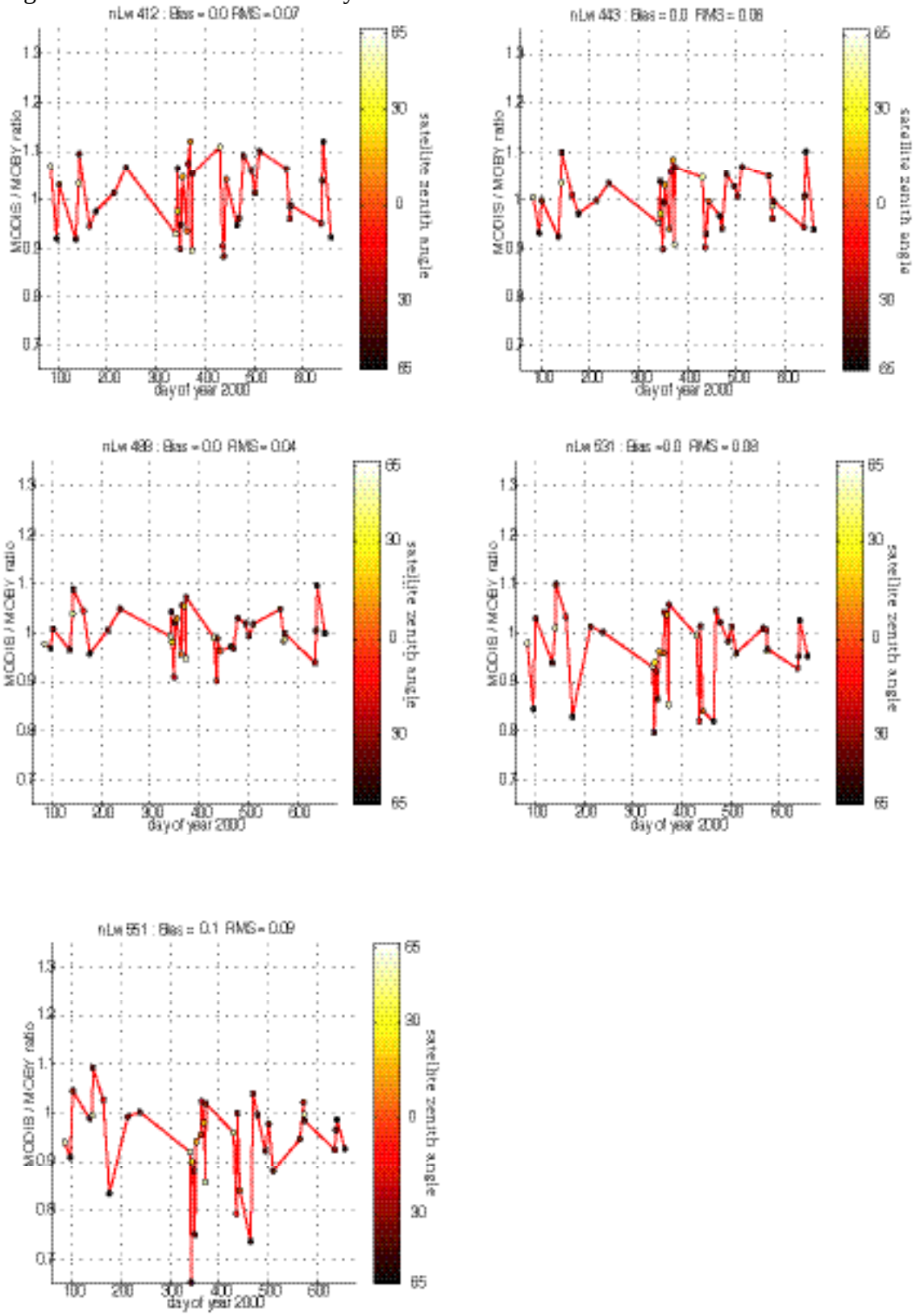


B2. Calibration MODIS/MOBY Matchups

The performance of the correction and calibration procedures can be evaluated from in situ matchups. The matchups shown in Figure 2 and 3 are from MODIS Hawaii granules located over the MOBY buoy site. The in situ data includes a preliminary stray light correction determined by NIST for the MOS profiling instrument applied to both MOBY buoy instruments. In situ data is included from only the top arm of the buoy measured at the time of the 2000hr overpass. Satellite Matchup points were required to have a quality <=1, tau <0.1, and not be within 20 pixels of the scan edge.

