11.4 Polarimetric Weather Radar Calibration Using Solar Scans

Using the Sun for WSR-88D Z_{DR} Calibration

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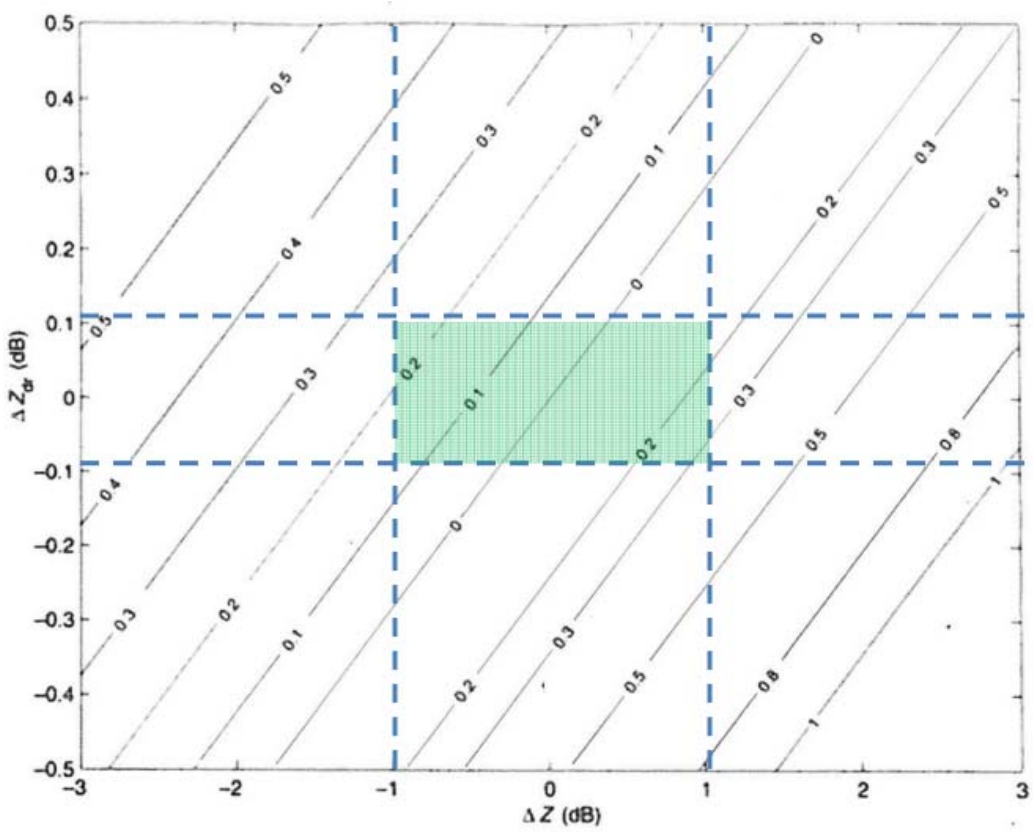
31st Conference on Environmental Information Processing Technologies

Using the Sun: Overview

- Motivation: Meeting calibration requirements
  - Within 1.0 dB for Reflectivity (Z)
  - 0.1 dB for Differential Reflectivity (Z_{DR})
- Antenna parameters are key elements
  - Gain, beam width and pointing accuracy
  - Differential gain (antenna bias)
- Offline tests
  - Baseline methods
  - Planned upgrades
- Routine monitoring with sun spikes

Calibration Requirements

- Bringi and Chandrasekar provide an error analysis



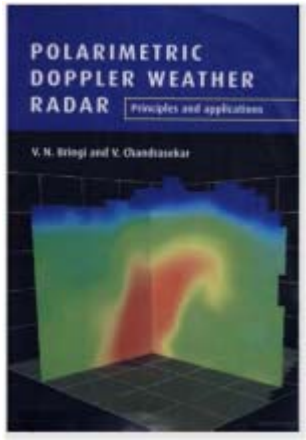
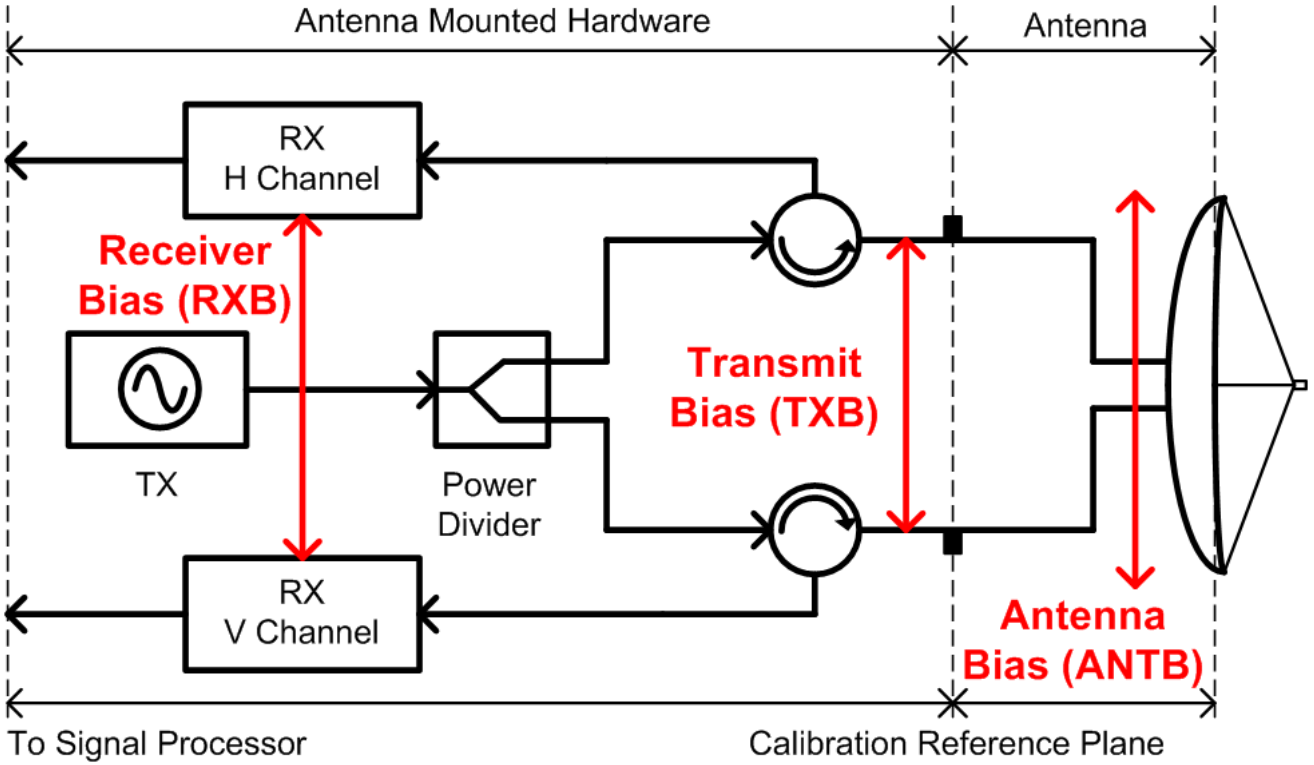


Image from Polarimetric Doppler Weather Radar, Principles and Applications, 2001

Fig 8.8. Contours of normalized bias error in (ΔR/R) due to biases in Z_H(ΔZ, dB) and Z_{DR}(ΔZ_{DR}, dB). The line marked 0 indicates zero bias error.

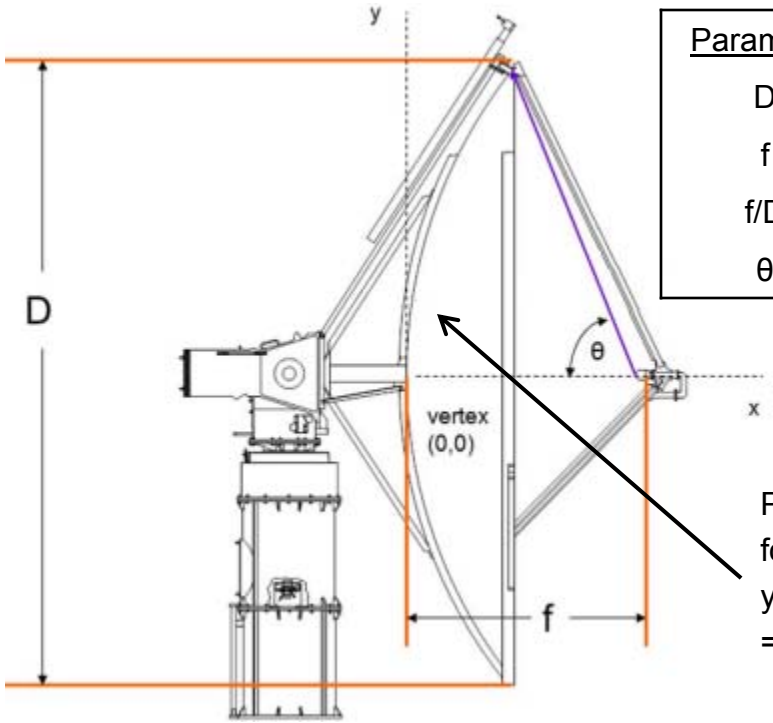
WSR-88D Z_{DR} Engineering Calibration Architecture



