SSSP: Short-path Summer Solstice Propagation

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Introduction

For many years DXers on 50MHz have been surprised by the unexpected and excellent short-path propagation from Japan to Europe and North America. In 2006, short-path QSOs from W to EU and KL7 to EU were also reported. This propagation, which occurs around the summer solstice of June 21st, has been generally described as 'Multi-hop Sporadic-E' and has been reported from the 1970s onwards. I would like to ask: "Who undertook the surveys or deep studies on this type of propagation?" and: "Why has it been assumed to be Multi-hop Es?"

SSSP or S^{3}P is an acronym for Short-path Summer Solstice Propagation, a name which Chris, G3WOS and I have called this type of propagation and which I believe NOT to be based on multiple hops. SSSP has been discovered in the Northern hemisphere but symmetrically there should also be similar propagation at the December Solstice in the Southern hemisphere. Because the December Solstice is called the Winter Solstice in the Northern Hemisphere one might want to call it as SWSP (Short-path Winter Solstice Propagation) but in this article I will refer to both SSSP and SWSP simply as the SSSP to avoid any confusion.

Here I define SSSP as the short-path propagation around the June Solstice in the Northern Hemisphere and the similar propagation around the December Solstice in the Southern Hemisphere.

In June 1999, I first found SSSP through a 50MHz CW QSO with Toivo, OH7PI and until this year (2006), I have continued running propagation tests called 'The Six Metre Propagation Test Campaign around the Summer Solstice'. Although the amount of collected data is small and the exact mechanism is yet unknown, in this article I will introduce and hypothesise about the cause and nature of this type of propagation.

Why has it been called 'Multi-hop Es'?

Figure 1 shows the usual model of multi-hop Es. In this usual model, 50MHz signals are refracted by E-layer clouds and reflected or bounced from the surface of the earth several times between the transmitter and receiver - often described as one-hop or two-hop sporadic-E. However, I believe that assuming this mode of propagation stretches credibility when talking about summer short-path propagation between Japan and Europe.

Assuming the height of the E-cloud to be about 90 to 100km, the maximum one-hop distance will be around 2,000km maximum. The distance of JA

– EU propagation is between 10,000 and 12,000 km, thus the number of hops via classic multi-hop Es needs to be five, six or even more. With JA – NA paths, we have a large area of sea on the path, but on the JA – EU path there is only the Eurasian continent and no water thus the 50MHz signal will be scattered and/or absorbed by the inefficient ground surface. The short-path JA – EU QSOs seen this year are strong at the peak and the tone of CW signal is pure with little if no distortion i.e. they do not appear to have been dispersed or scattered from as would be expected from a signal that has been exposed to multiple reflections from the earth's uneven ground. Such distortion can be easily observed on EME signals. Because of this issue, I am confident that the multi-hop Es model is not adequate to explain the propagation we have experienced this summer and for which I have adopted the term SSSP.

The discovery of SSSP

In the spring of 1999, I acquired a special station license of 1kW output for 1.8 MHz to 50MHz. As in many countries, in Japan we need an explanatory document for the application of a 1kW output license for 50MHz. In my application I wrote that I wanted to study FAI (Field-Aligned Irregularities) in the E-region as this was a newly found and currently unexplained phenomenon on amateur bands. After the initial inspection of the kW station in which my station was approved, I was praised by the inspection officer for the document explaining my requirement for high-power on 50MHz.

After a just a few months, on the evening of June 23rd 1999, I found that the 48.25 MHz TV carrier from Europe was strong and called CQ on 50.105. Almost immediately, Toivo, OH7PI called me. The QSO was the first QSO between JA and OH in Cycle 23. Toivo's CW signal was a pure tone with slow QSB of around 10 – 30 seconds. From that day, I called CQ every day on 50MHz and many stations in a wide number of European countries including SM, OH, G, GD, DL, SP, OZ, YO, F, PA gave me receiving reports of my signal through the internet.

