FreeDV+ Performance vs. Ionospheric Propagation

Simulations using PathSim by AE4JY

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March 2014

1. INTRODUCTION

FreeDV plus Video is a new amateur radio soundcard mode combining digital voice (FreeDV) and video (ZL2AFP's FFT-TV) on HF. The performance of FreeDV with propagation (using PathSim) has been documented by Tony Bombardiere, K2MO, in one of his excellent videos (see "FreeDV HF Path Tests" – his videos are posted to his "Sandydiesel" channel on YouTube).

The author (WA6NUT), seeing Tony's work, felt that a modest PathSim study should be made for FreeDV plus Video. Users of FreeDV plus Video know that this mode requires careful frequency tuning for the received video signal -- this might indicate particular sensitivity to Doppler frequency spread effects as the HF signal propagates.

2. TEST SETUP

The test setup is shown in Figure 1 (p. 8). Three laptop PC's were used. The first laptop generated the composite digital voice (FreeDV) and video (FFT-TV) signal, applying this signal to the PathSim input at the second laptop. The video consisted of the Microsoft test video WNDSURF1.AVI played in a continuous loop. After processing by PathSim (simulating the effects of the selected standard propagation), the PathSim output signal was applied to the third laptop. This laptop used the FreeDV and FFT-TV receiving software to provide voice and video display. One of the video

subcarriers is highlighted in yellow on the bottom WinWarbler waterfall. The frequency of the highlighted subcarrier is displayed on the WinWarbler AFC readout (about 2.100 kHz). The FreeDV SNR reading on each screenshot provides an indication of received voice quality. Screenshots were taken of the laptop screen for each standard PathSim propagation mode selected (shown in Appendix 1 and 2, pp. 9 and 14).

3. TEST RESULTS

The objective of this study was to determine the sensitivity of FreeDV plus Video to differential time delay and Doppler frequency spread. The four standard propagation modes in Appendix 1 were selected for this study. Screenshots 1 and 4 (see Appendix 1, p. 9) have low values of time delay and Doppler spread, so one would expect only minor effects to be noticed in the received FreeDV and FFT-TV video. Examination of Screenshot 1 (p. 10) and Screenshot 4 (p. 13) verifies this. However, the anomalies in Screenshot 4 show that the higher Doppler spread value (= 1.5 Hz) may exceed the maximum value for acceptable video. Screenshot 1 (FreeDV plus Video) can be compared with K2MO's video "Test #1", 1400 mode (FreeDV only, no video).

Screenshot 2 has a low time delay value and a high Doppler spread value, so one would expect poor performance if FreeDV plus Video is sensitive to Doppler spread. Examination of Screenshot 2 (p. 11) shows the video image obscured by noise, and that the Doppler spread value (= 10 Hz) far exceeds the value for acceptable video. Screenshot 2 (FreeDV plus Video) can be compared with K2MO's video "Test #2", 1400 mode (FreeDV only, no video).

Screenshot 3 has a high time delay value and a low Doppler spread value, so one would expect poor performance if FreeDV plus Video is sensitive to time delay. Examination of Screenshot 3 (p. 12) shows only minor artifacts in the received video image, and that FreeDV plus Video is not particularly sensitive to differential time delay.

Comparison of Screenshots 1, 3 and 4 shows that the video component handles Doppler spread up to 1 Hz with acceptable image quality. Screenshot 3 (FreeDV plus Video) can be compared with K2MO's video "Test #4", 1400 mode (FreeDV only, no video).

4. CONCLUSIONS

FreeDV plus Video shows sensitivity to Doppler frequency spread, with the ability to tolerate Doppler frequency spread up to about 1 Hz (only five of the PathSim simulations have Doppler frequency spread values exceeding 1 Hz). The mode shows good tolerance to differential time delay values up to (and perhaps beyond) 7 mS (none of the PathSim simulations have time delay values exceeding 7 mS).

High-latitude (over-the-pole) paths are especially difficult for the video component of FreeDV plus Video, making contacts between the central U.S. and Europe almost impossible.

It may be helpful to remember that the FFT-TV image is a sideways waterfall, with frequency along the vertical axis and time along the horizontal axis. Brightness and color are affected by frequency modulation (or phase change) in the received subcarriers. A new "waterfall" (image) is generated every second. This may explain some of the unusual propagation-caused artifacts in some of the received images (the High Latitude Quiet screenshot, for example). It may be possible to show correspondence between propagation-caused features in the FreeDV waterfall and artifacts in the received video image.

5. MORE SCREENSHOTS

Screenshots were taken for almost all the remaining PathSim standard propagation simulations. See Appendix 2, p. 14.

6. REFERENCES

PathSim by Moe Wheatley, AE4JY

https://www.moetronix.com/ae4jy/pathsim.htm

Use of High Frequency Ionospheric Channel Simulators (CCIR 520-2)

http://www.itu.int/dms_pubrec/itu-r/rec/f/R-REC-F.520-2-199203-W!!PDF-E.pdf

Testing of HF Modems with Bandwidths of Up to About 12 kHz Using Ionospheric Channel Simulators (ITU-R F.1487)

http://www.itu.int/dms_pubrec/itu-r/rec/f/R-REC-F.1487-0-200005-I!!PDF-E.pdf

Jacobs, G., Cohen, T., Rose, R., "The New Shortwave Propagation Handbook", CQ Communications, 1995, Section 7.12, pp. 7-25 to 7-26

Blaunstein, N. and Plohotniuc, E., "Ionospheric and Applied Aspects of Radio Communication and Radar", CRC Press, 2008, pp. 136-138

http://www.books.google.com/books?isbn=1420055178

K2MO's FreeDV video, "FreeDV HF Path Tests"

https://www.qsl.net/wa6nut/FreeDV HF Path Tests – K2MO.mp4

FreeDV website

https://freedv.org

FreeDV plus Video website

https://www.qsl.net/wa6nut/FreeDVplusVideo

Microsoft VFW Test Video, WNDSURF1.AVI (part of AVISAMPLE.EXE)

