How to describe sound?

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Outlines

- Introduction to sound measurement
- Visualizing the temporal-spectral modulation of a sound signal
- Observing the long-term change of soundscape

Sound measurement

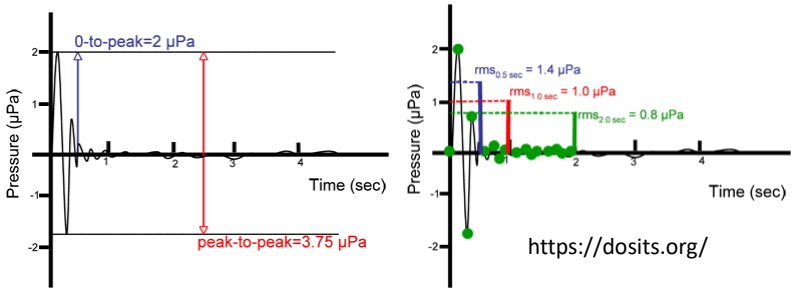
- Microphones (in air) and hydrophones (underwater) convert sound pressure into electrical signals
- Measurement of sound intensity

$$P = \frac{Voltage(mV)}{Sensitivity\left(\frac{mV}{Pa}\right)} \qquad I(db) = 10log_{10}\left(\frac{p^2_{Sound}}{p^2_{Reference}}\right) = 20log_{10}\left(\frac{p_{Sound}}{P_{Reference}}\right)$$

  - Reference:
    - 20 μPa in air
    - 1 μPa for underwater sound
  - A 20-dB increase is a 100-fold increase in power, and a 30-dB increase is a 1000-fold increase in power.

Characterizing the loudness

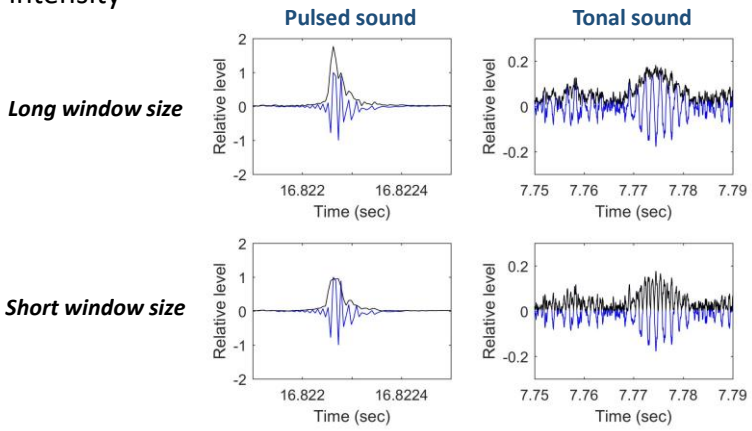
- Depends on different purpose, you may need to select different methods to characterize the loudness
  - 0-to-peak
  - Peak-to-peak
  - Root-mean-square (RMS)



