Currents: A Weather Data Sonification Project

By Andy Jarema

Communicating the existential threat posed by climate change is essential to achieving a courageous leadership and strong policy changes needed to avoid the most catastrophic possible futures in store for our planet. Composers and other artists have much to offer in the conversation about our shifting planet through the power of artistic storytelling mediums. Making an audience *feel* scientific data can keep the conversation afloat about the urgency of climate change and the ominous shifts in weather patterns on our planet.

Currents is a multifaceted and ongoing musical work that centers around two guiding questions: How can we use sonification to musically depict weather and climate data, and how can this musical narrative affect how we feel about the data? Specifically, *Currents* sonifies a database comprising forty years of data created by the National Oceanic and Atmospheric Administration (NOAA) that tracks Billion-Dollar Weather and Climate Disasters in the United States. In this article, I discuss my first iteration of the piece, providing insight into the sonification process of *Currents,* including technical challenges in the sonification process, how the data elements were sonified, and important questions that emerged when translating big data into a creative musical work.

Currents

Information about climate change traditionally relies on communicating rigorous evidence from the scientific community: facts, figures, graphs, and data. But truthfully, I have only personally been moved to change by artistic works. It was a film that first lit my passion to fight climate change (*An Inconvenient Truth*, a documentary by Davis Guggenheim from 2006), and an author that convinced me to take my most potent individual climate action by eating no animal products (Jonathan Safran Foer's *We Are The Weather: Saving the Planet Begins at Breakfast*). As a composer, I find myself wondering what we artists have to offer in terms of making people feel something different about the alarming climate data presented to us by the scientific community.

Currents is a fixed audio-visual work created in Max/MSP that covers all forty years of data (1980-2019) in roughly eight minutes.[1] It utilizes visual graphs, field recordings, and synthesized sounds to provide a lofty overview of the entire dataset and gives the numbers a more compelling artistic narrative.

I want to begin by outlining the initial challenging steps of working with the data used for creating *Currents*. I hope that this will help illuminate the issues with big data sonification other composers might face in the future. Max/MSP was the software I chose for the data sonification process due to my familiarity with the programming language, however my technological abilities quickly had to expand to accommodate the multiple moving parts needed to access and sort such a large web-based data set. The composition's Max patch utilizes a feature introduced in Max 8 known as "Node.js," which is a Javascript-based method of communicating with web-based resources. "Node.js" assisted with accessing a JSON data file of the Billion-Dollar Weather and Climate Disasters database through the NOAA website, including sorting and parsing the data into three columns of information: number of billion-dollar weather events per year, the cost of each individual billion-dollar weather event, and the number of deaths that occurred with each event. From there, a "coll" object in Max was used to store and export the three columns of data as three separate .txt files to my harddrive. By reimporting the .txt files back into three separate "coll" objects, Max was able to travel through the data and create the basis for translating these numbers into sonic information.

I want to stress that accessing and parsing this data was non-intuitive, oblique, and challenging. It was a frustrating monthslong endeavor filled with failed experiments, desperate shifting through YouTube tutorials, and re-tooling existing Java script code designed for other purposes entirely. Smaller data sets might be able to be fed into an audio program like Max/MSP rather quickly, but there seems to be no single method of sonifying large data sets without the use of multiple programming techniques (Max/MSP, Node.js, Javascript, JSON files) which creates a high barrier of entry into this process for the average

composer.

After accessing and parsing the data, Max/MSP was used to sonify the weather data using field recordings and generative FM synthesized sounds. The field recordings used in this piece were recorded with my Zoom H4 recorder in Great Smoky Mountains National Park (crickets, birds) and Hawai'i Volcanoes National Park (hydrophone recording of the ocean). The three sets of natural sounds (crickets, birds, ocean) represent three different environments (land, sky, and sea), functioning as an abstract barometer that allows us to check in and take readings on the health of three distant biomes on our planet.

