2017 HF Eclipse Experiment

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WG0R
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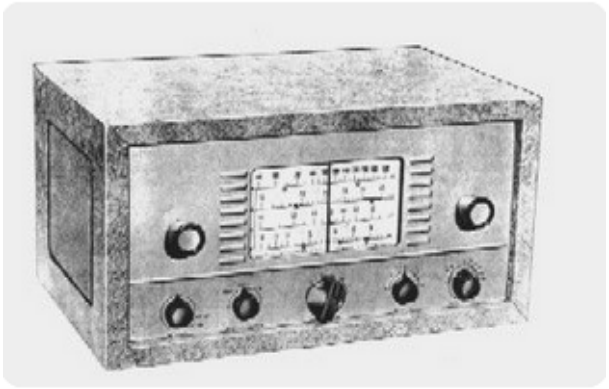
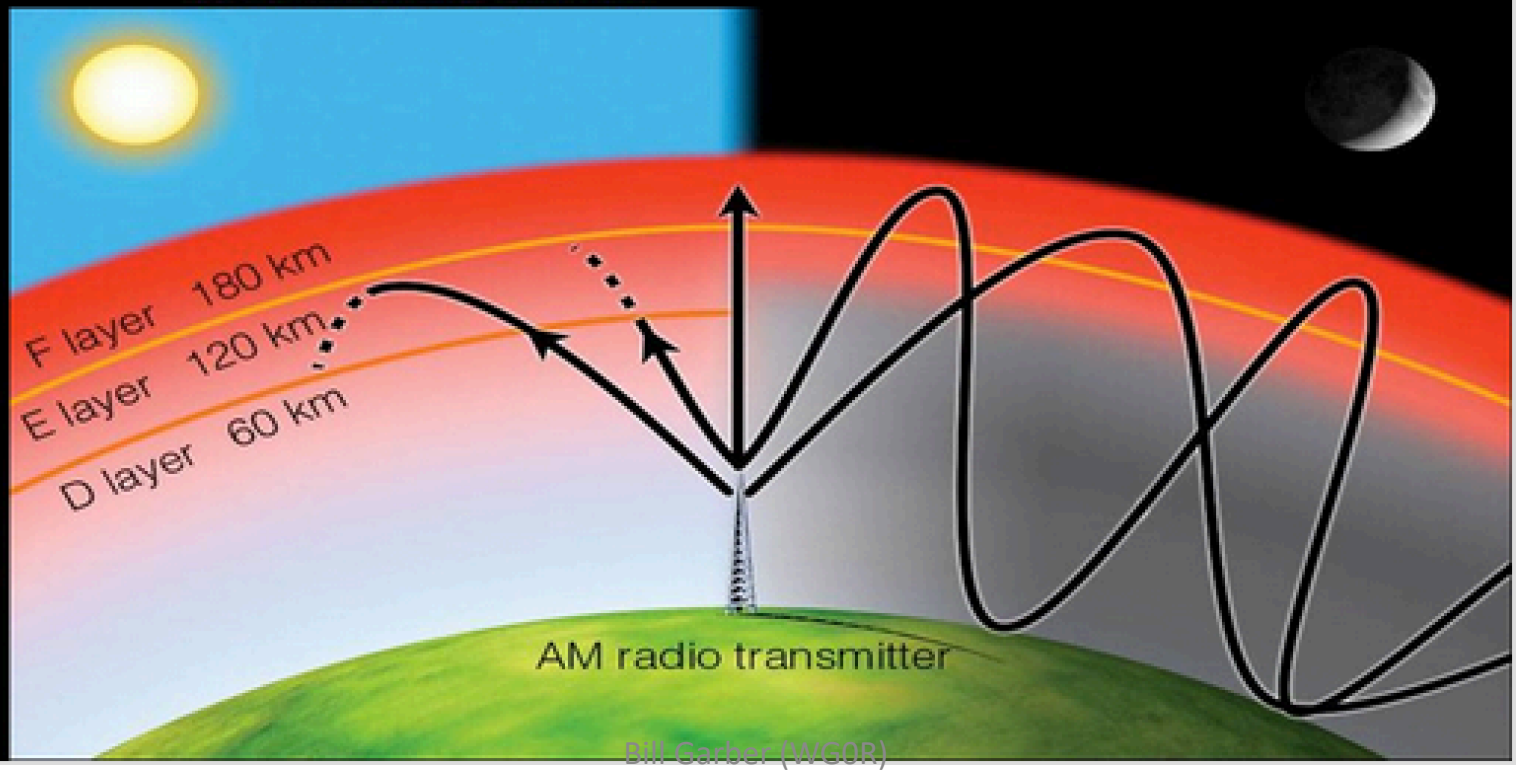
My Experience with Ham/CW/Propagation

- El Camino College (1963-1964)
  - Electronics course (8-units credit/Course (32 total credits for the 2-year program)
    - Mr. Rowan Talked about using meteor trails to transmit classified messages.
      - One-shot chance for short period! Very interesting!
- Ham Radio Experience:
  - 1957: Buddy & I Built Heathkit AR-3 receivers, contested with listening to DX/number of hits.
  - 1957-2009: Silence, but always in the back of my mind
  - '08: Hired at International Game Technology
    - Many hams involved with Gaming machine programming/support
    - Met Dave Foster (NG7R), Mike Shelby (W7RIS)
    - One tech asked if I was a Ham. Finally reached ignition!
  - Dec '09: Technician ticket
  - Jul '10: Extra ticket
  - Fall '16: CwOps first level. (Learned about "Reverse Beacon Network").
  - Spring '17: CwOps second level (Scott Gilbert (KF7GGN) facilitated)
  - Still working to "head copy" (or copy at all).



Day & Night Propagation

- **The Ionosphere and Radio Wave Propagation**
  - the D layer is good at absorbing AM radio waves
  - D layer dissapears at night.... the E and F layers bounce the waves back to the earth
  - this explains why radio stations adjust their power output at sunset and sunrise

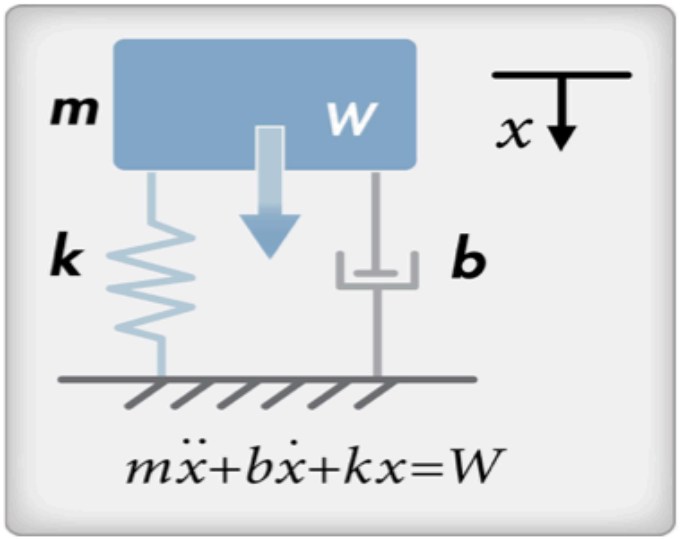


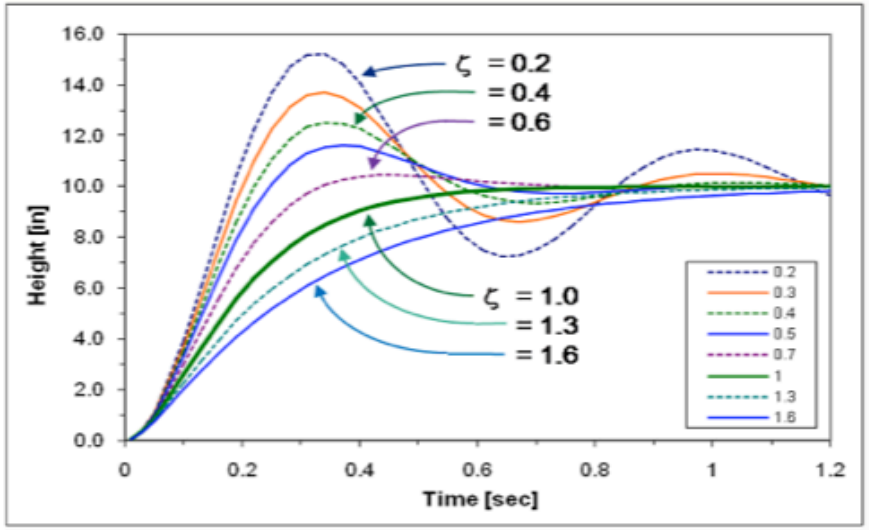
Engineering Thoughts

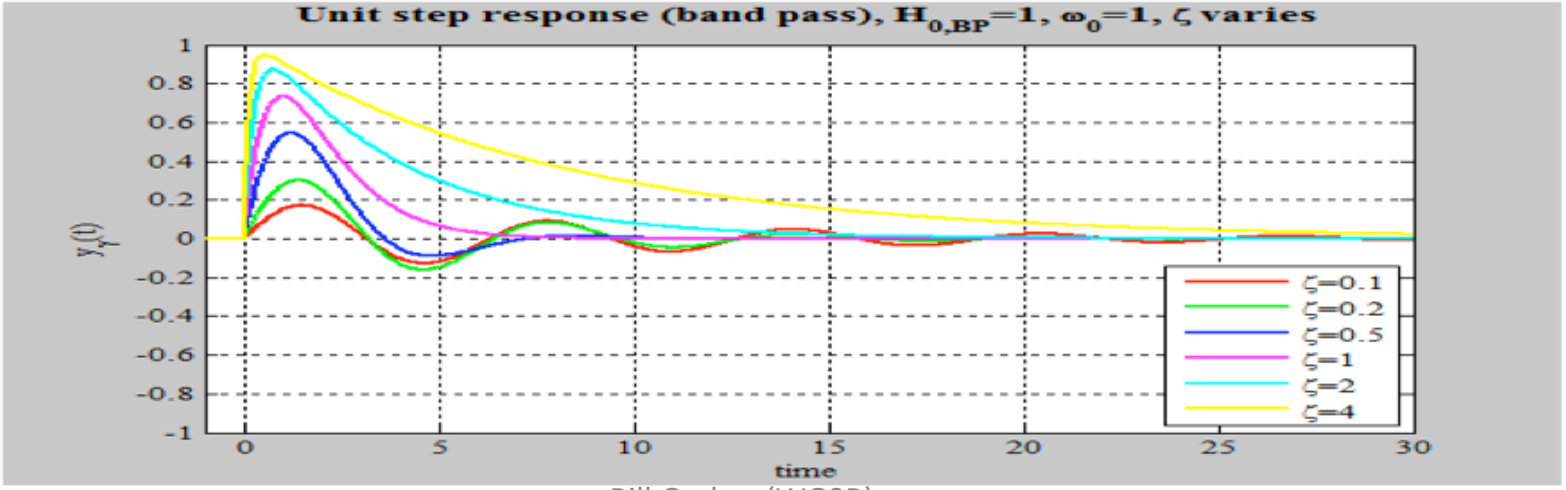
- Eclipse like “Impulse Response” (Engineering tool)
  - Impulse Response Explores system responses (Spring/Mass/Damper): Used in many disciplines
    - Short pulse input
    - Instrumented output
    - Analysis of resonances and corrections in system performance
  - Day/night shortened with moon’s artificial night
- https://en.wikipedia.org/wiki/Impulse_response

Impulse Response

Spring-Mass-Damper System Responses







Reverse Beacon Network (RBN)

- Transmit CW “CQ” or “TEST” message with callsign >= twice.
- Listeners (“Skimmers”) pickup wideband signal, decode “Test” or “CQ” with the Callsign, report to RBN.
- Process allows checking the RBN and selecting your callsign in almost real-time
  - Downloadable database includes following useable data:
    - Callsign, DX prefix, Frequency, Band, DX (Your callsign), mode (Call type) , dB level, Date/timestamp, speed, Transmission Mode
- http://www.reversebeacon.net/main.php

Experiment Resources

- KX3/KXPA100/PX3 Transceiver/Amp/Panadapter
  - KX3 System capable of memory transmit (macro) of CW messages
  - RBN: Multi-band receivers “sniffing” the bands and reporting to database almost realtime.
- Carolina Windom antenna at 30 ft AGL, strung at 330/150 degrees between two Oak trees

Experiment Prep

- 3 bands (17-20-40 (Plus one 80))
- Transmit every five minutes
  - Looping timer (“Howler” on Mac system)
- Load message into memory bank/test
  - “TEST WG0R, TEST WG0R, TEST WG0R 100W WNDM 30FT STRUNG 330/150 DEG DE WG0R SK”
    - 2.5 minutes transmit @ 23 Words Per Minute (WPM), 3 bands
    - 2.5 slack
- Use “Sawtooth” method (Low-> high, High -> low) Iterate @ 5 minute intervals
- Use Extra bands (Lower usage density)
  - 7009, 14018, 18082 (3507 on 80 meters (one test))

Eclipse Times (Local) {Zulu PM}

- Corvallis
  - Duration: 2h 32m 28s
  - Totality: 1m 42s
  - Pre-Eclipse: Defined State 0
  - Partial began: (9:04) {4:04} Defined State 1
  - Full began: (10:16:53) {5:16} Defined State 2
  - Maximum: (10:17:43) {5:17}
  - Full ended: (10:18:35) {5:18}
  - Partial ended: (11:37:21) {6:37} Defined State 3

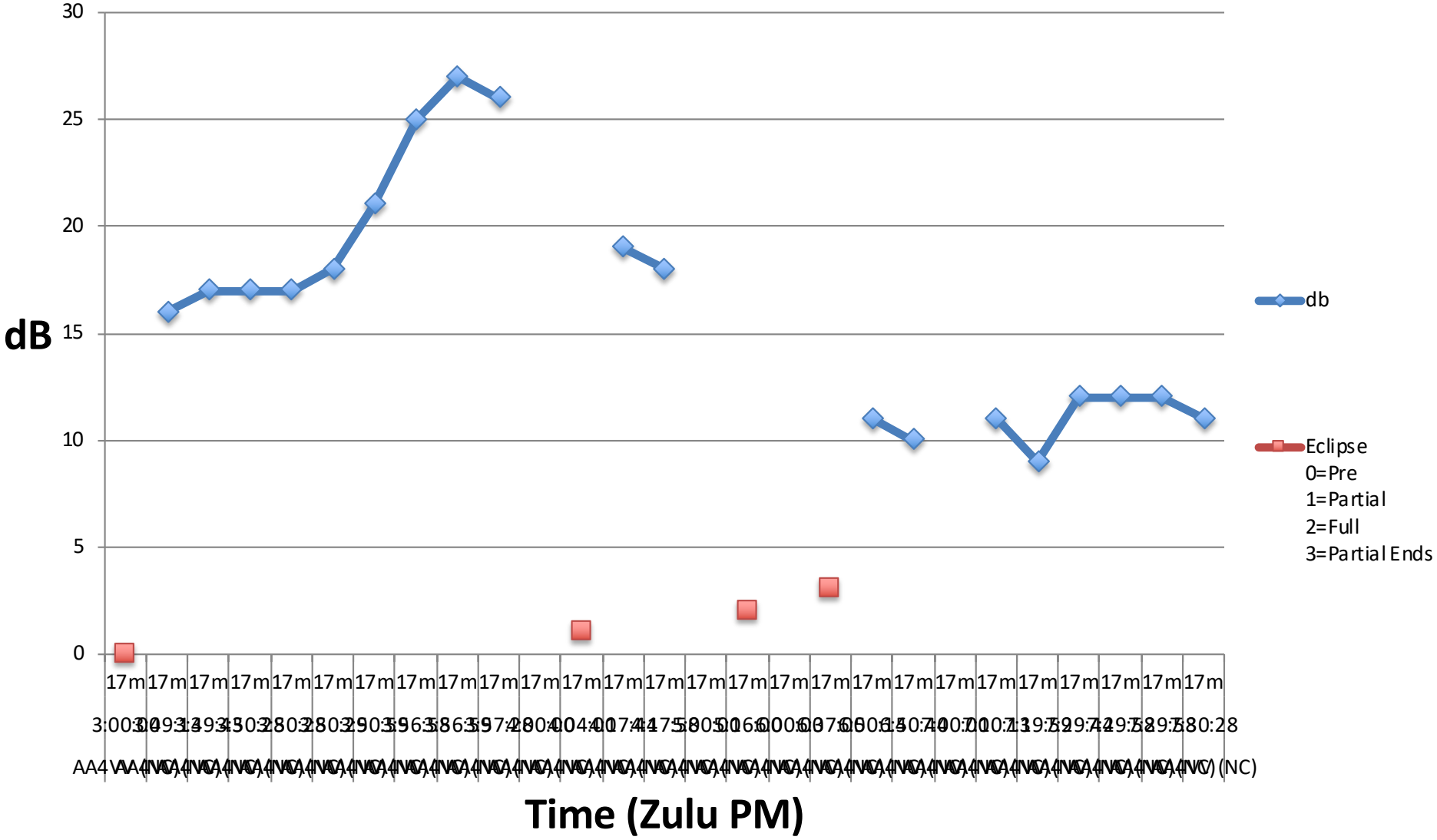
Process

- Mac computer used
- Use fixed frequencies (Fixed inside each band)
- Transmit 100W
- 23 WPM
  - Run Activities
    - Select frequency at high or low band
    - Auto Tune the system at each band
    - Transmit
    - Alternately, Sawtooth up/down frequency, and test each band
    - Test every 5 minutes
- Transmit from 8:45 to 12:30 local time

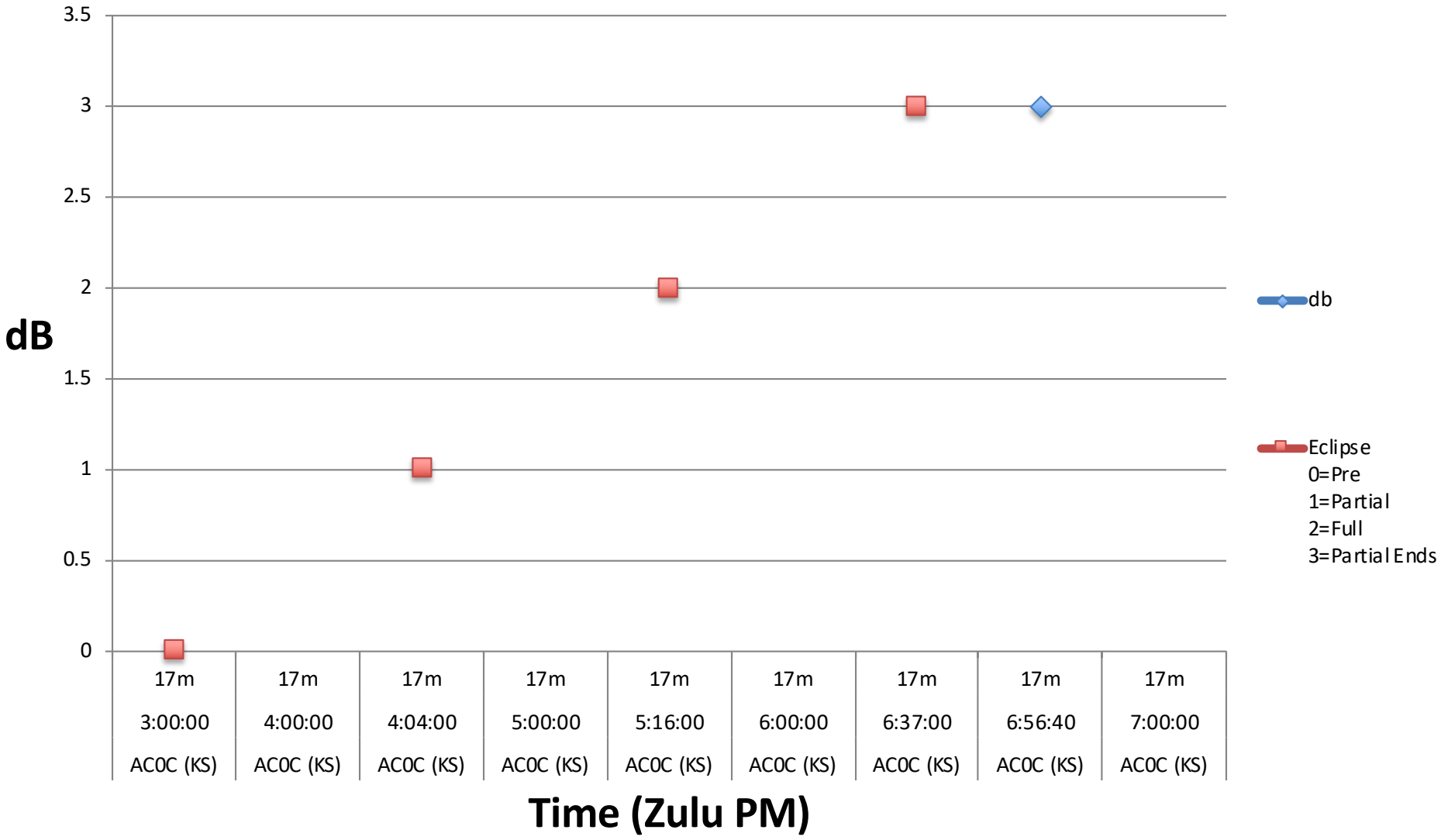
Pre Picture with Metadata

- 17 Meter logs

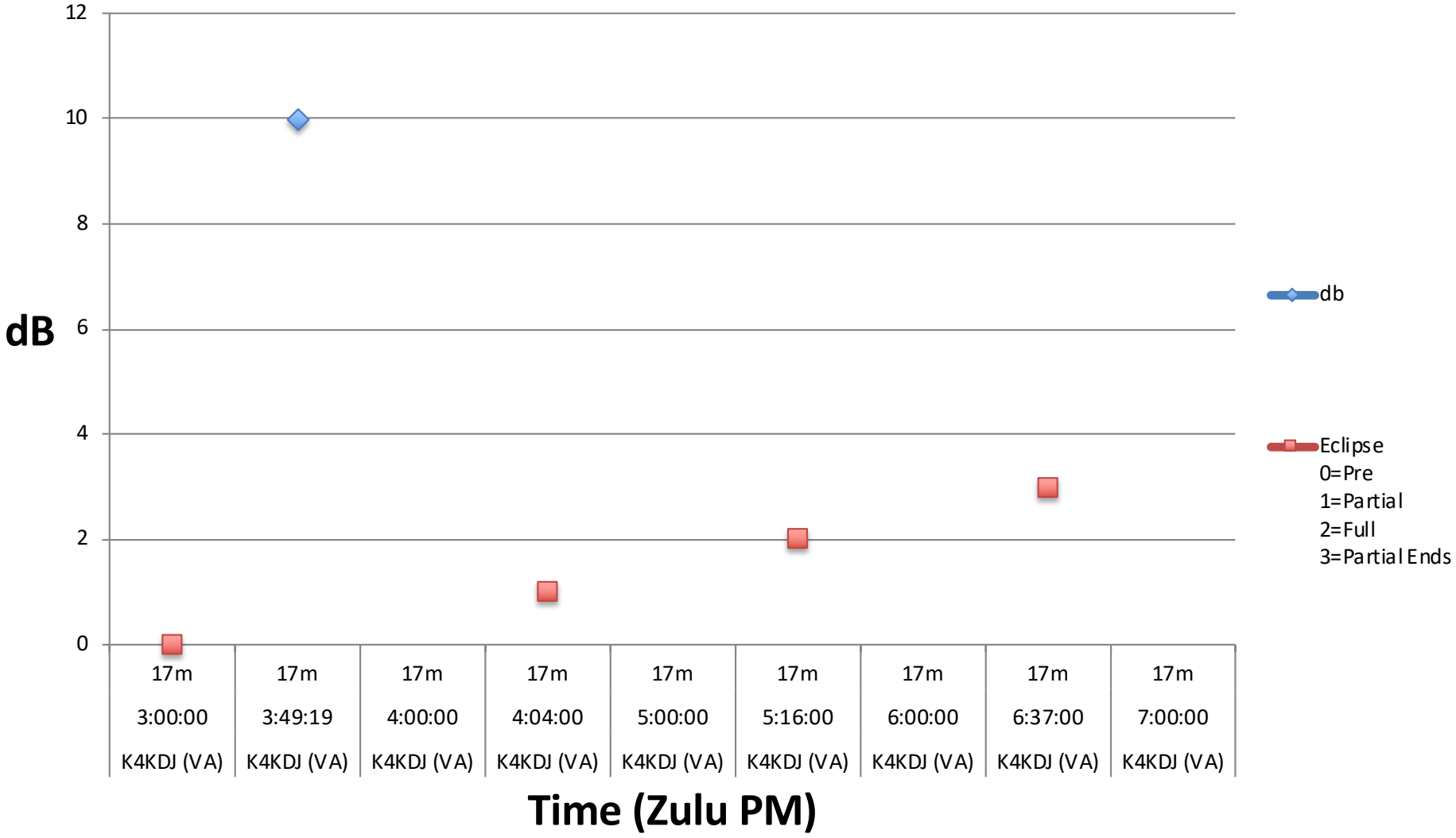
AA4VV (North Carolina) 17 meter Eclipse Signal Strength



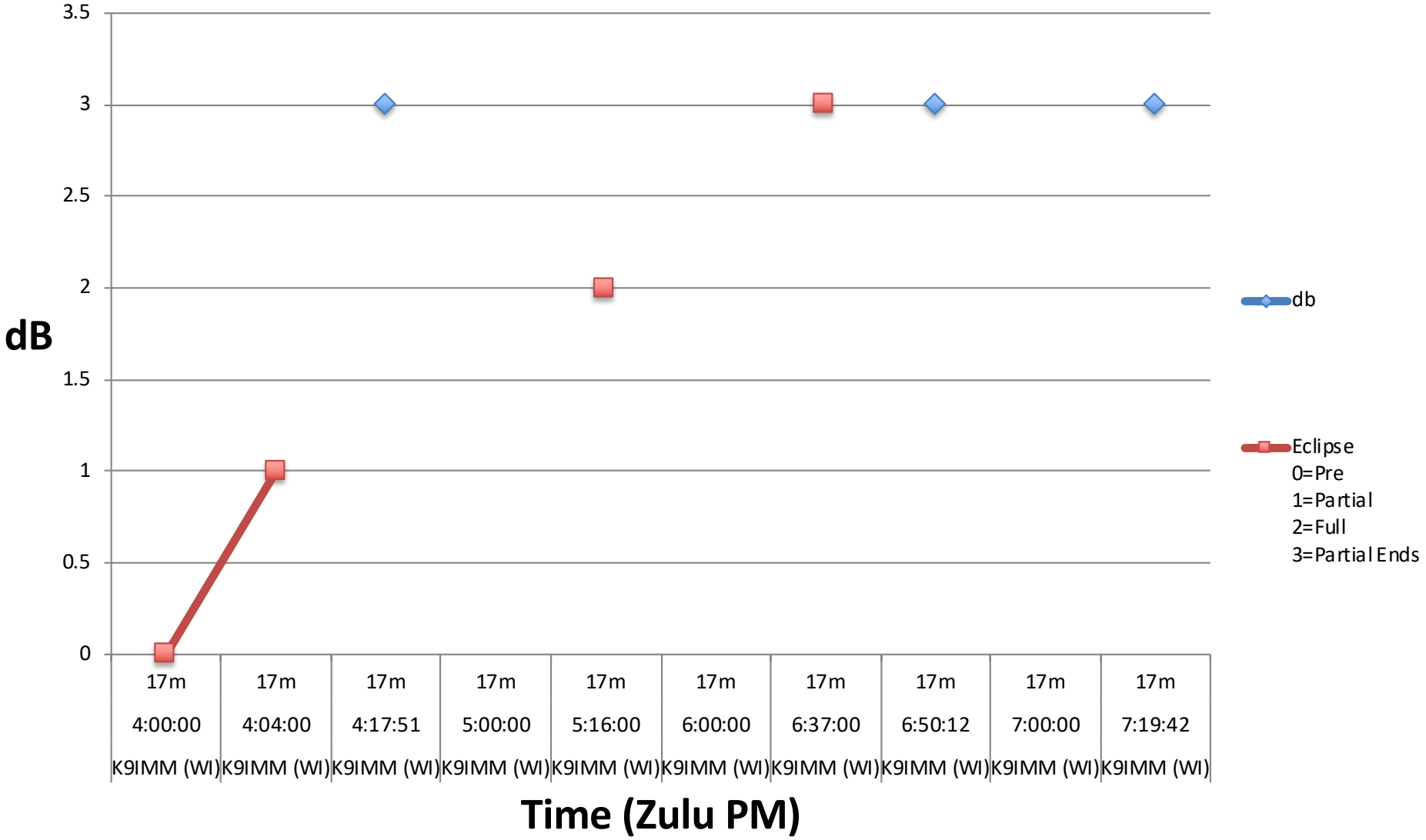
AC0C (Kansas) 17 meter Eclipse Signal Strength



K4KDJ (Virginia) 17 meter Eclipse Signal Strength

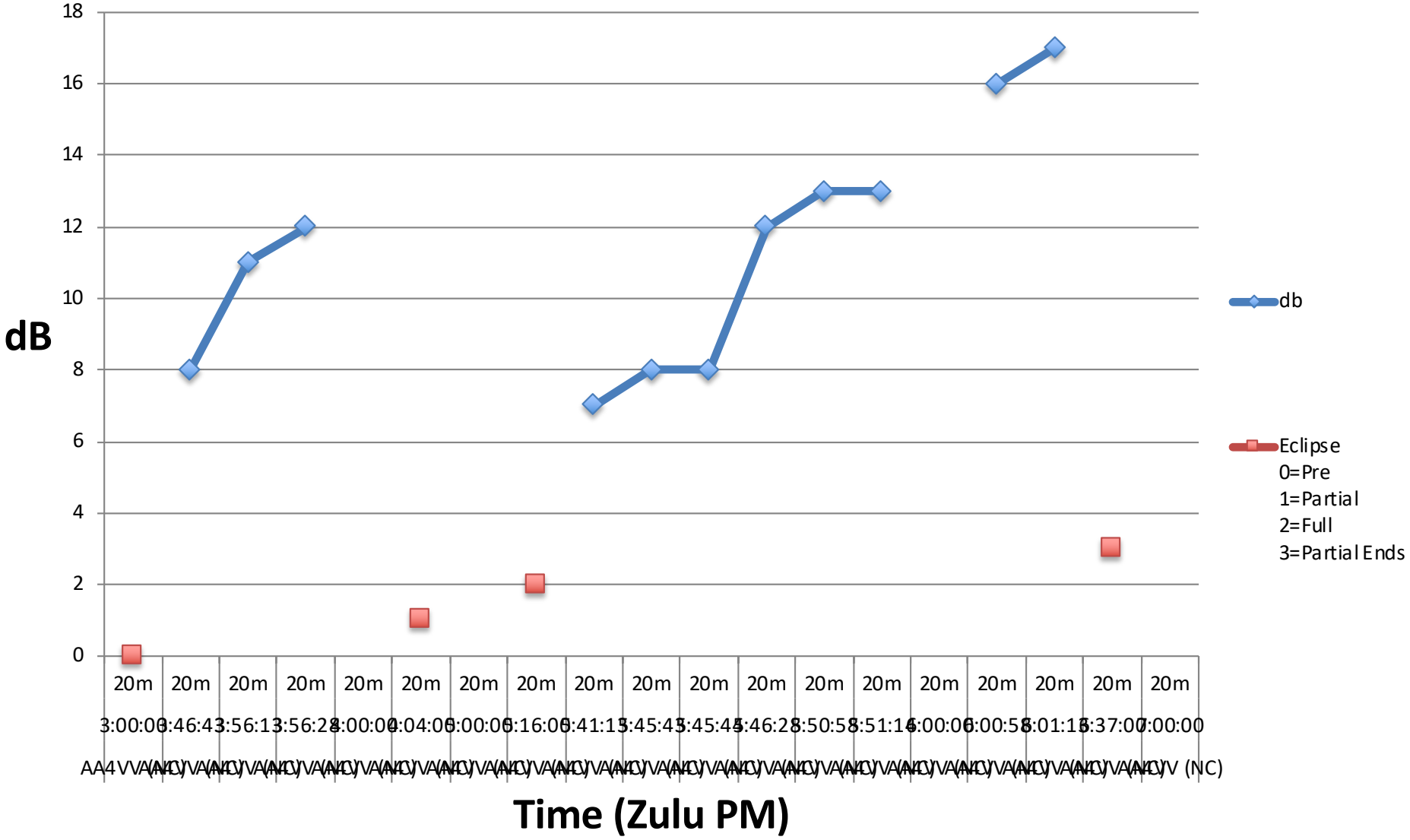


K9IMM (Wisconsin) 17 meter Eclipse Signal strength

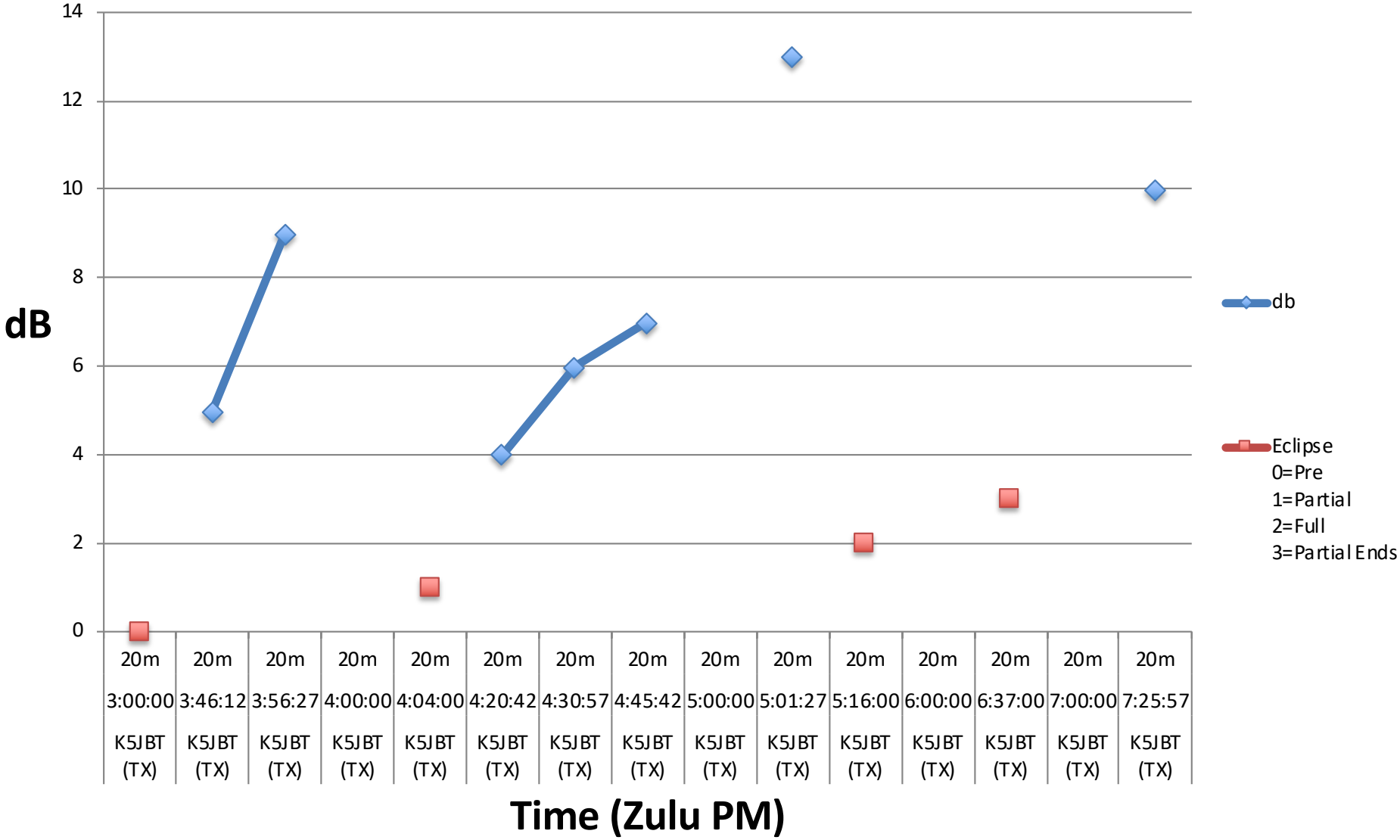


- 20 Meter logs

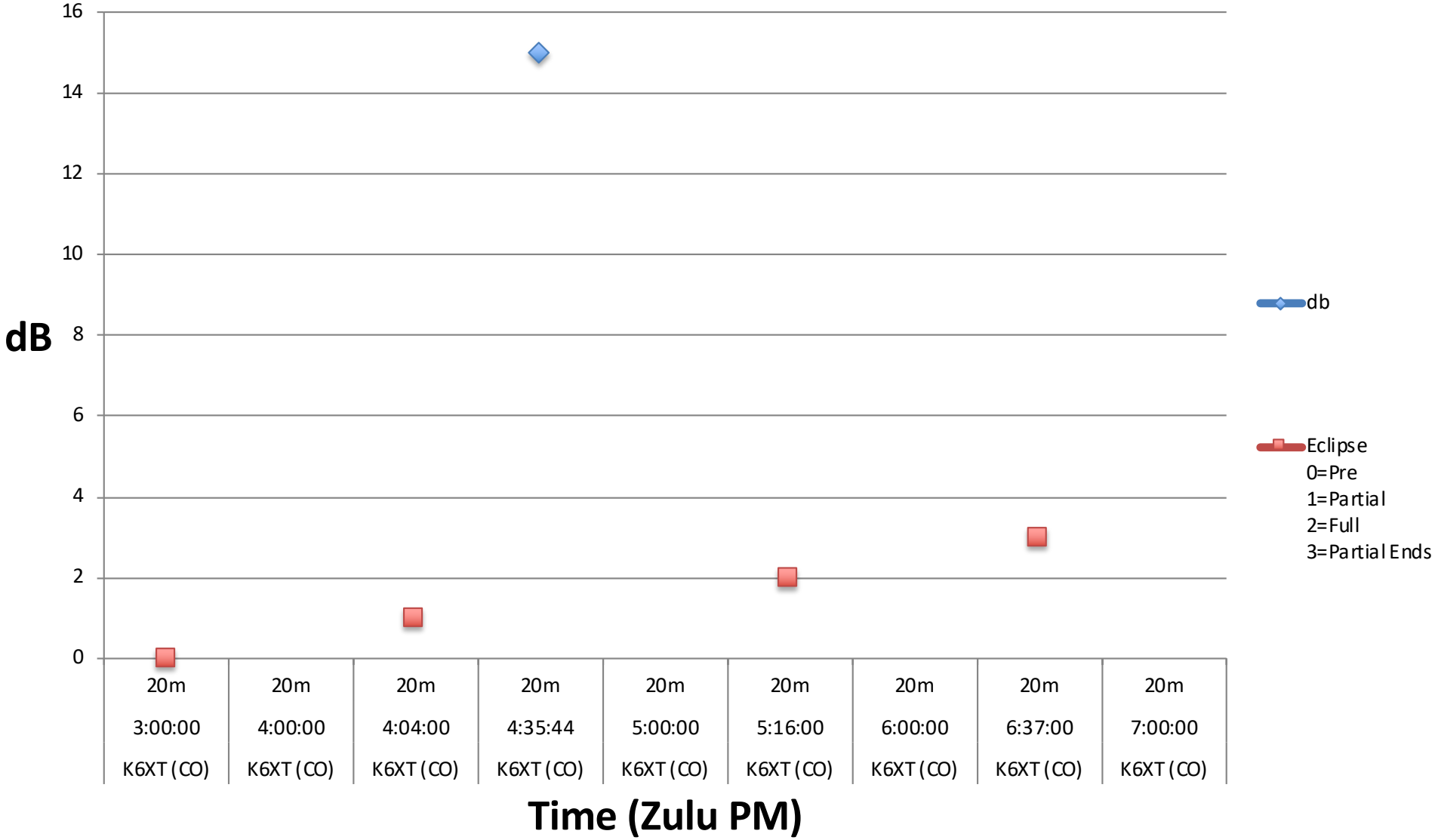
AA4VV (North Carolina) 20 meter Signal Strength



