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Monitoring the Performance of the Polarimetric WSR-88D
Calibration and Sensitivity

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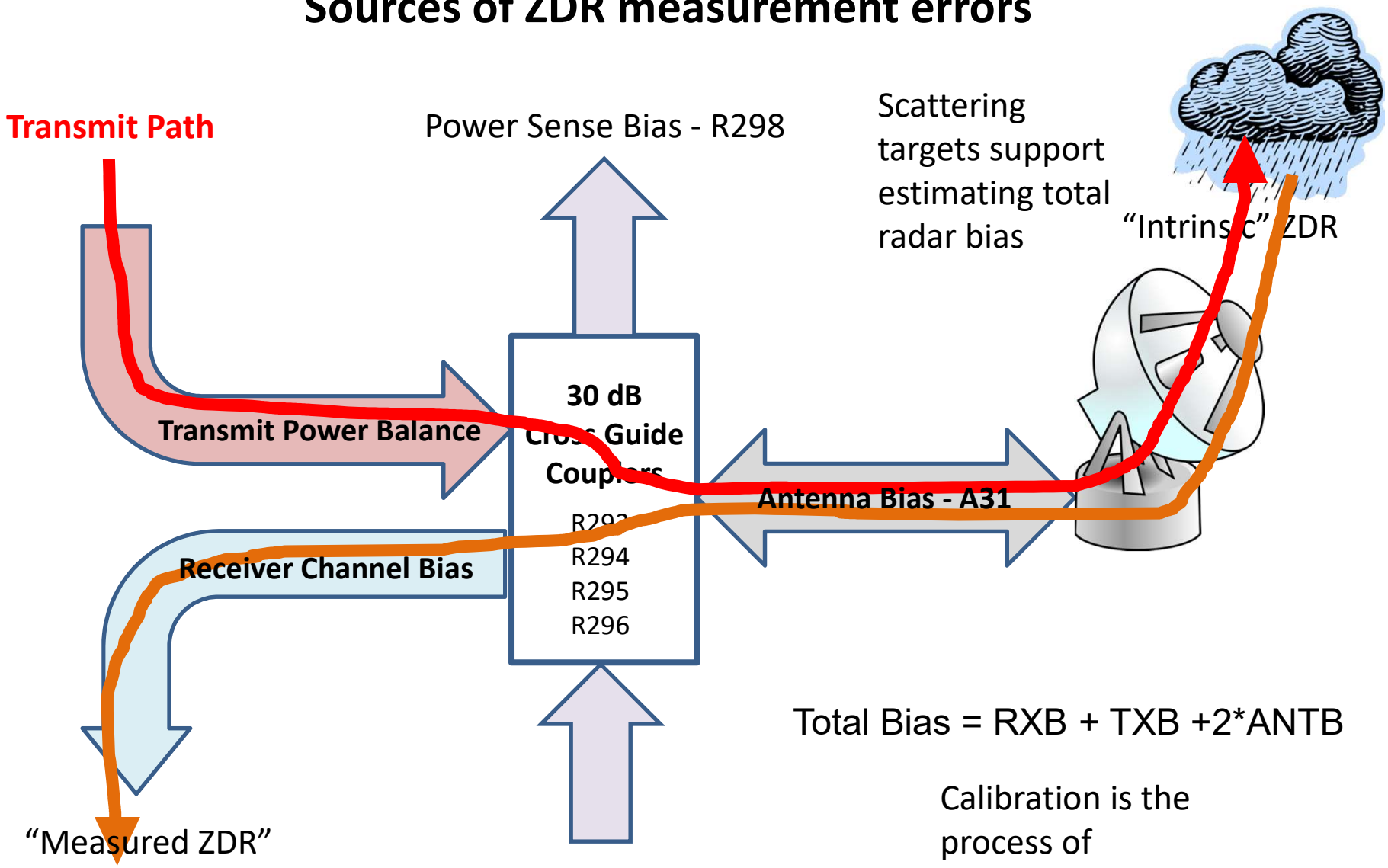
Differential Reflectivity (ZDR) Calibration in the WSR-88D

- Estimates the ZDR bias of the radar
- Requires an uncertainty of < 0.1 dB
- Accomplished via “engineering” technique
  - Power meter measurements
  - Solar scans
  - Subject to errors and environmental effects
- The WSR-88D cannot point vertically
  - Difficult to verify calibration
- Radar bias estimated with *external targets*
  - rain, ice/dry snow, Bragg scatter, sunspikes

