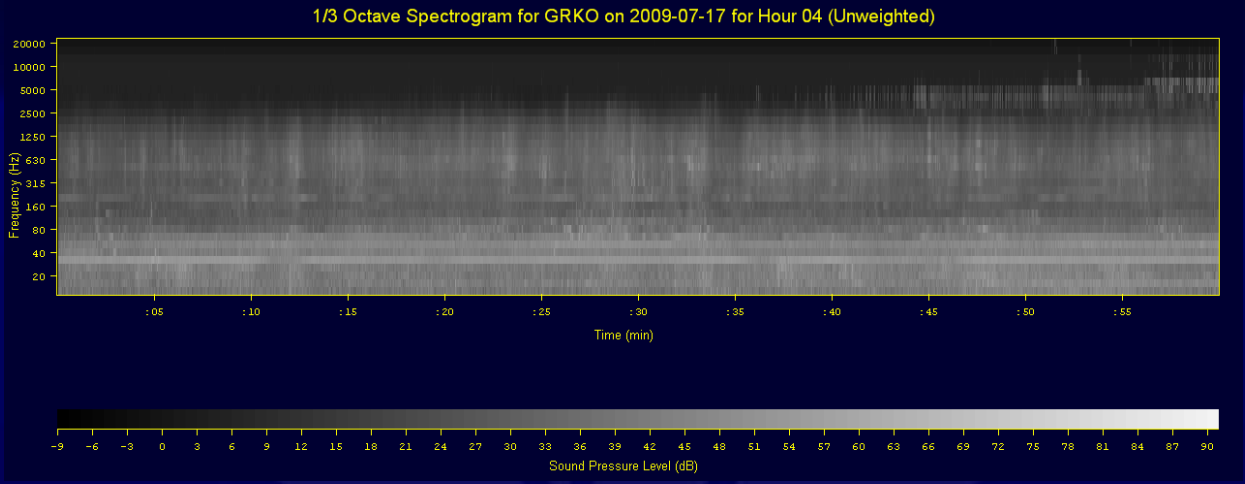

Automated analysis and interpretation of long-term soundscape audio recordings

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Mountains & Minds

Outline

- Introduction
- Long-term acoustical acquisition
  - Soundscape studies (thousands and thousands of hours)
  - Environmental monitoring
- How to present soundscape information?
  - Spectrograms
  - Aural snapshots
  - Time-lapse aural presentation
- Conclusion

Introduction

- Long-term soundscape studies are now feasible and desirable
- Interpretation and presentation is difficult due to extreme length of the data
- What is needed:
  - Automated analysis tools
  - Useful comparison metrics
  - Meaningful presentation techniques

Example: Grant-Kohrs Ranch National Historic Site

- Deer Lodge, Montana
- A working cattle ranch commemorating the heritage of American cowboys, stock growers, and cattle operations during the 19th and 20th centuries.
- Congress: established in 1977 to maintain the site as a working ranch.
- Cultural soundscape is essential: all the sights, sounds, and sensations associated with ranching.

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Long-Term Collection

Project Presentation Challenges

- Audio recording lasting 365 days = 8,760 hours (525,600 minutes)
- Long segments of natural quiet with sections of recognizable biophony, geophony, and anthrophony
- Visitors to a web site or visitor center spend only a few minutes: can we compress meaningfully by 1/200,000 ?

