Cooperative Institute For Climate & Satellites

AMSU-A Asymmetry for Window Channels

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Characterization

- Comparison with CRTM simulations
- Clear sky over tropical and sub-tropical oceans (30N – 30S)
- Three cloud screening approaches
  - AMSU L2 cloud products
  - PATMOS-x (AVHRR) cloud probability
  - ERA Interim cloud probability
- Stratification with SST, PW and wind speed (Emphasize of this presentation)
- Yearly data: N15 – 2000, 2004, 2008
  N16 – 2008
  N18 – 2008 (*)
  MetOp-A – 2008

Possible Causes

- Antenna pointing angle error
- Bias in polarization vector orientation
- Sidelobe effects and other hardware configuration problem
- Asymmetric atmosphere and surface

Correction (next step)

- Integrate the results from geolocation correction and stratification results
- Correct pointing angle error and bias in polarization vector orientation

Literature Review

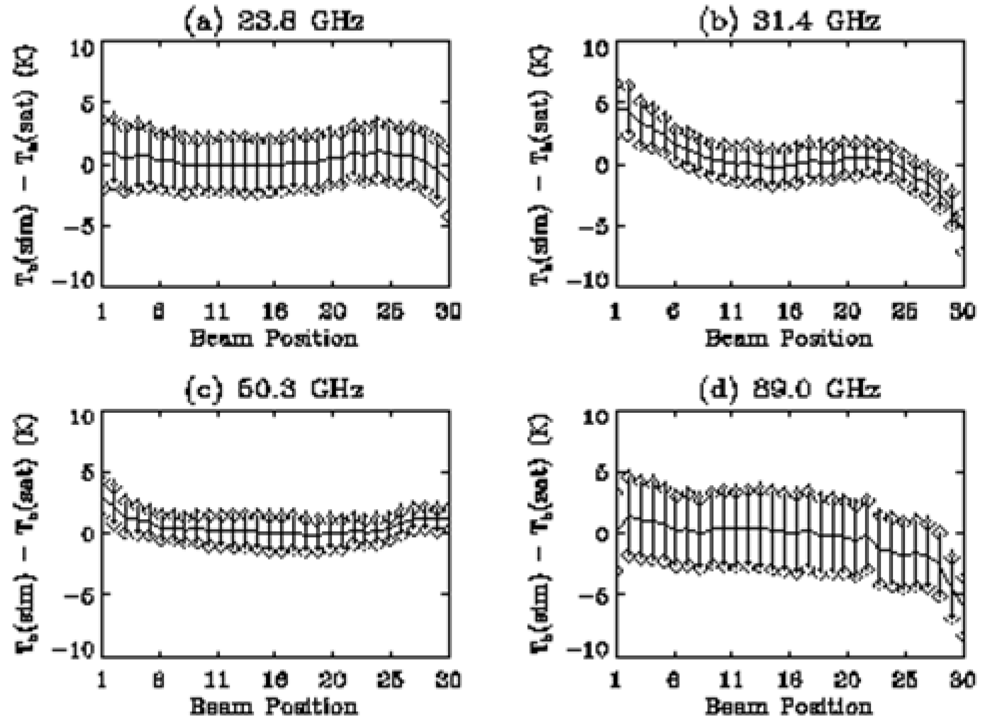


Figure 1. Mean biases of simulated brightness temperatures from observed temperatures versus beam positions under clear atmosphere over oceans at (a) 23.8 GHz, (b) 31.4 GHz, (3) 50.3 GHz, and (d) 89 GHz. Note that beam positions 1–30 correspond to the ranging of the scan angle of −47.85°–47.85° with an increment of 3.3°. The vertical bars show the standard deviation of the biases corresponding to each beam position.

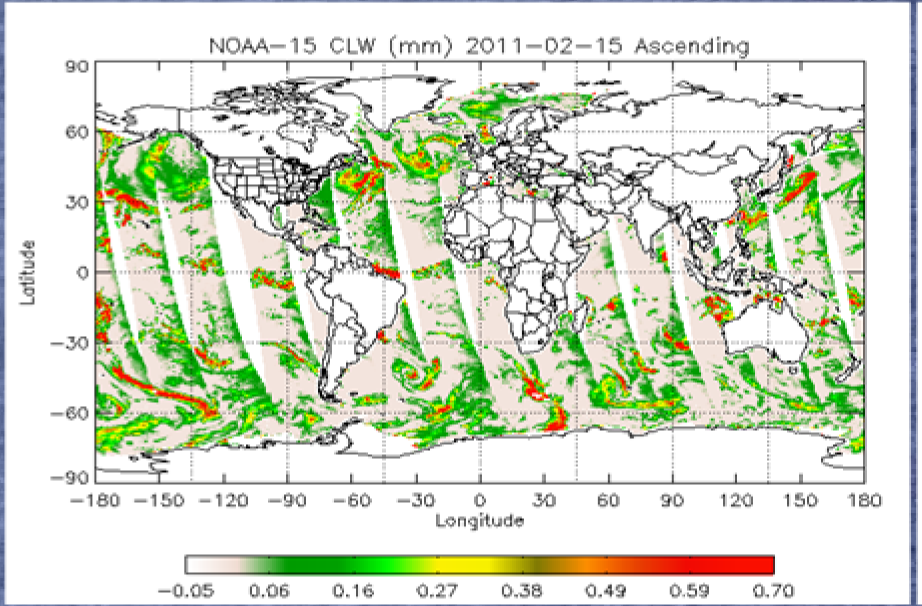
$$I = A^2(\theta,\psi,\varphi)I_h + B^2(\theta,\psi,\varphi)I_v,$$

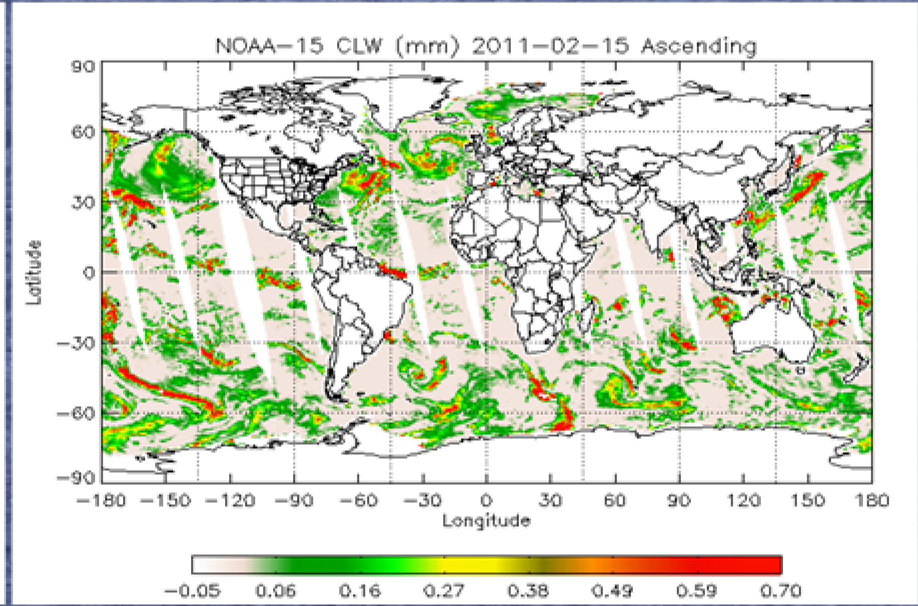
First addressed in Weng et al. (2000) and Weng et al. (2003)

Attribute to
Polarization misalignment or
Antenna pointing angle error

- θ – Antenna Reflector Normal Angle
- ψ – Polarization Alignment Angle
- φ – Sensor Scan Angle

Impact of AMSU-A Tb Asymmetry on Products

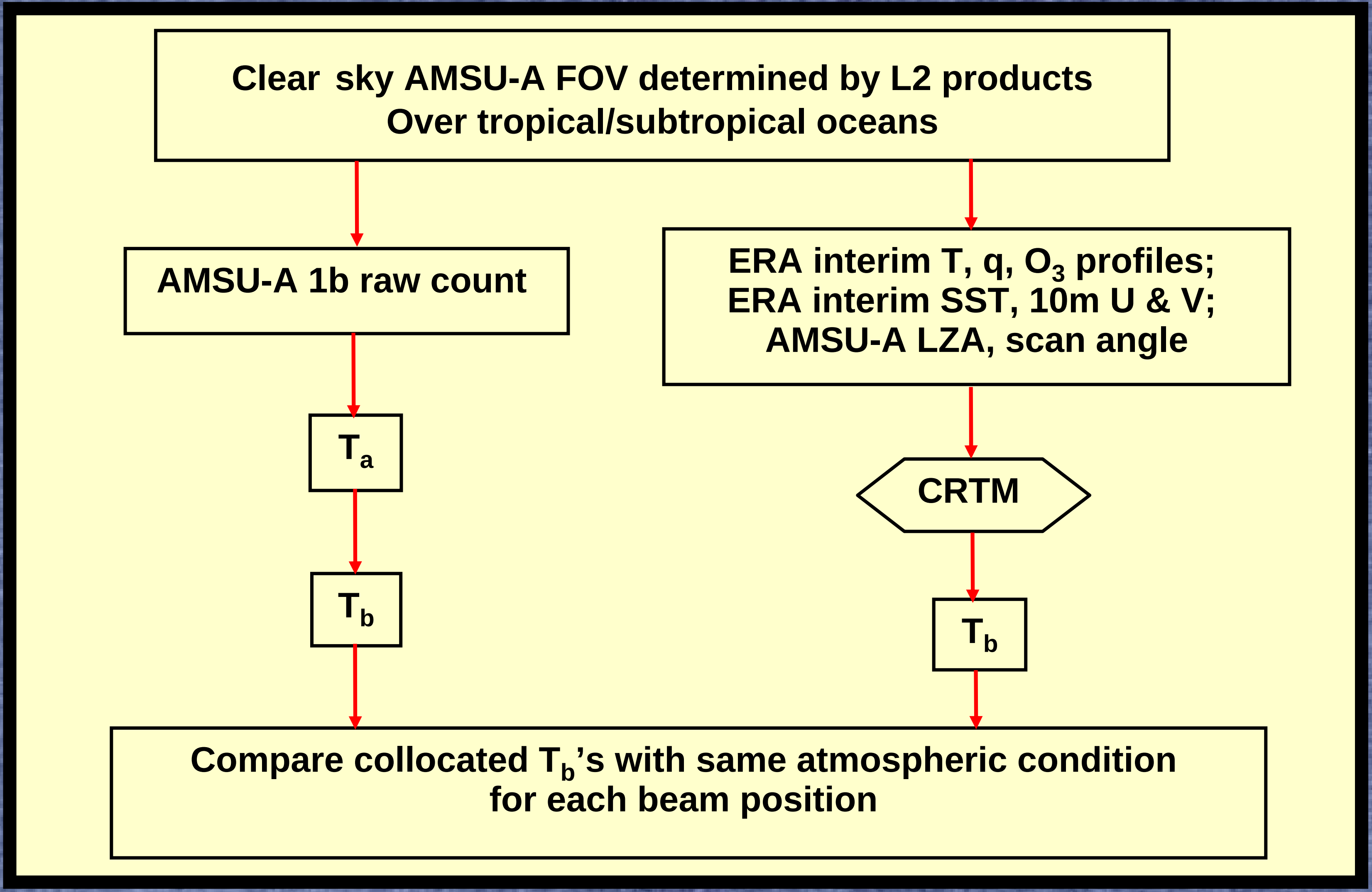




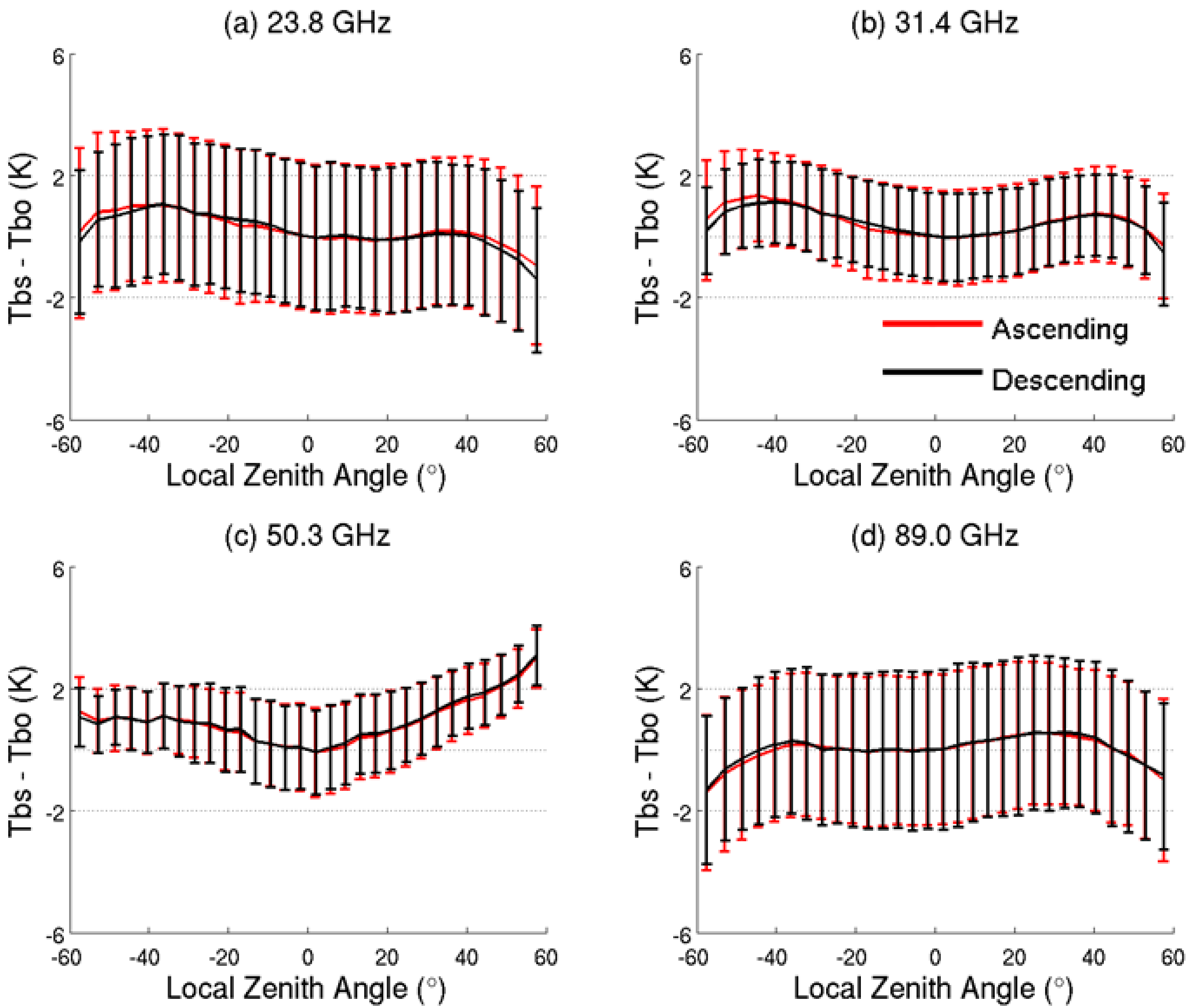
Before Correction (02/15/2011)

After Correction (02/15/2011)

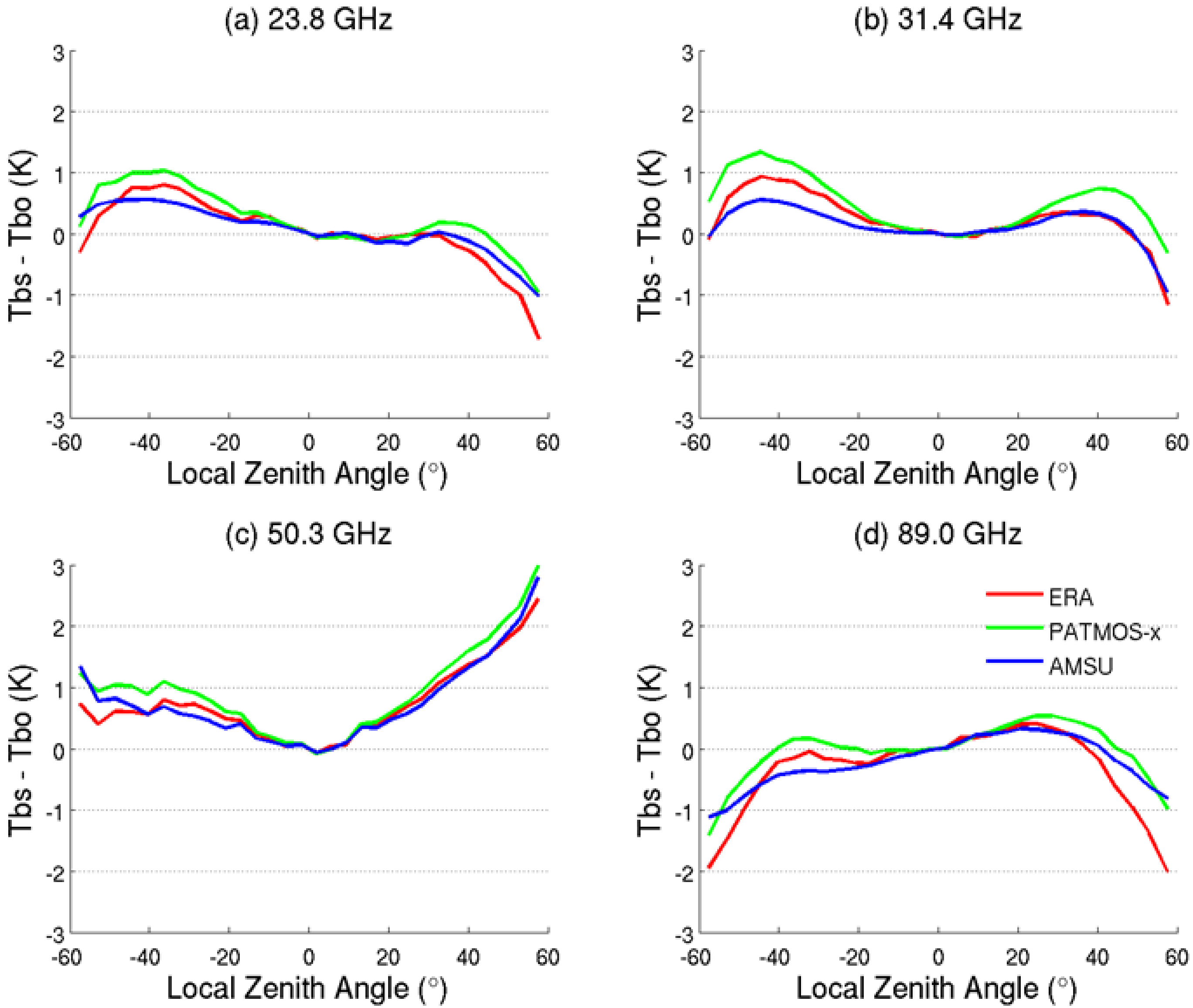
Characterization Scheme



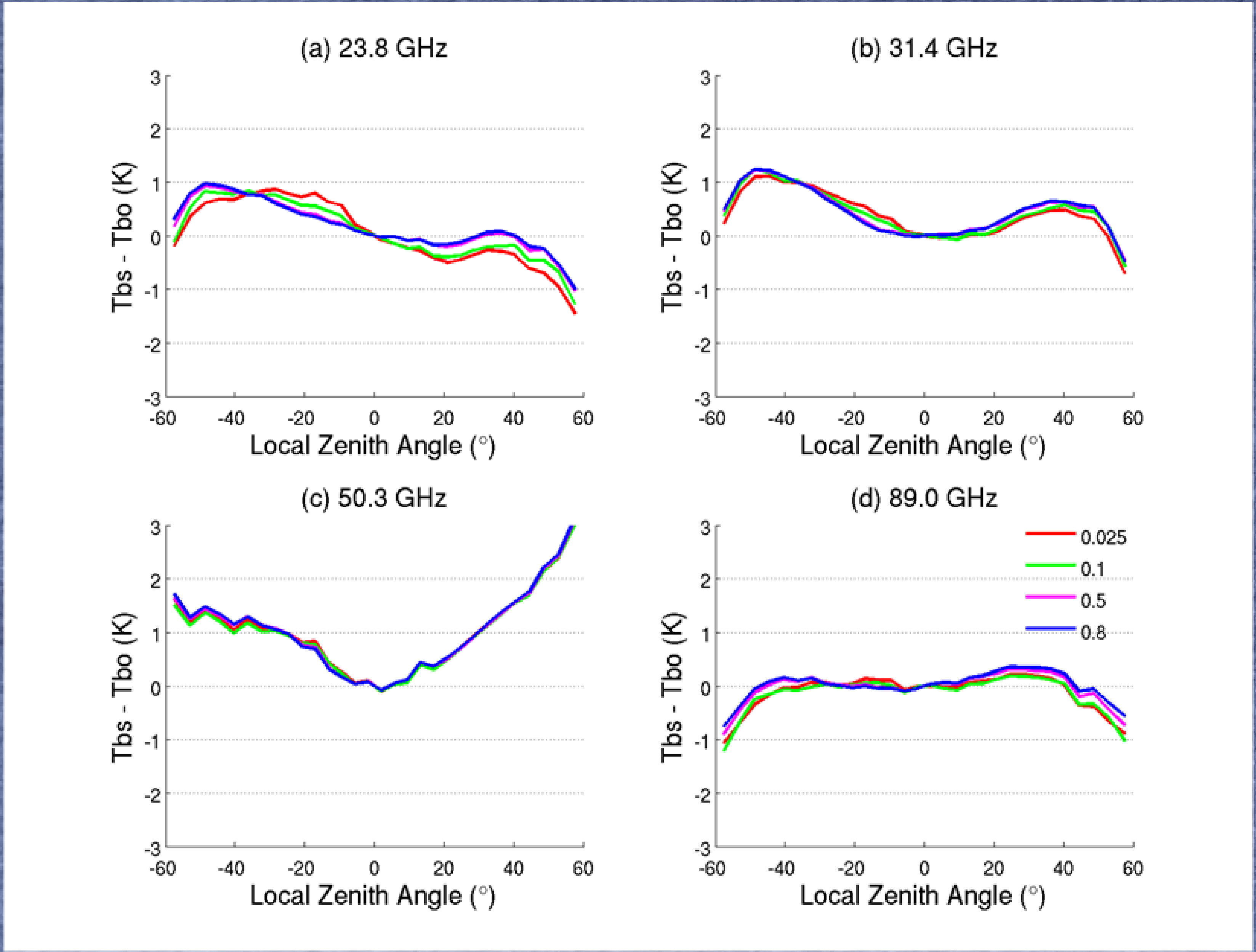
General Result of Asymmetry Characterization