Total Bias =
RXB +
TXB +
2ANTB

Bias	Test Method	Frequency	Note
RXB	Injected test signals	Every volume scan	Must know test signal bias, coupler losses
TXB	Sampled power	Every 8 hours	Must know power sense bias, coupler losses
ANTB	Solar scans	Monthly	Must include RXB to derive antenna bias

WSR-88D Antenna Physical Design



Parameter	Value
D	8.53 m
f	3.2 m
f/D	0.375
θ	67.3°

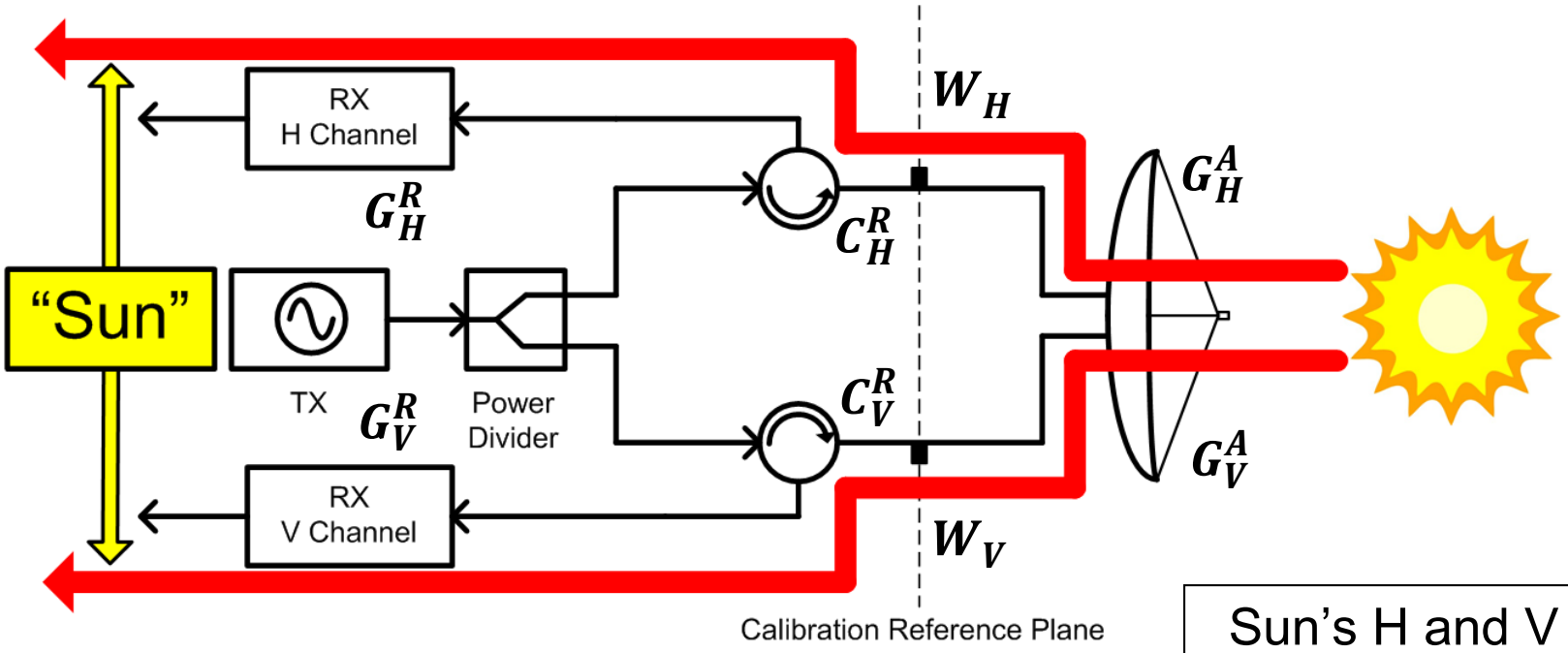
Parabolic figure
focus at (p,0)
$y^2 = 4px$
$= 4(3.2)x = 12.8x$

Far field distance

$$d = \frac{2D^2}{\lambda} = 1455\ m$$

Range testing or in-situ measurements are impractical for antennas of this size

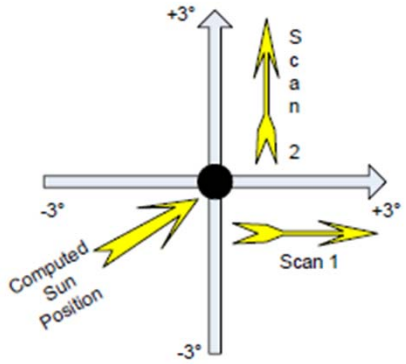
Solar Calibration



Sun's H and V noise powers are equivalent

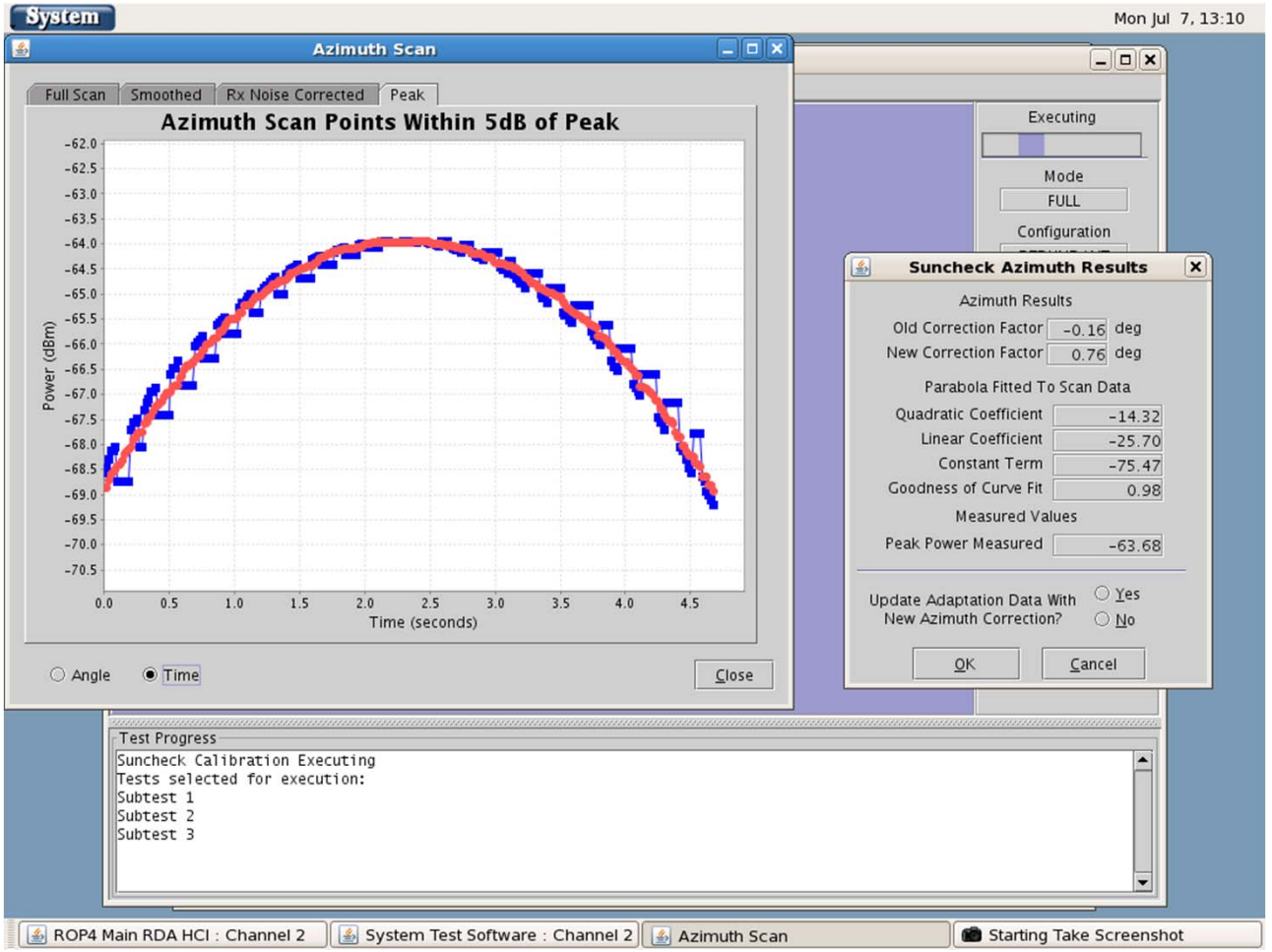
$$\text{"Sun"} \rightarrow \frac{G_V^A\, W_V\, C_V^R\, G_V^R}{G_H^A\, W_H\, C_H^R\, G_H^R} = \frac{Sun_V}{Sun_H}$$

