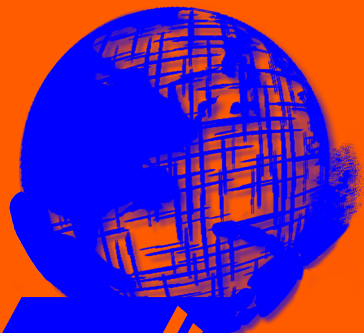


# DACA 2022

CONFERENCE ON DATA ART FOR CLIMATE ACTION



HONG KONG

PROCEEDINGS / CATALOGUE

GRAZ

**Conference on Data Art for Climate Action 2022  
Proceedings|Catalogue**

Editor: PerMagnus Lindborg  
Design: Viki Wen Xingtong

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# DACA Team

Chair :: PerMagnus **Lindborg**, School of Creative Media, City University of Hong Kong [SCM, CityU]

Co-Chair :: Katharina **Groß-Vogt**, Institute for Electronic Music and Acoustics, Kunstuniversität Graz, Austria (IEM, KUG)

Artwork Chair :: Ryo **Ikeshiro**, SCM

Paper Chair :: Christian **Sandor**, Paris-Saclay University, France

Concert Chair :: IOhannes **zmölnig**, IEM

Research Assistant & AV Production :: Manni **Chen**, SCM

Research Assistant :: Tom **Tse** Chun Hong, Dept. Media & Communication [COM], CityU

Design for Logo & Promo :: Marie **Chan** Ching Yee, COM

Design for Proceedings|Catalogue & posters :: Viki **Wen** Xingtong, SCM

AV Documentation :: Thore Flynn **Hadre**, SCM

AV Documentation :: Muhammad **Salik**, Computer Science Dept., CityU

All-rounder :: Charlotte **Ma** Cheuk Chun, SCM

All-rounder :: Daye **Yoon**, SCM

All-rounder :: Simon **Windtner**, KUG

## DAT/ACT Data Art for Climate Action Gallery

Curators :: Ryo **Ikeshiro** & Lina **Simon**, SCM

Production Assistant :: **Gui** Ren, SCM

Posters & Key Visual Design :: Kasin **Fong** & Lina **Simon**, SCM

Website Design :: Tobias **Tang**

Videos :: Green **Mok** Yuk Kuen, SCM

Photos :: Kasin **Fong**, SCM

## Advisors

Shauhrat S. **Chopra**, School of Energy and Engineering [SEE], CityU

Ray **LC**, SCM

Zheng **Bo**, SCM

Markus **Reymann**, Thyssen-Bornemisza Art Stiftung

Richard **Parncutt**, University of Graz, Austria

Animesh **Singh**, Network of Environmental Student Societies & [SEE]

# Welcome to DACA!

We are delighted at the School of Creative Media, City University, Hong Kong, to be able to host this pioneering conference on Data Art for Climate Action (DACA 2022) which takes place at the School between from the 11<sup>th</sup> to the 15<sup>th</sup> of January 2022. It goes without saying that there is nothing that is more urgent today than to mobilise awareness and understanding of the catastrophic impact of man-made climate change upon the global ecosystem. Unfortunately, as the reaction to Covid-19 has demonstrated, we live in a world where an alarming and reactionary scepticism has developed towards the knowledge afforded by science, a knowledge that is embodied above all in the heady abstractions of data. It is thus critically important that we become more aware of the kind of data that is out there about the climate change induced transformations in our environment as a prelude to mitigating action. Art, especially digital media art, as the papers and artworks at this conference demonstrate, has a uniquely valuable role to play in making data visible, approachable and meaningful through strategies of visualization, sonification and story-telling, and I want to congratulate and thank all the participants.

This is a dual-hub conference taking place in Hong Kong and in Graz, Austria, connected by live feeds. It consists of student workshops, two keynotes, three paper sessions, an art exhibition in Hong Kong, an Alograve (a live coded performance using data from Hong Kong Observatory), and a sound installation in Graz featuring several works. I know from personal experience how complicated it is to pull off successfully a hybrid conference of this nature and I would like to thank Dr. PerMagnus Lindborg for his visionary leadership and organisational skills that have made the whole thing possible, as well as his supporting team and our colleagues in Graz for their collaboration. Many thanks also to our key partners, especially the Hong Kong Observatory who have become such a vital ally in developing the nexus between art and science at the School, and our main conference sponsor, the Environment and Conservation Fund of Hong Kong.

Richard **Allen** is Chair Professor at City University of Hong Kong and Acting Dean of the School of Creative Media

Sandy Man Kuen **Song** is Assistant Director of Hong Kong Observatory and President of the Commission for Aeronautical Meteorology of the World Meteorological Organisation

# Data Art for Climate Action

DACA 2022 is a dual-hub conference on interactive sonification and visualisation for climate science communication. It is supported by the Environment and Conservation Fund, the School of Creative Media, and the Cultural and Sports Committee at City University, in partnership with Hong Kong Observatory, Institute of Electronic Music and Acoustics and Kunstuniversität Graz, Wegener Center for Climate and Global Change (Austria), Frontiers Journal, Thyssen-Bornemisza Art Contemporary Privatstiftung (Switzerland), and the Network of Environmental Student Societies (HK).

DACA is about sonification and visualisation of climate data with a purpose of exploration, awareness, education, and action. Through open source dissemination of knowledge, we aim at contributing towards a diverse, equitable, and inclusive community of researchers, artists, activists, and students.

The overarching goal of DACA is to support scientists and artists who seek to work more closely together and create perceptualisations of climate data that excite and surprise people. Both sonification and visualisation are processes of data perceptualization, with aesthetic and practical ramifications. Data art is the study, interpretation, and representation of scientific measurements in ways that excite and surprise. While science speaks through words, numbers, and diagrams, art communicates through movement, images, sound, and sculpture. Working together, artists and scientists can reach further and engage more people in concerted action. The Conference reaches out to artist-scientists who create spectacular audiovisual data displays that explicate, clarify, and highlight large-scale climate developments. It aims to increase awareness of global sustainability goals and stimulate action among both experts and general audiences.

Join the Conference and explore possibilities to fuse climate action and data art. DACA will be a focal point and physical/online meeting-place to allow researchers, artists, and activists to exchange best practices and experiences. We aim to stimulate a renewed look at what artists can do for science, and how scientists can approach art as a means for discovery and communication.

In the spirit of sustainable action, DACA does not endorse long-haul flights and instead encourages participants to travel by train to Graz or Hong Kong, or participate via the Internet.

PerMagnus **Lindborg**, DACA Chair (Hong Kong)

Katharina **Groß-Vogt**, DACA Co-Chair (Graz)

# Keynote Speakers

## Andrea **Polli** :: Hack the Grid: Public Art and Climate Change

Dr Polli will present Hack the Grid, excerpts from her book and series of projects designed to advance the original definition of “hacking”: to make something your own. Hack the Grid employs public art in the built environment, media, and community engagement to promote greater understanding of energy production and consumption. Through this, she encourages audiences to experiment with energy-related technologies and ideas, to make more informed choices about energy consumption and advocate for greener energy industries.

The notion of “hacking” is learning through remaking. To ‘hack’ as we define it is to take something readily available and reconfigure it—realizing new questions, uses, and representations along the way. To understand something from the inside out. In short, to make something your own. The ongoing project ‘Hack the Grid’ is absolutely not advocating for the scary, destructive definition of “hacking” that promotes theft, fear, and destruction. (not ‘cyberwarfare’) The definition of hacking is creative and generative; it is an action in the service of knowledge, cultural production, and civic engagement. The goal for Hack the Grid is to foster greater understanding about energy consumption. Through this, one can make energy on one’s own by experimenting with energy-related technologies, using media and image-making to explore new ideas. One can also make more informed choices about energy consumption, in addition to advocating for the kind of energy in homes and communities.

Polli has been committed to creating works that engage with climate and atmospheric science for over 20 years. She spent two months working alongside National Science Foundation climate scientists in Antarctica and traveled throughout the Arctic, Europe and the US interviewing atmospheric scientists. She spent over 15 years studying and recording soundscapes around the world - including Antarctica, and in addition, created digital sonification technology to translate numerical environmental data into soundscapes inspired by the natural world. She developed a similar technology to translate real time sensor data to light for public artworks and creates light in motion that is organically immersive and moves in space in ways similar to a natural soundscape. This presentation will share several of these public light works visualizing climate and other environmental phenomena that aim to engage the minds of the next generation with urgent environmental issues.

Polli is a Professor with appointments in the College of Fine Arts and School of Engineering at the University of New Mexico (UNM). She holds the Mesa Del Sol Endowed Chair of Digital Media and directs the Social Media Workgroup, a lab at the University’s Center for Advanced Research Computing. As an educator, Polli has created student-centered professional development, theory, practice and field-based courses and experiences for practicing artists, engineers and makers. [andreapolli.com](http://andreapolli.com)

## Moritz **Stefaner** :: Visual Rhetorics

As it seems, we have hit a wall in the visual rhetorics surrounding global warming. What comes after “red” and “very red” in the color scale? How many ice bears can we show on shrinking sheets of ice? How can we move beyond those visuals cliches? Moritz Stefaner investigates how we can make global warming sensually more accessible through data visualization — and thus, hopefully, more graspable. His course Beyond heatmaps at HfK Bremen resulted in climate sonification, data sculptures and ice interfaces. Project Ukko presents a novel visual language for seasonal wind forecasts, used in expert tools as well as ambient data installations. And as the winner of National Geographic Ocean Plastic Innovation Challenge with Perpetual Plastic — a 46 ft data sculpture made from beach debris, showing the fate of all plastic ever produced — raised awareness for the huge challenge of ocean pollution in South-East Asia. Finally, with Susanne Jaschko he investigates how food can be a medium for information, in their workshop series Data Cuisine.

As a self-employed “Truth and Beauty Operator”, Moritz Stefaner keeps chasing the perfect shape for information. With a background in Cognitive Science and Interface Design, his work beautifully balances analytical and aesthetic aspects in mapping complex phenomena to support data-driven decision making. In the past, Moritz has helped clients like the OECD, Google News Initiative, Salesforce, World Economic Forum, Deutsche Bahn and the Max Planck Research Society to find insights and beauty in large data sets. He is the record winner of the Kantar Information is Beautiful awards and his work has been exhibited at Venice Biennale of Architecture, SIGGRAPH, Max Planck Science Gallery, Fondation EDF, and Ars Electronica. As a writer, Data Stories podcast co-host, and sought-after keynote speaker and workshop facilitator, Moritz Stefaner continues to excite more and more people about the magic that can emerge when art and science connect deeply. Visit <https://truth-and-beauty.net>

## Featured Artists

### Renick **Bell**

HKO\_hot\_temp\_rain\_sea\_1884-2021\_20220225 [audio]

*“One of [the algorave] scene’s more flabbergasting producers,”* (Mixmag magazine). *“Algorave kingpin - one of the leading figures of the algorave movement, and watching him make his music is just as fun as dancing to it.”* (Resident Advisor). Bell improvises bass-heavy algorithmically generated music full of percussion and noise by live coding with open source software, including software he has written called Conductive. Each performance is new and unique, *unheard* before the event even by Bell, with his live programming activity projected for the audience to see. <https://renickbell.net/>

### moon.**noon** aka Moon Hung

HKO\_hot\_temp\_rain\_sea\_1884-2021\_20220225 [video]

Moon Hung aka moon.noon is a generative artist who creates real-time audio-visual and experiments based in Hong Kong. He likes to take real-world quantities like sound, sight, time, and sensory data and weave them into abstract audio-visual vignettes and storytelling experiences. <https://instagram.com/moooon.nooooon/>

### Just **Bee** aka Abby Yuen Hui Ching

Dancing on Eggshells

Just Bee aka Abby Yuen Hui Ching, is one of Hong Kong's biggest underground tastemakers in the bass music scene and part of the award-winning Unchained crew, Just Bee's immediately recognisable style has seen her rocking decks from warehouses to the rooftops all across the city. Whether she's crafting inviting house vibes at the Grand Hyatt Hotel, or high-energy all-night sets at Oil Club and Oma, Just Bee remains a master selector across genres, playing at some of the hottest festivals and venues including Outlook Festival, Clockenflap, Social Room, Popinjays, Mihn and Quality Goods Club. <https://www.justbeehk.com/>

# DAT/ACT Data Art for Climate Action Gallery

DAT/ACT brings together a collection of artworks responding to climate change, the defining crisis of our time. Perhaps a contraction at first glance, the title is open to interpretation and visitors may detect a variety of possibilities in both meaning and pronunciation. Should it say “DATA”? Is the data incomplete? Does it contain an imperative, a command to “act”? Or does it refer to a written law, as in an Act of Parliament? Should it rhyme with “tact”? Is it an abbreviation of “ACTION”? Does it indicate something performative? Does the “/” mean that it is an either/or statement? Should we choose one or the other?

Many of the works use data as material through visualisation and sonification, the process of presenting data and information through graphical means and non-speech sounds respectively. These techniques can serve a didactic purpose by conveying the science and data behind climate change. But their use in an artistic context can progress beyond merely being visual and auditory display or a formalist exercise. How the data is communicated via the audio and the visuals becomes inseparable from the aesthetic concerns of the sound and the moving image.

What is required in comprehending the title and the works in the exhibition is not necessarily any missing “data” – the evidence behind climate change is overwhelmingly clear – but perhaps a response on the part of both the artist and the viewer/listener in order to supplement the context conveyed. This response or “act” is not merely a direct call to action which leads to practical outcomes – the works presented are not only a way of raising awareness of a worthy cause, nor simply a form of agitprop or activism. After all, exhibiting works on the subject of climate change in a gallery setting could quite rightly be considered as preaching to the converted at best, cynically riding on a wave of popular sentiment, or worse. Rather, what is necessary is a consideration of how artists can engage with the topic of climate change, and how the viewer/listener can in turn engage with such artworks. The act required becomes a form of interpretation or reflection, or the formation of subjectivity, in experiencing the association of sensory affect with the context of climate data and its real-world implications. Questions to consider could include the following:

- How do you enjoy a piece of music when its upward trajectory is thanks to global warming?
- How pleasing to the eye can an image showing carbon emission increase be?
- How apparent should the data be in audio and visual patterns generated by climate data?
- How amusing should a satirical take on climate change be?
- Should the success of this exhibition be assessed in terms of behavioural changes in the visitors to the gallery or the wider public? (No)
- Should you make an effort to reduce your carbon footprint after visiting this exhibition? (Yes)

DAT/ACT asks visitors to consider the possibilities of “data art for climate action,” its limits and how to exceed them.

Ryo **Ikeshiro** & Lina **Simon**, Co-Curators

# Committees & Reviewers

## Papers

Christian **Sandor** (Chair)

Shauhrat **Chopra**

Katharina **Groß-Vogt**

Ryo **Ikeshiro**

## Artworks

Ryo **Ikeshiro** (Chair)

Katharina **Groß-Vogt**

Ray **LC**

PerMagnus **Lindborg**

Elke **Reinhuber**

## Works-in-Progress

Ryo **Ikeshiro**

PerMagnus **Lindborg**

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Ryo **Ikeshiro**

Pete **Kellock**

Jonathan **Kemp**

Alisa **Kobzar**

Ray **LC**

Sara **Lenzi**

PerMagnus **Lindborg**

Raul **Masu**

Michiko **Oki**

Elke **Reinhuber**

Martin **Rumori**

Dawn **Scarfe**

Jonathan **Weinel**

Ashley **Wong**

Iohannes **Zmölnig**

# Program

Date	Day	Event	UTC 0	HK	Graz	Dur	Session	Location
2022-02-22	Tues	Workshop	3:45	11:45	4:45	15	Intro	M6075
			4:00	12:00	5:00	60	Talk #1 :: Climate monitoring and communication	
			5:00	13:00	6:00	120	Forming groups, brainstorming	
			7:00	15:00	8:00	120	Workshop #1 :: visualisation	
			9:00	17:00	10:00	105	Workshop #2 :: sonification	
			10:45	18:45	11:45	15	Wrap up	
2022-02-23	Wed	Workshop	4:00	12:00	5:00	60	Talk #2 :: Public artwork about climate	M6075
			5:00	13:00	6:00	240	Group work	
			9:00	17:00	10:00	45	Presentations & Discussion	
		Break	9:45	17:45	10:45	45	---	MMT
		Conference	10:30	18:30	11:30	30	Conference opening	
			11:00	19:00	12:00	30	Exhibition opening	
			11:30	19:30	12:30	50	Audiovisual event #1	MMT
2022-02-24	Thu	Conference	7:35	15:35	8:35	10	Intro	Future Cinema
			7:45	15:45	8:45	60	Papers #1	
		Break	8:45	16:45	9:45	15	---	
		Conference	9:00	17:00	10:00	90	Papers #2	
		Break	11:30	19:30	12:30	30	---	MMT
		Conference	12:00	20:00	13:00	60	Keynote :: Moritz Stefaner	
			13:00	21:00	14:00	40	Audiovisual event #2	
2022-02-25	Fri	Conference	6:50	14:50	7:50	10	Intro	Future Cinema
			7:00	15:00	8:00	80	Works-in-Progress #1	
		Break	8:20	16:20	9:20	10	---	
		Conference	8:30	16:30	9:30	90	Panel #1 :: Exploring Designs	
		Break	10:00	18:00	11:00	90	Workshop Demos	MMT
			11:30	19:30	12:30	30	---	
		Conference	12:00	20:00	13:00	60	Keynote :: Andrea Polli	
			13:00	21:00	14:00	75	Algorave :: Bell & Moon	
2022-02-26	Sat	Conference	5:50	13:50	6:50	10	Intro	Future Cinema
			6:00	14:00	7:00	60	Papers #3	
			7:00	15:00	8:00	60	Works-in-Progress #2	
		Break	8:00	16:00	9:00	90	Exhibition Tour: DAT/ACT	Singing Waves
			9:30	17:30	10:30	30	---	
		Conference	10:00	18:00	11:00	90	Panel #2 :: Communicating Climate Change	Future Cinema
			11:30	19:30	12:30	30	Closing (HK)	
Date	Day	Event	UTC 0	HK	Graz	Dur	DAC/ACT Exhibition	Location
2022-01-21	Fri	Exhibition	11:00	19:00	12:00		Opening	Singing Waves
2022-02-24	Wed		10:00	18:00	11:00		Closing	
Date	Day	Event	UTC 0	HK	Graz	Dur	Session	Location
2022-03-05	Sat	Conference	7:45	15:45	8:45	15	Intro	IEM
			10:00	18:00	11:00	30	Installation opening	
			10:30	18:30	11:30	90	IEM Concert	Ligeti Hall
			12:00	20:00	13:00	90	Installation tour	
		Break	13:30	21:30	14:30	30	---	IEM
		Conference	14:00	22:00	15:00	30	Closing (Graz)	

# Papers

## **Artistic Interpretation of Scientific Data on Extreme Weather to Raise Public Awareness for Urban Resilience**

**Dr. Shaurhat Chopra**

School of Energy and Environment, City University of Hong Kong

**Scott Hessels**

School of Creative Media, City University of Hong Kong

**Kayo Chang Black**

School of Creative Media, City University of Hong Kong

shessels@cityu.edu.hk

### **Abstract**

The aftermath of Typhoon Mangkhut in the autumn of 2018 not only paralyzed Hong Kong's transportation infrastructure but also highlighted the city's dire need for more effective communication on extreme weather to the public and policymakers to improve urban resilience. In recent years, artistic practices have been merged with scientific data to create a bridge between science, art, and public awareness. In the spring of 2019, the students of the School of Creative Media at the City University of Hong Kong created artworks by re-interpreting weather and atmospheric data from the Hong Kong Observatory (HKO). This resulted in an exhibition called "Blown Away: Art, Science, and Extreme Weather" where a 10-question survey was administered to gauge the level of impact of the artworks. This interdisciplinary effort between art and science, education, and climate change communication received positive responses. Public awareness and understanding of climate change through art are the focus of this study, considering public acceptance of policies is essential for policymakers. Our study emphasizes that artistic interpretation of extreme weather data can be a powerful tool to engage the public in issues of urban resilience.

### **Introduction**

Typhoon Mangkhut was one of the most powerful typhoons that ravaged Hong Kong. At its peak, it reached No. 10—the highest on the tropical storm warning signal system. Unlike other parts of the world when a deadly storm strikes, there was a small death toll in Hong Kong, and the majority of the city maintained electricity and water. However, on September 17, 2018, the day after the storm, the effects of the storm became more apparent. Over 4,600 fallen trees blocked over 600 roads and the light-rail tracks, causing the suspension of bus routes and rail services (Cheung, 2018). The blocked roads and suspended rail services forced millions of commuters to attempt to use the Mass Transit Railway (MTR) to go to work. This influx of commuters caused major congestions across Hong Kong and stranded commuters in chaotic MTR stations for hours. This paralysis of public transport, in addition to other damages as a result of the storm, led assessors to estimate that the storm cost the city over USD 1 billion in insurance claims (Tsang, 2018).

Days after Typhoon Mangkhut, The Collaborating Centre for Oxford University and CUHK for Disaster and Medical Humanitarian Response (CCOUC), a non-profit research center between Oxford University and The Chinese University of Hong Kong, administered the survey "Climate Change and



Health in Hong Kong: Response to Natural Disasters and Epidemics." This study aimed to assess Hong Kong residents' attitudes and knowledge about severe weather and disaster prevention. Though only 29.4% claim that the government's performance during Typhoon Mangkhut had room for improvement, 69.8% stated to have been affected by roadblocks or traffic issues (CCOUC, 2018). Despite the damage caused by Typhoon Mangkhut, the CCOUC research also found that 92.2% of the respondents do not believe Hong Kong is a disaster-prone area, and only 52.2% planned to prepare themselves for future disasters (CCOUC, 2018). Multiple sources claim that climate change will lead to stronger storms in the future, and coastal cities such as Hong Kong need to be better prepared (Kao, 2017; NASA, 2013). However, the CCOUC study demonstrates that Hong Kong people are overly trusting in the resilience of the city. There is a need for more effective climate change communication to enhance public awareness on the effects of a severe weather event on cities.

Modern society is critically dependent on the stability and performance of complex infrastructure networks such as water, communication technology, safety, energy, manufacturing, transportation, and government (Chopra et al., 2016). These infrastructure assets, systems, and networks, known as Critical Infrastructure Sections (CIS) provide essential services and form a city's backbone (Chopra and Khanna, 2015). Modern cities are increasingly dependent on the stability of their CIS, and therefore, governments and international agencies seek to improve their city's resilience to survive extreme weather events such as floods, storms and extreme temperatures associated with climate change (Jaroszowski et al., 2014). While there have been efforts that develop knowledge and tools necessary for adapting to climate change impacts on the 'network of networks' within cities (Linkov et al., 2014), there is a need to communicate the severity of vulnerabilities and transfer knowledge on urban resilience to the public.

Currently, in Hong Kong, only satellite images and storm trajectory maps provided by organizations such as the Hong Kong Observatory (HKO) inform the public about the potential damage a powerful typhoon could cause. However, satellite imagery and weather maps reverse human perspective and experience. For instance, the HKO Radar Image uses different color indicators for different rainfall rate. The color indicators are decided by the observatory and are not physically related to the rainfall rate. Even though it can differentiate the rainfall rate in a particular area, the public might not be familiar with the color indicator and may not be able to comprehend how heavy is the rainfall. The images have been flattened to accommodate our dependence on a single-point perspective and enhanced with false colors that are not indicative of the storm. As a result, they do not adequately inform Hong Kong residents to understand its horrific potential impact on the city. In this paper, we argue that there is a need for more emotive data representations on extreme weather to showcase the urgency to tackle climate change to the public. Visualization is the human activity of forming mental models or imagining things (Spence, 2001). The students in this project are developing data visualizations, which is the process of transforming climate change data into artistic data representations, to enhance the public's sensitivity towards climate change. The artworks are the visual representations that are presented to the public. Through this project, we present student artworks that visualize data on the effects of severe weather events in order to influence public attitudes regarding resilient cities.

### Current Gaps in the Literature

Throughout human history, humans have always observed and recorded weather to predict their outcomes. Using art to interpret weather data is not a new phenomenon, though the emergence of new media art in the 20th century provided attractive alternatives in how we represent weather and communicate the effects of severe weather events.

### New Media Art

According to Tribe and Jana, new media art is described as "projects that make use of emerging media technologies and are concerned with the cultural, political, and aesthetic possibilities of these tools" (Tribe, 2006). New Media art emerged in the mid-20th century when technological progress and the developments in the art created a condition for art, science, and technology to intertwine (Quaranta, 2013). The media critic Geert Lovink describes new media art as a "transitional, hybrid art form, a multi-disciplinary 'cloud' of micro-practices" that is also a community "that does not produce art, but tests and explores the artistic medium (of the future) for the benefit of (future) generations" (Lovink, 2007). Others have claimed that in the recent years, the most significant 'artistic' developments happened outside the art world, often involving those who do not see themselves first and foremost as artists—they regard themselves as researchers, scientists, and activists (Blais and Ippolito, 2006).

To demonstrate the "micro-practices of a community," in the new millennium, artists continued to push boundaries in the realm of new media art for the benefit of future generations. South Korean artist Zune Lee created Weather Pong (2011) (Lee, 2011), a variation of the classic Atari arcade game Pong (1972) to encourage participants to think about how pollution affects the environment and human emotions. He drew together air-quality data sourced from environmental sensors and the public's feelings about the weather as expressed on Twitter through live feeds and utilized established application programming interfaces (APIs) to create a thought-provoking and participatory game (Randerson et al., 2015). Pulse (2018) is by American sculptor and fiber artist Janet Echelman, who embedded an 11,600-square foot fountain in the historic Dilworth Park. The work traces in the surface of the fountain the paths of the subway and trolley lines that converge under the park (Echelman, 2018). Each time a train passes through, viewers can experience the transit

lines that bring more than 70,000 passengers to the site each day by a four-foot-tall curtain of colorful atomized mist travel across the park fountain's surface (Echelman, 2018). A Montreal-based artist, François Quévillon, created *Dérive*, (2018), which allows the public to interact with an unpredictable digitized space where live astronomical and meteorological data collected on the Internet determine the appearance, soundscape, and navigational conditions (Quévillon, 2018). Many of the recent new media artworks demonstrate a merge of science/engineering elements to artistic/creative practices. Furthermore, many of the works are participatory nature, which forces the viewer to become a participant, an active agent who experiences our ever-evolving society rather than a merely passive observer.

In 2015, artist Refik Anadol created Virtual Depictions: San Francisco, a public art project that consisted of a series of parametric data sculptures to tell the story of the city and the people for the 350 Mission's media wall (Anadol, 2015). According to Anadol, the goal of this work was to use urban infrastructure data to make the invisible visible by embedding media arts into architecture to create a new way to experience a living urban space (Anadol, 2015). This similar approach in new media art can be a viable solution in creating accessible severe weather public warning system and helpful data representations to assist the public in understanding the effects of a severe weather event. New media art can be a starting point to inform the Hong Kong public about the need for resilient cities, acting as a bridge to interpret scientific data.

### Weather Warning and Art

While scientists and mariners have been recording and predicting weather and researchers developing new approaches to severe weather communication, artists are also contributing to the field. Hundreds of years before the advent of electronic technologies, artists had been inspired to create artwork based on their observations of weather. Leonardo Da Vinci, using black chalk on paper, created *A deluge* (1517-1518), which showed the flux of a dynamic system of clouds and water

(Randerson et al., 2015). In 1776, during Captain James Cook's second southern voyage, William Hodges painted *A View of Cape Stephen with Water Spouts*, where he created a scientifically accurate depiction of the tubular water flow of a vast spout of seawater (Randerson et al., 2015). In the early 20th century, meteorological art 'made' by the weather itself started to appear in Marcel Duchamp's *Unhappy Readymade* (1919). In a letter, Duchamp instructed his sister to hang a geometry textbook by strings on the balcony to allow the wind to choose its own problems as it turned and tore the pages (Naumann and Duchamp, 1982).

In recent years, artists have been blurring the line between weather warning systems and artistic expression. 'Eco-Art' is an art form that emphasizes on materiality and can be broadly defined as an ecological art, which seeks to preserve, remediate or vitalize the life forms, resources, and ecology of Earth (Guy et al., 2013). Artworks that specifically address environmental and climate change issues have often been labelled as 'Eco-Art' (Guy et al., 2013). There is an example from Singapore in which eco-art became a potential means to emphasize environmental issues such as climate change and recycling within the local, regional, and global contexts (Guy et al., 2013). Other artists have created artwork with public awareness in mind. Artist Billy Apple created *Severe Tropical Storm 9301 Irma* (2015), a complex audio-visual and typographical schema (Apple, 2015). He fused the satellite charts of Irma from above and his own encounter with the same storm while traveling on a cargo ship in March 1993. Taiwanese artist Huai-Wen Chang, in collaboration with Micro Architecture Studio (MAS), devised *Museum in the Clouds* (2018) (Chang, 2014-2018). Installed on the second-floor façade of Taipei Fine Arts Museum, the work comprises a curved steel frame with sail-like membranes, which follow the movements of the wind. It interacts with the weather station on the roof of the museum, records the museum's microclimate, and reflects this with water vapor and lighting that is visible from both outside and inside the museum (Chang, 2014-2018).

Eco-art seeks to revitalize and remediate Earth's ecology while Apple and Chang represent a movement where artists use data as a form of their practices—a collaboration between science and art for the public good.

### The Fusion of Art and Science

The fusion of art and science to inform and engage the public about the effects of climate change is attracting attention. Roslyn Taplin explores climate change art and their prospect of connecting viewers with some realization of future implications (Taplin, 2014). Caitlin De Bérigny and colleagues discuss how an interactive installation artwork, *Reefs on the Edge*, can engage and inform the public about the effects of climate change in the ocean.

(Bérigny et al., 2014). The work incorporates tangible user interface objects, environmental science, and multiple art forms to aid in the visualization of coral reef ecosystems that are under threat (Bérigny et al., 2014).

Participatory and experience-focused artwork also influenced the realm of weather and art. Around the time new media art began to emerge, artists and other practitioners embraced the dynamic patterns of weather as a direct feed in kinetic, systems-based, and changeable forms and began to use weather as a vehicle of transformation (Randerson et al., 2015). The Fitzroy's storm glass became a source of inspiration in the 20th century for artists such as Hans Haacke and Alan Sonfist's. Haacke's *Condensation Cube* (1963-1965) is a self-regulating system of the atmosphere inside a single clear acrylic cube (Randerson et al., 2015). Sonfist's *Crystal Enclosure* (1965) is a sphere containing natural mineral crystals that convert to gas then recrystallize with fluctuations of temperature and light

(Randerson et al., 2015). The perpetually changing, self-contained system is a metaphor for Earth's ecosystem. Fujiko Nakaya, a Japanese artist, also experimented with a meteorological element of fog in which she created a low-lying fog over the Pepsi Pavilion at the Osaka World's Fair in 1970, one of many projects she has developed using mist and fog. (Randerson et al., 2015).

In the early 2000's, our desire for an instant daily weather report calls for new imagining processes and techniques of disseminating information. With new media art, the difference between creative and scientific means of meteorological representation has diminished. Artists started to use the same tools and meteorological data streams as scientists to gather digital weather media for their practice (Randerson et al., 2015). Thorbjørn Lausten's installation *Magnet* (2008) is an abstract grid of pulsating colored shapes based on the live feeds of geomagnetic and meteorological data from Scandinavian science institutions

(Randerson et al., 2015). Instead of occupying a god's-eye-view of the weather system from above, Lausten's *Magnet* activated senses through the optical play of color afterimages, creating a new system of weather visualization based on pulsation, movement, and temporal responsivity (Randerson et al., 2015). Artists such as Germaine Koh, John Nelson, and Random International have also used weather data to create artwork that enables viewers to experience weather data. Koh's *Candelabrum* (2008) uses street lamp poles with custom LED chandelier responding in real-time to wind speed, wind direction, humidity, and rainfall. In 2010, John Nelson, a mapmaker and the User Experience and Mapping Manager for IDV Solutions, a data visualization company, created a bottoms-up view of known tropical storms and hurricanes since 1851. Nelson took the storm-path data from National Oceanic and Atmospheric Administration (NOAA) and laid it on a "South Pole stereographic" map of the world, which recorded and represented all recorded tropical storms and hurricanes since 1851 (Solutions, 2012). *Rain Room* (2012), created by Random International, is a complex open system made from custom software, 3-D tracking cameras, solenoid valves, pressure regulators, and custom-designed tiles to create indoor rain. While the viewer enters the space, he or she is at once exposed to and protected from the water (Randerson et al., 2015). The recent weather-related new media art took the flat, 2-D representation of weather such as satellite maps and made them 3-D or

immersive, allowing viewers to experience the weather data with all senses.

As with contemporary new media art, much of new media weather art is participatory, allowing viewers to experience the weather data the artists interpreted. Olafur Eliasson created *The Weather Project* (2003-2004) in the Turbine Hall of Tate Modern (Eliasson, 2003) is such an example. Before the exhibition, Eliasson surveyed the museum staff about the weather published the results in magazines. Promotional materials also appeared on taxis and billboards around London. For the exhibition, Eliasson created a false sun made of industrial parts, mirrored ceiling, and water vapor to create conversations around the weather. Through his work, he illustrates that experiences of weather, like nature, cannot be regarded as common to all (Randerson et al., 2015).

Similarly, Karolina Sobecka's *Thinking Like a Cloud* (2013-2015) invited participants to experience meteorological phenomena. Sobecka designed a cloud-collecting instrument to extract humidity and collect liquid content, complete with pollutants and microbiomes (Randerson et al., 2015). In cloud-tasting events, Sobecka asked volunteers to ingest the cloud, which encouraged a conversation on human effect on the climate (Randerson et al., 2015). Eliasson and Sobecka's works are two of the many examples of participatory new media weather work that are effective in enabling participants to become agents in the process of art-making and thus gain a deeper understanding of the weather data.

Apple's *Severe Tropical Storm 9301 Irma* (2015) and Chang's *Museum in the Clouds* (2018) have paved the way to create visual representations that informs the public of severe weather events. New media weather art helps viewers experience the effects of climate change but are not always effective in visualizing the effects of severe weather events. The examples above indicate that there is value in visualizing data through emotive art. To create more effective data representations to communicate severe weather events and other negative effects of climate change, we argue



that there are needs for more collaborations between weather data and artistic practices and future creatives to produce works that focus residents' attention on climate change.

### Climate Change Communication

Climate change has become an increasingly important topic not only for national weather services and scientists but also for researchers in interdisciplinary fields. However, lack of information on climate change is not the only constraint for triggering a change in attitude. More information does not mean more climate-sensitive residents. The lack of effective communication with the public can be one of the reasons that cause low sensitivity of the public towards climate change issues. The widening gap between public perception and scientific consensus raises the need for effective communication of the science of climate change (Gough et al., 2016). Climate change communication studies the public's perception of climate change and how we communicate about climate change to affect attitudes, beliefs, and behaviours of the public (Chadwick, 2017). Chadwick mentions that there is a need for informational messages related to climate change to strengthen climate change knowledge and communicators that provide messages with accurate scientific consensus. The difficulty in creating solid mental images of climate change and the use of psychologically distant images cause people to be less concerned about climate change (Chadwick, 2017). Gough, Dunn, and Bérigny promote artistic collaborations to create experiences that interact with the audience in an understandable way (Gough et al., 2016). New modes of delivery, such as museums and galleries, can attract the public and raise public awareness of climate change. Many researchers are exploring alternative media to engage and inform the public about climate change, such as adopting polar bears as an icon (Born, 2018), playing an educational video game (Dulic et al., 2016), and viewing popular films about the erratic fluctuation of climate (Sakellari, 2015). Furthermore, there have been different approaches to improve climate change communication, such as training environmental

educators (Lambert and Bleicher, 2014) and applying communication theory (Ballantyne, 2016). It is evident that the field is robust and involves many disciplines, including design, social sciences, and education. In order to attract the public and inform them effectively about climate change, creative and emotive data representations by using art is a potential area of exploration in climate change communication for effective communication.

To summarize, there is an opportunity for artists to collaborate with scientists to create new media art for climate change communication to influence public attitudes. The overarching goal of this study is to investigate the effectiveness of artistic visual representation of scientific data to raise public awareness towards climate change and extreme weather. We present student artwork that visualizes data on the effects of severe weather events to influence public attitudes regarding resilient cities. To study the reaction of the public and evaluate the effectiveness of the artistic data representation, we organised an exhibition to present the students' artistic data representations and administered a survey during the exhibition.

### Methodology

In this study, we examined the public attitudes towards emotive data representations on climate change created by the students from the School of Creative Media at the City University of Hong Kong as an experiment. The students had a course on "SM3733-Special Topics in Creative Media" that resulted in an exhibition, titled "Blown Away: Art, Science, and Extreme Weather" (<http://weather.scm.cityu.edu.hk/>). Through their coursework, the students explored issues including climate change, weather modification, atmospheric optics, and satellite remote sensing, and produced artworks that mobilize the audience's perception and affection towards the Earth and the atmosphere. The School of Creative Media has been leading art and science expeditions to remote endangered ecosystems in which students partner with scientists at field research stations and collect the same data. Once returning to Hong Kong, they convert the data into new

media artworks. This iteration of the course was offered in partnership with the School of Energy and Environment and focussed on urban resilience to extreme weather in the context of Hong Kong, which was greatly impacted by the 2018 Typhoon Mangkhut.

In the winter semester of 2019, students from the School of Creative Media at the City University of Hong Kong created artistic data representations to inform the Hong Kong public of the effects of severe weather events. Twenty-one students hailed from different parts of the globe: Hong Kong, China, Germany, Hungary, and Switzerland. The course coordinator, a new media artist, in collaboration with a scientist from School of Energy and Environment, guided the students to develop concepts and construct the artistic data representations.

