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

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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

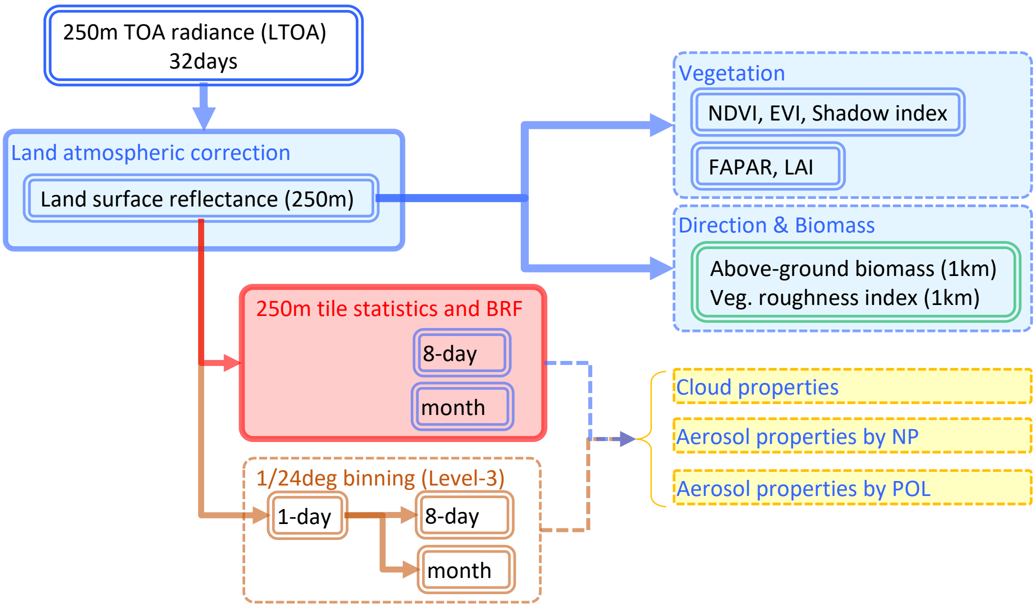

Fig. 1 Operation flow around the GCOM-C Land Atmospheric Correction
The part marked by the red color indicates this process (G4C).

2. Method

(1) BRF kernel

Bi-directional reflectance is modeled by the following equation,

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

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

rsaz =saz · d2r

rsoz=soz · d2r

rrea=|rea · d2r|

csaz=cos(rsaz)

csoz=cos(rsoz)

crea=cos(rrea)

tsaz=tan(rsaz)

tsoz=tan(rsoz)

calp=csoz · csaz+sin(rsoz) · sin(rsaz) · crea

alp=acos(calp)

dlt=sqrt($tsoz^2$+$tsaz^2$ –2 · tsoz · tsaz · crea)

knl(1)=((pi–rrea) · crea+sin(rrea)) · tsoz · tsaz/(2 · pi) – (tsoz+tsaz+dlt)/pi

knl(2)=(4./3. /pi)/(csoz+csaz) · ((pi/2–alp) · calp +sin(alp)) · (1. +1. /(hspt+alp / (1.5 · d2r))) –1./3.

where, d2r=pi/180, and pi=3.14159265

The parameter hspt is originally 1.0, however, it set to 5.0 to be stable regression (after Ver. 2).

(2) Temporal weighting for 8-day statistics

Data from day=d_0–20 to day=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.

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

wj(d) = 1.0, when d >=0,

where d = day–d_0, and wk0=0.04 · 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.

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

where $w_{rcv} = (10 – N_{used}) / N_{rcv}$, or $w_{rcv} = 0.5$ if $w_{rcv}>0.5$.

(3) Regression to the Kernel

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

$$cost = S^2 + w1 + w2 + w12$$

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

$$w1 = \exp(-10.+c1/uk1 \cdot 10.) \cdot wk0 \ (c1 \geqq 0); \underline{w1 = \exp(-10.-c1/uk1 \cdot 100.) \cdot wk0 \ (c1<0)}$$

$$w2 = \exp(-10.+c2/uk2 \cdot 10.) \cdot wk0 (c1 \geqq 0); \underline{w2 = \exp(-10.+c2/uk2 \cdot 100.) \cdot wk0 \ (c2<0)}$$

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

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

3. Output parameters

(1) 8-bit QA_flag

See Table 1

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

(2) **_Ninput

Input data number.

(3) **_Nused

Used data number which does not include the recovered samples

(4) **_Date

Date identificator 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 BRF 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.

In the standard processing, the following RSRF variables are processed:
Rs_VN01~11, Rs_VN08P, Rs_VN11P, Rs_PI01~02, Rs_SW01~04, Tb_TI01~02, GEOV, GEOI, GEOP, and SWR

The name tags of the output files are:
RV01~11Q, RN08K, RN11K, RP01~02K', RS01~04K, RT01~02Q, GEOVQ, GEOIQ, GEOPK, and SWR_Q.

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.