11.2 Geographical and Seasonal Availability of Light Rain, Dry Snow, & Bragg Scatter to Estimate WSR-88D Z_{DR} System Bias

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American Meteorological Society
31st Environmental Information Processing Technologies

Goals

- Measure system Z_{DR} bias with accuracy ± 0.1 dB when the true Z_{DR} is ± 1.0 dB
  - Important for Quantitative Precipitation Estimates
  - Best we think we can do currently is measure biases of ± 0.2 dB
- Understand the availability of external meteorological targets geographically and seasonally with which to measure system Z_{DR} bias

Methods for Estimating WSR-88D System Z_{DR} Bias

- Hardware based (ZDRB)
  - $Z_{DR}(offset) = 2 * ANTB + RCB + TXB = ZDRB$

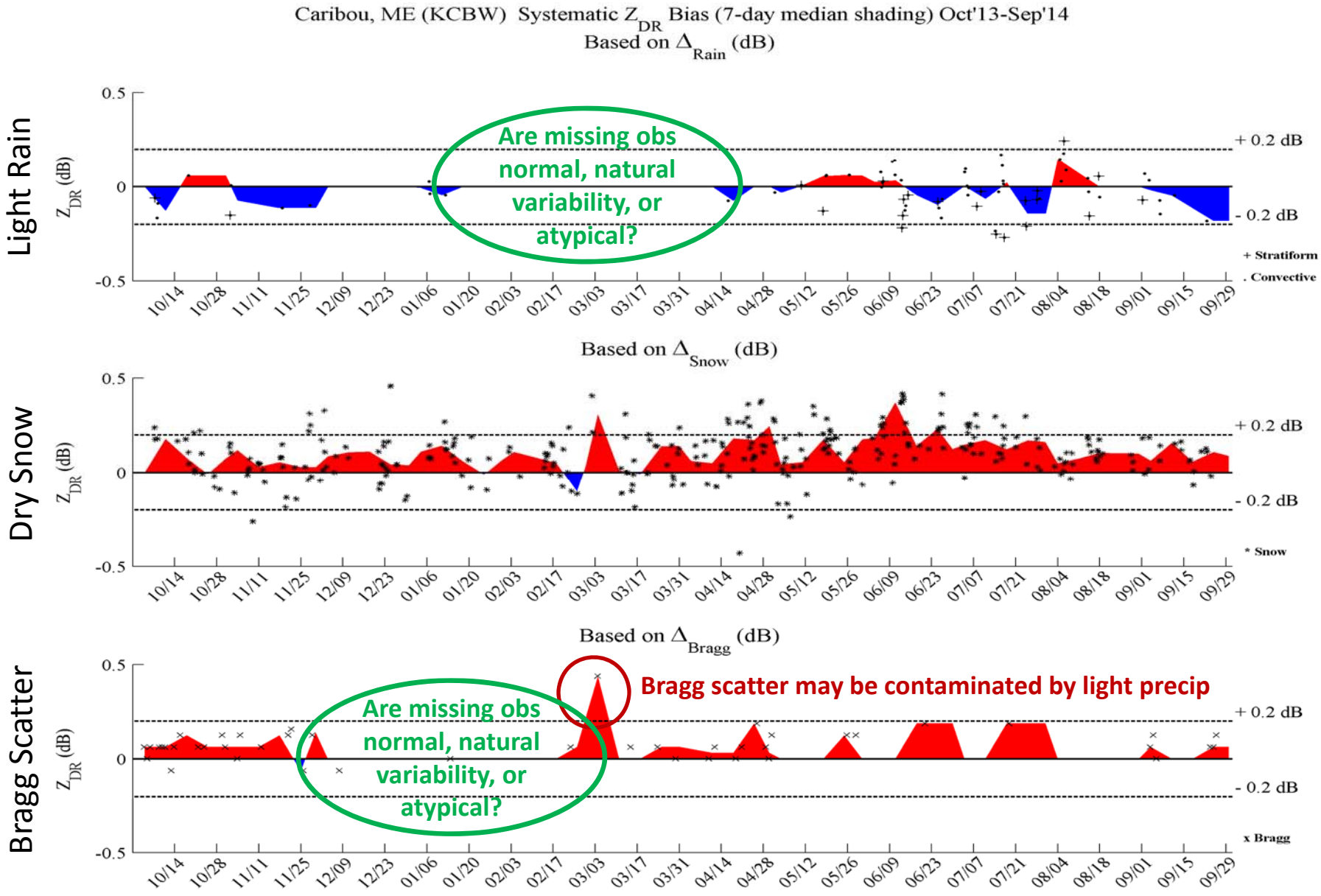
    Antenna Bias (ANTB) checked periodically, Receiver Bias (RCB) checked each volume scan, Transmitter Bias (TXB) checked every 8 hr
- Meteorological echo-based Z_{DR} bias
  - Light rain
    - Z_{DR} averaged for reflectivity between 19.0 and 30.5 dBZ
    - Below melting layer by at least 1 km but above 1° elevation
    - Median of 3-6 hours continuous sampling taken as event bias
  - Dry snow
    - Z_{DR} averaged for reflectivity between 15 and 25 dBZ, SNR ≥ 20 dB
    - Other filters for RHO_{HV}, and PHI_{DP}
    - 1 km above melting layer and above 1° elevation
    - Median of 3-6 hours continuous sampling taken as event bias

Methods for Estimating WSR-88D System Z_{DR} Bias (cont'd)

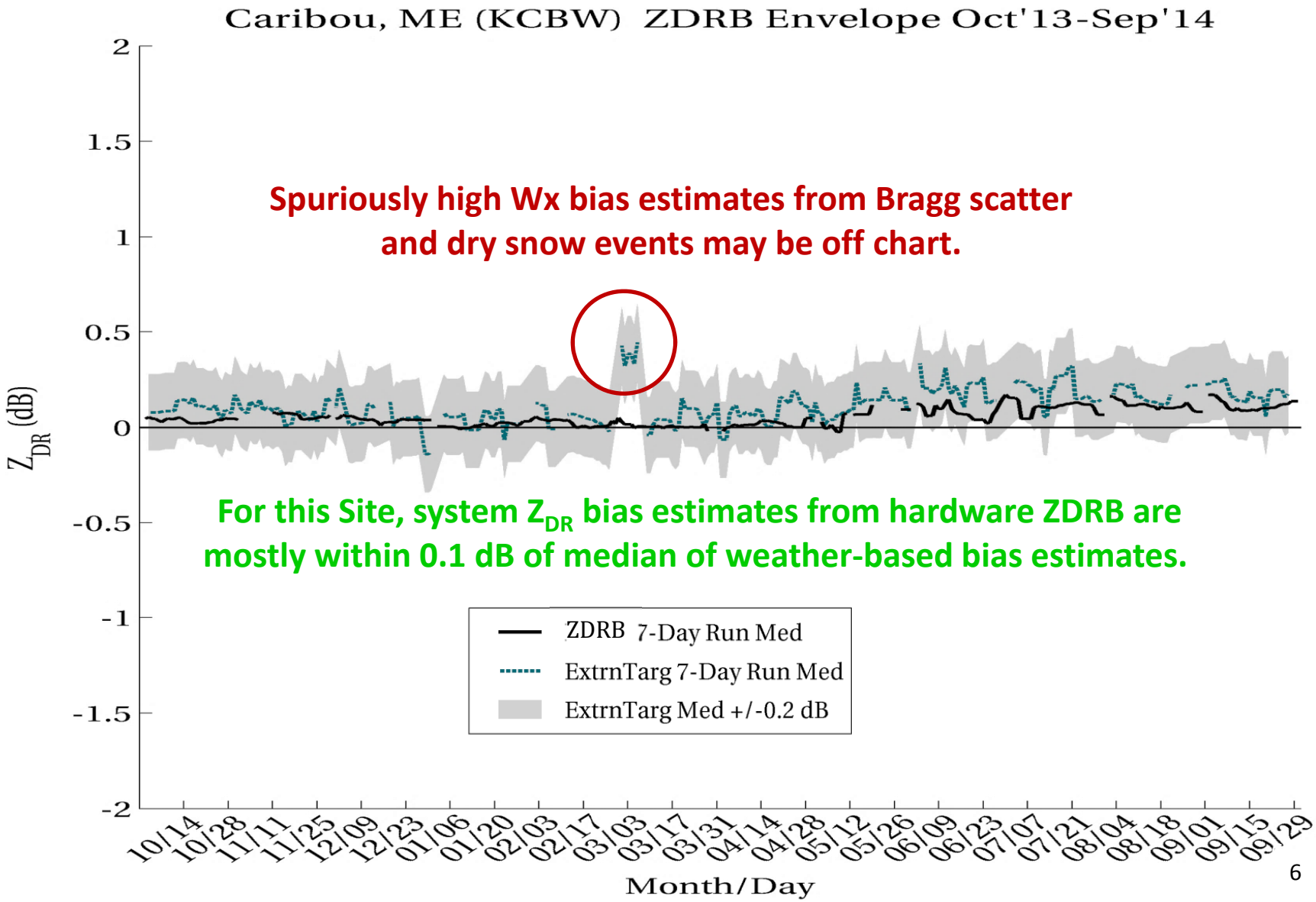
- Meteorological echoes (cont'd)
  - Bragg scatter
    - Now limited to 2 hour window 17-19 UTC fleetwide – 1 daily estimate possible
    - Continuous monitoring done on 17 sites for Jan, Apr, Jul, & Oct for this study

      Continuous bias estimate will become available fleetwide in May 2015
    - Limited to 2 volume coverage patterns (21 & 32) – 9 possible
      - Used most often for clear air
    - Elevations 2.5 to 4.5 deg for sensitivity
    - Filters on Z, V, W, SNR, & RHO_{HV}
    - Other filters for light precipitation & biota contamination
    - Mode of >10,000 bin histogram of Z_{DR} values taken as event bias
    - In this study we take one event per day even with continuous monitoring

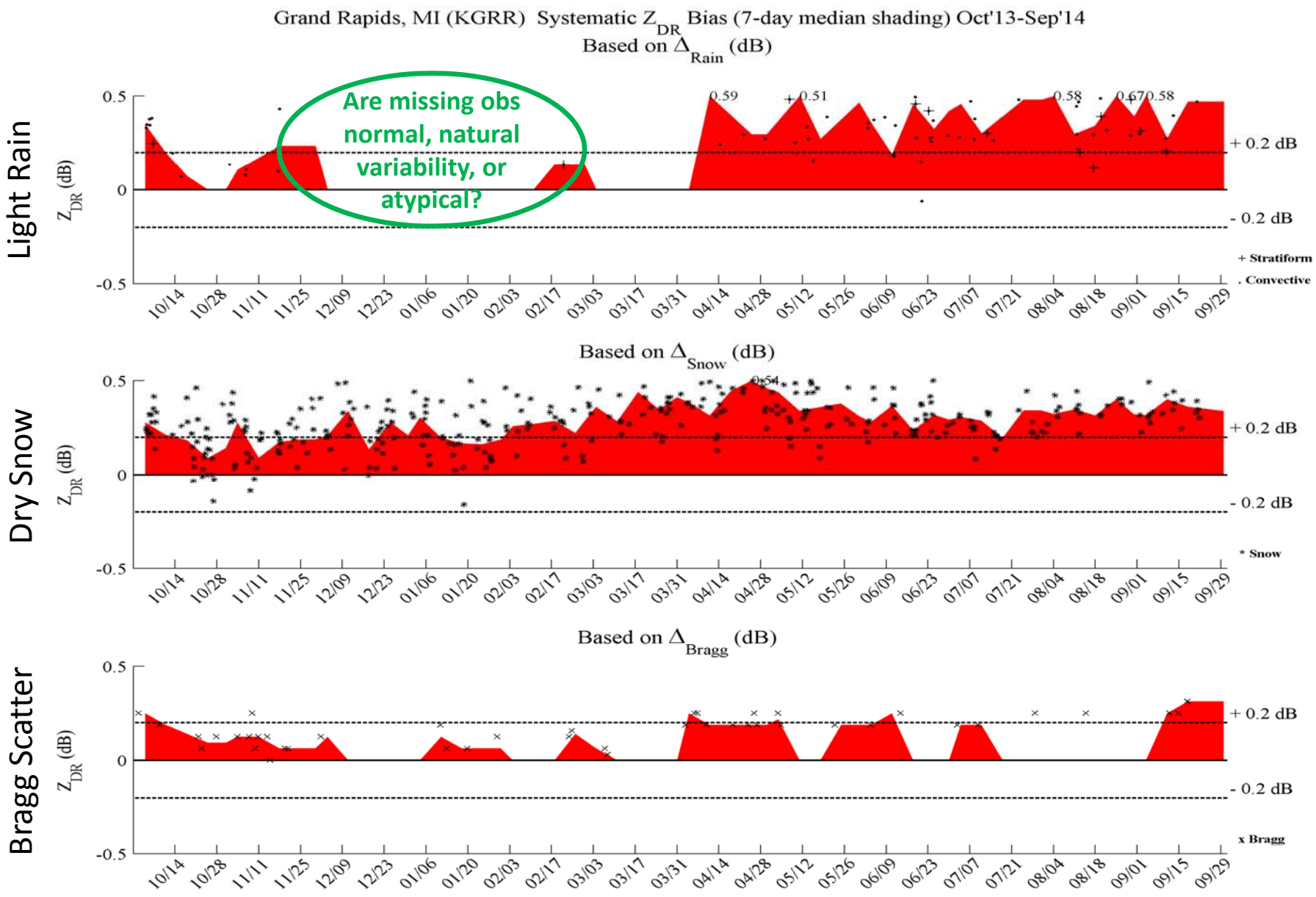
KCBW Shade Chart October 2013 – September 2014



