CTU Presenta

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Centro Fiera del Garda Montichiari (Bs)

La Propagazione in 160 m.

IV3PRK - Pierluigi Mansutti









160m Propagation

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Assumption

- Carl Luetzelschwab K9LA is one of the most authoritative studious of ionospheric propagation, with particular interest on 160m
 - He cooperates with ARRL and the propagation columns of the main american radio magazines; a lot of the published material is downloadable from his website: <u>http://mysite.ncnetwork.net/k9la</u>
 - Since many years his propagation lectures are appreciated in the most important DX conventions
- This presentation, shown by K9LA in the RSGB convention 2010, has been translated in Italian language and modified <u>after his</u> <u>authorization</u> with the addition of further pages
 - My comments and the 18 years historical graphs, show what kind of DX can be expected on 160m, and WHEN can be to worked by an <u>average</u> station in Italy.

IV3PRK

What We're Going to Cover

- Quick Cycle 24 update
- Fundamental physical truths
- Normal propagation
- Interesting observations
- 160m predictions (or lack thereof!)
- Summary

Cycle 24 Update - Sunspots



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Cycle 24 Update - Ap



Geomagnetic field is the quietest we've ever seen

Foreword

- There's still a lot we don't know about 160m propagation
- The biggest area where we lack a good of understanding appears to be the lower ionosphere – i.e., the D region and lower E region
 - We really don't have any day-to-day parameters tied to this area of the ionosphere
- Thus don't expect this presentation to be "The Secrets of 160m Revealed"
- Recommendation to better "understand" propagation on 160m, be very active on topband

Fundamental Physical Truths

What Does It Take to Make a QSO?

- Enough ionization to refract signal back to Earth
 - MUF not a problem on 1.8 MHz even in the dead of night at solar minimum



Global Ionospheric Chart for 2009/12/15 06:00:00 UTC

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Ray Tracing vs Elevation Angles



- E region still comes into play at night at low elevation angles
 - foE approximately 0.4 MHz at night
 - Angles below approximately 7° are refracted back to Earth by the E region
 - High angles don't escape

What Does It Take to Make a QSO?

- Low geomagnetic activity
 - Very important and prohibitive on the high latitude paths
 - Minor influences on the low and transequatorial paths



What Does It Take to Make a QSO?

- Strong enough signal to be readable
 - Ionospheric absorption on 1.8 MHz is the real problem too much and signal is below your noise floor (which is usually not your receiver MDS)



low noise receiving antenna are very helpful for serious DXing

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Refraction and Absorption

- Refraction and absorption are inversely proportional to the square of the frequency
- Thus for a given electron density profile
 - The lower the frequency, the more the refraction (bending)
 - The lower the frequency, the more the absorption

160m RF is bent the most and incurs the most absorption

Ray Tracing on 28 MHz



- o-wave and x-wave pretty much follow the same path
 - Index of refraction approximately the same
 - X-wave bends a tiny bit more
- o-wave and x-wave pretty much incur the same amount of loss
 - Absorption approximately the same
- Apogee ~ 240 km

on higher HF bands, o-wave and x-wave propagate approximately equally

Ray Tracing on 1.8 MHz

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and polarization at mid to high latitudes on

160m tends towards elliptical (à vertical)

• O-wave and x-wave <u>do not</u> follow the same path

- Index of refraction significantly different
- x-wave bends much more
- O-wave and x-wave <u>do not</u> incur the same amount of loss
 - Absorption significantly different
 - x-wave usually considered to be out of the picture when operating frequency is near the electron gyrofrequency
 - ranges from .7 to 1.7 MHz worldwide
- Apogee for o-wave ~ 170 km
 - 160m wave doesn't get as high into the ionosphere

What a difference from 80m !



- Both waves start with an elev. angle of 15 deg.
 - the 1.8 MHz wave is refracted at 164km and reaches the ground at 1.149 km distance (1° hop) after leaving 10.8 dB for absorption loss the 3.8 MHz wave is refracted at 215km and reaches a distancr of 1.531 km after leaving only 2.1 dB for absorption loss.

