A report on the Comms monitoring system

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1 Introduction

The Auger South array depends on wireless communication for the transfer of data from the individual tanks. By sending this information by radio, there exists the possibility for interference in communications. It is in our best interest to monitor the communications health of the array to diagnose potential problems, data loss, and to ensure correct reporting.

The Comms files are hosted on the case ftp server, *ftp hea.cwru.edu*, accessed with the old Auger username (cuyam) and password. The folder (*comms*) on the ftp server contains both the zipped format in which the files arrive (*comms/zip*) and the unzipped data (*comms/raw_data*). The raw data files are organized by date (*comms/raw_data/by_date/yyyy/mm/dd*) and by file type, determined by three letter extension. The files of these types are split into NETLOG, containing BSUs > 30 (decimal), and NETLOG2, containing BSUs < 30 (decimal) in order to reduce stress on the communications system. The file types are .ARQ, .MEM, .TXT, .DAT, .BAD, .REP, and .ZIP. The files currently parsed for information are the .ARQ, .MEM, and .TXT files. We have written Python programs using the SciPy and Matplotlib libraries to plot output graphs of the data in order to interpret the status of the system.

1.1 .ARQ (*comms/raw_data/ARQ*)

Labeled by NETLOG(NETLOG2)_YYYY_MM_DD_MM_DD.ARQ

The .ARQ files are organized by date and NETLOG(NETLOG2), and describe the time and subscriber of an ARQ (Automated Repeat reQuest).

Format:

Time(hh:mm:ss) - Radio ID(in HEX) - ARQ level(01-07) - BSU # (in HEX),

1.2 .MEM (*comms/raw_data/BSU*)

Labeled by NETLOG(NETLOG2)_YYYY_MM_DD_BSU_##.MEM, where ## indicates BSU number.

The .MEM files are organized by date and BSU number and are located in the comms/raw_data/BSU folder. They are used for identifying the relation between radio ID and subscriber ID.

Format:

##(increases from 0) - Radio ID(in DEC) - Subscriber ID (in DEC) - Tank name

1.3 .TXT (*comms/raw_data/TXT*)

.TXT files without SYSTEM∼1 in the filename are packet delay diagnostics and are currently unused.

Sample from NETMON2_2009_06_15_06_15.TXT (Lines 1-11):

(4)[15/6/09-00:02:09] Average packet delay on 192.168.11.70 ¿ 500

(4)[15/6/09-00:02:19] Average packet delay returned to normal on 192.168.11.70 (delay=0)

(4)[15/6/09-00:06:29] Average packet delay on 192.168.11.70 ¿ 500

(4)[15/6/09-00:06:29] Average packet delay on 192.168.21.70 ¿ 500

(4)[15/6/09-00:06:29] Average packet delay on 192.168.31.70 ¿ 500

(4)[15/6/09-00:06:39] Average packet delay returned to normal on 192.168.11.70 (delay=0)

1.3.1 SYSTEM∼1.TXT Files

The SYSTEM∼1.TXT files are the the report summary from the NetMon Terminal. Most of the features in the SYSTEM∼1.TXT files are described in the online comms manual, specifically in *NetMon - Comms System Control Terminal.*[2] The files contain radio strength information, number of disconnections, and various forms of BSU information.

We pull data from the following sections within the SYSTEM∼1.TXT files:

Disconnected Subscribers Report

Subscriber - 3000 - is disconnected (BSU - 2, Timeslot - 21)

Subscriber - 294 - is disconnected (BSU - 15, Timeslot - 27)

Link Disconnections Report

1 disconnections logged for Subcriber 421

1 disconnections logged for Subcriber 544

Link Signal Strength Report

Subscriber ID 2058 - Uplink -99 dBm average (78867 Packets) - Downlink -68 dBm average (78863 Packets)

Subscriber ID 1516 - Uplink -95 dBm average (86399 Packets) - Downlink -78 dBm average (86398 Packets)

Sector Signal Strength Report

Base Station 11 - Downlink -67 dBm average over 5011114 packets - Uplink -69 dBm average over 5011142 packets

Base Station 12 - Downlink -67 dBm average over 5084234 packets - Uplink -69 dBm average over 5084367 packets

Sector ARQ Report

56594 ARQ errors logged for Base Station 11

13638 ARQ errors logged for Base Station 12

Base Station Temperature Logging

Base Station 11 - Hourly Temp Log >> Daily Min 17 deg C >> Daily Max 21 deg C

Base Station 12 - Hourly Temp Log >> Daily Min 17 deg C >> Daily Max 21 deg C

1.4 .DAT (comms/raw_data/DAT)

This section only contains files from 2002.

1.5 .BAD (*comms/raw_data/BAD*)

The .BAD files are labeled by NETLOG_YYYY_MM_DD_hh.BAD and only contain data from five days in 2005.

1.6 .REP (*comms/raw_data/REP*)

The .REP files have different formatting than the ZIP/.REP files. The file names are organized by BSU, see key below.

Format:

Channel - Signal Strength(dBm) - Normalized count

NETLOG prefixed files:

SI489D∼1-BSU44
SI589D∼1-BSU48
SI3891∼1-BSU41
SI3895∼1-BSU42
SI4491∼1-BSU35
SI4495∼1-BSU36
SI4891∼1-BSU45
SI4895∼1-BSU46
SI4899∼1-BSU43
SI5899∼1-BSU47
SIGSTR∼1-BSU31
SIGSTR∼2-BSU32
SIGSTR∼3-BSU33
SIGSTR∼4 -BSU34

COMPDATA -multiple lists of BSU # - by timeslot/channel-DOES NOT follow format of remaining REP files

NETLOG2 prefixed files:

SI4C81∼1-BSU15
SI4C85∼1-BSU16
SI409D∼1-BSU24
SI509D∼1-BSU28
SI3091∼1-BSU21

SI3095∼1-BSU22
SI4091∼1-BSU25
SI4095∼1-BSU26
SI4099∼1-BSU23
SI5099∼1-BSU27
SIGSTR∼1-BSU11
SIGSTR∼2-BSU12
SIGSTR∼3-BSU13
SIGSTR∼4-BSU14

COMPDATA -multiple lists of BSU # - by timeslot/channel-DOES NOT follow format of remaining REP files

1.7 .ZIP (*comms/raw_data/ZIP*)

.ZIP files are labeled by NETLOG(NETLOG2)_YYYY_MM_DD_PING.ZIP or NETLOG(NETLOG2)_YYYY_MM_DD_REP.ZIP. The format inside the ZIP files is NETLOG(NETLOG2)/REPORTS/dd hh#.PIN(dd hh#.REP). These files appear to be what Little Brother and Big Brother are receiving on a 15 minute basis. Unfortunately for monitoring, we only receive these files containing a full day, i.e. on a daily basis not a 15 minute basis. # in the filename represents the quarter hour segment to which the data corresponds, i.e. 0 = hh:00, 1 = hh:15, 3 = hh:30, 4 = hh:45

ZIP/.PING

Format:

RouterID (1-4)- # of Ping Transmissions- # Ping Replies - Min Reply Time (ms) - Max Reply time (ms)- Average Reply time (ms)-???

ZIP/.REP

Format:

SubscriberID - Parent BSU ID - Average Signal Strength(dBm) - Packet Count - # of ARQ requests-???

2 ARQ Diagnostics

We are capable of reading the .ARQ files and producing a graph of the daily rate of ARQs equaling 7, the point at which the radio stops requesting a resend of data and the data becomes lost, as a percentage of the total ARQ (01-07) rate for the day. The scale of this output can range from a few days up to the full set of ARQ data thus allowing for a measure of ARQ 07 rate over any time range in question. The ARQ percent is also graphed on a position basis for a day by matching the radio signal reporting the ARQ to its location in the array. This allows for the determination of individual subscribers or BSUs that appear to demonstrate a problem. The location maps are produced on a daily basis and can be produced for any date contained within the .ARQ and .MEM files.

Figure 1 shows a five week range of ARQ data ending on September 24, 2011. The vertical axis shows the percentage of ARQ 07 out of all reported ARQs for

those dates in a log based scale. The average ARQ 07 rate is around 0.1% and 'spike' instances range from 3% to 10% with a 10% ARQ 07 rate being cause for concern. On the ∼10% ARQ 07 days we examine closely what aspects may have caused or be a symptom of such an outbreak.

