



GCOM-C SGLI

Map projection & GeoTIFF conversion Tool

User's Manual

Version 1.1

Mar. 2022

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GCOM-C project

User's Manual Change Records (1/1)

Ver.	Rev.	Date	Page	Contents
1.0	-	Jul. 2021		First edition
1.0	A	Jul. 2021	2	Added a note about the geolocation-shift of half pixels
1.1	-	Mar. 2022	4-5	Added options of -a, -n, -z, and -c
			8	Added definition of the filename for option -c
			9	Changed TIFF tag settings for option -a, -n, -z and -c
			11	Added Scene/Image start/end time in the Global_attributes

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1. Introduction

This user's manual explains how to use the "Map projection and GeoTIFF conversion tool for GCOM-C/SGLI HDF5 products". The tool is used to convert the imageries in HDF5 files of SGLI products into the generic GeoTIFF files through map projections of geodetic latitude/longitude or polar stereographic coordinates. The type of tool is CUI (Character User Interface) so that users can install it into their own system or scripts for mass processing.

2. System Requirements

Hardware Requirements

- CPU Intel Xeon/Core-i7 or higher
- Memory 1GByte or higher.

Operating Systems

- Linux Kernel 2.6 or higher (64bit)
The operation test has been done on RHEL7/CentOS7.
- Windows Windows 10 (64bit)

3. Input Products / Available Datasets

Available input SGLI HDF5 products for this tool are L1B scenes/half-paths, L2-scenes, and L2-tiles.

3.1 L1B scene/half-path products

Available datasets in the L1B scene/half-path products of three sensors (VNR, IRS, POL) are as follows:

```
Geometry_data/  
  Obs_time_*, Sensor_*, Solar_*  
Image_data/  
  Lt_*, Land_water_flag, QA_flag
```

Whole data are projected for the scenes of VNR and IRS, whereas a user specified range of latitudes is projected for the half-path of POL.

The data including the tilt-driving (the change of tilt-angles) are available for POL, though only the data in the pre- and post-driving are projected while the data during the driving is not projected.

3.2 L2 scene products

Available datasets in the four L2-scene products (NWLR, IWPR, SST, OKID) are as follows:

```
Geometry_data/  
    Sensor_*, Solar_*,  
Image_data/  
    NWLR_*, PAR, QA_flag, TAU*_*, CDOM, CHLA, TSM, SST,  
    Cloud_probability, OKID
```

3.3 L2 tile products

All the datasets in the L2-tile products that have the size of 4800 x 4800 or 1200 x 1200 at the data-type of 8bits-unsigned or 16bits-signed/unsigned integer in the groups of Image_data or Geometry_data are available. The frame of the output imagery is determined from the range of valid pixels on the dataset. No file is output if the specified dataset has no valid pixels.

The details of the datasets in the L2-tile products can be found at:

https://suzaku.eorc.jaxa.jp/GCOM_C/data/product_std.html

Note that this tool do not correct the geolocation-shift of half pixels included in L2 tile products of until version 2003. The details of the geolocation-shift of half pixels can be found at:

<https://shikisai.jaxa.jp/faq/faq0086.html>

4. Operation

Put the downloaded .exe file at any folder/directory in your file system. No installation is required. Run the .exe file at a command prompt (a terminal for Linux).

```
> SGLI_geo_map_linux(win).exe [hdf_filename(*.h5)] [OPTIONS]
```

OPTIONS:

