CLIMATE (COMMUNICATION) EMERGENCY

Mapping climate change representations across the online weather forecast landscape

MASTER THESIS

Politecnico di Milano – School of Design
Master of Science in Communication Design
a.y. 2022 / 2023

SUPERVISOR

Matteo Ciastellardi

CO-SUPERVISOR

Richard Rogers

STUDENT

Daniele Dell'Orto

TABLE OF CONTENT

ABSTRACT

Online weather forecasts worldwide deal with the extremisation of weather patterns, which is the most tangible expression of the climate crisis humans are facing. They have the opportunity to create meaningful, engaging and empowering communications on an issue which is urgent but difficult to picture, perceive and manage. In order to evaluate weather websites' potential of producing shared comprehension and fostering relevant action, climate change-related content from various case studies has been collected and mapped. Texts, images and interfaces have been analysed in a Digital Methods' framework through three protocols based on communicative contexts (special reports on the climate crisis - everyday practices - coverage of extreme weather events). The data has been mapped in various visualisations, part of a comprehensive report designed to encourage atonomous exploration and pattern detection. Finally, representations have been assessed in terms of their efficacy, in accordance with criteria and principles defined on the basis of existing literature on climate change communication. While the analysis has found that the online weather forecasts' landscape is increasingly addressing climate change through the coverage of its impacts—extreme weather events in particular—it also highlighted that the depictions often lack the capability to push meaningful reactions in individuals and communities.

Introduction →

Despite humanity is starting to experience on its own skin the dangerous impacts of extreme weather events fueled by greenhouse gases emissions, there haven't yet been policies and agreements capable of properly addressing the crisis. In a context in which governments and international organisations prove to be reluctant to seriously confront the global threats we face, citizens and individuals could play a fundamental role, influencing the political agenda through expressions of concern and demands of relevant responses. For this to happen, however, there needs to be a shared understanding of the climate emergency stressing both urgency and agency, the need for action as well as the concrete possibilities in that sense. The online weather forecast landscape can play a critical role in sharing knowledge on the issue through meaningful, engaging and empowering communications. Weather websites are globally spread, and at the same time they deal with the most concrete expression of climate change. They have the opportunity to connect localities to the wider picture, engaging communities through concrete accounts of extreme weather events and finally empowering them in the demand of systemic change.

This research tries to the state of the art of climate change representations across online weather forecasts. The analysis is aimed at detecting trends, patterns, recurring features and imaginaries—and, in the end, determining how effective they tend to be. In order to evaluate the general landscape, climate-change-related content from various case studies was collected and analysed. The resulting map took the shape of a printed report, structured through three research protocols answering three different questions:

PROTOCOL 1
How do weather forecast agencies represent climate change when they are explicitly asked to?

PROTOCOL 2
How do weather forecast platforms represent climate change in their everyday practice?

PROTOCOL 3
How do weather forecast platforms represent climate change in connection to extreme weather events?

The data is organised inside each protocol according to three main data types: texts, images and urls. Data of each and every type is gathered and evaluated with a digital methods' approach and through the production of visualisations meant for investigation. Key aspects of the visualisations include their layered and dense display, as well as their tendency to limitate abstraction as much as possible in order to maintain a connection with the original media object they represent. The printed report is intended as a device for an unconstrained exploration of the climate change representations' landscape pictured, through which the viewers can make their own sense of the data.

