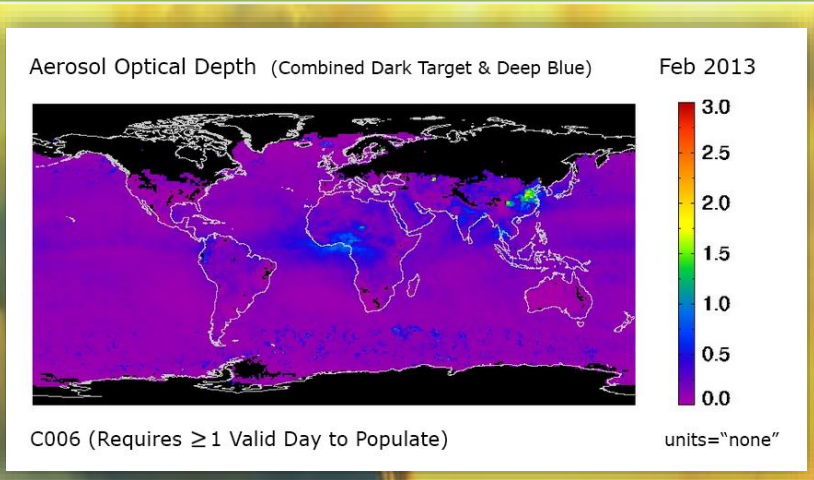
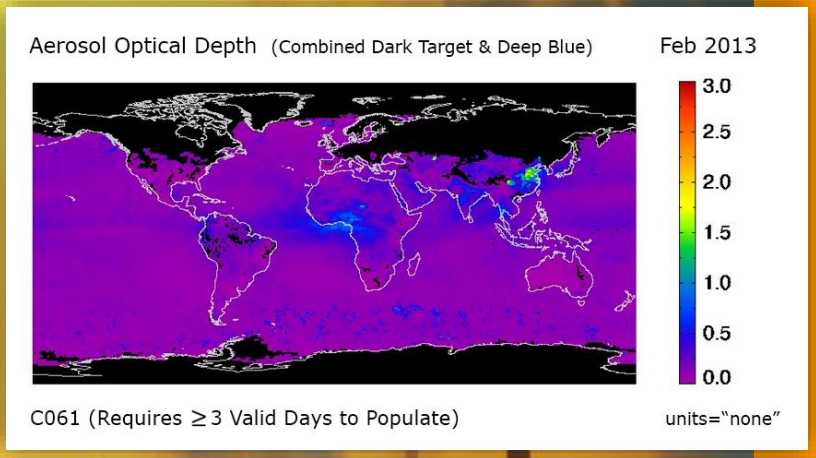
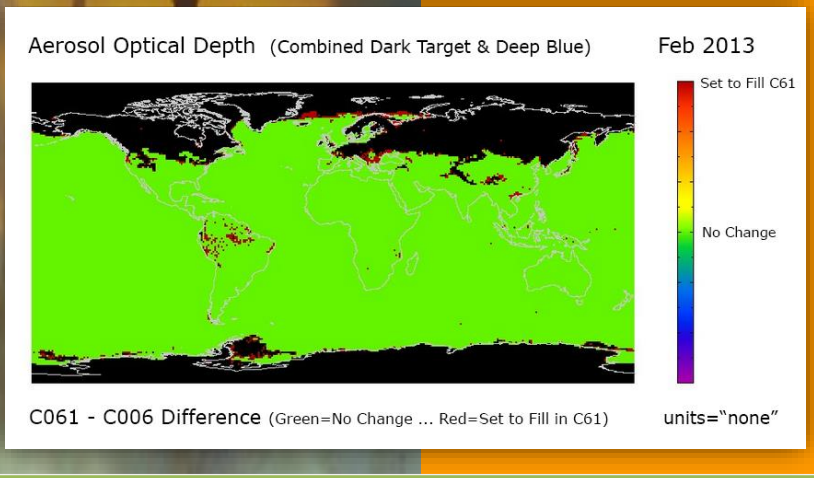
Collection 6.1 Change Document
MODIS Atmosphere Level-3 Global Products
Daily (08_D3), Eight Day (08_E3), & Monthly (08_M3)







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1.0. Introduction

This document describes the Collection 6.1 (061) changes to MODIS Atmosphere Level-3 (L3) Products, which is comprised of three products covering three temporal periods: Daily (08_D3), Eight Day (08_E3), and Monthly (08_M3).

It should be noted that there are no 061 changes to the Daily and Eight Day L3 – other than the changes that propagate into L3 from L2 Product input changes. Users should review the 061 change documents for L2 Aerosol and Cloud Products (available on the MODIS-Atmosphere website) for details.

The only high-level program changes to the L3 Products is isolated in the Monthly product – where a change in both the operational software was made as well as a myriad of changes to the Common Data Language (CDL) File Specification and HDF Structure File.

First, as a bit of background, L3 Atmosphere products contain hundreds of 1°×1° global gridded Scientific Data Sets (SDSs) or statistics derived from a set of L2 input products:

Level 2 (L2) Product Inputs to Level 3 (L3)

- Aerosol (04_L2) (The C61 change relates to Aerosol parameters in Monthly)
- Water Vapor (05_L2)
- Cloud (06_L2)
- Atmosphere Profile (07 _L2)
- Cloud Mask (35_L2) (Not read directly into L3; comes indirectly through the Cloud Product.)

Upshot: The 061 changes to the MODIS Atmosphere L3 Products is isolated in the Monthly Product (08_M3) and further isolated within the Monthly Product to L3 Scientific Data Sets (SDS's) derived from the Aerosol (04_L2) input data product only.

Product	C61 Change Status
Daily (08_D3)	No Change (except for L1B & L2 input changes that propagate into L3)
Eight Day (08_E3)	No Change (except for L1B & L2 input changes that propagate into L3)
Monthly (08_M3)	Weighting Scheme Change for Aerosol related SDS's only

Table 1. Summary of Collection 061 Change Status

2.0. Identifying Collection 061 L3 HDF Files

MODIS Level-3 Hierarchical Data Format (HDF) product files have standardized filenames that are detailed below.

Terra (AM) Platform:

MOD08_D3.AYYYYDDD.VVV.YYYYDDDHHMMSS.hdf

Aqua (PM) Platform:

MYD08_D3.AYYYYDDD.VVV.YYYYDDDHHMMSS.hdf

Definitions:
MOD08_D3 = Earth Science Data Type Name
A = Acquisition Date
YYYYDDD = Data Year and Day of Year
VVV = Collection Version
YYYYDDDHHMMSS = Processing Date & Time
hdf = Suffix denoting HDF file

Note that: (i) all times are UTC times, not local times, and (ii) the MOD08_D3 prefix represents a daily L3 Terra platform file. Daily Aqua platform files have the prefix MYD08_D3. Eight day files have the prefix MOD08_E3 and MYD08_E3. Monthly files have the prefix MOD08_M3 and MYD08_M3.

The Collection 061 HDF files will have 061 in the "VVV" part of the filename

3.0. Background & Justification of Collection 061 Changes

3.1. The old (original) scheme for populating multiday grids

The old MODIS Atmosphere L3 multiday scheme required just 1 day (in each L3 1x1 degree grid cell) out of the multi day period to be populated (non fill) in order for that grid cell to populate in the Multiday (E3 or M3) Product.