Baseline WSR-88D Calibration Method



Free, 2007

Scan in both azimuth and elevation, compute sun position and compare to known value



Computing Antenna Bias from Solar Scans

- Pointing accuracy is important
- Two dimensional (Box) scans are best
- Scan under operational conditions

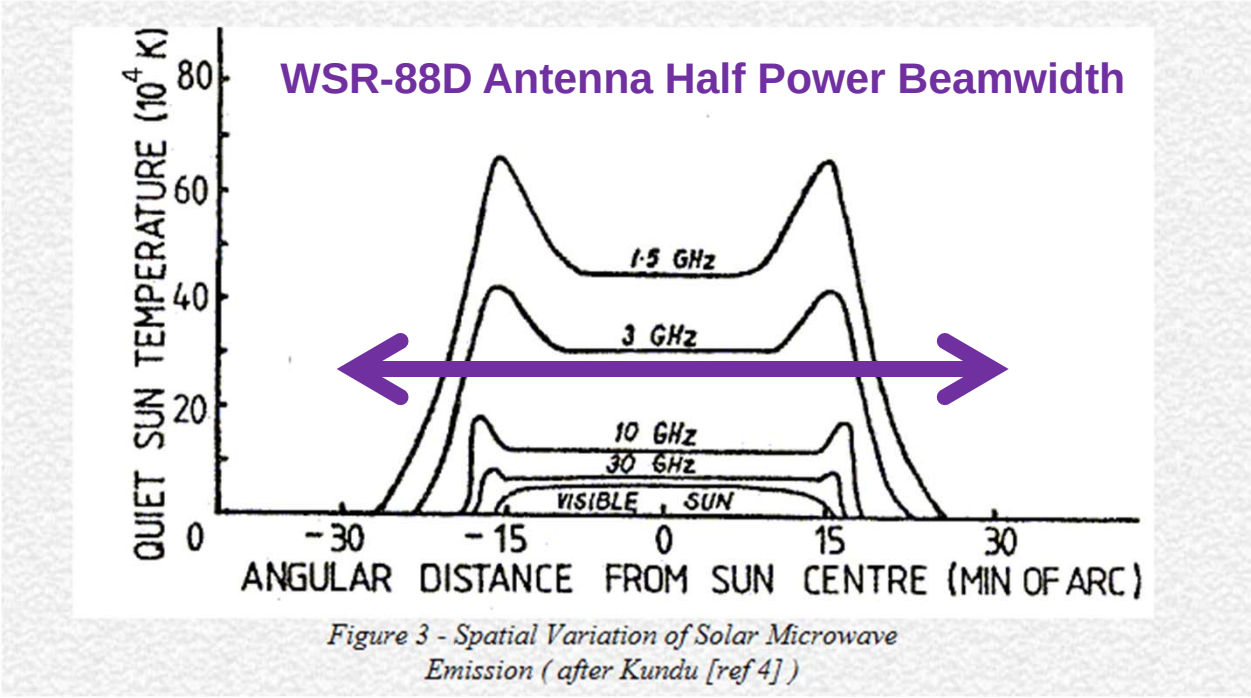
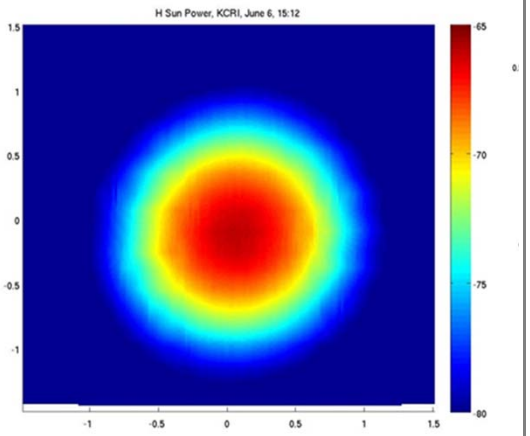


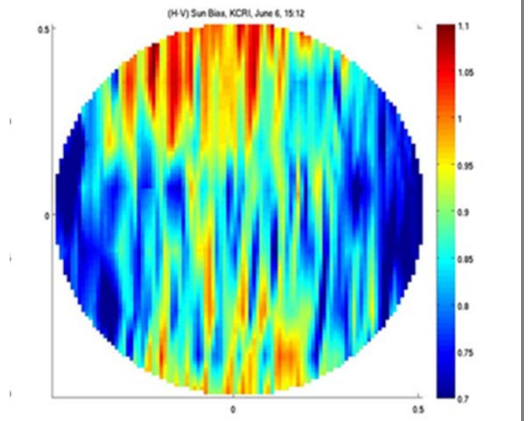
Figure 3 - Spatial Variation of Solar Microwave Emission (after Kundu [ref 4])

Kundu, M. R., 1965, Solar Radio Astronomy (Wiley, N. Y.)

