The INSPIRE Journal

Volume 10 Number 1

November 2001

INSPIRE Completes Its 10th Year!

As INSPIRE looks ahead to the next 10 years we find that there are many exciting possibilities. In this edition of *The INSPIRE Journal* we hear from an interesting variety of people who are active in the field of VLF natural radio:

- Joshua Resnick tells about leading a group of students from Kodiak, Alaska, on a VLF radio expedition sponsored by INSPIRE.
- Shawn Korgan of Gilcrest, Colorado, compares the performance of the INSPIRE VLF2 receiver with the SK-1, a receiver Shawn designed and built. This is especially useful as INSPIRE proceeds with the development of the VLF3 receiver – the next generation.
- Flavio Gori of Florence, Italy, describes the ideal instrumentation for radio research of all types, including VLF.
- Bill Pine of Ontario, California, describes the operation of the latest version of GRAM, the spectrogram software for the PC. Richard Horne, the developer of the program, has offered this shareware prpogram free of charge to INSPIRE participants.
- Many INSPIRE observers share their data from the Coordinated Observations last April.

And the INSPIRE beat goes on ….

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The INSPIRE Journal is a publication of The INSPIRE Project, Inc., a nonprofit educational/scientific corporation of the State of California. The purpose of the INSPIRE Project, Inc., is to promote and support the involvement of students in space science research. All officers and directors of the corporation serve as volunteers with no financial compensation. The INSPIRE Project, Inc., has received both federal and state tax-exempt status (FEIN 95-4418628). The *Journal* is published two times per year: November 1 and April 1. Submission deadlines: October 1 and March 1

Contributions to the *Journal* may be sent to:

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billpine@earthlink.net
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The INSPIRE CD

A CD of natural radio observations is being compiled and will be available next spring. Details will appear in the April/2002 edition of the *Journal*. The CD will consist of .wav files suitable for analysis using GRAM software. Featured on the CD will be the "best of" recent observations including some from Robert Bennett and Shawn Korgan. The price will be $10. If you would like to get your order in early, you will receive your CD as soon as they are available.

The INSPIRE VLF3 Receiver is on its Way!

The redesign process is underway for the new VLF3. This will represent a major change in design and performance. We still have a way to go in the process, but it is hoped that the new receiver will be offered for sale in the April/2002 *Journal*. The price of the VLF3 has not been established, so there is no way to order early. Watch the INSPIRE web site for an announcement, but it is not expected that the VLF3 will be ready before March or April 2002.

Assembled INSPIRE VLF2 Receivers No Longer Available

Our supply of assembled VLF2 receivers has been exhausted and this product will no longer be offered. We still have a limited number of VLF2 kits available for shipping. When those are gone we will not have any receivers available until the VLF3 is ready to ship.

Subscription Information Included on the Address Label

You can determine the status of your subscription to *The INSPIRE Journal* by looking at the address label. In the upper right corner of the label is a 2-digit number that indicates the year your subscription will expire. All subscriptions expire with the November issue. If your label shows "01", then this issue will be the last under this subscription. If your label shows "02", then your subscription is good through the November 2002 issue. If you have any questions or if you feel that the information shown is incorrect, please contact the editor.

Write for *The INSPIRE Journal*

The procedure for contributing articles for *The INSPIRE Journal* could not be simpler! Just send it in! Any format is acceptable. Electronic format is easier to work with. A Word file on disk for either the PC or Mac platform is preferred. An email message will work, too. If that does not work for you, a paper copy will do. Any diagrams or figures can be scanned in.

What about topics? Anything that interests you will probably interest most INSPIRE participants. As long as the topic is related to natural radio or the equipment used, it will get printed. The deadlines for submissions are March 1 for the spring edition and October 1 for the fall edition. Don't worry about the deadlines, though. If you miss a deadline, you will just be very early for the next edition!

We at INSPIRE are looking forward to hearing from you.

Coordinated Observation Schedule
November 2001

By Bill Pine Ontario, CA

The Coordinated Observations for November/2001 will be held on November 17 and 18. All data is welcome and should be submitted even if the conditions are quiet. It is not required that you observe on both days. Any data you can contribute is valuable. The procedure to use for Coordinated Observations will be as follows:

1. Use the Data Cover Sheet and Data Log forms found at the end of the *Journal*.
2. Put a voice introduction at the start of each session indicating your INSPIRE Team name (and number, if assigned), the date, local time and UT time.
3. Record for 12 minutes at the start of each hour that you can monitor on the specified days. Keep a detailed written log of all signals that you hear and indicate any items of interest. When you submit your tapes, spectrograms will be made of any parts of the tape that you indicate.
4. Place a time mark on the tape on the hour and each two minutes for the next 12 minutes. Use Coordinated Universal Time (UTC) for all time marks.
5. Record at 8 AM and 9 AM **LOCAL** time.
6. In addition, record on other hours to compare results with those in neighboring time zones. For example, an observer in the Central Time Zone might record at 7 AM (8 AM EDT), at 8 and 9 AM CDT and at 10 AM (9 AM MDT).
7. Use 60 minute tapes (30 minutes per side) with two sessions per side. It is preferred that you record on one side of the audio tape only.
8. Label all tapes and logs to indicate the sessions monitored and send to:

   Bill Pine
   Chaffey High School
   1245 N. Euclid Avenue
   Ontario, CA 91762

9. Your tapes will be returned with spectrograms of your data. An article reporting on the results will appear in the next *Journal*.
10. SPECIAL NOTE: If you are hearing whistlers, replace the data tape after 12 minutes with a "Whistler" tape and continue recording with time marks every two minutes. If we get whistlers, this would be a good opportunity to try to determine the "footprint" of a whistler (the "footprint" is the geographical area where a whistler can be detected).

Specified Coordinated Observation Dates for November/2001:

Saturday, November 17

Sunday, November 18

High Latitude VLF Project

By: Joshua Resnick
St. Innocent's Academy
Kodiak, Alaska

Co-Authors: Benjamin Christy, Harrison Colborn, Innocent Damiano, Philip Drake, David Gilbert, Jimmie Lilly, William Price, Caleb Wood

Abstract

Alaska presents a unique opportunity to study natural and manmade VLF signals. The availability of real wilderness, local aurora activity, and the proximity of various domestic and foreign navigation signals all contribute to a colorful VLF environment. In this project the students of St. Innocent's Academy in Kodiak, AK, employed a VLF-2 receiver to investigate the VLF environment at a remote mountain location on Kodiak Island. A radio housing was engineered and constructed, the radio was operated, and a variety of interesting VLF signals were recorded and analyzed.

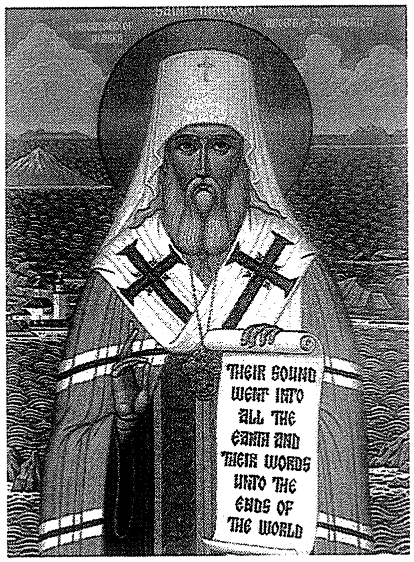
Motivation

All of creation has a harmony within it. Every tree, mountain, creature, and even the unseen environment displays a beautiful structure that is the seal of the Creator. At St. Innocent's Academy in Kodiak, Alaska, we try to attune ourselves to the natural environment around us so that we might experience this harmony and the glory of God's creation. St. Innocent of Alaska, who is our school's patron, was dialed into this harmony and through this saw the true importance of science. In between his missionary adventures throughout Alaska, Fr. John Veniaminov[1] established ten weather stations on the island of Unalaska between the years 1825 and 1830. He kept very detailed records of temperature, humidity, cloud formations, precipitation, tides and currents, wind velocity, earthquakes, volcanic activity, and other natural phenomena. This love for nature and science, and a fiery zeal for God are virtues that we are striving to touch into as a school.

The motivation of our fall 2001 science course is to walk in the footsteps of our patron in our scientific methods and understanding. Our main course project will be the construction of a permanent environmental monitoring station at our school that will employ a thermometer, barometer, anemometer, wind vane, psychrometer, pyranometer, gamma ray detector, and seismometer. The VLF receiver project fits perfectly into this course in that it monitors a

[1] St. Innocent's name as a priest was John before he was consecrated Metropolitan of Moscow.

fundamental part of our environment that is beyond the scope of traditional meteorology. If St. Innocent had known about the ionosphere and its importance he certainly would have studied its daily and long term patterns. Such patterns are a hidden source of beauty in creation. With St. Innocent as our guide we went forward to investigate the VLF spectrum. Through this project we all came to appreciate the wisdom of God in creation on a much deeper level.



A contemporary icon of St. Innocent

St. Innocent in old age as metropolitan of Moscow.

Project Goals

The main goal of this project was to use our VLF radio to hear lightning strikes around the world and also to learn about the ionosphere. To achieve this goal we had to do a significant amount of initial work. The first step was to design a structure to protect our radio and antenna and hold them steady for operation. Then we constructed our design using the materials that were available in the school's wood-shop. We were able to accomplish this task in several days.

Our next goal was to choose an acceptable location to set up the radio and its housing that was far from power-lines or other sources that might interfere with the signal. Pyramid Mountain was chosen because it is several miles from any large power transmission lines. Once operated in an acceptable location we intended on recording the received VLF signal using a portable laptop computer. This signal would then later be analyzed using spectral analysis techniques to identify its various components.

Our final goal, and one that pertains to the entire project, was to experience an Alaska adventure. This goal was achieved when we actually began to climb the mountain. We had to conquer steep climbs bearing somewhat heavy backpacks and overcome various obstacles along the way. The climb itself was an excellent experience and our project was a success. The entire group came home with a little more knowledge and an adventure under their belt.

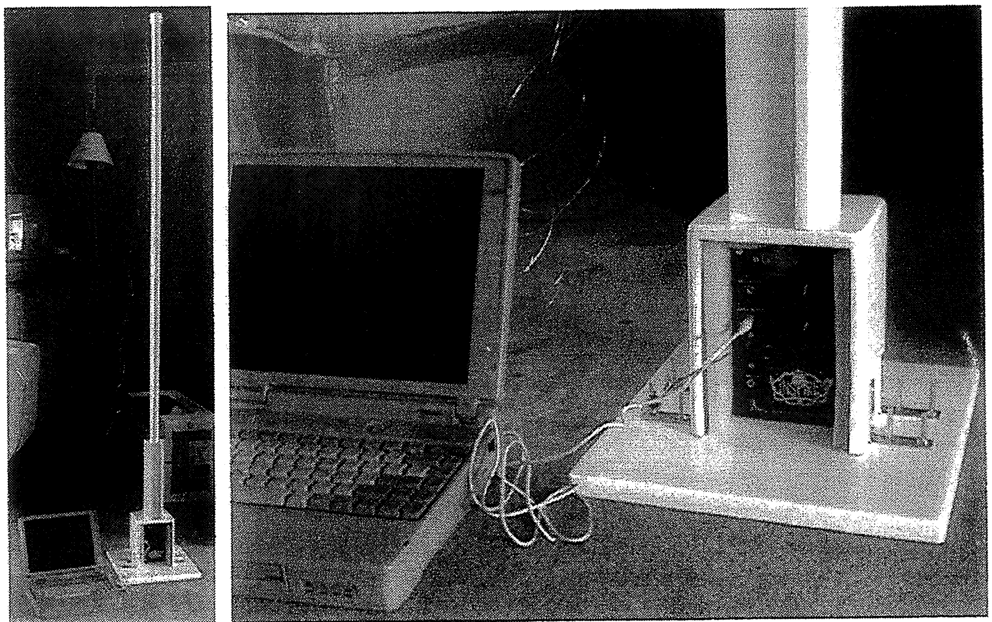
Radio Kit Assembly

The INSPIRE VLF-2 Receiver Kit was of high quality and was an enjoyable challenge to assemble. There were no missing or broken components and the instructions were very clear. The radio was well designed and picked up a strong 60 Hz hum the moment it was turned on in the lab. The only problem that was encountered during construction was the misalignment of the screw holes that secure the faceplate to the project box. Unfortunately the class was not able to work together as a team to assemble the radio due to time constraints. However, several students are interested in assembling their own VLF-2 kits as independent projects.

Design and Construction

Two major challenges that we anticipated were weather and terrain. While we did not plan on using the radio in heavy rain, high winds would be unavoidable. We had to build some sort of housing to protect the radio from the elements and make it stable even in the steep terrain of dirt and rock. We spent an hour brainstorming and settling on a design, and then actually laid out the dimensions of the housing. We decided that using any large pieces of metal near the antenna would alter the signal but that the antenna would still need to be covered to avoid interference from wind or rain. We first designed a 1' X 1' X 1" base for stability and a 5.75" X 7.5" X 5" box to contain the radio that was constructed from .5" plywood. We then decided that 6' long, 1' ID PVC tube would be used to guard the antenna. This tube would be secured on top with 8.5' long 20 lb. test nylon lines and on the bottom with a 3" X 3" X 1' plywood chimney attached to the top of the housing.

After brainstorming we separated into groups and constructed the various components of the housing. The wooden components were then finished with wood filler and epoxy paint and the end result was functional and aesthetic. Most of our ideas worked perfectly except for the antenna housing. Wind at the test site cause the antenna to bounce around inside the PVC tower. This bouncing caused interference from charges inside the plastic tube being picked up by the antenna. We tried to jury-rig the assembly at the test site by stuffing some foam into one end of the tube. When this failed to eliminate all of the vibration the PVC tower was removed and the plastic lines were tied directly to the top of the antenna.



Radio housing and laptop computer for data acquisition.

Experimental

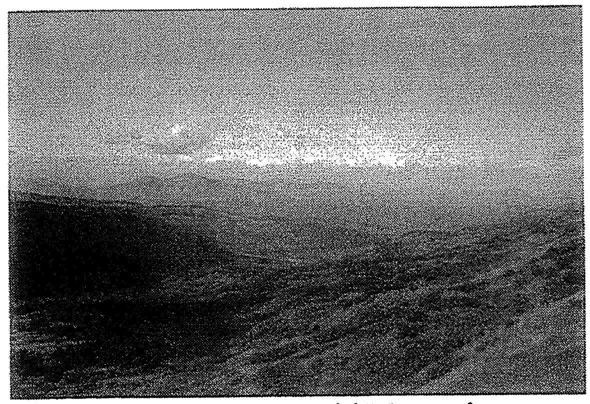
On October 2nd we set off to Pyramid Mountain (57° 47' Lat., 152° 35' Lon., 2400') on Kodiak Island, AK, to record VLF signals with our radio. On the way up to our destination we observed a grouping of mysterious Coast Guard antennas comprised of many shapes and sizes. We were concerned that they might interfere with the reception of radio waves from the ionosphere.

When we arrived at the base of Pyramid Mountain we assembled our group and began the ascent. After going a few hundred feet we realized that we had forgotten the poly vinyl chloride (PVC) housing for the antenna. We detailed one man to return to the vehicle to retrieve the forgotten piece of equipment. Not long after the first halt one of our class members had to return to the vehicle for health reasons. Unbeknownst to us at the time he took his backpack with him that contained the stakes for anchoring the nylon line. We continued upward for about an hour until we reached a suitable site to set up our mobile field lab. Everything proceeded smoothly until we realized that we had no anchor for our PVC antenna housing. We improvised by tying the nylon lines to our backpacks in which we placed rocks for weight.

After we had the computer and VLF receiver set up we began monitoring the radio. What we heard was an ionospheric researcher's worst nightmare: wretched hollow banging noises issuing from the computer speaker. A quick evaluation revealed that the antenna was not secure in the PVC housing. We attempted to compensate by stuffing some foam into the tube around the antenna. A second attempt told us that this had failed to totally eliminate the vibrations. We then removed the PVC housing altogether and tied the anchor lines directly to the antenna and this solved the problem. Our instructor who was so wary of damaging the antenna was the very person who walked into an anchor line causing it to bend! Luckily the antenna was still functional.

At 10:04 a.m. we set the computer to record the signal for half an hour while we made the final steep climb to the peak of the mountain. When we returned to our field lab we were delighted that our efforts to record the signal had been successful. After we packed up our equipment we had an uneventful hike down the mountain. We were excited to return home and analyze our findings.

The class completes the setup of the radio



The view from Pyramid Mountain.

Signal Analysis

The data was recorded digitally with a laptop computer using Goldwave software. With the PVC sheath removed the wind became a large source of noise as ions from the air impinged on the antenna. Fortunately, and quite unexpectedly, the strong winds died down at the site for most of the duration of the recording.

The signal was very rich with at least eight different identifiable components. The predominating component of the signal appears to be from the LORAN navigation system. This component shows up as dashed vertical lines in the spectral analysis as seen in Figure 1.

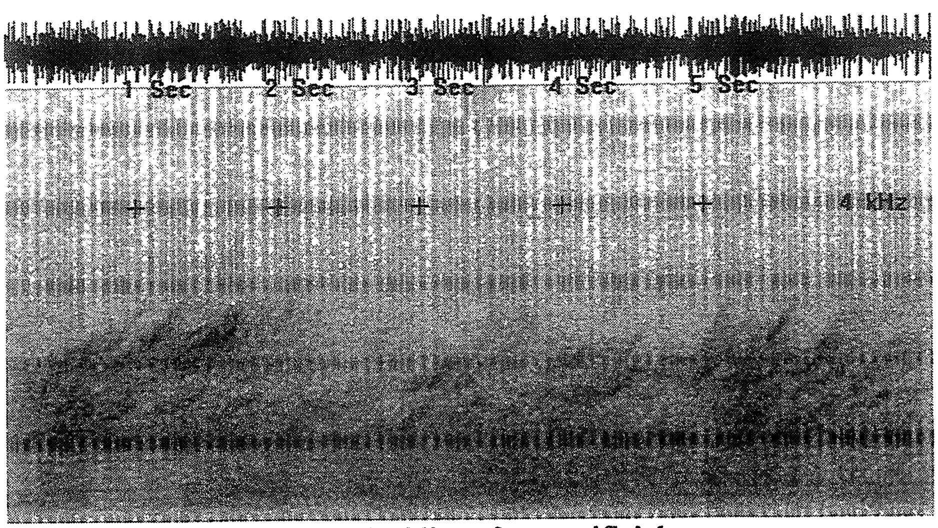


Figure 1: Vertical lines from artificial source

The LORAN signal consists of pulses that occur at a fixed interval. This signal, however, has a period that varies and consists of patterns of pulses that seem to change over time. Therefore, there is some question as to the origin of this signal component.

The most predominant natural component of the signal was chorus activity – a common type of activity at high latitudes. The chorus sounded like a large flock of birds but was obstructed by the LORAN signal. Using a digital filter with Goldwave the LORAN signal was removed so that the chorus could be clearly seen in the spectrogram shown in Figure 2. Another source of natural radio that we recorded was from distant lightning strikes reflected from the ionosphere. These strikes or "spherics" had the characteristic crackling sound but did not predominate the signal. They appear in the spectral analysis as continuous lines through the frequency range.

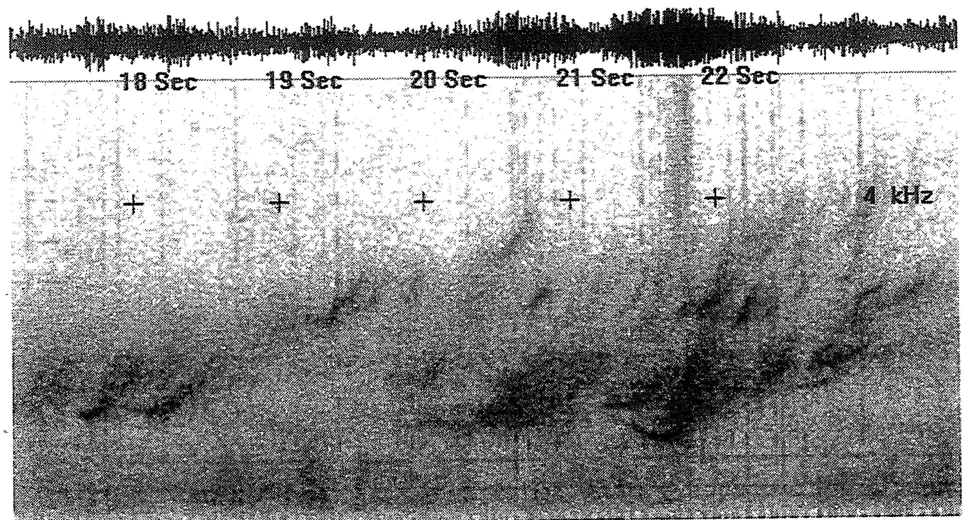


Figure 2: Spectrogram of chorus activity attributed to the aurora

Another interesting artificial signal component that could not be heard because it occupied a very high portion of the spectrum stands out in Figure 3. Figure 3 was produced by filtering out the LORAN signal and producing a spectrogram of the signal from 10 kHz to 17 kHz over a period of 10 seconds. The signal consisted of three tones following one another: 14.9 kHz, 12.7 kHz, and 12 kHz. The pattern of three tones repeated around every 3.5 seconds for the entire duration of the half-hour signal record. We are fairly certain that this is the Russian navigation system called Alpha. The Alpha system is a scaled down version of the US system called Omega that was turned off in 1997 after it was antiquated by the GPS system. There were also present in the signal four continuous tones that we cannot match up with any known source at 21.4 kHz, 19.9 kHz, 16.4 kHz, and 13.1 kHz. These four lines can be seen with the Russian Alpha signal in Figure 3.

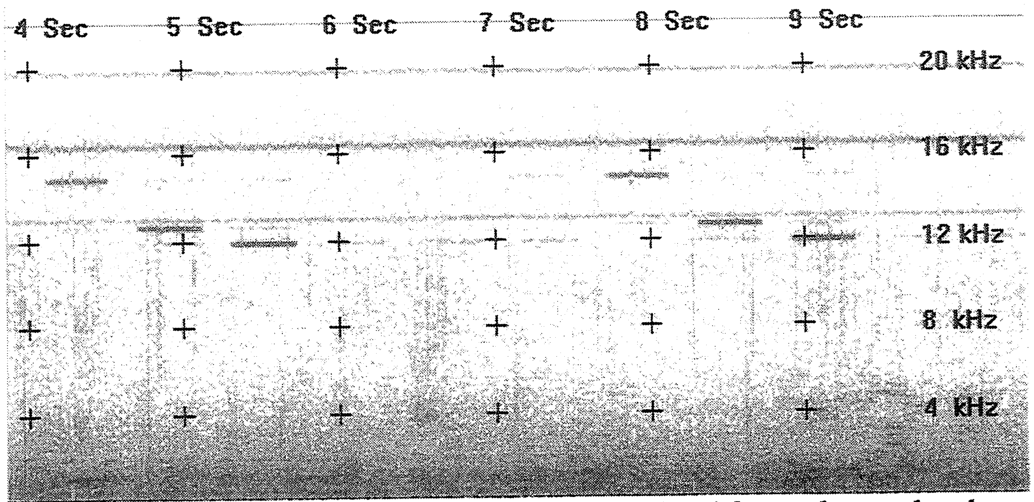


Figure 3: Spectrogram of OMEGA signal and four unknown bands.

The six signal components that remained present for the duration of the recording period included: sferics, chorus, LORAN, Alpha Navigation System, physical wind, and three high frequency lines of unknown origin. In addition to these there was one very interesting transient that lasted for about 10 seconds. The spectrogram from this signal is shown in Figure 4 (the LORAN signal component has been digitally removed). This transient is out of the ordinary for a natural signal such as a whistler because of its increasing frequency.

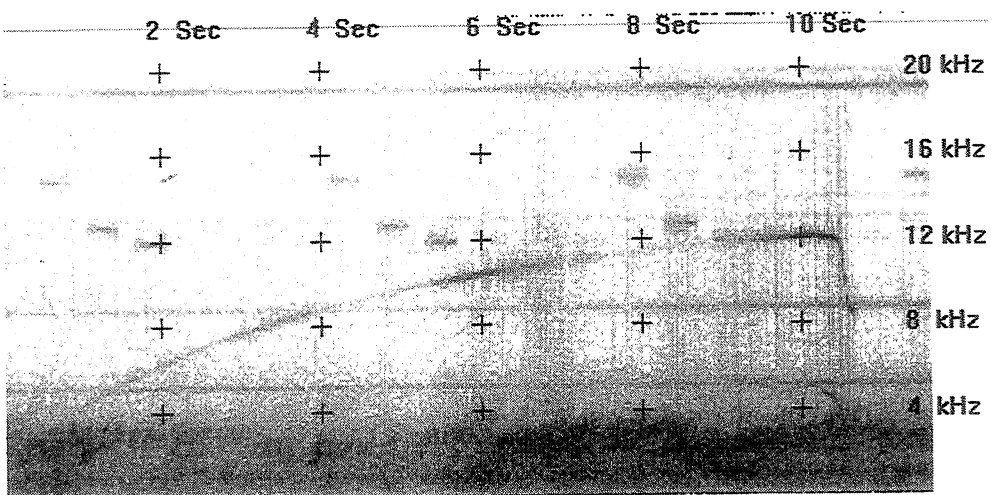


Figure 4: 10 second long transient with increasing frequency.

Conclusions

Throughout the VLF project many new concepts and skills were developed. We learned about the ionosphere, lightning, electromagnetic waves, and frequency spectrum. We designed a radio and antenna housing, decided on a location to conduct the experiment, used the equipment successfully, and then analyzed the signal. There were various successes and failures during our experiment. Our successes include the construction of a portable and sturdy radio housing, finding a suitable experiment location, and identifying several interesting VLF signals. The only real failure was a poor antenna housing design. If we were to repeat the project we would have done the experiment on the top of Pyramid Mountain despite the treacherous climb. During our signal analysis we learned that there is a fundamental difference between the structure of manmade radio waves and that of natural ones. Man made radio waves tend to consist of repeating patterns, fixed intervals, or constant frequencies and natural radio waves consist of random intervals and changing frequencies.

This project illustrated the importance of the ionosphere, which is something we could have never understood otherwise. Above all, it helped us more deeply appreciate the hidden wisdom of God's creation.

Acknowledgements

We at St. Innocent's Academy would like to extend our gratitude to the people and institutions that made this project and science course possible. We would first like to thank Mr. Pine and the INSPIRE team for providing the VLF-2 receiver. We would also like to thank the following benefactors for sponsoring the fall 2001 science course: St. Sergius and Herman Eastern Orthodox Church in Syracuse, NY, Holy Resurrection Orthodox Church in Boston, MA, St. Mary's Albanian Orthodox Church and St. George's Orthodox Cathedral in Worcester, MA, the faculty and staff of Worcester Polytechnic Institute (WPI), Data Translation of Framingham, MA, Agilent Technologies, and Walt's Hobbies of Syracuse, NY.

References

All spectrographs in this report were developed with Spectrogram V. 2.3 by R.S. Horne.

McGreevy, Stephen P. *The VLF Listener's Handbook.*
http://www.triax.com/vlfradio/vlfhndbk.htm

Wermuth, Monk Andrew. *From Earth to Heaven: The Apostolic Adventures of St. Innocent of Alaska.* Ouzinkie, AK.:St. Herman of Alaska Press, 1997.

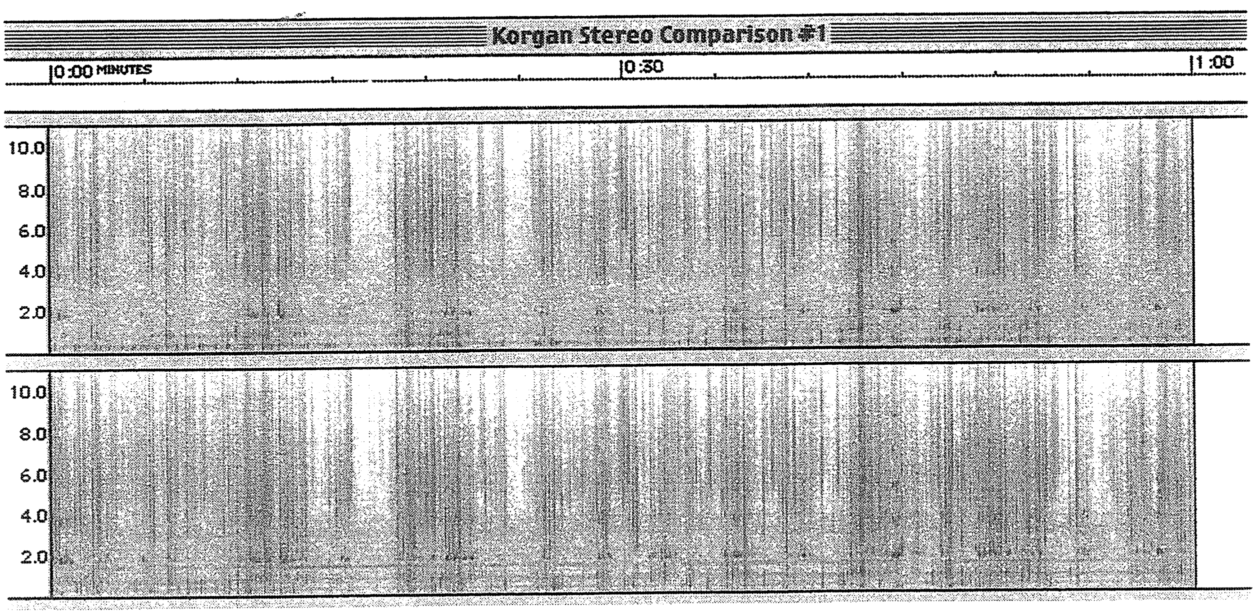
Two VLF Receivers:
SK-1 and VLF2
Quick Comparisons and Notes

By Shawn Korgan
Gilcrest, CO

The VLF2 receiver arrived May 21st, just two days after it was sent. The reason I was receiving a VLF2 receiver stemmed back to a conversation held with INSPIRE's Bill Taylor and Bill Pine just a few days previous. We were discussing VLF receivers and their sensitivity to VLF signals and why some receivers (such as my SK-1) appear to be more sensitive to VLF signals. I was unsure at the time whether this extra sensitivity was due to my location at a higher geomagnetic latitude or due to my receiver's ability to hear fainter signals. I asked Bill Taylor if I could borrow a VLF2 receiver for comparison purposes and a few days later one was in the mail.

While the receiver was in the mail, I had several days to look over the schematic of the VLF2 receiver. After experimenting for several years with VLF receiver designs, I noticed a few changes that could potentially be made to the front-end of the VLF2 receiver that would dramatically improve the sensitivity of the VLF2 receiver to weak VLF signals. I will discuss a few of these design tips further in this article.

The first day I had a chance to try theVLF2receiver was on May 22nd. This would prove to be a great morning to see the spectacular scenery of nature but not a very productive day for receiver testing due to an extreme amount of lightning this particular morning. The day following would prove to be the perfect day for receiver testing and comparison.

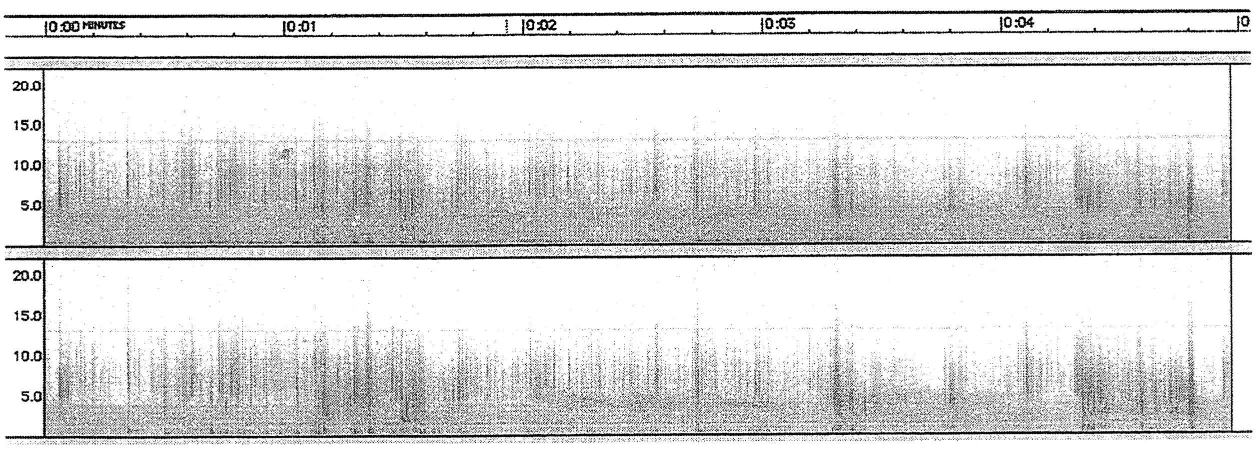


A 1-minute comparison spectrogram.
The VLF2 is on the top track (right channel) and the SK-1 is on the bottom track left channel).
NOTE: Spectrograms for this article were created by the editor using Shawn's tapes.

On May 23rd, I arrived at my recording location at approximately 5:00 a.m. and began the setup of the VLF2 receiver along with the SK-1 receiver. I had the intention that morning of running the audio from both receivers simultaneously into the tape recorder, making a stereo comparison of the audio from both receivers. I was on a mission to find out why I was hearing such amazing signals here in Colorado. Was it the receiver I was using? Or, was it my particular location in the country?

May 23rd provided the perfect listening conditions necessary for testing the two receivers and also for making a 40-minute stereo comparison tape. When I first arrived, the lightning was going strong. By 7:30 a.m. the lightning was calming down and the best activity of the morning was beginning. This is the point where I started the tape recording.

When I first hooked up the VLF2 receiver , I noticed two things right off the bat. First, the VLF2 receiver appeared to have a lot more noise in the VLF signal when compared to the SK-1 receiver and, second, there was a lot more in the way of low frequency response with the VLF2 receiver. Beginning with the low frequency response, I found the lightning on the VLF2 receiver had a lower frequency response to it than my homebuilt SK-1 receiver. Frequency response is more of a preference in my opinion, so this was not an issue. The lower frequency response is great for monitoring low frequency events. I often use this type of setting to catch whistlers that descend down to 300 Hz here in Colorado.



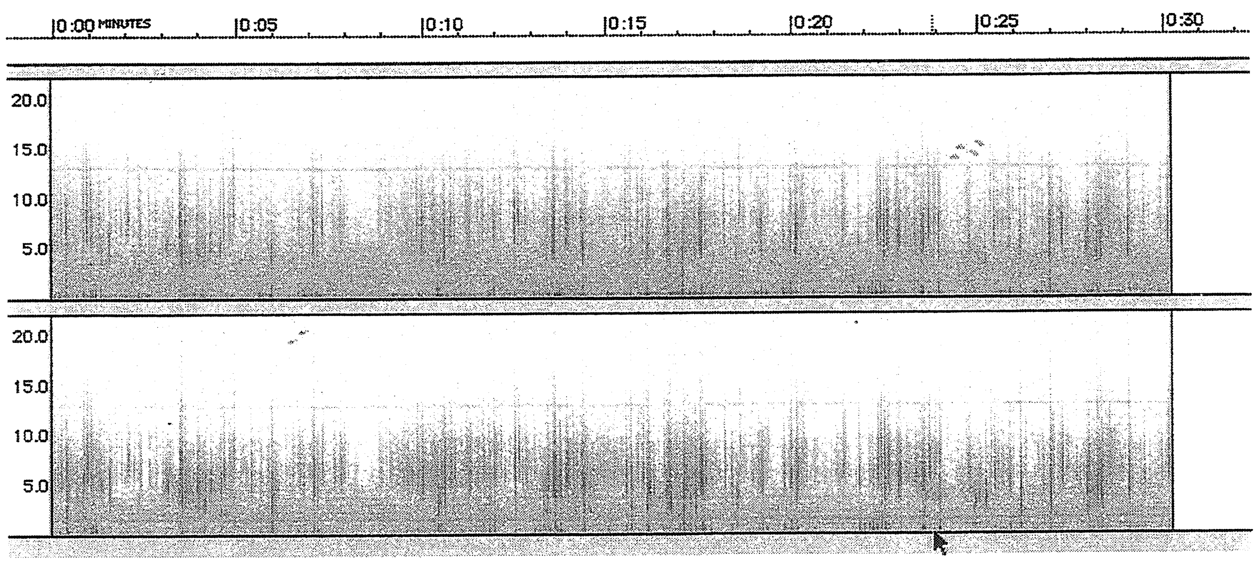
A short (5 second) spectrogram. The VLF2 is on the top track and the SK-1 is on the bottom track.

As for the apparent increase in noise, well, there really was an increase in noise. The extra noise in the VLF2 receiver was being created, first, by a lower gate bias resistance (resistance between the incoming signal and the ground) and secondly, by higher resistance in series with the incoming signal than was being used in my SK -1 receiver. To hear the faintest VLF signals, a receiver needs a design that allows the least amount of resistance possible in series with the VLF signal and the highest amount of gate bias resistance feasible and still have a functioning circuit. By raising the total gate bias resistance of the VLF2 receiver to 44M ohms and by lowering the resistance in series with the incoming signal, the extra noise in the VLF2 receiver should all but disappear. I noticed that as I lowered the gate bias resistance on my SK-l receiver from 100 megohms of resistance to 1M ohms of resistance (the total gate bias resistance of the VLF2 receiver) that my receiver increased in noise to the point that it was tied with the VLF2 receiver when it came to additional noise in the signal.

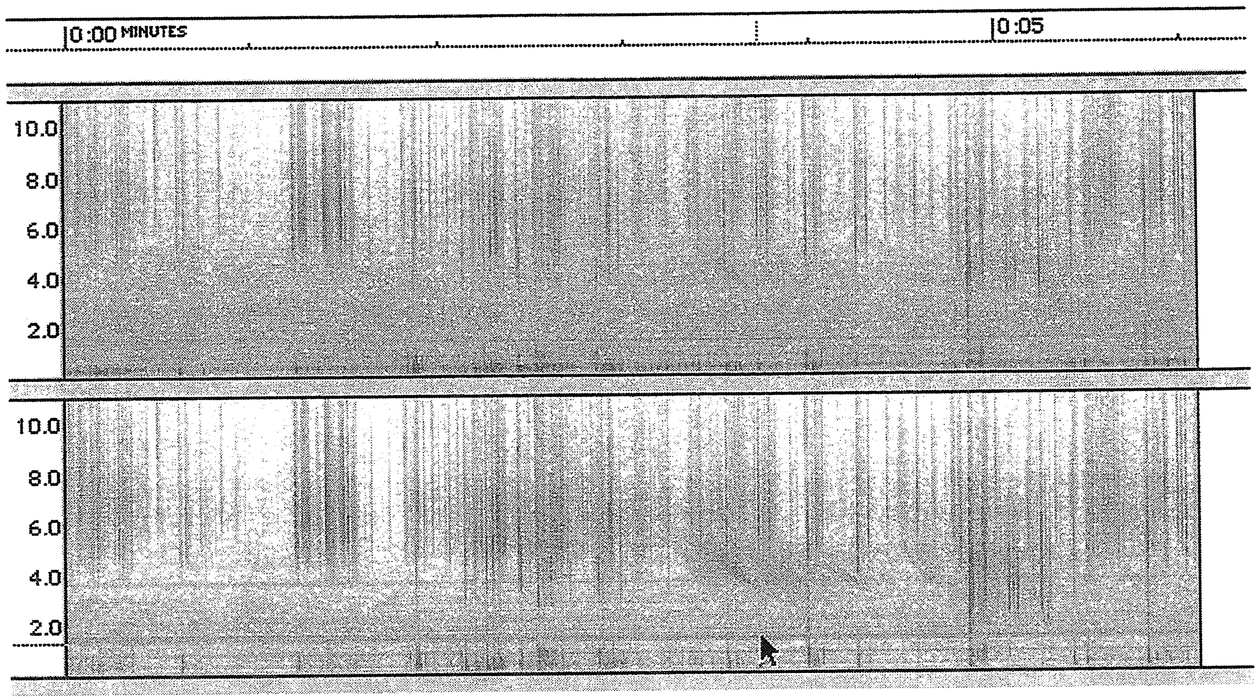
Upon reviewing a spectrograph of the tape, one could clearly see not only the difference in low frequency response but also the difference in the signal to noise ratio between each of the two receivers. The SK-1 was able to hear at least three times more detail than the VLF2 although both receivers were hooked to identical 8' E-field antennas.

The SK-1 captured many double and triple whistlers toward the end of the tape recording which appeared only as faint single whistlers on the VLF2 receiver that were barely above the noise floor.

As for the overall performance of the VLF2 receiver, it is a very fine VLF receiver and a great performer. With a few simple changes, I believe it has the potential to be even better -- one of the most sensitive VLF receivers in the country.



A 30 second file with VLF2 on top and SK-1 on the bottom. The arrow points to a whistler at about 24 seconds.



Close up of the whistler. Arrow points to whistler in the SK-1 spectrogram.
The whistler is less prominent in the VLF2 spectrogram.

So, was the reason I was hearing such incredible signals here in Colorado because of my location or because of my receiver? Well, it appears to be a touch of both! The VLF2 receiver was catching at least a third of the "faintest" VLF signals being captured by the SK-I receiver. This was proof that I was not doing anything special on my end. The VLF2 receiver was hearing the same signals as the SK-I receiver although with just a touch more noise in the signal. Therefore, I had to conclude that it was not only the SK-I receiver that was allowing me to hear such wonderful VLF signals here in Colorado but also my location. After reading Robert A. Helliwell's book, Whistlers and Related Ionospheric Phenomena, I was pleasantly surprised to find that the greatest number of whistlers are heard at a north geomagnetic latitude of 50 degrees. Fifty degrees would correspond with my location which is just north of Boulder, Colorado. It is the combination of a very sensitive receiver and one of the best listening spots in the country that makes the whistlers too hot to handle at times here in Colorado.

I mailed the VLF2 receiver back to INSPIRE May 29th. I felt fortunate to have had an opportunity to test it.

A NATURAL RADIO MAC-SOFTWARE PROJECT

By: Flavio Gori
INSPIRE European Coordinator
Florence, Italy

Introduction:

In the radio waves field, as happens in many other research fields, hardware instruments are as important as they are expensive. In past years only professional laboratories could afford them. Later some Spectrum Analyzers and Oscilloscope were available for a restricted team of radio amateurs (hams). Recently computers have become powerful permitting software developers to design programs able to resemble powerful hardware though much cheaper than hardware instruments. This is not to say that software is cheap, of course, only to say that is cheaper than those hardware tools. So hardware and software have to become cheaper, but this is well known. Besides, that is another story.

Around 1996/97 computers became powerful enough to run powerful technical software. Not in every situation does software have enough power to run good instruments and usually Spectrogram/Sonogram (sound in the time/frequency domain) programs need large memory space besides strong power to run software and allow the user to monitor what is going on in real time.

While CD, external hard disk, DVD or tapes, or any other means can be easy to use for a professional research team, for amateur people involved in this field, it can become a hard problem to solve. I believe a Spectrogram/Sonogram is the perfect tool to understand what is going on in the VLF/ULF fields, a frequency group where many things have to be found.

This, unfortunately, means that we need so much memory space to store data, unless you can find a system to start the software when "the" signal you are looking for may appear. I believe that sometimes an unexpected signal may be extremely important and, since the threshold is not triggered, the signal may be lost.

This article should serve as a first step to create a good kind of discussion between Inspire members involved in Natural Radio emissions, below 15 kHz until 0.01 Hz. I am sure that all of you know very well what a perfect software tool may have, to meet our needs. Probably we need an Oscilloscope, a Spectrum Analyzer and a Spectrogram/Sonogram.

Maybe all in a single all-purpose package, or each instrument in a different software package. These tools already exist, of course, though they are designed for different fields of use and very seldom can they meet our Natural Radio needs at all. We have to underline that one software exists created just for VLF and below: it is "Spectrogram" for PC. Please take a look there to understand many features our software has to have, though it also lacks something important.

In my three years long research through the Internet it has never happened that one software package works for all that I need. So I'll begin this first step, hoping that all of you may give his ideas to understand what the perfect software has to be.

My Ideal Package:

What I am thinking about is a package of software instruments including three tools. One is a Digital Scope – Oscilloscope - which lets me monitor 24 hours a day but records only when a given threshold amplitude noise is passed for "n" time. In this situation the record will start from the very first moment the noise began. If we have a recording session, the scope will monitor the condition one time every (for example) minute. If the noise amplitude is still on, the scope will record the situation, writing the UTC time of the measurement. When it finds the signal has changed and the amplitude returns back below the threshold, it will write the changing situation, its hour and minute, and stop recording. Of course, it could also record when the amplitude goes lower than expected.

A Spectrum Analyzer should allow saving in automatic just when a signal arrives, or when the signal goes over a given threshold, saving memory on the hard disk and work for the observer. Again, the S.A. should allow to use all the capacity of the computer display so the software allows the monitoring of a large range of frequency. It will be wonderful to monitor a wide frequency range, say until 30-50 kHz, if we want.

If and when we are able to resolve the memory space problem (where to store a big amount of data) we should then consider Sonogram (time vs. frequency) software. I am sure it would be considered as "The Perfect Tool" to understand a frequency range, especially (but not only) a range not fully understood at all. No other instrument can supply more data and in so good form, in my opinion. We could think of something like the Spectrogram/Sonogram capability of SoundEdit. Unfortunately SoundEdit is no longer developed by MacroMedia, and I don't know who is working on it now. If someone is doing that please let me know.

You can click on the Inspire Project Home Page:

http://image.gsfc.nasa.gov/poetry/inspire/

to better understand the VLF signals.

Software for us should allow the logarithmic scale to be displayed and very well done. Moreover we need to control in the ULF realm, say as low as 0.01 Hz, with a perfect resolution, choosing the bandwidth to work/record, as well as to write about 7-10 notes-bars in every sonogram page, for future reference. One more requirement has to be real-time sonogram making: hearing and seeing at the same time, in real time. One more plus: in every sonogram page it is important to display the time scale (as hh:mm:ss, in GMT or in any other time we like to set, such as the internal time of our Mac) to better resolve the time of the various signals we see on the sonogram and also to correlate them with other recordings from other sides of the world.

The VLF radio range has to fight with the strong 50 (or 60) Hz noise. This is a hard problem to solve, especially for one who lives in the so-called modern town, worldwide. In the last years some people have thought about how to solve this problem. One way to try would be to design a solution in two steps. First, using hardware, designing an interface notch filter able to catch the noise and its harmonics and by filtering, reduce this strong noise by about 70-80%. The other part of the noise should be cut off by a similar filtering by software, to be included in our package.

Another kind of need is related to the need to record for many hours, the only way to get around high quantity of data. Only a large mass of data would allow us to detect the signals we need to extrapolate anything useful. This will be possible only when we can establish a station receiving at home, and this will be when a noise canceller will work well.

On the other side many of us would want to record other kinds of signals, manmade or natural, in VLF radio frequencies, say no more than 40 kHz, as well as lower, say down to 0.1 Hz. In the last field, we need a careful recording tool that is able to catch any kind of signal that may be around including signals that can be heard and those that cannot be heard by the human ear. A record that can be created in "normal time" and that needs longer time, as a slowing varying signal, or field. The sonogram capability should supply invaluable help. I believe that this kind of "noise" might be extremely useful to find also, if not especially, in the ULF side. In these fields we don't need to record and display the incoming signals in real time, though a Spectrogram software is still needed. This may be considered a strong field of future research searching for unheard signals.

One good promising research in the field may also be the noise floor of a given place. A Spectrum Analyzer may be considered the perfect instrument to understand the local situation without using too much disk space. This could be used with the Spectrogram: while the Sonogram monitors every signal, the Spectrum Analyzer can tell us when and how the noise floor may vary. The recording system to monitor noise might be the one said about the threshold.

If we are looking for just a way to understand if, when and how a local noise floor works, we may do as follows. Say that we might record 24 hours a day but display just a signal/noise ratio average every "n" minutes, in order to create a display for the 24 hours, every day. After 30 days the computer and the software will calculate an average to form the one month situation made by the 30 days averaging. In the same system we could calculate the yearly average, from the monthly base averages.

An important and simple plus will be the computer-video capability to split in two parts (up and down) the recorded files, to let us compare two same date recordings of the same frequency, in different years.

I'd like that at least two of these software instruments should work at the same time, getting a real time comparison with a cross reference, an important way to compare a research. One fine utility would allow the Mac to start up the recording session at the time we'll choose, and stop after "n" time. What should be included is a "Timer" plug-in, so we could start and stop our recording sessions as many times as we want, scheduling for a night, a week or one month in a very simple and useful way. We should leave home/lab for sea or mountains with no pain. Better than ever if we'll be able to establish a net connection. From our vacation site we could monitor the virtual site lab, realizing what is going on.

The Bottom Line:

So, the tool I think we need is a Spectrogram-Oscilloscope-Spectrum Analyzer especially designed for VLF/ULF radio range. While the Oscilloscope and Spectrum Analyzer have to have good trigger and timer capabilities as well as the recording system already described for long time recording sessions. Spectrogram, in particular, has to be able to work in real time, with log scale from 15 kHz down to 0.01 Hz, resembling SoundEdit as well as Spectrogram. It can directly record in the hard disk both audio and graphics with no limitation other than the hard disk space and can provide a bandwidth choice, from 0.1 Hz to 15 kHz, permitting us to write some notes below each sonogram for future reference.

A PowerBook with that software, a good ground, antenna and the Inspire VLF receiver may be the standard portable receiving station able to digitize immediately the session avoiding any loss from A/D converting (tape to disk) and saving time.

E mail me:

I strongly ask every Mac user who would like use this software package to drop me a line at this address:

gori@mail630.gsfc.nasa.gov

Of course, and I'll say again, I'm asking you for additions/corrections to the requirements described earlier. Opinions from all of you may be extremely useful to develop the right software for Natural Radio researchers.

Later, when I'll know which kind of product we want, I will ask some Mac software developers about the possibility of producing such a tool, how much this software would cost for each person, in a shareware way, keeping Inspire members informed about the entire situation. A product like this could be extremely useful for the scientific Mac community worldwide, showing, one more time, that Mac can do a very good job in all the fields. I ask you to inform as many hams as you can about this project, to determine the real amount of people who may be involved. This can supply important information for the real base of users: everyone interested in the Project please drop me a line to let me understand how many people are in "the MacGroup".

So write me your ideas, your suggestions. What do you think a good VLF/ULF software has to be for your needs? No one can say it better than you people who go in the field, the Inspire(d) people. Inspire Journal and LoScrittoio.it will publish your suggestions. All together maybe we can produce "the" software we want.

Good links to realizing what is around:

MacTheScope – Commercial package software, unfortunately cannot record a long audio file in the Spectrogram mode, many other features useful for us:
http://www.channld.com/software.html#anchor326873

MacCro - Good Shareware Oscilloscope/Spectrum Analyzer:
http://www.ozemail.com.au/~narge/philip/maccro.html

MacRTA - Commercial- Precise Oscilloscope and Spectrum Analyzer:
http://exo.com/~vesphd/MacSLMPage8.HTML

Canary - Commercial - Very good Spectrogram created for Bioacoustics:
http://www.birds.cornell.edu/BRP/CanaryInfo.html

SoundView - a very good freeware:
http://www.physics.swri.edu/SoundView/SoundView.html

Useful site to check new Macsoftware release:
http://www.versiontracker.com/

The site devoted to "Spectrogram", just for PC:
http://www.monumental.com/rshorne/gram.html

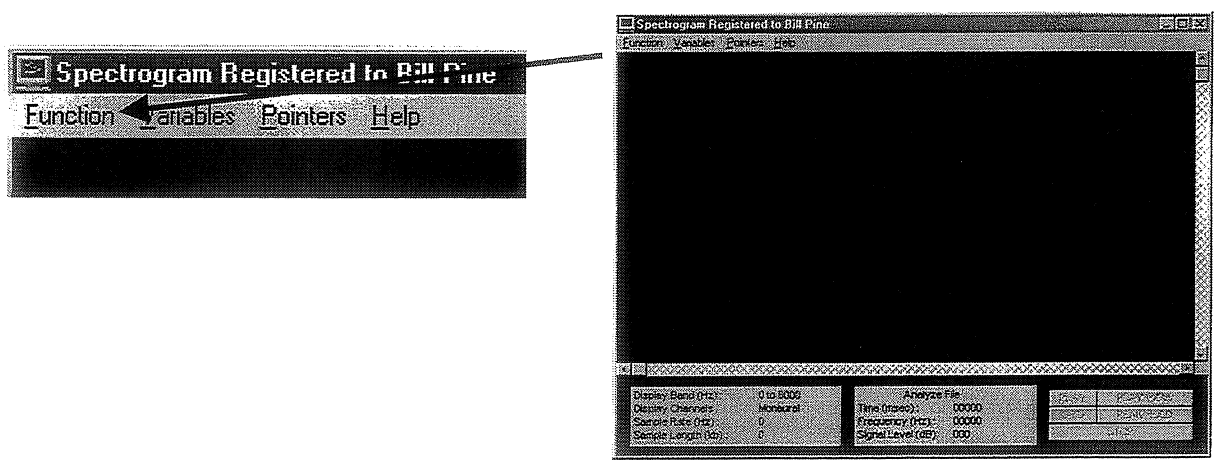
Data Analysis on the PC
Spectrogram version 6.2.3
A Brief Tutorial

by: Bill Pine
The INSPIRE Project, Inc.
Chaffey High School
Ontario, CA

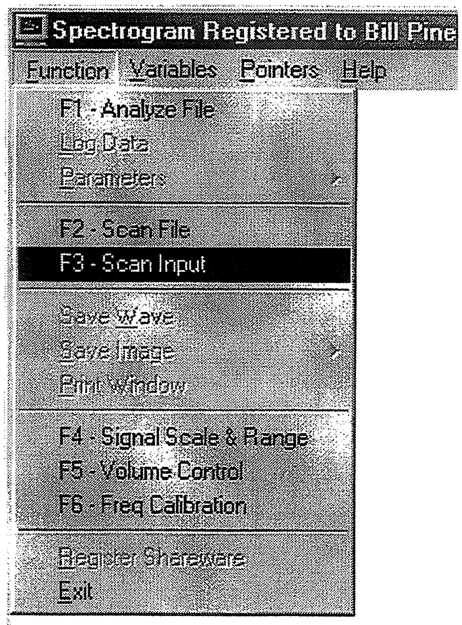
Spectrogram is a program for the PC for creating frequency-time spectrograms. It is ideally suited for analyzing INSPIRE data. The author, Richard Horne, has been a long-time supporter of INSPIRE. In the past he has allowed INSPIRE to distribute **Spectrogram** (or GRAM) to INSPIRE participants. As with many software programs, GRAM has evolved and improved over the years. The latest version is offered as a shareware program over the Internet for $25. Richard Horne is again making this software available at no cost to INSPIRE participants. You will find out how to take advantage of this generous offer at the end of this article.

What I would like to use as a format for this tutorial is the analysis of some actual INSPIRE data from the Coordinated Observations of April/2001. When Robert Bennett submitted his tapes and logs he said, in a note to the author, "You have got to listen to this portion of the tape!" in reference to recordings made from 6 AM to 7:30 AM on April 21. Now Robert is an experienced observer and has recorded many whistlers and other interesting signals from his remote location in the desert near Las Cruces, New Mexico, so when he made a special note about this session, I knew it would be special. I plan to transfer portions of his recordings to CDR and make them available to INSPIRE participants.

So here we go… We start with the opening screen of GRAM.

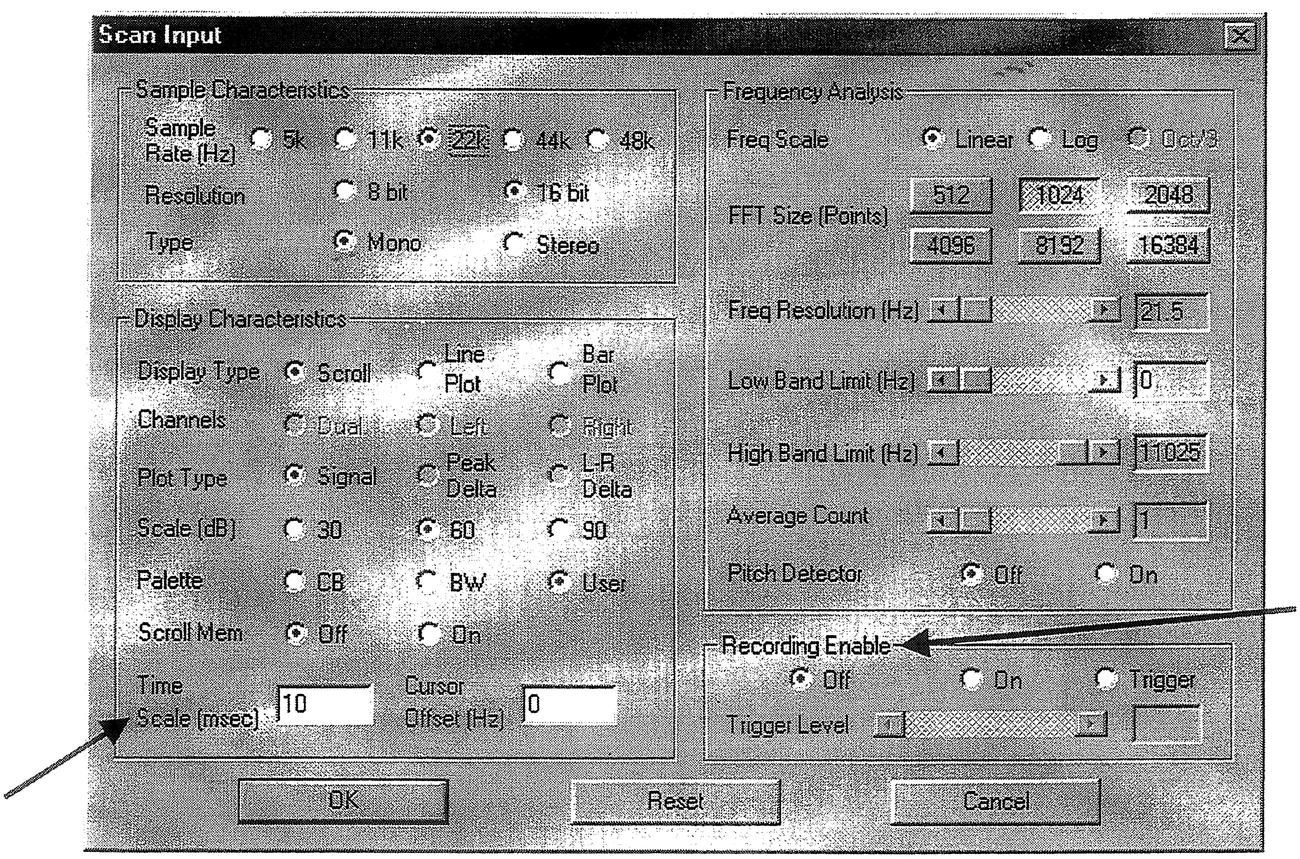


Select **Function**



Select **Scan Input**.

This will bring up the parameters window for Scan Input.

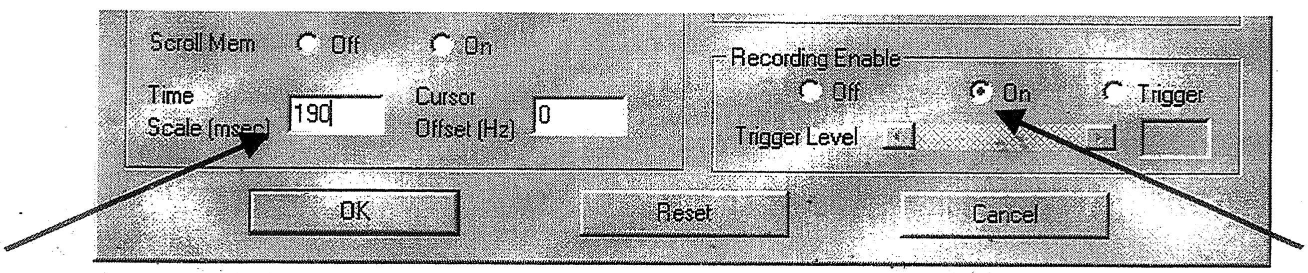


This will give you some idea of the things you can control with GRAM. The important entries for our purposes are Time Scale (msec) and Recording Enable.

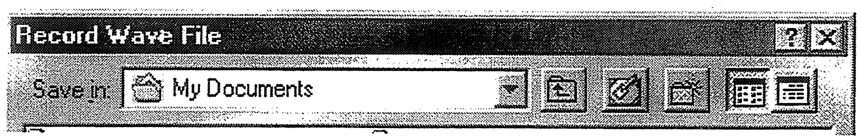
Time Scale (msec) indicates the time between displays of data points. What it really determines is how much time will fit in the GRAM display window. The default value is "10" which allows about 6 seconds to be displayed at a time. The following table shows the display time for various Time Scale settings.

Time Scale Setting	Display Time (seconds)
10	6
16	10
48	30
95	60
190	120

I usually make spectrograms of 2 minutes of a tape at a time. This keeps the .wav file size down and makes the data easier to work with. The default Sampling Rate is 22 kHz (upper left of the parameter window. At this setting you can display frequencies up to 11 kHz (half the sampling rate). A 2-minute .wav file size at these settings will be 5 MegaBytes.

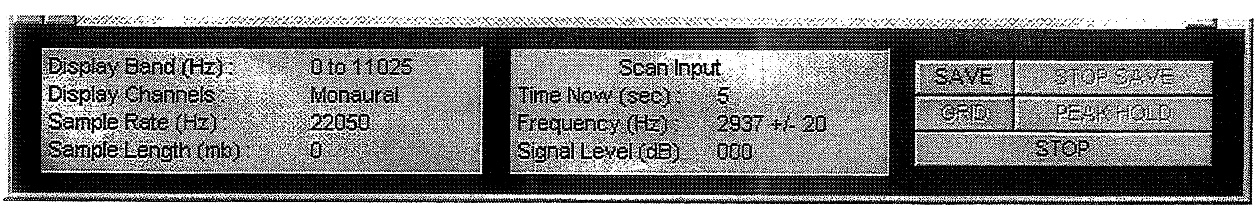


Click **OK** and you will see a directory window:

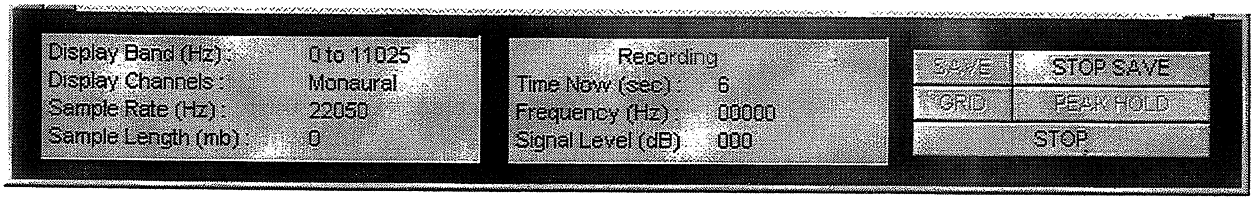


Choose a directory and file name for the .wav file that will be created.

Click **SAVE** and the directory window will disappear and you will se the Scan Input screen. If the tape recorder is playing into the microphone input of the computer, you will see a spectrogram slowly forming from the left edge of the screen. You are not creating a .wav file yet! The bottom area of the screen looks like this:



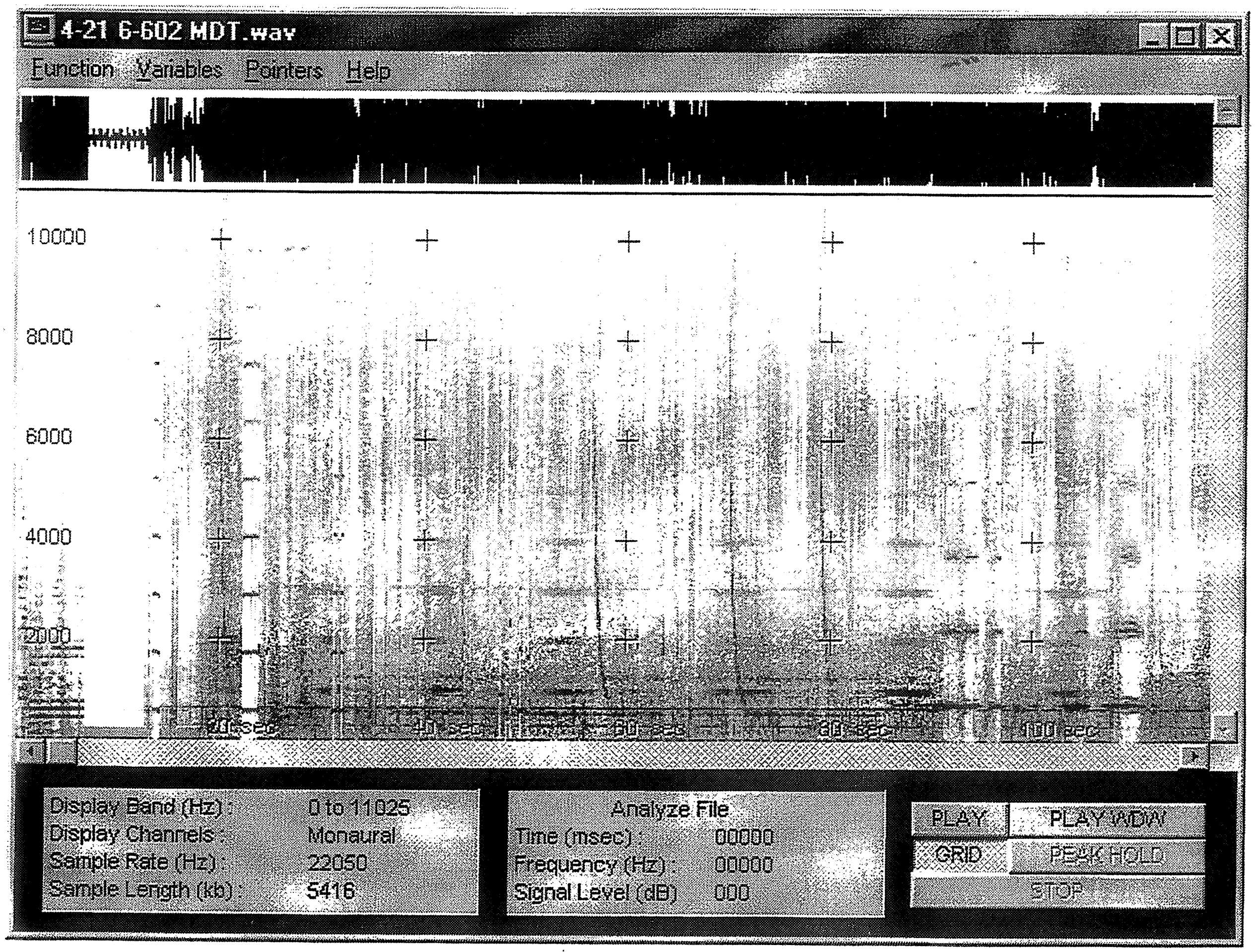
Click on **SAVE** and the bottom of the screen will change to this:



"Scan Input" in the center panel changes to "Recording" (in red) to indicate a .wav file is being created. NOTE: the default setting for Recording Enable is "Off", so if you do not get the **SAVE** option, go back to the Scan Input parameter screen and set Recording Enable to "**On**".

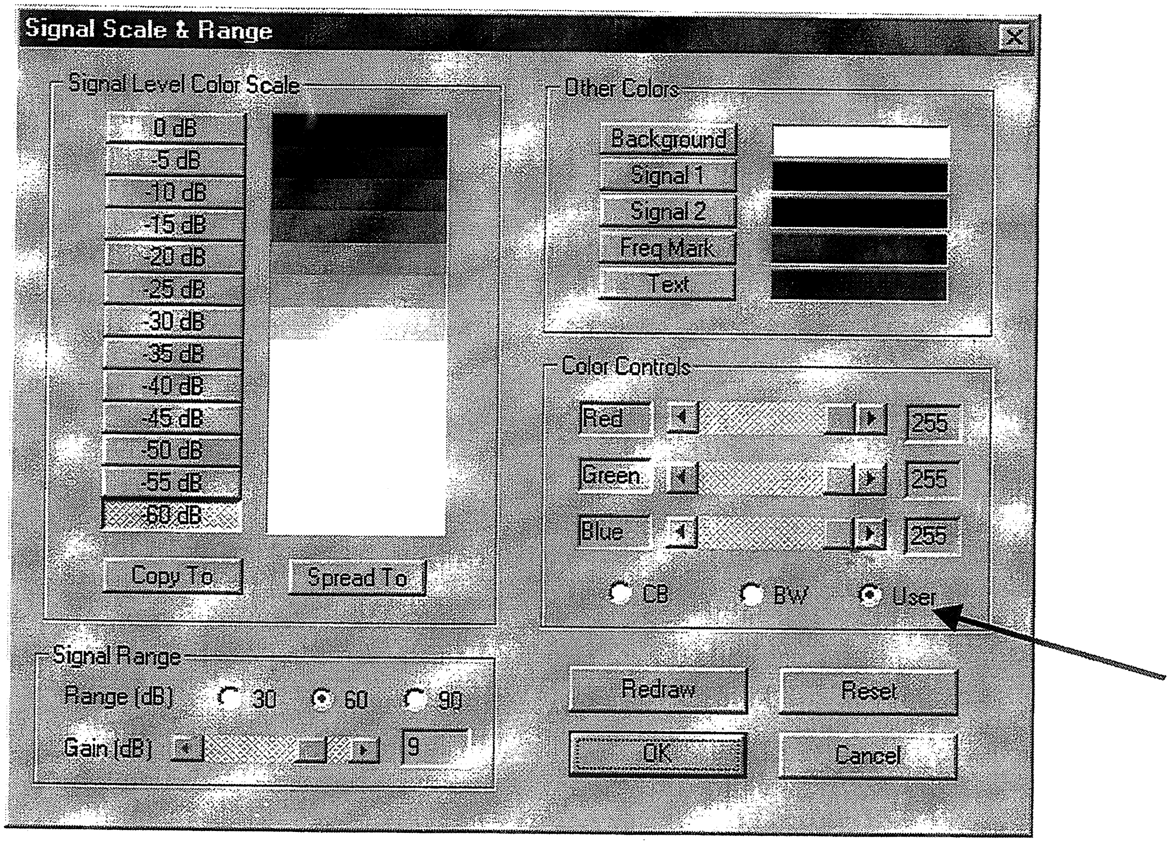
You will see the spectrogram being created as the tape is played. I am using a Radio Shack CTR-117 monaural recorder with the ALC set to "OUT". I use a "Y" connector at the "EAR" jack of the recorder with one output going to the computer and the other to headphones. This allows me to hear the tape and watch the spectrogram being created at the same time.

The following is a spectrogram of the tape from 6 AM MDT to 6:02 MDT. After the file is created, from **Function**, select **Analyze File** and select the **filename** just created. You will see the Analyze File parameter window. Set the Time Scale to **195**, click **OK** and you will see the following.



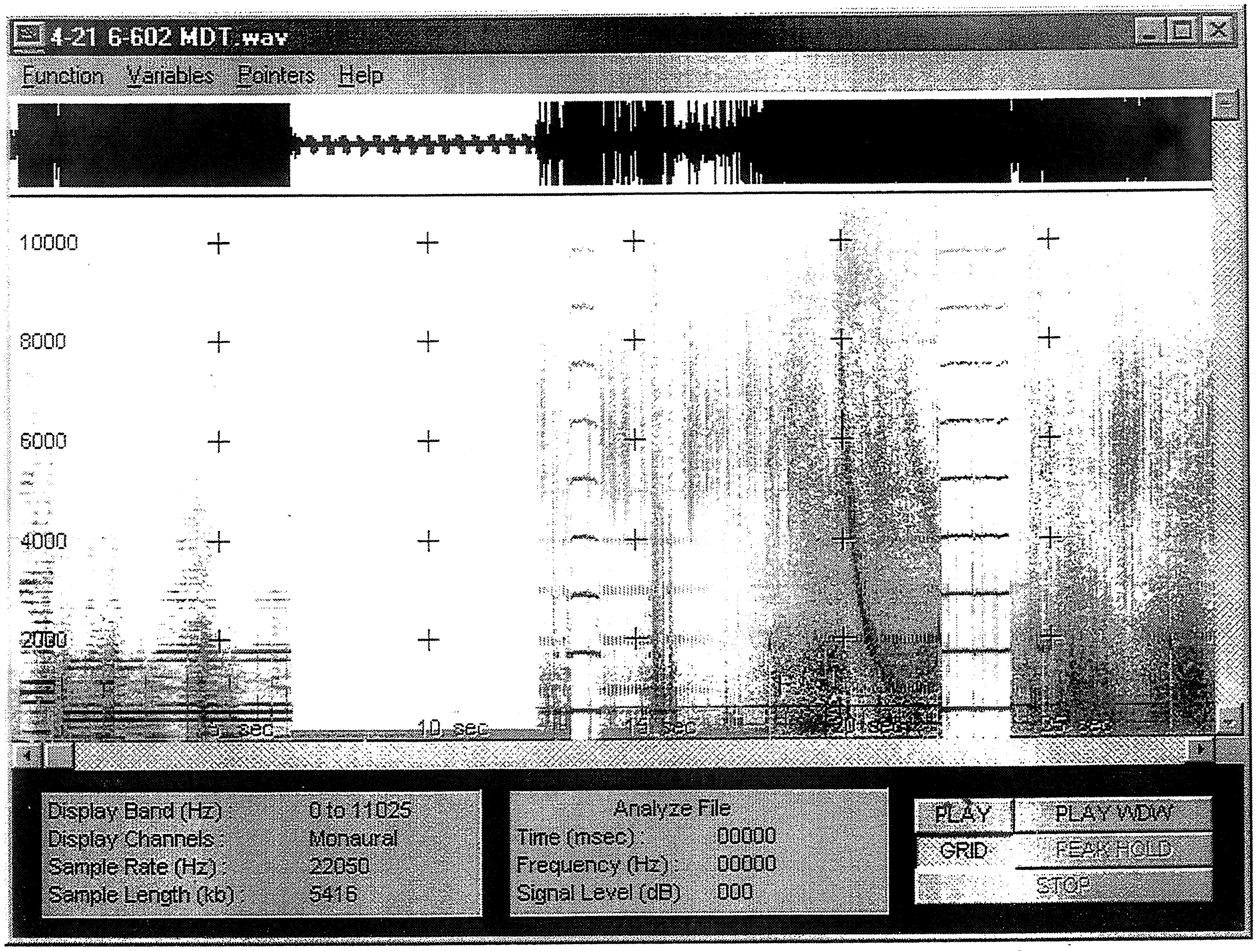
In this view, GRID is turned on showing the frequencies scale at the left and the time scale across the bottom. These grid markings can be hard to read and will not copy well for this article. On my computer screen, I set the color of the grid to red, which makes it easier to see.

The display for GRAM can be in color, or black-and-white. That selection is made using **F4** or **Function**, then **Signal Scale and Range**.

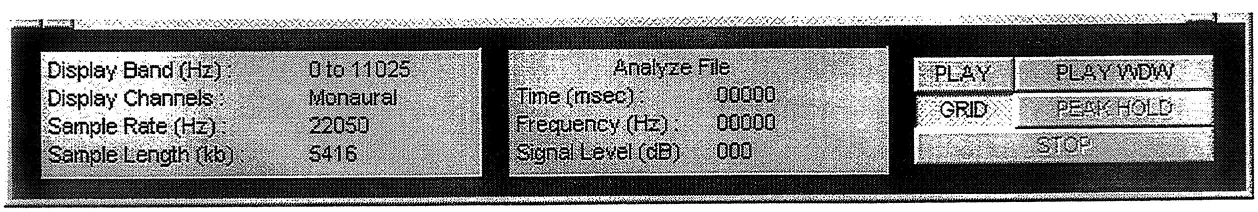


If you select User, you can customize the display. This shows the Signal Scale and Range panel I have created. I found that when using the default **BW** settings the spectrograms were very dark. By setting levels below 30 dB to "white" and using the gray scale above 30 dB, I get the spectrograms in this article. Setting Text to "red" gives the red grid and scale markings. You can experiment with the settings while you are scanning input and watch the changes happen on the spectrogram as it is being created.

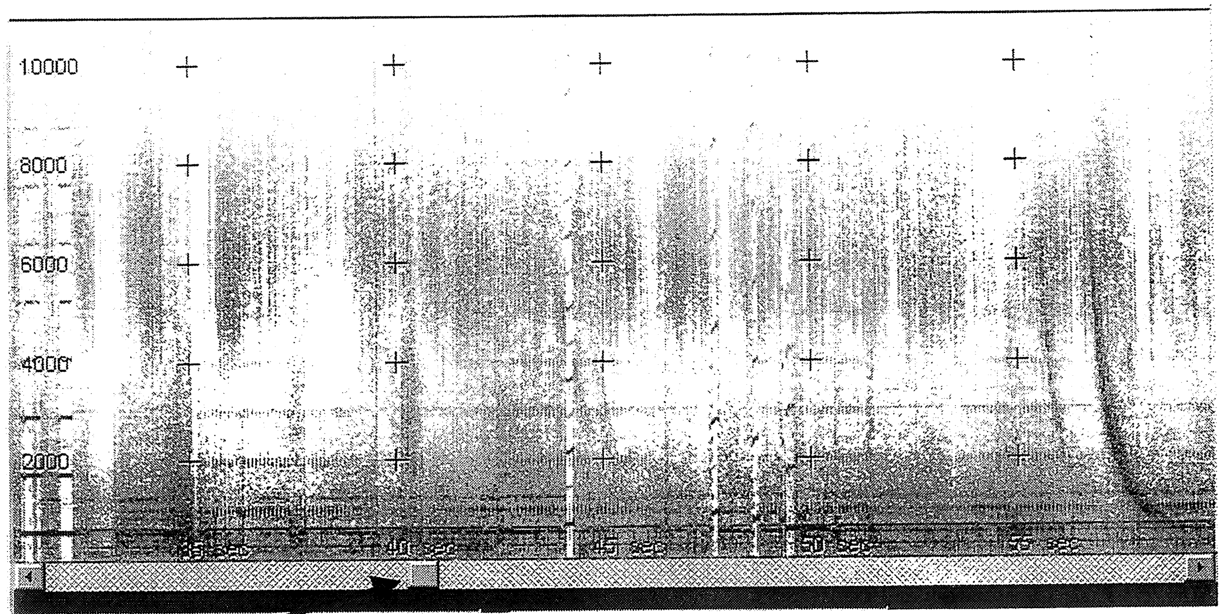
Whistlers (and there were many in the two minutes!) are not easy to see in the 2-minute display window. For a closer look at part of the spectrogram, go to **Parameters**, then **Change** and change the Time Scale to **48**, which will show a 30 second window. The 2-minute file is shown in 30-second segments next. Some of the screens have been trimmed to save space. Whistlers are easy to see in this display.



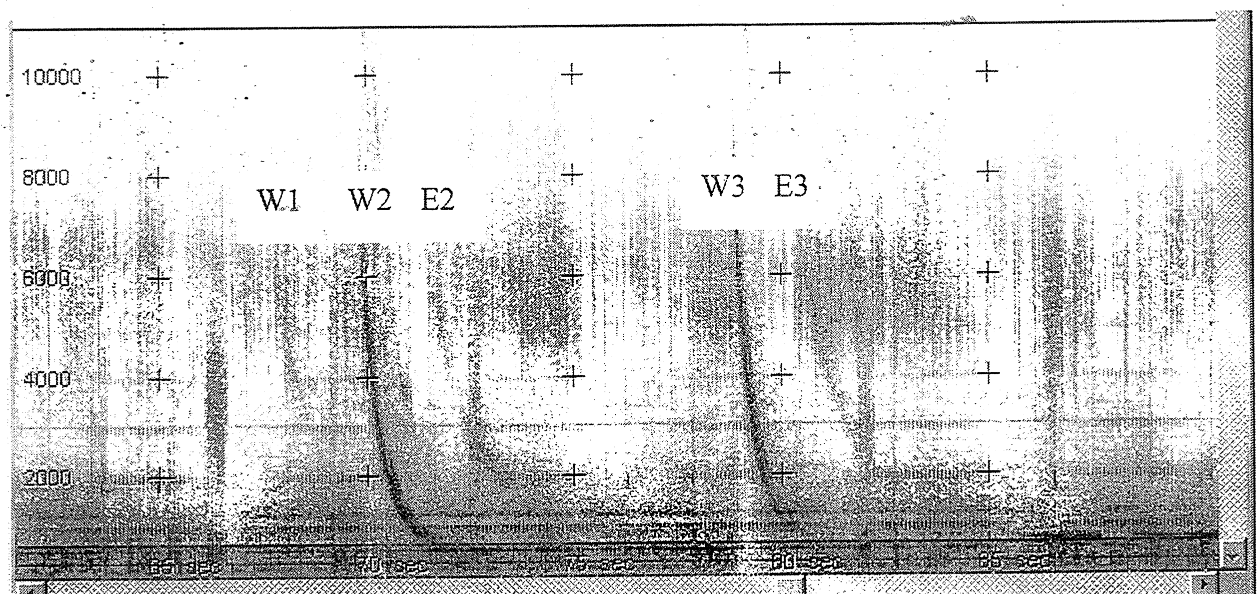
This is the first 30 seconds. You can use the PLAY button to play the entire file or the PLAY WDW button to play the part of the file that is displayed. The file starts with the 0600 WWV (1200 UT) tone. Notice that there is a gap from about 7 to 12 seconds as the cable was being transferred and some oscillation at about 13 seconds and 22-24 seconds as levels were being adjusted. A strong whistler appears at 20 seconds followed by an echo that is lost in a brief time of oscillation.



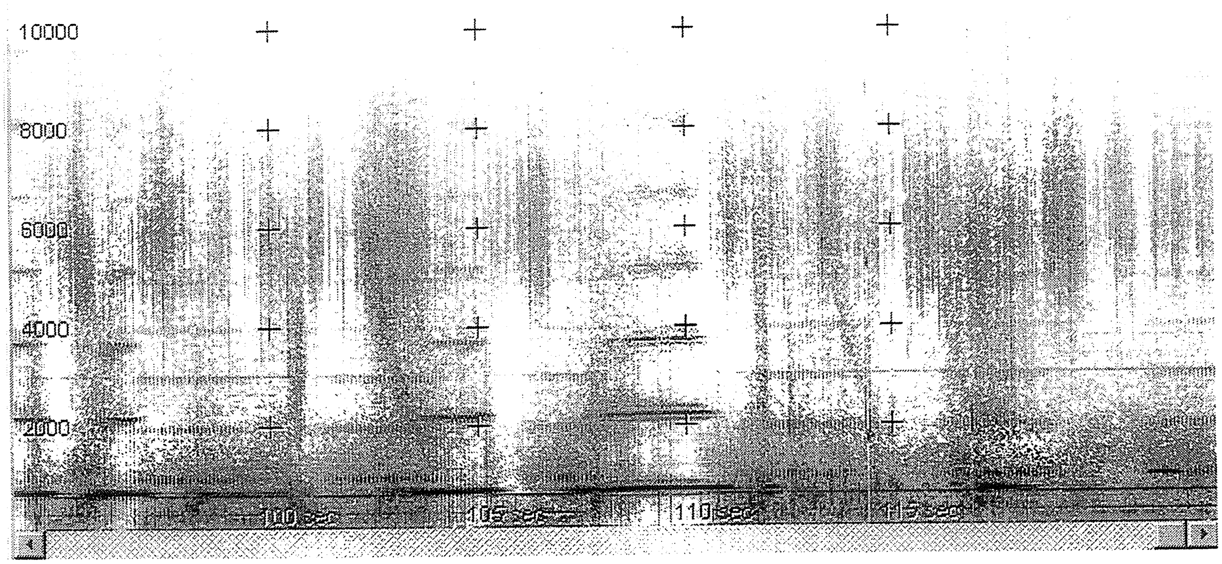
The bottom left panel shows information about the file. Notice that the entire file length is shown (5416 kBytes) even though only part of the file is displayed. The center panel shows the position of the cursor as it is moved by mouse to various parts of the display.



Use the slider below the spectrogram to move to the next 30 seconds of the file. A strong whistler appears at about 56 seconds preceded by a weaker one. A couple of weak ones appear at 45 seconds.

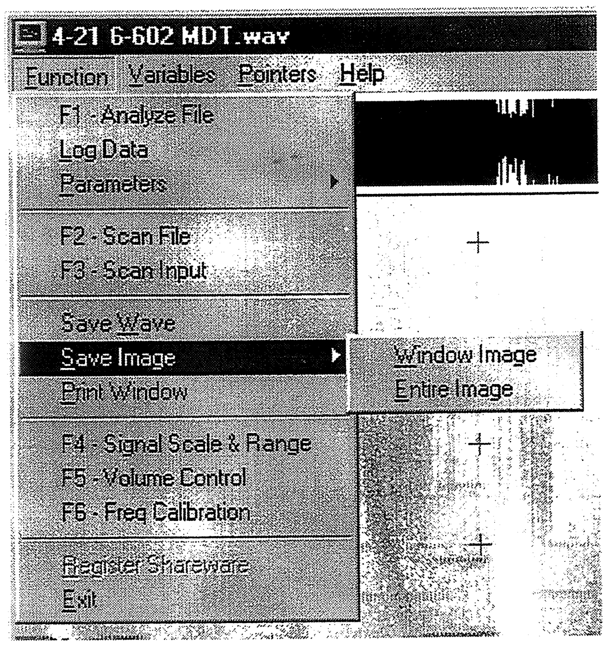


Time 60 to 90 seconds. Whistlers are labeled. W1 is weak. W2 is strong with an echo E2 following. W3 is strong with an echo E3 following. Note how the echoes follow the whistlers by the same amount of time and the shape of the echo is less steep indicating more dispersion resulting from the extra round trip in the magnetosphere.



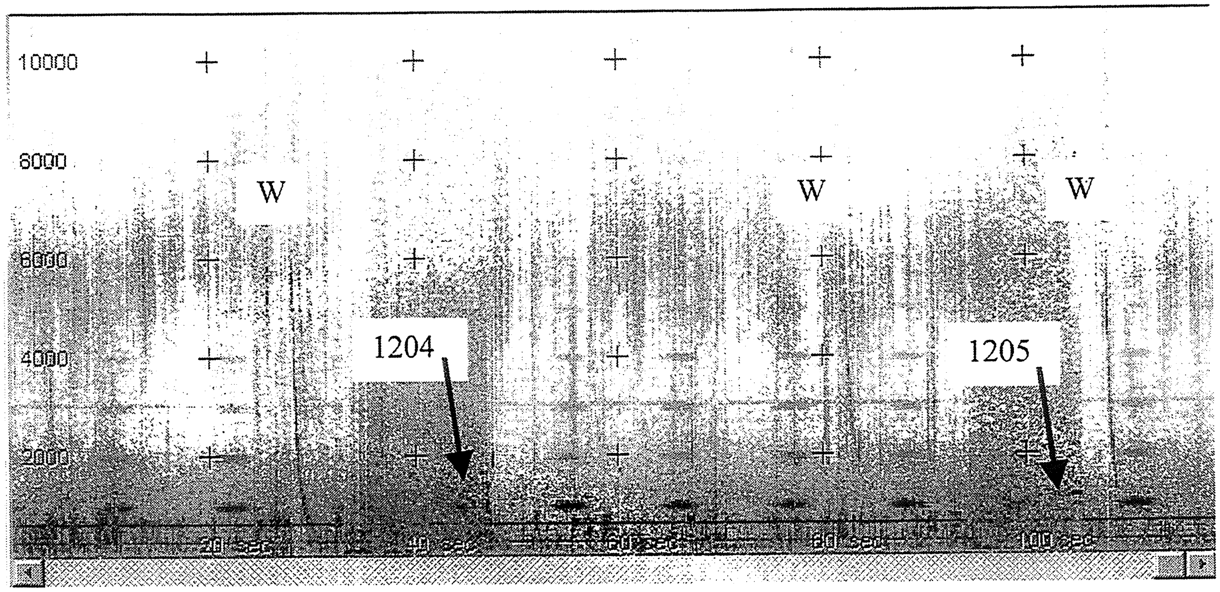
Time 90 seconds to 120 seconds. A couple of good whistlers are seen at 103 seconds and 114 seconds. The series of horizontal lines are from a strong LORAN signal at about 1 kHz and several harmonics of the signal. On the tape this sounds like a loud ringing.

To save images of the spectrogram you can use the **Function** menu from the main screen.

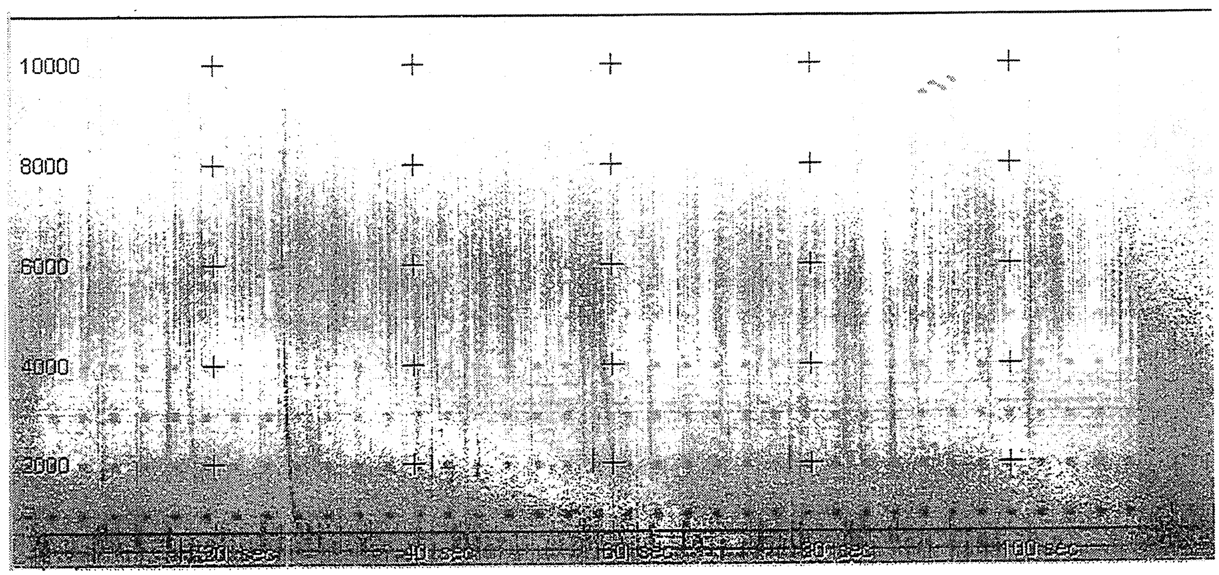


Select **Save Image** and then either **Window Image** or **Entire Image**. You will then be prompted to choose either **jpeg** or **bitmap** format and for a filename and location to put the file. Once saved the image can be inserted in a document and sized and cropped.

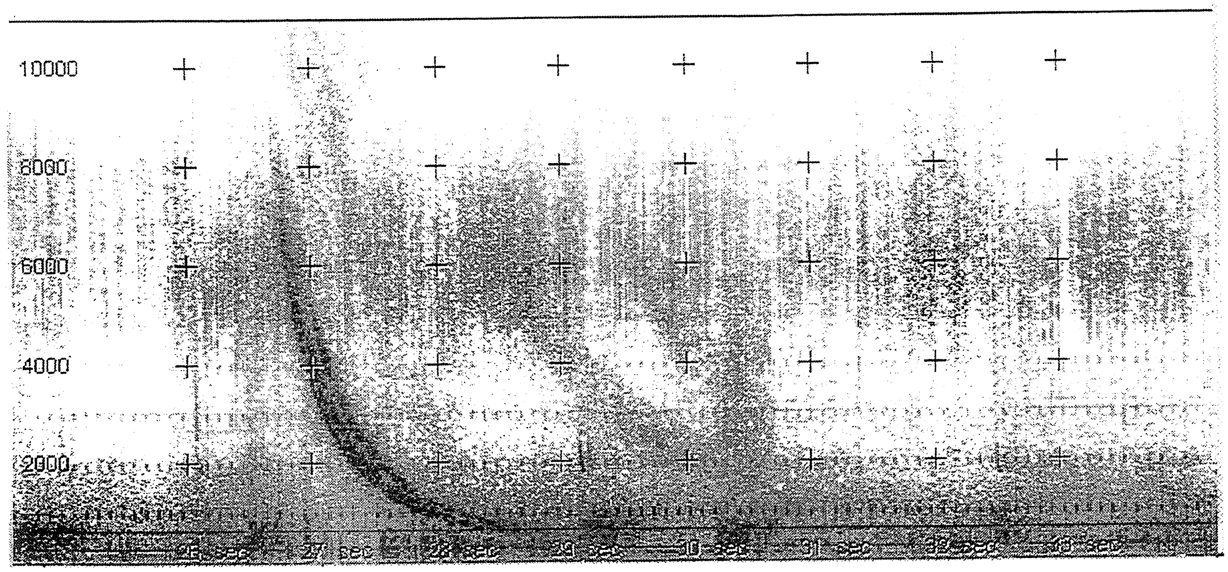
For this article, I have been using the Print Screen keyboard option (**Alt + Print Screen**) to place a screen image on the clipboard. It can then be pasted, sized and cropped any way you want. Print Screen copies an image of the GRAM screen, not the entire computer screen.



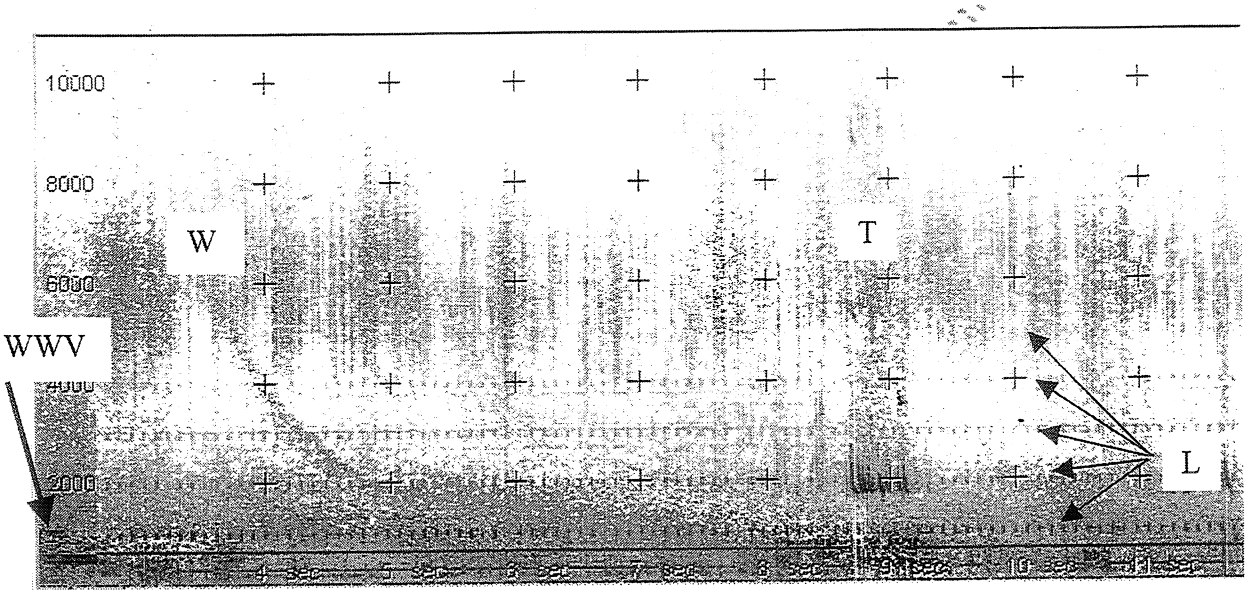
WWV time marks of 1024 UT (6:04 MDT) and 1205 UT are indicated. Even with 2 minutes displayed in the window, several whistlers are evident (W).



This file starts at 1207 and ends at 1209. A strong whistler appears at 25 seconds.



The Time Scale setting was changed to "16" making the display 10 seconds. The strong whistler (26.5 s) is followed by another (27 s) with echoes of each (28.5 s and 29.5 s). Notice that the whistler extends well below the tweek cutoff frequency of around 2 kHz. This indicates that the whistler arrived in the lower atmosphere near to observing site and was not ducted there by the Earth-ionosphere waveguide that would have cut off the portion of the whistler below 2 kHz.



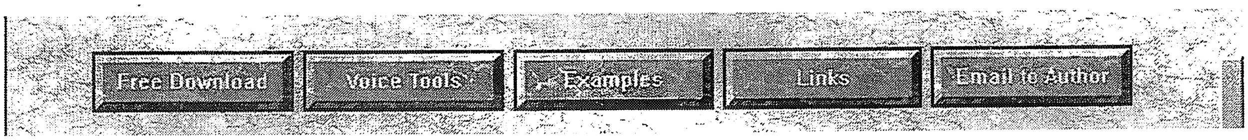
The first 10 seconds shows the WWV tone at 1207 UT, a good whistler (W) and a burst of tweeks (T). LORAN signals (L) appear as horizontal rows of dots and sound on the tape like a rapid series of clicks.

With the Time Scale set at **10** I played the file and watched the spectrogram roll by. In the 2 minutes I counted 11 strong whistlers, 2 echoes (described above) and 4 weak whistlers that were seen on the spectrogram but not heard. Robert Bennett certainly hit a gold mine of natural radio on the morning of April 21, 2001.

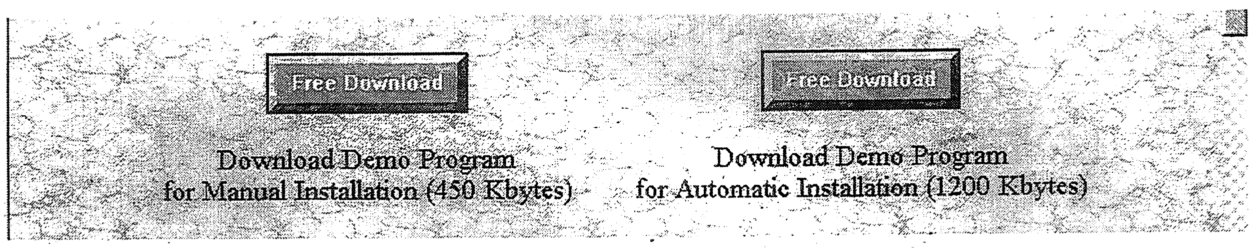
GRAM does an admirable job of analyzing the data. This latest version is a quantum leap ahead of previous versions and is being offered as shareware for $25. Go to:

http://www.visualizationsoftware.com/gram.html

Near the bottom of the opening screen, select **Free Download**.



I recommend the Automatic Installation option. GRAM installs in about a minute.



The free download gives you a version of the program that will work for 10 sessions. To get a permanent version, you need a User Name and User Key. To get these, send an email to Richard Horne at:

rshorne@mnsinc.com

Indicate that you are an INSPIRE participant and the $25 fee will be waived. Richard will send you the necessary information to register your copy of GRAM.

This tutorial was designed to get you started in natural radio data analysis. The capabilities of GRAM are much more extensive than those used for this article. This is an outstanding, user-friendly (and free!) program that will serve your analysis needs well.

INSPIRE COORDINATED OBSERVERS

April/2001

This is the first roster of all who have contributed observations since the end of the Mir-based INTMINS observations. New team numbers have been assigned in two categories: school teams are indicated with an "S"; individuals and non-school related teams are indicated with an "I".

(Unless noted otherwise, all longitudes are West and latitudes are North.)

Team #	Observer	Location	Longitude/Latitude
S-1	Kathryn Robinson. O'Connor High School	Helotes, TX	98° 47' / 29° 35'
S-2	Mark Mueller Brown Deer High School	Brown Deer, WI	87° 56' / 43° 10'
S-3	Elizabeth Quick John Marshall High School	San Antonio, TX	98° 72' / 29° 54'
S-4	Bill Pine Chaffey High School	Ontario, CA	117° 41' / 34° 14'
S-5	Jim Hoback John Jay High School	San Antonio, TX	
I-1	Shawn Korgan	Gilcrest, CO	104° 67' / 40° 22'
I-2	Linden Lundback	Watrous, Sask,	105° 22' / 51° 41'
I-3	Robert Bennett	Las Cruces, NM	106° 44' / 32° 36'

Report on Coordinated Observations 4/2001

By Bill Pine
Ontario, California

The purpose of the Coordinated Observation Program is to provide an opportunity for INSPIRE participants to gather data at convenient times for purposes of comparing the resulting signals and attempting to interpret them. Since there is no manmade source of VLF that is being studied here, the signals of interest are those of natural origin. As in most natural radio listening, we would like to hear something "interesting". Most of the time that would be whistlers, but other sounds such as tweeks, chorus, triggered emissions and even hiss are also interesting. Observing whistlers, however, remains the prize for faithful listening. The problem with whistlers is that they are not the most common natural radio signal. Since coordinated listening schedules are determined arbitrarily and in advance of the listening sessions, it is only a matter of luck if whistlers are available to be detected. The experience of the author is that whistlers are heard about once every four or five morning sessions. When they are present, you will probably hear a lot of them until the rotation of the earth carries the ducting magnetic field lines into an unfavorable alignment.

Conditions during April/2001 were mixed. Some observers were treated to an abundance of whistlers. This was especially true for those observers who listened earlier than just at the 8 AM and 9 AM times. When whistlers are present, it is more likely that they will be heard the closer to dawn that you observe. The following report includes sample spectrograms from contributing observers.

The following tables summarize the sessions monitored by observers.

Date	4/21					4/22				
Time	1200	1300	1400	1500	1600	1200	1300	1400	1500	1600
Team										
S-1										
S-2										
S-3	C									
S-4									P	P
S-5		C	C							
I-1										
I-2		C	C	C	C		C	C	C	C
I-3	M	M	M	M						

Date	4/28					4/29				
Time	1200	1300	1400	1500	1600	1200	1300	1400	1500	1600
Team										
S-1	C	C	C							
S-2		C	C							
S-3										
S-4				P	P				P	P
S-5		C	C							
I-1						M	M	M	M	
I-2							C	C	C	C
I-3	M	M	M							

Times indicated are UT times.
The letter in the box indicates the time zone of the observer:
E = EDT = UT– 4, C = CDT = UT – 5,
M = MDT = UT – 6 and P = PDT = UT – 7

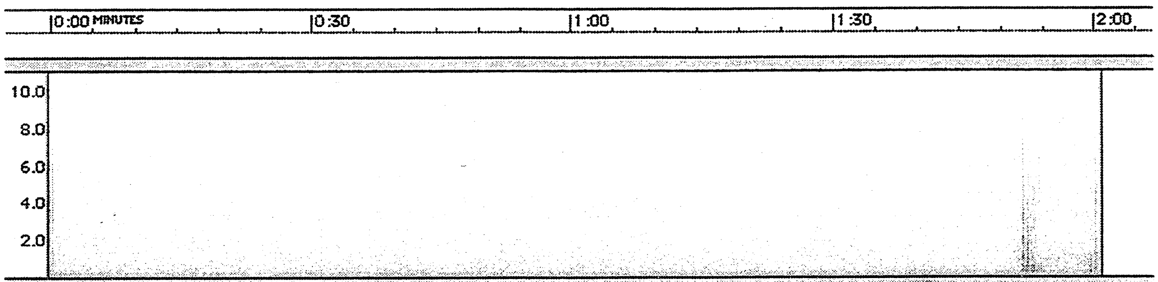
Observers:	Team S-1	Kathryn Robinson, O'Connor High School Helotes, TX	(CDT)
	Team S-2	Mark Mueller, Brown Deer High School Brown Deer, WI	(CDT)
	Team S-3	Elizabeth Quick, John Marshall High School San Antonio, TX	(MDT)
	Team S-4	Bill Pine, Chaffey High School Ontario, CA	(PDT)
	Team S-5	Jim Hoback, John Jay High School San Antonio, TX	(MDT)
	Team I-1	Shawn Korgan, Gilcrest, CO	(MDT)
	Team I-2	Linden Lundback, Watrous, Sask,	(CDT)
	Team I-3	Robert Bennett, Las Cruces, NM	(MDT)

For analysis purposes, a spectrogram was made of the first two minutes of each 12-minute hourly session. Additional spectrograms were made of any items of interest and of any segments requested by the observer. Time marks were placed on the tape every two minutes and a complete log was made of each session.

4/21/01 1200 UT

The first report on April 21 comes from John Marshall High School in San Antonio, Texas. Marshall High is the home of the "Thundering Rams" and they have adopted that name for their INSPIRE team. At 7:00 AM CDT the team was in place and observing. The team consisted of Elizabeth Quick, Physics teacher, and Paul Nolasco, Matt Fischel, Philip Vincent, Sarah Schott and Kevin Phipps.

The Thundering Rams fell victim to the INSPIRE corollary of Murphy's Law: Murphy goes on every trip! The team did a great job on the time marks and logging even though they heard not much more than sferics at low intensity levels. Unfortunately, no signal appears on the recorded tape. Below is a spectrogram of the first 2 minutes of the session.



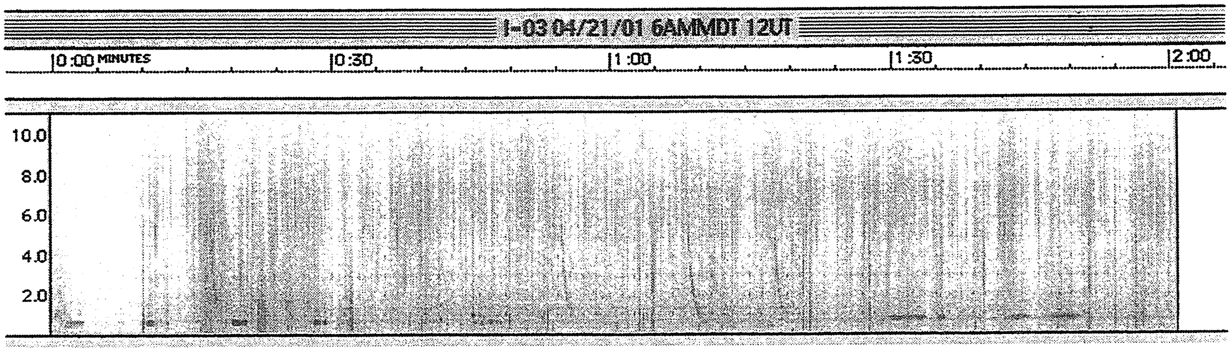
All that appears on the spectrogram is a voice print of Sarah Schott saying "12:02 Mark".

Sarah also provides an amusing narrative of the Thundering Rams' day of observing.

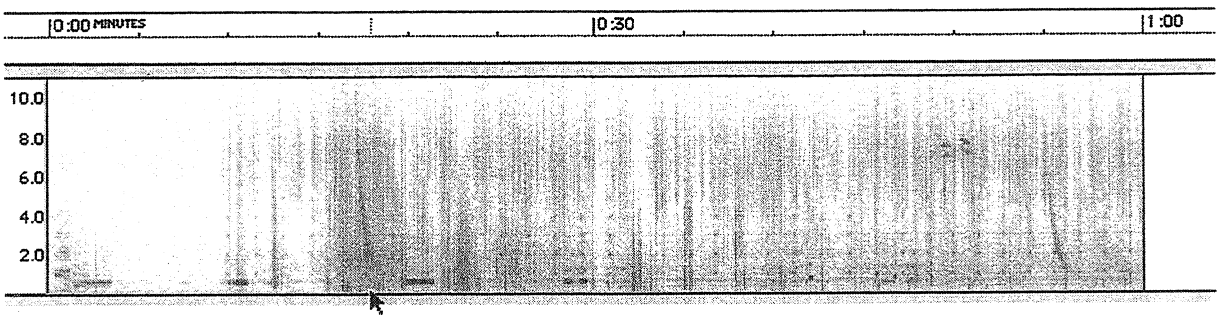
Donuts, Orange Juice, and Radio waves

John Marshall High School students and teacher set out on an adventure to collect radio waves on Saturday, April 21. Sarah Schott, Matt Fischel, Philip Vincent, Paul Nolasco, and their "fearless" leader Mrs. Elizabeth Quick started at 6:15 in the morning and brought along guest listeners Sarah Vincent (Philip's sister), Kevin Phipps (a fellow physics student), and Dr. Ralph Hill from Southwest Research. The adventure started when all tried someewhat successfully to awake to the sound of our noisy alarm clocks. Trying to wake up eight physicists at the crack of dawn on a Saturday morning is quite a difficult task. We met at Taft High School, at 6:30 precisely, then proceeded to approximately two and a half miles due west of San Antonio. Along our paved path to the middle of a wooded area we came upon a large tree strewn straight across our path. Sadly believing we would have to turn away from our perfect listening location, Matt Fischel came to the rescue. Jumping quickly from his truck, Matt lifted and moved the large tree with help from Paul Nolasco. Muscles bulging, sweat dripping from their foreheads, the two boys carried our intrusive obstacle away. As the rest of us got back into our cars, what did we come upon but an ox (funny that we live in Texas!). A large, black, mean bull stood about ten feet away. Most of us started shrieking and screaming except for Philip's older sister Sarah. The brave girl ran towards the bull flailing her arms. The poor bull was more scared of us than we were of it. We were relieved to witness the ox leave so quickly. When we finally arrived at our listening sight, we all helped to set up our equipment. Philip Vincent recorded our introduction. We all took turns marking time, listening to and observing the radio waves, and recording our data. We heard mostly spherics, although we were hoping for whistlers. Our INSPIRE team, the "Thundering Rams", recorded data for two intervals of twelve minutes. As we sat to eat donuts and drink orange juice, we smiled as we recalled the fun we had building the receiver. We just couldn't wait to help the new INSPIRE team next year.

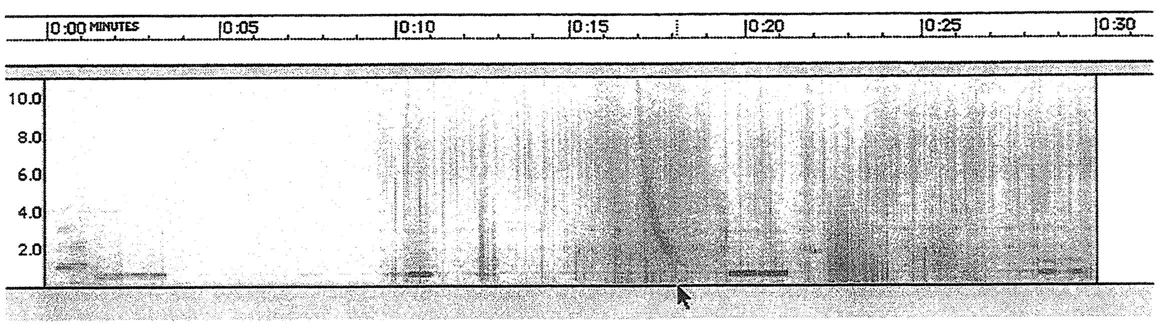
In Las Cruces, New Mexico, Team I-3, Robert Bennett was hearing quite a bit of activity.



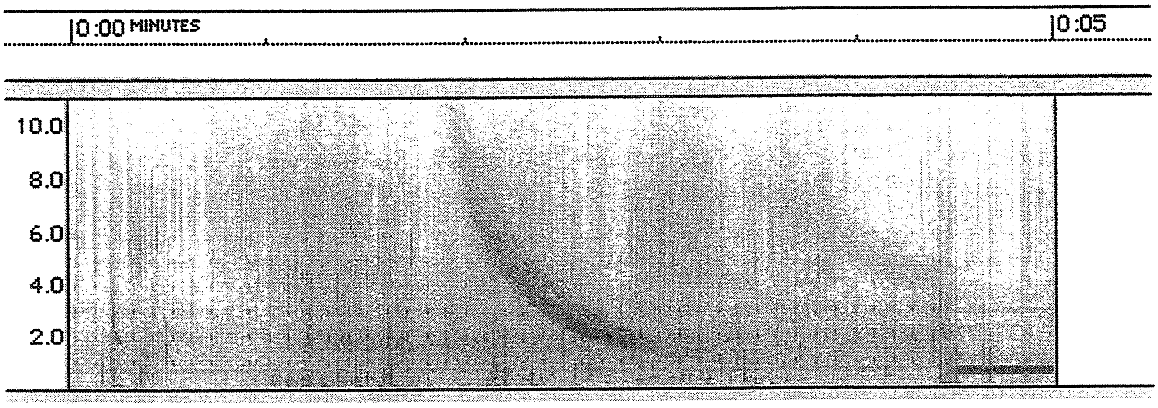
There are some intermittent tones of unknown origin below 1 kHz. LORAN is present. Virtually no power line hum audible. Strong whistlers. Another example of outstanding natural radio data, Robert!



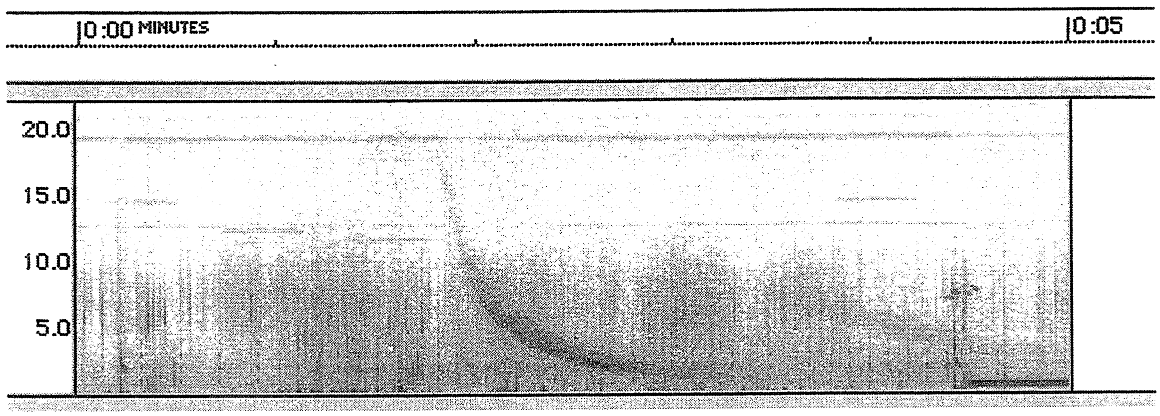
The arrow points to a whistler in the first 30 seconds.



Same whistler.



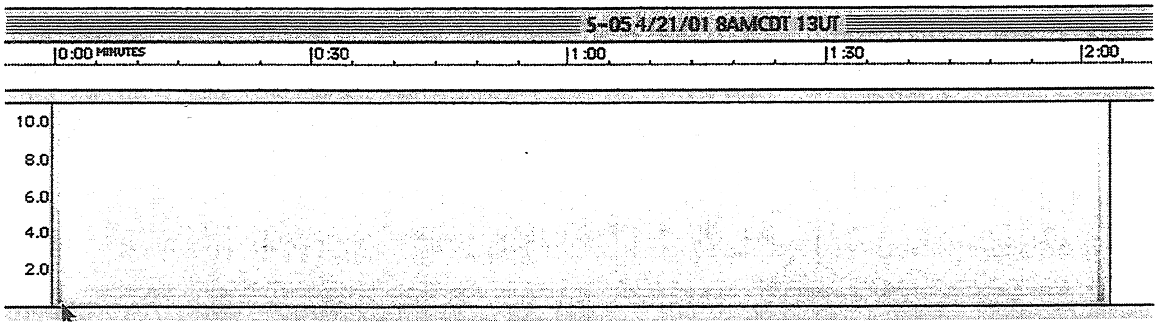
Closeup of the whistler and its echo.



I decided to increase the frequency range to 22.05 kHz to see what the top of the whistler looks like. ALPHA tones are visible (but not audible to these old ears!) and what is probably a communication signal below 20 kHz. The whistler starts at about 18 kHz.

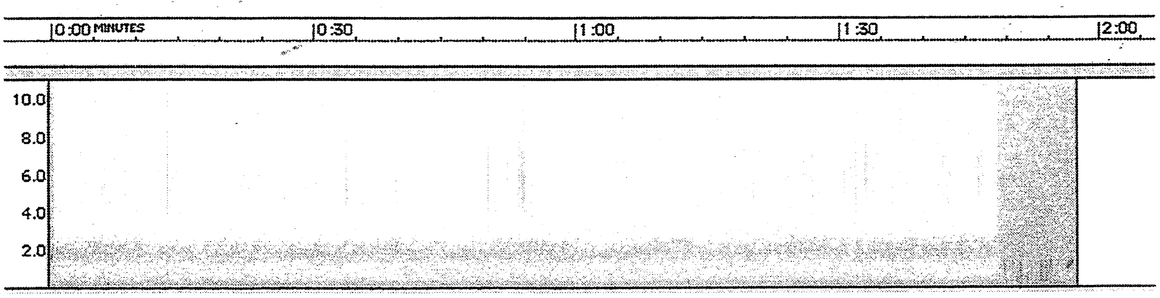
4/21/01 1300 UT

Jim Hoback of John Jay High School in San Antonio, Texas, and his students observed on April 21. The session was plagued by the constant presence of a strong commercial radio station. I have heard intermittent signals from commercial stations occasionally on tapes submitted by observers, but never this strong or continuous. The techniques of this team were good, but the result, unfortunately, was no natural radio.

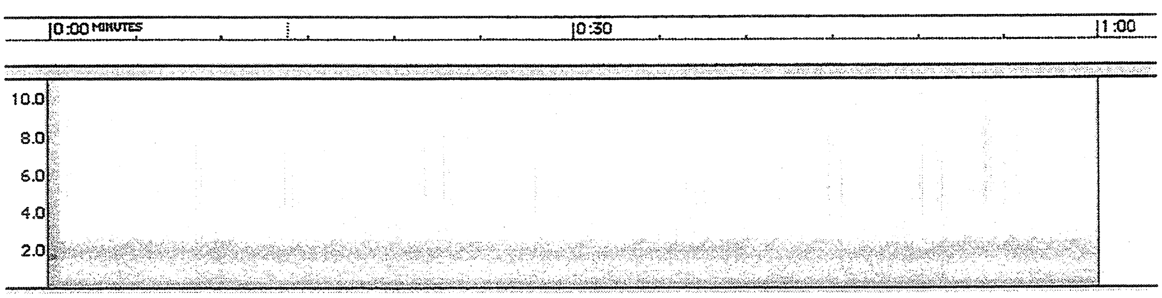


The arrow points to a voice print of the time mark "8 AM". A similar mark at "8:02" appears at the end of the spectrogram.

Linden Lundback and Brian Cowan in Watrous, Saskatchewan, CANADA, had quiet conditions with some sharp, clear sferics and persistent chorus. Chorus seems to be very common at their latitude.



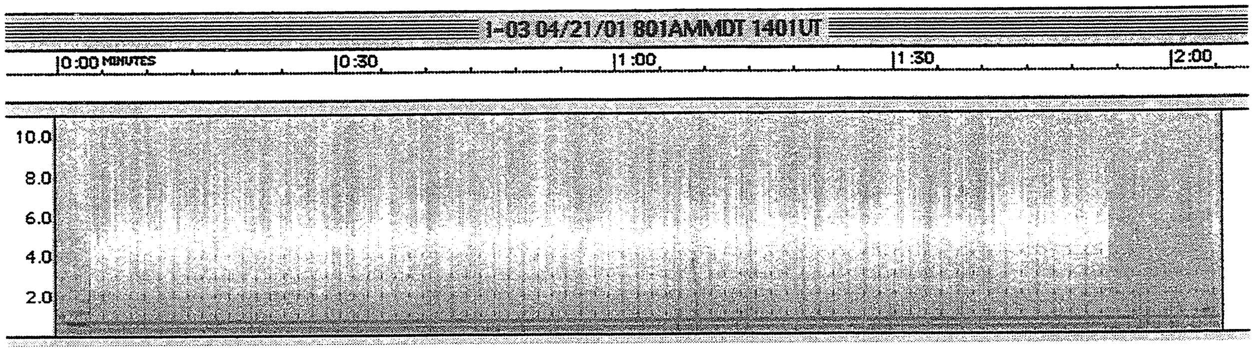
The first two minutes.



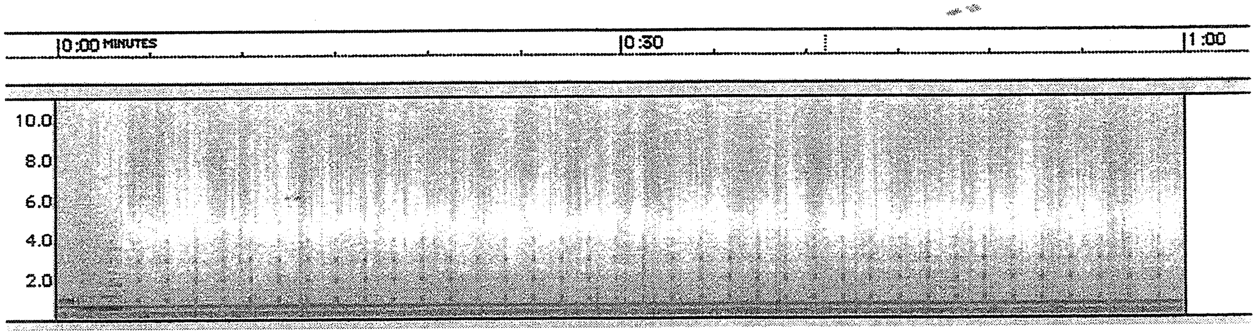
The first minute.

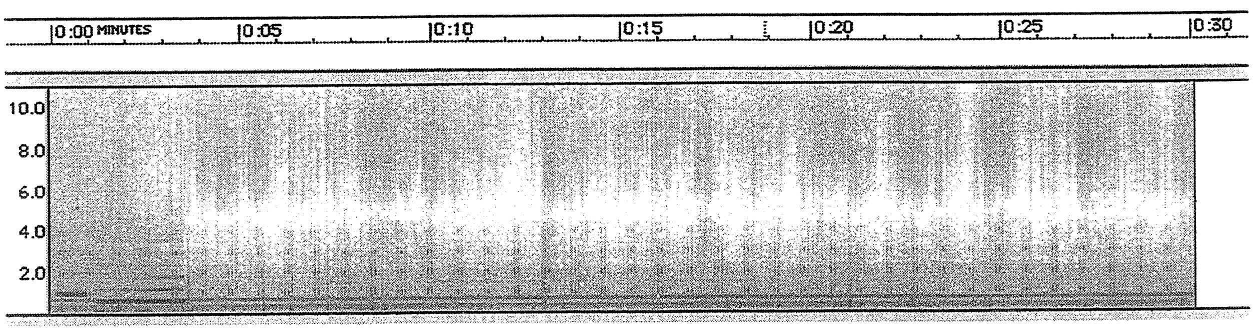
4/21/01 1400 UT

At 1400 UT we return to New Mexico and Robert Bennett. Robert changed to a long wire antenna, so the sensitivity was increased. That resulted in the appearance of a low level hum band at the low frequencies and the appearance of strong sferics. LORAN signals appear on almost all of Robert's data and can be seen as a vertical series of marks occurring at regular intervals of a little less than a second.



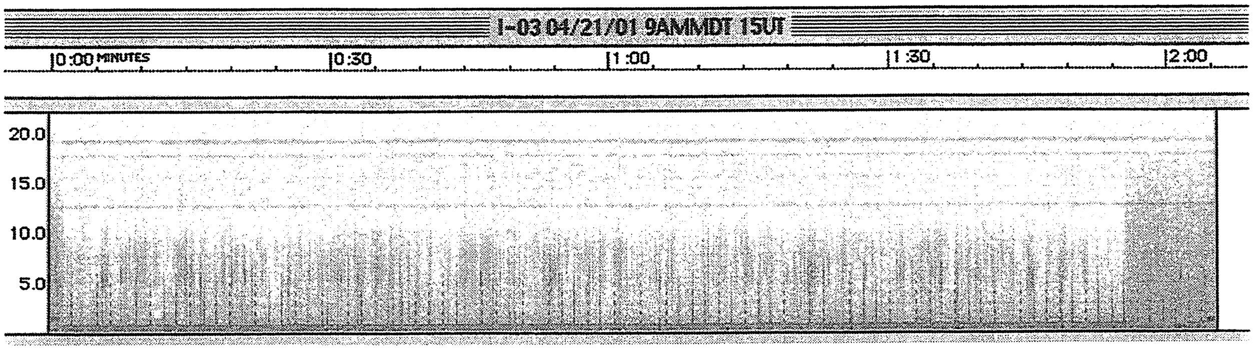
As noted in his log, hum is more pronounced, but still well out of the way of the action.



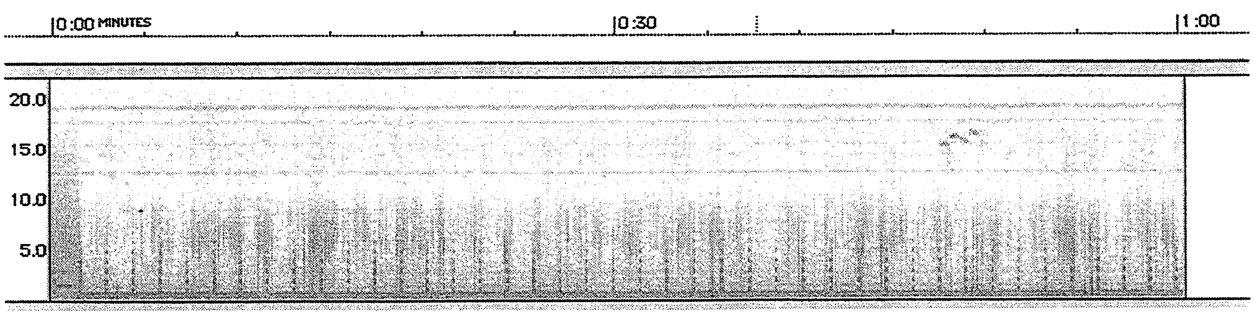


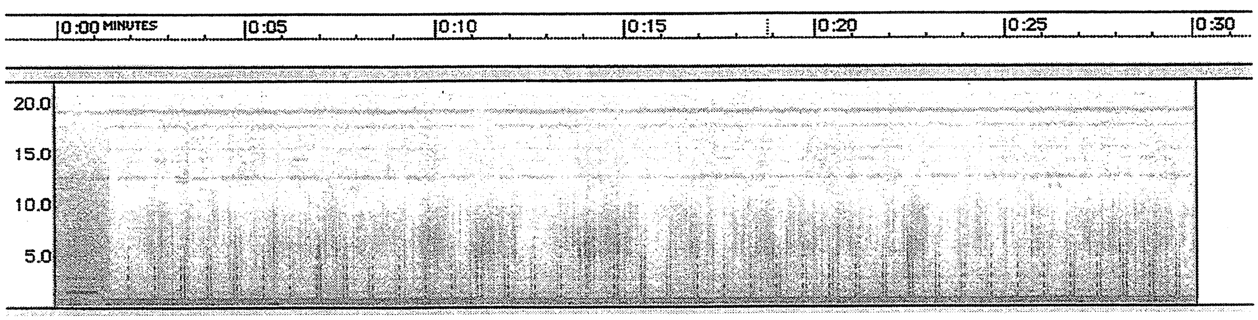
4/21/01 1500 UT

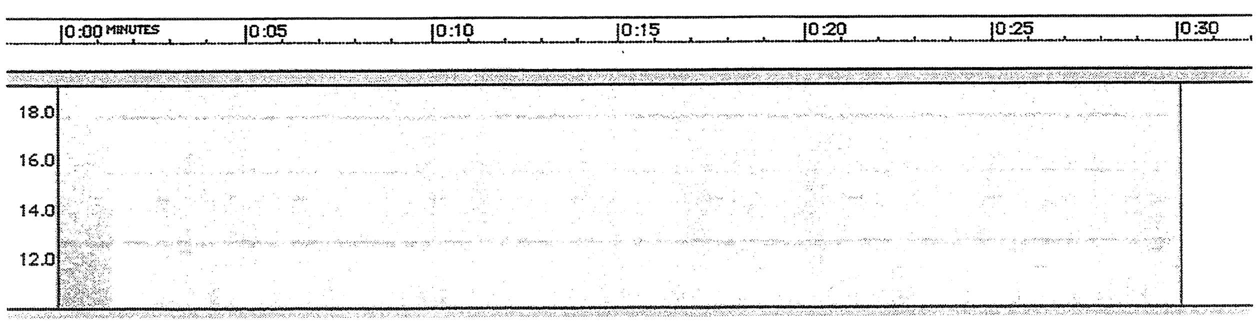
Robert Bennett, Las Cruces, New Mexico.



The full 0-22 kHz frequency range is show to include the Alpha navigation signals between 12 kHz and 15 kHz. A continuous signal just below 20 kHz is also present. A 60 Hz hum band appears at low frequencies.



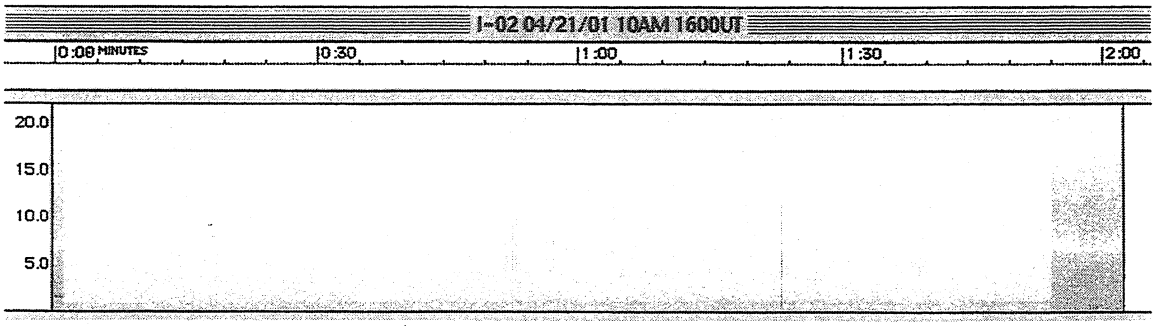




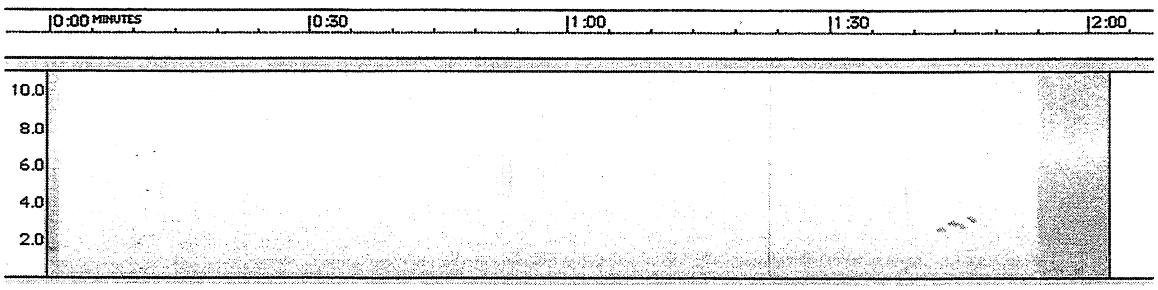
A close up of the range from 10 kHz – 19 kHz showing ALPHA and the carrier at about 18 kHz

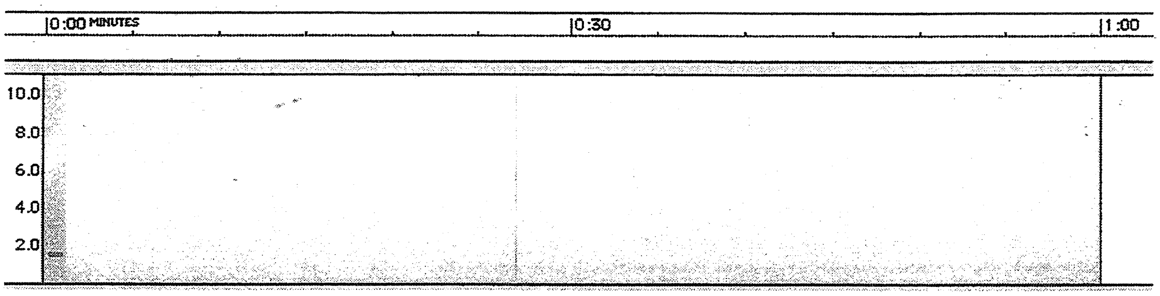
4/21/01 1600 UT

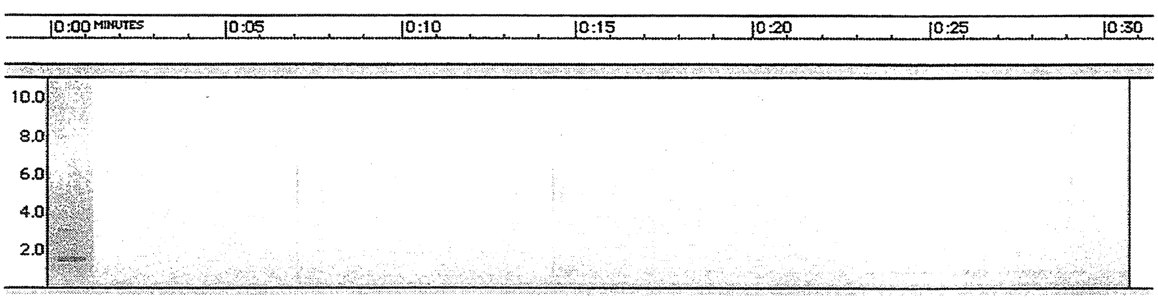
We finish April 21 back in Canada with Linden Lundback and Brian Cowan.



Activity has quieted down significantly from earlier in the day.

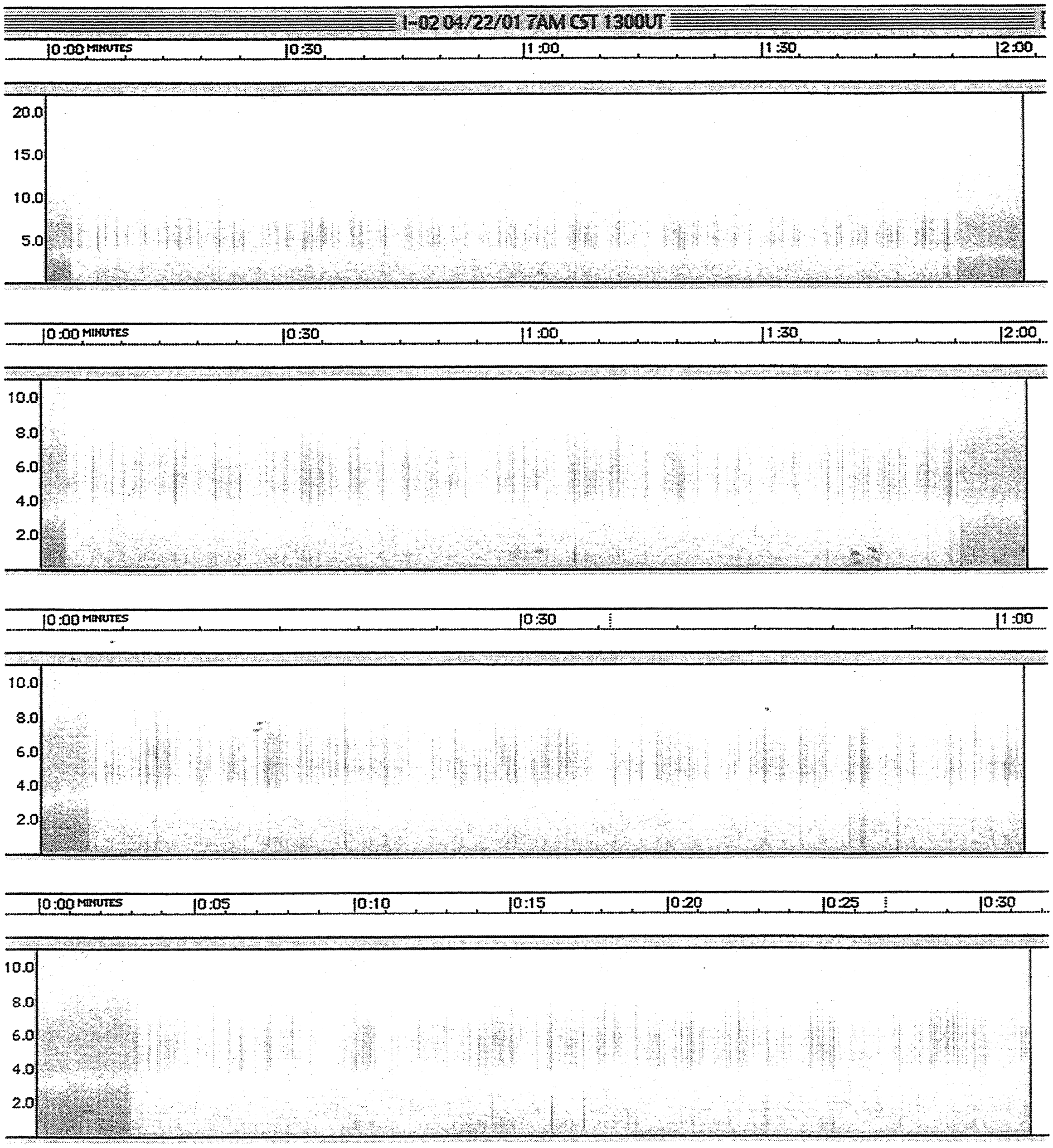






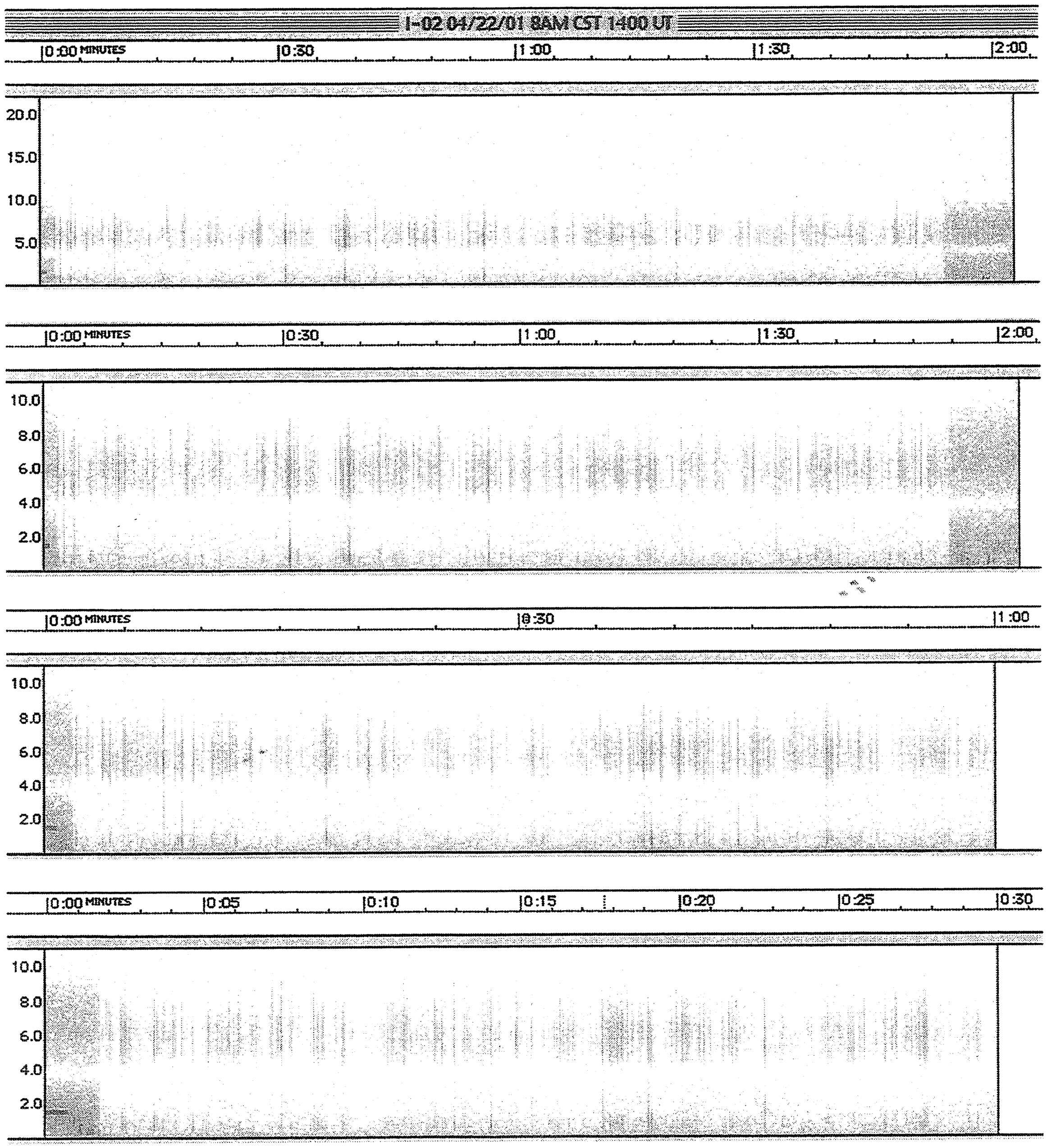
4/22/01 1300 UT

We start April 22 in Canada with Linden Lundback and Brian Cowan. Strong, dense sferics predominate.



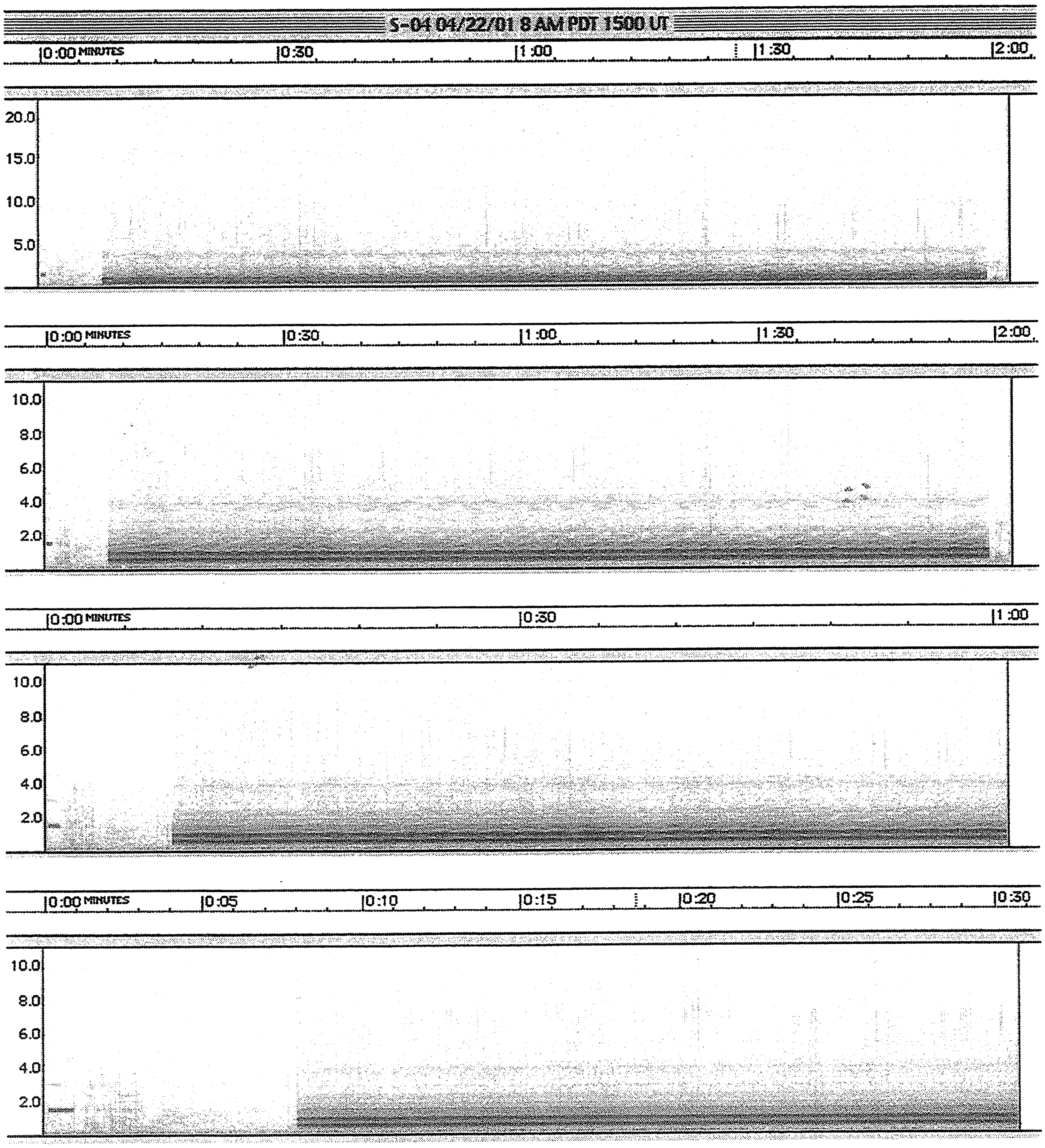
4/22/01 1400 UT

Still in Saskatchewan, Canada, conditions have not changed.



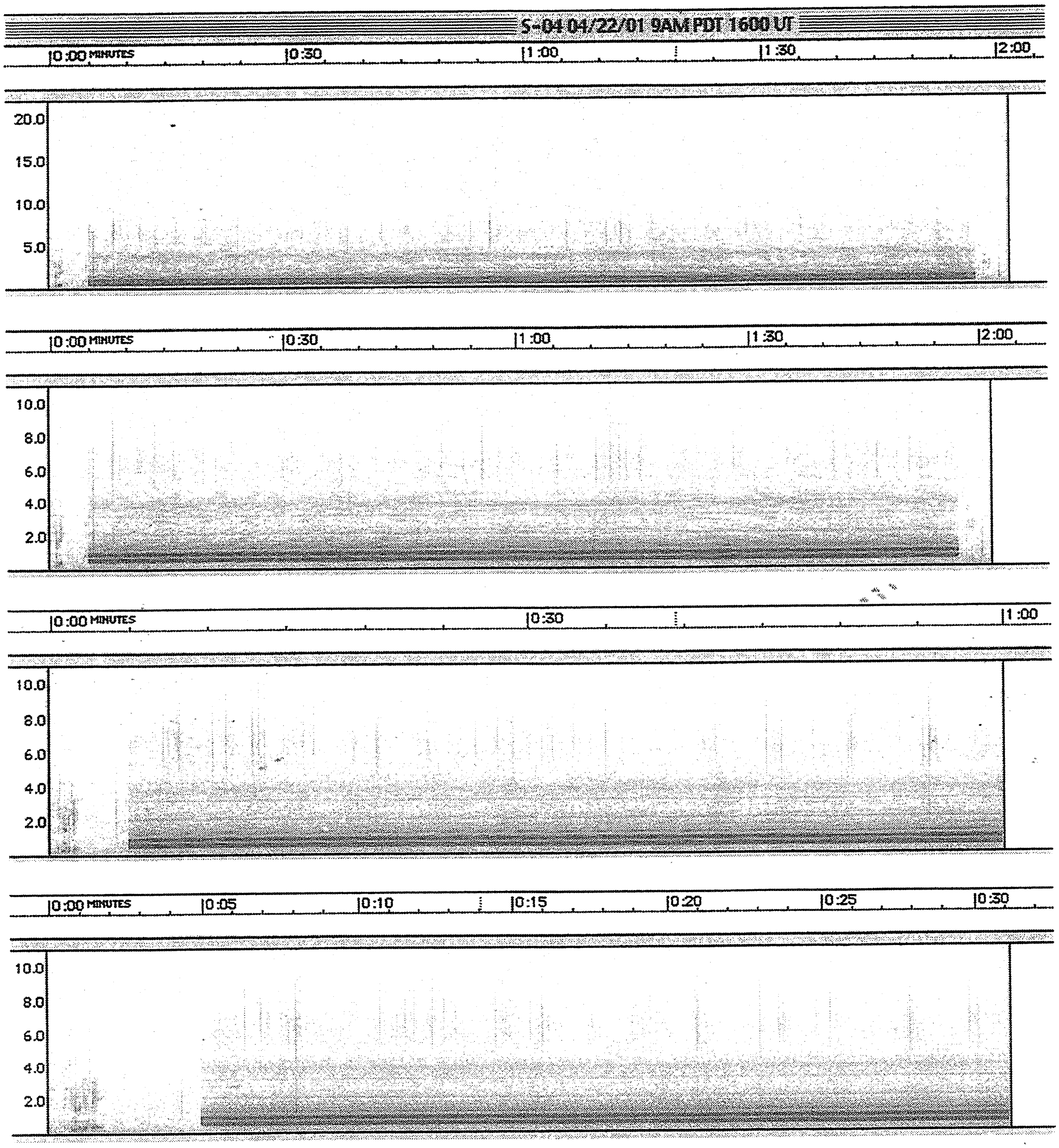
4/22/01 1500 UT

The Chaffey High School team in Ontario, California, made the following observations. The dark bars running horizontally across the bottom are from 60 Hz power line signals. Even though the 60 Hz hum is strong, sferics are still audible on the tape and visible as vertical lines on the spectrograms.



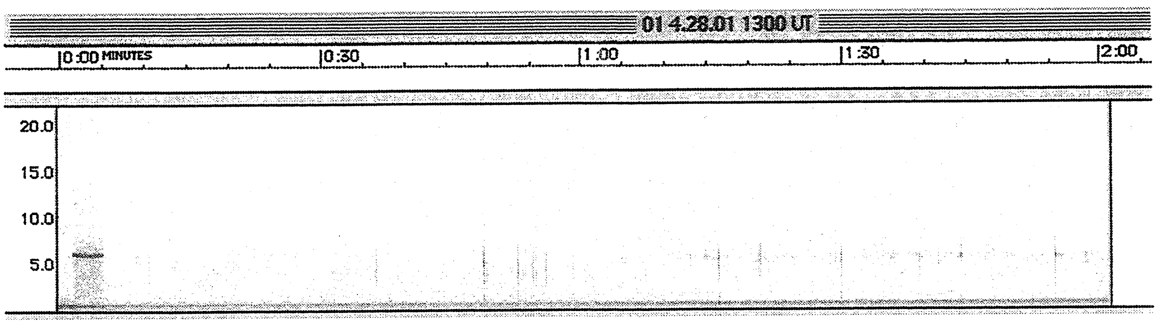
4/22/01 1600 UT

Conditions remain the same in California as April 22 comes to a close.

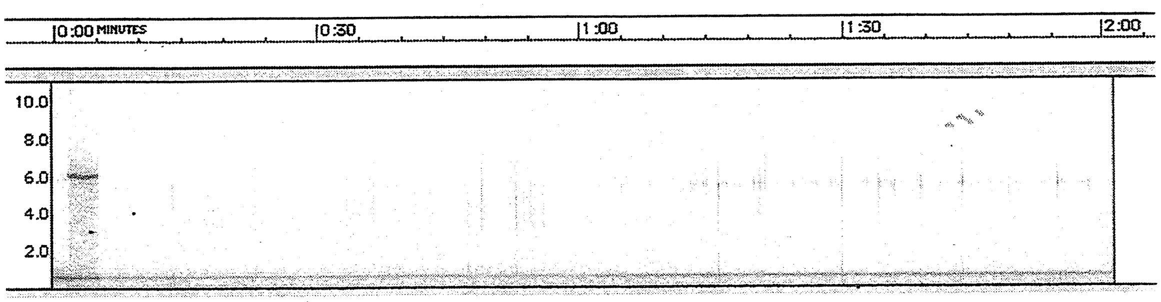


4/28/01 1200 UT

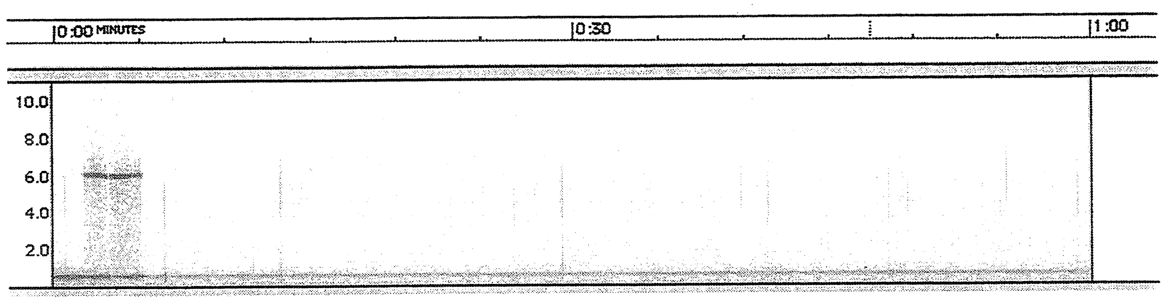
April 28 opens in Helotes, Texas, near San Antonio. Kathryn Robinson, Physics teacher at Sandra Day O'Conno High School, is joined by Justin Hammond on a "deserted hill top" 10 miles northwest of San Antonio. This team also experienced difficulties with commercial radio stations. If the antenna was kept low to the ground the radio station was not strong, but if the antenna was raised the radio station predominated.

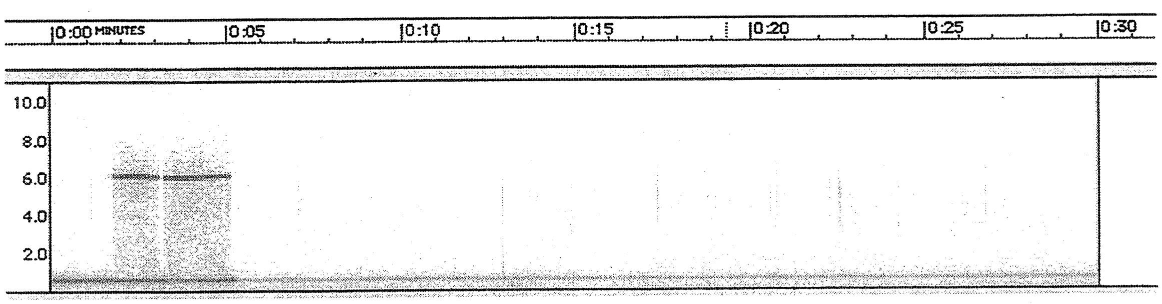


The horizontal line at about 6 kHz is feedback while the receiver was adjusted.



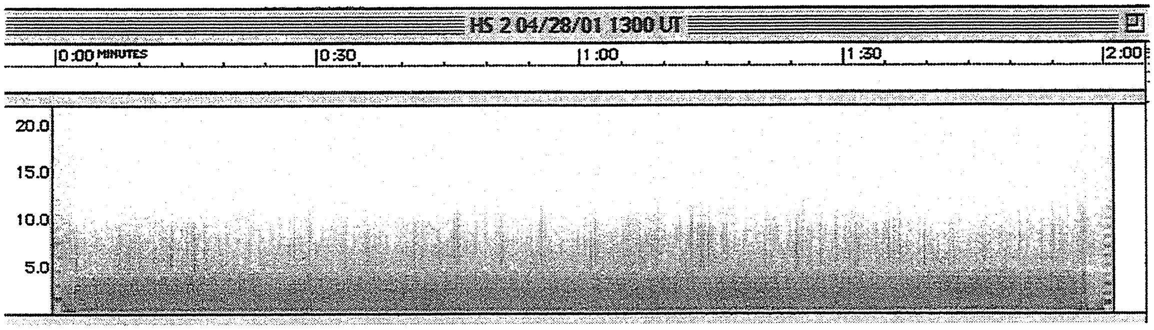
Sferics and bursts of sferics show up clearly just as they are easily heard on the tape. Some power line hum is present below 1 kHz.



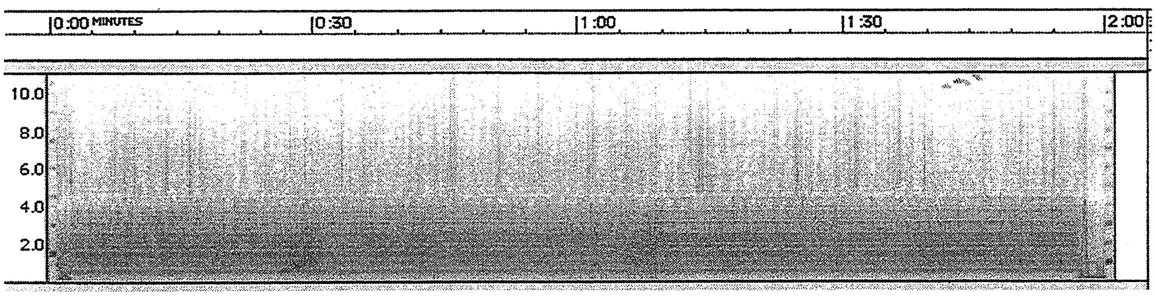


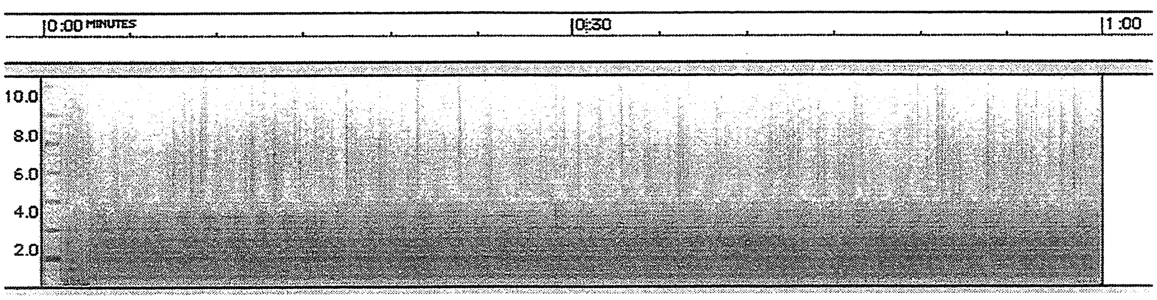
4/28/01 1300 UT

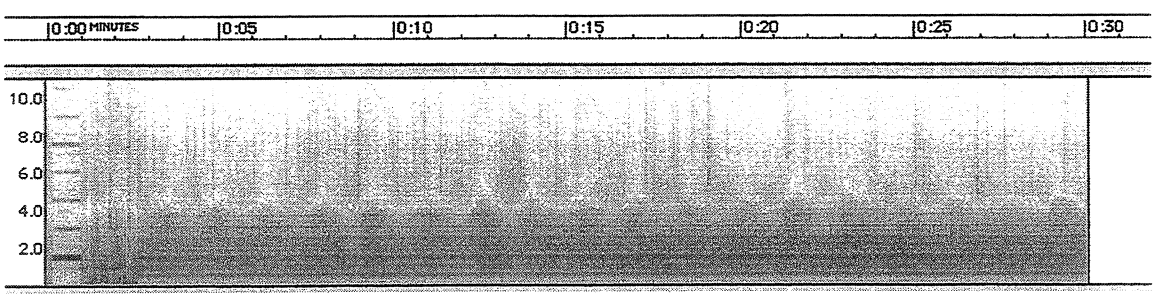
Mark Mueller, Physics teacher at Brown Deer High School in Brown Deer, Wisconsin, was joined by David Quosig and Jin Domencich in an "open field near the high school" for these observations. Apparently the proximity of the school contributed a large amount of power line hum.



There is an enormous amount of manmade signal filling the region below 4 kHz. Sferics are easily heard and seen above the hum. This does not sound like Mark's usual quiet site!

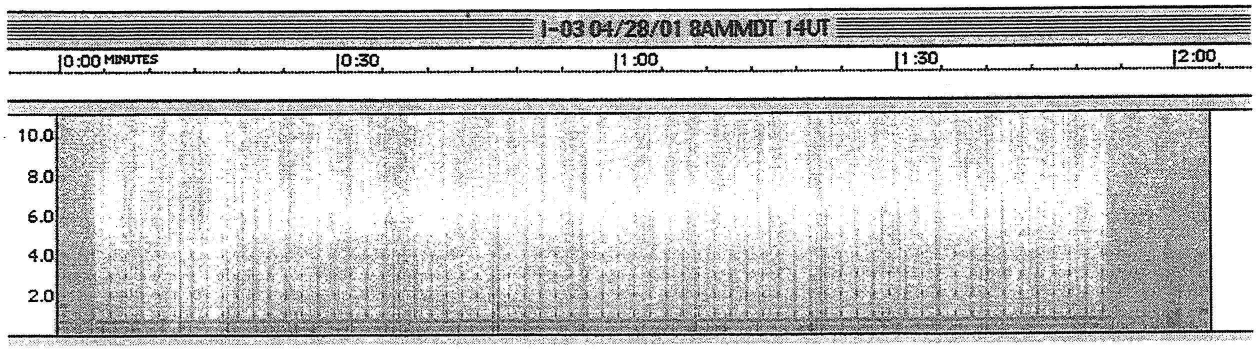




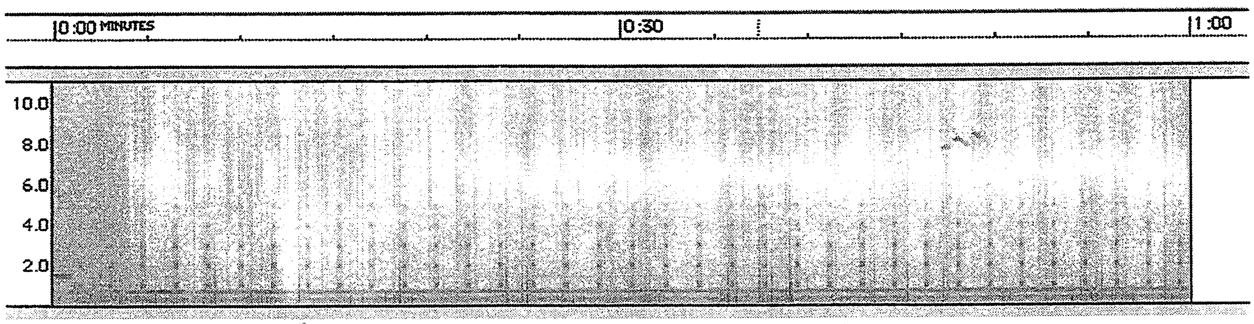


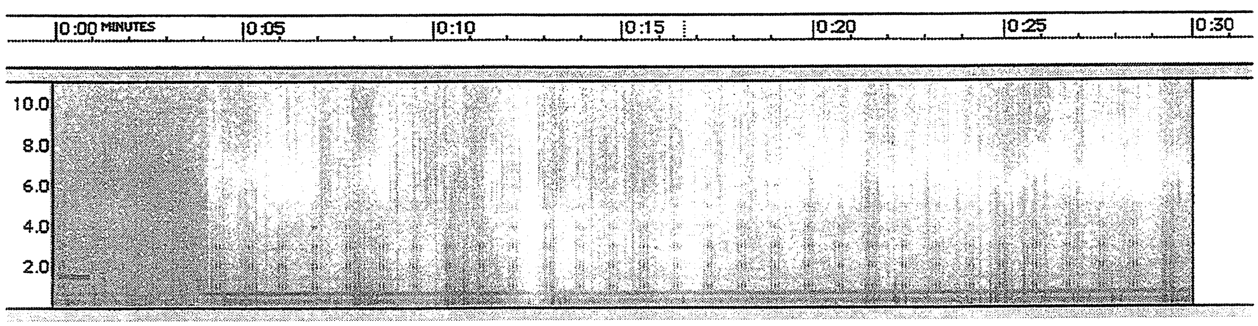
4/28/01 1400 UT

Robert Bennett in Las Cruces, New Mexico provides the following data. Note the strong power line hum even though Robert's observing site is quite remote. Many whistlers were heard this morning.



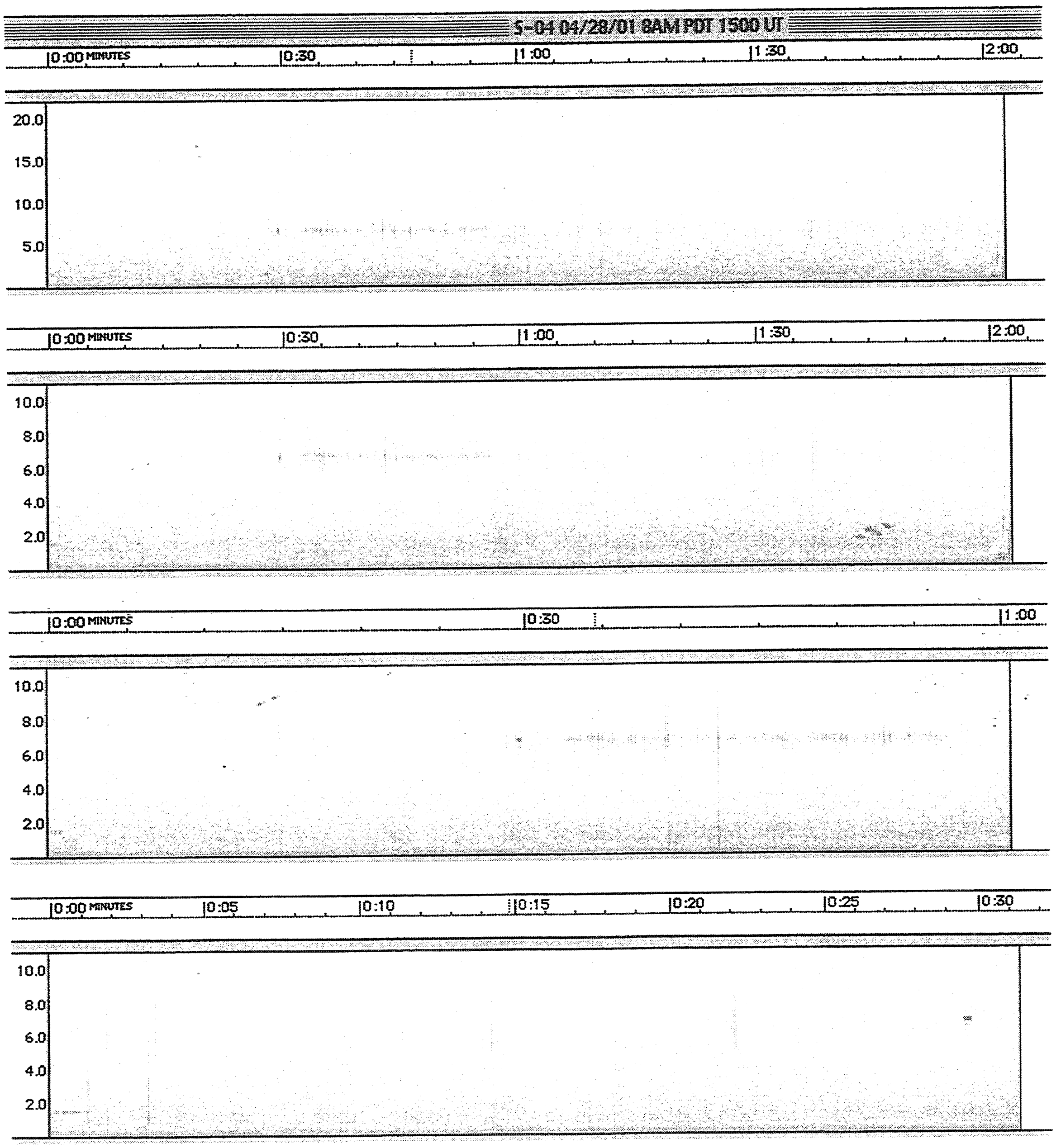
Power line hum is present as is the LORAN navigation signal.





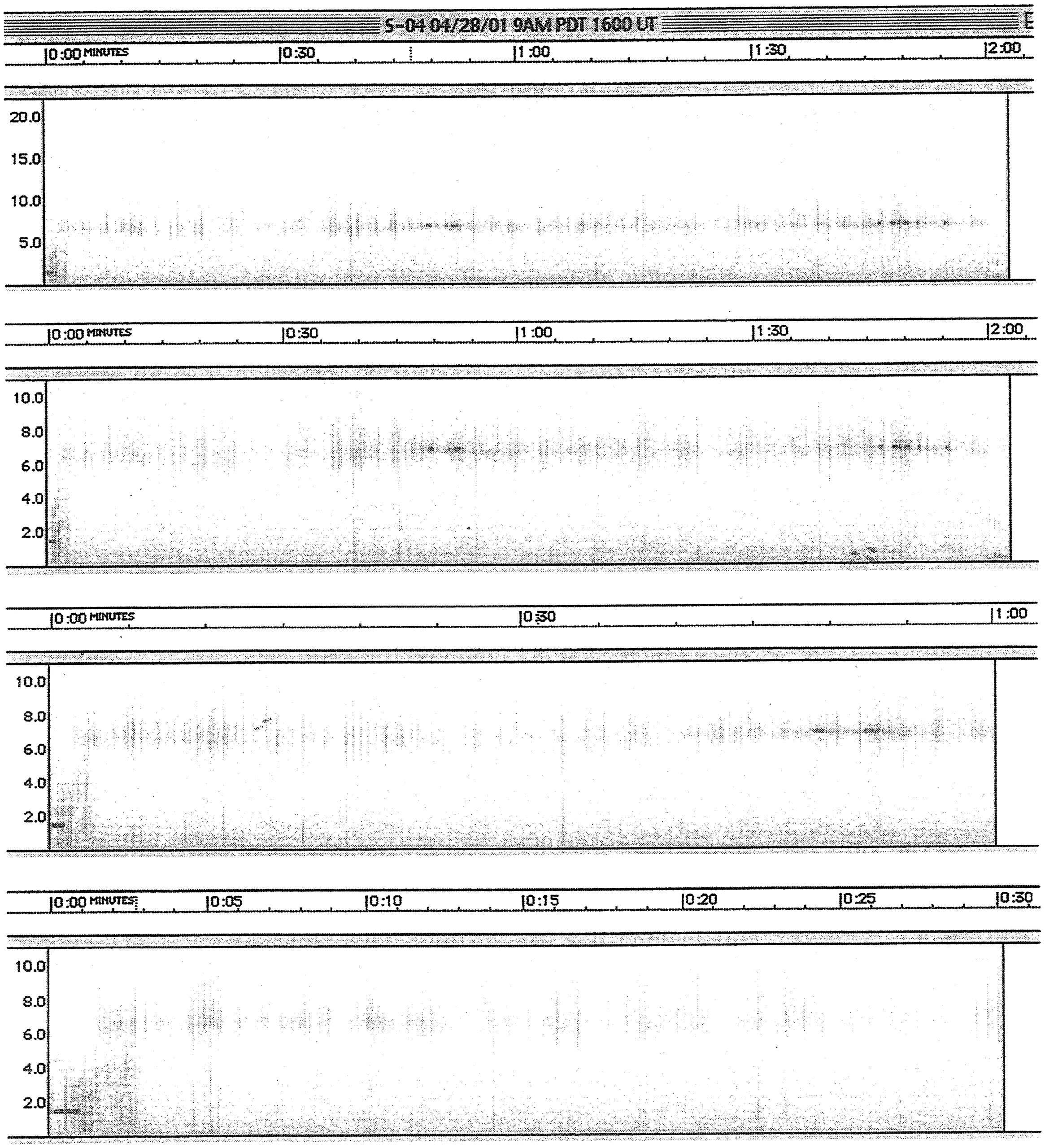
4/28/01 1500 UT

In California, the Chaffey High School team found quiet conditions on April 28. The strong 60 Hz signal from the previous weekend has disappeared. It is possible that someone was operating a portable generator nearby before.



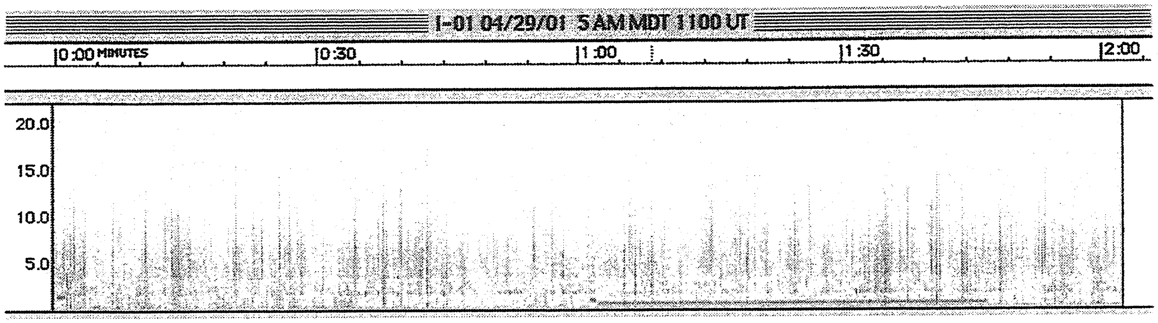
4/28/01 1600 UT

Chaffey High School, Ontario, California. Conditions are similar. A different receiver was used for this hour.

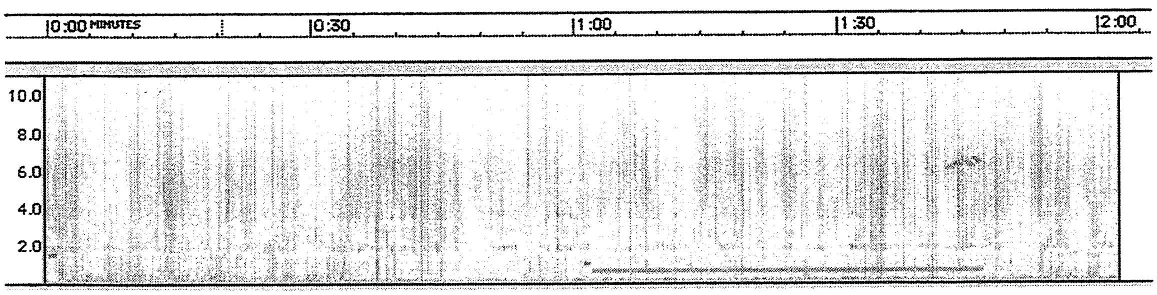


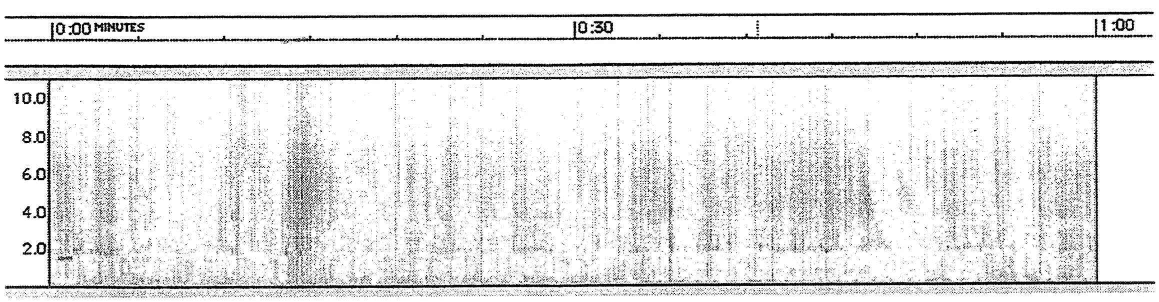
4/29/01 1100 UT

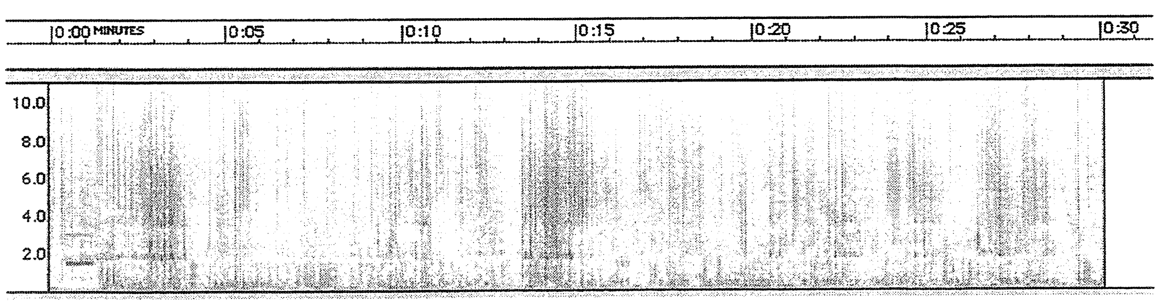
Shawn Korgan, in Gilcrest, Colorado, got an early start at 5 AM MDT (1100 UT).



From Shawn: "On this tape, I messed up a software setting and caused the two track to overlay. The solid line at less than 1 kHz is the clock ticking on WWV." This starts just after the one minute point. Strong, dense sferics with tweeks and whistlers are abundant on this tape.

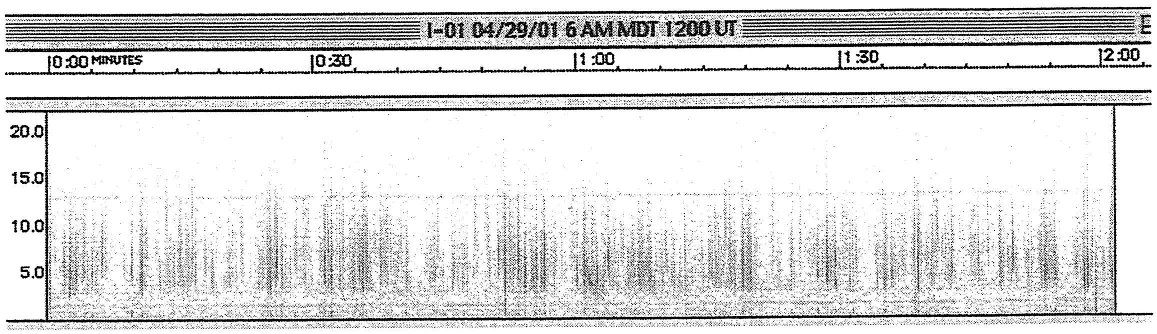




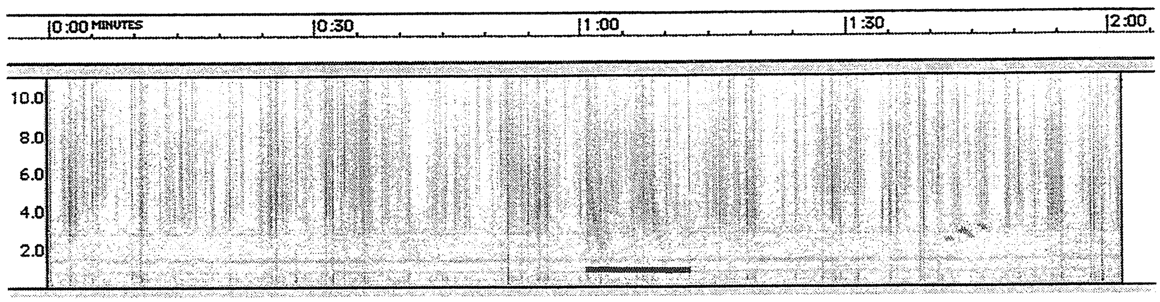


4/29/01 1200 UT

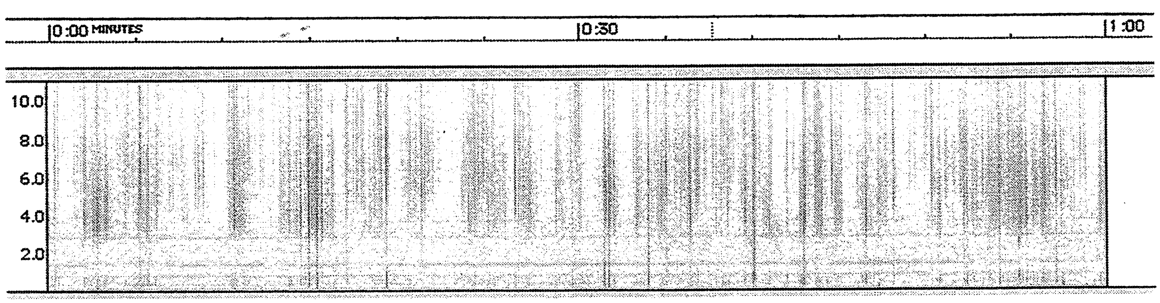
Still in Colorado with Shawn Korgan.

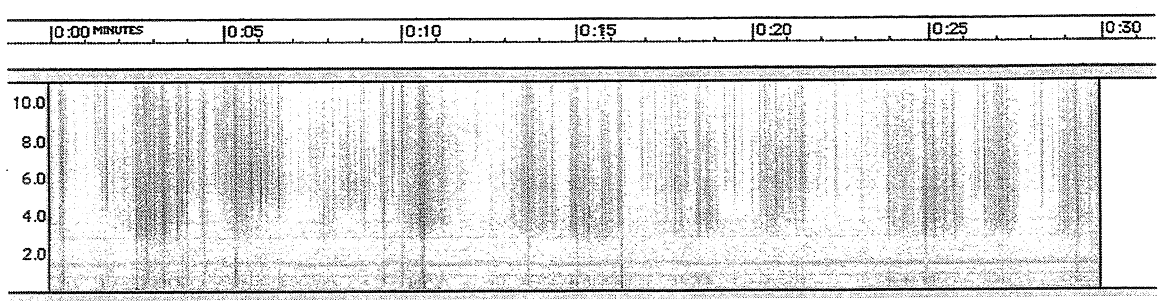


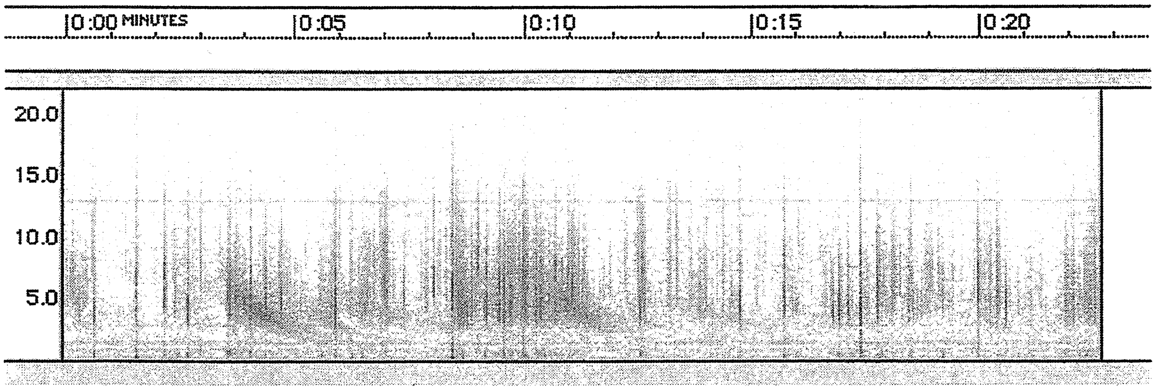
Note the whistlers just after one minute. A separate picture of these was made later.



Whistlers are indicated (▬▬▬).



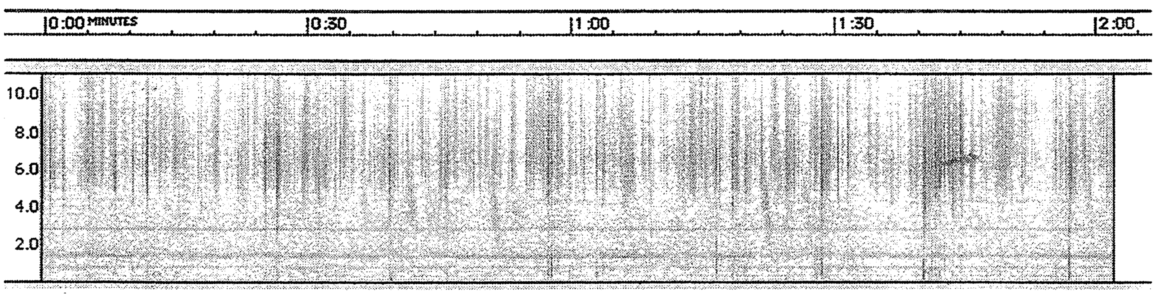


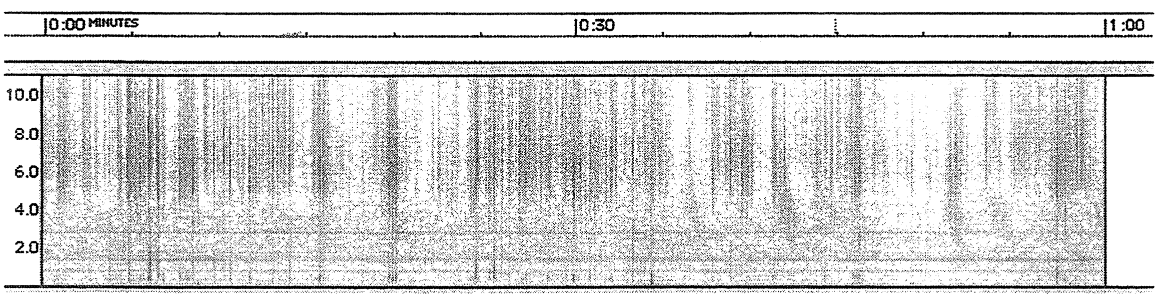


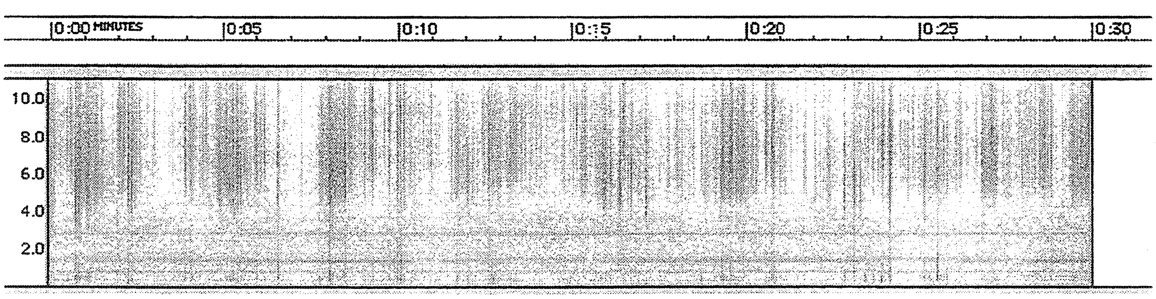
Whistler logged at 120101 UT.

4/29/01 1300 UT

Still more from Shawn Korgan in Colorado. Strong sferics and whistlers.

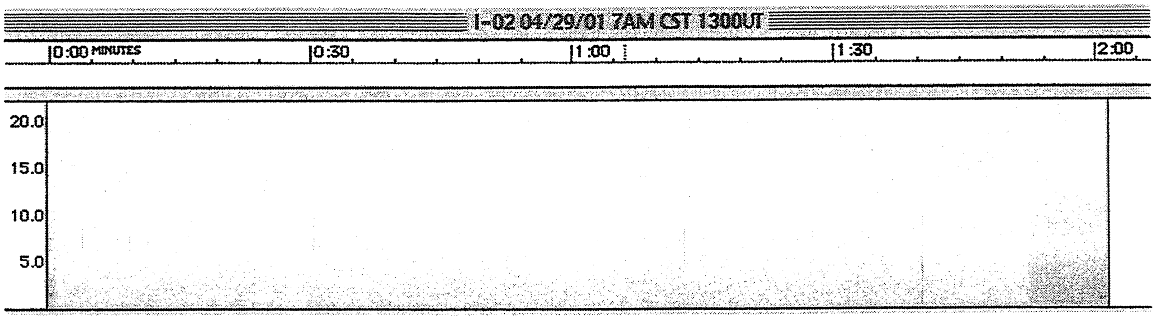




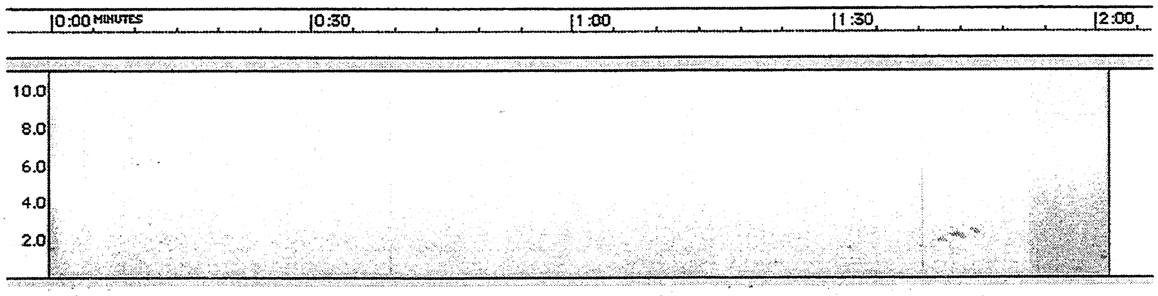


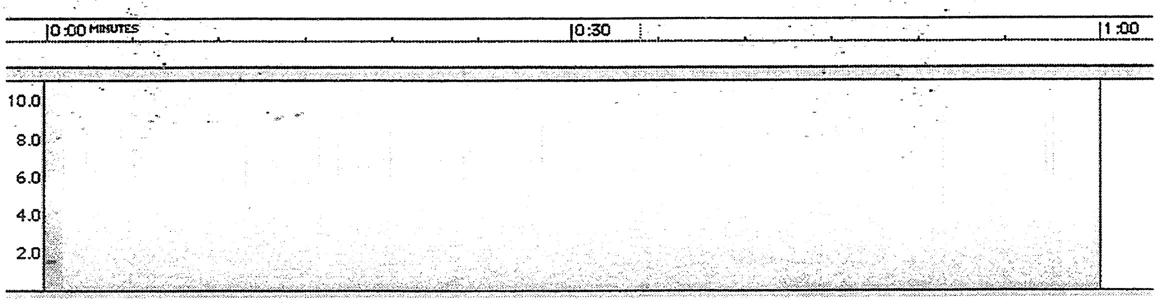
4/29/01 1400 UT

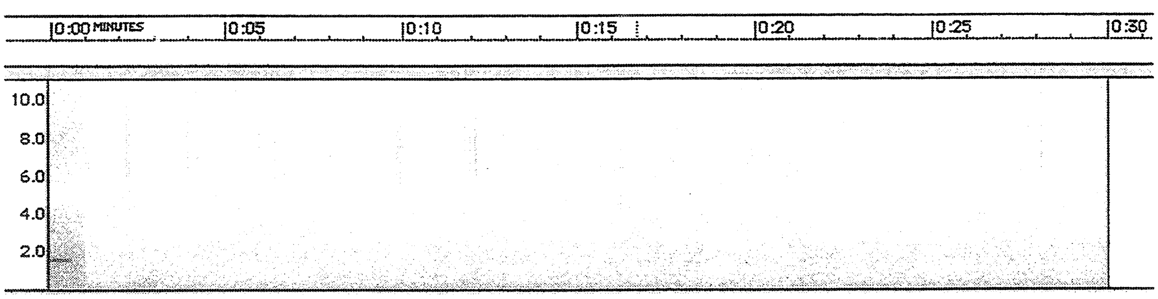
Linden Lundback and Brian Cowan find quiet conditions in Saskatchewan, Canada.



Low density, low intensity sferics.

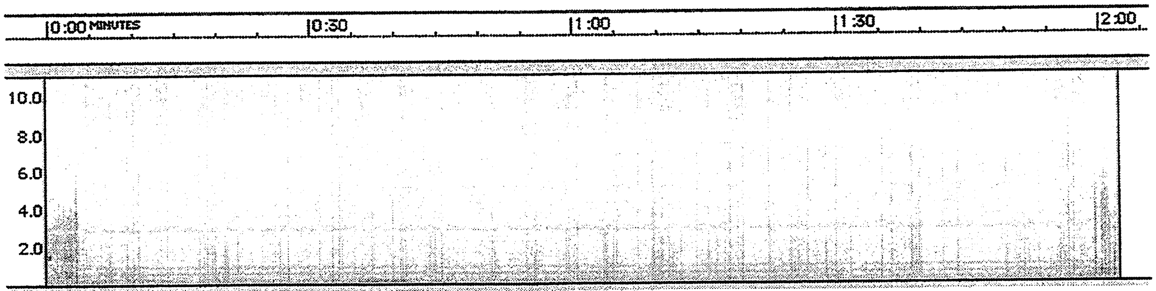


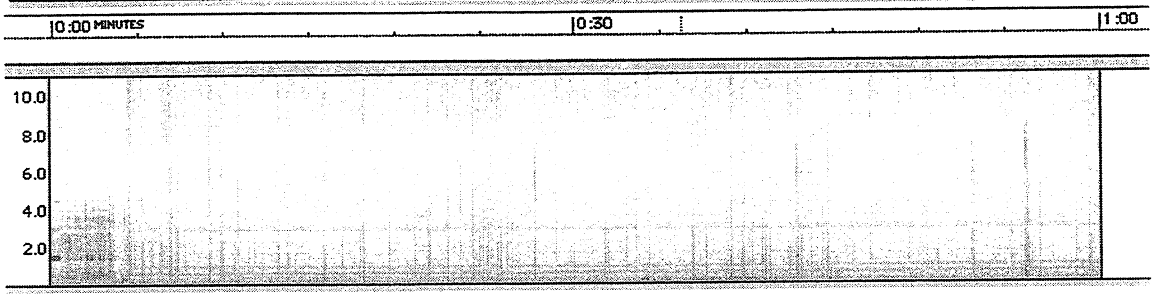




4/29/01 1500 UT

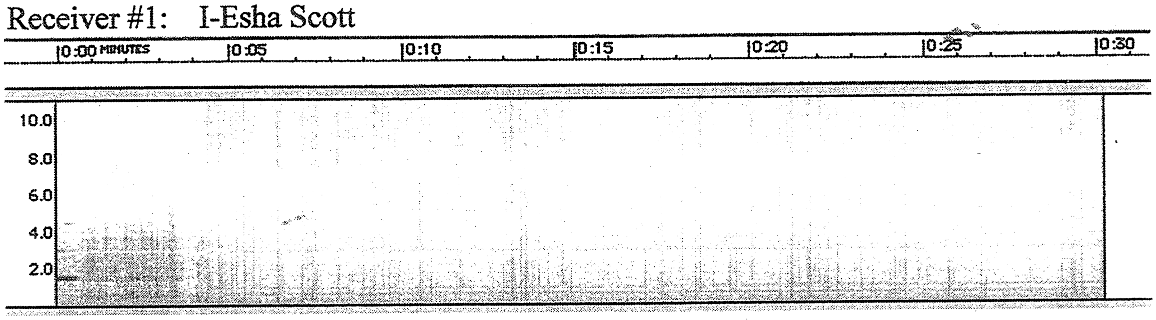
The Chaffey High School Team also found quiet conditions on April 29.



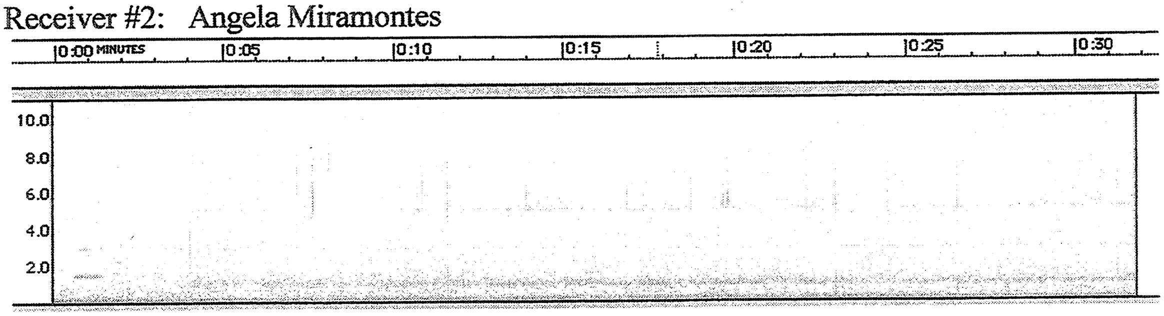


The first 30 seconds from each of the 3 receivers are compared.

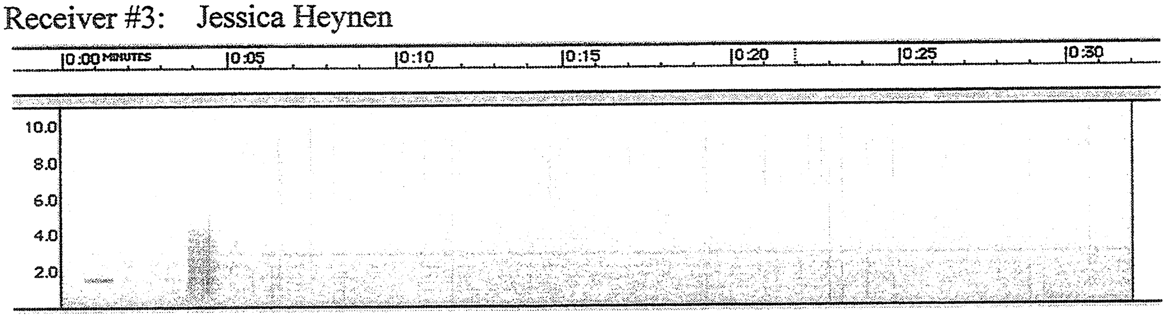
Receiver #1: I-Esha Scott



Receiver #2: Angela Miramontes

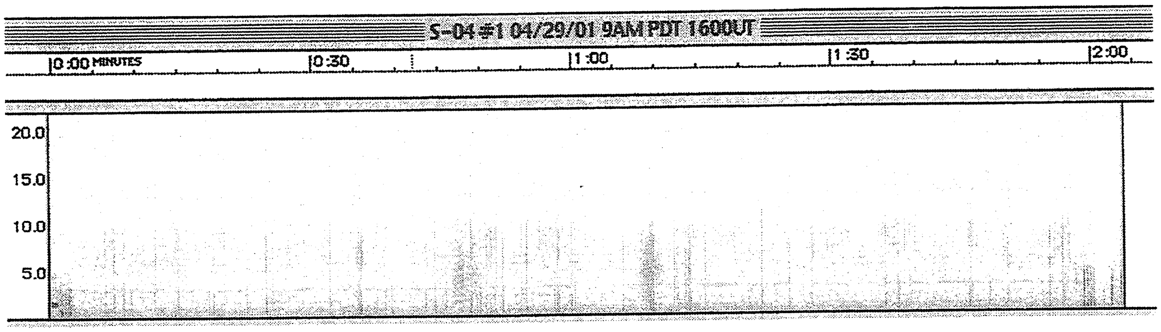


Receiver #3: Jessica Heynen

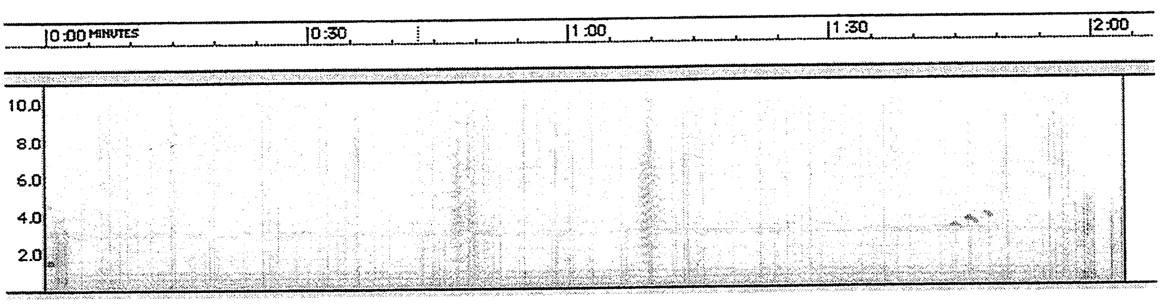


4/29/01 1600 UT

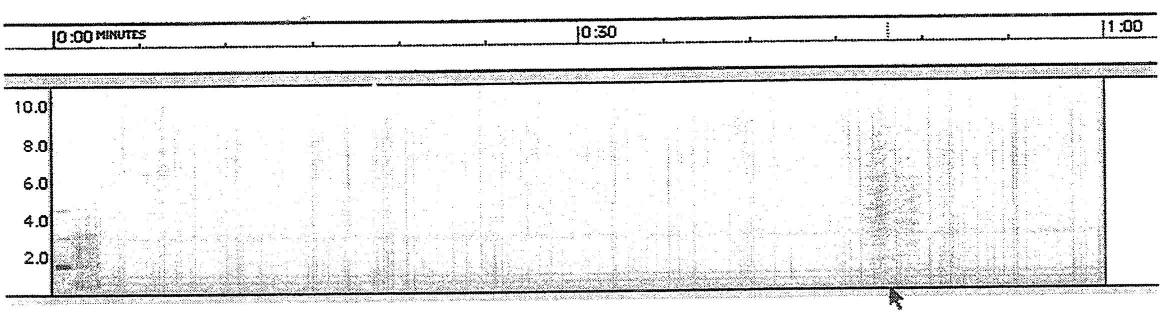
Conditions were so quiet in California, we were looking for <u>any</u> kind of signal.



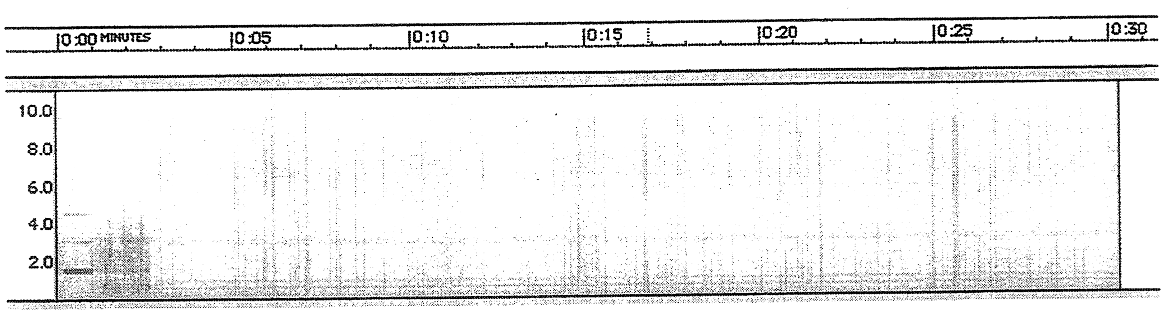
Receiver #1: I-Esha Scott



Motorcycles at 42 s and 1:08. (Radio waves from the ignition system.)

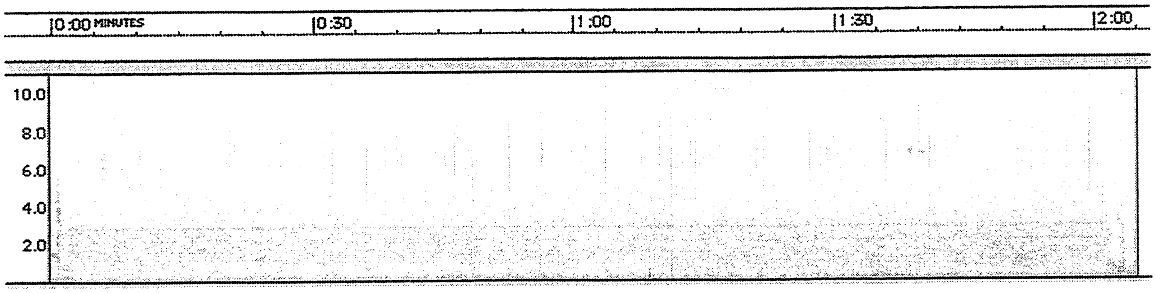


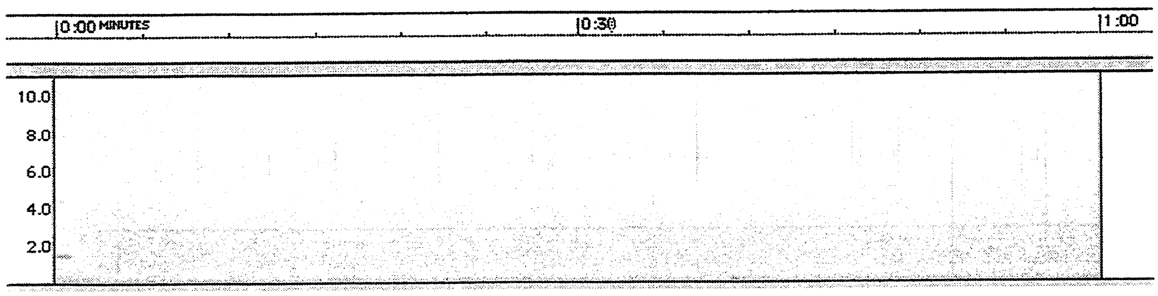
Arrow points to 2 motorcycles.

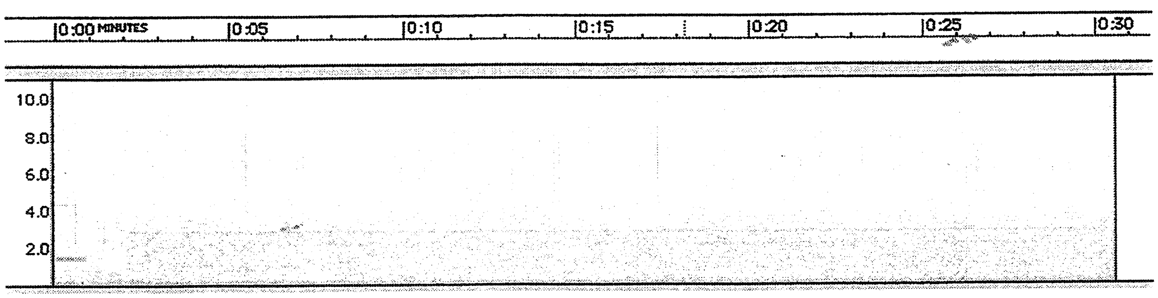


First 30 seconds.

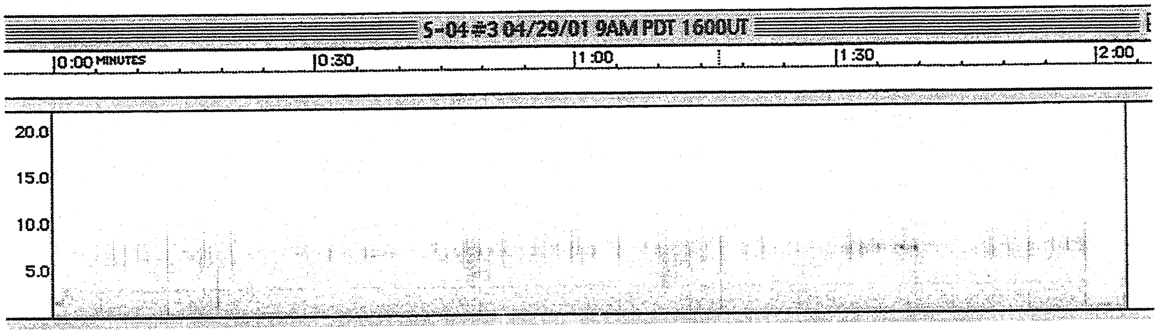
Receiver #2: Angela Miramontes



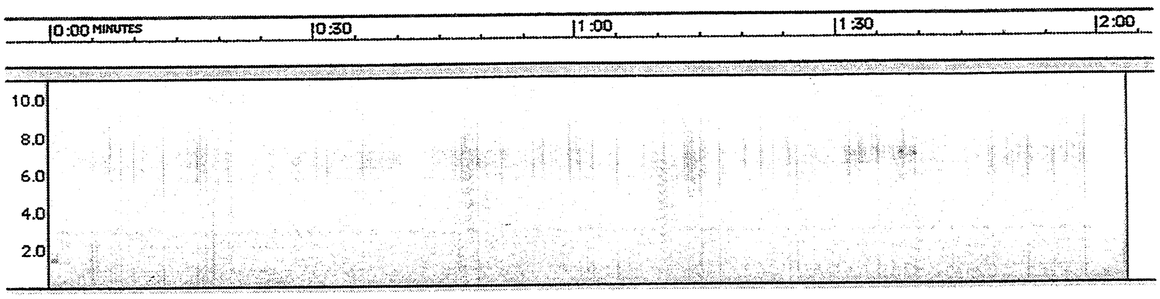




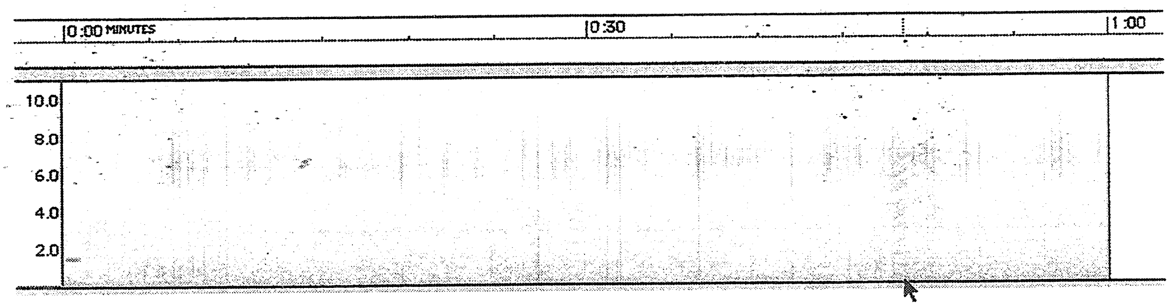
First 30 seconds.



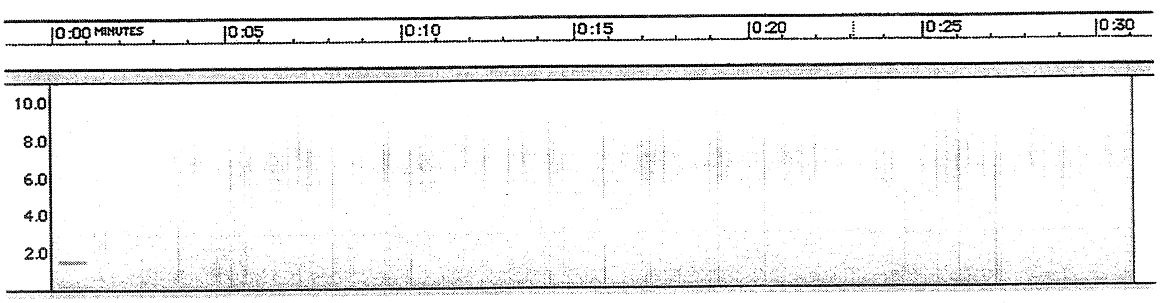
Receiver #3: Jessica Heynen



Motorcycles at 43 seconds and 1:10.



Arrow: Motorcycle



First 30 seconds.

And thus ends the April/2001 Coordinated Observations. Not with a bang, but with some motorcycles!

Data Log Cover Sheet (copy as needed)

INSPIRE Observer Team ______________________ Team Number: ____

Equipment: Receiver ______________________

Recorder ______________________

Antenna ______________________

WWV radio ______________________

Site description: ____

Longitude: _____° _____' W Latitude: _____° _____' N

Personnel: ________________ ________________ ________________

________________ ________________ ________________

Team Leader address: Name ______________________

Street ______________________

____

City, State, Zip, Country ______________________

email: ___________________________

Local Time to UT Conversion Table

EST + 5 = UT	EDT + 4 = UT
CST + 6 = UT	CDT + 5 = UT
MST + 7 = UT	MDT + 6 = UT
PST + 8 = UT	PDT + 7 = UT

INSPIRE Data (copy as needed)

INSPIRE Observer Team ____________________ Team Number: ____

Coordinated Observation Date: __________ Receiver ________

Tape Start Time (UT) __________ Tape Start Time (Local) __________

Local weather: ______________________________

Code: M - Mark (WWV or Voice) S - sferics T - tweek W - whistler A - Alpha C – chorus
Sferic Density: D: ___ Scale of 1-5 (1 – Very Low, 3 – Medium, 5 – Very High)

Time (UT)	Entry		Observer
________	M-WWV M-V S T C W________________	D: ___	________
________	M-WWV M-V S T C W________________	D: ___	________
________	M-WWV M-V S T C W________________	D: ___	________
________	M-WWV M-V S T C W________________	D: ___	________
________	M-WWV M-V S T C W________________	D: ___	________
________	M-WWV M-V S T C W________________	D: ___	________
________	M-WWV M-V S T C W________________	D: ___	________
________	M-WWV M-V S T C W________________	D: ___	________
________	M-WWV M-V S T C W________________	D: ___	________
________	M-WWV M-V S T C W________________	D: ___	________
________	M-WWV M-V S T C W________________	D: ___	________
________	M-WWV M-V S T C W________________	D: ___	________
________	M-WWV M-V S T C W________________	D: ___	________
________	M-WWV M-V S T C W________________	D: ___	________
________	M-WWV M-V S T C W________________	D: ___	________
________	M-WWV M-V S T C W________________	D: ___	________
________	M-WWV M-V S T C W________________	D: ___	________
________	M-WWV M-V S T C W________________	D: ___	________