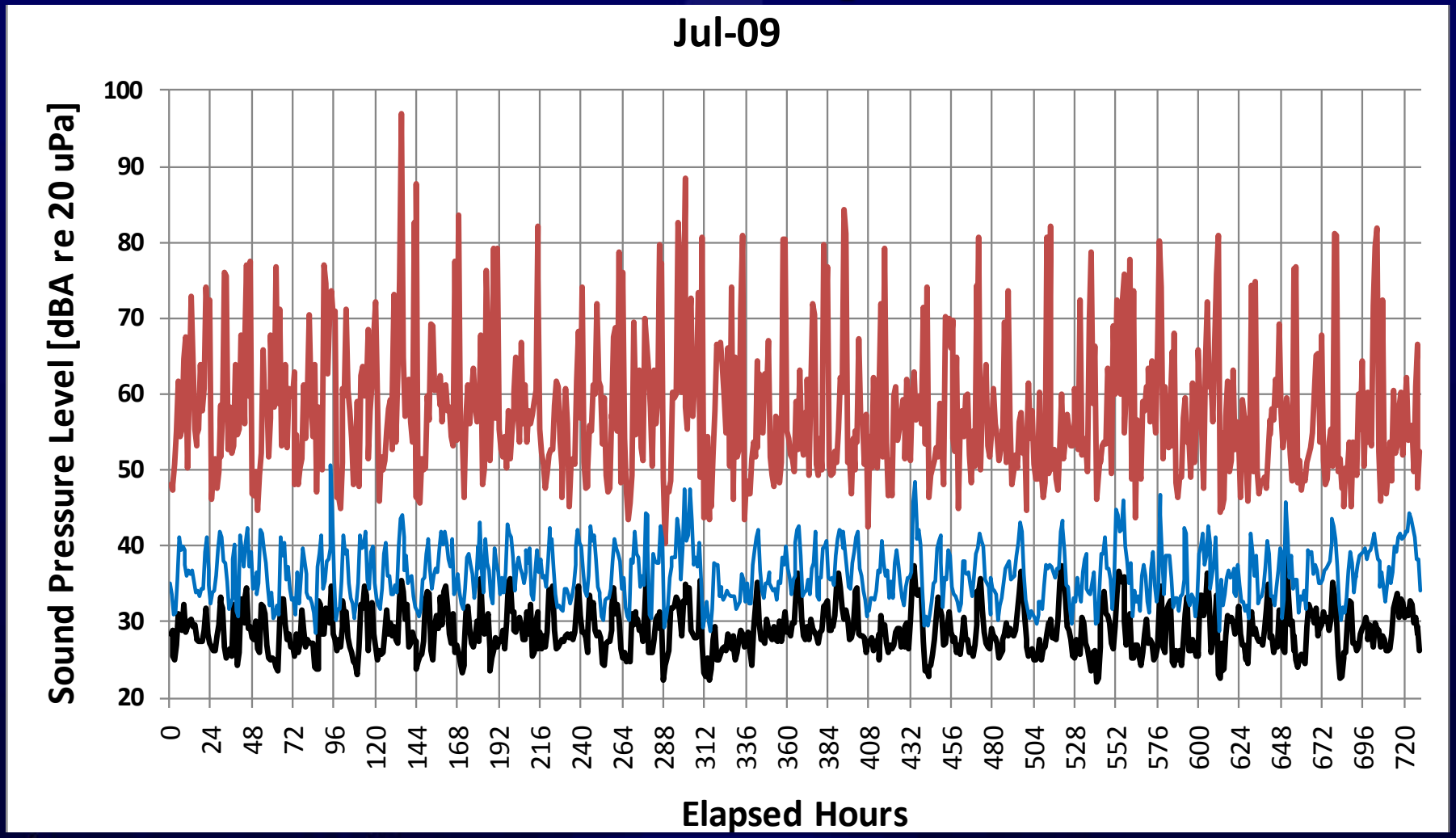
Some options

- Automated SPL min/max/average graphs
- Spectrographic displays
- Audio samples of “highlights”
- Time-lapse aural display

