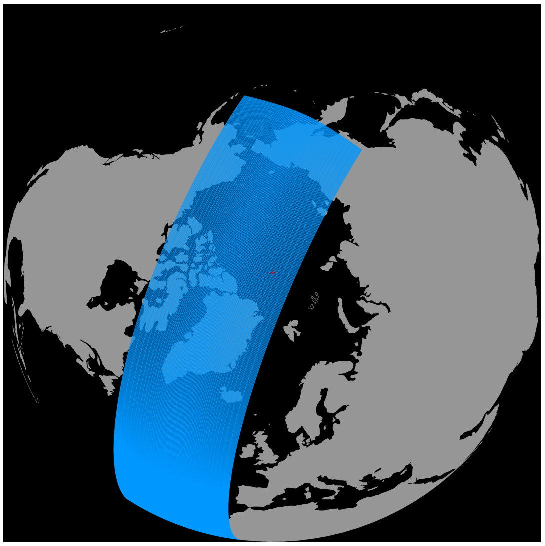
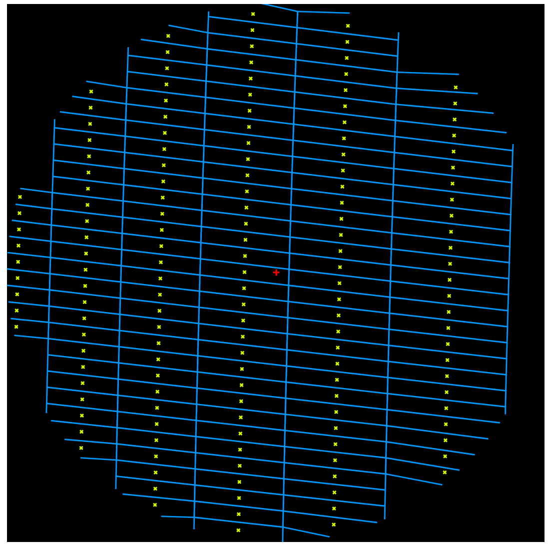
OMPIXCOR README FILE

Date of this Document: 6 December 2010





Overview

The standard OMI Level 1b data product [OMI 2007] provides geodetic latitude and longitude for the center of each ground pixel in the OMI swath. However, pixel corner coordinates are not available. The motivation for the development of the OMI ground pixel corner products, OMPIXCOR and OMPIXCORZ, was the common need for visualization of derived OMI data products, provision of ground pixel area for computations of trace gas emissions per area, the facilitation of the development of cross-platform pixel mapping applications (*e.g.*, between OMI and MODIS), and to generally aid validation studies, to name just a few.

This document provides a description of the OMPIXCOR and OMPIXCORZ data products. OMPIXCOR contains ground pixel corner co-ordinates and ground pixel sizes for OMI global-mode and rebinned spatial zoom-in observations from the UV-1, UV-2, and VIS channels; OMPIXCORZ contains the corresponding quantities for the spatial zoom-in mode. Ground pixel coordinates differ between the three channels due to (a) different integration times between UV-1 vs. UV-2 and VIS, and (b) due to a small difference in alignment of the UV-2 and VIS channels. Hence, a full set of all ground pixel quantities is provided for each of the individual channels.

Ground pixel corner coordinates provided by OMPIXCOR[1] come in two flavors: Non-overlapping (tiled) pixels, and overlapping pixels corresponding to 75% of the energy in the along-track field of view. Tiled pixels share corners between adjacent pixels both across and along track. Overlapping pixels share corners across track but overlap along track with the previous and next swath lines. The OMPIXCOR developers make no recommendation as to which type of pixel should be used for which application, but notes that, while tiled pixels may provide cleaner maps, overlapping pixels likely provide more accurate derivation of, *e.g.*, tonnage of SO_2 over a particular area.

The images above show the outline of non-overlapping ground pixels from the UV-2 channel for the northern hemisphere part of an OMI orbit. The right image is shows a zoom from the left centered over the North pole (red plus sign): Pixel outlines are shown in blue, and pixel center coordinates are marked with yellow crosses).

