GCOM-C/SGLI geometric correction algorithm

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RESTEC, Sep. 2020 (v2.003)

1. Overview

The GCOM-C/SGLI geometric correction algorithm processes the Level-1B images into the Level-2 (LTOA) tiles on Sinusoidal (EQA) coordinates. The algorithm consists of

1) the orientation process (G2A), which supports the precise correction by utilizing the ground control points (GCPs),

2) the ortho/mosaic process (G2B/G2C), which mosaics the multiple Level-1B images through the ortho-rectification by using the digital elevation model (DEM), and

3) the GCP matching (G2D), which automatically measures the GCPs with an image matching technique.

Figure 1 shows the geometric correction flow of GCOM-C/SGLI images (including the Level-1B process).
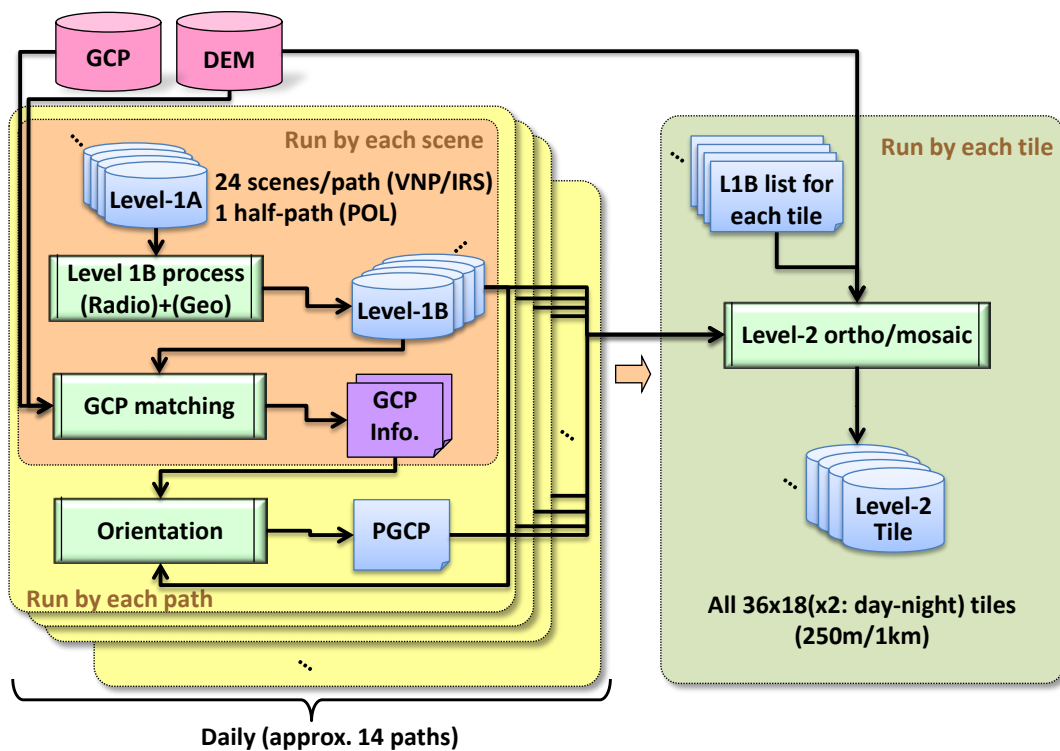

Figure 1. Geometric correction flow from Level 1A to Level 2.

2. Orientation

The orientation process (G2A) estimates the orientation parameters of geometric models in SGLI sensors by using the collinearity equations defined from the GCPs. The algorithm is based on the one used in the SGLI's predecessor GLI, which utilizes the least-square fit of GCP errors in a manner of the traditional photogrammetry [1]. The initial orientation parameters to be estimated are set to the attitude errors of the satellite (including the sensor alignment errors), while they can be changed depending on the on-orbit calibration. The linear dynamics of the errors, as well as the constant bias, are compensated in a path-basis. The process inputs the Level-1B datasets as well as GCPs (GCP_info) in a target path; and then, it output the estimated attitude errors as well as the residuals of GCPs to the PGCP file. Figure 2 shows the processing flow of the orientation.
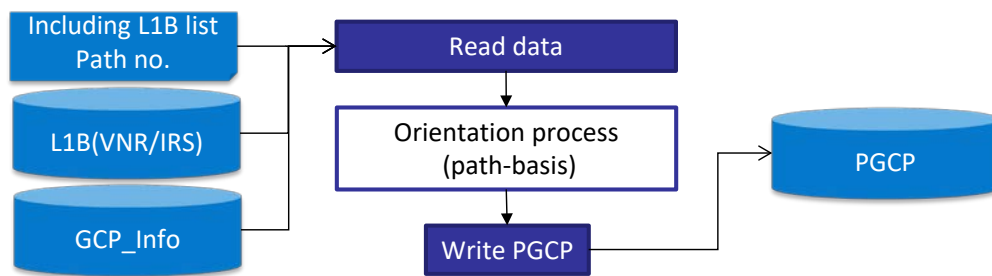