http://cd.textfiles.com/10000soundssongs/AVI/

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Format changes 5/4/19

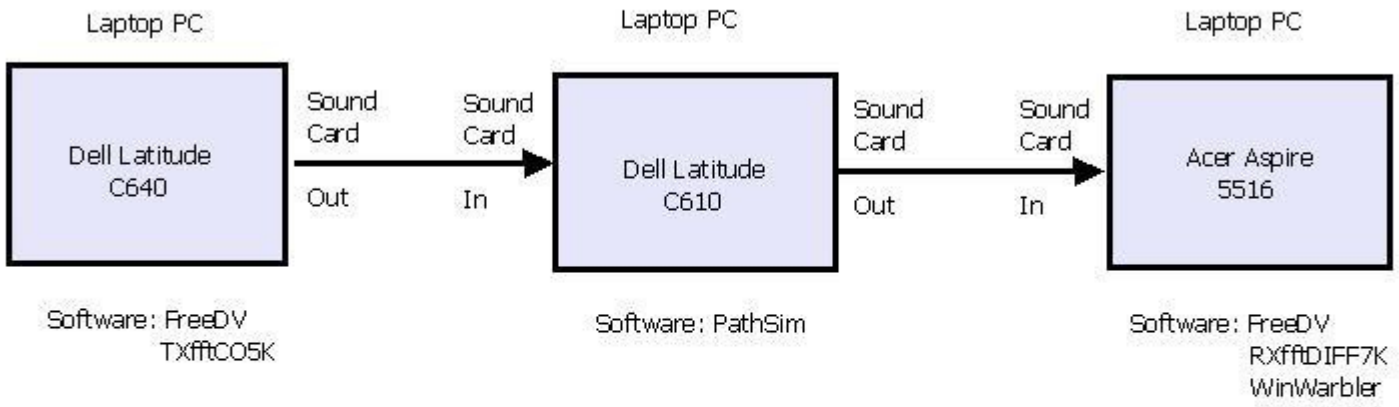

Figure 1

FreeDV plus Video
PathSim Propagation
Simulation Setup

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3/2/2014

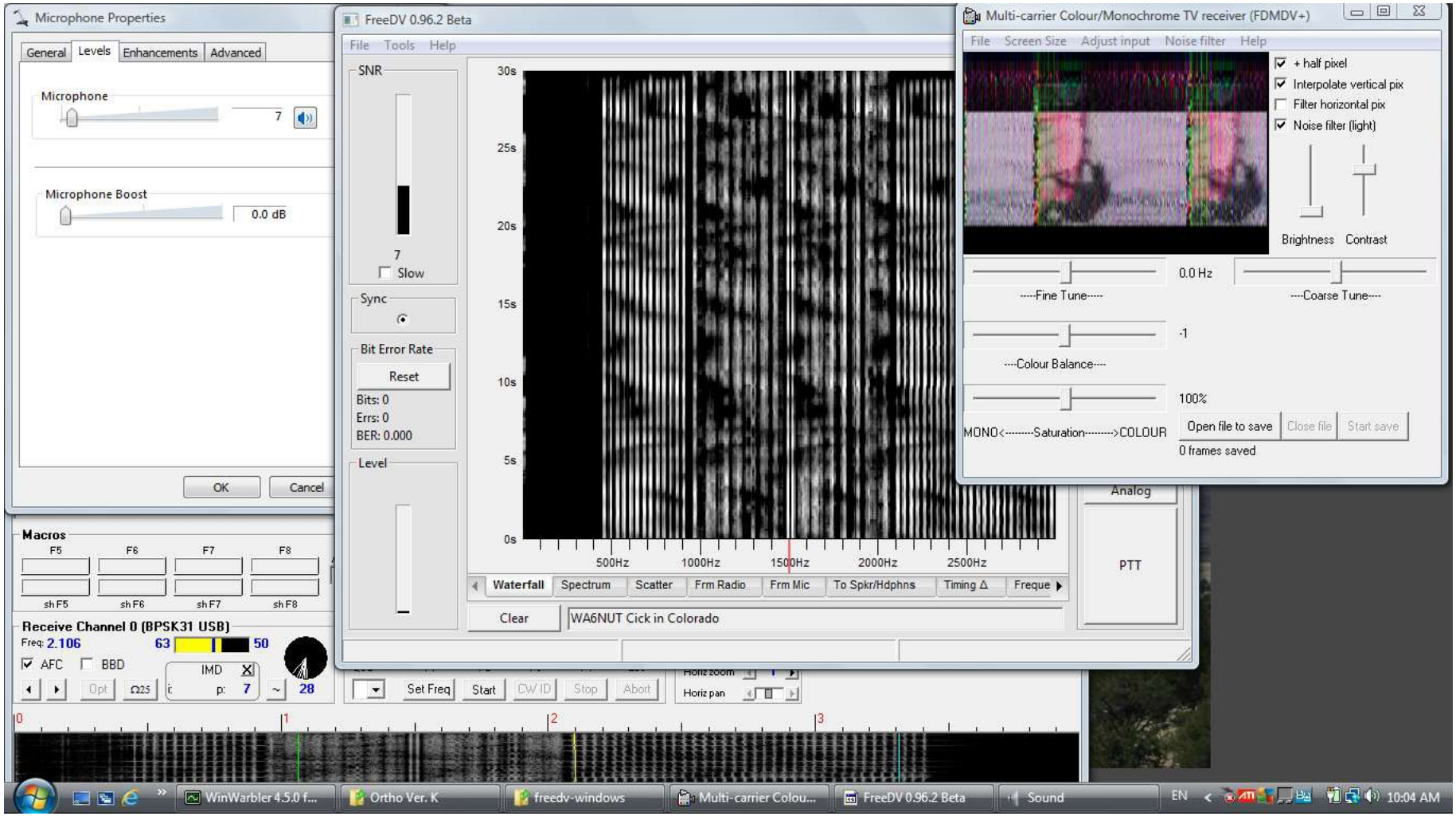
FreeDV+ Ionospheric Propagation

Receiver Screenshots with PathSim Standard Simulations

Appendix 1

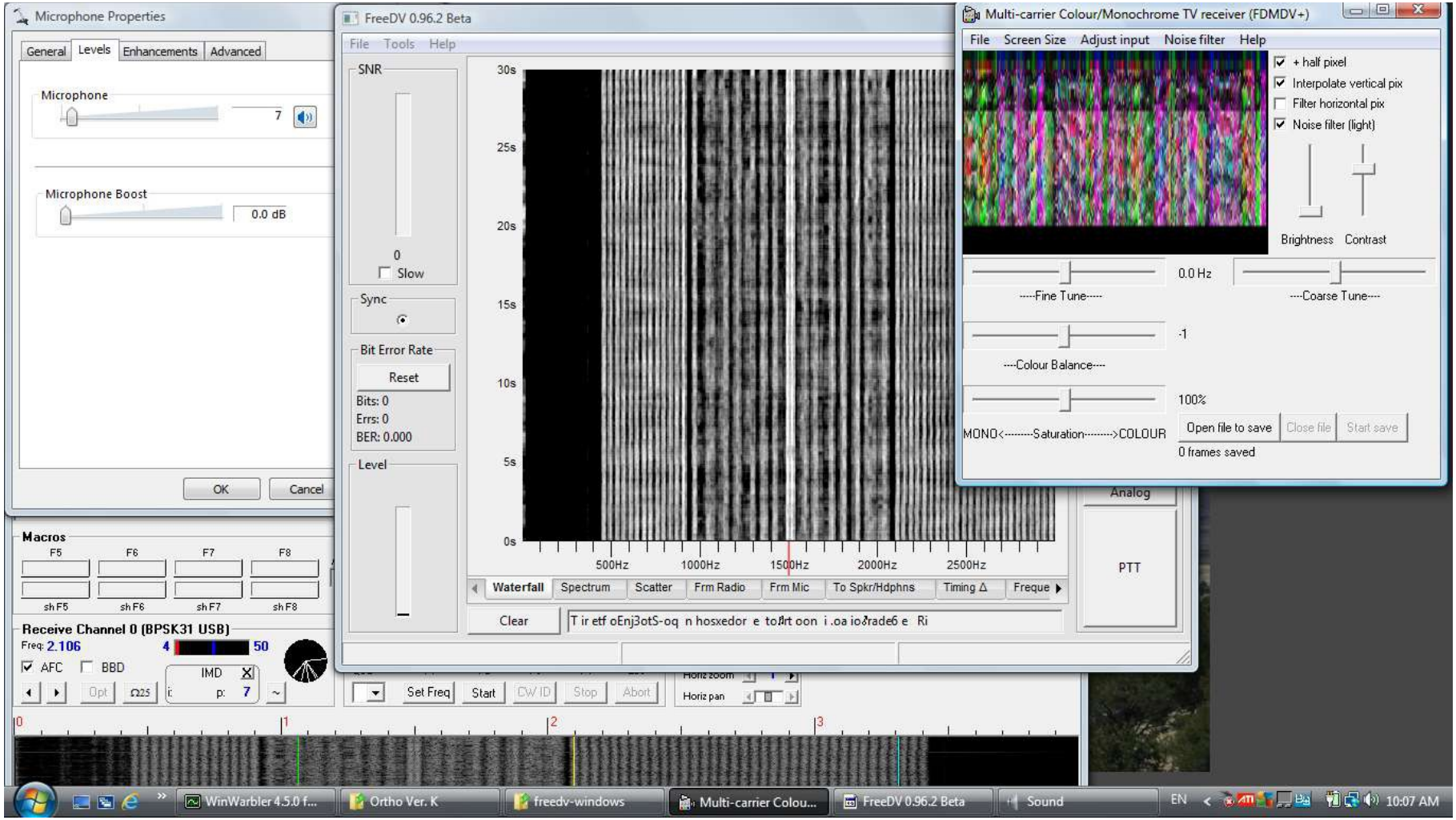
Screenshot	Page	Simulation	Diff. Time Delay (mS)	2 Sigma Doppler Spread (Hz)
1	10	CCIR 520-2 Poor K2MO FreeDV video Test #1	2.0	1.0
2	11	High Latitude Moderate K2MO FreeDV video Test #2	3	10
3	12	Mid Latitude Disturbed NVIS K2MO FreeDV video Test #4	7	1
4	13	Low Latitude Moderate	2	1.5

