Assessment of the Version 6 MWR Calibration

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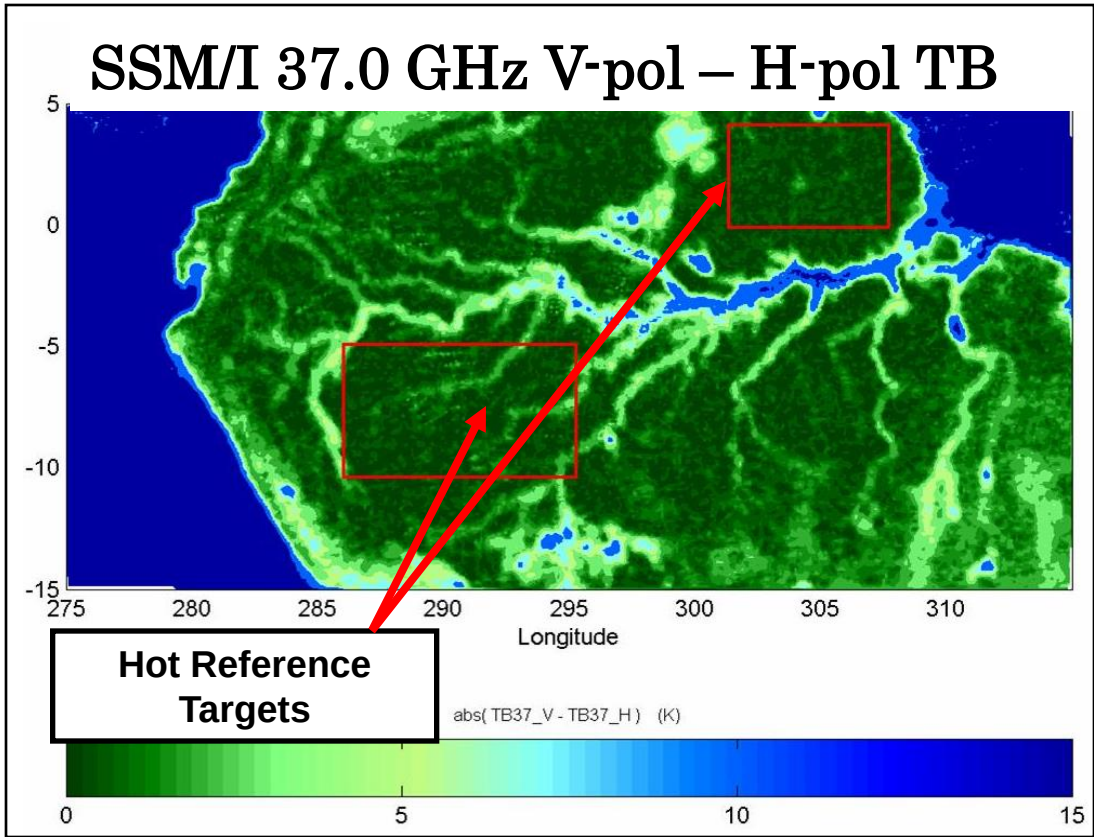
Overview

- **MWR can be used to retrieve water vapor, cloud liquid water, wind and rain over the ocean**
  - **Can supplement Aquarius retrieval algorithm**
    - Roughness correction
    - Rain flagging/correction
- **Objective is to apply techniques used to calibrate the Jason series altimeter radiometers to MWR**
  - **Compare TBs to natural on-Earth references**
  - **Assess stability over time**
- **Since MWR swath is formed from independent beams, it is critical to assess inter-beam calibration biases over the full dynamic range of the instrument**

On-Earth Natural T_B References

- **Compare T_B to hot and cold absolute brightness temperature references**
  - **Vicarious Cold Reference** ***(Ruf, 2000, TGARS)***
    - *Stable, statistical lower bound on ocean surface brightness temperature*
  - **Amazon pseudo-blackbody regions (18-40 GHz)** ***(Brown and Ruf, 2005, JTECH)***
    - *T_{HOT}(frequency, incidence angle, Local Time, Time of year)*

- **Sample references over time and instrument temperature**



Vicarious Cold Reference

- **Cold reference represents a statistical lower bound on ocean surface brighness temperature**
  - **Warmest TB that has a 0% probability of occurring**
  - **Condition exists for calm, dry conditions at an optimum SST**
- **Theoretical values determined from a radiative transfer model used with open ocean island radiosonde observations**
  - **Absolute uncertainty between models at ~1K level**

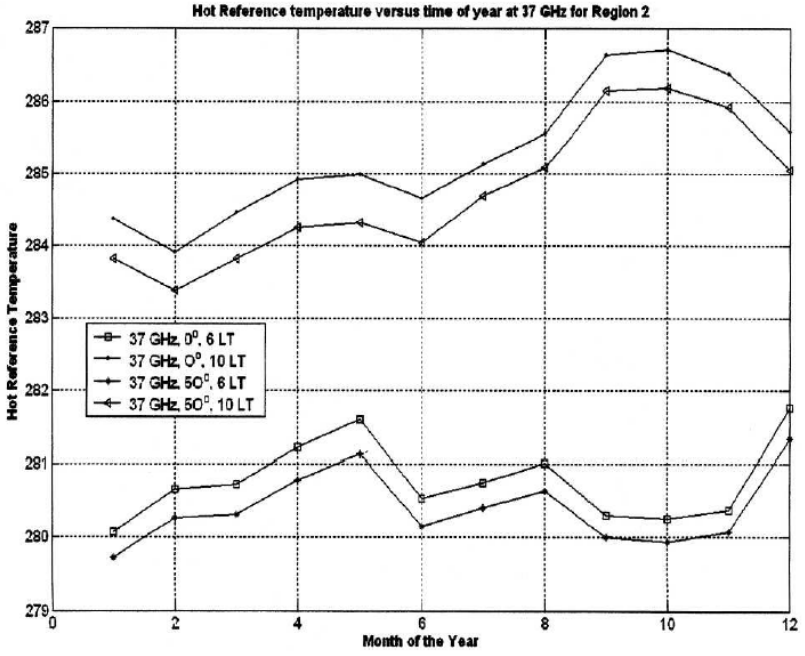
Theoretical Vicarious Cold Reference (K)	23H	37V	37H
EIA 52°	108.4	198.4	132.1
EIA 58°	104.8	212.4	126.9

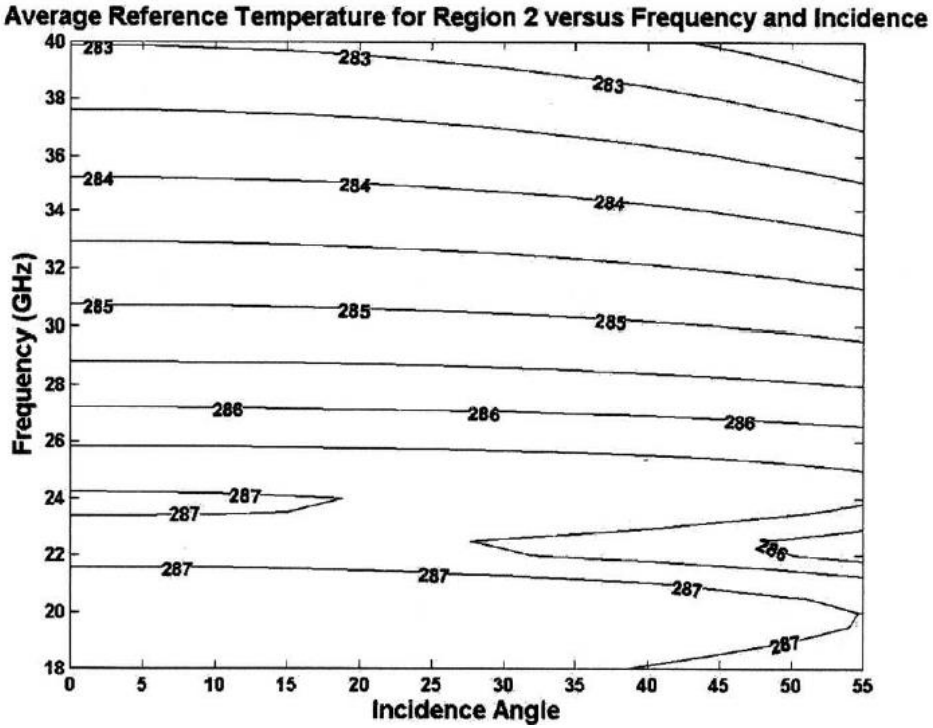
Amazon Reference

- **Theoretical value for Amazon regions determined from model tuned to SSM/I observations**
  - **Strong diurnal component (~6K) and weak annual component (<2K)**
- **Uncertainty in model estimated to be ~1K**

