DCC Verification Data Document

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This document is provided to the GSICS community along with the DCC verification data package that consists of one month (July 2012) of DCC pixel-level data acquired from seven geostationary satellites over their domains. The package also contains a sample Fortran program that can read the data set, apply angular constraints and homogeneity filters to the DCC pixels, and perform BRDF corrections based on Hu model. This document describes the DCC verification data set in detail and provides guidelines for using the sample read code.

1. Introduction

On June 14, 2013, NASA LaRC provides to the GSICS archive one month (July 2012) of DCC verification data acquired from seven geostationary satellites (GEOSats), namely, GOES15, GOES13, Meteosat-9, Meteosat-7, FY2E, COMS, and MTSAT2, over their specific GEO domains. A sample Fortran code for reading these data files is also provided with the dataset. This document describes the methodology used in identifying the DCC pixels over the GEO domains and how the various DCC parameters are written into the DCC data files. In addition, it also provides guidelines for using the sample read code, which implements all the angular constraints and homogeneity thresholds for DCC filtering, and applies the Hu model for BRDF corrections.

The goal of this document is for each GPRC to reproduce the July 2012 monthly PDFs at the end of the document, with DCC technique defined in this document by the August 15, 2013 GSICS DCC telecom #2. Once each GPRC has verified that their code and approach matches these results, they can be confident in optimizing the DCC technique to derive the most stable temporal visible trends that reflects the degradation of their instrument.

2. DCC data acquisition

A fixed DCC domain confined to ±20° latitude and ±20°E-W longitude, and centered at the GEO sub-satellite point is defined for each geostationary satellite. Figure 1 shows the equatorial domains where the DCC verification data were acquired for GOES15, GOES13, Meteosat-9, Meteosat-7, FY2E, COMS, and MTSAT2. The nominal sub-satellite longitudes for these GEOSats are listed in Table 1.

For each GEO satellite, all DCC pixels (11µm BT<205°K) acquired from consistent-time daily images are archived into a monthly binary file (e.g. COMS_cold_2012_07,

MET9_cold_2012_07, etc.). Table 2 gives the GEO-specific image times that are used for obtaining these DCC data files. The image times are chosen close to Aqua-MODIS overpass time (1:30 PM local) for the GEO sub-satellite longitude.
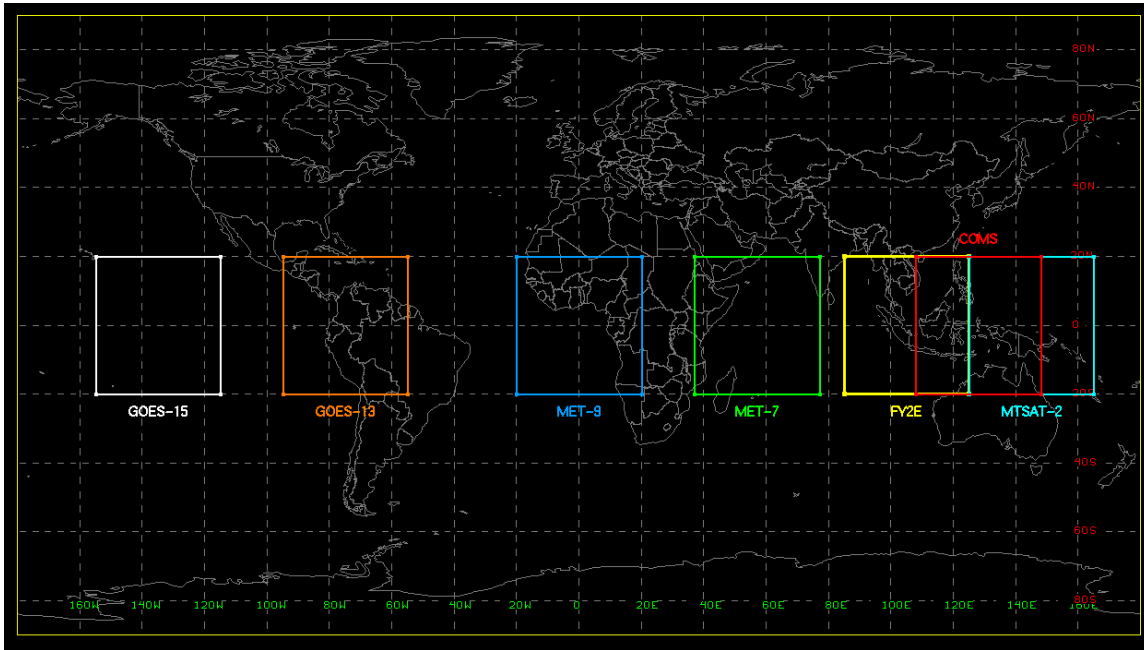
Figure 1: GEO Satellites DCC domains