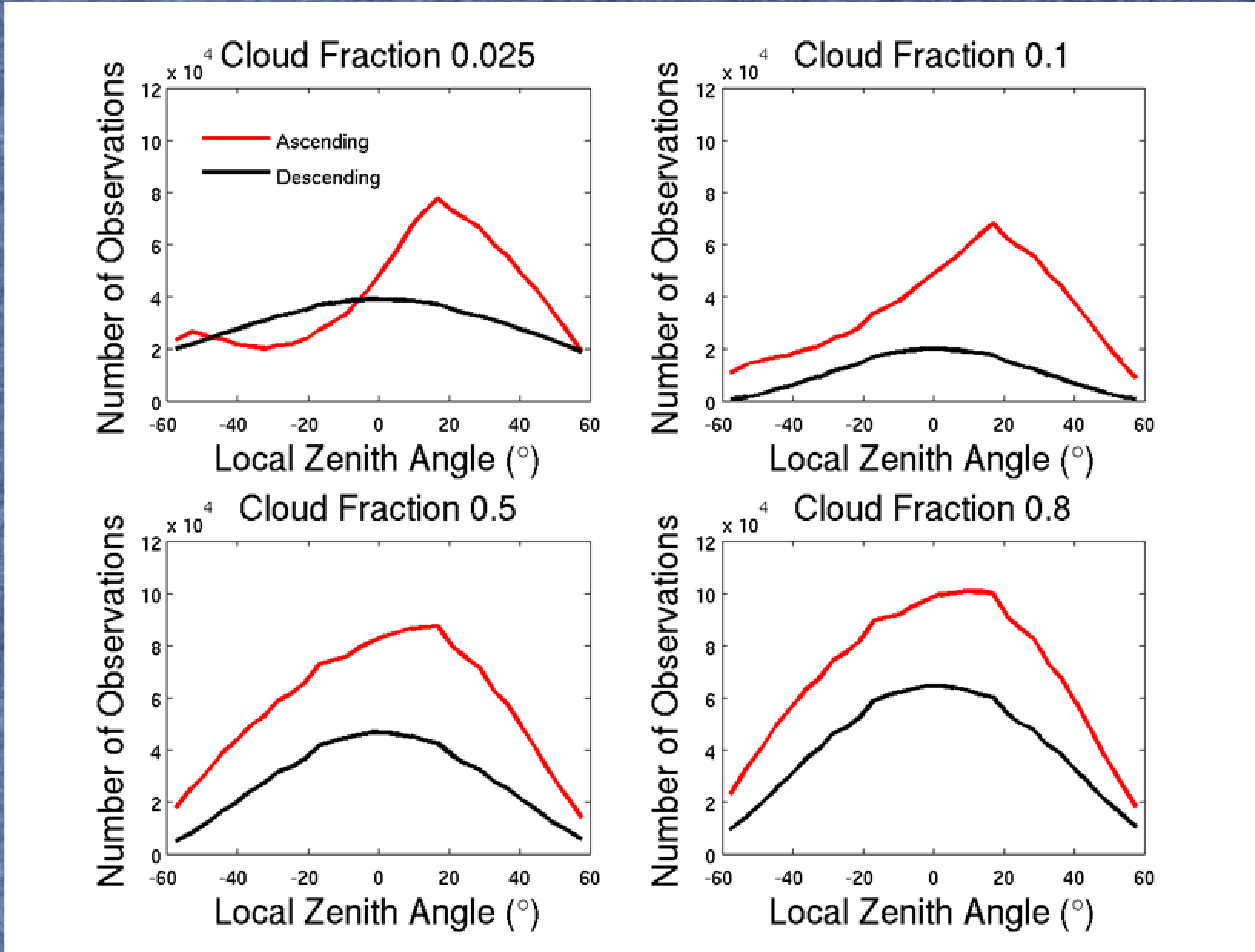
Comparison of Different Cloud-Screening Approaches



Comparison of Different Cloud Fraction for PATMOS-x Approach

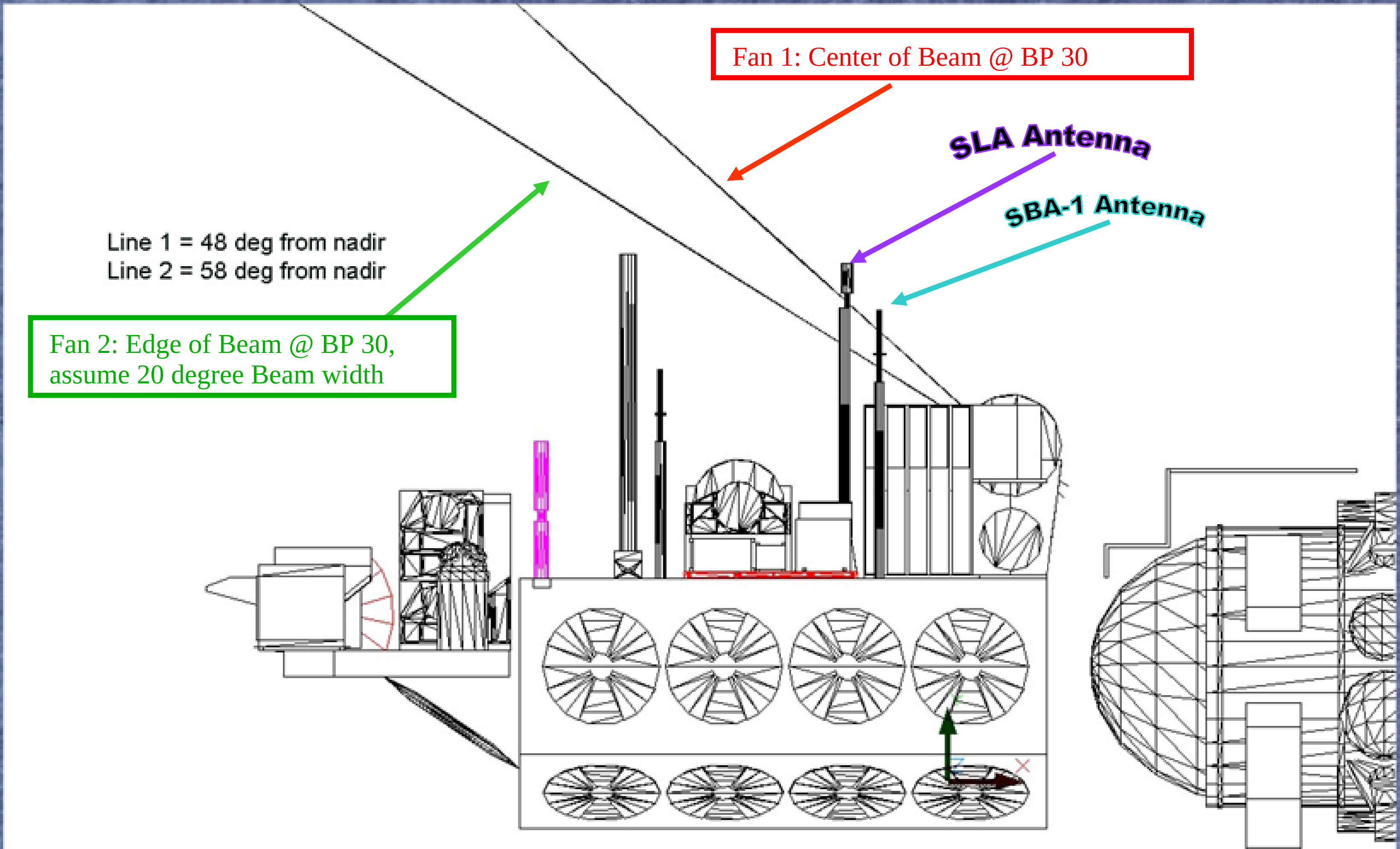


Comparison of Number of Observation for PATMOS-x Approach



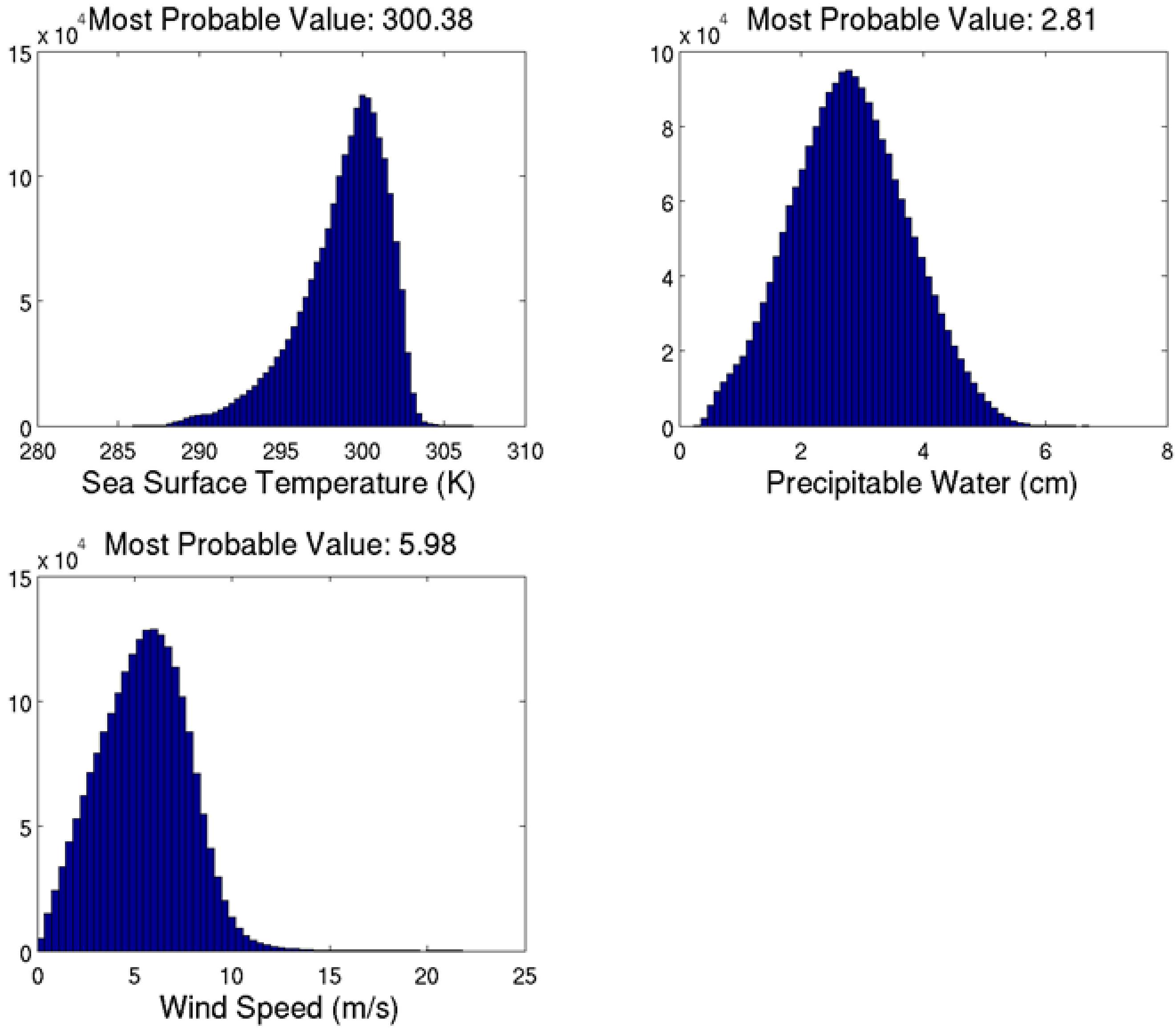
AMSU-A Hardware Configuration

23.8 GHz & 31.4 GHz : AMSU-A2;   50.3 GHz : AMSU-A1-2;   89.0 GHz : AMSU-A1-1



AMSU-A2 Fan Beam – Credit to Bill Blackwell

Histogram of Physical Variables – NOAA-18, 2008



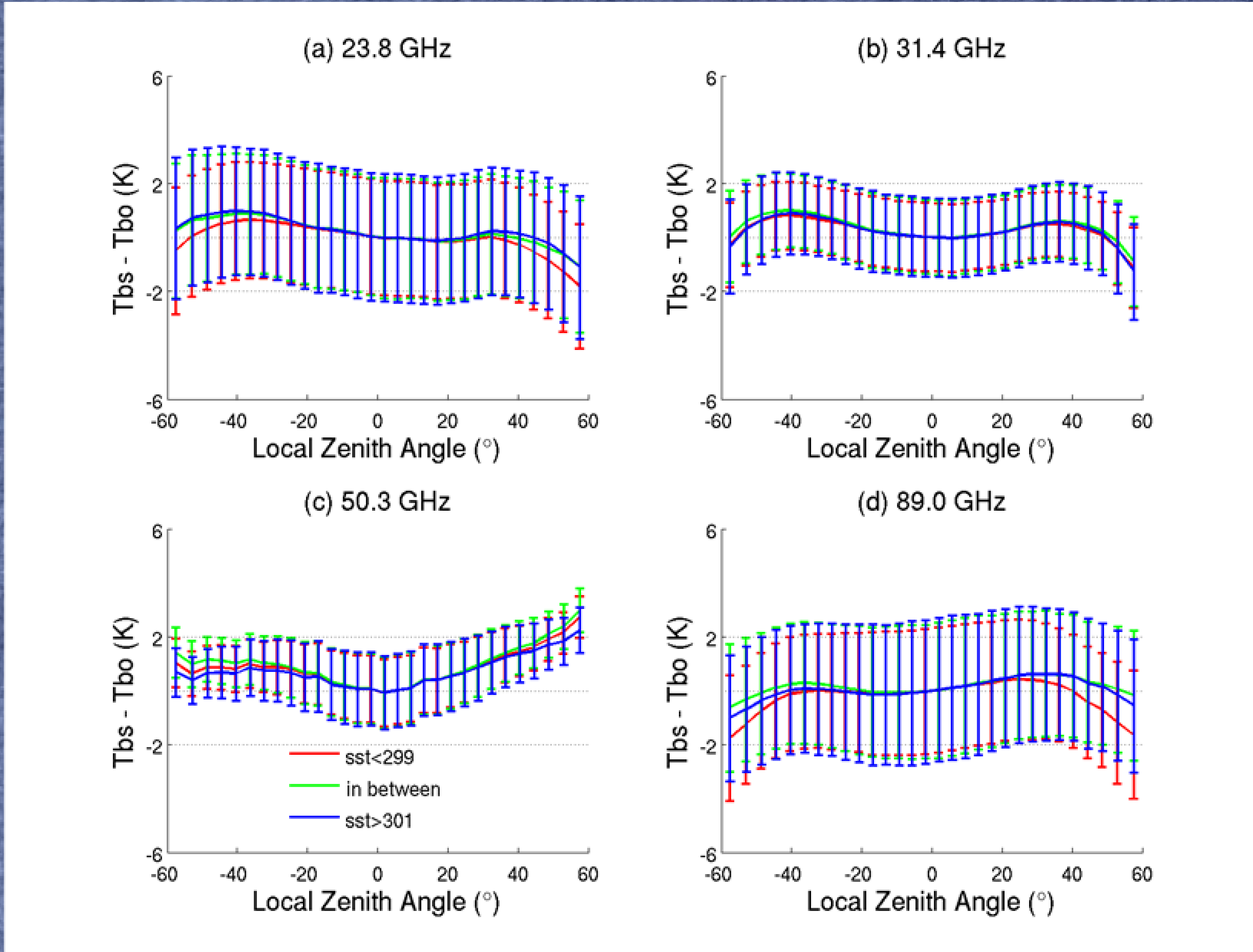
Comparison of Most Probable Values (MPV)

	NOAA-15	NOAA-16	NOAA-18	MetOp-A
SST (K)	300.15 (00) 301.07 (04) 300.48 (08)	300.33	300.38	300.04
PW (cm)	2.96 (00) 2.79 (04) 2.89 (08)	2.92	2.81	2.75
Wind Speed (m/s)	6.04 (00) 6.14 (04) 6.46 (08)	6.62	5.98	6.08

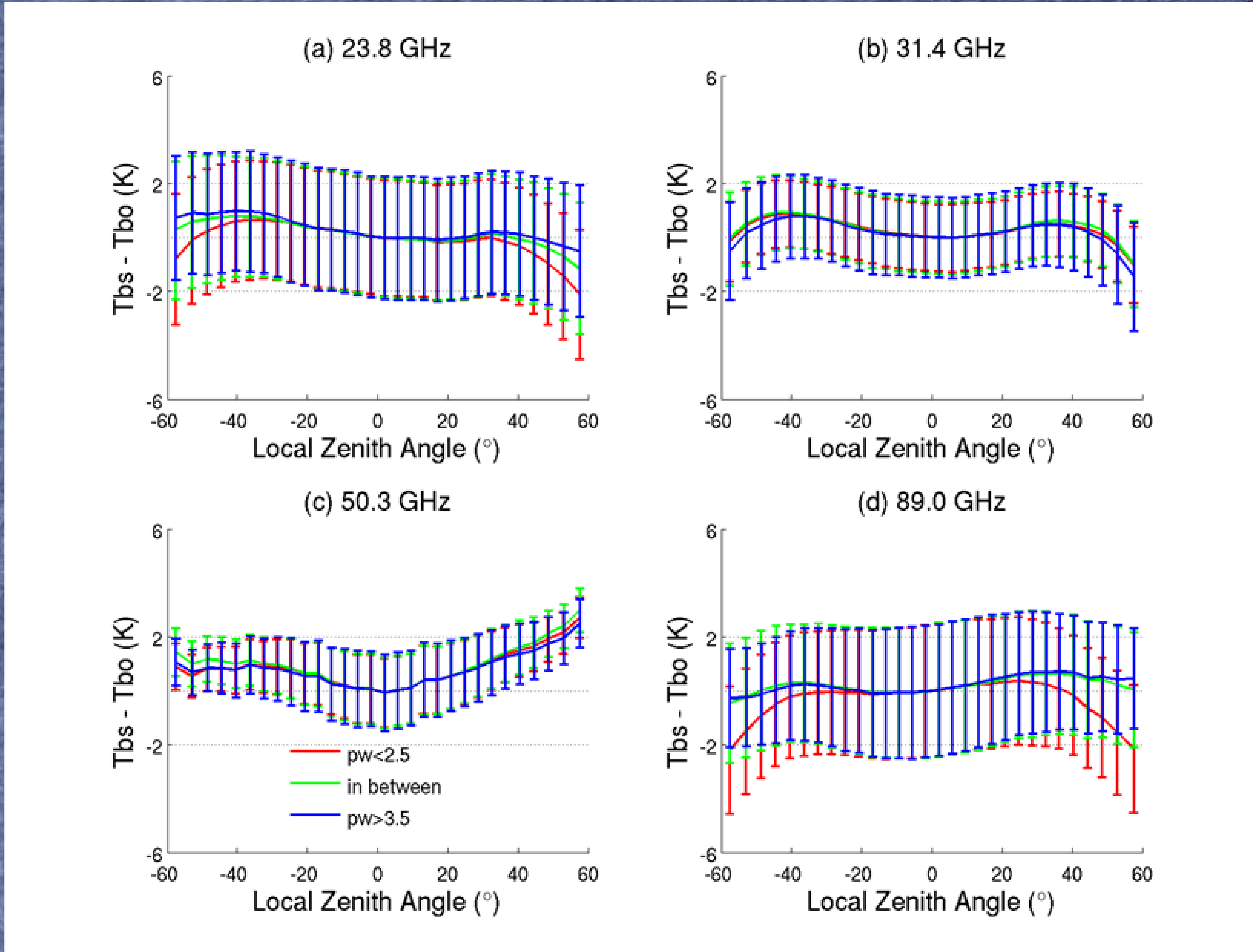
Statistic of Number of Observations for Parameter Range, NOAA-18, 2008

SST (K)	%	PW (cm)	%	WS (m/s)	%
< 299	44.36	< 2.5	38.47	< 5	41.66
299 ~ 301	34.24	2.5 ~ 3.5	38.12	5 ~ 7	32.93
> 301	21.40	> 3.5	23.41	> 7	25.41

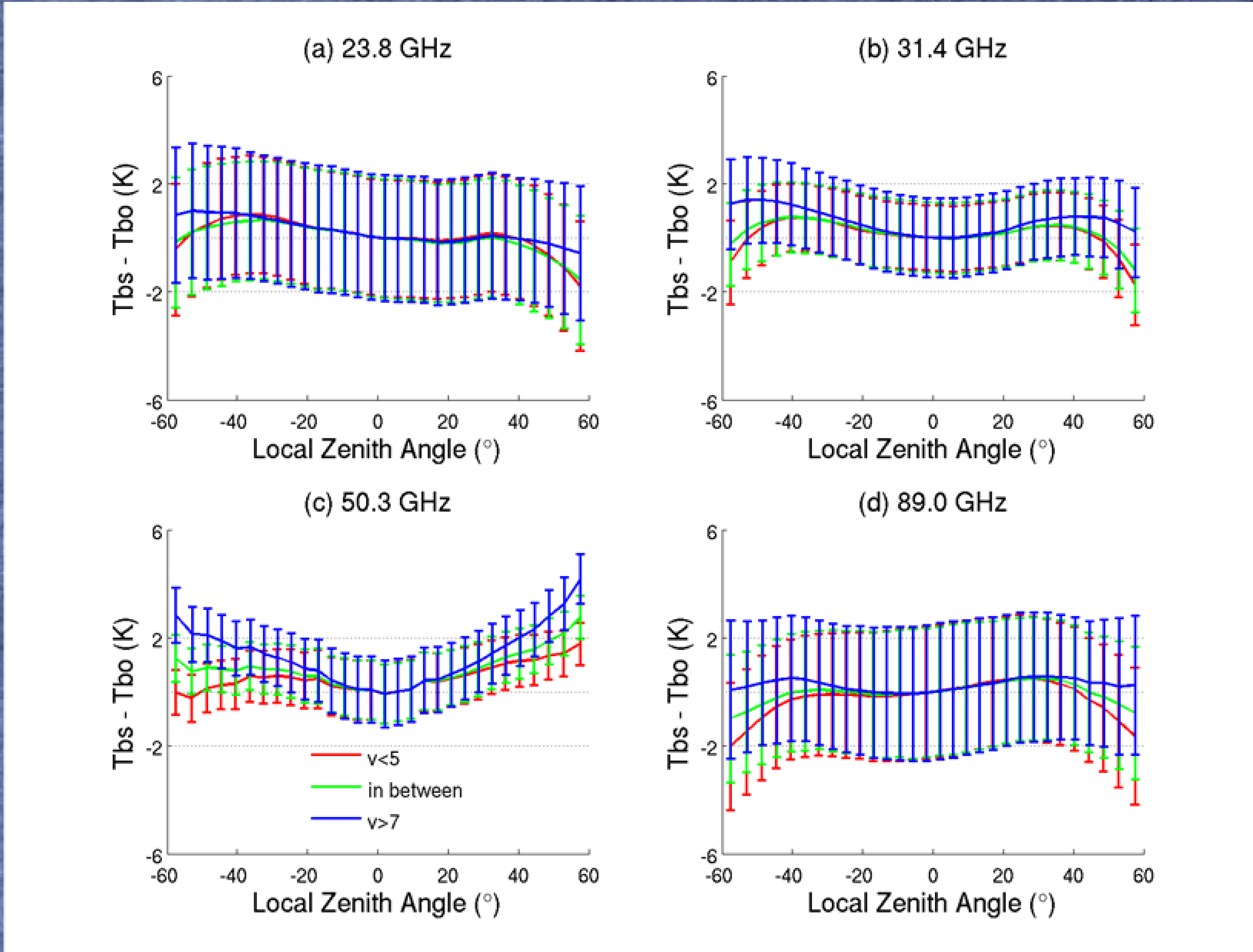
Asymmetry with Sea Surface Temperature – Window Channels, NOAA-18, 2008