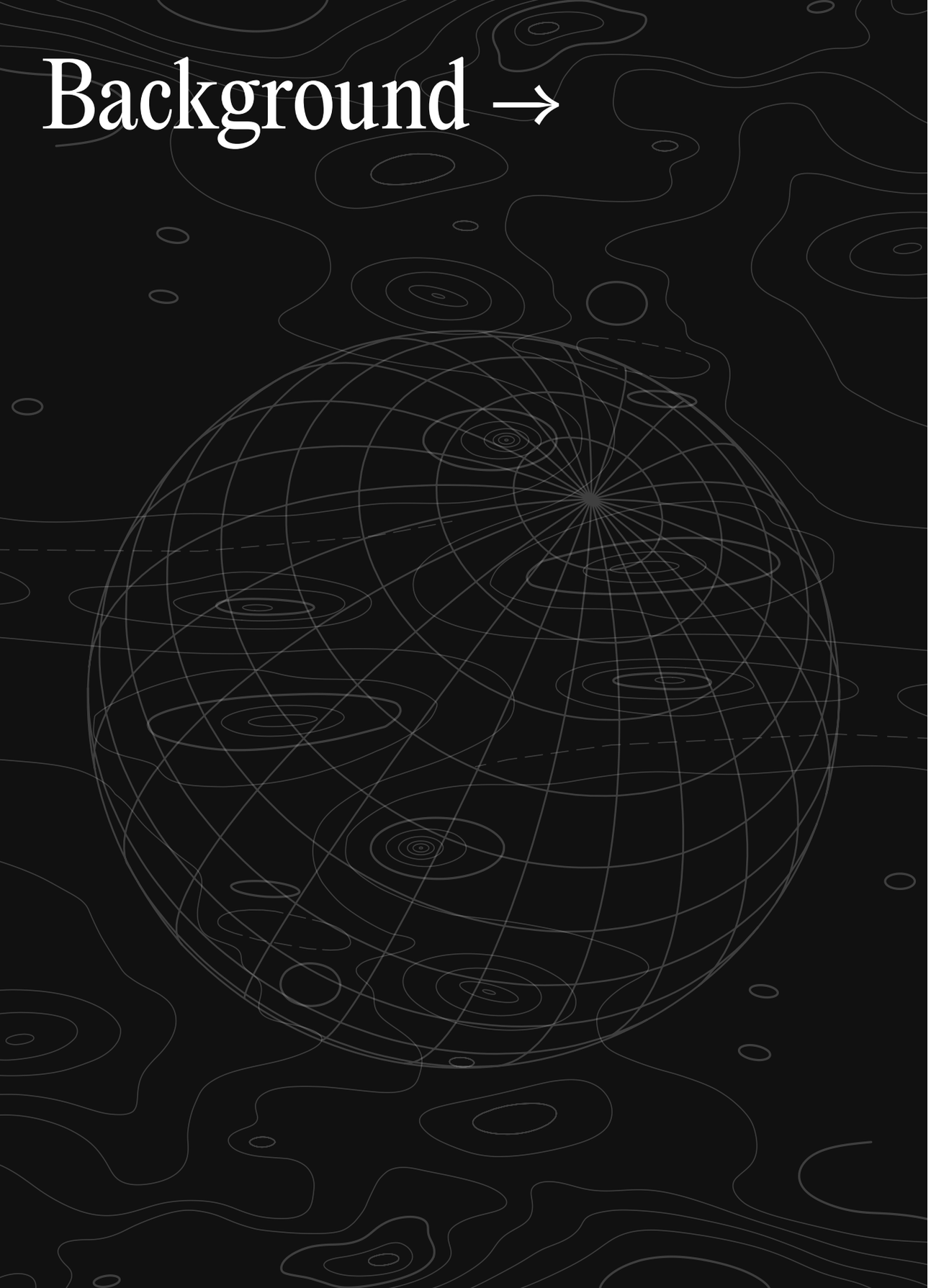
The thesis you're reading outlines the conceptual and methodological framework around the report, and it is structured in three sections:

1) BACKGROUND, a literature-based account of the societal and institutional management of the climate emergency, the difficulties connected to the crisis' communication and perception, and the opportunities for meaningful representation of it.

2) METHODOLOGY, a detailed explanation of the case studies considered, the criteria for their evaluation and the methods and processes involved in the analysis.

3) DISCUSSION, a dissertation in which I will evaluate the landscape of climate change representations inspected, providing insights and findings in accordance with the criteria previously defined.

The report works alongside the thesis as a separate independent artefact, containing the visualisations produced through the protocols as well as the description of the processes which generated them.



CLIMATE CHANGE AND ITS MANA GEMENT

The side products of modernisation

Climate change (also “climate crisis” or “climate emergency”) refers to the long-term shifts in temperatures and weather patterns caused mainly by the accumulation in the atmosphere of carbon dioxide and other greenhouse gases (GHGs) produced by human activity (Stern & Great Britain Treasury, 2006, p. iv). It is a pressing issue of enormous proportions, which if not promptly handled by institutions and societies will have dire consequences on humanity as a whole. Not only its global dimension, but also specific characteristics both in its intrinsic nature and in the way it’s perceived and treated by societies, identify the climate crisis as a peculiarly contemporary crisis: it’s a direct consequence of progress, it’s increasingly discussed on multiple societal levels, and it’s moving behavioural change in individuals as well as the implementation of new policies (Beck, 1992). Since the 1990s the complex relation between progress, threats and communities is the subject of various sociological studies centred around the concept of *risk society*.

German sociologist Urlich Beck, one of the fathers of risk society theories, argues that many contemporary societies are becoming aware that modernisation, especially in the form of industrialisation, produced not only wealth but also “hazardous side effects” (p. 20). The optimistic representation of progress gets contaminated with suspicion and fear: a process which promised freedom from the whims of nature subjected people to a whole new class of risks. Climate change fits perfectly in this perspective: it is a new kind of threat since it’s no longer primarily natural but it’s the outcome of humanity’s attempt to rule nature (Giddens, 1991). It can be conceived as a force put in motion by humans, but no longer under human control. The impacts of human activities have altered the biogeochemical cycles of the planet to the point that the current geological age has been identified as “anthropocene”: mankind is now the major influence on climate and environment (Fehlinger, 2020a).