### Exhibition

The students exhibited their work in a group show titled "Blown Away: Art, Science and Extreme Weather" on the 28th and 29th of April, 2019. The show took place at Tai Kwun Centre for Heritage & Art in Hong Kong, the former Victoria prison that has been restored and renovated into an artistic and cultural hub. Viewers walked through a collection of interactive installations, films, photographs, mixed-media sculptures, documentation of performative installations, and 3-D data visualizations created by students. In total, there were roughly 2,000 visitors over the two days exhibition period.

### Concepts of Artistic Data Representations

Benjamin Bratton's idea of "the stack" and the principles of speculative design are the core theoretical frameworks that informed the students' work. "The stack" is what Bratton calls a "megastructure" that illustrates the different facets of interconnected layers in the field cybersecurity (Bratton, 2016). Speculative design is an emerging research strategy thrived on the imagination that aims to open up new perspectives and to create spaces for discussion and debate about alternative ways of being (Dunne, 2013). Applying the concepts of "the stack" and speculative design, students re-imagine datasets and imagery from HKO

regarding typhoons and temperature spikes in the territory, as well as datasets from remote radar stations, and weather balloon launchpads. Using weather field station sites, online resources, datasets, and equipment related to aerial imagery and weather monitoring, students transformed critical environmental data into new media artworks for an exhibition. Through the students' exploration of time-based, multivariate/multidimensional visualizations, the objective of the researchers is to address the finding of the CCOUC that the people of Hong Kong are overly trusting in the resilience of their city. They are not fully aware of the fact that due to climate change; future storms are going to be more severe than Typhoon Mangkhut and that the negative impacts of a severe weather event are going to worsen. To inform the public, students interpreted scientific data by utilizing their artistic and creative sensibilities to create climate change data representations. While in this paper we describe four most representative artworks, additional details, including descriptions, images and videos, for other student projects are available on the exhibition website (<http://weather.scm.cityu.edu.hk/>).

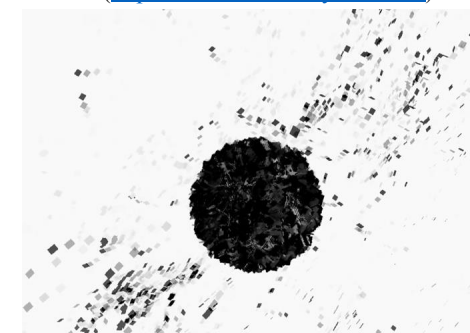


Fig 1. Wind-ow, Ka Lok Wesker Shek 2019 Courtesy of the School of Creative Media.

Wind-ow (2019) is an interactive installation by Ka Lok Wesker Shek (see Figure 1., <https://vimeo.com/335761108>) (Shek, 2019). A 3D interactive animation of the storm modeled using wind speed and air pressure datasets from Typhoon Mangkhut, the work responds when a viewer approaches by mimicking the sound of the storm—the closer the viewer, the louder the audio of the installation, the more intense the

animation. The experience is supposed to simulate the wind hitting the window during the typhoon, using clips of news reports of Typhoon Mangkhut. The speed of the recording sped up and slowed down based on wind data. Wind-ow is often the first artwork viewers interact with upon entering the exhibition.



Fig 2. Fry, Ji Ziwei, 2019 Courtesy of the School of Creative Media.

Ji Ziwei's Fry Hong Kong (2019) resonated with many viewers as it visually illustrates the severe effects of ground-breaking high temperatures registered in Hong Kong in recent years (see Figure 2.,

<https://vimeo.com/335761040>) (Ji, 2019). Ji used custom fabricated metal rods to create a mold in the shape of different parts of Hong Kong. In a series of live performances in Kowloon, Hong Kong Island, New Territories, and Lantau, Ji places fresh eggs inside the mold and cooks them based on the highest recorded ground temperature in each location. Ji Ziwei's Fry Hong Kong (2019) resonated with many viewers as it visually illustrates the severe effects of ground-breaking high temperatures registered in Hong Kong in recent years (Ji, 2019). The viewers commented on how effective this visual representation was to illustrate the serious consequences of extreme heat.

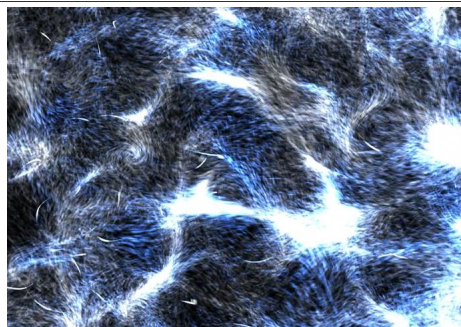


Fig 3. Winds of Blakeana, Márton Tőkés, 2019 Courtesy of the School of Creative Media.

Márton Tőkés's Winds of Blakeana (2019) is a real-time data visualization that interprets the data from HKO's 28 wind stations around the city (see Figure 3.,

<https://vimeo.com/337050246>) (Tőkés, 2019b). Taking data directly from the HKO's website, Tőkés presented the data in an ever-flowing and continuous animation. Viewers are mesmerized by the real-time data of wind, gust, and direction combined with a light-color setting that evokes the current air temperature and the time of the day.



Fig 4. A Bittersweet Reminder, Andy Schaub, 2019 Courtesy of the School of Creative Media.

In a sound installation, A Bittersweet Reminder, artist Andy Schaub created a music box that gently plays a Brahms lullaby that is controlled by wind datasets from Typhoon Mangkhut (see Figure 4.,

<https://vimeo.com/335761101>) (Schaub, 2019). The lullaby represents both home and safety, which is broken apart into pieces according to the increasingly violent winds. As the melody is dramatically affected by the

storm data, the sound becomes an alternative way to present natural force and danger. Viewers commented that the distortion of the familiar lullaby is an effective way to comprehend the power of Typhoon Mangkhut.

### Effectiveness Evaluation of the Artistic Data Visualizations

The researchers administered a 10-questions survey at the site of the exhibition of the students' artwork, "Blown Away: Art, Science, and Extreme Weather" in April 2019. The objectives of the survey are 1) to identify Hong Kong residents' perception and behaviors towards climate change and the impacts of a severe weather event (such as a typhoon); and 2) to assess whether art can help Hong Kong residents understand the effects of a severe weather event (such as a typhoon) before it takes place. The study is approved after ethical review by the research committee at the City University of Hong Kong. Since the focus of this research is to raise public awareness, the perception of individuals after seeing the artistic data representations can be used as a reference to evaluate the effectiveness in using art to interpret severe weather data. A survey allows us to gain insight with simple questions that are easy to understand within a short time period, which enabled us to carry out surveys even during the peak hours of the exhibition. In addition, the response can act as a conclusion of the individual's perception after seeing all the artistic data representations when the individual's memory is still fresh. For instance, a yes/no response on whether the artistic data representation helps understand climate change-related issues can provide a comprehensive perception of the individual on the effectiveness of artistic data representation. The survey was conducted during the two days exhibition period, and the respondents were chosen randomly from the visitors. The survey questions included the background of the respondents (age, profession, and area of residents), their knowledge of climate change and extreme weather, how the extreme weather had affected their life, and their perception of the effectiveness artistic data representation. In total, 182 people participated. The results from

the survey were processed analytically to evaluate whether the general public endorses the need for artistic visual representations of extreme weather-related data.

### Results

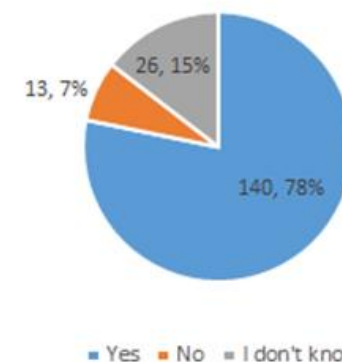
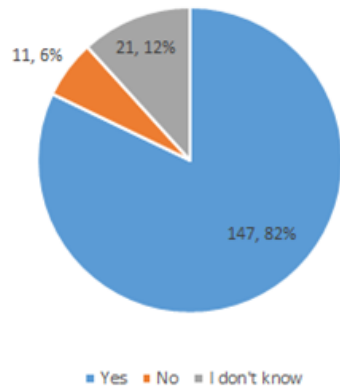


Fig 5. Responses to the survey question: "Do you think the Hong Kong government and/or news media need better visualizations to inform you about climate change impacts such as typhoons, extreme heat and rising sea level?"

Based on the results of the survey, 64% respondents claimed that the Hong Kong government and the media provided sufficient information about the Typhoon Mangkhut, and 83% claimed that they were prepared for it. However, among the 179 responses, 78% of the respondents indicate that the Hong Kong government and news media need better visualizations to inform them about extreme weather-related to climate change. With 95% confidence level ( $p=0.05$ ), the chi-squared test result (Chi-square value = 163.654,  $P$  value = 0) shows that the result is statistically significant. Even though majority of the survey respondents acknowledge that the Hong Kong government and news media do a good job at alerting the public, they also highlighted the need for better visualizations to communicate the possible impacts of climate change and extreme weather events.





**Fig 6.** Responses to the survey question: "After seeing the artworks, do you think art can help you understand the effects of typhoons, extreme heat and other negative impacts such as rising sea level and loss of life?"

On questions regarding the effectiveness of the artistic data representations displayed at the exhibition, among the 179 responses, 82% of the respondents acknowledge that art can help them understand the effects of typhoons, extreme heat, and other negative impacts, such as rising sea level and loss of life after seeing the artistic data representations. With 95% confidence level ( $p=0.05$ ), the chi-squared test result (Chi-square value = 192.581,  $P$ -value = 0) shows that this result is significantly different from a sample set of random responses. The result from the statistical analysis shows that the responses are not random, and the majority agree that artistic data representations may play a role in communicating the effects and negative impacts of climate change and extreme weather.

### Discussion

The findings of the survey complemented the results from the CCOUC survey while providing some solutions to the issues it identified. Hong Kong residents believe that traffic disruption was the one effect of Typhoon Mangkhut that affected many residents. While the majority of participants in both studies claim that they received enough information about the typhoon, the participants from the CCOUC stated that the government needs to

improve their performance. Similarly, the participants from the current study believe that the government can provide better visualizations to help Hong Kong residents understand the effects of a typhoon (CCOUC, 2018). The current study shows that the public responds positively to data visualizations interpreted through artistic practices. The majority of the respondents agrees that artistic data representation can help them in understanding climate change-related issues, and there is a need for better data visualization from the Hong Kong and news media. To improve extreme weather communication in Hong Kong, the government and organizations such as HKO can collaborate with artists to re-interpret data in a way that reflects reality. They can take a cue from the Weather Channel in the United States who have developed compelling visualizations during weather reports. In 2018, the Weather Channel video segment made using augmented reality to illustrate the storm water surge during Hurricane Florence went viral (Feldman, 2019). In this short clip, the anchor annotated a ground-based visualization as he stood on a street as the intensity of the storm increased. This video enabled viewers to see the impacts of the storm before the landfall—flooding streets, carrying away cars, and submerging homes. Viewers praised the video in the comment section as they understood how the hurricane could directly affect them instantly. Unlike many weather satellite images with the flattened perspective of God's Eye View, this video clip was effective because it visualizes the storm from our eye level.

Since traffic delays as a result of the paralysis of public transportation was one of the major impacts from Typhoon Mangkhut, visualizations need to indicate how a severe weather event could impact the transportation infrastructures within the city. For instance, in addition to exhibiting Winds of Blakeana

(2019) at the "Blown Away" exhibition, Márton Tökés, also presented MTR. Veins, a 3D data visualization of the Mass Transit Railway (MTR) system of Hong Kong (see ESF 1) (Tökés, 2019a). Visualized as a biological system of veins and blood, Tökés

used data from the Travel Characteristic Survey to determine the ridership at different MTR stations at specific times of the day, using the metaphor of blood clots to represent overflowing at each station (Arup, 2014). The work aims to provide a new way of looking at public transportation data to gain insights valuable for urban planning and design. Tökés's work could serve as a foundation to continue creating emotive visual representations that can raise public awareness on the resilience of the city's public transportation and the impacts of climate change.

Public awareness and understanding of climate change are the focus of this study because the public acceptance of policies is essential for policymakers. As mentioned before, without imagery on the climate change issue, the public can be less sensitive to climate change. By utilizing new media art, we can help the public to visualize the impacts of climate change. For instance, by just looking at the graph of the highest temperature due to climate change, the public has difficulty in understanding how hot it is. In Ji Ziwei's Fry Hong Kong project, the student cooked fresh eggs with ground-temperature. Using daily life experiences, such as cooking eggs, the artist presents one of the impacts of climate change to the viewers in a more accessible way. This resonates with the work of Gough, Dunn & Bérigny (2015), that emphasize engaging the viewers in an accessible way (Gough et al., 2016). Hohl shows an example of interdisciplinary collaboration that visualizes electrical power generation through a physical experience (Hohl, 2011). The viewers pedal on bicycles and produce electricity that is displayed on a screen (Hohl, 2011). The viewer can then compare the power generated to daily life experiences of energy consumption, such as switching on a bulb (Hohl, 2011). This connects the abstract unit of science with daily life physical experiences, which helps the viewer imagine the complexity better. Similarly, the viewers can imagine how high the ground temperature is through Ji Ziwei's Fry Hong Kong project. A better understanding of climate change impact may influence the

public acceptance of climate change policies for resilient cities. The significance of new media art in climate change communication further urges the need for training artists to present climate change data in artistic ways.

Though visual representations have proven to be useful in this study, it is evident that visualization models have limitations. Specifically, the dataset of various networks will have uncertainty, and when modeled together in a visualization, these will increase uncertainty. The use of art in data visualization may overlook the issue of uncertainty. For this reason, it is imperative to train artists to understand uncertainty in data and learn to collaborate with scientists to ensure a realistic scenario is depicted. The current project is not calling for art to resolve uncertainty or to replace scientific data. Instead, we argue that applying artistic practices to interpret scientific data can enhance climate change communication to evoke action from the public.

### Conclusion

The Collaborating Centre for Oxford University and CUHK for Disaster and Medical Humanitarian Response (CCOUC) study showed that effective climate change communication is needed to enhance Hong Kong resilience as typhoons will become increasingly severe in the coming years due to climate change. The current climate change communications are problematic. The flattened, God's Eye View perspective of satellite images and the false colors on weather maps do not represent the physical reality of the storm.

Furthermore, these images do not inform the public of the potential consequences of the typhoon. The current research implemented a collaboration between art and science between a university, City University of Hong Kong, and a public institution, HKO with the goal to create visual representations to communicate the effects of climate change from an emotive, participatory and immersive perspective.

Throughout history, humans have observed and recorded weather data to understand and

prepare for storms and other severe weather events. Artists have also used weather and weather data as sources of inspiration. In recent years, new media art has enabled participatory and immersive experiences to aid the public to understand climate change. However, more collaboration between weather data and artistic practices are needed to communicate the effects of a severe weather event, such as a typhoon. During the case study at the City University of Hong Kong, students from the School of Creative Media used their artistic practices to re-interpret the weather and meteorological data provided by the HKO. They created interactive installations, films, photographs, mixed-media sculptures, documentation of performative installations, and 3-D data visualizations and exhibited them at Tai Kwun Centre for Heritage & Art in Hong Kong. The results of the survey administered at the site of the exhibition indicate that the public engaged positively with the artistic data representations and that the visualizations helped them understand the effects of a severe weather event.

The current research does not suggest that art should replace science or that the artistic interpretation of weather and atmospheric data is superior to the original data. What we argue is that by applying artistic practices in the interpretation of scientific data, we may be able to enhance climate change communication and better inform and engage the public and policymakers about the effects of severe weather events. Art, in other words, can act as a bridge between science and the public, enabling scientists to better communicate their findings outside of their community.

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## Weblink

<https://weather.scm.cityu.edu.hk/>

## Authors Biographies

Dr. Shauhrat S. Chopra received his PhD in Civil and Environmental Engineering from the University of Pittsburgh, USA. His doctoral dissertation was focused on resilience of complex systems including economic systems, industrial symbiosis, and critical infrastructure systems at urban and national levels. His data-driven research is focused on designing and applying systems level modeling approaches for building a sustainable future.

Scott Hessels is an American artist who explores new relationships between the moving

image and the environment. He has mixed cinema with emerging technologies including sensors, robotics, GPS, and adaptive materials, often partnering key science organizations. His films and new media installations have shown internationally in museum exhibitions focusing on both technology and fine art. His recognitions include patents, references in books on new media art, and coverage in cultural media like *Wired* and *Discover*. He is also executive producer of the Extreme Environments Programme which organizes art/science expeditions to environmentally significant sites.

Kayo Chang Black is a Taiwanese Canadian writer who explores hybrid identities, global citizenship, and the intersection of cultures. Her career as an academic librarian brought her to the UAE, Bahrain, and Hong Kong.

## Sonifying data, taking action on Climate Change: a review of cases from the Data Sonification Archive

Sara Lenzi and Paolo Ciuccarelli

Center for Design, College of Arts Media and Design, Northeastern University, Boston MA

[s.lenzi@northeastern.edu](mailto:s.lenzi@northeastern.edu)

### Abstract

We present a review of cases of data sonification projects dedicated to climate change. The cases are sourced from the Data Sonification Archive, a curated online collection of sonifications.

### Introduction

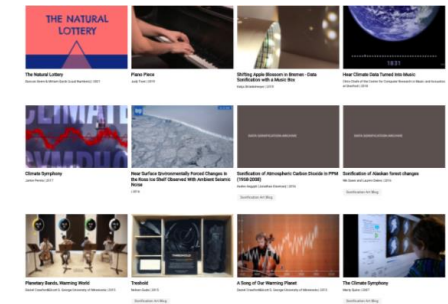
The Data Sonification Archive (DSA) (<https://sonification.design>) is a curated collection of sonification projects launched in early 2021. This online archive is motivated by the need of gathering a deeper understanding on the field of data sonification, its evolution, and its current status.

In recent years, we have witnessed an increase in sonification projects that aim to communicate complex, socially relevant phenomena to a larger public (Lenzi et al. 2020), a transition that the community of data sonification and auditory display advocated for on several occasions.

### Data Sonification and Climate Change

Climate change is one of the most prominent scientific topics of our times. Because it is also a social issue, it is no surprise that sonification of data related to climate change is a well-represented case in the Data Sonification Archive, with 19 projects uploaded to date.

The release dates of projects span from 2013 to 2021. They are either submitted to the Archive by the community through the online form or directly added by the curators (**Figure 1**).



**Fig 1.** An overview of the sonification projects on climate change hosted on the Sonification Archive.

Some authors are very active. For example, Lindborg released several instances of 'Locust Wrath' (Lindborg, 2018) over two years from 2013 to 2015, adapting the original multi-channel immersive installation to different contexts as a sculptural auditory display and a live dance performance (2015a) or an interactive iOS (2015b). Pereira released six sonification projects between 2017 and 2020, each project highlighting different consequences of climate change. Crawford and George released two projects, in 2013 and 2015, which translated the global rise in temperature in the form of classical Western music: as a cello solo in the case of 'A Song of Our Warming Planet' (2013) and as a string quartet in the case of 'Planetary Band, Warming World' (2015). Interestingly, the projects were published in the form of videos where, after an introduction by the authors, the sonification is performed while visualization of the same data appears on screen, as a sort of subtitle to help the public associate what they



hear with what is a perhaps a more familiar sensory modality. The same strategy is used by Foo (2015) in 'Too Blue - Mapping Coastal Louisiana's Land Loss with Music' and by Chafe (2018). The latter used abstract synthesized sounds to convey the correlation between rising CO<sub>2</sub> levels and the increase in temperature, using data from a five-hundred year period, from 1666 to 2016.

In 'Anthropocene in C Major' (Pereira 2021) a 45-minute orchestral piece is accompanied by a visualization of the dataset so as to work as a performance guide for the public. Classical Western music is also the choice of Guda (2015), Twet (2019), and Sawe and Oakes (2016). The project 'Shifting Apple Blossom in Bremen' (Striedelmeyer 2019) stands out in that data are sonified (as well as visualised) through a music box which the user (e.g. an exhibition visitor) manually activates in order to hear the data. Audification (Dombois & Eckel 2011) is used only in one case as a method to sonify seismic data on ice melting (Chaput et al., 2016) for the purpose of scientific research. More recently, Green and Quick (2021) have turned data from traditional ice measurements in Nenana, Alaska, into techno music for their podcast series Loudnumbers.

Public engagement with techno-scientific knowledge and its potential societal impact is still an open issue. We believe design can play a central role by creating multisensory experiences like the ones represented in the DSA.

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## Weblink

Link to the Data Sonification Archive: <https://sonification.design>. The Climate Change collection of cases can be accessed by selecting 'Climate Change' from 'the list of topics in the search engine'.

## Author Biographies

Sara Lenzi is Research Scientist at the Center for Design, College of Arts Media and Design, Northeastern University. She holds a PhD in Design from the Politecnico di Milano and a MA in Philosophy from the University of Bologna, Italy. A trained classical musician, she founded the first sound branding agency in Asia and co-founded soundDesign.info, the online magazine specialised in sound communication. Her current research focus is on data sonification and, more in general, on the interrelations between sound design practices and design methodologies and tools. In 2021 she co-founded, together with Paolo Ciuccarelli, the Data Sonification Archive.

Architect and Communication Designer, Paolo Ciuccarelli is Professor of Design at Northeastern after twenty years at Politecnico di Milano, Italy. At Politecnico he founded the DensityDesign Research Lab, an award winning laboratory for data visualization and information design. Paolo's research focuses on design transformations that help make sense of data and information to improve decision making processes, especially with non-experts stakeholders and for controversial complex social issues. He develops tools and methods to understand the evolution of the design

discipline in the frame of a meta-design approach.



## The Anthropocene Maze - an interactive listening experience of our ecological footprint on selected habitats

A. Kobzar<sup>1</sup>, B. Brands<sup>1</sup>, V. Drack<sup>1</sup>, J. Leitner<sup>2</sup>, K. Groß-Vogt<sup>1</sup>, and C. Amon<sup>3</sup>

<sup>1</sup> University of Music and Performing Arts Graz, Austria

<sup>2</sup> University of Graz, Austria

<sup>3</sup> Joanneum Research, Graz, Austria

Corresponding author: vogt@iem.at

### Abstract

The Anthropocene Maze is an interactive sound installation. It consists of a wooden floor equipped with Pyzoflex® technology and an AmbiSonics audio environment. Footsteps' sounds are modified in the ambiance of different habitats' soundscapes that suffer from human influence. The installation has been exhibited and evaluated at a university's campus.

### Introduction

The Anthropocene Maze is the outcome of a Masters' students group project in the field of sonic interaction design at the Institute of Electronic Music and Acoustics (IEM) of the University of Music and Performing Arts Graz<sup>1</sup>. The students were provided with an interactive floor by Joanneum Research that registers any change in pressure on its surface (see below and Fig. 1) . Combining the floor with the institute's infrastructure, we created an interactive sound environment on the topic of the Anthropocene. The floor can thus be seen as metaphor for the ecological footprint of humankind.

Various research has shown that the manipulation of the sounds of footsteps (e.g., while walking, dancing, or doing sports) has an impact on the perception and behavior of test participants. For instance, lighter footsteps lead to a perceived lighter body weight (Tajadura-Jiménez, Basia, Deroy, Fairhurst, Marquardt, and Bianchi-Berthouze 2015) and change your gait or even make you more physically active (Maculewicz, Erkut, and Serafin 2016). Therefore we decided to use the floor for manipulating footstep

<sup>1</sup><https://iem.kug.ac.at>



**Figure 1:** Presentation of the Anthropocene Maze at the campus of the Technical University of Graz, Austria, in July 2021. The outdoor venue intensified the perception of virtual acoustic habitats.

sounds and thus induce the feeling of walking in a specific environment. Additionally, ambient sounds support this perception and contextualize the footstep sounds in an immersive audio environment.

The narrative for the Anthropocene Maze followed the idea of a maze game with different scenes to walk through. The maze is guided by *Ariadne*, a computer voice, that leads through a time travel of some undefined far future back into the present time, 2021. Five different environments are visited in random order. The installation has been presented and

evaluated on one afternoon in July 2021 outside of the university's building. In an online questionnaire, their impressions have been collected, as discussed at the end of this paper. A demo video of the event can be found at <https://phaidra.kug.ac.at/o:125838>.

### Technical Set-up

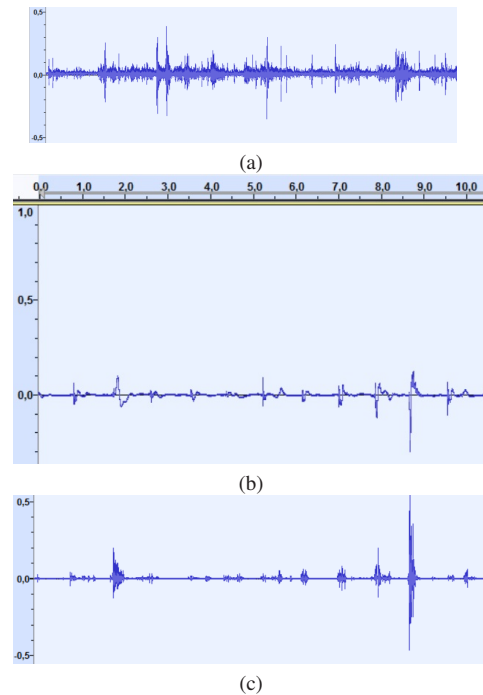
The Pyzoflex® Smart Floor is roughly 2.2 square meters large, and is surrounded by a ring of loudspeakers with a diameter of ca. 2 meters. The space of the floor is thus rather limited for real walking, but turned out to be sufficient for our purpose. The floor consists of 6 wooden floor tiles each of them equipped with 3 single Pyzoflex® sensors (Zirkel, Scheipl, Stadlober, Rendl, Greindl, Haller, and Hartmann 2013) printed on 175  $\mu\text{m}$  thin PET substrate. Each sensor has a size of 8 times 4 centimeters. The sensors are directly integrated into the wooden floor tiles for maximum mechanical coupling. This ensures a high sensitivity to structure-borne sound induced by physical interaction on its surface.

Around this floor, ten portable Genelec 8020 loudspeakers were mounted as a ring of six speakers in 1,5 meters height and four speakers placed on each corner of the floor, tilted upwards. The software was written in PureData<sup>2</sup> (Pd), a graphical programming language for music and sound effects. The ambient sound scenes were prepared within Reaper<sup>3</sup> DAW (digital audio workstation).

The sequence of the story was fixed using q-lists with pre-defined timing. Still, each user experienced a different, random order of scenes. The initial plan of a more interactive setting could not be realized within the project's time for technical reasons - the floor output are 16 highly coupled signals with very small signal-to-noise ratio. Therefore, a regional tracking of steps could only be realized with a large error.

### Sounding steps

The implemented version uses two algorithms to generate augmented footstep sounds. For aggregated surfaces, such as gravel, it worked well to use the overall amplitude of the signal as an envelope for a granular, but static, soundfile. This approach



**Figure 2:** Simple augmentation of the footstep signal as measured by the floor (b), showing the example with gravel sounds as basic sound (a). The amplitude of the signal is calculated, amplified, and used as an envelope for the primary sound, resulting in interactive footstep sounds (c). The primary sound in this example has a length of 4 seconds and is looped. (b) and (c) share the same time axis over 10 seconds (as shown in (b)).

is shown by the example of walking on gravel, see Fig. 2. For hard attacks of steps on surfaces such as concrete, a step detection algorithm was implemented that triggers footstep sounds according to the audio scene.

This approach is highly interactive, reacting to all nuances of the movement, but only works for aggregated surfaces, such as gravel, water, dry leaves, or mud. For hard attacks we implemented a step detection algorithm, that consists of two stages. First, the sensor signals have been preprocessed in order to compensate the unexpedient qualities of the direct sensor signals. Then, an onset detection algorithm was designed to produce the final triggers. Since no pre-amplifier had been used to enhance input sensitivity every channel of the sensor array

<sup>2</sup><https://pureda.info/>

<sup>3</sup><https://www.reaper.fm/>

has been preprocessed by a fairly high amount of input gain of 60dB. A one-pole lowpass filter was applied to reduce high frequency noise. Further a 2nd order polynomial non-linear processing stage had been applied.

The following onset detection algorithm mainly consists of the BONK object of Pd. The underlying algorithm of this Pd-object was designed to distinguish the onsets of percussive instruments. It outputs the energies in frequency bands, when an onset was detected. We used this output to compute the overall energy of a step by summing up the energies in each band. An energy threshold and a frame-based time threshold have been used afterwards to filter out false positive detections.

### AmbiSonics sound environment

To obtain an immersive listening experience, all sound was composed in 3<sup>rd</sup>-order Ambisonics (Zotter and Frank 2012) and decoded onto the loudspeaker setup. The soundfiles for the ambient sounds were pre-rendered in Reaper using the IEM Plug-In Suite<sup>4</sup> and then loaded and played back automatically by the Pd-patch. The original single-channel footstep soundfiles were decoded live in AmbiSonics using a simple encoder within the Pd-patch. The soundscape was encoded onto the loudspeaker setup using the AllRADecoder plugin<sup>4</sup> which employs the AllRAD approach with appropriate max- $r_E$  weighting.

### Sound design

The sound design was composed using individual soundfiles from several online non-commercial archives<sup>5</sup>.

We tried to implement the idea of proxemic zones, as defined by Hall (1963), cited in (Collins 2020). In the public zone (+ 3.7 meters), ambient sounds refer to the environment one is in; for instance, rustling of leaves or distant animals' calls. In the social zone (120cm-3.7m) we may find closer sounds in the ambience, for instance approaching animals that appear louder, closer, and more narrowly placed in the soundscape. Even closer, the personal zone (46-120 cm) relates to the size of the floor. Here, we placed the step sounds, played back from the four

<sup>4</sup>Freely available at <https://plugins.iem.at>

<sup>5</sup><https://www.soundarchive.online/>, <https://aporee.org/maps/>, and <https://freesound.org/>

bottom loudspeakers. Finally, the intimate zone (0-46cm) would be ideal in order to address the listener very personally - such as listening to a mono file over headphones; it is harder to realize with a distant ring of loudspeakers. To make Ariadne's voice as intimate as possible, we played her voice back in mono through all upper channels, and reached an omni-present, superior impression of her. In a more classic interpretation of film sound design, the proxemic zones correspond to layers for background (ambience), midground (steps, special events in the ambience) and foreground (Ariadne).

### The story of the maze

On our rather small floor, the user should be motivated to stay longer than a few steps of trying out his or her step sounds. Therefore, the concept of storytelling was taken in the account- the person should be immersed and engaged to reveal the whole story. The principle of first-person spatial narration for virtual reality (VR) was used as a base: with the help of familiar connotations, e.g., the sound of a door opening for changing from one scene to the next, the story could be easily moved forward.

The property of virtual environments or computer games - to respond in real-time to the actions of the user - creates a space in which specific rules of engagement apply. This interactive space in ludology is known as the *magic circle*. The term has been coined by Huizinga who states that "to play is to step out of real life into a temporary sphere of activity with a disposition all of its own" (cited in (Palitov 2018)[p. 56]).

In particular, the idea of the Anthropocene Maze was inspired by a Maze game, the Honeycomb maze<sup>6</sup>, where players need to find their way from one room to the next. In our maze, the player moves from one scene to the next, and is guided by Ariadne. The concept of Ariadne was chosen as a futuristic navigator with a computer voice that guides through the plot. It fills the gap in the immersive experience, as the user cannot, for instance, feel the cold of the Arctic or see the surrounding rain forest.

The individual ambient scenes are described in Table 1. Additionally to these five scenes, the *lobby* was used in the beginning and in the end. It used

<sup>6</sup>[https://keshiheads.fandom.com/wiki/Honeycomb\\_Maze](https://keshiheads.fandom.com/wiki/Honeycomb_Maze)

	Ambient sounds	Steps
Glacier	An echoic, spacious environment, where an Iceberg is crushing.	Harsh steps on gravels.
Venice	The scene is build by sea gulls and church bells.	Wading through water.
Woods	An idyllic wood is bit by bit transformed into a logging place.	Dry leaves on smooth forest soil.
Tropical forest	Monkeys in a tropcial forest with excited monkeys approaching.	Wet leaves and puddles.
Lab for endangered birds	Deficient lab equipment plays back incorrect songs that should train birds their forgotten songs (triggered with the step detection).	Lab floor.

**Table 1:** The five ambient scenes for the Anthropocene Maze. Each scene evolves from an initial, rather natural setting to a second one where more anthropogenic sounds appear.

a futuristic sound evoking a large, artificial room as “time engine”. One cycle of the Anthropocene Maze took 8:30 min.

### Exhibition and evaluation

The interactive installation was presented on an afternoon outside of the IEM’s building in July 2021. This set-up was chosen to comply with possible restrictions due to the Corona pandemic. The Maze was tested by a dozen passers-by and employees and students of the institute. The outside presentation lead to some technical problems, for instance the step detection algorithm on the floor not being on a plane surface was less reliable. However, the psychological effect of being outside, underneath of real trees, even supported the feeling of immersion and naturalness of the sound scenes, as was reported by several visitors.

To evaluate the installation, an online survey was conducted, and the participants were asked to complete the questionnaire right after leaving. The aim was to learn about their impressions of overall experience, aesthetics, and immersion, as well as the functionality of the interactive floor. In total, nine participants took part in the survey, three of them female and six male, whose age was between 26 and 65 years (see Tab. 2). The survey was conducted in German, the lingua franca of all subjects. For evaluation we used open questions as well as rating scale questions with a seven-step Likert scale.

First, and as a central question, we asked the participants, “under which impression did you leave the installation?”. Further, we questioned which scenes the participants could remember, also checking if the

Age:	26-35	36-45	46-55	56-65
	4	3	1	1
Gender:	male	female	diverse	
	6	3	0	

**Table 2:** Subjects of online survey.

scenes could be correctly identified; how well the audience was immersed in the experience; and how well the system reacted to the footsteps. Finally, the voice of Ariadne and the length of the installation could be evaluated.

The users left the installation with positive feelings; e.g., four participants responded with similar terms for being “animated”, three mentions of “relaxed” and twice “inspired”. Only two responses were neutral and none were negative. Furthermore, feedback included descriptive notions such as “futuristic” or “green” (uncertain what the subject meant). One person stated that leaving the installation feels like being back on solid ground after jumping on a trampoline and feeling weird.

On average, the participants were able to name three scenes and only one participant was able to remember all five scenes. Some scenes were remembered but not identified correctly (e.g., Woods as “construction site”). The scene remembered most often was the Tropical Forest (by 8 persons), Venice (as shore, beach or sea; 7P), Glacier (6P), Woods (4P), and Lab for Endangered Birds (as bird’s land and room with thundering steps; 2P). The immersion in the Maze had an average rating of 5.8 out of 7 (standard deviation, SD, of 1.3), and the floor’s step reaction was perceived as similarly well (average of 5.1 with SD of 1.5). Ariadne’s voice

was mainly described as artificial (4P), but “suiting for the installation”, as well as childlike (2P). It was perceived rather neutral to positive. Regarding the immersion in the individual scenes, we see a trend of differences that the ones that were remembered most were rated as most immersive; but results are not significant due to the small number of participants. Also the differences of perception of step’s sounds for each scene individually has similar, medium ratings; but we saw that very salient sounds (e.g., wading through water) were rated higher than more subtle steps (e.g., rustling leaves in the Wood). The length of the installation was suitable for all but one participant - who would have liked it to be even longer.

The results gave us a clear idea of the strengths and weaknesses of the installation that can be used to elaborate it further. This is true both on a technical level (e.g., the reaction to the steps being slightly too slow) and comparing the sound design of different scenes (e.g., prominent step sounds make more impression and are remembered better). In general, the positive attitude of people leaving the installation was astonishing to some of the authors: it seems that the depressing topic was relieved by the ambiance of natural soundscapes and the neutral voice of Ariadne.

### Conclusions

The Anthropocene is a sound installation with the narrative of traveling back to different habitats in 2021 that are increasingly degraded by human influence. Test participants reported that they left with rather pleasant feelings and arousing curiosity. This makes us wonder if it is better to show such a depressing topic in a way that is still amenable for people, so they like it and stay for the whole story.

In general, we would have liked to create an even more interactive, game-like atmosphere. A few users reported that they had expected more interaction possibilities than turned out to be. Still, with the resources given for the project, the goal of raising interest to the topic and keeping people attentive for a longer time span worked out.

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## All Together Now: Multimodal Communication for Climate Action

**PerMagnus Lindborg**

SoundLab, School of Creative Media, City University of Hong Kong

pm.lindborg@cityu.edu.hk

### Abstract

“Climate change is an unprecedented and growing threat. The arguments for action are clear” (Guterres 2017). Notwithstanding the UN Secretary-General’s call, it has proven a hard challenge to present complex science so that non-specialists are convinced. Without developing a deeper affinity towards science, climate denialism will remain prevalent. To date, climate science is most commonly communicated using texts and still images. Could we gain a deeper understanding of climate change by listening to a sonification of the data that scientists use? How do sounds and visuals come together in a multimodal representation to convey the inherent meaning in the data? The present paper is primarily a literature review. Secondly, it aims to position perception psychology, especially crossmodal interaction, as a key to design approaches of multimodal communication for climate action.

### Introduction

Knowledge of crossmodal interaction patterns between our auditory and visual senses (Spence 2011) inform the development of methods for sonification (Kramer 1994) and visualization (Lankow 2012; Aparicio & Costa 2015). To ensure that sounds and visuals communicate the meaning in the data in unambiguous, non-contradictory, and perceptually effective ways, three areas of research must be combined: perception psychology, display design, and communication. From a biological perspective, sensory information processing is always multimodal (Mesulam 1998; Nanay 2020). Communicating information multimodally is effective and robust, because the higher

bandwidth and balance between sensory modalities can reduce cognitive load (Obrenović et al. 2006). Research has shown that using audio clips alongside visual graphics and text allows people to better understand complex phenomena (Chandler et al. 2015), and that emotionally congruent audiovisuals lead to more intense emotional responses (Pan [Fada] et al. 2019; Vuoskoski et al. 2016). The three characteristics of effective infographics, in order of priority, are comprehension, retention, and appeal (Lankow 2012) and they apply equally well to audiovisual data displays.