The remaining biases after correction and calibration factors are applied are generally <1% with an RMS <10%. This is on the order of the accuracy of the in situ measurements. The cross scan correction factors appear to perform well, as seen in the relatively flat response across the scan line, removing most of the severe east-west bias previously present (not shown).

Figure 3 Time series Modis/Moby ratio



MODIS SeaWiFs global matchup comparisons

Three days of MODIS 4.63km binned products were compared to same day retrieval SeaWiFS products binned to the same 4.63km spatial resolution as MODIS, Figure 4. The SeaWiFS data was from reprocessing 4 calibrated against stray light correct in situ data. The MODIS/SeaWiFS matchups include only collocated bins that had been assigned the highest quality for both sensors.

For the linear fits shown the bisector of the MODIS vs SeaWiFS and SeaWiFs vs MODIS was determined and the distance perpendicular to this line was used in calculating the weights. Thus, there is no true independent variable and the presence of errors in both sensors is assumed.

The nLw comparisons show good agreement, generally <3% difference. The MODIS OC3M chlorophyll algorithm (chlor_a2) produces results consistent with SeaWiFS, <10% difference depending on the retrieval day. Additional comparisons will be needed to evaluate any systematic differences between the two sensors.

Figure 4 a nLw 412 and nlw443 Modis-SeaWifs comparisons

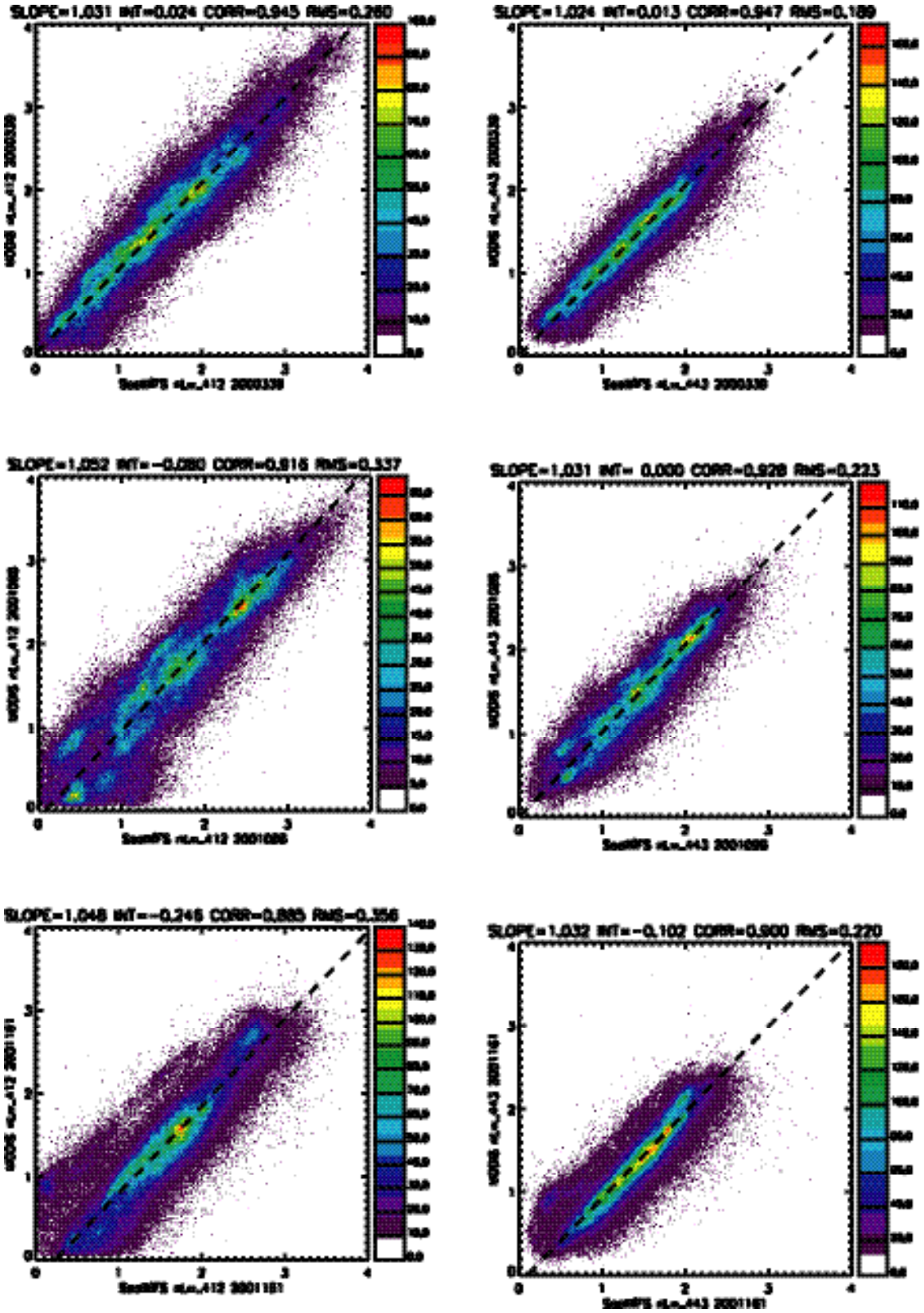


Figure 4b nLw 490 and nlw551 Modis-SeaWifs comparisons

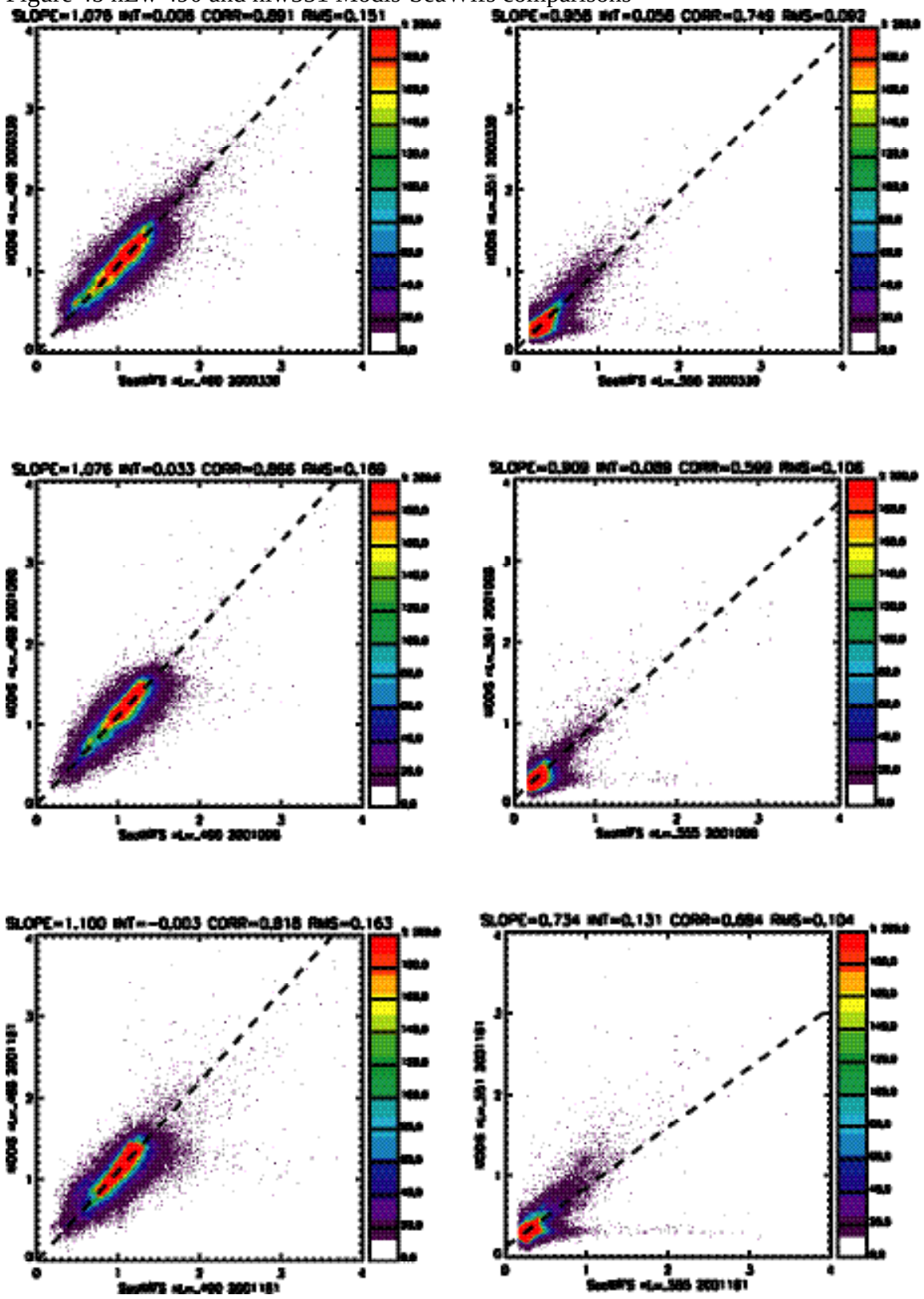
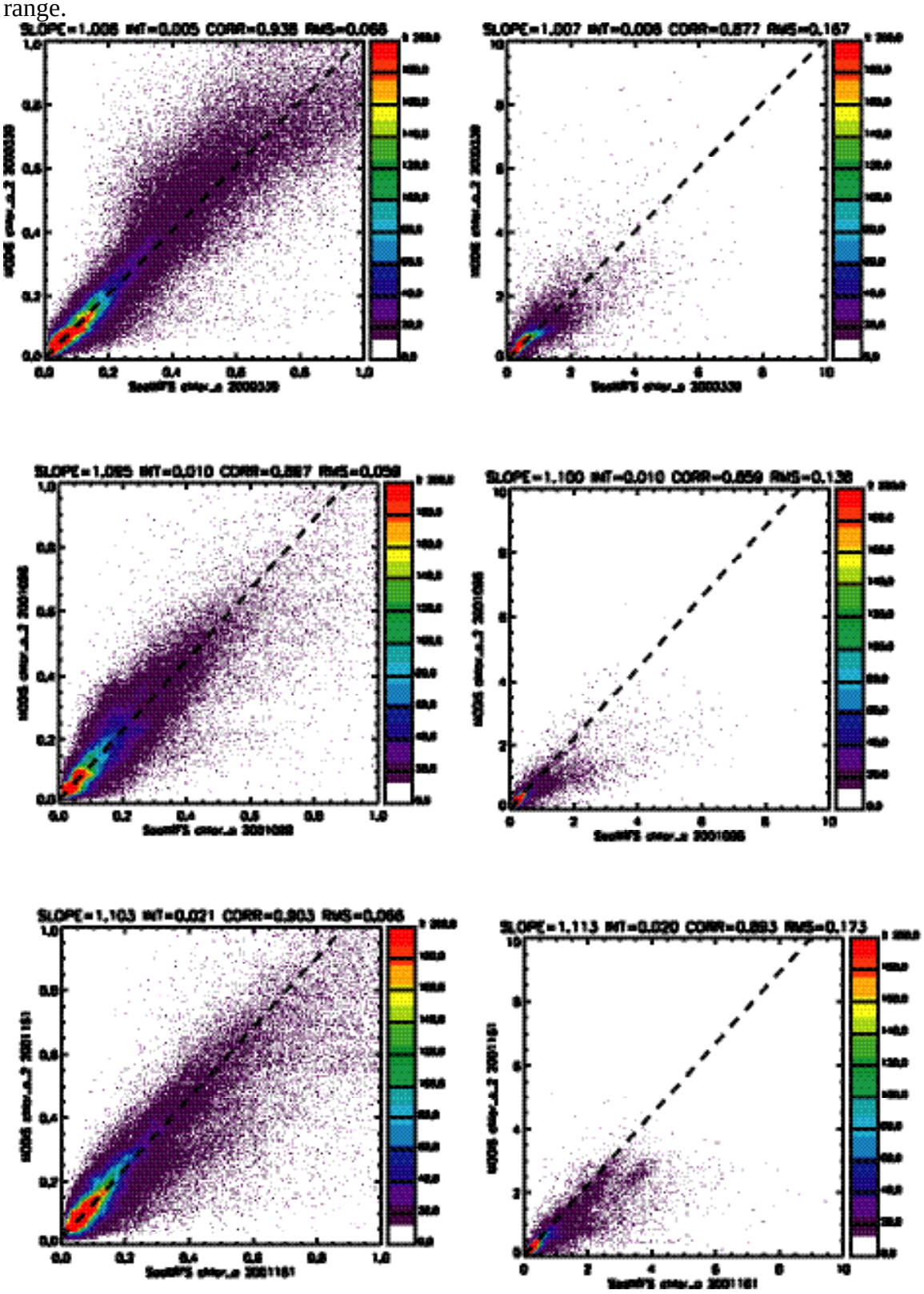