Thus for a distance of 9.300 km (from Italy to Japan or to U.S.West Coast) under normal "multi hop" propagation we require:

- 6 hops on 80 m. with total absorption loss of 12.8 dB
- 8 hops on 160 m. with total absorption loss of 87.4 dB

Multi-hop on 160m

- Based on previous slides, multi-hop propagation on 160m is via hops that are short and lossy
 - "Short" is relative but it's not 3000 or 4000 km hops like on the higher frequencies
- Per our present understanding of the lower ionosphere, at night a 1500 Watt signal with quarter-wave verticals on both ends can go about 10,000 km before being below the noise level of our receiving system (usually limited by external noise)
 - Daytime limit around 1000 1500 km

This Suggests Ducting

Distances at and greater than 10,000 km are likely due to ducting in the electron density valley above the nighttime E region peak



Ducting incurs less loss due to less transits through the absorbing region and less ground reflections

NM7M's Work with GCRs

- Galactic cosmic rays are mostly very high energy protons coming in from all directions – day and night
- Quiet magnetic field (solar min) lets more in – more ionization in the lower ionosphere
- Active magnetic field (solar max) keeps them out
- GCR measurement on Earth (and thus impact to ionosphere) is 180° out of phase with solar cycle



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CGRs and the Valley

- NM7M's theory is that galactic cosmic rays play an important role in the valley formation, and thus ducting
- At solar maximum, not many GCRs ionizing the valley – nice and deep
 - Extremely long distance
 DXing best at solar max
 - NM7M has some interesting plots of QSO distance vs GCR decrease, but there is conflicting data
- At solar minimum, too many GCRs ionizing valley – fills up more and all we have left is lossy multi-hop



W4DR Observations

personal e-mail, late December 2009

"I have been DXing on 160 since 1970, with for the most part aboveaverage antennas.

During this present sun spot minimum (the last 2 years and especially the last 8 weeks) I have worked more polar path stations, Zones 17, 18, 19 and 23 plus some 40's than I have in the previous 37 years. This included my first ever zone 23 on Dec 12.

On the other hand I have not worked any long path or bent path SE Asians in the last 4-5 years."

tends to confirm that 160m propagation across the poles is best at solar minimum, and long distance DXing per NM7M's hypothesis may need a bit more geomagnetic field activity

IV3PRK Observations: this graph shows the total of weighted openings with OCEANIA (13.000 to 18.000 km distance) since 1992, related with solar flux, geomagnetic activity and galactic



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IV3PRK Observations: from this graph, representing only New Zealand path (18.000 km.), appears even better the absolute lack of openings from 2000 to 2004 – during solar maximum, and thus with lowest GCRs



This agrees with the comments of Greg, ZL3IX, on the other side

IV3PRK Observations: this graph, representing a lower latitude path to VK6 (13.500 km), appears to be better towards solar maximum and thus here we find a match with NM7M GCRs theory



..... but it must to be verified with the new cycle 24 !

K1ZM Observations

- Over the years I have had MANY experiences on the longpath from VY2ZM
- in 2008 I used to work over 100 JA's from 0745z 1200z in the morning (this shortpath) - and then in the afternoon, via the LONGPATH I might work 26 more JA's starting at 2020z and ending up about 2205z with JA6/JA4 contacts in Southern JA.
 - In this latter case, I was competing with EU stations which is a real challenge to do.
- I have also worked 9V1 on both CW and SSB mode via the longpath at 2305z from VY2ZM; also VK6HD and VK6VZ (both on CW and SSB mode) near his sunrise time - I think it was around 2100z or so some years ago
 - I have copied YC0LOW via the LP near his sunrise but no qso was ever made - this in Dec 2010)

Jeff confirms W4DR observations about great conditions across the poles, but disagrees on the very long distance paths, as he worked many longpath QSOs also during these last years of solar minimum.

IV3PRK Observations

- Not many of us can afford a lowband dream station like VY2ZM with an impressive and very efficient antenna system, surrounded by the sea and far from most manmade noise.
 - I would settle also for his K1ZM location on Cape Cod, MA !
- Instead my station is an "average" one, without the possibility to stretch any Beverage in the needed directions, and fighting continuously against the increasing noise with every kind of other short receiving antennas.
- I reached almost 300 countries on 160m, but unlike Jeff, I never enjoyed the thrill of working a DX over the long path.
- Recently I realized that a LP QSO could be possible also from Italy: but we need to be "there" at the right time to get the opportunity of our "spotlight".
- Going through the logs of ZL8X I found 105 QSOs with Europe over the long path - 4 of which with northern Italy – not many of them have the antennas of K1ZM !
 - There have been 7 days of LP openings via SW from about 06.30z until EU SR

It is confirmed once again that 160m propagation allows sometimes unbelievable DX with challenge to the fundamental phisical truths!

