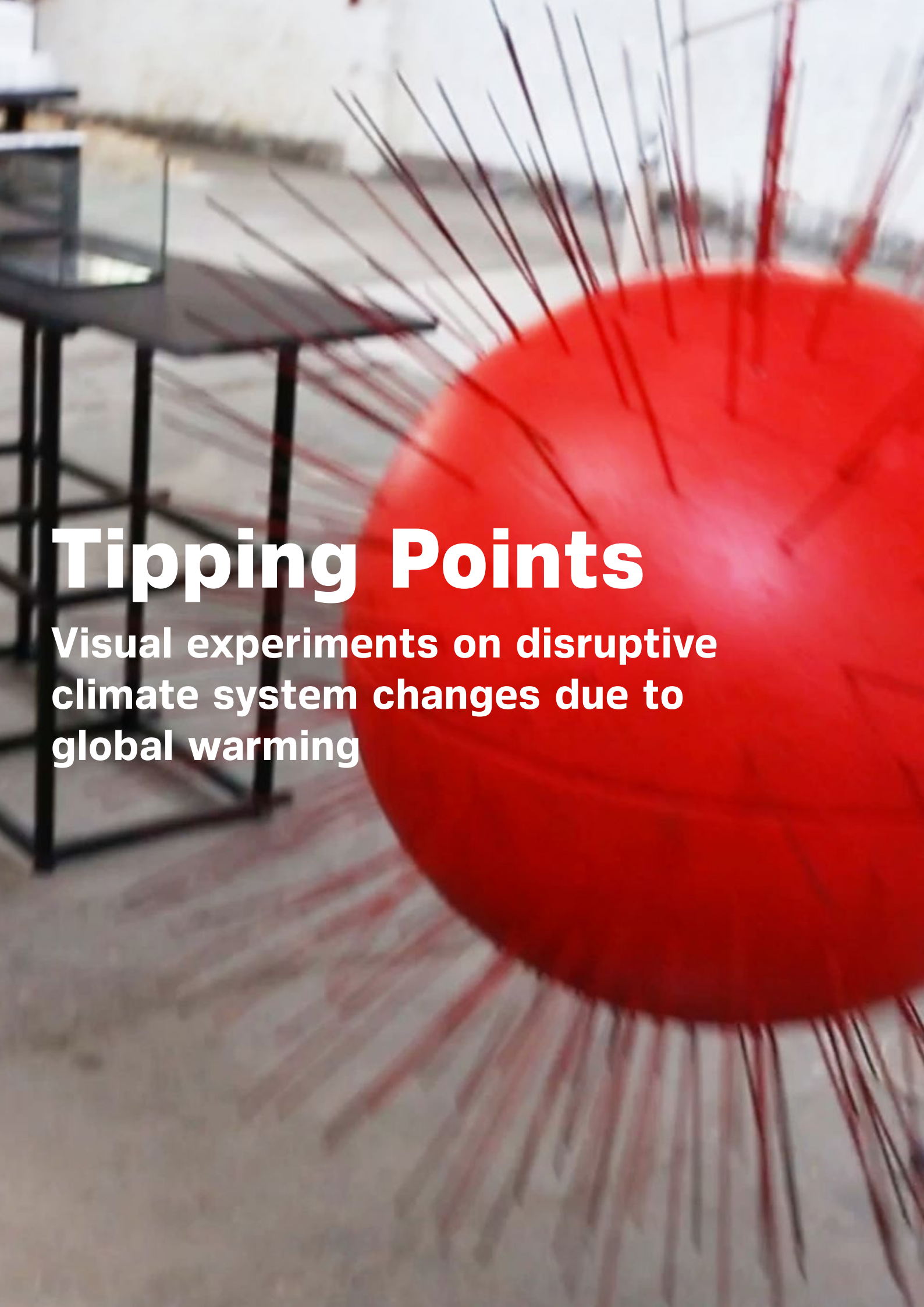


Tipping Points

Visual experiments on disruptive climate system changes due to global warming

https://vimeo.com/363540500

Tipping Points

With human activities and rising temperatures, large-scale elements of the Earth's climate system have the potential to tip into new states. These are visualisations of a range of these tipping elements.

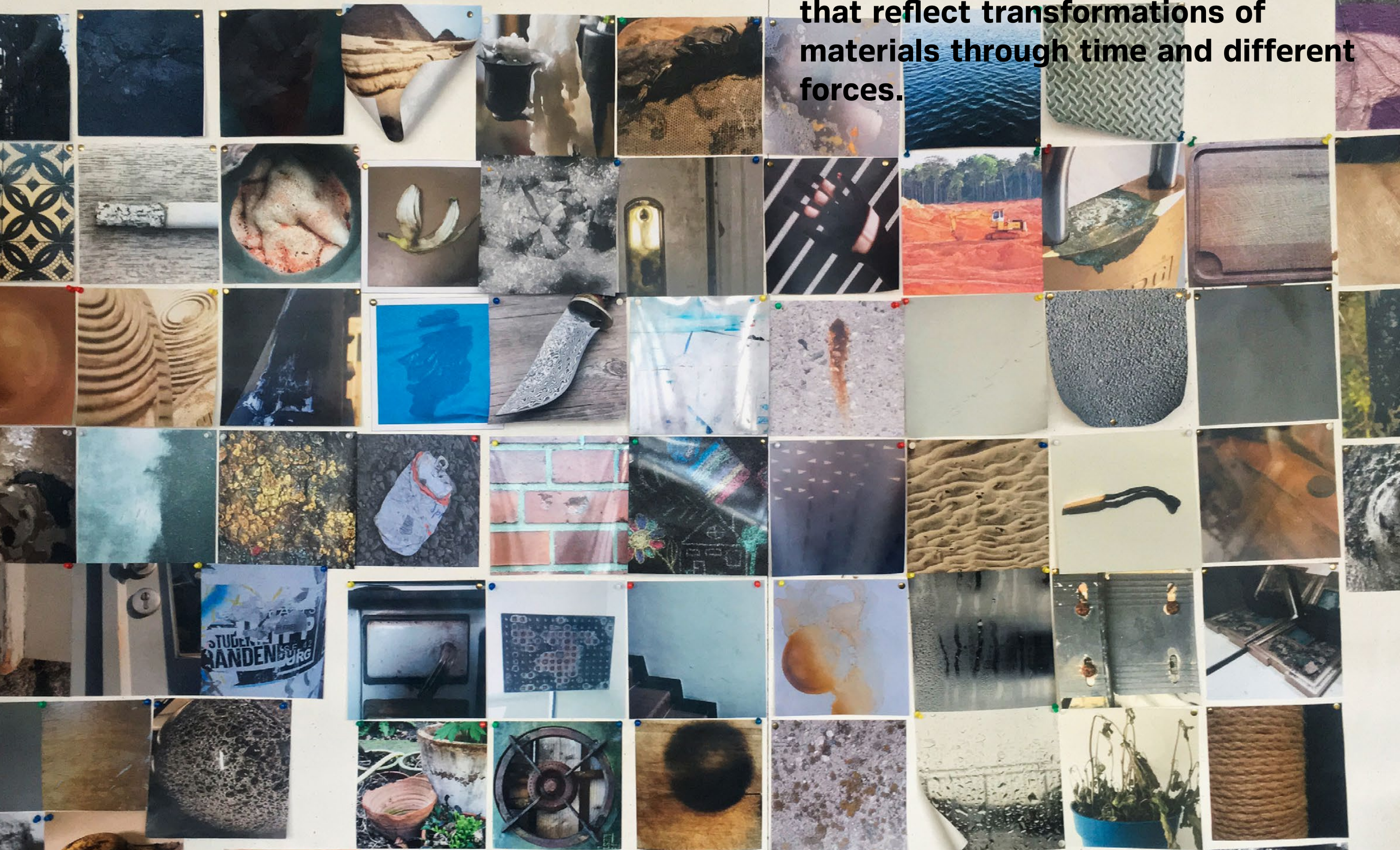
With the increasing warming of the global climate system, environmental changes can occur first slowly and then suddenly in various regions of the world. The moment of this tilting into a new state is called Tipping Point. Once set in motion, these non-linear processes can amplify themselves and, through complex interactions, may lead to a further increase in temperatures and global warming. The further effects are often hard to predict and partly irreversible. Examples of climate tipping elements are the disappearance of the boreal forests, the retreat of Arctic sea ice, the destabilisation of the Indian monsoon or the loss of coral reefs. In total there are about 16 tipping elements.

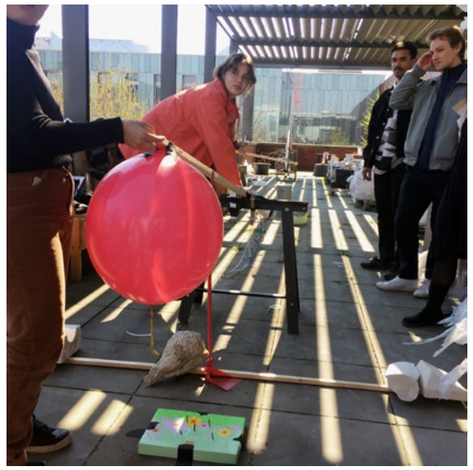
In the summer semester 2019, ten of these climate tipping elements were staged by design students of the Potsdam University of Applied Sciences as spatial installations in order to make the devastating dynamics of these possible tipping points vivid and sensual. This involved the depiction of dynamic processes, the visualisation of scientific data and findings as well as the handling of the uncertain and the unpredictable.

