Long Term Trends in 6-Meter Sporadic E Occurrences

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Most dedicated VHF operators are very aware of the diurnal and seasonal probabilities of 6-Meter sporadic E. For example, here in the northern hemisphere, sporadic E (hereafter abbreviated Es) occurs most often in the summer months in the late morning and early evening hours. Has this been the norm since Es was discovered? And what about worldwide patterns of Es – has it remained the same? The purpose of this month's feature is to review the diurnal, seasonal and worldwide occurrence patterns of Es over the years.

Es was identified by Sir Edward Appleton in 1930 based on observations of the ionospheric E layer showing occasional irregularities. In the spring of 1950 Ernest K. Smith began work on his master's thesis at Cornell University – he wanted to prove that over 400 reports of the reception of television stations at distances of 500 to 1600 miles was due to Es. He followed this up with his PhD thesis by doing a macroscopic study of worldwide Es using ionosondes, which was published in early 1957.

Late 1950s

During the IGY (International Geophysical Year – July 1, 1957 to December 31, 1958) many more ionosondes came on line, and Smith's earlier data was updated (reference 1). Figure 1 depicts the diurnal and seasonal probabilities of Es in the northern hemisphere. Figure 2 depicts the worldwide probabilities of Es for May thru August daytime. The data is from reference 1.

