Comparison of SAPHIR & MHS Measurements Near 183.3 GHz

J. R. Wang
Science System & Applications, Inc.
10210 Greenbelt Road, Suite 600
**Lanham, MD 20706**

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Outline

- **Double Difference Method:**

  - MeghaTropique SAPHIR (1Base, V1.02 – V1.05), METOPA (MHS), and NOAA18 (MHS) Measurements, and NCEP Reanalysis Data for the Period July 2012 – March 2013. Data Source: GSFC PPS site.

  - Co-location of SAPHIR, METOPA, and NCEP, and of SAPHIR, NOAA18, and NCEP Data Sets.

  - Radiative Transfer Calculations of SAPHIR and MHS channels Using the Co-located NCEP Temperature, Relative Humidity, and Pressure Profiles.

  - Derivation of Biases from Double Differences of Measured and Calculated Radiances (T_bs)

- **Retrieval Method:**

  - Retrieval of RH Profiles Using SAPHIR T_bs From the Above Data Sets.

  - Prediction of MHS T_bs from the Retrieved RH profiles (More Details Later)

- **Preliminary Results of SAPHIR – SSMIS (F17) Comparison.**

- **Summary.**

Typical Scatter Plot of Co-locate SAPHIR_ METOPA Pixels

SAPHIR (183.3±6.8 GHz) & METOPA (190.3 GHZ)   August 2012
Co-located Dist ≤ 2 km, Time Diff. ≤ 15 min., Obs. Ang. Diff. ≤ 1 Deg.

(A) No Screening

(B) Screening With Tbs From
Both Sensors ≥ 240 K
& Tb Diff. ≤ 15 K

Bias±STD
−0.37± 3.82
7080 Samples

Bias±STD
−0.35± 1.64
6935 Samples

METOPA Brightness, K

SAPHIR Brightness, K
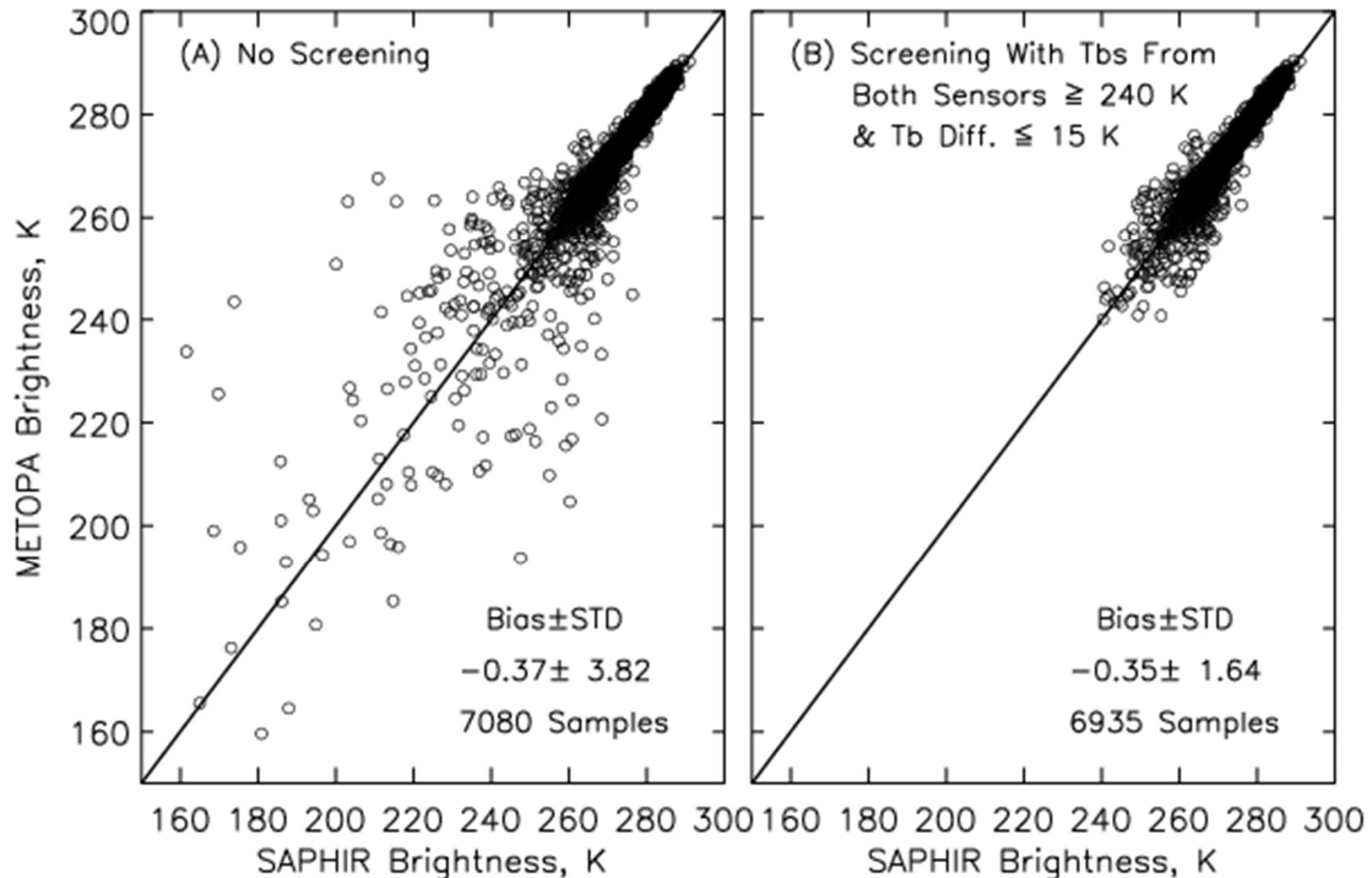
Time Distribution of Co-located Samples
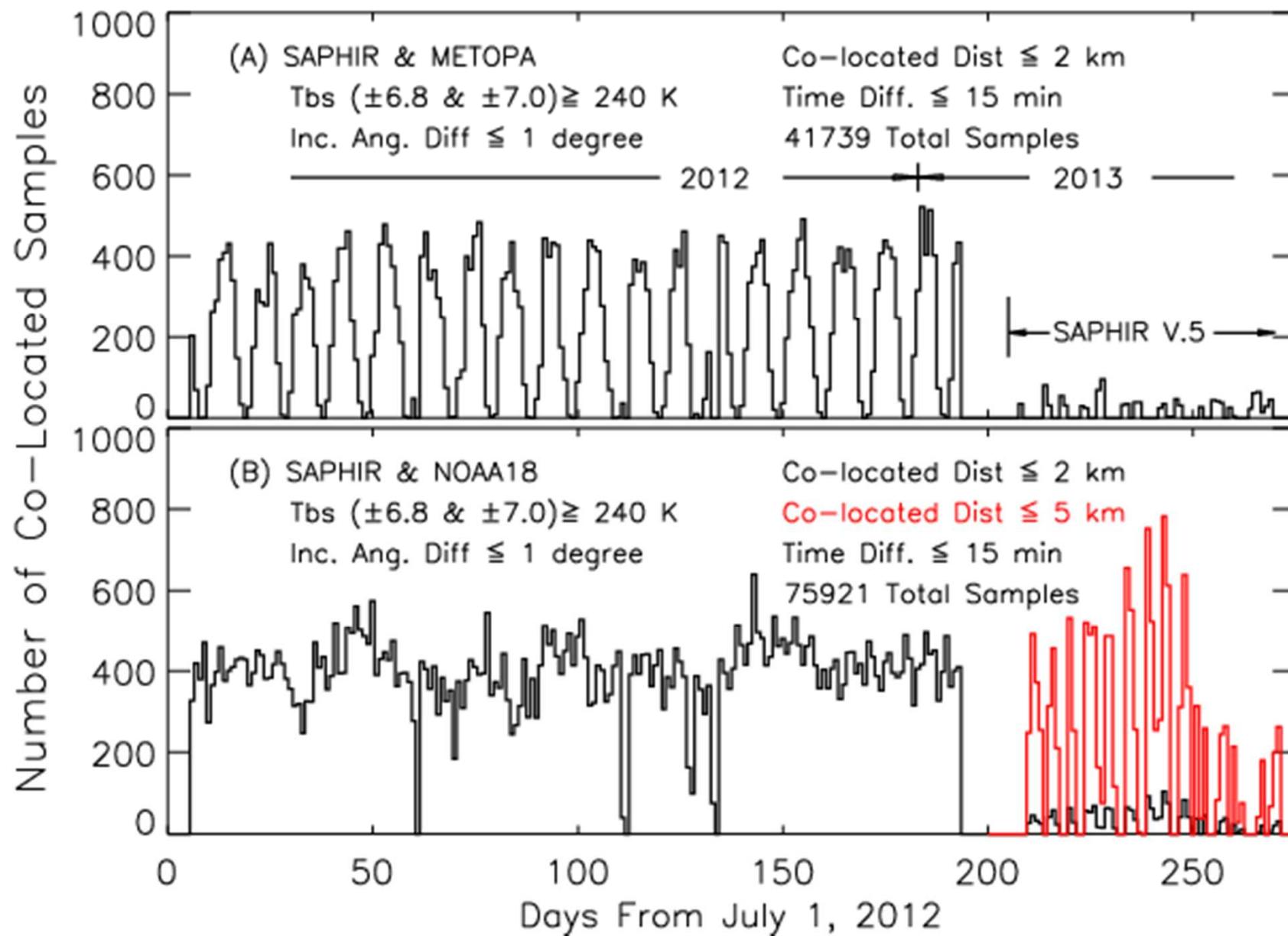
Example of Co-located Data Sets (with NCEP)

Co-located Dist ≤ 2 km, Time Diff. ≤ 15 min, Ch. 5 of SAPHIR & MHS Tb ≥ 240 K
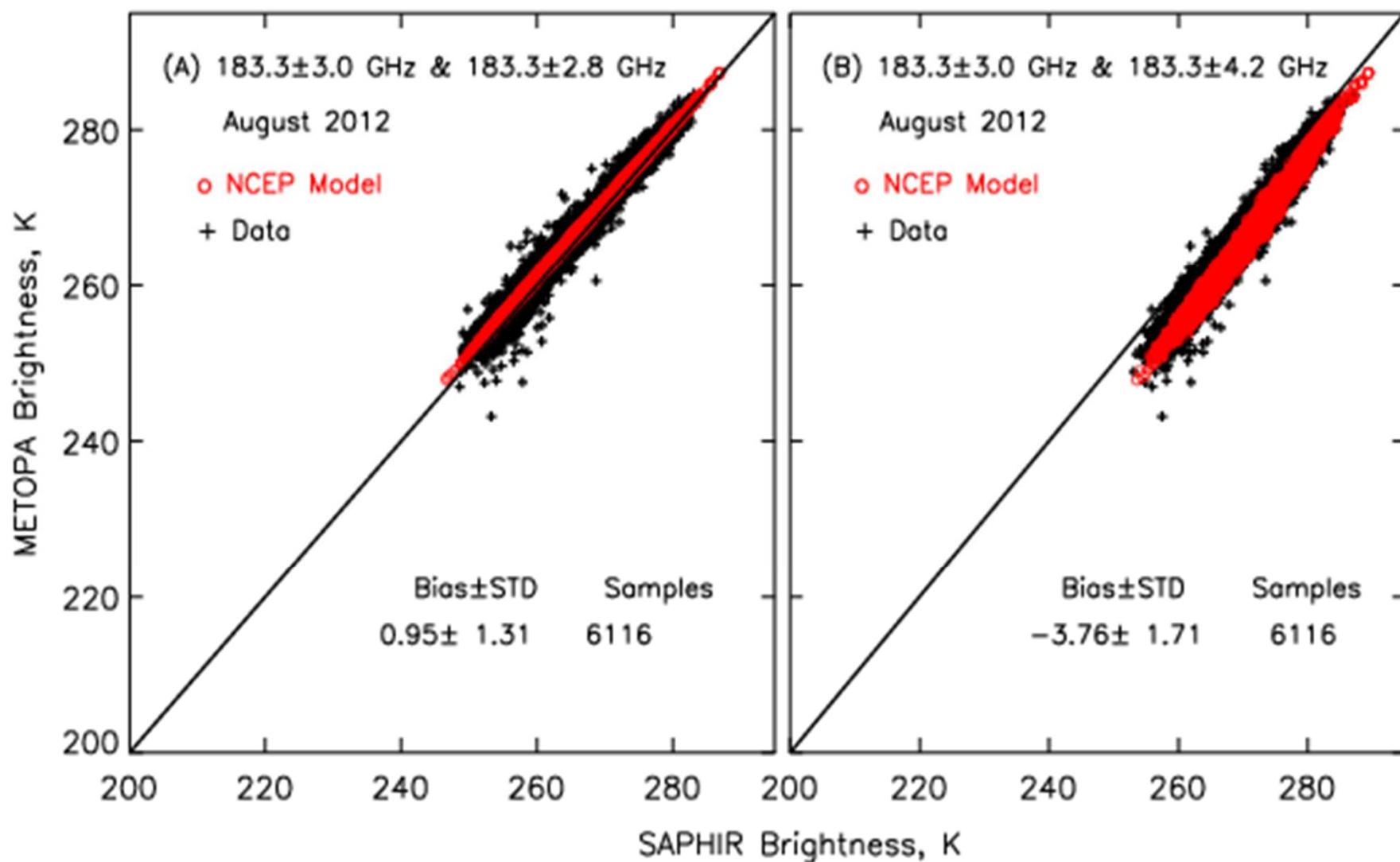
(A) 183.3±3.0 GHz & 183.3±2.8 GHz

