THE VLF STORY

A LISTENER'S STORY ABOUT ELF/VLF "NATURAL RADIO" EMISSIONS OF EARTH IN THE 0.1 TO 10 kHz FREQUENCIES.

By Stephen P. McGreevy, early 1995, revised April 2007

In memory of Joyce Cathell and Donald Cyr

Authors forward: This story was originally written for the book *A Whistler Serenade* from Stonehenge Viewpoint Press (1995) at the invitation of the publisher in early 1995. A fair portion of that book discussed various theories (some quite whismsical) on Crop Circles, and the even more complex pictograms that were appearing in rapidly increasing numbers in English wheat and other crop fields throughout central/southern England. The late Donald Cyr, publisher and co-author of *A Whistler Serenade*, was fascinated by these beautiful circles and the various other shapes of the pictograms, and he along with friend and partner James Brett conjectured many scientific and pseudo-scientific theories about them, including one theory that they were being caused by whistlers. While I really didn't think whistlers were their cause (from what I knew about whistlers and VLF radio waves in general), I myself was intensely fascinated by what I was reading and seeing about Crop Circles in Don's publications. I was keeping an open mind while offering my very gentle and good-natured refute of Cyr and Brett's "Whistler-Crop Circle Theory." while exercising a glimmer of hope that, somehow, whistlers and crop-circles might be related in some way, however remotely. Therefore, please bear this in mind when you come across mention of Crop Circles later on in this writing that it was discussed within this context.

Secondly, there have been many findings since the classical "magneto-ionic duct theory" pertaining to whistler generation was developed by R. Heliwell in the late 1950's. This has to do with the travel of whistler-mode electromagnetic waves along magnetic lines-of-force from the source lightning stroke to the opposite hemisphere to be heard as a "one-hop whistler." Conjugate points were thought to be rather fixed, but anecdotal observations by listeners such as myself and also more detailed scientific studies and analysis of whistler-mode waves tell give a much more dynamic picture of Earth's magnetic-field. Please refer to the section about this and Kimura's writing further down in this piece. - *S. P. McGreevy, 12 October 1997*

Also read Bill Hooper's Journal 15 DAYS IN DEATH VALLEY. Bill spent 15 days attempting to record whistlers during NASA's INSPIRE expeiments in March 1992. A great read along with my own story here - SpM

Relatively few people know of (and even fewer have heard) the beautiful radio "music" produced naturally by several processes of nature including lightning storms and aurora, aided by events occurring on the Sun. I have been fascinated with listening to naturally-occurring radio signals since about the middle of 1989, hearing my first whistlers almost immediately after first trying out a rudimentary receiving apparatus I had put together for the occasion.

Whistlers, one of the more frequent natural radio emissions to be heard, are just one of many natural radio "sounds" the Earth produces at all times in one form or another, and these signals have caught the interest and fascination of a small but growing number of hobby listeners and professional researchers for the past four decades.

"Natural Radio," a term coined in the late 1980's by California amateur listener and researcher Michael Mideke, describes naturally-occurring electromagnetic (radio) signals emanating from lightning storms, aurora (The Northern and Southern Lights), and Earth's magnetic-field (the magnetosphere). Conditions within Earth's magnetosphere and between the Sun and the Earth are called "space-weather."

The majority of Earth's natural radio emissions audible with ground-based radio receivers occur in the extremely-low-frequency and very-low-frequency (ELF/VLF) radio spectrum - specifically, at AUDIO frequencies between approximately 100 to 10,000 cycles-per second (0.1--10 kHz). Unlike sound waves which are vibrations of air molecules that our ears are sensitive to, natural radio waves are vibrations of electric and magnetic energy (radio waves) which - though occurring at the same frequencies as sound - cannot be listened to without a fairly simple radio receiver to convert the natural radio signals directly into sound.

Whistlers are magnificent sounding bursts of ELF/VLF radio energy initiated by lightning strikes which "fall" in pitch. A whistler, as heard in the audio output from a VLF "whistler receiver," generally falls lower in pitch, from as high as the middle-to-upper frequency range of our hearing downward to a low pitch of a couple hundred cycles-per-second (Hz). Measured in frequency terms, a whistler can begin at over 10,000 Hz and fall to less than 200 Hz, though the majority are heard from 6,000 down to 500 Hz. Whistlers can tell scientists a great deal of the space environment between the Sun and the Earth and also about Earth's magnetosphere.

The causes of whistlers are generally well known today though not yet completely understood. What is clear is that whistlers owe their existence to lightning storms. Lightning stroke energy happens at all electromagnetic frequencies simultaneously--that is, from "DC to Light." Indeed, the Earth is literally bathed in lightning-stroke radio energy from an estimated 1,500 to 2,000 lightning storms in progress at any given time, triggering over a million lightning strikes daily. The total energy output of lightning storms far exceeds the combined power output of all man-made radio signals and electric power generated from power plants.

Whistlers also owe their existence to Earth's magnetic field (magnetosphere), which surrounds the planet like an enormous glove, and also to the Sun. Streaming from the Sun is the Solar Wind, which consists of energy and charged particles, called ions. And so, the combination of the Sun's Solar Wind, the Earth's magnnetosphere surrounding the entire Planet, and lightning storms all interact to create the intriguing sounds and great varieties of whistlers.

How whistlers happen from this combination of natural solar-terrestrial forces is (briefly) as follows: Some of the radio energy bursts from lightning strokes travel into space beyond Earth's ionosphere layers and into the magnetosphere, where they follow approximately the lines-of-force of the Earth's magnetic field to the opposite polar hemisphere along "ducts" formed by ions streaming toward Earth from the Sun's Solar Wind. Solar-Wind ions get trapped in and aligned with Earth's magnetic field. As the lightning energy travels along a field-aligned duct, its radio frequencies become spread out (dispersed) in a similar fashion to light shining into a glass prism. The higher radio frequencies arrive before the lower frequencies, resulting in a downward falling tone of varying purity.

In this manner, a whistler will be heard many thousands of miles from its initiating lightning stroke--and in the opposite polar hemisphere! Lightning storms in British Columbia and Alaska may produce whistlers that are heard in New Zealand. Likewise, lightning storms in eastern North America may produce whistlers that are heard in southern Argentina or even Antarctica. Even more remarkably, whistler energy can also be "bounced back" through the magnetosphere near (or not-so-near) the lightning storm from which it was born! There will be additional discussion of this "theory of whistlers" in the next few pages.

Considered my many listeners to be the "Music of Earth," whistlers are amongst the accidental discoveries of science. In the late 19th century, European long-distance telegraph and telephone operators were the first people to hear whistlers. The long telegraph wires often picked up the snapping and crackling of lightning storms, which was mixed with the Morse code "buzzes" or voice audio from the sending station. Sometimes, the telephone operators also heard strange whistling tones in the background. They were attributed to problems in the wires and connections of the telegraph system and disregarded.

The first written report of this phenomenon dates back to 1886 in Austria, when whistlers were heard on a 22-km (14 mile) telephone wire without amplification. A paper by W.H. Preece (1894) appearing in Nature Magazine describes operators at the British Government Post Office who listened to telephone receivers connected to telegraph wires during a display of aurora borealis on March 30 & 31, 1894. Their descriptions suggest they heard whistlers and the "bubbling/murmuring" sounds of "Chorus" from aurora.

During World War I, the Germans and Allied forces both employed sensitive audio-amplifiers to eavesdrop on the enemy's telephone communications. Metal stakes were driven into the ground next to enemy telephone wires and were connected to tube-type high-gain amplifiers, whereby the audio signal in the telephone wires could be eavesdropped. This early form of electronic espionage worked fairly well most of the time, despite the bubbling and crackling background noise made by lightning--but not always.

On some days, the telephone conversations they were eavesdropping on were partially or wholly drowned out by strange whistling sounds. Soldiers at the front would say, "you can hear the grenades fly." These whistling sounds, described as sounding almost like "piou," were at first attributed to the audio amplifiers' circuitry reacting adversely to strong lightning discharge noises. When laboratory tests on the high-gain audio amplifiers failed to recreate the whistling sounds, the phenomena was then considered "unexplainable" at that time. (H. Barkhausen, 1919).

In 1925, T. S. Eckersly of the Marconi Wireless Telegraph Company in England, described disturbances of a musical nature that had been known to "radio" engineers for many years. They were heard when a telephone or any other "audio-recorder" system was connected to a large aerial. What they were hearing are now known as "tweeks," a common ringing and pinging sound that lightning discharge radio energy (sferics) atmospherics sound like at night with a VLF receiver or audio amplifier. Several people began to observe how lightning and auroral displays coincided with many of the strange sounds they were hearing with their audio apparatus (Barkhausen, Burton, Boardman, Eckersly, et al.).

In the 1930's, the relationship of whistlers and lightning discharges was hypothesized, and in 1935, Eckersly arrived at the commonly accepted explanation that lightning initiated radio waves traveling into Earth's "ionosphere" caused these tweek sounds. They were getting "close." Interest in whistlers waned during World War II but was renewed with the development of sound spectrographs and spectrum analyzers, which could trace the time-versus-frequency component of audio sounds. This technology was developed mainly for the study of the sound characteristics of speech and other sounds, but these also were fine tools for the exploration of whistlers, as well (R. K. Potter, 1951).

It was during this time that L.R.O. Story in Cambridge, England, had begun an in-depth investigation into the nature and origin of whistlers. Armed with information presented by Barkhausen, Boardman, et al., a homemade spectrum analyzer and other audio-frequency radio equipment, Storey studied whistlers in earnest, discovering several types of whistlers that were or were not audibly associated with lightning discharge "clicks" in the receiver. He was able to make graphs of many kinds of whistlers, forming the basis of the modern "magneto-ionic" theory of their origin, and also the effects of Earth's magnetic storms on whistlers.

Storey's conclusion that whistlers were formed by lightning discharge energy echoing back and forth along the lines-of-force of earth's magnetic field suggested that there was a much higher than expected ion density in the outer ionosphere and beyond, and that the source of this "extra" ionization was linked to the sun. He also (correctly) presumed these ions from the sun also were responsible for magnetic storms and auroral displays. Story, while mainly concentrating on whistlers, was able to hear and categorize a number of other audio-frequency emissions that he heard, including Dawn Chorus, steady hiss, and certain "rising whistlers," also known as "risers".

