2016 Long Haul Six Meter Es Season- Where did it go?

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Introduction

Complain, complain, and complain. It seemed like every time I visited a 6 meter related chat page during 2015 and 2016, all I read was how bad the six meter Es season was. “This is the worst season ever” was a typical comment and actually a headline in the “World Above 50 MHz” column, a 2 part series published in the August and September 2016 issues of QST. Well, it’s time for me to complain to the complainers and my questions are: “How bad was it?” and “How was it bad?”.

When folks complain, there is obviously a reason but certainly it is important to quantify the reasoning behind the complaint by reference to some foundation of data. In this way an A-B comparison can be performed to possibly assist us in learning some of the deep dark secrets of the mystery of Sporadic E.

In this paper, I will cite evidence and reference material that may help to explain why and how the 2016 long haul 6M Es season may have been different from many others. I will also cite statistical foundations where possible.

Scientific Rigor

Although every attempt has been made to follow scientific best practices while writing this paper, it must be understood that this paper was written by an amateur observer and is largely based upon amateur observations. Therefore, any conclusions drawn or even the data presented must not be considered scientifically rigorous. Here is a good definition of scientific rigor and best practices: http://www.livescience.com/20896-science-scientific-method.html.

This PDF document was designed to be an electronic document and is best read on a device with Internet access. Therefore, references typically shown at the end are included as embedded hyperlinks within the body of the text at the appropriate points. Readers of the paper hard copy of this document will miss out on the convenience of being able to quickly “toggle” over to related reference material at key points but the URLs to the supporting documents are all listed and can be referred to at a later time.

Data Points Defined

Within this document and many others I have authored, I will regularly refer to the term “Data Points”. By definition, a data point is considered a smaller part of a data set which will contain an aggregation of data points. A more formal definition may be found at the following link:

https://en.wikibooks.org/wiki/Data_Science:_An_Introduction/Definitions_of_Data#What_is_a_Data_Point.3F

Different people use different methods to produce data points. In fact, Pat Dyer, WA5IYX (SK) preferred to use minutes of propagation as the primary data point to produce his final data sets. The link to the WA5IYX VHF Propagation website is: http://www.qsl.net/w/wa5iyx/ and contains a wealth of information.

In my particular case I will define a data point as follows:

A separate and unique (no dupes allowed) fully audible complete callsign heard from the speaker or headset (or worked) within the 50 MHz band and within a 1 hour period starting at the top of each individual hour and ending at 59 minutes and 59 seconds into that particular hour.

This means that for the following hour, dupes from any previous hours are allowed and beacon reception counts as a data point because the “data point counter” resets at the top of each hour.

An example might be if I hear the CS5BALG beacon first at 1030 UTC and later at 1103 UTC it would count as 1 data point for each hour (part of the hourly data set) and a total of 2 data points (part of the daily data set).

I prefer plotting hourly results at the hourly 30 minute point e.g. 12:30 which implies a resolution of that time +/- 30 minutes for better resolution understanding vs. even hourly plots which may be misleading.

