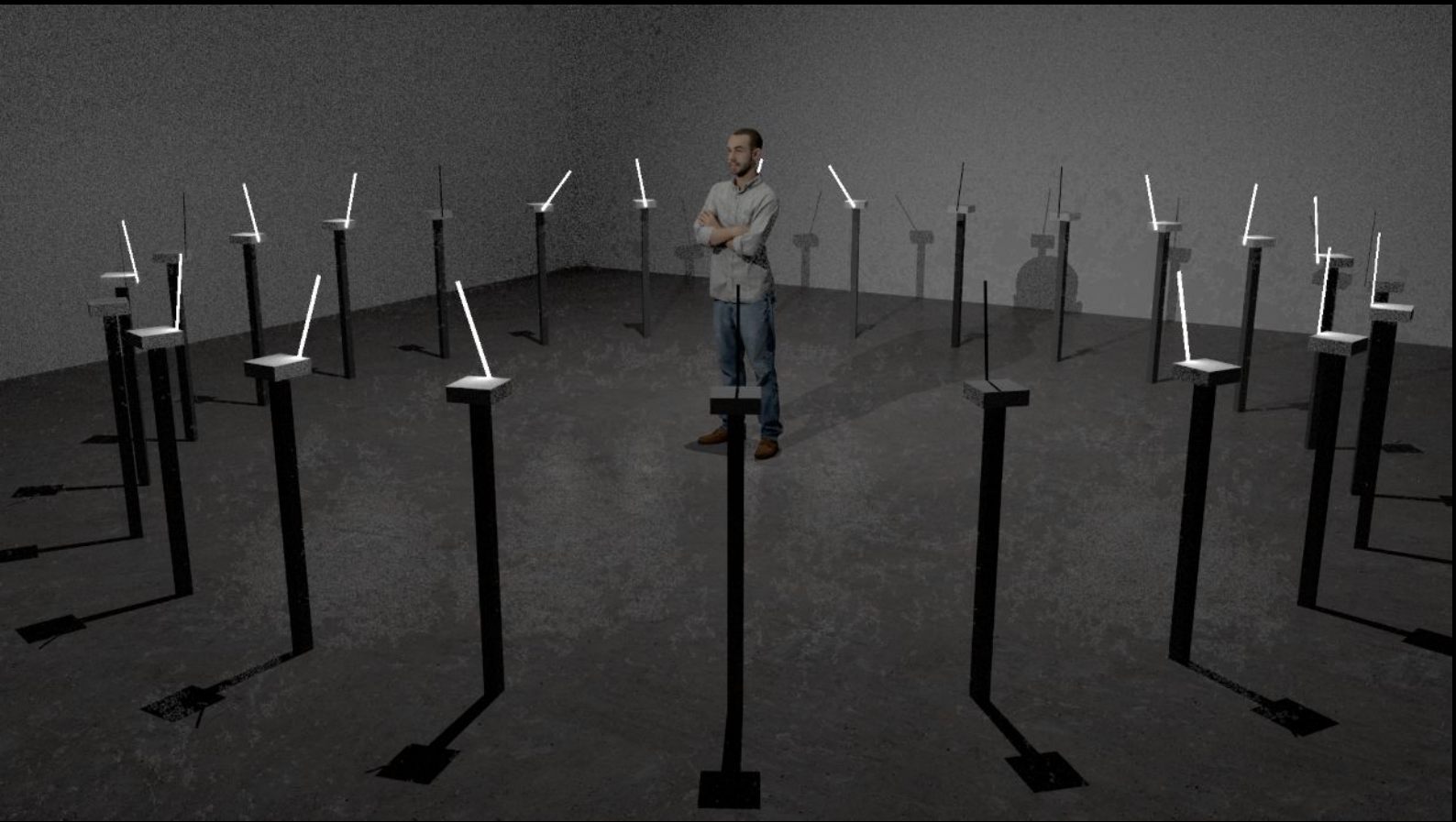


# The Tipping Point

*Data-driven Light & Sound Kinetic Installation*



A proposal for a data-driven light & sound kinetic installation for JRC SciArt

Artist: Yiannis Kranidiotis — Scientist: Frank Dentener

# The Tipping Point

(Working Title)

*Data-driven Light & Sound Kinetic Installation*

Artist: Yiannis Kranidiotis

Scientist: Frank Dentener (European Commission, Joint Research Centre)



## The Problem

UN Secretary-General Antonio Guterres recently said, “...time is running out. Irreversible climate tipping points lie alarmingly close.”<sup>1</sup>

Greenhouse gases from human activities are the most significant driver of observed climate change since the mid-20th century<sup>2</sup>. As greenhouse gas emissions from human activities increase, they build up in the atmosphere and warm the climate, leading to many other changes around the world—in the atmosphere, on land, and in the oceans. Because many of the major greenhouse gases stay in the atmosphere for tens to hundreds of years after being released, their warming effects on the climate persist over a long time and can therefore affect both present and future generations.

