Solar Activity and Amateur Radio

References

http://en.wikipedia.org/wiki/Sun_spots

http://en.wikipedia.org/wiki/Solar_cycle

http://en.wikipedia.org/wiki/Skywave

http://en.wikipedia.org/wiki/List_of_Solar_cycles

http://en.wikipedia.org/wiki/K-index

http://www.arrl.org/news/the-k7ra-solar-update-239

http://www.arrl.org/news/the-sun-the-earth-the-ionosphere

History

- Sunspots were first mentioned by the Chinese and the Greeks 400 B.C. – 300 B.C.
- The Maunder Minimum 1645-1715 occurred just as sunspots were being discovered and counted, making research difficult
- Rudolf Wolf was the first to study historical annual variations in sunspots in 1848

Physical Characteristics

- Caused by the interaction of charged particles with the sun's magnetic field
- Inhibits rise of heated matter from the interior to the surface
- Therefore, they are cooler and appear dark
- 3000-4500 deg K, versus 6000 deg K
- Surface endpoints of tubes of magnetic flux
- Each north magnetic pole sunspot has a corresponding south magnetic pole sunspot at the other end of the tube

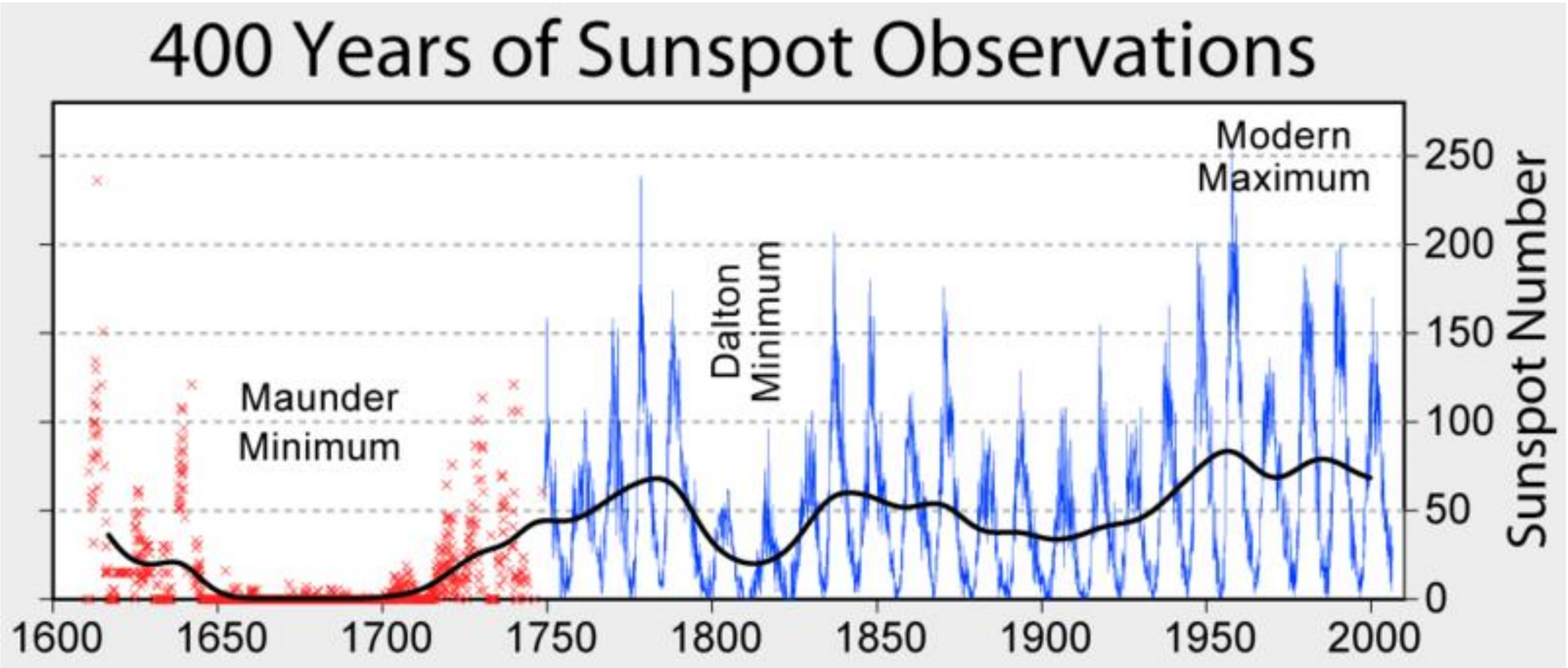
- The sunspot number varies in an 11 year cycle, which is actually a 22 year cycle
- During one 11 year cycle, north magnetic sunspots appear in the geographic north of the sun
- During the next cycle, south magnetic sunspots appear in the geographic north of the sun