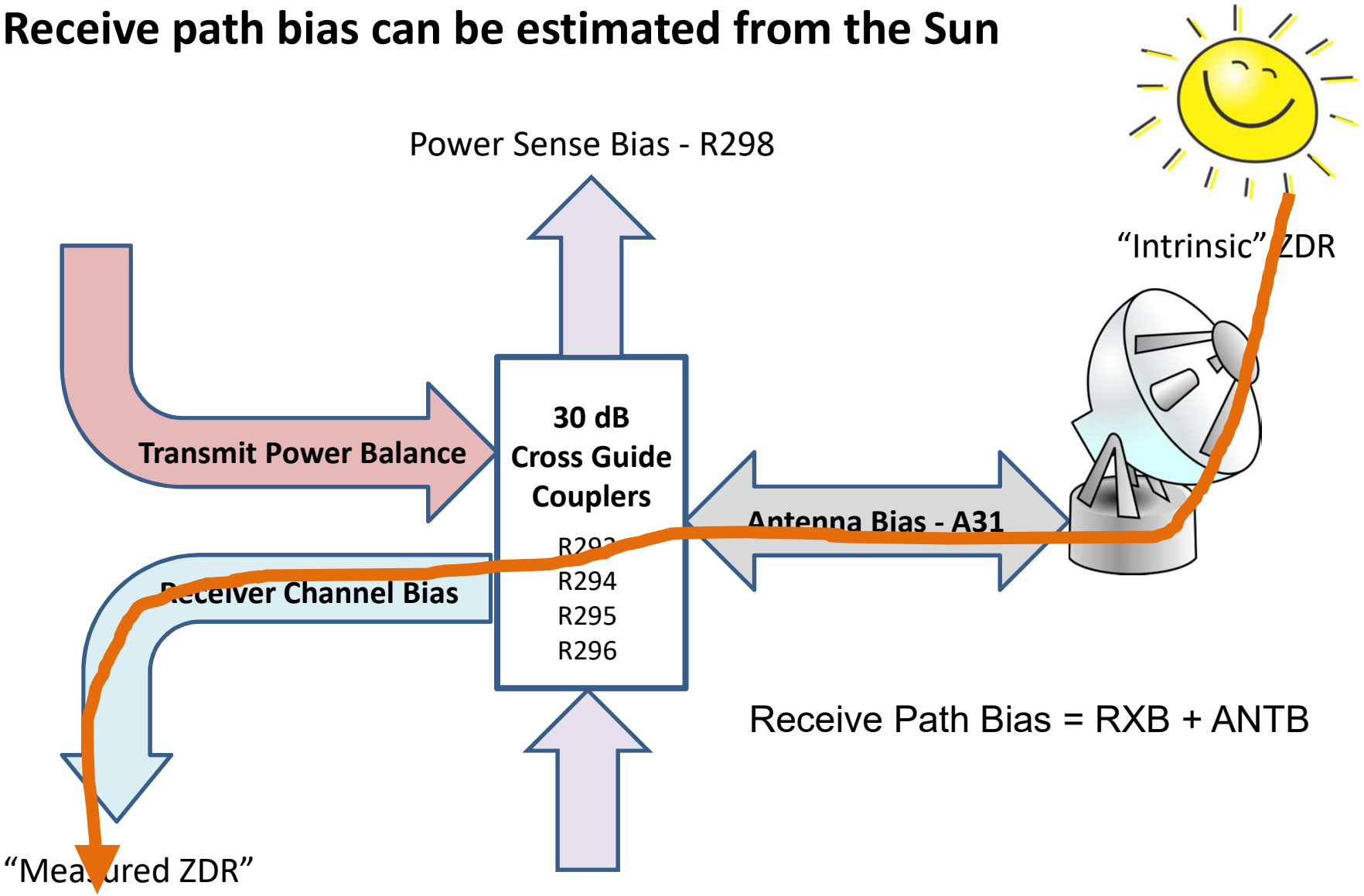
Sources of ZDR measurement errors



Total Bias = RXB + TXB +2*ANTB

Calibration is the process of measuring these parameters

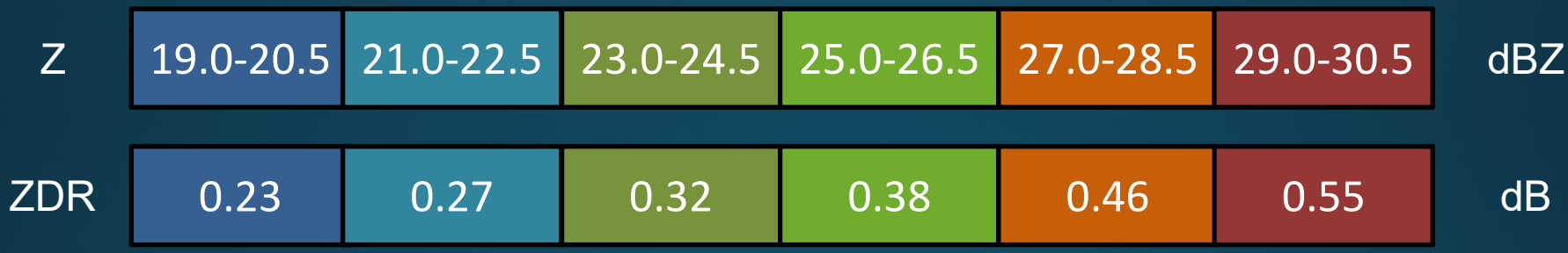
Receive path bias can be estimated from the Sun



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.

