Inter-Calibration on the FY3/MWRI

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Outline

- Introduction of FY-3 MWRI
- Inter-Calibration of FY-3B MWRI and AMSR-E/AMSR2
- Inter-Calibration of FY-3C MWRI and SSMIS
- Inter-Calibration of FY-3B MWRI and FY-3C MWRI
- Conclusion

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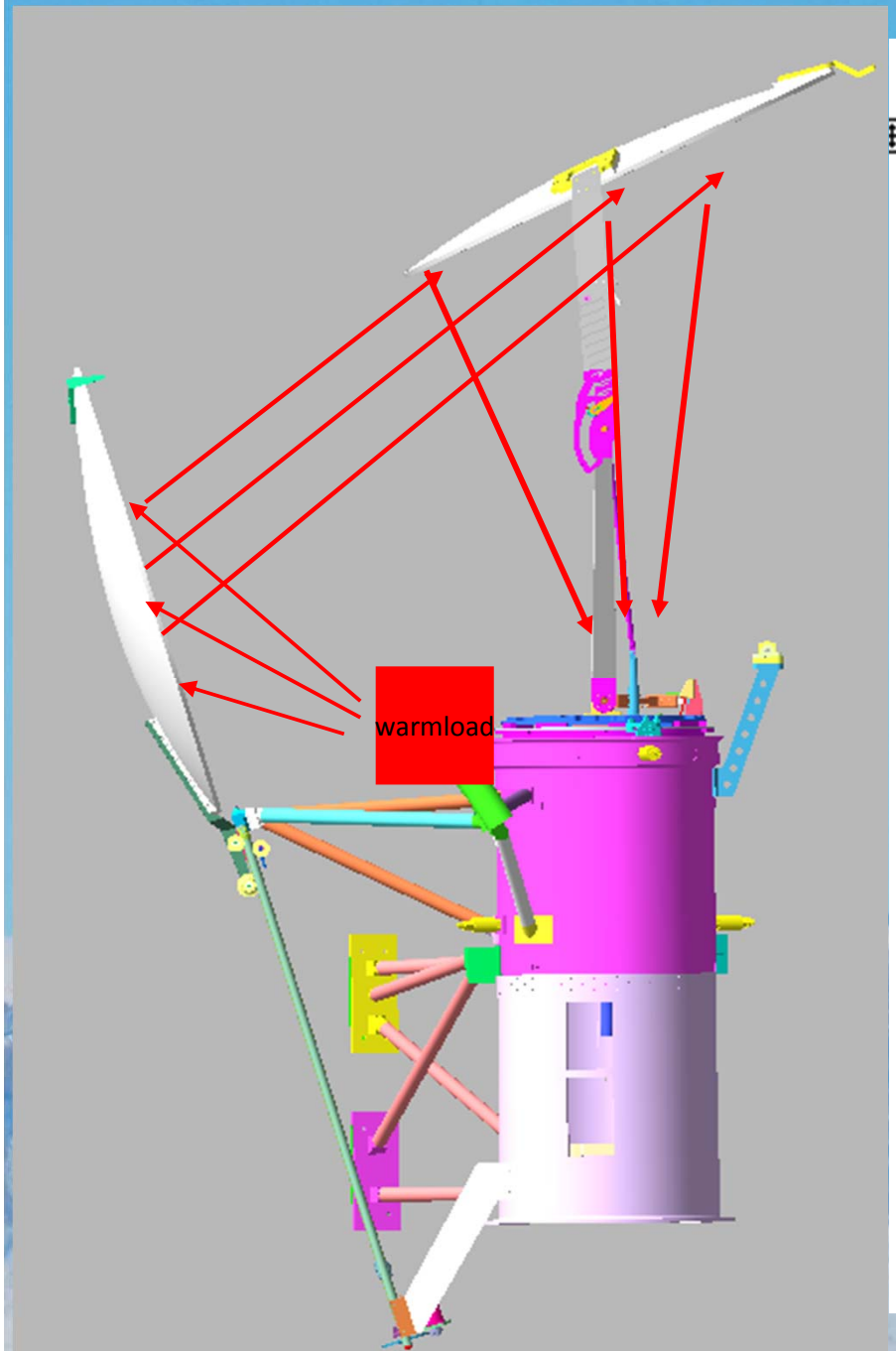
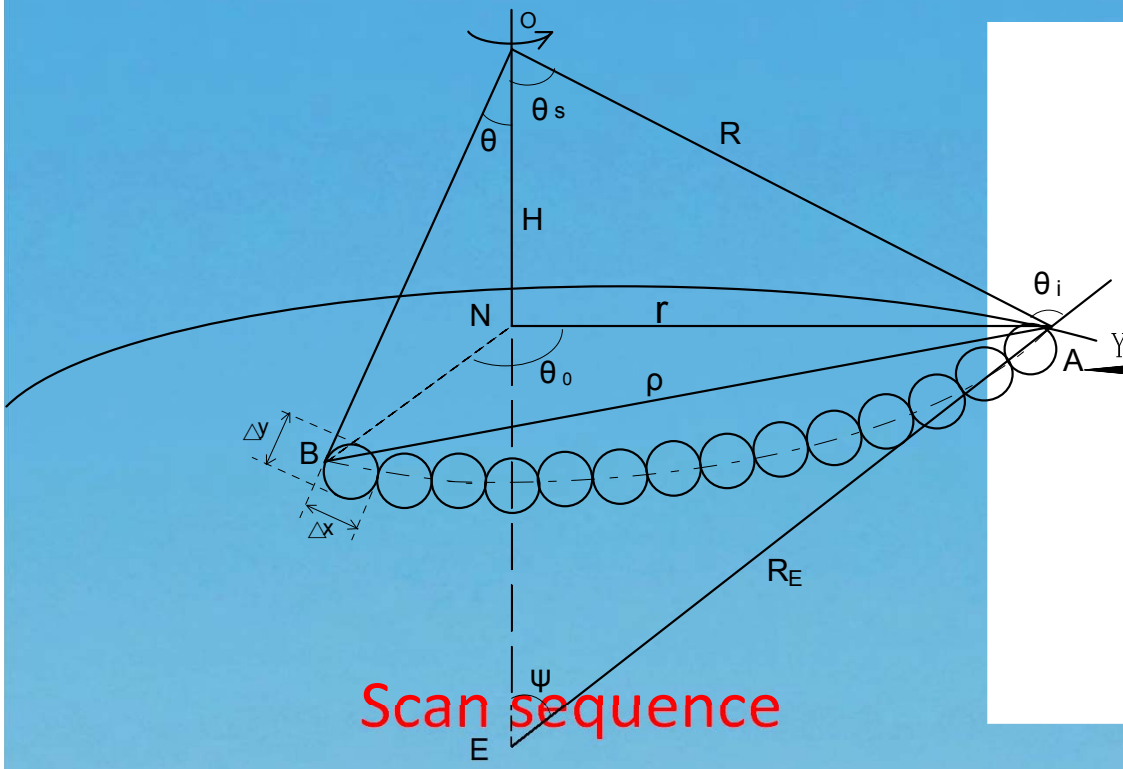
Introduction of FY-3 MWRI