Through thematic introductions, experimental studies with material and mechanisms, rational observations and poetic abstractions, a space full of tipping points was created that operate in a field of tension between control and the unpredictable. The result is a video documentation of these installations.

Unintended patterns

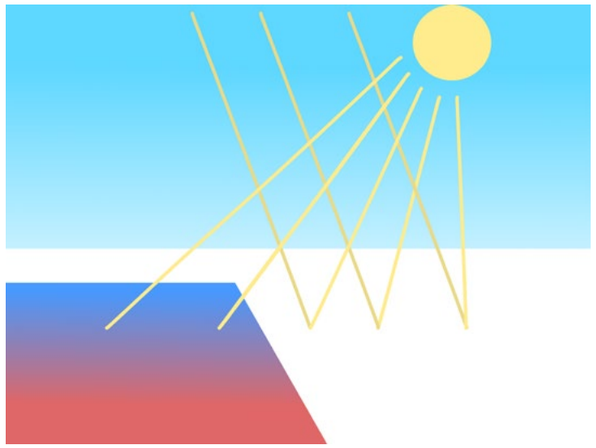
A photographic collection of structures, processes and patterns that reflect transformations of materials through time and different forces.



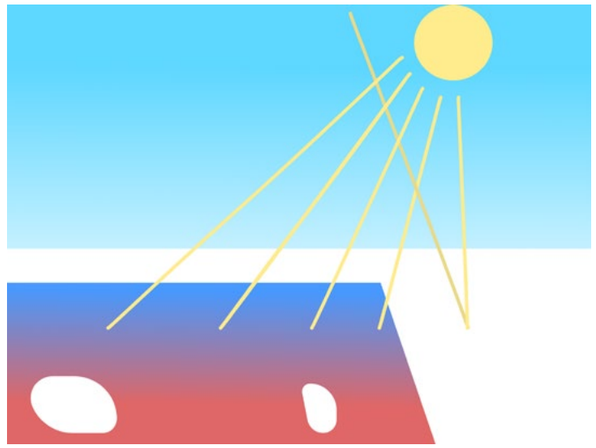


Climate seesaw

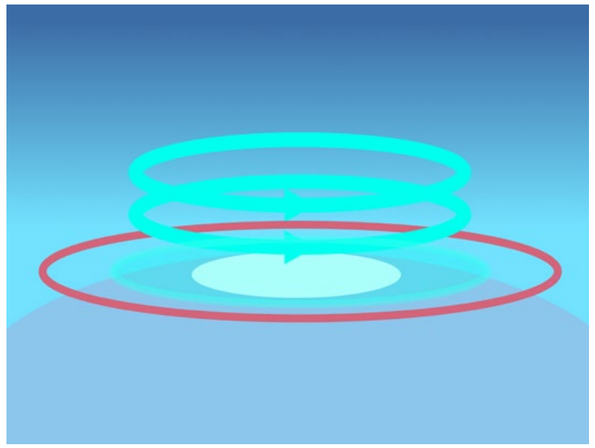
Experimentations with mechanics of tipping, considering acceleration, air flow, sounds, material behaviours, heat development and rules of physics.



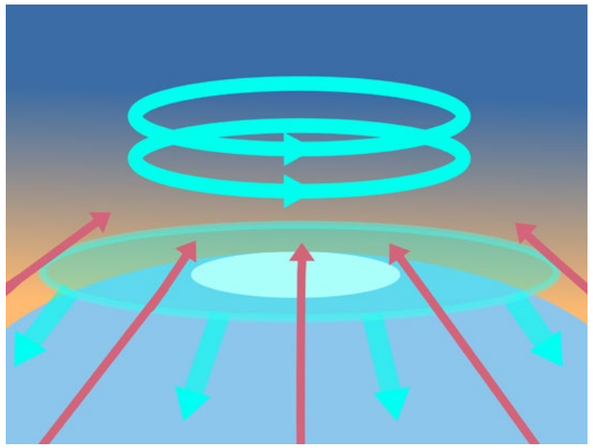
Ice reflects sunlight.



Melting of Arctic sea ice leads to more open water.

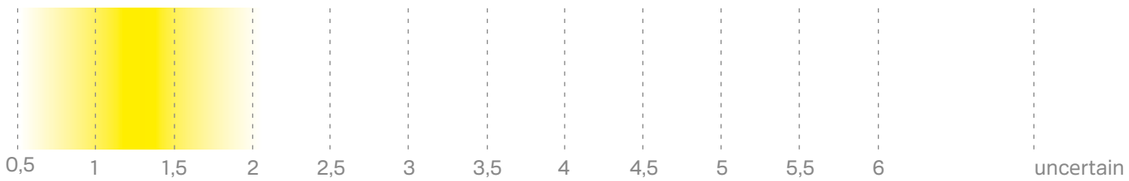


Jetstream is stable.

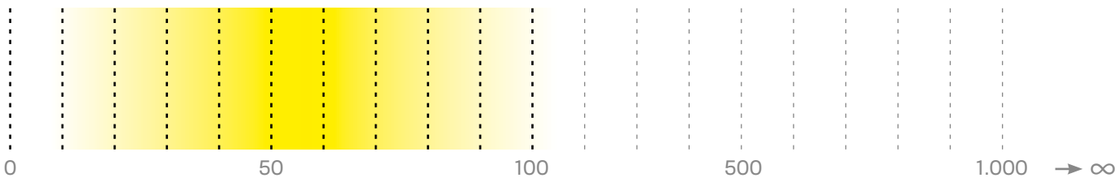


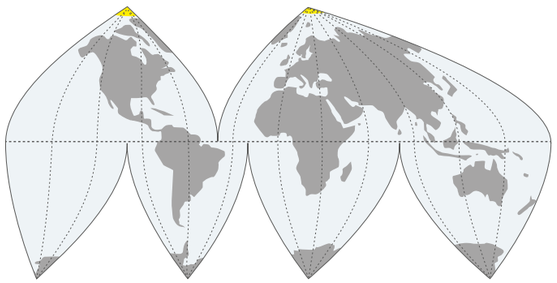
Jetstream becomes unstable and can't stop air from circulating.

Occurrence with
global warming of °C



Transition timescale
in years





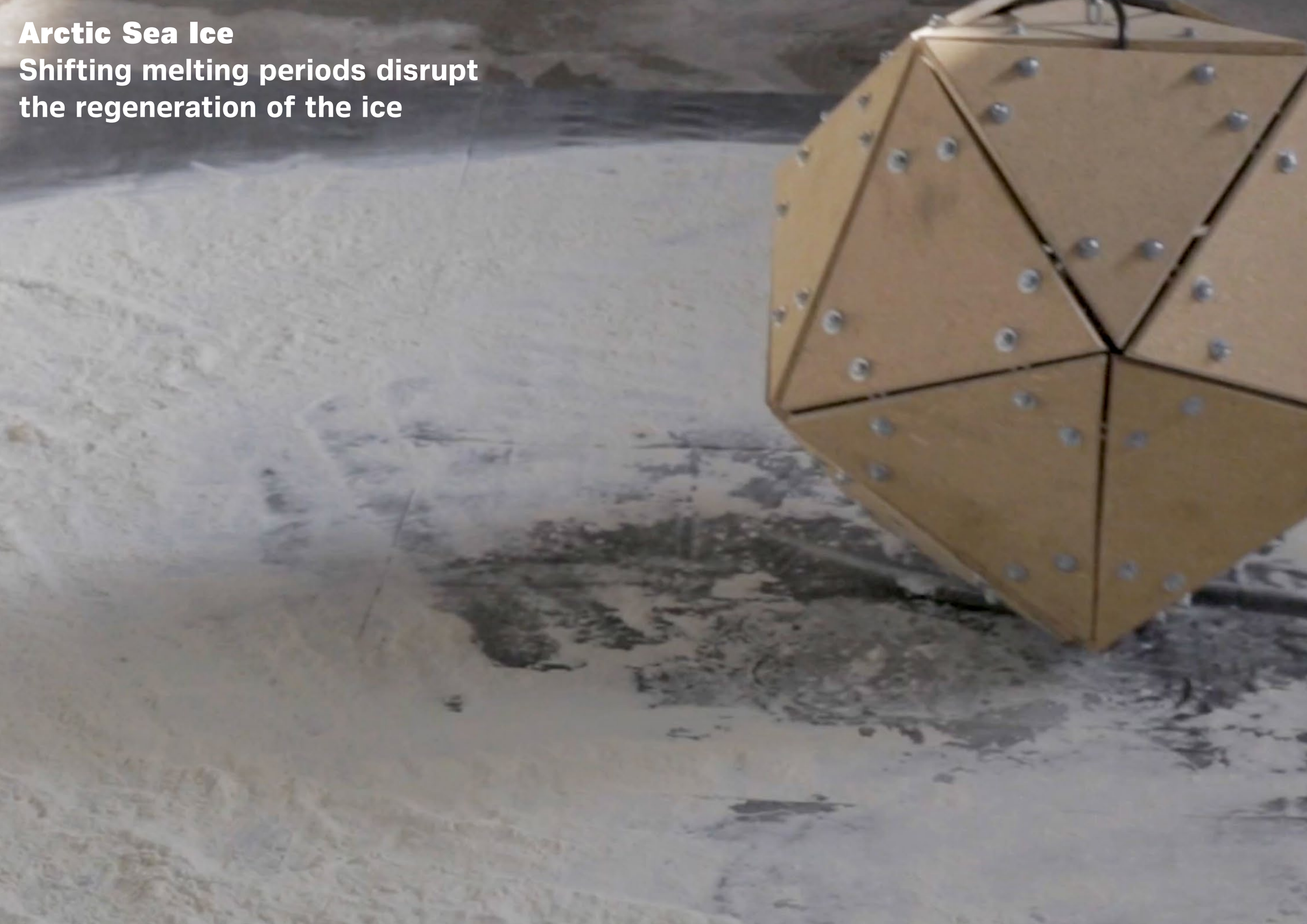
Arctic Sea Ice

Viccha Kreng
Linus Langkabel

System dynamics
Ice reflects more sunlight back into the atmosphere and therefore absorbs less heat than the surrounding water. When the sea ice melts, less sunlight is reflected and more heat is absorbed, thus the Arctic sea ice melts even faster.
The decline in sea ice might also speed up global warming. Today more than half of the reflecting surface is gone, which speeds up the melting process.