List of Solar Cycles

- Cycle Started Finished Duration (years) Maximum (monthly SSN (Smoothed Sunspot Number))[4] Minimum (monthly SSN; end of cycle)[5][6] Spotless days (end of cycle)[7][8][9]
- Solar cycle 1 March 1755 June 1766 11.3 86.5 11.2
- Solar cycle 2 June 1766 June 1775 9.0 115.8 7.2
- Solar cycle 3 June 1775 September 1784 9.3 158.5 9.5
- Solar cycle 4 September 1784 May 1798 13.7 141.1 3.2
- Solar cycle 5 May 1798 December 1810 12.6 49.2 0.0
- Solar cycle 6 December 1810 May 1823 12.4 48.7 0.1
- Solar cycle 7 May 1823 November 1833 10.5 71.5 7.3
- Solar cycle 8 November 1833 July 1843 9.8 146.9 10.6
- Solar cycle 9 July 1843 December 1855 12.4 131.9 3.2 ~654
- Solar cycle 10 December 1855 March 1867 11.3 97.3 5.2 ~406
- Solar cycle 11 March 1867 December 1878 11.8 140.3 2.2 ~1028
- Solar cycle 12 December 1878 March 1890 11.3 74.6 5.0 ~736
- Solar cycle 13 March 1890 February 1902 11.9 87.9 (Jan 1894) 2.7 ~938
- Solar cycle 14 February 1902 August 1913 11.5 64.2 (Feb 1906) 1.5 ~1019
- Solar cycle 15 August 1913 August 1923 10.0 105.4 (Aug 1917) 5.6 534
- Solar cycle 16 August 1923 September 1933 10.1 78.1 (Apr 1928) 3.5 568
- Solar cycle 17 September 1933 February 1944 10.4 119.2 (Apr 1937) 7.7 269
- Solar cycle 18 February 1944 April 1954 10.2 151.8 (May 1947) 3.4 446
- Solar cycle 19 April 1954 October 1964 10.5 201.3 (Mar 1958) 9.6 227
- Solar cycle 20 October 1964 June 1976 11.7 110.6 (Nov 1968) 12.2 272
- Solar cycle 21 June 1976 September 1986 10.3 164.5 (Dec 1979) 12.3 273
- Solar cycle 22 September 1986 May 1996 9.7 158.5 (Jul 1989) 8.0 309
- Solar cycle 23 May 1996 December 2008 [10] 12.6 120.8 (Mar 2000) 1.7 821 [11]
- Solar cycle 24 December 2008 [10]
- Mean 10.6 114.1 5.8

