Precipitation Processing System (PPS)

NASA Global Precipitation Measurement (GPM) Microwave Imager (GMI) Level 1B (L1B) Algorithm Theoretical Basis Document (ATBD) Version 2.3

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REVISION HISTORY

Revision 5, Version 2.3, February 2016

In this revision, the following describes the calibration changes from Version 03 (V03) GPM Microwave Imager (GMI) Level 1B (L1B)/Base to Production Version 04 (V04) GMI L1B/Base.

1. Adjustment of spillover coefficients of all GMI channels. This adjustment is the major improvement from V03 to V04 in GMI antenna pattern correction (APC). The adjustment of spillover is based on the data from GMI inertial hold and refinements of the analysis performed by the GMI manufacturer. Table 2.12 shows comparisons of APC coefficients reflecting the changes due to spillover adjustments. Brightness temperature (Tb) changes vary from channel to channel and are functions of brightness temperatures. Figure 2.32 demonstrates the Tb changes for all channels in their normal temperature range. For channels 1-5, Tb reduced ~3 – 6 K at their maximums. For channels 10-13, Tb increased ~2 – 4 K at their maximums. For channels 6-9, Tb increased ~0.1 K at their maximums.
2. Adjustment of antenna-induced along-scan bias correction. This is a minor adjustment and may result in Tb changes of less than 0.1 K.
3. Adjustment of magnetic correction coefficients. This is also a minor adjustment and may result in Tb changes of less than 0.1 K.

All of these corrections are implemented in V04 GMI L1B/Base as well as Integration and Testing Environment 043 (ITE043) and ITE057. There were no code adjustments for these updates.

Revision 4, Version 2.0, December 2015

In this revision, using additional post-launch deep-space maneuver data, Ball Aerospace and Technologies Corporation (BATC)/Remote Sensing Systems (RSS) revised antenna pattern correction coefficients for some of the channels (Section 2.2). A Noise Equivalent Delta Temperature (NEDT) computation was also added in Section 2.5.

Revision 3, Version 1.0, September 2014

In this revision, using post-launch deep-space maneuver data, BATC/RSS provided an algorithm to correct errors induced by instrument susceptibility to magnetic fields (Section 2.4). There were also along-scan corrections on main reflector antenna patterns (Section 2.2). Post-launch validation (Section 2.5) was revised to include analyses of GMI antenna temperature (Ta)/Tb data in the September 2014 public release. Algorithms for detecting radio frequency interference (RFI) on cold load were also revised (Section 2.1.5). In Section 1, spectrum response charts for all channels were added.

Revision 2, Version 0.4, June 2014

In this revision, the GMI L1B algorithms were updated with new Ball sensor data and code updates for the public release on June 16, 2014. Sections 2.1.5 and 2.1.6 were updated accordingly to comply with the algorithm updates, including new Table 2.9, Maximum values for correction code computation, and new Figure 2.5, Sample GMI 10 GHz V channel Ta (upper) and 166 GHz V channel Ta (lower).

Revision 1, Version 0.3, April 2014

In this revision, post-launch studies from BATC/RSS provided new tables of on-orbit hot/cold sample ranges (Table 2.4, Hot load sampling, and Table 2.6, Cold sky sampling). Non-linearity look-up tables (Appendix A) and diode excess temperature look-up tables (Appendix C) were updated, and the number of scans to be averaged in multi-scan calibration was also revised (Section 2.1).

1. INTRODUCTION

1.1 OBJECTIVE

This document describes the GMI Level 1B algorithm developed by PPS. It consists of physical bases and mathematical equations for GMI calibration, as well as after-launch activities. The document also presents high-level software design. Parts of this document are from the Remote Sensing Systems (RSS) GMI Calibration ATBD and the BATC Calibration Data Book as contributed by the BATC GMI manufactory contract. The GMI L1B geolocation algorithm is described in a separate Geolocation Toolkit ATBD.

1.2 INSTRUMENT DESCRIPTION

GMI is a conically scanning microwave radiometer on board the GPM core satellite. The core satellite flies in a 407-km circular orbit with a 65° inclination angle. The GMI has 13 channels at frequencies of 10.65, 18.7, 23.8, 36.64, 89, 166, and 183.31 GHz. Except the heritage hot load and cold load that are commonly used for linear sensor radiometric calibrations, hot noise diodes and cold noise diodes are implemented in the GMI to determine the non-linearity and noise levels of the measurements. Figure 1.1 and Figure 1.2 show the main components of the GMI.

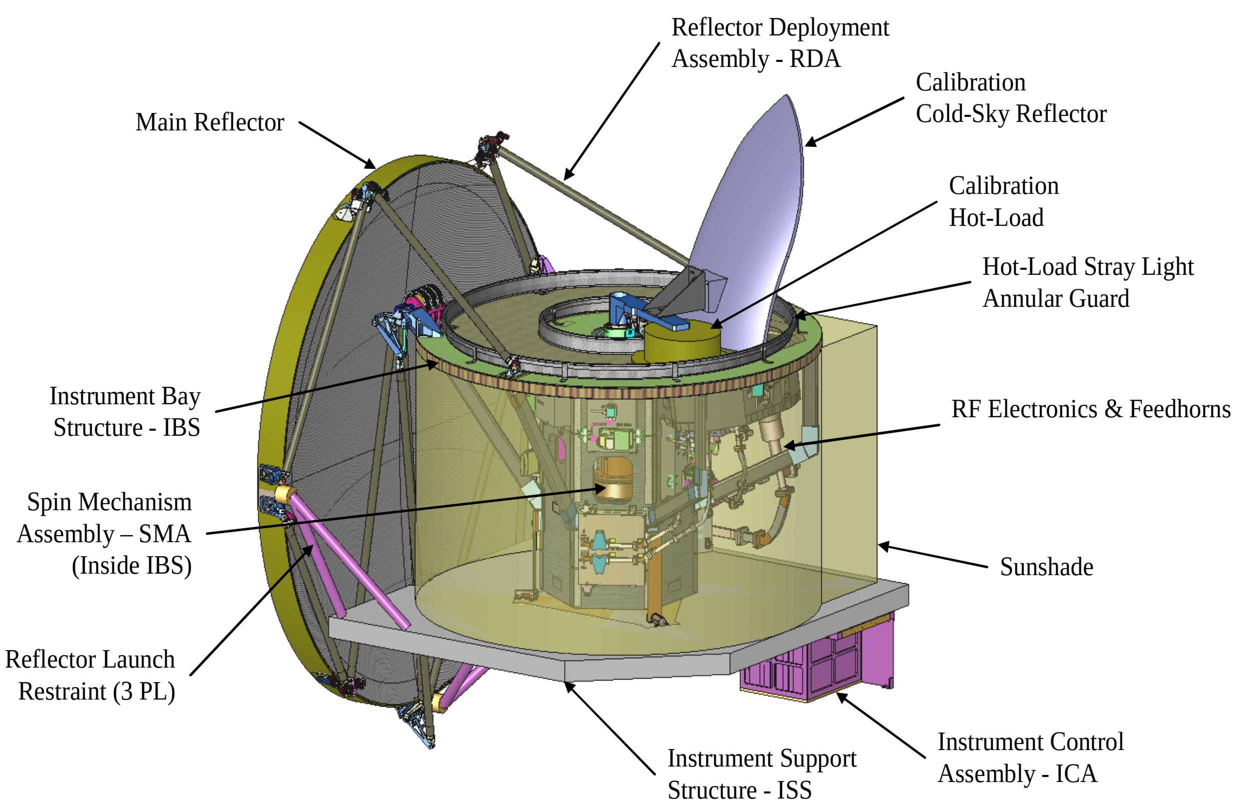

Figure 1.1. GMI instrument stowed configuration; provided by BATC.

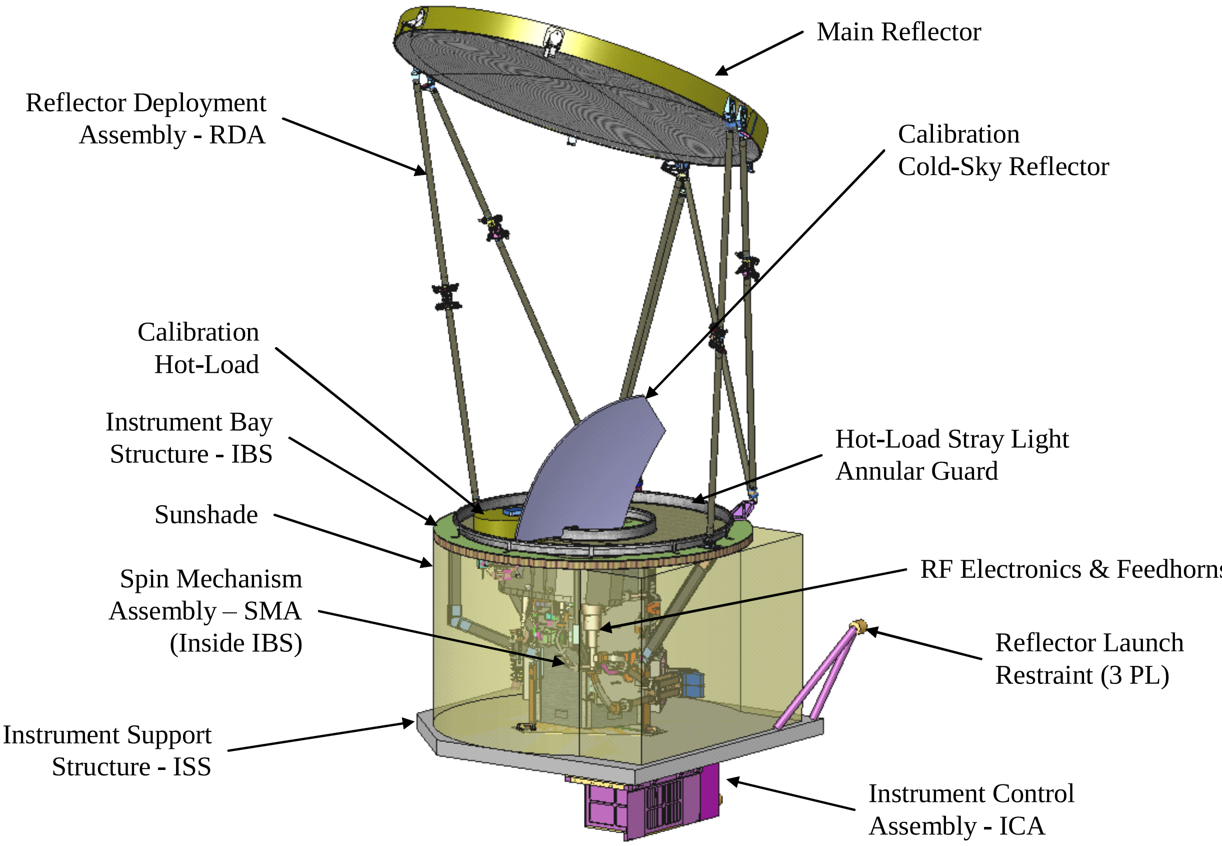

Figure 1.2. GMI instrument deployed configuration; provided by BATC.

Key GMI sensor data include:

Nominal altitude: 407 km
Orbital inclination: 65 deg
Spin rate: 32 rpm
Scan time: 1.875 sec
Earth swath width: 885 km
Earth viewing sector: 145 deg
Earth samples: 221
Integration time: 3.6 msec
Dish size: 1.22 m

The GMI 1Base file also includes antenna temperature of full rotation swaths (about 500 samples). Some of the important sensor specifications can be found in Table 1.1.

Table 1.1. Reference for important instrument and orbital parameters.

Channel #	Center Frequency (GHz)	pol	Nadir Angle (degree)	Earth Incidence Angle (degree)	Beam width (degree)	Footprint (km×km)	Cold samples per scan	Hot samples per scan	Earth samples per scan	Band width (MHz)
1,2	10.65	v/h	48.5	52.821	1.72	32.1×19.4	19/25	13/19	211/221	100
3,4	18.7	v/h	48.5	52.821	0.98	18.1×10.9	31/37	13/19	211/221	200
5	23.8	v	48.5	52.821	0.85	16.0×9.7	31/37	13/19	211/221	400
6,7	36.64	v/h	48.5	52.821	0.81	15.6×9.4	45/51	19/25	211/221	1000
8,9	89	v/h	48.5	52.821	0.38	7.2×4.4	45/51	25/31	211/221	6000
10,11	166	v/h	45.36	49.195	0.37	6.3×4.1	45/51	27/33	211/221	4000
12	183.31 ±3		45.36	49.195	0.37	5.8×3.8	45/51	27/33	211/221	2000
13	183.31 ±7		45.36	49.195	0.37	5.8×3.8	45/51	27/33	211/221	2000

For a number of samples, the first is for radar blanking on and the second is for radar blanking off. However, the cold and hot sample tables were revised after launch (see Table 2.6 and Table 2.4 for the best samples used in calibration).

Figure 1.3 to Figure 1.15 demonstrate the typical spectral response of the 13 GMI channels.

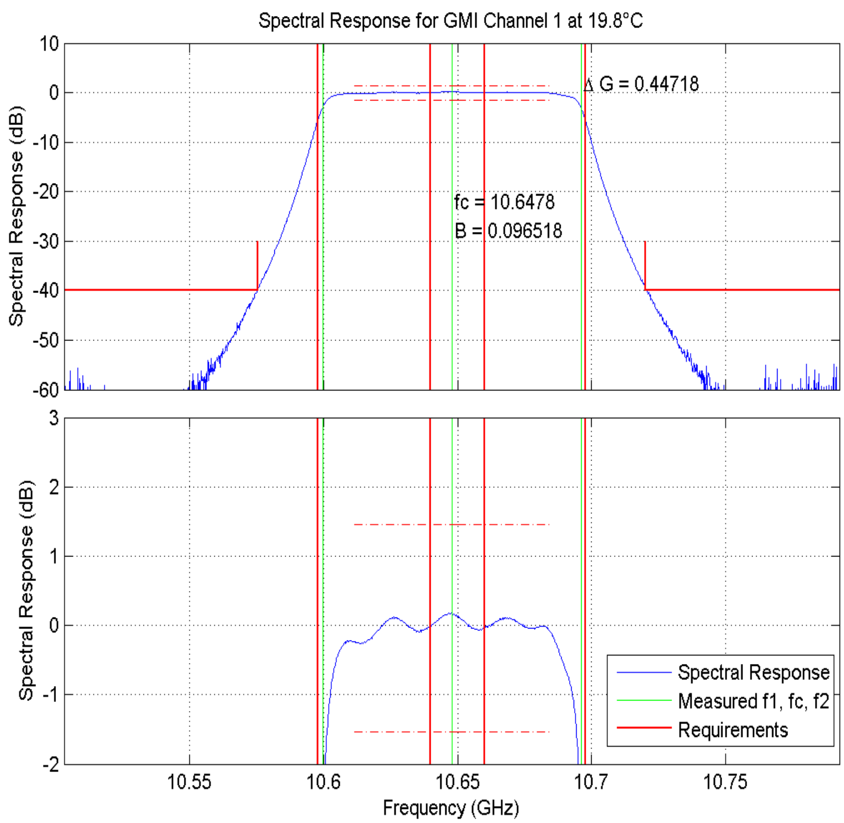

Figure 1.3. Band-pass and gain variation verification data for channel 1 at 19.8°C.

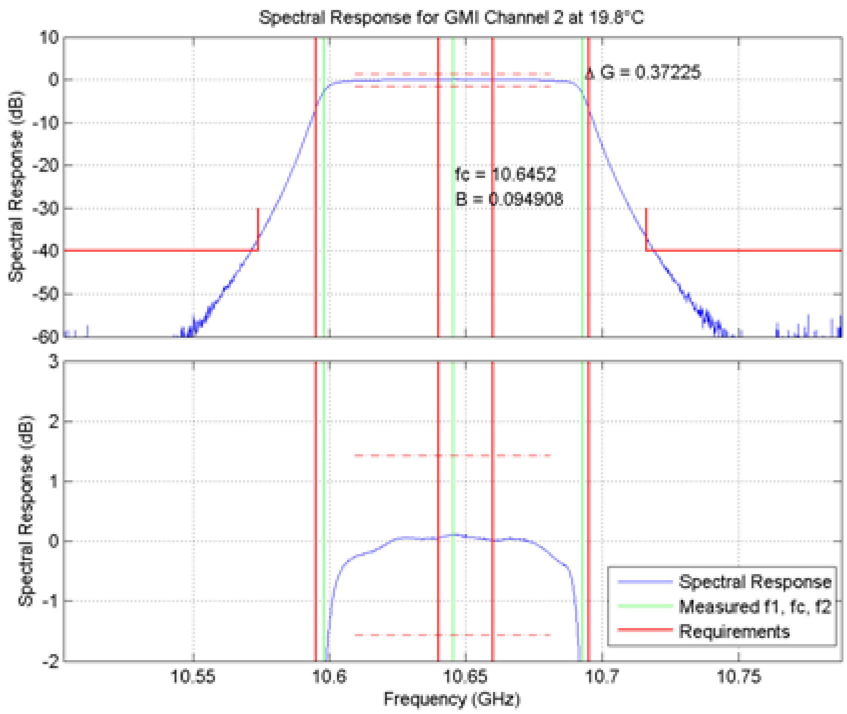

Figure 1.4. Band-pass and gain variation verification data for channel 2 at 19.8°C.

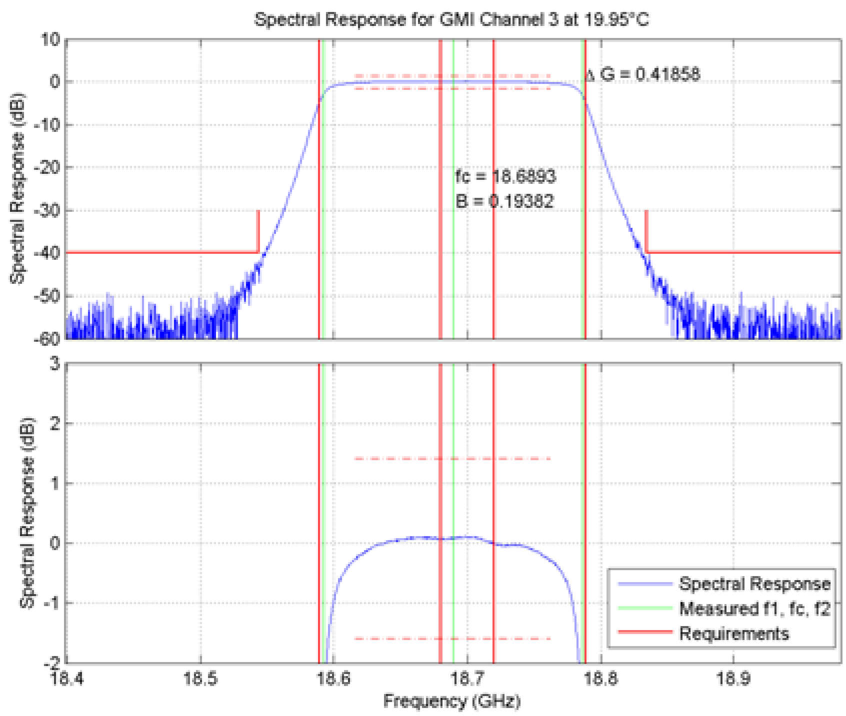

Figure 1.5. Band-pass and gain variation verification data for channel 3 at 19.95°C.

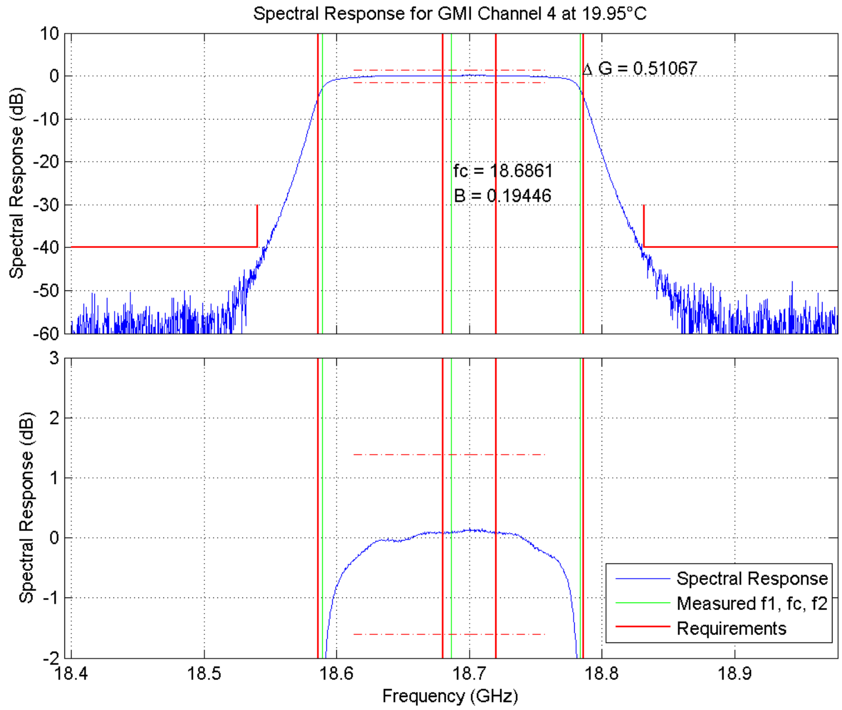

Figure 1.6. Band-pass and gain variation verification data for channel 4 at 19.95°C.

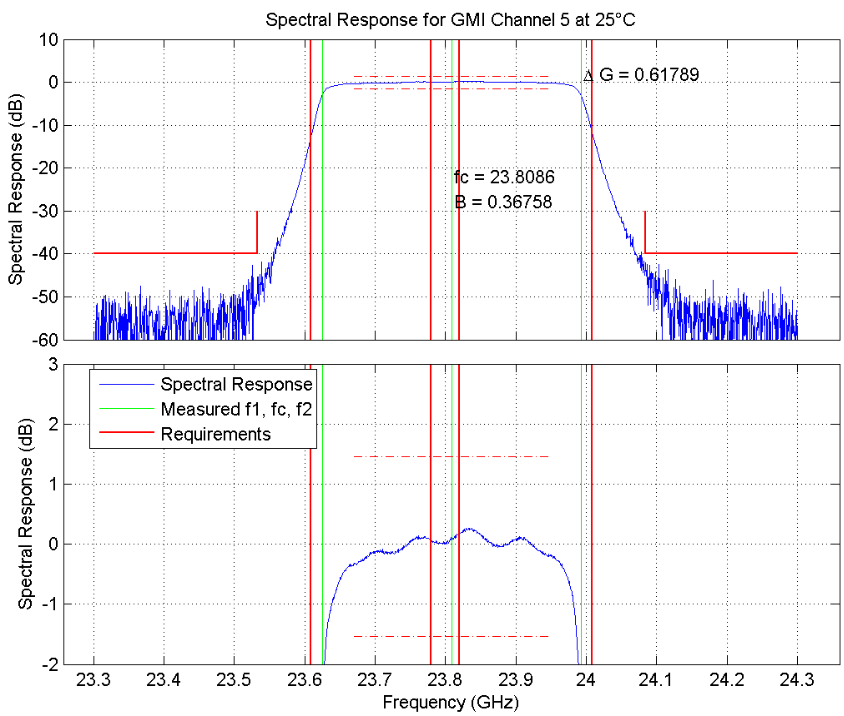

Figure 1.7. Band-pass and gain variation verification data for channel 5 at 25°C.

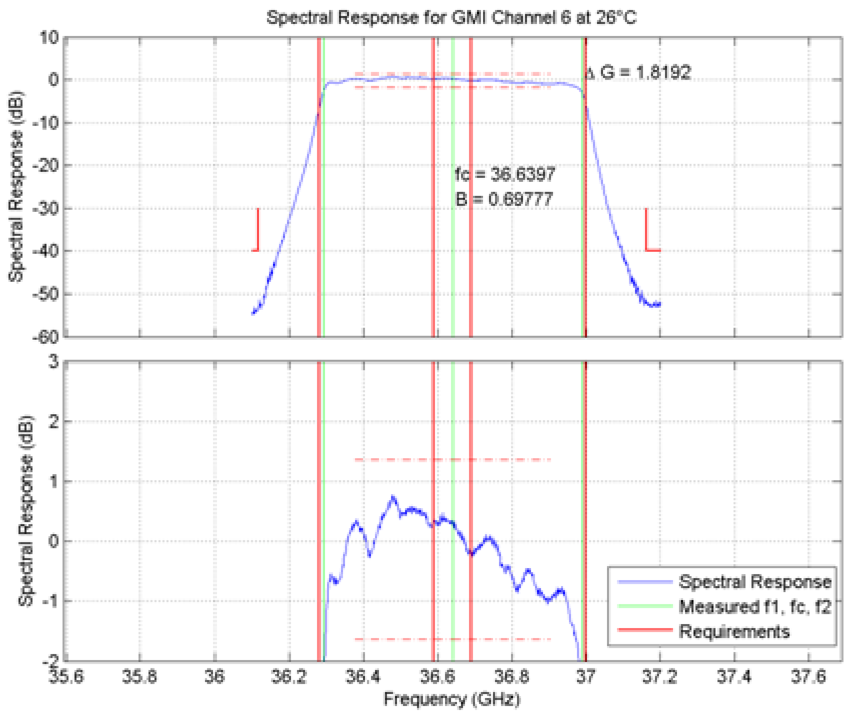

Figure 1.8. Band-pass and gain variation verification data for channel 6 at 26°C.

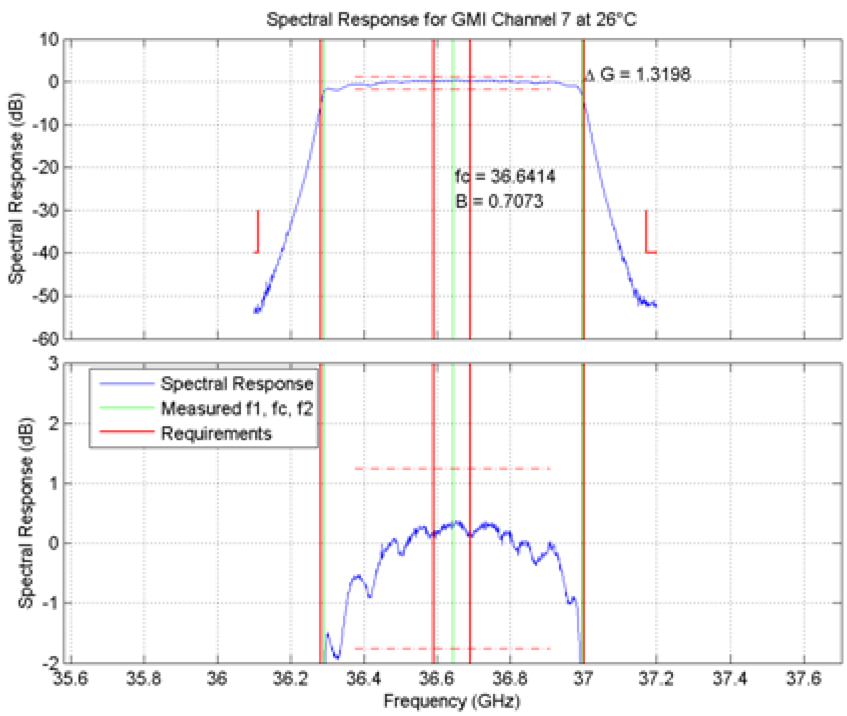

Figure 1.9. Band-pass and gain variation verification data for channel 7 at 26°C.

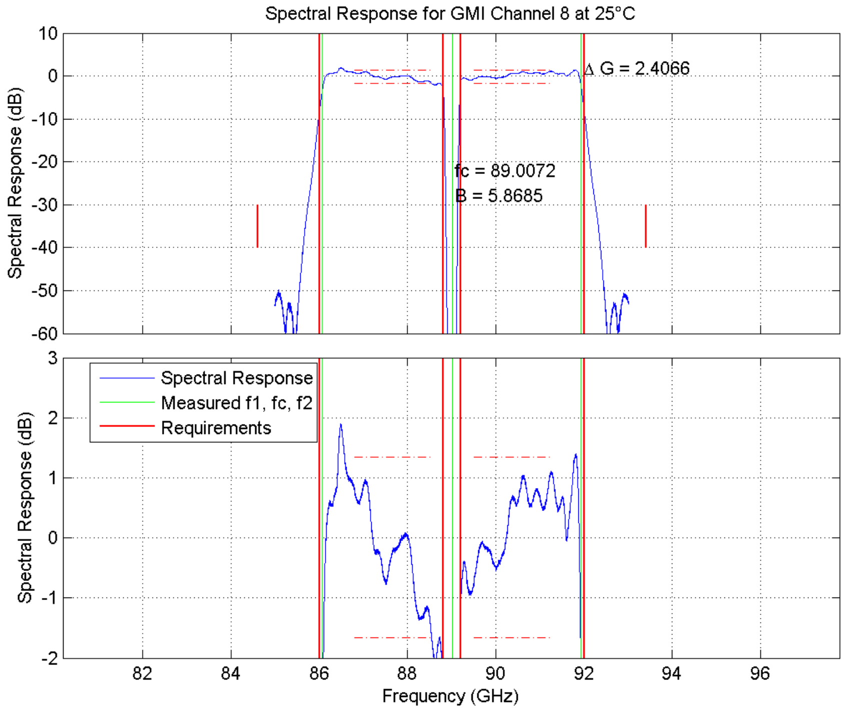

Figure 1.10. Band-pass and gain variation verification data for channel 8 at 25°C.

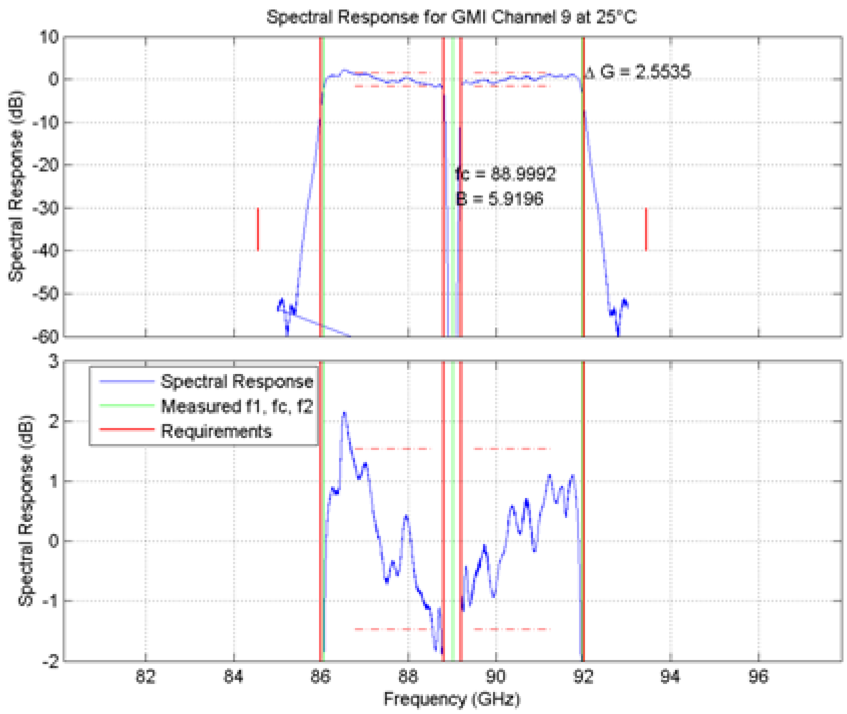

Figure 1.11. Band-pass and gain variation verification data for channel 9 at 25°C.

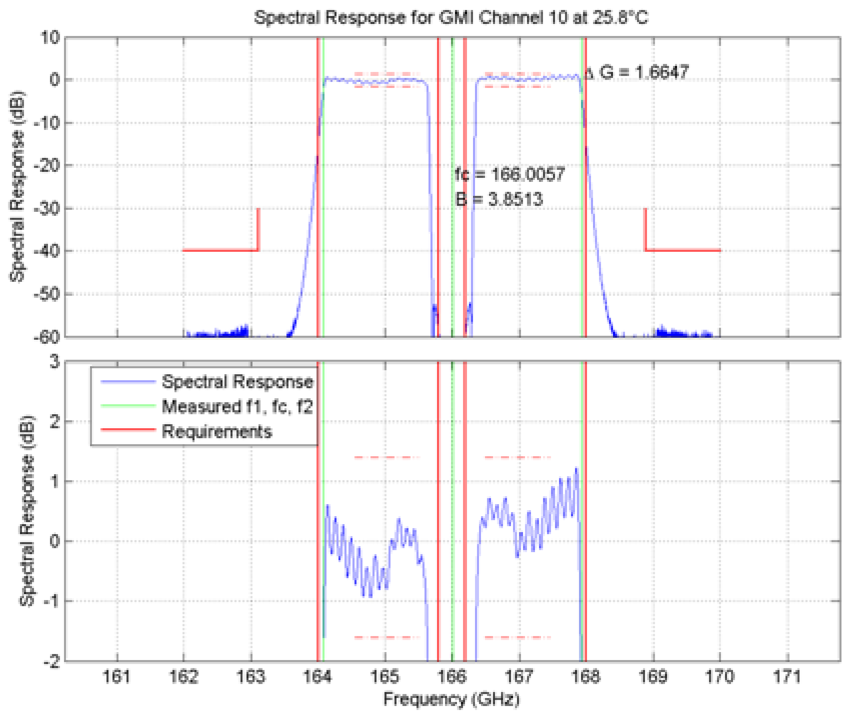

Figure 1.12. Band-pass and gain variation verification data for channel 10 at 25.8°C.

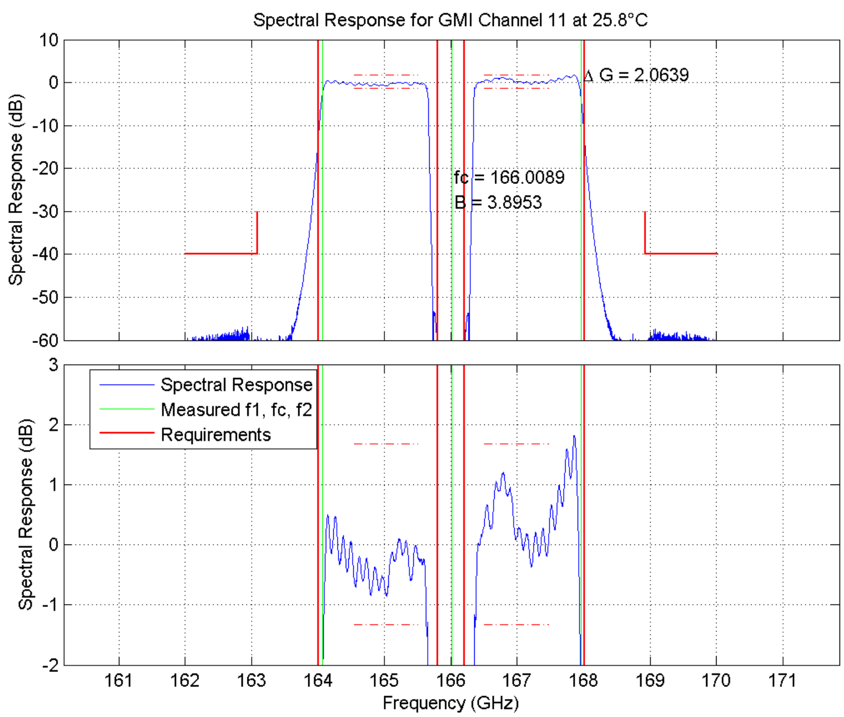

Figure 1.13. Band-pass and gain variation verification data for channel 11 at 25.8°C.

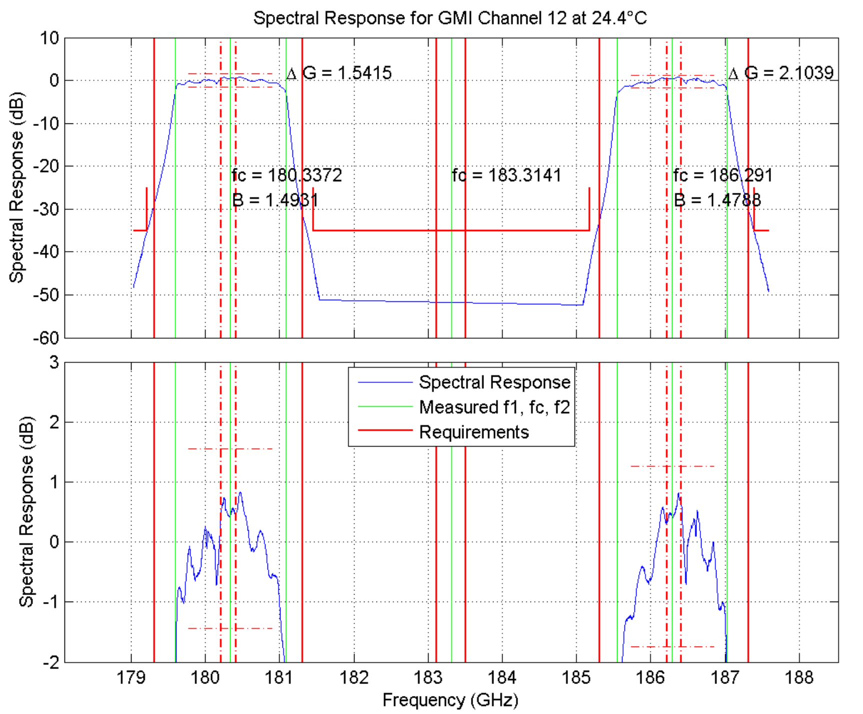

Figure 1.14. Band-pass and gain variation verification data for channel 12 at 24.4°C.

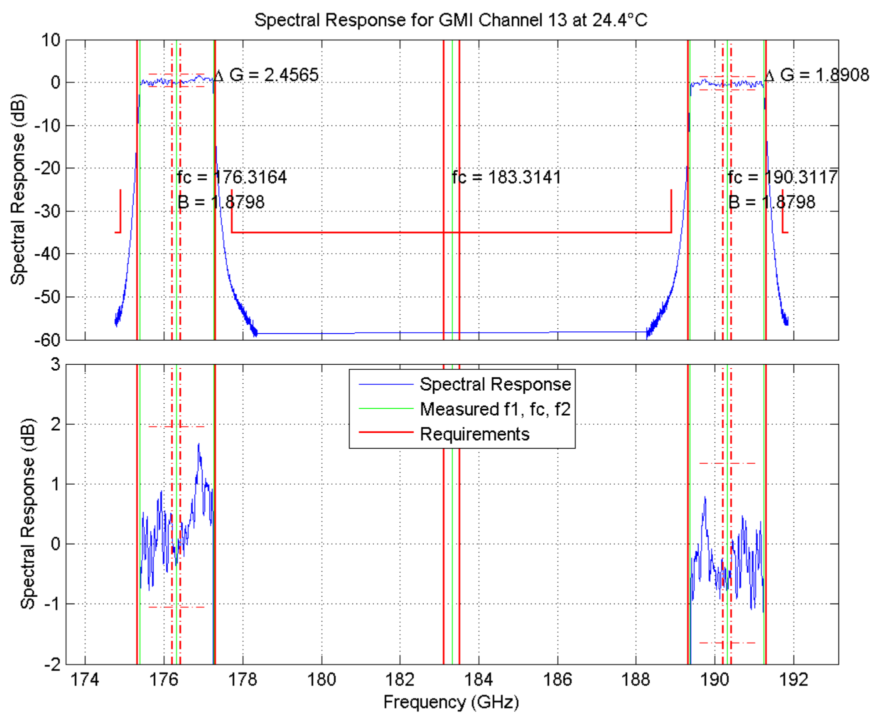

Figure 1.15. Band-pass and gain variation verification data for channel 13 at 24.4°C.

1.3 L1B ALGORITHM OVERVIEW

The Level 1B algorithm and software transform Level 0 counts into geolocated and calibrated antenna temperatures (Ta) and brightness temperatures (Tb). Ta is obtained by utilizing the sensor radiometric calibration as well as various corrections based on after-launch analyses. Tb is derived from Ta after antenna pattern correction (APC) and along-scan corrections. Figure 1.16 describes the relationship between algorithm components and products (or output).

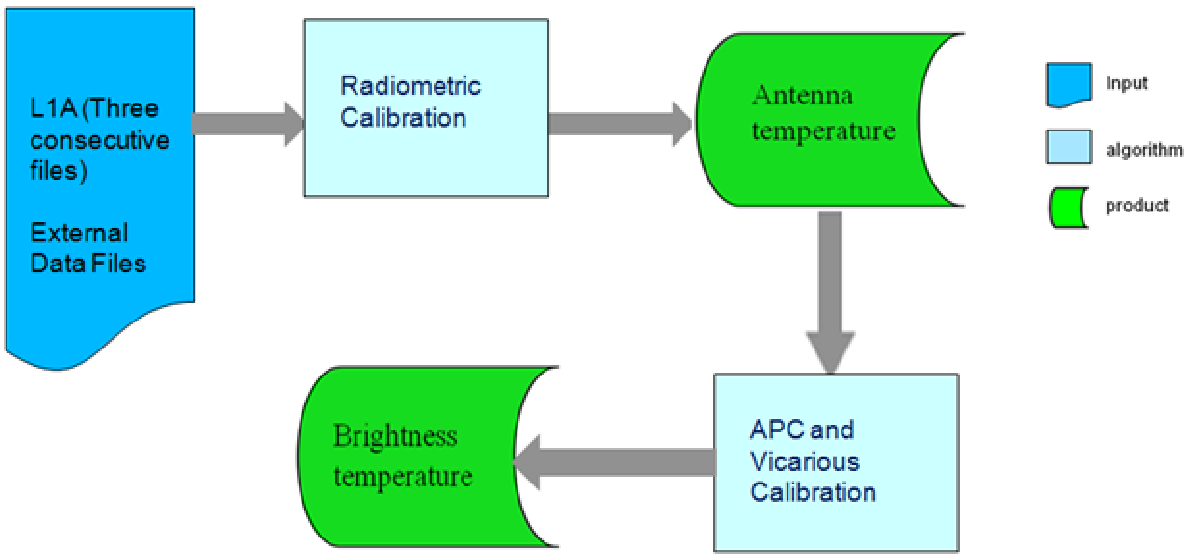

Figure 1.16. The top-level flow chart of the GMI L1B algorithm.