Figure 4c Chlorophyll Modis-SeaWifs comparisons column 1:full data range Column 2 reduce
range.



MODSST

While the bulk of our activities have focused on the ocean color products during this time frame the MODIS SST 11-12um product was declared validated. Time series analysis and comparisons with both MAERI and buoy matchups were in reasonable agreement. The validated Sea Surface Temperature (11 micrometer) data have well defined uncertainties and are suitable for longer term and systematic scientific studies and publication. However, improvements in the SST data are ongoing, and there will be later improved versions. The entire time series of Collection 3, i.e. November 2000 to the present, is considered validated.

Problems still remain with the 4um SST algorithm and we continue to analyze matchups, time series, and coefficient estimation procedures and radiative transfer models to better understand the issue with these channels.

B3. Direct Broadcast

Work has begun on making available to the general public real-time level-2 Oceans direct broadcast data for the East coast U.S. We have set up a mechanism to receive via ftp the 2.5min level 1b from the Goddard receiving station and modified our ocean programs to except the direct broadcast format for input into the standard Oceans level-2 code.

B.4 Systems Support

Modifications/Additions to DSP:

mextract,mcalibrate:
New programs for matchup database.

Problems fixed:

modcol:

Change nlw_678_max to rho_wn_max. If either aerosol model is 16 then quality is 3 (bad). Fix units for Lg865 to Reflectance. Change nlw_678_max to rho_wn_max, and change test value to reflectance. Add rho_t_max to processing log, and change test value to chan 14 instead of 13. Fix SeaWiFS oc3m algorithm. Fix CFE calculation. Split long lines to get rid of compiler warnings. Fix K_490 quality algorithm (constants were too small). Fix seawifs checks for which band is largest. Fix setting of unprocessed value for chlor_a and susp_solids. Various little changes to avoid divide by zero. Fix buffers for reading ahead geolocation info. Default quality of edge pixels to bad (3). Remove old debugs. Initialize all flags for each iteration of the pixel loop. Don't mix integer constant with reals for CoccoConNewNeg. Save space for the geolocation arrays that aren't used, but still passed to the routine that reads the l1b records. Shorten the 'if' structure in anlywc by removing

duplicates. Specify which Gordon bands are represented by the quality if bits 23-24 of L2a file. Use real constants instead of integer constants for initializing lambda (add '.' to each). Fix comments for k490 tests. Add Quality_Bits attribute to product SDS's to hold which quality bits pertain to the SDS. Use -1 instead of zero for default quality for first and last few lines. Fix pixel carryover to stop at 4. Fix quality for FLH and FLE. Put SeaWiFS OC3M quality in proper place instead of in place for chlor_modis. PEB and PUB pixels with negative values are now quality 3. Add option 'usef0var' to correct for solar distance. Move calls to set quality to after all product values are moved into output arrays so that setcolqual can see all the product values for the current pixel. Make sure cloud mask bytes are ordered correctly for portability. Add option to restrict edge pixel by changing their quality values to 3. Set bit 16 in MODOCL2 L2_flags to note edge quality change. Fix comments to use CFE instead of FLE. Make the satellite zenith angles negative for the first half of the line. Save the aerosol models for the call to setcolqual for the fluor. updates. Change the polarization calculation so that only the Rayleigh part of the total radiance is corrected. Don't use F0CORR, already removed from E_RAD (a reflectance). Convert RAY_Q/U to reflectance (from radiance/F0) to match E_RAD (reflectance). Add another polarization file in 302061 so we can have one for north of the sun, and one for south. Add quadratic time correction. 678 checks now set the B_*_Cloudy bits instead of B_Sun_Glint. Check B_*_Cloudy flag for bad nLw quality. Fix the new quadratic time equation.