August 2012

o NCEP Model
+ Data

Bias±STD   Samples
0.95± 1.31   6116

(B) 183.3±3.0 GHz & 183.3±4.2 GHz

August 2012

o NCEP Model
+ Data

Bias±STD   Samples
−3.76± 1.71   6116

METOPA Brightness, K

SAPHIR Brightness, K

Brightness Difference & Double Difference Between SAPHIR and METOPA (183.3±1 GHz)

August 2012,   183.3±1.1 GHz & 183.3±1.0 GHz

(A) SAPHIR − NCEP   METOPA − NCEP

0.82 ± 6.03 K   0.87 ± 6.18 K

(B) (METOPA − NCEP) − (SAPHIR − NCEP)

0.05 ± 1.47 K   6116 Samples
± 0.02 K
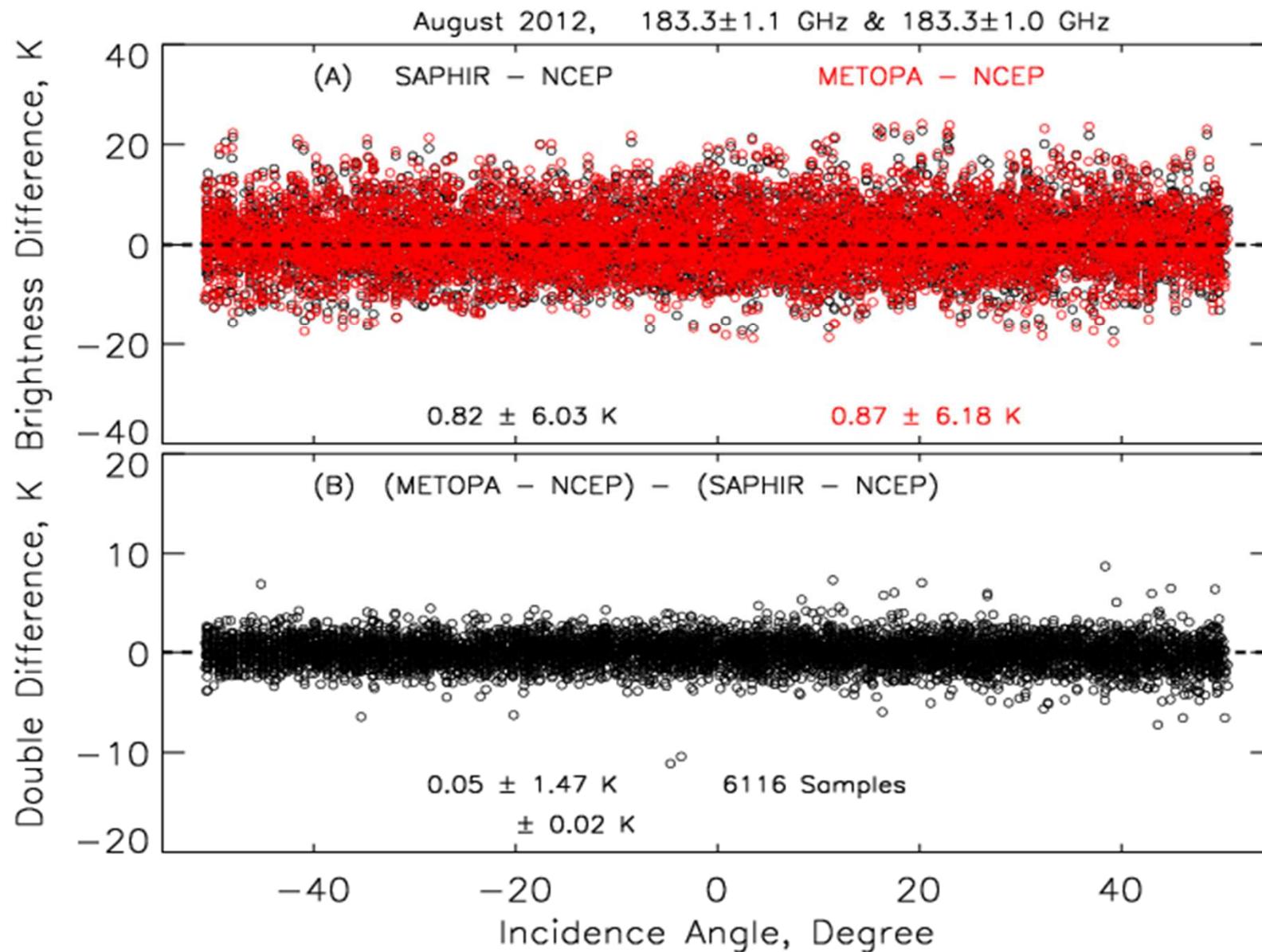
Brightness Difference & Double Difference Between SAPHIR and METOPA (183.3±3 & 183.3±2.8 GHz)

August 2012, 183.3±2.8 GHz & 183.3±3.0 GHz

(A) SAPHIR − NCEP   METOPA − NCEP

0.72 ± 4.37 K   0.72 ± 4.29 K

(B) (METOPA − NCEP) − (SAPHIR − NCEP)

0.00 ± 1.32 K   6116 Samples
± 0.02 K

Incidence Angle, Degree
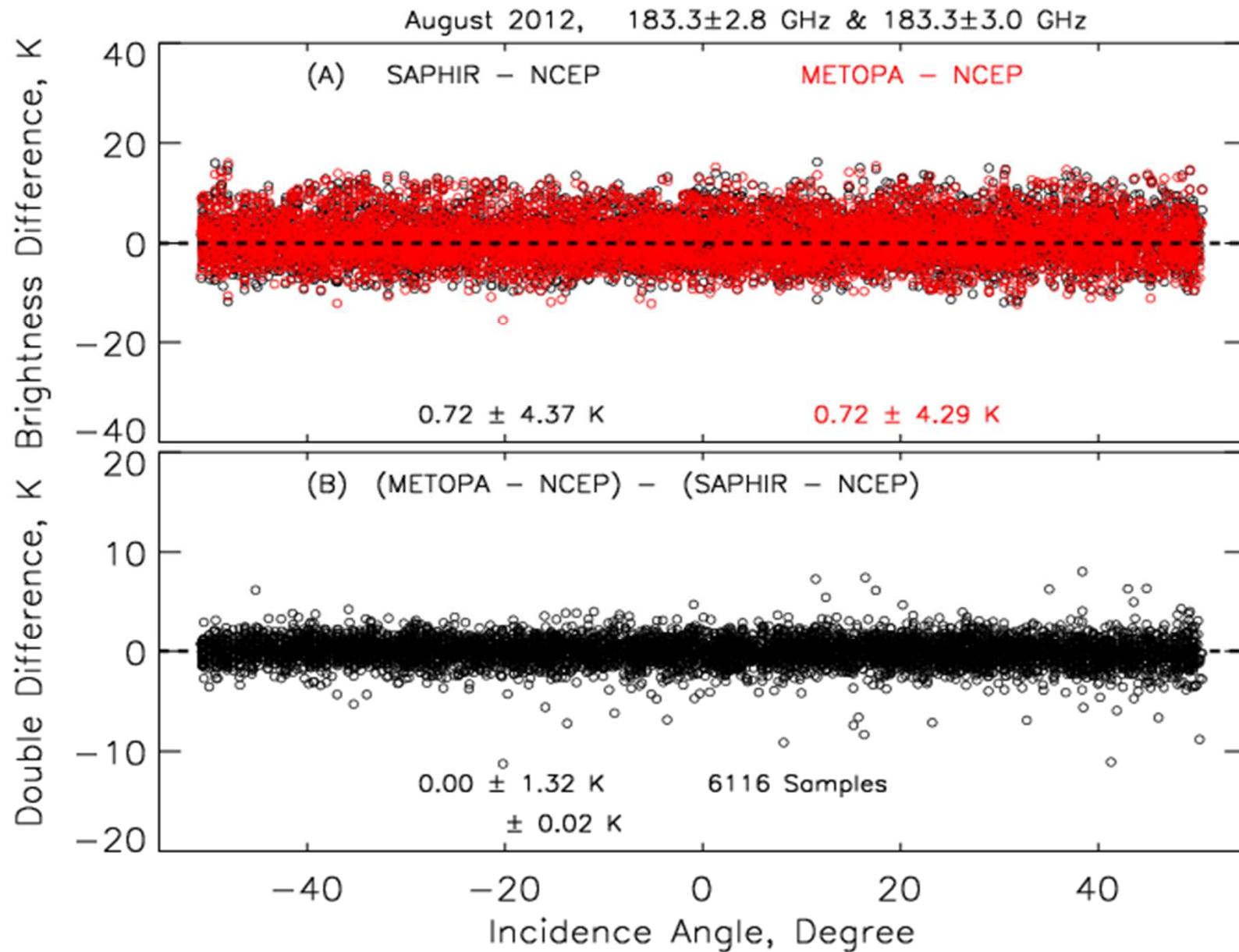
Brightness Difference & Double Difference Between SAPHIR and METOPA (183.3±7 & 183.3±6.8 GHz)
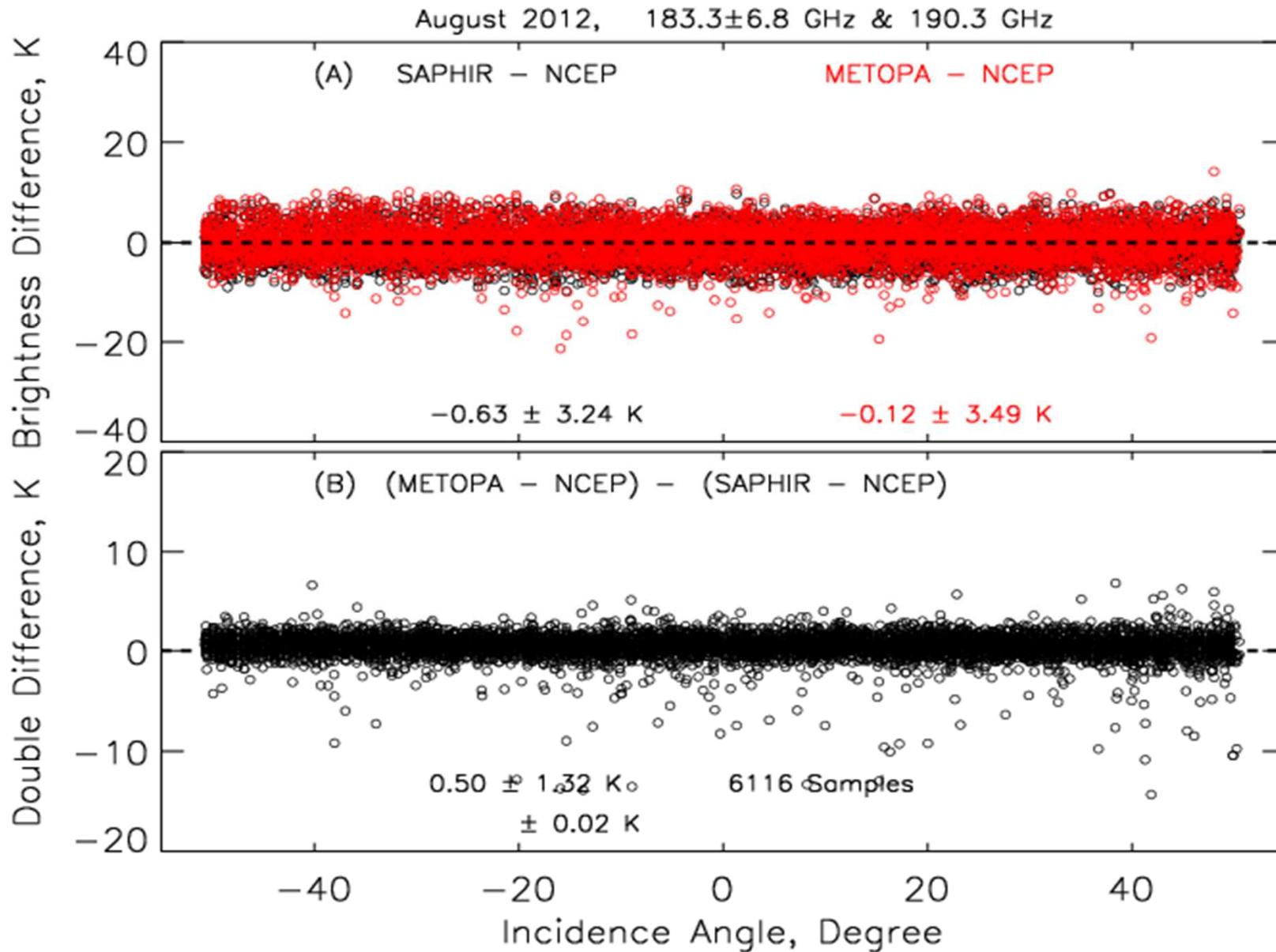
Brightness Difference & Double Difference Between SAPHIR and NOAA18 (183.3± 3 & 183.3±2.8 GHz)

October 2012,   183.3±2.8 GHz & 183.3±3.0 GHz

(A)   SAPHIR − NCEP   NOAA18 − NCEP

0.82 ± 4.54 K   0.94 ± 4.47 K

(B) (NOAA18 − NCEP) − (SAPHIR − NCEP)