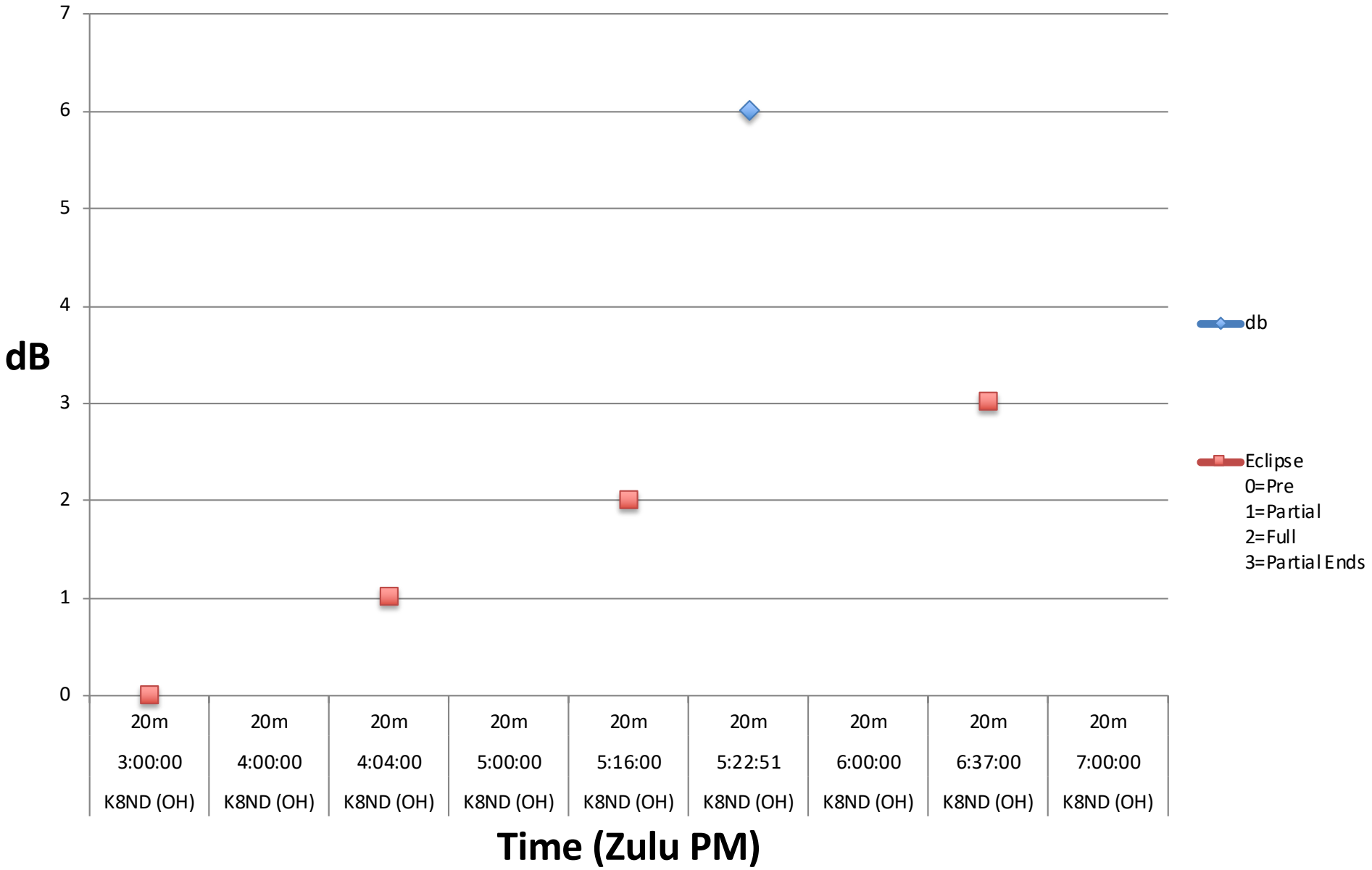
K5JBT (Texas) 20 meter Eclipse Signal Strength



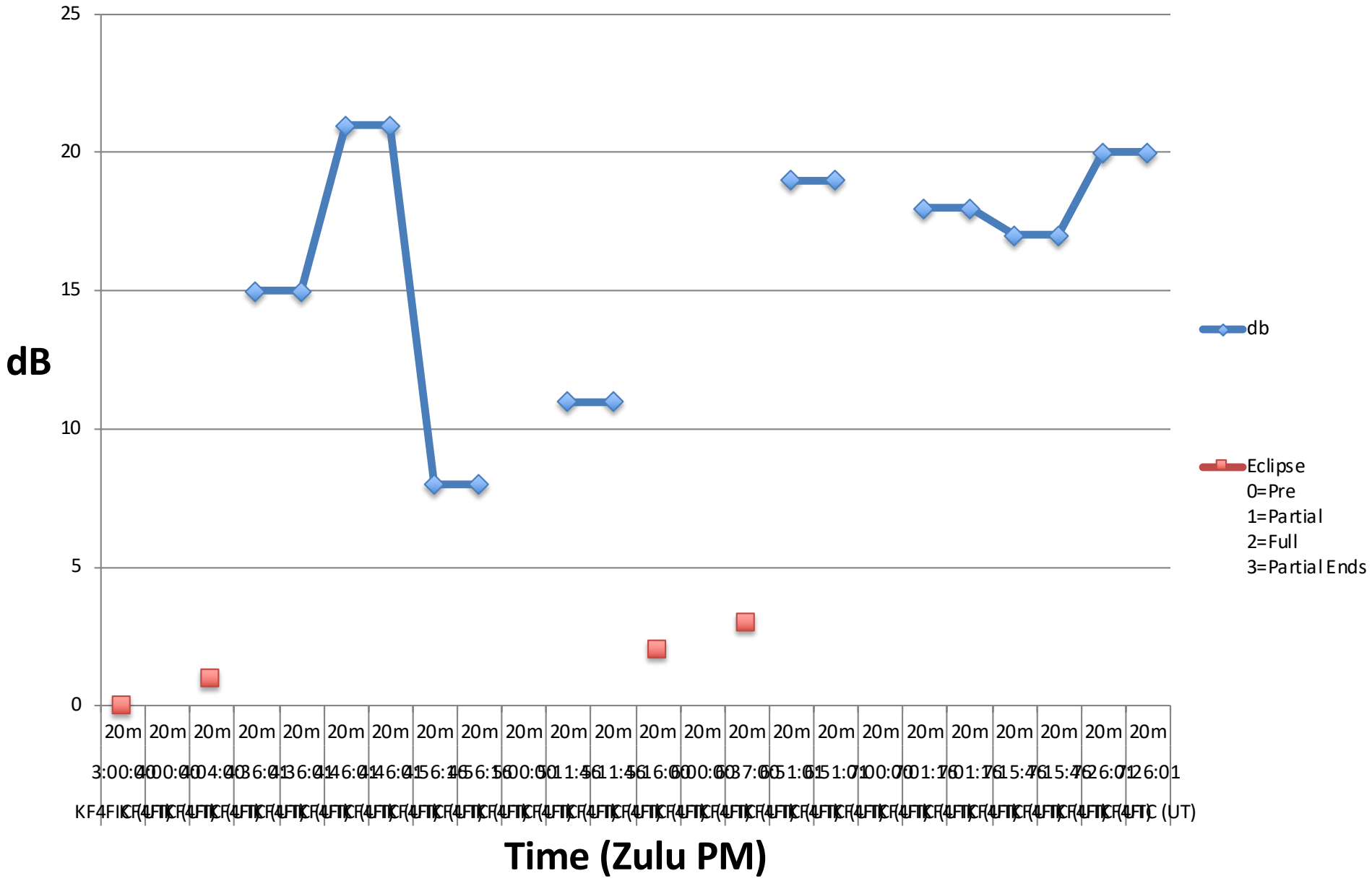
K6XT (Colorado) 20 meter Eclipse Signal Strength

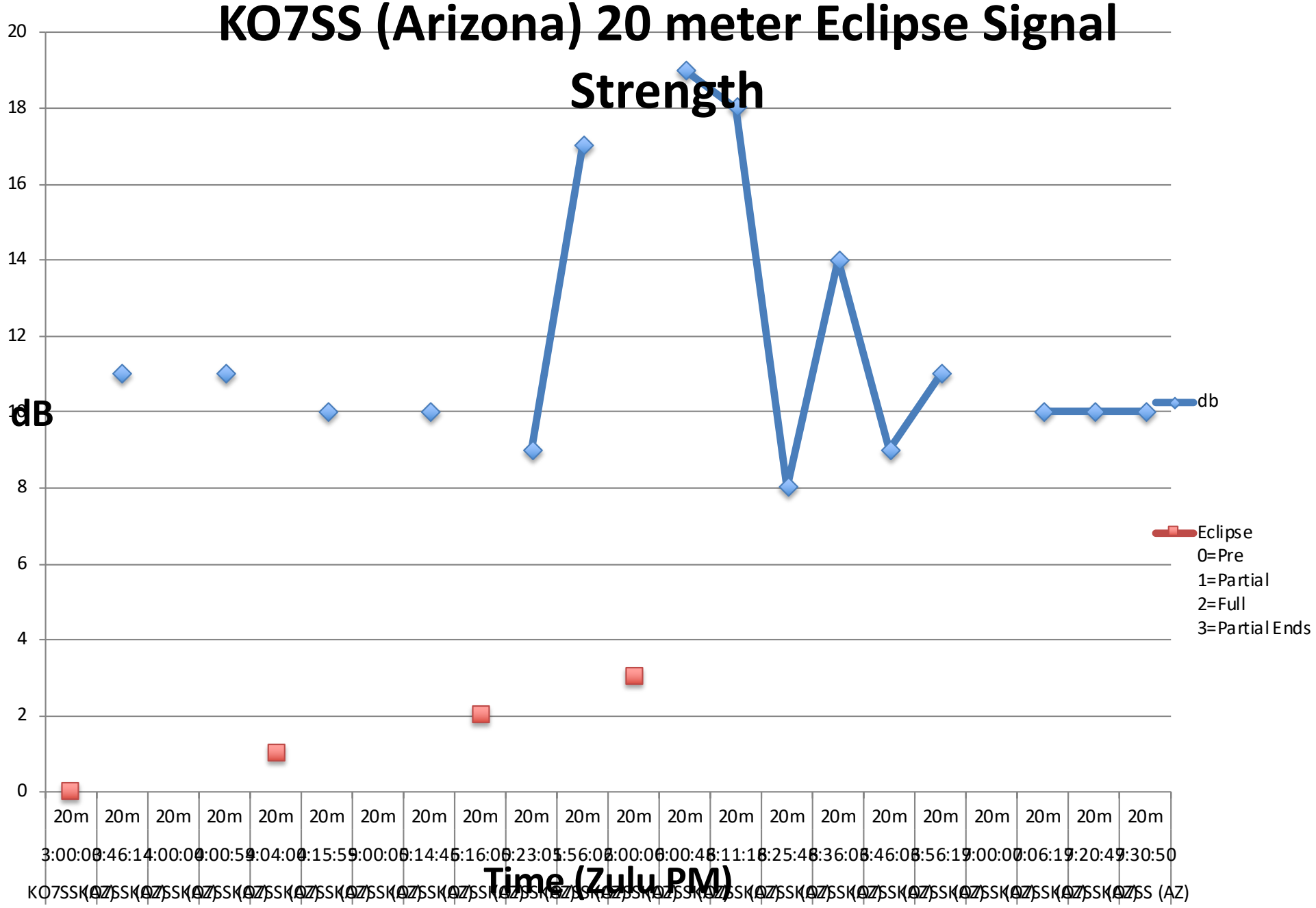


K8ND (Ohio) 20 meter Eclipse Signal Strength

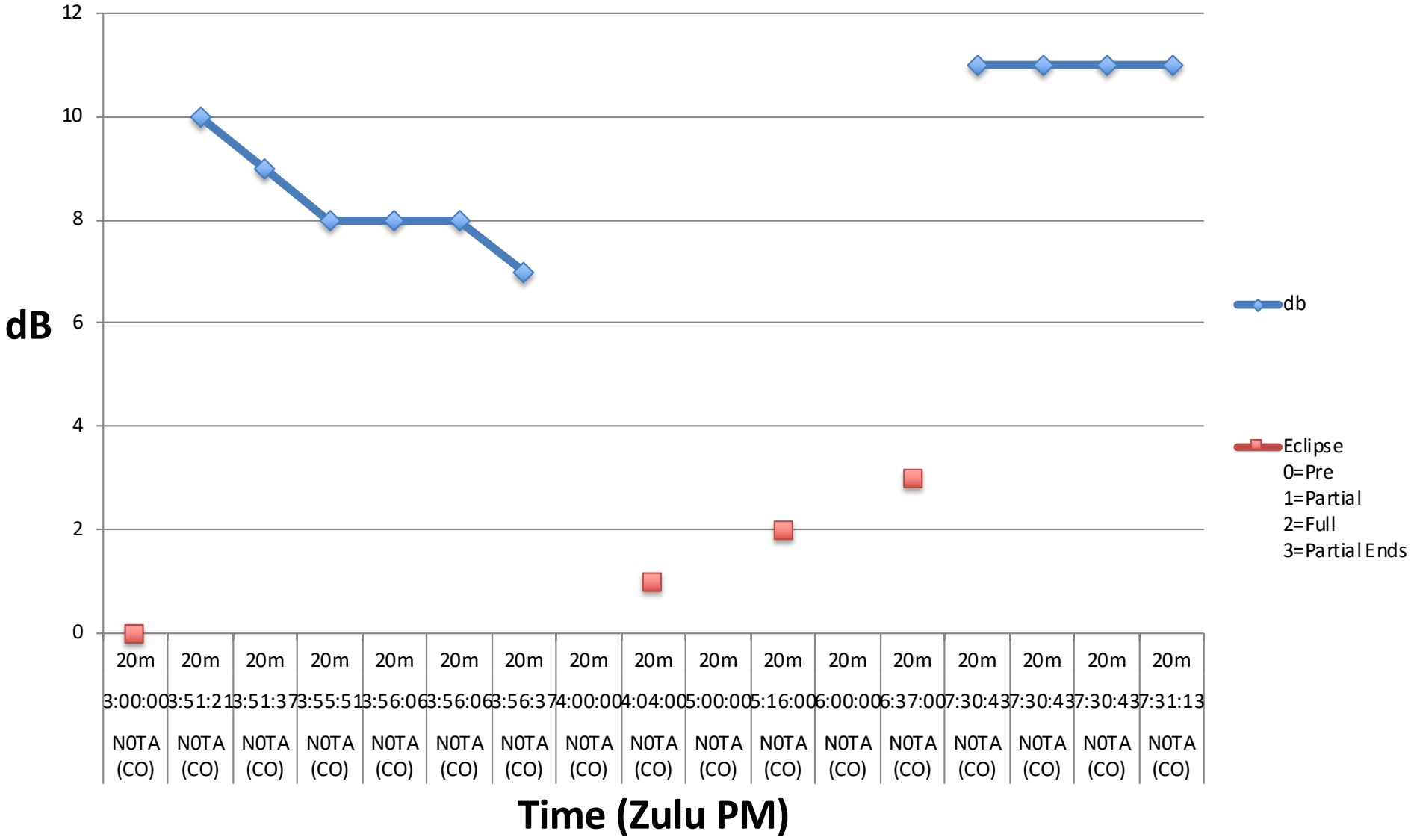


K4FIC (Utah) 20 meter Eclipse Signal Strength

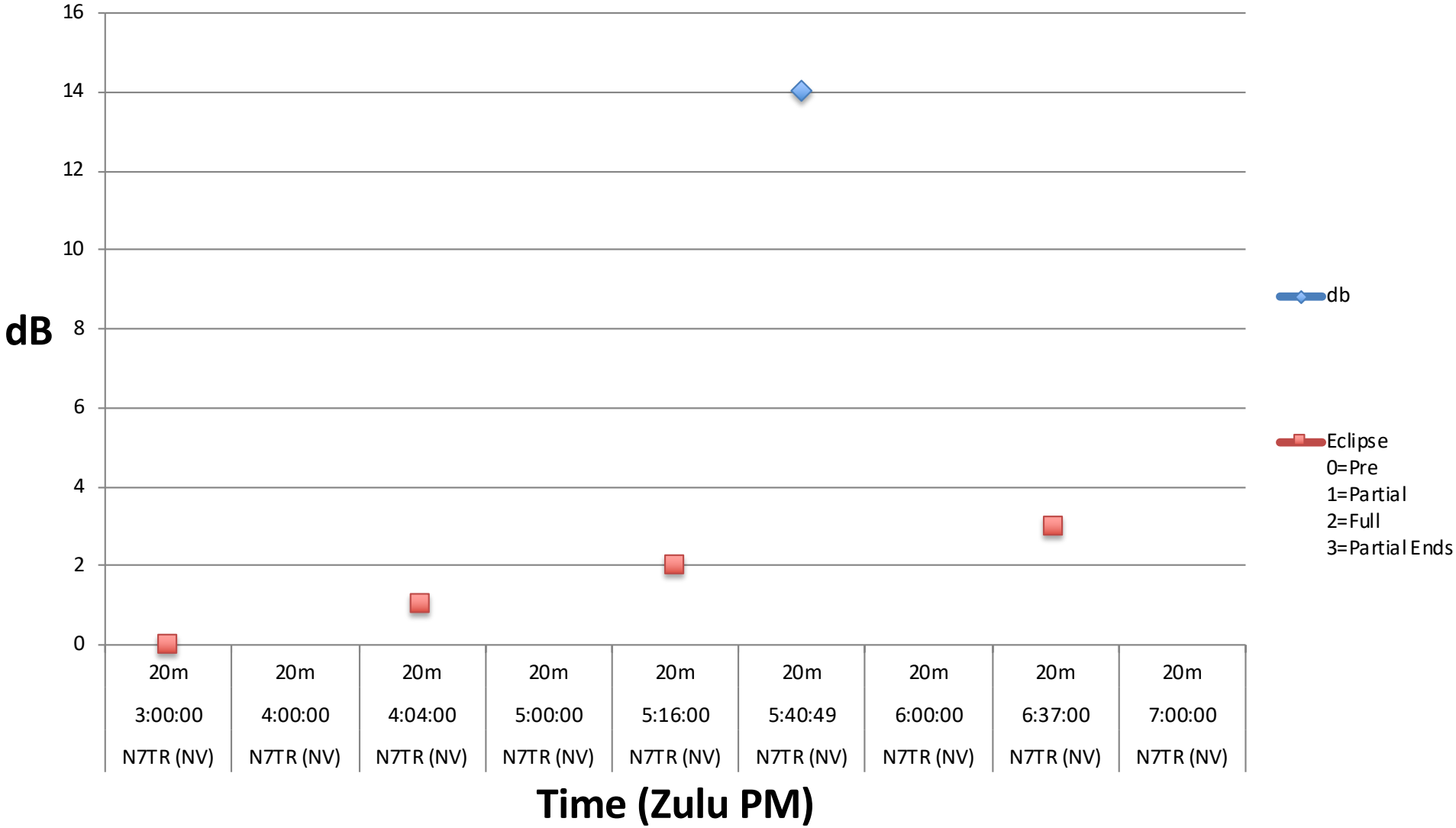


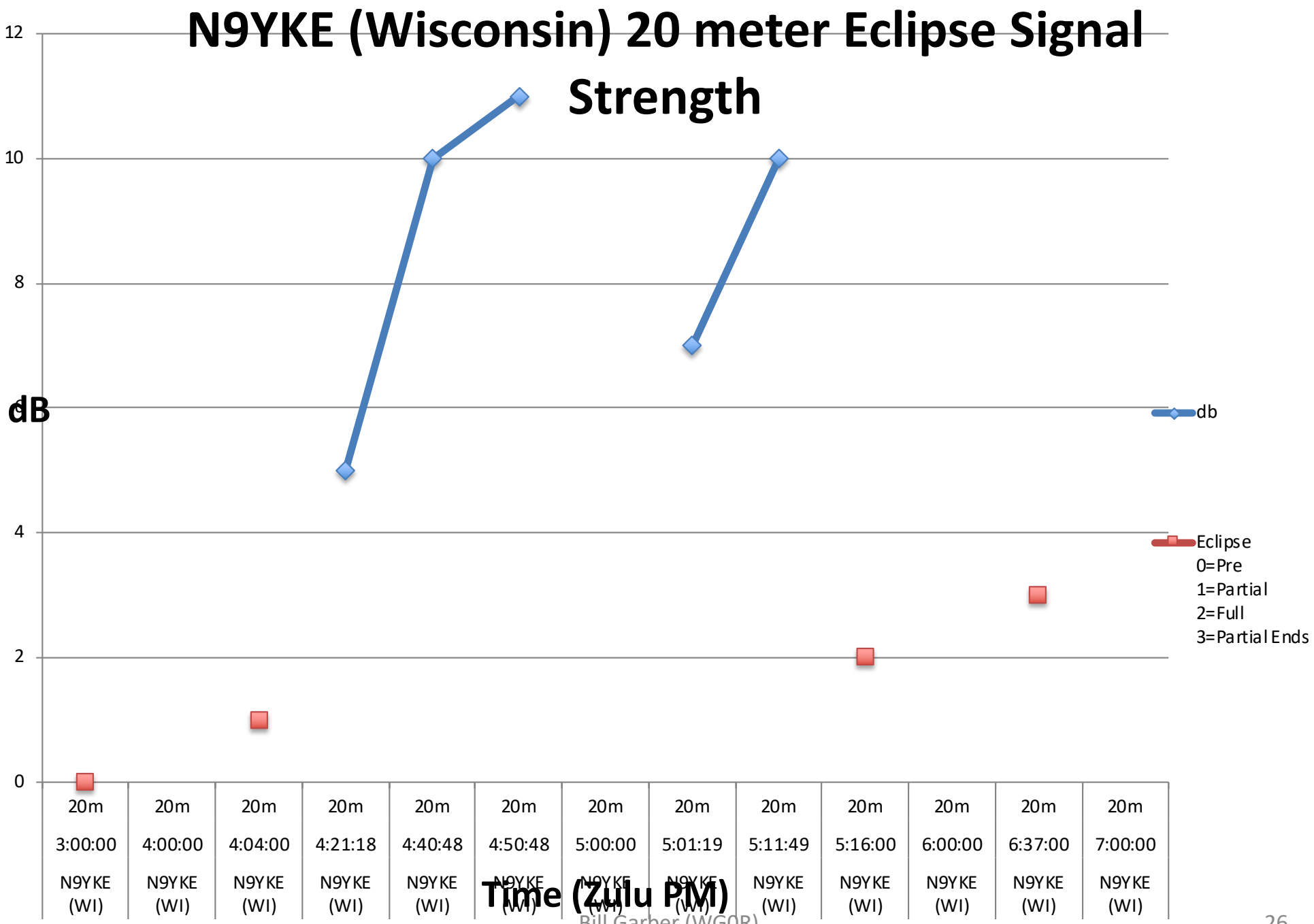

KO7SS (Arizona) 20 meter Eclipse Signal Strength
dB
Time (Zulu PM)
db
Eclipse
0=Pre
1=Partial
2=Full
3=Partial Ends
KO7SS (AZ)

N0TA (Colorado) 20 meter Eclipse Signal Strength

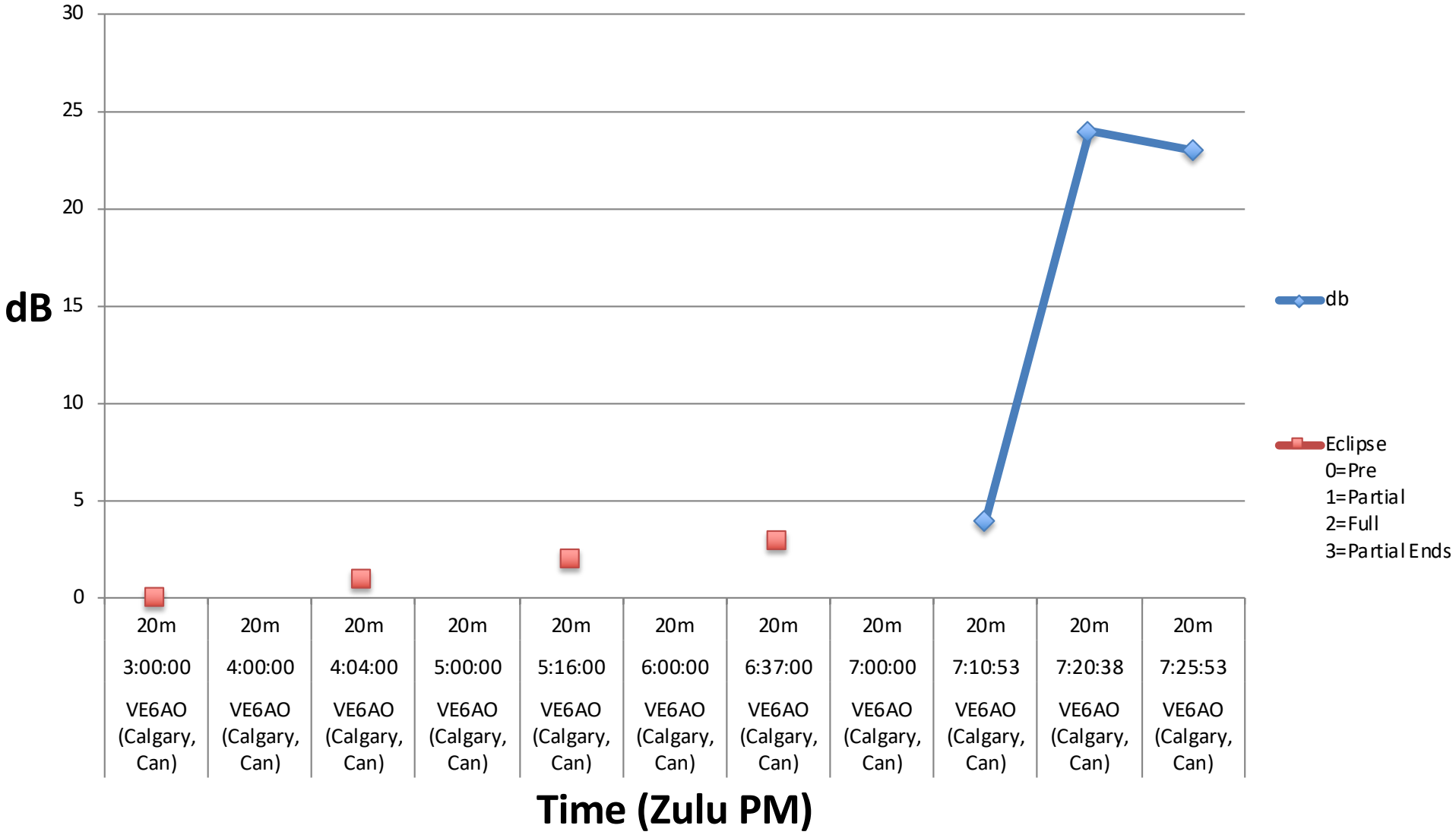


N7TR (Nevada) 20 meter Eclipse Signal Strength

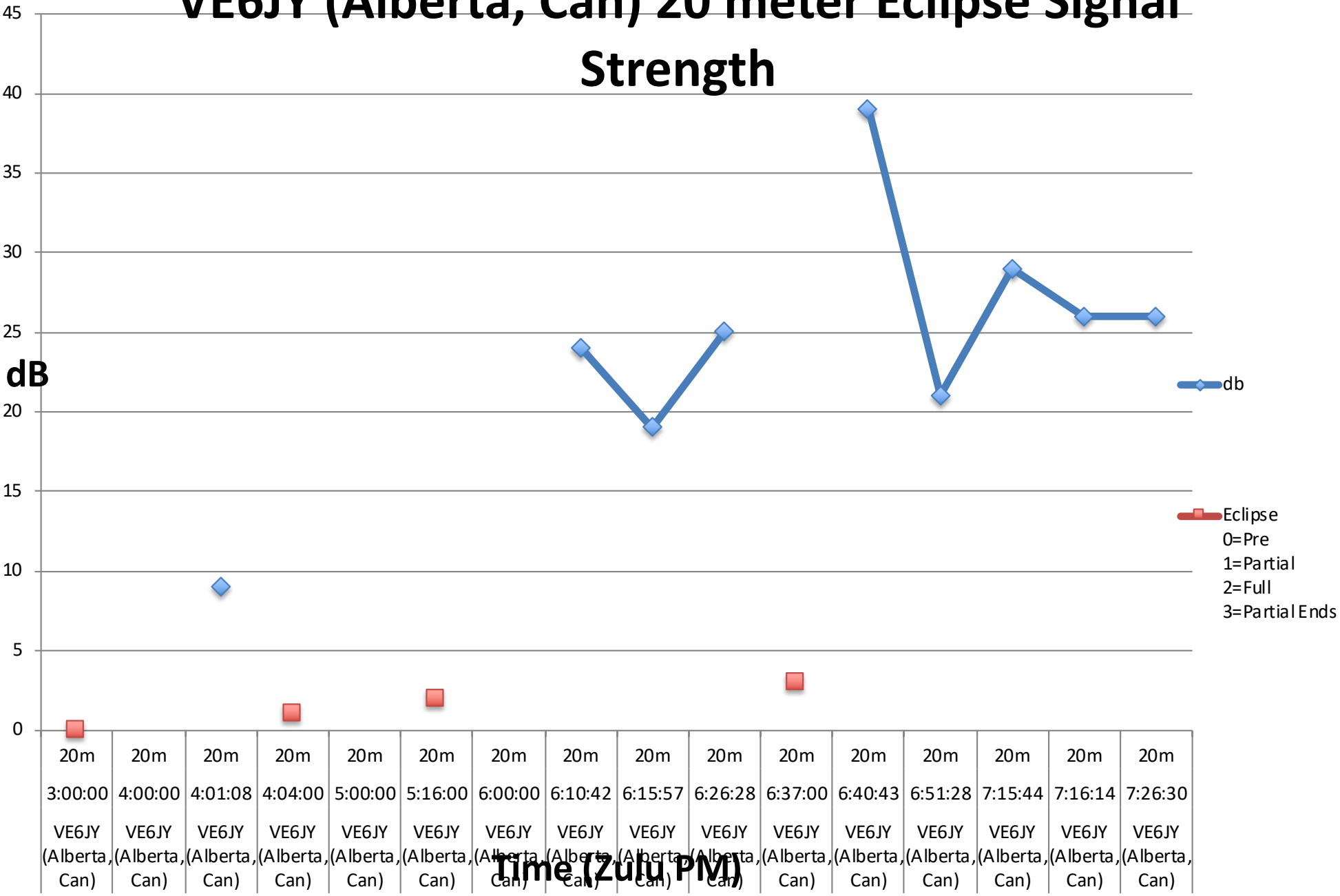



N9YKE (Wisconsin) 20 meter Eclipse Signal Strength
12
10
8
6
4
2
0
dB
db
Eclipse
0=Pre
1=Partial
2=Full
3=Partial Ends
20m 3:00:00 N9YKE (WI)
20m 4:00:00 N9YKE (WI)
20m 4:04:00 N9YKE (WI)
20m 4:21:18 N9YKE (WI)
20m 4:40:48 N9YKE (WI)
20m 4:50:48 N9YKE (WI)
20m 5:00:00 N9YKE (WI)
20m 5:01:19 N9YKE (WI)
20m 5:11:49 N9YKE (WI)
20m 5:16:00 N9YKE (WI)
20m 6:00:00 N9YKE (WI)
20m 6:37:00 N9YKE (WI)
20m 7:00:00 N9YKE (WI)
Time (Zulu PM)

