MOBY238 and 40 Deployment Final Report

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MOBY238 - 21 Jun 2007 - 10 Sep 2007
MOBY240 - 28 Mar 2008 - 20 Aug 2008

Overview of problems

- M238: The only problem with M238 was the decrease in the UV for LuMid. The problem started on day 1 and affected the 345nm data first. As the deployment continued the problem got more severe and began affecting bluer wavelengths. By the end of the deployment (81 days later), 345 nm was down by 20% and the problem was beginning to effect 390 nm.
- Between deployments we were fortunate that Mike Feinholz had time to do a number of cals while MOBY was in the tent. These data show the decrease in the UV region continued after the buoy was out of the water, Mike's cal covered a three month period.
- M240: The UV problem which started with M238 continued in M240. The LuMid data at 345 nm started 30% low and the problem could now be seen at 390 nm. By the end of the deployment the 345 nm data were down by 60%, 390 nm was down by around 18% and the decrease was just starting to effect the 480-490 nm data.

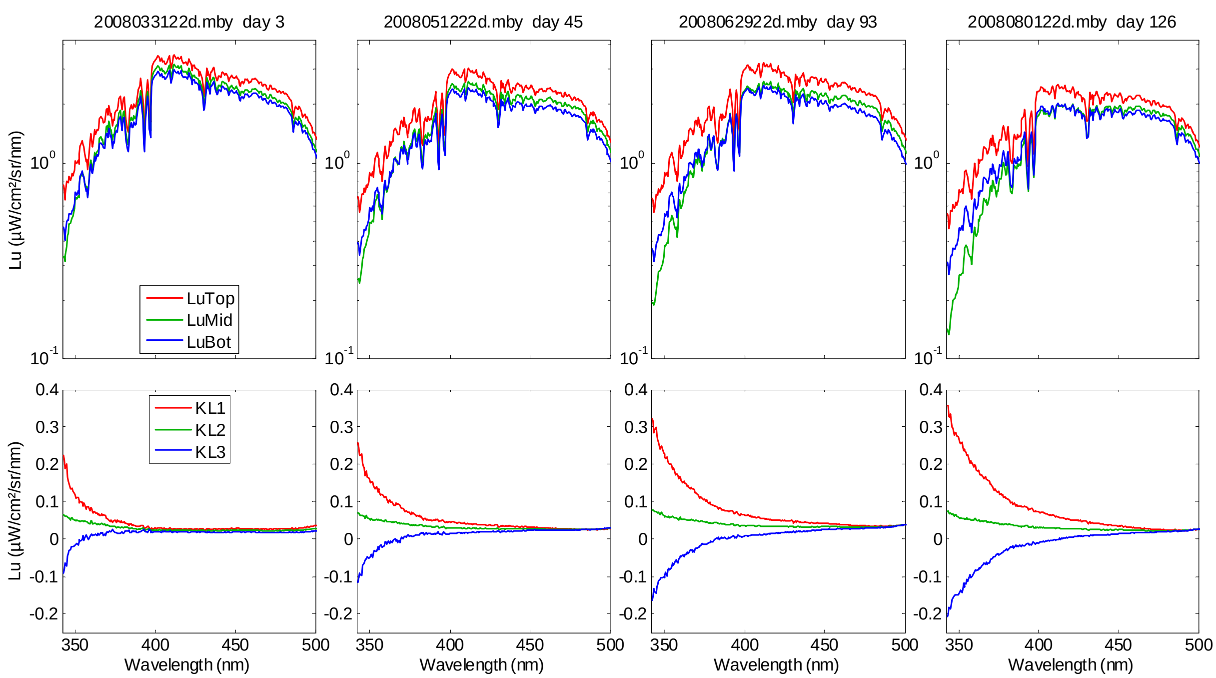

Figure 1. MOBY240 Time series of the progression of the decrease of the LuMid UV data. The top panels are the Lu top, middle and bottom data and the bottom panels are the corresponding K_L's.

Figure 1 shows the progression of the problem from the start of M240 to the end of the deployment. It is easiest to see the problem in the K_L's. K_{L1}(top,mid), K_{L2}(top,bot) and K_{L3}(mid,bot) diverge more and more as the deployment continues. This is caused by the decrease in the LuMid's UV data (green line, top panel).

Solution

During the June 7, 2011 telcon with the MOBY team, Ken Voss suggested using the good K_{L2} (top-bot) data to adjust LuMid to make K_{L3}(mid bot) same as K_{L2} (top bot). This should also fix K_{L1} (top,mid). So the following equations were used to create an new LuMid using the LuBot data and K_{L2}(top,bot).

