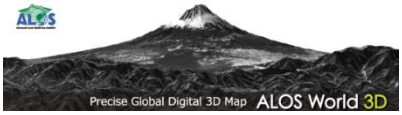

ALOS Global Digital Surface Model (DSM)

ALOS World 3D-30m (AW3D30)
Version 4.1

Product Description
Edition 1

April 2024

Earth Observation Research Center
Japan Aerospace Exploration Agency
(JAXA EORC)

Table of Contents

Revision record （AW3D30 Version4.0・4.1）

Product Version	Date	Product Description (Edition)	Chapter	Contents of revision
4.0	2023/4	Edition 1	-	Revised new edition for version 4.0
			Chp.1	Added a description of version 4.0 released in March 2023
			Chp.2	Added the information of “Copernicus DEM GLO-30” in Table 1
				Added the information of “Copernicus DEM GLO-30” in Table 4
			Chp.3	Addition of a reference document
4.1	2024/4	Edition 1	-	Revised new edition for version 4.1
			Chp.1	Added a description of version 4.1 released in March 2024
			Chp.2	Added the information of “Arctic DEM v4” in Table 1
				Added the information of “Arctic DEM v4” in Table 4

Past record（AW3D30 Version3.2 Before）

Product Version	Date	Chapter/ Table	Contents of revision
1.0	2015/3/31	-	First edition
1.1	2017/3/6	Chp.1	Addition of the explanation on the void-filling of DSM values in cloud and snow masked pixels
		Chp.2.1/ Table 1	Format definition change of mask (MSK) file
		Chp.2.3/ Table 3	Field addition to quality assurance information (QA) file
		Chp.5	Chapter addition for references
2.1	2018/4/25	Chp.1	Addition of explanation on the void-filling of DSM
		Chp.2.1/ Table1	Clarification of file composition contents of AW3D30
		Chp.2.2/ Table 2	Field No.59～64, Clarification of title of the category.
		Chp.2.2/ Table 2	Field No.80, Deletion description of MSK details.
		Chp.2.3/ Table 3	Clarification of title of the category.
		Chp.2.3/ Table 3	Addition of version of source product to QAI file
		Chp.3.1/ Table 5	Correction of fluctuation of description
		Chp.5	Addition of references
2.2	2019/4/9	Chp.1	Addition of ver. 2.2 description
		Chp.2	Correction for ver. 2.2
		Chp.5	Addition of reference URLs
2.2	2020/2/28	Chp.2	Correction of Table 1 and 2
3.1	2020/4/2	Chp.1	Addition of ver. 3.1 description
		Chp.2	Addition of naming rule and zonal pixel spacing, Correction for ver. 3.1
		Chp.5	Addition of references and URLs
3.1	2020/05/15	Chp.2	Correction of Table 1 and 3
3.1/3.2	2021/1/4	-	Revised new edition for version 3.2/3.1
3.2	2021/1/5	Chp.3	Addition of a reference document
3.2	2021/3/31	Chp.1	Added a description of version 3.2 released in March 2021
		Chp.2	Added a note in Table 3, No.89
			Added a note in Table 6 and 8, GeoAsciiParams

1. Overview

Since 2014, the Japan Aerospace Exploration Agency (JAXA) has proceeded the project to develop the precise global digital 3D map **“ALOS World 3D” (AW3D)**[*1] covering the global land areas through the use of 3 million scene archives acquired by the PRISM panchromatic optical sensor on the Advanced Land Observing Satellite "DAICHI" (ALOS) operated from 2006 to 2011. The developed digital 3D map consists of digital elevation model (DEM) or digital surface model (DSM) that can represent land terrains with approximately 5 meters in spatial resolution and orthorectified PRISM nadir looking images. The digital 3D map have been utilized in a wide variety of applications such as map development, damage prediction of natural disasters, and water resource investigation.

Based on the AW3D DSM dataset, JAXA is processed and released the “ALOS World 3D-30m” (AW3D30) DSM dataset, which has approximately 30 meters of spatial resolution. AW3D30 dataset is free to use for everyone, therefore we hope that this dataset will be widely used in scientific research, education, and new services based on geospatial information.

*1: Chapter 3.References, 1) and 2)

1.1. Updates History of AW3D30

Version 1.0 released on May 2015

The first version of the “ALOS World 3D-30m” (AW3D30).

Version 1.1, March 2017

Void values in the cloud and snow pixels between 60 degrees North and 60 degrees South were filled with existing DEMs by the Delta Surface Fill [*2] method.

*2: Chapter 3.References, 5)

Version 2.1, April 2018

The source AW3D DSM has been upgraded to version 2. Masks of the land water and low correlation pixels were also filled with existing DEMs in addition to the cloud and snow pixels between 60 degrees north and 60 degrees south. In Japan area, filling was carried out after updating coastline information.

Note that only AVERAGE resampling product is provided from this version since there is not much difference between AVERAGE and MEDIAN product that were contained in previous version.

Version 2.2, April 2019

This is an improved version of the northern region over 60 degrees north. In this version, along with the complement of no-data or low-quality area, updating of coastline was also performed.

Version 3.1, April 2020 (North of 60 degrees south latitude), January 2021 (South of 60 degrees south latitude)

This is a version created by reconsidering the format in the high latitude area, auxiliary data and processing method.

Different pixel spacing for each latitude zone was adopted at high latitude area. Coastline data, which is one of the auxiliary data, was changed, and new supplementary data was used. In addition, as a source data for Japan, AW3D version 3 was also used. Furthermore, the method of detecting anomalous values in the process was improved.

Version 3.2, January 2021

This is an improved version of 19 tiles at low latitude region. Partial anomaly was corrected by new supplementary data.

The 19 tiles that replaced version 3.1 are following.

N002W079, N004E100, S001E117, S001W051, S002E016, S002E137, S002W051, S002W053, S003W044, S003W061, S003W063, S003W064, S004E119, S005W059, S006W064, S006W066, S007W064 , S008E140 , S008W063

Version 3.2, March 2021

This is an improved version of 2 tiles at northern region over 60 degrees north. Incorrect sea mask over land were deleted. The 2 tiles that replaced version 3.1 are following.

N067E179、N068E179

Version 3.2, January 2022

This is an improved version of 7 tiles at low latitude region. The 7 tiles that replaced version 3.2 are following.