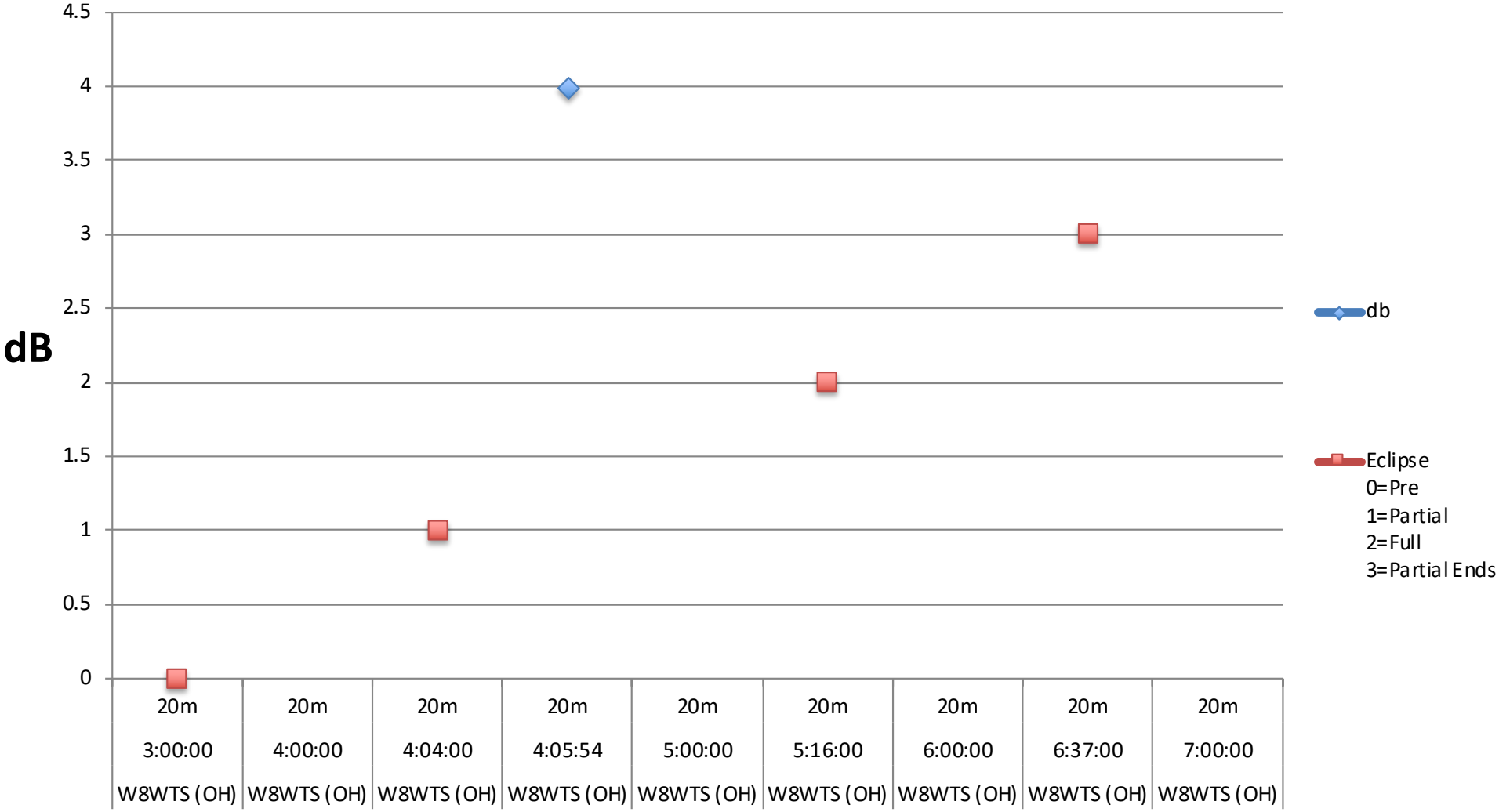
VE6AO (Calgary, Can) 20 meter Eclipse Signal Strength



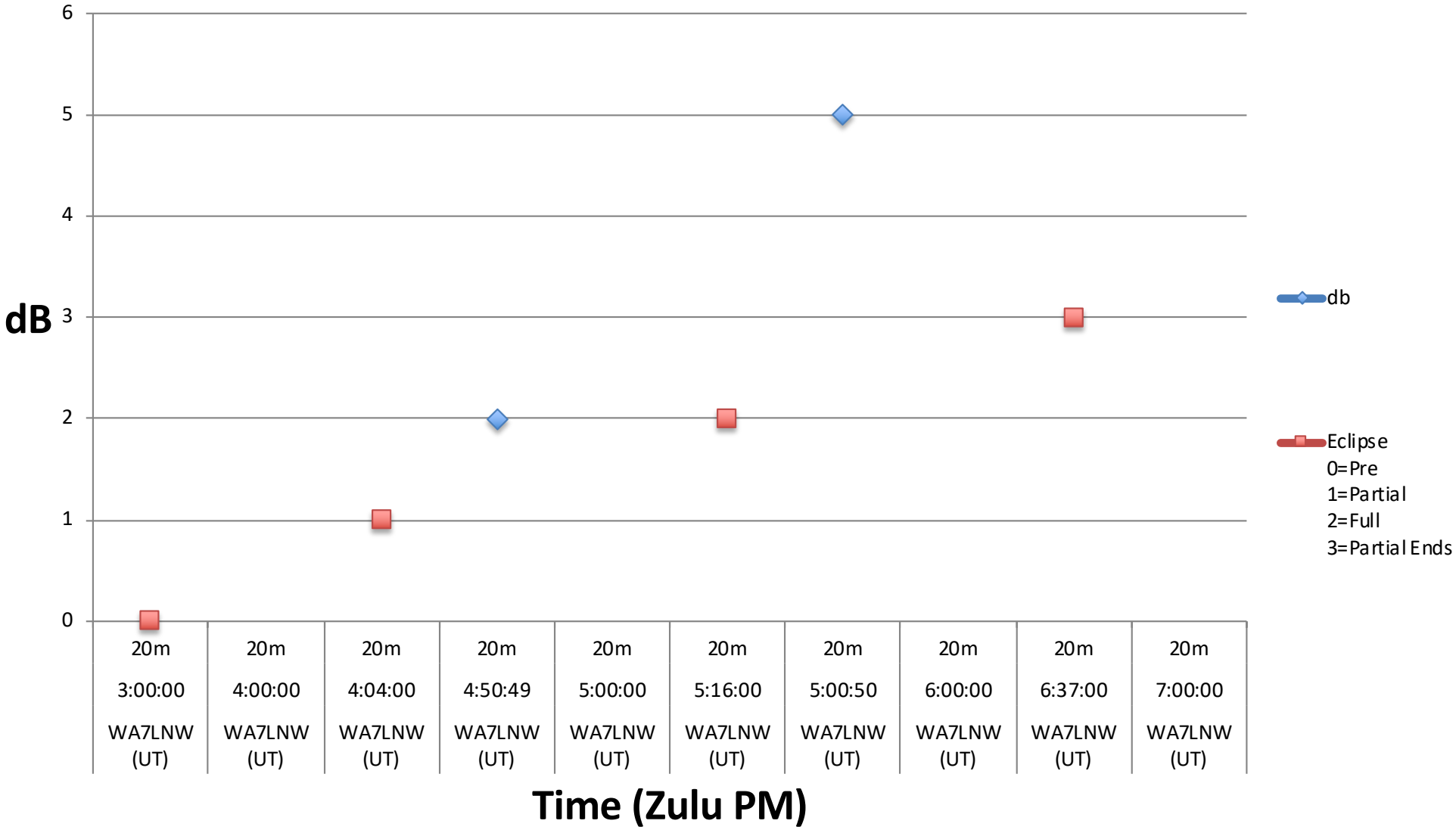
VE6JY (Alberta, Can) 20 meter Eclipse Signal Strength



W8WTS (Ohio) 20 meter Eclipse Signal Strength

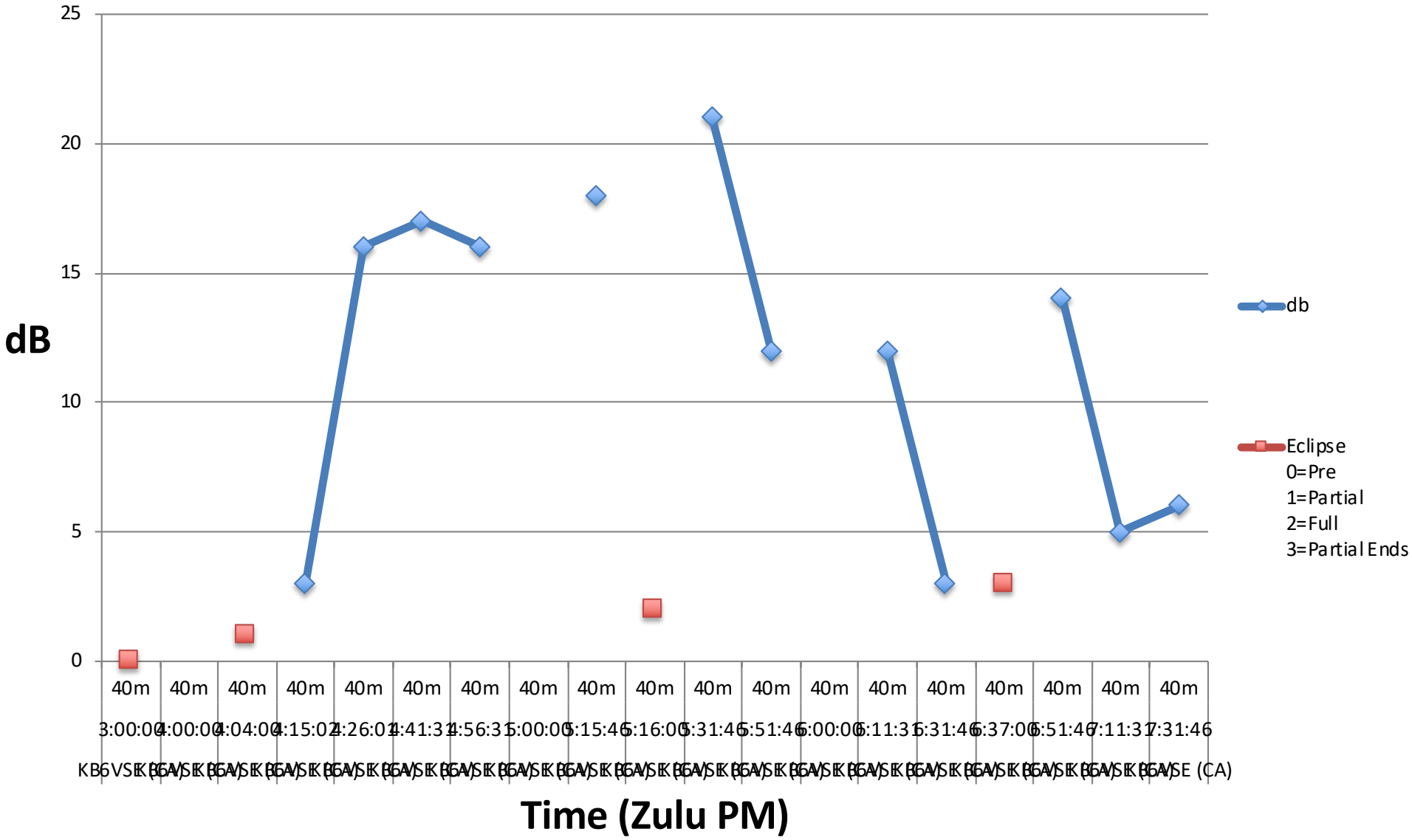


WA7LNW (Utah) 20 meter Eclipse Signal Strength

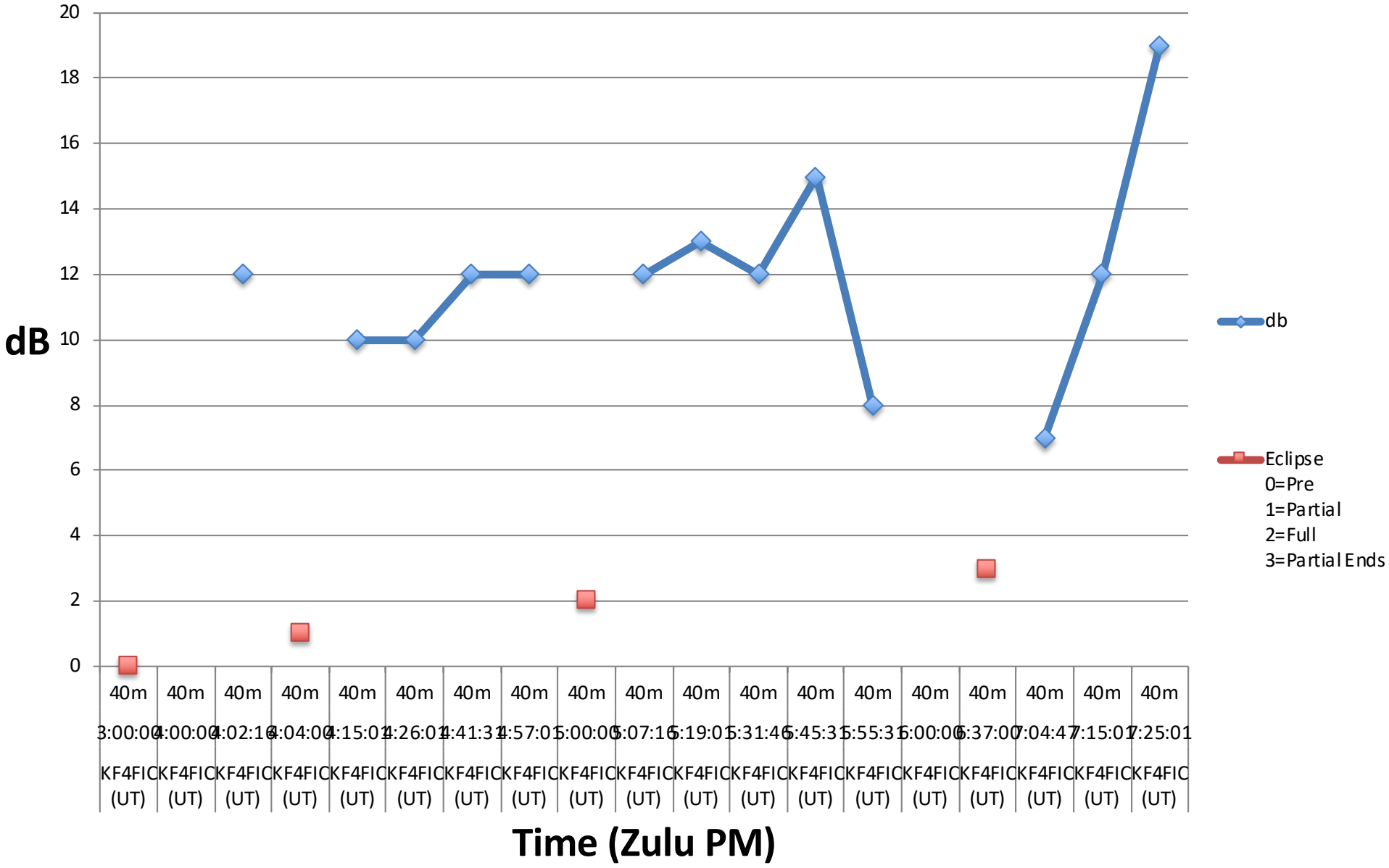


- 40 Meter logs

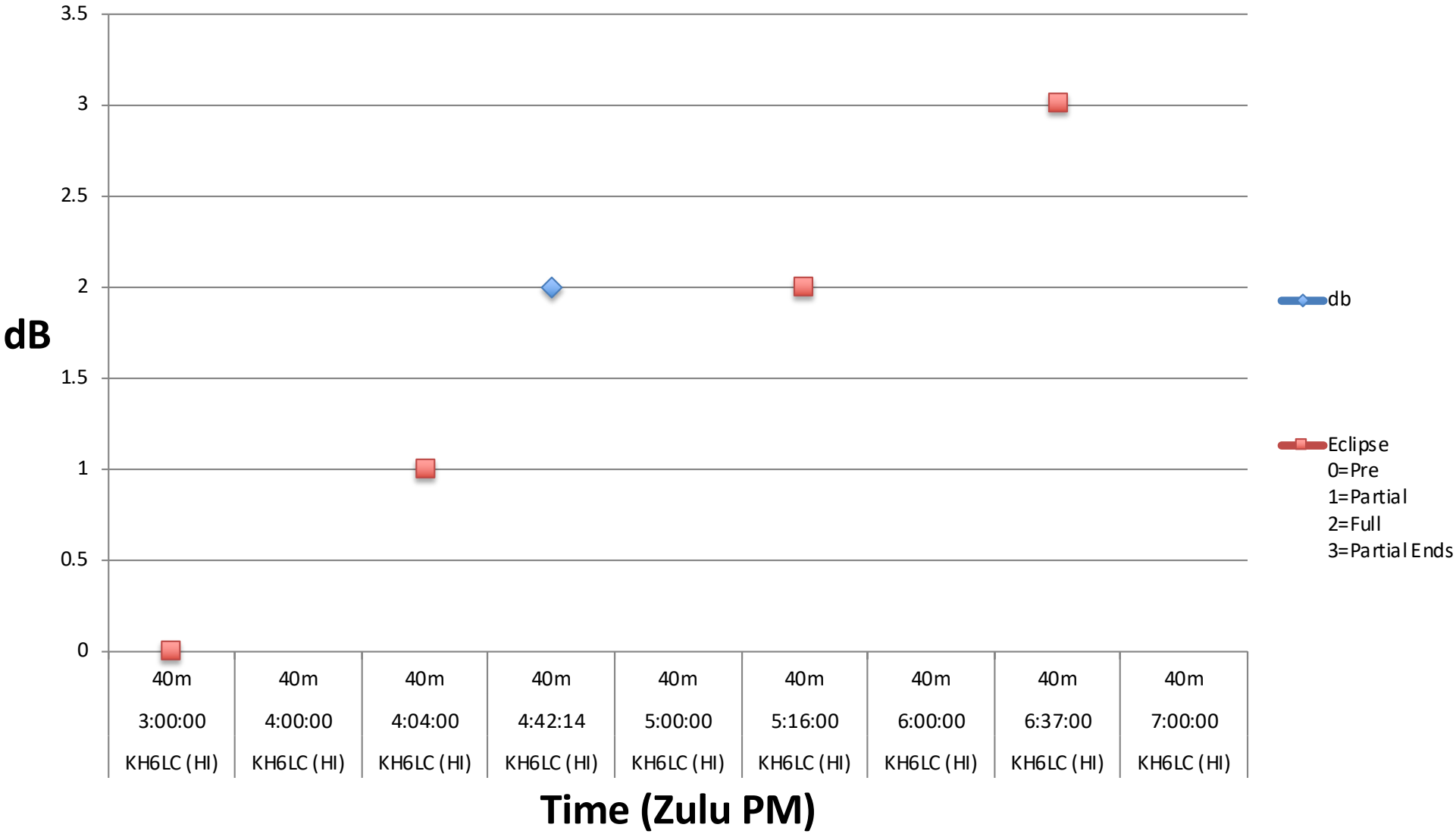
KB6VSE (California) 40 meter Eclipse Signal Strength



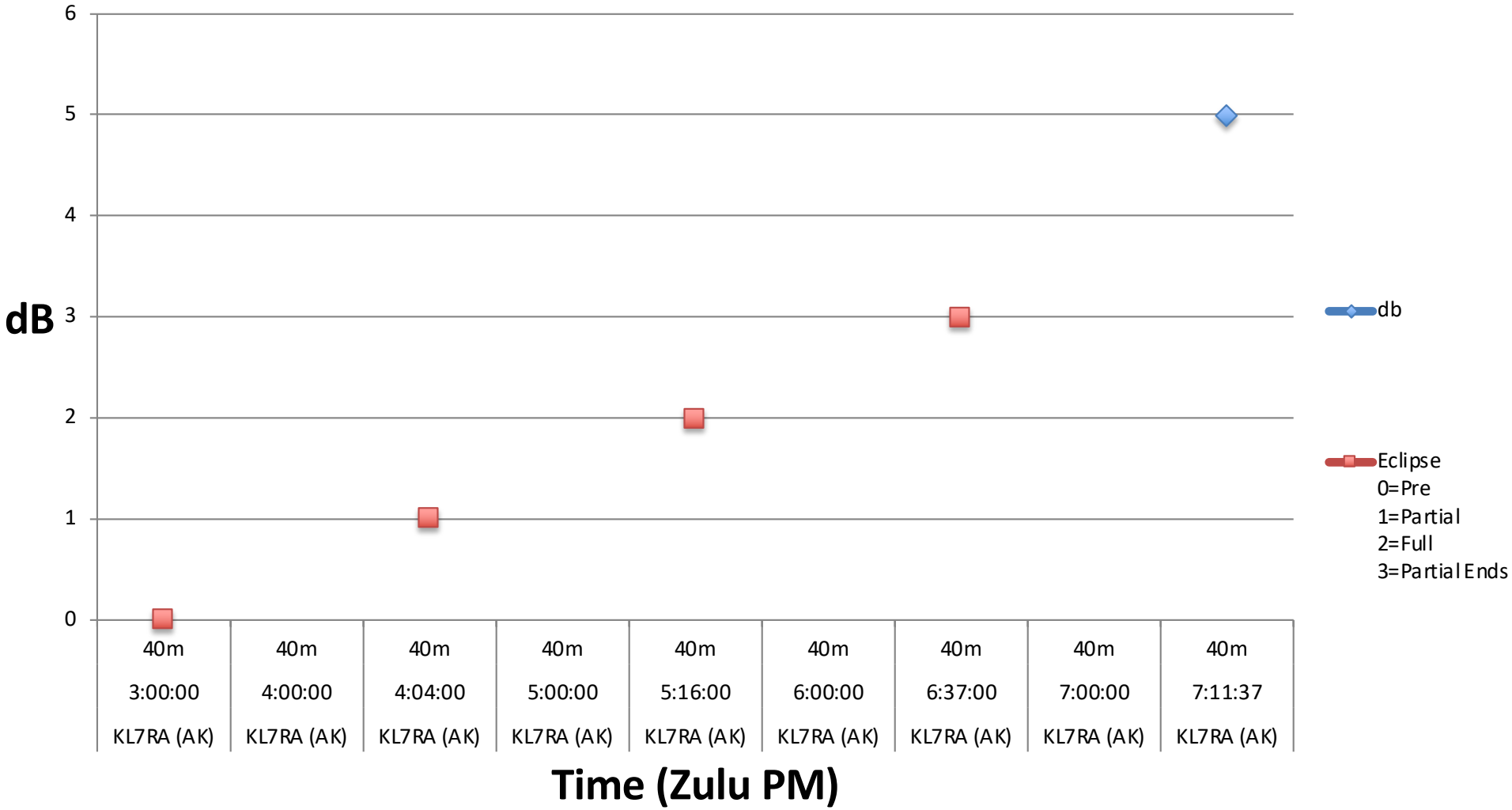
KF4FIC (Utah) 40 meter Eclipse Signal Strength



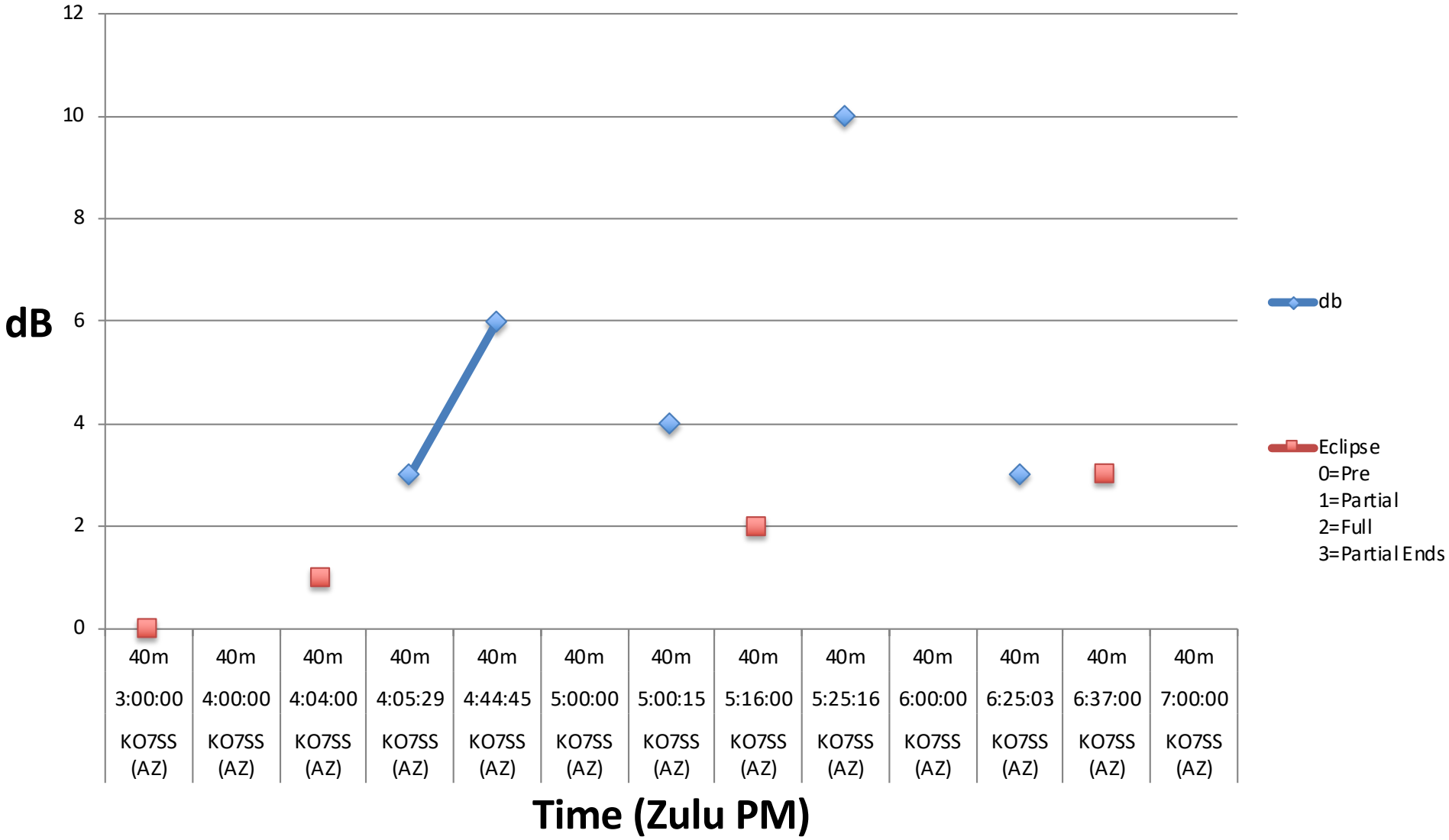
KH6LC (Hawaii) 40 meter Eclipse Signal Strength



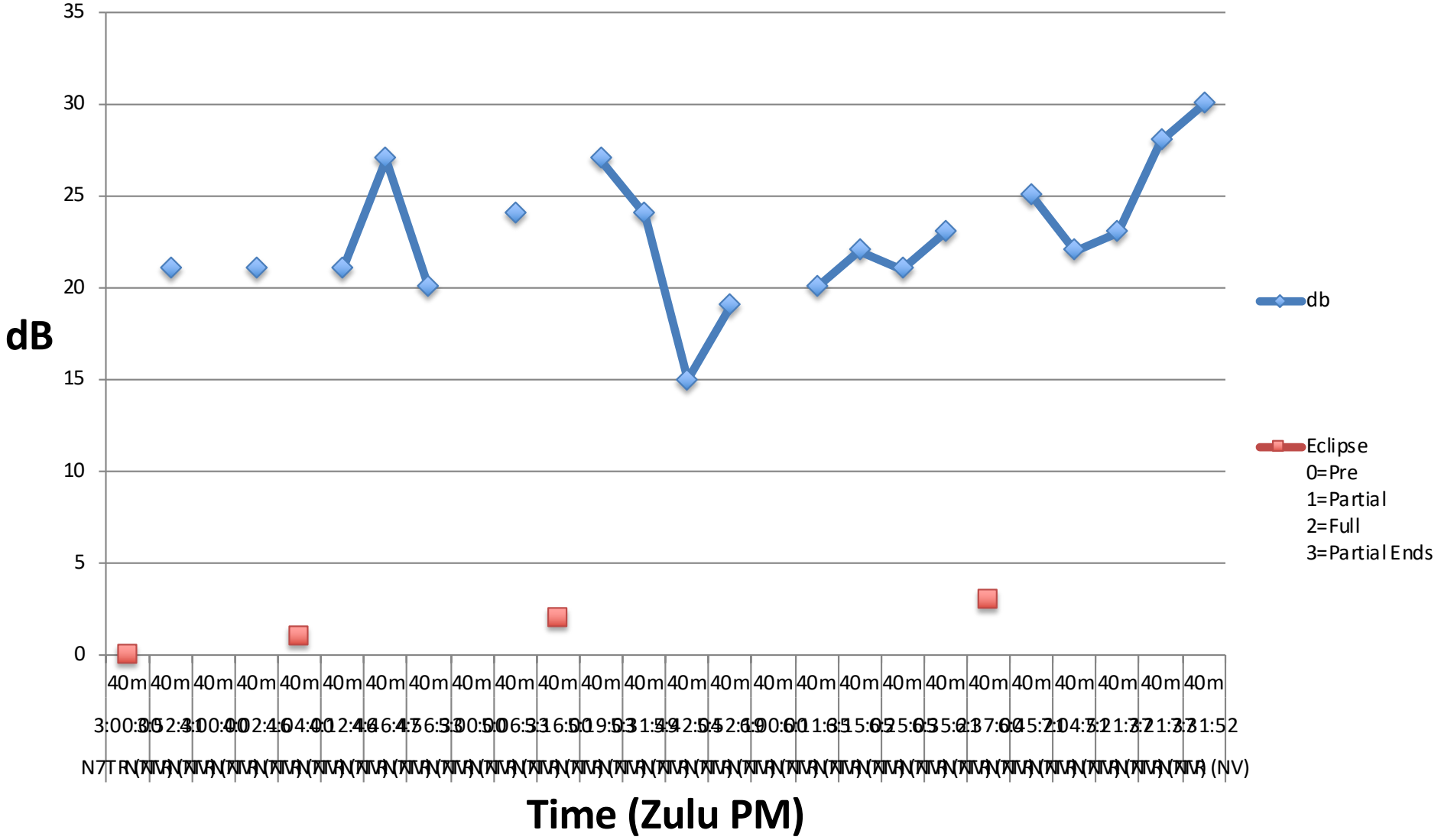
KL7RA (Alaska) 40 meter Eclipse Signal Strength



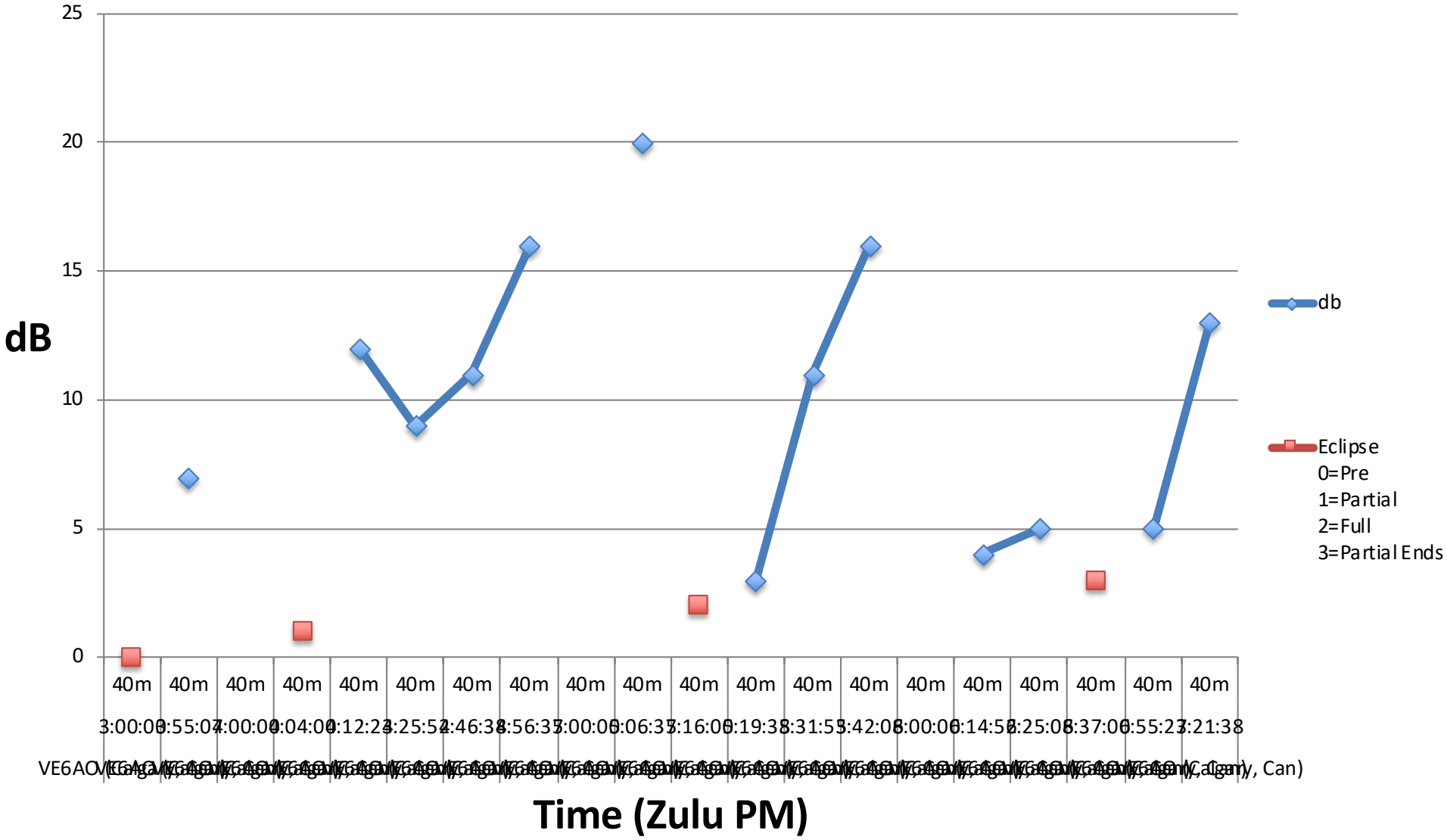
KO7SS (Arizona) 40 meter Eclipse Signal Strength



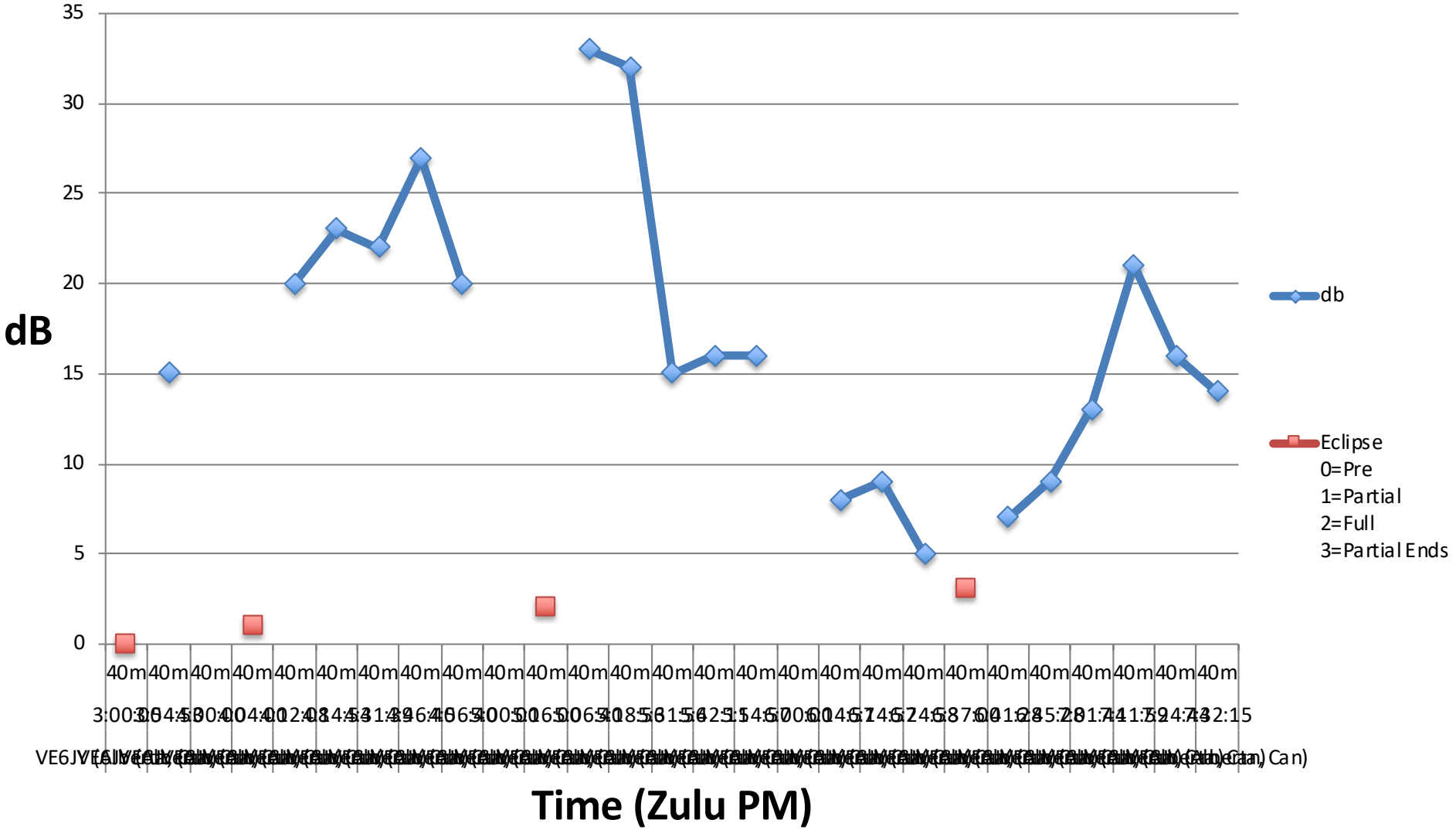
N7TR (Nevada) 40 meter Eclipse Signal Strength