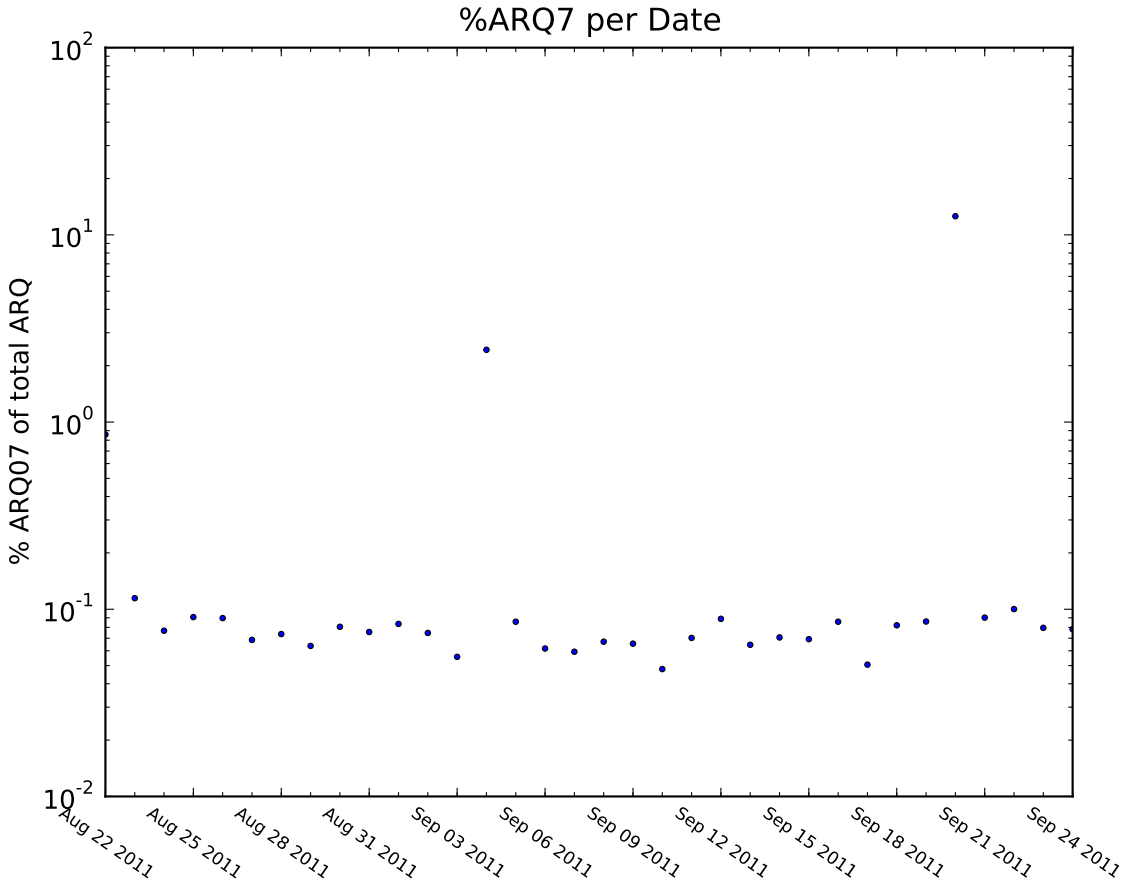

Figure 1: The percent of ARQs reaching level 7 out of all ARQs for the entire array. Abnormal days above 10% ARQ 07s are reported as major events.

Figures 2 and 3 show the ARQ 07 percentages for individual subscribers on the array, representing September 19, 2011 and September 20, 2011 respectively. September 19, 2011 is a typical day with an ARQ 07 percentage of 0.09%. As can be seen in Figure 2, the array map has no gray filled stations. However, on September 20, 2011, an ARQ 'spike' occurred with an ARQ 07 percent of 12.6%. In Figure 3, dark gray can be seen in the northern portion of the array, congregating in the BSUs of 31, 32 and 35. By examining output files, the main

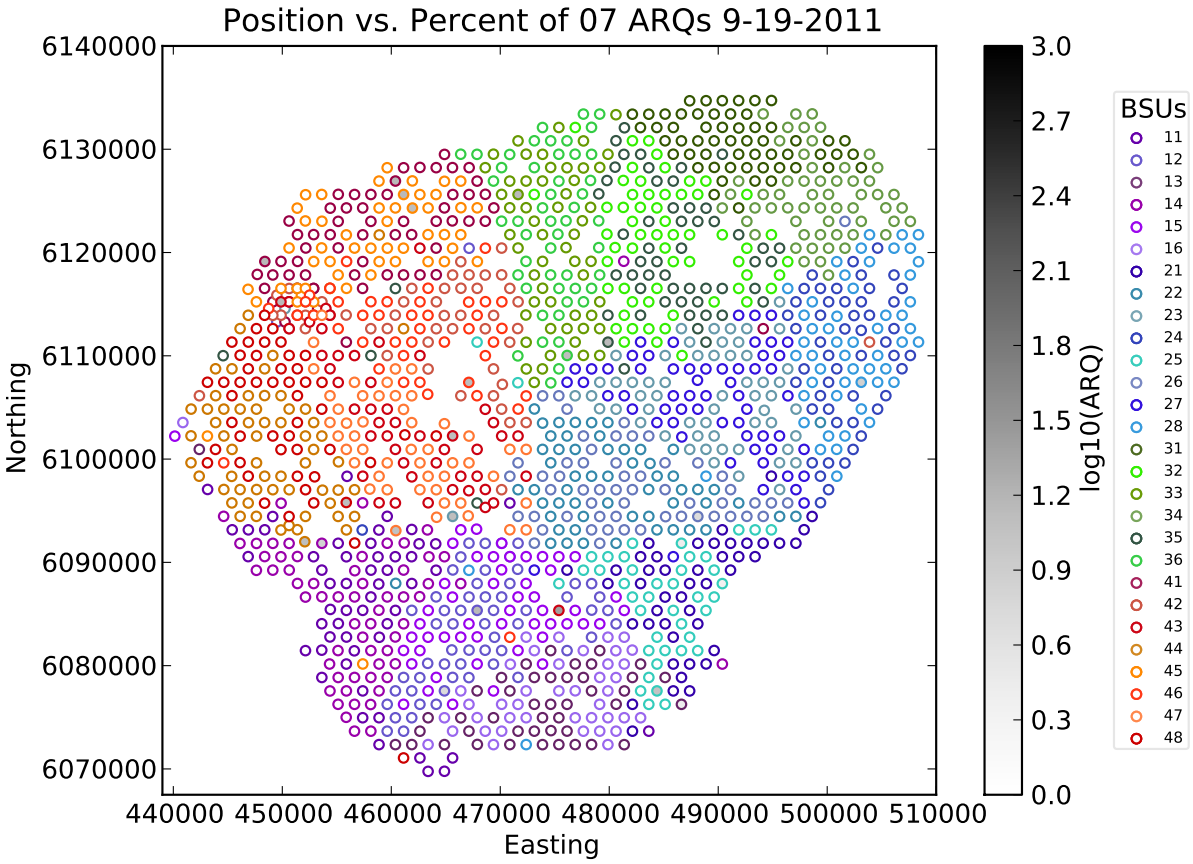

Figure 2: The percent of ARQs reaching level 7 out of all ARQs for specific subscribers represented in map form for September 19, 2011. Darker gray represents higher numbers of ARQs reaching level 7. Colored rings represent corresponding BSUs.

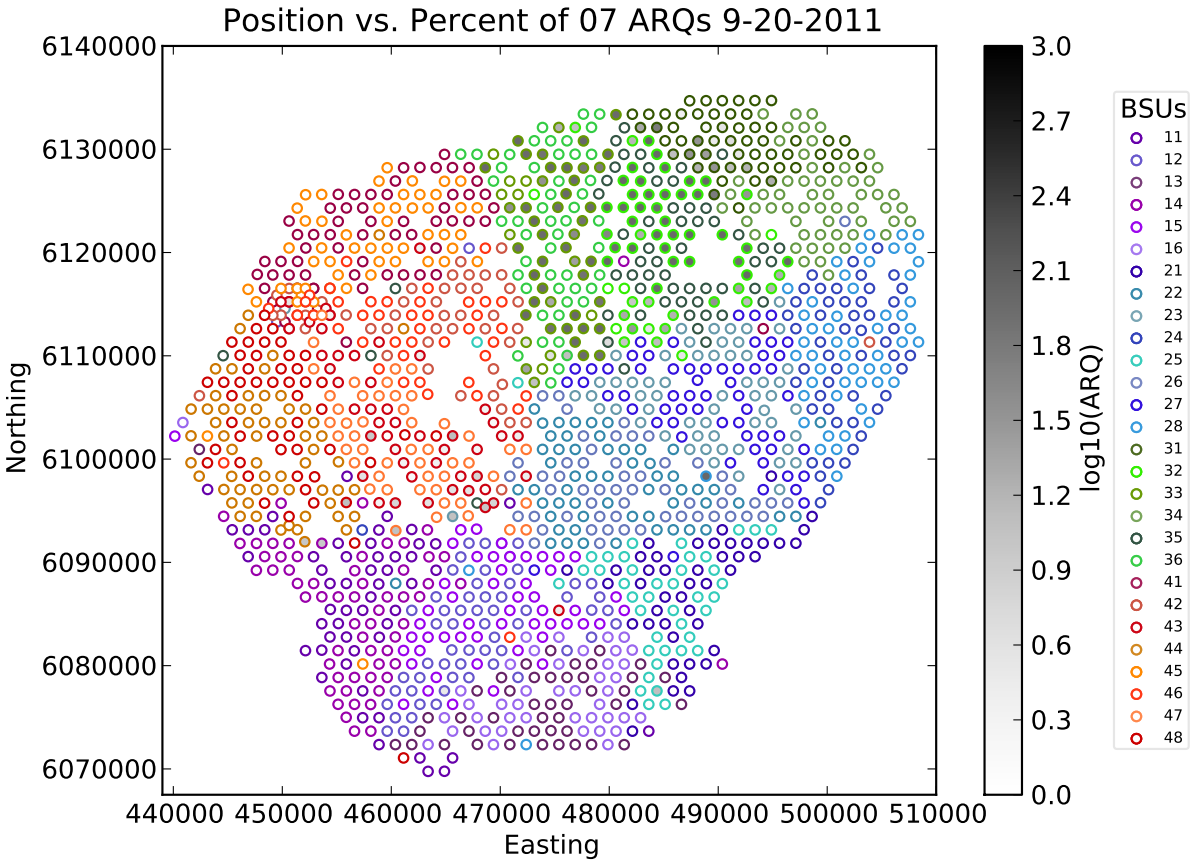

Figure 3: The percent of ARQs reaching level 7 out of all ARQs for specific subscribers represented in map form for September 20, 2011. Darker gray represents higher numbers of ARQs reaching level 7. Colored rings represent corresponding BSUs.