The awareness of the risks produces a general push to react and manage them as far as possible. However, the sense of urgency grows proportionally to the feeling of powerlessness and incapability to deal with the threats: in the end, societies end up organising themselves in function of risk management, through what Beck defines as “systematic ways of dealing with hazards and insecurities induced and introduced by modernization itself” (p. 21). The social structures change, and threats become the centre of power relations, interactions, conflicts and collective action. Institutions redefine themselves as professional risk handlers for the community, and most of the policies are focused on trying to prevent dramatic outbreaks or, more often, reduce their impacts.

Welfare state’s decline and rise of climate concern

The first theory about man-made climate change dates back to **1896**, when the Swedish scientist Svante Arrhenius released a publication regarding the possible correlation between the burning of fossil fuels and the rise of the planet’s average temperature. However, scientists and activists started raising serious concern and asking those in power to implement policies to prevent and confront the issue only in the 1970s (Weart, 2023). For decades, triggering an event on such a scale seemed far beyond human power, and even if any change had happened people would expect some kind of natural balance to take over and restore the “normal” cycles. This perception of humankind as puny when confronted with natural laws started to be shaken

with the advent of the atomic bomb: after the open-air tests of the 1950s and 1960s in both the United States and the USSR, nothing seemed beyond human power anymore.

Apart from setting the first roots for the distrust in modernisation and progress, the experimentation with nuclear weapons pushed new studies on the global biosphere. In the late **1950s**, a group of american scientists lead by Roger Revelle brought further the ideas of Arrhenius, suggesting that because of the rise of dioxide gas levels in the atmosphere "the average global temperature might climb a few degrees Celsius before the end of the 21st century" (Weart, 2023, Impacts of Climate Change section), producing violent effects on the earth's climate. It was in an account of the team's work, that the term "global warming" was first used in the modern sense. However, both the expression and the research behind it didn't reach far from the minor scientific community that produced them. Furthermore, the experts themselves were deeply uncertain on the actual trend of climate change, and the unpredictability contributed to the perception of the issue as distant in the future.

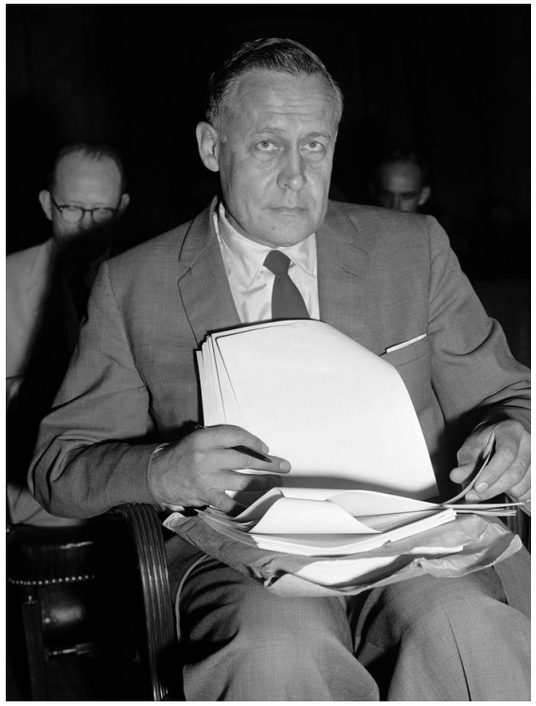


FIG 01. The father of global warming studies Roger Revelle before offering testimony on the dangers of atomic fallout to a joint Senate-House Committee hearing in Washington, D.C., May 28, 1957.

The **1970s** were characterised by the rise of worry in the scientific community, and their attempt to bring the topic to the attention of society as a whole. Anyway, experts often disagreed on the actual impacts of human activity on the climate system, and the accounts they made often presented contrasting scenarios. Global warming theory was countered by the idea of a global cooling, based on the supposed weakening of sunlight due to dust and smog particles in the atmosphere. When fed with climate theories, the public was, if anything, confused. The complexity of natural laws—reaffirmed by the scientists' inability to understand them—happened to reassure people from the risk of human activity having such serious impacts on the world.