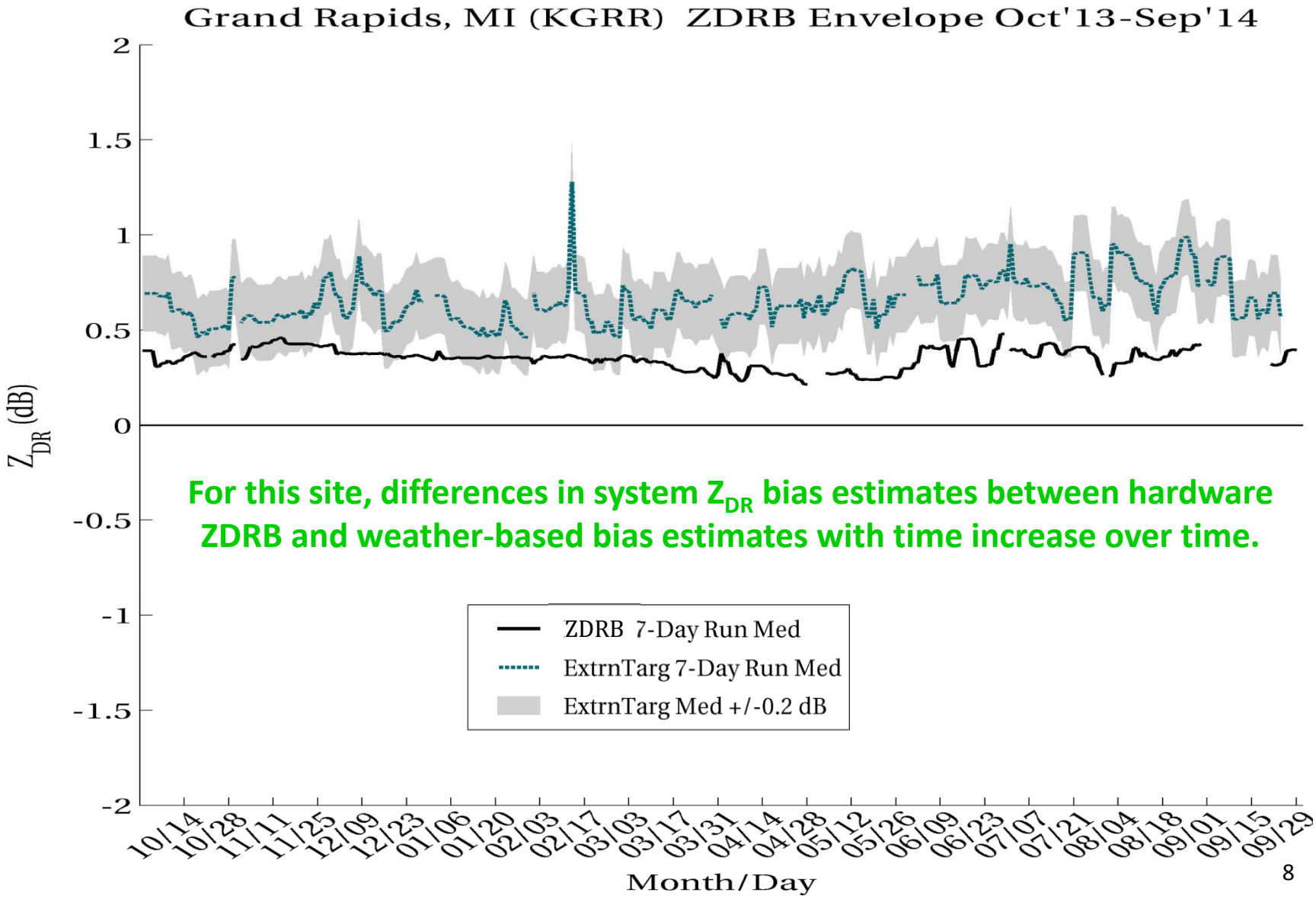
KCBW ZDRB – Weather Estimated Z_{DR} Bias Comparison
October 2013 – September 2014



KGRR Shade Chart October 2013 – September 2014

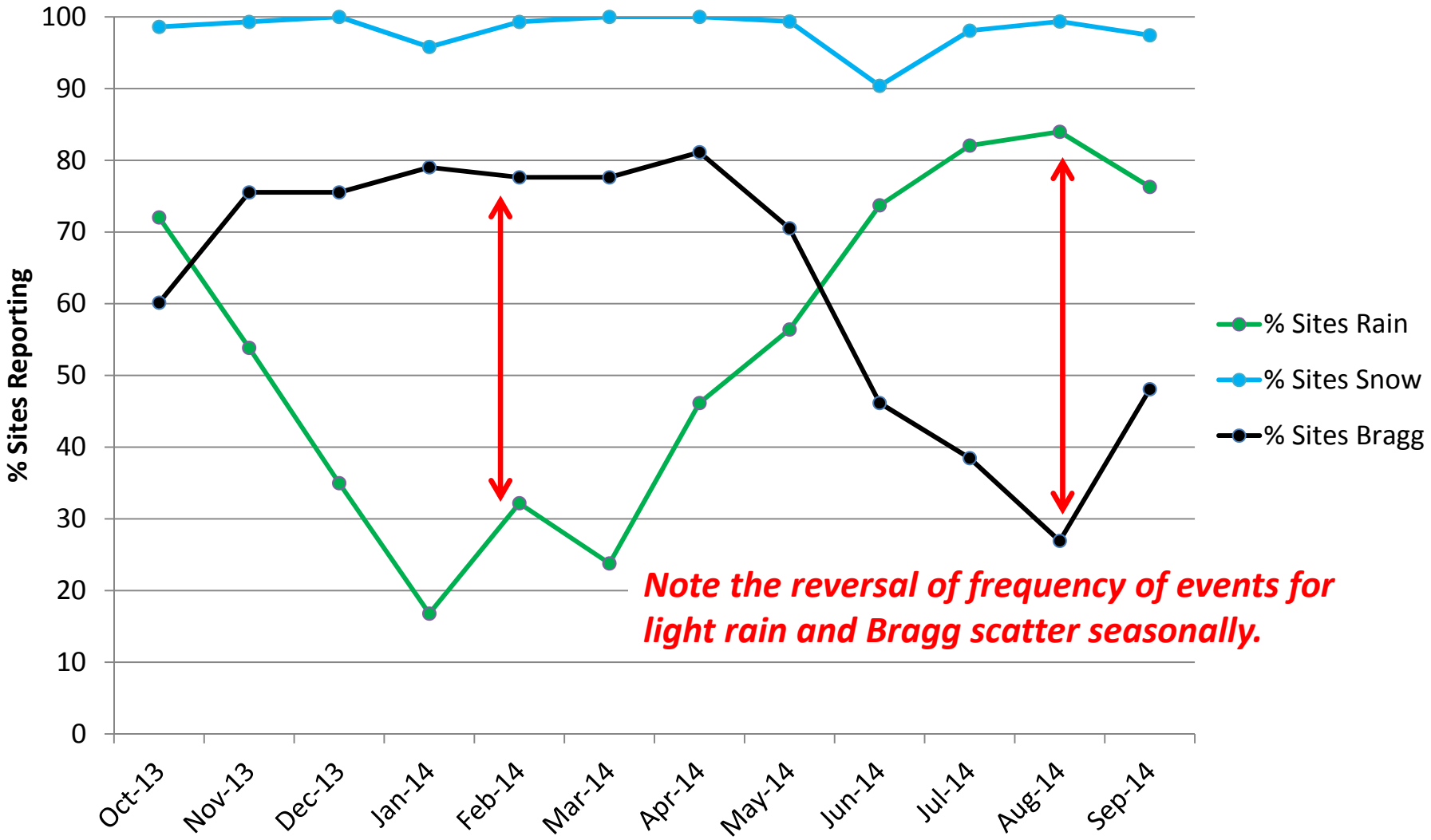


KGRR ZDRB – Weather Estimated Z_{DR} Comparison
October 2013 – September 2014

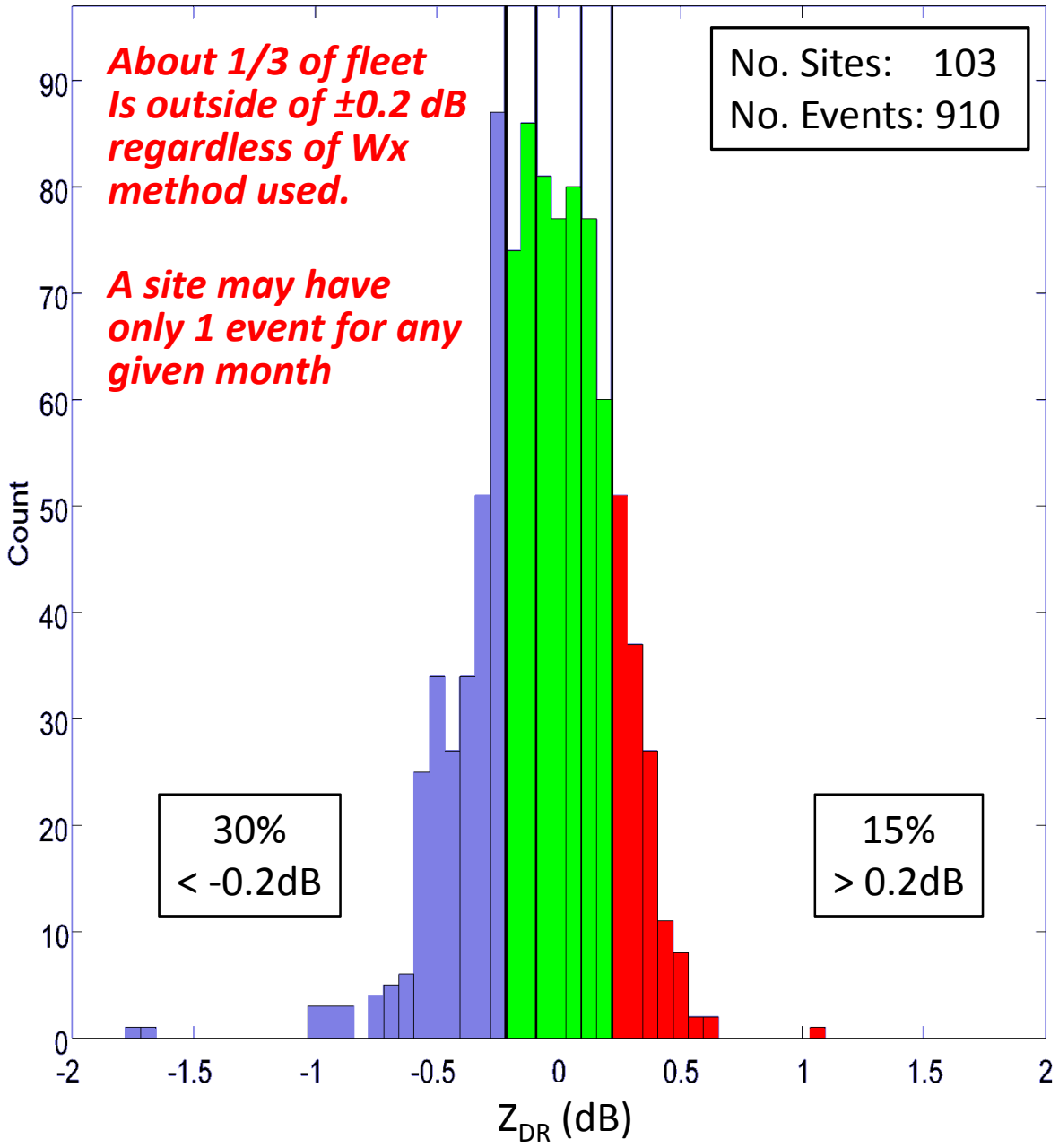


For this site, differences in system Z_{DR} bias estimates between hardware ZDRB and weather-based bias estimates with time increase over time.