0.13 ± 1.39 K   11366 Samples
± 0.01 K
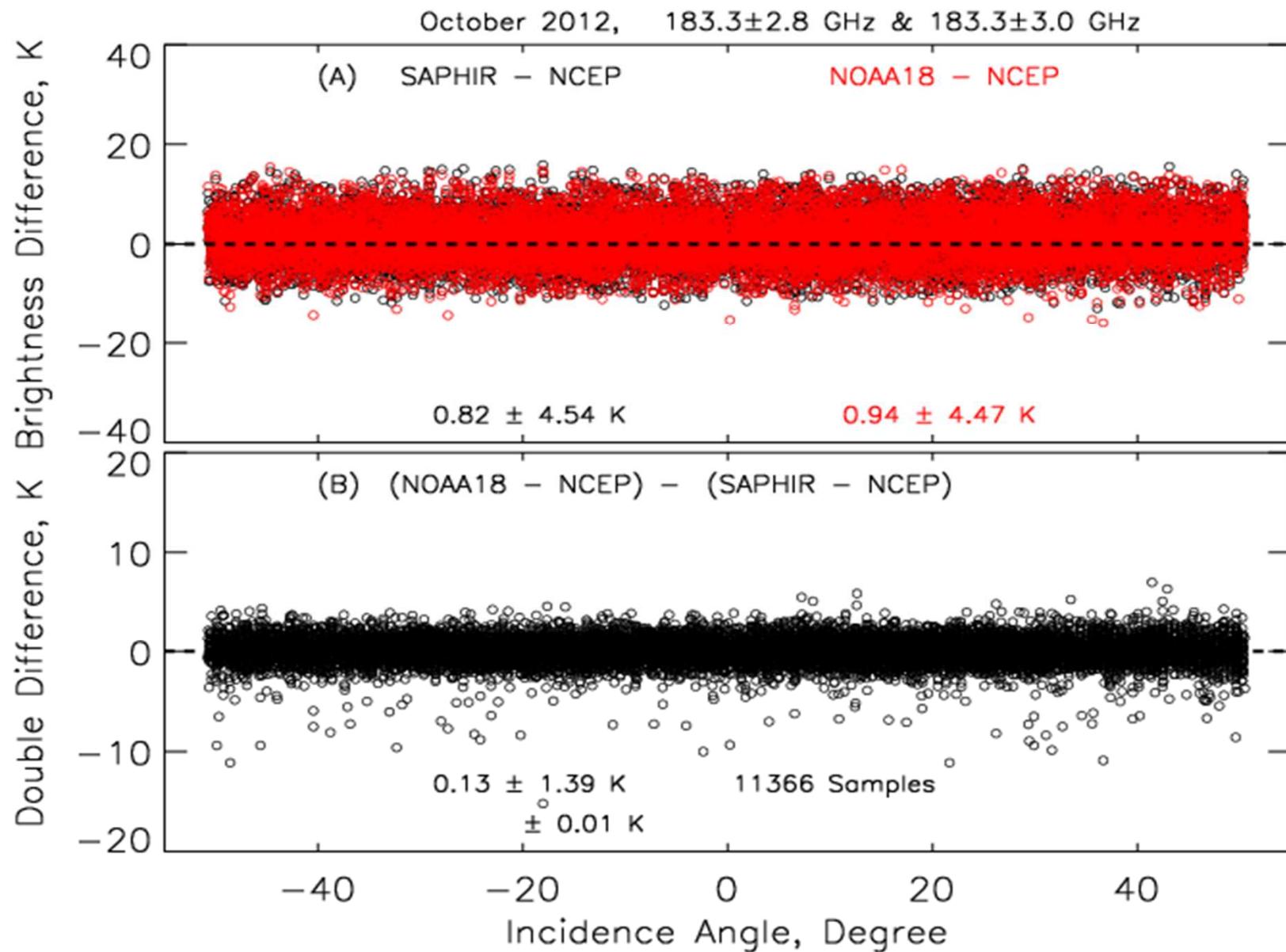
A Brief Summary of Double Difference Results

| Date Month/Year	METOP_A - SAPHIR			NOAA18 - SAPHIR		
	183.3±1	183.3±3	190.3	183.3±1	183.3±3	190.3
07/2012	0.10 ± 1.48	0.07 ± 1.30	0.58 ± 1.32	0.04 ± 1.51	0.12 ± 1.39	0.18 ± 1.48
	± 0.02	± 0.02	± 0.02	± 0.02	± 0.01	± 0.02
08/2012	0.05 ± 1.47	0.00 ± 1.32	0.50 ± 1.32	0.02 ± 1.57	0.15 ± 1.42	0.17 ± 1.47
	± 0.02	± 0.02	± 0.02	± 0.01	± 0.01	± 0.01
09/2012	-0.00 ± 1.48	0.04 ± 1.33	0.54 ± 1.31	-0.05 ± 1.56	0.07 ± 1.44	0.10 ± 1.54
	± 0.02	± 0.02	± 0.02	± 0.02	± 0.01	± 0.02
10/2012	0.02 ± 1.46	0.00 ± 1.31	0.57 ± 1.30	0.03 ± 1.52	0.13 ± 1.39	0.15 ± 1.51
	± 0.02	± 0.02	± 0.02	± 0.01	± 0.01	± 0.01
11/2012	0.06 ± 1.62	-0.07 ± 1.38	0.57 ± 1.31	-0.02 ± 1.56	0.05 ± 1.40	0.03 ± 1.60
	± 0.02	± 0.02	± 0.02	± 0.02	± 0.01	± 0.02
12/2012	0.08 ± 1.52	-0.03 ± 1.31	0.58 ± 1.20	0.03 ± 1.56	0.08 ± 1.43	0.34 ± 1.42
	± 0.02	± 0.02	± 0.01	± 0.01	± 0.01	± 0.01
01/2013	0.13 ± 1.53	-0.04 ± 1.32	0.64 ± 1.22	0.05 ± 1.55	0.12 ± 1.33	0.46 ± 1.18
	± 0.03	± 0.03	± 0.02	± 0.02	± 0.02	± 0.02
02/2013	0.10 ± 1.43	0.00 ± 1.24	0.63 ± 1.39	-0.01 ± 1.37	0.02 ± 1.25	0.32 ± 1.17
	± 0.07	± 0.06	± 0.05	± 0.05	± 0.04	± 0.04
03/2013	-0.09 ± 1.43	-0.07 ± 1.31	0.57 ± 1.15	-0.01 ± 1.44	-0.01 ± 1.17	0.43 ± 1.00
	± 0.06	± 0.06	± 0.05	± 0.06	± 0.05	± 0.04

Retrieval Method

- **Physical Iterative Technique (16 iterations max.)**

- **Using the SAPHIR 6-Channel T_bs from the Co-located Data Sets Above as Input to Estimate Humidity Profiles.**

- **NCEP Relative Humidity Profiles as Initial Guess; Keeping Temperature & Pressure Profiles Fixed.**

- **Convergent Condition:** $\varepsilon = \sqrt{\sum_{i=1}^{i=n} (T_{bm}^i - T_{bc}^i)^2 / (n-1)}$ **≤ 1 K,**

  where n = 6, and T_{bm} and T_{bc} are the measured and calculated T_bs

- **Using the Retrieved Humidity Profiles and Original Temperature and Pressure Profiles to Predict the MHS T_bs.**

