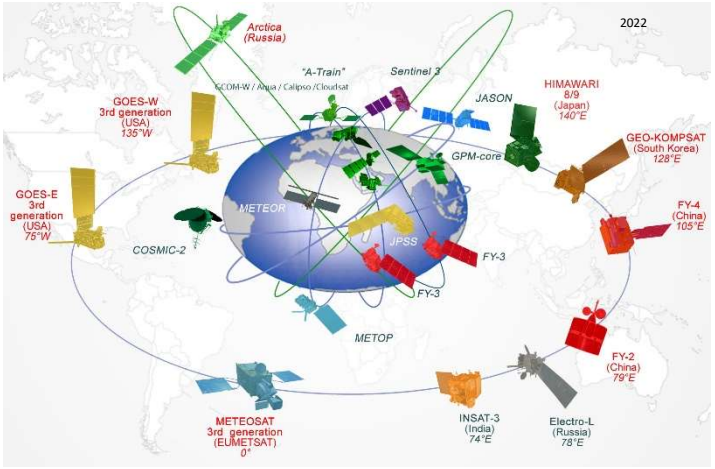

JMA report on historical satellite data recalibration for climatological application

Presented to CGMS-48 WG-II session, agenda item 6 (JMA-WP-05)

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Background

- JMA have operated GEO satellites since 1978.
- Recalibration works of historical GEO imagers at JMA are:

  VNIR: RTM based vicarious calibration approach in collaboration with Univ. of Tokyo and Chiba Univ. for GMS-5 (2000 – 2003) data

  IR: This study

- Recalibration of IR (11 μm) and WV channels for GMS to MTSAT-2 was performed under SCOPE-CM/IOGEO framework.

This study was done in collaboration with EUMETSAT during Tasuku Tabata's stay as 1-year visiting scientist at EUMETSAT (John et al., 2019 and Tabata et al., 2019).

	Operation	VNIR	SWIR	WV	IR
GMS	1978 – 1981	1			1
GMS-2	1981 – 1984	1			1
GMS-3	1984 – 1989	1			1
GMS-4	1989 – 1995	1			1
GMS-5	1995 – 2003	1		1	1
GOES-9	2003 – 2005	1	1	1	2
MTSAT-1R	2005 – 2010	1	1	1	2
MTSAT-2	2010 – 2015	1	1	1	2
Himawari-8	2015 –	6	1	3	7
Himawari-9	(2022 –)	6	1	3	7

Outcomes

- Daily correction parameters (slope and offset) for Level-1 IR radiance data on GMS,-2,-3,-4,-5, GOES-9, MTSAT-1R and -2 satellites tied to a single “primary” reference sensor
- Spectral Band Difference Adjustment Factors (SBAF) to mitigate differences among GEO imagers’ SRF
- These parameters are available on JMA/MSC Web page.
  - https://www.data.jma.go.jp/mscweb/en/oper/calibration/recalibration_ir.html

Methodology outline

- Recalibration
  1) Make collocation data set of GEO and reference LEO sensor observation
  2) Compute pseudo GEO imager radiances based on the reference sensor data. For AIRS and IASI, the approach is based on GSICS one.
  3) Compute correction parameters from linear regression of the pseudo and observed GEO imager radiances

- Bridge among reference and GEO sensors
  1) Gaps among reference sensors are tied to a single “primary” reference sensor by double-difference (DD) approach.
  2) Gaps among GEO sensors are tied each other by SBAF approach.