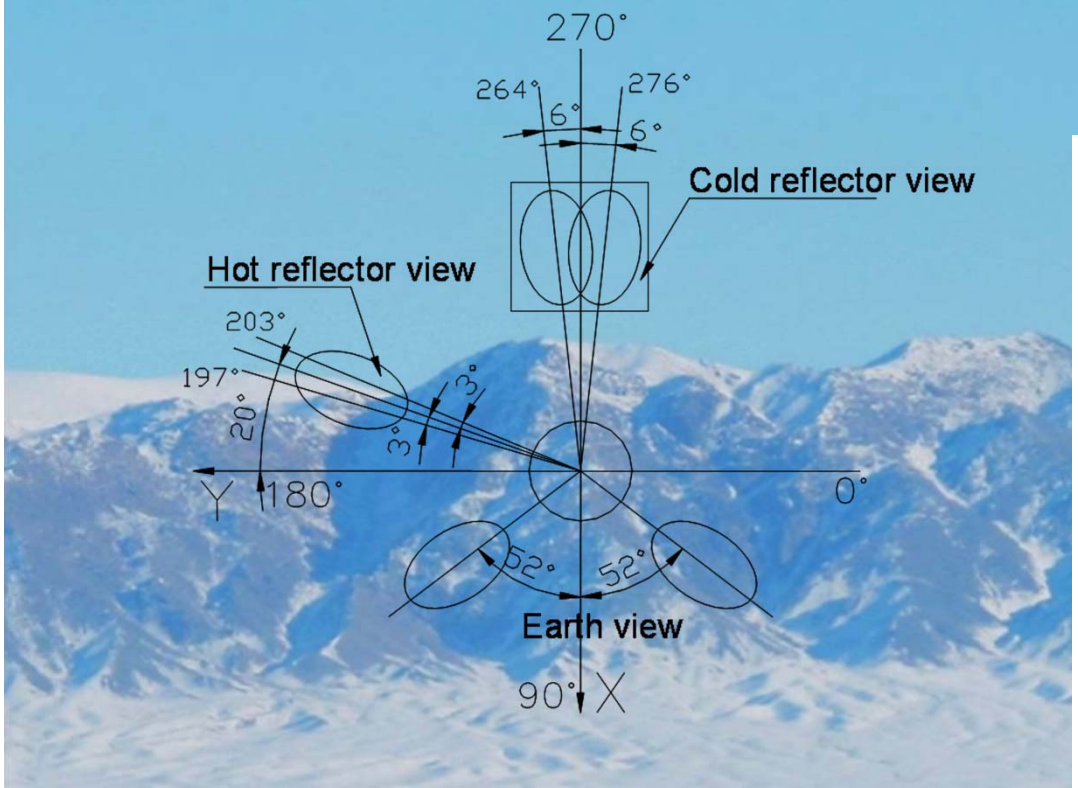


Instrument Characteristics

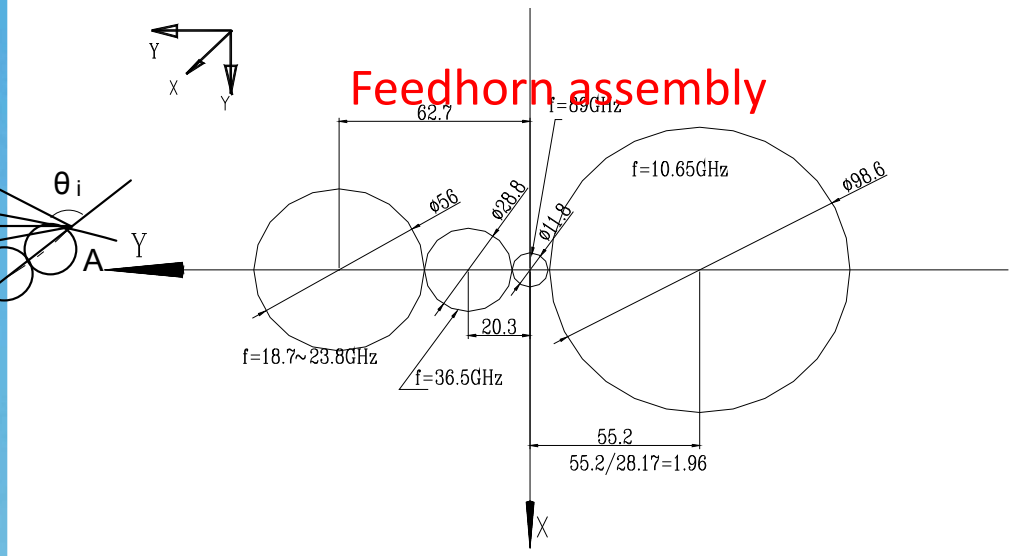
Frequencies (GHz)	10.65	18.7	23.8	36.5	89
Polarization	V.H.	V.H.	V.H.	V.H.	V.H.
Bandwidth (MHz)	180	200	400	900	3000
Sensitivity (k)	0.5	0.5	0.8	0.5	1.0
Calibration error (k)	1.0	2.0	2.0	2.0	2.0
Dynamic Range (k)	3 – 340				
Sampls/scan	240				
Main beam efficiency	> 90%				
Groun Resolution ≤ (km × km)	51 × 85	30 × 50	27 × 45	18 × 30	9 × 15
Scan mode	Conical scanning				
Orbit width (Km)	1400				
Viewing Angle (°)	45 ± 0.1				
Scan period (s)	1.7 ± 0.1				



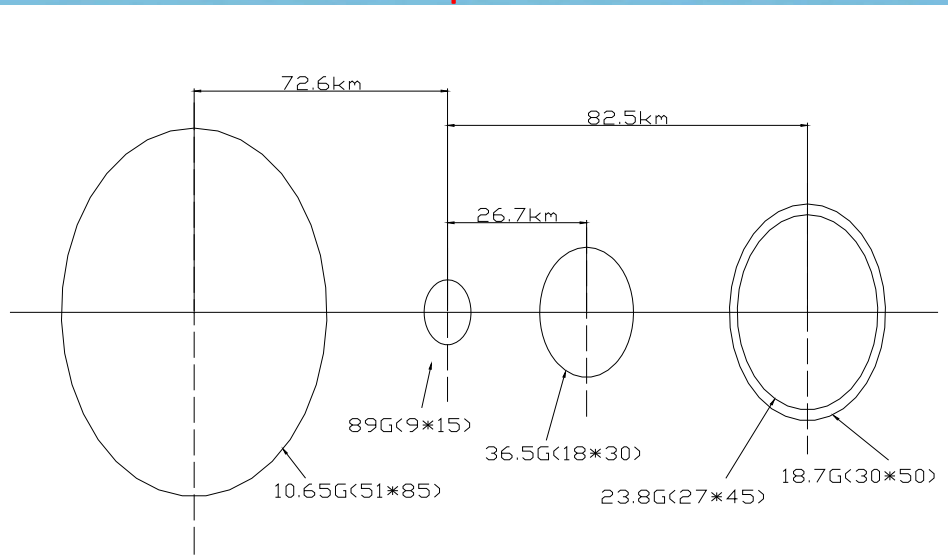
Scan sequence



Feedhorn assembly



Antenna Pattern Ground footprint



Inter-Calibration of FY-3 MWRI

- Confirm the on-orbit accuracy of FY-3 MWRI;
- To build long term record BT data base.

- FY-3B MWRI, With AMSR-E and AMSR2 (DD Method);
- FY-3C MWRI, With SSMIS (SNO Method).

- Also do the comparison of FY-3B and FY-3C MWRI (SNO Method).

