Collection 005 Change Summary for the MODIS Atmosphere Level-3 Products

Paul A Hubanks & Dr. Michael D. King
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The Collection 005 Level-3 operational software contains several significant software modifications (bug fixes) and numerous (extensive) parameter/statistic changes. Due to the massiveness and complexity of the total change, the suite of L3 software was delivered in four stages during the period from July 2004 to April 2005.

It should be noted that several bug fixes made to the "upstream" version of the MODIS Atmosphere L3 Tiling code (MOD_PR08T) will propagate through to, and fix isolated data errors in, all the L3 distributed products: daily, eight-day, and monthly (08_D3, 08_E3, and 08_M3, respectively).

Software Changes:

Software changes were implemented to fix 3 general errors: **1.)** A Joint Histogram statistic binning error that occurs when a L2 data point falls exactly on any bin boundary, **2.)** A Histogram statistic computational error that occurs for parameters where no QA exists or is passed (an event isolated to the Cloud Top Property histograms), and **3.)** Correcting the Pixel Count statistic fill value (changing from 0 to the standard fill of -9999).

A more detailed description of each bug and an outline of specific code changes made to the MODIS Atmosphere L3 Tiling code to correct each of these bugs, follows:

- **Joint Histogram Statistic binning error.** Corrected the Joint Histogram binning logic in subroutine ComputeJointPDFCounts_OneBox (a routine in ComputeStatistics.f90). The old incorrect logic was double counting L2 pixels that fell exactly on any joint histogram bin boundary. In other words, a single L2 pixel that fell on a joint histogram bin boundary was causing the counter to increment in both adjacent bins – therefore this coding error will only show itself when L2 data points fall exactly on specified joint histogram bin boundaries. Generally this causes an error in the counts of 0 to 5%; however in some very isolated (few) parameters/bins that had very small total counts, errors in counts did reach as high as 50%.

- **Cloud Top Properties Histogram Statistic computation error.** Modification to call Histogram computation routines with QA only when QA is set and/or needed. Without this modification some 06_CT (cloud top properties) histogram statistics contain slight errors. (Errors are on the order of 5-10% in roughly 5% of the L3 grid cells for 06_CT (cloud top properties) marginal histograms only). An additional modification was made related to this problem, to initialize QA arrays with 0's (the default (fill) QA value). This is needed for joint histograms made purely with 06_CT parameters since UW does not rigorously set QA (Cloud Top Property QA appears to be set to 7, an invalid QA value, in all L2 (input) granules).

- **Pixel Count Statistic fill value correction.** Changed the fill value in all Pixel Count SDS's from 0 to the standard fill value of -9999. This correction was done to make the fill region of the PixelCount statistics/images consistent with other statistics (SDS's). The specific software changes made were: Corrected the logic in subroutine ComputeFraction (a routine in ComputeStatistics.f90) to assign a fill value to PixelCount statistic where the Fraction statistic is set to fill. An identical bug fix was implemented for the parallel case of PixelCounts computed with simple statistics. Corrected the logic in subroutine ComputeSimpleStatsNoQA_OneBox (a routine in ComputeStatistics.f90) to assign a fill value to PixelCount statistic where other statistics (Mean, Minimum, Maximum, StandardDeviation) are set to fill.

- **Added Uncertainty Statistic Computation.** The PGE69 (five-degree tiling), PGE56 (daily), PGE70 (eight-day), and PGE57 (monthly) packages were modified to add a new statistical computation called "Uncertainty" - a new innovative measurement of the computed uncertainty in various L3 (gridded) mean Cloud Optical Property parameters (Cloud Optical Thickness, Cloud Effective Radius, and Cloud Water Path). This new statistic, derived from Level-2 (L2) pixel-level uncertainties, is considered an important enhancement to clarify results and improve scientific conclusions drawn from intra-instrument comparisons of these key Cloud Optical Property parameters. Four "flavors" of this statistic will be computed in the L3 suite:

    - The regular unweighted uncertainty, noted by an SDS suffix of "Mean_Uncertainty"
    - The QA confidence weighted uncertainty, noted by an SDS suffix of "QA_Mean_Uncertainty"
    - The regular unweighted log uncertainty, noted by an SDS suffix of "Log_Mean_Uncertainty"
    - The QA confidence weighted log uncertainty, note by an SDS suffix of 'QA_Log_Mean_Uncertainty".

- **Added an input data screen for the Log_Mean and Log_Standard_Deviation computations.** These statistics are provided only for the parameters of Cloud Optical Thickness (Tau) field. Due to a digitization anomaly in the upstream Level 2 Cloud Optical Properties algorithm, small but finite L2 values are truncated to zero and propagated into the Level 3 code. These 0 values represent a clear scene, but they are now trapped by the L3 code and replaced by the smallest non-zero Tau (0.01) that can be stored in the L2 file. This adjustment allows the Level 3 code to recognize very thin clouds and represent them with Cloud Optical Thicknesses values closely approximating the "digitized" values lost at L2. It should be noted that a late Collection 005 change was implemented in the 06_OD (L2 Optical Properties algorithm) removing this digitization error in the upsteam data; therefore making this change in the L3 code unnecessary, however the L3 code was delivered prior to this L2 change being made.