It's in the **1980s**, thanks to the proliferation of studies as well as improved computer models, that the majority of the scientific community started to agree on the nature and risks of climate change. Before the end of the decade, the climate crisis really began to get to the general public's attention. Weart cites some data from a US-based report:

"*In September 1988 a poll found that 58% of Americans recalled having heard or read about the greenhouse effect. It was a big jump from the 38% that had heard about it in 1981, and an extraordinarily high level of public awareness for any scientific phenomenon. Most of these citizens recognized that 'greenhouse effect' meant the threat of global warming, and most thought they would live to experience climate changes. In other polls, a majority of Americans said that they thought the greenhouse effect was 'very serious' or 'extremely serious,' and that they personally worried 'a fair amount' or even 'a great deal' about global warming. Fewer than one-fifth said they worried 'not at all' or had no opinion.*" (Weart, 2023, The Public and Climate Change Since 1980 section)

While the scientific community agreement on the topic was critical to the rise of the general public's awareness of it, the reception and framing of the climate crisis was also deeply influenced by social and political changes happening in those years. During

the 1970s and 1980s most western societies were affected by welfare states' displacement: social institutions and forms weakened and became more fluid, communities fragmented and eroded, economics were increasingly dislocated and globalised. Individuals were made more responsible for themselves, deprived of the institutional protections and guarantees they had before. At the same time, the explosion of worldwide connections made everyone more dependent on forces beyond their reach, especially market forces (Bauman, 2007). People have now to be self-reliant in a world of global competition, and the contradiction between responsibility and dependence is a key reason why western countries in the 1970s and 1980s are identified as the birthplace of risk society: the new societal conditions create a general feeling of powerlessness, vulnerability and loss of control that fosters fear towards the future and consciousness and suspicion towards side effects of progress (Beck, 1992; Furedi, 1997). The idea of the climate crisis as an issue of which humankind is directly responsible, but not in control anymore, deeply resonates with the situation of people after the decline of welfare states: it's the environmental equivalent of the forces that threaten individuals in society.

FIG 02. Dr. James E. Hansen from NASA stating in front of a Congress Committee that "it is time to stop waffling so much and say that the evidence is pretty strong that the greenhouse effect is here", June 24, 1988.

Policies for the climate emergency

With growing concern in the scientific community, experts started to focus their efforts not only on informing the general public, but more and more on trying to influence government policy. In 1985 climate scientists from 29 nations gathered at a conference in Austria and agreed to call on the world's governments to act by creating international agreements to restrict greenhouse gas emissions. However, it took another 3 years—and a proof of the climate crisis dangerous effects—for the topic to make its appearance on public agendas. Summer **1988** was the hottest on record in many countries in the world, including the United States, and the extensive coverage of the heatwave's impacts by newspapers, magazines and televisions drew public attention to the climate. In that context and with widespread public concern, outcries about global warming couldn't be left unheard. When a major international meeting of scientists in Toronto addressed policymakers, asking once again to provide strict regulations on emissions, the United States—and the United Nations consequently—responded.

For a global issue such as the climate crisis, the response had to be global: there was the need for new forms of political cooperation putting global concerns above national interests (Masco, 2010). The tool of choice in this sense were *Global Environmental Assessments* (GEAs): "formal efforts to assemble selected knowledge with a view toward making it publicly available in a form intended to be useful for decision making" (Clark et al., 2006, p. 3), the first major one being the International Ozone Assessment initiated in 1981. GEAs are touchpoints between the scientific community and governments with the purpose of providing policy-relevant advice (Borie et al., 2021), and they mostly come in the form of bureaus of scientists. They are generally issue-specific: scientists in the bureau gather all existing knowledge on the issue of concern, proceed with further studies, and release reports addressing the steps to take in dealing with the situation. Gov-

FIG 03. The first session of the Intergovernmental Panel for Climate Change (IPCC) in 1988.

ernments access the reports and—in theory—translate scientists' advice into viable policies. The GEA created in response to public and scientific concern on climate change was the *Intergovernmental Panel for Climate Change* (IPCC).

The IPCC was built in 1988 by the WMO (World Meteorological Organization) and the UNEP (United Nations Environment Programme). Although managed under the auspices of the United Nations, the Panel was structured as a hybrid body made of individuals appointed independently by each government: they participated not only as science experts, but also as official representatives of their states. With the foundation of the IPCC a cyclic international process was established: roughly twice a decade the panel would release an *Assessment report* resulting from the assembling of the most recent research, its analysis and the reach of a consensus; the report would then be the foundation for international negotiations in a *Conference of the Parties* (COP), with the purpose of providing guidelines for individual national policies (Weart, 2023). So far the IPCC has released 6 official Assessment Reports (AR), plus various specials.

- **1990** → FAR (*First Assessment Report*)
- **1995** → SAR (*Second Assessment Report*)
- **2001** → TAR (*Third Assessment Report*)
- **2007** → AR4 (*Fourth Assessment Report*)
- **2013-14** → AR5 (*Fifth Assessment Report*)
- **2021-22** → AR6 (*Sixth Assessment Report*)

COPs have been held every year starting from 1995, with the aim of producing international regulations on the basis of the IPCC reports to deal with the climate crisis. Key agreements on emission reductions resulting from the conferences have been:

- The KYOTO PROTOCOL, adopted in **1997** and gone into effect in **2005** after a complex ratification process with 141 signatory nations.
- The PARIS AGREEMENT, adopted in **2015** by 185 signatory nations.