https://dosits.org/

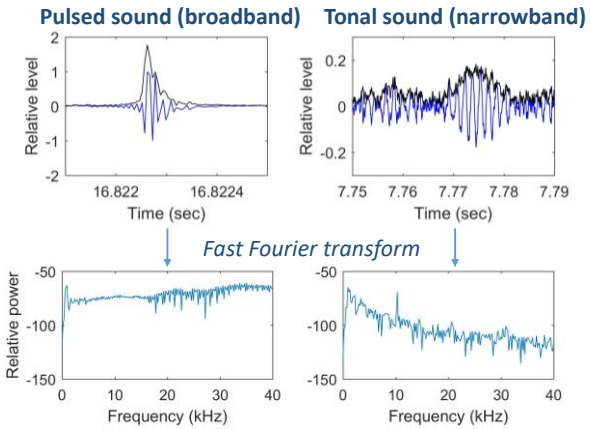
Temporal modulation

- Choose a window size to measure the temporal change of intensity



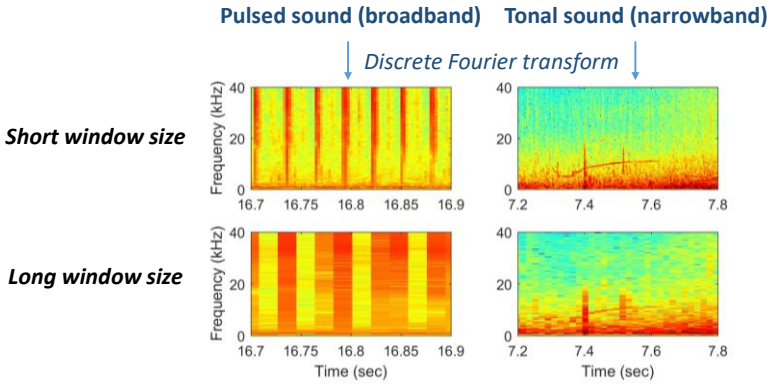
Spectral modulation

- Power spectrum is the most common way to analyze the frequency of sound



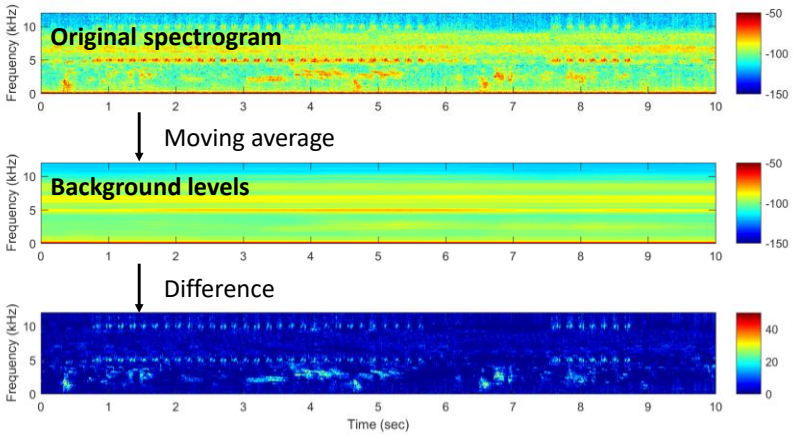
Temporal-spectral modulation

- A spectrogram displays temporal-spectral change of power
- Useful for characterizing acoustic features of animal vocalizations



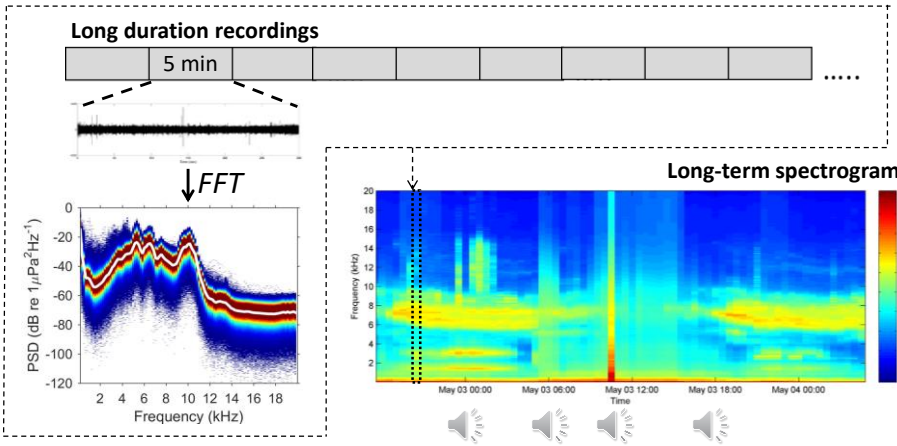
Emphasize transient signals by spectral equalization

- Transient signals can be emphasized by removing background
- Various methods of spectral equalization



