Progress on FY-3/MWRI FCDR

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GSICS MWSG

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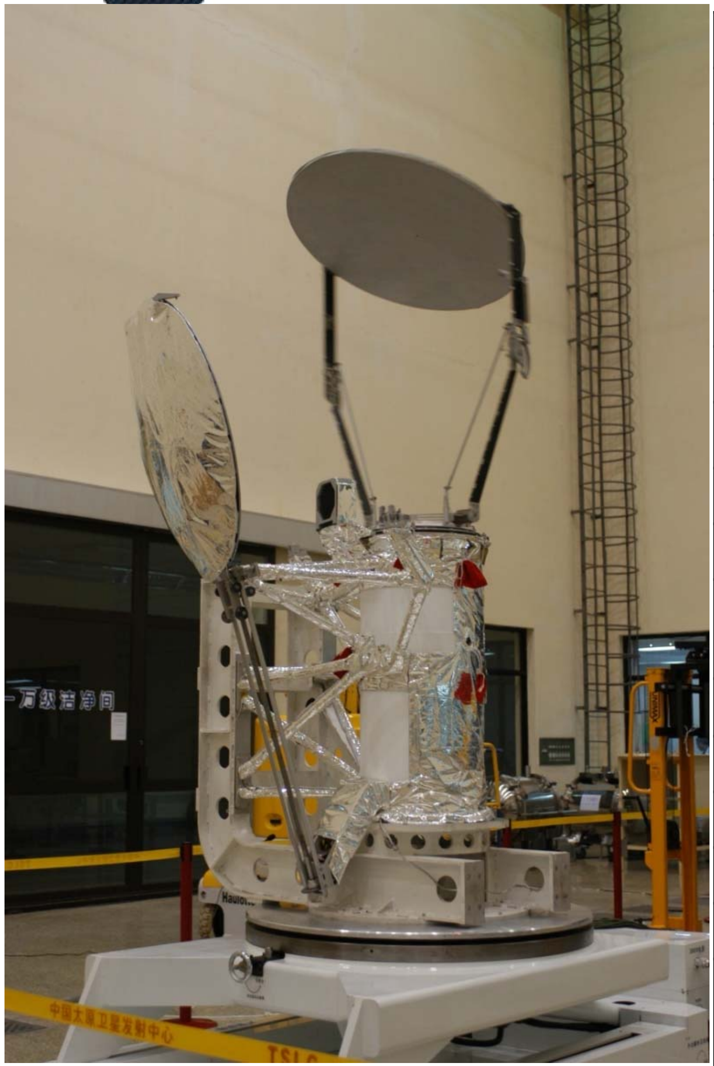
FY-3/MWRI Introduction



Frequency(GHz)	10.65	18.7	23.8	36.5	89
Polarization	V.H	V.H	V.H	V.H	V.H
Band Width(MHz)	180	200	400	900	2×2300
NeDT(k)	0.5	0.5	0.5	0.5	0.8
Accurancy(k)	2.0	2.0	2.0	2.0	2.0
BT Range(k)	3～340				
Scan Points	266(1.8s)				
Black Body Stability	0.3K				
Nonlinear	<1K				
Main Beam	≥90%				
Resolution ≤(km×km)	51×85	30×50	27×45	18×30	9×15
Beam of different Channel	<0.07°				
Scan	Conic				
Orbit Width(Km)	≥1400				
Antenna angle(°)	45				
Scan Period(s)	1.8±0.1（1.7/2.0）				
Scan Period Stability(ms)	≤0.36ms*（2 Scan lines）				
	≤1ms(30 minutes)				

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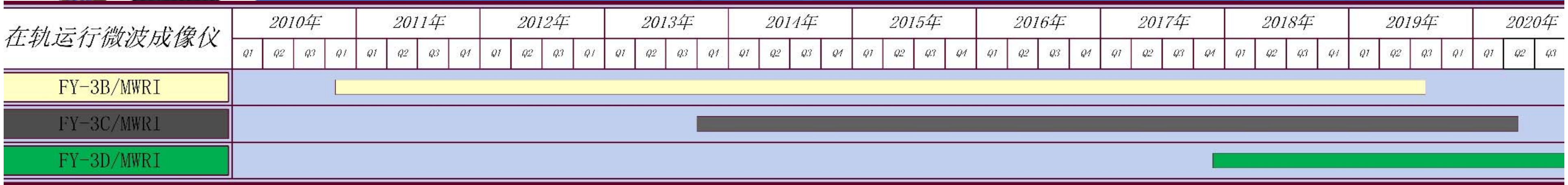
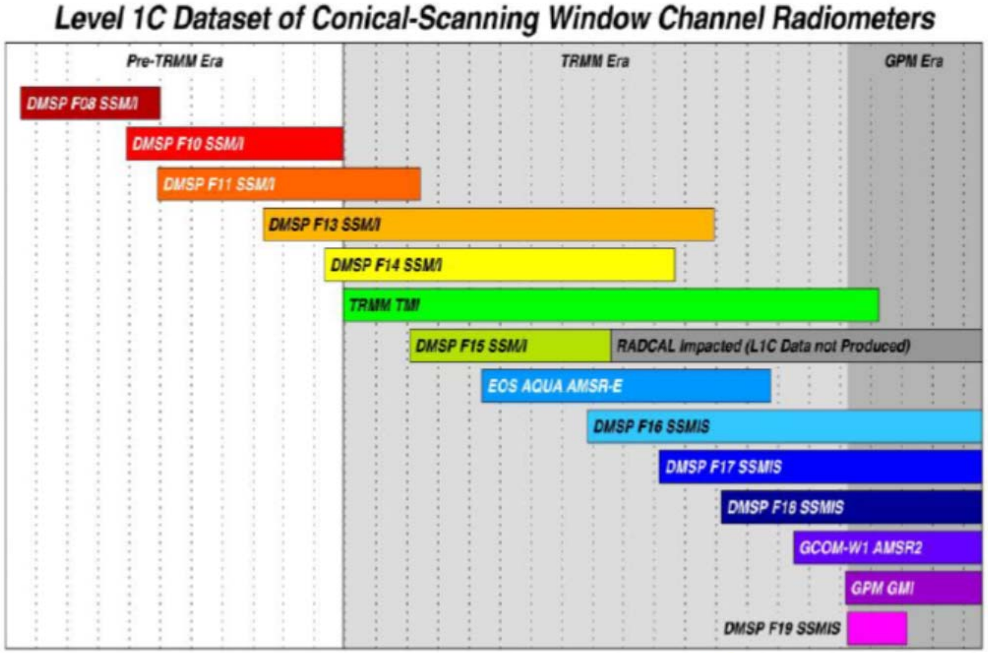
Current Status and Future Plan

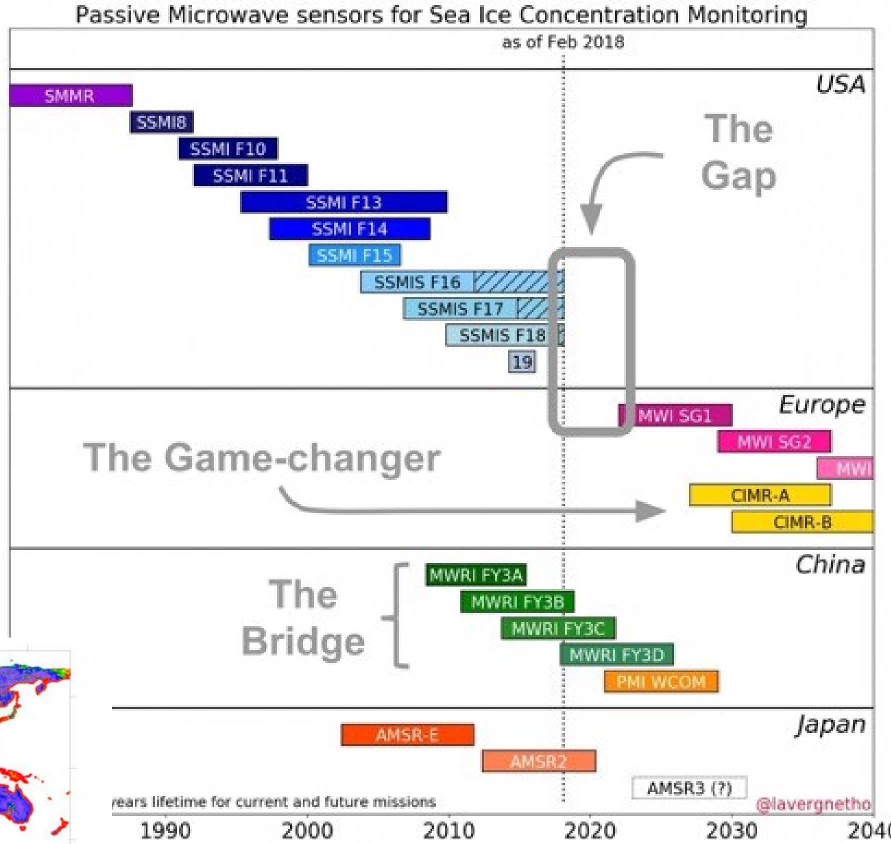


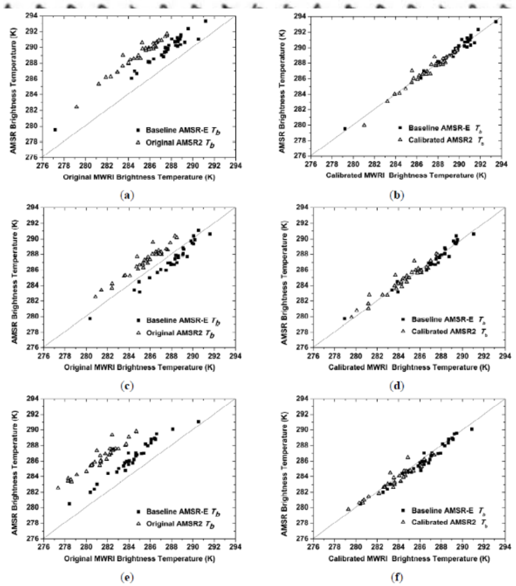
2021:FY-3F(Morning orbit, Antenna size: 1.8m);
2022:FY-3P(Low orbit, Antenna size: 1.6m);
2023:FY-3G(Afternoon orbit, Antenna size: 1.8m);
Antenna performance and NedT improved based on FY-3 02

