WAVES AND TORNADOES

RELATING SOUND TO SEVERE STORMS

A key challenge in severe weather forecasting is determining which thunderstorms are likely to be tornadic with enough lead time to give a good warning, especially if tornadic and nontornadic thunderstorms are close to each other. Research at the University of Nebraska-Lincoln in collaboration with Oklahoma State University is investigating whether infrasound may be a useful tool to help. In this activity you will explore sound and learn how it might be used to detect tornadoes.

What you need:

- An internet connection and a computer with a speaker

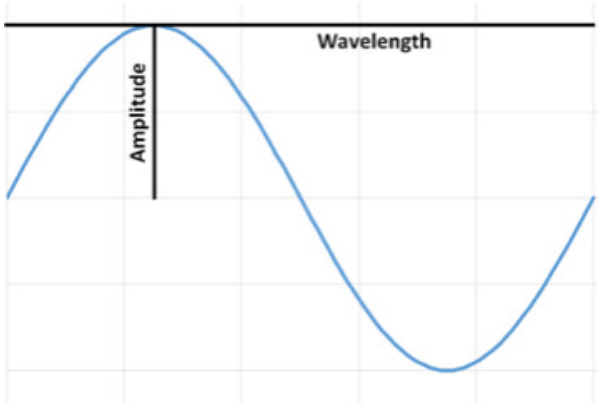
First, we'll learn about sound, which travels as a wave through the air.

All waves have similar structure:

Amplitude: determines how loud a sound is (related to decibels).

Frequency: how many wavelengths pass your location in one second.

High-pitched sounds have a high frequency (a lot of waves pass your location in a short time), while low-pitched sounds have a small frequency.



Go to this website: https://academo.org/demos/virtual-oscilloscope/

Allow the website to use your microphone.

1) Make the lowest-pitch sound you can and draw the resulting wave.

2) Make the highest-pitch sound you can and draw the resulting wave.

3) How are your two sketches different?

Now we will experiment with sounds of different frequencies.

Go here: https://spectrogram.sciencemusic.org/

1) Click and hold down your mouse button with your cursor on the black space. This generates a tone with the frequency value shown above your cursor. Frequency (measured in Hz) indicates how many waves pass your ears per second!

2) Experiment with making sounds of different frequencies by moving your cursor around on the black space.

3) Most humans can hear from about 20 Hz to about 15,000-20,000 Hz depending on age. Get a group of people together and have everyone record the highest-frequency and lowest-frequency sounds they can detect. This may be easier if you change the frequency range (upper right of the page). Compare these values—is there a relationship between frequency detected and age? Typically, as we age, we lose the ability to hear higher-frequency sounds.

4) Go to the 'Tuning' option (upper left) and allow the website to use your microphone. Make various sounds and draw their frequency. Make some low/deep sounds and some high/shrill sounds, and note that low sounds have lower frequency. Nevertheless, most sounds contain a wide range of frequencies!

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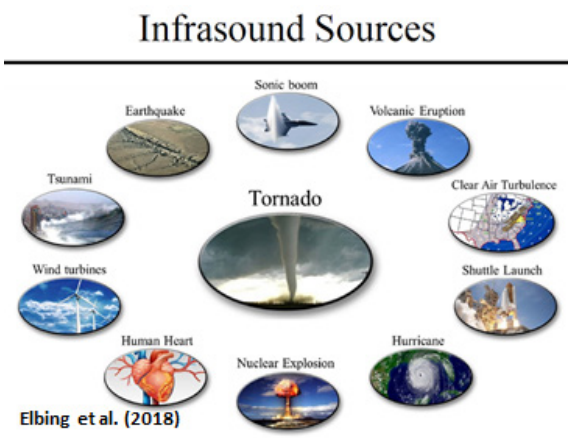
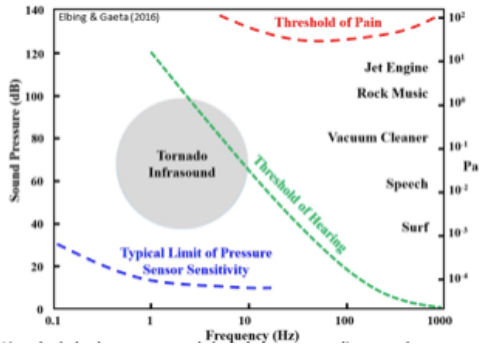
Infrasound is sound which is below human hearing (very low frequency)! Many familiar things make infrasound. Note that other explosions (such as from a quarry) also generate infrasound.

1) What infrasound sources are present in your region?
2) If you were trying to 'listen' to tornado infrasound, how might the sources in your area affect your measurements?



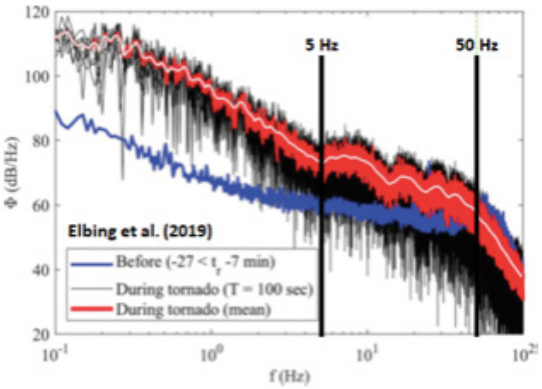
Tornadoes are a known source of infrasound. So, if we can detect this sound, we might be able to know that a tornado is occurring or going to occur soon. Given other sources of infrasound, even within thunderstorms, this is a complicated question. Let's think about how tornado infrasound fits in with the rest of the sound waves that might be detected.



Sound is characterized by its frequency (as you've learned) and its level of loudness, or amplitude, measured in decibels (left side of the figure). For example, a jet engine (upper right side of the figure) makes a very loud, high-frequency sound.

1) What are some other loud sounds? What are some other high-frequency sounds?
2) Is tornado infrasound relatively 'loud' or 'quiet'? How does its loudness compare with that of other common sounds you're used to hearing?
3) Can humans hear any of the sound produced by tornadoes?

Now let's look at some real data from a tornadic storm!
As above, this figure shows the frequency content of sound measured before (blue line) and during (black/red/white lines) a weak Oklahoma tornado in 2017, and the vertical axis again gives an indication of how 'loud' the sound is:



1) Sound with a frequency <5 Hz is mostly wind noise. How would you describe this sound?
2) Sound in the range of 5-50 Hz is not wind noise and was present when the weak tornado was occurring. How would you describe this sound? Could you hear any of it (recall your test of hearing range, above)?
3) Notice that the 'loudness' of the sound in the 5-50 Hz range oscillates or increases and decreases over small frequency ranges. These are called harmonics and may indicate characteristics of the sound source. For a tornado, these harmonics may sometimes indicate size of the tornado producing the sound, but this is a topic of active research!

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