Study of Odd Discontinuties at the Intl Date Line on D+N Aqua-Terra Images
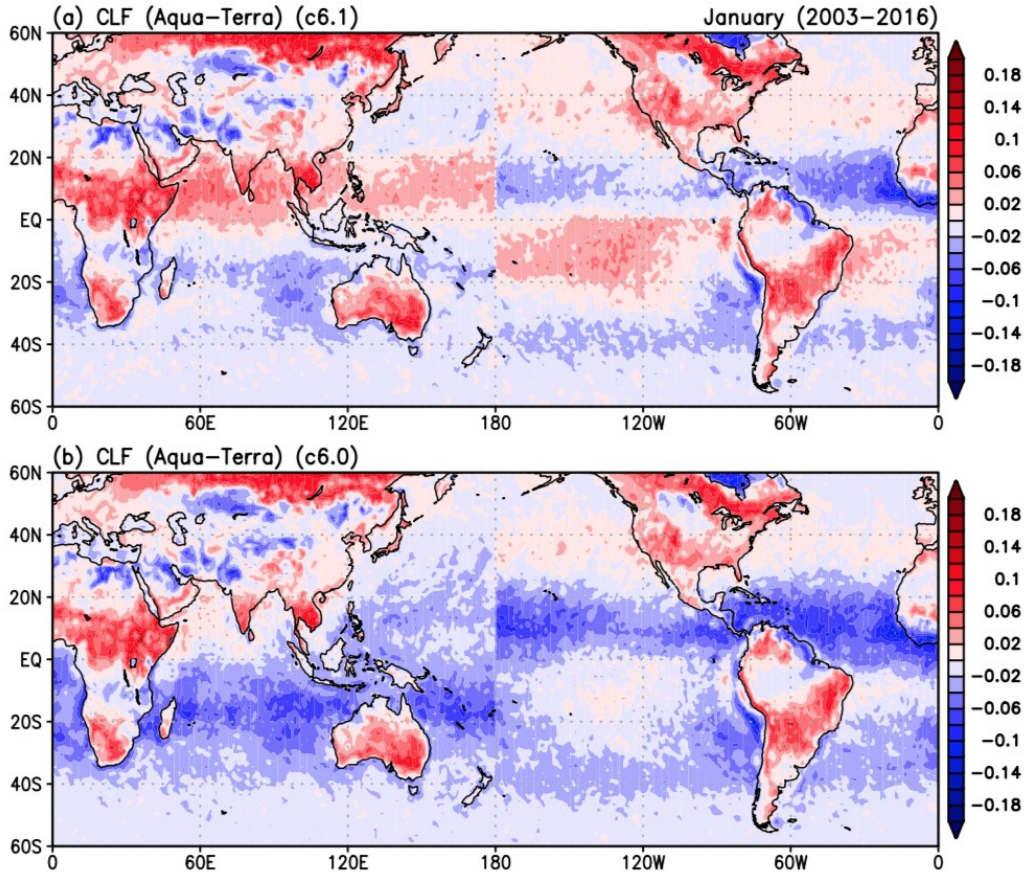
This plot was made by Kyu Kim back in the Summer of 2018 showing there is a marked discontinuity at the dateline but only for Cloud Fraction from Cloud Mask D+N (Aqua – Terra) both the Mean and the Pixel Counts.

This plot is for Cloud Fraction Differences for January's from 2003-2016

It's noteworthy that from the images on page 1, this dateline discontinuity shows up in both c6.1 (top) and c6.0 (bottom) … the new defn of day correction which uses a hard cutoff at 0 and 180 degrees longitude was introduced in C6.0 and continued in C6.1, so it's not surprising this linear discontinuity shows up in both C6 and C6.1

That being said, I would be curious to see if this anomaly showed up in C5.1, which used the old 0000 to 2400 defintion of day.   I would think that with the choppy "endpoints" or "edges" in each day in C5.1 (that is not based on a hard longitude line) that the 5.1 data would not show this same sort of vertical linear effect at 180 degrees that appears in C6 and C6.1

Transposing the image on page 1 to show a more typical view (the native way the data is stored in the files and how we typically view L3 images on the AI website, there does not appear to be an obvious linear discontinuity feature around the Grenwich Meridian (0 degrees longitude). However there is somewhat of a "flipping" of + to – around the equator with the deltas in one 180 degree zone vs the other. However it's not clear if that is a problematic signature.
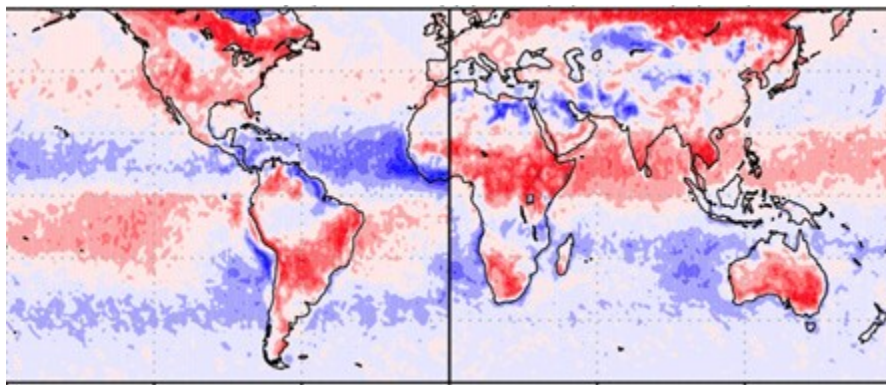

From Gala:

"I can run MARA on CRGMule. MARA has definition of day coded in and it is flexible. I can turn it on or off as I feel like. So this is actually a very easy thing to do and I've done this experiment before. You can see the result in this MARA newsletter. When you have definition of day on, you get a nice daytime image (so that tau/re looks great) but you have this horrid night-time image and any SDS that's D+N will have a pattern just as the third panel there, combined. This is an image of scan start time, which is also a D+N SDS. If you have the definition of day off, you get a kinda messy-looking daytime image because there is always an extra piece of an orbit dangling and overlapping stuff. I can run the cloud fraction, no problem, but the result will be exactly like what I have in this document."

"This pattern is present without shifting for every single day of the year, so it doesn't matter how many days you look at. It will never, ever wash out. I will set up a run for a month on CRGMule to show how this pattern does not wash out because it is a static pattern, not a dynamic one. "

The next plot is for Cloud Fraction Diffs for July's from 2003-2016, which shows the same discontinuity.
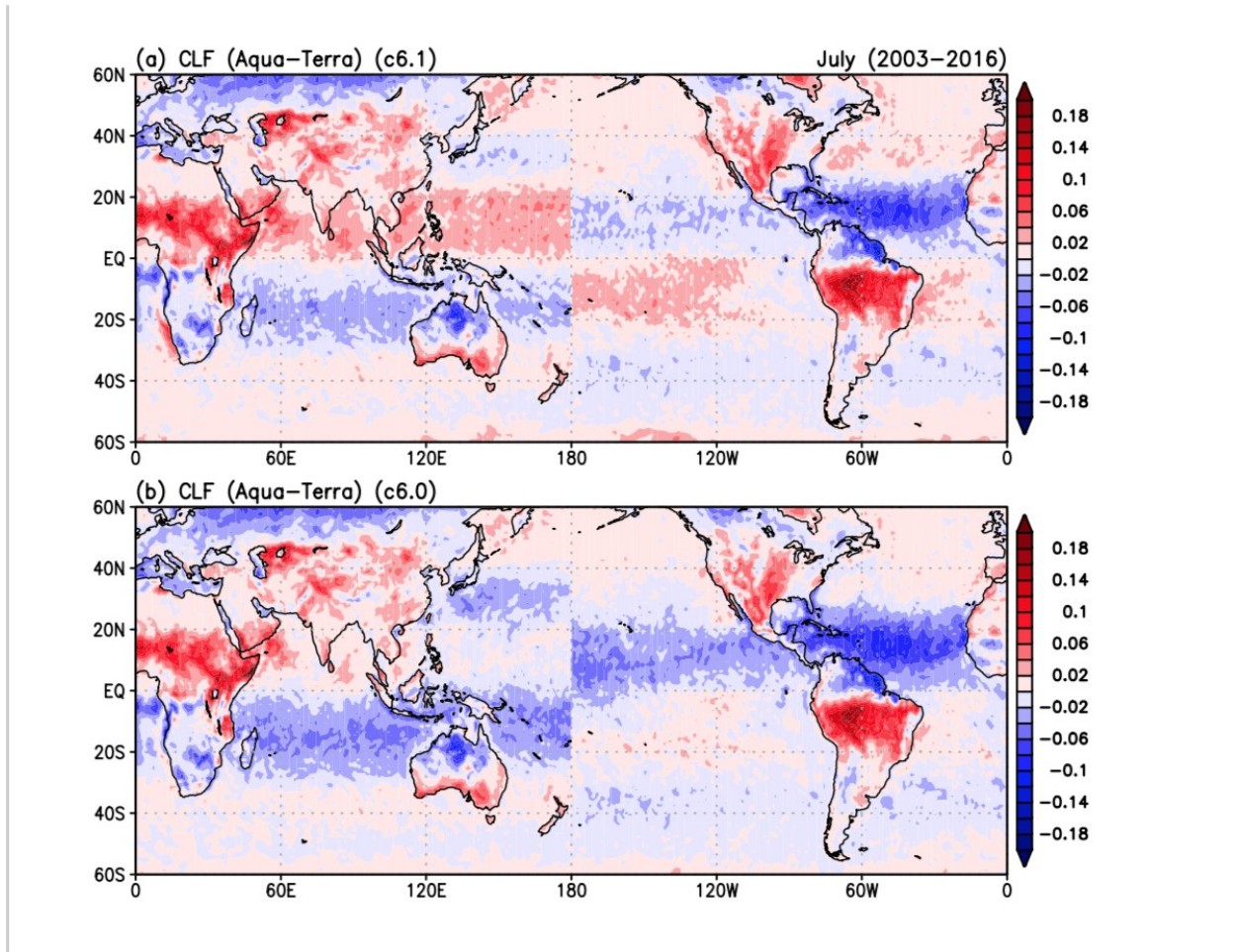
However If you look at Day only or Night only, it disappears.

Therefore, this discontinuity is NOT seen in Cloud Retrieval Fraction because we do DAY ONLY for COP retrievals. This odd signature noted in the first set of images seems to be indirectly related to D+N aggregations.
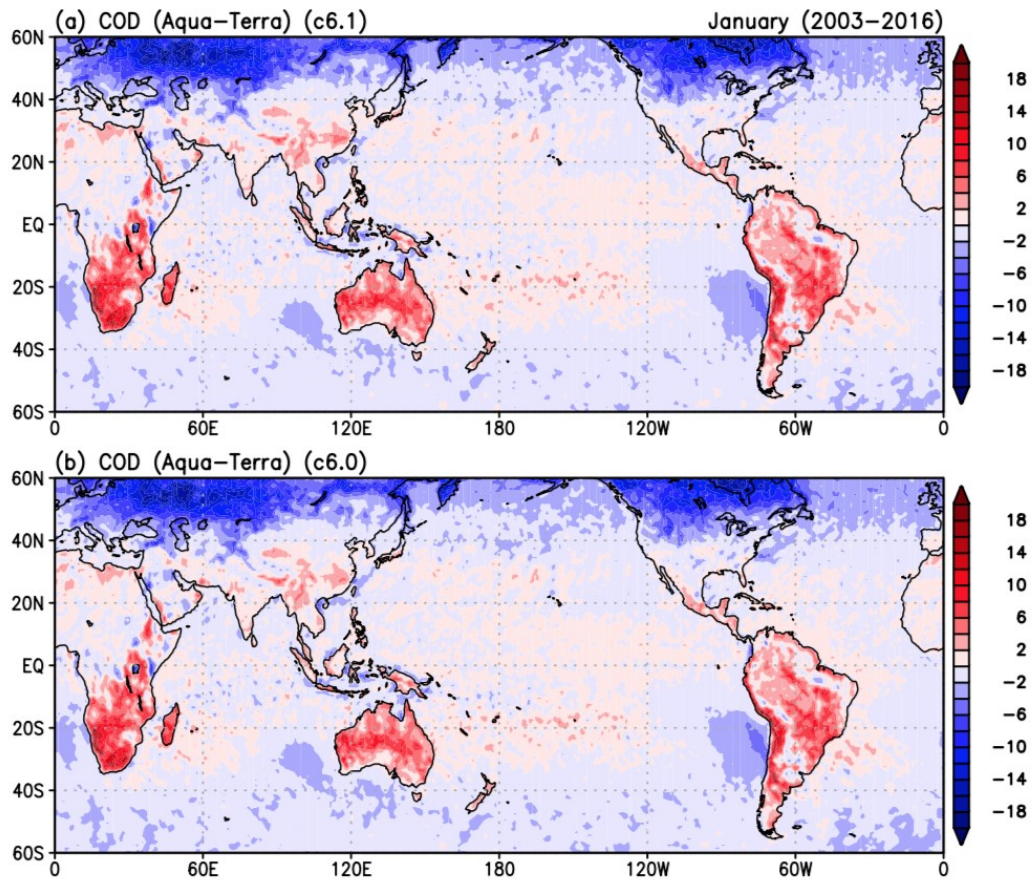
That being said, it's interesting that other parameters that had both Day and Night aggregations, like CTP and CTT looked absolutely fine with no discontinuity. Plotted below are CTP and CTT (for D+N and Aqua-Terra)