However, the actual institutional action to contrast climate change has been so far deeply insufficient. This is first-of-all due to the fact that the IPCC was designed by the Reagan administration as a tool for paralysis: while the reports need absolute consensus in the Panel in order to be published, many participants over the years proved to be tied to the interests of the government they represented (Weart, 2023). That's the case, for example, of delegates representing Saudi Arabia and Kuwait (notoriously oil-exporting nations) who in 1995 deliberately disputed specific sentences to weaken the conclusions of the Second Assessment Report (Mann, 2021). The IPCC was subsequently reformed various times, with major changes in its procedures in 1993, 1999 and 2010 (Borie et al., 2021). There's not only that: the COPs aims often clashed with the libertarian positions of many countries, hostile to committing to substantial obligations. The Kyoto protocol took years to be ratified, years in which notable emitters withdrew from the agreement—between them, the United States under Bush's presidency. The Paris Agreement had wider support, also because it was less ambitious: each government volunteered individual targets for reducing emissions. Anyway, most nations are already failing to comply even with the shy goals they set, proving to be unable to deal effectively with the problem (Leahy, 2019).

In order to provide significant responses to the climate crisis, systemic changes are required. The scientific community has agreed that it's important to act now and to do it on two levels: adapting to the conditions already underway and at the same time fighting to mitigate the entity of the change. As Stern puts it, "The benefits of strong, early action considerably outweigh the costs. [...] At the same time, given that climate change is happening, measures to help people adapt to it are essential. And the less mitigation we do now, the greater the difficulty of continuing to adapt in future" (Stern, 2007, p.ii). Both reactions are necessary at this point, and governments have the responsibility of supporting people in adaptation while at the same time driving a world-wide shift towards a low-carbon economy (Stern, 2007). Governments bear such responsibility since Individual behaviours alone can't make the difference we need, also because people often operate within a broader context that enables or constrains them from taking action (Corner et al., 2018). Emissions must be regulated through the governments' interference in market dynamics: the burning of fossil fuels is the result of supply and demand. Policies should take account of both sides, working for diminishing demand - with carbon pricing and/or incentives for renewables—as well as limiting supply—with fossil fuel divestment (Mann, 2021). Both approaches are necessary, and must be applied in a framework in which the price of the shift is paid by institutions and fossil fuel companies rather than individual citizens.

The shift is technically possible: "Peer-reviewed research demonstrates authoritatively that even without any technological innovation—that is, using current renewable energy and energy-storage technology—we could meet up to 80 percent of global energy demand by 2030 and 100 percent by 2050." (Mann, 2021, p. 137). However, as previously highlighted, governments are failing in providing the much needed systemic change. In this context, individuals can have a critical role influencing the political agenda, underpinning and scrutinising policies, as well as driving production patterns by responsible consumption when they can afford it (O'Neill & Hulme, 2009; Moser, 2010). Public leverage in the governments' management of the climate crisis is crucial, and runs through sustained expressions of concern, demands for policies, support of climate-focused organisations and of politicians who will back climate-friendly policies. In order for the people to take part in this process, however, a shared understanding of the climate crisis is needed. Understanding and push for action can and should be fostered through meaningful and empowering communication.

THE KNOTS IN CLIMATE CRISIS DIVULGATION

An issue beyond individual perception

Communicating the climate crisis isn't an easy task. Coherently with the account of modern hazards by risk society theories, climate change has some peculiar traits which make it especially hard to conceive: it's global, long term and can be fully understood only through scientific filters.

The climate emergency is GLOBAL since its biggest risks are absolute and go over class-specific barriers, even if it doesn't completely transcend society (Beck, 1992; Giddens, 1991; Furedi, 1997). Social and economical differences are enhanced by the hazards of climate change, due to the unfair relation between the distribution of the impacts and the readiness to tackle them. In a global perspective, not every country will see the same changes in temperature or rainfall patterns and not every country will be affected by the rising sea level to the same degree. But also, not every country has the same capability and resources to adapt. Unfortunately, the countries most vulnerable to the impacts of global warming are often located in the global south, and lack the funds to undertake adaptation and protection investments. In addition to that, they are generally the least responsible in terms of emissions (Wendler, 2022): the crisis is an amplifier of inequalities on the global level. However, differences in the experiences of the emergency are mainly in terms of impact intensity, while in some terms the hazards will affect the whole planet.

The climate crisis is LONG-TERM since the effects of current emissions will be clearly visible only in the future and the impacts will interest generations and generations to come (Stern & Great Britain Treasury, 2006). It is a process where causes and effects are temporally far one from the other, and their connection can only be imagined.