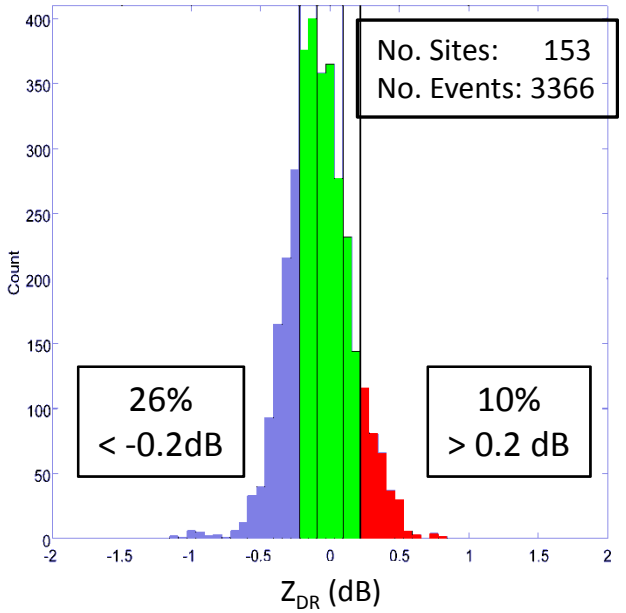
Percent of WSR-88Ds With 1 or More Events per Month for Each Weather Method



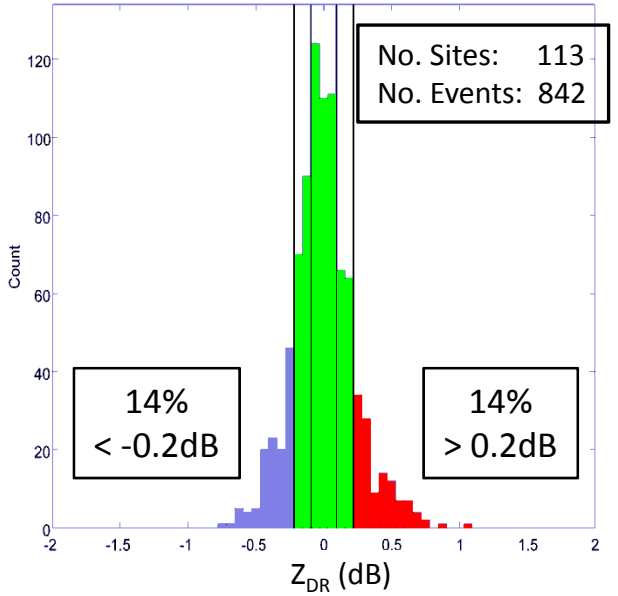
October 2013 Light Rain Z_{DR} Bias



July 2014 Dry Snow Z_{DR} Bias

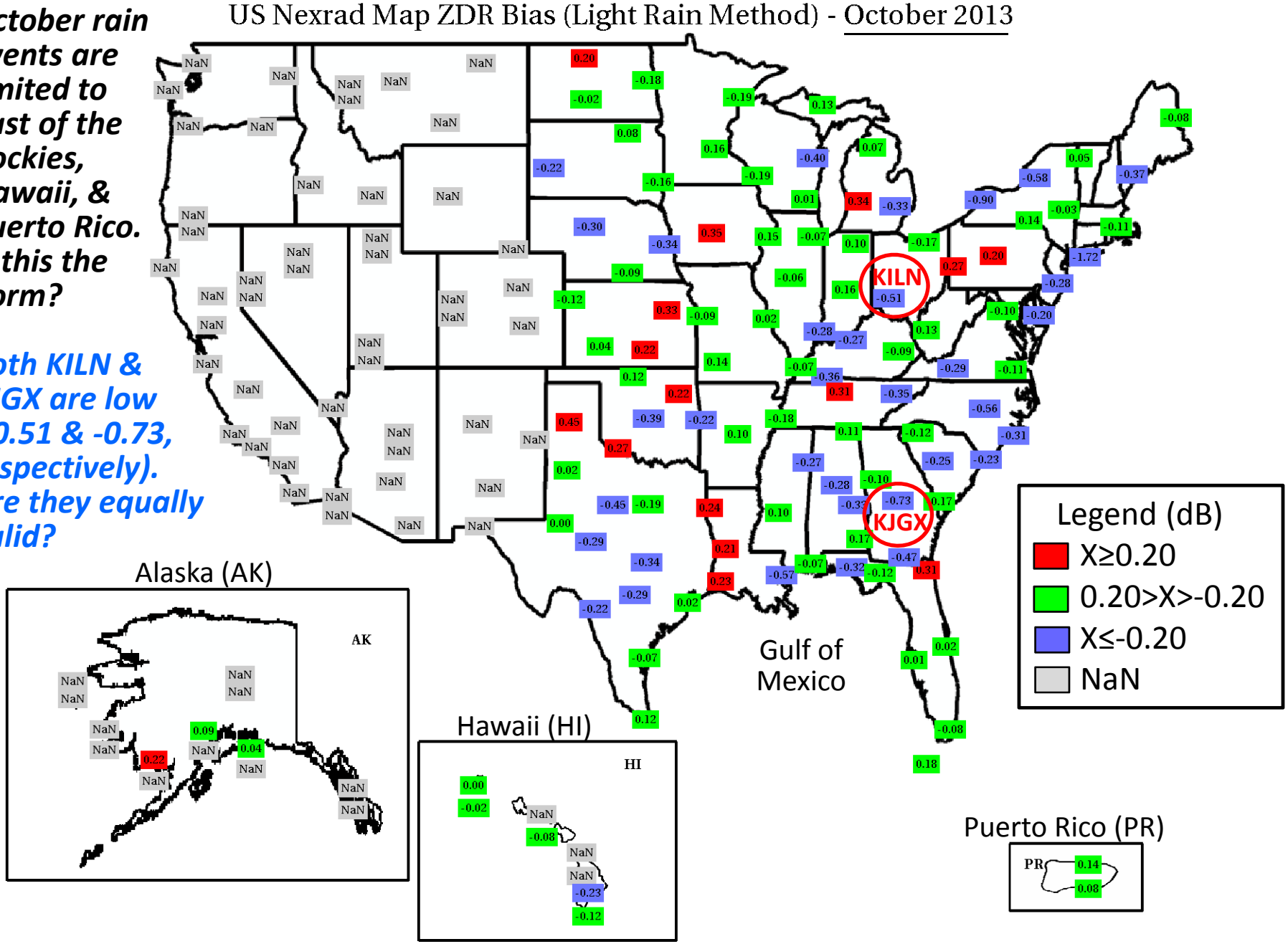


January 2014 Bragg Scatter Z_{DR} Bias



October rain events are limited to east of the Rockies, Hawaii, & Puerto Rico. Is this the norm?

Both KILN & KJGX are low (-0.51 & -0.73, respectively). Are they equally valid?

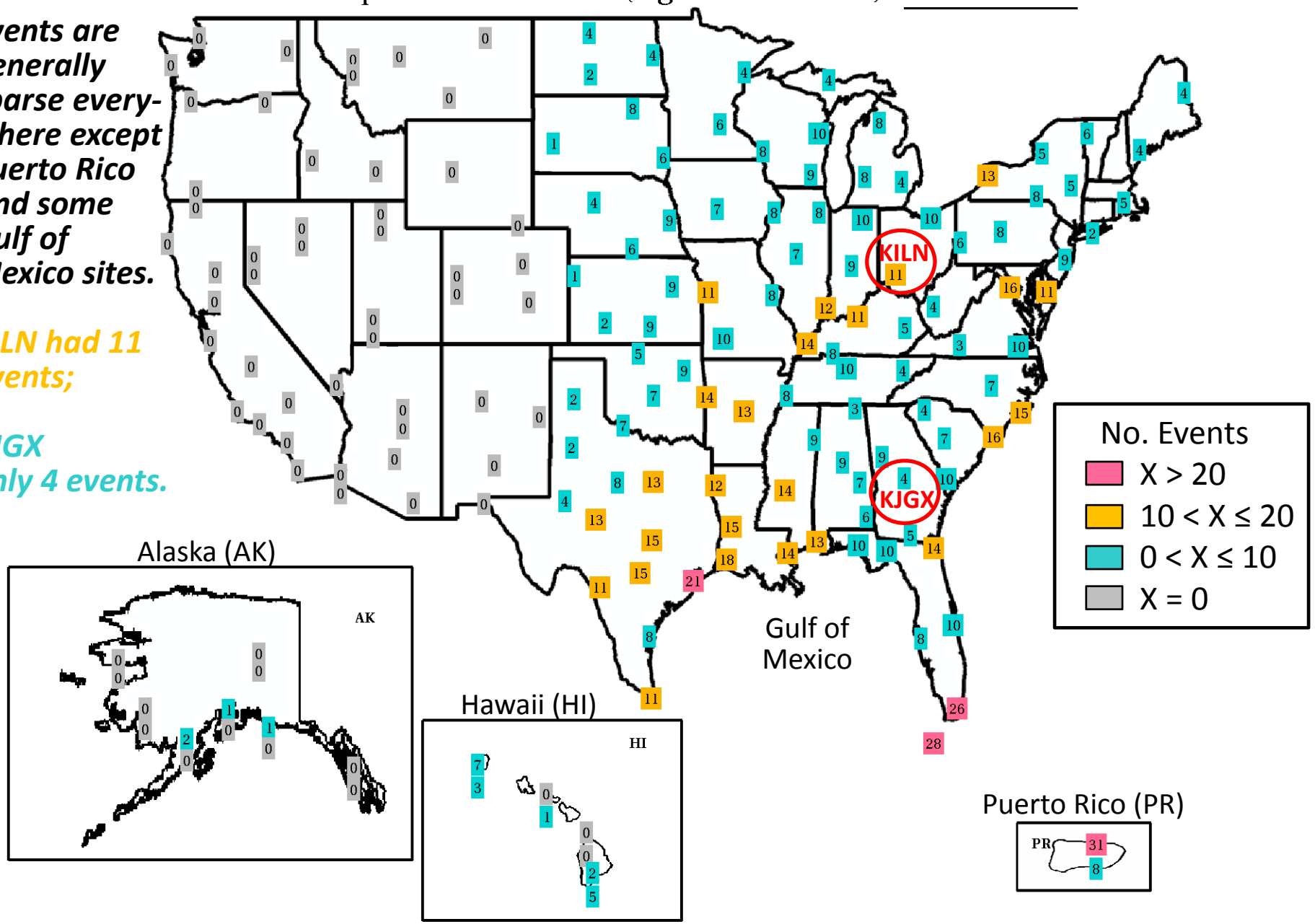


US Nexrad Map Number of Events (Light Rain Method) - October 2013

Events are generally sparse every-where except Puerto Rico And some Gulf of Mexico sites.