modsst:

Add modcol cloud tests: new wang3sub.f, new nmc and ozone input files, replace nlw_678_max input coeff with rho_t_max and rho_wn_max, add glint scaling coeff (glintsc). Fix rho_wn test to set flag if zcmu0 is zero. Put bright26 in the Q2 file in place of alternate sst (night sst with Reynolds). Add 'Quality_Bits' attribute to the product SDS's to show which two bits hold the quality for the product. sst4qual daytime data is always quality 3. Land and unprocessed pixels are quality 3. Reflectance channels (14 and 16) are already normalized for f0var (yearly solar variation). Fix comments to match {}'s. Fix debug message to allow two digit channel number. Fix check for invalid geolocation. Add comments. Don't process box if center pixel is bad. Change satellite zenith angle in Q2 to be negative for the first half of the line. Fix bounds check for radinv array. Add quadratic time correction.

msbin:

Change quality description to start with bit number one instead of zero. Fix dataday dates, and day/night metadata for AQUA. Use large enough array for flag bit description. Fix setting of day/night for aqua and terra.

Baseline has no quality, so always return zero for good. Fix some comments. Read correct chlor_modis quality (it is separte from pig_total). If Quality_Bit attribute is in input file then use it to find the quality value for the product. Don't create or replace a bin if the pixel is a negative ocean color value. Only sum in negative ocean color values if the quality is 3 (bad). Write out L2 scaling attributes for mapper. Fix processing log, output file names, to allow more than 9 input files. Only check Quality_Bits for bands that have quality values. Only check for negative values in the 36 ocean color products, not the qc products. Add ability to bin all 4 extra modcol output files. Fix some typos in new code to bin all 4 extra modcol output files. Return error (-3) instead of null if input file open fails. Fix geolocation angles (they weren't used, but they were scaled incorrectly).

mtbin:

Write out L2 scaling attributes for mapper.

mcloud:

Write out L2 scaling attributes for mapper.

mmap:

Add 'usescale' option to use scaling information from coeff file (or pcf) or use L2 scaling information from input file attributes (for mean and standard deviation maps). Use L2 scaling from attributes only for mean and standar deviation maps.

mfill:

Use WATPCT instead of WATBINS to calculate output size so that it will work with any resolution. Write out L2 scaling attributes for mapper.

mspc:

Change array that holds number of data values per bin to 4 bytes to handle month and year totals. Baseline is always quality zero so all pixels are always binned. Write out L2 scaling attributes for mapper.

atmcorshr:

Add 'usescale' option to use scaling information from coeff file (or pcf) or use L2 scaling information from input file attributes (for mean and standard deviation maps). Use L2 scaling from attributes only for mean and standar deviation maps.

mfill:

Use WATPCT instead of WATBINS to calculate output size so that it will work with any resolution. Write out L2 scaling attributes for mapper.

mspc:

Change array that holds number of data values per bin to 4 bytes to handle month and year totals. Baseline is always quality zero so all pixels are always binned. Write out L2 scaling attributes for mapper.

atmcorshr:

rayleigh_rough.f: moved from modcol so modsst can use it also.
hdf_io_tools.c: Return FAIL instead of NULL (to appease a picky linux compiler).

binshr:

Use the actual number of bins in our 4km grid to calculate % water, instead of using the larger AABINS. Change array that holds number of data values per bin to 4 bytes to handle month and year totals. Baseline is always quality zero so all pixels are always binned. Read L2 scaling attributes from input and write them out to the output file. Change number of msbin input files to allow for extra modcol outputs. Return error (-3) instead of null if input file open fails.