In conclusion, the climate crisis can only be fully read through science because of its scale. Its temporal and spatial dimensions make it invisible to individual experience. Climate itself is an ABSTRACT concept built by tracking, connecting and mapping values in different locations over time: Individuals face meteorological conditions (such as temperature and humidity) in a specific moment in a specific place, not long term trends in global regions. Our understanding of climate change is deeply rooted in scientific knowledge and tools that go beyond individual perception (Pelletier, 2021). It is a topic that needs to be visualised in order to be seen, needs to be represented through media devices in order to be understood. Without the translation and abstractions accomplished by the media, climate change (and climate in general) wouldn't even be known (Schneider & Nocke, 2014).

Not only is the climate emergency fully understandable through science only, but science itself can't provide a fully defined picture of it. That is because of its immense complexity and the extreme amount of variables involved (Moser, 2010), but also because science itself is UNCERTAIN by definition. The scientific endeavour provides us with the most trustworthy information about the world to which we can aspire, but it doesn't provide absolute truth (Giddens, 1991). Knowledge needs to be constantly scrutinised, revised and updated. The first computer models able to interpret current climate in relation to the past and to greenhouse gases emissions came only in the 1980s, more than 80 years after Svante Arrhenius started talking about a human-caused increase in global temperatures. Even now that all models point in the same direction and highlight the same risks (Cairo, 2019), uncertainty is often still stuck to the people's perception and conceptualisation of the climate emergency.

Climate change's conflictual definition

Uncertainty means that the definition of climate change is open to social processes in which its meaning, the connected risks and the ways of dealing with it are negotiated not only on the basis of science, but also on the basis of personal and collective beliefs and perceptions (Beck, 1992). In this context science condemned itself through the refusal of absolute truth to be subjected to cultural and social acceptance. It's as if the representation provided by science contained some gaps, and in the attempt to fill the gaps individuals and communities distorted the whole representation. The bigger the gaps appear, the more space to individual filling is left, the more distorted the representation gets. That is why uncertainty in relation to the climate crisis is often stressed by actors with specific political and/or economical interests (Glassner, 2018): they intend to replace the scientific definition of the issue with their whole distorted picture, in order to shape people's perceptions and—as a consequence—behaviours. As in the risk society framework, risk determination is a conflictual process with a direct effect on hierarchies and power structures, but it's also a competition where not everybody plays at the same level: effectively pushing a definition above the others requires means of influence and persuasion.

The main conflict on climate change definition over time has been that brought on by fossil-fuel-related industries. They've been very aware of the threats related to emissions for decades—an internal research team of the american multinational ExxonMobil produced accurate estimates of global warming as early as in 1977—but kept everything hidden as long as they could (McCarthy,

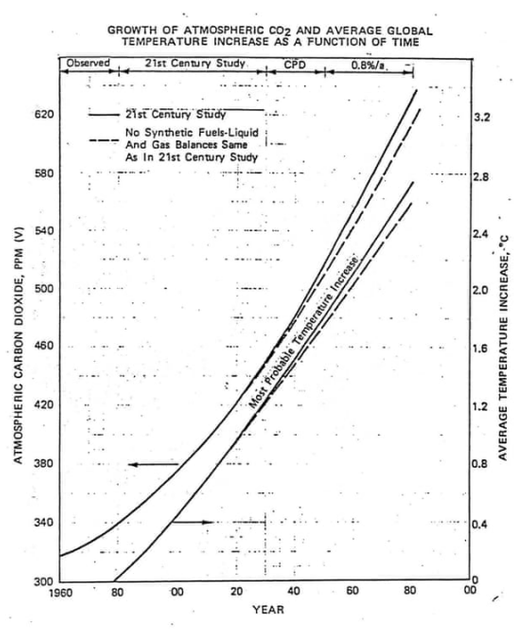
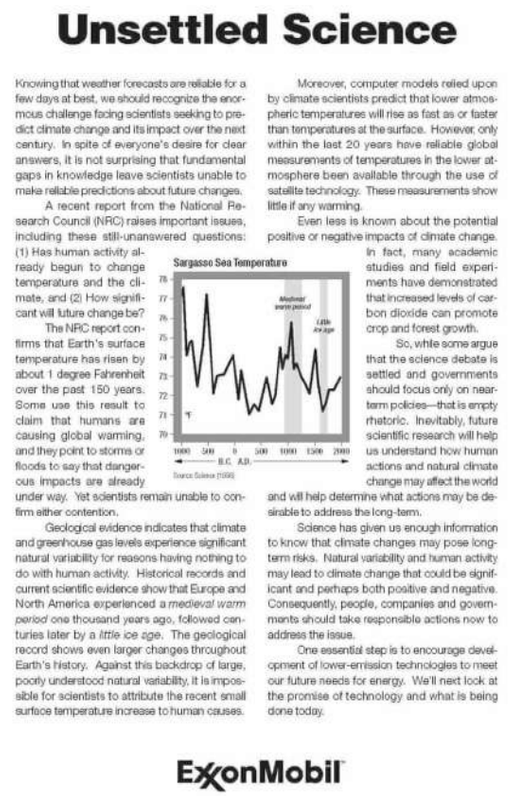


FIG 04. 1982 Exxon internal briefing document predicting the future growth of carbon dioxide levels (left axis) and global temperature (right axis).