Reference sensors

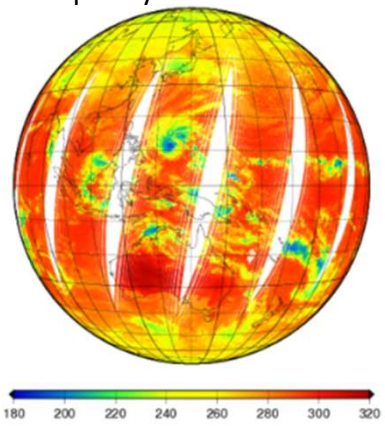
Sensor	Satellite	Period
HIRS/2	TIROS-N NOAA-6-14	1978 – 2006
AIRS	Aqua	2002-
IASI	Metop-A/B	2007-

Recalibration: How to compute the pseudo GEO radiance for HIRS/2

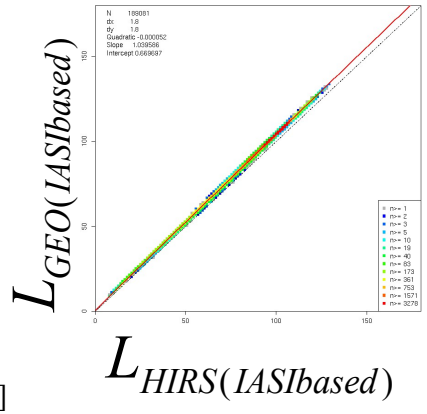
1) GEO and HIRS radiances are simulated by composition of IASI-A L1C data for various scenes (~200,000) of spectra.
2) Regression coefficients of the simulated GEO and HIRS rad. are computed (= SBAF).

$$L_{GEO(IASIbased)} = a_{SBAF} L_{HIRS(IASIbased)} + b_{SBAF}$$

1) Simulated MTSAT-1R/JAMI 10.8 μm by IASI-A



2) SBAF by the regression



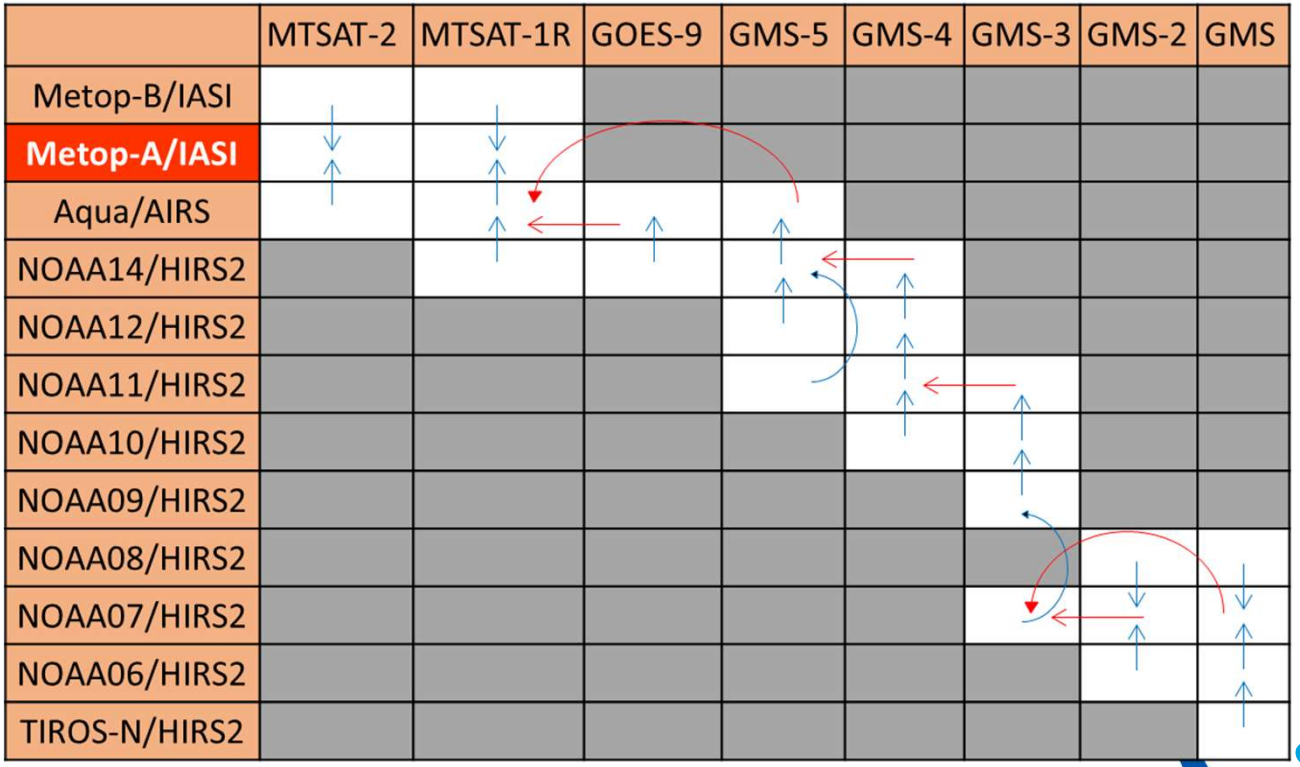
3) The SBAF are applied to HIRS collocation data (= pseudo GEO radiance)