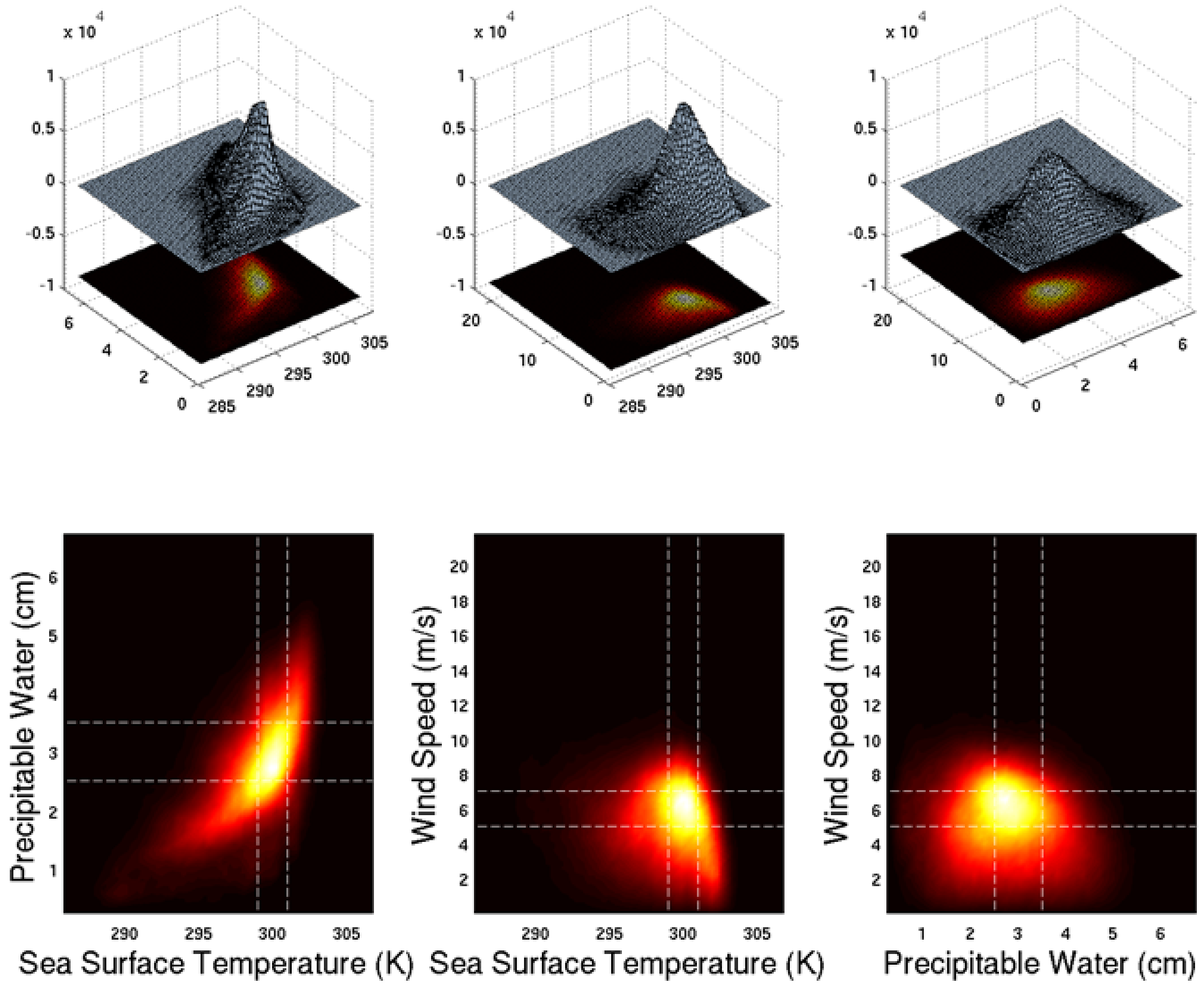
Asymmetry with Precipitable Water – Window Channels, NOAA-18, 2008



Asymmetry with Wind Speed – Window Channels, NOAA-18, 2008



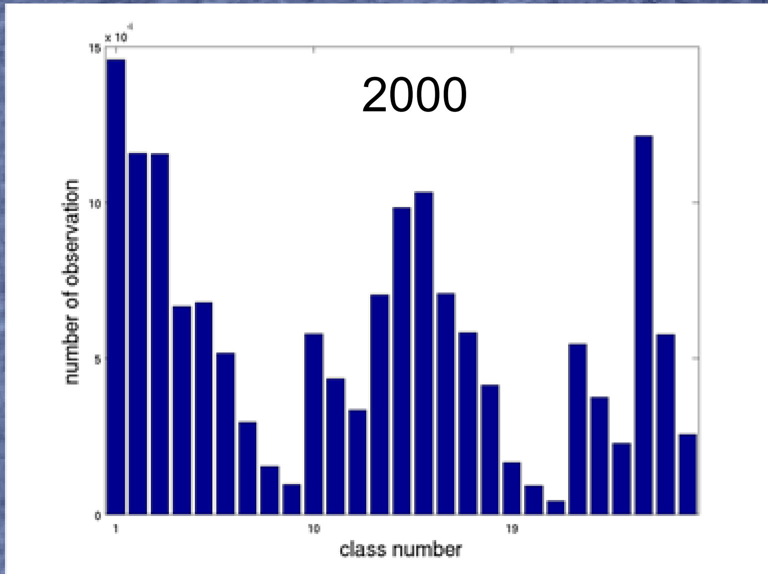
2D Histogram of Physical Variables – NOAA-18, 2008

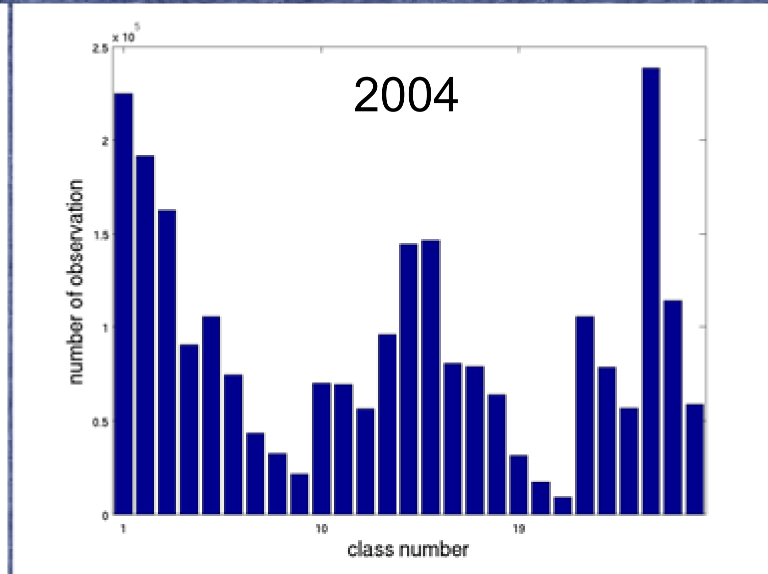


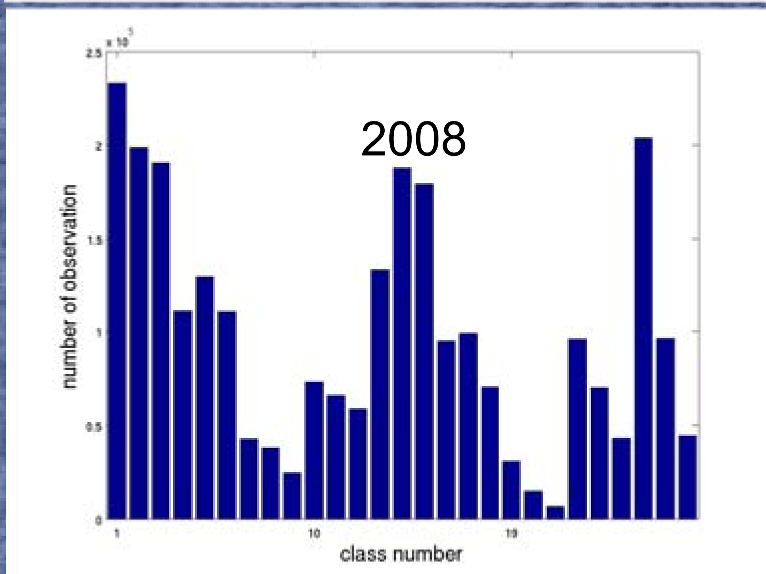
Definition of 27 Class

C#	SST	PW	V	C#	SST	PW	V	C#	SST	PW	V
1	<299	<2.5	<5	10	mid	<2.5	<5	19	>301	<2.5	<5
2	<299	<2.5	mid	11	mid	<2.5	mid	20	>301	<2.5	mid
3	<299	<2.5	>7	12	mid	<2.5	>7	21	>301	<2.5	>7
4	<299	mid	<5	13	mid	mid	<5	22	>301	mid	<5
5	<299	mid	mid	14	mid	mid	mid	23	>301	mid	mid
6	<299	mid	>7	15	mid	mid	>7	24	>301	mid	>7

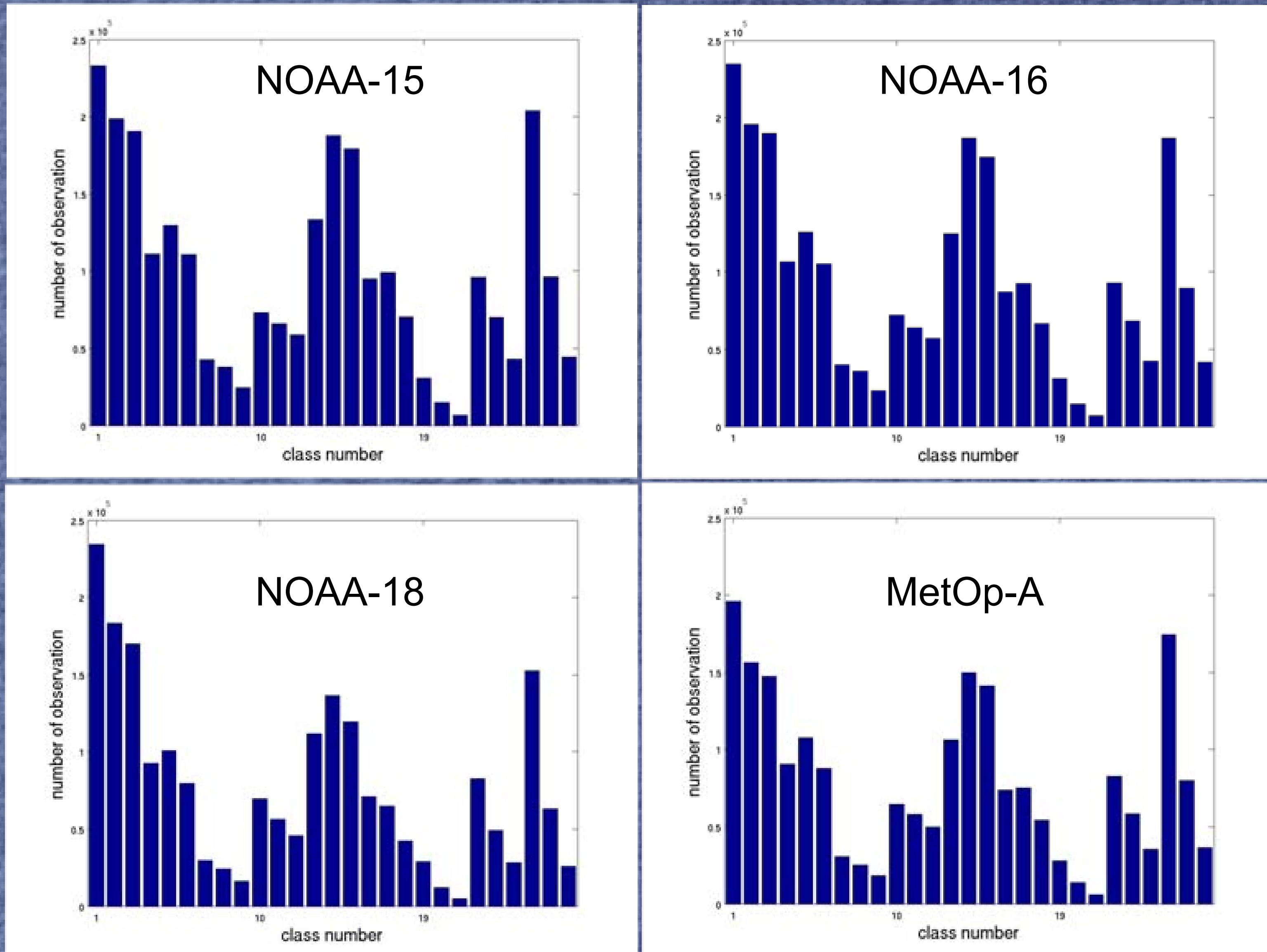
Histogram of 27 Class – NOAA-15



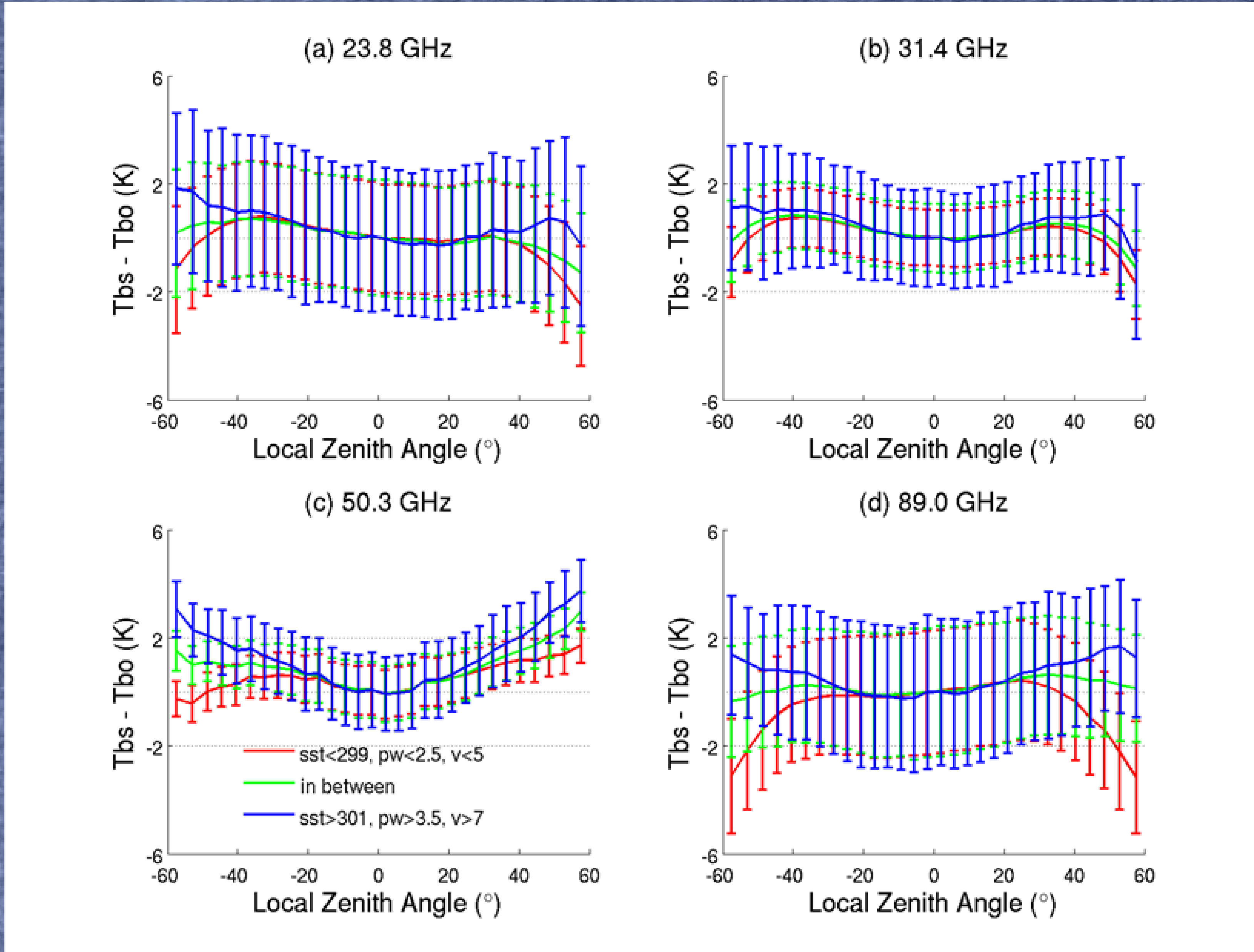




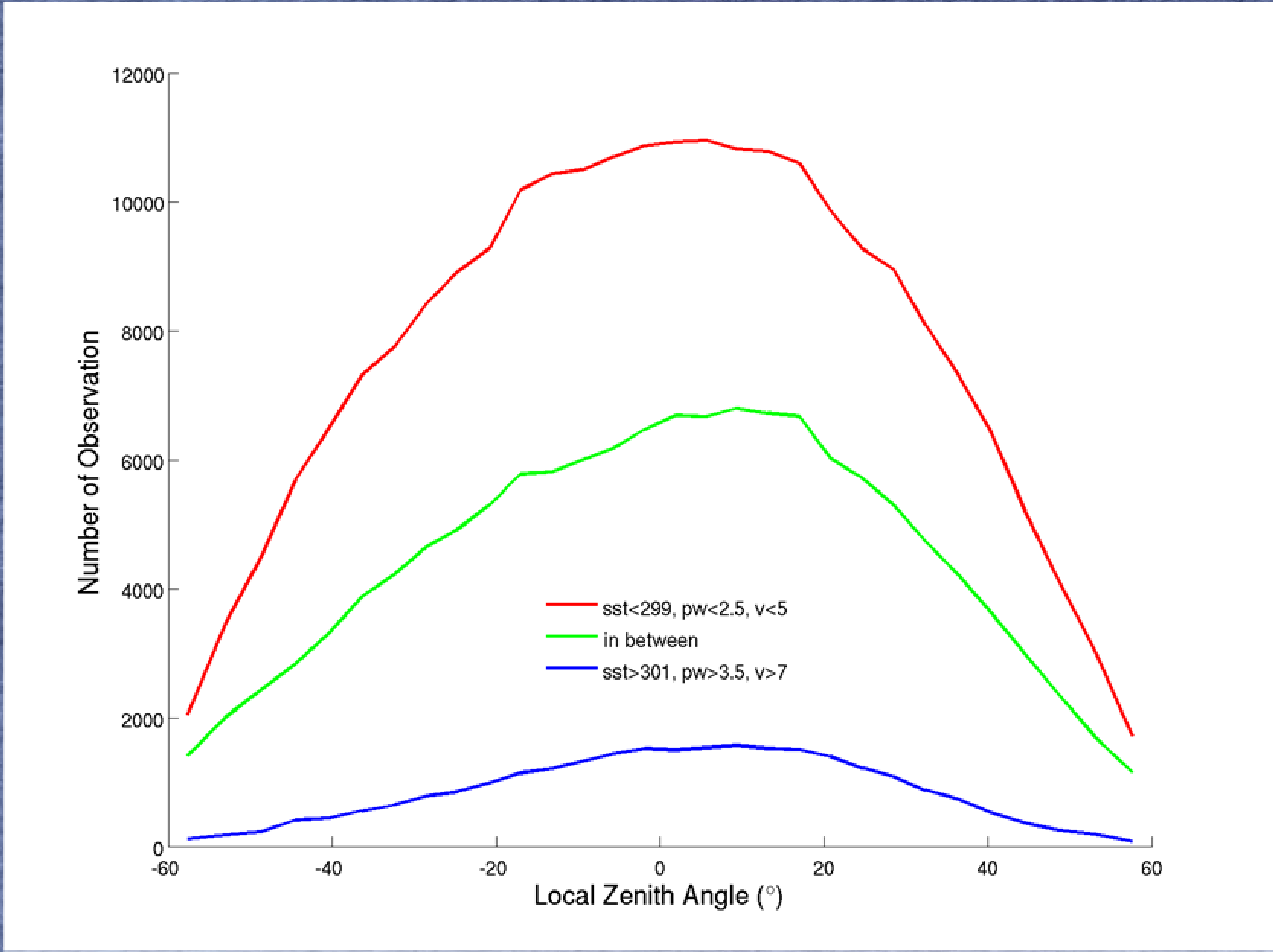
Histogram of 27 Class – Whole Year 2008



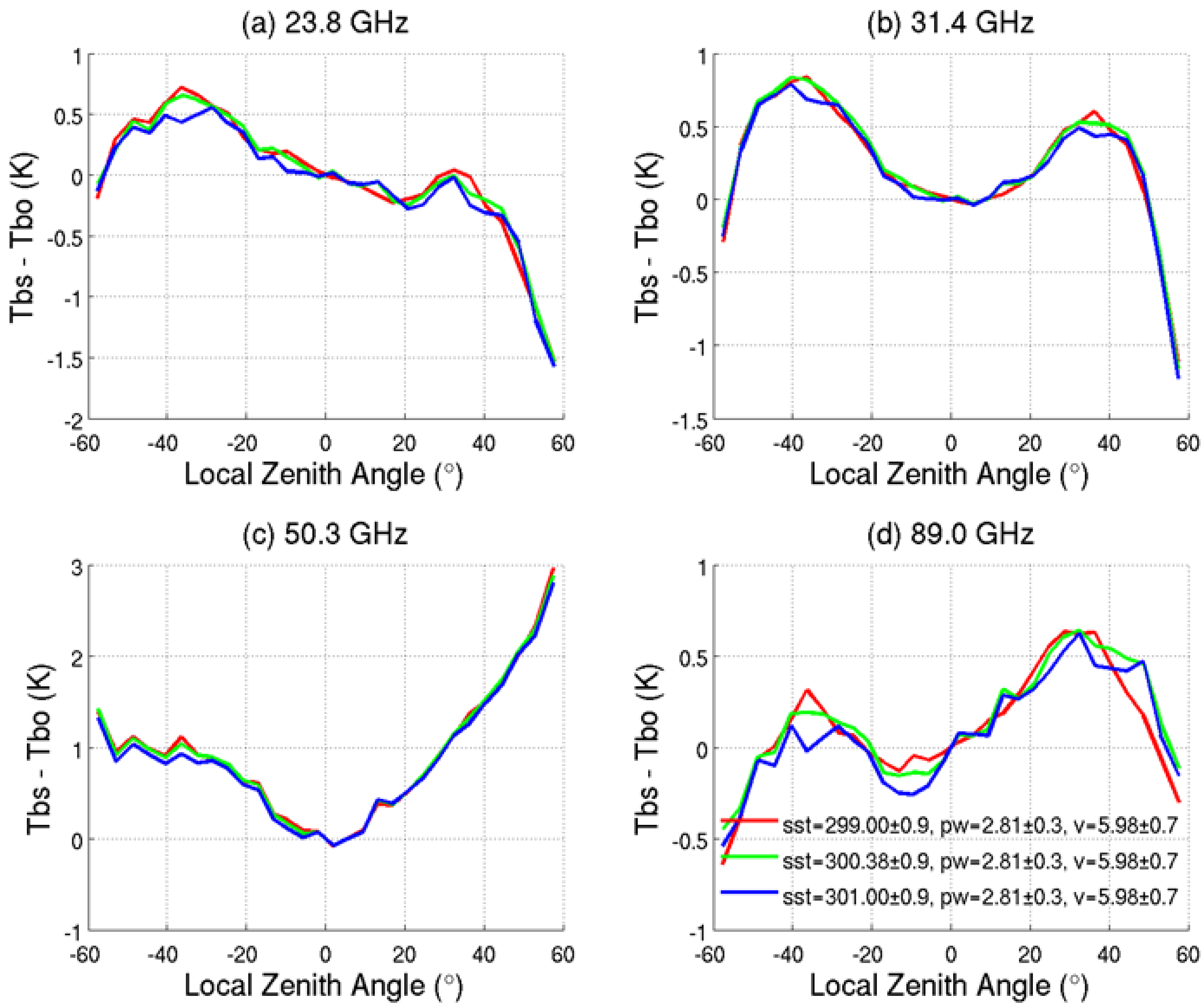
Asymmetry with Selected Combined Cases – Window Channels, NOAA-18, 2008