N021W157、N049W122、N050W122、N055W132,N055W161、N057W135、N057W137

Version 3.2, February 2022

This is an improved version of 5 tiles at low latitude region. The 5 tiles that replaced version 3.2 are following.

N016E046、N017E046、N023E049、N035E075、N036E074

Version 4.0, April 2023

“Copernicus DEM GLO-30" was added to version 4.0 as the elevation data used to supplement AW3D30, and 1,876 tiles were corrected.

1. Partial anomalies were corrected to 2 tiles at low latitude region, which following tiles were replaced version 4.0.
   N042E043、N043E043

2. The sea area masks around Caspian sea area were disabled and supplemented with elevation data for 54 tiles. The corrected tiles are as follows;

   N036E050、N036E051、N036E052、N036E053、N036E054、N037E048、N037E049、N037E050
   N037E053、N037E054、N038E048、N038E049、N038E053、N038E054、N039E048、N039E049
   N039E052、N039E053、N039E054、N040E049、N040E050、N040E052、N040E053、N041E048
   N041E049、N041E052、N042E047、N042E048、N042E051、N042E052、N043E047、N043E050
   N043E051、N044E046、N044E047、N044E050、N044E051、N045E046、N045E047、N045E048
   N045E049、N045E050、N045E051、N045E052、N045E053、N046E048、N046E049、N046E050
   N046E051、N046E052、N046E053、N047E050、N047E051、N047E052

3. The Antarctic coastline has been updated with the ALOS operation period, and 44 tiles have been revised accordingly. In addition, 3 tiles were removed from the public because of the coastline update. The tiles modified and removed are as follows.

   【revision】
   S066W061、S066W062、S067W061、S068W061、S068W062、S069E070、S069E071、S069E072
   S069E073、S069W061、S069W062、S070E073、S070E074、S072W100、S074W083、S074W084
   S075W061、S075W062、S075W063、S076W056、S076W057、S076W058、S076W059、S076W060
   S076W061、S076W062、S077W052、S077W053、S077W054、S077W055、S077W056、S078E169
   S078E170、S078E171、S078E172、S078E173、S078E174、S078E175、S078E176、S078E177
   S078E178、S078W050、S078W051、S078W052

   【not open】
   S069E074、S076W055、S077W051

4. For the South American continent, comparison was made using Copernicus DEM GLO-30 as reference data, and among the ranges detected as anomaly values in AW3D30, the range where the STK number of AW3D30 was 2 or less were invalidated. Then, 1,786 tiles were corrected. The tile creation range is N014W085 (upper left) to S057W033 (lower right), and the detailed tile names are omitted.

Version 4.1, April 2024

“Copernicus DEM GLO-30" and “ArcticDEM v4” was added to version 4.1 as the elevation data used to supplement AW3D30, and 19,051 tiles were corrected for the global except Japan and Antarctica. In preparing this product, anomalies were extracted from absolute difference values between “AW3D30v3.1 and 3.2 “and “Copernicus DEM GLO-30 “by adding the conditions of area size and local incidence angle calculated from the global PALSAR-2 mosaic image. Those anomalies were invalidated and complemented with other reference DSM. (Please download the AW3D30 global tile list from the web.)

【not open】

S020E165

2. AW3D30 dataset

2.1. File component

A tile of this dataset covers the unit area of 1 degree latitude and longitude. The tile ID stands for the latitude and longitude at lower-left (southwest) corner. For every tile, the set of files shown in Table 1 is stored as a zip compressed file.

Table 1 File component of AW3D30 dataset

File type	Contents and details	Notes
DSM file (DSM) [GeoTIFF format]	Height above sea level • Integer (signed 16 bit) raster data (little endian) • Equirectangular projection • Pixel spacing: basically 1 arcsec (approx. 30 m), latitude dependent*1 • DSM values are average over the range of 1 arcsec grid pixel (Round off to the integer) • Elevation (in meter) converted from the ellipsoidal height based on ITRF97 and GRS80, using EGM96*2 geoid model • Value “-9999” is stored in void pixels • Value “0m” is stored in sea pixels	*1: Table 1 for details *2: 4.URLs 1) *3: Inverse Distance Weighted method 3.References 5) *4: Land water and low correlation mask indicates the area with low correlation in the calculation of the source 2.5m/5m resolution DSM. In v2.1 or later version, the value was filled by other data sets. So this mask is applicable for v1.0 and v1.1. *5: Based on the following v1.0-v2.1 ・SWBD, GSHHG ・PRISM image (Japan) v2.2 or later ・OpenStreetMap ・GSI Coastline (Japan) 4.URLs 2)-5) *6: 4.URLs 6) *7: 4.URLs 7) *8: 4.URLs 8) *9: 4.URLs 9) *10: 4.URLs 10) *11: 4.URLs 11) *12: 4.URLs 12) *13: 4.URLs 13)
Mask file (MSK) [GeoTIFF format]	Mask information • Byte (8 bit) raster data • Equirectangular projection • Pixel spacing: basically 1 arcsec (approx. 30 m), latitude dependent • Lower 1-2 bit: Valid/Invalid, Mask Information (Cloud and snow, Land water and low correlation, Sea) • Lower 3-8 bit: Elevation dataset used for the void-filling processing, filled/not filled by IDW method*3 Details of the mask 0000 0000 (0x00): Valid 0000 0001 (0x01): Cloud and snow mask (invalid) 0000 0010 (0x02): Land water and low correlation mask*4 (valid) 0000 0011 (0x03): Sea mask*5 (valid) 0000 0100 (0x04): GSI DTM*6 (valid) 0000 1000 (0x08): SRTM-1 v3*7 (valid) 0000 1100 (0x08): PRISM DSM (valid) 0001 0000 (0x10): ViewFinder Panoramas DEM*8 (valid) 0001 1000 (0x18): ASTER GDEM v2*9 (valid) 0001 1100 (0x1C): ArcticDEM v2*10 (valid) 0010 0000 (0x20):TanDEM-X 90m DEM*11 (valid) 0010 0100 (0x24):ArcticDEM v3*10 (valid) 0010 1000 (0x28):ASTER GDEM v3*9 (valid) 0010 1100 (0x2C): REMA v1.1*12 (valid) 0011 0000 (0x30):Copernicus DEM GLO-30*13(valid) 0011 0100 (0x34):ArcticDEM v4*10 (valid) 1111 1100 (0xFC): applied IDW method (gdal_fillnodata) (valid)	
Stacking number file (STK) [GeoTIFF format]	Stack number of PRISM DSM scenes used to produce source AW3D 2.5m/5m DSM • Byte (8 bit) raster data • Equirectangular projection • Pixel spacing: basically 1 arcsec (approx. 30 m), latitude dependent • STK values are average over the range of 1 arcsec grid pixel (Round off to the integer)	
Header information file (HDR) [Text format]	Meta data about the product*14 • Derived from HDR file of the source AW3D 2.5m/5m DSM	*14: Table 3 for details
Quality assurance information file (QAI) [Text format]	Quality assurance information*15 • Added the information of 30m DSM to the source AW3D 2.5m/5m DSM	*15: Table 4 for details
List file (LST) [Text format]	List of Scene IDs used to produce source AW3D 2.5m/5m DSM*16 • ID, type, orbit number, RSP path/frame, stereo mode, observation date	*16: v2.1 later