- **Compare the Measured and Predicted MHS T_bs & Obtain Biases.**

# Retrieval Flow Chart

Retrieval Statistics

Megha. SAPHIR Retrieval Stat.   August 2012

Observed & Calculated Tbs   August 2012
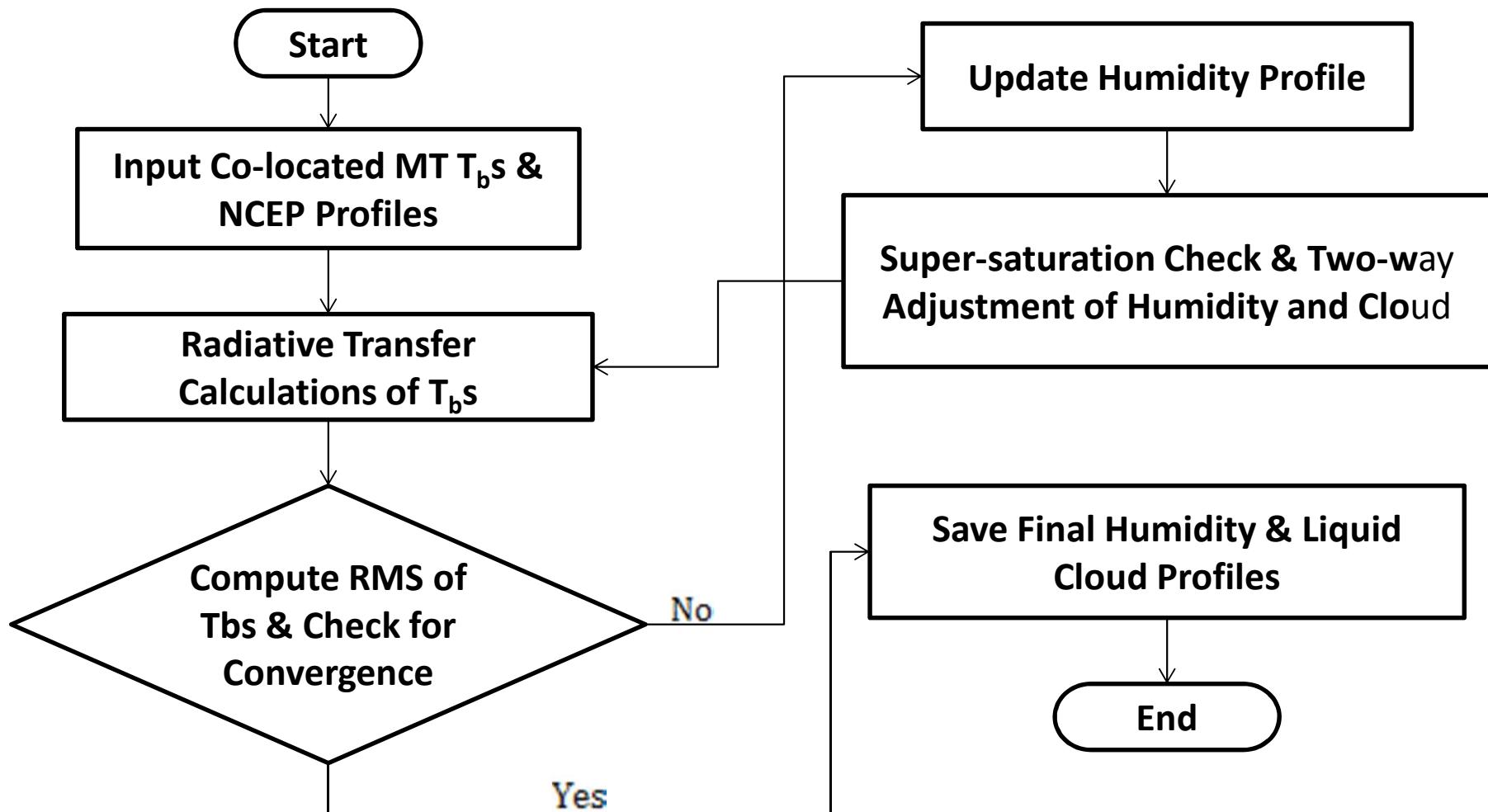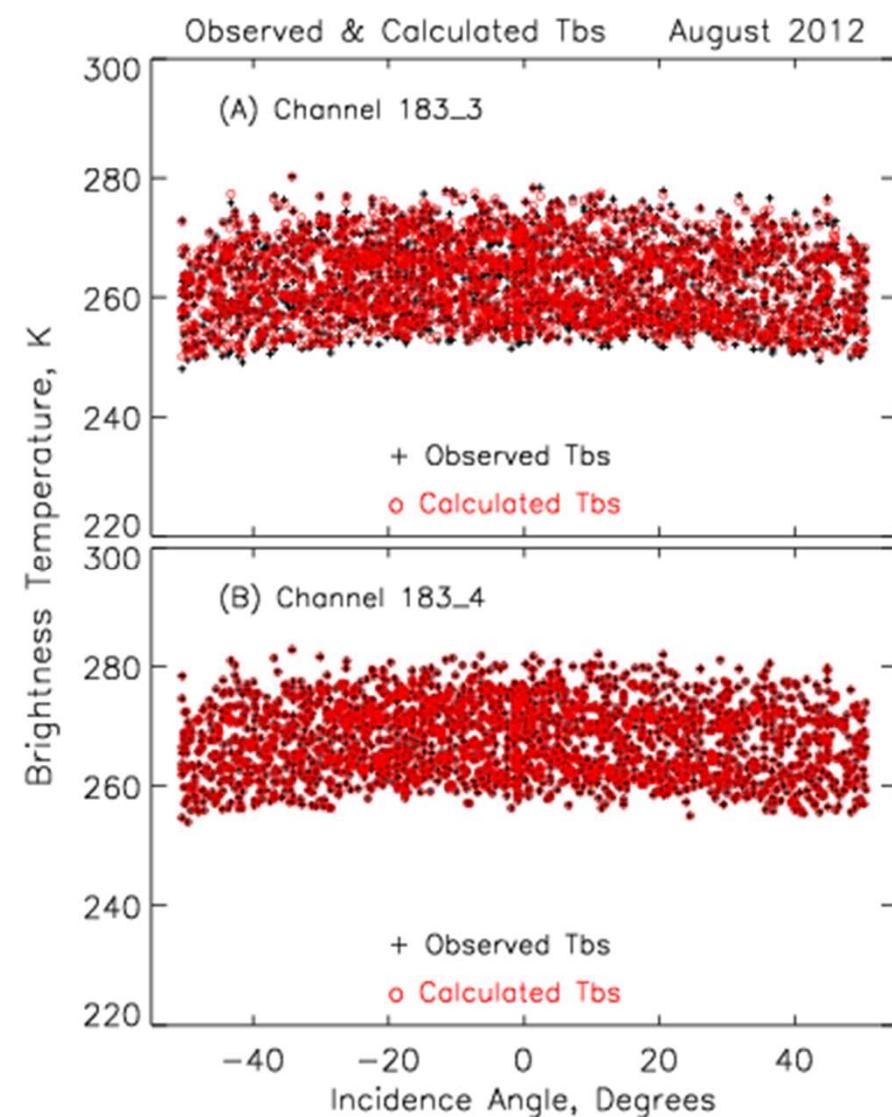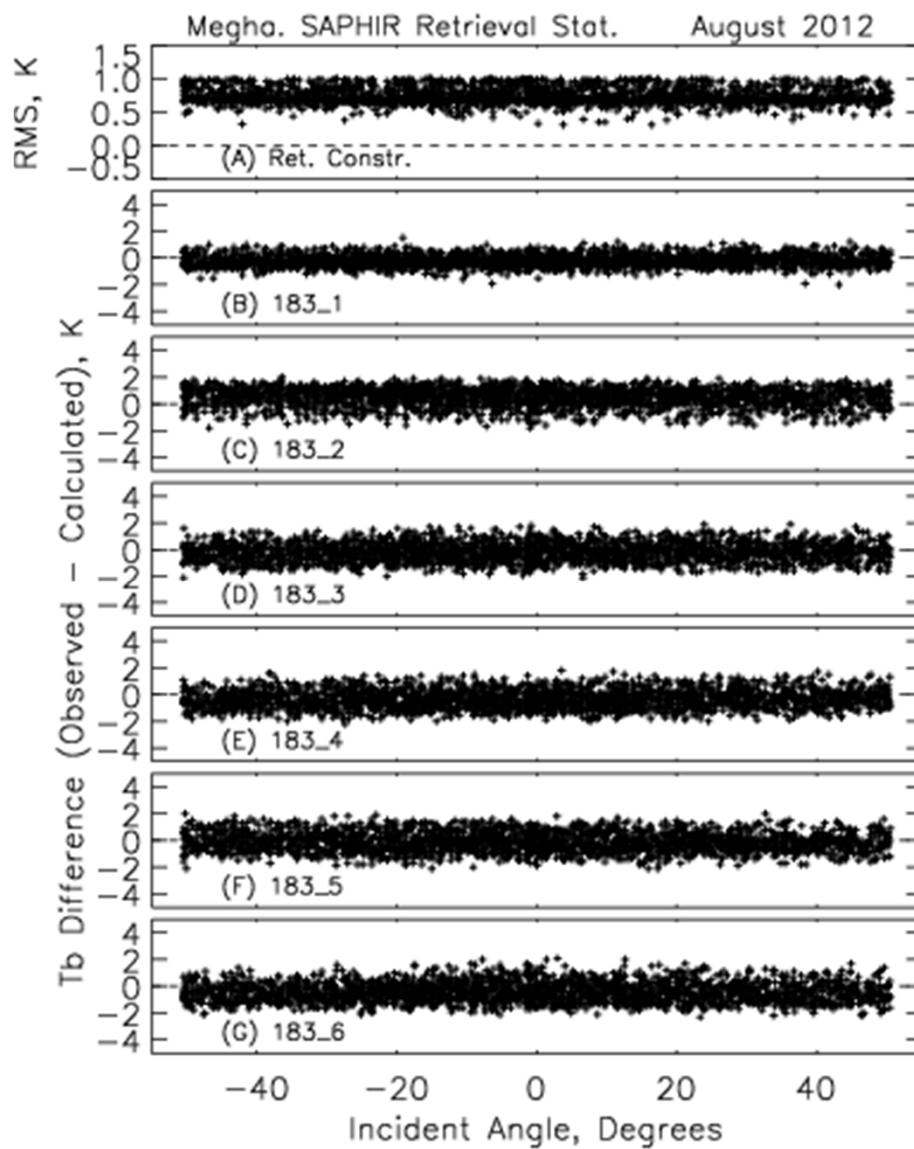
Predicted METOPA Tbs Using Retrieved Humidity Profiles (ε ≤ 1 K)
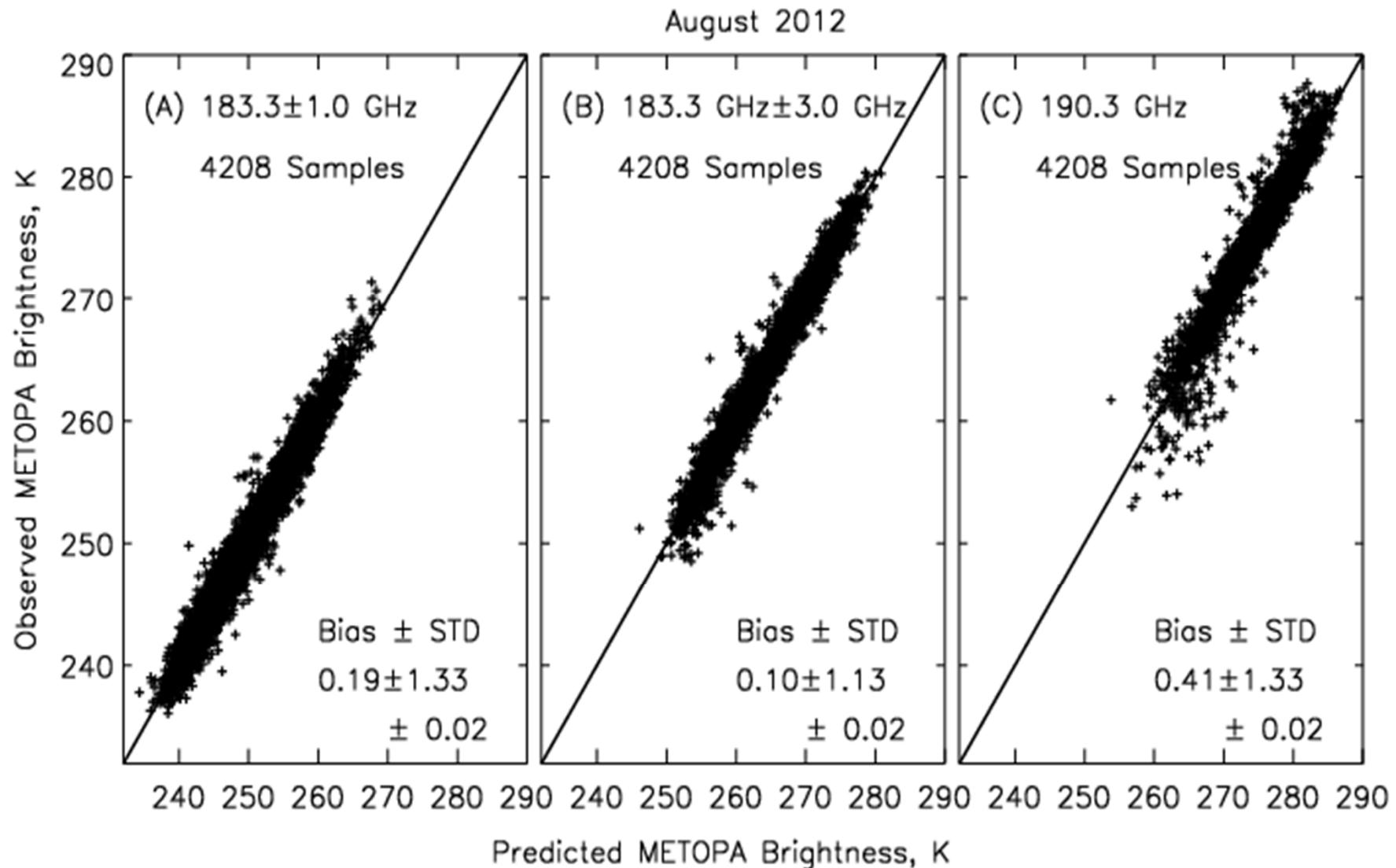
August 2012

(A) 183.3±1.0 GHz
4208 Samples
Bias ± STD
0.19±1.33
± 0.02

(B) 183.3 GHz±3.0 GHz
4208 Samples
Bias ± STD
0.10±1.13
± 0.02

(C) 190.3 GHz
4208 Samples
Bias ± STD
0.41±1.33
± 0.02

Observed METOPA Brightness, K

Predicted METOPA Brightness, K

Predicted NOAA18 T_bs Using Retreved Humidity Profiles ($\varepsilon \leq 1$ K)

October 2012

(A) 183.3±1.0 GHz — 8232 Samples — Bias ± STD 0.27±1.39 ± 0.02

(B) 183.3 GHz±3.0 GHz — 8232 Samples — Bias ± STD 0.26±1.18 ± 0.01

(C) 190.3 GHz — 8232 Samples — Bias ± STD 0.02±1.45 ± 0.02

Observed NOAA18 Brightness, K

Predicted NOAA18 Brightness, K
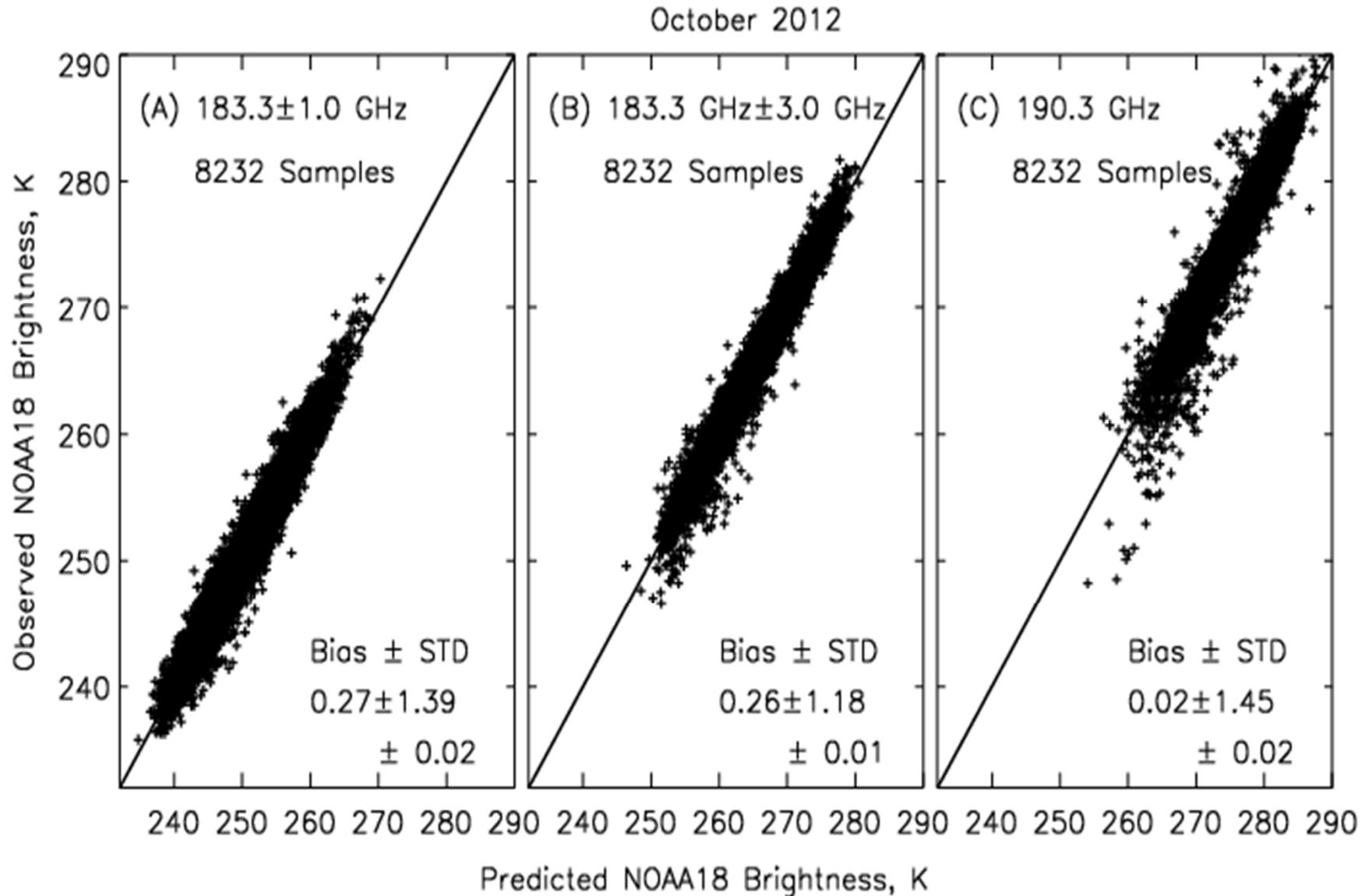
Predicted NOAA18 T$_b$s Using Retreved Humidity Profiles ($\varepsilon \leq 1$ K) (Comparison of Different Sampling Strategies)

