Brightness Temperature Calibration of SAC-D/Aquarius Microwave Radiometer (MWR)

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CONAE

AQ Cal/Val Meeting

Pasadena, CA

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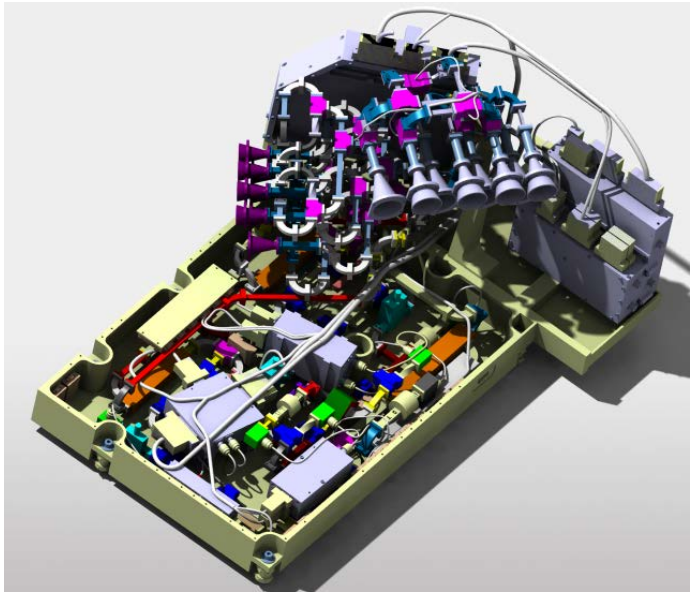
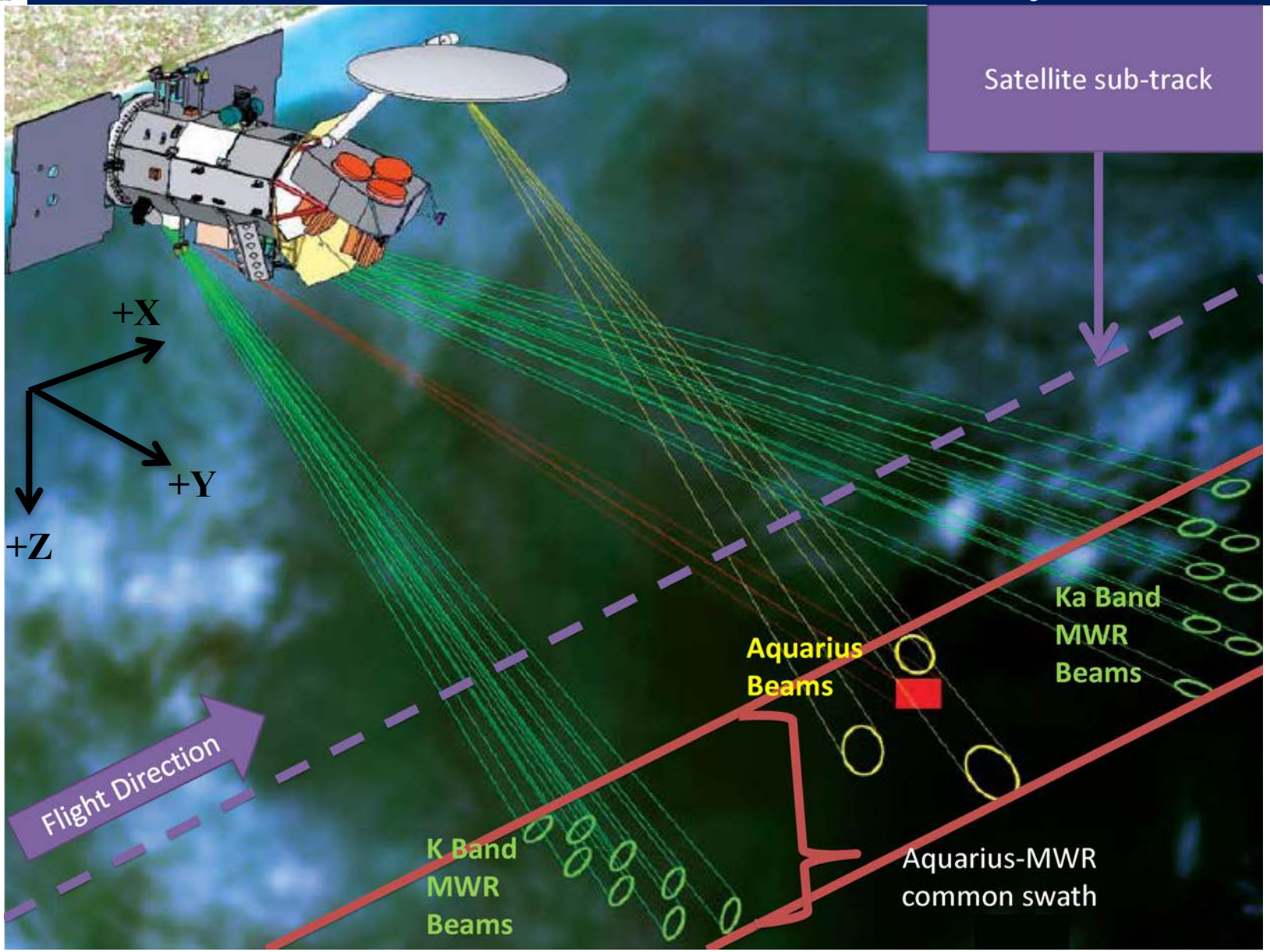
MWR Instrument Overview

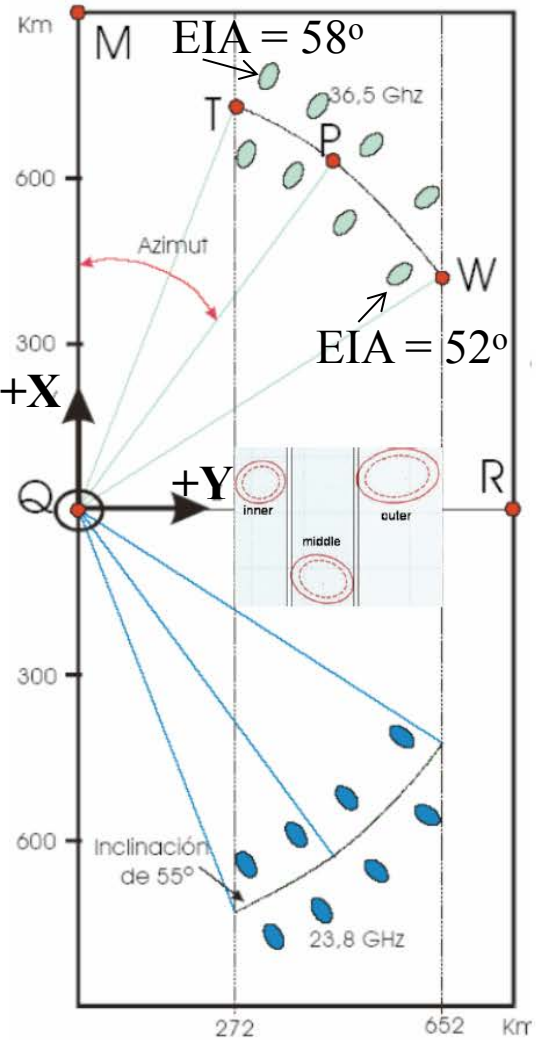
- ❑ Two Frequency Bands
  - K – (23.8 GHz) : H-Pol Only
  - Ka – (36.5 GHz): V, H,+45° & -45° Pol
- ❑ Two reflector antenna
  - Matched beamwidths

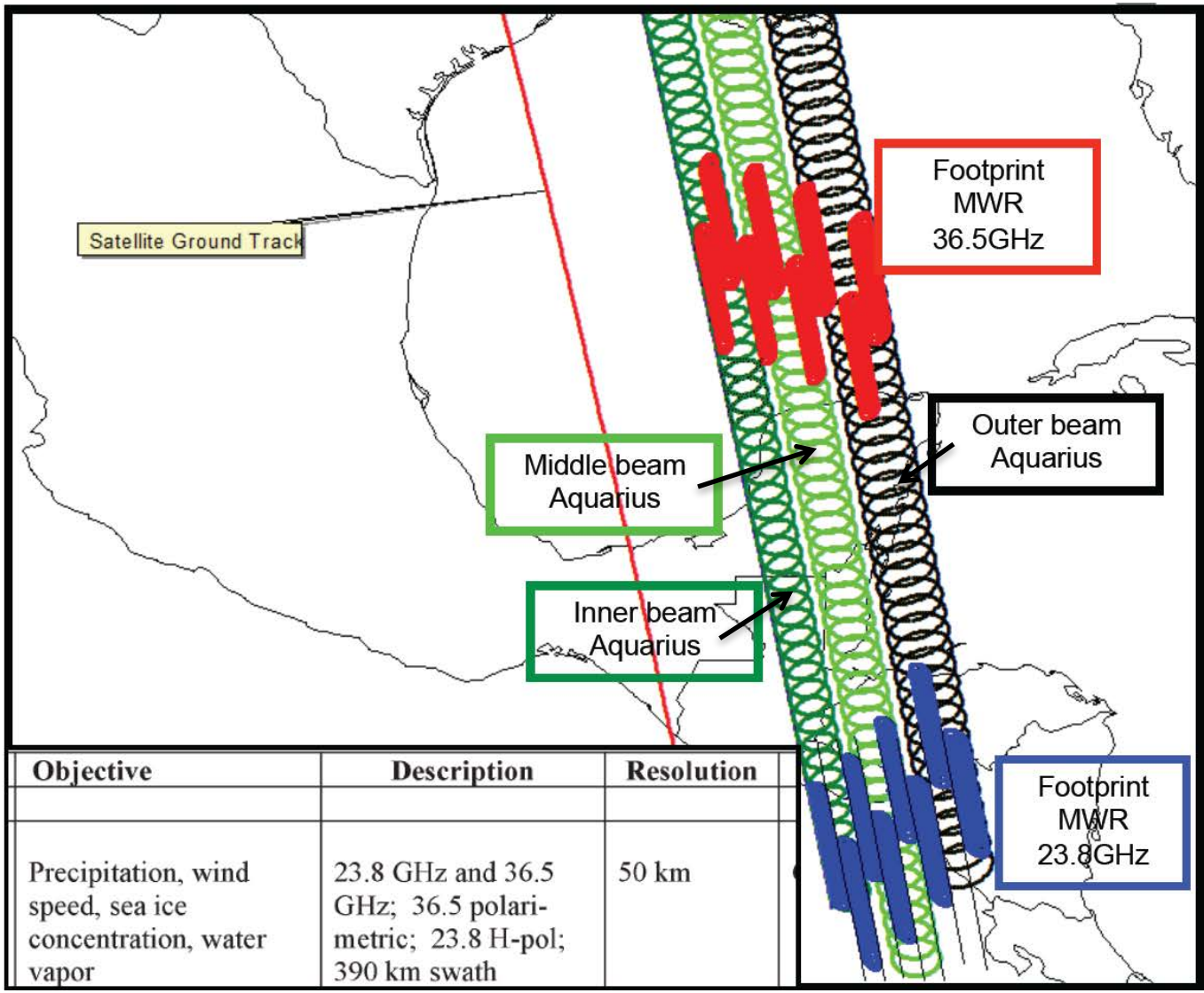


MWR Sensor Geometry



MWR Sensor Geometry

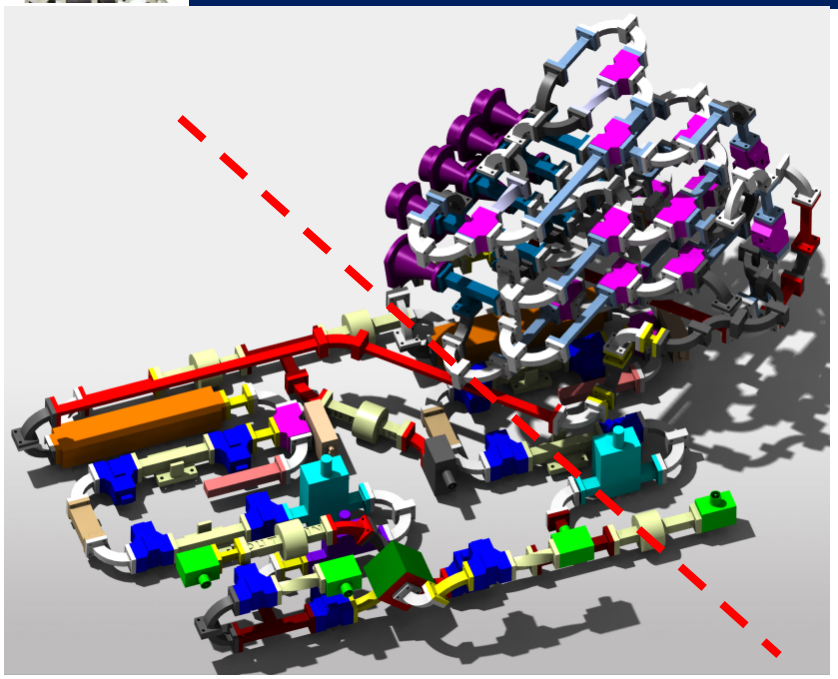


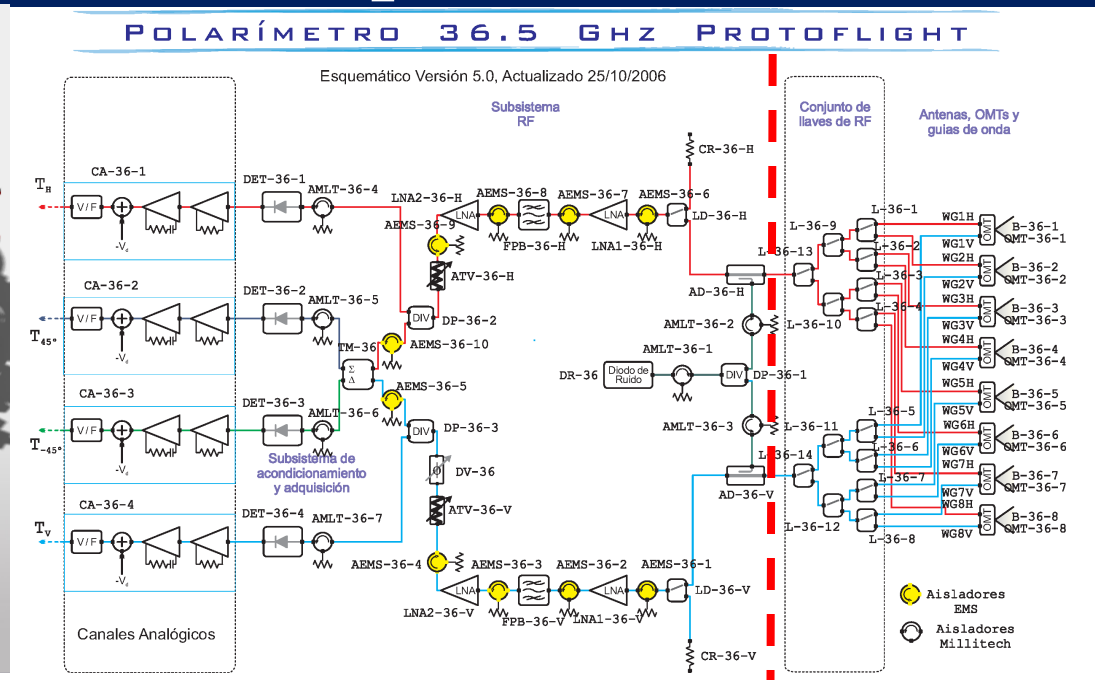


Objective	Description	Resolution
Precipitation, wind speed, sea ice concentration, water vapor	23.8 GHz and 36.5 GHz; 36.5 polarimetric; 23.8 H-pol; 390 km swath	50 km