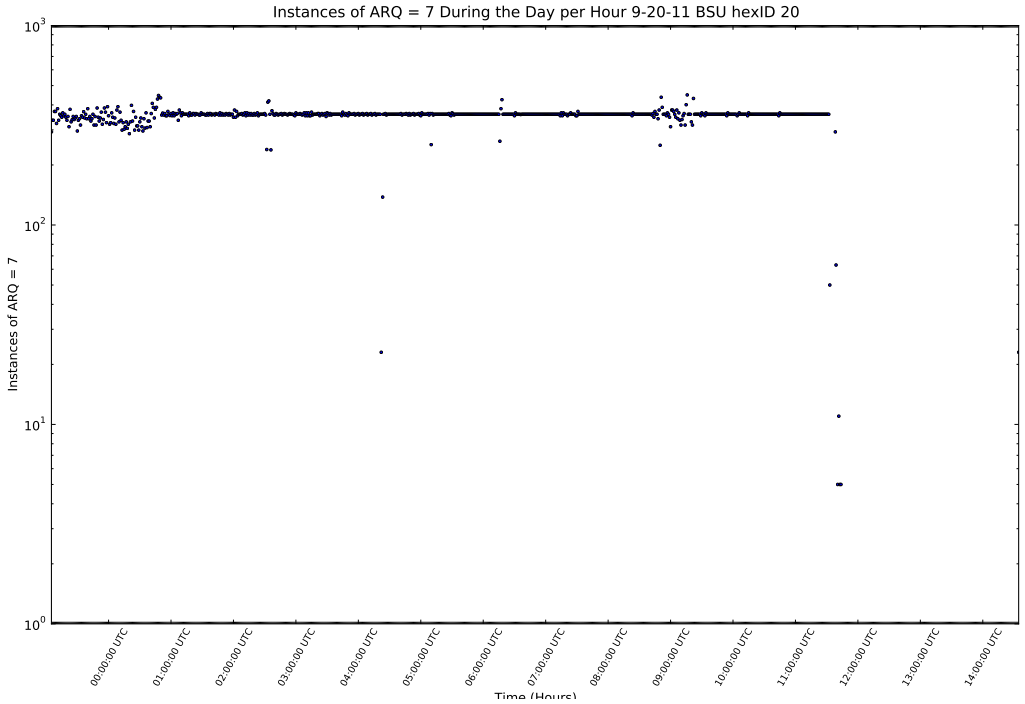

Figure 4: The count of ARQs reaching level 7 per minute for BSU 32 on September 20, 2011. Maximum number of ARQs that can be reported per minute by the array is 360 reports.

contributer of the spike on September 20, 2011 was revealed to be BSU 32, and the spike duration was from 23:00 UTC on September 19 through just before 12:00 UTC on September 20. This can be seen in Figure 4. The structure of the ARQ data reporting by the comms system allows for up to 360 ARQ reports per minute for each BSU for all levels of ARQ. ARQ spikes tend to display the maximum number of reports for ARQ level 7s during the spike time frame.

3 BSU Diagnostics

Currently BSU diagnostics consist of three elements: ARQ percent of packets, BSU radio signal strength, and BSU temperature. All three diagnostics are preformed on a daily basis. On the ARQ percent of packet graph the ARQ percent of packet is graphed in red along with the 5 week average percent in blue for each BSU. This allows for performance checks of the ARQ rate per packet for the BSUs and aids the identification of problem stations. The radio signal strength is shown on a similar graph with downlink signal strength in red and uplink in blue. There should be a small difference between the two signals. If there is a large difference between the signal strengths it may indicate a communications malfunction or some form of interference. The BSU temperature graphs show the maximum and minimum temperatures recorded by the BSU in red and blue respectively. This allows a determination if the BSU is mis-calibrated or experiencing a malfunction in its electronics and may determine if there is temperature dependence for producing errors.

3.1 BSU ARQs

Figure 5 displays a typical measure of the BSU ARQ packet percent. The red marked ARQ daily values are within the standard deviation error bars of the blue marked rolling average. For error bars missing a lower bound, the value of these lower limits is negative and, since the vertical axis is in log scale, are undefined on the graph. In contrast the ARQ 'spike' day seen in Figure 6 displays ARQ packet percent values greater than the average, primarily in the BSUs ranging from 31 to 36. BSU 32 shows the greatest difference and is the BSU reporting the ARQ 'spike' as described in the previous section on ARQ diagnostics.

3.2 BSU Signal Strength

The BSU signal strength can be seen on a normal day in Figure 7 and on a spike day in Figure 8. Downlink signal strength is marked in red and has a $\sim$5 dBm greater strength than the Uplink marked in blue. This $\sim$5 dBm difference is a known part of the design, referenced in the comms manual[2], and is to be expected. A greater difference between downlink and uplink indicates an issue with signal communications. An example of such a large difference can be seen in Figure 8.

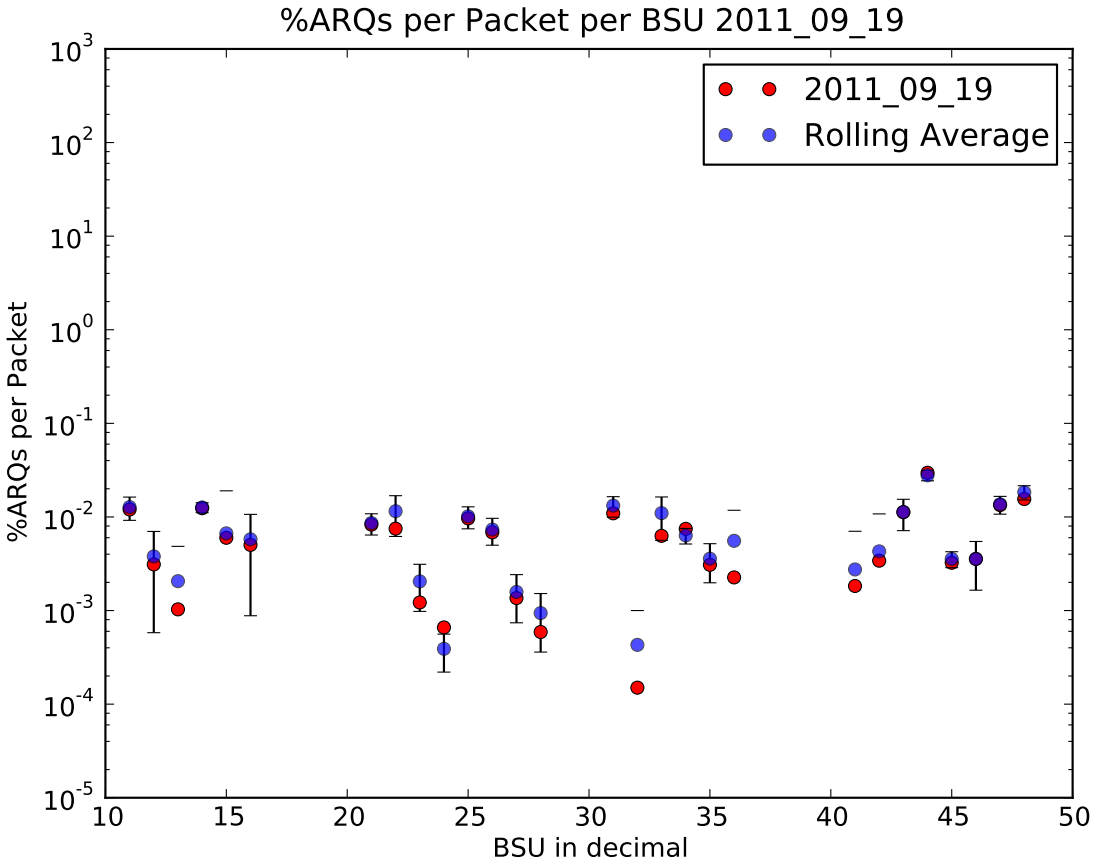

Figure 5: The percent of ARQ packets out of all packets sent to the BSUs, organized by BSU. The red markers represent the current day's percent. Blue markers represent the five week rolling average, including standard deviation errorbars.