FreeDV+ Ionospheric Propagation



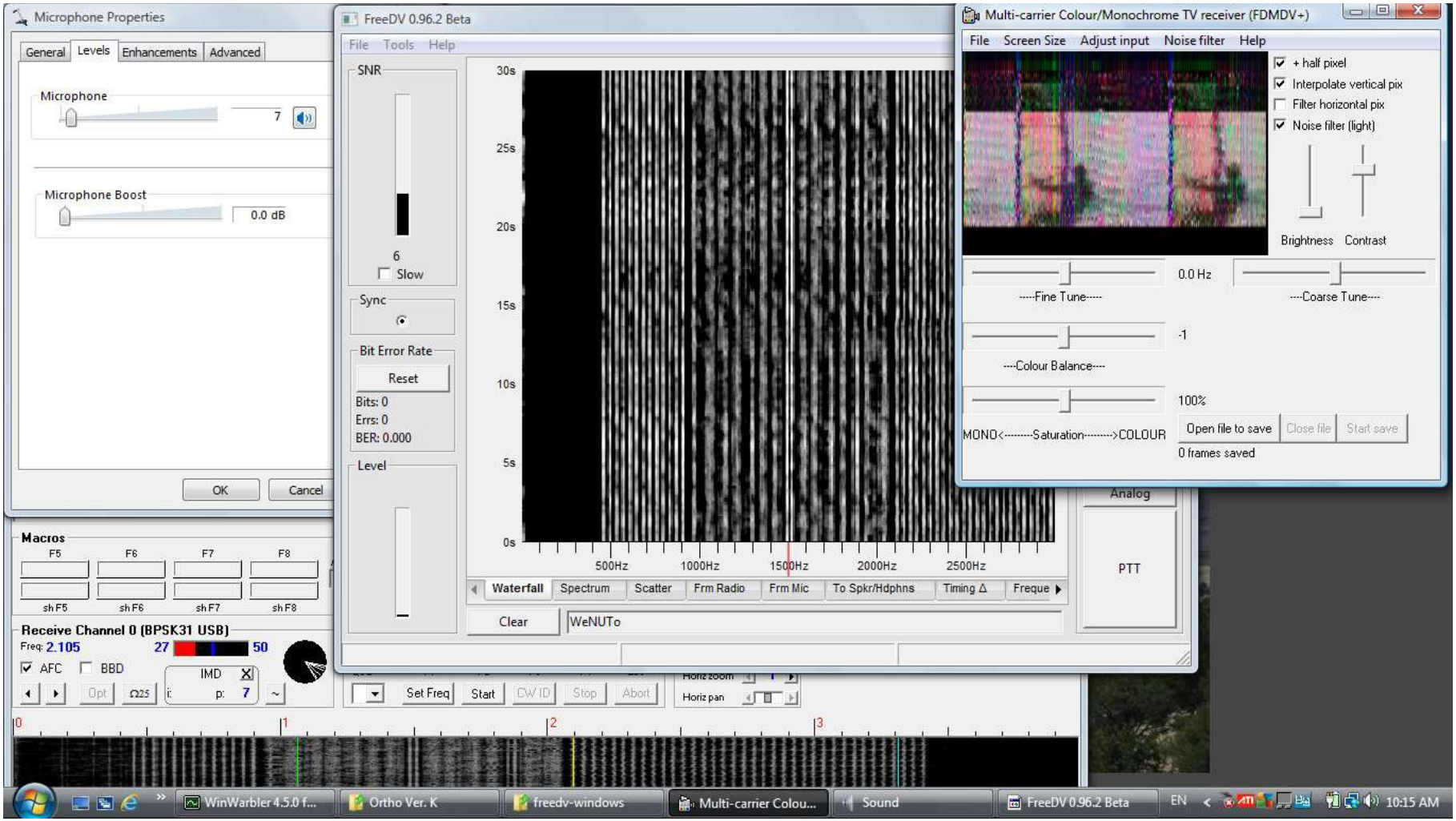
Screenshot 1: CCIR 520-2 Poor

FreeDV+ Ionospheric Propagation



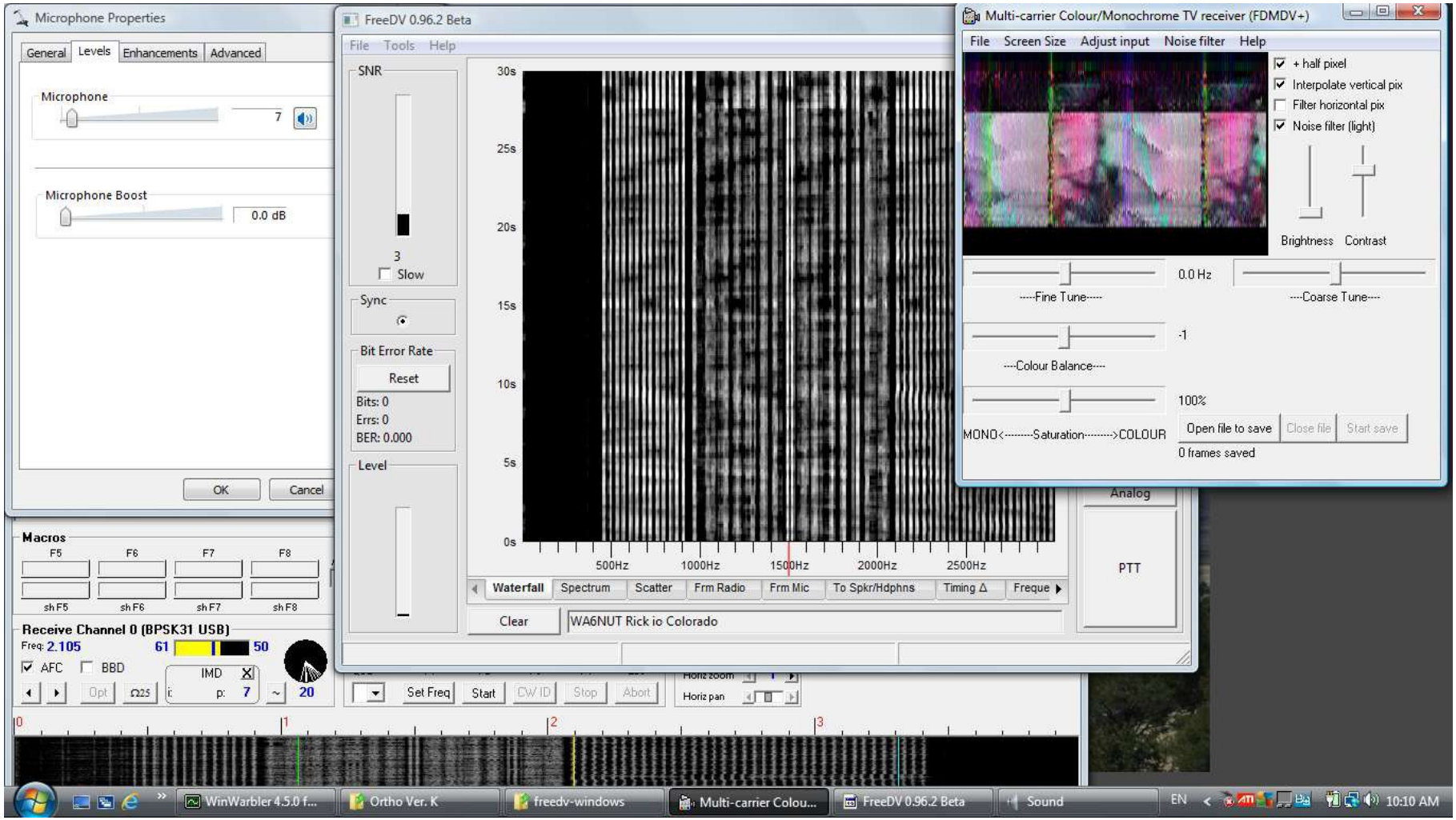
Screenshot 2: High Latitude Moderate

FreeDV+ Ionospheric Propagation



Screenshot 3: Mid Latitude Disturbed

FreeDV+ Ionospheric Propagation



Screenshot 4: Low Latitude Moderate

FreeDV+ Ionospheric Propagation

Receiver Screenshots with PathSim Standard Simulations

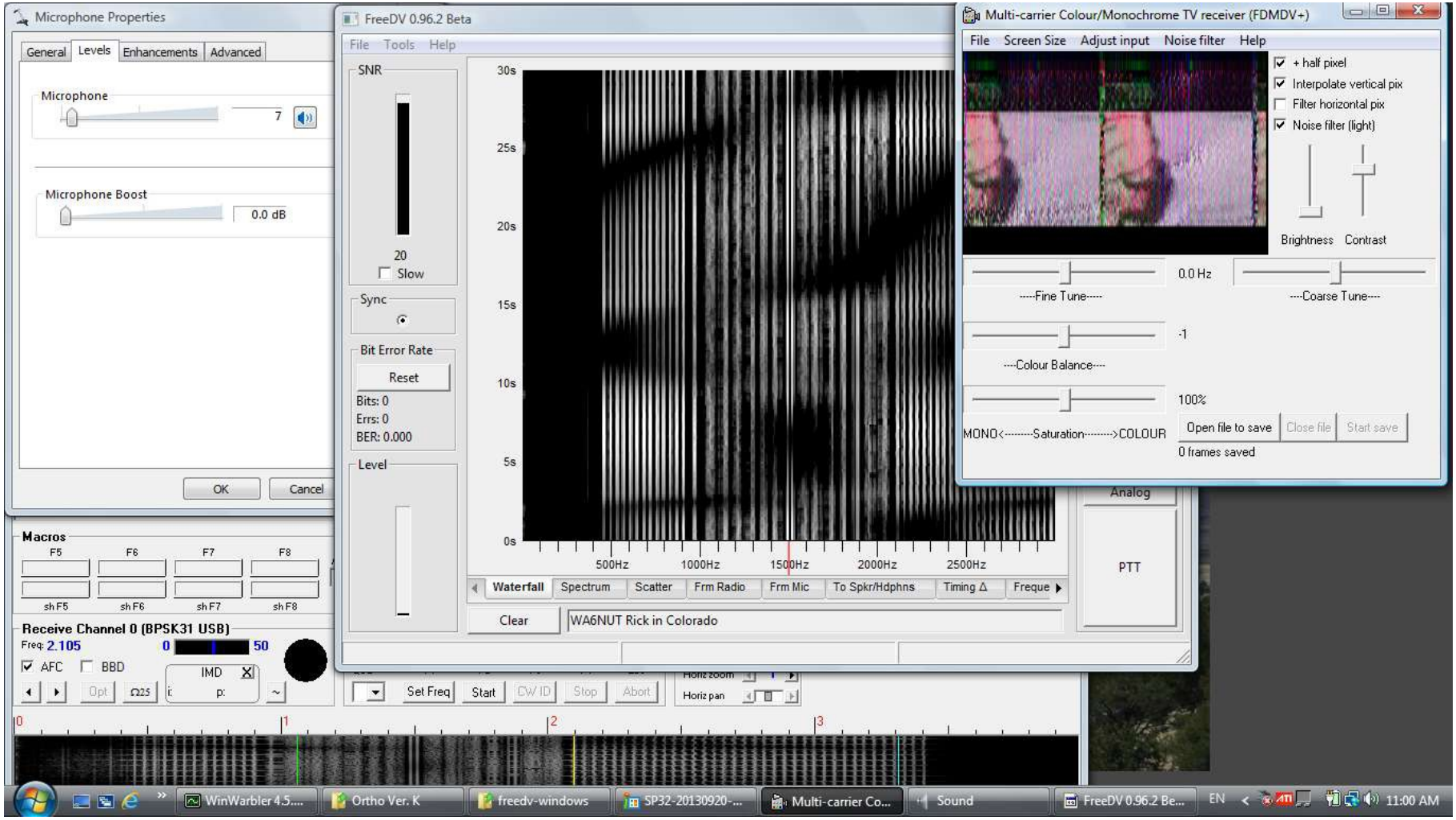
Appendix 2

Screenshot	Page	Simulation	Diff. Time Delay (mS)	2 Sigma Doppler Spread (Hz)
5	16	CCIR 520-2 Good	0.5	0.1