A central objective of the European Green Deal<sup>3</sup> is to set out the trajectory for the EU to be climate neutral by 2050. As a milestone towards this target, the EU Commission proposed a 2030 target to reduce greenhouse gas emissions by 55 per cent compared to 1990.

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1 “Climate action: ‘Time is running out’, UN chief tells ministers”, <https://news.un.org/en/story/2021/09/1101772>

2 IPCC Sixth Assessment Report, <https://www.ipcc.ch/assessment-report/ar6/>

3 A European Green Deal, [https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal\\_en](https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en)

A tipping point is the point at which small changes become significant enough to cause a larger, more critical change that can be abrupt, irreversible, and lead to cascading effects. The concept of tipping points was introduced by the IPCC 20 years ago, but then it was thought they would only occur if global warming reached 5°C. Recent IPCC assessments, however, suggested that tipping points could be reached between 1°C and 2°C of warming.

**Here are the major climate tipping points.**

**Greenland ice sheet:** The Greenland ice sheet contains enough water to raise global sea levels by over 6m and its melting is accelerating. From 1992 to 2018, it lost close to four trillion tons of ice. While its disintegration is not likely to be abrupt, there could come a point beyond which its eventual collapse is irreversible for millennia.

**The West Antarctic Ice Sheet (WAIS):** The WAIS is vulnerable to collapse because it sits on bedrock below sea level and is affected by the ocean's warming. A new study<sup>4</sup> found that if the WAIS melted, it could raise sea levels three feet more than previous projections of 3.2m; Antarctica as a whole contains enough ice to raise global sea levels by over 70m.

**Atlantic Meridional Overturning Circulation (AMOC):** The AMOC is one of the main global ocean currents and is critical to regulating climate. Cold salty water, which is dense and heavy, sinks deep into the ocean in the North Atlantic, and moves along the bottom until it rises to the surface near the equator, usually in the Pacific and Indian Oceans. If the AMOC shuts down<sup>5</sup>, it would cause significant cooling along the east coast of the U.S. and Western Europe. This, in turn, would alter rainfall patterns, make sea levels rise, cause more drying, and reduce agriculture in the U.K. and in extended regions in Western Europe, that are now experiencing a relatively mild sea-climate.

**Thawing permafrost:** Permafrost is ground that remains frozen for two or more consecutive years and is composed of rock, soil, sediments, and ice. Some permafrost has been frozen for tens or hundreds of thousands of years. As it warms and thaws the permafrost<sup>6</sup>, microbes come out of hibernation and break down the organic carbon in the soil, releasing CO<sub>2</sub> and methane, which then trigger even more warming and melting. The 2019 Arctic Report Card from NOAA<sup>7</sup> found that the Arctic's thawing permafrost could be releasing 300 to 600 million tons of carbon per year into the atmosphere.

**ENSO:** El Niño and La Niña are the warm and cool, naturally occurring weather patterns across the tropical Pacific—the El Niño-Southern Oscillation, or ENSO. Every two to seven years, the pattern alternates, bringing disruptions in temperature and precipitation. As the ocean warms, it could push ENSO past a tipping point, which would make El Niño events

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4 Antarctic Ice Sheet melting to lift sea level higher than thought, <https://news.harvard.edu/gazette/story/2021/04/study-says-antarctic-ice-sheet-melt-to-lift-sea-level-higher-than-thought/>

5 Changes in Ocean 'Conveyor Belt' Foretold Abrupt Climate Changes by Four Centuries, <https://news.climate.columbia.edu/2019/03/20/amoc-ocean-conveyor-belt-climate-change/>

6 Why Thawing Permafrost Matters, <https://news.climate.columbia.edu/2018/01/11/thawing-permafrost-matters/>

7 Arctic Report Card 2019, [https://arctic.noaa.gov/Portals/7/ArcticReportCard/Documents/ArcticReportCard\\_full\\_report2019.pdf](https://arctic.noaa.gov/Portals/7/ArcticReportCard/Documents/ArcticReportCard_full_report2019.pdf)

more severe and frequent and could increase drought in the Amazon.