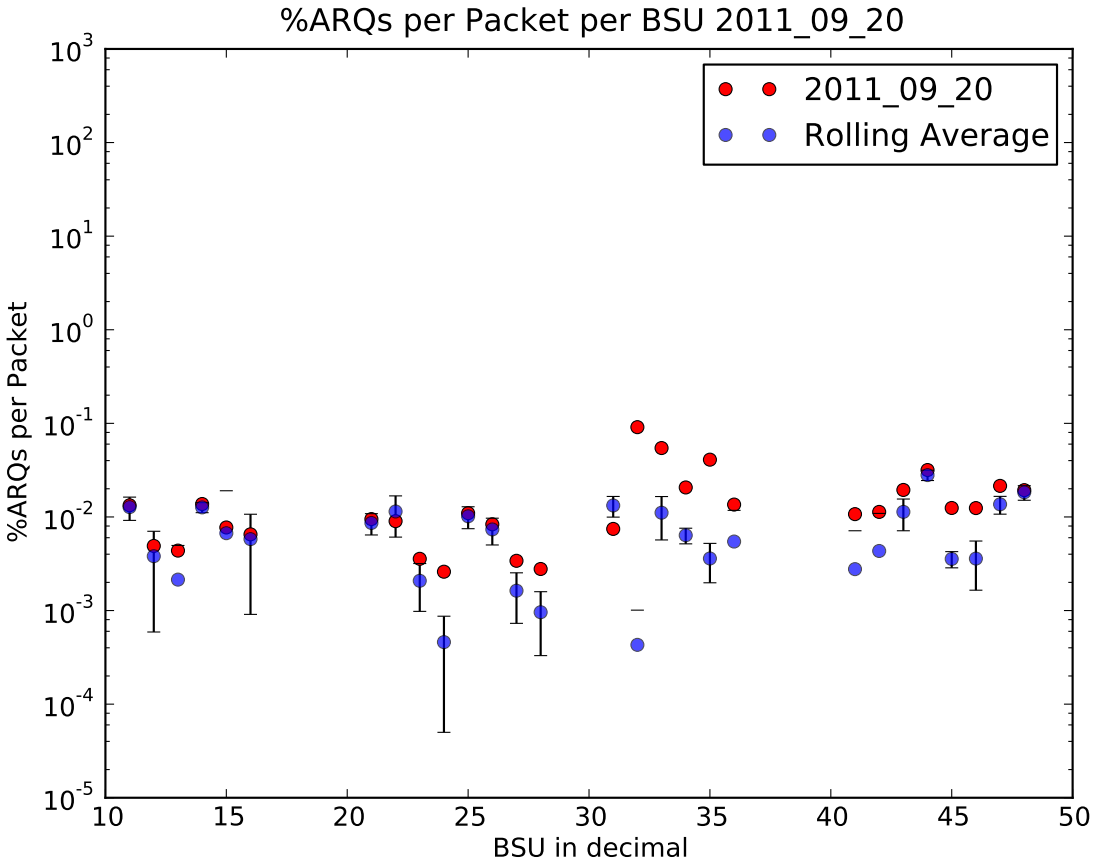

Figure 6: The percent of ARQ packets out of all packets sent to the BSUs, organized by BSU. The red markers represent the current day's percent. Blue markers represent the five week rolling average, including standard deviation errorbars.

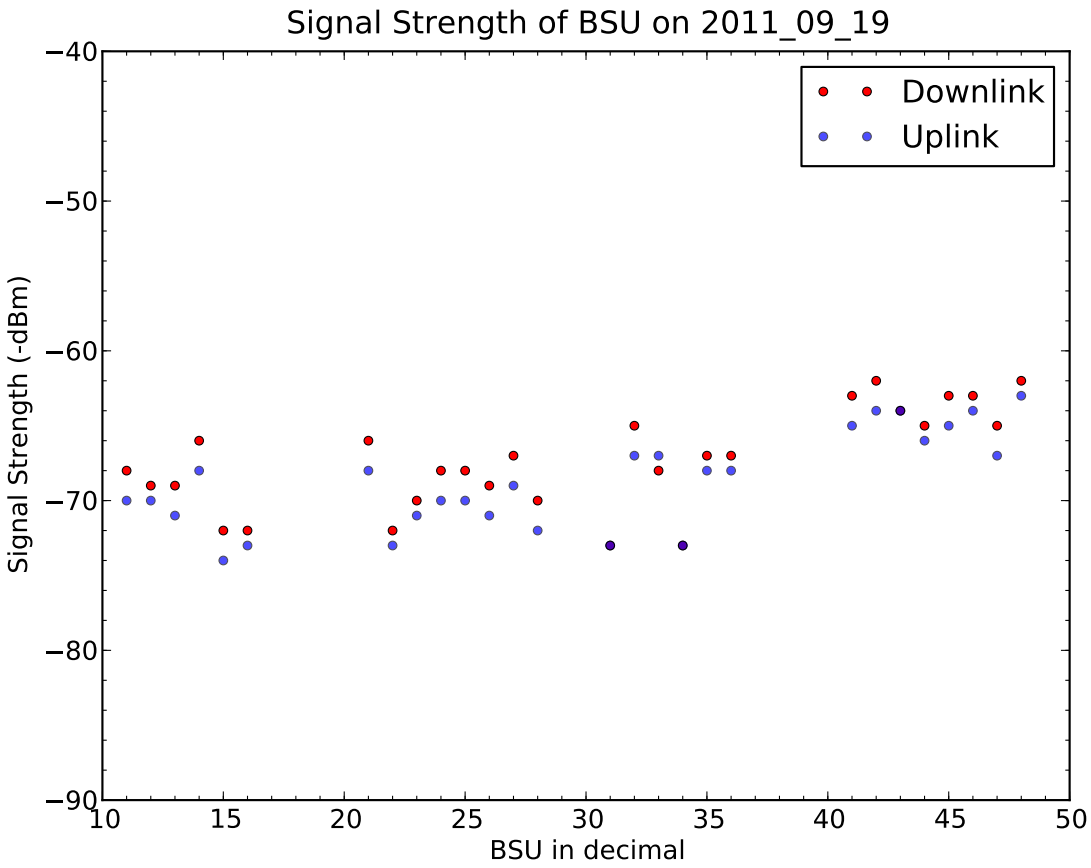

Figure 7: The signal strength as reported by the BSUs. The red markers represent downlink signal strength. Blue markers represent uplink signal strength. Large gaps between the two indicate problems in one of the signals.

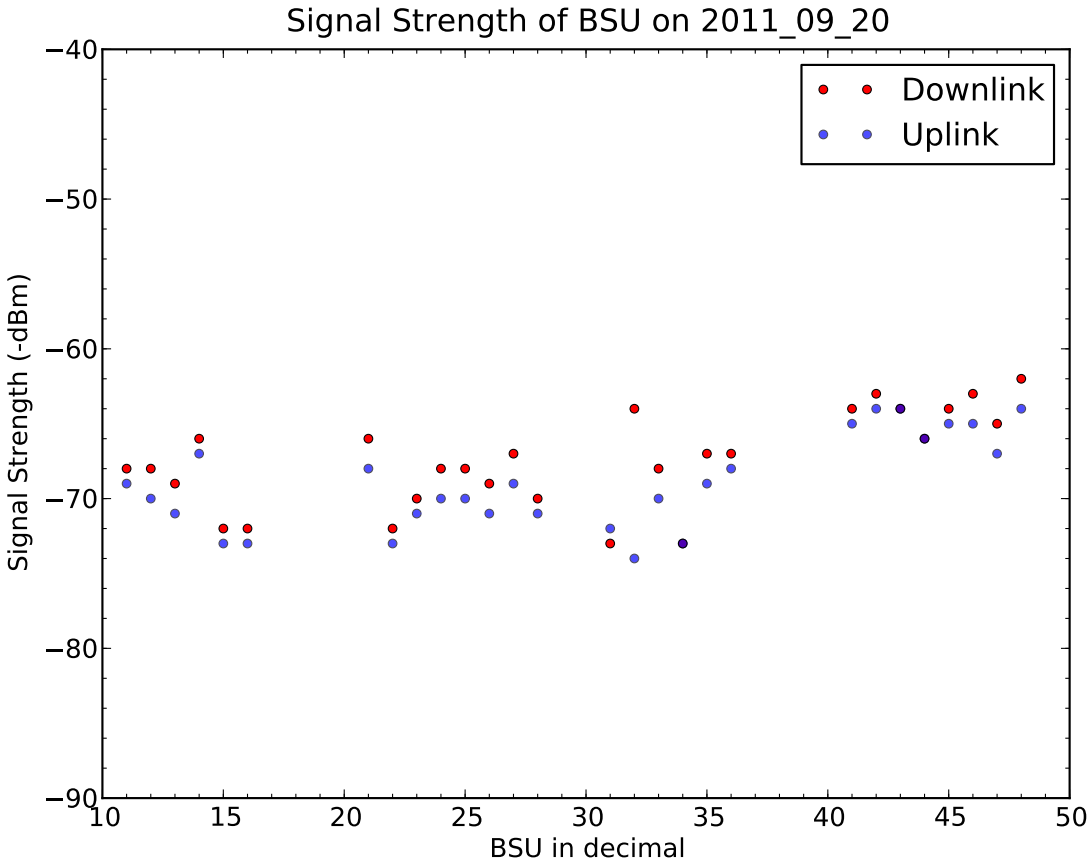

Figure 8: The signal strength as reported by the BSUs. The red markers represent downlink signal strength. Blue markers represent uplink signal strength. Large gaps between the two indicate problems in one of the signals.