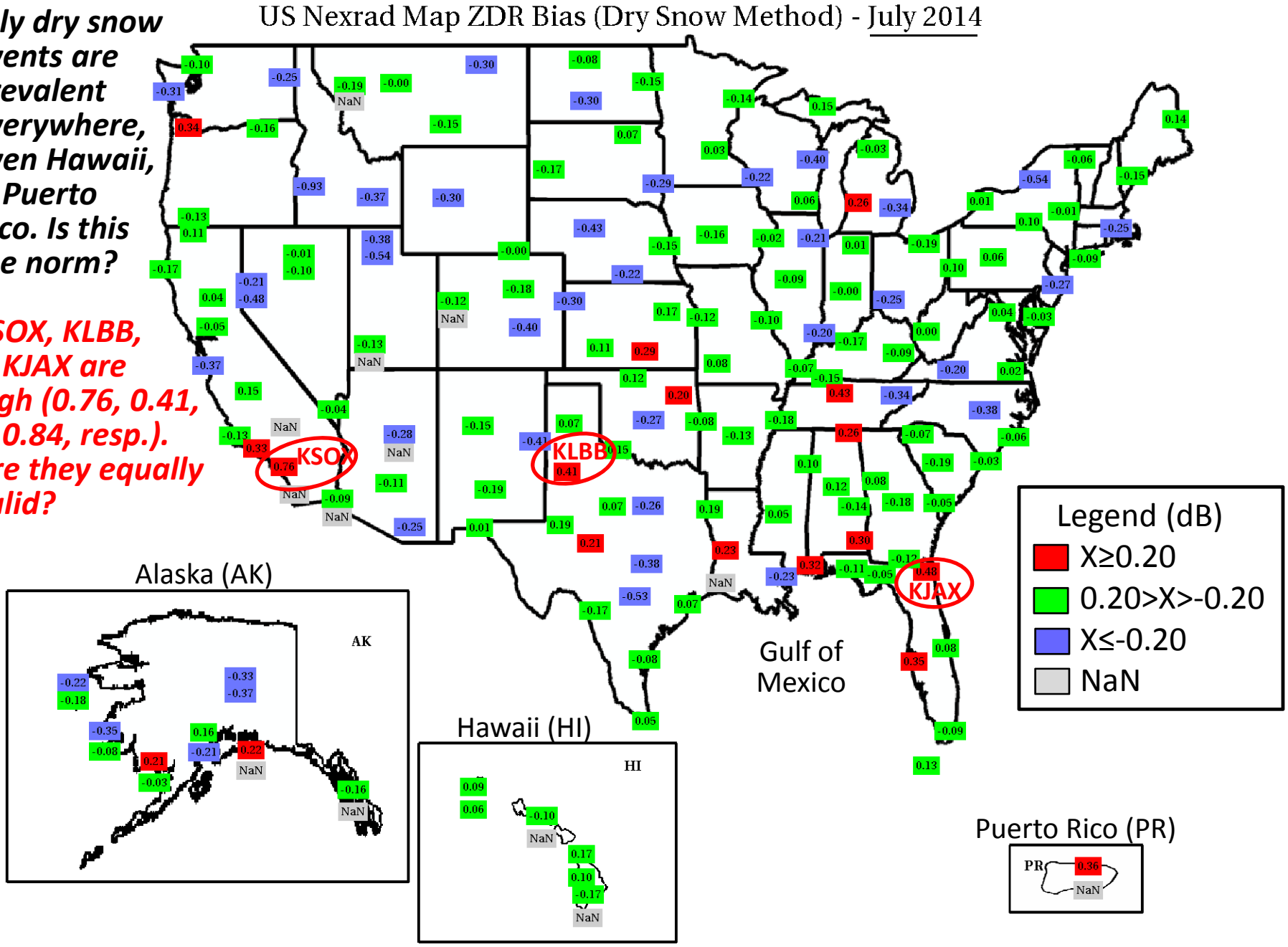
KILN had 11 events;

KJGX only 4 events.



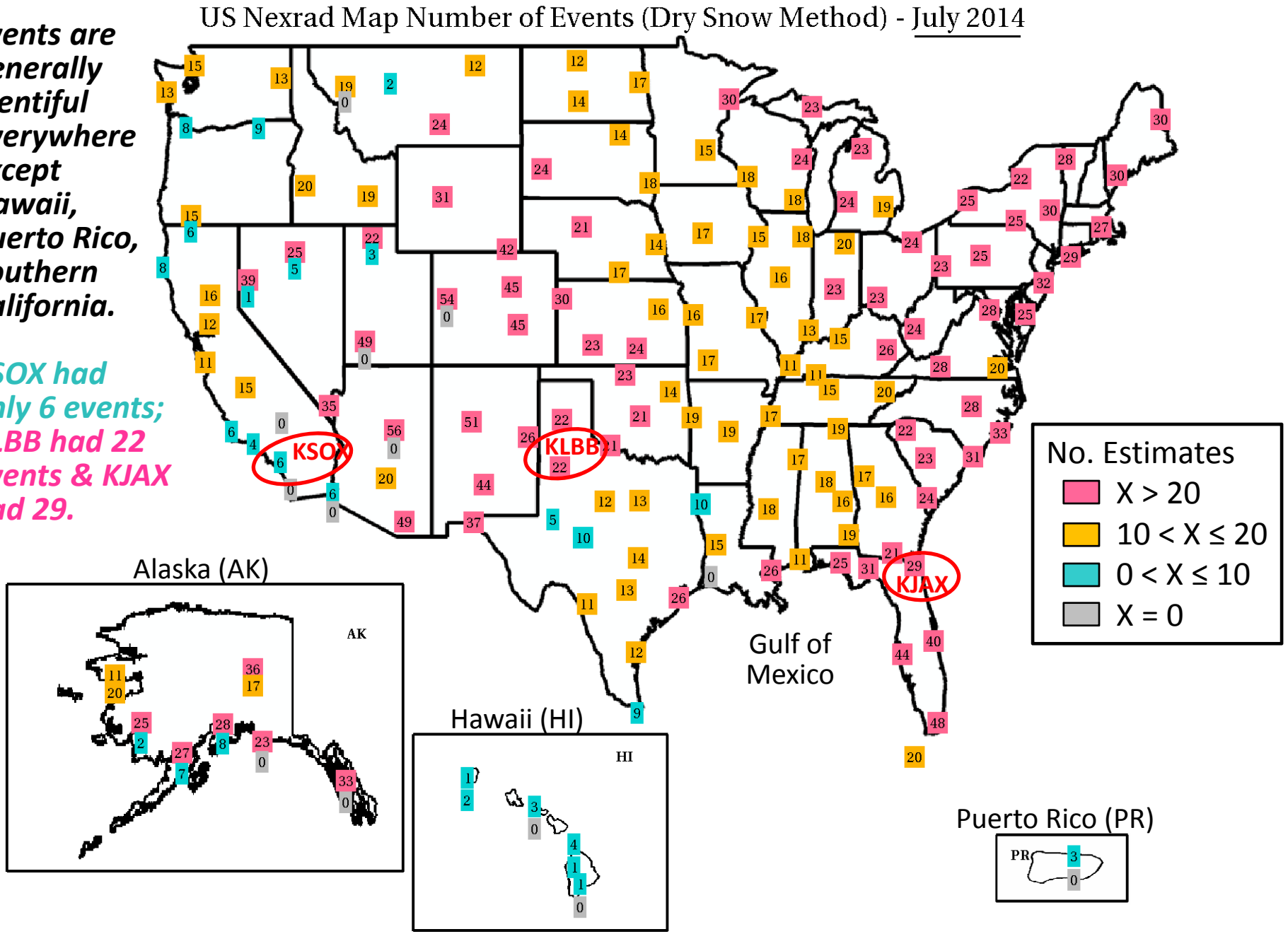
July dry snow events are prevalent everywhere, even Hawaii, & Puerto Rico. Is this the norm?

KSOX, KLBB, & KJAX are high (0.76, 0.41, & 0.84, resp.). Are they equally valid?



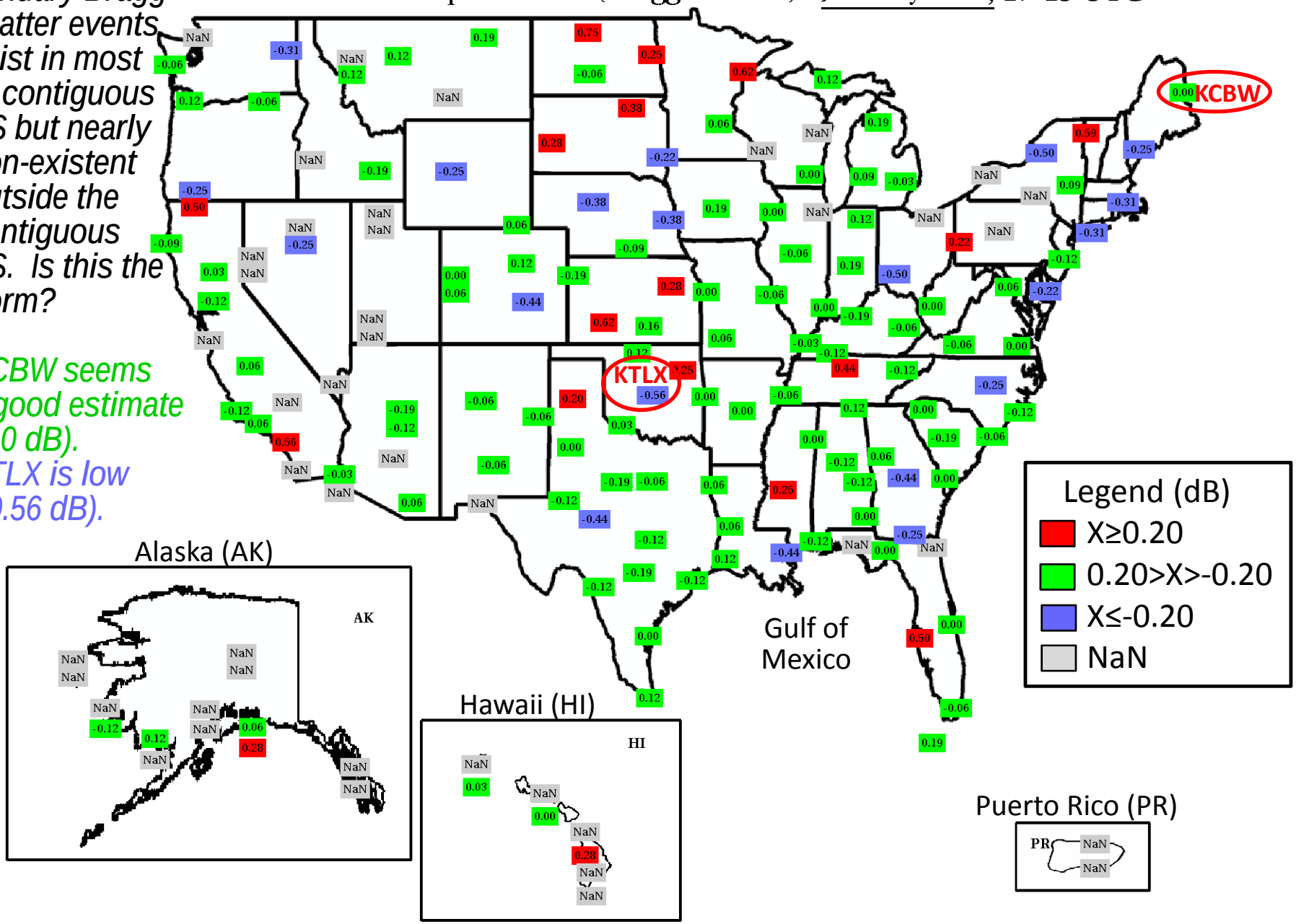
Events are generally plentiful everywhere except Hawaii, Puerto Rico, Southern California.

KSOX had only 6 events; KLBB had 22 events & KJAX had 29.



January Bragg scatter events exist in most of contiguous US but nearly non-existent outside the contiguous US. Is this the norm?

