Algorithm Theoretical Basis Document

GCOM-C/SGLI Level-3 Map (G7A)

31 March 2017

Masahiro Hori

Japan Aerospace Exploration Agency

Contents

1. Introduction

1.1 Objectives

The objective of the G7A algorithm is to make map-projected images of the SGLI Level-3 (L3) spatially- or temporally- binned geophysical variable (GV) products. Map projection is the equirectangular (EQR) projection for all products and only for cryosphere products polar stereographic (PS) projection is also available. The spatial resolutions are kept the same as the input.

1.2 Development strategy

The G7A algorithm is designed to use a same program code for making map-projected images of all GVs in order to make the maintenance of the code simple. Basically the output of the G7A processing contains map projected spatial and temporal average (AVE) of GV 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 outputs of these two GVs are customized so that the ratio of the number of snow/ice cover observation or cloud type to the number of total observations within each bin is calculated. Finally, to make the addition or deletion of processing target GVs quite easy, the GV names of the processing 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 L3 Map algorithm (G7A) 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 G7A processing

Input Product ID	Long Name	Geophysical Variables (GVs)	Output Product ID	Output Variables*1
RV01	Land surface reflectance	Rs_VN01	**RV01**	AVE, QA_flag
RV02		Rs_VN02	**RV02**	Same as above
RV03		Rs_VN03	**RV03**	Same as above
RV04		Rs_VN04	**RV04**	Same as above
RV05		Rs_VN05	**RV05**	Same as above
RV06		Rs_VN06	**RV06**	Same as above
RV07		Rs_VN07	**RV07**	Same as above
RV08		Rs_VN08	**RV08**	Same as above

RV09		Rs_VN09	**RV09**	Same as above
RV10		Rs_VN10	**RV10**	Same as above
RV11		Rs_VN11	**RV11**	Same as above
RS01		Rs_SW01	**RS01**	Same as above
RS02		Rs_SW02	**RS02**	Same as above
RS03		Rs_SW03	**RS03**	Same as above
RS04		Rs_SW04	**RS04**	Same as above
RT01		Rs_TI01	**RT01**	Same as above
RT02		Rs_TI02	**RT02**	Same as above
RN08		Rs_VN08P	**RN08**	Same as above
RN11		Rs_VN11P	**RN11**	Same as above
RP01		Rs_PI01	**RP01**	Same as above
RP02		Rs_PI02	**RP02**	Same as above
GEOV		Absolute_relative_ azimuth*3 Sensor_zenith Solar_zenith	**GEOV**	Same as above
GEOP		Absolute_relative_ azimuth_PL*3 Sensor_zenith_PL Solar_zenith_PL	**GEOP**	Same as above
GEOI		Absolute_relative_ azimuth_IR*3 Sensor_zenith_IR Solar_zenith	**GEOI**	Same as above
NDVI	Normalized difference vegetation index	NDVI	**NDVI**	Same as above
EVI_	Enhanced vegetation index	EVI	**EVI_**	Same as above
SDI_	Shadow index	SDI	**SDI_**	Same as above
LAI_	Leaf area index	LAI	**LAI_**	Same as above
FPAR	Leaf area index	FAPAR	**FPAR**	Same as above
AGB_	Above-ground biomass	AGB	**AGB_**	Same as above
VRI_	Vegetation roughness index	VRI	**VRI_**	Same as above
LST_	Land surface temperature	LST	**LST_**	Same as above
SGSL	Snow grain size of	SIST	**SGSL**	Same as above

	shallow layer			
SIST	Snow and ice surface temperature	SIST	**SIST**	Same as above
SICE	Snow and ice cover extent	SICE	**SICE**	Stat (= N_{used}), QA_flag
CFRX[*2]	Cloud properties	CLTYPE	**CFRX**[*2]	Stat (= N_{used}), QA_flag
CLTT		CLTT	**CLTT**	AVE, QA_flag
CLTH		CLTH	**CLTH**	Same as above
COTW		CLOT_W	**COTW**	Same as above
CERW		CLER_W	**CERW**	Same as above
COTI		CLOT_I	**COTI**	Same as above
AOTO	Aerosol optical thickness over ocean by NP	AROT_ocean	**AOTO**	Same as above
AOTL	Aerosol optical thickness over land by NP	AROT_land	**AOTL**	Same as above
AAEO	Aerosol Angstrom Exponent over ocean by NP	ARAE_ocean	**AAEO**	Same as above
AAEL	Aerosol Angstrom Exponent over land by NP	ARAE_land	**AAEL**	Same as above
AOTP	Aerosol properties by PL	AROT_pol_land	**AOTP**	Same as above
AAEP	Aerosol properties by PL	ARAE_pol_land	**AAEP**	Same as above
ASSA	Aerosol properties by PL	ARSSA_pol_land	**ASSA**	Same as above
SST_	Sea surface temperature	SST	**SST__**	Same as above
PAR_	photosynthetically available radiation	PAR	**PAR_**	Same as above
L380	nLw @ 380nm	NWLR_380	**L380**	Same as above
L412	nLw @ 412nm	NWLR_412	**L412**	Same as above
L443	nLw @ 443nm	NWLR_443	**L443**	Same as above
L490	nLw @ 490nm	NWLR_490	**L490**	Same as above