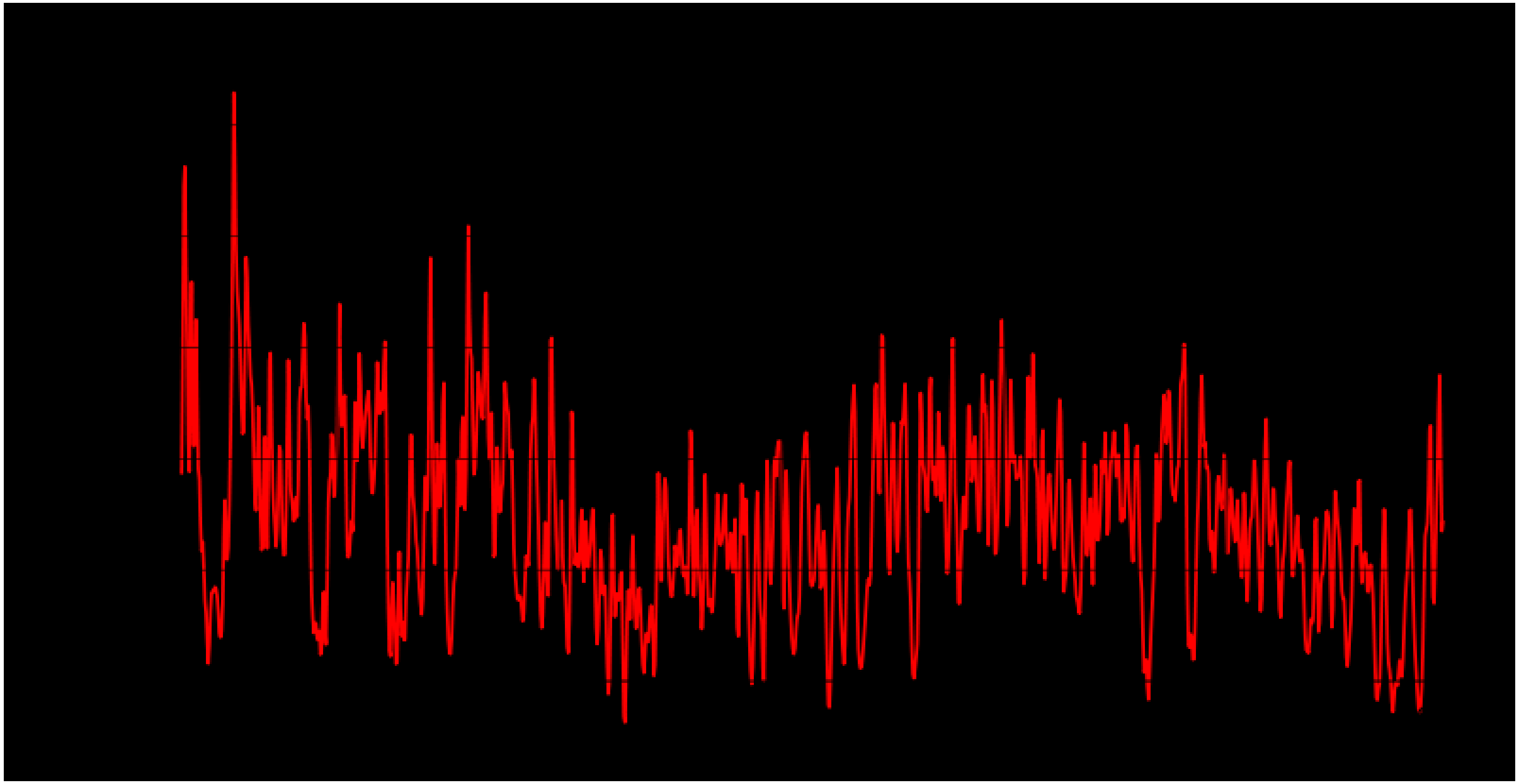
Effect on the Earth

- Climate – The Maunder Minimum corresponds to the Little Ice Age, during which glaciers advanced through northern Europe
- Sunspots emit solar prominences and solar flares, causing charged particles to impact the earth
- Prehistoric sunspot levels can then be measured by C14 levels



400 Years of Sunspot Observations
Modern
Maximum
Dalton
Minimum
Maunder
Minimum
Sunspot Number
0
50
100
150
200
250
1600
1650
1700
1750
1800
1850
1900
1950
2000