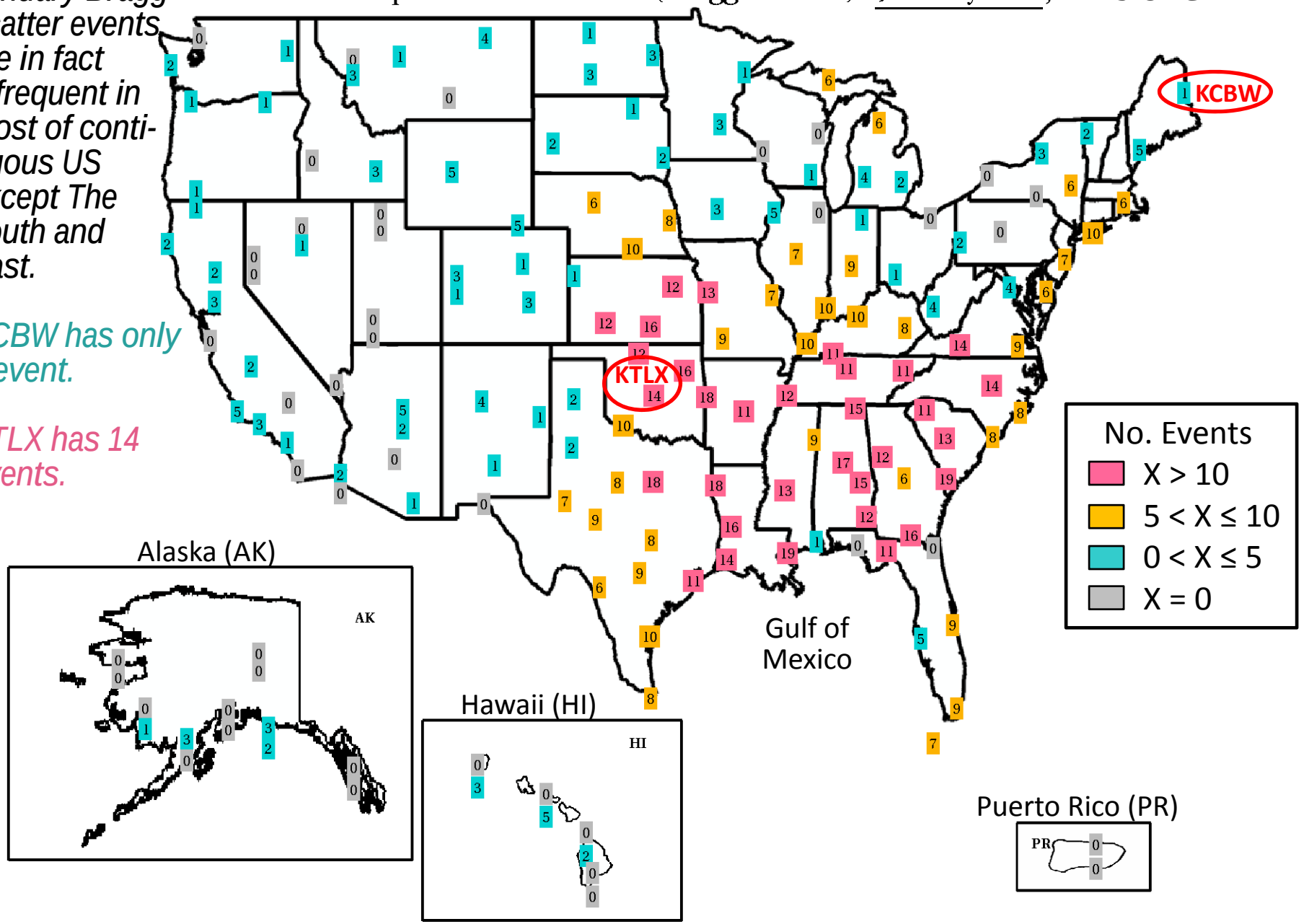
KCBW seems a good estimate (0.0 dB). KTLX is low (-0.56 dB).



January Bragg scatter events are in fact infrequent in most of conti-guous US except The south and East.

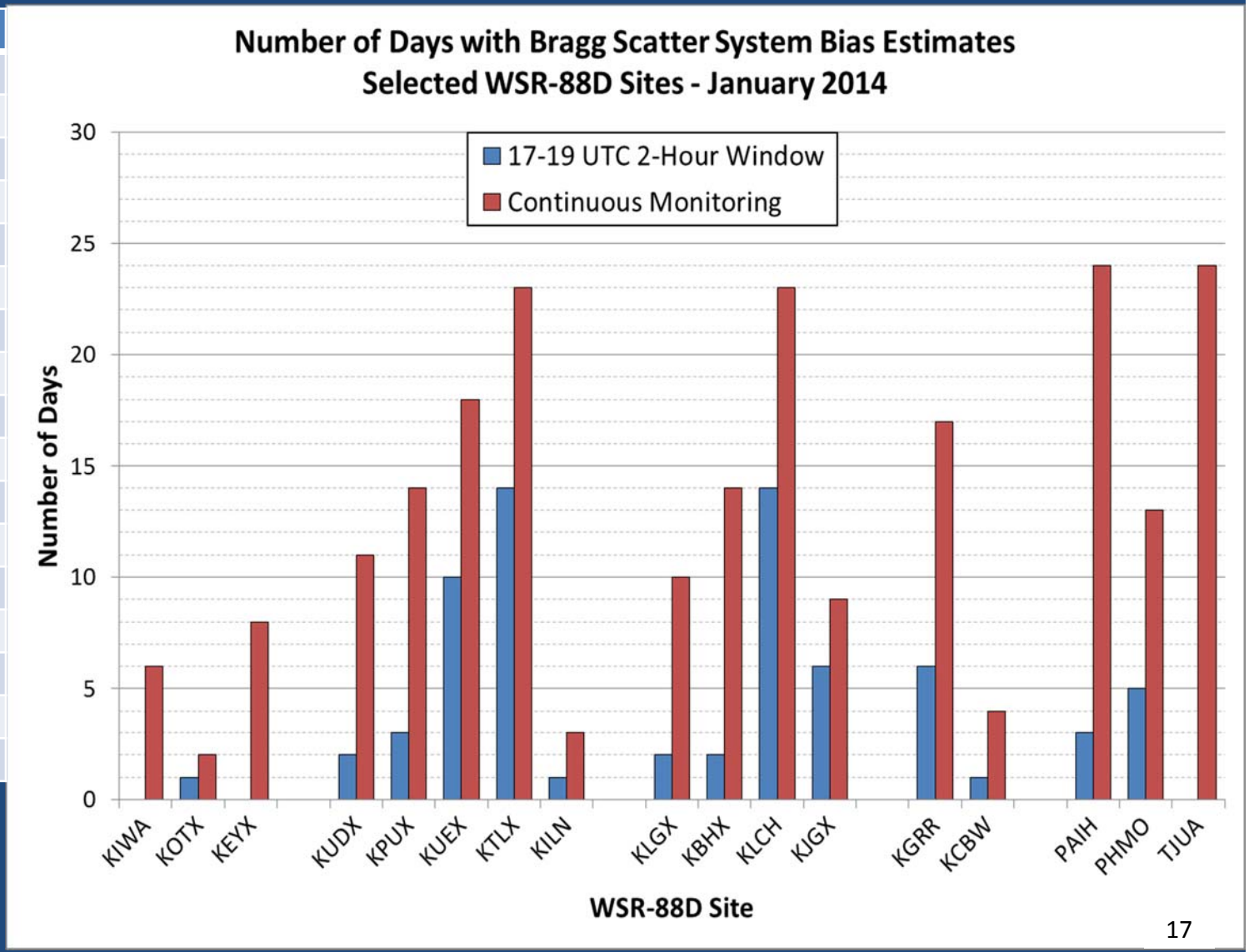
KCBW has only 1 event.

KTLX has 14 events.

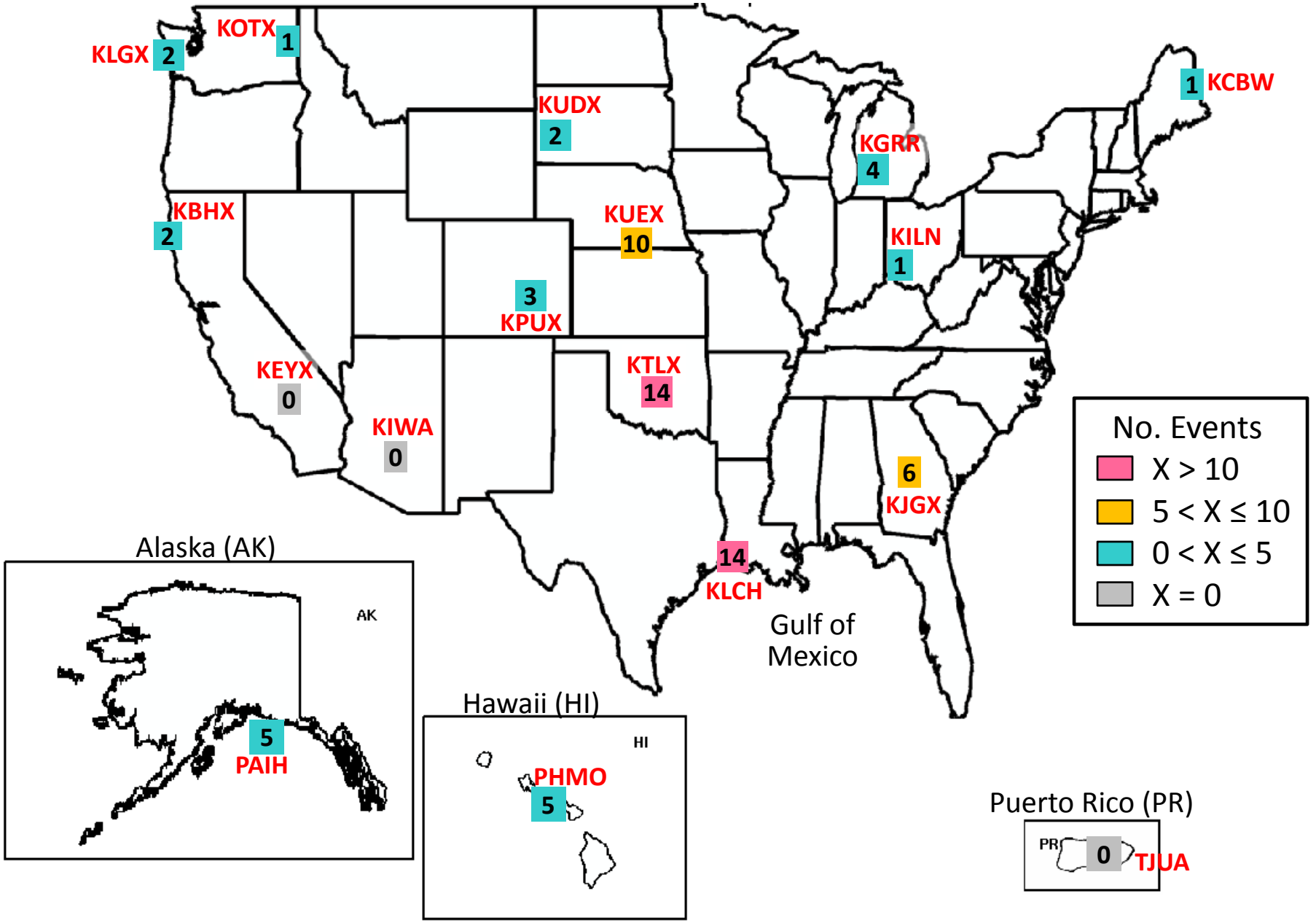


January 2014 2-Hour (17-19 UTC) vs. Continuous Bragg Scatter Sampling for 17 WSR-88Ds