$$L_{GEO(pseudo)} = a_{SBAF} L_{HIRS(obsevation)} + b_{SBAF}$$

The correction parameters are estimated from the pseudo GEO radiance and the observed GEO radiance.

How to Bridge Ref. and GEO sensors

- In this study, IASI-A is adopted as prime reference.
- Reference sensors' gaps are tied by using the double-difference (DD) approach.
- GEO sensors' gaps are tied by the SBAF approach. (=Homogenization)



- SBAF approach
- DD approach

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Results: TB bias in original L1 (vs. IASI-A)

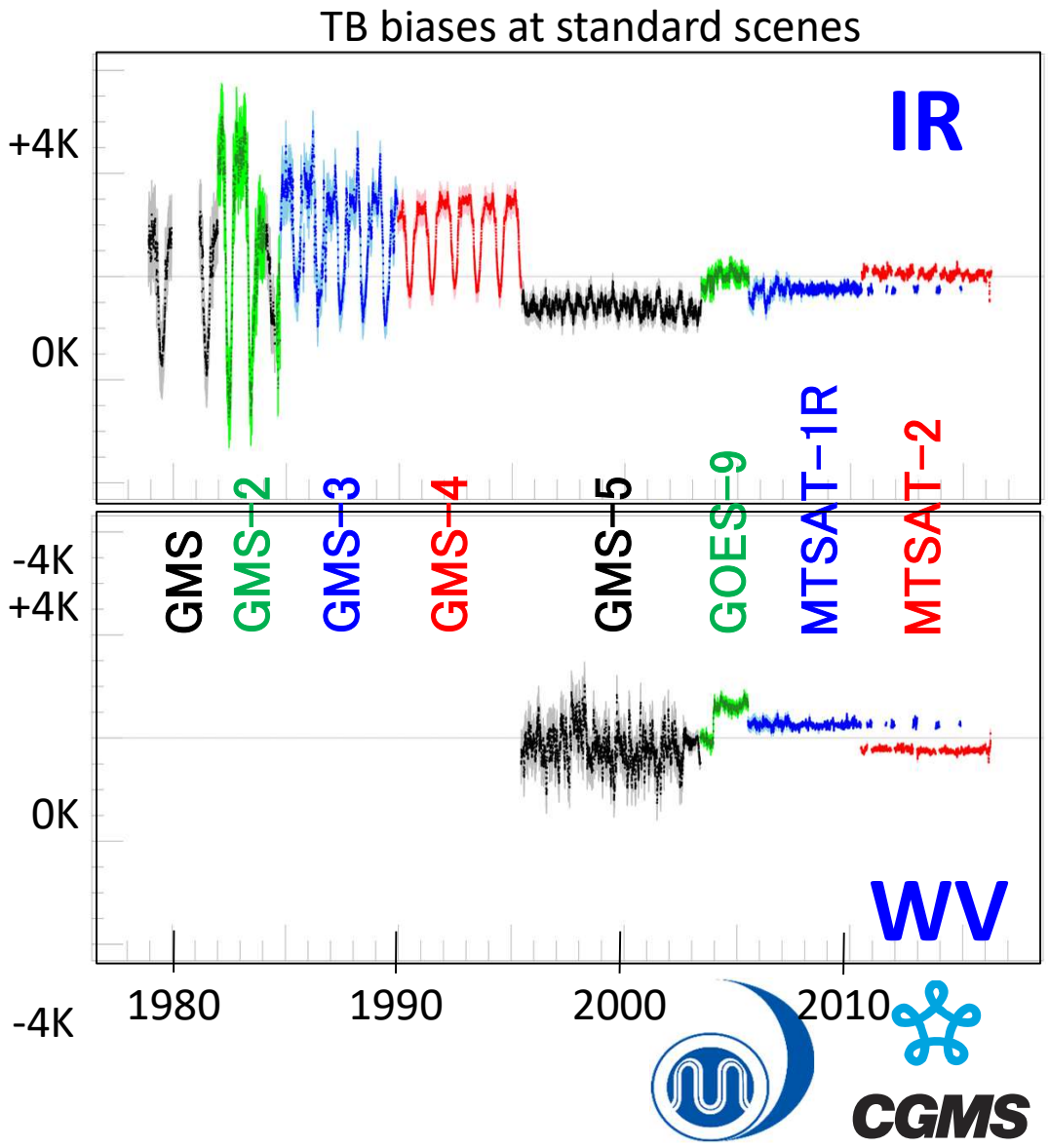
Tb bias: Monitored sensors vs. IASI-A

IR

- Seasonal variations until GMS-4 seems to be related thermal conditions of sensors.
- The issue was improved in GMS-5.

WV

- Seasonal variations (~1 K) with big uncertainty in GMS-5 is caused by spectral gap with HIRS/2.
- Jump in Dec 2003 is caused by updates of ground processing system.



The standard scenes were calculated for each channel using RTTOV-11 with the 1976 US Standard Atmosphere for nadir condition in clear sky at night over an ocean surface with a Sea Surface Temperature of 288.15 K and a wind speed of 7 m/s.