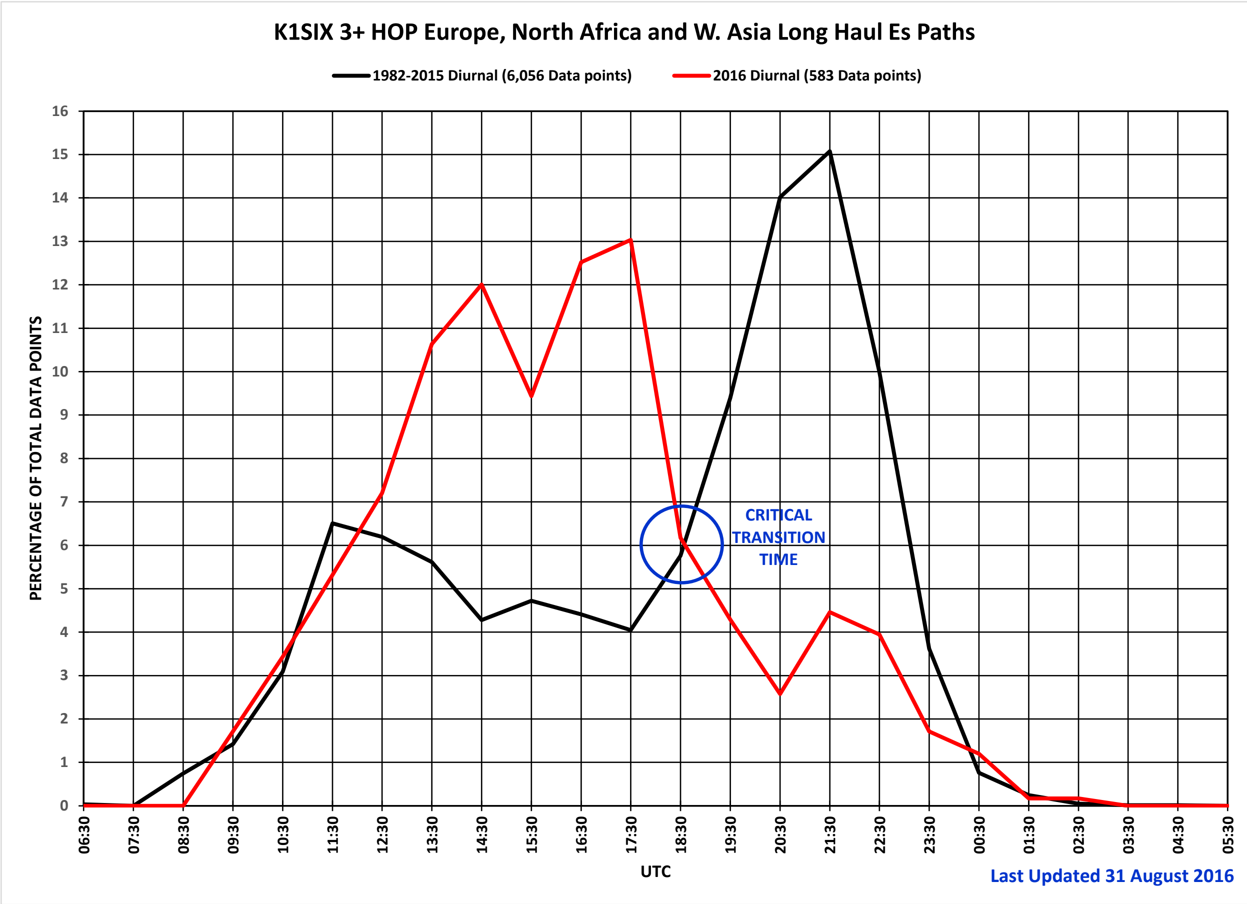
I also utilize these data points for a separate data set that assesses seasonal “quality” on a daily basis and further information may be found at this link: http://www.k1six.com/K1SIX_Transatlantic_Quality.pdf

Although some may disagree with my methodology, this is not a contest; it is the accumulation of data for measurement and comparison purposes that I have consistently used since 1982 and it is what it is because I say so. Anything and everything that qualifies as a transatlantic, non-equatorial zone path of 3 or more hops is counted and the results tend to favor mostly Temperate Zone long haul paths.

However, there is a big risk of failed “good science” here because I am only a casual observer with significant dedication but subject to periods of non-availability. A really “rigorous” methodology would require an automated system running 24 x 7 x 365 to scan the band and count qualifying data points. So much for good science! However, the more data points accumulated over time (sampling) will help to wash out the issue of completely variable non-availability. The more data, the better.

NOTE: This document and the companion paper “Long Haul Six-Meter Sporadic E by ‘The Numbers’” are pre-release draft versions (shown as Rev. 0.00 with the first release to be Rev. “O”) that I wanted to share with the 6M community early on. MUCH MORE INFORMATION WILL BE ADDED AS MY TIME PERMITS! For now, please refer to the preliminary diurnal comparisons shown on page 3 and the information beyond.