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Inter-Calibration of FY-3B MWRI and AMSR-E/AMSR2

- AMSR-E: from 2002-05 to 2011-10
- AMSR2: from 2012-05 to present
- FY-3B MWRI: from 2010-11 to present

- There is a 7 month gap between AMSR-E and AMSR2
- Double difference (DD) method to do the Inter-Calibration

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Double Difference

Double Difference (DD) and Single Difference (SD)

$$DD(AMSR2, AMSR\text{-}E) = SD(AMSR2, MWRI) - SD(AMSR\text{-}E, MWRI)$$

$$SD(AMSR2, MWRI) = T_{b\_AMSR2} - T_{b\_MWRI}$$

$$SD(AMSR\text{-}E, MWRI) = T_{b\_AMSR-E} - T_{b\_MWRI}$$

Relationship of AMSR-E/MWRI and AMSR2/MWRI

$$T_{b\_AMSR-E} = a_1 + b_1 \cdot T_{b\_MWRI}$$

$$T_{b\_AMSR-2} = a_2 + b_2 \cdot T_{b\_MWRI}$$

Relationship of AMSR-E/AMSR2

$$T_{b\_AMSR-E} = a + b \cdot T_{b\_AMSR2}$$

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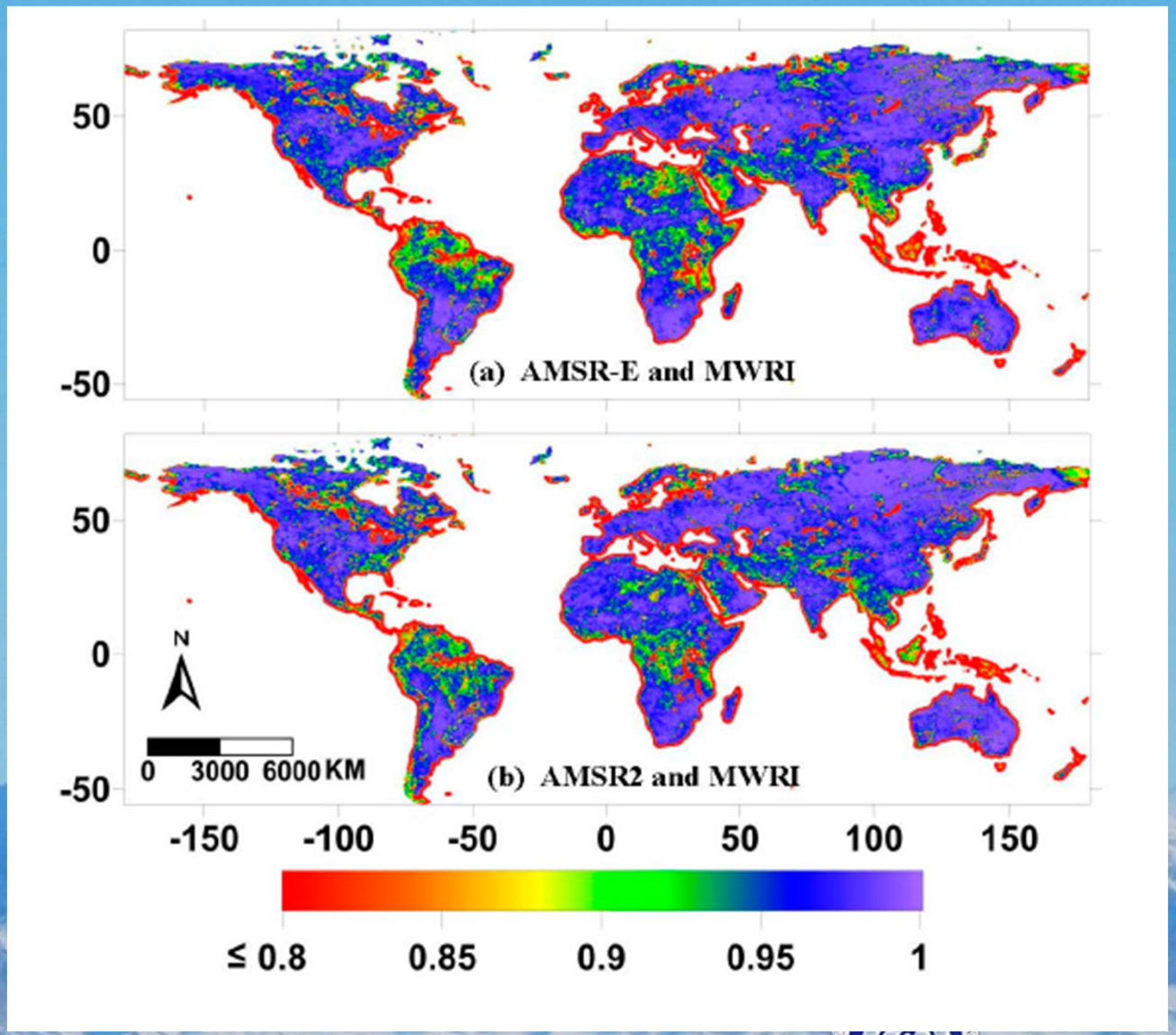
Sensors Configuration

Instrument Configurations			
Specifications	**AMSR-2**	**AMSR-E**	**MWRI**
Satellite Platform	GCOM-W1	AQUA	FY3B
Altitude	700 km	705 km	836 km
Equator Crossing Time	1:30 p.m. Ascending	1:30 p.m. Ascending	1:40 p.m. Ascending
(Local time zone)	1:30 a.m. Descending	1:30 a.m. Descending	1:40 a.m. Descending
Antenna Size	2 m (Diameter)	1.6 m (Diameter)	0.977 m × 0.897 m
Incident Angle	55	55	53
Spatial Resolution (km × km)			
Band (GHz)	**AMSR-2**	**AMSR-E**	**MWRI**
6.93	62 × 35	75 × 43	N/A
7.3	62 × 35	N/A	N/A
10.65	42 × 24	51 × 29	85 × 51
18.7	22 × 14	27 × 16	50 × 30
23.8	19 × 11	32 × 18	45 × 27
36.5	12 × 7	14 × 8	30 × 18
89.0	5 × 3	6 × 4	15 × 9

Inter-Calibration data (23H Ascending)



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Reason of difference at Land/Water border

- 25km GRID Resample method;
- Resolution difference of MWRI/AMSR;
- Following FY-3 MWRI will improve on it.

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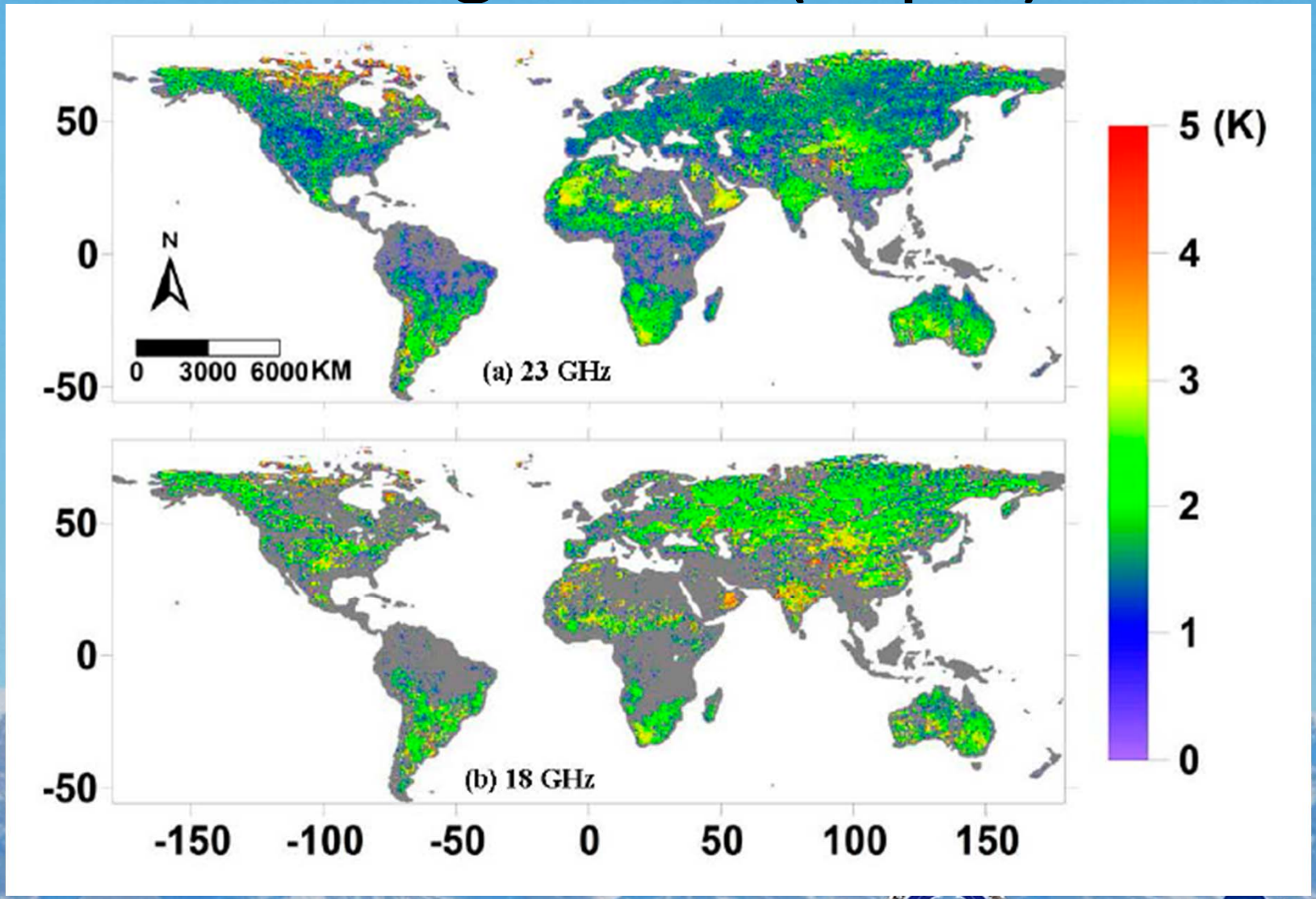
RESULT: DD of AMSR-E and AMSR2 Using MWRI (H-pol)