1.4 L1B DATA DESCRIPTION

The standard Level 1B GMI data are geolocated and calibrated microwave antenna temperature (Ta) and brightness temperature (Tb) in two separate data files. The base Ta data file (GMIBASE) includes all calibration parameters and measurements that are used to generate Ta and all navigation parameters that are used to "geolocate" the pixel. The base Ta data file also includes two full scan swaths. Four geolocated swaths in GMIBASE are as follows:

1. Low-frequency swath (S1, channels 1-9, 221 pixels).
2. High-frequency swath (S2, channels 10-13, 221 pixels).
3. Full low-frequency swath (S3, maximum 500 pixels).
4. Full high-frequency swath (S4, maximum 500 pixels).

The Tb data file (1BGMI) includes all parameters for corrections of Ta. 1BGMI only has S1 and S2 swaths. Both GMIBASE and 1BGMI include sufficient information to reverse the calibration process.

Standard L1B data are in the format of a full orbit (about 90 minutes). Realtime L1B data are processed in a 5-minute time period.

2. CALIBRATION ALGORITHM

2.1 RADIOMETRIC CALIBRATION

The GMI sensor spins continuously. In each complete rotation, the sensor measures Earth radiation in a section of 140 degrees. Beyond 140 degrees up to 145 degrees, the sensor may also take valid Earth measurements if applicable. The other section of the rotation is used for calibration purposes. For channels 1-7, operational GMI has a calibration cycle that repeats every two scan rotations. In the first scan rotation, noise diodes are turned off and the cold sky and the hot load are sampled for the purpose of radiometric calibration. In the second rotation, noise diodes are turned on and the cold sky plus noise diode and hot load plus noise diode are sampled for 10-37 GHz channels. The two-scan calibration cycle provides four calibration points to calculate not only the gain and offset of the receivers, but also the excess noise temperature of the noise diodes and the nonlinearity of the receivers. For other channels (89 GHz to 183 GHz), all scans have a scan-by-scan calibration cycle (collecting hot and cold calibration data only for all scans). The calibration assembly configuration is shown in Figure 2.1. Cold sky reflector and hot load are stationary. They do not rotate with the instrument. The hot load tray mounts to the deck and rotates with the instrument.

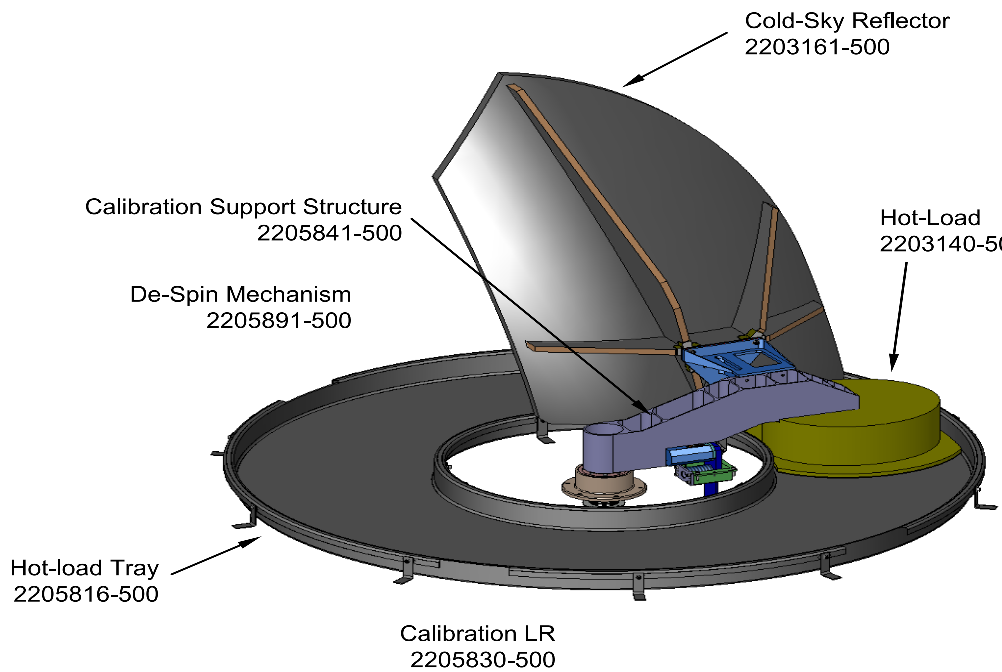

Figure 2.1. Calibration assembly configuration; taken from BATC data book.

The GMI uses a non-linear three-point in-flight calibration to derive antenna temperature. The four-point calibration is used to monitor the sensor non-linearity and to calibrate when hot load measurements are not available for the 10-36 GHz channels.

2.1.1 Non-linear Radiometric Calibration

If the transfer function is perfectly linear, two calibration points (hot and cold loads) would uniquely determine the state of the Earth observation. However, in reality, they are slightly nonlinear. Figure 2.2 shows a schematic diagram of the GMI nonlinear calibration approach as compared to the traditional linear calibration in the TRMM Microwave Imager (TMI).

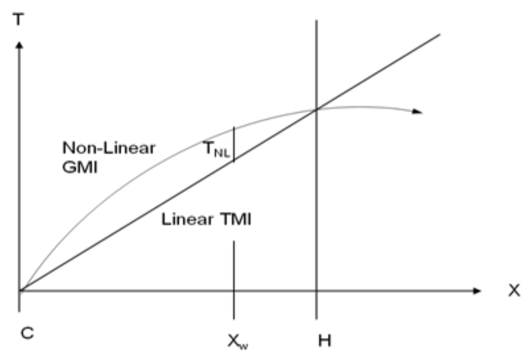

Figure 2.2. Schematic diagram of GMI non-linear calibration.

Equation (2.1) shows the GMI non-linear calibration equation for each of the 13 GMI channels. This is a quadratic radiometric transfer function.

$$\mathbf{T_a = X{*}T_h + (1\text{-}X){*}T_c - 4{*}T_{nl}{*}X{*}(1\text{-}X)} \qquad (2.1)$$

where:
$\mathbf{T_a}$**:** antenna temperature for each pixel of the scan.
$\mathbf{T_h}$**:** mean hot load temperature of the scan; $\mathbf{T_c}$**:** mean cold sky temperature of the scan.
$\mathbf{T_{nl}}$**:** peak non-linearity generated from look-up table or computed from four-point calibration.
$\mathbf{X = (C - C_c)/ (C_h - C_c)}$**:** radiometer response.
C: Earth view count of the pixel; $\mathbf{C_c}$**:** mean cold load count; $\mathbf{C_h}$**:** mean hot load count.

The PPS L1B algorithm uses a more conventional form (2.2) derived from the above basic equation (2.1) such that PPS will be able to trend gain, offset, and nonlinearity against the Earth view counts.

$$\mathbf{T_a = (b + b_{nl}) + (a + a_{nl})C + c_{nl}C^2} \qquad (2.2)$$

$\mathbf{a = (T_h - T_c)/ (C_h - C_c)}$**:** gain in linear equation.
$\mathbf{a_{nl} = - 4\, T_{nl}\, (C_h + C_c)/(C_h - C_c)^2 = -ua^2\, (C_h + C_c)}$**:** gain due to non-linearity.

$$\mathbf{u = 4\, T_{nl} / (T_h - T_c)^2} \qquad (2.3)$$

$\mathbf{b = (C_h\, T_c - C_c\, T_h)/ (C_h - C_c)}$**:** offset in linear equation.
$\mathbf{b_{nl} = ua^2\, C_h\, C_c}$**:** non-linear offset.
$\mathbf{c_{nl} = ua^2}$**:** non-linear gain.

Look-up tables of **u** are provided by the sensor manufacturer as a function of receiver gain and receiver temperature (see Appendix A). Four-point calibration also computes the **u** in the algorithm but outputs it in $\mathbf{T_{nl}}$ format. All of these coefficients are written out in the data products such that one may easily retrieve the count back from $\mathbf{T_a}$. The algorithm can switch between equation (2.2) and equation (2.1). The nonlinearity term of equation (2.1) can be expanded as:

$$\mathbf{T_a^{nl} = -4*T_{nl}*X_i*(1-X_i) = b_{nl} + a_{nl}C + c_{nl}C^2 = ua^2(C_h C_c - (C_h + C_c)C + C^2)}$$

$$\mathbf{= ua^2(C-C_h)(C-C_c)} \qquad (2.4)$$

with tie points at $\mathbf{C_h}$ **and** $\mathbf{C_c}$ and maximum nonlinearity point at $\mathbf{C = (C_h + C_c)/2}$.

For a typical 36 GHz V channel with high gain, assume $\mathbf{T_c=3K, T_h=300K, C_c=20351, C_h=38104, u=-2.388E-5}$. We can derive the maximum $\mathbf{ua^2 (C-C_h)(C-C_c) = 0.5266\ K}$ at $\mathbf{C=(C_h + C_c)/2=29772}$.

The nonlinearity is also calculated on-orbit by the four-point calibration method for 10-36 GHz channels. If nonlinearity drifts a statistically significant amount, the data can be updated using on-orbit trending.

2.1.2 Hot Load View

The hot load consists of a non-rotating calibration target that intercepts the line-of-sight between the feed horns and the main reflector as the feed horns pass beneath the hot calibration load during each scan. The temperature of the hot load is passively controlled and will be between 240 K and 330 K over all on-orbit conditions. Figure 2.3 shows the GMI hot load calibration target. The load is sized to allow a minimum of four measurements per view for all channels. The hot load is sampled multiple times per rotation of the main reflector.

At a certain point and time, sunlight may strike the hot load and cause additional gradients that cause its effective temperature to deviate from what the platinum resistance thermometers (PRTs) read. The GMI hot load is designed to minimize such effect. However, it will still need to be analyzed during the post-launch calibration and validation.

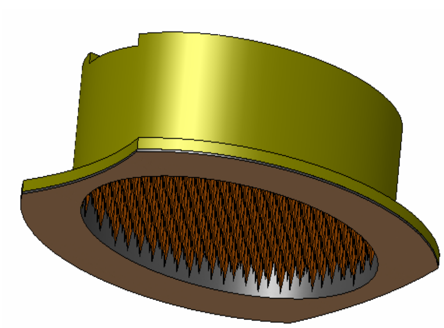

Figure 2.3. GMI hot load; taken from GMI PDR day 4-5: Calibration assembly (Randy Keller).

Hot load temperature $\mathbf{T_h}$ for scan i_n**:**
The mean hot load temperature for each scan is determined by the following equations:

Resistance of the PRT: $R_T=(C_T-C_{lo})(R_{hi} - R_{lo})/(C_{hi}-C_{lo}) + R_{lo}$ (2.5)

Resistances of high calibration resistor R_{hi} = 2800.08 (preliminary), and low resistor R_{lo} = 1500.04 (preliminary) for the 11 PRTs.

C_T, C_{hi}, C_{lo} are raw counts of the PRT, high-calibration resistor, and low-calibration resistor retrieved from telemetry.

Temperature of the PRT: $T_T = \sum_k a(k) R^k_T$ (in ^{o}C) (2.6)

Following is a table to show typical C_{hi}, C_{lo}, and a(k) (k=0,1,2,3,4,5). However, C_{hi}, C_{lo} are actually read from telemetry for each scan and may deviate from their typical values.

Table 2.1. PRT temperature coefficients.

PRT#	C_{hi}	C_{lo}	a(0)	a(1)	a(2)	a(3)	a(4)	a(5)
HL1	45201.6	10033.94	-260.3268548	0.162461012	-4.58202E-05	2.52991E-08	-6.611E-12	6.92314E-16
HL2	45201.6	10033.94	-256.6634276	0.153105919	-3.64844E-05	2.06898E-08	-5.48131E-12	5.82286E-16
HL7	45201.6	10033.94	-229.1336105	0.081543673	3.70996E-05	-1.71872E-08	4.26292E -12	-4.19728E-16
HL8	45201.6	10033.94	-239.1461698	0.10633824	1.27543E-05	-5.16554E-09	1.28903E-12	-1.24749E-16
HL9	45201.6	10033.94	-265.1250734	0.172522043	-5.44843E-05	2.87902E-08	-7.24365E-12	7.28819E-16
HL10	45201.6	10033.94	-227.5221504	0.080916951	3.41126E-05	-1.36997E-08	2.84902E-12	-2.20101E-16
HL11	45201.6	10033.94	-173.9211332	-0.056511813	0.000174168	-8.47823E-08	2.08193E-11	-2.03058E-15
HL12	45201.6	10033.94	-220.8544276	0.062438765	5.3899E-05	-2.41548E-08	5.58068E-12	-5.02863E-16
HL13	45201.6	10033.94	-231.8990945	0.08994359	2.70811E-05	-1.12182E-08	2.51066E-12	-2.1678E-16
HL14	45201.6	10033.94	-247.547878	0.127616967	-8.95689E-06	5.78887E-09	-1.44903E-12	1.46345E-16
HL15	45201.6	10033.94	-241.1117667	0.113170615	3.50976E-06	6.80404E-10	-4.94577E-13	8.72336E-17

Scan average and tray correction:

Scan hot load temperature $\mathbf{T_{Tave}}$ (i), i=1,2, is split into two categories. $\mathbf{T_{Tave}}$ (1) is averaged over PRT #1 and #8-10 for the use of 10, 166, and 183 GHz channels. $\mathbf{T_{Tave}}$ (2) is averaged over PRT #2 and #11-14 for the use of 18, 23, 36, and 89 GHz channels. PRT #7 (base) and PRT #15 are not used in calibration. Figure 2.4 demonstrates the geometry of the GMI hot load.

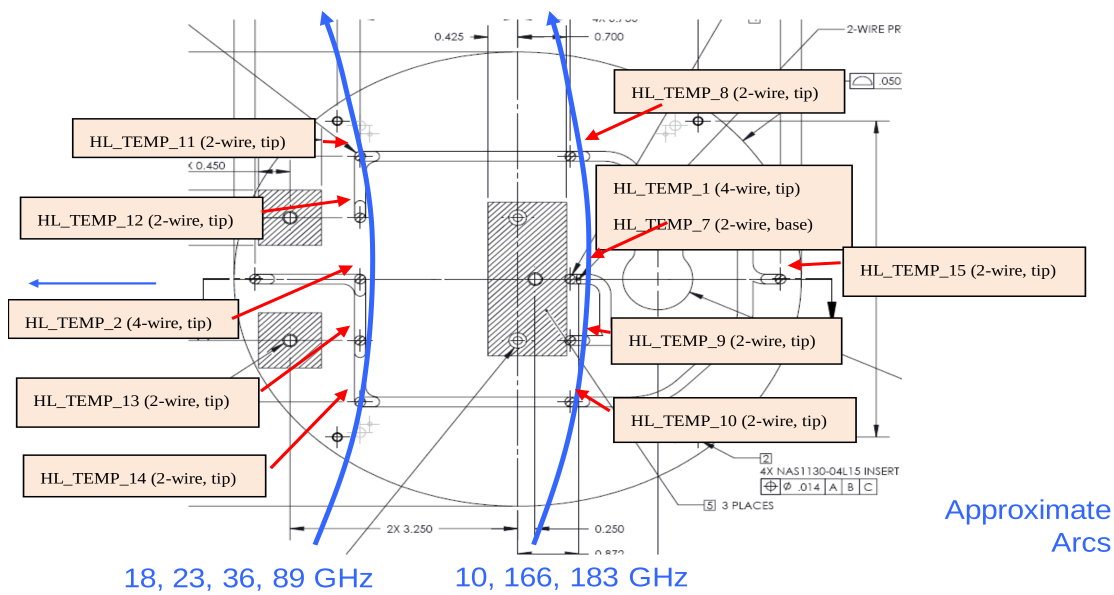

Figure 2.4. GMI hot load geometry.

Correction using hot load tray temperature:

$\mathbf{T_{hscan}(i)} = w_0 + w_1\mathbf{T_{Tave}(i)} + u_0 + u_1(\mathbf{T_{Ttray}} - \mathbf{T_{Tave}(i)}) + u_2(\mathbf{T_{Ttray}} - \mathbf{T_{Tave}(i)})^2 + u_3(\mathbf{T_{Ttray}} - \mathbf{T_{Tave}(i)})^3$ (2.7)

b(j), w_0, w_1, u_0, u_1, u_2, u_3 for all channels are summarized in Table 2.2 (revised).

Table 2.2. Cubic correction coefficients for hot load temperatures.

Frequency (GHz)	pol	w0	w1	u0	u1	u2	u3
10.65	Vpol	0.000	1.000	0.006	0.001842	8.64057E-06	1.43994E-08
10.65	Hpol	0.000	1.000	0.006	0.001842	8.64057E-06	1.43994E-08
18.7	Vpol	0.000	1.000	0.034	0.005192	2.55512E-05	4.56092E-08
18.7	Hpol	0.000	1.000	0.034	0.005192	2.55512E-05	4.56092E-08
23.8	Vpol	0.000	1.000	0.039	0.006980	3.41741E-05	6.07519E-08
36.64	Vpol	0.000	1.000	0.061	0.007250	3.50306E-05	5.9566E-08
36.64	Hpol	0.000	1.000	0.061	0.007250	3.50306E-05	5.9566E-08
89	Vpol	0.000	1.000	0.078	0.009411	4.39606E-05	6.89555E-08
89	Hpol	0.000	1.000	0.078	0.009411	4.39606E-05	6.89555E-08
166	Vpol	0.000	1.000	0.055	0.008895	4.30404E-05	7.46213E-08
166	Hpol	0.000	1.000	0.055	0.008895	4.30404E-05	7.46213E-08
183.3 ±3	Vpol	0.000	1.000	0.055	0.008895	4.30404E-05	7.46213E-08
183.3 ±7	Vpol	0.000	1.000	0.055	0.008895	4.30404E-05	7.46213E-08

Resistance of the tray: $R'_T=(C'_T-C'_{lo})(R'_{hi} – R'_{lo})/(C'_{hi}-C'_{lo}) + R'_{lo}$ (2.8)

Resistances of high calibration resistor R'_{hi} = 3157 (preliminary), and low resistor R'_{lo} = 1195 (preliminary) for the tray.

C'_T, C'_{hi}, C'_{lo} are raw counts of the tray, high-calibration resistor, and low-calibration resistor retrieved from telemetry.

Temperature of the tray: $T_T = \sum_k a(k)R'^k_T$ (in ºC) (2.9)

Following is a table to show how typical C'_{hi}, $C'_{lo,}$ and a(k) (k=0,1,2,3,4,5). C'_{hi}, C'_{lo} are read from telemetry.

Table 2.3. Tray temperature coefficients.

C'_{hi}	C'_{lo}	a(0)	a(1)	a(2)	a(3)	a(4)	a(5)
58170.308	7706.137	-238.3771643	0.108516065	7.18387E-06	-1.12508E-09	8.5039E-14	2.92338E-18

Average over multi-scans:

Since the hot load counts are multi-scan averaged, it is preferable that the hot load temperature is averaged over the same number of scans.

$\mathbf{T_h}=\Sigma_i k(i)\ \mathbf{T_{hscan}(i)} /\Sigma_i k(i)$

$\mathbf{T_h}$ are averaged over 16 scans for channels 1-4, index scan -7 to +8 scans, over 14 scans for channel 5, index scan -6 to +7 scans, over 12 scans for channels 6-7, index scan -5 to +6 scans, over 5 scans for channels 8-13, index scan and ±2 scans.

Hot load count for scan $\mathbf{i_n}$ is determined by equation (2.10).

The hot load counts are corrected for errors induced by Earth's magnetic field before they are processed for calibration (see Section 2.4).

$$\mathbf{C_h} = (\Sigma_i \Sigma_j\, k(i,j) C_{hot}(i,j)) / \Sigma_i \Sigma_j\, k(i,j) \quad (2.10)$$

$j=1,2,3, \ldots n_{hot}$. n_{hot} is the number of hot samples of each scan for each channel.
$i = i_n - N_h, i_n - N_h + 1, i_n - N_h + 2, \ldots, i_n + N_h$. i_n is the scan number of the granule to be calibrated and $2N_h + 1$ is the number of scans within the screen window.

The hot load sampling tables are shown as follows. However, the best table is used in the code.

Table 2.4. Hot load sampling.

	Nominal Sample Table		Spare1 Sample Table		Best Samples to Use (Revised by or-orbit data)	
Frequency	Hot Start	Hot End	Hot Start	Hot End	Hot Start	Hot End
10 GHz	272	282	269	285	273	283
18 GHz	306	316	303	319	307	317
23 GHz	306	316	303	319	306	318
36 GHz	352	366	349	369	352	367
89 GHz	327	346	324	349	325	347
166 GHz	315	339	312	342	320	335
183 GHz	329	353	326	356	330	350

Collect data when the noise diode is off.

For channels 1-4, $\mathbf{C_h}$ are averaged over 8 scans. If the diode is off for the index scan i_n (index scan): i_n, $i_n\pm2$, $i_n\pm4$, $i_n\pm6$, i_n+8. If the diode is on for the index scan: $i_n\pm1$, $i_n\pm3$, $i_n\pm5$, $i_n\pm7$. For channel 5, $\mathbf{C_h}$ are averaged over 7 scans. If the diode is off for the index scan i_n (index scan): i_n, $i_n\pm2$, $i_n\pm4$, $i_n\pm6$. if the diode is on for the index scan: $i_n\pm1$, $i_n\pm3$, $i_n\pm5$, i_n+7. For channels 6-7, $\mathbf{C_h}$ are averaged over 6 scans. If the diode is off for the index scan i_n (index scan): i_n, $i_n\pm2$, $i_n\pm4$, i_n+6. If the diode is on for the index scan: $i_n\pm1$, $i_n\pm3$, $i_n\pm5$. For channels 8-13, $\mathbf{C_h}$ is always averaged over five scans: i_n, $i_n\pm1$, $i_n\pm2$.

Hot load + noise diode counts for scan i_n:
The hot load + noise diode counts are corrected for errors induced by Earth's magnetic field before they are processed for calibration (see Section 2.4).

$$\mathbf{C_{hn}} = (\Sigma_i \Sigma_j\, k(i,j) C_{hot+diode}(i,j)) / \Sigma_i \Sigma_j\, k(i,j) \quad (2.11)$$

Collect data when the noise diode is on.

For channels 1-4, $\mathbf{C_{hn}}$ are averaged over 8 scans. If the diode is on for the index scan i_n (index scan): i_n, $i_n\pm2$, $i_n\pm4$, $i_n\pm6$, i_n+8. If the diode is off for the index scan: $i_n\pm1$, $i_n\pm3$, $i_n\pm5$, $i_n\pm7$. For channel 5, $\mathbf{C_{hn}}$ are averaged over 7 scans. If the diode is on for the index scan i_n (index scan): i_n, $i_n\pm2$, $i_n\pm4$, $i_n\pm6$. If the diode is off for the index scan: $i_n\pm1$, $i_n\pm3$, $i_n\pm5$, i_n+7. For channels 6-7, $\mathbf{C_{hn}}$ are averaged over 6 scans. If the diode is on for the index scan i_n (index scan): i_n, $i_n\pm2$, $i_n\pm4$, i_n+6. If the diode is off for the index scan: $i_n\pm1$, $i_n\pm3$, $i_n\pm5$.

Bad-case handling:
The mean and variance of hot load counts and hot load + noise diode counts are computed for each granule. The algorithm takes mean ± 3 sigma (6 sigma if variance is small) as valid values. If certain scans are missing or invalid, the algorithm will continue to the next scan until the number of scans to be averaged is equal to the number described above for all channels. However, the maximum number of scans to be searched is 20. If there is no valid hot load information within ±10 scans, the algorithm will perform linear interpolation using the closest scans before and after the index scan and set the calibration quality flag to non-zero (0 indicates good calibration). If there is no hot load information within 200 scans, the algorithm will either use the hot load backup algorithm if cold sky measurements are available, or else generate missing Ta/Tb data for this scan.

2.1.3 Cold Sky View

The cold calibration point is provided by the cold sky reflector (CSR), which allows the feed horns to view targets with a temperature of approximately 2.7 K. The cold sky view is also sampled multiple times per rotation of the main reflector and over multiple rotations of the main reflector. Table 2.5 shows mean cold sky temperature T_c for all GMI channels.

Table 2.5. Mean cold sky temperature T_c for all GMI channels.

Frequency (GHz)	10.65	18.7	23.8	36.64	89.0	166.0	183.31
Cold Load Temperature	2.74	2.75	2.77	2.82	3.27	4.43	4.76

Cold load counts for scan i_n:
The cold load counts are corrected for errors induced by Earth's magnetic field before they are processed for calibration (see Section 2.4). The mean cold sky count is determined by equation (2.12).

$$\mathbf{C_c} = (\Sigma_i \Sigma_j k(i,j) C_{cold}(i,j))/\Sigma_i \Sigma_j k(i,j) \tag{2.12}$$

j=1,2,3, … n_{cold}. n_{cold} is the number of cold samples of each scan for each channel.

$i = i_n - N_h, i_n - N_h + 1, i_n - N_h + 2, \ldots, i_n + N_h$. i_n is the scan number of the current scan to be calibrated and $2N_h + 1$ is the number of scans within the screen window. Collect data when the noise diode is off. The cold load sampling tables are shown as follows. However, the best table is used in the code.

Table 2.6. Cold sky sampling.

	Nominal Sample Table		Spare1 Sample Table		Best Samples to Use* (Revised based on on-orbit data)	
Frequency	Cold Start	Cold End	Cold Start	Cold End	Cold Start	Cold End
10 GHz	340	353	337	356	342	368
18 GHz	368	393	365	396	390	410
23 GHz	368	393	365	396	388	408
36 GHz	418	459	415	462	437	460

89 GHz	392	433	389	436	410	440
166 GHz	381	422	378	425	392	442
183 GHz	395	436	392	439	398	452

Collect data when the noise diode is off.

For channels 1-7, $\mathbf{C_c}$ is averaged over 5 scans. If the diode is off for the index scan i_n (index scan): i_n, i_n±2, i_n±4. If the diode is on for the index scan: i_n±1, i_n±3, i_n+5. For channels 8-13, $\mathbf{C_c}$ is averaged over five scans: i_n, i_n±1, i_n±2.

Cold load + noise diode counts for scan i_n:

$$\mathbf{C_{cn}} = (\Sigma_i \Sigma_j k(i,j) C_{cold+diode}(i,j)) / \Sigma_i \Sigma_j k(i,j) \quad (2.13)$$

The cold load + noise diode counts are corrected for errors induced by Earth's magnetic field before they are processed for calibration (see Section 2.4).

Collect data when the noise diode is on.

For channels 1-7, $\mathbf{C_{cn}}$ are averaged over 5 scans. If the diode is on for the index scan i_n (index scan): i_n, i_n±2, i_n±4. If the diode is off for the index scan: i_n±1, i_n±3, i_n+5.

Bad-case handling:

The cold sky view is a more complex combination of sources than the hot load. Contributions other than from cold space come from reflections and emission from the instrument. There is also Earth view intrusion into the cold sky view primarily through the backlobe of the CSR. The backlobe looks at the main reflector, which sees the Earth. The CSR is tilted up at an angle sufficient that little contamination comes from the Earth directly.

Due to the orbital and cold sky view geometry, the Moon may intrude into the cold sky view. This lunar intrusion has been clearly observed by many other satellite microwave radiometers that employ cold sky calibration (SSMI, SSMI/S, TMI, AMSR, and WindSat). The calibration algorithm will remove as much as possible of the contaminations of the cold sky view.

The mean and variance of cold sky counts and cold sky + noise diode counts are computed for each granule (if Moon index is set, the value will be excluded to compute mean and variance). The algorithm takes mean ± 3 sigma (6 sigma if variance is small) as valid values. If certain scans are missing or invalid, the algorithm will continue to the next scan until the number of scans to be averaged is equal to the numbers described above for all channels.

However, the maximum number of scans to be searched is 20. If there is no valid cold load information within ±10 scans, the algorithm will perform linear interpolation using the closest scans before and after the index scan and set the calibration quality flag to non-zero (0 indicates good calibration). If there is no cold load information within 400 scans, the algorithm will generate missing Ta/Tb data for this scan.

2.1.4 Nonlinearity

Nonlinearity is determined by receiver gain and receiver temperature. Receiver gain is read from telemetry and determined by the following table.

Table 2.7. Receiver gain settings.

Channels	low gain	normal gain	high gain
10 GHz	6	4	2
18 GHz	6	4	2
23 GHZ	6	4	2
36 GHz	6	4	2
89 GHz	6	4	2
166 GHz	4	2	1
183 GHz	5	4	3

Receiver temperatures are retrieved using a similar way of retrieving tray temperature.

Resistance of the receiver: $R'_T=(C'_T-C'_{lo})(R'_{hi} - R'_{lo})/(C'_{hi}-C'_{lo}) + R'_{lo}$ (2.14)

Resistances of high-calibration resistor R'_{hi} = 3157 (preliminary), and low-calibration resistor R'_{lo} = 1195 (preliminary) for the tray.

C'_T, C'_{hi}, C'_{lo} are raw counts of the tray, high-calibration resistor, and low-calibration resistor retrieved from telemetry.

Temperature of the receiver: $T_{receiver} = \sum_k a(k) R'^{k}_T$ (in ^oC) (2.15)

Following is a table to show typical C'_{hi}, $C'_{lo,}$ and a(k) (k=0,1,2,3,4,5). C'_{hi}, C'_{lo} are read from telemetry.

Table 2.8. Receiver temperature polynomial coefficients.

Freq	C'_{hi}	C'_{lo}	a(0)	a(1)	a(2)	a(3)	a(4)	a(5)
10GHz	58170.308	7706.137	-235.8509438	0.099626991	1.74703E-05	-6.44468E-09	1.37026E-12	-1.1467E-16
18GHz	58170.308	7706.137	-236.0646535	0.100765016	1.63998E-05	-6.02941E-09	1.29013E-12	-1.08618E-16
36GHz	58170.308	7706.137	-236.2001883	0.100808265	1.64408E-05	-6.03744E-09	1.29008E-12	-1.08434E-16
36GHz	58170.308	7706.137	-236.0667138	0.100417622	1.67243E-05	-6.14661E-09	1.31071E-12	-1.09965E-16
89GHz	58170.308	7706.137	-236.1859287	0.100662332	1.65911E-05	-6.10118E-09	1.30393E-12	-1.09648E-16
166GHz	58170.308	7706.137	-236.2362645	0.100930691	1.63367E-05	-6.00249E-09	1.28482E-12	-1.08198E-16
183GHz	58170.308	7706.137	-236.1070635	0.100466029	1.67138E-05	-6.13536E-09	1.30677E-12	-1.09468E-16

Look-up tables of **u** are provided by the sensor manufacturer as a function of receiver gain and receiver temperature (see Appendix A) for all channels. **u** is also computed from the four-point algorithm for trending and comparisons.

2.1.5 Moon and RFI Corrections

Moon Correction:
The geolocation tool computes the Moon vector $\mathbf{V}_{\mathbf{moon}}$ for each scan in the GMI coordinate system (GICS). The algorithm computes the angle ($\boldsymbol{\theta}$) between Moon vector and cold beam pointing vectors $\mathbf{V}_{\mathbf{cold}}$ in the GICS for all cold view samples.

$$\cos\theta = \mathbf{V}_{\mathbf{moon}} \cdot \mathbf{V}_{\mathbf{cold}} / (|\mathbf{V}_{\mathbf{moon}}| |\mathbf{V}_{\mathbf{cold}}|) \qquad (2.16)$$

$$= [V_{moon}(x) V_{cold}(x) + V_{moon}(y) V_{cold}(y) + V_{moon}(z) V_{cold}(z)] / \{ [V_{moon}(x)^2 + V_{moon}(y)^2 + V_{moon}(z)^2]^{1/2} [V_{cold}(x)^2 + V_{cold}(y)^2 + V_{cold}(z)^2]^{1/2} \}$$

If $\boldsymbol{\theta} < 6$ degrees, the algorithm sets the Moon index to non-zero and the cold sample is excluded for calibration. If the Moon index is set for a large section of the swath (> 20 scans), the algorithm will use valid scans before and after the event to perform linear interpolation.

Appendix B provides the look-up tables of cold beam pointing vectors (revised). The following figures show an example of Moon flags, and scan averaged cold counts before correction and after correction. Figure 2.5 is the index from production for low-frequency swath channels. The value of index is the number of cold samples contaminated by the Moon's light. The intrusion occurred around scans 2200 to scans 2400 for 18, 23, 36, and 89 GHz channels. Figure 2.6 shows the spikes of mean cold counts around this area before corrections. Figure 2.7 shows the results from the current version, and the spikes due to Moon intrusion are removed.

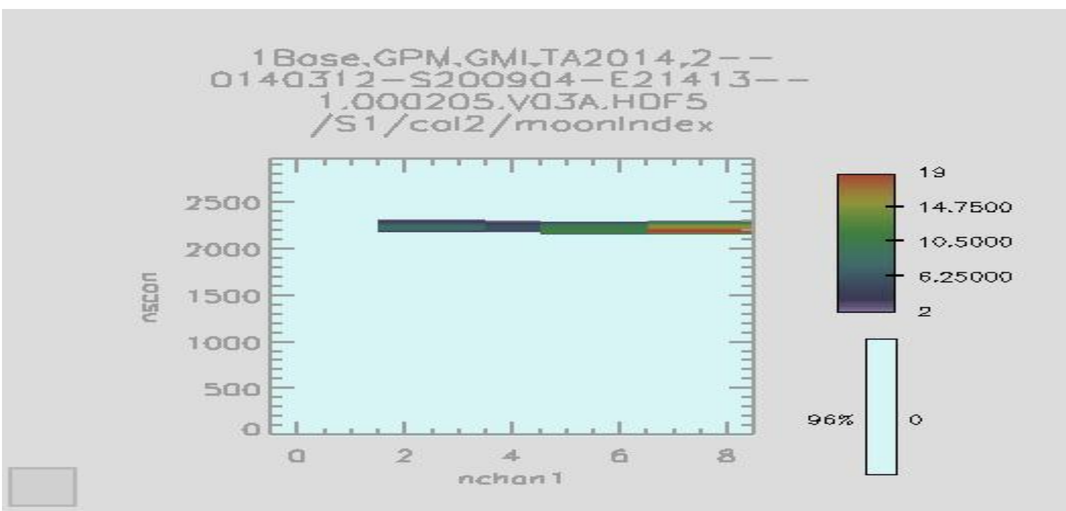

Figure 2.5. Moon flags for S1, indicates Moon intrusions onto 18 GHz to 89 GHz channels.

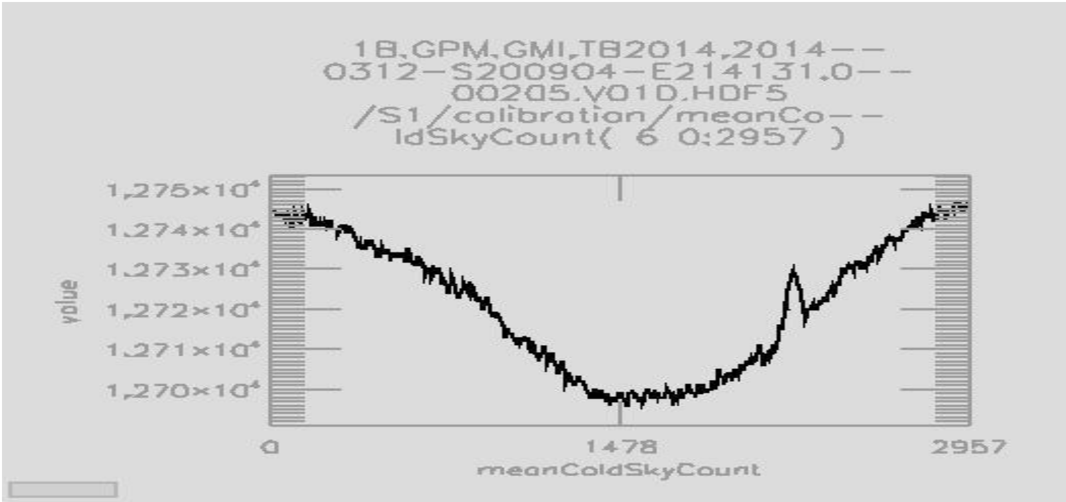

Figure 2.6. Scan cold counts of 36 GHz H channel with no Moon correction in V01D data.

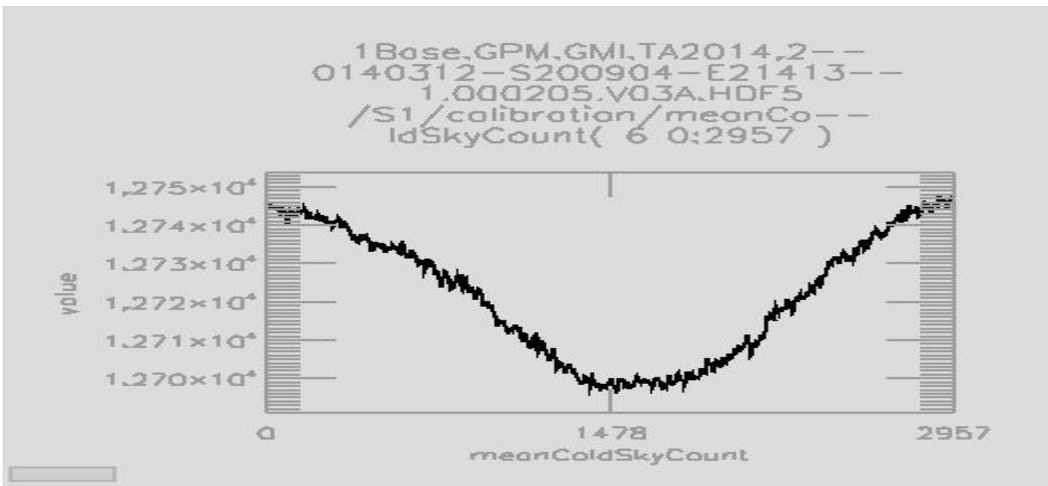

Figure 2.7. Scan cold counts of 36 GHz H channel with Moon correction in V03A data.

RFI Correction:

There are two RFI flagging methods in the algorithm. One is a simple limit check based on minimum cold count of the scan assuming that the intrusion is only to part of the cold sample sections. If the whole scan is contaminated, the scan is labeled as bad calibration and will be handled by bad-case handling as described in Section 2.1.3.

The simple limit check method first determines the lowest value from all cold samples of a scan. The code then computes the maximum cold count value derived from the following table:

Table 2.9. Maximum gradients of cold counts within each scan.

Channels:	1	2	3	4	5	6	7	8	9	10	11	12	13
Cold Offset	130	122	118	132	78	78	78	78	78	198	198	198	198
Cold + NoiseD Offset	240	232	202	198	122	116	112						

Maximum value = Lowest value + offset. If a cold sample within this scan is larger than the maximum value, it will be flagged (to non-zero). This method tends to under-flag the radio frequency interference (RFI) cold samples by about 20%.

The other method is based on the iterative mean comparison/dilation method. The method is quite complicated and has the following steps:

Step 1: Scan averaging – Create a scan average, ignoring data that already have been flagged. On the first iteration, all data will be included. First, the data are averaged over the cold samples within each scan; then, multiple scans are averaged together. For channels with noise diodes, this is done separately for the cold and cold + noise scans. In this version, three effective scans are used for all channels.

Step 2: Removal of scan average – For each sample within the each scan, the scan average from step 1 is removed.

Step 3: Cold swath flattening – This is done for each along-scan cell position by taking the median across all scans of the orbit. The computed variation is then subtracted from the result of step 2. This step provides additional sensitivity by removing scan-repeating variations.

Step 4: Thresholding – All cold samples from the result of step 3 are compared to a pre-determined threshold for each channel and noise diode state (Table 2.10). Data exceeding the threshold or that have been flagged on a previous iteration are flagged.

Step 5: Robust dilation – This step widens and fills in the flagged region. For each cell, if at least k cells in the surrounding $m \times n$ region are flagged, then that cell is additionally flagged. If less than k cells are flagged, then the cell is set to unflagged. This method will unflag spurious noise measurements, allowing the user to set the thresholds in step 4 below 3-sigma, providing higher sensitivity.

Step 6: Iterate – Repeat steps 1-5 for a specified number if iterations.

Table 2.10. Cold counts threshold of second RFI flagging method.

Channel	Cold count threshold	Cold+noise count threshold	Cold scan average scans	Number of Iterations	Dilation window (m_{samp} x n_{scan})	Dilation number of samples threshold (k)
10V	24.0	62.0	3	3	3 x 15	5
10H	24.7	62.0	3	3	3 x 15	5
18V	27.3	57.4	3	6	3 x 15	5
18H	25.0	55.1	3	6	3 x 15	5
23V	23.9	40.0	3	3	3 x 15	5
36V	22.9	36.8	3	3	3 x 15	5
36H	22.9	36.3	3	3	3 x 15	5
89V	22.6		3	3	3 x 15	5
89H	21.0		3	3	3 x 15	5
166V	56.8		3	3	3 x 15	5
166H	55.1		3	3	3 x 15	5
183VA	54.5		3	3	3 x 15	5
183VB	49.0		3	3	3 x 15	5

The second method with the chosen thresholds tends to over-flag the cold sample about 20-30%. The algorithm actually uses both flagging methods to determine the final flagging value of a cold sample. If a sample is flagged (to non-zero) by the first method, the sample is flagged as an RFI sample. If a sample is flagged by the second method but not by the first method, the code searches a window of 15 samples by 61 scans to see if any of the cold samples in the window are flagged by the first method. If one or more cold samples within the window are flagged by the first method, the sample is flagged; otherwise, the sample is not flagged. If a cold sample is flagged, the sample is excluded from calibration.

The following figures show the results before and after the correction. Figure 2.8 is the index from production for the 18 GHz H channel. The total cold sample number is 21 for this channel. The intrusion occurred around scan 2400 to scan 2500. Figure 2.9 shows the spikes of mean cold counts around this area before corrections. Figure 2.10 shows the results from the current version, and the spikes due to warm RFI intrusion are removed.