Story's studies throughout the early-to-mid 1950's made an important contribution to whistler theory by showing that whistlers travel very nearly in the direction of Earth's magnetic field. In 1952, the results of Storey's work were presented by J. A. Radcliffe to the Tenth General Assembly of the URSI held in Sydney Australia, exciting considerable interest among the delegates in attendance. Radcliffe's report greatly stimulated whistler research at Stanford University, headed by the "Father of Whistler Research," R. A. Helliwell.

In 1954 at the next URSI General Assembly held in the Hague (Netherlands), whistler theory was discussed in depth, and plans were devised to study whistlers at opposite "conjugate" points of Earth's magnetic field. Lightning storm atmospherics observed in one hemisphere were heard as "short whistlers" (1-hop whistlers) in the opposite hemisphere. This notable observation was conducted by Helliwell at Stanford in California and aboard the U.S.S. Atka located in the South Pacific near the opposite magnetic conjugate point. Lightning storms generating atmospheric static "pops" as heard in the ship's onboard VLF receivers were heard nearly simultaneously in Stanford as short whistlers.

Even more verification of Storey's whistler was confirmed by the observation of whistler "echo trains" simultaneously heard in Alaska and in Wellington, New Zealand, which lies at the opposite magnetic conjugate from Alaska. With this generalized history of whistler discovery and research in mind, I should pause this history lesson and now explain whistler theory in somewhat greater detail.

The generally accepted theory of whistlers (Storey, Morgan, Helliwell) is as follows (the following few paragraphs are taken directly from the text of my WR-3 "Whistler Receiver" Listening Guide and repeat some information presented earlier in this article as well as hopefully making clearer some terms I've been tossing about): The Earth's outer magnetic field (the "magnetosphere") envelopes the Earth in an elongated doughnut shape with its "hole" at the north and south magnetic poles. The magnetosphere is compressed on the side facing the Sun and trails into a comet-like "tail" on the side away from the Sun because of the "Solar Wind" which consists of energy and particles emitted from the Sun and "blown" toward Earth and the other planets via the Solar Wind. Earth's magnetosphere catches harmful electrically charged particles and cosmic rays from the Sun and protects life on Earth's surface from this lethal radiation.

Among the charged particles caught in the magnetosphere are ions (electrically charged particles), which collect and align along the magnetic field "lines" stretching between the north and south magnetic poles. These magnetic-field aligned ions bombarding Earth's magnetosphere form "ducts" which can channel lightning- stroke electromagnetic impulse energy. Whistlers result when an electromagnetic impulse (sferic) from a lightning- stroke enters into one of these ion-ducts formed along the magnetic lines of force, and is arced out into space and then to the far-end of the magneto-ionic duct channel in the opposite hemisphere (called the opposite "magnetic conjugate"), where it is heard as a quick falling/descending emission of pure note tone or maybe as a brief "swish" sound.

Whistlers sound the way they do because the higher frequencies of the lightning-stroke radio energy travel faster in the duct and thus arrive before the lower frequencies in a process researchers call "dispersion." A person listening with a VLF receiver like the WR-3 in the opposite hemisphere to the lightning stroke (at the far end of the Magnetospheric duct path) will hear this "short" or "1-hop" falling note whistler. One-hop whistlers are generally about 1/3 of a second to 1 second in duration. If the energy of the initial short/1-hop whistler gets reflected back into the magneto-ionic duct to return near the point of the originating lightning impulse, a listener there with a VLF receiver will hear a "pop" from the lighting stroke impulse, then roughly 1 to 2 seconds later, the falling note sound of a whistler, now called a "long" or "2-hop" whistler.

Two-hop whistlers are generally about 1-4 seconds in duration depending on the distance the whistler energy has traveled within the magnetosphere. One-hop whistlers are usually higher pitched than two-hop whistlers. The energy of the originating lightning stroke may make several "hops" back and forth between the northern and southern hemispheres during its travel along the Earth's magnetic field lines-of-force in the magnetosphere. Researchers of whistlers have also observed that the magnetosphere seems to amplify and sustain the initial lightning impulse energy, enabling such "multi-hop" whistlers to occur, creating long "echo trains" in the receiver output which sound spectacular! Each echo is proportionally longer and slower in its downward sweeping pitch and is also progressively weaker. Conditions in the magnetosphere must be favorable for multi-hop whistler echoes to be heard. Using special receiving equipment and spectrographs, whistler researchers have documented over 100 echoes from particularly strong whistlers--imagine how much distance the energy from the 100th echo has traveled--certainly millions of miles!

Generally, only one to two echoes are heard if they are occurring, but under exceptional conditions, long "trains" of echoes will blend into a collage of slowly descending notes and can even merge into coherent tones on a single frequency, hard to describe here, but quite unlike any familiar sounds usually heard outside of a science-fiction movie!

Back to the history of whistler research. Plans for studying whistlers, chorus, and other audio-frequency natural radio phenomena were formulated by Dr. J. G. Morgan of the University of New Hampshire in Hanover as well as Dr. Helliwell at Stanford, for the International Geophysical Year which would begin in 1957. Over 50 receiving stations were set up at many locations all over the globe, including remote locations in northern Canada, Alaska, Europe including Scandinavia, and even Antarctica. This period was the beginning of the most intensive professional study of whistlers ever.

In the early 1960's, a couple of satellites (IEEE-1, Injun, Allouette) destined for low Earth Orbit were outfitted with VLF receivers. These satellite-based VLF radio receivers successfully recorded whistlers, and greatly enhanced scientific knowledge of natural VLF radio emissions. During the 1970's, space probes, such as Pioneer and Voyager, would discover whistlers happening on other planets of our Solar System, such as Jupiter and Saturn, which both have enormous and powerful magnetospheres. These Gas Giants also have huge magnetospheres and their own polar aurora as well.

The 1980's saw increasing hobbyist and amateur observations of whistlers, thanks to the increasingly easy availability of solid-state electronic parts and VLF receiver construction articles and notes. By 1985, whistler articles and receiver designs would appear in several electronic and radio hobbyist magazines, and also radio club bulletins - most notably, the Longwave Club of America's monthly bulletin, THE LOWDOWN. Several LWCA members including Michael Mideke, Mitchell Lee, Ev Pascal, Ken Cornell, and others, would publish and or design and use their own successful whistler receiver versions. These hobbyist whistler receivers tended to use small loop or wire antennas, unlike the "professional" VLF receivers used during the late 50's and early 1960's, which used very large loop and/or tall vertical "pole" antennas.

One radio "mentor" who sparked my fascination with whistlers and Natural Radio is a gentleman named Michael Mideke, who has been an avid enthusiast involved in various esoteric radio (and non- radio) pursuits since the early 1970's. Mike taught me quite a considerable amount of knowledge about longwave radio receiving and transmitting experimentation at radio frequencies much higher than Natural Radio, and he himself began regularly monitoring Natural Radio about the middle of 1988, more than a year before I would hear my first whistler in the Oregon desert.

For the past 25 years, Mike, his wife Elea, and two sons lived as caretakers on a large ranch in a remote central California canyon, far from electric powerlines. Here, Mike was able to string out antenna wires over thousands of feet in length and running in several different compass directions, and connect them to his plethora of radio receivers. His remote, electrically-quiet location was also ideal for listening to whistlers. Over the years, Mike has also made many hundreds of hours of recordings of amazing radio sounds of the Earth. He was particularly fortunate to be able to monitor 24 hours a day during the height of the sunspot cycle - from 1989-1991 - when solar activity, geo-magnetic disturbances, and whistlers were most numerous.

Mike also passed along the results of his own receiver experimentation, thus positively influencing my own receiver experimentation. In late summer of 1990, I began experimenting with whistler receivers employing short "whip" antennas no longer than 5 to 6 feet in length. These "whip receivers" successfully monitored whistler activity, though my earliest versions lacked sensitivity.

I must credit the original idea of using a short whip antenna to a longtime close friend and fellow whistler enthusiast, Gail West, who lives in Santa Rosa, California and has accompanied me on many of my road trips and whistler listening expeditions. Gail repeatedly witnessed my frustration with stringing out unwieldy wire antennas, and on one particular morning (summer 1989) in the northern Nevada desert, commented "it sure would be nice to use just a small whip antenna rather than long wires for a whistler receiver antenna."

Also, while on a solo listening session in the hills of Marin County, California in February 1990, I heard a strong whistler howl from the tape recorder's speaker with nearly all but about 10 feet of antenna wire rolled back onto the spool. This experience reminded me of Gail's idea and made the whip antenna idea seem more plausible. While the idea of a hand-held whistler receiver seemed somewhat wishful thinking early on in my experimentation with whistler receivers, it would become reality in just over two years of whistler listening and receiver tinkering.

Increasingly better and more sensitive yet simpler whip antenna whistler receivers were continuously devised on my workbench. On a beautiful spring morning in May 1991 while hiking on a trail in the mountains east of San Diego with friend Frank Cathell of Conversion Research, I demonstrated my BBB-2 whip antenna whistler receiver. Frank was so fascinated with this receiver that he jumped on the bandwagon, and by August 1991 after a furious 3 months' of receiver tinkering, Frank and I created a sensitive battery-powered whistler receiver that required only a small 33-inch antenna, was cigarette pack sized and very portable, called the "WR-3," and we shortly began selling this new pocket receiver on a casual basis.

The WR-3 opened up whistler monitoring to practically everyone--even non-technical people--willing to at least undertake the effort of finding a reasonably powerline "hum" free location where whistlers and other natural VLF radio phenomena could then be listened to and enjoyed as easily as listening to regular broadcast radio. At this point thanks to the WR-3, whistlers and lightning sferics were very easy to hear--now it was just up to Mother Nature to put on a show.

My difficulties with whistler receivers and antennas were now behind me, but I still retain very fond memories of the beginnings of my own interest in whistler listening and study. In June 1989, Gail and I heard our first whistlers "live" while camped deep in the eastern Oregon desert near Steens Mountain. In anticipation of the trip and not yet aware of more advanced receiver circuits available for this pursuit, I built a crude "whistler-filter" which I knew would at least block out a lot of the potential man-made signals which might overload my tape- recorder's audio-amplifier.

During the days leading up to desert trip, Summer thunderstorms had been plaguing the Great Basin areas of central and northern Nevada--the result of the typical summertime "monsoonal" moisture which sometimes gets driven up northward from the southwestern states of Arizona and New Mexico toward the inter-mountain region of the western U.S. (including Utah and Nevada). July and August are the months of the most spectacular lightning storm displays that pound almost daily throughout the deserts and mountains of western North America.