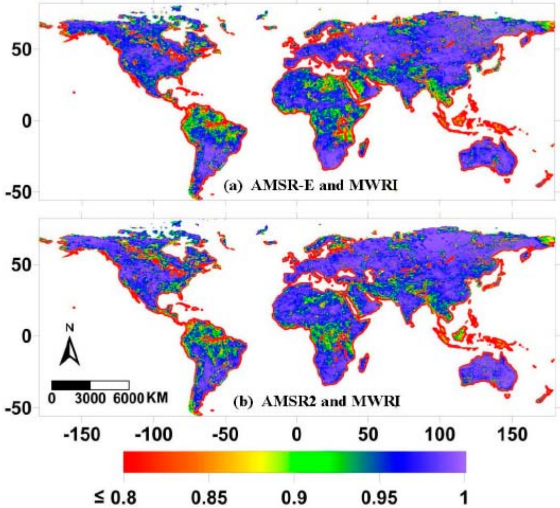
	FY-3A/B/C/D MWRI	**FY-3F/G/P MWRI**
Frequency（GHz）	10/18/23/36/89	10/18/23/36/50/89/118/166/183
Antenna（m）	1	1.8/1.6
NedT（K）	0.8/1.0	0.5/0.8
Accuracy（K）	2.0	0.8/1.2
Co-location（Km）	/	2
Main beam	0.9	0.95

Global Radiometer(Imager) History and Future









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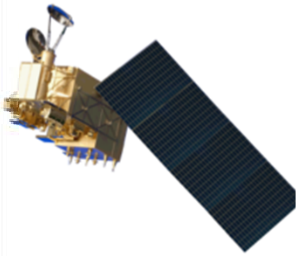


GMI

Channel	At launch η	V04 η	ΔTb at 200 K
10.65 V-pol	0.94435	0.95404	1.94
10.65 H-pol	0.94369	0.95404	2.07
18.7 V-pol	0.93968	0.95603	3.27
18.7 H-pol	0.94082	0.95603	3.04
23.8 V-pol	0.96601	0.97075	0.95
36.64 V-pol	0.9959	0.99535	−0.11
36.64 H-pol	0.9959	0.99535	−0.11
89.0 V-pol	0.9981	0.99734	−0.15
89.0 H-pol	0.9981	0.99734	−0.15
166.0 V-pol	1.0	0.98814	−2.37
166.0 H-pol	1.0	0.98814	−2.37
183.31±3 V-pol	1.0	0.99212	−1.58
183.31±7 V-pol	1.0	0.99212	−1.58

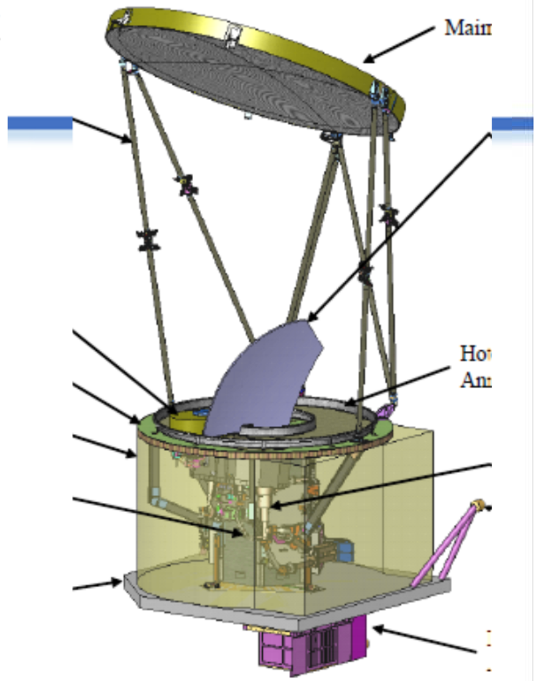
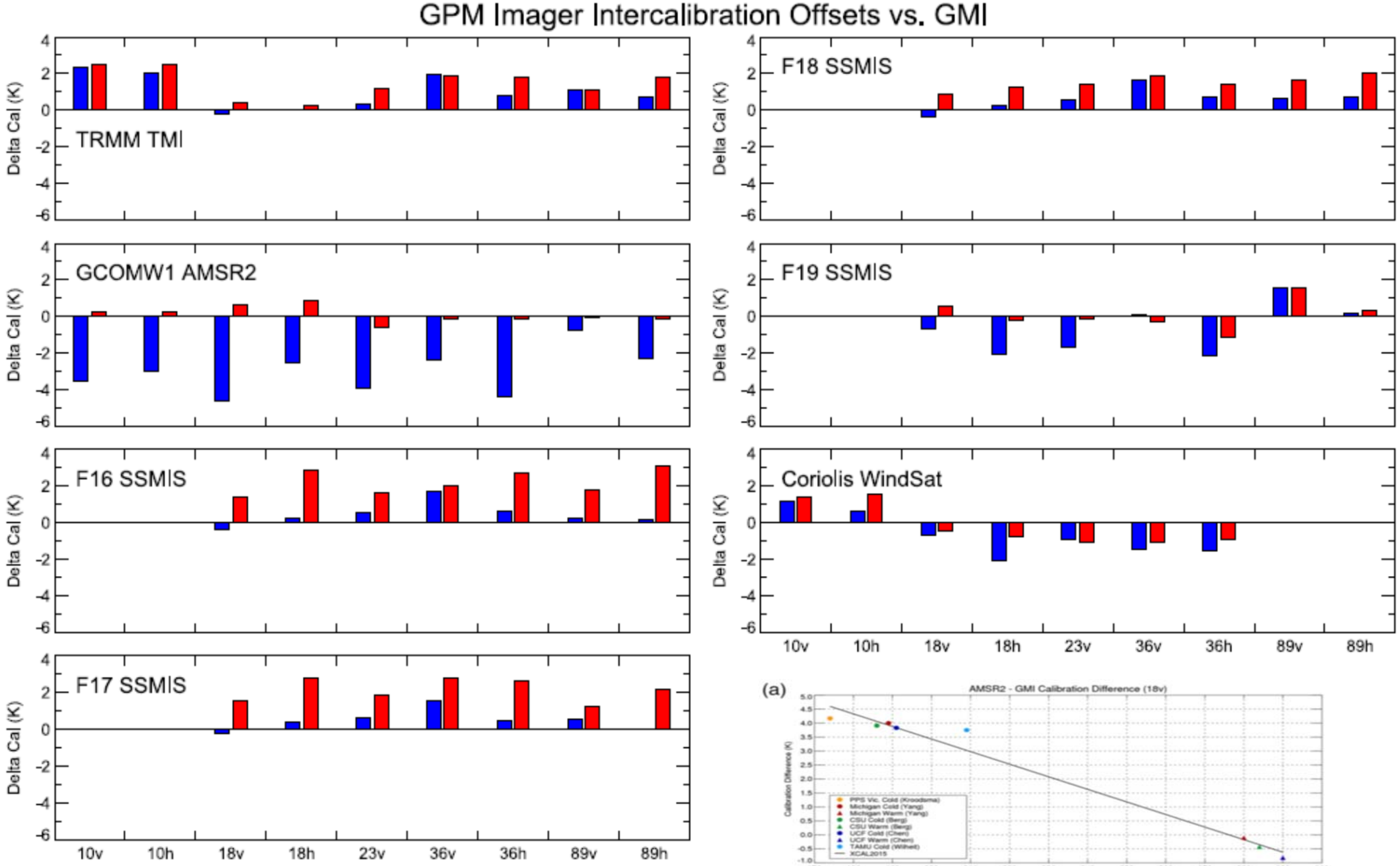


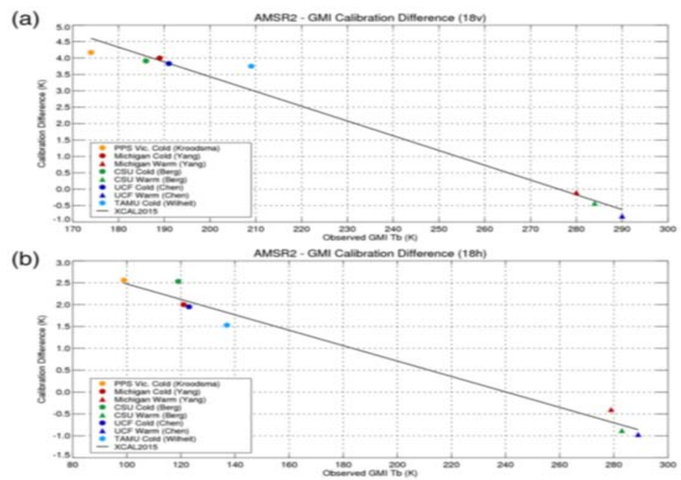
TABLE 9. On-orbit error analysis for GMI over ocean scenes. The results show an rms of all GMI channels. DSC stands for deep space calibration.

Error term	Static bias (K)	Time-varying error (1σ) (K)	Notes
Earth magnetic field correction	0	0.08	20% of rms for all channels
Instrument magnetic correction	0	0.02	20% of rms for all channels
Count bias correction	0.04	0	20% of DSC count bias, rms for all channels
Hot load	0.06	0.10	Preflight predict (1σ), scaled to 200-K ocean
Cold sky	0.04	<0.01	Preflight predict (rms), scaled to 200-K ocean
Nonlinearity	0.05	0	Preflight predict (1σ), scaled to 200-K ocean
Along-scan bias correction	0.00	0.02	20% of rms for all channels
Total T_A error	0.10	0.13	RSS of contributors
Inertial hold backlobe Earth T_B	0.07	<0.01	Results from 2-K error of $T_{B,\mathrm{eff}}/2$
Inertial hold T_A calibration	0.21	0.02	Results from 0.2-K error of $(T_{\mathrm{Av}} + T_{\mathrm{Ah}})/2$
Inertial hold spillover annulus	0.07	<0.01	Results from 30% error on η_a
Total spillover correction error	0.23	0.02	RSS of contributors
X-pol correction error	0.03	0.03	25% of value, rms for all channels
Total T_B error (ocean scene)	0.25	0.14	RSS of T_A, spillover, and X-pol errors

X-Cal



GPM Imager Intercalibration Offsets vs. GMI
TRMM TMI
F18 SSMIS
GCOMW1 AMSR2
F19 SSMIS
F16 SSMIS
Coriolis WindSat
F17 SSMIS
Delta Cal (K)
10v
10h
18v
18h
23v
36v
36h
89v
89h