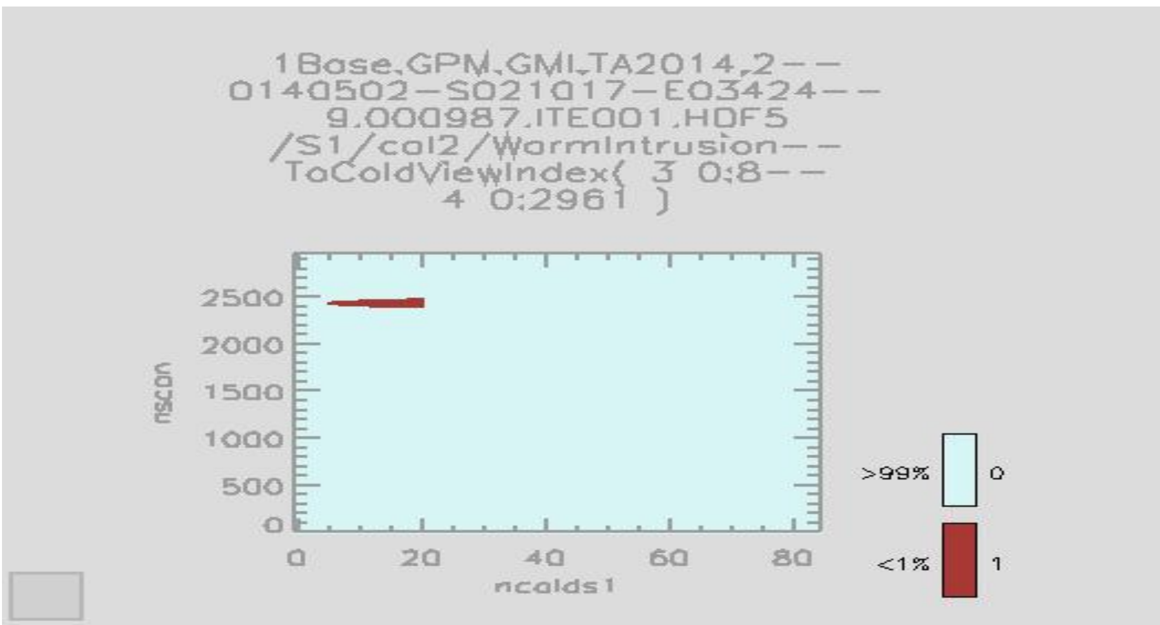

Figure 2.8. Cold samples that are flagged as warm intrusions for 18 GHz H channel.

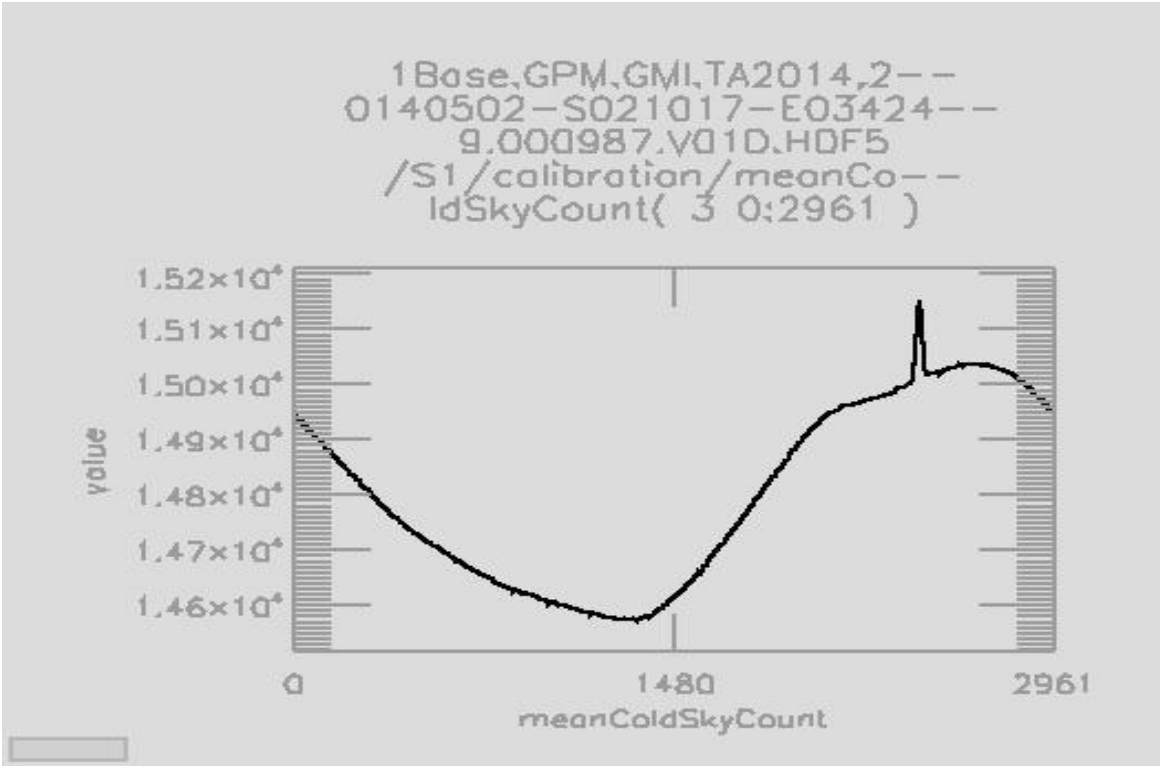

Figure 2.9. Scan cold counts of 18 GHz H channel with no correction in V01D data.

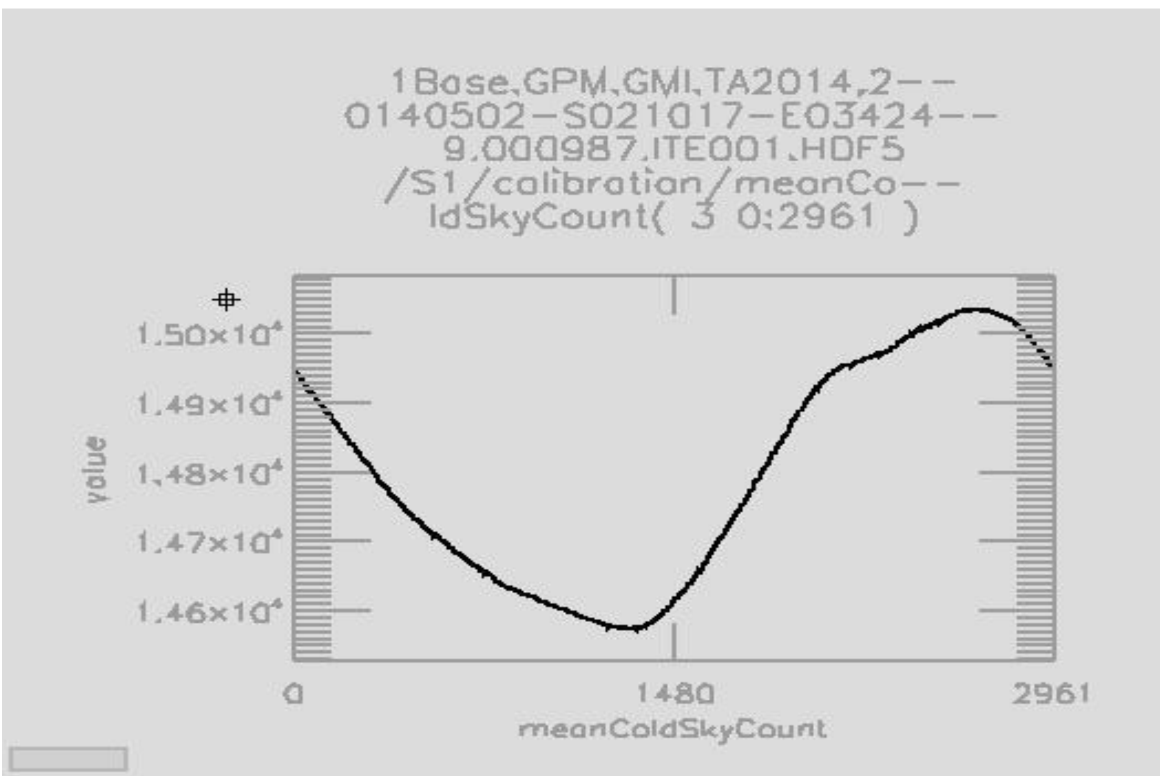

Figure 2.10. Scan cold counts of 18 GHz H channel with RFI correction in ITE001 data.

2.1.6 <u>Earth View</u>

A forward section of about 145° is used to view the Earth targets. The normal data have 221 samples for each scan. However, in cases when the data beyond 140° are useful, one scan may have more than 221 pixels. The data beyond the normal Earth view range can be retrieved from GMIBASE full rotation antenna temperatures. Due to the difference of incidence angles between lower frequency (channels 1-9) and high-frequency (channels 10-13) channels, the swath widths, as well as the geolocations of the two groups, are different. Figure 2.11 shows antenna temperatures of 10 GHz V (low-frequency swath) and 166 GHz V (high-frequency swath) channels.

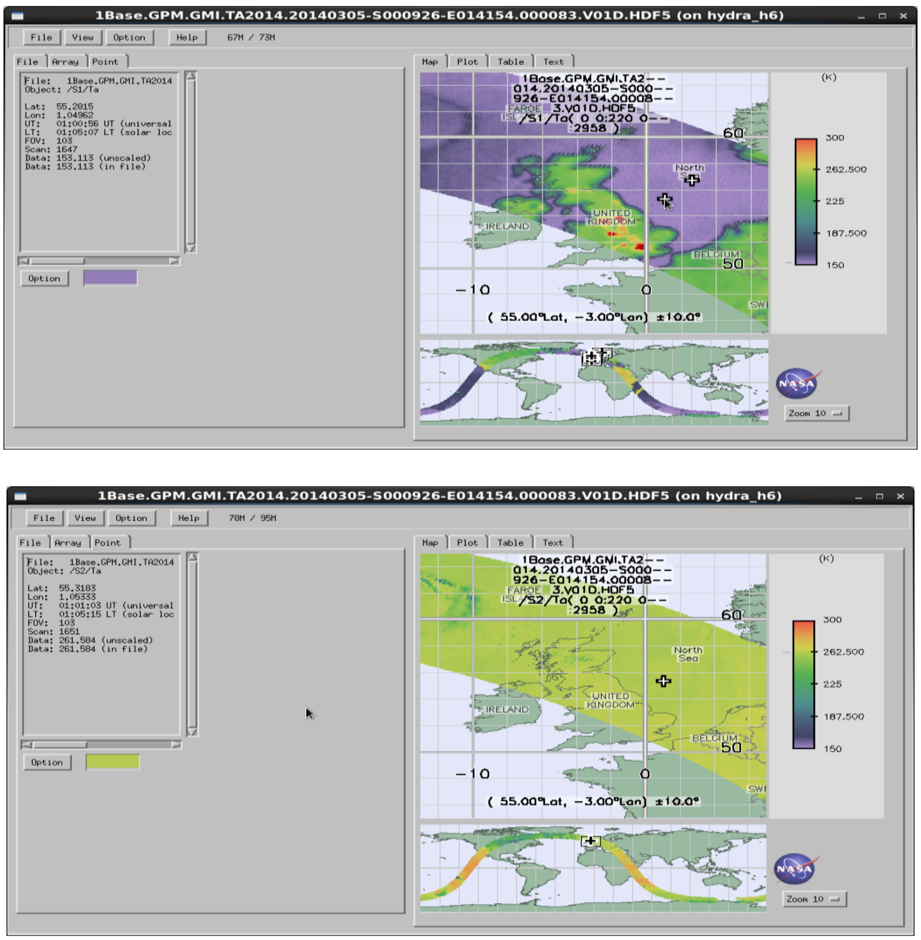

Figure 2.11. Sample GMI 10 GHz V channel Ta (upper) and 166 GHz V channel Ta (lower).

There is RFI to the Earth view samples (for example, Figure 2.11 upper panel in England). Currently, the code flags Earth view pixels if Tb is greater than 325 K for all channels. The Earth view counts are corrected for errors induced by Earth's magnetic field before they are used to derive antenna temperature Ta (see Section 2.4).

2.1.7 Noise Diodes and Four-Point Calibration

The noise diodes are implemented for channels 1-7. These noise diodes are turned on every other scan such that additional calibration measurements are taken to perform four-point calibration to determine sensor nonlinearity. Figure 2.12 is the schematic diagram of four-point calibration.

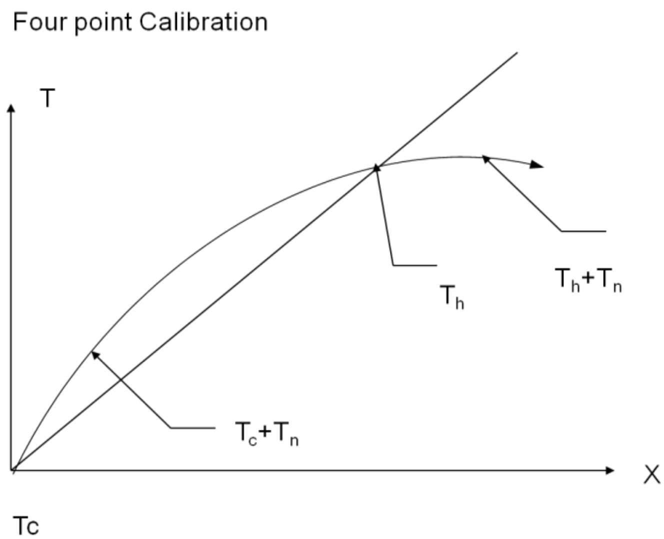

Figure 2.12. Schematic diagram of GMI four-point calibration.

For cold load + noise diode measurement, the equation is:

$$\mathbf{T_{cn} = T_c + T_n = X_{cn}*T_h + (1-X_{cn})*T_c - 4*T_{nl}*X_{cn}*(1-X_{cn})} \quad (2.17)$$

where
$\mathbf{T_n}$: noise diode excess temperature.
$\mathbf{X_{cn} = (C_{cn} - C_c)/ (C_h - C_c)}$.
$\mathbf{C_{cn}}$: cold load + noise diode count.

The equation is similar for hot load + noise diode measurement:

$$\mathbf{T_{hn} = T_h + T_n = X_{hn}*T_h + (1-X_{hn})*T_c - 4*T_{nl}*X_{hn}*(1-X_{hn})} \quad (2.18)$$

where
$\mathbf{X_{hn} = (C_{hn} - C_c)/ (C_h - C_c)}$.
$\mathbf{C_{hn}}$: hot load + noise diode count.

The nonlinearity can be derived from equation (2.17) and (2.18):

$$\mathbf{T_{nl} = (T_h - T_c)/4 * (X_{hn} - X_{cn} - 1)/(X_{hn}(1- X_{hn}) - X_{cn}(1 - X_{cn}))} \quad (2.19)$$

And then the $\mathbf{T_n}$ can be determined by either (2.17) or (2.18).

2.1.8 Back-up Calibration and Blanking Algorithm

Using $\mathbf{C_{cn}}$ and trended $\mathbf{T_{cn} = T_c + T_n}$ we may derive a hot load back-up algorithm in case there is no hot load information for a section with more than 20 scans.

The trended $\mathbf{T_n}$ can be derived from the look-up table as a function of diode temperatures (data can be found in Appendix C).

$$\mathbf{T_a = X_b * T_{cn} + (1\text{-}X_b) * T_c - 4 * T_{nl} * X_b * (1\text{-}X_b)} \quad (2.20)$$

where: $$\mathbf{X_b = (C - C_c) / (C_{cn} - C_c)} \quad (2.21)$$

Blanking:

If blanking is on, the following correction is made to derive a corrected Earth count C_{corr}:

$$C_{corr} = (C - 32500)\frac{t_{int}}{t_{int} - N_B t_B} + 32500 \quad (2.22)$$

where t_{int} is the nominal integration period of 0.00355 seconds, N_B is the effective number of blanking pulses during an integration period, and t_B is the blanking duration. The corrected Earth count C_{corr} is then used to compute $\mathbf{T_a}$.

2.2 ANTENNA PATTERN CORRECTION

Corrections of the calibrated antenna temperatures are performed following the radiometric calibration in order to transform calibrated antenna temperature to brightness temperature. The antenna pattern correction involves first correcting for the antenna spillover.

For vertical polarized channels:

$$\mathbf{T_a^{v1} = T_a/\eta_v - T_c(1- \eta_v)/\eta_v} \quad (2.23)$$

For horizontal polarized channels:

$$\mathbf{T_a^{h1} = T_a/\eta_h - T_c(1- \eta_h)/\eta_h} \quad (2.24)$$

where $\mathbf{T_a}$ is the measured antenna temperature, η_v and η_h are the spillover coefficients for V and H channels, and $\mathbf{T_c}$ is the radiometric temperature of cold space, corrected for the approximation to the Rayleigh-Jeans law. Values of Tc for each channel are given in Table 2.5. η_v and η_h for all channels are given in Table 2.11.

Table 2.11. Coefficients for computing APC.

f [GHz]	10.65	18.7	23.8	36.64	89	166	183.31
a_{vh}	0.00363	0.00280	0.00211	0.00094	0.00119	0.01339	0.01104
a_{hv}	0.00366	0.00292	N/A	0.00094	0.00119	0.01339	N/A
η_v	**0.95404**	**0.95603**	**0.97075**	**0.99535**	**0.99734**	**0.98814**	**0.99212**
η_h	**0.95404**	**0.95603**	N/A	**0.99535**	**0.99734**	**0.98814**	N/A
$1\text{-}\eta_v$	**0.04596**	**0.04397**	**0.02925**	**0.00465**	**0.00266**	**0.01186**	**0.00788**

$1-\eta_h$	**0.04596**	**0.04397**	N/A	**0.00465**	**0.00266**	**0.01186**	N/A
λ	N/A	N/A	**1.02881**	N/A	N/A	N/A	**1.00794**
ξ	N/A	N/A	**0.295**	N/A	N/A	N/A	**-0.038**
R	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

Secondly, the APC corrects for the emissivity of the reflector.

$$\mathbf{T_a^v = T_a^{v1}/R + T_{refl}(1- R\,)/R} \quad (2.25)$$
$$\mathbf{T_a^h = T_a^{h1}/R + T_{refl}(1- R\,)/R} \quad (2.26)$$

where **R** is the RF reflectivity of the main reflector, and $\mathbf{T_{refl}}$ is the measured temperature of the reflector. The values of R are given in Table 2.8. Since R=1:

$$\mathbf{T_a^v = T_a^{v1}} \quad (2.27)$$
$$\mathbf{T_a^h = T_a^{h1}} \quad (2.28)$$

Thirdly, the APC corrects for the cross-polarization:

$$\mathbf{T_b^v =((1-a_{hv})\, T_a^v - a_{vh}\, T_a^h)/(1- a_{hv}- a_{vh})} \quad (2.29)$$

$$\mathbf{T_b^h =((1-a_{vh})\, T_a^h - a_{hv}\, T_a^v)/(1- a_{hv}- a_{vh})} \quad (2.30)$$

Values of $\mathbf{a_{hv}}$ and $\mathbf{a_{vh}}$ are given in Table 2.8. Substitute equations (2.24) to (2.28) to equations (2.29) and (2.30), and we can get:

$$\mathbf{T_b^v = C_n^vT_a^v - D_n^vT_a^h - E_n^v} \quad (2.31)$$
$$\mathbf{T_b^h = C_n^hT_a^h - D_n^hT_a^v - E_n^h} \quad (2.32)$$

where

$\mathbf{C_n^v =(1-a_{hv})\,/(\eta_v(1- a_{hv}- a_{vh}))}$

$\mathbf{D_n^v = a_{vh}//(\eta_h(1- a_{hv}- a_{vh}))}$

$\mathbf{E_n^v = T_c[(1- \eta_v\,)(1-a_{hv})\,/\eta_v - (1- \eta_h\,)\, a_{vh}/\eta_h]/\,(1- a_{hv}- a_{vh})}$

$\mathbf{C_n^h =(1-a_{vh})\,/(\eta_h(1- a_{hv}- a_{vh}))}$

$\mathbf{D_n^h = a_{hv}//(\eta_v(1- a_{hv}- a_{vh}))}$

$\mathbf{E_n^h = T_c[(1- \eta_h\,)(1-a_{vh})\,/\eta_h - (1- \eta_v\,)\, a_{hv}/\eta_v]/\,(1- a_{hv}- a_{vh})}$

Equations (2.31) and (2.32) can be combined into equation (2.33):

$$\mathbf{T_b = C_nT_a - D_nT_a^* - E_n} \quad (2.33)$$

$\mathbf{T_a^*}$: Antenna temperature of cross-polarized channel of the $\mathbf{T_a}$.

For 23 GHz and 183 GHz channels, there are no cross-polarized channels; equation (2.33) is simplified to:

$\mathbf{T_b = C_n T_a \ - E_n}$

The value of $\mathbf{C_n}$ and $\mathbf{E_n}$ for these channels is given in Table 2.12.

$\mathbf{C_n = \lambda, E_n = - \xi}$, for each corresponding channel.

Table 2.12. Comparison of APC coefficients between V04 and V03.

Channel Number	Frequency GHz	C_n		D_n		E_n	
		V03	**V04**	**V03**	**V04**	**V03**	**V04**
1	**10.65 V**	1.062802	1.052007	0.003875	0.003833	0.161459	0.131997
2	**10.65 H**	1.063577	1.052039	0.003904	0.003864	0.163503	0.131997
3	**18.7 V**	1.067189	1.048938	0.002993	0.002946	0.176538	0.126479
4	**18.7 H**	1.066024	1.049064	0.003125	0.003027	0.172972	0.126479
5	**23.8 V**	1.033860	1.028810	0.000000	0.000000	-0.282590	-0.295000
6	**36.64 V**	1.005063	1.005618	0.000946	0.000946	0.011610	0.013174
7	**36.64 H**	1.005063	1.005618	0.000946	0.000946	0.011610	0.013174
8	**89.0 V**	1.003099	1.003863	0.001195	0.001196	0.006225	0.008721
9	**89.0 H**	1.003099	1.003863	0.001195	0.001196	0.006225	0.008721
10	**166.0 V**	1.013758	1.025926	0.013758	0.013924	0.000000	0.053170
11	**166.0 H**	1.013758	1.025926	0.013758	0.013924	0.000000	0.053170
12	**183 ± 3**	1.000000	1.007940	0.000000	0.000000	0.000000	0.038000
13	**183 ± 7**	1.000000	1.007940	0.000000	0.000000	0.000000	0.038000

In addition to the APC, the antenna effect on the Earth view along-scan bias has been derived from data produced by Remote Sensing Systems together with data from the cold space maneuver, and the correction is applied in the algorithm. The antenna effect is subdivided into two terms: an additive term and a multiplicative term. The additive portion most likely comes from the backlobes for the 10-23 GHz channels, while the multiplicative term comes from edge of scan effects such as the cold sky reflector multi-layer insulation (MLI) intruding into the sidelobes of the feeds. The correction is performed on the calibrated brightness temperatures (after the antenna pattern correction), and is represented as:

$$T_{b\text{-corr}} = T_b - \Delta T_{const} - (T_{intru} - T_b)\, \Delta t_{multi} \quad (2.34)$$

where
T_b is the calibrated brightness temperature.
ΔT_{const} is the constant along-scan bias term and can be found in Appendix D.
T_{intru} is the temperature of the intrusion in Table 2.13.
Δt_{multi} is the multiplicative bias term (units of K/K) and can be found in Appendix E.

Table 2.13. Values for T_{intru} for each GMI channel.

	10 V	10 H	18 V	18 H	23 V	36 V	36 H	89V	89H	166V	166H	183VA	183VB
T_{intru}	175	175	175	175	175	125	125	0	0	0	0	0	0

Figure 2.13 demonstrates the correction for 10 GHz V (upper panel) and 10 GHz H (lower panel) channels. Typically, the correction has significant effects on samples near the edge of the scan. The correction is after the magnetism corrections described in Section 2.4 and therefore both curves in the figures are already corrected for errors induced by magnetism.

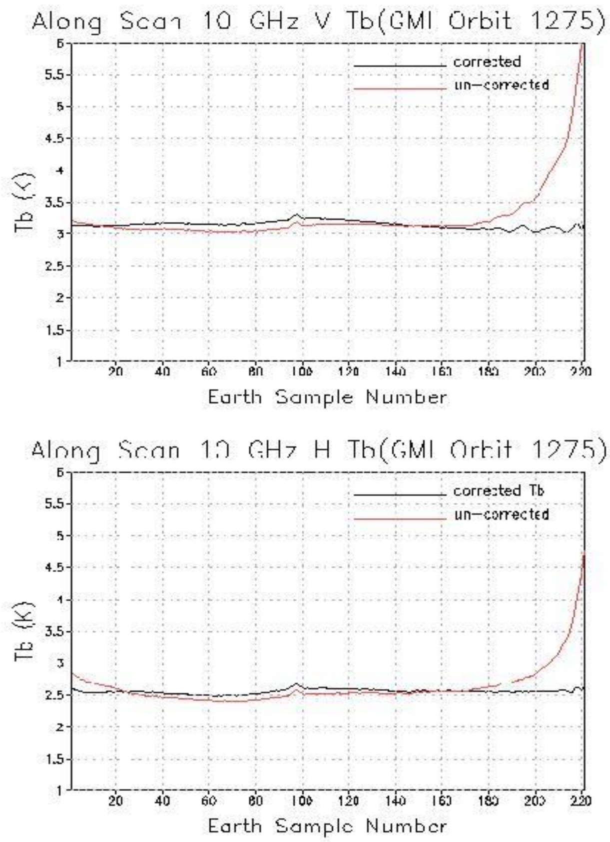

Figure 2.13. Along-scan correction on Tb for 10 GHz channels. Red line: un-corrected, Black line: corrected.

2.3 INPUT, OUTPUT, AND ALGORITHM FLOWCHART

The input files for calibration include three consecutive L1A files and external tuning files. The L1A includes already geolocated Earth counts, and SC and HK telemetry for the designed time period. There is one L1A file immediately before the processing orbit and one L1A file immediately after for the best multi-scan calibration. The tuning file will include all externally determined data such as APC coefficients and hot load PRT weights. Key input parameters are listed in Table 2.14 and the flow diagram of GMI calibration is displayed in Figure 2.14.

The key output parameters include geolocated and calibrated Ta and Tb, as well as parameters required by higher level algorithms such as incidence angle, Sun glint angle, etc. The details of output parameters are presented in separate documents: GMI Base File Specification, and GMI L1B File Specification.

Table 2.14. Key input parameters.

Parameter	Dimension	Unit	Description	Source
Noise Diode Indicator	ns_{cans}		All Scans	SC Packets
Earth View Count	n_{chan}, n_{scans}, n_{pixels}	Counts	All Scans	SC Packets
Hot Load Count	n_{chan}, n_{scans}, $n_{hsample}$	Counts	Every Other Scan	SC Packets
Cold Load Count	n_{chan}, n_{scans}, $n_{csample}$	Counts	Every Other Scan	SC Packets
Hot Load + Noise Diode Count	n_{chan}, n_{scans}, $n_{hsample}$	Counts	Every Other Scan	SC Packets
Cold Load + Noise Diode Count	n_{chan}, n_{scans}, $n_{csample}$	Counts	Every Other Scan	SC Packets
Hot Load Temperature	11, n_{scans}	Kelvin	All Scans	SC Packets
Cold Sky Temperature	n_{chan}, n_{scans}	Kelvin	All Scans	Tuning Data
Hot Load Tray Temperature	n_{scans}		All Scans	SC Packets
APC Coefficients	3, n_{chan}		All Scans	Tuning Data
Nonlinearity	3, n_{chan}	Kelvin	All Scans	Tuning Data
Correction Tables	n_{chan}, n_{pixels}		All Scans	Tuning Data

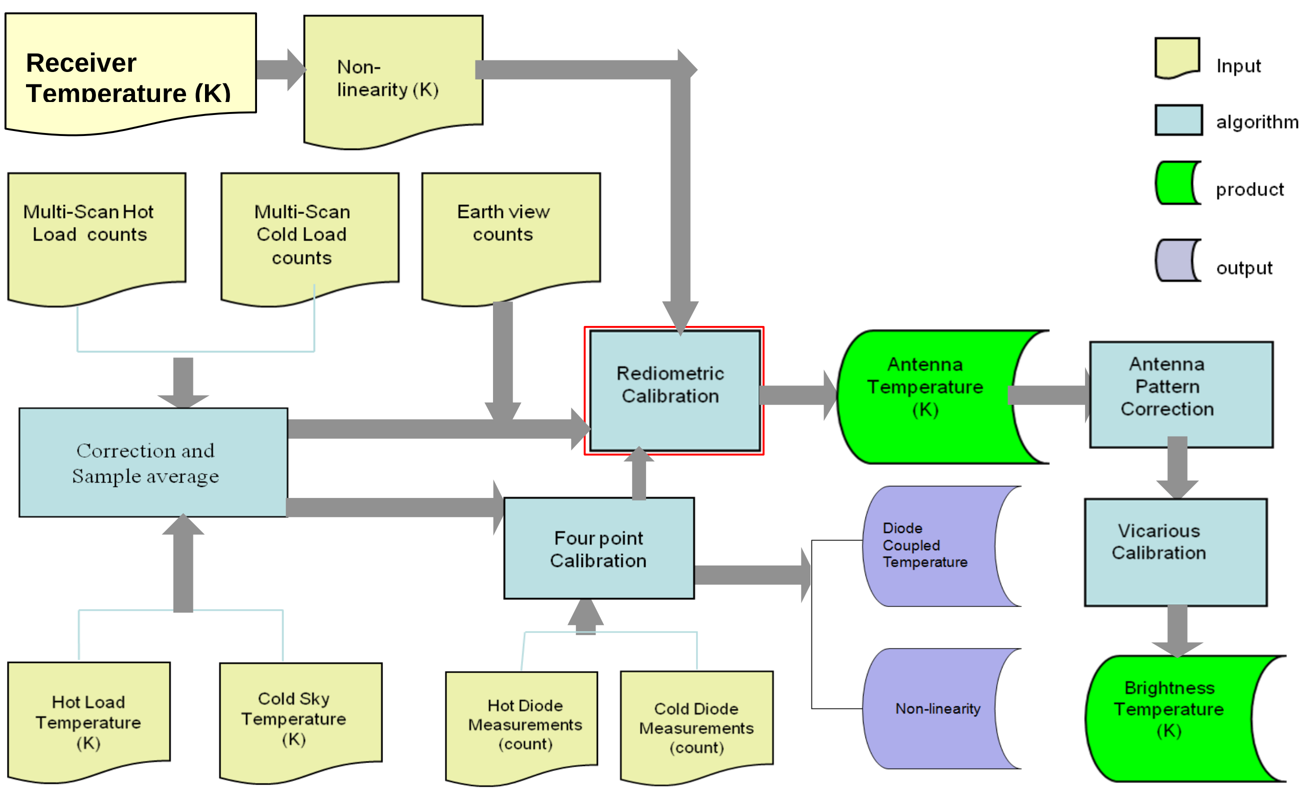

Figure 2.14. Flow chart of GMI L1B calibration process.

The algorithm is written in C. The code design is demonstrated in Table 2.15.

Table 2.15. L1B code design.

main.c	Call getCommandLine.c to get input and output file information. Check all input files; if OK and not empty, call doScan.c. Close all files.
doScans.c	Call readTune.c, collectCalibrationData.c to collect calibration data. Start Loop to all scans: Call getScan.c to collect scan telemetry data. Call process.c to process the scan.
process.c	Call getSwath1.c and getSwath2.c to put geolocation data and L1A counts into the output data structure. Call missl1b.c to assign missing values for the rest of the output data structure. If the scan is not a missing scan: Call calscan.c to perform calibration and fill all output data structure. Call writescan.c to write out the output data into the output HDF file.
calscan.c	Perform radiometric calibration. If it is for GMIBASE, fill out all GMIBASE data structure. If it is for 1BGMI, call antencorr.c to perform antenna pattern correction and fill out all 1BGMI data structure.

2.4 DEEP-SPACE MANEUVER AND CORRECTION ON ERROR INDUCED BY MAGNETIC FIELD

During the deep-space maneuver, it was found that the GMI receivers exhibit a small but detectable variation in output when exposed to a changing magnetic field. Each receiver exhibits the variation due to the Earth's magnetic field, observatory magnetic fields, and instrument magnetic fields. The magnetometers on the spacecraft directly measure the magnetic field from the Earth and spacecraft, which provides means for a correction of those terms. The combined Earth and spacecraft magnetic field cause a one-cycle sinusoid across the full 360-degree scan. As for the instrument magnetic fields, two main sources of magnetic field have been identified: 1) spin mechanism, and 2) feed switches on the launch restraints. The spin mechanism causes a small ripple in the counts at 96 cycles per revolution. The reed switches on the launch restraints cause blips in the scan as the receivers pass the launch restraints. The blips are most noticeable at the 10 GHz H-pol channel, the receiver closest to the Instrument Bay System (IBS) launch restraints, although they can also be seen in other channels. The change in receiver output due to instrument magnetic fields has now been shown to exist in GMI ground data and has been very stable from ground to on-orbit.

The magnetic correction is applied to the full-scan radiometer counts prior to calibration and has the following form:

$$C_{corr}=C - \mathbf{S} \cdot \mathbf{B} - \gamma \qquad (2.35)$$

C_{corr} represents the corrected counts from the receiver.
C represents the uncorrected counts from the receiver.
The vector **B** is the magnetic field vector. The vector **S** is the susceptibility vector.

And γ is a look-up table sample-dependent bias that captures the variations due to the magnetics of the instrument; it is provided in Appendix F.

Or we can rewrite equation (2.35) as equation (2.36) by separating magnetic field $\mathbf{v}_{mag}$ and scan angle θ:

$$C_{corr}=C- \alpha(\mathbf{v}_{mag})\cos(\theta)- \beta(\mathbf{v}_{mag})\sin(\theta) -\delta(\mathbf{v}_{mag})- \gamma \qquad (2.36)$$

$\mathbf{v}_{mag}$ is the voltage output vector (x, y, z).
$\theta = 0.6912 *i$ is the scan angle of the sample; *i* is full-scan sample index starting at 1 and progressing to 500.

Dot coefficients $\alpha(\mathbf{v}_{mag})$, $\beta(\mathbf{v}_{mag})$, and $\delta(\mathbf{v}_{mag})$ are dependent upon whether magnetic fields derived from magnetometers on the spacecraft or derived from another source of Earth's magnetic field are used.

When using a GPM Three-Axis Magnetometer (TAM) reading from the spacecraft, the $\mathbf{V}_{mag}$ (in volts) components are:

$V_x= -15.0 + 0.007326 \text{ x } V_{Counts}(x)$
$V_y= -15.0 + 0.007326 \text{ x } V_{Counts}(y)$
$V_z= -15.0 + 0.007326 \text{ x } V_{Counts}(z)$

and

$\alpha(\mathbf{v}_{mag}) = \mathbf{V}_{mag} . \mathbf{S_a} =V_x*S_a(x)+V_y*S_a(y)$
$\beta(\mathbf{v}_{mag}) = V_{mag} . \mathbf{S_b} =V_x*S_b(x)+V_y*S_b(y)$
$\delta(\mathbf{v}_{mag}) = 0.0$

Magnetic susceptibility vectors $\mathbf{S_a}$ and $\mathbf{S_b}$ are provided by BATC are shown in the following tables (Table 2.16 and Table 2.17):

Table 2.16. BATC susceptibility vector S_a.

$\mathbf{S_a}$	Channels												
	10V	10H	18V	18H	23V	36V	36H	89V	89H	166V	166H	183±3	183±7
$S_a(x)$	2.4566	-4.6	0.9821	-1.782	2.3998	3.7706	1.6739	-0.2792	3.4051	-1.2956	-2.9619	-0.2307	-1.5386
$S_a(y)$	-2.9305	4.619	1.1131	-0.9076	1.1477	-5.8881	-2.2984	-0.2806	-0.4871	1.2812	4.2001	-1.1519	-3.9776
$S_a(z)$	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.17. BATC susceptibility vector S_b.

$\mathbf{S_b}$	Channels												
	10V	10H	18V	18H	23V	36V	36H	89V	89H	166V	166H	183±3	183±7
$S_b(x)$	2.6051	-2.4256	-0.3482	2.2221	-1.3746	4.8544	1.7936	0.5234	-0.5368	0.3828	-2.1692	1.7842	5.1143
$S_b(y)$	1.73	-2.7362	2.2958	-1.2728	3.4557	2.828	1.432	0.0853	3.9825	-0.9051	-1.5563	-0.0135	-2.0837
$S_b(z)$	0	0	0	0	0	0	0	0	0	0	0	0	0

The final implementation uses the Earth's magnetic fields based on International Geomagnetic Reference Field (IGRF) 2011 software and data. The major reason for this decision is that the GPM realtime system doesn't have the input of magnetometer readings at the processing time and that the correction using IGRF 2011 is slightly better. The susceptibility vector **S** in Table 2.16 is derived based on the IGRF 2011 magnetic field. However, the corrections using TAM data are tested and results are also evaluated.

When using the Earth's magnetic field based on IGRF 2011:
First we compute the volts from the Earth's magnetic field by $V_{volts} = 0.0001 * V_{earthmag.}$
We rotate the V_{volts} two times to transform the V_{volts} from the Earth-Centered, Earth-Fixed (ECEF) coordinate system into the GPM flight axes **Bs** (Geolocation Toolkit ATBD).

The susceptibility vectors **S** are provided by RSS and are shown in Table 2.18.

B= **R** ·**Bs** where:

$$\boldsymbol{R} = \begin{matrix} \cos(\theta) & sin(\theta) & 0 \\ -sin(\theta) & cos(\theta) & 0 \\ 0 & 0 & 1 \end{matrix} \quad \text{and} \quad \boldsymbol{Bs} = \begin{matrix} Vx \\ Vy \\ Vz \end{matrix}$$

Using equation (2.35), we get:
$C_{corr}=C -(S_x(V_x \cos(\theta) + V_y\sin(\theta))+S_y(-V_x\sin(\theta) + V_y\cos(\theta))+S_zV_z) - \gamma$

or:
$\alpha(\mathbf{v}_{mag}) = S_xV_{x\,+}\ S_yV_y$
$\beta(\mathbf{v}_{mag}) = S_xV_{y\,-}\ S_yV_x$
$\delta(\mathbf{v}_{mag}) = S_zS_z$
for equation (2.36).

Table 2.18. RSS susceptibility vector S.

Channel	Sx	Sy	Sz
1	3.432785e+00	-2.059160e+00	1.397440e-01
2	-4.275016e+00	2.738752e+00	-7.392064e-02
3	1.889397e+00	6.719831e-01	-1.642689e-02
4	-1.242618e+00	-1.990708e+00	1.370751e-03
5	2.811633e+00	1.495198e+00	2.567597e-02
6	3.546198e+00	-4.985580e+00	-1.912243e-02
7	1.779466e+00	-1.837115e+00	9.478380e-04
8	-4.488613e-01	-4.083641e-01	-2.211949e-02
9	3.354606e+00	5.226006e-01	-2.995524e-02
10	-1.159396e+00	-1.982078e-01	-1.256910e-02
11	-2.874757e+00	2.330512e+00	-4.316371e-02
12	-2.295020e-01	-1.764391e+00	-1.337891e-02
13	-1.441512e+00	-5.167575e+00	1.085761e-02

The following figures show the corrections of errors induced by a magnetic (MAG) field for a deep-space maneuver orbit. Figure 2.15 compares the magnetic fields from GPM housekeeping data (TAM reading) and from IGRF 2011. The results are consistent in the coordinate system. The contrinution of the spacecraft to the total magnetic field is small.

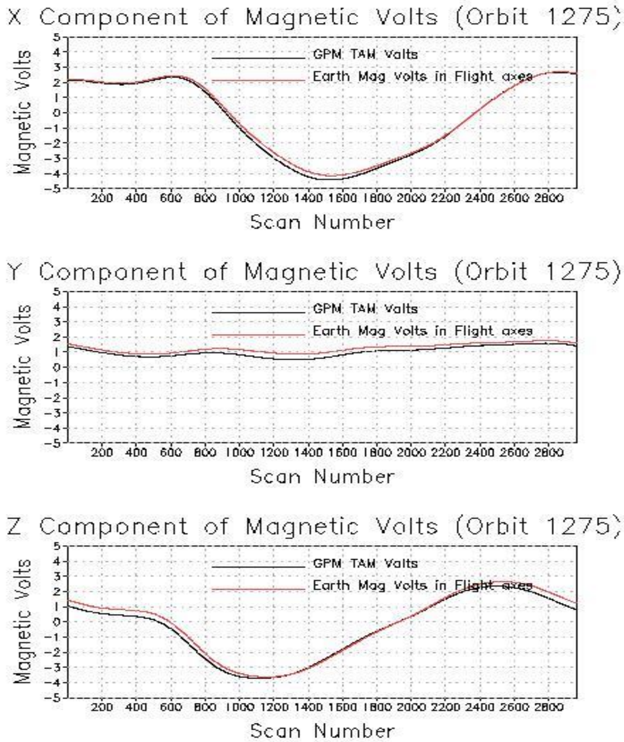

Figure 2.15. Magnet volts from Earth's magnetic fields and GPM TAM.

Figure 2.16 shows along-track and along-scan variations before and after magnetism corrections. The along-track anomalies of 10 GHz V resemble the X-components of a magnetic field before correction. The along-track anomalies of the 10 GHz H channel are out of phase with the X-components of a magnetic field before correction. These variations are gone after magnetism corrections. The along-scan biases induced by a magnetic field are corrected for Ta. However, the along-scan biases due to antenna patterns are not corrected for Ta. These biases are large near the edges of scans. They are corrected in Tb (Figure 2.17). Figure 2.18 to Figure 2.29 demonstrate the magnetism and along-scan corrections for all other channels.