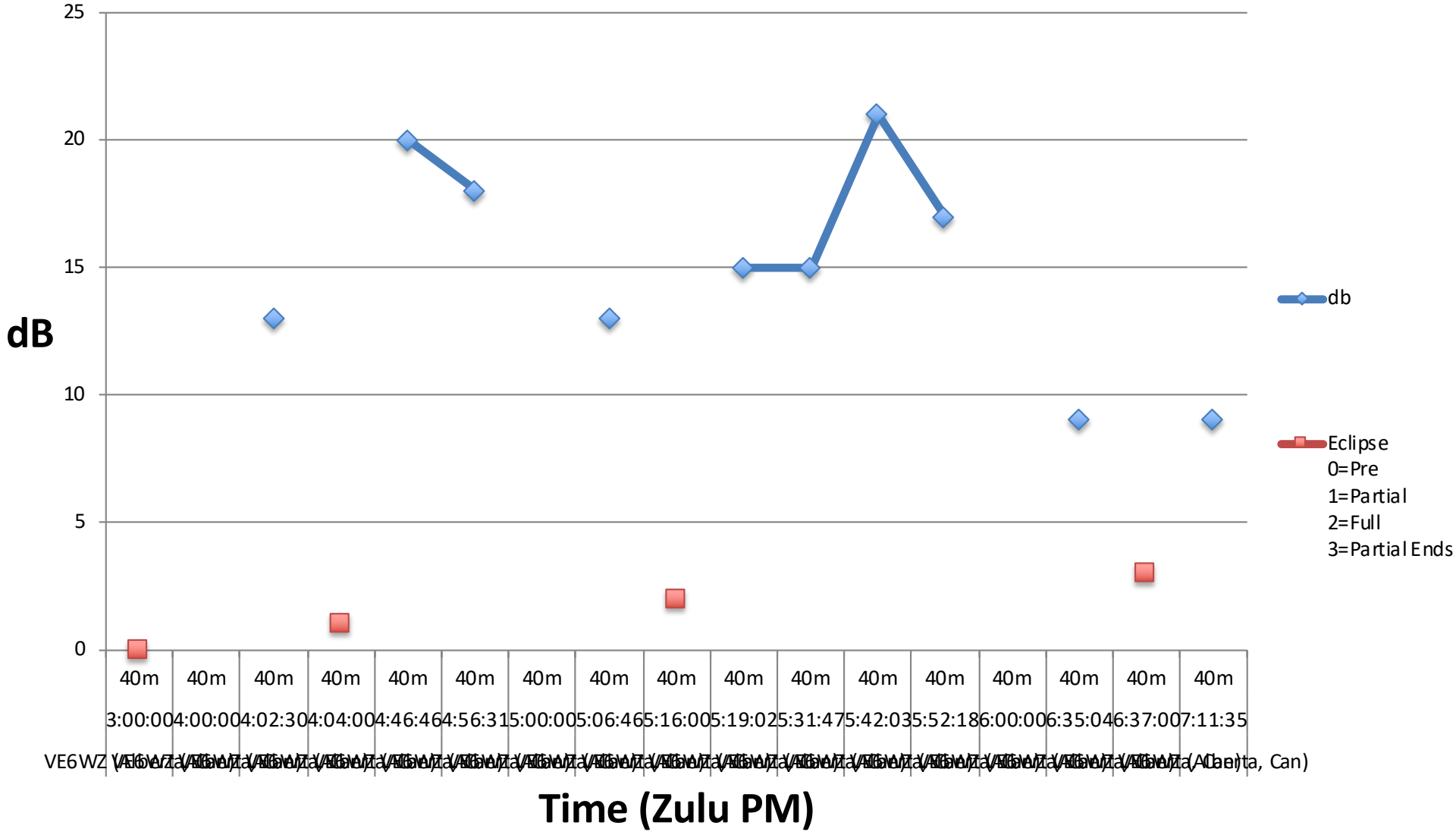
VE6AO (Calgary, Can) 40 meter Eclipse Signal Strength



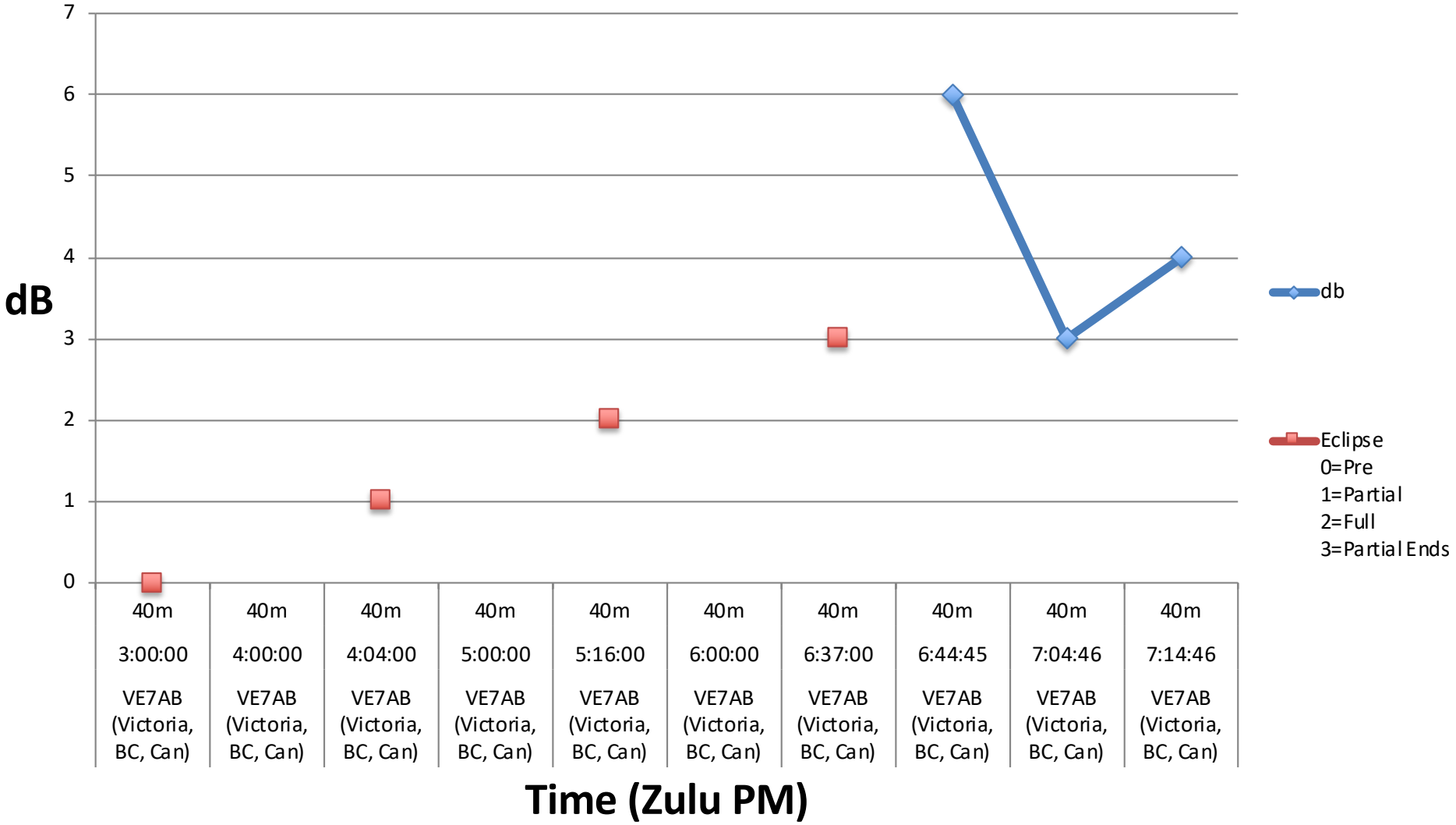
VE6JY (Alberta Can) 40 meter Eclipse Signal Strength



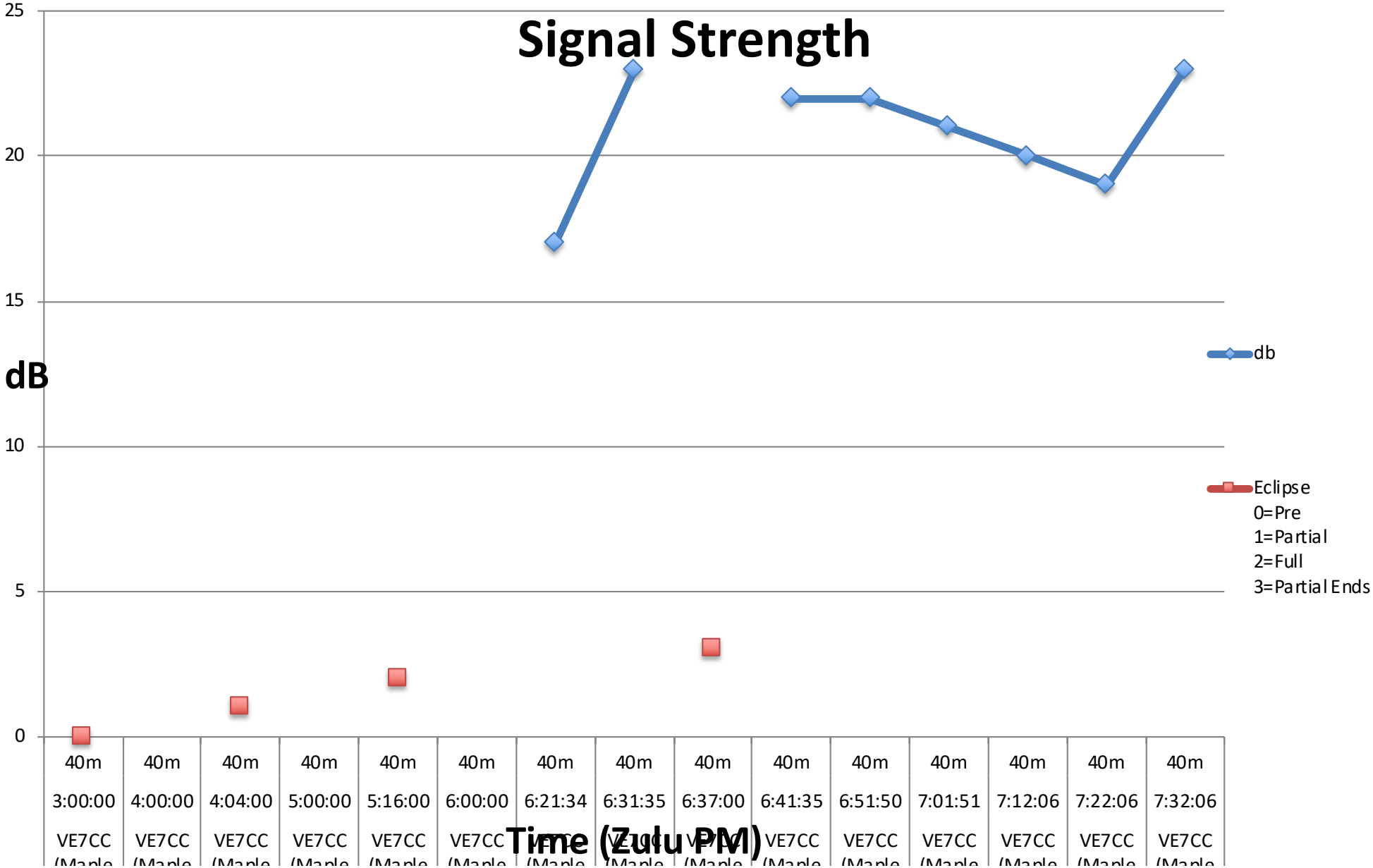
VE6WZ (Alberta, Can) 40 meter Eclipse Signal Strength



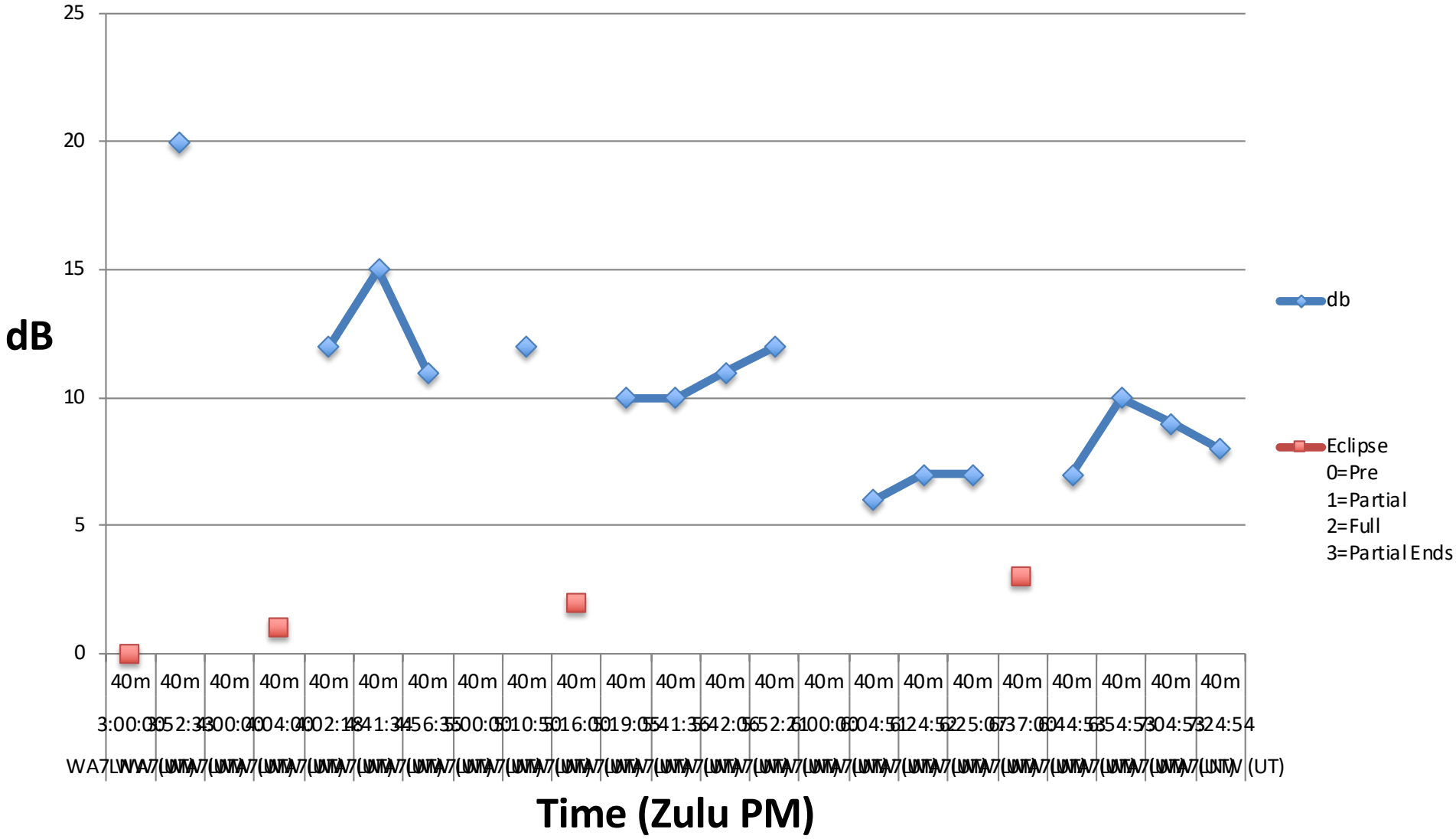
VE7AB (Victoria, Can) 40 meter Eclipse Signal Strength



VE7CC (Maple Ridge, BC, Can) 40 meter Eclipse Signal Strength

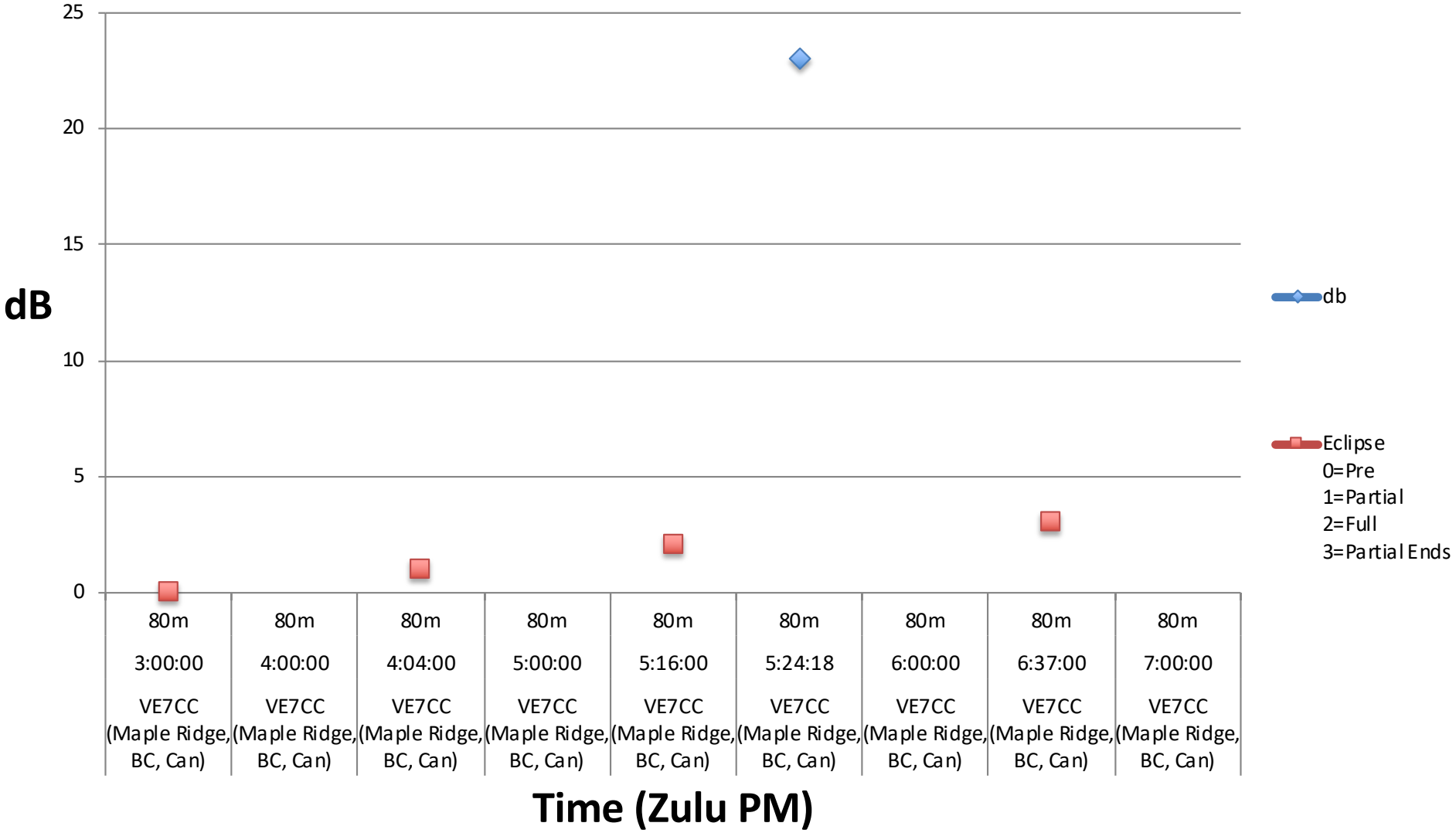


WA7LNW (Utah) 40 meter Eclipse Signal Strength



- 80 Meter log

VE7CC (Maple Ridge, BC, Can) 80 meter Signal Strength



Issues Experienced

- 2 PA Faults
  - Autotuner “hunting” with high SWRs on 17 meters
    - Low Power Supply Voltage (< 9 Volts)
      - Replaced 1 m coiled supply lines with 10 inch
- Running during Totality (2 places at one time)
  - Performed one Totality transmission
- Video not achieved (wanted to get video with IPhone)
  - Did get pre picture with metadata

Results/Observations

- Approximately RBN 150 skimmers online during eclipse
- 17 meters tanked
  - No hits from {4:17} to {6:50} – 2h 33m
- One Colorado station did not receive throughout the Partial period (N0TA, 20m)
- One Wisconsin station was only received during partial period (N9YKE, 20m)
- Another Wisconsin station received low-level signal (3dB), but was stable throughout (K9IMM, 17m)
- Two Canadian stations did not receive until more than ½ hour after eclipse over (VE6AO, 20), VE6WZ, 20)
- Only one hit from several stations:
  - 17m: KS (AC0C), VA (K4KDJ)
  - 20m: CO (K6XT), OH (K8ND), NV (N7TR), OH (W8WTS)
  - 40m: HI (KH6LC), AK (KL7RA)
  - One 80 meter hit on one 80 meter trial (VE7CC)

“One-hit” Phases, Levels

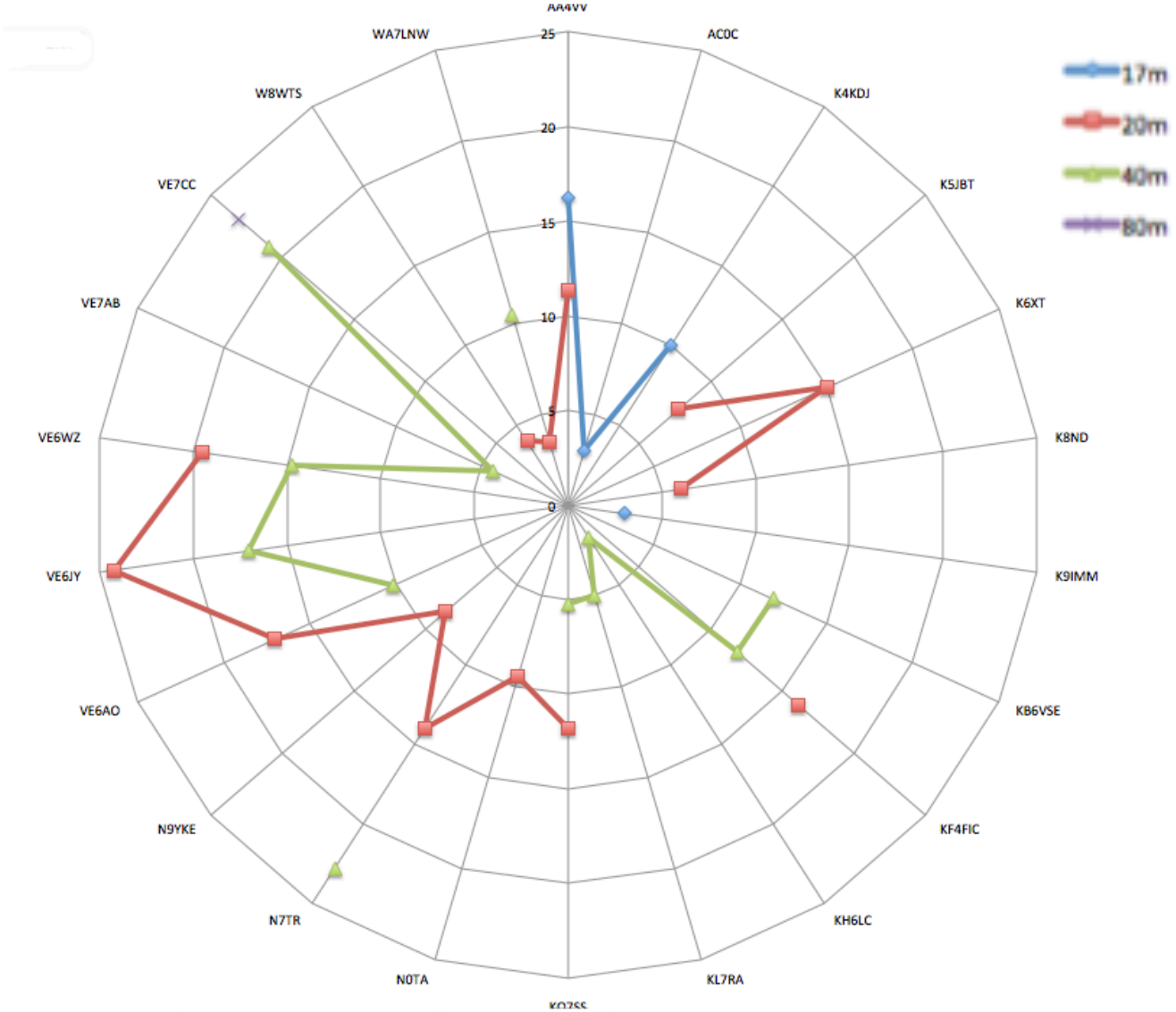
Phase(SingleHit)	db	callsign	count
2 ≤ Phase(SingleHit) ≤ 3	12 ≤ db < 17	N7TR (NV)	1
2 ≤ Phase(SingleHit) ≤ 3	2 ≤ db < 7	AC0C (KS)	1
〃	〃	K8ND (OH)	1
〃	〃	KL7RA (AK)	1
1 ≤ Phase(SingleHit) < 2	12 ≤ db < 17	K6XT (CO)	1
〃	2 ≤ db < 7	KH6LC (HI)	1
〃	〃	W8WTS (OH)	1
0 ≤ Phase(SingleHit) < 1	10 ≤ db < 12	K4KDJ (VA)	1

- All but one was during the eclipse
- All levels were at or below 17 dB
- Even though low-level, are they significant because they were hits at all? (Eclipse opened channels, even though they were not robust)

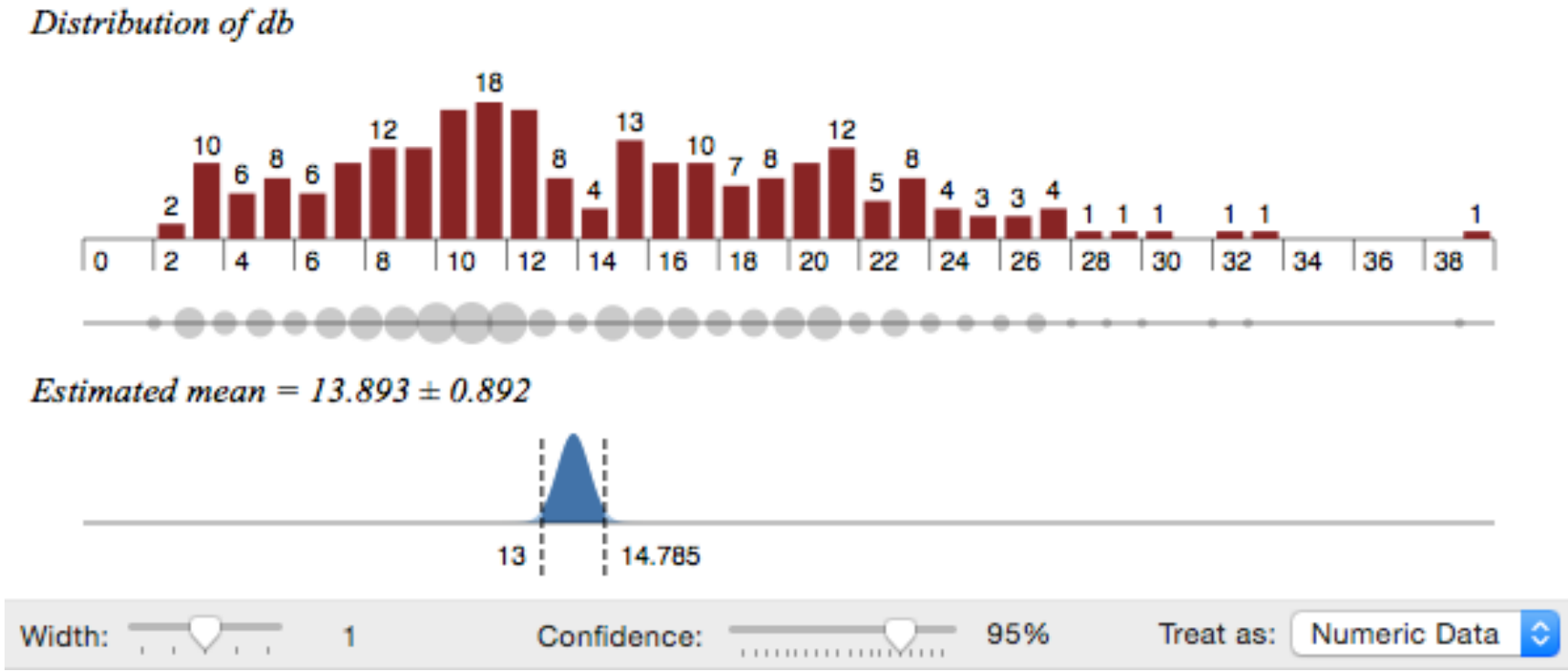
Station Logs Into RBN

count	Callsign	Bearing (Deg)
32	KF4FIC (UT)	102.8 ≤ Bearing (Deg) < 117
30	AA4VV (NC)	82.2 ≤ Bearing (Deg) < 102.8
29	VE6JY (Alberta, Can)	6.5 ≤ Bearing (Deg) < 35.9
20	KO7SS (AZ)	117 ≤ Bearing (Deg) < 152
20	N7TR (NV)	152 ≤ Bearing (Deg) ≤ 357.2
18	WA7LNW (UT)	117 ≤ Bearing (Deg) < 152
16	VE6AO (Calgary, Can)	35.9 ≤ Bearing (Deg) < 82.2
12	KB6VSE (CA)	152 ≤ Bearing (Deg) ≤ 357.2
12	VE6WZ (Alberta, Can)	35.9 ≤ Bearing (Deg) < 82.2
10	N0TA (CO)	102.8 ≤ Bearing (Deg) < 117
9	VE7CC (Maple Ridge, BC, Can)	6.5 ≤ Bearing (Deg) < 35.9
7	K5JBT (TX)	102.8 ≤ Bearing (Deg) < 117
5	N9YKE (WI)	35.9 ≤ Bearing (Deg) < 82.2
3	K9IMM (WI)	82.2 ≤ Bearing (Deg) < 102.8
3	VE7AB (Victoria, BC, Can)	152 ≤ Bearing (Deg) ≤ 357.2
1	AC0C (KS)	82.2 ≤ Bearing (Deg) < 102.8
1	K4KDJ (VA)	82.2 ≤ Bearing (Deg) < 102.8
1	K6XT (CO)	117 ≤ Bearing (Deg) < 152
1	K8ND (OH)	82.2 ≤ Bearing (Deg) < 102.8
1	KH6LC (HI)	152 ≤ Bearing (Deg) ≤ 357.2
1	KL7RA (AK)	152 ≤ Bearing (Deg) ≤ 357.2
1	W8WTS (OH)	35.9 ≤ Bearing (Deg) < 82.2

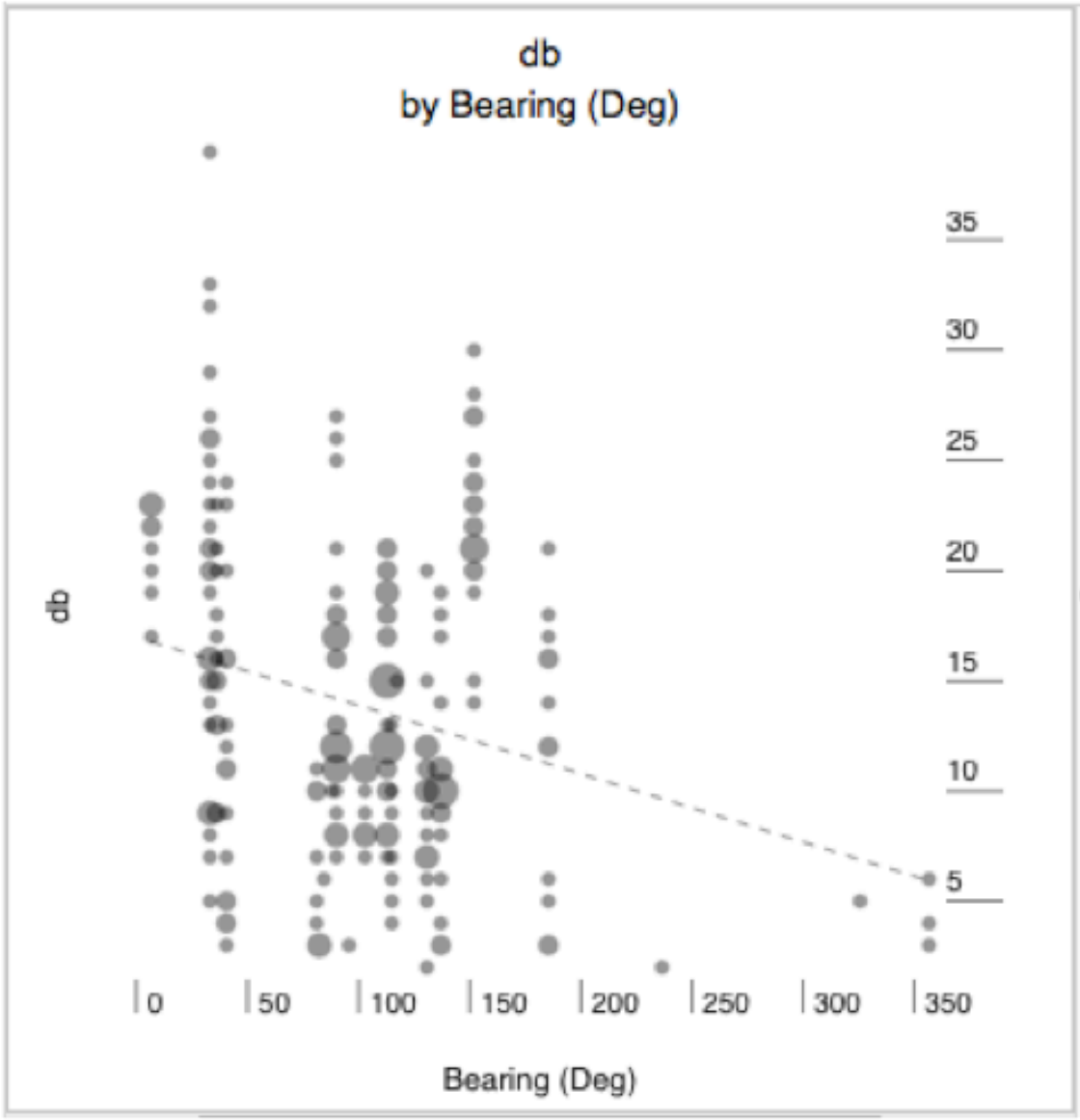
Station Logs by Station/Band



Distribution of “Skimmer” dB

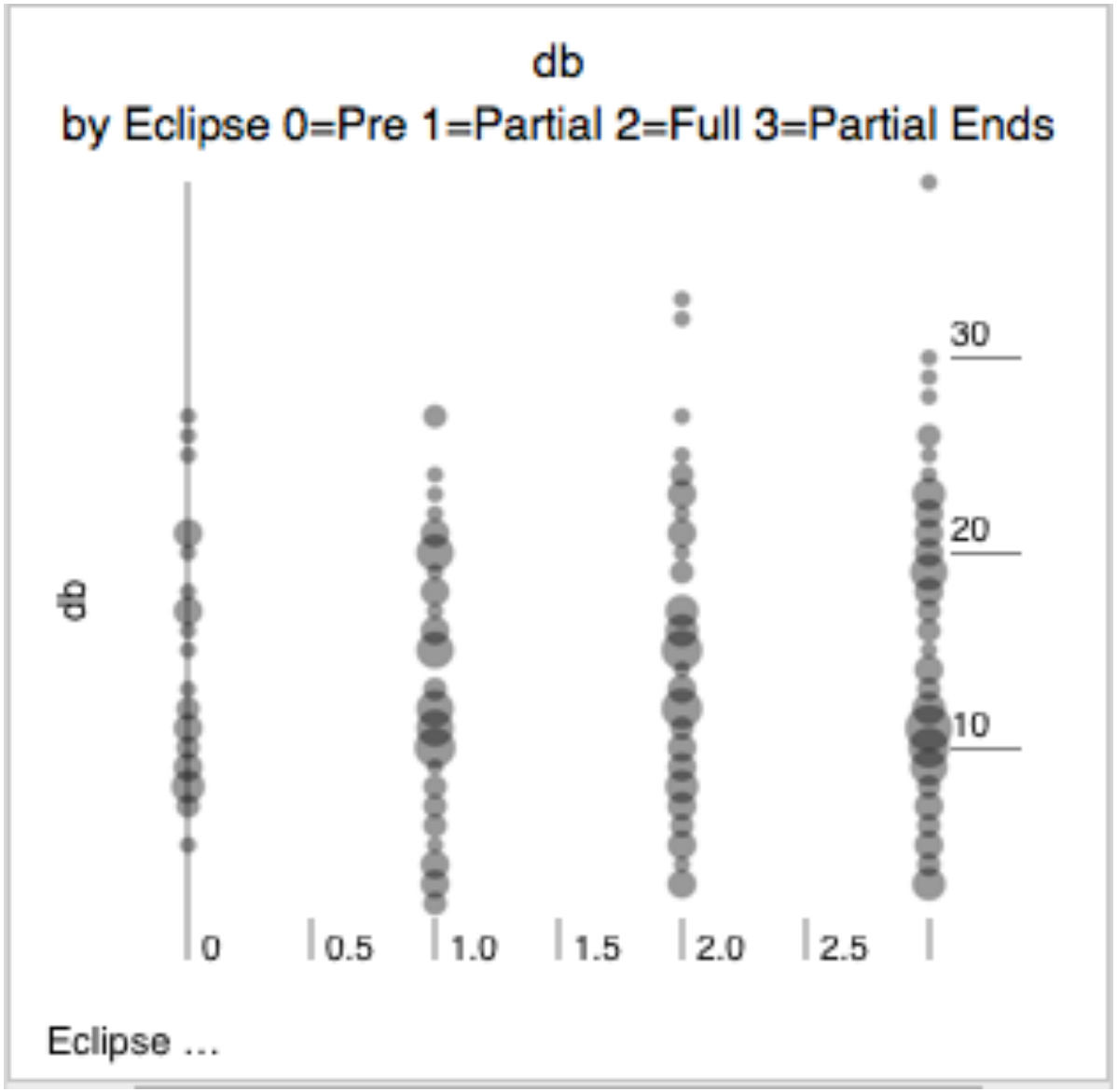


Db By Bearing



Antenna: Carolina Windom @ 30 ft AGL, strung @ 150/330 degrees

dB By Eclipse Phase



Caveats

- Skips in receiving may be caused by skimmers being offline for periods of time (Probably not a factor, but is a possibility)
- Potentially “Outgunned” by the “Big Guns” in pileups

Post-mortem

- In retrospect, I would:
- Shorten my message to just the “TEST” and callsign
  - reduce the transmission time, and explore the other two lower bands that the transceiver can work on (80 and 160)
    - My antenna is not too effective on those two
      - » 160 has lots of noise, being in the city
      - » It would have been good to see how they reacted
      - » Those two bands were expected to be the most impacted

Follow-on/other Actions/Possibilities

- Have contacted Oregon State Statistics Chair and asked if they take on “Citizen” projects. She may pursue if someone wants to take on this as a project.
  - No takers
- I might look more globally at other stations RBN data
- Have forwarded this presentation to Dr. Tamitha Scov (SpaceWeatherWoman.com)
  - She gives solar weather reports on Ham Nation routinely.

