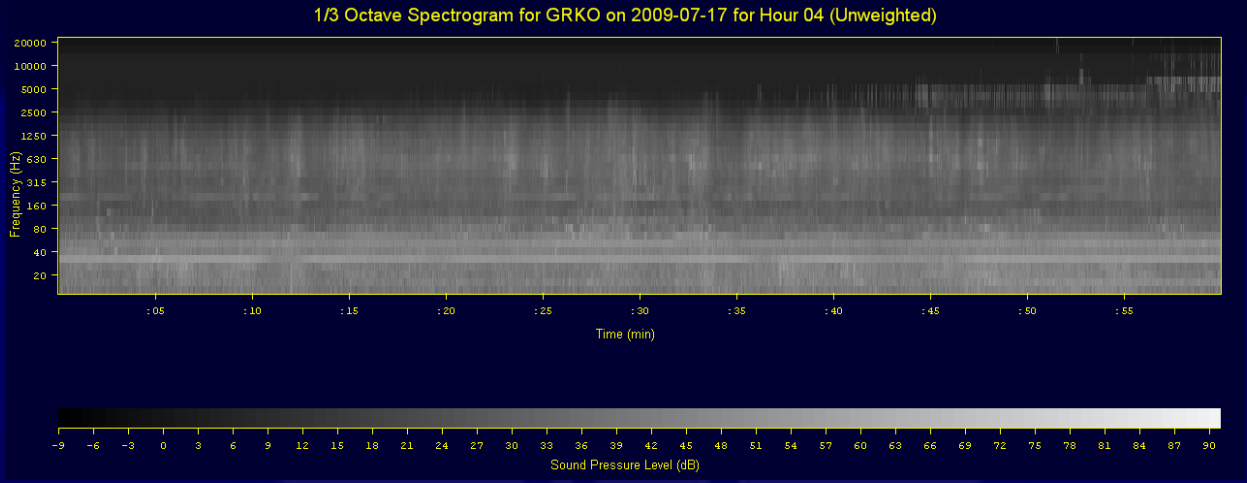

Maintaining sonic texture with time scale compression by a factor of 100 or more

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Mountains & Minds

Outline

- Introduction
- Long-term acoustical acquisition
  - Soundscape studies (thousands and thousands of hours)
  - Environmental monitoring
- Problem: how to present the data
- Sonic texture: statistics and analysis
  - 1/3rd octave band analysis
  - Frame-to-frame level changes
  - Sonic event map
  - Examples
- Conclusion

Introduction

Sound *texture*

- A loosely-defined term intended to express
  - Low-level *background* sounds
  - Occasional distinctive *foreground* sounds
  - Reverberation characteristics
  - Spectro-temporal trends
- There is an assumption of self-similarity on various time scales

Introduction (cont.)

Why is there any interest in extreme time compression?

- Long-term soundscape studies
- National Park Service sound management
  - Example: Grant-Kohrs Ranch (GRKO) National Historic Site
- Similarity to time-lapse photography: fast depiction of a slow temporal scene

National Park Service Act (1916)

- *"...to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."*

NPS Management Policies 2006

National Park Service *Management Policies 2006* include natural and cultural sound resources within park units.

- Section 4.9: Soundscape Management
  Excerpt: "The Service will restore to the natural condition wherever possible those park soundscapes that have become degraded by unnatural sounds (noise), and will protect natural soundscapes from unacceptable impacts."
  http://www.nps.gov/policy/mp/policies.html#_Toc157232745

- Section 5.3.1.7: Cultural Soundscape Management
  Excerpt: "The Service will preserve soundscape resources and values of the parks to the greatest extent possible to protect opportunities for appropriate transmission of cultural and historic sounds that are fundamental components of the purposes and values for which the parks were established."