Crossmodal interaction is a field of study in perception psychology (Spence 2011; Nanay 2018; Küssner 2013, 2014; Marin & Leder 2013; Chapados & Levitin 2008). Any data can be translated into sound through methods of sonification and into visuals through visualization methods. Effective translation of the meaning inherent in real-world data should be based on principles of ecological perception (Gaver 1993; Clarke 2005; Dubus & Bresin 2013; Lindborg 2018). Therefore, the application of crossmodal interaction research to the design of sonification–visualisation should start by identifying and operationalising a robust set of shared (amodal) correspondences between auditory and visual senses. Certain fundamental correspondences are well established, such as between the perceived loudness of noise and the brightness of white light (Stevens 1955) and many others are currently being investigated (Spence & Sathian 2020).

### Crossmodal interaction

In psychology, crossmodal interaction refers to when information in one sensory channel

influences perception in another channel. Related concepts are crossmodal correspondence, crossmodal binding, and crossmodal plasticity (Spence 2011). They constitute the wider research theme of multisensory integration, also known as multimodal perception. Sensory information processing is inherently multimodal (Nanay 2020). Normally, all our senses are employed to perceive the environment. Our sensory-perceptual-cognitive system has developed so as to maximise simultaneous multisensory input streams and provide an organism with a coherent representation of the physical environment, and in the case of higher mammals, consciousness (Mesulam 1998).

The senses help each other. One sensory modality may stand in when another cannot be used, such as when we find our way through a pitch-black room using touch and hearing. Sensory modalities may compete for cognitive attention, such as when the taste of a cold potato is overcome by the smell of a green apple. This effect has been called 'spill over' (Deroy & Spence 2016). An example of crossmodal interaction is the McGurk effect (McGurk & MacDonald 1976). It happens when you hear the speech sound /ba/ and simultaneously see a mouth form /ga/, producing the perception of /da/. In this case, the interaction presents itself as a sort-of perceptual compromise, or as McGurk called it: an illusion. That vision does not always dominate our multisensory perception of the world is shown by the 'beep-flash' illusion (Shams et al. 2000). In an ingenious experiment, a single flash was simultaneously presented with multiple beeps to subjects, who perceived multiple illusory flashes. This established that visual perception could be altered by auditory stimuli. Moreover, crossmodal interactions can form robust and generalizable patterns that express a form of 'weak synesthesia' (Martino & Marks 2001) or 'algorithmic synesthesia' (Sagiv et al. 2009), constituting a non-pathological personality trait in the general population. Studies have provided evidence that many non-arbitrary crossmodal correspondences exist between auditory and visual perceptions (Bresin 2005;

Palmer et al. 2013; Lindborg & Friberg 2015; Whiteford et al. 2018; Lindborg 2019b).

Our auditory system has two strong points. Firstly, its fine time resolution enables communication of complex auditory information, such as speech and music; secondly, hearing is capable of fully three-dimensional spatial localization (with higher resolution in the frontal field). These are the two main reasons why sound is crucial in the design of immersive spaces, such as physical multimedia installation, film, Virtual Reality, AR, XR and so forth. (Larsson et al. 2010; cf. Azuma 1997).

To compare, our visual sensory system has two other advantages. Firstly, detailed symbolic information can be communicated in small and localized parts of the optic environment; and secondly, we can quasi-instantaneously perceive the arrangement and character of elements in a visual scene and store it in an effective mental representation: a kind of 'snapshot'. Much visual perception research uses very brief and static stimuli (e.g. Marković & Gvozdenovi 2001). However, optical spatial perception is limited to the field of vision, which has a width and height of approx. 120° (static binocular perception), in total catching a ninth of the full sphere at any point in time; this fraction is increased by eyeball movement and body repositioning.

On the one hand, we can spot visual objects from much further away than we can hear their sound, but on the other, we can hear sounds through walls or in darkness. Moreover, our auditory system is always active, including during sleep, as humans do not have 'ear lids'. It is clear that the basic modes of functioning of our senses are complementary, and for good evolutionary reasons.

### Perceptualization

The term 'perceptualization' was advanced for situations where multiple sensory modalities are combined to represent a set of data (Grinstein & Smith 1990; see also Obrenović et al. 2006). Extending the 'classic' definition (Kramer 1994; Hermann et al. 2011), the author has defined sonification as "any technique that

translates data into non-speech sound, with a systematic, describable, and reproducible method, in order to reveal or facilitate communication, interpretation, or discovery of meaning that is latent in the data, having a practical, artistic, or scientific purpose" (Liew & Lindborg 2020). Meanwhile, visualization can be seen as "the process of making visual whatever is communicating specific knowledge. This may include the visualization of data, or simply the use of visual cues to illustrate, differentiate, or show a hierarchy of information" (Lankow 2012 p. 20). However, just as 'sonification' as defined above excludes speech (i.e. acoustic symbols), in this paper we consider 'visualization' the translation of data into non-semantic visuals: that is, excluding text, numbers, emojis, and other optical symbols.

Recent research shows that sonification can overcome barriers in science communication, because "the translation from data into audio reveals changing variables to the listener through changes in sonic dimensions, such as frequency, pitch, amplitude, and location in the stereo field. In musical contexts, data can map to these sonic dimensions, as well as higher-order musical dimensions, such as tempo, form, and timbre" (Sawe et al. 2020). In a large meta-study, Dubus and Bresin (2015) charted strategies for the sonification of real-world physical processes. They are applicable to the context of sonification-visualization of climate geodata. The central design strategy is referred to as 'parameter mapping'. The parameters in question describe the input space, that is, measurements of the environment (time stamped and geo-tagged) gathered from physical sensors, such as temperature, air pressure, ocean salinity, or human movement measures such as flow vectors of pedestrians and traffic, surface and air transport, financial movements, and so on and so forth. The 'mapping' is a network, more or less complex, that describes the relationships (which can be dynamic) between the parameters of source data and the parameters of sound generation. The mapping algorithm consists of two components: linkages that specify which perceptual sonic dimension is representing a

given physical dimension in the source data, and transfer functions that specify the numerical relationship and ranges from input to output for each linkage (Walker & Nees 2015; Lindborg 2018).

### Art and science

Kramer (1994) was keenly aware of the perceptual qualities of data sonification that are necessary for it to be received and understood as meaningful. He argued for the use of scientific evaluation criteria to gauge the success of sonification – systematicity, objectivity, and replicability – so that it might "be used as a scientific method" (Hermann 2008). This resulted in sonification being seen as a discipline that is closely associated with information engineering. In reaction, some argued that data sonification could benefit from knowledge about auditory perception gained in artistic fields, notably sound art and electroacoustic composition (Vickers & Hogg 2006, 2017; Barrass & Vickers 2011). The criteria for evaluating a successful sonification might draw on a range of physiological and psychological responses, such as those investigated in music emotion research. One example is the BRECVEMA theoretical framework for how sound elicits affective responses (Juslin & Västfjäll 2008; Juslin 2013). Emotions related to aesthetics can be measured in terms of qualia, that is, concepts such as 'beauty', 'interest', and 'awe' (Menninghaus et al. 2019; Schindler et al. 2017), and thus be part of the discussion of what makes a sonification strategy 'good' or 'useful'. Moreover, a given sonification might be understood within an Aesthetic Perspective Space in terms of informatics or music (Vickers & Hogg 2006), and with concrete links between sounds and the real-world phenomena they represent, or with abstract linkages that establish themselves through metaphor (Lindborg 2019). Thus, sonification involves several techniques and purposes that, while complying with Kramer's original definition, also aims to satisfy aesthetic appreciation and to reify the attractiveness of discovery.

Aesthetic sonification is not arbitrary. While a scientific approach (systematicity and reproducibility) is fundamental, successful designs build on ecological perception, i.e. the principle that organisms learn patterns meaningful for survival through exposure and from interacting with the environment (Gaver 1993; Clarke 2005; Lindborg 2018). This is related to the concept of embodied or enactive perception. Noë (2004) stated that “perceiving is a way of acting... What we perceive is determined by what we do (or what we know how to do)”. He based visual perception in touch, i.e. the bodily perception of acoustic pressure. Extending this idea, it was suggested that “touching is to embodied visual perception what vocalizing is to auditory perception: homo faber precedes homo sapiens” (Lindborg 2019).

Sonification–visualization techniques must not be aestheticized to the point that scientific criteria are neglected. In the context of science communication, researchers have pointed out that “data sonification need not necessarily be musical in nature, and many scientifically-useful auditory graphs are not particularly musical, or even pleasant to listen to. There are some rationales for abstracting the sonification... abstraction can bring some interesting choices to the communicator.” (Sawe et al. 2020). In this context, ‘interesting’ should be understood as a precise psychological concept. The Appraisal-of-Interest Model (Silvia 2005), a component in theories of aesthetic appreciation (Berlyne 1974; Juslin 2019), was developed to explain the perceived interestingness of a range of visual objects, from basic graphics to art paintings. This concept has been constructively applied to research in urban soundscapes (Axelsson 2011), auditory perception and emotion (Juslin & Västfjäll 2008), and music perception (Juslin 2019), but is rare in the context of sonifications (cf. Ramakrishnan et al. 2009).

### Climate action

“The science is beyond doubt. The world’s top scientists have been shouting it from the rooftops.” (Guterres 2017). But why should

they have to shout? One imagines that scientists might have preferred to calmly “demonstrate how the data are meaningful, appeal to various audiences, and engage stakeholders in the relevance of the research” (Chandler et al. 2015). Academics are under pressure not only to conduct better science, but to communicate their findings effectively to decision-makers as well as undertake public engagement activities - to “envisage the optimal processes and techniques for translating data into understandable, consumable modes of representation for audiences to digest” (idem).

Scientific communication is a balancing act, because science must acknowledge uncertainties in measurements and predictions. However, keeping knowledge within a group of experts may lead to an ‘information deficit’, a fallacy whereby abundant information is assumed to lead to better understanding simply by existing (e.g. in scientific publications), but fails in its purpose because the meaning is “inaccessible and misaligned with the needs of different audiences” (Jacobs et al. 2017). It is a conundrum that plays into the hands of climate denialists and groups with selfish agendas.

The Guardian YouGov-Cambridge Globalism Project recently conducted a poll in 23 countries (total N>25,000; Milman & Harvey 2019). It showed that the USA has the highest prevalence of climate denialists among countries considered to be ‘developed’ (as classified by United Nations 2014). A staggering 13% of Americans agreed with the statement that “the climate is changing but human activity is not responsible at all”. The percentage of denialists in China, about 6%, is comparable to what was reported from a “rare national survey” in 2012, that “93 percent of Chinese people think climate change is happening” and “it will cause themselves harm” (quoted in Dembicki 2017). However, the Guardian poll reveals that the prevalence of denialists in China is still higher than in most European countries, including the UK. Pan [Yeheng] and collaborators (2019) analysed differences in style in the communication of climate science in American, UK, and Chinese media reports from the UN-led Cop21 conference in 2015. They identified ten

concepts or ‘frames’ in the text corpus using a qualitative method. The frame ‘in it together’ was significantly more common in Chinese media reports, while that of climate ‘apocalypse’ was significantly more common in UK and US media. It has been suggested that “the particular relationship between the Chinese media and science” causes climate reporting in China to focus on political events rather than the science itself (Jia 2017), with the Party leadership recently declaring climate action and awareness a national undertaking (Dembicki 2017). To compare, a recent Hong Kong survey (N=1011) found that a large minority (26%) believed they would only experience a “small impact” of climate change over the next five years. A quarter of the population was only vaguely committed to adapting their behaviour. When asked about their “children’s and grandchildren’s future”, a hard core of 6% claimed the impact would remain “small”. Meanwhile, four out of five respondents said that the Hong Kong Government is responsible for tackling climate change, and more than half think it had not done enough so far (HK2050isNOW.org 2020).

### Conclusion

To reach people impervious to traditional science dissemination, this paper posits an interdisciplinary approach based on crossmodal perception and multimodal communication design. Interdisciplinary projects are often based on the notion that both science and art are “founded essentially on curiosity, but the challenge and the difficulty reside in the reality of bringing together contrasting methodologies that frequently use very different written and visual languages” (Ruddock et al. 2017). The authors warn about “‘image fatigue’...the disengagement with the subject that can occur through saturation” but offer no solution. In fact, the approach they describe is skewed towards visual communication of science: for example, the word ‘visualization’ occurs 17 times, while ‘sonification’, or any other word relating to auditory perception, is absent. This reflects an oculocentric over-reliance on text and visual information as mediums for communication. As an alternative, researchers

have proposed to “move away from...static visualisations, and visual narratives with simplistic messages” (Jacobs et al. 2017) and instead communicate through “data displays that embed”, and embody, knowledge about climate science “in more sensory, tangible and visceral representations” which will make the scientific data “come alive” (Polli 2011). This is possible by creating “dynamic and performative experiences of scientific data...that support engagement with issues of complexity, uncertainty and risk” (Jacobs et al. 2017).

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### Author Biography

PerMagnus Lindborg, PhD, is a research-driven composer and sound artist, author of more than a hundred media artworks and compositions, commissioned or selected for ArtScience Museum (Singapore 2021), Osage Gallery (Hong Kong 2021), Banga Gallery (Hong Kong 2020/21), CubeFest (Virginia 2019), Berlin Konzerthaus (2018), Xuhui Museum (Shanghai 2017), Tonspur (Vienna 2016), National Gallery (Singapore 2015), Onassis Centre (Athens 2014), World Stage Design (Cardiff 2013), Moderna Museet (Stockholm 2008), Centre Pompidou (Paris 2003), etc. Won awards for short films at World Film Carnival (2021), Cannes Short, and TIFF (2020), and for composition at SSO [First Prize] (Norway 2002), Forum [Audience Prize] (Canada 1996), Young Artist and TONO Awards (Norway 1998, 1999, 2003). Referred publications in PLoS One, Leonardo, Applied Acoustics, Frontiers, Applied Sciences, JAES, IRCAM-Delatour, Springer-LNCS, and conference proceedings such as SMC, ICMC, ICMPC, NIME, and ICAD. Serves as Regional Director for Asia-Oceania of the International Computer Music Association, and as Associate Professor at the School of Creative Media, City University of Hong Kong.

## Are Forests Money or Mitigation - Understanding the Impact of Carbon Cap and Trade Markets on Deforestation and Emissions

Saloni Shah

Parsons School of Design  
salonieshah@gmail.com

### Abstract

The economic sector plays a significant role in achieving the ambitious target set by the Paris Agreement of limiting the increase in the global average temperature to well below 2°C above pre-industrial levels. Policies are being discussed and implemented nationally as well as internationally to achieve this target through mitigation, adaptation, and environmental integrity. 'Carbon Market' mechanisms are one of the major sets of policies aiming to lower greenhouse gas emissions. Most of these carbon markets utilize forestry credits to offset the emissions of major polluters. Programs such as REDD+ (Reducing Emissions from Deforestation and Forest Degradation) provide these offset credits. They are an increasing concern as they have not only failed to mitigate, but they are also actively contributing to increasing emissions, deforestation, human rights violations, and environmental justice violations.

The project aims to bridge the gap between knowing about carbon markets and systematically understanding the carbon markets and their implications. It visualizes case studies to understand policy inclusion, loopholes, and implications. The project concludes with climate mitigation proposals suggested by expert organizations, indigenous people, and NGOs. This project intends to reflect the grave consequences of these policies on the most vulnerable population and discourage similar incentives based on payment

for ecosystem services such as The Blue Carbon Initiative.

### 1. Introduction

Anthropogenic impacts have become the primary emergent force affecting the future of the planet. They are altering climate faster today than it ever has been. This is a global problem created by few and impacting the most. Countries in the Global North consisting of 15% global population are responsible for about 75% of carbon dioxide emissions. One of the major causes of climate change is unsustainable levels of emissions emitted by overconsumption. There is a huge gap between the consumption of Global North vs. Global South. An extremely wealthy individual from these developed countries may emit as much carbon as 70,000 poor individuals in the world's poorest countries. (J. Timmons Roberts 2007) On the contrary, the major repercussion of this overconsumption impacts unequally on the poor and vulnerable populations on the frontlines who are least responsible for these impacts.

Global climate policies designed to mitigate are usually influenced by the countries of the Global North and have starkly unequal repercussions on the poor and developing economies of the Global South. The burden of responsibility is equally distributed even though the responsibility of the cause was disproportionate. The disparity was carried forward as emission trading was adopted by the Kyoto Protocol in 1997. Under the protocol, each of the industrialized countries was



assigned targets of allowed emissions for the commitment period. It allows countries with less emission to sell their surplus permitted emissions to other countries that were over their target. It also allowed trading away these emissions internationally, in case they did not want to intend to make the reductions at source. The idea was to achieve balance globally. However, it added a layer of disparity as transnational corporations of Global North was incentivized to continue polluting by using offsets from poor and developing economies. This business opportunity was later carried forward in the Paris Protocol resulting in continued implementation nationally and internationally.

The emissions could be traded or sold under the protocol in four different units. i.e. actual reductions, land-use reductions, joint implementation, and clean development mechanism. Each unit has led to severe ecological damage and has resulted in social conflicts in most of the target developing and poor economies. This project focuses on land use reduction unit that focuses on land use, land-use change, and forestry (LULUCF). It is a key component leading to mass deforestation around the globe. Vegetation and soils act as terrestrial sinks by accumulating carbon in the terrestrial ecosystem. Human activities impact these terrestrial sinks, through LULUCF activities and consequently, the exchange of CO<sub>2</sub> (carbon cycle) between the terrestrial biosphere system and the atmosphere is altered. (United Nations Framework Convention on Climate Change n.d.) Forests are tightly packed with living systems that stock a huge amount of carbon within them. Hence, one of the most significant units for climate change mitigation under LULUCF are Forests. As a result, the forest became a commodity storing carbon, and Reducing Emissions from Deforestation and Forest Degradation (REDD+) was introduced to conserve that commodity.

REDD+ projects are project types in areas where existing forests are at risk of land-use change or reduced carbon storage. The program

promotes management, conservation, and increase in forest carbon stocks by encouraging public and private investment. It basically remunerates to keep forests alive without cutting them down as a measure to prevent greenhouse gases associated with deforestation and forest degradation from being released. (Furtado 2017) These forests also remove and sequester carbon dioxide and carbon from the atmosphere. Hence, this system has become a commodity that offsets emissions of major polluters around the globe. Carbon Markets such as California Cap and Trade buy some offsets from REDD+ programs. REDD+ became global when three organizations of United Nations i.e. Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), and the United Nations Environment Programme (UNEP) adopted a program known as UN-REDD to implement national REDD+ strategies in developing countries.

The project visualizes the impacts of an international protocol on emissions, deforestation, and land grabs at multiple locations in UN-REDD Partner Countries. Using a systemic and critical perspective, this project seeks to create a visual narrative informing the population regarding the hidden and less discussed consequences of the local and international carbon markets and forestry credits. It concludes with an understanding of the impacts of other developing market mechanisms for payment of ecosystem services which are way more dangerous and could drag the global climate beyond tipping points.

## 2. Understanding the Basics of Emissions Trade

Emissions trading was initiated with a simple goal: to promote a systemic and affordable transition from fossil fuel energy to clean energy using emission reduction targets. An emission trading is also known as Carbon trading as carbon dioxide is a major greenhouse gas concerning climate change. The trading consists of two major components: 'cap and

trade' and 'offsetting'. The combination of this mechanism is also known as 'Carbon Market'.

### 2.1. Cap and Trade

Under the scheme of 'cap and trade', governments or intergovernmental bodies begin by setting a limit (cap) on permissible emissions for an area. It then distributes or auctions these emission allowances that total the cap to the major polluters of that area. In theory, the cap gradually reduces reducing the supply of permits. The reduction ensures scarcity and retains the value of the permit. The corporations that do not have sufficient permit allowances to cover their emissions must either buy extra offsets from auctions, private markets or make reductions in their emissions. The scarcity would result in an overall reduction in emissions as the permits would be sold at a higher price. Hence, the cap is basically a legal regulatory measure to limit, restrict and reduce emissions; while the trading component is responsible for creating a financial market mechanism. For instance, the cap on permissible emissions of a particular state is 4 MTCO<sub>2</sub>e (The emissions are measured in MTCO<sub>2</sub>e: Metric Tons of Carbon Dioxide Equivalent). The government would then distribute the permits to the biggest polluters of the state i.e. two transnational corporations. Under the scheme, both of the corporations would receive permits to emit 2 MTCO<sub>2</sub>e with strict compliance. The first corporation failed to reduce its emissions and emitted 3 MTCO<sub>2</sub>e, while the second corporation is able to reduce its emissions and emits 1 MTCO<sub>2</sub>e. Hence, in this case, the second corporation could trade and sell its extra permit to the first corporation gaining economic rewards for its reduction. In theory, a cap reduces each year resulting in the overall reduction of emissions while the trade is intended to achieve an overall balance of emissions each year within the capped area.

### 2.2. Emission offsetting

Under the scheme of cap and trade, emission reduction can also be achieved through emission/carbon offsetting. An offset is a

reduction of GHG emission achieved outside the capped area in order to compensate for emissions made inside the capped area. Offsets could be 'Emissions Saving Projects/ Clean Development Mechanism' or 'Forestry Credits'. For instance, a forest conservation project in the forests of developing economies such as the Democratic Republic of Congo, Africa, and Peru, South America could be used to offset emissions of a company such as Walt Disney Company in developed economies such as the United States.

## 3. Limitations of the carbon markets

Carbon Markets extends the extractivist and free-market logic posing fake solutions to address the climate change crisis. It supports programs like REDD+ which legalizes and incentivizes deforestation and forest degradation. For instance, if a forest logger goes beyond its permit for deforesting, then they would buy a permit somewhere else. The entire mechanism is based on the concept someone else will save the emission that the individual is emitting. Below we discuss some of the major limitations of this market mechanism.

### 3.1. Incentivizing Polluters

The cap and trade has failed to incentivize actual/net emission reductions in most of the schemes. It has failed to regulate its emissions according to its desired targets. Permits are awarded according to existing and forecasting levels of emissions. Hence corporations forecast extensive expansion plans demanding sufficient free permits. As it turns out in the course of the years the projects were overestimated and actual emissions were much lower. Hence, in most cases, the polluters are granted more than sufficient permits to cover their existing level of emissions for free. These excess permits are then resold in private markets for huge profits. Due to ample supply, with low demand; the prices of these permits fall cheap in the markets making it easier for

corporations to continue polluting. Jutta Kill author of the book

*“Trading Carbon: How it Works and Why it is Controversial” briefly explains the magnitude of the profits that polluters are making in an interview with Heinrich Böll Foundation saying “We see that not only has complying with emissions limits been cheap for the industry, it has been a profit maker for the largest polluters in Europe. From around 2008 until 2014, the largest polluters in the European Union have made profits worth more or less 24 billion euros from the emissions trading scheme. Twenty-four billion! Polluters are not paying – they are being paid. The Emissions Trading Scheme in the EU really has turned into a corporate welfare scheme.” (Heinrich Böll Foundation 2017)*

In a gist, the mechanism that was supposed to cost the polluters has ended up incentivizing them.

### 3.2. Commodification of Ecosystems

Forests inhabit countless biological and genetic diversity of trees, plants, animals, and microorganisms. It is a complex network of dependencies and inter-dependencies supporting the diversity of life. They are also capable of sequestering huge proportions of carbon dioxide from the atmosphere. Hence, they are also known as ‘Natural Sinks’. These sinks are quantified by the market mechanisms according to the carbon stock stored in them. The value of the forest depends directly on carbon stored in them rather than the species and the diversity it holds. For example, there are two pieces of land. One holds a forest with huge biodiversity but the plants have low carbon accumulation and the other is a farm of monoculture trees with high carbon storage. The concerning body would decide to sacrifice the forest instead of monoculture farms due to its carbon accumulation. It misuses equivalences of Carbon dioxide, saying that you can destroy one ecosystem but at the same time preserve the other. (Heinrich Böll

Foundation 2017) Forests become a mere provider of ecosystem service for sequestering under the policy. Hence, permits are distributed and corporations could offset their emissions by buying carbon stocks from forest ecosystems from developing and poor countries. For instance, a forest in Brazil could be used as an offset to issue allowances for a corporation in California.

Carbon offsetting basically offers compensation to poor and developing countries to conserve their carbon stocks, so major polluters could expand their business on-site. It acts as an incentive for major polluters around the globe to delay action using natural ecosystems as temporary sinks. It led to the creation of the financial market of carbon stocks. The offsets became so popular that in 2016, REDD+ was the most transacted project type sold by brokers, retailers, and other intermediaries. (Hamrick May 2017) The market started drawing attention of private investors, big farmers, corrupt government officials, and transnational corporations. The value and market for forest land increased tremendously and due to industrial lobbying and corruption, healthy and protected forests were now on sale to the biggest polluters. As the program remunerates forest landowners; farmers and local authorities start displacing the indigenous population and peasants leading to mass land grabbing and migration.

### 3.3. Increasing Emissions

Offset programs such as REDD+ trade the carbon that is ‘supposedly stored’ in a biocultural forest of the partnering countries as a credit to aid transnational corporations of excess emissions. Hence, the offsets under these programs do not lead to any actual reductions in the concentrations of CO<sub>2</sub>. At best they result in no net increase in the atmospheric concentrations. (Stabinsky 2021) For instance, Chevron- one of the state’s largest polluters used the offsets under the California Cap and Trade program to expand a refinery processing heavy crude oil from fracking and

tar sands in Richmond, California. Theoretically, this expansion should lead to a massive increase in emissions; however, the company claimed no net increase in emissions as excess emissions would be offset through the increased credits provided under the trading system.

Many of the “solutions” currently being promoted incorrectly and dangerously assume that all those fossil emissions might be captured in natural ecosystems. But the carbon dioxide from fossil fuels being dug up and burned is additional to the carbon that is already cycling between the active pools. We are putting significant stress on all these pools by pushing them to take up additional fossil CO<sub>2</sub>, as their capacity to do that is very limited and the impacts of that continued uptake are huge.

### 3.4. Indigenous Land grabs

The capitalist mindset of a human-centric society has led to the destruction and extraction of ecosystems. The indigenous forest territories encompass up to 22 percent of the world’s land surface and they coincide with areas that hold 80 percent of the planet’s biodiversity. (Sobrevila 2008) The land is usually managed by a community without individual legal proprietorship. Due to industrial lobby and corruption, land rights are snatched from these populations and transferred for so-called environmental projects. As the land ownership is transferred, it often leads to biodiversity loss as the carbon stock is evidently just stored in trees and soil. It leads to the degradation of forests and ultimately results in deforestation for industrial farming adding up to current emissions. Meanwhile, the indigenous population and peasants are left with no livelihood leading to migration and environmental injustice. These environmental atrocities are now being identified as “ecocides” as such drastic changes have been made to environments.

In the same interview, Jutta Kill discusses a case study on such ecocide where a carbon credit company planted eucalyptus trees around a National Park. As the local communities considered it their farmlands, they refused to stop farming in the territory leading to local conflict for international offsets. She says *“The result of the carbon offset project was that armed guards, that were partly guarding the National Park but also now guarding the tree planting off the offset project, destroyed the crops and even shot at people, who were entering the National Park – their land. People lost any means of providing their food, any way of growing their own food. And if you have very little, losing the little that you have really is a problem. This carbon offset project really caused misery for local communities. Again, for what? So that an audience in Amsterdam can enjoy a carbon neutral classical concert? Nothing against classical concerts – but that we pretend there have been no carbon emissions for that pleasure, because somebody somewhere else, a community that has contributed really nothing to the problem of climate change, loses the basis for its livelihood?” (Heinrich Böll Foundation 2017).*

Programs like REDD+ have been proved to be inefficient to provide financial support to indigenous forest dwellers or peasants who are least responsible for forest degradation. They can only be benefited under the program if they portray that they are a threat to their own forest lands contributing to the false perception smallholder land use in the forest is major cause of forest loss. “After all, without evidence of the threat of deforestation, there are no emissions from deforestation that could be avoided – and there can be no REDD+ payment without proof that REDD+ measures have contributed to reducing emissions that would otherwise have been released.” (Heinrich Böll Foundation 2016)

### 3.5. Deforestation

To understand deforestation, we need to precisely define forests. United Nations Framework Convention on Climate Change (UNFCCC) defines forests as an area of land with a minimum area of 0.05-1.0 hectares with tree crown cover of more than 10-30 percent where the trees have the potential to reach a minimum height of 2-5 meters at maturity. Young natural stands and all plantations which have yet to reach a crown density of 10-30 percent or tree height of 2-5 meters are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest. (UNFCCC 2001)

According to Food and Agriculture Organization forest includes natural forests and forest plantations. It is used to refer to land with a tree canopy cover of more than 10 percent and an area of more than 0.5 ha. Forests are determined both by the presence of trees and the absence of other predominant land uses. The trees should be able to reach a minimum height of 5 m. Young stands that have not yet but are expected to reach a crown density of 10 percent and tree height of 5 m are included under forest, as are temporarily unstocked areas. The term includes forests used for purposes of production, protection, multiple-use or conservation (i.e. forest in national parks, nature reserves, and other protected areas), as well as forest stands on agricultural lands (e.g. windbreaks and shelterbelts of trees with a width of more than 20 m), and rubberwood plantations and cork oak stands. The term specifically excludes stands of trees established primarily for agricultural production, for example, fruit tree plantations. It also excludes trees planted in agroforestry systems. (UNFCCC 2001)

Countries participating in the UN-REDD program can define their individual definitions

within those ranges. For instance, Ghana defines a forest as an area of land with a minimum area of 0.1 hectares with tree crown cover of more than 15 percent where the trees have the potential to reach a minimum height of 2 meters at maturity; while Brazil defines a forest as an area of land with a minimum area of 1 hectare with tree crown cover of more than 30 percent where the trees have the potential to reach a minimum height of 5 meters at maturity. There is a lack of consistency with the definitions of forests within the United Nations (UN). The definitions do not differentiate between natural forests and forest plantations. There is a similar case in the definitions of deforestation and forest degradation where the ambiguity in the definitions is used to exploit available resources.

Developing countries participating in the climate change mitigation mechanism of reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks (REDD+), need to determine a national forest reference emission level (REL) as part of their national monitoring system, which serves as a benchmark to measure the impact of their REDD+ actions. and on the development of a REL. In a case study of Indonesia a report finds that the total area of deforestation between 2000 and 2009 was 4.9 million ha when using the Food and Agriculture Organization (FAO) definition, 18% higher when using a 'natural forest definition' and 27% higher when using the national definition. (Erika Romijn 2013) The ambiguity in these definitions are one of the main concerns as the loggers might keep exploiting until they hit the national threshold leading to huge deforestation, forest degradation, biodiversity loss, and loss of carbon stocks leading to increased emissions. "A growing number of publications show that REDD+ does not combat the underlying causes of deforestation and that its measures frequently trigger or amplify local conflicts. Even after almost twelve years, there is no

evidence that REDD+ is an effective instrument against large-scale deforestation. This is not only the case for the objectives of simultaneously stopping wholesale deforestation and compensating forest peoples for protecting forests, but also with regard to its financing via trading in carbon credits." (Heinrich Boll Foundation 2016)

### 4. The Evidence

Programs like REDD+ have an international impact. However, the average person is unaware of these programs. Policy frameworks could be hundreds of pages and usually contain jargon that dissuades an average person from learning about it. This project aims to humanize these policies and encourage people to systemically understand them through visualizations. It looks at different programs and emphasizes complex correlations within multiple datasets. It makes use of qualitative, quantitative, and geographical data in order to assess the impacts of the REDD+ program on UN-REDD Partner Countries. It uses cumulative data of 54 out of 65 partner countries. (see Table 1) The 54 countries are selected as per the data availability. Four important datasets i.e. tree cover loss, carbon dioxide emissions, land grab, and ethnographic findings of existing REDD+ projects are utilized for quantifying the impacts. The data processing and conclusions for each visualization are explained below.

#### 4.1. Quantifying the Success of REDD+ Program

The primary aim of REDD+ was to reduce deforestation, forest degradation, and emissions associated with them. The project utilizes the Global Forest Watch dataset for quantifying tree cover loss and carbon dioxide emission data. It provides country-level data for tree cover loss categorized by percentage canopy cover. For assessment of tree cover loss, it uses 10% canopy cover data as per FAO forest definition, 30% canopy cover data as per UNFCCC forest definition, and 50% canopy cover data as the upper limit of the definition

concluded by the research of Nophea Sasaki & Francis E. Putz. The data was later processed for a rate of change per year to understand the trend and correlations. The trend reached its peak in the year 2016 with the most deforestation and emissions. It is apparently the same year when REDD+ was the most transacted project type in voluntary carbon markets. (Hamrick May 2017) This could be a potential correlation that could conclude the impact of voluntary carbon markets on deforestation and carbon dioxide emissions through REDD+. The quantitative analysis conclusions include the following.

##### a. Forest Area

The area considered as forest largely varies with different definitions. The largest gap is in the peak year of 2016 (see Table 2). There is a gap of 2.43 million hectares between the definition of FAO and the definition recommended by research. The difference approximately equates to the land area of the United Kingdom.

##### b. Rate of Change in Forest Area (2001-2016)

The rate of change is vastly increased when comparing the segments of 2001-2008 to 2008-2016. According to the definition of FAO, the rate of increase from 2001-2008 is 53.47%; while the increase from 2008-2016 is 96.77%. There is a similar case when we compare different definitions.

##### c. Carbon Dioxide Emissions

The carbon dioxide emissions refer to the loss of aboveground biomass at the country level. It largely varies with different definitions with the largest gap in the peak year of 2016 as well (see Table 3). There is a gap of 345.72 metric tons between the definition of FAO and the definition recommended by research. The difference approximately equates to the consumption of 1, 47,260 liters of petroleum.

##### d. Rate of Change in Emissions (2001-2016)



The rate of change is increasing when comparing the segments of 2001-2008 to 2008-2016. According to the definition of FAO, the rate of increase from 2001-2008 is 42.57%; while the increase from 2008-2016 is 97.14%. There is a similar case when we compare different definitions.

#### 4.2. Locating the Resource Grabs

As discussed in Chapter 3, the trend of land grabs increased as the definitions of the forest could include forest, industrial farms, biomass plantations. The project utilizes the global land monitoring initiative data provided by Land Matrix. The geographical data assists in locating the locations of the grabs which in most cases overlap the forest area. They are divided into three groups i.e. Caribbean-Latin America, Africa, and Asia-Pacific. (Sarah Milne 2018) Each data point not only provides information about the geographical location but also informs about the company responsible for the land grab, the status of the deal, and potential use of the land. The geographical land use analysis concludes that the agriculture-related land uses i.e. farming, non-food agricultural commodities, and timber plantation accounts for 59% of the land grabs. Additionally, under the FAO's definition of forest, these lands could be remunerated under the REDD+ program.

#### 4.3. Ethnographic findings of existing REDD+ projects

REDD+ and other forestry programs have an unequal impact on the indigenous population living in the forests at the project location. The project visualizes the dataset of the research conducted by Crawford School of Public Policy. It is a detailed dataset concluded from the analysis of 53 reference cases. They represent 42 distinct REDD+ project sites from 20 countries from different regions (40% Africa, 17% Americas, 43% Asia and Pacific). The data reflect on ethnographic findings on subjects such as local confusion or lack of awareness of the program, financial benefits not delivered to local actors, negative local

views of the program, implementation of measurement reporting and verification systems, new boundaries demarcation under the program, its influence on local tenure arrangements, state property demarcation as part of the program, social tension and conflict due to the program, ongoing forest clearance in the target area, problems with leakage and violation of new REDD+ boundaries. This study assists the current argument further into proving the negative impacts on REDD+ project locations as well as negative impacts on the local population on and around the site.

#### 5. The Bigger Threat

Emerging new terrestrial and aquatic carbon sequestration programs have distorted the boundaries of climate change mitigation and resource grabbing. Blue/Green Economy initiated these carbon complexes with programs focusing on natural sinks of forests, farmlands, and oceans. It intends to conserve carbon and not the ecosystem through green capitalism initiatives such as REDD+ for forests, climate-smart agriculture for farmlands, and blue carbon initiative for oceans. They have initiated a new phase of 'green grabbing' where land and resource grabs are done with a private agenda in the name of environmental protection. (Tramel 2016) We have entered an era where climate change mitigation has become an opportunity for transnational corporations and governments to create market-based capitalist strategies turning climate mitigation into a lucrative economic opportunity. Initiatives such as 'Landscape REDD', 'climate-smart agriculture', 'biodiversity offsets', 'forest restoration credits', 'community development credits' have all been proposed as ways to allow the continuation of corporate destruction. (Kill 2015)

The real threat and the next emerging huge carbon complex is a program in making known as the 'Blue Carbon Initiative'. It translates the idea REDD+ program of the commodification of complex natural systems to a linear commodity of carbon sequestration to marine

mangroves, tidal marshes, and seagrass meadows. In April 2021, SAV program - a collaborative project between Virginia Institute of Marine Science (VIMS), University of Virginia and the Nature Conservancy applied for the first seagrass project for the carbon credit certification with the non-profit Verra. So far, Verra has issued a grand total of just under 970,000 credits (representing 970,000 metric tons of CO<sub>2</sub> equivalents) to blue carbon projects. (Jones 2021). Soon after that in May 2021, the Blue Carbon Project Gulf of Morrosquillo was launched in partnership with Apple. This initiative is researching and developing a model to calculate and evaluate the carbon potential of Mangrove ecosystems in the Sinú River in Cispata, Colombia. "*This new [carbon-measuring] methodology means mangroves can now be a financially viable carbon investment, which will drive the funding communities need to keep them standing*" said Paula Sierra, information and research coordinator at Colombia's Institute of Marine and Coastal Research. However, these programs are highly debated by fish worker movements as an initiative for 'Ocean Grabbing' in the forms of deep-sea drilling and ports, militarized zones, development for tourism, and destructive industrial fishing practices like trawling impacting the coastal and fisher communities. (Tramel 2016) Under such programs, small-scale fishers and workers are blamed for overfishing, pollution, and degradation, restricting their access to the sea; while industrial fishing by industries is often overlooked under the policy of offsetting. It is not far off when the world oceans would be forced to enter the market mechanisms creating false solutions and distractions on an unprecedented level.

