Microwave Sensor Subgroup Report

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March 2～5, 2010
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Missions & Objectives of MSSG

- Missions:
  - To foster high quality calibration and validation of microwave sensors for remote sensing purposes. These include both active and passive types, airborne and spaceborne sensors.
- Objectives
  - Facilitate international cooperation and co-ordination in microwave sensor Cal/val activities by sharing information on sensor development and field campaigns
  - Promote accurate calibration and validation of microwave sensors, through standardization of terminology and measurement practices
  - Provide a forum for discussion of current issues and for exchange of technical information on evolving technologies related to microwave sensor cal/val

Review resent developments

- MSSG is inactive, compared with other subgroup, due to lack of concentrated task;
- Diversity of type of instruments and applications need to provide more focus for the individual sensor types whilst retaining the possibility for interdisciplinary discussion and cross-fertilization of ideas by concentrating on specific applications;
- Appointing appropriate coordinator –typically a PI or other similar person who is heavily involved in cal/valactivities for a particular (type of) instrument
- Enhance coordination with other organizations and plans by providing focused information about CAL/VAL;

Identified focal areas

- Altimeters (e.g. Jason-1/-2, RA-2, HY-2/ALT, Cryosat-2, future WSOA)
- Scatterometers (e.g. Quikscat, ASCAT)
- Cloud and Precipitation Radars (e.g. TRMM, CPR)
- Radiometers (e.g. sounders, imagers)
- Ice sounders and GPR
- GNSS and GNSS-Reflected signal applications

Coordination and Cooperation with other Groups

- It is important that we maintain good contact with other groups with which there is a degree of overlap or common interest
- Some notable groups with which some level of contact has already been established are:
  - GSICS
  - X-CAL
  - IEEE GRSS IFT-TC
- More groups need to be coordinated:
  - International Ocean Vector Winds Science Team (IOVWST, for scatterometer)
  - BIPM (for microwave radiometric standard)

Future activities

- Passive microwave sensors
- Active microwave sensors
  - Scatterometer
  - Altimeters
  - Spaceborne meteorological radar
  - Ground penetrating radar

Passive microwave sensors

- For prelaunch calibrations
  - Identify reference standards for pre-launch calibration of microwave radiometers from existing standards or specifications, to promote the cross-comparison of microwave radiometers developed by different agency and flown on different satellites;
  - Develop CEOS/WGCV standards and recommendations as proposed guidelines and reference standards for calibration of passive microwave sensors.
- For post-launch cal/val
  - Identify cross-calibration and validation methodology for cal/val of microwave sounders;
  - Identify appropriate calibration sites (Amazon forest, Dome C, desert, etc) for cal/val of microwave imagers, setup database of these sites.

Active microwave sensors

- Identify the post-launch cal/val procedures for different type of scatterometers (fixed beam, scanning beam, etc)
- Coordinating scatterometer data (C band and Ku band) for potential proposed calibration site (Amazon forest, Dome C, etc), setup database for cal/val of scatterometer on these sites;
- Collecting information of artificial calibration facilities/sites (South China sea, and other similar facilities) for scatterometers;
- Collecting information of calibration sites for radar altimeters.

Future work plan

- Organize a workshop for cal/val of non-imaging microwave sensors;
- Formulate of detailed work plan of MSSG for future two years;
  - Standardization of calibration of passive microwave sensors;
  - Collecting information of cal/val sites for microwave imagers, scatterometers and altimeters;
  - Coordinating passive and active microwave data on selected sites for cal/val applications;
  - Coordinating with other groups and organizations.

China Report to WGCV-31

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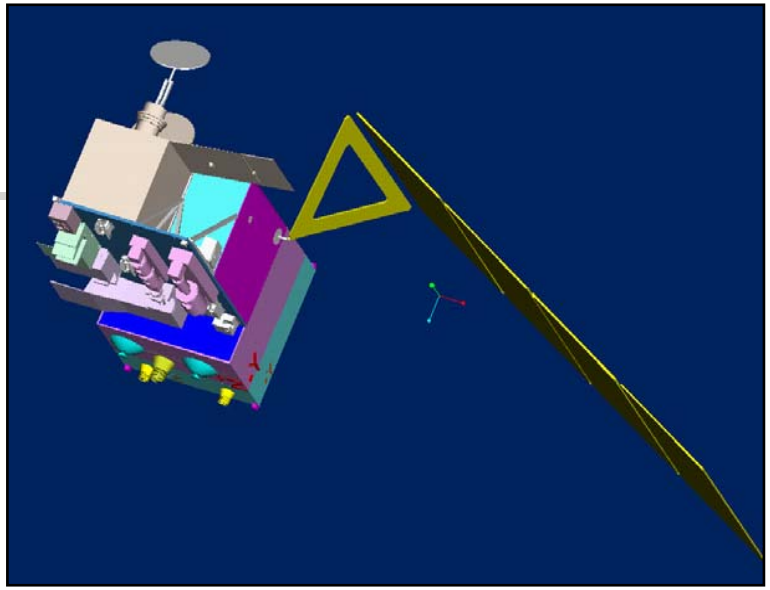
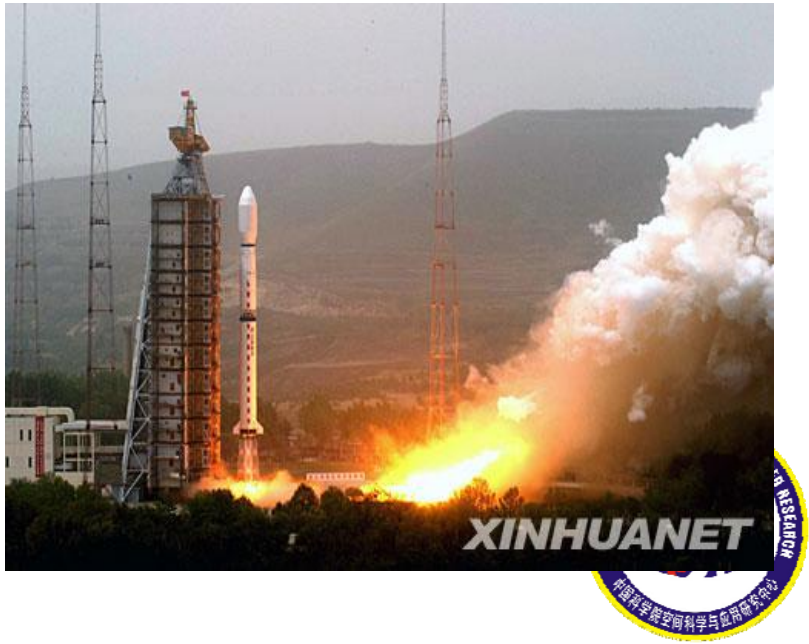
Contents

- Status of FY-3 Meteorological Satellite
- Prelaunch and post-launch Calibrations of MWHS of FY-3

FY-3

- China's new generation polar-orbit meteorological satellite.
- Launched on May 27, 2008 from Taiyuan Launch Site in northern China.