  http://www.nps.gov/policy/mp/policies.html#CulturalSoundscapeManagement5317

Soundscape Regulatory Context

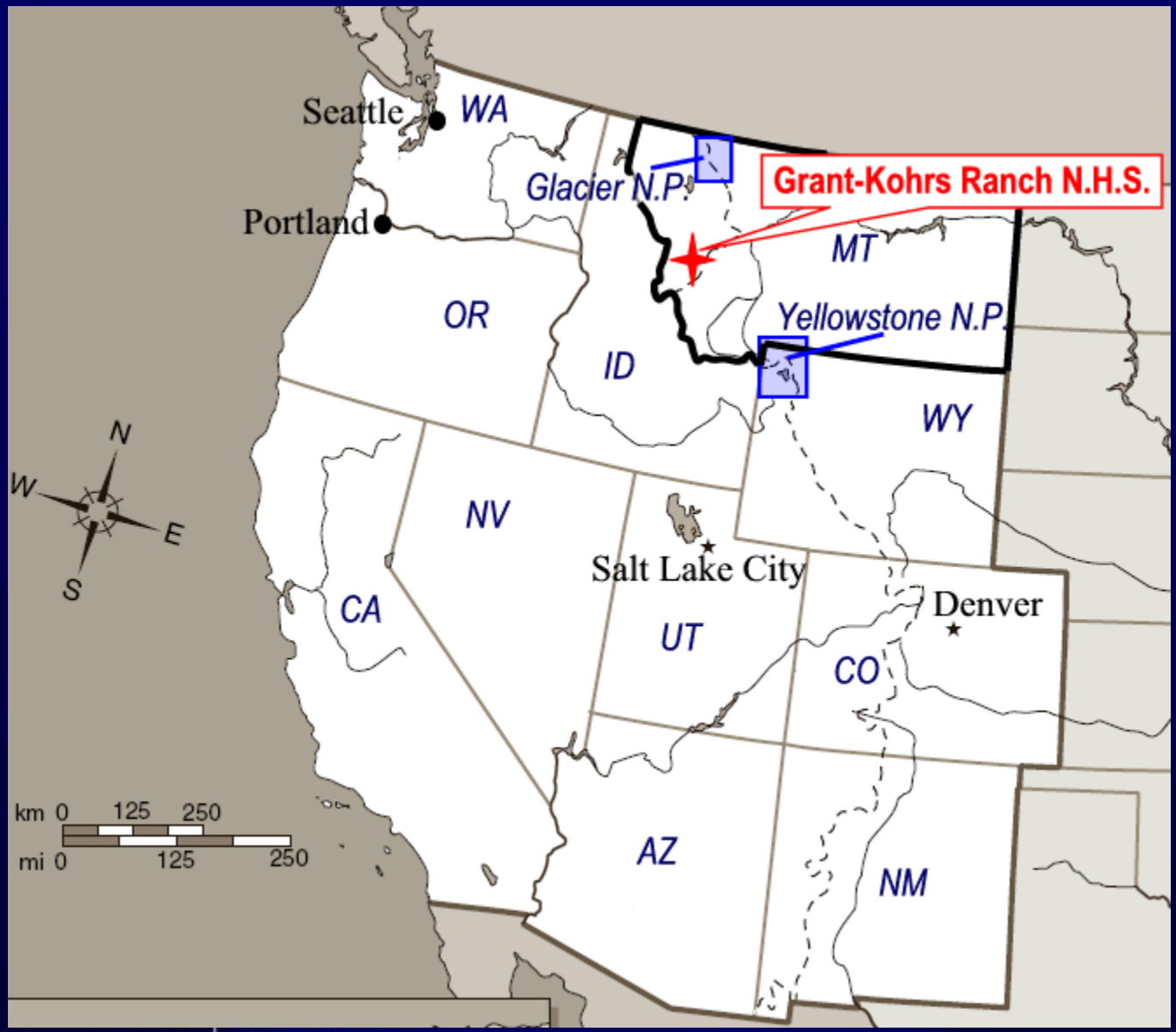
- 1872 Yellowstone National Park Act
- 1916 National Park Service (NPS) Organic Act
- 1949 Executive Order 10092 (Boundary Waters no-fly zone)
- 1964 Wilderness Act
- 1969 National Environmental Policy Act
- 1972 Noise Control Act
- 1987 National Parks Overflights Act (NPOA)
- 1988 Special Federal Aviation Regulation (SFAR) 50-2 (GRCA)
- 2000 National Parks Air Tour Management Act
- 2000 NPS Director's Order #47 (soundscape preservation)
- 2002 Winter Use Plan (Yellowstone)
- 2006 NPS Management Policies (soundscapes)

- Miller, Nicholas, P., "US National Parks and management of park soundscapes: a review," Applied Acoustics, vol. 69(2), pp. 77-92, February 2008

- R.C. Maher, J. Gregoire, and Z. Chen, "Acoustical monitoring research for national parks and wilderness areas," Preprint 6609, Proc. 119th Audio Engineering Society Convention, New York, NY, October 2005.