3.2. A new scheme envisioned for populating multiday grids

Some time ago, the Aerosol Team noticed that the standard existing scheme (of just a single D3 grid could populate an M3 grid) used to populate the L3 Monthly product was leading to residual snow/cloud contamination. Since the L3 Monthly Product was (and is) heavily used to study Aerosols in the scientific and research community – it was thought it was an important undertaking to solve. In those problematic grid cells it was found that in many cases just 1 day

out of 30 days had a spurious Aerosol retrieval – and after some study the Aerosol group decided they would rather have a minimum of 3 valid (non-fill) days be required before populating the monthly grid (instead of the current 1 day).

The Aerosol group was unsure at the time how to handle the Eight Day or if a modification was needed there at all. The Eight Day product was not known to be heavily used by the Aerosol community so adjusting that seemed to be a lesser priority.

This modification in the Monthly Program Executable (PGE57) required substantial changes in the Fortan 90 operation software (about 1000 lines of new code was needed); as well as changes in the Common Data Language (CDL) File Specs and subsequent HDF Structure Files, where two new local attribute settings had to be defined and switched on for each and every Aerosol related Scientific Data Set (SDS) statistic. This new logical switch in the HDF Structure file is what branched the software into a new logical pathway.

In addition, new HDF Structure/Template files had to be created with new local attributes specified for each SDS which has this new requirement. This totaled roughly 500 modified lines in the Common Data Language (CDL) File Specifications – which are then used to create new HDF Structure/Template files.

After the Monthly (M3) PGE changes were made, a number of monthly tests were run to see how the data changed using this new "Minimum 3 Day" logic. Test runs were made for February, May, August, and November 2013 so a complete seasonal cycle could be studied.

After testing it was decided that the change was working as desired, and much of the snow/ice and cloud contamination had been removed from the Monthly (M3) Aerosol SDS's using this new scheme.

At this point attention was turned to the Eight Day (E3) product. At first, the Aerosol team thought that using the same 3 day screen might be good to try -- however after some extensive testing, it was found that using a 3 day minimum was too restrictive with only 8 days in the aggregation period. (See Figure 2)

Finally it was decided that the old logic of using 1 out of 8 days (12.5%) for the E3, and 3 of 30 days (10.0%) for the M3, was a nice qualitative match in terms of relative population of input pixels (12.5% vs. 10%). So in the end, the optimal course was that only the M3 would be modified with the new 3 day minimum logic, while the E3 would use the old logic of a single D3 being allowed to populate an E3 grid.

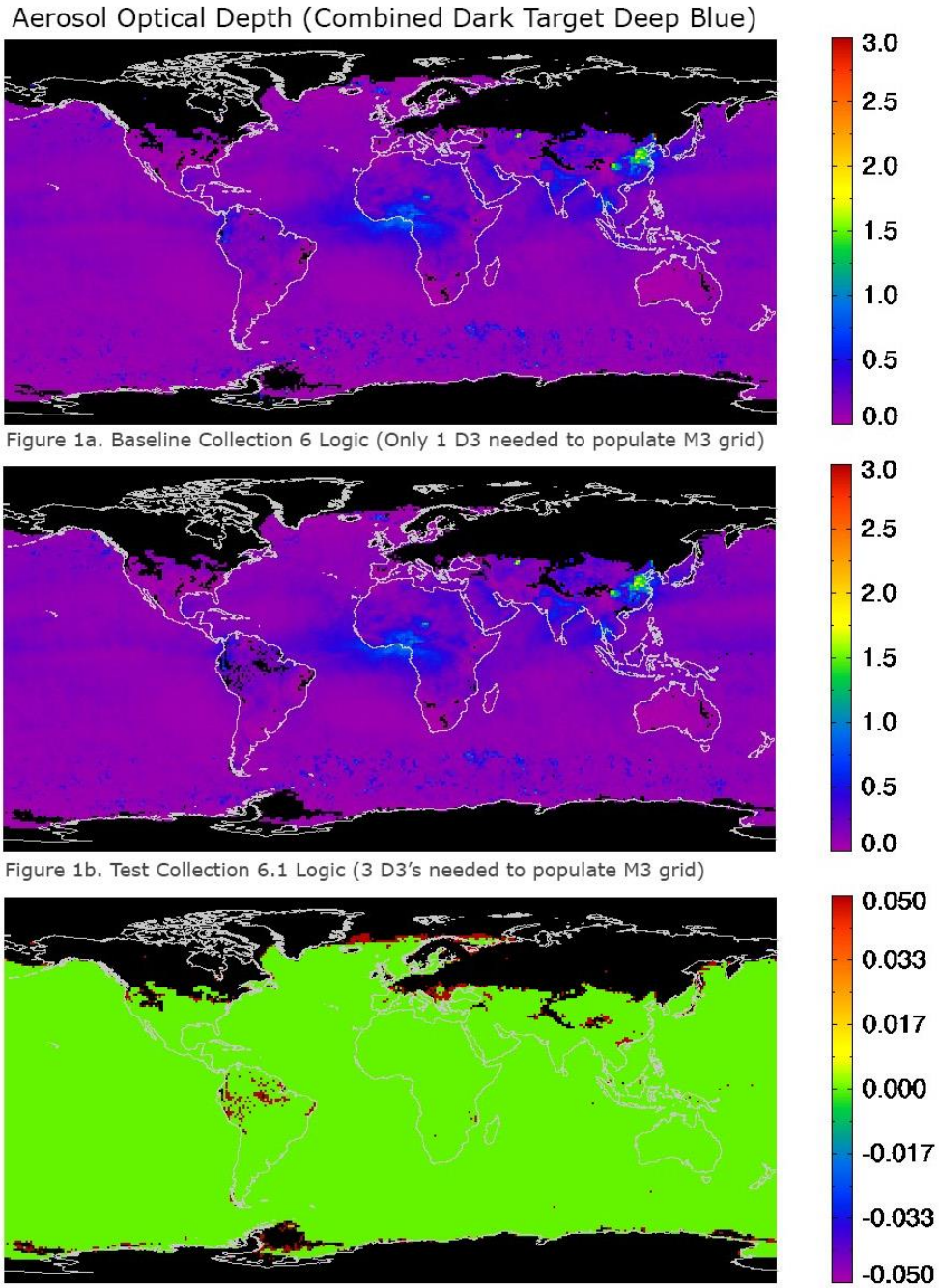


Figure 1. Example of the C61 code for Monthly data (test period was Feb 2013). The conclusion was the C61 logic produced a result that was ideal and a significant improvement for the Aerosol Team. It provided just enough masking to reduce cloud and snow/ice contamination.