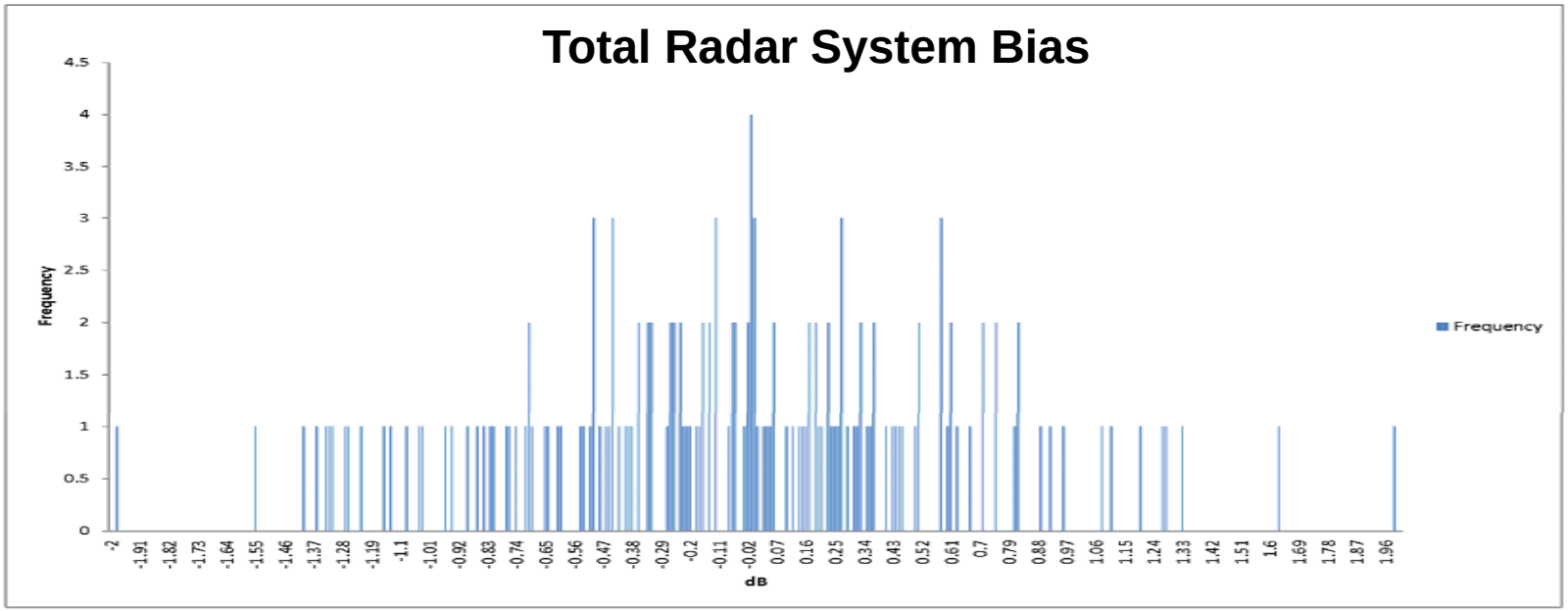
H Sun Power

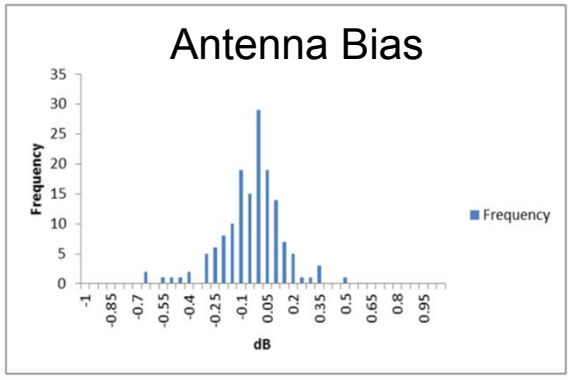


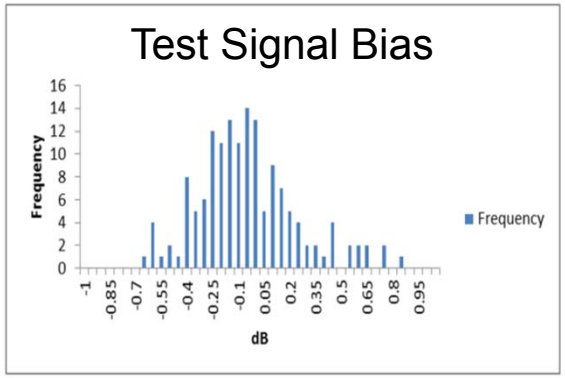
(H-V) Sun Bias

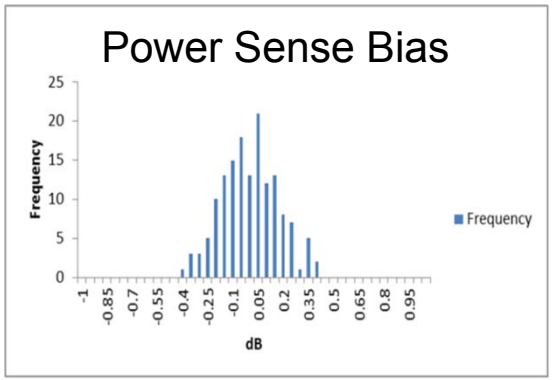


Typical Distribution of Calibration Parameters

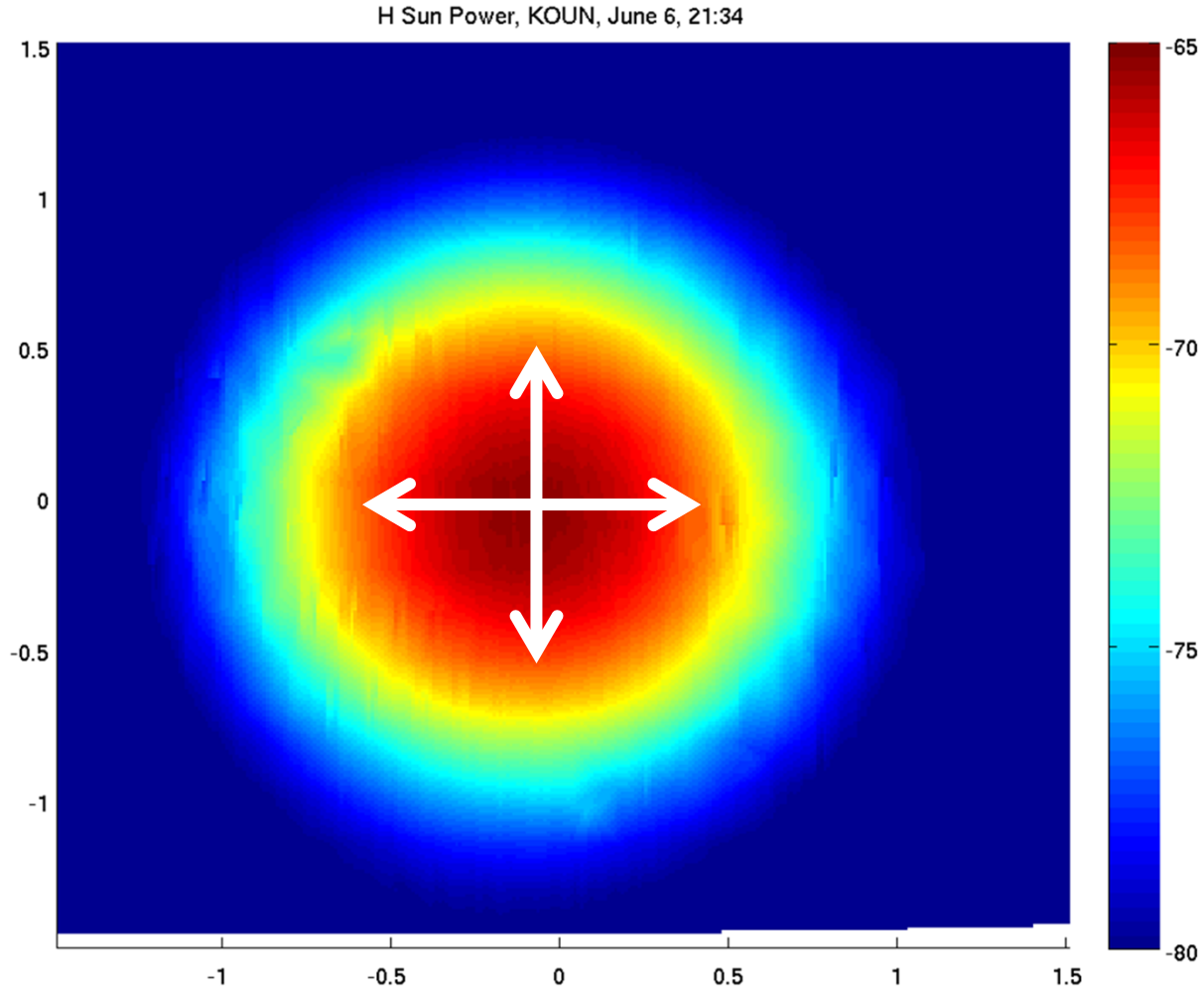




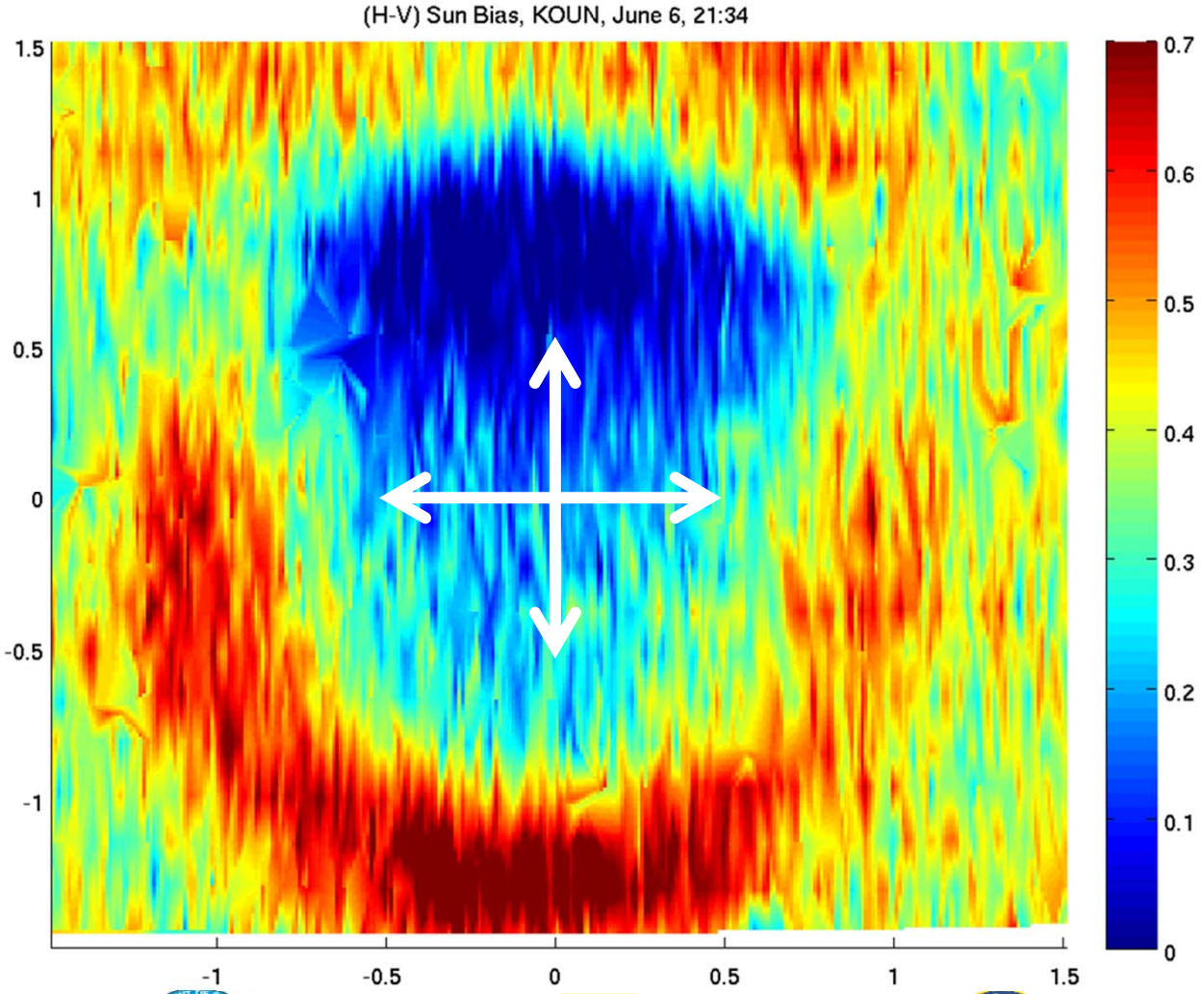




Solar “Box” Scans

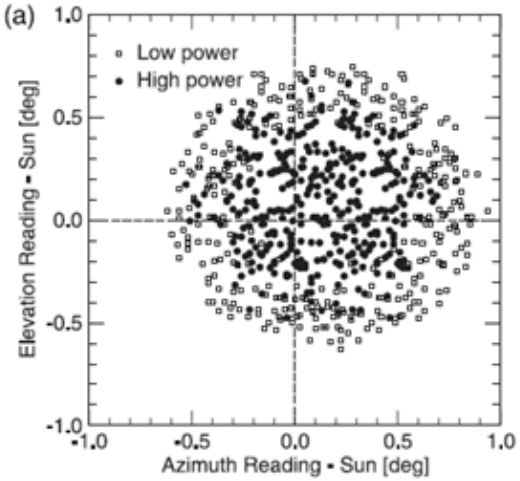


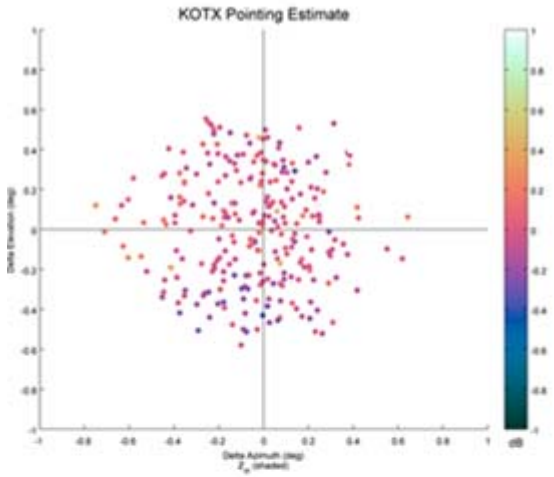
Solar “Box” Scans



Monitoring Receive Paths with Daily Sun Spikes

Received solar power from Trappes radar in 2008