SPL Graphs

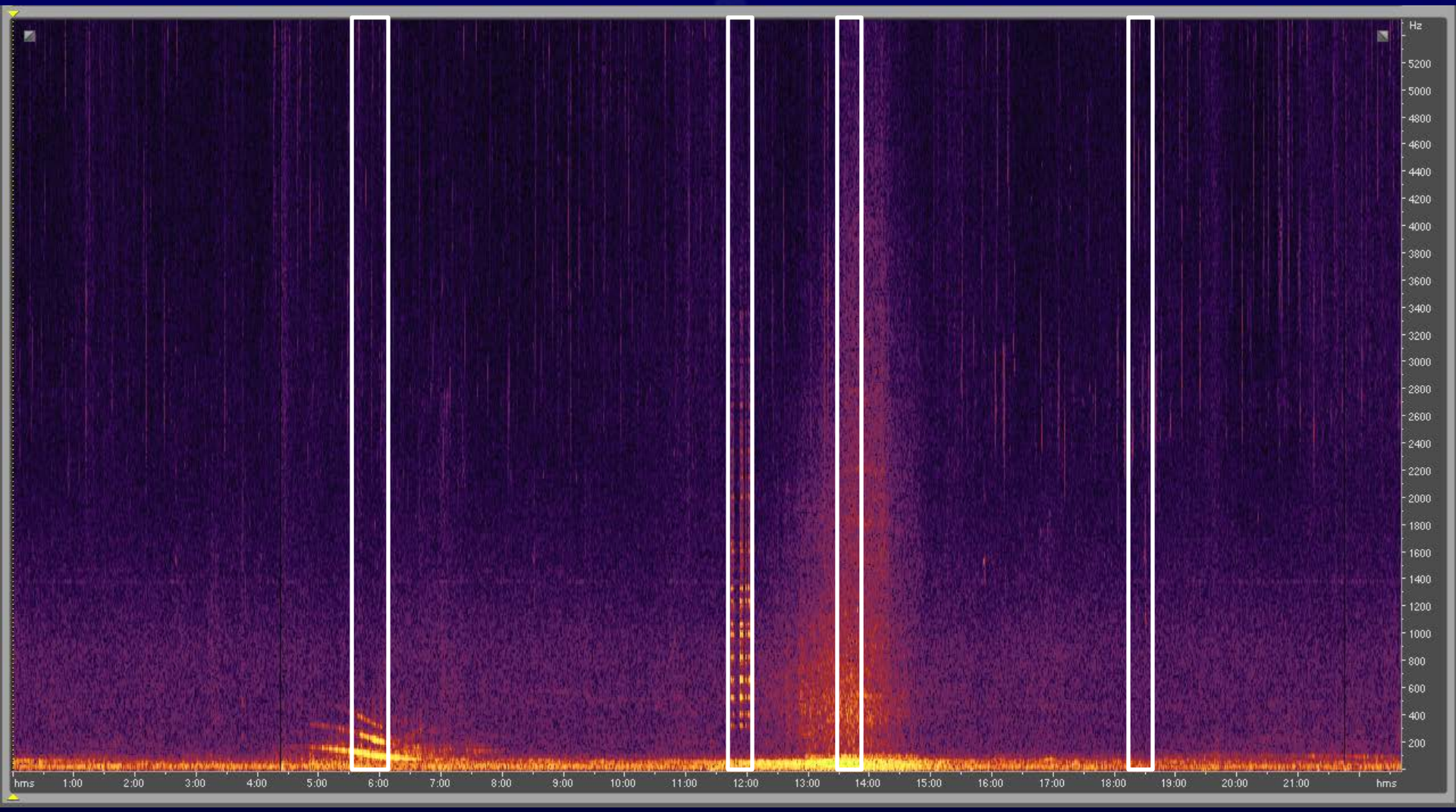
- Presents information on maximum, minimum, and average sound levels
- Relatively simple to produce
- Interpretation still required
- Little information in general about sound sources and distributions