**Tipping point interactions:** A recent study of the WAIS<sup>8</sup>, the Greenland ice sheet, the AMOC, ENSO, and the Amazon rainforest tipping points found that they could interact with one another before temperatures reach 2°C. This interaction would enable tipping to occur at lower thresholds than previously expected.

## Future or Last Steps

The EU is committed to mitigating climate emissions and tackle climate risk through adaptation. With the Green Deal for Europe<sup>9</sup> it strives to achieve climate neutrality by 2050 and adopt a new, more ambitious climate change adaptation strategy. The Strategy<sup>10</sup> has four principle objectives: to make adaptation smarter, swifter and more systemic, and to step up international action on adaptation to climate change.

Global environmental change has forced us to reconsider our relationship to nature. In Michel Serres' book "Le Contrat Naturel", the author calls for a natural contract to be negotiated between Earth and its inhabitants. Our survival depends on the extent to which humans join together and act globally, on an earth now conceived as an entity.

Michel Serres wonders<sup>11</sup>:

"Who am I? A tremor of nothingness, living in a permanent earthquake. Yet for a moment of profound happiness, the spasmodic Earth comes to unite herself with my shaky body. Who am I, now, for several seconds? Earth herself. Both communing, in love she and I, doubly in distress, throbbing together, joined in a single aura.

I saw her formerly with my eyes and my understanding; at last, through my belly and my feet, through my sex I am her. Can I say that I know her?

Would I acknowledge her as my mother, my daughter, and my lover together?

Should I let her sign?"

*[Michel Serres, The Natural Contract]*

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8 Interacting tipping elements increase risk of climate domino effects under global warming, <https://esd.copernicus.org/articles/12/601/2021/>

9 European Green Deal, [https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal\\_en](https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en)

10 EU Adaptation Strategy, [https://ec.europa.eu/clima/eu-action/adaptation-climate-change/eu-adaptation-strategy\\_en](https://ec.europa.eu/clima/eu-action/adaptation-climate-change/eu-adaptation-strategy_en)

11 Michel Serres, *Le contrat naturel*, Paris, 1990, pg. 124

# The Artwork

“The Tipping Point” (working title) is a proposal for a data driven light and sound kinetic installation of 24 custom metronomes. The artwork highlight the urgency and the increased risk that one or several tipping elements in the climate system might cross a critical threshold, resulting in severe consequences for the global climate, ecosystems and human societies. Using data from the IPCC Sixth Assessment Report<sup>12</sup> the installation begins a journey through the rise of the global temperature. Starting from 1950 to the present and then to the future as describe on the SSP5<sup>13</sup> (Shared Socioeconomic Pathways) projection model, a future where fossil fuel will still be the basis of our economy and energy system.