Forestry and Land Use activities were used to offset 50.7 MtCO<sub>2</sub>e in 2018, creating a financial market of approximately 171.9 million USD in voluntary carbon market according to a report by Ecosystem Marketplace. (Hamrick May 2017) The world is just beginning to commodify complex natural systems into linear capitalist programs.

The idea to privatizing natural resources by putting an economic value is a false solution. A study completed of "558 offset projects between 1990-2011 found that despite offset attempts the net loss of habitats was 99%" (Hache 2019). The habitat loss exacerbated by deforestation leads to biodiversity loss, forest degradation, and carbon loss increasing the overall emissions. The consequences further lead to increased resource grabs, and human rights violations.

The threats could amplify beyond magnitude if not restricted and stopped immediately. The solution is to target the problem at the source and mitigate it. The future should essentially be defined by the policies protecting the vulnerable and actual nature conservationists rather than transnational corporations.

#### 6. A Ray of Hope

The countries of the Global North have constantly distracted the global population with fake schemes increasing the wealth gap further while snatching the basic rights from the vulnerable. Carbon Markets haven't worked so far; in fact, they may be doing more harm than good. It is evident the emissions saving projects in the Global South are not capable of offsetting the damage done by Global North. Mechanisms such as REDD+ are inefficient as they fail to address the root causes of the problem itself i.e. burning of fossil fuels and excessive consumption of food, timber, and metals by developed countries. It has to be acknowledged that each community across the globe has unequal contributions. The countries of the Global North have contributed the most to this crisis. Hence, now is a good time for them to take the initiative of system change promoting organized degrowth instead of passing the burden to the Global South. The relocation of facilities from a country with strict compliance (strict environmental legislation, labor laws, transparency laws, human rights legislation, and environment democracy) to a country with poor compliance should be prohibited. The governments should

comply with a strict cap without offset trading to phase out polluting mechanisms and transition to clean energy.

Privatization of natural resources is one of the major limitations of these policies and markets. As discussed above, they usually result in additional social and environmental stress. Forest land with community forest management systems in place have been found to have higher levels of biodiversity than those managed by the government or through conservation programs by non-profits or corporations. Hence, assigning forest land management to indigenous communities could not only lead to increased biodiversity but their ancestral forest knowledge could also potentially lead to restoring symbiotic relationships with the ecosystem increasing the carbon storage and overall health of the forest. The governments and stakeholders should hence focus on utilizing these knowledge systems to achieve sustainable goals especially the ones relating to forest management and agroforestry.

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# Narrating Climate Change: speculative data stories in comic form for affecting climate action

**Zijing Song, Yating Sun, RAY LC**

City University of Hong Kong School of Creative Media, Hong Kong, Hong Kong SAR

Academy of Art University, San Francisco, USA

LC@raylc.org

## Abstract

Climate change is difficult to rationalize due to it being remote in both its effects and in where it operates. Using purely physical arguments like statistics and policy debates cannot persuade people to the side of climate change action, because explicit mandates don't align people's own intrinsic motives with those of climate action. Instead, narratives and visual communication can influence viewers implicitly by the way they show and reinforce actions and ways of thinking that align with climate action. In this study we created comics designed on the human level to promote ideas like future-based thinking, sharing of responsibility, and caring for each other, as well as data visualizations that illustrate future consequences of climate change for the purpose of averting negative alternative realities. We test these strategies on readers unfamiliar with the theme of the stories, reading them as common manga about characters and situations. We then surveyed these readers to find that data stories can affect the way they interpret narratives to align with pro-climate attitudes such as sharing and future-vision, and that readers are focused on the human-level of the data and story as opposed to the physical resource level. Thus speculative data provides a way to influence individuals' climate change attitudes by showing alternative realities and positive attributes of collective responsibility and planning-for-the-future in data story form.

**Keywords:** design fiction; data comics; climate action; data visualization; data narratives.

## Introduction

Climate change is a major crisis of our generation. However, people often regard climate change as remote and impersonal (Leiserowitz 2006; Weber 2006), and far from the way we experience reality. Changing the mindset of non-scientific communities and climate change skeptics is difficult due to ingrained beliefs of skeptics and the attribution of climate change to hearsay and political rhetoric. Climate communication strategies that use more personal strategies like storytelling and visual communication are needed to develop pro-environmental behaviors and attitudes (Boykoff 2019). These long-term behaviors for social good need to activate intrinsic motivations, which can develop when experiencing narratives aligned with particular social purposes (LC and Mizuno 2021). We apply a novel genre of data comics (Bach et al. 2017) which combines speculative story design (Dunne and Raby, 2013) and data visualization in the form of comics to generate an appealing and persuasive climate action narration.

On the physical level, climate change involves a set of phenomena like consumption, natural resource limitations, increases in population, and lack of policies in sustainability. These issues are not addressed here because directly imposing evidence and scientific facts on the public is not effective for behavioral change (Pawlik, 1991) due to their essentially extrinsic motives. Rather, we intend to tackle the human level, addressing phenomena like immediate gratification, human myopia, taking comfort in ignorance, belief in lack of individual influence, and desensitized negative outcomes. To promote



long-term behaviors that align with climate awareness using visual communication, we use the medium of the comic, which has broad appeal to capture even climate skeptic's attention without appearing to preach about climate change. We use data communication methods embedded in the comic to diffuse the difficulty of the topic and reduce the negative reaction to scientific content, using speculative data visualization to narrate possible realities designed to provoke thinking about consequences of individual actions and alignment of intrinsic motivations with social goals for positive climate action.

## Background

### Design fiction as climate communication

Design fiction is a strategy for narrating potential futures by varying a particular premise (Blythe 2017), considering potential futures within social and cultural narratives (Bleecker 2009). Design fiction can provide a narrative strategy for social influence by showing the effects of alternative visions (Moezzi, Janda, and Rotmann 2017). Evidence suggests that narratives can strengthen the attitude-behavior relationship (Rhodes, Toole, and Arpan 2016), so reading climate fiction may help activate pro-environmental behavior in individuals who already have strong pro-environmental attitudes. Moser (2016) showed that climate fiction leads to greater public comprehension of negative consequences caused by climate changes compared with reading about research. However, unlike Moser, Jones (2014) pointed that there is no strong evidence to show climate storytelling is more persuasive than communicating evidences in real life. They do not account, however, for fiction purposely designed for *positive* persuasion for actions that can contribute to positive climate action as opposed to seeing negative effects of climate change.

### Comics and visualisation in climate communication

In scientific communication, illustrations play significant roles as visual explanations (Schreiner 1997) that reflect the structure of the concept presented (Farinella 2018). Such visual communication, reflected in the comic, has the potential to convey the complexity of reality despite being accessible to the public (Darnhofer 2018). Comics can engage wider audiences with its visual and character-driven approaches (Farinella 2018). Moreover they support contextual storytelling based on aspect transitions that convey mood and sense of place, allowing for implicit influence through environmental design as opposed to explicit forms of narrative influence (McCloud 1994). Influence through contextual and graphical means avoids the explicit argumentation that doom climate change discussions to failure.

### Speculative data visualization and data comics

Researchers in diverse fields have become interested in how to create data visualization and affect viewers' attitudes (Sheppard 2005; Kim and DiSalvo 2010; Ballantyne 2018). Speculative visualization has the potential to combine data visualization and graphic design to show data in a meaningful and intelligible way while being accessible to the general public (Kim and DiSalvo 2010). Since viewers may reimagine thought-provoking questions through visual examination, the data we present becomes "stories" used to influence public awareness (Kim and DiSalvo 2010). Therefore, combining the influences of design fiction and data visualization may create more effective climate change communication in a narratively persuasive form.

To effectively achieve data visualization and engage viewers in decoding messages and making informed decisions beyond the limitations of complexity of data and visualizations, more recent attention has focused on the novel genre of data comics (Bach et al. 2018). It utilizes the narrative concepts and visual information of traditional comics to express data-related insights through

visualizations designed to communicate complex, usually scientific ideas (Wang, Dingwall, and Bach 2019; Bach et al. 2018). We develop the use of data comics to express the narrative aspects of identifying with climate action, transferring traditional patterns of infographics presentation to narrative forms for particular social purposes.

## Narrative Design

### Story and headline writing

We begin by specifying particular design purposes for climate change action. These are not physical resource arguments like overconsumption or resource destruction, but rather human phenomena that we believe are the central cause of the climate catastrophe. These include immediate gratification, myopia, the idea that an individual's effect doesn't matter, comfort in ignorance, etc. Since this research aims to reach general audiences and audiences who may be climate change skeptics, climate issues are not directly mentioned in the stories. The work may be read covertly as simple a comic rather than a form of climate fiction. The titles of the stories also reflect subtle cues such as *Redemption Park*, *New Revolia*, and *Every Flash of Light Is the Sun of Another World*, all of which evoke themes of rebirth, community responsibility, and learning from an experience.

### Comic design

We designed five stories to address different human phenomena propagating climate change. For example, one story is *Sonia McDougal*, based on the story structure of "Rebirth" (Booker, 2004) and designed to dispel the idea of maximizing immediate gains over future considerations. It tells the story of a shoe business entrepreneur named Sonia who must make a decision about her company, whether to invest in long term research and development, or to push the product widely to the general public. In her personal life she takes the approach of immediate needs and gratification, as opposed to settling down. Then after choosing to maximize profit in her professional

life, the business fails, teaching Sonia an important lesson in the "Rebirth" theme. She realizes she should consider a long-term plan and decides to take action in her personal life, to finally settle down with her boyfriend. The illustration uses a science fiction comic book style which is more to show the story theme: the yet-to-be-produced shoe which works in any weather and can predict the rain using electronics. The science fiction look subtly points out a future-directed theme in comic design, which is espousing future-directed over immediate-directed lifestyles.

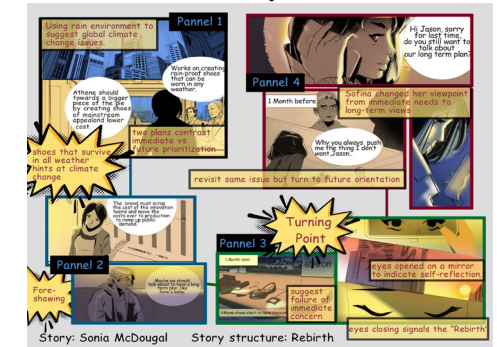


Fig 1. Persuasion through visual design in Sonia McDougal.

Other subtle cues abound in the visual comic. For example, to show the research and development that involves experimental shoes that survive in all weather, we designed a rain motif found in several scenes in the story. To show the the turning point in Sonia's life after the business failure, we showed eyes opened on a mirror to indicate self-reflection, then the shoe business building in a diagonal position to indicate failing, followed by eyes closing, which signals the "Rebirth" structure that also hope to change the audience's own viewpoint from immediate needs to long-term views. These moments establish the change undergone by the character using aspect transitions as a way to apply environmental storytelling to the work (McCloud 1994). The "Rebirth" theme is emphasized in the recurrent scene structures during Sonia's two encounters with her boyfriend.



Fig 2. Contextual storytelling by visual design in New Revolia.

### Data visualization in comic

According to Bach et al. (Bach et al. 2017), there are four significant elements in data comics: visualization, flow, narration, words and pictures. In Sonia McDougal, one panel with a graph was added to show the increase in randomness of day-to-day rainfall, which is used to support the idea of research and development for future gains of the company in order to create smart rain-proof shoes (Fig 4). To keep the balance between data and context in our work while pushing forward the narrative (Bach et al. 2018), a distribution map on typhoon incidence in current and future times was given in the storytelling line. Note that these are not real data, but rather attempts to tell the story of future situations using data as narrative. Hence the speculative data story approach develops a hypothetical view of the world that then allows the reader to extrapolate about the consequences of following the direction of the main character in prioritizing current over future considerations.



Fig 3. Using data visualization to describe future scenarios in the context of the narrative in Sonia McDougal.

Since comics have the advantage of splitting complex processes into less complex sections for easy understanding (Bach et al. 2018), it allows viewers to follow complex relationships and scientific ideas. Two panels in New Revolia are examples. First, a graphic map implicitly explains the main reason for the shipwreck - the melt of glaciers caused by global warming. In the following turning point, a heated discussion about the social values among two groups of characters (scientists and bunnies man) occurred and one scientist put forward a reasonable solution to distribute food equally. Then, the food distribution plan is visualized using graphics that not only indicate the idea of the plan, but also uses the form of the data graph in showing people and their carbon footprint to narrate the idea of sharing of responsibility in the context of the story.

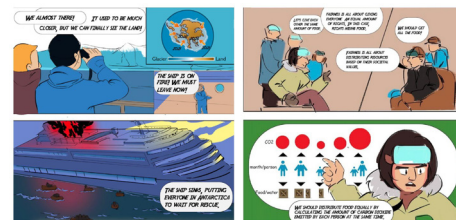


Fig 4. Using data visualization in New Revolia to describe strategies for sharing carbon emission responsibilities.

### Magazine layout

Since this design object intends to have subtle influence on climate change skeptics, it is presented as a magazine-formatted tabloid, to design for the idea that climate change skeptics tend to read sensational newsmagazines. The comic is printed on A4 size (210mm×297mm)

newsprint and full-page layout, including 12 pages and 5 stories (*Sonia McDougal*, *Redemption Park*, *VO*, *Every Flash of Light Is the Sun of Another World*, *New Revolia*). All the fronts of text and elements follow comic-drawing style. In order to help readers easily understand the content and panels, the designers set the layout according to the "Z-path", from left to right and downward, which is preferred by new comic readers (Cohn 2013). Since the different visual emphases to page layout and panel composition have the potential to improve the dramatic effects of a story or plot, the character panels in every story are zoomed out and emphasized to help the development of storytelling.

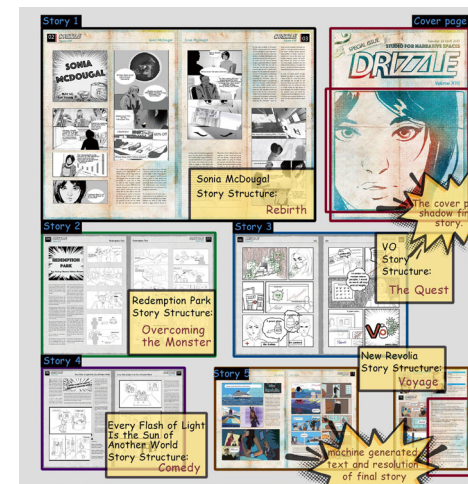


Fig 5. Layout of Drizzle and design purpose for each story.

### Methods

Inspired by climate communication based on narrative and data visualization strategies, we aimed to investigate how people interpret two climate comics designed to influence interpretation leading to alignment with pro-climate action:

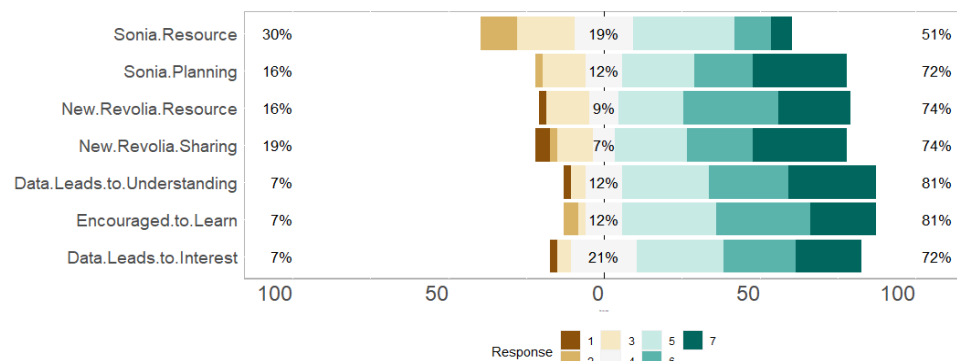
**RQ1:** Does speculative data comics have potential to improve the audience's climate change awareness and lead to climate friendly actions? If so, how does this process occur at the level of particular story and data designs?

**RQ2:** What can we learn from the way people interpret data comics designed to influence pro-climate action, in order to create effective climate action communication?

Online surveys are conducted to evaluate the influences and effectiveness of these comics. The questionnaire was divided into 5 sections: demographic Information, reactions to Sonia McDougal and New Revolia, the purposes of comics, self report of climate attitudes, and a donation game. First, we collected demographic information of participants (including age groups, gender and educational background) to be sure we get a range of different backgrounds. After that, participants were asked to read the two comics and answer several questions related to their understanding and feelings about story plots, story structures, painting styles, layout, characters, data visuals and environment graphics. Here, we ask people to interpret the comics purely on what the stories they tell and the data it visualizes, without mentioning the climate action purpose of comics. In section 3, we evaluate the effectiveness of the comics and how readers interpret them in context of climate change. Then, based on a relevant survey measuring positive environmental change awareness and intentions (Christensen and Knezek 2015), we created a self-efficacy scale about climate change attitude to measure how pro-climate each reader is. Finally, we tested participants' climate action via a question about donation: "Suppose that you receive \$20 as salary after completing this questionnaire, and you can choose to donate this money to a climate protection organization. How much would you like to donate out of the \$20?"

The questionnaire was made and distributed in the Google survey form. Participants were recruited and paid through an online research participants recruitment platform - Prolific (n=43, 15 male, 27 female, 1 non-binary). We used R 4.0.3 and RStudio 1.3 to process, analyze, and plot the data. The participants' short responses to questions about interpretation of particular aspects of the story were then qualitatively coded and analyzed.





**Fig 6.** Quantitative data from survey (To see text of survey questions used: [sites.google.com/view/dacadrizzle](https://sites.google.com/view/dacadrizzle)).

## Findings and discussion

### Quantitative results

In general, participants reported being quite positive about the way the design of stories and data visuals contributed to learning about climate change. Moreover in the Sonia McDougal story, there's a significant difference between the way people perceived the climate change purpose as opposed to the edification over physical resource level (Wilcoxon,  $p=0.00306$ ), indicating that the story design led readers to consider the idea of future-directed thinking (the core theme of the story) more than the physical aspects of climate change.

However this positivity about climate change can be due to the self-reported support of climate change, for the climate change attitude scale revealed a general agreement of over 80% above 4 (1-7 scale) in every question in the survey, e.g. "How strongly do you believe the facts and data of climate change?," "How strongly do you agree climate change will impact future generations?," etc. (Christensen and Knezek 2015) This indicates that readers already report highly on pro-climate attitudes, and hence the story may not be tested against a population that are climate change skeptics.

We also do not see a significant correlation between the median pro-climate rating in the attitude survey with the donation amount ( $R=0.245$ , linear least squares), meaning that

the donation assay was not useful for establishing whether participants were pro-climate action.

### Qualitative feedback

**Reactions to data comics:** When asking about the story based questions (including individual reactions to specific story plots, graphs, the decisions of characters, future development of stories etc.), participants obtained a better understanding based on data visualization (including visual symbols, colours, shapes and sizes). In Particular, they mentioned the benefits of data visualization for adding credibility and acceptability to narrations in comics.

*"The smaller you are, the less you give and should take."* -P3

*"The graph is simple, but it adds credibility to the comic."* - P14

*"Food given based on how much each person will contribute to CO2 emission, so they are trying to minimise emission."* - P17

*"Easy to understand. The shapes of the circles are in different sizes depending on the person, and that's the amount of resources they should get in "box quantities."* - P18

*"The first graph supports Sonia's statement that weather has been unpredictable, but also shows a level increase in the amount of rainfall. The second image shows how the weather*

*patterns shown in the first image have developed into storms."* - P44

However, some participants may reconsider the rationality of stories based on the accuracy of data shown in comics. Thus, designers should be more cautious in selecting and presenting reliable and scientific data in the storytelling context if they are used to persuading traditional argument strategies. For instance, several responses queried the fairness of the distribution plan shown in the graph based on personal understanding and reflection.

*"The figures don't involve any specific gender."* - P36

*"They use pseudo science environmental charts."* -P33

*"Not very scientific."* -P44

This underscores the lack of understanding about speculative story design. Readers may be assuming graphs to tell truths even when they give hypothetical scenarios the extrapolates based on current climate change understanding.

### Personal perceptions about climate action purpose:

Responses from participants who already have good climate awareness suggested that data comics is a more engaging and provoking form for viewers. (P44: *"I am already well informed on the subject but it definitely engaged my interest and I found it very thought provoking."*) However, several participants mentioned that data may become exaggerated and fictitious during the process of visualization. (P6: *"The data in the comics is more fictional than the scientific data."*; P8: *"The comic maybe present some exaggeration due to impact in the viewer, and also add some color and shapes."*) Although participants may feel confused about the accuracy of data in comics and fictional stories, they still preferred data comics as a creative climate change communication. (P14: *"The data from the comic is very generalized and imprecise, but it is expressive and attracts the reader's attention."*)

**Limitations of data comics:** Based on the analysis of participants' willingness to adopt pro-climate change actions, a limitation of data comics was the length of stories. Participants emphasized the significance of the length of story lines which can make audiences immersive in the story's environment.

*"The comics were too short to provoke a catarsis."* -P16

*"...longer story lines to take one on a journey."* -P10

On the other hand, participants also pointed out that they realized the urgency of climate change not only from reading these climate action comics. (P36: *"Not from the comic alone."*) To further support the effectiveness of data visualization in climate comics, designers should think more about the connections between narrations and specific situations in reality which may enable users to take pro-climate change behaviors. (P14: *"It is important to show specific situations with which the reader can identify and imagine himself in the future."*)

### Conclusions

In this research we explored how speculative data comics can be designed to enable climate change awareness and nudge audiences to take pro-environment behaviors in a visually appealing and intelligible way. We designed and distributed *Drizzle*, a comic magazine that has the covert purpose of climate action without advertising itself as about climate change. We then evaluated the way the comic stories can narratively persuade readers in regards to climate action. Quantitative data showed that participants were more likely to focus on the theme of future-thinking in a story as opposed to physical issues like resource limitations. Although several participants felt confused about the rationality and accuracy of data comics and fictional stories, the majority of them still reported positive influences in climate awareness and alignment with positive climate action goals. However, the majority of our participants reported having a

pro-environment perspective. This suggests that to better evaluate our design, we should look for groups more antagonistic to climate action to better evaluate the implicit effects of narratives and speculative data on climate change attitudes.

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# Artworks

## Extreme Weather in Three Movements

**András Blazsek**

andrasblazsek@gmail.com

### Abstract

This presentation is proposed as a concert in three movements titled *Global Solar Radiation – Severe Typhoon Mangkhut – Estimated Maximum Surface Wind*. The movements have been designed for the traditional concert hall or auditorium with the idea that the audience will listen to all three for the entirety of their duration. The composition combines data sonification and field recordings to perform different permutations of the same event—tropical cyclone Mangkhut (Hong Kong, 2018)—with the aim of giving listeners access to its multiple timescales and spatial dimensions. It asks them to return to this one incident of extreme weather to both reflect on the broader timeline of which it was a part and resist the desensitising flow of information about such events.

### Extreme Weather in Three Movements

The term *Global Solar Radiation* is used to refer to an index of each calendar day's solar radiation level. The data sonified in this first movement of the concert is the index from September to December 2018. The lowest tone on the scale can be heard on the 16<sup>th</sup> day of September when tropical cyclone Mangkhut hit the Guangdong region from the South China Sea. The radiation level in Hong Kong on that day was very low because the storm created a shield over the city. For compositional reasons, the same low tone returns at the end of the movement, and is repeated for six cycles.

*Severe Typhoon Mangkhut* is composed from a combination of sonified meteorological data and a field recording captured on the 16<sup>th</sup> day of September 2018, when Mangkhut hit Hong Kong. The field recording was made in a flat on Ap Lei

Chau, an island just south of Hong Kong Island, connected to South Island by a bridge and the MTR. The recording was made inside an empty room on the 6<sup>th</sup> floor of a podium-tower building and was processed through a cleaning software, then edited together with sonification of meteorological data from the same day. It is an approximately 20 minute-long section of the sonic event that the typhoon created when it hit the city.

*Estimated maximum surface wind* sonifies the numerical values of the estimated surface wind speed between the dates of 7<sup>th</sup> to the 17<sup>th</sup> of September during which Mangkhut hit Hong Kong. Samples were taken every 6 hours and the value has been set as meter per second. The increase of wind speed can be clearly heard through the sonification which makes the meteorological event present by transforming it into a very short sonic event. This movement changes the tempo and scale of the previous long, drawn movement, *Severe Typhoon Mangkhut*.

The musical composition is assembled from three sonic events so that the listener experiences typhoon Mangkhut in different scales of temporality. In the first movement, Mangkhut is part of a larger timeline, part of a sequence of events—social unrest, tropical cyclone, coronavirus—that happened in Hong Kong between 2018 and 2020. The second movement gives insight into how time and sound was perceived on the day of the typhoon, immersing the listener in the actual soundscape of the event. The last movement tries to capture Mangkhut at yet another scale—a matter of days—and shows how the wind speed increased and decreased after the typhoon left the territory.

In 2020, COVID-19 was declared a global pandemic; simultaneously, new technical terms became part of everyday language: first wave, second wave, “flattening the curve,” all of which relate to prevention methods for decreasing the number of virus cases in certain contexts. As the result of the new conditions established by the pandemic and by our awareness of climate change—through, for example, the report of the Intergovernmental Panel on Climate Change (IPCC)—interaction between data and humans also grows in scale. For example, according to the IPCC, the global surface temperature increase of 0.8 to 1.3 Celsius from 2010-2019 will likely increase further over the next decade. This measurement can be seen and read as a visualisation in the report of the United Nations (IPCC AR6 WGI, 2021). One of the major roles of this report is to visualise data to argue that human activities will further contribute to the change of the climate and to enforce preventive measures to stop it. In his analysis of what he calls “hyperobjects”, Timothy Morton suggests that change of our climate is not something we can sense at an everyday level—at least not now—rather, it expands in space and time and can only be experienced as parts or fragments: as heatwaves; as increased number of rains and floods; or as scientific visualizations of data.

Jussi Parikka further describes this fragmentation and argues that our contemporary condition is constructed from very slow and very short temporalities which have been the result of our technological culture, anthropocentrism and exploitation of the planet. We are in a “shift from the focus on technologies to the wider environmental and other rhythms that permutate our technological culture” (Parikka, 2016). His idea of *temporal conglomerations*, which informs both long term processes through contemporary geopolitics and permutations of events like shock waves, may now also be found in the waves of cases with the pandemic. The concert performs different permutations of the same event—Typhoon Mangkhut—in order to gain access to

multiple timescales of events, and uses sonification, or the auditory display of data, as one means to do so.

Studies about data sonification suggest that auditory display of data can enhance data analysis processes. Researchers argue that data analysis has largely been left to computers, therefore a human—a trained person or an expert—has no chance to make a second choice or overwrite certain assumptions that the computer makes about the gathered information. Large amounts of data cannot be easily accessed by a user but sonification can be one way that a researcher or control personality would be able to intervene and contribute to the analysis to get a better result (Hermann, 2011). Therefore, sonification is a growing field that can create a new perceptual condition. It will probably proliferate into workflows and may later become part of everyday life more than we ever imagined. The concert also reflects on the issues with this technological possibility.

The field recordings from the second movement, *Severe Typhoon Mangkhut*, were previously installed on audio monitors in the former synagogue of Samorin, the Slovak-Hungarian town where my family is from. This contested territory was claimed by various geopolitical entities over the course of the 20<sup>th</sup> century, passing from Austria-Hungary to Czechoslovakia, to Kingdom of Hungary back to Czechoslovakia, then most recently to the Slovak Republic. During World War II, the Jewish residents of the town were violently displaced, some perishing from the Holocaust, some returning, but most never re-establishing residence there. Installed in the stairwell that leads visitors from a side entrance to the synagogue’s women’s balcony, the field recordings from Hong Kong took on new meaning in this context, conjuring the traumas of the past and projecting those of the future in the apathy of the present.



Fig 1. *Severe Typhoon Mangkhut*, 2018, Andras Blazsek, digital image,

## Biography

András Blazsek (Hungary/Slovak Republic, 1984) is a research-based mixed-media artist who works in sound, sculpture, installation and media archaeology focusing on visualization, sonification and modes of translating sound into architectural environments. He is a founding member of the Hungarian-Slovak collective BA– Unrated, recently exhibited by the Ludwig Museum (Budapest) in collaboration with ZKM (Karlsruhe). His work has been presented by LACE (Los Angeles), Futura (Prague) and Residency Unlimited (New York) among others. He received the Baker-Tilly Award 2020 for his site-responsive installation at Kunst Im Tunnel (Dusseldorf). Since 2019, he has worked as a part-time lecturer at the School of Creative Media at the City University of Hong Kong and at the Academy of Visual Arts at Hong Kong Baptist University. He lives and works in Hong Kong.

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## Weblink

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- <https://www.dropbox.com/s/fweh9j13mja0ac0/Amigzaj-6-Track2-Mangkhut.wav?dl=0>
- <https://www.dropbox.com/s/m8pvj48fkmswayu/Amigzaj-6-Track3-Estimated-Surface-Wind.wav?dl=0>



## The echo from the Earth: The melting city

Yu Kwan Yukko Chan

myVoice, 95 Bedford Road, Kowloon, Hong Kong  
yukko@fntp.net

Pak Lun Fung

Institute for Atmospheric and Earth System Research (INAR),  
University of Helsinki, 00140 Helsinki, Finland  
pak.fung@helsinki.fi

### Abstract

One of the grand challenges our mother Earth is facing is global warming. If we do not cut down the emission of greenhouse gases (GHG), the global surface temperature and the global mean sea level rise are likely to increase by 5.5 °C and 2 m, respectively, by the end of this decade. Low-lying island nations are on the verge of being submerged if the situation continues. In order to bring this inconvenient truth into the spotlight, we propose to build the installation artwork “The echo from the Earth: The melting city” which mimics the consequences of global warming with different elements. By using the actual projection data, we visualize and sonify the alarming projection figures to the public. This could serve as a good example of connecting science, art and society.

### Background and Objectives

Global warming has been an increasingly alarming global challenge. According to IPCC (2021), the global surface temperature could experience a 5.5 °C rise by the end of this century based on a very high greenhouse gases (GHG) emissions scenario (SSP5-8.5). This temperature increase is likely attributed by the emission of greenhouse gases. Out of all GHG, carbon dioxide (CO<sub>2</sub>) has played an important role in this global warming problem. It is virtually certain that the land surface will continue to warm more than the ocean surface (likely 1.4 to 1.7 times more), and is also virtually certain that the Arctic will continue to warm more than the global surface temperature, with high confidence above two times the rate of global warming. Therefore, this makes the glaciers in the Arctic more prone to melting. Under the very high GHG emissions scenario (SSP5-8.5), the global mean sea level rise is

likely to be 2 m by 2100 and 5 m by 2150 relative to 1995-2014 due to continuing deep ocean warming and ice sheet melt.

IPCC (2021) also stresses that relative sea level rise is very likely in the oceans around small islands, and along with storm surges and waves will exacerbate coastal inundation in small islands and atolls. These small island nations, such as Caribbean and Pacific Oceans, are more vulnerable because of the extreme weather and climate variability. As sea levels continue to rise, people and cultures on the islands are being threatened. These nations may not be a big contributor to GHG emissions, yet they are on the verge of being submerged for some other countries that emit more GHG by capita.

One of the objectives of the proposed artwork is to raise the awareness of global warming and one of its consequences: sea level rise. We narrow down to the focus on the nations that are under immediate climate danger. We also hope to inspire the audience to rethink their way of living and listen to the echo from the Earth.

### Creative Concept

The installation art named “The echo from the Earth: The melting city” consists of three parts: the isolated top, the middle box and the bottom stand (Figure 1).

This top part is called “melting city” which is made of wood and plastic for the upper platform and the lower melting part, respectively. This part is attached from the ceiling in the exhibition venue and is isolated from the rest of the installation. The dimension is 1.5 m x 1.5 m x 1.7 m (H). This resembles the extreme heat that we are suffering in different parts of the world, and at the same time, it also resembles the melting of the Arctic icebergs.

The middle part “submerged island” (dimension: 1.5 m X 1.5 m x 1.1 m (H)) is the consequence of the melting city in the previous part. It is constituted by the form of seawater that is made of resin surrounded by four acrylic plates. The seawater is transformed from the melting city submerging some low-lying islands. The acrylic box has a symbolic meaning of the greenhouse. This gives a hint to the audience that the increasing emission of greenhouse gases is one of the root reasons for sea-level rise and consequently the submerged island.

The bottom part is a wooden box of a height of 1.2m with an opening of diameter of 20cm at the top. This hole allows rays to travel upwards through the “submerged island” and in the end to the “melting city”. Inside the wooden box is the multimedia centre that situates a projector and a loudspeaker connected with a laptop. From here, the installation could engage the audience with visual and audio impacts.

We project bright and shiny waves forming a spectacular image through the different media in the installation. This dynamic pattern resembles the advanced technology that brings human convenience, but in the meanwhile, it could destroy the mother Earth in some other ways.

In terms of audio impact, we mimic the echo from the Earth by a piece of audio clip with varying frequencies and rhythms, which are based on the projection of increasing CO<sub>2</sub> emission and temperature rise under the very high GHG emissions scenario. This audio stimulates an uncomfortable situation that global warming brings to people. In this way, we bridge the gap between science and art.

### Resources Requirement

Dimension: (tentative) 1.5 m x 1.5 m x 4 m (H)  
Material: Resin, plastic, acrylic, wood  
Equipment: a computer, a loudspeaker, a projector with extension cables  
Setup time: 3 hours  
Preferred location: Multimedia Theatre, SCM, Hong Kong

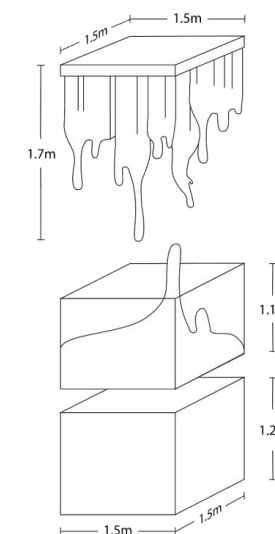


Fig 1. *The echo from the Earth: The melting city*, 2021, Yu Kwan Yukko Chan and Pak Lung Fung, Mixed media: plastic, wood, resin, acrylic and multimedia.

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### Weblink

<https://youtu.be/SwQDEbSK3co>

### Author(s) Biography(ies)

Yu Kwan Yukko Chan has been the artistic director of myVoice since 2013. She is a theatre/film creator. Her artistic interests include directing, writing, acting and installation arts. She believes art connects people and art can voice out for the community.

Pak Lun Fung is currently pursuing a Ph.D. degree with the topic on the derivation of air quality parameters proxy in urban regions. His research interests include machine learning, remote sensing, sustainability and science communication. He has a strong motivation to bridge his science interests with artworks.

## *Inflow*

**Frank Ekeberg**

Artist / Music Composer

[mail@frankekeberg.no](mailto:mail@frankekeberg.no)

### Abstract

This is a proposal for performance of the electroacoustic music composition *Inflow*. The work is composed in 3<sup>rd</sup> order ambisonics and intended for performance on a fully immersive multi-channel loudspeaker system. *Inflow* concerns global sea level rise and its consequences for weather, climate, land and society. The structural framework of the work is based on the Earth's hydrological cycle where water melts, evaporates, condenses and freezes. It has a duration of 14'24".

### Description of the work

*Inflow* takes as its starting point sound materials recorded above and below water, in liquid and solid form – sometimes recognizable, sometimes heavily processed – combined into a compositional structure that builds on the Earth's hydrological cycle where water melts, evaporates, condenses and freezes. In this cycle, water absorbs, stores and releases energy and distributes energy around the globe via air and ocean currents that lead to warmer and cooler regions and seasons. Even a minimal increase in temperature will disturb this cycle's fragile balance and affect the distribution of water to areas that will experience lushness, flooding, drought and desertification. This fragility is illustrated in the work by playing on the balance between stability and breakdown, accumulation and disintegration, transformation and permanence.

Spatialization and integration of spatial elements are important structural devices in the work, which is composed as a fully immersive, 3D sound environment.

### Technical requirements

The concert version of *Inflow* is a 16-channel sound file for periphonic 3<sup>rd</sup> order ambisonics decoding. The performance requires a uniform, full-range, multi-channel playback system capable of this format. Number of speakers for playback should be suitable for 3<sup>rd</sup> order ambisonics or higher (minimum 16 channels).

### Weblink

A stereo rendering of *Inflow* can be heard at <https://soundcloud.com/mail-128-1/inflow-stereo/s-fUy2v9pT9ZZ>. Multi-channel ambisonics files are available upon request.