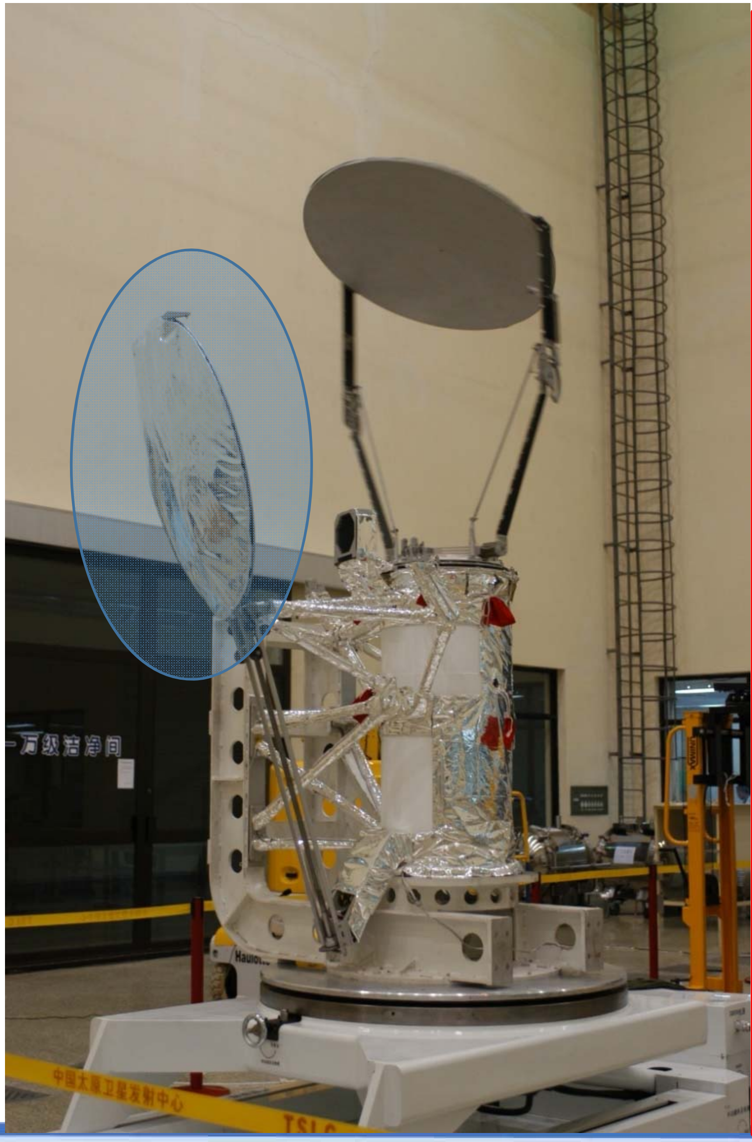
(a)
AMSR2 - GMI Calibration Difference (18v)
(b)
AMSR2 - GMI Calibration Difference (18h)

SNO/Double Difference

Satellite (sensor)	6–7 GHz	10 GHz	19 GHz	23 GHz	31–37 GHz	85–92 GHz	150–166 GHz	183 GHz
GPM (GMI)		10.65v	18.7v	23.8v	36.64v	89.0v	166.0v	183.31 ± 3v
Conical		10.65h	18.7h		36.64h	89.0h	166.0h	183.31 ± 7v
TRMM (TMI)[a]		10.65v	19.35v	21.3v	37.0v	85.5v		
Conical		10.65h	19.35h		37.0h	85.5h		
GCOM-W1 (AMSR2)	6.925v	10.65v	18.7v	23.8v	36.5v	89.0v (A)		
	6.925h					89.0h (A)		
Conical	7.3v	10.65h	18.7h	23.8h	36.5h	89.0v (B)		
	7.3h					89.0h (B)		
DMSP *F16–F19* (SSMIS)			19.35v	22.235v	37.0v	91.655v	150.0h	183.31 ± 1h
conical			19.35h		37.0h	91.655h		183.31 ± 3h
								183.31 ± 6.6h
MetOp-A/B,						89qv	157.0qv	183.31 ± 1qh
NOAA-18/NOAA-19 (MHS)								183.31 ± 3qh
cross track								190.31qv
Suomi-NPP (ATMS)				23.8qv	31.4qv	88.2 qv	165.5qh	183.31 ± 1.0qh
cross track								183.31 ± 1.8qh
								183.31 ± 3.0qh
								183.31 ± 4.5qh
								183.31 ± 7.0qh
Megha-Tropiques (SAPHIR)								183.31 ± 0.2qh
cross track								183.31 ± 1.1qh
								183.31 ± 2.8qh
								183.31 ± 4.2qh
								183.31 ± 6.8qh
								183.31 ± 11qh
Coriolis (WindSat) conical[b]		10.7v	18.7v		37.0v			
	6.8v	10.7h	18.7h	23.8v	37.0h			
	6.8h	10.7–3rd	18.7–3rd	23.8h	37.0–3rd			
		10.7–4th	18.7–4th		37.0–4th			

Incidence angle：
GMI： 52.821
MWRI： 53
AMSR2： 55

Error Source of MWRI Calibration



- Back lobe of hot reflector
- Emission of hot reflector
- Hot load efficiency
- RFI Via cold reflector
- Non-linearity of receiver

Roadmap of Recalibration

$$L_W = \\ = T_{EA}(1-\eta_A) \\ - \eta_A\{T_{ET}(1-\eta_T) \\ + \eta_T[(1-\varepsilon)T_{EC}(1-\eta_H) + (1-\varepsilon)T_H\eta_H \\ + \varepsilon T_R]\}$$

$$L_{nl} = u \times G^2 \times (C_O - C_C) \times (C_O - C_W)$$

$$u = f(T_{rec}, AGC)$$

$$L_O \\ = L_W + \frac{L_W - L_C}{C_W - C_C} \times (C_O - C_W) + L_{nl} + \Delta L_A$$

（1） Back-lobe
（2） hot reflector ε；
（3） Hotload
（4） non-linear correction

$$\Delta L_A = L_{sys}\left[\frac{1}{\Delta v \tau} + \left(\frac{\Delta G}{G}\right)^2\right]^{1/}$$

Calibration Equation and Parameters needs Corrected

$$L_O = L_W + \frac{L_W - L_C}{C_W - C_C} \times (C_O - C_W) + L_{nl} + \Delta L_A$$

Calibration Target

$$L_W = T_{EA}(1-\eta_A) + \eta_A\{T_{ET}(1-\eta_T) + \eta_T[(1-\varepsilon)T_{EC}(1-\eta_H) + (1-\varepsilon)T_H\eta_H + \varepsilon T_R]\}$$

Receiver

$$L_{nl} = u \times G^2 \times (C_O - C_C) \times (C_O - C_W)$$

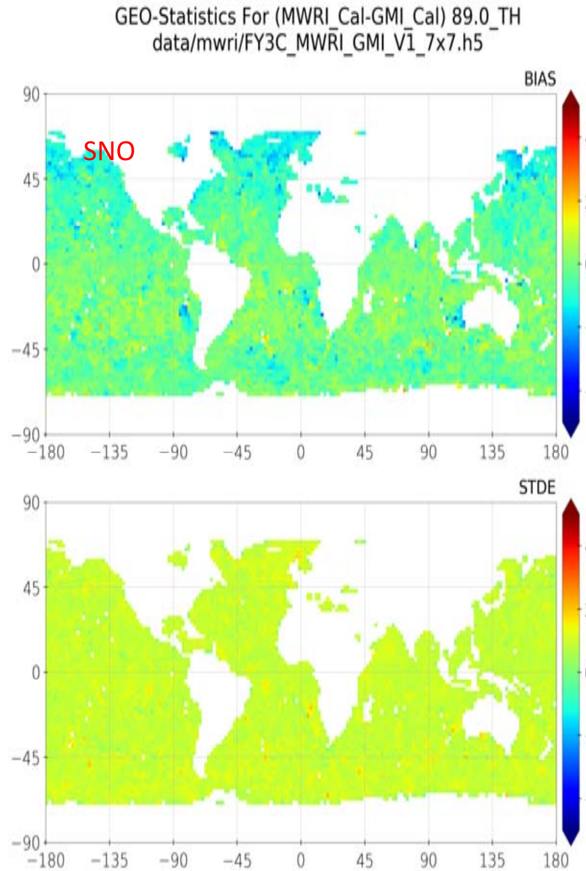
$$u = f(T_{rec}, AGC)$$

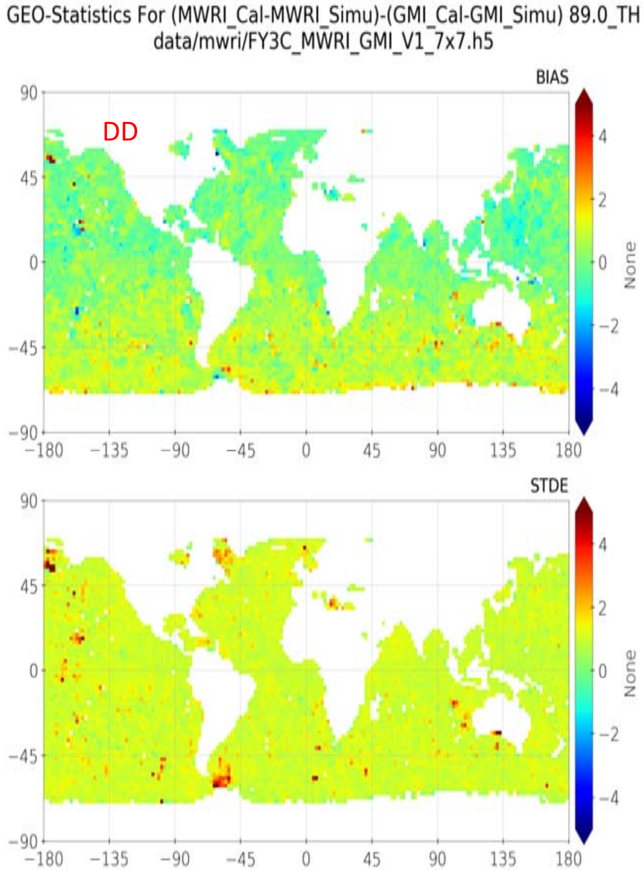
$$\Delta L_A = L_{sys}\left[\frac{1}{\Delta v \tau} + \left(\frac{\Delta G}{G}\right)^2\right]^{1/2}$$

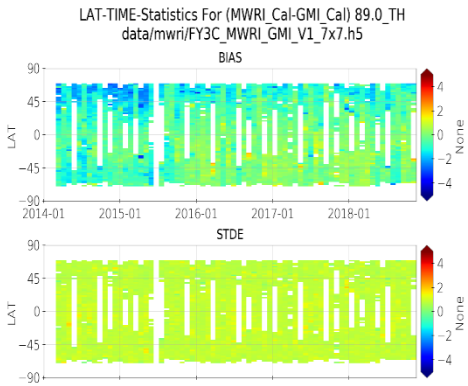
Parameters type

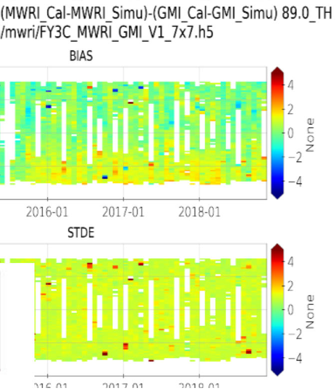
Green box	Reflector
Red box	Source
Blue box	Receiver