- **Patched code to handle dead Aqua detectors in band 6 when subsampling 1km L2 data on a 5km geolocation grid.** Added a new runtime parameter (Subsampling_Start_Detector) to the process control file (PCF) that identifies the starting (first) along-track position of subsampled L2 input. Subsequent samples are taken every 5th line.

Starting in Collection 005, the 4th detector (instead of the 3rd as in Collection 004), is used as the starting point for sampling. Across-track, data are still sampled starting at the 3rd pixel (as done previously in Collection 4), with subsequent samples every 5th pixel. Note 1: During L3 processing, Level 2 (L2) parameters at 1 km resolution are sampled at the 5 km resolution of the Geolocation data stored in the L2 products. These parameters include the NIR Water Vapor (05_L2), Cirrus Detection (06_L2), and Cloud Optical Properties (06_L2). Note 2: The change in start detector (from the 3rd to the 4th) was prompted by the failure of Aqua MODIS detectors 3 and 8 in band 6. The change is extended to Terra data as well after studies showed that Terra detector pairs 4 and 9 provided the most representative results on 5km grid cell. Note 3: Geolocation data is read in from the Level 2 products and is not amenable to change at L3. This means that L3 processing will associate a science observation at detector line 3 with geolocation information at line 2. This could have a minor effect along the boundaries of the 1 degree L3 grid cells where L2 grid points could be shifted into a neighboring L3 grid box - however due to the large samples in each 1 degree cell, the effect on statistics will be negligible.

- **Modified code to handle partial Cloud Optical Property retrievals at L2.** A partial retrieval is defined when the L2 Cloud Optical Thickness is retrieved but the L2 Cloud Effective Radius is missing. For L3 computations, these partial retrievals needed to be completely screened out of all statistical computations because it was found that these partial retrievals were not as reliable as full retrievals. It should be noted that partial retrievals occur only in the Liquid, Undetermined, or Combined cloud phase in the primary, single layer cloud (1L), and 1.6/2.1 micron (1621) optical property retrievals.

Parameter (SDS) Changes:

Numerous changes in the science product, via modifications to product CDL file specification and HDF template (structure) file, were made. Unless otherwise specified, these changes apply to all distributed L3 products (Daily, Eight-Day, and Monthly).

Most of the changes occurred in the Cloud Optical Properties part of Cloud (06_L2) derived parameters; and secondarily to the Aerosol (04_L2) derived parameters. These changes include:

Changes to Aerosol Product (04_L2) derived parameters:

- Corrected the local attributes of two recently added Aerosol-derived parameters:
    - Aerosol_Cloud_Mask_Cloud_Fraction_Land
    - Aerosol_Cloud_Mask_Cloud_Fraction_Ocean

The local attributes were changed to reflect changes in the 04_L2 HDF input file where numbers were modified to be stored at true unitless fractions that range from 0 to 1, instead of percent fractions that range from 0 to 100. The scale factor and valid range was modified in L3 to maximize the number of significant digits stored. This change was done to make the Aerosol cloud fractions consistent with other cloud fractions computed and stored in the suite of L2 and L3 products.

- Added Aerosol_Cloud_Mask_Cloud_Fraction(_Land & _Ocean).

- Added Number_Pixels_Used(_Land & _Ocean) for Aerosol retrievals.

- Clarified Optical_Depth_by_models_ocean longname description to include a key to the 9 aerosol type models.

- Deleted all Aerosol Flux parameters.

- Modified the valid range and histogram bin boundaries for seven Aerosol parameters all were related to Aerosol Optical Depth or Angstrom Exponent. The range was typically adjusted from [0.0 to 3.0] to [-0.1 to 5.0].

Changes to Cloud Product (06_L2) Optical Properties Process (06_OD) derived parameters:

- Several SDS names had to be shortened due to a 63 character limit in HDF-EOS. This name shortening, which broke the naming convention standard implemented up to now, was done by substituting "_Hist_" for "_Histogram_". The new shortened SDS names for the 3 affected SDS's are:
  Cloud_Optical_Thickness_1L_Liquid_Joint_Hist_vs_Effect_Radius
  Cloud_Optical_Thickness_1621_Liquid_Joint_Hist_vs_Effect_Radius
  Cloud_Optical_Thickness_1621_Ice_Joint_Hist_vs_Effect_Radius

  Added a new joint histogram Optical Properties Cloud Phase vs. Cloud Top Temperature for single-layer clouds only. The new SDS is called Cloud_Phase_Optical_Properties1L_Joint_Histogram_vs_Temperature. Note that the convention of using "_1L_" in the SDS name to denote single layer clouds was broken here due to a SDS-name length limit of 63 characters.