### Author Biography

Frank Ekeberg is a transdisciplinary artist, music composer and researcher working in the intersection of art, science and technology. His work explores issues of ecology, time, spatiality and transformation, with a particular focus on nature spaces, ecosystems and the interplay between human and non-human worlds. His research-based approach often involves collaborations within as well as beyond the art field. Ekeberg has composed and designed sound for concert performance, dance, film, theater, radio plays and intermedia installations, and his work is widely presented in festivals, exhibitions, concerts and conferences around the world. He was awarded the 2017 Smithsonian Artist Research Fellowship, and is currently Research Associate at the Smithsonian National Museum of Natural History in Washington D.C., USA. Most of the time he lives and works in Trondheim, Norway.

## Ingenmannsland, a sound installation

**Frank Ekeberg**

Artist / Music Composer  
[mail@frankekeberg.no](mailto:mail@frankekeberg.no)

### Abstract

This is a proposal to exhibit the immersive sound installation “Ingenmannsland” (No Man's Land / Niemannsland). The installation deals with deforestation, habitat destruction and species extinction, with a particular focus on the boreal rainforests of Norway. It is a generative work where the sound elements undergo real-time transformations to reflect historical and projected data on deforestation and extinction rates.

### Description of the work

In his 1924 poem “Stå vakt om naturen” (Keep Guard over Nature), Norwegian poet and environmentalist Theodor Caspari (1853-1948) calls for “a shining ‘No-man's-land’” where “the creator is quiet” and natural forces roam. He warned against the threat posed to mountains, waters and forests and their inhabitants by “ill culture” and “fumes and roar of machines” (Caspari, 1945). A *no-man's-land* refers both to land undisturbed by human activities as well as to areas of conflict. The ambiguity of the expression reflects the discrepancy between the Norwegian myth of nature as plentiful, unbreakable and accessible, while at the same time it is subjected to fast-paced, destructive extraction and exploitation.

*Ingenmannsland* takes as a starting point the rainforest that once lined much of the western coast of Norway. Today only scattered fragments remain of this biome, and it is now on the red-list of endangered habitat types. 80 percent of the coastal rainforest has been lost only in the past 100 years, and it is predicted to disappear entirely within the next five decades (WWF, 2020a). Despite numerous warnings of species decline, loss of biodiversity and the

importance, especially of old-growth forests, for carbon capture and storage, only 3.8 percent of Norwegian forests are currently protected (WWF, 2020b).

The sound material in *Ingenmannsland* is recorded in some of the remaining rainforest, where each audio component is extracted to be processed individually. There are obvious field recordings of forest as we hear it, but also sounds captured inside trees, underwater in swamps, and of birds and insects in flocks and swarms as well as in isolation.

*Ingenmannsland* starts out as a realistic soundscape – wind in the trees, birds and insects flying about, perhaps some rain and dripping water. Over time the sounds of flying wildlife gradually diminish, and many go extinct. When a tipping point is reached, sounds start to re-appear, but these are different – more static and artificial, as if we are entering another reality. It becomes a speculative environment based on projected future scenarios, and asks questions such as: What happens when forests disappear or dry out? Can our natural environment be replenished? Will it be replaced by artificial life? What is the function of biomimicry?

### Technical requirements

*Ingenmannsland* is an immersive installation where sound is spatialized with the ambisonics and VBAP techniques, and requires a uniform multi-channel loudspeaker system. The number and configuration of loudspeakers must be adapted to the size and shape of the exhibition space. As a minimum, eight loudspeakers are required – four on floor level, four on ceiling level. Larger spaces require more loudspeakers to ensure full and even coverage of the listening space. The work should preferably be

installed near large windows with view of the outdoors.

Equipment needed:

- loudspeakers with suitable mounts (number depending on size of space)
- amplifiers (unless active loudspeakers)
- cables between amplifiers and loudspeakers

Artist provides:

- Raspberry Pi computer
- audio interface / DAC
- cables from DAC to amplifiers



Fig 1. *Ingenmannsland*, 2019, Frank Ekeberg, sound installation. From the exhibition *House of Norway* (2019) at Museum Angewandte Kunst, Frankfurt am Main, Germany. Photo: Frank Ekeberg

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- WWF (2020b). *Den fantastiske skogen*. <https://www.wwf.no/dyr-og-natur/skog-og-regnskog/skog>

### Weblink

Additional images and sound examples can be found at:

[https://www.frankekeberg.no/ingenmannsland\\_en](https://www.frankekeberg.no/ingenmannsland_en)



Fig 2. *Ingenmannsland*, 2019, Frank Ekeberg, sound installation. From the exhibition *The White, the Green and the Dark: Contemporary Positions from Norway* (2020) at Felleshus, Berlin, Germany. Photo: Sabine Schirdewahn

### Author Biography

Frank Ekeberg is a transdisciplinary artist, music composer and researcher working in the intersection of art, science and technology. His work explores issues of ecology, time, spatiality and transformation, with a particular focus on nature spaces, ecosystems and the interplay between human and non-human worlds. His research-based approach often involves collaborations within as well as beyond the art field. Ekeberg has composed and designed sound for concert performance, dance, film, theater, radio plays and intermedia installations, and his work is widely presented in festivals, exhibitions, concerts and conferences around the world. He was awarded the 2017 Smithsonian Artist Research Fellowship, and is currently Research Associate at the Smithsonian National Museum of Natural History in Washington D.C., USA. Most of the time he lives and works in Trondheim, Norway.



## Without strings

Hongshuo Fan

NOVARS research centre, The University of Manchester  
hongshuo.fan@manchester.ac.uk

### Abstract

“Without strings”, is a real-time environmental data interactive audio-visual installation. It was inspired by the traditional Chinese ink painting and the Guqin performance. It emphasizes the “hidden” and “blank” in ink painting and the “Improvisation by feeling surrounding” in the Guqin performance. The visual part is a virtual tree that grew by absorbing environmental data, and the sound part utilises a physical modelling Guqin synthesizer driven by a pre-trained AI model. The combination of visual and sound creates an artistic reflection of how the machine senses the world, also a natural and immersive experience for the audience.

### Installation structure

Without strings is realised through real-time audio-visual fusion and designed to complete an entire growth cycle in 24 hours. The sound part is composed of two layers. Firstly, as the source material of the sound part, the Guqin sound is produced from the physical modelling synthesiser[1], driven by the pre-trained model generated music information and affected by the environmental data changes in real-time. The neural network model is LSTM based recurrent neural network[2] trained with the traditional Guqin dataset[3]. Secondly, the transformed sound layer is produced by combining several digital sound process modules’ that apply the transforms to the sound source.

The visualisation part can be divided into three layers. Firstly, The near scenery layer placed the main object tree that implements L-systems[4] in TouchDesigner[5]. Secondly, the far scenery layer is the main music visualisation part which the system collects the spectrum data of the output audio, then maps to the 3D

geometry grid’s height data to produce a mountain silhouette-like shape. Lastly, to establish a dynamic connection between the far and near scenery layers, a connection layer representing the “water” is placed in the mid of the virtual space. The connection layer is a dynamic texture of a rippled image generated with the incoming environment data.

### Technical specification

“Without strings” is a wall installation that can be presented on a single wall but needs a quiet room for the immersive experience. The Sensor part could wireless connect to the Raspberry pi via Bluetooth; Raspberry pi could connect to the computer (central system) via Wi-Fi or ethernet cable. The Sensor should be placed somewhere to have free aeration with outdoor air to obtain real-time environmental data. The computer and audio interface can be hidden anywhere safe.



Fig 1. *Without strings*, 2020, Hongshuo Fan, Audio-visual installation, Copyright (c) 2020 Hongshuo Fan.

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### Weblink

Demo link:

<https://drive.google.com/file/d/1Pab3LW32NI9XJE0uAw1GHuyJaqnCsWuv/view?usp=sharing>

### Author Biography

Hongshuo Fan is a Chinese cross-disciplinary composer, new media artist and researcher. His work has involved various real-time interactive multimedia contents, such as acoustic instruments, live electronics, generative visuals, light and body movements. His research and creative interest focus on the fusion of traditional culture and cutting-edge technology in the form of contemporary art. His output spans live interactive electronics, installations, and audio-visual works. Hongshuo is currently a PhD candidate at NOVARS Research Centre (The University of Manchester), also the teaching assistant for the interactive Media Technologies course and postgraduate technical leader on the MANTIS System (a 56-speaker cluster).

## A MULTIMEDIA REPRESENTATION OF THE INCREASE OF GLOBAL WARMING FROM 1940 TO 2016

Enrico Dorigatti

www.enricodorigatti.com

enrico@enricodorigatti.com

### Abstract

76 is an audiovisual work that, based on actual environmental data, proposes a multimedia artistic representation of the increase of the Earth temperature over the last seven decades. After a general overview of the piece and an explanation of the data themselves, brief definitions of the concepts of “climate change” and “audiovisualisation” will be proposed. Later on, the work will itself will be discussed.

### Introduction

76 is a multimedia fixed work composed of high-definition visuals and a stereo audio track. It is 3',56" long and it offers an artistic representation, both visive and auditive, of the rising Earth temperature. Based on actual scientific data, it takes into account the anomalies—positive or negative ones—registered by NOAA and published by NASA and comprising, at the time of writing this paper, the years from 1880 to 2016 [1]. From this series, the time interval considered for the realisation of the work ranges from 1940 to 2016. This choice is because except for some sporadic years—such as 1946-51, 1954-56, 1964-68 and some other few—the temperature has more often registered a positive anomaly, with 2016 that reached one of +0,9363 °C, being recorded as the hottest year to date and second only to 2020 [2].

Besides the artistic, data-driven visuals, which will be explained later on, 76 offers a clear visualisation of the data processed from time to time. Bottom and centred, there is a numeric representation of the value of the actual temperature from 1940 (+13,99 °C) to 2016 (+14,86 °C). This number is linearly interpolated from the data of the year

considered to the data of the following one. Therefore, its changing rate is proportional to the difference in °C occurring between the two years. Moreover, on the upper-left corner, the year taken into account is reported; each year has a duration, in the artwork, of 3".

Lastly, the name of the piece itself is derived from the interval of years considered, which is composed of 76 years.

### Climate change

Climate change is a convenient way to describe spectra of different phenomena caused mainly by anthropisation and humans' activities. The increasing of the global average temperature—besides being the core data of this work—is perhaps the most significant and observable phenomenon, with several direct consequences such as ice-melting, rising of sea levels and warming of waters. Moreover, there are also indirect ones, such as changes in the food chain and animals' biological cycles due to seasonal imbalances [3]. Alterations of Earth temperature are the result of a perturbation of the planet's energy balance; and once this system is perturbed, feedbacks arise, enhancing or suppressing the perturbation [4]. The consequence of this cycle is the generation of the aforementioned phenomena, on the top of which can be added sudden atmospherical events, such as the recent water storms and heatwaves which strained the European inland.

### Temperature anomaly

Accordingly to [5], it can be described as «how much warmer or colder than the long-term average [...] something is». Therefore, it reports how much the Earth temperature registered the

most recent year differs from the long-term average.

### Audiovisualisation

Audiovisualisation is a term that can be used to describe the «Simultaneous sonification and visualisation of the same data source [...]» [6]. The duplication of data over these two different media reinforces the listener-viewer's experience, which takes the shape of an augmented sonification. The relationship sounds-images has been deeply explored in the artistic context, and so is still being. It traces its origins back to the first half of the past century, with works-experiments such as *An Optical Poem* (Oskar Fischinger, 1938), and is nowadays explored by multimedia artists such as Ryoichi Kurokawa and many others. However, audiovisualisation has a practical meaning out of the artistic domain too, being employed in tools like spectroscopes and oscilloscopes.

In 76 both audio and video are related to the data. However, it is easier to identify this relationship in the images, rather than in sounds. Indeed, images have been designed to offer first of all a descriptive visual experience, and then an artistic one. On the contrary, audio was created with the primary purpose to express a concept artistically while describing a series of data in the background.

### The genesis of the artwork

As 76 is based upon a series of data, it is from their collection and adaption to the scope of the project that its realisation began. Subsequently, the video was the first of the two media created and, on top of that, audio was designed and added at a later stage.

### Video

The video is composed of three main parts: the main visuals, centred; the top-left corner label showing the year considered and the bottom, centred one showing the value of the linear interpolation between the year considered and the following one. While the sole purpose of the latter is to show in a clear way the data processed, the former is itself related to the concept of audiovisualisation, as it changes the

colour of its background as the temperature increases. Starting from a white glow, it reaches an intense read one.

However, the most important part of the artwork is the globe placed in the centre. It is an artistic representation of the Earth realised—by layering one on the top of the other—different particle systems. As the different years are processed, their recorded temperature and anomaly determine the size of the portion of the model that has to be greyed, glitched and distorted, representing the amount of alteration of the climate equilibrium. As for the label reporting the temperature, the greyed area is linearly interpolated between the year taken into account and the following one. Therefore, it is ever-changing.

The size of the greyed area reaches its minimum in 1956, with a temperature of +13,70 °C—yet it still has a slight impact on the Earth model—, and suddenly ramps up, with the following two years almost touching +14 °C. During the last years of the series, all the Earth goes covered, as the temperature is far above +14 °C. Following this reasoning, it is self-explanatory why the visuals start with the Earth obscured for almost a quarter, as the first year considered, 1940, registered a +13,99 °C.

### Audio

Audio offers an artistic representation of the dramatic process of global heating while following the evolution of the visuals. It was designed by using as sources three important speeches related to climate and its protection. One is of Barack Obama [7], and one is of Leonardo DiCaprio [8], both recorded at the 2014 Climate Summit. Moreover, there is also a sharp and courageous speech held by young Swedish activist Greta Thunberg at the Austrian World Summit 2021 [9]. These materials have been manipulated to represent the current situation where, although many people are fighting for climate justice, the overall, global response to this emergency is often fragmented, weak or ineffective. Furthermore, these speeches have been altered using audio effects, by mapping different parameters to the temperature data. For

example, this is why Obama's speech slowly morphs into a monophonic bassline as temperature increases.

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## Weblink

<https://drive.google.com/file/d/1KT9jKAnnQ39m9yCJcqKRSbn7SQ3IS2V8/view?usp=sharing>

## Author Biography

Enrico Dorigatti is a sound designer and sound artist based in Italy. He has a strong interest in multimedia, music, technology and the contact points between them. After a diploma as an IT specialized technician, he obtained a Bachelor's Degree and a Master's Degree in electronic music. During his studies, he attended many masterclasses held by, among the others, Daniel Teruggi, James O'Callaghan, Alvise Vidolin, David Pirrò, Antonio Camurri, Barry Truax. He is the developer of URALi, a software library designed to provide easy to access and easy to use audio synthesis and manipulation functionalities to Unity programmers. This ongoing project was presented at the XVI SMC conference, as part of the scientific program. URALi is at the ground of several artistic works such as *Life*, an auto-generative multimedia software performed, among other occasions, at the XXII CIM and the Biennale d'Arte Contemporanea di Salerno 2018. Other of his works have been selected and performed nationally and internationally in festivals and conferences. From late 2019, as a sound artist and sound designer, he has been part of Movimento Creative Label, an Italian creative collective. In 2021 he has been resident artist for Art Stays (SLO).

# The Natural Lottery: turning climate data into techno music

Duncan Geere & Miriam Quick

Loud Numbers  
numbersloud@gmail.com

## Abstract

### Introduction

The climate crisis is the most urgent problem currently faced by humankind. But its incremental nature makes communicating that urgency a challenge. We believe that data sonification can help.

Data sonification is the art of turning data into sound or music. One of the earliest and most successful examples is the Geiger Counter, invented in 1908 to measure radioactivity. But today sonification is all around us - from the "beep" of the heart monitor in a hospital, to the "ping" you hear when your smartphone receives a message.

Sonification is particularly effective at communicating seemingly abstract or distant concepts with emotional impact. For example, in 2014, Tactical Technology Collective sonified data on apartment building collapses in Egypt<sup>1</sup>, creating a compelling, visceral sound experience out of relatively dry statistics.

We wanted to see if we could replicate the effect with climate data.

### The Natural Lottery

*The Natural Lottery* is a unique musical composition created from data about the impact of climate change. It was originally published as the first episode of the Loud Numbers podcast<sup>2</sup> in June 2021.

We chose to use techno as the genre to work in because it's all about cycles and endless flow. *The Natural Lottery* shows what happens when natural cycles are disturbed by human activity, tipping the balance out of alignment.

With *The Natural Lottery*, we aimed to create a greater sense of urgency around the climate crisis by simultaneously reaching people on an emotional and an informational level.

The unconventional framing of the Nenana sweepstake story and techno music grabs the listener's attention, while the rising chords and siren communicate panic and urgency.

We believe this leads to a deeper, more visceral experience than a traditional chart or graph might, which can help convince people of the importance of the climate crisis and the need for immediate action.

### Sound Mappings

The sonification combines data from multiple datasets. The primary dataset comes from the Nenana Ice Classic<sup>3</sup>, a sweepstake held annually in the town of Nenana, Alaska.

Residents place a tripod on the frozen Tanana river, and place bets on when the ice will melt, causing the tripod to fall over. The competition has been held annually since 1916, making its records<sup>4</sup> a valuable source of data for climatologists studying how the planet - and particularly the polar regions - are changing.



Fig 1. Tripod on the Tanana River in Nenana - part of the Ice Classic, 2008. Frank K. from Anchorage, Alaska, USA // CC BY 2.0.

In the sonification, we mapped the Nenana data to the pitch of chords. The higher the pitch of the chords in the track, the earlier the ice melted that year (using a 10-year moving average). These chords go up and down in pitch, but on the whole they get higher as the music progresses, showing the ice melting earlier and earlier as climate change in Nenana takes hold.

Two other data layers can be heard in the track. During the winter, the aurora borealis swirls through the skies of Alaska and its strength rises and falls in eleven-year sunspot cycles.

These are sonified as an ethereal shimmer in the background, based on real data from the Royal Observatory of Belgium<sup>5</sup> - the louder the sound, the more sunspots heard in a given month.

Then there's CO<sub>2</sub>. In the background of the track, faint at first and louder and louder over time, you'll hear a siren. The pitch of the siren represents carbon dioxide levels in the atmosphere, measured by the observatory at Mauna Loa in Hawaii<sup>6,7</sup>.

CO<sub>2</sub> levels rise and fall each year as forests grow and die back in the northern hemisphere, which has more land. That's why the pitch of the siren wobbles a little. But they also increase over time and rise to a worrying climax near the end of the track.

Finally, there are a whole lot of other musical elements that don't represent any data. They're just there to make the track sound good.

## Methods

To create the sonification, we used Google Sheets to process the data, Sonic Pi to turn it into music, and Logic Pro X to turn that music into a track.

The track was produced and mixed by Miriam Quick and Duncan Geere, and mastered by Queer Ear Mastering.

## Equipment

The music should ideally be presented in a space that is as close to a nightclub as possible, with a large-scale soundsystem, strobe lighting and a smoke machine. Lights could be synced up to match the temperature variations, using shades of blue and red like Ed Hawkins' Warming Stripes<sup>8</sup>.

Additionally, either the music or the entire podcast episode (18mins) could also be presented as a smaller-scale audio-only installation, either in a gallery and/or online.

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4. Nenana Book of Guesses.  
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<http://www.sidc.be/silso/datafiles>
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7. Monthly CO<sub>2</sub> data for 2015-2020 from the US National Oceanic and Atmospheric Administration (NOAA)  
[https://gml.noaa.gov/webdata/ccgg/trends/co2/co2\\_mm\\_gl.txt](https://gml.noaa.gov/webdata/ccgg/trends/co2/co2_mm_gl.txt)

8. Warming Stripes by Ed Hawkins.

<https://showyourstripes.info/>

## Weblink

▶ Episode 1: The Natural Lottery

<https://www.youtube.com/watch?v=qFN97g815sw> (music starts at 8m 09s)

## Author Biographies

Duncan Geere is an information designer based in Helsingborg, Sweden, interested in climate and the environment. He works to communicate complex, nuanced information to a wider audience for clients like Information is Beautiful, the Gates Foundation, Conservation International, and Project Drawdown. He currently works part-time for the climate charity Possible, and he's also a generative artist and musician.

Miriam Quick is a data journalist, researcher and author who explores novel ways of communicating data. She has written data stories for the BBC, worked as a researcher for Information is Beautiful and the New York Times and co-created artworks that represent data through images, sculpture and sound. Her first book, *I am a book. I am a portal to the universe.*, co-authored with Stefanie Posavec, was published in September 2020.



## The Weep of Trees

### Band of Weeds

<https://www.kallehamm.fi/band-of-weeds-2/>

<https://www.kallehamm.fi/the-weep-of-trees/>

### Band of Weeds

Olli Aarni, Lauri, Ainala, Kalle Hamm, Hermanni Keko +  
featuring plants

### Abstract

*The Weep of Trees* utilizes the monitoring data of the Hyytiälä Forestry Field Station on the stress reactions of living trees for felling the proximate trees. The emission of VOC particles in trees before and after thinning have been used in the work. Additionally, stress clicks on tree trunks, variations in sap flows and the jarring pecking of three-toed woodpecker are sonified and used in the artwork.

*The Weep of Trees* is part of the Climate Whirl Arts Program at INAR (Institute for Atmospheric and Earth System Research) at University of Helsinki and developed in collaboration with Hyytiälä Forestry Field Station.

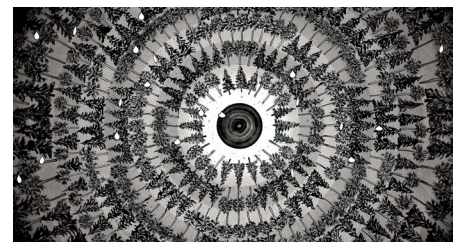
### The Weep of Trees

*The Weep of Trees* is based on the poem called *The Weep of a Birch Tree* in the *Kalevala*. The sage Väinämöinen listens to the birch's complaint about how people treat it badly. At the end of the poem, Väinämöinen fells the birch and makes a new kantele out of it for himself. The first one, made of pike's jaw, sank to the bottom of the sea while Väinämöinen was fighting against Louhi, the queen of Pohjola.

Researcher Matthew Hall uses the poem *The Weep of a Birch Tree* as one example of the animistic plant relationship of Finns in the pre-Christian period, in which plants are understood as active subjects and persons. Actually, the poem was written by Lönnrot himself, the collector and editor of the *Kalevala*. He wrote the article sharing his own personal opinion on how contemporaries treated the forest and its trees, and published it in the newspaper 1850's.

According to him, the Finns were the enemies of the forest, because the boys already hit the trees with their axes for fun. Workers, travellers, and shepherds ignited forest fires through their carelessness. Shingles and tinders were torn so that the tops of the trees were left to rot and destroy new vegetation. By absurd rinsing, the forests were destroyed.

*The Weep of Trees* is a modern version of *The Weep of a Birch Tree*. Unlike Lönnrot's version, where Väinämöinen has to fell a birch to make a kantele (ie a musical instrument), in *The Weep of Trees*, the tree does not have to be felled to make it a musical instrument. With the help of current technology, the reactions of trees, for example stress, can be measured with various devices. These measurements can be converted into audible sounds in the human ear.



*The Weep of Trees*, 2021, Band of Weeds, audio files and algorithm, courtesy of Band of Weeds.

### Weblink to the Artwork

<http://www.hermannikeko.net/kasvihyytialatone/>

### Authors and Biography

Band of Weeds is a sound collective, which was founded in 2015. At first, it was only a conceptual band created by Kalle Hamm and Dzamil Kamanger, and existed only on a paper. It became a real band, which releases LPs and gives live concerts, in 2017. The first album – *Other-Than-Human* – was released in autumn 2017, and the EP *Waiting for the Extinction* 😞 in the spring 2019. The current members of the band are now Olli Aarni, Lauri Ainala, Kalle Hamm and Hermanni Keko featuring different plants depending on the project. All the sound material is recorded from the plants using the method developed by the Soviet botanist Ivan Gunar. There are ionised liquids running inside the plant tissues and the changes in their electro-magnetic field can be converted to the sound range audible for the human ear.

## The Waiting for the Extinction 😞

### Band of Weeds

<https://www.kallehamm.fi/band-of-weeds-2/>  
<https://www.kallehamm.fi/waiting-for-the-extinction/>

### Band of Weeds

Olli Aarni, Lauri, Ainala, Kalle Hamm, Hermann Keko +  
featuring plants

### Abstract

*Waiting for the Extinction* 😞 is the second release by the Band of Weeds, published 2019. It is dealing with global warming through two arctic plants. A climate change and other human activities might cause a large scale extinction on the planet. The film presents two species, which are growing in Finland and are endangered due the global warming: Siberian primrose (*Primula nutans*) and glacier buttercup (*Ranunculus glacialis*).

### Waiting for the Extinction 😞

The Siberian primrose is a species covered by EU directive and is endangered and fully protected in Finland and Sweden. Many of its habitats have disappeared due to eutrophication of the water, the end of coastal grazing and the spread of strong competitors.

The glacier buttercup is the world's northernmost flowering vascular plant. If mountain and Arctic glaciers melt, the glacier buttercup will no longer be able to retreat to higher or more northerly habitats. This is particularly obvious for species living in the mountains and fells. Suitable habitats for them will simply disappear.

The Band of Weeds uses microvolt sensors to record changes in the magnetic fields of plants and then produces musical works

from the collected biodata. All of the sounds on the film were produced from biodata recorded from the Siberian primrose and glacier buttercup) in the plants' natural habitat in Norway at Trollholmsund, Mugnetinden and the Øksfjordjøkelen glacier.



Siberian primrose, *Assisted Migration*, 2019, Band of Weeds, sound files and video, Courtesy of Band of Weeds.



Glacier buttercup, *Like a Polar Bear* 😞, 2019, Band of Weeds, sound files and video, Courtesy of Band of Weeds.

### Weblink to the Artwork

<https://www.kallehamm.fi/waiting-for-the-extinction/>

### Authors and Biography

Band of Weeds is a sound collective, which was founded in 2015. At first, it was only a conceptual band created by Kalle Hamm and Dzamil Kamanger, and existed only on a paper. It became a real band, which releases LPs and gives live concerts, in 2017. The first album – *Other-Than-Human* – was released in autumn 2017, and the EP *Waiting for the Extinction* 😞 in the spring 2019. The current members of the band are now Olli Aarni, Lauri Ainala, Kalle Hamm and Hermann Keko featuring different plants depending on the project. All the sound material is recorded from the plants using the method developed by the Soviet botanist Ivan Gunar. There are ionised liquids running inside the plant tissues and the changes in their electro-magnetic field can be converted to the sound range audible for the human ear.

## Industrial Average Campfire

**Morgan Jenks**

MFA, Texas A&M University  
morgan@morganjenks.com

### Abstract

This is a market visualizer in the form of a campfire. The forms rising from the fire are called candlesticks, a type of box and whisker chart used by traders to track the price action of financial assets. Just as the combustion of wood produces flames, smoke, and ash, the continuous digital transactions in global markets produce these graphs. Although not visualizing atmospheric data directly, society's relationship to finance is arguably a key element of the global response to climate change.

### What is the Average of Industry?

Since prehistoric times, humans have burned wood. Creating fire has been a fundamental technique that has protected and provided power to people. A site of social gathering, making food, a defensive construction as well as a weapon, fire is also the primordial greenhouse gas producing technology.

The advance of technologically developed society follows a trajectory of tool creation (so far, greatly involving the use of combustion) to the present day. We have engineered our environment to a comfortable state, and having an open fire may seem more of a novelty. With quality of life deeply enmeshed in industrial processes in the place of survival skills, people rely on all manner of prostheses from buildings, to vehicles, to the various forms of single-use

vast networks of physical processes and converts into the power to create the conditions of human habitats and care, with affluent populations contributing a disproportionately large part of greenhouse gas emissions (Wiedmann et al. 2020, 2).

Largely however, the effects of capital transactions are abstracted away from view. When buying a computer, for example, the work involved is distributed across immense ranges of scale and distance, from extracting natural materials, to manufacturing, shipping and all of the organizational work before, between and after. For the purchaser, it all distills to one single number: the price of the product. Getting a computer is now a simpler task for the end purchaser than setting a log on fire.

This concealing abstraction is also present in the virtual construction of the campfire: the fire will never go out, so long as the program is running. The required material inputs to this fire are omitted from the simulation, masked away by the apparent persistence of the campfire. The same masking of inputs and externalities happens with charting markets: The chart only presents market activity, omitting the complex interactions in the world at large, collapsing them to a single number moving in one dimension over a constant of time.

Market analysts do take more expanded views of inputs and outputs for the purpose of competing and maximizing profit, but the collective financial industry has taken - and

of capital growth. Establishment policy willfully omits critical concerns and complex ecological interactions in favor of preserving current levels of net worth. Leading financial journals have significantly omitted environmental effects from their reporting and analysis (Diaz-Rainey et al 2017, 254). Regulatory structures lack substantial power to enforce monitoring and policy on industry (Thistlethwaite 2015, 3). The fossil fuel industry is massively subsidized and kept afloat by governments and banks, and banks and market makers themselves have been massively bailed out repeatedly as a means to preserve the current valuation of capital (Dawlabani 2018, 3).

As long as the impression of stability persists and people are still willing to participate, the market effectively omits the current trajectory of the climate. Fossil Fuel production is still expanding, belying corporations' public image campaigns which tout the industry's investments in sustainable energy (Kirsch et al 2021, 37). Fossil fuel corporations have spent more money on propaganda for climate change denial than practical reform (Bousso 2018). The profit motive of the financial elite drives a positive feedback loop, similar to the thermochemical chain reaction of a flame.

In the case of affluent modern society, lack of money - combined with a relative lack of practical survival skills - could drive existential panic as climate change progresses. People under pressure naturally retreat to acting on impulses toward safety and survival, and furthermore, immediate desire for comfort and aversion to discomfort may often override longer-term physiological needs (Zheng et al. 2016, 2). In an ecological collapse scenario, affluent society will likely become only more dependent on technological infrastructure, interfaced with via money.

Wealth inequality presents a key aspect of the dynamic in climate finance. As an

example, consider that the wealthiest 1% of the global population holds roughly 43% of the global wealth. If we consider just the top 2% of the global wealthy, that 2% holds over 50% of the wealth. It would take basically 99% of humanity to collectively form a majority stake in a simple two sided bidding war against the top 1%. The bottom 98% couldn't win against the top 2%. This is an oversimplification, but quite clearly, the world's wealthiest individuals are critically needed to step up and take decisive action in reform.

### The Other Side of the Coin

Insofar as profit drives the decisions of industry, finance can be wielded beyond insulating the affluent, towards reform. There are encouraging examples of both divestment and investment being employed as a tactic to change corporate behavior. Recently, the activist hedge fund Engine No. 1, with support from various shareholders and pension funds, has managed to place 3 sustainability-oriented board members on Exxon Mobil's board of 12 directors. The collective cooperation surrounding Engine No. 1's efforts is very notable as Engine No. 1 only holds an 0.02% stake in Exxon Mobil.

Divestment from fossil fuels, and corresponding investment in sustainable industry is also trending. Comparing two aggregate funds, IEO (iShares U.S. Oil & Gas Exploration & Production ETF) and ICLN (iShares S&P Global Clean Energy Index Fund), we can see that both dropped significantly around the 2008 financial crisis. The Oil and Gas fund recovered relatively quickly but has been oscillating below peak levels ever since and is currently at 65% of its all time peak value (IEO Index Chart 2021). ICLN on the other hand shows a different history. ICLN did not bounce back soon after 2008, is currently 56% of the all-time peak value, but has seen an

outsized increase in investment since the March 2020 crash (ICLN Index Chart 2021). Over the past three years, ICLN has increased in value drastically more than IEO.

These shifts are positive and likely to continue. There is still a lot of ground to cover, but ironically in terms of financial formations, this actually means that the underdog renewable energy sector has massive growth potential, especially if the funding from fossil fuels is simply transferred over to renewables. The market capitalization (the sum total of money invested) for fossil fuels is over 4 trillion USD, whereas the market capitalization of renewable energy is around 881 billion USD (Prasad 2021).

2020 saw a massive increase in new investors participating in financial trading, and traders entered the market at an accelerating pace (McCabe 2021). Could the popular rise of financial trading become a productive path towards ecological symbiosis?

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## Weblink

<https://morganjenks.com/industrialAverageCampfire.html>

## Author Biography

Morgan Jenks is an audiovisual artist born in 1985. Their work has been featured in venues across the US, UK, South Korea, Germany and the Netherlands, including the Telfair Museum and the International Computer Music Conference. Their creative output largely revolves around developing interactive software and a regard for humanity's relationship to the environment.



# a letter to Humboldt - climatologically informed multimedia co-creation

Alisa Kobzar<sup>1</sup>, Lisa Mc Guire<sup>2</sup>

<sup>1</sup> Institute of Electronic Music and Acoustics  
University of Music and Performing Arts, Graz, Austria

<sup>2</sup> independent artist, Graz, Austria

<sup>1</sup> [alisa.kherson1989@gmail.com](mailto:alisa.kherson1989@gmail.com)

<sup>2</sup> [lisamariamcguire@gmail.com](mailto:lisamariamcguire@gmail.com)

## Abstract

„a letter to Humboldt“ is a collaborative multimedia composition of the duo rotkäppchen, which consists of the composer and multimedia artist Alisa Kobzar and dancer Lisa Mc Guire. Rotkäppchen aims to create an essential multimedia experience by combining live audio-, video-, dance- improvisation according to certain reaction rules.

## Introduction

Duo rotkäppchen (Alisa Kobzar – composer, multimedia artist; Lisa Mc Guire – dancer, performer) is an intermedial collaboration between dance, music and visual art, artistic result of which happens in real-time and never repeats in the same way. The main idea is based on developing the language of nonverbal communication between the dancer and composer/visual artist by means of active co-following (active listening, active seeing) and immediate reactions. Using the means of technologically extended art, these reactions could be performed both with the help of the human factor and with the help of pre-programmed sensors' data, derived from human actions (diverse movement, sound, picture analysis). The project-oriented reaction-communication chains are developed before the performances as current representations of the project's state. Technology in this multimedia collaboration extends/stretches the art forms, supports the indirect connections between

diverse art forms, bringing up as a result “melted”, merged individual and always different art form.

The project „a letter to Humboldt“ has been developed during 2019-2021 and presented in different formats and contexts, including AudioMostly 2020 conference concert „Extended realities“ (Graz, 2020), full-length performance in Theater im Keller (Graz, 2021), Pointless.ness exhibition (Graz, 2019).

## Topic

Alexander von Humboldt (1769-1859) was a German geographer, naturalist, explorer and the first person to describe the phenomenon and cause of human-induced micro-climate change (energy production, water use and emissions), in 1800 and 1831 wrote several books, based on observations generated during his travels. How could he react on the climate changes today? In the piece „a letter to Humboldt“ duo rotkäppchen wants to pay people's attention to the beauty and at the same time vulnerability of the nature. Humboldt wrote (Humboldt, A., J. Wilson, 1995): “When forests are destroyed, as they are everywhere in America by the European planters, [...] the springs are entirely dried up[...]. The beds of the rivers remaining dry during a part of the year, are converted into torrents, whenever great rains fall on the heights. The sward and moss disappearing from the brush-wood on the sides of the mountains, the waters falling in

rain are [...] slowly augmenting the level of the rivers, they furrow during heavy showers the sides of the hills, bear down the loose soil, and form those sudden inundations that devastate the country,” - and this quote has become the main topic for I and III parts of „a letter to Humboldt“. The piece is focused on explorations of the nature and climate problems nowadays (drought, overuse of minerals, deforestation), collecting information for a metaphorical „letter“-report with the means of multimedia art.

## Multimedia Components

„(A)rtists [...] are keen on unifying the art forms by integrating their formerly separate identities in the process and performance of new dance works“ (Toenjes, J., 2007) has been from the start the main vector of the project.

The choreographer (who is also the dancer) is creating music by her movements, the music creates choreography by expressive phrases and motives, choreography controls video, video shapes choreography - all the improvised interactions are happening live on the stage during the piece.

The main method of composing interactions between dancer and musician/multimedia artist was constantly addressing following questions: What is the causing action (which media produces it?) and what is the responding one? This questions have shaped the process of narrative's creation. Piece consists of 3 global parts, divided into sections or local parts. The I part explores the problem of drought, II - human overuse of minerals, III - deforestation. Each local part has at least several interaction models, for example: I global part I local part („Sailing“) - water speed reacts on dancer's rowing motions, wind sound is controlled by dancer's hand movements and by dancer's rotation. The presence of such interaction is

considered to be intuitively understandable for audience, and clearly defined for the performers in order to initiate co-play between them.

Apart from the interaction-based co-play, the piece's dramaturgy is shaped by the superpositions of media. According to Timbrell (Timbrell, H. M., 2011): „There are also many instances where neither the dancer nor the visual projections acknowledge the presence of one another...“. For example, in III part, during the transition between „forest conducting - preparation“ and „forest conducting - performance“ the dancer stays for several seconds still, without any movements, being completely involved into concentration before „going onto the stage“, while the video actively moves on top of her, creating the impression of the fast-forwarding or rewinding the piece's content, which is going to be performed in several seconds.

These interaction models address some issues, which are typical for the situation of non-automatic live co-play. The main issue is the presence of delays between the action and reaction, which could be minimised with the means of extra technology. In order to minimise the delays, the performers are staying all the time concentrated on every detail, which co-player creates with her means of art, which makes for musician and multimedia artist almost impossible to watch her controller or computer screen, being all the time focused on the dancer.

## Music and Visuals

All the audio instruments for live music performance are composed in SuperCollider<sup>1</sup>. Interaction is performed with the help of Korg NanoKontrol2 MIDI controller.

The same controller is used for live video interaction in the Resolume<sup>2</sup> video software.

<sup>1</sup> <http://supercollider.github.io>

<sup>2</sup> <http://resolume.com>

The content of the visual layer has been created (modelled, animated, filmed with virtual cameras) with the help of ZBrush<sup>1</sup>, Cinema4D<sup>2</sup> softwares, as well as Unity<sup>3</sup> game engine.