ARRL Analyses

- 670,000 spots into RBN
- Will be interesting if the statisticians can find a successful model of what went on globally during the eclipse, with the aid of Space Weather experts.
- Other analyses, as well (542,000 spots into PSKReporter)

Speculations

- The single-spot logs hint at the propagation activity being raised due to the eclipse, even though the signal strengths were marginal. Significant?
- The short duration exposed only a short window into what happens in normal daily ionospheric activity (Only a short portion of the "time constant" exposed)
  - Day/Night transitions in eclipse too short to catch the actual properties of normal propagation
- Activity related to eclipse likely went on for more than the 3:45 hour experiment
- What caused some stations to receive significant signals as the moon started to block the sun and to decouple from the sun?

Conclusions

- Some bands and paths were enhanced, others diminished
- Interesting, mind-boggling stuff!
- As usual, more questions than answers!
- RBN is a useful tool for signal propagation analysis
  - Straightforward exporting of daily raw data

Post-2017 Eclipse Experiment Analysis (During COVID-19 Social Distancing)

April, May 2020

2017 Results/Observations From the Prior Experiment Summary

- Approximately 150 Reverse Beacon Network "skimmers" online during eclipse
- 17 meters tanked
  - No hits for 2h 33m (67% of Experiment Time)
- One Colorado station did not receive throughout the Partial eclipse Period on 20m
- One Wisconsin station was only received during partial Eclipse period on 20m
- Another Wisconsin station received low-level signal (3dB), but was stable when received on 17m (Only one time before eclipse and two after the eclipse)
- Two Canadian stations did not receive until more than ½ hour after eclipse over on 20m
- Only one hit from several stations:
  - 17m: KS (AC0C), VA (K4KDJ)
  - 20m: Colorado, Ohio (2 stations), Nevada
  - 40m: Hawaii, Alaska
  - One 80 meter hit on one 80-meter trial. (The only 80m transmission made.)

2017 Speculations About Results

- The single-spot logs hint at the propagation activity being raised significantly due to the eclipse, even though the signal strengths were marginal.
- The short experiment duration exposed only a short window into what happens in normal daily ionospheric activity (Only a short portion of the natural, daily "time constant" exposed)
  - The short "Day/Night transitions" in the eclipse were too short to catch the actual properties of normal daily propagation.
- Activity related to eclipse likely went on for lot longer than the 3:51 hour experiment. (Thought in 2020: The Time Constant for decay may be longer than the rising "impulse" time, possibly due to the atmosphere being in an excited state.)
- What caused some "skimmer" stations to receive significant signals as the moon started to block the sun and to decouple from the sun?
  - SIGNIFICANT signal peaks occurred as the Moon and Sun began coupling and when separating from each other.

Techniques deployed in 2020 Analysis

"R" program used

- 1) Principal Components Analysis (PCA)
- 2) Cluster Analysis (CA)
- 3) Regression Analysis (RA)
- 4) Plots

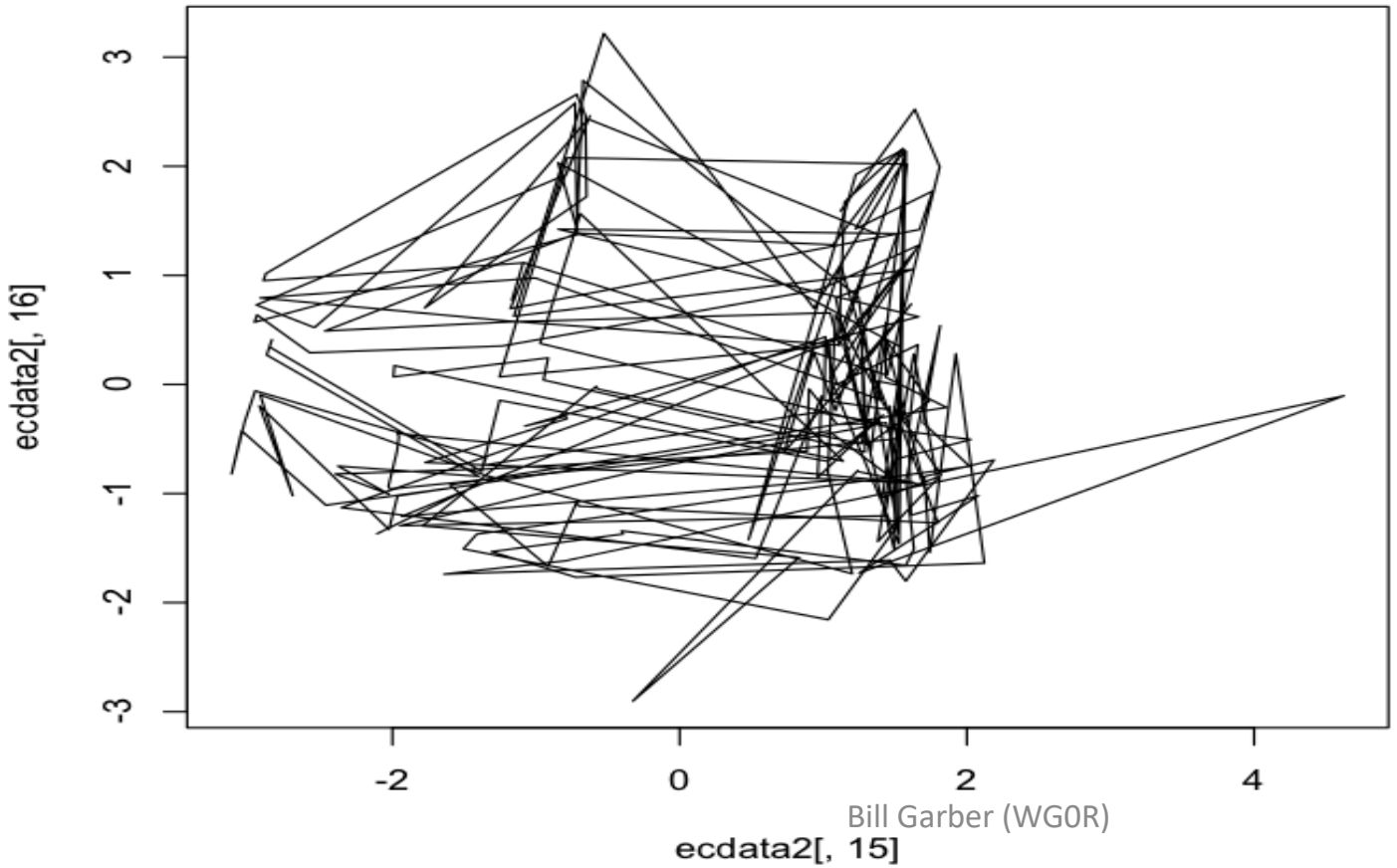
“R” Program

- Used a statistical package called “R”
  - Free
  - Open Source
  - Many built-in Statistical methods
  - Helps to discover patterns in the data
  - Helps to separate correlations between variables
  - Does not require extensive coding
    - Many procedures are one-line calls to R implementations

A Tour Through the Experiment Space

(plot of data correlation results from time(1) to time(231)

Gives some overview of the density and pattern of the data, but how can the data be unscrambled?

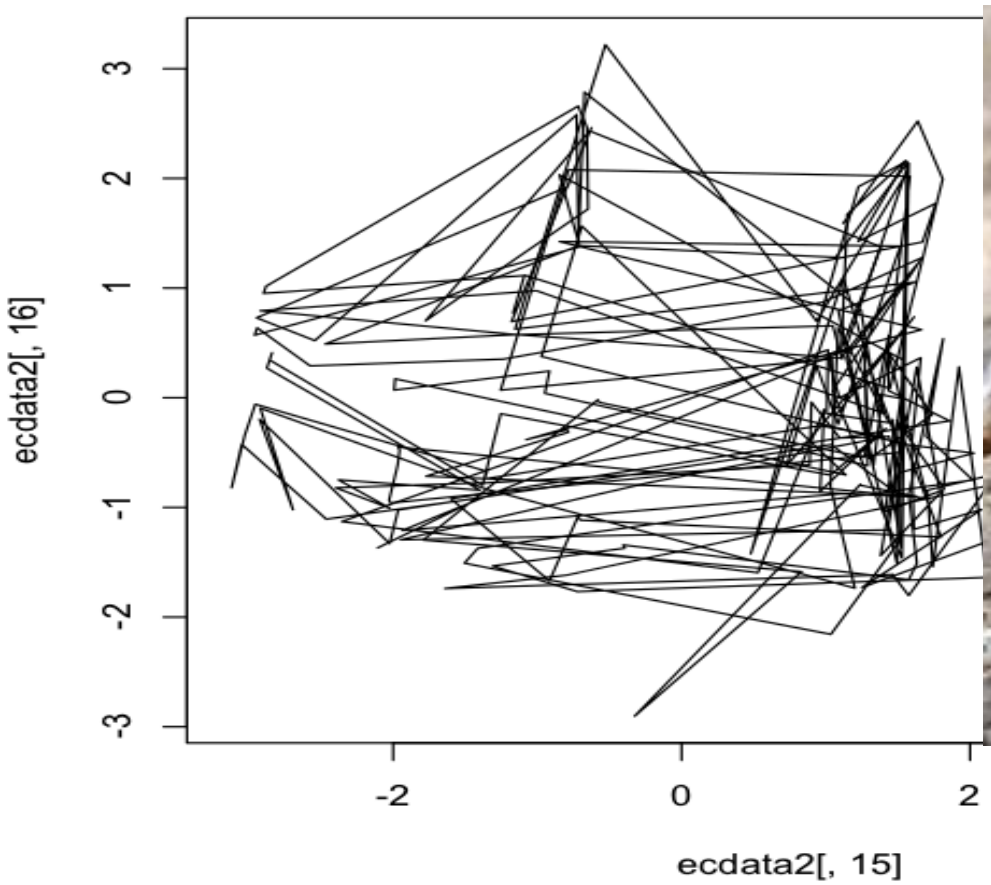


Line plot of the data space (1 to 231)

A Tour Through the Experiment Space

(plot of data correlation results from time(1) to time(231)

Gives some overview of the density and pattern of the data, but how can the data be unscrambled?



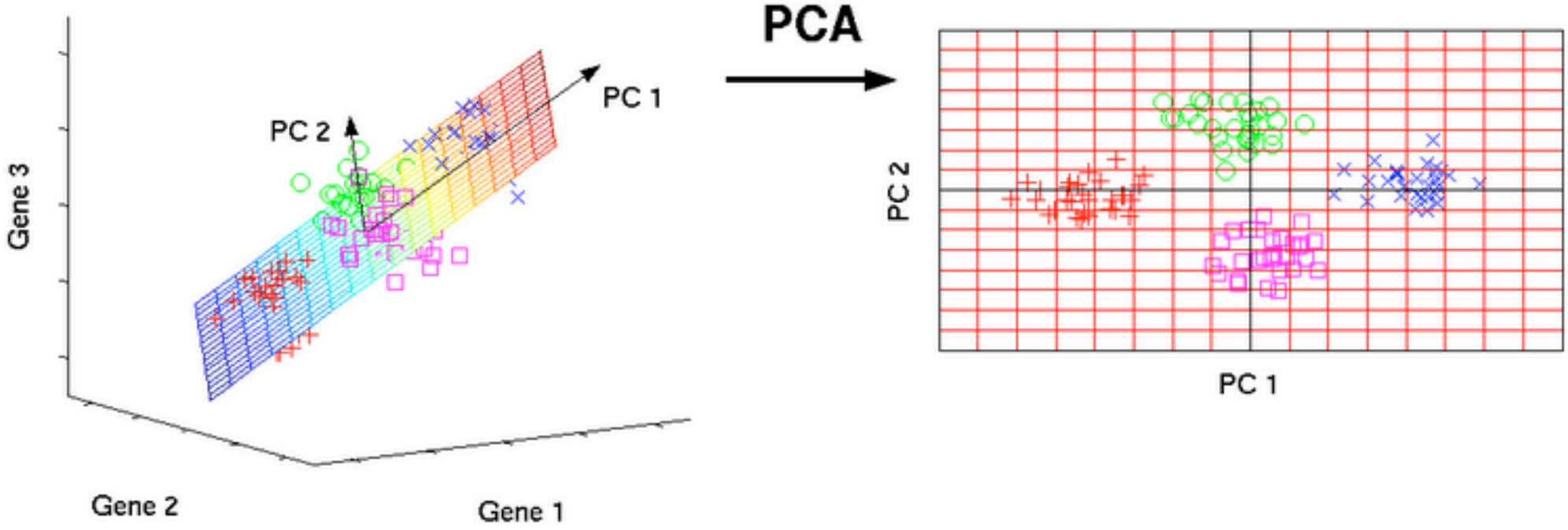
1) Principal Components Analysis (PCA)

- Given a collection of points in two, three, or higher dimensional space, a "best fitting" line can be defined as one that minimizes the average squared distance from a point to the line. The next best-fitting line can be similarly chosen from directions perpendicular to the first.
- Repeating this process yields an orthogonal basis in which different individual dimensions of the data are uncorrelated.
  - These basis vectors are called Principal Components, and several related procedures form the tools of Principal Component Analysis (PCA).

The PCA Idea

Original Data Space

Component Space



Source: nlpca

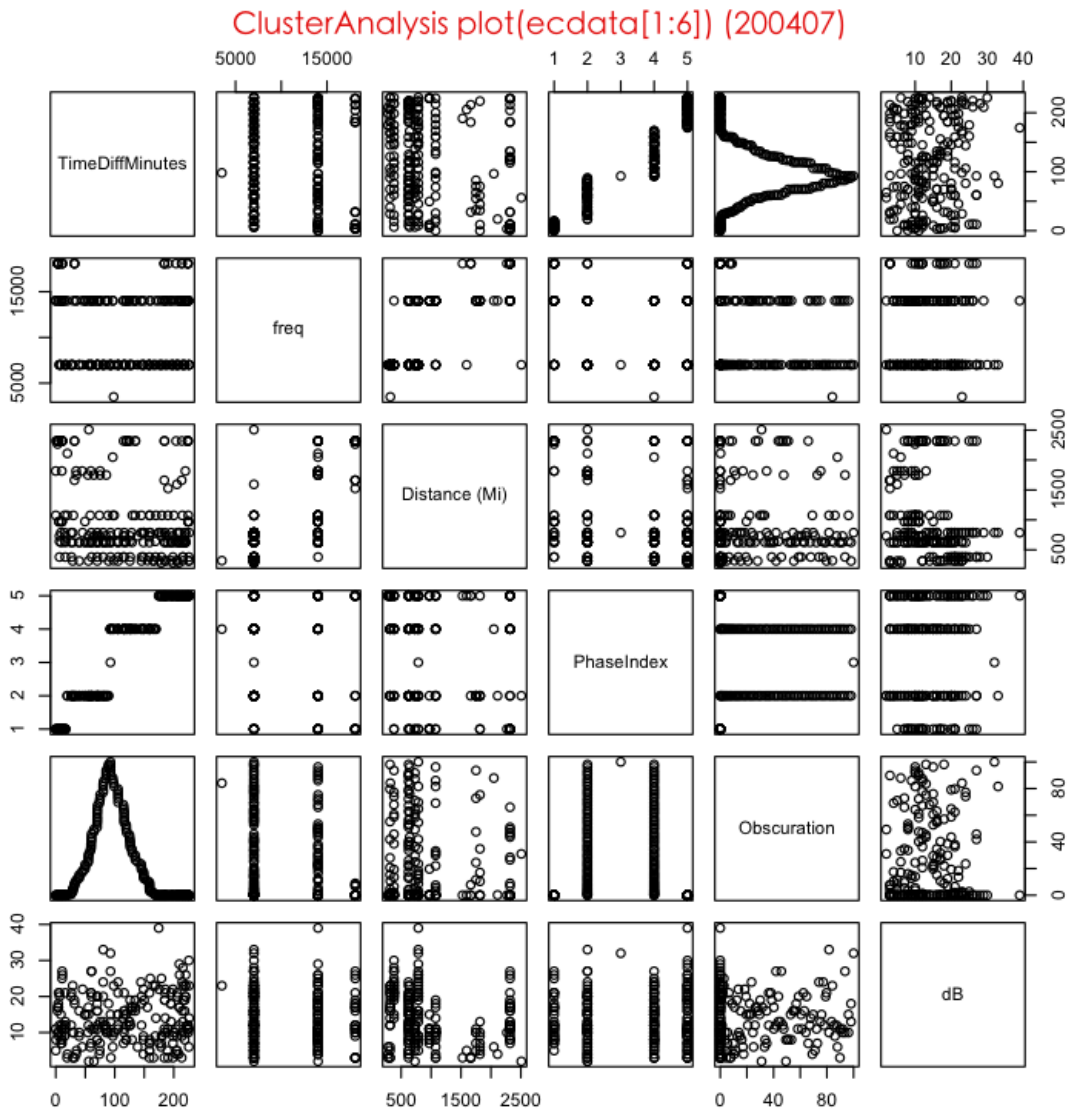
Original Parameters Explored

- TimeDiffMinutes
  - Time from start to finish in minutes (0 – 231) *(3 hours, 51 minutes)*
- Freq
  - Frequency (Hz)
- "Distance (Mi)"
  - Distance from Corvallis to the receiving station in miles
- PhaseIndex
  - The phase of the eclipse
    - PreCoupling
    - Eclipsing
    - FullEclipse
    - Revealing
    - PostEclipse
- Obscuration
  - The area of the Sun blocked by the moon
- dB
  - The signal strength received at each receiving station
- Band
  - 80 , 40, 20, 17
- StateCountry
  - US State and other country

Final Parameters Used

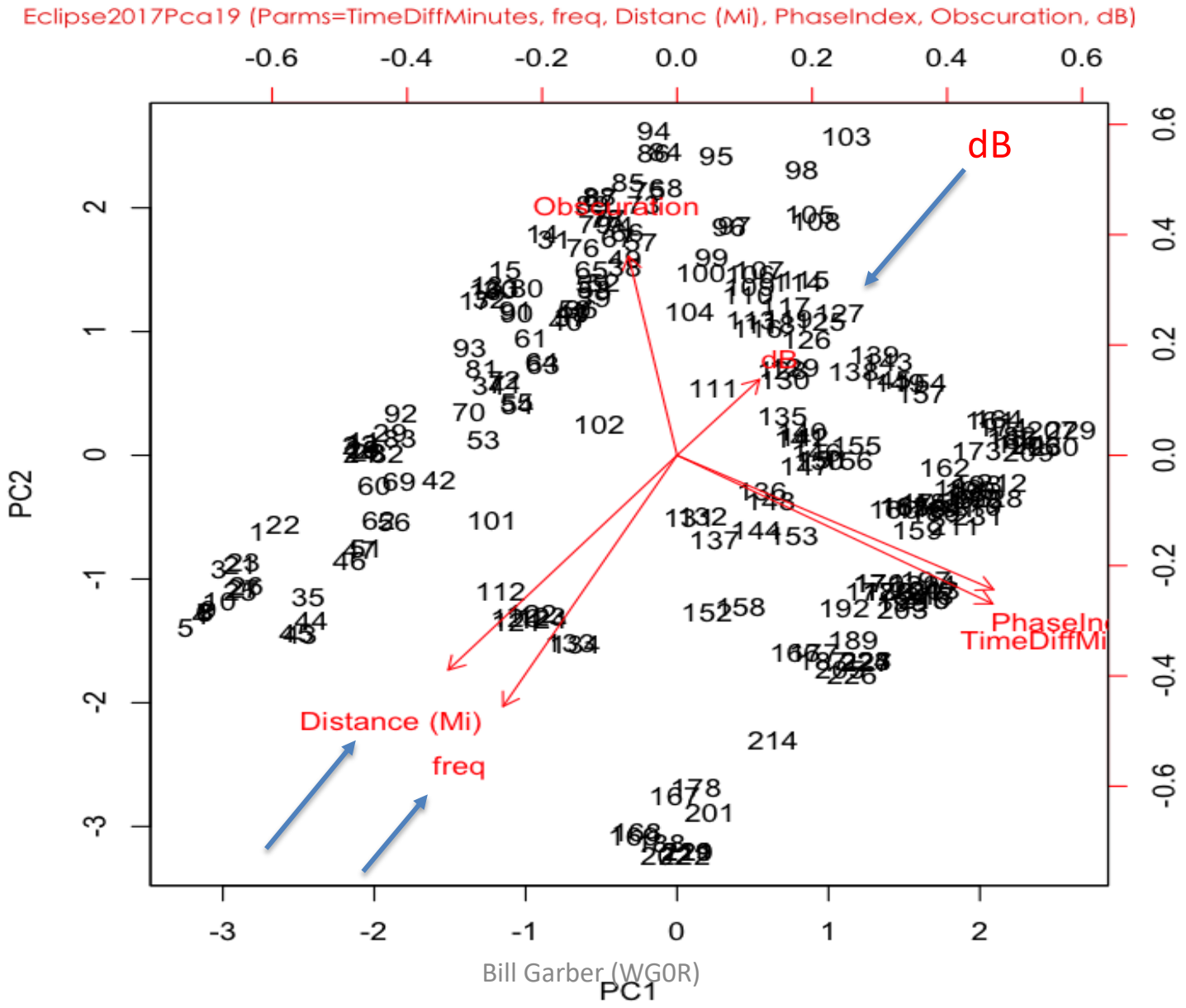
- Due to correlations and some parameters not adding significant contribution to the analysis, the following were used:
- TimeDiffMinutes
- Freq
- “Distance (Mi)”
- PhaseIndex
- Obscuration
- dB

Original Dataset Plot



Biplot of PCA Components

(Distance, Freq, Time/Phase, Obscuration, & dB)

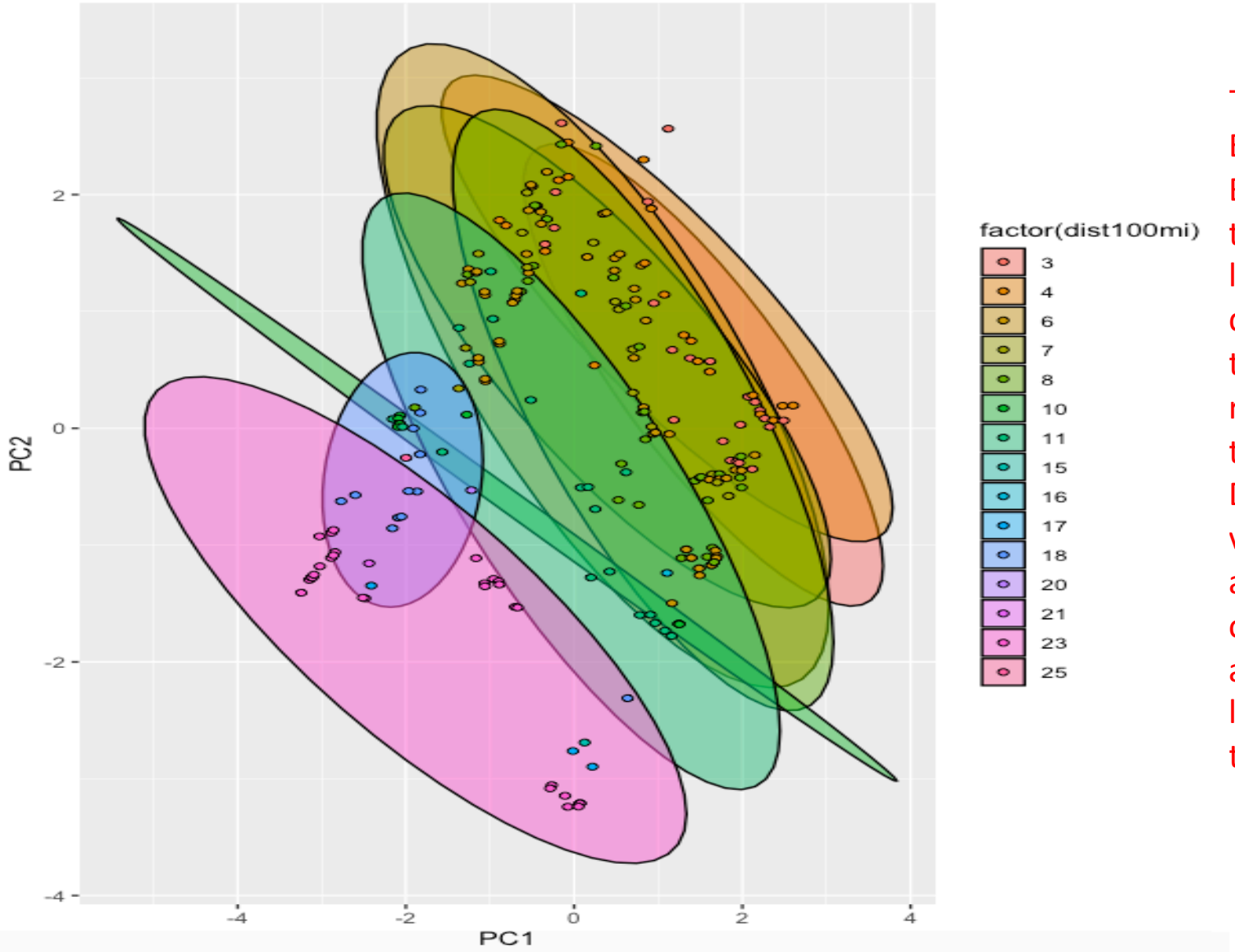


General Characteristics Same

- Note in the following slides, in general, the slopes of each of the factors being evaluated are similar, with a few glaring exceptions.

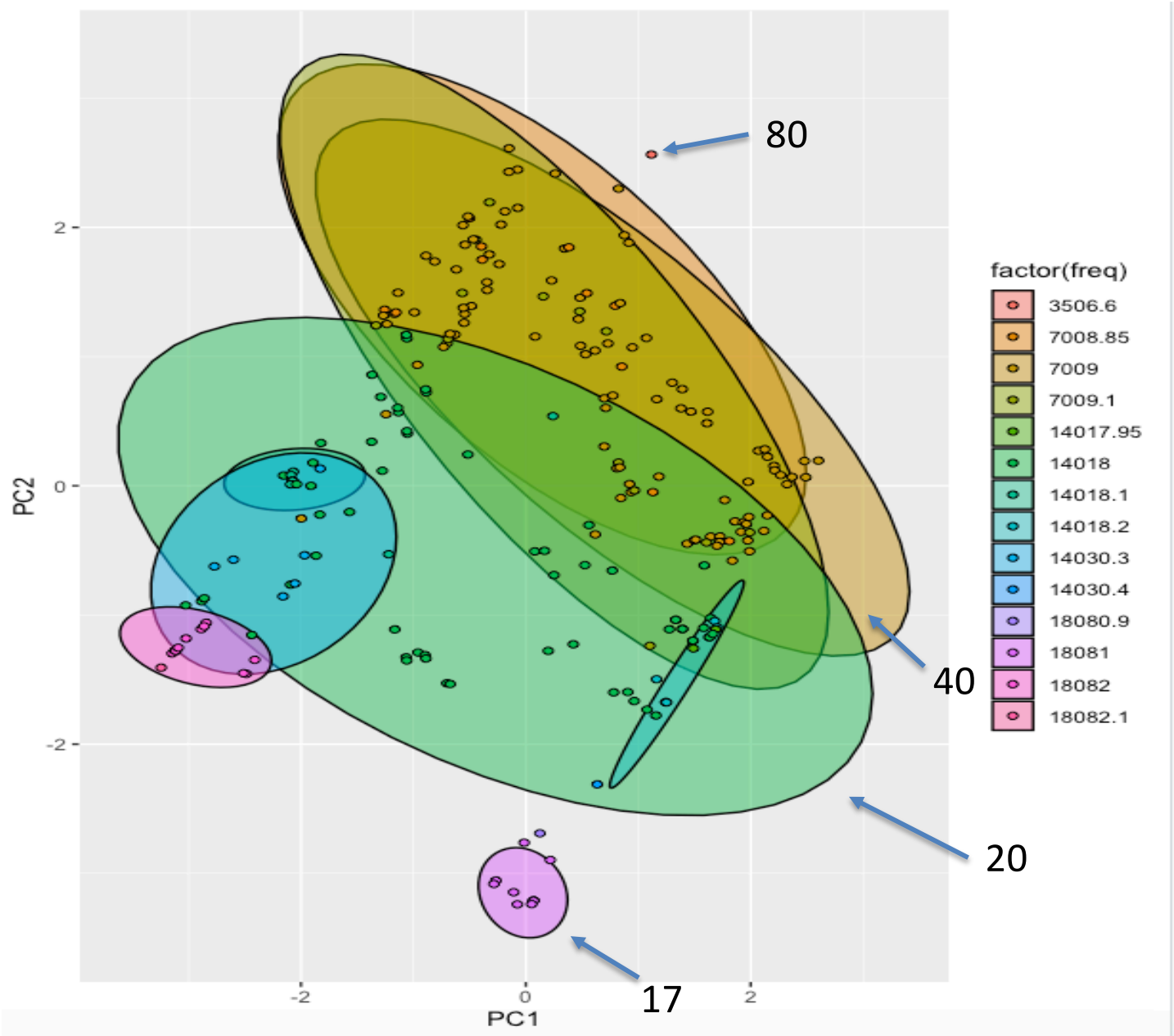
- The "horseshoe" characteristic shape in the Biplot just displayed is visible in all the slides.

PCA by Distance (per 100 miles) with 95% Confidence "Ellipse/Circle"



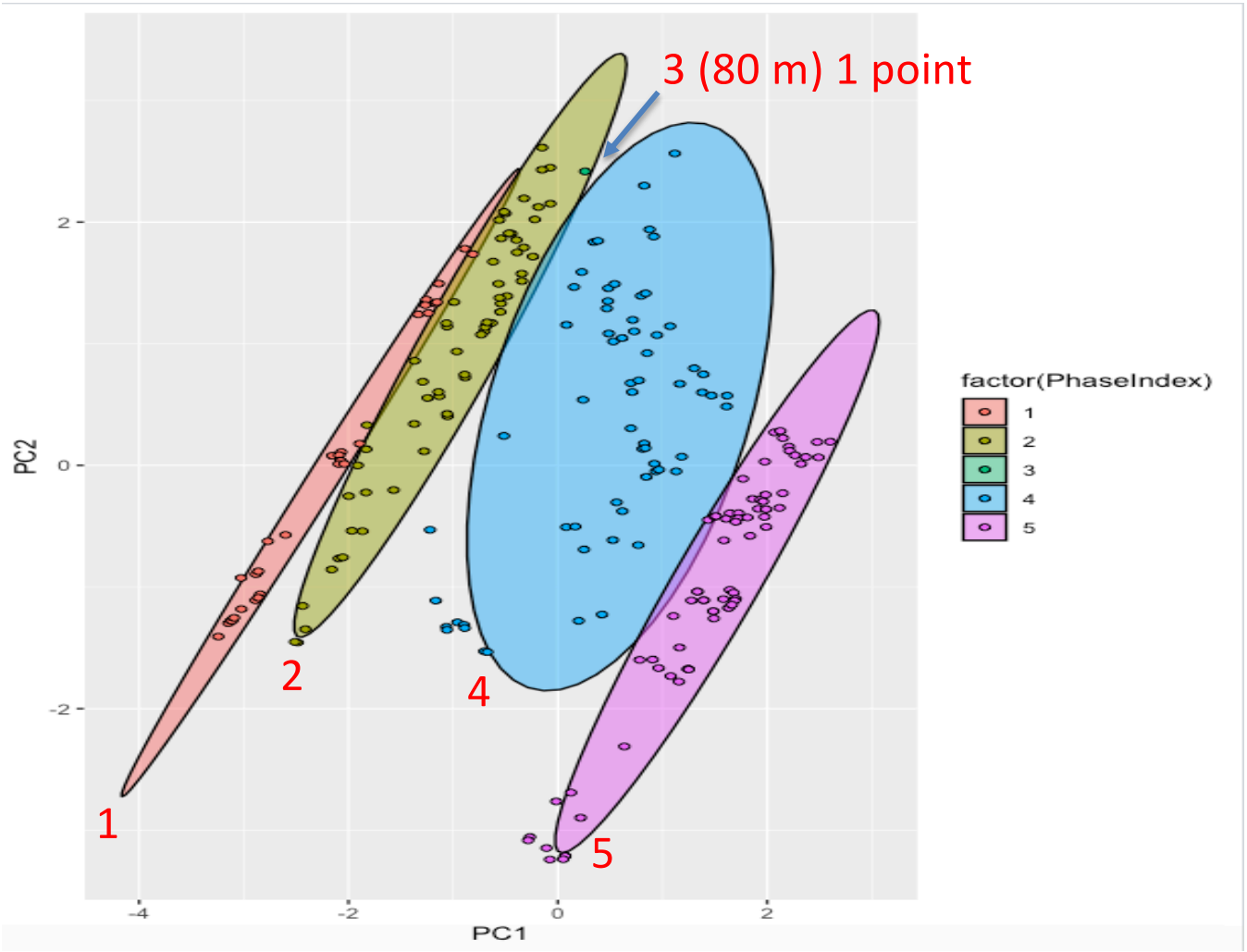
The 95% Confidence Ellipses support the Biplot evidence that the main effect of dB level is due to the distance from the transmitter to the received stations, for the most part (the Distance and dB vectors in the Biplot are diametrically opposed. Frequency also influences the lateral separation of the ellipses.)

