Interesting Trans-Equatorial Propagation (TEP) on 6 Meters

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In December, I received an e-mail from Pete, VE3IKV/VA3RA relating his TEP QSOs from the Caribbean on 6 meters. In November 2003 he went to Saba PJ6. After sunset, he worked deep into Patagonia (a sparsely populated region at the southern end of South America, governed by Argentina and Chile) on SSB. November 2003 was almost two years after the second peak of Cycle 23, with a smoothed sunspot number of around 90 (per the new sunspot record). I took a look at this path with the mapping feature in W6ELProp. Figure 1 is that image with my additional annotations.

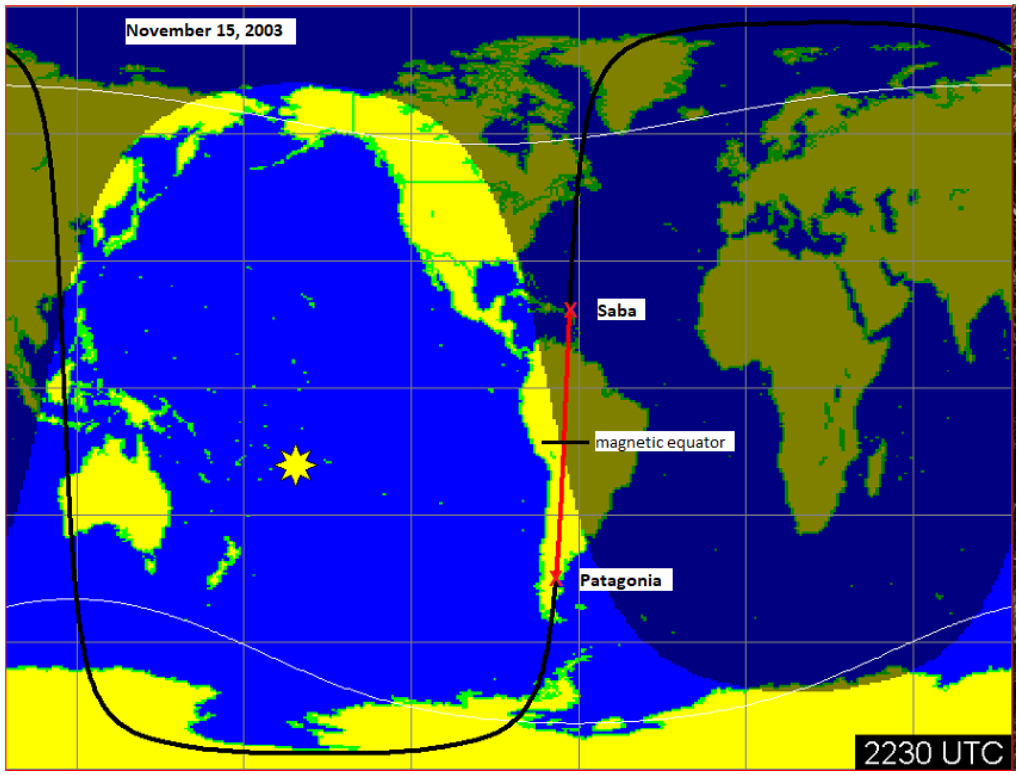

Figure 1

The TEP path is the red line (it's also the short path between Saba and Patagonia, whereas the black line is the long path), and is just under 7,000 km. This is a classical TEP path because:

1) it's pretty much North-South
2) the magnetic equator is close to the middle of the path and is perpendicular to the path
3) Saba and Patagonia are located such that they can take advantage of the two high-electron-density areas on each side of the magnetic equator (not shown – more on this later)

In November 2012 (between the two peaks of Cycle 24 at a smoothed sunspot number of around 85), Pete traveled to PJ7. On November 23 at 2210 UTC he heard the ZD8VHF 6m beacon (6,080 km) and at 2220 UTC he worked TR8CA (8,158 km) on 6m CW.

I looked at the path from PJ7 to ZD8, again with the mapping feature in W6ELProp. Figure 2 is that image.