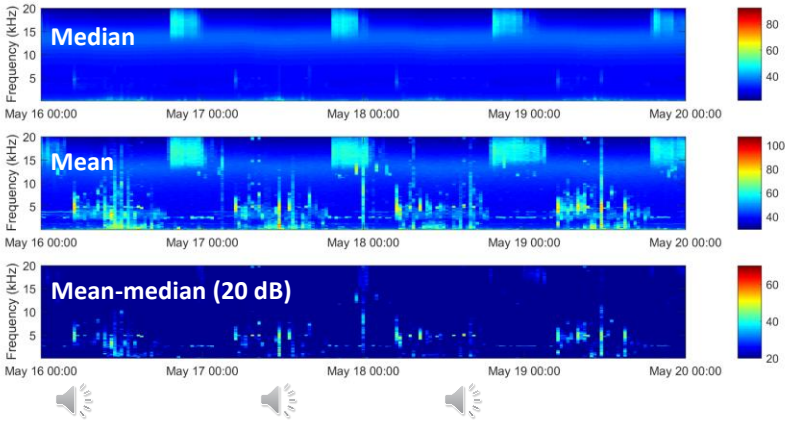
Investigating soundscape by long-term spectrogram

- Choose a time resolution and then compress the acoustic data by statistical methods (median, mean…)



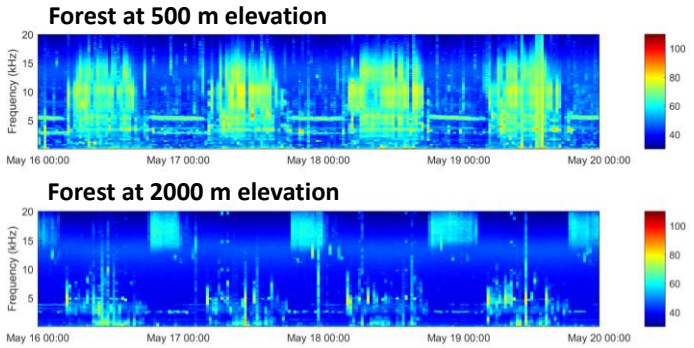
Search animal vocalization from long-term spectrograms

- Median-based LTS: animal chorus, environmental noise
- Difference-based LTS: transient signals (biotic or abiotic)



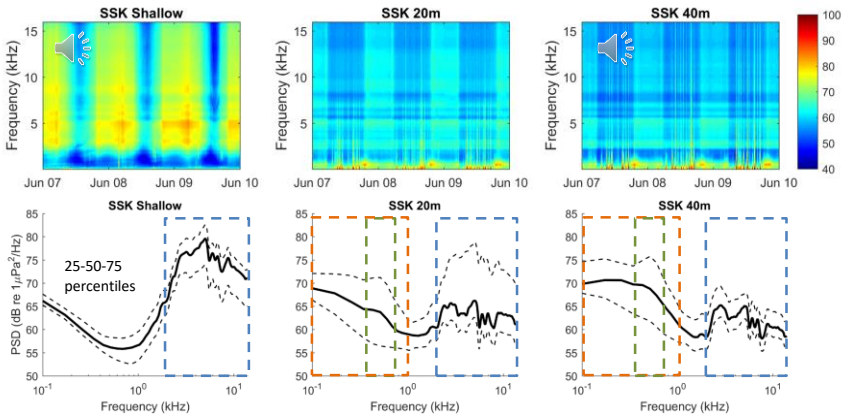
Temporal-spatial change of soundscape

- Identifying various soundscape components
  - Low frequency: environmental or anthropogenic noise
  - High frequency: biological sounds



An example of coral reef soundscape

- Various sound sources contributed the soundscape
  - **LTS-median:** snapping shrimps, fish chorus, shipping activities



Summary

- **Sound measurement**
  - Sound intensity is generally measured in decibel (dB), which is a logarithmic way of describing a ratio between measuring and reference pressure
  - 0-to-peak, peak-to-peak, root-mean-square (RMS)
- **Visualizing a sound**
  - Energy envelope (temporal modulation)
  - Power spectrum (spectral modulation)
  - Spectrogram (temporal-spectral)
- **Change of soundscape**
  - Statistics (mean, median, difference) based long-term spectrogram
  - Identification of soundscape components

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