PCA by Frequency



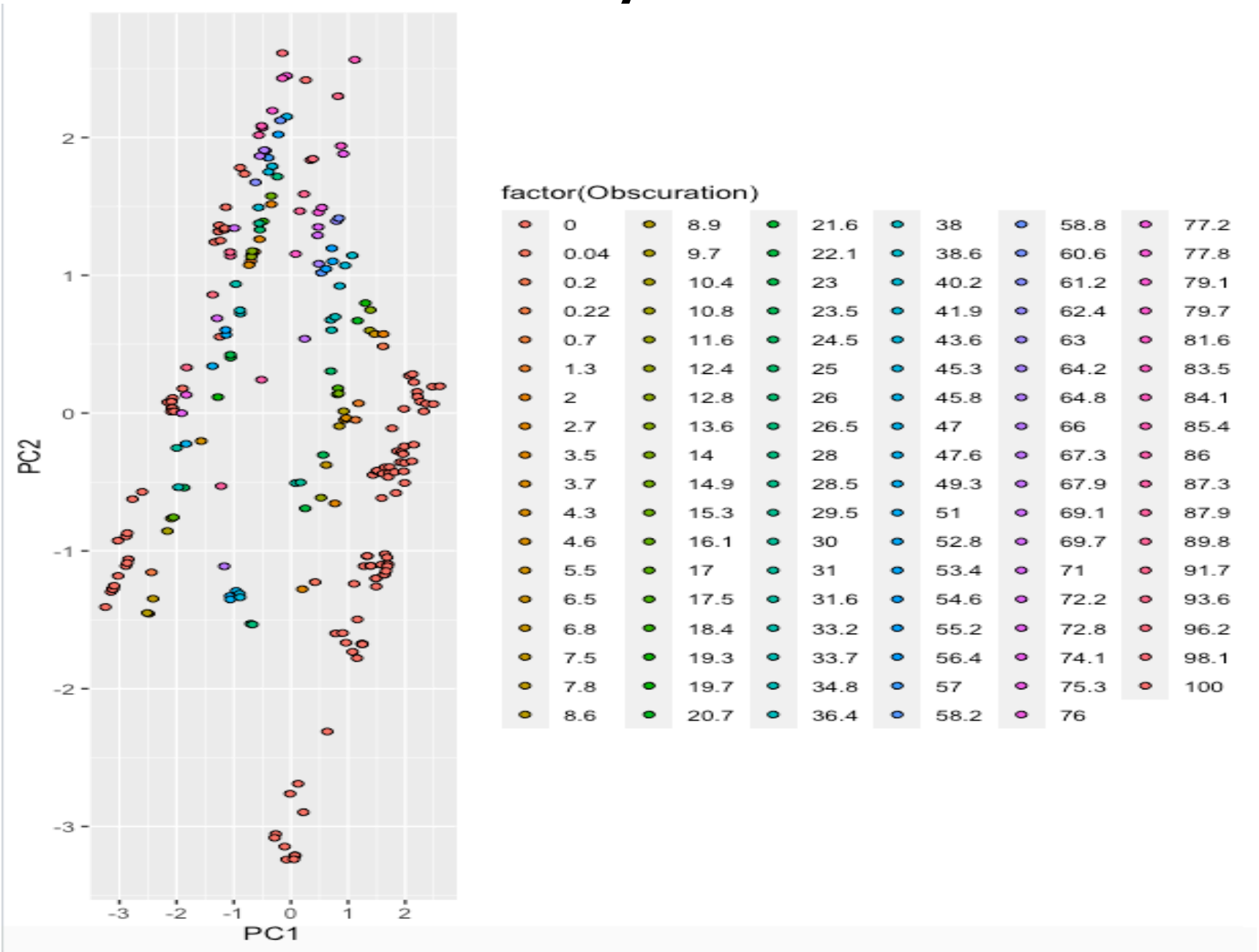
- Frequency had had much to do with the variation in dB values. Significant differences exist.
  - Even slight differences in 20-meter frequencies widened the distances and nature of the ellipses.
- 17-meters had the lowest dB values.

PCA by Time/Phase with 95% Confidence Ellipses



Also significant differences With Phase of eclipse! The numbers represent the time sequence throughout the experiment, and the ellipse masses "drift" from lower-left to upper-right. The 80-meter signal was one of the "hottest" signal levels received during the experiment. (I regret that I didn't do more with that band during the experiment!! 😳)

PCA by Obscuration

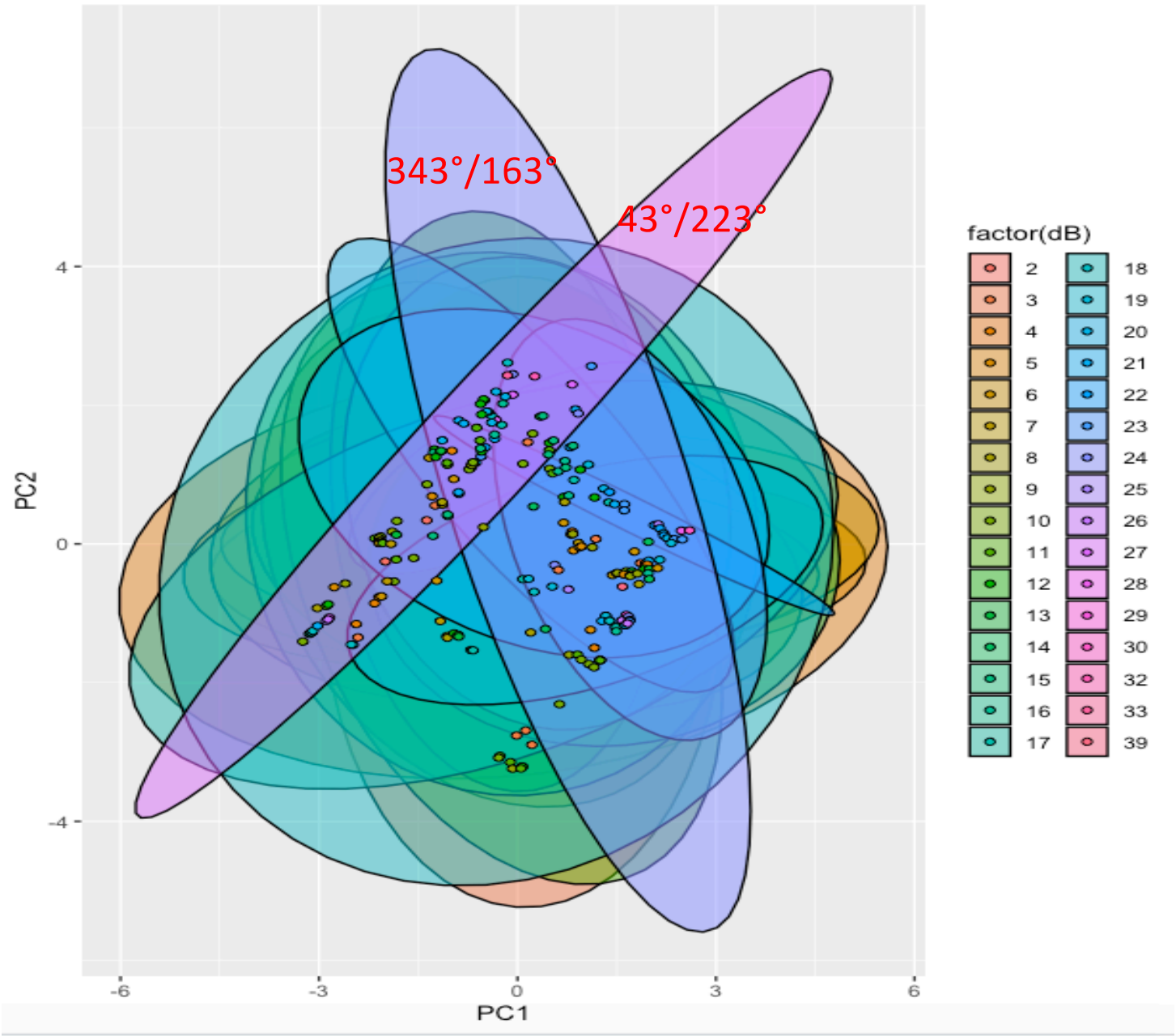


factor(Obscuration)

0	0.04	0.2	0.22	0.7	1.3	2	2.7	3.5	3.7	4.3	4.6
5.5	6.5	6.8	7.5	7.8	8.6	8.9	9.7	10.4	10.8	11.6	12.4
12.8	13.6	14	14.9	15.3	16.1	17	17.5	18.4	19.3	19.7	20.7
21.6	22.1	23	23.5	24.5	25	26	26.5	28	28.5	29.5	30
31	31.6	33.2	33.7	34.8	36.4	38	38.6	40.2	41.9	43.6	45.3
45.8	47	47.6	49.3	51	52.8	53.4	54.6	55.2	56.4	57	58.2
58.8	60.6	61.2	62.4	63	64.2	64.8	66	67.3	67.9	69.1	69.7
71	72.2	72.8	74.1	75.3	76	77.2	77.8	79.1	79.7	81.6	83.5
84.1	85.4	86	87.3	87.9	89.8	91.7	93.6	96.2	98.1	100	

It's interesting that values below 5 and/or above 70, as well as the single "Full Eclipse" value (Phase 3 at 100%) seem to "encapsulate" those in the Transition phases (2 or 4)

PCA by dB

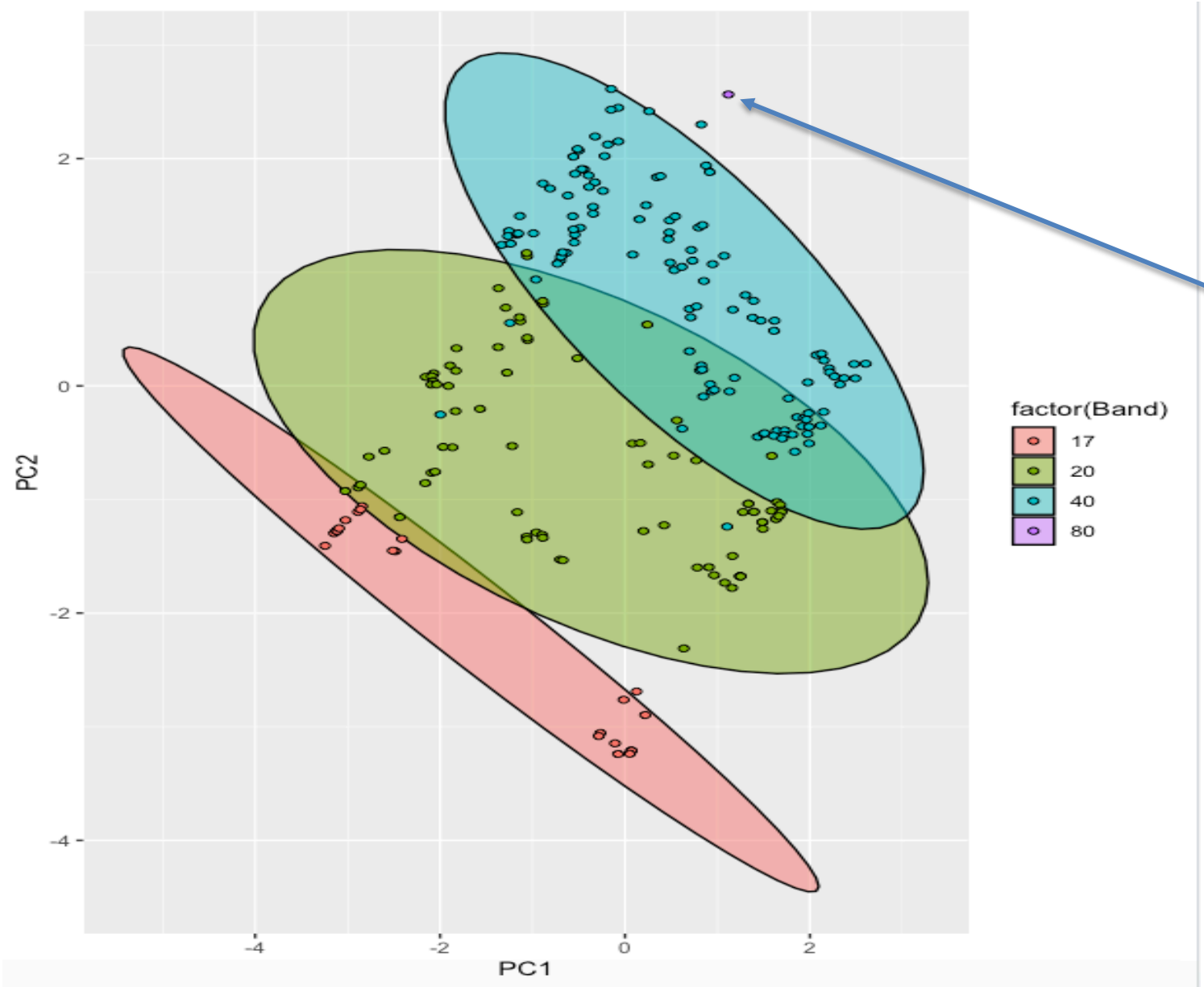


The ellipse bearing 343°/163° is the 24 dB value, seemingly influenced by the Obscuration.

The ellipse bearing 43°/223° is the 26 dB value, seemingly influenced by the Distance and Frequency.

The rest are more omnidirectional.

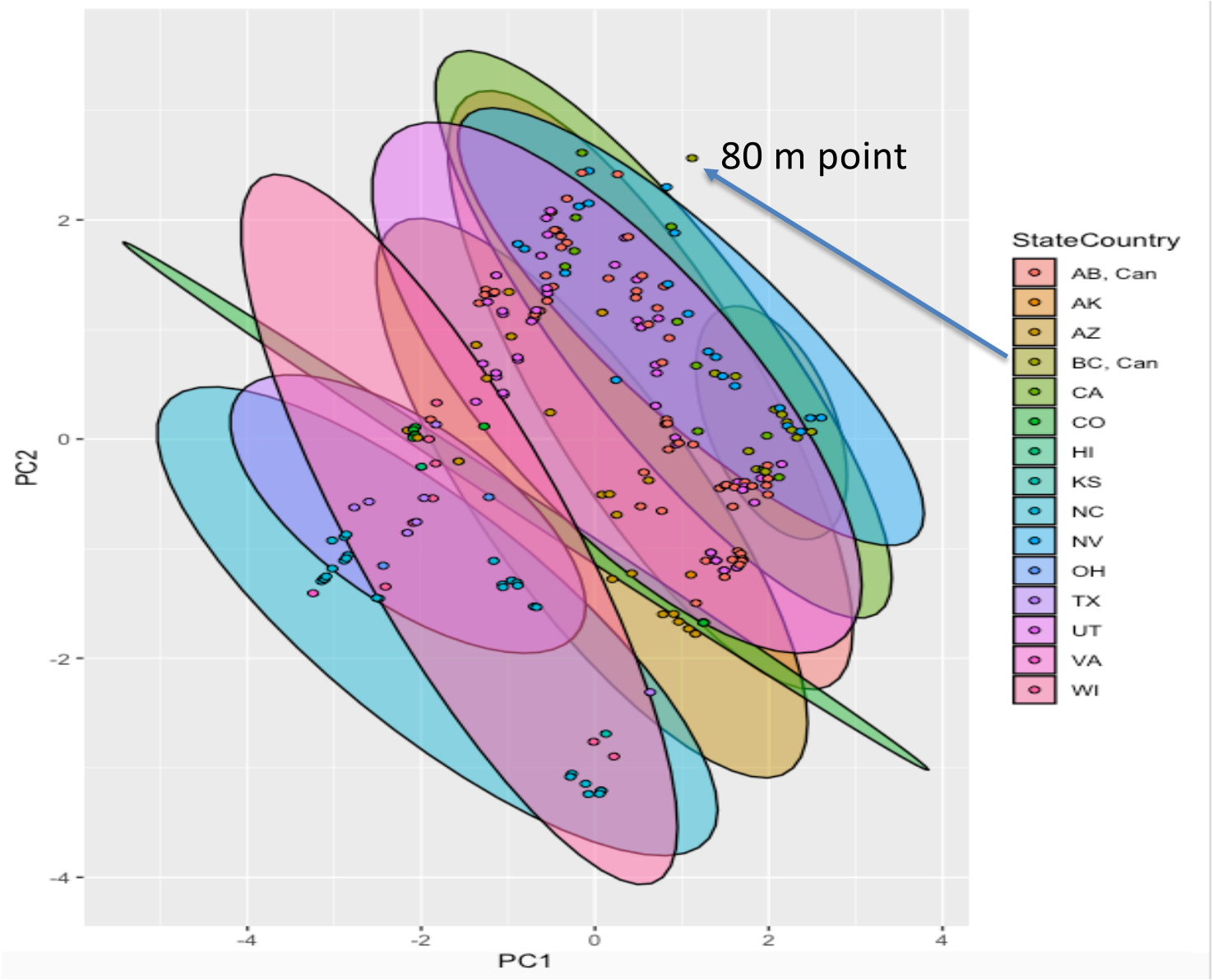
PCA by Band with 95% Confidence Ellipses



Very significant difference Between Bands!

80-meter single point is at the top-right of the plot (as noted by the “dB” vector in the Biplot.)

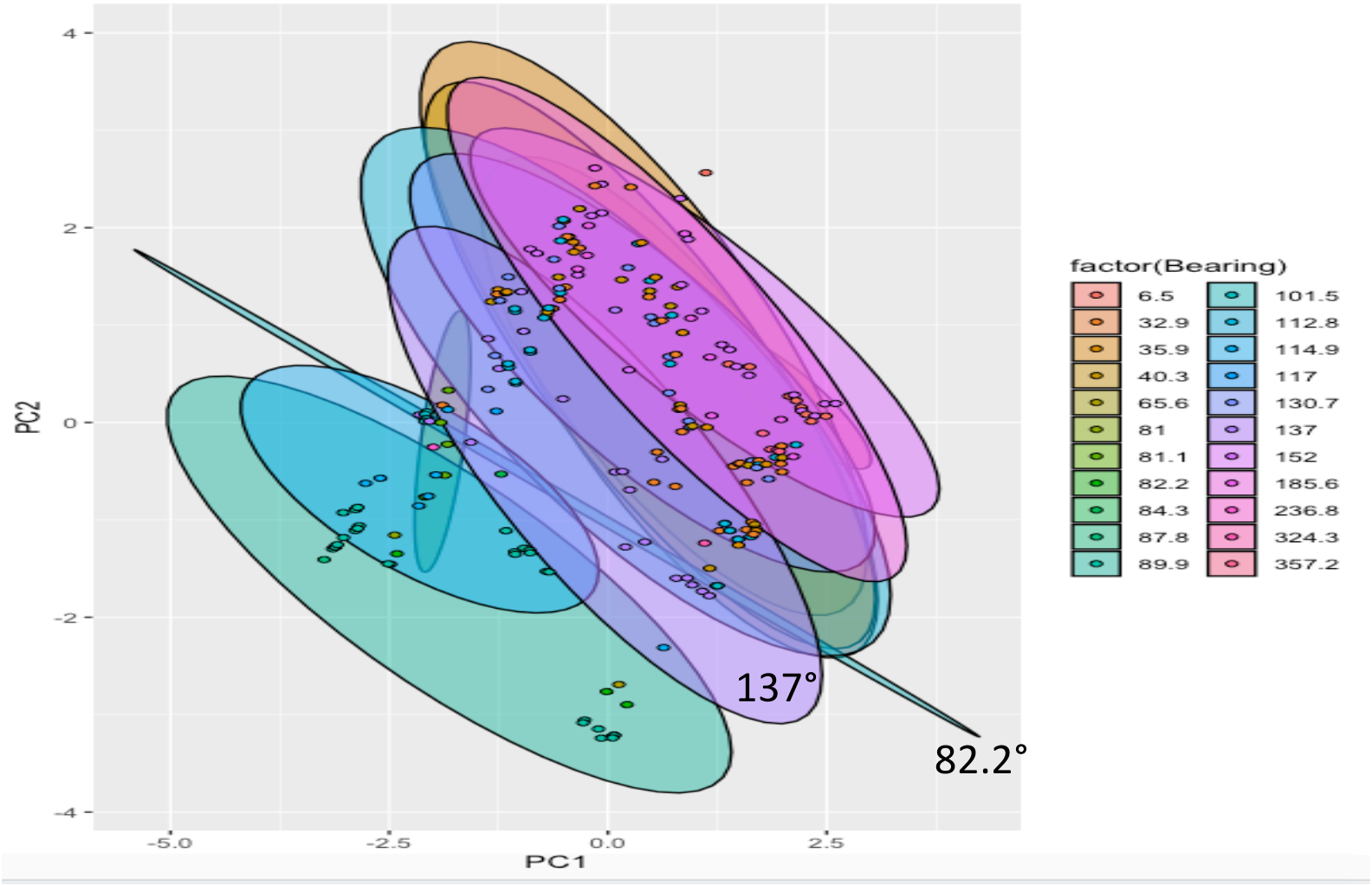
PCA by State/Country with 95% Confidence Ellipses



Lots of overlap, which seems logical, given the interactions of distance, frequency, azimuth, time, sun/moon interactions, "Grayline influence", etc.

The ellipses "tilt" from bottom right to upper left, which from the Biplot are associated mainly with time, phase, and obscuration.

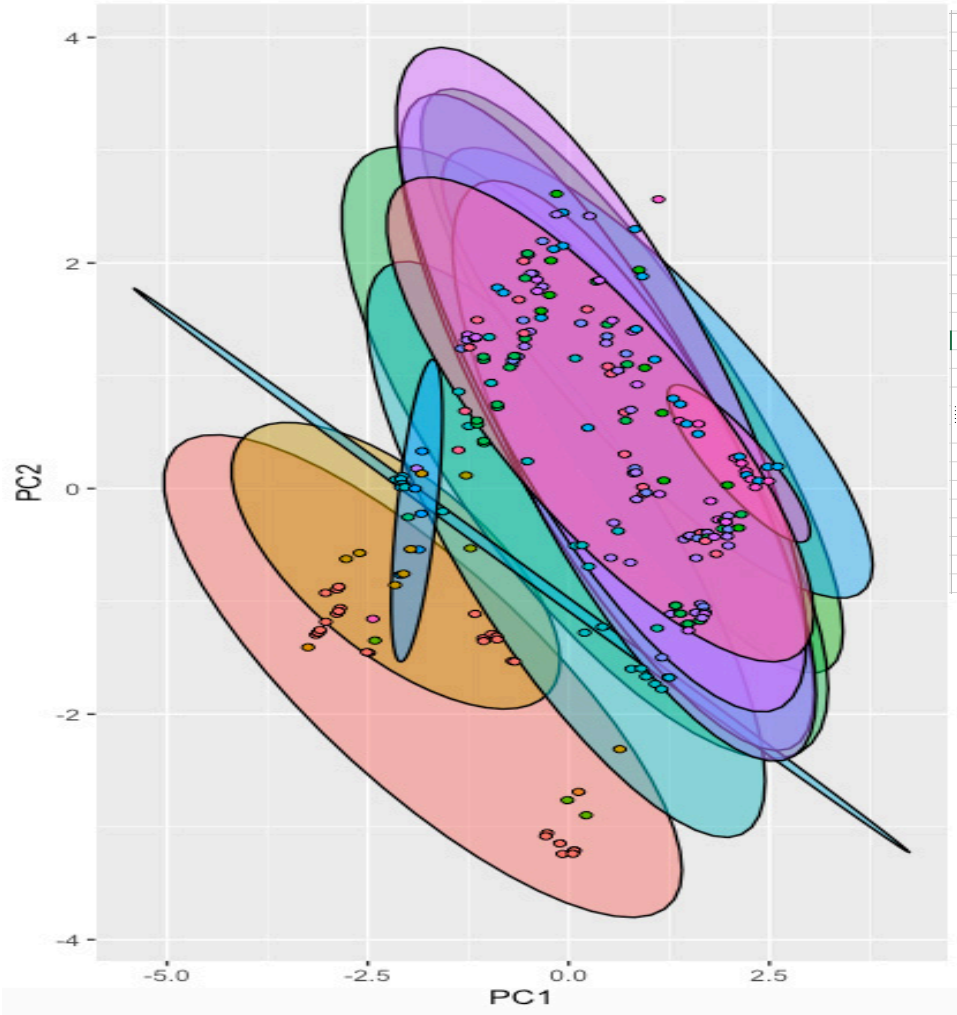
PCA By Bearing with 95% Confidence Ellipses



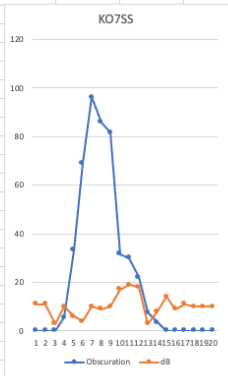
There is complete separation between the 82° to 89° bearings and the rest of the Bearing angles.

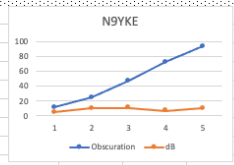
The 89.9-degree, very thin ellipse demarked the two main groupings of bearings, while the 137-degree bearing bridged between the two main groupings.

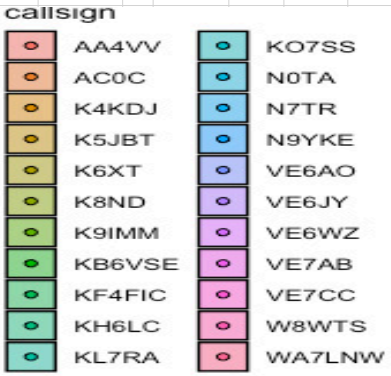
PCA by Callsign with 95% Confidence Ellipses



PhaseIndex	Obscuration	dB	BandValue	callsign
1	0	11	0	KO7SS
1	0	11	0	KO7SS
2	0	3	0	KO7SS
2	5.5	10	0	KO7SS
2	33.2	6	0	KO7SS
2	69.1	4	0	KO7SS
2	96.2	10	0	KO7SS
4	86	9	0	KO7SS
4	81.6	10	0	KO7SS
4	31.6	17	0	KO7SS
4	30	19	0	KO7SS
4	22.1	18	0	KO7SS
4	7.5	3	0	KO7SS
4	3.5	8	0	KO7SS
4	0.04	14	0	KO7SS
5	0	9	0	KO7SS
5	0	11	0	KO7SS
5	0	10	0	KO7SS
5	0	10	0	KO7SS
5	0	10	0	KO7SS
2	11.6	5	0	N9YKE
2	24.5	10	0	N9YKE
2	47.6	11	0	N9YKE
2	72.8	7	0	N9YKE
2	93.6	10	0	N9YKE







Not surprisingly, the callsigns are essentially identical to the Bearing plot.

The slopes of the groups are very similar, although KO7SS (AZ: Thin, most horizontal) and N9YKE (WI: Most vertical) are "outliers" in the orientation.

Overall, there is much Overlap, with the blue/purplish groups being mostly segregated from the orange/pink groups.

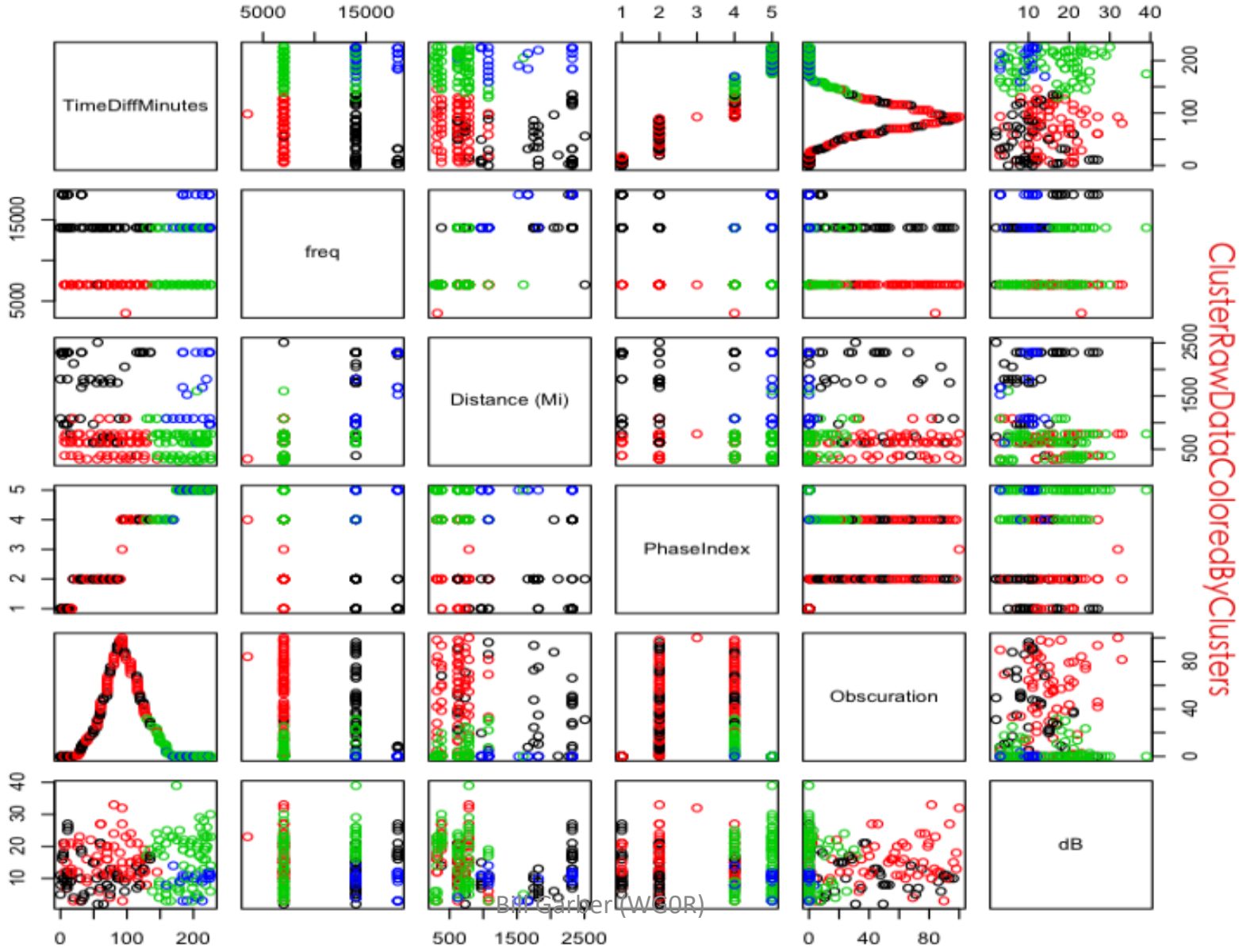
The two greenish groups overlap the rest of the other main groups.

It appears that the obscuration, and Phase, and Time are the main influences of the tilt from upper left to lower right.

2) Cluster Analysis (CA)

- Statistical classification technique in which cases, data, or objects (events, people, things, etc.) are subdivided into groups (clusters) such that the items in a cluster are very similar (but not identical) to one another and very different from the items in other clusters.
- It is a discovery tool that reveals associations, patterns, relationships, and structures in masses of data.
  - It can be used as a tool to monitor Social Distancing 😜.

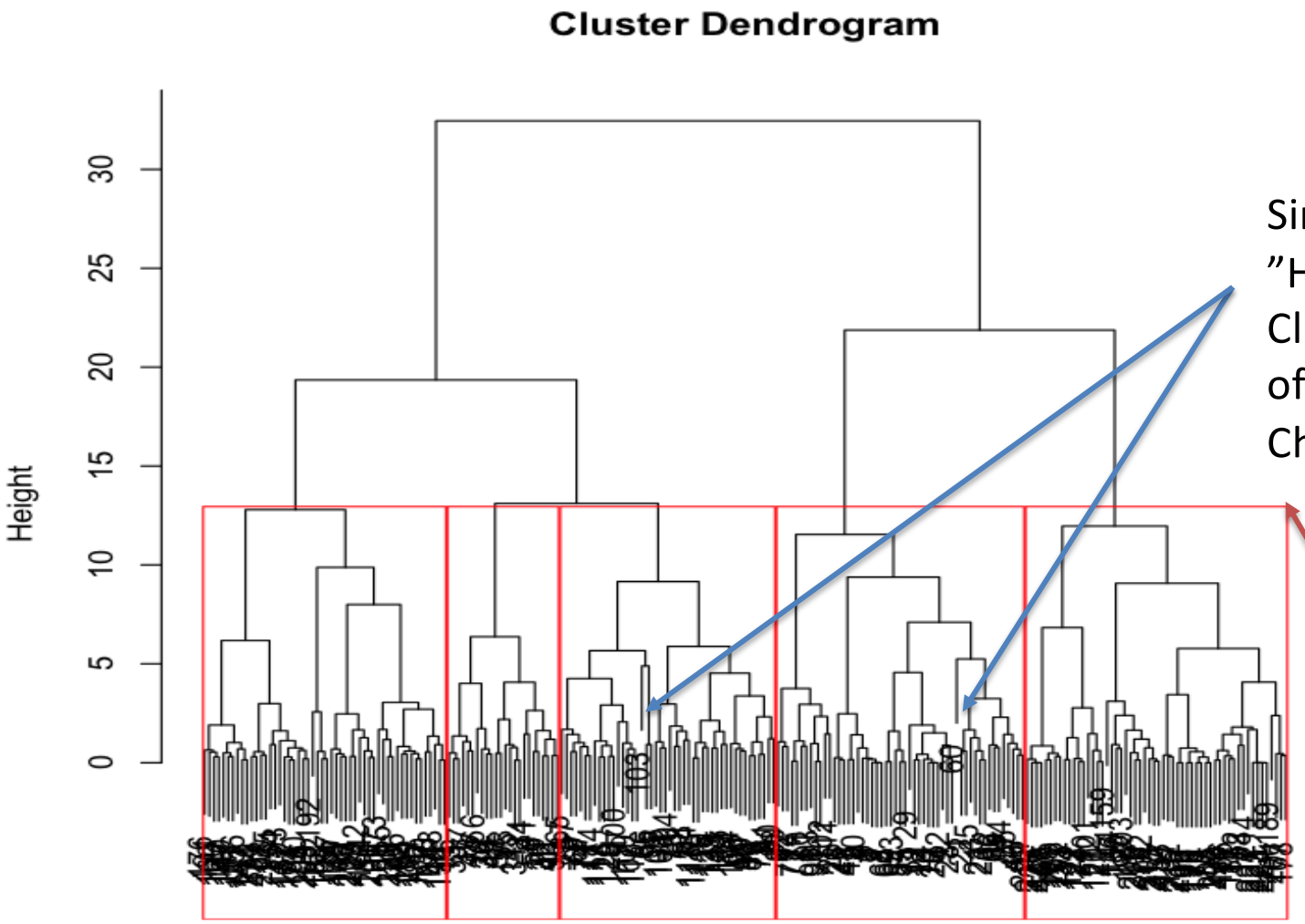
Raw Data Colored by Cluster



Cluster Dendrogram

- Plots a hierarchy of all points, with their groupings in a more consolidated way, ending with the grouping of all points.
  - It's Like a Family Tree presentation
  - There are methods to add a line of demarcation based on the number of groups to display.
    - This can also show single point "groups."