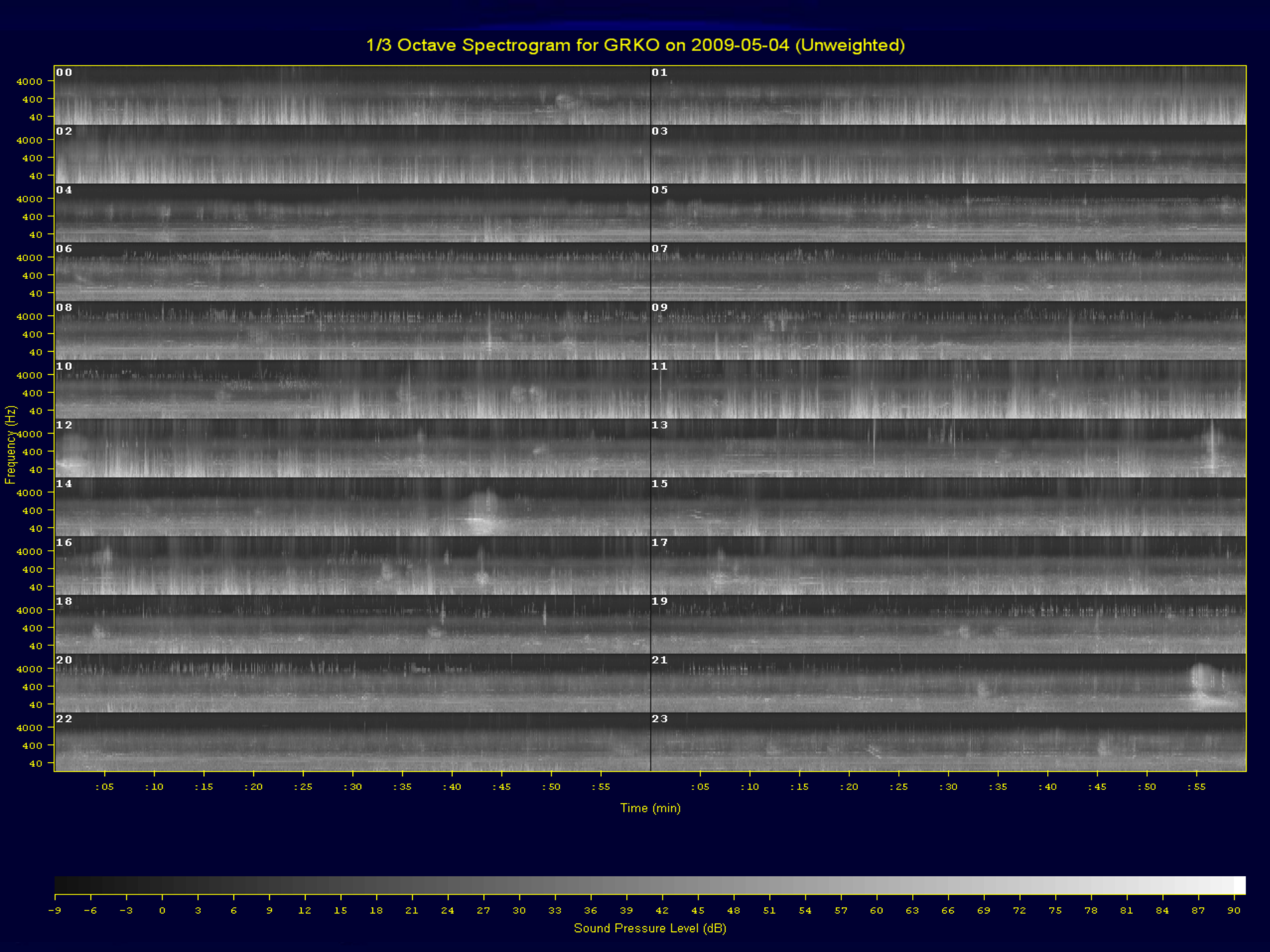
SPL Graphs


Jul-09
Sound Pressure Level [dBA re 20 uPa]
100
90
80
70
60
50
40
30
20
0
24
48
72
96
120
144
168
192
216
240
264
288
312
336
360
384
408
432
456
480
504
528
552
576
600
624
648
672
696
720
Elapsed Hours

Spectrographic Display

- Conveys time-frequency-energy distribution
- Condenses a lot of information into a compact form
- May be confusing to the public unless explained
- Works best if audio playback allowed (point and click)


Hz
5200
5000
4800
4600
4400
4200
4000
3800
3600
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
hms
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
hms


1/3 Octave Spectrogram for GRKO on 2009-05-04 (Unweighted)
00
01
02
03
04
05
06
07
08
09
10
11
12
13
14
15
16
17
18
19
20
21
22
23
4000
400
40
Frequency (Hz)
:05
:10
:15
:20
:25
:30
:35
:40
:45
:50
:55
Time (min)
-9
-6
-3
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
45
48
51
54
57
60
63
66
69
72
75
78
81
84
87
90
Sound Pressure Level (dB)