Option&Parameter	Description
-d DATASET	Set the target dataset at DATASET (ex: Image_data/Lt_VN01). This is mandatory for L2-scene or -tile products, whereas it is optional for L1B products. Process all the image datasets (Image_data/Lt_*) for the L1B products when this was not specified.
-o OUTPUTDIR	Set a directory for output files to OUTPUTDIR. If this was not specified, the tool outputs files to a current directory.
-p	Set the map projection to Polar-Stereo (PS). It is not applicable for scenes over the equator. The default is Geodetic-Latitude/Longitude.
-s SPACING	Set the pixel spacing to SPACING. The unit is arc-sec for Geodetic-Latitude/longitude coordinates, while it is meter for PS coordinates. The defaults are as follows: Mode: G-Lat/Lon PS Q(250m): 7.5 arc-sec 250m H(500m): 15 arc-sec 500m K(1km): 30 arc-sec 1km The applicable ranges are 7.5~180 arc-sec for Geodetic-Latitude/Longitude and 250m~6km for PS. For the IRS/L1B without -d option, specify the spacing for the data of 1km-mode so that the data of 250m-mode and of 500m-mode are projected with the spacing of its 1/4 and 1/2 respectively.
-r RESAMPLING	Select the resampling method from NN, BL, or CC with a number specified at RESAMPLING. The definitions of numbers are as follows: 0 = NN, 1 = BL, and 2 = CC. The default is NN for flag datasets and is BL for others. Select NN for L2-tile products to prevent the gaps on the edge of tiles especially if the output imageries on neighboring tiles will be mosaicked.
-m	Mask the stray-light correction flag (MSB2bits) in DN value of TOA radiance (Lt_*).

-b TYPEPOL	<p>Select output data type in POL/L1B products with a number specified at TYPEPOL.</p> <p>The definitions of numbers are as follows:</p> <ul style="list-style-type: none"> -1 = output only stokes parameters (Lt_PI*, Lt_PQ*, Lt_PU*) 1 = output only polarimetric raw images (Lt_P1*, Lt_P2*) 0 = output all the images
-u UPPERLAT	<p>Set the upper latitude at UPPERLAT for the projection of POL/L1B products. This is mandatory for POL/L1B products. The unit is 0.1 degree.</p>
-l LOWERLAT	<p>Set the lower latitude at LOWERLAT for the projection of POL/L1B products. This is mandatory for POL/L1B products. The unit is 0.1 degree.</p> <p>The maximum/minimum ranges between upper- and lower-latitudes are 15.0 degrees/5.0 degrees respectively.</p>
-t TILT	<p>Select a tilt angle to be projected for imageries including tilt-driving in POL/L1B products with a number specified at TILT. The definitions of numbers are as follows:</p> <ul style="list-style-type: none"> 0 = the tilt angle before the driving is used. 1 = the tilt angle after the driving is used. <p>If this is not specified (default), the projection of two tilt angles are delimited at the line of the driving-center on the ground.</p>
-a METADATA	<p>Set band offset/scaling(slope) values from HDF attributes to GDAL_METADATA Tag (42112) with an option specified at METADATA. This is equivalent to options of -a_scale/-a_offset in gdal_transrate. The definition of the options is as follows:</p> <ul style="list-style-type: none"> default = default Offset/Slope in HDF attributes are set, reflectance = Offset_reflectance/Slope_reflectance in HDF attributes are set.
-n NO_DATA	<p>Set nodata value to GDAL_NODATA Tag (42113) with an option specified at NO_DATA. This is equivalent to the option of -a_nodata in gdal_transrate. (ex: -n 65535). Only one nodata value can be set in each output file.</p>
-z	<p>Apply the LZW compression to the images.</p>

<p>-c DATASET</p>	<p>Set the target datasets at DATASET for band-composite file output. This is applicable for images in Image_data group as follows:</p> <p>L1B or L2/LTOA = Lt_* and QA_flag, L2/RSRF = Rs_*,Tb_*,Rp_*, and QA_flag, Others = QA_flag and its corresponding uint16 image.</p> <p>Specify target band-names separated by commas (,) without any blanks. The applicable band-names for L1B, L2/LTOA, or L2/RSRF are as follows:</p> <p>VN01,VN02,VN03,VN04,VN05,VN06,VN07, VN08,VN09,VN10,VN11,VN08P,VN11P, SW01,SW02,SW03,SW04,TI01,TI02, P1_p60,P1_0,P1_m60,P2_p60,P2_0,P2_m60, PI01,PQ01,PU01,PI02,PQ02,PU02,PL01,PL02, QA_flag, (ex: -c VN03,VN05,VN08,QA_flag).</p> <p>The hyphen(-) can be used to specify successive band-numbers for the band-names in ascending order (ex: -c VN01-11,SW01-03).</p> <p>The wildcard(*,?) can be used except for a first character of the band-name (i.e., V, S, T, or P) in double quotes (ex: -c "SW*,TI*", -c "P?01").</p> <p>When images that have different original pixel spacing are specified, the pixel spacing of the output images are set based on the minimum of them, while the output images which have other pixel spacing are oversampled to it.</p> <p>For L2-scenes or -tiles except for LTOA and RSRF, specify the target data-name and its corresponding QA_flag separated by a comma (,) without any blanks. (ex: -c SST,QA_flag)</p> <p>If options of -c and -d are specified at the same time, the option -c is valid while the option -d is ignored.</p>
<p>-h</p>	<p>Print a usage message and exit.</p>
<p>-v</p>	<p>Print version and license information and exit.</p>