Grant-Kohrs Ranch National Historic Site (1977)

- 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: maintain the site as a working ranch.
- Cultural soundscape is essential: all the sights, sounds, and sensations associated with ranching.


Seattle
WA
Portland
Glacier N.P.
Grant-Kohrs Ranch N.H.S.
MT
OR
Yellowstone N.P.
ID
WY
N
W
E
S
NV
Salt Lake City
CA
Denver
UT
CO
km 0 125 250
mi 0 125 250
AZ
NM

Long-Term Sound Collection

Soundscape

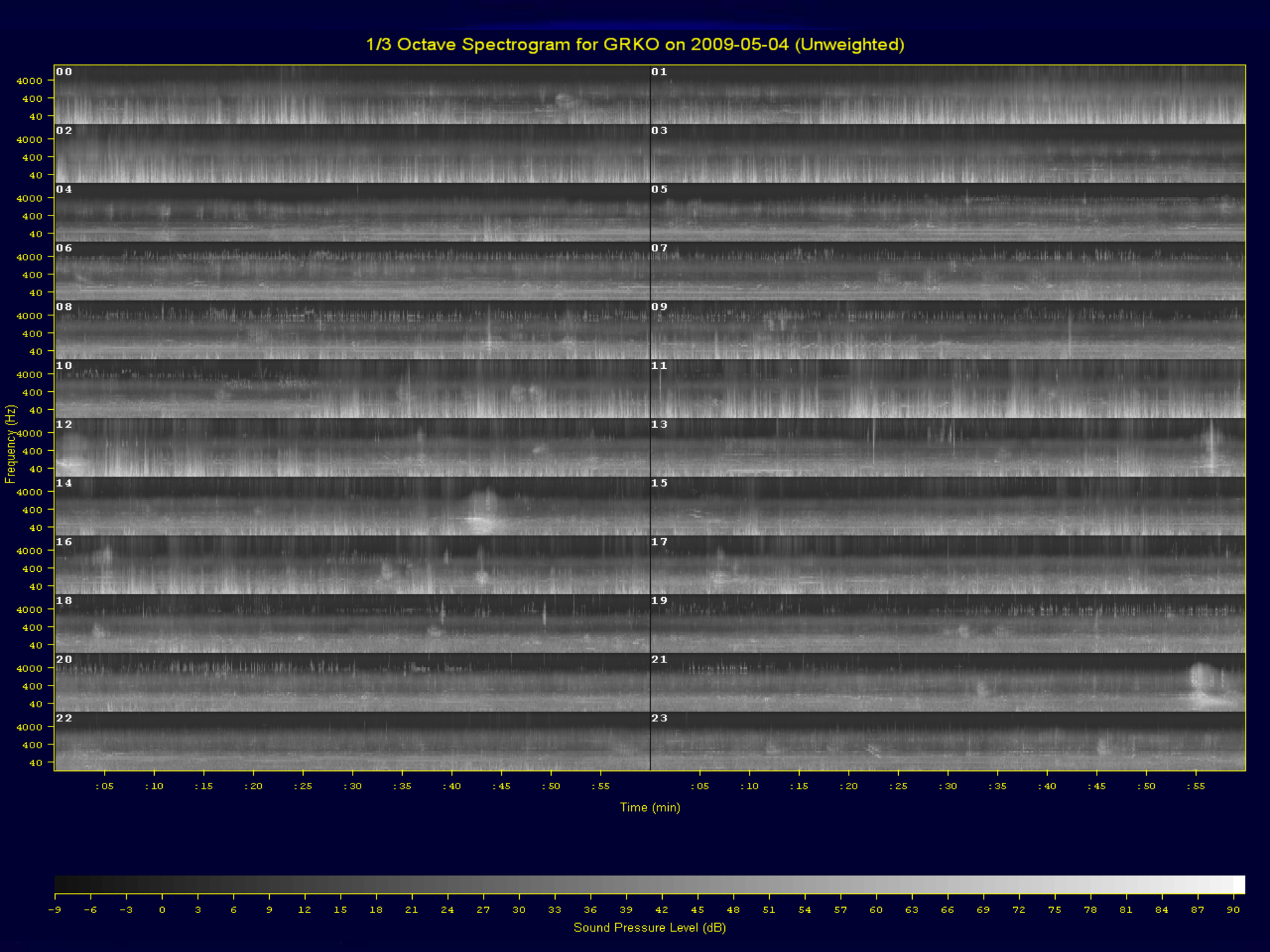
Three Sonic Components (*Krause*):