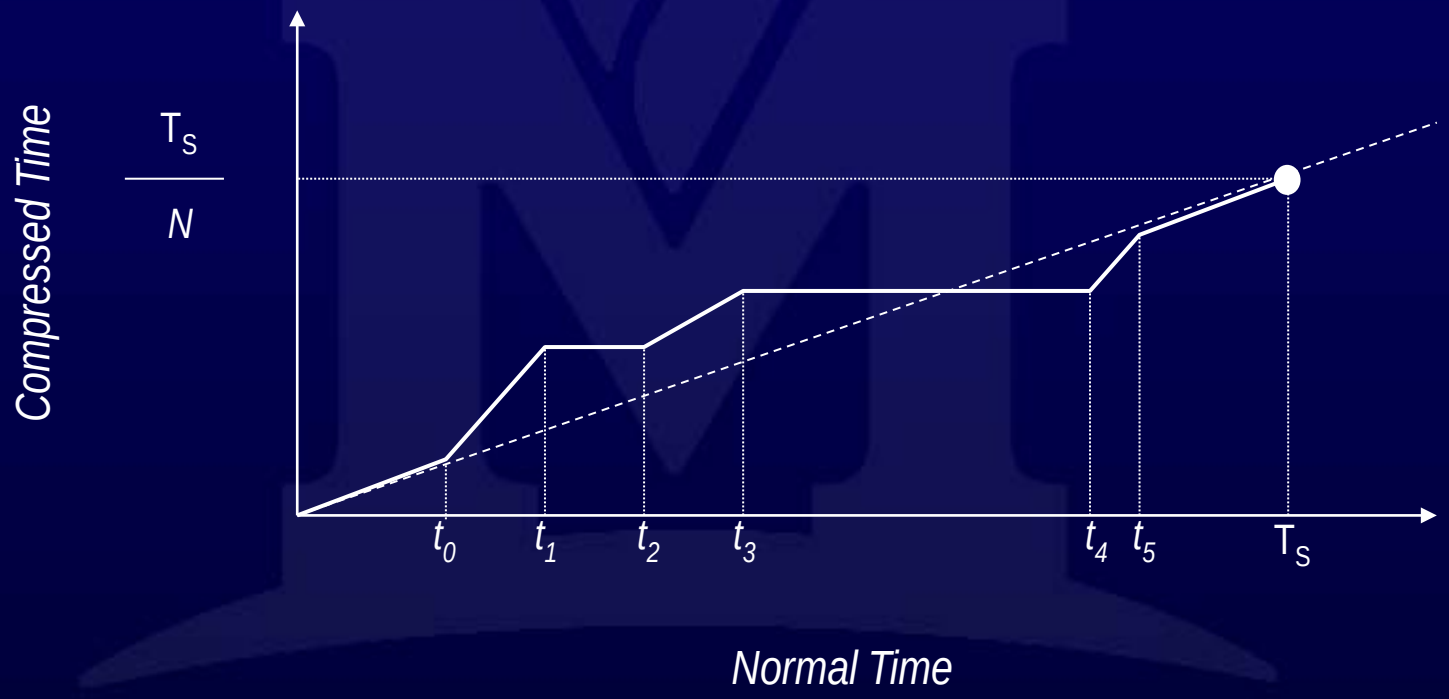
Audio highlights excerpts

- Identify and extract “interesting” sound examples
- The visitor can quickly sample the range of sounds and sound textures
- Generally requires considerable audition and manual preparation
- May give a non-representative indication of the actual sound texture

Time-lapse aural display

- Goal: represent the aural sound texture for many minutes of real time audio with only a few seconds of seamless excerpts
  - Aural equivalent of time-lapse photography
- Challenge: defining and capturing sound texture in an aurally meaningful manner
  - Simple block-downsampling may not capture sonic *texture* effectively