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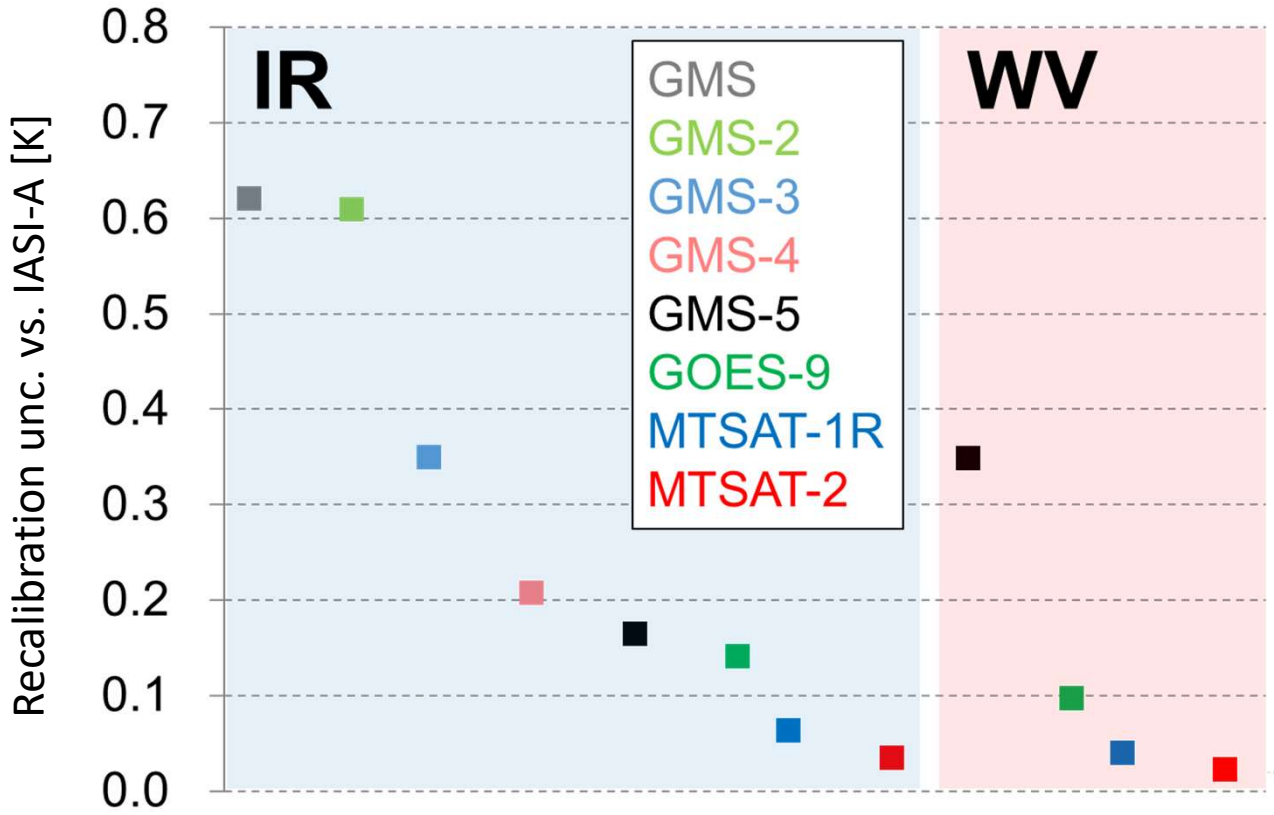
Recalibration uncertainties