(a) CTT (Aqua–Terra) (c6.1) January (2003–2016)

(b) CTT (Aqua–Terra) (c6.0)
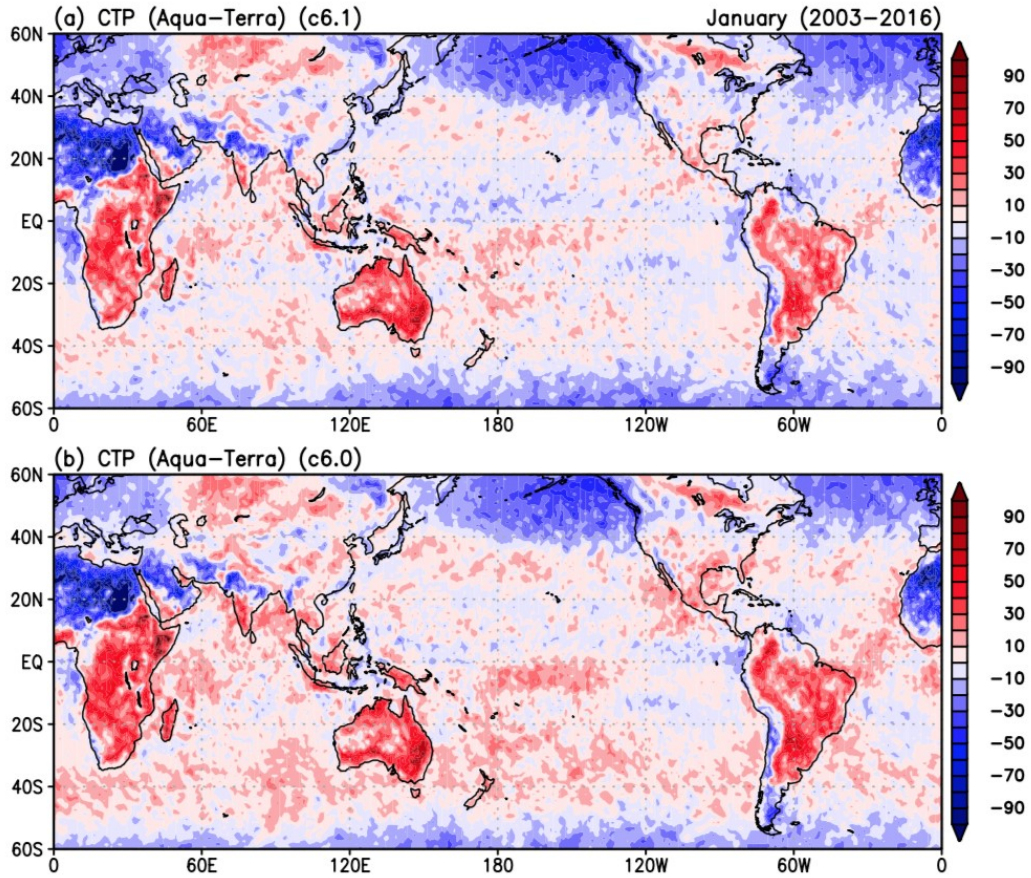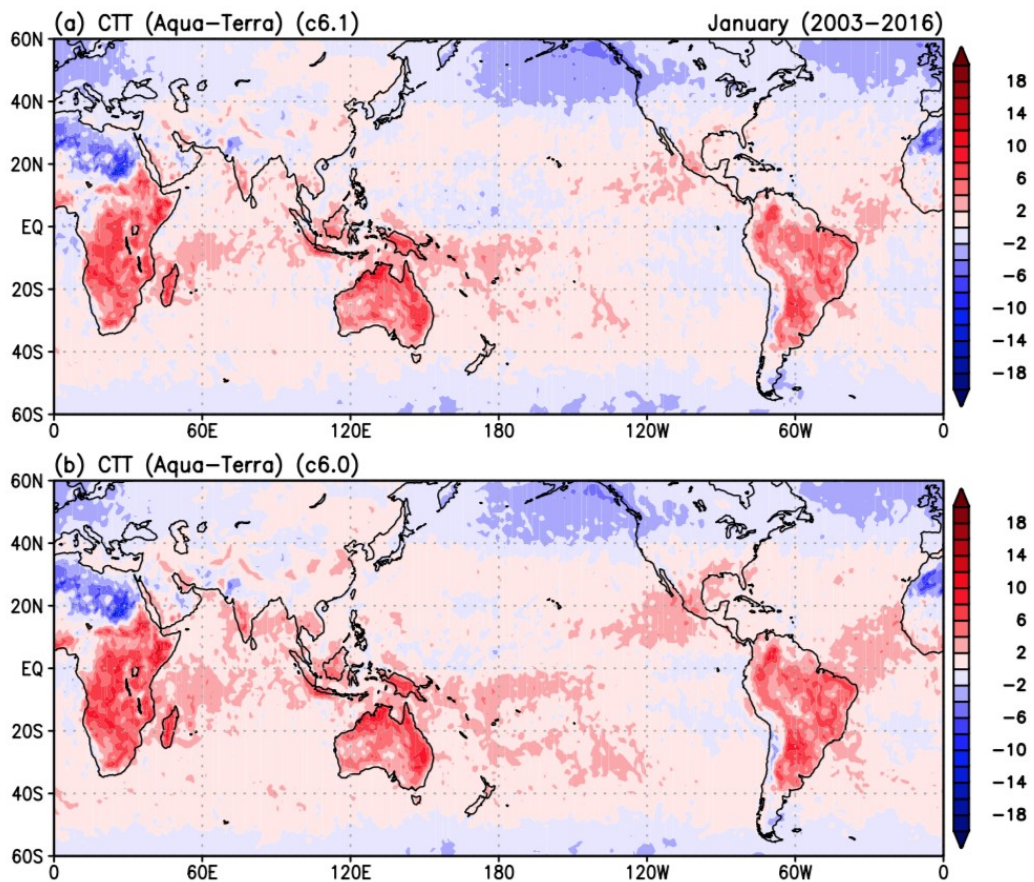
So D+N aggregations of other Cloud Top Property parameters have no issue. The discontinuity issue is isolated only in Cloud Fraction from Cloud Mask when you combine D+N and look at a difference of Aqua-Terra.

So the million dollar question is: What's different about D+N Cloud Fraction from Cloud Mask vs. other D+N cloud top property parameters?

Well one obvious difference is Cloud Fraction does contain clear sky data while the other CTP-related parameters do not.

At this point I was curious if I would also see this discontinuity signature (noted in the first set of images) in our L3 files for just 1 month (and not a multi-month/multi-year average)

First I looked at M3 data from Jan 2008

I looked at Cloud_Fraction_Mean_Mean (D+N) **Aqua-Terra** for an entire Month (M3)

I can see from the image below that there are signs of a discontinuity setting up at the dateline and at the grenwich meridian (see how the peak Fraction differences seem to SHIFT north and south slightly (about the equator) at those 2 meridians.   In other words, it does seem odd there is a strip of bright yellow and reds north of the equator from 0 to 180E (Asia) – but the strip of bright yellow and reds is south of the equator from 180W to 0 (Pacific/N.A).   Why does that happen?   (note that the 180 longitude is in the center of my Panoply imagery below vs. 180 being on the edges in K.Kims images (previous).

Cloud Fraction (from Cloud Mask)   Day+Night   Aqua - Terra Difference   January 2008

Data Min = −0.3, Max = 0.4, Mean = 0.0
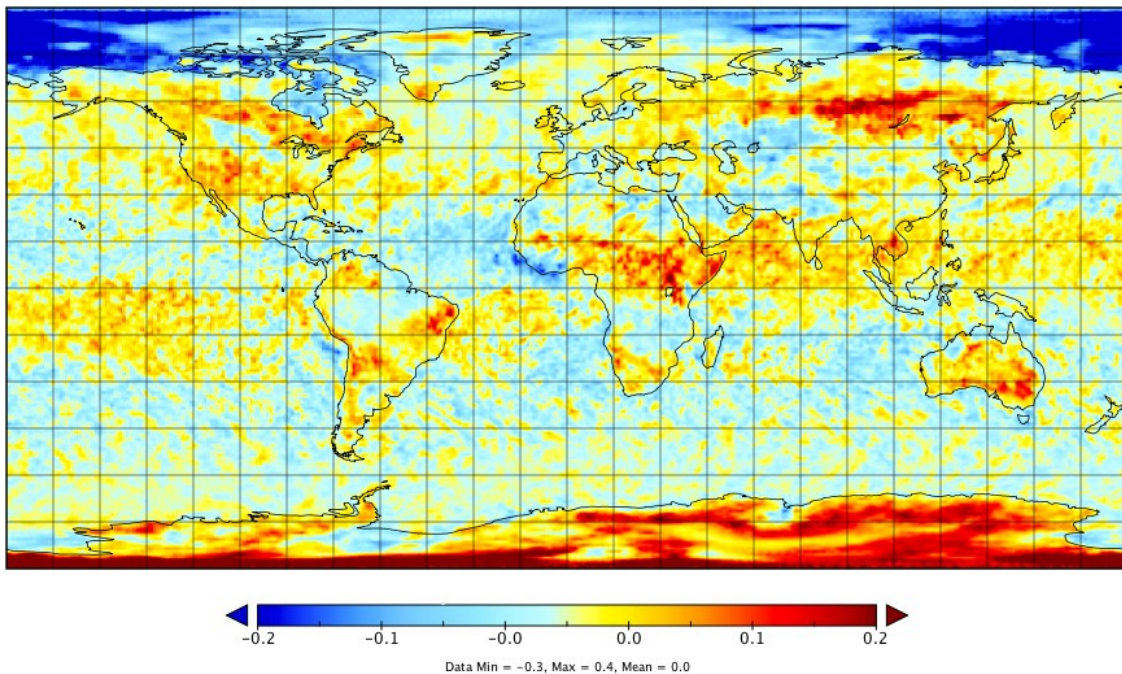
One theory is that the discontinuity in the first set of images (Cloud Fraction from Cloud Mask) only occurs there because that is a parameter that is:

1.) computed for both D and N and

2.) contains CLEARS

Why is adding clears so critical?   It appears that by adding clears, you end up with more recognizable patterns that mimic patterns seen in total pixel count data (since the only null case is fills).

With other parameters that don't contain clears (like CTP or CTT) there is a null case of both fill AND clear sky so the patterns tend to smear out a bit more and don't leave such obvious well-defined signatures.