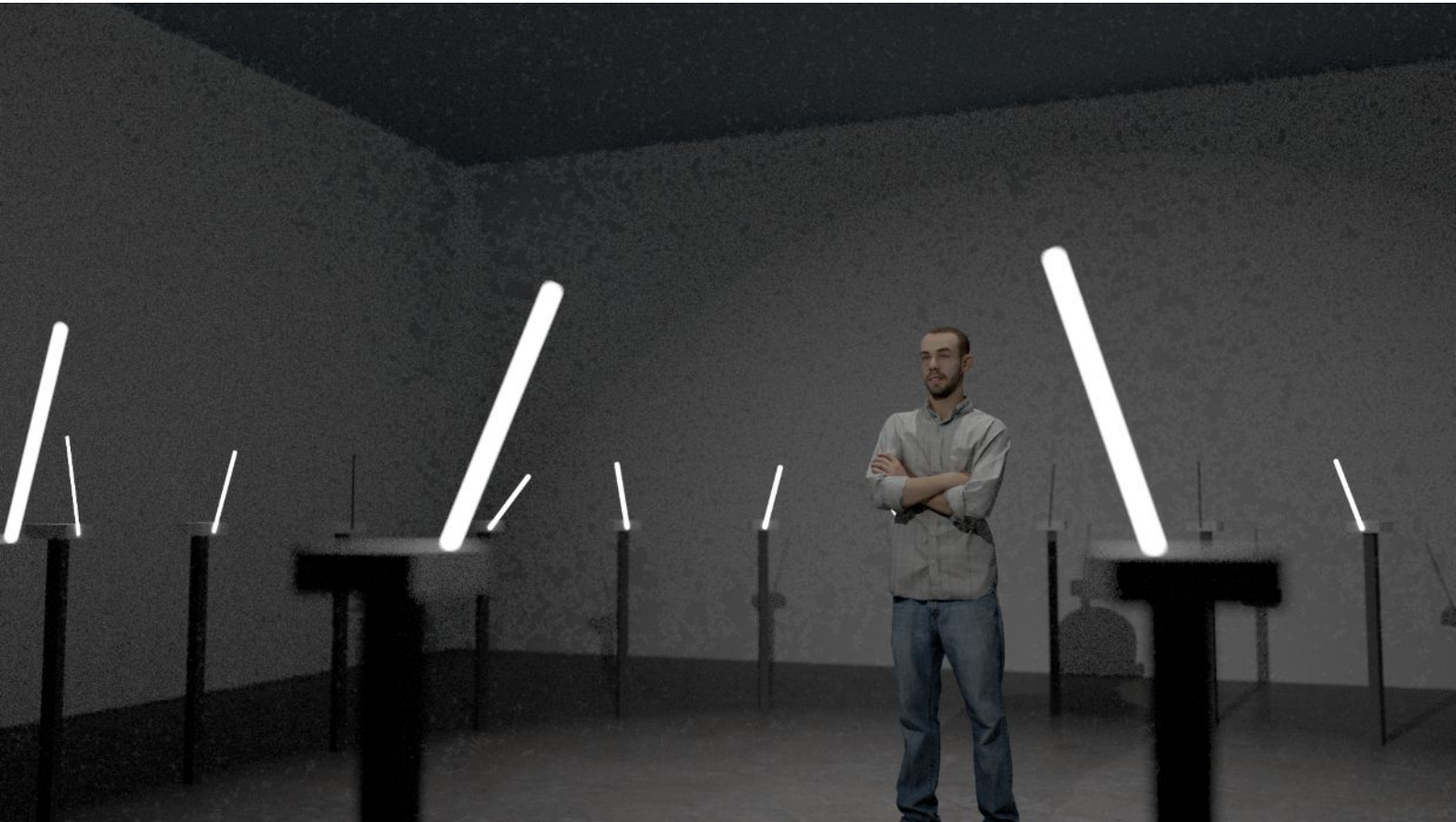
*3D rendering of the installation*

Each metronome has a light emitting rod that will be moving and pulsating in different frequencies like a normal music metronome. All metronomes can be controlled from a central microcontroller. At the beginning all metronomes stand without motion. Then the data from the global temperature rise per year will start to feed the installation and one by one the metronomes will start to operate (moving, emitting light and ticking). As the global temperature will rise, the metronomes will be oscillating faster in higher frequencies. At some random point all metronomes will stop immediately. This moment is the tipping point of the climate change where temperature rise will start to activate other catastrophic events. The installation will stay still and silent for a couple of minutes. After this pause the installation will reset and start over again.

<sup>12</sup> IPCC Sixth Assessment Report, <https://www.ipcc.ch/report/ar6/wg1/>