Figure XX. K1SIX ACTUAL ARCHIVED RESULTS

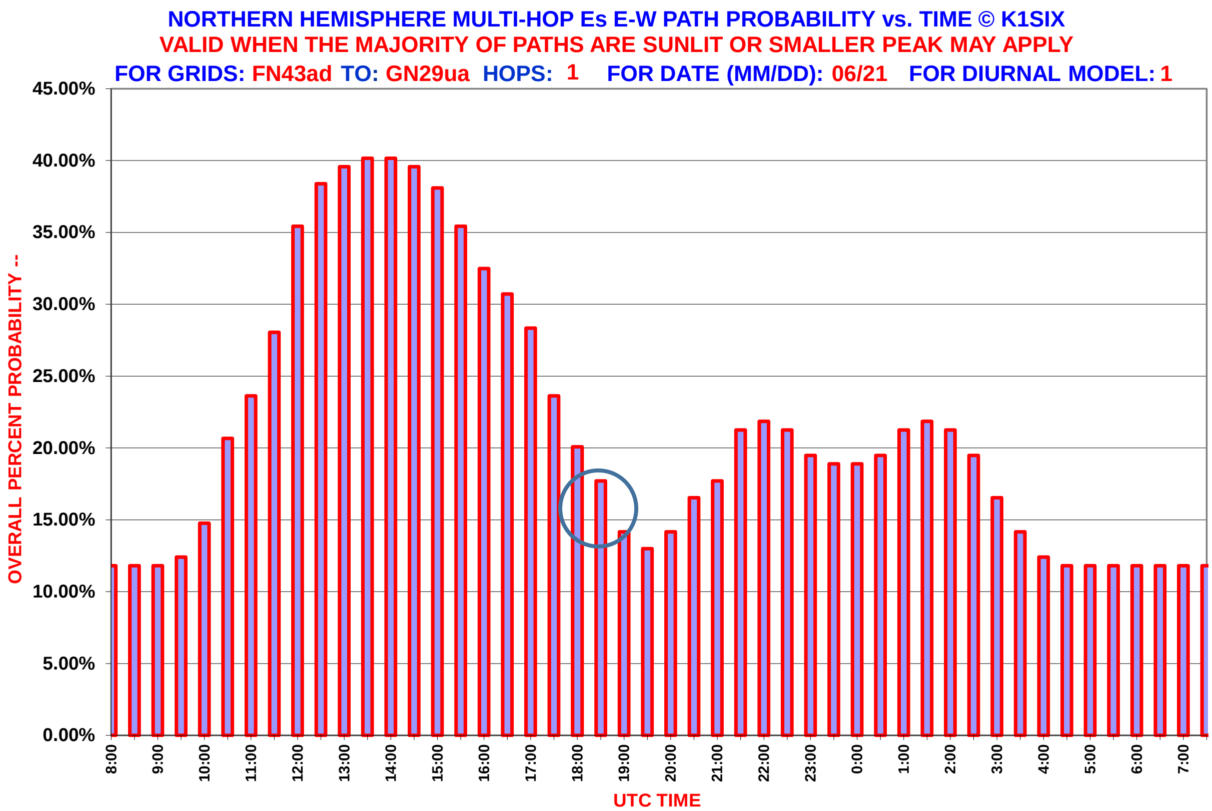


<u>Since 1982 to date</u>, the only previous seasons that exhibited an AM peak significantly stronger than the PM peak were:

2006 with an AM 37.8% peak at 1130Z and a PM 13.3% peak at 2030Z, a 2.8:1 ratio and also in the year 2005. However, I was not available for a significant portion of the summer 2005 Es season. So, the 2016 diurnal plot above is remarkable and represents a 2.9:1 ratio favoring a delayed AM peak near maximum solar elevation at the path midpoints whereas the previous 33 year data suggests a favored PM peak by a factor of 2.3:1 over the AM peak. Something seems wrong here. However, there is certainly a close match for the onset of long haul (eastbound) Es events, based upon sunrise and the waning of these events based upon sunset. The solar elevation angles are a critical factor as they are blended and merged across the numerous refraction points associated with long haul multi-hop Es representing a complex scenario. The more hops, the more complex and I call this "***The Geographic Latitude Factor***", tied to Solar Elevation.

Note: My final diurnal plot is updated at the end of each season and may be found at the following link: http://www.k1six.com/K1SIX_XATL_DiurnalVariation.pdf. This is a summation of the results of all years. Once the 2016 data were added, the plot changed significantly and this is also remarkable as this is only one year of data added to the previous 33 years with 6,056 pre-existing data points. This could indicate an insufficient sample or a new trend that is beginning to emerge. Time will tell.

Figure XX. Modeled Unblended Single Hop Results using the Es_Predict.xls Utility



The above plot, an attempt at a "fit", was obtained utilizing the tools within the Microsoft Excel Es_Predict.xls utility which is available for free download on my website at http://www.k1six.com. The utility includes a single hop model that is time adjusted and a derivative of the efforts of E.K. Smith in Davies, 1990 and often referenced in Sporadic E related papers. The derivative plot utilized as the model may be found at the link http://www.k1six.com/1HOP_Diurnal.pdf.