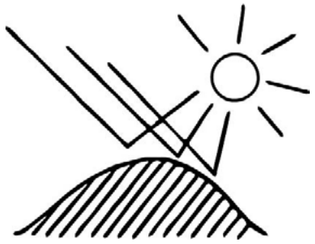
Tipping point scenario
The melted ice is now habitat for a wide range of animals that live in the Arctic. Also, the Arctic sea ice protects lower latitudes from extreme weather conditions which would hit the coastlines immensely. When the cold water from the melted ice is flowing south, it may change large-scale weather dynamics on Earth.
The Arctic summer sea ice might disappear within this century. As this might become a new economic opportunity for fishing, tourism and oil industry, the risk for the environment becomes even bigger.

Interpretation
The construction consists of a pendulum, flour and black foil. The pendulum is an icosahedron, which symbolises a manmade climate change with its industrial look.
Its motion represents the shifting between sea ice formation and melting. While it moves, it blows the flour on the foil and shows the albedo effect in an abstract form.
Materials: flour, chain, MDF, three small fans.

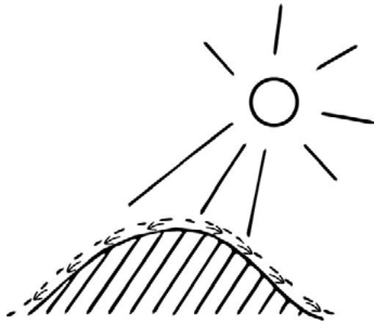


Arctic Sea Ice

Shifting melting periods disrupt the regeneration of the ice



The ice shield reflects the majority of the heat radiation.



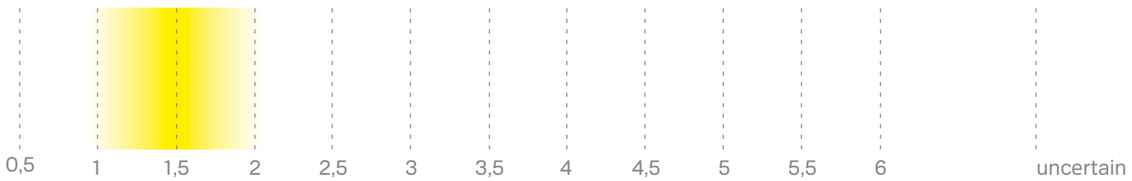
A thin layer of melt water is formed, which heats up and causes the underlying ice to melt more quickly.

The meltwater runs into cracks and destabilizes the ice sheet.

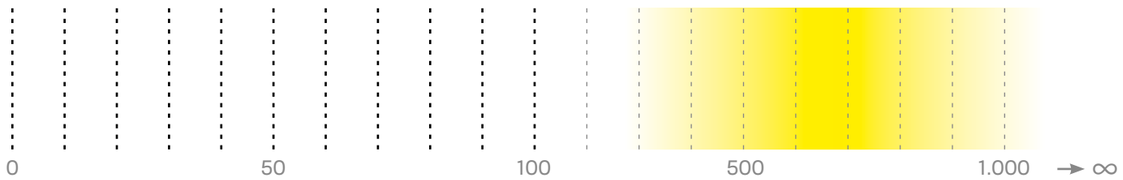
Large ice chunks break into the sea. This is called calving.

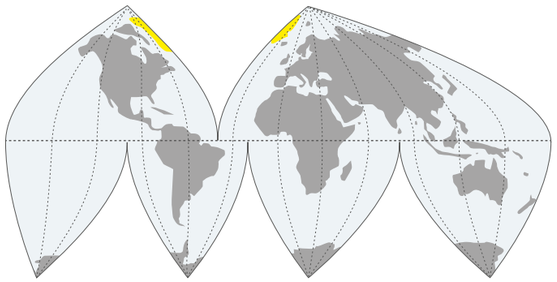
The melting of the land ice leads to a rise of the sea level.

Occurrence with global warming of °C



Transition timescale in years





Greenland Ice Sheet

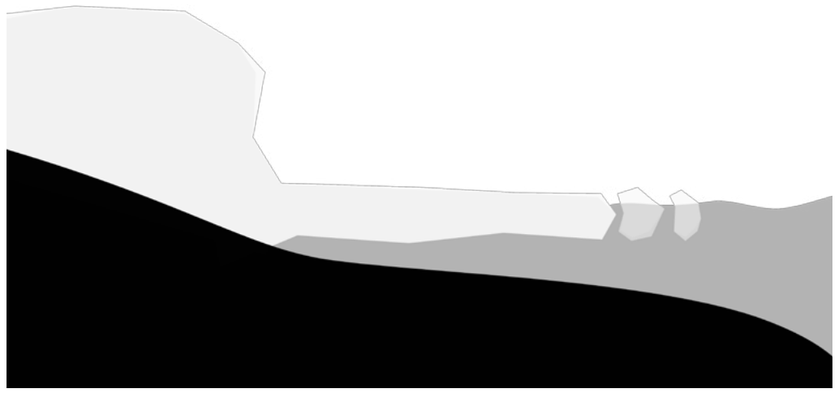
Josephine Kähler
Kira Vogtmann

System dynamics
The Greenland ice sheet is the second largest ice body in the world and covers over 80% of Greenland. Ice can be lost due to melting in summer and ice discharge into the ocean, while snow leads to an accumulation of ice. Changes in this balance influence the sea level. If the Greenland ice sheet would disappear completely, global sea level would rise by approx. 7m.

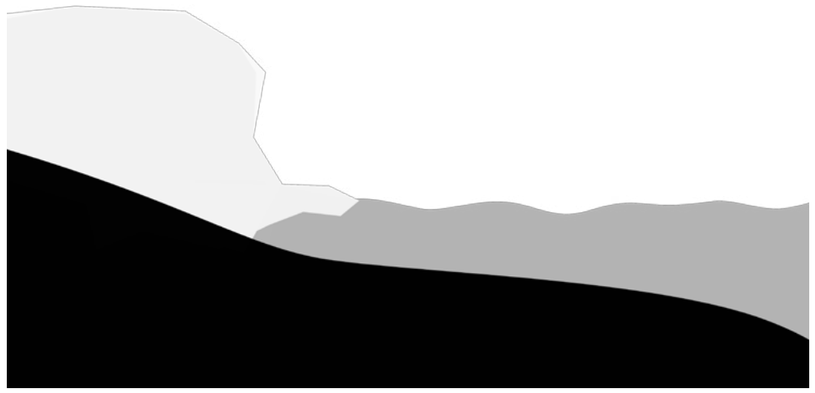
Tipping point scenario
The Greenland ice sheet already loses ice at an accelerating rate, as temperatures are rising with climate change. Increased melt during summer runs off into the ocean and thereby raises global sea levels. In addition, ice flow is accelerated and the calving of icebergs into the ocean increases. This leads to a thinning of the ice sheet. As the air temperature is higher at a lower surface altitude, thinner ice melts even faster. This destabilises the ice sheet even more, causing rising sea levels worldwide.

Interpretation
Water bombs are held together by a thin paper membrane. In the melting process, the membrane tears after some balloons are burst by the needles of the sun. The resulting water wave pours out onto a radial scale drawn on the ground, spreads out to the seven metre mark and washes away cities written in sugar along the way.
Materials: latex balloons, paper, wood, metal wire, styrofoam ball, rod, sugar, chalk.

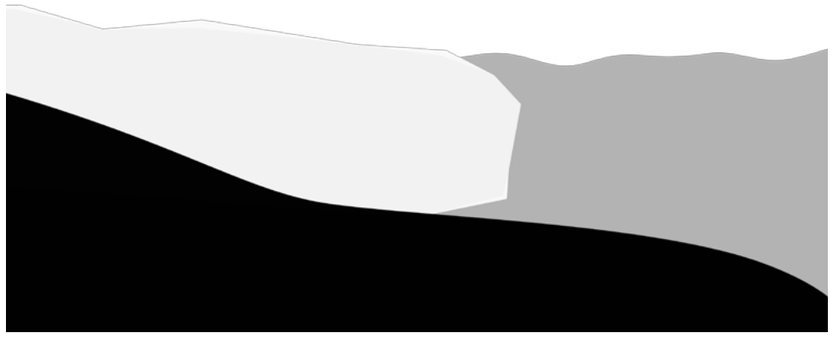
Greenland Ice Sheet
Melting processes lead to rising sea levels



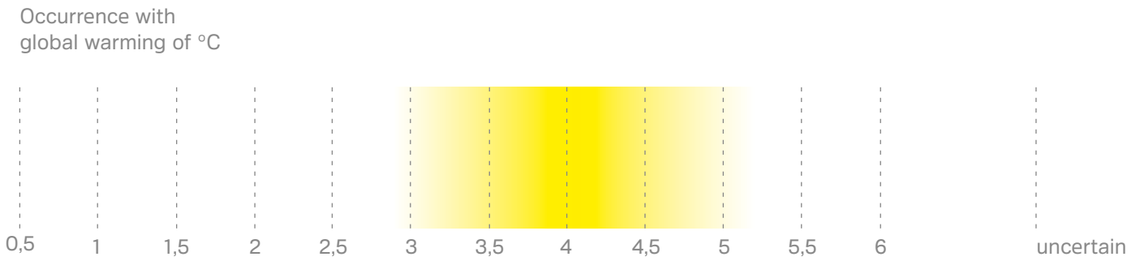
Shelf ice holding back the land ice.