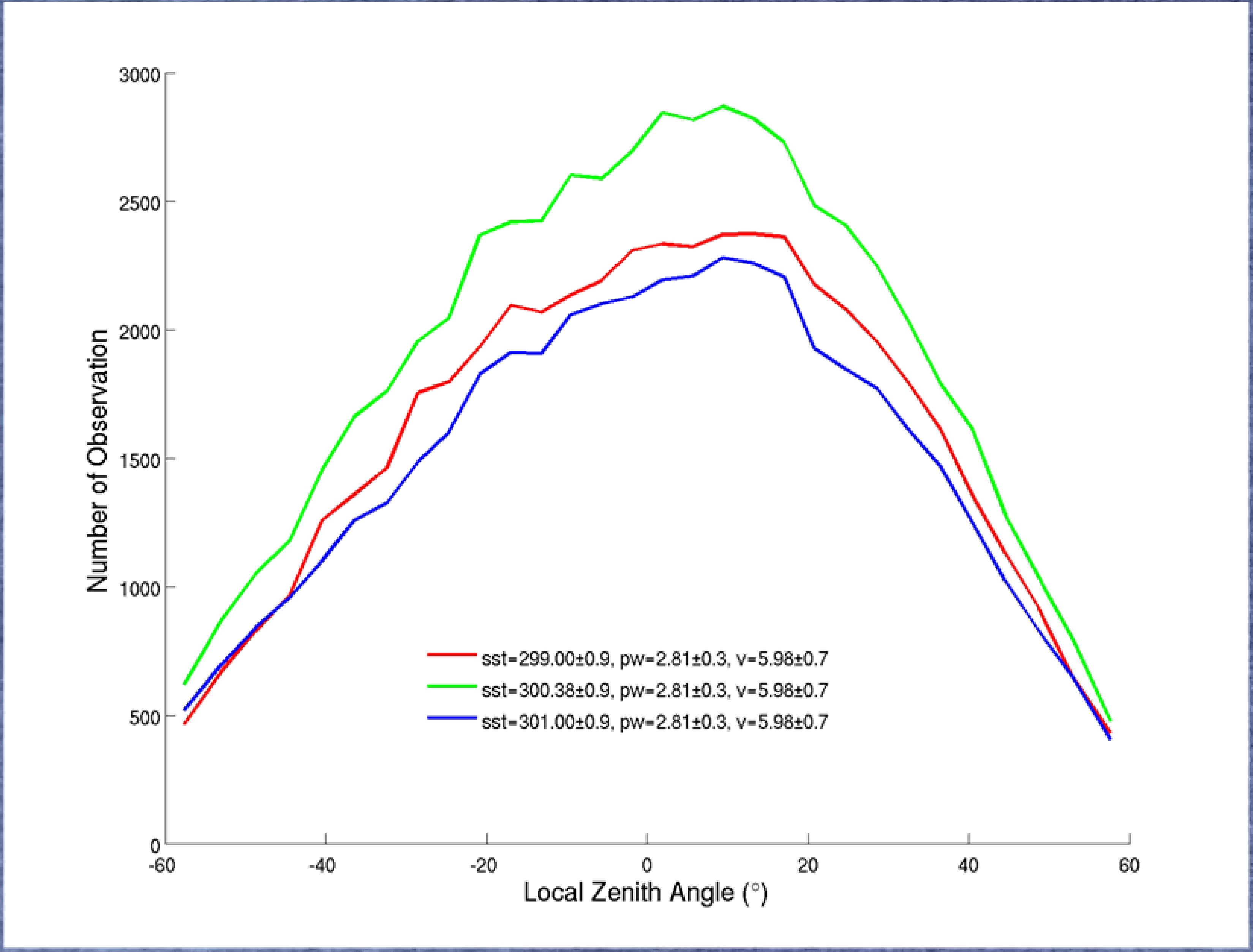
Number of Observations with Selected Combined Cases, NOAA-18, 2008



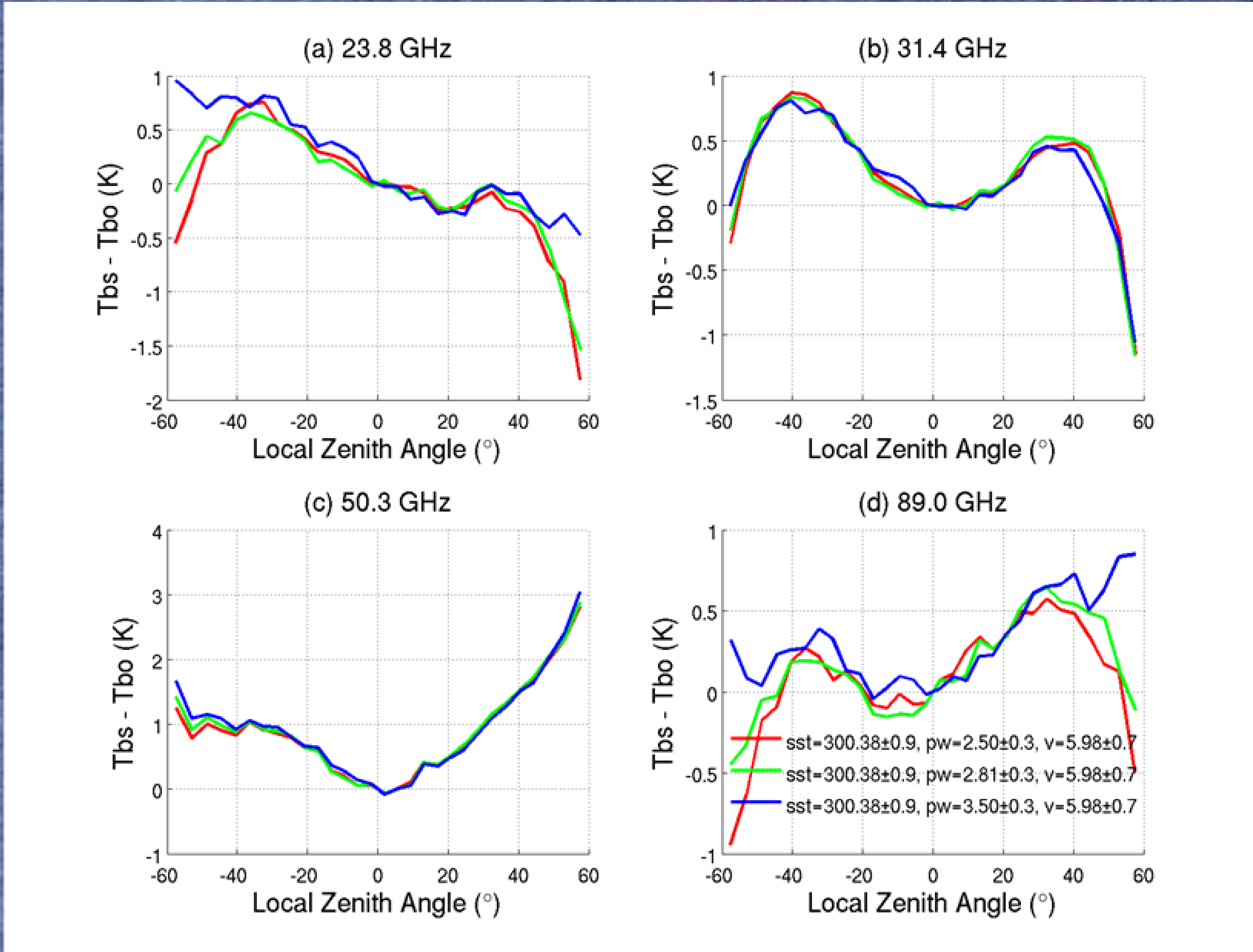
Mean Difference at MPV – Window Channels, Changing SST, NOAA-18, 2008



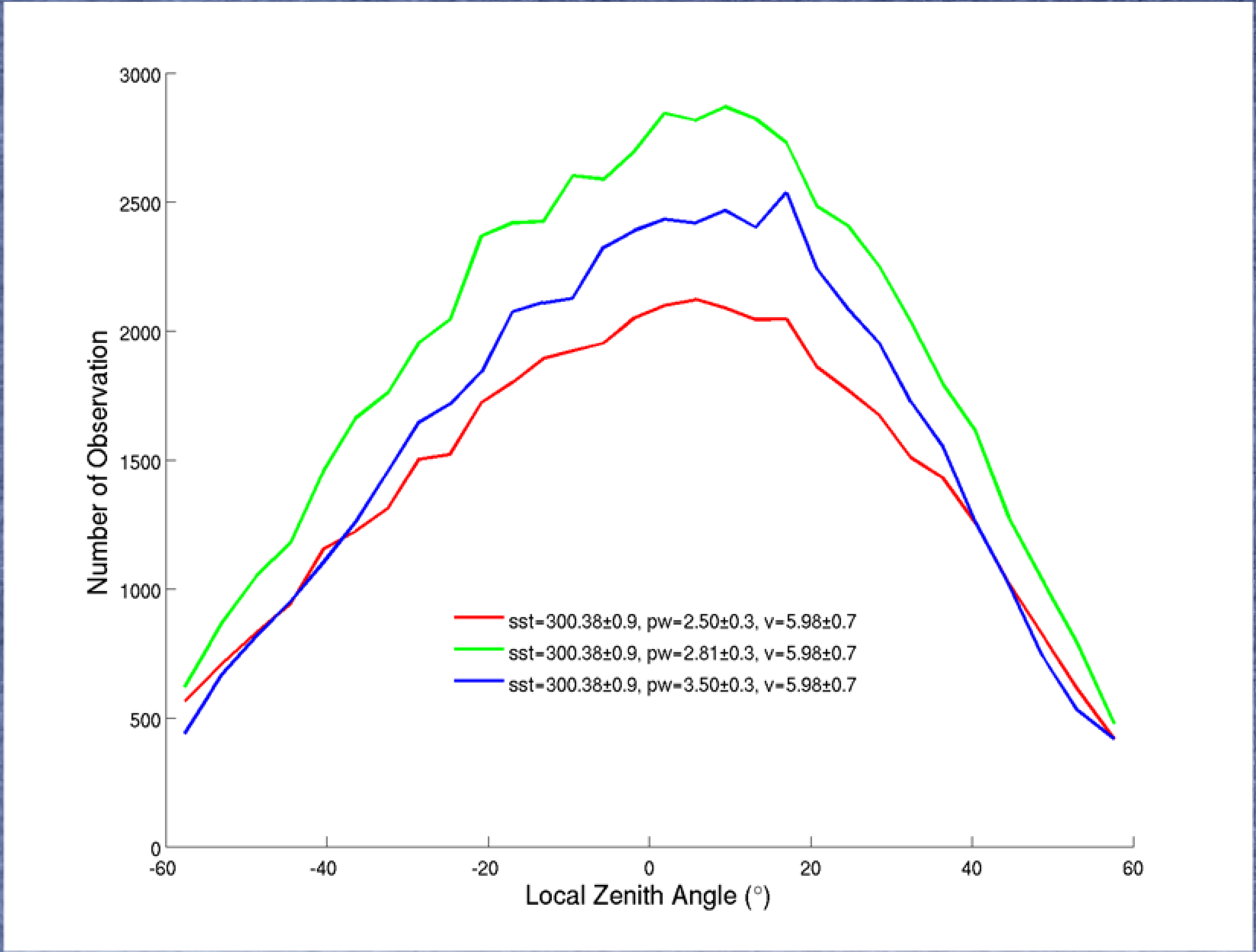
Number of Observations at MPV – Changing SST, NOAA-18, 2008



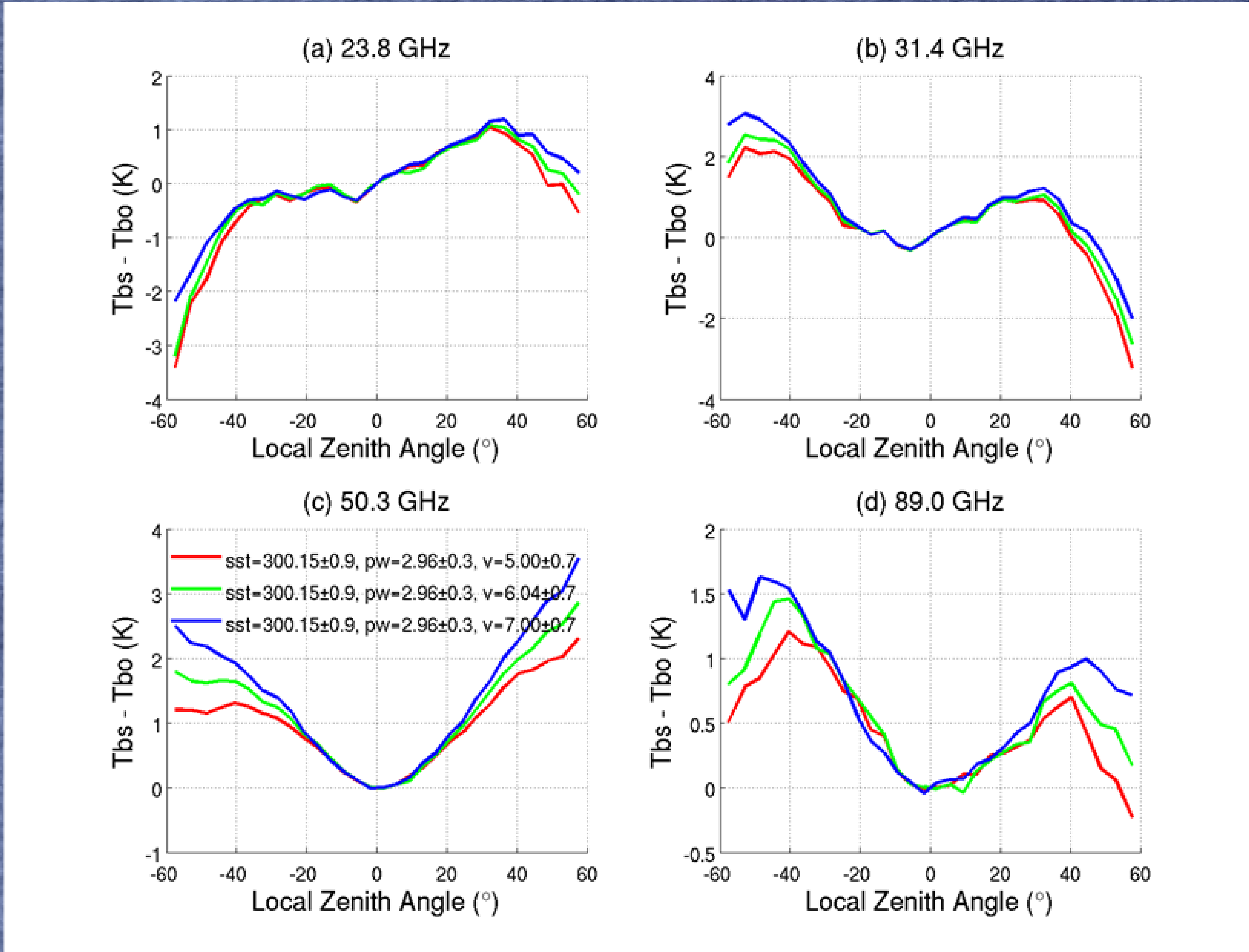
Mean Difference at MPV – Window Channels, Changing PW, NOAA-18, 2008



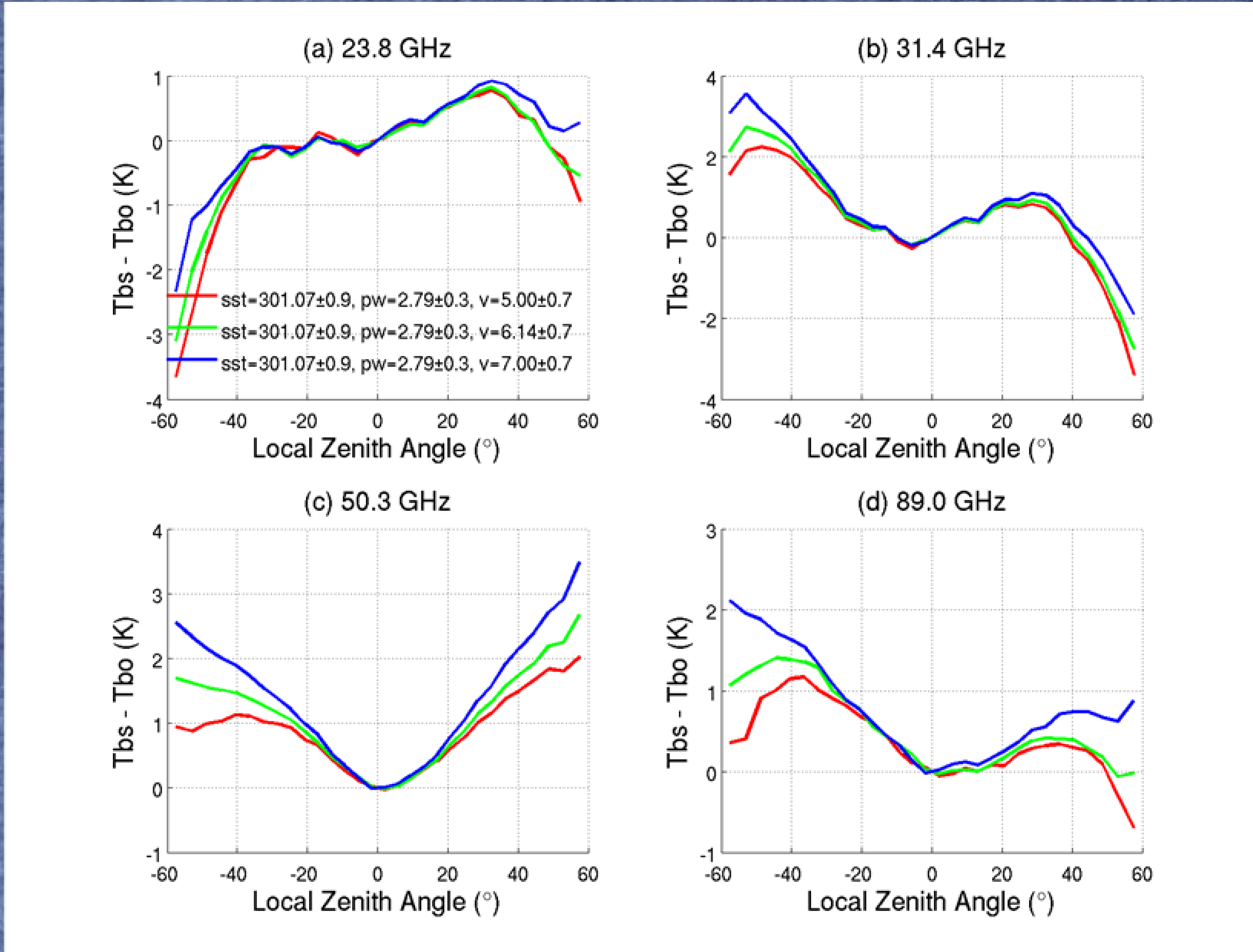
Number of Observations at MPV – Changing PW, NOAA-18, 2008