Release History and Release-Specific Information

OMPIXCOR(Z) Algorithm Version	1.1.6
Collection/Product Version[1]	003
This Public Release	6 December 2010
First Public Release	6 December 2010
Known Issue List	None known.

Contact

For questions and comments related to the OMPIXCOR dataset please contact the developers, Thomas P. Kurosu (tkurosu@cfa.harvard.edu) and Edward A. Celarier (edward.a.celarier@nasa.gov), who have the overall responsibility for this product.

1 For the remainder of the document, OMPIXCOR will denote both applications, unless the spatial zoom product OMPIXCORZ is mentioned specifically.

Algorithm Description

Computation of the ground pixel corners proceeds in several steps, and starts out with the derivation of the non-overlapping (Tiled) pixel corners, from which the overlapping (75FoV) pixel corners are computed by appropriate scaling. The algorithm outlined below considers a shape of the Earth according to the WGS84 Ellipsoid [WGS84]. All computations are done in Cartesian rather than polar coordinates in order to avoid singularities at the poles.

1. Computation of Tiled pixel corners

In the derivation of the Tiled pixel corners, two basic assumptions are made: (a) the pixel boundary separating two along-track pixels is defined by the half-way point along track between the two pixel center coordinates, and (b) the pixel boundary of the innermost two across-track pixels (in 1-based counting, cross-track positions 30 and 31 for UV-2 and VIS, 15 and 16 for UV-1) is defined by the "swath center", *i.e*., the half-way point X across-track between the two pixel center coordinates.

Across-track mid-points between ground pixel centers are computed iteratively starting at the centerswath center of scan line n, ${}^nM = {}^nX_{30,31}$ going outward towards the swath edges in both east and west directions: The distance d between the swath center ${}^nM$ of swath line n and one of the adjacent pixel centers (*e.g*., ${}^nc_{30}$ for position 30 for UV-2) is computed, and the next pixel boundary (between positions 29 and 30 in this case) is found by extrapolating the line between ${}^nM$ and ${}^nc_{30}$ by d to ${}^nX_{29,30} = {}^nc_{30}\text{-}d$. In this manner, all 59 inner cross-track boundaries ${}^nX_{1,2}$ through ${}^nX_{56,60}$ can be computed. At the swath edges, ${}^nX_{0,1}$ and ${}^nX_{60,61}$ are extrapolated using a 4th order polynomial fit to the 5 outer-most pixel boundaries instead of simple linear extrapolation. At the end of this step, a set 61 (UV-2 and VIS) or 31 (UV-1) values ${}^nX_{i,i+1}$ exists for all swath lines n, $0 \le n \le$ nTimes-1 and cross-track edges i, $0 \le i \le$ nXtrack , in the OMI swath.

Along-track inner midpoints ${}^{n,n+1}T_{i,i+1}$ between adjacent swath lines n and $n+1$ are computed from the ${}^nX_{i,i+1}$ by simple linear interpolation along-track between the ${}^nX_{i,i+1}$ and ${}^{n+1}X_{i,i+1}$, and along-track endpoints (for the first and last swath line) are derived by 4th order polynomial extrapolation. The resulting set of ${}^{n,n+1}T_{i,i+1}$, $0 \le n \le$ nTimes-1 and $0 \le i \le$ nXtrack, are the Tiled pixel corner coordinates for the entire swath.

2. Computation of 75FoV pixel corners

The 75FoV pixels share cross-track pixel boundaries with the tiled pixels (see Figure 1 below) but differ in the position of the along-track pixel edges. Their corner coordinates ${}^nF^{\pm}_{i,i+1}$ are computed using the half-way points ${}^nX_{i,i+1}$ (as computed during the derivation of the Tiled pixel corners, see above) and the satellite coordinates S_n, $0 \le n \le$ nTimes-1. The along-track width of each side separating two FoV pixels of swath line n is taken to be the full-width half maximum (FWHM) of the field-of-view. For each half-way point ${}^nX_{i,i+1}$ and satellite position S_n, the distance $D_i = ({}^nX_{i,i+1}, S_n)$ is computed. This is used to scale the FWHM of the *instantaneous* field-of-view (IFOV). The IFOV weighting function w is assumed to have the form $w(y) = \exp(-y^4/\rho)$, where ρ is chosen such that w has a FWHM corresponding to a 1˚ FWHM for the IFOV at the distance D_i. The IFOV weighting function is then used to compute the field-of-view weighting function W, which is the convolution of w with the along-track coordinate of the IFOV center over the 2 s exposure time:

$$W(x) = \int_{-1}^{+1} dt\, w(x-kt).$$

Here k is the ground-track speed of the sub-satellite point, which is not scaled to take account of the difference between the sub-satellite point track speed and the (slightly smaller) off-nadir pixel center track speeds. The FWHM of W is then the FWHM of the field-of-view, K_i. The flight verctor is computed for each along-track pixel edge between half-way points, namely ${}^nV_i = {}^{n+1}X_{i,i+1} - {}^nX_{i,i+1}$, in km. Finally, the FoV pixel corners ${}^nF^{\pm}_{i,i+1}$ are computed from the half-way points ${}^nX_{i,i+1}$, the flight vector ${}^nV_i$, and the field-of-view FWHM K_i:

$${}^nF^{\pm}_{i,i+1} = {}^nX_{i,i+1} \pm \frac{K_i\,{}^nV_i}{2\left|{}^nV_i\right|}.$$

3. Implementation of Pixel Corner Computations

The Tiled pixel corners are computed on-line as described in Section 2, since they depend on the actual values of the pixel center coordinates. For the 75FoV pixel corners, rather than computing them on-line, along-track scale factors have been derived that are used to multiply the Tiled pixel corner values. The basic assumption here is that there is no variation in the relative increase of the 75FoV over the Tiled pixels for a given channel, observation mode, and cross-track position. Hence, the 75FoV pixel corners can quickly and easily be derived from the Tiled pixel corners by appropriate along-track scaling. Scaling factors have been pre-computed using a set of reference orbits to which both the original 75FoV code and the Tiled pixel corner computation was applied for a large range of swath lines. The scale factors were then determined as the MEAN of the ratio of FoV75-to-Tiled ground pixel corners of all swath lines, as a function of channel, observation mode, and cross-track position.

Figure 1 shows examples of 75FoV and Tiled pixel shapes at three cross-track positions from the same swath line. Figure 2 shows across-track (panel a) and along-track (panel b) extent of global and spatial zoom-in mode ground pixels for all OMI channels. 75FoV and Tiled pixels at a given cross-track position have the same cross-track size, ranging from 26 km (UV-2 and VIS in global mode) at the center of the swath to about 160 km at the swath edges. Along-track extent of 75FoV pixels ranges from 14 km at the center of the swath to about 28 km at the edges, while all Tiled pixels have a constant along-track size of 13 km.

4. Computation of Ground Pixel Area

Once the four corners of an OMI ground pixel are known, its area is easily computed using spherical trigonometry. Trigonometric function, however, exhibit numerical instabilities around singularities (the poles), which can lead to large errors in pixel area due to even small rounding errors. Ground pixel sizes for both 75FoV and Tiled pixels have therefore been pre-computed from the same set of reference orbits used in the determination of Tiled-to-FoV75 scale factors. The small error in pixel area due to latitude-dependence of the Earth curvature in the WGS84 ellipsoid is deemed acceptable, particularly since rounding errors will lead to larger errors in pixel area at high latitudes. Values of ground pixel area, rounded to two significant digits, for all channels in global and zoom-in observation mode are listed in Table 1, and are shown in Figure 3. Rebinned spatial zoom-in pixels, positions 16-45 in 1-based counting, have the same areas as the corresponding global mode pixels at those positions.

Data Quality Assessment

No data quality assessment is performed in OMPIXCOR processing, outside the obvious check for validity of the ground pixel center latitudes and longitudes. The user is encouraged to consult the quality flags of whatever OMI Level 2 data product is being used in conjunction with the OMPIXCOR pixel information.