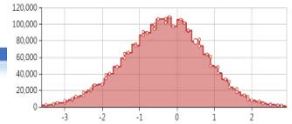
SNO and DD Between MWRI and GMI(89H)

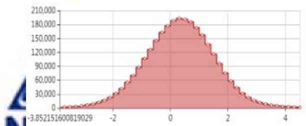












Advantage of Double Difference

- MWRI $Bt^{M} B^{M}$
- GMI $Bt^{G} B^{G}$
- Real BT of SNO points: Bt^{TM}, Bt^{TG}
- SNO： $Bt^{M} - Bt^{G} = (Bt^{TM} + \sigma^{M}) - (Bt^{TG} + \sigma^{G}) = (Bt^{TM} - Bt^{TG}) + (\sigma^{M} - \sigma^{G})$
- DD： $(Bt^{M} - B^{M}) - (Bt^{G} - B^{G}) = (Bt^{TM} + \sigma^{M}) - (Bt^{TG} + \sigma^{G}) - (B^{M} - B^{G}) = (Bt^{TM} - Bt^{TG}) + (\sigma^{M} - \sigma^{G}) - (B^{M} - B^{G}) = (\sigma^{M} - \sigma^{G}) + (Bt^{TM} - B^{M}) - (Bt^{TG} - B^{G}) \cong (\sigma^{M} - \sigma^{G})$

Difference of Model accuracy in the 2 SNO points (~0)

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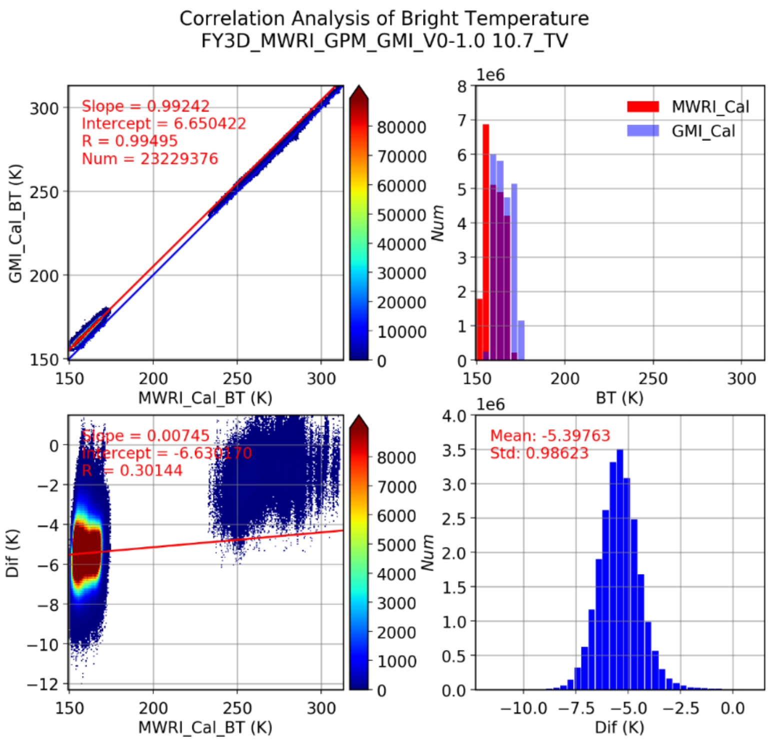
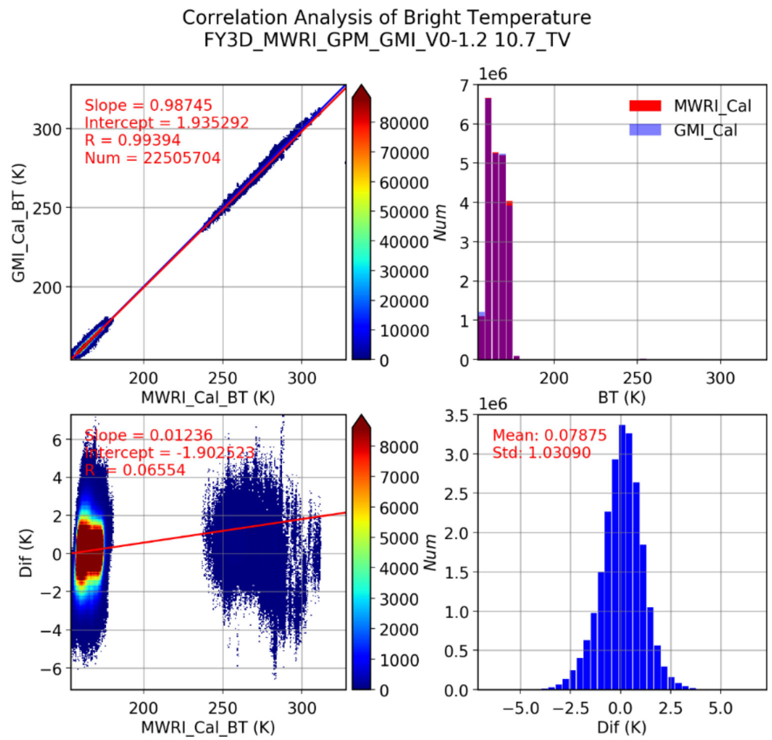
MWRI Recalibration Algorithm

Algorithm	**V1.0**	**V2.0**	
		V1.1	V1.2
Back lobe	Using single orbit get back lobe factor	Global data	Improve data quality control
Hot reflector	Correction based on A/D Bias	Correction based on difference of physical temperature of hotload and hot reflector	Improve data quality control
Hot load	-	Using rain forest data to get better hot load parameter	Using data near the hotload temperature
Nonlinear	-	Using new back lobe, hot reflector and hot load parameters, and double difference data of ocean surface, do the correction of u, and the releation ship between u and receiver temperature.	Using different AGC

	Re-cal Parameters	**Re-cal time series**
FY-3B/MWRI	2014	2010-2019
FY-3C/MWRI	2014	2013-2020
FY-3B/MWRI	2018	2017-present


Correlation Analysis of Bright Temperature
FY3D_MWRI_GPM_GMI_V0-1.0 10.7_TV
Slope = 0.99242
Intercept = 6.650422
R = 0.99495
Num = 23229376
GMI_Cal_BT (K)
MWRI_Cal_BT (K)
MWRI_Cal
GMI_Cal
Num
BT (K)
1e6
Slope = 0.00745
Intercept = -6.630170
R = 0.30144
Dif (K)
Mean: -5.39763
Std: 0.98623


Correlation Analysis of Bright Temperature
FY3D_MWRI_GPM_GMI_V0-1.2 10.7_TV
Slope = 0.98745
Intercept = 1.935292
R = 0.99394
Num = 22505704
GMI_Cal_BT (K)
MWRI_Cal_BT (K)
MWRI_Cal
GMI_Cal
Num
BT (K)
1e6
Slope = 0.01236
Intercept = -1.902523
R = 0.06554
Dif (K)
Mean: 0.07875
Std: 1.03090

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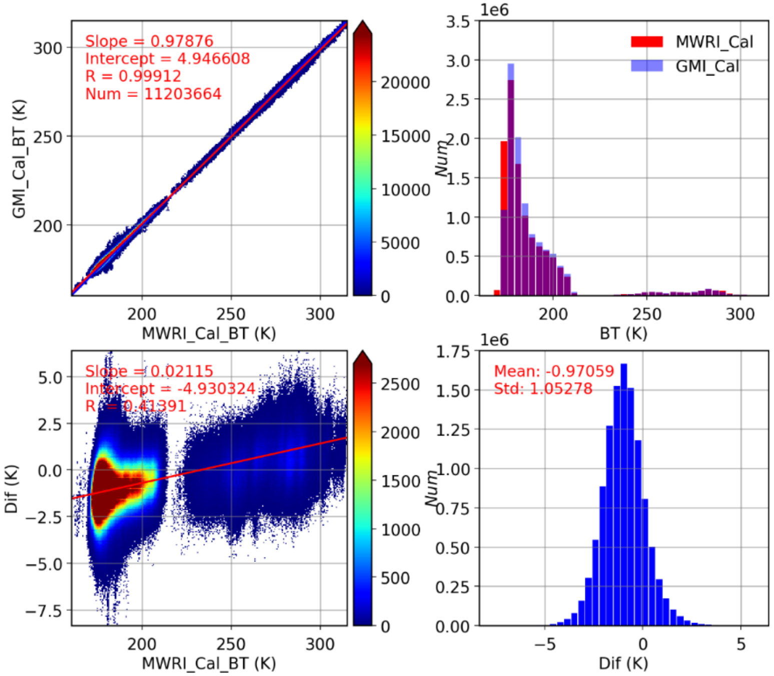
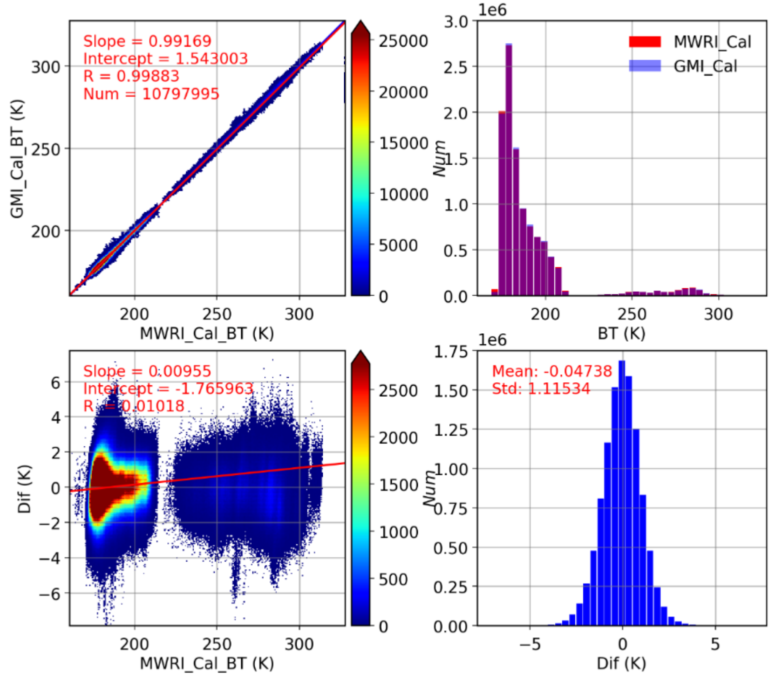
Correlation Analysis of Bright Temperature
FY3D_MWRI_GPM_GMI_V0-1.0 18.7_TV