Average Hot Reference at MWR Observing Times

Theoretical Amazon Hot Reference (K)	23H	37V	37H
EIA 52º	286.9	283.5	283.5
EIA 58º	286.8	283.3	283.3





MWR VCR Compared to Theoretical Values

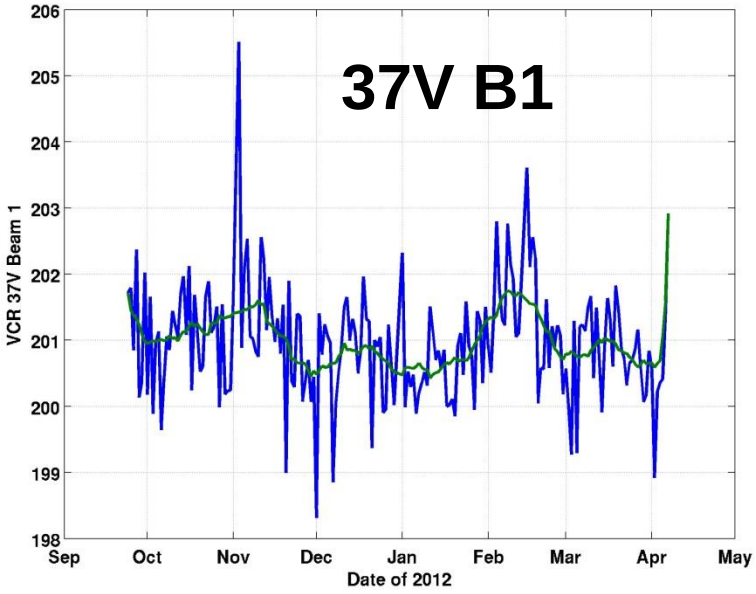
37V	*Beam 1*	*Beam 3*	*Beam 5*	*Beam 7*
	Beam 2	*Beam 4*	*Beam 6*	*Beam8*
EIA 52º	200.9	201.0	200.3	200.5
EIA 58º	213.6	212.9	212.7	213.2
37H				
EIA 52º	129.1	129.7	129.2	129.0
EIA 58º	123.9	124.0	124.3	123.6

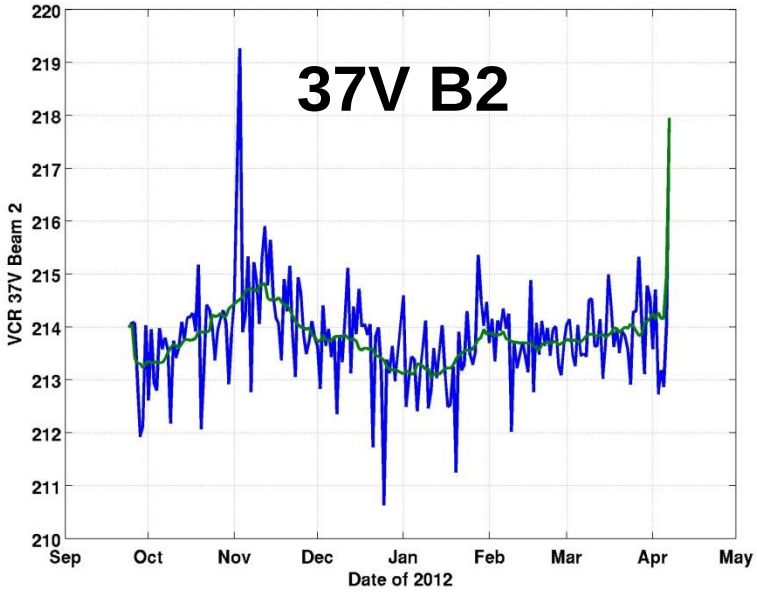
37V	*Beam 1*	*Beam 3*	*Beam 5*	*Beam 7*
	Beam 2	*Beam 4*	*Beam 6*	*Beam8*
EIA 52º	**2.5**	**2.6**	**1.9**	**2.1**
EIA 58º	**1.2**	**0.5**	**0.3**	**0.8**
37H				
EIA 52º	**-3.0**	**-2.4**	**-2.9**	**-3.1**
EIA 58º	**-3.0**	**-2.9**	**-2.6**	**-3.3**

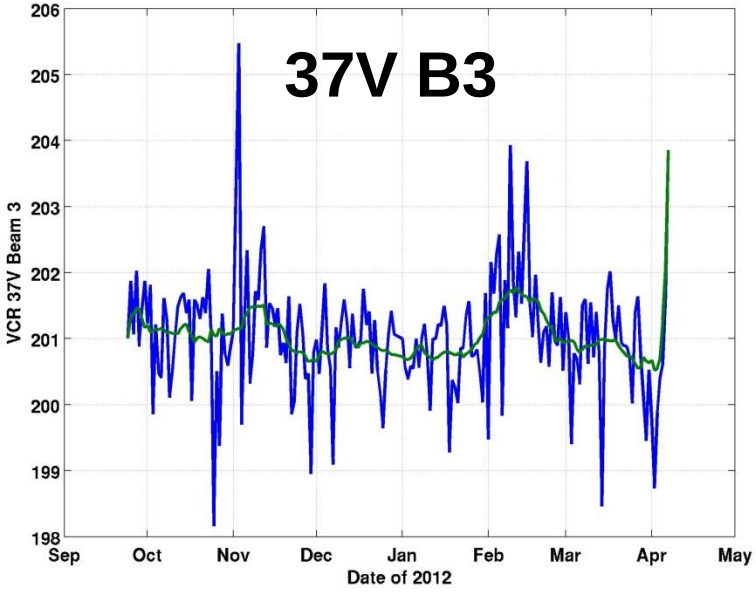
MWR Amazon TBs compared to Model

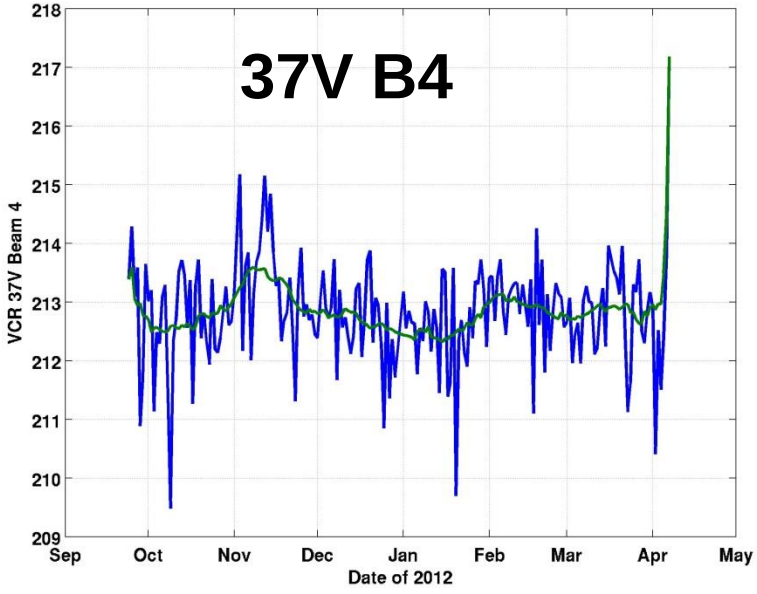
23H	*Beam 1*	*Beam 3*	*Beam 5*	*Beam 7*
	Beam 2	*Beam 4*	*Beam 6*	*Beam8*
EIA 52º	284.8 (-2.1)	286.8 (-0.1)	286.6 (-0.3)	285.8 (-1.1)
EIA 58º	286.5 (-0.3)	286.2 (-0.6)	286.6 (-0.2)	286.7 (-0.1)
37V				
EIA 52º	284.6 (1.1)	284.8 (1.3)	284.5 (1.0)	285.8 (2.3)
EIA 58º	284.9 (1.6)	284.8 (1.5)	285.2 (1.9)	285.4 (2.1)
37H				
EIA 52º	284.8 (1.3)	284.7 (1.2)	284.4 (0.9)	285.9 (2.4)
EIA 58º	286.7 (3.4)	286.2 (2.9)	286.6 (3.3)	286.9 (3.6)

