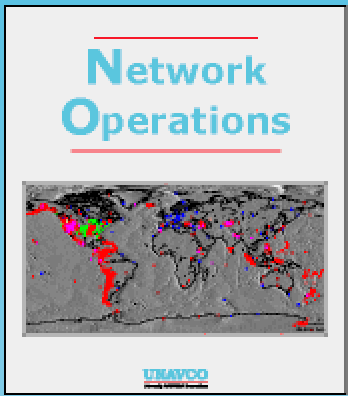

Iridium & GPS Antenna Interference Test

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Author: Nic Flores

Abstract

The communication frequency of an Iridium antenna is in the band of 1610 to 1626.5 MHz. Unavco Inc. uses iridium communications links to download GPS data from remote GPS stations. The L1 and the L2 frequencies (used by GPS receivers) are in the 1575.42 MHz and 1227.60 MHz respectively. Since the Iridium band is rather close to the GPS L1 frequency we have reason to believe that one must have an effect on the other. The elementary analysis in this report aims to study/monitor the effect of iridium phone calls on GPS data.

Equipment Used

- 1 Iridium antenna model SAF5350-C. This antenna is a passive L-band antenna designed to operate with the NAL Research satellite modems and trackers. It provides continuous converge from 1610 to 1626.5 MHz specifically for the Iridium network. The SAF5350-C is suitable for harsh environment and long term operations. It is impact, UV, chemical and jet fuel resistant (ref. Iridium Manual).

- 1 GPS campaign that included (supplied by the Polar Group at Unavco Inc.):
    1. one Trimble antenna mounted on a tripod:
       SN # = 02200646 AT = TRM29659.00
    2. one Trimble NetRS GPS receiver POLAR2:
       SN# = 4705127767 RT = TRIMBLE NETRS
    3. power supplied by a single solar panel and a single battery

Experiment Design

We fixed the iridium antenna to a pole at height of 168.2cm above the ground. The GPS antenna was mounted on a tripod and then moved 10ft at a time away from the iridium antenna.

The GPS antenna began at 10ft way from the iridium. The GPS antenna spent one UTC day at 10ft, 20ft, 30ft, 40ft, 50ft, 60ft, and 70ft away from the iridium antenna and GPS data was collected at each distance. Table 1 shows the dates with corresponding distances.

UTC Date	Doy	Dist. GPS is from Irid. ant.	GPS ant. slant height in cm.	Date GPS ant. was placed at Dist.
08-02-2007	214	10	113.8	08-01-2007/2330-2340
08-01-2007	213	20	113.7	07-31-2007/2350-0015
07-25-2007	206	40	111.4	07-24-2007/2327-2337
07-26-2007	207	50	108.4	07-25-2007/0006-0012
07-27-2007	208	60	105.3	07-26-2007/2230-2245
07-30-2007	211	70	109.5	07-27-2007/2315-2332

Table 1. Table 1 displays the UTC date and day of year the GPS antenna spent a specific distance away from the iridium antenna. **NOTE**: The days of year are not in sequence since we need to re-place the antenna at different distance on different days to record a good set of GPS data.

The iridium antenna was scheduled to download data every day from two sites, MIN0 (remote site) and GNET (local site), on the even hours between 00:00:00 UTC to 14:59:59 UTC.