March 2013

(A) 183.3±1.0 GHz
419 Samples
Bias ± STD
0.17±1.22
± 0.06

Dist ≤ 5 km
3190 Samples
Bias ± STD
0.17±1.20
± 0.02

(B) 183.3 GHz±3.0 GHz
419 Samples
Bias ± STD
0.06±0.97
± 0.05

Dist ≤ 5 km
3190 Samples
Bias ± STD
0.14±0.98
± 0.02

(C) 190.3 GHz
419 Samples
Bias ± STD
0.28±1.09
± 0.05

Dist ≤ 5 km
3190 Samples
Bias ± STD
0.28±1.11
± 0.02

Observed METOP2 Brightness, K

Predicted METOP2 Brightness, K
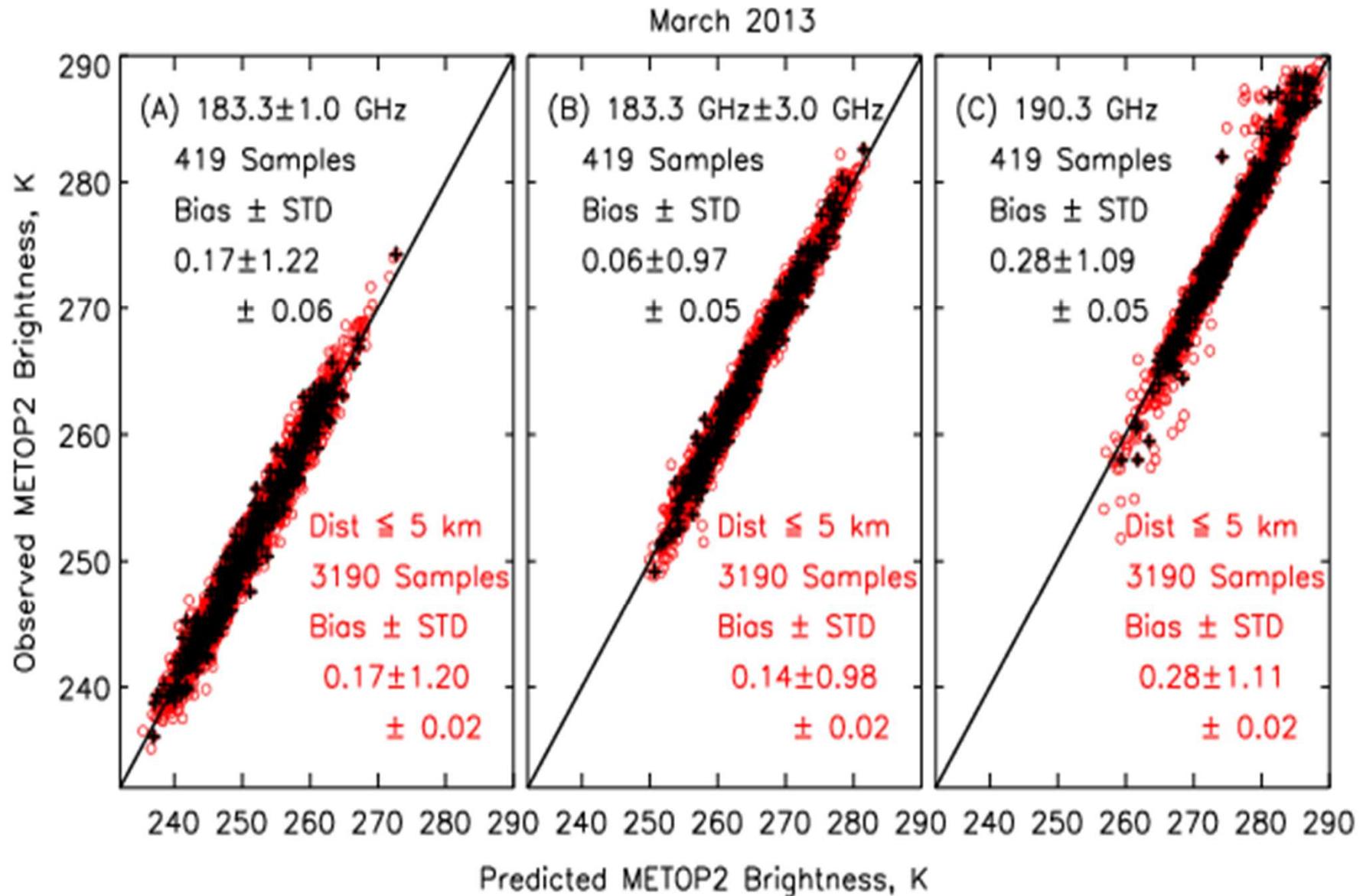
Comparison of NCEP & Retrieved RH Profiles

October 2012
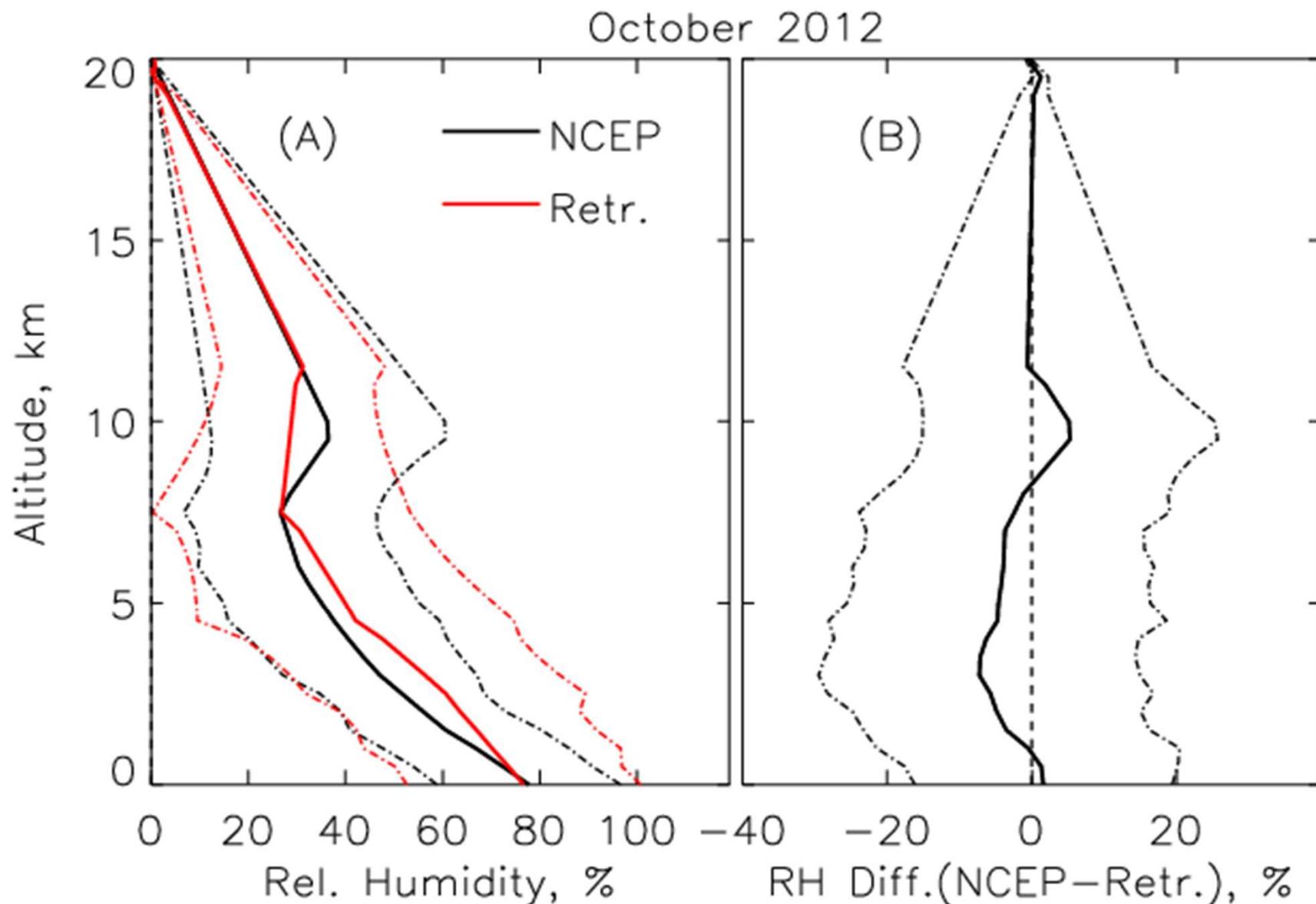
Distribution of Retrieval RMS (Year 2012-13)

(A) Megha & METOP_A
41739 Total Samples

(B) Megha & NOAA18
75921 Total Samples

Number of Samples

Megha Retrieval RMS, K
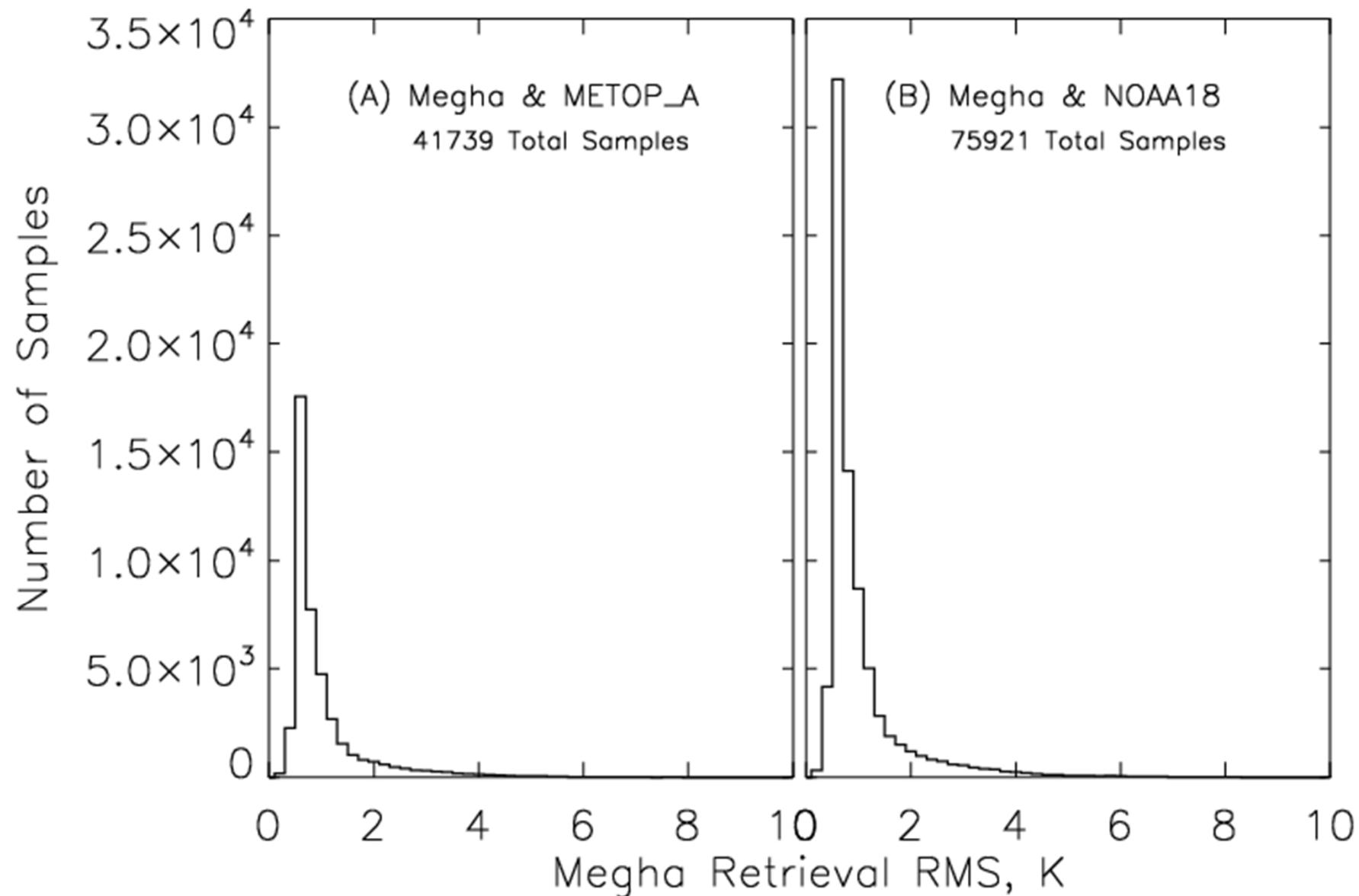
Spatial Distribution of Retrieval Pixels