- ***Biophony*** -- animal and biological sounds
- ***Geophony*** -- geological, hydrological, and meteorological sounds
- ***Anthrophony*** -- sounds caused by humans and human activity

NPS GRKO Project Results

- For 365 days:
  - 1 second Leq ⅓-octave sound levels
  - Wind speed and temperature measurements every 10 seconds
  - Digital audio recordings (64 kbps MP3)

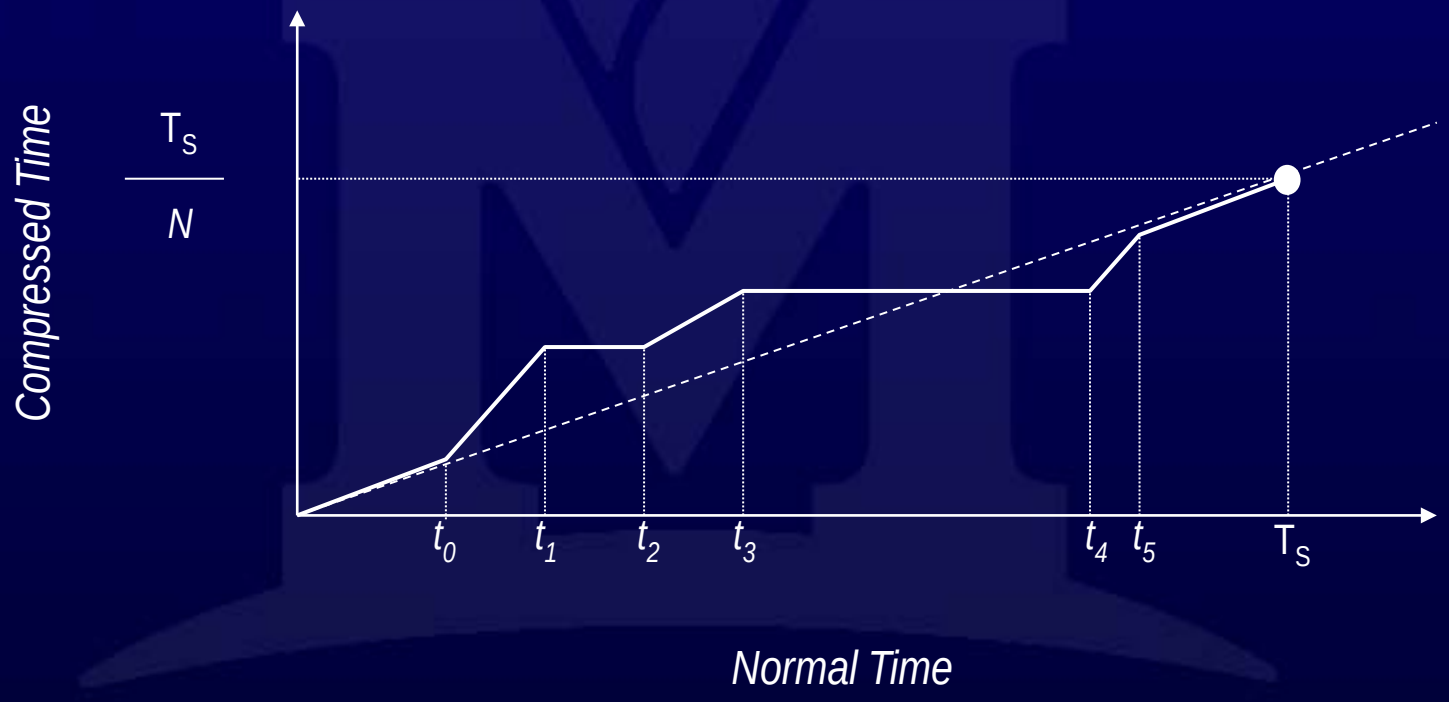
- 8,760 hours of audio


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)

Why extreme time scale compression?