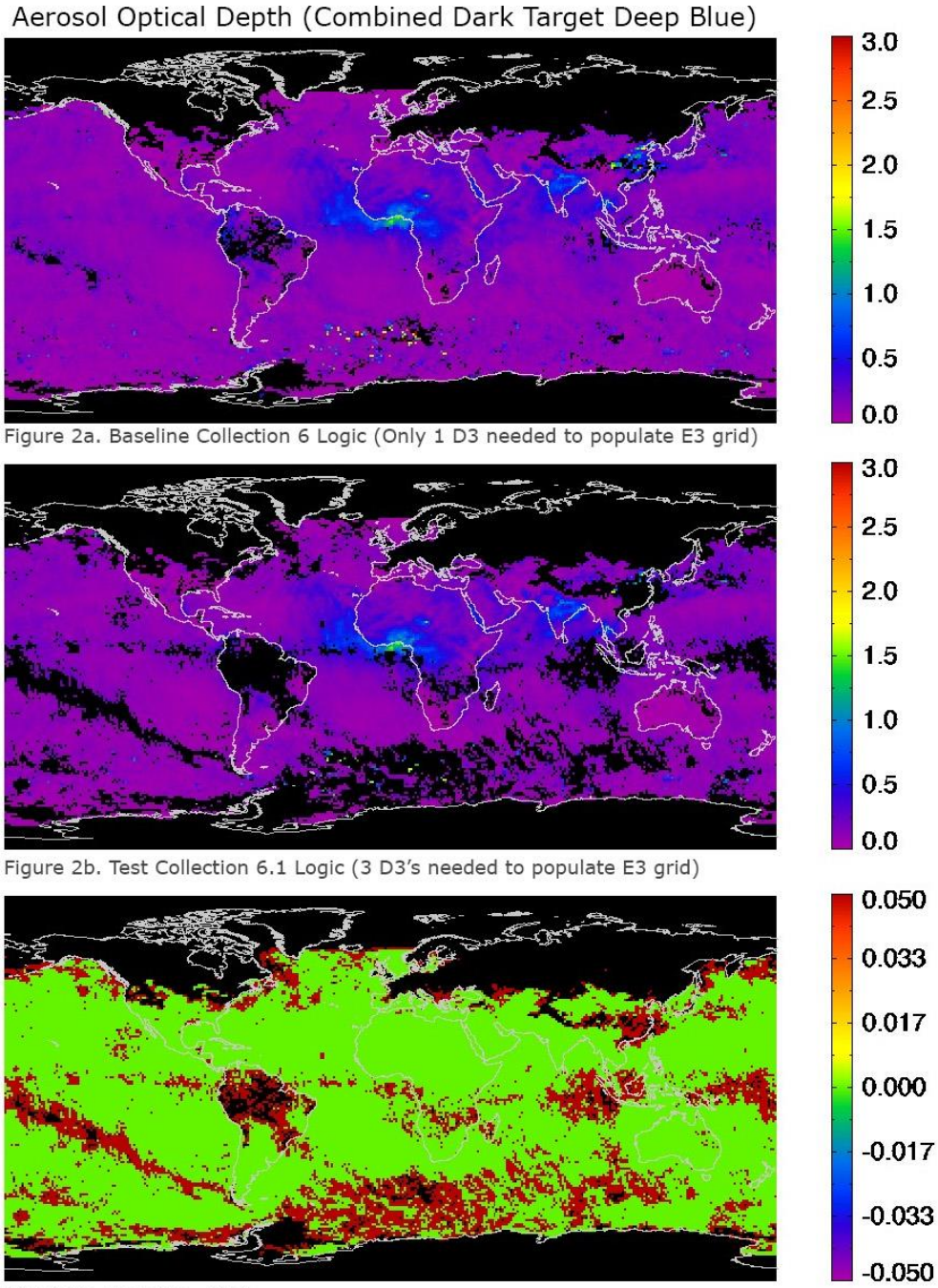


Figure 2. A test of the C61 code for Eight Day data (test period was 2-9 Feb 2013). The conclusion was the C61 logic produced a result that was "too extreme" (that is, too much data was filtered out). So this approach was abandoned for Eight Day L3 data and no changes ended up being made to that code.

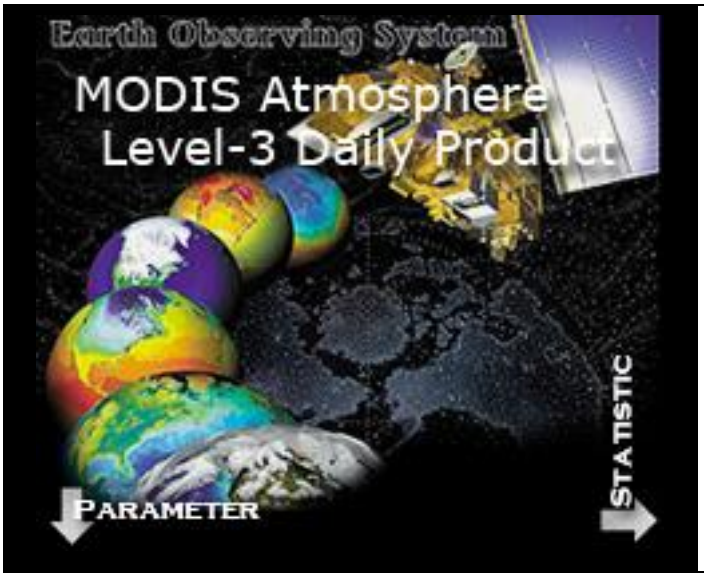
The statistical set shown below is a complete listing of all Aerosol statistics that were modified with this new 3 day mininum logic.

L3 Statistics generated from Aerosol (04_L2) inputs are:

- Simple Statistics (Mean_Mean, Mean_Std, Mean_Min, Mean_Max)
- Simple Standard Deviation Statistics (Std_Deviation_Mean)
- Simple QA Statistics (QA_Mean_Mean, QA_Mean_Std, QA_Mean_Min, QA_Mean_Max)
- Simple QA Standard Deviation Statistics (QA_Std_Deviation_Mean)
- Pixel Counts (Pixel_Counts)
- Marginal (1D) Histogram Counts (Histogram_Counts)
- Joint (2D) Histogram Counts (Joint_Histogram)

Table 2 shows a complete inventory of Aerosol related parameters and statistics derived in the MODIS Atmosphere Level-3 (L3) Monthly Product (08_M3). All of the Statistical SDS's that are represented by dots in Table 1, show the full domain of SDS's which are affected by the new Collection 6.1 Level-3 (L3) Monthly logic.

L3 Monthly (M3) Aerosol SDS Statistic Inventory



	Mean_Mean	Mean_Std	Mean_Min	Mean_Max	Std_Deviation_Mean	QA_Mean_Mean	QA_Mean_Std	QA_Mean_Min	QA_Mean_Max	QA_Std_Deviation_Mean	Histogram_Counts (n)	Confidence_Histogram (4)	Pixel_Counts	JHisto_vs_Opt_Depth (nxn)
Derived from L2 Aerosol (04_L2)														
Combined														
01. Aerosol_Scattering_Angle	●	●	●	●	●						●		●	
02. Aerosol_Optical_Depth_Land_Ocean	●	●	●	●	●						●		●	
03. Aerosol_Avg_Cloud_Distance_Land_Ocean	●	●	●	●	●								●	
04. AOD_550_Dark_Target_Deep_Blue_Combined	●	●	●	●	●						●			
Land Only														
01. Aerosol_Optical_Depth_Land (3)	●	●	●	●	●	●	●	●	●	●	●	●		
02. Aerosol_Number_Pixels_Used_Land (10)	●	●	●	●	●	●	●	●	●	●	●			
Ocean Only														
01. Aerosol_Optical_Depth_Average_Ocean (7)	●	●	●	●	●	●	●	●	●	●	●	●		
02. Aerosol_Optical_Depth_Small_Ocean	●	●	●	●	●	●	●	●	●	●	●	●		
03. Aerosol_PSML003_Ocean	●	●	●	●	●	●	●	●	●	●	●	●		
04. Aerosol_Optical_Depth_by_models_Ocean (9)	●	●	●	●	●	●	●	●	●	●		●		
05. Aerosol_Number_Pixels_Used_Ocean (10)	●	●	●	●	●	●	●	●	●	●	●			
06. Aerosol_AE1_Ocean (8x9)														●
07. Aerosol_AE2_Ocean (8x9)														●
08. Aerosol_OD_Ratio_Small_Ocean (5x9)														●
Deep Blue Aerosol														
01. Deep_Blue_Aerosol_Optical_Depth_Land	●	●	●	●	●						●			
02. Deep_Blue_Aerosol_Optical_Depth_550_Land	●	●	●	●	●						●			
03. Deep_Blue_Angstrom_Exponent_Land	●	●	●	●	●						●			
04. Deep_Blue_Single_Scattering_Albedo_Land (3)	●	●	●	●	●						●			
05. Deep_Blue_Number_Pixels_Used_550_Land	●	●	●	●	●						●			
06. AOD_550_Dark_Target_Deep_Blue_Combined	●	●	●	●	●						●			

Table 2. A complete list of the Aerosol related SDS's that had the new C061 three-day minimum screening applied. Each dot in the table represents a single SDS (which might have multiple waveband dimensions, shown in parens after the SDS Parameter Name prefix). The SDS name is made by combining the Parameter prefix with the Statistic suffix that each dot intersects.