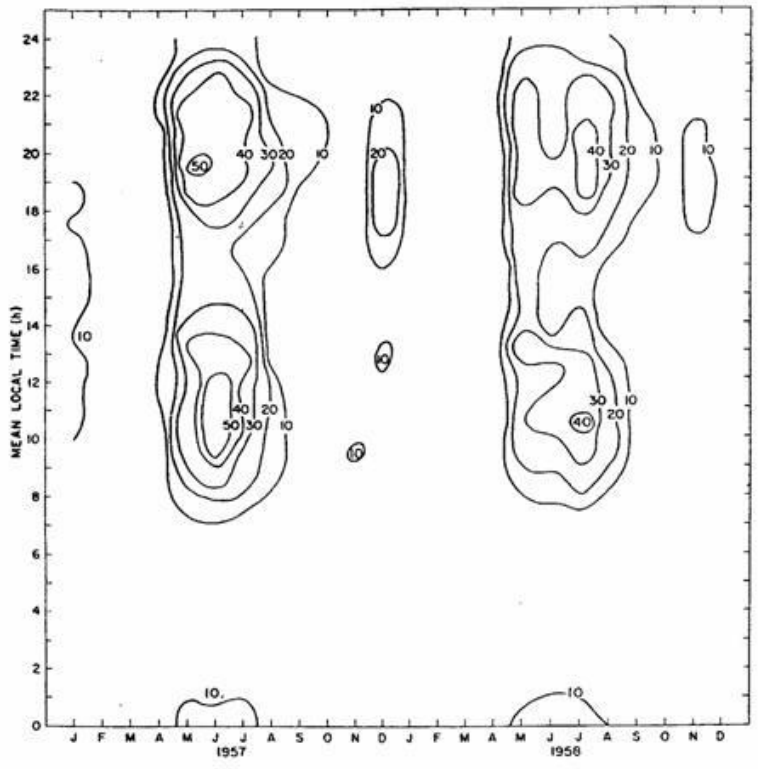

Figure 1 – Northern Hemisphere Diurnal and Seasonal Data – Late 1950s

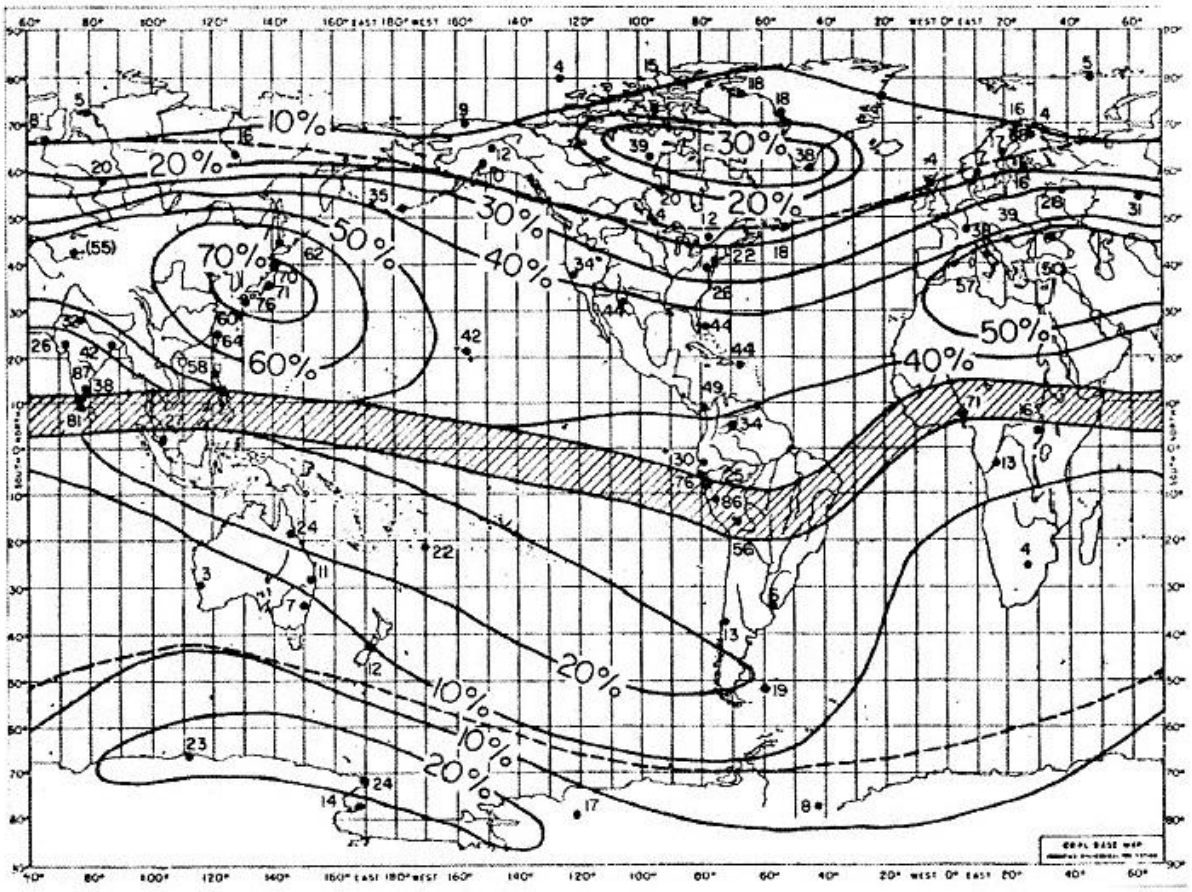

Figure 2 – May Thru August Daytime Worldwide Data – Late 1950s

From these two figures, we can conclude the following for the late 1950s:

1) Mid-latitude Es in the northern hemisphere occurred most often in the summer months (May thru August) during the late morning local time and early evening local time. There was a secondary peak in occurrence in December in the early evening.

2) Mid-latitude Es in the northern hemisphere summer occurred with pretty much equal probability in North America and Europe. There was a significantly enhanced area of occurrence in the summer centered over Japan.

Now let's look at more recent data.

<u>Early 2000s</u>

GPS (global positioning system) has provided us with a great tool to collect ionospheric data while doing its job of telling us where we are in the world. For example, we can put together a worldwide picture of the electron densities in the F2 region from the measurement of the difference in phase of the two GPS frequencies. The difference in the phase shift is translated to

a TEC (total electron content) value, which can then be translated to an electron density. For more on TEC, please read last month's Monthly Feature.

Another example of data from GPS is anomalies in the E region and F region of the ionosphere that can be used to predict scintillation at high latitudes and in the equatorial ionosphere, respectively. Finally, SNR (signal to noise ratio) and phase variations of the GPS frequencies can be used to identify Es in the worldwide ionosphere.

Figure 3 depicts the worldwide diurnal variation of Es for June thru August 2002. Figure 4 depicts the worldwide distribution of Es for June thru August 2002. Figure 5 depicts the worldwide distribution of Es for December 2002 to February 2003. The data is from reference 2.

