Users' Guide for GSICS Harmonization

Fred Wu and Hui Xu

2025-05-21

Overview

- Global Space-based Inter-Calibration System (GSICS).
  - Sponsored by WMO and CGMS
  - Primarily NOAA, EUMETSAT, JMA, CMA, and KMA (meteorological satellite operators).
  - Also “space agencies” (NASA, ESA, JAXA, …) and other entities.
- Main goal is to “inter-calibrate”, or harmonize measurements by similar channels on different instruments of different agencies.
- Current Reference:
  - NOAA-20 VIIRS for VNIR channels. METOP-B IASI for IR channels.

$$R_{harmonized} = a_h + b_h R_{original}$$

Earlier Discussions

- 2021-09-08: Proposed at the CWG meeting.
- 2021-09-27: Created WR.
- 2021-11-26: Drafted Users Guide, including file name, format, updating frequency and procedure.
- 2021-12-03: Briefed AWG for feedback.
- 2022-01-14: Cleared by AWG.
- 2022-01-31: Discussed at (and approved by) AART.
- 2022-02-02: Planned for implementation at the CWG.
- 2023-03-15: Implemented into the L1b (with fill values).
- 2023-04-12: CWG verified the format & values.
- 2025-03-19: Proposed the valid values of GSICS Harmonization.
- 2025-04-09: Addressed users' comments and concerns.
- 2025-05-07: Added Python code.

Implementation

$$R_h = a_h + b_h R_o$$

Variable	Name	Dimension 1	Dimension 2	Type	Unit
$a_h(3,16)$	GSIC Harmonization Offset	3 times – prelaunch, last, current	16 channels	Real	Same as ABI L1b radiance
$b_h(3,16)$	GSIC Harmonization Slope	3 times – prelaunch, last, current	16 channels	Real	Unitless

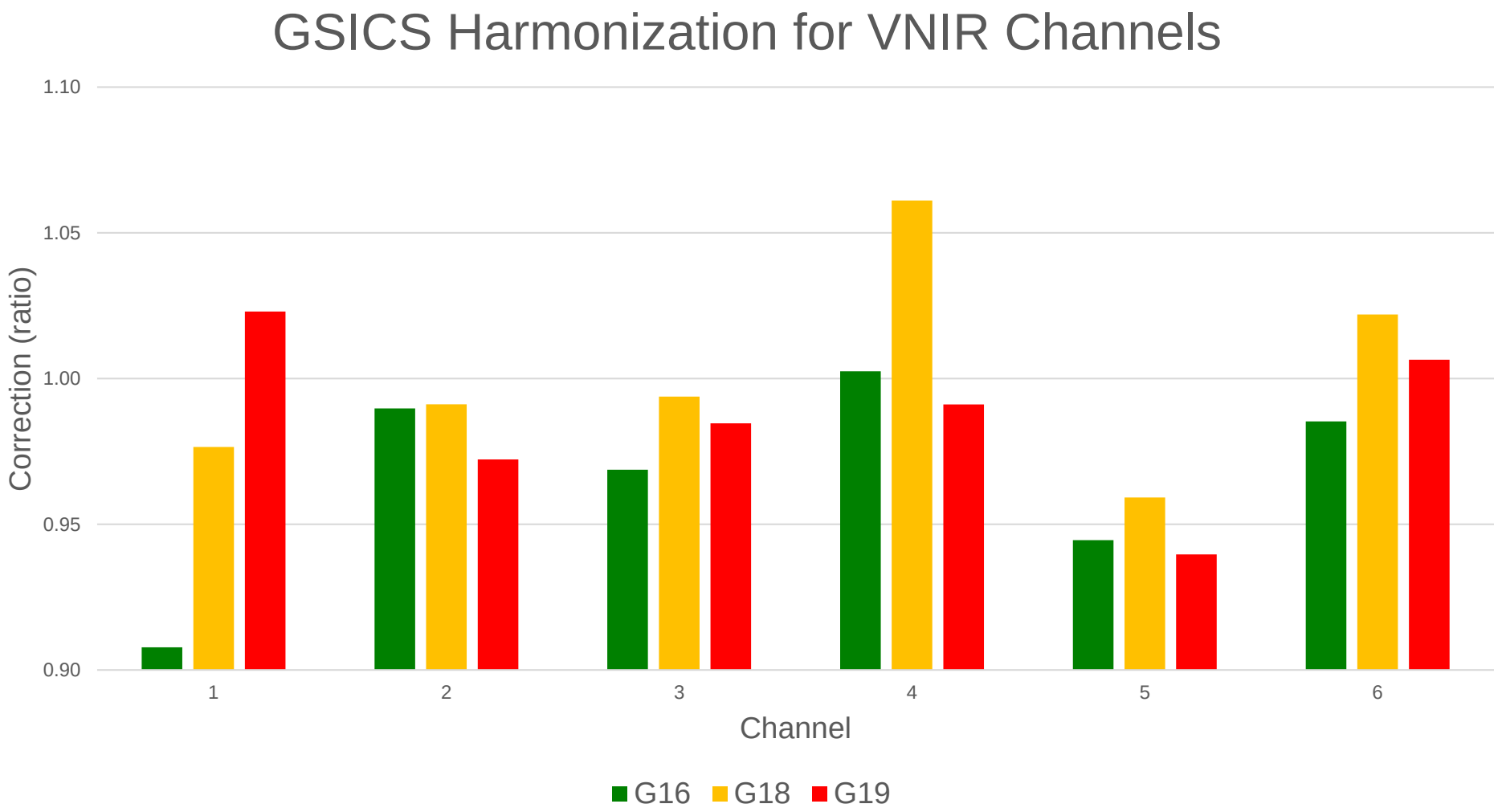
Nominally, $a_h = 0$, $b_h = 1$, and $R_h = R_o$.