Diffuse spectral radiance attenuation coefficient, K_L, is computed between two observed depths. For K_{L3} it is calculated between the mid and bottom arm (this is the K_L with the large down turn in the UV).

$$K_{L3} = -\frac{\ln\left(\dfrac{L_2 R_{N2}}{L_3 R_{N3}}\right)}{(z_2 - z_3)} \qquad \textbf{(1)}$$

where L_2 and L_3 are the radiance at the two depths (mid and bot arms), z_2 and z_3 are the depths (of the mid and bot arms), and R_{N2} and R_{N3} are the surface irradiance ratios computed as

$$R_{N2} = \frac{E_{SR}}{E_{s2}} \qquad \textbf{(2)}$$

$$R_{N3} = \frac{E_{SR}}{E_{s3}}.$$

E_{SR} is the reference surface irradiance (LuTop Es) and E_{S2} and E_{S3} are the surface irradiances at depths 2 and 3 (mid and bot). E_{SR}, E_{S2} and E_{S3} are surface irradiance taken before Lu top, middle and bottom respectively

K_{L2} (top-bot) is calculated similarly, using the top and bottom arms. The top and bottom arms had no problems and K_L's derived from these two arms looked really good. So Ken's idea was to use the K_{L2}(top-bot) to figure out how much we needed to adjust the LuMid to make it's K_{L3}(mid-bot) equal to K_{L2}(top-bot). So we start by defining the two K_L's as equal. And then solved for LuMid or L_2.

$$-\frac{\ln\left(\dfrac{L_1 R_{N1}}{L_3 R_{N3}}\right)}{(z_1 - z_3)} = -\frac{\ln\left(\dfrac{L_2 R_{N2}}{L_3 R_{N3}}\right)}{(z_2 - z_3)} \qquad \textbf{(3)}$$

The above equation is K_{L2} == K_{L3}. The right is equal to $K_{L2.}$ So we rewrite the equation as...

$$K_{L2} = -\frac{\ln\left(\dfrac{L_2 R_{N2}}{L_3 R_{N3}}\right)}{(z_2 - z_3)} \qquad \textbf{(4)}$$

$$K_{L2} = -\frac{\ln(L_2 R_{N2}) - \ln(L_3 R_{N3})}{(z_2 - z_3)} \quad \textbf{(5)}$$

$$K_{L2} = \frac{\ln(L_3 R_{N3}) - \ln(L_2 R_{N2})}{(z_2 - z_3)} \quad \textbf{(6)}$$

$$K_{L2} \cdot (z_2 - z_3) = \ln(L_3 R_{N3}) - \ln(L_2 R_{N2}) \quad \textbf{(7)}$$

$$K_{L2} \cdot (z_2 - z_3) - \ln(L_3 R_{N3}) = -\ln(L_2 R_{N2}) \quad \textbf{(8)}$$

$$\ln(L_3 R_{N3}) - K_{L2} \cdot (z_2 - z_3) = \ln(L_2 R_{N2}) \quad \textbf{(9)}$$

$$\exp(\ln(L_3 R_{N3}) - K_{L2} \cdot (z_2 - z_3)) = L_2 R_{N2} \quad \textbf{(10)}$$

$$L_{2new} = \frac{\exp(\ln(L_3 R_{N3}) - K_{L2} \cdot (z_2 - z_3))}{R_{N2}} \quad \textbf{(11)}$$

The result is L_{2new} which are LuMid data who's UV section is "fixed" using the LuBot and K_{L2}(top-bot) data. If you calculate K_{L3}(mid-bot) using the new LuMID data then K_{L3}(mid-bot) will equal K_{L2} (top-bot), green line in Figure 1.