Payloads onboard on FY-3A

Abbreviation	*Instrument Full Name*
VIRR	Visible and InfraRed Radiometer
IRAS	InfraRed Atmospheric Sounder
MWTS	MicroWave Temperature Sounder
MWHS	MicroWave Humidity Sounder
MERSI	MEdium Resolution Spectral Imager
SBUS	Solar Backscatter Ultraviolet Sounder
TOU	Total Ozone Unit
MWRI	Microwave Radiation Imager
SIM	Solar Irradiation Monitor
ERM	Earth Radiation Measurement
SEM	Space Environment Monitor

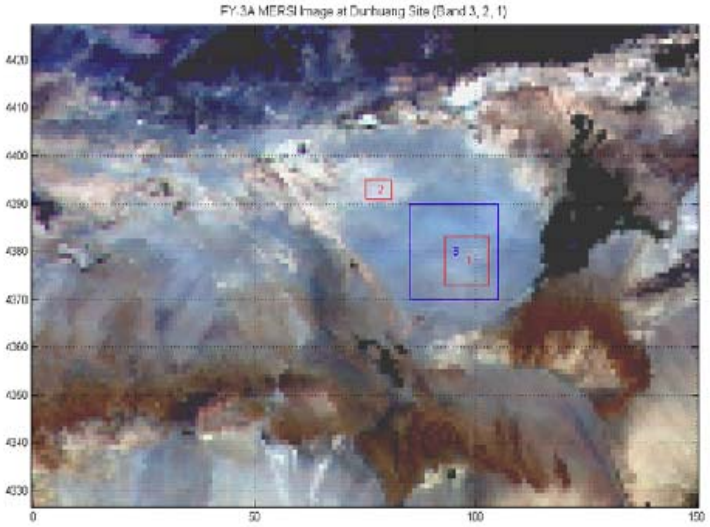
Specifications of FY-3 Payloads

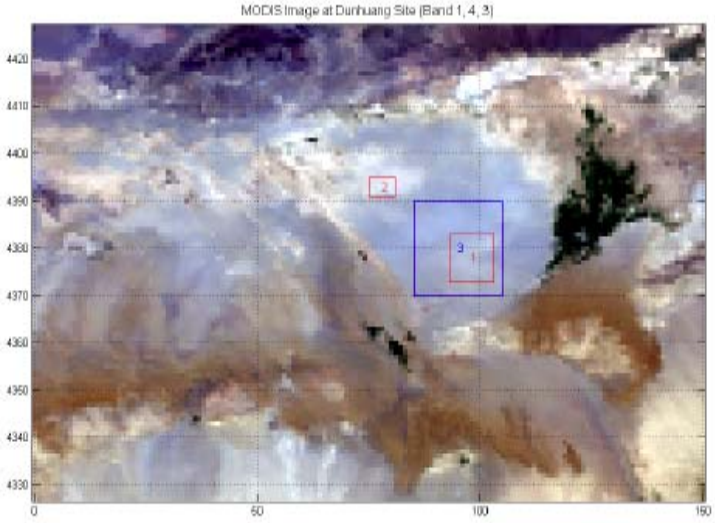
Name of Instrument	Number of Channels	Spectral range	Field of Views /line	Spatial Resoluation at Sub point (km)
VIRR	10	0.43 – 12.5 μ m	2048	1.1
IRAS	26	0.69 – 15.5 μ m	56	17
MWTS	4	50 – 57 GHz	15	50/75
MWHS	5	150 – 183 GHz	90	15
MERSI	20	0.41 – 12.5 μ m	2048/8192	1.1/250
SBUS	12	252 – 380 nm	240	70/10
TOU	6	309 – 361 nm	31	50
MWRI	6	10.65 – 150 GHz	240	15-70

In-orbit test and calibration

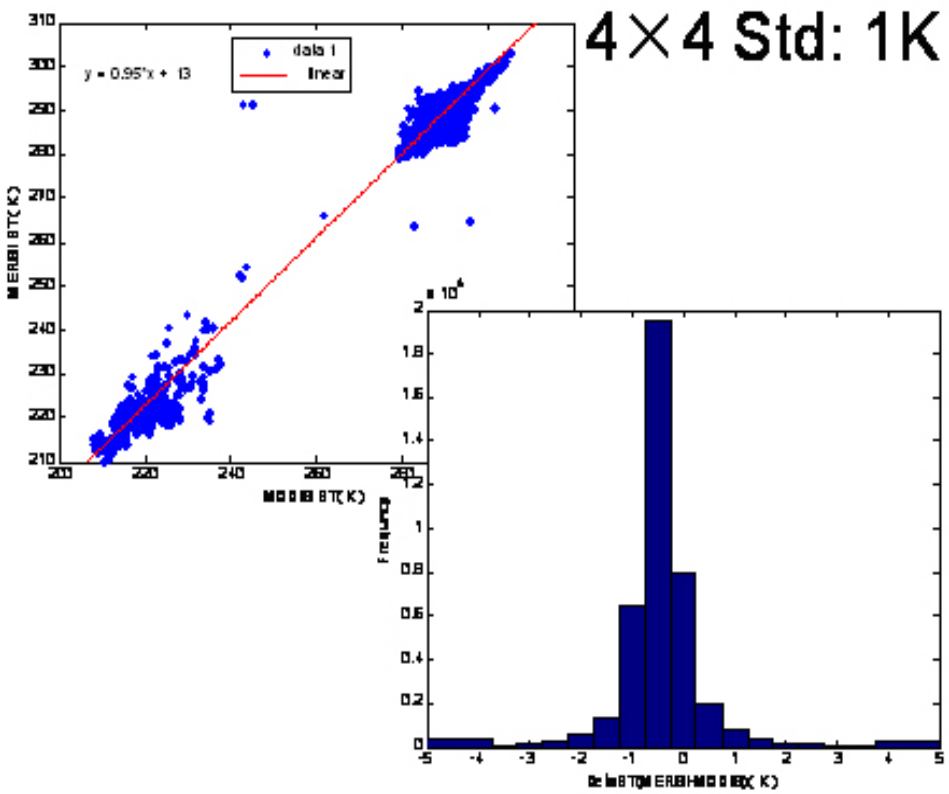
- MERSI: Cross-calibration with EOS-MODIS on Dunhuang Calibration Site
- Other results