3.3 BSU Temperature

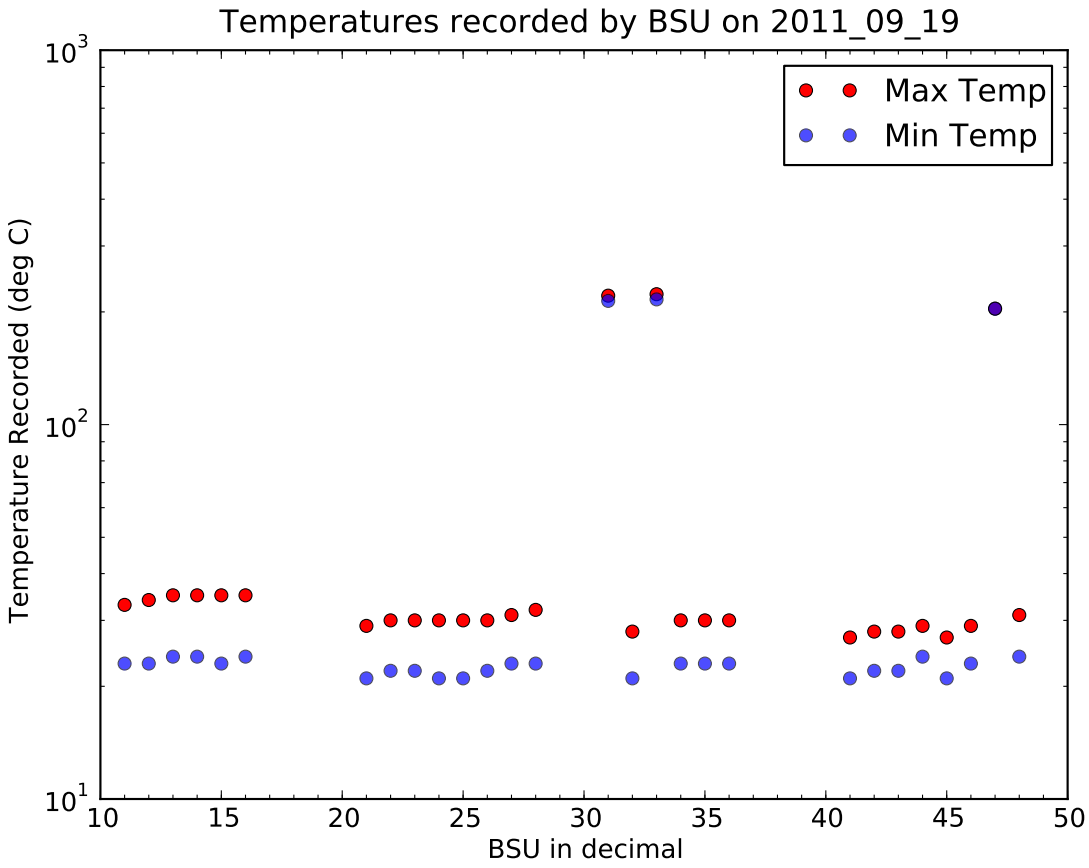

Figure 9: The report of the minimum and maximum temperatures at the BSUs in Celsius on September 19, 2011. The red markers represent maximum temperature. Blue markers represent the minimum temperature.

The BSU temperature is an additional diagnostic taken to determine if temperature may play a role in communication errors. Figure 9 shows a normal day on September 19, 2011 and Figure 10 shows an ARQ spike day. BSUs 31, 33 and 47 are mis-calibrated and always report temperatures near 200 degrees Celsius.

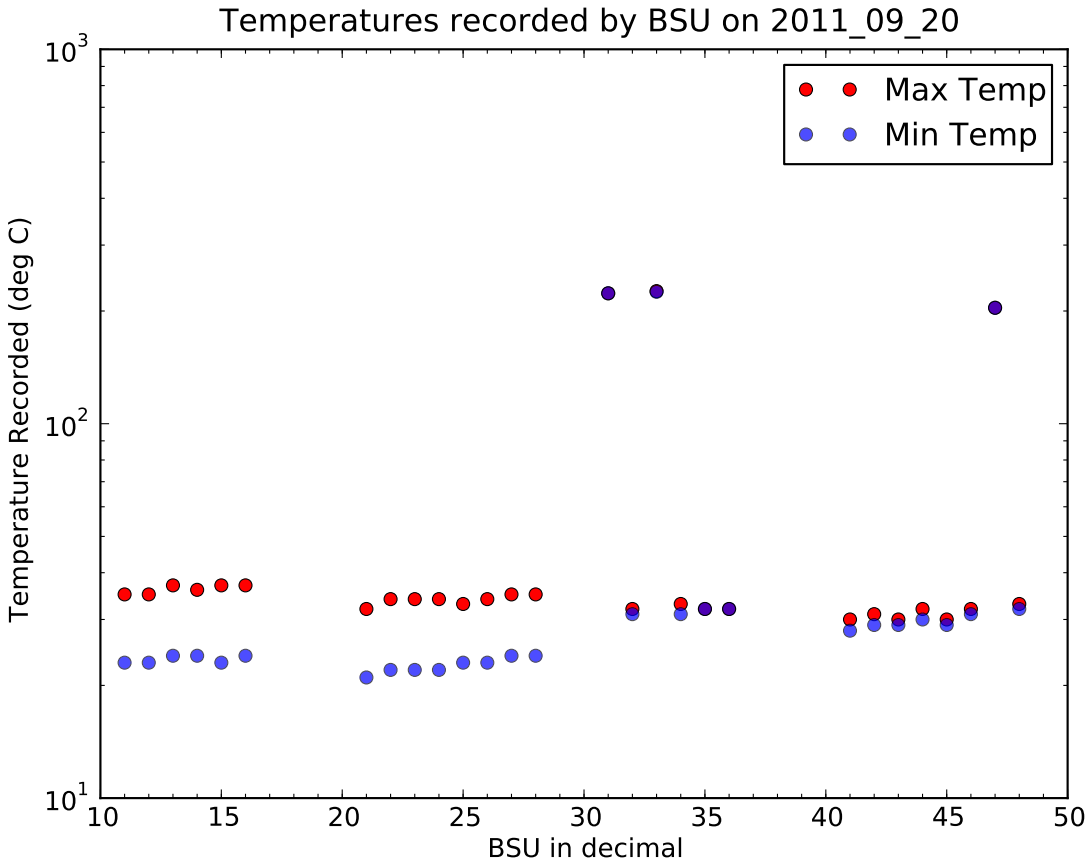

Figure 10: The report of the minimum and maximum temperatures at the BSUs in Celsius on September 20, 2011. The red markers represent maximum temperature. Blue markers represent the minimum temperature.

4 Radio Diagnostics

Using the SYSTEM~1.TXT files and the .BSU files, we are capable of mapping the uplink and downlink signal strength of the subscribers in addition to the difference between uplink and downlink. Abnormal signal strength or a large discrepancy between uplink and downlink strength indicate problems within the array that can be confirmed through additional channels to determine where the problems occur. The maps also indicate what subscribers are not producing outputs in the SYSTEM~1.TXT files, indicated in a light mauve/purple. In addition, we produce maps of disconnected(non-reporting) subscribers and reporting subscribers with repeated disconnections for further diagnostics.

4.1 Disconnected Subscribers

The Figures 11 and 12 show a map of the subscribers recorded as disconnected in the "Disconnected Subscribers Report' section of the SYSTEM~1.TXT files. The blue markers show the locations of the subscribers listed and the mauve markers fill out the array for ease of viewing. A typical day, as seen in Figure 11, shows few disconnections, and those disconnections are scattered throughout the array. A 'spike' day, such as Figure 12, shows a clustering of disconnections near the 'spiking' BSU and can be used to identify the problem area.

4.2 Number of Disconnections

The maps seen in Figures 13 and 14 are maps of the number of disconnections reported in the "Disconnections Report." These do not report the same data as the "Disconnected Subscribers Report." The Number of disconnections is shown by intensity with brighter colors indicating a higher number of repeat disconnections. Large numbers of low disconnections (< 100) are not indications of a problem and can occur on large portions of the map on normal operation days. This can be seen in Figure 13 on the western side of the array. Clusters of high disconnections indicate a problem and can bee seen in Figure 14 in the northern portion of the array near BSU 32. The location of a single malfunctioning subscriber can also be identified using these maps.