EIA – Earth Incidence Angle

MWR Int. Cal. : Simplified Model





- Three State Dickie Radiometer

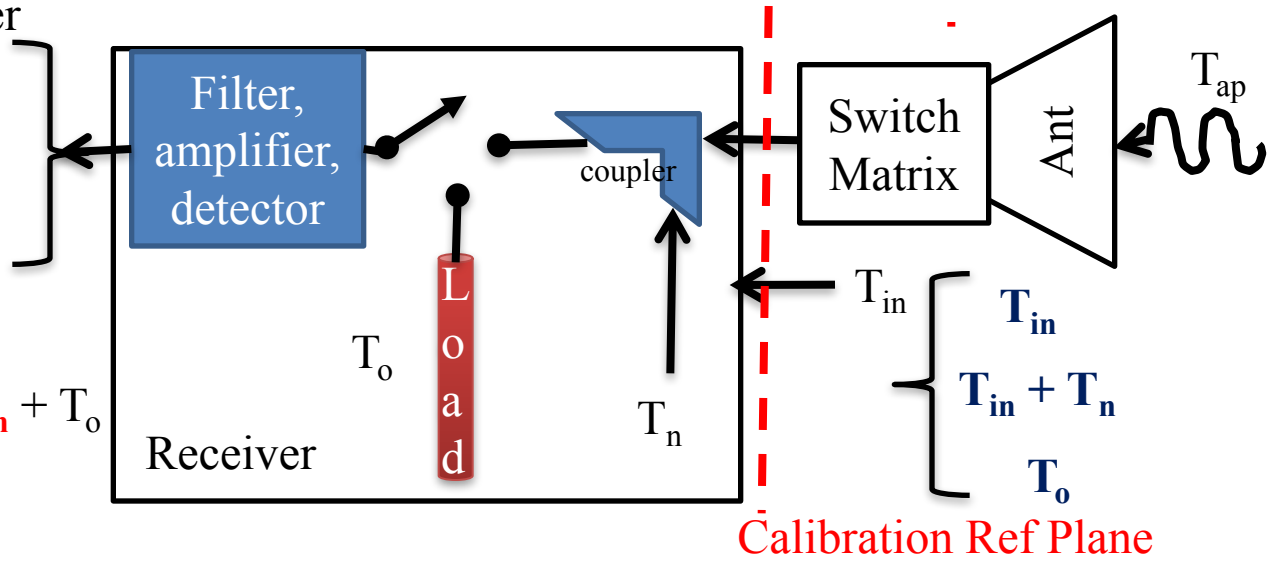
$$C_{in} = GT_{in} + offset$$

$$C_{in+n} = G(T_{in} + T_n) + offset$$

$$C_o = GT_o + offset$$

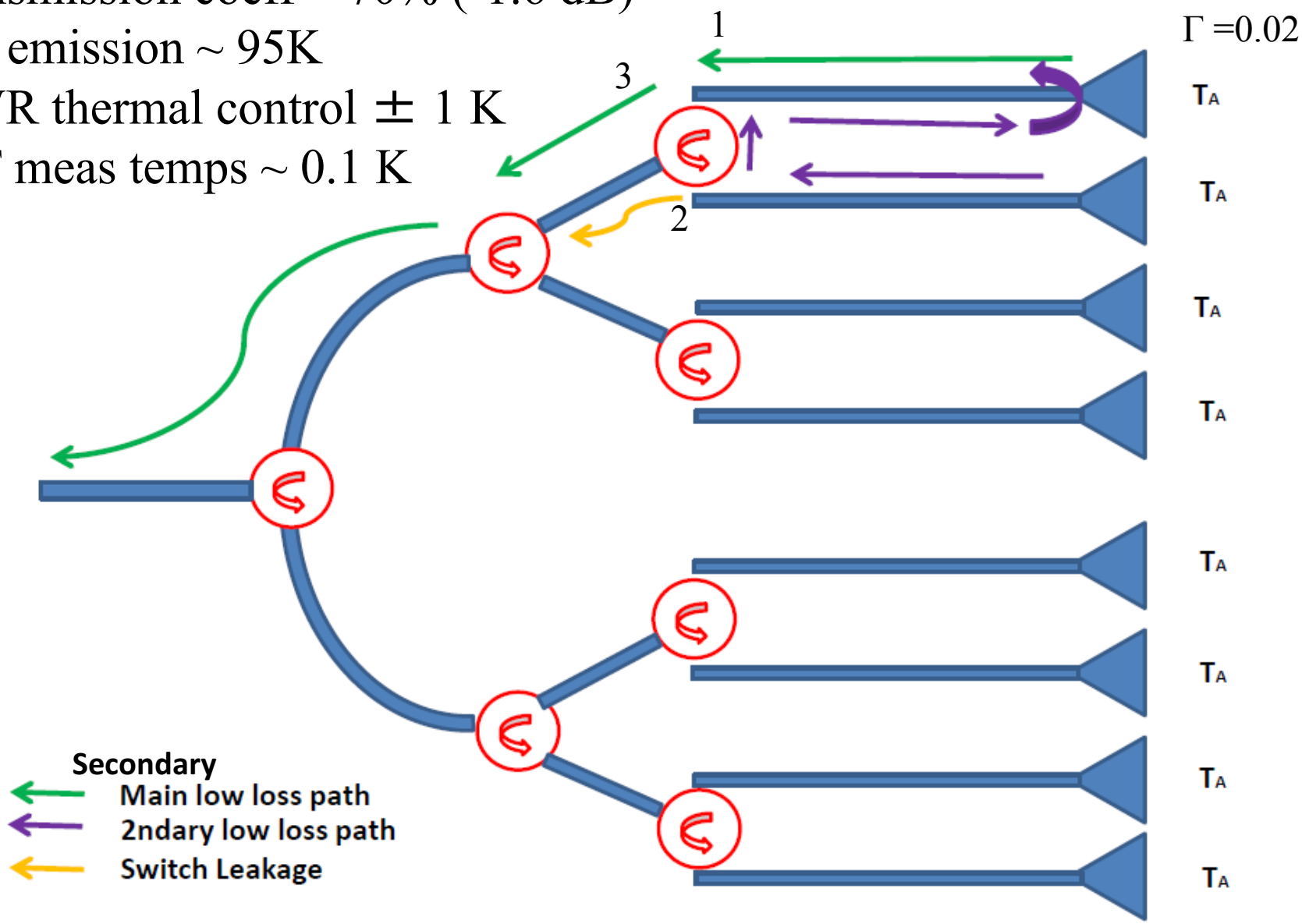
- Calibration Equation:

$$T_{in} = \{(C_{in} - C_o)/(C_{in+n} - C_{in})\} * T_n + T_o$$

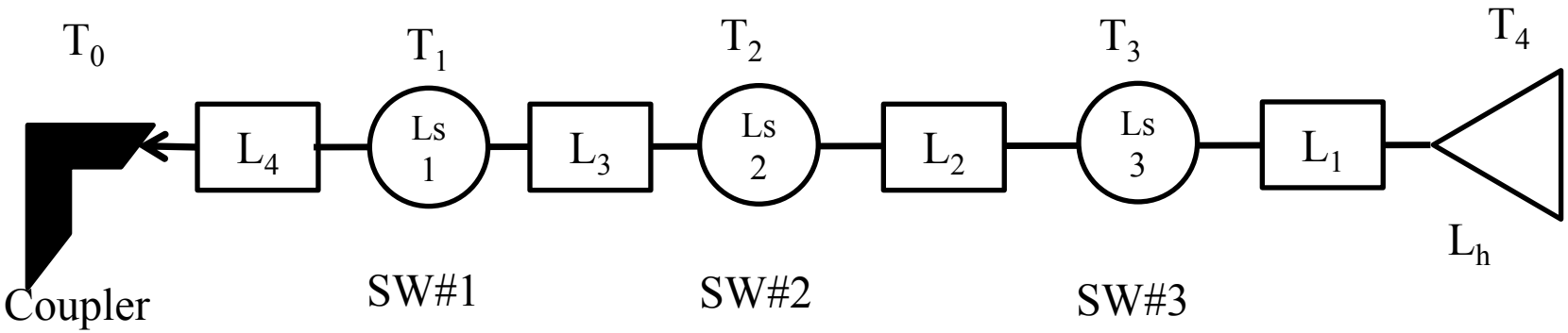


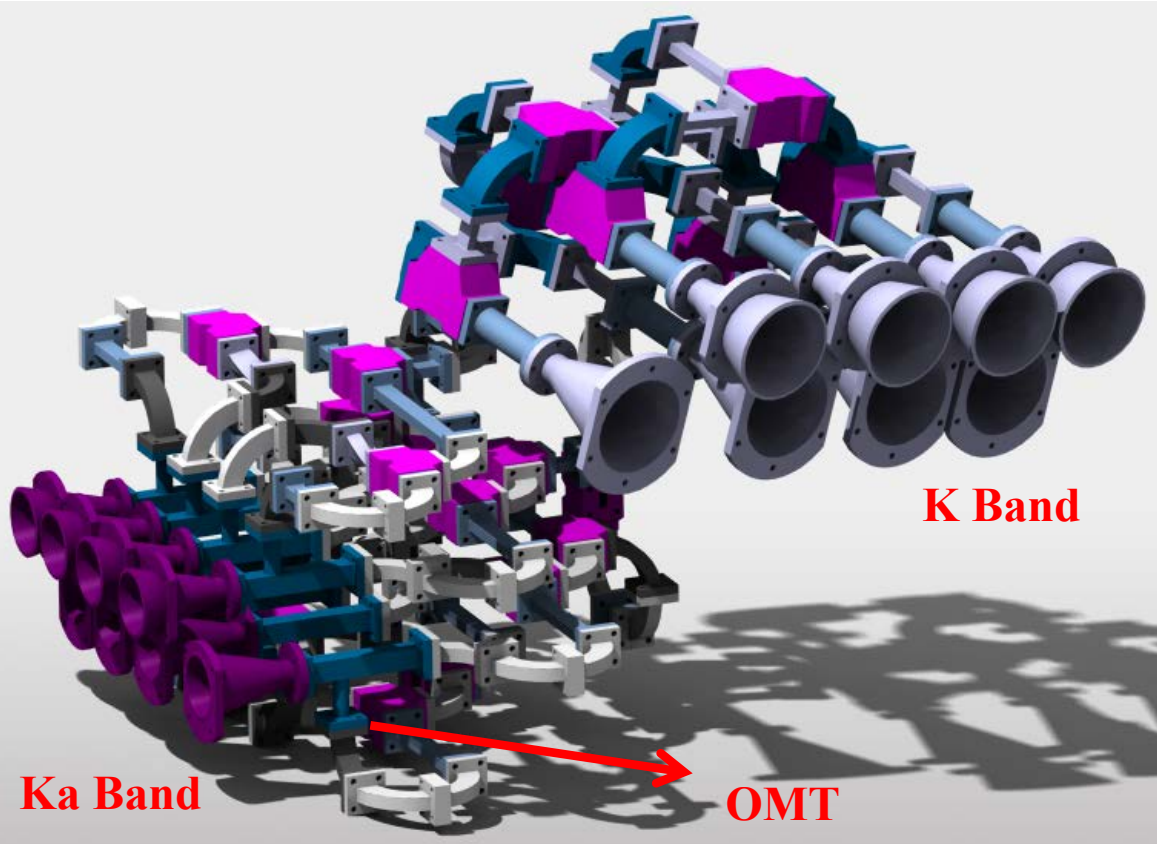
SW Matrix Cal: Primary & Secondary Path

- Transmission coeff ~ 70% (-1.6 dB)
- Self emission ~ 95K
- MWR thermal control ± 1 K
- PRT meas temps ~ 0.1 K



SW Matrix Cal : Simplified block diagram





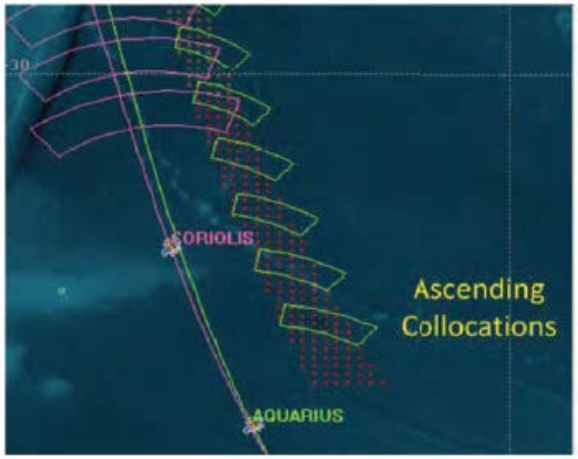
- OMT for Ka band horns
- 8 feed horns connects to a single receiver
- 3 layers of switch (4-2-1)
- For a single feed horn path
  - 4 waveguide loss sections
  - 3 switch losses
  - 1 feed horn, OMT loss