MERSI/FY-3 vs MODIS/EOS over Dunhuang Site

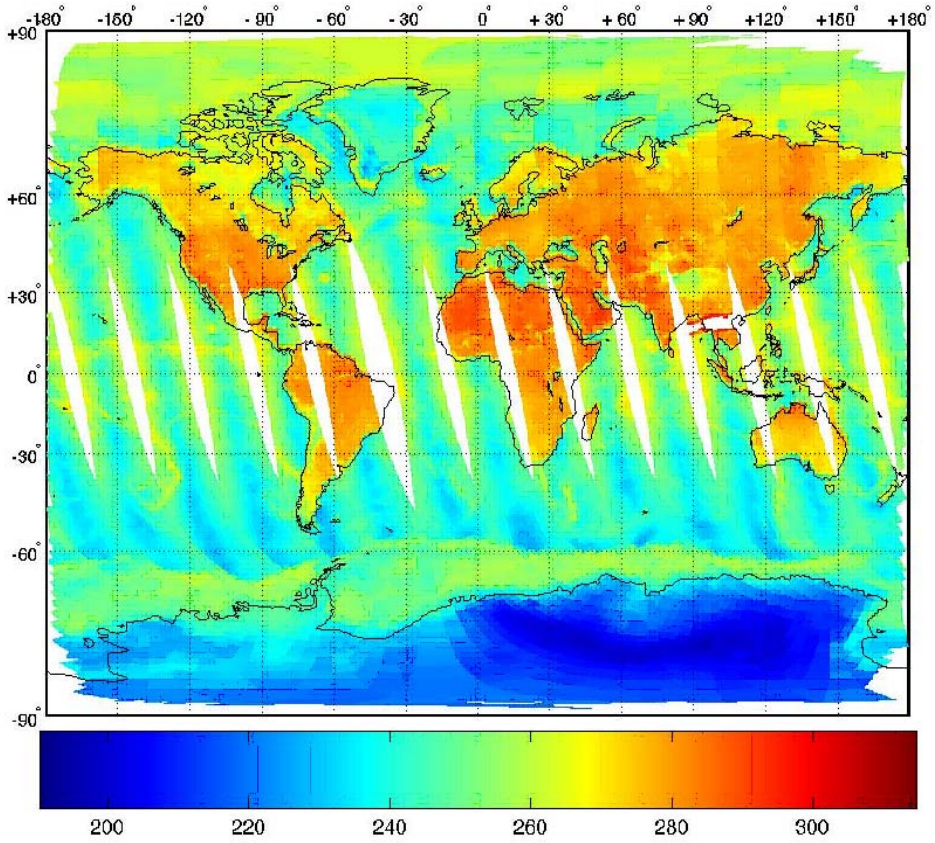




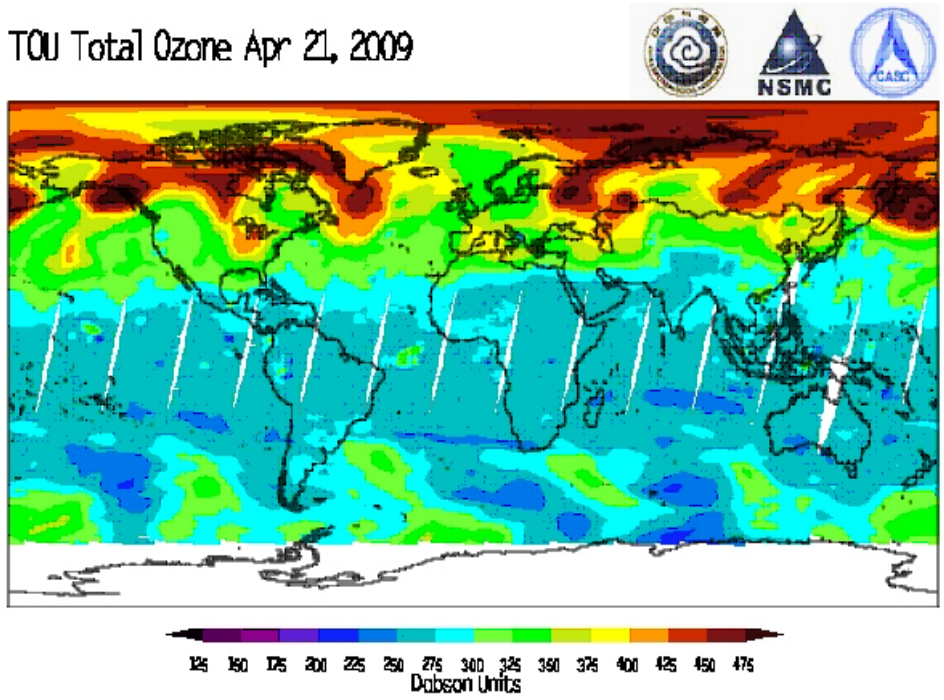
Cross-cal: IR channel #5 of MERSI and MODIS has an difference of -0.5~1.5K



Global BT Image by MWTS/FY-3



FY-3A/TOU 2009.04.21



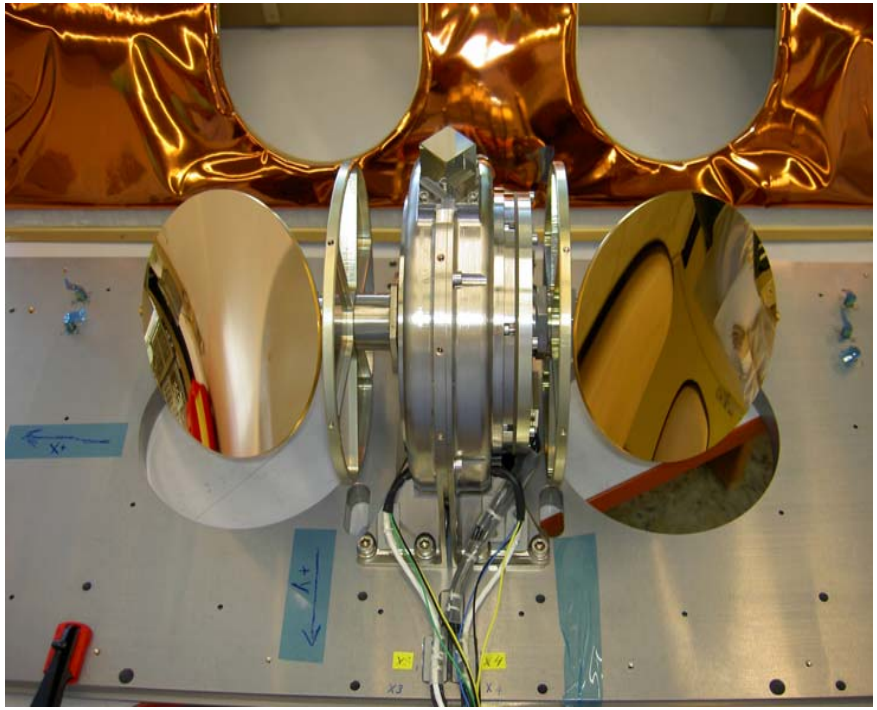
Prelaunch and post-launch Calibrations of MWHS of FY-3

- Prelaunch calibration
- Post-launch test and calibration

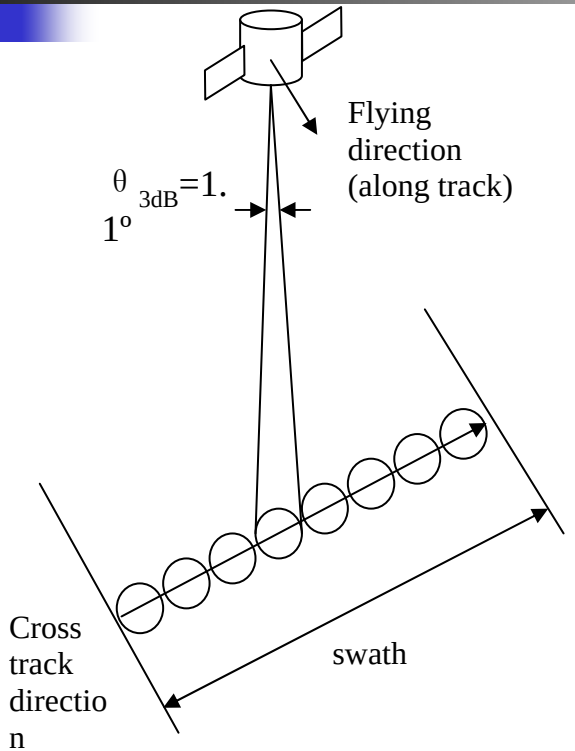
Microwave Sensors of FY-3A

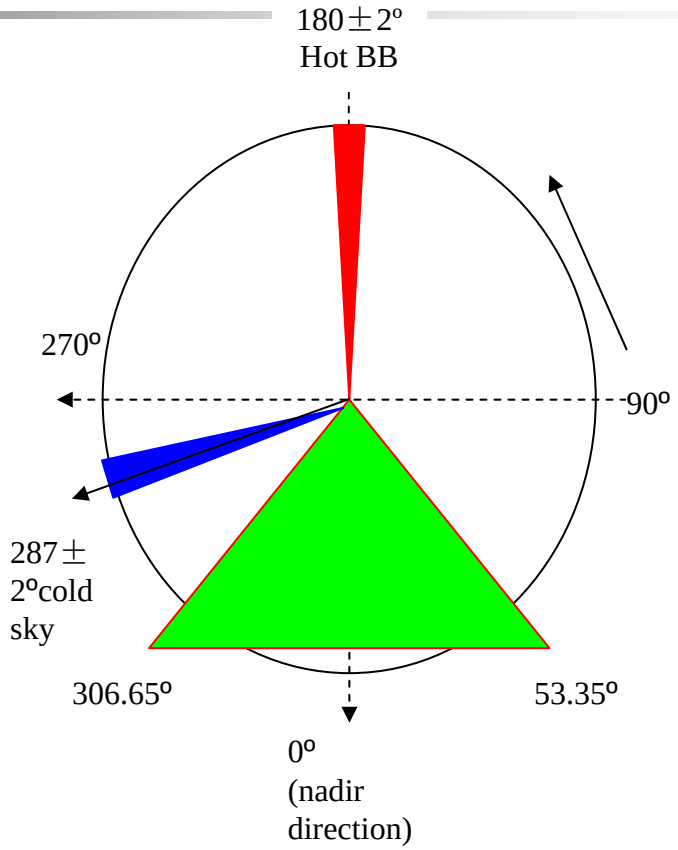
Instrument	No of Channels	Frequency Range	Pixels per scan	Nadir Resolution (km)	Purpose
MWTS	4	50 – 57 GHz	15	50-75	Atmospheric Temperature Contour
MWHS	5	150 – 183 GHz	98	15	Vapor contour, surface properties
MWRI	12	10.65 – 150 GHz	240	15-70	Rain rate, cloud water content, vapor volume, etc