- Added a new joint histogram Cloud Optical Thickness vs. Cloud Top Pressure (for combined (all) phase clouds only) tuned for making direct comparisons to ISCCP (International Satellite Cloud Climatology Project). Histogram bins were defined to match those already in use for ISCCP data and was devised so that comparisons with those data can be made directly. The new SDS is called Cloud_Optical_Thickness_ISCCP_Joint_Histogram_vs_Pressure.

- Added three new joint histogram statistics (SDS's) that relate Cloud Phase (from both the UW and GSFC Cloud Phase Determination algorithms) to Cloud Top Temperature:
  - Cloud_Phase_Optical_Properties_Joint_Histogram_vs_Temperature
  - Cloud_Phase_Infrared_Day_Joint_Histogram_vs_Temperature
  - Cloud_Phase_Infrared_Night_Joint_Histogram_vs_Temperature

- Added four new multilayer-cloud related parameters depicting the ratio of Multi-Layer Clouds to all (All-Layer) Clouds by Phase. Each of these parameters has two SDS's associated: Fraction and Pixel_Counts:
  - ML_Fraction_Liquid
  - ML_Fraction_Ice
  - ML_Fraction_Undetermined
  - ML_Fraction_Combined

- Consolidated and re-ordered the bins in the Cloud_Phase_Infrared histograms from 7 to 5. The old 7-bin specification included two bins that are no longer being used in the L2 Cloud Phase Infrared input data. The new 5-bin categories are: Clear, Liquid Water Clouds, Ice Clouds, Mixed Phase Clouds, and Undetermined Phase Clouds (in that order).

- Updated numerous Optical Property QA Flags to reflect updates to the 06_L2 input HDF product file. The QA flags in 06_L2 files was updated to 1.) remove flags that were not being set and/or used and 2.) to add new flags that add value and functionality (such as the new multi-layer cloud flag, and flags for the 1.6 / 2.1 retrieval).

- Added four new parameters needed to properly weight numerous Optical Property SDS's in the Eight Day and Monthly L3 products. The new parameters are:
    - Cloud_Fraction_1L_Liquid
    - Cloud_Fraction_1L_Ice
    - Cloud_Fraction_1621_Liquid
    - Cloud_Fraction_1621_Ice

- Corrected the "Weighting_Parameter_Dataset" in numerous Eight-day and Monthly Optical Property parameters. This was needed due to the implementation of numerous SDS name changes in the upstream Daily HDF product.

- Deleted three Optical Property joint histograms (vs. Effective Emissivity). These were found to be of limited usefulness and were deleted to save space (since they were quite large).

- Added four Optical Property joint histograms (vs. Cloud_Top_Pressure).

- Clarified High_Cloud_Fraction and Cirrus_Fraction_Infrared longname description to assist data users in their meaning and use.

- Clarified Atmospheric_Water_Vapor longname description (Atmospheric pressure-levels for "high" and "low" were defined).

- Clarified Water_Vapor_Near_Infrared longname description.

- Corrected Cloud_Water_Path valid ranges. These were incorrectly specified in Collection 004 data and previous.

- The following parameter name changes were implemented in Cloud Optical Property derived parameters:
    - Changed all "_Water" SDS names to "_Liquid" (denoting liquid water clouds)
    - Changed "Successful_(Phase)_Cloud_Retrieval_Fraction" SDS names to
    - "Cloud_Fraction_(Phase)"
    - Changed "Water_Path" SDS names to "Cloud_Water_Path"

- Added four new primary cloud optical property retrieval joint histograms (Cloud Optical Thickness and Cloud Effective Radius vs. Cloud Top Pressure for liquid water and ice

clouds only.

- Added three new single layer clouds only joint histograms made from the primary cloud optical property retrieval parameters.
- Added supplementary 1.6/2.1 micron cloud optical property retrieval Tau, Re, WP statistics (6 new parameters).
- Added two new 1.6/2.1 micron cloud optical property retrieval joint histograms.
- Deleted three cloud optical property joint histograms (Cloud Optical Thickness and Cloud Effective Radius vs. Cloud_Effective_Emissivity).
- Added Cloud Optical Thickness, Cloud Effective Radius, and Cloud Water Path statistics for single layer liquid water and ice clouds only (6 new parameters).
- Added multilayer cloud fractions aggregated by phase (4 new parameters).
- Clarified all Cloud Optical Property longnames.
- Added 28 new Uncertainty SDS's. These new statistics are only added to various Cloud Optical Property (06_OD) derived parameters and are used to estimate the uncertainty in the Mean and QA Mean gridded statistics (based on pixel-level (L2) uncertainties).
- Adjusted the valid range of Cloud Effective Radius Ice from 6-60 to 5-90. This was necessary due to the implementation of a new ice library in the upstream 06_L2 Cloud Optical Properties algorithm. This expanded range of valid values required an additional (new) "high" (60-90 micron) bin to be added to a number of pre-existing histograms and joint histograms; and also required an adjustment of the "low" bin to range down to 5 microns (from 6). Parallel changes were also required in the Cloud Water Path Ice histograms, whose values depend on the Cloud Effective Radius Ice parameter. This change also required an adjustment to the "valid_range" and "long_name" local attribute of numerous Cloud Optical Property derived SDS's.