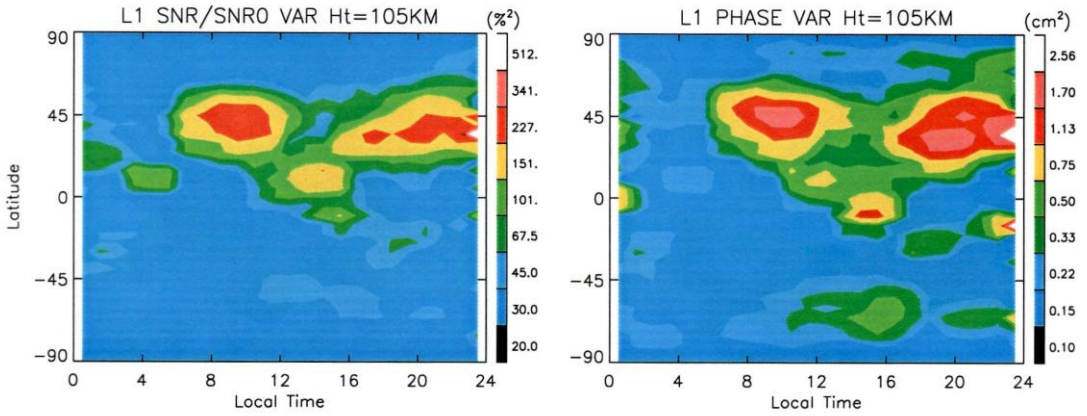

Figure 3 – Worldwide June Thru August Diurnal Data - 2002

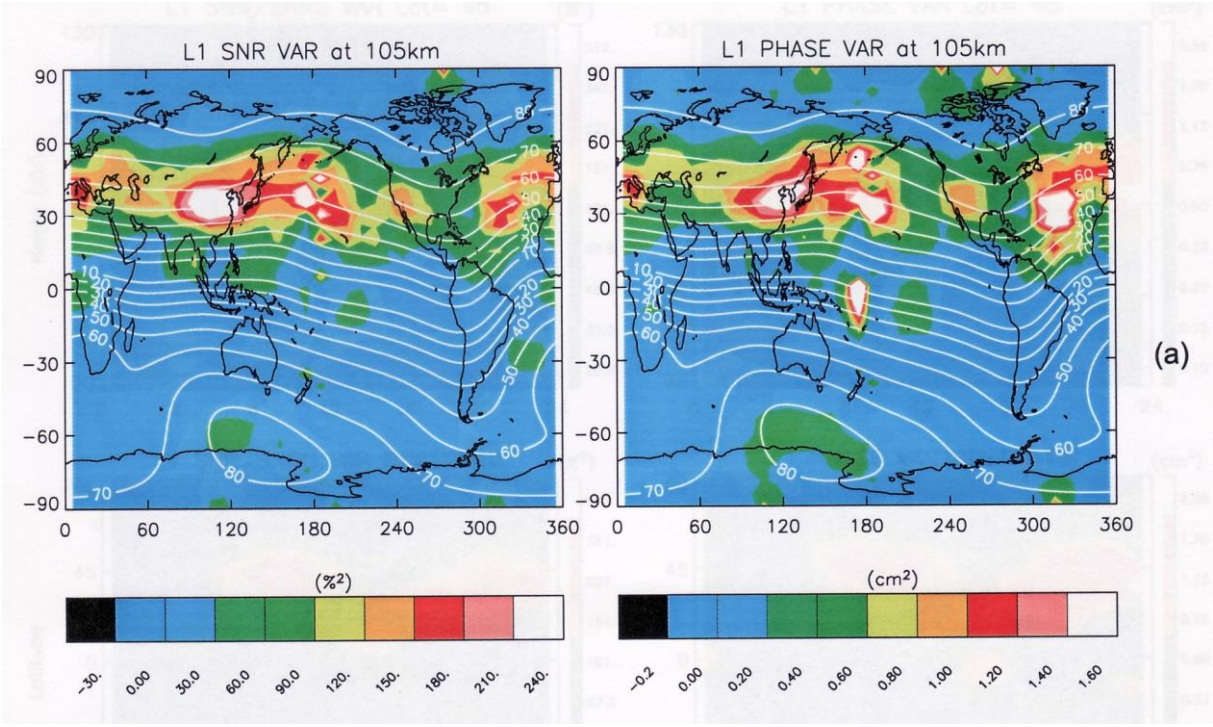

Figure 4 – Worldwide June Thru August Data - 2002

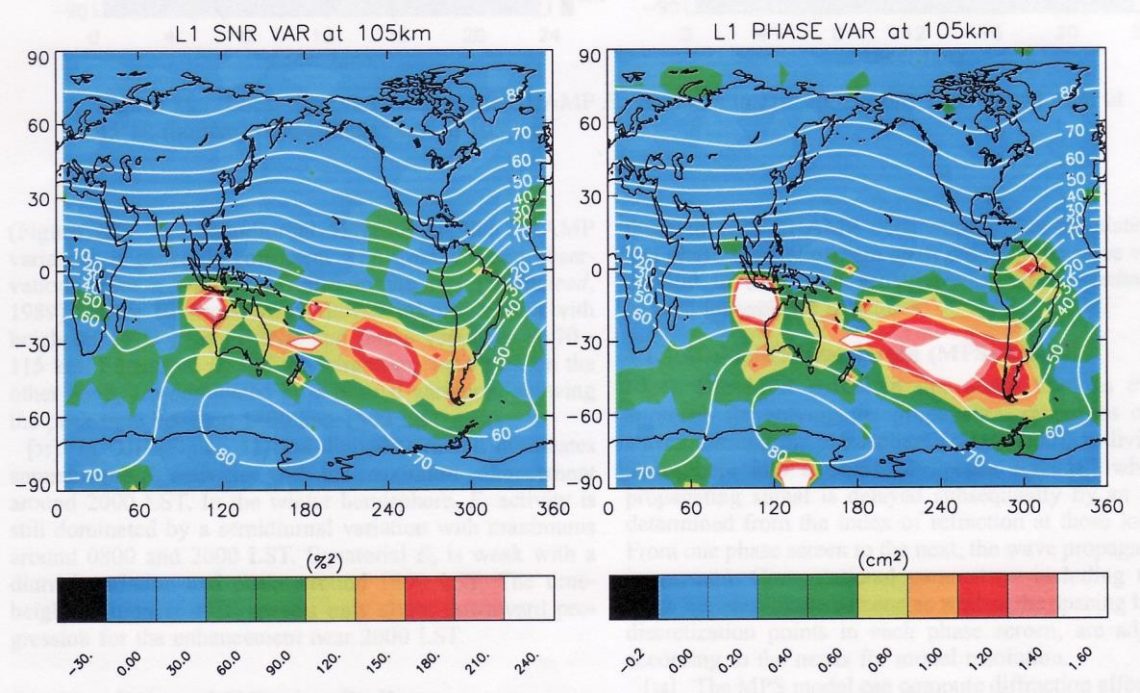

Figure 5 – Worldwide December to February Data – 2002/2003

From these three figures, we can conclude the following for 2002/2003:

1. Mid-latitude Es in the northern hemisphere occurred most often in the summer months during the late morning local time and early evening local time. There was little, if any, Es in the northern hemisphere in the winter months.

2. Mid-latitude Es in the northern hemisphere summer occurred more in Europe than in North America. There was a significantly enhanced area of occurrence in the summer centered over Southeast Asia (west of Japan).

Long Term Changes

Based on a comparison of the late 1950s data to the more recent 2002/2003 data, we see that Es may have disappeared in North America during the winter. And the enhanced Es in the northern hemisphere summer has moved to a position west of Japan.

There is more GPS data to review. For example, reference 3 corroborates that Europe had more Es than North America during the summers of 2007 and 2008. But it's inconclusive (at least in my opinion) with respect to the enhancement being over Southeast Asia or Japan. The diurnal variation peaking in the late morning and early evening in the northern hemisphere summer months is corroborated.

Although changes in some Es patterns are suggested, we really need more data to raise confidence in any conclusions. I'm sure the GPS data is out there – one just needs to find it and

sift through it. Of course Amateur Radio reports and ionosonde data would be a good source of data, too.