GPS Data Processing

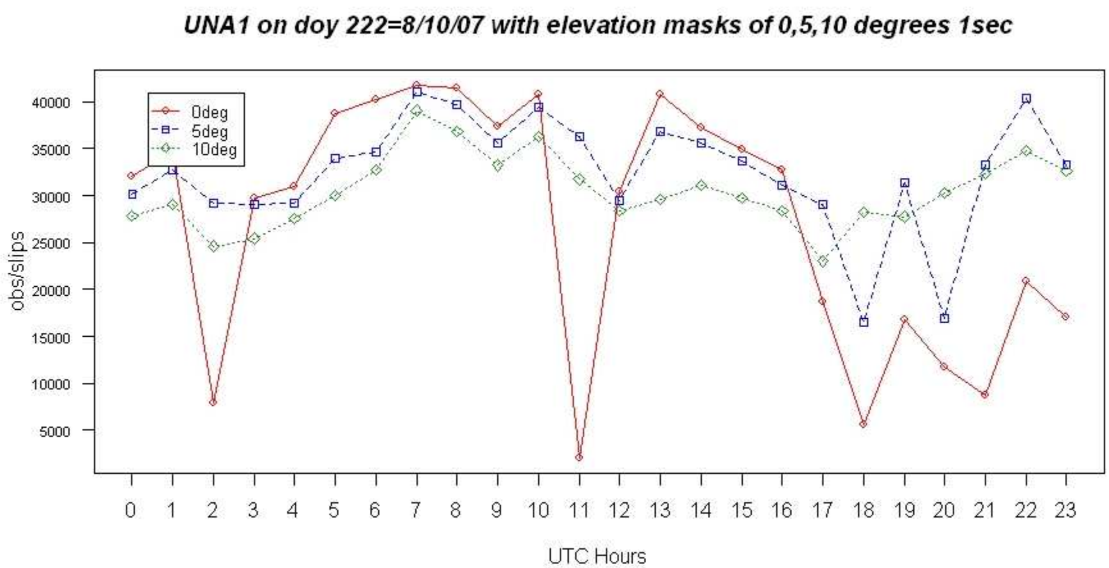
GPS data was processed with Unavco's own pre-processing software, Teqc. Since no GPS data processing happens at Unavco other than with Teqc we only report a single statistic given to us by Teqc, the ${}^{obs}/_{slip}$.

The receiver, POLAR2, was configured to record *.T00* and *.BNX* hourly and daily 1 second and 5hrz data. We only report our findings for *.T00* hourly 1 second data. Scripts were used to download the raw data from the receiver. Then *runpkr00* was used to translate the raw data into *.dat* and *.eph* files. Teqc then uses *.dat* files to extract *.07N* (navigation) and *.07O* (observation) files. In QC mode Teqc takes in the navigation and observation files and outputs *.07S* (sum) file. The sum file is a report of the GPS data recorded. We used two pieces of this file to detect possible iridium effects in our GPS data, the "qc plot" and the ${}^{obs}/_{slip}$. Since Teqc has the option of processing raw data at different degree cutoffs and this has an effect on the ${}^{obs}/_{slip}$ statistic we also report the effects at 0, 5, and 10 degree cutoffs.

A typical hourly 1 second qc plot of a receiver not involved in the experiment looks like:

```
version: teqc  2007Aug6

 SV+|-----------|-----------|-----------|-----------|-----------|-----------+ SV
 11|ooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooo| 11
 26|ooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooo| 26
 25|ooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooo| 25
 29|ooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooo| 29
  8|ooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooo|  8
 28|ooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooo| 28
 17|eeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeee| 17
 27|ooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooo| 27
 19|oooooooooooooooooooooooooooooooooooooooooooo+++++++++++++m+L+++L+++++++| 19
-dn|                                                                       |-dn
+dn|                                                                       |+dn
+10|99999999999999999999999999999999999999999999999999888888888888888888888|+10
Pos|ooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooo|Pos
Clk|                                                                       |Clk
   +|-----------|-----------|-----------|-----------|-----------|-----------+
00:00:00.000                                                    00:59:59.000
2007 Aug  2                                                      2007 Aug  2

*********************
QC of RINEX  file(s) : UNAV214a.07O
input RnxNAV file(s) : UNAV214a.07N
*********************
```

A typical plot of the $^{obs}/_{slip}$ for a receiver not involved in the experiment looks like:



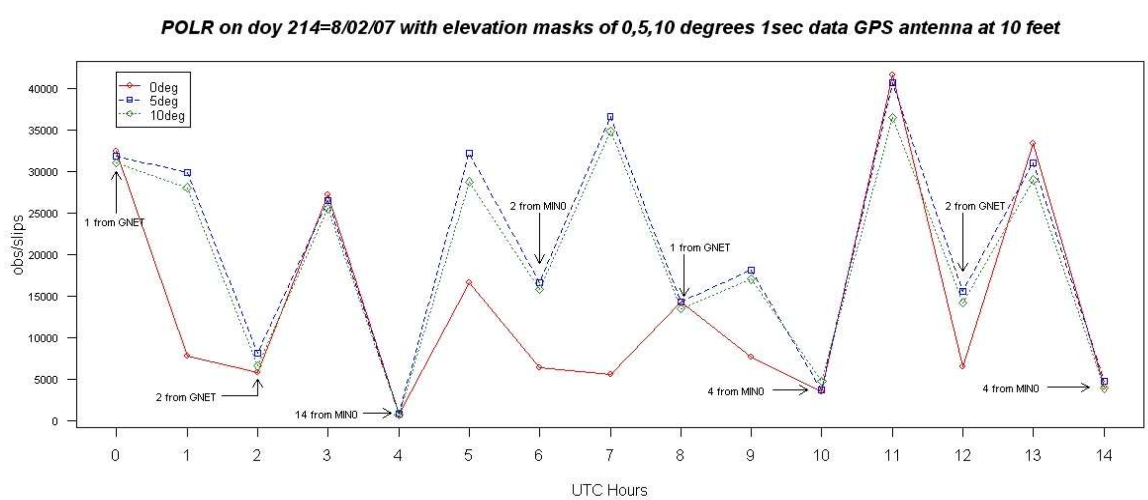
Notice that there are low $^{obs}/_{slip}$ values on hours 2, 11, and 18-23 for the 0 degree cutoff. We assume that low $^{obs}/_{slip}$ values occur throughout the day for some reason or another. We hope that if there are any low values of $^{obs}/_{slip}$ during the experiment that they coincide with Iridium downloads.