6	17	CCIR 520-2 Moderate	1.0	0.5
		CCIR 520-2 Poor (see Appendix 1)		
7	18	Doppler Fading	--	--
8	19	Flutter Fading	0.5	10.0
9	20	High Latitude Disturbed	7	30
		High Latitude Moderate (see Appendix 1)		
10	21	High Latitude Quiet	1	0.5
11	22	Low Latitude Disturbed	6	10
		Low Latitude Moderate (see Appendix 1)		
12	23	Low Latitude Quiet	0.5	0.5

FreeDV+ Ionospheric Propagation

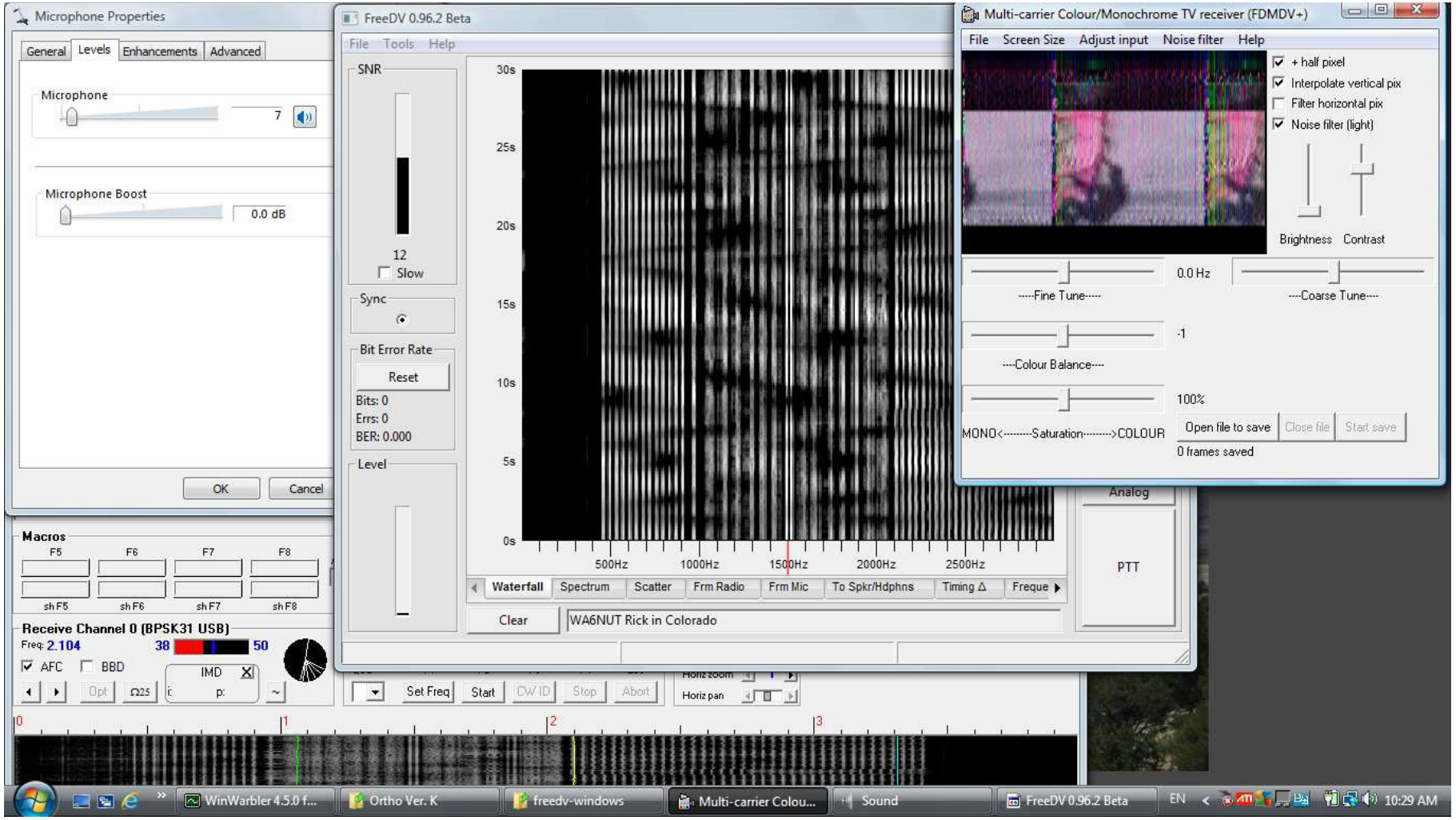
Screenshot	Page	Simulation	Diff. Time Delay (mS)	2 Sigma Doppler Spread (Hz)
13	24	Mid Latitude Disturbed	2	1
		Mid Latitude Disturbed NVIS (see Appendix 1)		
14	25	Mid Latitude Moderate	1	0.5
15	26	Mid Latitude Quiet	0.5	0.1