- Length of recordings is unwieldy: automated playback assistance is needed
- Researchers and the public would like a meaningful sampling
- Simple block-downsampling may not capture sonic *texture* effectively

Non-uniform time warp concept



Options

- Formal time-scale compression
- Manual editing
- Block downsampling
- Transition and event-based selection
- Computational Auditory Scene Analysis?

Texture Retention?

Example: compress 24 hours of audio into 12 minutes (N=120)

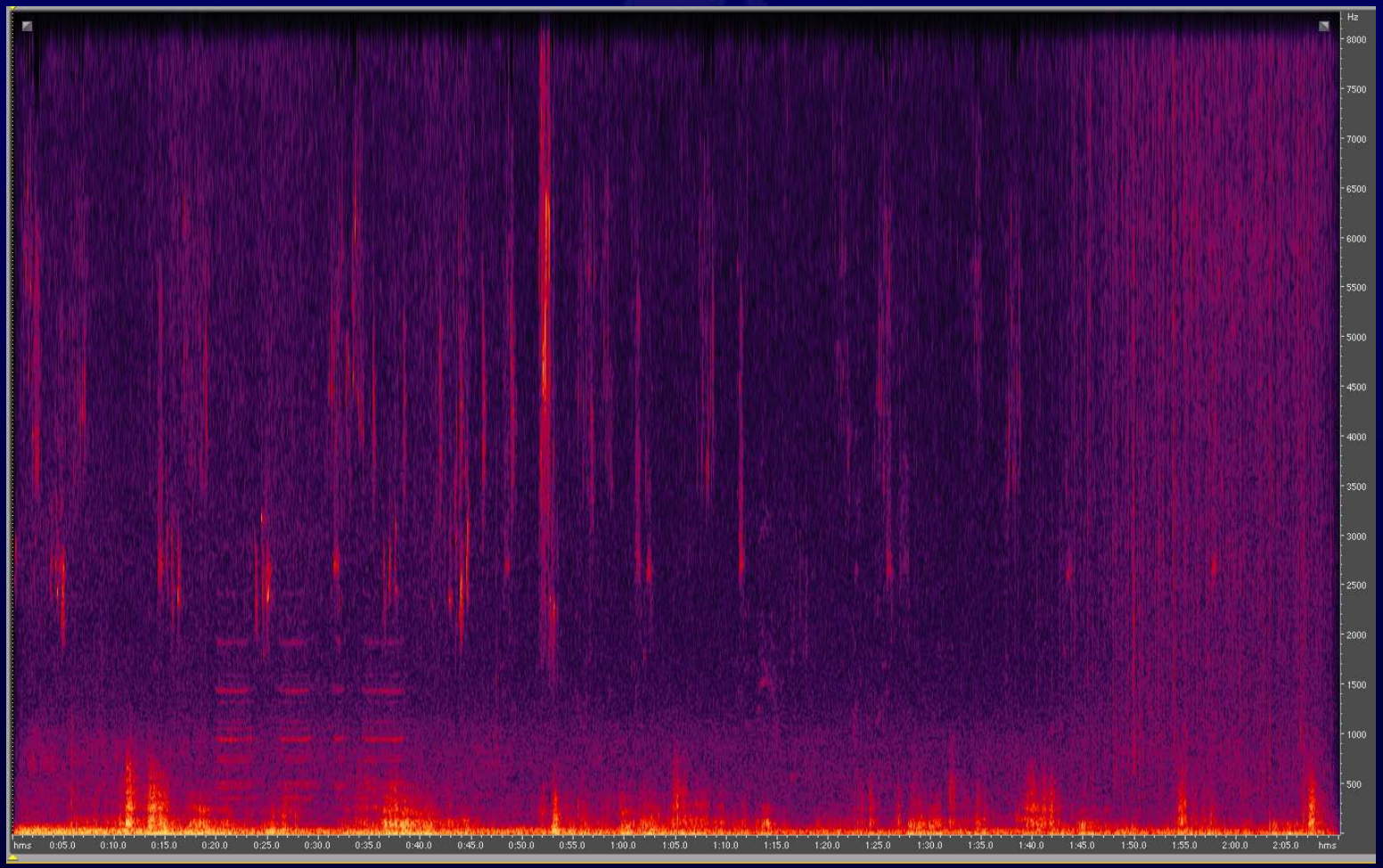
- Choose 1 second of sound every two minutes?
- Choose the most representative 1 second of sound from every two minute interval?
- Strategy: we have 720 seconds to “cover” 86,400 seconds, so “choose wisely.”