A Summary Table

Although written out in the *bulleted* listing above, an alternate view of the overall parameter and SDS changes are displayed in the table below. The table highlights specific changes to the parameter and SDS list in the MODIS Atmosphere L3 daily (08_D3) product. Cells in the table highlighted in *green* show new parameters and/or SDS's added for Collection 005. Parameter cells highlighted in *orange* show where parameter name changes were implemented. Cells highlighted in *red* show parameters and/or SDS's that were deleted for Collection 005.

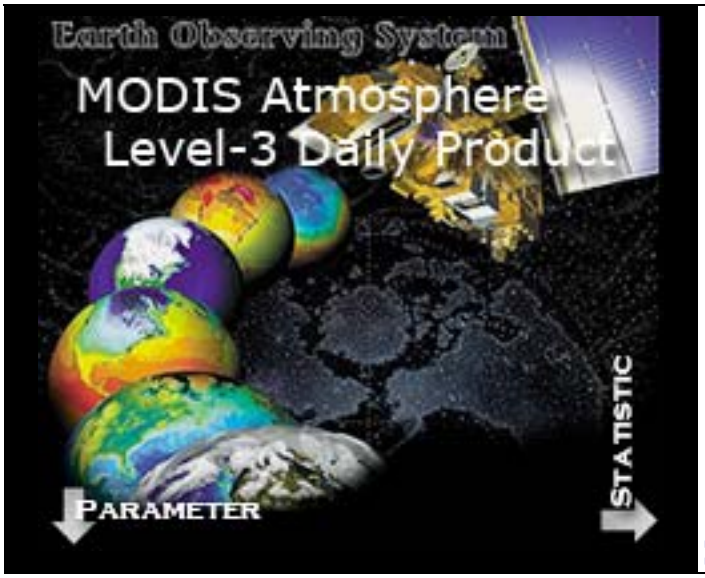
Note that the list of changes in parameters and SDS's for the eight-day and monthly products are nearly identical to the daily product, so for simplicity, only the daily list is shown here.

Specific SDS names can be determined by combining the parameter name with the statistic name where each dot in the table occurs. For example, the first dot in the table represents the SDS Scat-

tering_Angle_Mean. Numbers in parentheses after various parameter and/or statistic names shows the dimension. If no number is shown, the dimension is one (1). If the letter "n" is shown (for example after "Histogram Counts", the dimension is greater than one (1) and varies by parameter.

L3 Daily Global (08_D3) Statistics
Collection 005 Updates

= Added = Renamed = Deleted



	Mean	Standard_Deviation	Minimum	Maximum	QA_Mean	QA_Standard_Deviation	Histogram_Counts (n)	Confidence_Histogram (4)	Fraction	Pixel_Counts	Mean_Uncertainty	QA_Mean_Uncertainty	Log_Mean_Uncertainty	QA_Log_Mean_Uncertainty	Log_Mean	Log_Standard_Deviation	QA_Log_Mean	QA_Log_Standard_Deviation	Regression_Slope	Regression_Intercept	Regression_R-Squared	Regression_Mean_Square_Error	Joint_Histogram_vs_Effect_Radius (nxn)	Joint_Histogram_vs_Temperature (nxn)	Joint_Histogram_vs_Emissivity (nxn)	Joint_Histogram_vs_Pressure (nxn)
Derived from L2 Aerosol (04_L2)																										
Combined Land & Ocean																										
01. Scattering_Angle	•	•	•	•			•			•																
02. Solar_Zenith	•	•	•	•						•																
03. Solar_Azimuth	•	•	•	•						•																
04. Sensor_Zenith	•	•	•	•						•																
05. Sensor_Azimuth	•	•	•	•						•																
06. Optical_Depth_Land_And_Ocean	•	•	•	•						•																
07. Optical_Depth_Ratio_Small_Land_And_Ocean	•	•	•	•						•																
08. Reflected_Flux_Land_And_Ocean	•	•	•	•						•																
Land Only																										
09. Corrected_Optical_Depth_Land (3)	•	•	•	•	•	•	•	•																		
10. Optical_Depth_Ratio_Small_Land	•	•	•	•	•	•	•	•																		
11. Mass_Concentration_Land	•	•	•	•	•	•	•	•																		
12. Transmitted_Flux_Land (2)	•	•	•	•	•	•	•	•																		
13. Reflected_Flux_Land (3)	•	•	•	•	•	•	•	•																		
14. Angstrom_Exponent_Land[1]	•	•	•	•	•	•	•	•											•	•	•	•				
15. Mean_Reflectance_Land_All_QA47 (3)	•	•	•	•	•	•	•	•																		
16. Mean_Reflectance_Land_All_QA66 (3)	•	•	•	•	•	•	•	•																		
17. Path_Radiance_Land_QA47 (2)	•	•	•	•	•	•	•	•																		
18. Path_Radiance_Land_QA66 (2)	•	•	•	•	•	•	•	•																		
19. Critical_Reflectance_Land_QA47 (2)	•	•	•	•	•	•	•	•																		
20. Critical_Reflectance_Land_QA66 (2)	•	•	•	•	•	•	•	•																		
21. Aerosol_Cloud_Mask_Cloud_Fraction_Land	•	•	•	•						•																
22. Number_Pixels_Used_Land (2)	•	•	•	•						•																
Ocean Only																										
23. Effective_Optical_Depth_Average_Ocean (7)	•	•	•	•	•	•	•	•																		