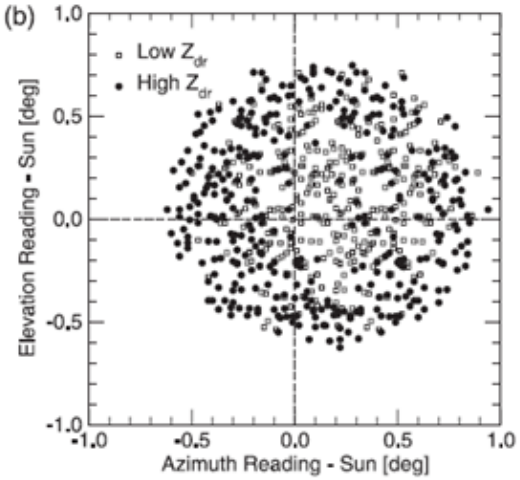


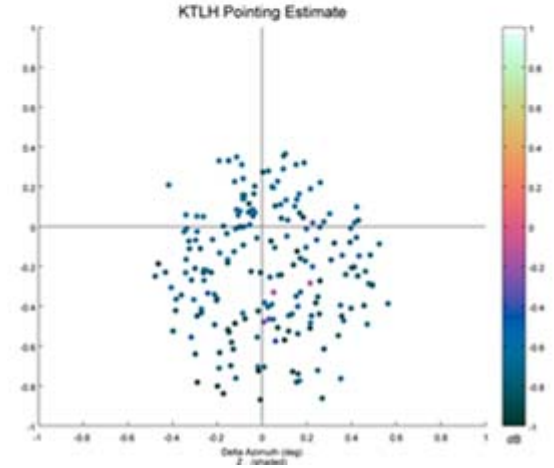


Pointing Estimate from KOTX radar.

Median Z_{DR} = -.012 dB

Differential reflectivity (Z_{DR}) from the same scans



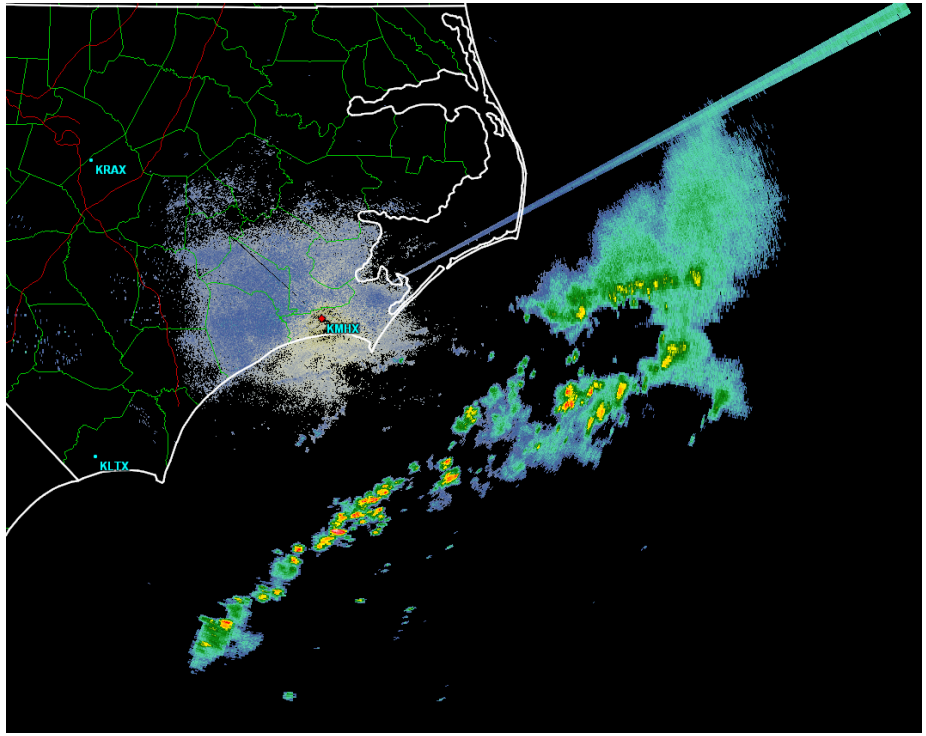


Pointing Estimate from KTLH radar.

Median Z_{DR} = -.72 dB

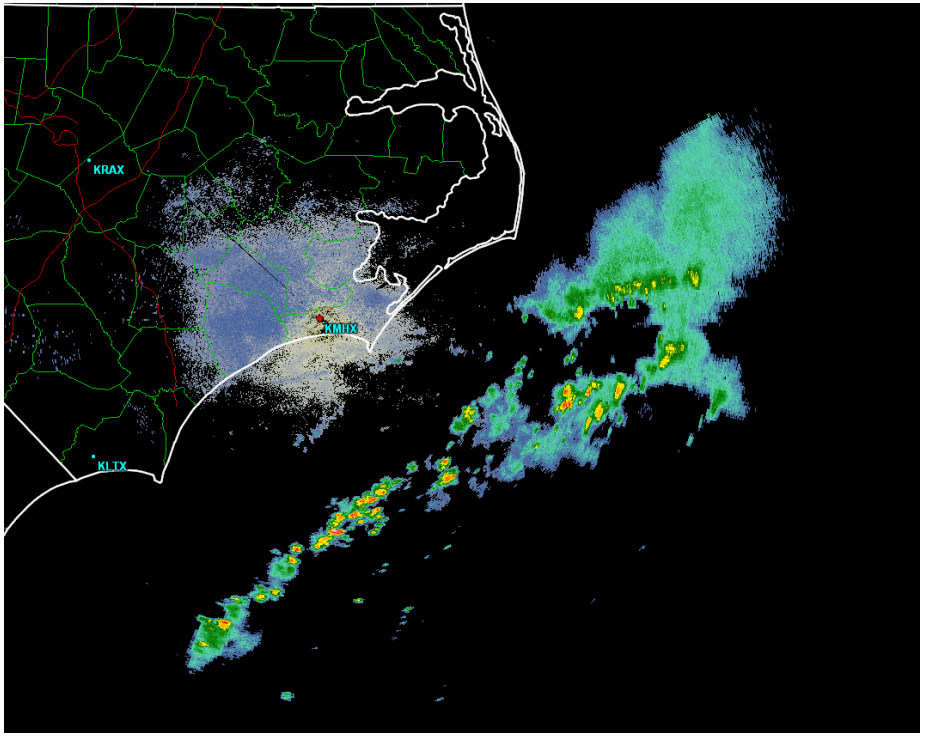
Holleman, I, A. Huuskonen, R. Gill, P. Tabary, 2010: Operational Monitoring of Radar Differential Reflectivity Using the Sun. J. Atmos Oceanic Technol., 27, 881-887.