Non-uniform time warp concept

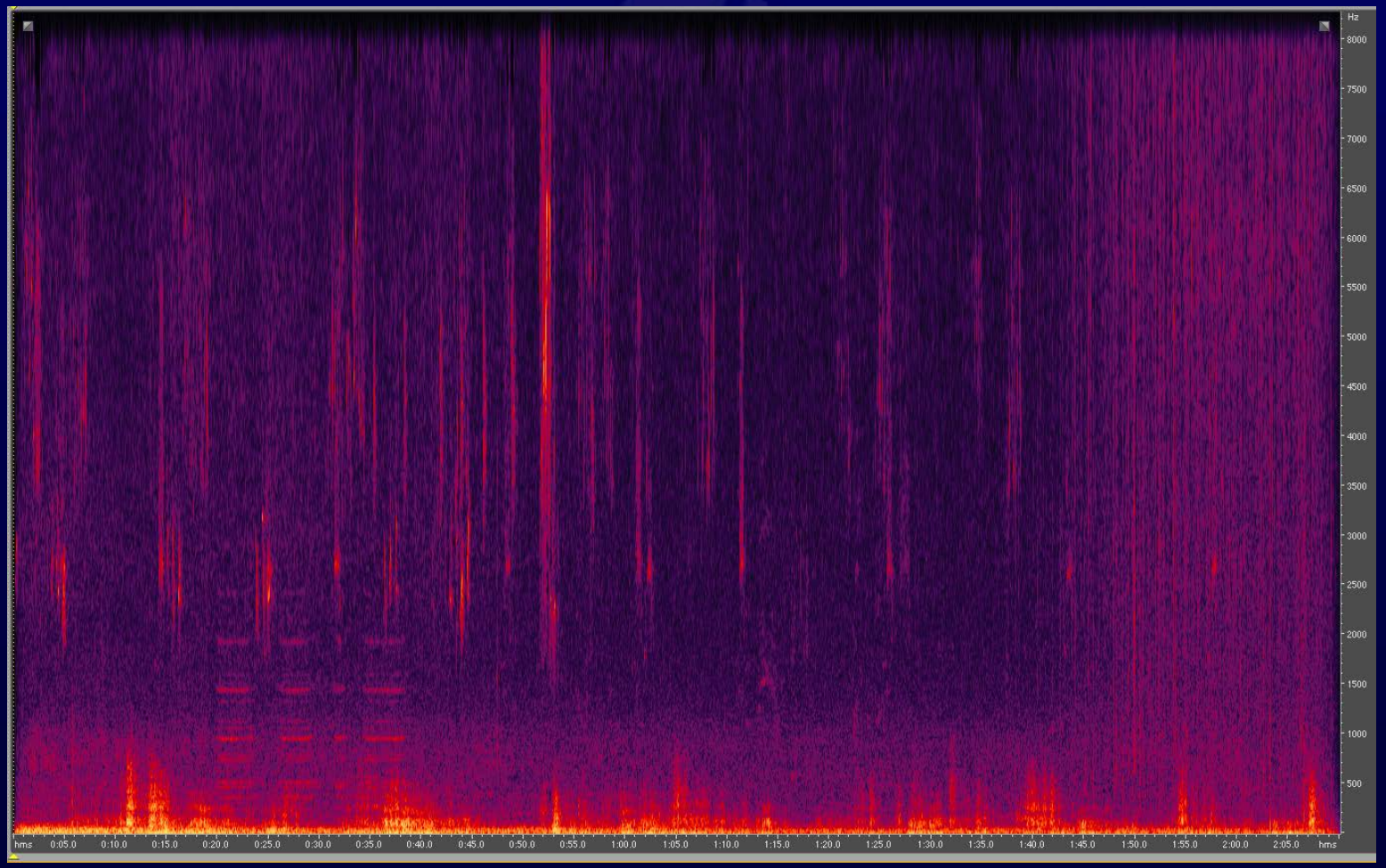


Approach for time-lapse aural display

- Create a spectral transition map: identify textural boundaries in the audio
- Determine available segments based on compression factor *N*
- Assign segments to the transitions in order of priority
- Segment the audio and concatenate with overlap-add