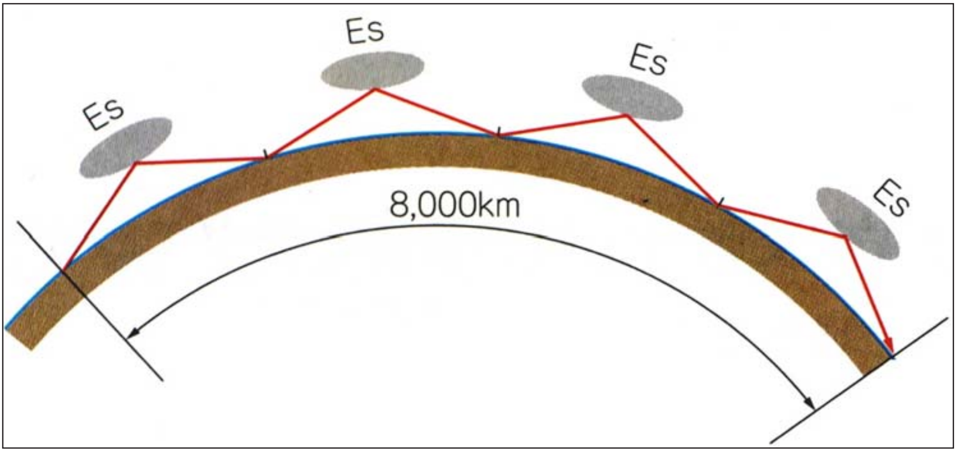

Figure 1: A model of 'Multi-hop Es'. We need to ask ourselves whether this is really correct.

Furthermore, on July 10th a very strong opening started between JA and SM7FJE and around thirty-five JAs were lucky enough to have made QSOs to Europe. In addition, I completed a QSO with YO4AUL. This QSO has been recognized as the first YO - JA 50MHz QSO following YO stations obtaining permission to operate on 50MHz.

Ever since 1999, I have been running 'The Six Metre Propagation Test Campaign' around the Summer Solstice and have called CQ on 50MHz for many days every single season. I have often posted messages to the UKSMG announcement page regarding the campaign and discussed the nature of this propagation, but reception of my views was not always particularly good. Almost all the contributors over the years thought that the widely accepted mechanism of Multi-hop Es was the simplest explanation. But now I am happy to report that many other 50MHz operators are open to the idea that this propagation is actually caused by a different mechanism that I have termed SSSP. A turning point was the unprecedented and totally unpredicted almost daily occurrence of strong JA – EU propagation during the summer of 2006 extending as far as the UK on several days.

Table 1 shows a summary of JA – NA and JA – EU SSSP openings from 1990 to 2006. It is clear that the same kind of propagation occurs almost every year and is seemingly not influenced by solar activity; the peak of Cycle 22 was 1989 - 1991 and the peak of Cycle 23 was 1999 – 2001. 2006 is the bottom of cycle 23's solar activity. Please note 'none' in Table 1 means no data was obtained, there is a possibility propagation occurred, but if it did it was not noted.

Table 1: SSSP Openings from JA to NA and EU, 1990-2006.

1990	June	KL7
1991	May	KL7
1992	June	W6, W7
	July	YU, OK, OH, OE, DL
1993		none
1994		none
1995	July	W6, W7, VE7
1996	July	KL7
1997		none
1998	May	W6
	July	W5, W6, W7
1999	June	OH, SM, YO, W
	July	W5, W7
2000	June	W5, W6, W7, W8, W9, WØ, KL7
	July	W5, W6, W7, W9, WØ, VE
2001	June	W6, W7, KL7, SP, S5, 9A, OK, OZ, PA, HB9, OE, OH, DL, 5B, JY
	July	W6, W7, KL7
2002	June	W6
2003	June	W6, W7, VE, 5B
	July	W5, W6, W7, UX0, Z3, 9H, LZ, 9A, SP, YU
2004	June	I, SP, OH, ES, 9H, UT, 5B, W6
2005	June	W7, 9H, G, SV8, LY, OH, YU, YO, I, 5B
	July	W6, W7, KL7, I, 5B
2006	May, June, July	Many W and EU!