VCR Stability Over Time

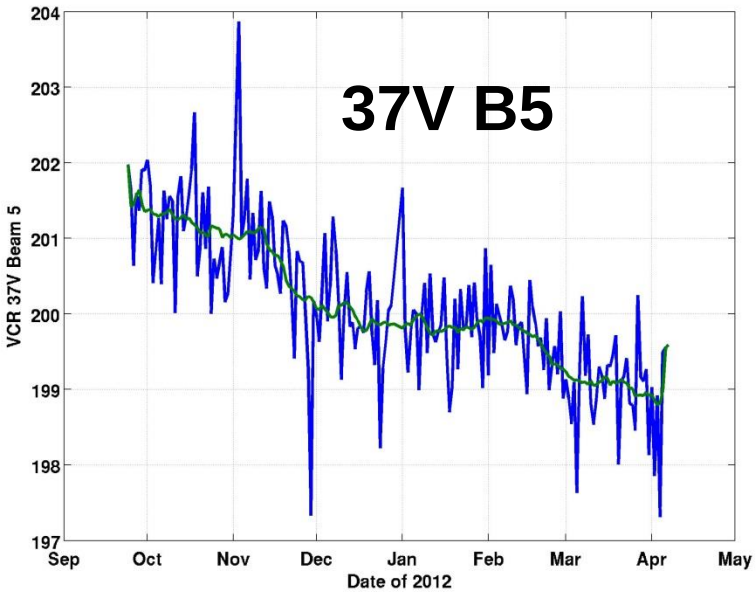


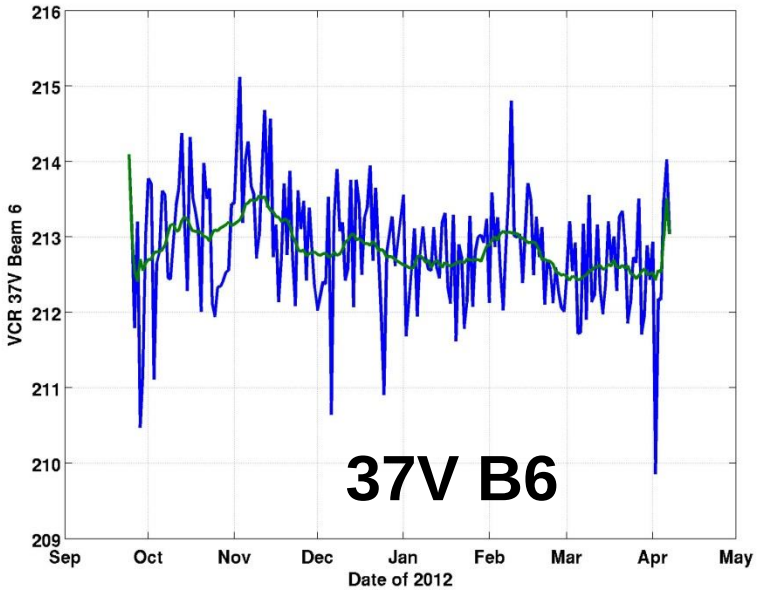


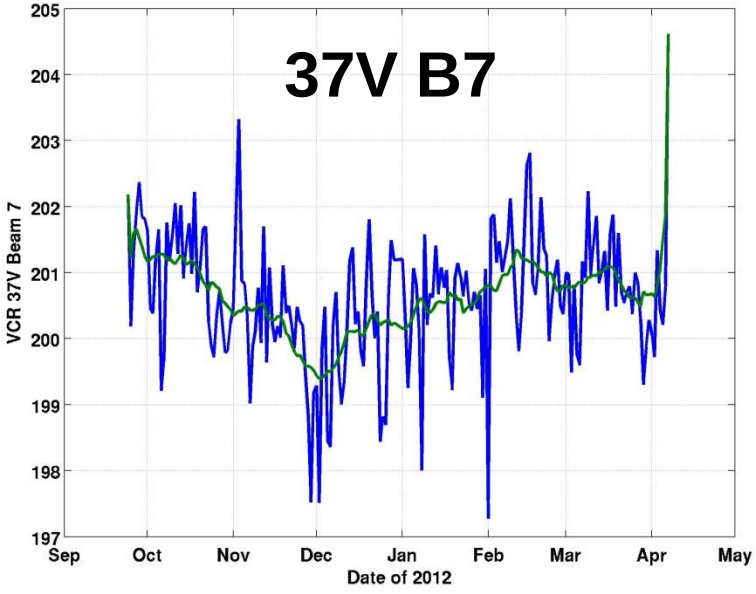


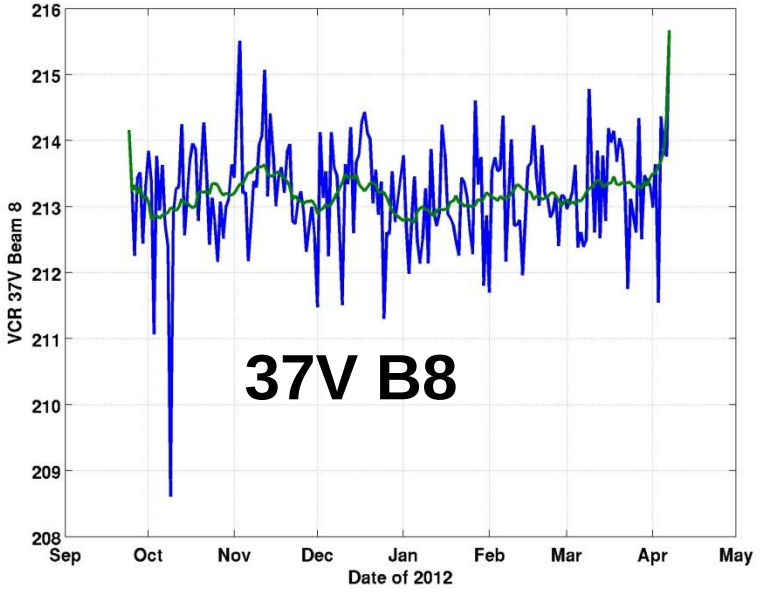


VCR Stability Over Time

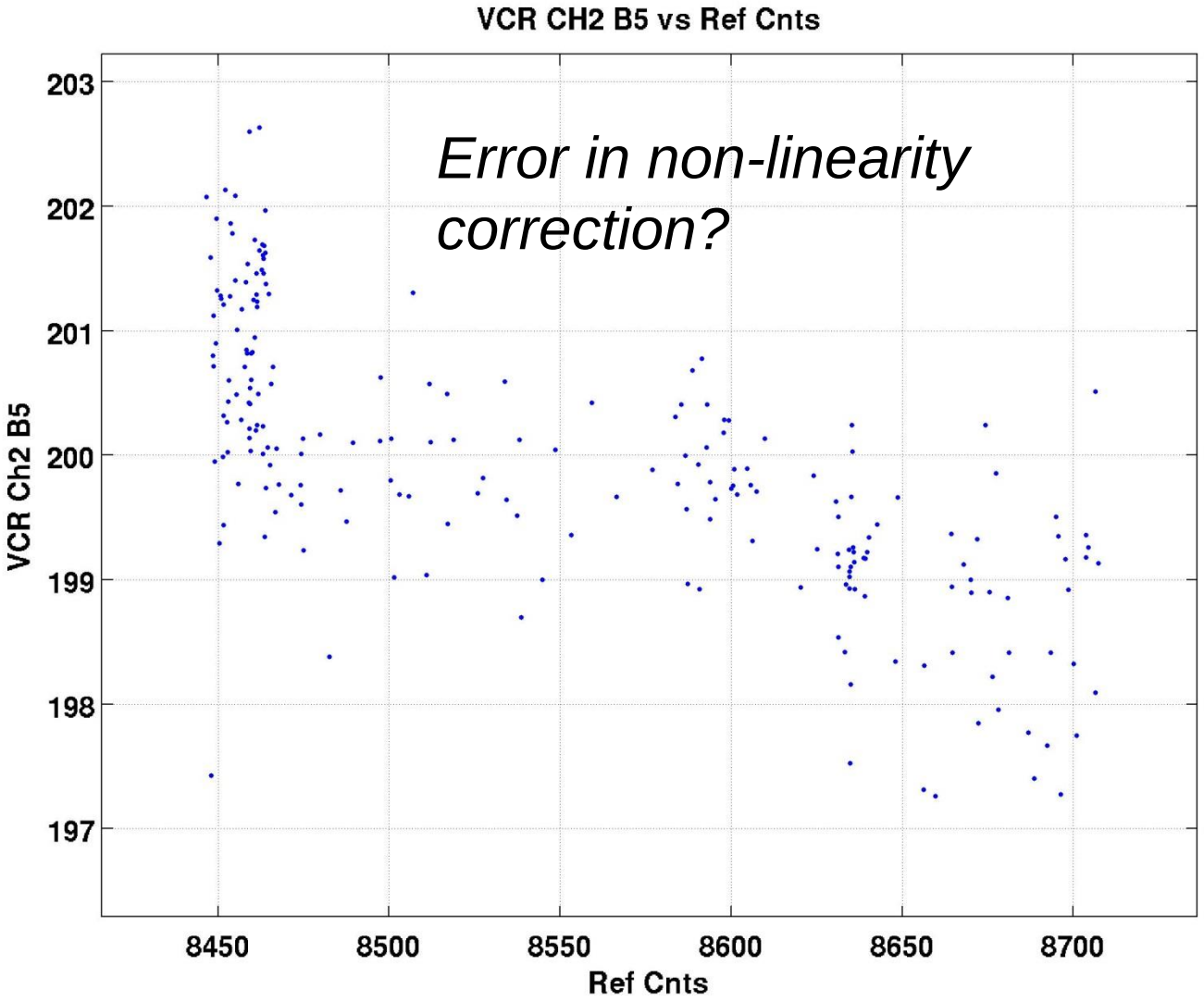


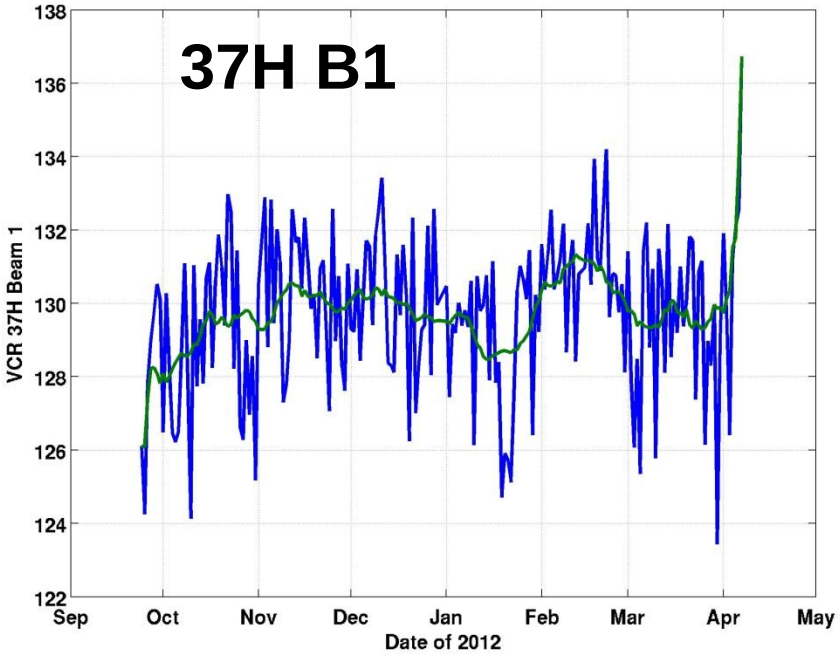






37 V Beam 5


VCR CH2 B5 vs Ref Cnts
Error in non-linearity correction?
VCR Ch2 B5
203