2.2. File naming rule

The naming rule for each file that composes AW3D30 version 3.2/3.1 dataset is as follows.

General：

[Product ID]_[Tile ID]_[Kind of file].[Extention]

[Product ID]：ALPSMLC30 (Table 3 No.2)

[Tile ID]：Latitude/Longitude (Table 3 No.1)

[Kind of file]：DSM、MSK、STK、HDR、QAI、LST (Table 1)

[Extention]：tif、txt (Table 1)

Example：

ALPSMLC30_N035E138_DSM.tif (DSM file)

ALPSMLC30_N035E138_MSK.tif (Mask file)

ALPSMLC30_N035E138_STK.tif (Stacking number file)

ALPSMLC30_N035E138_HDR.txt (Header information file)

ALPSMLC30_N035E138_QAI.txt (Quality assurance information file)

ALPSMLC30_N035E138_LST.txt (List file)

2.3. Latitude dependent pixel spacing

AW3D30 v3.1 uses pixel spacing for each latitude zone in order to keep the pixel spacing in the longitude direction at approximately 30 m even in high latitude regions. Table 2 shows specific values of spacing.

AW3D30 version 3.2 are zone Ⅰ of Table 2 since those are low latitude region.

Table 2 AW3D30 v3.1 latitude dependent pixel spacing

Zone	Latitude range (North/South)	Pixel spacing (Latitude)	Pixel spacing (Longitude)	Data size of 1˚x1˚ tile
Ⅰ	0˚- 60˚	1.00”	1.00”(30.922m - 15.500m)	3600 x 3600
Ⅱ	60˚- 70˚	1.00”	2.00”(31.000m - 21.215m)	1800 x 3600
Ⅲ	70˚- 80˚	1.00”	3.00”(31.822m - 16.161m)	1200 x 3600
Ⅳ	80˚- 90˚	1.00”	6.00”(32.322m - 0.000m)	600 x 3600

2.4. Header information file format

Table 3 shows the detailed items in the header information (HDR) file included in the AW3D30 dataset.

Table 3 Items in AW3D30 header information (HDR) file

Field No.	Description	Number of Bytes	Start Byte Position	Type	Note
Product Record	Data Identifier				Field No.1-35
	Product Information Product Identifier Details				
1	Tile ID = 'NNNNNNNNbbbbbbbb' NNNNNNNN: Same as No.4	16	1	A16	
2	DSM Product ID = 'AABBBCDEEbbbbbbb' (fixed) AA : Satellite code = 'AL':ALOS BBB : Sensor code = 'PSM':PRISM C : Grid type = 'L': Lat-Lon D : DSM Version = 'C':3 EE : DSM pixel spacing = '30': 30m	16	17	A16	
3	Product type = 'PSM-DSMbbbbbbbbbb' (fixed)	16	33	A16	
4	Mesh code = 'NNNNNNNNbbbbbbbb': Geographic coordinates at lower left corner of lower left pixel	16	49	A16	
5	Satellite name = 'ALOSbbbb' (fixed)	8	65	A8	
6	Sensor code = 'PSMbbbbb': PRISM (fixed)	8	73	A8	
7	Coordinates = 'LTLNbbbb': Lat-Lon (fixed)	8	81	A8	
8	DSM version = 'Cbbb': 3 (fixed)	4	89	A4	
9	DSM grid spacing (sec) = 'b1.00bbb' (fixed)	8	93	A8	Standard at low-mid latitudes
10	Blank (fixed)	28	101	A28	
	Subtotal	128			
	Mesh Information Mesh Identifier				
11	Mesh upper-left line number = 'bNNNNN.N'	8	129	F8.1	Addresses correspondence to the corner of a pixel, not its center. Since each pixel/line integer value is assigned at pixel center, pixel/line number for four corners is described with real values.
12	Mesh upper-left column number = 'bNNNNN.N'	8	137	F8.1	
13	Mesh upper-right line number = 'bNNNNN.N'	8	145	F8.1	
14	Mesh upper-right column number = 'bNNNNN.N'	8	153	F8.1	
15	Mesh lower-left line number = 'bNNNNN.N'	8	161	F8.1	
16	Mesh lower-left column number = 'bNNNNN.N'	8	169	F8.1	
17	Mesh lower-right line number = 'bNNNNN.N'	8	177	F8.1	
18	Mesh lower-right column number = 'bNNNNN.N'	8	185	F8.1	
19	Mesh upper-left latitude (deg.) = 'NNNNNNNN.NNNNNNN' (-90.0000000 - 90.0000000)	16	193	F16.7	Negative value for southern hemisphere
20	Mesh upper-left longitude (deg.) = 'NNNNNNNN.NNNNNNN' (-180.0000000 - 180.0000000)	16	209	F16.7	Negative value for west longitude
21	Mesh upper-right latitude (deg.) = 'NNNNNNNN.NNNNNNN' (-90.0000000 - 90.0000000)	16	225	F16.7	Negative value for southern hemisphere
22	Mesh upper-right longitude (deg.) = 'NNNNNNNN.NNNNNNN' (-180.0000000 - 180.0000000)	16	241	F16.7	Negative value for west longitude
23	Mesh lower-left latitude (deg.) = 'NNNNNNNN.NNNNNNN' (-90.0000000 - 90.0000000)	16	257	F16.7	Negative value for southern hemisphere
24	Mesh lower-left longitude (deg.) = 'NNNNNNNN.NNNNNNN' (-180.0000000 - 180.0000000)	16	273	F16.7	Negative value for west longitude
25	Mesh lower-right latitude (deg.) = 'NNNNNNNN.NNNNNNN' (-90.0000000 - 90.0000000)	16	289	F16.7	Negative value for southern hemisphere
26	Mesh lower-right longitude (deg.) = 'NNNNNNNN.NNNNNNN' (-180.0000000 - 180.0000000)	16	305	F16.7	Negative value for west longitude