Signal Strength

The signal strength reported by the individual subscribers for downlink and uplink can be seen on an average day in Figures 15 and 16 respectively. It is difficult to determine on first glance if there is an issue by looking at the downlink and uplink maps. For this reason we produce difference maps of the signal strength by subtracting the value of the uplink strength from the downlink strength. A typical day as seen in Figure 17 is unremarkable with a few higher difference areas of little issue. A spike day, seen in Figure 18, shows a cluster of subscribers reporting a large difference, in this case a +10 dBm difference in the problem region around BSU 32, on September 20, 2011. Similar

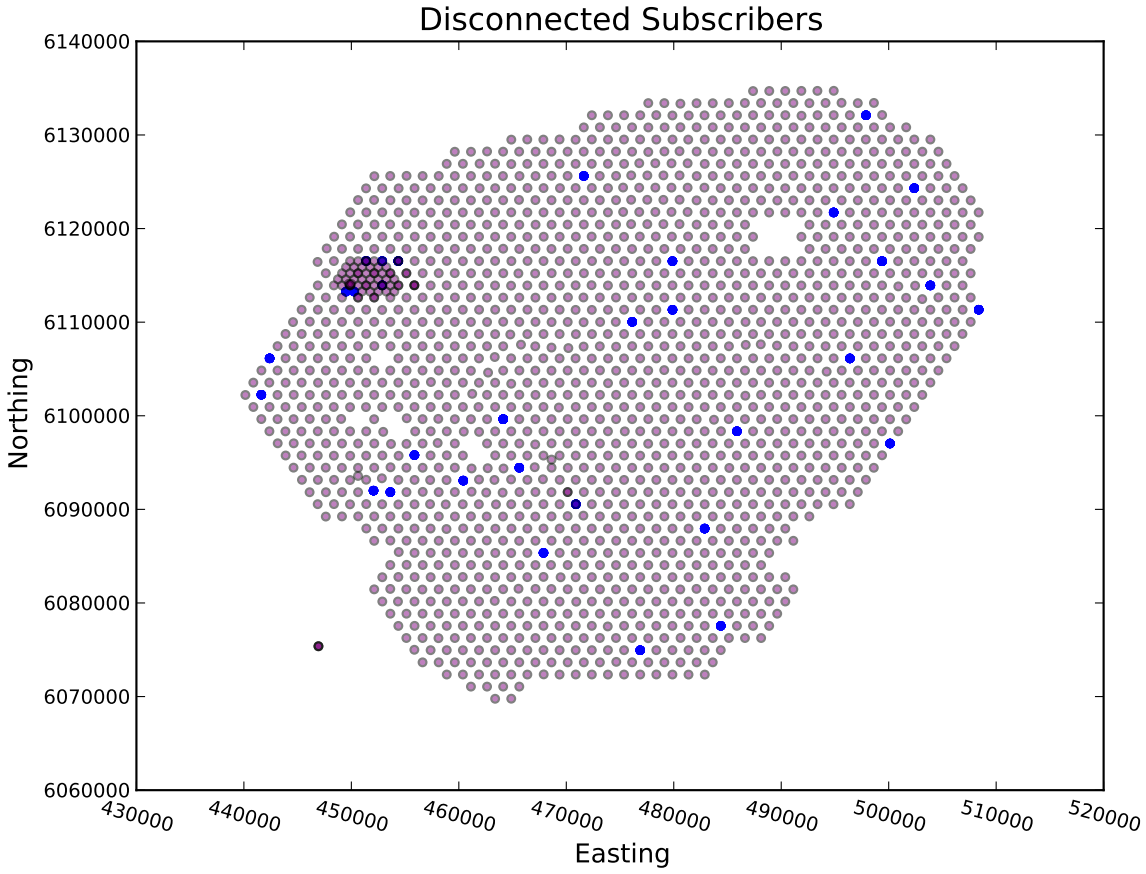

Figure 11: This map shows in blue what subscribers are listed as disconnected in the "Disconnected Subscribers Report" section of the SYSTEM~1.TXT files on a normal operation day. The mauve shows the location of subscribers not listed in the report and is used to aid interpretation of the map.

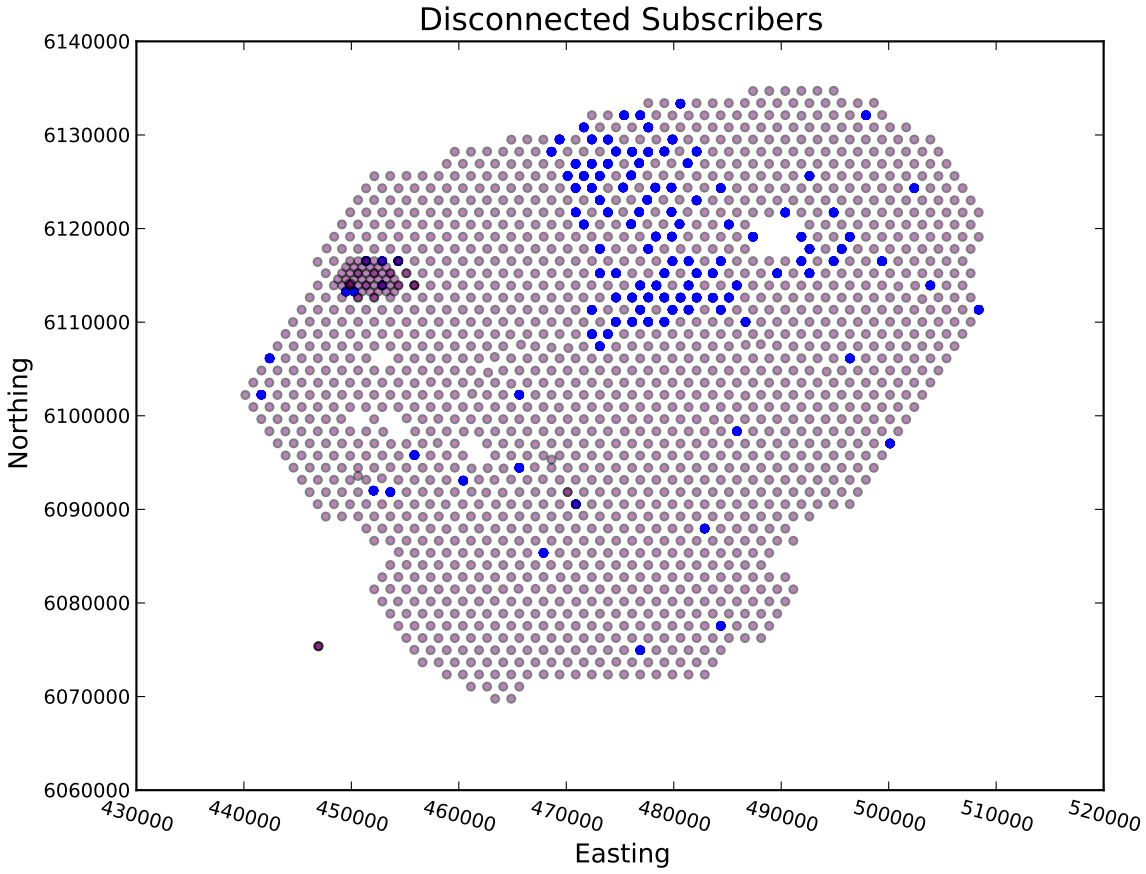

Figure 12: This map shows in blue what subscribers are listed as disconnected in the "Disconnected Subscribers Report" section of the SYSTEM~1.TXT files on the ARQ spike day of September 20, 2011. The mauve shows the location of subscribers not listed in the report and is used to aid interpretation of the map.

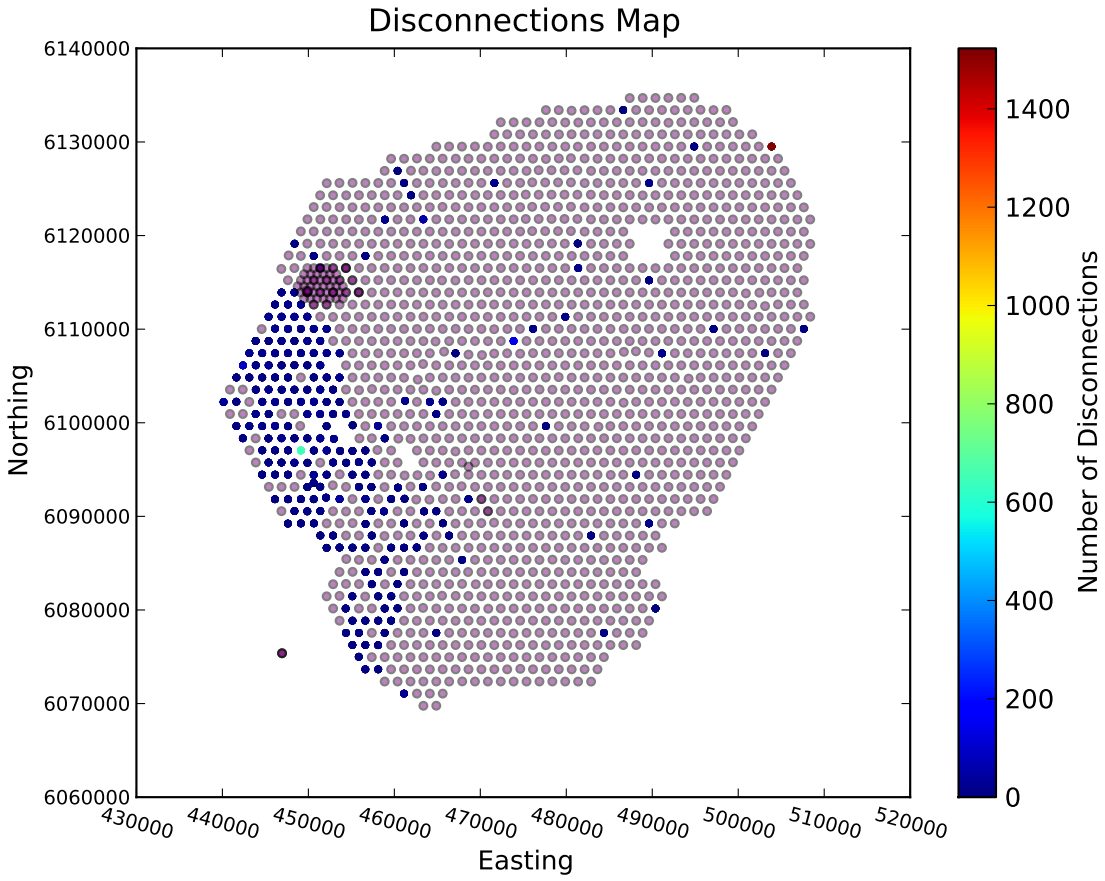

Figure 13: This map shows which subscribers are listed and the number of disconnections reported in the "Link Disconnections Report" section of the SYSTEM~1.TXT files. The mauve shows the location of subscribers not listed and is used to aid interpretation of the map.