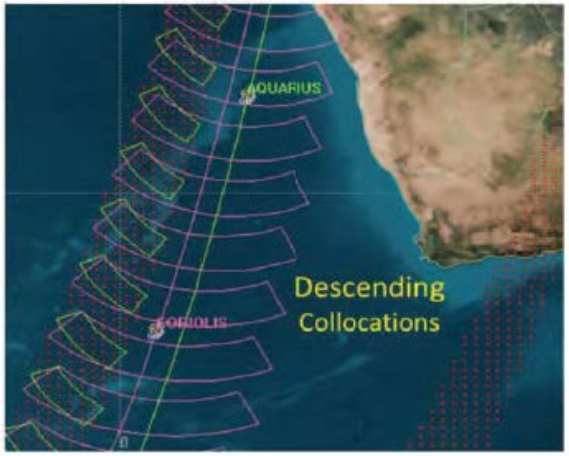
Choice of Windsat

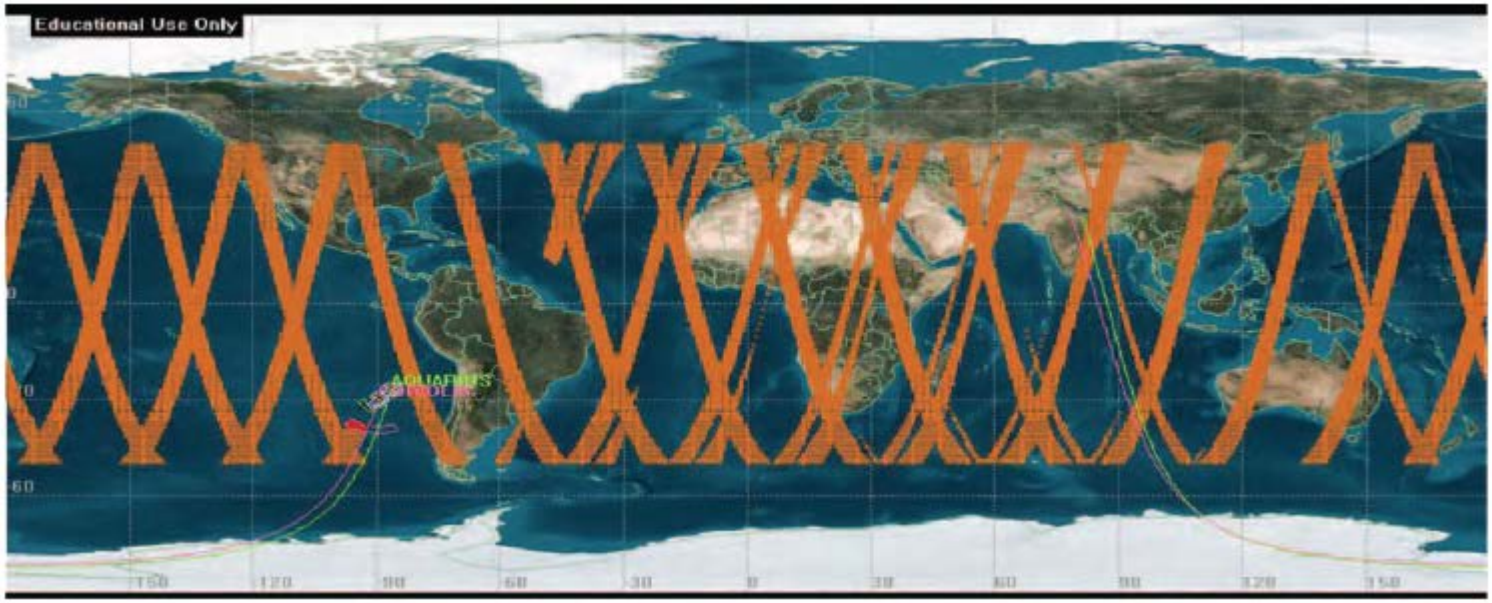
Similarities

Parameter	WindSat	MWR
Altitude	840 Km	657 Km
Eccentricity	0.00134	0.00120
Orbit Inclination	98.7°	98.01°
Ascending Node	6 p.m.	6 p.m.
Channels	6.5, 10.7, 18.7, 23.8 & 37 GHz (V,H)	23.8 GHz (H) & 36.5 GHz (V,H)
Swath Width	~ 950 Km	~ 380 Km
Earth Incidence Angle	53°	52° & 58°

Geometry



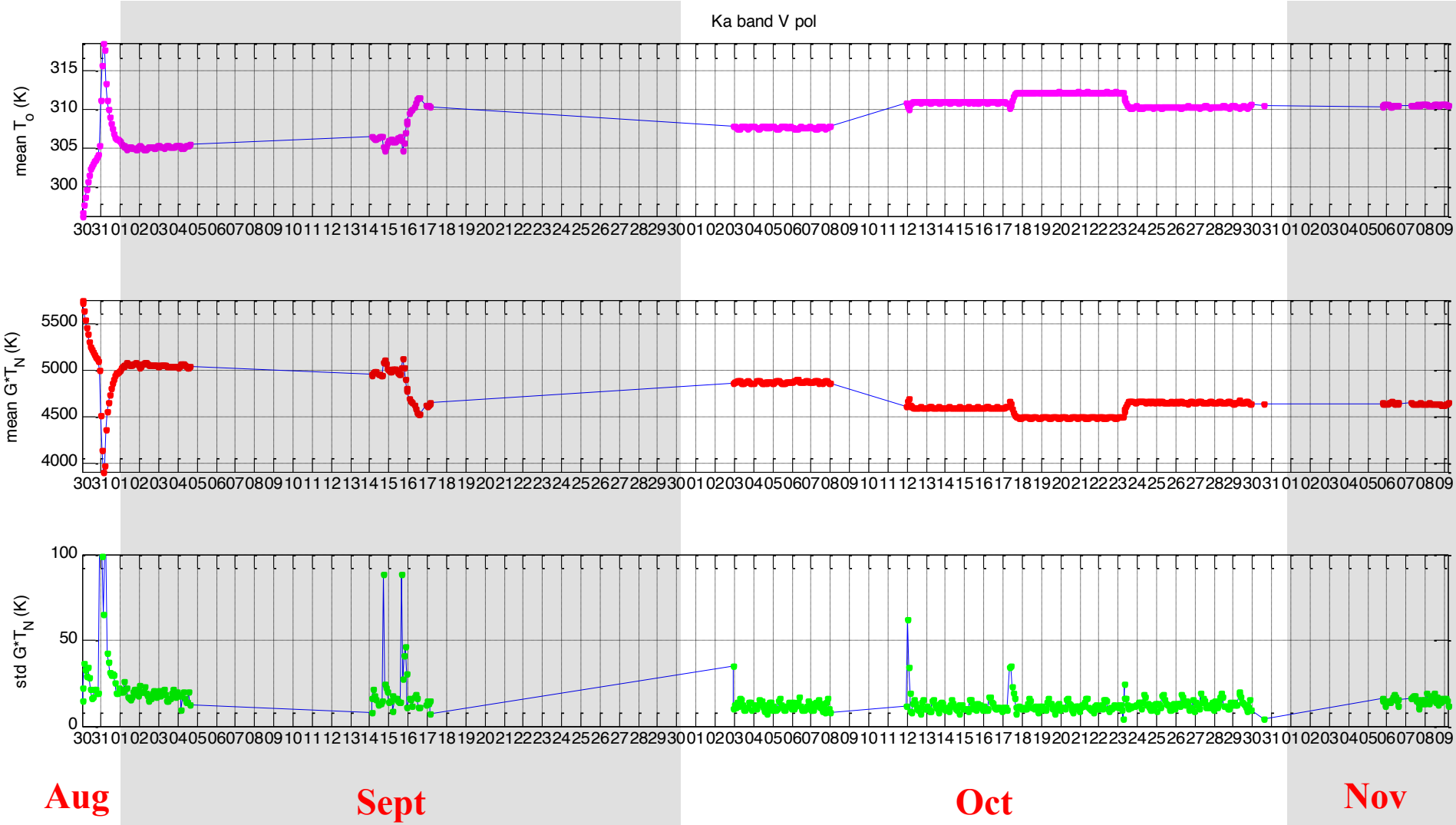




MWR and Windsat collocations swath in 45 hours

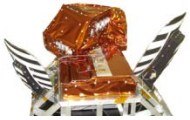
MWR On-Orbit Check-out

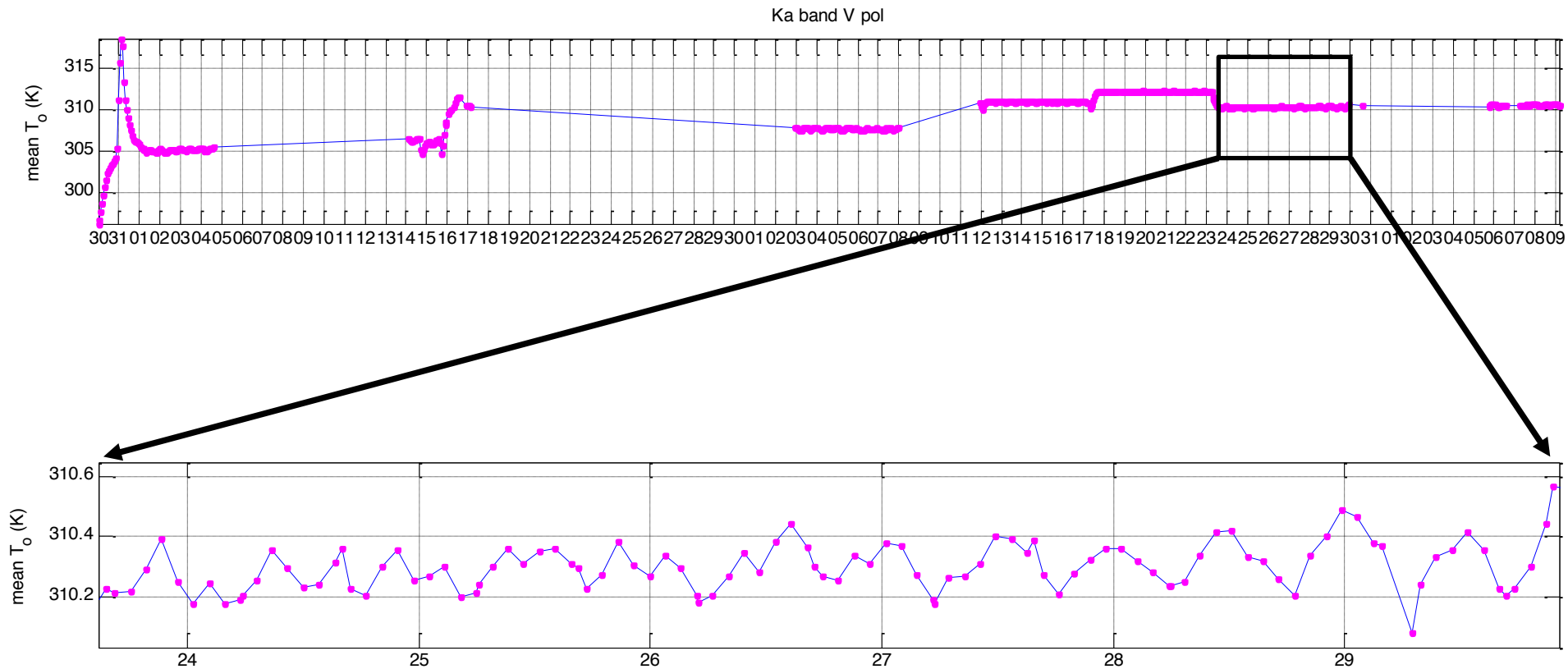
Ka Band V pol Diagnostics



Each point is an Orbit Average

MWR Thermal Control





Days of Oct,2011

Receiver Internal temperature was controlled within 0.5 K for a duration of approx. 6 days

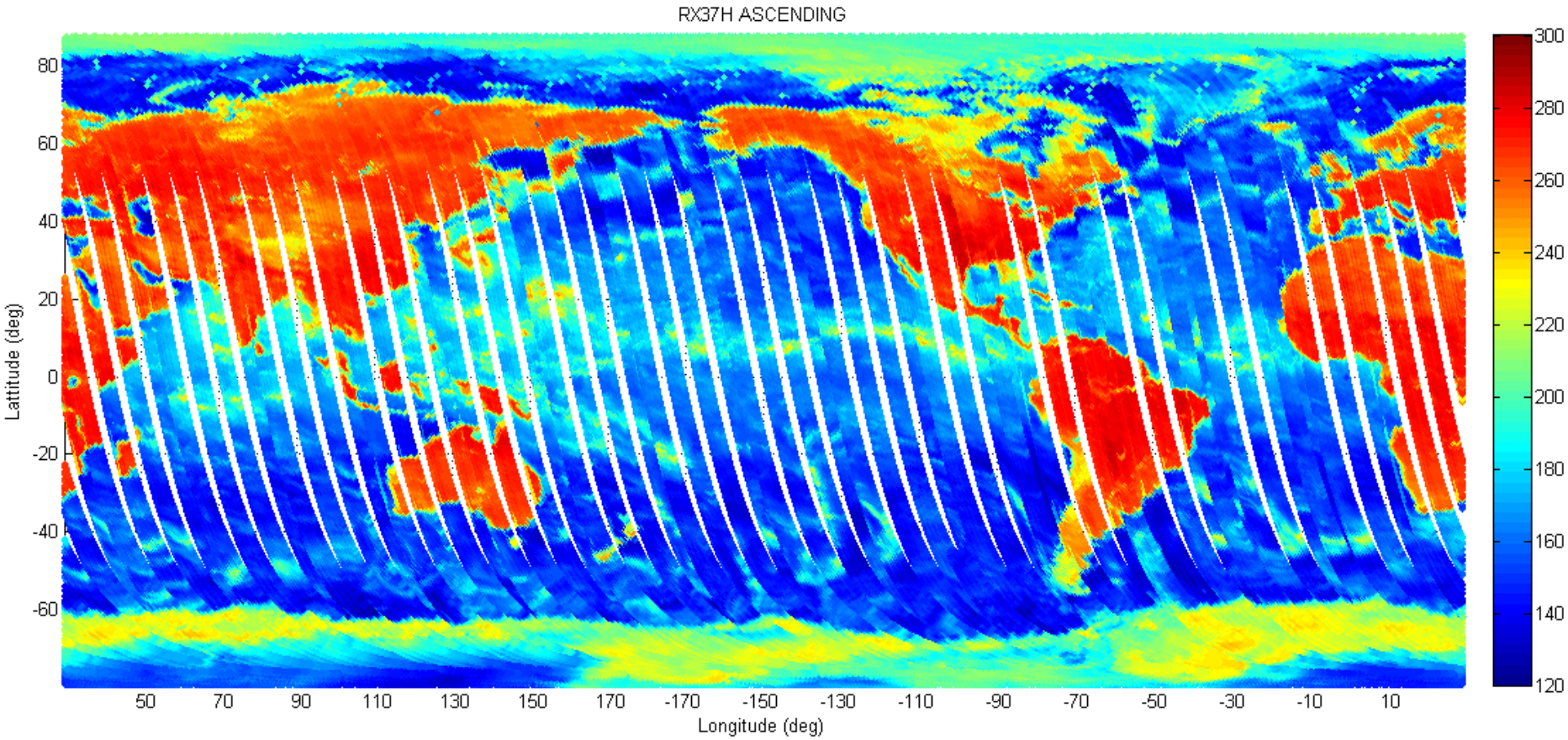
MWR OOCO Summary

OOCO – On Orbit Check Out

- MWR turn-on evening Aug 30th, 2011
- First Tb images were produced ~ 6 hours after data reception on Wed Aug 31st
- Preliminary inter-satellite Tb calibration with WindSat completed on Sunday Sept 4th
- First geophysical retrieval on Tues Sept 6th