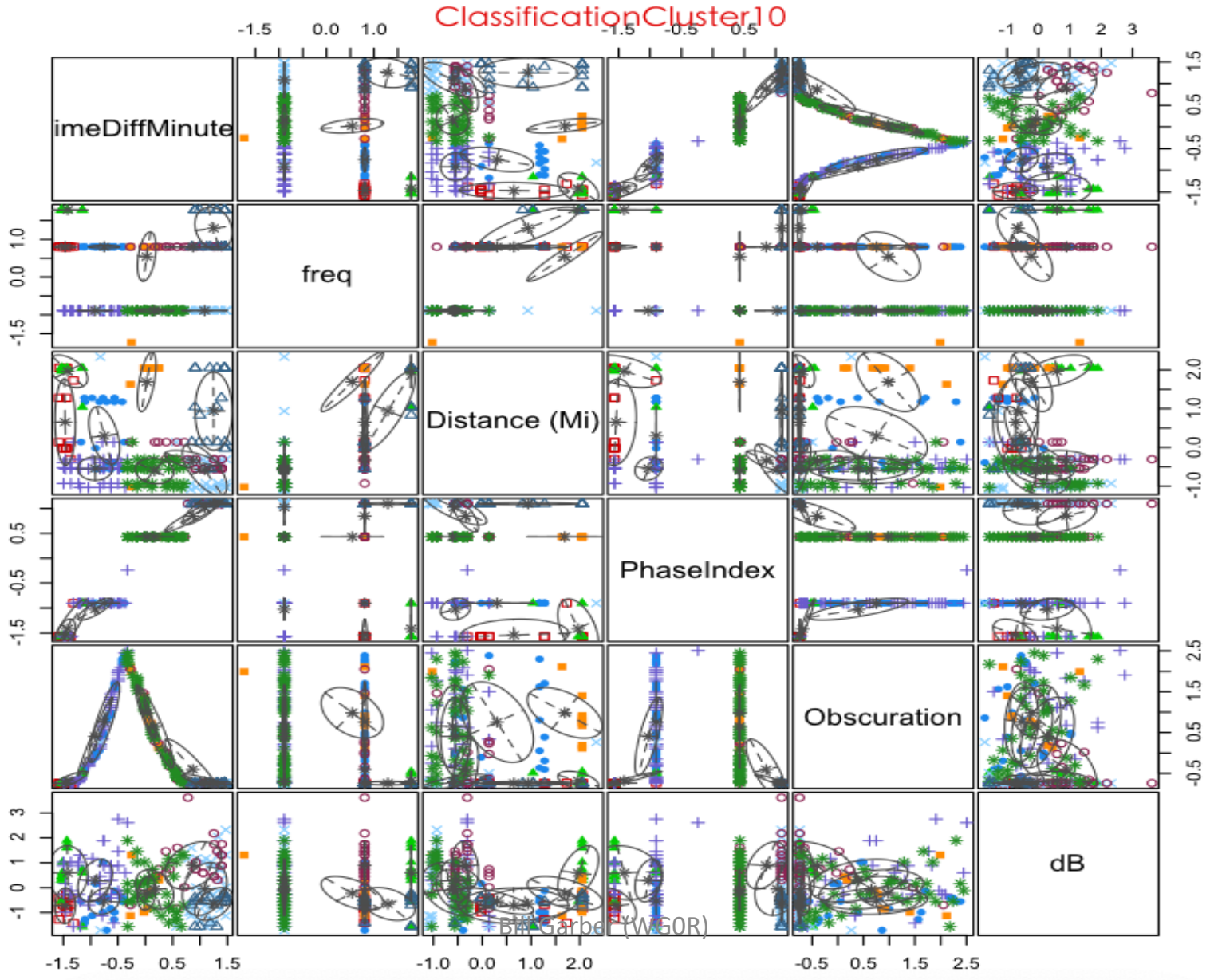
Cluster Dendrogram with 5 Groups Specified



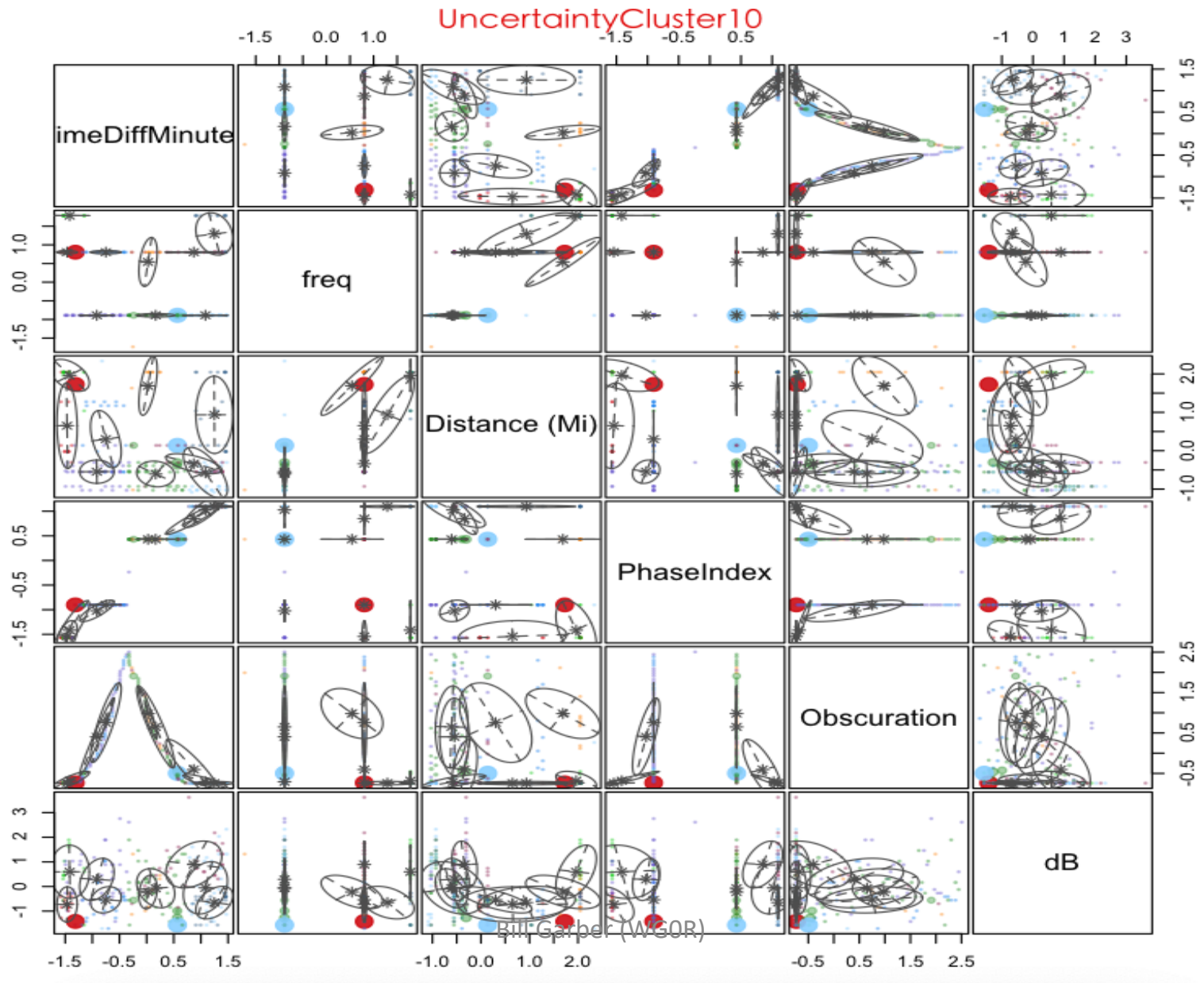
Single-point "Hanging Clusters" (Kind of like "Hanging Chads"

Demarcation Line set at Height to provide 5 Clusters

Classification CA

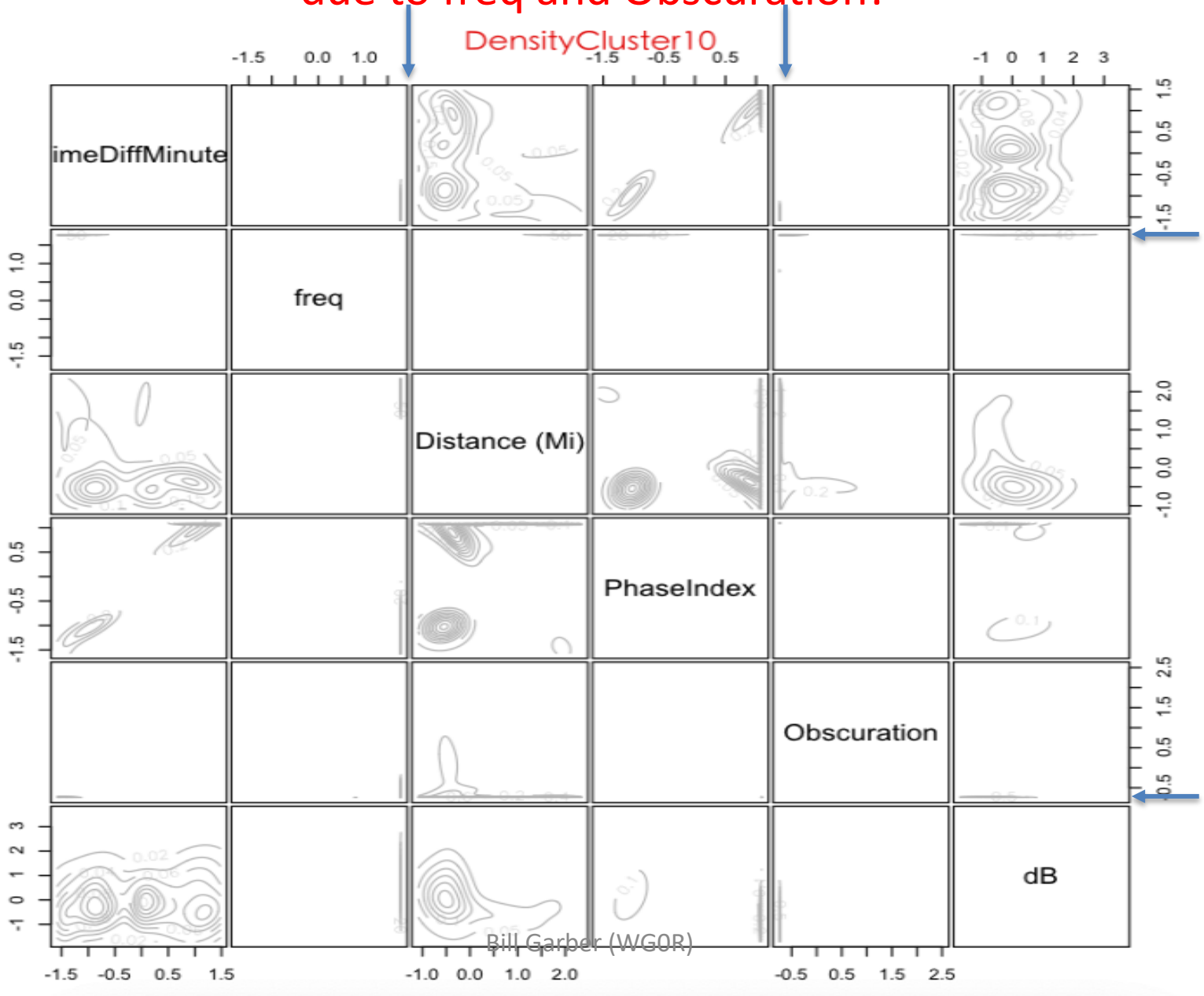


Uncertainty CA



Density CA

Interesting that there are only a few small clusters due to freq and Obscuration!



3) Regression Analysis (RA)

- Looked at 3 levels of regression factors with increasing numbers of Principal Components factors (2, 4, 6)
- The Stats improved remarkably with each additional Principal Component, starting very low and improving “exponentially”.

Regression Statistics

Two Components

- lm(formula = dB ~ PC1 + PC2, data = ecdata6)
- Residuals:
- Min 1Q Median 3Q Max
- -12.7838 -4.5858 -0.9256 4.7917 24.1833
- Coefficients:
- Estimate Std. Error t value Pr(>|t|)
- (Intercept) 13.8701 0.4346 31.912 < 2e-16 ***
- PC1 1.0595 0.2932 3.614 0.000372 ***
- PC2 1.1931 0.3304 3.611 0.000375 ***
- ---
- Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
- Residual standard error: 6.606 on 228 degrees of freedom
- Multiple R-squared: 0.1027,Adjusted R-squared: 0.09484
- F-statistic: 13.05 on 2 and 228 DF, p-value: 4.309e-06

Four Components

lm(formula = dB ~ PC1 + PC2 + PC3 + PC4, data = ecdata6)

Residuals:

Min 1Q Median 3Q Max

-1.3173 -0.3475 0.1104 0.3180 1.8929

Coefficients:

Estimate Std. Error t value Pr(>|t|)

(Intercept) 13.87013 0.03320 417.76 <2e-16 ***

PC1 1.05951 0.02240 47.30 <2e-16 ***

PC2 1.19308 0.02524 47.27 <2e-16 ***

PC3 -6.61669 0.03385 -195.47 <2e-16 ***

PC4 -0.93915 0.03719 -25.25 <2e-16 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.5046 on 226 degrees of freedom

Multiple R-squared: 0.9948, Adjusted R-squared: 0.9947

F-statistic: 1.083e+04 on 4 and 226 DF, p-value: < 2.2e-16

Six Components

lm(formula = dB ~ PC1 + PC2 + PC3 + PC4 + PC5 + PC6, data = ecdata6)

Residuals:

Min 1Q Median 3Q Max

-1.324e-14 -2.120e-15 -5.130e-16 6.980e-16 1.631e-13

Coefficients:

Estimate Std. Error t value Pr(>|t|)

(Intercept) 1.387e+01 7.421e-16 1.869e+16 <2e-16 ***

PC1 1.060e+00 5.006e-16 2.116e+15 <2e-16 ***

PC2 1.193e+00 5.641e-16 2.115e+15 <2e-16 ***

PC3 -6.617e+00 7.566e-16 -8.746e+15 <2e-16 ***

PC4 -9.391e-01 8.313e-16 -1.130e+15 <2e-16 ***

PC5 -9.999e-01 1.487e-15 -6.726e+14 <2e-16 ***

PC6 -2.851e-02 3.805e-15 -7.493e+12 <2e-16 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

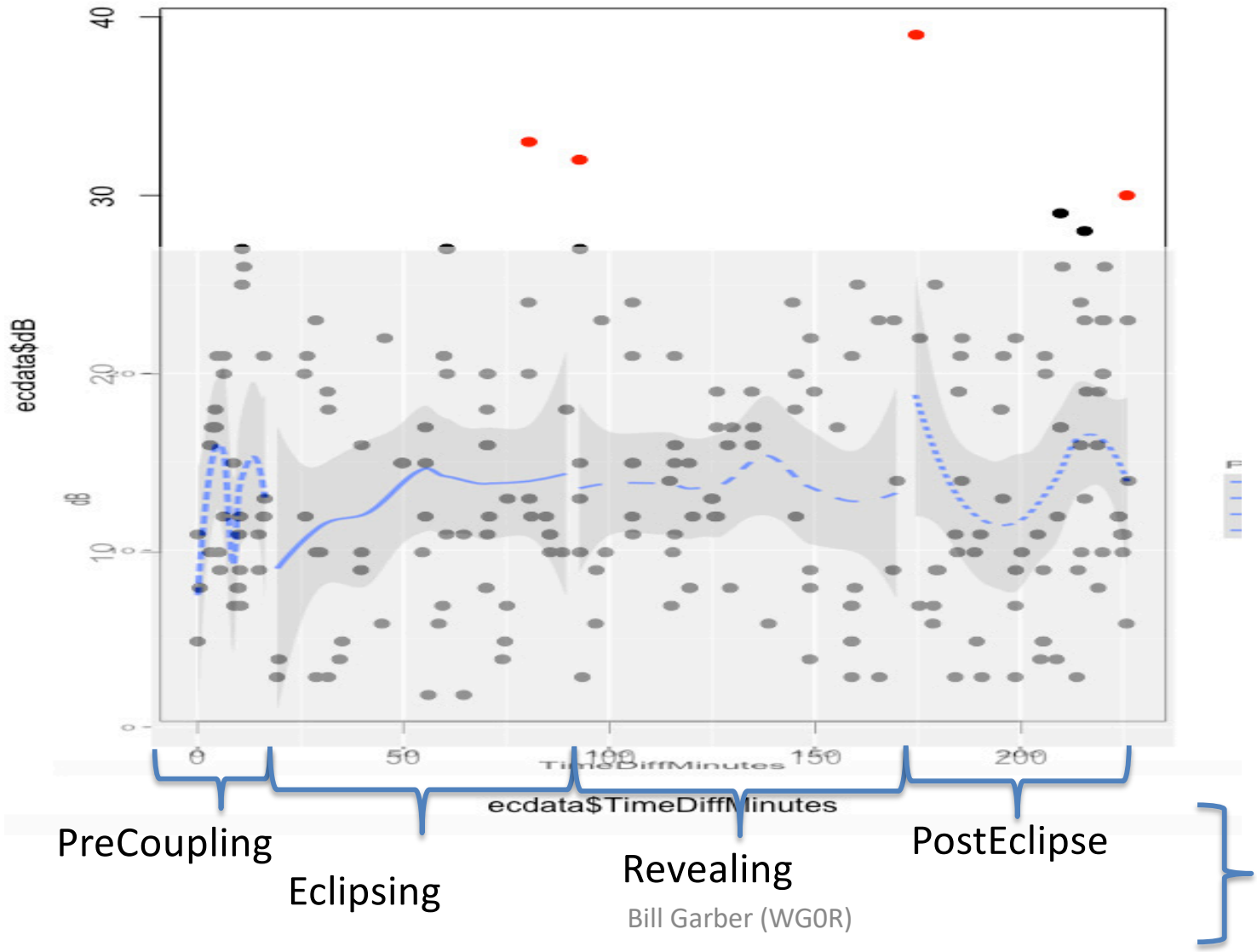
Residual standard error: 1.128e-14 on 224 degrees of freedom

Multiple R-squared: 1,Adjusted R-squared: 1

F-statistic: 1.453e+31 on 6 and 224 DF, p-value: < 2.2e-16

Raw Data

with Overlay of Smoothing broken out by Phase



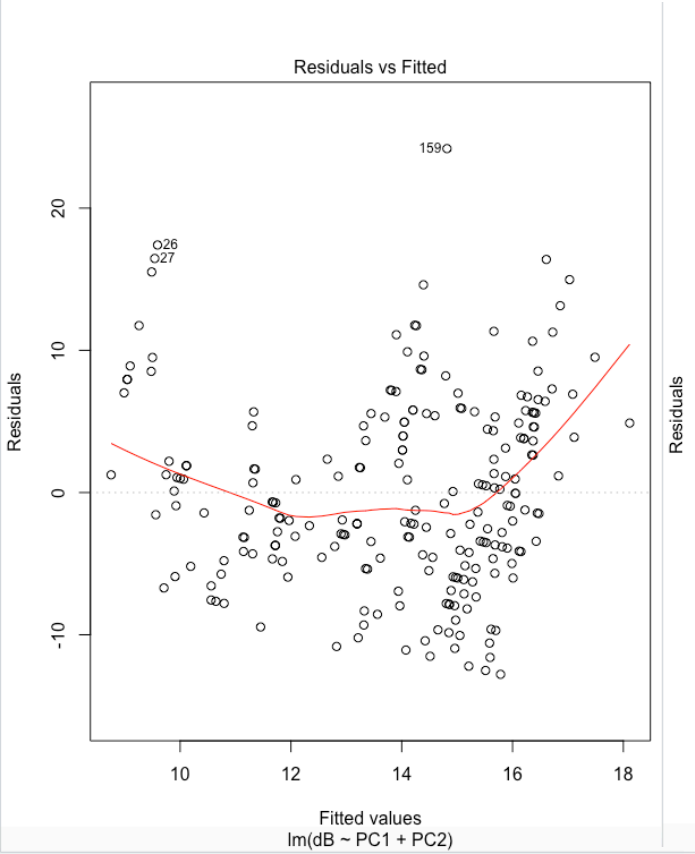
The four red dots at the top of the plot were outliers in the first runs of Regression Analysis model exploration. (with two Principal Components being used.)

Residuals vs Fitted

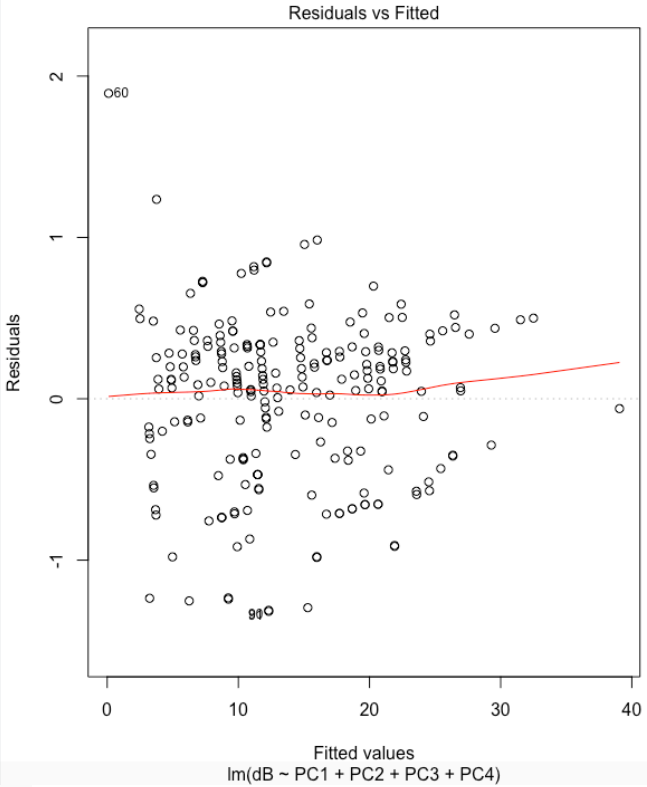
Objective is horizontal red line with no nonlinear relationships present

3 outliers are in “6” plot (First, third & fourth points in the experiment data set, for unknown reasons.)

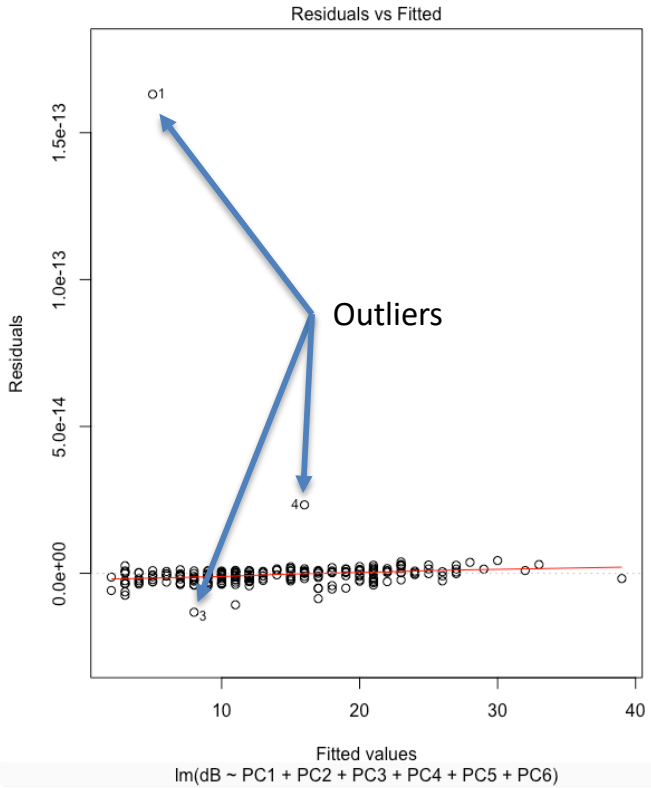
2



4



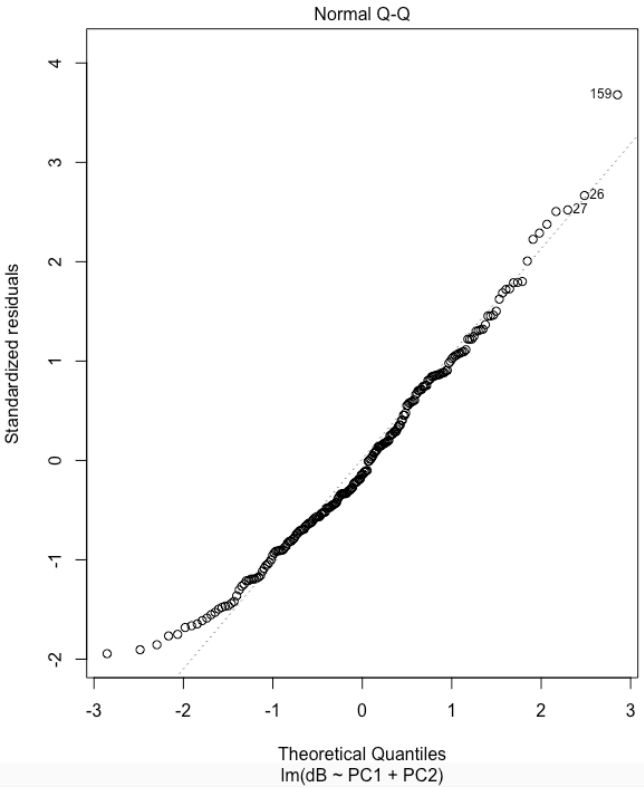
6



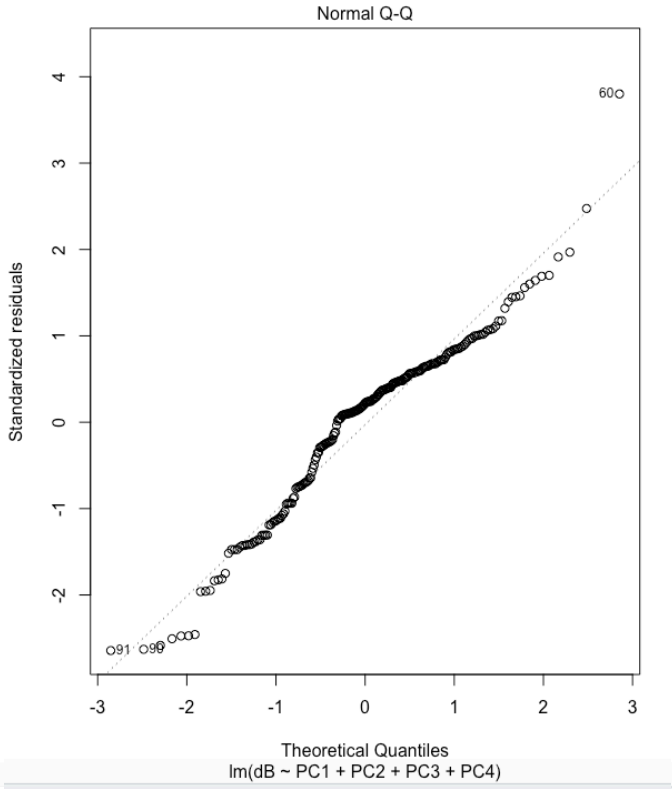
Normality Plots

The outliers really bias the plot scales

2



4



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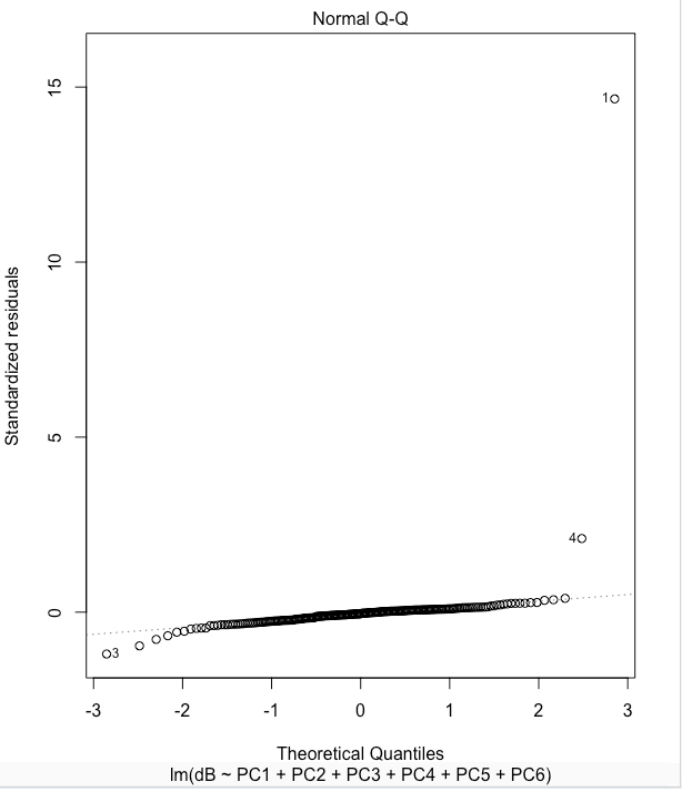
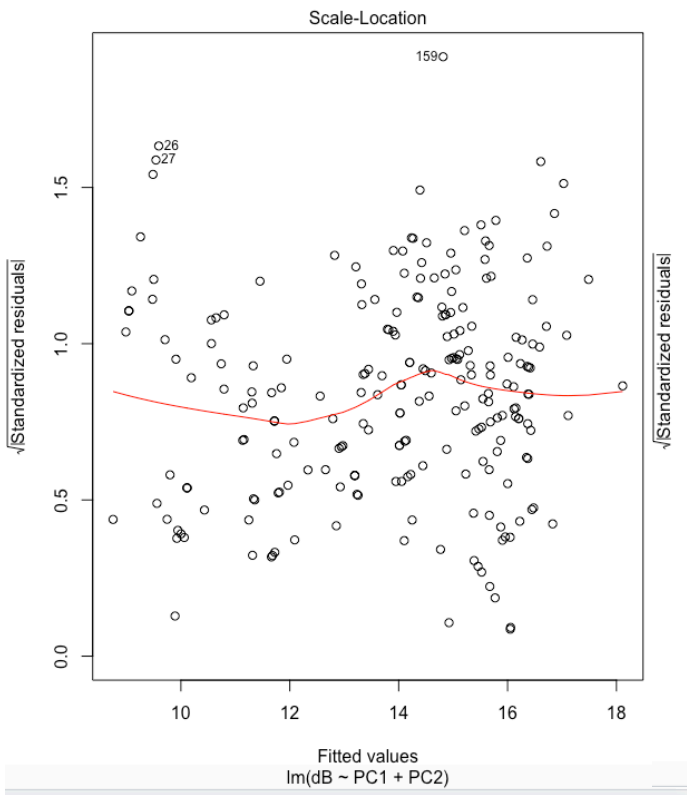


Scale-Location Plots

Check for Equal Variances

Checks if residuals are spread equally across the range of values

2



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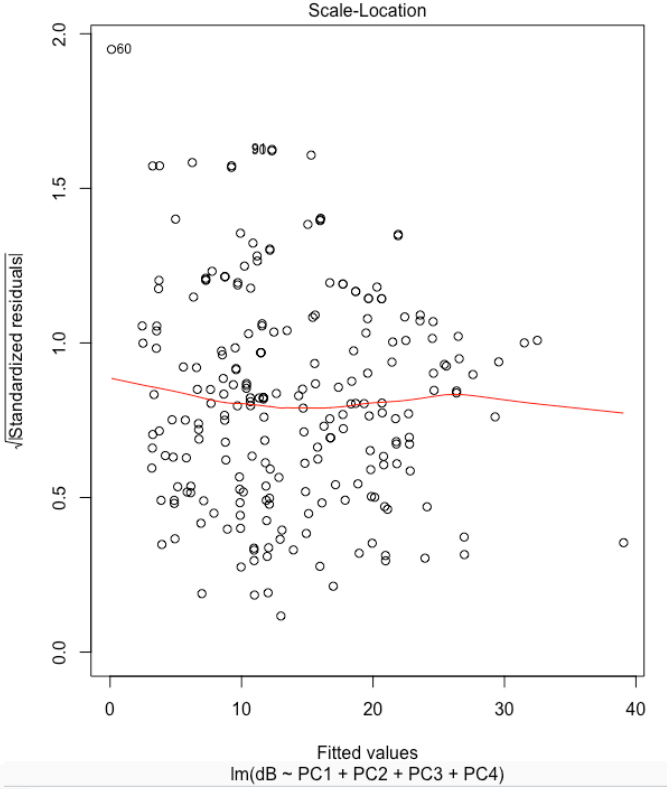

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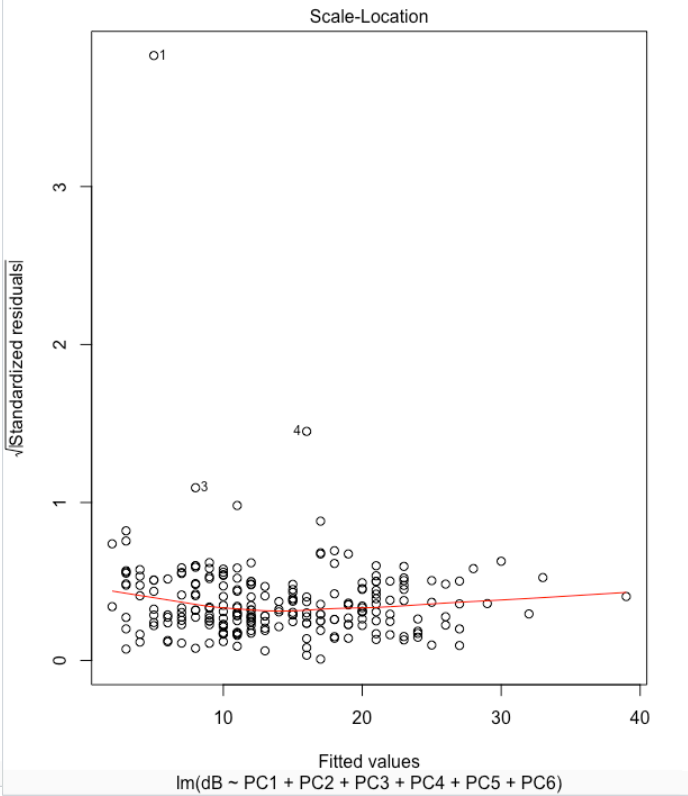
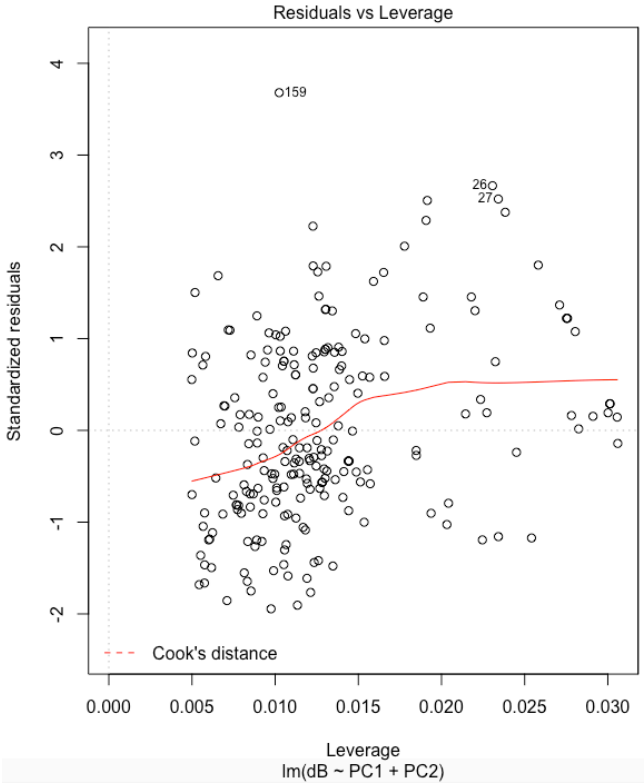


Residuals vs. Leverage Plots

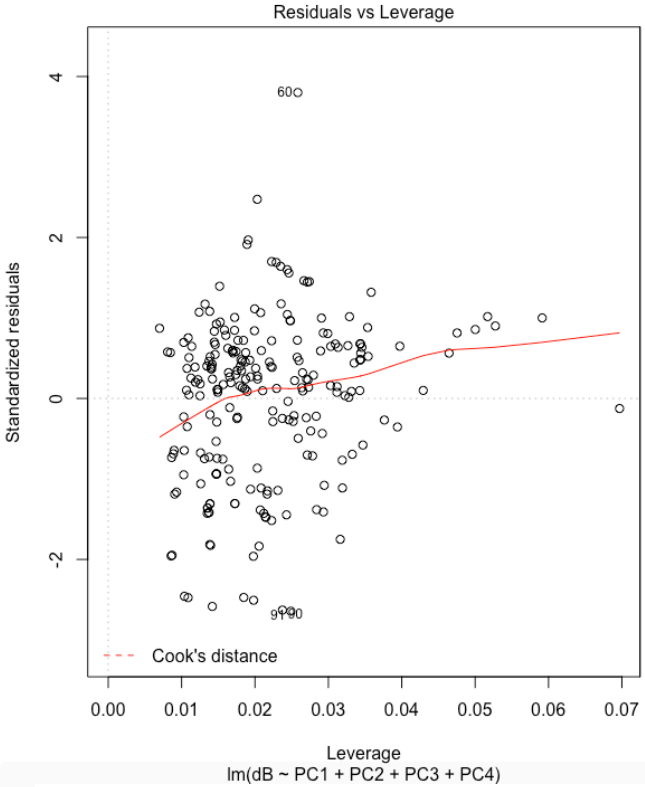
Finds Influential cases

Checks for outlier's potentials to modify the regression line (Cook's Distance used)