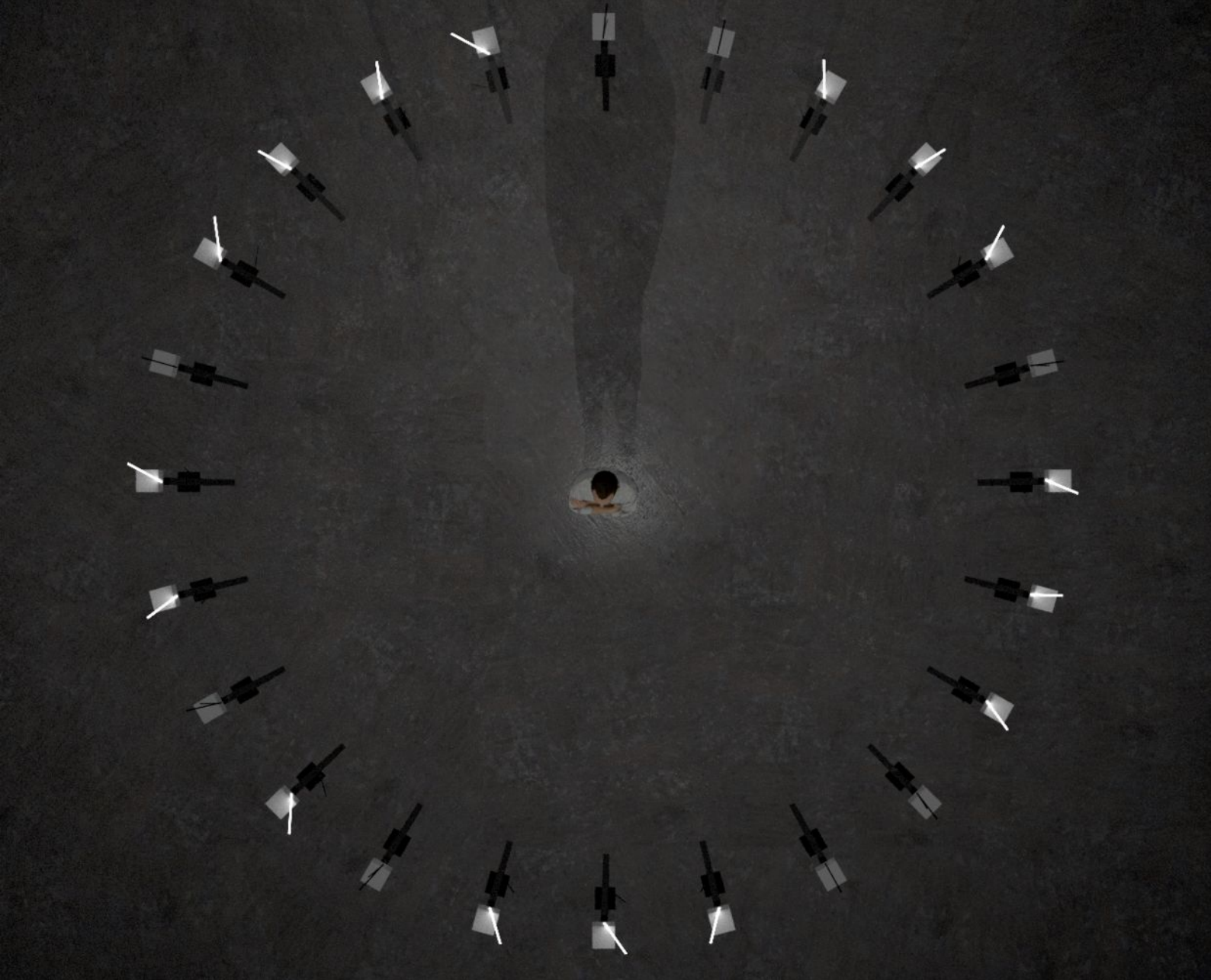
<sup>13</sup> Shared Socioeconomic Pathways, [https://en.wikipedia.org/wiki/Shared\\_Socioeconomic\\_Pathways](https://en.wikipedia.org/wiki/Shared_Socioeconomic_Pathways)

The sound of each metronome will be a simple "tick" sound. This will sound like a Geiger counter, the instrument used for detecting radiation. As more and more metronomes will start to tick fast, the overall soundscape will resemble the alarming sound of a Geiger counter approaching a dangerous radioactive space (please watch the video by following the link provided on the next page).