FreeDV+ Ionospheric Propagation



Screenshot 5: CCIR 520-2 Good

FreeDV+ Ionospheric Propagation



Screenshot 6: CCIR 520-2 Moderate

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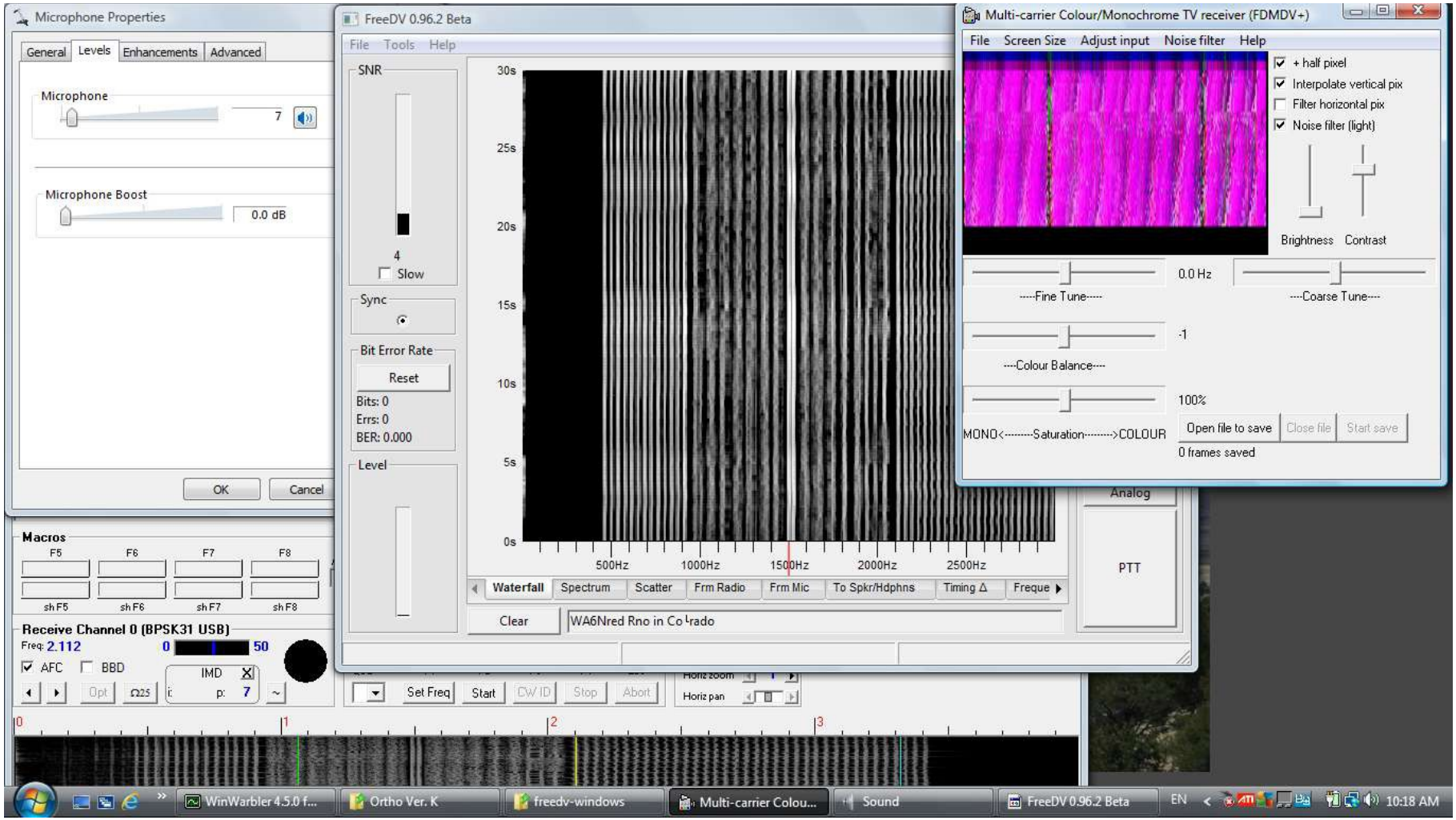
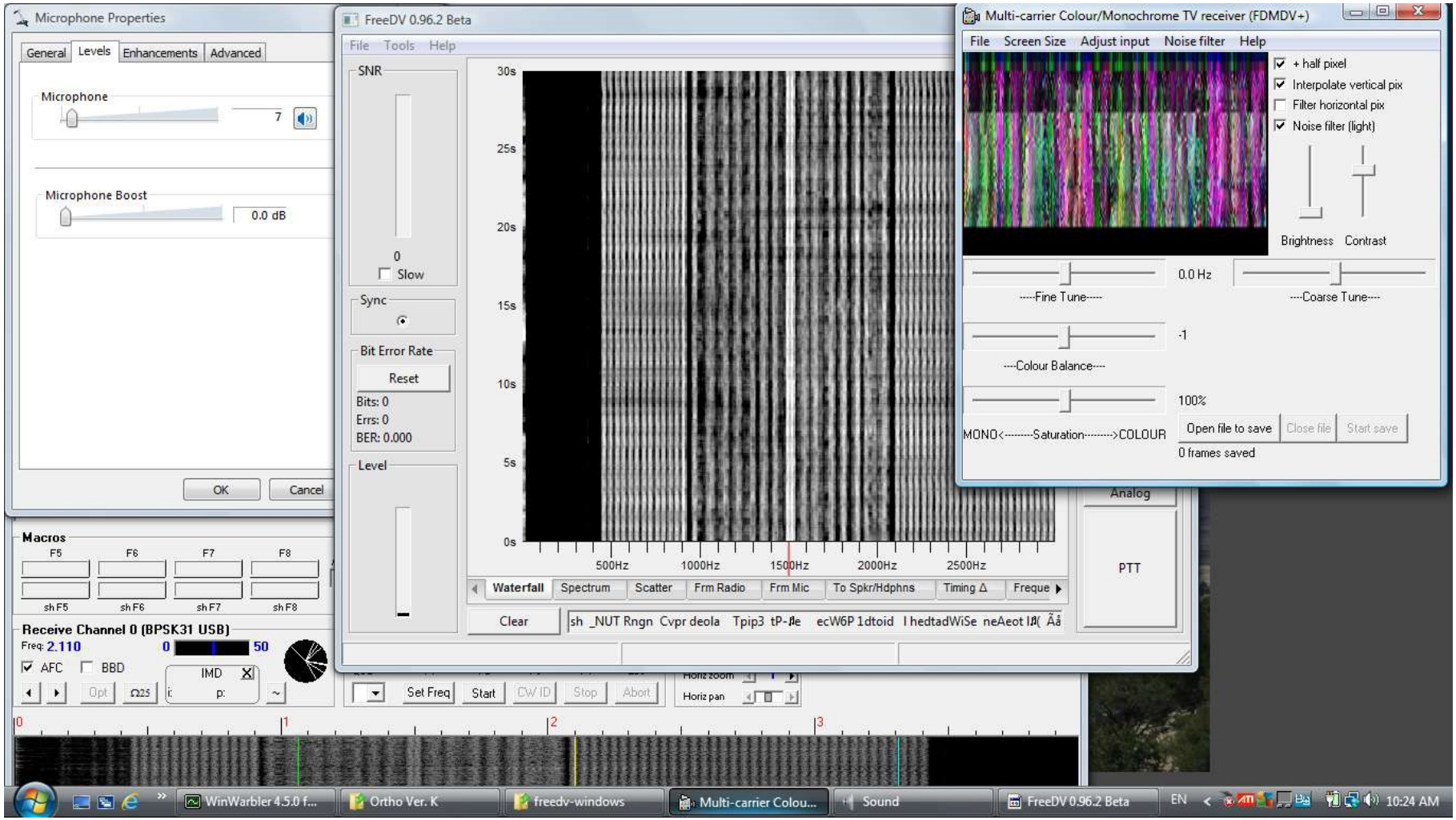