Typically, $a_h = 0$ for VNIR and $b_h = 1$ for IR.

Coefficients (Numerical)

	GOES-16		GOES-18		GOES-19	
Channel	A	B	A	B	A	B
1	0.0000	0.9078	0.0000	0.9765	0.0000	1.0230
2	0.0000	0.9897	0.0000	0.9912	0.0000	0.9723
3	0.0000	0.9687	0.0000	0.9938	0.0000	0.9846
4	0.0000	1.0025	0.0000	1.0611	0.0000	0.9911
5	0.0000	0.9445	0.0000	0.9592	0.0000	0.9396
6	0.0000	0.9853	0.0000	1.0220	0.0000	1.0065
7	0.0001	1.0000	-0.0010	1.0000	-0.0010	1.0000
8	-0.0188	1.0000	-0.0102	1.0000	-0.0206	1.0000
9	-0.0425	1.0000	-0.0697	1.0000	-0.1175	1.0000
10	-0.0262	1.0000	0.0321	1.0000	-0.0559	1.0000
11	-0.0579	1.0000	-0.0571	1.0000	-0.0136	1.0000
12	-0.1161	1.0000	-0.0389	1.0000	-0.1298	1.0000
13	-0.0602	1.0000	-0.0611	1.0000	-0.0877	1.0000
14	0.0223	1.0000	-0.0273	1.0000	-0.0390	1.0000
15	0.0206	1.0000	0.0668	1.0000	0.0281	1.0000
16	-0.2504	1.0000	0.2135	1.0000	-0.9346	1.0000

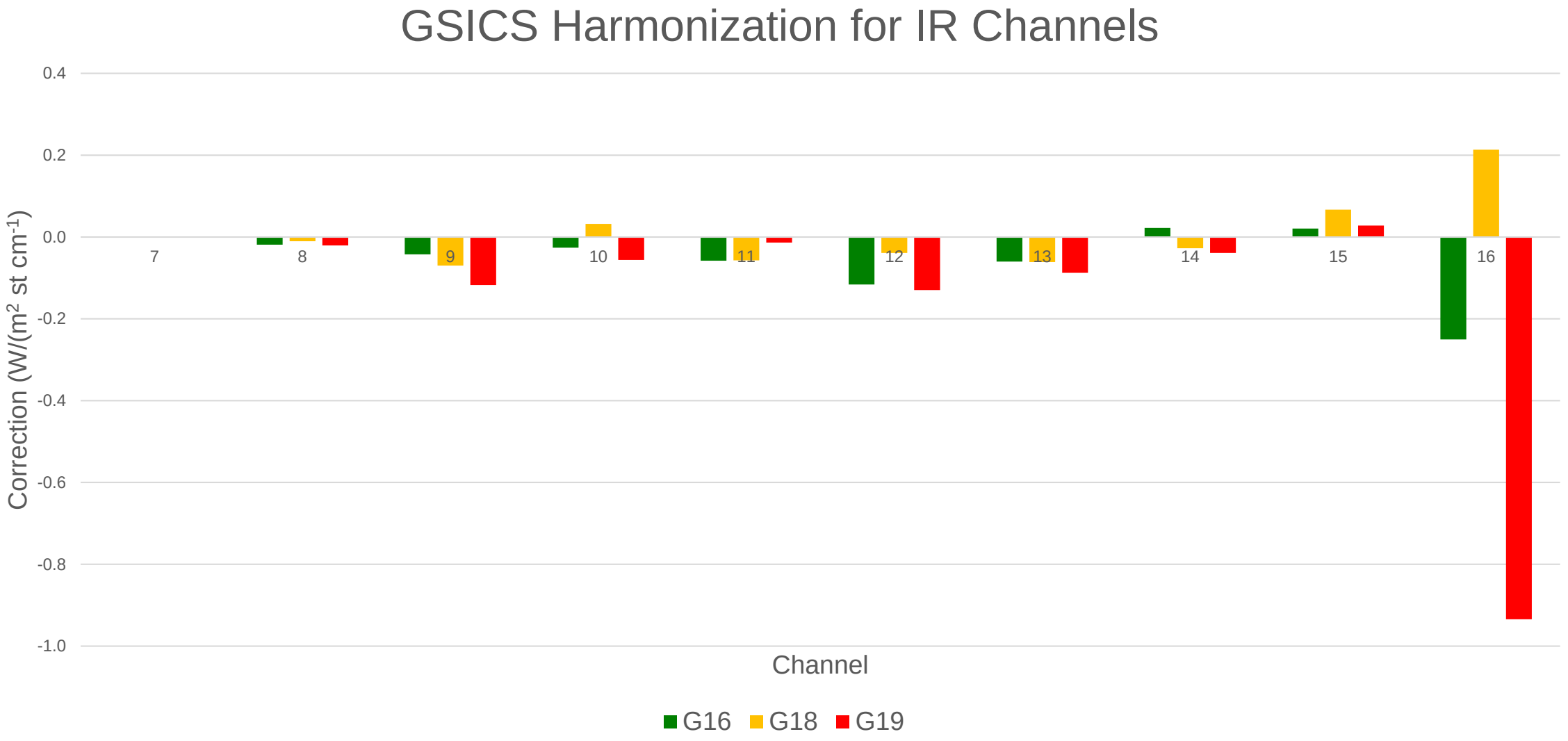
Coefficients (Graphic for VNIR)