4.0. Direct Comparison of Collection 6 and Collection 6.1

4.1. Aerosol

The Level-2 (L2) Aerosol Algorithm was updated for Collection 6.1. Shown in Figure 3 are how those differences will look on a monthly time scale.

It should be noted that no only does the Collection 6.1 version of the Aerosol parameter shown in Figure 3, have the new Monthly logic applied which slightly restricts the domain of valid pixels (screening out L3 1x1 degree grid cells with likely cloud or snow/ice contamination); but additional changes are captured which flowed in from a modified C6.1 Level-2 (L2) Aerosol algorithm which had a number of changes and improvements.

A highlight of those Level-2 (L2) C6.1 Aerosol algorithm changes are:

Dark Target Aerosol

- Modified the sediment mask to make It more robust (ocean only)
- Degraded the quality of aerosol retrievals to zero if there are more than 50% coastal or 20% water pixels in 10x10 km grid (land only)
- Modified algorithm for Aerosol retrieval over land surface when urban percentage is larger than 20% using a revised surface characterization. MODIS land cover type data set is used to identify urban pixels. The revised surface ratios for urban regions were created using MYD09 spectral surface reflectance product. (land only)
- Added reflectance, standard deviation, aerosol cloud fraction, and number of pixels for retrievals when optical depth is zero or very small. All earlier PGE04 Versions (Collections) reported only optical depth in these cases. (land only)

Deep Blue Aerosol

- Improved Smoke Detection Mask for weakly absorbing smoke (which looks like cloud in some spectral bands)
- Artifact and shadowing reduction in heterogeneous terrain
- Improved Surface Modeling in elevated terrain
- Updated regional and seasonal aerosol optical models

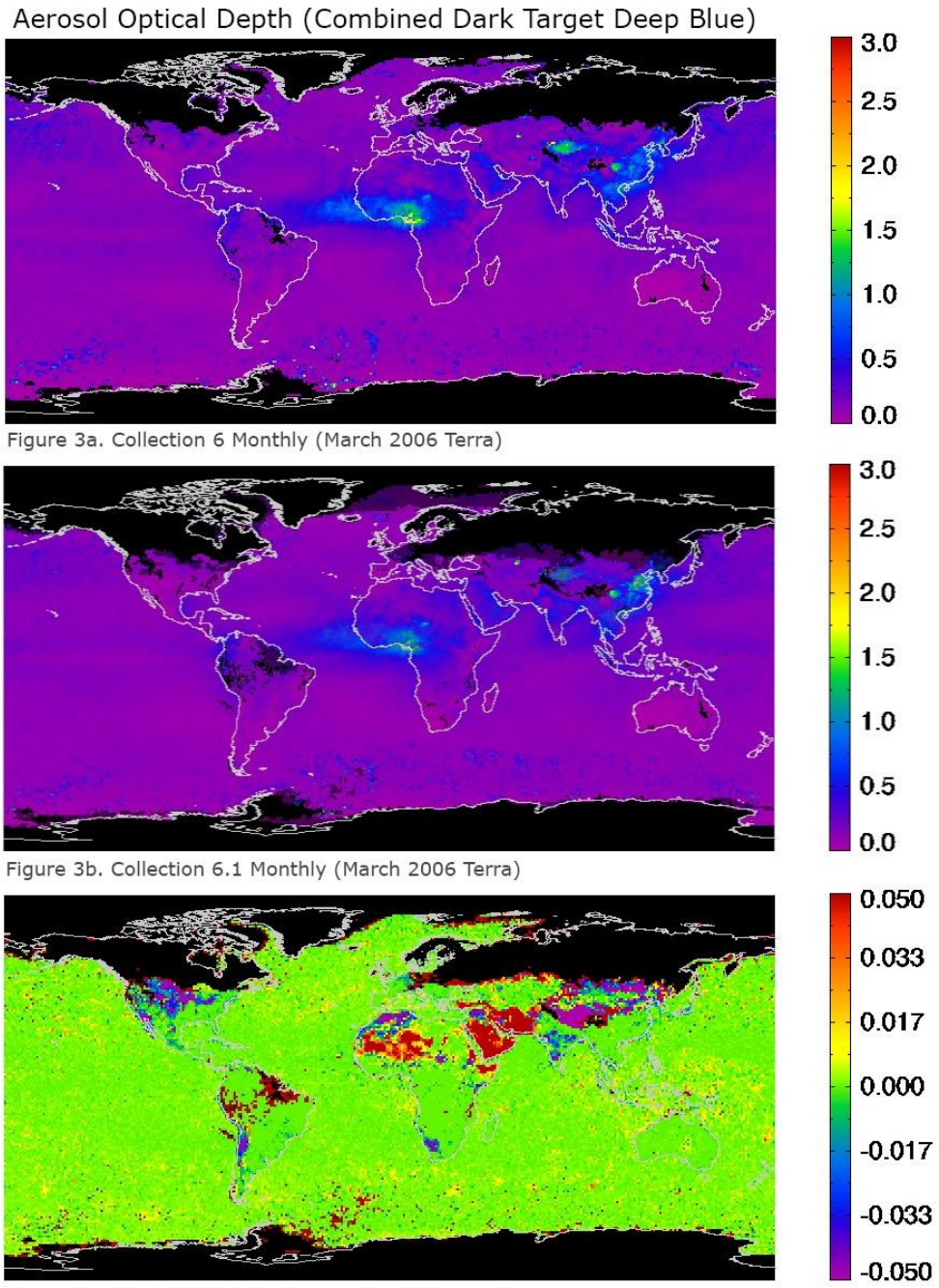


Figure 3. A comparison of C6 vs. C61 Monthly data (March 2006). The more dramatic differences in the results were mostly due to changes to the L2 Aerosol algorithm for C61 propagating into L3. The more stringent masking in the C61 monthly code allowed some contaminated grids to be set to fill.

4.2. Cloud Optical Properties

The Level-2 (L2) Cloud Optical Properties Algorithm was updated for Collection 6.1. Shown in Figures 4 and 5 are how those differences will look on a monthly time scale for 2 of the key Scientific Data Sets (SDS's): Cloud Effective Radius (for Liquid Water Clouds) and Cloud Optical Thickness (for Liquid Water Clouds).