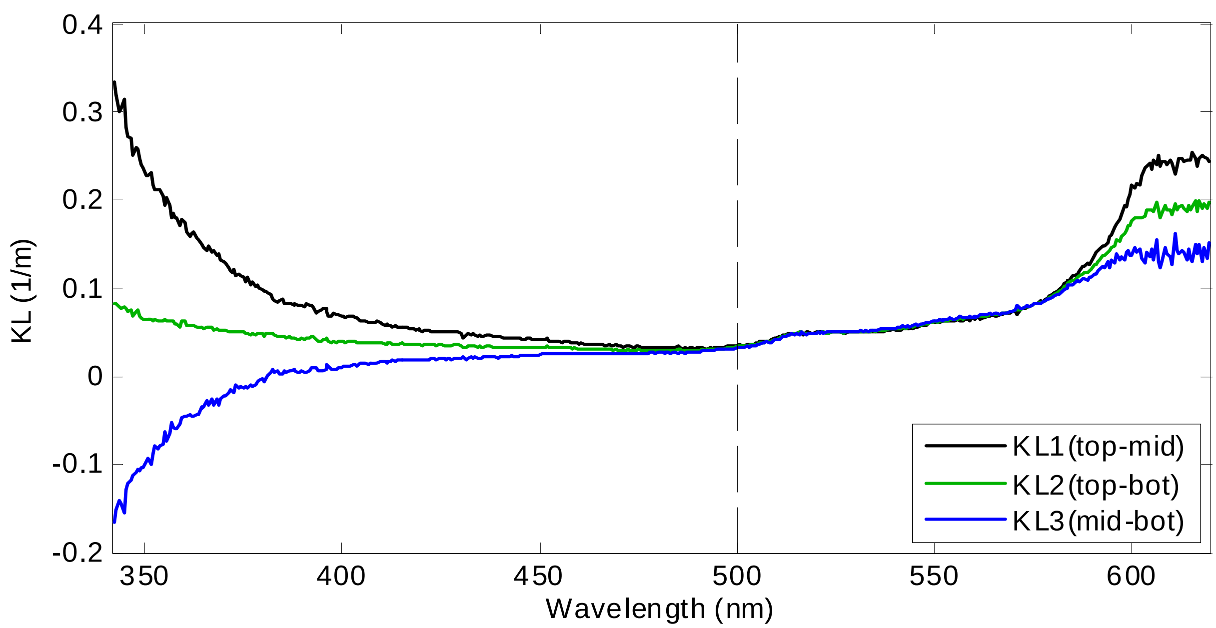

Figure 2. The three KL's calculated from the Lu Top, Middle and Bottom arms. Notice the trumpet shape created between 340 and 500 nm by the decrease in the LuMid's UV data. Also note that around 575 nm the KL's diverge. This is not related to the UV problem.

The new LuMid created would generate a K_{L3} (blue line in Figure 2) which was identical to K_{L2} (green line in Figure 2). There are two problems with this. K_{L2} and K_{L3} are not the same after 575 nm mostly due to Raman scattering. So the new and measured LuMid's need to be merged together. We chose 500 nm as the wavelength to merge the two LuMid's. 500 nm is not affected by the UV problem, the divergence of K_L in the red or by Raman scattering at redder wavelengths.. From 500-950 nm the measured LuMid would be used. From 340 - 500 nm the new LuMid would be used. To accomplish this merger the new LuMid had to be adjusted up or down to match the measured LuMid at 500 nm. The final result is a new LuMid which does not have the UV problem. The changes over time relative to the new LuMid by wavelength are shown in Figure 3.