Correlation Analysis of Bright Temperature
FY3D_MWRI_GPM_GMI_V0-1.2 18.7_TV



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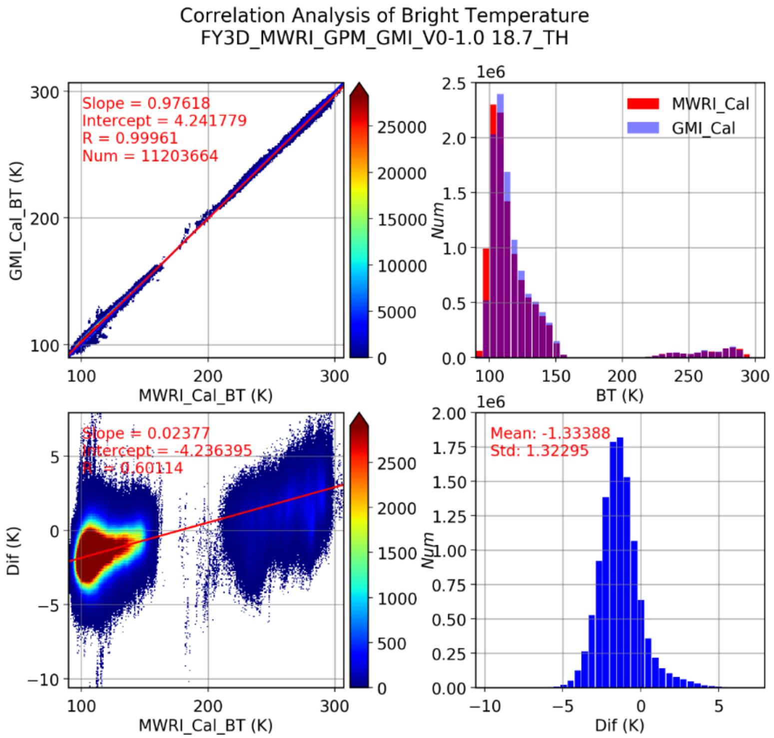
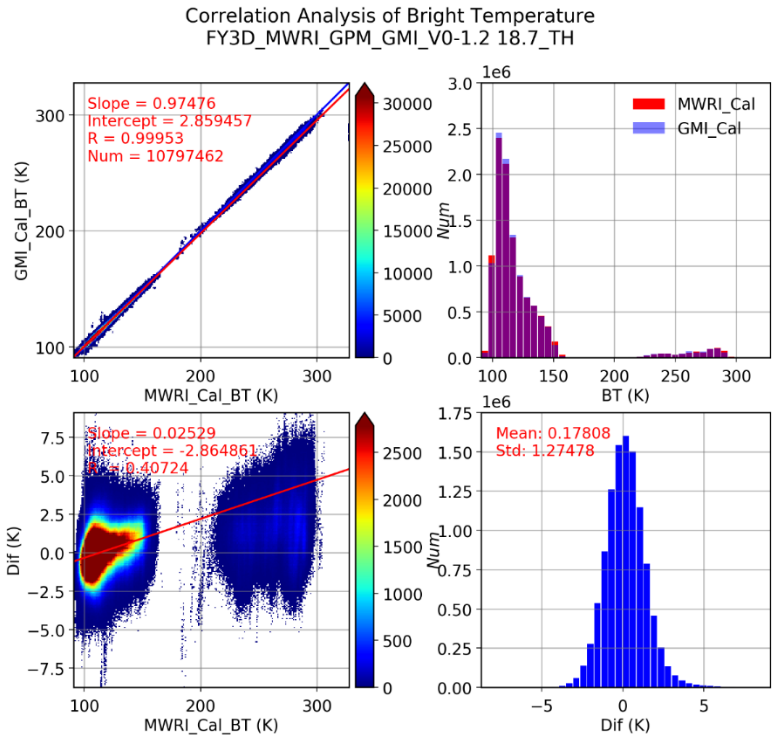

Correlation Analysis of Bright Temperature
FY3D_MWRI_GPM_GMI_V0-1.0 18.7_TH
Slope = 0.97618
Intercept = 4.241779
R = 0.99961
Num = 11203664
GMI_Cal_BT (K)
MWRI_Cal_BT (K)
MWRI_Cal
GMI_Cal
Num
BT (K)
1e6
Slope = 0.02377
Intercept = -4.236395
R = 0.60114
Dif (K)
Mean: -1.33388
Std: 1.32295
Dif (K)


Correlation Analysis of Bright Temperature
FY3D_MWRI_GPM_GMI_V0-1.2 18.7_TH
Slope = 0.97476
Intercept = 2.859457
R = 0.99953
Num = 10797462
GMI_Cal_BT (K)
MWRI_Cal_BT (K)
MWRI_Cal
GMI_Cal
Num
BT (K)
1e6
Slope = 0.02529
Intercept = -2.864861
R = 0.40724
Dif (K)
Mean: 0.17808
Std: 1.27478
Dif (K)

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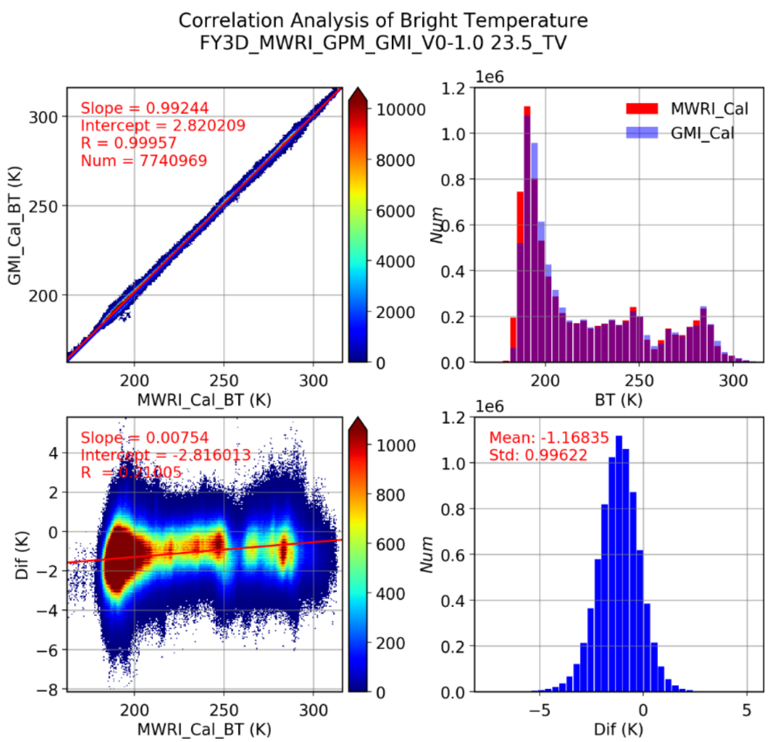
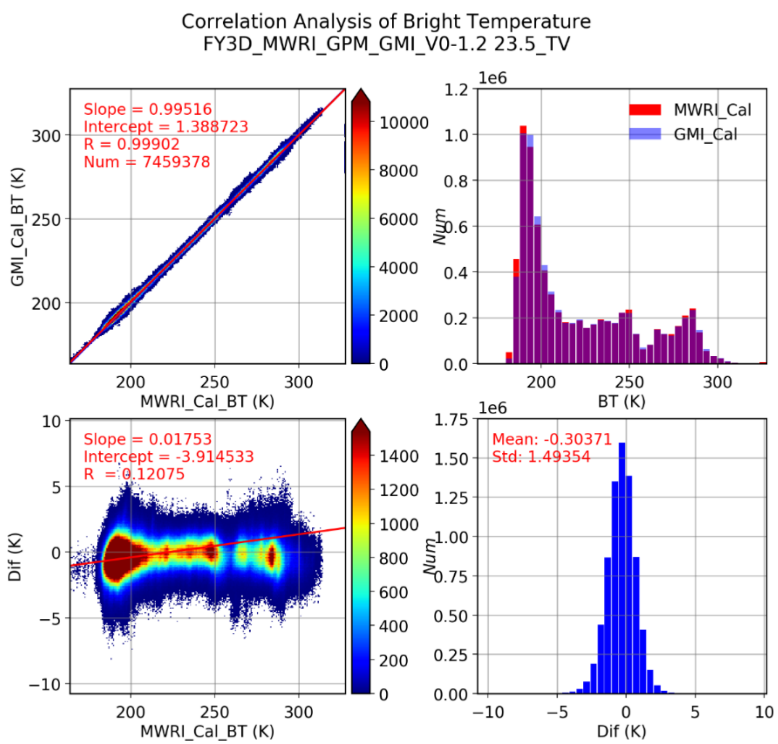
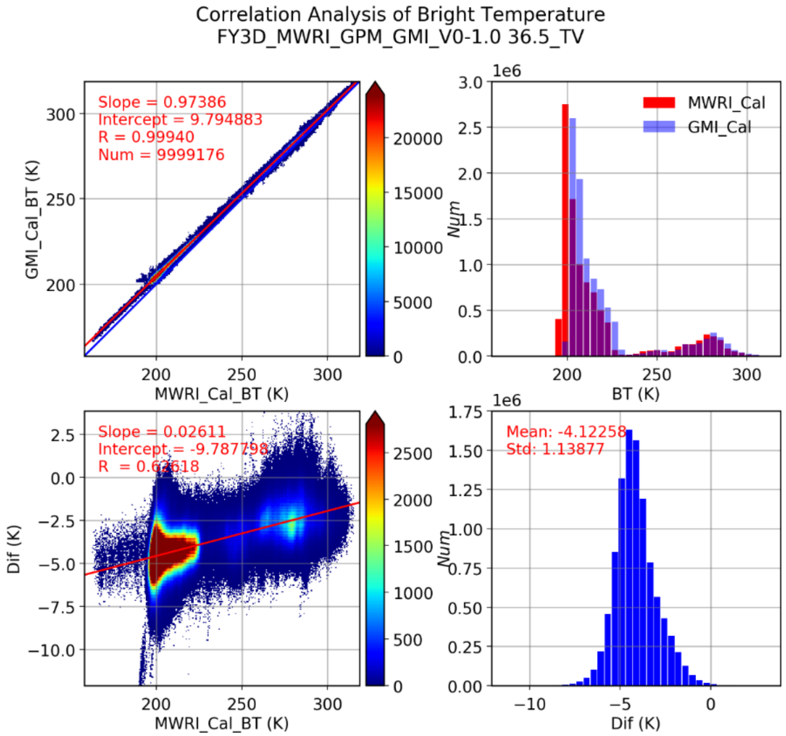
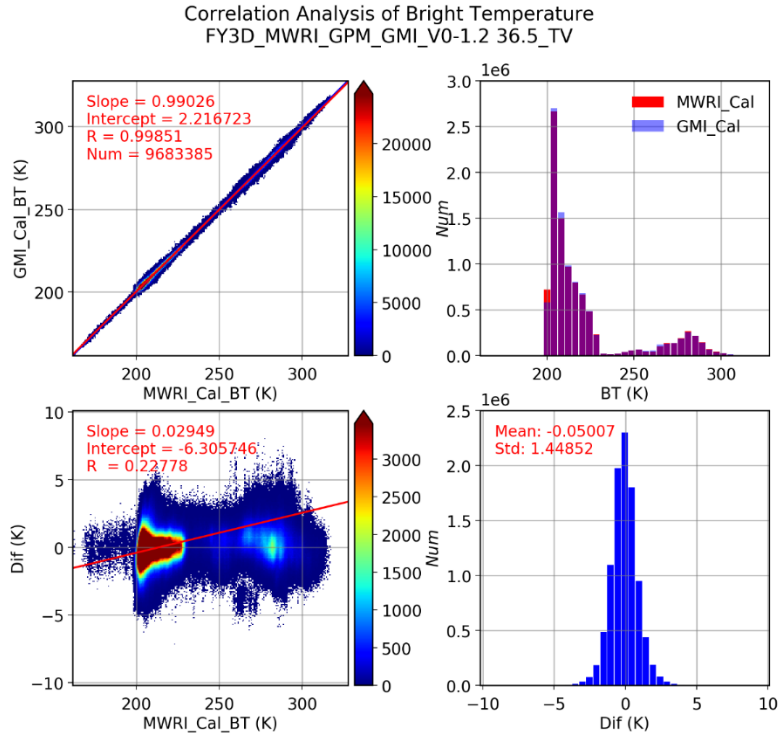