A highlight of those Level-2 (L2) C6.1 Cloud Optical Property algorithm changes are:

Cloud Optical Properties

- New Surface Type used by the OD code explicitly alerts users which surface type was used in the retrievals. Previous flags in earlier versions were sometimes inconsistent with OD surface assumptions
- The C6 gap filled spectral surface albedo is implemented to replace the previous version. Further the previous albedo was only processed through 2013, the new albedo dataset now runs through 2016.
- All Cloud Optical Property SDSs are now assigned fill values when the 1km Cloud Top (CT) product is fill. This primarily affects southern Africa and the southern Indian Ocean where a black body warm up / cool down issue is known to intermittently cause CT retrieval failures.

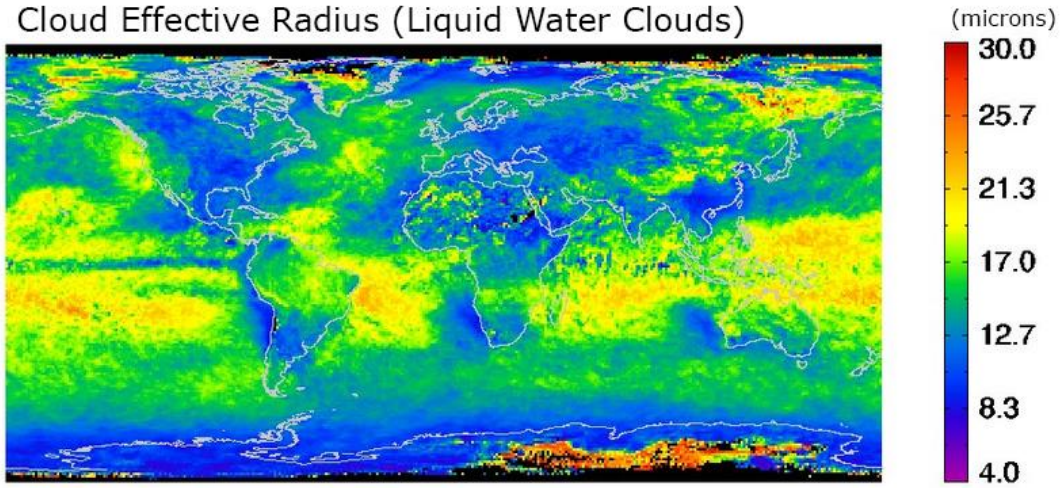


Figure 4a. Collection 6 Monthly (March 2006 Terra)

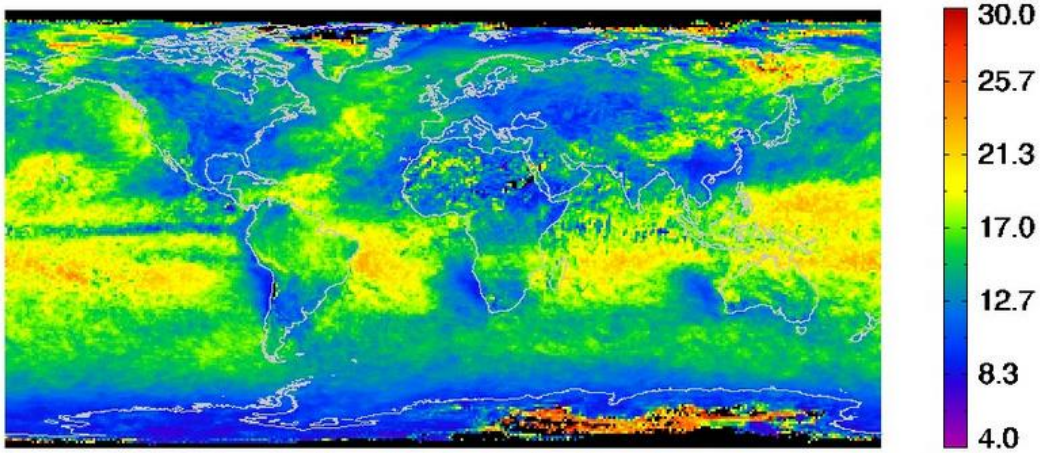


Figure 4b. Collection 6.1 Monthly (March 2006 Terra)

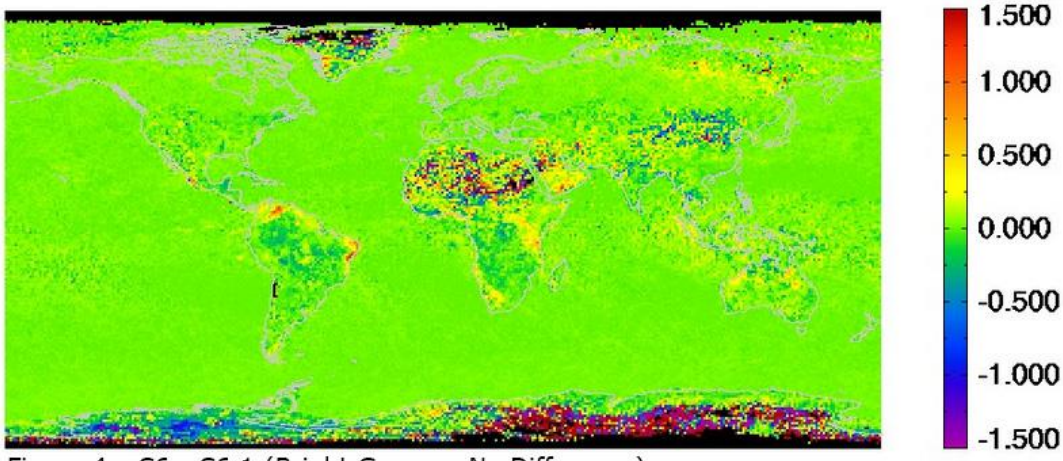


Figure 4c. C6 - C6.1 (Bright Green = No Difference)

Figure 4. A comparison of C6 vs. C61 Monthly data (March 2006). Differences in the results were due to changes to the L2 Cloud Optical Properties algorithm for C61 propagating into L3.

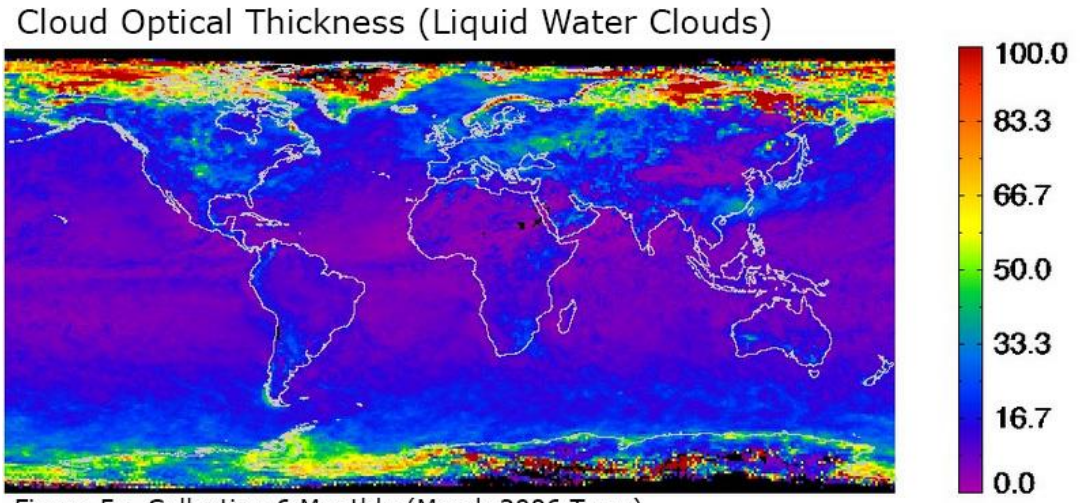


Figure 5a. Collection 6 Monthly (March 2006 Terra)