Characteristics of SSSP propagation

The following is a summary of the characteristics of SSSP propagation obtained through my activity and tests.

1. Band: 50MHz

2. Period of occurrence: End of May through end of July every year

(Northern Hemisphere) and around the December Solstice (Southern Hemisphere, extrapolated)

3. Time of propagation:

JA – NA 21 – 02 UTC morning in JA, evening/night in USA

04 – 09 UTC afternoon in JA, night/morning in USA

JA – EU 04 – 10 UTC afternoon in JA, morning in Europe

4. Antenna direction: On or near short-path azimuth

5. Paths: Mainly JA – NA, JA - EU but West Coast W - EU and KL7 - EU have also been reported. Almost all paths are in the daylight area of the earth and all are in the same hemisphere. (Note: To date, SSSP has been seen in the Northern Hemisphere only but there is a possibility in the Southern Hemisphere)

6. On JA-EU opening: 5Bs have frequently been reported (4X and ZC also but less frequent).

7. Length of openings: Open areas are 'spotty' on both sides and move on a day-by-day basis.

8. Signal strength: Generally signals are weak with slow 10 – 30 second QSB and without any flutter. This is one of the features of the propagation that provides evidence that the signal path of SSSP never touches to surface of the earth. More on this later.

9. Power: A high transmitter ERP is needed. Stations with 100 or 200W and single Yagi is possible but the crest time or usable time is short.

Possible mechanism for SSSP propagation

I would like to attempt to explain the core mechanism behind SSSP. As you all know I am just one of the many radio amateurs around the world who operate on 50MHz and I have no way of directly measuring electron density in situ or by rocket-based observation myself. However, I am confident that SSSP has a different propagation mechanism from that assumed for multi-hop Es, the usual model accepted for this type of propagation.

Figure 2 on page 40 shows the first control point (Point A) at which the 50MHz signal is bent. I assume that point A could be located in either the E-layer or the higher F1 layer. If it lies in the E-layer, the height of Point A is around 90 –100 km with a maximum one-hop distance of about 2,000 km. If the control point lies in the F1-layer, the height would be around 200 km and the maximum hop distance would be 3,000 km.

Please note that in the SSSP model that the path never actually touches the ground. When it is assumed that Point A lies in the E-layer, the second control point (Point B) is a maximum of 3,000 km away from a station. If Point A is assumed to be located in the F1-layer, point B is a maximum of 4,500 km away.

It is often said [Ref 1] that the F1 layer is likely to occur in the daylight time of a summer season and constantly has an MUF of 4 to 5 MHz which is nearly independent of solar activity. When assuming F1-layer as the first control point of a 50MHz signal, the incident angle should be less than five degrees by the secant law.

In the actual SSSP openings I have experienced I have had to set my stacked yagis to an elevation angle of around 15 degrees compared to normal F2 propagation when it is usually set to

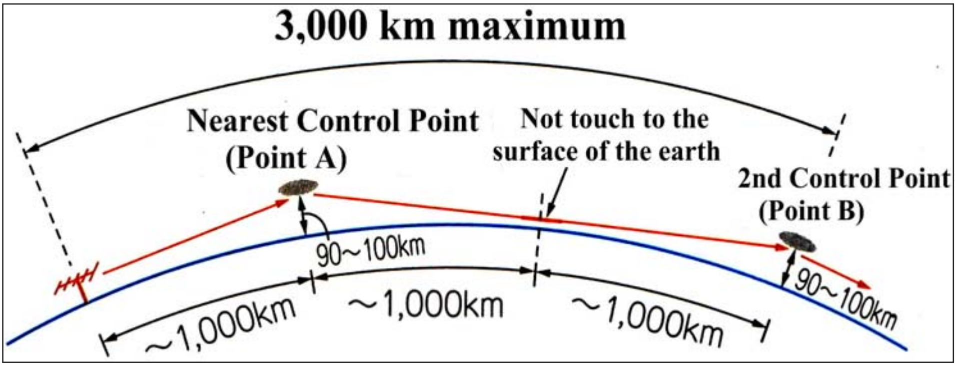

Figure 2: A model of the nearest control point of SSSP.