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RESULT: Ascending

Pairwise Comparisons	H_Pol			V_Pol		
	Bias	STD	Percentage	Bias	STD	Percentage
			10 GHz			
MWRI-AMSR-E	−2.78	2.09	42.86	−3.13	1.29	59.46
MWRI-AMSR2	−5.85	2.22	40.51	−4.61	1.59	56.43
			18 GHz			
MWRI-AMSR-E	−0.34	1.68	47.22	0.20	1.12	61.18
MWRI-AMSR2	−2.80	1.54	49.50	−1.35	1.34	61.79
			23 GHz			
MWRI-AMSR-E	−2.58	1.34	60.83	−2.36	0.98	66.01
MWRI-AMSR2	−4.67	1.03	65.21	−3.75	0.94	69.28
			36 GHz			
MWRI-AMSR-E	−3.06	1.69	49.07	−4.01	1.18	60.06
MWRI-AMSR2	−4.39	1.29	54.96	−4.83	0.98	63.20
			89 GHz			
MWRI-AMSR-E	−1.83	1.66	27.24	−1.66	1.06	32.95
MWRI-AMSR2	−1.98	1.54	28.94	−2.33	1.03	36.15

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RESULT: Descending

Pairwise Comparisons	H_Pol			V_Pol		
	Bias	STD	Percentage	Bias	STD	Percentage
			10 GHz			
MWRI-AMSR-E	−1.39	2.53	36.10	−2.23	1.52	52.46
MWRI-AMSR2	−4.04	2.73	33.95	−4.34	1.67	48.92
			18 GHz			
MWRI-AMSR-E	0.84	2.25	41.76	1.07	1.43	54.68
MWRI-AMSR2	−0.93	2.21	41.12	−1.07	1.52	53.26
			23 GHz			
MWRI-AMSR-E	−1.16	2.29	60.21	−1.52	1.56	61.53
MWRI-AMSR2	−3.00	1.97	60.30	-3.19	1.40	60.62
			36 GHz			
MWRI-AMSR-E	−1.41	2.28	47.22	−2.84	1.37	56.53
MWRI-AMSR2	−3.00	1.81	50.56	−3.94	1.30	57.71
			89 GHz			
MWRI-AMSR-E	−0.20	1.62	34.20	−0.39	1.14	34.42
MWRI-AMSR2	−0.84	1.85	34.57	−1.27	1.44	36.96

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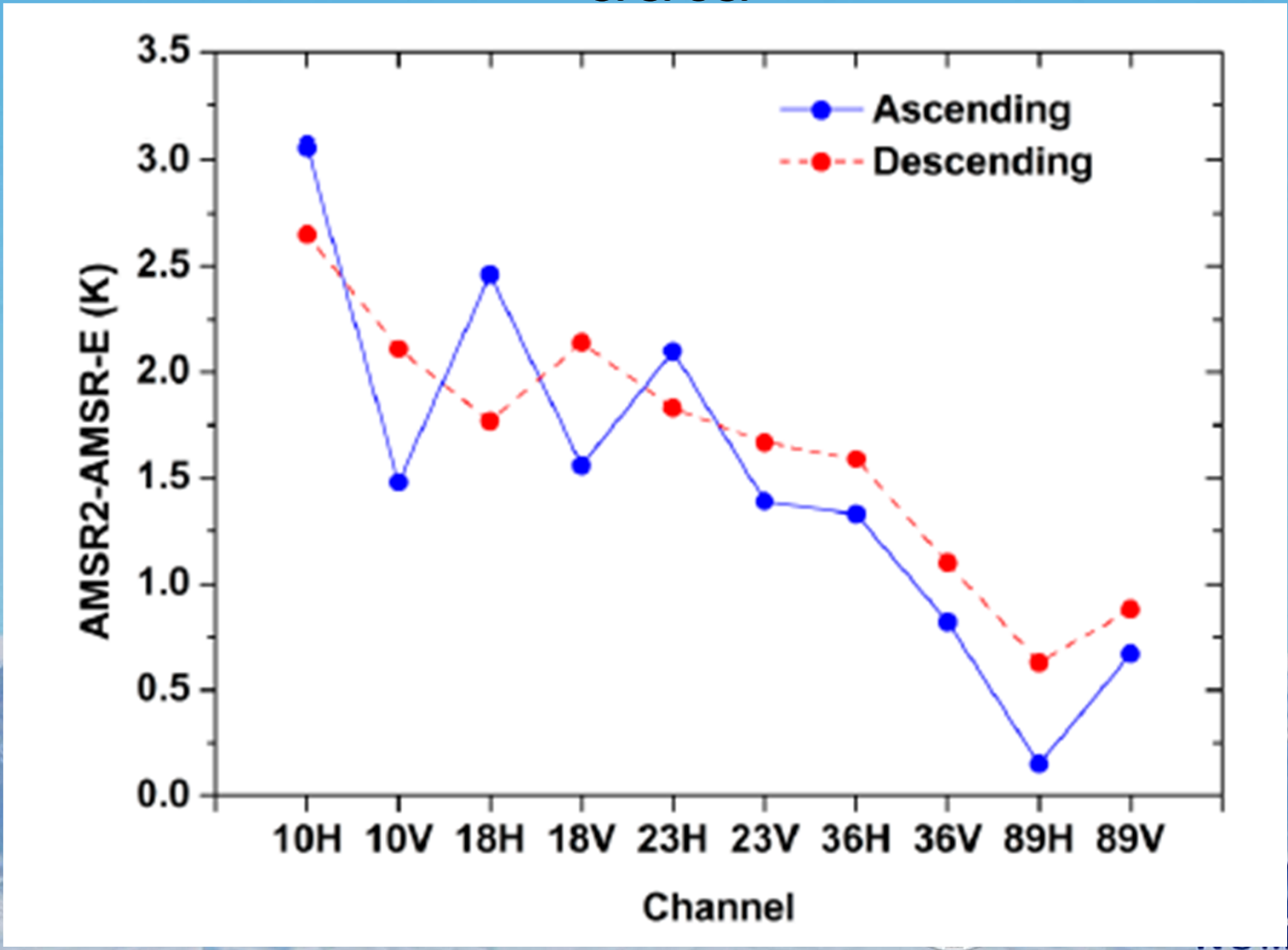
Global Mean Biases Between AMSR-E and AMSR2 using overlapping MWRI data