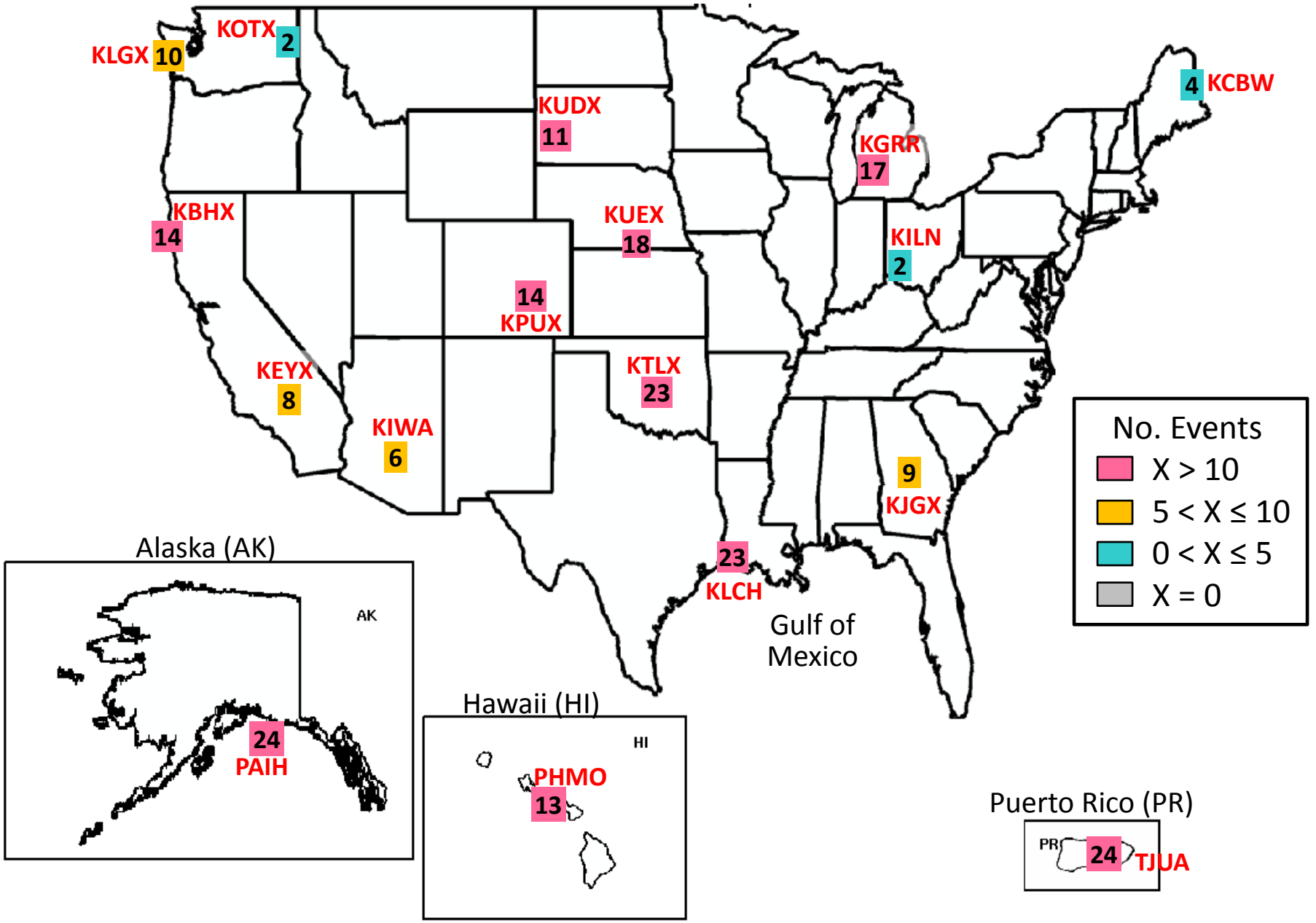
ICAO	WSR-88D Site
KIWA	Phoenix, AZ
KOTX	Spokane, WA
KEYX	Edwards AFB, CA
KUDX	Rapid City, SD
KPUX	Pueblo, CO
KUEX	Hastings, NE
KTLX	Oklahoma City, OK
KILN	Cincinnati, OH
KLGX	Langley Hill, WA
KBHX	Eureka, CA
KLCH	Lake Charles, LA
KJGX	Robbins AFB, GA
KGRR	Grand Rapids, MI
KCBW	Caribou, ME
PAIH	Middleton, AK
PHMO	Molokai, HI
TJUA	San Juan, PR



No. of Days with Bragg Scatter Estimates, Jan '14, 17-19 UTC Time Window



No. of Days with Bragg Scatter Estimates, Jan '14, Continuous Monitoring



Summary / Conclusions

- The dry snow method provides high availability geographically and seasonally but also shows high variance of estimates
- Light rain is most prevalent during the summer months and sparse during the cool seasons
- Bragg scatter during the 2 hr (17-19 UTC) time window is more common fleetwide during the cool season but really is most prevalent in the southern and eastern US. Contamination from biota and limited use of VCPs 21 and 32 may also limit number of events
- Computing Bragg scatter continuously (24/7) increases the number of days with Bragg scatter events almost 4-fold

Thank you!
Questions?

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For the full year's set of monthly maps for each weather method click on the link below and then click on Supplemental maps for this conference paper.

www.roc.noaa.gov/WSR88D/Applications/AppsPapers.aspx

Backup Slides

Light Rain Method

- Z_{DR} medians are calculated for six separate reflectivity (Z) categories from 19.0 to 30.5 dBZ for each volume scan
  - A correction factor (in dB) based on climatology is subtracted from the median Z_{DR} of each category:

0.23	0.27	0.32	0.38	0.46	0.55

  - The average of the six categories within this time frame is computed
  - Spatial filters include:
    - Range > 10 km
    - Height at least 1 km below the melting layer
    - Elevation > 1.0°
- "Events" must have continuous coverage over 3-6 hrs
  - Can have multiple events per day

Dry Aggregate Snow Method

- Estimated only on bins classified as Dry Snow by the Hydrometeor Classification Algorithm (HCA)
- Extra filters:
  - 15 dBZ < Z < 25 dBZ
  - Elevations > 1°
  - SNR ≥ 20 dB,
  - $0.98 < RHO_{HV} < 1.0$
  - PHI < 100°
  - Bins must be completely, but no more than 1 km above the melting layer
  - Must have at least 500 Z_{DR} bins that pass filters per volume
  - Standard deviation Z_{DR} < 0.5 dB

Dry Aggregate Snow Method Cont.

- 3-6 hr Events
  - Average of the Z_{DR} values that pass the filters
  - Subtract 0.2 dBZ (climatological value of dry snow) to get the Event bias
- Can be estimated at the same time as a rain Event as long as dry aggregate snow is observed above the melting level
- Dendrites and Platelets can bias Z_{DR} high
- Subtraction correction can bias Z_{DR} low

Note: Aggregates are clumps of frozen precipitation (particularly ice crystals)

Bragg Scatter Method

- Bragg distinguished by refractivity gradients generally caused by turbulent eddies
  - **Intrinsic Z_{DR} = 0.0 dB** (no subtraction correction needed)
  - Often found at the top of the Convective Boundary Layer
- Filters:
  - VCP 32 and 21 only currently (may change to allow more)
  - 10-80 km in range only
  - $Z < 10$ dBZ
  - $|V| > 2$ m/s
  - $W > 0$ m/s
  - SNR < 15 dB
  - $0.98 < \rho_{HV} < 1.05$
  - Elevations 2.5-4.5°

Bragg Scatter Method Cont.

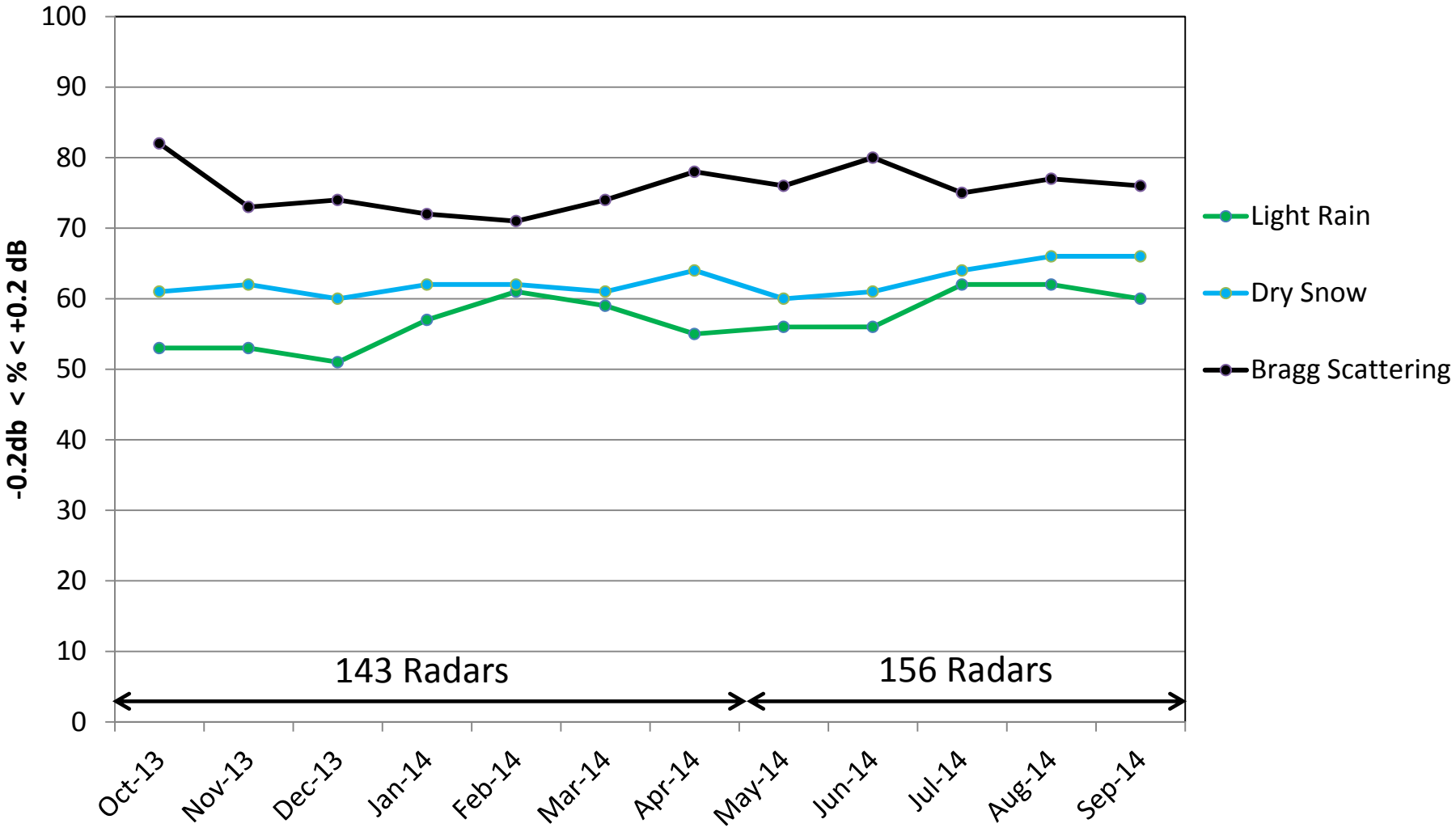
- Additional filters:
  - Z at the 90th percentile ≤ -3 dBZ (precipitation filter)
  - Need at least 10,000 bins that pass filters
  - Inter-Quartile Range (IQR) < 0.9 (biota filter)
- 2 hr Events
  - Currently only 17-19 UTC