24. Optical_Depth_Ratio_Small_Ocean	•	•	•	•	•	•	•	•																	
25. Effective_Radius_Ocean	•	•	•	•	•	•	•	•																	
26. Mass_Concentration_Ocean	•	•	•	•	•	•	•	•																	
27. Cloud_Condensation_Nuclei_Ocean	•	•	•	•	•	•	•	•																	
28. Angstrom_Exponent_1_Ocean[2]	•	•	•	•	•	•	•	•											•	•	•	•			
29. Angstrom_Exponent_2_Ocean[3]	•	•	•	•	•	•	•	•											•	•	•	•			
30. Asymmetry_Factor_Average_Ocean (7)	•	•	•	•	•	•	•	•																	
31. Backscattering_Ratio_Average_Ocean (7)	•	•	•	•	•	•	•	•																	
32. Transmitted_Flux_Average_Ocean (7)	•	•	•	•	•	•	•	•																	
33. Reflected_Flux_Average_Ocean (7)	•	•	•	•	•	•	•	•																	
34. Optical_Depth_by_models_Ocean (9)	•	•	•	•	•	•		•																	
35. Aerosol_Cloud_Mask_Cloud_Fraction_Ocean	•	•	•	•						•															
36. Number_Pixels_Used_Ocean	•	•	•	•						•															

Derived from L2 Water Vapor (05_L2)

37. Water_Vapor_Near_Infrared_Clear	•	•	•	•	•	•	•	•																	
38. Water_Vapor_Near_Infrared_Cloud	•	•	•	•	•	•	•	•																	

Derived from L2 Cloud (06_L2)

Cirrus Detection

39. Cirrus_Reflectance	•	•	•	•	•	•	•																		
40. Cirrus_Fraction_SWIR								•	•																

Cloud Top Properties

41. Cloud_Top_Pressure	•	•	•	•			•			•														•	
42. Cloud_Top_Pressure_Day	•	•	•	•			•			•														•	
43. Cloud_Top_Pressure_Night	•	•	•	•			•			•														•	
44. Cloud_Top_Temperature	•	•	•	•			•			•															
45. Cloud_Top_Temperature_Day	•	•	•	•			•			•															
46. Cloud_Top_Temperature_Night	•	•	•	•			•			•															
47. Cloud_Effective_Emissivity	•	•	•	•			•			•															
48. Cloud_Effective_Emissivity_Day	•	•	•	•			•			•															
49. Cloud_Effective_Emissivity_Night	•	•	•	•			•			•															
50. Cloud_Fraction	•	•	•	•			•			•															
51. Cloud_Fraction_Day	•	•	•	•			•			•															
52. Cloud_Fraction_Night	•	•	•	•			•			•															
53. Cirrus_Fraction_Infrared								•	•																
54. High_Cloud_Fraction_Infrared								•	•																
55. Cloud_Phase_Infrared							•																		
56. Cloud_Phase_Infrared_Day							•																	•	
57. Cloud_Phase_Infrared_Night							•																	•	

Cloud Optical Properties (Primary Retrieval)