Table 3 Items in AW3D30 header information (HDR) file (continued)

Field No.	Description	Number of Bytes	Start Byte Position	Type	Note
27	Mesh upper-left map address X (km) = 'NNNNNNNN.NNNNNNN'	16	321	F16.7	All blank for LTLN product For UTM, X in southern hemisphere includes false northing 10,000km, and Y includes false easting 500km
28	Mesh upper-left map address Y (km) = 'NNNNNNNN.NNNNNNN'	16	337	F16.7	
29	Mesh upper-right map address X (km) = 'NNNNNNNN.NNNNNNN'	16	353	F16.7	
30	Mesh upper-right map address Y (km) = 'NNNNNNNN.NNNNNNN'	16	369	F16.7	
31	Mesh lower-left map address X (km) = 'NNNNNNNN.NNNNNNN'	16	385	F16.7	
32	Mesh lower-left map address Y (km) = 'NNNNNNNN.NNNNNNN'	16	401	F16.7	
33	Mesh lower-right map address X (km) = 'NNNNNNNN.NNNNNNN'	16	417	F16.7	
34	Mesh lower-right map address Y (km) = 'NNNNNNNN.NNNNNNN'	16	433	F16.7	
35	Blank (fixed)	16	449	A16	
	Subtotal	336			
Processing Information	Processing Details				Field No.36-58
	Map Projection	Map Projection Parameters			
36	Coordinates = 'LTLNbbbb' (fixed)	8	465	A8	
37	PS origin latitude (deg.) = 'NNNNNNNN.NNNNNNN'	16	473	F16.7	All blank for LTLN and UTM product
38	PS origin longitude (deg.) = 'NNNNNNNN.NNNNNNN'	16	489	F16.7	
39	PS reference latitude (deg.) = 'NNNNNNNN.NNNNNNN'	16	505	F16.7	
40	PS reference longitude/ UTM central meridian (deg.) = 'NNNNNNNN.NNNNNNN'	16	521	F16.7	All blank for LTLN product
41	Hemisphere = 'bbbN':North / 'bbbS':South	4	537	A4	
42	UTM zone no. = 'bbb1' - 'bb60'	4	541	I4	All blank for LTLN and PS product
43	Angle between vertical axis of coordinates and true north direction (deg) = 'NNNNNNNN.NNNNNNN'	16	545	F16.7	At mesh center All blank for LTLN product
44	Blank (fixed)	32	561	A32	
	Subtotal	128			
	Datum	Datum Parameters			
45	ECR coordinates = 'ITRF97bbbbbbbbbb' (fixed)	16	593	A16	
46	Ellipsoid model = 'GRS80bbbbbbbbbbb' (fixed)	16	609	A16	
47	Equator radius of ellipsoid model (km) = 'NNNNNNNN.NNNNNNN' (fixed)	16	625	F16.7	
48	Polar radius of ellipsoid model (km) = 'NNNNNNNN.NNNNNNN' (fixed)	16	641	F16.7	
49	Inverse flattening (1/f) of ellipsoid model = 'NNNNNNNN.NNNNNNN' (fixed)	16	657	F16.7	
50	Blank (fixed)	48	673	A48	
	Subtotal	128			
	DSM Data	DSM Data Parameters			
51	Coordinates = 'LTLNbbbb': Lat-Lon (fixed)	8	721	A8	Same as field No.7
52	DSM type = 'Cbbb': Absolute (fixed)	4	729	A4	Same as field No.8
53	Vertical grid spacing (sec)/(m) = 'bb1.00bb' (fixed)	8	733	A8	Second for LTLN Meter for UTM and PS
54	Horizontal grid spacing (sec)/(m) = 'bbN.NNbb'	8	741	A8	

Table 3 Items in AW3D30 header information (HDR) file (continued)

Field No.	Description	Number of Bytes	Start Byte Position	Type	Note
55	Height resolution of DSM (m) = '1bbbbbbb' (fixed)	8	749	I8	
56	Height type = 'Obbb': Orthometric Height (fixed)	4	757	A4	
57	Geoid data = 'XXXXXXXXXXXXXXXX' 'GSI-2000bbbbbbbb': Japan Geoid 2000 'NGA-EGM96bbbbbbb': EGM96	16	761	A16	All blank for height type 'E' (Ellipsoid height)
58	Blank (fixed)	8	777	A8	
	Subtotal	64			
Quality Record	Quality Information from the 5m DSM				Field No.59-64
59	Mask (00000000) (%) = 'bNNN'	4	785	I4	Right-aligned
60	Mask (00000001) (%) = 'bNNN'	4	789	I4	
61	Mask (00000010) (%) = 'bNNN'	4	793	I4	
62	Mask (00000011) (%) = 'bNNN'	4	797	I4	
63	DSM data quality (Rate of valid pixels) = 'bbbX' 'G': Good = 100 - 81 % 'F': Fair = 80 - 51 % 'P': Poor = 50 - 0 %	4	801	A4	
64	Blank (fixed)	44	805	A44	
	Subtotal	64			
Format Record	Data Format Information				Field No.65-82
65	Header record length (byte) = 'bbbbNNNN'	8	849	I8	Variable header file size
66	Data column length (number of pixels for each line) = 'bbbNNNNN' (fixed)	8	857	I8	
67	Data line length (number of pixels for each column) = 'bbbNNNNN' (fixed)	8	865	I8	
68	Byte order = 'LSBbbbbbb':Little endian (fixed)	8	873	A8	
	Subtotal	32			
	DSM Data Format	DSM Data Format Structures			
69	Number of bits for DSM 1 pixel (bit) = 'bb16' (fixed)	4	881	I4	
70	Number of pixels for DSM 1 data (pixel) = 'bbb1' (fixed)	4	885	I4	
71	Number of bytes for DSM 1 data (byte) = 'bbb2' (fixed)	4	889	I4	
72	Bit start for DSM 1 pixel (bit) = 'bbb0' (fixed)	4	893	I4	
73	Bit end for DSM 1 pixel (bit) = 'bb15' (fixed)	4	897	I4	
74	Number of DSM files = 'bbb1' (fixed)	4	901	I4	
75	Blank (fixed)	8	905	A8	
	Subtotal	32			
	MSK Data Format	MSK Data Format Structures			
76	Number of bits for MSK 1 pixel (bit) = 'bbb8' (fixed)	4	913	I4	
77	Number of pixels for MSK 1 data (pixel) = 'bbb1' (fixed)	4	917	I4	
78	Number of bytes for MSK 1 data (byte) = 'bbb1' (fixed)	4	921	I4	