The External Targets

1. Light Rain: ZDR depends on Z



2. Ice/Dry Snow: Intrinsic ZDR is 0.2 dB
3. Bragg Scatter: Expect 0 dB ZDR
4. Sunspikes: Sun is un-polarized – “ZDR” is 0 dB

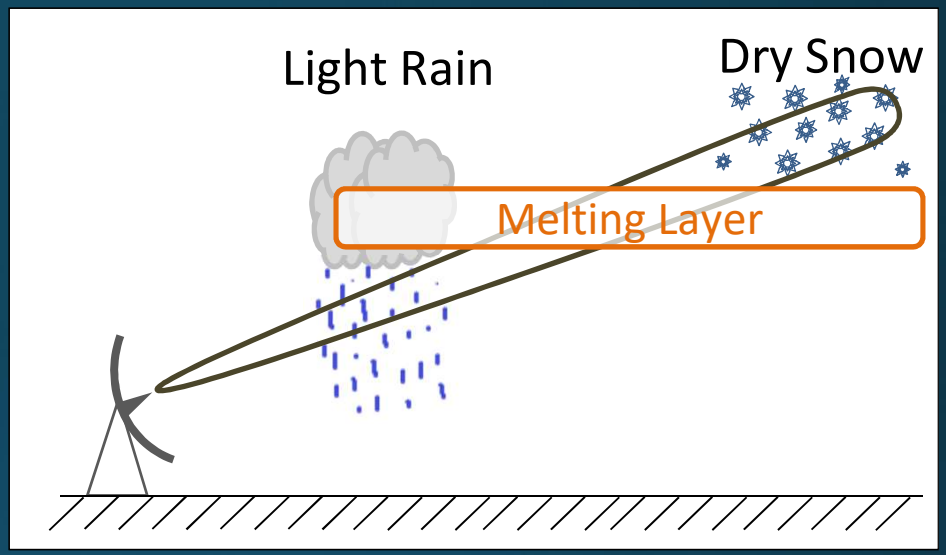
How do the methods differ?

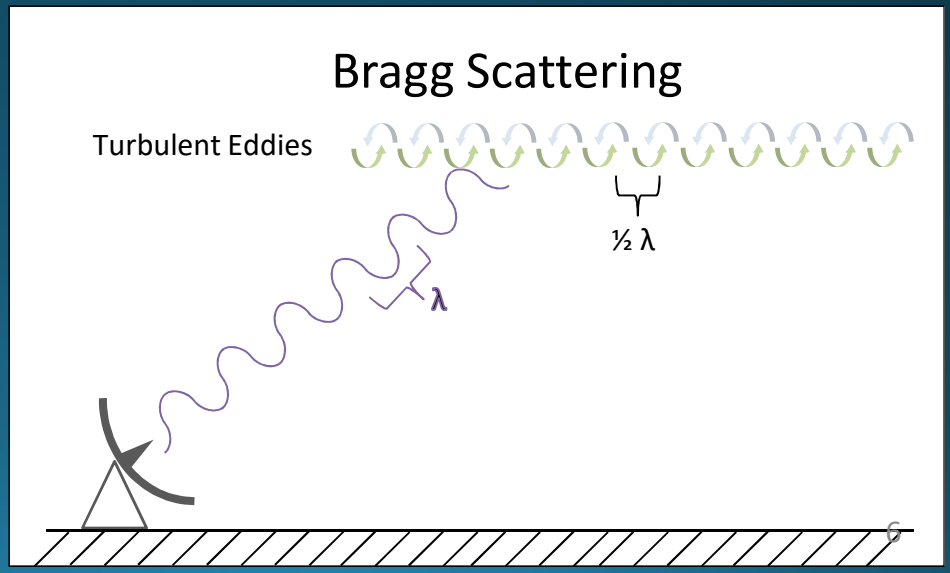
Each method is independent and includes distinct caveats

- 2 Methods Related to Precipitation:
  - Light Rain (liquid precipitation)
  - Dry Snow (frozen precipitation)

Filters on the data are in place to select desired returns and avoid contaminants

- 1 Method Related to Clear Air
  - Bragg scattering associated with refractivity gradients





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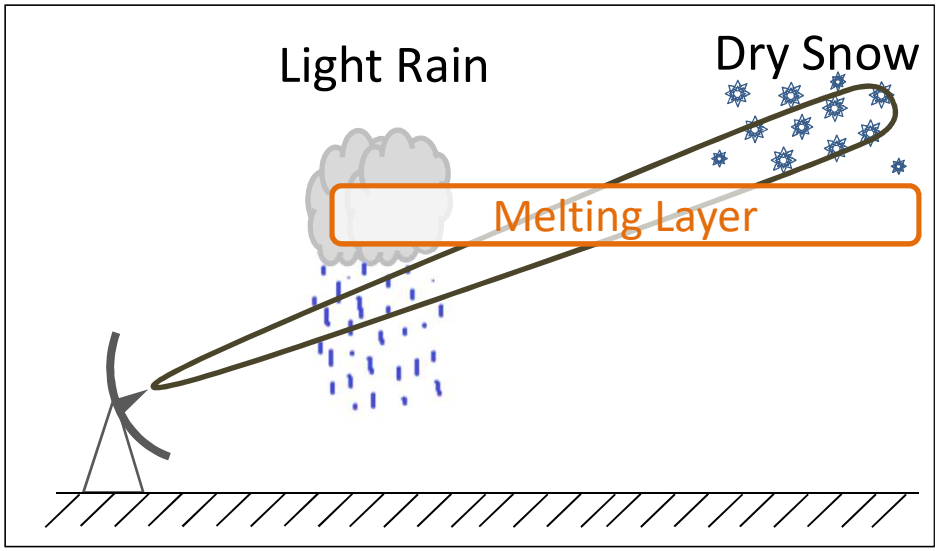