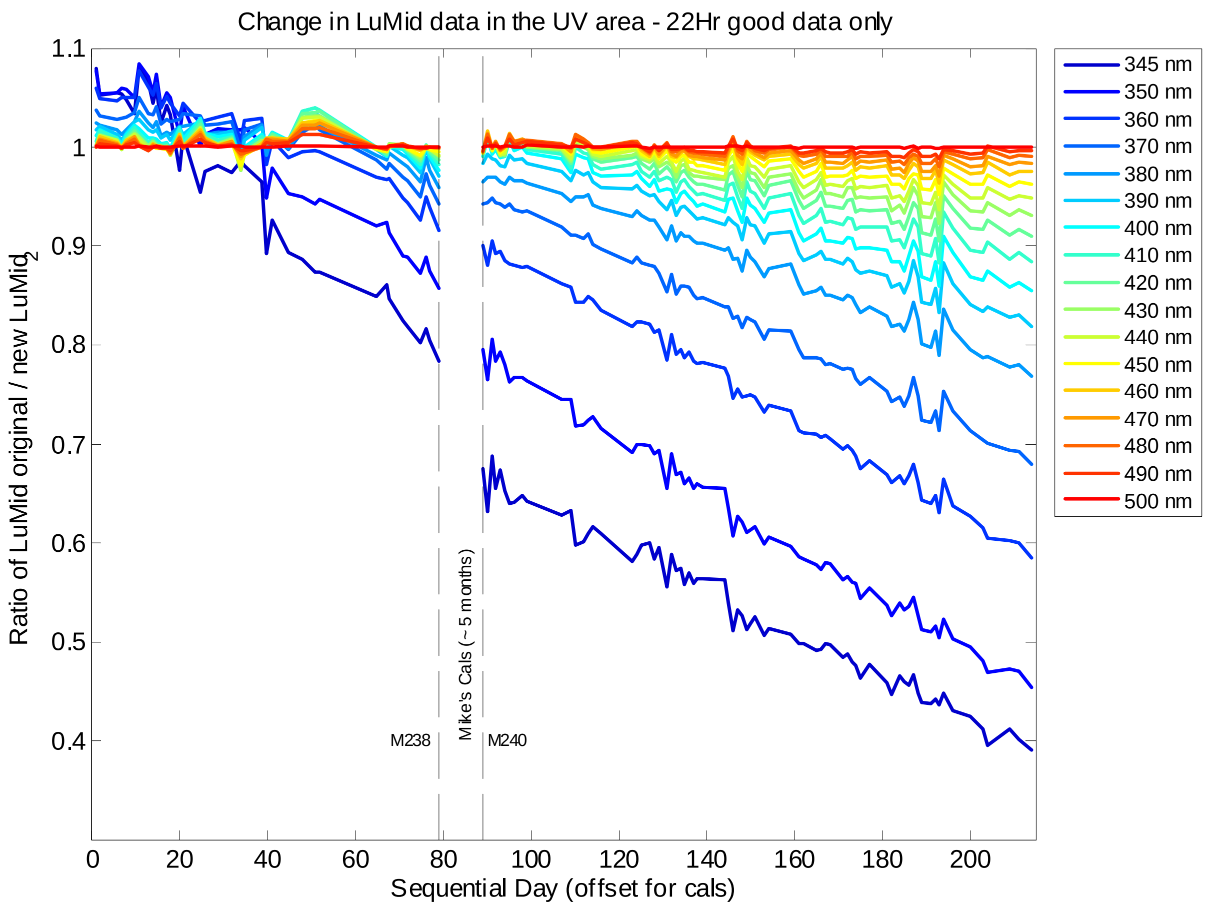

Figure 3. MOBY238 and 240 ratio of original data over the new LuMid data. This shows that by the end of the deployment 345 nm was 60 percent lower than predicted.

Figure 3 shows the very nice linear correction across two deployments. If Figure 4 were inserted into the graph then you would see a continuous linear decline in the UV wavelengths from M238, to cals in the tent, and through the M240 deployment. It is still not known what caused this decline. Other deployments have exhibited this problem but none have been extensive enough to affect the satellite weighted data.