The top graph tracks the number of billion dollar weather events that occur in each year (40 data points) and is sonically depicted with crickets (center pan). There is an inverse pitch relationship between the sound and the data, where a higher number of weather events correlates to a lower shift in the pitch of the cricket recording. This was primarily an artistic choice given that the cricket recording takes on an alarm bell-like quality at lower pitch levels. The middle graph tracks the cost of each individual weather event (258 data points) and is sonically depicted with a crackling underwater hydrophone recording of the ocean (right pan). A higher cost triggers a longer articulation (envelope release) of the sound, and significantly high-cost events over $20 billion trigger the sound of loud ocean waves. The bottom graph tracks the deaths caused by each individual weather event (258 data points) and is sonically depicted with a bird call (left pan). There is also an inverse pitch relationship similar to the cricket sounds (a higher death toll triggers a ghostly, lower pitched bird call) and significantly fatal events over 100 deaths trigger the sound of chickadees (chickadees use an intricate language of bird calls as a way to broadcast perceived threat levels in its environment).

In addition to the three sonified elements operating at a micro level in the piece, there are sonic elements that function on a much larger time scale to convey a broader narrative in the data. Taken as a whole, the forty year data set outlines an overall rising trend of billion dollar weather events. To artistically reflect the urgency of this narrative, certain

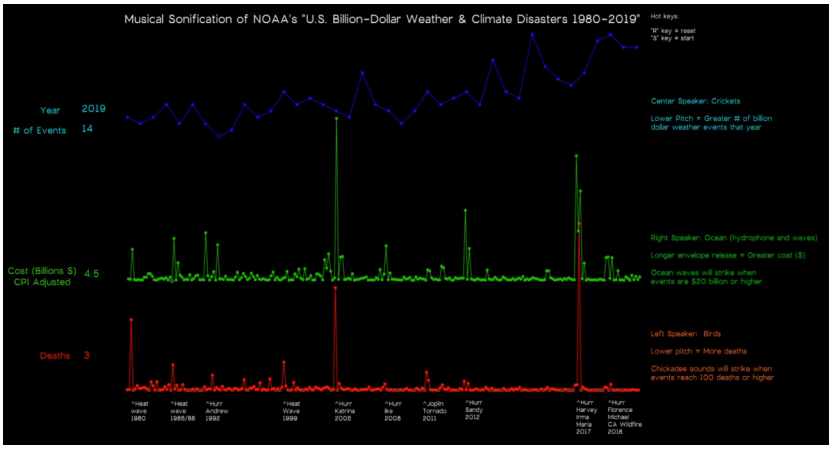

Figure 1: still taken from *Currents* to demonstrate these visual graphs and sonified elements

musical elements such as tempo (a gradual accelerando over time) and timbre (stark FM synthesized sounds layering in over the field recordings) unfurl over the eight minutes time span of the piece. Approximately half way through the piece, another hydrophone recording sneaks into the right speaker. The recording slowly begins creeping to fill the left speaker, dropping in pitch as it goes along. The recording wildly increases in pitch and speed at the end of the piece (the year 2020), further signifying urgency as the sound burns and crackles out of control.

One question that frequently emerged in the sonification process of *Currents* was how to address the tension between data accuracy and creative artistry. Being faithful to the data in order to tell a scientifically sound narrative was a priority, but on the other hand I found myself taking creative licenses in the sake of creating a compelling musical narrative. One of these challenges was figuring out how to scale and calibrate the data in the sonic domain. For example, the number of events per year was easy to sonify into the pitch domain due to its relatively limited range of data (there were 0 to 16 events, which was sonified into a two octave range of notes from C2 to C4). But the cost