Screenshot 7: Doppler Fading

FreeDV+ Ionospheric Propagation



Screenshot 8: Flutter Fading

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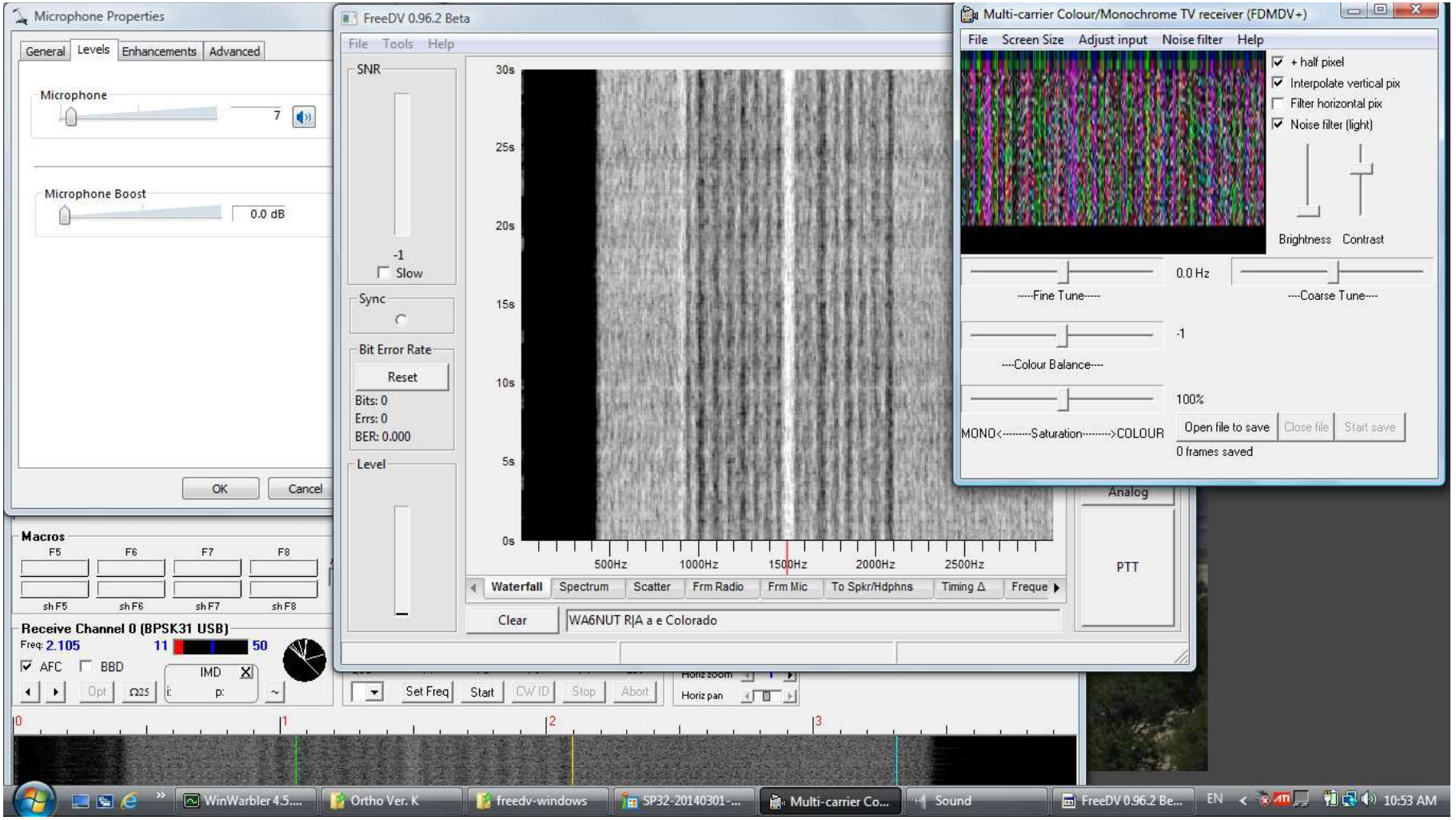
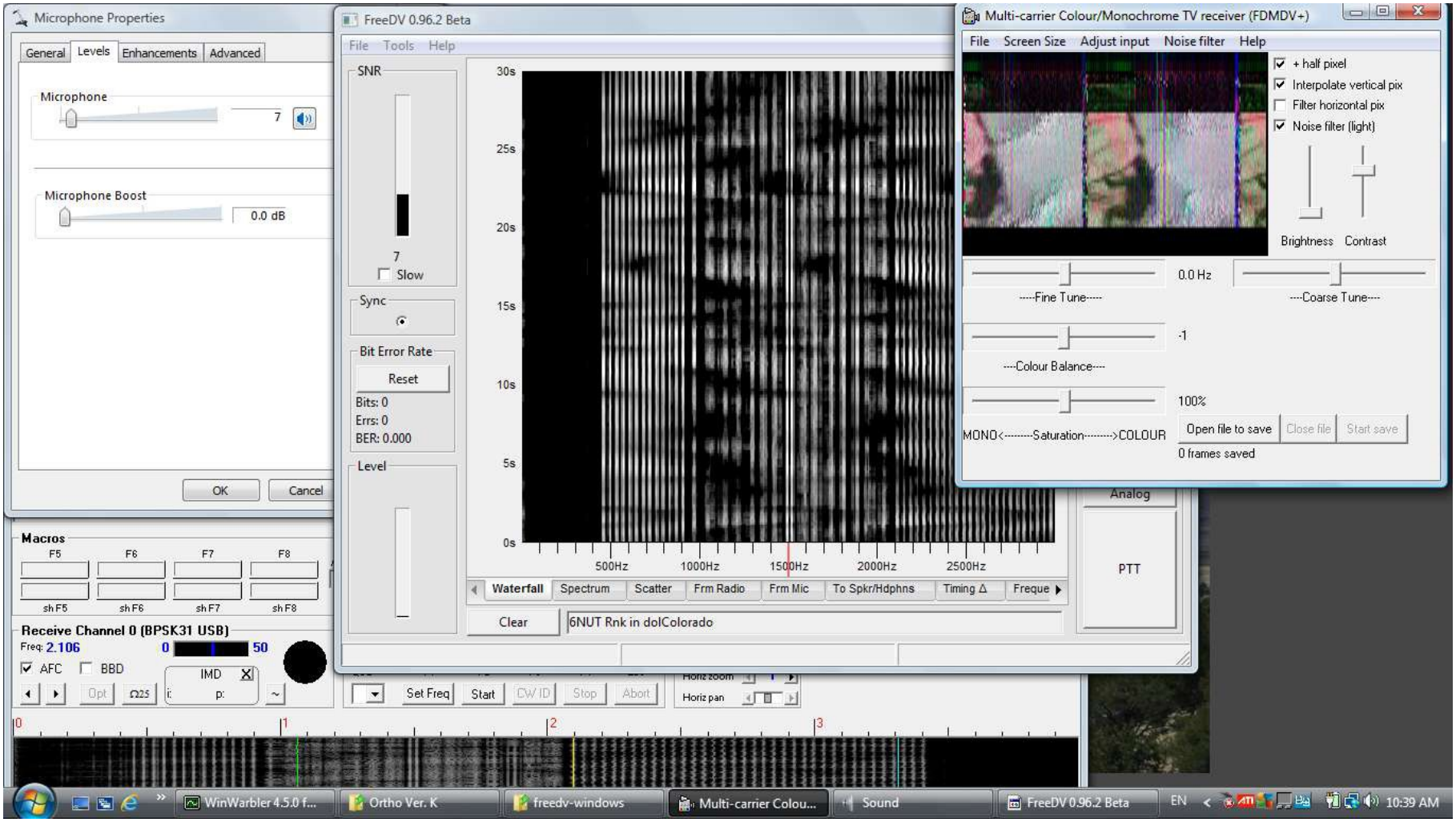