36.5 GHz H-pol T_b

First 5 days (only ascending passses)



36.5 GHz V-pol T_b

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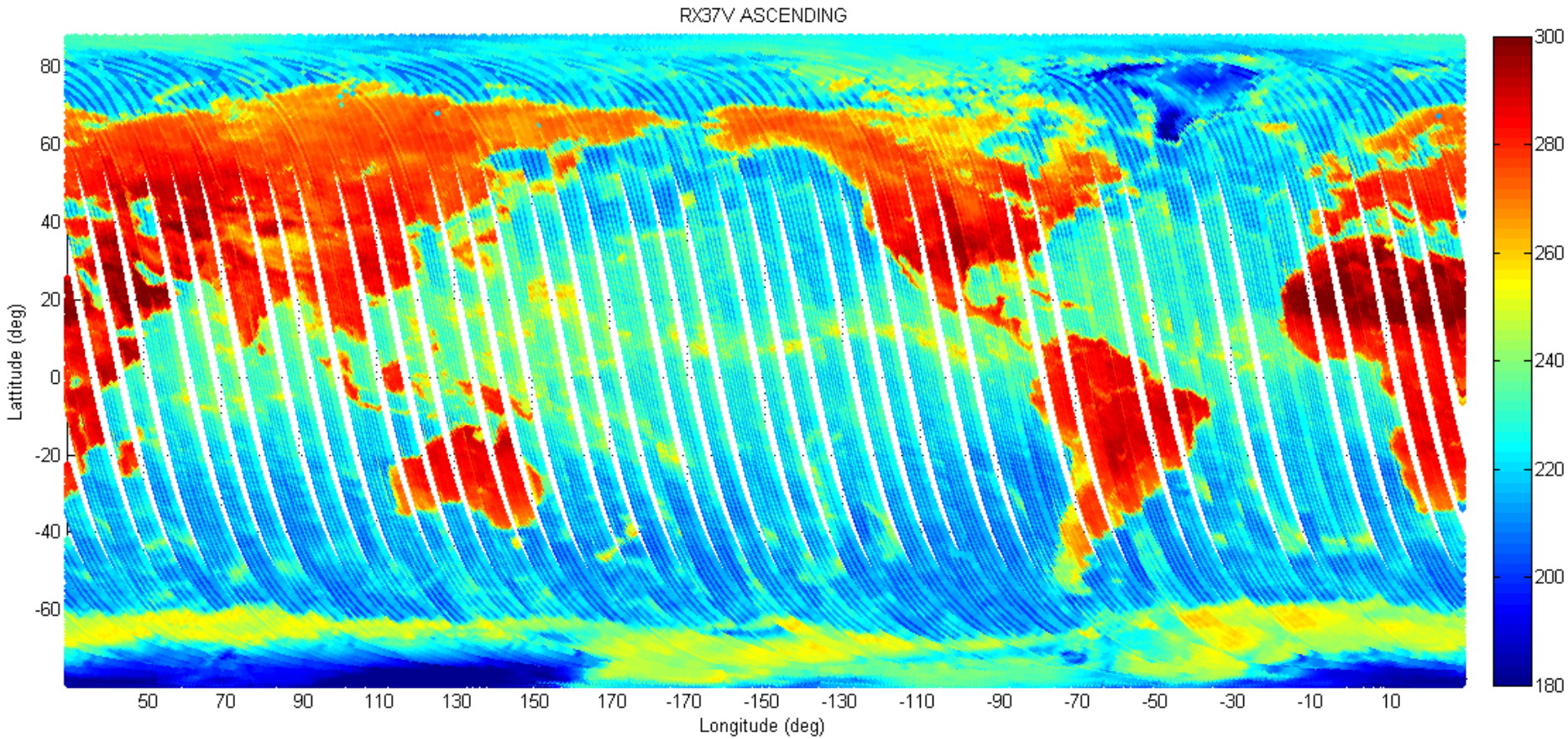
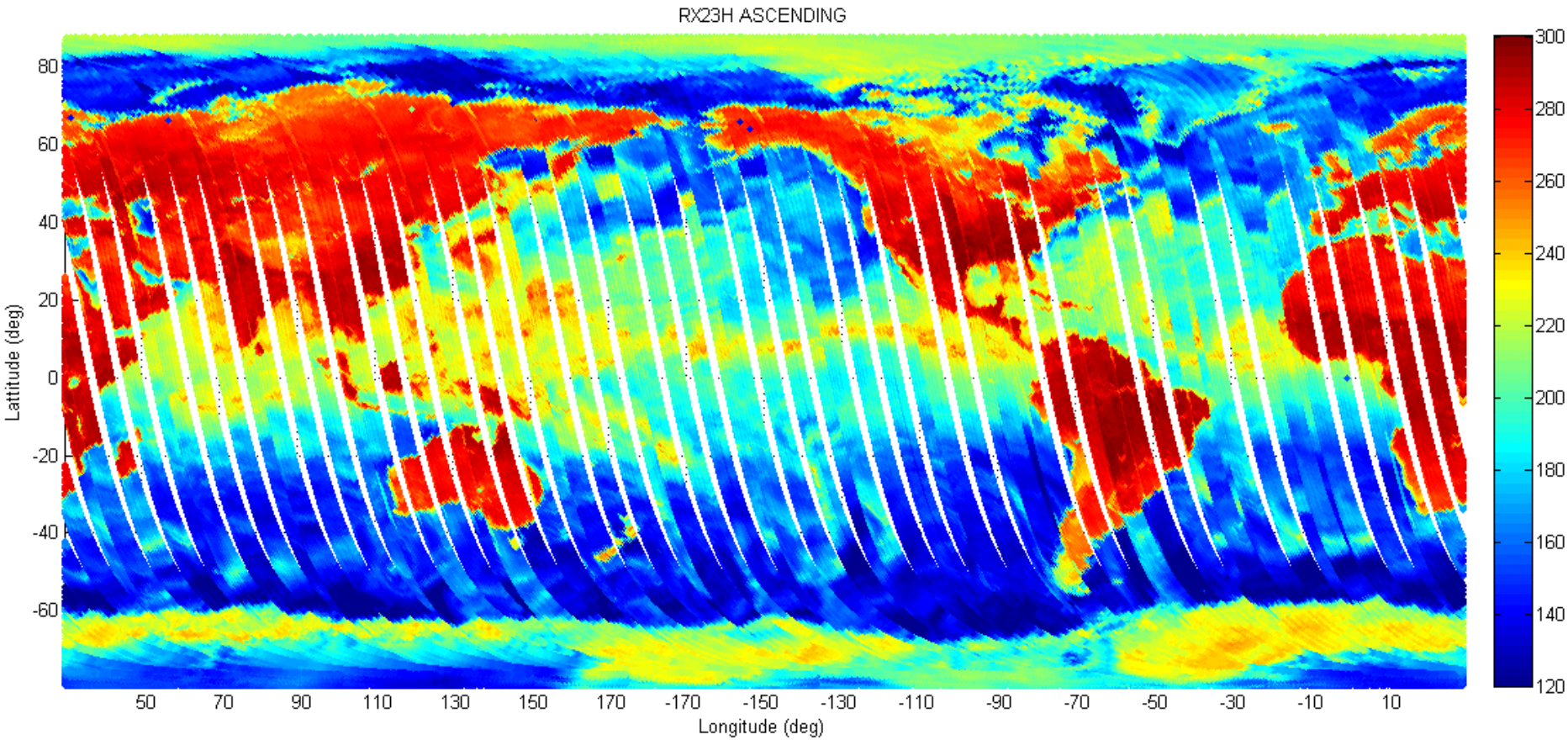


23.8 GHz H-pol T_b

First 5 days (only ascending passses)



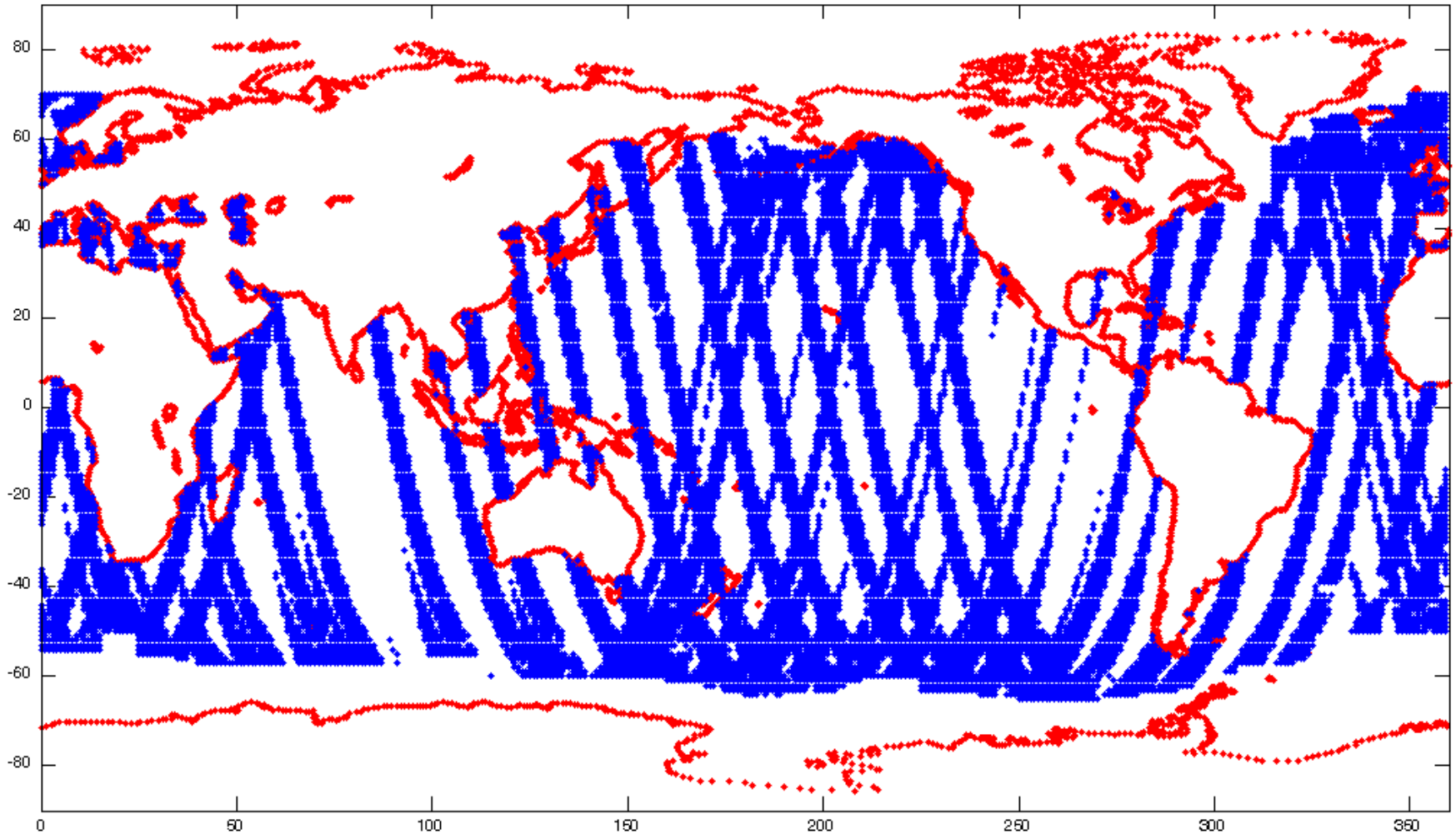
Inter-Satellite Radiometric Calibration

- Inter-satellite radiometric calibration (X-Cal) was performed using the WindSat radiometer

- Near simultaneous, collocated comparisons between MWR and WindSat ocean Tbs
  - Initially 65 revs of MWR Tbs used (now 146 revs available)
  - MWR Tbs converted to 53° Earth Incidence Angle (Using Radiative Transfer Model) before WindSat comparison – double differences
  - Collocation cells were 1° x 1° Lat-Lon boxes
  - Comparisons performed per beam basis
    - 3 chans x 8 beams = 24 total

MWR/WindSat 1st X-Cal Results (46 revs ocean calib)