Figure 2.   Processing flow of the orientation.

3. Level-2 (LTOA) ortho/mosaic

The Level-2 ortho/mosaic process (G2B/G2C) mosaics the multiple Level-1B images into the Level-2 (LTOA) tiles on Sinusoidal coordinates through the ortho-rectification by using the digital elevation model (DEM) as well as the precise correction by utilizing the orientation parameters (PGCP). In the Sinusoidal coordinates the global areas are divided into 36 x 18 tiles while each tile has an area of approximately 1200 km x 1200 km (10° x 10° at the equator). Figure 3 shows the tile frame structure of the LTOA products [2].
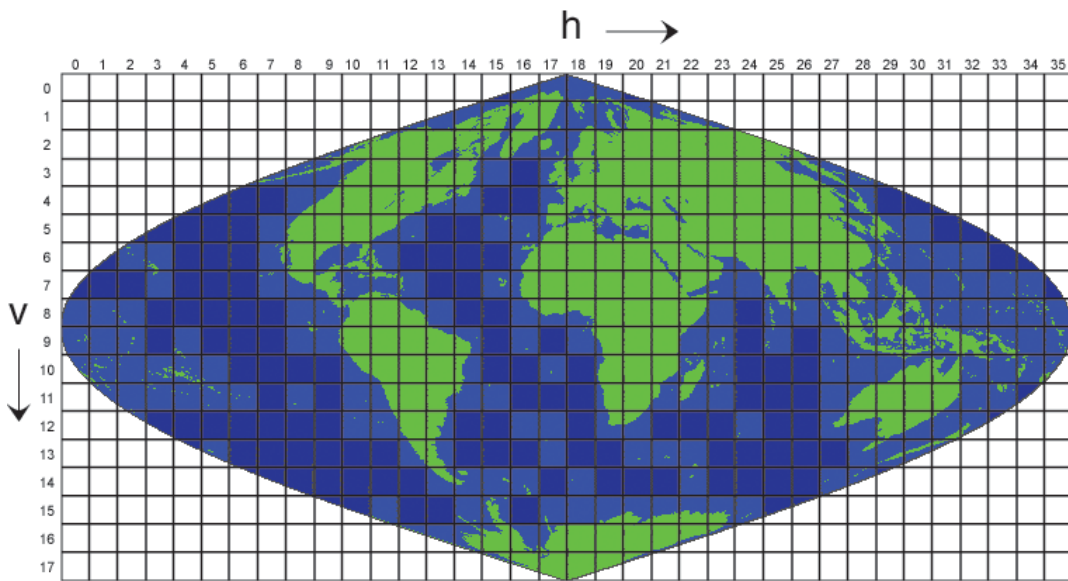

Figure 3.   Sinusoidal tiles for LTOA product [2]