Examples:

- 1) Process all images (Lt_*), mask stray-light flags, the resampling is NN, the spacing is 10 arc-sec, the output directory is "./output" for L1B/VNR product.
> SGLI_geo_map_linux.exe [L1B/VNR].h5 -m -r 0 -s 10.0 -o ./output

- 2) Process Image_data/Lt_VN11, mask stray-light flags, the output directory is "." (current) for L1B/VNR product.
> SGLI_geo_map_linux.exe [L1B/VNR].h5 -d Image_data/Lt_VN11 -m

- 3) Process Geometry_data/Sensor_zenith, the output directory is "." (current) for L1B/VNR product.
> SGLI_geo_map_linux.exe [L1B/VNR].h5 -d Geometry_data/Sensor_zenith

- 4) Process Image_data/Lt_TI01, the map projection is PS, the output directory is "." (current) for L1B/IRS product.
> SGLI_geo_map_linux.exe [L1B/IRS].h5 -d Image_data/Lt_TI01 -p

- 5) Process all images (Lt_*), the latitude-range is N45 to N30, for L1B/POL product.
> SGLI_geo_map_linux.exe [L1B/POL].h5 -u 45.0 -l 30.0

- 6) Process Image_data/Lt_VN11, mask stray-light flags, the output directory is "." (current) for L2/LTOA product.
> SGLI_geo_map_linux.exe [L2/LTOA].h5 -d Image_data/Lt_VN11 -m

5. Output Files

The output files are map-projected imageries in GeoTIFF (.tif) format and ancillary information in XML (.xml) format for processed datasets in an input HDF product file. The file is separated into two files at the longitude 180 degrees when the imagery projected on the geodetic latitude and longitude coordinates overlaps the longitude 180 degrees.

5.1 File naming

The rules of naming for output files are as follows:

L1B POL without option -t:

GID_ULAT_LLAT_SDS.tif/.xml

where,

GID is the Granule ID of an input HDF product,

ULAT is the upper latitude specified at the option -u (S90.0~N90.0),

LLAT is the lower latitude specified at the option -l (S90.0~N90.0),

SDS is the name of a dataset.

Example:

GC1SG1_201806250054L04800_1BSG_POLDK_1002_N45.0_N30.0_Lt_P1_0.tif

GC1SG1_201806250054L04800_1BSG_POLDK_1002_N45.0_N30.0_Lt_P1_0.xml

L1B POL with option -t:

GID_ULAT_LLAT_TILT_SDS.tif/.xml

where,

TILT is the tilt-angle of pre- or post-driving (T-45~T+45)

Example:

GC1SG1_~(same as above example)~_N45.0_N30.0_T+45_Lt_P1_0.tif

GC1SG1_~(same as above example)~_N45.0_N30.0_T+45_Lt_P1_0.xml

Other:

GID_SDS.tif/.xml

Example:

GC1SG1_201806250119R04810_1BSG_VNRDQ_1002_Lt_VN11.tif

GC1SG1_201806250119R04810_1BSG_VNRDQ_1002_Lt_VN11.xml

Separated files overlapping longitude 180 degrees:

“_E” and “_W” are added at the ends of file names (without extensions) for separated files, where the former and the latter are the imageries in the eastern side (~180°) and in the western side (-180°~) respectively.

Example:

```
GC1SG1_202107030044H04008_1BSG_IRSDQ_2003_Lt_TI01_E.tif
GC1SG1_202107030044H04008_1BSG_IRSDQ_2003_Lt_TI01_E.xml
GC1SG1_202107030044H04008_1BSG_IRSDQ_2003_Lt_TI01_W.tif
GC1SG1_202107030044H04008_1BSG_IRSDQ_2003_Lt_TI01_W.xml
```

SDS name for output files processed with the band-composite option -c:

The specified characters at DATASET are used as it is for the SDS name after the commas and the wildcard characters (*,?) are replaced to ‘_’ and ‘x’, respectively. The datatype-identifiers (Lt_, Rs_, Tb_, or Rp_) are inserted ahead each of the band-names for L1B or L2/LTOA or L2/RSRF. If the QA_flag is specified, it is attached at the end of the SDS name..