MWR-Windsat Collocations

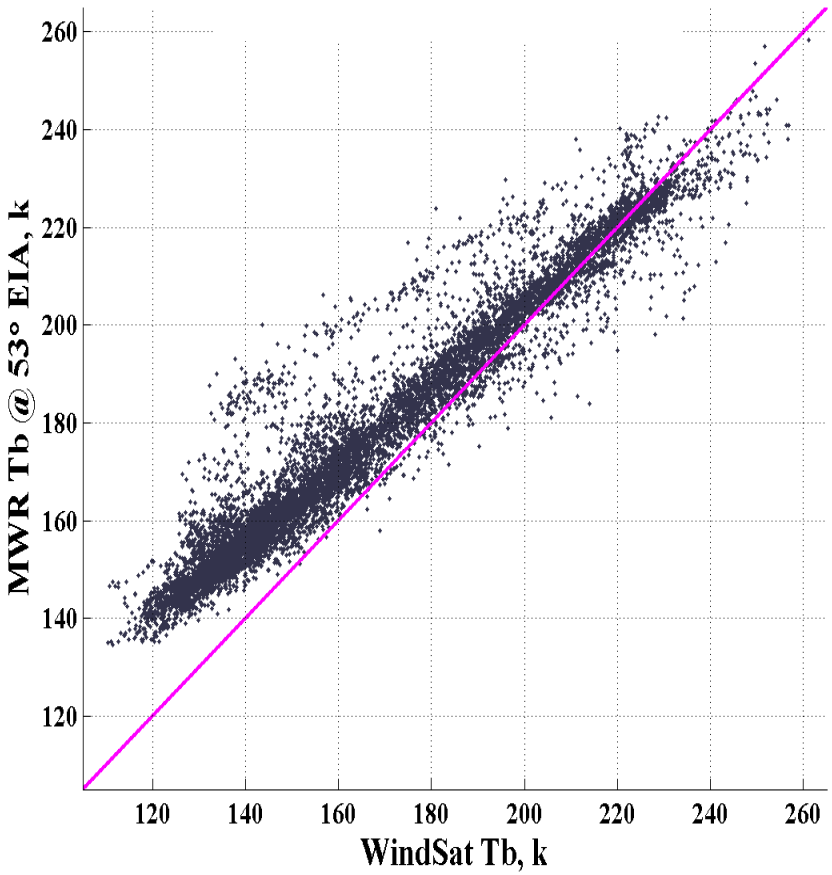


1° x 1° collocations for 65 revs of MWR T_bs used

Example Beam # 1, 23 GHz H-pol

Pre-Launch TV Calib

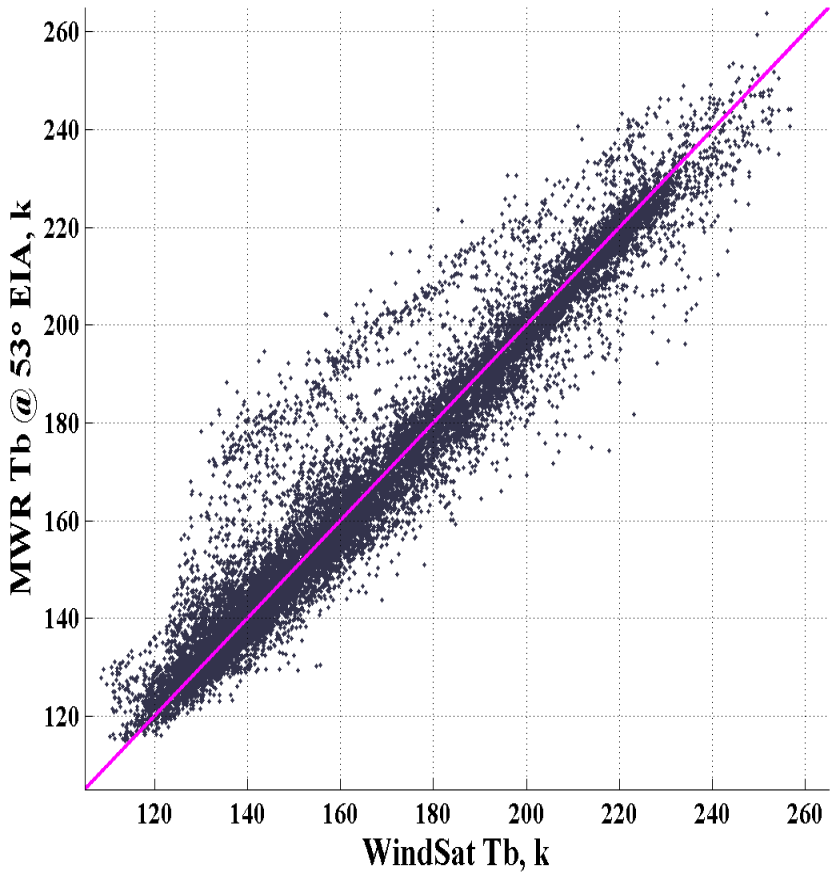
Tb v2.0



Post-Launch X-cal

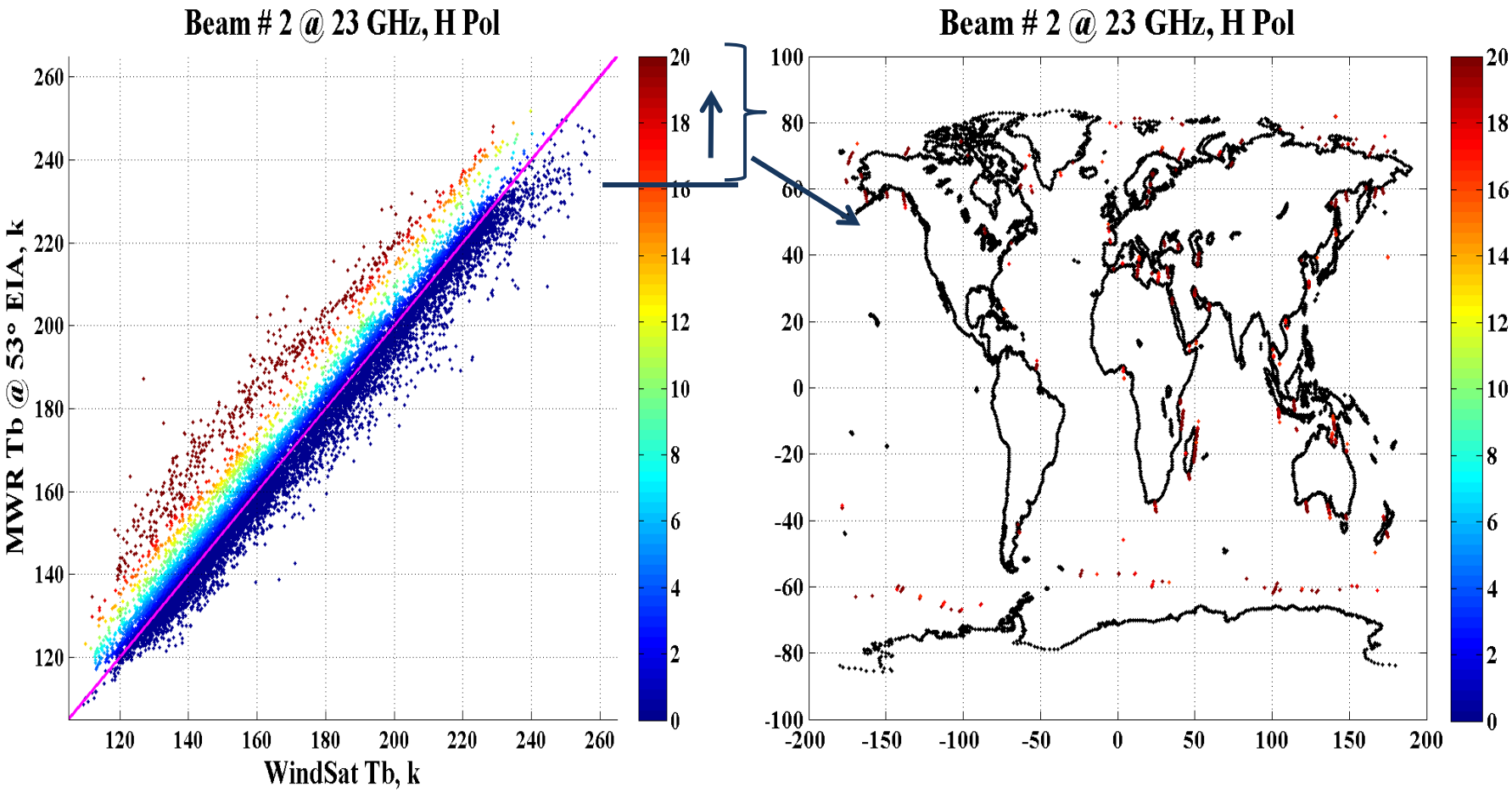
Tb v2.1

Linear adjustment



Beam # 2, 23 GHz H-pol cont

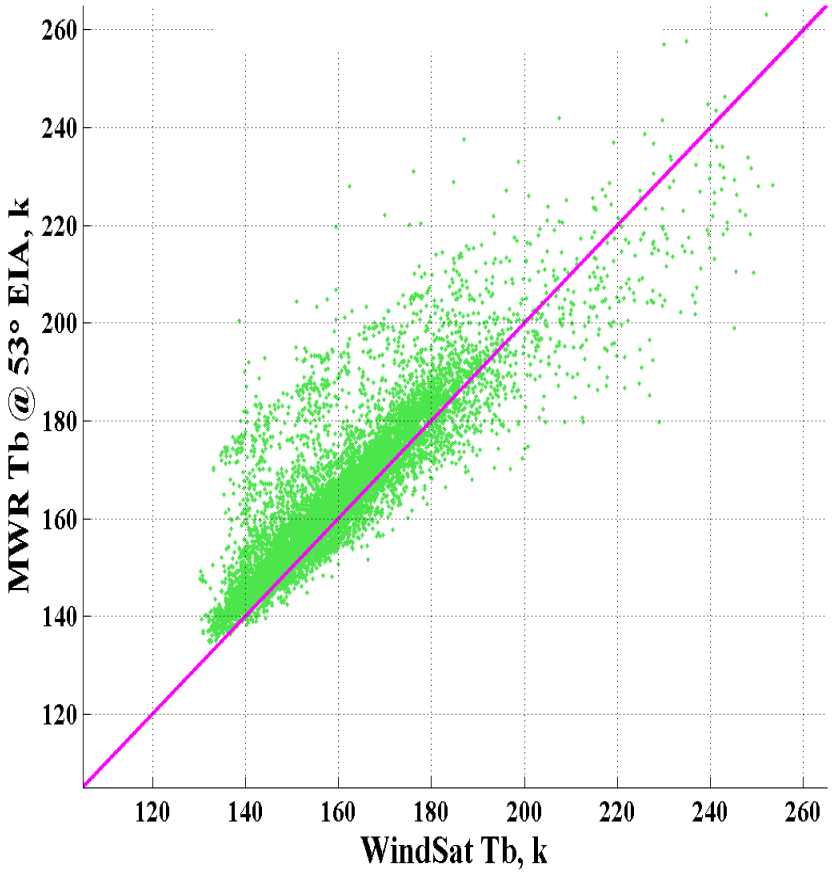
Locations of outlyer points are associated with land masses and sea ice and therefore should be deleted from ocean calibration