Distrubution of Retrieval Samples (August 2012)
o All Samples   o RMS ≤ 1 K
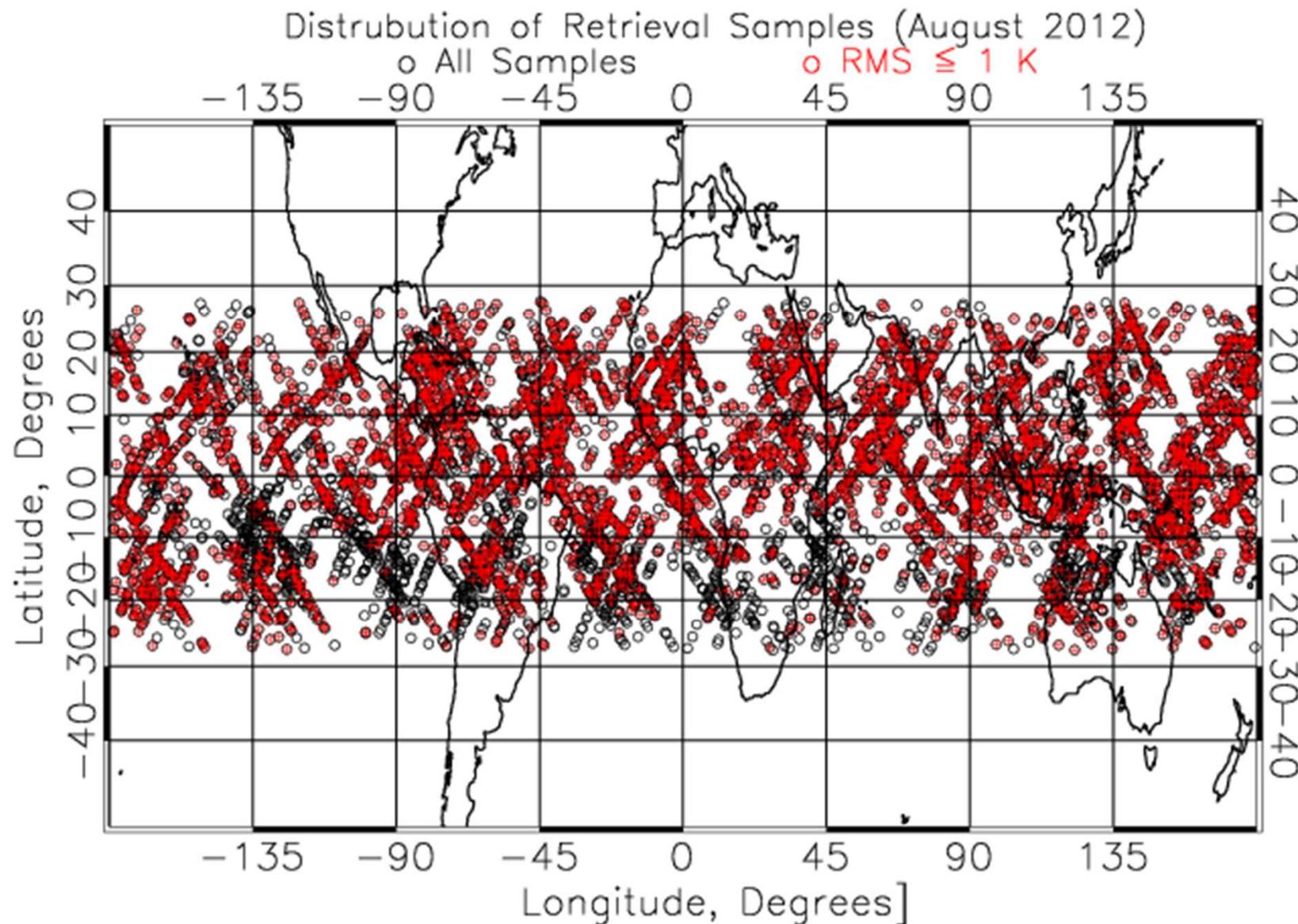
Summary of Biases Derived From Retrieval Method
($\varepsilon \leq 1$ K)

Date Month/Year	METOP_A - SAPHIR			NOAA18 - SAPHIR		
	183.3±1	183.3±3	190.3	183.3±1	193.3±3	190.3
07/2012	0.21 ± 1.34	0.07 ± 1.13	0.46 ± 1.36	0.20 ± 1.40	0.21 ± 1.19	0.08 ± 1.37
	± 0.02	± 0.02	± 0.03	± 0.02	± 0.01	± 0.02
08/2012	0.19 ± 1.33	0.10 ± 1.13	0.41 ± 1.33	0.24 ± 1.45	0.23 ± 1.22	0.09 ± 1.46
	± 0.02	± 0.02	± 0.02	± 0.02	± 0.01	± 0.02
09/2012	0.25 ± 1.35	0.09 ± 1.17	0.29 ± 1.37	0.17 ± 1.42	0.17 ± 1.21	-0.01 ± 1.40
	± 0.02	± 0.02	± 0.02	± 0.02	± 0.01	± 0.02
10/2012	0.23 ± 1.34	0.07 ± 1.16	0.35 ± 1.38	0.27 ± 1.39	0.26 ± 1.18	0.02 ± 1.45
	± 0.03	± 0.02	± 0.02	± 0.02	± 0.01	± 0.02
11/2012	0.15 ± 1.51	0.07 ± 1.24	0.41 ± 1.36	0.22 ± 1.42	0.17 ± 1.20	-0.08 ± 1.56
	± 0.02	± 0.02	± 0.02	± 0.02	± 0.01	± 0.02
12/2012	0.24 ± 1.38	0.07 ± 1.18	0.42 ± 1.29	0.18 ± 1.39	0.21 ± 1.19	0.28 ± 1.34
	± 0.03	± 0.02	± 0.02	± 0.02	± 0.01	± 0.01
01/2013	0.24 ± 1.34	0.08 ± 1.18	0.38 ± 1.28	0.09 ± 1.40	0.37 ±1.18	0.57 ± 1.37
	± 0.03	± 0.03	± 0.03	± 0.03	± 0.02	± 0.03
02/2013	0.15 ± 1.22	0.11 ± 1.10	0.45 ± 1.22	0.14 ± 1.25	0.19 ± 0.94	0.07 ± 1.09
	± 0.07	± 0.06	± 0.07	±0.05	± 0.04	± 0.05
03/2013	0.20 ± 1.28	-0.10 ± 1.17	0.29 ± 1.31	0.17 ± 1.22	0.06 ± 0.97	0.28 ± 1.09
	± 0.07	± 0.06	± 0.07	± 0.06	± 0.05	± 0.05

Double Difference Using Retrieved Humidity Profiles
(Example of widely separated frequencies)

August 2012,   183.3±2.8 GHz & 190.3 GHz

(A)   ○ SAPHIR − RevNCEP   METOPA − RevNCEP

0.003 ± 0.74 K   0.32 ± 1.44 K

(B) (METOPA − RevNCEP) − (SAPHIR − RevNCEP)

0.32 ± 1.66 K   4159 samples

± 0.03 K
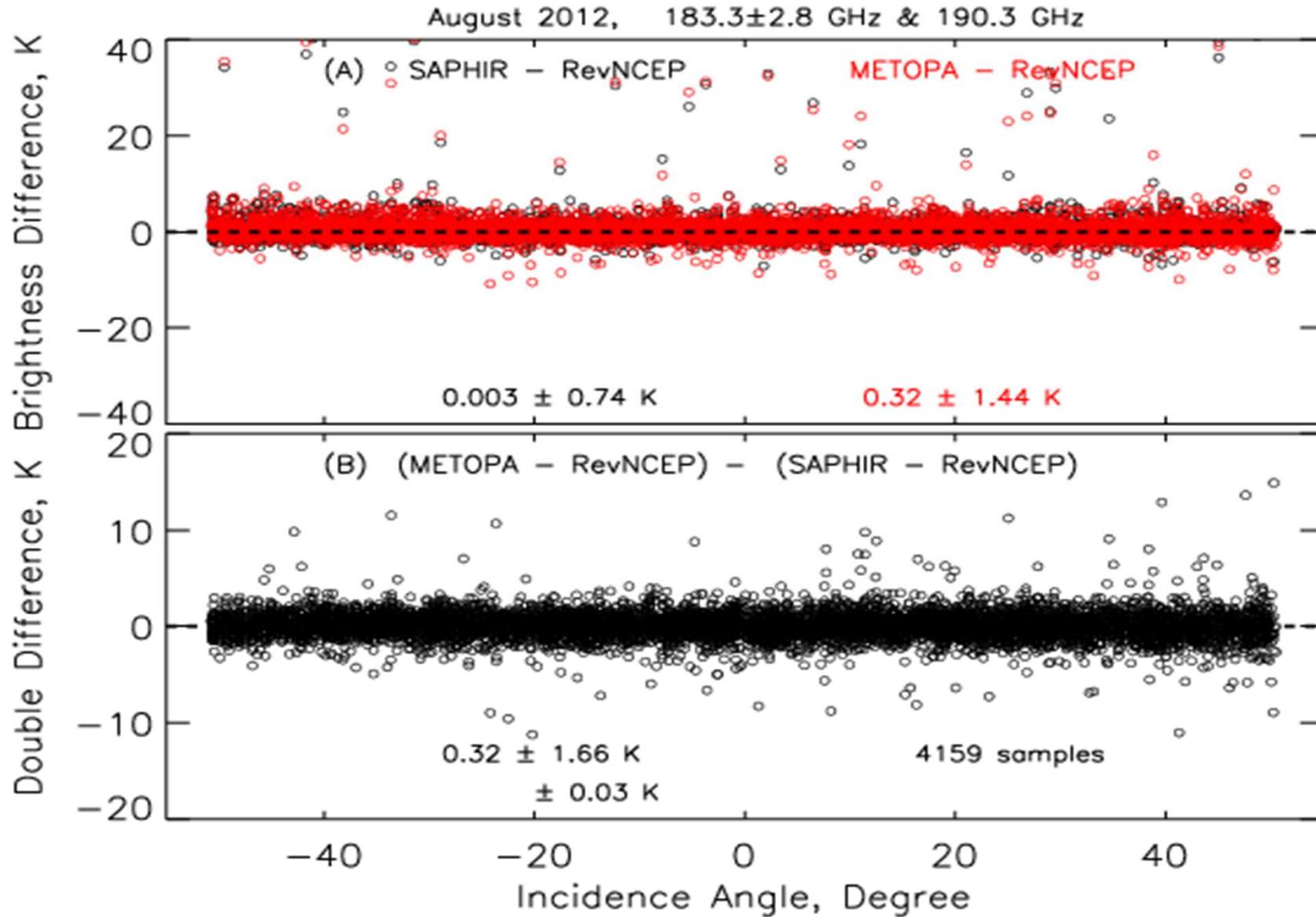
Double Difference Using NCEP Profiles for the Same Pair of Channels

August 2012,   183.3±2.8 GHz & 190.3 GHz
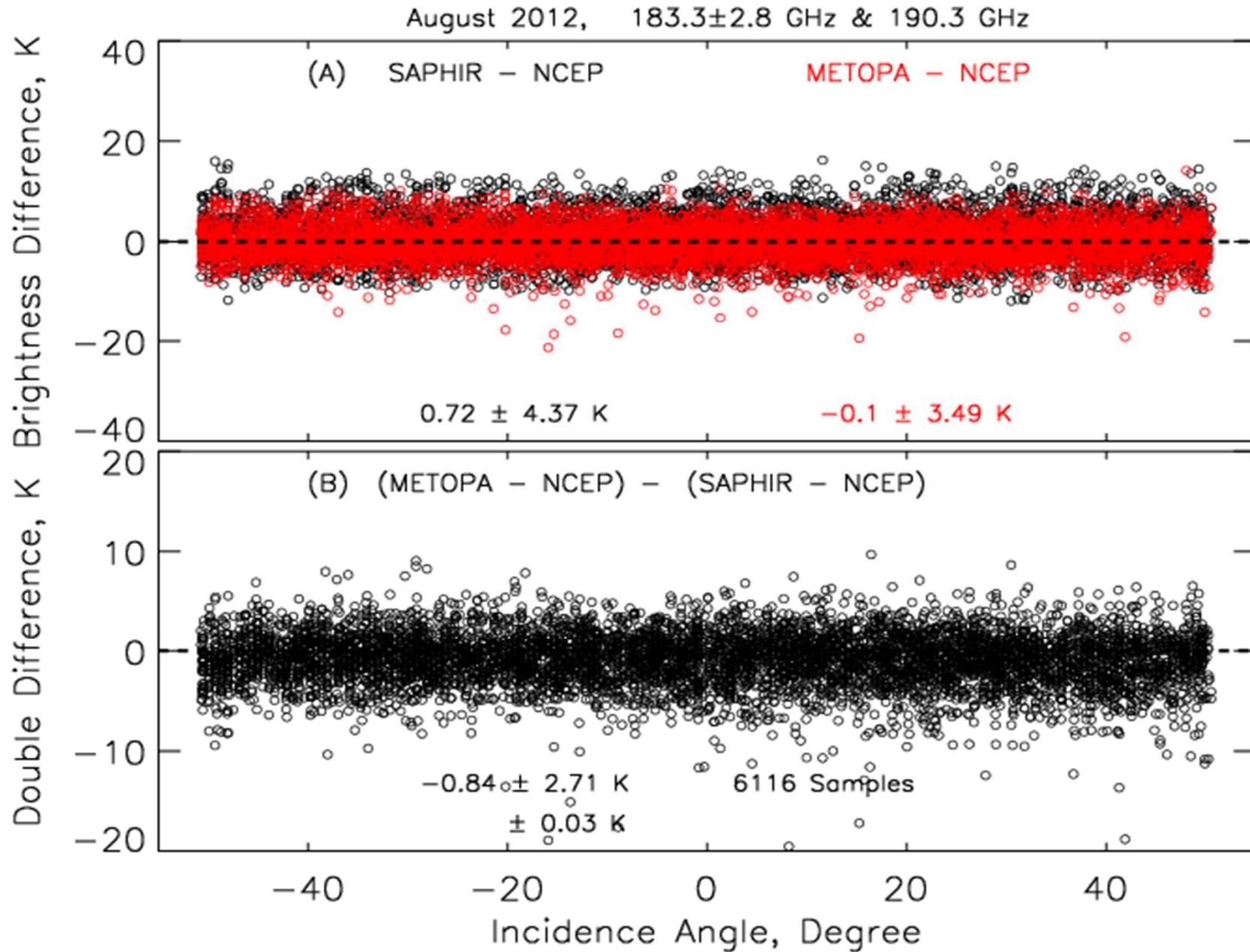
Comparison of DD Methods Using NCEP & Revised NCEP Profiles
(SAPHIR & METOPA, August 2012)

Summary of Biases (DD & Ret.)