Example:

```
Option: -c VN03,VN05,VN08
GC1SG1_202103100138K05510_1BSG_VNRDQ_2002_Lt_VN03_VN05_VN08.tif
GC1SG1_202103100138K05510_1BSG_VNRDQ_2002_Lt_VN03_VN05_VN08.xml
Option: -c "SW*,TI*,QA_flag"
GC1SG1_202103100138K05510_1BSG_IRSDQ_2002_Lt_SWx_Tix_QA_flag.tif
GC1SG1_202103100138K05510_1BSG_IRSDQ_2002_Lt_SWx_Tix_QA_flag.xml
Option: -c "V*,S*,T*,P*"
GC1SG1_20210310D01D_T0529_L2SG_RSRFQ_2000_Rs_Vx_Sx_Tb_Tx_Rs_Px.tif
GC1SG1_20210310D01D_T0529_L2SG_RSRFQ_2000_Rs_Vx_Sx_Tb_Tx_Rs_Px.xml
```

5.2 GeoTIFF tags/keys

Table 5.2-1 and 5.2-2 show the tags and keys respectively in the output GeoTIFF files.

Table 5.2-1 TIFF tag settings

Tag	Value
TIFFTAG_IMAGEWIDTH	image width
TIFFTAG_IMAGELENGTH	image height
TIFFTAG_BITSPERSAMPLE	8 or 16
TIFFTAG_COMPRESSION	COMPRESSION_NONE or COMPRESSION_LZW
TIFFTAG_PHOTOMETRIC	PHOTOMETRIC_MINISBLACK
TIFFTAG_ORIENTATION	ORIENTATION_TOPLEFT
TIFFTAG_SAMPLESPERPIXEL	1 to n (if option -c specified)
TIFFTAG_ROWSPERSTRIP	image height
TIFFTAG_SAMPLEFORMAT	SAMPLEFORMAT_INT or SAMPLEFORMAT_UINT
TIFFTAG_PLANARCONFIG	1 or 2 (if option -c specified)
TIFFTAG_GDAL_METADATA*	xml data
TIFFTAG_GDAL_NODATA*	text data
GTIFF_TIEPOINTS	6 parameters of model tie point tag
GTIFF_PIXELSCALE	3 parameters of model pixel scale tag
GTIFF_ASCIIPARAMS	text data

*) Extended tags

Table 5.2-2 GeoTIFF key settings

Key	Value
GtModelTypeGeoKey	ModelTypeProjected
GtRasterTypeGeoKey	RasterPixellsArea
GeographicTypeGeoKey	GCS_WGS_84
GeogAngularUnitsGeoKey	Angular_Degree
GtCitationGeoKey	text data
PCSCitationGeoKey	text data
GeogLinearUnitsGeoKey (PS only)	Linear_Meter
ProjectedCSTypeGeoKey (PS only)	KvUserDefined
ProjectionGeoKey (PS only)	KvUserDefined
ProjCoordTransGeoKey (PS only)	CT_PolarStereographic
ProjLinearUnitsGeoKey (PS only)	Linear_Meter
ProjNatOriginLatGeoKey (PS only)	latitude of the image projection plane (= 71 or -71)
ProjStraightVertPoleLongGeoKey (PS only)	longitude as the vertical axis of the image frame (= 0)
ProjFalseEastingGeoKey (PS only)	0
ProjFalseNorthingGeoKey (PS only)	0

The reference information of the GeoTIFF format is as follows:

GeoTIFF Format Specification

GeoTIFF Revision 1.0

Specification Version: 1.8.2

Last Modified: 28 December, 2000.

<http://geotiff.maptools.org/spec/geotiffhome.html> (accessed Jul. 1, 2021)

5.3 XML ancillary file

Table 5.3-1 shows the settings of tags and contents in the output XML files.