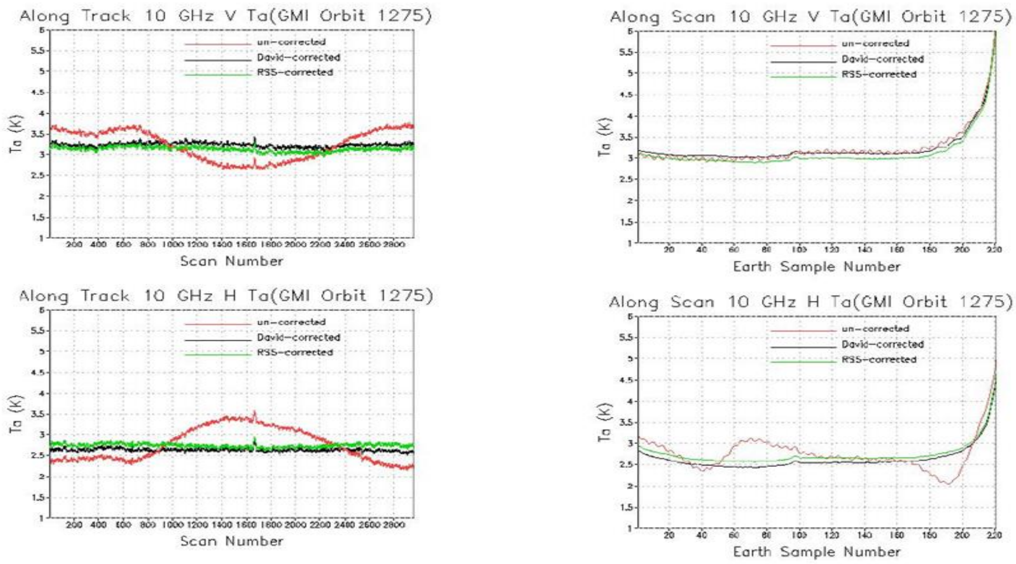

Figure 2.16. MAG corrections for Ta of 10 GHz V and H channels. Left: along track. Right: along scan. The green line is the results implemented for both GMI production and NRT.

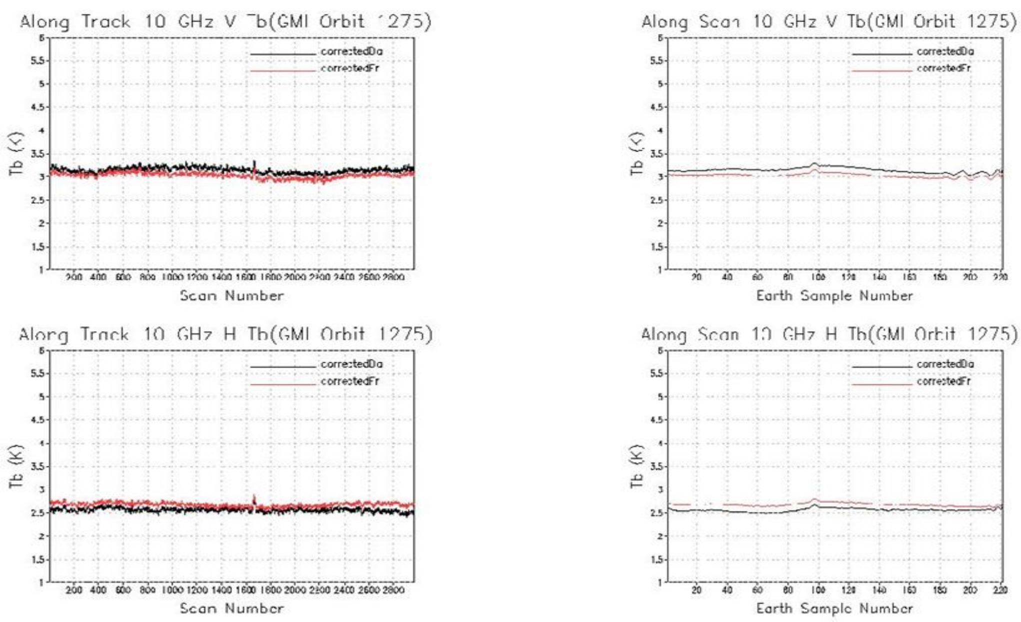

Figure 2.17. MAG + APC corrections for Tb of 10 GHz V and H channels. Left: along track. Right: along scan. The red line is the results implemented for both GMI production and NRT.

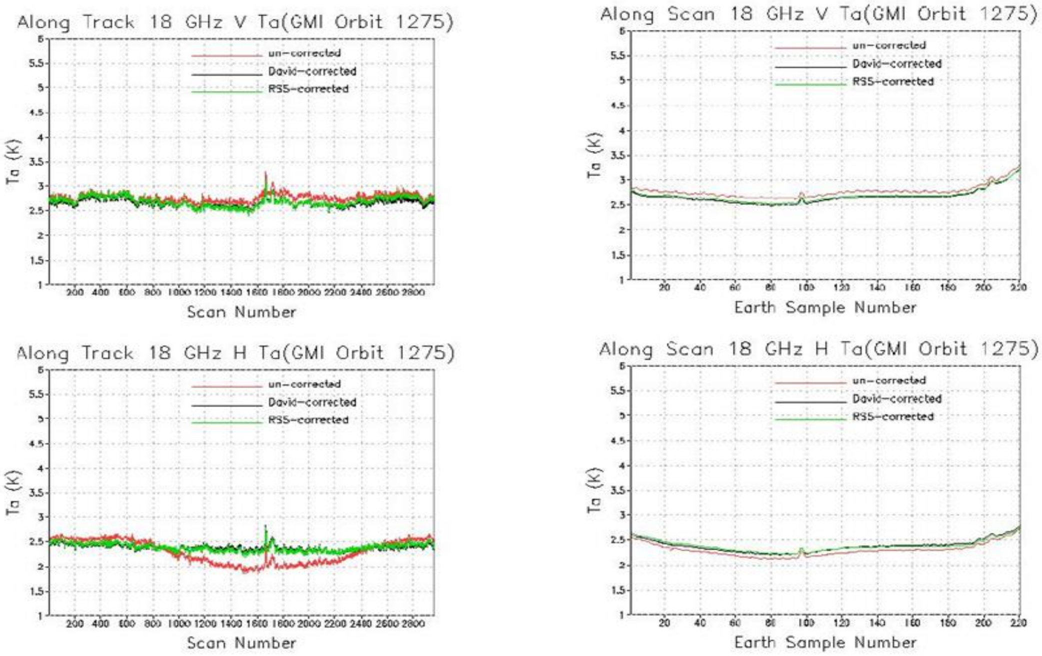

Figure 2.18. MAG corrections for Ta of 18 GHz V and H channels. Left: along track. Right: along scan. The green line is the results implemented for both GMI production and NRT.

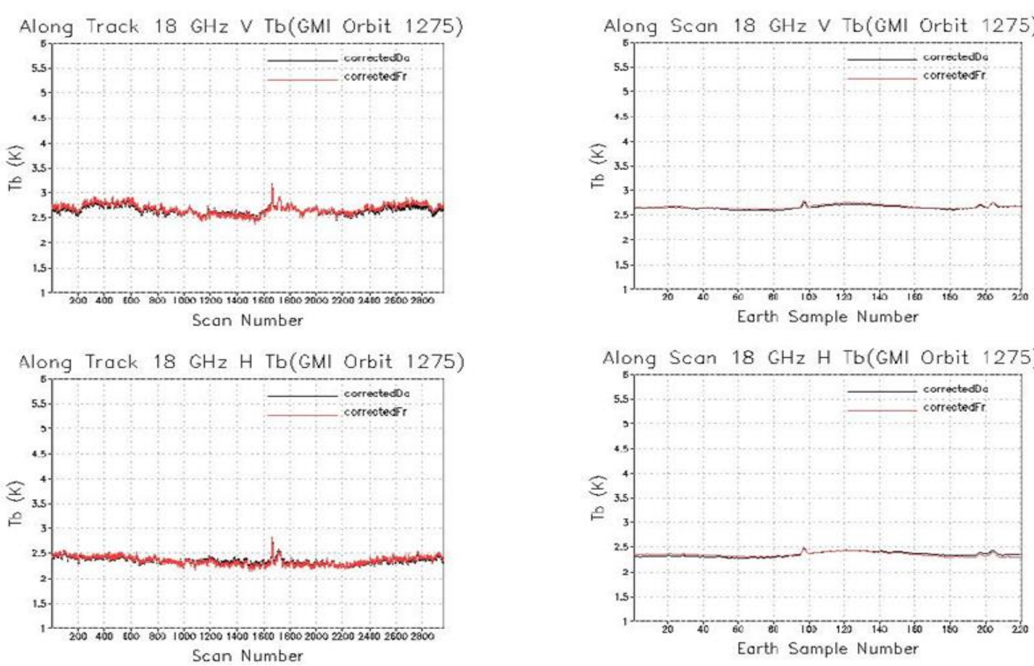

Figure 2.19. MAG + APC corrections for Tb of 18 GHz V and H channels. Left: along track. Right: along scan. The red line is the results implemented for both GMI production and NRT.

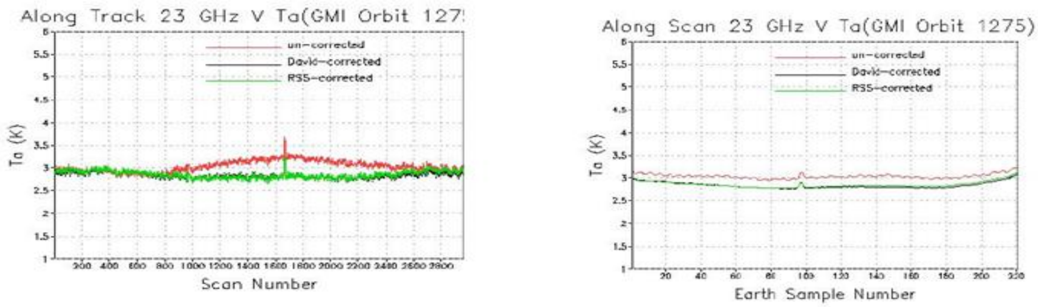

Figure 2.20. MAG corrections for Ta of 23 GHz V and H channels. Left: along track. Right: along scan. The green line is the results implemented for both GMI production and NRT.

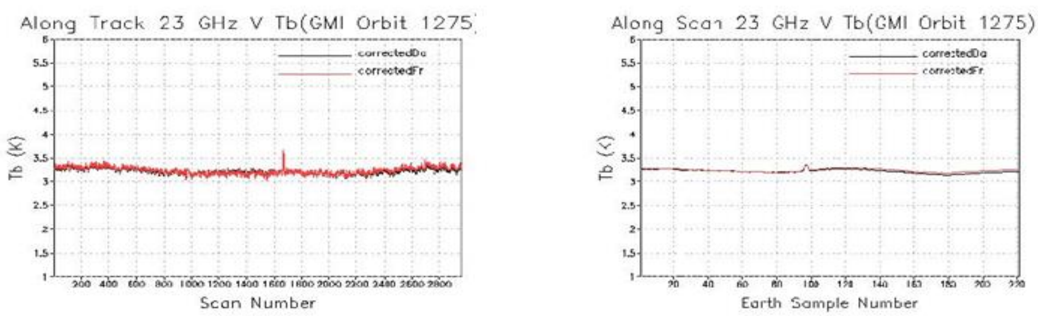

Figure 2.21. MAG + APC corrections for Tb of 23 GHz V and H channels. Left: along track. Right: along scan. The red line is the results implemented for both GMI production and NRT.

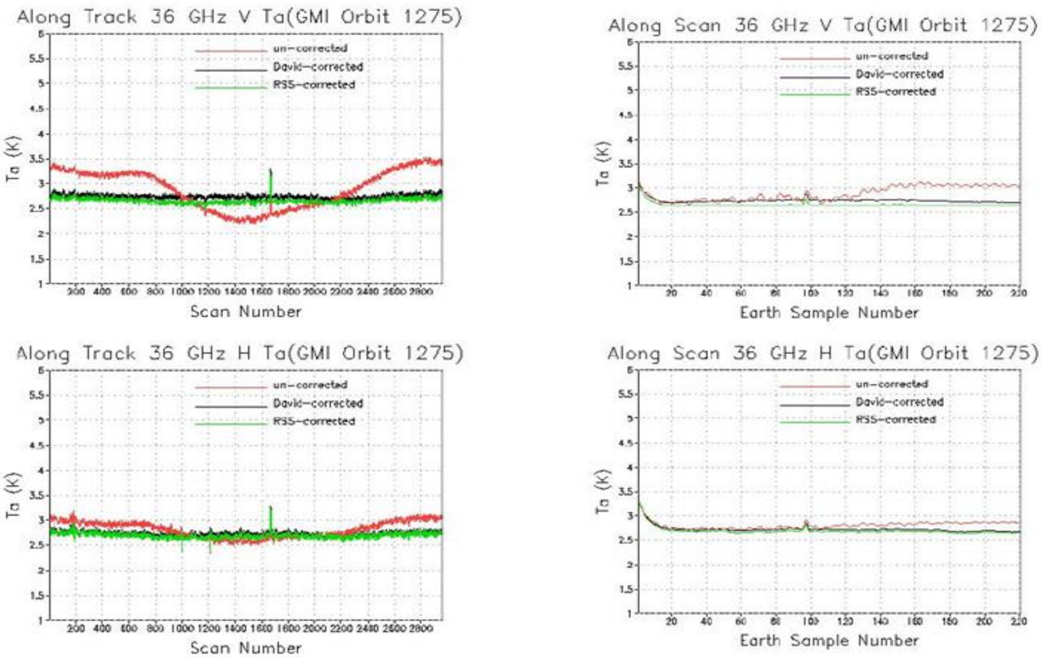

Figure 2.22. MAG corrections for Ta of 36 GHz V and H channels. Left: along track. Right: along scan. The green line is the results implemented for both GMI production and NRT.

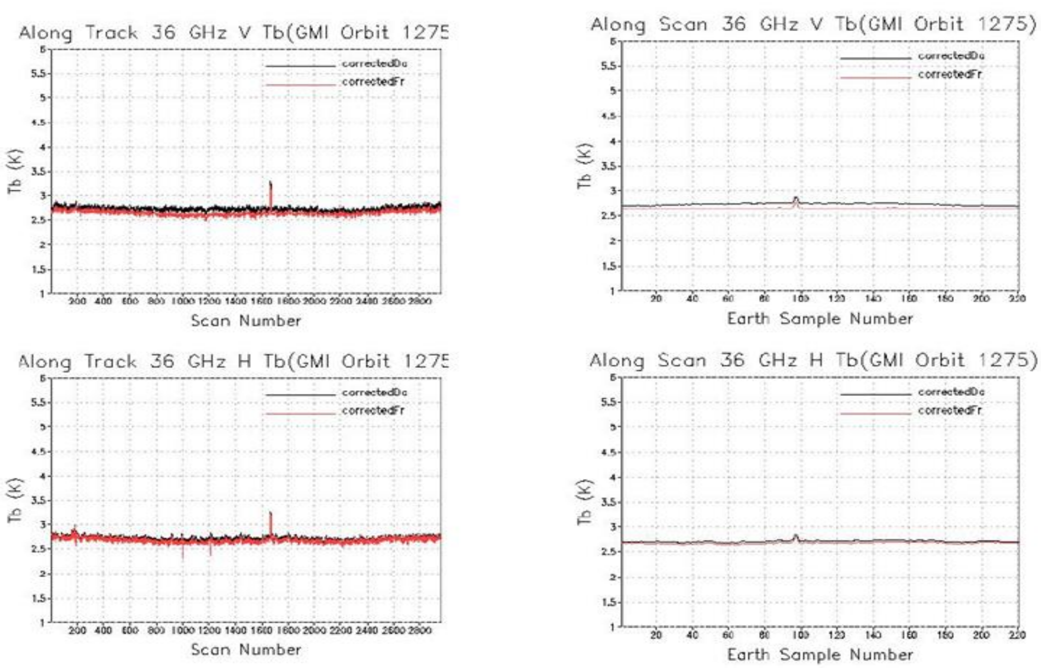

Figure 2.23. MAG + APC corrections for Tb of 36 GHz V and H channels. Left: along track. Right: along scan. The red line is the results implemented for both GMI production and NRT.

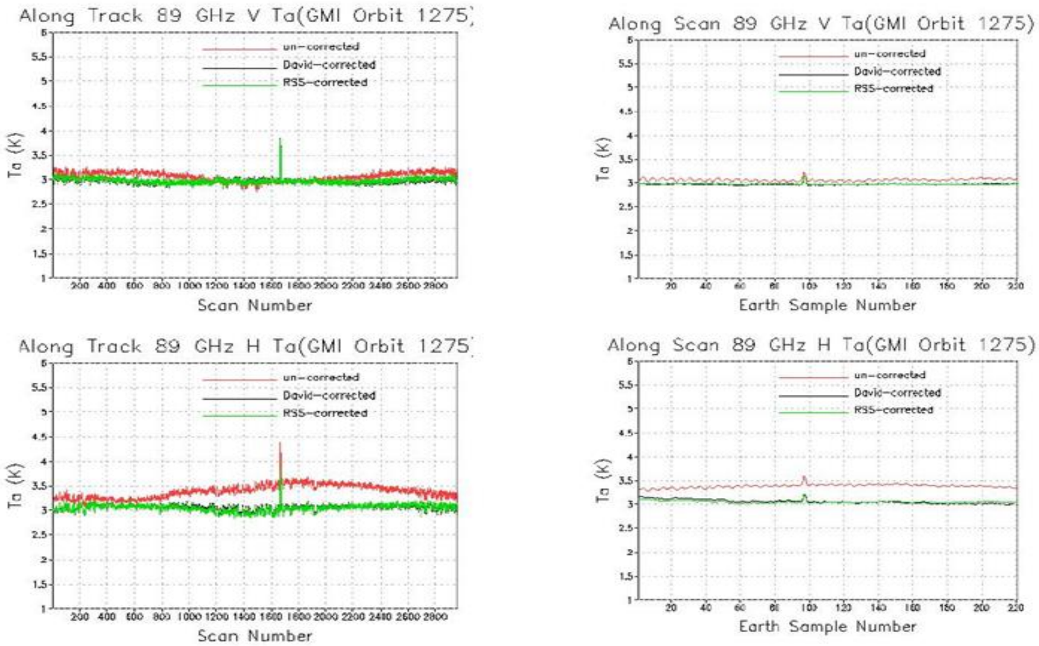

Figure 2.24. MAG corrections for Ta of 89 GHz V and H channels. Left: along track. Right: along scan. The green line is the results implemented for both GMI production and NRT.

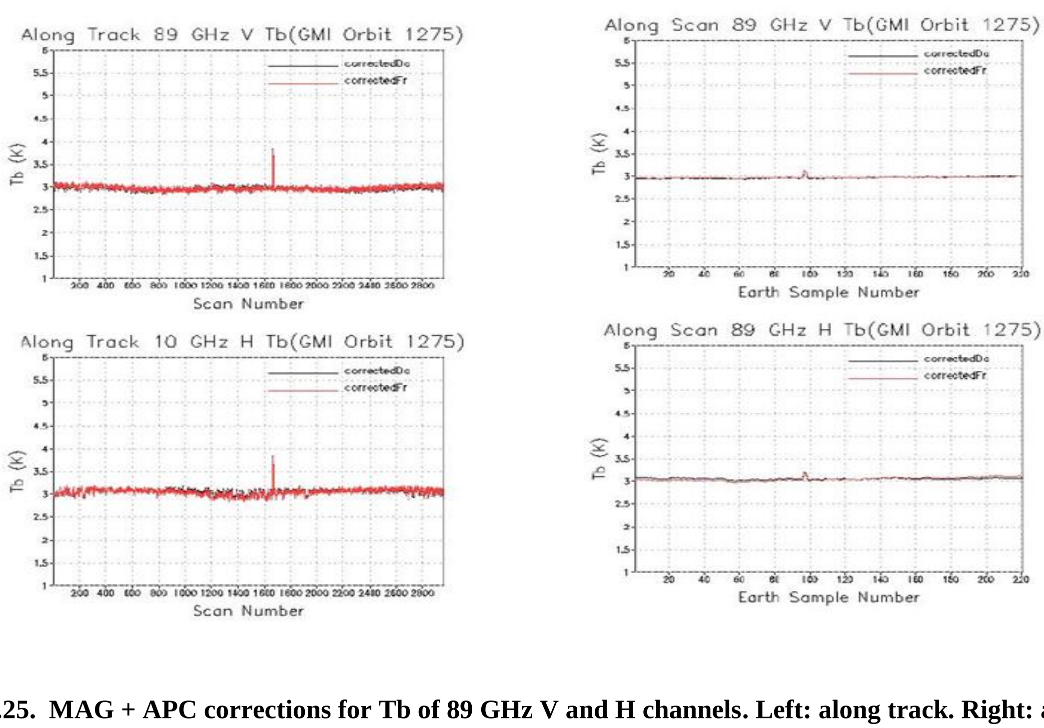

Figure 2.25. MAG + APC corrections for Tb of 89 GHz V and H channels. Left: along track. Right: along scan. The red line is the results implemented for both GMI production and NRT.

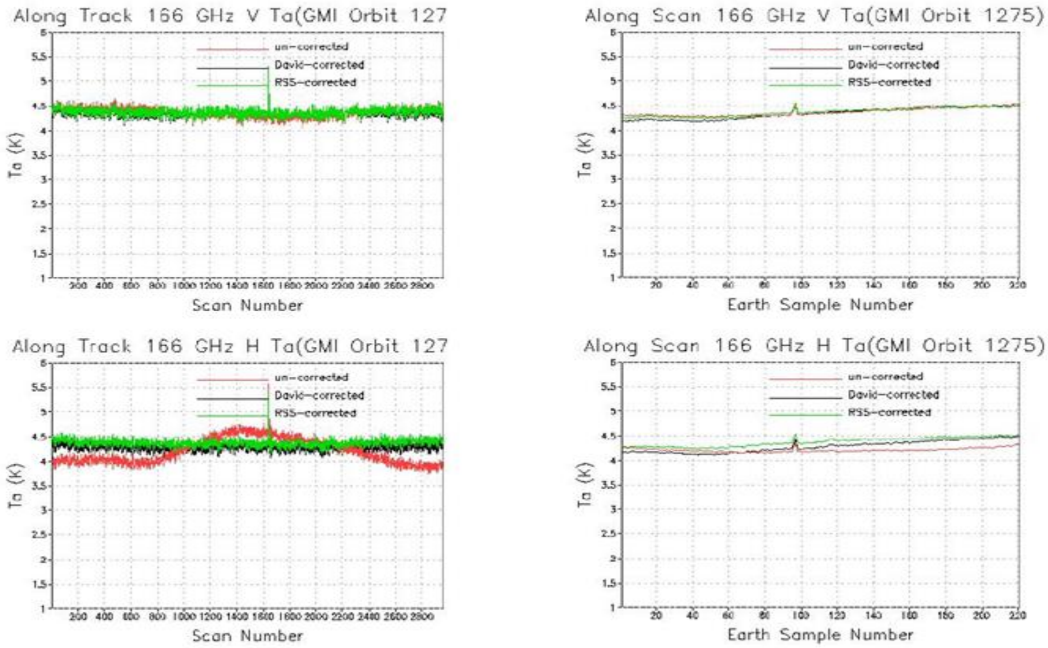

Figure 2.26. MAG corrections for Ta of 166 GHz V and H channels. Left: along track. Right: along scan. The green line is the results implemented for both GMI production and NRT.

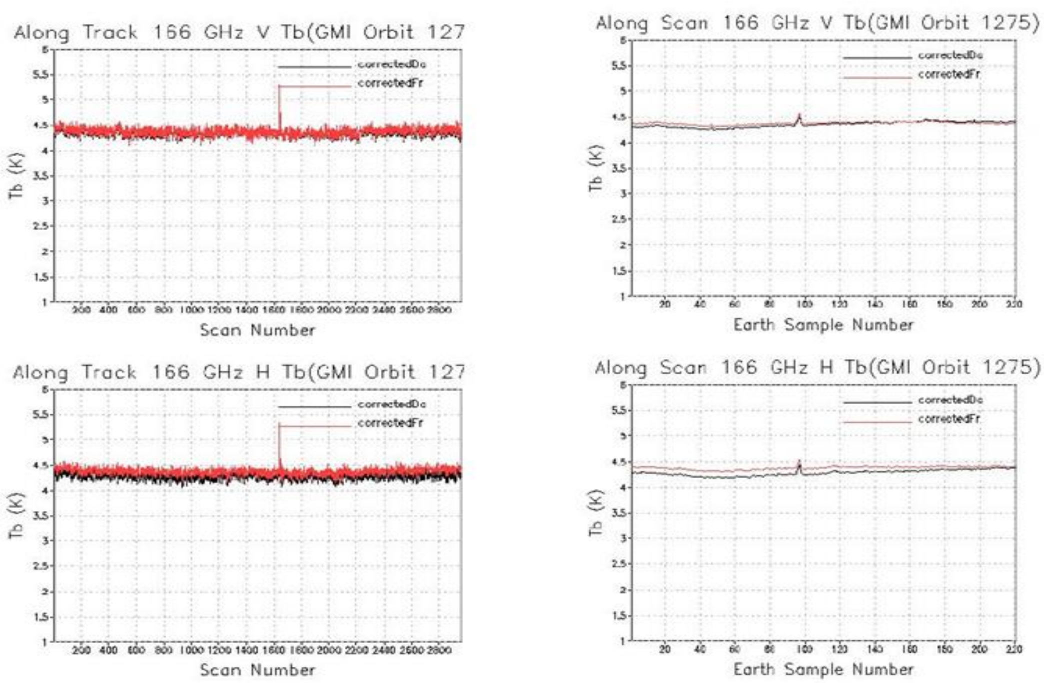

Figure 2.27. MAG + APC corrections for Tb of 166 GHz V and H channels. Left: along track. Right: along scan. The red line is the results implemented for both GMI production and NRT.

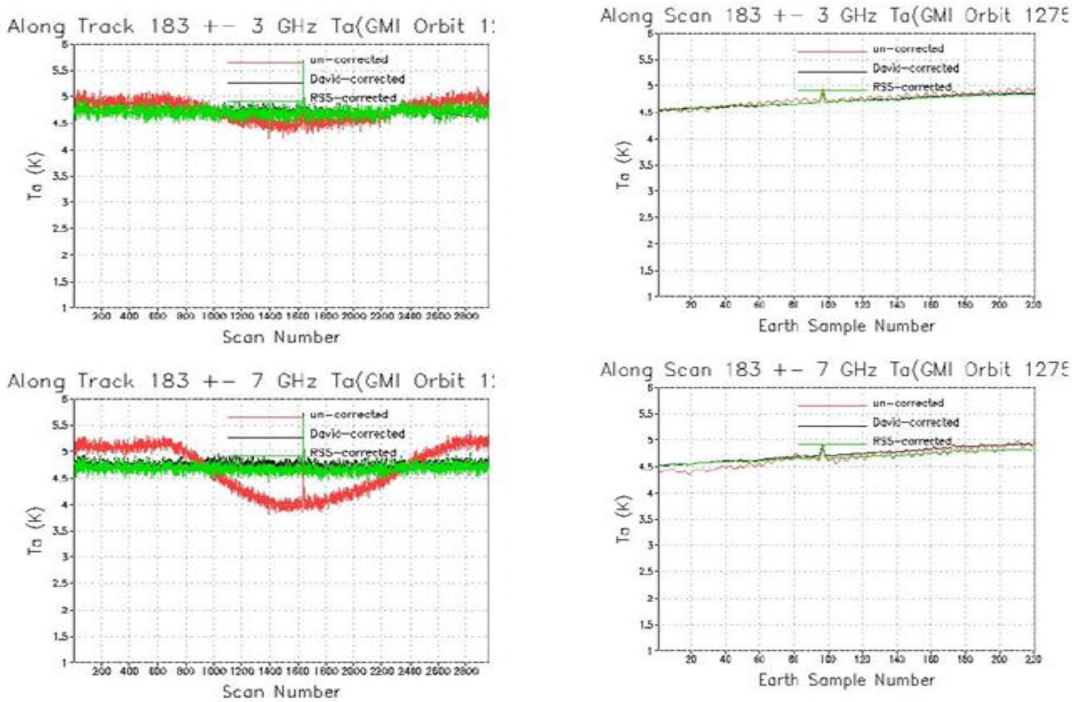

Figure 2.28. MAG corrections for Ta of 183 ±3 GHz and 183 ±7 GHz channels. Left: along track. Right: along scan. The green line is the results implemented for both GMI production and NRT.

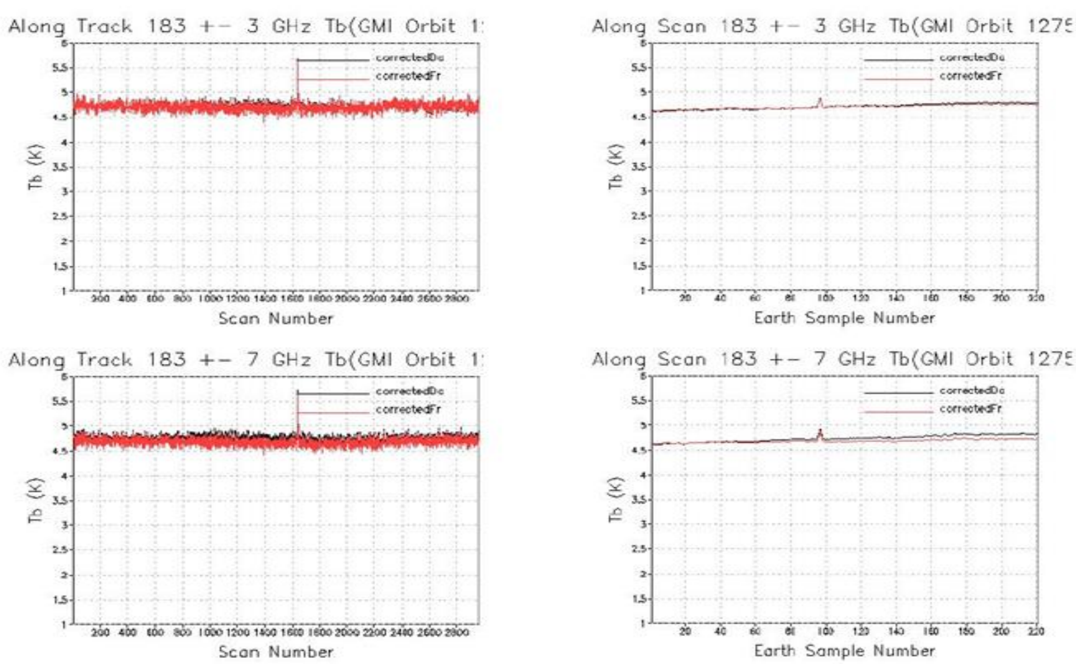

Figure 2.29. MAG + APC corrections for Tb of 183 ±3 GHz and 183 ±7 GHz channels. Left: along track. Right: along scan. The red line is the results implemented for both GMI production and NRT.

2.5 POST-LAUNCH VALIDATION

In addition to the validation described in Section 2.2 and Section 2.4, analyses are performed to compare biases between the current production version (V03B) and an earlier version (V03A) of production for the period when data are available.

V03B corrects the scan biases seen in many of the channels, most notably in 10.65H. The corrections added to V03B are combinations of magnetism correction described in Section 2.4 and along-scan antenna pattern correction described in Section 2.2. Figure 2.30 shows the scan biases for the nine low-frequency channels. The scan biases are shown as single differences (SDs) using the vicarious cold calibration method. Single differences calculated using GMI 1C V03A are shown in blue, and SDs using V03B are shown in red.

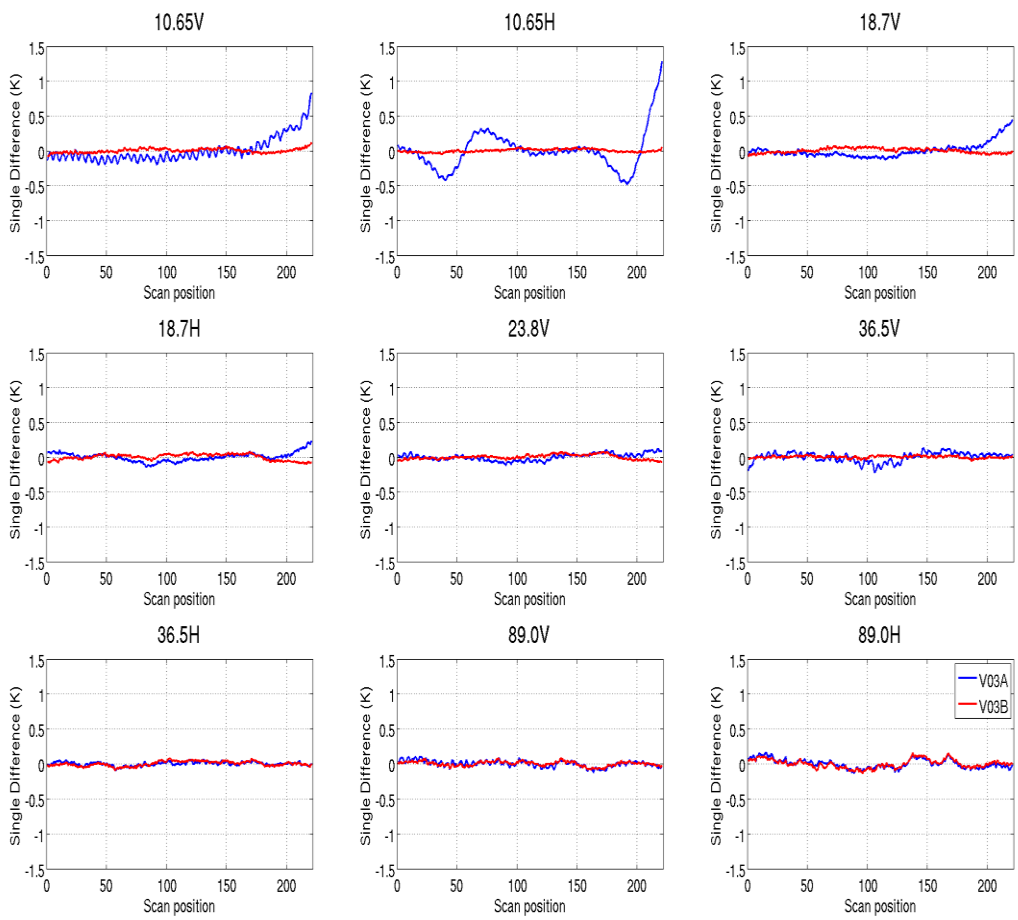

Figure 2.30. Vicarious cold calibration single differences by scan position for V03A (blue) and V03B (red). V03B scan biases show less variation across the scan than V03A, most notably for 10.65H.

V03B also corrects for the magnetic anomaly in the data that appears when splitting the data by yaw orientation and ascending/descending orbits. Figure 2.31 shows the vicarious cold calibration single differences, shown as the ascending SD minus the descending SD at each yaw orientation. This value should ideally be zero; however, some channels show a discrepancy using the V03A data. This is most obvious at 36.5V. V03B corrects for this discrepancy, reducing it to <0.1 K.

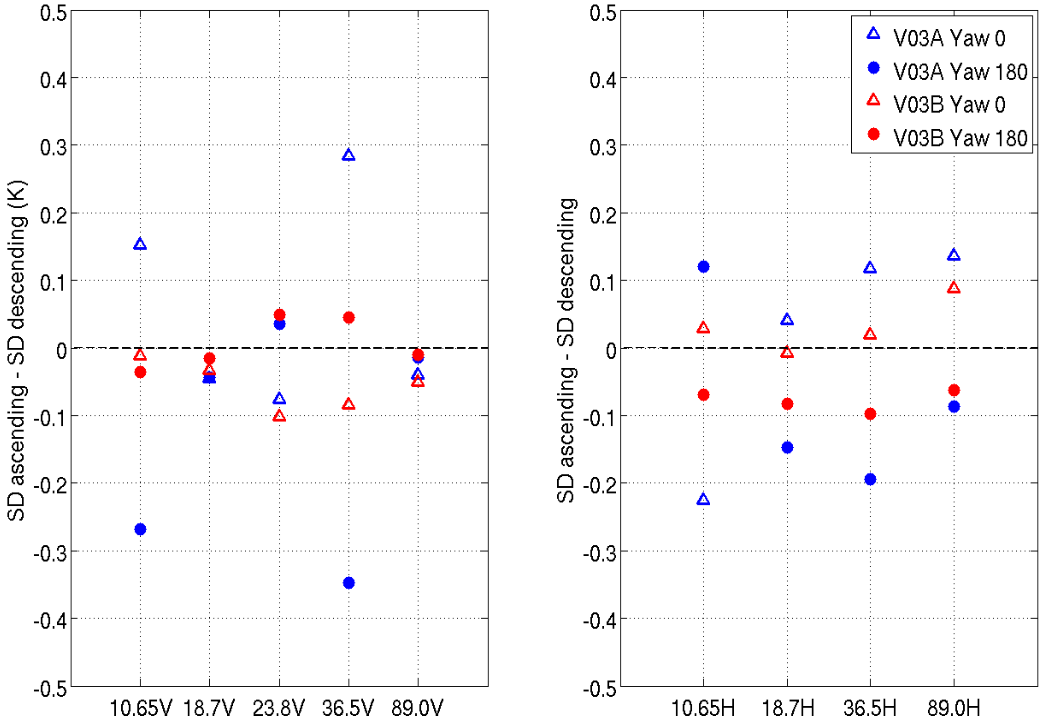

Figure 2.31. Ascending – descending SDs by yaw orientation for V03A (blue) and V03B (red). V03B reduces the discrepancy between the ascending and descending SDs, most notably at 36.5V.

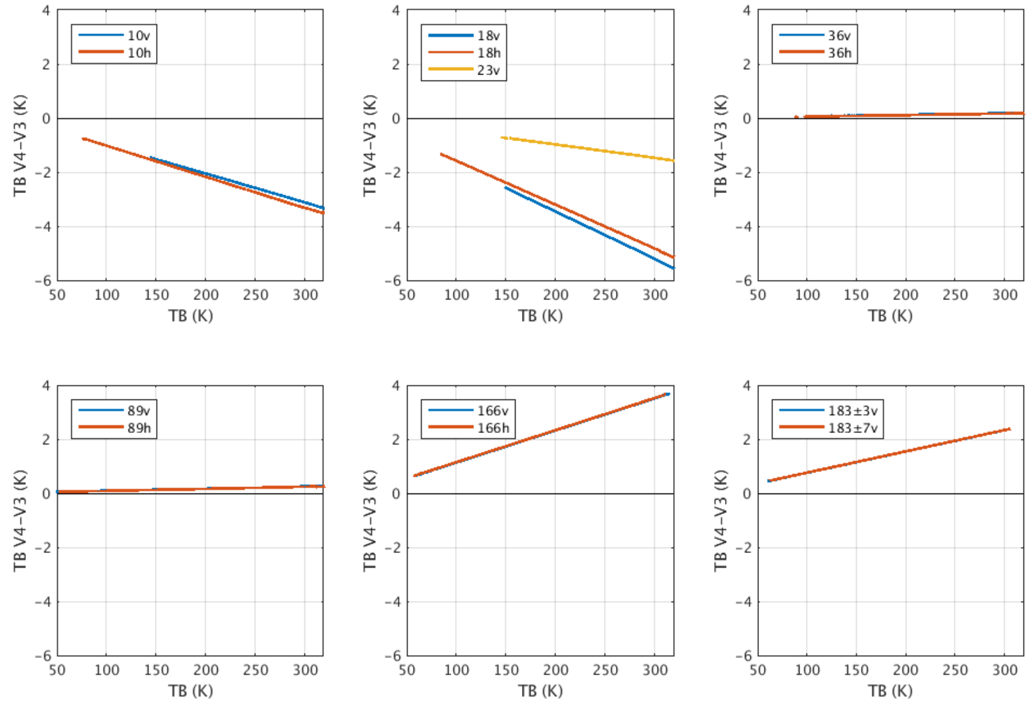

Figure 2.32. GMI Tb changes from V03 to V04.

The Noise Equivalent Delta Temperature (NEDT) for cold load counts for the 13 GMI channels is shown in Figure 2.33. Values before orbit number 720 are those derived from the at-launch version of products, and values thereafter are those derived from the after-launch adjustments. For cold counts, the adjustment reduced NEDT significantly for channels 3-9. The adjustment does not affect the hot load NEDT significantly (Figure 2.34).

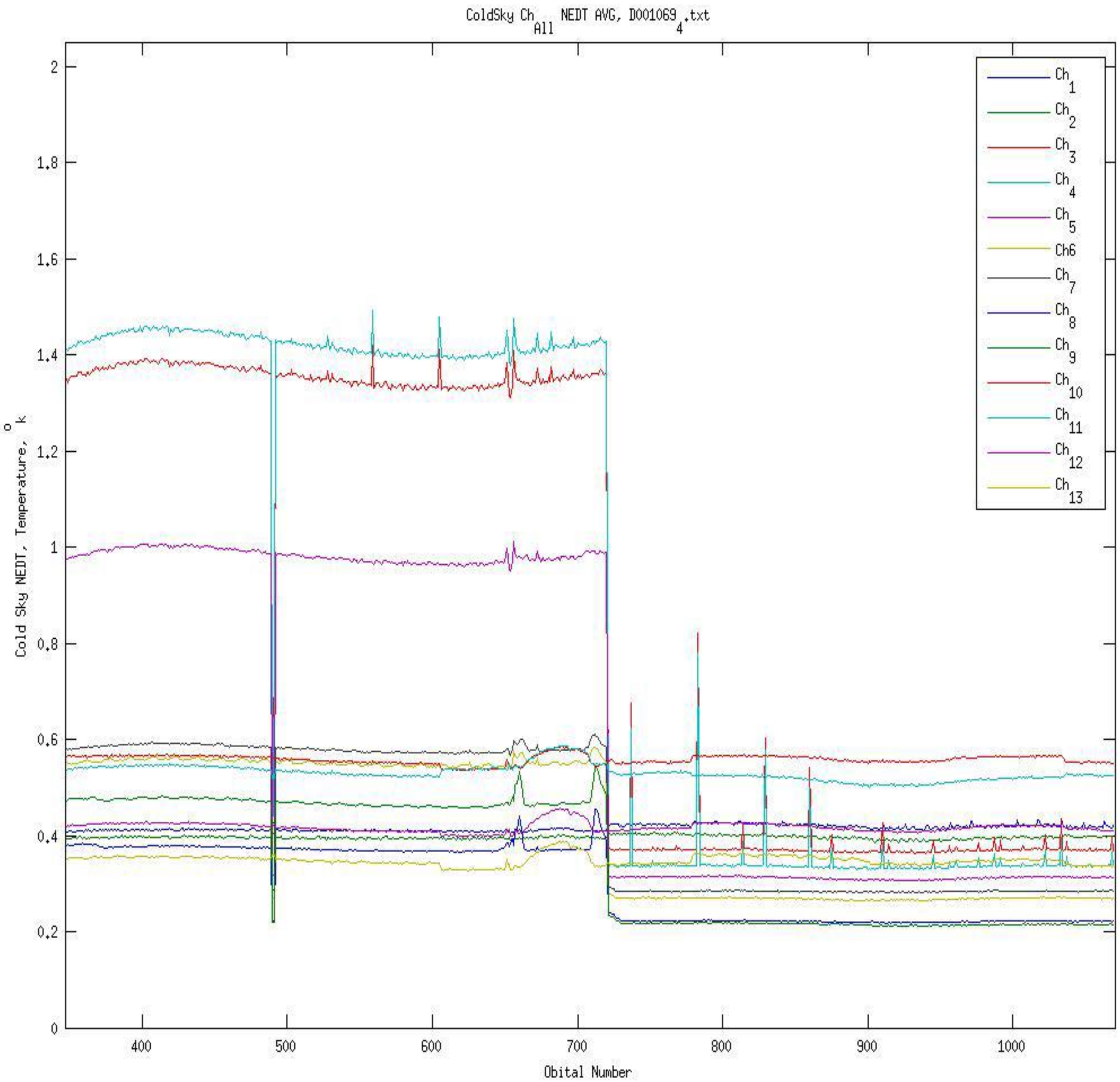

Figure 2.33. Cold load NEDT for 13 GMI channels.