*3D renderings of the installation*





*3D rendering of the installation*

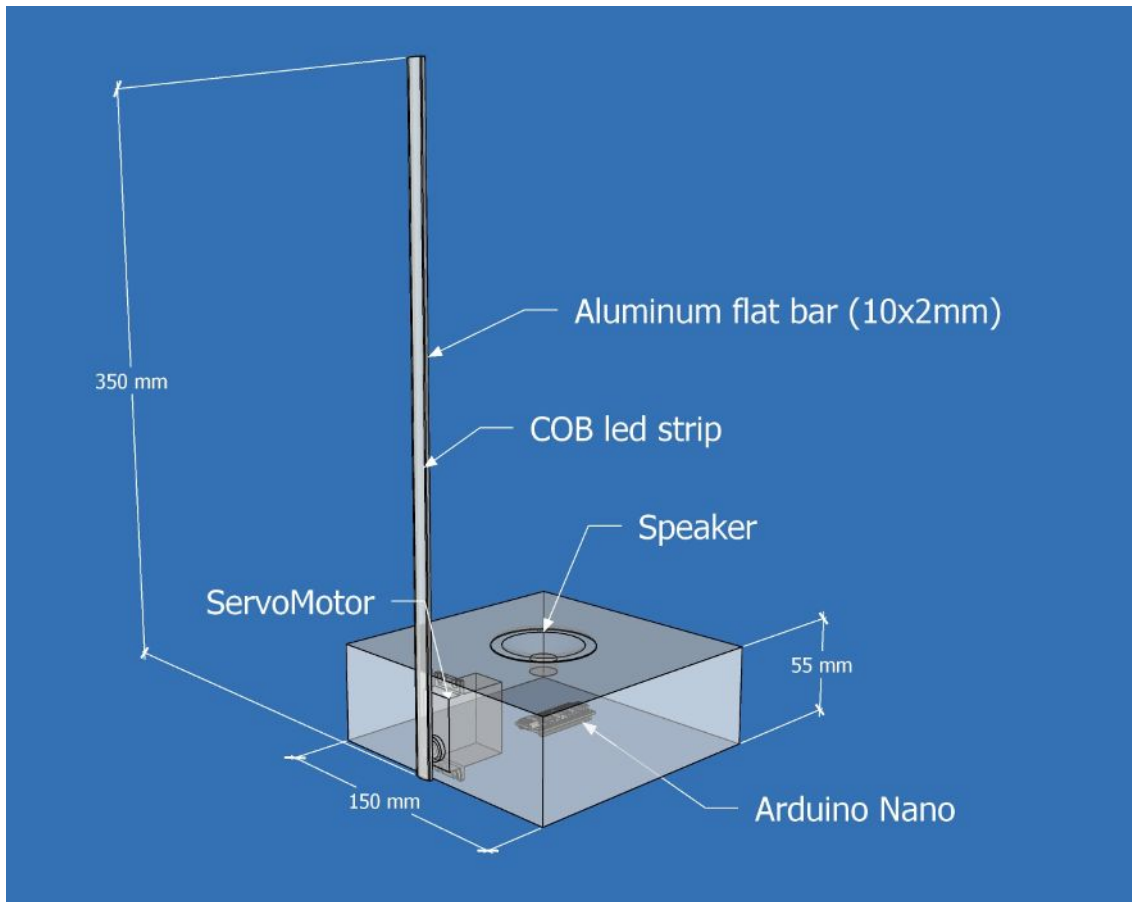
## Video Simulation of the Installation

For a better understanding of the setup, motion light, and sound, I created a 3D video simulation of the installation.

Follow the link bellow, to watch it:

<https://www.youtube.com/watch?v=Aeb56OovjHU>

# Technical Diagram

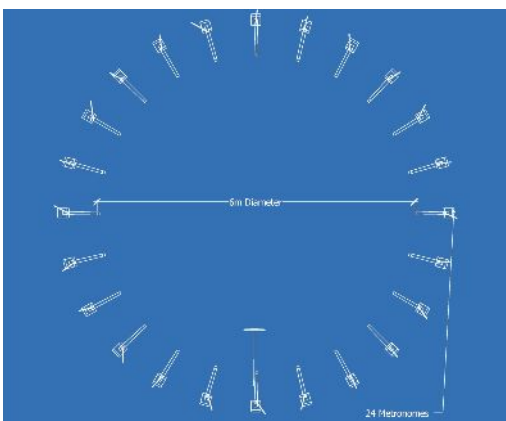


*Basic technical diagram of a single custom metronome*

Each metronome will be custom-made. The basic parts of the metronome are:

- A light flat bar made of aluminum with a COB led strip on both sides.
- A servo motor for moving the light flat bar.
- A speaker to produce the “ticking” sound.
- An Arduino Nano for controlling the servo and playing audio through the speaker
- A case that will contain the components.

All metronomes will be linked to a central Arduino, which will provide data and control the entire installation.