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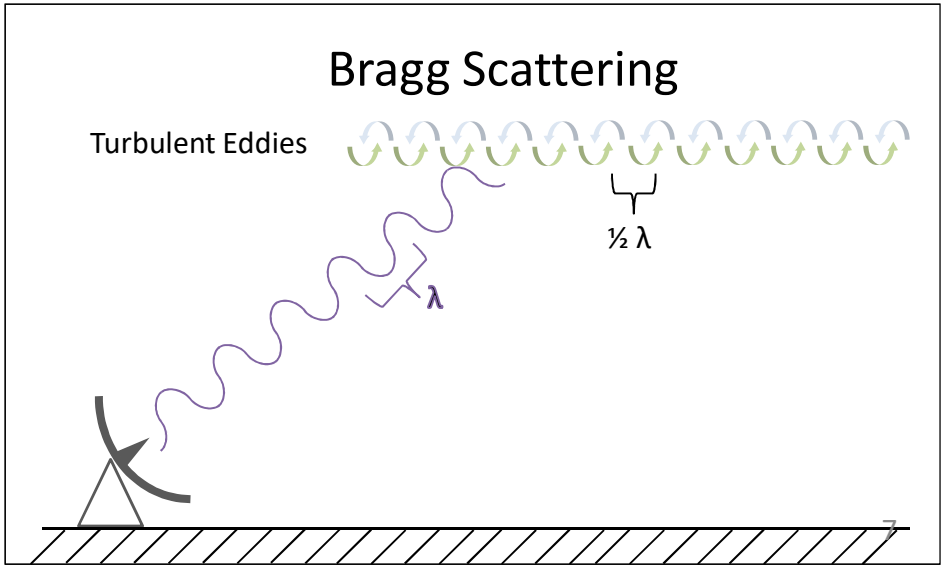


