

ATBD of BRDF calculation from GCOM-C surface reflectance data (G4C)

Hiroshi Murakami,

JAXA/EORC,

Mar. 2020 (v2.000: Main revisions of Ver. 2 is underlined)

1. Introduction

GCOM-C BRDF product (processing tag name is G4C) derive coefficients of the kernels of bi-directional reflectance function (BRF) are derived from N days of GCOM-C atmospheric corrected surface reflectance (RSRF product) (see Fig. 1).

- Kernel developed by Maignan et al., 2004 is used
- In the case of 8-days mean, N = 28 days (parameter), but the statistics are weighted to the target average period (see section 2 (2))
- Nadir reflectance is calculated at the solar angles of the observation latitude and the date

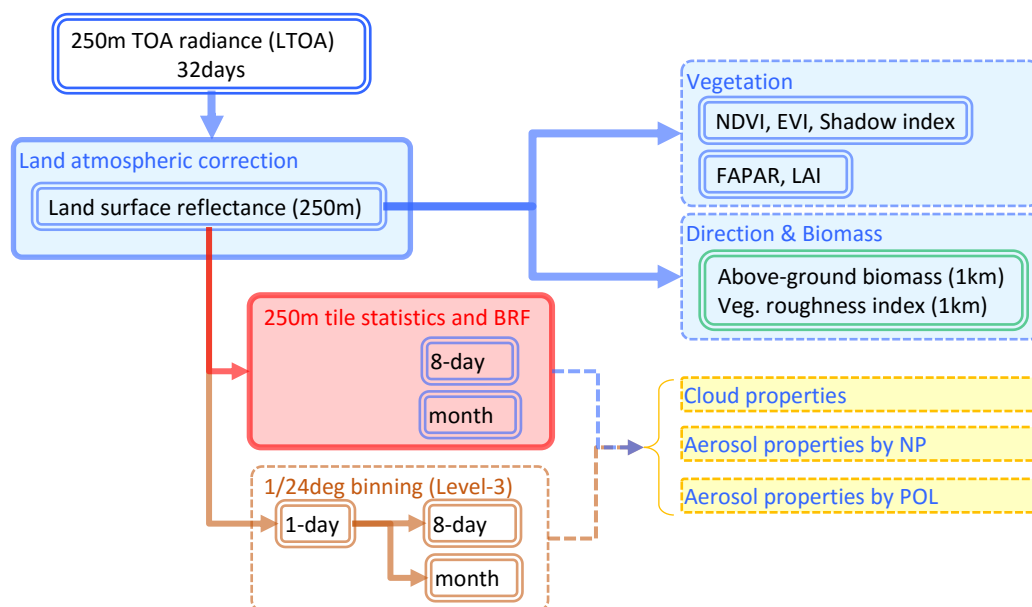


Fig. 1 Operation flow around the GCOM-C Land Atmospheric Correction
The part marked by the red color indicates this process (G4C).

2. Method

(1) BRDF kernel

Bi-directional reflectance is modeled by the following equation,

$$\text{Reflectance} = c0 + c1 \cdot \text{kn1}(1) + c2 \cdot \text{kn1}(2)$$

Coefficients $c0$, $c1$, and $c2$ is the target variables of the process. BRF kernel $\text{kn1}(1,2)$ is calculated using satellite zenith (saz), satellite azimuth (saa), and relative azimuth ($\text{rea} = \text{solar - satellite azimuth}$) angles (Maignan et al., 2004).

$$\text{rsaz} = \text{saz} \cdot \text{d2r}$$

$$\text{rsoz} = \text{soz} \cdot \text{d2r}$$

$$\text{rrea} = \lfloor \text{rea} \cdot \text{d2r} \rfloor$$

$$\text{csaz} = \cos(\text{rsaz})$$

$$\text{csoz} = \cos(\text{rsoz})$$

$$\text{crea} = \cos(\text{rrea})$$

$$\text{tsaz} = \tan(\text{rsaz})$$

$$\text{tsoz} = \tan(\text{rsoz})$$

$$\text{calp} = \text{csoz} \cdot \text{csaz} + \sin(\text{rsoz}) \cdot \sin(\text{rsaz}) \cdot \text{crea}$$

$$\text{alp} = \arccos(\text{calp})$$

$$\text{dlt} = \sqrt{\text{tsoz}^2 + \text{tsaz}^2 - 2 \cdot \text{tsoz} \cdot \text{tsaz} \cdot \text{crea}}$$