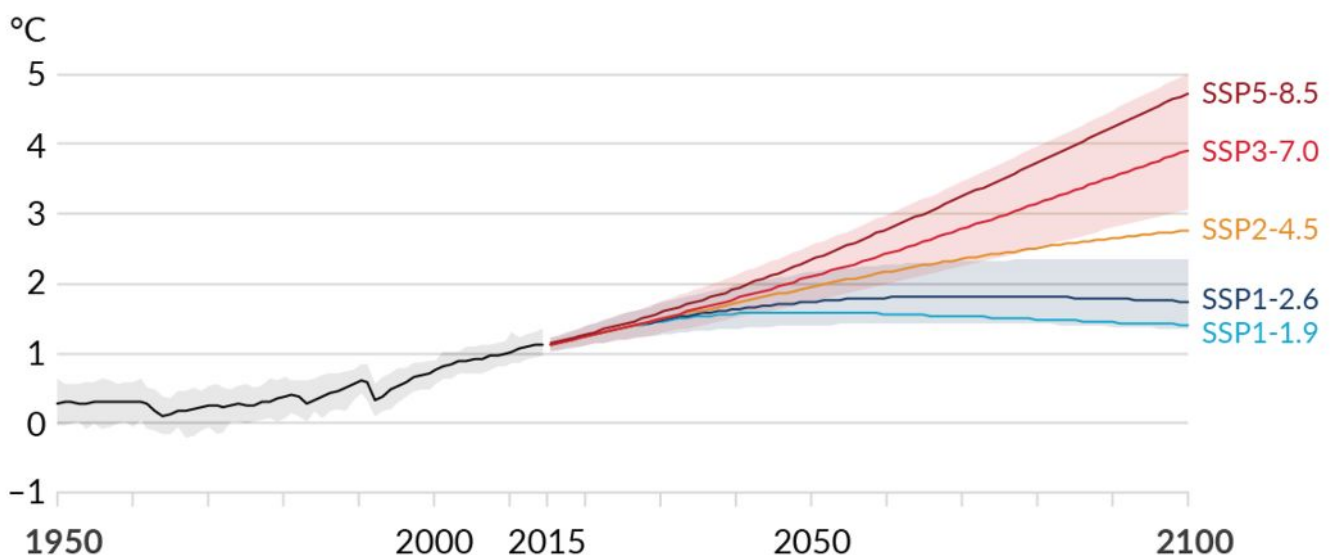
*A circular arrangement of 24 metronomes with a 6m diameter is proposed.*



# The Science

Based on the PCC Sixth Assessment Report and on the SPM\_Figure\_8a we can get the global surface temperature changes in °C relative to 1850–1900. These changes were obtained by combining Coupled Model Intercomparison Project Phase 6 (CMIP6) model simulations with observational constraints based on past simulated warming, as well as an updated assessment of equilibrium climate sensitivity. Changes relative to 1850–1900 based on 20-year averaging periods are calculated by adding 0.85°C (the observed global surface temperature increase from 1850–1900 to 1995–2014) to simulated changes relative to 1995–2014. For the future projections Shared Socioeconomic Pathways (SSPs) scenarios are used. SSP are scenarios of projected socioeconomic global changes up to 2100. They are used to derive greenhouse gas emissions scenarios with different climate policies.

## (a) Global surface temperature change relative to 1850–1900



The data of the above diagram are available in csv format from the IPCC website<sup>14</sup>.

Shared Socioeconomic Pathways (SSPs) are scenarios of projected socioeconomic global changes up to 2100. They are used to derive greenhouse gas emissions scenarios with different climate policies.

The scenarios are:

**SSP1:** *Sustainability (Taking the Green Road)*

**SSP2:** *Middle of the Road*

**SSP3:** *Regional Rivalry (A Rocky Road)*

**SSP4:** *Inequality (A Road divided)*

**SSP5:** *Fossil-fueled Development (Taking the Highway)*

<sup>14</sup> IPCC Sixth Assessment Report Data, <https://www.ipcc.ch/report/ar6/wg1/figures/summary-for-policymakers/figure-spm-8>

They have been used to help produce the IPCC Sixth Assessment Report on climate change, published on 9 August 2021.