Configuration of MWHS antennas

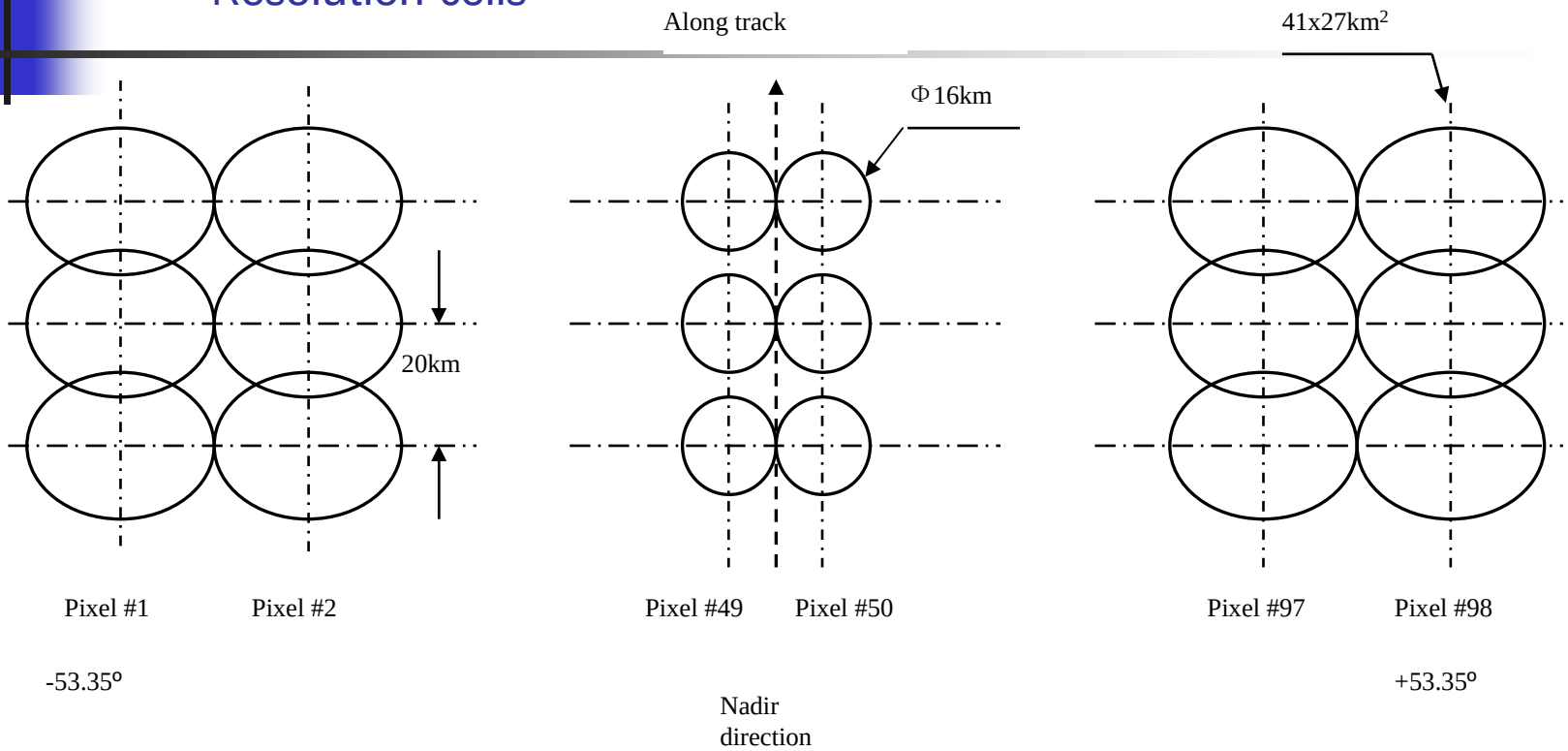


Observation geometry of MWHS

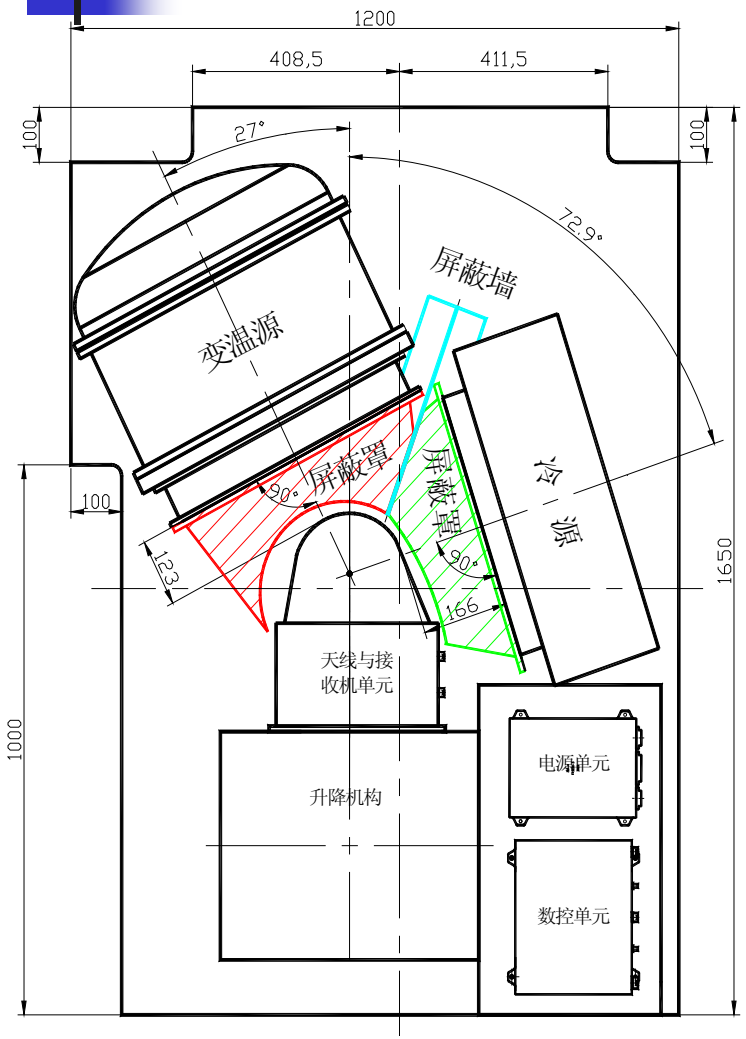


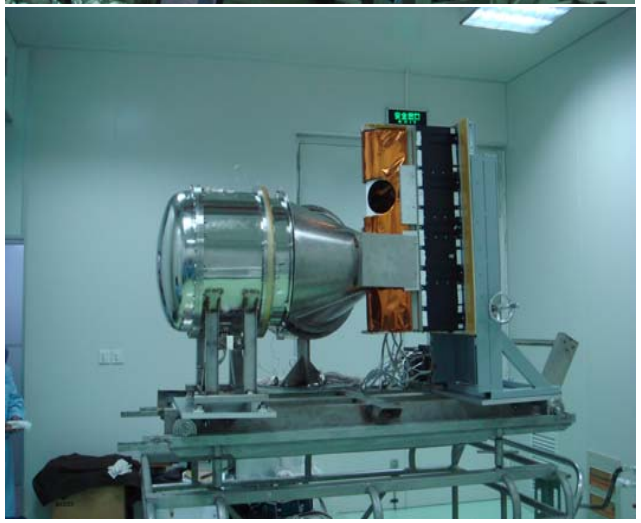


Resolution cells



Prelaunch calibration-Thermal Vacuum Calibration





Correction of Blackbody Calibrator BT and receiver bandwidth

$$R_w(ch) = e\frac{2h\nu^5}{c^3}\frac{1}{\exp(\frac{h\nu}{kT})-1}$$

$$T_m = b_0 + b_1 T$$

b_0

Channel #	150-1	150-2	183-1	183-2	183-3
b_0	-0.000392	-0.000381	-0.000073	-0.000340	-0.007791
b_1	1.000067	1.000065	1.000010	1.000048	1.001380

$$T = aV^2 + bV + c$$

Calibration of the thermometer of calibrator

thermometer	c	b	a
150#1	-44.4015	13.01964	0.075295
150#2	-43.8289	13.0025	0.075738
150#3	-44.0101	13.15914	0.071654
150#4	-43.9276	13.17714	0.073064
150#5	-48.7926	15.61536	0.110644
183#1	-42.9486	12.95181	0.077483
183#2	-43.3911	12.97981	0.079036
183#3	-43.6468	13.00958	0.076234
183#4	-43.6841	13.09144	0.074722
183#5	-48.7831	15.43125	0.116951