Active Noise Estimation Eliminated Sun Spikes

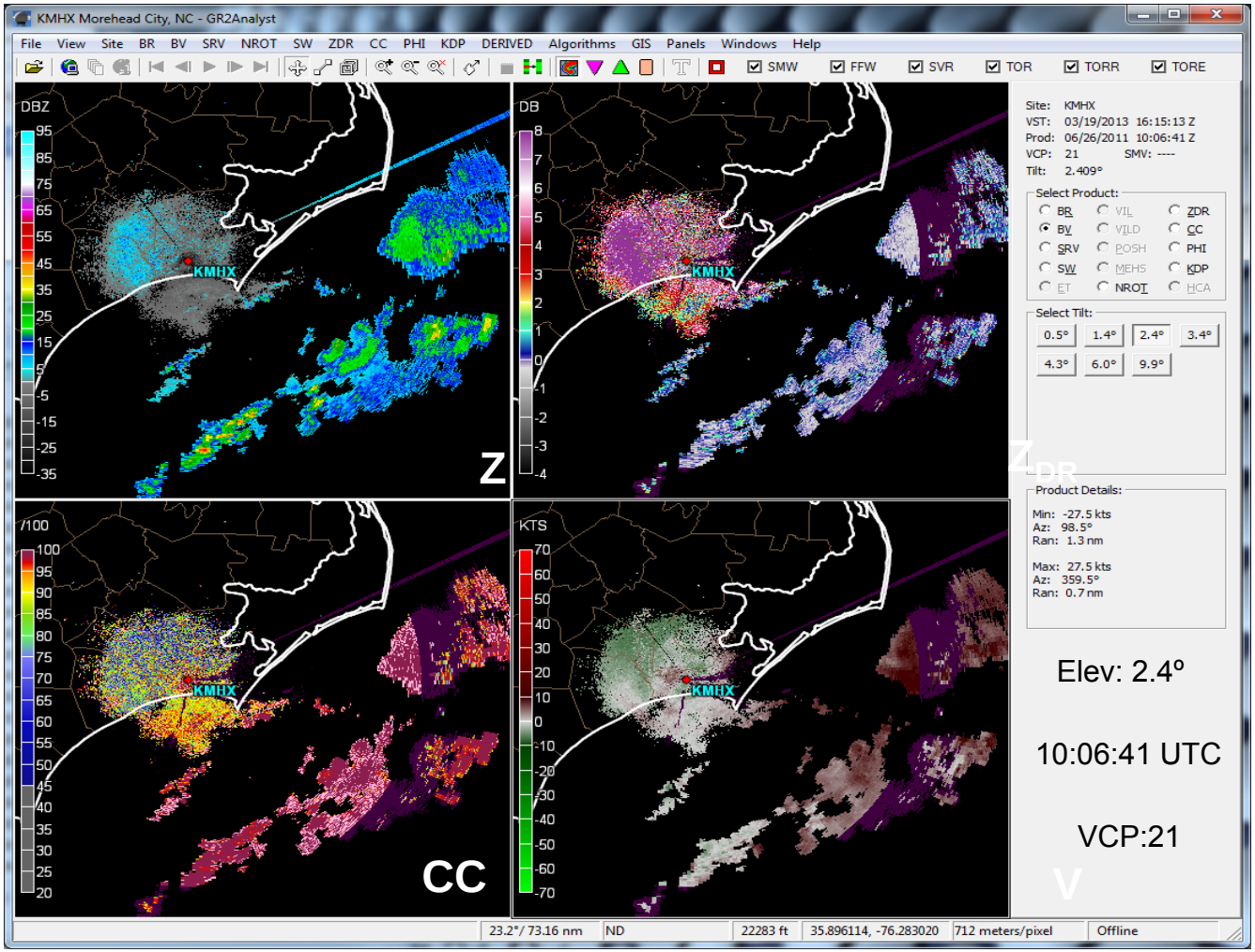


Pre Software Build 14.0

Post Software Build 14.0



Sun Spike from KMHX



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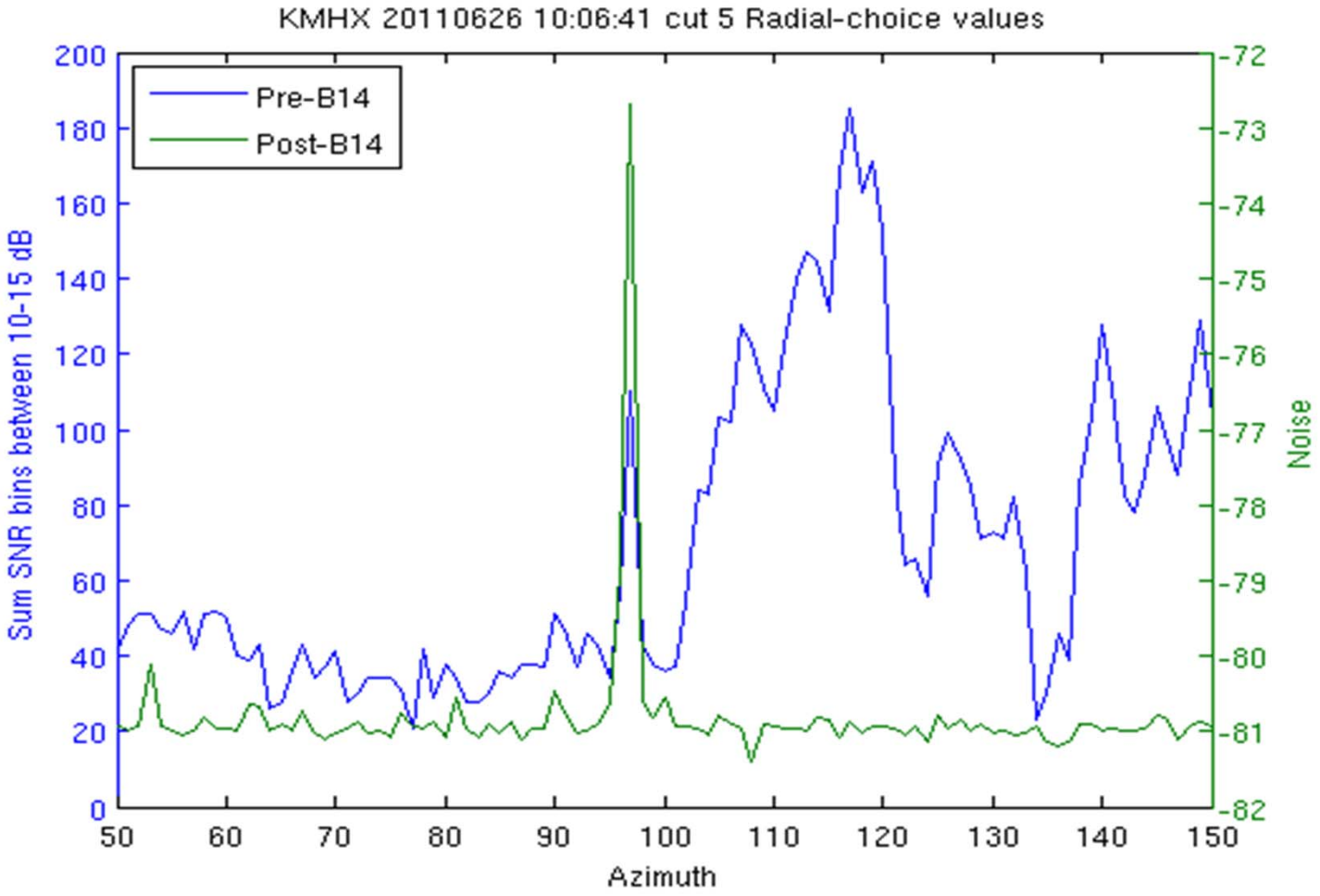
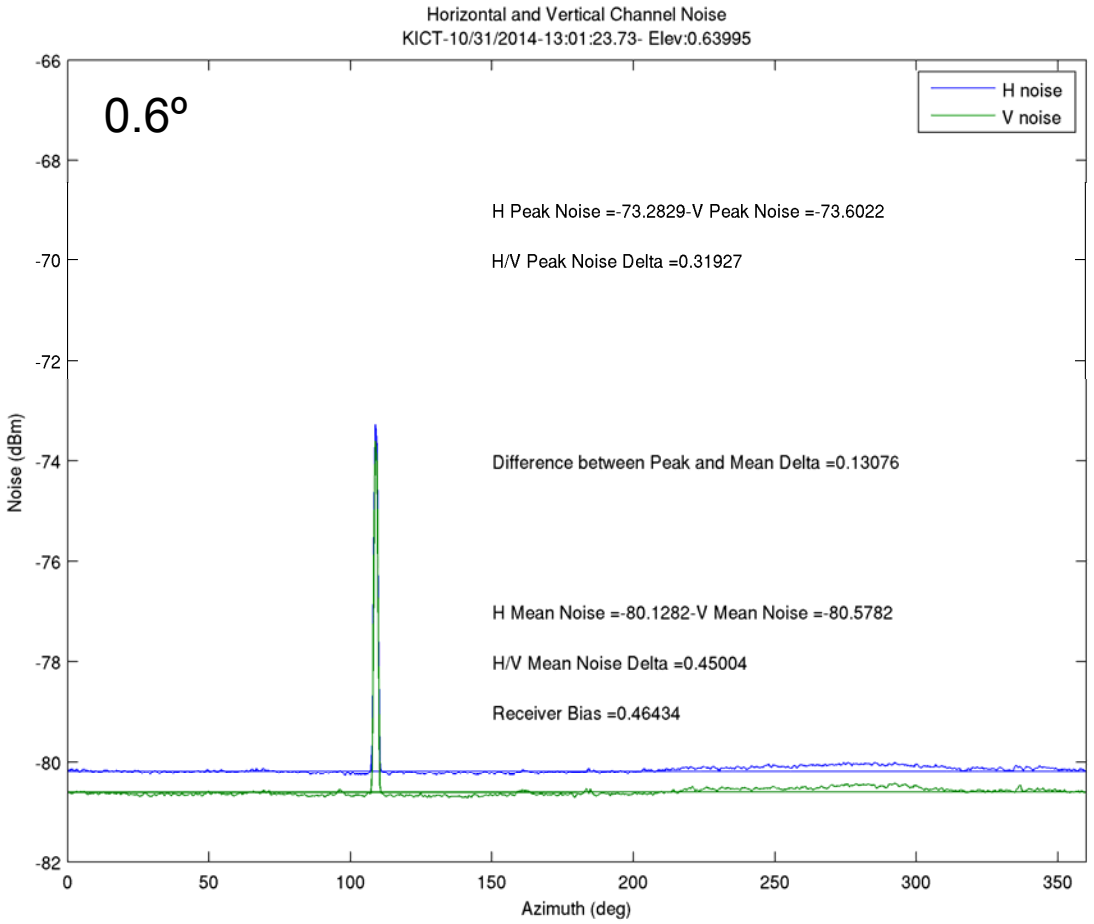
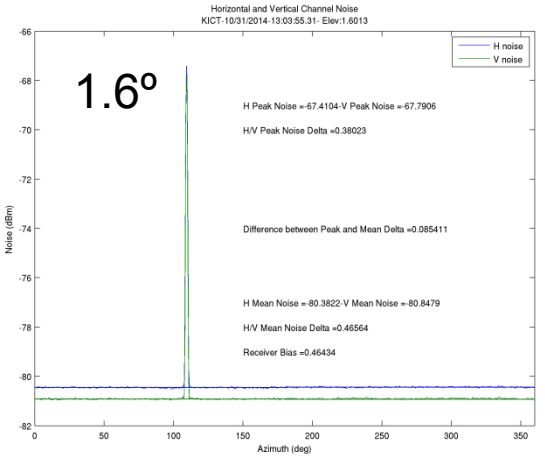
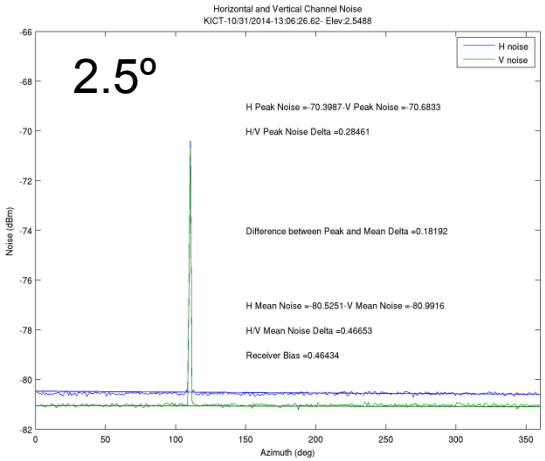
Sun Spike from KMHX