The tiles of two grid spacing, i.e., 250 m (LTOAQ/G2B) and 1 km (LTOAK/G2C), are separately defined, so that the tiles of LTOAQ and LTOAK include 4800 x 4800 grids and 1200 x 1200 grids, respectively. Moreover, the descending (day time) and the ascending (night time) tiles are independently defined in each of them. Namely, there are four tile frames, i.e., LTOAQ-day, LTOAQ-night, LTOAK-day, and LTOAK-night. The mosaicking is daily-basis where approximately 14 paths are observed in each day. On overlapping areas of neighboring paths a pixel that has smallest sensor zenith angle is preferentially assigned in the mosaicking. The ASTER/GDEM version 2 [3] is used as the global DEM input. In the LTOAK processing the 250 m images of LTOAQ are preferentially set with 4 x 4 pixel averaging if it exists instead of setting the 1 km images of Level-1B. Figure 4 shows the processing flow of the Level-2 ortho/mosaic.
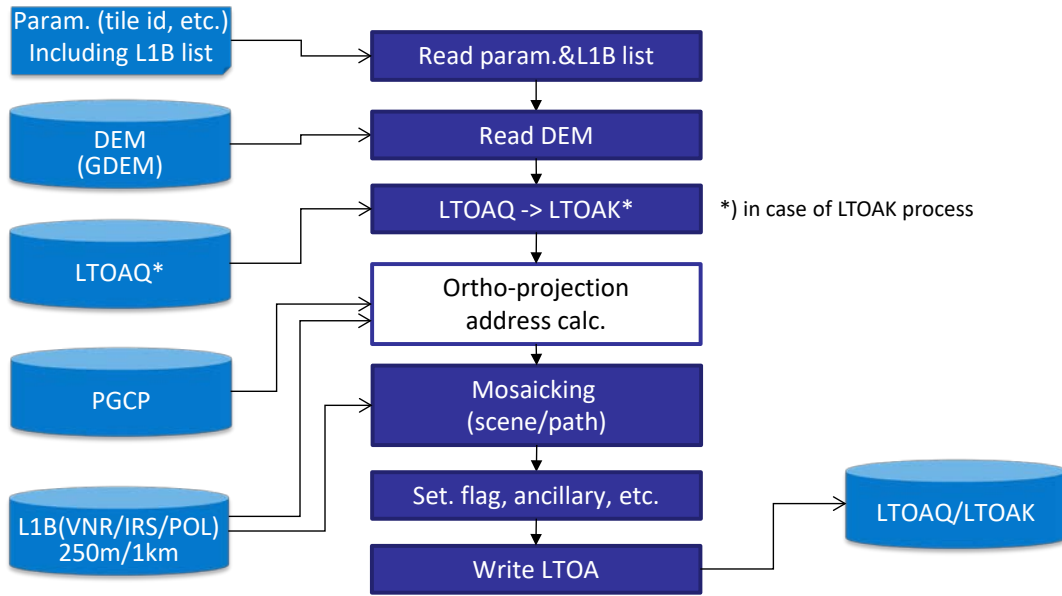
Figure 4. Processing flow of the Level-2 ortho/mosaic.

The LTOAQ tile includes not only 250 m images but also other images as follows:

1) LTOAQ includes IRS 1km images of SW01, SW02, and SW04, whereas it does not include the IRS 1km images of SW03, TI01, and TI02.

2) LTOAQ includes the POL 1 km images only if it includes 250 m images of VNR or IRS.

3) The IRS 500 m images of TI01 and TI02 are up-sampled to 250 m with NN resampling and are set to LTOAQ

The geometric ancillary data i.e., the azimuth/zenith angles of the sensor/solar, observing time, and relevant flags are mosaicked to LTOA tiles as well as the image data.

For address conversions between the geodetic latitude/longitude coordinates and the image coordinates (i.e., grid addresses) in LTOA tiles, see Appendix 1.