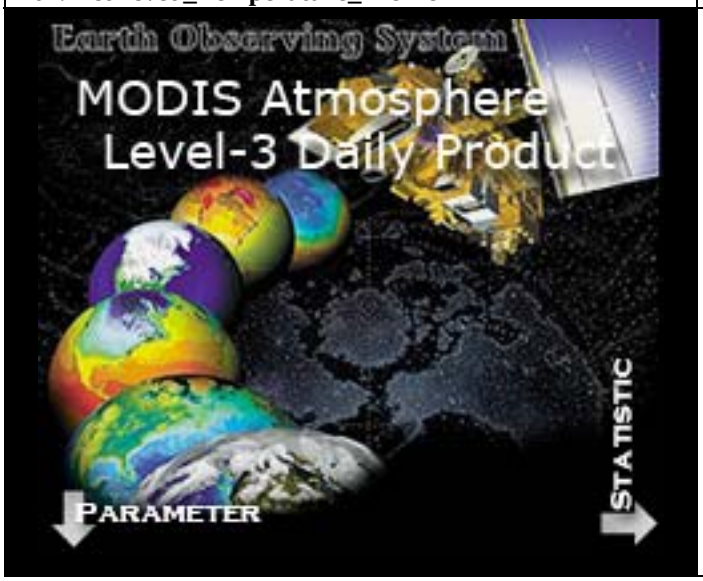
58. Cloud_Optical_Thickness_Liquid	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•					•	•	•	•
59. Cloud_Optical_Thickness_Ice	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•					•	•	•	•
60. Cloud_Optical_Thickness_Undetermined	•	•	•	•	•	•									•	•	•	•								
61. Cloud_Optical_Thickness_Combined	•	•	•	•	•	•									•	•	•	•								
62. Cloud_Optical_Thickness_ISCCP[8]																										•
63. Cloud_Effective_Radius_Liquid	•	•	•	•	•	•	•	•			•	•												•	•	•
64. Cloud_Effective_Radius_Ice	•	•	•	•	•	•	•	•			•	•												•	•	•

65. Cloud_Effective_Radius_Undetermined	•	•	•	•	•	•																				
66. Cloud_Effective_Radius_Combined	•	•	•	•	•	•																				
67. Cloud_Water_Path_Liquid	•	•	•	•	•	•	•	•			•	•														
68. Cloud_Water_Path_Ice	•	•	•	•	•	•	•	•			•	•														
69. Cloud_Water_Path_Undetermined	•	•	•	•	•	•																				
70. Cloud_Water_Path_Combined	•	•	•	•	•	•																				
71. Cloud_Phase_Optical_Properties																								•		
(Primary Cloud Fraction)																										
72. Cloud_Fraction_Liquid									•	•																
73. Cloud_Fraction_Ice									•	•																
74. Cloud_Fraction_Undetermined									•	•																
75. Cloud_Fraction_Combined									•	•																
(Primary Retrieval Single-Layer Clouds only)																										
76. Cloud_Optical_Thickness_1L_Liquid[4]	•	•	•	•	•	•	•				•	•												•		
77. Cloud_Optical_Thickness_1L_Ice[5]	•	•	•	•	•	•	•				•	•												•		•
78. Cloud_Effective_Radius_1L_Liquid	•	•	•	•	•	•	•				•	•														
79. Cloud_Effective_Radius_1L_Ice	•	•	•	•	•	•	•				•	•														
80. Cloud_Water_Path_1L_Liquid	•	•	•	•	•	•	•				•	•														
81. Cloud_Water_Path_1L_Ice	•	•	•	•	•	•	•				•	•														
82. Cloud_Phase_Optical_Properties1L																								•		
(Single-Layer Cloud Fraction)																										
83. Cloud_Fraction_1L_Liquid									•	•																
84. Cloud_Fraction_1L_Ice									•	•																
(Multi-Layer Cloud Fraction)																										
85. Cloud_Fraction_ML_Liquid									•	•																
86. Cloud_Fraction_ML_Ice									•	•																
87. Cloud_Fraction_ML_Undetermined									•	•																
88. Cloud_Fraction_ML_Combined									•	•																
(Ratio of Multi-Layer Clouds to All-Layer Clouds by Phase)																										
89. ML_Fraction_Liquid									•	•																
90. ML_Fraction_Ice									•	•																
91. ML_Fraction_Undetermined									•	•																
92. ML_Fraction_Combined									•	•																
(Supplementary 1.6/2.1 µm Retrieval)																										
93. Cloud_Optical_Thickness_1621_Liquid[6]	•	•	•	•	•	•	•																	•		
94. Cloud_Optical_Thickness_1621_Ice[7]	•	•	•	•	•	•	•																	•		
95. Cloud_Effective_Radius_1621_Liquid	•	•	•	•	•	•	•																			
96. Cloud_Effective_Radius_1621_Ice	•	•	•	•	•	•	•																			
97. Cloud_Water_Path_1621_Liquid	•	•	•	•	•	•	•																			
98. Cloud_Water_Path_1621_Ice	•	•	•	•	•	•	•																			
(Supplementary 1.6/2.1 µm Cloud Fraction)																										
99. Cloud_Fraction_1621_Liquid									•	•																
100. Cloud_Fraction_1621_Ice									•	•																

Derived from L2 Atmospheric Profiles (07_L2)