To obtain this plot, using a 1-Hop model, I first created a path to an approximate termination point of grid JN35 from my own grid of FN43ad. This location was chosen because most (but not all) of the European propagation for the 2016 Es season fell in southern Europe between Portugal and Greece. The results were 3 hops with a path midpoint of HO31gp which was actually 2 hop range. Next, to force the path to 1 hop range, I ran a path model to the HO31gp grid and that midpoint turned out to be GN29ua (at 1,507 km with an MUF ~ 72.0 MHz). Thus the results above reflect a modeled 1 hop path between FN43ad and GN29ua directly along the path to termination point JN35 with the estimated refraction point 105 km above grid FN86hk (GEOMAGNETIC LAT +55.72°), right near the southern boundary of Auroral Zone influence. Geomagnetic conversions are available thanks to the efforts of The World Data Center for Geomagnetism, Kyoto University, Japan at the following link: http://wdc.kugi.kyoto-u.ac.jp/igrf/gggm/

Please note that the Es_Predict Utility presently does ***NOT account for solar elevation angles***. Thus, for this particular path to the east, UTC times after ~22:30 UTC would be considered "dark" on the eastern end of the path and any correlated 1 hop values after that time would rapidly drop to ~ 12% for the summer solstice date modeled if the same model were applied for a solution all the way out to grid JN35.

The above model yields a 1.84:1 ratio favoring an AM peak between 12:30- 15:00 UTC vs. a PM peak at 2200 UTC with values beyond that to 04:00 UTC assumed to be equal to "dark path" ~12% probability.

A Parade of Coronal Holes

The 2016 Es season certainly saw its share of Coronal Holes; almost one right after the other at the most critical time for long haul Es which I consider to be 13 June through 15 July. In fact during this 33 day period I show a 34 year average probability of 3x hop Es across the pond of 38.2% and the VE3EN data using a different methodology yields a probability of 61.4%. Please refer to the following link to compare my results to those of VE3EN at: http://www.k1six.com/K1SIXvsVE3EN_Seasonal.pdf. The chart contains hyperlinks that refer to the source data which was updated at the end of the 2016 long haul Es season. ***My personal results for these 33 days in 2016 yielded 20 days of detected 3x+ hop for a probability of 60.6%. However, some of these openings were short lived. For this same 33 day period I added 302 data points to the database capturing 108 on 13 June 2016 alone and 52 on 13 July 2016, the best two days. The 34 year average of data points for this same 33 day period is 120.2 however there is a significant growth factor that must be considered over the entire period and due to this factor, I have switched to 3 year moving averages to assess a particular season in terms of accumulated data points. Please refer to the chart shown at http://www.k1six.com/K1SIX_XATL_Days_Open.pdf to view the most recent season results including the "growth factor". Therefore, using 3 year moving averages for the previous 3 years of 2013- 2015 to assess and compare this season during only the magic 33 day period yields 21 days for an average probability of 3+ hop detection of 63.6% and 237 data points.***

Using 3 prior year moving averages and comparing those results with 2016 results reveals nothing extraordinary. In fact, for the entire 2016 Es season I accumulated more total data points than any other total of 34 seasons on record with a previous record of 554 in 1995. However, there is something subtle that may stand out above "the noise".

Returning to the issue of coronal holes and their potential to negatively impact long haul 50 MHz Es raises some doubt. If there is a proven negative correlation with particles contained in the Solar Wind plasma cloud that envelopes the earth vs. the formation of Sporadic E, I would tend to fear Coronal Holes more than mostly short lived solar flares and the occasional CME. Some Coronal Holes tend to be quite large and can spew particles at our planet for days on end when they are geoeffective. This is exactly what happened during the 2016 long haul Sporadic E season. ***But the big question is: Is there a correlation between the Solar Wind plasma and the particles contained within and the formation of Sporadic E capable of MUFs in the 50 MHz band?***

Geoeffective Coronal Holes and of course Solar Flares with geoeffective CMEs can also influence our planet's magnetic field. ***So a follow up question must be: Is there a correlation between our planet's magnetic field and the formation of Sporadic E capable of MUFs in the 50 MHz band?***

Before I even attempt to answer these questions and I will make an attempt, it is necessary to take a step back and review a history of coronal holes throughout past years that may have occurred during a period most likely to produce long haul northern hemisphere Sporadic E in the 50 MHz band. To accomplish this, I referred to this link: http://www.solen.info/solar/coronal_holes.html and created a table counting only those coronal holes that happened to occur ***only within the magic 33 day window of 13 June through 15 July +/- a few days*** as these are the highest Es probability days that would likely be impacted by some external influence. Coronal holes that are renumbered in the "Comment" column are said to be recurrent and can have lifetimes that last months. A typical coronal hole, if there is such a thing, would be expected to impact us for approximately 2 to 3 consecutive days per Carrington rotation of ~ 27.3 days, slightly varying with solar latitude. In some cases, multiple coronal holes may have impacted overlapping dates.