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Difference before and after calibration

Ascending

Climate Type	Before Calibration			After Calibration		
	Bias	RMSE	Correlation	Bias	RMSE	Correlation
Polar	−4.01	4.65	0.96	0.19	1.11	0.99
Continental	−3.88	4.08	0.97	−0.18	0.97	0.98
Tropical	−2.59	2.88	0.90	0.04	0.46	0.98
Dry	−2.34	2.74	0.97	−0.01	0.58	0.99
Temperate	−3.00	3.18	0.97	0.05	0.58	0.99

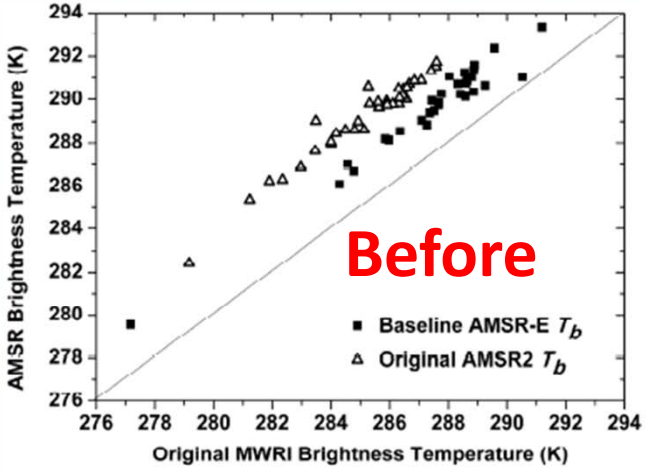
Descending

Climate Type	Before Calibration			After Calibration		
	Bias	RMSE	Correlation	Bias	RMSE	Correlation
Polar	−3.05	3.92	0.94	0.03	1.12	0.98
Continental	−2.51	2.83	0.97	−0.04	0.63	0.99
Tropical	−0.80	1.52	0.79	−0.31	0.51	0.92
Dry	−1.14	1.64	0.97	−0.07	0.54	0.99
Temperate	−2.01	2.33	0.96	−0.06	0.47	0.99

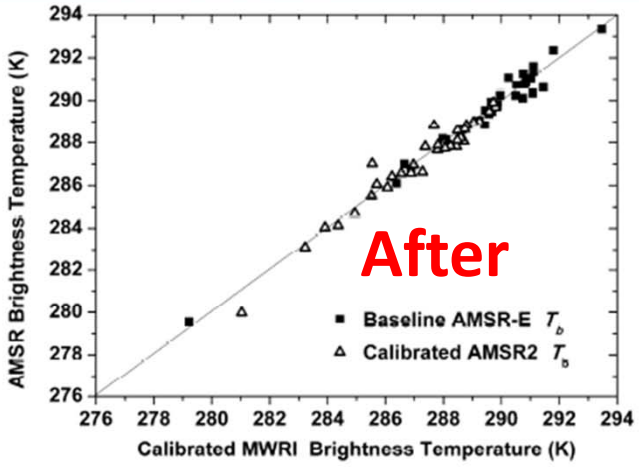
23H

18H

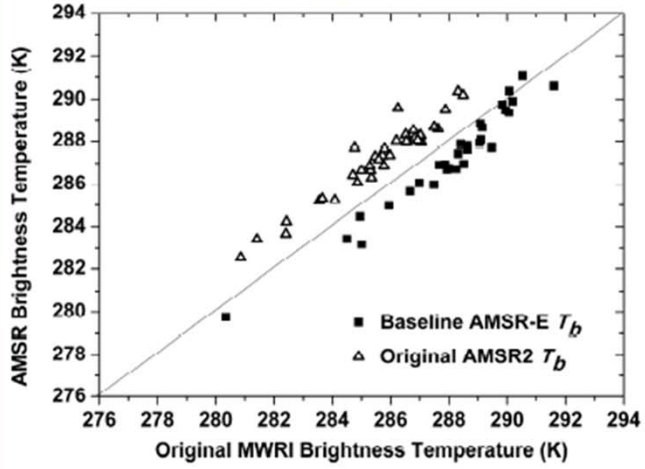
10H



(a)



(b)



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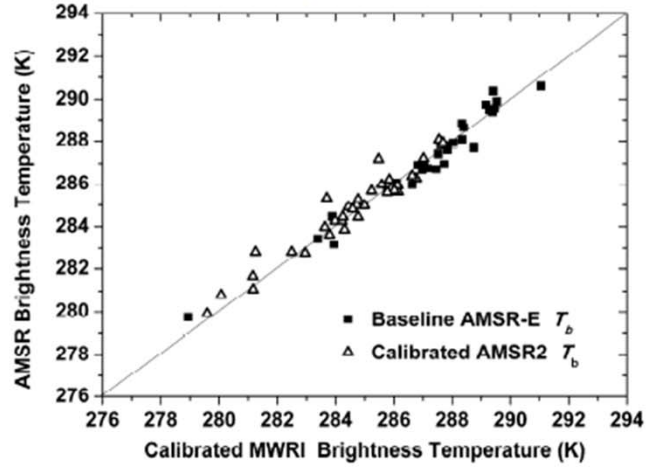

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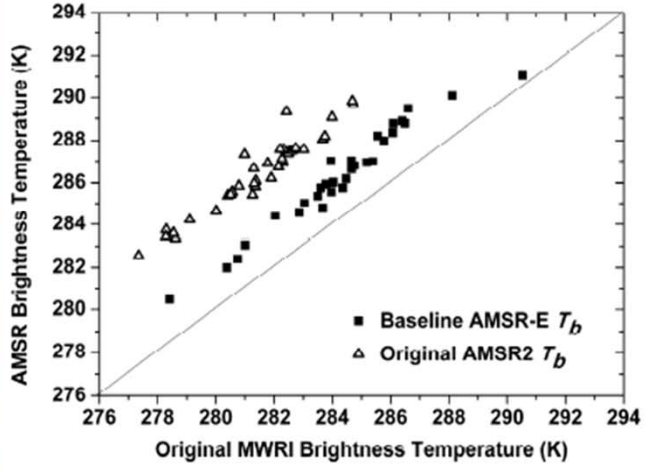
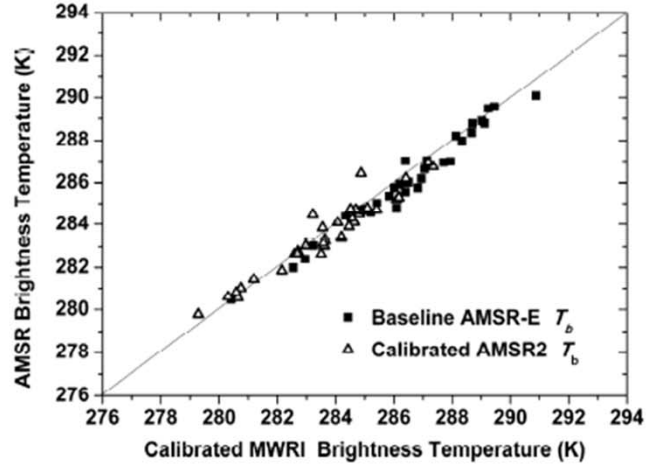


(e)



(f)

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Reason of difference of AMSR-E/AMSR2

- Slight Difference of local passing time;
  - For all 10 channels, AMSR-E-AMSR2 always negative;
  - The difference decrease while Frequency increase;
  - Partly explain the difference.
- Why Dry area has lowest value while polar area has highest value?