Its interesting that Gala Wind saw a very similar geometric pattern formed by the overlap (max pixels) which had an asymmetry at the date line (caused by a "restart" or "reset" of orbits at those two longitudinal meridians (0 and 180 degrees), which was introduced by the defn of day boundary). See her images below.   But she only saw that when she combined Day and Night. That max number of pixels pattern being shifted from north of the equator to south of the equator at the date line and the grenwich meridian.
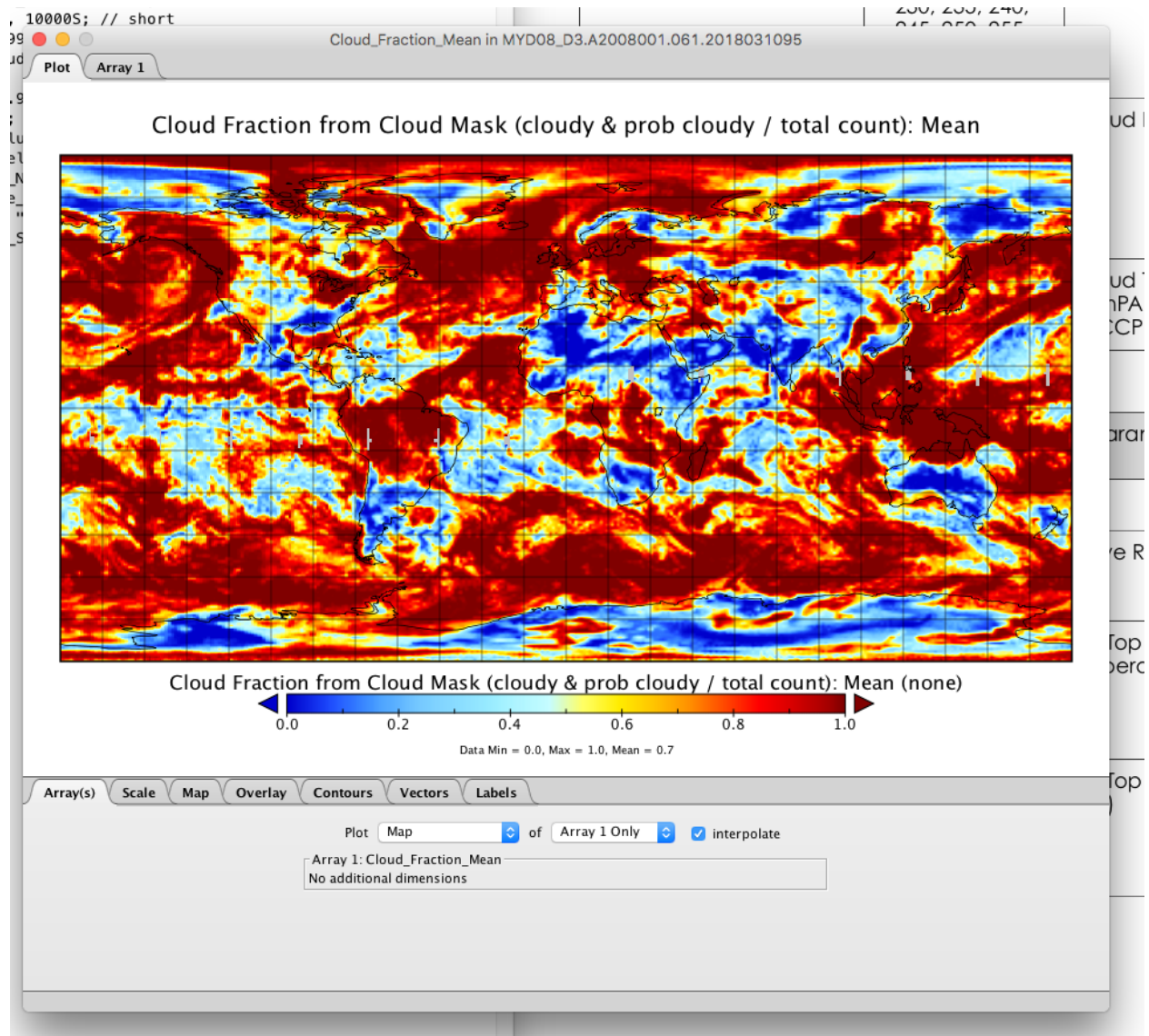
To clarify, Gala did some orbit analyses and found that in the full Pixel Count data, for the Day only (far left) and Night only (center) both had fairly well behaved patterns, but when she combined Day and Night (far right) a new signature appeared showing shifts in the maximum pixel pattern at the date line and the grenwich meridian. Apparently, this has something to do with the orbit geometries and the way they are both "reset" at the date line and grenwich.

Note that in Gala's images below, this is basically ALL pixels, which is something you would see in Cloud Mask from Cloud Fraction when you combined D and N (since that parameter contains clears, which effectively picks up all pixels and only excludes fills.
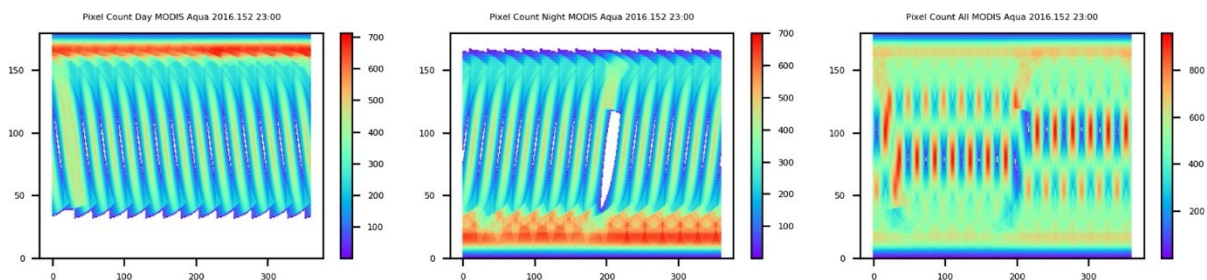
What about regular Daily D3 Cloud Fraction D+N can we still see that pattern?
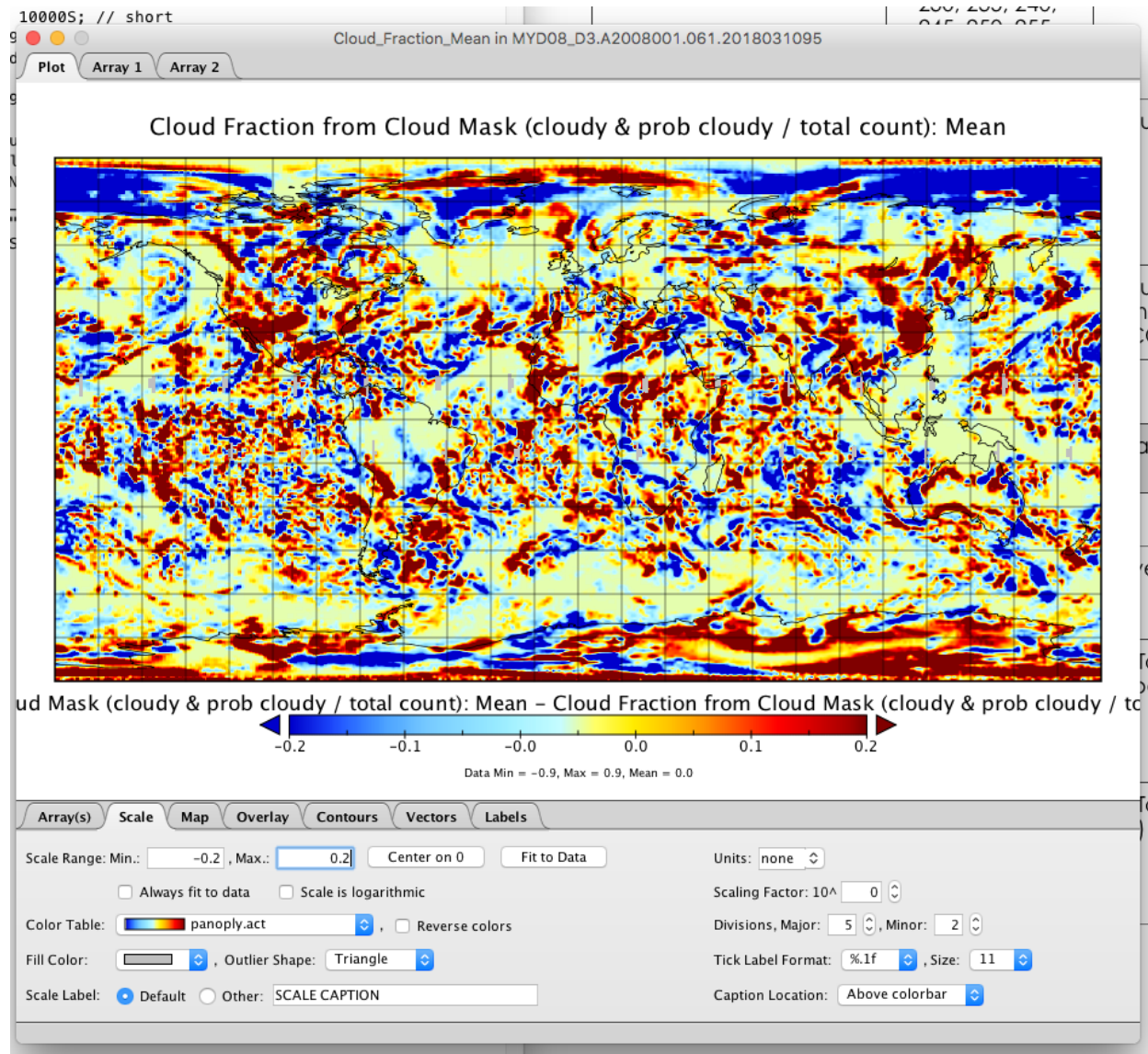
This is Aqua

This is Terra

Cloud Fraction from Cloud Mask (cloudy & prob cloudy / total count): Mean

Cloud Fraction from Cloud Mask (cloudy & prob cloudy / total count): Mean (none)

Data Min = 0.0, Max = 1.0, Mean = 0.7
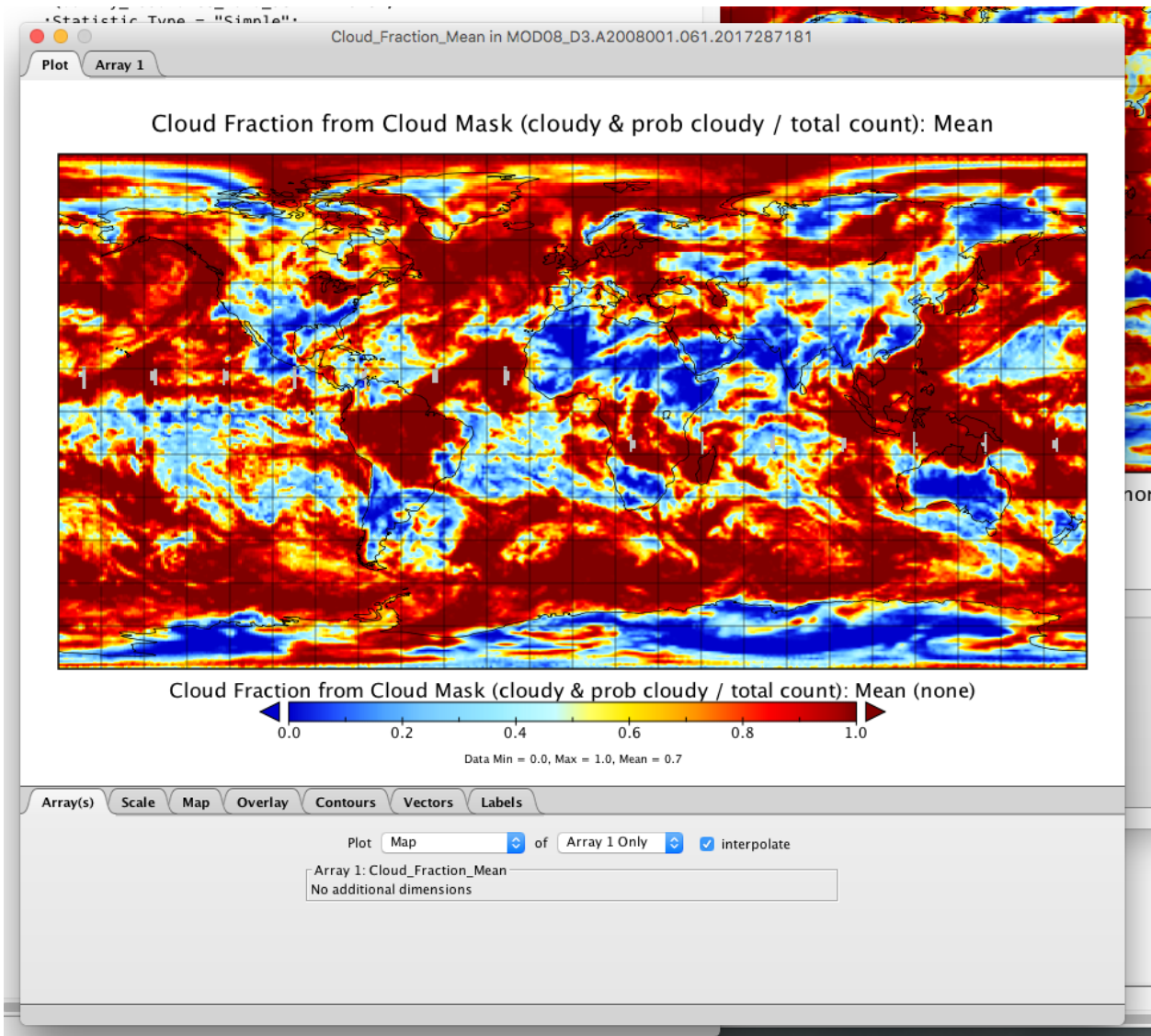
This is the Aqua-Tera Daily Difference … D+N

I believe that I might be seeing a tiny bit of the disconnect at the dateline and grenwich, however its not as pronounced or obvious.   Its harder to see.   Is there a shift of the peak differences north and south of equator?   Again it's not obvious in the Daily (D3)