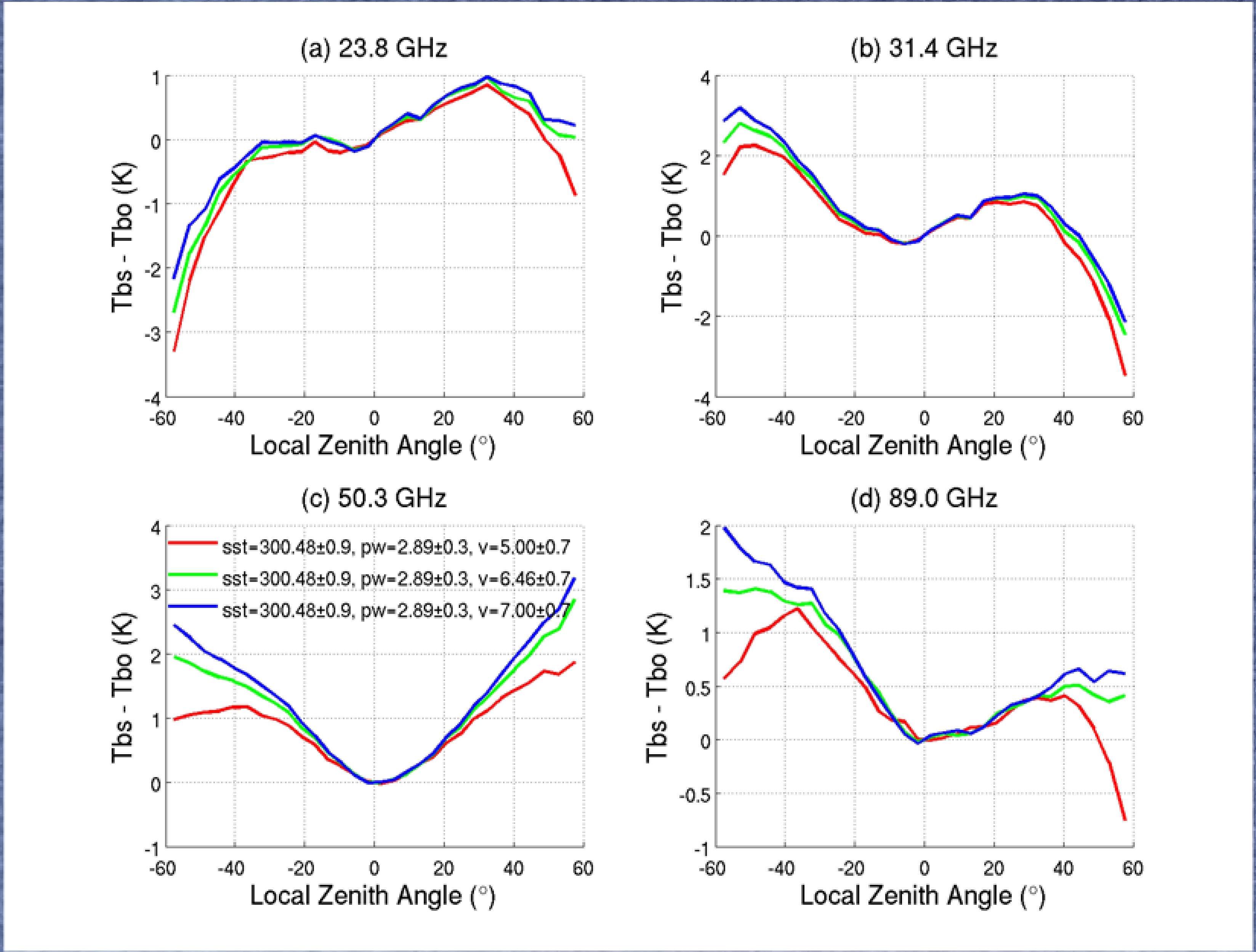
Mean Difference at MPV – Window Channels, Changing Wind Speed, NOAA-15, 2000



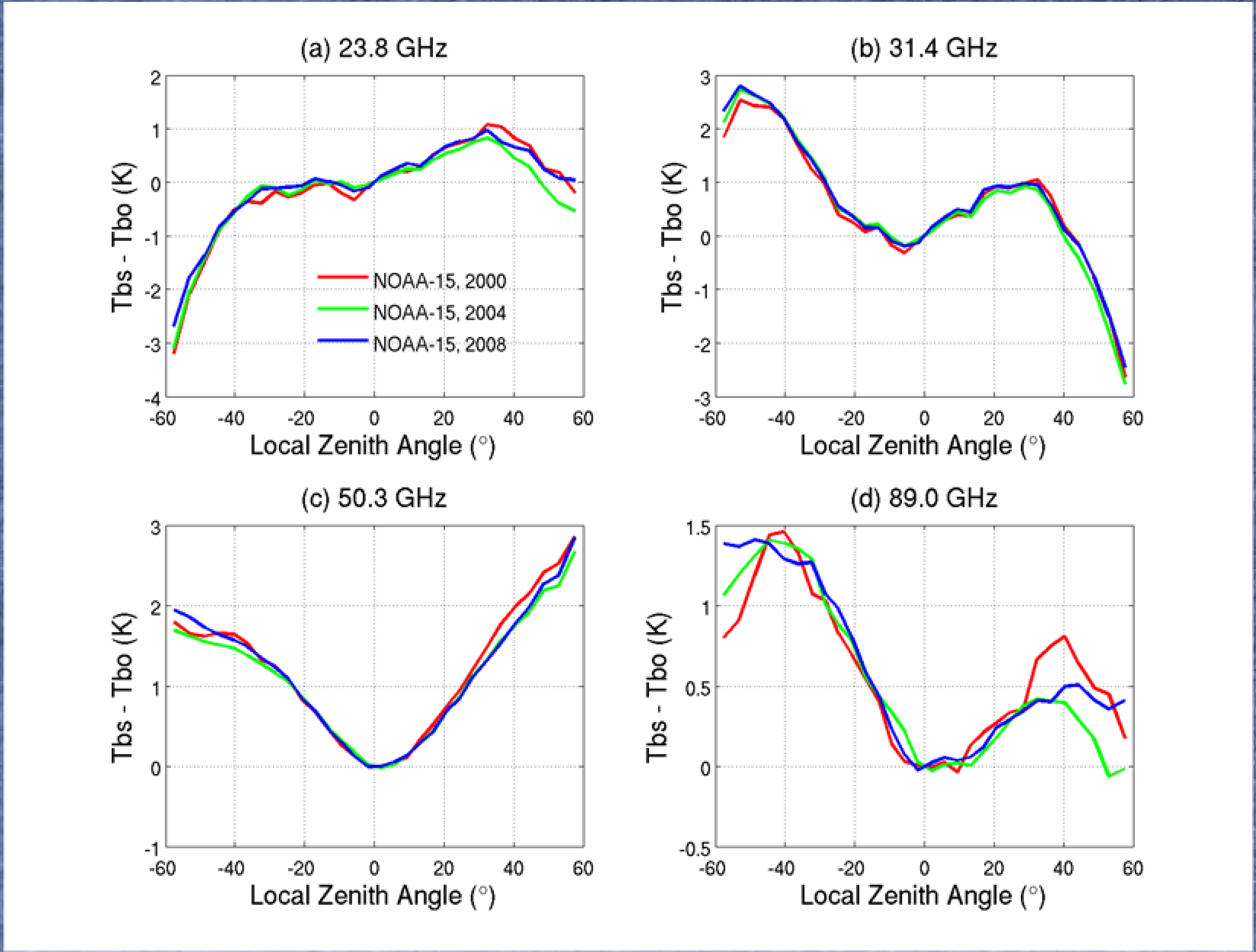
Mean Difference at MPV – Window Channels, Changing Wind Speed, NOAA-15, 2004



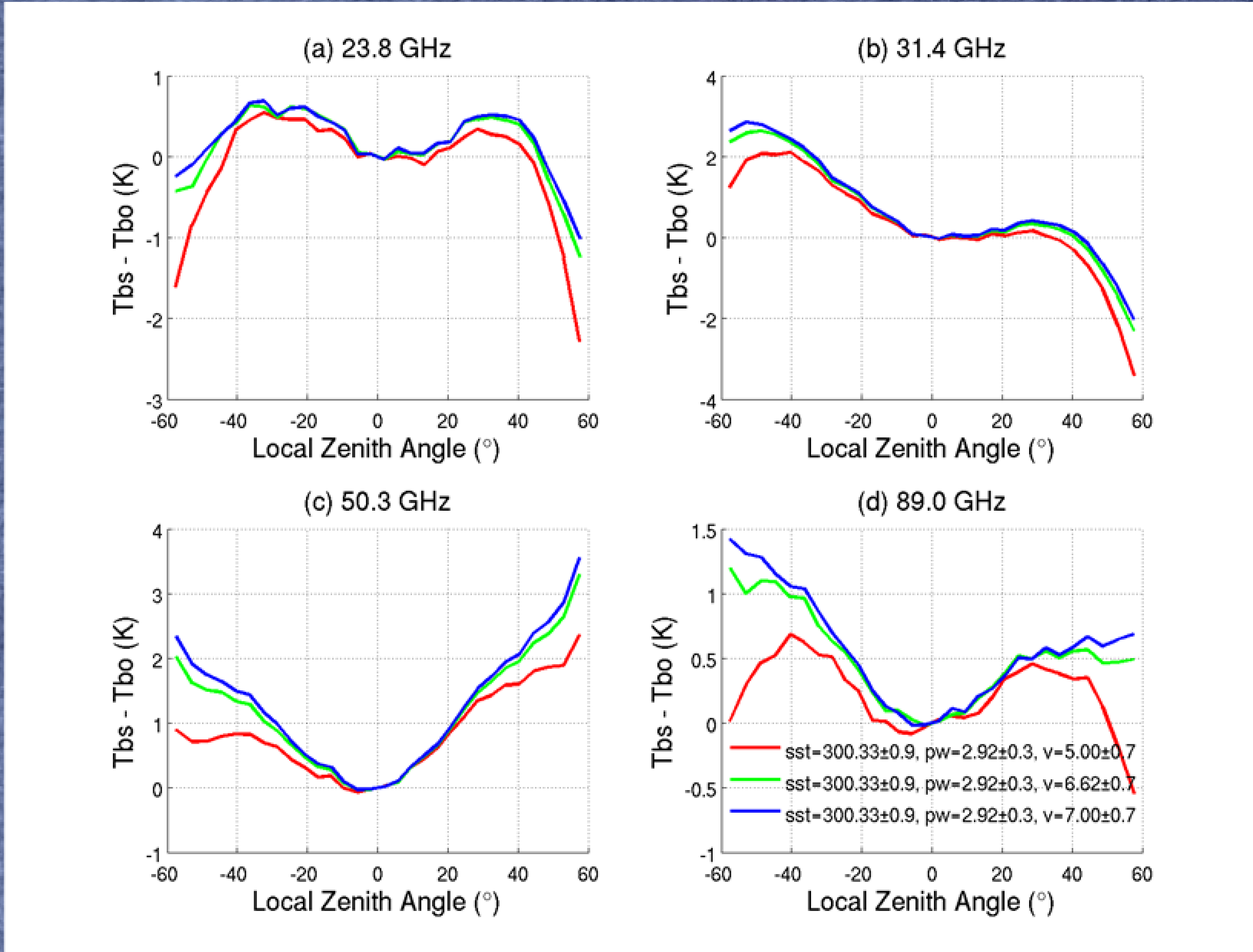
Mean Difference at MPV – Window Channels, Changing Wind Speed, NOAA-15, 2008



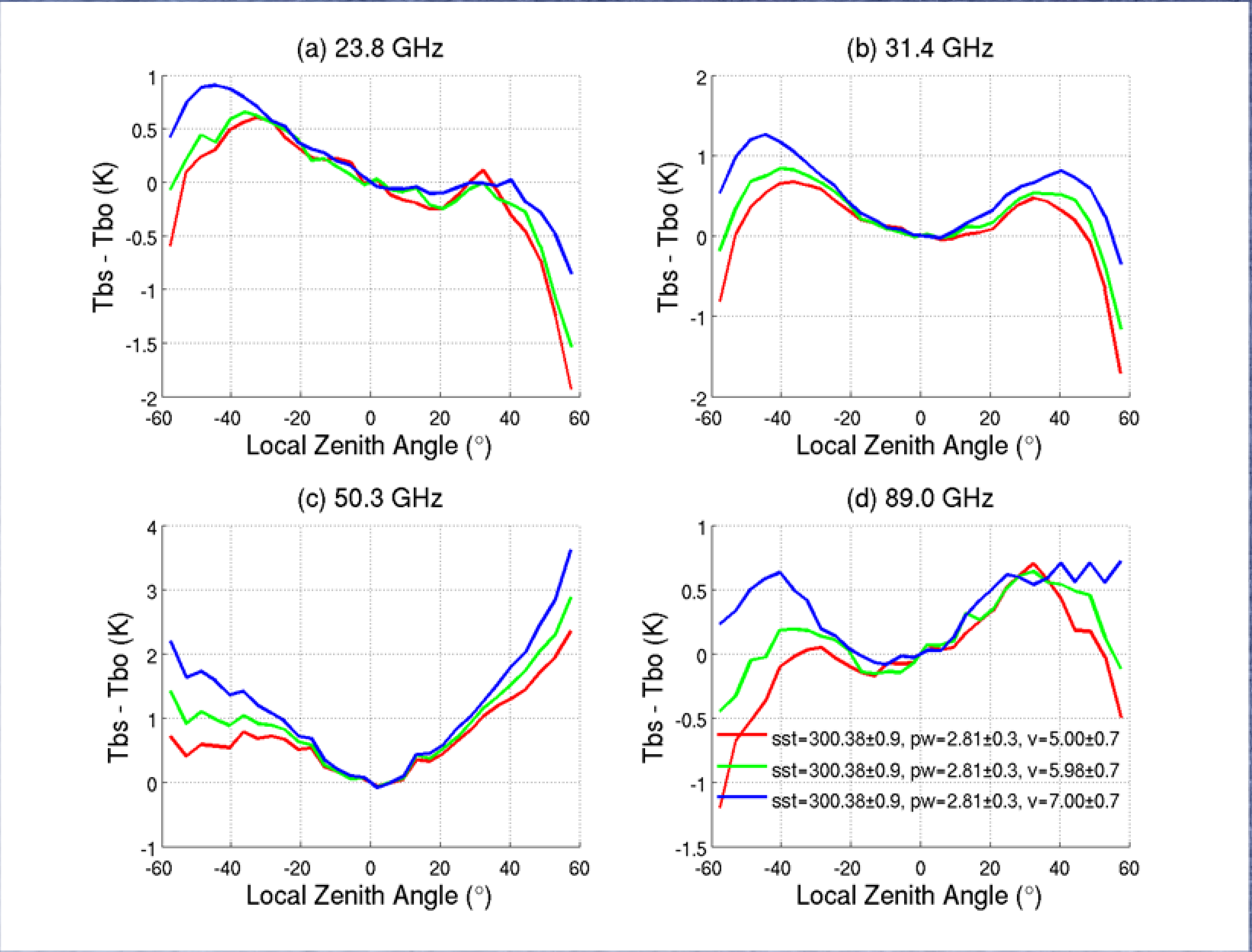
Mean Difference at MPV – Window Channels, NOAA-15, 2000~2008



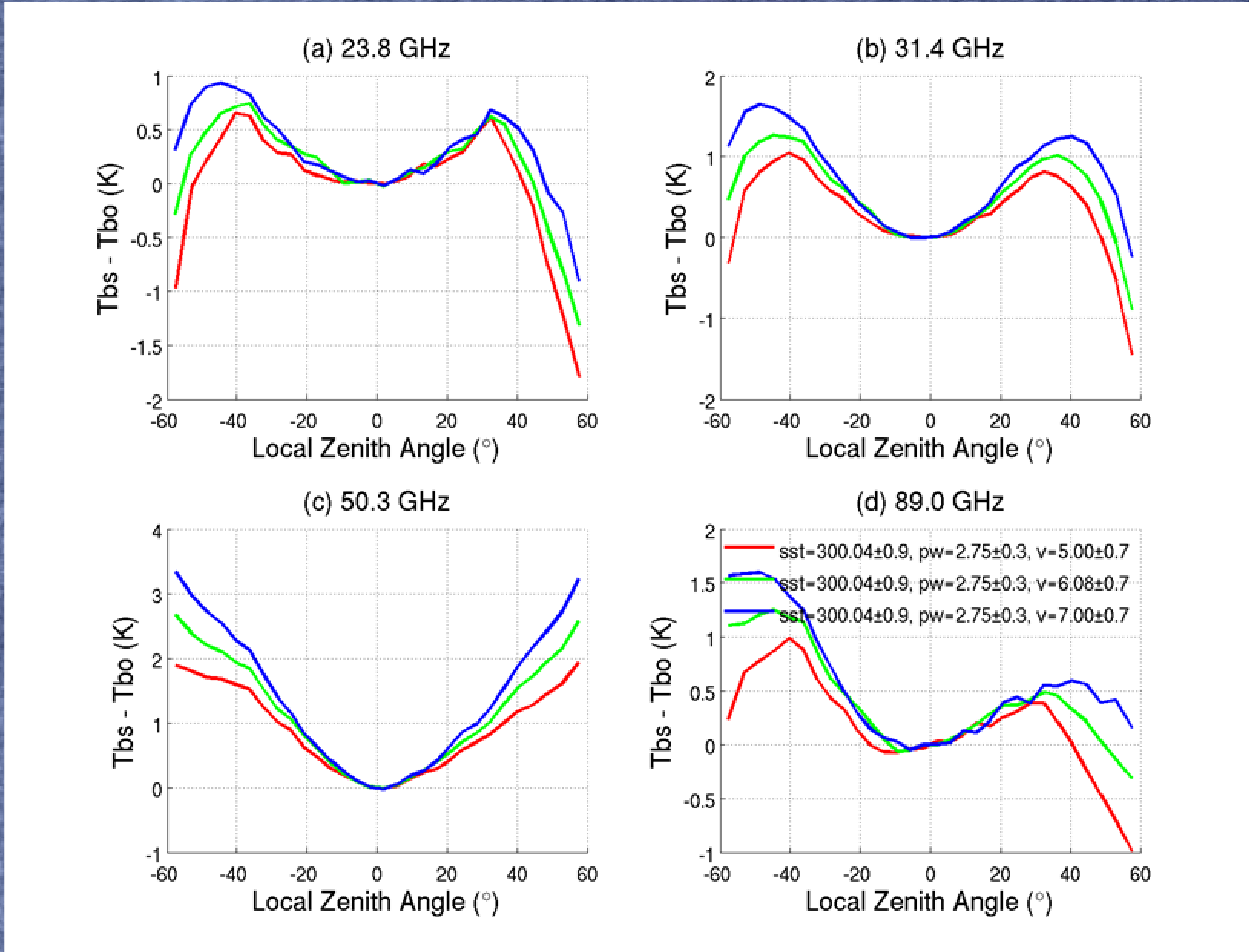
Mean Difference at MPV – Window Channels, Changing Wind Speed, NOAA-16, 2008



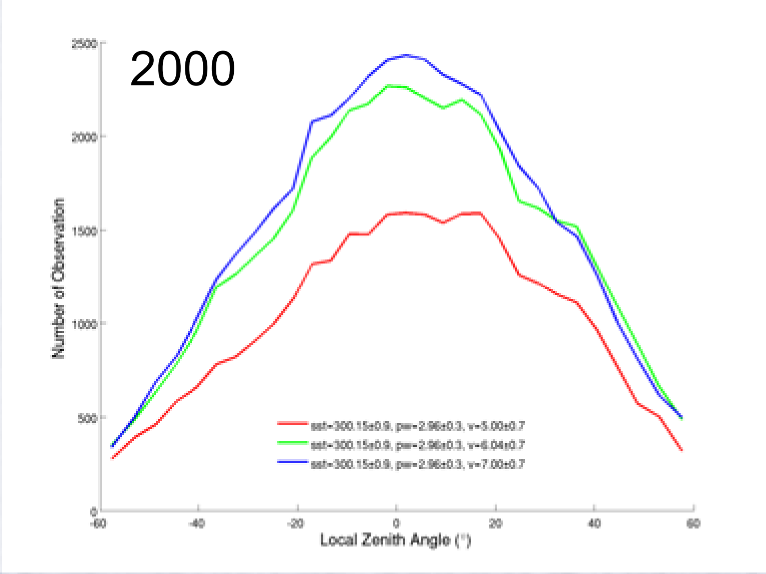
Mean Difference at MPV – Window Channels, Changing Wind Speed, NOAA-18, 2008

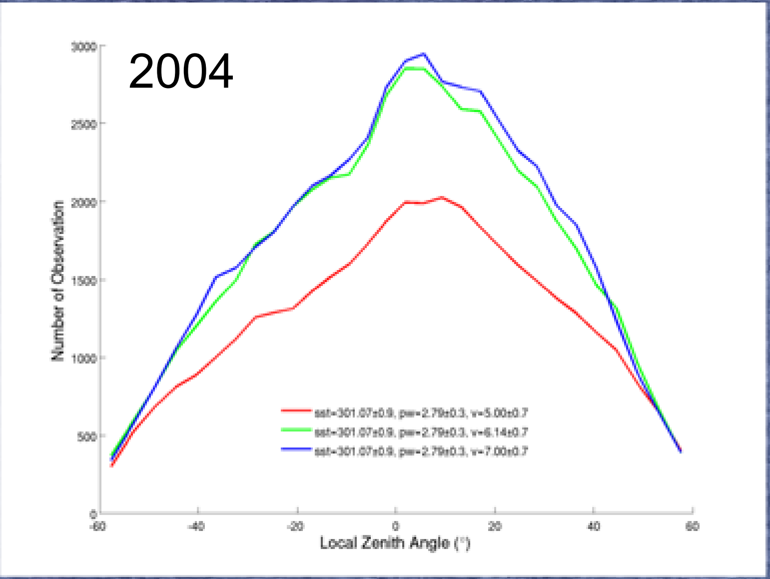


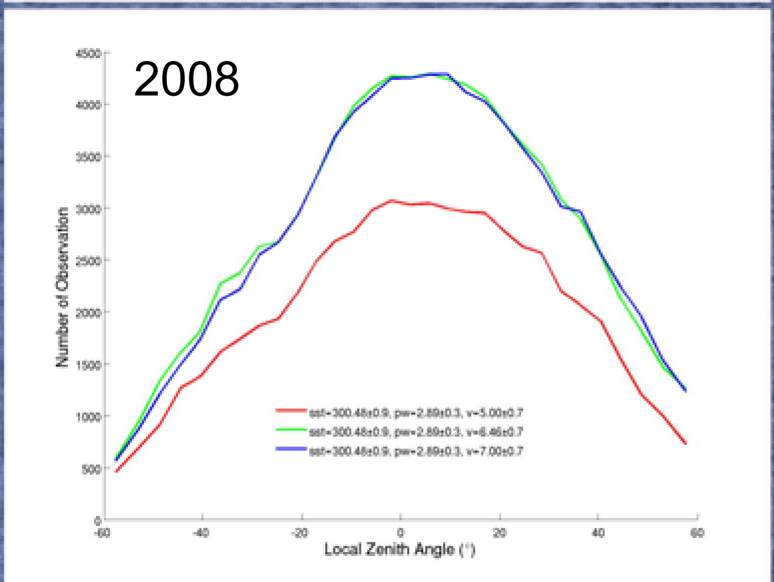
Mean Difference at MPV – Window Channels, Changing Wind Speed, MetOp-A, 2008