Product Description

A 2600 km wide OMI swath contains either 60 (UV-2 and VIS in global mode; all channels in spatial zoom-in channels) or 30 (UV-1 in global mode; all channels in rebinned spatial zoom-in mode) cross-track pixels. The OMPIXCOR data product contains information on ground pixel corner coordinates and ground pixel area computed from the latitude and longitude ground pixel center coordinates provided in the OMI Level 1b product.

OMPIXCOR data are written in HDF-EOS5. Each OMPIXCOR output file contains three swaths, one for each of the OMI channels. These swath names, which are identical for OMPIXCOR and OMPIXCORZ, are listed in Table 2. Each swath contains identically named sets of dimensions (Table 3), geolocation fields (Table 4), and data fields (Table 5).

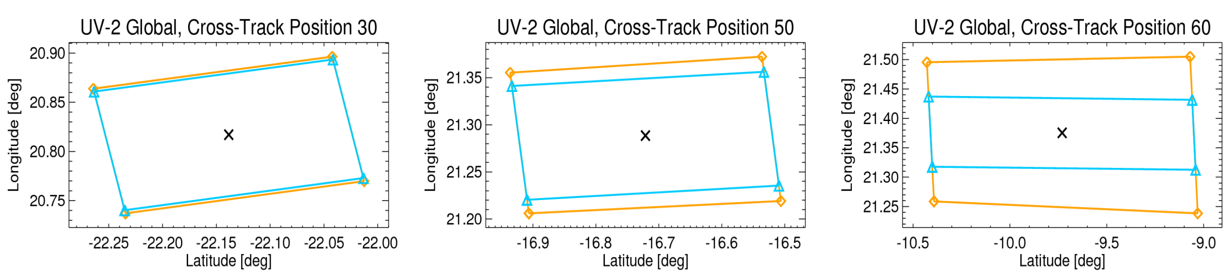


Figure 1: Across-track 75%FoV (orange lines, diamonds) and Tiled (cyan lines, triangles) pixel shapes for three selected cross-track positions from the same swath line. Pixel centers are marked with a black cross. Note that the two types of pixels share across-track boundaries but differ along-track. Differences in pixel orientation are due to the orientation of the OMI swath relative to the North-South direction.