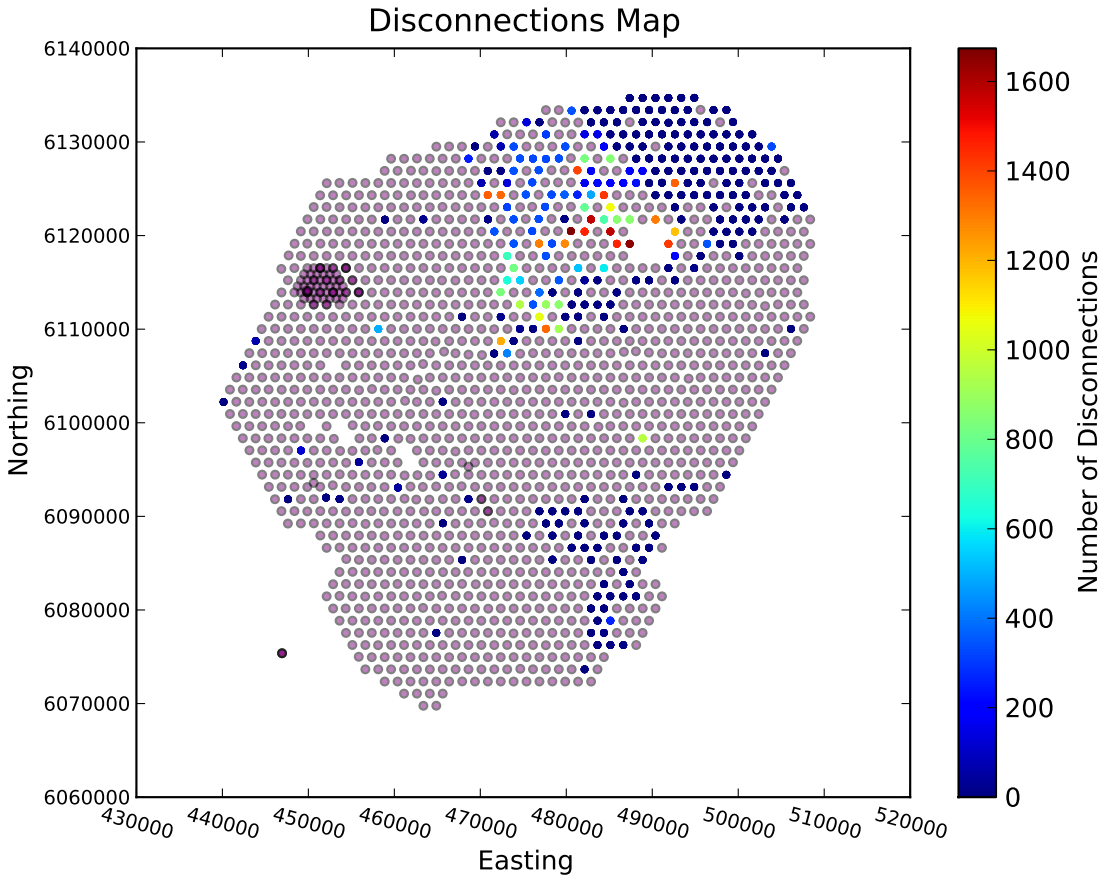

Figure 14: This map shows which subscribers are listed and the number of disconnections reported in the "Link Disconnections Report" section of the SYSTEM~1.TXT files. The mauve shows the location of subscribers not listed and is used to aid interpretation of the map.

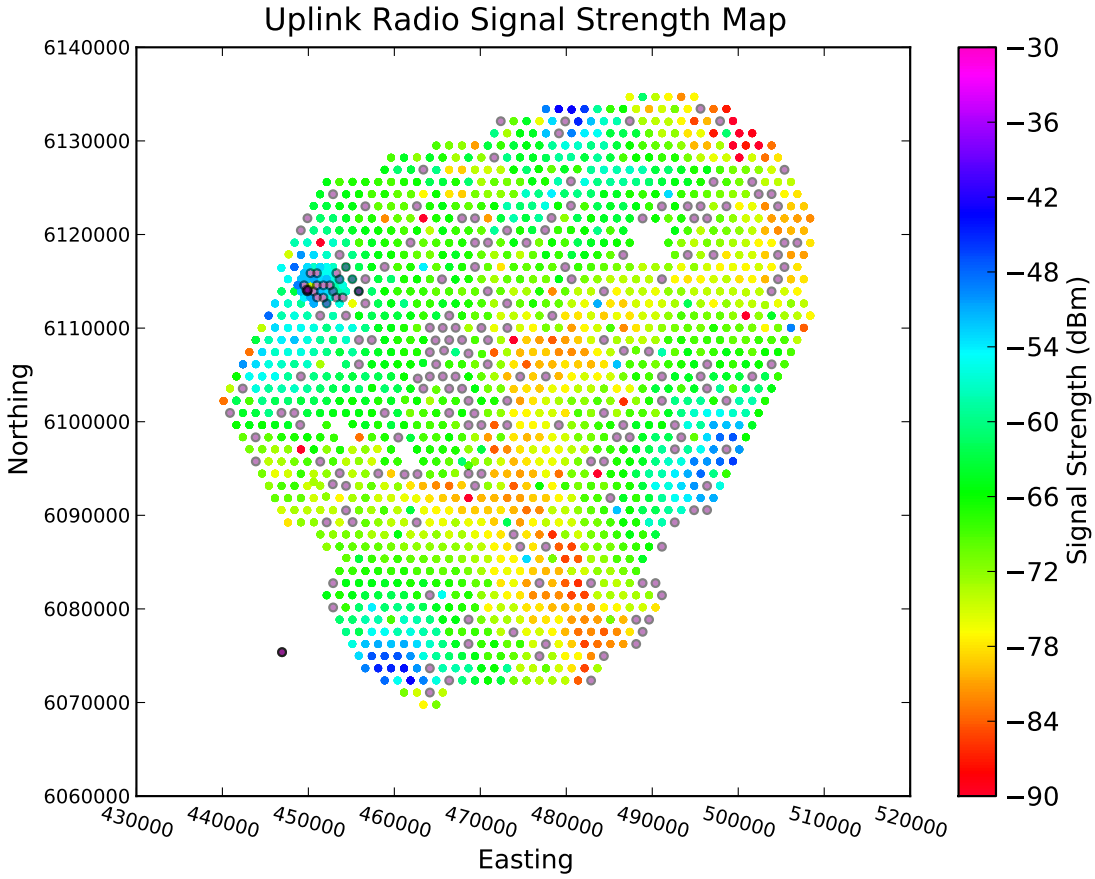

Figure 15: This map shows the downlink signal strength of the subscribers. Points represented in mauve show the location of subscribers reporting no signal strength data.

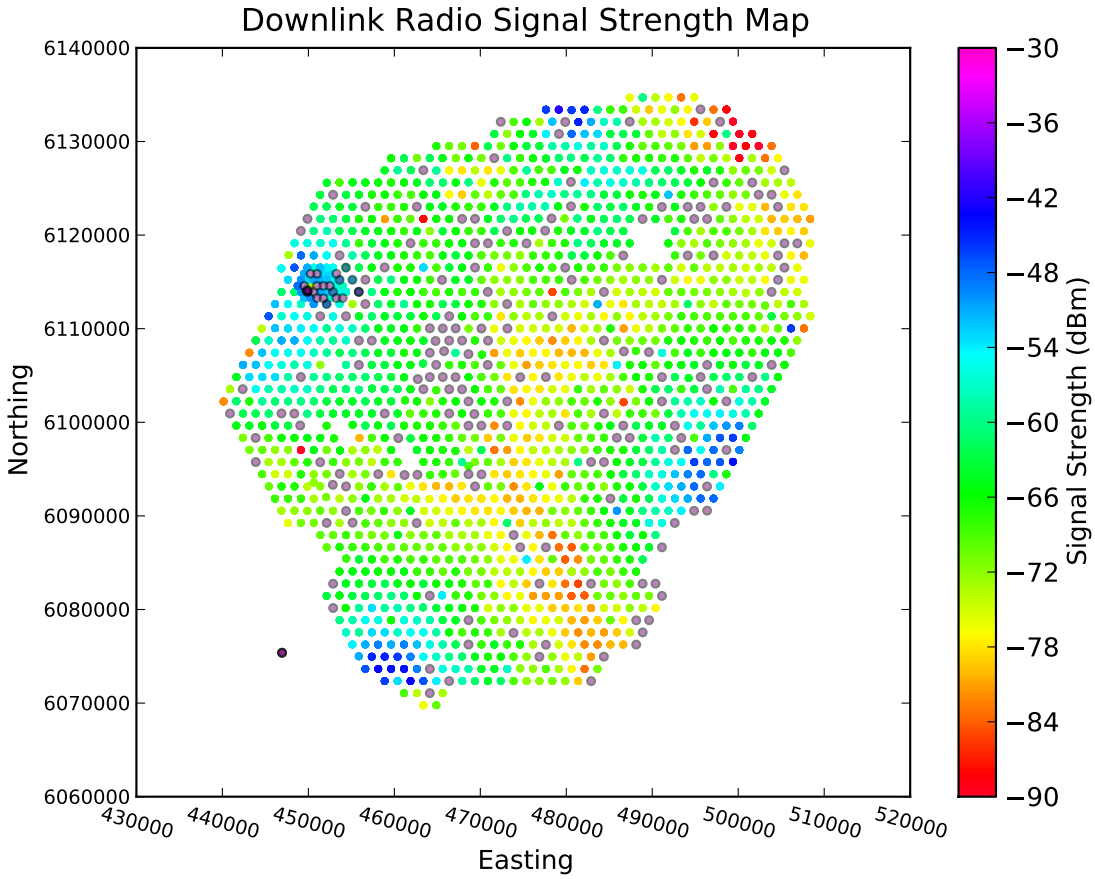

Figure 16: This map shows uplink signal strength of the subscribers. Points represented in mauve show the location of subscribers reporting no signal strength data.