Sonic Event Map

- Identify *transitions* in the background sound
- Locate intermittent foreground sounds
- Allocate available coverage in the “optimum” manner within the constraints

Example Spectrogram

8kHz



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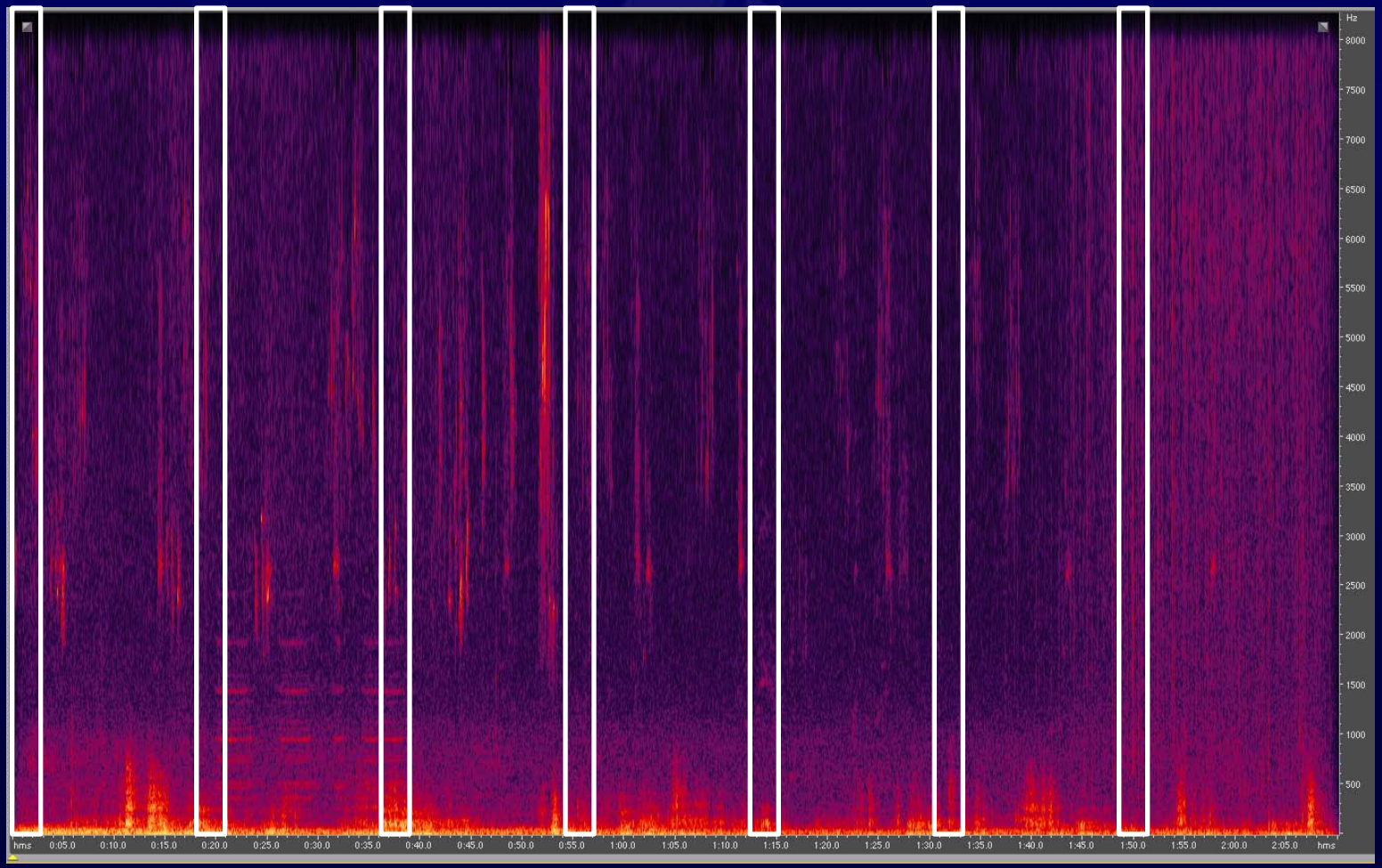
2’ 10”

Uniform N=7 ?