Table XX. Raw Coronal Hole Counts* and Impact* during the Critical 33 Day Window +/- a few days

YEAR	RAW COUNT	DAYS IMPACTED	NOTES
2016	9	26	CH739 – CH746 + CH748 (CH739 impacted 9 total days)
2015	3	13	CH672, 675 & 676 (CH672 impacted 6 total days)
2014	1	2	CH626
2013	2	11	CH573 impacted 6 days, CH574 impacted 5 days
2012	2	7	CH521 impacted 5 days, CH522 impacted 2 days
2011	**12**	**28**	**CH454 - CH465**
2010	4	12	CH408 (4), 410 (4) and CH412 - CH413 (2 days each)
2009	3	7	CH371 (3 days), CH372- CH373 (2 days each)
2008	3	14	CH331 (5 days), CH332 (4 days) and CH333 (5 days)
2007	5	16	CH272, 273, CH275- CH277 (5 days)
2006	4	16	CH228 (5 Days) - CH231
2005	3	7	CH171, CH173 and CH174
2004	5	14	CH101 - CH105 (CH103 5 days)
2003	6	26	CH43 - CH48 (**CH46 11 days**)
AVE	**4.42**	**14.21**	**AVERAGE for all 14 Years**

****There was no attempt to isolate trans-equatorial from polar coronal holes***

The 2016 data for the critical period of 13 June – 15 July indicates an above average number of coronal holes potentially impacting an above average number of days. However, there were many similar complaints of poor long haul 6M Es during 2015 and that particular year yields below average values.

2011 stands out as the most active for potential coronal hole effects during the critical 33 day period and for that entire season I realized 24 days of 3+ hop transatlantic Es against a 3 year moving average projection of 24 days. In addition, in 2011 I worked 7 JA stations and missed a contact with one on 25 June with my JA results posted at http://www.k1six.com/K1SIX_JA_SSSP.pdf. 2003 yielded 31 days against a 3 year moving average projection of 25 days. My annually updated plots are posted at http://www.k1six.com/K1SIX_XATL_Days_Open.pdf. It must be remembered that the 3 year moving average forecast for any particular year is the sum of items (days or data points) for the 3 ***previous*** years divided by 3. So that if anything really strange happened during any particular Es season, it would likely result in a large deviation between actual and forecasted values and I am just not seeing that at my particular location where 3 hops fall into a highly populated portion of western Europe and the majority of paths cross the Atlantic at moderate geomagnetic latitudes at the border between the Auroral and Temperate Zones. A station to my north, in the Rocky Mountain States, the Pacific Northwest or California will face an entirely different scenario as would those in more northern Europe. I will now add in the new term: ***"The Geomagnetic Latitude Factor"*** as another consideration along with the simply solar elevation angle based "***Geographic Latitude Factor***" mentioned earlier. All of these factors blended across vast distances in terms of time zones (Geographic) and Es Zones perhaps reacting differently to "externals".

Solar Wind Impact on Long Haul Multi-Hop Six-Meter Es

As an attempt to determine if there is any ***high level relationship*** between the Solar Wind Plasma and magnetic component, commonly referred to as "The Numbers" vs. the probability of long haul Multi-Hop Six-Meter Es, I developed a Microsoft Excel parsing tool to pull values from the Ace Spacecraft SWEPAM and MAG data files located at this link: ftp://sohoftp.nascom.nasa.gov/sdb/goes/ace/monthly/ and the Potsdam TAB files located at this link: ftp://ftp.gfz-potsdam.de/pub/home/obs/kp-ap/tab/ and create an output that looks like this for 13 June 2016:

SWS	Density	ION (k)	Bt	Bz	Kpp
529.0	2.8	135,900	5.1	-0.3	1.53

The values shown above are a daily AVERAGE for the chosen time period only

The results obtained are carefully tied to the customized peak probability times for K0GU, K1SIX, K6QXY and KL7KY for long haul 6M Es paths to Europe. Then placed, by pasting the values, into a date tagged database with an accumulator that averages all values that are entered. So this becomes a ***high level summary*** for each individual to determine if anything special stands out that may justify further research on particular dates.