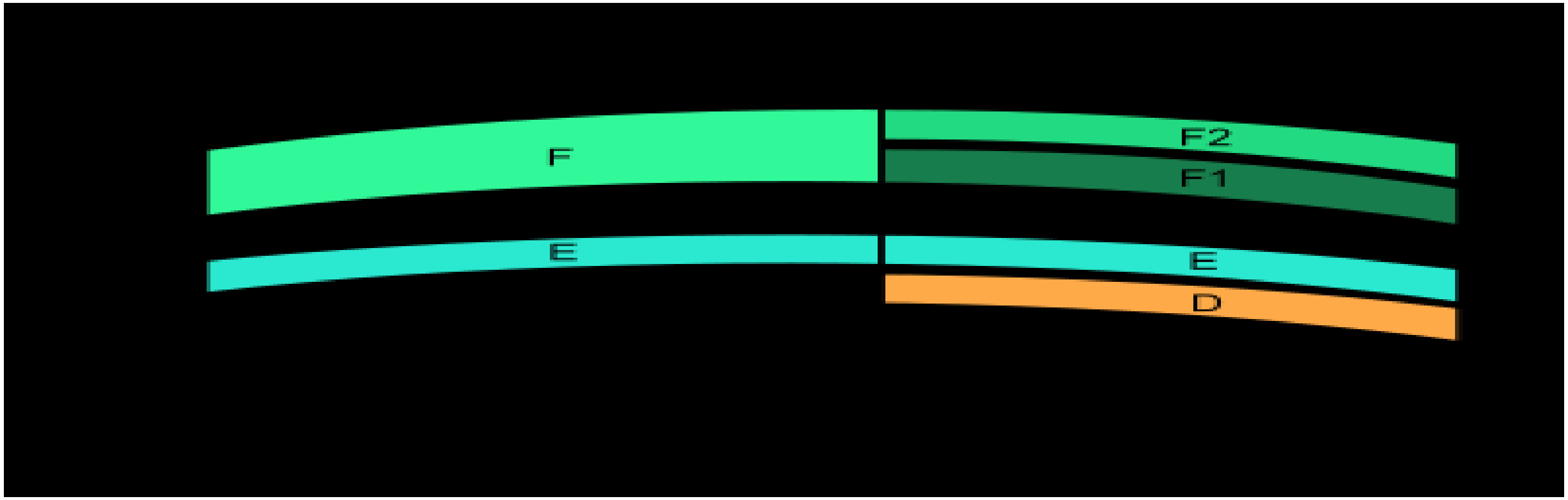
11,000 year variations



Ionosphere

- Charged particles and electromagnetic radiation from the sun striking the upper atmosphere causes charged layers to form
- More charged particles cause stronger layers
- The D layer is generally an absorption layer, especially for the lower frequencies
- The E layer is also generally an absorption layer

Ionosphere Layers



- E – 100 km, F1 – 200 km, F2 – 300 km

Night Day

- When the E layer is especially heavily ionized, Sporadic E propagation can occur, which includes frequencies as high as VHF
- Sporadic E is generally short lived in time, and small geographically
- The F layer, or F1 and F2 layers , are mainly responsible for long range propagation of the higher HF frequencies 20 through 10 meters
- The F layer nearly disappears at night during the low years of the sunspot cycle

- The passage of radio waves through the ionosphere is analogous to light passing through a lens
- The speed of propagation changes with charge density, just as the speed of light slows down in a lens compared to free space
- The higher the charge density, the more bending that will occur

- The ionosphere is not necessarily parallel to the surface of the earth.
- If tilted toward or away from you, can cause your transmission to have a different distance than your reception
- “You can hear them, but they can’t hear you”
- If tilted to the side, propagation may be in a different direction that your antenna is pointed

Solar Indices

- Solar activity is measured by several numbers
- Sun Spot number – a weighted count of the number of sunspots, where large spots count more than small ones
- Solar Flux – a measure of solar radiation at the wavelength of 10.7 cm
- K Index – a measure of geomagnetic activity
- A Index – also a measure of geomagnetic activity

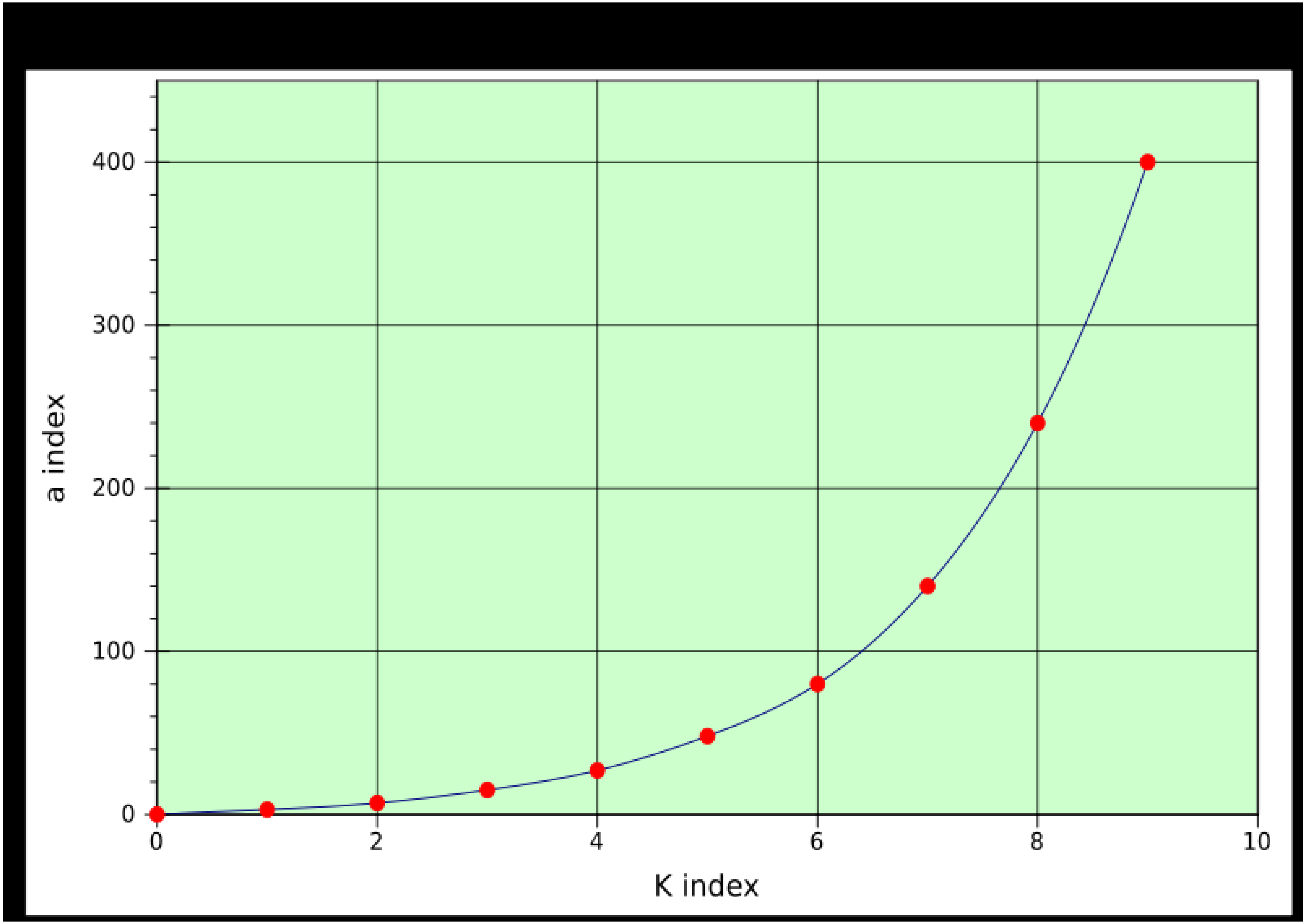
- Solar Flux is related to Sunspot Number
- From 10/12/2012 report - The sunspot numbers for October 4-10 were 56, 55, 39, 37, 41, 63 and 71, with a mean of 51.7. The 10.7 cm flux was 109.5, 106.2, 98.8, 98.1, 103.4, 106.2 and 112, with a mean of 104.9.
- From the 5/26/2000 report - Sunspot numbers for May 18 through 24 were 297, 239, 282, 271, 207, 150 and 185 with a mean of 233. 10.7 cm flux was 252.9, 254.3, 245.6, 232.3, 214.9, 204.3 and 189.4, with a mean of 227.7