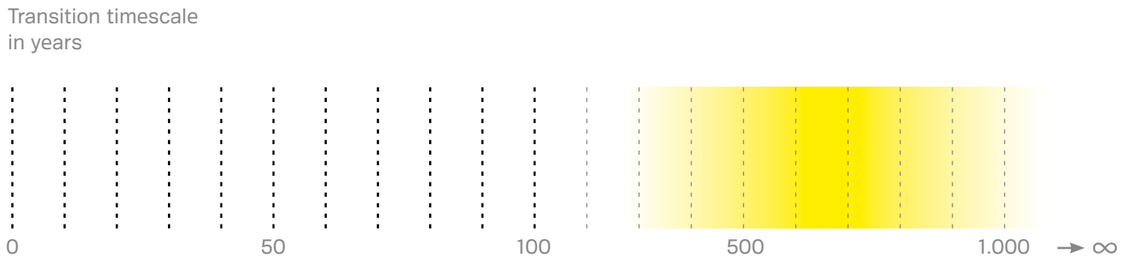


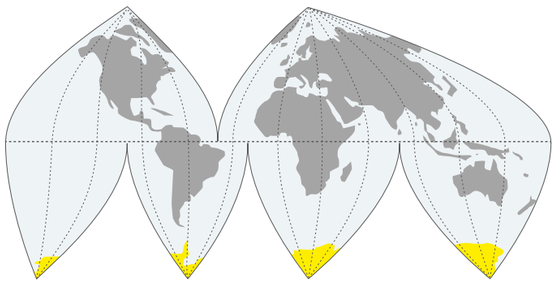
Melting of the shelf ice.



Land ice sliding into the ocean.







Antarctic Ice Shield

Till Schneeberger
Pascal Struck

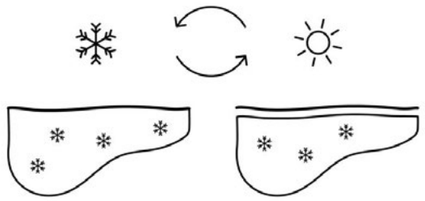
System dynamics
The Antarctic ice sheet is the biggest fresh water reservoir on Earth, holding enough water to raise global sea levels by 58 metres. Especially in West Antarctica, large ice shelves prevent the ice masses from draining into the ocean. Warming waters around the continent destabilize these barriers, resulting in accelerated ice losses and hence increasing sea levels. Knowing how fast ice is melting is key to understanding one of the largest contributions to global sea-level rise.

Tipping point scenario
If temperatures around the world continue to rise, we might reach a tipping point where the Antarctic ice sheet is losing its barriers towards the world's oceans. Then, ice masses could start to slide unhamperedly into the ocean resulting in a massive long-term sea level increase.
This will pose a serious threat to the world's coastal cities and a danger to a lot of ecosystems. Without stopping CO2 emissions, most of Antarctica's ice shelves might be lost within this century.

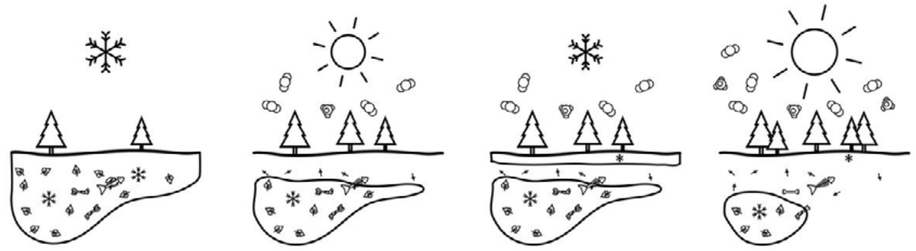
Interpretation
The ongoing process can be described as the slow melting of an ice barrier which holds back a far bigger mass of ice. That mass will then slide towards a big body of water, rising its water level.
Styrofoam symbolizes ice and melts as soon as it gets in contact with acetone. A ramp with a pouring mechanism is triggered by a "2-degree-scissors" cutting a string.
A big block of styrofoam filled with stones is held back by a small styrofoam barrier on that ramp representing the shelf ice.
Materials: glass-aquarium, acetone, styrofoam, stones, MDF.

Antarctic Ice Sheet

Melting shelf ice increases global sea level

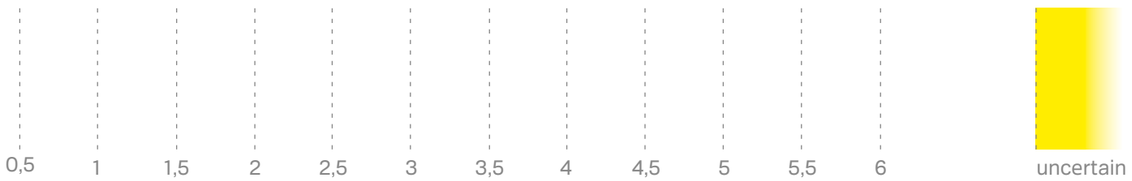


The upper (active) layer melts every summer. The lower layer stays frozen all year.

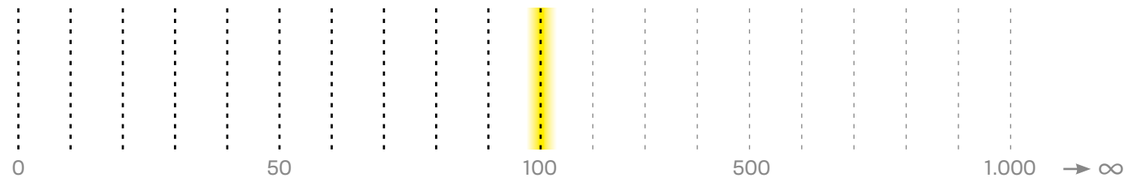


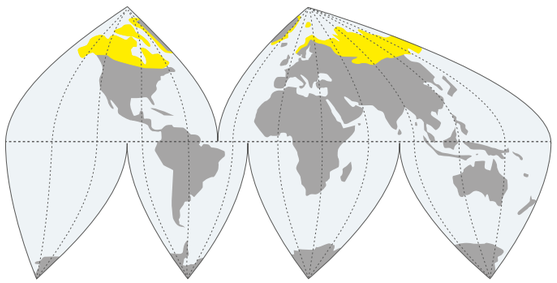
The melting ice sets free animal and plant residues. As these get metabolised by detriments, the greenhouse gases methane and carbon dioxide rise into the atmosphere.

Occurrence with
global warming of °C



Transition timescale
in years





Permafrost

Peter Schwarz
Aaron Schwerdtfeger
Robin Wenzel

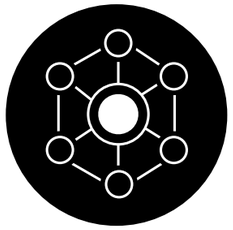
System dynamics
Permafrost is permanently frozen soil over a period of two years or more. It consists of an active layer that melts every summer and a constantly frozen layer. The permafrost conserves animal- and plant residues that may be over thousands of years old. As these residues get decomposed, the greenhouse gases methane and carbon dioxide rise into the atmosphere.

Tipping point scenario
Determining a certain point where the permafrost might tip is subject of ongoing research. The tipping itself is not likely to manifest in a short period of time. The tipping point is mostly defined by the melting of layers that had been frozen for hundreds of years.
Once this process has started it may amplify due to a positive feedback loop that constantly increases the greenhouse effect and heats our atmosphere, causing even more thawing.

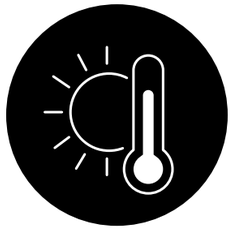
Interpretation
The installation flips things upside down. Three large slowly melting ice cubes embody the huge amounts of frozen ground hidden underneath the Earth's surface. As it's slowly melting, the ice drips on the metal plate and evaporates. This represents greenhouse gases that heat the Atmosphere and cause the ice to melt even faster. The moment of collapse is hard to predict, since the ice is only held by chains until the aggregate states decay.
Materials: wood, biomass, ice, metal chains, straps, aluminium sheet, hotplates.