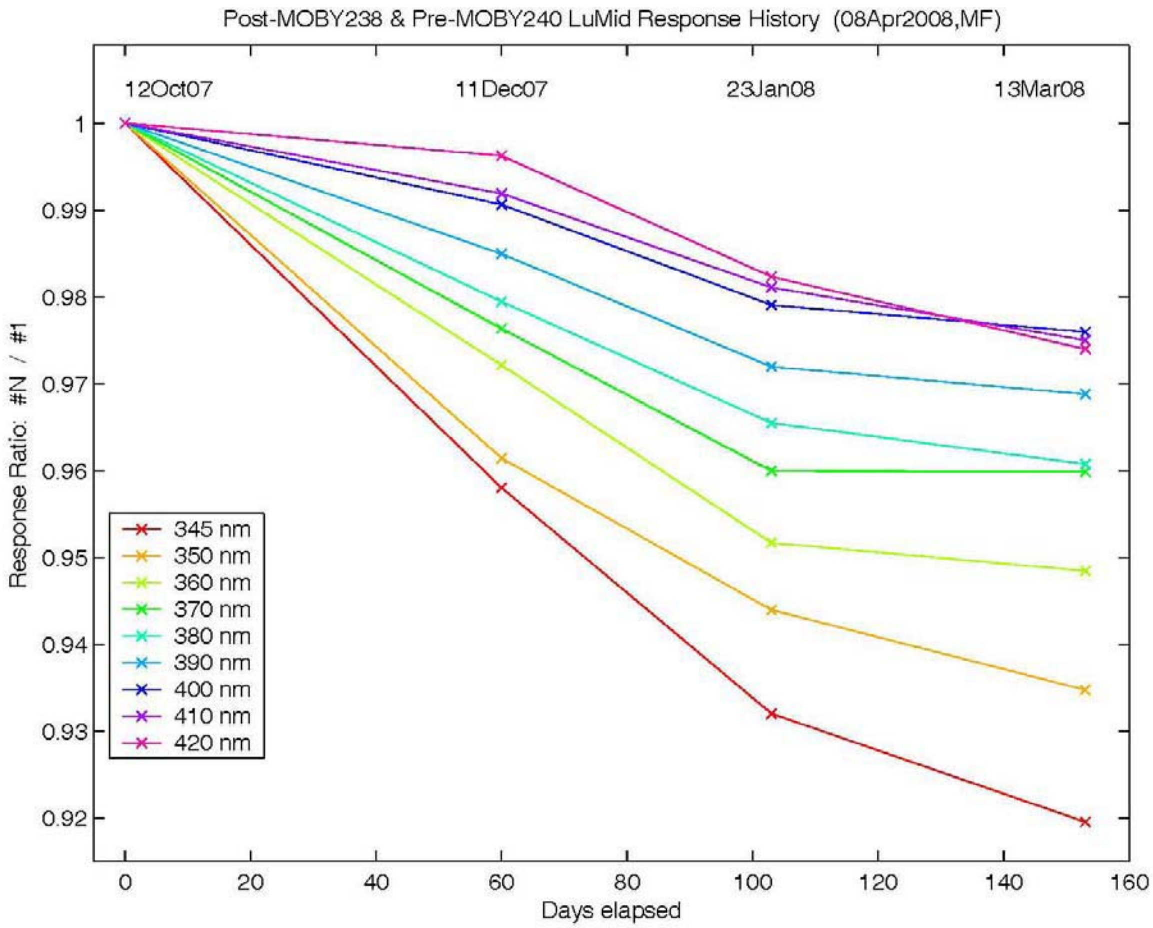

Figure 4. Mike's graph showing the continuing drift of the LuMid's UV region while MOBY was in the tent between deployments.

We were fortunate that Mike had time to do a number of cals while MOBY was in the tent. The graph above shows the decrease in the UV region continued after the buoy was out of the water. It looks like it decreased by another 8% at 345 nm.

The resulting new LuMid was then used to recalculate the two Kl's, Lw's and nLw's. Below is a listing of the new variables created. Two Lw's used LuMid in their calculation, Lw1 and Lw7. Lw1 is calculated from LuTop and Kl(top,mid), Lw7 is calculated from LuMid and Kl(mid,bot). The new Lw's calculated from the new LuMid were given the numbers Lw12 and Lw13. Lw12 is equivalent to Lw1 and Lw13 is equivalent to Lw7. Two types of nLw's were calculated as well. nLw is calculated using the CZCS method and nLw2 is calculated as Lwn2 = (Lw/Es).*(Fo/Res), where Fo is the Thuillier (2003) solar spectrum and Res is the earth-sun distance.

New LuMid(UV cor): MOS Upwelled Radiance (μW/cm²/sr/nm), P = 5.1
New LuMid(UV cor): Diffuse Attenuation (1/m) Kl1 Lu1-Lu2
New LuMid(UV cor): Diffuse Attenuation (1/m) Kl3 Lu2-Lu3
New LuMid(UV cor): Water-Leaving Radiance Lw12, Lu1 and Kl1 (Lu1-Lu2)
New LuMid(UV cor): Water-Leaving Radiance Lw13, Lu2 and Kl3 (Lu2-Lu3)
New LuMid(UV cor): Solar-Norm. Lw, nLw12, Lu1 and Kl1 (Lu1-Lu2)
New LuMid(UV cor): Solar-Norm. Lw, nLw13, Lu2 and Kl3 (Lu2-Lu3)
New LuMid(UV cor): nLw2 12, Lw12 over Es VR9
New LuMid(UV cor): nLw2 13, Lw13 over Es VR17

All the new data were then satellite weighed. The following graphs show the change for the