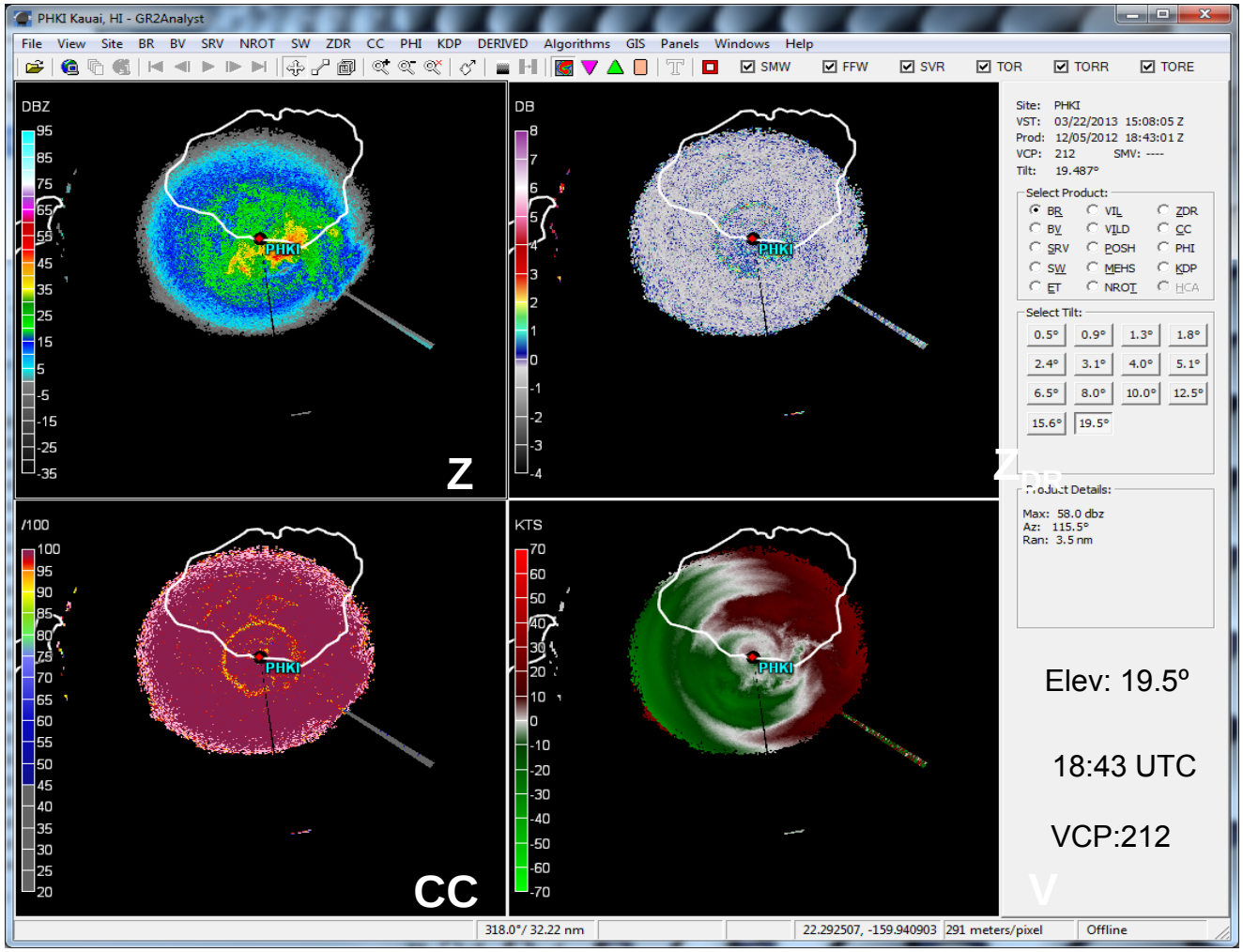
Sun Spikes Visible at Multiple Elevations