As Gail and I arrived at our intended campsite in the Black Rock Desert of northern Nevada, one of the more fiercer-looking cumulonimbus clouds drifted in our direction, and a light rain began to patter the parched desert dirt. Shortly thereafter, the wind picked up accompanied by the rumble of thunder. It looked like we were going to be in for quite a bit of this judging by the looks of the clouds. As we tried to set up our "Tahjmatent"--a huge dome tent which was tall enough to stand up in and roomy enough for 10 people to sleep in--the winds started to blow so hard all Gail and I could do was just stand there holding the now horizontally flailing tent.

The situation seemed rather dismal, however the skies to the north looked almost cloud-free, so we decided to cram our big wad of a tent and other supplies back into my small Toyota coupe and head farther north to an alternate location in Oregon about 100 miles away. We would return to the Black Rock Desert the following month under clear skies.

Arriving in the Alvord Desert of south-eastern Oregon with about 1 1/2 hours of sunlight left, we set up the tent under clear blue skies while occasionally stealing glances at the still ominous- looking skies to the distant south, hoping it would not come up our way. Fortunately, we were spared any further harassment from the weather and I became confident I could unroll my nearly 500 meter-long wire across the sagebrush. I connected my whistler filter to this wire and "grounded" the other connection to the car. Connecting my tape-recorder to the filter, I was rewarded by loud snapping and crackling from all the lightning happening south of us.

Alvord Desert, south-eastern Oregon on the evening of 08 June 1989. The next morning at sunrise, I heard my first "live" whistler. Photo taken by Gail West

The following morning at sunrise under cloudless skies, I turned on the tape-recorder and listened to the now greatly reduced amount of lightning static. But, a few of the louder lightning "pops" had whistlers (or what I thought sounded like "whizzers") happening a second or two afterward! I shouted for joy and thrust the headphones at Gail for her to listen, too. We were hearing our first whistlers, though they sounded different from the few I had heard recorded on cassette tape by Michael Mideke back in central California. The whistlers went on for an hour or so then died away.

The following morning, the whistlers were back, but even louder! An already very enjoyable desert trip had turned into a milestone for me! Now that I had heard whistlers on my own, I became "hooked" with this very esoteric aspect of radio listening. I had been enjoying shortwave listening to stations around the world and amateur "ham" radio for the past dozen years, but this was something very new and fascinating - something that played well into my other casual and hobby interests in geo-physics, meteorology, and radio wave propagation studies.

Over the next few years, I would learn a great deal about natural radio phenomena and how to build excellent receiving equipment to listen for whistlers and the like. One of my main goals was to build a whistler receiver that would not require a whole roll of antenna wire but only a small whip antenna - a desire which came to fruition in the spring of 1990, when I "accidentally" heard a loud whistler while rolling up the final few meters of antenna wire. I knew it was possible to hear whistlers with small antennas, and as I've already mentioned, a prototype to my portable hand-held "WR-3" receiver was devised a in the spring of 1991 with the help of another radio friend, Frank Cathell of Conversion Research.

In addition to all of my whistler receiver tinkering, trials and successes mentioned above, serious and regular natural radio listening (and quality recordings) began in February 1991, when nearly every Sunday morning well before sunrise (the "prime time" to listen for whistlers), I would pack my favorite whistler receiver, a small reel-to-reel tape recorder, and lunch into a knap sack and bicycle to the nearby hills. Upon reaching the base of the hills, I would then dismount and walk the bike up via a fire access-road to my favorite listening spot--a flat ridge-line overlooking much of Marin County, San Francisco, and San Pablo Bay at an elevation of about 600 feet above sea-level--which I began calling "Whistler Hill." There, I would listen for whistlers, and if there were any happening, run the tape recorder. I was rewarded by many beautiful sunrises and many nice whistlers on my weekly visits to Whistler Hill, and I was quite happy with my current receiver, a unit which used a 66-inch whip antenna, called the "MC-1."

One memorable morning near Easter 1991, a "huge" whistler--the loudest of the morning--occurred just as the sun began peeking above the north- northeastern horizon. It was in this year that I would really discover the aesthetic beauty of whistler listening while out in nature! While I was always glad to hear whistlers in the hills, it was not always easy to awake at 4 a.m. in the cold and bicycle the few miles up to Whistler Hill. Many of those Sunday mornings would have been better spent sleeping a few hours longer, but Oh!, was I so glad when those whistlers would be pouring forth in my receiver's headphones as another gorgeous sunrise was forthcoming--then I was always glad I made the effort to get up early! But then again, I would sometimes get up to Whistler Hill only to hear NOTHING except the ever-present crackling of Earth's ongoing electrical storm commotion. And if the weather was gloomy, I was usually tempted to ride back home instead of continuing on my usual 8-10 mile bike and hike.

Why DIDN'T I stay home and listen to whistlers from the comfort of my bed, as is generally possible with more conventional broadcast radio? The problem lies with the electric-mains grid which has spread nearly every place man has settled. Alternating-current electric power lines emit "hum" at 60 cycles- per-second in the Americas, and 50 c.p.s. (Hz) in Europe and Asia. In addition to these "fundamental" AC power frequencies, "harmonic" energy is also radiated (120, 180, 240, 300, 360 Hz, etc.), or as in Europe and Asia: 100, 150, 200, 250, 300 Hz, etc.)- often to well above 1 or 2 kHz. Since whistler receivers are sensitive to these electric power frequencies, any natural radio events which might be occurring get masked by this terribly annoying humming sound, should one try to listen anywhere near AC powerlines.

The only solution to AC power-line "hum" is to locate a listening spot away from AC power poles and wires--often as far as several miles before the hum levels are reduced to low or nil levels. This necessitates walking, hiking, bicycling, or driving to remote locations where there are few or no AC power lines - easy to do in many parts of California and the West but often very difficult in flat land or urban locales. Sometimes--and with good filters in the whistler receiver--one can listen as close as a couple-hundred feet (or maybe even closer) to residential AC electric wires.

On a few fortunate and astounding occasions, whistlers can get so loud as to even be heard through the loud power-line hum levels encountered in a suburban backyard, demanding the whistler listener to immediately relocate to their favorite "quiet" listening spot in order to hear and tape record such magnificently giant whistlers, and at the same time praying that the monster whistlers still are going on when the whistler receiver is again turned on! Murphy's Law and my experiences generally suggest they will be gone and not to return until another inopportune time...

My tape libraries of whistlers and other natural radio phenomena vastly increased in late 1992 and throughout 1993 and early 1994. The stimulus to get out and make natural radio recordings came when, after purchasing a "camper-van" in July 1992, Gail and I headed up California's North Coast, stopping for the night at Westport Union Landing Beach north of Fort Bragg. We heard nice whistlers that evening and morning during darkness using our WR- 3's clamped in the van's rear doors while laying in our comfy beds.

Occasionally, however, one or both WR-3's would slip out of the door and nearly hit our heads. Gail came up with an idea to have a whistler receiver with an antenna that could remain outside while a control box could be put next to the beds. Well, I got right to work on this great idea of hers upon returning home, and quickly designed an excellent "WR-4" whistler receiver in which the receiving antenna (2.5 meters in length) is mounted on the van's read door ladder and the control-box containing filter switches, headphone and tape-recorder jacks, etc. could be placed next to the bed! Now, I could make recordings while comfortably in bed, even while dozing off - letting the recorder run for 45 minutes or until I awoke to monitor the situation.

First use of the WR-4B van-based VLF receiver with roof-top whip antenna assembly in Black Rock Desert of north-western Nevada, 11 October 1992. Later, after losing this antenna assembly in Oregon, the more successful rear-door mounted vertical was developed for the Big Canadian trip of September 1993.

Since recording became very "convenient" while camping -no more sore arms holding the receiver out the window or standing out in the cold and wind, and not as much sleep deprivation as before--I (alone or with Gail) was now able to locate to superbly quiet camping/listening locations deep in the western deserts, the northern Plains of North America, or near mountainous areas and wait for conditions to present interesting natural radio sounds. The past couple of years has seen the combining of my enjoyment of camping and road trips with natural radio listening, culminating in the Summer 1996 SOLAR-MINIMUM VLF RECORDING EXPEDITION to northern Manitoba in late summer 1996 (and 30 hours of incredable natural VLF radio tapes!).

The ease of whistler listening with the van-based WR-4 and later, the WR-4b (additional LC filter circuit) and our love or camping trips has resulted in about a hundred hours of recording between 1993 and 1996 from over 25,000 miles of travel - a natural radio tape library which has become one of the better ones from an amateur, but I have no doubt that Mike Mideke's has to clearly be the FINEST amateur/hobby tape library in the world recorded from ONE location, since he LIVED in a quiet location free from strong powerline "hum" and has not had to travel to enjoy natural radio.

When Donald Cyr initially inquired in late 1994 if I would like to contribute some thoughts on whistler listening and experiences during the past couple of years since I last contributed material to his book*: America's First Crop Circle; Crop Circle Secrets Part 2*, I said "sure, I'd love to write something for your new book."

Don was interested in any information I might be able to offer, such as where the best places to hear whistlers are, or if I found any particular places that whistlers were consistently stronger than in other locations. I assume he was hopeful that my findings might tie in to his theory, which I'll call "The Marion Island-Wiltshire Plain Crop Circle Theory," (a name I have created for this article) that suggests whistlers--at least the ones which might have caused many English Crop Circles in the late 1980's and early 1990's--are highly localized phenomena that are launched at a given point, such as Marion Island in the south Atlantic Ocean, and are ducted via the magnetosphere along a line-of-force to the northern hemisphere, specifically, to southern England, where they, if they do not cause odd impressions in wheat fields of the Wiltshire Plain, will nonetheless be very LOUD indeed to one listening for them with a whistler receiver.

Don's theory, backed by his friend and colleague James Brett, was first presented to his readers in *CROP CIRCLE SECRETS, PART 1*, published in 1991 and highly recommended reading for this discussion as is *PART 2*, published in 1992. This particular book of Don's generated a good deal of interesting dialogue, and discussion. Of course, Don and James's Crop Circle Theory was really aimed at stimulating query and discussion about the what the mysterious forces which might be creating such incredible and beautiful impressions in the English landscape - and that is the true driving force of inquiry and research.

Other theories were pondered, suggested, debated, and dismissed by various contributors to Don's books, and they ranged from elaborate UFO theories, vortices and balls of light, military exercises (there are several military installations in that English region), underground forces of electromagnetic nature, to suppositions that they were plain and simply, artistic hoaxes concocted in the night by creative people armed with poles and chains.