Observations

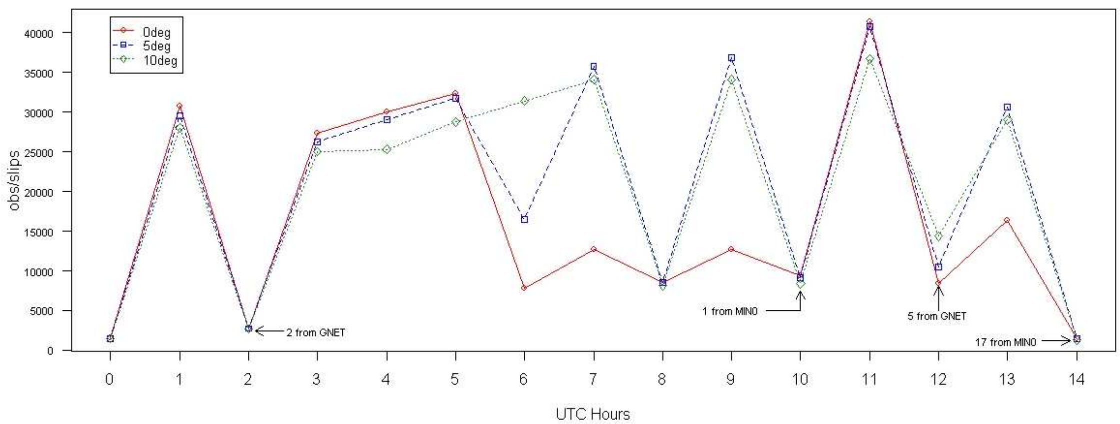
On the day that the GPS antenna was 10ft away from the Iridium antenna we noticed qc-plots of the form:

```
version: teqc  2007Aug6

 SV+|-----------|-----------|-----------|-----------|-----------|-----------+ SV
 28|ooooooooooIooooooooooooooooooooooooooooooooooo.L--------                | 28
 20|oooooooooooooooooooooooooooomoooooooooooooooooooooooo,ccccL----          | 20
  9|oooooooIoooooooooooooooIIooooooooooooooooooooooooooooooooooooooooooooooo|  9
  4|oooooooooooooooooooooIIooooooooooooooooooooooooooooooooooooooooooooooooo|  4
  2|ooooooooooooooooooooooooooooooIooooooooooooooooooooooooooooooooooooooooo|  2
  5|oooooooooooIIIoIooooooIoIoIoIIoooooooooooooIoooooooooooooooooooooooooooo|  5
 12|eeeeeeeeeeeeeeeeeeeeeeeIeeeeeeeeIeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeee| 12
 17|eeeeeeeIeeeeeeeeeeeeeeeIeeeeeeeeeee2eeeeeeeIeeeeeeeeeeeeeeeeeee2eeeeeeee| 17
 30|        ------------ooooooooooooooooooIooooooooooooooooooooooooooooooooo| 30
 10|                             ---------.cLooooooooooo,ooooooooooooooooooo| 10
-dn|         1111111111           1111111            111111     1           |-dn
+dn|        111111111111         111111111          11111111  1111          |+dn
+ 0|88888888999999999999999999999aaaaaaaaaaaaaaaaaaaaaaaaaaa9999998888888888|+ 0
Pos|ooooooooooooooooooooooooooooooooooooooooooooooooo                       |Pos
Clk|                                                                        |Clk
   +|-----------|-----------|-----------|-----------|-----------|-----------+
04:00:00.000                                                    04:59:59.000
2007 Aug  2                                                      2007 Aug  2

*********************
QC of RINEX  file(s) : POLR214e.07O
input RnxNAV file(s) : POLR214e.07N
*********************
```