Beam # 1, 37 GHz H-pol

Pre-Launch

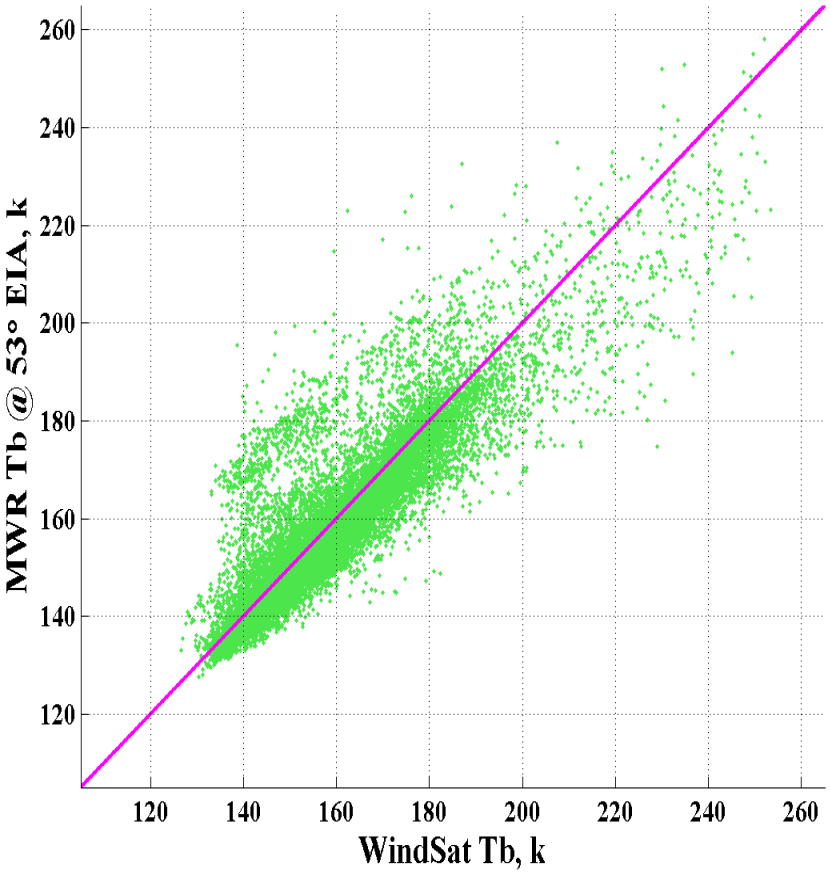
Tb v2.0



Post-Launch

Tb v2.1

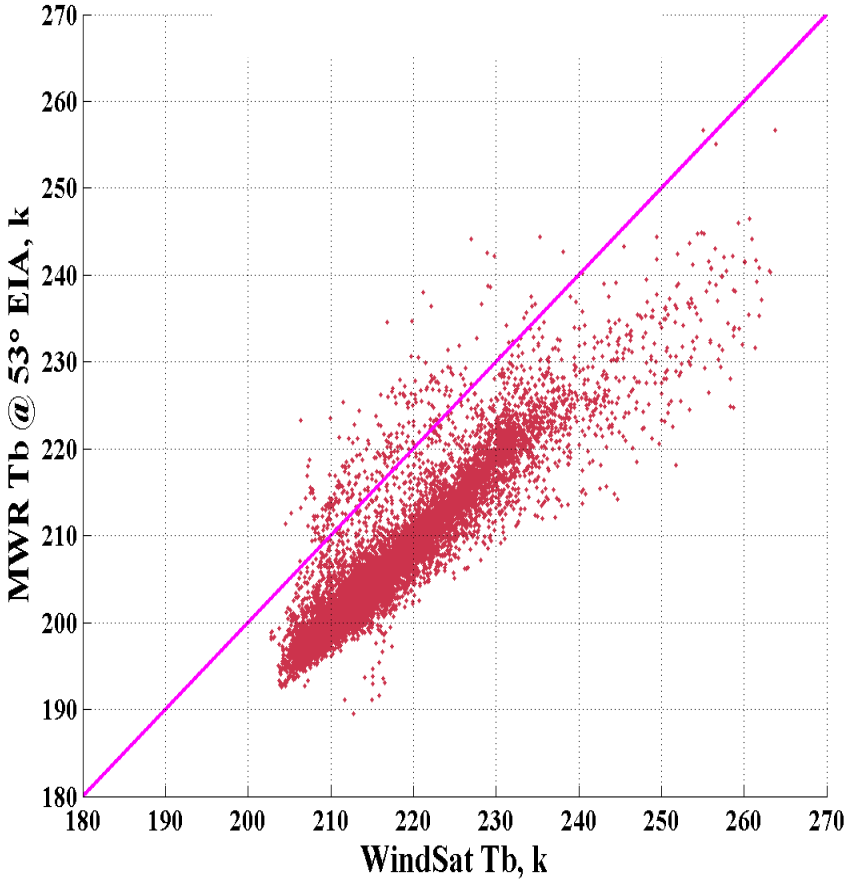
Bias adjustment



Beam # 1, 37 GHz V-pol

Pre-Launch

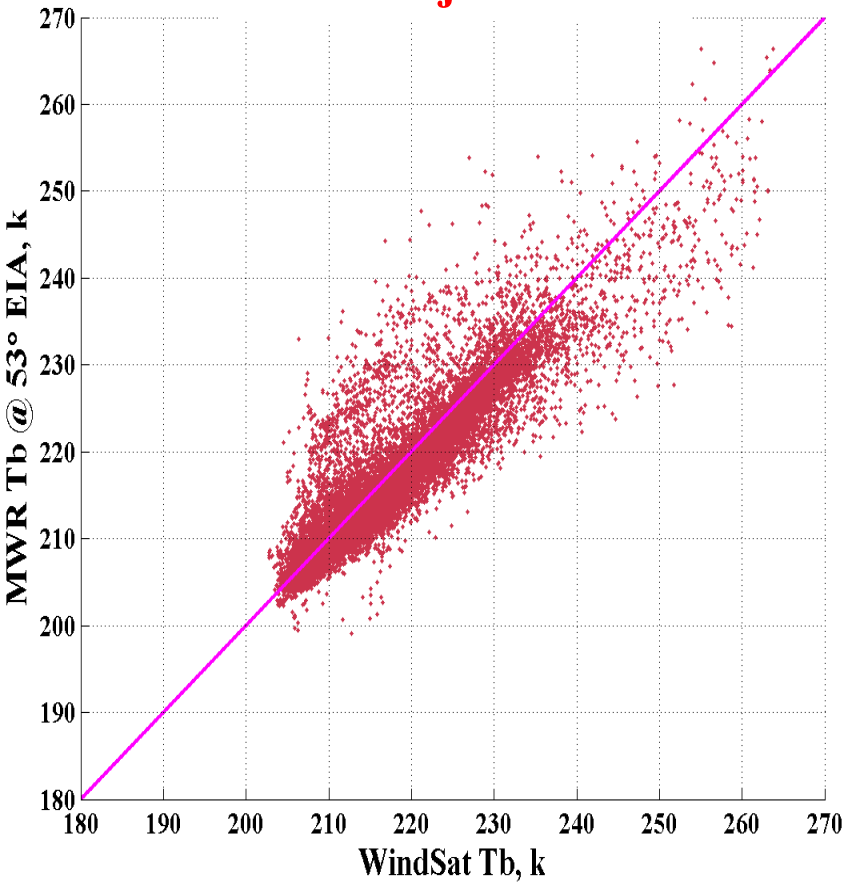
Tb v2.0



Post-Launch

Tb v2.1

Bias adjustment

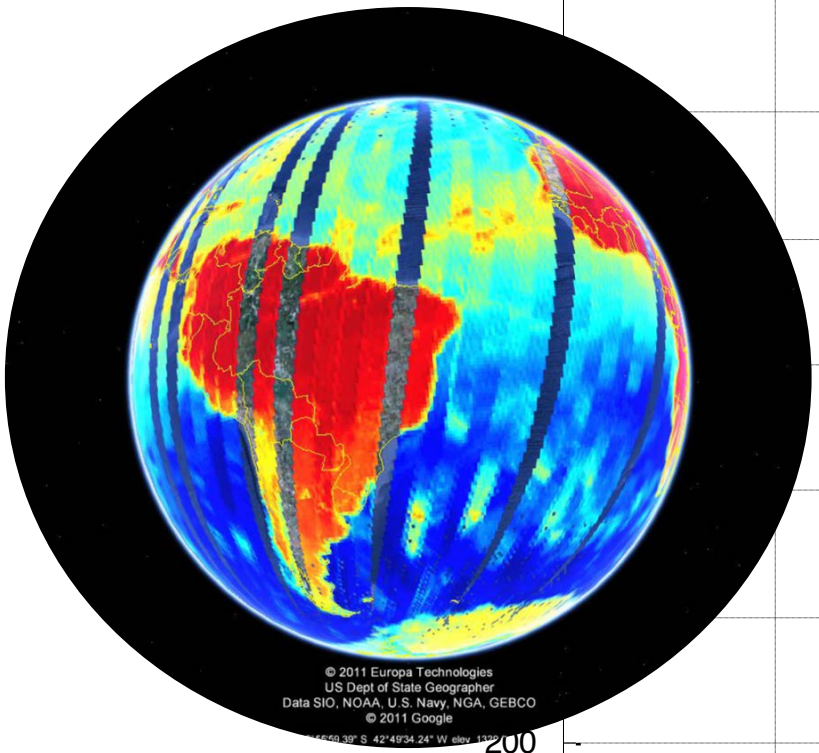


Calibration Algorithm v2.2

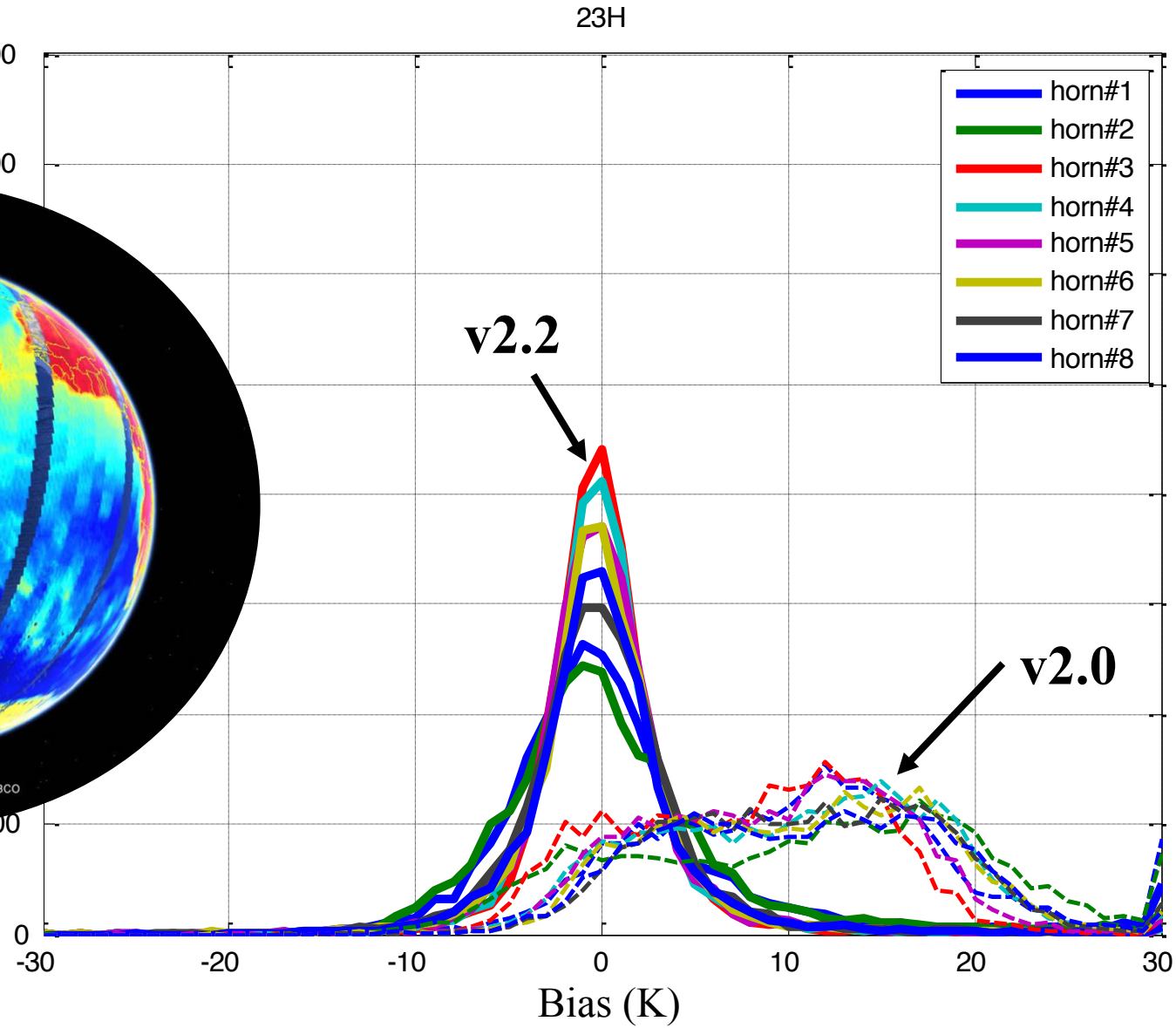
- The slope-offset correction coefficients from the v2.1 algorithm was further tuned after obtaining 127 additional orbits of MWR/WindSat collocations
- Final APC with correct beam balancing (v2.2)
  - Equate MWR Ta & WindSat Tb
- The following charts compare orbital average histograms of MWR biases
  - Pre-launch (v2.0) algorithm and the final post-launch algorithm (v2.2)