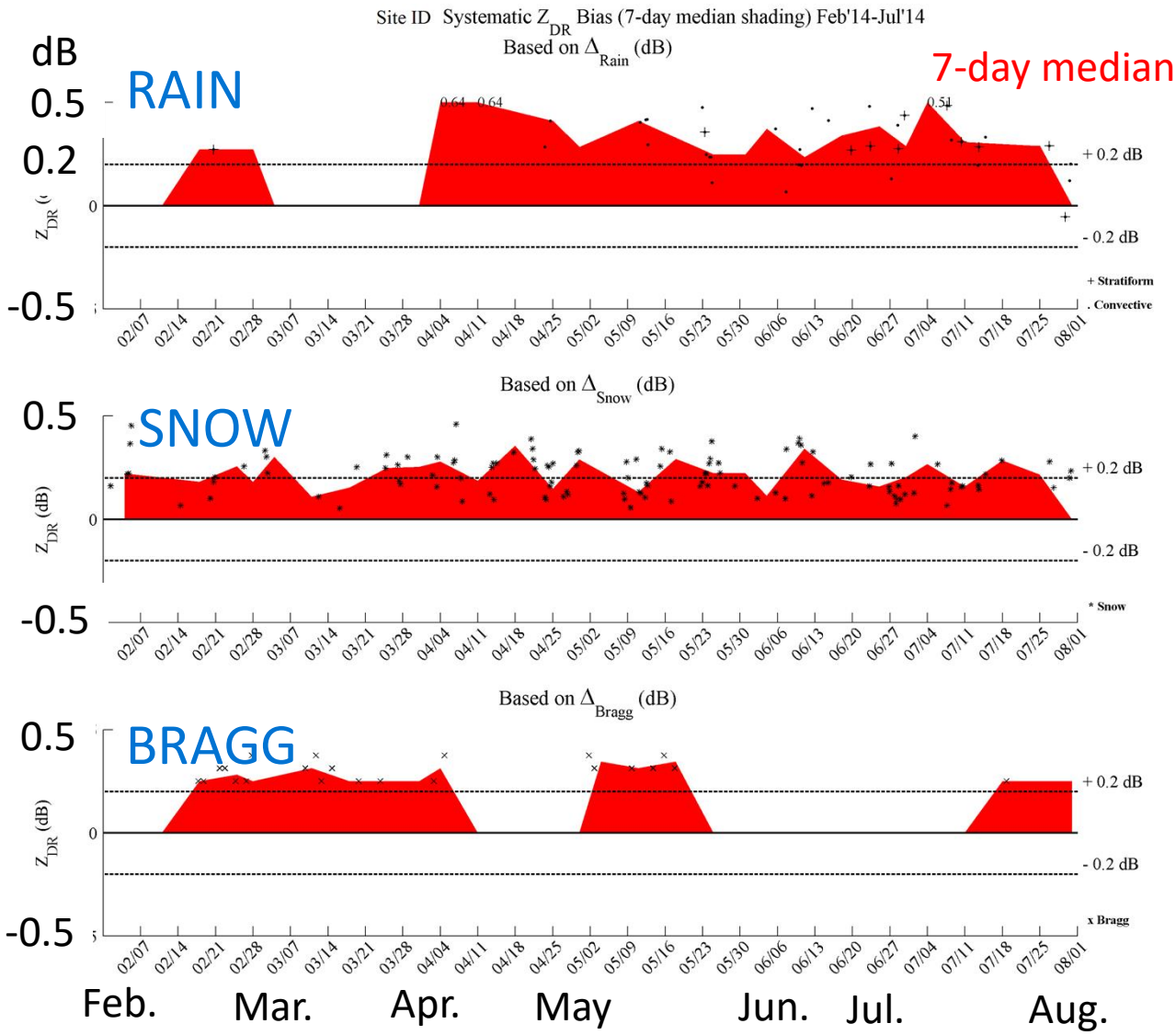
Radar Operations Center Program

- Estimated radar bias produced each volume for all radars
- Results displayed in “Shade Charts”
  - Rain, ice/dry snow, Bragg
- Charts available to field operators
- Sites exhibiting bias outside +/- 0.2 dB are assisted with corrective action
- “Composite” charts include transmit and receive path information and hardware calibration info
- Shade Charts and technical information on web site

https://www.roc.noaa.gov/WSR88D/Operations/Hotline.aspx

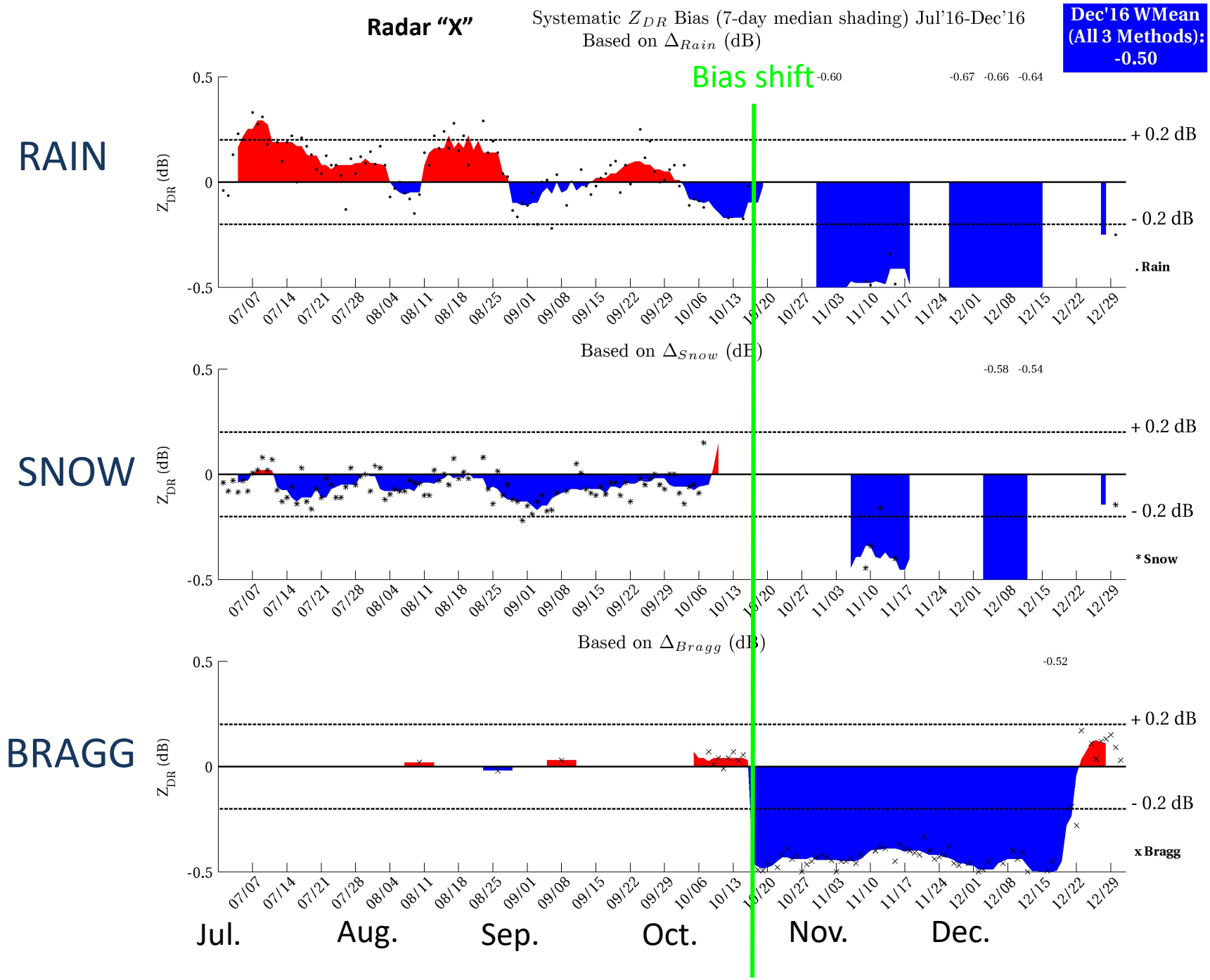
What's a ZDR Bias Shade Chart?