202
201
200
199
198
197
8450
8500
8550
8600
8650
8700
Ref Cnts


37H B1
VCR 37H Beam 1
Date of 2012
Sep
Oct
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Dec
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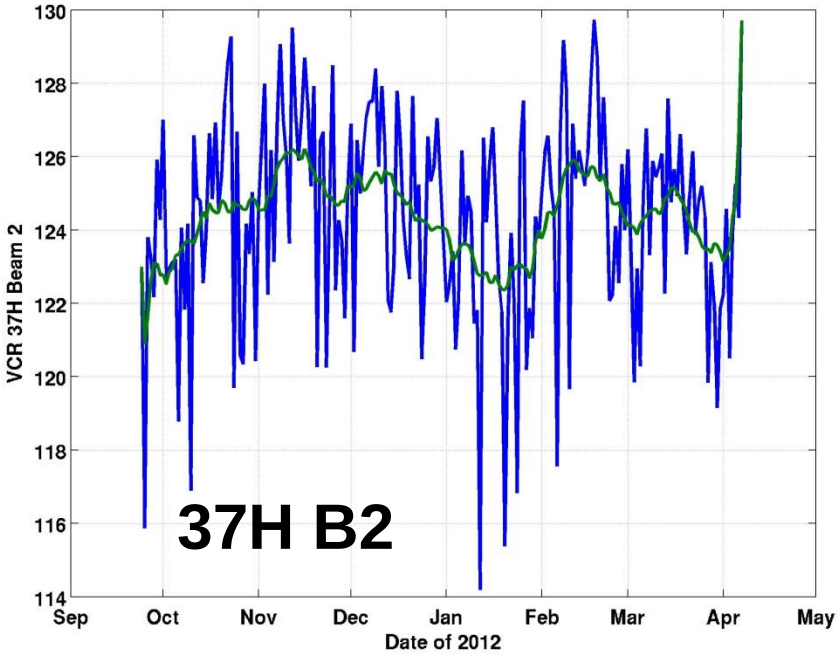
37H B2
VCR 37H Beam 2
Date of 2012
Sep
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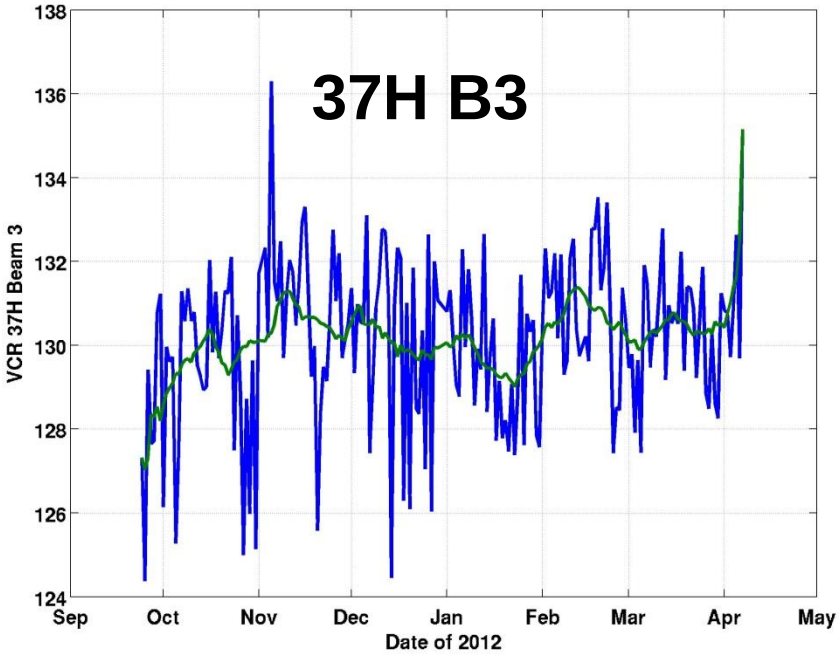
May