Don and James were fascinated by the whistler theory as presented by researchers Storey Helliwell, The Institute of Radio Engineers (I.R.E.), et al., and they thought this theory was as good (if not better than most) at explaining a possible origin of Crop Circles. What seemed fascinating to Don and James was that Marion Island, also home to a secretive military installation, was at the far end of a magnetospheric duct, i.e., at a conjugate point to south-western England. Perhaps lightning storms, enhanced by the odd geography of Marion Island, or perhaps, a secret military experiment there, were generating great bursts of electromagnetic energy that would enter a magnetospheric field- aligned duct and arrive in England as a powerful whistler, which would cause Crop Circle by perhaps affecting the stems of the wheat stalks in odd manners.

From a scientific point of view, however--and from what both amateur and professional whistler listeners and researchers have found--it is hard to believe whistlers were so concentrated in their energy area and also "intelligent" to create such lovely patterns in the English fields. Radio engineers and other "technical" people involved with radio waves generally know that it is impossible to confine a radio wave to an area or volume less than 1/2 its wave length. In the case of whistler energy emerging from the confines of its duct and resuming the velocity of light (300,000 km/186,000 miles per second), its (full-wave) size is from 19 miles at 10 kHz to almost 190 miles at 1 kHz--pretty large!

Mike Mideke eloquently expressed this reality in the final few paragraphs on page 27 and the first few paragraphs of page 28 of *CROP CIRCLE SECRETS. Part 2.* Also, the power of a radio wave (also known as the "field-strength") from even the strongest and loudest whistlers ever heard and/or recorded by anyone have never been as strong as the VLF radio waves generated from nearby lightning storms, though the lesser energy from whistlers is of course sustained much longer than the split-second burst of energy from a lightning stroke, and, or course, whistler radio energy does differ substantially from a lightning bolt's.

While whistlers would hardly seem to be so super-concentrated in their strength and focal area to cause such intricate and sharply defined impressions in plant material like crop circles, data gathered in the past 35 years by manned and un-manned monitoring stations located worldwide has found that whistlers do occupy a "footprint"--that is-they are heard loudest at a given location at ground level, and then gradually weaken as one moves concentrically away from "ground zero."

Most whistlers are heard in a 500 to 1000 mile radius from the exit point region of its duct, though it's sound characteristics may be different from one place to another within this whistler reception area. Whistlers also tend to cluster in the middle and upper-middle latitudes of the globe - between 25 and 60 degrees north/south, and are rarely heard at the "geomagnetic equator"--a wandering latitudinal line on the globe at the half way point of any great-circle line drawn from Earth's magnetic north pole to Earth's magnetic south pole.

Most of the continental United States and southern Canada are between these latitudes to hear not only splendid whistlers but also beautiful VLF radio "chorus" from Auroral displays. The same goes for most of Europe, especially the British Isles and Scandinavia.

Back in the Black Rock Desert, northwestern Nevada on 22 September 1996 in the late afternoon.

In the Southern hemisphere; southern Argentina and Chile; the southern parts of Australia, particularly Tasmania; New Zealand; and perhaps, the Cape Horn region of South Africa, are similarly at the right latitudes to hear whistlers and chorus. The South Island of New Zealand and the Tierra del Fuego region of South America, plus the Antarctic Peninsula, are where the good displays of Aurora and auroral chorus can be seen and heard.

Listening to whistlers from near one's home town or on road trips can be very enjoyable and inspiring, but it is even more fun to travel abroad and check out whistler reception in other parts of the world. In late May of 1992, my father and I went on holiday to Ireland, enjoying a 12-day coach tour of the entire country. I brought my pocket-sized WR-3 whistler receiver, hoping to catch and record some "Irish whistlers."

The first night happened to be at the Clare Inn not far from Dromoland Castle and Newmarket- on-Fergus. Surrounding this hotel was a beautiful golf course, small lake, meadows, and woodlands. There were only a few powerlines near the hotel and main road to Ennis, leaving much of the golf course and meadowland fairly free from excessive Ac power hum, and therefore, good spots to listen for whistlers, as I tested out a few hours after we arrived bleary-eyed from an all night flight across the northern Atlantic.

In anticipation of hearing whistlers in this quiet and exotic location, I spent much of the pre-midnight period walking around with my Sony LW/MW/SW/FM radio, enjoying the Irish Radio Telefis Eireian (RTE) 1 & 2 radio networks, and the nighttime reception of British and European mediumwave (AM) stations, tape recording much of this reception with my trusty micro-cassette machine.

At around midnight, after the BBC on longwave 198 from Droitwich signed-off after the maritime weather report and a cheery "good night," I flicked on my WR-3. Lo and behold, there were nice whistlers, albeit only occasionally, since it still was a bit "early" for the really good whistler shows, which like to start up after 4 am. Catching some sleep in the woods (the hotel was rather far-off at this point) I awoke around 3 am, turned on the WR-3 to hear more whistlers--and there were LOTS of them, followed by weak "Auroral chorus" that rose up from the static at around 0400, and remained past my first Irish sunrise, when I drifted back to the hotel room to catch an hour or so of terribly-needed sleep!

That night would prove to be the only place our tour group would spend the night where there was open space - the rest of the hotels we stayed in would be located in towns or deep within Dublin, and surrounded by hundreds of electrical lines with no access to large open spaces. I had to be happy with broadcast listening with the Sony, which was always very interesting, anyway. It sure was great to now have natural radio recordings from outside the West Coast.

While scientists and hobby whistler listeners have pretty much determined what regions of Earth are in "whistler country," it is never possible to predict where, at any given time or on any given day, whistlers will be heard--loudly, weakly, or even at all. It's conceivable there are days where a whistler hardly occurs anywhere on the globe--undeniably there are days and even weeks when not a single whistler is heard by listeners located in otherwise ideal whistler reception regions of Earth, such as Ireland and Europe, the northern tier of the U.S., southern Canada, New Zealand, and so forth.

Conversely, there are days when there seem to be whistlers happening nearly everywhere, as though a giant switch was turned on somewhere in Earth's magnetosphere to issue forth a barrage of weak and strong whistlers too frequent to count! Like weather fronts and hurricanes, it would appear that given a day when things are ripe for strong whistler production, the locations that strong whistlers are heard constantly changes, depending on the locations of lightning storms; the magnetospheric whistler duct beginnings and end points; and the day/night region of the globe - particularly the midnight to 6 a.m. period - which, as we all know, moves westward 15 degrees an hour.

Thanks to simultaneous whistler monitoring and tape recording efforts, first by 1950's and 60's whistler researchers such as Storey, Morgan, Helliwell, etc.; and later by coordinated amateur and student study groups, hundreds of individual whistlers have been documented. Their findings have determined that the average whistler is heard in an area of about 500 miles radius, though the "big whoppers" may be heard as far as 2000 to 3000 miles from its loudest "arrival point."

One of my favorite examples of intense scrutiny of individual whistlers (by at least 25-30 listening groups or single monitors), was of "The Giant Whistlers" of the morning of March 28, 1992, specifically, of two whistlers occurring about an hour apart. In and of itself, these two huge whistlers are not really different from other strong whistlers which occur in the hundreds and maybe thousands throughout any season, but it WAS remarkable in that they were serendipitously caught on tape by so many listeners, who were participating in a high school student monitoring effort coordinated by a team of scientists and high school professors, called "PROJECT INSPIRE."

The INSPIRE effort was sanctioned by NASA to study the ground reception pattern of radio wave emissions from a special "modulated electron-beam" generator (called "ATLAS") aboard the Space Shuttle (STS-45), which flew in late March, 1992. A schedule of ATLAS "transmissions" was established in hopes that the ground-based VLF radio receivers set up by the student groups would hear its emissions. Unfortunately, the shuttle-based ATLAS unit failed after only two (unheard) transmissions. Fortunately, it was decided the students groups and other individuals should adhere to their INSPIRE listening schedule, and also to "backup" listening schedules arranged for the mornings of March 26-30, 1992. It was during many of these scheduled regular and backup listening periods that many interesting natural radio events were captured, including several strong and powerful whistlers.

A very detailed report entitled PROJECT INSPIRE DATA REPORT was produced in August 1992 by Michael Mideke, who was the project's data analyst. It is from this report where the following interesting scenarios of whistler reception has been interpreted. Back to the two "Giant Whistlers" of March 28, 1992. Bill Hooper, shivering at 4 a.m. Pacific time in his camper near California's Death Valley, started his tape recorders running once again. Bill was one of many experienced whistler enthusiasts who was monitoring individually but part of the larger INSPIRE student effort. He had set up one of the most sensitive whistler receiving stations--by far--of the entire group participating in the INSPIRE listening sessions, thanks in part to his remote desert location, great distance from any electric power lines combined with plenty of room for a large antenna and very sensitive whistler receivers of his own original design.

At precisely 4:02:38 a.m. PST, or 12:02:38 Universal (Greenwich Mean) Time, an extremely strong (long, 2-hop) whistler was recorded by Bill at his Death Valley listening site. So very strong was this whistler that it briefly overloaded Bill's receiving system. It also produced a "4-hop echo" which was also clearly recorded on his tape. This whistler was also heard and recorded as far away as the U.S. midwestern region and eastern seaboard, but much weaker and "truncated"--that is--only a fairly narrow spectrum of this huge whistler, in the 3-6 kHz range, propagated eastward. This whistler was also heard weakly to moderately in south-central Texas--but again--was somewhat truncated there like farther east. Interestingly, a large part of Texas was experiencing heavy rains and lightning storms- whistler receivers in southeastern Texas were picking up very strong, local-like lightning stroke "sferics."

If the source lightning of this whistler was in Texas, one wonders how it arrived so loud in the California desert! Perhaps it was generated by lightning strikes somewhere else, perhaps to the north or northeast of California, and far enough as to not really make much of an obvious sferic "pop" in the whistler receiver.

An hour later, a nearly identical strong whistler to the one at 12:02 UT occurred at 13:03:03 UT, this time heard by myself as well as Mike Mideke and others listening in Arizona New Mexico, and even Minnesota. Unlike the earlier big whistler, this particular whistler as heard in Minnesota was stronger. It also was not as "truncated" as was the earlier strong whistler. Interestingly, the sferic generated from the causative lightning stroke was rather weak in California, unlike its whistler.

Clearly, on this morning the big whistlers were concentrated in the western United States even though the lightning storms weren't. It should be noted there were days when the whistlers were stronger in the eastern United States and were weaker "out West," and point out how the locations of strong whistler activity change day-by-day and can't easily be tied to where lightning is happening. More on this in a bit.