$$\text{kn1}(1) = ((\pi - \text{rrea}) \cdot \text{crea} + \sin(\text{rrea})) \cdot \text{tsoz} \cdot \text{tsaz} / (2 \cdot \pi) - (\text{tsoz} + \text{tsaz} + \text{dlt}) / \pi$$

$$\text{kn1}(2) = (4./3. / \pi) / (\text{csoz} + \text{csaz}) \cdot ((\pi/2 - \text{alp}) \cdot \text{calp} + \sin(\text{alp})) \cdot (1. + 1. / (\text{hspt} + \text{alp} / (1.5 \cdot \text{d2r}))) - 1./3.$$

where, $\text{d2r} = \pi/180$, and $\pi = 3.14159265$

The parameter hspt is originally 1.0, however, it set to 5.0 for the Ver. 2 to be stable regression.

(2) Temporal weighting for 8-day statistics

Data from $\text{day} = \text{d}_0 - 20$ to $\text{day} = \text{d}_0 + 7$ (d_0 is the start day of the target 8-day) are inputted to use enough number of samples for the regression. The data on a day are weighted for the regression.

$$\text{wj}(d) = 0.0004 / (0.0004 + (d/30.)^2 \cdot \text{wk0}), \text{ when } d < 0$$

$$\text{wj}(d) = 1.0, \text{ when } d \geq 0,$$

where $d = \text{day} - \text{d}_0$, and $\text{wk0} = 0.04 \cdot 0.04$ (corresponding to the regression error $S = 0.04$).

The weight of Level-2 data samples recovered from previous days (the number is N_{rcv}) are reduced by w_{rcv} as follows.

$$\underline{\text{wj}(d) = \text{wj}(d) \cdot w_{\text{rcv}},}$$

$$\underline{\text{where } w_{\text{rcv}} = (10 - N_{\text{used}}) / N_{\text{rcv}}, \text{ or } w_{\text{rcv}} = 0.5 \text{ if } w_{\text{rcv}} > 0.5.}$$

(3) Regression to the Kernel

To avoid negative value, the coefficients, $c0$, $c1$, and $c2$ are calculated by minimize the

cost,

$$\text{cost} = S^2 + w1 + w2 + w12$$

$$S^2 = \sum_d \{ (Rs_d - (c0 + c1 \cdot knl(1)_d + c2 \cdot knl(2)_d))^2 \cdot wj(d) \}$$

$$w1 = \exp(-10 + c1/uk1 \cdot 10) \cdot wk0$$

$$w2 = \exp(-10 + c2/uk2 \cdot 10) \cdot wk0$$

$$w12 = (c1/uk1 \cdot c2/uk2)^2 \cdot wk0$$

where Rs_d is the level-2 surface reflectance of day= d , knl_d is the BRDF kernel of day= d , $uk1=0.1$, and $uk2=1.0$.

3. Output parameters

(1) 8-bit QA_flag

See Table 1

(2) **_Ninput

Input data number.

(3) **_Nused

Used data number which does not include the recovered samples

(4) **_Date

Date identifier of RSRF/'//trim(inpm).

(5) **_AVE

This is an average of RSRF variables (Polarization data), nadir normalized RSRF variables (thermal infrared data), or nadir normalized RSRF variables or 2nd-minimum (other variables or the ocean area).

(6) **_c0, _c1, _c2

$c0$, $c1$, and $c2$ coefficients of the BRDF kernel.

Note Rs_VN08P and Rs_PI01 are used for the $c0-2$ of $VN08P$ ("RN08K" in the file name), and Rs_VN11P and Rs_PI02 is used for the $c0-2$ of $VN11P$ ("RN11K" in the file name).

(7) **_RMS

Root mean square (RMS) of BRDF model regression is stored to refer the possible error of the reflectance. A simple RMS is stored in the ocean or areas of $c1$, $c2 = 0$ due to insufficient sample number.

(8) **_MIN

Minimum of RSRF variables.

(9) **_MAX

Maximum of RSRF variables.

Table 1 QA_flag bit

Bit	Explanation
0	No data
1	Land (1) or water (0)
2	Insufficient sample number ($N < 4$)
3	BRDF kernel regression error
4	Out of range
5	Spare
6	Spare
7	Spare

4. Reference

- F. Maignan, F.-M. Breon, R. Lacaze, Bidirectional reflectance of Earth targets: Evaluation of analytical models using a large set of spaceborne measurements with emphasis on the Hot Spot, *Remote Sensing of Environment* 90 (2004) 210–220.