37H B3
VCR 37H Beam 3
Date of 2012
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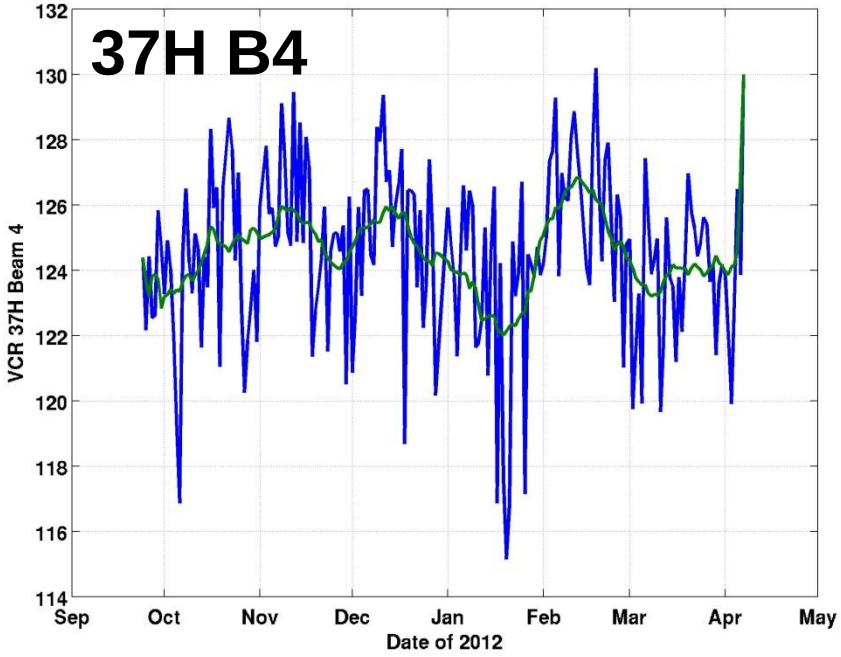
37H B4
VCR 37H Beam 4
Date of 2012
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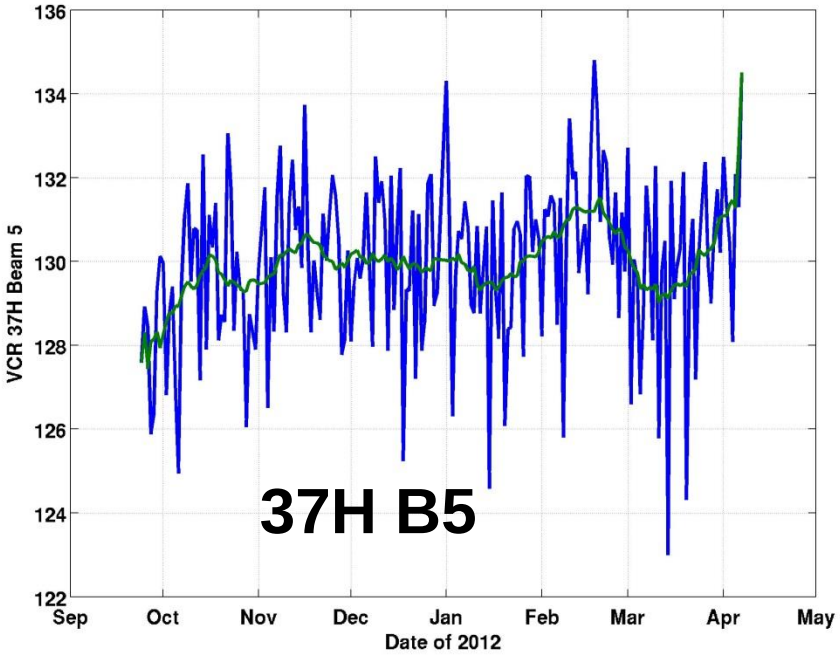
VCR 37H Beam 5
136
134
132
130
128
126
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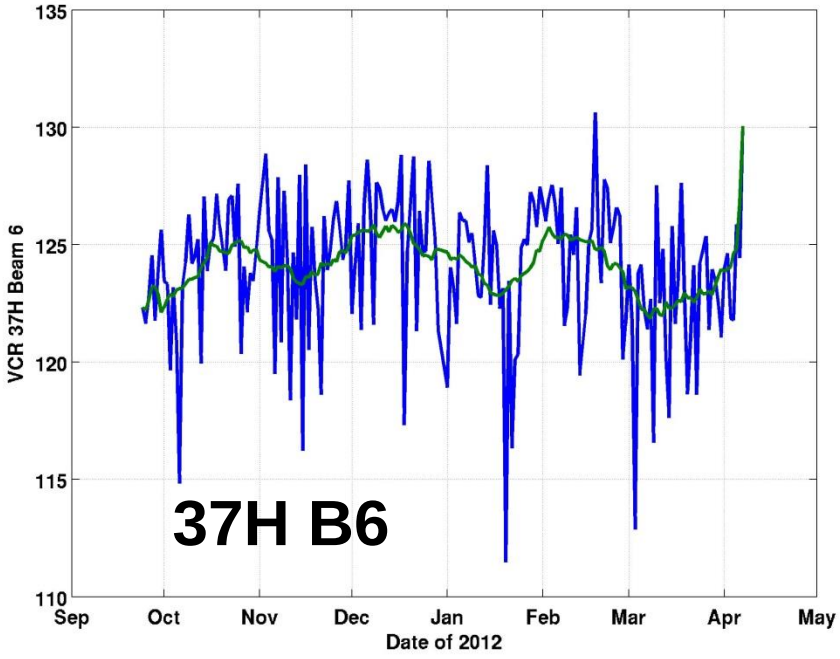
Mar
Apr
May
Date of 2012
37H B5


VCR 37H Beam 6
135
130
125
120
115
110
Sep
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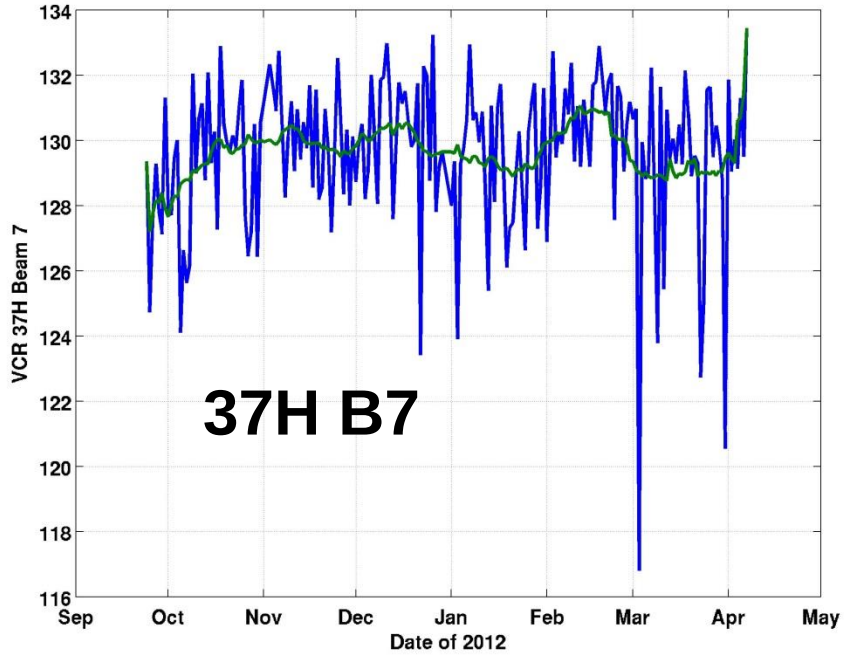
May
Date of 2012
37H B6


VCR 37H Beam 7
134
132
130
128
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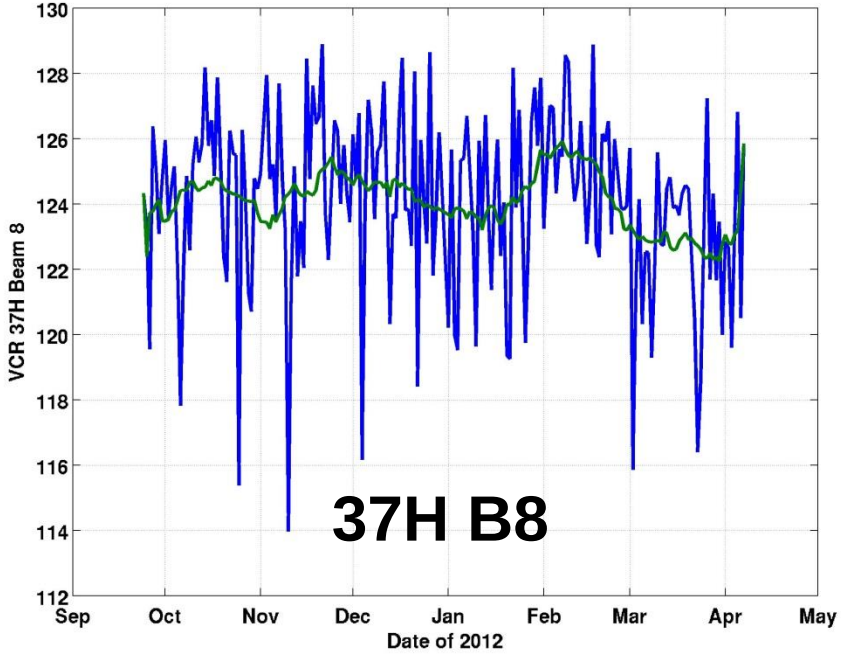
May
Date of 2012
37H B7