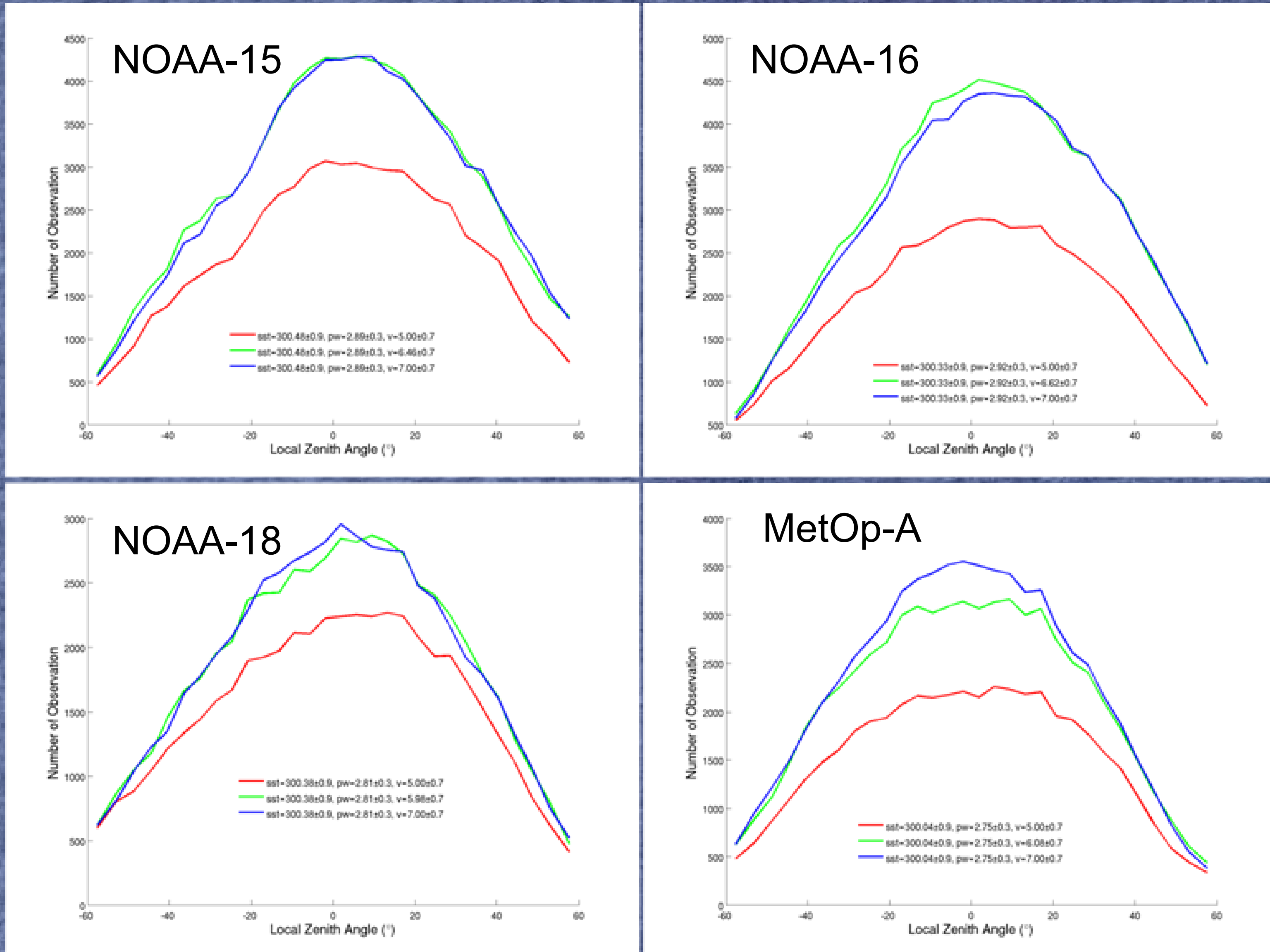
Number of Observations at MPV – Changing Wind Speed, NOAA-15



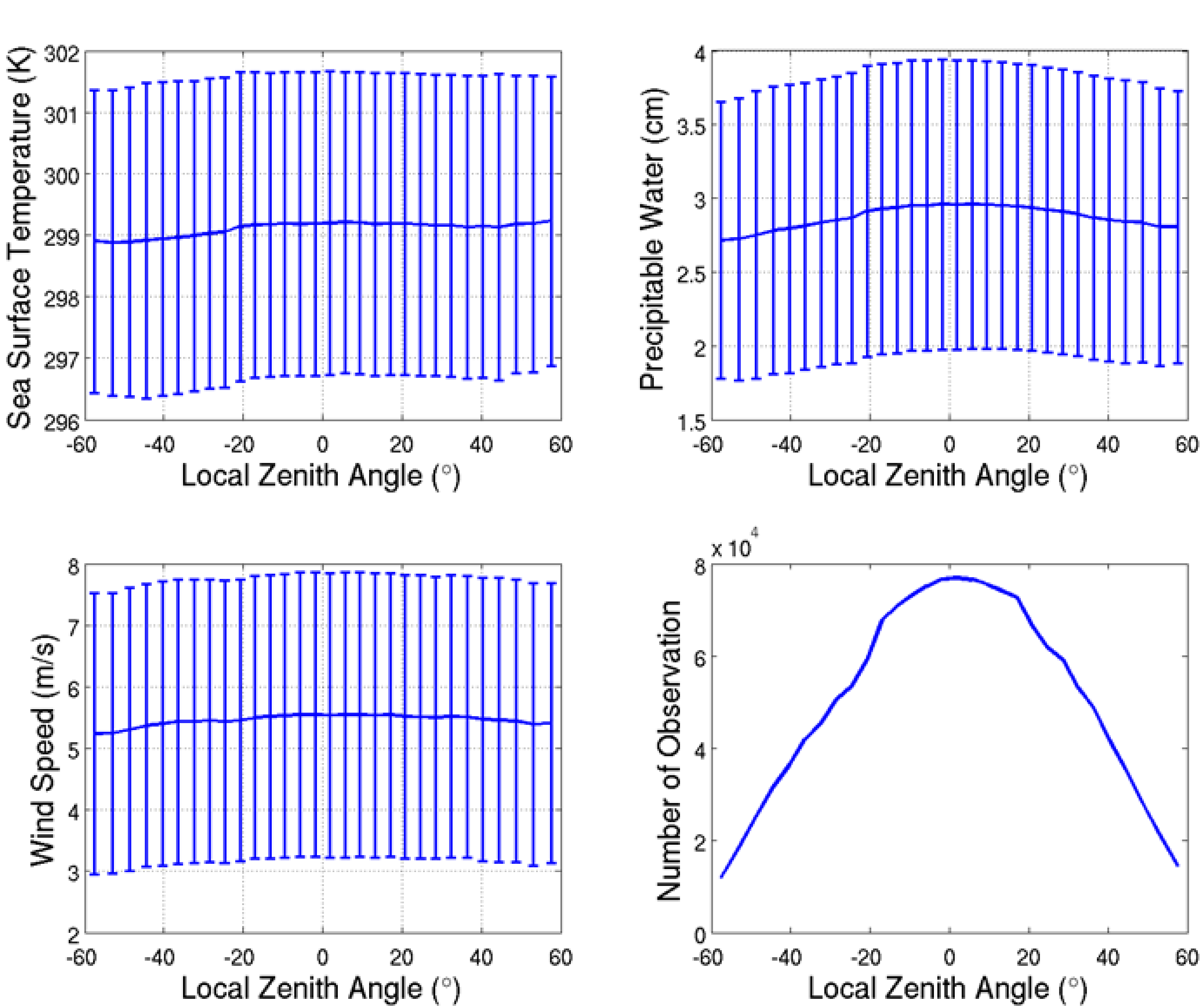




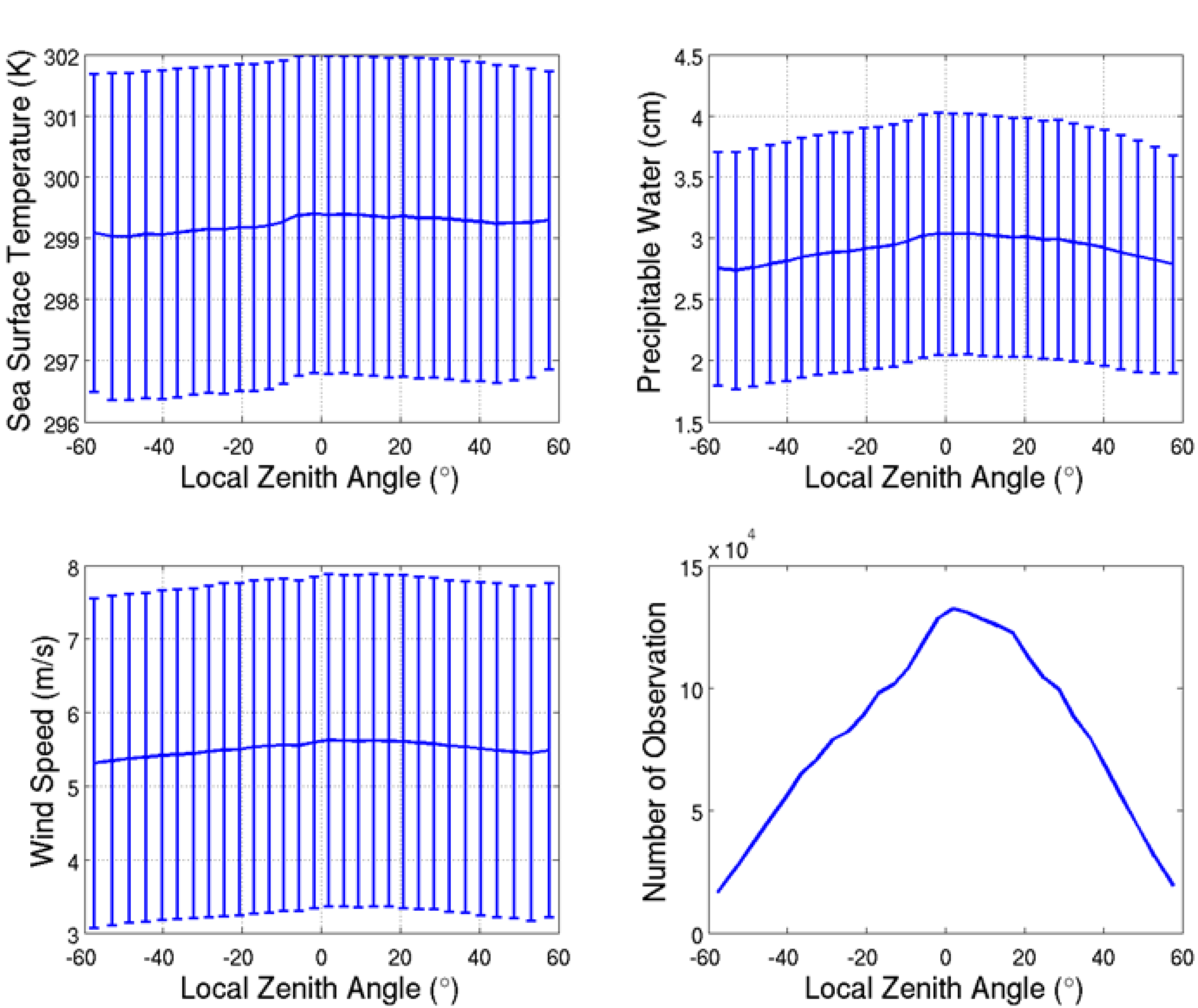
Number of Observations at MPV – Changing Wind Speed, 2008