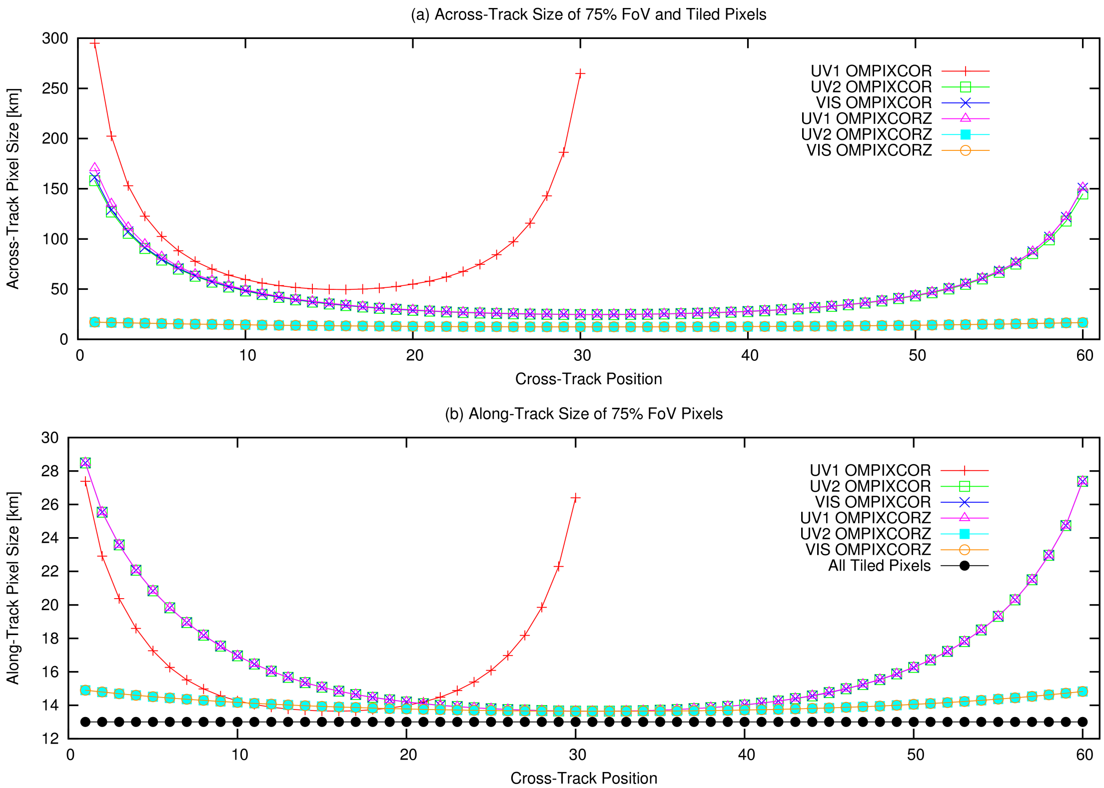


Figure 2: (a) Across-track and (b) Along-track ground pixel size in km for 75%FoV pixels in global (OMPIXCOR) and spatial zoom-in (OMPIXCORZ) observation mode. Note that Tiled ground pixels have a constant along-track size of 13 km independent of channel and observation mode.

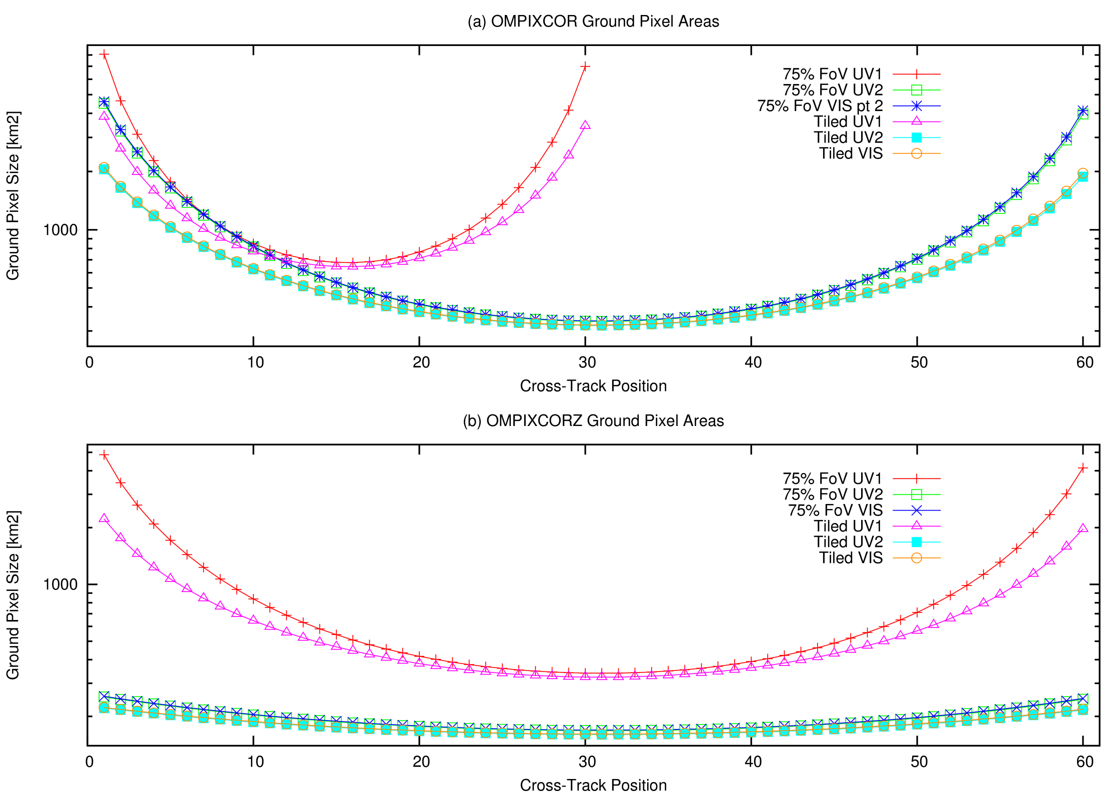


Figure 3: Tiled and 75%FoV ground pixel areas in km^2 for all OMI channels in (a) global mode and (b) spatial zoom-in mode observation.