VCR 37H Beam 8
130
128
126
124
122
120
118
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114
112
Sep
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Date of 2012
37H B8

Inter-Beam Calibration

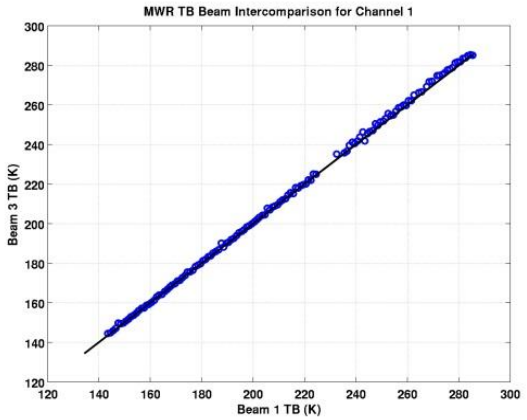
- **Important to assess relative calibration between beams over the on-Earth dynamic range of TB**
- **Applied method that finds homogeneous areas over the ocean and land where observations across the region are uncorrelated with observing location**
  - **the long term average will reduce to a common mean for each MWR beam at common incidence angle**
- **Basic assumption is that over short distances, the difference between at two points is uncorrelated with brightness temperature level and has zero mean**

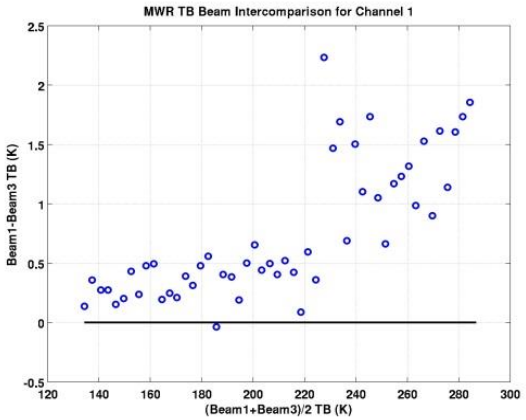
$$\frac{1}{N}\sum_{i=1}^{N}\left(T_{Bi}(x)-T_{Bi}(x+\Delta x)\right)=0$$

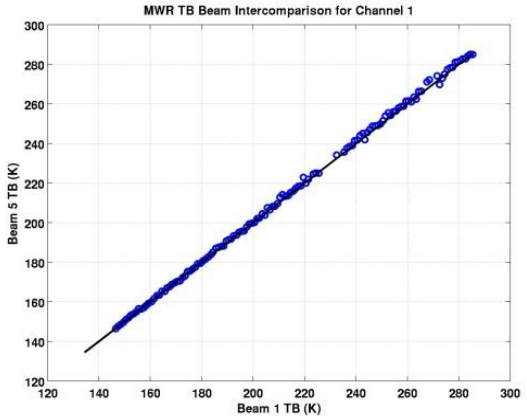
Methodology

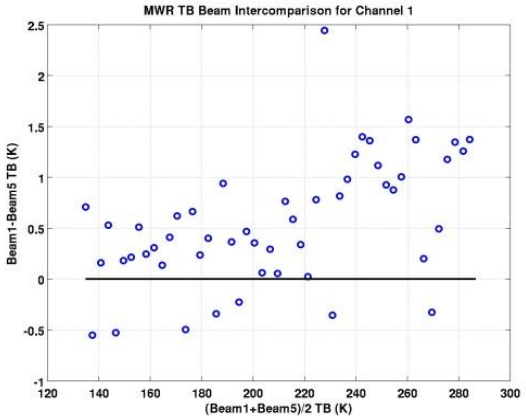
- MWR data averaged in 2.5 x 2.5 degree grid boxes
- Boxes with large along-track spatial variability are excluded to select calm homogeneous conditions
  - Along track stability a proxy for cross track stability
- Inhomogeneous scenes, such as sea ice are also excluded
- Over time, the observations across the region will reduce to a common mean for each MWR beam at common incidence angle allowing an inter-beam assessment over the full dynamic range
- Comparisons are shown relative to beam 1 and beam 2 for each channel for version 6 beta 2
  - i.e. beam 1 vs 3,5,7 and beam 2 vs 4,6,8