Table 1: Nominal sub-satellite longitudes

Satellite	GOES-15	GOES-13	MET-9	MET-7	FY2E	COMS	MTSAT-2
Orbit	135°W	75°W	0W	57°E	105°E	128°E	145°E

Table 2: Consistent-time daily images used for obtaining DCC data

Satellite	GMT image time
GOES-15	21:52 SH, 22:22 SH, 22:00 NH, and 22:30 NH
GOES-13	19:15 NH and 19:45 NH
MET-9	13:15 FD and 13:30 FD
MET-7	09:00 FD and 09:30 FD
FY2E	06:01 FD and 07:01 FD
COMS	05:00 ENH and 05:15 FD
MTSAT2	03:32 FD and 04:32 FD

Note that the so-obtained monthly DCC file contains raw DCC data without any angular constraints and visible/IR homogeneity thresholds applied. Since the DCC pixels are selected at the nominal pixel resolution of ~4km, the associated visible pixel is sub-sampled from the nominal 1-km visible pixels and are not averaged. The only exception is Meteosat-8/9, where both visible and IR pixels have the same 3-km nominal resolution. We provide raw monthly DCC data files for all seven GEO satellites mentioned above. Along with the visible count and IR BT values, nine other parameters are also recorded into the monthly binary files. Each parameter is written as a 4-byte floating-point number (big-endian format). The relative azimuthal angle (RAZ) assumes that forward scatter = 0°. Table 3 provides a list of these parameters in the same sequence as they are written into the binary files.

If anyone finds significant differences in any of these parameters, please contact Raj Bhatt, whose contact information is listed at the end of this document. We may have made some flawed assumptions, coding errors or acquired some erroneous inputs.

Table 3: DCC parameters written into the monthly binary files

SN	GEO Satellites						
	GOES-15	GOES-13	MET-9	MET-7	FY2E	COMS	MTSAT2
1	σVIS	σVIS	σVIS	σVIS	σVIS	σVIS	σVIS
2	σIR	σIR	σIR	σIR	σIR	σIR	σIR
3	SZA	SZA	SZA	SZA	SZA	SZA	SZA
4	VZA	VZA	VZA	VZA	VZA	VZA	VZA
5	RAZ	RAZ	RAZ	RAZ	RAZ	RAZ	RAZ
6	0.65μm	0.65μm	0.65μm	0.65μm	0.65μm	0.65μm	0.65μm
7	11μm	11μm	0.86μm	11μm	11μm	11μm	11μm
8	Lat.	Lat.	1.60μm	Lat.	Lat.	Lat.	Lat.
9	Lon.	Lon.	11μm	Lon.	Lon.	Lon.	Lon.
10	GMT	GMT	Lat.	GMT	GMT	GMT	GMT
11	DOY	DOY	Lon.	DOY	DOY	DOY	DOY
12			GMT				
13			DOY				

Where,

σVIS: standard deviation of 3x3 visible pixel block (used for visible homogeneity test)

σIR: standard deviation of 3x3 IR pixel block (used for BT homogeneity test)

GMT: scan time GMT

DOY: day of year

An illustrative example

Consider an example of Meteosat-9 monthly raw DCC file (MET9_cold_2012_07). The total size of the file is 13,455,000 bytes, and the number of parameters recorded for each pixel is 13 (Table 3). The first four bytes (read as big-endian format) give the σVIS parameter for the first DCC pixel. The next 4 bytes give the σIR value for the same pixel, and so on. Thus, after reading the first 13 x 4 = 52 bytes, the same parameters for second DCC pixel repeats. The total number of DCC pixels in the file can also be computed from the file-size as 13455000/52 = 258750.