- In the report for 6/29/2007 Sunspot numbers for June 21 through 27 were 0, 0, 0, 0, 11, 11 and 15 with a mean of 5.3. 10.7 cm flux was 65.5, 65.3, 65.9, 66.9, 67.6, 70.5, and 73.2, with a mean of 67.8.
- Higher Sunspot and Solar Flux numbers mean a stronger F layer and better propagation
- Lower numbers mean worse propagation

- The 10.7 cm flux is the measure of radiation at a UHF frequency, approx. 3000 MHz
- The radiation that causes F layer ionization is ultraviolet at a wavelength of 100 to 1000 Ångströms
- The radiation that causes E layer ionization is soft X-rays at a wavelength of 10 to 100 Ångströms
- The radiation that causes D layer ionization is hard X-rays at a wavelength of 1 to 10 Ångströms
- 1 Ångström = 10^{-8} cm

A and K Indices

- The K Index is measured every 3 hours at various locations on earth, and varies from 1 – Calm, to 9 – Severe Storm
- The A Index is a daily average calculated from the K Index. It varies from 1 to 400
- The K Index is roughly proportional to the logarithm of the A Index
- The a Index is the equivalent of the K, the A is the average of the 8 a's for the day



a index
400
300
200
100
0
0
2
4
6
8
10
K index

- Equivalent range a for given K
- K 0 0+ 1- 1 1+ 2- 2
- a 0 2 3 4 5 6 7

- K 2+ 3- 3 3+ 4- 4 4+
- a 9 12 15 18 22 27 32

- K 5- 5 5+ 6- 6 6+ 7-
- a 39 48 56 67 80 94 111

- K 7 7+ 8- 8 8+ 9- 9
- a 132 154 179 207 236 300 400

- A value of K, a, or A without a subscript is a local value based on one observatory
- A subscript of p as in **Kp, ap, Ap,** means a weighted planetary average
- An A Index of 15 or below, or a K Index at or below 3 is acceptable for propagation

Software

- Radio Station WWV gives the summary of the Solar Flux and A and K indices at 18 minutes past the hour
- Most DX Clusters can give the latest, or a history of these numbers with the command
- “show wwv”
- The ARRL gives a summary of numbers on a weekly basis as Bulletins or emails or as web page
- Once a week Solar Flux or Sunspot is sufficient, but A and K can change rapidly

- The numbers can be entered into propagation forecast programs such as Propview from DX Labs