provided a unique challenge since this data mostly operated in a narrow band (costs for each weather event hovered mostly between one and 20 billion) with occasional outliers stretching the upper bounds of the data (Hurricane Katrina's 192 billion being the highest). If this data was sonified directly into the pitch domain, it resulted in a flat pitch output with mostly imperceptible pitch changes (semitones or tones) with occasional jumps to a higher note when an outlier occurred. On the other hand, adjusting my sonification to pick up the nuance in smaller values failed to sonically capture the magnitude of the outliers when they occurred (in some cases, the outlier was so high it produced a pitch outside the range of human hearing). To fix this, I created "parameter bands" (Figure 2) that would sonify different ranges of data to different ranges of pitches: 1-10 billion was sonified within a one octave range (C4 to C5), 10-100 billion in another octave (C5 to C6), and the upper outliers between 100-167 in a final octave (C6 to C7). These types of decisions throughout the sonification process of *Currents* forced me to confront the boundaries between scientific accuracy and creative artistry, ultimately helping to shape my narrative intentions and clarify the messaging behind the piece.

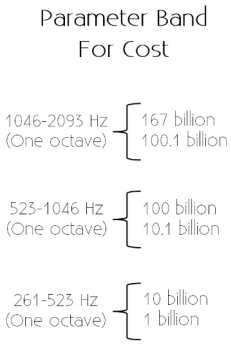

Figure 2: Paramter Bands

Another question that emerged in the sonification process was how to utilize big data in an ethical way. A valid critique of *Currents* is that the data points scrolling across the screen can feel objective, impersonal, and disconnected from individual experience. I myself was a part of one of these extreme weather events (2014 Detroit flooding) and seeing the data point slip so quickly across the screen somewhat diminishes my harrowing recollection of that day. It especially makes me uncomfortable to see the data points for deaths, real human lives being lost, ticking away across the screen with an almost impassionate calculus. It reinforces the

narrative that the problem of climate change feels too massive, its complexities and horrors beyond any sort of action that can possibly reverse its course. If the objective of climate-related art is to emotionally move people to awareness (and therefore- action), I sometimes wonder if using such a large data set is always the most potent approach.

This is where *Currents* blossoms into not just one iteration, but an overarching weather data sonification project. Shortly after the premiere of this fixed audio-visual iteration at the 2020 Earth Day Art Model Festival, I began working on the next chapter of the *Currents* project. As opposed to a fixed audio-visual piece sweeping through mountains of data, the next iteration of *Currents* zoomed in on seven specific weather events out of the 258 catalogued in the database. I crafted notated sheet music shaped by data sonification techniques and enlisted seven wind/percussion players to perform these short solo works with live electronic processing via Max/MSP. For example, the aforementioned 2014 Detroit flooding was outlined by a percussion player using five different instruments to depict the five inches that fell on Detroit in roughly five hours. Using hourly precipitation amounts from the Weather Underground, I mapped out the rate of rainfall and projected this timeline overtop the 31 measures of the piece. The percussion player adds a new instrument into the mix after each new inch of rain falls, leading to an eventual flood of five instrument sounds bolstered by Max's live processing into back-masked "waves" of percussion sound. This iteration of *Currents* felt so much more personal: the depiction of individual weather events, a community of live musicians tangibly engaging with the music, the inclusion of a single weather event that personally affected me and my community. Though, related to the previous question of data accuracy versus creative artistry, this project took many more artistic liberties and did not have the same rigorous adherence to the numbers that the first audio-visual iteration did.

To me, *Currents* functions as a blueprint, an ever evolving set of works that strives to make artistic narratives out of scientific data. At its heart it is a project concerned with communicating an artistic narrative

about climate change, and I hope to continue to adapt the project into radically new mediums to reach as many audiences as possible. Perhaps it could be adapted into sheet music for young beginning band players and include a curricular element that could facilitate climate change discussion in the classroom. Or perhaps it could function as a video game, an interactive fiction piece using the programming language Twine that combines written and sonic narratives in a way that implicates the audience into its process (video games demand the player's participation for the genesis of the story to occur). I believe we as artists have so much to offer in the conversation about our shifting planet through the power of artistic storytelling mediums, and making an audience feel something different then scientific data can show, keeping the conversation afloat about the urgency of climate change and the ominous shifts in weather patterns on our planet.

Notes

[1] Recording of *Currents* www.youtube.com/watch?v=97J1CG88UV0 (last access Nov 11, 2023).