Permafrost

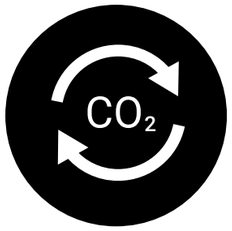
Defrosting giant masses of biomass releases greenhouse gases



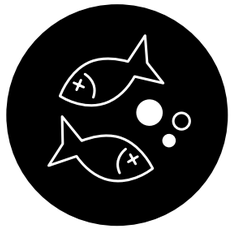
Methane hydrate



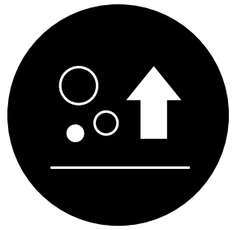
Temperature rising.



Conversion to CO2.



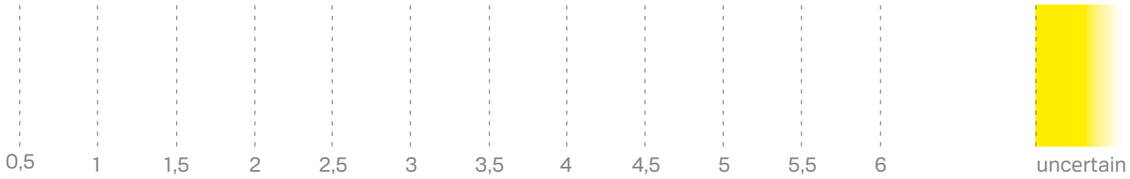
Acidification of seawater.



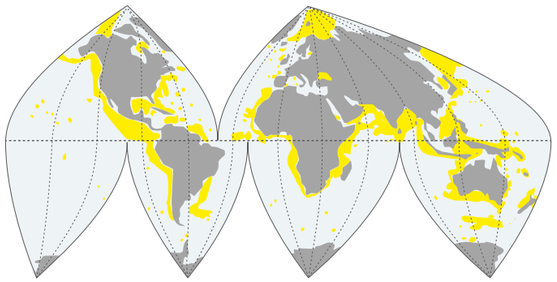
Methane rises into the atmosphere.

Once in the atmosphere, it adds significantly to global warming.

Occurrence with
global warming of °C



Transition timescale
in years



Methane Hydrates (marine)

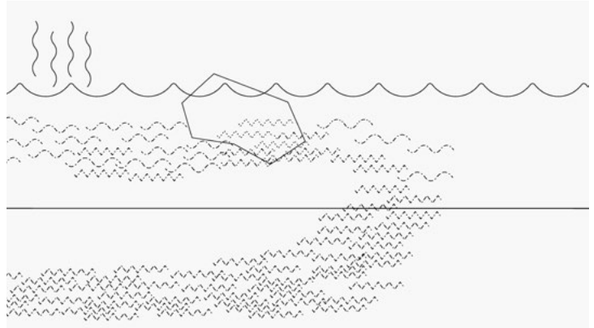
Marie Louis Hippler
Julia Scholz

System dynamics
Large amounts of methane are trapped in on the ocean floor inside ice structures called Methane Hydrates. The hydrates could melt and would release the methane into the ocean, just due to because of a deep sea warming of a few degrees Celsius.

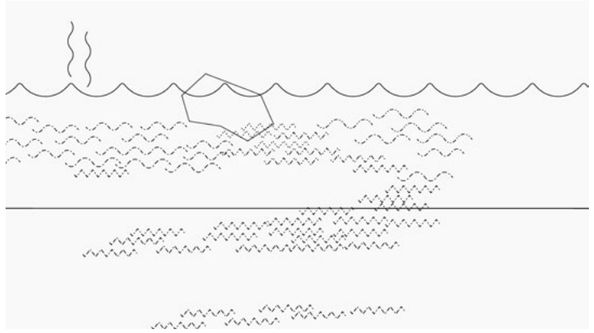
Tipping point scenario
Methane is a very powerful greenhouse gas and the sudden release of large amounts are considered a cause of past and future climate changes.
The most likely impacts of melting hydrate reservoirs are therefore a long-term methane source, elevating atmospheric methane, contributing to the ocean acidification and substantially affecting the ecosystems.

Interpretation
The ocean acidification caused by the release of a large amount of Methane Hydrate is symbolised by the destructive process of filled balloons, standing for representing the Methane Hydrates. White colour splashes on corals to represent their destruction so they become white and visually die.
Materials: metal and wood construction, ropes, latex balloons, plaster objects.

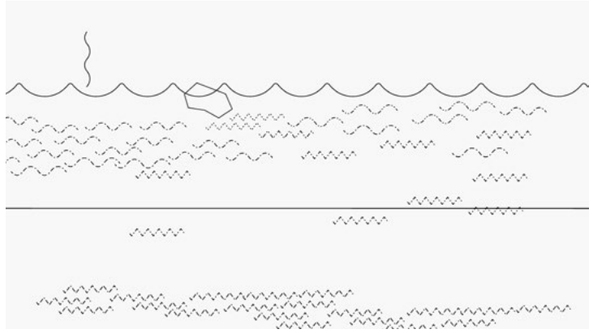
Methane Hydrates (marine)
Methane hydrates contribute to the ocean acidification and accelerate the global warming as they are released into the atmosphere



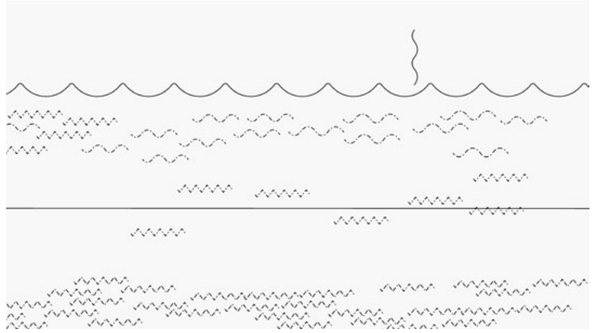
Under optimal conditions, oceanic heat escapes into the air by the ocean stream. The water temperature sinks even lower by ocean ice. Through freezing of the water salinity rises. This sudden change in temperature and especially the higher salinity effects that denser water sinks quickly into deeper water layers, where it displaces the water southwards.



The difference of the air temperature and the water temperature is now rather low leading to a faster melting of marine ice and less re-freezing of water. The density of the ocean stream is lower since water is warmer now. Thus the water sinks down less effectively which means that water in deep water layers cannot be displaced.

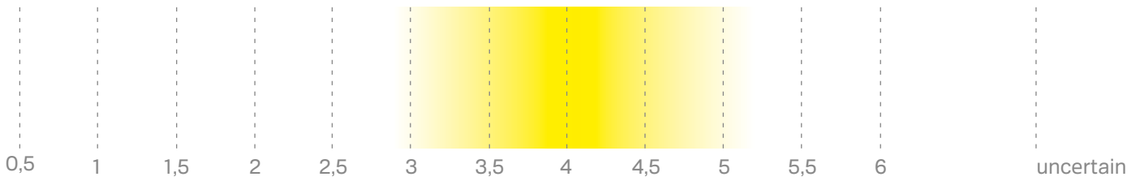


The difference in air temperature and water temperature decreases, so that heat emission of the ocean stream is quite low. Marine ice is almost non-existent. The water density increases not much anymore, and so water does not sink into lower water layers.

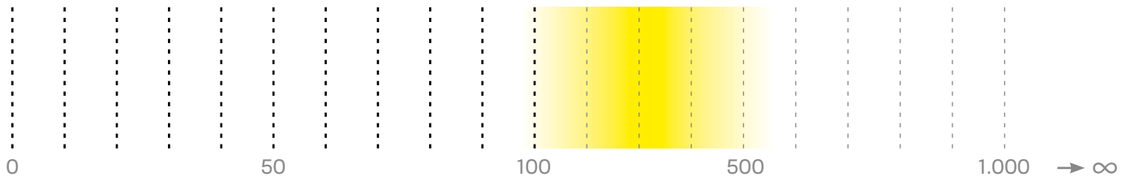


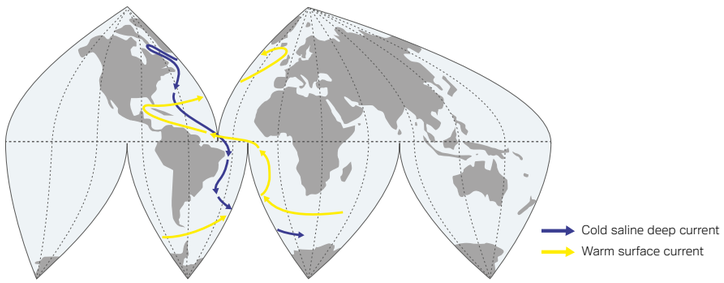
There is no marine ice left, main heat emission moved further northwards. The ocean stream is interrupted and the water gets slowly colder.