While we are on the subject of loud whistlers and speculation on their originating lightning strokes, I have an anecdotal whistler story of my own to bring in at this point. While on our September 1993 "Big Trip" in my van and eventually to tour the Canadian provinces of Manitoba westward to British Columbia, Gail and I stopped in the eastern Nevada desert about 20 miles west of Wendover, Utah to catch several hours of sleep. Gail and I had driven most of the night across the Silver State after a brief stop the evening before at another favorite natural radio listening spot an hours's drive east of Reno, where we had heard and taped a marvelous variety whistlers, some very strong like the ones recorded by the INSPIRE listening groups in March 1992.

Very sleepy and exhausted after 250 miles east-bound on Interstate 80, we took a remote exit off the freeway and headed south down a wide, unpaved road running alongside some railroad tracks. In the dark, we noticed there were powerlines running along the train tracks, but determined to stop in a spot where we could get some sleep and record whistlers (which I was sure must still be roaring), we kept on going until we saw another smooth dirt road branching away at right angles away from the tracks and pesky wires. Making occasional checks for powerline hum with my WR-3, we drove far enough from the wires--at least 5 miles--to where I couldn't hear any hum with my WR-3 whatsoever. By this time, we were just too tired (and now cold) to even set up the better WR-4B whistler receiver's antenna. I just had enough energy to get in the back of the van and tuck myself under the covers, falling quickly asleep.

Awaking a few hours later, I noticed it was somewhat light with a slate-gray sky. Time to set up the WR-4's 10-foot copper-pipe antenna and check out the whistler band. As predicted, there were wonderfully loud "growler" type whistlers roaring out of fairly light background sferic static. I hopped back into bed and switched on my cassette recorder, capturing these great whistlers onto a 90 minute tape. My WR-4B whistler receiver was once again proving to be a truly superb receiver with its van- attached pipe antenna and convenient bedside control box, while the trusty WR-3 made a nice spot checking receiver. With the WR- 4B, I could snuggle under the covers and run tape - even if I fell asleep while recording. It certainly was a vast improvement over holding our WR-3's out the vehicle window or clamped in the van's door as we did that August 1992 night up the California Coast, and Mike Mideke even commented in a letter: "I was wondering when you'd get out of hand-held mode!"

This September 17, 1993 morning, Gail and I were having a nice time parked once again in the beautiful high desert surrounded by beautiful mountains, pungent sagebrush, whistlers roaring in the headphones, and few cares in the world. The entire 4,500 mile trip through 10 states and 4 provinces was completed in about 2 weeks and over 10 hours of natural radio recordings, including wonderful "auroral chorus" while watching the northern lights dance overhead in Alberta.

Companion story addendum: "*Aurora in Alberta: Two Minutes of Wonder*" by S. P McGreevy. 26sept93.htm

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While many of my whistler and chorus tapes were recorded while tired, semi or fully asleep, I was not able to critically scrutinize what things I was recording until I got home. Herein lies the beauty of taping what you hear - events can be listened to again and again - in my case usually for the sheer beauty of Earth's natural radio sounds, but also for scientific analysis if necessary. Also, subtle events are sometimes missed while monitoring live due to fatigue, the distraction of beautiful surroundings, and so forth.

What I can explain about those great big eastern Nevada whistlers of September 17, 1993 is as follows: They were coming from rather weak but distinct and clean "tweeking pops," the kind which are produced by fairly distant ground strikes. Now, I've listened to a lot of lightning sferics while watching the lightning strikes making them, and the sounds of lightning static can be as varied as the visual strikes. I've noticed that the big, bright, single cloud to ground lightning strikes can deliver a very loud but clean "pop" in the whistler receiver's output. Cloud-to-cloud lightning, sometimes trigger other nearby in--cloud lightning, sounds more "crackly" or like the crushing of a Walnut in a nutcracker.

Anyway, interspersed amongst the numerous weak sferics and occasional, huge whistler generating popping tweek were occasional strong and semi-local lightning sferics - dry sounding and not tweeking - that were generating very weak and quite diffuse ("hissy") whistlers. These strong sferics were coming from lightning within about 50-100 miles of my listening location. Seems they just weren't generating big whistlers - or if they were, the whistlers were arriving SOMEWHERE ELSE strong but distant enough to explain their rather weak strengths near their source lightning. So, this idea of lightning stroke energy entering a duct or ducts to travel to the magnetic conjugate and then back again to the general area of their generating lightning strokes is a fairly simplistic explanation and not entirely satisfactory. And, as simplistic explanations tend to do, it fails to consider more complex events taking place...

It is my supposition that, somewhere, as they merrily arch along the magnetic-field lines, whistler ducts can cross, combine, and/or excite each other. In my mind this helps explain why 2- hop whistlers don't always "land" near where their originating lightning stroke occurred, but can wind up a thousand or more miles away! If you will, whistlers can "jump rail" and enter adjacent ducts, winding up curiously far from where they should arrive--whistler wanderlust.

As such, it is hard to believe southern England and Marion Island would have a dedicated whistler duct connecting them "together" and transferring Marion Island Lightning into Wiltshire whistler crop circles! More than likely, lightning energy from Marion Island winds up occasionally as a short whistler in southern England, but maybe an hour, day or week later, is sending whistlers into France, Spain, Iceland, or maybe Moscow - and these wandering whistlers are "bouncing back" as 2-hop whistlers now even more removed from their parent lightning storms!

I think conjugate points (and their associated "impact zones"), caused by variations in the exact position of Earth's magnetic field, can vary daily and even hourly--call it "conjugate end- point drift." If the solar wind is pushing against the magnetosphere, either gently - or as can be the case after solarflares and "coronal mass ejections" from the Sun - rather violently, then the motion of Earth's magnetic field lines and any whistler ducts present within them must also get tugged and pulled to various degrees from their "normal" positions. This--and my suggested whistler duct crossings, jumps, and re-combinations--must be partial explanations of why lightning in Texas sometimes causes strong 2-hop whistlers in California, or why Nebraska lightning generates huge whistlers in Manitoba that are weaker in Nebraska. Where was the Nevada lightning of the morning of September 17, 1993 sending strong whistlers (if any) to? Where were the rather weak lightning sferics that generated such giant eastern Nevada whistlers? I can also ask, just where was the lightning that spawned southern England's artistic whistlers?

One can't neatly package the fascinating whistler phenomenon with magnetic conjugate points, lightning stroke counts, fixed impact zones, et cetera, et cetera, and expect to easily explain what in reality is a mind-boggling dynamic process that changes like a kaleidoscope and never repeats.

While it is intriguing (and even fun) to try and scientifically unravel the phenomenon of whistlers, part of their allure is that they are just there to be listened to - they are as nice to hear as sunsets are to see, and the reasons for their existence must sometimes take a back seat to the beauty of their tones.

Neither myself or anyone else have yet to determine if there are "special places" where, perhaps due to local terrain or geology, whistlers are louder and more frequent than average. But, they may exist somewhere. Intriguingly, Edson Hendricks, a researcher into the mysterious "Marfa Lights," heard extremely loud whistlers issuing forth from a very crude and seemingly insensitive whistler receiver during a display of these strange and spooky colored balls of lights occasionally seen in the desert near Marfa Texas for nearly 50 years. (See the document "Seeing the Marfa Lights..."

Ed was listening right near powerlines, and their "hum" would have surely been overpowering to more sensitive whistler receivers like my WR- 3, WR-4b or BBB-4, and also Mike Mideke's fine RS-3/4's, but Ed tells of these very pure whistler-like notes far stronger than the weakish background hum, as heard in the output of his simple receiver. Something is going on there in west Texas that needs further checking out, and it again points to the great need for more people to join in the whistler listening movement.

We would know vastly more about whistlers if there were as many people listening to whistlers as were watching the prime-time fare on television - a silly and hopeless wish - but even 100 or more people joining the whistler listening movement and coordinating listening schedules would give a clearer idea of when and where whistlers are coming and going. Whistler monitoring observations combined with information about where lightning storms and whistler source strikes were occurring would vastly help to exhibit this relationship. We could see if a pattern emerges or if things were more random with regards to location of the loudest whistlers and locations of their source lightning.

(Author's note: Long after I wrote this piece and surmised from my many years of listening to VLF and observing whistlers that magnetic field conjugate points were not really fixed on two given points in Earth's opposite hemispheres, such as Marion island and southern England, I came across an intriguing scientific paper in the American Geophysical Union's *Geophysical Monograph 53*, page 161, entitled *Ray Path's of Electromagnetic Waves in the Earth and in Planetary Magnetospheres*. This copyright 1989 paper written by Iwane Kimura of the Dept. of Electrical Engineering II, Kyoto, Japan, presents many graphs, mathematical formulae and diagrams of bi-polar magnetic field models of Earth showing wave-path tracings of man-made VLF signals transmitted from Siple Station in Antarctica and received by orbiting satellites. One particular paragraph written by in this article summarizes up nicely the potential for a great variability of whistler paths and conjugate points:

"For ray tracing of whistler mode waves in the earth magnetosphere, the simplest model of the geomagnetic field is a dipole model. Most of the ray tracing techniques treating wave phenomena in the earth magnetosphere have been based on the dipole model. Actually however, real geomagnetic field lines are known to be fairly deformed from dipole field lines, so that for whistler waves, whose propagation are strongly governed by the geomagnetic field direction, ray paths calculated using the dipole model will differ considerably from those in the actual magnetosphere." *Iwane Kimura*

If whistlers aren't enough of a fascinating pursuit, there are a host of other natural radio "sounds" which can be heard at the 0.1-10 kHz audio-frequency portion of the radio spectrum to keep enthusiasts hooked on these Earth radio sounds. One of the more common (but less frequent than whistlers) are "chorus," which consists of a series of sharply-rising notes, called "risers." This fairly common phenomenon (but not as common as whistlers) can mimic the sounds of a flock of birds chirping, frogs croaking, or seals barking. Chorus occurs during magnetic storms, when Earth's magnetosphere receives a barrage of high- speed energetic particles cascading into it from solar flares on the Sun or from energy ejections from the Sun's "coronal holes" which allow to escape the Sun in streams traveling at sub-light speeds.

This phenomenon of magnetic storms is also responsible for the Aurora Borealis and Australis--the Northern and Southern Lights--seen in the sky at higher latitudes close to Earth's Arctic and Antarctic regions. Chorus can happen during visible aurora and is called "Auroral Chorus"--this sometimes can also be heard over a widespread area at around local sunrise, when it is called "the Dawn Chorus." Often accompanying Earth's magnetic storm associated auroral displays and natural radio chorus is "hiss," "wavering-tones," and other endless varieties of natural radio sounds.