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Inter-Calibration of FY-3C MWRI and SSMIS

- (Simultaneous Nadir Overpass)SNO Method;
- For most microwave imager, Conical scattering;
  - Do not need nadir;
  - Simultaneous over pass (15 min in our study);
  - Uniform subsurface (BT std in 3x3 pixel less than 2K in our study);

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FY-3C MWRI and DMSP-F17/SSMIS

Channels	Land		Sea		Polar	
	Mean（K）	Rmse（K）	Mean（K）	Rmse（K）	Mean（K）	Rmse（K）
18H	1.76	2.48	-2.59	3.38	-0.85	1.88
18V	1.30	2.08	-2.82	3.51	-1.13	2.13
23V	-0.17	1.71	-1.79	2.69	-2.09	2.58
36H	-2.81	3.12	-2.12	2.78	-2.85	3.12
36V	-2.46	2.83	-3.43	3.64	-2.91	3.11

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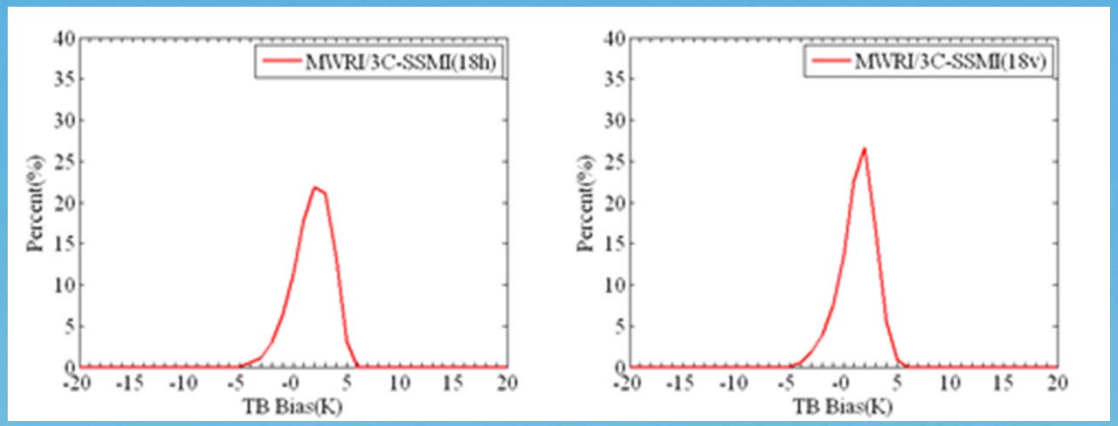
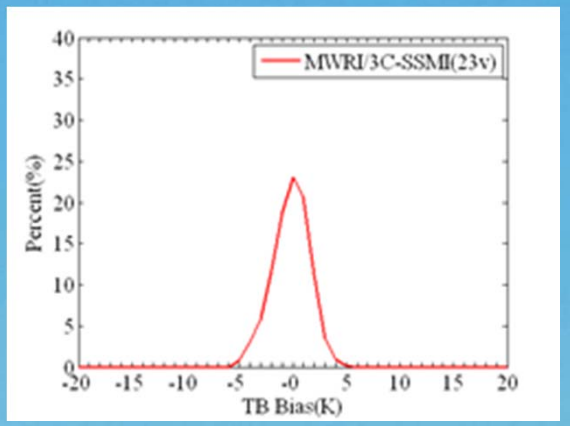
Bar(land)

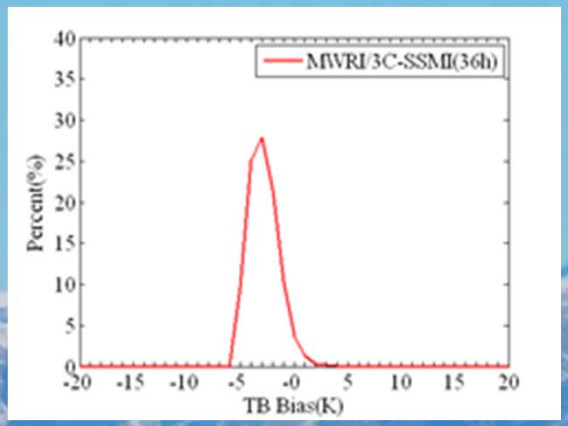


18H

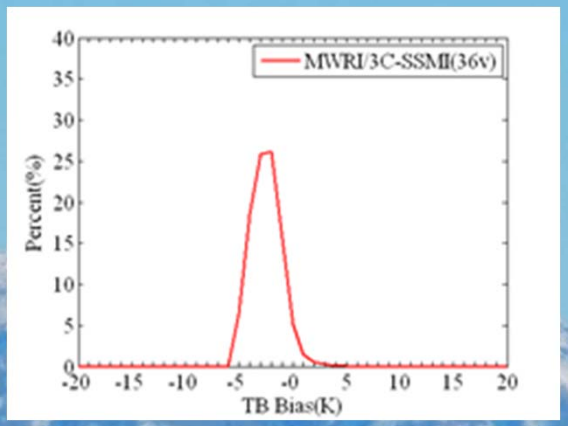
18V



23V



36H



36V

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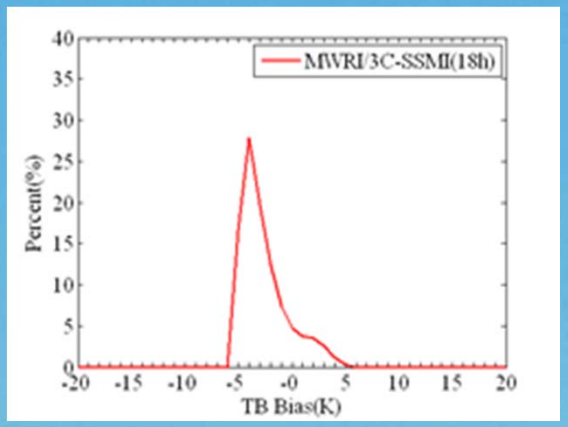
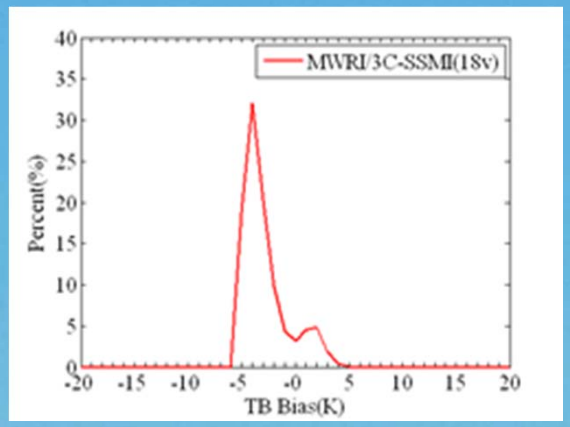
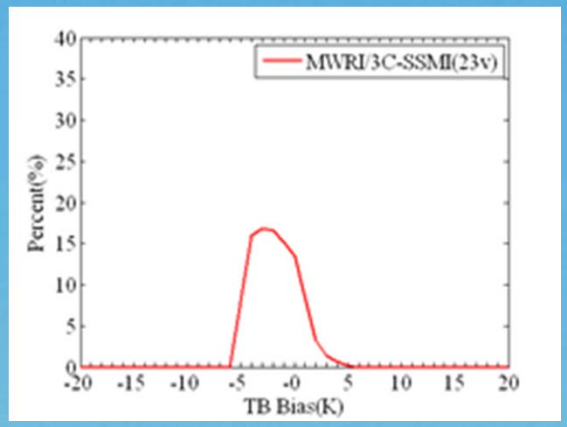
Bar(Sea)