Table 1: Numerical values of OMPIXCOR and OMPIXCORZ ground pixel areas [km²]

Cross-Track Position	***Global Mode (OMPIXCOR)***						***Spatial Zoom-In Mode (OMPIXCORZ)***					
	UV-1		UV-2		VIS		UV-1		UV-2		VIS	
	75% FoV	Tiled	75% FoV	Tiled	75% FoV	Tiled	75% FoV	Tiled	75% FoV	Tiled	75% FoV	Tiled
1	8075.21	3833.99	4502.75	2054.83	4596.48	2097.55	4861.46	2217.81	253.83	221.48	255.67	223.07
2	4638.08	2631.62	3240.25	1649.17	3296.36	1677.68	3449.41	1755.39	246.33	216.52	248.09	218.05
3	3116.91	1988.90	2493.50	1374.21	2531.02	1394.88	2629.34	1449.00	239.39	211.85	241.08	213.34
4	2281.51	1595.09	1995.38	1175.54	2022.28	1191.37	2089.71	1231.06	233.00	207.52	234.63	208.97
5	1768.76	1332.03	1644.26	1025.55	1664.45	1038.11	1713.60	1068.67	227.08	203.43	228.64	204.84
6	1434.67	1146.67	1386.24	909.04	1402.01	919.37	1438.65	943.46	221.62	199.65	223.13	201.01
7	1206.68	1010.87	1189.49	816.11	1202.15	824.76	1230.56	844.41	216.55	196.07	218.01	197.40
8	1047.35	909.42	1036.19	740.64	1046.57	748.05	1068.80	764.03	211.88	192.77	213.29	194.06
9	932.08	832.13	914.30	678.02	922.94	684.40	940.98	697.92	207.52	189.65	208.89	190.90
10	848.70	773.28	816.21	625.77	823.56	631.41	838.13	642.62	203.53	186.76	204.85	188.00
11	786.77	728.31	736.21	581.32	742.54	586.30	754.72	596.06	199.79	184.05	201.10	185.24
12	742.39	694.90	670.50	543.62	676.03	548.10	686.03	556.29	196.38	181.53	197.64	182.72
13	710.51	670.70	615.83	510.97	620.73	515.03	629.34	522.30	193.18	179.19	194.41	180.33
14	690.25	654.93	570.27	483.00	574.63	486.70	581.82	492.84	190.26	177.02	191.47	178.16
15	678.95	646.39	531.79	458.44	535.75	461.86	542.04	467.39	187.55	175.00	188.74	176.10
16	677.19	645.05	499.35	437.32	502.92	440.48	508.19	445.17	185.08	173.13	186.25	174.23
17	683.93	650.44	471.62	418.63	474.92	421.57	479.64	425.86	182.78	171.41	183.93	172.49
18	700.51	663.29	448.05	402.51	451.10	405.29	455.06	408.90	180.71	169.84	181.85	170.92
19	727.48	683.78	427.78	388.20	430.65	390.79	434.23	394.15	178.80	168.41	179.91	169.44
20	767.46	713.68	410.51	375.92	413.22	378.41	416.20	381.21	177.09	167.08	178.20	168.14
21	823.08	753.74	395.62	365.01	398.19	367.34	400.92	369.99	175.52	165.90	176.61	166.93
22	899.87	807.66	383.01	355.76	385.43	358.05	387.69	360.22	174.15	164.84	175.23	165.88
23	1004.55	877.76	372.14	347.58	374.50	349.75	376.60	351.85	172.90	163.90	173.98	164.91
24	1150.38	971.34	363.13	340.85	365.38	342.99	367.06	344.63	171.84	163.07	172.91	164.10
25	1354.69	1095.17	355.44	334.95	357.69	337.03	359.26	338.65	170.89	162.35	171.96	163.36
26	1652.33	1265.18	349.32	330.34	351.49	332.38	352.70	333.63	170.12	161.76	171.19	162.79
27	2103.03	1503.82	344.34	326.47	346.48	328.49	347.64	329.70	169.46	161.26	170.52	162.26