Table 3 Items in AW3D30 header information (HDR) file (continued)

Field No.	Description	Number of Bytes	Start Byte Position	Type	Note
79	Bit start for MSK 1 pixel (bit) = 'bbb0' (fixed)	4	925	I4	
80	Bit end for MSK 1 pixel (bit) = 'bbb7' (fixed)	4	929	I4	
81	Number of MSK files = 'bbb1' (fixed)	4	933	I4	
82	Blank (fixed)	40	937	A40	
	Subtotal	64			
System Record	Data Processing System Information				Field No.83-90
83	Processing date (JST) = 'YYYYMMDDbbbbbbbb' YYYY : Year MM : Month DD : Day	16	977	A16	Processing date of source AW3D
84	Processing time (JST) = 'HHMMSSbbbbbbbbbb' HH : Hour MM : Minute SS : Second	16	993	A16	Processing date of source AW3D
85	Processing country = 'JAPANbbbbbbbbbbb' (fixed)	16	1009	A16	
86	Processing organization = 'JAXAbbbbbbbbbbbb' (fixed)	16	1025	A16	
87	Processing facility = 'EORC-AGAPbbbbbbb' (fixed)	16	1041	A16	
88	Software version = 'VVV-RRR-YYYYMMDDbbbbbbbb' VVV : Version No. RRR : Release No. YYYY : Release year MM : Release month DD : Release date	24	1057	A24	
89	Document version = 'N.Nb'	4	1081	A4	Version of base document Not exist for software version 002-000-20120330
90	Blank (fixed)	20	1085	A20	
	Subtotal	128			
Reserved					Field No.91
91	Blank (fixed)	4	1105	I4	
	Subtotal	4			
	Total	1108			

2.5. Quality assurance information file format

Detailed items in the quality assurance information (QAI) file included in the AW3D30 dataset are summarized in Table 4. First half of the items are the quality assurance information obtained from the source AW3D 2.5m/5m DSM dataset that is the origin of AW3D30 30m DSM. Table 5 shows criteria for comprehensive evaluation.

Table 4 Items in AW3D30 quality assurance information (QAI) file

Category	Item	Key	Value (sample)
Source 2.5m DSM 4 tiles (Japan) Source 5m DSM 1 tile (except Japan)	Comprehensive assessment: accuracy[*1]	TOTAL_ACCURACY	G
	Comprehensive assessment: completeness[*1]	TOTAL_INTEGRITY	G
	Comprehensive assessment: reliability[*1]	TOTAL_RELIABILITY	G
	Average of difference: SRTM	SRTM_AVERAGE	1.9333076
	Standard deviation of difference: SRTM	SRTM_STDEV	8.6490392
	RMS of difference: SRTM	SRTM_RMS	8.47604
	Maximum of difference: SRTM	SRTM_MAX	68.509979
	Mode of difference: SRTM	SRTM_MODE	3
	Average of difference: ASTER GDEM	ASTER_AVERAGE	-0.55988584
	Standard deviation of difference: ASTER GDEM	ASTER_STDEV	14.906643
	RMS of difference: ASTER GDEM	ASTER_RMS	14.5537
	Maximum of difference: ASTER GDEM	ASTER_MAX	141.71265
	Mode of difference: ASTER GDEM	ASTER_MODE	0
	Number of comparison points with ICESat	ICESAT_NUM	53
	Average of difference: ICESat	ICESAT_AVERAGE	0.470889
	Standard deviation of difference: ICESat	ICESAT_STDEV	3.57531
	RMS of difference: ICESat	ICESAT_RMS	3.57259
	Maximum of difference: ICESat	ICESAT_MAX	14.0139
	Mode of difference: ICESat	ICESAT_MODE	0
	Average of relative error between stacked images	REL_STACK_AVERAGE	2.18556
	Standard deviation of relative error between stacked images	REL_STACK_STDEV	1.13929
	Number of valid pixel	MASK_NUM_VALID	574972351
	Number of cloud and snow masked pixel	MASK_NUM_CLOUDSNOW	2360
	Number of inland water and low correlation masked pixels	MASK_NUM_INLANDWATER	831055
	Number of sea masked pixels	MASK_NUM_SEA	194234
	Rate of valid pixel	MASK_RATE_VALID	0.998216
	Rate of cloud and snow masked pixels	MASK_RATE_CLOUDSNOW	0.0000041
	Rate of inland water and low correlation masked pixels	MASK_RATE_INLANDWATER	0.0014428
	Rate of sea masked pixels	MASK_RATE_SEA	0.000337212
	Correlation coefficient: average	CORREL_AVERAGE	0.635053
	Correlation coefficient: standard deviation	CORREL_STDEV	0.251597
	Correlation coefficient: maximum	CORREL_MAX	1
	Correlation coefficient: minimum	CORREL_MIN	-1

Table 4　Items in AW3D30 quality assurance information (QAI) file (continued)