Correlation Analysis of Bright Temperature
FY3D_MWRI_GPM_GMI_V0-1.0 23.5_TV
Slope = 0.99244
Intercept = 2.820209
R = 0.99957
Num = 7740969
GMI_Cal_BT (K)
MWRI_Cal_BT (K)
MWRI_Cal
GMI_Cal
Num
BT (K)
1e6
Slope = 0.00754
Intercept = -2.816013
R = 0.21005
Dif (K)
MWRI_Cal_BT (K)
Mean: -1.16835
Std: 0.99622
Num
Dif (K)


Correlation Analysis of Bright Temperature
FY3D_MWRI_GPM_GMI_V0-1.2 23.5_TV
Slope = 0.99516
Intercept = 1.388723
R = 0.99902
Num = 7459378
GMI_Cal_BT (K)
MWRI_Cal_BT (K)
MWRI_Cal
GMI_Cal
Num
BT (K)
1e6
Slope = 0.01753
Intercept = -3.914533
R = 0.12075
Dif (K)
MWRI_Cal_BT (K)
Mean: -0.30371
Std: 1.49354
Num
Dif (K)


Correlation Analysis of Bright Temperature
FY3D_MWRI_GPM_GMI_V0-1.0 36.5_TV
Slope = 0.97386
Intercept = 9.794883
R = 0.99940
Num = 9999176
GMI_Cal_BT (K)
MWRI_Cal_BT (K)
1e6
MWRI_Cal
GMI_Cal
Num
BT (K)
Slope = 0.02611
Intercept = -9.787798
R = 0.62618
Dif (K)
MWRI_Cal_BT (K)
Mean: -4.12258
Std: 1.13877
Num
Dif (K)


Correlation Analysis of Bright Temperature
FY3D_MWRI_GPM_GMI_V0-1.2 36.5_TV
Slope = 0.99026
Intercept = 2.216723
R = 0.99851
Num = 9683385
GMI_Cal_BT (K)
MWRI_Cal_BT (K)
1e6
MWRI_Cal
GMI_Cal
Num
BT (K)
Slope = 0.02949
Intercept = -6.305746
R = 0.22778
Dif (K)
MWRI_Cal_BT (K)
Mean: -0.05007
Std: 1.44852
Num
Dif (K)

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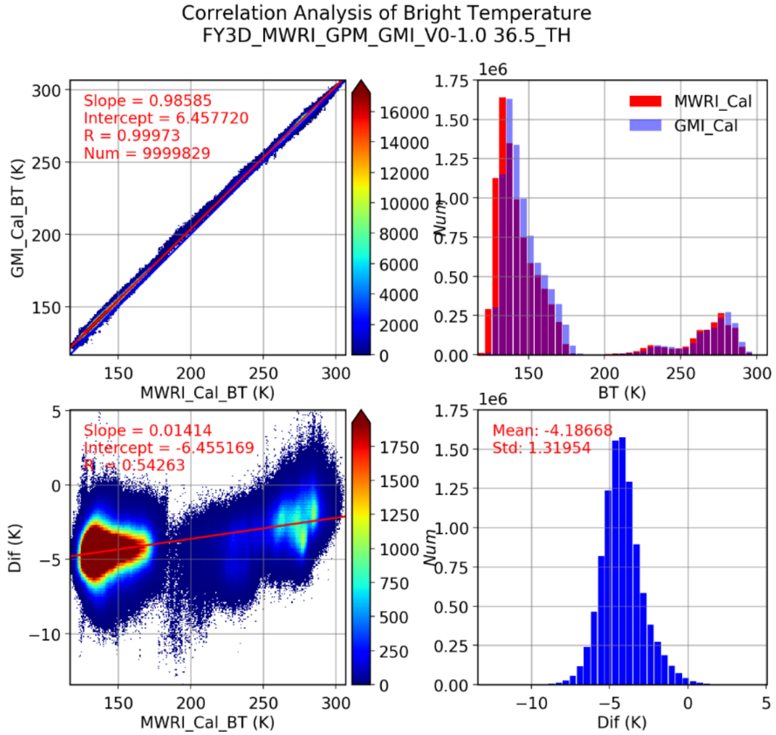
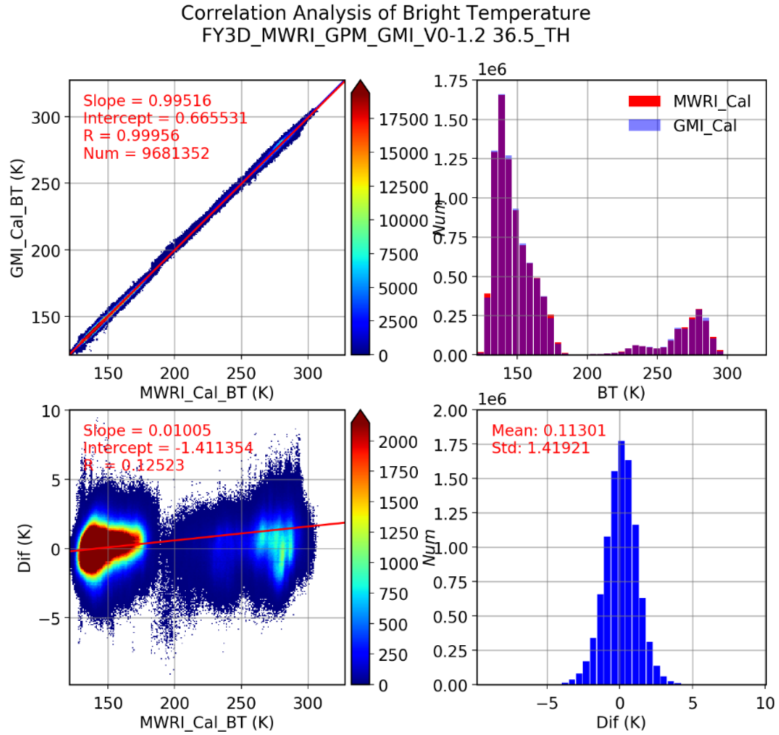
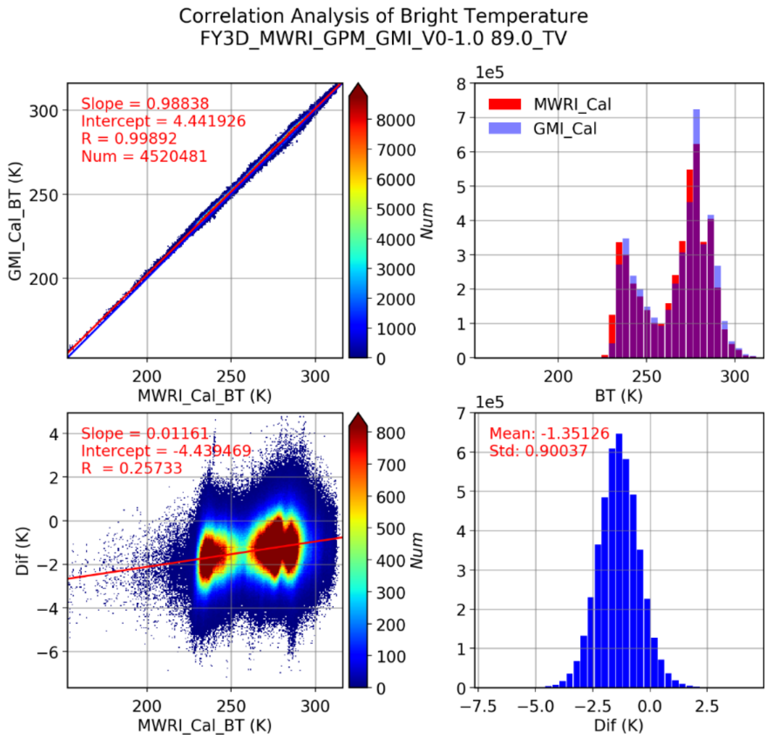
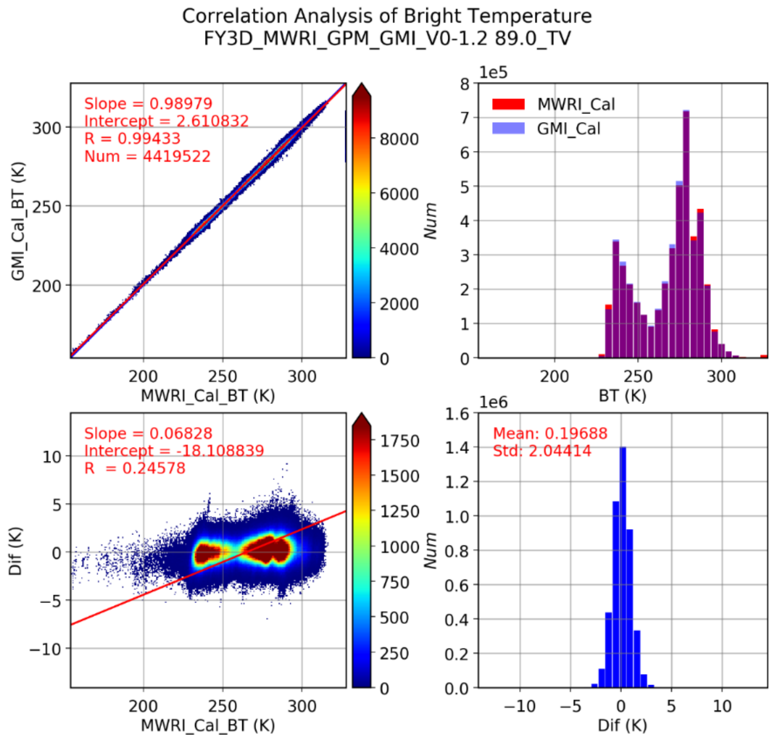