Possible Causes of Change

One of the parameters that could contribute to worldwide Es occurrence pattern changes is the change in the Earth's magnetic field – both in field strength and inclination. Reference 4 discusses these changes with respect to changes in F2 region parameters – hmF2 (the height of the maximum F2 region electron density) and foF2 (the F2 region critical frequency). If the F2 region is affected, it is possible Es could be affected, too.

Meteoric deposition rates and winds at Es altitudes are two other possibilities. I'm sure there may be other possible causes of change. This is an interesting topic for deeper investigation by VHF aficionados.

For more information about Es, check out Jon N0JK's *World Above 50 MHz* column in the August 2016 issue of QST.

References:

1. H. I. Leighton, A. H. Shapely and E. K. Smith; *The Occurrence of Sporadic E during the IGY*; Central Radio Propagation Laboratory, National Bureau of Standards, Boulder Colorado

2. Dong L. Wu, Chi O. Ao, George A. Hajj, Manuel de la Torre Juarez and Anthony J. Mannucci; *Sporadic E morphology from GPS-CHAMP radio occultation*; Journal of Geophysical Research, Vol 110, A01306, doi:10,1029/2004JA010701, 2005

3. Christina Arras; *A Global Survey of Sporadic E Layers bases on GPS Radio Occultations by CHAMP, GRACE and FORMOSAT-3/COSMIC*; PhD dissertation, Scientific Technical Report STR10/09, September 2010, University of Leipzig

4. Ingrid Cnossen and Arthur D. Richmond; *Changes in the Earth's magnetic field over the past century: Effects on the ionosphere-thermosphere system and solar quiet (Sq) magnetic variation*; Journal of Geophysical Research: Space Physics, Vol 118, 849-858, doi:10.1029/2012JA018447, 2013