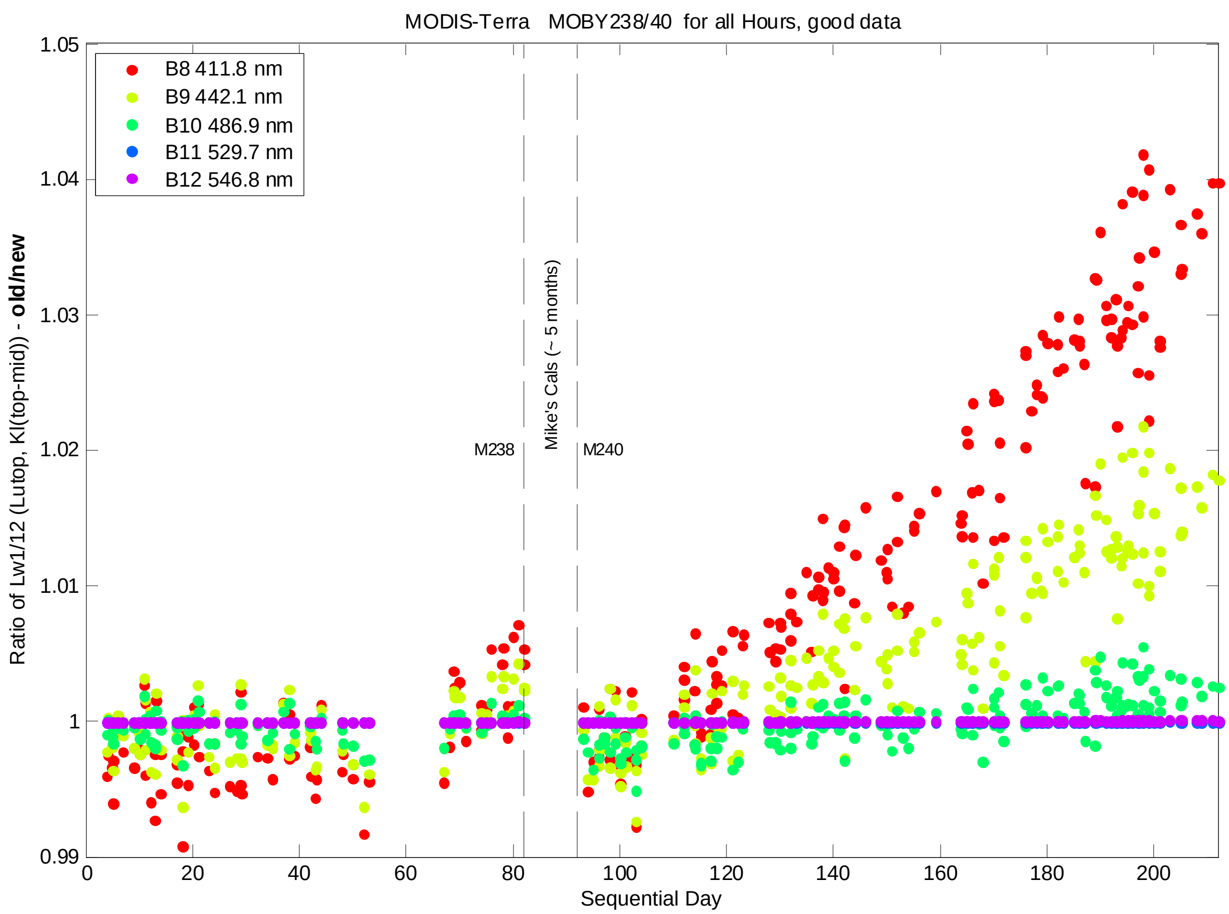

Figure 5. Time series showing the changes in MODIS-Terra bands from Lw1 and Lw12 for deployments M238 and 40.

Because Lw1 and 12 are influenced by LuMid through KL(top,mid) thereforethe changes are small. You can see even thought the problem was clear at 345 nm for M238. The effect on the 411 nm band is negligible until the end of the deployment. The change for M240 is larger with the maximum being 4% for the 411 nm band. The only changes seen for bands greater than 500 nm is from the effect of the out-of-band signal.