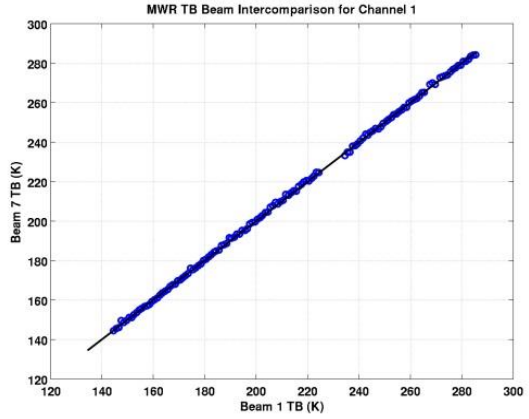
23.8 GHz – Hpol Beam 1 vs 3,5,7

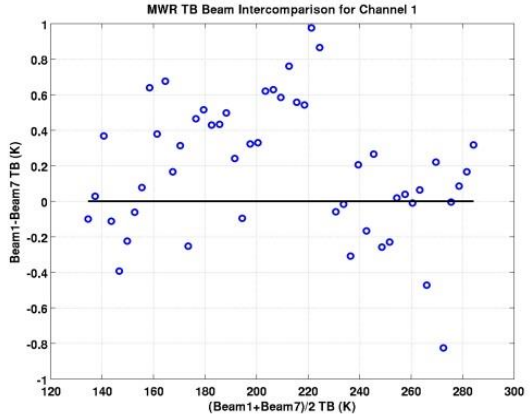




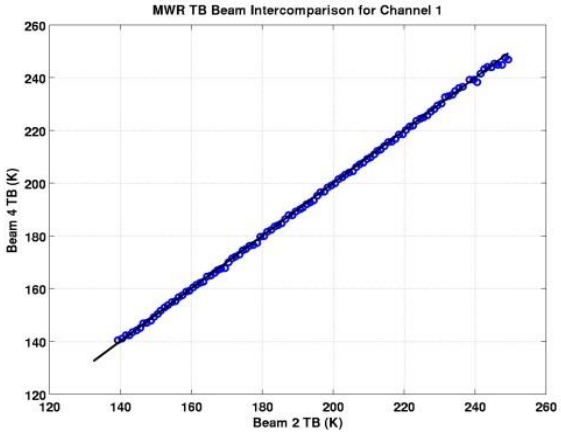


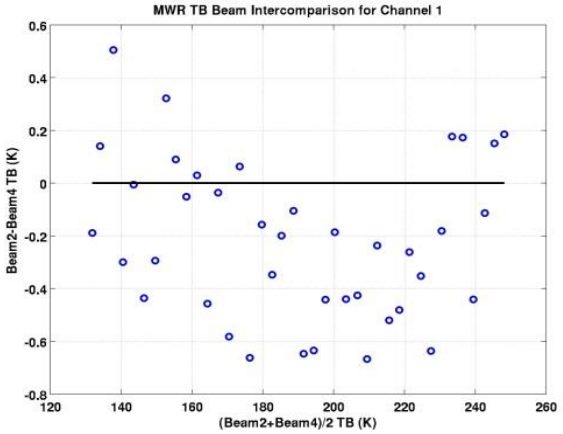


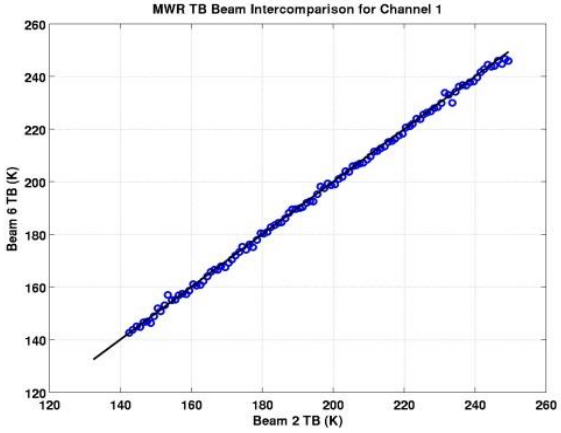


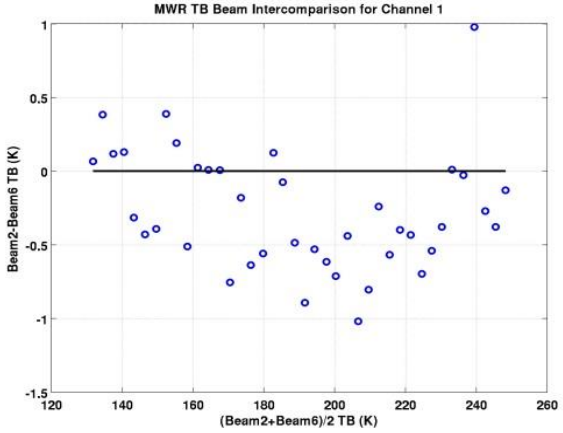


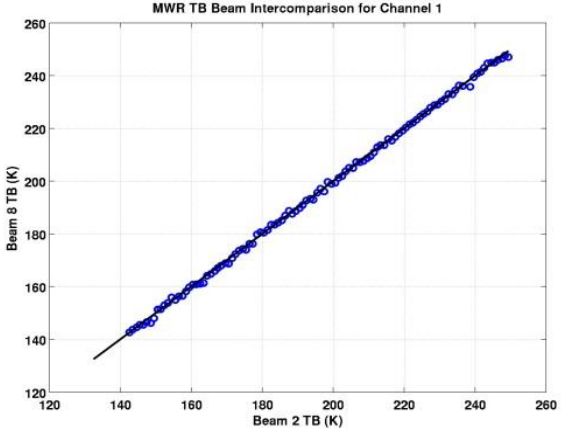
23.8 GHz – Hpol Beam 2 vs 4,6,8

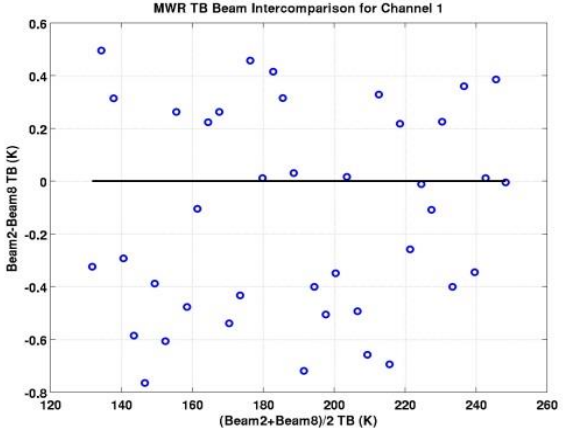






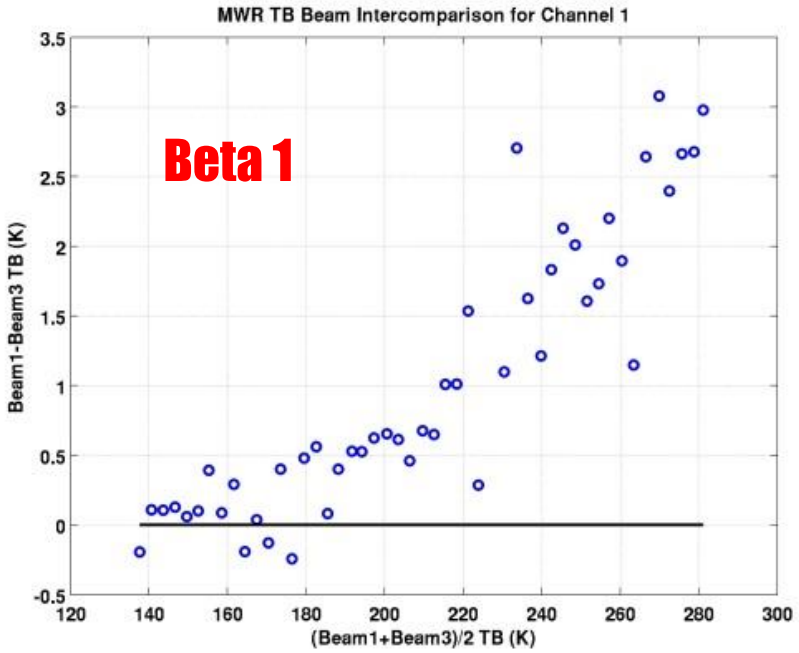


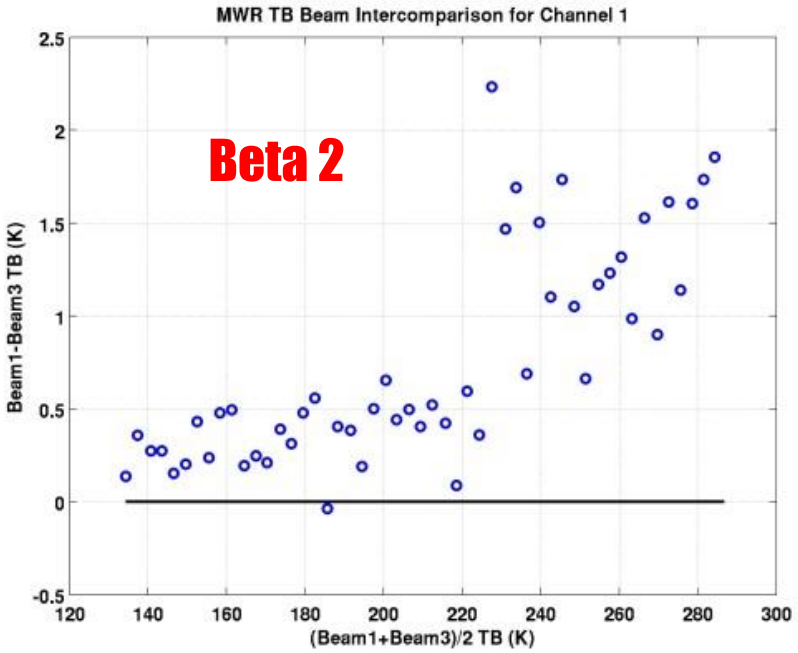




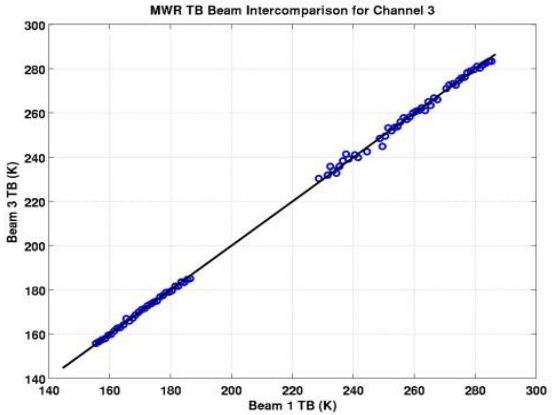
Linearity Correction Assessment

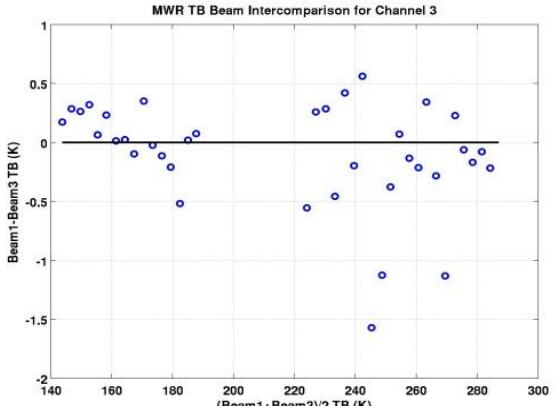
- A non-linearity correction was applied to version 6 (Ghazi et al. 10/29/2013 cal/val presentation)
- For the 23.8 GHz channel, the linearity correction was applied in version 6 beta 2, but not beta 1
- A non-linear relative bias between beams 1 and 3 for the 23.8 GHz channel is clear in beta 1
- It is still present in beta 2, but significantly reduced