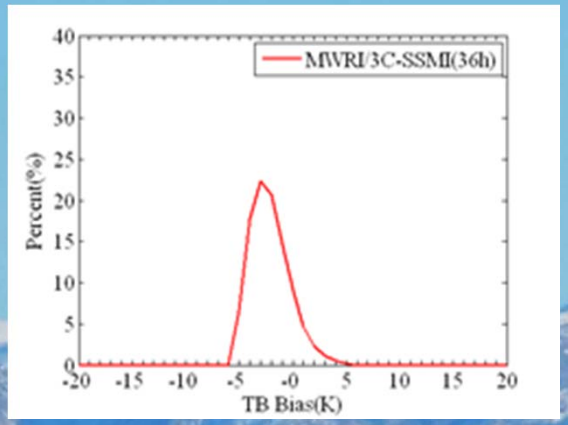
18H



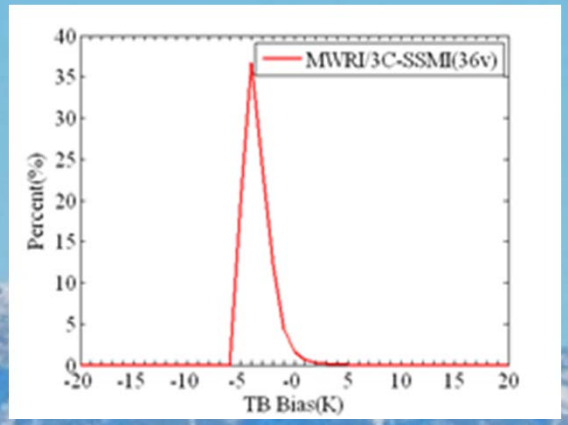
18V



23V



36H



36V

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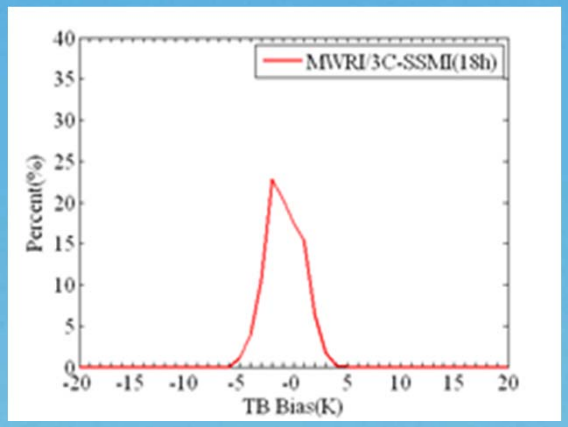
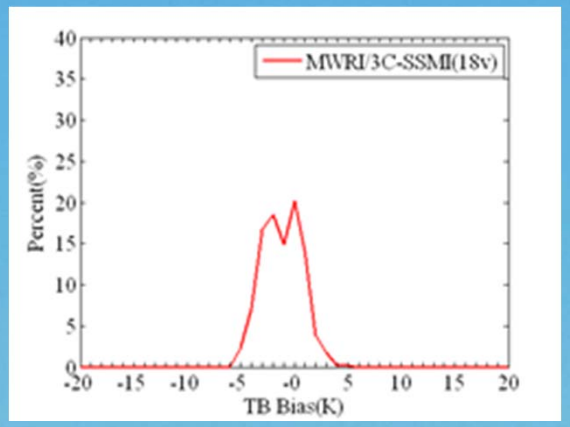
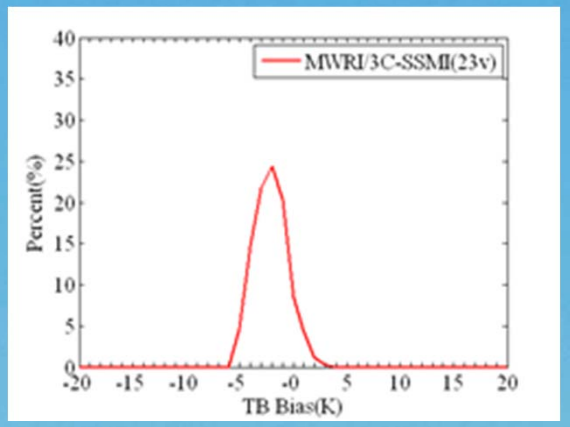
Bar(Polar)



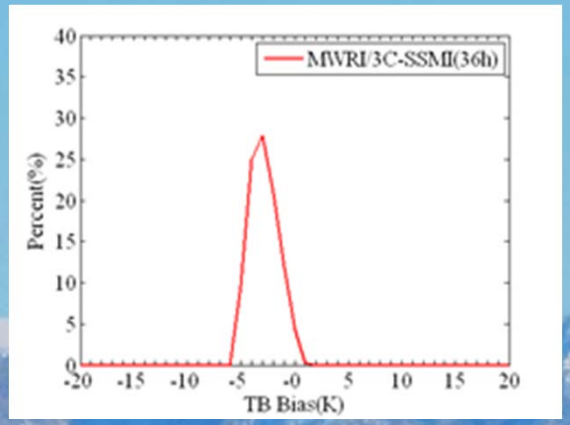
18H



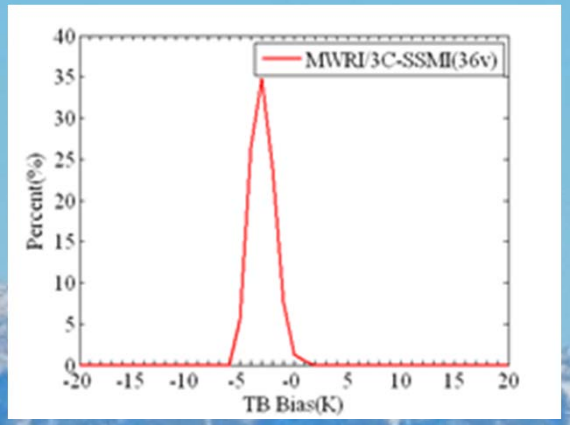
18V



23V



36H



36V

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Inter-Calibration of FY-3B MWRI and FY-3C MWRI

Channels	Polar	
	Mean（K）	Rmse（K）
10H	-1.38	1.85
10V	-0.79	1.42
18H	0.20	1.43
18V	-0.80	1.39
23H	-0.35	1.53
23V	-0.37	1.22
36H	-1.34	1.72
36V	-0.38	1.44
89H	-0.35	1.18
89V	-1.45	1.83