Just when lightning seemed a rather common and well studied phenomenon, awesome as it is, Mother Nature throws another "wow!" at mankind. It seems we can now add the terms "red sprites"and "blue blobs" to our lightning storm vernacular. I am fascinated by recent videotaped evidence presented to the world scientific community and also general public pertaining to massive red and blue bursts of lights occurring as high as 20 to 30 miles above lightning storms.

For years, pilots of high-altitude aircraft were reporting sightings of strange blue and red lights seen above lightning storm clouds which were occurring at the same time as lightning flashes in the clouds below. In the summer of 1994, scientists from the University of Alaska Geophysical Institute in Fairbanks, Alaska were at last able to very clearly videotape these incredible lights using high-speed video cameras located on the ground and aboard two aircraft flying over storms in the U.S. Midwest. As though squirted out of a spray bottle, bursts of red light can be seen bursting upward in a stream right over lightning strokes and flourishing in a great cloud of light, lasting for about 1/10th of a second.

Fascinating as these baffling red and blue lights are, what's even more intriguing to natural radio listeners like myself is a quote from one of the researchers, David Sentman of the U. of Alaska Geophysical Institute, who says that the radio signals, when played through an audio speaker "sound like eggs hitting a griddle." Sounds like the hundreds of thousands of "crackling" sferics I have heard and tape recorded through the years, many of them (but certainly not all or most) have set off nice whistlers. I have always pondered at the sheer LENGTH of many of these lighting sferic crackles--quite a few of them are about a second in duration, and there are occasionally crackles which carry on for almost 2 seconds! These times seem far longer than any actual flashes of lightning I've ever witnessed, although it would seem lightning strokes can trigger other lightning strokes (via these immense radio energy impulses), seemingly supporting the reasons for such lengthy sferic "crackles."

Now, it would seem I've been hearing the radio sounds of sprites and blobs - I wonder if re-naming my WR-3 "Whistler Receiver" to a "Sprite & Blob Receiver" might be appropriate. Seriously, there is thought amongst whistler listeners that these weird lightning strike emissions are what may be causing whistlers, since they offer visible evidence of a linkage of energy from above the lightning storm clouds toward the ionosphere. They do not occur during every lightning stroke, just like whistlers do not happen after every lightning stroke. Since the Aurora Borealis and Australis (more commonly referred to as the Northern and Southern Lights) also generate fantastic VLF radio sounds, it remains a dream of mine to video-tape the Northern Lights while simultaneously recording their radio emissions onto the audio sound track.

I have watched aurora in Canada dance in the skies and listened to their beautiful whistling and squawking in the whistler receiver--bursts in intense aurora would also create bursts of auroral radio sounds. I understand the U. of Alaska Geophysical Institute in Fairbanks (the same folks studying the "Red Sprites" and "Blue Blobs" over lightning storms) has created an extremely sensitive (equivalent to 2 million ISO) video camera. They videotaped beautiful auroral displays in the Alaskan nighttime skies with astounding high clarity and detail, something never before achieved. Most auroral photography requires time-exposures with still cameras to turn out brightly. But then, the fine detail of the auroral curtains becomes smeared due to the motion of the auroral displays.

In early September 1995, I flew up to Fairbanks Alaska to visit a friend. Natural Radio was not the primary intention of this trip but I was determined to go out and check listening conditions, as Fairbanks at the southern edge of the main auroral oval region, thus on most clear nights sees some sort of auroral activity. Much to my luck (once again!), the first night there, September 6th, was clear and beginning at about midnight, the aurora started to be seen in the northern skies, then an hour later, filled the sky repeatedly for 3 hours--at times so bright I could read a book in the light--far brighter than a bright, full moon! The next day, Patti loaned me her truck and suggested I drive up the Chatanika River Valley to the north-east of Fairbanks. Alaska Highway 6 becomes a well-maintained wide, gravel/dirt road into the boreal forests and away from all electric powerlines. Very remote! By this time of year, the fall colors were already blazing from the Birch and Apsen trees mixed with the conifers. At a place about 45 miles north-east of Firrbanks, I decided to take a spur road off the Highway and give a listen on my WR-3E receiver. The time was about 11 a.m. and I didn't expect to hear much, but I was totally astounded to hear very loud chorus and hissband, and hastlly set-up my MArantz tape deck to tape this spendid activity! The resulting recordings appeared in my 'Electric Enigma CD' and sound-files can be downloaded and listened to at a couple of my natural radio audio-files web sites. I recorded chorus for 3 hours--a long time--but it was everchanging and would undergo surges now and then--correspondednt with auroral sub-storms. It turns out that the first 4 days of my Alaskan visit were very stormy geo-magnetically - the most stormy periods in several months and a great treat for me! Some of the auroral events I saw on a couple of nights up there were also seen as far south as northern Idaho and Montana.

After returning home to California, I was determined to head up north again and be under the auroral zone...I just loved those Northern Lights and the natural radio sounds I heard! The late spring and summer of 1996 saw me driving two lengthy road trips in my van toward Canada's auroral zone: the first one up as far north as Hay River, NWT and the second one into central Manitoba east of Flin Flon. The June 1996 Alberta and NWT trip's goal was to experience midnight twilight and to see what VLF phenomena could be heard at that time of the year and the fact that is was at solar-minimum. One of my first stops in an electrically-quiet location was in a remote spot about 60 km northwest of Peace River, Alberta and to the west of Dixonville, off of the MacKenzie Highway. The location I found was a grazing area in the Whitemud River watershed (Whitmud PGA). I arrived the afternoon of June 1st, 1996 at about 4 p.m. local time and flipped on my WR-3E. Again, like in Alaska, I caught some incredable-sounding natural radio noises--stuff I had never heard before more to the south! The next morning as sunrise was starting (about 4 a.m. MDT), I recorded some amazing 'wavering tones' that appear on my audio-file web site. More tapes filled with an amazing variety of really wierd-sounding stuff! I also saw some faint aurora to the north, but being that it was about 3 weeks before summer solstice, there was considerable twilight in the sky all night, masking the view of the aurora somewhat. Two days later, I arrived in the NWT on 03 June 1996, driving as far north as Great Slave Lake, which was still frozen in its middle--the white ice floes were plainly visible out in the middle of the lake, blocking the MacKenzie River outlet from the lake and wreaking havoc on the ferry run across that enormous river.

I spent a couple of nights next to the immense, north-flowing Hay River near Alexandria Falls, but was able to record only about an hour of strange 'ghostly-tones' heard late in the afternoon of June 5th, 1996. Perhaps, if I stayed there another day or two, there might have more natural radio sounds to record, but I was quite satisfied with what I'd recorded the previous week anyway! The trip southward back home was long, tedious, but worth it, and I made a stop at Waterton Peace Park and adjoining Glacier National Park as I headed south, finding more good, quiet locations to record natural radio--the best location being Belly River Campground in Waterton Park, Alberta.

In mid-august 1996, I once again departed on a longer road trip with the intent of making it up north back into the aurora zone. Since the auroral zone's southern-most edge reaches south into southern Ontario and Manitoba, I figured that it would be less mileage to intercept the auroral zone somewhere in western Manitoba, Canada than drive farther north into BC or Alberta again. The geo-magnetic latitude of central Manitoba is similar to the Fairbanks, AK area but much closer to California compared to Alaska. I was really prepared for this trip and intended to comprehensively study solar-minimum-period natural ELF-VLF radio phenomena as well as watch for auroral events.

Late August sees much longer nights and no twilight masking of aurora in central Manitoba, unlike if I were to have been there in June, so I hoped to see and photograph the Northern Lights again. Needless to say, the trip was an astounding sucess both for auroral photography and for an incredable variety of natural radio events captured onto tape. The full report of which can be seen at this Internet address:http://www.auroralchorus.com/mb96log.htm. Many audio files taped from my large collection of tapes from that trip can also be heard at the natural radio audio-files web sites.

I was not able to get up north toward the auroral-zone in 1997, and there was not much to hear farther south in Oregon and California for the most parts, save for about 10 nights worth of fabulous whistlers in the spring and autumn of that year and also some weak chorus events. However, 1998 has been quite a year so far!

In mid-March while camping in the northern Panamint Valley section of Death Valley National Park, I caught a splendid 'whistler shower' (when several whistlers per second occur) that is not very common during solar-minimum time at lower latitudes such as in California during in 1996 and 1997. This was clear evidence to me that solar-activity is rapidly increasing once again along with more natural radio events to be heard.

The next highlight was in mid-June of this year (1998) when my father and I headed up to Glacier National Park in Montana and adjoining Waterton International

Peace Park in Alberta, Canada. This was a ground-breaking trip in which I recorded for the first time on very sensitive equipment STEREO natural radio recordings using two sensitive, large loop receiving systems--the loops being oriented 90 degrees apart (cross-azimuth). (Please see the audio-files pages at: http://www.spaceweathersounds.com/sndbites.htm

Back in April 1996, I had tried stereo recording on two small-loop receivers in the northern Nevada high-desert with some interesting results, as there were a couple of days of very strong whistlers and some weak dawn chorus--interestingly one of the best whistler events I'd ever heard, despite it being near solar-minimum--just my good fortune again, I suppose--in the right place at the right time. I again tried out these two insensitive loops in Alberta Canada June 1 - 3, 1996 with some interesting results, but not very satisfactorily due to their insensitivity. The resulting recordings on this rather insensitive equipment sparked my interest in trying it again sometime with larger loop antennae and more refined receivers, later to be developed prior to the June 1998 Alberta recording sessions in Waterton Peace Park just mentioned.

Speaking of receivers and such, the very most basic receiver required to pick-up and record whistlers and all of the other Natural Radio signals of Earth is a tape-recorder audio amplifier connected to a wire antenna (aerial) of sufficient length to transfer enough radio energy into the tape- recorder's audio amplifier to successfully record them--we're trying to receive audio-frequency electromagnetic energy.

In actual practice, however, this crude tape-recorder/audio- amplifier "receiver" will most likely also intercept your local broadcast station transmitting in the long or medium-wave band as well as other signals, and it may not have enough "sensitivity" since tape-recorder inputs rarely are well "matched" in impedance for wire aerials but prefer microphones and such. Fortunately, whistler receivers are not too complicated to construct--or today--affordably purchased ready-built. At the very minumum, just a handful of parts and a couple of specialized transistors can form the basis of a good "whistler receiver" that will perform very satisfactorily.