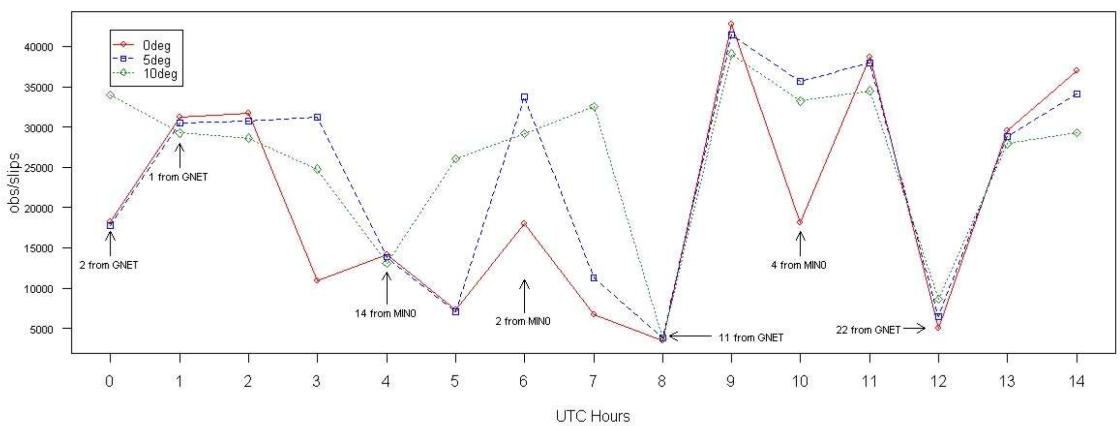
The "I"'s mean that an ionospheric delay (phase) slip occurred. These "I"'s bring down the value of $^{obs}/_{slip}$. This observation leads us to examine plots of UTC Hours versus $^{obs}/_{slip}$ values to see if we had significantly lower $^{obs}/_{slip}$ values on the even hours (the hours when the Iridium was scheduled to download). Here are those plots:



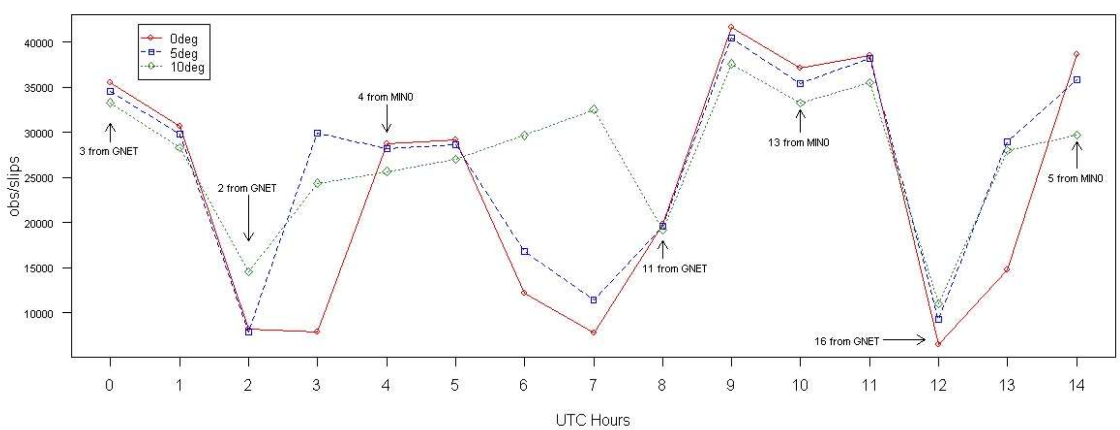
POLR on doy 213=8/01/07 with elevation masks of 0,5,10 degrees 1sec data GPS antenna at 20 feet