8kHz



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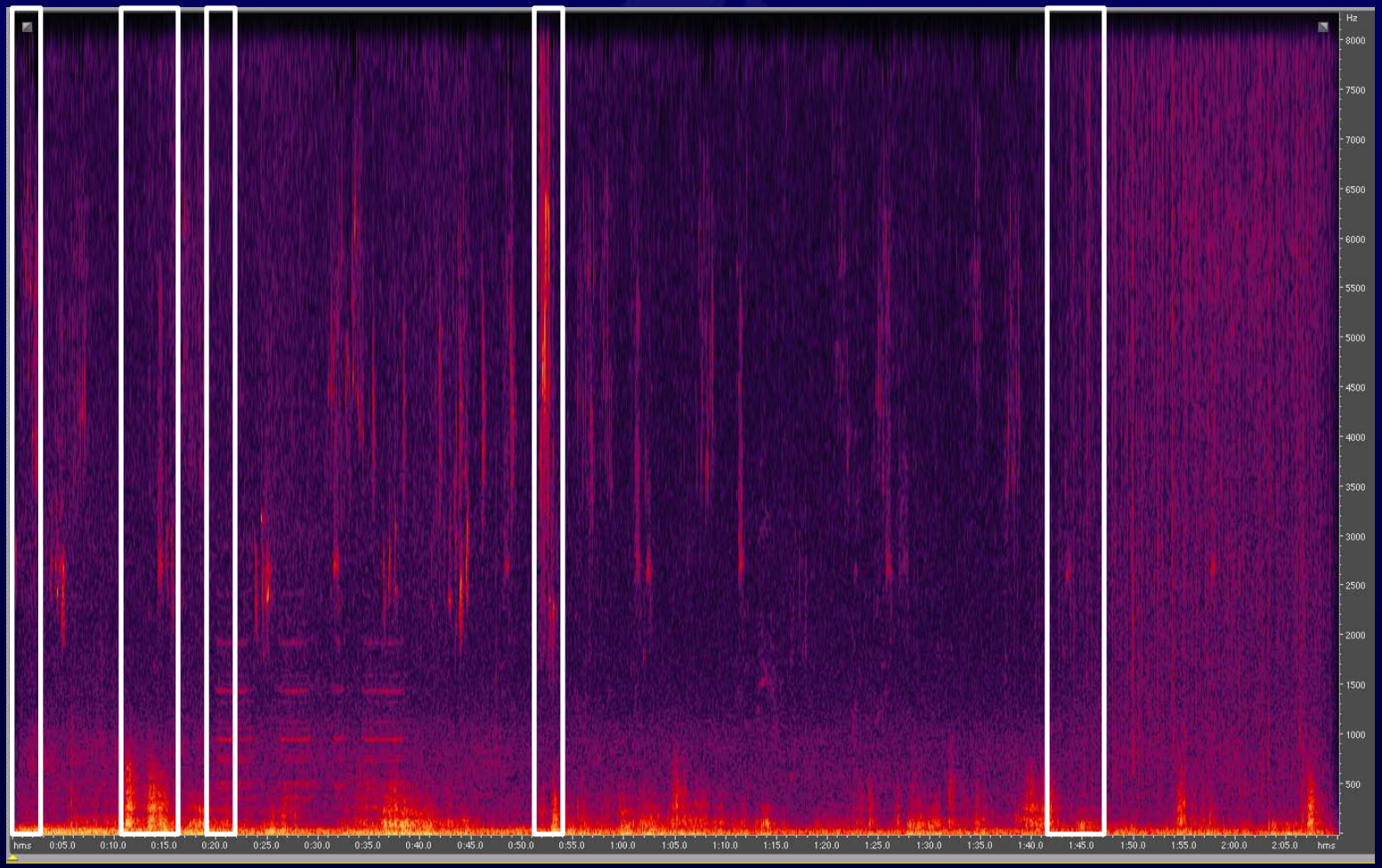
2’ 10”

Example Transition Map (N=7)