+ DD (METOPA)   o DD (NOAA18)   + Ret. (METOPA)   o Ret. (NOAA18)

(A) 183.3±1.0 GHz

(B) 183.3±3.0 GHz

(C) 190.3 GHz

Bias (MHS – SAPHIR), K

7   8   9   10   11   12   1   2   3

2012   2013
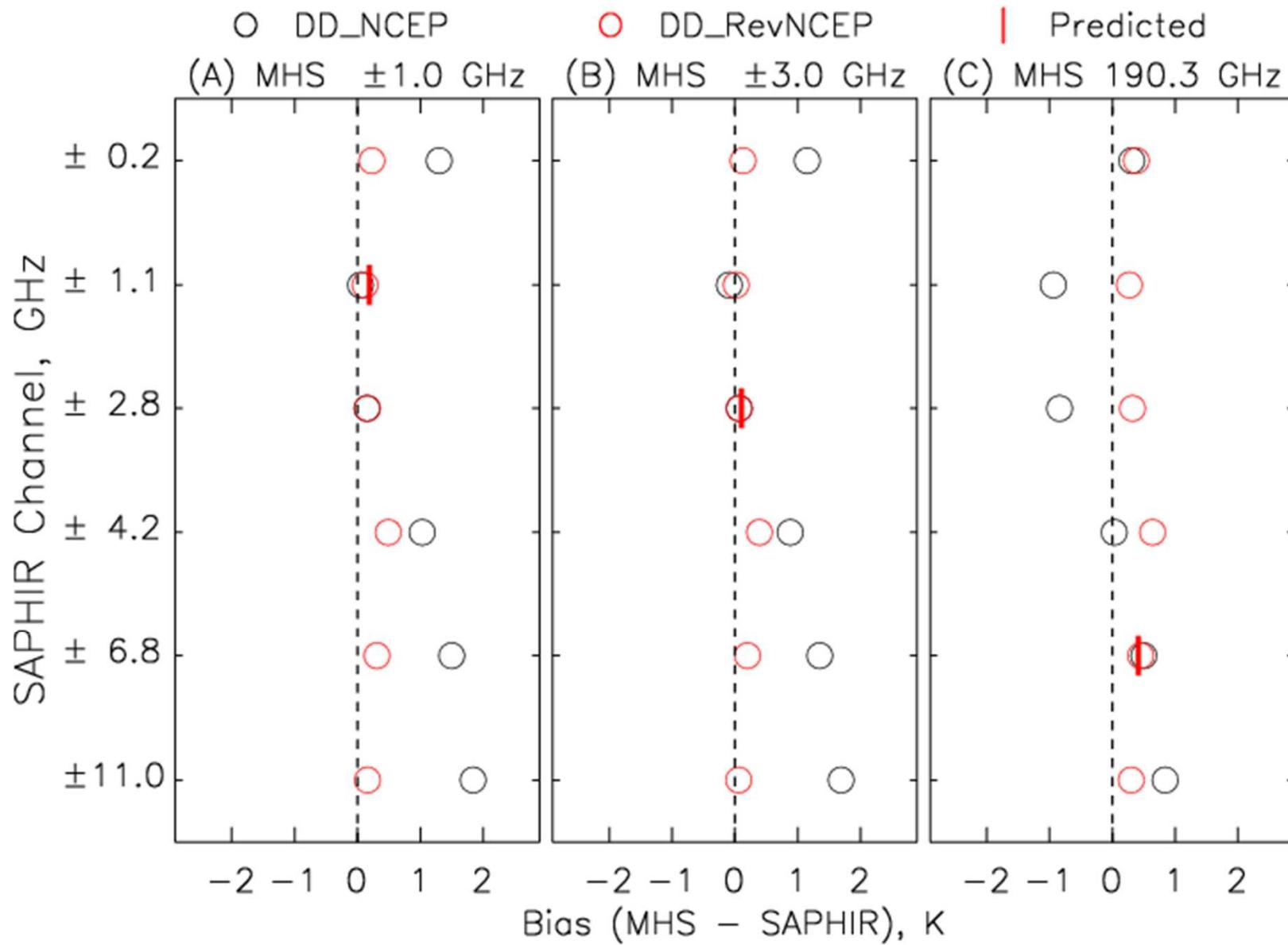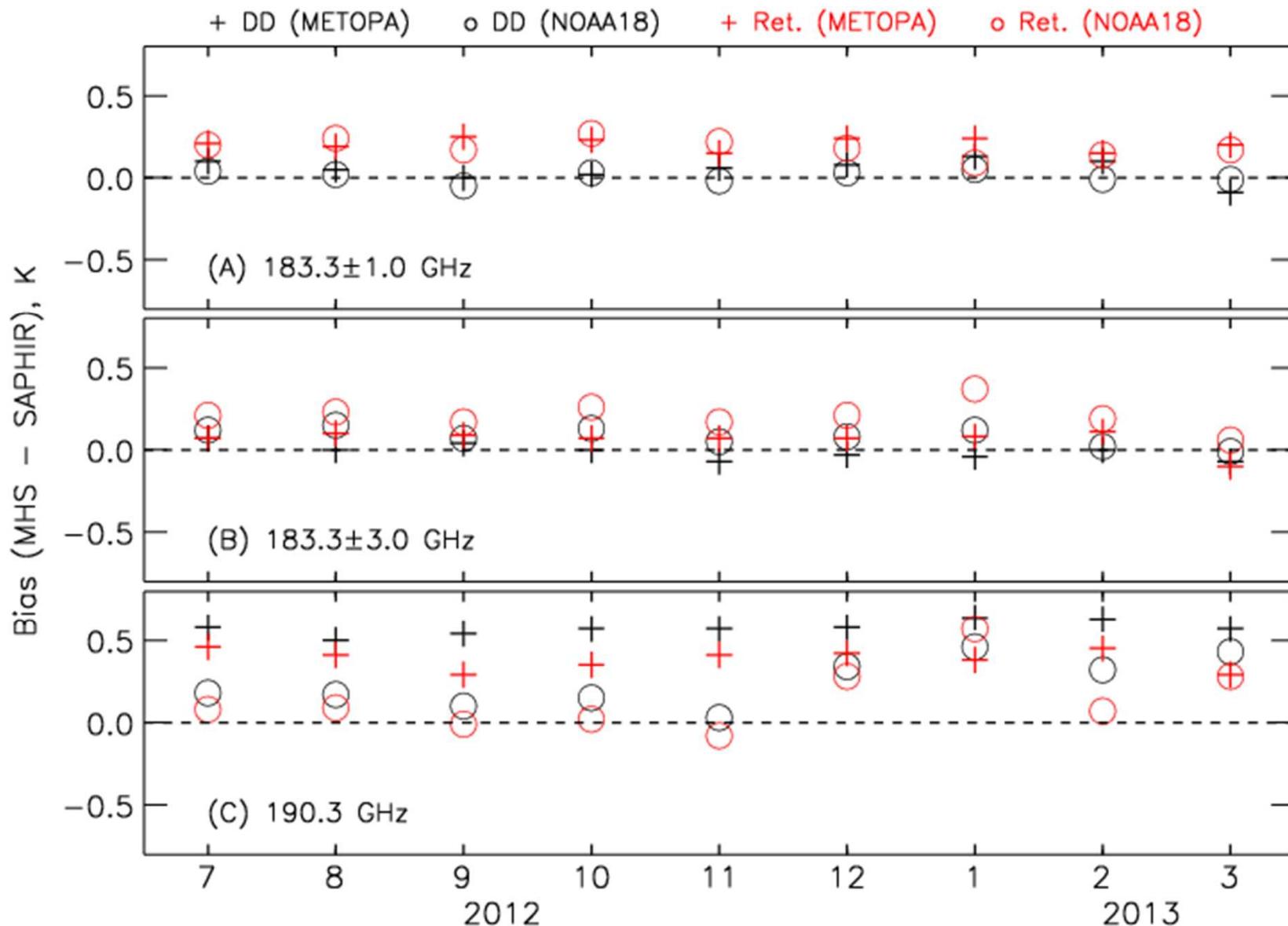
Typical Brightness Diff. Distribution of the Co-located SAPHIR & F17 Pixels

July 2012   SAPHIR & SSMIS_F17 Brightness Difference
Time Diff. ≤ 3 min, ,Dist. ≤ 1 km,   F17(±6.8) & SAPHIR(±6.8) ≥ 240 K

(A) 183.3±1.1 GHz & 183.3±1.0 GHz

o Data(F17−SAPHIR)   o NCEP(F17−SAPHIR)

(B) 183.3±2.8 GHz & 183.3±3.0 GHz

o Data(F17−SAPHIR)   o NCEP(F17−SAPHIR)

(C) 183.3±6.8 GHz & 183.3±6.8 GHz

o Data(F17−SAPHIR)   o NCEP(F17−SAPHIR)

Brightness Difference (F17 − SAPHIR), K

Incidence Angle, Degree
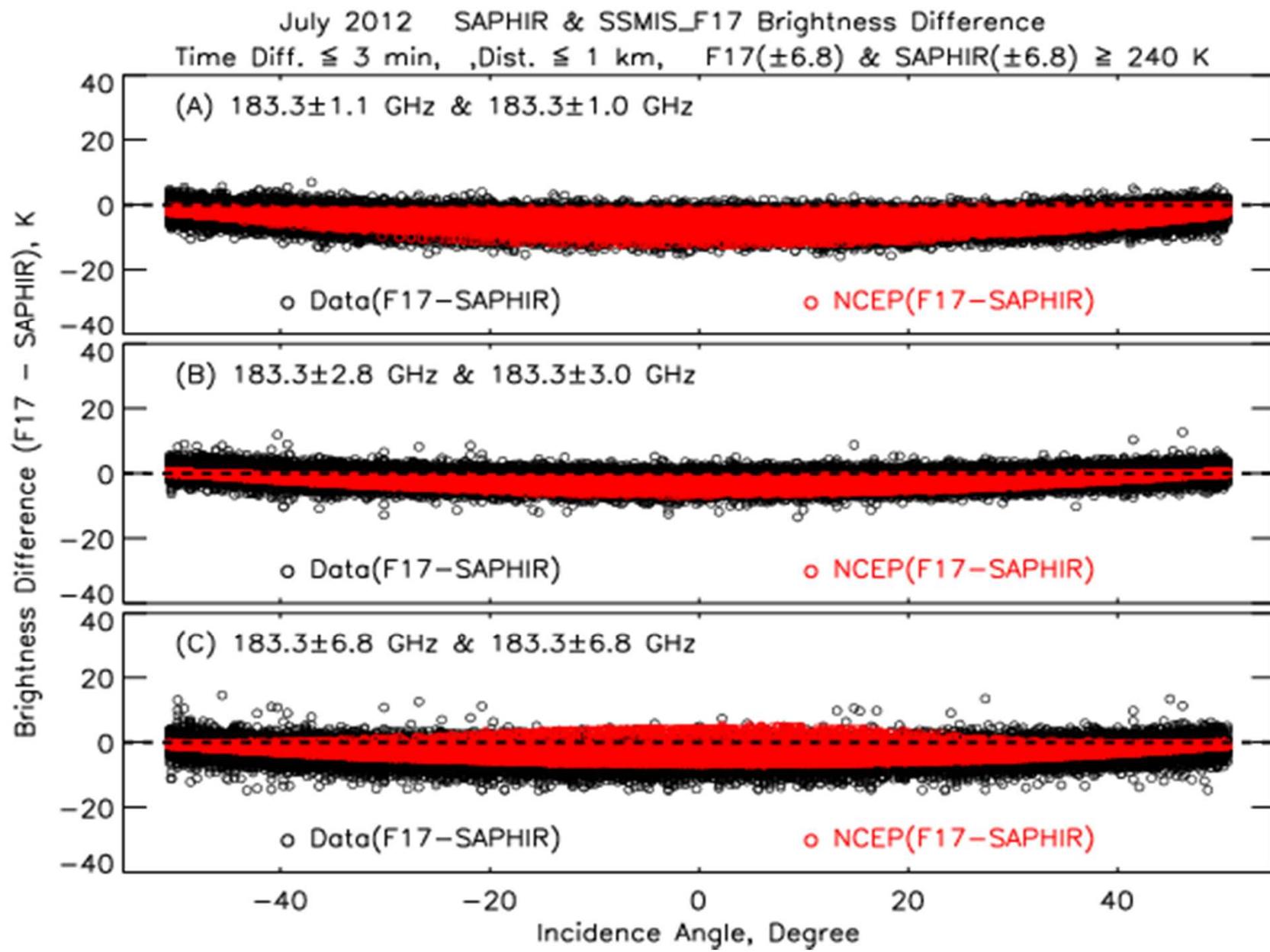
Results of Double Difference Using NCEP Profiles