Unsettled Science

Knowing that weather forecasts are reliable for a few days at best, we should recognize the enormous challenge facing scientists seeking to predict climate change and its impact over the next century. In spite of everyone's desire for clear answers, it is not surprising that fundamental gaps in knowledge leave scientists unable to make reliable predictions about future changes.

A recent report from the National Research Council (NRC) raises important issues, including these still-unanswered questions: (1) Has human activity already begun to change temperature and the climate, and (2) How significant will future change be?

The NRC report confirms that Earth's surface temperature has risen by about 1 degree Fahrenheit over the past 150 years. Some use this result to claim that humans are causing global warming, and they point to storms or floods to say that dangerous impacts are already under way. Yet scientists remain unable to confirm either contention.

Geological evidence indicates that climate and greenhouse gas levels experience significant natural variability for reasons having nothing to do with human activity. Historical records and current scientific evidence show that Europe and North America experienced a *medieval warm period* one thousand years ago, followed centuries later by a *little ice age*. The geological record shows even larger changes throughout Earth's history. Against this backdrop of large, poorly understood natural variability, it is impossible for scientists to attribute the recent small surface temperature increase to human causes.

Moreover, computer models relied upon by climate scientists predict that lower atmospheric temperatures will rise as fast as or faster than temperatures at the surface. However, only within the last 20 years have reliable global measurements of temperatures in the lower atmosphere been available through the use of satellite technology. These measurements show little if any warming.

Even less is known about the potential positive or negative impacts of climate change. In fact, many academic studies and field experiments have demonstrated that increased levels of carbon dioxide can promote crop and forest growth.

So, while some argue that the science debate is settled and governments should focus only on near-term policies—that is empty rhetoric. Inevitably, future scientific research will help us understand how human actions and natural climate change may affect the world and will help determine what actions may be desirable to address the long-term.

Science has given us enough information to know that climate changes may pose long-term risks. Natural variability and human activity may lead to climate change that could be significant and perhaps both positive and negative. Consequently, people, companies and governments should take responsible actions now to address the issue.

One essential step is to encourage development of lower-emission technologies to meet our future needs for energy. We'll next look at the promise of technology and what is being done today.

Sargasso Sea Temperature

ExxonMobil

FIG 05. ExxonMobil 2000 advertorial in The New York Times promoting climate denial.

2023). Starting from the 1980s, when the issue was starting to gain coverage by the media, they "spent millions of dollars on lobbying, advertising, and 'reports' that mimicked scientific publications" (Weart, 2023, Introduction and Summary section), striving to convince the public that global warming didn't exist at all. To counter the spreading concern about the issue, they went as far as to create a consortium of fossil fuel interests known as the *Global Climate Coalition* in 1989, with the aim of disparaging every call for action against global warming. The Coalition constituted "a facade of impressive-sounding organisations, institutions, and individuals who would challenge—through newspaper op-eds, public debates, fake scientific articles, and any other means available—the basic science of climate change" (Mann, 2021, pp.30-31). They cooperated with many conservative politicians to promote the narration that no clear human role in global warming and climate change could be established. Their methods often included sophisticated communication devices: for example, favouring the term "climate change" over "global warming" because less threatening (changes are not necessarily for worse) and always pairing it with "theory" in order to make it perceive as uncertain. Interestingly enough, the same scientific community started using "climate change" as well, since it's a more comprehensive description of the various impacts of the problem: increases of temperatures are also connected with sea level rise, changes in precipitations, altering in ocean currents, and so on. With the building of more and more scientific evidence, positions of open denial became difficult to sustain. However, the efforts of fossil-fuel corporations simply shifted to softer forms of denialism, using various strategies to delay action. Mann identifies six of them (Mann, 2021).