Cold and hot bias correction: compared with the calibrator with varying temperature

	CH1		CH2	
IF temp.(K)	hot (K)	cold (K)	hot (K)	cold (K)
277.59	0.2698	1.0614	0.2525	0.8023
287.32	0.1141	1.1083	0.0803	0.9301
296.92	0.1129	1.2422	0.1091	1.0105
307.04	0.0079	1.1937	0.0501	1.1243

	CH3		CH4		CH5	
IF temp. (K)	hot (K)	cold (K)	hot (K)	cold (K)	hot (K)	cold (K)
270.03	0.6267	1.0714	0.7514	1.2806	0.4979	1.4491
281.3	0.5948	1.1059	0.5778	1.1223	0.4853	1.3425
290.68	0.4779	1.1554	0.5938	1.2228	0.5213	1.5274
300.12	0.5411	1.3065	0.4921	1.4586	0.342	1.781

Emission characteristics of onboard calibrator

Frequency GHz	* 140	147	150	153	173,31	180,31	183,31	186,31	193,31	* 220
ε_f	0,9989	0,9988	0,9990	0,9989	0,9989	0,9990	0,9990	0,9990	0,9989	0,9990
$\Delta\varepsilon_f \cdot 10^4$	≤ 9									
$r_f^0 \cdot 10^4$	6,7	7,0	6,3	6,7	6,6	5,6	6,3	5,9	6,6	6,0
$\Delta r_f^0 \cdot 10^4$	4,2									
A_{ef} (sm^2)	165									
ΔA_{ef} (sm^2)	2,5									

$$R_A(C) = a_0 + a_1 C_A + a_2 C_A^{\,2}$$

Evaluation of receiver nonlinearity

IF temp.(K)	Ch1	Ch2
277.59	0.014864	0.018875
287.32	0.016268	0.026682
296.92	0.019719	0.028557
307.04	0.01976	0.030223

IF temp.(K)	Ch3	Ch4	Ch5
270.03	0.00062	0.002987	0.006579
281.30	0.005329	0.002877	0.00756
290.68	0.007624	0.003981	0.005207
300.12	0.006069	0.005538	0.006516

BT accuracy after corrections

Channel # / temperature	150-1	150-2	183-1	183-2	183-3
0℃	0.17	0.10	0.09	0.37	0.18
10℃	0.22	0.26	0.18	0.15	0.36
20℃	0.12	0.10	0.10	0.11	0.17
30℃	0.09	0.11	0.19	0.22	0.17

Pre-launch calibration results

- Nonlinear error
- Sensitivity
- Calibration accuracy

Nonlinear error

Channel #	Temperature (C)	Linearity coeff.	Nonlinearity error (K)
150-1	0	0.99999	0.14
	10	0.999987	0.21
	20	0.999981	0.13
	30	0.99998	0.06
150-2	0	0.999982	0.09
	10	0.999962	0.26
	20	0.999957	0.07
	30	0.999952	0.08
183-1	0	1	0.07
	10	0.999993	0.21
	20	0.999986	0.10
	30	0.999991	0.16
183-2	0	0.999994	0.28
	10	0.999997	0.15
	20	0.999995	0.13
	30	0.99999	0.15
183-3	0	0.99998	0.15
	10	0.999982	0.31
	20	0.99999	0.10
	30	0.999985	0.10

Sensitivity

150-1	Earth Target	Hot Target	Cold Target	Both Target
0	0.67	0.7	0.76	0.73
10	0.76	0.75	0.86	0.79
20	0.74	0.71	0.84	0.76
30	0.75	0.73	0.85	0.78
average	0.73	0.7225	0.8275	0.765
150-2	Earth Target	Hot Target	Cold Target	Both Target
0	0.54	0.57	0.55	0.51
10	0.66	0.67	0.64	0.65
20	0.66	0.65	0.65	0.61
30	0.66	0.66	0.65	0.63
average	0.63	0.6375	0.6225	0.6

183-1	Earth Target	Hot Target	Cold Target	Both Target
0	0.69	0.65	0.74	0.76
10	0.72	0.7	0.77	0.8
20	0.66	0.69	0.71	0.73
30	0.69	0.7	0.74	0.76
Average	0.69	0.685	0.74	0.7625
183-2	Earth Target	Hot Target	Cold Target	Both Target
0	0.76	0.68	0.81	0.82
10	0.79	0.74	0.82	0.84
20	0.72	0.73	0.76	0.77
30	0.75	0.74	0.79	0.81
Average	0.755	0.7225	0.795	0.81
183-3	Earth Target	Hot Target	Cold Target	Both Target
0	0.58	0.68	0.67	0.65
10	0.57	0.76	0.6	0.63
20	0.58	0.73	0.61	0.66
30	0.57	0.75	0.61	0.65
average	0.575	0.73	0.6225	0.6475

Calibration accuracy

Observed BT（K）	150-1	150-2	183-1	183-2	183-3
180	1.00	0.91	1.10	1.12	0.94
300	1.00	0.91	1.04	1.05	0.86

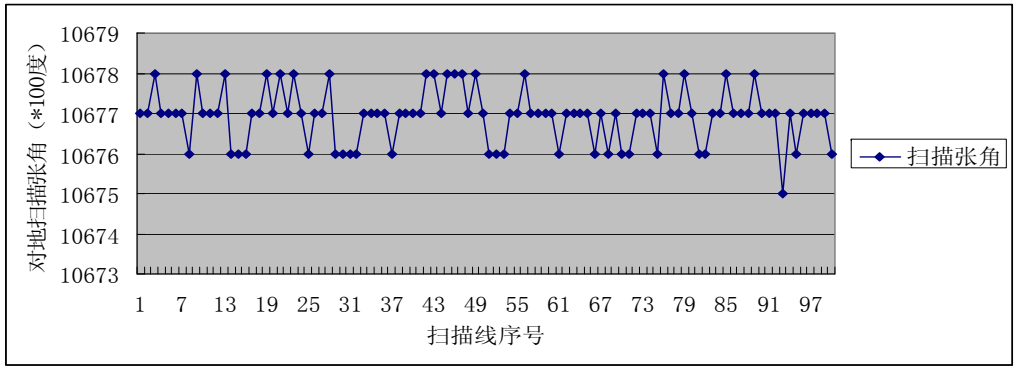
pre-launch calibration results

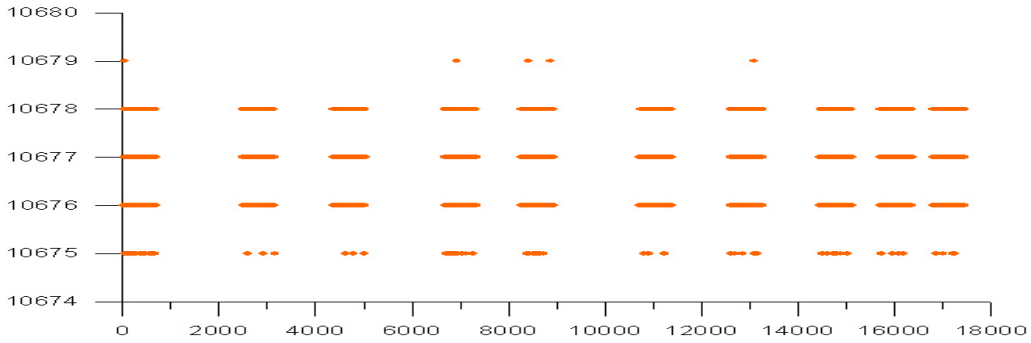
Channels/specifications		Designed specifications	Achieved specifications	Specifications of AMSU-B
ΔT	150GHz(V)	≦1.1K	0.83K	0.84K
	150GHz(H)	≦1.1K	0.63K	
	183±1GHz	≦1.2K	1.09K	1.06K
	183±3GHz	≦1.1K	0.92K	0.70K
	183±7GHz	≦1.2K	0.82K	0.60K
Dynamic range		3～340K	3～340K	3～300K
Calibration accuracy		≦1.5 K	<1.2K	1.0K