Table 5.3-1 Tags and contents in the output XML files

Tags	Contents
GeoTIFFAncillary	
Process_information	
Software_name	The name of the tool.
Software_version	The version of the tool.
Processing_time	Local (CPU) day/time of the processing.
Map_projection	Selected map projection ("Geodetic Latitude/Longitude" or "Polar Stereographic").
Pixel_spacing	Pixel spacing (in degrees for Lat/Lon or in meters for PS).
Resampling_method	Resampling method ("NN", "BL", or "CC").
MSB2bitsMask	"Applied" or "None".
Upper_latitude	Upper latitude specified at option -u (only L1B/POL).
Lower_latitude	Lower latitude specified at option -l (only L1B/POL).
Fixed_tilt_angle	"Pre-angle of tilt-driving" or "Post-angle of tilt-driving" (only L1B/POL with option -t).
Data_information	
Granule_ID	Granule ID of processed HDF product.
Dataset_name / Dataset_nn_name	Name of the processed HDF dataset. Band no. (nn) is inserted for band-composite files.
HDF_attributes	
Global_attributes	
Scene_start_time/ Image_start_time	Scene or Image start time is set as the names of XML tags are copied from the HDF attributes
Scene_end_time/ Image_end_time	Scene or Image end time is set as the names of XML tags are copied from the HDF attributes
Image_data or Geometry_data (Parent group of the processed dataset)	
attributes (the names of HDF Group attributes)	All attributes in the HDF Group are set as the names of XML tags are copied from the names of HDF attributes.
SDS_name (the name of the processed dataset)	
attributes (the names of HDF dataset attributes)	All attributes in the HDF dataset are set as the names of XML tags are copied from the names of HDF attributes.

6. License information

The tool includes the open-source libraries for the file interface of the HDF5 and the GeoTIFF. Their license information is as follows:

Copyright Notice for HDF5 (Hierarchical Data Format 5) Software Library

=====

HDF5 (Hierarchical Data Format 5) Software Library and Utilities

Copyright (c) 2006-2018, The HDF Group.

NCSA HDF5 (Hierarchical Data Format 5) Software Library and Utilities

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<https://www.hdfgroup.org/licenses> (accessed Jul. 1, 2021)

libgeotiff Licensing

=====

Code by Frank Warmerdam has this copyright notice:

* Copyright (c) 1999, Frank Warmerdam

Code by Niles Ritter is under this licence:

* Written By: Niles D. Ritter.

* Copyright (c) 1995, Niles D. Ritter

<https://github.com/OSGeo/libgeotiff/blob/master/libgeotiff/LICENSE>

(accessed Jul. 1, 2021)

7. Appendix

7.1 The map projection for imageries in SGLI/HDF products

This section briefly explains the algorithms of map projections for the SGLI datasets in this tool.

L1B scene/half-path products

For the L1B scene/half-path products, the Rational Polynomial Coefficients (RPC) is internally generated and used for the map projection. The RPC is a rational polynomial function of three-degrees, which transform the three-dimensional coordinates of object-space (X, Y, Z) into the two-dimensional coordinates of image-space (L, P), and is also being used in the ortho-projection in the latest version of L2/LTOA. The equation of the RPC is as follows:

$$L' = \frac{f_1(X',Y',Z')}{f_2(X',Y',Z')}, \quad P' = \frac{f_3(X',Y',Z')}{f_4(X',Y',Z')}$$

$$f(X, Y, Z) = c_1 + c_2Y + c_3X + c_4Z + c_5XY + c_6YZ + c_7ZX + c_8Y^2 + c_9X^2 + c_{10}Z^2 \\ + c_{11}XYZ + c_{12}Y^3 + c_{13}X^2Y + c_{14}Z^2Y + c_{15}Y^2X + c_{16}X^3 + c_{17}Z^2X \\ + c_{18}Y^2Z + c_{19}X^2Z + c_{20}Z^3$$

$$L' = \frac{L-L_0}{L_s}, \quad P' = \frac{P-P_0}{P_s}, \quad X' = \frac{X-X_0}{X_s}, \quad Y' = \frac{Y-Y_0}{Y_s}, \quad Z' = \frac{Z-Z_0}{Z_s} .$$

The generation of the RPC is based on the rigorous projection model which consists of the physical sensor model of the SGLI, the orbit/attitude data of the GCOM-C, and the alignment models of the instruments, which are included in the L1B HDF products. Figure 7.1-1 shows the schematic view of the projection model for the RPC generation. To cover the relatively wide areas (swath and lines) of the SGLI scene/half-path, multiple RPCs are generated internally for divided blocks of the imagery.