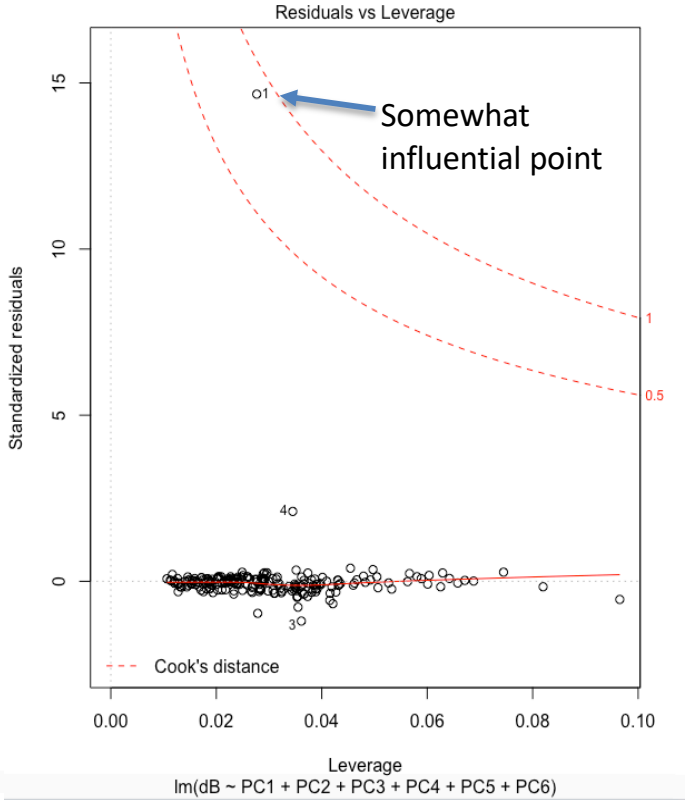
2



4

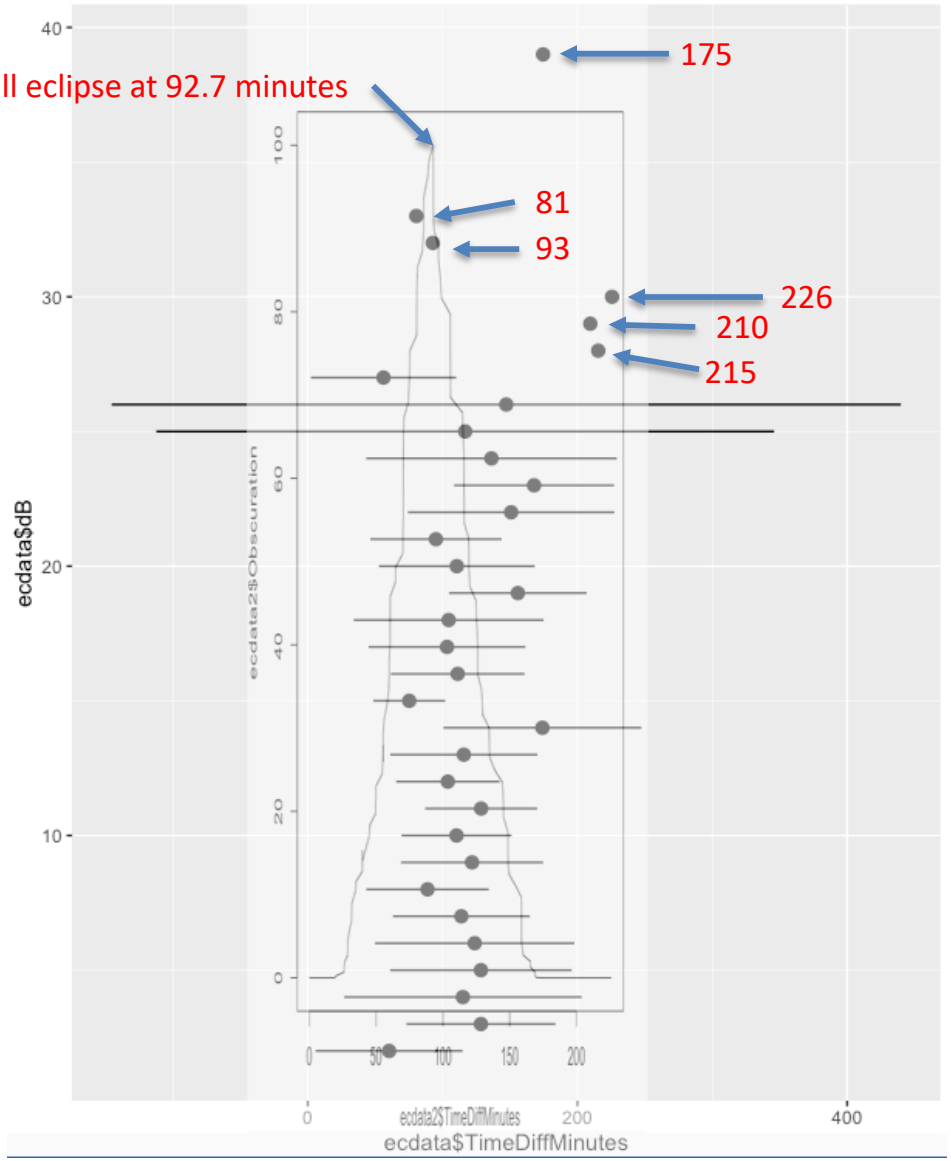


6



dB Levels vs. TimeDiffMinutes

db levels vs time into the experiment
with overlay of the Mean values and summary time statistics

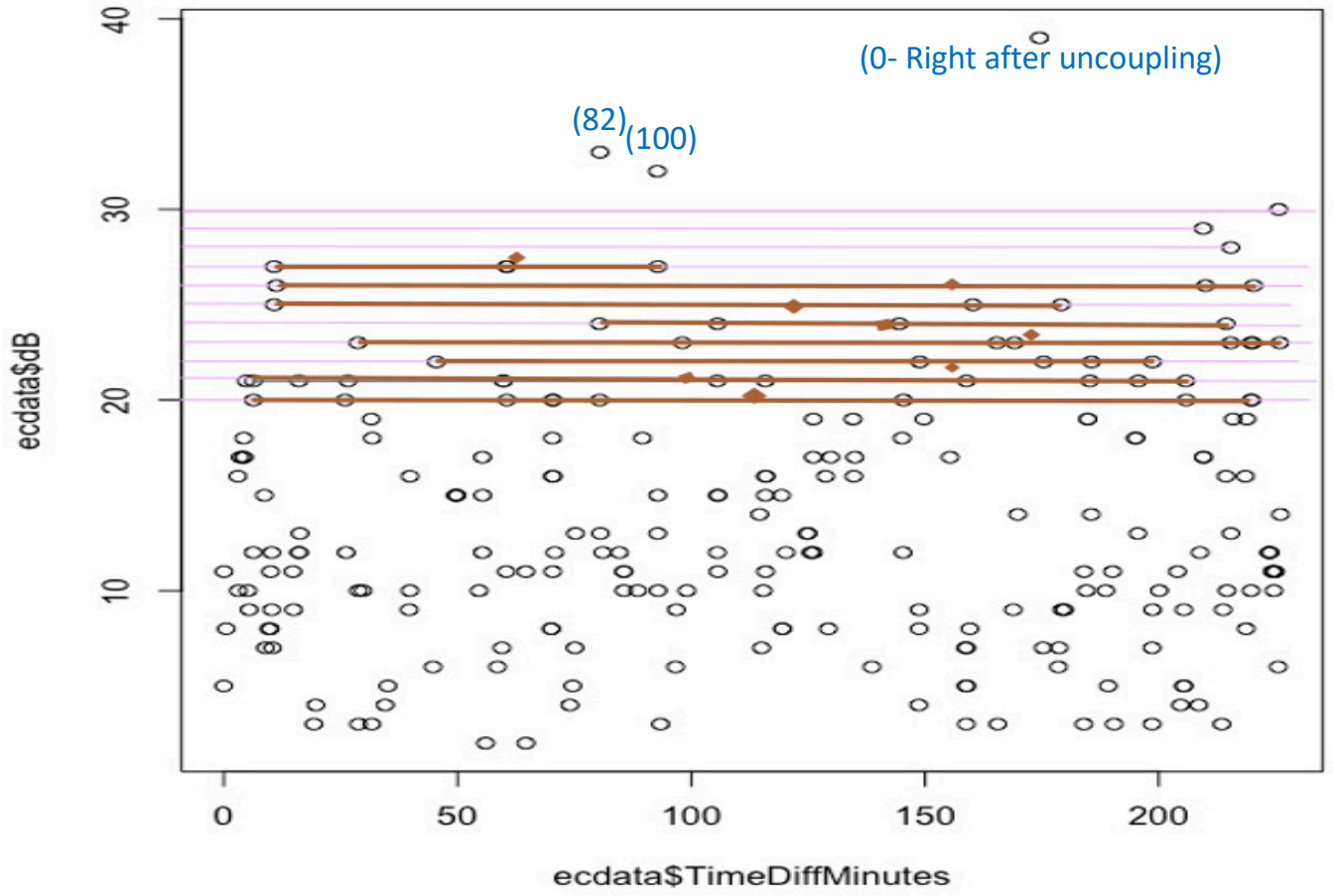


The numbers at the right are the times, in minutes, of the progression of the experiment at each point.

Many high values were seen more than 2 hours after full eclipse (Points 210 to 226.)

dB vs. Time Into the Experiment, in Minutes

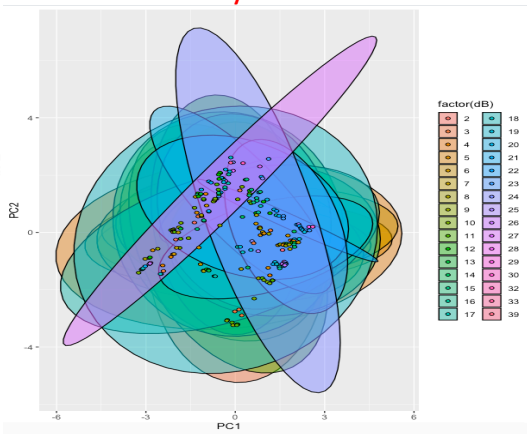
- The darkened bands are the spans of Signal reports throughout the experiment.
- ( ) values indicate percentage of Solar Obscuration, if non-zero.
- All single values above 27 dB were from Alberta or NV.



This is a breakout of the prior graph, using the Raw Data set between 20 and 30 dB.

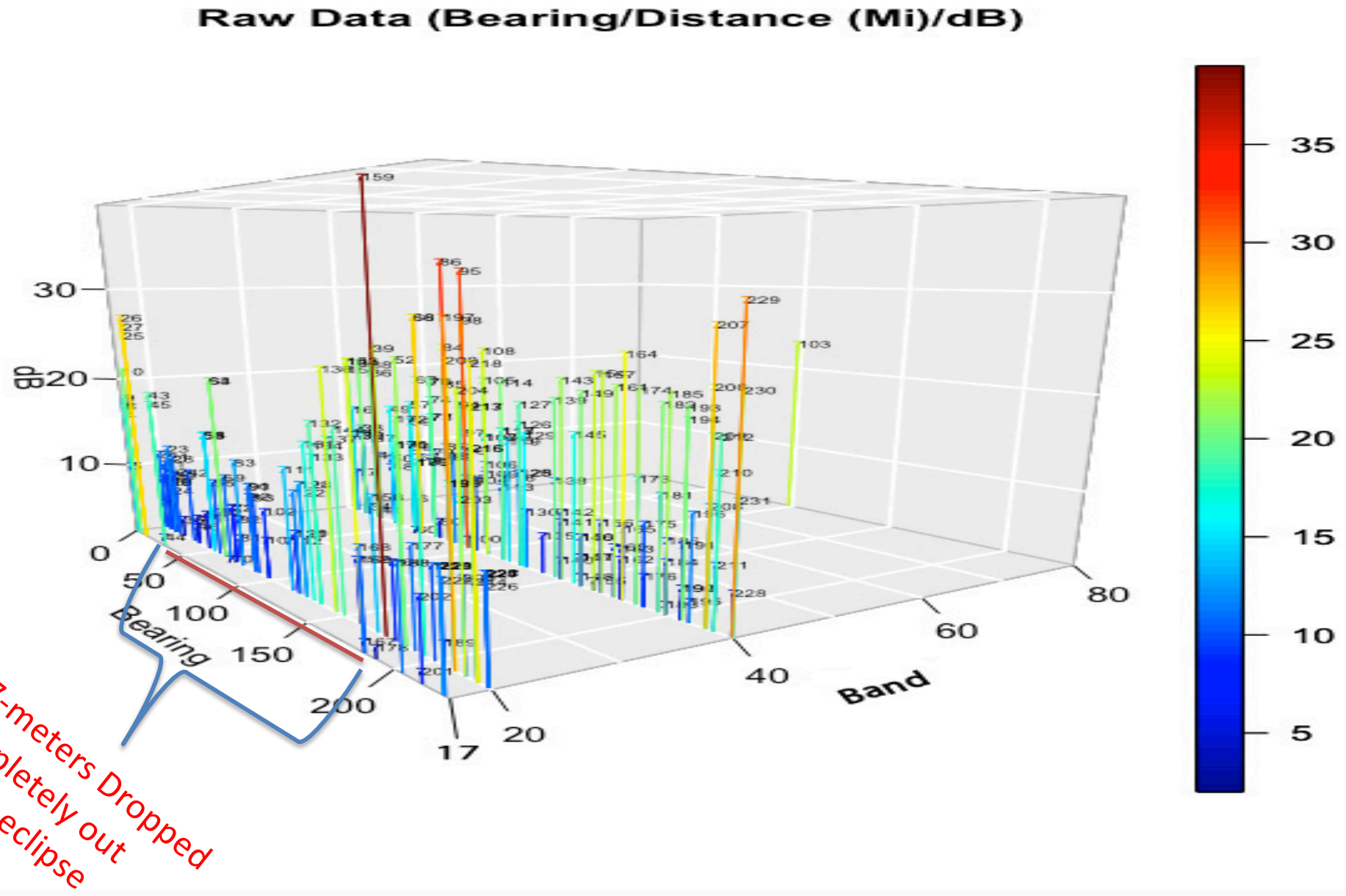
There were a couple unusual orientations with some readings in this range. See below

PCA by dB

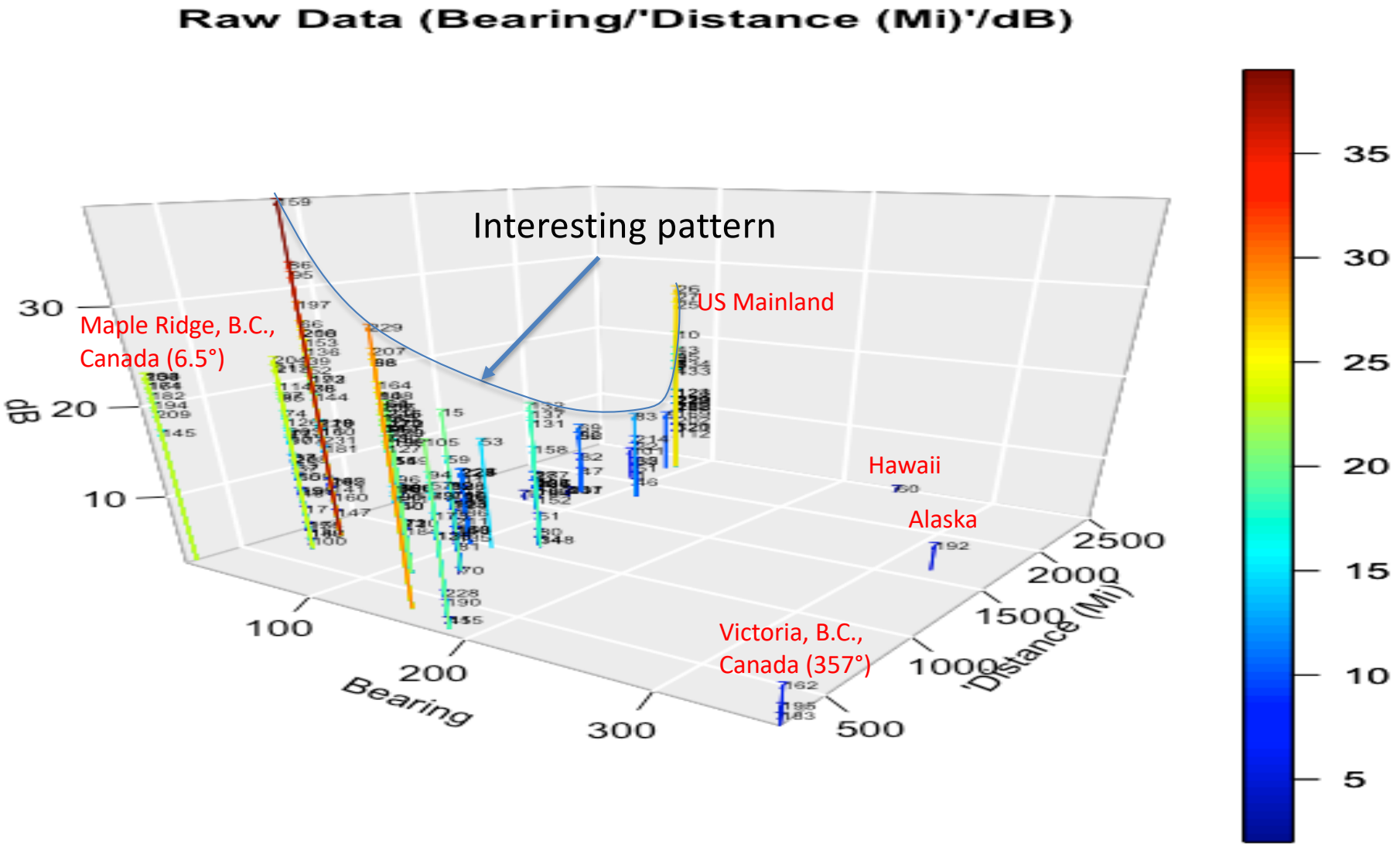


Bill Garber (WG0R)

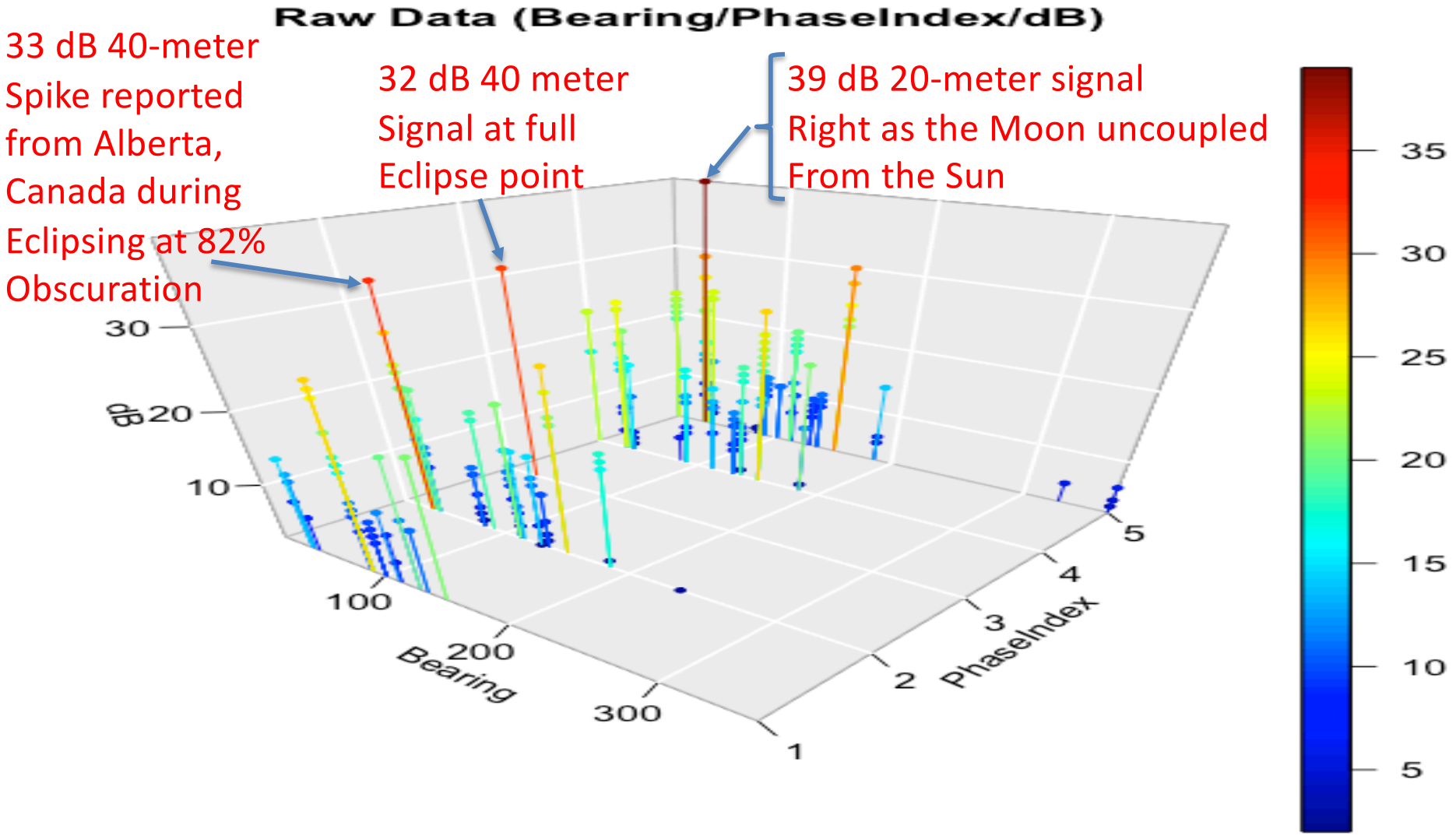
dB by Bearing, Band



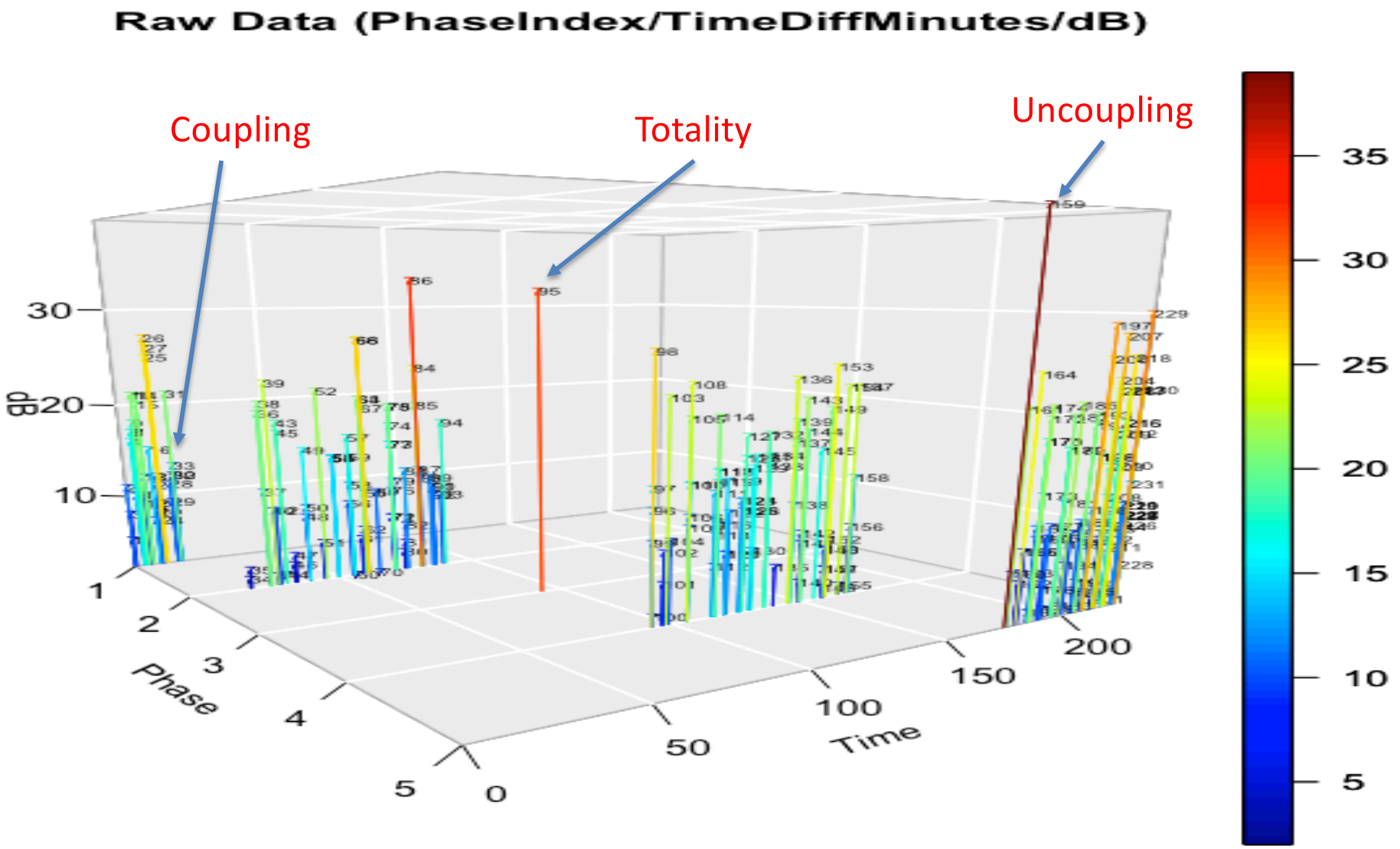
dB by Bearing, Distance



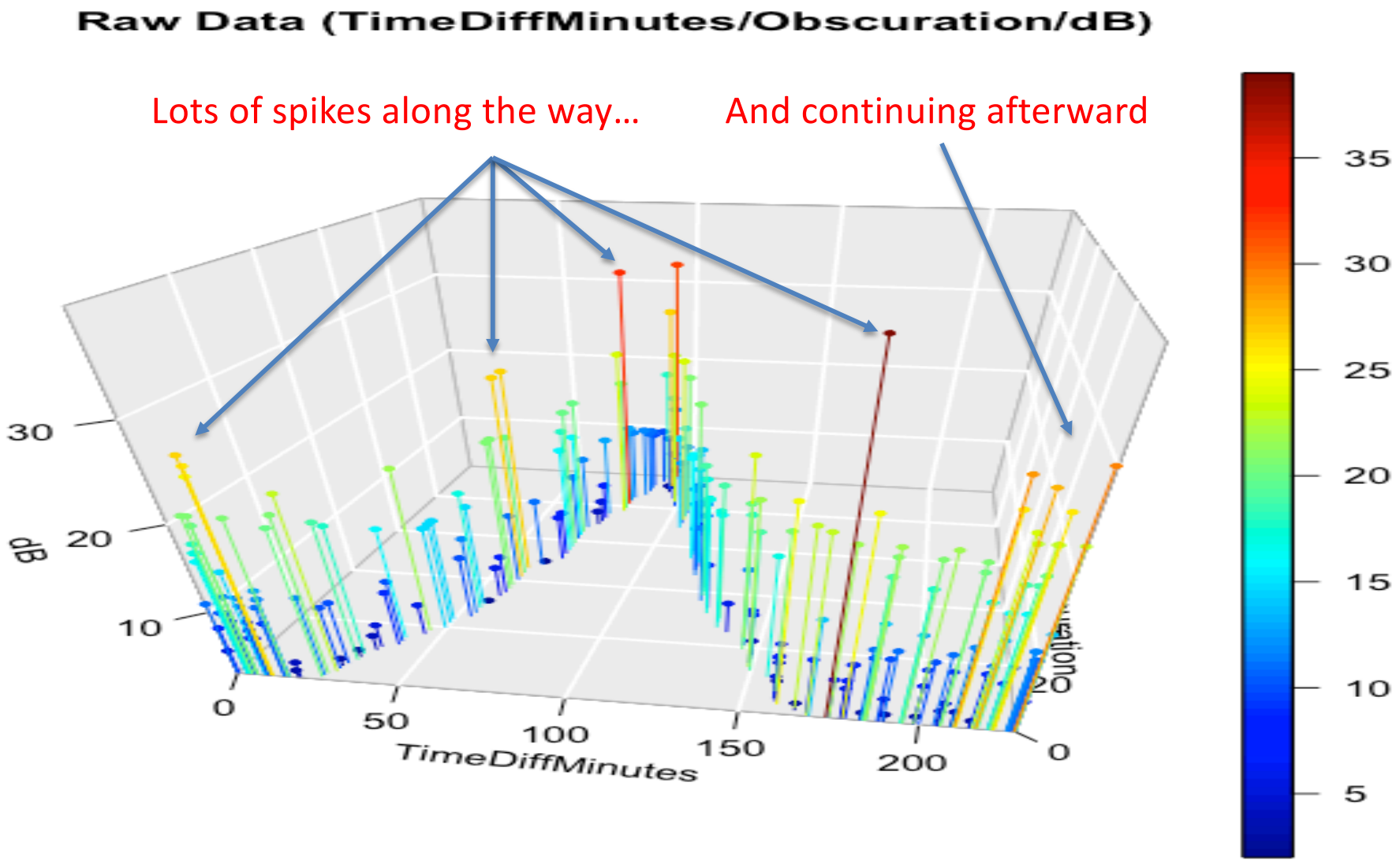
dB by Bearing, Phase



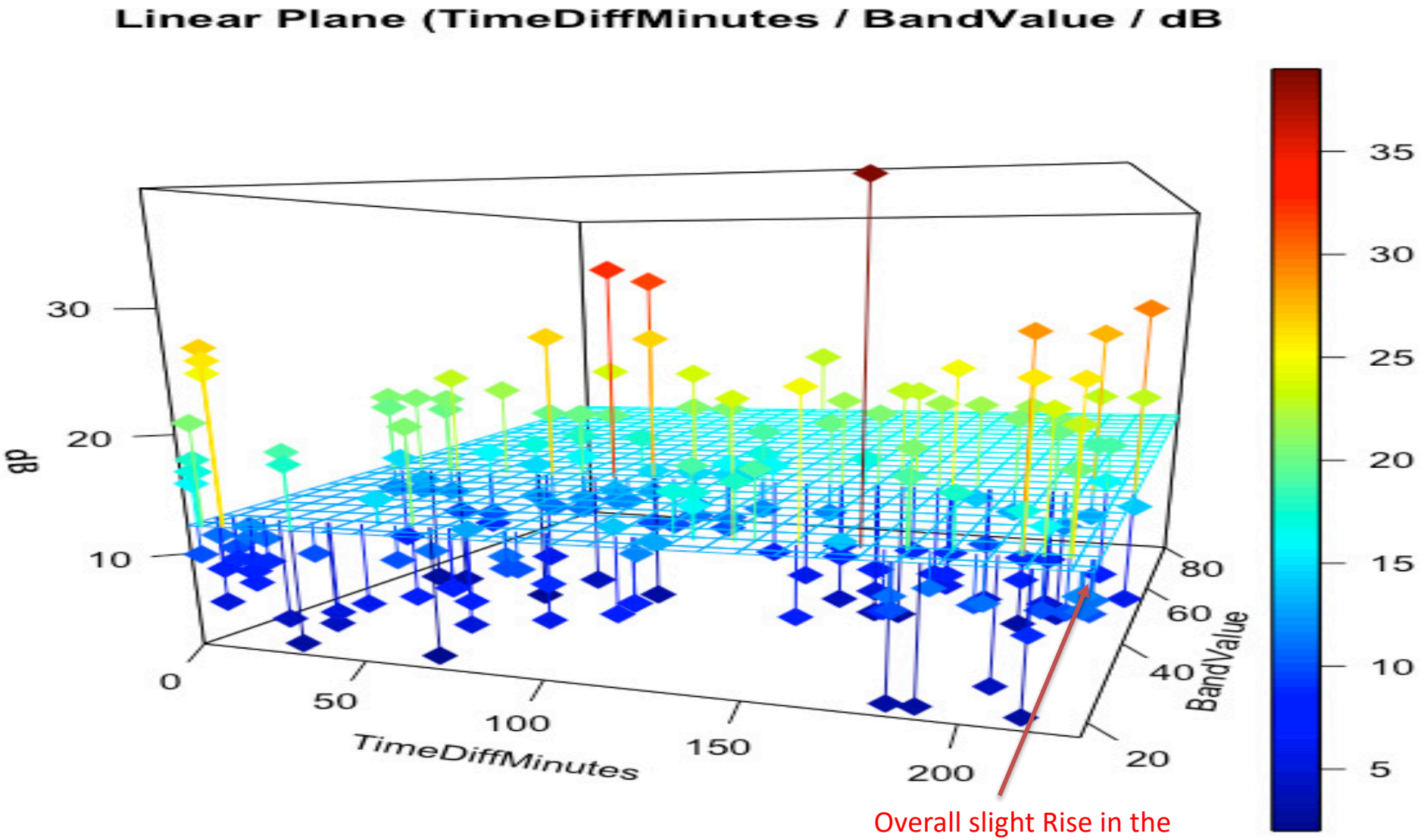
dB by Phase, Band



dB by time, Obscuration

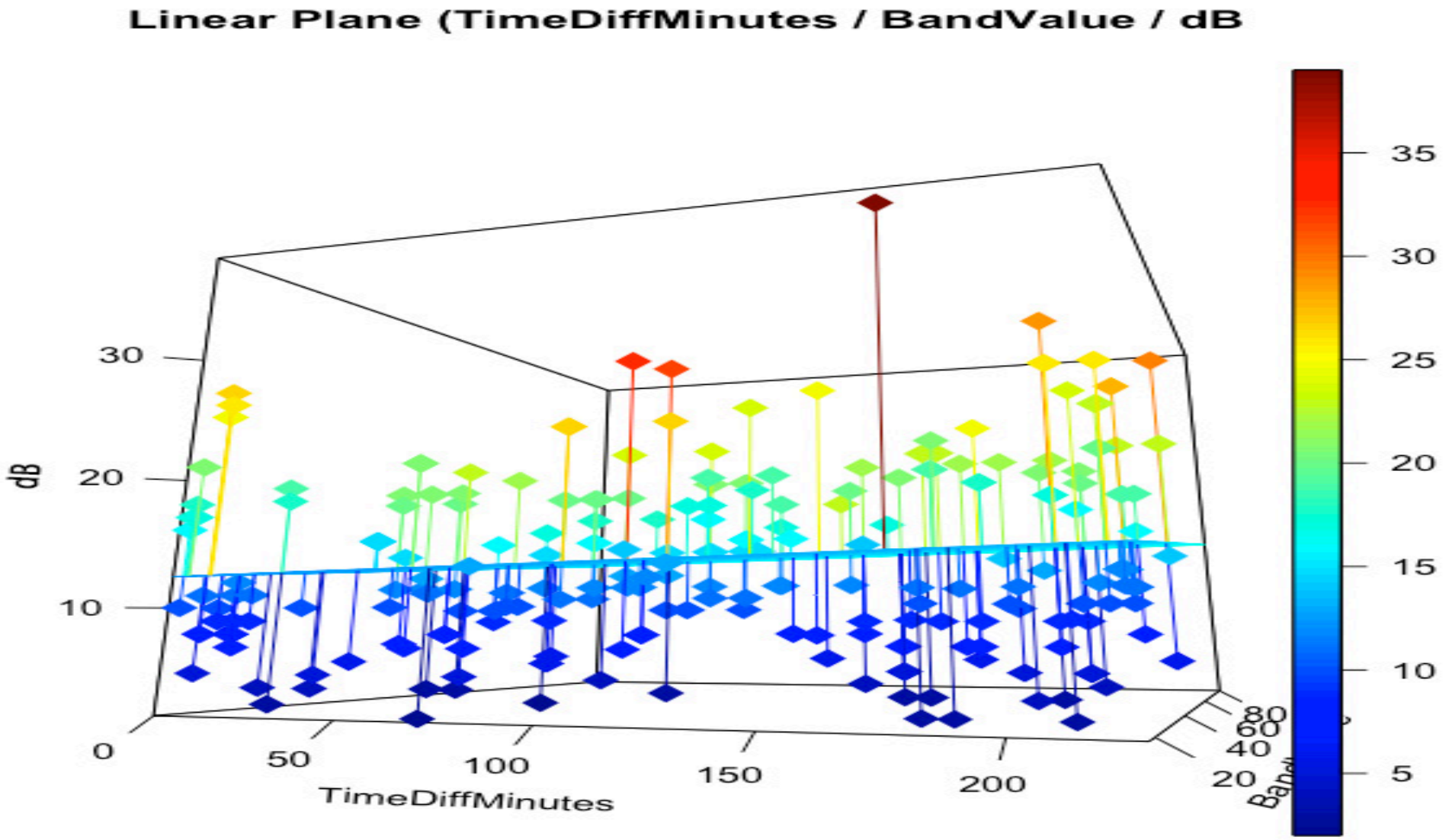


Linear dB Plane by Time, Band



Linear dB Plane by Time, Band

(In-Plane View)



Summary

- The eclipse impacted the propagation across the multiple parameters used and over the time of the experiment, and the Analysis tools used were very helpful.
- The factors in the Biplot gave insight into what's going on with the propagation during the eclipse.
- The Principal Components Analysis and Cluster Analysis highlighted areas that were similar in nature, and each of the analyses used had their own distinct ways of showing the clusters and yielded different views of the data.
- The Regression Analysis yielded a perfect (R^2=1) model for the dataset (although there are 3 outliers in the final model that couldn't be resolved with removal of them in the data set).
- The 17-meter band completely dropped out of the picture during the eclipse!
- Exploring the 80-meter, and perhaps the 160-meter bands would have likely yielded interesting results, as these were undoubtedly influenced more by the eclipse than the four explored, but my Off-center-fed Windom antenna is not very efficient in those bands. (Reducing the length of the Test message would have allowed the two other bands to be explored within the 5-minute test intervals.
- The R Program is very useful, and I look forward to doing something with interactions using it.