Now lets looks at data for Monthly M3 This is January 2008 only

Lets start with Daytime Only

This is Aqua Daytime Only
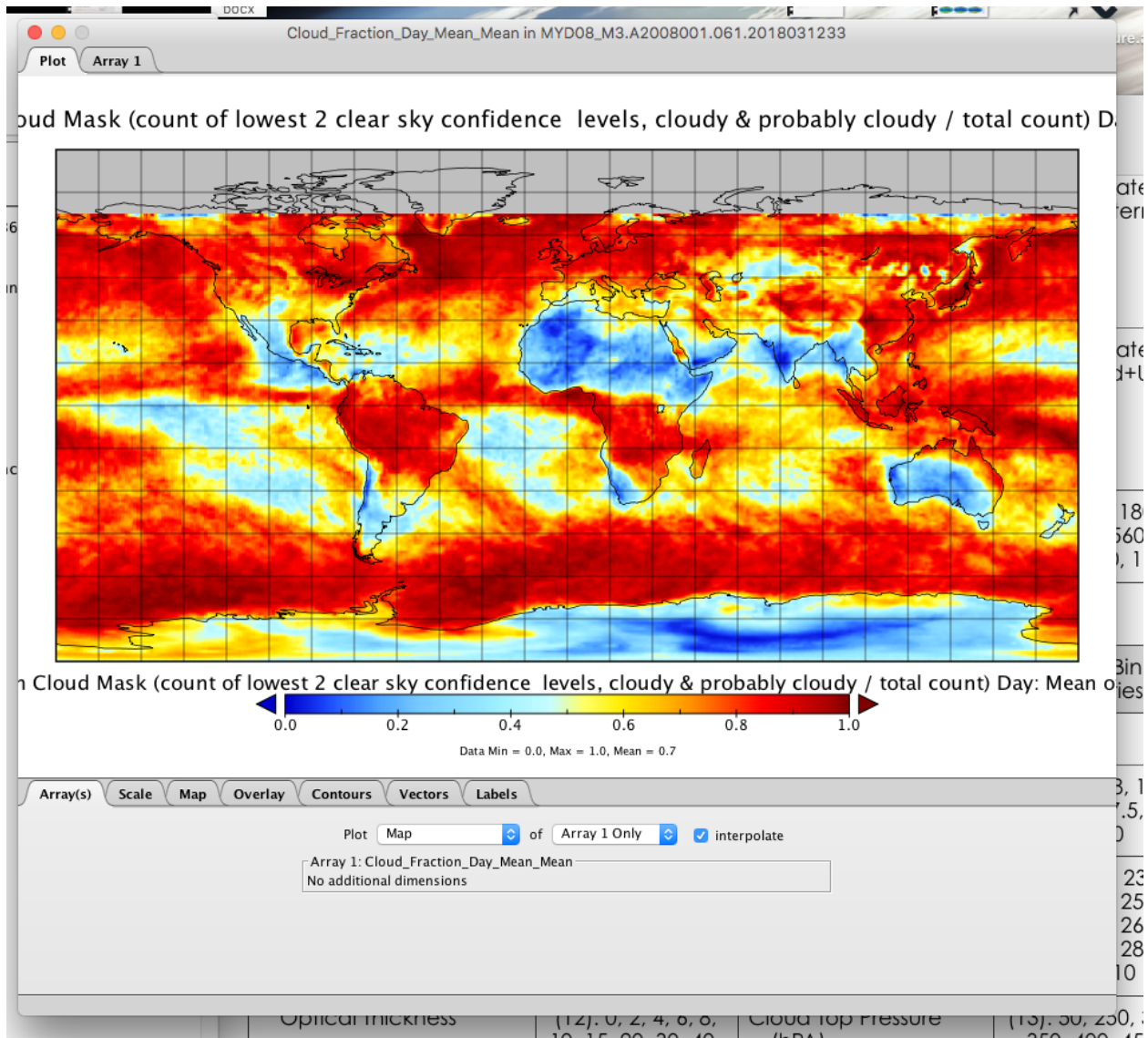
This is Terra Daytime Only
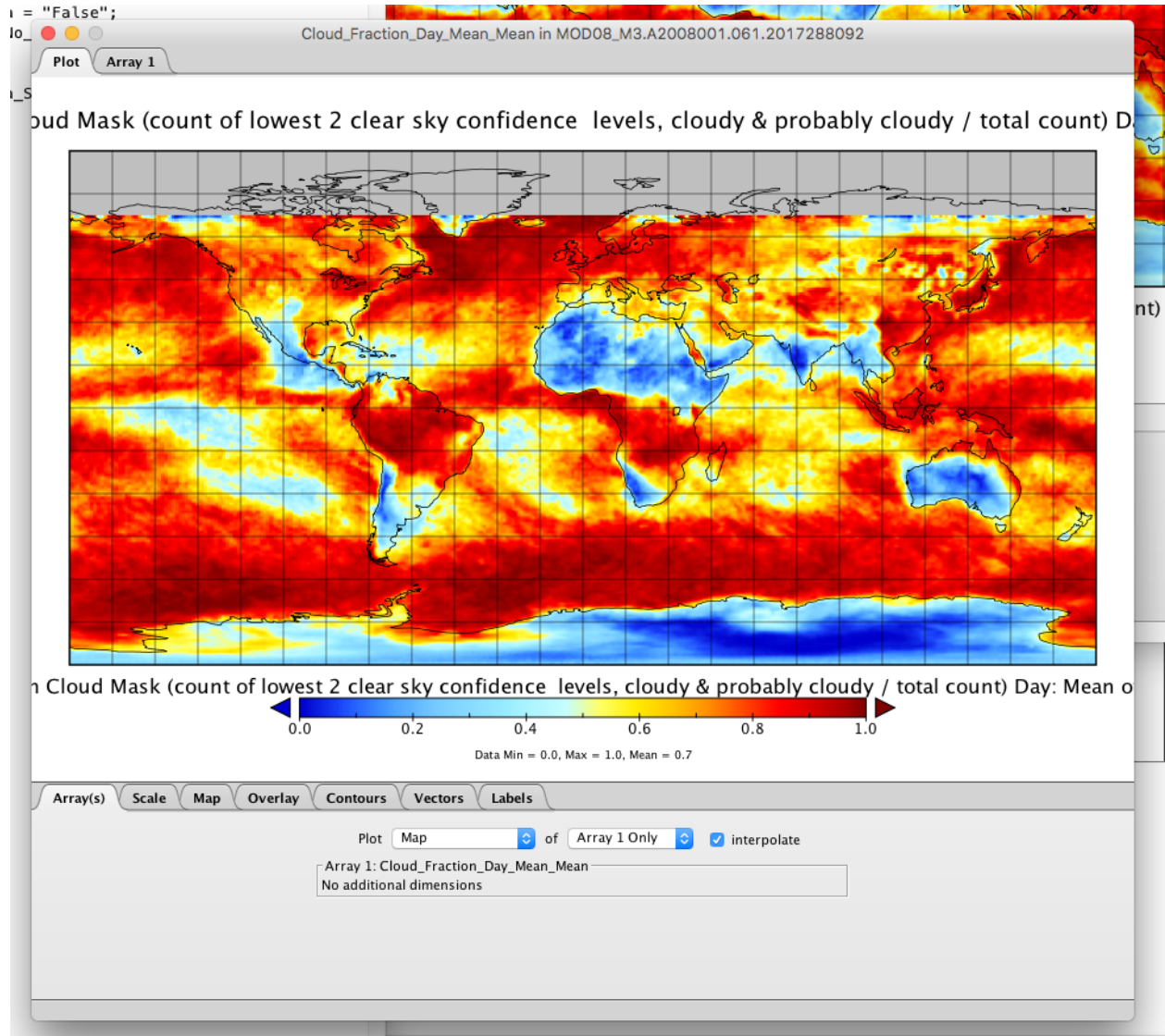
This is the difference … (Daytime only)