From ZL8X 160m log – Kermadec DXped. 2010

Nr. 908 EU QSOs via SP (Bleu sq.) and Nr. 105 QSOs via LP (Black sq.)

Pin colours: azure =>3 stations per Grid Sq., green =>5, bleu =>8, red => 10

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How and When was such ZL8 QSO via LP possible? DX Atlas: 29 Nov. – time 06.30z (3 QSO with I4 and 1 with I2 from 06.37 to 06.48)



Normal Propagation

Common Darkness

- Best place for 160m RF is in the dark ionosphere
 - The term "common darkness" along a path came from W4ZV in his 1991 Proceedings of Fine Tuning article and his 13 Jan 97 topband reflector post



K9LA sunset

STØ sunrise

4 hours and 25 minutes of common darkness K9LA - iv3prk - CU Italy 2011

Peaking time of 160m openings from IV3PRK to North Atlantic Area (W1, W2, W3 and VE1, VE2, VY2 stations) counted each day of the year, through all the years



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Peaking time of 160m openings from IV3PRK to Central U.S.A. (W6 and W0 call area) counted each day of the year, through all the years



Peaking time of 160m openings from IV3PRK to southern part of S.A. (below the Equator) counted each day of the year, through all the years



Peaking time of 160m openings from IV3PRK to JAPAN counted each day of the year, through all the years



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Interesting Observations

some of them make you wonder about our age-old beliefs

Signal Enhancements

- Most prevalent on the western end of the path when the eastern end is around sunrise
 - can bring a signal from no copy (below your noise) to perfect Q5 copy for tens of minutes
- Similar enhancements reported on the eastern end of the path when the western end is around sunset
- Enhancements believed to be tied to ducting
- Ducting (specifically getting out of the duct) may also have a lot to do with spotlight propagation



VE7DXR recording of Meyerton (South Africa) shortwave station showing ~13 dB enhancement

Skewed Paths



Image from "Skewed Paths to Europe on the Low Bands", K9LA, CQ, August 1999

Don't always assume a great circle path - remember the lower the frequency, the more the wave refracts (both in the vertical plane and in the horizontal plane)

If there's going to be a skewed path, 160m is the most likely band

The auroral oval is probably the most likely cause of skewed paths

Spike in the K Index



- Many observations of enhanced propagation across the high latitudes right before (or concurrent with) a spike in the K index
- Includes improved propagation on the AM broadcast band
- Mechanism may be tied to an increased
- With less ionization of the F layer, there is an increase in the deepness of the Field
- But until a point where the upper layer collapses and the signal is lost in the space

We experienced very strong signals in the evening from East and SE directions or good signals in the morning from West Coast skewed over West or SW paths

Spike in the K Index

- This is a recent example:
 - Feb. 01, 2011 16z: Aurora = 9
 - at 18z the K index jumps to 4



From 160m log of IV3PRK:

- 17.15z ZL3IX 559 559
 - Greg is active every day, but I was not hearing him since Jan.14
- 19.33z VK4MA 599 599
- 19.36z VK3PA 579 569
 - No QSOs with Eastern Australia stations since last Srptember
- 20.26z T88ZM 559 559
 - Answered my CQ on a quiet band
- 22.09z 9L1BTB 589 599
 - Loud and heard answering my CQ on the back of Rx antenna
- Unusual for me: NO calls from JA
 - Is this path too close to the Aurora Oval?

The Gray-line, or "Terminator" is the line around the Earth that separates the areas of daylight and darkness. Along this band the D layer is absent, while the F layer ionization is still good allowing very efficient propagation on low bands, especially on 80 and 40m, more than on 160 m



At left : 24 Feb.- <u>sunrise gray-line</u> through West Africa, ZD7, ZD9, VP8 3Y0, and up to Hawaii is. Right: 24 Feb. - <u>sunset gray-line</u> from Alaska through Central and South Africa

Gray Line



- N6FF to A61AJ
 - Nov 29, 1999 at 1455 UTC (N6FF sunrise)
- N6FF heard A61AJ best from the southwest
 - SW on sunrise end, SE on sunset end
- Suggests long path, but true great circle path has too much daylight
- Is it a skewed path?
 - Where's the skew point?
- What path did the RF follow?
- Are we fooled by short path?