Correlation Analysis of Bright Temperature
FY3D_MWRI_GPM_GMI_V0-1.0 36.5_TH
Slope = 0.98585
Intercept = 6.457720
R = 0.99973
Num = 9999829
GMI_Cal_BT (K)
MWRI_Cal_BT (K)
1e6
MWRI_Cal
GMI_Cal
Num
BT (K)
Slope = 0.01414
Intercept = -6.455169
R = 0.54263
Dif (K)
MWRI_Cal_BT (K)
1e6
Mean: -4.18668
Std: 1.31954
Num
Dif (K)


Correlation Analysis of Bright Temperature
FY3D_MWRI_GPM_GMI_V0-1.2 36.5_TH
Slope = 0.99516
Intercept = 0.665531
R = 0.99956
Num = 9681352
GMI_Cal_BT (K)
MWRI_Cal_BT (K)
1e6
MWRI_Cal
GMI_Cal
Num
BT (K)
Slope = 0.01005
Intercept = -1.411354
R = 0.12523
Dif (K)
MWRI_Cal_BT (K)
1e6
Mean: 0.11301
Std: 1.41921
Num
Dif (K)

CMA NSMC

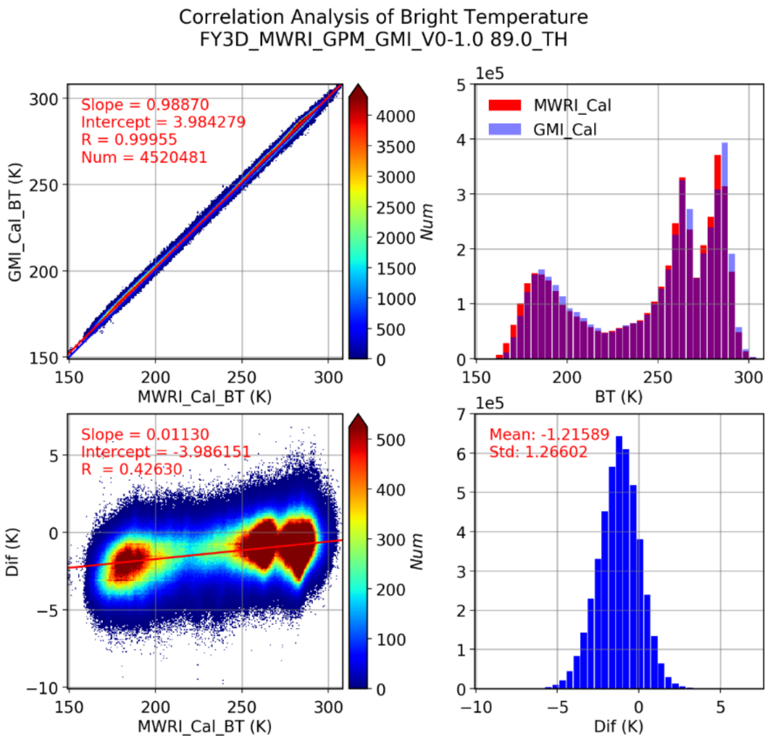


Correlation Analysis of Bright Temperature
FY3D_MWRI_GPM_GMI_V0-1.0 89.0_TV
Slope = 0.98838
Intercept = 4.441926
R = 0.99892
Num = 4520481
GMI_Cal_BT (K)
MWRI_Cal_BT (K)
Num
1e5
MWRI_Cal
GMI_Cal
BT (K)
Slope = 0.01161
Intercept = -4.439469
R = 0.25733
Dif (K)
MWRI_Cal_BT (K)
Num
1e5
Mean: -1.35126
Std: 0.90037
Dif (K)

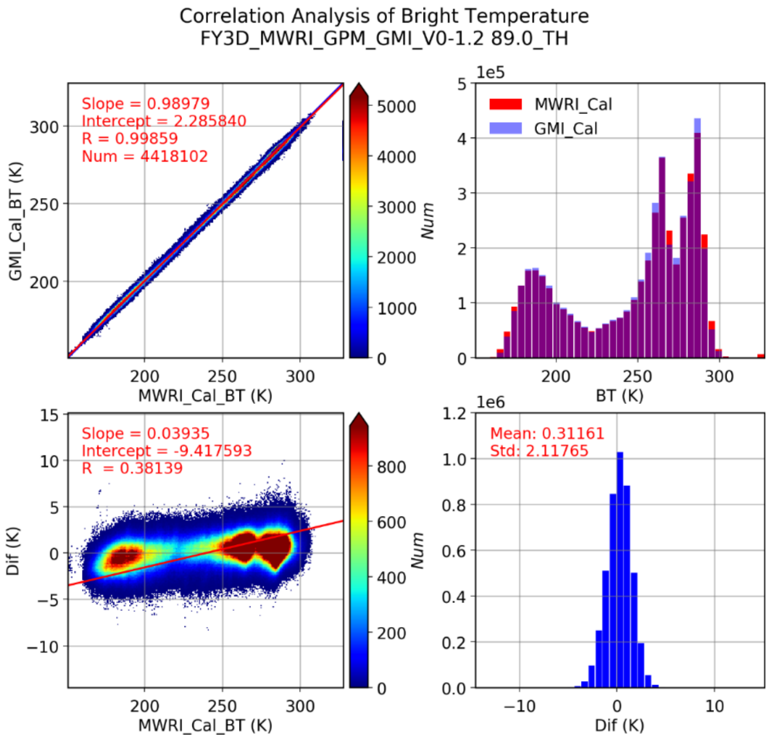


Correlation Analysis of Bright Temperature
FY3D_MWRI_GPM_GMI_V0-1.2 89.0_TV
Slope = 0.98979
Intercept = 2.610832
R = 0.99433
Num = 4419522
GMI_Cal_BT (K)
MWRI_Cal_BT (K)
Num
1e5
MWRI_Cal
GMI_Cal
BT (K)
Slope = 0.06828
Intercept = -18.108839
R = 0.24578
Dif (K)
MWRI_Cal_BT (K)
Num
1e6
Mean: 0.19688
Std: 2.04414
Dif (K)

CMA NSMC



Correlation Analysis of Bright Temperature
FY3D_MWRI_GPM_GMI_V0-1.0 89.0_TH
Slope = 0.98870
Intercept = 3.984279
R = 0.99955
Num = 4520481
GMI_Cal_BT (K)
MWRI_Cal_BT (K)
Num
1e5
MWRI_Cal
GMI_Cal
BT (K)
Slope = 0.01130
Intercept = -3.986151
R = 0.42630
Dif (K)
MWRI_Cal_BT (K)
Num
1e5
Mean: -1.21589
Std: 1.26602
Dif (K)

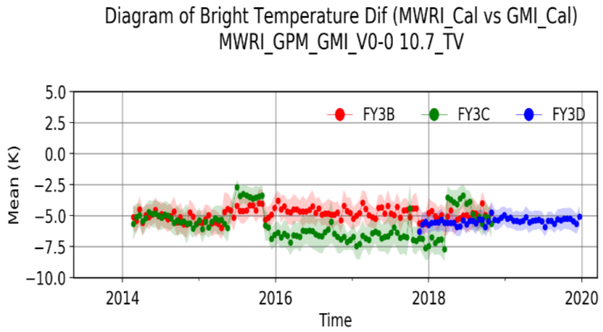


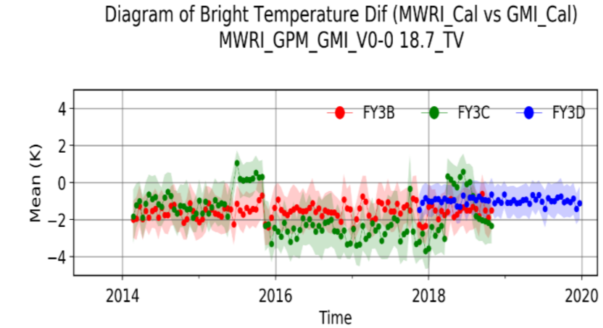
Correlation Analysis of Bright Temperature
FY3D_MWRI_GPM_GMI_V0-1.2 89.0_TH
Slope = 0.98979
Intercept = 2.285840
R = 0.99859
Num = 4418102
GMI_Cal_BT (K)
MWRI_Cal_BT (K)
Num
1e5
MWRI_Cal
GMI_Cal
BT (K)
Slope = 0.03935
Intercept = -9.417593
R = 0.38139
Dif (K)
MWRI_Cal_BT (K)
Num
1e6
Mean: 0.31161
Std: 2.11765
Dif (K)