Category	Item	Key	Value (sample)
Source 2.5m DSM 4 tiles (Japan) Source 5m DSM 1 tile (except Japan)	Correlation coefficient histogram: from -1.0 to -0.9	CORREL_HIST_-1.0to-0.9	2215
	Correlation coefficient histogram: from -0.9 to -0.8	CORREL_HIST_-0.9to-0.8	0
	Correlation coefficient histogram: from -0.8 to -0.7	CORREL_HIST_-0.8to-0.7	3
	Correlation coefficient histogram: from -0.7 to -0.6	CORREL_HIST_-0.7to-0.6	7
	Correlation coefficient histogram: from -0.6 to -0.5	CORREL_HIST_-0.6to-0.5	41
	Correlation coefficient histogram: from -0.5 to -0.4	CORREL_HIST_-0.5to-0.4	261
	Correlation coefficient histogram: from -0.4 to -0.3	CORREL_HIST_-0.4to-0.3	1518
	Correlation coefficient histogram: from -0.3 to -0.2	CORREL_HIST_-0.3to-0.2	6901
	Correlation coefficient histogram: from -0.2 to -0.1	CORREL_HIST_-0.2to-0.1	36766
	Correlation coefficient histogram: from -0.1 to 0.0	CORREL_HIST_-0.1to0.0	212610
	Correlation coefficient histogram: from 0.0 to 0.1	CORREL_HIST_0.0to0.1	919562
	Correlation coefficient histogram: from 0.1 to 0.2	CORREL_HIST_0.1to0.2	3565829
	Correlation coefficient histogram: from 0.2 to 0.3	CORREL_HIST_0.2to0.3	12236681
	Correlation coefficient histogram: from 0.3 to 0.4	CORREL_HIST_0.3to0.4	33412879
	Correlation coefficient histogram: from 0.4 to 0.5	CORREL_HIST_0.4to0.5	70300296
	Correlation coefficient histogram: from 0.5 to .0.6	CORREL_HIST_0.5to0.6	111074518
	Correlation coefficient histogram: from 0.6 to 0.7	CORREL_HIST_0.6to0.7	132675287
	Correlation coefficient histogram: from 0.7 to 0.8	CORREL_HIST_0.7to0.8	122173898
	Correlation coefficient histogram: from 0.8 to 0.9	CORREL_HIST_0.8to0.9	75815662
	Correlation coefficient histogram: from 0.9 to 1.0	CORREL_HIST_0.9to1.0	12537417
	Number of stacking: average	STACK_AVERAGE	4.76069
	Number of stacking: standard deviation	STACK_STDEV	1.91647
	Number of stacking: Minimum	STACK_MIN	0
	Number of stacking: Maximum	STACK_MAX	14
Intermediate 5m DSM mask information (Japan)	Number of valid pixel	AW3Dv3.1_MASK_NUM_VALID	550984124
	Number of cloud and snow mask pixel	AW3Dv3.1_MASK_NUM_CLOUDSNOW	2595589
	Number of inland water and low correlation mask pixels	AW3Dv3.1_MASK_NUM_INLANDWATER	0
	Number of sea mask pixels	AW3Dv3.1_MASK_NUM_SEA	22420287
	Rate of valid pixel	AW3Dv3.1_MASK_RATE_VALID	95.65696597
	Rate of cloud and snow mask pixels	AW3Dv3.1_MASK_RATE_CLOUDSNOW	0.45062309
	Rate of inland water and low correlation mask pixels	AW3Dv3.1_MASK_RATE_INLANDWATER	0
	Rate of sea mask pixels	AW3Dv3.1_MASK_RATE_SEA	3.892410938
Intermediate 30m DSM mask information	Number of valid pixel	DegradeAVE_MASK_NUM_VALID	12412309
	Number of cloud and snow mask pixel	DegradeAVE_MASK_NUM_CLOUDSNOW	46079
	Number of inland water and low correlation mask pixels	DegradeAVE_MASK_NUM_INLANDWATER	0
	Number of sea mask pixels	DegradeAVE_MASK_NUM_SEA	501612
	Rate of valid pixel	DegradeAVE_MASK_RATE_VALID	95.7739892
	Rate of cloud and snow mask pixels	DegradeAVE_MASK_RATE_CLOUDSNOW	0.35554784
	Rate of inland water and low correlation mask pixels	DegradeAVE_MASK_RATE_INLANDWATER	0
	Rate of sea mask pixels	DegradeAVE_MASK_RATE_SEA	3.870462963

Table 4　Items in AW3D30 quality assurance information (QAI) file (continued)

Category	Item	Key	Value (sample)
Product 30m DSM mask information	Number of cloud and snow mask pixel (after void-filling)	GapFillAVE_MASK_NUM_CLOUDSNOW	0
	Number of pixels filled with GSI 10m DEM	GapFillAVE_MASK_NUM_FILLED_GSI10	26019
	Number of pixels filled with SRTM-1 Version 3	GapFillAVE_MASK_NUM_FILLED_SRTM-1_V3	0
	Number of pixels filled with PRISM DSM	GapFillAVE_MASK_NUM_FILLED_PSM	20060
	Number of pixels filled with ArcticDEM v4	GapFillAVE_MASK_NUM_FILLED_ArcticDEM_v4	0
	Number of pixels filled with ArcticDEM v3	GapFillAVE_MASK_NUM_FILLED_ArcticDEM_v3	0
	Number of pixels filled with ArcticDEM v2	GapFillAVE_MASK_NUM_FILLED_ArcticDEM_v2	0
	Number of pixels filled with ASTER GDEM v3	GapFillAVE_MASK_NUM_FILLED_GDEM_v3	0
	Number of pixels filled with TanDEM-X 90m DEM	GapFillAVE_MASK_NUM_FILLED_WorldDEM_v3	0
	Number of pixels filled with Viewfinder Panoramas DEM (Only for version 3.2)	GapFillAVE_MASK_NUM_FILLED_VPD	0
	Number of pixels filled with REMA v1.1 (Only for version 3.1 South of 60 degrees South)	GapFillAVE_MASK_NUM_FILLED_REMA_v1.1	0
	Number of pixels filled with Copernicus DEM GLO-30	GapFillAVE_MASK_NUM_FILLED_COP-DEM_GLO-30	4483
	Number of pixels filled with ArcticDEM_v4	GapFillAVE_MASK_NUM_FILLED_ArcticDEM_v4	0
	Number of pixels filled with IDW method	GapFillAVE_MASK_NUM_FILLED_FillNoData	0
	Rate of cloud and snow mask pixel (after void-filling)	GapFillAVE_MASK_RATE_CLOUDSNOW	0
	Rate of pixels filled with GSI 10m DEM	GapFillAVE_MASK_RATE_FILLED_GSI10	0.200763889
	Rate of pixels filled with SRTM1 Version 3	GapFillAVE_MASK_RATE_FILLED_SRTM-1_V3	0
	Rate of pixels filled with PRISM DSM	GapFillAVE_MASK_RATE_FILLED_PSM	0.154783951
	Rate of pixels filled with ArcticDEM v3	GapFillAVE_MASK_RATE_FILLED_ArcticDEM_v3	0
	Rate of pixels filled with ArcticDEM v2	GapFillAVE_MASK_RATE_FILLED_ ArcticDEM_v2	0
	Rate of pixels filled with ASTER GDEM v3	GapFillAVE_MASK_RATE_FILLED_GDEM_v3	0
	Rate of pixels filled with TanDEM-X 90m DEM	GapFillAVE_MASK_RATE_FILLED_WorldDEM_v3	0
	Rate of pixels filled with Viewfinder Panoramas DEM (Only for version 3.2)	GapFillAVE_MASK_RATE_FILLED_VPD	0
	Rate of pixels filled with REMA v1.1 (Only for version 3.1 South of 60 degrees South)	GapFillAVE_MASK_RATE_FILLED_REMA_v1.1	0
	Rate of pixels filled with Copernicus DEM GLO-30	GapFillAVE_MASK_RATE_FILLED_COP-DEM_GLO-30	0.000778
	Rate of pixels filled with IDW method	GapFillAVE_MASK_RATE_FILLED_FillNoData	0
Void-filled product	Version of void-filled product	VERSION_GapFill_PRODUCT	3.1
Source product	Version of source product	VERSION_AW3D_PRODUCT	3