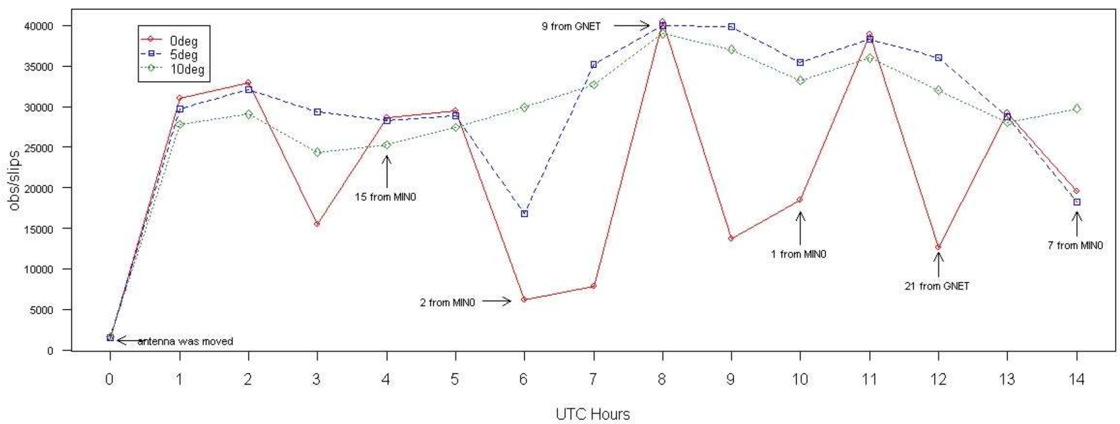
POLR on doy 204=7/23/07 with elevation masks of 0,5,10 degrees 1sec data GPS antenna at 30 feet



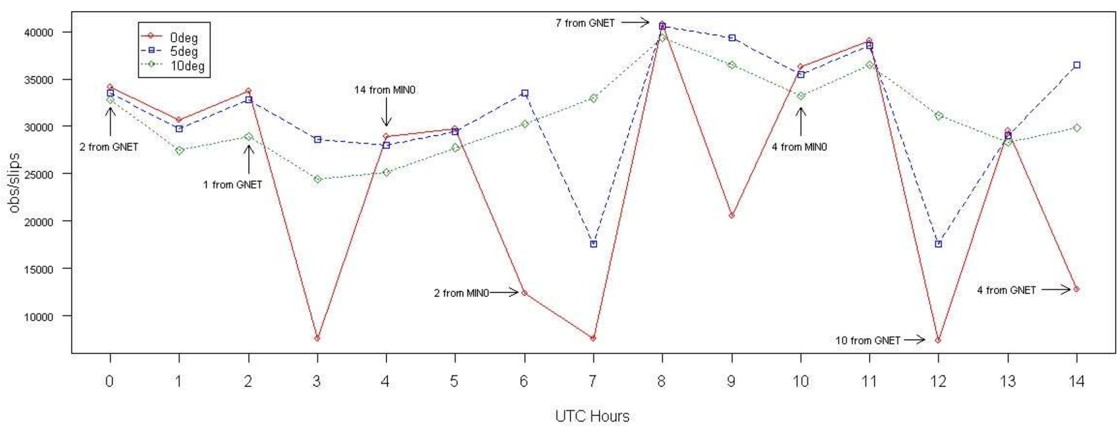
POLR on doy 206=7/25/07 with elevation masks of 0,5,10 degrees 1sec data GPS antenna at 40 feet



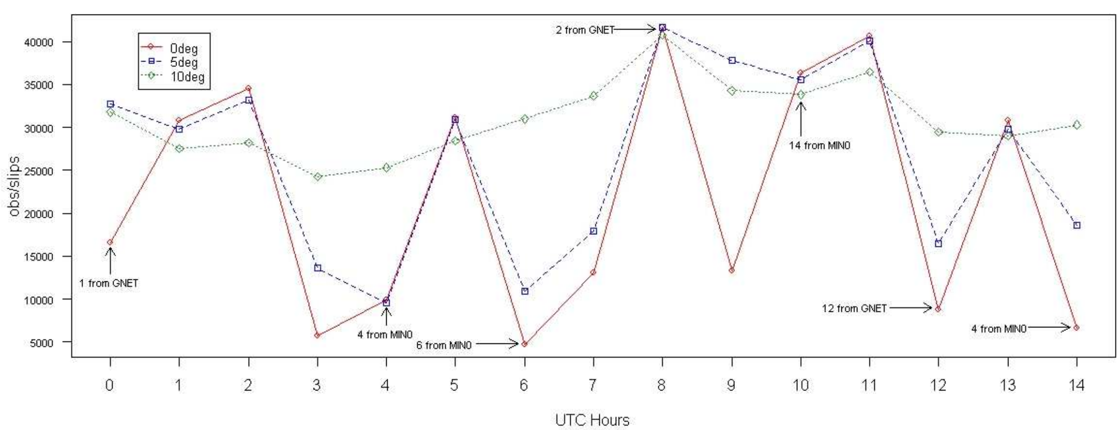
POLR on doy 207=7/26/07 with elevation masks of 0,5,10 degrees 1sec data GPS antenna at 50 feet