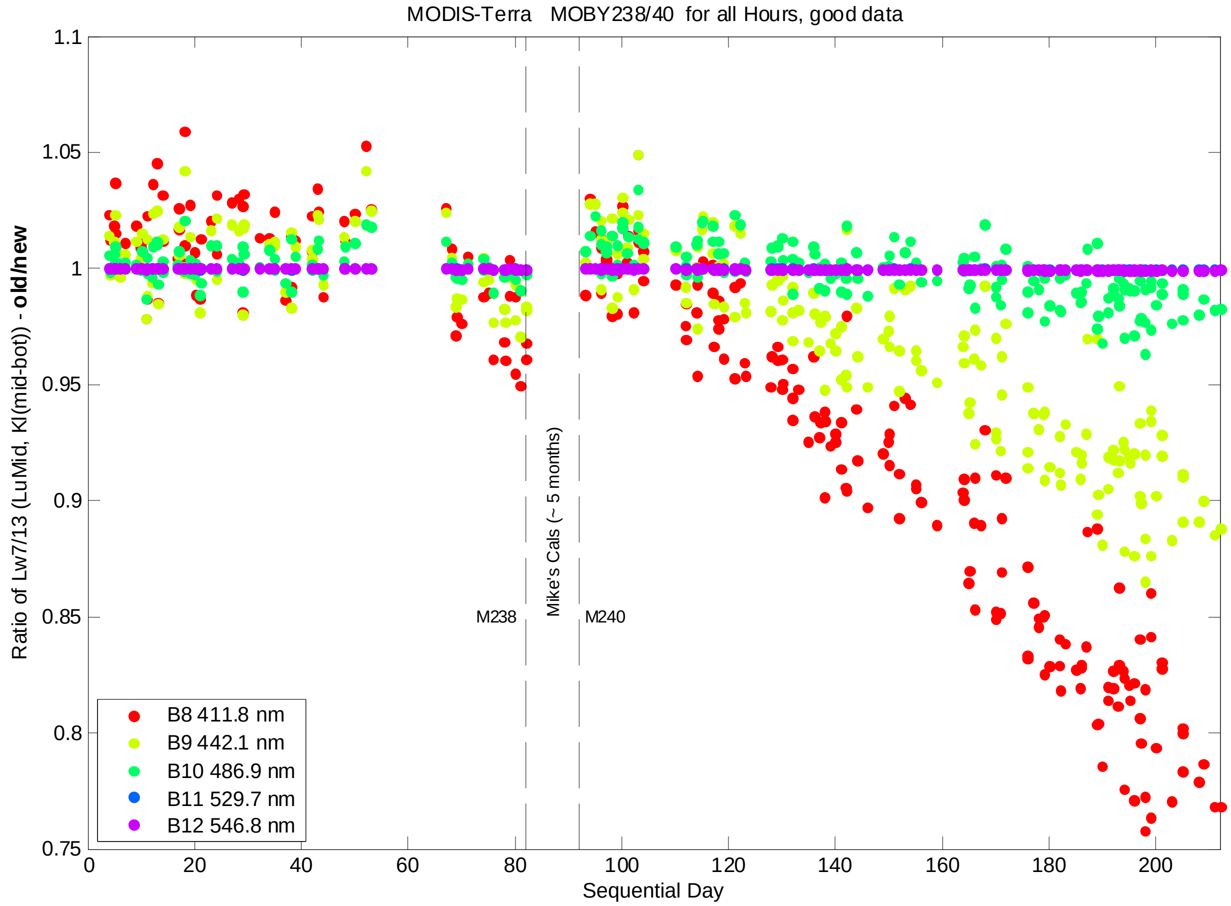

Figure 6. Time series showing the changes in MODIS-Terra bands from Lw7 and Lw13 for deployments M238 and 40.

Because Lw7 and13 are calculated usind LuMid, as the Lu, therefore the changes between the two Lw's is much larger. Up to 30% higher for the 411 nm band.

Once I was sure the calculations were working and applied correctly, we needed to determine how well LuMid was being recreated. So the same programs were run on M241 a deployment which did not have any problems with its LuMid data.