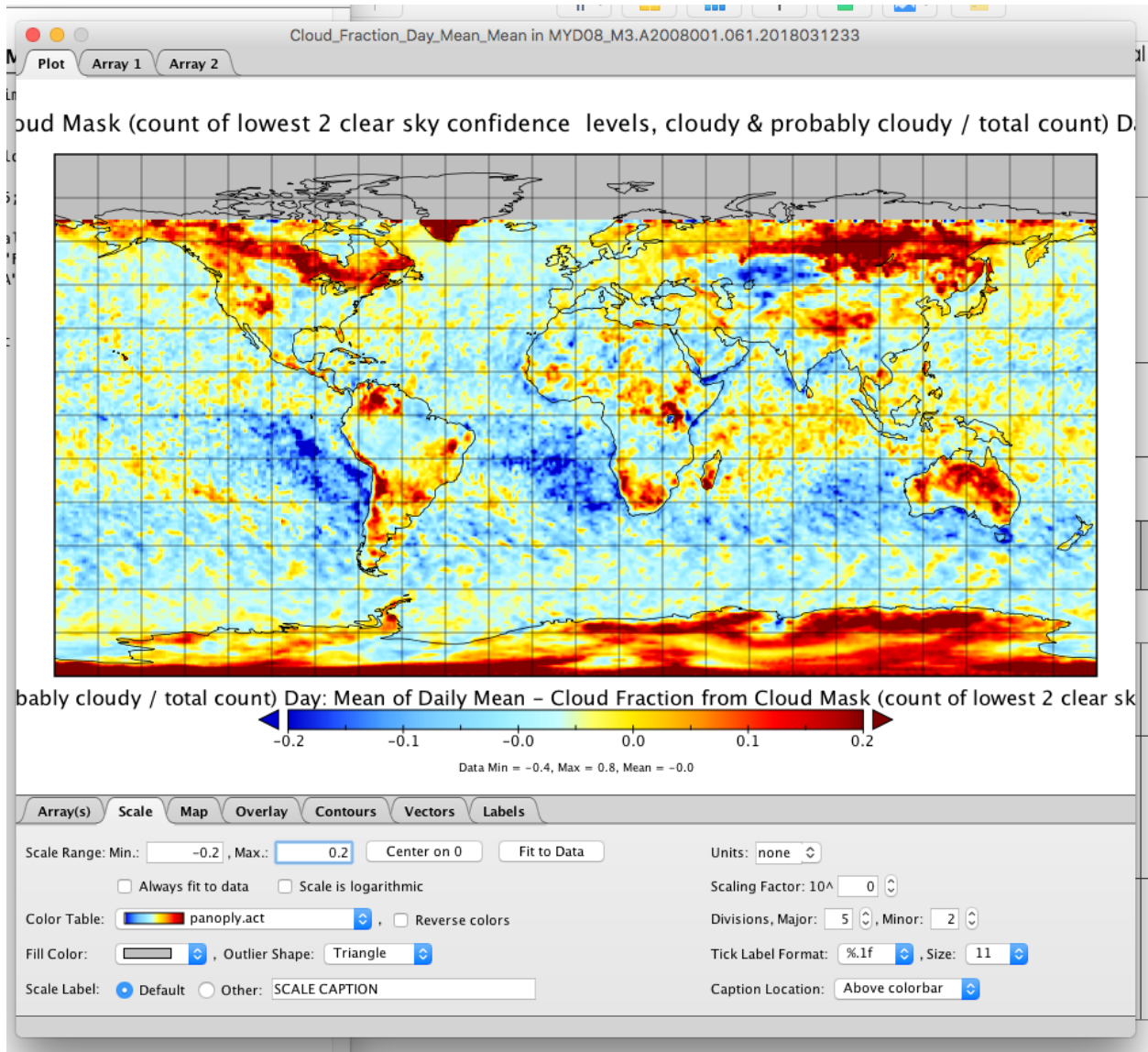

So it looks like Day ONLY is fine! With no obvious discontinuity

Now lets looks at Nighttime only for M3

This is January 2008 again

This is Aqua but Nighttime only
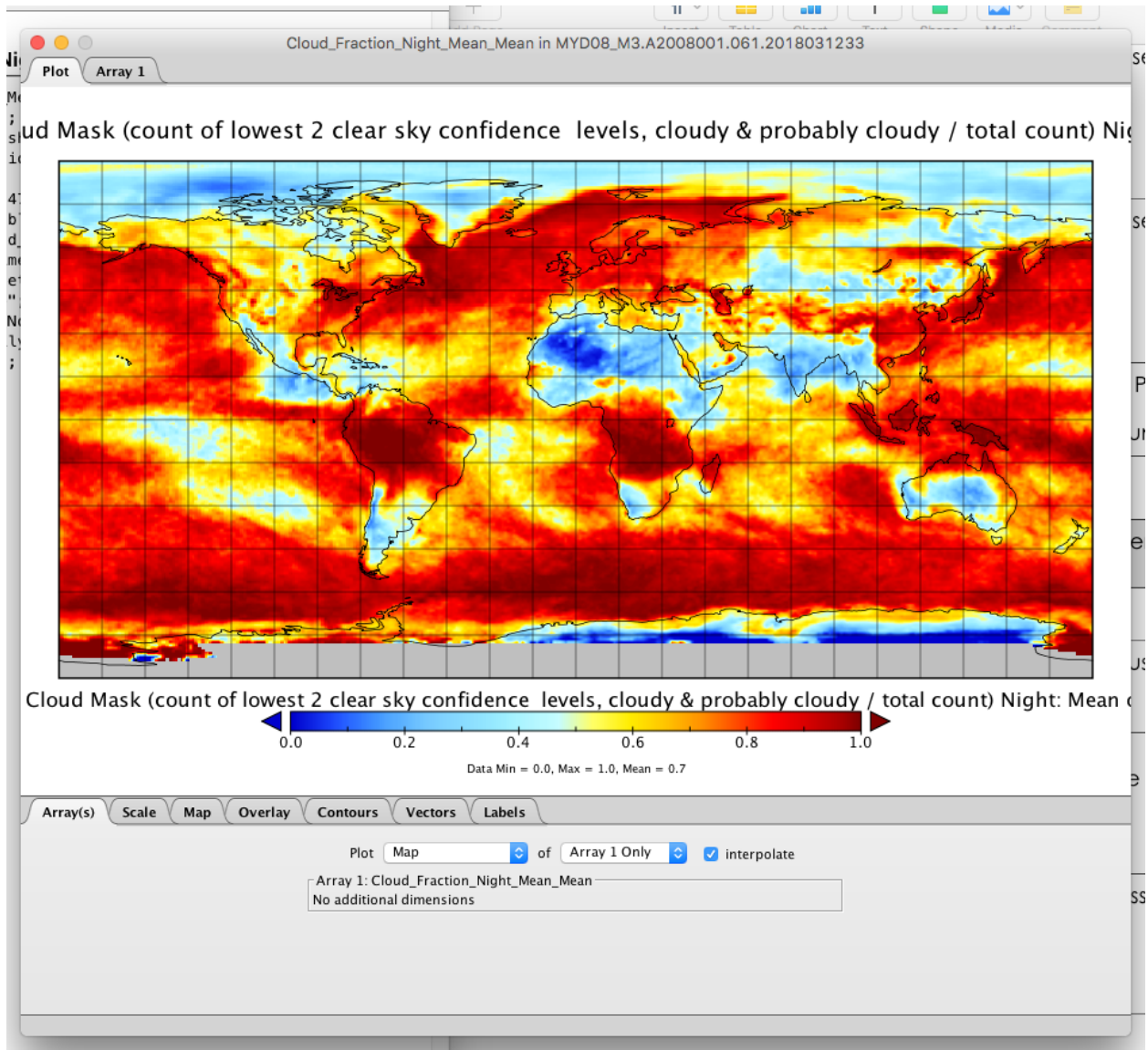
This is Terra but Nighttime Only
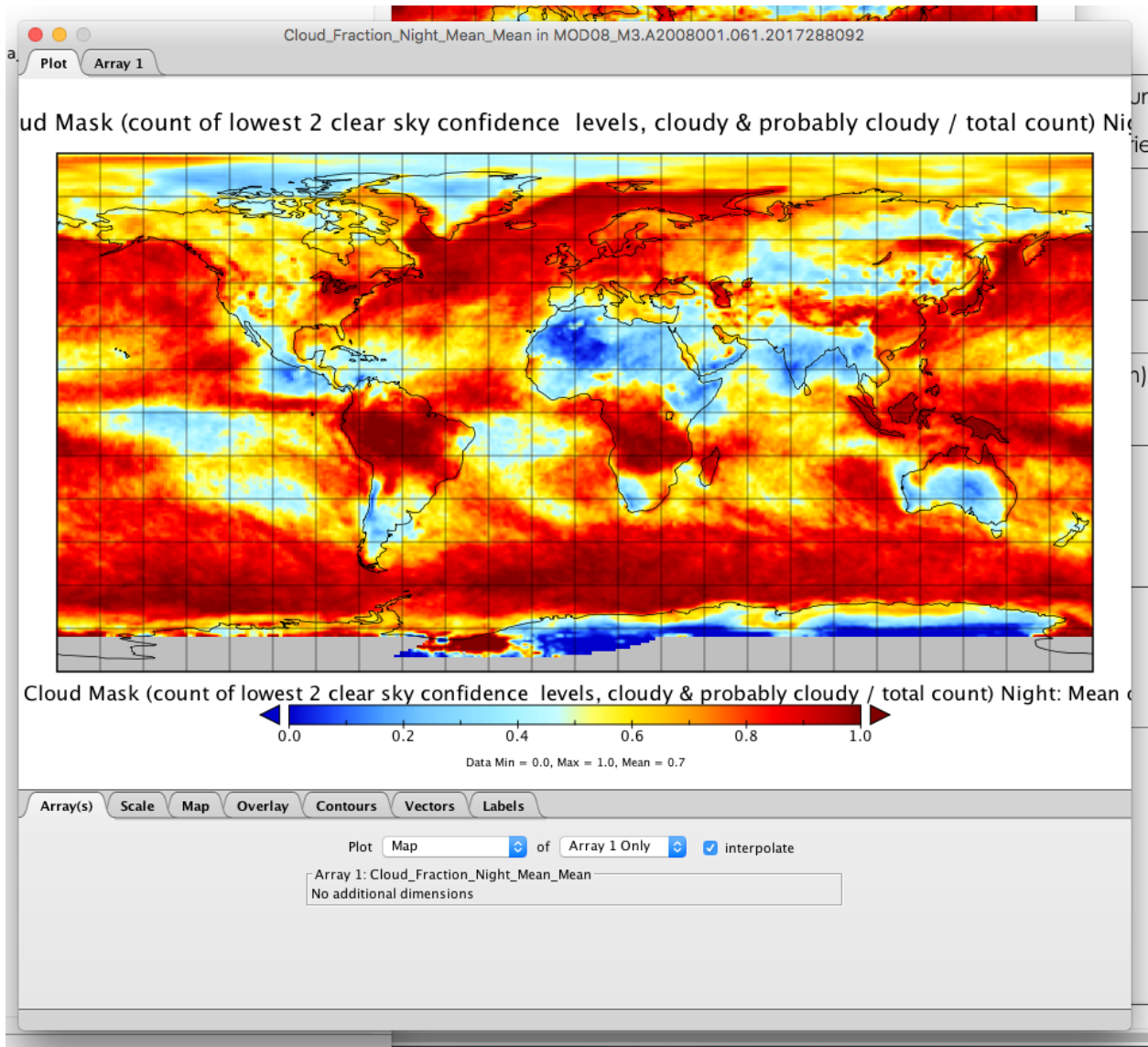
This is the A-T difference (Nighttime only)
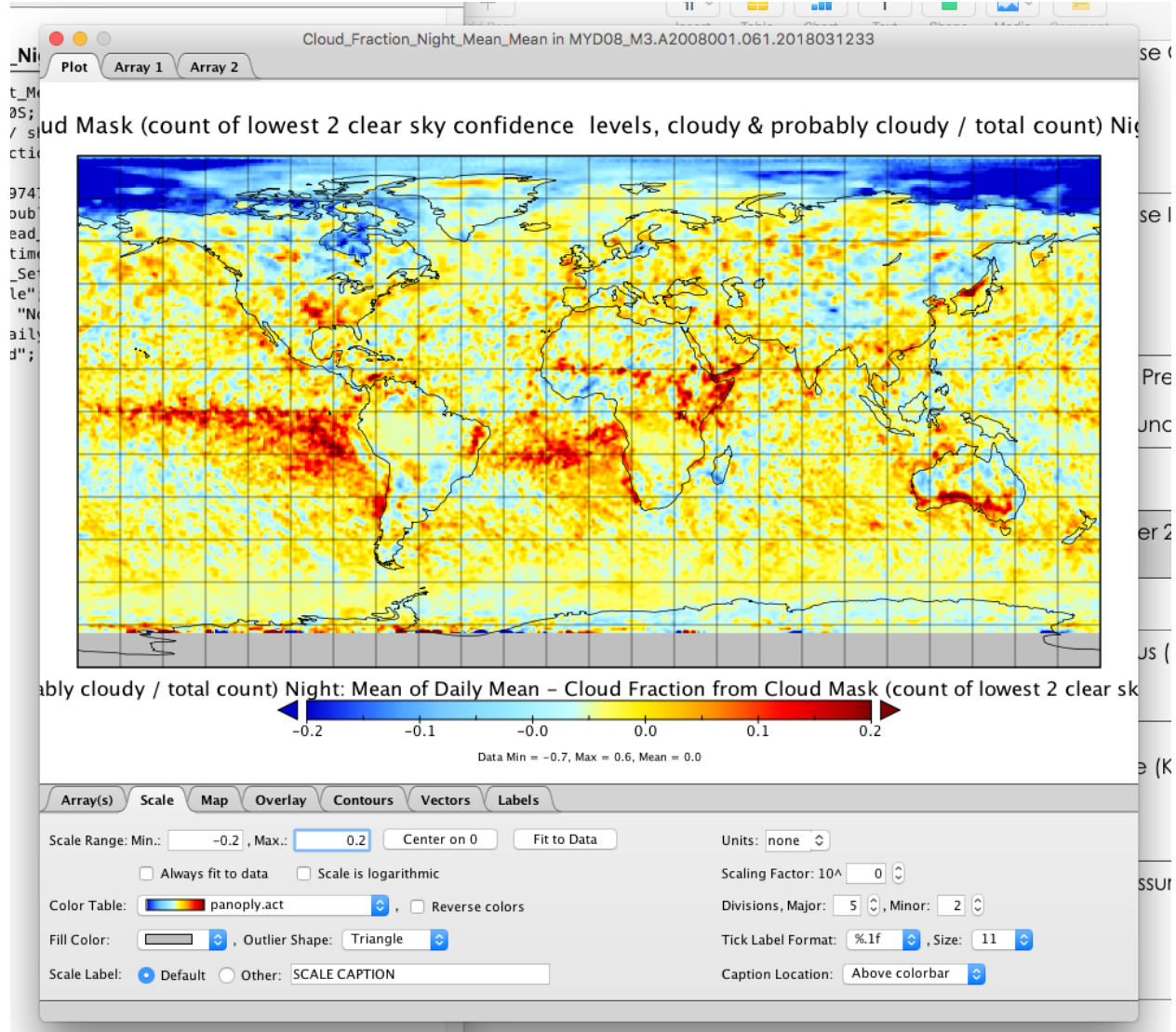
Again for Night only data, this looks fine with no obvious discontinuity.

Now lets looks at D+N for M3 This is January 2008 only!

This is Aqua (D+N)

Cloud_Fraction_Mean_Mean in MYD08_M3.A2008001.061.2018031233

Cloud Mask (count of lowest 2 clear sky confidence levels, cloudy & probably cloudy / total count)

om Cloud Mask (count of lowest 2 clear sky confidence levels, cloudy & probably cloudy / total count): Mean of D