Difference from reference is < 5% in general, with minor exception for B04 of G18 and B05 of G16/G19.

The larger difference for G16 B01 is partly because of the reference at the time (S-NPP VIIRS, ~2% brighter than NOAA-20 VIIRS) and partly because of the Solar Diffuser degradation (~2%) that has not been accounted for.

Coefficients (Graphic for IR)



Python Example

```
import netCDF4 as nc
# Open the ABI Level 1b file
filename = './DR_ABI-L1b-RadF-M6C01_G19_s*_e*_c*.nc'
ds = nc.Dataset(filename)
# Read the original radiance
R_o = ds.variables['Rad'][:]
# Select the desired radiance:
# 0: The current coefficients;
# 1: The last valid coefficients;
# 2: The pre-launch coefficients
choice = 0
# Read the GSICS Harmonization coefficients:
a_h = ds.variables['a_h_NRTH’][choice]
b_h = ds.variables['b_h_NRTH’][choice]
# Apply the coefficients to generate the desired radiance
R_h = a_h0 + b_h0 * R_o
```

Q&A 1: Implementation Strategy

- Opt-Out: **Apply** the coefficients to L1b
  - This was planned, and adopted by partners.
  - User get the harmonized radiance by default, and can retrieve the original radiance with effort.
- Opt-In: **Attach** the coefficients to L1b, and let user to decide.
  - This was preferred by NOAA users who are more concerned with continuity and compatibility.
  - User get the original radiance by default, and can obtain the harmonized radiance with effort.
- NOAA's preference has been consistent.
  - Outside and inside (before and during) GOES-R Program.
  - For Imager, coefficients are provided independent of L1b (GVAR).
  - For ABI, coefficients are part of L1b metadata but still are not to apply.

Q&A 2: B02 Correction

- Shortly after the launch of GOES-16, its Band 2 was found to be significantly brighter (> 10%) than commonly accepted values.
- There was no consensus on the root cause.
- GSICS Correction (an earlier name for Harmonization) was suggested as a remedy, but it was decided not to “correct” without knowing what was wrong.
- The compromise was to restore to the prelaunch radiance calibration (reduced by ~7%).
- To be consistent, the B02 “K-LUT” of later ABIs was also adjusted to their prelaunch values, even though GOES-19 was not much brighter than the reference.

Q&A 3: GSICS Harmonization Update

- Conceptually, GSICS Harmonization is meant to be updated with time to account for calibration deficiency.
- Practically, frequent updated is unlikely for most of ABI channels.
  - GSICS Harmonization for ABI IR channels needed no update after the Provisional.
    - Later calibration updates, such as the resampling kernels for a few channels, may not impact the GSICS Harmonization.
    - Update for SRF, requested for GOES-17 & GOES-19 but has not happened, could trigger an update of GSICS Harmonization.
  - GSICS Harmonization probably should be updated twice for GOES-16 B01 in its 8+ years of operation, and may be once for another one or two channels.
- This is different from earlier generation of instruments (Imager and AVHRR) that do not have onboard solar calibration, which is a perpetual deficiency that requires frequent update.

Q&A 4: Harmonize Two ABIs

- GSICS Harmonization is designed to harmonize any number of instruments – U. S. or foreign, NOAA or other agencies, GEO or LEO, …
- In practice, one may need to harmonize only two instruments, e.g., mimic GOES-16 radiance using GOES-19.

$$R_{h16} = b_{h16} R_{o16} \quad (a_{h16} = 0), \; R_{h19} = b_{h19} R_{o19} \quad (a_{h19} = 0)$$

$$\text{Since } R_{h16} = R_{h19}, \text{So } R_{o16} = \frac{b_{h19}}{b_{h16}} R_{o19}$$