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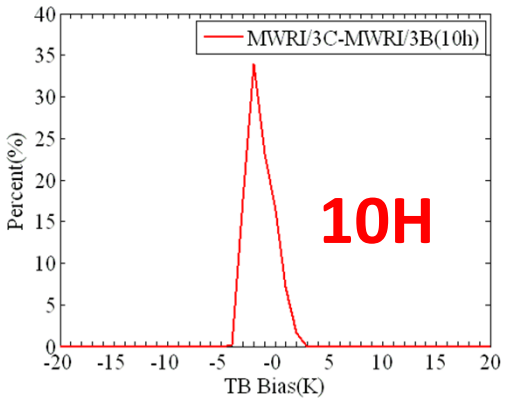
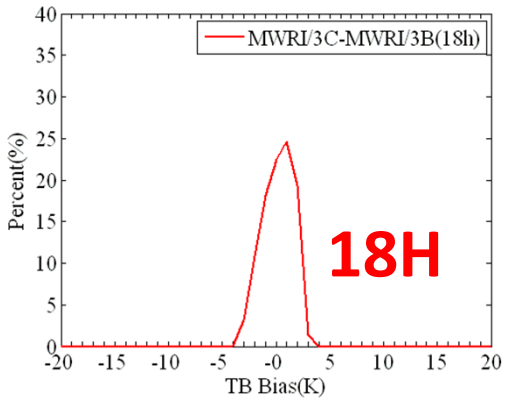
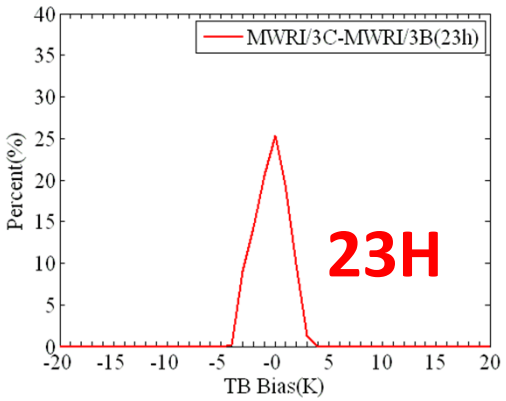
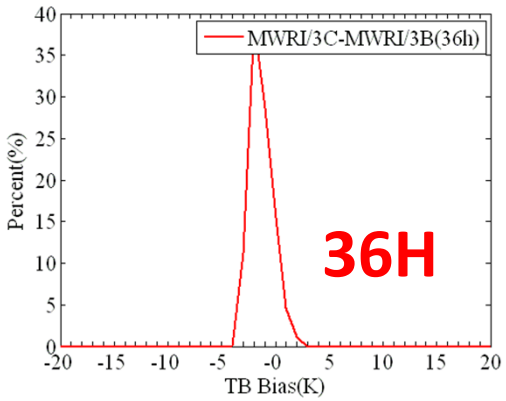
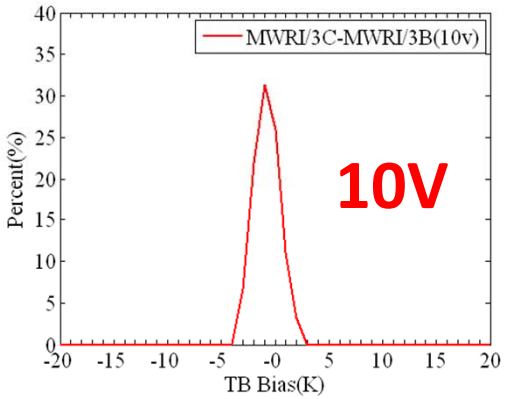
Bar

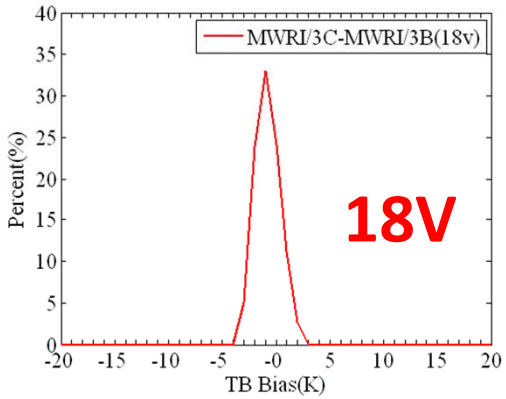

MWRI/3C-MWRI/3B(10h)
10H
Percent(%)
TB Bias(K)

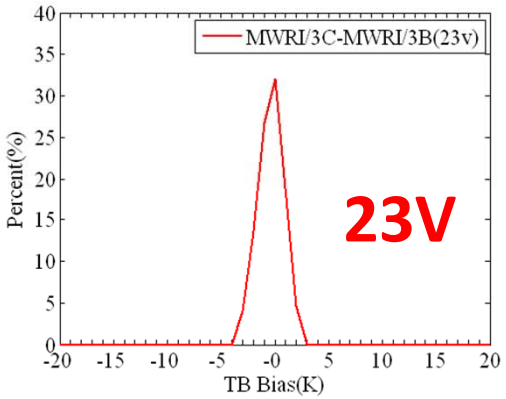

MWRI/3C-MWRI/3B(18h)
18H
Percent(%)
TB Bias(K)

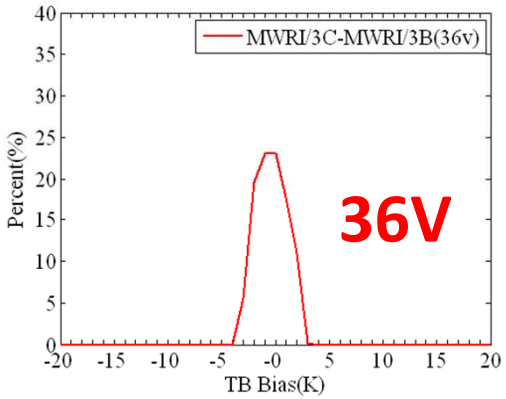

MWRI/3C-MWRI/3B(23h)
23H
Percent(%)
TB Bias(K)

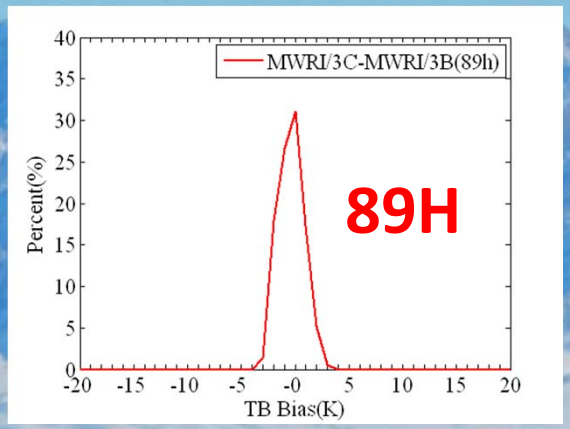

MWRI/3C-MWRI/3B(36h)
36H
Percent(%)
TB Bias(K)

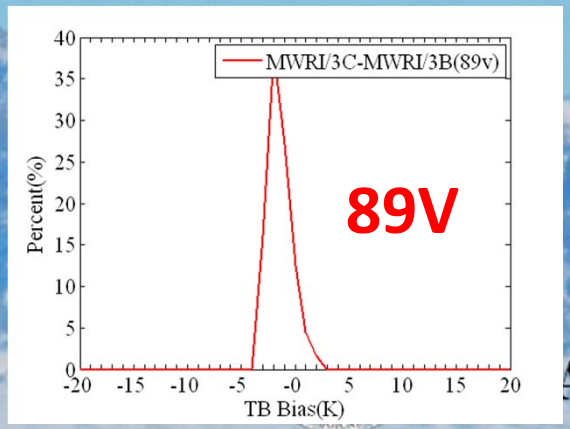

MWRI/3C-MWRI/3B(10v)
10V
Percent(%)
TB Bias(K)


MWRI/3C-MWRI/3B(18v)
18V
Percent(%)
TB Bias(K)


MWRI/3C-MWRI/3B(23v)
23V
Percent(%)
TB Bias(K)


MWRI/3C-MWRI/3B(36v)
36V
Percent(%)
TB Bias(K)


MWRI/3C-MWRI/3B(89h)
89H
Percent(%)
TB Bias(K)


MWRI/3C-MWRI/3B(89v)
89V
Percent(%)
TB Bias(K)

NSMC

Conclusion

- With Double Difference method, FY-3B/MWRI can do the inter-calibration between AMSR-E and AMSR2, AMSR-E, AMSR2, FY-3B/MWRI,FY-3C/MWRI and following scheduled FY-3 series MWRI can be used to build a long term BT data-set;
- Compared with SSMIS (SNO), bias are from 0.17K(23V Land)-3.43K(36V Sea), RMSE are from 1.71K(23V Land)-3.51K(18V Sea);
- Comparison between FY-3B and FY-3C MWRI shows a good stability of FY-3 Series microwave imager.

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Thanks

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