28	2837.93	1858.30	340.69	323.71	342.82	325.75	343.64	326.63	168.97	160.89	170.04	161.91
29	4154.22	2421.99	338.03	321.64	340.19	323.67	340.98	324.55	168.59	160.61	169.66	161.62
30	6990.38	3442.16	336.67	320.67	338.79	322.69	339.29	323.28	168.38	160.46	169.44	161.48
31	—	—	336.21	320.32	338.37	322.37	338.88	322.96	168.27	160.38	169.35	161.40
32	—	—	337.00	321.05	339.16	323.10	339.40	323.44	168.33	160.45	169.41	161.48
33	—	—	338.73	322.39	340.95	324.50	341.24	324.87	168.50	160.59	169.59	161.62
34	—	—	341.78	324.87	344.03	327.00	344.04	327.10	168.84	160.86	169.93	161.90
35	—	—	345.86	327.98	348.16	330.20	348.25	330.34	169.28	161.21	170.38	162.27
36	—	—	351.37	332.30	353.75	334.53	353.54	334.44	169.89	161.72	171.00	162.77
37	—	—	358.05	337.38	360.54	339.72	360.46	339.65	170.62	162.27	171.74	163.36
38	—	—	366.43	343.72	369.02	346.14	368.66	345.88	171.52	162.99	172.66	164.08
39	—	—	376.26	351.11	378.96	353.57	378.73	353.31	172.55	163.79	173.71	164.89
40	—	—	388.13	359.85	391.00	362.41	390.51	361.99	173.76	164.75	174.94	165.85
41	—	—	401.87	369.86	404.91	372.60	404.54	372.10	175.11	165.75	176.31	166.91
42	—	—	418.18	381.49	421.48	384.42	420.84	383.71	176.65	166.96	177.87	168.11
43	—	—	437.08	394.74	440.55	397.88	440.06	397.11	178.34	168.23	179.59	169.42
44	—	—	459.30	410.02	463.21	413.41	462.42	412.46	180.23	169.69	181.51	170.88
45	—	—	485.17	427.44	489.36	431.14	488.72	430.10	182.31	171.23	183.61	172.46
46	—	—	515.66	447.48	520.38	451.52	519.47	450.29	184.58	172.96	185.92	174.19
47	—	—	551.44	470.44	556.74	474.97	555.81	473.74	187.08	174.79	188.44	176.08
48	—	—	593.76	496.87	599.84	501.96	598.62	500.56	189.79	176.81	191.19	178.10
49	—	—	643.96	527.42	651.01	533.19	649.77	531.87	192.74	178.96	194.17	180.30
50	—	—	704.13	562.93	712.45	569.59	710.91	568.07	195.94	181.30	197.43	182.66
51	—	—	776.78	604.47	786.66	612.18	785.12	610.77	199.42	183.82	200.93	185.22
52	—	—	865.43	653.44	877.33	662.53	875.60	661.00	203.18	186.51	204.76	187.94
53	—	—	974.99	711.77	989.81	722.60	988.07	721.17	207.24	189.39	208.88	190.89
54	—	—	1112.85	782.05	1131.55	795.19	1129.74	793.76	211.63	192.49	213.35	194.02
55	—	—	1289.65	867.95	1313.92	884.08	1312.21	882.95	216.39	195.80	218.15	197.40
56	—	—	1522.28	974.84	1554.44	995.25	1552.95	994.28	221.54	199.35	223.37	201.00
57	—	—	1836.87	1110.76	1881.35	1137.43	1880.72	1137.10	227.09	203.16	228.99	204.87
58	—	—	2276.37	1288.97	2340.42	1325.06	2340.93	1325.34	233.08	207.23	235.11	208.99
59	—	—	2915.82	1531.84	3012.80	1583.27	3016.81	1585.00	239.58	211.60	241.67	213.43
60	—	—	3966.63	1882.67	4130.99	1961.00	4139.71	1965.02	246.62	216.27	248.83	218.17

