Algorithm Theoretical Basis Document

GCOM-C/SGLI Level-3 Spatial Binning
(G5A)

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1. Introduction

1.1 Objectives

The objective of the G5A algorithm is to take spatial statistics of SGLI Level-2 (L2) daily geophysical variable (GV) products reducing the spatial resolution to 1/24 deg. (land, cryosphere, and ocean) or 1/12 deg. (atmosphere).

1.2 Development strategy

The G5A algorithm is designed to use a same program code for taking statistics of all GVs in order to make the maintenance of the code simple. Basically the output of the G5A processing contains the same statistics variables except for the case of snow and ice cover extent (SICE) and cloud type (CLTYPE) in cloud properties (CLPR) product (see next sub-section). The SICE and CLTYPE are flag products and the statistical outputs of these two GVs are customized so that the number of snow/ice cover observation or cloud type within each bin with a spatial resolution of 1/24 deg. for SICE and 1/12 deg. for CLTYPE is counted. Finally, to make the addition or deletion of GVs quite easy, the GV names of the statistical targets are defined in an external text file so that the change could be made without compiling the code.

1.3 Processing targets and outputs

Processing targets of the L2 GV statistics are all SGLI products for land, cryosphere, ocean, and atmosphere. Input and output variables are summarized in Table 1.

Table. 1 List of the target products, GVs, and output types of the G5A processing

<table>
<thead>
<tr>
<th>Input Product ID</th>
<th>Long Name</th>
<th>Geophysical Variables (GVs)</th>
<th>Output Product ID</th>
<th>Output Variables*1</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSRF</td>
<td>Land surface reflectance</td>
<td>Rs_VN01, Rs_VN02, Rs_VN03, Rs_VN04, Rs_VN05, Rs_VN06, Rs_VN07, Rs_VN08, Rs_VN09, Rs_VN10, Rs_VN11, Rs_SW01, Rs_SW02</td>
<td>RV01, RV02, RV03, RV04, RV05, RV06, RV07, RV08, RV09, RV10, RV11</td>
<td>AVE, RMS, N_used, N_input, MIN, MAX, Date, QA_flag</td>
</tr>
<tr>
<td>Layer</td>
<td>Feature Description</td>
<td>Parameters</td>
<td>Notes</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>-------------------------------------------</td>
<td>------------</td>
<td>------------------------</td>
<td></td>
</tr>
<tr>
<td>VGI_</td>
<td>Vegetation index</td>
<td>NDVI, EVI, SDI</td>
<td>Same as above</td>
<td></td>
</tr>
<tr>
<td>LAI_</td>
<td>Leaf area index</td>
<td>LAI, FAPAR</td>
<td>Same as above</td>
<td></td>
</tr>
<tr>
<td>AGB_</td>
<td>Above-ground biomass</td>
<td>AGB, VRI</td>
<td>Same as above</td>
<td></td>
</tr>
<tr>
<td>LST_</td>
<td>Land surface temperature</td>
<td>LST</td>
<td>Same as above</td>
<td></td>
</tr>
<tr>
<td>SIPR</td>
<td>Snow and ice physical properties</td>
<td>SGSL, SIST</td>
<td>Same as above</td>
<td></td>
</tr>
<tr>
<td>SICE</td>
<td>Snow and ice cover extent</td>
<td>SICE</td>
<td>N_snow1, N_snow2, N_snow3, N_used, N_input, Date, QA_flag</td>
<td></td>
</tr>
<tr>
<td>CLPR</td>
<td>Cloud properties</td>
<td>CLTYPE</td>
<td>CFRX^2, N_used, N_input, Date, QA_flag</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>CLTT</td>
<td>AVE, RMS,</td>
<td></td>
</tr>
<tr>
<td>Column</td>
<td>Description</td>
<td>CLTH</td>
<td>CLOC_W</td>
<td>CLER_W</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
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<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>ARNP</td>
<td>Aerosol properties by NP</td>
<td>AROT_ocean</td>
<td>AROT_land</td>
<td>ARAE_ocean</td>
</tr>
<tr>
<td>ARPL</td>
<td>Aerosol properties by PL</td>
<td>AROT_pol_land</td>
<td>ARAE_pol_land</td>
<td>ARSSA_pol_land</td>
</tr>
<tr>
<td>STD</td>
<td>Sea surface temperature (Day)</td>
<td>SST</td>
<td>SST_</td>
<td>Same as above</td>
</tr>
<tr>
<td>SSTDN</td>
<td>Sea surface temperature (Night)</td>
<td>SST</td>
<td>SST_</td>
<td>Same as above</td>
</tr>
<tr>
<td>NWLR</td>
<td>Normalized water leaving radiance, aerosol parameters and photosynthetically available radiation</td>
<td>PAR</td>
<td>NWLRL_380</td>
<td>NWLRL_412</td>
</tr>
<tr>
<td>IWPR</td>
<td>In-water properties</td>
<td>CHLA</td>
<td>TSM</td>
<td>CDOM</td>
</tr>
</tbody>
</table>