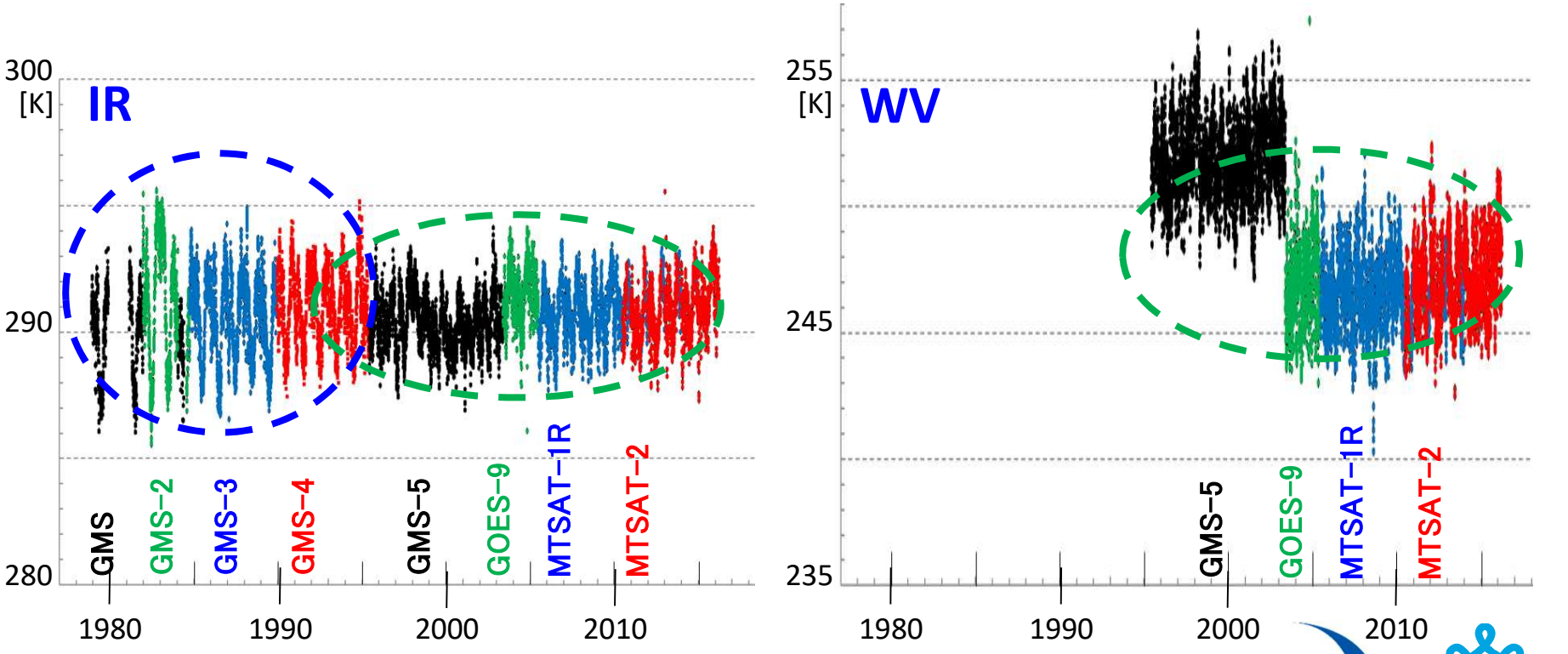
- Long chains to the prime reference (IASI-A) results in large uncertainties (e.g., ~0.6 K in GMS/GMS-2 IR channels)