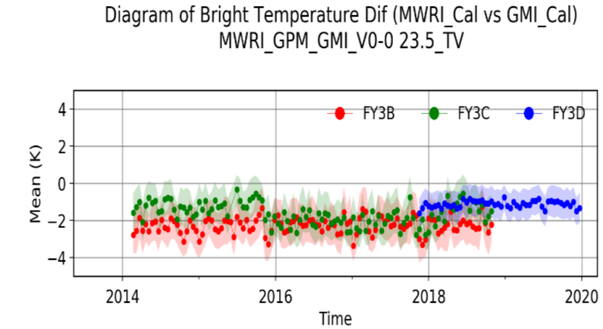
CMA NSMC

FY-3B/C/D MWRI time series

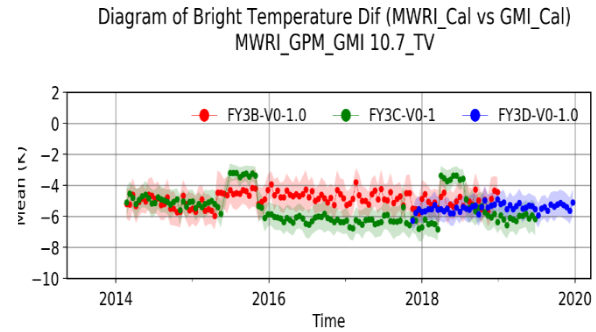
Operational

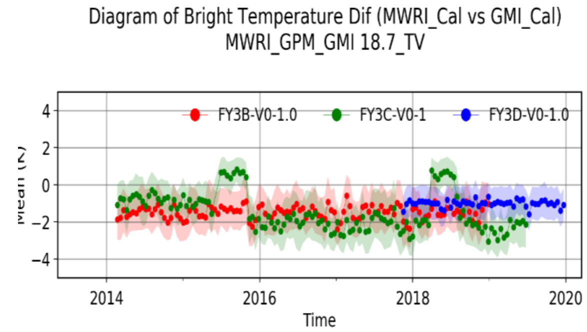


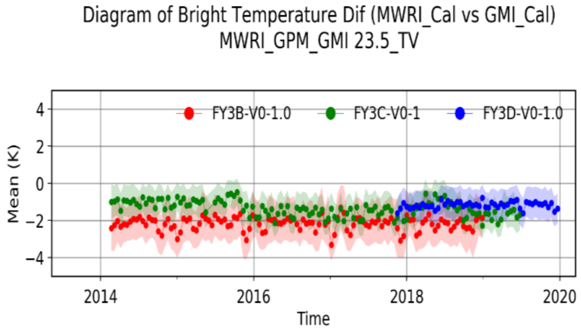




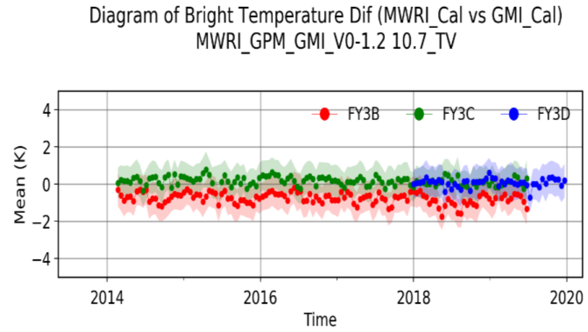
Recal V1.0

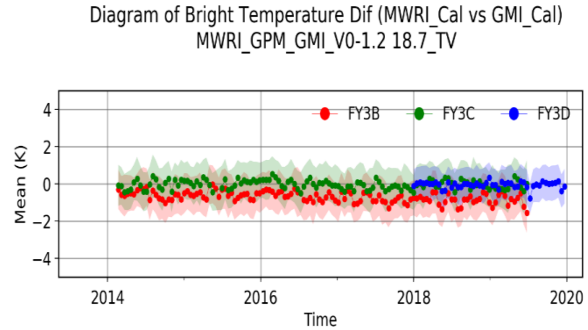


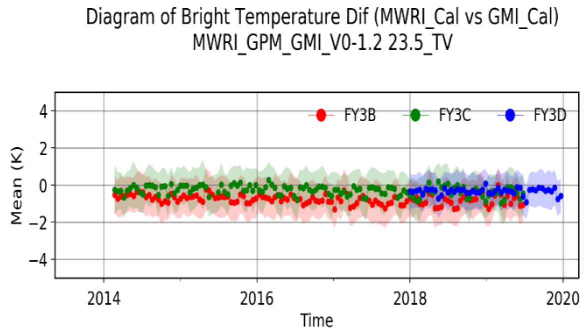




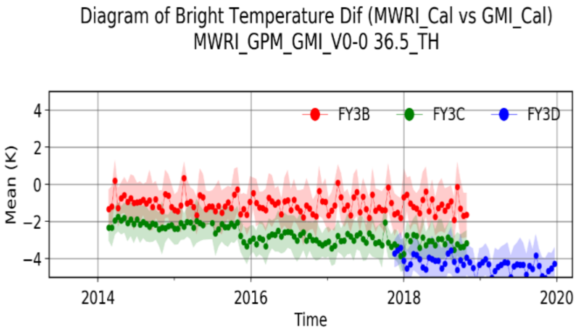
Recal V2.0

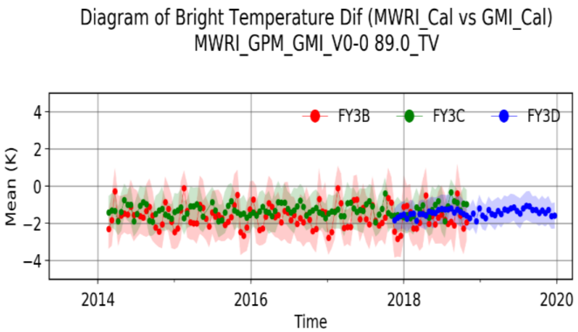


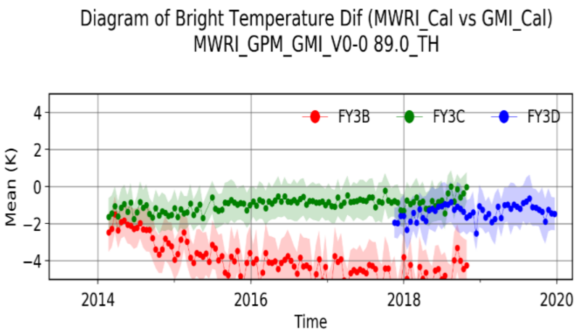




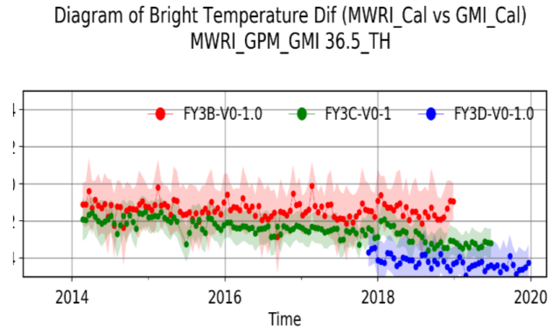
Operational

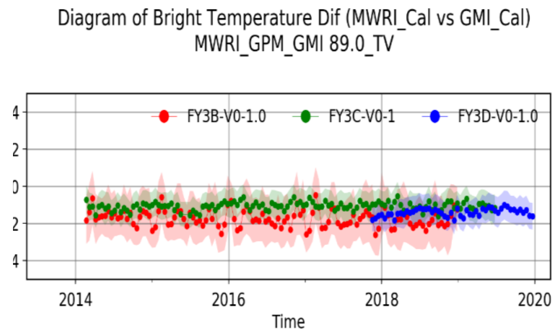


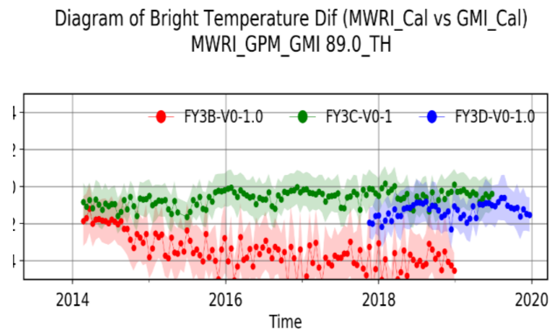




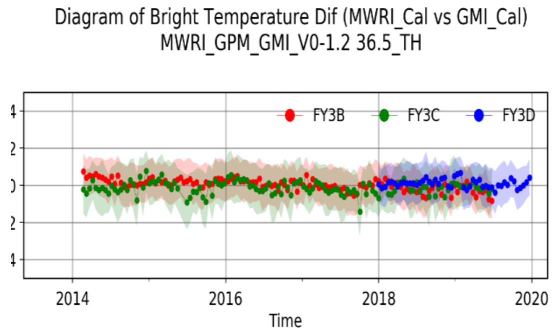
Recal V1.0

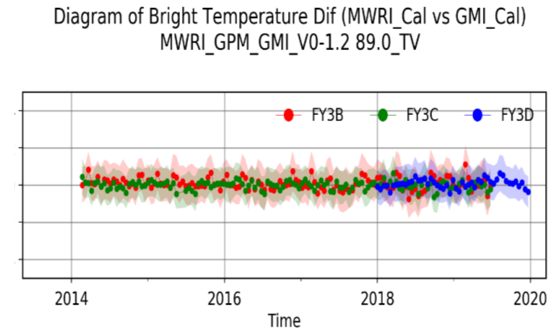


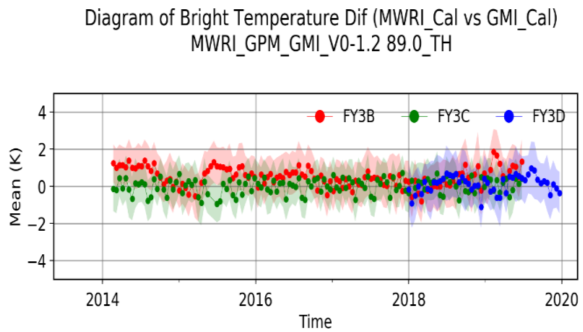




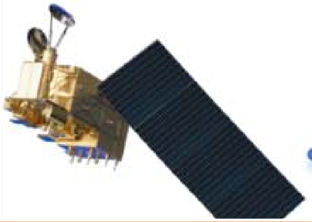
Recal V2.0







CMA NSMC



FY-3B/C/D MWRI

channel	Typical BT (K)	Mean of RMSE (K)		
		operational	Recal V1.0	Recal V2.0
FY-3B				
10V	166.2	5.00	5.00	1.15
10H	91.8	5.66	5.68	1.21
18V	119.4	1.91	1.87	1.26
18H	127.5	3.12	3.15	1.34
23V	224	2.51	2.46	1.29
36V	223.5	5.76	5.59	0.94
36H	172.1	1.62	2.03	1.10
89V	268.8	2.13	2.19	1.02
89H	248.8	4.24	3.85	1.34
FY-3C				
10V	166.2	5.85	5.85	0.88
10H	91.8	8.12	8.15	0.91
18V	119.4	2.27	2.72	1.07
18H	127.5	2.13	2.13	1.08
23V	224	1.95	1.95	1.10
36V	223.5	3.69	3.69	1.04
36H	172.1	2.87	2.87	1.26
89V	268.8	1.62	1.62	0.88
89H	248.8	1.38	1.38	1.15
FY-3D				
10V	166.2	5.51	5.51	0.91
10H	91.8	6.80	6.87	1.04
18V	119.4	1.32	1.33	0.93
18H	127.5	1.79	1.80	1.08
23V	224	1.41	1.45	1.02
36V	223.5	4.28	4.24	0.94
36H	172.1	4.41	4.39	1.09
89V	268.8	1.64	1.63	0.93
89H	248.8	1.82	1.76	1.33

Thanks