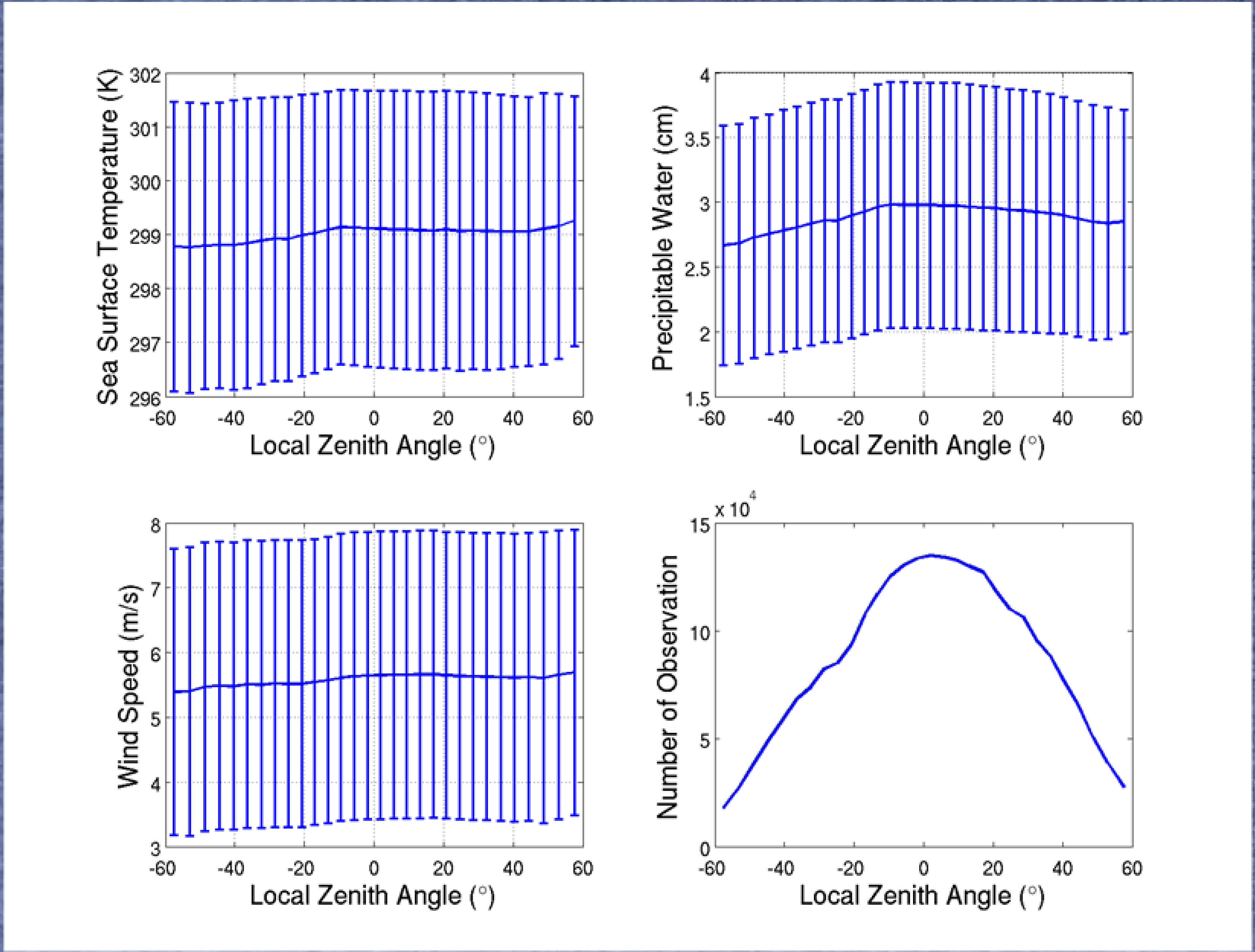
Angular Distribution, NOAA-15, 2000



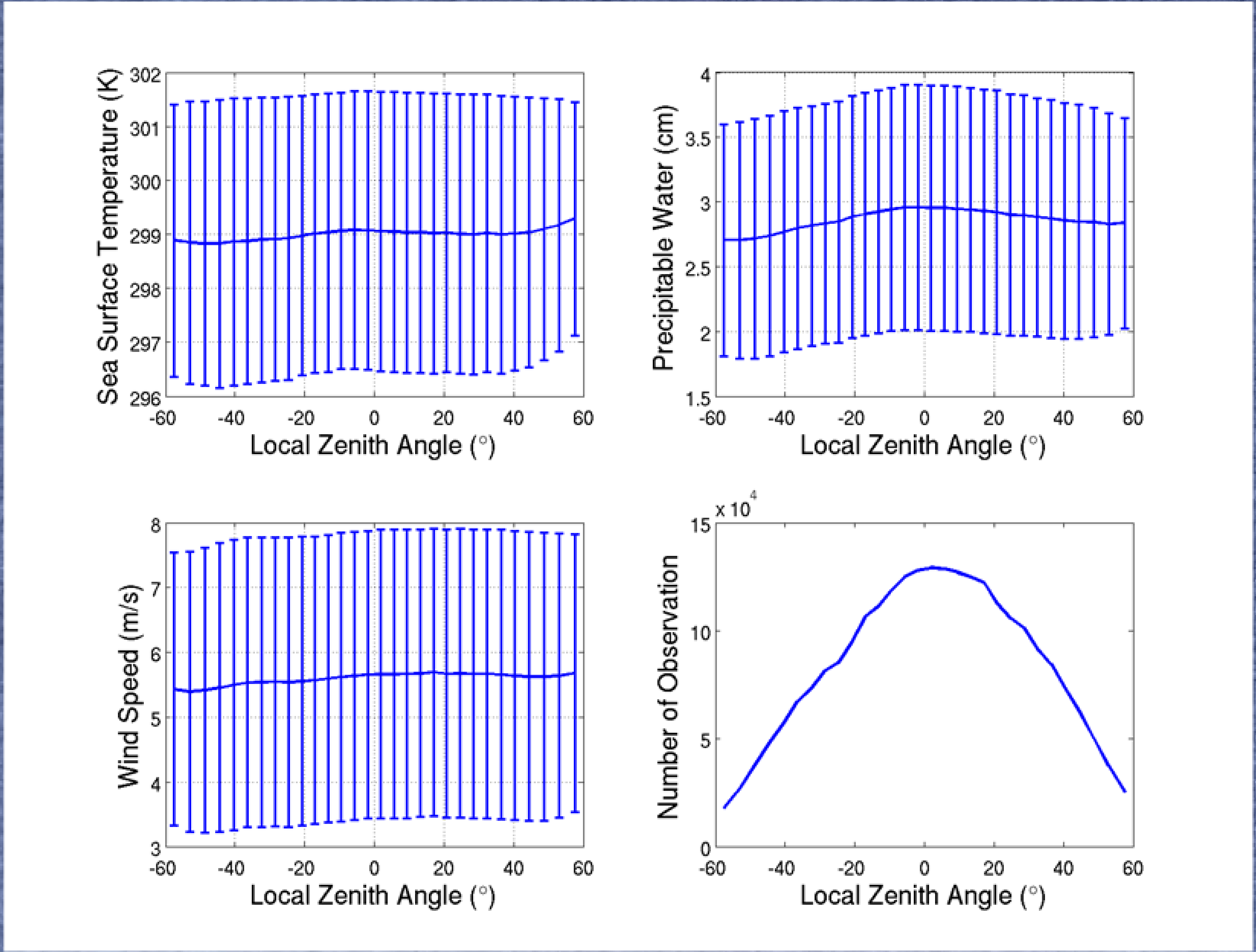
Angular Distribution, NOAA-15, 2004



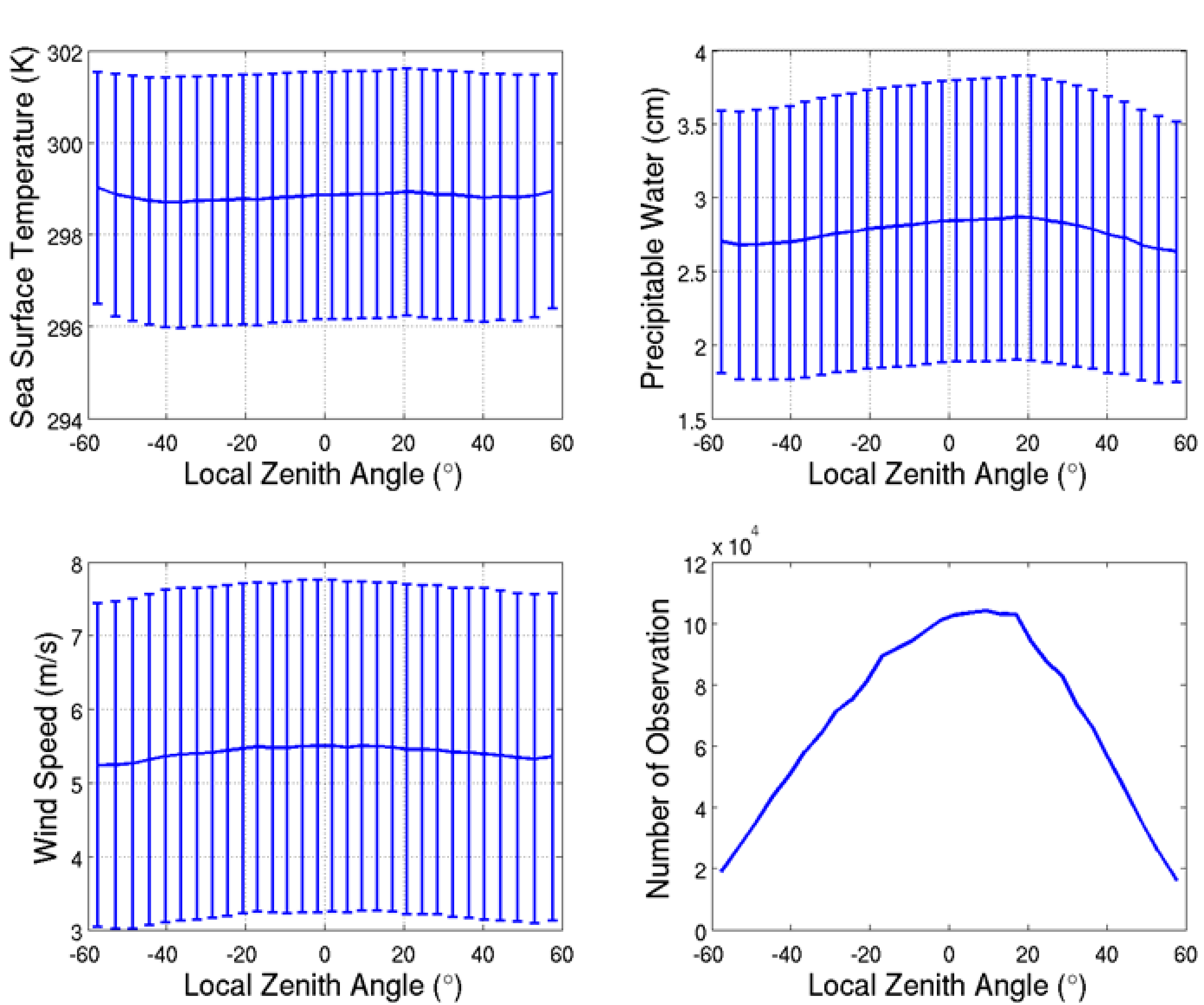
Angular Distribution, NOAA-15, 2008



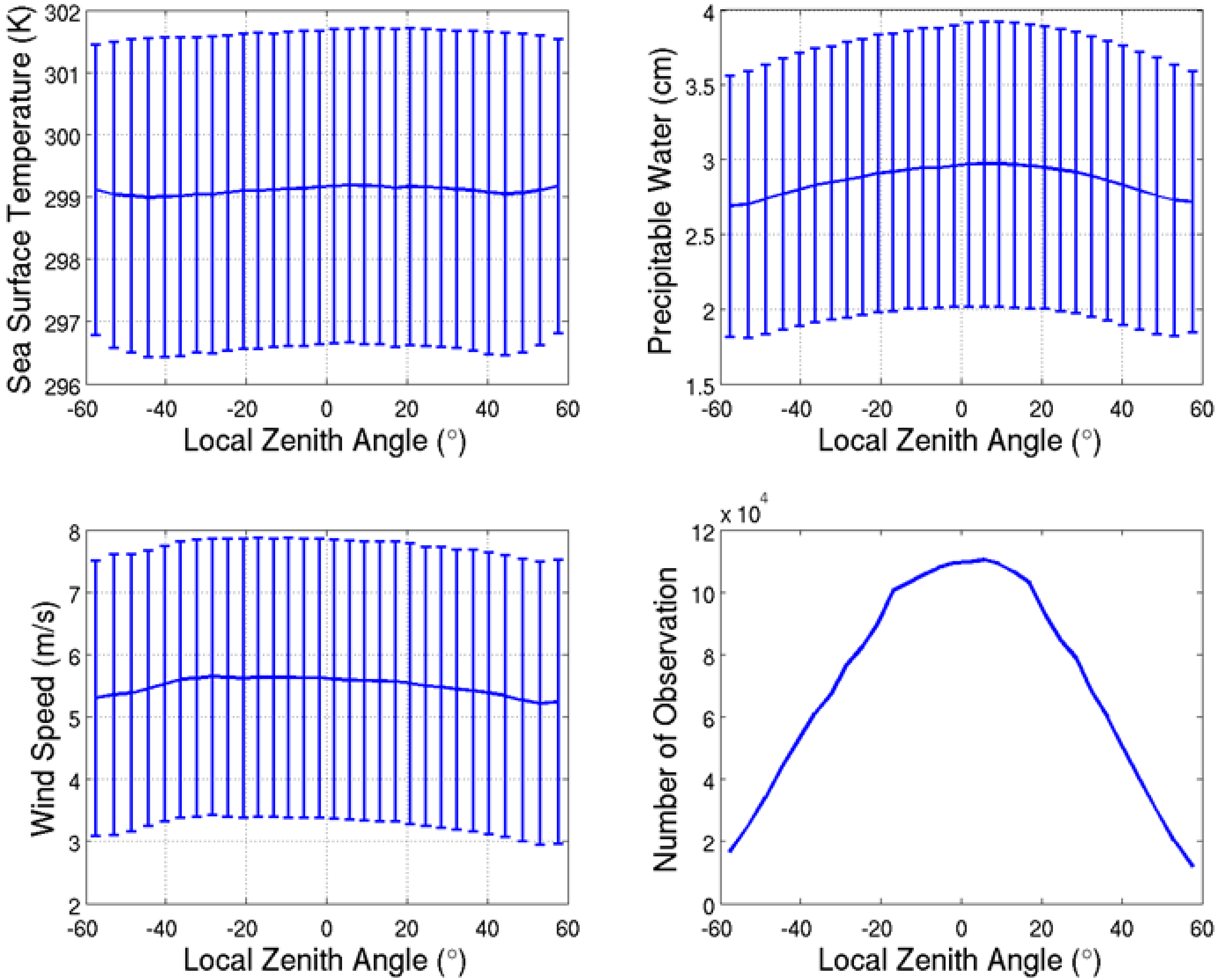
Angular Distribution, NOAA-16, 2008



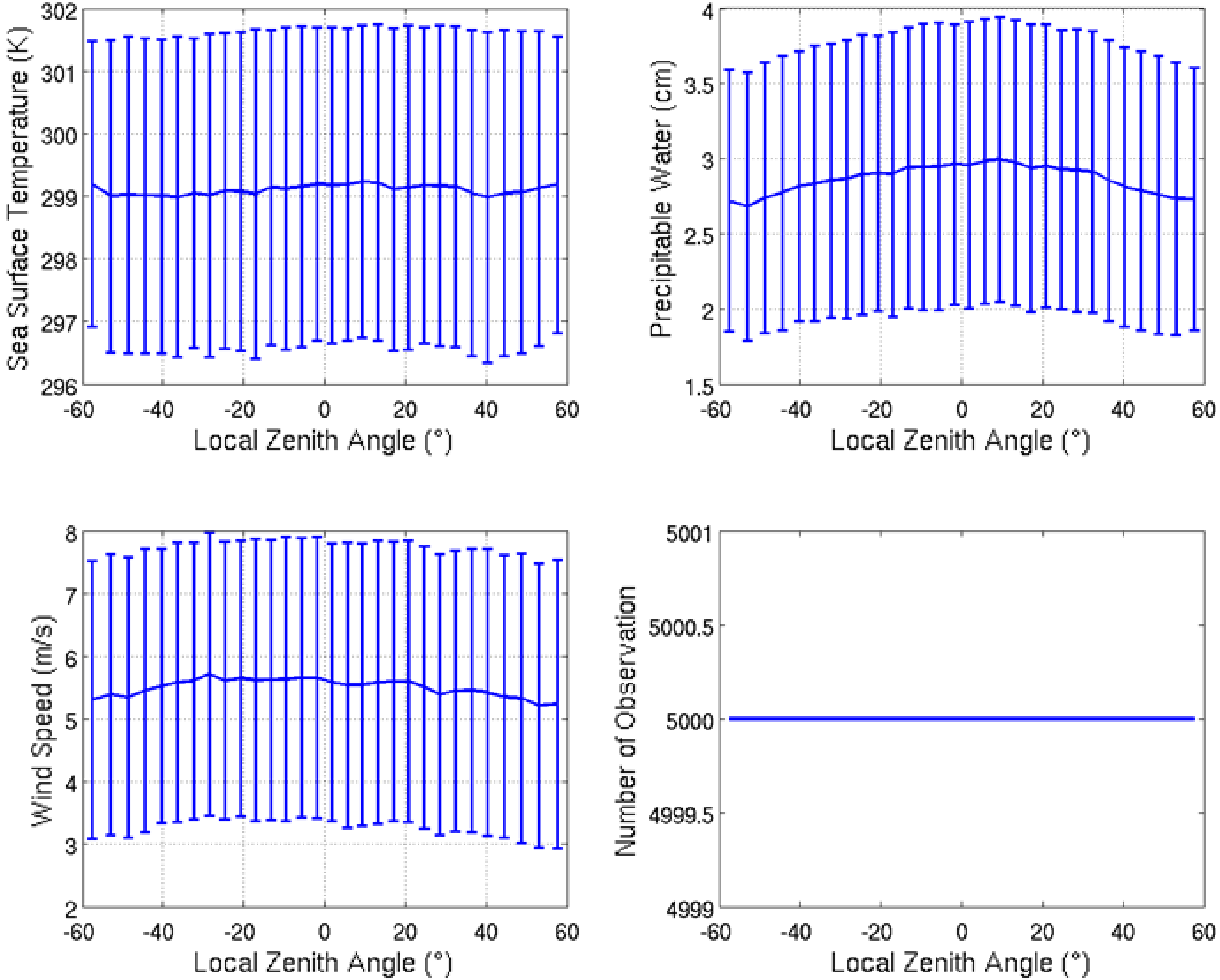
Angular Distribution, NOAA-18, 2008



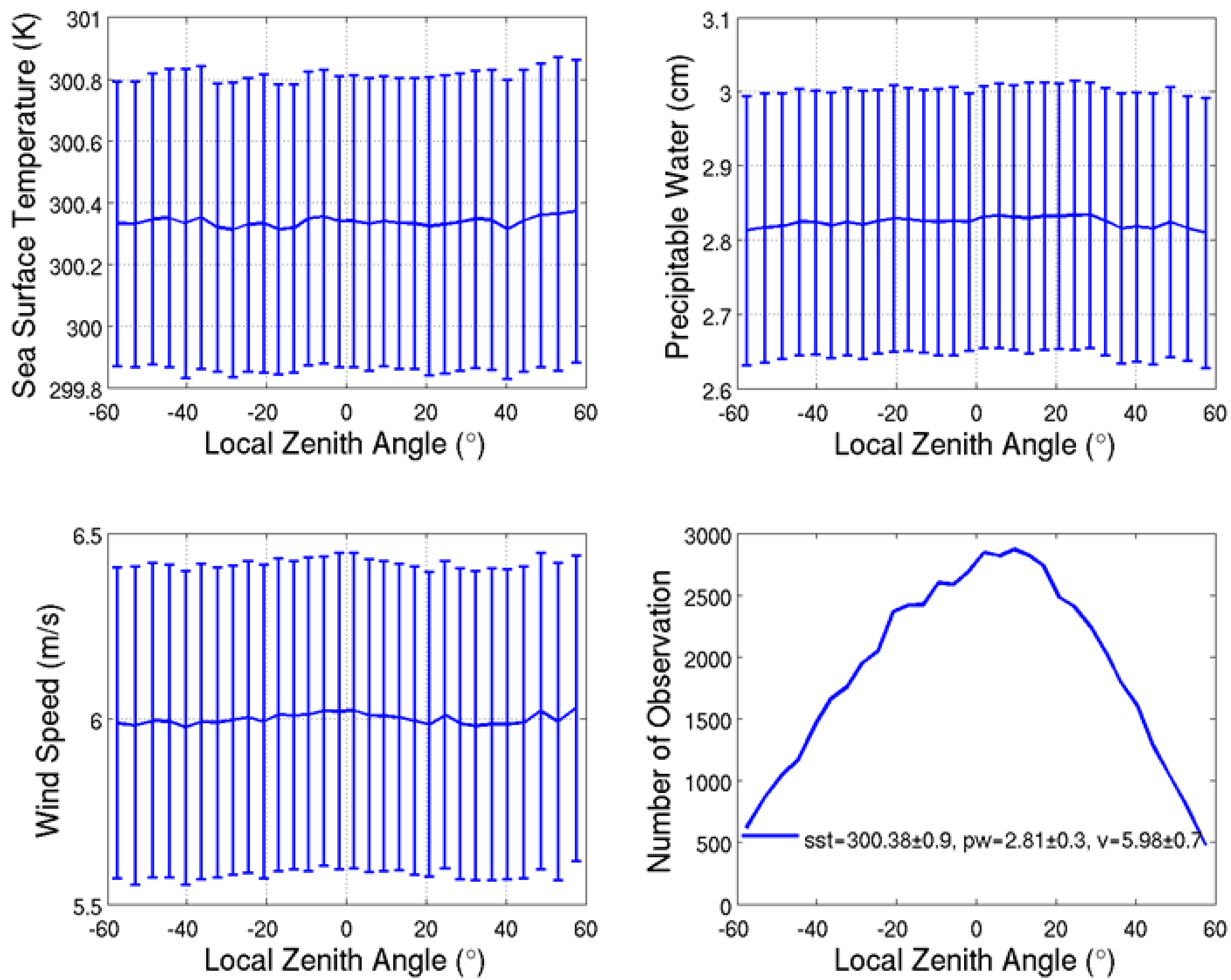
Angular Distribution, MetOp-A, 2008



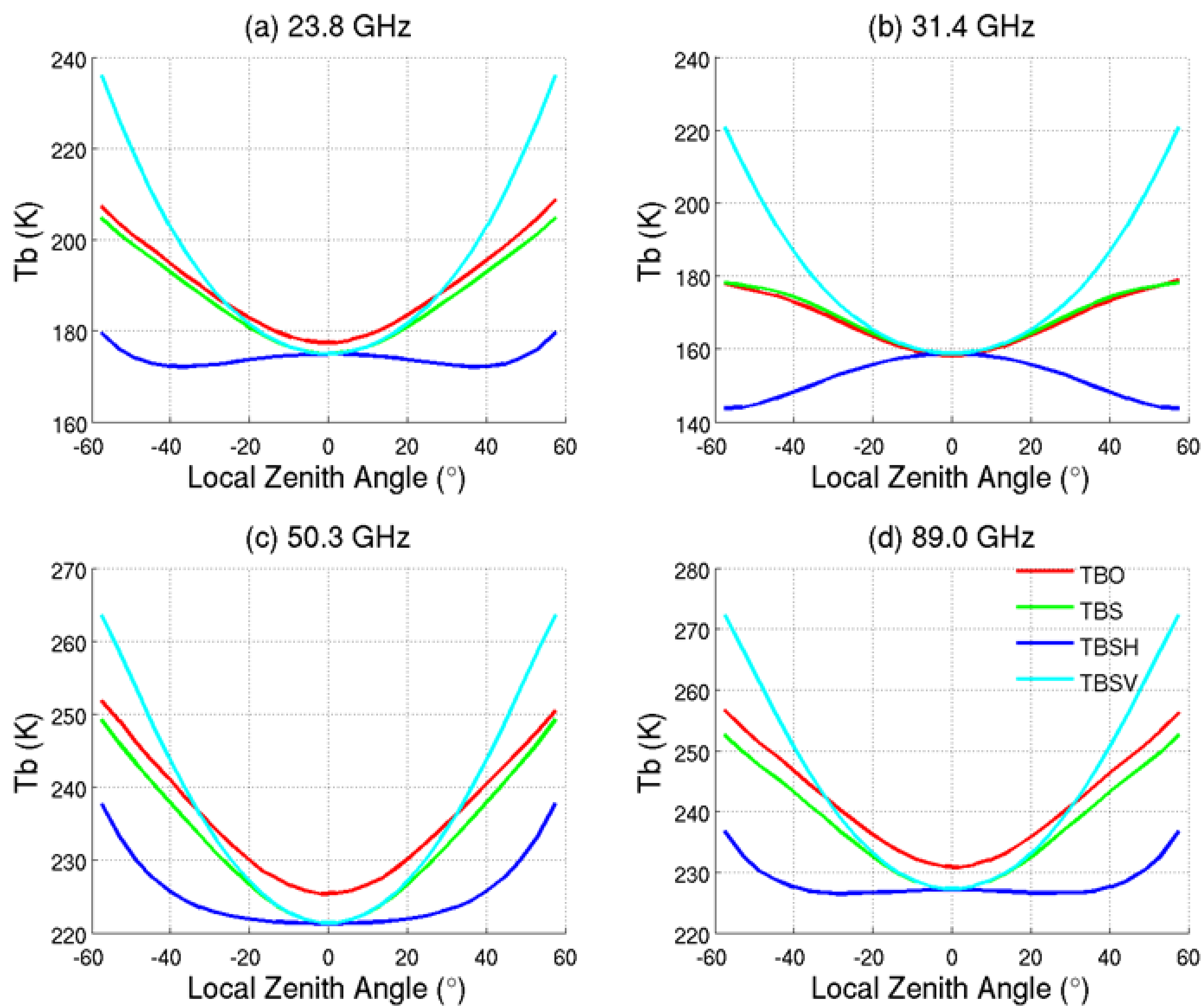
Angular Distribution, MetOp-A, 2008 – Fixed Number of Observations



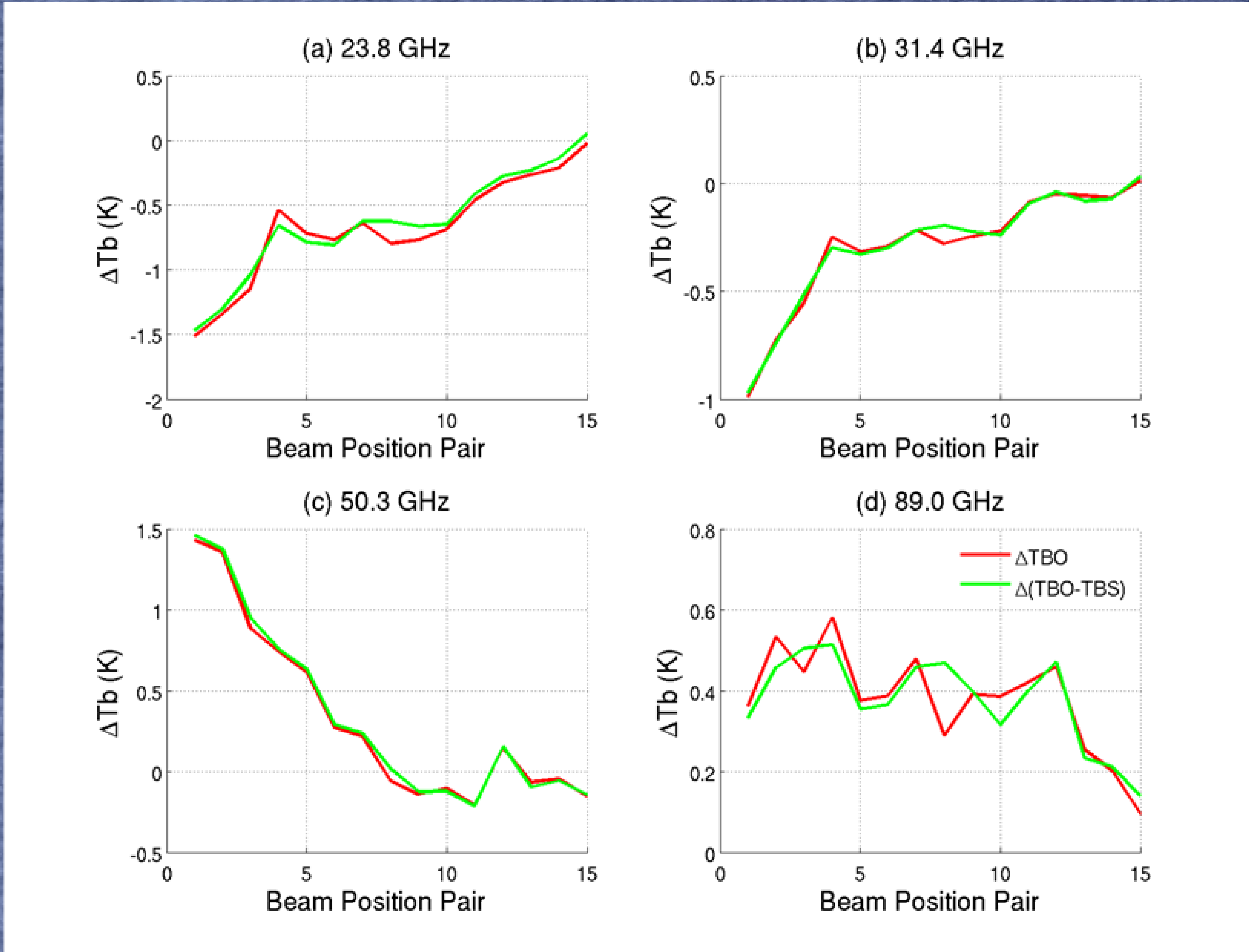
Angular Distribution, NOAA-18, 2008, Near Most Probable Value



Brightness Temperature, Observed and Simulated



Delta Brightness Temperature, Left - Right



Advantage of Using CRTM

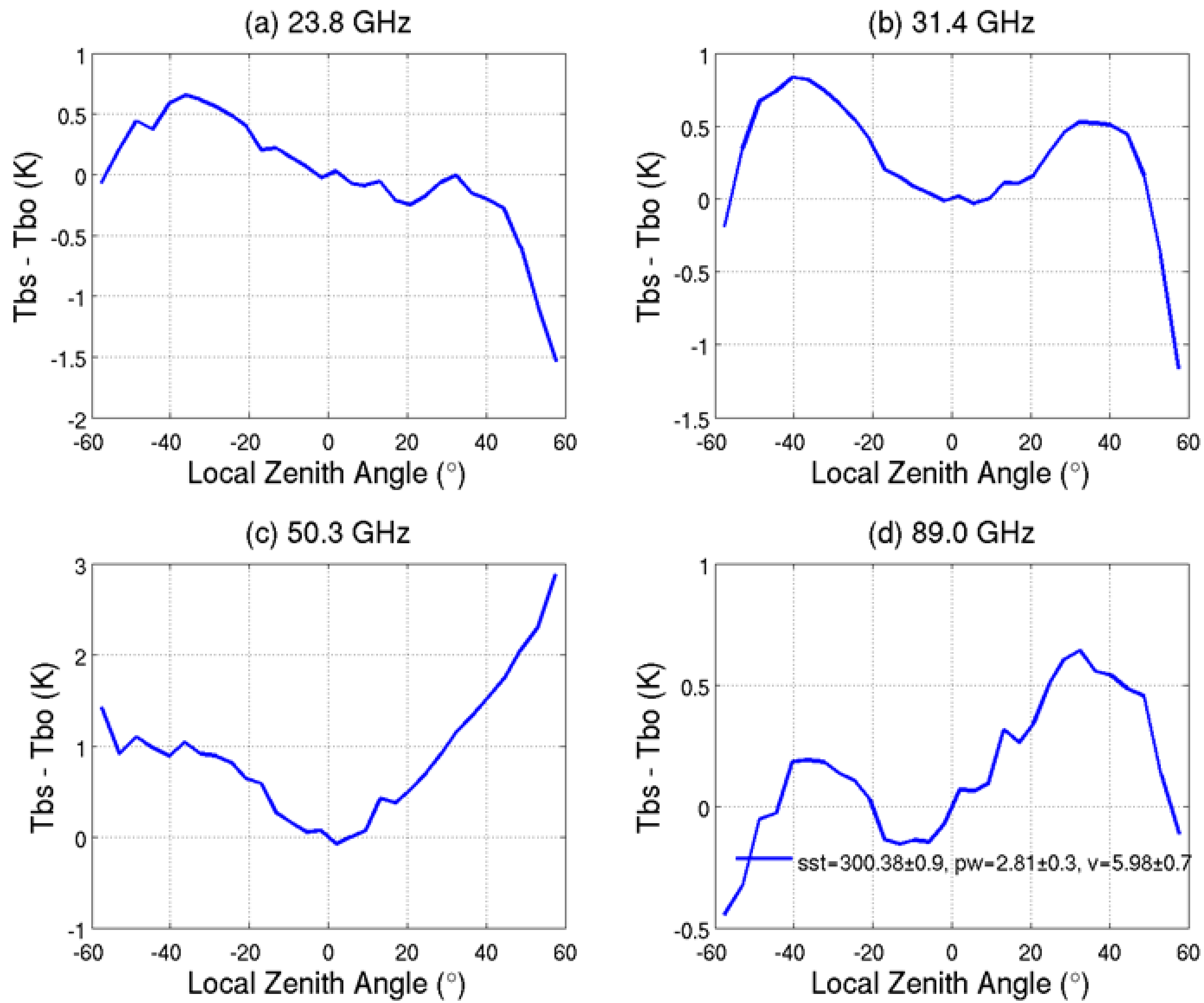
1. Quantify both symmetric bias and asymmetric bias without introducing much extra error