July 2012, 183.3±2.8 GHz & 183.3±3.0 GHz

(A) F17 – NCEP   SAPHIR – NCEP

1.09 ± 5.60 K   0.29 ± 5.33 K

(B) (F17 – NCEP) – (SAPHIR – NCEP)

0.79 ± 1.99 K   34117 samples

± 0.01 K

Brightness Difference, K

Double Difference, K

Incidence Angle, Degree
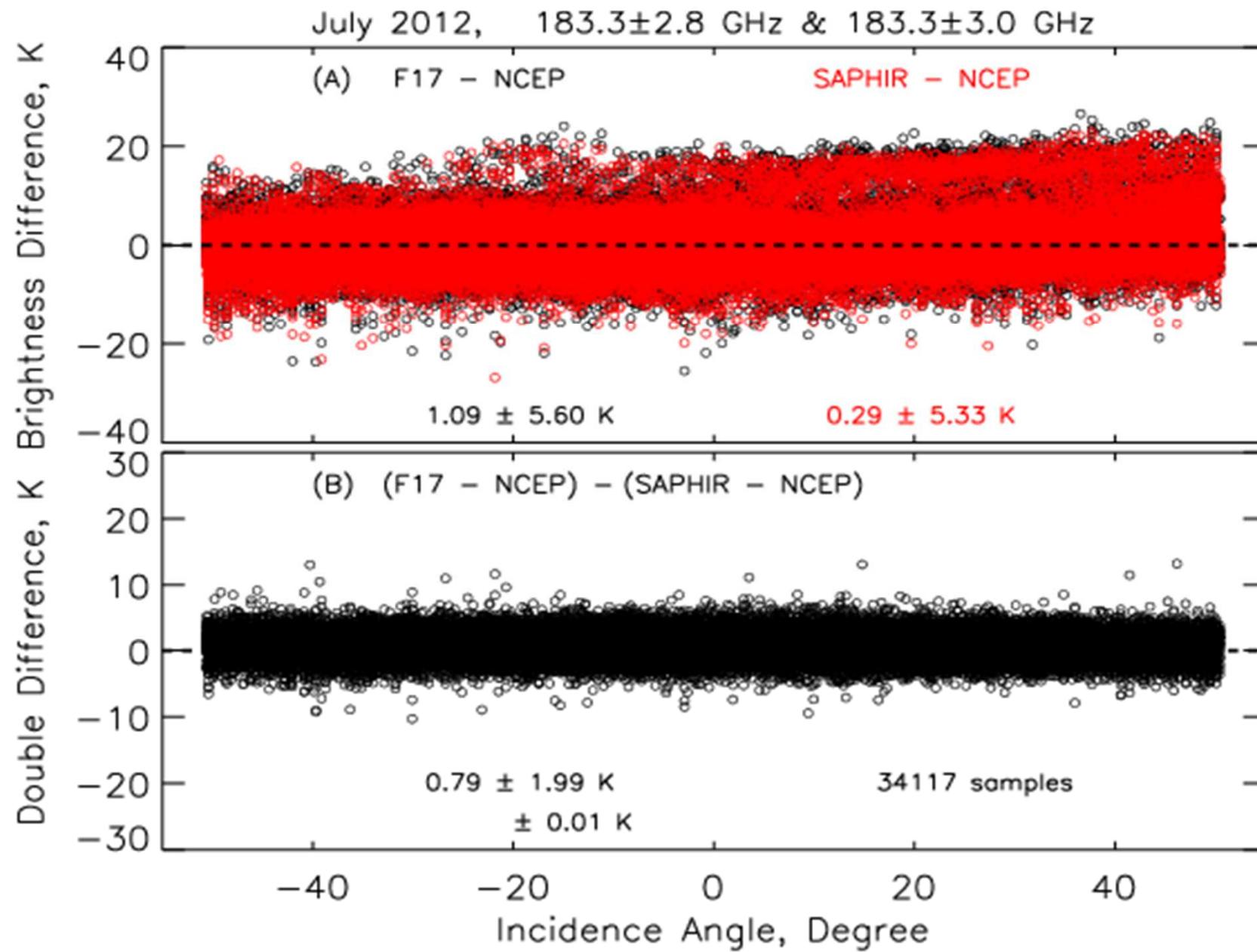
Comparison of the Observed & Predicted F17 T$_b$s

July 2012   F17 – SAPHIR

Comparison of the Observed & Predicted F18 T_bs

August 2012   F18 − SAPHIR

(A) 183.3±1.0 GHz
59287 Samples

Bias ± STD
−0.76±2.59
± 0.01
DD −1.00±2.79

(B) 183.3±3.0 GHz
59287 Samples

Bias ± STD
0.04±2.14
± 0.01
DD 0.22±2.37

(C) 183.3±6.8 GHz
59287 Samples

Bias ± STD
−1.13±2.23
± 0.01
DD −0.61±2.68

Observed SSMIS_F18 Brightness, K

Predicted SSMIS_F18 Brightness, K
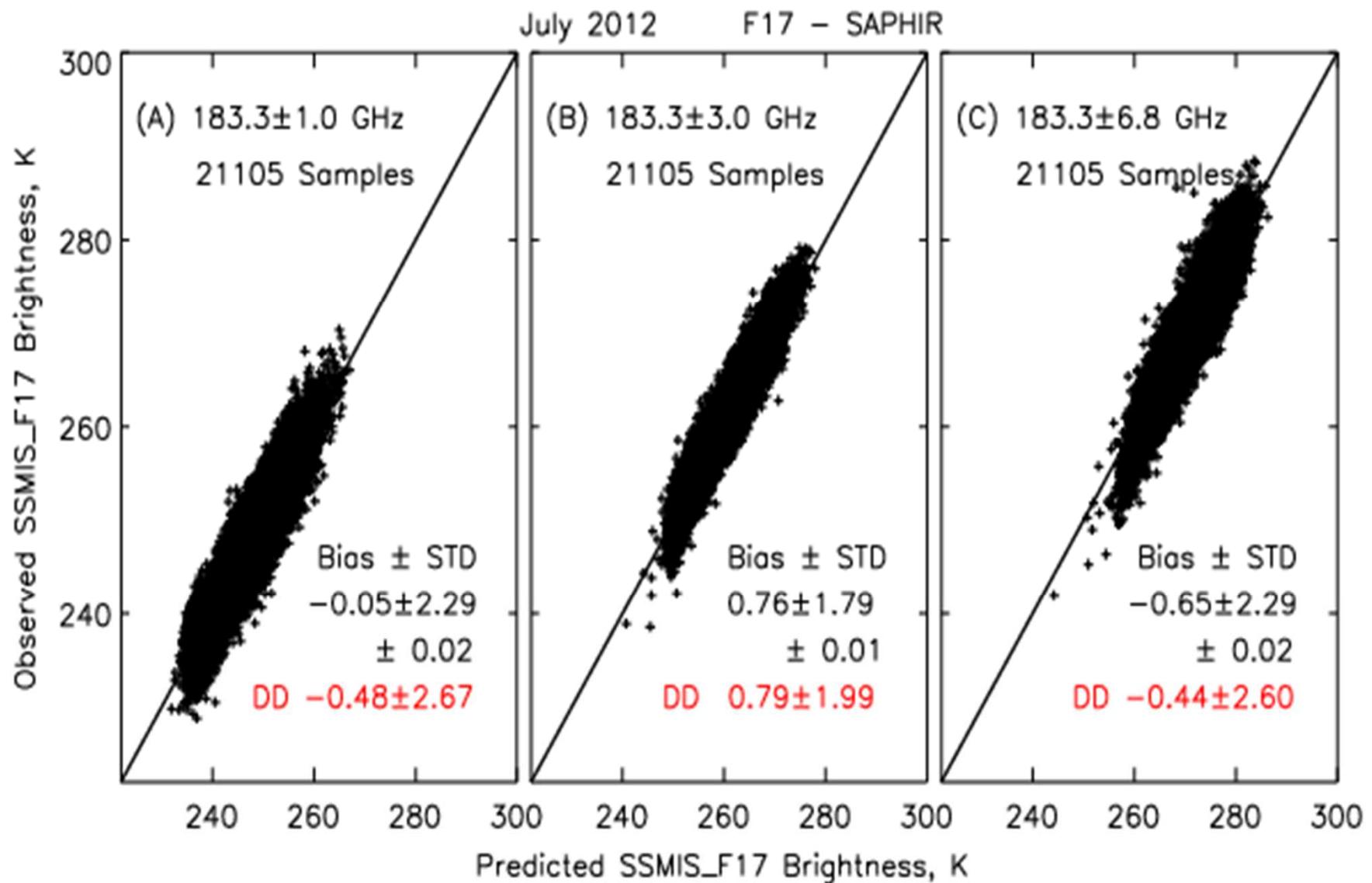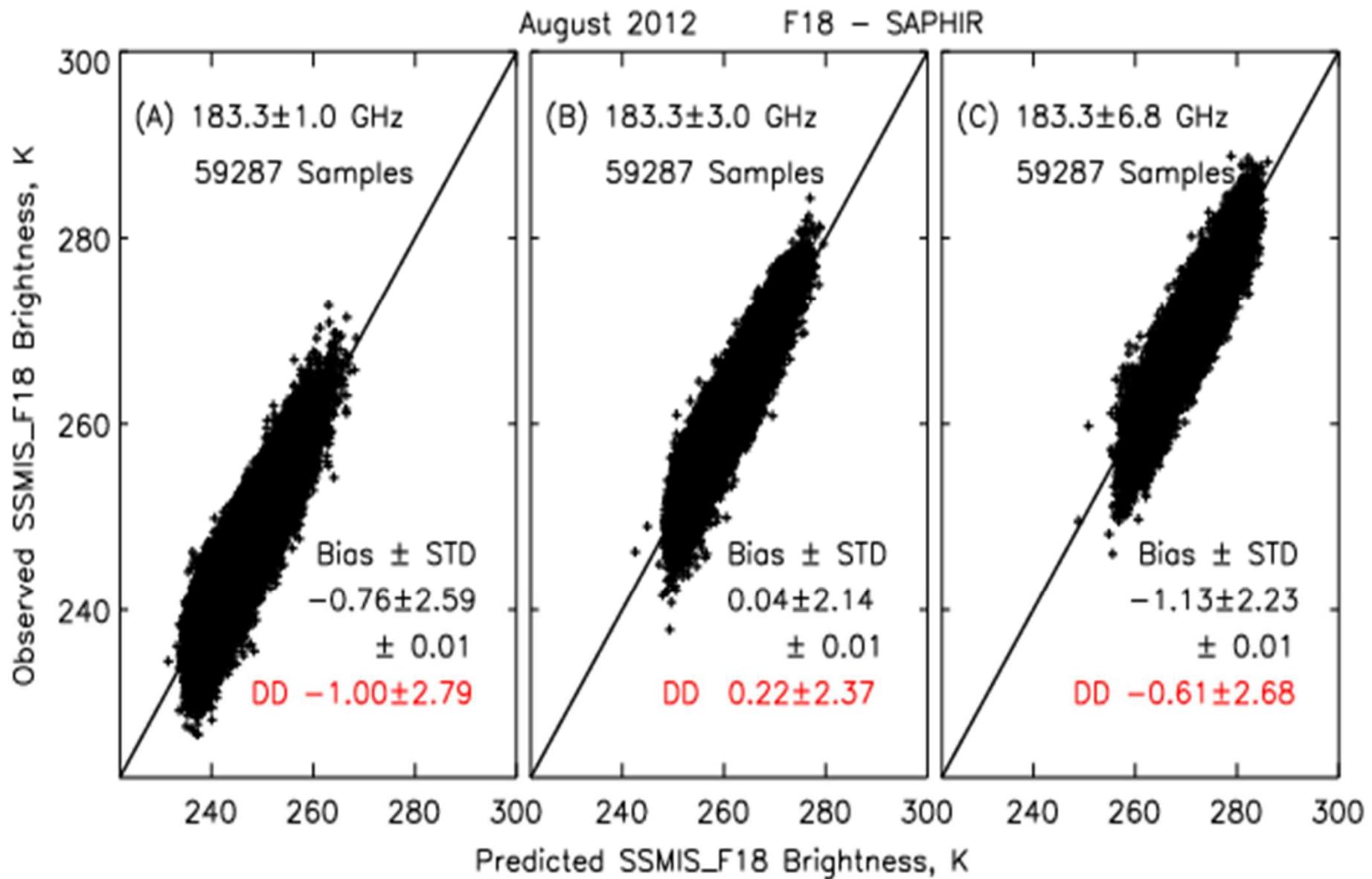
Summary

- The Double Difference Method Gives Results That Are Comparable to Those of Retrieval Approach, When Frequencies Are Close).

- When Retrieval Constraint with RMS ≤ 1 K, the Valid Samples Are Reduced by nearly 40%. When the Constraint is relaxed to RMS ≤ 2 K, the Sample Loss is less than 20%.

- The Biases Between the Measured & Predicted MHS are ≤ 0.5 K for Both METOP_A & NOAA18.

- Spatial Distribution of the Divergent Retrievals Appears to Occur Randomly.

- Preliminary Results of SAPHIR-SSMIS (F17) Comparison give biases of Less Than 1 K Between the two sensors.