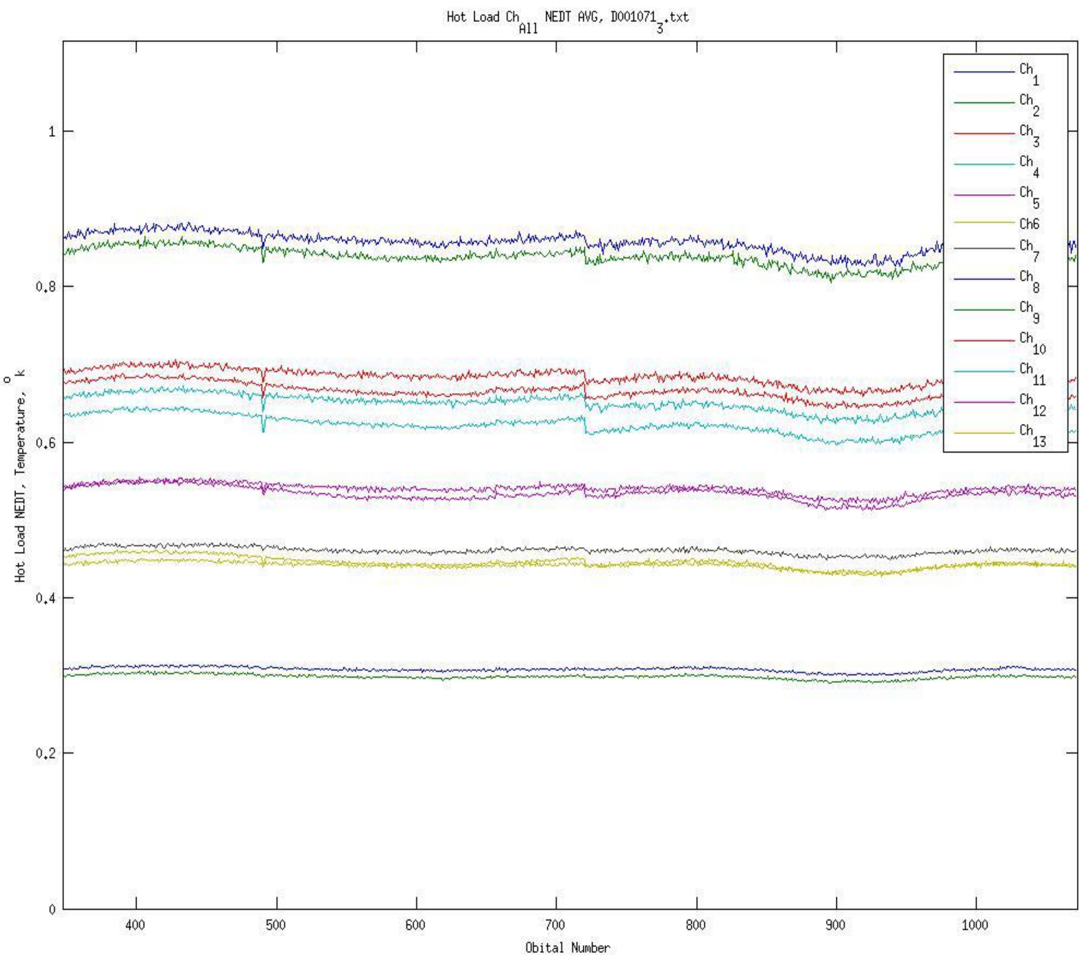

Figure 2.34. Hot load NEDT for 13 GMI channels.

BATC provided on-orbit NEDT computation code using data from the hot load for trending purposes. The NEDT is subdivided into two main components: the random "white" noise component and the gain drift. The method of computing the white noise component is via the single-sample Allan standard deviation, which can be computed by first differencing neighboring calibrated hot load samples and then taking the root mean square (RMS) of the differences divided by the square root of 2:

$$\sigma_{T-Allan} = \left(\frac{1}{2N_{scans}(h2-h1)} \sum_{j=1}^{N_{scans}} \sum_{i=h1+1}^{h2} \left(T_h(i,j) - T_h(i-1,j)\right)^2 \right)^{1/2}$$

where N_{scans} is the total number of valid scans over which the NEDT is computed (for channels with noise diodes, N_{scans} is the total number of valid scans with noise diodes OFF), *h*1 is the starting sample of the hot load, *h*2 is the end sample of the hot load, *i* is the sample index, *j* is the scan index of all scans over which the NEDT is computed (for channels with noise diodes, it is the index to all scans with noise diodes OFF over which the NEDT is computed), and $T_h\,(i, j)$ is the antenna temperature of the hot load for sample *i* and scan *j*. In order to reduce the uncertainty of the calculation, it is suggested that N_{scans} represent an orbit of data.

From the Allan standard deviation, the system noise temperature of the channel is computed as follows:

$$T_{sys} = \sigma_{T-Allan}\sqrt{B\tau}$$

where B is the channel bandwidth in Hz and τ is the integration period in seconds, which is 0.00355 seconds for all GMI channels. Further, the receiver noise temperature can be computed:

9.652E+7 9.493E+7 1.9383E+8 1.9448E+8 3.6787E+8 6.9840E+8 7.0753E+8 2.93317E+9 2.96033E+9 1.92600E+9 1.94783E+9 1.35767E+9 1.87867E+9

$$T_{rcvr} = T_{sys} - \langle T_h \rangle$$

where $\langle T_h \rangle$ represents the average hot load temperature over the duration of N_{scans}. The total NEDT (including gain drift) is:

$$NEDT = \frac{1}{\eta_p}\left(\frac{1}{N_{scans}(h2-h1+1)}\sum_{j=1}^{N_{scans}}\sum_{i=h1}^{h2}\left(\frac{300K+T_{rcvr}}{T_{h-b}(j)+T_{rcvr}}\right)^2 \left(T_h(i,j)-T_{h-b}(j)\right)^2\right)^{1/2}$$

where η_p is the spillover coefficient (which references the data to the reflector aperture), and $\overline{T}_h(j)$ is the hot load brightness temperature at scan j. The term $(300K + T_{rcvr})/(\overline{T}_h(j) + T_{rcvr})$ scales the NEDT to an equivalent 300K input antenna temperature.

3. REFERENCES

1. BATC, 2014: GMI Calibration Data Book.
2. Bilanow, S., 2010: PPS Geolocation Toolkit Architecture and Design Specification.
3. Bilanow, S., 2010: PPS Geolocation Toolkit ATBD.
4. Stout, J. M., 2010: PPS File Specification.
5. Wentz, F. J., and M. Thomas, 2008: GMI Calibration ATBD.

4. ACRONYMS

AMSR	Advanced Microwave Scanning Radiometer
APC	Antenna Pattern Correction
ATBD	Algorithm Theoretical Basis Document
BATC	Ball Aerospace & Technologies Corporation
CSR	Cold Sky Reflector
ECEF	Earth-Centered, Earth-Fixed
GHz	Gigahertz
GICS	GMI Coordinate System
GMI	GPM Microwave Imager
GPM	Global Precipitation Measurement
GSFC	Goddard Space Flight Center (Greenbelt, MD)
HDF	Hierarchical Data Format
HK	Housekeeping
IBS	Instrument Bay System
IGRF	International Geomagnetic Reference Field
ITE	Integration and Testing Environment
L1A	Level 1A
L1B	Level 1B
MAG	Magnetic
MLI	Multi-Layer Insulation
NASA	National Aeronautics and Space Administration
NEDT	Noise Equivalent Delta Temperature
NRT	Near-Realtime
PDR	Preliminary Design Review
PPS	Precipitation Processing System
PRT	Platinum Resistance Thermometer
RFI	Radio Frequency Interference
RMS	Root Mean Square
RSS	Remote Sensing Systems
SC	Spacecraft
SD	Single Differences
SSMI	Special Sensor for Microwave Imager
SSMI/S	Special Sensor for Microwave Imager/Sounder
Ta	Antenna Temperature
TAM	Three-Axis Magnetometer
Tb	Brightness Temperature
Tc	Mean Cold Sky Temperature
TMI	TRMM Microwave Imager
TRMM	Tropical Rainfall Measuring Mission
UT	Universal Time
V03, V04	Version 03, Version 04

5. APPENDIX A. NONLINEARITY PARAMETER "U"

Nonlinearity parameter "u"

Temp (˚C)	10 GHz V			10 GHz H		
	Low Gain	Nom Gain	High Gain	Low Gain	Nom Gain	High Gain
-10.0	-6.646000e-06	-8.455000e-06	-8.489000e-06	-7.507000e-06	-8.864000e-06	-1.130150e-05
-9.0	-6.606000e-06	-8.358000e-06	-8.367000e-06	-7.354000e-06	-8.741000e-06	-1.107250e-05
-8.0	-6.564000e-06	-8.262000e-06	-8.246000e-06	-7.205000e-06	-8.619000e-06	-1.084750e-05
-7.0	-6.520000e-06	-8.166000e-06	-8.125000e-06	-7.058000e-06	-8.498000e-06	-1.062640e-05
-6.0	-6.476000e-06	-8.070000e-06	-8.006000e-06	-6.913000e-06	-8.377000e-06	-1.040920e-05
-5.0	-6.430000e-06	-7.975000e-06	-7.888000e-06	-6.772000e-06	-8.257000e-06	-1.019590e-05
-4.0	-6.382000e-06	-7.880000e-06	-7.771000e-06	-6.632000e-06	-8.138000e-06	-9.986590e-06
-3.0	-6.334000e-06	-7.786000e-06	-7.654000e-06	-6.496000e-06	-8.020000e-06	-9.781200e-06
-2.0	-6.284000e-06	-7.692000e-06	-7.539000e-06	-6.362000e-06	-7.902000e-06	-9.579740e-06
-1.0	-6.233000e-06	-7.598000e-06	-7.425000e-06	-6.230000e-06	-7.786000e-06	-9.382210e-06
0.0	-6.180000e-06	-7.504000e-06	-7.312000e-06	-6.101000e-06	-7.670000e-06	-9.188610e-06
1.0	-6.126000e-06	-7.411000e-06	-7.200000e-06	-5.975000e-06	-7.554000e-06	-8.998940e-06
2.0	-6.071000e-06	-7.319000e-06	-7.088000e-06	-5.852000e-06	-7.440000e-06	-8.813210e-06
3.0	-6.014000e-06	-7.226000e-06	-6.978000e-06	-5.730000e-06	-7.326000e-06	-8.631400e-06
4.0	-5.956000e-06	-7.134000e-06	-6.869000e-06	-5.612000e-06	-7.213000e-06	-8.453530e-06
5.0	-5.897000e-06	-7.043000e-06	-6.761000e-06	-5.496000e-06	-7.100000e-06	-8.279590e-06
6.0	-5.836000e-06	-6.952000e-06	-6.653000e-06	-5.383000e-06	-6.989000e-06	-8.109590e-06
7.0	-5.774000e-06	-6.861000e-06	-6.547000e-06	-5.272000e-06	-6.878000e-06	-7.943510e-06
8.0	-5.711000e-06	-6.770000e-06	-6.442000e-06	-5.164000e-06	-6.768000e-06	-7.781360e-06
9.0	-5.646000e-06	-6.680000e-06	-6.337000e-06	-5.059000e-06	-6.658000e-06	-7.623150e-06
10.0	-5.580000e-06	-6.591000e-06	-6.234000e-06	-4.956000e-06	-6.550000e-06	-7.468870e-06
11.0	-5.513000e-06	-6.501000e-06	-6.132000e-06	-4.855000e-06	-6.442000e-06	-7.318520e-06
12.0	-5.444000e-06	-6.412000e-06	-6.031000e-06	-4.758000e-06	-6.335000e-06	-7.172100e-06
13.0	-5.374000e-06	-6.324000e-06	-5.930000e-06	-4.663000e-06	-6.228000e-06	-7.029620e-06
14.0	-5.303000e-06	-6.235000e-06	-5.831000e-06	-4.570000e-06	-6.123000e-06	-6.891060e-06
15.0	-5.231000e-06	-6.148000e-06	-5.733000e-06	-4.480000e-06	-6.018000e-06	-6.756440e-06
16.0	-5.157000e-06	-6.060000e-06	-5.635000e-06	-4.393000e-06	-5.913000e-06	-6.625750e-06
17.0	-5.081000e-06	-5.973000e-06	-5.539000e-06	-4.308000e-06	-5.810000e-06	-6.498990e-06
18.0	-5.005000e-06	-5.886000e-06	-5.444000e-06	-4.226000e-06	-5.707000e-06	-6.376160e-06
19.0	-4.927000e-06	-5.800000e-06	-5.349000e-06	-4.146000e-06	-5.605000e-06	-6.257270e-06
20.0	-4.847000e-06	-5.714000e-06	-5.256000e-06	-4.070000e-06	-5.504000e-06	-6.142300e-06
21.0	-4.767000e-06	-5.628000e-06	-5.164000e-06	-3.995000e-06	-5.404000e-06	-6.031270e-06
22.0	-4.685000e-06	-5.543000e-06	-5.072000e-06	-3.923000e-06	-5.304000e-06	-5.924170e-06
23.0	-4.602000e-06	-5.458000e-06	-4.982000e-06	-3.854000e-06	-5.205000e-06	-5.821000e-06
24.0	-4.517000e-06	-5.373000e-06	-4.893000e-06	-3.788000e-06	-5.107000e-06	-5.721760e-06
25.0	-4.431000e-06	-5.289000e-06	-4.804000e-06	-3.724000e-06	-5.009000e-06	-5.626460e-06
26.0	-4.344000e-06	-5.205000e-06	-4.717000e-06	-3.662000e-06	-4.912000e-06	-5.535080e-06
27.0	-4.255000e-06	-5.122000e-06	-4.631000e-06	-3.604000e-06	-4.816000e-06	-5.447640e-06
28.0	-4.165000e-06	-5.039000e-06	-4.545000e-06	-3.547000e-06	-4.721000e-06	-5.364130e-06
29.0	-4.074000e-06	-4.956000e-06	-4.461000e-06	-3.494000e-06	-4.627000e-06	-5.284550e-06
30.0	-3.981000e-06	-4.874000e-06	-4.377000e-06	-3.443000e-06	-4.533000e-06	-5.208900e-06
31.0	-3.887000e-06	-4.792000e-06	-4.295000e-06	-3.394000e-06	-4.440000e-06	-5.137190e-06
32.0	-3.792000e-06	-4.710000e-06	-4.214000e-06	-3.349000e-06	-4.347000e-06	-5.069400e-06

33.0	-3.696000e-06	-4.629000e-06	-4.133000e-06	-3.305000e-06	-4.256000e-06	-5.005550e-06
34.0	-3.598000e-06	-4.548000e-06	-4.054000e-06	-3.265000e-06	-4.165000e-06	-4.945630e-06
35.0	-3.498000e-06	-4.468000e-06	-3.975000e-06	-3.227000e-06	-4.075000e-06	-4.889640e-06
36.0	-3.398000e-06	-4.387000e-06	-3.898000e-06	-3.191000e-06	-3.986000e-06	-4.837580e-06
37.0	-3.296000e-06	-4.308000e-06	-3.822000e-06	-3.159000e-06	-3.897000e-06	-4.789460e-06
38.0	-3.193000e-06	-4.228000e-06	-3.746000e-06	-3.128000e-06	-3.809000e-06	-4.745260e-06
39.0	-3.088000e-06	-4.149000e-06	-3.672000e-06	-3.101000e-06	-3.722000e-06	-4.705000e-06
40.0	-2.982000e-06	-4.071000e-06	-3.598000e-06	-3.076000e-06	-3.636000e-06	-4.668670e-06
41.0	-2.875000e-06	-3.992000e-06	-3.526000e-06	-3.053000e-06	-3.550000e-06	-4.636270e-06
42.0	-2.766000e-06	-3.914000e-06	-3.454000e-06	-3.033000e-06	-3.465000e-06	-4.607800e-06
43.0	-2.656000e-06	-3.837000e-06	-3.384000e-06	-3.016000e-06	-3.381000e-06	-4.583270e-06
44.0	-2.545000e-06	-3.760000e-06	-3.315000e-06	-3.001000e-06	-3.298000e-06	-4.562670e-06
45.0	-2.432000e-06	-3.683000e-06	-3.246000e-06	-2.989000e-06	-3.215000e-06	-4.545990e-06

Temp (˚C)	18 GHz V			18 GHz H		
	Low Gain	Nom Gain	High Gain	Low Gain	Nom Gain	High Gain
-10.0	-1.607120e-06	-2.020000e-06	-1.292400e-06	4.404120e-07	9.944000e-07	2.942460e-06
-9.0	-1.583660e-06	-1.960000e-06	-1.278210e-06	4.594960e-07	1.070000e-06	2.985510e-06
-8.0	-1.560160e-06	-1.890000e-06	-1.263370e-06	4.786690e-07	1.145000e-06	3.028340e-06
-7.0	-1.536630e-06	-1.830000e-06	-1.247900e-06	4.979310e-07	1.218000e-06	3.070950e-06
-6.0	-1.513070e-06	-1.770000e-06	-1.231790e-06	5.172830e-07	1.290000e-06	3.113330e-06
-5.0	-1.489480e-06	-1.710000e-06	-1.215040e-06	5.367250e-07	1.361000e-06	3.155500e-06
-4.0	-1.465860e-06	-1.650000e-06	-1.197650e-06	5.562560e-07	1.430000e-06	3.197440e-06
-3.0	-1.442210e-06	-1.590000e-06	-1.179620e-06	5.758770e-07	1.498000e-06	3.239150e-06
-2.0	-1.418530e-06	-1.540000e-06	-1.160950e-06	5.955880e-07	1.565000e-06	3.280650e-06
-1.0	-1.394830e-06	-1.480000e-06	-1.141640e-06	6.153880e-07	1.631000e-06	3.321920e-06
0.0	-1.371090e-06	-1.430000e-06	-1.121700e-06	6.352770e-07	1.695000e-06	3.362970e-06
1.0	-1.347320e-06	-1.370000e-06	-1.101110e-06	6.552570e-07	1.758000e-06	3.403800e-06
2.0	-1.323520e-06	-1.320000e-06	-1.079890e-06	6.753250e-07	1.820000e-06	3.444400e-06
3.0	-1.299690e-06	-1.270000e-06	-1.058030e-06	6.954840e-07	1.881000e-06	3.484780e-06
4.0	-1.275830e-06	-1.210000e-06	-1.035530e-06	7.157320e-07	1.940000e-06	3.524940e-06
5.0	-1.251940e-06	-1.160000e-06	-1.012390e-06	7.360700e-07	1.998000e-06	3.564880e-06
6.0	-1.228020e-06	-1.110000e-06	-9.886101e-07	7.564970e-07	2.055000e-06	3.604590e-06
7.0	-1.204070e-06	-1.060000e-06	-9.641930e-07	7.770140e-07	2.111000e-06	3.644080e-06
8.0	-1.180090e-06	-1.010000e-06	-9.391370e-07	7.976200e-07	2.165000e-06	3.683350e-06
9.0	-1.156080e-06	-9.670000e-07	-9.134420e-07	8.183160e-07	2.218000e-06	3.722390e-06
10.0	-1.132040e-06	-9.200000e-07	-8.871090e-07	8.391020e-07	2.270000e-06	3.761220e-06
11.0	-1.107970e-06	-8.750000e-07	-8.601360e-07	8.599770e-07	2.320000e-06	3.799820e-06
12.0	-1.083870e-06	-8.300000e-07	-8.325250e-07	8.809420e-07	2.369000e-06	3.838190e-06
13.0	-1.059740e-06	-7.860000e-07	-8.042750e-07	9.019960e-07	2.417000e-06	3.876350e-06
14.0	-1.035580e-06	-7.420000e-07	-7.753860e-07	9.231400e-07	2.464000e-06	3.914280e-06
15.0	-1.011390e-06	-7.000000e-07	-7.458580e-07	9.443740e-07	2.509000e-06	3.951990e-06
16.0	-9.871740e-07	-6.590000e-07	-7.156910e-07	9.656970e-07	2.554000e-06	3.989480e-06
17.0	-9.629240e-07	-6.180000e-07	-6.848860e-07	9.871100e-07	2.597000e-06	4.026740e-06
18.0	-9.386430e-07	-5.790000e-07	-6.534410e-07	1.008610e-06	2.638000e-06	4.063780e-06
19.0	-9.143330e-07	-5.400000e-07	-6.213580e-07	1.030200e-06	2.679000e-06	4.100600e-06
20.0	-8.899930e-07	-5.020000e-07	-5.886360e-07	1.051890e-06	2.718000e-06	4.137200e-06

21.0	-8.656230e-07	-4.650000e-07	-5.552750e-07	1.073660e-06	2.756000e-06	4.173570e-06
22.0	-8.412220e-07	-4.290000e-07	-5.212760e-07	1.095520e-06	2.792000e-06	4.209720e-06
23.0	-8.167920e-07	-3.930000e-07	-4.866370e-07	1.117470e-06	2.827000e-06	4.245650e-06
24.0	-7.923310e-07	-3.590000e-07	-4.513600e-07	1.139510e-06	2.861000e-06	4.281360e-06
25.0	-7.678410e-07	-3.250000e-07	-4.154430e-07	1.161640e-06	2.894000e-06	4.316840e-06
26.0	-7.433200e-07	-2.930000e-07	-3.788880e-07	1.183860e-06	2.926000e-06	4.352100e-06
27.0	-7.187700e-07	-2.610000e-07	-3.416940e-07	1.206170e-06	2.956000e-06	4.387140e-06
28.0	-6.941890e-07	-2.300000e-07	-3.038620e-07	1.228560e-06	2.985000e-06	4.421960e-06
29.0	-6.695780e-07	-2.000000e-07	-2.653900e-07	1.251050e-06	3.013000e-06	4.456550e-06
30.0	-6.449370e-07	-1.710000e-07	-2.262790e-07	1.273630e-06	3.039000e-06	4.490920e-06
31.0	-6.202660e-07	-1.420000e-07	-1.865300e-07	1.296300e-06	3.064000e-06	4.525070e-06
32.0	-5.955650e-07	-1.150000e-07	-1.461420e-07	1.319050e-06	3.088000e-06	4.558990e-06
33.0	-5.708340e-07	-8.830000e-08	-1.051150e-07	1.341900e-06	3.111000e-06	4.592690e-06
34.0	-5.460730e-07	-6.260000e-08	-6.344930e-08	1.364840e-06	3.132000e-06	4.626170e-06
35.0	-5.212820e-07	-3.770000e-08	-2.114470e-08	1.387860e-06	3.153000e-06	4.659430e-06
36.0	-4.964610e-07	-1.380000e-08	2.179880e-08	1.410980e-06	3.171000e-06	4.692460e-06
37.0	-4.716100e-07	9.340000e-09	6.538120e-08	1.434180e-06	3.189000e-06	4.725270e-06
38.0	-4.467280e-07	3.160000e-08	1.096020e-07	1.457480e-06	3.205000e-06	4.757860e-06
39.0	-4.218170e-07	5.290000e-08	1.544620e-07	1.480860e-06	3.221000e-06	4.790230e-06
40.0	-3.968760e-07	7.340000e-08	1.999610e-07	1.504330e-06	3.234000e-06	4.822370e-06
41.0	-3.719040e-07	9.300000e-08	2.460990e-07	1.527900e-06	3.247000e-06	4.854290e-06
42.0	-3.469030e-07	1.120000e-07	2.928750e-07	1.551550e-06	3.258000e-06	4.885990e-06
43.0	-3.218710e-07	1.300000e-07	3.402910e-07	1.575290e-06	3.268000e-06	4.917470e-06
44.0	-2.968090e-07	1.470000e-07	3.883450e-07	1.599120e-06	3.277000e-06	4.948720e-06
45.0	-2.717170e-07	1.630000e-07	4.370380e-07	1.623050e-06	3.284000e-06	4.979750e-06

Temp (˚C)	23 GHz V		
	Low Gain	Nom Gain	High Gain
-10.000000	2.467000e-06	2.973000e-06	5.915010e-06
-9.000000	2.351000e-06	2.924000e-06	5.918900e-06
-8.000000	2.239980e-06	2.876000e-06	5.920720e-06
-7.000000	2.133950e-06	2.829000e-06	5.920450e-06
-6.000000	2.032910e-06	2.782000e-06	5.918110e-06
-5.000000	1.936850e-06	2.736000e-06	5.913700e-06
-4.000000	1.845790e-06	2.691000e-06	5.907210e-06
-3.000000	1.759700e-06	2.647000e-06	5.898640e-06
-2.000000	1.678610e-06	2.603000e-06	5.888000e-06
-1.000000	1.602500e-06	2.561000e-06	5.875280e-06
0.000000	1.531390e-06	2.519000e-06	5.860490e-06
1.000000	1.465250e-06	2.477000e-06	5.843620e-06
2.000000	1.404110e-06	2.437000e-06	5.824670e-06
3.000000	1.347950e-06	2.397000e-06	5.803650e-06
4.000000	1.296780e-06	2.358000e-06	5.780550e-06
5.000000	1.250600e-06	2.319000e-06	5.755380e-06
6.000000	1.209410e-06	2.282000e-06	5.728130e-06
7.000000	1.173200e-06	2.245000e-06	5.698810e-06
8.000000	1.141980e-06	2.209000e-06	5.667410e-06

9.000000	1.115740e-06	2.174000e-06	5.633930e-06
10.000000	1.094500e-06	2.139000e-06	5.598380e-06
11.000000	1.078240e-06	2.105000e-06	5.560750e-06
12.000000	1.066970e-06	2.072000e-06	5.521050e-06
13.000000	1.060680e-06	2.040000e-06	5.479270e-06
14.000000	1.059390e-06	2.008000e-06	5.435420e-06
15.000000	1.063080e-06	1.977000e-06	5.389490e-06
16.000000	1.071760e-06	1.947000e-06	5.341480e-06
17.000000	1.085420e-06	1.918000e-06	5.291400e-06
18.000000	1.104070e-06	1.889000e-06	5.239240e-06
19.000000	1.127720e-06	1.861000e-06	5.185010e-06
20.000000	1.156340e-06	1.834000e-06	5.128700e-06
21.000000	1.189960e-06	1.808000e-06	5.070310e-06
22.000000	1.228560e-06	1.782000e-06	5.009850e-06
23.000000	1.272150e-06	1.757000e-06	4.947310e-06
24.000000	1.320730e-06	1.733000e-06	4.882700e-06
25.000000	1.374290e-06	1.710000e-06	4.816010e-06
26.000000	1.432840e-06	1.687000e-06	4.747250e-06
27.000000	1.496380e-06	1.665000e-06	4.676410e-06
28.000000	1.564900e-06	1.644000e-06	4.603490e-06
29.000000	1.638420e-06	1.624000e-06	4.528500e-06
30.000000	1.716920e-06	1.604000e-06	4.451430e-06
31.000000	1.800410e-06	1.585000e-06	4.372290e-06
32.000000	1.888880e-06	1.567000e-06	4.291070e-06
33.000000	1.982340e-06	1.550000e-06	4.207780e-06
34.000000	2.080790e-06	1.533000e-06	4.122410e-06
35.000000	2.184230e-06	1.517000e-06	4.034960e-06
36.000000	2.292660e-06	1.502000e-06	3.945440e-06
37.000000	2.406070e-06	1.488000e-06	3.853840e-06
38.000000	2.524470e-06	1.474000e-06	3.760170e-06
39.000000	2.647850e-06	1.461000e-06	3.664420e-06
40.000000	2.776230e-06	1.449000e-06	3.566590e-06
41.000000	2.909590e-06	1.438000e-06	3.466690e-06
42.000000	3.047940e-06	1.427000e-06	3.364720e-06
43.000000	3.191270e-06	1.417000e-06	3.260660e-06
44.000000	3.339600e-06	1.408000e-06	3.154540e-06
45.000000	3.492910e-06	1.400000e-06	3.046330e-06

Temp (˚C)	36 GHz V			36 GHz H		
	Low Gain	Nom Gain	High Gain	Low Gain	Nom Gain	High Gain
-10.0	-2.635890e-05	-3.163000e-05	-2.800700e-05	-2.322100e-05	-2.965000e-05	-2.593830e-05
-9.0	-2.612630e-05	-3.140000e-05	-2.758510e-05	-2.307380e-05	-2.945000e-05	-2.545650e-05
-8.0	-2.589420e-05	-3.117000e-05	-2.717110e-05	-2.292530e-05	-2.925000e-05	-2.498570e-05
-7.0	-2.566250e-05	-3.094000e-05	-2.676480e-05	-2.277530e-05	-2.904000e-05	-2.452580e-05
-6.0	-2.543130e-05	-3.071000e-05	-2.636640e-05	-2.262380e-05	-2.884000e-05	-2.407700e-05
-5.0	-2.520050e-05	-3.048000e-05	-2.597580e-05	-2.247090e-05	-2.863000e-05	-2.363910e-05
-4.0	-2.497020e-05	-3.025000e-05	-2.559310e-05	-2.231650e-05	-2.842000e-05	-2.321220e-05

-3.0	-2.474030e-05	-3.001000e-05	-2.521810e-05	-2.216070e-05	-2.821000e-05	-2.279630e-05
-2.0	-2.451080e-05	-2.977000e-05	-2.485100e-05	-2.200350e-05	-2.800000e-05	-2.239140e-05
-1.0	-2.428180e-05	-2.954000e-05	-2.449170e-05	-2.184480e-05	-2.779000e-05	-2.199750e-05
0.0	-2.405330e-05	-2.930000e-05	-2.414020e-05	-2.168470e-05	-2.757000e-05	-2.161450e-05
1.0	-2.382510e-05	-2.906000e-05	-2.379650e-05	-2.152310e-05	-2.736000e-05	-2.124250e-05
2.0	-2.359750e-05	-2.881000e-05	-2.346060e-05	-2.136010e-05	-2.714000e-05	-2.088150e-05
3.0	-2.337020e-05	-2.857000e-05	-2.313260e-05	-2.119560e-05	-2.693000e-05	-2.053150e-05
4.0	-2.314340e-05	-2.833000e-05	-2.281240e-05	-2.102970e-05	-2.671000e-05	-2.019250e-05
5.0	-2.291710e-05	-2.808000e-05	-2.250000e-05	-2.086240e-05	-2.649000e-05	-1.986450e-05
6.0	-2.269120e-05	-2.783000e-05	-2.219540e-05	-2.069360e-05	-2.627000e-05	-1.954740e-05
7.0	-2.246570e-05	-2.758000e-05	-2.189860e-05	-2.052330e-05	-2.604000e-05	-1.924140e-05
8.0	-2.224070e-05	-2.733000e-05	-2.160970e-05	-2.035160e-05	-2.582000e-05	-1.894630e-05
9.0	-2.201610e-05	-2.708000e-05	-2.132860e-05	-2.017850e-05	-2.559000e-05	-1.866220e-05
10.0	-2.179200e-05	-2.683000e-05	-2.105530e-05	-2.000390e-05	-2.537000e-05	-1.838910e-05
11.0	-2.156830e-05	-2.658000e-05	-2.078980e-05	-1.982790e-05	-2.514000e-05	-1.812690e-05
12.0	-2.134510e-05	-2.632000e-05	-2.053210e-05	-1.965050e-05	-2.491000e-05	-1.787580e-05
13.0	-2.112230e-05	-2.607000e-05	-2.028230e-05	-1.947150e-05	-2.468000e-05	-1.763560e-05
14.0	-2.089990e-05	-2.581000e-05	-2.004020e-05	-1.929120e-05	-2.445000e-05	-1.740650e-05
15.0	-2.067800e-05	-2.555000e-05	-1.980600e-05	-1.910940e-05	-2.422000e-05	-1.718830e-05
16.0	-2.045660e-05	-2.529000e-05	-1.957960e-05	-1.892610e-05	-2.399000e-05	-1.698100e-05
17.0	-2.023550e-05	-2.503000e-05	-1.936100e-05	-1.874150e-05	-2.375000e-05	-1.678480e-05
18.0	-2.001500e-05	-2.476000e-05	-1.915030e-05	-1.855530e-05	-2.351000e-05	-1.659960e-05
19.0	-1.979480e-05	-2.450000e-05	-1.894730e-05	-1.836780e-05	-2.328000e-05	-1.642530e-05
20.0	-1.957510e-05	-2.423000e-05	-1.875220e-05	-1.817870e-05	-2.304000e-05	-1.626200e-05
21.0	-1.935590e-05	-2.397000e-05	-1.856490e-05	-1.798830e-05	-2.280000e-05	-1.610970e-05
22.0	-1.913710e-05	-2.370000e-05	-1.838540e-05	-1.779640e-05	-2.256000e-05	-1.596840e-05
23.0	-1.891870e-05	-2.343000e-05	-1.821380e-05	-1.760300e-05	-2.232000e-05	-1.583810e-05
24.0	-1.870080e-05	-2.316000e-05	-1.804990e-05	-1.740820e-05	-2.207000e-05	-1.571880e-05
25.0	-1.848330e-05	-2.288000e-05	-1.789390e-05	-1.721200e-05	-2.183000e-05	-1.561040e-05
26.0	-1.826630e-05	-2.261000e-05	-1.774570e-05	-1.701430e-05	-2.158000e-05	-1.551300e-05
27.0	-1.804970e-05	-2.234000e-05	-1.760530e-05	-1.681510e-05	-2.133000e-05	-1.542660e-05
28.0	-1.783360e-05	-2.206000e-05	-1.747270e-05	-1.661460e-05	-2.108000e-05	-1.535120e-05
29.0	-1.761790e-05	-2.178000e-05	-1.734800e-05	-1.641250e-05	-2.083000e-05	-1.528680e-05
30.0	-1.740260e-05	-2.150000e-05	-1.723100e-05	-1.620910e-05	-2.058000e-05	-1.523340e-05
31.0	-1.718780e-05	-2.122000e-05	-1.712190e-05	-1.600420e-05	-2.033000e-05	-1.519090e-05
32.0	-1.697340e-05	-2.094000e-05	-1.702060e-05	-1.579780e-05	-2.008000e-05	-1.515950e-05
33.0	-1.675950e-05	-2.066000e-05	-1.692710e-05	-1.559000e-05	-1.982000e-05	-1.513900e-05
34.0	-1.654600e-05	-2.037000e-05	-1.684150e-05	-1.538080e-05	-1.957000e-05	-1.512950e-05
35.0	-1.633300e-05	-2.009000e-05	-1.676360e-05	-1.517010e-05	-1.931000e-05	-1.513100e-05
36.0	-1.612040e-05	-1.980000e-05	-1.669360e-05	-1.495790e-05	-1.905000e-05	-1.514340e-05
37.0	-1.590820e-05	-1.951000e-05	-1.663140e-05	-1.474440e-05	-1.879000e-05	-1.516690e-05
38.0	-1.569650e-05	-1.922000e-05	-1.657700e-05	-1.452930e-05	-1.853000e-05	-1.520130e-05
39.0	-1.548530e-05	-1.893000e-05	-1.653050e-05	-1.431290e-05	-1.827000e-05	-1.524670e-05
40.0	-1.527440e-05	-1.864000e-05	-1.649170e-05	-1.409500e-05	-1.800000e-05	-1.530310e-05
41.0	-1.506410e-05	-1.835000e-05	-1.646080e-05	-1.387560e-05	-1.774000e-05	-1.537050e-05
42.0	-1.485410e-05	-1.805000e-05	-1.643770e-05	-1.365480e-05	-1.747000e-05	-1.544890e-05
43.0	-1.464460e-05	-1.776000e-05	-1.642240e-05	-1.343260e-05	-1.720000e-05	-1.553820e-05

44.0	-1.443560e-05	-1.746000e-05	-1.641490e-05	-1.320890e-05	-1.694000e-05	-1.563860e-05
45.0	-1.422700e-05	-1.716000e-05	-1.641530e-05	-1.298370e-05	-1.667000e-05	-1.574990e-05

Temp (˚C)	89 GHz V			89 GHz H		
	Low Gain	Nom Gain	High Gain	Low Gain	Nom Gain	High Gain
-10.0	-2.184000e-05	-2.410000e-05	-1.565000e-05	-2.298000e-05	-2.940000e-05	-2.031000e-05
-9.0	-2.150000e-05	-2.397000e-05	-1.608000e-05	-2.273000e-05	-2.922000e-05	-2.056000e-05
-8.0	-2.116000e-05	-2.384000e-05	-1.650000e-05	-2.248000e-05	-2.902000e-05	-2.079000e-05
-7.0	-2.083000e-05	-2.371000e-05	-1.691000e-05	-2.224000e-05	-2.883000e-05	-2.101000e-05
-6.0	-2.051000e-05	-2.357000e-05	-1.729000e-05	-2.200000e-05	-2.863000e-05	-2.123000e-05
-5.0	-2.020000e-05	-2.344000e-05	-1.767000e-05	-2.177000e-05	-2.843000e-05	-2.143000e-05
-4.0	-1.989000e-05	-2.330000e-05	-1.802000e-05	-2.154000e-05	-2.823000e-05	-2.162000e-05
-3.0	-1.959000e-05	-2.316000e-05	-1.836000e-05	-2.132000e-05	-2.802000e-05	-2.180000e-05
-2.0	-1.930000e-05	-2.302000e-05	-1.869000e-05	-2.111000e-05	-2.781000e-05	-2.197000e-05
-1.0	-1.902000e-05	-2.287000e-05	-1.900000e-05	-2.090000e-05	-2.760000e-05	-2.213000e-05
0.0	-1.875000e-05	-2.273000e-05	-1.930000e-05	-2.070000e-05	-2.738000e-05	-2.228000e-05
1.0	-1.848000e-05	-2.258000e-05	-1.958000e-05	-2.050000e-05	-2.717000e-05	-2.242000e-05
2.0	-1.822000e-05	-2.243000e-05	-1.984000e-05	-2.030000e-05	-2.694000e-05	-2.255000e-05
3.0	-1.797000e-05	-2.228000e-05	-2.009000e-05	-2.012000e-05	-2.672000e-05	-2.267000e-05
4.0	-1.772000e-05	-2.213000e-05	-2.032000e-05	-1.994000e-05	-2.650000e-05	-2.277000e-05
5.0	-1.749000e-05	-2.198000e-05	-2.054000e-05	-1.976000e-05	-2.627000e-05	-2.287000e-05
6.0	-1.726000e-05	-2.183000e-05	-2.074000e-05	-1.959000e-05	-2.604000e-05	-2.296000e-05
7.0	-1.704000e-05	-2.167000e-05	-2.093000e-05	-1.943000e-05	-2.580000e-05	-2.303000e-05
8.0	-1.682000e-05	-2.151000e-05	-2.110000e-05	-1.927000e-05	-2.556000e-05	-2.310000e-05
9.0	-1.662000e-05	-2.135000e-05	-2.126000e-05	-1.911000e-05	-2.532000e-05	-2.316000e-05
10.0	-1.642000e-05	-2.119000e-05	-2.140000e-05	-1.897000e-05	-2.508000e-05	-2.320000e-05
11.0	-1.623000e-05	-2.103000e-05	-2.152000e-05	-1.882000e-05	-2.483000e-05	-2.323000e-05
12.0	-1.605000e-05	-2.086000e-05	-2.163000e-05	-1.869000e-05	-2.459000e-05	-2.326000e-05
13.0	-1.587000e-05	-2.070000e-05	-2.173000e-05	-1.856000e-05	-2.434000e-05	-2.327000e-05
14.0	-1.570000e-05	-2.053000e-05	-2.181000e-05	-1.843000e-05	-2.408000e-05	-2.327000e-05
15.0	-1.555000e-05	-2.036000e-05	-2.187000e-05	-1.831000e-05	-2.382000e-05	-2.327000e-05
16.0	-1.539000e-05	-2.019000e-05	-2.192000e-05	-1.820000e-05	-2.356000e-05	-2.325000e-05
17.0	-1.525000e-05	-2.002000e-05	-2.195000e-05	-1.809000e-05	-2.330000e-05	-2.322000e-05
18.0	-1.511000e-05	-1.984000e-05	-2.197000e-05	-1.799000e-05	-2.304000e-05	-2.318000e-05
19.0	-1.499000e-05	-1.967000e-05	-2.197000e-05	-1.789000e-05	-2.277000e-05	-2.313000e-05
20.0	-1.487000e-05	-1.949000e-05	-2.195000e-05	-1.780000e-05	-2.250000e-05	-2.307000e-05
21.0	-1.475000e-05	-1.931000e-05	-2.192000e-05	-1.771000e-05	-2.222000e-05	-2.300000e-05
22.0	-1.465000e-05	-1.913000e-05	-2.188000e-05	-1.763000e-05	-2.195000e-05	-2.292000e-05
23.0	-1.455000e-05	-1.895000e-05	-2.182000e-05	-1.756000e-05	-2.167000e-05	-2.283000e-05
24.0	-1.446000e-05	-1.876000e-05	-2.174000e-05	-1.749000e-05	-2.139000e-05	-2.272000e-05
25.0	-1.438000e-05	-1.858000e-05	-2.165000e-05	-1.742000e-05	-2.110000e-05	-2.261000e-05
26.0	-1.430000e-05	-1.839000e-05	-2.155000e-05	-1.736000e-05	-2.081000e-05	-2.249000e-05
27.0	-1.424000e-05	-1.820000e-05	-2.142000e-05	-1.731000e-05	-2.052000e-05	-2.235000e-05
28.0	-1.418000e-05	-1.801000e-05	-2.129000e-05	-1.727000e-05	-2.023000e-05	-2.221000e-05
29.0	-1.413000e-05	-1.782000e-05	-2.113000e-05	-1.722000e-05	-1.993000e-05	-2.206000e-05
30.0	-1.408000e-05	-1.762000e-05	-2.096000e-05	-1.719000e-05	-1.963000e-05	-2.189000e-05
31.0	-1.405000e-05	-1.743000e-05	-2.078000e-05	-1.716000e-05	-1.933000e-05	-2.172000e-05