Screenshot 9: High Latitude Disturbed

FreeDV+ Ionospheric Propagation



Screenshot 10: High Latitude Quiet

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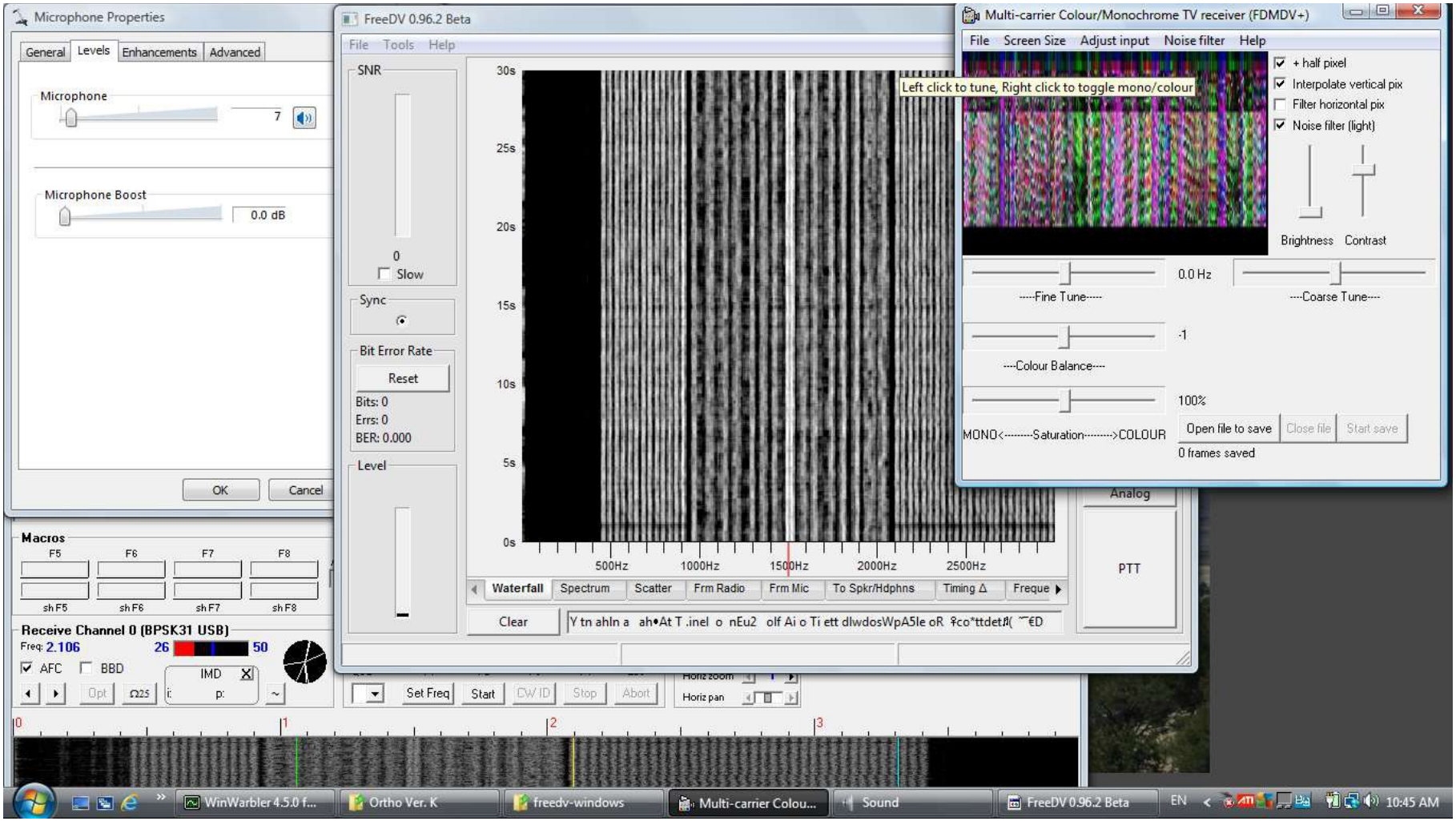
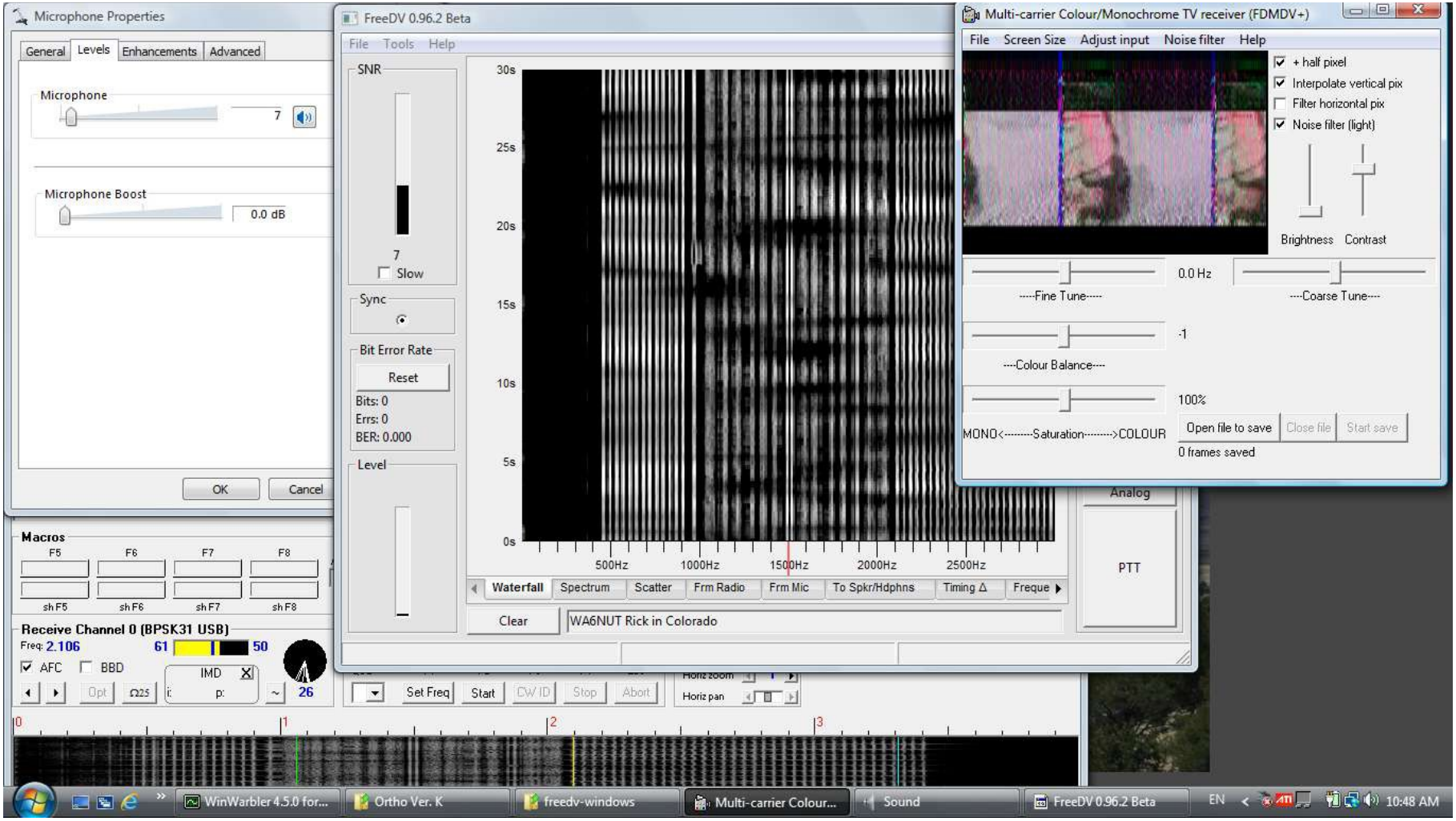