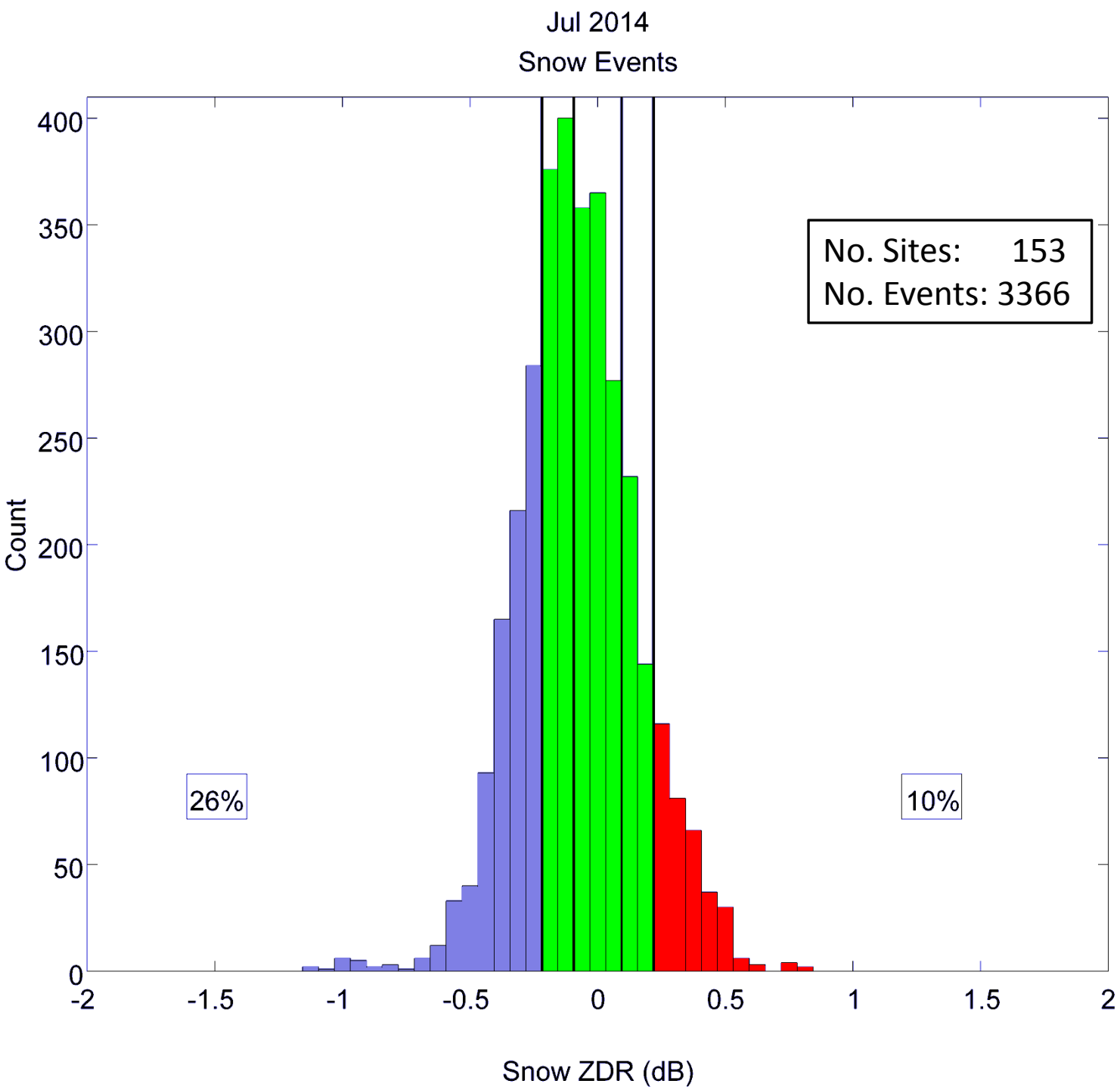
★Will be potentially available every volume scan in Build 16 (12-volume running average of the Z_{DR} mode)

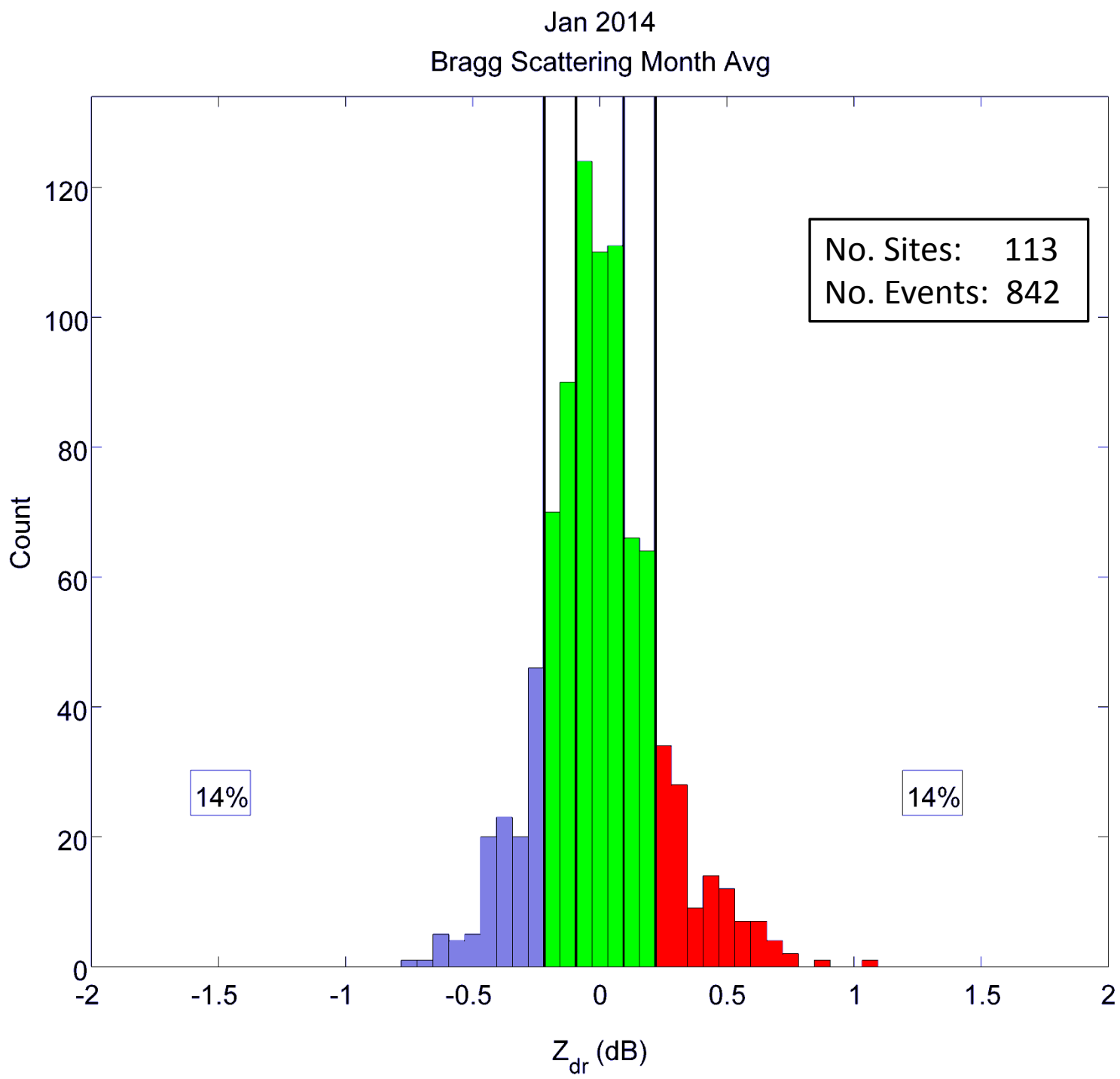
Bragg Scatter Method Cont.

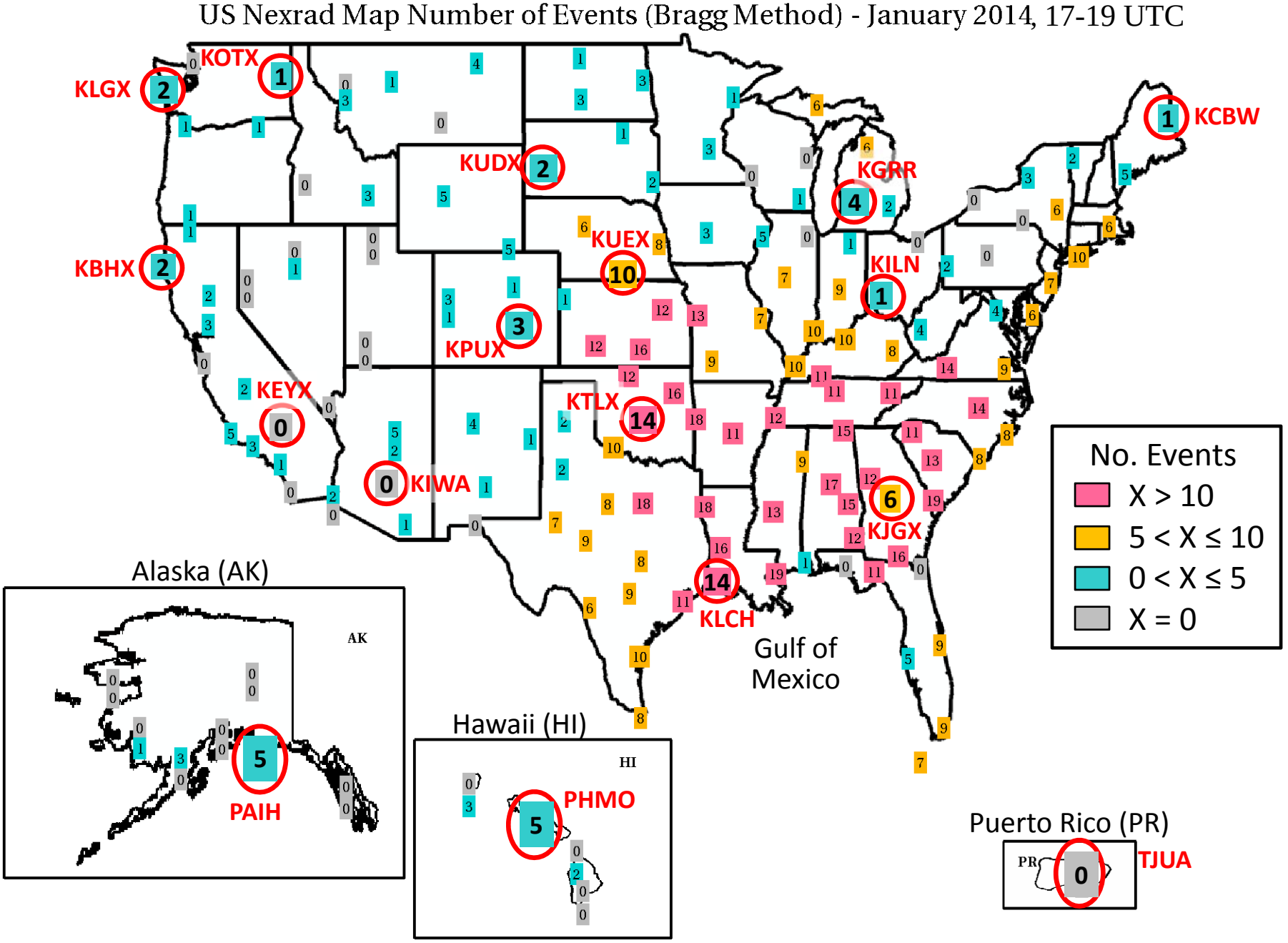
- Precipitation contamination can bias Z_{DR} high
- Return from Bragg scattering has a weak signal, and if noise is comparable to the signal it could bias the estimate towards 0.0 dB
  - Assuming the noise estimates are similar in both H and V channels