Whatever kind of ELF/VLF receiver you choose to employ in your natural radio listening sessions, be prepared for increasing natural radio activity to start on a rapid increase beginning early 1999 as Solar Cycle 23 heads upward toward solar-maximum by the middle of the year 2000 or early 2001--soon enough now and a great way to welcome in the new Millenium! Listening conditions (in other words, what is being heard now) already is much better and more interesting at lower latitudes such as CAlifornia and Nevada (where I do most of my listening curently) than back in 1996 when sunspots were few.

Epilogue: 1999 to 2001:

In January 1999, I traveled down to Culver City near Los Angeles to do a talk at the Museum of Jurassaic Technology (www.mjt.org), at the invitation of curator Marina McDougall and Museum founder, David Wilson, two extremely wonderful people of many I met there while preparing for my talk, and also at the reception afterwards. Dr. Umran Inan of Stanford University STARLABS (the premiere entity involved in early natural radio research and current lightning-storm phenomena research) did a presentation of his organization's fascinating work. Friend Ed Hendricks also attended the session. As you may recall from earlier mention in this story, Ed is intensly studying the strange "Marfa Lights" seen in west Texas near the town of Marfa, and in the general area surrounding the town. Ed has been working on a really intriguing three-dimensional receiving system employing 3 loop antennas oriented in an X-Y-Z axis in order to examine and document radio emissions arising out of these odd lights, increasingly seen as we head back to solar-maximum once again. Ed had just returned from Marfa in late December 1998, having spent about 10 days there.

Alas, the Lights did not appear in the area over the period Ed was there to observe, but what he examined with a simple loop receiver he brought along (including one of his prototype copper-pipe-shielded loop antennas) intrigued me: Natural ELF/VLF Radio emissions at audio frequencies seemed to be, somehow, *amplified in that region*, including the ubiquitous lightning static that permeates the background at all times at VLF radio frequencies. On his way back, Ed stopped at a few other places, in including Joshua Tree National Park--an intensly beautiful and scenic place and also splendid place to record Natural Radio, being far from AC powerlines. Ed didn't hear nearly the high level of VLF reception (whistlers, etc., including lightning static) at Joshua Tree Park, nor at any other location he visited before and after his stay near Marfa Texas.(!!) After further questioning and discussion, it became apparant that it was neither due to a receiver fault or maladjustment, nor to an unusual upsurge in natural radio activity over the period he was in Marfa. Ed is a very meticulous observer of the Marfa Lights phenomenon and also in his technical achievements, so I trust his observations without doubt.

It seemes to us at this point in time that there is some sort of geological ananomoly in the Marfa region possibly responsible for enhanced VLF reception and possibly for the Marfa Lights themselves, but we hesitate to come to any quick or rash conclusion until we both return to the area and do further studies.

SEEING THE MARFA LIGHTS - By Edson C. Hendricks (Text file)

As the Marfa Lights occurrences are increasing concurrently to the increase in sunspot numbers and associated geomagnetic dusturbances, I think we are on to something here, and this is going to be a path of research for us both this year, along with an anticipated Natural Radio expedition I hope to take to Canada in the auroral-zone to record many hours worth of natural radio phenomena in stereo using my dual-loop receiving system, hopefully for a new compact-disc release for all to enjoy and marvel.

Ed has graciously permitted me to include his Marfa Lights observations, written in his hand, here on this website.

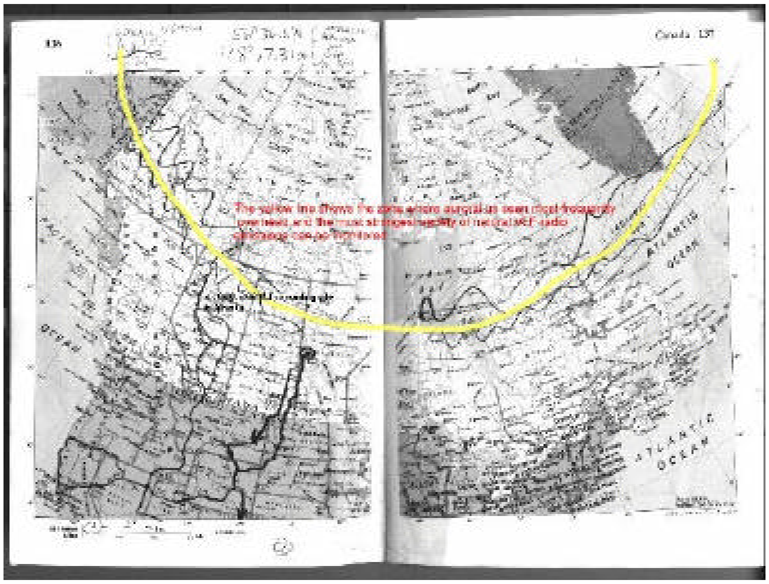
Update: August 2000 (Solar Maximum) Natural VLF Radio Expedition to Alberta Canada

The June 1998 trip to Waterton Park, Alberta to record natural radio in stereo was so successful that I embarked upon another trip to northern Alberta, arriving at an intended destination on 07 August 2000. The story of that trip and another one to central Saskatchewan follow...

August 2000 (Solar Maximum) VLF recording expedition to northern Alberta, Canada

(Note: references to CD tracks pertain to a future release I am currently working on, entitled "Auroral Chorus III" a double-CD album due to be released in late 2001).

In early August 2000, right near the time when the Sun was at its highest amount of activity and when sunspots were most numerous (called "Solar Maximum"), I embarked on another recording expedition to the same location in northern Alberta, Canada near the Whitemud River where I had recorded fabulous natural radio four years prior in June 1996. This location is within public lands called "Whitemud Provincial Grazing Area." Besides being timed at the height of the sunspot cycle, I chose the month of August to make my expedition to northern Alberta because the weather is still warm but the nights are long and dark enough to see aurora. Additionally, space-weather conditions for excellent auroral displays and natural VLF radio events are best closer to the equinoxes: mid-August to early October, and mid-February through mid-April.



Maps showing August 2000 and June 1996 northern Alberta recording locations and where the auroral zone is

This time, I carried with me equipment that would allow me to make STEREO recordings from two large-loop antennas that I hang in trees and point in different directions 90-degrees apart from each other - one loop for the right channel and another loop for the left channel. The spectacular results of this August 2000 Alberta recording expedition are presented in tracks 1 to 16 of Disc One.

Whitemud PGA - Northern Alberta VLF recording location, 10 August 2000. Red-colored "left-channel" loop is visible in the foreground.

During the eight days I was in the northern Alberta boreal forest August at the Whitemud PGA natural VLF radio recording location (August 7 to 14, 2000), the sun became very active. Not only did I record the gorgeous variety of natural radio signals you will hear in Disc One, but I photographed over 40 pictures of the aurora, especially in the early morning hours of August 12, 2000. A composite of several photos of the most beautiful auroral displays photographed in Alberta early the morning of 12 August 2000

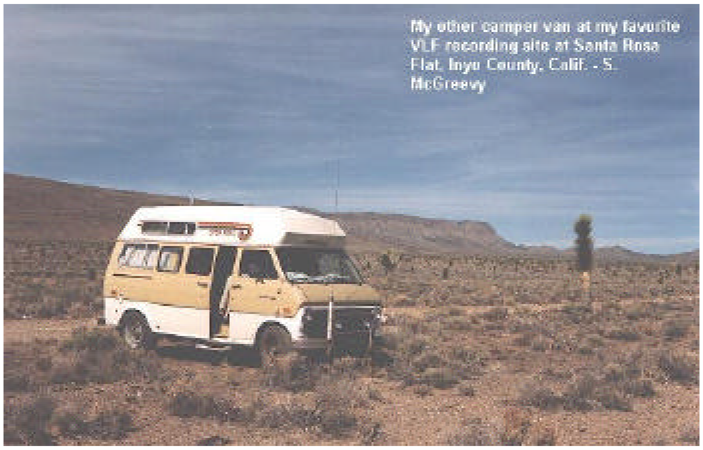
Thumbnail photot os 12 August 2000 auroral over northern Alberta, Canada (McGreevy)

Occasionally, even people living farther away from Earth's poles can be treated with views of the aurora in the nighttime skies - usually during a few rare but extremely powerful surges of the Sun's solar wind that occur during periods of maximum sunspots. The early morning hours of August 12, 2000 was one of those nights when the wonderful displays of the Northern Lights I witnessed and photographed were also seen by my friends in the southeastern California desert. That night and early morning, I was treated to a double-whammy of a sky show: spectacular full-sky auroral displays in green and red colors, and also the peak of the Perseids meteor shower whereby a few of the larger Perseids meteors actually punched dark lines or tunnels through the auroral curtains, then within seconds would be filled in and erased by the constantly moving aurora!

Another glorious display of the aurora was seen in the wee hours of March 31, 2001, including by myself. Shortly after I witnessed red aurora in the skies directly overhead my home in Inyo County, California near Death Valley National Park and Mt. Whitney in the Sierra Nevada, I loaded the recording equipment in my camper-van and headed to a local recording spot away from sources of electrical interference, hoping there would be some interesting natural radio signals to record. It was eerie driving a lonely desert highway totally devoid of man-made lights while watching green and red aurora fill the skies to the north!

One image of aurora photographed in the desert of Inyo County, California on 31 March 2001 - S. McGreevy

I was rewarded with nearly two days of great natural radio sounds resulting from the great solar-storm of March 31st, and tracks 17 and 18 on Disc One are the results. The image just above show rare aurora overhead my home near Lone Pine, California, at Santa Rosa Flat 25 miles to the east of Lone Pine showing green and red aurora to the north beyond the Nelson Range. There was great natural radio phenomena occurring right at the time these photos were taken, and also over the next couple of days afterward.



Inyo County, eastern California VLF recording location at Santa Rosa Flat. S. McGreevy

Friend Shawn Korgan in northeastern Colorado also captured some lovely natural VLF radio sounds over the same two days, and a bit of his recordings are on track 19 of Disc One. It is now figured that the period between August 2000 and April 2001 was the peak of Solar Cycle 23.