Post-launch test and calibrations

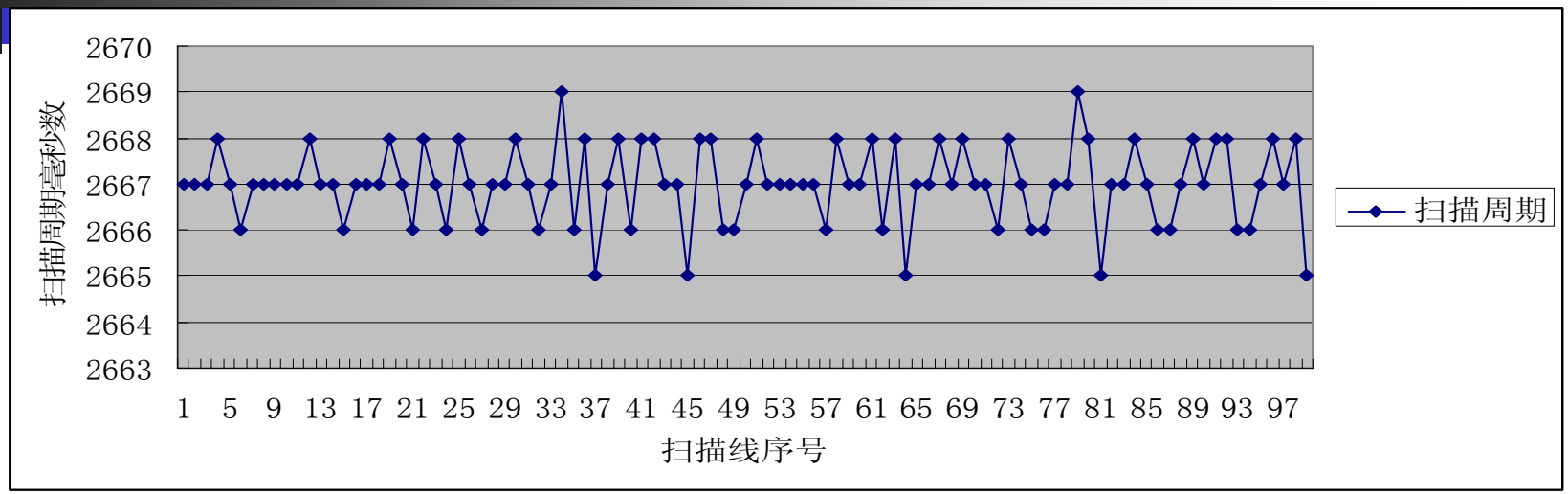
Observation angles

106.77±0.02

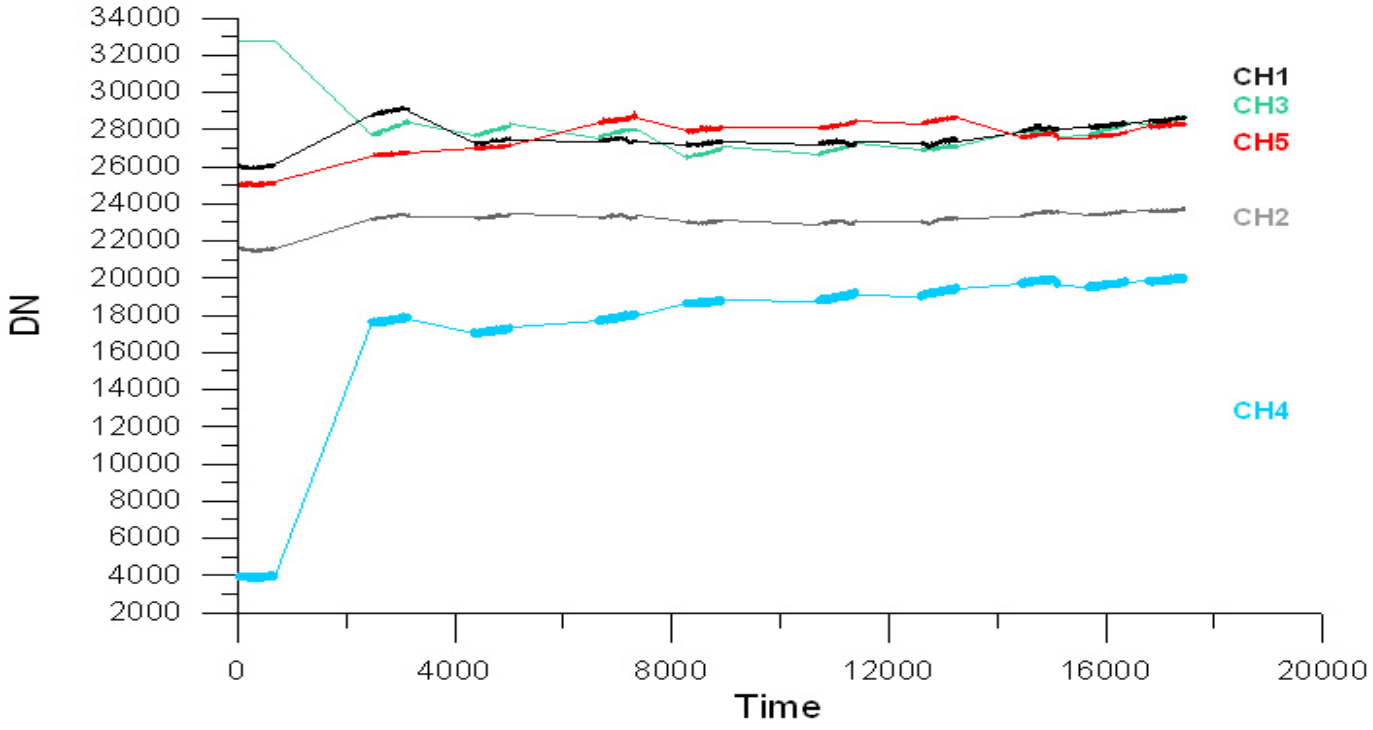




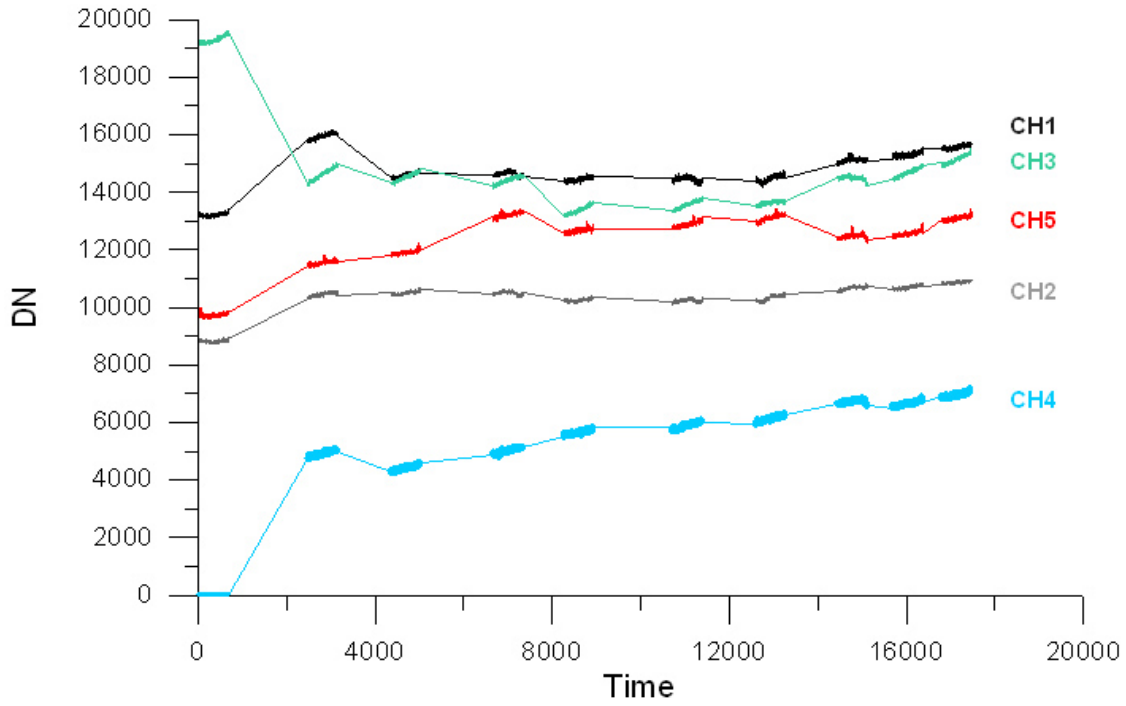
Scanning period



Stability of onboard calibrators

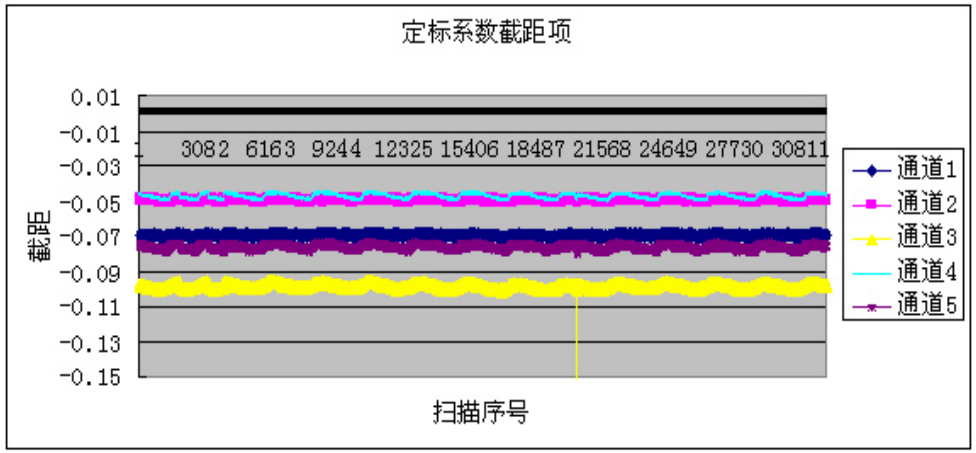


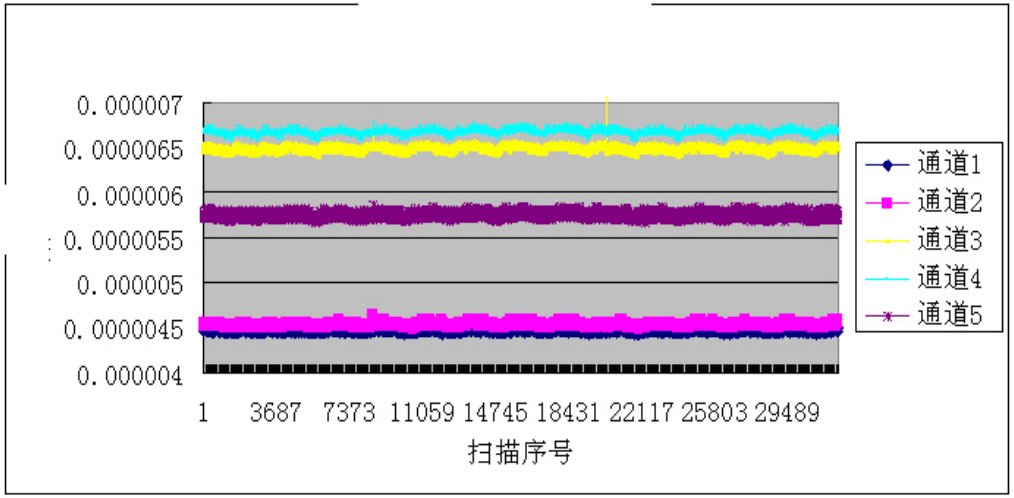