POLR on doy 208=7/27/07 with elevation masks of 0,5,10 degrees 1sec data GPS antenna at 60 feet



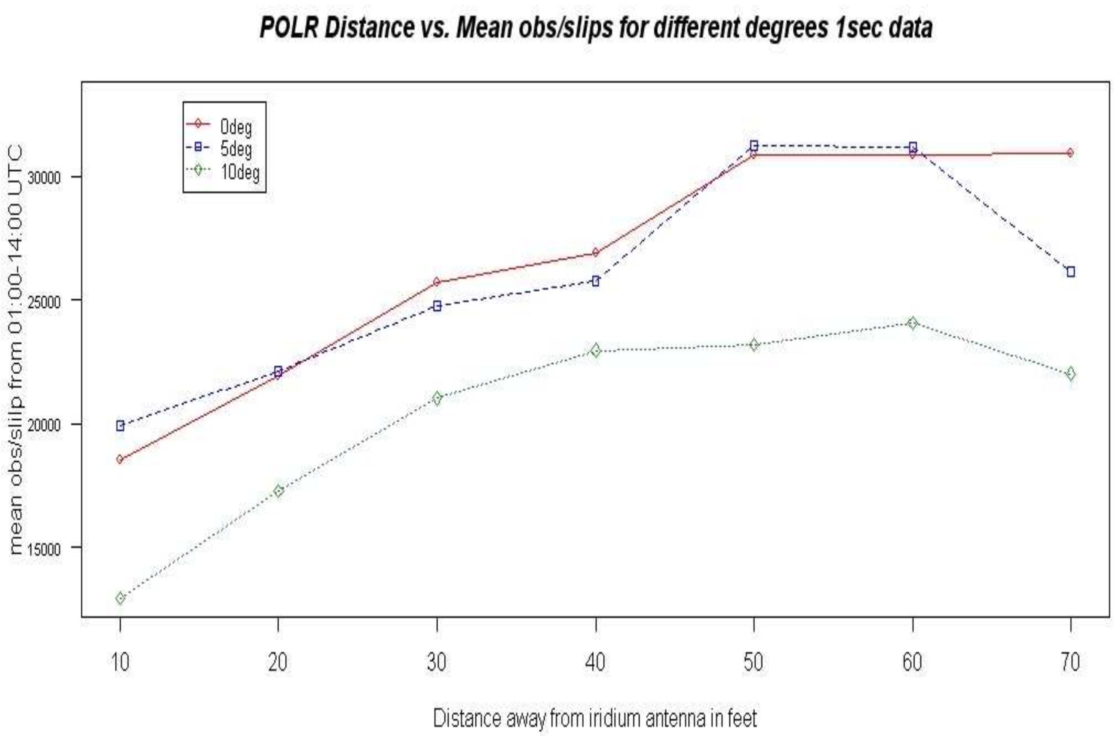
POLR on doy 211=7/30/07 with elevation masks of 0,5,10 degrees 1sec data GPS antenna at 70 feet



NOTE: The "# from <station>" in the plots signifies the number of files downloaded from a station.

Several observations can be made from these plots.

1) A lower ${}^{obs}/_{slip}$ value is evident on the even hours at 10ft.
2) The iridium downloads seem to have little effect on the ${}^{obs}/_{slip}$ values for the 10 degree cutoff plot at 70ft.
3) The more files that are downloaded the more likely it is that there will be a low ${}^{obs}/_{slip}$ value.
4) The iridium download seems to still have an effect on the 0 and 5 degree plot lines at 70ft.
5) It is evident that the mean ${}^{obs}/_{slip}$ increases as the distance between the antennas increases as the following plot shows



Conclusion

The iridium has an effect on the quality of GPS data and the effect is less as the distance between the two increases. From these observations it seems that a distance of $>70ft$ the effects is significantly less than at 10ft but still evident. These observations lead us to suggest that a distance $>100ft$ between two antennas should have little to no effect on the GPS data.

Suggestions for further testing:

1) Hold the GPS antenna fixed and move the iridium antenna.
2) Record lo12/26/200712/26/2007nger than one day data sets at each distance.