32.0	-1.402000e-05	-1.723000e-05	-2.058000e-05	-1.713000e-05	-1.903000e-05	-2.153000e-05
33.0	-1.400000e-05	-1.703000e-05	-2.037000e-05	-1.711000e-05	-1.872000e-05	-2.133000e-05
34.0	-1.399000e-05	-1.683000e-05	-2.013000e-05	-1.710000e-05	-1.841000e-05	-2.113000e-05
35.0	-1.398000e-05	-1.663000e-05	-1.989000e-05	-1.709000e-05	-1.810000e-05	-2.091000e-05
36.0	-1.399000e-05	-1.642000e-05	-1.963000e-05	-1.709000e-05	-1.778000e-05	-2.068000e-05
37.0	-1.400000e-05	-1.622000e-05	-1.935000e-05	-1.709000e-05	-1.746000e-05	-2.044000e-05
38.0	-1.402000e-05	-1.601000e-05	-1.906000e-05	-1.710000e-05	-1.714000e-05	-2.019000e-05
39.0	-1.404000e-05	-1.580000e-05	-1.875000e-05	-1.712000e-05	-1.682000e-05	-1.993000e-05
40.0	-1.408000e-05	-1.559000e-05	-1.843000e-05	-1.714000e-05	-1.649000e-05	-1.966000e-05
41.0	-1.412000e-05	-1.538000e-05	-1.809000e-05	-1.716000e-05	-1.616000e-05	-1.938000e-05
42.0	-1.417000e-05	-1.516000e-05	-1.774000e-05	-1.719000e-05	-1.583000e-05	-1.909000e-05
43.0	-1.422000e-05	-1.495000e-05	-1.737000e-05	-1.723000e-05	-1.549000e-05	-1.879000e-05
44.0	-1.429000e-05	-1.473000e-05	-1.698000e-05	-1.727000e-05	-1.515000e-05	-1.848000e-05
45.0	-1.436000e-05	-1.451000e-05	-1.658000e-05	-1.732000e-05	-1.481000e-05	-1.816000e-05

Temp (˚C)	166 GHz V			166 GHz H		
	Low Gain	Nom Gain	High Gain	Low Gain	Nom Gain	High Gain
-10.0	-1.902190e-05	-2.344340e-05	-2.142110e-05	-1.283290e-05	-1.617280e-05	-1.431040e-05
-9.0	-1.891470e-05	-2.255690e-05	-2.103910e-05	-1.295210e-05	-1.566520e-05	-1.422220e-05
-8.0	-1.880250e-05	-2.169830e-05	-2.066560e-05	-1.306150e-05	-1.516990e-05	-1.413080e-05
-7.0	-1.868560e-05	-2.086770e-05	-2.030060e-05	-1.316100e-05	-1.468680e-05	-1.403630e-05
-6.0	-1.856370e-05	-2.006510e-05	-1.994420e-05	-1.325080e-05	-1.421600e-05	-1.393860e-05
-5.0	-1.843700e-05	-1.929040e-05	-1.959630e-05	-1.333080e-05	-1.375740e-05	-1.383770e-05
-4.0	-1.830550e-05	-1.854370e-05	-1.925700e-05	-1.340090e-05	-1.331100e-05	-1.373370e-05
-3.0	-1.816910e-05	-1.782500e-05	-1.892620e-05	-1.346130e-05	-1.287680e-05	-1.362650e-05
-2.0	-1.802790e-05	-1.713420e-05	-1.860400e-05	-1.351180e-05	-1.245490e-05	-1.351620e-05
-1.0	-1.788180e-05	-1.647140e-05	-1.829030e-05	-1.355250e-05	-1.204520e-05	-1.340260e-05
0.0	-1.773080e-05	-1.583660e-05	-1.798510e-05	-1.358340e-05	-1.164780e-05	-1.328590e-05
1.0	-1.757510e-05	-1.522970e-05	-1.768850e-05	-1.360460e-05	-1.126260e-05	-1.316610e-05
2.0	-1.741440e-05	-1.465080e-05	-1.740040e-05	-1.361590e-05	-1.088960e-05	-1.304310e-05
3.0	-1.724890e-05	-1.409990e-05	-1.712090e-05	-1.361740e-05	-1.052880e-05	-1.291690e-05
4.0	-1.707860e-05	-1.357690e-05	-1.684990e-05	-1.360910e-05	-1.018030e-05	-1.278750e-05
5.0	-1.690340e-05	-1.308190e-05	-1.658750e-05	-1.359090e-05	-9.843960e-06	-1.265500e-05
6.0	-1.672330e-05	-1.261490e-05	-1.633360e-05	-1.356300e-05	-9.519880e-06	-1.251930e-05
7.0	-1.653840e-05	-1.217590e-05	-1.608820e-05	-1.352530e-05	-9.208040e-06	-1.238050e-05
8.0	-1.634860e-05	-1.176480e-05	-1.585140e-05	-1.347770e-05	-8.908440e-06	-1.223850e-05
9.0	-1.615400e-05	-1.138170e-05	-1.562310e-05	-1.342040e-05	-8.621060e-06	-1.209330e-05
10.0	-1.595460e-05	-1.102650e-05	-1.540340e-05	-1.335320e-05	-8.345910e-06	-1.194490e-05
11.0	-1.575020e-05	-1.069930e-05	-1.519220e-05	-1.327630e-05	-8.083000e-06	-1.179340e-05
12.0	-1.554110e-05	-1.040010e-05	-1.498960e-05	-1.318950e-05	-7.832310e-06	-1.163870e-05
13.0	-1.532710e-05	-1.012890e-05	-1.479550e-05	-1.309290e-05	-7.593860e-06	-1.148090e-05
14.0	-1.510820e-05	-9.885630e-06	-1.460990e-05	-1.298660e-05	-7.367640e-06	-1.131990e-05
15.0	-1.488450e-05	-9.670330e-06	-1.443290e-05	-1.287040e-05	-7.153650e-06	-1.115570e-05
16.0	-1.465590e-05	-9.483000e-06	-1.426440e-05	-1.274440e-05	-6.951890e-06	-1.098830e-05
17.0	-1.442250e-05	-9.323630e-06	-1.410450e-05	-1.260860e-05	-6.762360e-06	-1.081780e-05
18.0	-1.418420e-05	-9.192230e-06	-1.395310e-05	-1.246290e-05	-6.585060e-06	-1.064410e-05
19.0	-1.394110e-05	-9.088810e-06	-1.381030e-05	-1.230750e-05	-6.420000e-06	-1.046730e-05

20.0	-1.369310e-05	-9.013350e-06	-1.367600e-05	-1.214230e-05	-6.267160e-06	-1.028730e-05
21.0	-1.344020e-05	-8.965850e-06	-1.355020e-05	-1.196720e-05	-6.126560e-06	-1.010410e-05
22.0	-1.318260e-05	-8.946330e-06	-1.343300e-05	-1.178240e-05	-5.998190e-06	-9.917770e-06
23.0	-1.292000e-05	-8.954780e-06	-1.332430e-05	-1.158770e-05	-5.882040e-06	-9.728260e-06
24.0	-1.265260e-05	-8.991190e-06	-1.322420e-05	-1.138330e-05	-5.778130e-06	-9.535590e-06
25.0	-1.238040e-05	-9.055580e-06	-1.313260e-05	-1.116900e-05	-5.686460e-06	-9.339750e-06
26.0	-1.210330e-05	-9.147930e-06	-1.304960e-05	-1.094490e-05	-5.607010e-06	-9.140740e-06
27.0	-1.182130e-05	-9.268250e-06	-1.297510e-05	-1.071110e-05	-5.539790e-06	-8.938570e-06
28.0	-1.153450e-05	-9.416540e-06	-1.290910e-05	-1.046740e-05	-5.484810e-06	-8.733230e-06
29.0	-1.124290e-05	-9.592790e-06	-1.285170e-05	-1.021390e-05	-5.442050e-06	-8.524730e-06
30.0	-1.094640e-05	-9.797020e-06	-1.280280e-05	-9.950570e-06	-5.411530e-06	-8.313060e-06
31.0	-1.064500e-05	-1.002920e-05	-1.276250e-05	-9.677450e-06	-5.393240e-06	-8.098220e-06
32.0	-1.033880e-05	-1.028940e-05	-1.273070e-05	-9.394530e-06	-5.387180e-06	-7.880220e-06
33.0	-1.002780e-05	-1.057750e-05	-1.270750e-05	-9.101800e-06	-5.393350e-06	-7.659050e-06
34.0	-9.711870e-06	-1.089360e-05	-1.269280e-05	-8.799270e-06	-5.411750e-06	-7.434720e-06
35.0	-9.391110e-06	-1.123770e-05	-1.268660e-05	-8.486920e-06	-5.442380e-06	-7.207220e-06
36.0	-9.065500e-06	-1.160970e-05	-1.268900e-05	-8.164770e-06	-5.485250e-06	-6.976550e-06
37.0	-8.735030e-06	-1.200970e-05	-1.269990e-05	-7.832810e-06	-5.540340e-06	-6.742720e-06
38.0	-8.399710e-06	-1.243770e-05	-1.271940e-05	-7.491040e-06	-5.607670e-06	-6.505720e-06
39.0	-8.059550e-06	-1.289360e-05	-1.274740e-05	-7.139470e-06	-5.687230e-06	-6.265550e-06
40.0	-7.714520e-06	-1.337750e-05	-1.278400e-05	-6.778090e-06	-5.779020e-06	-6.022220e-06
41.0	-7.364650e-06	-1.388940e-05	-1.282910e-05	-6.406900e-06	-5.883040e-06	-5.775730e-06
42.0	-7.009930e-06	-1.442930e-05	-1.288270e-05	-6.025900e-06	-5.999290e-06	-5.526060e-06
43.0	-6.650350e-06	-1.499710e-05	-1.294490e-05	-5.635090e-06	-6.127770e-06	-5.273240e-06
44.0	-6.285920e-06	-1.559290e-05	-1.301570e-05	-5.234480e-06	-6.268490e-06	-5.017240e-06
45.0	-5.916640e-06	-1.621660e-05	-1.309490e-05	-4.824060e-06	-6.421430e-06	-4.758080e-06

Temp (˚C)	183± 3 GHz V			183 ±7 GHz H		
	Low Gain	Nom Gain	High Gain	Low Gain	Nom Gain	High Gain
-10.0	-3.020000e-05	-1.893000e-05	-2.557000e-05	-2.546170e-05	-2.235580e-05	-2.983840e-05
-9.0	-2.994000e-05	-1.924000e-05	-2.504000e-05	-2.519400e-05	-2.237860e-05	-2.928050e-05
-8.0	-2.969000e-05	-1.955000e-05	-2.452000e-05	-2.492760e-05	-2.239260e-05	-2.873320e-05
-7.0	-2.943000e-05	-1.983000e-05	-2.401000e-05	-2.466260e-05	-2.239780e-05	-2.819660e-05
-6.0	-2.918000e-05	-2.010000e-05	-2.352000e-05	-2.439880e-05	-2.239410e-05	-2.767050e-05
-5.0	-2.892000e-05	-2.036000e-05	-2.304000e-05	-2.413640e-05	-2.238160e-05	-2.715510e-05
-4.0	-2.867000e-05	-2.060000e-05	-2.258000e-05	-2.387530e-05	-2.236030e-05	-2.665030e-05
-3.0	-2.841000e-05	-2.082000e-05	-2.212000e-05	-2.361560e-05	-2.233020e-05	-2.615610e-05
-2.0	-2.816000e-05	-2.103000e-05	-2.168000e-05	-2.335710e-05	-2.229120e-05	-2.567260e-05
-1.0	-2.791000e-05	-2.123000e-05	-2.125000e-05	-2.310000e-05	-2.224350e-05	-2.519970e-05
0.0	-2.765000e-05	-2.141000e-05	-2.084000e-05	-2.284420e-05	-2.218690e-05	-2.473740e-05
1.0	-2.740000e-05	-2.157000e-05	-2.044000e-05	-2.258970e-05	-2.212150e-05	-2.428570e-05
2.0	-2.715000e-05	-2.172000e-05	-2.005000e-05	-2.233650e-05	-2.204720e-05	-2.384460e-05
3.0	-2.690000e-05	-2.185000e-05	-1.967000e-05	-2.208460e-05	-2.196420e-05	-2.341420e-05
4.0	-2.665000e-05	-2.197000e-05	-1.930000e-05	-2.183410e-05	-2.187230e-05	-2.299440e-05
5.0	-2.639000e-05	-2.207000e-05	-1.895000e-05	-2.158490e-05	-2.177160e-05	-2.258520e-05
6.0	-2.614000e-05	-2.216000e-05	-1.862000e-05	-2.133700e-05	-2.166210e-05	-2.218670e-05
7.0	-2.589000e-05	-2.223000e-05	-1.829000e-05	-2.109040e-05	-2.154380e-05	-2.179870e-05

8.0 -2.564000e-05 -2.229000e-05 -1.798000e-05 -2.084510e-05 -2.141660e-05 -2.142140e-05
9.0 -2.539000e-05 -2.233000e-05 -1.768000e-05 -2.060120e-05 -2.128070e-05 -2.105470e-05
10.0 -2.514000e-05 -2.236000e-05 -1.739000e-05 -2.035860e-05 -2.113590e-05 -2.069870e-05
11.0 -2.490000e-05 -2.237000e-05 -1.712000e-05 -2.011730e-05 -2.098230e-05 -2.035320e-05
12.0 -2.465000e-05 -2.236000e-05 -1.685000e-05 -1.987730e-05 -2.081990e-05 -2.001840e-05
13.0 -2.440000e-05 -2.234000e-05 -1.661000e-05 -1.963860e-05 -2.064860e-05 -1.969420e-05
14.0 -2.415000e-05 -2.231000e-05 -1.637000e-05 -1.940130e-05 -2.046850e-05 -1.938070e-05
15.0 -2.390000e-05 -2.226000e-05 -1.615000e-05 -1.916520e-05 -2.027960e-05 -1.907770e-05
16.0 -2.366000e-05 -2.219000e-05 -1.594000e-05 -1.893050e-05 -2.008190e-05 -1.878540e-05
17.0 -2.341000e-05 -2.211000e-05 -1.574000e-05 -1.869710e-05 -1.987540e-05 -1.850370e-05
18.0 -2.316000e-05 -2.201000e-05 -1.555000e-05 -1.846500e-05 -1.966010e-05 -1.823270e-05
19.0 -2.292000e-05 -2.190000e-05 -1.538000e-05 -1.823430e-05 -1.943590e-05 -1.797220e-05
20.0 -2.267000e-05 -2.177000e-05 -1.522000e-05 -1.800490e-05 -1.920290e-05 -1.772240e-05
21.0 -2.243000e-05 -2.163000e-05 -1.508000e-05 -1.777670e-05 -1.896110e-05 -1.748320e-05
22.0 -2.218000e-05 -2.147000e-05 -1.494000e-05 -1.754990e-05 -1.871050e-05 -1.725460e-05
23.0 -2.194000e-05 -2.130000e-05 -1.482000e-05 -1.732450e-05 -1.845100e-05 -1.703670e-05
24.0 -2.169000e-05 -2.111000e-05 -1.472000e-05 -1.710030e-05 -1.818270e-05 -1.682940e-05
25.0 -2.145000e-05 -2.091000e-05 -1.462000e-05 -1.687750e-05 -1.790570e-05 -1.663270e-05
26.0 -2.120000e-05 -2.069000e-05 -1.454000e-05 -1.665590e-05 -1.761970e-05 -1.644660e-05
27.0 -2.096000e-05 -2.046000e-05 -1.447000e-05 -1.643570e-05 -1.732500e-05 -1.627120e-05
28.0 -2.072000e-05 -2.021000e-05 -1.441000e-05 -1.621680e-05 -1.702150e-05 -1.610630e-05
29.0 -2.048000e-05 -1.994000e-05 -1.437000e-05 -1.599930e-05 -1.670910e-05 -1.595210e-05
30.0 -2.023000e-05 -1.966000e-05 -1.434000e-05 -1.578300e-05 -1.638790e-05 -1.580850e-05
31.0 -1.999000e-05 -1.937000e-05 -1.432000e-05 -1.556810e-05 -1.605790e-05 -1.567560e-05
32.0 -1.975000e-05 -1.906000e-05 -1.432000e-05 -1.535450e-05 -1.571910e-05 -1.555330e-05
33.0 -1.951000e-05 -1.873000e-05 -1.432000e-05 -1.514220e-05 -1.537140e-05 -1.544160e-05
34.0 -1.927000e-05 -1.839000e-05 -1.435000e-05 -1.493120e-05 -1.501490e-05 -1.534050e-05
35.0 -1.903000e-05 -1.803000e-05 -1.438000e-05 -1.472160e-05 -1.464960e-05 -1.525000e-05
36.0 -1.879000e-05 -1.766000e-05 -1.442000e-05 -1.451320e-05 -1.427550e-05 -1.517020e-05
37.0 -1.855000e-05 -1.727000e-05 -1.448000e-05 -1.430620e-05 -1.389260e-05 -1.510100e-05
38.0 -1.831000e-05 -1.687000e-05 -1.456000e-05 -1.410050e-05 -1.350090e-05 -1.504240e-05
39.0 -1.807000e-05 -1.645000e-05 -1.464000e-05 -1.389620e-05 -1.310030e-05 -1.499440e-05
40.0 -1.783000e-05 -1.602000e-05 -1.474000e-05 -1.369310e-05 -1.269090e-05 -1.495710e-05
41.0 -1.759000e-05 -1.557000e-05 -1.485000e-05 -1.349140e-05 -1.227270e-05 -1.493040e-05
42.0 -1.736000e-05 -1.511000e-05 -1.497000e-05 -1.329090e-05 -1.184560e-05 -1.491430e-05
43.0 -1.712000e-05 -1.463000e-05 -1.511000e-05 -1.309180e-05 -1.140980e-05 -1.490880e-05
44.0 -1.688000e-05 -1.413000e-05 -1.526000e-05 -1.289410e-05 -1.096510e-05 -1.491400e-05
45.0 -1.664000e-05 -1.362000e-05 -1.542000e-05 -1.269760e-05 -1.051160e-05 -1.492980e-05

6. APPENDIX B. COLD BEAM POINTING VECTORS

10 GHZ

Samp#	Rotate Angle	pointing theta	pointing phi	unit vector xhat	yhat	xhat
342	165.234894	70.396698	-100.428001	-0.170529	-0.926472	0.335514
343	165.926102	70.930199	-101.105003	-0.182057	-0.927418	0.326728
344	166.617294	71.445297	-101.783997	-0.193626	-0.928034	0.318217
345	167.308502	71.941803	-102.463997	-0.205214	-0.928329	0.309989
346	167.999695	72.419701	-103.143997	-0.216797	-0.928314	0.302048
347	168.690903	72.879097	-103.825996	-0.228402	-0.927990	0.294394
348	169.382095	73.320000	-104.509003	-0.240008	-0.927367	0.287030
349	170.073303	73.742302	-105.193001	-0.251609	-0.926453	0.279961
350	170.764496	74.146103	-105.876999	-0.263183	-0.925258	0.273188
351	171.455704	74.531303	-106.563004	-0.274759	-0.923781	0.266714
352	172.146896	74.898003	-107.250000	-0.286316	-0.922032	0.260539
353	172.838104	75.246101	-107.938004	-0.297848	-0.920017	0.254668
354	173.529297	75.575699	-108.626999	-0.309352	-0.917742	0.249100
355	174.220505	75.886803	-109.317001	-0.320824	-0.915213	0.243837
356	174.911697	76.179298	-110.008003	-0.332260	-0.912436	0.238883
357	175.602905	76.453201	-110.700996	-0.343671	-0.909408	0.234237
358	176.294098	76.708603	-111.393997	-0.355022	-0.906149	0.229900
359	176.985306	76.945503	-112.087997	-0.366325	-0.902655	0.225874
360	177.676498	77.163803	-112.782997	-0.377578	-0.898933	0.222160
361	178.367706	77.363602	-113.480003	-0.388791	-0.894978	0.218758
362	179.058899	77.544800	-114.177002	-0.399931	-0.890810	0.215670
363	179.750107	77.707497	-114.875999	-0.411024	-0.886417	0.212896
364	180.441299	77.851700	-115.574997	-0.422038	-0.881817	0.210435
365	181.132507	77.977303	-116.276001	-0.432998	-0.876999	0.208291
366	181.823700	78.084297	-116.976997	-0.443871	-0.871982	0.206463
367	182.514893	78.172798	-117.680000	-0.454683	-0.866751	0.204951
368	183.206100	78.242798	-118.384003	-0.465417	-0.861319	0.203754

18 GHZ

Samp#	Rotate Angle	pointing theta	pointing phi	unit vector xhat	yhat	xhat
390	192.786896	67.668503	-115.852997	-0.403382	-0.832415	0.379957
391	193.478104	67.879501	-116.431999	-0.412393	-0.829544	0.376548
392	194.169296	68.073799	-117.016998	-0.421419	-0.826424	0.373403
393	194.860504	68.251602	-117.606003	-0.430427	-0.823071	0.370522
394	195.551697	68.412804	-118.199997	-0.439428	-0.819480	0.367907
395	196.242905	68.557404	-118.797997	-0.448402	-0.815661	0.365558
396	196.934097	68.685402	-119.402000	-0.457376	-0.811598	0.363477
397	197.625305	68.796799	-120.009003	-0.466300	-0.807318	0.361665
398	198.316498	68.891602	-120.622002	-0.475215	-0.802797	0.360121
399	199.007706	68.969902	-121.238998	-0.484087	-0.798054	0.358845
400	199.698898	69.031502	-121.861000	-0.492926	-0.793079	0.357841

401 200.390106 69.076599 -122.487000 -0.501712 -0.787884 0.357105
402 201.081299 69.105003 -123.119003 -0.510469 -0.782450 0.356641
403 201.772507 69.116898 -123.753998 -0.519150 -0.776807 0.356447
404 202.463699 69.112198 -124.394997 -0.527792 -0.770926 0.356523
405 203.154907 69.090797 -125.040001 -0.536360 -0.764827 0.356871
406 203.846100 69.052902 -125.690002 -0.544865 -0.758502 0.357488
407 204.537292 68.998398 -126.344002 -0.553285 -0.751959 0.358376
408 205.228500 68.927399 -127.002998 -0.561630 -0.745191 0.359532
409 205.919693 68.839699 -127.667000 -0.569891 -0.738196 0.360959
410 206.610901 68.735397 -128.335999 -0.578063 -0.730975 0.362655

23 GHZ

Samp#	Rotate Angle	pointing theta	pointing phi	unit vector xhat	yhat	xhat
388	191.431305	67.178902	-114.904999	-0.388174	-0.835999	0.387848
389	192.122498	67.422501	-115.486000	-0.397337	-0.833502	0.383926
390	192.813705	67.648697	-116.070000	-0.406474	-0.830764	0.380277
391	193.504898	67.857597	-116.656998	-0.415583	-0.827790	0.376901
392	194.196106	68.049103	-117.246002	-0.424645	-0.824590	0.373803
393	194.887299	68.223198	-117.837997	-0.433671	-0.821159	0.370982
394	195.578506	68.379997	-118.432999	-0.442656	-0.817501	0.368439
395	196.269699	68.519402	-119.029999	-0.451584	-0.813626	0.366175
396	196.960907	68.641403	-119.629997	-0.460463	-0.809529	0.364192
397	197.652100	68.746101	-120.232002	-0.469278	-0.805220	0.362489
398	198.343307	68.833397	-120.836998	-0.478037	-0.800694	0.361068
399	199.034500	68.903297	-121.445000	-0.486735	-0.795952	0.359930
400	199.725693	68.955902	-122.056000	-0.495371	-0.790996	0.359072
401	200.416901	68.991096	-122.668999	-0.503924	-0.785837	0.358498
402	201.108093	69.009003	-123.285004	-0.512405	-0.780467	0.358206
403	201.799301	69.009499	-123.903000	-0.520795	-0.774898	0.358197
404	202.490494	68.992599	-124.524002	-0.529103	-0.769121	0.358472
405	203.181702	68.958397	-125.147003	-0.537312	-0.763148	0.359029
406	203.872894	68.906799	-125.774002	-0.545442	-0.756960	0.359868
407	204.564102	68.837799	-126.403000	-0.553461	-0.750577	0.360991
408	205.255295	68.751503	-127.033997	-0.561365	-0.744002	0.362395

36 GHZ

Samp#	Rotate Angle	pointing theta	pointing phi	unit vector xhat	yhat	xhat
437	218.862000	65.356300	-116.477997	-0.405270	-0.813570	0.416966
438	219.553207	65.578697	-117.061996	-0.414275	-0.810832	0.413434
439	220.244400	65.783096	-117.648003	-0.423227	-0.807854	0.410183
440	220.935593	65.969498	-118.236000	-0.432124	-0.804640	0.407213
441	221.626801	66.137901	-118.827003	-0.440976	-0.801186	0.404526
442	222.317993	66.288200	-119.419998	-0.449764	-0.797501	0.402125
443	223.009201	66.420601	-120.014000	-0.458471	-0.793598	0.400008
444	223.700394	66.534897	-120.611000	-0.467121	-0.789463	0.398178

445	224.391602	66.631203	-121.210999	-0.475708	-0.785100	0.396635
446	225.082794	66.709602	-121.811996	-0.484203	-0.780528	0.395378
447	225.774002	66.769897	-122.416000	-0.492627	-0.775731	0.394411
448	226.465195	66.812202	-123.021004	-0.500949	-0.770731	0.393732
449	227.156403	66.836403	-123.628998	-0.509191	-0.765510	0.393343
450	227.847595	66.842697	-124.238998	-0.517337	-0.760082	0.393241
451	228.538803	66.831001	-124.851997	-0.525393	-0.754438	0.393428
452	229.229996	66.801201	-125.466003	-0.533329	-0.748598	0.393906
453	229.921204	66.753403	-126.083000	-0.541166	-0.742546	0.394672
454	230.612396	66.687698	-126.702003	-0.548885	-0.736293	0.395724
455	231.303604	66.603897	-127.321999	-0.556469	-0.729849	0.397067
456	231.994797	66.502098	-127.945999	-0.563950	-0.723189	0.398696
457	232.686005	66.382301	-128.570999	-0.571284	-0.716341	0.400612
458	233.377197	66.244400	-129.199005	-0.578491	-0.709287	0.402816
459	234.068405	66.088600	-129.828003	-0.585539	-0.702050	0.405302
460	234.759598	65.914803	-130.460007	-0.592447	-0.694610	0.408073

89 GHZ

Samp#	Rotate Angle	pointing theta	pointing phi	unit vector xhat	yhat	xhat
410	203.262405	63.735401	-114.912003	-0.377765	-0.813313	0.442511
411	203.953598	64.046799	-115.466003	-0.386640	-0.811782	0.437630
412	204.644806	64.340500	-116.023003	-0.395492	-0.809991	0.433015
413	205.335999	64.616600	-116.583000	-0.404318	-0.807944	0.428665
414	206.027206	64.874901	-117.144997	-0.413101	-0.805651	0.424587
415	206.718399	65.115501	-117.709999	-0.421851	-0.803110	0.420781
416	207.409607	65.338501	-118.278000	-0.430564	-0.800325	0.417247
417	208.100800	65.543701	-118.848000	-0.439222	-0.797306	0.413989
418	208.792007	65.731201	-119.419998	-0.447823	-0.794058	0.411007
419	209.483200	65.901001	-119.996002	-0.456390	-0.790567	0.408303
420	210.174393	66.053101	-120.573997	-0.464892	-0.786854	0.405878
421	210.865601	66.187500	-121.153999	-0.473324	-0.782921	0.403732
422	211.556793	66.304199	-121.737999	-0.481711	-0.778754	0.401867
423	212.248001	66.403198	-122.322998	-0.490007	-0.774381	0.400284
424	212.939194	66.484596	-122.912003	-0.498251	-0.769780	0.398981
425	213.630402	66.548203	-123.502998	-0.506408	-0.764968	0.397962
426	214.321594	66.594101	-124.097000	-0.514490	-0.759941	0.397227
427	215.012802	66.622200	-124.693001	-0.522478	-0.754709	0.396776
428	215.703995	66.632698	-125.292000	-0.530382	-0.749265	0.396607
429	216.395203	66.625504	-125.893997	-0.538195	-0.743611	0.396722
430	217.086395	66.600601	-126.498001	-0.545902	-0.737758	0.397120
431	217.777603	66.557999	-127.105003	-0.553509	-0.731698	0.397802
432	218.468796	66.497704	-127.713997	-0.560998	-0.725442	0.398767
433	219.160004	66.419701	-128.326004	-0.568378	-0.718982	0.400014
434	219.851196	66.323997	-128.940994	-0.575642	-0.712319	0.401544
435	220.542404	66.210503	-129.557999	-0.582772	-0.705465	0.403357
436	221.233597	66.079399	-130.177994	-0.589774	-0.698411	0.405449

437	221.924805	65.930603	-130.800995	-0.596644	-0.691157	0.407821
438	222.615997	65.764000	-131.425995	-0.603360	-0.683716	0.410473
439	223.307205	65.579803	-132.054001	-0.609931	-0.676079	0.413402
440	223.998398	65.377899	-132.684006	-0.616337	-0.668257	0.416608

166 GHZ

Samp#	Rotate Angle	pointing theta	pointing phi	unit vector xhat	yhat	xhat
392	192.407501	70.125999	-97.226196	-0.118316	-0.932966	0.339965
393	193.098694	70.708900	-97.949600	-0.130556	-0.934775	0.330379
394	193.789902	71.274498	-98.673599	-0.142842	-0.936230	0.321045
395	194.481094	71.822601	-99.398300	-0.155166	-0.937336	0.311970
396	195.172302	72.353401	-100.124001	-0.167526	-0.938101	0.303154
397	195.863495	72.866699	-100.849998	-0.179902	-0.938533	0.294604
398	196.554703	73.362602	-101.577003	-0.192300	-0.938638	0.286321
399	197.245895	73.841202	-102.304001	-0.204697	-0.938427	0.278307
400	197.937103	74.302299	-103.032997	-0.217117	-0.937898	0.270568
401	198.628296	74.746002	-103.762001	-0.229524	-0.937067	0.263104
402	199.319504	75.172302	-104.490997	-0.241911	-0.935941	0.255917
403	200.010696	75.581200	-105.222000	-0.254304	-0.934517	0.249011
404	200.701904	75.972702	-105.953003	-0.266667	-0.932811	0.242387
405	201.393097	76.346703	-106.683998	-0.278994	-0.930829	0.236048
406	202.084305	76.703400	-107.417000	-0.291314	-0.928569	0.229993
407	202.775497	77.042702	-108.150002	-0.303588	-0.926044	0.224225
408	203.466705	77.364502	-108.884003	-0.315828	-0.923256	0.218747
409	204.157898	77.668999	-109.617996	-0.328015	-0.920217	0.213558
410	204.849106	77.956001	-110.353996	-0.340176	-0.916919	0.208661
411	205.540298	78.225601	-111.089996	-0.352275	-0.913380	0.204056
412	206.231506	78.477898	-111.825996	-0.364309	-0.909606	0.199742
413	206.922699	78.712700	-112.564003	-0.376305	-0.905586	0.195724
414	207.613907	78.930099	-113.302002	-0.388229	-0.901340	0.192001
415	208.305099	79.130096	-114.040001	-0.400077	-0.896872	0.188574
416	208.996307	79.312698	-114.779999	-0.411876	-0.892171	0.185442
417	209.687500	79.477898	-115.519997	-0.423593	-0.887256	0.182607
418	210.378693	79.625702	-116.261002	-0.435239	-0.882124	0.180069
419	211.069901	79.756104	-117.001999	-0.446795	-0.876784	0.177829
420	211.761093	79.869003	-117.745003	-0.458289	-0.871226	0.175889
421	212.452301	79.964600	-118.487000	-0.469672	-0.865475	0.174246
422	213.143494	80.042801	-119.231003	-0.480987	-0.859510	0.172901
423	213.834702	80.103500	-119.974998	-0.492198	-0.853350	0.171856
424	214.525894	80.146797	-120.721001	-0.503333	-0.846981	0.171111
425	215.217102	80.172798	-121.466003	-0.514344	-0.840431	0.170663
426	215.908295	80.181297	-122.212997	-0.525270	-0.833676	0.170516
427	216.599503	80.172401	-122.959999	-0.536080	-0.826735	0.170668
428	217.290695	80.146103	-123.708000	-0.546784	-0.819601	0.171120
429	217.981903	80.102402	-124.456001	-0.557363	-0.812285	0.171871
430	218.673096	80.041298	-125.205002	-0.567828	-0.804780	0.172920

431	219.364304	79.962799	-125.955002	-0.578174	-0.797086	0.174269
432	220.055496	79.866898	-126.706001	-0.588397	-0.789204	0.175916
433	220.746704	79.753601	-127.457001	-0.598477	-0.781147	0.177861
434	221.437897	79.622902	-128.209000	-0.608426	-0.772904	0.180105
435	222.129105	79.474701	-128.962006	-0.618236	-0.764476	0.182648
436	222.820297	79.309196	-129.716003	-0.627903	-0.755866	0.185486
437	223.511505	79.126198	-130.470001	-0.637408	-0.747083	0.188623
438	224.202698	78.925903	-131.225006	-0.646758	-0.738119	0.192054
439	222.592896	79.758797	-122.005997	-0.521575	-0.834479	0.177778
440	223.284103	79.737900	-122.761002	-0.532490	-0.827479	0.178136
441	223.975296	79.698196	-123.517998	-0.543308	-0.820269	0.178817
442	224.666504	79.639801	-124.276001	-0.554009	-0.812859	0.179819

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Samp#	Rotate	pointing	pointing	unit vector		
	Angle	theta	phi	xhat	yhat	xhat
398	194.253693	64.489403	-92.211899	-0.034858	-0.901825	0.430694
399	194.944901	65.236504	-92.911201	-0.046143	-0.906864	0.418889
400	195.636093	65.964798	-93.611801	-0.057559	-0.911473	0.407313
401	196.327301	66.674400	-94.313797	-0.069095	-0.915660	0.395970
402	197.018494	67.365303	-95.017197	-0.080742	-0.919433	0.384868
403	197.709702	68.037399	-95.722000	-0.092489	-0.922800	0.374014
404	198.400894	68.690804	-96.428101	-0.104324	-0.925769	0.363413
405	199.092102	69.325500	-97.135597	-0.116240	-0.928348	0.353070
406	199.783295	69.941399	-97.844498	-0.128227	-0.930545	0.342992
407	200.474503	70.538597	-98.554703	-0.140275	-0.932369	0.333182
408	201.165695	71.117104	-99.266296	-0.152377	-0.933828	0.323645
409	201.856903	71.676804	-99.979301	-0.164525	-0.934929	0.314386
410	202.548096	72.217796	-100.694000	-0.176717	-0.935680	0.305408
411	203.239304	72.740097	-101.408997	-0.188921	-0.936093	0.296714
412	203.930496	73.243698	-102.126999	-0.201177	-0.936166	0.288308
413	204.621704	73.728500	-102.845001	-0.213426	-0.935917	0.280195
414	205.312897	74.194603	-103.565002	-0.225697	-0.935346	0.272376
415	206.004105	74.641899	-104.286003	-0.237966	-0.934464	0.264855
416	206.695297	75.070503	-105.009003	-0.250244	-0.933275	0.257634
417	207.386505	75.480400	-105.733002	-0.262510	-0.931789	0.250714
418	208.077698	75.871597	-106.458000	-0.274757	-0.930013	0.244098
419	208.768906	76.244003	-107.184998	-0.286998	-0.927949	0.237789
420	209.460098	76.597702	-107.913002	-0.299210	-0.925607	0.231787
421	210.151306	76.932701	-108.641998	-0.311390	-0.922994	0.226095
422	210.842499	77.248901	-109.373001	-0.323549	-0.920109	0.220715
423	211.533707	77.546402	-110.105003	-0.335667	-0.916965	0.215647
424	212.224899	77.825104	-110.838997	-0.347755	-0.913559	0.210894
425	212.916107	78.085197	-111.572998	-0.359777	-0.909911	0.206454
426	213.607300	78.326500	-112.309998	-0.371778	-0.906004	0.202330
427	214.298492	78.549103	-113.046997	-0.383705	-0.901864	0.198523
428	214.989700	78.752899	-113.786003	-0.395588	-0.897481	0.195035

429 215.680893 78.938004 -114.527000 -0.407421 -0.892859 0.191864
430 216.372101 79.104401 -115.267998 -0.419169 -0.888015 0.189013
431 217.063293 79.251999 -116.012001 -0.430877 -0.882932 0.186482
432 217.754501 79.380898 -116.755997 -0.442493 -0.877636 0.184270
433 218.445694 79.491096 -117.501999 -0.454045 -0.872113 0.182379
434 219.136902 79.582603 -118.249001 -0.465514 -0.866375 0.180807
435 219.828094 79.655296 -118.998001 -0.476910 -0.860416 0.179558
436 220.519302 79.709297 -119.748001 -0.488215 -0.854246 0.178630
437 221.210495 79.744499 -120.499001 -0.499426 -0.847869 0.178025
438 221.901703 79.761101 -121.251999 -0.510552 -0.841276 0.177739
439 222.592896 79.758797 -122.005997 -0.521575 -0.834479 0.177778
440 223.284103 79.737900 -122.761002 -0.532490 -0.827479 0.178136
441 223.975296 79.698196 -123.517998 -0.543308 -0.820269 0.178817
442 224.666504 79.639801 -124.276001 -0.554009 -0.812859 0.179819
443 225.357697 79.562698 -125.036003 -0.564603 -0.805240 0.181142
444 226.048904 79.466797 -125.796997 -0.575070 -0.797423 0.182787
445 226.740097 79.352203 -126.558998 -0.585405 -0.789410 0.184752
446 227.431305 79.218903 -127.322998 -0.595617 -0.781190 0.187037
447 228.122498 79.066803 -128.087997 -0.605686 -0.772774 0.189643
448 228.813705 78.896004 -128.854004 -0.615605 -0.764164 0.192569
449 229.504898 78.706497 -129.621994 -0.625383 -0.755350 0.195812
450 230.196106 78.498299 -130.391006 -0.635000 -0.746341 0.199374
451 230.887299 78.271301 -131.162003 -0.644460 -0.737129 0.203254
452 231.578506 78.025497 -131.934006 -0.653745 -0.727723 0.207452
398 194.253693 64.489403 -92.211899 -0.034858 -0.901825 0.430694
399 194.944901 65.236504 -92.911201 -0.046143 -0.906864 0.418889
400 195.636093 65.964798 -93.611801 -0.057559 -0.911473 0.407313
401 196.327301 66.674400 -94.313797 -0.069095 -0.915660 0.395970
402 197.018494 67.365303 -95.017197 -0.080742 -0.919433 0.384868
403 197.709702 68.037399 -95.722000 -0.092489 -0.922800 0.374014
404 198.400894 68.690804 -96.428101 -0.104324 -0.925769 0.363413
405 199.092102 69.325500 -97.135597 -0.116240 -0.928348 0.353070
406 199.783295 69.941399 -97.844498 -0.128227 -0.930545 0.342992
407 200.474503 70.538597 -98.554703 -0.140275 -0.932369 0.333182
408 201.165695 71.117104 -99.266296 -0.152377 -0.933828 0.323645
409 201.856903 71.676804 -99.979301 -0.164525 -0.934929 0.314386
410 202.548096 72.217796 -100.694000 -0.176717 -0.935680 0.305408
411 203.239304 72.740097 -101.408997 -0.188921 -0.936093 0.296714
412 203.930496 73.243698 -102.126999 -0.201177 -0.936166 0.288308
413 204.621704 73.728500 -102.845001 -0.213426 -0.935917 0.280195
414 205.312897 74.194603 -103.565002 -0.225697 -0.935346 0.272376
415 206.004105 74.641899 -104.286003 -0.237966 -0.934464 0.264855
416 206.695297 75.070503 -105.009003 -0.250244 -0.933275 0.257634
417 207.386505 75.480400 -105.733002 -0.262510 -0.931789 0.250714
418 208.077698 75.871597 -106.458000 -0.274757 -0.930013 0.244098
419 208.768906 76.244003 -107.184998 -0.286998 -0.927949 0.237789
420 209.460098 76.597702 -107.913002 -0.299210 -0.925607 0.231787