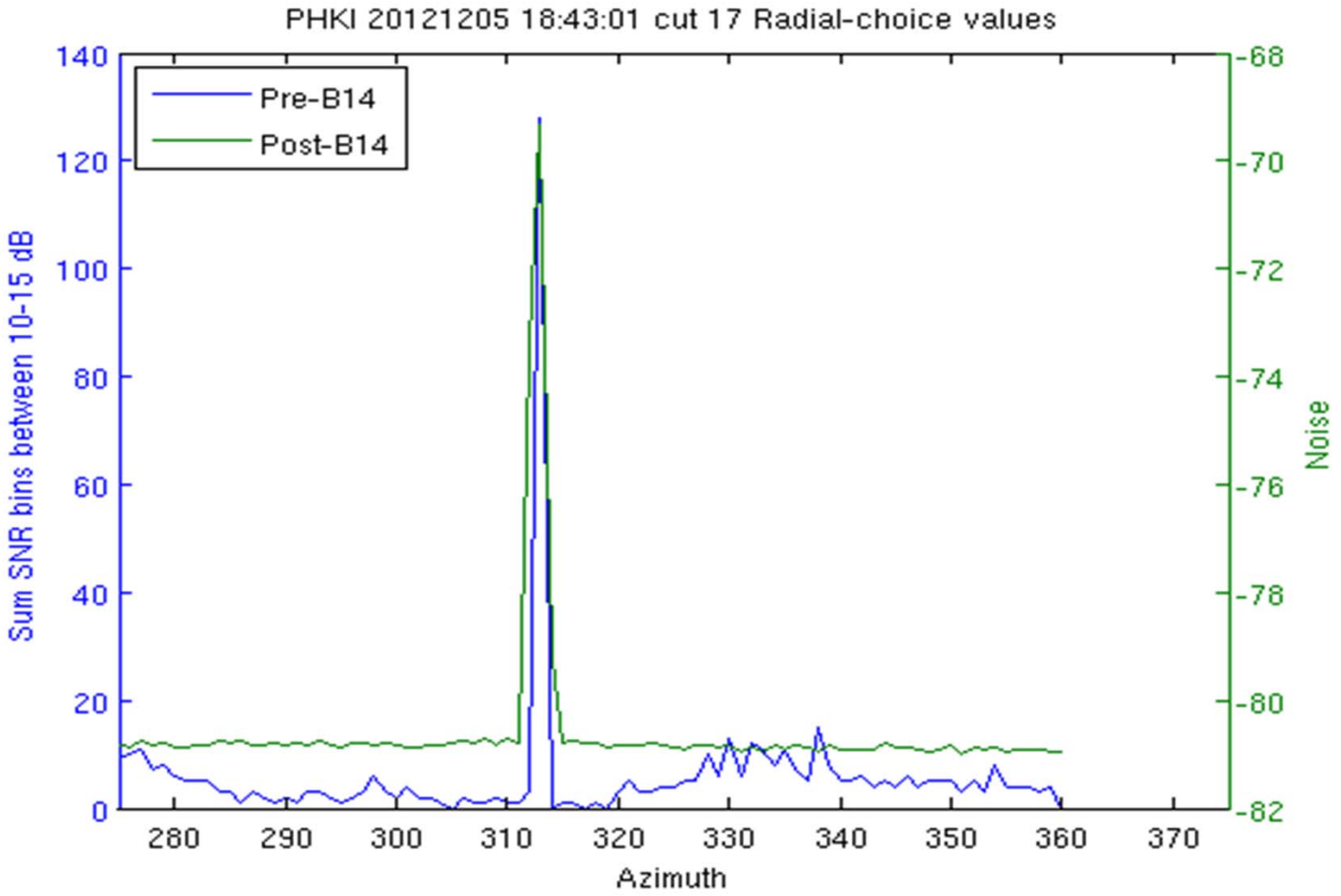




Sun Spike from PHKI

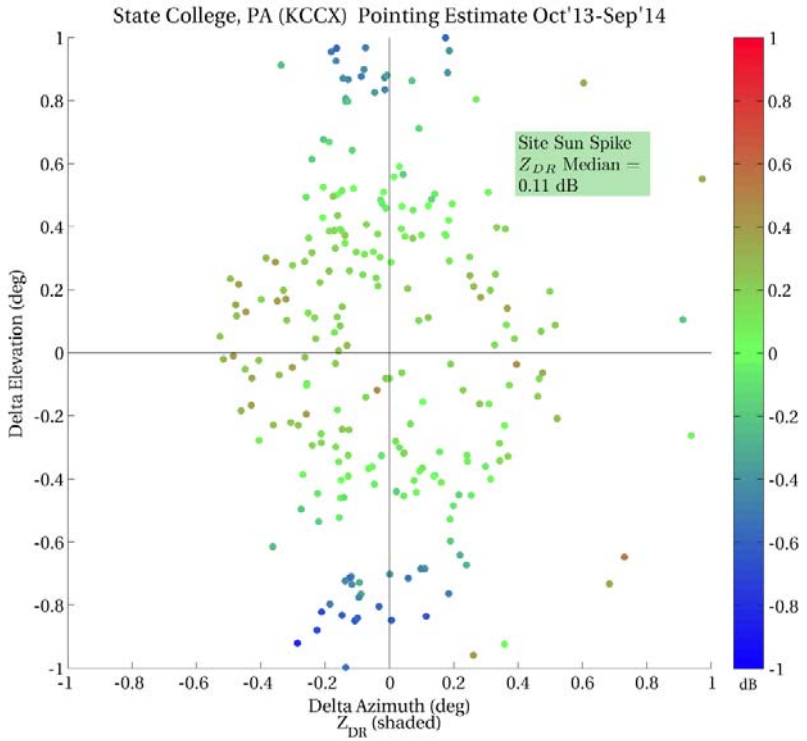


Sun Spike from PHKI

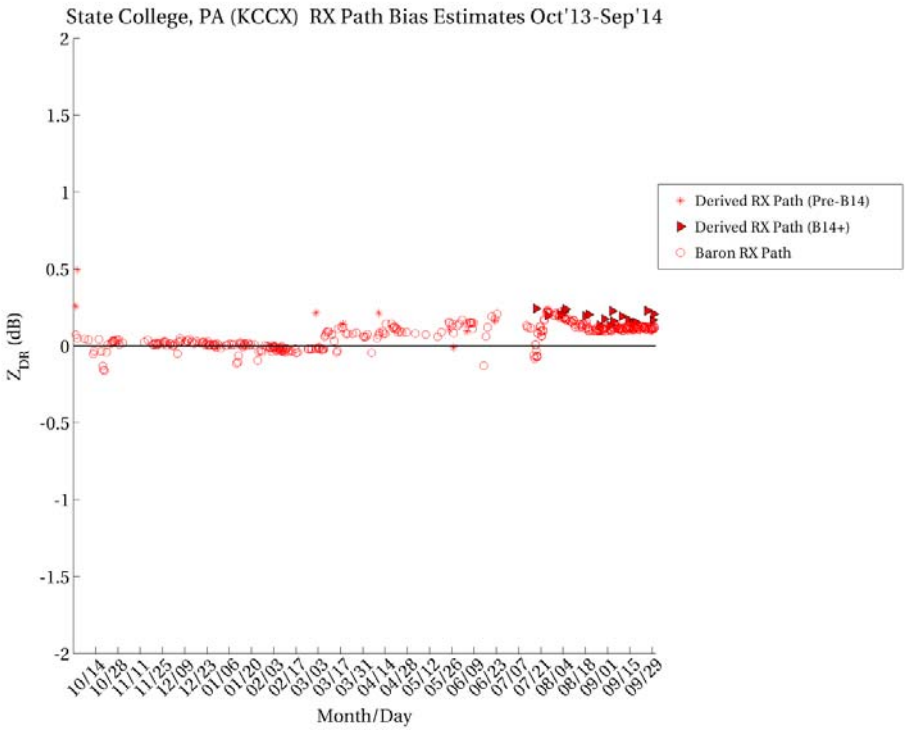


Sunspike Data from KCCX

Radar A - Z_{DR} Bias and Pointing Data

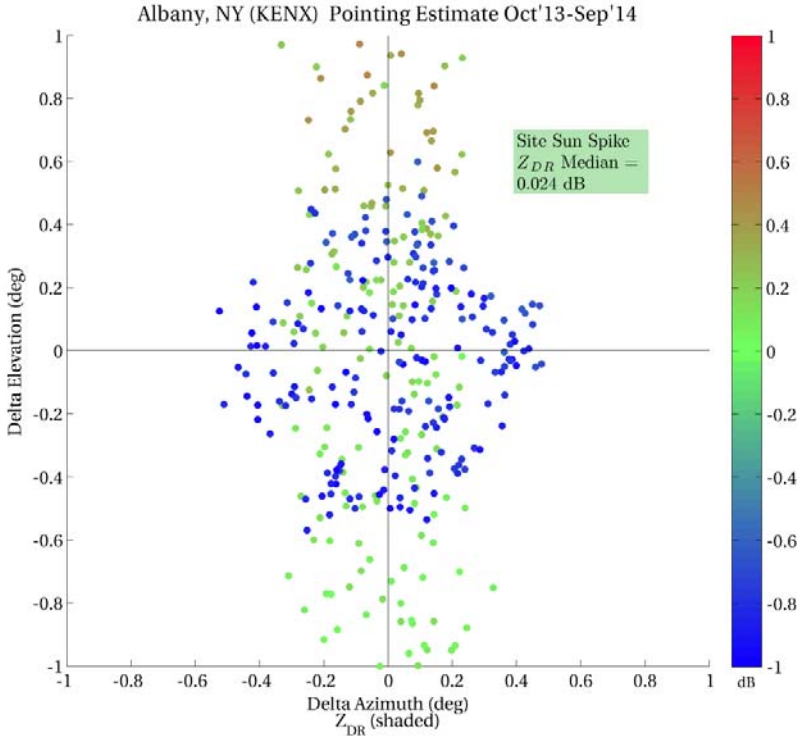


Radar A - Derived RX Path, Sun Spikes and Test Signal



Sunspike Data from KENX

Radar B - Z_{DR} Bias and Pointing Data



Radar B - Derived RX Path, Sun Spikes and Test Signal