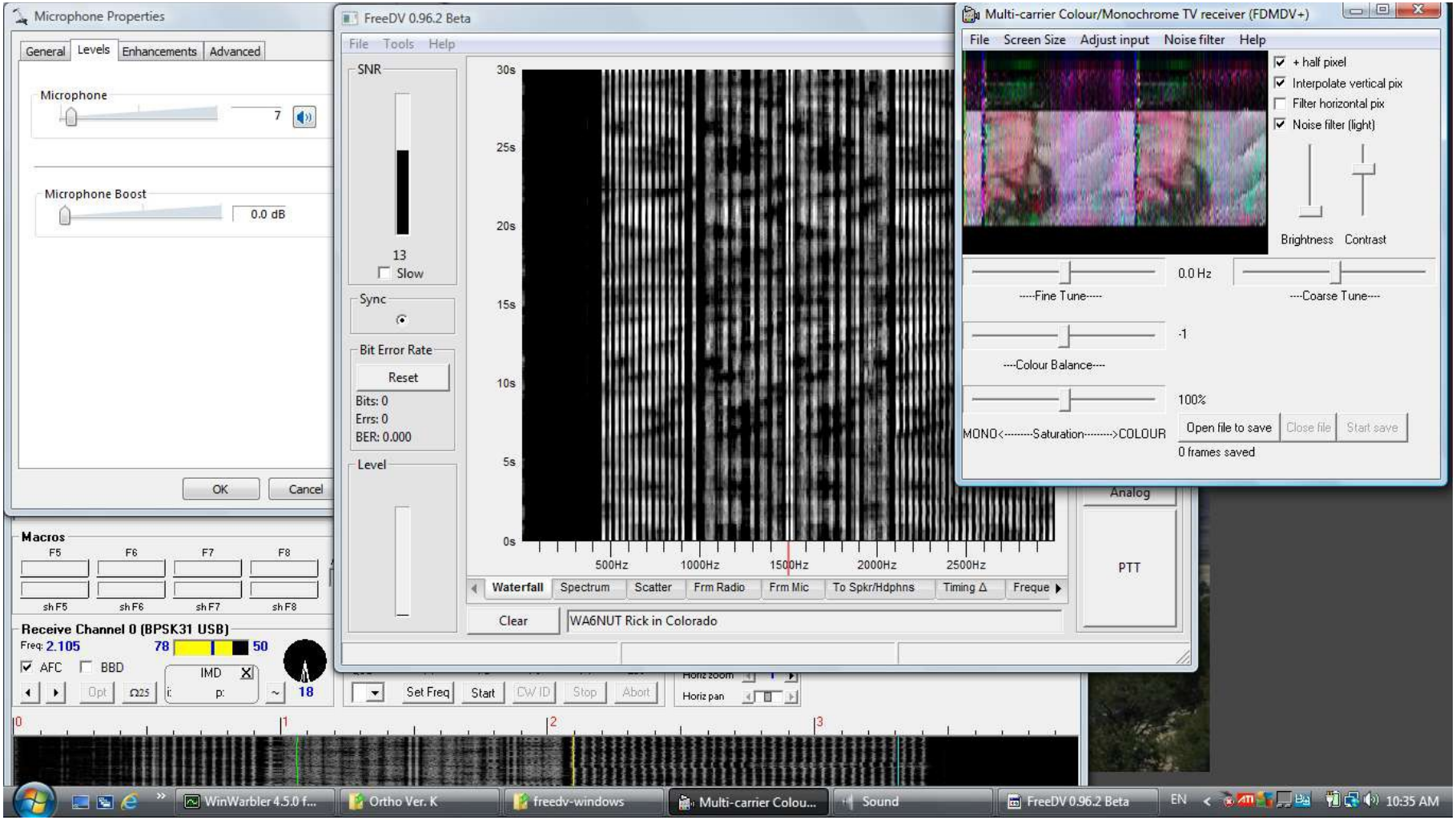
Screenshot 11: Low Latitude Disturbed

FreeDV+ Ionospheric Propagation



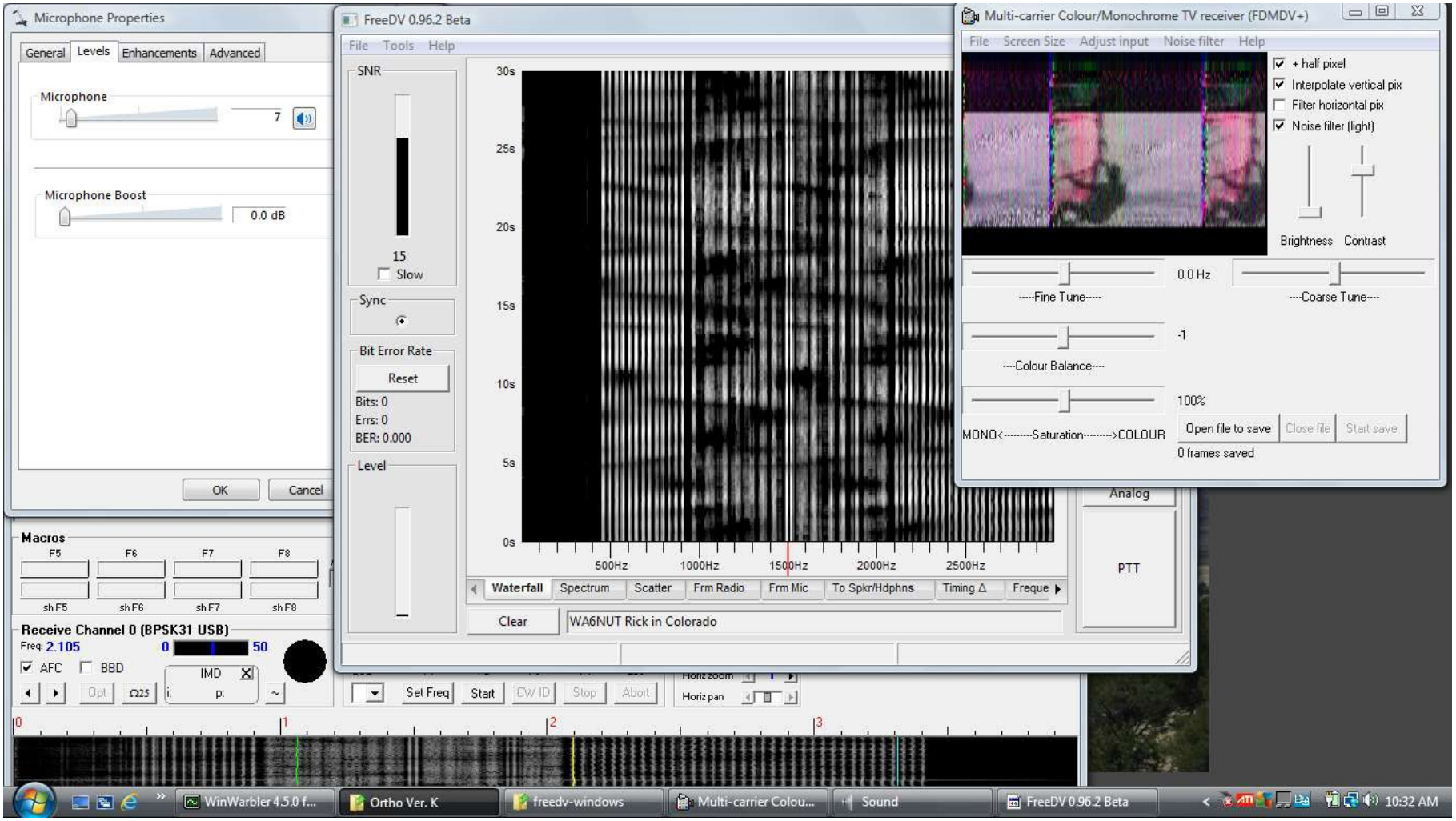
Screenshot 12: Low Latitude Quiet

FreeDV+ Ionospheric Propagation



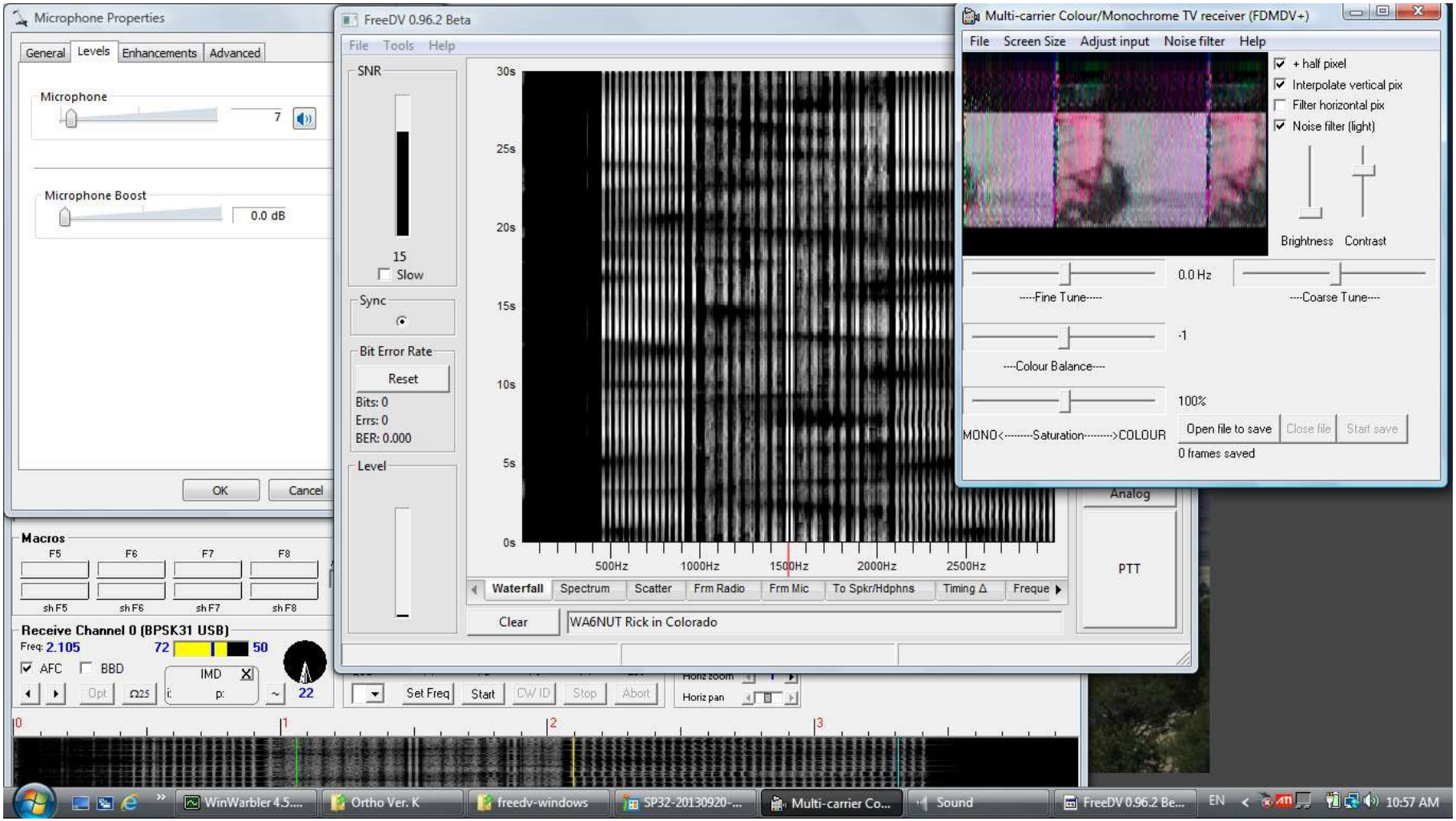
Screenshot 13: Mid Latitude Disturbed

FreeDV+ Ionospheric Propagation



Screenshot 14: Mid Latitude Moderate

FreeDV+ Ionospheric Propagation



Screenshot 15: Mid Latitude Quiet