Table 2: OMPIXCOR and OMPIXCORZ Swath Names

OMI Channel	Swath Name
UV-1	OMI Ground Pixel Corners UV-1
UV-2	OMI Ground Pixel Corners UV-2
VIS	OMI Ground Pixel Corners VIS

Table 3: OMPIXCOR and OMPIXCORZ Swath Dimensions

Field Name	Field Type	Description	Value
nTimes	HE5T_NATIVE_INT	Number of swath lines in an OMI granule	Variable (usually about 1650)
nXtrack	HE5T_NATIVE_INT	Number of cross-track positions in a swath line	Variable (either 30 or 60)
Ncorners	HE5T_NATIVE_INT	Number of corner coordinates per pixel	4
nUTCdim	HE5T_NATIVE_INT	Character length of a single *TimeUTC* field entry	27

Table 4: OMPIXCOR and OMPIXCORZ Geolocation Fields

Field Name	Field Type	Dimensions	Description
Latitude	HE5T_NATIVE_FLOAT	nXtrack,nTimes	Geodetic latitude [deg] at the center of the ground pixel
Longitude	HE5T_NATIVE_FLOAT	nXtrack,nTimes	Geodetic longitude [deg] at the center of the ground pixel
SpacecraftAltitude	HE5T_NATIVE_FLOAT	nTimes	Altitude of EOS-Aura Spacecraft [m]
SpacecraftLatitude	HE5T_NATIVE_FLOAT	nTimes	Latitude of EOS-Aura Spacecraft [deg]
SpacecraftLongitude	HE5T_NATIVE_FLOAT	nTimes	Longitude of EOS-Aura Spacecraft [deg]
Time	HE5T_NATIVE_DOUBLE	nTimes	Time at Start of Swath Line (s, TAI93)
TimeUTC	STRING	nUTC,nTimes	Coordinated Universal Time

Table 5: OMPIXCOR and OMPIXCORZ Data Fields

Field Name	Field Type	Dimensions	Description
FoV75Area	HE5T_NATIVE_FLOAT	nXtrack	Mean Area [km^2] for 75% Field of View Pixels on the WGS-85 Ellipsoid
FoV75CornerLatitude	HE5T_NATIVE_FLOAT	nXtrack,nTimes	Corner Latitudes [deg] for 75% Field of View Pixels on the WGS-85 Ellipsoid (CCW relative to flight direction: LL,LR,UR,UL)
FoV75CornerLongitude	HE5T_NATIVE_FLOAT	nXtrack,nTimes	Corner Longitudes [deg] for 75% Field of View Pixels on the WGS-85 Ellipsoid (CCW relative to flight direction: LL,LR,UR,UL)
TIledArea	HE5T_NATIVE_FLOAT	nXtrack	Mean Area [km^2] for Tiled Pixels on the WGS-85 Ellipsoid
TiledCornerLatitude	HE5T_NATIVE_FLOAT	nXtrack,nTimes	Corner Latitudes [deg] for Tiled Pixels on the WGS-85 Ellipsoid (CCW relative to flight direction: LL,LR,UR,UL)
TiledCornerLongitude	HE5T_NATIVE_FLOAT	nXtrack,nTimes	Corner Longitudes [deg] for Tiled Pixels on the WGS-85 Ellipsoid (CCW relative to flight direction: LL,LR,UR,UL)

References

OMI 2007: OMI Level 1b README File.

WGS84: http://en.wikipedia.org/wiki/World_Geodetic_System