101. Total_Ozone	•	•	•	•	•	•	•	•																		
102. Total_Totals	•	•	•	•	•	•	•	•																		

	Mean	Standard_Deviation	Minimum	Maximum	QA_Mean	QA_Standard_Deviation	Histogram_Counts (n)	Confidence_Histogram (4)	Fraction	Pixel_Counts	Mean_Uncertainty	QA_Mean_Uncertainty	Log_Mean_Uncertainty	QA_Log_Mean_Uncertainty	Log_Mean	Log_Standard_Deviation	QA_Log_Mean	QA_Log_Standard_Deviation	Regression_Slope	Regression_Intercept	Regression_R-Squared	Regression_Mean_Square_Error	Joint_Histogram_vs_Effect_Radius (nxn)	Joint_Histogram_vs_Temperature (nxn)	Joint_Histogram_vs_Emissivity (nxn)	Joint_Histogram_vs_Pressure (nxn)
103. Lifted_Index	•	•	•	•	•	•	•	•																		
104. Atmospheric_Water_Vapor	•	•	•	•	•	•	•	•																		
105. Atmospheric_Water_Vapor_Low	•	•	•	•	•	•	•	•																		
106. Atmospheric_Water_Vapor_High	•	•	•	•	•	•	•	•																		
107. Retrieved_Temperature_Profile	•	•	•	•						•																



[1] *Regressions are against Corrected Optical Depth Land (1st or 0.47 µm solution)*

[2] *Regressions are against Effective Optical Depth Average Ocean (2nd or 0.55 µm solution)*

[3] *Regressions are against Effective Optical Depth Average Ocean (4th or 0.87 µm solution)*

[4] *Joint Histogram with Cloud_Effective_Radius_1L_Liquid*

[5] *Joint Histogram with Cloud_Effective_Radius_1L_Ice*

[6] *Joint Histogram with Cloud_Effective_Radius_1621_Liquid*

[7] *Joint Histogram with Cloud_Effective_Radius_1621_Ice*

[8] *Joint Histogram uses ISCCP-like bin boundaries*

MODIS Level-3 Joint Histograms Parameters and Bin Boundaries

Collection 005 Update

Parameter 1	(Bins): Bin Boundaries	Parameter 2	(Bins): Bin Boundaries	Day/ Night
Liquid water clouds				
Optical thickness	(11): 0, 2, 4, 6, 8, 10, 15, 20, 30, 40, 50, 100	Effective radius (μm)	(10): 2, 4, 6, 8, 10, 12.5, 15, 17.5, 20, 25, 30	Day
Optical thickness Single Layer	"	Effective radius (μm) Single Layer	"	Day
Optical thickness 1621	"	Effective radius (μm) 1621	"	Day
Optical thickness	"	Cloud top temperature (K)	(12): 230, 235, 240, 245, 250, 255, 260, 265, 270, 275, 280, 285, 290	Day
Optical thickness	"	Cloud top pressure (hPA)	(13): 200, 250, 300, 350, 400, 450, 500, 550, 600, 700, 800, 900, 1000, 1100	Day
Effective radius (μm)	(10): 2, 4, 6, 8, 10, 12.5, 15, 17.5, 20, 25, 30	Cloud top temperature (K)	(12): 230, 235, 240, 245, 250, 255, 260, 265, 270, 275, 280, 285, 290	Day
Effective radius (μm)	"	Cloud top pressure (hPA)	(13): 200, 250, 300, 350, 400, 450, 500, 550, 600, 700, 800, 900, 1000, 1100	Day
Ice clouds				
Optical thickness	(11): 0, 0.5, 1, 2.5, 5, 7.5, 10, 15, 20, 30, 50, 100	Effective radius (μm)	(13):5, 8, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 90	Day
Optical thickness Single Layer	"	Effective radius (μm) Single Layer	"	Day
Optical thickness 1621	"	Effective radius (μm) 1621	"	Day
Optical thickness	"	Cloud top temperature (K)	(13): 190, 200, 210, 220, 225, 230, 235, 240, 245, 250, 255, 260, 265, 270	Day
Optical thickness	"	Cloud top pressure (hPa)	(16): 50, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 700, 800, 900, 1000, 1100	Day
Optical thickness	"	Effective emissivity	(10): 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0	Day
Optical thickness Single Layer	"	Effective emissivity	"	Day
Effective radius (μm)	(13): 5, 8, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 90	Cloud top temperature (K)	(13): 190, 200, 210, 220, 225, 230, 235, 240, 245, 250, 255, 260, 265, 270	Day
Effective radius (μm)	"	Cloud top pressure (hPa)	(16): 50, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 700, 800, 900, 1000, 1100	Day
All clouds				
Cloud top pressure (hPa)	(3): 1, 400, 700, 1000	Effective emissivity	(3): 0.0, 0.5, 0.95, 1.0	Day
Cloud top pressure (hPa)	"	Effective emissivity	"	Night