421 210.151306 76.932701 -108.641998 -0.311390 -0.922994 0.226095
422 210.842499 77.248901 -109.373001 -0.323549 -0.920109 0.220715
423 211.533707 77.546402 -110.105003 -0.335667 -0.916965 0.215647
424 212.224899 77.825104 -110.838997 -0.347755 -0.913559 0.210894
425 212.916107 78.085197 -111.572998 -0.359777 -0.909911 0.206454
426 213.607300 78.326500 -112.309998 -0.371778 -0.906004 0.202330
427 214.298492 78.549103 -113.046997 -0.383705 -0.901864 0.198523
428 214.989700 78.752899 -113.786003 -0.395588 -0.897481 0.195035
429 215.680893 78.938004 -114.527000 -0.407421 -0.892859 0.191864
430 216.372101 79.104401 -115.267998 -0.419169 -0.888015 0.189013
431 217.063293 79.251999 -116.012001 -0.430877 -0.882932 0.186482
432 217.754501 79.380898 -116.755997 -0.442493 -0.877636 0.184270
433 218.445694 79.491096 -117.501999 -0.454045 -0.872113 0.182379
434 219.136902 79.582603 -118.249001 -0.465514 -0.866375 0.180807
435 219.828094 79.655296 -118.998001 -0.476910 -0.860416 0.179558
436 220.519302 79.709297 -119.748001 -0.488215 -0.854246 0.178630
437 221.210495 79.744499 -120.499001 -0.499426 -0.847869 0.178025
438 221.901703 79.761101 -121.251999 -0.510552 -0.841276 0.177739
439 222.592896 79.758797 -122.005997 -0.521575 -0.834479 0.177778
440 223.284103 79.737900 -122.761002 -0.532490 -0.827479 0.178136
441 223.975296 79.698196 -123.517998 -0.543308 -0.820269 0.178817
442 224.666504 79.639801 -124.276001 -0.554009 -0.812859 0.179819
443 225.357697 79.562698 -125.036003 -0.564603 -0.805240 0.181142
444 226.048904 79.466797 -125.796997 -0.575070 -0.797423 0.182787
445 226.740097 79.352203 -126.558998 -0.585405 -0.789410 0.184752
413 204.621704 73.728500 -102.845001 -0.213426 -0.935917 0.280195
414 205.312897 74.194603 -103.565002 -0.225697 -0.935346 0.272376
415 206.004105 74.641899 -104.286003 -0.237966 -0.934464 0.264855
416 206.695297 75.070503 -105.009003 -0.250244 -0.933275 0.257634
417 207.386505 75.480400 -105.733002 -0.262510 -0.931789 0.250714
418 208.077698 75.871597 -106.458000 -0.274757 -0.930013 0.244098
419 208.768906 76.244003 -107.184998 -0.286998 -0.927949 0.237789
420 209.460098 76.597702 -107.913002 -0.299210 -0.925607 0.231787
421 210.151306 76.932701 -108.641998 -0.311390 -0.922994 0.226095
422 210.842499 77.248901 -109.373001 -0.323549 -0.920109 0.220715
423 211.533707 77.546402 -110.105003 -0.335667 -0.916965 0.215647
424 212.224899 77.825104 -110.838997 -0.347755 -0.913559 0.210894
425 212.916107 78.085197 -111.572998 -0.359777 -0.909911 0.206454
426 213.607300 78.326500 -112.309998 -0.371778 -0.906004 0.202330
427 214.298492 78.549103 -113.046997 -0.383705 -0.901864 0.198523
428 214.989700 78.752899 -113.786003 -0.395588 -0.897481 0.195035
429 215.680893 78.938004 -114.527000 -0.407421 -0.892859 0.191864
430 216.372101 79.104401 -115.267998 -0.419169 -0.888015 0.189013
431 217.063293 79.251999 -116.012001 -0.430877 -0.882932 0.186482
432 217.754501 79.380898 -116.755997 -0.442493 -0.877636 0.184270
433 218.445694 79.491096 -117.501999 -0.454045 -0.872113 0.182379
434 219.136902 79.582603 -118.249001 -0.465514 -0.866375 0.180807

435 219.828094 79.655296 -118.998001 -0.476910 -0.860416 0.179558
436 220.519302 79.709297 -119.748001 -0.488215 -0.854246 0.178630
437 221.210495 79.744499 -120.499001 -0.499426 -0.847869 0.178025
438 221.901703 79.761101 -121.251999 -0.510552 -0.841276 0.177739
439 222.592896 79.758797 -122.005997 -0.521575 -0.834479 0.177778
440 223.284103 79.737900 -122.761002 -0.532490 -0.827479 0.178136
441 223.975296 79.698196 -123.517998 -0.543308 -0.820269 0.178817
442 224.666504 79.639801 -124.276001 -0.554009 -0.812859 0.179819
443 225.357697 79.562698 -125.036003 -0.564603 -0.805240 0.181142
444 226.048904 79.466797 -125.796997 -0.575070 -0.797423 0.182787
445 226.740097 79.352203 -126.558998 -0.585405 -0.789410 0.184752
446 227.431305 79.218903 -127.322998 -0.595617 -0.781190 0.187037
447 228.122498 79.066803 -128.087997 -0.605686 -0.772774 0.189643
448 228.813705 78.896004 -128.854004 -0.615605 -0.764164 0.192569
449 229.504898 78.706497 -129.621994 -0.625383 -0.755350 0.195812
450 230.196106 78.498299 -130.391006 -0.635000 -0.746341 0.199374
451 230.887299 78.271301 -131.162003 -0.644460 -0.737129 0.203254
452 231.578506 78.025497 -131.934006 -0.653745 -0.727723 0.207452

7. APPENDIX C. DIODE EXCESS TEMPERATURE

DIODE TEMP	10V	10H	18V	18H	23V	36V	36 H
-20	216.7974	189.1753	210.8547	204.4932	169.5805	186.7644	196.9413
-19	217.2523	189.5013	211.5019	205.0137	170.2769	186.9826	197.3097
-18	217.702	189.8234	212.1486	205.5354	170.9708	187.2026	197.6782
-17	218.1466	190.1415	212.7948	206.0583	171.6621	187.4245	198.0467
-16	218.5859	190.4557	213.4405	206.5824	172.3509	187.6481	198.4153
-15	219.0201	190.7659	214.0856	207.1076	173.0371	187.8735	198.7838
-14	219.4491	191.0722	214.7302	207.634	173.7207	188.1007	199.1525
-13	219.8728	191.3745	215.3743	208.1616	174.4018	188.3297	199.5211
-12	220.2914	191.6728	216.0179	208.6903	175.0804	188.5605	199.8898
-11	220.7048	191.9671	216.6609	209.2203	175.7564	188.7931	200.2585
-10	221.1129	192.2575	217.3034	209.7514	176.4298	189.0275	200.6273
-9	221.5159	192.544	217.9454	210.2837	177.1007	189.2637	200.9961
-8	221.9137	192.8265	218.5869	210.8172	177.769	189.5017	201.3649
-7	222.3063	193.105	219.2278	211.3518	178.4348	189.7415	201.7338
-6	222.6937	193.3796	219.8682	211.8876	179.098	189.983	202.1027
-5	222.9991	193.6428	220.5081	212.4247	179.7587	190.2264	202.4716
-4	223.3015	193.9017	221.1474	212.9628	180.4168	190.4716	202.8406
-3	223.6011	194.1564	221.7862	213.5022	181.0723	190.7185	203.2096
-2	223.8977	194.4069	222.4245	214.0428	181.7253	190.9673	203.5786
-1	224.1914	194.6531	223.0623	214.5845	182.3757	191.2179	203.9477
0	224.4822	194.8951	223.6995	215.1274	183.0236	191.4702	204.3168
1	224.7701	195.1328	224.3363	215.6715	183.6689	191.7244	204.686
2	225.0551	195.3663	224.9724	216.2167	184.3117	191.9803	205.0552
3	225.3371	195.5956	225.6081	216.7632	184.9519	192.238	205.4244
4	225.6162	195.8206	226.2432	217.3108	185.5896	192.4976	205.7936
5	225.8924	196.0413	226.8779	217.8596	186.2247	192.7589	206.1629
6	226.1656	196.2578	227.5119	218.4095	186.8572	193.0114	206.5373
7	226.436	196.4701	228.1455	218.9607	187.4872	193.2656	206.9117
8	226.7034	196.6781	228.7785	219.513	188.1147	193.5216	207.2861
9	226.9679	196.8819	229.411	220.0665	188.7396	193.7795	207.6606
10	227.2295	197.0815	230.043	220.6212	189.3619	194.0391	208.0351
11	227.4881	197.2768	230.6744	221.1771	189.9817	194.3005	208.4096
12	227.7438	197.4678	231.3054	221.7341	190.5989	194.5638	208.7842
13	227.9966	197.6546	231.9358	222.2923	191.2135	194.8288	209.1588
14	228.2465	197.8372	232.5656	222.8517	191.8256	195.0956	209.5335
15	228.4935	198.0155	233.195	223.4123	192.4352	195.3642	209.9082
16	228.7375	198.1896	233.8238	223.9741	193.0422	195.6346	210.2829
17	228.9786	198.3594	234.4521	224.537	193.6466	195.9068	210.6577
18	229.2168	198.525	235.0799	225.1011	194.2485	196.1808	211.0324
19	229.4521	198.6864	235.7071	225.6664	194.8479	196.4566	211.4073
20	229.6845	198.8435	236.3338	226.2329	195.4446	196.7342	211.7821
21	229.9139	198.9964	236.96	226.8005	196.0388	197.0136	212.157
22	230.1404	199.145	237.5857	227.3693	196.6305	197.2947	212.5319

23 230.364 199.2893 238.2108 227.9393 197.2196 197.5777 212.9069
24 230.5847 199.4295 238.8354 228.5105 197.8062 197.8625 213.2819
25 230.8024 199.5654 239.4595 229.0829 198.3902 198.1491 213.6569
26 231.0172 199.697 240.083 229.6564 198.9716 198.4374 214.032
27 231.2291 199.8244 240.7061 230.2311 199.5505 198.7276 214.4071
28 231.4381 199.9476 241.3286 230.807 200.1268 199.0195 214.7823
29 231.6442 200.0665 241.9505 231.3841 200.7006 199.3133 215.1574
30 231.8473 200.1811 242.572 231.9624 201.2718 199.6088 215.5326
31 232.0475 200.2916 243.1929 232.5418 201.8405 199.9062 215.9079
32 232.2448 200.3977 243.8133 233.1224 202.4066 200.2053 216.2832
33 232.4392 200.4997 244.4332 233.7042 202.9702 200.5062 216.6585
34 232.6306 200.5974 245.0525 234.2872 203.5312 200.809 217.0338
35 232.8191 200.6908 245.6713 234.8713 204.0896 201.1135 217.4092
36 233.0047 200.78 246.2896 235.4566 204.6455 201.4198 217.7846
37 233.1874 200.865 246.9074 236.0431 205.1988 201.7279 218.1601
38 233.3672 200.9457 247.5246 236.6308 205.7496 202.0379 218.5356
39 233.544 201.0222 248.1413 237.2197 206.2978 202.3496 218.9111
40 233.7179 201.0944 248.7575 237.8097 206.8435 202.6631 219.2867
41 233.8889 201.1624 249.3731 238.4009 207.3866 202.9784 219.6622
42 234.057 201.2262 249.9883 238.9933 207.9272 203.2955 220.0379
43 234.2221 201.2857 250.6029 239.5869 208.4652 203.6144 220.4135
44 234.3844 201.3409 251.2169 240.1816 209.0006 203.9351 220.7892
45 234.5437 201.3919 251.8305 240.7776 209.5335 204.2575 221.165

8. APPENDIX D. APC ALONG-SCAN BIAS

APC_ALONG_SCAN_BIAS ΔT_{const} in K, l4 (sample #,13 channels) x 221 (pixel)

S#	ch1	ch2	ch3	ch4	ch5	ch6	ch7	ch8	ch9	ch10	ch11	ch12	ch13
7	-0.0521	0.0689	0.0435	0.1785	0.0512	-0.0086	0.0306	0.0242	0.0661	-0.1135	-0.1164	-0.0781	-0.0998
8	-0.0532	0.0631	0.042	0.173	0.0528	-0.0085	0.0304	0.024	0.0655	-0.1125	-0.1154	-0.0774	-0.0989
9	-0.0543	0.0572	0.0404	0.1675	0.0536	-0.0084	0.0301	0.0238	0.0649	-0.1115	-0.1143	-0.0767	-0.098
10	-0.0554	0.0514	0.0388	0.1619	0.0539	-0.0083	0.0298	0.0235	0.0643	-0.1104	-0.1133	-0.076	-0.0971
11	-0.0565	0.0456	0.0372	0.1564	0.0536	-0.0082	0.0295	0.0233	0.0637	-0.1094	-0.1122	-0.0753	-0.0962
12	-0.0576	0.0398	0.0355	0.1509	0.053	-0.0082	0.0293	0.0231	0.0631	-0.1084	-0.1112	-0.0746	-0.0953
13	-0.0588	0.0339	0.0338	0.1453	0.0521	-0.0081	0.029	0.0229	0.0625	-0.1073	-0.1101	-0.0739	-0.0944
14	-0.0599	0.0281	0.0321	0.1398	0.0512	-0.008	0.0287	0.0227	0.0619	-0.1063	-0.109	-0.0731	-0.0935
15	-0.0610	0.0223	0.0303	0.1343	0.0502	-0.0079	0.0284	0.0224	0.0613	-0.1053	-0.108	-0.0724	-0.0926
16	-0.0621	0.0165	0.0284	0.1287	0.0495	-0.0079	0.0281	0.0222	0.0607	-0.1043	-0.1069	-0.0717	-0.0917
17	-0.0632	0.0107	0.0265	0.1232	0.0481	-0.0078	0.0279	0.022	0.0601	-0.1032	-0.1059	-0.071	-0.0908
18	-0.0643	0.0048	0.0245	0.1177	0.0468	-0.0077	0.0276	0.0218	0.0595	-0.1022	-0.1048	-0.0703	-0.0898
19	-0.0655	-0.0010	0.0225	0.1121	0.0455	-0.0076	0.0273	0.0216	0.0589	-0.1012	-0.1037	-0.0696	-0.0889
20	-0.0666	-0.0068	0.0205	0.1066	0.0442	-0.0075	0.027	0.0213	0.0583	-0.1001	-0.1027	-0.0689	-0.088
21	-0.0677	-0.0126	0.0185	0.1011	0.0428	-0.0075	0.0267	0.0211	0.0577	-0.0991	-0.1016	-0.0682	-0.0871
22	-0.0688	-0.0185	0.0165	0.0955	0.0415	-0.0074	0.0265	0.0209	0.0571	-0.0981	-0.1006	-0.0675	-0.0862
23	-0.0699	-0.0243	0.0145	0.09	0.0402	-0.0073	0.0262	0.0207	0.0565	-0.097	-0.0995	-0.0668	-0.0853
24	-0.0710	-0.0301	0.0125	0.0845	0.0389	-0.0072	0.0259	0.0205	0.0559	-0.096	-0.0985	-0.066	-0.0844
25	-0.0722	-0.0359	0.0105	0.0789	0.0376	-0.0072	0.0256	0.0202	0.0553	-0.095	-0.0974	-0.0653	-0.0835
26	-0.0733	-0.0417	0.0085	0.0734	0.0362	-0.0071	0.0254	0.02	0.0547	-0.0939	-0.0963	-0.0646	-0.0826
27	-0.0744	-0.0476	0.0066	0.0679	0.0349	-0.007	0.0251	0.0198	0.0541	-0.0929	-0.0953	-0.0639	-0.0817
28	-0.0755	-0.0534	0.0046	0.0623	0.0336	-0.0069	0.0248	0.0196	0.0535	-0.0919	-0.0942	-0.0632	-0.0808
29	-0.0766	-0.0592	0.0026	0.0593	0.0323	-0.0068	0.0245	0.0194	0.0529	-0.0908	-0.0932	-0.0625	-0.0799
30	-0.0777	-0.0650	0.0006	0.0563	0.0309	-0.0068	0.0242	0.0191	0.0523	-0.0898	-0.0921	-0.0618	-0.079
31	-0.0789	-0.0709	-0.0014	0.0532	0.0296	-0.0067	0.024	0.0189	0.0517	-0.0888	-0.091	-0.0611	-0.0781
32	-0.0800	-0.0767	-0.0034	0.0502	0.0283	-0.0066	0.0237	0.0187	0.0511	-0.0877	-0.09	-0.0604	-0.0771
33	-0.0811	-0.0825	-0.0054	0.0472	0.027	-0.0065	0.0234	0.0185	0.0505	-0.0867	-0.0889	-0.0597	-0.0762
34	-0.0822	-0.0883	-0.0074	0.0442	0.0256	-0.0065	0.0231	0.0183	0.0499	-0.0857	-0.0879	-0.0589	-0.0753
35	-0.0833	-0.0941	-0.0094	0.0411	0.0243	-0.0064	0.0228	0.018	0.0493	-0.0846	-0.0868	-0.0582	-0.0744
36	-0.0845	-0.1000	-0.0114	0.0381	0.023	-0.0063	0.0226	0.0178	0.0487	-0.0836	-0.0857	-0.0575	-0.0735
37	-0.0855	-0.1055	-0.0134	0.0351	0.0217	-0.0062	0.0223	0.0176	0.0481	-0.0826	-0.0847	-0.0568	-0.0726
38	-0.0861	-0.1060	-0.0154	0.032	0.0203	-0.0061	0.022	0.0174	0.0475	-0.0815	-0.0836	-0.0561	-0.0717
39	-0.0867	-0.1065	-0.0174	0.029	0.019	-0.0061	0.0217	0.0172	0.0469	-0.0805	-0.0826	-0.0554	-0.0708
40	-0.0874	-0.1071	-0.0194	0.026	0.0177	-0.006	0.0215	0.0169	0.0463	-0.0795	-0.0815	-0.0547	-0.0699
41	-0.0880	-0.1076	-0.0214	0.023	0.0164	-0.0059	0.0212	0.0167	0.0457	-0.0784	-0.0805	-0.054	-0.069
42	-0.0886	-0.1081	-0.0234	0.0199	0.0151	-0.0058	0.0209	0.0165	0.0451	-0.0774	-0.0794	-0.0533	-0.0681
43	-0.0892	-0.1086	-0.0254	0.0169	0.0137	-0.0058	0.0206	0.0163	0.0445	-0.0764	-0.0783	-0.0525	-0.0672
44	-0.0898	-0.1092	-0.0274	0.0139	0.0124	-0.0057	0.0203	0.0161	0.0439	-0.0754	-0.0773	-0.0518	-0.0663
45	-0.0904	-0.1097	-0.0294	0.0108	0.0111	-0.0056	0.0201	0.0158	0.0433	-0.0743	-0.0762	-0.0511	-0.0653
46	-0.0910	-0.1102	-0.0314	0.0078	0.0098	-0.0055	0.0198	0.0156	0.0427	-0.0733	-0.0752	-0.0504	-0.0644
47	-0.0916	-0.1107	-0.0334	0.0048	0.0084	-0.0054	0.0195	0.0154	0.0421	-0.0723	-0.0741	-0.0497	-0.0635
48	-0.0923	-0.1113	-0.0354	0.0018	0.0071	-0.0054	0.0192	0.0152	0.0415	-0.0712	-0.073	-0.049	-0.0626
49	-0.0929	-0.1118	-0.0374	-0.0013	0.0058	-0.0053	0.0189	0.015	0.0409	-0.0702	-0.072	-0.0483	-0.0617
50	-0.0935	-0.1123	-0.0394	-0.0043	0.0045	-0.0052	0.0187	0.0147	0.0403	-0.0692	-0.0709	-0.0476	-0.0608
51	-0.0941	-0.1128	-0.0414	-0.0073	0.0031	-0.0051	0.0184	0.0145	0.0397	-0.0681	-0.0699	-0.0469	-0.0599
52	-0.0947	-0.1134	-0.0434	-0.0104	0.0018	-0.0051	0.0181	0.0143	0.0391	-0.0671	-0.0688	-0.0462	-0.059
53	-0.0953	-0.1139	-0.0454	-0.0134	0.0005	-0.005	0.0178	0.0141	0.0385	-0.0661	-0.0678	-0.0454	-0.0581
54	-0.0959	-0.1144	-0.0474	-0.0164	-0.0008	-0.0049	0.0176	0.0139	0.0379	-0.065	-0.0667	-0.0447	-0.0572
55	-0.0965	-0.1149	-0.0494	-0.0195	-0.0022	-0.0048	0.0173	0.0136	0.0373	-0.064	-0.0656	-0.044	-0.0563
56	-0.0972	-0.1154	-0.0514	-0.0225	-0.0035	-0.0047	0.017	0.0134	0.0367	-0.063	-0.0646	-0.0433	-0.0554
57	-0.0978	-0.1160	-0.0534	-0.0255	-0.0048	-0.0047	0.0167	0.0132	0.0361	-0.0619	-0.0635	-0.0426	-0.0545
58	-0.0984	-0.1165	-0.0554	-0.0285	-0.0061	-0.0046	0.0164	0.013	0.0355	-0.0609	-0.0625	-0.0419	-0.0535
59	-0.0990	-0.1170	-0.0573	-0.0316	-0.0074	-0.0045	0.0162	0.0128	0.0349	-0.0599	-0.0614	-0.0412	-0.0526
60	-0.0996	-0.1175	-0.0593	-0.0346	-0.0088	-0.0044	0.0159	0.0125	0.0343	-0.0588	-0.0603	-0.0405	-0.0517
61	-0.1002	-0.1181	-0.0613	-0.0376	-0.0101	-0.0044	0.0156	0.0123	0.0337	-0.0578	-0.0593	-0.0398	-0.0508
62	-0.1008	-0.1186	-0.0633	-0.0407	-0.0114	-0.0043	0.0153	0.0121	0.0331	-0.0568	-0.0582	-0.0391	-0.0499
63	-0.1015	-0.1191	-0.0653	-0.0437	-0.0127	-0.0042	0.015	0.0119	0.0325	-0.0557	-0.0572	-0.0383	-0.049
64	-0.1021	-0.1196	-0.0673	-0.0467	-0.0141	-0.0041	0.0148	0.0117	0.0319	-0.0547	-0.0561	-0.0376	-0.0481

65	-0.1027	-0.1202	-0.0693	-0.0497	-0.0154	-0.004	0.0145	0.0114	0.0313	-0.0537	-0.055	-0.0369	-0.0472
66	-0.1033	-0.1207	-0.0713	-0.0528	-0.0167	-0.004	0.0142	0.0112	0.0307	-0.0526	-0.054	-0.0362	-0.0463
67	-0.1039	-0.1212	-0.0733	-0.0558	-0.018	-0.0039	0.0139	0.011	0.0301	-0.0516	-0.0529	-0.0355	-0.0454
68	-0.1045	-0.1217	-0.0753	-0.0588	-0.0194	-0.0038	0.0137	0.0108	0.0295	-0.0506	-0.0519	-0.0348	-0.0445
69	-0.1051	-0.1223	-0.0773	-0.0619	-0.0207	-0.0037	0.0134	0.0106	0.0289	-0.0495	-0.0508	-0.0341	-0.0436
70	-0.1057	-0.1228	-0.0793	-0.0649	-0.022	-0.0037	0.0131	0.0103	0.0283	-0.0485	-0.0498	-0.0334	-0.0427
71	-0.1064	-0.1233	-0.0813	-0.0679	-0.0233	-0.0036	0.0128	0.0101	0.0277	-0.0475	-0.0487	-0.0327	-0.0417
72	-0.1070	-0.1238	-0.0833	-0.071	-0.0247	-0.0035	0.0125	0.0099	0.0271	-0.0464	-0.0476	-0.032	-0.0408
73	-0.1076	-0.1244	-0.0853	-0.074	-0.026	-0.0034	0.0123	0.0097	0.0265	-0.0454	-0.0466	-0.0312	-0.0399
74	-0.1082	-0.1249	-0.0873	-0.077	-0.0273	-0.0033	0.012	0.0095	0.0259	-0.0444	-0.0455	-0.0305	-0.039
75	-0.1088	-0.1254	-0.0893	-0.08	-0.0286	-0.0033	0.0117	0.0092	0.0253	-0.0434	-0.0445	-0.0298	-0.0381
76	-0.1094	-0.1259	-0.0913	-0.0831	-0.0299	-0.0032	0.0114	0.009	0.0247	-0.0423	-0.0434	-0.0291	-0.0372
77	-0.1100	-0.1265	-0.0933	-0.0861	-0.0313	-0.0031	0.0111	0.0088	0.024	-0.0413	-0.0423	-0.0284	-0.0363
78	-0.1106	-0.1270	-0.0953	-0.0891	-0.0326	-0.003	0.0109	0.0086	0.0234	-0.0403	-0.0413	-0.0277	-0.0354
79	-0.1113	-0.1275	-0.0973	-0.0922	-0.0339	-0.003	0.0106	0.0084	0.0228	-0.0392	-0.0402	-0.027	-0.0345
80	-0.1119	-0.1280	-0.0993	-0.0952	-0.0352	-0.0029	0.0103	0.0081	0.0222	-0.0382	-0.0392	-0.0263	-0.0336
81	-0.1125	-0.1285	-0.1013	-0.0982	-0.0366	-0.0028	0.01	0.0079	0.0216	-0.0372	-0.0381	-0.0256	-0.0327
82	-0.1131	-0.1291	-0.1033	-0.1012	-0.0379	-0.0027	0.0098	0.0077	0.021	-0.0361	-0.0371	-0.0249	-0.0318
83	-0.1137	-0.1296	-0.1053	-0.1043	-0.0392	-0.0026	0.0095	0.0075	0.0204	-0.0351	-0.036	-0.0241	-0.0309
84	-0.1143	-0.1301	-0.1073	-0.1073	-0.0405	-0.0026	0.0092	0.0073	0.0198	-0.0341	-0.0349	-0.0234	-0.0299
85	-0.1149	-0.1306	-0.1093	-0.1103	-0.0419	-0.0025	0.0089	0.007	0.0192	-0.033	-0.0339	-0.0227	-0.029
86	-0.1156	-0.1312	-0.1113	-0.1134	-0.0432	-0.0024	0.0086	0.0068	0.0186	-0.032	-0.0328	-0.022	-0.0281
87	-0.1162	-0.1317	-0.1133	-0.1164	-0.0445	-0.0023	0.0084	0.0066	0.018	-0.031	-0.0318	-0.0213	-0.0272
88	-0.1168	-0.1322	-0.1153	-0.1194	-0.0458	-0.0023	0.0081	0.0064	0.0174	-0.0299	-0.0307	-0.0206	-0.0263
89	-0.1174	-0.1327	-0.1173	-0.1224	-0.0472	-0.0022	0.0078	0.0062	0.0168	-0.0289	-0.0296	-0.0199	-0.0254
90	-0.1180	-0.1333	-0.1192	-0.1255	-0.0485	-0.0021	0.0075	0.0059	0.0162	-0.0279	-0.0286	-0.0192	-0.0245
91	-0.1186	-0.1338	-0.1212	-0.1285	-0.0498	-0.002	0.0072	0.0057	0.0156	-0.0268	-0.0275	-0.0185	-0.0236
92	-0.1192	-0.1343	-0.1232	-0.1315	-0.0511	-0.0019	0.007	0.0055	0.015	-0.0258	-0.0265	-0.0178	-0.0227
93	-0.1198	-0.1348	-0.1252	-0.1346	-0.0524	-0.0019	0.0067	0.0053	0.0144	-0.0248	-0.0254	-0.017	-0.0218
94	-0.1205	-0.1354	-0.1272	-0.1376	-0.0538	-0.0018	0.0064	0.0051	0.0138	-0.0237	-0.0243	-0.0163	-0.0209
95	-0.1211	-0.1359	-0.1292	-0.1406	-0.0551	-0.0017	0.0061	0.0048	0.0132	-0.0227	-0.0233	-0.0156	-0.02
96	-0.1217	-0.1364	-0.1312	-0.1437	-0.0564	-0.0016	0.0059	0.0046	0.0126	-0.0217	-0.0222	-0.0149	-0.0191
97	-0.1223	-0.1369	-0.1332	-0.1467	-0.0577	-0.0016	0.0056	0.0044	0.012	-0.0206	-0.0212	-0.0142	-0.0182
98	-0.1229	-0.1375	-0.1352	-0.1497	-0.0591	-0.0015	0.0053	0.0042	0.0114	-0.0196	-0.0201	-0.0135	-0.0172
99	-0.1236	-0.1380	-0.1372	-0.1527	-0.0604	-0.0014	0.005	0.004	0.0108	-0.0186	-0.0191	-0.0128	-0.0163
100	-0.1215	-0.1367	-0.1392	-0.1558	-0.0617	-0.0013	0.0047	0.0037	0.0102	-0.0175	-0.018	-0.0121	-0.0154
101	-0.1194	-0.1353	-0.1412	-0.1588	-0.063	-0.0012	0.0045	0.0035	0.0096	-0.0165	-0.0169	-0.0114	-0.0145
102	-0.1173	-0.1339	-0.1432	-0.1618	-0.0644	-0.0012	0.0042	0.0033	0.009	-0.0155	-0.0159	-0.0107	-0.0136
103	-0.1152	-0.1325	-0.1452	-0.1649	-0.0657	-0.0011	0.0039	0.0031	0.0084	-0.0145	-0.0148	-0.0099	-0.0127
104	-0.1130	-0.1311	-0.1472	-0.1679	-0.067	-0.001	0.0036	0.0029	0.0078	-0.0134	-0.0138	-0.0092	-0.0118
105	-0.1109	-0.1298	-0.1492	-0.1709	-0.0683	-0.0009	0.0033	0.0026	0.0072	-0.0124	-0.0127	-0.0085	-0.0109
106	-0.1088	-0.1284	-0.1512	-0.1739	-0.0697	-0.0009	0.0031	0.0024	0.0066	-0.0114	-0.0116	-0.0078	-0.01
107	-0.1067	-0.1270	-0.1485	-0.1712	-0.071	-0.0008	0.0028	0.0022	0.006	-0.0103	-0.0106	-0.0071	-0.0091
108	-0.1046	-0.1256	-0.1457	-0.1684	-0.0723	-0.0007	0.0025	0.002	0.0054	-0.0093	-0.0095	-0.0064	-0.0082
109	-0.1025	-0.1242	-0.143	-0.1657	-0.0736	-0.0006	0.0022	0.0018	0.0048	-0.0083	-0.0085	-0.0057	-0.0073
110	-0.1004	-0.1229	-0.1403	-0.1629	-0.0749	-0.0005	0.002	0.0015	0.0042	-0.0072	-0.0074	-0.005	-0.0064
111	-0.0983	-0.1215	-0.1376	-0.1602	-0.0763	-0.0005	0.0017	0.0013	0.0036	-0.0062	-0.0064	-0.0043	-0.0054
112	-0.0962	-0.1201	-0.1348	-0.1574	-0.0776	-0.0004	0.0014	0.0011	0.003	-0.0052	-0.0053	-0.0036	-0.0045
113	-0.0941	-0.1187	-0.1321	-0.1547	-0.0789	-0.0003	0.0011	0.0009	0.0024	-0.0041	-0.0042	-0.0028	-0.0036
114	-0.0920	-0.1173	-0.1294	-0.1519	-0.0802	-0.0002	0.0008	0.0007	0.0018	-0.0031	-0.0032	-0.0021	-0.0027
115	-0.0899	-0.1159	-0.1267	-0.1491	-0.0816	-0.0002	0.0006	0.0004	0.0012	-0.0021	-0.0021	-0.0014	-0.0018
116	-0.0878	-0.1146	-0.1239	-0.1464	-0.0829	-0.0001	0.0003	0.0002	0.0006	-0.001	-0.0011	-0.0007	-0.0009
117	-0.0857	-0.1132	-0.1212	-0.1436	-0.0842	0	0	0	0	0	0	0	0
118	-0.0836	-0.1118	-0.1185	-0.1409	-0.0855	0.0001	-0.0003	-0.0002	-0.0006	0.001	0.0011	0.0007	0.0009
119	-0.0815	-0.1104	-0.1157	-0.1381	-0.0869	0.0002	-0.0006	-0.0004	-0.0012	0.0021	0.0021	0.0014	0.0018
120	-0.0794	-0.1090	-0.113	-0.1354	-0.0882	0.0002	-0.0008	-0.0007	-0.0018	0.0031	0.0032	0.0021	0.0027
121	-0.0773	-0.1077	-0.1103	-0.1326	-0.0895	0.0003	-0.0011	-0.0009	-0.0024	0.0041	0.0042	0.0028	0.0036
122	-0.0752	-0.1063	-0.1076	-0.1299	-0.0908	0.0004	-0.0014	-0.0011	-0.003	0.0052	0.0053	0.0036	0.0045
123	-0.0731	-0.1049	-0.1048	-0.1271	-0.0921	0.0005	-0.0017	-0.0013	-0.0036	0.0062	0.0064	0.0043	0.0054
124	-0.0709	-0.1035	-0.1021	-0.1244	-0.0902	0.0005	-0.002	-0.0015	-0.0042	0.0072	0.0074	0.005	0.0064
125	-0.0688	-0.1021	-0.0994	-0.1216	-0.0883	0.0006	-0.0022	-0.0018	-0.0048	0.0083	0.0085	0.0057	0.0073
126	-0.0667	-0.1008	-0.0967	-0.1188	-0.0864	0.0007	-0.0025	-0.002	-0.0054	0.0093	0.0095	0.0064	0.0082
127	-0.0646	-0.0994	-0.0939	-0.1161	-0.0845	0.0008	-0.0028	-0.0022	-0.006	0.0103	0.0106	0.0071	0.0091

128	-0.0625	-0.0980	-0.0912	-0.1133	-0.0826	0.0009	-0.0031	-0.0024	-0.0066	0.0114	0.0116	0.0078	0.01
129	-0.0604	-0.0966	-0.0885	-0.1106	-0.0807	0.0009	-0.0033	-0.0026	-0.0072	0.0124	0.0127	0.0085	0.0109
130	-0.0583	-0.0952	-0.0857	-0.1078	-0.0788	0.001	-0.0036	-0.0029	-0.0078	0.0134	0.0138	0.0092	0.0118
131	-0.0562	-0.0938	-0.083	-0.1051	-0.0769	0.0011	-0.0039	-0.0031	-0.0084	0.0145	0.0148	0.0099	0.0127
132	-0.0541	-0.0925	-0.0803	-0.1023	-0.075	0.0012	-0.0042	-0.0033	-0.009	0.0155	0.0159	0.0107	0.0136
133	-0.0520	-0.0911	-0.0776	-0.0996	-0.0731	0.0012	-0.0045	-0.0035	-0.0096	0.0165	0.0169	0.0114	0.0145
134	-0.0499	-0.0897	-0.0748	-0.0968	-0.0712	0.0013	-0.0047	-0.0037	-0.0102	0.0175	0.018	0.0121	0.0154
135	-0.0478	-0.0883	-0.0721	-0.094	-0.0693	0.0014	-0.005	-0.004	-0.0108	0.0186	0.0191	0.0128	0.0163
136	-0.0457	-0.0869	-0.0694	-0.0913	-0.0674	0.0015	-0.0053	-0.0042	-0.0114	0.0196	0.0201	0.0135	0.0172
137	-0.0436	-0.0856	-0.0667	-0.0885	-0.0655	0.0016	-0.0056	-0.0044	-0.012	0.0206	0.0212	0.0142	0.0182
138	-0.0415	-0.0842	-0.0639	-0.0858	-0.0636	0.0016	-0.0059	-0.0046	-0.0126	0.0217	0.0222	0.0149	0.0191
139	-0.0394	-0.0828	-0.0612	-0.083	-0.0617	0.0017	-0.0061	-0.0048	-0.0132	0.0227	0.0233	0.0156	0.02
140	-0.0373	-0.0814	-0.0585	-0.0803	-0.0598	0.0018	-0.0064	-0.0051	-0.0138	0.0237	0.0243	0.0163	0.0209
141	-0.0352	-0.0800	-0.0557	-0.0775	-0.0579	0.0019	-0.0067	-0.0053	-0.0144	0.0248	0.0254	0.017	0.0218
142	-0.0331	-0.0786	-0.053	-0.0748	-0.056	0.0019	-0.007	-0.0055	-0.015	0.0258	0.0265	0.0178	0.0227
143	-0.0310	-0.0773	-0.0503	-0.072	-0.0541	0.002	-0.0072	-0.0057	-0.0156	0.0268	0.0275	0.0185	0.0236
144	-0.0288	-0.0759	-0.0476	-0.0692	-0.0522	0.0021	-0.0075	-0.0059	-0.0162	0.0279	0.0286	0.0192	0.0245
145	-0.0267	-0.0745	-0.0448	-0.0665	-0.0503	0.0022	-0.0078	-0.0062	-0.0168	0.0289	0.0296	0.0199	0.0254
146	-0.0246	-0.0731	-0.0421	-0.0637	-0.0484	0.0023	-0.0081	-0.0064	-0.0174	0.0299	0.0307	0.0206	0.0263
147	-0.0225	-0.0717	-0.0394	-0.061	-0.0465	0.0023	-0.0084	-0.0066	-0.018	0.031	0.0318	0.0213	0.0272
148	-0.0204	-0.0704	-0.0367	-0.0582	-0.0446	0.0024	-0.0086	-0.0068	-0.0186	0.032	0.0328	0.022	0.0281
149	-0.0183	-0.0690	-0.0339	-0.0555	-0.0427	0.0025	-0.0089	-0.007	-0.0192	0.033	0.0339	0.0227	0.029
150	-0.0162	-0.0676	-0.0312	-0.0527	-0.0408	0.0026	-0.0092	-0.0073	-0.0198	0.0341	0.0349	0.0234	0.0299
151	-0.0141	-0.0662	-0.0285	-0.05	-0.0389	0.0026	-0.0095	-0.0075	-0.0204	0.0351	0.036	0.0241	0.0309
152	-0.0120	-0.0648	-0.0257	-0.0472	-0.037	0.0027	-0.0098	-0.0077	-0.021	0.0361	0.0371	0.0249	0.0318
153	-0.0099	-0.0635	-0.023	-0.0445	-0.0351	0.0028	-0.01	-0.0079	-0.0216	0.0372	0.0381	0.0256	0.0327
154	-0.0078	-0.0621	-0.0203	-0.0417	-0.0332	0.0029	-0.0103	-0.0081	-0.0222	0.0382	0.0392	0.0263	0.0336
155	-0.0057	-0.0607	-0.0176	-0.0389	-0.0312	0.003	-0.0106	-0.0084	-0.0228	0.0392	0.0402	0.027	0.0345
156	-0.0036	-0.0593	-0.0148	-0.0362	-0.0293	0.003	-0.0109	-0.0086	-0.0234	0.0403	0.0413	0.0277	0.0354
157	-0.0015	-0.0579	-0.0121	-0.0334	-0.0274	0.0031	-0.0111	-0.0088	-0.024	0.0413	0.0423	0.0284	0.0363
158	0.0006	-0.0565	-0.0094	-0.0307	-0.0255	0.0032	-0.0114	-0.009	-0.0247	0.0423	0.0434	0.0291	0.0372
159	0.0027	-0.0552	-0.0067	-0.0279	-0.0236	0.0033	-0.0117	-0.0092	-0.0253	0.0434	0.0445	0.0298	0.0381
160	0.0048	-0.0538	-0.0039	-0.0252	-0.0217	0.0033	-0.012	-0.0095	-0.0259	0.0444	0.0455	0.0305	0.039
161	0.0069	-0.0524	-0.0012	-0.0224	-0.0198	0.0034	-0.0123	-0.0097	-0.0265	0.0454	0.0466	0.0312	0.0399
162	0.0090	-0.0510	0.0015	-0.0197	-0.0179	0.0035	-0.0125	-0.0099	-0.0271	0.0464	0.0476	0.032	0.0408
163	0.0111	-0.0496	0.0043	-0.0169	-0.016	0.0036	-0.0128	-0.0101	-0.0277	0.0475	0.0487	0.0327	0.0417
164	0.0132	-0.0483	0.007	-0.0141	-0.0141	0.0037	-0.0131	-0.0103	-0.0283	0.0485	0.0498	0.0334	0.0427
165	0.0154	-0.0469	0.0097	-0.0114	-0.0122	0.0037	-0.0134	-0.0106	-0.0289	0.0495	0.0508	0.0341	0.0436
166	0.0175	-0.0455	0.0124	-0.0086	-0.0103	0.0038	-0.0137	-0.0108	-0.0295	0.0506	0.0519	0.0348	0.0445
167	0.0196	-0.0441	0.0152	-0.0059	-0.0084	0.0039	-0.0139	-0.011	-0.0301	0.0516	0.0529	0.0355	0.0454
168	0.0217	-0.0427	0.0179	-0.0031	-0.0065	0.004	-0.0142	-0.0112	-0.0307	0.0526	0.054	0.0362	0.0463
169	0.0238	-0.0414	0.0206	-0.0004	-0.0046	0.004	-0.0145	-0.0114	-0.0313	0.0537	0.055	0.0369	0.0472
170	0.0259	-0.0400	0.0233	0.0024	-0.0027	0.0041	-0.0148	-0.0117	-0.0319	0.0547	0.0561	0.0376	0.0481
171	0.0280	-0.0386	0.0261	0.0051	-0.0008	0.0042	-0.015	-0.0119	-0.0325	0.0557	0.0572	0.0383	0.049
172	0.0301	-0.0372	0.0288	0.0079	0.0011	0.0043	-0.0153	-0.0121	-0.0331	0.0568	0.0582	0.0391	0.0499
173	0.0322	-0.0358	0.0315	0.0107	0.003	0.0044	-0.0156	-0.0123	-0.0337	0.0578	0.0593	0.0398	0.0508
174	0.0343	-0.0344	0.0343	0.0134	0.0049	0.0044	-0.0159	-0.0125	-0.0343	0.0588	0.0603	0.0405	0.0517
175	0.0364	-0.0331	0.037	0.0162	0.0068	0.0045	-0.0162	-0.0128	-0.0349	0.0599	0.0614	0.0412	0.0526
176	0.0385	-0.0317	0.0397	0.0189	0.0087	0.0046	-0.0164	-0.013	-0.0355	0.0609	0.0625	0.0419	0.0535
177	0.0406	-0.0304	0.0424	0.0217	0.0106	0.0047	-0.0167	-0.0132	-0.0361	0.0619	0.0635	0.0426	0.0545
178	0.0476	-0.0209	0.0452	0.0244	0.0125	0.0047	-0.017	-0.0134	-0.0367	0.063	0.0646	0.0433	0.0554
179	0.0544	-0.0117	0.0479	0.0272	0.0144	0.0048	-0.0173	-0.0136	-0.0373	0.064	0.0656	0.044	0.0563
180	0.0613	-0.0025	0.0506	0.0299	0.0163	0.0049	-0.0176	-0.0139	-0.0379	0.065	0.0667	0.0447	0.0572
181	0.0681	0.0067	0.0533	0.0327	0.0182	0.005	-0.0178	-0.0141	-0.0385	0.0661	0.0678	0.0454	0.0581
182	0.0749	0.0162	0.0561	0.0354	0.0201	0.0051	-0.0181	-0.0143	-0.0391	0.0671	0.0688	0.0462	0.059
183	0.0819	0.0259	0.0588	0.0382	0.022	0.0051	-0.0184	-0.0145	-0.0397	0.0681	0.0699	0.0469	0.0599
184	0.0888	0.0360	0.0615	0.041	0.0239	0.0052	-0.0187	-0.0147	-0.0403	0.0692	0.0709	0.0476	0.0608
185	0.0959	0.0465	0.0643	0.0437	0.0258	0.0053	-0.0189	-0.015	-0.0409	0.0702	0.072	0.0483	0.0617
186	0.1031	0.0574	0.067	0.0465	0.0278	0.0054	-0.0192	-0.0152	-0.0415	0.0712	0.073	0.049	0.0626
187	0.1103	0.0687	0.0697	0.0492	0.0297	0.0054	-0.0195	-0.0154	-0.0421	0.0723	0.0741	0.0497	0.0635
188	0.1177	0.0803	0.0724	0.052	0.0316	0.0055	-0.0198	-0.0156	-0.0427	0.0733	0.0752	0.0504	0.0644
189	0.1251	0.0923	0.0752	0.0547	0.0335	0.0056	-0.0201	-0.0158	-0.0433	0.0743	0.0762	0.0511	0.0653
190	0.1327	0.1047	0.0779	0.0575	0.0354	0.0057	-0.0203	-0.0161	-0.0439	0.0754	0.0773	0.0518	0.0663