near 0 degrees. So it is likely that Point A is nearer than the model shown in Figure 2. At the present time I believe that the E-layer is a more likely contender for the first control point at both the JA and EU ends of the path. I assume that the 50MHz signal in Japan is bent at the first control point (point A) above the Japan Sea and reaches the second control point (point B) at around 55 degrees North which is located near the Lake Baikal in eastern Siberia. From Point B the 50MHz signal is carried by the region of 'Polar Mesosphere Summer Echo' or PMSE. PMSE is a strong radar echo phenomena obtained by radar observations at both North and South Polar regions at around 80 - 90 km above the ground.

It is reported [Ref 2] that PMSE has been observed for between 150 to 210 days of the year. PMSE also exactly matches the time period when we see SSSP propagation, between the end of May and the end of July. It is also reported that PMSE occurs at 52 – 78 degrees N in northern hemisphere and has a Bragg Scale of three metres.

In regards to the explanation of PMSE and the Bragg Scale, I would recommend that you search the Internet for further information as there are many papers and articles on this subject that can be found. The paper named "Polar Mesosphere Summer Echo (PMSE): review of observations and current understanding" M.Rapp and E-J.Lubken, 2004, can be directly obtained from *http://www.copernicus.org/EGU/acp/acp/4/2601/acp-4-2601.pdf*, [Ref 2]. I believe this is the best paper for the radio amateurs like ourselves.

In this article I simply mention that the Bragg Scale of three metres can be translated to the frequency of 50MHz. The PMSE region refracts our 50MHz signals especially efficiently and I believe this to be one of the main reasons why SSSP has been reported on 50MHz and not on 28 or 144 MHz for many years.

The average height of the PMSE region is 88 km above the ground which is by coincidence very near to the height of E-layer. The PMSE region consists of suspended ice particles that are caused by the very low temperature of around 150K at that height. Multiple studies regarding the polar mesosphere have reported that such a low temperatures are a result of the greenhouse warming effect that we are all familiar with these days.

I would now like to attempt to explain the complete mechanism of SSSP. Please see figure 3 below. The E (or F1) layer provides the nearest control point for the stations at both ends of the link and PMSE region connects the two control points over the polar region. The 50MHz signal will be bent at the nearest control point and will propagate through the PMSE region covering the Arctic pole without ever touching the surface of the earth. I believe this to be the core proposed mechanism of SSSP and provides a good explanation for the lack of distortion and the strength of signals I have observed in my study.

If SSSP does use the PMSE region as a type of chordal propagation, we can say that SSSP is a completely new type of propagation caused directly by the effect of greenhouse warming due to the activities of human beings. For all of us, SSSP is a newly discovered propagation on our amateur bands. If so, that's really exciting!

We can monitor the electron density of the Auroral oval in the Arctic polar area on a nearly real-time basis by looking at *http://www.sec.noaa.gov/pmap/pmapN.html*. On this page we can imagine how 50MHz signals could propagate over the polar region.

Figure 4 on page 42 shows the image of the auroral oval of the Arctic pole at 06 UTC on July 19th 2006. This was one of the excellent days when I made many QSOs with European stations via SSSP. The map shows how a high electron density area covers the JA – EU path.