Impacts of recalibration + GEO sensor homogenization

TBs averaged over ± 30 deg. of Sub Satellite Point (SSP)

- Original GEO data with operational calibration information



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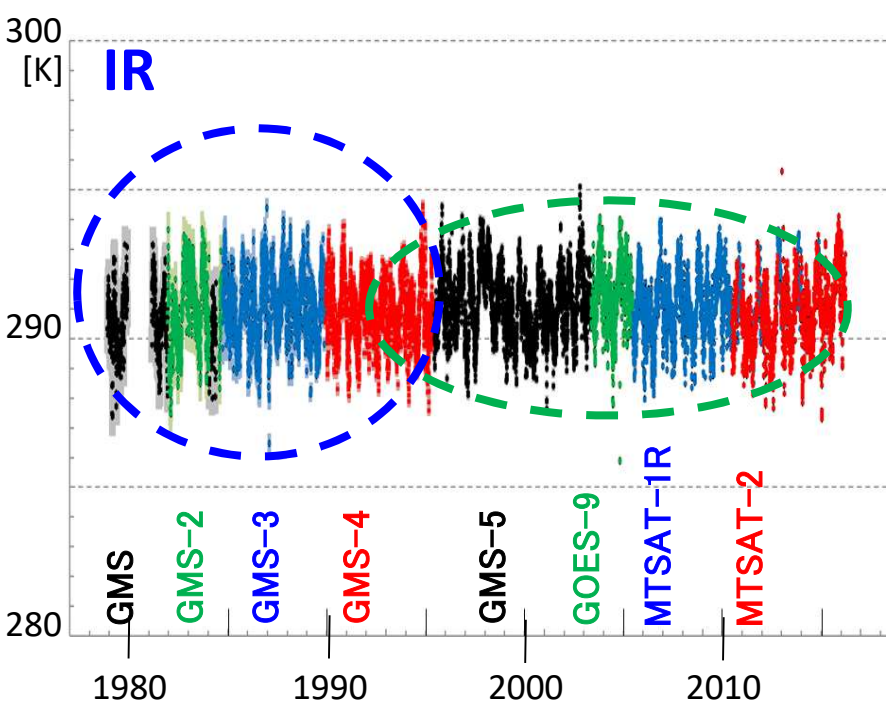
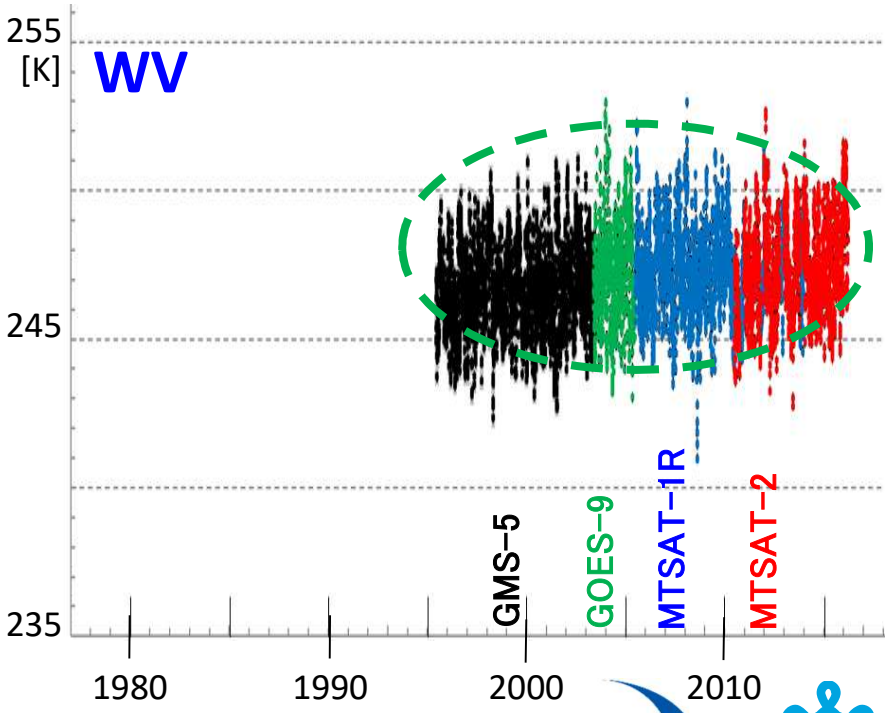
Impacts of recalibration + GEO sensor homogenization