Data Min = 0.0, Max = 1.0, Mean = 0.7

Array 1: Cloud_Fraction_Mean_Mean
No additional dimensions
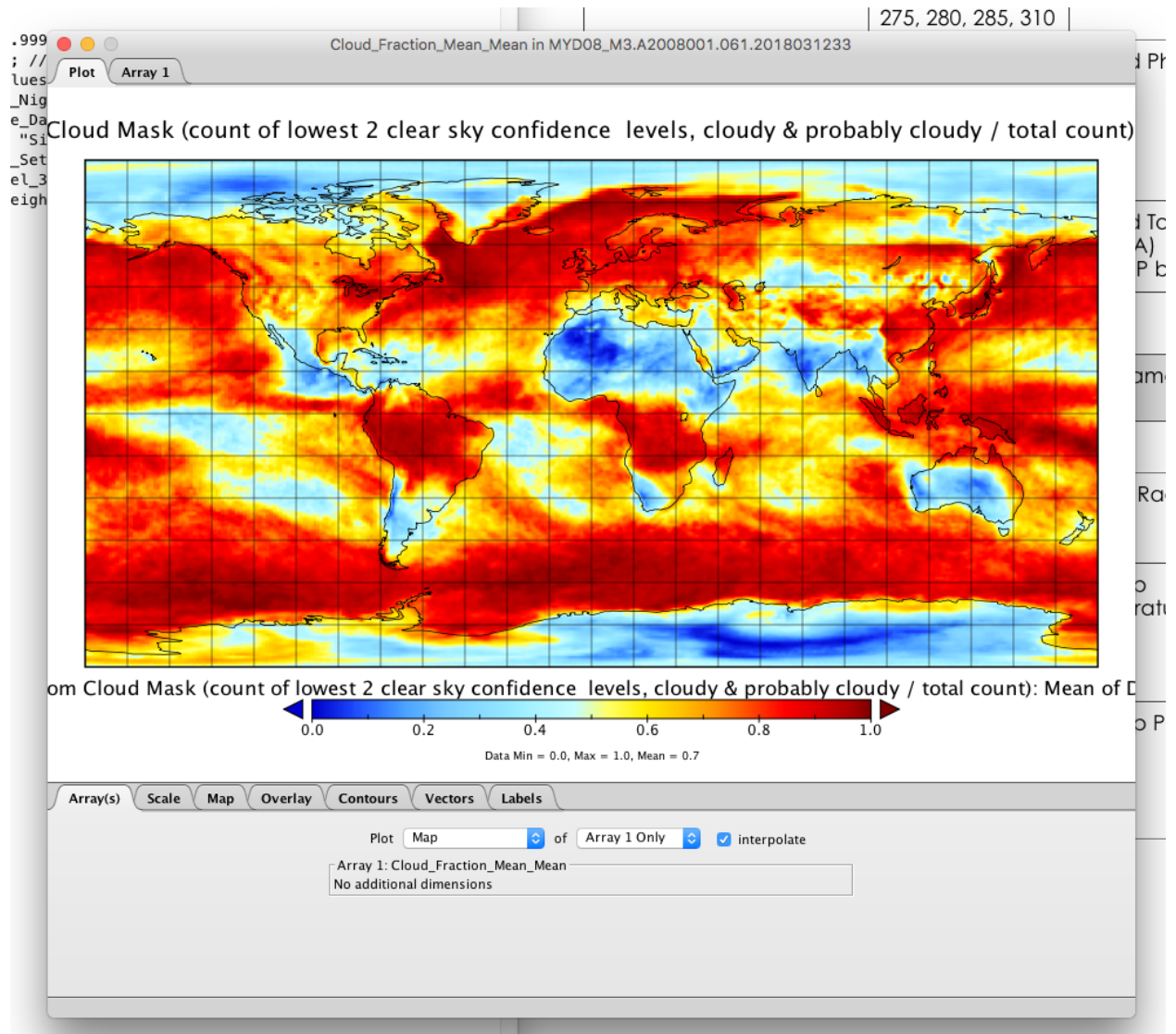
This is Terra (D+N)
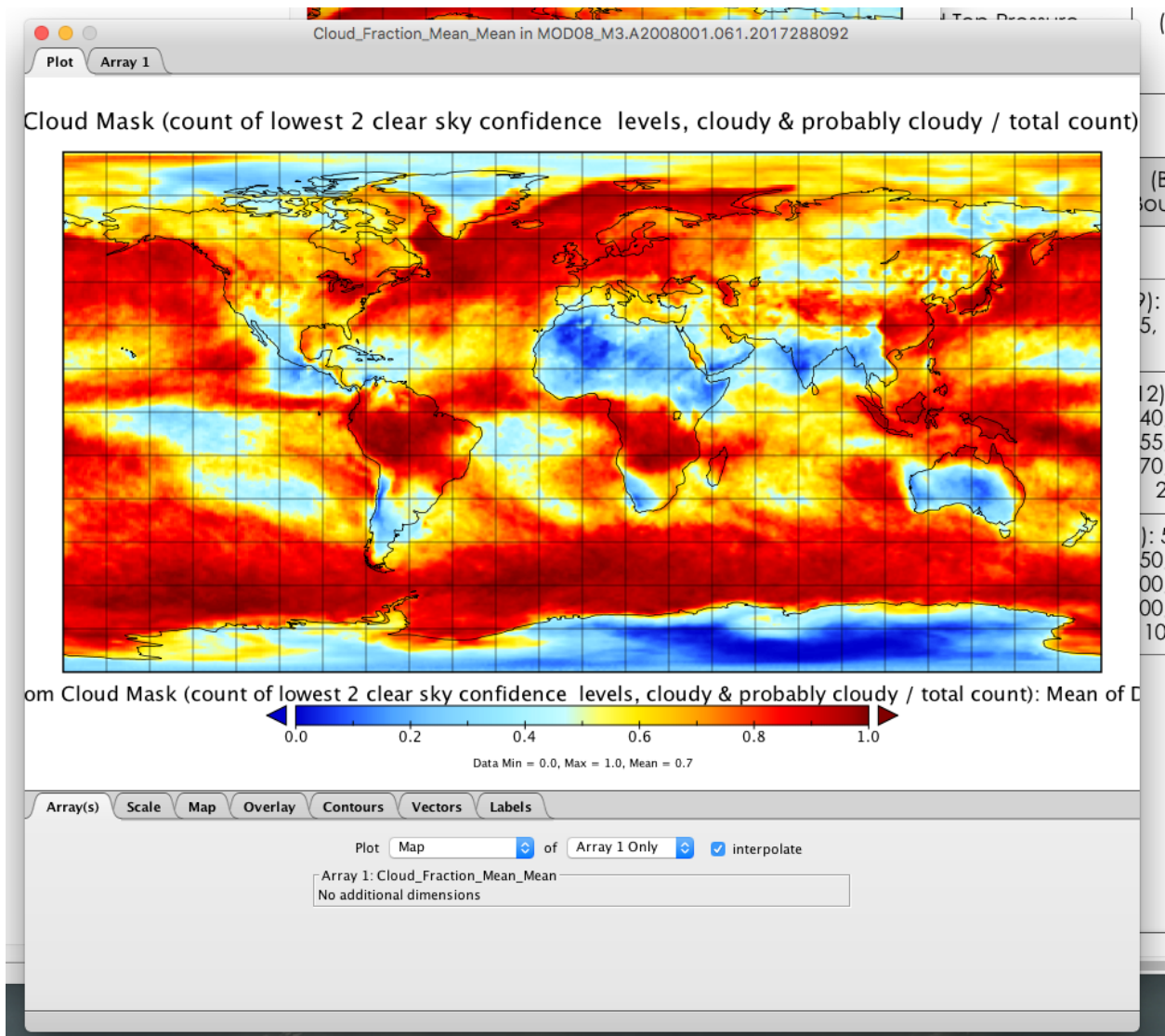
This is the difference … (D+N)
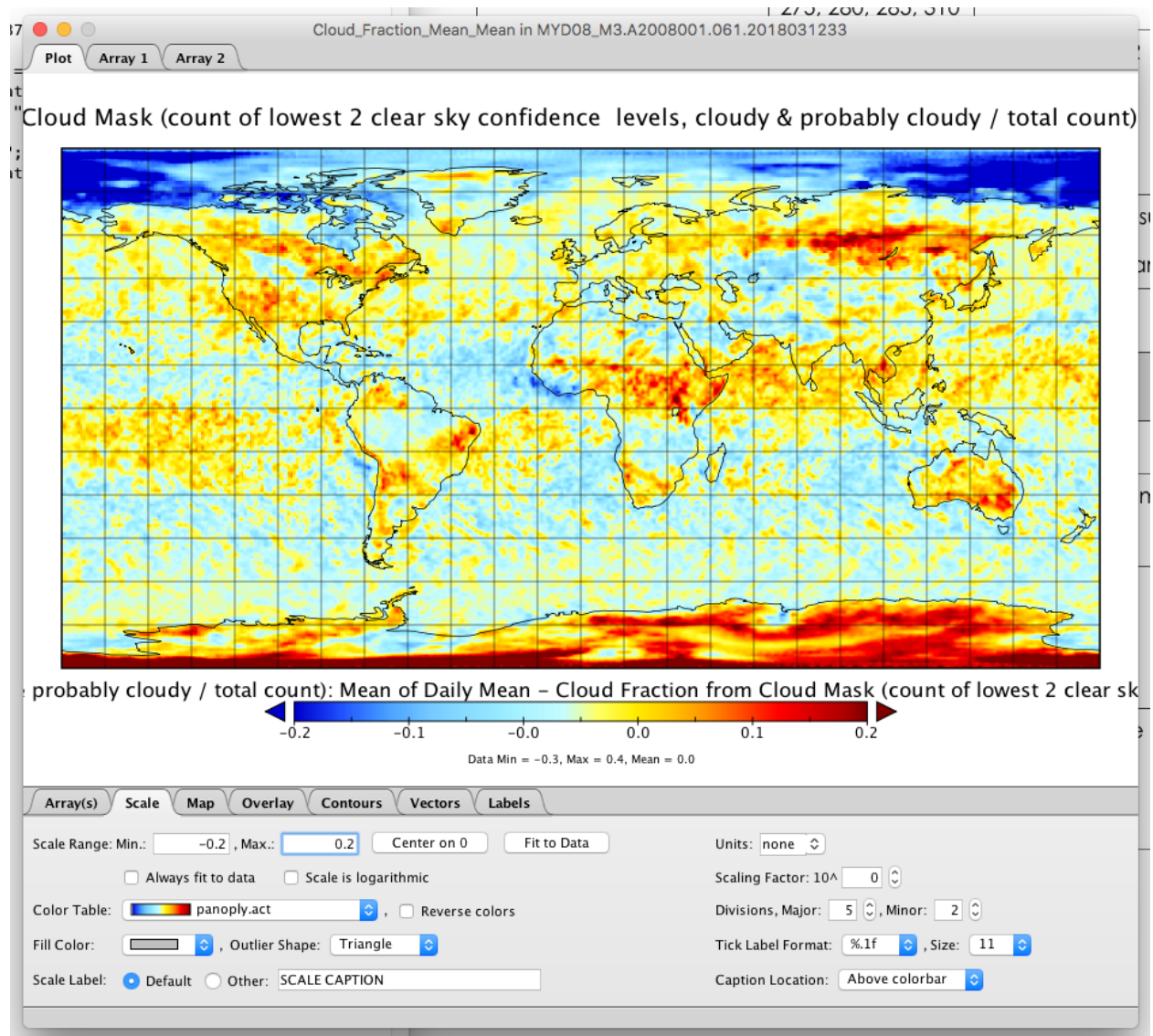
Ok, so the 0 and 180 degree discontinuity does seem to appear … I am seeing a bit of a systematic shift of the peak differences North and South of the equator, which shift at the markers of 0 and 180 degrees longitude.

Just a quick FYI that ALL of the CTP parameters are UNWEIGHTED Means in the M3 (so called synoptic means) this is different from how we do COP parameters in M3 (those are pixel count weighted). So the computation in L3 going from D3 Cloud Fraction to M3 Cloud Fraction is simply add up the 30 or 31 D3 Cloud Fractions and divide by the total number of days with non-fill fractions. It's a pure unweighted mean, extremely simple to compute.

SUMMARY: cont discuss w aero group on their C7 L3 aer prod if their willing ot sign off on reverting to the old c5 23   if no go on 00-24 then I'd need to split out L3 aerosol to a stand alone product (and not have a combined mod08 for cld+aer

Clearly this odd signature in the data appears to require

1.) Day+Night Combined (no anomalous signature in day only or night only)
2.) Aqua–Terra or Terra-Aqua (no anomalous signature when using a single platform)
3.) Time periods 1 month or longer to more clearly see (it's still there in shorter periods)
4.) Impacted science data must include clears (clear sky)
5.) Likely to need the C6 Defn of Day adjustment with hard cutoffs at the Intl Date Line

This combination (shown by Kyu Kim) is only possible in the **Cloud Fraction from Cloud Mask parameter for Day+Night and only if Aqua-Terra or Terra-Aqua is being viewed**; and not in any other parameter, which is why we only see the discontinuity there (in that case).

It's still not intuitively obvious why this systematic pattern in the Pixel Count data seems to influence the actual Cloud Fraction data, but clearly it does as seen in both the first figure and the final figure.

I am not sure why, but I believe it might have something to do with the fact that Clears are included in this parameter. So perhaps in regions of increased pixel count patterns, the final CF product has the "opportunity" to pick up many more clears? I am not 100% sure about that though, I am grasping for straws. Any ideas from SP or KM?

This is a perplexing problem, but definitely **isolated in a single parameter** the Cloud Fraction from Cloud Mask and ONLY if you look at Day+Night AND only if you difference Aqua and Terra data at time frames longer than 1 month.

I don't see any simple way to solve this, but I am open to suggestions from SP or KM. Seeminly, if we reverted back to the 0000 to 2400 UTC Defn of Day, this issue would tend to smear out, however I would like to see that proved before I sign onto that statement. The good news is, this only appears in a single parameter, and you have to combine the data in a specific way to see it.

Question: Would this effect be isolated only in the C6 Defn of Day Correction?

I believe that the standard 0000 to 2400 definition of day used in C51 and previous will NOT show discontinuity "lines" at 0 and 180 longitude.   This is because for that standard defn of day, there is a choppiness at the dateline and grenwich meridian (oribal gaps and overlaps).

For the Defn of Day correction used starting in C6, a limited set of data (CM D+N A-T) will show this linear (vertical) disconinuity at 0 and 180 because that C6 defn of day formula actually uses those 2 meridians of 0 and 180 to make a hard cut off of the data.

That all being said, I do think we will continue to see the N/S shift of peaks about the equator in the regions betweein 0 and 180, but they wont be as obvious without the linear discontinuity demarking that shift.