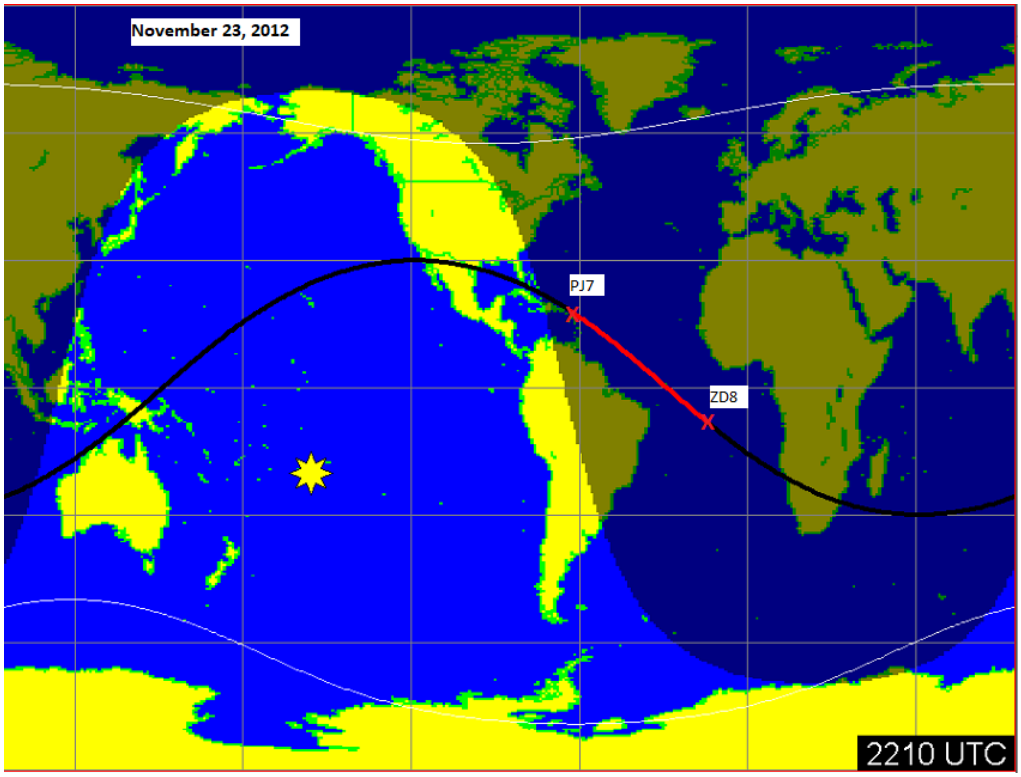

Figure 2

My first thought was "this isn't a TEP path because it's not North-South". But I decided to look at the electron densities along the path. Figure 3 comes from Proplab Pro V3 (a ray tracing program from Solar Terrestrial Dispatch using IRI 2007 as its F2 region model) for the ZD8VHF beacon reception at PJ7 on November 23, 2012 at 2210 UTC. The data on Figure 3 is in terms of the plasma frequency along the path. The electron density in electrons per cubic meter equals the plasma frequency squared over 81. The higher the plasma frequency, the higher the electron density.

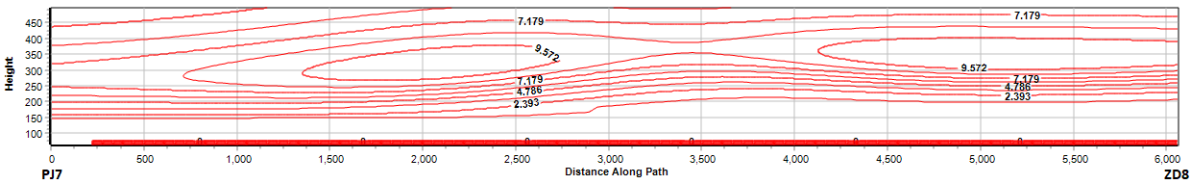

Figure 3

PJ7 is on the extreme left at 0 km and ZD8 is on the extreme right at 6,080 km. Note the two areas of the highest plasma frequencies (9.572 MHz, which equals 1.13 x 10^{12} electrons per cubic meter) on either side of about 3,500 km from PJ7. This 3,500 km distance from PJ7 is the magnetic equator.

These two areas of high electron density (also known as the crests of the equatorial ionosphere) are the tell-tale signature of a TEP path. The stations are far enough away from the magnetic equator to take advantage of a chordal hop across the magnetic equator. Figure 4 is a sketch of this concept.