*1: Evaluation items and strategies in comprehensive assessment are as follows.
1) Comprehensive assessment - accuracy: statistical evaluation on the absolute difference from existing global topographic data such as SRTM-3, ASTER GDEM, and ICESat
2) Comprehensive assessment - completeness: evaluation on the area occupancy of cloud and snow mask and land water and low correlation mask to land areas
3) Comprehensive assessment - reliability: statistical evaluation on the histograms of correlation coefficients in stereo-pair matching and on stacking number
Table 5 shows the criteria for comprehensive evaluation

*2: Descriptions of source products are applicable for v2.1 or later ('-' indicates the tile was not made from AW3D)

Table 5　Criteria for comprehensive evaluation in QAI file

Item	Good	Fair	Poor
Accuracy	＜5m	＜7m	≧7m
Completeness	≧90%	≧70%	＜70%
Reliability	≧1.5	≧1.0	＜1.0

2.6. TIFF tag settings for GeoTIFF product

Tables 6 to 8 summarize the TIFF tag settings for GeoTIFF product (DSM file, mask file and stacking number file) included in AW3D30 dataset.

Table 6　TIFF tag settings for GeoTIFF product (DSM file)

Tag	ID	Type	Number	Value (Sample)
NewSubfileType	254	Long	1	0
ImageWidth	256	Short	1	3600
ImageLength	257	Short	1	3600
BitsPerSample	258	Short	1	16
Compression	259	Short	1	1 (No compression)
PhotometricInterpretation	262	Short	1	1 (Black is zero)
ImageDescription	270	Ascii	20	Product Version 3.2 or later
StripOffsets	273	Long	3600	14408 21608 28808 36008 43208 50408 …
Orientation	274	Short	1	1
SamplesPerPixel	277	Short	1	1
RowsPerStrip	278	Short	1	1
StripByteCounts	279	Long	3600	7200 7200 7200 7200 7200 7200 …
XResolution	282	Rational	1	1/1
YRresolution	283	Rational	1	1/1
PlanarConfiguration	284	Short	1	1 (Chunky format)
SampleFormat	339	Short	1	2 (Signed integer)
ModelPixelScale	33550	Double	3	0.000278 0.000278 0.000000
ModelTiepoint	33922	Double	6	0.000000 0.000000 0.000000 138.000000 35.000000 0.000000
GeoKeyDirectory	34735	Short	24	1 1 0 5 1024 0 1 2 1025 0 1 1 2048 0 1 4326 2052 0 1 9001 2054 0 1 9102
GeoAsciiParams	34737	Ascii	7	WGS-84 (Not exist for southern region over 60 degrees south)

Table 7　TIFF tag settings for GeoTIFF product (MSK files)

Tag	ID	Type	Number	Value (Sample)
ImageWidth	256	Short	1	3600
ImageLength	257	Short	1	3600
BitsPerSample	258	Short	1	8
Compression	259	Short	1	1 (No compression)
PhotometricInterpretation	262	Short	1	1 (Black is zero)
ImageDescription	270	Ascii	20	Product Version 3.2 or later
StripOffsets	273	Long	1800	192378 216378 240378 264378 288378 312378 …
SamplesPerPixel	277	Short	1	1
RowsPerStrip	278	Short	1	2
StripByteCounts	279	Long	1800	7200 7200 7200 7200 7200 7200 …
PlanarConfiguration	284	Short	1	1 (Chunky format)
SampleFormat	339	Short	1	1 (Chunky format)
ModelPixelScale	33550	Double	3	0.000278 0.000278 0.000000
ModelTiepoint	33922	Double	6	0.000000 0.000000 0.000000 138.000000 35.000000 0.000000
GeoKeyDirectory	34735	Short	32	1 1 0 7 1024 0 1 2 1025 0 1 1 2048 0 1 4326 2049 34737 7 0 2054 0 1 9102 2057 34736 1 1 2059 34736 1 0
GeoDoubleParams	34736	Double	2	298.257224 6378137.000000
GeoAsciiParams	34737	Ascii	8	WGS 84|
GDAL_NODATA	42113	Ascii	7	255

Table 8　TIFF tag settings for GeoTIFF product (STK file)

