Background

As illustrated in the four biomes' log-frequency power spectrograms, the stream and ocean biomes' audio is the most volatile, with a wide band of constantly active and changing frequencies, while forest and mountain biomes are much more spectrally static, with particular bands of changing frequencies, largely due to animal life in the audio.

Summary of Principal Component Analysis by Biome

For each biome's audio (forest, mountain, ocean, stream), 25 audio features were extracted to form the feature vector for analysis: root mean square spectral energy, spectral centroid, spectral bandwidth, spectral rolloff, spectral novelty, and ten Mel Frequency Cepstral Coefficients. Then, principal component analysis was performed to derive two primary components from the 25 features. Audio feature contributions to each biome's audio are as follows:

Forest

Component 1 depends substantially on MFCCs 11, 4, and 9, with lesser but significant contributions made by spectral bandwidth and spectral rolloff.

Component 2 depends largely on RMS energy, spectral centroid, rolloff, and novelty, as well as MFCCs 5 and 6.

Mountain

Component 1 depends substantially on spectral bandwidth and rolloff, as well as MFCCs 6, 10, 8, and 5.

Component 2 depends largely on MFCCs 2, 13, and 15, as well as spectral novelty.

Ocean

Component 1 depends substantially on spectral bandwidth, as well as MFCCs 2, 3, and 9, and 19.

Component 2 depends largely on RMS energy, as well as MFCCs 6, 10, and 15.

Stream

Component 1 depends substantially on RMS energy, spectral centroid, spectral bandwidth, and spectral rolloff (but not spectral novelty).

Component 2 depends largely on MFCCs 4, 6, 13, 14, and 12.

Feature Contribution Summary

RMS Energy

One would expect RMS energy (roughly correlated with loudness) to dominate this analysis; it appears as an important component in the forest, ocean, and stream biomes; however, this feature is noticeably absent in the mountain biome, emphasizing the perceptible fact that this biome's audio is notably more static than the others' with respect to loudness.

Spectral Centroid

This feature played a substantial role in the forest and stream biomes, but mattered less for the mountain and ocean biomes.

Spectral Bandwidth and Rolloff

These two related features mattered substantially for all four biomes.

Spectral Novelty

Spectral novelty mattered for the mountain, forest, and ocean biomes, but mattered much less for the stream biome.

Mel Frequency Cepstral Coefficients (MFCCs)

A unique set of MFCCs characterizes each biome; this said, all four biomes' audio is largely band-limited noise (acoustically defined as aperiodic pressure fluctuations), in which many octaves are changing unpredictably. For this reason, there's not a clean break in contribution between any two or more sets of MFCCs; rather, the features range from contribution magnitudes of .05 to about .30 without any sudden jump from a low to a high value.

Biome Summary

Forest

The first of the two forest excerpts contain two bands of changing spectral energy, one very low and one very high. The third excerpt includes a wide band of rapidly changing low and low-mid frequencies, possibly due to a nearby body of water, windy conditions, or a nearby freeway.

Mountain

Like the forest audio, the first two audio excerpts contained low and low-mid bands of changing frequencies. The third excerpt was uniformly quiet throughout the entire spectrum.

Ocean

The ocean audio exhibited near full-band spectral energy, with the third excerpt, recorded the closest to the shoreline, shifting its low-pass cut-off frequency according to the rhythms of breaking waves.

Stream

Like the ocean, the stream biome exhibited wide-band noise; however, the stream audio's band ended substantially higher than the ocean's; the third excerpt was an exception, in that the presence of a waterfall feature in the background of the stream created a substantial low-frequency noise floor.