Parameter 1	(Bins): Bin Boundaries	Parameter 2	(Bins): Bin Boundaries	Day/ Night
Cloud top pressure (hPa)	“	Effective emissivity	“	Day + Night
All clouds				
Cloud top temperature (K)	(17): 190, 200, 210, 220, 225, 230, 235, 240, 245, 250, 255, 260, 265, 270, 275, 280, 285, 290	Cloud phase optical properties	(3): Water, Ice, Undetermined	Day
Cloud top temperature (K)	“	Cloud phase IR	(4): Water, Ice, Mixed, Uncertain	Day
Cloud top temperature (K)	“	Cloud phase IR	“	Night
Optical thickness (ISCCP boundaries)	(7): 0, 0.3, 1.3, 3.6, 9.4, 23, 60, 100	Cloud top pressure (hPa) (ISCCP boundaries)	(7): 0, 180, 310, 440, 560, 680, 800, 1100	Day

Purple color denotes new joint histograms and updated bin boundaries for Collection 005

Note:
1st bin includes values equal to both the low and high bin boundary,
2nd through the nth bin includes values equal to the high bin boundary only

Cloud Product (06_L2) derived Histogram Parameters and Bin Boundaries

Collection 005 Update

Cloud Top Properties

Parameter	Bin Boundaries	Bins	Units
Cloud_Top_Pressure Cloud_Top_Pressure_Day Cloud_Top_Pressure_Night	1.0, 100.0, 200.0, 300.0, 400.0, 500.0, 600.0, 700.0, 800.0, 900.0, 1000.0, 1100.0	11	hPa
Cloud_Top_Temperature Cloud_Top_Temperature_Day Cloud_Top_Temperature_Night	190.0, 200.0, 210.0, 220.0, 225.0, 230.0, 235.0, 240.0, 245.0, 250.0, 255.0, 260.0, 265.0, 270.0, 275.0, 280.0, 285.0, 290.0	17	K
Cloud_Effective_Emissivity Cloud_Effective_Emissivity_Day Cloud_Effective_Emissivity_Night	0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0	10	*none*
Cloud_Fraction Cloud_Fraction_Day Cloud_Fraction_Night	0.0, 0.2, 0.4, 0.6, 0.8, 1.0	5	*none*
Cloud_Phase_Infrared Cloud_Phase_Infrared_Day Cloud_Phase_Infrared_Night	0, 1, 2, 3, 6 *(note: 0=clear, 1=water, 2=ice, 3=mixed, 6=undetermined phase)*	5	*none*

Cloud Optical Properties

Parameter	Bin Boundaries	Bins	Units
Cloud_Optical_Thickness_Liquid Cloud_Optical_Thickness_1L_Liquid Cloud_Optical_Thickness_1621_Liquid	0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 11.0, 12.0, 13.0, 14.0, 15.0, 16.0, 17.0, 18.0, 19.0, 20.0, 21.0, 22.0, 23.0, 24.0, 25.0, 26.0, 27.0, 28.0, 29.0, 30.0, 32.0, 34.0, 36.0, 38.0, 40.0, 42.0, 44.0, 46.0, 48.0, 50.0, 60.0, 70.0, 80.0, 90.0, 100.0	45	*none*
Cloud_Optical_Thickness_Ice Cloud_Optical_Thickness_1L_Ice Cloud_Optical_Thickness_1621_Ice	0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 15.0, 20.0, 25.0, 30.0, 40.0, 50.0, 60.0, 70.0, 80.0, 90.0, 100.0	30	*none*
Cloud_Effective_Radius_Liquid Cloud_Effective_Radius_1L_Liquid Cloud_Effective_Radius_1621_Liquid	2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 11.0, 12.0, 13.0, 14.0, 15.0, 16.0, 17.0, 18.0, 19.0, 20.0, 22.0, 24.0, 26.0, 28.0, 30.0	23	microns
Cloud_Effective_Radius_Ice Cloud_Effective_Radius_1L_Ice Cloud_Effective_Radius_1621_Ice	5.0, 8.0, 10.0, 15.0, 20.0, 25.0, 30.0, 35.0, 40.0, 45.0, 50.0, 55.0, 60.0, 90.0	13	microns
Cloud_Water_Path_Liquid Cloud_Water_Path_1L_Liquid Cloud_Water_Path_1621_Liquid	0.0, 10.0, 20.0, 50.0, 100.0, 150.0, 200.0, 250.0, 300.0, 350.0, 400.0, 450.0, 500.0, 1000.0, 2000.0	14	g/m^2
Cloud_Water_Path_Ice Cloud_Water_Path_1L_Ice Cloud_Water_Path_1621_Ice	0.0, 10.0, 20.0, 50.0, 100.0, 150.0, 200.0, 250.0, 300.0, 350.0, 400.0, 450.0, 500.0, 1000.0, 2000.0, 4000.0, 6000.0	16	g/m^2

Purple color denotes new joint histograms and updated bin boundaries for Collection 005

Note:
1st bin includes values equal to both the low and high bin boundary,
2nd through the nth bin includes values equal to the high bin boundary only