2. Direct link between environment variables and radiance / brightness temperature
   Make it possible for stratification

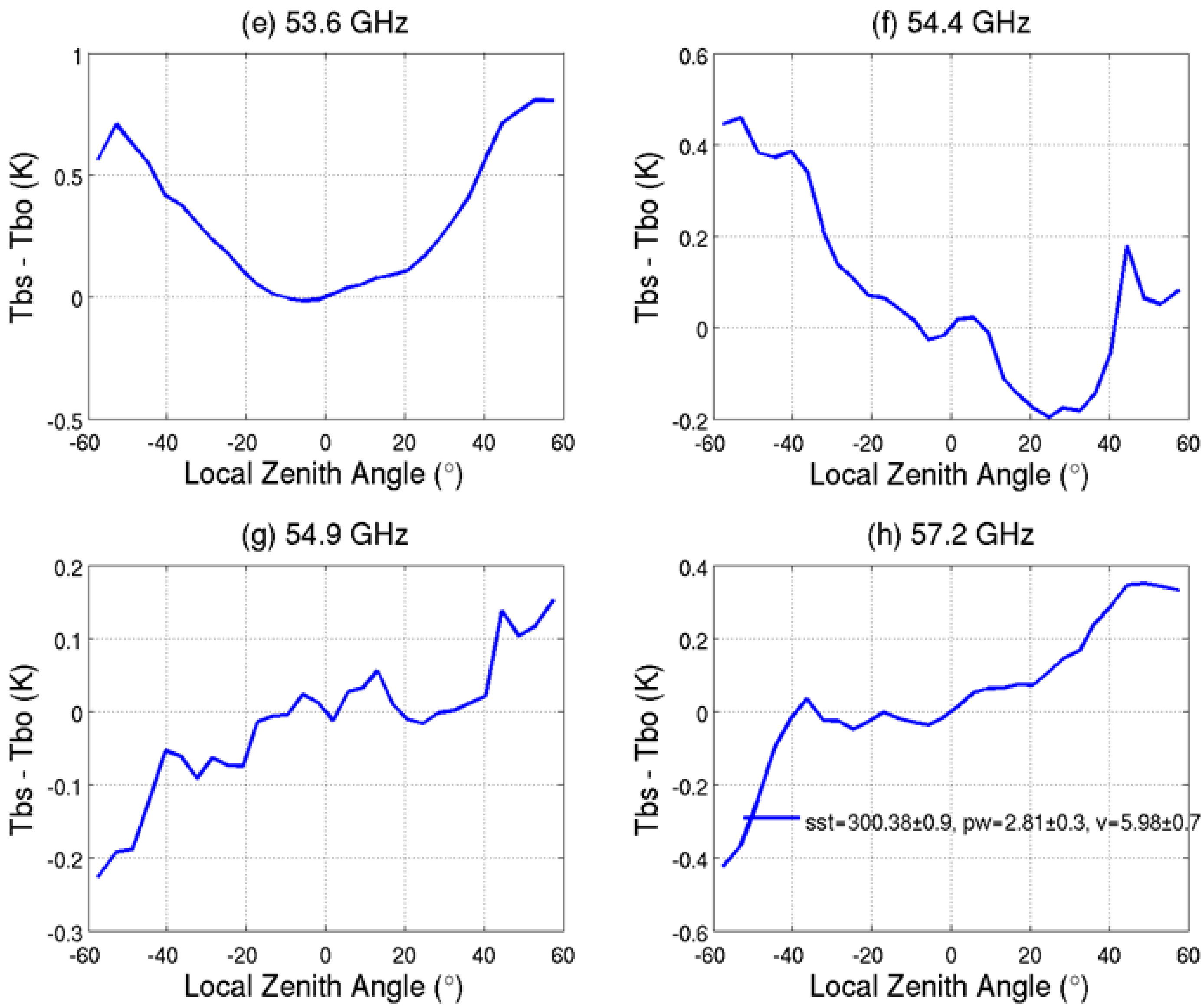
3. Essential component in polarization related calculation

4. Essential component in double difference technique

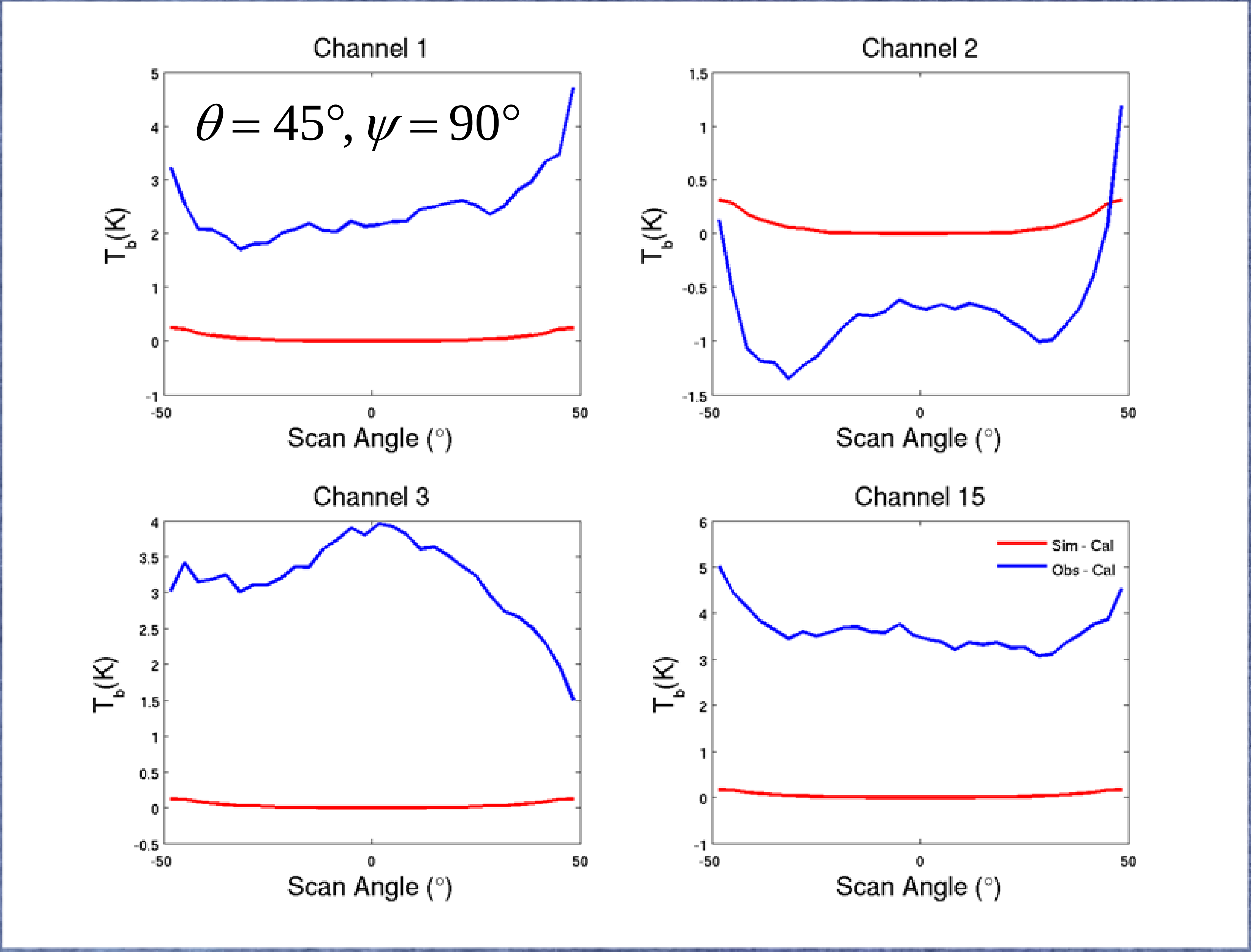
Asymmetry for Window Channels



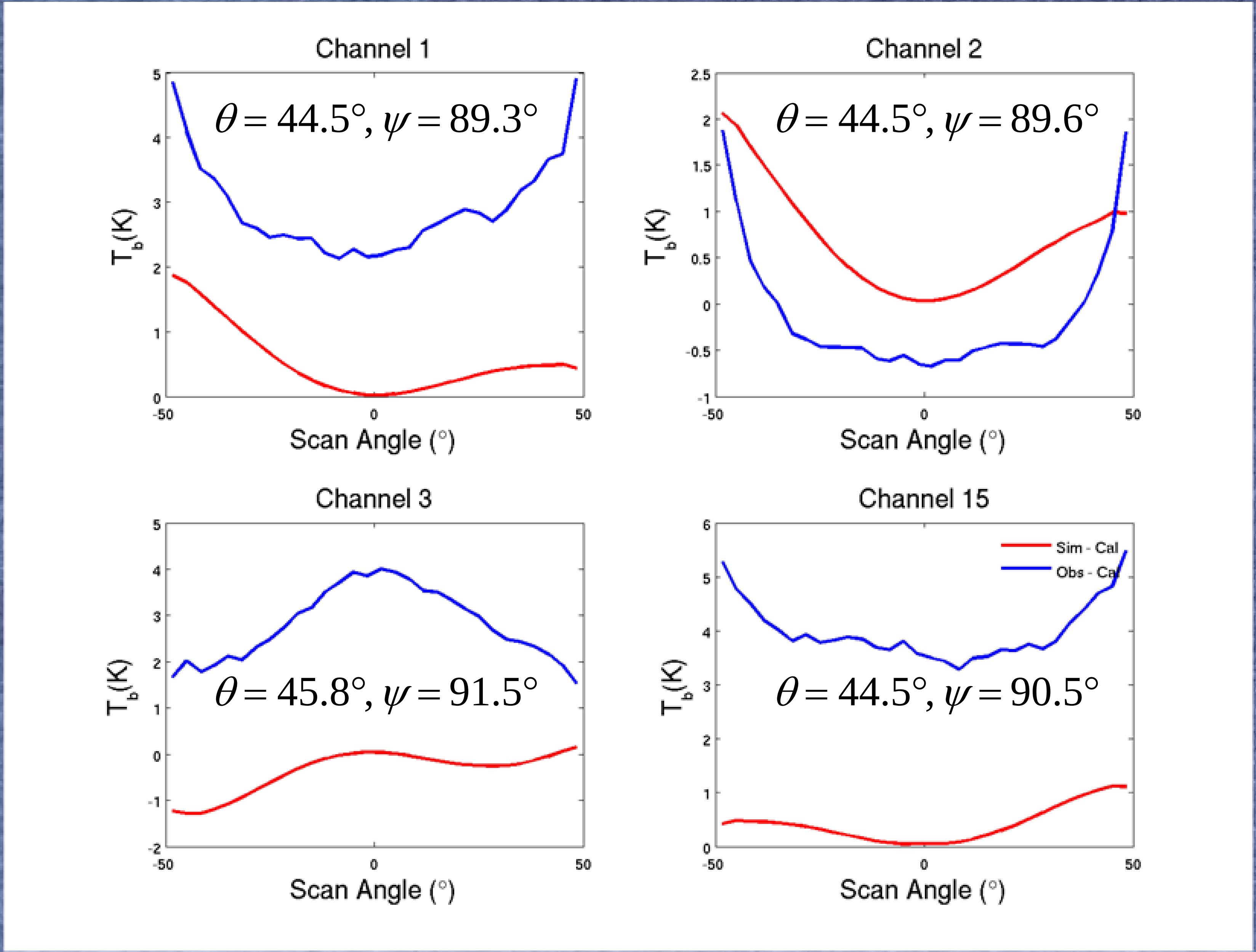
Asymmetry for Sounding Channels



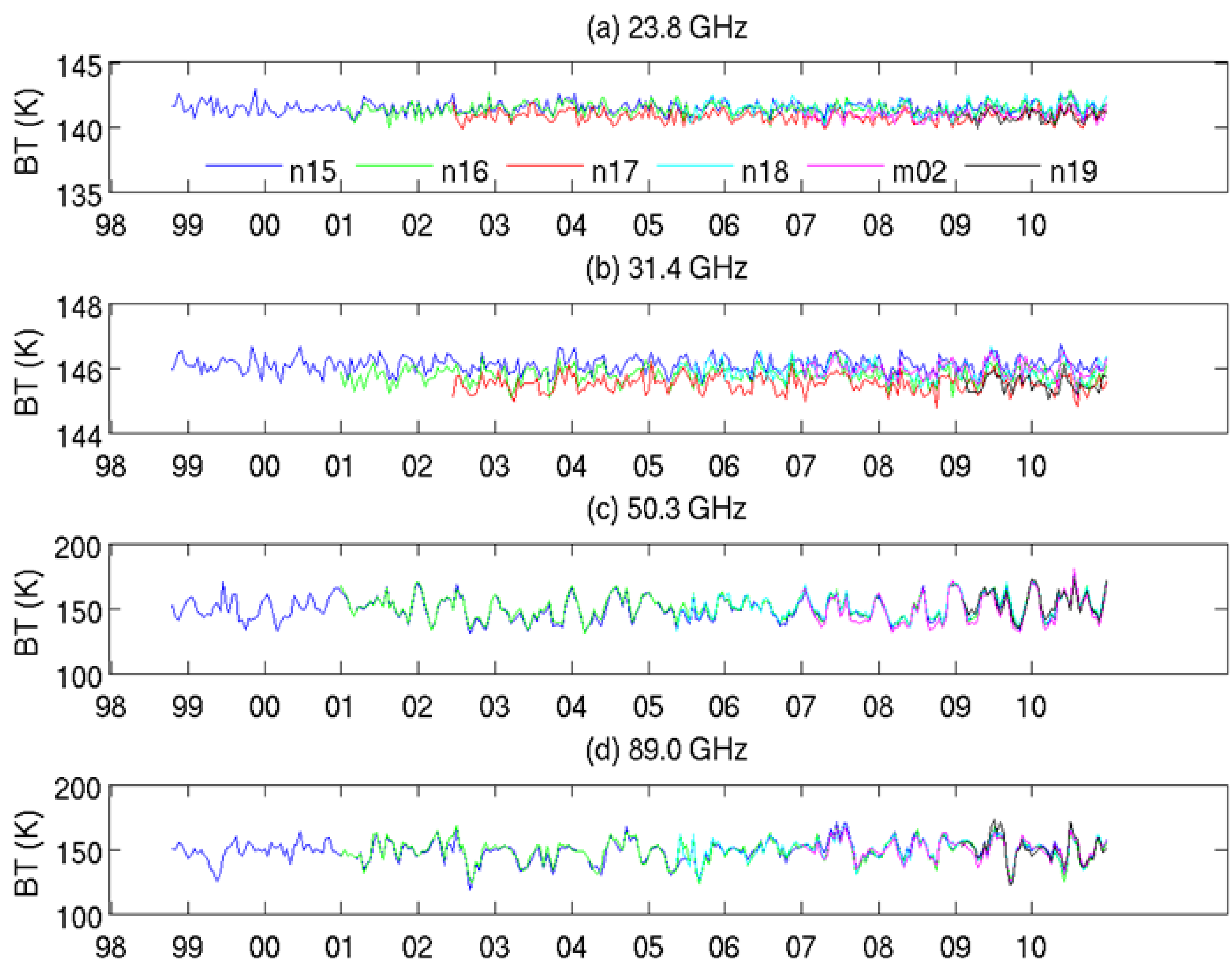
Brightness Temperature Difference before Adjusting Angles



Brightness Temperature Difference after Adjusting Angles



Vicarious Cold Reference, Nadir View, All Satellites

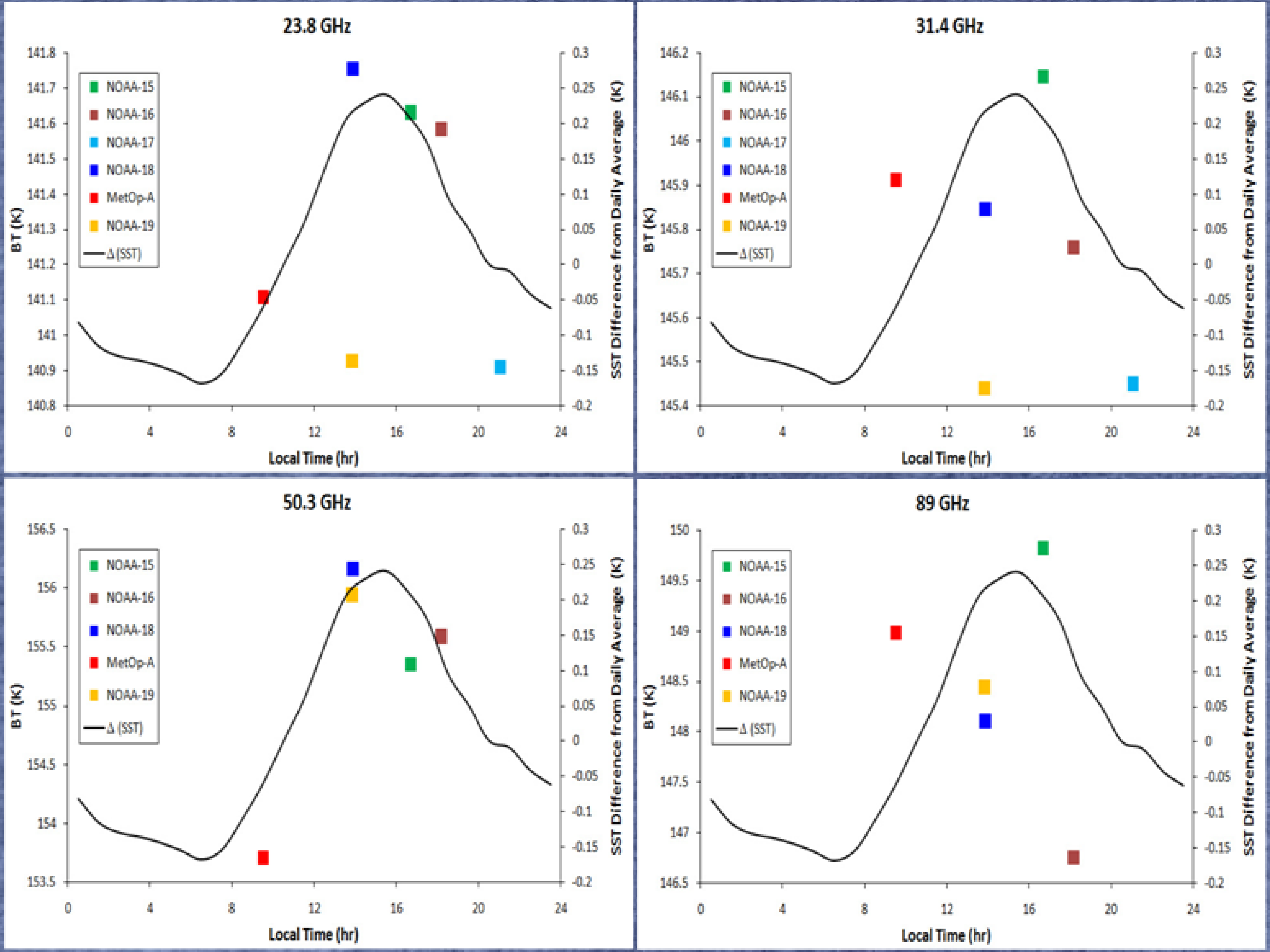


Linear Regression Coefficients

$BT(t) = BT0 + a^* t$

BT0	23.8 GHz	31.4 GHz	50.3 GHz	89.0 GHz
n15	141.5024	146.0852	148.7607	146.4928
n16	141.3595	145.7706	149.7894	148.1746
n17	140.9372	145.5226	NaN	NaN
n18	141.4347	145.9841	148.4020	149.8420
m02	140.8219	145.9652	146.0052	151.6106
n19	140.8275	145.5493	153.6547	153.1574
a	23.8 GHz	31.4 GHz	50.3 GHz	89.0 GHz
n15	0.0001	0.0001	0.0088	0.0145
n16	0.0008	0.0001	0.0123	0.0068
n17	-0.0008	-0.0001	NaN	NaN
n18	0.0013	-0.0009	0.0509	0.0048
m02	0.0032	-0.0006	0.0706	-0.0290
n19	0.0024	-0.0022	0.0293	-0.1292

Average 2010 Vicarious Cold Reference vs. SST Diurnal Variability



Conclusion

1. There is no much difference between ascending and descending nodes regarding to asymmetry
   But number of observation in descending node is almost half as that of ascending node
   The difference of number of observation mostly arise from cloud screening

2. The asymmetry is quite sensitive to combined physical conditions
   This may indicate environmental condition also have impacts on asymmetry
   Uncertainties might also arise from ERA-Interim data and CRTM

3. 31.4 GHz and 50.3 GHz asymmetries are not sensitive to sea surface temperature or precipitable water
   Wind speed is the most important physical variable to impact asymmetry

4. The asymmetry is pronounced even in a specific physical condition

5. The asymmetry pattern is stable through years, but quite different among on-board satellites

6. The mean precipitable water is not even at 30 beam positions

7. Sounding channels may provide sensor pointing information

8. How to use vicarious cold reference is still a question for us