As I mentioned earlier, the "PARSER" portion of the Excel application is time sensitive and associated with only the specific times when a particular individual would be expected to realize highest probability for a particular path based on their diurnal on record. An example for KL7KY is shown at this link: http://www.k1six.com/KL7KY_Eu_Diurnal.pdf and the "PARSER" customized for KL7KY will pull values beginning 2 hours in advance of KL7KY's onset and through the end time of the diurnal maximum only. Therefore for KL7KY, the averaged and customized parsing formula would reflect only 0700 – 1200 UTC values to create an overall database summary that looks like this:

KL7 Es to Europe for:	7	Total Dates Sampled	
KL7KY Parameter	**LO**	**HIGH**	**AVE**
Averaged SWS (kms)	**299.9**	**382.5**	333.9
Averaged Proton Density (p/cc)	**0.3**	**4.8**	3.0
Averaged ION Temp. (k)	**18,783**	**83,250**	44,611
Averaged MAG Bt	**1.8**	**6.6**	4.3
Averaged MAG Bz	**-3.4**	**1.5**	-0.94
Averaged Potsdam Kp	**0.44**	**1.89**	1.17
% Days with -Bz Average	**85.71%**	**72**	**Data Pts.**

Note that the summary created contains all the statistical information required to determine validity and it is obvious that there is not a large sample for KL7KY data for polar paths to Europe. An example of a single dated database record for KL7KY, with a total of 20 data points looks like this:

DATE	SWS	p/cc	TEMP	Bt	Bz	Kpp	Flag	Pts.	Notes
07/09/14	345.9	4.7	65,420	5.1	-2.0	1.2	1	20	1006-1115Z

My (K1SIX) time sensitive and customized parsing formula runs from 0500 – 2300 UTC due to the large period of time that I may experience 3+ Hop six-meter Es to Europe and like all the others, that time period is determined by my own personal diurnal on record shown at: http://www.k1six.com/K1SIX_XATL_DiurnalVariation.pdf and those overall results when I experienced qualifying propagation to date were:

Es Propagation to Eu/N. Afr. for:	**107**	**Days Sampled**	**2,964**	**Data Pts.**
K1SIX Xatl GOOD Parameter	**LO**	**HIGH**	**AVE**	**DEV %**
Averaged SWS (kms)	**275.7**	**751.3**	436.4	-1.87%
Averaged Proton Density (p/cc)	**0.5**	**14.9**	3.5	9.89%
Averaged ION Temp. (k)	**15,637**	**711,438**	107,000	-4.94%
Averaged MAG Bt	**1.7**	**13.4**	5.0	-3.15%
Averaged MAG Bz	**-7.8**	**5.2**	-0.09	-63.20%
Averaged Potsdam Kp	**0.14**	**4.90**	1.70	-9.99%
% Good Days with -Bz Average	**49.53%**	**For period 25 May 2001 to Present**		

For my data ***only***, ***qualifying data <u>must only be between 15 May and 15 August</u>*** to exclude as much potential of Es linkage into F-Layer propagation as practical ***AND a qualifying event must have produced <u>a minimum of 10 data points</u>***. This will exclude things like reception of the CS5BALG beacon for 10 minutes during an entire day.

In my case a new column has been added to the summary: "DEV%". This is because I am attempting an A-B comparison test with ***only those "33 magic days" between 13 June and 15 July***, known to have very high probability for me of producing an event; that failed to produce an event. To further qualify a "non-event day" in terms of data points, the value for the entire day must be zero. In addition, the dates are screened so that in most cases there must be 3 or more successive days producing zero data points and as a fail-safe I have requested others in my close proximity, expected to share the same diurnal characteristics, to review the non-event dates in case I may have been unavailable and in some cases records were purged. This is not great science but as practical as possible for amateur methodology.

Therefore, the "DEV%" column value represents the deviation A-B test difference in percent between days of qualifying propagation vs. qualifying non-event days and is an average of all values in the database for K1SIX data only. This is used as part of the "high level overview" to determine if further research is justified or perhaps just a big waste of time. Does anything stand out?