L530	nLw @ 530nm	NWLR_530	**L530**	Same as above
L565	nLw @ 565nm	NWLR_565	**L565**	Same as above
L670	nLw @ 670nm	NWLR_670	**L670**	Same as above
T670	Taua @ 670nm	TAUA_670	**T670**	Same as above
T865	Taua @ 865nm	TAUA_865	**T865**	Same as above
CHLA	Chlorophyll-a concentration	CHLA	**CHLA**	Same as above
TSM_	Total suspended matter	TSM	**TSM_**	Same as above
CDOM	Colored dissolved organic matter	CDOM	**CDOM**	Same as above

*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 Input and output of CLTYPE statistics in the descending orbit is cloud fractions for individual cloud types. The "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 input variable named as "Ncfr1" is used to take temporal statistics and store them 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 as "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" in the G5A and G6A processing.

*3 Absolute relative azimuth angle (araz) is converted from sensor and solar azimuth angles by araz = | sensor_azimuth – 180.0 – solar_azimuth | and then its statistics (AVE, RMS, MAX, MIN) are calculated and stored in the output file of the G5A processing.

Basically (except for the case of flag products (SICE and CLTYPE)) the statistics variables stored in the input files are the eight values or flag of Ave, RMS, N_{used}, N_{input}, Min, Max, Date, QA_flag (see ATBD of G5A and G6A). 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 input file.

2. Theoretical Description

2.1 Processing flow

Figure 1 indicate the flow of the G7A L3 Map projection processing. Spatial resolutions are kept the same as the input without projection. The output of G7A processing contains global EQR projected map image of AVE (PS projected images of Northern Hemisphere and Southern Hemisphere are also available only for cryosphere products).

.