- A way to monitor Z_{DR} bias from a **single** radar
  - Information from most recent month and 6 months prior

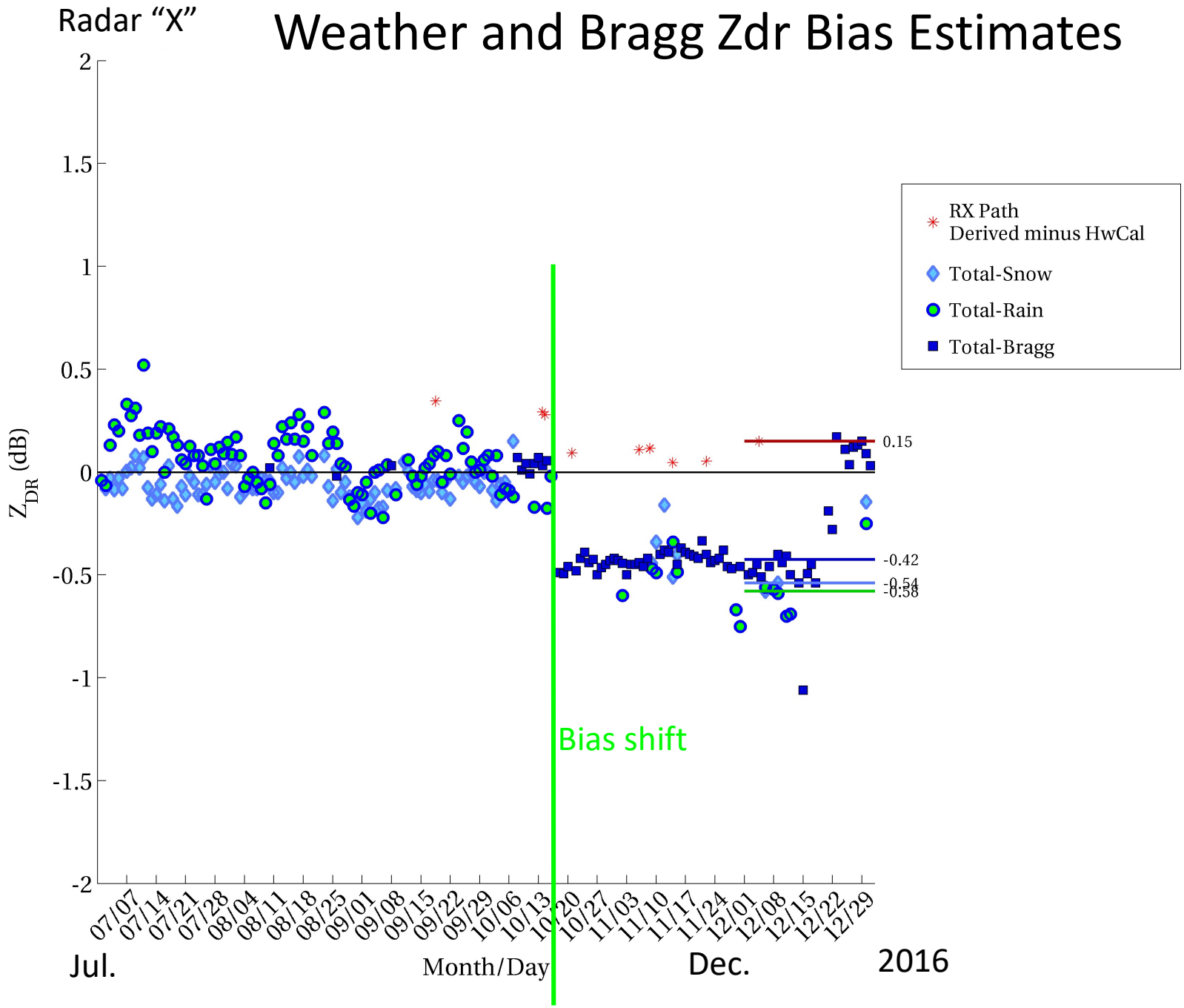


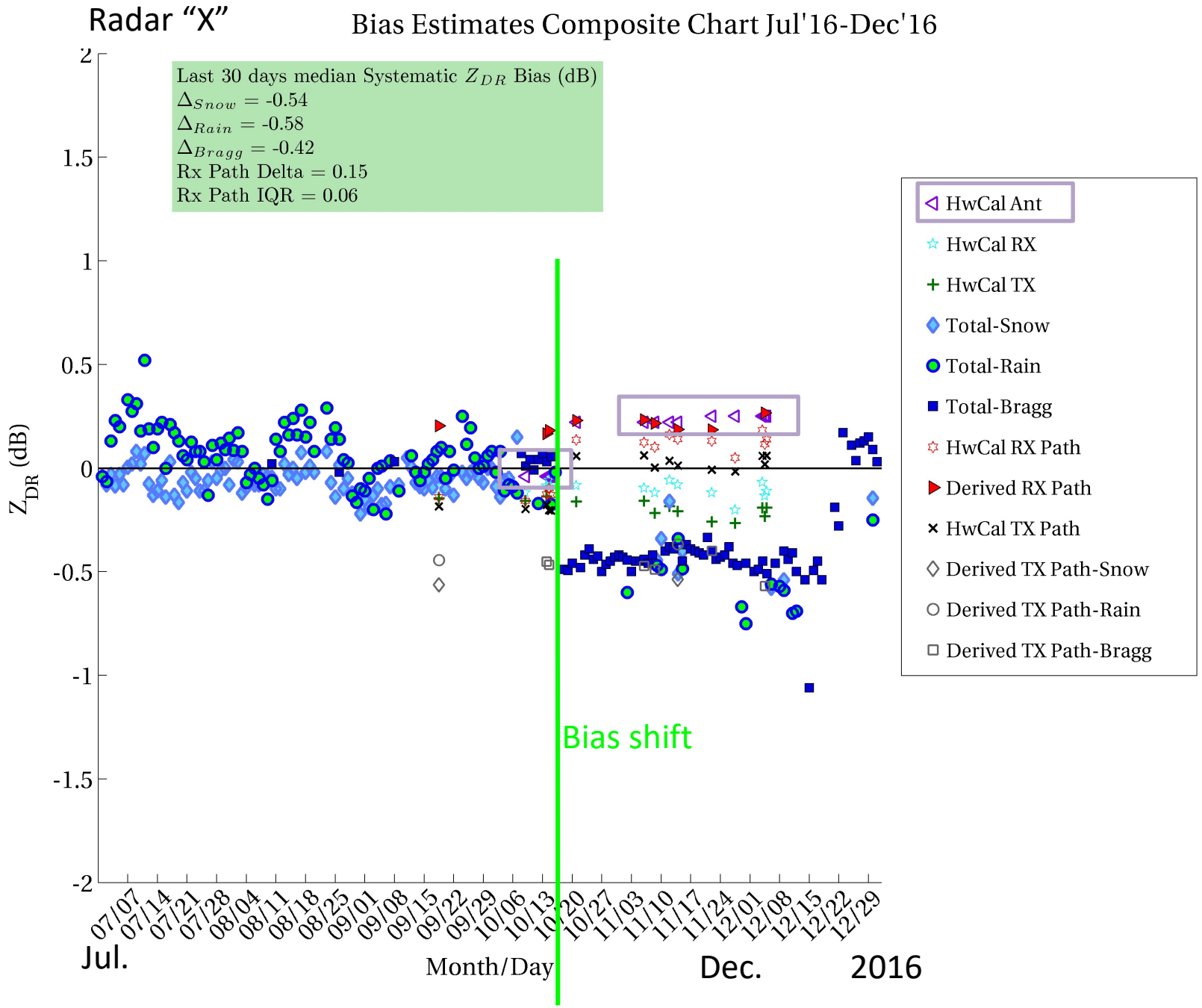
An Example Follows (Radar “X”)

- Shift in bias estimate observed last October
- An error had occurred in the antenna bias
  - Due to misinterpretation of a maintenance note
  - Incorrect sun bias test results entered
- Radar Operations Center technicians worked with site personnel and corrected the problem
- See following charts (shade and composite)
  - Estimated error from external targets
  - Transmit, receive, and antenna bias data


Radar "X"
Systematic Z_{DR} Bias (7-day median shading) Jul'16-Dec'16
Based on Δ_{Rain} (dB)
Dec'16 WMean (All 3 Methods): -0.50
Bias shift
-0.60
-0.67 -0.66 -0.64
RAIN
Z_{DR} (dB)
0.5
0
-0.5
+ 0.2 dB
- 0.2 dB
. Rain
Based on Δ_{Snow} (dB)
-0.58 -0.54
SNOW
* Snow
Based on Δ_{Bragg} (dB)
-0.52
BRAGG
x Bragg
07/07 07/14 07/21 07/28 08/04 08/11 08/18 08/25 09/01 09/08 09/15 09/22 09/29 10/06 10/13 10/20 10/27 11/03 11/10 11/17 11/24 12/01 12/08 12/15 12/22 12/29
Jul. Aug. Sep. Oct. Nov. Dec.