8kHz



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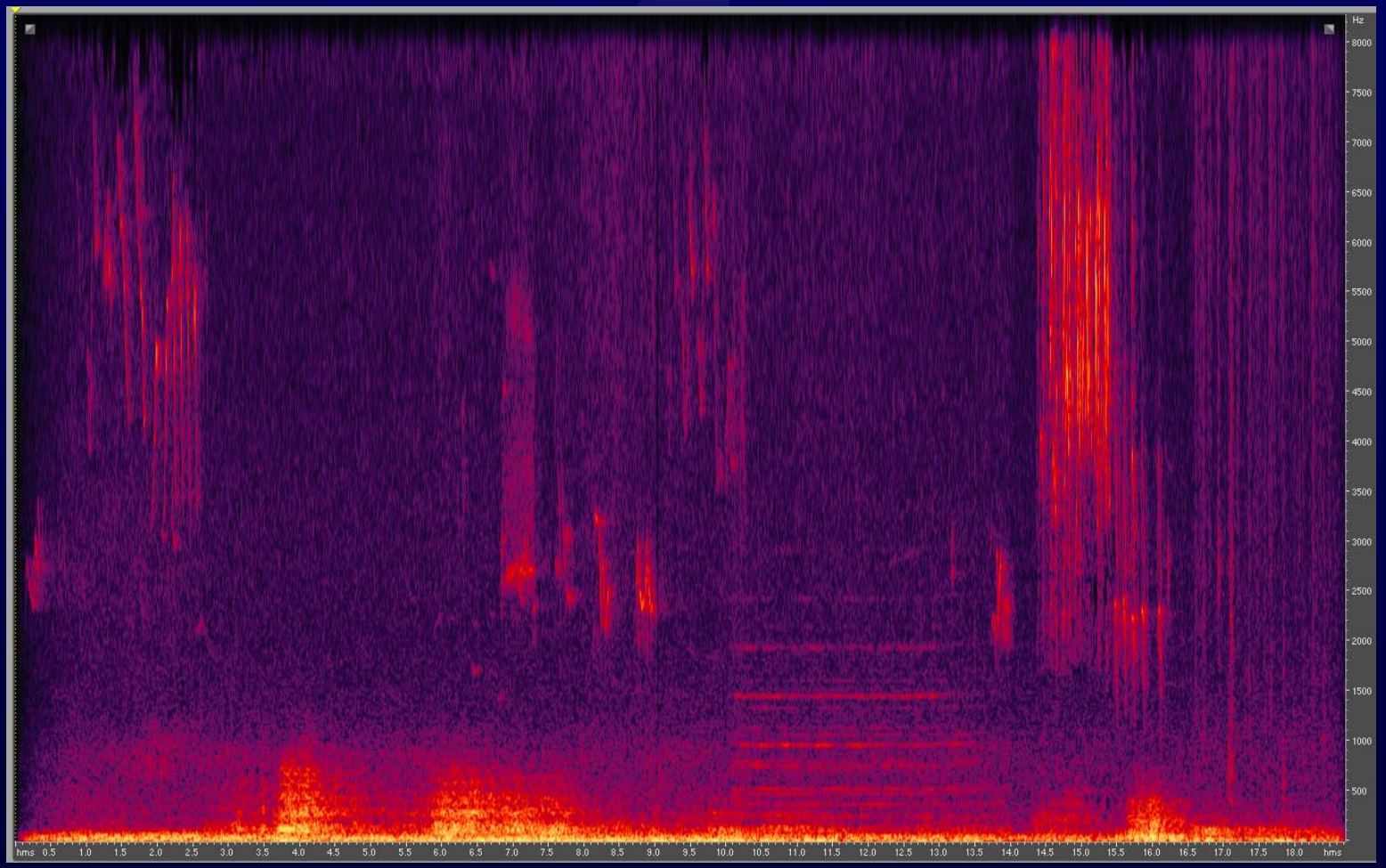
2’ 10”

Reconstructed Signal (N=7)

8kHz



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18”

Conclusions and Future Work

- General strategy works well, but reliability is not yet guaranteed
- Desire automatic segmentation and sound source identification
- Need an objective formula for texture determination and classification
- Key realization: *this is really a subjective data compression problem*

Thank you for your attention.

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

Acknowledgements

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