191	0.1403	0.1174	0.0806	0.0602	0.0373	0.0058	-0.0206	-0.0163	-0.0445	0.0764	0.0783	0.0525	0.0672
192	0.1481	0.1303	0.0833	0.063	0.0392	0.0058	-0.0209	-0.0165	-0.0451	0.0774	0.0794	0.0533	0.0681
193	0.1559	0.1435	0.0861	0.0658	0.0411	0.0059	-0.0212	-0.0167	-0.0457	0.0784	0.0805	0.054	0.069
194	0.1637	0.1568	0.0888	0.0685	0.043	0.006	-0.0215	-0.0169	-0.0463	0.0795	0.0815	0.0547	0.0699
195	0.1717	0.1704	0.0915	0.0713	0.0449	0.0061	-0.0217	-0.0172	-0.0469	0.0805	0.0826	0.0554	0.0708
196	0.1797	0.1841	0.0943	0.074	0.0468	0.0061	-0.022	-0.0174	-0.0475	0.0815	0.0836	0.0561	0.0717
197	0.1878	0.1979	0.097	0.0768	0.0487	0.0062	-0.0223	-0.0176	-0.0481	0.0826	0.0847	0.0568	0.0726
198	0.1959	0.2119	0.0997	0.0795	0.0506	0.0063	-0.0226	-0.0178	-0.0487	0.0836	0.0857	0.0575	0.0735
199	0.2040	0.2260	0.1024	0.0823	0.0525	0.0064	-0.0228	-0.018	-0.0493	0.0846	0.0868	0.0582	0.0744
200	0.2122	0.2403	0.1052	0.085	0.0544	0.0065	-0.0231	-0.0183	-0.0499	0.0857	0.0879	0.0589	0.0753
201	0.2204	0.2547	0.1079	0.0878	0.0563	0.0065	-0.0234	-0.0185	-0.0505	0.0867	0.0889	0.0597	0.0762
202	0.2287	0.2694	0.1106	0.0906	0.0582	0.0066	-0.0237	-0.0187	-0.0511	0.0877	0.09	0.0604	0.0771
203	0.2370	0.2842	0.1238	0.1029	0.0601	0.0067	-0.024	-0.0189	-0.0517	0.0888	0.091	0.0611	0.0781
204	0.2453	0.2993	0.137	0.1152	0.062	0.0068	-0.0242	-0.0191	-0.0523	0.0898	0.0921	0.0618	0.079
205	0.2537	0.3148	0.1502	0.1275	0.0675	0.0068	-0.0245	-0.0194	-0.0529	0.0908	0.0932	0.0625	0.0799
206	0.2621	0.3306	0.1634	0.1399	0.073	0.0069	-0.0248	-0.0196	-0.0535	0.0919	0.0942	0.0632	0.0808
207	0.2706	0.3469	0.1766	0.1522	0.0785	0.007	-0.0251	-0.0198	-0.0541	0.0929	0.0953	0.0639	0.0817
208	0.2791	0.3637	0.1898	0.1645	0.084	0.0071	-0.0254	-0.02	-0.0547	0.0939	0.0963	0.0646	0.0826
209	0.2877	0.3811	0.203	0.1768	0.0895	0.0072	-0.0256	-0.0202	-0.0553	0.095	0.0974	0.0653	0.0835
210	0.2964	0.3992	0.2161	0.1892	0.095	0.0072	-0.0259	-0.0205	-0.0559	0.096	0.0985	0.066	0.0844
211	0.3052	0.4179	0.2293	0.2015	0.1005	0.0073	-0.0262	-0.0207	-0.0565	0.097	0.0995	0.0668	0.0853
212	0.3140	0.4375	0.2425	0.2138	0.106	0.0074	-0.0265	-0.0209	-0.0571	0.0981	0.1006	0.0675	0.0862
213	0.3229	0.4579	0.2557	0.2262	0.1115	0.0075	-0.0267	-0.0211	-0.0577	0.0991	0.1016	0.0682	0.0871
214	0.3319	0.4792	0.2689	0.2385	0.117	0.0075	-0.027	-0.0213	-0.0583	0.1001	0.1027	0.0689	0.088
215	0.3411	0.5015	0.2821	0.2508	0.1225	0.0076	-0.0273	-0.0216	-0.0589	0.1012	0.1037	0.0696	0.0889
216	0.3504	0.5246	0.2953	0.2631	0.128	0.0077	-0.0276	-0.0218	-0.0595	0.1022	0.1048	0.0703	0.0898
217	0.3597	0.5488	0.3085	0.2755	0.1335	0.0078	-0.0279	-0.022	-0.0601	0.1032	0.1059	0.071	0.0908
218	0.3692	0.5738	0.3217	0.2878	0.139	0.0079	-0.0281	-0.0222	-0.0607	0.1043	0.1069	0.0717	0.0917
219	0.3789	0.5996	0.3346	0.3001	0.1445	0.0079	-0.0284	-0.0224	-0.0613	0.1053	0.108	0.0724	0.0926
220	0.3886	0.6263	0.3475	0.3125	0.1494	0.008	-0.0287	-0.0227	-0.0619	0.1063	0.109	0.0731	0.0935
221	0.3985	0.6535	0.3603	0.3248	0.154	0.0081	-0.029	-0.0229	-0.0625	0.1073	0.1101	0.0739	0.0944
222	0.4084	0.6813	0.373	0.3371	0.158	0.0082	-0.0293	-0.0231	-0.0631	0.1084	0.1112	0.0746	0.0953
223	0.4184	0.7093	0.3857	0.3494	0.1616	0.0082	-0.0295	-0.0233	-0.0637	0.1094	0.1122	0.0753	0.0962
224	0.4285	0.7373	0.3983	0.3665	0.1648	0.0083	-0.0298	-0.0235	-0.0643	0.1104	0.1133	0.076	0.0971
225	0.4386	0.7649	0.4109	0.3847	0.1674	0.0084	-0.0301	-0.0238	-0.0649	0.1115	0.1143	0.0767	0.098
226	0.4487	0.7918	0.4235	0.4042	0.1696	0.0085	-0.0304	-0.024	-0.0655	0.1125	0.1154	0.0774	0.0989
227	0.4587	0.8175	0.4359	0.425	0.1714	0.0086	-0.0306	-0.0242	-0.0661	0.1135	0.1164	0.0781	0.0998

9. APPENDIX E. APC ALONG-SCAN MULTIPLICATIVE BIAS TERM

Δt_{multi} in K/K 14 (sample number, 13 channels) x 221 (pixels)

S#	ch1	ch2	ch3	ch4	ch5	ch6	ch7	ch8	ch9	ch10	ch11	ch12	ch13
7	0	0	0	0	0	3.23E-03	4.80E-03	0	0	0	0	0	0
8	0	0	0	0	0	2.76E-03	4.10E-03	0	0	0	0	0	0
9	0	0	0	0	0	2.34E-03	3.48E-03	0	0	0	0	0	0
10	0	0	0	0	0	1.98E-03	2.93E-03	0	0	0	0	0	0
11	0	0	0	0	0	1.66E-03	2.46E-03	0	0	0	0	0	0
12	0	0	0	0	0	1.38E-03	2.04E-03	0	0	0	0	0	0
13	0	0	0	0	0	1.14E-03	1.69E-03	0	0	0	0	0	0
14	0	0	0	0	0	9.36E-04	1.38E-03	0	0	0	0	0	0
15	0	0	0	0	0	7.65E-04	1.12E-03	0	0	0	0	0	0
16	0	0	0	0	0	6.23E-04	9.11E-04	0	0	0	0	0	0
17	0	0	0	0	0	5.06E-04	7.34E-04	0	0	0	0	0	0
18	0	0	0	0	0	4.11E-04	5.91E-04	0	0	0	0	0	0
19	0	0	0	0	0	3.34E-04	4.74E-04	0	0	0	0	0	0
20	0	0	0	0	0	2.71E-04	3.80E-04	0	0	0	0	0	0
21	0	0	0	0	0	2.19E-04	3.03E-04	0	0	0	0	0	0
22	0	0	0	0	0	1.75E-04	2.39E-04	0	0	0	0	0	0
23	0	0	0	0	0	1.34E-04	1.81E-04	0	0	0	0	0	0
24	0	0	0	0	0	9.40E-05	1.25E-04	0	0	0	0	0	0
25	0	0	0	0	0	5.04E-05	6.68E-05	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0
41	0	0	0	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0	0	0	0	0	0	0

50	0	0	0	0	0	0	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	0	0	0	0	0	0
58	0	0	0	0	0	0	0	0	0	0	0	0	0
59	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0
61	0	0	0	0	0	0	0	0	0	0	0	0	0
62	0	0	0	0	0	0	0	0	0	0	0	0	0
63	0	0	0	0	0	0	0	0	0	0	0	0	0
64	0	0	0	0	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0	0	0	0	0	0
66	0	0	0	0	0	0	0	0	0	0	0	0	0
67	0	0	0	0	0	0	0	0	0	0	0	0	0
68	0	0	0	0	0	0	0	0	0	0	0	0	0
69	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0	0
71	0	0	0	0	0	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0	0	0	0	0	0
73	0	0	0	0	0	0	0	0	0	0	0	0	0
74	0	0	0	0	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0	0	0	0	0
76	0	0	0	0	0	0	0	0	0	0	0	0	0
77	0	0	0	0	0	0	0	0	0	0	0	0	0
78	0	0	0	0	0	0	0	0	0	0	0	0	0
79	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0
81	0	0	0	0	0	0	0	0	0	0	0	0	0
82	0	0	0	0	0	0	0	0	0	0	0	0	0
83	0	0	0	0	0	0	0	0	0	0	0	0	0
84	0	0	0	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0	0	0	0	0
86	0	0	0	0	0	0	0	0	0	0	0	0	0
87	0	0	0	0	0	0	0	0	0	0	0	0	0
88	0	0	0	0	0	0	0	0	0	0	0	0	0
89	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0
91	0	0	0	0	0	0	0	0	0	0	0	0	0
92	0	0	0	0	0	0	0	0	0	0	0	0	0
93	0	0	0	0	0	0	0	0	0	0	0	0	0
94	0	0	0	0	0	0	0	0	0	0	0	0	0
95	0	0	0	0	0	0	0	0	0	0	0	0	0
96	0	0	0	0	0	0	0	0	0	0	0	0	0

97 0 0 0 0 0 0 0 0 0 0 0 0 0
98 0 0 0 0 0 0 0 0 0 0 0 0 0
99 0 0 0 0 0 0 0 0 0 0 0 0 0
100 0 0 0 0 0 0 0 0 0 0 0 0 0
101 0 0 0 0 0 0 0 0 0 0 0 0 0
102 0 0 0 0 0 0 0 0 0 0 0 0 0
103 0 0 0 0 0 0 0 0 0 0 0 0 0
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116 0 0 0 0 0 0 0 0 0 0 0 0 0
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121 0 0 0 0 0 0 0 0 0 0 0 0 0
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125 0 0 0 0 0 0 0 0 0 0 0 0 0
126 0 0 0 0 0 0 0 0 0 0 0 0 0
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128 0 0 0 0 0 0 0 0 0 0 0 0 0
129 0 0 0 0 0 0 0 0 0 0 0 0 0
130 0 0 0 0 0 0 0 0 0 0 0 0 0
131 0 0 0 0 0 0 0 0 0 0 0 0 0
132 0 0 0 0 0 0 0 0 0 0 0 0 0
133 0 0 0 0 0 0 0 0 0 0 0 0 0
134 0 0 0 0 0 0 0 0 0 0 0 0 0
135 0 0 0 0 0 0 0 0 0 0 0 0 0
136 0 0 0 0 0 0 0 0 0 0 0 0 0
137 0 0 0 0 0 0 0 0 0 0 0 0 0
138 0 0 0 0 0 0 0 0 0 0 0 0 0
139 0 0 0 0 0 0 0 0 0 0 0 0 0
140 0 0 0 0 0 0 0 0 0 0 0 0 0
141 0 0 0 0 0 0 0 0 0 0 0 0 0
142 0 0 0 0 0 0 0 0 0 0 0 0 0
143 0 0 0 0 0 0 0 0 0 0 0 0 0

144	0	0	0	0	0	0	0	0	0	0	0	0	0
145	0	0	0	0	0	0	0	0	0	0	0	0	0
146	0	0	0	0	0	0	0	0	0	0	0	0	0
147	0	0	0	0	0	0	0	0	0	0	0	0	0
148	0	0	0	0	0	0	0	0	0	0	0	0	0
149	0	0	0	0	0	0	0	0	0	0	0	0	0
150	0	0	0	0	0	0	0	0	0	0	0	0	0
151	0	0	0	0	0	0	0	0	0	0	0	0	0
152	0	0	0	0	0	0	0	0	0	0	0	0	0
153	0	0	0	0	0	0	0	0	0	0	0	0	0
154	0	0	0	0	0	0	0	0	0	0	0	0	0
155	0	0	0	0	0	0	0	0	0	0	0	0	0
156	0	0	0	0	0	0	0	0	0	0	0	0	0
157	0	0	0	0	0	0	0	0	0	0	0	0	0
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159	0	0	0	0	0	0	0	0	0	0	0	0	0
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161	0	0	0	0	0	0	0	0	0	0	0	0	0
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164	0	0	0	0	0	0	0	0	0	0	0	0	0
165	0	0	0	0	0	0	0	0	0	0	0	0	0
166	0	0	0	0	0	0	0	0	0	0	0	0	0
167	0	0	0	0	0	0	0	0	0	0	0	0	0
168	0	0	0	0	0	0	0	0	0	0	0	0	0
169	0	0	0	0	0	0	0	0	0	0	0	0	0
170	0	0	0	0	0	0	0	0	0	0	0	0	0
171	0	0	0	0	0	0	0	0	0	0	0	0	0
172	0	0	0	0	0	0	0	0	0	0	0	0	0
173	0	0	0	0	0	0	0	0	0	0	0	0	0
174	0	0	0	0	0	0	0	0	0	0	0	0	0
175	0	0	0	0	0	0	0	0	0	0	0	0	0
176	0	0	0	0	0	0	0	0	0	0	0	0	0
177	0	-2.66E-05	0	0	0	0	0	0	0	0	0	0	0
178	0	-9.22E-05	0	0	0	0	0	0	0	0	0	0	0
179	0	-1.33E-04	0	0	0	0	0	0	0	0	0	0	0
180	0	-1.57E-04	0	0	0	0	0	0	0	0	0	0	0
181	0	-1.73E-04	0	0	0	0	0	0	0	0	0	0	0
182	0	-1.86E-04	0	0	0	0	0	0	0	0	0	0	0
183	0	-2.00E-04	0	0	0	0	0	0	0	0	0	0	0
184	0	-2.18E-04	0	0	0	0	0	0	0	0	0	0	0
185	0	-2.42E-04	0	0	0	0	0	0	0	0	0	0	0
186	0	-2.73E-04	0	0	0	0	0	0	0	0	0	0	0
187	0	-3.12E-04	0	0	0	0	0	0	0	0	0	0	0
188	0	-3.58E-04	0	0	0	0	0	0	0	0	0	0	0
189	0	-4.10E-04	0	0	0	0	0	0	0	0	0	0	0
190	0	-4.68E-04	0	0	0	0	0	0	0	0	0	0	0

191	0	-5.31E-04	0	0	0	0	0	0	0	0	0	0	0
192	0	-5.96E-04	0	0	0	0	0	0	0	0	0	0	0
193	0	-6.63E-04	0	0	0	0	0	0	0	0	0	0	0
194	0	-7.30E-04	0	0	0	0	0	0	0	0	0	0	0
195	0	-7.96E-04	0	0	0	0	0	0	0	0	0	0	0
196	0	-8.60E-04	0	0	0	0	0	0	0	0	0	0	0
197	0	-9.22E-04	0	0	0	0	0	0	0	0	0	0	0
198	0	-9.79E-04	0	0	0	0	0	0	0	0	0	0	0
199	0	-1.03E-03	0	0	0	0	0	0	0	0	0	0	0
200	0	-1.08E-03	0	0	0	0	0	0	0	0	0	0	0
201	0	-1.13E-03	0	0	0	0	0	0	0	0	0	0	0
202	0	-1.17E-03	0	0	0	0	0	0	0	0	0	0	0
203	4.39E-05	-1.21E-03	0	0	0	0	0	0	0	0	0	0	0
204	1.22E-04	-1.24E-03	0	0	0	0	0	0	0	0	0	0	0
205	2.11E-04	-1.28E-03	0	0	0	0	0	0	0	0	0	0	0
206	3.09E-04	-1.31E-03	0	0	0	0	0	0	0	0	0	0	0
207	4.15E-04	-1.34E-03	0	0	0	0	0	0	0	0	0	0	0
208	5.28E-04	-1.37E-03	0	0	0	0	0	0	0	0	0	0	0
209	6.45E-04	-1.39E-03	0	0	0	0	0	0	0	0	0	0	0
210	7.67E-04	-1.42E-03	0	0	0	0	0	0	0	0	0	0	0
211	8.94E-04	-1.44E-03	0	0	0	0	0	0	0	0	0	0	0
212	1.03E-03	-1.45E-03	0	0	0	0	0	0	0	0	0	0	0
213	1.17E-03	-1.46E-03	0	0	0	0	0	0	0	0	0	0	0
214	1.33E-03	-1.46E-03	0	0	0	0	0	0	0	0	0	0	0
215	1.50E-03	-1.44E-03	0	0	0	0	0	0	0	0	0	0	0
216	1.71E-03	-1.40E-03	0	0	0	0	0	0	0	0	0	0	0
217	1.96E-03	-1.32E-03	0	0	0	0	0	0	0	0	0	0	0
218	2.26E-03	-1.21E-03	0	0	0	0	0	0	0	0	0	0	0
219	2.64E-03	-1.04E-03	0	0	0	0	0	0	0	0	0	0	0
220	3.13E-03	-8.01E-04	0	0	0	0	0	0	0	0	0	0	0
221	3.74E-03	-4.81E-04	0	0	0	0	0	0	0	0	0	0	0
222	4.51E-03	-5.62E-05	0	0	0	0	0	0	0	0	0	0	0
223	5.49E-03	4.96E-04	0	0	0	0	0	0	0	0	0	0	0
224	6.72E-03	1.20E-03	0	0	0	0	0	0	0	0	0	0	0
225	8.25E-03	2.09E-03	0	0	0	0	0	0	0	0	0	0	0
226	1.02E-02	3.20E-03	0	0	0	0	0	0	0	0	0	0	0
227	1.25E-02	4.56E-03	0	0	0	0	0	0	0	0	0	0	0

10. APPENDIX F. ALONG-SCAN CORRECTION DUE TO MAGNETICS OF GMI

1B_TAM_GAMMA γ 14 (sample # and 13 channel) x 465 (sample) in counts

1 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
2 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
3 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
4 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
5 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
6 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
7 -1.5427 0.693 -0.7793 -0.2168 1.0172 2.5582 0.3591 -0.36 -0.8298 1.4666 0.7478 -0.8739 -3.3214
8 1.1761 -1.0654 -0.784 -0.619 0.1167 2.8052 0.0962 -0.0183 -0.9616 1.2781 0.7195 -1.4878 -3.3936
9 2.1259 -1.2476 0.0167 -0.6946 -0.4803 1.8569 -0.2254 1.0035 -0.3964 0.9846 0.6181 -1.3241 -2.4085
10 -0.0197 0.3954 0.9972 -0.1176 -0.0149 1.5874 0.1698 1.9573 0.3679 0.9029 0.702 -0.2914 -1.5232
11 -1.8841 1.1246 1.3532 0.6928 1.1614 2.3689 0.9569 1.2111 -0.0631 0.8921 0.5651 1.0619 -0.8884
12 -1.7787 0.4004 0.5935 0.6181 1.6215 3.7654 1.2431 -0.929 -1.5899 0.9874 0.5028 0.4508 -0.7557
13 0.2561 -1.2375 0.3722 0.2642 1.0486 4.3396 1.3778 -1.3691 -2.1208 0.9425 0.3305 -0.7994 -1.5779
14 1.929 -2.1708 1.0919 -0.0428 0.0974 3.232 0.8588 -0.1771 -1.6226 0.8277 0.1958 -1.4092 -1.2423
15 0.8681 -0.8639 2.0378 0.07 -0.022 2.0853 1.207 1.7289 0.0705 0.6078 0.1726 -1.0586 -0.5538
16 -1.7608 0.8156 2.2715 0.323 0.6513 1.6185 1.4586 1.7649 0.3692 0.7756 0.2607 0.0695 -1.0716
17 -3.023 1.1248 1.7486 0.6695 1.4827 1.9729 1.7147 0.1009 -0.3948 0.6624 0.0544 -0.6297 -2.5945
18 -1.5519 -0.6003 0.693 0.1776 1.4118 2.2119 1.4374 -0.9169 -1.2252 0.5496 0.0701 -1.9681 -3.8149
19 1.2456 -2.3263 1.2466 -0.3605 0.1958 1.1678 0.7632 -0.0648 -0.7279 0.4021 -0.1717 -2.7575 -4.0787
20 1.4299 -1.9782 1.6217 -0.6651 -0.5691 -0.0941 0.2193 1.2294 0.2673 0.1494 -0.1545 -2.9065 -3.7382
21 -0.7981 -0.4274 1.8181 -0.2704 -0.3624 0.1077 0.9717 2.1496 1.2623 0.1085 -0.0998 -2.1866 -4.0004
22 -2.5439 -0.0395 1.1655 -0.0151 0.3301 0.9905 1.382 1.5399 1.1948 0.2791 0.0295 -1.1919 -3.4068
23 -1.6368 -1.5199 -0.1575 -0.0389 0.5714 2.2722 1.6578 -0.0558 0.1643 0.3094 -0.025 -2.0703 -4.1203
24 1.1191 -3.8728 -0.7203 -0.4351 -0.2283 2.5155 1.3678 0.0145 0.0301 0.4458 0.1425 -3.0395 -4.9839
25 2.8698 -4.857 -0.3889 -0.6445 -1.2015 1.0534 0.7195 0.8669 0.4268 0.2306 0.2739 -3.4141 -4.891
26 1.565 -3.9332 0.2108 -0.434 -1.2726 0.1063 0.6304 1.5154 0.6906 -0.0547 0.2214 -2.9655 -4.5962
27 -0.4638 -2.9687 0.185 0.0565 -0.5456 0.2628 1.0384 1.1439 0.423 0.1533 0.3172 -1.1911 -3.496
28 -1.1663 -3.5406 -0.6006 0.6407 0.2855 1.6516 1.1624 -0.9616 -1.1063 0.1857 0.0816 -0.8786 -2.4956
29 0.6232 -5.6075 -1.2965 0.2232 0.0755 3.1175 1.2864 -1.945 -2.2706 0.3944 0.1049 -1.8452 -2.7521
30 2.7741 -7.2187 -0.9195 -2.3373 -0.7592 2.3507 0.7358 -0.8883 -1.7751 0.4275 0.1658 -2.2628 -2.354
31 2.593 -6.7559 -0.0059 -0.0976 -1.1081 0.9296 0.5047 0.3383 -0.815 0.0738 0.006 -2.2686 -1.7037
32 0.2005 -5.298 0.5503 0.0456 -0.6242 0.5097 0.948 0.9871 0.0121 0.2485 -0.0793 -1.2229 -1.6061
33 -1.5894 -5.169 0.2574 0.2359 0.1372 0.7059 1.0363 0.0379 -0.1569 0.353 -0.0902 -0.3595 -1.1055
34 -0.5658 -6.8254 -0.9294 -0.086 0.4474 1.2104 0.663 -1.1833 -1.123 0.4931 -0.1374 -1.7349 -2.918
35 1.6634 -9.0637 -0.9538 -0.6869 -0.2834 0.4446 -0.0653 -0.7044 -0.9604 0.3168 -0.2208 -2.8814 -4.4282
36 2.6057 -10.0995 -0.1734 -0.9145 -1.1531 -0.9755 -0.6871 0.4206 -0.3 0.2463 -0.0821 -3.1134 -4.2779
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171 -0.3747 -4.2219 -0.7629 -0.3949 0.4929 3.0286 0.3342 0.087 -0.1745 -0.3197 -0.0984 -2.3082 -3.6485
172 -0.79 -3.4472 0.111 -0.8974 -0.3785 2.772 0.2332 0.2692 -0.2703 -0.3006 -0.0864 -2.6295 -2.8984
173 -2.6938 -2.2992 0.627 -1.0266 -0.4867 3.5548 0.5937 0.2474 -0.2334 -0.8104 -0.4069 -1.1237 -1.5963
174 -3.7545 -2.1058 0.2488 -0.736 -0.04 4.068 0.7765 0.0897 0.235 -0.6875 -0.4327 0.2441 -0.0941
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177 0.2525 -5.7185 -0.5746 -1.3059 -1.0264 0.91 -0.628 -0.0431 -0.2528 -0.6056 -0.5124 -2.4219 -2.838
178 -1.3604 -5.4361 0.0742 -1.3396 -1.0665 1.4613 -0.1615 0.2754 0.1489 -0.8031 -0.5768 -0.6923 0.1683
179 -2.6528 -5.8179 -0.1713 -1.0001 -0.274 2.436 0.2695 0.322 0.2516 -1.0014 -0.6416 1.539 2.8213
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333 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -0.2795 0.1233 -0.554 -0.2998 -1.8791 -2.4241
334 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.3051 0.3456 -1.7824 -0.9059 -0.7291 -0.2044
335 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.9166 0.6845 -2.2987 -1.794 0.5945 1.7039
336 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.1582 0.8361 0.0 0.0 1.8646 1.7996
337 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.1882 0.4184 0.0 0.0 1.3738 0.973
338 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -0.7288 -0.0207 0.0 0.0 -0.3763 -1.4988
339 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -1.0559 -0.2247 0.0 0.0 -0.1318 -1.3223

340 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.133 0.1185 0.0 0.0 1.4303 2.4118
341 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.2659 0.7235 0.0 0.0 2.3506 2.7718
342 -5.2112 -0.3199 0.0 0.0 0.0 0.0 0.0 1.3941 0.9694 0.0 0.0 2.1331 1.4598
343 -5.7728 -1.1296 0.0 0.0 0.0 0.0 0.0 -0.3007 0.0759 0.0 0.0 0.6969 0.2119
344 -4.1971 -2.6811 0.0 0.0 0.0 0.0 0.0 -1.4468 -0.8635 0.0 0.0 -0.1299 -0.6175
345 -2.3528 -3.8346 0.0 0.0 0.0 0.0 0.0 -1.1401 -1.0647 0.0 0.0 0.7086 1.7195
346 -2.2133 -4.3036 0.0 0.0 0.0 0.0 0.0 -0.2328 -0.7048 0.0 0.0 1.6453 3.3359
347 -2.7936 -4.7398 0.0 0.0 0.0 0.0 0.0 -0.6635 -1.0316 0.0 0.0 1.4811 2.2516
348 -3.304 -4.9606 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -0.3738 0.0131
349 -2.7276 -5.5113 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -2.6176 -3.0172
350 -0.8208 -6.3509 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -3.1255 -2.8259
351 0.0951 -6.731 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
352 -0.9464 -6.6052 0.0 0.0 0.0 3.4639 2.5989 0.0 0.0 0.0 0.0 0.0 0.0
353 -2.7868 -5.8687 0.0 0.0 0.0 3.4924 2.606 0.0 0.0 0.0 0.0 0.0 0.0
354 -3.4366 -5.8761 0.0 0.0 0.0 3.3303 2.5958 0.0 0.0 0.0 0.0 0.0 0.0
355 -1.7052 -6.7865 0.0 0.0 0.0 3.1235 2.5961 0.0 0.0 0.0 0.0 0.0 0.0
356 0.1082 -7.6705 0.0 0.0 0.0 3.0105 2.587 0.0 0.0 0.0 0.0 0.0 0.0
357 -0.3423 -7.8579 0.0 0.0 0.0 3.1228 2.7663 0.0 0.0 0.0 0.0 0.0 0.0
358 -0.9413 -8.1761 0.0 0.0 0.0 2.5958 2.5403 0.0 0.0 0.0 0.0 0.0 0.0
359 -1.3319 -8.1976 0.0 0.0 0.0 2.0451 2.2267 0.0 0.0 0.0 0.0 0.0 0.0
360 0.0928 -9.5953 0.0 0.0 0.0 1.8843 2.1569 0.0 0.0 0.0 0.0 0.0 0.0
361 2.5591 -11.2486 0.0 0.0 0.0 1.2925 1.7647 0.0 0.0 0.0 0.0 0.0 0.0
362 3.6953 -11.8912 0.0 0.0 0.0 1.2091 1.6814 0.0 0.0 0.0 0.0 0.0 0.0
363 3.2067 -11.8183 0.0 0.0 0.0 0.9933 1.3614 0.0 0.0 0.0 0.0 0.0 0.0
364 2.897 -11.6007 0.0 0.0 0.0 0.5377 0.7809 0.0 0.0 0.0 0.0 0.0 0.0
365 3.6705 -12.3056 0.0 0.0 0.0 0.6464 0.6399 0.0 0.0 0.0 0.0 0.0 0.0
366 6.6427 -14.4667 0.0 0.0 0.0 0.2671 0.1061 0.0 0.0 0.0 0.0 0.0 0.0
367 8.9933 -15.0705 0.0 0.0 0.0 -0.2147 -0.6085 0.0 0.0 0.0 0.0 0.0 0.0
368 8.9232 -13.5189 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
369 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
370 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
371 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
372 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
373 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
374 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
375 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
376 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
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383 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
384 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
385 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
386 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
387 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
388 0.0 0.0 0.0 0.0 2.3541 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
389 0.0 0.0 0.0 0.0 0.8642 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
390 0.0 0.0 2.3715 3.4213 0.6896 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
391 0.0 0.0 1.534 2.3219 1.001 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
392 0.0 0.0 0.1109 1.6467 1.4415 0.0 0.0 0.0 0.0 -5.3631 5.9755 0.0 0.0
393 0.0 0.0 -0.8069 0.5936 0.6883 0.0 0.0 0.0 0.0 -5.0409 5.6464 0.0 0.0
394 0.0 0.0 -0.8368 -0.4722 -0.6525 0.0 0.0 0.0 0.0 -5.1065 5.1107 0.0 0.0
395 0.0 0.0 -0.5763 -1.0915 -1.3221 0.0 0.0 0.0 0.0 -5.1447 4.5999 0.0 0.0
396 0.0 0.0 -0.795 -1.1478 -0.9062 0.0 0.0 0.0 0.0 -4.9267 4.1864 0.0 0.0

397 0.0 0.0 -1.8273 -0.8973 0.2903 0.0 0.0 0.0 0.0 -4.5341 3.8007 0.0 0.0
398 0.0 0.0 -2.6219 -1.37 0.5506 0.0 0.0 0.0 0.0 -4.2584 3.444 -6.0325 -6.8839
399 0.0 0.0 -2.3551 -2.0969 -0.8302 0.0 0.0 0.0 0.0 -4.1921 2.9088 -5.2626 -5.0137
400 0.0 0.0 -1.5786 -2.2875 -1.7666 0.0 0.0 0.0 0.0 -4.3725 2.4257 -4.117 -3.1739
401 0.0 0.0 -0.8142 -2.1399 -1.6566 0.0 0.0 0.0 0.0 -4.2635 2.0329 -3.2987 -3.8245
402 0.0 0.0 -0.5285 -1.575 -0.8575 0.0 0.0 0.0 0.0 -3.8842 1.7664 -3.9606 -5.2262
403 0.0 0.0 -0.8394 -1.3149 -0.1453 0.0 0.0 0.0 0.0 -3.5658 1.5182 -5.3059 -7.5869
404 0.0 0.0 -0.8101 -1.5902 -0.6251 0.0 0.0 0.0 0.0 -3.3421 1.1729 -5.3764 -6.9269
405 0.0 0.0 0.0213 -1.3933 -1.238 0.0 0.0 0.0 0.0 -3.416 0.8612 -4.2568 -4.0056
406 0.0 0.0 1.1986 -0.6352 -0.8962 0.0 0.0 0.0 0.0 -3.4321 0.573 -3.1962 -3.5149
407 0.0 0.0 1.7848 0.6776 0.4927 0.0 0.0 0.0 0.0 -3.1924 0.3633 -3.0119 -4.7059
408 0.0 0.0 1.8695 2.1001 2.5237 0.0 0.0 0.0 0.0 -2.6759 0.2496 -4.4053 -6.1625
409 0.0 0.0 2.0903 3.0818 0.0 0.0 0.0 0.0 0.0 -2.4694 0.0866 -5.1991 -6.7734
410 0.0 0.0 3.4093 4.1688 0.0 0.0 0.0 -1.4214 -0.3906 -2.339 -0.109 -4.2811 -4.2136
411 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -0.2453 -0.0004 -2.371 -0.3558 -3.1027 -2.8237
412 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.7176 0.3606 -2.052 -0.4665 -2.3143 -3.7647
413 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -0.2047 -0.3691 -1.4866 -0.5301 -2.8379 -4.3784
414 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -1.7556 -1.8272 -0.9353 -0.6043 -4.1386 -6.0353
415 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -1.7233 -2.4002 -0.5308 -0.6946 -3.8143 -5.2196
416 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -0.377 -1.8244 -0.4608 -0.9657 -2.8233 -3.3896
417 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0904 -0.9884 -0.293 -1.299 -1.9908 -3.8799
418 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0561 -0.9236 0.122 -1.481 -1.7521 -4.7897
419 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -1.0199 -2.5049 0.5856 -1.7121 -3.612 -7.371
420 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -1.9484 -3.6183 0.8488 -1.9405 -3.9181 -7.1464
421 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -1.0254 -3.4861 0.8195 -2.2507 -2.5118 -3.8281
422 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.4964 -2.6745 0.7279 -2.6457 -1.2055 -2.3648
423 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.2177 -2.3263 0.8703 -2.824 -0.1428 -2.6589
424 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -0.193 -3.3471 1.3654 -2.7344 -0.6682 -2.9125
425 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -1.6056 -4.6528 1.7175 -2.7392 -1.7196 -3.7475
426 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -1.7637 -5.1835 2.2041 -2.4762 -0.9023 -1.5825
427 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -0.4244 -4.5882 2.7008 -1.9085 0.2857 1.1076
428 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0222 -3.7627 3.3274 -1.2949 1.8304 1.3798
429 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.7355 -3.9833 4.3247 -0.5822 2.0976 0.9625
430 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -0.7466 -5.299 4.8882 -0.374 0.7359 -0.1945
431 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -1.2837 -6.0722 5.1661 -0.2923 0.4175 0.2985
432 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -0.0596 -5.5281 5.0708 -0.4135 1.3052 2.8227
433 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.7154 -4.2994 4.8402 -0.8044 2.2242 3.4
434 0.0 0.0 0.0 0.0 0.0 0.0 0.0 2.3289 -3.867 4.8513 -1.0181 2.798 2.5349
435 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.8304 -4.7093 5.1329 -1.1457 1.5938 1.7642
436 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -0.5417 -5.8035 5.1524 -1.511 0.5176 0.4065
437 0.0 0.0 0.0 0.0 0.0 0.0 1.7816 0.5614 -0.1475 -5.7711 4.8546 -1.662 1.0604 2.3259
438 0.0 0.0 0.0 0.0 0.0 0.0 1.1573 0.255 1.2335 -4.8437 4.4564 -1.9661 2.3351 4.7792
439 0.0 0.0 0.0 0.0 0.0 0.0 0.619 0.0667 2.344 -3.9949 4.3708 -2.1041 3.7658 5.1648
440 0.0 0.0 0.0 0.0 0.0 0.0 0.8474 0.0475 1.6987 -4.2408 4.6258 -2.1383 4.5943 6.2208
441 0.0 0.0 0.0 0.0 0.0 0.0 1.914 0.2789 0.0 0.0 5.0575 -2.0817 4.1308 6.0718
442 0.0 0.0 0.0 0.0 0.0 0.0 2.4788 0.2609 0.0 0.0 5.5681 -1.5968 4.6799 7.2231
443 0.0 0.0 0.0 0.0 0.0 0.0 2.549 0.319 0.0 0.0 0.0 0.0 6.3949 11.365
444 0.0 0.0 0.0 0.0 0.0 0.0 2.3335 0.6294 0.0 0.0 0.0 0.0 7.6199 11.5106
445 0.0 0.0 0.0 0.0 0.0 0.0 1.6312 0.5327 0.0 0.0 0.0 0.0 7.9374 10.1231
446 0.0 0.0 0.0 0.0 0.0 0.0 1.0858 0.2112 0.0 0.0 0.0 0.0 6.5648 8.8168
447 0.0 0.0 0.0 0.0 0.0 0.0 0.4113 -0.3151 0.0 0.0 0.0 0.0 5.1854 7.2597
448 0.0 0.0 0.0 0.0 0.0 0.0 -0.02 -0.6276 0.0 0.0 0.0 0.0 5.3586 8.559
449 0.0 0.0 0.0 0.0 0.0 0.0 -0.491 -0.4946 0.0 0.0 0.0 0.0 5.8076 9.3531
450 0.0 0.0 0.0 0.0 0.0 0.0 -1.6231 -0.66 0.0 0.0 0.0 0.0 6.5295 8.38
451 0.0 0.0 0.0 0.0 0.0 0.0 -2.0926 -0.8427 0.0 0.0 0.0 0.0 5.5685 7.1549
452 0.0 0.0 0.0 0.0 0.0 0.0 -1.5059 -0.6921 0.0 0.0 0.0 0.0 3.8195 5.1144
453 0.0 0.0 0.0 0.0 0.0 0.0 -1.5409 -0.8652 0.0 0.0 0.0 0.0 0.0 0.0

454 0.0 0.0 0.0 0.0 0.0 -2.1098 -0.9175 0.0 0.0 0.0 0.0 0.0 0.0
455 0.0 0.0 0.0 0.0 0.0 -2.768 -0.7624 0.0 0.0 0.0 0.0 0.0 0.0
456 0.0 0.0 0.0 0.0 0.0 -3.1079 -0.6157 0.0 0.0 0.0 0.0 0.0 0.0
457 0.0 0.0 0.0 0.0 0.0 -1.9739 -0.0306 0.0 0.0 0.0 0.0 0.0 0.0
458 0.0 0.0 0.0 0.0 0.0 -0.6175 0.5127 0.0 0.0 0.0 0.0 0.0 0.0
459 0.0 0.0 0.0 0.0 0.0 0.1637 1.1302 0.0 0.0 0.0 0.0 0.0 0.0
460 0.0 0.0 0.0 0.0 0.0 0.8777 2.0178 0.0 0.0 0.0 0.0 0.0 0.0
461 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
462 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
463 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
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465 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

11. APPENDIX G. CHANGES FROM VERSION 03 TO VERSION 04

The following describes the changes from Version 03 (V03) GMI L1B/Base to Production Version 04 (V04) GMI L1B/Base.

CALIBRATION

1. Adjustment of spillover coefficients of all GMI channels. This adjustment is the major improvement from V03 to V04 in GMI antenna pattern correction (APC). The adjustment of spillover is based on the data from GMI inertial hold and refinements of the analysis performed by the GMI manufacturer. Table 2.12 shows comparisons of APC coefficients reflecting the changes due to spillover adjustments. Tb changes vary from channel to channel and are functions of brightness temperatures. Figure 2.32 demonstrates the Tb changes for all channels in their normal temperature range. For channels 1-5, Tb reduced ~3 – 6 K at their maximums. For channels 10-13, Tb increased ~2 – 4 K at their maximums. For channels 6-9, Tb increased ~0.1 K at their maximums.
2. Adjustment of antenna-induced along-scan bias correction. This is a minor adjustment and may result in Tb changes of less than 0.1 K.
3. Adjustment of magnetic correction coefficients. This is also a minor adjustment and may result in Tb changes of less than 0.1 K.

All of these corrections are implemented in V04 GMI L1B/Base as well as ITE043 and ITE057. There were no code adjustments for these updates.

GEOLOCATION

There are no pixel geolocation changes between Versions 03 and 04; however, there is a notable change affecting Sun angles. This change is due to the correction of a typographical error in the calculation of Sun angle in the V03 Geolocation Toolkit code, which causes maximum error of about 6 degrees in the vector directions, reported solar beta angles, and Sun glint angles. This significant change was implemented on December 4, 2014, for V03 processing. This implementation resulted in a change of the V03 GMI L1B/Base version from V03B to V03C. The correction is included in the GMI L1B/Base V03C and ITE043 data from December 4, 2014, but is not included in the V03B and ITE043 data before December 4, 2014.

Another bug in computation of Sun glint angles in the V03 Geolocation Toolkit was discovered and corrected in the V04 Geolocation Toolkit. This was due to a bug in the code that rejected computing Sun glint angle when a scan time coincidence was at noon UT. This error has a very remote chance of occurring with a scan time coincidence at noon UT within microseconds.

All of these Geolocation Toolkit corrections are implemented in V04 GMI L1B/Base and in ITE057.

OTHERS

NEDT computation was added to the GMIBase code, and the data format was revised to include the NEDT parameter.