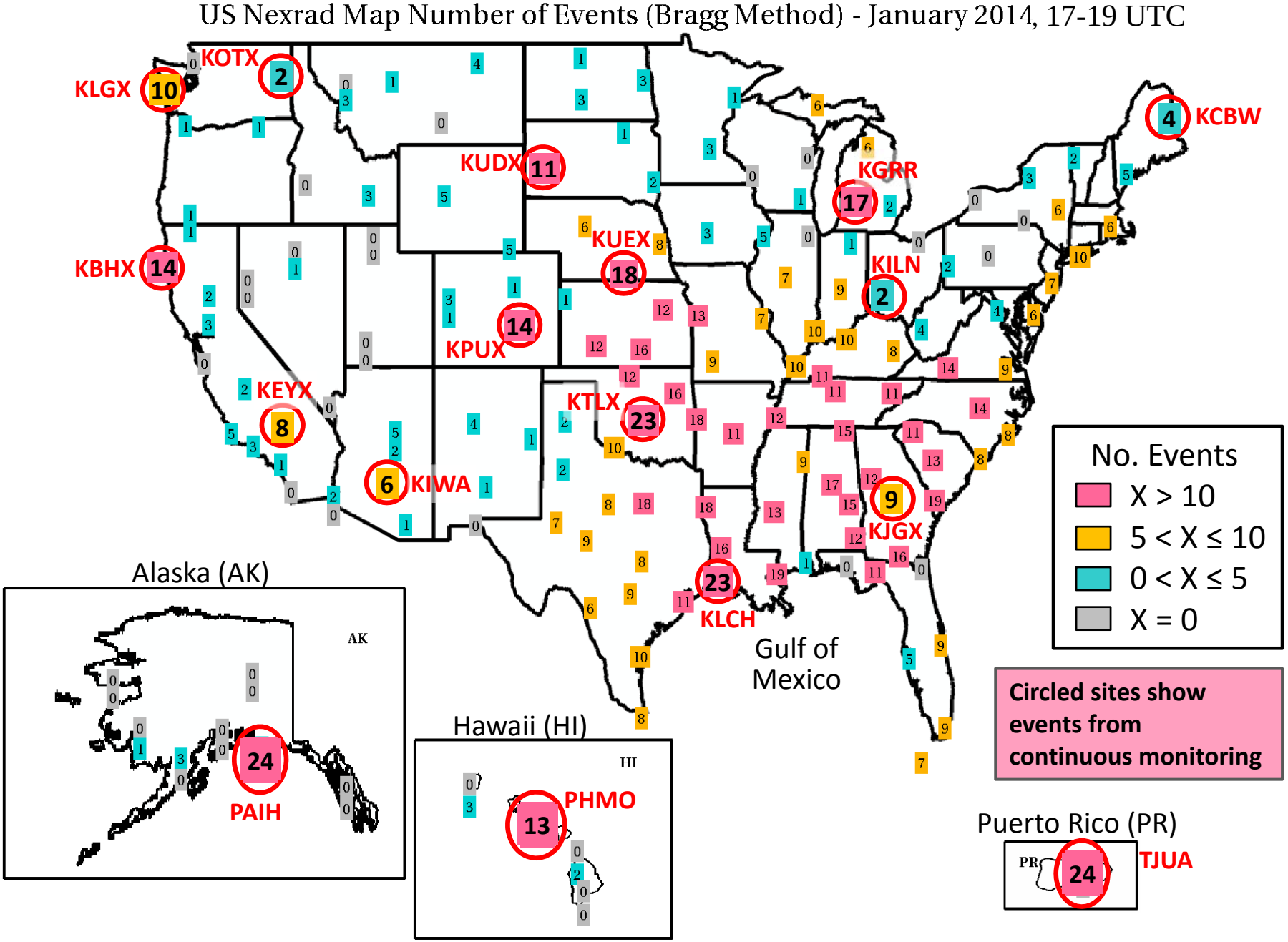
Percent of WSR-88Ds With Estimated System Z_{DR} Bias < ±0.2 dB for Each Weather Method



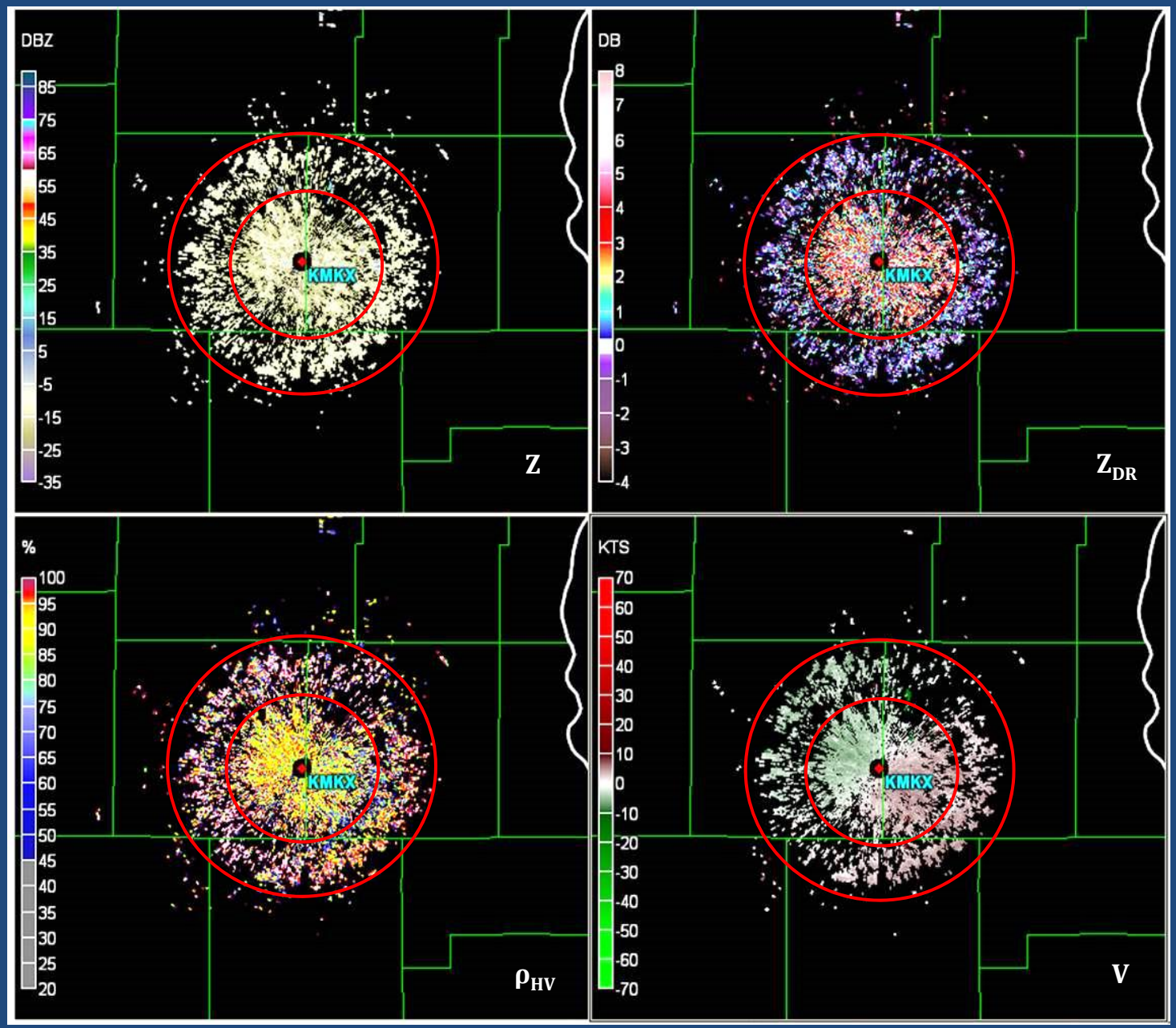

Jul 2014
Snow Events
No. Sites: 153
No. Events: 3366
26%
10%
Count
Snow ZDR (dB)
0
50
100
150
200
250
300
350
400
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2


Jan 2014
Bragg Scattering Month Avg
No. Sites: 113
No. Events: 842
14%
14%
Count
Z_{dr} (dB)
0
20
40
60
80
100
120
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2

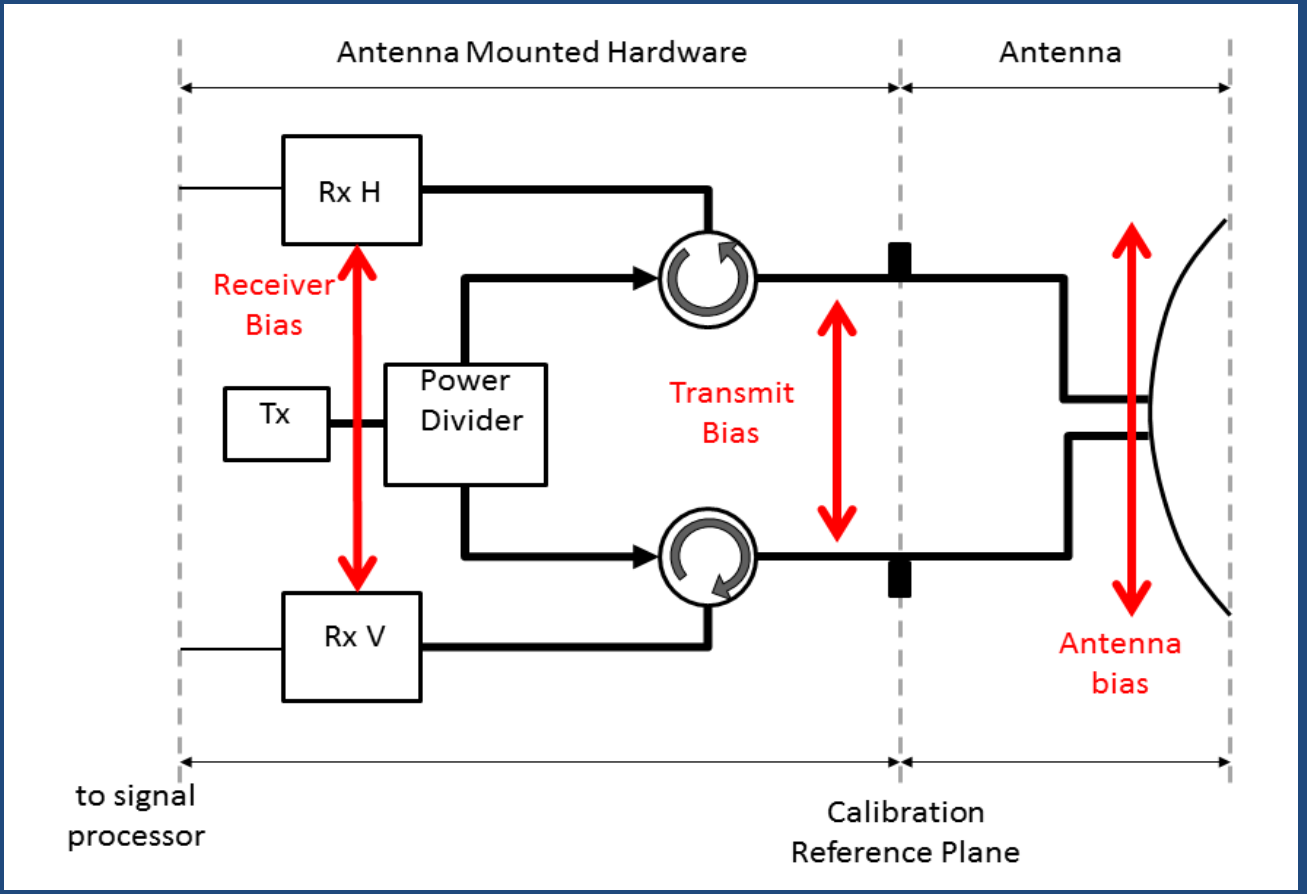

US Nexrad Map Number of Events (Bragg Method) - January 2014, 17-19 UTC
KLGX 2
KOTX 1
KBHX 2
KUDX 2
KUEX 10
KPUX 3
KEYX 0
KIWA 0
KTLX 14
KGRR 4
KILN 1
KCBW 1
KJGX 6
KLCH 14
Gulf of Mexico
Alaska (AK)
AK
PAIH 5
Hawaii (HI)
HI
PHMO 5
Puerto Rico (PR)
PR
TJUA 0
No. Events
X > 10
5 < X ≤ 10
0 < X ≤ 5
X = 0


US Nexrad Map Number of Events (Bragg Method) - January 2014, 17-19 UTC
KOTX 2
KLGX 10
KUDX 11
KGRR 17
KCBW 4
KUEX 18
KBHX 14
KILN 2
KPUX 14
KEYX 8
KTLX 23
6 KIWA
9 KJGX
23 KLCH
Gulf of Mexico
No. Events
X > 10
5 < X ≤ 10
0 < X ≤ 5
X = 0
Circled sites show events from continuous monitoring
Alaska (AK)
AK
24 PAIH
Hawaii (HI)
HI
13 PHMO
Puerto Rico (PR)
PR
24 TJUA

Example of Bragg Scatter Milwaukee, WI, November 10, 2013, 18:04 UTC, 2.5° Elev.



WSR-88D Z_{dr} Engineering Calibration Architecture



Total Bias = RXB + TXB +2ANTB

RXB - test signals - each volume - must know test signal bias and coupler losses
TXB - sampled power - 8 hours - must know power sense bias and coupler losses
ANTB - solar scans - monthly - must include RXB to derive antenna bias

Measuring the Biases with built in test equipment (BITE) and solar scans

Receiver bias checked each volume scan

Transmitter bias checked every eight hours (performance check)

Antenna bias checked periodically with a solar scan

the test signal and power sensing equipment biases must be known and corrected