Next I evaluated the carefully screened "non-event days" only during my 33 day magic window, high probability period, going back to 2001 to produce the following summary report:

Es Propagation to Eu/N. Afr. for:	133	Days Sampled	0	Data Pts.
K1SIX Parameter for NO PROP	**LO**	**HIGH**	**AVE**	**DEV %**
Averaged SWS (kms)	266.1	756.2	444.8	2.35%
Averaged Proton Density (p/cc)	0.1	13.1	3.2	-9.38%
Averaged ION Temp. (k)	10,768	341,000	112,566	5.83%
Averaged MAG Bt	1.7	14.5	5.2	3.28%
Averaged MAG Bz	-8.4	5.6	-0.24	168.86%
Averaged Potsdam Kp	0.29	5.24	1.88	11.78%
% Bad Days with -Bz Average	55.64%	For period 25 May 2001 to Present		

The deviation values in the "DEV%" column here are compared against the average values shown for days of qualifying propagation between 13 June to 15 July, again to determine if anything stands out as worthy of follow-up research, based upon the entire period 0f 25 May 2001 through present.

Comparing the results (I also show Low and High spreads) reveals nothing outstanding in "The Numbers" related to the plasma and particles contained within. Even the Solar Wind Speed comparisons show marginal deviation between what is essentially good and bad. There is a slight "bump" in particle density but not really enough to raise an eyebrow.

The largest deviation shown in the comparison is that which would impact our magnetic field.

Finally, I assessed the non-event days for only the 2016 season, again only for the "33 day Magic Period" of 13 June through 15 July to produce the following summary report:

Es Propagation to Eu/N. Afr. for:	10	Days Sampled	0	Data Pts.
K1SIX 2016 NO PROP	**LO**	**HIGH**	**AVE**	**DEV %**
Averaged SWS (kms)	466.3	632.5	559.6	25.81%
Averaged Proton Density (p/cc)	2.0	8.5	3.6	13.06%
Averaged ION Temp. (k)	133,933	275,333	196,852	74.88%
Averaged MAG Bt	3.4	10.0	5.9	12.51%
Averaged MAG Bz	-1.5	3.6	-0.05	-78.12%
Averaged Potsdam Kp	1.67	3.38	2.47	31.23%
% Bad Days with -Bz Average	50.00%	For period 6/13/16 - 7/15/16 only		

In this particular case, the values in the "DEV%" column represent the deviation from the values in the non-event table shown previously. However, it is my belief that due to the very small statistical sample shown, there is no conclusive evidence that "A Parade of Coronal Holes" during the 2016 Northern Hemisphere Es season may have contributed to a degraded long haul Es season, severely distorting an established diurnal expectation and combined with the previous Table **XX** Coronal Hole assessment and the previous A-B comparison of "The Numbers" and provided that those statistical samples are valid, I just don't see any relationship to Coronal Holes especially impacting 2016 other than the potential for magnetic field disruption and those disruptions have been going on for eons.

Critical Transition Time Lead-In

As this paper is primarily focused on extremely long haul six-meter Sporadic E, which is certainly of interest to the avid 6M DXer, it is time to introduce yet another factor that will have influence when attempting to communicate over vast distances: "***The Geographic Longitude Factor***".

The Geographic Longitude Factor is simply another way of factoring in how many time zones a particular long-haul ray path may encounter and the solar elevation angles associated with each refraction zone because each refraction zone will experience a different time dependent solar elevation angle at any given instant in time. This is really an oversimplification because we are all well aware that near summer solstice, Polar Regions will experience long periods of some level of daily sunlight (aka "The Land of the Midnight Sun"). Therefore, the previously mentioned "***Geographic Latitude Factor***" must also be a considered to have influence when combined with "The Geographic Longitude Factor" and these considerations will apply during a period peaking near summer solstice +/- approximately 50 days for a total long-haul season that could yield positive results of approximately 100 days, depending upon one's ***Geographic Latitude Factor*** and the particular paths of interest. Finally, it is also necessary to consider "***The Geomagnetic Latitude Factor***" when dealing with long haul paths and how geomagnetic conditions may influence the entire ray path. So in reality there are three primary influencing factors to consider for determining long-haul six-meter Sporadic E extreme DX potential.