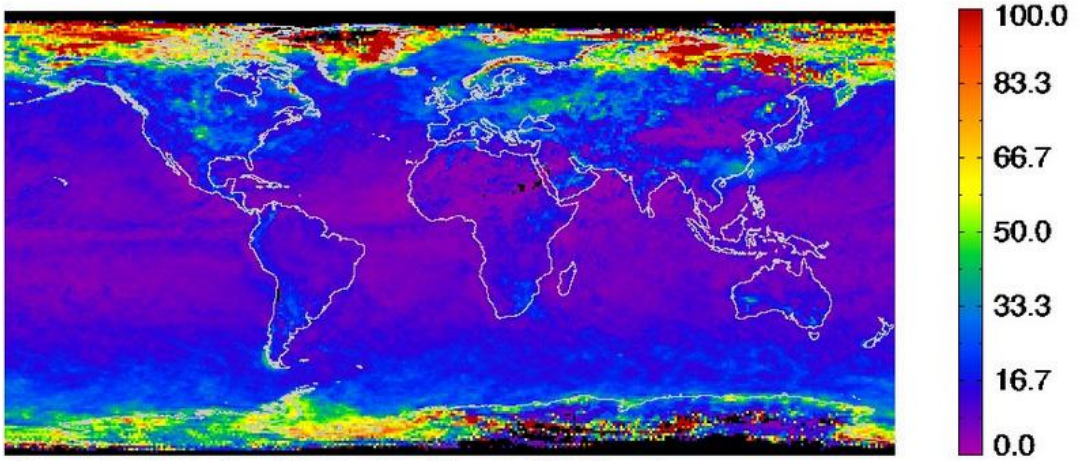


Figure 5b. Collection 6.1 Monthly (March 2006 Terra)

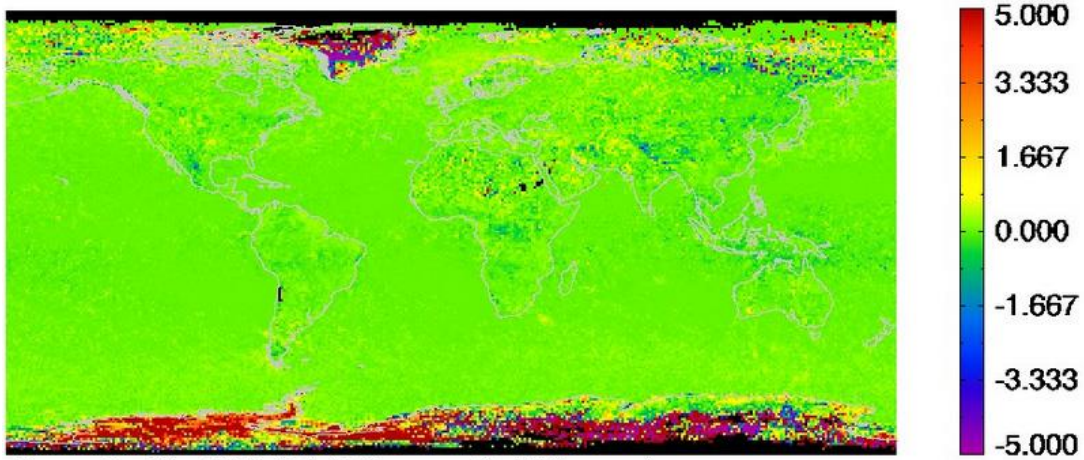


Figure 5c. C6 - C6.1 (Bright Green = No Difference)

Figure 5. A comparison of C6 vs. C61 Monthly data (March 2006). Differences in the results were due to changes to the L2 Cloud Optical Properties algorithm for C61 propagating into L3

4.3. Cloud Top Properties

The Level-2 (L2) Cloud Top Properties Algorithm was updated for Collection 6.1. Shown in Figure 5 are how those differences will look on a monthly time scale for just 1 of the key Scientific Data Sets (SDS's): Cloud Top Pressure (for Daytime only) .

A highlight of those Level-2 (L2) C6.1 Cloud Top Property algorithm changes are:

Cloud Top Properties

- Electronic Crosstalk contamination, striping, and long term drift has been reduced in atmospheric band 27 by using a linear crosstalk correction algorithm -- this has improved key upstream L1B data. Additional products were impacted by drift and subsequent correction in 8.6 and 7.3 radiances. IR Cloud Phase was impacted as previously far too many clouds were tagged ice phase – the calibration fix noted above has mostly corrected this issue. Finally, in the CO2 slicing cloud top pressure algorithm, previously too many clouds had cloud top pressures that were anoma-lously low. The crosstalk correction has mitigated this problem as well.

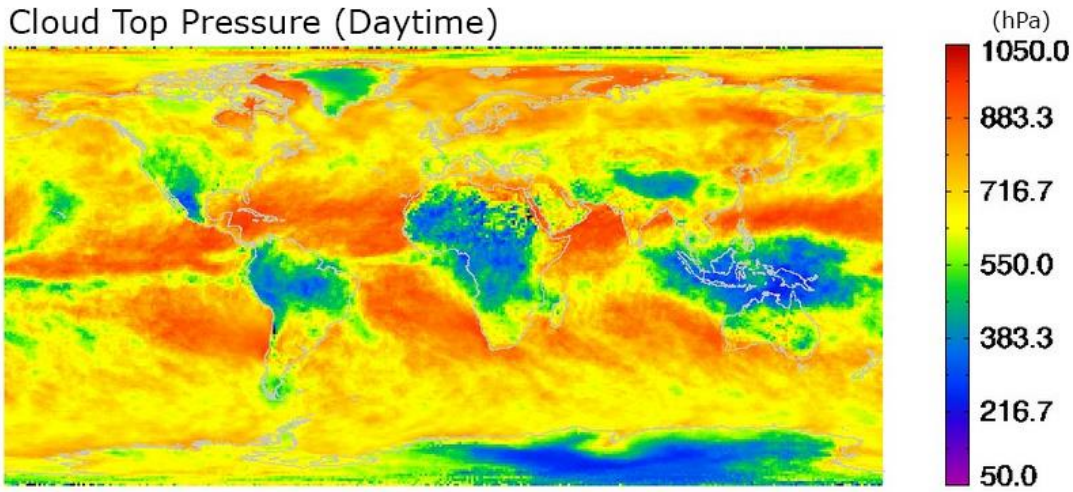


Figure 6a. Collection 6 Monthly (March 2006 Terra)