modlib/io:

Fill in description for Dsp__PGS_Close (was missing).
modlib/mocean:

Check for FAIL instead of NULL from hdf routines. Change a swath attribute, GROUP=DataField , OBJECT=DataField_1 , parameter DimList to be DimList=("XDim", "YDim") so that the HEW subsetter can subset our modis maps.

modlib/modisio:

Fix mirror side for big and little endian. Make v2_meta_init extern instead of static because it is used by PGE17 and PGE19.

msstshr5/avhrrin1.rat :

Make equivalent to mcolshr8 include file (colorin1.rat) so a program can call both of them.

modinc:

New luns to bin extra modcol output files. Add B_Lw_restrict to show edge pixels that were changed to quality 3.

B.5 Team Interactions

Participate in weekly teleconferences with MCST, PIP and Oceans and intermittent teleconferences and meetings with MODIS QAWG and interactions with MODIS Ocean PI's to coordinate algorithm and quality level and flag definition updates. With the announcement that the MODIS 11-12um SST product is validated we worked closely with the PR office to create still and animated SST images and associated text.

C. Future Activities

C.1 Processing Development

Revised calibration with absolute stray light corrected Moby data. We expected to receive the official NIST stray light correct Moby data in the spring time frame. When that is received we will need to repeat the analysis to create the epoch inter-detector, cross scan, and mirror side corrections. We will also revisit the correction and calibrations factors more intensely for the new A-side. Additional work need to be done to create a more proper cross-scan correction using corrections to bands 15 and 16 and to correct bands 13 and 14 nLw in such a (consistent) way so that the FLH products are not adversely effected.

We will continue to work on improving the cox-munk sunglint correction. From our analysis to date it is clear that the shape of the current cox-munk correction is not appropriate and will require an adjustment factor to widen the application of the correction based on windspeed and by spectral band. In addition we would like to explore a vector based cox-munk calculation. We will also plan to incorporate an NIR correction in the atmospheric correction algorithm from Howard Gordon. The official V4.0 delivery to MODAPS will occur once the stray light corrected calibration, sunglint and NIR corrections are complete.

While V4.0 will be a dramatic improvement over the previous version we expect some problems to still exist. We believe that to completely eliminate the striping in the level-2 products will require unique per detector cross scan and mirror side correction factors,

not the average behavior to be used in V4.0. We also believe that polarization is playing a role in some of the remaining problems.

It is also expected that MCST will be delivering new Level-1b LUT's in the future. Each new MSCT delivery requires Oceans to completely evaluate correction and calibration tables.

We also need to redo revisit calibration and correction factors (interdetector, mirror side corrections, cross-scan changes, and spectral calibrations) for SST, since now we're back on A-side electronics and working under a different set of LUTs.

We will also make code changes as needed for cross platform compatibility, specifically to enable processing on alpha and unix platforms in addition to the standard SGI systems.

C.2 Matchup Database

Continued work with D. Clark to collect MOBY and MOCE data. Will continue to extract 5x5 boxes of MODIS pixels for MAERI and buoy matchups for SST. We also will continue our work in comparing retrievals from other sensors, eg. SeaWifs, AVHRR

C.3 Direct Broadcast

We plan on creating a dynamic web page with a 14 day rolling archive to deliver the direct broadcast data to the public. This will include composite images for the U.S. East coast to be made available in GIF images, and binary format in addition to the standard EOS HDF of the 2.5min level 2 granules. We currently plan composites for true color L1b, SST, and Chlor_a2.

C.4 Systems Support

We plan to continue upgrading the RSMAS SCF in terms of disk and tape storage in anticipation of the launch of AQUA which will double the data loads at the Miami SCF.

C.5 Team Interactions

Continue participate in weekly teleconferences with MCST, PIP and Oceans and intermittent teleconferences and meetings with MODIS QAWG and interactions with MODIS Ocean PI's to coordinate algorithm and quality level and flag definition updates. We will also continue to interact with the PR office as needed. We have also begun strong interactions with the SeaWiFs product office in regard to activities relating to merged SeaWiFS MODIS products, and Ocean color validation activities.