The reason I believe that -- is this pattern shift takes place in the SPAN of longitudes between the Date Line and the Grenwich Meridian. Not just near those 2 boundaries (which is where the defn of day would impact data).   This seems to have something to do with the way the Aqua and Terra obits overlap and create well defined patterns, that shift back and forth across 0 and 180 longitude. But you have to have these 3 intersecting characteristics in order to see this issue

1. Combined Node (D+N)
2.   Aqua–Terra Differences (or T-A)
3. Include Clear Sky data

Without all 3 of the above noted characteristics, you will see no impact. And these three characteristics can only occur in **Cloud Fraction from Cloud Mask for combined D+N and only when you difference the platforms.**

FootNote:

I did wonder if one averaged or combined Aqua and Terra cloud fractions over a month, rather than taking differences, would the discontinuity pattern still emerge or change?

As a test of this I took the Average of Terra and Aqua CMCF for D+N. The results are below:
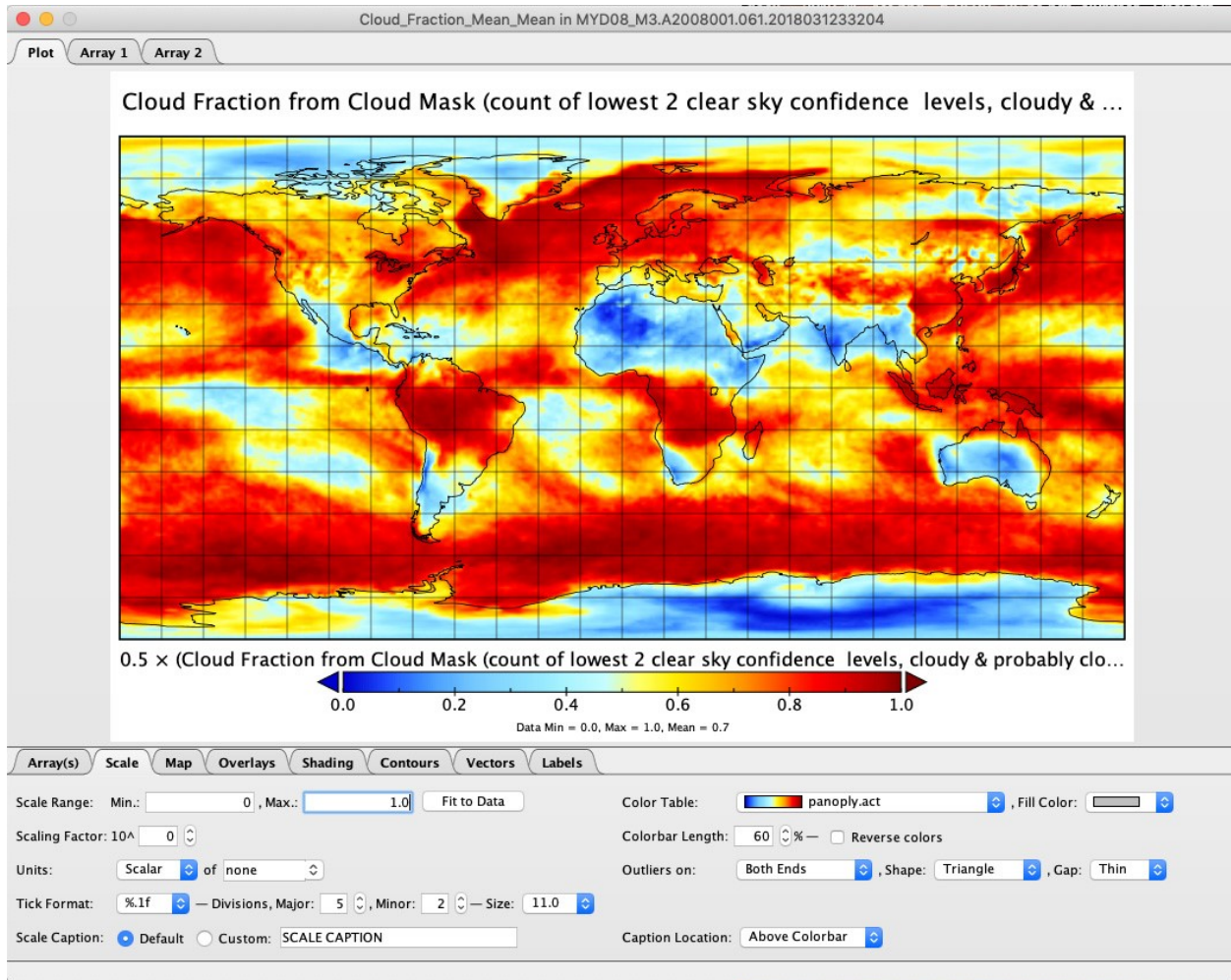
There does not appear to be any obvious discontinutiy or asymmetry when you do averaging, at least showing with this particular color bar.

To be sure I took the previous image and put the date line in the center (rather than on the edges)

It still looks good! No unusual or obvious anomalous signatures, at least showing with this colorbar.
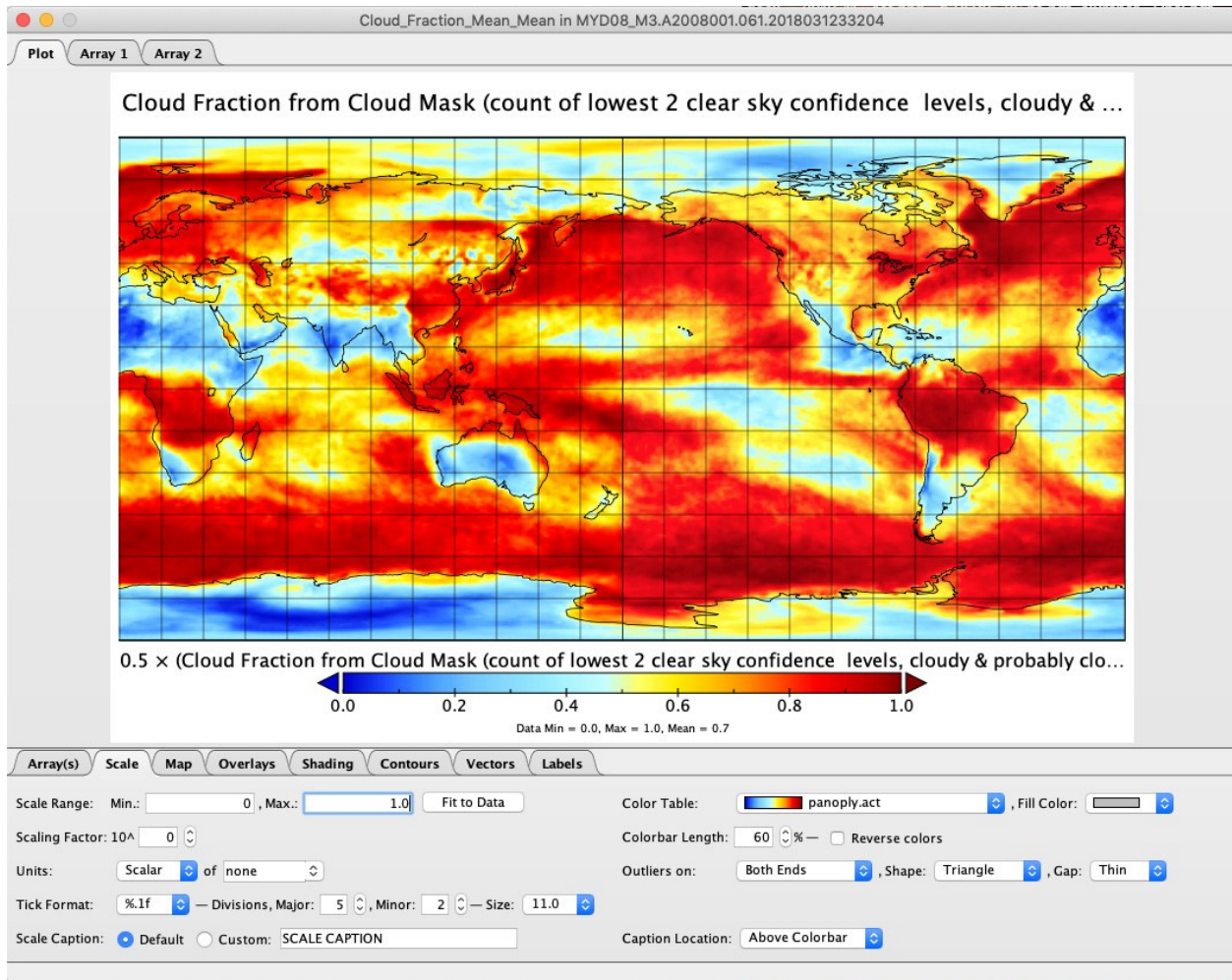
So the upshot is apparently you can ONLY see (or more easily see) the discontinuity or asymmetry by DIFFERENCING A-T … it seems to disappear when AVERAGING A & T (at least when using this color bar).

It would have been nice if I could have proven to mysef that turning OFF the Defn of Day Correction C6 … still shows the N/S of equator bias in the Monthly Differences for CMCF D+N

I am not sure if SP or KM are hot to trot to see this (so don't interrupt your important work!)

I would love to see this from Gala using Mara:

Compare 6.1 vs. 6.0

08_D3 over a few days   (or 06_L2 built up granule by granule over a few days)

(Note that these signatures might not show up very well until a month of data is aggregated)

Look at Cloud Fraction from Cloud Mask (D+N) (called "Cloud_Fraction") only

Aqua-Terra Difference (A-T)

I think the Means will show the issue, however the Pixel_Counts might also show the problem.

That might be interesting to see as well.

What I would expect to see,

0 and 180 longitude discontinuity that appears as a line in C61

And that line tends to disappear in the C6 data

However I do expect both C51 and C6/61 to show the "shift" N to S about the equator in the zones in between those meridians.   However it will be harder to spot in the C51 data without the linear discontinuity at 0 and 180 longitude.

Gala's MARA Newsletter: January 2019

As requested during a telecon on 01/11/2019 the MARA newsletter now includes the picture of the MARA board with completed items marked as such. Completed items are indicated in hot pink as that is the color most dissimilar to everything else on the board.
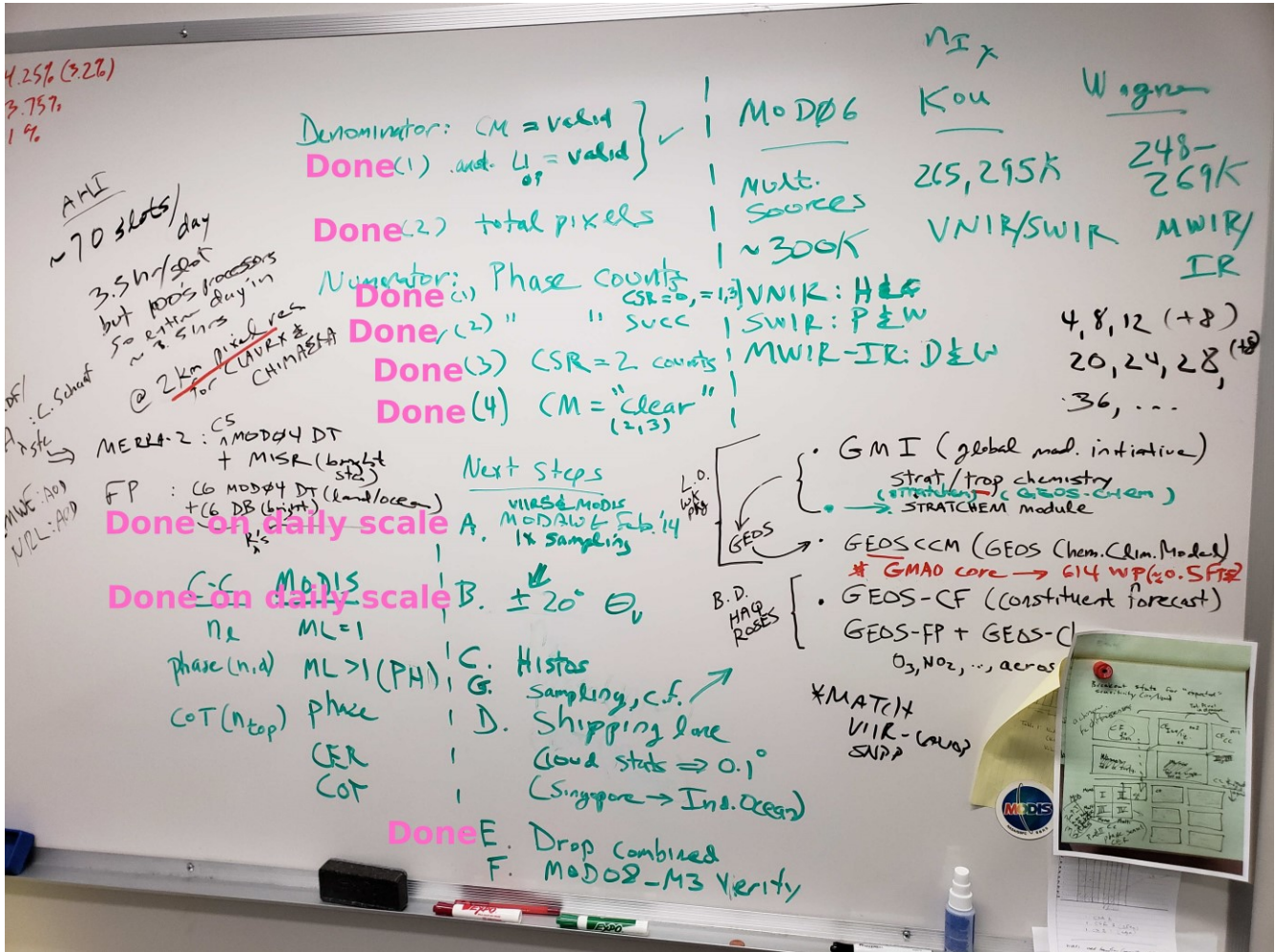
The monthly test just to test phase separation promised in the mid-July 2018 issue has been cancelled due to continued success of matching the daily results produced by MOD08 and due to necessity of VIIRS integration.