Tag	ID	Type	Number	Value (Sample)
NewSubfileType	254	Long	1	0
ImageWidth	256	Short	1	3600
ImageLength	257	Short	1	3600
BitsPerSample	258	Short	1	8
Compression	259	Short	1	1 (No compression)
PhotometricInterpretation	262	Short	1	1 (Black is zero)
ImageDescription	270	Ascii	20	Product Version 3.2 (Tag for version 3.2 only)
StripOffsets	273	Long	3600	14408 18008 21608 25208 28808 32408 …
Orientation	274	Short	1	1
SamplesPerPixel	277	Short	1	1
RowsPerStrip	278	Short	1	1
StripByteCounts	279	Long	3600	3600 3600 3600 3600 3600 3600 …
XResolution	282	Rational	1	1/1
YRresolution	283	Rational	1	1/1
PlanarConfiguration	284	Short	1	1 (Chunky format)
ModelPixelScale	33550	Double	3	0.000042 0.000042 0.000000
ModelTiepoint	33922	Double	6	0.000000 0.000000 0.000000 138.000000 35.000000 0.000000
GeoKeyDirectory	34735	Short	24	1 1 0 5 1024 0 1 2 1025 0 1 1 2048 0 1 4326 2052 0 1 9001 2054 0 1 9102
GeoAsciiParams	34737	Ascii	7	WGS-84 (Not exist for southern region over 60 degrees south)

2.7. GeoTIFF key settings for GeoTIFF product

Table 9 to 11 show the Geo key settings for GeoTIFF product (DSM file, mask file and stacking number file) included in AW3D30 dataset.

Table 9 Geo key settings for GeoTIFF product (DSM file)

Key	ID	Type	Number	Value (Sample)
GTModelTypeGeoKey	1024	Short	1	2 (ModelTypeGeographic)
GTRasterTypeGeoKey	1025	Short	1	1 (RasterPixelIsArea)
GeographicTypeGeoKey	2048	Short	1	4326 (GCS_WGS_84)
GeogLinearUnitsGeoKey	2053	Short	1	9001 (Linear_Meter)
GeogAngularUnitsGeoKey	2054	Short	1	9102 (Angular_Degree)

Table 10 Geo key settings for GeoTIFF product (MSK file)

Key	ID	Type	Number	Value (Sample)
GTModelTypeGeoKey	1024	Short	1	2 (ModelTypeGeographic)
GTRasterTypeGeoKey	1025	Short	1	1 (RasterPixelIsArea)
GeographicTypeGeoKey	2048	Short	1	4326 (GCS_WGS_84)
GeogCitationGeoKey	2049	Ascii	7	WGS 84
GeogAngularUnitsGeoKey	2054	Short	1	9102 (Angular_Degree)
GeogSemiMajorAxisGeoKey	2057	Double	1	6378137
GeogInvFlatteningGeoKey	2059	Double	1	298.257224

Table 11 Geo key settings for GeoTIFF product (STK file)

Key	ID	Type	Number	Value (Sample)
GTModelTypeGeoKey	1024	Short	1	2 (ModelTypeGeographic)
GTRasterTypeGeoKey	1025	Short	1	1 (RasterPixelIsArea)
GeographicTypeGeoKey	2048	Short	1	4326 (GCS_WGS_84)
GeogLinearUnitsGeoKey	2053	Short	1	9001 (Linear_Meter)
GeogAngularUnitsGeoKey	2054	Short	1	9102 (Angular_Degree)

3. References

1) T. Tadono, H. Ishida, F. Oda, S. Naito, K. Minakawa, and H. Iwamoto, “Precise Global DEM Generation by ALOS PRISM”, ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol.II-4, pp.71-76, 2014.

2) J. Takaku, T. Tadono, and K. Tsutsui, “Generation of High Resolution Global DSM from ALOS PRISM”, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, ISPRS, Vol.XL-4, pp.243-248, 2014.

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7) J. Takaku, T. Tadono, K. Tsutsui, and M. Ichikawa, “Quality Improvements of ‘AW3D’ Global DSM Derived from ALOS PRISM”, Proc. IGARSS2018, IEEE, Valencia, Spain, pp.1612-1615, 2018.

8) J. Takaku, T. Tadono, M. Doutsu, F. Ohgushi, and H. Kai, “Updates of ‘AW3D30’ ALOS Global Digital Surface Model with Other Open Access Datasets”, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, ISPRS, Vol.XLIII-B4-2020, pp.183–189, 2020.

9) J. Takaku, T. Tadono, M. Doutsu, F. Ohgushi, and H. Kai, “Updates of ‘AW3D30’ ALOS Global Digital Surface Model in Antarctica with Other Open Access Datasets”, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLIII-B4-2021, 401–408, 2021.

4. Related URLs

1) EGM96 (NGA/NASA)
https://cddis.nasa.gov/926/egm96/egm96.html

2) SWBD (NASA/JPL)
https://dds.cr.usgs.gov/srtm/version2_1/SWBD/

3) GSHHG (former GSHHS) (University of Hawaii/NOAA)
https://www.soest.hawaii.edu/pwessel/gshhs/index.html

4) OpenStreetMap Coastlines (Jochen Topf & Christoph Hormann)
https://osmdata.openstreetmap.de/data/coastlines.html

5) GSI Coastline Vector Data*1
https://fgd.gsi.go.jp/download/ref_kihon.html *Only in Japanese

6) GSI Digital Topographic Map 5m and 10m Mesh Data*1
https://fgd.gsi.go.jp/download/ref_dem.html *Only in Japanese

7) SRTM-1 v3 (NASA/JPL)
https://www2.jpl.nasa.gov/srtm/

8) Viewfinder Panoramas DEM（Jonathan de Ferranti）
http://viewfinderpanoramas.org/dem3.html

9) ArcticDEM v2, v3 (NGA/NSF)
https://www.pgc.umn.edu/data/arcticdem

10) ASTER GDEM v2, v3 (NASA/METI)
https://asterweb.jpl.nasa.gov/gdem.asp

11) TanDEM-X 90m DEM（DLR）
https://geoservice.dlr.de/web/dataguide/tdm90/

12) REMA v1.1（PGC, University of Minnesota）
https://www.pgc.umn.edu/data/rema/

13) Copernicus DEM GLO-30（ESA）
https://spacedata.copernicus.eu/ja/collections/copernicus-digital-elevation-model

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found here. (Pages 23-24)

Copernicus Digital Elevation Model GLO-30-F was accessed on December 2022 from https://registry.opendata.aws/copernicus-dem.

*1： Approved by the GSI based on Survey Act (Utilization) R 1JHs 1312

5. Point of contact

Please contact to the ALOS Science Project via e-mail to the address below for any questions or inquiries regarding the use of the dataset. For our future reference, it is highly appreciated sending the offprints and copies of the research results using the dataset to the following point of contact.

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