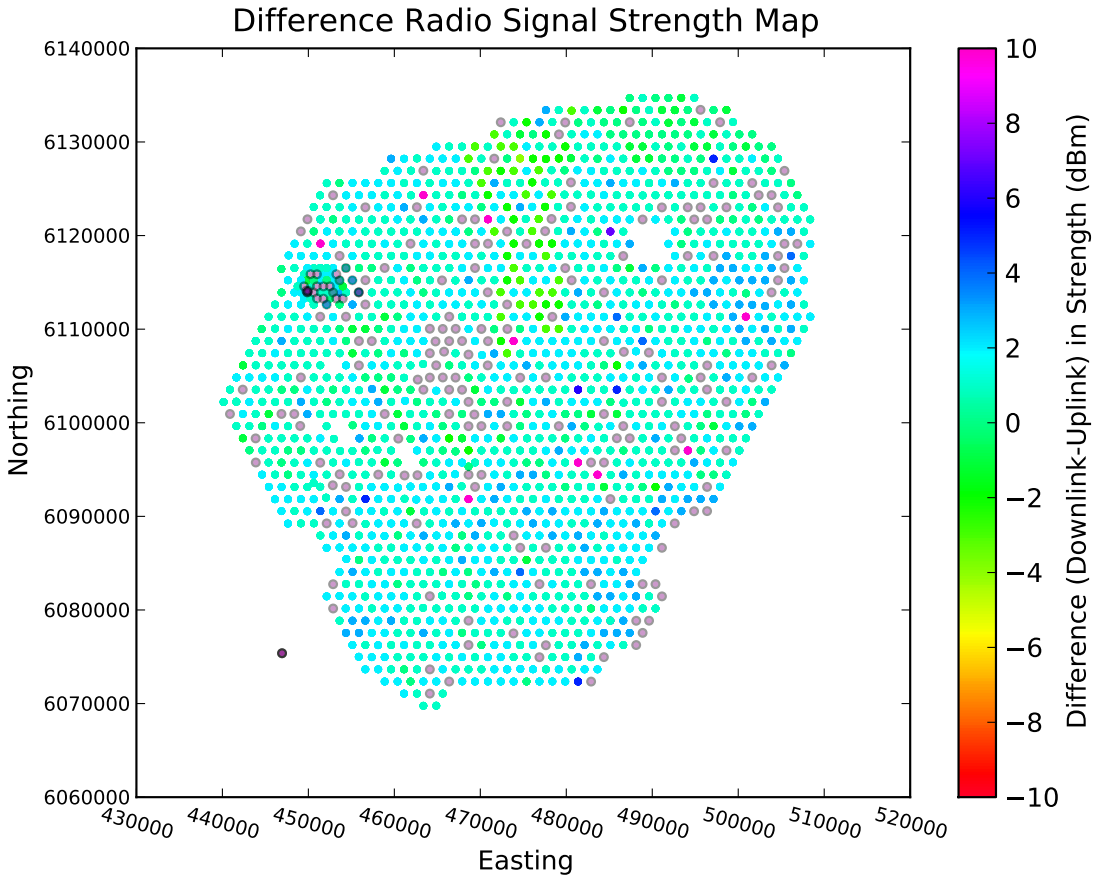

Figure 17: This map shows the difference between the reported downlink and uplink (downlink minus uplink) signal strength of the subscribers on a typical day. Points represented in mauve show the location of subscribers reporting no signal strength data.

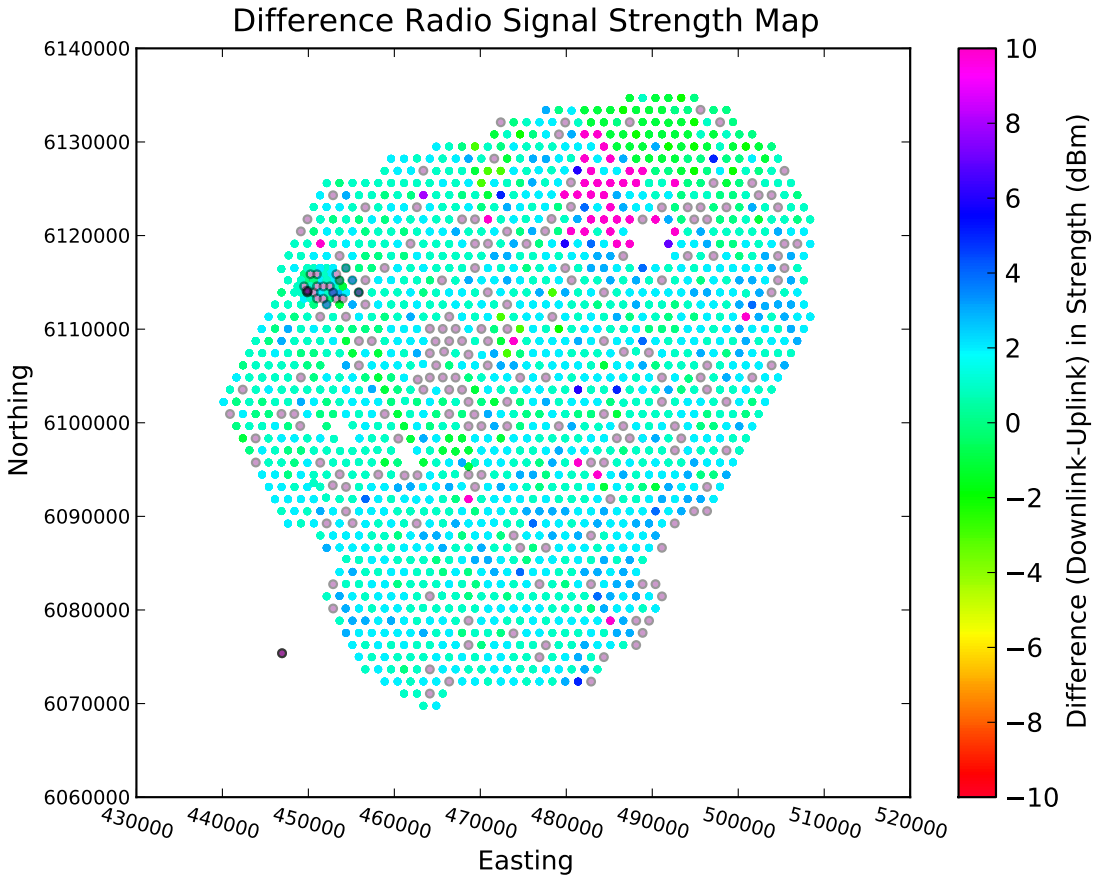

Figure 18: This map shows the difference between the reported downlink and uplink (downlink minus uplink) signal strength of the subscribers on an ARQ spike day. Points represented in mauve show the location of subscribers reporting no signal strength data.

Comms Diagnostic Error Conditions

Diagnostic Type	Error Threshold Conditions	Normal Operation Conditions
ARQ		
Weekly ARQs	ARQ07s $> 5\%$	ARQ07s $\sim 1\%$
ARQ Map	Cluster of stations with $log_{10}(ARQ) > 0.8$	No clustering and below $log_{10}(ARQ) = 0.5$
BSU		
BSU ARQ	ARQ above one σ from weekly average	ARQ at or below weekly average
Radio		
Signal Strength	More than 3 neighboring stations with difference $>$ |8| dBm	Difference of |5| dBm or below
Disconnected Subscribers	More than 5 neighboring stations disconnected	Disconnected stations are few and scattered
Number of Disconnections	Disconnection count $>$ 600	Disconnections counts below 400

Table 1: Table of error threshold conditions for diagnostic observations of comms monitoring.

clusters of large difference may determine other problem areas in cases where no ARQ spike occurs or there is communication interference. The individual subscribers with large difference may also be marked for inspection to determine if the communication difference is the result of a antenna malfunction, or if the problem is already known such as in an area of large interference or on the edge of communications range.

References

[1] Parts Management System, *http://pms.auger.org.ar/*.

[2] Pierre Auger Southern Observatory Communications System Operations Manual, *http://tdserver1.fnal.gov/auger/Auger_South_Comms_System_Operations_Manual/index.html*.