Stability of cold sky data



各通道冷空测值变化

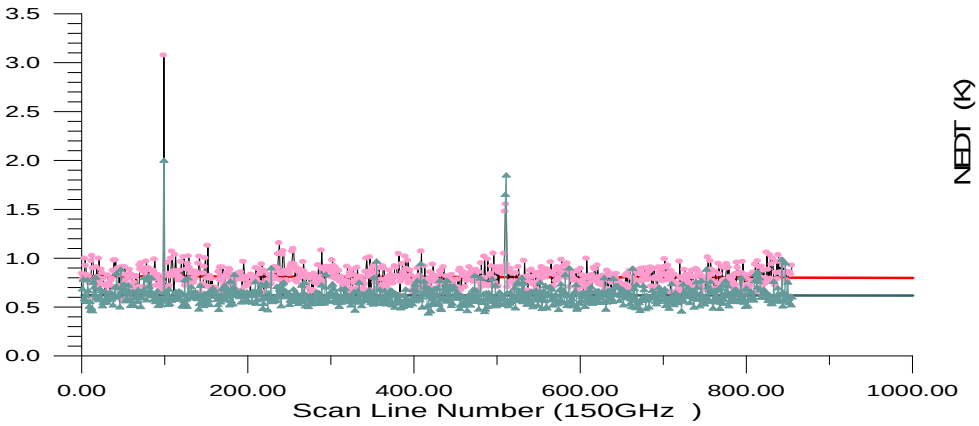
Stability of calibration coefficients

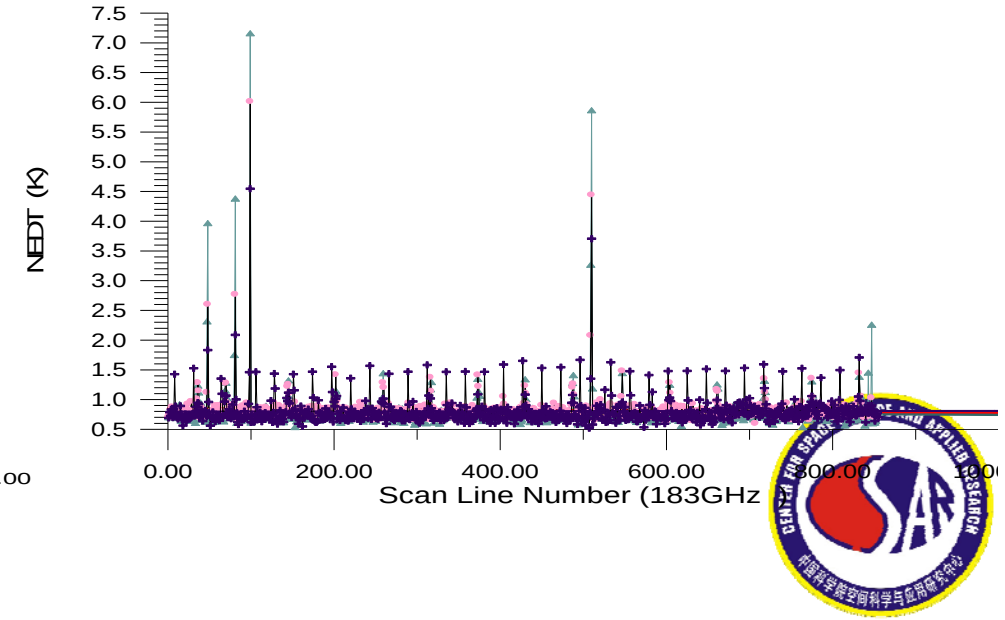




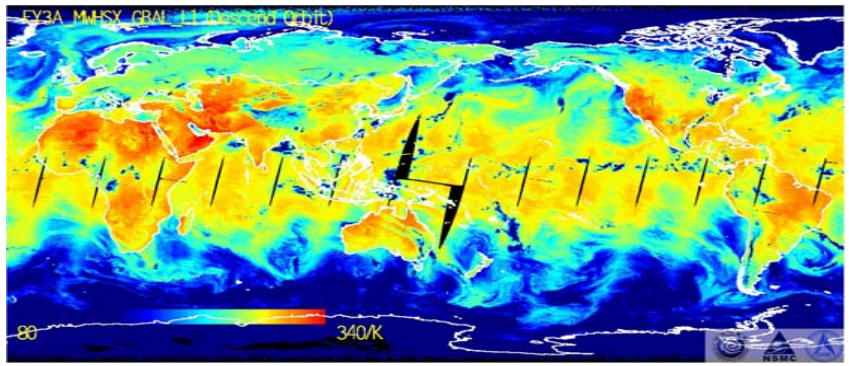
sensitivity

channels	1	2	3	4	5
NEdT(K)	**0.894891**	**0.695298**	**0.859518**	**0.902851**	**0.900807**