In the Southern Hemisphere, SSSP should also occur around the Decem-

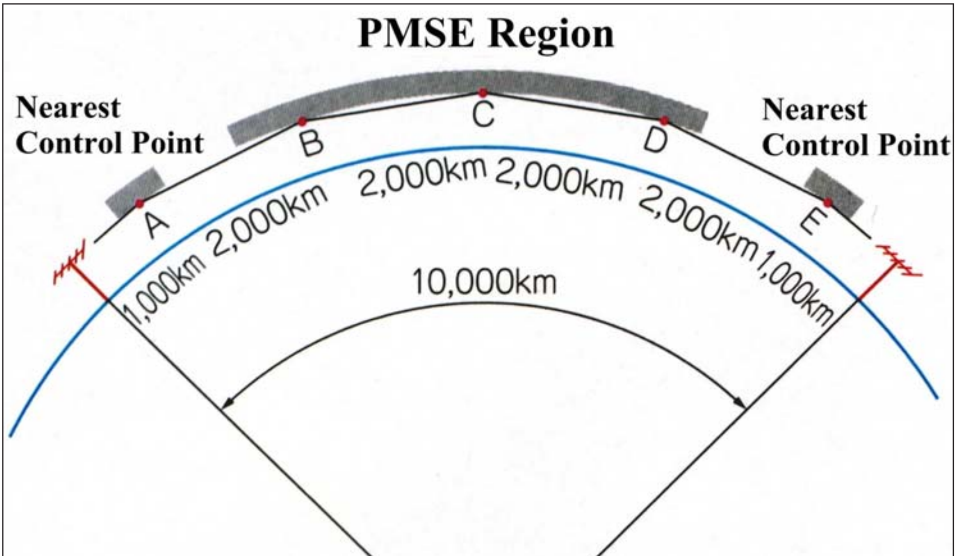

Figure 3: A model of end-to-end SSSP.

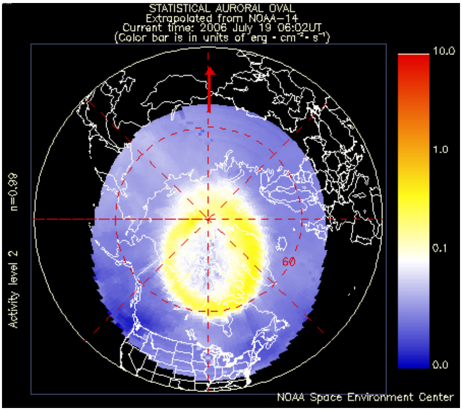

Figure 4: Map showing the electron density in the Auroral oval at 06 UTC on July 19th 2006.

ber Solstice. 50MHz operators in ZS, VK, ZL PY, LU, CE and others in the Southern Hemisphere are requested to look for this 'au naturel' gift as Christmas comes near!

One other point I need to mention in regard to SSSP is concerned with the elevation angle of my antenna. Figure 5 shows my current antenna system with 10 degrees of elevation angle. I am using two 10.7 metre boom eight-element yagis with an elevation mechanism. The stacking distance is 7.7 m and the average height is 30 metres AGL.

I am using 35 metres of RG17A/U coax cable. The yagis are based on the CL6DXZ from the Create Design company, optimised using the YO and AO software by K6STI. This horizontally-polarised, vertically-stacked pair of yagis exhibits very high SNR (Signal to Noise Ratio) on 50MHz compared to a single yagi configuration because of its sharp and clean radiation pattern in the vertical plane.

Additionally I am using a TS-940 and FT-1000MP with a home brew made transverter and a 1kW output linear amplifier. The receiving converter consists of a 2SK571 VHF FET and a double balanced mixer. This converter exhibits a low noise figure and high gain which is good enough for my DXing activities. My S-meter always reads s1 to s2 because of the high gain of the converter and because of artificial noise from the residential area surrounding my shack. But I need high sensitivity, especially on 50MHz.

The high dynamic range and noise blanker of the legacy HF band flagship transceivers address these challenging operating conditions. In the Japanese market these old transceivers can be obtained at affordable prices and they are very well suited for combining with 50MHz transverters.