Example Spectrogram

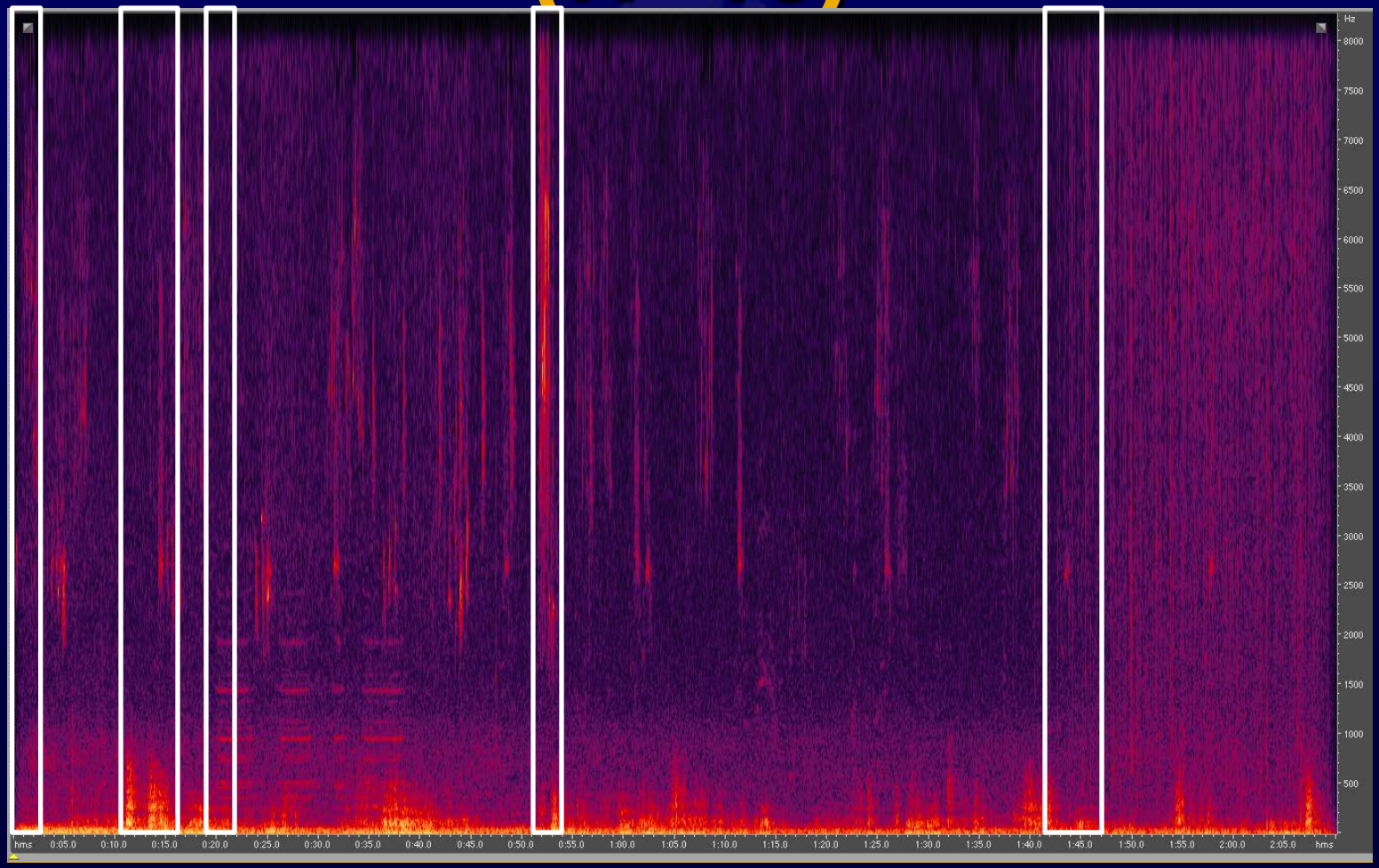
8kHz



0

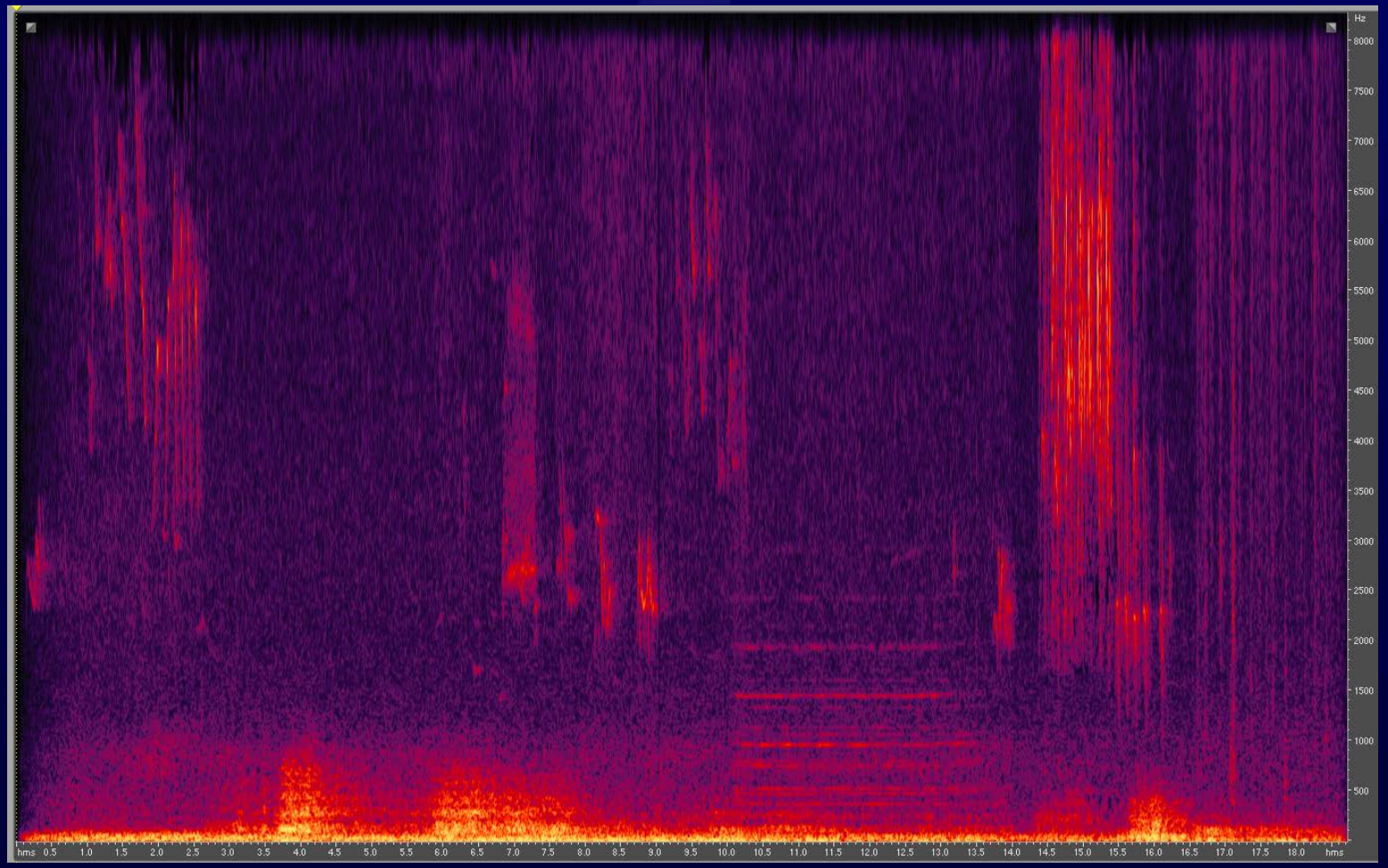
2’ 10”

Example Transition Map (N=10)



Reconstructed Signal (N=10)

8kHz



0

18”

Conclusion

- Long-term acoustical acquisition requires automated analysis and distillation tools
- Presenting days/weeks/months of audio is challenging
- Extreme time-scale compression is necessary for many applications
- Ongoing effort is needed in pattern detection and pattern matching

Acknowledgements

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  - Kathy Tonnessen, Natural Resources Research Coordinator
  - Lisa Gerloff, Executive Coordinator

Sound Examples

- March 18, 2009 9:34PM MDT (45”)
- April 15, 2009 6:13AM MDT (before dawn)(1’)
- May 1, 2009 11:22AM MDT (5’)
- May 4, 2009 6:23AM MDT (after dawn) (2.5’)
- July 6, 2009 ~noon (6.5’)
- Dec 30, 2009 9:30PM MST (2.5’)
- July 6, 2009 ~1:30PM MDT (2’)

- http://ece.montana.edu/rmaher/audio_monitor/grko.htm