3. DCC data processing

The monthly DCC raw file is processed further to identify pristine DCC pixels using the criteria listed in Table 4. The filtered DCC pixels are then corrected for Earth-Sun distance, solar zenith angle, and BRDF effects, and finally written into a new monthly file (e.g. DCC_2012_07_MET9). The DCC visible counts in the new monthly files are later used to construct the monthly probability distribution function (PDF). The content of the new monthly file is described in the next section.

Table 4: DCC thresholds

GEO parameter	DCC threshold
Window brightness temperature	BT11μm < 205°K
Brightness temperature homogeneity	Standard deviation of 3x3 pixels BT11μm < 1°K
Visible radiance homogeneity	Standard deviation of 3x3 pixels visible counts < 3%
Solar zenith angle	SZA < 40°
View zenith angle	VZA < 40°
Relative azimuth	10° < RAZ <170°

4. Software

A Fortran software package is provided that applies angular and homogeneity filters to the raw monthly DCC files (e.g. MET9_cold_2012_07). The software also implements the Hu model for the BRDF correction. Finally, a new monthly binary file is generated (e.g. DCC_2012_07_MET9). Table 5 describes the parameters in the new monthly file.

Table 5: DCC parameters written into the processed monthly binary files

SN	GEO Satellites						
	GOES-15	GOES-13	MET-9	MET-7	FY2E	COMS	MTSAT2
1	0.65μm	0.65μm	0.65μm	0.65μm	0.65μm	0.65μm	0.65μm
2	11μm	11μm	0.86μm	11μm	11μm	11μm	11μm
3	SZA	SZA	1.60μm	SZA	SZA	SZA	SZA
4	VZA	VZA	11μm	VZA	VZA	VZA	VZA
5	σIR	σIR	SZA	σIR	σIR	σIR	σIR
6	σVIS (%)	σVIS (%)	VZA	σVIS (%)	σVIS (%)	σVIS (%)	σVIS (%)
7	Lat.	Lat.	σIR	Lat.	Lat.	Lat.	Lat.
8	Lon.	Lon.	σVIS (%)	Lon.	Lon.	Lon.	Lon.
9	DOY	DOY	Lat.	DOY	DOY	DOY	DOY
10	RAZ	RAZ	Lon.	RAZ	RAZ	RAZ	RAZ
11			DOY				
12			RAZ				

a. Directory structure

The software package is named **DCC_Verification_Data_Package**. You should copy the entire package into your working directory. There is a separate data folder for each **GEO** and a common folder named **codes** for the program files. The monthly raw DCC files are located into **GEO/Monthly/**, whereas the processed monthly files go to **GEO/Monthly_BRDF/** location. There is another sub-folder named **FREQ** inside each GEO folder. The program writes out the total number of DCC pixels before and after filtering into an ASCII file (e.g. ntot_2012_07_MET9), which is saved into this sub-folder.
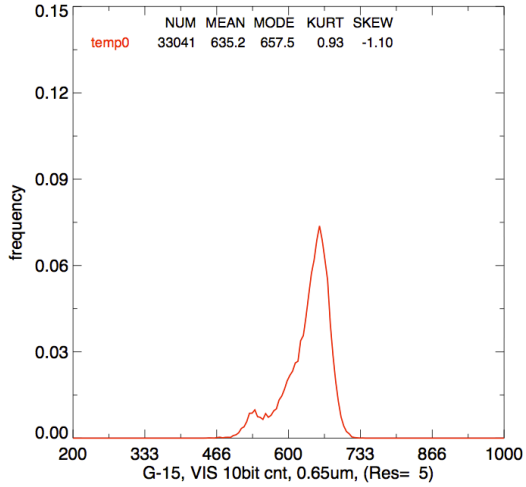
b. Source files