Occurrence with
global warming of °C



Transition timescale
in years





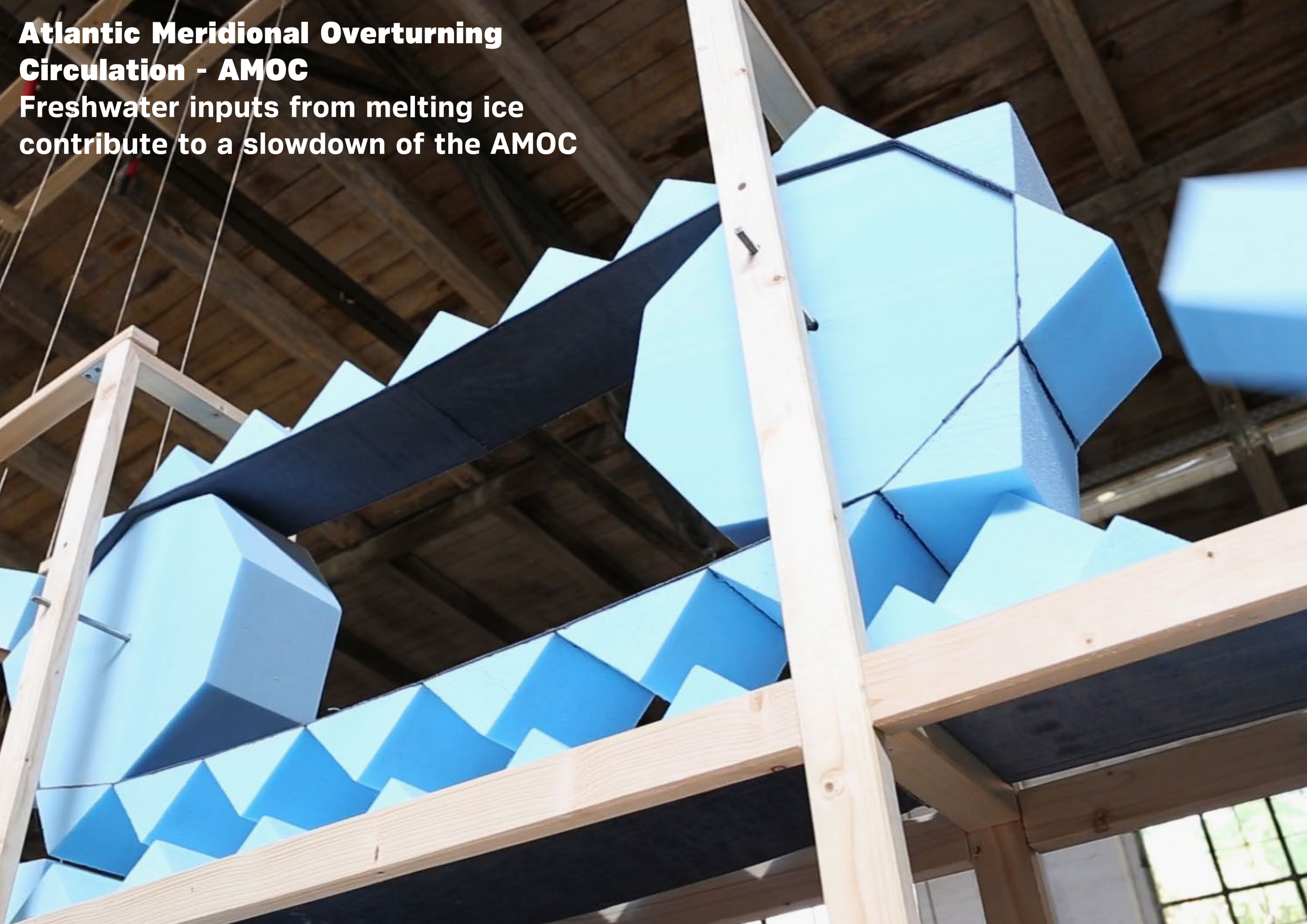
Atlantic Meridional Overturning Circulation (AMOC)

Undine Gnauck
Leonie Schatter

System dynamics
The AMOC is an ocean stream circulating between the southern hemisphere and the North Atlantic. As such, warm water from tropic regions and the gulf stream is transported northwards through the gulf stream. Low falling temperatures in the North Atlantic region and high increasing salinity due to ice formation lead to a higher density of the sea water, making it sink into deeper parts of the ocean sea where it displaces the water further below. Down there, a wake emerges. The displaced water streams back southwards in some detours and completes the AMOC.

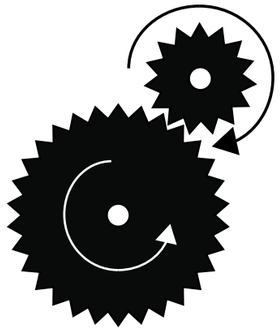
Tipping point scenario
Freshwater input from melting ice sheets, especially from Greenland, lower the salinity of the North Atlantic sea water. Furthermore, global warming leads to a higher water temperature. As a result, water density might not be sufficient anymore to power the circulation provoking its slow-down or even its complete interruption.
This would cause significant changes in Western European climate, where temperatures in winter would fall. The Baltic Sea for instance might freeze completely during winter months.

Interpretation
The installation shows a transport system with two solitary conveyors. Only the lower one has an engine. The moving parts are made of two materials in blue: polyurethane foam and jeans. Teeth for transportation are glued on ribbons; octagons serve as axis wheels; white cubes symbolize salt. The frame is mostly made of natural coniferous timber. The cubes must circulate between the transportation levels to connect them. Without the interlocking of the cubes the upper conveyor stops turning and stands still. Materials: wood, polyurethane foam, jeans fabric.

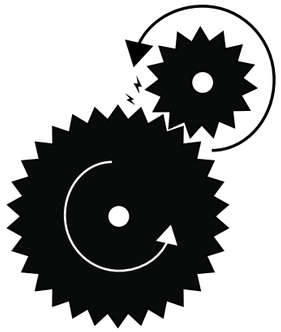


Atlantic Meridional Overturning Circulation - AMOC

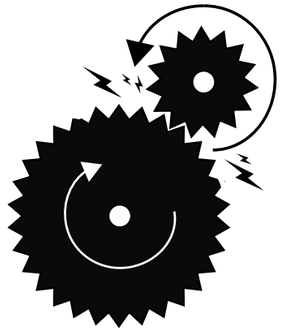
Freshwater inputs from melting ice contribute to a slowdown of the AMOC



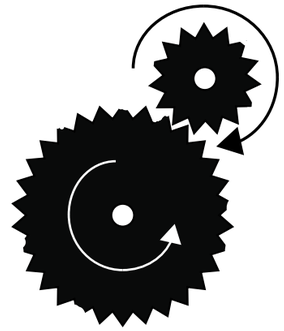
Circulating air and the surface water current in the South Pacific go hand in hand.



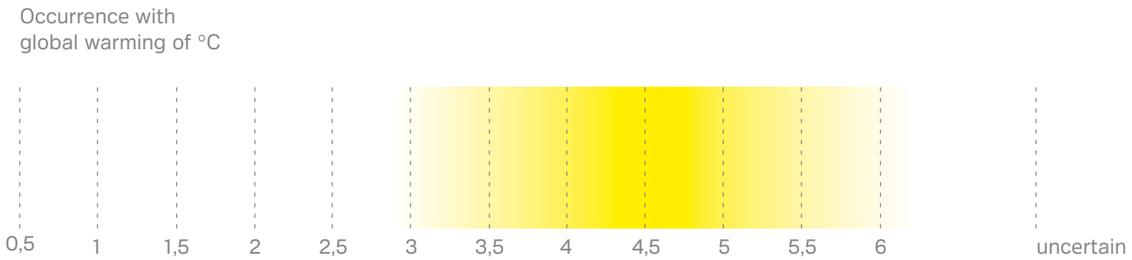
As the trade winds change, the circulating air takes on a different direction.

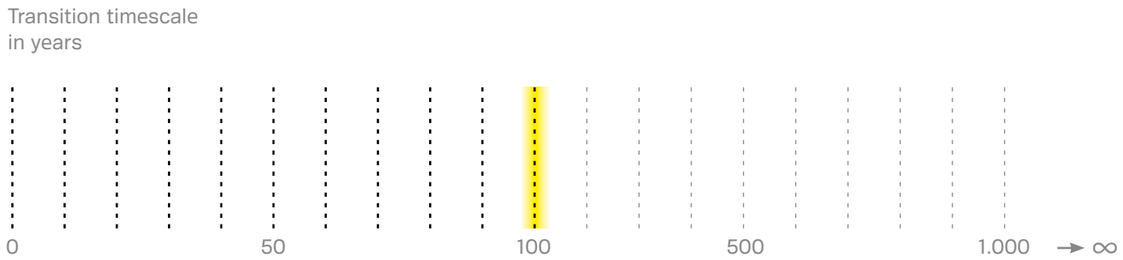


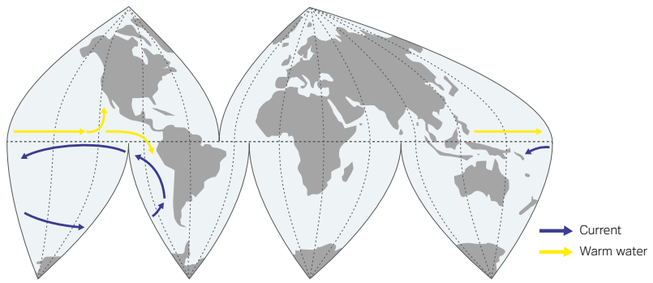
The water current also changes direction.



After some time, the cycles are back in sync, but they have less and less time to recover before the phenomenon repeats itself.







El Niño Southern Oscillation (ENSO)

Jan Lindstedt
Jakob Mayer

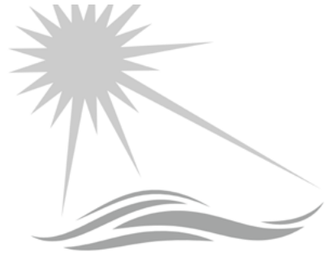
System dynamics
El Niño is a natural weather phenomenon that occurs between South America and Indonesia. During El Niño the trade winds are weakened and the surface water of the Ocean flows in the opposite direction warming the Pacific in the region of South America. This can for example have environmental impacts such as enhanced rainfall and flooding along the coast of South America. Conversely, there may also be droughts in Indonesia. At present, this phenomenon occurs every two to seven years.