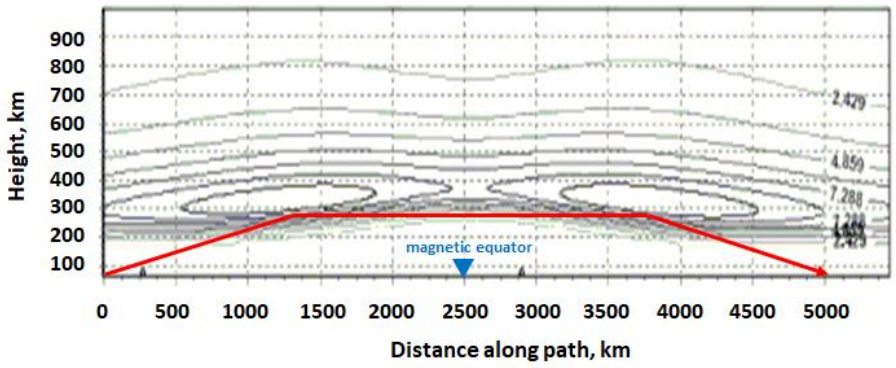

Figure 4

Note that the chordal hop does not have to be bent to return to Earth for a second hop – it covers its extreme distance in one "hop". The result of this is that the MUF (maximum useable frequency) for a chordal hop is higher than for two normal F2 hops, and it avoids a ground reflection loss from two normal hops (the frequency is high enough such that absorption from two extra transits through the D region is minimal).

So why was this a TEP path when it was not North-South? Let's look at the geomagnetic latitude map from NorthWest Research Associates at https://spawx.nwra.com/spawx/maps/maplats.html. On it I'll add the PJ7-to-ZD8 path, red circles indicating the midpoints of each crest and a red square for the magnetic equator. Figure 5 is this map.

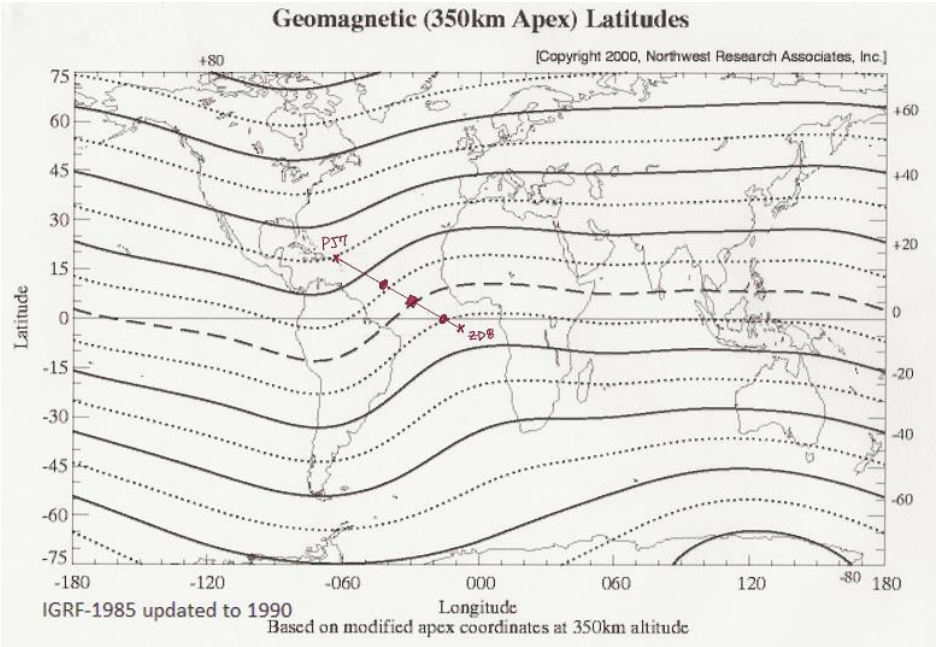

Figure 5

The red square (the magnetic equator derived from Figure 3) indeed falls right on the dashed magnetic equator line of the NWRA map. And the midpoints of the crests (also derived from Figure 3) are at latitudes about 10-11^{o} north and south of the magnetic equator – this is about where they should be.

Thus what enabled this path (and the PJ7-to-TR8CA path) was the fact that the magnetic equator was not east-west as in Figure 1. It was roughly southwest-northeast, which allowed a path pretty much perpendicular to it to take advantage of a TEP chordal hop.

Happy New Year to Everyone

2021 starts my 25th year of monthly writings