The process of composing the audio-visual instruments for interaction was directed by the concept of blind playing (so that both video and audio interactive layers could be performed with one controller and track-pad).

## Dance

The choreography interactions in „a letter to Humboldt“ is based on the active listening and immediate reactions. All three kinds of relationships, mentioned by Timbrell (Timbrell, H. M., 2011), are present in the project: 1) the dancer „initiates“ visual effect; 2) the dancer „responds“ to imagery; 3) juxtaposition of the dancer's body and visuals. Furthermore, creative interpretation of the practical issue of limited space between the beamer and projection surface opens a possibility to treat the dancer's shadow as an additional media layer.



Fig 1. a letter to Humboldt, 2021, duo „rotkäppchen“, still from the performance documentation, copyright duo „rotkäppchen“.

## Presentation Formats

The piece (Fig.1) could be presented as a live performance, being full length (around 35 min) or partly (around 15-20 min).

Technical requirements: stereo speakers, beamer, projection screen/wall, dance floor.

## Further work

„a letter to Humboldt“ as a piece, connected with data art topic, is considered to be a work in progress. In its further realisation, the piece's audio-visual content would be connected with the data, received from the Pandemic Media Space website<sup>4</sup>. The temperature, wind, humidity and air quality data would be used to influence and partially control the imagery and sound synthesis parameters.

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## Weblink

<https://youtu.be/YjbuXVJ0tvE>

## Authors Biographies

Alisa Kobzar (\*1989) - composer, multimedia artist, teacher, graduated (MA) from Kyiv National Music Academy (Ukraine) in 2014 (department of composition, instrumentation and musical informational technologies). Since 2018 she lives in Graz (Austria), studies Computer music in Graz University of Arts (with prof. G.Eckel) and works within the research project „Inter\_agency“, being a part of the organising committee of AIMC 2021 conference. Alisa took part in different international composers' masterclasses on instrumental and electronic music, festivals, workshops, residencies. Her music is performed in Ukraine, Poland, Germany, Austria, Sweden, Russia, Portugal, Italy, France, USA, Japan, Switzerland, Greece, UK. Her compositions include instrumental, chamber, symphonic, electronic, electroacoustic, acousmatic music, multidisciplinary and interactive multimedia projects.

Lisa McGuire (\*1991) – dancer, performer, gyrokinesis trainer. Got certification in IGTanz Steiermark, GYROKINESIS(R), GYROTONIC, studied in the summer-school of Martha Graham (New York, USA), attended private ballet classes along with Afro Modern Cuban dance class, as well as contemporary performance classes of Valentina Moar, Bostjan Ivanjsic, Tomas Danielis and others.

She took part in the La Strada festival (Graz, 2020) in the choreographic project of Kitt Johnson, choreographic project by Liz King (Graz, Austria, 2015), Refugium Graz (IGTanz), interactive dance-performance by Bühnenwerkstatt (Graz, Austria, 2017). Lisa had successful interactive performance improvisations with live musicians, sculpture, theatrical performances, she was filmed for dance videos and advertisements.

<sup>1</sup> <https://pixologic.com>

<sup>2</sup> <https://www.maxon.net/de/cinema-4d>

<sup>3</sup> <http://unity.com>

<sup>4</sup> <https://pandemic-media-space.com/data>

## Chikyuchi

**Vincent Ruijters**

Independent Artist, Japan  
[vincentruijters@gmail.com](mailto:vincentruijters@gmail.com)

### Abstract

People often have emotionally ingrained perspectives when it comes to climate action, making it difficult to argue against climate change denial using only objective measures like data and policy. Interactive games, however, engage audiences on a subconscious level, working to promote causes that align with the player's innate motivations. Instead of argumentation and data, we created a game exhibit that promotes the values that align with pro-climate action without explicitly persuading for climate action. We designed *Chikyuchi* based on the purpose of caring for a nonhuman entity that represents nature, engaging antagonistic viewpoints like climate change denial indirectly. The game uses the guise of a Tamagotchi to nudge audiences to pro-climate actions without policy-based arguments. Audiences can understand the exhibited game as communicating care-taking in environmental contexts as opposed to an intervention in resource depletion, interacting with the interactive instrument on a human purpose level as opposed to debating about resource and policy.

### Description

*Chikyuchi* is named from the Japanese 地球 *Chikyu*, meaning *Earth*, and anthropomorphizes regions of nature under constant decline due to human activity. The health of the Chikyuchi is in sync with this state of decline. Chikyuchi also talks about itself by learning the way humans talk about it. The particular species of Chikyuchi we show in this exhibit is the Amazonchi, based on the Amazon rainforest, with its currently dangerous ever decreasing rain forest mass. Chikyuchi is built from wood, with an electronic interface using a smart watch emulating the Tamagotchi device of Japan, where players must take care of the species due to low health.

**RAY LC**

City University of Hong Kong School of Creative Media  
<https://raylc.org>

Chikyuchi  
 2021

Wood, Electronics

15 x 15 x 7,5cm

Software Prototype:

<https://www.figma.com/proto/vKqY2BMMQ1xYuh10MHyL5a/>

### Artist Statement

Chikyuchi has both a critical and a speculative layer. The work criticizes the way we have been brought up in an environment that promotes building affective relationships with inanimate consumer products (Illouz 2007) like Tamagotchi (Clyde 1998), whilst failing to promote empathic bonds with nature.

This has left us with a strong affective relationship with consumerism and pop culture and an apathetic relation to nature. In the midst of the Climate Crisis, we find too little too late that a constant stream of fruitless disaster and panic news. This leads to an apathy of action to adequately handle the Climate Crisis. (T.J. 2017) Looking back to how anthropomorphic deities representing nature in humanoid forms was a way that enabled people to empathise and coexist with nature, Chikyuchi speculatively contemplates how to similarly use anthropomorphism in our current society for the same outcome (Tam, Lee, and Chao 2013). However in our case, it is not anthropomorphism embedded in religion, but embedded in a language that our generation grew up with and understands: consumer and pop culture. Thus, consumer and pop culture can become a gameful vehicle to reconnect people with nature instead of disconnecting them with it. In this project we will use play—namely Mimesis—as a means for audiences to make that care-taking connection (Caillouis 1961).

## Game Instrument

Chikyuchi is a virtual pet game, in which the player is tasked with taking care of the digital pet over time. The main avatar in the Chikyuchi game anthropomorphizes a natural resource (Amazon rainforest) declining at the rate of a hectare a minute in reality, leading to increased surface temperature and reduced rainfall.

Chikyuchi is connected to API data that determines the health of the character. Amazonchi is connected to the level of forestation in the deforestation API, reporting the size of the Amazon decreasing 2km<sup>2</sup> per second in the statistics menu of the game. The Chikyuchis are in bad health because deforestation and global warming have put the planet at risk. Although users are able to temporarily cheer up the Chikyuchis with thematically related food and games, increasing their mood, it won't change their critical health, which is always low due to human devastation.

The Chikyuchis also periodically chat about each crisis. It does this by generating text using the transformer language model GPT-2 trained on tweets related to deforestation and global warming over a 3-day period (temperature 0.8, 6500 epochs training). The text used reflects subtle forms of persuasion rather than direct invocation to the player, because the twitter-based training produced social media-post-like messages that subtly nudges the players.

### Exhibition Details

Exhibition will take place in a room or enclosed space with lighting, a table, and a sofa or chair or bean-bag, or comfortable furniture. The shells and two Chikyuchi devices are available in Hong Kong and can be shipped. The devices must be connected to a wall outlet via our custom cables, and connected to internet. Other implements on the table are for decoration and environmental storytelling purposes. The plinth and seating should be the same color. Plinth should have two holes for the cable outlets. While the devices can be played without cable, staff must reconnect in case of low battery. Audience interaction via projection (optional) is possible if the gallery is opened to interacting with guests from outside the local area.



Fig 1. Chikyuchi, 2021, Vincent Ruijters & RAY LC.

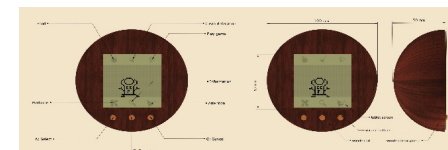


Fig 2. Specification of the Chikyuchi instrument.

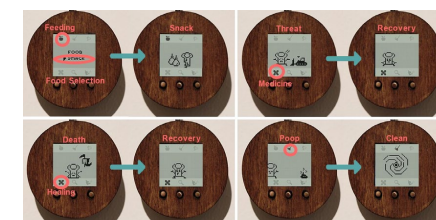


Fig 3. Examples of game play using Chikyuchi.

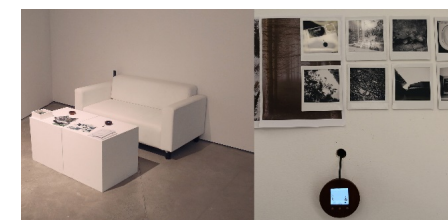


Fig 4. A possible arrangement for the Chikyuchi devices. (Left) Exhibition setup. (Right) Arrangement with climate-related photos and postcards on the table containing the device.



Fig 5. Electrical power and plinth arrangement for Chikyuchi.



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## Weblink

<https://recfro.github.io/chikyuchi/>

## Artists Biographies

Vincent Ruijters, PhD. Born 1988, The Netherlands. Based in Tokyo. Ruijters is an artist concerned with emotion and human relations in the context of contemporaneity. For this project Ruijters contemplates the relation of the contemporary human towards nature.

PhD in Intermedia Art at Tokyo University of the Arts. Solo exhibition (selected) 'Breathing IN/EX-terior' (Komagome SOKO gallery, Tokyo); Group exhibition (selected) 'Radical Observers' (Akibatamabi gallery, 3331 Arts Chiyoda, Tokyo). Curation: 'To defeat the purpose: guerilla tactics in Latin American art' (Aoyama Meguro Gallery, Tokyo). Awards: Japanese Gov. Scholarship (MEXT), Prins Bernhard Culture Fund Scholarship.

RAY LC is not just an artist, or just a scientist, or designer, despite working in each as his career. He applies technology and psychology to build interactive experiences that uplift vulnerable populations and empower empathetic communication, from the multidisciplinary perspectives of neuroscience, installation art, social good, and storytelling.

MFA Parsons School of Design, PhD UCLA. Select exhibitions: BankArt, 1\_Wall, Process Space LMCC, New York Hall of Science, Saari Residency, Kiyoshi Saito Museum, Elektra Montreal, ArtLab Lahore, Ars Electronica Linz, NeON Digital Arts Festival, New Museum, CICA Museum, NYC Documentary Film Festival, Burning Man, NeurIPS, Deonstrukt, Elektron Tallinn, Floating Projects, Jockey Club Creative Arts Centre, Osage Gallery.

## Appendix

A digital prototype version of game: <https://raylc.org/chairbots/3/>

The GPT-2 generated text pretrained to twitter feeds used when Chikyuchi speaks:

- This project is called Terrains, and it's in danger. It's a sad story to be told but an important story all the same.
  - It's as if we've learned.
  - Let's figure out a way to reward those that have remained optimistic for the future of this species.
  - Let's figure out a way to reward those that have remained vigilant & keep everything alive.
  - It is now or never. Please help us help you. A natural disaster is unfolding in a tragic way.
  - I don't think we should give up!
  - We can do this, I believe, because nature is the source of so many of us.
  - What I am doing right and what I have achieved despite unprecedented challenges.
  - What I am doing right now is eerily all I've got.
  - Never believe that you're too small to make a difference.
  - Sometimes my brain reminds me of everything awful humans do.
  - 1) We need to understand why it's happening
  - 2) We need to stop it from happening.
- Sometimes it becomes necessary to patch things up.
- That's the 1st thing when we wake up in the morning, is to be thankful to the Great Spirit for the Mother Earth.

## Drizzle: a storytelling exhibition using climate change data narratives

RAY LC, Zijing Song, Yating Sun

City University of Hong Kong School of Creative Media, Hong Kong  
Academy of Art University, San Francisco  
[LC@raylc.org](mailto:LC@raylc.org)

## Abstract

Climate change is difficult to grasp due to the remote nature of its action compared to immediate timeframes and surroundings, so arguments and statistics about its occurrence can fall on deaf ears, especially for science skeptics and climate change deniers, who interpret such persuasive strategies of political rhetoric. True change of people's opinions and habits requires not debates and data, but rather personal stories that align the viewer's own objectives with those of climate action. To show the consequences of climate change in data form that is palatable to climate change skeptics, we adapt a narrative strategy to show the data of climate change, creating a covert visual narrative in manga form showing both the ideals espoused by climate action and the climate change data in a visual narrative framework. These comic stories are presented for particular goals of climate action, such as individual responsibility, long-term vision, and collective conservation strategies, utilizing design fiction to narratively engage antagonistic viewpoints. To encourage audience involvement the full spread of the comic is presented on the wall of the gallery to allow visitors to read and share with others, immerse each other in the data it presents, and visually engage with the personal virtues that align with climate action without utilizing overt forms of argumentation and policy discussion.

## Introduction

Climate change is often perceived to be remote and impersonal to those living through it presently (Leiserowitz 2006; Weber 2006). It's often difficult to gain the attention of particularly polarized individuals such as the science and climate change skeptics. As such, creative forms of climate change communication strategies must be used to favor actions and perception that align with positive environmental action (Boykoff 2019). Often,

long-term behaviors for social good require activating intrinsic forms of motivation that align individuals with narratives designed for some particular social purpose (LC and Mizuno 2021). Using speculative storytelling in an engaged manner (Dunne and Raby 2013), we created an artwork in the form of a wall-sized manga that visually appeals to even science skeptics, and uses an implicit form of narrative persuasion to communicate climate change ideals and data representations without explicit forms of argumentation.

Physically speaking, climate change involves consumption, depletion of natural resources, uncontrolled populations, carbon emission, and failure of sustainable efforts. However, focusing on these policy and resource issues and providing hard evidence and scientific content to the public does not effectively alter human climate action behaviors (Pawlik 1991), due to the lack of immediacy and personal alignment of goals. Working on the human level on the other hand, we turn instead to phenomena like immediate gratification, future blindness, comfort in ignorance, lack of responsibility for group action, disbelief in individual influence, and habituation over negative consequences. Moreover visual representation of data in comic form can serve to disarm the audience, making scientific communication clearer (Bach et al. 2017). Data comics serves to fulfill both narrative goals and transmission of scientific data in a concise and friendly visual format.

To promote long-term behaviors that align with climate action, we used the medium of the comic to show two stories, "Sonia McDougal" and "New Revolia," in which are embedded data that promote climate awareness in a non-threatening visual exhibition format. This allows us to capture the attention of even climate skeptics while avoiding contentious climate change debate.



## Exhibition

*Drizzle* is a wall-sized comic to be mounted at the Wegener Center for Climate and Global Change of the University of Graz. Only two of the stories in the collection are shown in the exhibit: “Sonia McDougal” and “New Revolia.” The former narrates the story of a footwear entrepreneur who must choose between prioritizing short term gains vs. long term development of research and family priorities. The latter concerns resource sharing between a group of people stranded during a cruise. Each contains data stories about the way rainfall and weather patterns have been changing, and the allocation of resources to address such changes.

Along with the title page, 7 panels are printed on newspaper at 1.1x0.8m size and mounted on two walls or equivalent space. The spreads can be printed in situ and mounted without glass on white backing or frame, and well-lit with diffuse lighting. If space is limited, an alternative strategy involves display of the spread on a table on A1 size newspaper.

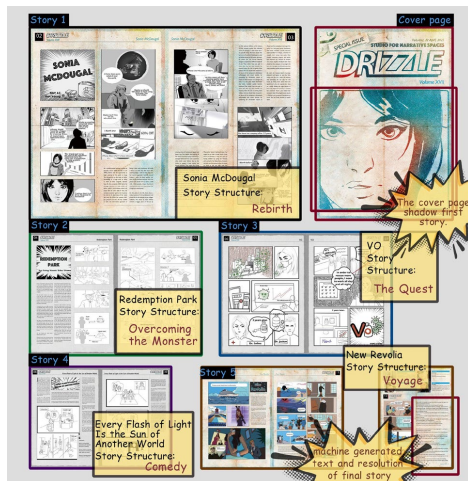


Fig 1. Full spread of *Drizzle*, 2021, RAY LC et al., newspaper print.



Fig 2. Full story of “Sonia McDougal” from *Drizzle*. Note the graphs on the left incorporated into the story plot.

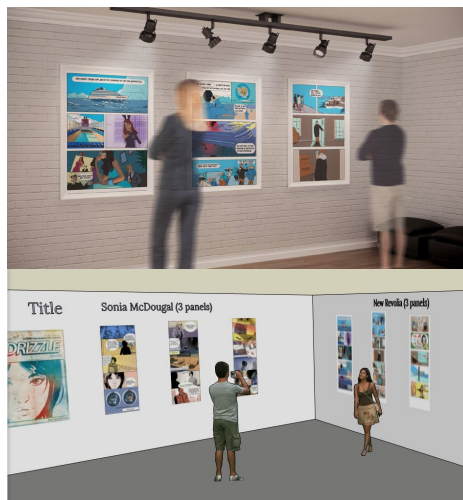


Fig 3. Exhibition form of *Drizzle*, each poster 1.1x0.8m.

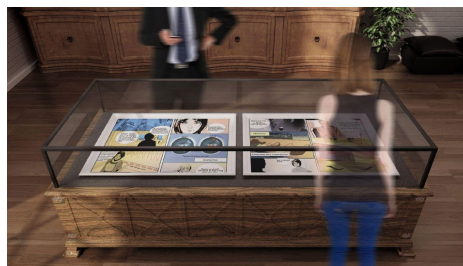


Fig 4. Alternative display strategy of *Drizzle*, newspaper print put on display, A0 size paper.

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## Weblink

<https://recfro.github.io/drizzle/>

## Author Biographies

RAY LC is not just an artist, or just a scientist, designer, or engineer, despite working in each as

his career. He applies technology and psychology to build interactive experiences that uplift vulnerable populations and empower empathetic communication, from the multidisciplinary perspectives of neuroscience, installation art, social good, and storytelling. He holds an MFA from Parsons School of Design and a PhD from UCLA. He is currently Assistant Professor of Creative Media at City University of Hong Kong.

RAY LC’s notable exhibitions include BankArt, 1\_Wall, Process Space LMCC, New York Hall of Science, Saari Residency, Kiyoshi Saito Museum, Elektra Montreal, ArtLab Lahore, Ars Electronica Linz, NeON Digital Arts Festival, New Museum, CICA Museum, NYC Documentary Film Festival, Burning Man, NeurIPS, Deconstruct, Elektron Tallinn, Floating Projects, Jockey Club Creative Arts Centre, Osage Gallery.

Zijing Song is a curatorial PhD student at School of Creative Media, City University. She has worked with public TV in Nanjing. Her work has been shown at Singing Waves Gallery @CityU and Floating Projects @JCCAC.

Yating Sun is an animator and art director at Institute of Digital Media Technology. Her work has been exhibited at Los Angeles City Hall and San Diego Animation Festival.

## Stairway to Helheim

PerMagnus Lindborg

SoundLan, School of Creative Media, City University of Hong Kong  
pm.lindborg@cityu.edu.hk

### Abstract

In Norse mythology, Helheim is the lowest part of the afterworld: the world of the dead. It is ruled by the goddess of death, Hel, a daughter of Loki. As visitors tread the steps of the central staircase of the Run Run Shaw Creative Media Centre, they are met with sonic objects falling onto them; cascading down the steps; obscenely bouncing like yoga balls, a hundred tennis balls, a thousand ping pong balls; splashing incessantly against their head as if they are crawling up a river; heavy objects crashing into invisible walls; objects sliding stealthily in the opposite direction.... The stream of sonic objects seemingly never-ending, the visitors will nevertheless eventually succeed to reach the highest floor. Released from the struggle, they float serenely into the calm of the top level – is Helheim a Parnassum, or is it Purgatory? Or is it another test altogether?

### Sonification

*Stairway to Helheim* is the second piece (after *Loki's Pain*, Lindborg 2020) in a project exploring sonification of geodata and taking inspiration from Nordic mythology (see Fig. 3). It is based on meteorological data for Hong Kong covering 138 years, between January 1884 and September 2021, of daily rainfall and temperature, monthly 'hot nights' and 'hot days', as well as yearly sea level averages in Victoria Harbour. The data were calculated from files graciously provided by Hong Kong Observatory (see Fig. 1). A total of 1654 rows of monthly data were rendered to an eight-channel piece with a total duration of 47 minutes and 27 seconds.

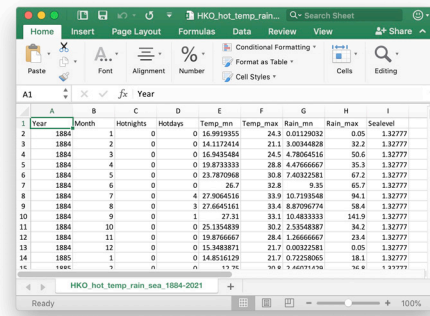


Fig 1. Weather data in CSV format used for the signification.

### Sonic material

The sonic material was based on action recordings of sound objects such as chairs, bottles, balls, and compact discs, made in October 2021 at [SoundLab](#), City University of Hong Kong, by the author assisted by Manni Chen and Daye Yoon (see Fig. 2). The author made post-recording edits in Logic Pro, data pre-processing in R, and sound synthesis in Max.

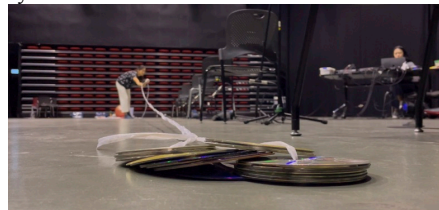


Fig 2. Snapshot from the recording sessions creating sonic material for *Stairway to Helheim*.

### First showing

*Stairway to Helheim* was first presented in November 2021 as part of the 10-day exhibition *Soundislands: Re:Sound*, co-curated by [Joyce Beetuan Koh](#) and [PerMagnus Lindborg](#) of [Soundislands](#), and [ArtScience Museum](#). The loudspeaker installation at the ArtScience museum was made by [Yong Rongzhao](#).

### Planned developments for DACA

If accepted for DACA, one more layer in the sonic composition will be added; namely, recorded voices speaking out (some of) the years and months as the sonification proceeds through the 138 years of data, along with a few personal remarks. Recordings will be made with Cantonese, Mandarin, and English speakers. The purpose of this addition is twofold: firstly, to anchor the sonic composition in its Hong Kong context, and secondly, to provide listening guidance for audiences who might only stay with the installation for a short time.

### Installation requirements

The proposed installation would be in the main staircase of the CMC building, with loudspeakers (type Genelec 8020 or 4030ip) distributed on several levels (maximally: from the platform above Ground Level to the 9th Floor) and sound played back from a MacMini and 8-channel audio card. The piece would not be played on a continuous loop, but rather, it would be launched at set times of the day during the DACA exhibition, according to a schedule that can be developed after liaising with the School and other users of the building.

### Weblinks

- Project website :: <https://soundislands.com/stairway-to-helheim/>
- Trailer :: <https://vimeo.com/645495067>
- Binaural version for headphone listening :: <https://drive.google.com/drive/folders/1arn3BWFC2FqAG8rcnrZsHhV8y71-0X0G?usp=sharing>
- Google Drive (all materials incl. 8ch file) :: <https://drive.google.com/drive/folders/1arn3BWFC2FqAG8rcnrZsHhV8y71-0X0G?usp=sharing>

### Author Biography

PerMagnus Lindborg's compositions and installations have been presented widely, in collaboration with HK New Music Ensemble (Hong Kong 2018, 2021); Lars Lien & Arctic Sinfonietta (Norway 2012, 2020); Good Company Arts (New Zealand 2017, 2019); Berlin PianoPercussion (Germany 2018); Freq Out (EU 2003-18, e.g. Moderna Museet Stockholm 2008); National Gallery (Singapore 2015); ArtsFission (Singapore 2011-15), Onassis Centre (Athens 2014); World Stage Design (Cardiff 2013); and K.622 (Paris 2001-03, e.g. Centre Pompidou 2003). First Prize Nordic Orchestra Composer (Stavanger 2002), Audience Prize Forum (Montreal 1996). PerMagnus studied piano and composition (BMus Oslo 1995), music computing (IRCAM Paris 1999), contemporary musicology (MPhil Paris 2003), and sound perception & design in multimodal environments (PhD KTH Stockholm 2015). Dr Lindborg is Associate Professor (sound art) at the School of Creative Media, City University of Hong Kong, and regularly publishes in journals and conferences. He is Review Editor for Frontiers, Asia-Oceania Regional Director and Music Coordinator of ICMA, and founder of SOUNDISLANDS. He has initiated the DACA 2022 conference on Data Art for Climate Action.

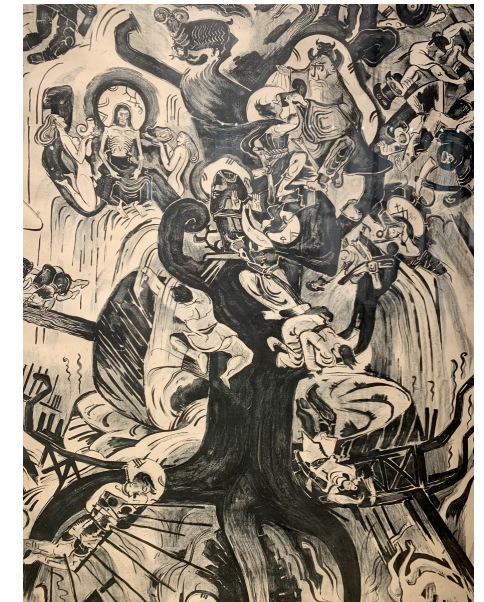


Fig 3. Ossian Elgström: Yggdrasil, Ragnarök, & Viking Gods Of Asgard (ca 1930). PerMagnus is Ossian's great-grandson.



## [In]finite Octagon – A Dance-Film

**Angela Liong**

Arts Fission Dance Company Singapore  
Angela.liong@artsfission.org

**Joyce Beetuan Koh**

Nanyang Academy of Fine Arts Singapore  
btkoh@nafa.edu.sg

**Yeo Chee Kiong**

Nanyang Academy of Fine Arts Singapore  
ckyeo@nafa.edu.sg

### Abstract

Climate change is disrupting the equilibrium of the elements in nature. This disruption allows artists opportunities to make a creative response to the state of our environment in crisis. In our work *[In]finite Octagon* – a 30-minute dance-film - we reflect on the ancient Chinese Eight Trigram [八卦 *Bā guà*] as a microcosm of the world. Each trigram is assigned to a specific element in the octagon; wind, fire, water, mountain, heaven, earth, lake and thunder.

### Film: Dance, Music, Installation

Conceived by dance-maker Angela Liong, *[In]finite Octagon* is a lush 30-minute film featuring dance, new sounds using traditional

instruments, and a fluid art installation to reinterpret the legend of the Eight Immortals (<https://mythopedia.com/chinese-mythology/gods/eight-immortals/>) through abstract, contemporary attributes.

We seek to update this age-old concept of existence and relationships between the natural elements in the era of Anthropocene through a filmic composition of music, dance and visuals, eliciting the collective conscience about climate change and its menacing impact to life. Relating to one of the themes in DACA, climate awareness, the dance-film reignites ancient people's awe and connection to nature that modern urbanites lack in their endless pursuit to control and manipulate environmental resources for the purpose of economic gains.



Fig 1. *[In]finite Octagon*, 2020, Liong, Koh, Yeo. Dance film, Arts Fission

The gathering of four dancers and four musicians - playing the roles of the eight immortals - was staged at a disused fish farm nestled among wild vegetations and an abandoned old school hall. This set the stage for a face-off with the natural elements locked in tumultuous dance (Fig. 1).

Comprising of a tenor voice, the Chinese percussion and a host of Chinese flutes, the music score is configured as a juxtaposition of sonorities or a collocation of sonic colours and movements (Fig.2). Composed by Joyce Beetuan Koh, the soundscape resonates with the narratives of the opposing forces and co-existence of the elements.

Sixty-four blue and white inflatable pieces (Fig.3) were created by sculptor Yeo Chee Kiong to form a modern-day *bā guà* (<https://en.wikipedia.org/wiki/Bagua>) installation. The movements of the dancers accentuate the spatial perspective and proportions, throwing the body towards the irrevocable course of tipping points in nature.

### Context

*[In]finite Octagon* is the first of four milestone presentations under *Project Search 8 Immortals* – a trans-water arts odyssey. The six-

year research project, which started in 2018, is inspired by the Chinese grassroots legend with the same name [八仙过海, 各显神通 *Bā xiān guò hǎi, gè xiǎn shén tōng*]. The project retrieves components from the original legend Eight Immortals Crossing the Sea and develops them into contemporary attributes with modern day concerns.

The symbol of the ocean encompassing life and culture in the original legend enables four milestones to address critical concerns in modern time. The topics of the four milestones are: *[In]finite Octagon*, *Imagine Ocean*, *Super Raft*, and *No Man Island*. Currently, we are in the making of the second milestone. The third and fourth milestones are anticipated to be completed by 2026.

We consider our project as 'art for climate action'. In a previous work, 'Locust Wrath' (2013), we used climate science data and we collaborated with the Tropical Marine Science Institute at the National University of Singapore who provided us with data. We strive to engage with the audiences in the appreciation and urgent conservation of our Planet's natural heritage.



Fig 2. *[In]finite Octagon*, 2020, Liong, Koh, Yeo. Dance film, Arts Fission

## Weblink

A 1m30s trailer of the dance film.  
<https://www.youtube.com/watch?v=RFJMHwCjVM>

## Technical Requirement for Screening

Ideally, the film should be screened in a large-screen setting with a 2k digital image projection format, 2048 x 1080 pixels. The frame rate is 24 frames per second. The duration is 30 minutes. Audio is on two channels.

## Authors Biographies

“Singapore’s shaman of dance” – **Angela Liong**, known for her penchant of drawing material from cultural heritage and mythologies to address the human spirit in her dance work. A prolific dance-maker, Angela has shaped the Singapore dance scene with her distinctive artistic language when she created the dance company ARTS FISSION in 1994. [www.artsfission.org](http://www.artsfission.org)

Originating from her interests in architecture and interdisciplinarity, composer **Joyce Beetuan Koh** explores notions of sonic canvas, space and theatre of music. She has a creative output ranging from concert music, dance collaborations, multimedia production, to interactive sound installations. [www.soundislands.com](http://www.soundislands.com)

Sculptor and installation artist, **Yeo Chee Kiong**, is fascinated with the language and spatial relationship between object, space and authorship. His work destabilises the familiar notions of spatial proportions and perspectives, whilst examining the human conditions in the construction of an extended surreal world. [www.cheekiongyeo.com](http://www.cheekiongyeo.com)



Fig 3. [In]finite Octagon, 2020, Liong, Koh, Yeo. Dance film, Arts Fission

# Waiting for Da Yu – Zhengzhou Precipitation Measurement

**Jung-Hua Liu**

Affiliations National Chung Cheng University, Chiayi, Taiwan  
 Electronic Addresses [emileliu@ccu.edu.tw](mailto:emileliu@ccu.edu.tw)

## Abstract

This artwork is created based on the GPM (Global Precipitation Measurement) IMERG (Integrated Multi-satellite Retrievals for GPM) Early Precipitation L3 1 day 0.1-degree x 0.1 degree (GPM\_3IMERGDE) from NASA. The dataset contains research-quality gridded global multi-satellite precipitation estimates with quasi-Lagrangian time interpolation, gauge data, and climatological adjustment. From this kind of data, I visualize the estimation of Zhengzhou where the God of Water - Da Yu worked on the flood. The artwork shows rainfall measurement of 68 coordinates from January 1st, 2016 to July 24th 2021. The rainfall numbers are transformed to rotating color cubes to animate it from the stellar sky to channels to emphasize the climate changes in 5 years.

## Introduction

We are experiencing unexpected climate changes, and we are like our ancestors facing risks from nature. The flood of Zhengzhou in July 2021 is a significant case. Da Yu, the famous ancient water engineer, was worshipped as the God of Water in China. He worked hard on dredging to avoid the risk of flood. The story of Da Yu inspired me to create an artwork. I imagined this work should contain both nature and human labor. We are experiencing unexpected climate changes.

## Data From the Sky

There are many satellites in outer space and they look at our earth as God staring at human beings. NASA provides global precipitation measurement calculated from data of multiple satellites. The satellites reported data every half hour. NASA provides 6,480,000 coordinates, and I choose 68 points in the Zhengzhou area

(112°42'E~114°14'E, 34°16'N~34°58'N) from January 1st, 2016 to July 24th 2021. Finally, I generated 2092 data files containing rainfall numbers of the Zhengzhou area.

## Visualization

I adopted three.js, a WebGL framework, to generate a data animation. I use coordinates and dates as coordinates and cubes represent rainfall numbers. The cubes are rotating as the stellar sky in the beginning, and the cubes are gradually constructing channels. As we are waiting for Da Yu, hope he can build channels to lead floods to the space/sea.

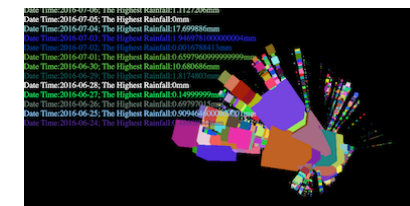


Fig 1. Still image of Waiting for Da Yu, 2021, Jung-Hua Liu, Web, Copyright acknowledgement.

## References

George J. Huffman, David T. Bolvin, Eric J. Nelkin, Erich F. Stocker, Jackson Tan. 2020: V06 IMERG Release Notes. NASA's Precipitation Processing Center, accessed 25 July, 2021, [https://gpm.nasa.gov/sites/default/files/2020-10/IMERG\\_V06\\_release\\_notes\\_201006\\_0.pdf](https://gpm.nasa.gov/sites/default/files/2020-10/IMERG_V06_release_notes_201006_0.pdf).

## Weblink

<https://decisive-awesome-soap.glitch.me/>.



### Author Biography

Jung-Hua Liu obtained his Ph.D. in Fine Art at the University of Leeds, UK. He is an assistant professor at National Chung Cheng University, Taiwan.

## The Torchbearer's Cave (1.0)

**Lukasz Mirocha**

Post-doctoral Research Fellow, Academy of Visual Arts, Hong Kong Baptist University  
lukaszmirocha@hkbu.edu.hk

### Motivation behind the project

The proposed work-in-progress addresses the challenge in communicating key indicators of the current climate crisis. Specifically, we are focusing on the rising number of CO<sub>2</sub> particle in earth's atmosphere. The concentration of carbon dioxide, together with other greenhouse gases, has a profound impact on the rise of planet's water and air temperatures, which in turn deeply impacts ecosystems both on land and in the oceans and lies at the core of current climate crisis. [1,2]

*The Torchbearer's Cave (1.0)*, by using combined visualization affordances of 3D graphics, and digital spherical photography, strives to render visible CO<sub>2</sub> particles that normally stay hidden from our senses. Despite growing public interest and media attention devoted to climate crisis, information about the concentration of greenhouse gases in the atmosphere still seem like just another type of abstract scientific data. Our visualization artwork challenges it by offering a more comprehensible way of making seemingly intangible decades-long scientific data on rapid rising level of carbon dioxide more relatable to the audience.

### The Torchbearer's Cave: Demo

The presentation aims to discuss the project in its current proof-of-concept stage, by demonstrating a working demo of an interactive software application. The software application uses three spherical photographs taken in real life locations (Shanghai, CN; Venice, IT ; and Hamburg, DE), which symbolise the global significance of the phenomenon. The photographs provide a snapshot, a still frame of a usual life of inhabitants of these urban places. People captured on the photographs seem to be

indifferent towards the air that encircles them. Only thanks to the user-controlled spotlight-type instance, one can visualize the concentration of CO<sub>2</sub> particles in a specific area, which stay visible for as long as they are lit by its light and disappear shortly after the spotlight is redirected. The application has been programmed to alter the number of CO<sub>2</sub> ppm (parts per million) every 10 seconds, starting from the levels observed in pre-industrial era and by reaching more detailed measurements that have been taken continuously since 1960s (conducted by NOAA, Mauna Loa / NASA). [3] This approach allows the viewer to observe the rapid acceleration of the number of CO<sub>2</sub> particles in the atmosphere in the last decades.

### Contribution to DACA

By presenting the project in the work-in-progress track, we hope to gather constructive feedback from fellow researchers / artists on the project in its current (early) stage, and importantly, on its future possible directions (e.g., presenting it as a VR experience, non-interactive animation, adding sound layer and so on). We also consider our possible participation in Data Art for Climate Action 2022 as an occasion to discuss the general potential of interactive computer graphics and immersive media for visualizing climate data / information in art and public outreach projects.



Fig 1. *The Torchbearer's Cave (1.0)*, 2021, Lukasz Mirocha, software application / interactive media, Copyright by Lukasz Mirocha.

### References

- [1] Taub, D. (2010) Effects of Rising Atmospheric Concentrations of Carbon Dioxide on Plants. *Nature Education Knowledge* 3(10):21.
- [2] Mondor, E. & Tremblay, M. (2010) Global Atmospheric Change and Animal Populations. *Nature Education Knowledge* 3(10):23.
- [3] David A. Burton, D.A. (2021) SeaLevel.info <https://www.sealevel.info/co2.html>.