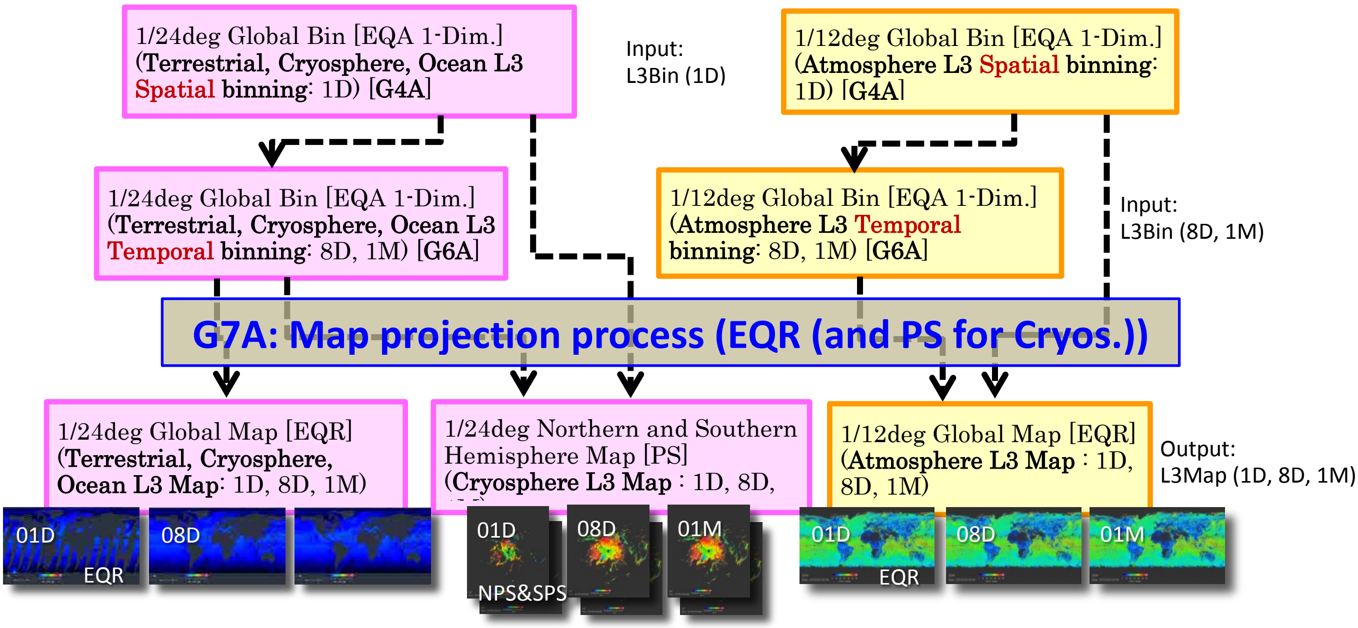


Fig. 1 Flow of the G7A L3 Map projection processing

2.2 Definition of the statistics employed in the G5A and G6A processing

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

$$\text{AVE} = \frac{1}{n}\sum_i xi$$

$$\text{RMS} = \sqrt{\frac{1}{n}\left(\sum_i xi^2\right)}$$

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

“N_{used}” is the number of valid GV data actually used in the statistics, whereas “N_{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. For example, when the Date value is 40 (i.e., 101000), then SGLI observations of 4^{th} and 6^{th} days in the temporal interval are used in the statistics.

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

Figure 2 show sample images of L3 Map projection.

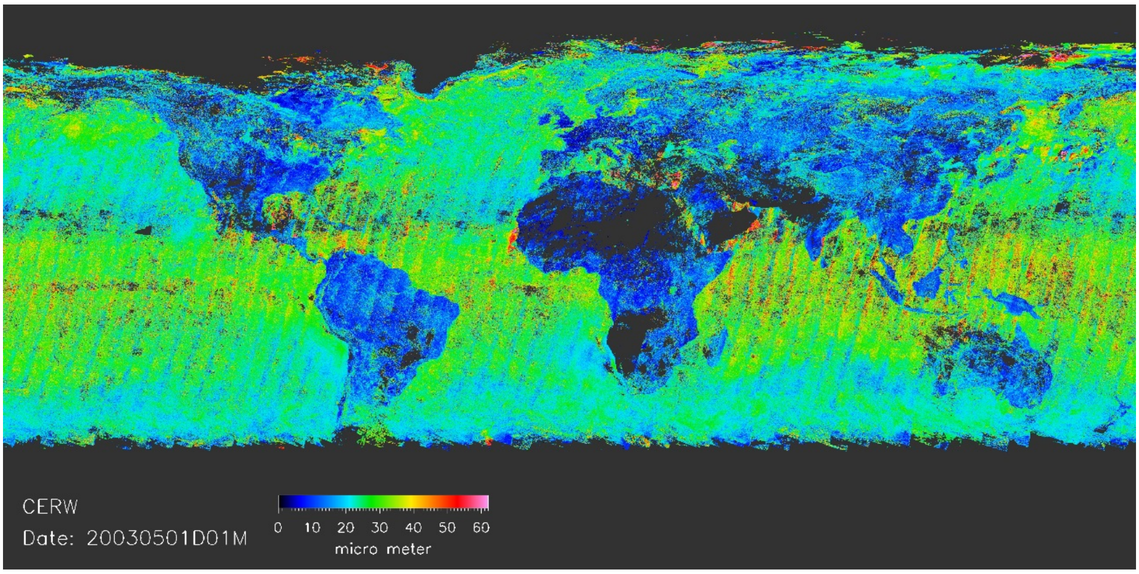


Fig. 2a L3 map image of water cloud effective radius (CERW)