*1 AVE: Average of valid GV data, RMS: Root Mean Square of valid GV data, N_used: Number of valid GV data actually used in the statistics, N_input: Number of input GV data, Min: Minimum of valid GV data, Max: Maximum of valid GV data, Date: Dates of the SGLI observations during the 8-day or 1-month interval period, QA_flag: Flag for quality assurance information, N_snow1: Number of snow or ice cover, N_snow2: Number of snow with vegetation or bare ice, N_snow3: Number of melting snow

*2 Output of CLTYPE statistics in the descending orbit is cloud fractions for individual cloud types. The “CFRX” and “cfrx” denotes the cloud fraction of type “x” which is the ID number of the ISCCP cloud classification. For example, in case of “cirrus cloud” the ISCCP ID is “1” and thus the output variable named as “Ncfr1” is stored in the output file with product ID of “CFR1”. In the ascending orbit cloud fraction is estimated for three layer of High, Middle, and Low, the results of which are stored in “CFRH or cfrh”, “CFRM or cfrm”, and “CFRL or cfrlh”, respectively. In addition, cloud fraction considering all the cloud types are also calculated and generated with the ID of “CFRA” and “cfra”.

*3 Sensor and Solar azimuth angles are firstly converted to absolute relative azimuth angle (araz) defined as araz = | sensor_azimuth – 180.0 – solar_azimuth | and then its statistics (AVE, RMS, MAX, MIN) are calculated and stored in the output file.
Basically (except for the case of flag products (SICE and CLTYPE)) the statistics variables taken and stored in the output files are the eight values or flag shown in Table 1. When processing the flag products, the statistics of Ave, RMS, Min, and Max are not taken. Instead, only snow/ice or cloud counts are stored in the output file.

2. Theoretical Description
2.1 Processing flow

Figure 1 indicate the flow of the G5A L2 GV statistics processing. Spatial coverage and resolution of input files can differ depending on the observation fields. That is, for the processing of land and cryosphere products, the input files are the L2 daily tile GV products with spatial resolution of 250m/1km (land) and 1km (cryosphere). For the atmosphere, the L2 daily global-bin GV files with a resolution of 1/24 deg. are the input. For ocean products, L2 scene GV products with spatial resolution of 1km can be inputs. The output of G5A processing contains daily spatial statistics of GV(s) which are stored in one dimensional array in the output file. The number of output files depends on the GV contents in the input file. In case that an input file contains multiple GVs, the G5A process generates output files for every GVs separately (except for the cases of geometry data in RSRF). For example, the “VGI_“ product contains three GVs of NDVI, EVI and SDI as shown in Table 1. The outputs of the G5A processing for VGI_ are three files with the following product IDs, i.e., NDVI, EVI_, and SDI_.

Input: L2 Daily Products (Tile, Global Bin, Scene)

Output: L3Bin (1-Day)

Fig. 1 Flow of the G5A L2 GV statistics processing
2.2 Definition of the statistics

Equations for calculating “AVE” and “RMS” are the followings:

\[
\text{AVE} = \frac{1}{n} \sum x_i
\]

\[
\text{RMS} = \frac{1}{\sqrt{n}} \sqrt{\sum (x_i^2)}
\]

Where \( n \) is the total number of observation days with valid GVs, \( x_i \) is the daily value of a GV to be processed.

“\( N_{\text{used}} \)” is the number of valid GV data actually used in the statistics, whereas “\( N_{\text{input}} \)” is the number of all the input GV data.

“MIN” and “MAX” are the minimum and maximum of valid GVs data during the temporal interval.

“Date” is an 8-bit value storing the dates of SGLI observations used in the statistics calculation. However, always “1” is stored in this L3Bin-Daily product.

2.3 QA process

“QA_flag” currently stores flags for discriminating land and water. In future update, QA information for GVs will be included.

2.4 Sample images

Because the output statistics variables are stored in one-dimensional array, the output results cannot be visualized as images. The output one-dimensional array of G5A (and G6A) is projected to the equirectangular (EQR) map projection (and polar stereographic projection only for cryosphere products) in the G7A processing. Figure 2 illustrate the definition of the one-dimensional array of the G5A output.
3. Current status and remaining issues of the G5A code implementation

The G5A process works well without system errors. Processing speed and memory size are also within the expectations except for the cases of parts of ocean scene processing. Remaining tasks are the implementation of the QA_flag for the output of quality assurance information and the further speeding up of the ocean scene processing.