### Weblink

YouTube Screengrab:  
<https://www.youtube.com/watch?v=lr1N37Xpg5k>

### Author Biography

Dr. Lukasz Mirocha is a new media and creative software theoretician/practitioner working with immersive and real-time 3D media. Engaged in new media/digital technology research and practice for almost a decade, he has published on new media, digital aesthetics and digital design and exhibited artworks internationally. More on: <https://lukaszmirocha.com>

## AtmosActions: An Interactive Audiovisual Installation For a Human/Weather Interface

### Authors

**Hiromi Okumura**  
 Virginia Tech  
[ohiromi@vt.edu](mailto:ohiromi@vt.edu)

**Valerie Williams**  
 Director, Co'Motion Dance Theater  
[v@vfw.biz](mailto:v@vfw.biz)

**Dr. Jenn Kirby**  
 Goldsmiths, University of London  
[j.kirby@gold.ac.uk](mailto:j.kirby@gold.ac.uk)

**Dr. Thomas B Jobson**  
 Washington State University  
[tjobson@wsu.edu](mailto:tjobson@wsu.edu)

**Dr. Joseph Vaughan**  
 Washington State University  
[jvaughan@wsu.edu](mailto:jvaughan@wsu.edu)

### Abstract

Atmospheric Interactions is a real-time audiovisual installation which uses meteorological data from the PACCAR research building at Washington State University (Laboratory for Atmospheric Research). Three artists worked with atmospheric scientists to realize the project. The weather data from PACCAR is visualized and sonified in real-time and displayed in a hallway on a large TV screen. The installation captures the movement of people walking by and places them into the display. The aim is to encourage public awareness that humans are impacting climate and weather through an eye-catching display.

### Introduction

Climate Action is urgently needed to protect life. The IPCC highlighted that “human actions still have the potential to determine the future course of climate” in their Aug 21 press release (IPCC, 2021). This project was designed in consultation with atmospheric research scientists, Professor Thomas Jobson and Professor Joseph Vaughan, at WSU. The PACCAR weather station is a collection of meteorological instruments mounted to a 10 m tower atop the PACCAR building at Washington State University in Pullman, WA. Measurements include temperature, relative humidity, wind speed, wind direction,

atmospheric pressure, net shortwave radiation, and net longwave radiation.

We are exploring new ways of conveying weather information to people beyond the typical audience for such data through computer-mediated art. In this project, meteorological data is rendered as colors, moving shapes, and sounds, and the viewer is put 'in the picture' again. Our project seeks to reconnect people with their local weather as they live their lives indoors, and support their engagement with climate change, the most important story of our time.

### Data Visualization and Sonification

We aim to situate the participant within the data, providing a sensory experience of the atmosphere and encouraging the audience to reconnect with the weather through the experience of our installation.

### Visualization

Weather and atmosphere data called from the rooftop of the PACCAR Building are visualized using Isadora, a software program. Upon exiting the elevator, people will see triangles flowing in the direction of the wind, speeding or slowing as the wind does, and in colors that are related to air temperature. The 3D data of wind direction is translated to a 2D monitor in the accepted convention of North being up.

The visualization pays particular attention to the rooftop data, but also adds a camera that scans the corridor where people enter. People are more likely to pay attention when they see themselves, so the choice to use a camera pulls them to the display where they see an abstracted version of themselves and their movement changing the projection. The rooftop data is called every 60 seconds so there is an obvious connection to the wind direction when the triangles start moving in a different direction. Superimposing the visualized data on the abstracted person makes the point that we are affecting as well as affected by the weather and climate.

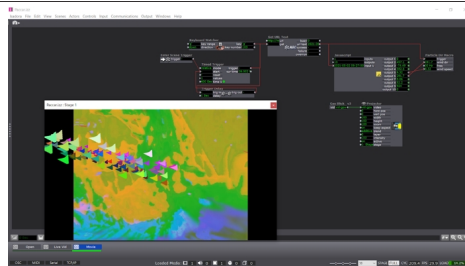


Fig 1. *Atmospheric Installations patch in Isadora*, 2021, Valerie Williams, digital visualization, Copyright Valerie Williams

### Sonification

The movement tracking in the visualization also feeds into the sonification and only when movement is detected via the camera are the sounds heard. The sonification is built using Max. The sound world could be categorized in terms of soundscape and pitched material. The soundscape includes wind, rain and forest environment. The wind is synthesized and mapped to the wind speed. The rain sound is a field recording and the volume is mapped to the amount of rainfall. The forest environment sound is a field recording and is not mapped to data.

The pitched material come from two different synths, Synth 1 and Synth 2. The tempo is controlled by the wind speed, and in Synth 1, the subdivision of the beat is controlled by air temperature. It will be at its fastest when the temperature is high and the wind is strong. Synth 2 is not mapped to a musical scale; the frequencies are mapped to relative humidity, atmospheric pressure, net shortwave radiation, and net longwave radiation.

The aim with the sonification is to be able to tell something about the current weather based on what is heard (speed of notes of Synth 1 and frequency of notes in Synth 2). The wind and rain are easier to understand. However, with listening over time, you can begin to tell more from the sonified data. In this case, the sound aspect of this project sits between auditory display and sonification. The artistic interpretation encourages a deeper engagement, as it requires us to spend longer listening in order to gain a deeper understanding. This is linked to how we understand our climate and

how sustained engagement is necessary to understand (and to limit) climate change.

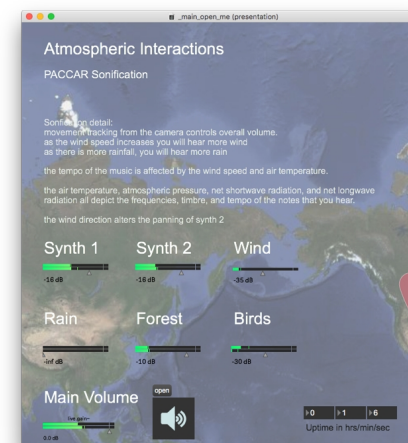


Fig 2. *Sonification Max Patch*, 2021, Jenn Kirby, patch. Copyright Jenn Kirby.

### Installation

The installation, at a minimum, requires a monitor/TV screen, a computer (running Windows or MacOS) with an internet connection, a webcam, audio speakers, cable connections, and a room that allows for both viewing and listening. The computer will need to have Isadora and Max installed. An installation guide will be provided. If the computer has the programming loaded, set up requires hanging and connecting the monitor to the computer, connecting and setting up the speakers, hanging and focusing the webcam and connecting it to the computer, and setting up the speakers.

It is also possible to expand the installation to multiple monitors and cameras, and a multi-channel surround sound system, such as IEM Cube at Graz. The installation is flexible and scalable.

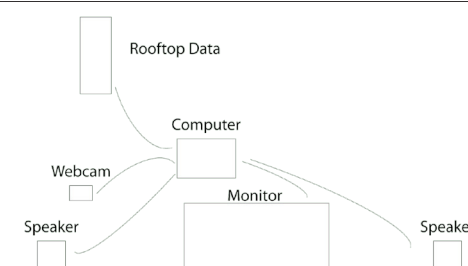


Fig 3. *The Installation Diagram*, 2021.

While the work was designed to be installed in the PACCAR building at WSU, we are interested in rendering meteorological and other atmospheric data in different locations to encourage participants to think about climate change beyond their own region. Given the somewhat standardized approach to collecting meteorological data, it is possible to parse data from another weather station, and install Atmospheric Interactions in other locations such as schools to form a visual global network. For instance, if it is to be installed in Hong Kong, we can customize the installation to run two versions in parallel showcasing the PACCAR data alongside a station in Hong Kong. The artists and scientists all live in different locations and time zones and are aware that the impact of climate change may exhibit differently in each of our locations.

### Conclusion

Climate change is slow moving temporal phenomena and difficult for an individual to experience as an immediate problem. So many of us spend our time indoors and in acclimatized environments that we lose connection even to our local weather.

We feel that awareness of the impact of climate change in regions beyond our own helps build empathy and encourages active engagement.

### References

IPCC (2021) Climate change widespread, rapid, and intensifying – IPCC. Available at: <https://www.ipcc.ch/2021/08/09/ar6c-wg1-20210809-pr/> (Accessed: 12 Aug 2021).

Laboratory for Atmospheric Research,  
Available at:  
<https://micromet.paccar.wsu.edu/roof/current.tx>  
t (Accessed: 12 Aug 2021).

### Weblinks

Visualization demonstration -  
<https://midwestartistmgmt.wixsite.com/valerie-williams/video>

Sonification demonstration -  
<https://u.pcloud.link/publink/show?code=XZU9yKXZamafanGp9YyOPhxpezjHJJuFlx4X>

### Authors' Biographies

Hiromi Okumura is a visual and performance artist, who believes in the power of Art and Science. Hiromi teaches at School of Visual Arts, Virginia Tech.

Valerie Williams is a choreographer, dancer, and director who believes technology should serve people. Working with musicians,

composers, designers and artists, she creates interactive environments that respond to dancers' movements.

Dr. Jenn Kirby is a composer, performer, lecturer and music technologist. Her output includes contemporary instrumental composition, electroacoustic music, live electronics and sound art. Jenn is a Lecturer in Electronic Music and Technology at Goldsmiths, University of London.

Dr. Thomas B Jobson is a Professor at the Department of Civil & Environmental Engineering, Laboratory for Atmospheric Research, Washington State University.

Dr. Joseph Vaughan is a Research Associate Professor, Laboratory for Atmospheric Research, Department of Civil & Environmental Engineering, Washington State University.

## Algorithmic Music Composition for The Environment

**Rosa Park**

San Francisco State University  
rosapark@sfsu.edu

### Abstract

“Algorithmic Music Composition for The Environment” is an interactive sound performance that represents scientific data of global warming and climate change. Playing along with the MIDI-equipped interactive interface, “Algorithmic Music Composition for The Environment” aims to reflect the impacts of the climate crisis through sound by representing the alarming records of diverse environmental sectors, such as global land-ocean temperature, Sea Level change, Antarctic Ice mass variation, atmospheric carbon dioxide (CO2) levels, and more. There have been several ongoing collaborative projects among scientists, artists, and musicians in the Bay Area to combat climate change and bring the urgency of this pressing issue to inspire people to take meaningful action through music [1]. Thus, the development of this project is aligned with those endeavors to strengthen collaborative efforts and interdisciplinary solutions, seeking new methods and techniques of experimental music that can raise awareness of environmental challenges.

### Description of The Musical Work

The main interface for the music composition of the project has been built in Pure Data (Pd, <https://puredata.info/>), a data flow programming language for electronic music. The Pd interface of the work is composed of various types of Graphical User Interface (GUI) objects in which the scientific data is stored in the form of tables. These tables contain the information of a growing number of weather-related catastrophes, including Land-Ocean Temperature from 1880 to 2020, Global Mean Sea Level (GMSL) variations data between 1993 and 2021, the monthly records of ocean

heat from 1957 to 2020, Antarctic Sea Ice Extent from 1978 to 2020, and CO2 emission trends from 1958 to 2021 measured by five different scientific research organizations that are NASA, NOAA Climate.gov, United States Environmental Protection Agency (US EPA), and the U.S. National Climate Assessment [2][3][4][5]. Values stored in the tables within Pd draw line graphs. Each table expresses unique sound qualities and textural complexities, reflecting regional and seasonal temperature extremes for each year and month since 1880. Figure 1. below shows the examples of the table compositions used in Pd.

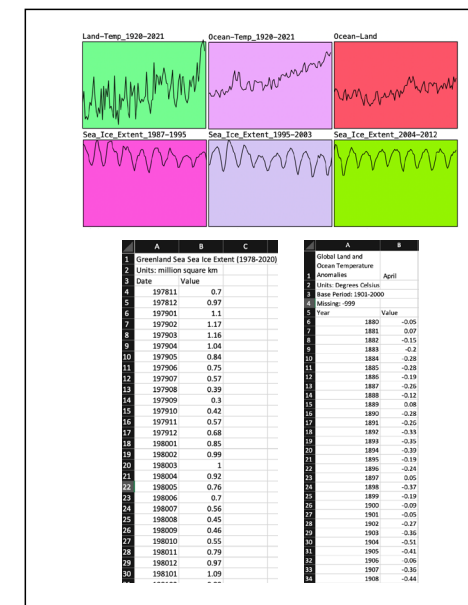


Figure 1: Examples of table compositions and line graphs within Pure Data (Pd), which reflects the data sheet of Greenland Sea Ice Extent (1978-2020) and Global Land and Ocean Temperature (1901-2000).



## The Compositional Process

Sounds generated algorithmically from the table arrays are played through the main Pd interface. The performer controls and improvises on the generated sounds through the GUI modules (Fig. 2) to respond to the trends of the latest climate data, interpreting a sense of urgency about the climate crisis. The key indicators of the GUI modules affect and change the sonic textures, such as tempo, pitch, note, and octave dramatically to provoke more compelling experiences of the increasing effects of climate change and ultimately portray its catastrophic consequences in the future. The sonification process allows the performer to add the conceptual domain to the soundscape by enhancing or revealing several notable troubling trends in the data through the main interface system (Fig. 3), which constantly plays sound based on the numbers implemented in the table arrays. By turning data into sound, the project aims to bring a message that climate change is far more than an environmental issue; it is the *cry* of the Earth, and the consequences of climate change are already here.

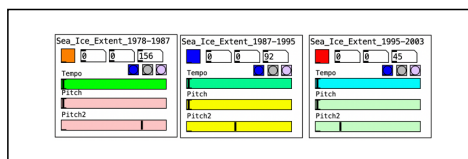


Figure 2. GUI Modules for “Arctic Sea Ice Extent.”

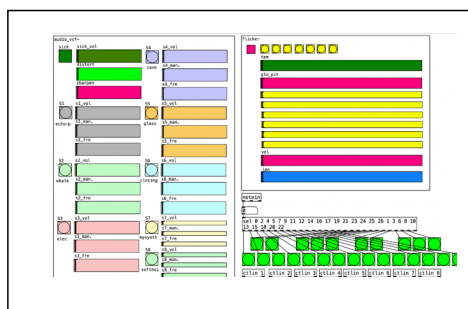


Figure 3. The main Pd interface design (in progress)

## References

- [1] “The Climate Music Project” in San Francisco:  
<https://climatemusic.org/>
- [2] NASA’s Global Climate Change: Vital Signs of the Planet: <https://climate.nasa.gov/vital-signs/carbon-dioxide/>
- [3] Climate.gov: <https://www.climate.gov/>
- [4] The United States Environmental Protection Agency (EPA): [https:// www.epa.gov/](https://www.epa.gov/)
- [5] National Climate Assessment:  
<https://nca2014.globalchange.gov/>

## Anthropocene in C Major

**Jamie Perera**

Jamie@jamieperera.com

## Abstract

'Anthropocene in C Major' is a visceral experience of human impact on earth, felt through a live performance that turns data into sound.

Over 45 minutes we travel through 12000 years to the present, listening to breakthroughs in human development from the invention of the wheel to the Industrial Revolution and beyond... but also inescapable data trends that tell of our exploitation of the planet and each other. At what now seems like a breaking point for our species, what can we learn from listening to the past, and what meaning can this bring to our present and future?



Fig 1. *Anthropocene In C Major – image – Global Co2 Levels, Global Sea Level, with Megafauna Extinction -10,000 BCE.* Electronic / Orchestral Performance, copyright Jamie Perera.

### Premise

Sonifying an object to feel the issues and information within it is a small act in provoking conversation. For me it's now a way to confront, express and experience the issues behind climate change, a practice that breaks down aspects of a seemingly impenetrable hyper-object.

What is revealed is that whether we see it or not we are all somewhere in the early stages of

ecological grief with inexorable links to consistent, inherited, systemic trauma. We're also trying our hardest to navigate change through muddy water while it keeps getting muddier, so it's difficult to know which way to turn. So how do we not become paralysed? How do we get through to hope and reconstruction? What's the process of getting to a place where we can respond?

Anthropocene In C Major is a response to climate change. Using sound as documentary and image as provocation, it invites audiences to confront their own climate grief, within the form of sonification and the scale of our existence on Earth.



Fig 2. *Anthropocene In C Major – image – Global Surface Temperature Levels, Global Co2 Levels, Global Population Global Sea Level, with Domestication of Cattle -9,000 BCE.* Electronic / Orchestral Performance, copyright Jamie Perera.

## Past Performances

- Silbersalz Science Festival (upcoming)
- CPH:DOX 2021 (headline)
- Electric Dreams Festival 2020
- conference in 2020.

**Audience comments:**

“Really evocative and atmospheric”

"I was captivated and unsettled"

"A melding of time and space and lots of reverberating images of who we are and what we leave behind"

## Performance and Installation Options

- 9 piece orchestra and computer
- Soloist and computer
- Computer only
- As part of a looping installation

For DACA I propose options b, c and d.

Accompanying visuals for AICM can be:

- AICM Abstract projected film
- A new collaboration with visual artists
- Illustrated performance guide
- Darkness

AICM's full DACA Technical Rider is available at the following link:

[https://drive.google.com/file/d/1\\_QSTq0Cm5fZ5aR5DLGw909H4o09T9-E3/view?usp=sharing](https://drive.google.com/file/d/1_QSTq0Cm5fZ5aR5DLGw909H4o09T9-E3/view?usp=sharing)

## Copyright and affiliations

The Anthropocene in C Major score, recording, various iterations, and AICM abstract film are wholly owned by Jamie Perera. Anthropocene In C Major was developed in CPH:LABS as part of the Climate Symphony works by Jamie Perera, Katharine Round and Leah Borromeo.

## References

Anthropocene in C Major data sources:

- Overall World Population
- Global GDP
- Meat & Dairy Production
- Global Oil Consumption
- Global Coal Consumption
- Global Gas Consumption
- Global Co2 Levels
- Global Surface Temperature Levels
- Global Sea Level
- Global Freshwater Biodiversity Loss
- Global Marine Biodiversity Loss
- Global Terrestrial Biodiversity Loss
- Global Nuclear Energy Consumption
- Global Traditional Biofuels Energy Consumption
- Global Hydroelectric Energy Consumption
- Global Plastics Production
- Global Fertiliser Consumption
- International Tourism
- Tropical Forest Loss

- Global Mean Ocean Acidification
  - Global Methane Levels
  - Global Nitrous Oxide Levels
  - Major Events Associated with The Anthropocene
- (Data sources available on request)

## Weblink

Anthropocene In C Major - Linktree document: <https://docs.google.com/document/d/10xSuYN1cynBGN2mE1-wFnVfgjybKnnWS2a645W4Cdbvo/edit?usp=sharing>

## Author Biography

Jamie Perera (BA Hons) uses sound to deconstruct objects - from social issues to maths equations - in ways that create provoking experiences for listeners.

He is one of the first artists to sonify the Holocene, with his composition "Anthropocene In C Major" performing internationally at major festivals, and with excerpt "Oil, Coal & Gas for 3 Cellos" commissioned by the Serpentine's General Ecology Project. Other notable work includes using radio static for an Emmy nominated film about child poverty in the USA, making music from mathematical proofs with mathematician Marcus Du Sautoy, generating a sonic "elephant in the room" to highlight data privacy issues for Mozilla, representing deaths from Coronavirus in the UK in a durational performance, using sound to show differences in conscious state with neuroscientist Anil Seth and creating a soundtrack out of guns for Amnesty International.

He has given talks on his practice for the FT, RNCM, WMA Hong Kong, the AKV Joost Ecology Futures MA, We Make Tomorrow Summit, and participated in the Serpentine's Back to Earth Summit with Hans Ulrich Obrist and Brian Eno. He is an associate of PRISM, the RNCM Centre for Practice & Research in Science & Music.

# Oceans Eat Cities

**Neil Rolnick**

Independent Composer  
neil@neilrolnick.com

## Abstract

Music for string quartet, with digital audio processing, and with video by R. Luke DuBois and Emilio Hernandez Cortes. The piece is in part a sonification of data describing the potential the impact of sea level rise on cities world wide.

## Program Notes

*Oceans Eat Cities* is a musical sonification of data which projects the likely impact rising sea levels will have on cities globally. It is also a musical representation of why we need to address the issue of climate change now.

The data used in the piece was supplied by Climate Central, of Princeton, NJ. It details how rising sea levels will inundate individual cities. It considers various possible scenarios based on the degree to which we mitigate the release of carbon emissions in the atmosphere. For each city, under each scenario, there is data which shows the percentage of the population which will be displaced.

I have used the two most extreme scenarios. In the scientific literature they're described according to the Representative Concentration Pathways (RCP), which track carbon emissions over time.

The first movement uses data from the scenario in which carbon emissions continue as they were in 2015, or RCP 8.5. The second movement uses data from the scenario in which we are successful in cutting most carbon emissions, or RCP 2.6. The first movement uses data from Shanghai (China), Mumbai (India), Bangkok (Thailand), and Osaka (Japan). The second movement uses data from Miami (USA), Sidoarjo (Indonesia), and Tianjin (China).

The basic data mapping of the piece is very simple: After an initial statement of a one-

minute musical idea, the idea is repeated, but with the percentage of population which will be impacted by sea level rise in the particular scenario reflected by subtracting that percentage of the notes from the music. The data changes every 5 years, and that time frame is reflected with a musical change every 20 seconds or so, ranging from the year 2015 to 2100. The years from which data is taken are marked in the score as boxed text. As you might expect, the first movement nearly disappears, since it reflects the scenario of "business as usual" in terms of carbon emissions. The second movement changes, but not nearly as drastically.

There is a video which accompanies the piece, created by R. Luke DuBois and Emilio Hernandez Cortes, and available at <https://youtu.be/veEHLTaBxwQ>. The video shows street maps of the cities whose data is being used in each movement, and the year. As the score moves through the years of the 21st century, each map is overlaid with blue, representing the encroachment of the ocean as projected in Climate Central's data.

A second level of data mapping involves the processing of the acoustic sounds of the quartet, and it is more or less the inverse of the process described above. Using the same data sets as are used to subtract notes from the musical materials, the volume of the processing is increased to reflect the percentage of population in the city which will be displaced by the rising sea level. The processing covers portions of the music, just as the ocean will cover portions of the cities.

## Performance History

*Oceans Eat Cities* was performed at the 2015 COP21 UN Climate conference in Paris, at the invitation of Climate Central. It has also been performed at several venues in Paris, New York

City and at the Visiones Sonoras Festival in Morelia, Mexico.

### Performance Requirements

It will be necessary to have a string quartet to perform *Oceans Eat Cities*, unless it is simply streamed using the video track linked above.

In performance, a large screen should be visible above the players for the video projection. The digital audio and video tracks can be played together in Ableton Live, or using another DAW which supports video. Two audio channels are sent to the house sound system, and a third audio channel containing a click track is sent to the for players, who should be wearing earbuds.

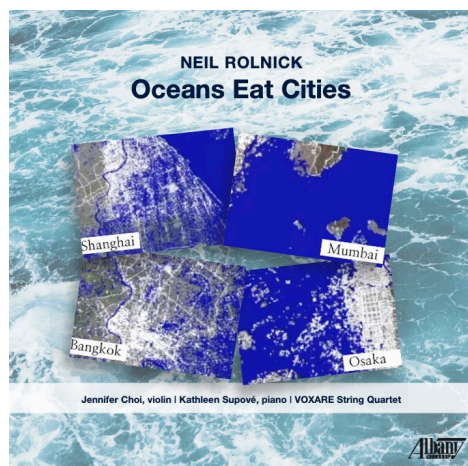


Fig 1. *Oceans Eat Cities*, 2015, Neil Rolnick, cover of CD from Albany Records.

### Weblink

Link to video track, with audio from the CD:

<https://youtu.be/veEHLTaBxwQ>

Link to performance with string quartet:

<https://youtu.be/JxEYBKx6elQ>

### Composer Biography

Composer Neil Rolnick pioneered the use of computers in musical performance, beginning in the late 1970s. Based in New York City since 2002, his music has been performed world wide, including recent performances in France, China, Mexico and across the US. His string quartet *Oceans Eat Cities* was performed at the 2015

UN Global Climate Summit in Paris. In 2016 he was awarded an ArtsLink residency in Belgrade, Serbia. In 2017 he was a fellow at the Bogliasco Foundation in Italy, and received a New Music USA Project Grant. In 2019 he received a NYSCA Individual Artist Grant. He has released 21 CDs of his music.

His work ranges from digital sampling and interactive multimedia to acoustic vocal, chamber and orchestral works. Throughout the 1980s and '90s he was responsible for the development of the first integrated electronic arts graduate and undergraduate programs in the US, at Rensselaer's iEAR Studios, in Troy, NY.

Though much of his work connects music and technology, and is therefore considered "experimental" music, Rolnick's music has always been highly melodic and accessible, and has been characterized by critics as "sophisticated," "hummable and engaging," and as having "good senses of showmanship and humor."

## "A Bitter-Sweet Reminder" «隱韻»

Andy Schaub

Final-Year Student at School of Creative Media

aschaub2-c@my.cityu.edu.hk

### About the Work

Despite the growing awareness of global warming, we are still experiencing more and more extreme weather all around the world.. With this sound installation, I would like to express the inevitable fact that in the end, nature always wins.



Fig 1. *A Bitter-Sweet Reminder (whole Artwork)*, 2018, Andy Schaub, Sound-Installation, All Rights reserved by Andy Schaub 2021.

### Concept

"A Bitter-Sweet Reminder" is a sound installation made up of a simple music box gently playing a familiar lullaby inside a transparent cabinet. The live sound is

manipulated by a program that uses the wind datasets from the severe Typhoon Mangkhut in 2018 in an algorithm that destroys the melody. Representing both home and safety, the music box plays a Brahms classic that is broken apart into pieces based on the increasingly violent winds. As the melody is dramatically affected by the storm data, sound becomes an alternative way to present natural force and danger.



Fig 2. *A Bitter-Sweet Reminder (Ableton & Max System)*, 2018, Andy Schaub, Sound-Installation, All Rights reserved by Andy Schaub 2021.

### How it works technically

A small motor rotates the handle of the music box in a steady tempo, while a dynamic microphone captures the raw sound of the music box and plays it through the digital workstation (Ableton). The Mangkhut wind data gives a timeline and an increase/decrease of the deconstruction level (distortion, redux and detuning) added to the raw live recording. Two speakers placed on both sides of the installation play the final output of the signal. A display placed at the inner bottom of the Plexiglas cabinet shows the wind force data (km/h). It gives a visual connection between the data and



the effected sound. The data gradually affects the sound of the playing music box (lullaby) in patterns of 60-100 seconds followed by a 15-30 seconds break of raw music box sound. This pattern repeats throughout the exhibition.

### Previous exhibition

I had the valuable opportunity to exhibit this artwork at Tai Kwun around two years ago as part of a class project on extreme weather. I would like to further develop this piece to make the execution more sophisticated and impactful.

### Equipment

Most of the equipment is already part of my personal equipment. There are only a few items I might need to borrow from the School of Creative Media equipment center such as 2 speakers and a laptop. Here is a list of all the individual parts used for the final execution:

- 2 Monitor Speakers
- 1 Laptop with Max MSP & Ableton live
- 1 Audio Interface
- 1 Rode Dynamic microphone
- 1 Screen to visualize the wind data
- Some cables
- 1 Box to store the equipment
- 1 busbar for electricity supply

### Space

The Plexiglas cabinet itself has a length of 30cm, a width of 30cm and a height of 120cm (30x30x120). The total width including the placement of the 2 speakers on each side is around 60-150cm depending on the space available. The most ideal environment to place the artwork is against a wall in a room with dim lights since the red neon light within the cabinet is on all the way.

### Set-up time

The whole artwork can be set up and be ready within 1 hour.

### Youtube link

<https://youtu.be/uq3eWNpZAHg>

### Biography

Andy Schaub, originally from Switzerland, is a Final-Year Creative Media student who moved to Asia due to his interest in Chinese culture and language. With a passion for sound design and experimental music, Andy likes to combine different media to sonically and visually express the viewpoint of a stranger living and experiencing life on the other side of the earth.

## Data Wayfaring: Soundwalking through Sonification

### Tim Shaw

Culture Lab and Fine Art,  
Newcastle University, UK  
[tim.shaw@ncl.ac.uk](mailto:tim.shaw@ncl.ac.uk)

### Abstract

In this augmented soundwalk I propose to take a group of people on a journey around Graz, Austria. Participants will experience a combination of live soundscape composition, constructed from real-time sounds of the environment, and data sonification from immediate environmental data streams collected through wearable sensors. By engaging audience members with the sound and data of the immediate environment the experience will promote thinking around how present environmental issues connect with a broader, more global context. In keeping with the hybrid format of the DACA conference, sound, data and video will also be broadcast online allowing for remote audiences to connect with the work. This artwork builds on my previous projects *Ambulation*<sup>1</sup> and *Netwalk*<sup>2</sup>, to include the live sonification of immediate environmental data.

### Soundwalking & Sonification

Both soundwalking and sonification are potential methods for revealing and attending to aspects of our shared perceptual environments. Soundwalking is a method for attending to an environment through movement and listening. Developed through the research of the World Soundscape Project, the practice of soundwalking was motivated by attempting to acknowledge the changing soundscape of the contemporary world (Westerkamp, 1974).

Sonification is the practice of turning data into sound, a way of being able to understand complex data streams through listening. Sometimes used as an alternative to

visualisation, it is a method commonly employed by scientists, designers, artists and musicians in attempt to understand and render data in new ways (Hermann et al, 2011).



Fig 1. Tim Shaw (2020). *Ambulation* at LUFF, Lausanne – Photo: Francois Gendre

Data Wayfaring proposes a combination of these two practices, a listening walk engaging with environmental signals investigating a novel way of navigating data through movement. This piece extends two previous projects *Ambulation* and *Netwalk*. *Ambulation* (Shaw and Bowers, 2020) is a soundwalk which uses field recording techniques and listening technologies to create a walking performance using environmental sound. *Netwalk* is an augmented soundwalk which broadcasts altered soundscapes and processed video to an online audience. Developed during the lockdowns of 2020 it has become a method for sharing an embodied soundwalking experience to remote audiences. The research around the development and presentation of these sound walks contributes to the idea of field recording and sound walking as a live, procedural practice, moving away from the ideas of the movement of documentary material from one place to another or the playback of fixed audio files.

<sup>1</sup> <https://tim-shaw.net/augmented/>

<sup>2</sup> <https://net-walk.net/>

<sup>2</sup> <https://net-walk.net/>



This soundwalk will creatively investigate the complex relationship between human perception, technology and the interspecies which share our soundscapes. By listening through multiple sensing technologies I will explore Graz as a giant sensor, using various techniques to sense its nuances and unearth its changes. I regard this activity as an act of creating a reciprocal, dialogical interchange between humans and non-humans, infrastructures and ecosystems.

Through a listening practice we can simultaneously hear, for example, the world moving, animals interacting, fall out electromagnetic signals from surveillance systems, pollution levels, telluric currents and cosmic weather. Listening, supported by technology, can encourage us to think and act differently about our shared spaces and can create a sense of commonality other than through visual culture.

With this project I demonstrate how having an open, improvisational approach to technologically supported soundwalking enables rich and unexpected results to occur and how this way of working can contribute to contemporary notions of soundwalking and sonification.

### Presentation Requirements

Data Wayfaring will take place outside in the public space and last for around 45 minutes. It would be beneficial to identify a good starting point where I can meet people and access different, diverse sounding spaces. We could meet outside a University building or by the entrance of a park for example. Physical participants should be advised to wear suitable clothing for walking outside (in January).

I will provide all the equipment needed to conduct the walk. This includes wireless headphones, a transmitter, wearable camera, Internet connection (via a portable hotspot), Bela board, sensors, controller, cables and spare batteries. Each walk will be limited to 15 people but I am able to run multiple walks throughout the conference if required. I will

need a place to charge the batteries for the broadcast equipment between walks. It would be helpful to have a volunteer to support me in gathering the people and handing out / collecting the headphones.

This piece runs on open-source technologies including Arduino, BELA and Pure Data. A technical description of the work can be found on a recent post I made on the Bela Blog<sup>3</sup>.



Fig 2: Tim Shaw (2021). Ambulation at Sonic Protest, Paris – Photo: Vincent Ducard

### References

- Hermann, Thomas et al. (2011) The Sonification Handbook, *Logos Publishing House*, Berlin, Germany.
- Shaw, Tim (2021) Ambulation: Exploring Listening Technologies for an Extended Sound Walking Practice – *Proceedings of NIME (New Interfaces for Musical Expression)*
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### Weblink

<https://tim-shaw.net/augmented/>

### Biography

Tim Shaw's practice is concerned with the many ways people listen, specifically how listening environments can be constructed or explored using a diverse range of techniques

<sup>3</sup> <https://blog.bela.io/ambulation-sound-walk-tim-shaw/>

and technologies. With a background in recording sound his practice is anchored in the creative use of field recordings. He is interested in appropriating communication technologies to explore how these devices change the way we experience the world. Tim presents work in galleries, festivals, museums, through residencies and cultural events nationally and internationally. Collaboration plays a central role in his approach, he has been lucky enough to make artistic work with Chris Watson, Phill Niblock, John Bowers, John Richards (Dirty Electronics) & Tetsuya Umeda. Recently his work has been presented at Cafe OTO, London (2021), Sonic Protest, Paris (2021), NNOI, Brandenburg (2021), Lokal INT, Biel (2021), LUFF, Lausanne (2020), Cave12, Geneva (2020), Novas Frequencias, Rio de Janeiro (2019), SoundArtist.ru, Moscow (2019), CAMP, France (2019), Arnolfini, Bristol (2018) & Experimental Intermedia, New York (2018). Tim is a Lecturer in Digital Media at Newcastle University and a member of the RADICAL research project investigating sonification, listening and aesthetics.

# **Works-in- Progress**

# Embedded BeeHive: Mapping Hive Health to Synthesizer Timbre

Matthew Blessing

Independent  
mbless@cct.lsu.edu

## Abstract

This paper outlines a conceptual work-in-progress for a sensor-embedded beehive. This beehive will follow the Kenyan Top-Bar design concept<sup>3</sup> (see: Fig.1), and will contain various sensors for tracking and recording the health of the hive. This data will then be used both to monitor the health and happiness of the bees, as well as influence the sound-design of linked musical synthesizers embedded within furniture in the home.



Fig 1. Kenyan Top-Bar hive design, 2021.

## Project Description and Preceding Work

### The Hive

This beehive will be traditionally fabricated using a standard top-bar design. This design was chosen for its ease of use to the beekeeper, its singular chamber for low-variable data collection, and its being relatively low-stress to the bee colony.

The design will be expanded to include a transparent recessed floor (see: Fig. 2) to house sensors to track temperature, humidity, barometric pressure, and sunlight intensity both at the entrance and rear of the hive. It will also

have microphones and a low-light camera for recording hive activity. This floor will be partitioned off to prevent bees from interacting with the electronics.

### Prior Work

This project is an extension of the author's previous work, building instruments and furniture with embedded sensors and speakers using a customized image of Raspbian<sup>5</sup> initially compiled for his dissertation work<sup>2</sup> and incorporating upgrades established in his work on "Women's Labor".<sup>8</sup>

Building from this established platform allows for faster development as well as easier integration with these preceding projects. In addition to monitoring the hive's health, using an ad-hoc connection this data can also be used to manipulate timbral parameters in the previously mentioned furniture instruments. This would allow for both an artistic sonification of the hive's data as well as a passive monitoring system for the beekeeper.

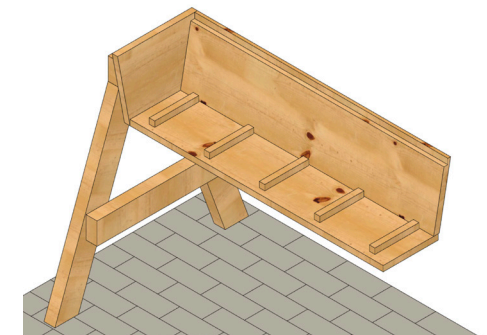


Fig 2. Recessed Floor will house electronic sensors, 2021.

## Technical Requirements

The hive will be built around a Raspberry Pi<sup>6</sup> using the above mentioned image. The author is currently refining Python code to connect the single-board computer to two SparkFun BME280<sup>10</sup> for temperature/humidity/pressure tracking, two Adafruit electret microphone boards<sup>1</sup> for audio recording, and a Pi-NoIR camera<sup>7</sup> for creating time-lapse videos.

This will ideally be renewably powered, using a battery power source<sup>4</sup> charged by a solar panel<sup>9</sup> mounted to the hive's roof.

## Anticipated Road Blocks

The author is actively researching whether the electronic sensors will be a disturbance to the hive because bees are sensitive to electromagnetism. The act of monitoring the hive's health may, in itself, be a detriment to said health. By reaching out to apiary science departments to get more information it should be possible to determine if the 5V electronics will be low enough in intensity to be negligible to the colony, or if the negative effects can be easily mitigated using shielded wiring.

## References

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[9] "Solar Panel Charger," accessed August 20, 2021. <https://www.sparkfun.com/products/16835>.

[10] "SparkFun Atmospheric Sensor Breakout," accessed August 20, 2021. <https://www.sparkfun.com/products/13676>.

## Weblink

Development Repository: <https://gitlab.com/blessing5150/beehive>

## Author Biography

Matthew Blessing is a composer, guitarist, and music technologist.

He graduated in May of 2021, receiving a doctorate in Experimental Music & Digital Media from Louisiana State University, with research exploring unique human-computer interfaces focusing on musical expression. Matthew's most recent work involves the design and digital fabrication of embedded instruments, with a heavy interest in allowing performative music to be more commonplace in the home. These instruments run on embedded Linux CPUs, such as the Raspberry Pi, connected to a variety of interactive sensors, amplifiers, and audio drivers.

Matthew previously received his masters degree in Global Composition from San Diego State University and bachelor degrees in Music Composition/ Theory and Classical Guitar Performance from Southern Illinois University-Carbondale.

# Sounding Numbers: empowering communities through artistic practices

**Crozzoli, Miguel Angel**

Rhythmic Music Conservatory, Copenhagen.  
miguelcrozzoli@edu.rmc.dk

## Abstract

In this project, I investigate the connection between science focused on sustainability and experimental composition and sound-art. The goal of Sounding Numbers is to increase community engagement and knowledge through the emotions that art awakens.