Tipping point scenario
Scientists assume that the effect of El Niño is more frequent and more pronounced due to global warming. Due to a higher frequency of El Niño, the affected areas are less likely to recover from the effects of the damage. Extreme flooding would devastate entire parts of South America's coastline, probably severely depleting Pacific fish stocks and increasing coral mortality.

Interpretation
The model reflects the rhythm of El Niño. At first, the pendulum oscillates back and forth at more even intervals, which represents the normal state. The further the global warming progresses, the faster it oscillates back and forth. In this process, the rope is unwound further, increasing the pendulum's deflection until it finally reaches the ground. There, the impact of the pendulum will show the effects of El Niño. Materials: wood (MDF), rope, nails, styrofoam.

El Niño Southern Oscillation - ENSO

Due to global warming, ENSO's intensity and frequency changes

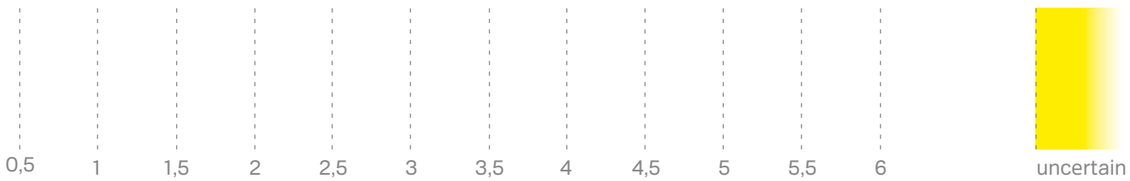


Sun heats up water and air. Trade winds arise. Water evaporates.

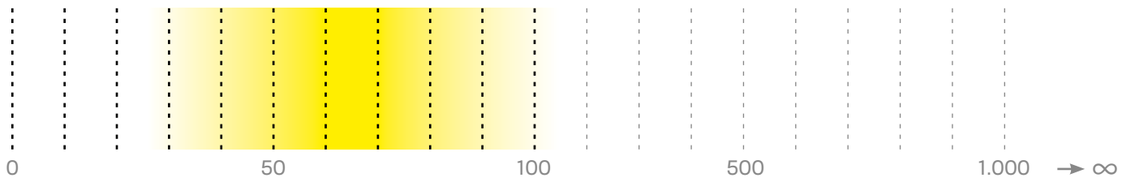
Wind drives rain clouds to the Indian subcontinent.

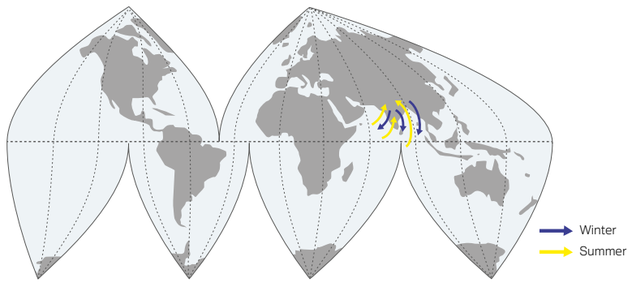
Clouds release rain over land, the rainy season starts.

Occurrence with global warming of °C



Transition timescale in years





Indian Monsoon

Adele Heymann
Lotti Maurer

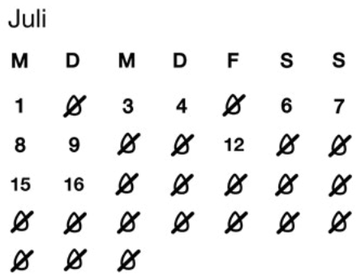
System dynamics
The Indian monsoon affects the Indian subcontinent where it is one of the longest known and most anticipated weather phenomena. It is caused by differing temperature trends over land and ocean. There is a wet season during summer time and a dry season during winter. It is only partly understood and difficult to predict.

Tipping point scenario
Normally there is a dry and wet period which is evenly distributed throughout the year. As global temperatures continue to rise, however, these periods become more irregular and extreme, leading to catastrophic flooding and crop-destroying droughts since certain weather phenomena tend to stay at the same place over a longer period of time. The Indian monsoon fluctuates by 4 to 12 percent more per degree Celsius of global warming. Without a regular monsoon, agriculture might become increasingly difficult endangering the food security of the Indian subcontinent.

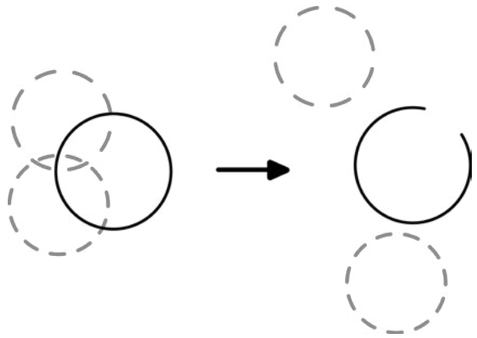
Interpretation
The installation includes rotating and rocking elements. Fans stand for the trade winds that drive the monsoon. The wind causes the object to rotate. Acrylic paint filled in at the top stands for the extreme rainfalls and is distributed irregularly through invisible holes of thin tubes on packing paper, which symbolises the Indian subcontinent. One of the fans begins to rotate, causing the spinning and rocking mechanism to swing more and more irregularly, and finally stops. Materials: metal base, wooden ball, aluminium arms, packing paper, plastic funnel, plastic tube and acrylic paint.

Indian Monsoon

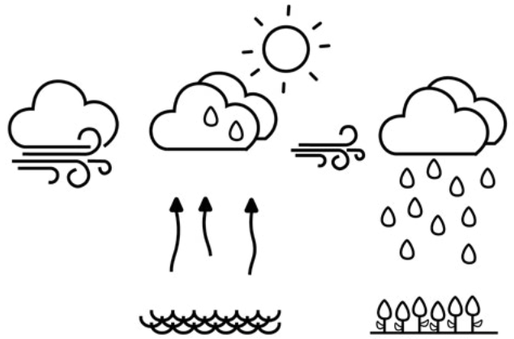
One of Asia's most important weather phenomena changes from regular to irregular cycles



The increasing loss of rainfall leads to water shortages in the region.

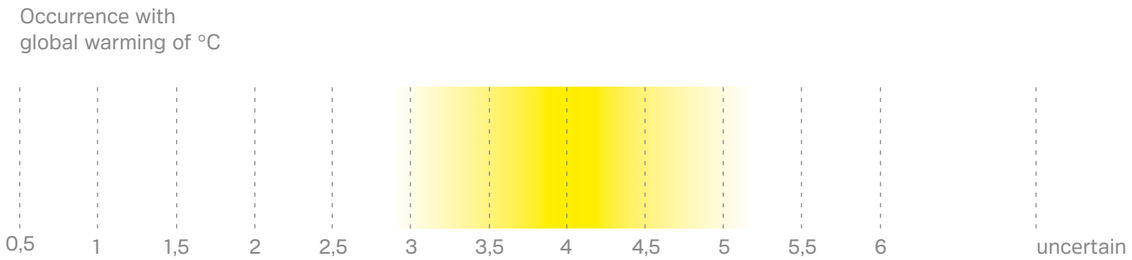


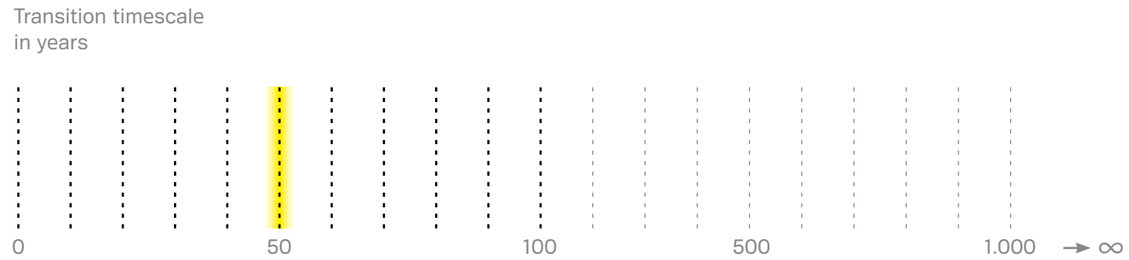
The West African monsoon is a complex climate system that depends on several interacting climatic systems.

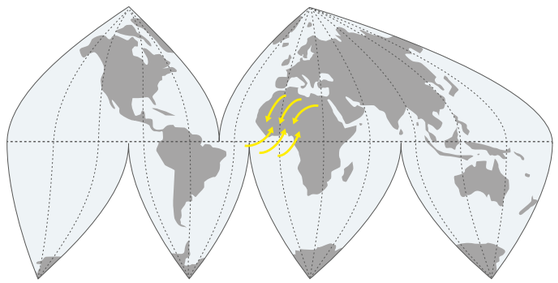


The lack of rain leads to crop failures, which are catastrophic for the local economy and population.

The lack of rain leads to crop failures, which are catastrophic for the local economy and population.