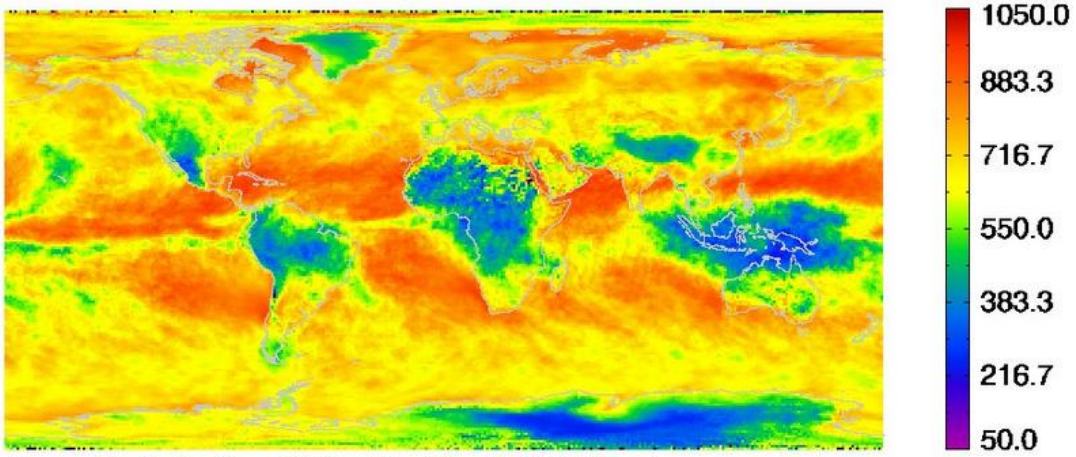


Figure 6b. Collection 6.1 Monthly (March 2006 Terra)

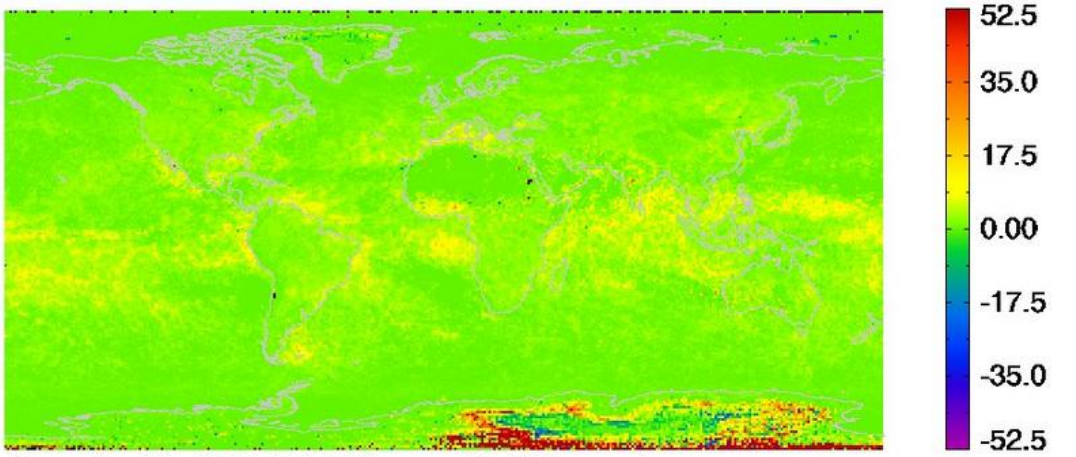


Figure 6c. C6 - C6.1 (Bright Green = No Difference)

Figure 6. A comparison of C6 vs. C61 Monthly data (March 2006). Differences in the results were due to changes to the L2 Cloud Top Properties algorithm for C61 propagating into L3.

4.4. Atmospheric Profiles

The Level-2 (L2) Atmospheric Profile Properties Algorithm was updated for Collection 6.1. Shown in Figures 6 and 7 are how those differences will look on a monthly time scale for 2 key Scientific Data Sets (SDS's): Atmospheric Water Vapor (for Lower Atmosphere) and Total Ozone.

A highlight of those Level-2 (L2) C6.1 Atmospheric Profiles algorithm changes are:

Atmospheric Profiles

- As outlined in the previous section, Electronic Crosstalk contamination, striping, and long term drift has been reduced in atmospheric band 27 by using a linear crosstalk correction algorithm -- this has improved key upstream L1B data. Additional products were impacted by drift and subsequent correction in 8.6 and 7.3 radiances. This crosstalk problem caused issues in the IR Water Vapor as well as other Atmospheric Profile parameters, all which are now much improved after this fix was applied.

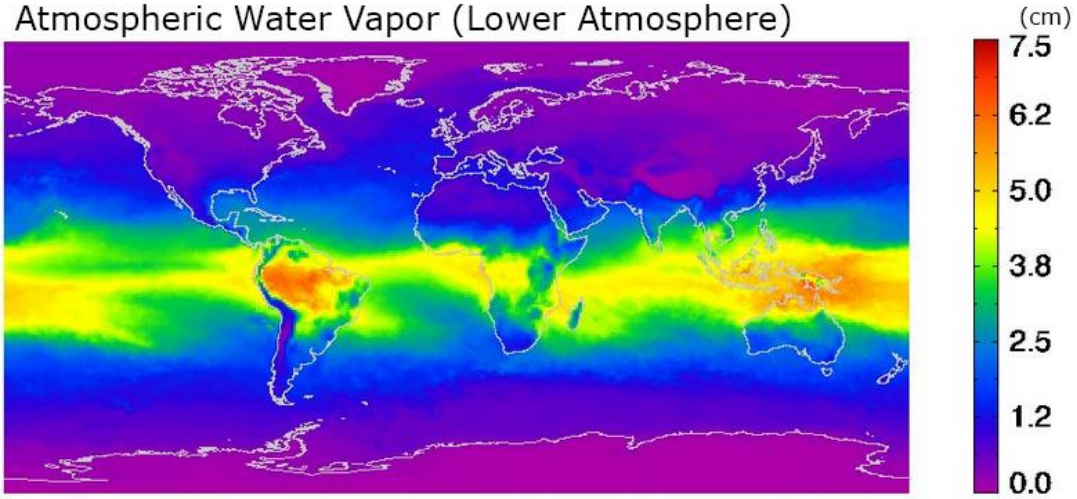


Figure 7a. Collection 6 Monthly (March 2006 Terra)

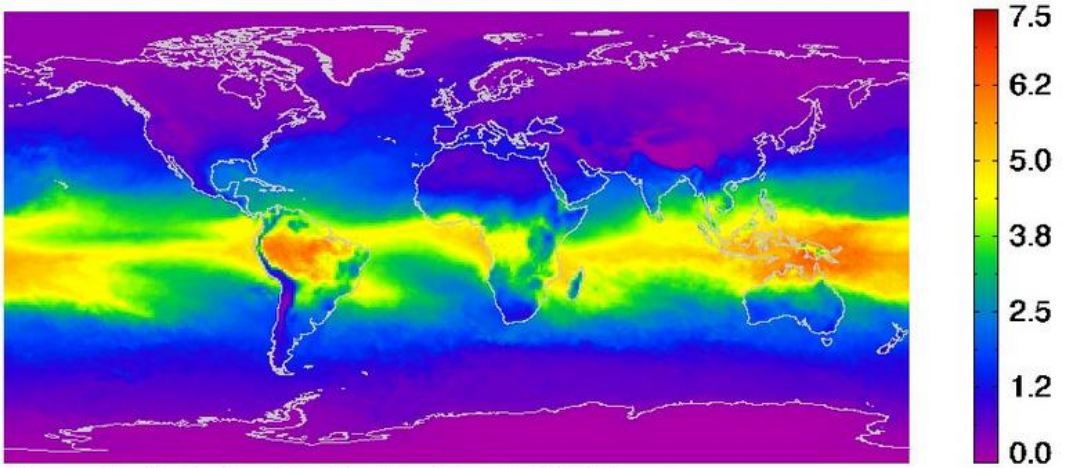


Figure 7b. Collection 6.1 Monthly (March 2006 Terra)