The first piece of this project is called 'I AM THE FOREST', where I worked with data from Global Forest Watch, an organization that offers data, technology, and tools to empower people. At the moment I'm developing my second series of works for Sounding Numbers, called 'I AM THE OCEAN'. In this piece, I use data from Sentinel-3 satellite from ESA, whose mission is to study the health of our marine biodiversity.

My ambition is to build a bridge between art and science, as I believe that the resulting artwork is a powerful dissemination tool that can actively engage communities under unexplored world views, creating new possibilities and understandings for a better society.

## Author Biography

I'm conducting research at the Soloist degree at the Rhythmic Music Conservatory in Copenhagen. This program represents the highest artistic level one can reach in Denmark, where I investigate new materialities and methods in the arts for participatory community artwork. As an artist, I always seek the limit of knowledge and beyond using sound as a tool to communicate through emotions. My language has always been deep and full of complexities but I strive for accessibility. I found my craftsmanship through research, so I immersed myself in many studies to materialize my desire for action. On this path, I released +21 records and founded and directed an organization to develop creative arts in connection to art activism.

## Weblink

[http://crozzoli.com/?page\\_id=226](http://crozzoli.com/?page_id=226)



## Sounding Climate: Exploring Climate Change Through Music and Maps

### Abstract

Art forms such as music and animation are ideal media to communicate the progression of human-caused climate change. In developing the *Sounding Climate* museum exhibit and web-based interactive, we sought to showcase climate model predictions of how temperature, precipitation, and Arctic sea ice are expected to change in the future under rising greenhouse gas concentrations, using an integrated auditory and visual experience. Engaging the senses while exploring the unfolding story of climate change has proved to be a powerful means of communicating the science behind the story and of conveying the urgency of preventative action. In this paper, we outline how our multidisciplinary team of artists, scientists, and others developed *Sounding Climate*, provide background information about the model data that we used, and share ideas for future work in which we invite others to collaborate and expand this unique experiential resource.

### Creating *Sounding Climate* in a Museum Exhibit and Online Interactive

To communicate anthropogenic climate change and natural climate variability, we used data produced by one of the world's leading climate models. We assigned a musical sound and color to each data point, and then portrayed these in the form of animated maps that combine both sound and color. The resulting sonifications and visualizations are featured in an interactive museum exhibit for public visitors at the National Center for Atmospheric Research (NCAR) in Boulder, Colorado (US).

Exhibits and public programs at NCAR attract nearly 100,000 visitors each year. In addition to *Sounding Climate* (Fig 1), exhibits about weather, climate change, air quality, Sun-Earth connections, the lab's architecture, the

layers of the atmosphere, supercomputing, and art are available in the public spaces within NCAR's Mesa Lab Visitor Center.



Fig 1. The *Sounding Climate* exhibit at NCAR in Boulder, Colorado (US)

Since the *Sounding Climate* exhibit debuted in 2018, we recognized the need for a web-based version that would reach an audience beyond our public visitors. During the 2020-2021 academic year, we collaborated with students in the University of Colorado's Computer Science Capstone Course to develop the web-based version of *Sounding Climate*. The students - Garrett Hempy, Priyanka Karki, Mattias Leino, Fahed Shaik, Nick Vomund, and Zhaoyi Xie - all had backgrounds in both computer science and music. The web-based version required new programming and less bulky data in order to be usable online. The web-based interactive was completed in April 2021 and is available at <https://listentoclimatechange.com/> (Fig 2). Accessibility features were added, including a dropdown menu of locations that users could select from in lieu of choosing a point on the map directly.

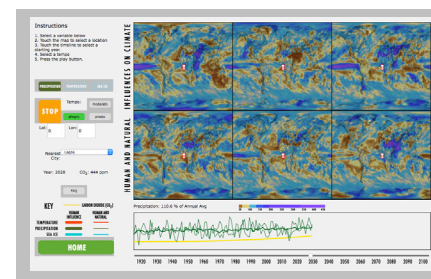


Fig 2. The *Sounding Climate* web-based interactive

### Utilizing Data from an Earth System Model

In *Sounding Climate*, sonification and visualization of model data provides the public with novel ways to understand climate change. The model data consist of forty simulations of Earth's climate from 1920 to 2100 under historical and projected "business as usual" scenarios for greenhouse gases, which are the results of the Community Earth System Model (CESM) Large Ensemble Project (Kay et al., 2015). We emphasize that these data are the same as those used in the Nobel prize-winning scientific reports of the Intergovernmental Panel on Climate Change (IPCC). The resulting sonifications and visualizations allow users to explore how precipitation, temperature, and Arctic sea ice change over time at any particular location, which they select. The animated maps and graphs in *Sounding Climate* include information on both the human-induced component of climate variability and change, as well as the natural component.

### Sonification of the Data

Sonification, using sound to understand data, can be a powerful tool for comprehending complex datasets and is especially helpful for conveying the temporal dimension and continuity of climate change. By linking model data to sound, visitors hear musical instruments that represent different aspects of climate (temperature, precipitation, carbon dioxide, and sea ice). The notes played by each instrument depend on the data values. Higher pitched

sounds are used to represent higher values. Lower pitched sounds are used to represent lower values. The musical scale changes from major to minor as carbon dioxide increases, heightening the emotional response elicited from the user. A graph of the sonified data at the selected location appears on the interactive screen as the music plays, representing change over time. The animations can be played at a variety of tempos, selected by the user. Sampled instruments (marimbas, clarinets, piano, and violins) were used for the museum exhibit, while synthesized tones generated from the "Tone.js Web Audio framework for creating interactive music" were used for the web-based version.

### Animated Map-based Visualizations

Visualization, associating color with values, can aid understanding of the spatial variability of climate data. *Sounding Climate* includes animated map-based visualizations of the model data, providing geographic context and making the entire dataset visible while the audio plays for a particular location. Visitors can compare maps of the human influence on climate and maps that show human and natural influences together, allowing visitors to get a visual sense of the extent of the anthropogenic influence on climate change.

### The Need for a Multidisciplinary Team

Creating the *Sounding Climate* interactive exhibit and informational wall panels for the NCAR museum, as well as the web-based version of the interactive experience, required diverse skills and thus collaboration by a multidisciplinary team. Climate scientists, a sound artist, data visualization experts, science educators, writers, a programmer, graphic designers, exhibit fabricators, and the computer science students all contributed to the development of *Sounding Climate*.

The team also included members who have interdisciplinary interests. For example, the sonification idea behind *Sounding Climate* was first conceived by climate scientist Dr. Clara Deser as she sang in a chorus and recognized the possibility of using music to convey the temporal dimension of climate change. She

approached sound artist Marty Quinn, who immediately embraced the idea, and applied his technical and musical skills to the project.

### Context and Novelty

While sonification of climate data is not new per se (see, for example, Fillella 2018; Hermann et al., 2011; Kruczkiewicz, 2018), the interactive and integrated sensory nature of *Sounding Climate* sets this project apart from previous efforts as far as we are aware. In particular, no other project has combined animations of global maps of historical and projected changes in temperature, precipitation and Arctic sea ice computed by a state-of-the-art global climate model with sonifications of these same data, and packaged them together into an interactive web-based tool for exploring climate change. *Sounding Climate* does not “tell” the user what climate change is; rather, it allows the user to find out on their own what climate change is: how it varies geographically and temporally, how it manifests differently in temperature, precipitation and Arctic sea ice, and how it is expressed within the envelope of natural climate variability (indeed, this latter point is often overlooked in the climate change discourse).

That said, the sonifications in *Sounding Climate* are quite primitive when compared with more sophisticated approaches that go beyond simple parametric coupling such as Model-Based Sonification or Wave Space Sonification [see the comprehensive overview in *The Sonification Handbook* (Hermann et al., 2011)]. These non-parametric strategies may uncover latent patterns in the data that are not apparent with the current sound design, and should be explored in future versions of *Sounding Climate*.

### Future Possibilities

We are looking for ways to extend *Sounding Climate* in the future. Currently the sonifications and visualizations are based on one scenario for projected changes in greenhouse gases, which assumes no mitigation efforts; however model output also exists for other scenarios which differ in how quickly humans make adjustments

to slow or stop emissions. A version that allows users to compare scenarios could communicate how our actions will affect future climate. Additionally, similar interactives could focus on other environmental impacts such as air quality, wildfire, rainfall extremes, floods, and sea level rise, which are also calculated by the model. All of the data from the NCAR climate model are publicly available. Another idea for extending *Sounding Climate* is to automatically transcribe the sonifications into musical notation, enabling live performances of humanity’s effects on climate. We welcome others who are interested in building upon *Sounding Climate* to be in touch with our team.

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## CASTED: A Physical and Conceptual Framework for Interdisciplinary Discourse on Ecology and Technology at the Intersections of Art and Science

### Michael Just

PhD Candidate, City University of Hong Kong, School of Creative Media

Founder, Michael Just Studio, Berlin

<https://www.mjust.com>

<https://www.casted.at>

### Abstract

I present CASTED - Center for Aesthetic, Social, Technological and Ecological Discourse. In doing so, I in part address the general topic of the conference from a meta-perspective: I discuss the philosophical implications, politics, potential ramifications and challenges of a development that aims at facilitating a sustained discourse that is in close connection to the conceptual orientation of DACA. The project is likewise located in close vicinity to Graz as one of the conference’s physical and institutional locations.

CASTED is an interdisciplinary residency currently being developed in south-east Austria on a property left to me by my grandparents. It aims to bring together artists, designers, architects, urbanists, cultural producers, thinkers, philosophers and scientists (as well as non-human participants) to reflect upon fundamental questions facing the planet. The small-scale organization takes a posthumanist position and puts a particular emphasis on thinking the human as embedded in ecological and technological networks and interdependencies. It provides a forum for rethinking questions concerning human-animal

relationships, ecology and agriculture, human and non-human actors, labor and automation, life and biotechnology, and the multiplicity of implications opened up through advances in technology and computer science. It is as much concerned with the production of knowledge as with the dissemination thereof and hence puts a strong emphasis on collaboration with local and international universities and institutions.



Fig. 1 CASTED, Geographical Location, Rohr im Burgenland, Austria



Fig. 2 CASTED, Physical location and surrounding environment, Rohr im Burgenland, Austria

My submission is neither a paper nor an artwork, rather it is an outline of and approach to how a micro-institution concerned with high-level knowledge production can be established and sustained. As such, it would lend itself to both tracks in that it could either be a presentation and poster, emphasizing its conceptual and philosophical as well as technical dimensions. Or it could be a video, as in an animated modeling sequence combined with footage taken on site that visualizes the architectural approach alongside descriptive voiceover. Of course, it could also be both. I give two examples of such animations in the following, both were developed at my studio using C4D and Unreal Engine 4. They are not related to DACA in any way but give a visual impression of the technology used:

<https://youtu.be/CN6wOCJtQ4M>

<https://youtu.be/5W2bBVUFKxI>

In my presentation, in whichever form it would ultimately be, I intend to focus on the following topics:

- Background and motivation: How was the location chosen and how is its concept significant?
- Posthumanism, Animality and Technicity: Rethinking Ways of Coexistence
- Interdisciplinarity, Art and Science
- Nature and the Technosphere

- Architecture not as Form but as “Formative Differentiation” (Massumi 2019), Fields and Forces

- Practicalities: Funding, Sustaining, Participants, Production and Dissemination

- Potential Collaborating Institutions

### References

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### Weblinks

<https://youtu.be/CN6wOCJtQ4M>

<https://youtu.be/5W2bBVUFKxI>

### Author Biography

Michael Just (born 1979, Frankfurt/Main, Germany, German and Austrian citizenship) is an interdisciplinary artist based in Berlin, Germany, southeast Austria and Hong Kong. He studied Fine Art at the Kunstakademie Düsseldorf with Daniel Buren (Master/Meisterschüler 2007), received an MFA in Art Practice from Goldsmiths, University of London, UK (2009) and participated in the Whitney Museum Independent Study Program in New York City, USA (2010/2011). He is

currently pursuing a PhD at the City University of Hong Kong, School of Creative Media.

He was a DAAD Postgraduate Fellow (2007/2008) and a recipient of the EHF-Fellowship, Konrad-Adenauer-Foundation (2007/2008). Residencies include the Palazzo delle Arti Napoli, Italy (2010), Villa Aurora Los Angeles, USA (2012), Dongcheng District Beijing, China (2017), the National Museum of Modern and Contemporary Art Seoul, South Korea (2018), 16×16, Lagos, Nigeria (2020) and the Agder Center for Contemporary Art, Kristiansand, Norway (2021). He was the recipient of the Deutsche Bank Prize for Emerging Sculptors (2005) as well as several project grants from the DAAD, Incontri Internazionale D'Arte, the J.F. Costopoulos Foundation, the Goethe-Institut, the Konrad-Adenauer-Foundation, Institut für Auslandsbeziehungen (IFA), Kunstfonds Bonn and Senat Berlin. He has taught and lectured in North America, Europe, Africa and Asia.



## Visualising the ancient Maya and environmental change

**Benjamin Keenan**

Dept. of Earth and Planetary Sciences, McGill University  
benjamin.keenan@mail.mcgill.ca

**Timothy Thomasson**

Dept. of Design and Computation Arts, Concordia University  
timothythomasson@gmail.com

### Abstract

We are developing a method to visually express the responses by the ancient Maya population to climate change through digital art. The lowland Maya adapted to their changing environment in different ways, and are thought to have abandoned their cities in response to a devastating drought around 730-900 CE. This pilot project aims to convert geochemical data and the archaeological site of Itzan into a high fidelity visualisation using 'game engine' technology to represent the changing population, vegetation and climate of the ancient Maya population over 6000 years. The project moves beyond conventional data visualisation to create an affectual experience that enables new ways for spectators to engage with complex patterns found in scientific data.

### Proposal

The research uses a range of geochemical proxies applied to a lake sediment core from Laguna Itzan, a cenote adjacent to the ancient Maya population centre of Itzan, including population (faecal stanols) and biomass burning (polycyclic aromatic hydrocarbons or PAHs) with isotopic analyses of plant wax n-alkanes as proxies for vegetation change.

The work demonstrates the complex interplay of environmental and societal changes over 6000 years. The data indicate that human population dynamics and patterns of land clearance for agriculture varied substantially, and that climatic change may have largely driven these patterns. Here, our artwork begins to fill the imaginative gaps—exploring the possibilities of narrative that stretch deep into that past.

The site of Itzan has been mapped with elevation data and archaeological findings. We will use this map alongside images of this site to meticulously re-create the environment digitally. Using real-time computer graphics

technology found in 'game engines' we will be able to simulate the shifting climate patterns extrapolated from the collected data. The computer-generated images will run synchronously with the data from the real site in Itzan accelerated over the course of 6000 years. The data becomes both representational and affectual, as the spectator witnesses thousands of years shifting before them; with day and night cycles, rain, wind, population, and vegetation all being simulated in real-time. alkanes as proxies for vegetation change.

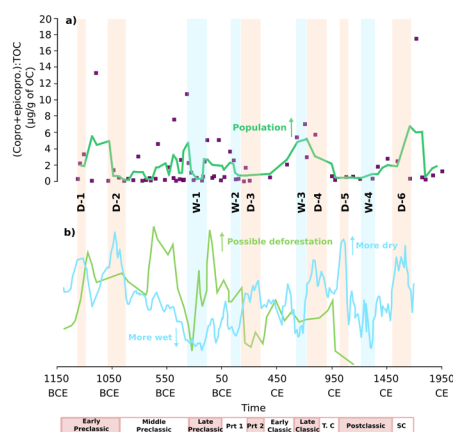


Fig 1. Environmental and demographic change over time. a) population change inferred from faecal stanols, and b) deforestation and climate change (Keenan et al. 2021).

This simulation is not a pre-recorded video with a definitive duration, but rather an application that is calculating each frame of the moving image in real-time. This means that the simulated environment that is being produced can be reactive, and interactive—constantly shifting between minutes, days, months, years, decades, and so on. The simulation is then creating the sense of a 'living' world full of strange possibilities and potentialities, as the algorithmic contingencies drawn from real-

world Itzan data are able to run their course in this digital space. This aliveness of the moving image occurs when the system becomes inhabited by real data from the natural world. Itzan becomes an unpredictable system imbued with high levels of variance and possibility. We can imagine the complex interplay between the human, non-human, and constant shifting and manipulation of the environment from a changing climate. Because of the work's vast timescale and carefully crafted imagery and simulation, the project moves far beyond a simple didactic representation of data toward something more obscure—where spectators are left to contemplate their relationship to the broader histories and possibilities of a past, present, and future earth.

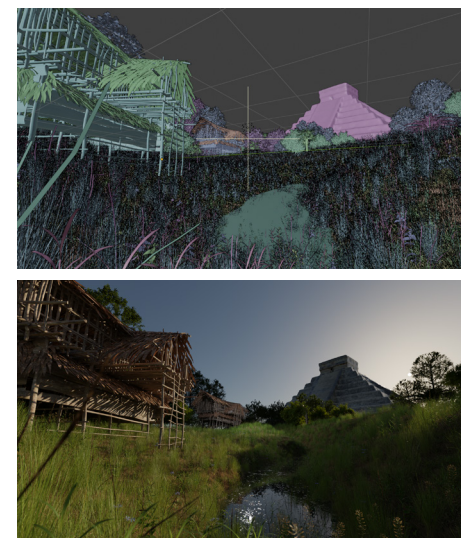


Fig 2. Proof of concept, 2021, Timothy Thomasson and Benjamin Keenan, computer generated image. Above: Computer-Generated Concept Image (Non-Rendered, viewport). Below: Computer-Generated Concept Image (Rendered)

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### Weblink

<https://drive.google.com/drive/folders/1nnuVF3aCT4Gpv0v1HGK9Lpr9INCskoUU?usp=sharing>

### Author Biographies

Benjamin Keenan is a biogeochemist using a combination of geochemical proxies applied to lake sediment cores to reconstruct changing climate, population, vegetation, and fire use over 3300 years around the ancient Maya population centre of Itzan, in the southwest Maya lowlands in the department of Petén, Guatemala. Benjamin is interested in the interaction between humans and their environment, migration as an adaptive response to climate change, and how perspectives from the past can inform responses to anthropogenic climate change. Benjamin's work has been covered by CBC, Radio Canada, Global News, CTV, Haaretz, Daily Mail, El Mundo, Archaeology Magazine, National Geographic, DW, Numerama, RT, Superinteressante, El Ciudadano and Le Climatoscope.

Timothy Thomasson is a digital artist based in Montreal. He primarily works with computer animation, and utilizes real-time technologies in many of his works to create continually generative environments and systems. Thomasson holds a BFA and MDes (expected 2021) from Concordia University in Design and Computation Arts. His work has been presented in various galleries and festivals in Montreal including during Nuit Blanche (2018), Montréal arts interculturels [MAI] (2018), MUTEK\_IMG at Center Phi (2018), Société des arts technologiques [SAT] (2019), Anteism (2021), Eastern Bloc Sight and Sound (2021), MUTEK (2021), ELEKTRA (2022), as well as at the Toronto Animation Society (2021), and The International Art Exhibition for New Technology [NTAA] (2022) in Ghent, Belgium



## Data Design From Below: CogniCity OSS in Urban Asia

**Nashin Mahtani**

Director, Yayasan Peta Bencana  
[nashin@petabencana.id](mailto:nashin@petabencana.id)

**Etienne Turpin**

Co-founder, CogniCity OSS  
[etienne@anexact.org](mailto:etienne@anexact.org)

### Abstract

CogniCity is a free and open source software for community-led disaster response and recovery in highly dense urban environments. Designed, tested, and operationally deployed in Southeast Asia's monsoon flooding, the system uses a novel humanitarian chatbot model to crowd-source disaster information through social media channels and then gathers, sorts, and displays these solicited reports in real-time on a web-based, mobile-centric map. The system operates as critical urban infrastructure that enables robust, reliable information sharing and communication among civilian residents, government agencies, and first responders.

Following successful deployments in Jakarta, Bandung, Surabaya and Semarang, CogniCity was expanded to the national scale in Indonesia and developed for additional hazards including volcanoes, earthquakes, typhoons, fires, and severe weather. Major pilot deployments are also underway in the Philippines and Vietnam, and numerous other test instances have been developed and deployed in other cities, including Hong Kong, to examine the potential for further development. As a crowdsourcing system that goes far beyond passive data mining, CogniCity is an enterprise-level software product for soliciting emergency information and displaying heterogeneous data in a synthetic, accessible format.

In this presentation, the authors will discuss their data design methodology as a “work in progress” that is constantly open to innovation, testing, and rethinking and redesign in new geographies. CogniCity researchers apply a wide range of expertise and attendant skill sets to the project, from anthropology and artistic research to systems engineering and statistics, as well as design, human and physical geography, hydrography and hydraulic network modelling, programming and UX/UI development, among many other disciplinary initiatives. They create a process whereby social science and design research approaches both compliment and inform the technical development of the code, and continually facilitate grassroots, community-led, street-level engagement and refinement of the system. Every element of the software, including humanitarian chat bots, web-based maps, and disaster-specific features, are built through a comprehensive co-development *process* with residents, experts, disaster managers and first responders. This methodology has allowed CogniCity to grow and flourish and ensured inclusive, community-led, user-centric design for every aspect of the project. As a pathbreaking example of design anthropology informing software development, CogniCity is an open system that is continuously improved through users' participation in the testing and prototyping of alternative social and technical approaches to information accessibility, resource distribution, and mutual aid.

### Weblink

<https://cognicity.info/>

### Author Biographies

Nashin Mahtani is an architectural theorist and designer, investigating the interplay of software aesthetics, ecological governance, and social behaviours to advocate for environmental justice. She is the director of Yayasan Peta Bencana [Disaster Map Foundation Indonesia], where she leads a multidisciplinary design research team in developing humanitarian infrastructures for climate adaptation.

Etienne Turpin is a philosopher, founding member of the design research practice anexact office, and co-founder of the open source software project CogniCity. He has worked as a Research Scientist at MIT, a Postdoctoral Fellow at Australia's Smart Infrastructure Facility, and held numerous teaching and research positions in the Higher Education Industry.

## Touching the Global Warming

Jean-Pascal Martin

jeanpascal.martin+daca@gmail.com

### Abstract

Sculpting global temperature measurements allows to make global warming perceptible and tangible. We therefore propose to project in a cylindrical coordinate system the global average monthly temperatures from 1901 to 2020, and to produce sculptures to facilitate the direct appreciation of the orders of magnitude and their evolution in time.

### Sculpting data to make it tangible

The sculptures offer a natural and immediate perception by their shape, size, or reaction to light. The estimation of their mass and its distribution is also intuitive. The feeling of balance or proportion allows us to appreciate it without thinking. The observation of the roughness or the shine lets us imagine its material, its resistance and its solidity.

The sculptures can be appreciated from many angles as one moves around them. Everyone can observe how the light reacts with the surfaces to refine the representation they make of them. The viewer can interact with it through movement. In a third time, he can touch it, notice its heat, its granularity, its solidity and check its weight.

A sculpture provides information in perceptual form, and sets the stage for a conceptual understanding in which trends and orders of magnitude are correctly perceived.

### Touching global warming

The 6th IPCC Assessment Report confirms it, an average global warming of more than 1°C is observed compared to 1901. In order to make this evolution perceptible, a physical representation determined in a cylindrical coordinate system ( $\rho$ ,  $\phi$ ,  $z$ ) is proposed. The years are on the  $z$  axis, the months on  $\phi$  (the months are separated by 30°) and the

temperatures are on  $\rho$ . The values of  $\rho$  are determined with respect to the year 1901, which is used as a reference year. Several versions were produced by 3D printing (Fig 1).



Fig 1. *Ascendance(s) 2018*, 2018, Jean-Pascal Martin, PLA sculptures obtained by 3D printing and painted, Copyright France n°5C3Z1M8.

Global average monthly data from 1901 to 2020 were used to produce *Ascendance 2021* (Fig 2), a 62.5 cm high sculpture made of fiberglass and concrete.



Fig 2. *Ascendance 2021*, 2021, Jean-Pascal Martin, fiberglass and concrete sculpture, Copyright France n°5C3Z1M8.

To ensure the overall fluidity of the form, intermediate values are calculated by B-spline interpolation algorithm. During construction, a manual smoothing is carried out by laying cohesive strips that cover the different layers. Fiberglass and resin consolidate the work. A concrete base ensures the stability of the whole while underlining the human origin of the represented phenomenon.

Other versions are being designed, based on regional data (France, Austria, Hong Kong, Svalbard). Other materials (PLA, solid wood, aluminum) and other sizes will be proposed.

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- [https://en.wikipedia.org/wiki/Cylindrical\\_coordinate\\_system](https://en.wikipedia.org/wiki/Cylindrical_coordinate_system)

### Author(s) Biography(ies)

Jean-Pascal Martin is an artist working with open data. He proposes sculptures and digital works questioning the spectators on the

evolution of the world. He sculpts global warming, destruction of biodiversity, ecological footprint of countries and paints the pollution of our cities.

As a passionate coder, he devotes his personal time on applying generative design algorithm to Data Art, mainly with environmental data set. He use data set to design paints, sculptures or to produce music.

Jean-Pascal Martin has a PhD in Cognitive Sciences applied to semiotic description of audiovisual content. He defined the tetrahedral sign which is a cognitive representation necessarily composed of a signified and a signifier and possibly of intensional and extensional referents.

As a professional, Jean-Pascal is committed to improving communication efficiency and user experience, and is passionate about lowering the carbon impact of digital services.

## GaiaSenses: mobile application for generating audiovisual compositions from planetary platforms

A. Moroni<sup>1</sup>, J. Ramos<sup>1</sup>, J. Manzolli<sup>2</sup>, P. Coltri<sup>3</sup>, R. Gonçalves<sup>3</sup>, J. Zullo Jr.<sup>3</sup>, B. Baily<sup>3</sup>, B. Veloso<sup>3</sup>, A. Cardoso<sup>4</sup>, P. Martins<sup>4</sup>, C. Dezotti<sup>5</sup>, G. Kuae<sup>5</sup>, T. Cardoso<sup>5</sup>, R. Shen<sup>5</sup>, E. Nascimento<sup>6</sup>, T. Lacerda<sup>6</sup>, I. Rigue<sup>6</sup>

<sup>1</sup>DISCF/CTI Renato Archer

<sup>2</sup>IA-NICS/University of Campinas

<sup>3</sup>CEPAGRI/University of Campinas

<sup>4</sup>DEI/University of Coimbra

<sup>5</sup>FEM/ University of Campinas

<sup>6</sup>IC/ University of Campinas

[Artemis.Moroni@cti.gov.br](mailto:Artemis.Moroni@cti.gov.br), [Josue.Ramos@cti.gov.br](mailto:Josue.Ramos@cti.gov.br)

[Jonatas@nics.unicamp.br](mailto:Jonatas@nics.unicamp.br)

[pcoltri@cpa.unicamp.br](mailto:pcoltri@cpa.unicamp.br), [renata@cpa.unicamp.br](mailto:renata@cpa.unicamp.br), [jurandir@cpa.unicamp.br](mailto:jurandir@cpa.unicamp.br), [bkbainy@cpa.unicamp.br](mailto:bkbainy@cpa.unicamp.br), [bfveloso@unicamp.br](mailto:bfveloso@unicamp.br)

[amilcar@dei.uc.pt](mailto:amilcar@dei.uc.pt), [pjmm@dei.uc.pt](mailto:pjmm@dei.uc.pt)

[cassio dezotti@gmail.com](mailto:cassio dezotti@gmail.com), [g172508@dac.unicamp.br](mailto:g172508@dac.unicamp.br), [t244540@dac.unicamp.br](mailto:t244540@dac.unicamp.br), [r205612@dac.unicamp.br](mailto:r205612@dac.unicamp.br)

[e233840@dac.unicamp.br](mailto:e233840@dac.unicamp.br), [t244712@dac.unicamp.br](mailto:t244712@dac.unicamp.br), [i234618@dac.unicamp.br](mailto:i234618@dac.unicamp.br)

### Abstract

Finding creative ways to put climate change in the spotlight is essential to motivating the participation that drives action. This proposal presents a collaborative project for the development of a mobile application, GaiaSenses, accessing planetary bases for the generation of audiovisual works. Such compositions will be created from data from the local region and will serve as an alert for local climatic conditions in relation to the plants. The compositions can be shared through social networks, eventually triggering actions to protect biodiversity. The GaiaSenses project has a strong potential to join efforts, generate synergies and contributions in the scientific, technological, artistic and social contexts. GaiaSenses' team is composed by researchers and students.

### The Proposal

We are responsible for the changes taking place in the world. We are concerned about deforestation actions and the consequent environmental imbalance caused by the loss of native vegetation. The removal of vegetation

causes a significant loss of biodiversity as well as the loss of habitat for animals and plants and directly affects the increase of endangered species. From an exploration of what came before (that is, History), while encompassing fundamental respect for life, what are we saying and doing, and how do our ideas and actions affect and reflect the world we inhabit?

GaiaSenses project adopted the Gaia myth as inspiration: Gaia is the Earth's personification, the ancestral mother of all life. The Gaia Paradigm proposes that living organisms interact with their inorganic surroundings on Earth to form a synergistic and self-regulating, complex system that maintains and perpetuates the conditions for life on the planet (Lovelock, 2007).

### Plant as Individual: GaiaSenses Concept

What do plants need to evolve or, at least, to survive? They need favourable climatic conditions to grow and thrive. For each stage of a plant's biological lifecycle (seed, germination, growth, reproduction, pollination, and seed

spreading), there are specific factors (e.g., temperature range, rain, sunshine) that are suitable to sustain their lives. If the environmental conditions are not adequate, such as extremely high temperatures, plants inhibit their physiological system's natural functioning. Therefore, understanding how plants respond to all these ecological conditions is essential to recognising their growth and interaction with other species. In this context, meteorological satellites can measure many of these conditions - such as the GOES-R (2021) the data collector of the GaiaSenses (CEPAGRI, 2021).

GaiaSenses proposes the development of a mobile application, through which people will daily receive audiovisual artworks created with data from their local region (Barth et al., 2020), concerning the local conditions regarding plants. GaiaSenses' team is composed by researchers and students.

### Conclusion

GaiaSenses project connects the botanical, the individual and the social worlds. Emphasises the humanisation of technology in an e-ecological network. GaiaSenses connects planetary scale platforms and geophysical locations with a system for creating generative artworks concerning the embodied and sensitive environment of the plants, resulting in a mobile application. A teaser is available at ([GaiaSenses, 2021](#))

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## The Sound of Clouds and other Environmental Memories

Joel Ong

Sensorium: Centre for Digital Art and Technology, York University  
joelong@yorku.ca

### Abstract

*The Sound of Clouds and other Sonic Memories* is an ongoing project that collects oral narratives/recollections of your earliest or most poignant sound memory. Arising from a dissatisfaction in the ocular-centric nature of memory - where events of value in our past are often supplanted by single photographs and videos - the project creates an archive of an audible past, to engages in creative processes around these fragments of memory. This was initiated through a residency at the UCLA SciArt centre and was focused at its onset on the memories of environmental sounds. For DACA, this project presents an alternative archive for environmental consciousness, focusing on the qualitative and allowing us to attend to the affect, community and accountability through sound. It presents a work in progress as a series of audio anecdotes and sound clips, as well as provides an opportunity for discourse around quantification, reduction and extraction of environmental data.

### Background

For some time now, I have been listening to descriptions of sonic memories of people I meet through informal conversations and the occasional interview. Some of this process has been formalized in my teaching at the University of Washington (2014-16) in electro acoustic music composition, and in workshops that I have conducted around alternative interpretations of the term 'resonance' since 2016. In 2012, I volunteered as assistant for the Blind Cafe in Seattle, advertised as a transformative experience where sighted and non-sighted patrons were invited to share a meal and enjoy music together in total darkness. This meant optically conditioning the entire dining hall to

block out any and all light prior to the meal. The week before, at one of the volunteer training sessions, we listened to instructions from the head waitress on how to best navigate and serve (often petrified) guests in the darkened space. She is blind, and as she gave advice to a room full of sighted volunteers about walking around tables by listening to incidental sounds of the chairs, calculating proximity and space with her voice, feeling shifts in temperature around food and people, I realized how imbalanced and impoverished my sensorium had been, and I was overwhelmed with a feeling of respect and appreciation for her heightened sensibilities. When it came to question time, I waited patiently to ask mine - "what is your favourite sonic memory?". She was a little taken aback by the question that came at the tail end of a string of logistical and budgetary conversations, but replied thoughtfully, almost in prose. I didn't take down what she said in its entirety, but I remember her saying it was the sound of rain, and in particular the sound of clouds that seemed to open up during a thunderstorm.

### Logistics

The project is divided into three parts:

1. an Oral interview where the person is asked quite simply 'what is their earliest/most poignant sonic memory'.
2. a Sculpting process where the interviewee provides a photograph of their ears. This is then sculpted in clay and attached to a binaural recording system
3. A Composition process where field recordings are then recorded through the binaural system and manipulated to create a composition that aligns with the sonic memory described.

The presentation of the work is malleable to adapt to different spaces. In the possibility of a site-specific presentation, a selection of 8-10 narratives are chosen, with listening stations for each spatially separated in the room, accessible through headphones to maximize the binaural effect. Online/virtual modes of presentation may include hosting of the narratives in Mozilla Hubs (or similar), and/or links to the archive on the webpage.

### Conceptual Considerations

The project arose from a dissatisfaction in the ocular-centric nature of memory, not least triggered by my own experience with my children, and seeing how my perception and memories of their early childhood were not only influenced but in certain cases entirely supplanted by digital photographs. The focus on intersubjective memory and text as a mediator for experiences, and its subsequent realization as an abstracted soundscape provides a strategy for collaborative and sonic "world-building" between interviewer and interviewee, between carbon-based and silicon-based memory databases, and between speech and *concrete* sounds (as in *musique concrete*)

The project also considers the increasing logic of extraction within paradigms of sonification and other data transduction techniques. Such 'extractive' mindsets have significantly contorted everything from colonialist discourses on land use/abuse and land sovereignty, the politics of surveillance and privacy even now where it regards to the sharing of personal information during the pandemic, even to emerging climate change mitigation efforts in examples such as the knee-jerk reflexes of carbon capture or geoengineering. This project approaches these within the lens of Dylan Robinson's *Hungry Listening* where his clarion call to "still your hungry listening" allows us to attend to the affect, community and accountability through sound. "Hungry listening prioritizes the capture and certainty of information over the affective feel, timbre, touch and texture of sound. Attending to affect alongside normative listening habits and biases allows us to imagine (or audiate) otherwise- to

develop strategies for different transformative politics of listening." (Robinson, 2020).

My considerations also extend self-reflexively to the process of interviewing as a form of extracting information for the project and in particular the internal evaluation of the veracity, appropriateness, and usefulness of the interviewee's comments to the project's aesthetic end goals. In such a project, ambiguity is welcomed, abstract prose and imageries form the basis of a communicative logic that is built on a shared poetics and not of information. Without the constraints of such teleological goals in place, these interviews aspire to be instances where memories that are valued by the individual can be amplified and appreciated for all their complexity.

My impetus for the project began in a profound experience of sonic narrative through the lens of a non-sighted individual and so a parallel concern that I hope to explore through this project is how much dis- and differing abilities factor into the curation of the interviews and the subsequent reception of the sound pieces. In addition, considerations of diverse demographics of race, geographical origin (that will lead to diverse sound memories), gender, and sexual orientation will play a role in the way this project will progress.

### Connection to DACA2022

This project was initiated through a residency at the UCLA SciArt centre and was focused at its onset on the memories of environmental sounds. For DACA, this project presents an alternative archive for environmental consciousness, focusing on the qualitative responses to the environment and the ways that these sounds reveal diverse experiences and engagement of climate change- such as through the recollection of natural disasters, the surprising advent of insect stridulation in an off-season, or the sound of wind that strikes a city that is not prepared for shifts in its local weather conditions. It presents a work in progress as a series of audio anecdotes and sound clips, as well as provides an opportunity for discourse around quantification, reduction and extraction of environmental data.

## Weblink

[www.arkfrequencies.com/the-sound-of-clouds-and-other-sonic-memories/](http://www.arkfrequencies.com/the-sound-of-clouds-and-other-sonic-memories/)

## Conclusion

By extending the well worked adage - 'take a walk in someone else's shoes' to include listening - 'listen through someone else's ears', the project asks - how do we hear through someone else's ears the same way we may imagine ourselves in someone else's shoes? Might we develop a deeper responsibility to the environment through the conservation of sounds that may be lost, or never again heard because of noisy anthropogenic changes to our soundscapes? How might we attend to the affect within each instance of listening, and create transformative politics of listening?



Fig 1. *The Sound of Clouds and other Sonic Memories*. Ongoing, Joel Ong, oral narratives/clay/sound. Copyright Joel Ong.

## Author Biography

Joel Ong (PhD, MSc. Bioart) is a media artist whose works connect scientific and artistic approaches to the environment. His recent works explore the visibility and audibility of ambient phenomena with a particular focus on the wind and the atmospheric microbiome. His individual and collaborative works have been featured at festivals and galleries internationally such as the Currents New Media Festival, Nuit Blanche Toronto, ISEA, the Seattle Art Museum, the Gregg Museum of Art and Design, the Penny Stamps Gallery, and the Ontario Science Centre. Joel is an alumni of SymbioticA, the Centre of Excellence in Biological Arts in Perth, Western Australia, and holds a PhD from DXARTS at the University of Washington. He was a recipient of the Petro-Canada Young Innovators Award in 2020 and was Artist in Residence with the UCLA SciArt Centre's "Atmospheres of Sound" project in 2021. He is Assistant Professor in Computational Arts and Director of Sensorium: The Centre for Digital Arts and Technology at York University in Toronto, Canada.

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