4. GCP matching

The GCP matching automatically measures the GCPs for VNR/IRS Level-1B images with an image matching techniques. The GCP is derived from the ortho-rectified ALOS/AVNIR-2 images (only nadir pointing) that have a geometric accuracy of 21.9 m (RMS) in its 10 m ground resolution [4]. The AVNIR-2 images, which have the size of 70 km x 70 km each, are automatically selected for target SGLI Level-1B images from the GCP database. Both of the SGLI and AVNIR-2 images are resampled on a common image coordinates in 50 m grid spacing for the image matching. Feature points are automatically extracted from the SGLI images with their local statistics as well as edge analysis so that outlier areas e.g., water, cloud, snow, or ice can be excluded before the matching process. The matching algorithm is based on the conventional normalized cross correlation and is measuring the tie-points between the feature points of SGLI images and the AVNIR-2 images. The blunders of the image matching are filtered with the correlation threshold of 0.9. The results of the measurement are finally output as the GCPs (GCP_info) with the latitude/longitude and height that were derived from the AVNIR-2 geometric information and the ASTER/GDEM, respectively. In the image matching only 250 m images of VN11 (868.5 nm) and SW03 (1630 nm) are used in VNR and IRS respectively whereas only band-4 (760~890 nm) is used in AVNIR-2. Figure 5 shows the processing flow of the GCP matching.
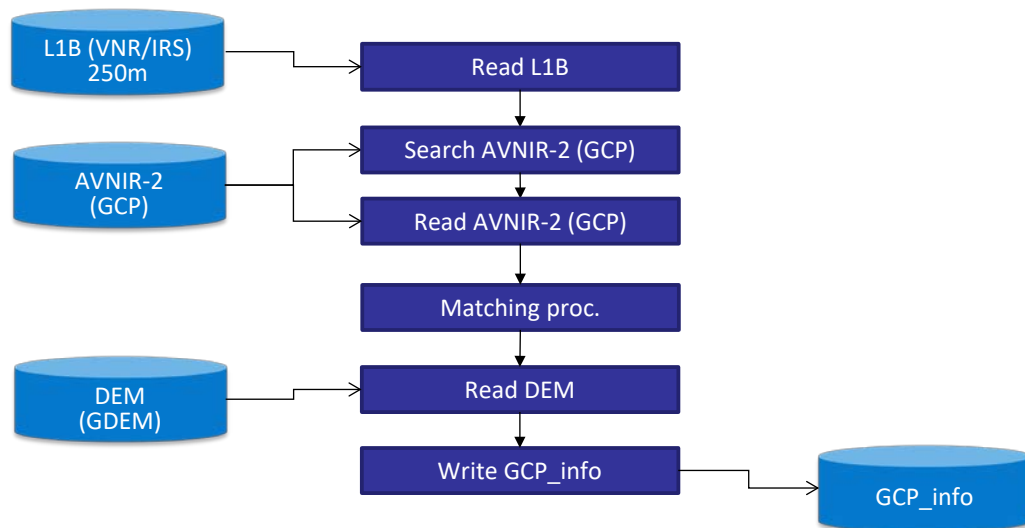

Figure 5.   Processing flow of the GCP matching.

Appendix 1

This appendix shows address conversions between the geodetic latitude/longitude coordinates and the image coordinates (i.e., grid addresses) in the Sinusoidal LTOA tiles.

The vertical/horizontal tile numbers (v, h) corresponding to a geodetic latitude/longitude (φ, λ) in degrees are given as

$$v = [9 - \varphi/10]_{roundoff} \, ,$$
$$h = [\lambda \cos\varphi'/10 + 18]_{roundoff} \, ,$$
$$\varphi' = \varphi \cdot \pi/180 \, ,$$

where $[\;]_{roundoff}$ is the rounding off to the nearest integer. The grid address (x, y) corresponding to the geodetic latitude/longitude (φ, λ) in the tile (v, h) is given as

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

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

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

Note that the origin of the grid address is the upper-left corner of the tile, where the center of the pixel is defined as (1, 1). The boundary of tiles corresponds to the edge of pixels so that neighboring tiles should not overlap each other (Figure 6).
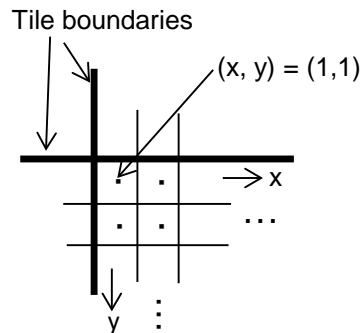

Figure 6.   The definition of the grid address of LTOA tiles

The geodetic latitude/longitude (φ, λ) corresponding to the grid address (x, y) in the tile (v, h) is given as

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

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

References

[1] T. Hashimoto, "Geometric Correction of ADEOS-II/GLI," International Archives of Photogrammetry and Remote Sensing, Vol. XXXIII, Part B1, pp.141-147, Amsterdam, 2000.

[2] R. E. Wolfe, D. P. Roy, and E. Vermote, "MODIS Land Data Storage, Gridding, and Compositing Methodology: Level 2 Grid," IEEE Transactions on Geoscience and Remote Sensing, Vol. 36, no. 4, pp.1324-1358, 1998.

[3] T. Tachikawa, M. Hato, M. Kaku, and A. Iwasaki, "Characteristics of ASTER GDEM version 2," Proc. IEEE IGARSS 2011, pp.3657-3660, 2011.

[4] JAXA/EORC, "Calibration Result of JAXA standard products (As of Sep. 6, 2011)," [Online]. Available: https://www.eorc.jaxa.jp/en/hatoyama/satellite/data_tekyo_setsumei/alos_hyouka_e.html. [Accessed Nov. 1, 2018].