TBs averaged over ± 30 deg. of Sub Satellite Point (SSP)

With recalibration + GEO sensor homogenization

- All GEO sensor data are normalized to MTSAT-2.
- Observation gaps among sensors are significantly reduced.





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Summary

- Recalibration algorithm for GMS/MTSAT and Meteosat imagers was jointly developed by EUMETSAT/JMA under SCOPE-CM/IOGEO project.
  - Correction coefficients for GEO imager data were computed by utilizing HIRS/2, AIRS and IASI as reference instruments.
  - SBAF to homogenize GEO imagers' SRF difference were computed from IASI-A, and new spectral gap-filling method were applied to generate pseudo GEO radiances from HIRS/2 and AIRS.
  - Double Difference approach was used for tying recalibration bias and uncertainty among sensors.
- Recalibration revealed ~3 K seasonal variations in IR (10.8 µm) channels of GMS to GMS-4, ~ 1 K seasonal variations in GMS-5 WV due to spectral gaps with HIRS/2.
- Two papers on this collaboration (Tabata et al. and John et al.) were published.
- The outcomes of the study are available on JMA/MSC Web page.

  https://www.data.jma.go.jp/mscweb/en/oper/calibration/recalibration_ir.html

References:

- John, V.O.; Tabata, T.; Rüthrich, F.; Roebeling, R.; Hewison, T.; Stöckli, R.; Schulz, J.; "On the Methods for Recalibrating Geostationary Longwave Channels Using Polar Orbiting Infrared Sounders.", Remote Sens., 2019, 11, 1171.
- Tabata, T.; John, V.O.; Roebeling, R.A.; Hewison, T.; Schulz, J.; "Recalibration of over 35 Years of Infrared and Water Vapor Channel Radiances of the JMA Geostationary Satellites", Remote Sens., 2019, 11, 1189.