Based upon a custom calculator that I developed, available within the Es_Predict Utility which is a "spinoff" from the original efforts of Pat Dyer, WA5IYX, and based upon a somewhat conservative estimate of 1° takeoff angles for well-equipped stations, no lower atmospheric refraction consideration and simple ground return on a per hop basis, the following table should approximate the maximum ranges to be expected along with the geographic longitude and associated time zones that could be expected for long-haul six-meter Es paths at a MUF of 50 MHz and an Es height of 65 miles yielding a single hop range of 2,082 km:

Table XX. 50 Mhz Long-Haul Range Estimates vs. Number of Hops

NUMBER of HOPS >2	Estimated Range in KM	Estimated Range in Miles
3	6,246	3,881
4	8,328	5,175
5	10,410	6,469

An example of the output from the custom calculator for 6M Es range using the parameters given, may be found at the following link on my website by scrolling down to the bottom of the document at: http://www.k1six.com/6M_Es_1_HOP_Range.pdf . In addition, this very issue is explored in the excellent 2010 paper by Jim Kennedy, K6MIO/KH6 on Page 1, table 1: ***"Extreme Multi-Hop 50 MHz Es"*** at the following link (I would strongly encourage all to read this paper and ***any*** from Dr. Jim Kennedy in their entirety): http://www.it9tyr.com/docs/ExtremeMultihopEs.pdf. Although the maximum range values may differ slightly from my results, there is essentially agreement in the concept that long-haul, generally east-west paths will span significant areas of time zone and solar elevation angle influence.

In the Propagation Column "Summer 6M Es Probabilities" in the March/April 2007 NCJ, Carl Luetzelschwab, K9LA demonstrates how long-haul mid-latitude Es paths can actually be modeled with several examples shown at this link: http://k9la.us/Summer_6m_Es_Probabilities.pdf. Of course, this modeling methodology is preferred over the method that I use in the Es_Predict spreadsheet provided the 1957 – 1958 foundation shown as Figure 1 is still valid as it accounts for the solar elevation angles at all the independent refraction points along a long haul path. Es_Predict does not and simply uses a sliding scale path midpoint adjustment for the limited data contributions of others used as diurnal models.

The main point in Carl's article is that in many cases, a double humped blended probability can be expected but this will largely depend upon the solar elevations at the far ends of the path. For some 5 hop paths this may not be realized as Carl illustrates in Figure 2 and is shown as a real world example for K0GU paths to mostly Europe at this link: http://www.k1six.com/K0GU_XATL_Es_Diurnal.pdf and KL7KY paths to Europe (limited data) at this link: http://www.k1six.com/KL7KY_Eu_Diurnal.pdf. I cannot verify the accuracy of Carl's Figure 3 Midwest to CT3 path model as I have no real data in hand but a nice example of the double hump from K6QXY to the Far East real data may be found at this link: http://www.k1six.com/K6QXY_JA_Diurnal.pdf. But my real data diurnal plot for Europe, N. Africa and W. Asia looks different with the latest composite posted at this link http://www.k1six.com/K1SIX_XATL_DiurnalVariation.pdf and the 6M transatlantic diurnal plot from EA7KW, shown at this link: http://www.k1six.com/EA7KW_Diurnal.pdf seems to support the notion of a higher probability of success during the latter peak vs. the earlier peak and a "Critical Transition Time" of ~1830 UTC that is a close match with my data for this path. If real, the expectation would be a stronger PM peak for Midwest to Europe paths as well, beginning slightly later than here, solar elevation angle dependent and based upon their initial 1st hop modeled time. Yet, all conventional modeling for long-haul Es paths will yield a result of a stronger earlier peak because this is the very foundation of the baseline single hop model. Perhaps something else is involved for extremely long haul Es paths.

Some temporarily links are placed here to be used later during this build:

2001 Paper by Jim Kennedy: “Time-of-Day Effects in Six-Meter Multi-hop Sporadic E Propagation”

https://www.bobcoopertvhistory.com/assets/cent-states-2001-tod-es-effects.pdf

July 28, 2014 Article by Kelly Dickerson: “Earth’s Magnetic Field Is Weakening 10 Times Faster Now”

http://sedonanomalies.weebly.com/geomagnetics.html

Indian Journal of Radio & Space Physics Vol 41, February 2012, pp 26 -38: “Diurnal and seasonal variations in sporadic E-layer (Es Layer) occurrences over equatorial, low and mid latitude stations- A comparative study”

http://nopr.niscair.res.in/bitstream/123456789/13629/1/IJRSP%2041%281%29%2026-38.pdf

“Influence of solar and geomagnetic activity on sporadic E-layer over low, mid and high latitude stations”

http://www.sciencedirect.com/science/article/pii/S0273117714007698