### Shared Socioeconomic Pathways in the IPCC Sixth Assessment Report

SSP	Scenario	Estimated warming (2041–2060)	Estimated warming (2081–2100)	Very likely range in °C (2081–2100)
SSP1-1.9	very low GHG emissions: CO2 emissions cut to net zero around 2050	1.6 °C	1.4 °C	1.0 – 1.8
SSP1-2.6	low GHG emissions: CO2 emissions cut to net zero around 2075	1.7 °C	1.8 °C	1.3 – 2.4
SSP2-4.5	intermediate GHG emissions: CO2 emissions around current levels until 2050, then falling but not reaching net zero by 2100	2.0 °C	2.7 °C	2.1 – 3.5
SSP3-7.0	high GHG emissions: CO2 emissions double by 2100	2.1 °C	3.6 °C	2.8 – 4.6
SSP5-8.5	very high GHG emissions: CO2 emissions triple by 2075	2.4 °C	4.4 °C	3.3 – 5.7

The IPCC Sixth report did not estimate the likelihoods of the scenarios but a 2020 commentary described SSP5-8.5 as highly unlikely, SSP3-7.0 as unlikely, and SSP2-4.5 as likely<sup>15</sup>.

However, a report citing the above commentary shows that RCP8.5 is the best match to the cumulative emissions from 2005 to 2020<sup>16</sup>.

15 Emissions – the ‘business as usual’ story is misleading, <https://www.nature.com/articles/d41586-020-00177-3>

16 RCP8.5 tracks cumulative CO2 emissions, <https://www.pnas.org/doi/full/10.1073/pnas.2007117117>

# The Residencies

## JRC Residency One

During my first week of residency at the Joint Research Centre in Ispra, I will collaborate with the scientist to research available historical data on greenhouse gases and temperature change, as well as available future projection models. The method for mapping these data to metronome frequencies will also be discussed and researched with the scientist. Computer software will be used to simulate installation behaviour. The details of the metronome design (size, materials, etc.) and implementation methods (3D print, wood, etc.) will also be decided during this phase.

## JRC Residency Two

During my second week-long residency at the Joint Research Centre in Ispra, I will present a working prototype of one metronome and test various data mapping methods with the scientist. During this phase, the final configuration of the metronomes (circular, linear, or other) as well as the total number of metronomes will be determined.

## Budget Estimation

This is a cost estimate for the proposed installation of 24 custom metronomes. If we decide to change the total number of metronomes, the final cost will be affected.

Description	Cost (€)
24 Servo motors	1,200
24 Arduino Nano	750
24 Speakers	250
17m COB light Strip	200
9m Aluminium flat bar	70
1 Arduino Uno	30
Various Cables/Components	100
Power Supply	50
Case & base	200
Construction/Implementation	1,500
<b>TOTAL</b>	<b>4,350</b>

NOTE: Artist fee have not been included in accordance with the guidelines.

## Yiannis Kranidiotis – BIO



*“Beyond the Realms of Sea and Land”  
(2020) Yiannis Kranidiotis — Light and Sound Kinetic Installation.*

Yiannis Kranidiotis (Athens, Greece), is an artist whose work explores the relationship between science and art, using mainly light, motion, and sound to create spaces and experiences where all coexist and interact. He often engages the visitor using interaction, while other times he uses data to drive the motion, the light, and the sound of his works. He is interested in exploring physical phenomena like natural repeatability or wave movement as well as creating sonification methods for scientific data from sources like exoplanets, gravitational waves, or the solar wind. The climate crisis and the increasing pollution of the planet with plastic are issues that also affect his practice. He has collaborated with choreographers and theatre directors in interdisciplinary projects, designing digital artworks, VR environments, and light installations. His work has been presented in many festivals and exhibitions. He has a BS in Physics from the University of Patras and an M.Sc. in Optics and Lasers from Essex University.

Website/Portfolio: <http://kranidiotis.gr/>

## Frank Dentener – BIO

Frank Dentener works since 30 years in the field of climate change, agriculture and atmospheric pollution. Frank is senior expert and group leader at the European Commission’s Joint Research Centre. He completed a Ph.D. in Physics with Nobel prize-laureate Paul Crutzen at Utrecht University. He is member of the scientific advisory board of the JPI FACCE, and co-chair of WMO’s Scientific Advisory Group on near-real-time applications, member of the WMO Model Measurement Fusion initiative, and he has served on a variety of international commissions. He has (co-) authored more than 200 peer-reviewed publications and 4 IPCC reports, Hirsch factor 96, and is a Clarivate highly cited scientist since 2015. Frank held assistant professorships at Wageningen and Utrecht

University, the Netherlands, PrivatDozent at the ETH in Switzerland, and currently affiliated with the Politechnical University of Torino. He supervised and examined ca. 10 Ph.D. and Habilitation candidates. Frank is an expert in atmospheric chemistry-land interactions, including ozone impacts on agricultural production systems, and climate change and mitigation and adaptation.