Weather and Bragg Zdr Bias Estimates

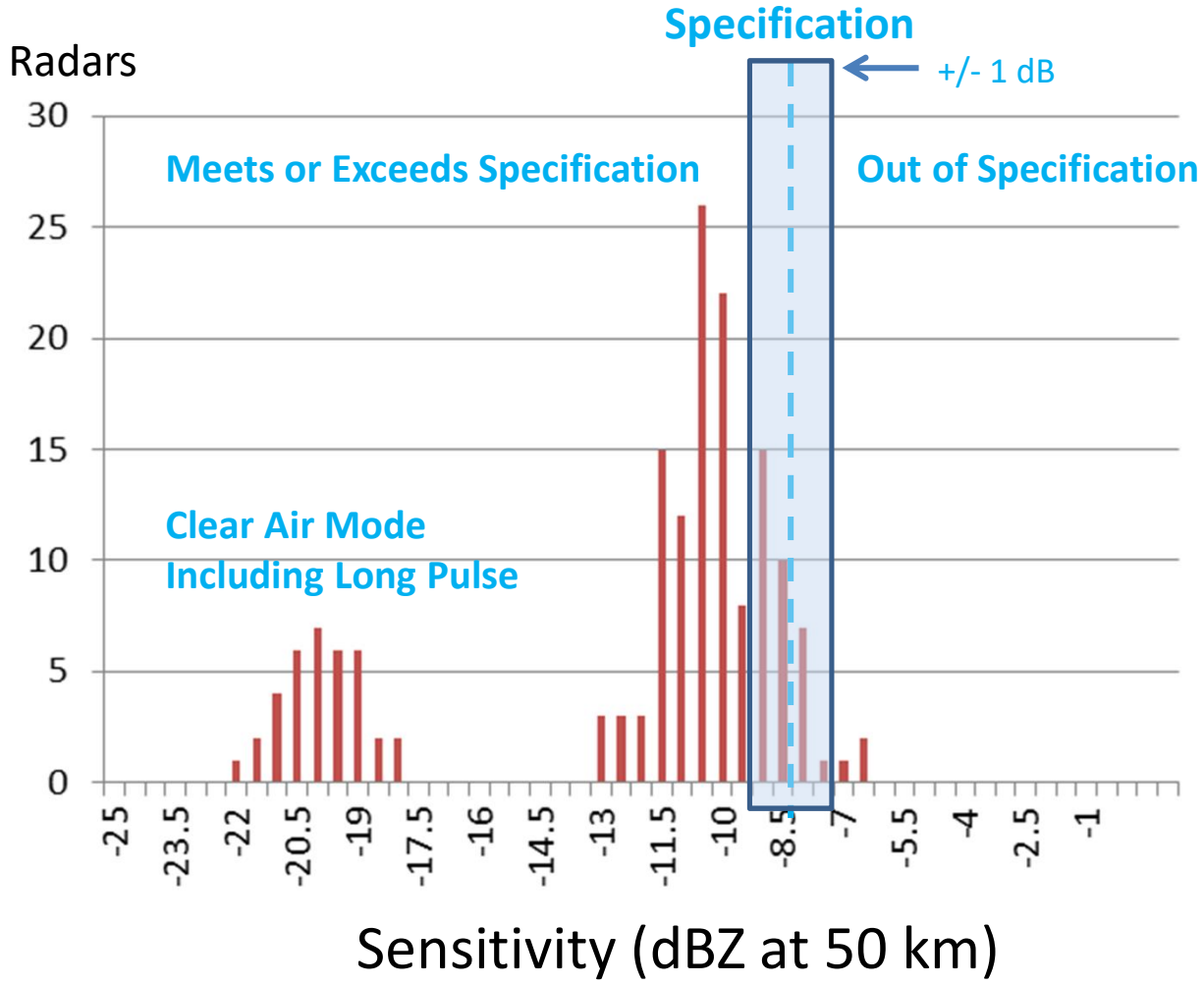



Radar "X"
Bias Estimates Composite Chart Jul'16-Dec'16
Last 30 days median Systematic Z_{DR} Bias (dB)
Δ_{Snow} = -0.54
Δ_{Rain} = -0.58
Δ_{Bragg} = -0.42
Rx Path Delta = 0.15
Rx Path IQR = 0.06
HwCal Ant
HwCal RX
HwCal TX
Total-Snow
Total-Rain
Total-Bragg
HwCal RX Path
Derived RX Path
HwCal TX Path
Derived TX Path-Snow
Derived TX Path-Rain
Derived TX Path-Bragg
Bias shift
Z_{DR} (dB)
Month/Day
Jul.
Dec.
2016

A Note on WSR-88D Sensitivity

- Minimum Z needed to produce 0 dB SNR
  - Spec. is -8.5 dBZ defined at 50 km,
  - Reflectivity Calibration Factor (dBZo) is sensitivity at 1 km
  - dBZo + 34 dB yields sensitivity at 50 km
  - Reported in Level 2 data
- Using reported Z calibration is subject to an uncertainty of +/- 1 dB
- Recent survey of dBZo from all sites shows…

Snapshot (one volume) Survey of Reported Calibration Constants - Derived Sensitivity



Final Thoughts

- ZDR calibration is difficult
  - Required tolerance is hard to achieve
  - Absent vertical pointing - must rely on other methods for verification
- The Radar Operations Center maintains an external monitoring system
- Approximately 70 % of the sites have estimated ZDR bias of less than 0.2 dB
- Most sites meeting sensitivity specification
- Continual improvement efforts in place
- Questions? Richard.L.Ice@noaa.gov

Bragg Scatter Detection by the WSR-88D Parts 1&2, Lindsey Richardson et al. (ROC), JTECH, Early Release, online