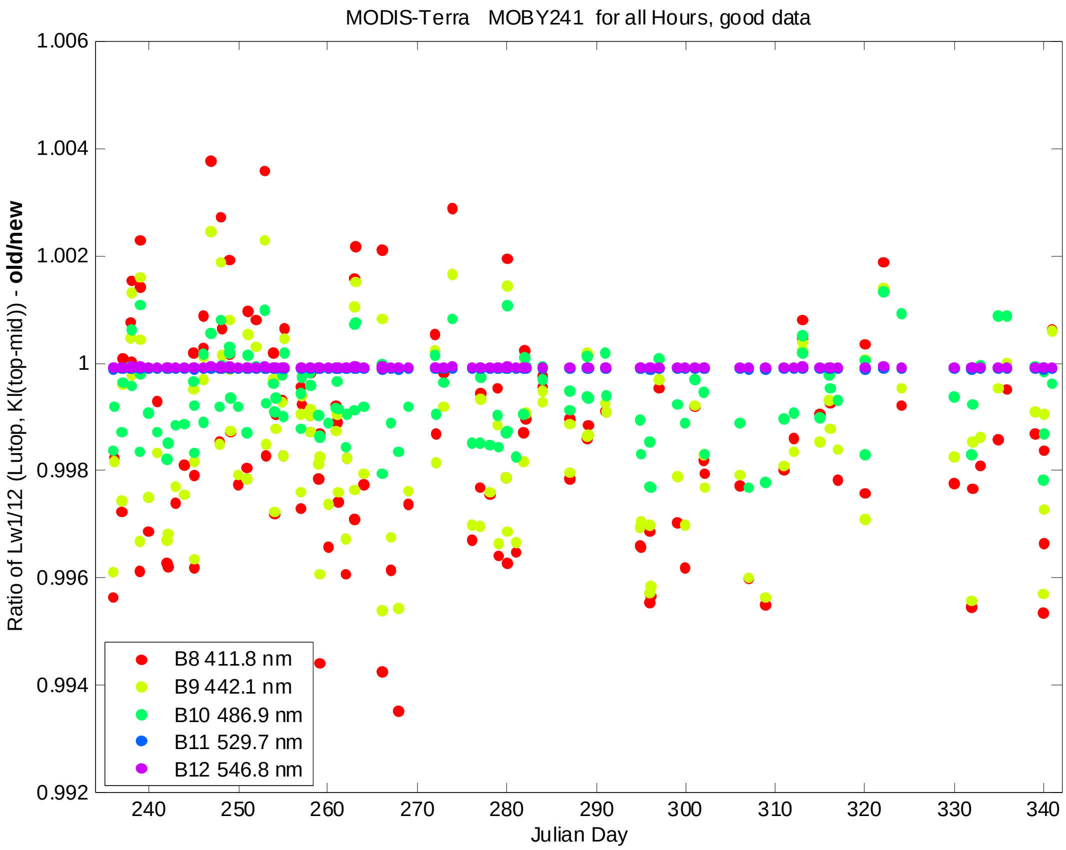

Figure 7. Time series showing the changes in MODIS-Terra bands from Lw1 and Lw12.

The same graphs are created for the M241 deployment. Remember that the LuMid from this deployment had no problems. So this graphs tells us how well we are recreating the LuMid

Table 1: Percent standard deviation (std) for the above ratios		
Band	Lw1/12	Lw7/13
8	0.20	1.56
9	0.1	1.25
10	0.08	0.64
11	0.0004	0.0031
12	0.0006	0.0050

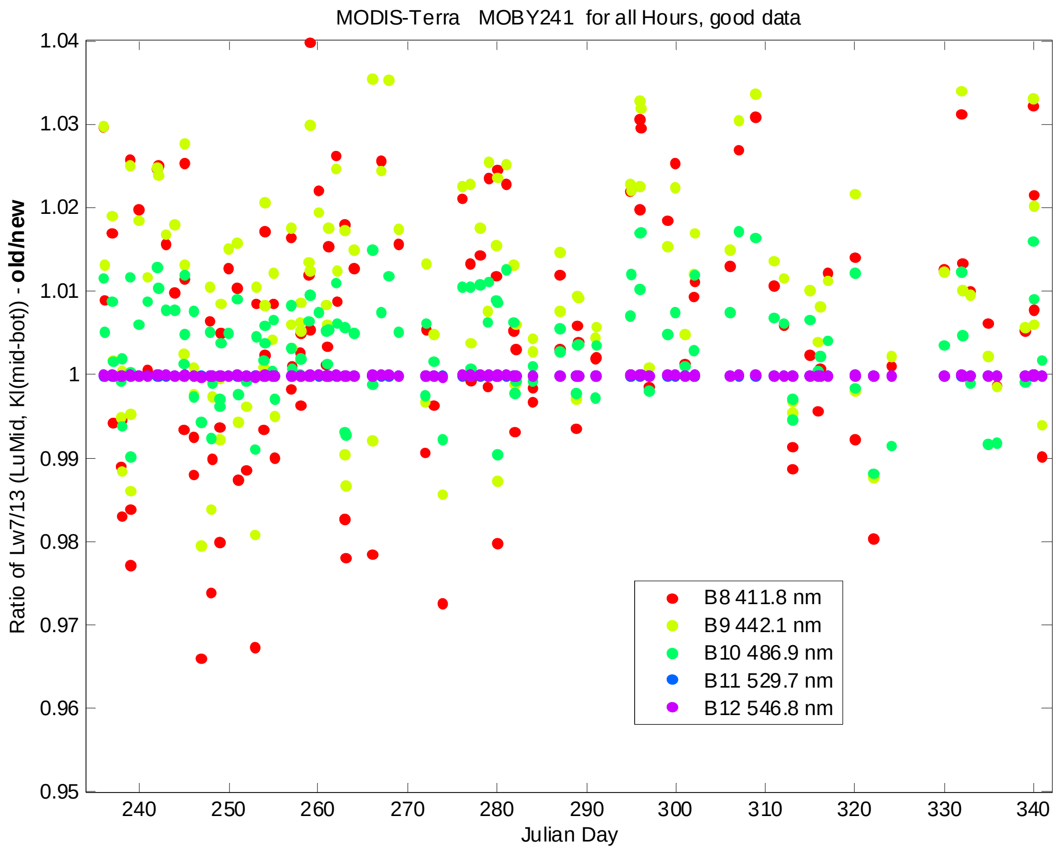

Figure 8. Time series showing the changes in MODIS-Terra bands from Lw7 and Lw13.

Both M238 and M240 were reprocessed and all the data was satellite weighted and uploaded to the MOBY website and gold directory.

For any questions about this data set or how the calculation were done please contact Yong Sung Kim at NOAA (email: Yong.Sung.Kim@noaa.gov).