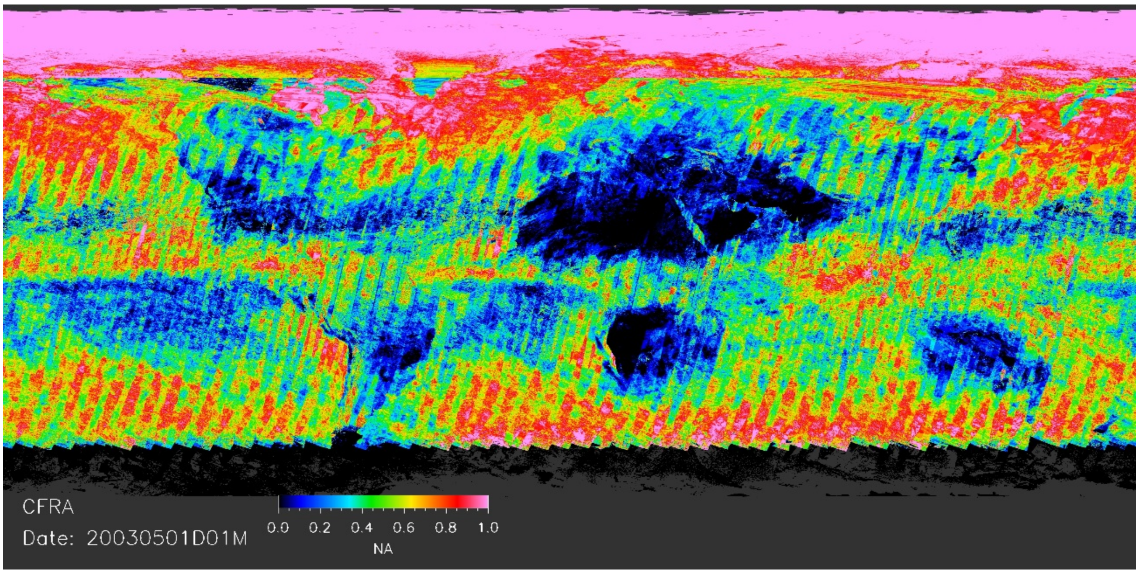


Fig. 2b L3 map image of cloud fraction of all type (CFRA)

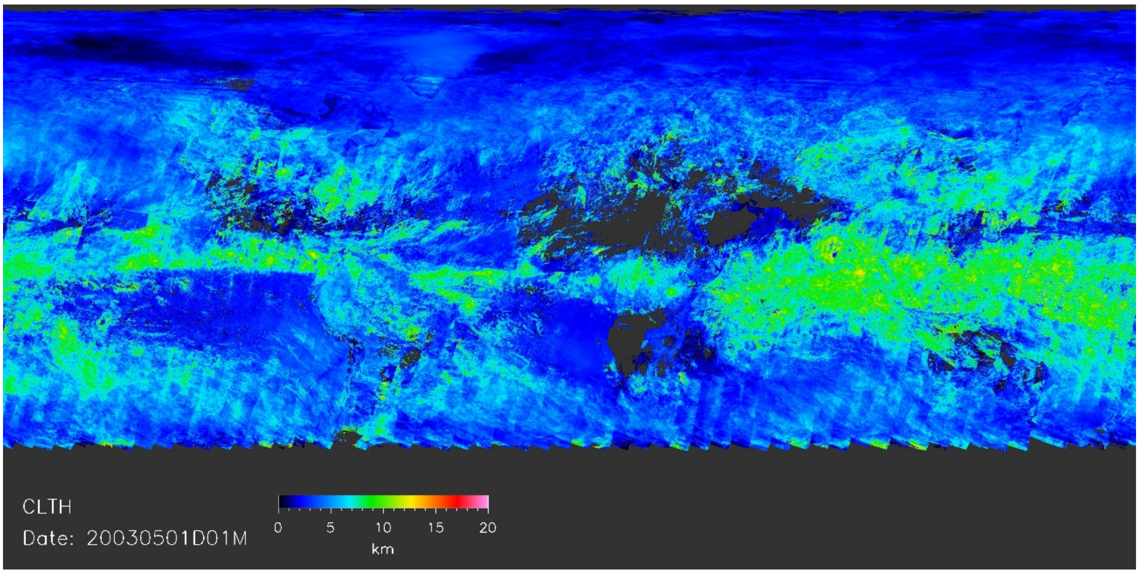
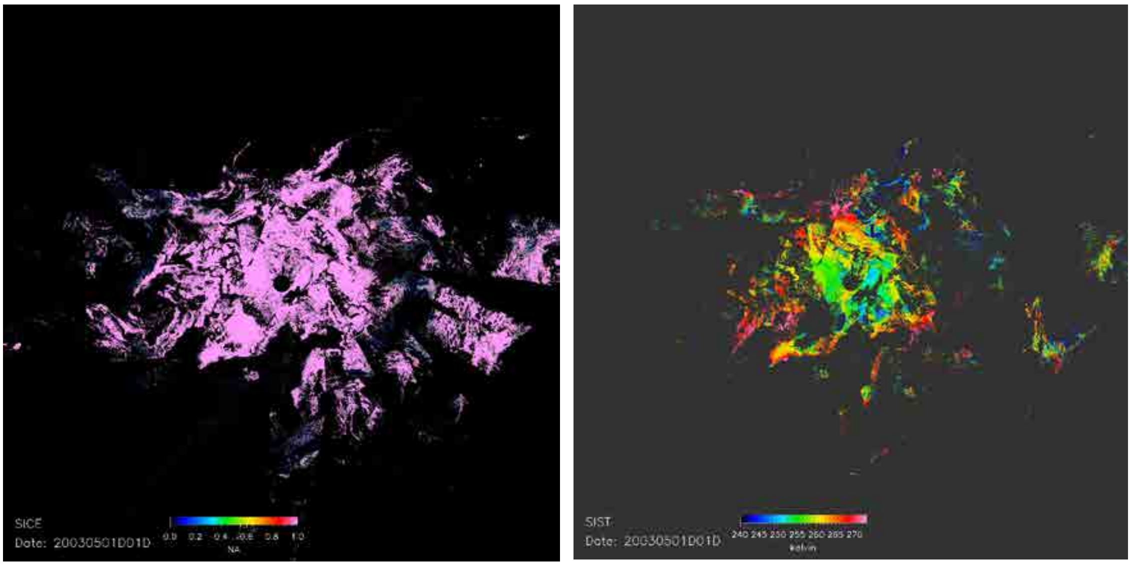