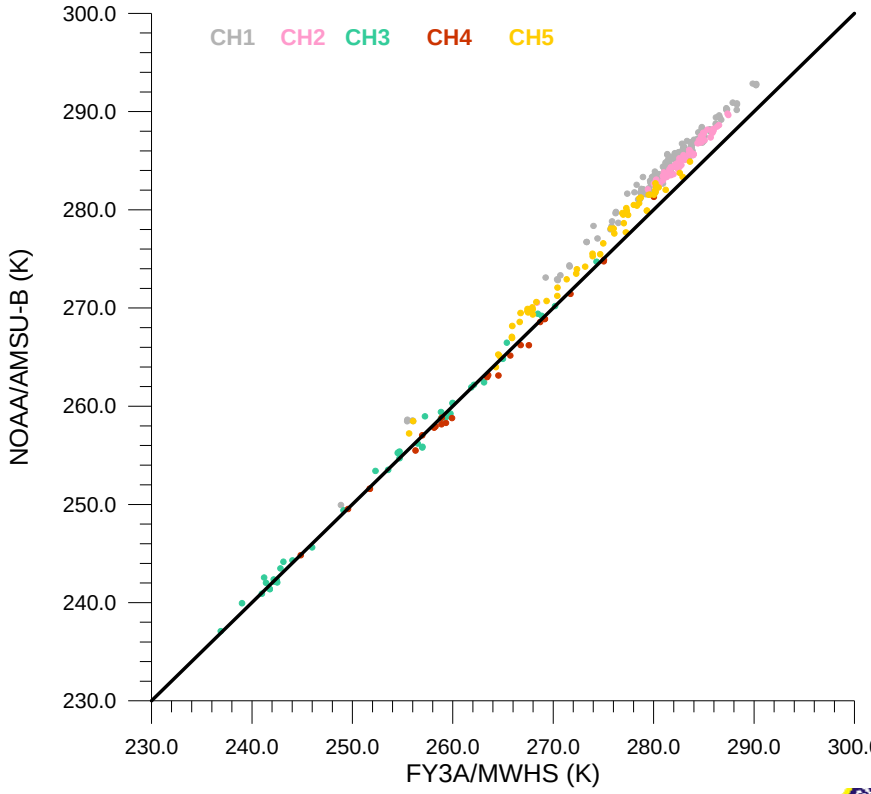




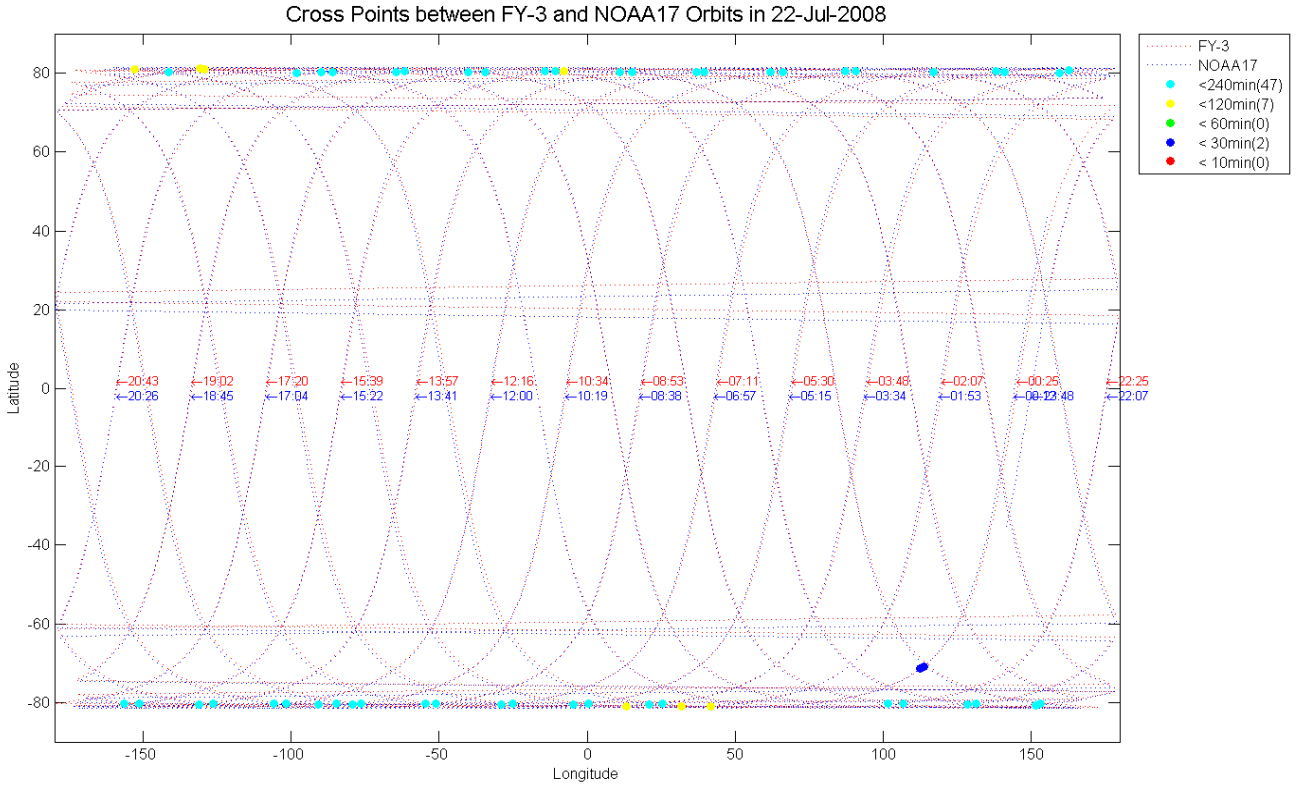
Cross Cal of MWHS



Global BT image of Channel #1
Of MWHS (2008.11.22)



Cross cal of MWHS/FY3 with AMSU-B/NOAA


Cross Points between FY-3 and NOAA17 Orbits in 22-Jul-2008
FY-3
NOAA17
<240min(47)
<120min(7)
< 60min(0)
< 30min(2)
< 10min(0)
Latitude
Longitude
80
60
40
20
0
-20
-40
-60
-80
-150
-100
-50
0
50
100
150
←20:43
←20:26
←19:02
←18:45
←17:20
←17:04
←15:39
←15:22
←13:57
←13:41
←12:16
←12:00
←10:34
←10:19
←08:53
←08:38
←07:11
←06:57
←05:30
←05:15
←03:48
←03:34
←02:07
←01:53
←00:25
←22:25
←22:07

Cross Cal of MWHS over the polar region

		FY3A/MWHS	NOAA17/AMSU-B	Tb(FY3A)-Tb(N17)
CH1	Tb(K)	178.3683	177.2133	-1.155
	σ (K)	1.687562	2.038363	
CH2	Tb(K)	177.3058		
	σ (K)	2.033599		
CH3	Tb(K)	208.3236	208.7155	0.3919
	σ (K)	1.640585	2.256896	
CH4	Tb(K)	192.6522	193.4067	0.7545
	σ (K)	2.550857	2.330858	
CH5	Tb(K)	183.0644	181.3400	-1.7244
	σ (K)	2.212211	2.108169	