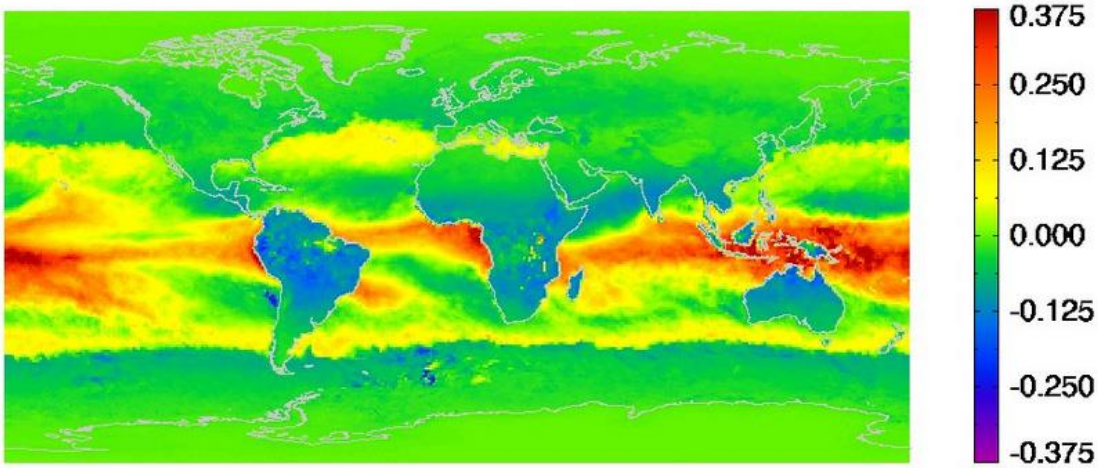


Figure 7c. C6 - C6.1 (Bright Green = No Difference)

Figure 7. A comparison of C6 vs. C61 Monthly data (March 2006). Differences in the results were due to changes to the L2 Atmospheic Profiles algorithm for C61 propagating into L3.

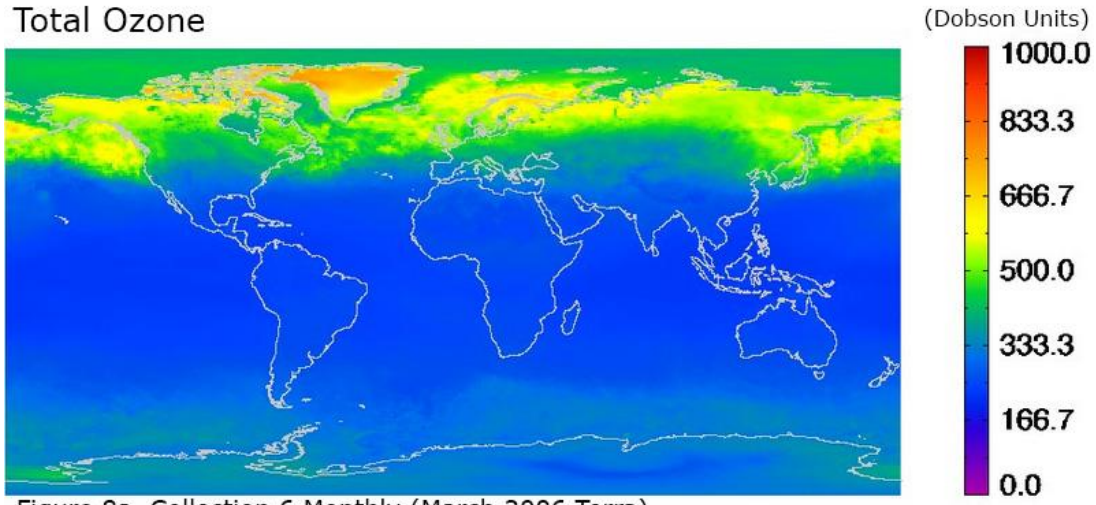


Figure 8a. Collection 6 Monthly (March 2006 Terra)

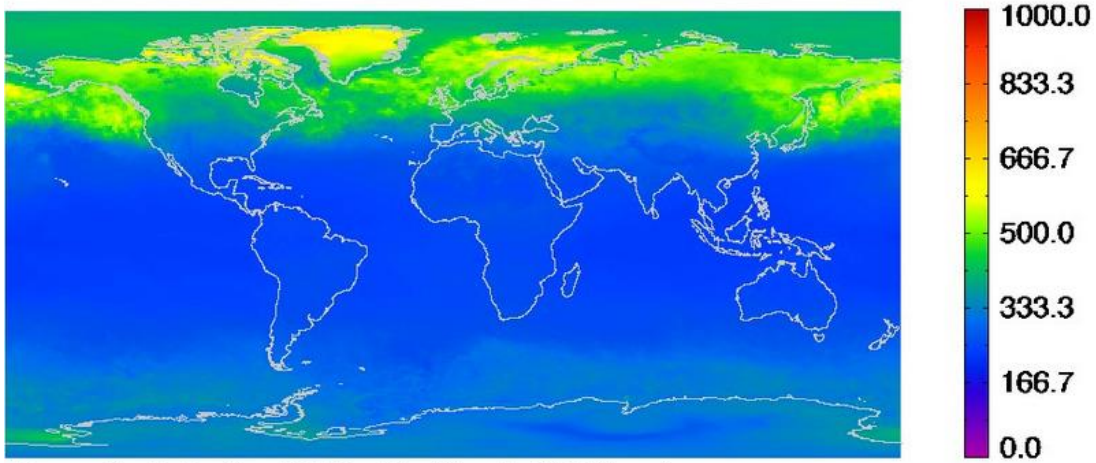


Figure 8b. Collection 6.1 Monthly (March 2006 Terra)

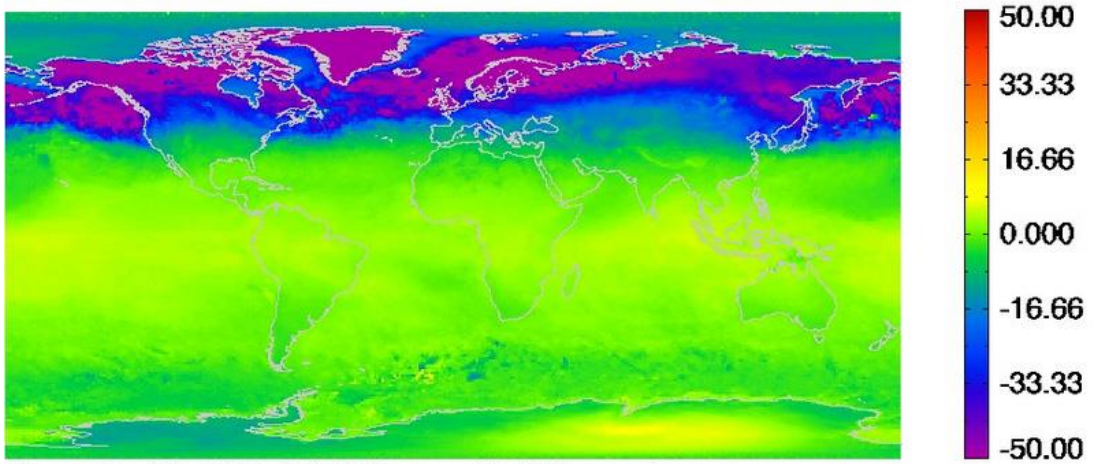


Figure 8c. C6 - C6.1 (Bright Green = No Difference)

Figure 8. A comparison of C6 vs. C61 Monthly data (March 2006). Differences in the results were due to changes to the L2 Atmospheic Profiles algorithm for C61 propagating into L3.