Fig. 2c L3 map image of cloud top height (CLTH)



. Fig. 2d (left) &2e (right) L3 map image of snow and ice cover extent (left: SICE) and snow and ice surface temperature (right: SIST) in the Northern Hemisphere

3. Current status and remaining issues of the G7A code implementation

The G7A process works well without system errors. Processing speed and memory size are also within the expectations. Remaining tasks are the implementation of the QA_flag for the output of quality assurance information.

Appendix 1: Equations for polar stereographic projection

Geographic coordinate (latitude: ϕ, longitude: λ) are calculated from map coordinates (horizontal: u, vertical: v) with the following equations,

$$\phi = NS \cdot \left(\frac{\pi}{2} - 2\tan^{-1}\left(\frac{\sqrt{v^2+u^2}}{R}\right)\right) \quad \text{Eq. (1)}$$

$$\lambda = \lambda_0 - NS \cdot \tan^{-1}\left(\frac{u}{v}\right) \quad \text{Eq. (2)}$$

where NS is a north-south identification factor (1 for northern and -1 for southern), λ_0 is the standard longitude (the longitude line which is parallel to the grid's y-axis (v-direction), along which latitude increases), and R is a scale factor (1000).

Fig. A1 indicates the map coordinates of the four corners (not the center of the pixel but the corner of the pixel) of a Northern PS projected image. Spatial resolution is 1/24 deg. The array size is 3500pixels × 3500 lines.

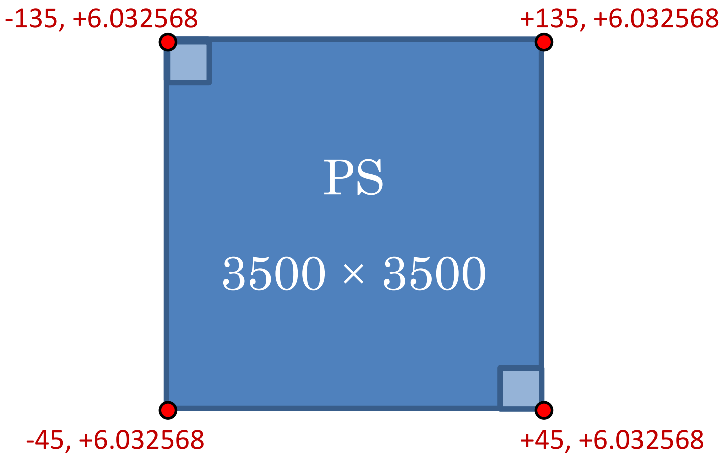


Fig. A1 Map coordinates of the four corners of the polar stereographic projection area.

For comparison purpose, Fig. A2 indicates the map coordinates of an EQR image.

Fig. A2 Map coordinates of the four corners of the equirectangular projection area.