The DCC software package has three source files: **DCC_Hu_model.f**, **DCC_lib.f**, and **Sample_DCC_Read.f**. They are all located inside the **codes** directory. The Hu model subroutine, **hualb(alb,sza,vza,azm,refl)**, is contained inside **DCC_Hu_model.f**. The **DCC_lib.f** file consists of other supporting subroutines including the Earth-Sun distance correction. **Sample_DCC_Read.f** is the main program to compile. It processes one satellite at a time. You can select a GEO by assigning an appropriate value to the variable **igeo** in the code. Look at the comments in the code for more details. There is a Makefile named **Sample_DCC_Read.make** inside the **codes** directory that can be run for compiling and linking all three source files, and to create an executable file for the main program (**Sample_DCC_Read**). The Hu model subroutine requires **hualb_data** file, which resides in the **codes** directory.
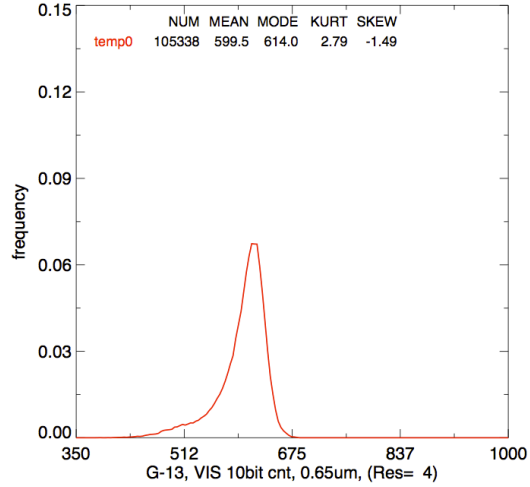
Next step from here would be reading the processed monthly file from **GEO/Monthly_BRDF/** location and plot the monthly PDF for all the DCC pixels. Figure 2 shows the PDF results obtained for the given DCC files. The histogram increments are given in the x-axis labels.
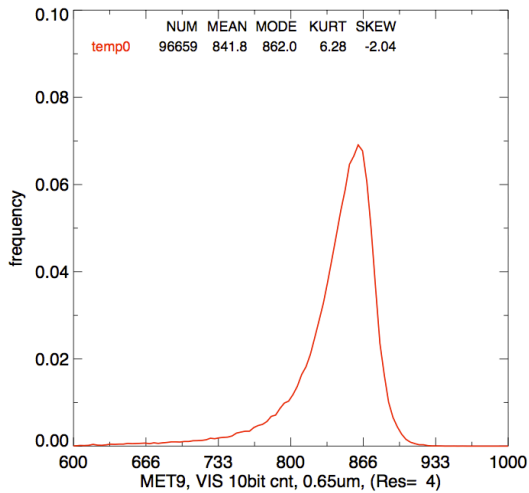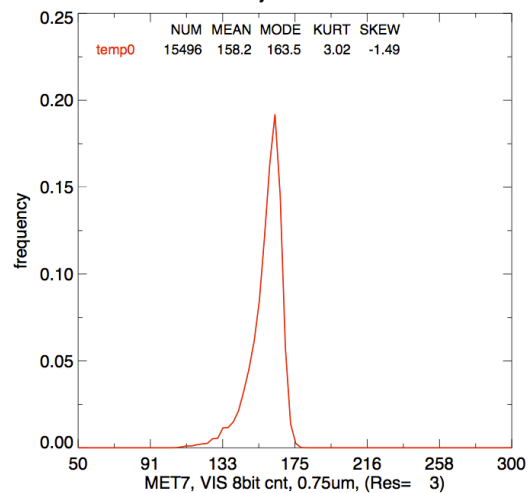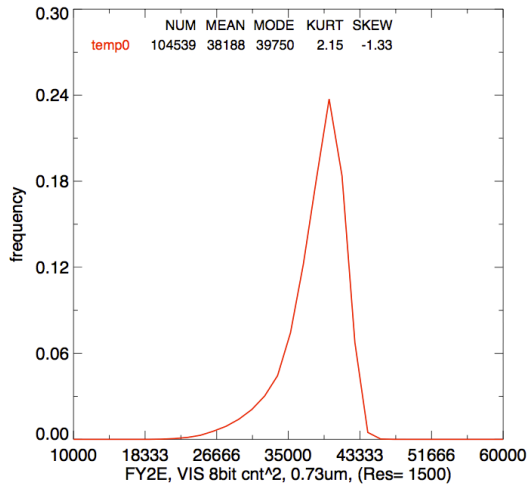
G-15 temperature bands
jul2012