Propagation Along the Terminator



 3Y0X (Feb '06) worked 287 Zone 4 stations from 0210 UTC (image on left) to 0901 UTC (image on right)

Note that this is short path

 Path only near terminator at 3Y0X end – and path gets away from the terminator quickly K9LA - iv3prk - CU Italy 2011

Propagation Along the Terminator



- 3Y0X worked 8 Zone 20 stations (YO, SV, LZ) from 00422 UTC (image on left) to 0522 UTC (image on right)
- Note that this is short path

 Path closer to the terminator – and not perpendicular
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Propagation Along the Terminator



 3Y0X only worked 1 JA at 0819 UTC Note that this is short path

 Path pretty much along the terminator This data indicates that gray line propagation on 160m on the short path is <u>not</u> efficient

- Our model of the ionosphere agrees with this data
 - But our model also says that Marconi's feat never should have happened – may be just a high latitude issue
 - And that VY2ZM on PEI never should have heard the 100 Watt GB3SSS Poldhu beacon on 1.96 MHz – same high latitude issue
- There's something going on that we don't understand

- Is solar minimum really the best time for 160m?
 - Geomagnetic field is quieter
- 160m appears to be best at solar minimum if your path goes through the auroral oval

IV3PRK to North America



From K9LA analysis of IV3PRK logs in the year 2004

path from IV3PRK to	# of QSOs	result
North America East Coast	106	92% of QSOs at $K \le 3$
North America Midwest	67	96% of QSOs at $K \le 3$
North America West Coast	26	100% of QSOs at $K \le 2$



West Coast is definitely better under Solar Minimum



Solar Min still best, but solar max hanging in there



Solar maximum holds up well when path not near aurora oval

North Magnetic Pole is Moving



As the north magnetic pole moves even farther north, will 160m propagation from the West Coast to Europe improve?



IV3PRK: West Coast (+KH6 e KL7) Season's openings

this graph is made of quantity and quality of the openings



Last seasons benefit of the exceptional quiet geomagnetic field, but the current one, despite the same numbers, looks like way down ! WHY ?

160m Predictions (or lack thereof!)

Predictions

- Our propagation predictions typically cover 3 30 MHz
 - There are additional variables that impact frequencies below 3 MHz (e.g., electron gyro-frequency), and I believe they are not all identified yet
- Several studies in the past used 10.7 cm solar flux and the A index
 - No good daily correlation seen
- Bring in space weather parameters
 - Do your own evaluation
 - OH2BO (way up north) monitors solar wind speed and dynamic pressure
 - NZ4O (formerly KN4LF) outlines parameters on his web site
 - I personally believe we haven't identified all the important parameters
- Correlation to AM broadcast propagation
 - N6RK brought this up on the topband reflector
 - May be localized effect or may be widespread effect
 - My analysis when we lived in Texas (1980s) didn't show any consistent results
 - There were days with enhanced 160m propagation but not enhanced AM broadcast propagation

Summary - Propagation

- Polar paths should generally be great now and for the next year or so
- Extremely long-distance paths may be hurt by this deep solar minimum
- Understand the concept of common darkness and learn how to determine it
- Watch for signal enhancements around sunrise and sunset
- Be very active to catch spotlight propagation to your area
- In general vertical polarization will work best
 - But you can't have too many antennas on 160m (who first stated that?)
- Don't shy away from elevated K-indices
 - Can provide skewed paths around the auroral zone
 - Can provide enhanced paths across the high latitudes
- Remember "southwest at sunrise" and "southeast at sunset" along the long path (even if we don't understand it, take advantage of it)
- Don't shy away from solar maximum
 - Even though S9+ signals on 10m are easier to deal with, be tough and stay on 160m

IV3PRK summery graph: synthesizes quantity and quality of DX openings towards all continents, quarterly grouped since 1992, related (or not related) with solar and geomagnetic activity, and cosmic radiations



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Reading Material

- ON4UN's prop. and Rx antenna chapters in his Low-Band DXing series
 - 5th Edition has been just published
 - Lots of practical information
- "DXing on the Edge" by K1ZM

– K9LA

– Cary Oler

- Topband history and a lot of useful info also for beginners
- Web sites with space weather info and 160m content
 - W8JI http://www.w8ji.com
 - W4ZV http://users.vnet.net/btippett/images/W4ZV.htm
 - IV3PRK http://www.iv3prk.it
 - VE6WZ http://www.qsl.net/ve6wz/geomag.html
 - NZ4O http://www.solarcycle24.org
 - VE3NE http://www.solarcycle24.com/
 - NW7US http://www.hfradio./org
 - http://mysite.ncnetwork.net/k9la
 - http://www.spacew.com

Apologies to any we missed !

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Thank You

IV3PRK – Pierluigi Mansutti