West African Monsoon

Henrike Haber
Vincenzo Werner

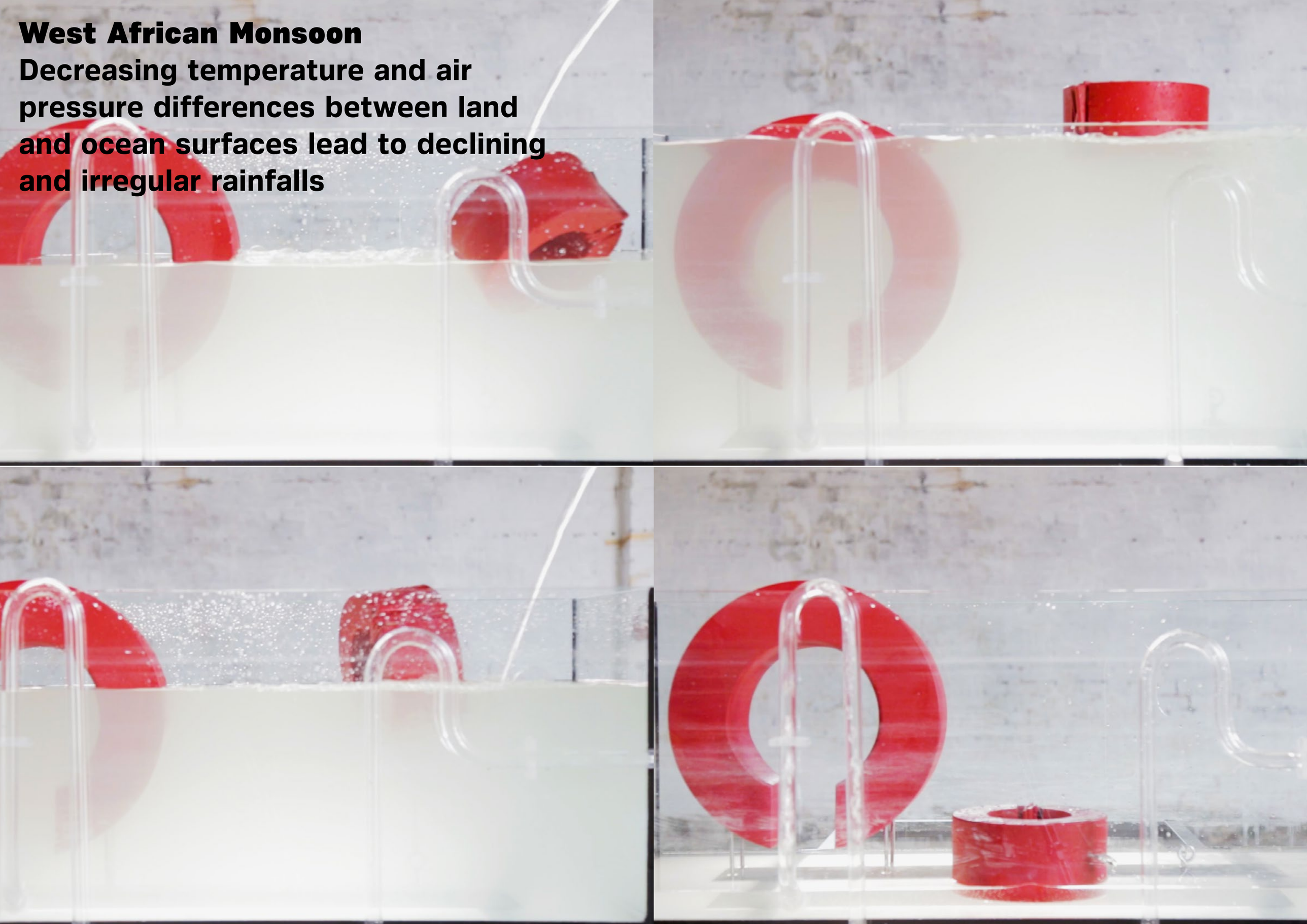
System dynamics
Due to the proximity or distance to the sun caused by the inclination of the Earth, air masses in the northern and southern hemispheres heat up differently. This results in high pressure areas in the warm regions and low pressure areas in the cooler regions leading to the formation of winds. Those absorb humidity over the ocean surfaces and release it again over the cooler West- and Central African land masses. Thus, the relationship between air and ocean temperatures is key.

Tipping point scenario
Higher ocean temperatures and altered ocean circulations lead to a smaller difference between air and ocean temperatures, resulting in weaker and more irregular rainfalls over the West and Central African land masses in the period from May to July. These are considered important socio-economic factors in the West African coastal region of the Gulf of Guinea, as almost 80 percent of the region's gross national product depends on the agricultural sector.

Interpretation
The complex and multifactorial climate tipping point is translated into a sculptural visualisation, with the pivot of the installation being water. Using the Pythagorean syphon principle, the climbing and declining of the water level visualises the disturbed circulations, tipping from a stable to an unstable irregular cycle. Materials: glass, bent acrylic glass tube, acrylic glass and varnished medium-density polyurethane foam.

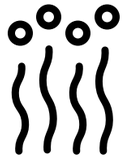
West African Monsoon

Decreasing temperature and air pressure differences between land and ocean surfaces lead to declining and irregular rainfalls

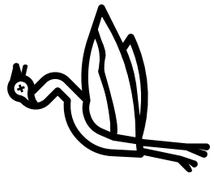


Forests are vital oxygen producers.

Increasing heat causes more forest fires.

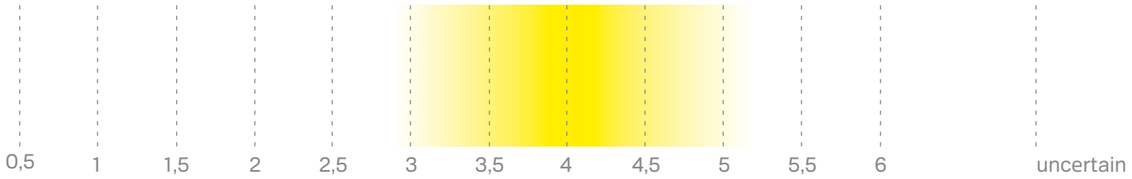


Dead wood releases harmful greenhouse gases such as C02 into the atmosphere.

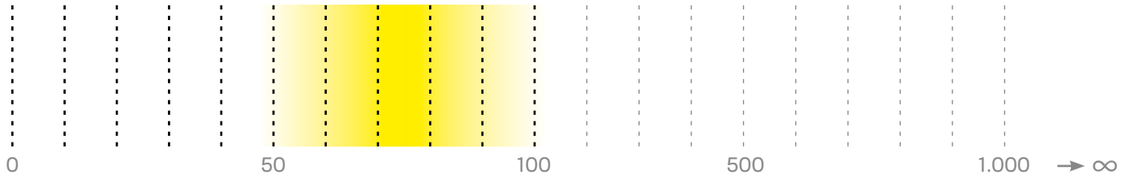


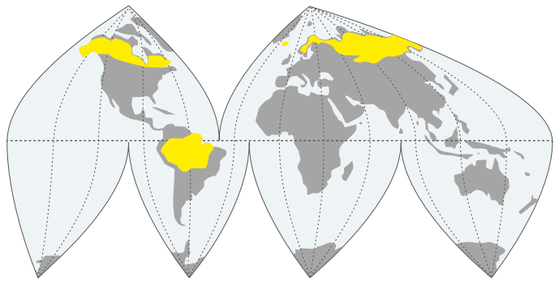
The dying of large forest ecosystems also causes a mass extinction of fauna.

Occurrence with global warming of °C



Transition timescale in years





Boreal Forests and Amazon Rainforest

Kenny Löffler
Mariana Reinhardt
Lele Schlaich
Muhammed Yapici

System dynamics
The Amazon rainforest is the world's largest CO2 reservoir and home to 25% of the world's species. In the last 50 years, however, 17% of the area has been lost to deforestation, road construction, logging and other land use changes such as plantations and cattle farming.
The Boreal Forest makes up about a third of the world's forests, consisting of spruce, pine, fir and larch.
It is an important repository for greenhouse gases, since dead trees are not completely decomposed in the cold, and their remainings store a lot of CO2.

Tipping point scenario
With the dieback of the forests through global warming, formerly captured CO2 is released into the atmosphere. The melting permafrost soil of the Boreal Forest leads to the release of more gases that may further intensify climate change. Consequences are rainfall changes, heat and drought stress, flooded coastal regions, and the loss of biodiversity. 400 indigenous tribes can lose their homes in the Amazon rainforest. The Earth's Boreal and rainforests could be transformed into savannahs, steppes or grass regions.

Interpretation
The focus of this tipping point lies on the chain reaction. Collapsing dominoes on a world map layout represent the Earth's forests. Large stones symbolise the most important forests: The Amazon Rainforest and the Boreal Forest. Green and white colour pigments support the effect. A chain of fire catching matches forms the end of the installation, leaving behind a forest after a dramatic fire.
Materials: spruce wood, pigments, matches, fire.

Boreal Forests and Amazon Rainforest

More frequent droughts, heat waves and deforestation lead to fires and insect outbreaks accelerating forest dieback

Tipping Points

Visual experiments on disruptive climate system changes due to global warming

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Atlantic Meridional Overturning Circulation (AMOC)
Undine Gnauck
Leonie Schatter

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Video & Audio Editing "AMOC"
Leonie Schatter

Set Photography
Jan Lindstedt
Jakob Mayer

Video Link
https://vimeo.com/363540500

References
Tipping elements in the Earth's climate system
Timothy M. Lenton, Hermann Held, Elmar Kriegler, Jim W. Hall, Wolfgang Lucht, Stefan Rahmstorf, Hans Joachim Schellnhuber. Proceedings of the National Academy of Sciences Feb 2008, 105 (6) 1786-1793

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