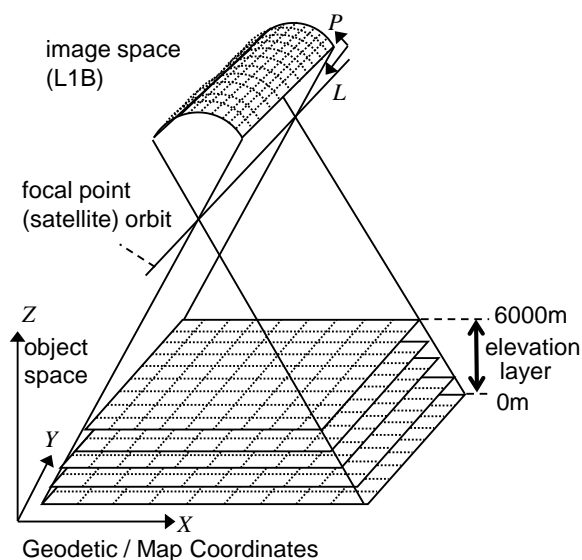


Fig. 7.1-1 Projection model for the RPC generation.

In the map projection, the output frame on the selected map coordinates is defined first by using the corner latitudes and longitudes of the scene. For POL imageries of half-paths, the range of latitudes specified with the tool-options is used instead. Then grids of fixed intervals are defined on the frame of output imagery and their corresponding addresses on the input L1B imagery are calculated with the RPCs. The map address of the grid on the output imagery is converted into the one defined for the RPC input.

The height (Z) input to the RPC is fixed to 0 (zero) since there is no input of the Digital Elevation Model (DEM), so that the imagery is projected onto the reference ellipsoid (GRS80). Therefore, the ortho(terrain)-correction is not applied in the output imageries, whereas it is being applied in all the L2-tile products that are derived from the LTOA.

Finally, all the corresponding addresses between the whole output imagery and the input L1B imagery are calculated with the bi-linear interpolation on the ones at the grids of fixed intervals. The digital values of pixels in whole output imagery are resampled from the input L1B imagery with them.

L2 scene products

For the L2 scene products, the RPC is not available since the HDF files do not include the data to reconstruct the rigorous projection model. Instead, the latitude and longitude data on the grids of 10 pixel intervals on the imagery, which are included at the group of Geometry_data in the HDF file, are used for the projection. The address on the input imagery corresponding to any latitude and longitude inside the scene is calculated with the bi-linear interpolation from the samples of its surrounding four grids

on the latitude and longitude data.

The procedure of the projection is the same as the one for the L1B scene/half-path products except for the calculation of corresponding addresses between the output and input imageries at the grids defined on the output imagery. However, the processing time is larger than that of the process with RPCs because it includes a searching step in the latitude and longitude data while there is no such step in the process with RPCs. The ortho(terrain)-correction is not applied in the output imageries as well.

L2 tile products

For the L2 tile products, the projection is directly performed with the equation between the sinusoidal coordinates of the input tile and the geodetic latitude and longitude coordinates defined as follows:

$$x = \frac{m(\lambda \cos \varphi' - 10h + 180)}{10} + 0.5,$$

$$y = \frac{n(90 - 10v - \varphi)}{10} + 0.5,$$

$$\varphi' = \varphi \cdot \pi / 180$$

$$m = n = \begin{cases} 4800 & (250\text{m mode}) \\ 1200 & (1\text{km mode}). \end{cases}$$

where, (x, y) is the address on the imagery, (φ, λ) is the geodetic latitude and longitude, and (v, h) is the vertical and horizontal tile number. The origin of the address on the imagery is the upper-left corner of the tile, where the center of the pixel is defined as $(1, 1)$.

For the projection on the Polar-stereo coordinates, the conversion to the latitude and longitude coordinates is additionally used. The frame of the output imagery is determined from the range of valid pixels on the dataset.