Summer 2001 Natural VLF Recording Expedition to Saskatchewan, Canada:

At the peak of the sunspot cycle, I decided in the spring of 2001 to plan for another natural VLF radio recording expedition back northward into the auroral-zone region of Canada. As I often like to see new places, I decided to head more to northeast again in lieu of another trip into northern Alberta - perhaps into Manitoba near where I spent 14 days on my Solar-Minimum VLF Expedition to Grass River Provincial Park, Manitoba in August 1996. It was during that 1996 expedition I recorded some of the very best chorus events I'd ever heard, but only in one-channel mono - not stereo, which I was now equipped for. Manitoba also is farther north in geomagnetic latitude compared to comporable places in Alberta at the same geographic latitude, owing to the positions of the north and south magnetic poles on Earth not being exactly where the geographical ("true") poles are.

On June 12th 2001, I departed the Owens Valley of California and headed east through northern Death Valley (in the cool of the night), camping at a few familiar and favorite places in the Snake Range of eastern Nevada. In Nevada's Great Basin National Park in the shadow of Wheeler Peak, I tested out and learned how to use a newly-purchased Sony Mini-Disc recording unit (model MZ-R70) - I was astounded at the quality of recordings from such a tiny little unit! No more balky cassette decks and their required frequent battery changes and tape azimuth problems common to cassette recording.

Passing through central Utah's red rock country, I stopped for the night not far from Arches National Monument on the evening of June 17th. Early the morning of June 18th, I would be treated to the best view of the Northern Lights (aurora) of the entire trip, thanks to a massive outburst of the Sun called a coronal mass ejection (CME). It turned out that that night and morning was the most active of the trip. Some brief VLF sounds captured begin Disc Two - 17 seconds of weak dawn chorus and a whistler - but it was not too spectacular VLF and the summertime lightning-storm static from storms in the Rocky Mountains, the Plains, and northern Mexico were quite strong that morning.

Gorgeous red aurora photographed in eastern Utah on 18 June 2001 at about 0200 MDT - S. McGreevy

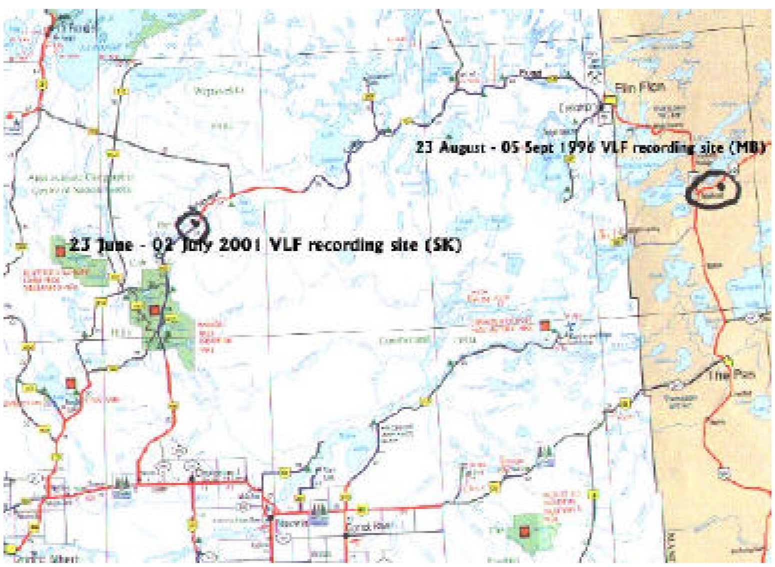
Camping the next night (June 18 - 19, 2001) in the Great Divide Basin of Wyoming, I did not see any aurora that night, probably because conditions were not favorable for aurora development. The following night near Sanders Montana near the Yellowstone River, I was fortunate to see some beautiful red rays - what I like to call pillars - in the northern skies. I was having a hard time sleeping because I was too busy recording passing trains as part of another recording project on the sounds of trains, and I had parked for the night in a perfect place for train recording! (Track 14 of Disc Two is one of my favorite of the eastern Montana train recordings - mostly because the sounds of the not too nearby train are accompanied by beautiful birdsong and a cricket chirping, being that it was recorded near daybreak.)

As I was arranging the microphone outside of the van for yet another approaching train, I glanced to the north and saw auroral pillars and rays reaching a quarter the way up into the skies.

Green and red aurora photographed at about 0230 MDT / 0830 UT on June 20, 2001 near Sanders, Montana. This was the last auroral display I saw during the summer 2001 trip due to all night twilight being visible farther northward in Saskatchewan. The fog visible under the aurora is along theYellowstone River valley. S. McGreevy

As I drove further north into Canada each day, I noticed the night skies were becoming brighter with all-night twilight. Indeed, I entered Canada on the Summer Solstice - the longest day of the year. That meant lots of daylight to drive by and enjoy scenery but it meant there was little chance to see any but the very brightest of auroral displays, and there were none to see the entire ten-day period I was in the northern Saskatchewan boreal forest. As such, I was thrilled to have been able to photograph aurora in Utah and Montana - those photographs compliment the pictures of full-sky aurora taken in northern Alberta in August 2000 and at home March 2001, presented herein.

I fell short of reaching my initial goal of central/northern Manitoba, deciding to cut short the mileage and head into central Saskatchewan not far from the geographical center of the province, about 300 km west of my 1996 Manitoba recording location. Heading north on Saskatchewan Highway 106 into the southern reaches of the northern boreal forest, I kept driving until powerlines running alongside the highway terminated at a microwave tower. At last(!), back into an area free from electrical lines that cause interference to natural VLF radio in the form of hum and buzz - the reason one cannot listen to natural radio in towns and cities.



Map showing June 2001 Saskatchewan location and also the August 1996 Manitoba VLF recording site to the east.

At my final destination and recording site at latitude 54.4 degrees north, I could take a walk in the woods without needing a flashlight. While not exactly the "midnight sun," the skies were light enough at local midnight in central Saskatchewan that only the brightest stars and planets were visible - similar to the sky about an hour after sunset at latitude 36.5 degrees north where I live.

Solar activity steadily fell after June 20th, and reached the lowest levels in many months by July 1st, 2001. Compared to August 2000 during the period when I was in northern Alberta, there was about only 25% of interesting natural VLF radio phenomena to record compared to Alberta in August 2000 or Manitoba in August 1996, the best day with the most beautiful VLF sounds being June 29th. It was on this particular trip that I realized that August (and September) is really the best month to head to the Far North with natural VLF radio and aurora in mind - with the exception of a day here and there, there seems to be a mid-summer lapse in vigorous natural VLF radio sounds to record compared to nearer the equinoxes.

A bonus of the Saskatchewan site compared to the northern Alberta site chosen in August 2000 was drier weather overall -- and woods much more devoid of pesky mosquitoes, although hoards of biting flies made up for the lack of mosquitoes. On a couple of days during the ten-day stay in the Saskatchewan woods I was plagued by lightning storms that moved into my vicinity. One particularly fierce but brief storm is caught on Track 13 of Disc Two - first rain, then hail is recorded, and later on, gorgeous birdsong as the storm receeded (see track guide further on). I was rewarded with a lovely rainbow after this particular storm passed on by.

After enjoying Canada Day in the northern woods (July 1st), I departed the Hanson Lake Game Preserve, Saskatchewan site on July 2nd and headed back southward again, deciding to head back into the Canadian Rockies at Waterton Lakes Park, stopping for four nights at the Belly River Campground. I usually prefer to avoid campgrounds due to their electrical and acoustic noise, but Belly River is a favorite spot and a nostalgic one - the place where I took my father on a retirement trip in June 1998 and where I met Barrette Golding, a freelance audio-producer whom recorded me recording natural radio sounds for a show he was later to produce for both National Public radio in the U.S. and the Canadian Broadcasting Corporation in Canada. A few recordings of the June 1998 Waterton Park visit are on my "Auroral Chorus II" CD.

Once again, Belly River Campground in Waterton Lakes National Park, Alberta didn't let me down - with incredible views of the nearby Rocky Mountains, this time lacking the dense smoke from fires in British Columbia that had plagued my prior visit in mid-August 2000. I felt a bit lazy though, and only erected one loop antenna (oriented to be most sensitive in a northeast/southwest direction) for I was in Waterton Park to relax and recouperate from the long trip to and from the northern woods of Saskatchewan. Tracks 10 through 12 of Disc Two (all mono) convey some of the natural VLF radio I caught over four nights stay at Belly River.

Since the summer of 2001, aI've decided for the next couple of years to stay close to home, not undertake long, greuling road-trips, and to concentrate on building up a website(s) with loads of audio sound-files, and to record natural VLF phenomena from the southwestern deserts.

Listening with my only WR-7 prototype in the Mojave National Preserve, Saturday morning, 22 March 2003, during a lovely whistler event.

In closing, I invite readers to join in and listen to the wonderful radio sounds of Mother Earth. You needn't be interested in science or be a radio buff, but need only to have the desire to lend an ear to the extraordinary yet ordinary. Like star gazing, Natural Radio listening redirects the mind and heart toward the wonder and beauty of the natural world.

Stephen. P. McGreevy, January 1995. (Updated and converted to HTML with photos December 1996. Additional revisions October 1997, August 1998, January and August 1999, September 2001)

References:

James Brett, *The Whistler Serenade*, Stonehenge Viewpoint Press, Santa Barbara, CA (1995), Edited by Donald Cyr.

Iwane Kimura, *Ray Paths of Electromagnetic Waves in the Earth and Planetary Magnetospheres* (Dept. of Electrical Engineering II, Kyoto University, Kyoto 606, Japan), (1989), American geophysical Union, *Geophysical Monograph 53* pp. 161-171

Robert A. Helliwell ("Father" of VLF research), *Whistlers and Related Ionospheric Phenomena*, Stanford University Press, (1965).

RELATED LINKS:

WR-3 VLF Receiver Listening Guide

WR-3 Natural VLF Radio ("Whistler") Receiver Information Sheet

DIRECTORY VLF-QUIET LOCATIONS: Contains a travelogue and several photos of many natural radio listening spots I've found. Some loactions contributed by other natural radio listeners too.

VLF SOUNDBITES (Audio files): Download WAV sound files of various natural VLF phenomena and view spectrograms of them. Links to two other web-sites containing my recordings.

McGreevy Ground-based VLF recordings - U. Iowa Server--Plasma Wave Group

1996 Solar-Minimum VLF Recording Expedition to Manitoba, Canada and Nevada, USA: Detailed report of VLF events between August 22 and September 23, 1996. Contains sound files, photographs, and the text body of the report on this recording expedition I mentioned earlier in this article.

CD: "Auroral Chorus 1 to 3: Music of the Magnetosphere" a compilation of three CD albums onto one MP3 CD, with photos and PDF e-books.

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REVISED 28 APRIL 2007 - (LINKS FIXED)

Wisdom is essential

Visits since 28 April 2007: