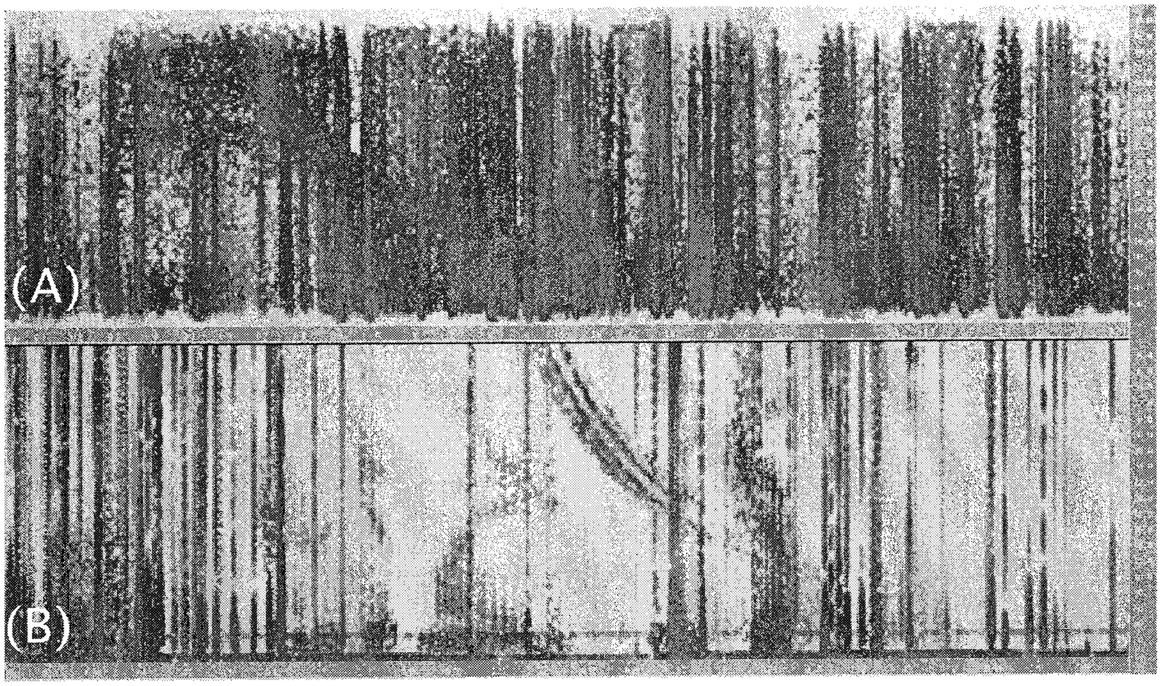


Figure 8: Panel A and B show frequency versus time spectrograms of a whistler observed by the Venture VLF receiver and Mideke's VLF receiver, respectively. Both are 3s displays starting at 16:40:31UT, extracted from longer recordings. The greater Mideke frequency content has been under sampled in order to display both with the same frequency scale. The ~1s difference in the start of the whistler is thought to be an error in identifying time in the Venture VLF, which uses overlaid video GPS information.

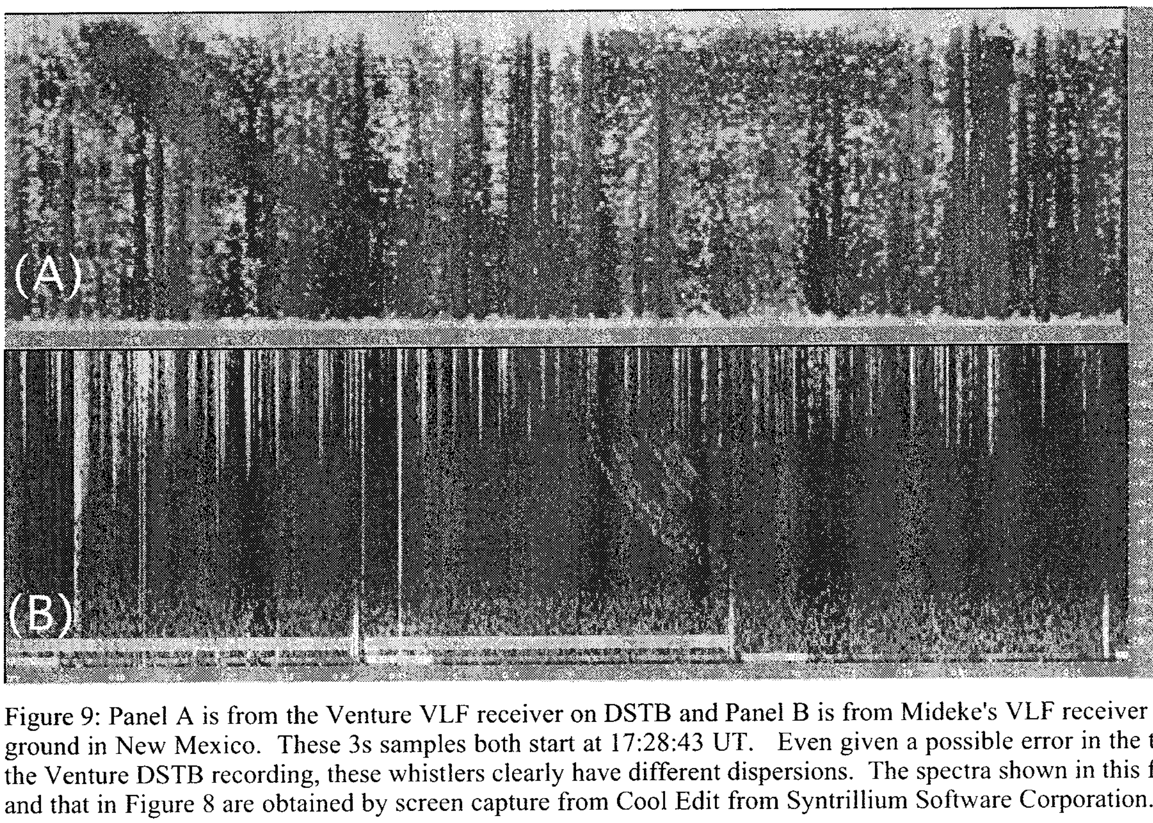


Figure 9: Panel A is from the Venture VLF receiver on DSTB and Panel B is from Mideke's VLF receiver on the ground in New Mexico. These 3s samples both start at 17:28:43 UT. Even given a possible error in the timing of the Venture DSTB recording, these whistlers clearly have different dispersions. The spectra shown in this figure and that in Figure 8 are obtained by screen capture from Cool Edit from Syntrillium Software Corporation.

The Panel A and B whistler signals in Figure 8 are very similar, but with approximately a 1s separation. The whistler signals in Figure 9 are not similar and must be from different whistlers received in flight and on the ground nearby. The first whistler comparison was made when the DSTB was at an altitude of about 18,932 meters, while the second was made at 31,949 meters height. During this time DSTB drifted about 25,000 meters down range. Five whistlers were found at about the same time in both these observations. None were found at exactly the same time and the Venture flight recording always leads the Rosedale recording. In only the first comparison, shown above in Figure 8, does the dispersion appear similar in the pair of compared whistlers. In all other cases, the flight whistler shows more dispersion than the one received on the ground. It is an interesting result that lacks a current explanation. One possibility is that the longer dispersion whistler is an odd multiple of the short dispersion whistler, which would result if one site recorded a one hop and the other a three hop whistler from the same lightning strike. Measurement of the dispersion has not yet been performed.

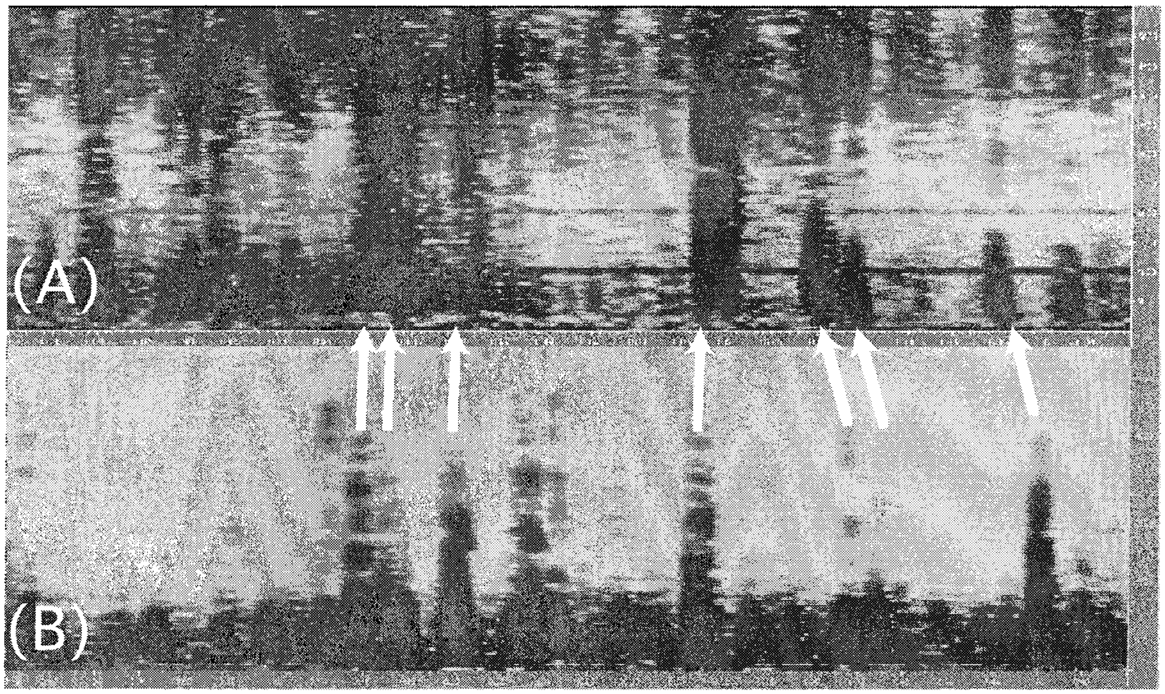


Figure 10: Frequency versus time excerpts are from the Venture ground recording in Huntsville, AL (A) and from the recording by David Jones just north of Phoenix City, AL (B). One half second of VLF is shown in both, starting at 18:30UT. The arrows point to spherics that may correspond between the two recordings.

No whistlers were observed at either of the two Alabama locations where VLF recordings were made on the ground during the flight of the DSTB. Since no whistlers were observed and plenty of spherics were, an attempt has been made to correlate spherics between the two locations. This is shown in Figure 10. The Huntsville recording is shown in Panel A and the Phoenix City recording in B. It wasn't immediately obvious when these spectrograms were first brought together that there was any correspondence. It was only after repeatedly listening to each of the half second clips that a repeated pattern of spherics appeared to be similar between the two. Arrows are drawn in Figure 10 calling out the spherics between the two panels that display this similar temporal pattern. While there are similarities in the general pattern, there are also differences in the details. There are spherics in each recording that are not present in the other.

The spherics suggested to have a common origin are shifted in time. If these spherics are related, the implication is that the shift is due to small differences in the path taken by the radio noise to the two locations. That difference can be accounted for by a difference in the direction of arrival and the distance from the lightning strike responsible for the spheric. While it isn't done here, it is possible in principle to draw arcs across the globe along which a single lightning strike must have occurred in order to account for two related spheric signals where there is a small delay in the time of arrival. Seven spheric pairs are suggested that can be used to draw seven arcs. The spheric pairs that most differ in their time of arrival are the fifth and sixth noted in the Figure. They differ by 0.008s and 0.013s in their arrival times at the two sites. If the same lightning strike caused both spherics, then the closest the lightning could be to Alabama is approximately 2400km and 3900km, respectively, along a line between the two sites. Since these two spherics arrived at the Huntsville location first, this "closest" location would be north of Alabama 6% to 10% of the way around the planet's circumference. Were the lightning along that line, and it need not be of course, then the lightning would have taken place almost to the North Pole. The arc described above starts at this high latitude in the North American continent and extends both east and west at ever increasing distance from the receiving sites. Given the uncertainties in the timing of these signals (time code signals are difficult to impossible to verify in some of the recorded cassettes) and the limited overlap in time between the two recordings, it does not make sense to pursue this analysis any further. The receipt of spheric signals has been used for many years to triangulate the location of lightning strikes, so doing it here would not be new in any event.

Summary

Neither text space nor time permits a full analysis and discussion of all the recorded VLF audio and flight video obtained during the Venture Crew experiment on the DSTB flight in the summer of 2005. The results presented demonstrate that interesting observations of natural low frequency radio emissions can be made at high altitude and can be used to compare to recordings on the ground at varying separations. These results also demonstrate what can be accomplished by high school students given the opportunity to learn about electronics, engineering, and science. While it was especially exciting for all involved to participate in such a large-scale high altitude flight experiment, we hope our readers realize that small payloads can be carried into the stratosphere by weather balloons permitting much the same experience as gained in our Venture Crew experiment on the DSTB. A few universities in the USA and possibly elsewhere in the world are engaged in amateur, instrumented weather balloon flights, some involving VLF receivers. We hope to hear about their VLF experiences in future editions of *The INSPIRE Journal.*

Acknowledgements

This article is dedicated to Bill Taylor, co-founder of the INSPIRE Project and former Chief Scientist of NASA's Space Station Freedom.

The Venture Crew's participation on the 2005 DSTB flight was sponsored by the NASA Marshall Space Flight Center Education Office. Much thanks for this opportunity must be extended to them and their interest in inspiring young students to pursue careers in engineering and science. The Venture students and mentors also wish to thank the DSTB project for allowing their participation in the test flight, to the INSPIRE Project for their support and willingness to publish this article, and to Michael Mideke and David Jones who volunteered for many hours of VLF field recording and many days waiting on stand-by for flight of the DSTB.

Field Notes – 2005

Robert Bennett
Las Cruces, NM

Editor's note: Bob is a faithful observer and reports here on his activities in 2005. Spectrograms and analysis, provided by the editor, will be incorporated in this report.

2005 has been a hectic year for me. I have spent most of my time dealing with health problems, trying to settle my father's estate, visiting my grandchildren and I have made several trips to the East Coast to attend weddings and visit relatives. These activities have left little time for Natural Radio monitoring.

So far his year, I have only managed two trips to a quiet location for natural radio monitoring. The first was 22-23 April and the second was on 21 August. Hopefully my schedule will be less hectic in October and November and I can return to my quiet site for more monitoring.

Check out the Journal-On-Line. The INSPIRE home page will soon contain a link to the on-line version of the *INSPIRE Journal*. The on-line version will include sound files for each spectrogram and color photos.

22-23 April 2005 Monitoring

During a site survey the previous summer, I discovered a good Natural Radio monitoring site in South Central New Mexico. The site is located in the Cibola National Forest near the Springtime primitive camp ground. Access to the site is by way of unimproved dirt roads and in some places the road is little more than a dirt trail. The road crosses several normally dry streambeds. Immediately after a rain, the streambeds have water in them and crossing them can be dangerous. The site is not accessible in wet weather without a four-wheel drive vehicle and when the roads are dry, cars, RVs and campers have trouble negotiating the steep dirt roads. From my home it takes about 4 hours to reach the site. The monitoring site is located at 33.5° North and 107.3° West. The site elevation is 6500 feet AGL and is on a flat area surrounded by mountains.

I arrived at the site on Friday 22 April at about 2 PM. I planned to spend two nights and return home on Sunday Morning. I spent an hour or so setting up camp and then spent the rest of the afternoon testing a large loop antenna. I did side by side comparisons using the loop and a modified INSPIRE VLF-2 receiver. The loop was used with a preamp. I compared the loop to a reference set-up. The reference set-up used a 6-foot vertical whip and the INSPIRE VLF-3 receiver. The following photograph shows the loop and test set-up. The loop receiving system performed very poorly in comparison to the reference system. I plan to write an *INSPIRE Journal* article about my loop antenna experiments as soon as I find time.

"Reading" Natural Radio Spectrograms

On the following spectrograms, the filename is shown at the top of the spectrogram. Sample filename:

1022051119U0519M02m
MMDDYYHHMMUHHMMM02m

The filename includes:

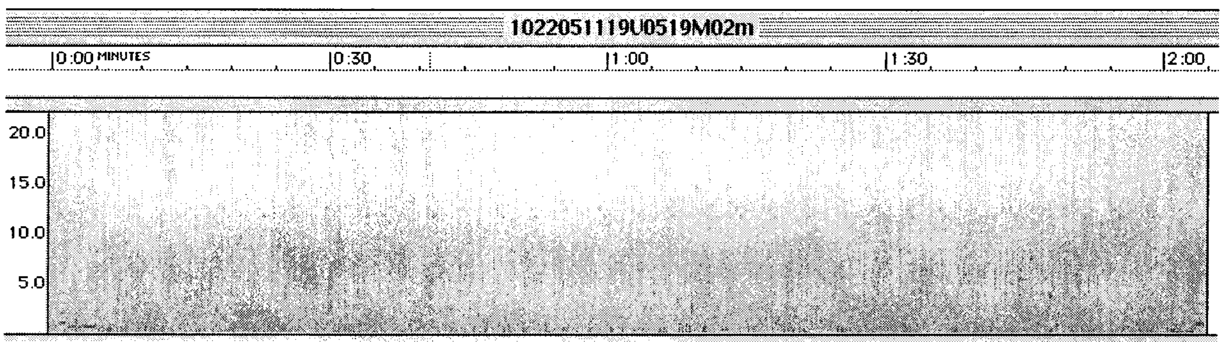
MMDDYY: month, day and year of observation.

HHMMSSU: the Universal time of the start of the file including the hour (HH), minute (MM) and second (SS). If fewer than six digits are shown, then the missing digits (MM and/or SS) are zeroes.

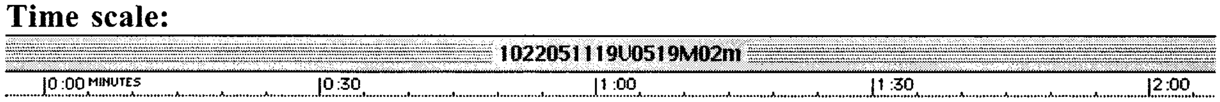
HHMMSSM: Mountain Daylight Time (Bob observes in New Mexico) of the start of the file. (Again, missing digits are zeroes.)

The final three characters are "02m" indicating that the length of the file is 2 minutes.

Also on the spectrogram

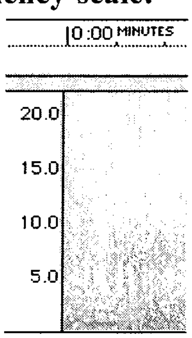


Time scale:



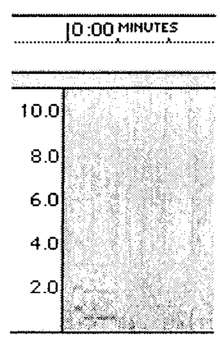
Typical lengths are 2 min, 1 min and 30 sec. Other lengths are possible.

Frequency scale:

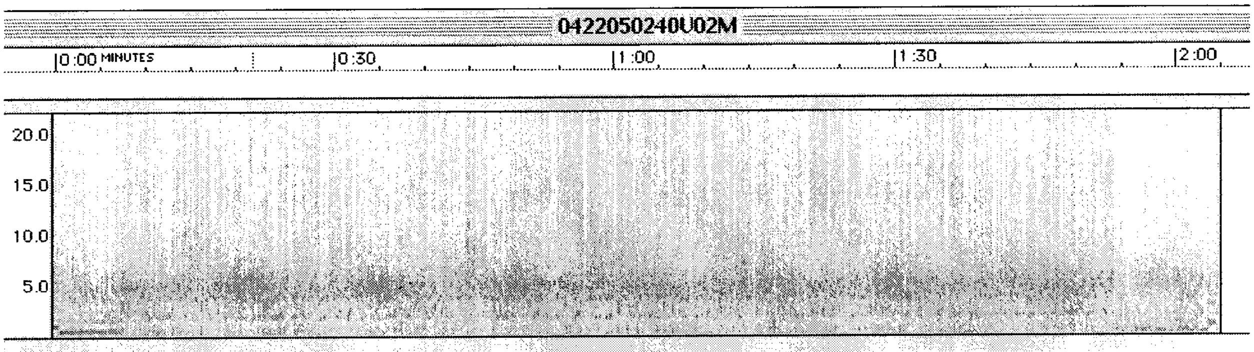


(Left) 0-22 kHz is the maximum frequency range of the software.

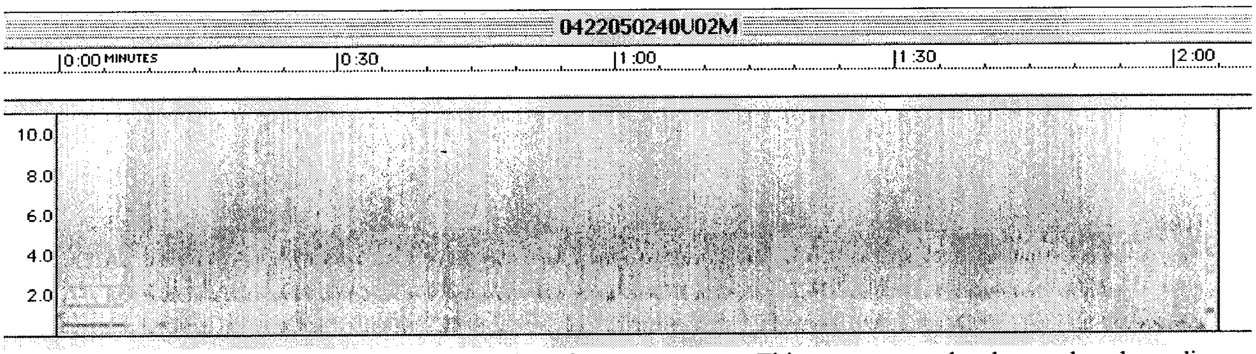
(Right) 0-11 kHz is the approximate frequency range of natual radio and the nominal frequency range of the VLF-3 receiver.



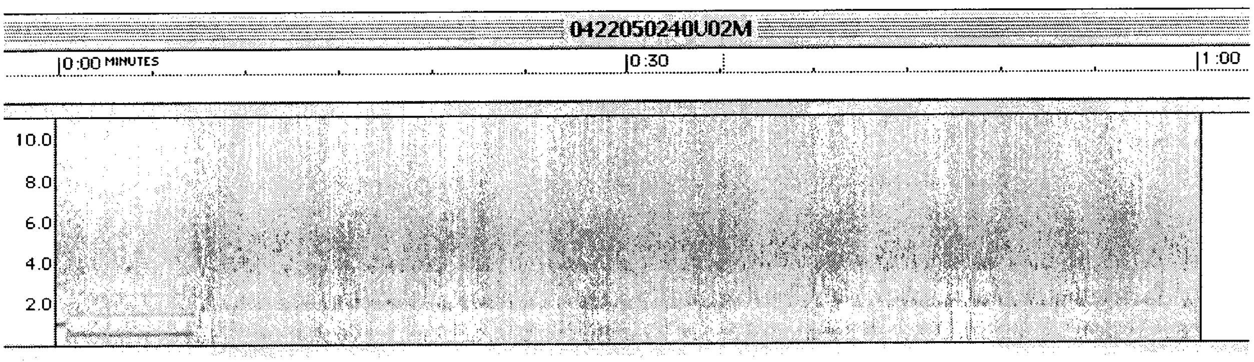
After dinner, at about 8:30 PM local time, I conducted a test recording using the VLF-3 and a 6-foot whip antenna. I was surprised to detect a whistler after about 10 minutes. I monitored natural radio signals until about 9 PM, checked in with my wife via amateur radio (there is no cell phone coverage at the site) and went to bed.



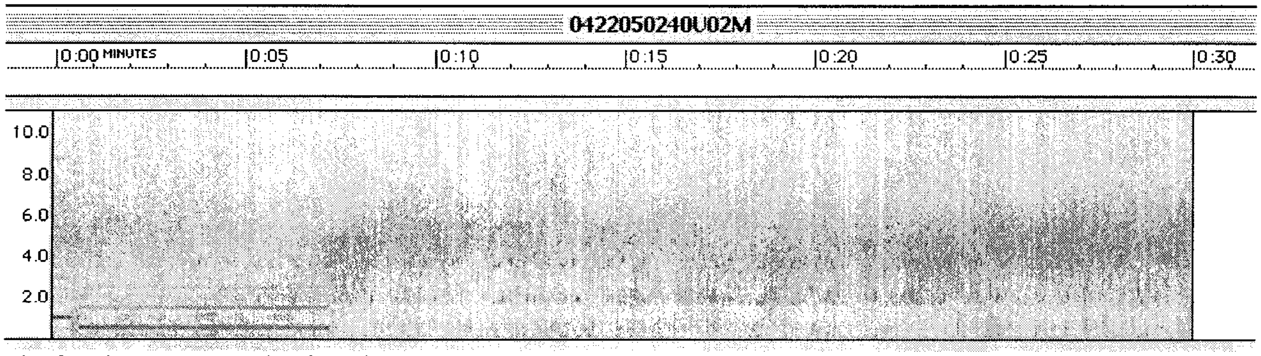
Two-minute spectrograms are created for each data session. This data is from the testing session on Friday, April 22. Additional spectrograms of various lengths are made of anything special, such as whistlers, and anything else noted by the observer or the analyst. The full 0-22 kHz range of frequencies is used on the first spectrogram.



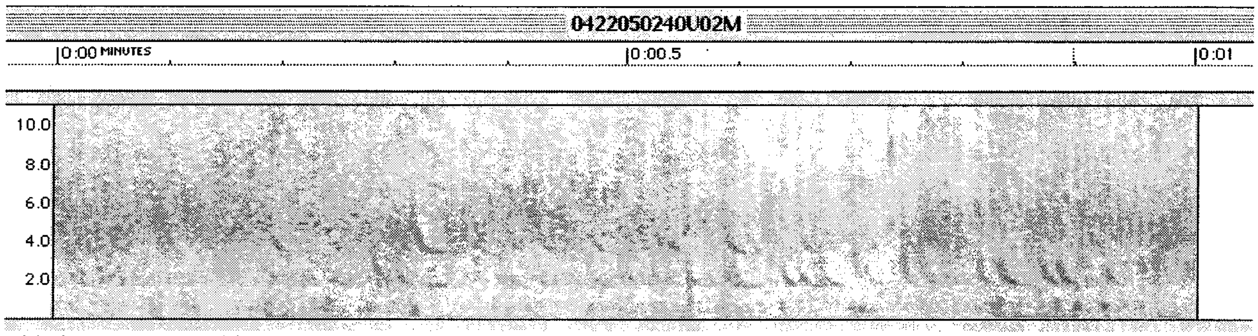
The second spectrogram created is using a 0-11 kHz frequency range. This range more closely matches the audio-range of natural VLF radio signals. The dash at the beginning of the spectrogram is the 1 kHz WWV tone at 0240 U. About 5 seconds of WWV content follows before WWV is switched out.



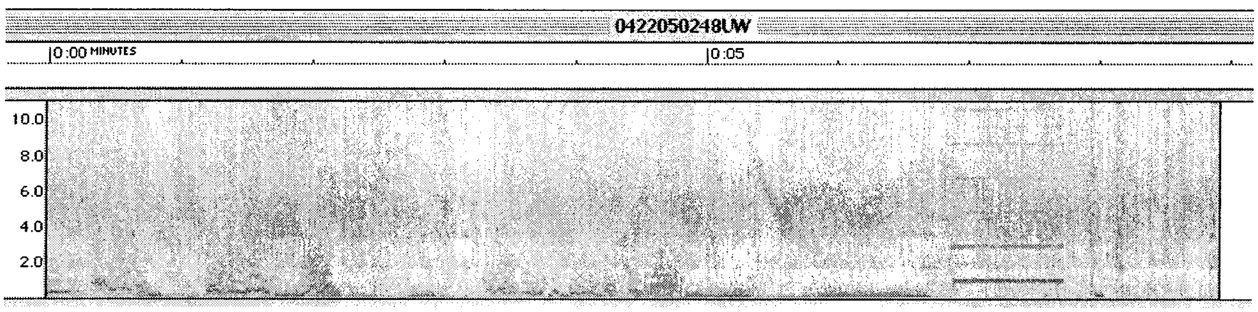
The third spectrogram is of the first minute of the session, using the 0-11 kHz range.



The fourth spectrogram is of the first 30 seconds of the session, using 0-11 kHz frequency range.



This is a one-second interval showing dense tweeks. Notice the bottoms of the hooks at about 2 kHz with harmonics of the stronger tweeks appearing at about 4 kHz.



Whistler logged at 0248 U on Friday, 4/22.

The temperature dropped to about 40° F over night and there was some light rain. I got up at 4 AM, built a fire to warm myself, had breakfast and started monitoring at 5 AM. My efforts were immediately rewarded by strong whistlers. I recorded 14 of them between 5 and 6 AM. Unfortunately, I did not bring many blank tapes with me so had to reduce my recording to the first 15 minutes of each hour. I recorded at 7, 8 and 9 AM. I recorded some very strong whistlers and several pairs of whistlers. By 9:15, the whistlers had just about stopped. At 10 AM, light rain started again and I took down my antennas just in case there was lightning. I planned to wait out the minor thunderstorm and monitor again that night and the next morning. However, a forest ranger stopped by and advised that I leave the area. He said that some of the dry streambeds were running water and if I delayed, I would be stranded. I am very glad I departed. It rained all Saturday night and very heavily on Sunday. If I had stayed, I would have been stranded until late Monday. I had a very enjoyable natural radio monitoring session.

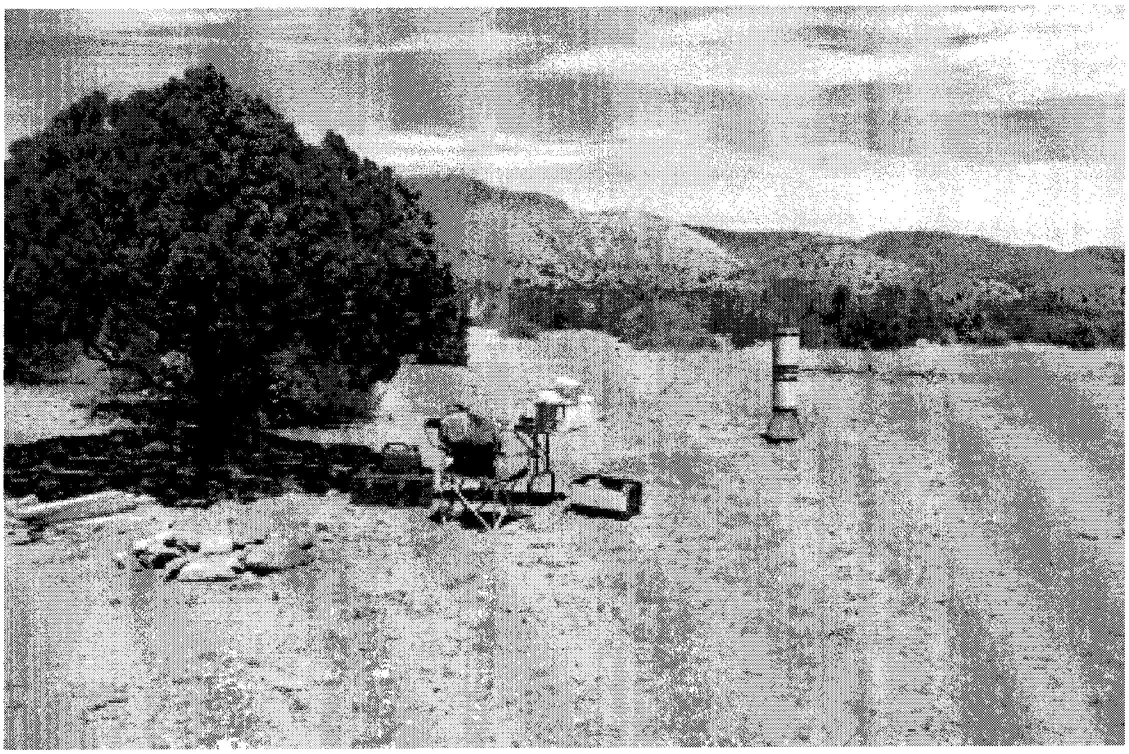


Figure-1. Large loop antenna (right rear) under test. The surrounding mountains may be seen in the background.

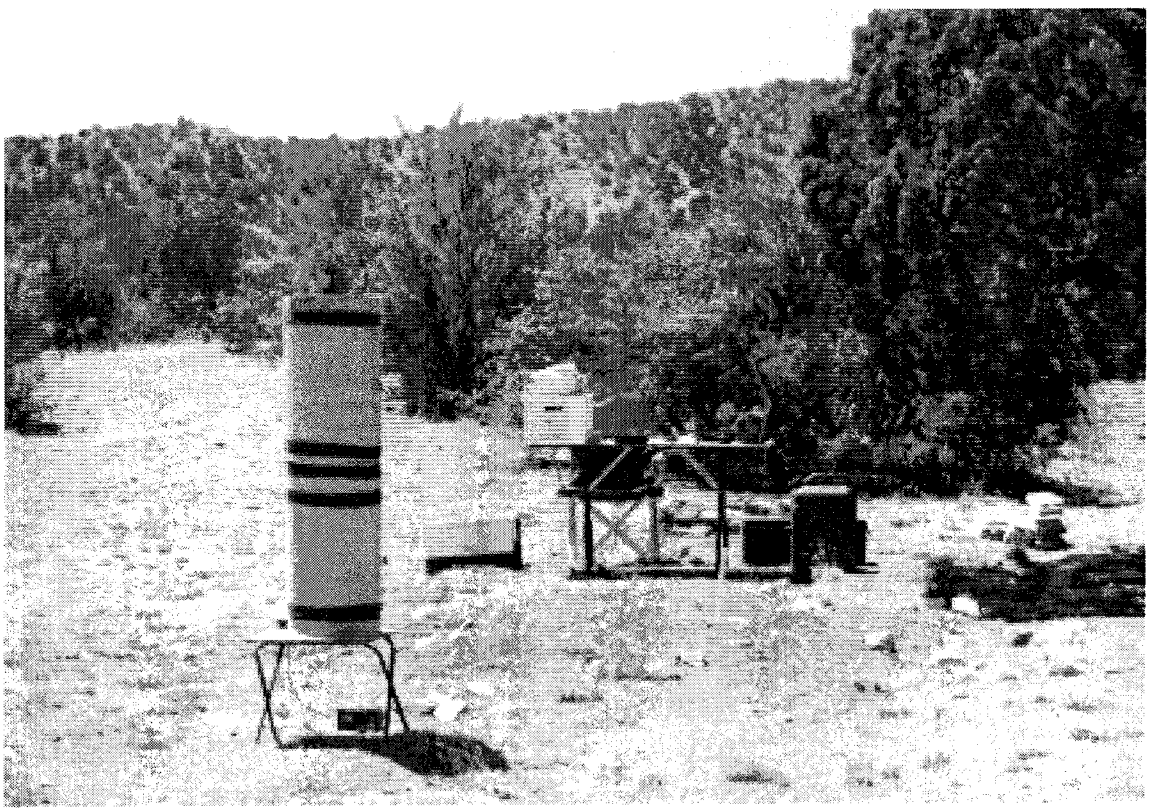
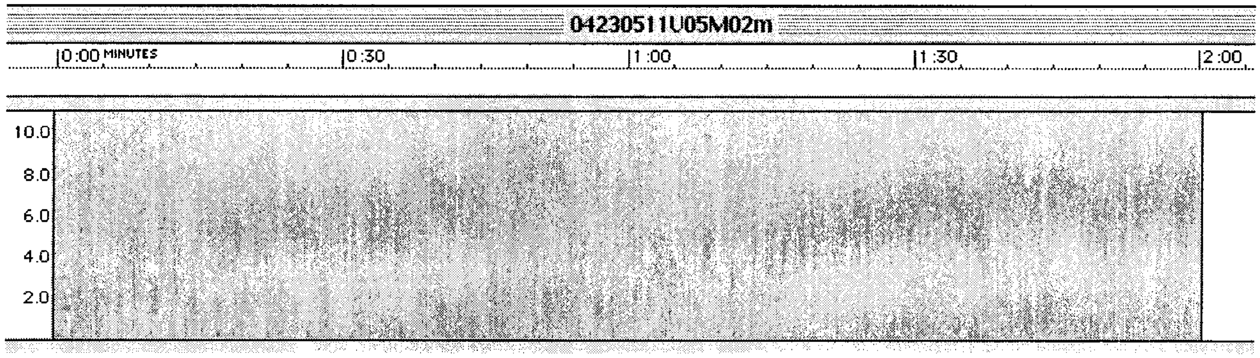
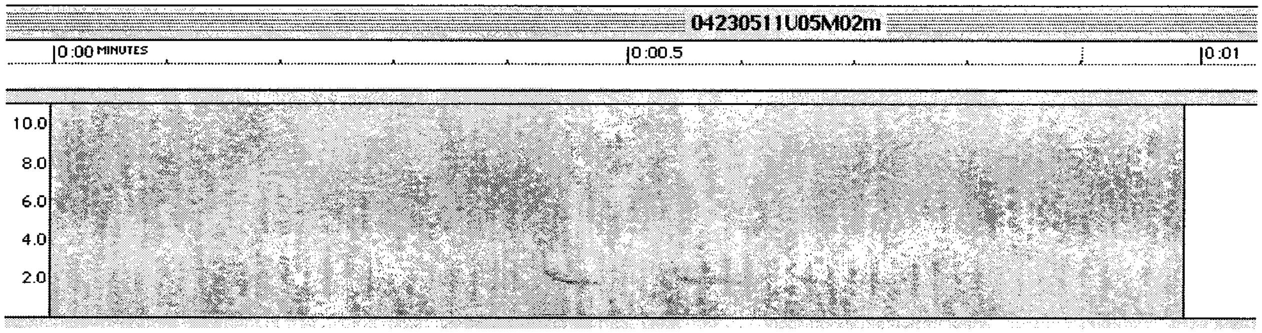


Figure-2. Testing the loop antenna(foreground). The loop preamp is on the ground under the loop and 25 feet of connecting coax runs to the modified VLF-2 on the table.

Data and whistlers from 4/23/05.

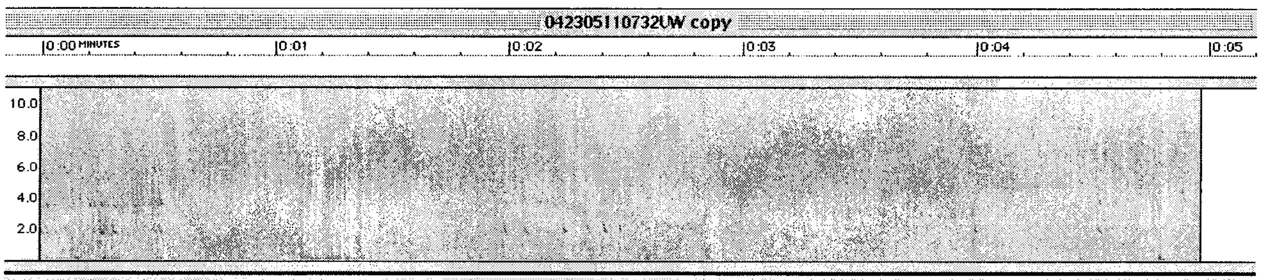


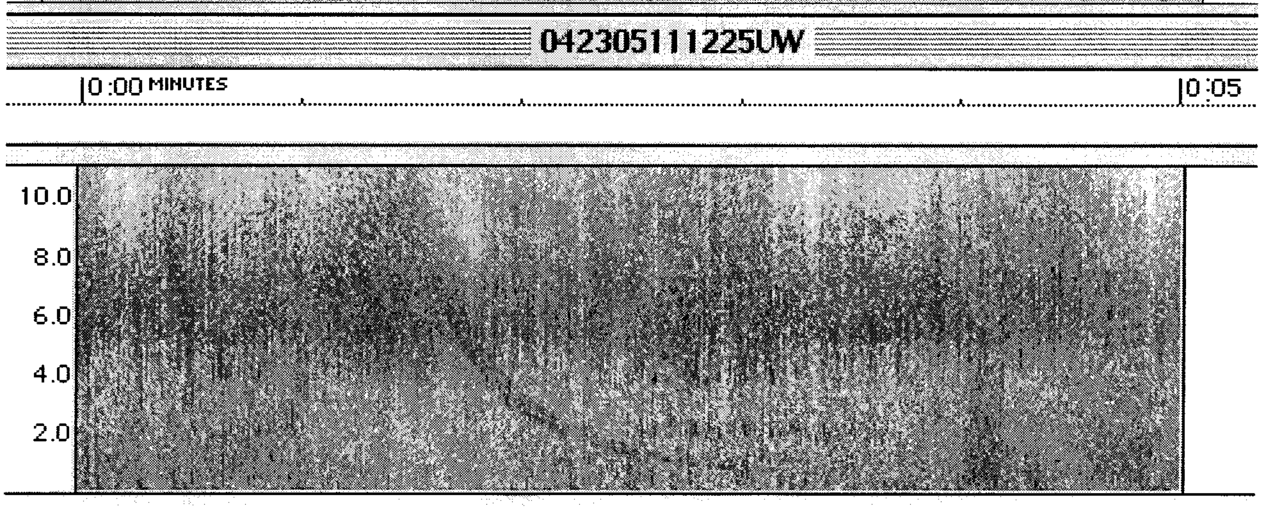
Data from 11U / 05 M.

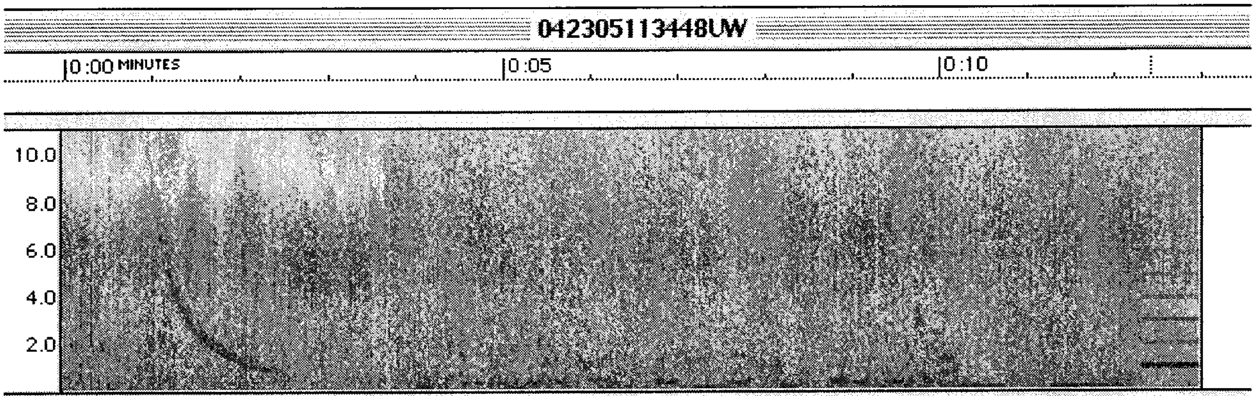


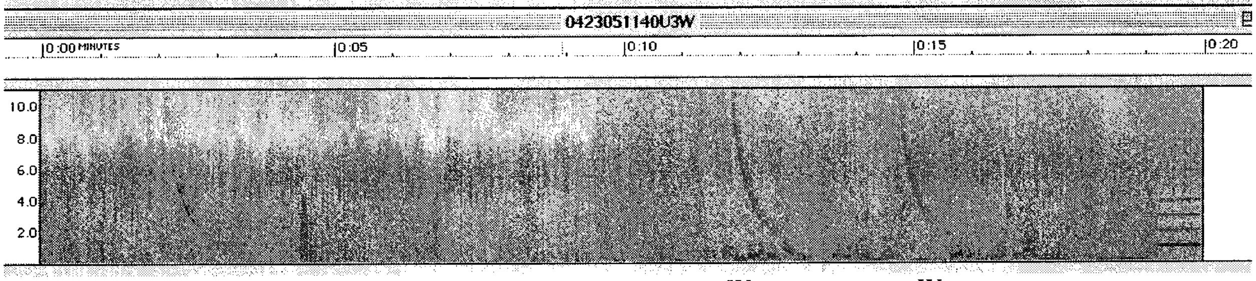
Strong tweeks in the interval :05 - :06 seconds from above.

A collection of whistlers from this session: (Note the time of each in the filename.)

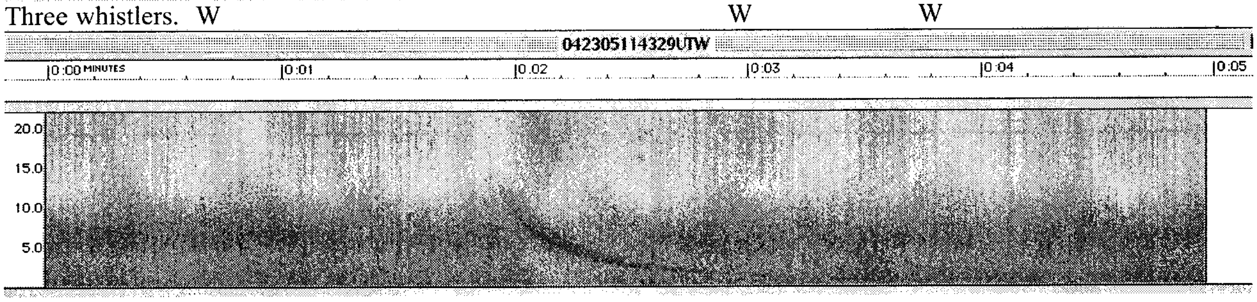






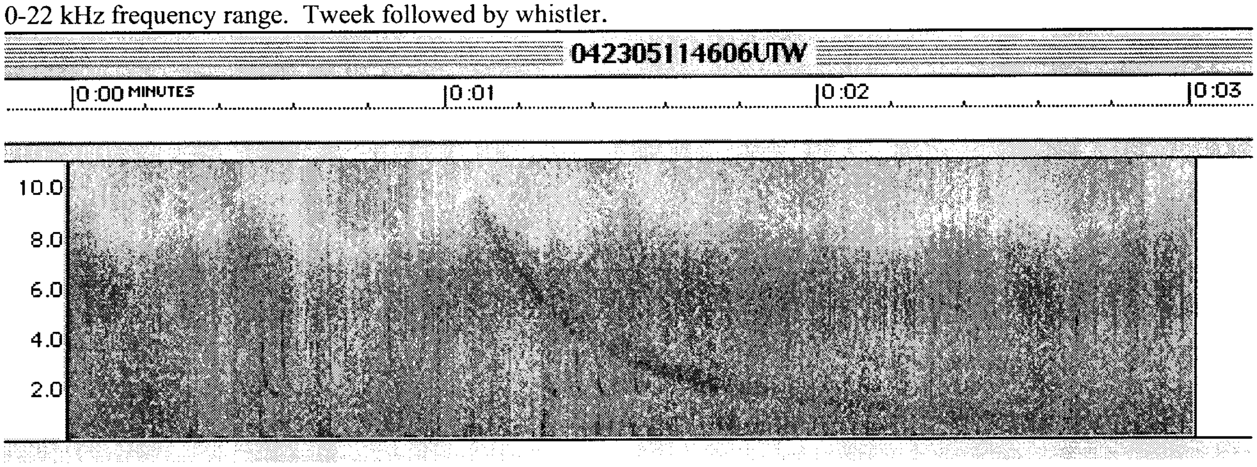


Three whistlers. W   W   W



T   W

0-22 kHz frequency range. Tweek followed by whistler.



T   W

Another tweek followed by whistler. The whistler is probably the result of the same lightning that caused the tweek. The tweek propagated within the ionosphere while the whistler traveled a much longer path along a magnetic field line in the magnetosphere. The way to recognize this phenomenon is to note when whistlers follow strong tweeks (or strong sferics) by the same time delay. Since lightning is random in timing, it is unlikely that the two would be coincidental in timing several times in a session. The two examples above confirm the observer's conclusion that the tweek and whistler are from the same lightning stroke.