	NUM	MEAN	MODE	KURT	SKEW
temp0	33041	635.2	657.5	0.93	-1.10

G-15, VIS 10bit cnt, 0.65um, (Res= 5)

G-13 temperature bands
jul2012

	NUM	MEAN	MODE	KURT	SKEW
temp0	105338	599.5	614.0	2.79	-1.49

G-13, VIS 10bit cnt, 0.65um, (Res= 4)

MET9 temperature bands
jul2012

	NUM	MEAN	MODE	KURT	SKEW
temp0	96659	841.8	862.0	6.28	-2.04

MET9, VIS 10bit cnt, 0.65um, (Res= 4)

MET7 temperature bands
jul2012

	NUM	MEAN	MODE	KURT	SKEW
temp0	15496	158.2	163.5	3.02	-1.49

MET7, VIS 8bit cnt, 0.75um, (Res= 3)

FY2E temperature bands
jul2012

	NUM	MEAN	MODE	KURT	SKEW
temp0	104539	38188	39750	2.15	-1.33

FY2E, VIS 8bit cnt^2, 0.73um, (Res= 1500)

COMS temperature bands
jul2012

	NUM	MEAN	MODE	KURT	SKEW
temp0	138627	623.4	650.0	2.05	-1.41

COMS, VIS 10bit cnt, 0.67um, (Res= 4)
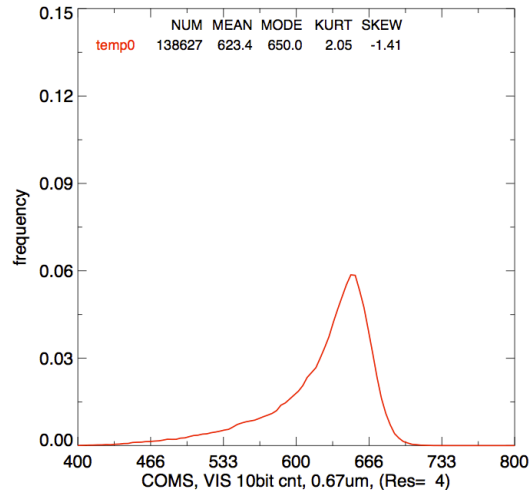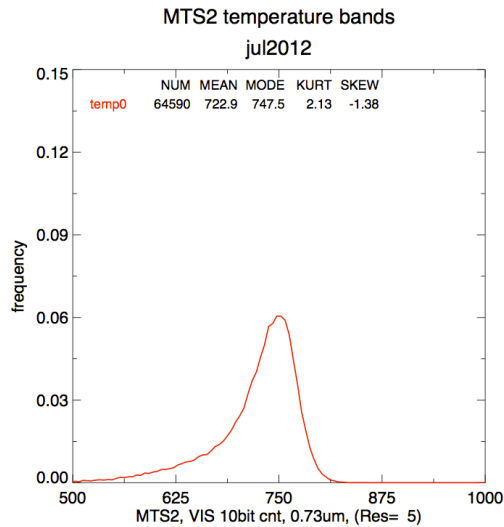
Figure 2: Monthly PDFs of DCC pixels acquired by GOES15, GOES13, Meteosat-9, Meteosat-7, COMS, FY2E, and MTSAT2 over their DCC domains in July 2012.

Important notes

- All geostationary data we have provided comes from MCIDAS.
- All view angles computed for DCC pixels are based on a constant nominal sub-satellite point latitude and longitude. McIDAS does not provide real-time sub-satellite point information.
- McIDAS converts FY2E 6-bit counts to 8-bit, by multiplying by 4. The 8bit counts are then squared in order to be proportional to radiance.
- Space counts are not subtracted in the raw DCC files. They are subtracted during processing by the Sample_DCC_Read code.
- You need to change all the directory paths in the source files according to your machine before you compile.

If you have any questions regarding this document, please contact Raj Bhatt at **rajendra.bhatt@nasa.gov**