To buy one of these cheap transceivers secondhand and use a high tower with large or stacked antennas and low-loss large diameter coax for 50MHz is the best way. Through understanding and realising the law and the rules (yes, Zen and the Art!) building an excellent system is not difficult today.

When I increase the elevation angle of my yagis (for instance from 0 to 10 degrees), the level of incoming noise decreases substantially, by up to 6 - 10dB. This is because of the elimination of nearby noise interference received on the underside of the main lobe. When further increasing the elevation angle, I frequently observe that the DX signal can be clearly heard whereas the level of interference rapidly reduces. As a result, the SNR of DX signals is much improved and this is very helpful when copying weak signals buried in the buzz when using SSSP.

In this year's Es season, from the end of May to the end of July 2006, I made some 180 QSO with EU stations including HV0 and 80 QSO with NA stations including W, VE and KL7. For almost all of these SSSP QSOs I found that the optimal elevation angle was in the range of 10 – 15 degrees although this maybe a particular result of my own location, system and the antenna. As the exact propagation characteristics of SSSP propagation is still unknown, the general access angle of elevation is also unknown. I heard stations using a single yagi without elevation which were making SSSP QSOs quite easily. They have a broad main lobe and could attain literally a wide range of propagation.

Stations with stacked Yagis should have a high SNR and a low elevation angle, but without an elevation mechanism they will suffer ultimately poorer SNR because of the weak DX signal from higher elevation angle and the loud TV buzz being simultaneously received. I recommend a single long-boom (1.5 - 2.5 WL) yagi with or without an elevation rotator, or vertically-stacked yagis with an elevation rotator for SSSP. Although a single yagi has a broad main lobe and can easily adapt any of the types of propagation encountered on 50MHz, the elevation mechanism will also make a sense on improving SNR of weak DX signal.

Figure 5: JE1BMJ's 10.7m boom, eight-element yagis stacked 7.7 m apart with an elevation rotation mechanism.

The great days of SSSP

Figure 6 on page 44 shows the GoogleEarth propagation map *(http://www.dxers.info/google/earth/index.php)* that Chris, G3WOS downloaded on June 14th, 2006. The paths, including JA – EU, JA - 5B and JA - 5T are indicated on it.

On that day I had QSOs with G4IGO, G3WOS, G4FVP, SV1LK, SV1SB, 9A6R, G4RGK and some Italian stations. Amazingly, Nicolas 5T5SN gave me a receiving report from Africa, about 13,500 km away!

On July 19th (see also Figure 4) I completed QSOs with the following stations: NL7Z, DK1MAX, I5IAR, ON7GB, DL7QY, OH2BC, I5TAT, DJ3TF, LY3UM, LY3DA, DL3BUE, SM3GSK, OH2BP, ON7BJ, DL7CM, DL2OE, F8ZW, OH2MA, DK3WG, DM2AYO, ON4AOI, PA3GND, DJ2BW and others.

Conclusions

Although there are still many unresolved or unknown phenomena in relation to SSSP propagation at the present time, I hope many 50MHz enthusiasts will continue to survey, research and exploit SSSP. For reasons outlined in this arti-

Figure 6: The 'GoogleEarth' propagation map for June 14th 2006.

cle this new mode of propagation provides QSO opportunities across great distances that were either unattainable or unnoticed in the past. Our primary goal should be to take advantage of this opportunity that provides considerable excitement equivalent to that experienced at the peak of the solar cycle using F2 propagation. SSSP even occurs in the dip of a solar cycle. I look forward to having an SSSP QSO with many of you on 50MHz in 2007!

References

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Acknowledgements

Thanks to all the 50MHz DXers who are using SSSP every season. And my special thanks to Chris Gare, G3WOS who assisted in the naming of this propagation, producing the GoogleEarth map and editing my poor English in this article [G3WOS: Han, your English is very good and infinitely better than my Japanese!].