$$MWR_{bias} = (T_a(obs) - T_b(sim))_{MWR} - (T_b(obs) - T_b(sim))_{Windsat}$$

23.8 GHz H-pol Bias Histogram

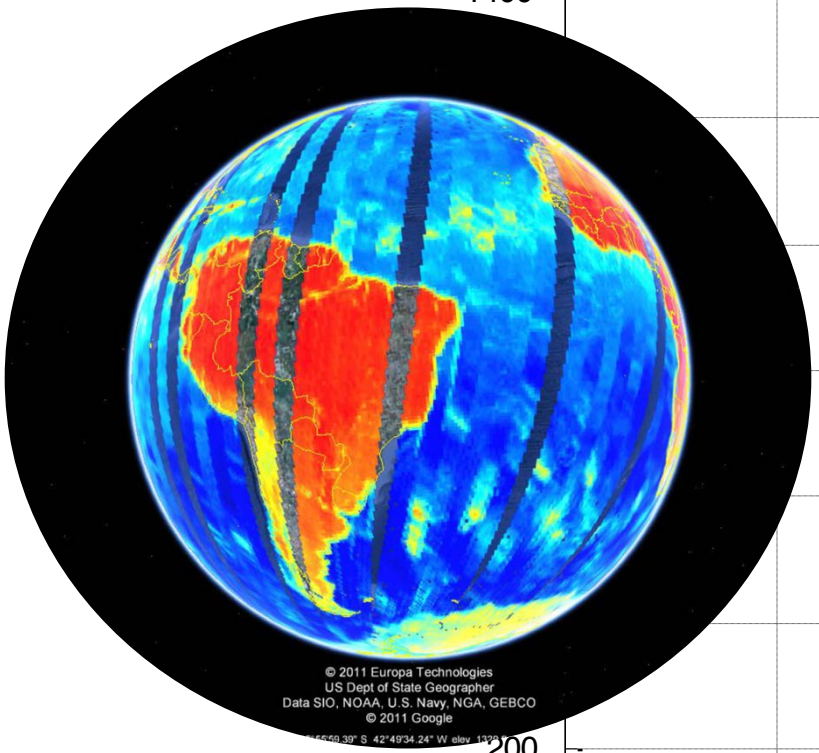


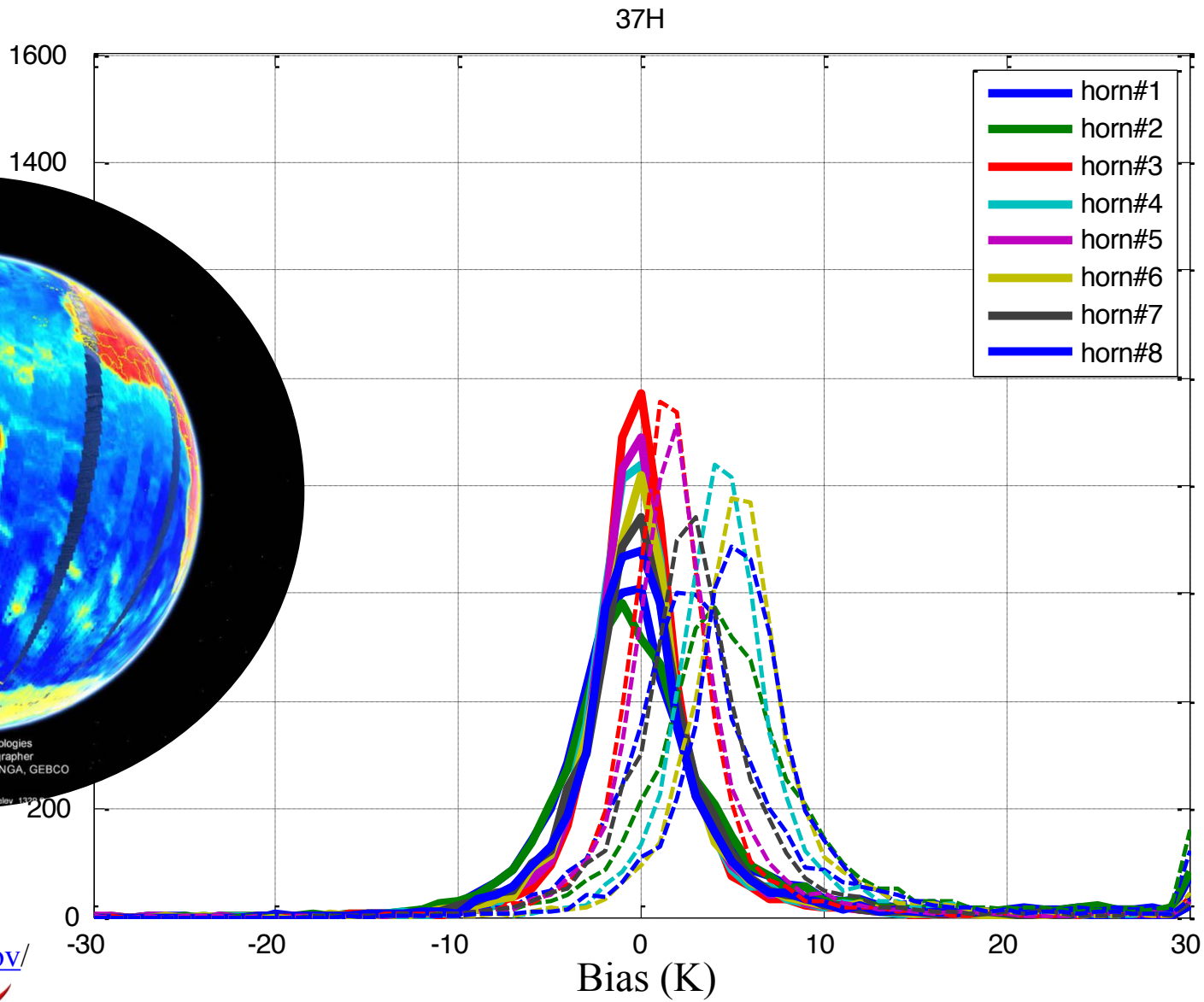
v2.2



v2.2 MWR Data
ftp://aqst@podaac.jpl.nasa.gov/

36.5 GHz H-pol Bias Histogram





v2.2

v2.2 MWR Data

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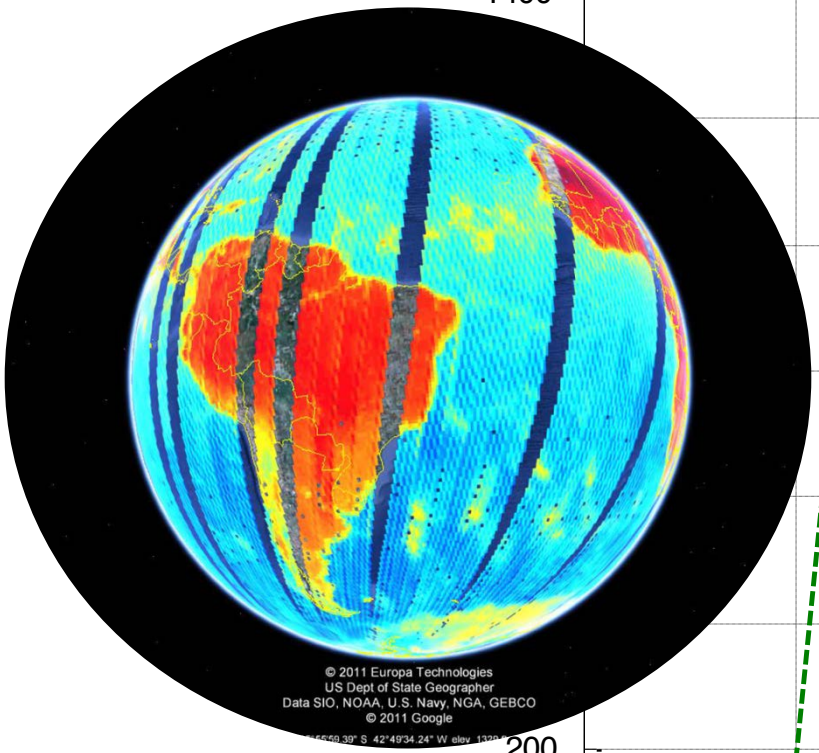
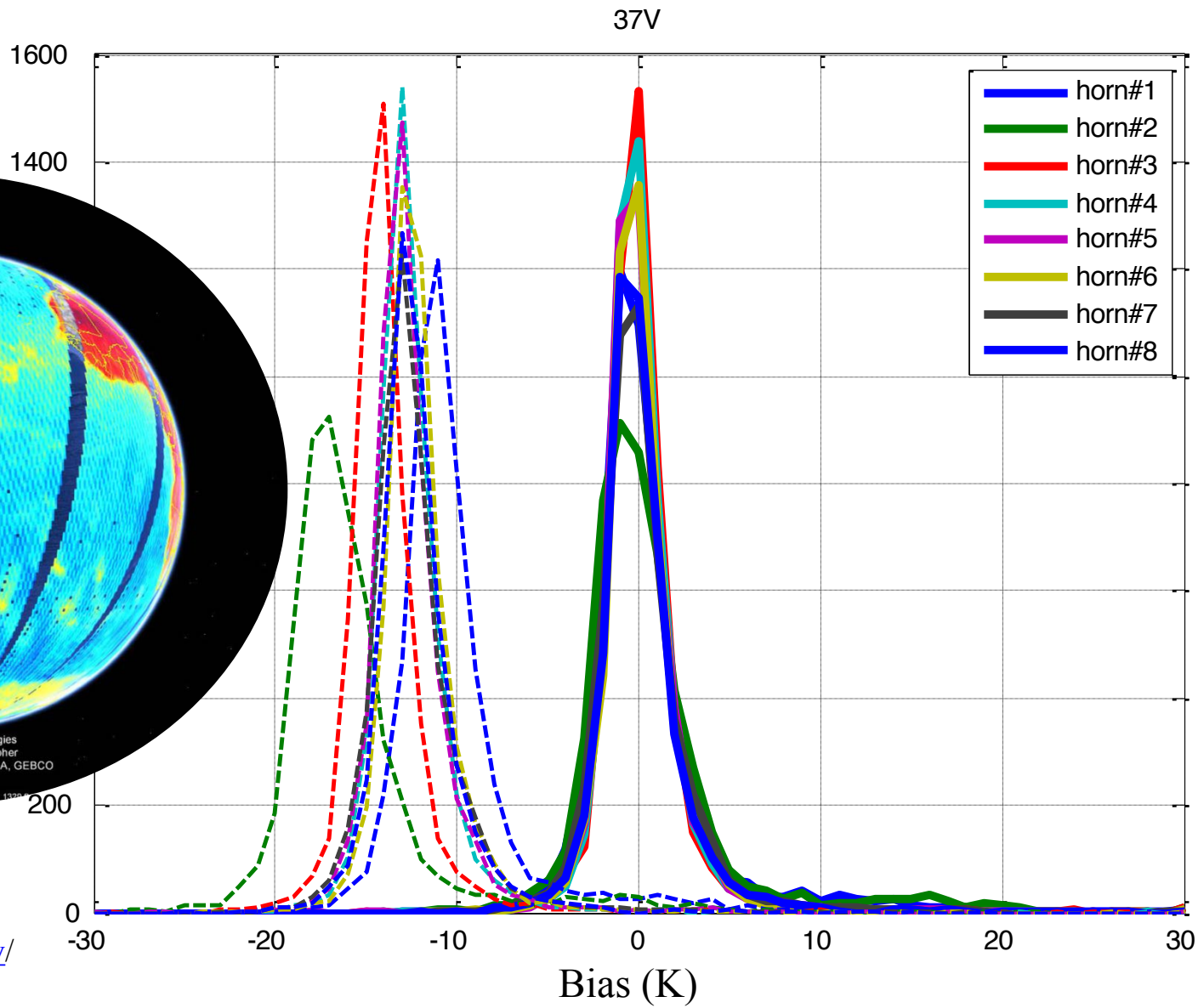
36.5 GHz V-pol Bias Histogram





v2.2

v2.2 MWR Data

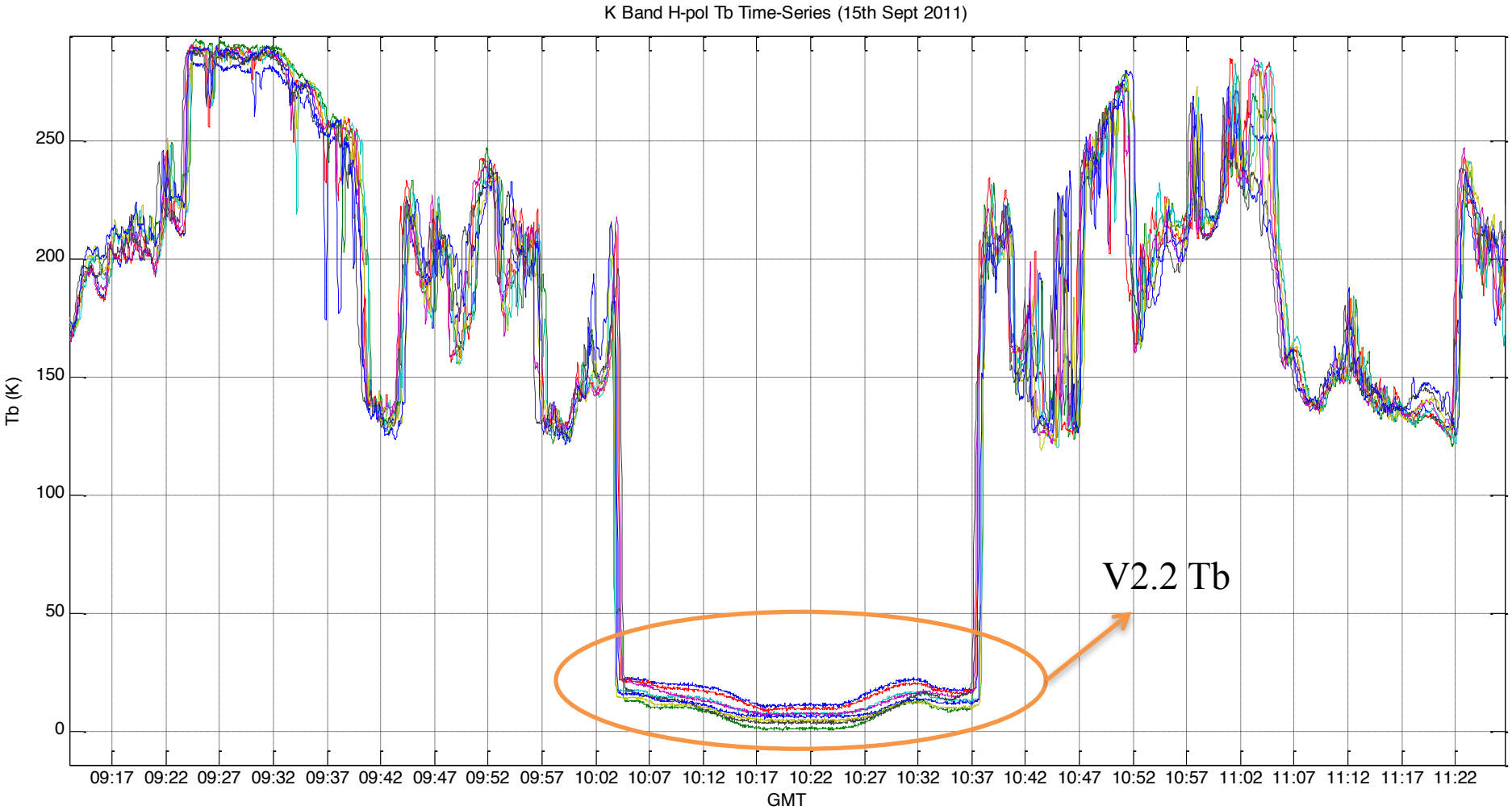
ftp://aqst@podaac.jpl.nasa.gov/

Determination of MWR NEDT during cold space look

11/11/2011

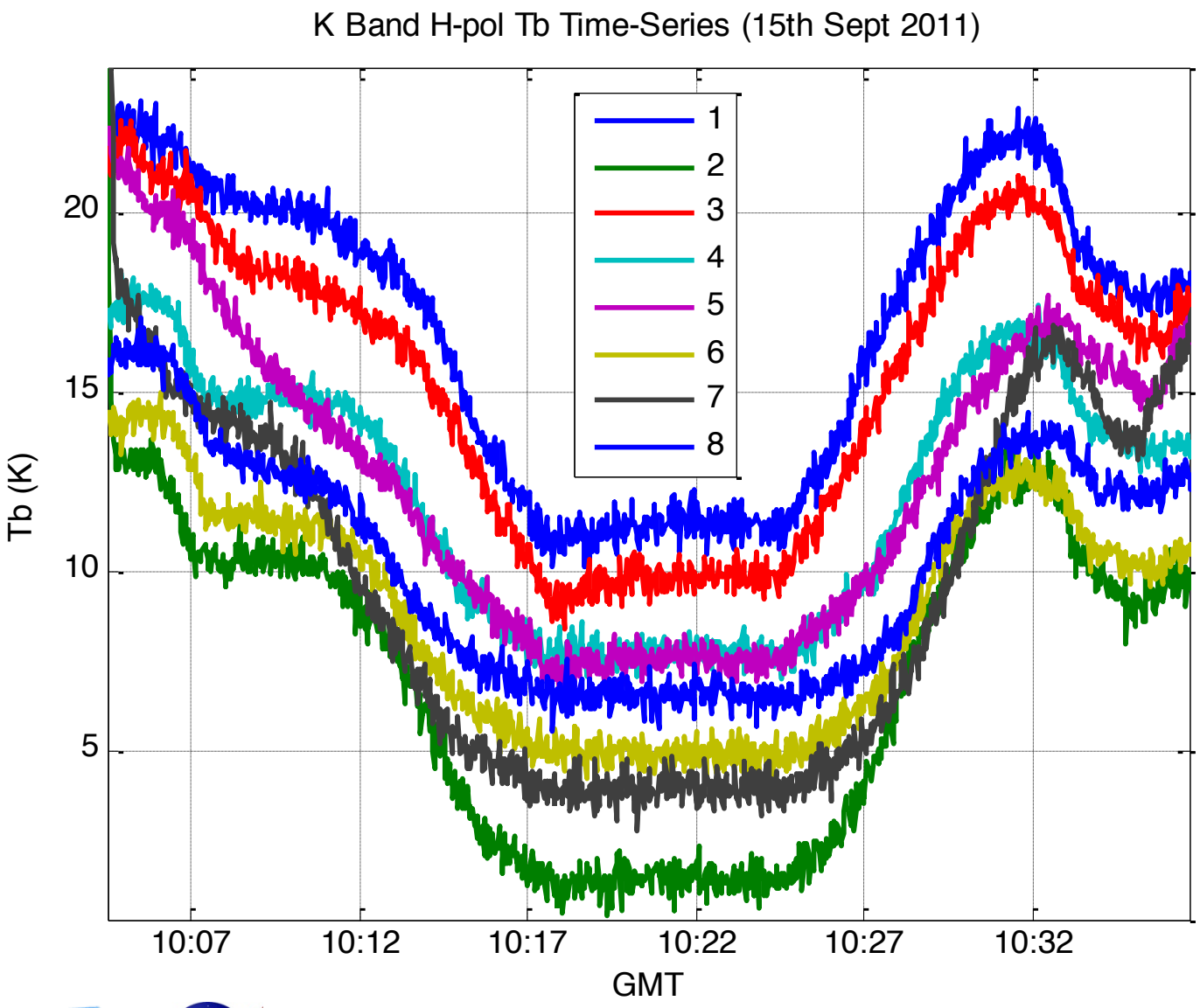
Determination of MWR NEDT during cold space look

Deep-Space(?) Look, 15th September, 2011

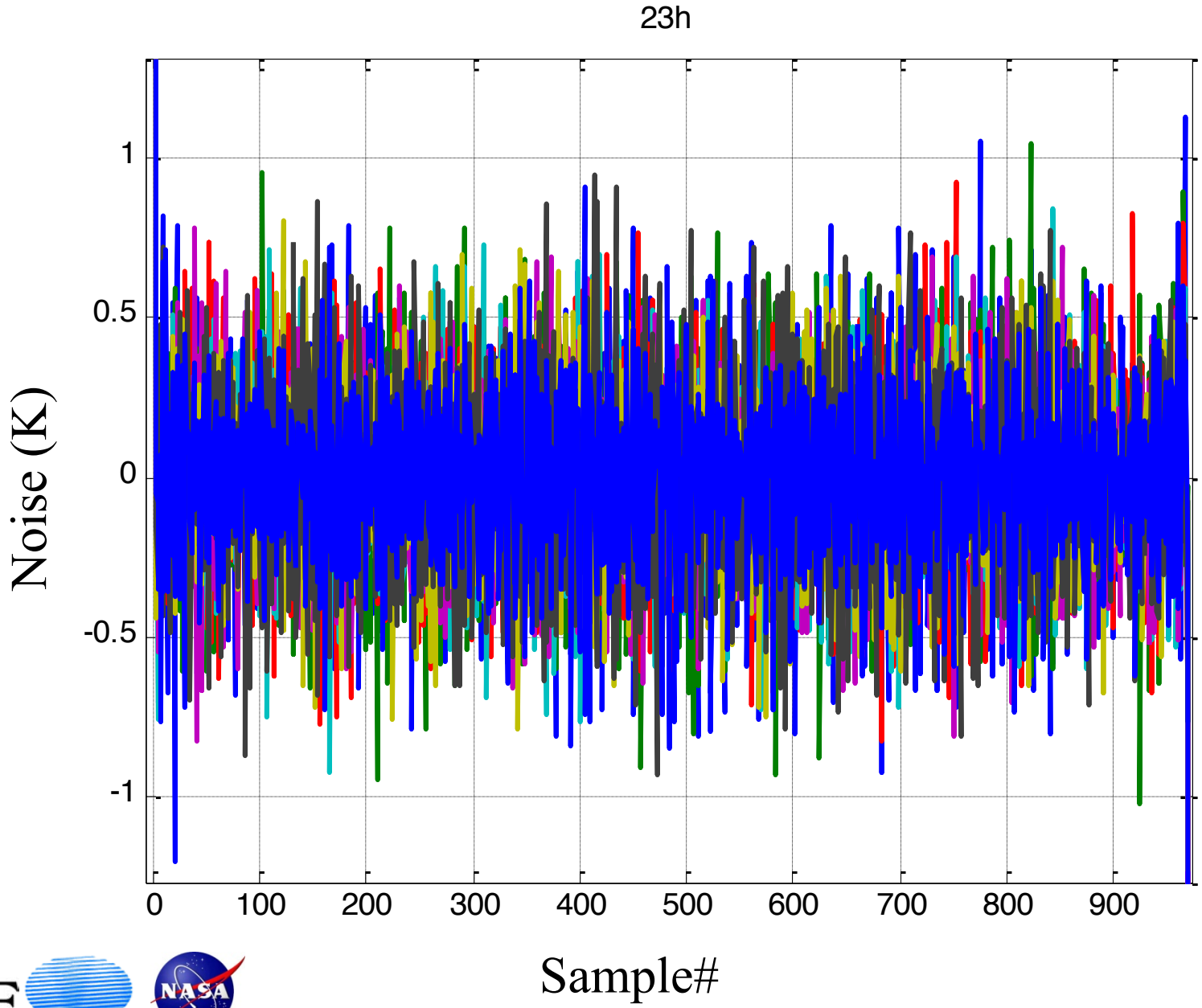


GMT Time

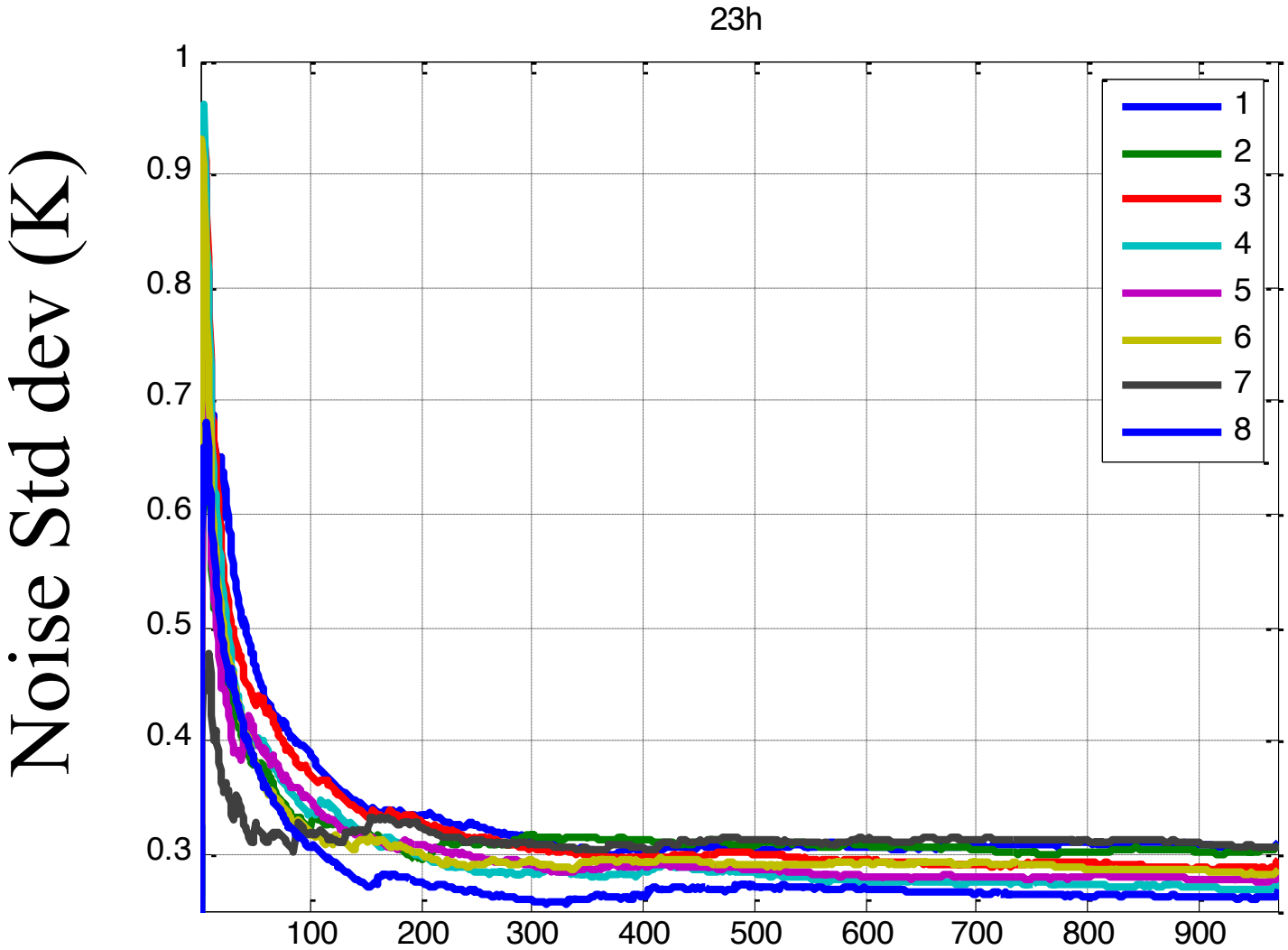
Zoomed In – Deep Space Look



Extracted Noise (Using FFT technique)



NEDT estimate vs. # of samples



# of sample
(used to compute std dev)

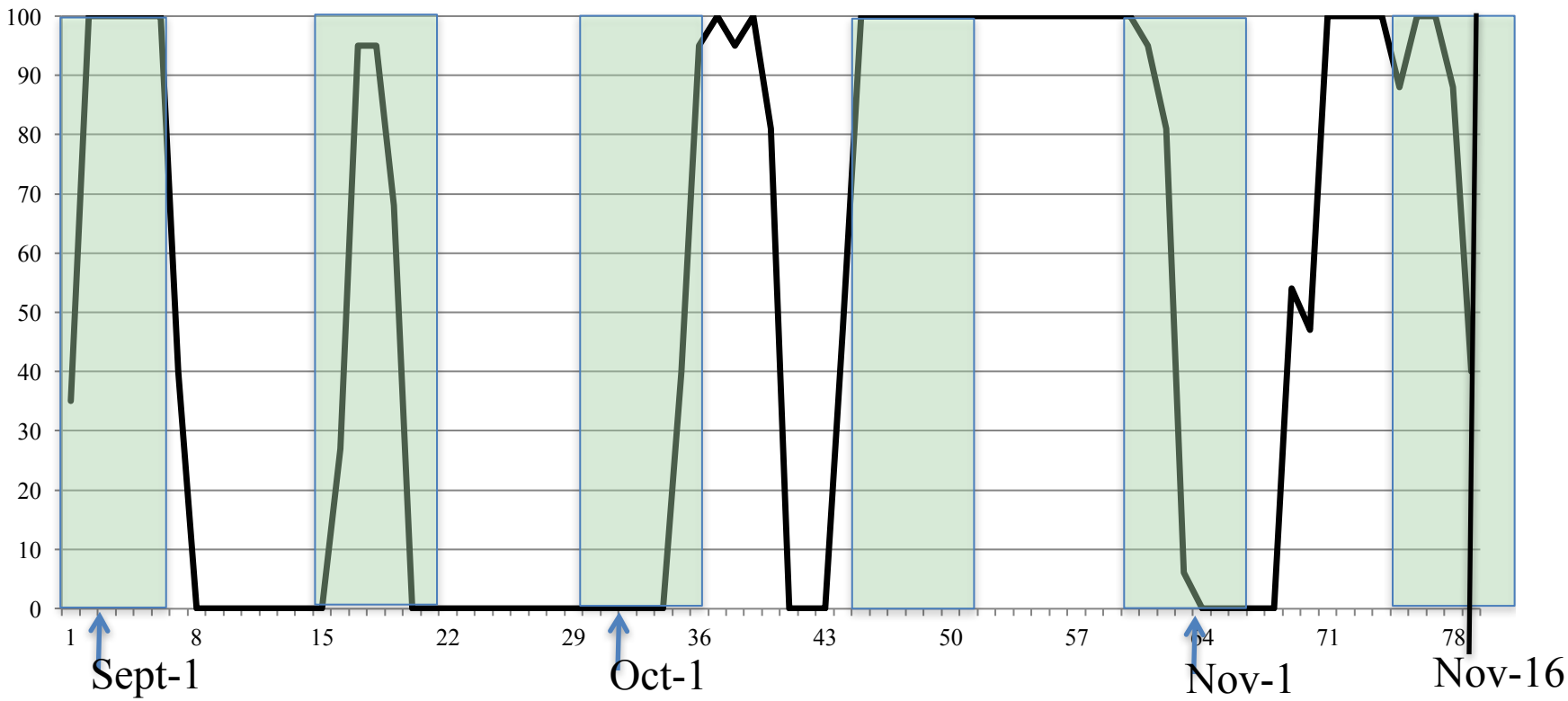
Final NEDT table

Beam #	1	2	3	4	5	6	7	8
23 H	.30	.30	.29	.27	.28	.28	.31	.26
37 H	.21	.22	.20	.20	.21	.22	.20	.22
37 V	.22	.24	.23	.22	.23	.21	.21	.22

Note: bandwidth of K-band receiver is less than that of Ka band; therefore NEDT is greater in K band.

Data Availability

- MWR turned on Aug 30 (day-1)
- Presently in 11th 7-day cycle
  - Only two cycles have continuous measurements



Data Posted on PODAAC

ftp://aqst@podaac.jpl.nasa.gov/

Password restricted to Cal/Val members