On VIIRS integration: MARA has undergone quite a few changes. We now externally control the switch between NetCDF4 and HDF4 data formats. The top level control file has a switch next to the instrument name. The group name can now be included together with the SDS name. Only single-level grouping is

presently supported (like the one in MODAWG output). There are no plans of supporting multi-level grouping (groups within groups) although it could be added if necessity existed. MARA is also now a parallel application that of course can either be compiled as a serial code, run in the cloud or as a full HPC application. In order to manage the job size MARA checks the granule corners for wther it should use the granule in order to speed things up a bit. For such purpose attributes have been added to the VIIRS-MODIS continuity cloud product. It turns out that particular attribute set is formatted different between operational MOD06 and MOD03. It is not known why that is, but that did lead to some temporary scratching of head. The ability to handle this formatting difference has been coded into MARA as MARA can use either MOD03 or MOD06 as geolocation source. There is no such complication for NetCDF4 MODIS and VIIRS products which track these attributes differently.

VIIRS aggregation has been nominally set to every 4th pixel across track and lines 4, 8 and 12 along-track for every 16-line whisk. We nominally chose to use the Aqua "definition of day" rules for aggregation of VIIRS data. We also wanted to compare that sampling to aggregation of VIIRS data done without any sampling at all. Figure 1 shows an example aggregation of mean liquid water cloud optical thickness from the VIIRS instrument for a single day: 2014 day 041. Left image shows the mean with sampling. Middle image shows the same quantity without any sampling, every single line of data is taken. The rightmost image shows the difference between the two. It was requested that for these tests VIIRS data was to be swath-limited to 65 degrees view zenith.
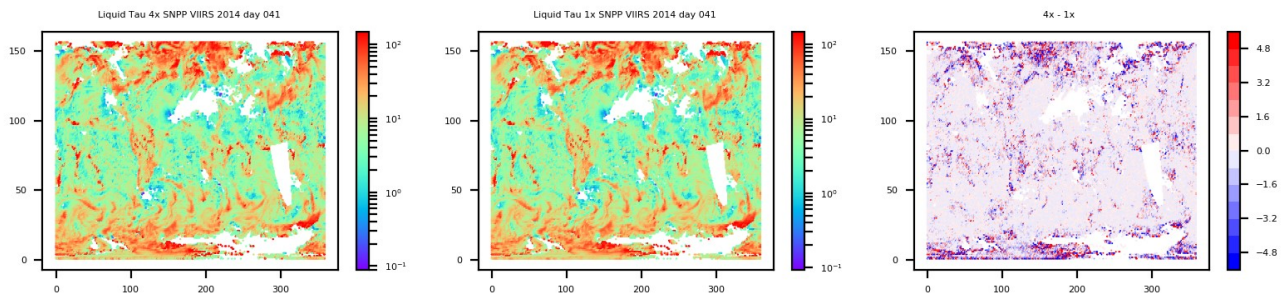

Figure 1: SNPP VIIRS aggregation of liquid water cloud optical thickness for 2014 day 041. Left image is VIIRS with sampling applied. Middle image is all VIIRS data included and the right image is the difference between the two.

The overall differences are mainly in the areas where the number of samples was on the low side to begin with, so not too terrible. One would expect differences to be present in areas like that. There is a fairly good chance that this might wash out on a monthly aggregation. One would like to perform a monthly aggregation. However VIIRS daily aggregation at 1x can only be done in an HPC or cloud environment. There is simply too much data to read and process. Such environments are not accessible at present time. This test will be performed on a monthly scale as soon as resources (both computing and data) are available.

Another item of note here is that one can't help but notice an orbital gap on the east side of the image. This gap is a result of application of Aqua "definition of day" rules to SNPP. SNPP and Aqua are not exactly aligned with each other time-wise. It would appear that using Aqua operational rules for SNPP may not be the best approach in the long run. Definition-of-day impacts are presently being investigated.

The ability to aggregate scan start time was also wanted and a feature of being able to expand the dataset if necessary to cover the swath has been added into MARA. The scan start time feature was wanted in support of the definition of day studies. Figure 2 shows the aggregation of scan start time for a single MODIS day: Aqua 2016 day 152. The leftmost panel shows "Day", middle one "Night" and the rightmost one is "all available data".
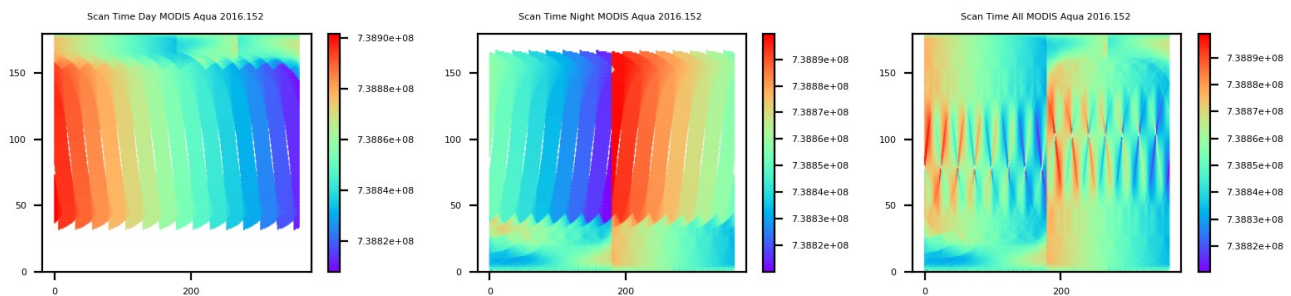

Figure 2: MODIS Aqua scan start time for 2016 day 152. The leftmost panel shows "Day", middle one is "Night" and rightmost one is "all available data".

The scan start time shows some interesting features. The daytime is very smooth-looking but not so for the night-time aggregation which shows a clear discontinuity along the Greenwich meridian. The absence of the discontinuity in the day and a very strong discontinuity during the night combine to create the effect in the "all data" image.

NCCS ADAPT is still working although only five of my nodes are presently available and to further complicate matters, the lead node Bespin101 is down. LVFS is also slow, but at least there is no outright filesystem crash. Despite those issues a monthly MARA run was set up to look at the scan start time aggregation for MODIS.

MARA started getting somewhat large and so it had been added to our general CVS repository. Anyone who is already a user of CHIMAERA can check out MARA by doing "cvs checkout MARA". A copy of CHIMAERA is presently necessary if you are running MARA because MARA uses parts of the CHIMAERA core. Chances are that for the time being anyone who would be using MARA is also a CHIMAERA user. If

that changes, this could be re-thought at a later date without any major issues. A separate repository just for the outward-facing CHIMAERA core sections might be in order.

In the July issue it was confirmed that the daily aggregation split by phase, matches the split done by operational MOD08. So we moved on to the next set of tasks. Various counts that MOD08 daily files include were desired to be included, specifically the total pixel count, the number of valid cloud mask pixels (which is not always the same), counts of cloudy pixels split by phase and counts of cloudy pixels split by CSR method while split by phase (a 4D SDS). These counts were extracted from the QA. For that, code for managing QA bits has been added to MARA. This was a feature on the general feature list for MARA. Unlike MOD08 MARA is not restricted to using only consecutive bits in a byte. It is possible to pick which bits are wanted and the combinations of those bits that are of interest. MARA then will extract just what is needed. The counts have been verified with MOD08 and the numbers matched precisely.

Narrowing of the swath by view zenith has been tested now. It had been implemented in the first version of MARA to ever run, but the feature had not been invoked until now. The specific aggregation has been VIIRS at 20 degree limit. However there is no equivalent to such aggregation in MOD08. In order to verify that the aggregation is working properly we instead tested the 32-degree VZA aggregation. Because MOD08 can not interactively screen data, MOD06 provides an SDS Cloud_Top_Pressure_Nadir_Day that had been pre-screened by solar zenith (85 degrees) and by view zenith (32 degrees). Therefore it would be possible to check the aggregation by first aggregating all available data from the Cloud_Top_Pressure_Nadir_Day SDS without any screening. Then this result would be compared to an aggregation of Cloud_Top_Pressure SDS where MARA would apply screening by solar zenith and view zenith as prescribed by Cloud_Top_Pressure_Nadir_Day. Normally this would require a code change. MARA allows to perform such aggregation via a control file, listed below.

====== END HEADER ======

*** Cloud Top Properties ***

-- Screening Pattern --

Solar: . | Solar_Zenith | 1 | Day

Sensor: . | Sensor_Zenith | 1 | Nadir

-- Datasets --

. | Cloud_Top_Pressure

-- Statistics --

1 | Mean

** END OF SECTION **

*** Cloud Top Properties ***

-- Screening Pattern --

All

-- Datasets --

. | Cloud_Top_Pressure_Nadir_Day

-- Statistics --

1 | Mean

** END OF SECTION **

** END OF INPUT **

Figure 3: MARA control file necessary to perform the Day/Nadir screening test.

Better than having to mess with code. Yes? No? Maybe so?

Figure 4 shows the result of test described above. The number of differences with tolerance set to 0.01mb is precisely zero as was desired.
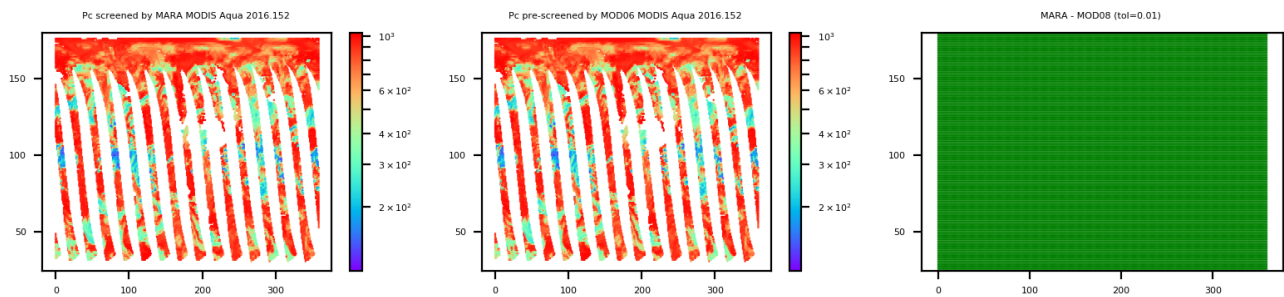

Figure 4. Result of cloud top pressure aggregation test for Aqua MODIS 2016 day 152. The left image shows aggregation of mean Pc screened by MARA. The middle image is aggregation of pre-screened

Pc provided by MOD06. The last image is a map of differences with tolerance set to 0.01mb, where any difference between the first two images that is greater than 0.01mb will be marked in either red or blue depending on the sign of the difference. There are no red or blue markers, only green. Therefore everything is running as it should.

One question that naturally arises from this exercise is as follows. The joint histograms of Pc and optical thickness are done by using the 5-km Cloud_Top_Pressure_Day product. Cloud_Top_Pressure_Day uses an 85 degree cut-off on solar zenith. Cloud_Optical_Thickness uses an 81.5 degree cut-off on solar zenith. Well, one might say that on the terminator line all would be well, the cloud optical thickness would cut off early and all counts would be zero. Let's say that we're looking at say day 152, polar night in Antarctica. The earlier cut-off of cloud optical thickness would manage the southern orbit edge. Well and good. Not so good about the northern edge where the data kind of wraps around. One ends up with additional counts of cloud top pressure in a row of grid boxes between 85 and 81 degrees and I'm not sure how it all fits together. Hopefully the additional CTP data simply gets tossed because it doesn't have a corresponding cloud optical thickness. Something that might need checking as far as operational MOD08 is concerned. It might be nothing or it might be something. It is difficult to say at this time as MARA presently does not have a joint histogram module.