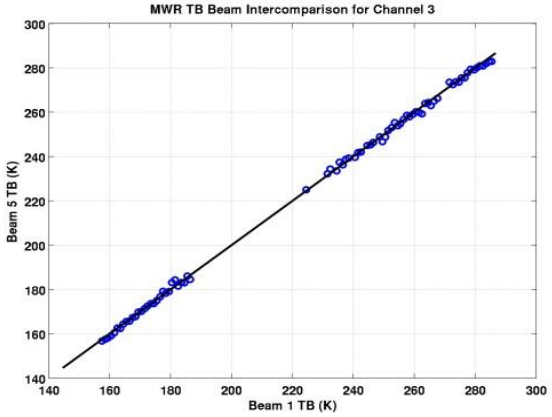


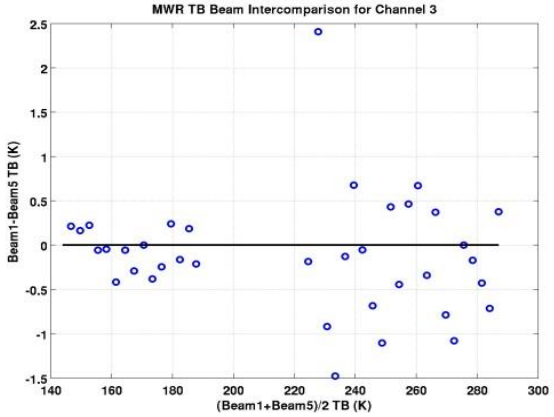


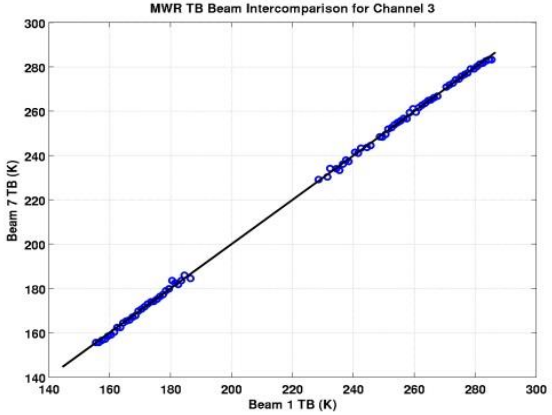
37 GHz – Hpol Beam 1 vs 3,5,7

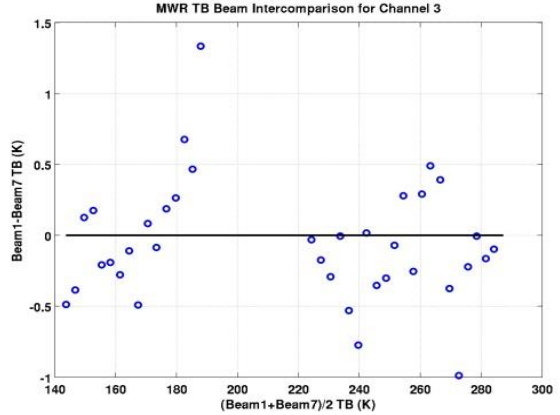




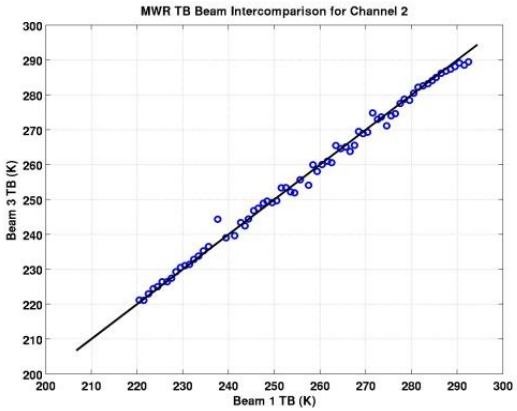


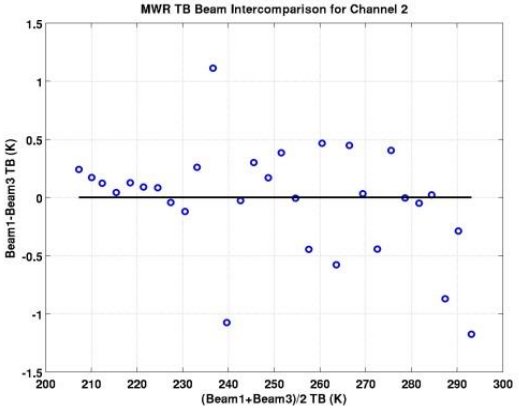


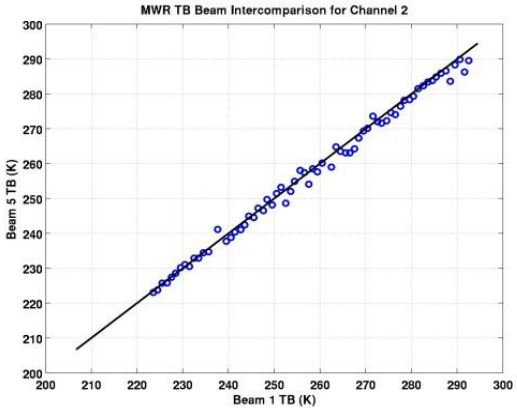


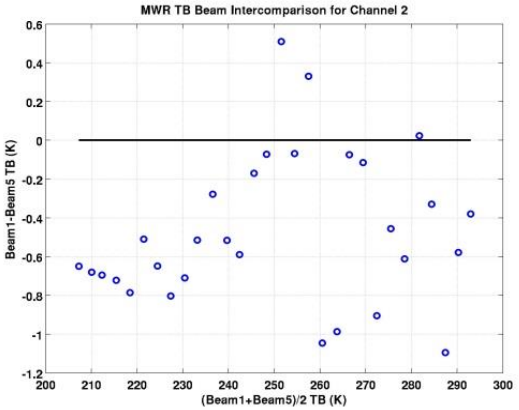


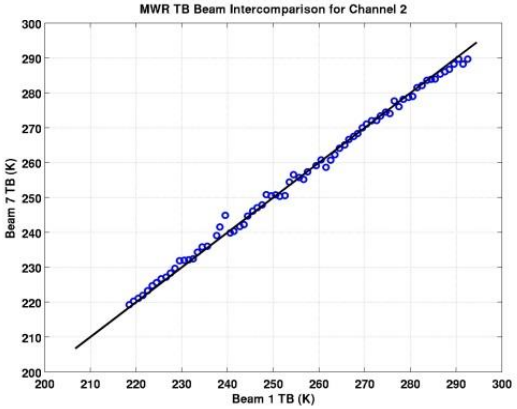
37 GHz – Vpol Beam 1 vs 3,5,7

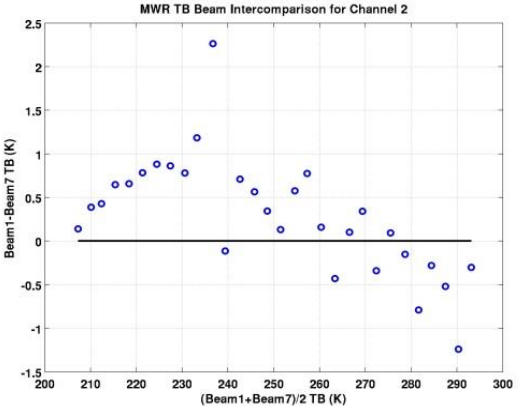












Conclusions

- **MWR calibration within about 2-3 K of the on-Earth reference models**
  - **~0.5 K level inter-beam biases observed over the reference regions**
- **37 GHz TBs stable in time to ~1K from September'12 to April'13**
  - **Exception is 37V beam 5 - possible non-linearity correction error?**
- **Inter-beam comparison method shows non-linear inter-beam biases**
  - **37 GHz channel shows better inter-beam calibration (biases < 0.5 K)**
  - **23.8 GHz channel show significantly more inter-beam bias (>1K at the warm end), but version 6 non-linearity correction show definitive improvement**
- **Version 6 shows continued improvement from earlier MWR data**