The first strategy is the evolution of simple DENIAL: it includes shifting the focus from the scientific to the personal level, attacking the researchers in order to discredit them instead of trying to counter the studies. The symbolic episode which marked the transition to this new stage of denial is the infamous *Climategate* of 2009: during the weeks leading to the COP15 in Copenhagen, text extracts from stolen mails between climate scientists were published. The words and phrases were taken out of context and rearranged in order to distort their meaning, with the aim to give the idea that climate change was a hoax deliberately produced by the scientists themselves. In particular, an iconic chart known as the *hockey stick graph* was strongly attacked, with the accusation of being distorted and misleading. The first version of this graph appeared more then ten years earlier, in a 1998 Nature paper by Michael Mann, Raymond Bradley, and Malcolm Hughes called "Global-Scale Temperature Patterns and Climate Forcing Over the Past Six Centuries". A version of the chart with a longer time scale was featured in 2001 in the IPCC's *Third Assessment Report* (Walsh, 2014). The graph shows the evolution of temperature anomaly in the last thousand years, and owes its name to the shape of the trend it visualises: with the words of one of the scientists that produced it: "the long, gentle cooling from the relatively warm conditions of the eleventh century into the so-called Little Ice Age of the seventeenth to nineteenth centuries resembles the downturned 'handle' of a hockey stick, and the abrupt warming spike of the past century is the upturned 'blade.'" (Mann, 2021, p. 38). Climate deniers contested it because they feared it, since it had proved to be highly compelling to the layperson: one didn't need to understand the physics, mathematics, or statistics underlying climate research to read the chart and understand its meaning (Mann, 2021, p. 38). The (fake) scandal of *climategate* got extensive coverage in conservative media outlets, and right-wing politicians joined the fray. This is another key feature of this new denial strategy: even if the narration is targeting only a minority motivated more by sense of belonging and political identity rather than facts, it is echoed through allied media companies (as well as bot armies on social networks). The purpose is to distort the perceived proportion of deniers in our societies, reducing the prominence of climate change management in the public discourse.

The second strategy is DOWNPLAY: instead of attacking the basic physical evidence, the focus is now on lessening the scale of impacts to the point of presenting climate change as almost pleasing.

The third strategy is DEFLECTION: it is based on the diversion of attention from governmental reforms and regulations to personal behaviour. While it is true that any real solution must involve both individual and systemic change, focusing only on the former acts as a distraction from the role of big polluters (Corner et al., 2018). British Petroleum knew this very well, when in the mid-2000s promoted the concept of a *personal carbon footprint* (amount of greenhouse gases generated by an individual on the basis of their actions). BP even launched one of the first carbon footprint calculators, as part of a public relations campaign (signed by the British agency Ogilvy) meant to reposition it as the environmentally conscious oil company. The idea they wanted to spread was simple yet very effective (from the company's point of view): it's not BP that is polluting, but rather each individual's lifestyle.

The fourth strategy is DIVIDE: also based on stressing individual choices, it weakens the climate activist community by creating rifts along personal behaviours such as meat consumption or travel habits. It is particularly effective since it attacks lifestyle choices, which are directly connected to one's sense of identity. By popularising finger pointing and behaviour shaming, this strategy aims to generate conflict and fragment communities. Internal divisions prevent climate advocates from speaking with one voice, reducing the efficacy of their efforts. At the same time, the focus on purity gives the conservatives the opportunity to present the climate activists as hypocrites, undermining the public trust towards them—and as a consequence their message. Interestingly enough, even when Greta Thunberg, the swedish girl who became the leader of the global youth climate movement, refused to fly and sailed across the atlantic ocean to take part to the 2019 *UN Climate Action Summit* in New York, much of the media attention was on her personal behaviour rather than her requests for the global leaders. Lastly, stressing the personal sacrifices frames climate action as an incredibly demanding activity, reducing the public's intention to engage in such activity.

The fifth strategy is DELAY: the promotion of solutions alternative to cutting emissions. Most of them are not viable at all, and all of them present unforeseeable side effects which are rarely mentioned. The solutions include carbon capture, geoengineering monstrosities and strategies of resilience.

The sixth strategy is DOOM: exaggeration of the climate threats to the point that no solution seems feasible anymore. Through the feeling of powerlessness, this strategy points to inaction: the same aim of denialism, reached from the opposite side. While denialism undermines urgency, doom dampens agency. A 2019 CBS News poll found that in the group of responders who don't feel climate change should be addressed, the percentage of people stating that there is "nothing we can do about it," was larger than that of people stating that "it's not happening." Apparently, doomism is currently a more effective producer of inaction than denialism.

Competing interests in traditional mass media

In in the process of climate change definition, strategies are useless without platforms. All actors crave stages and vehicles through which they can spread their perspectives, making them influential for the population at large. In the 1980s, when the climate crisis became a cause of concern for the majority of the population, the privileged platforms where information travelled were newspapers, magazines and television: the landscape was dominated by traditional mass media (Weart, 2023). Traditional mass media are defined by a top-down structure and a broadcasting paradigm: they embed a hierarchical power structure in which information flows from the top to the masses (McQuail, 2010). However, even if each company's vertices have an actual power on what visions to share and foster, they are not completely free: they have various ties with other actors in a complex system of relationships.

Herman and Chomsky conceive the ties in the mass media news industry in terms of filters: a piece of communication is designed to comply with multiple conditions in order to be approved by different subjects before it can be aired or published. More specifically, the subjects involved are mainly four: the direct owners of the media, the advertisers which take part in funding the media, the sources which provide the information and, to a certain extent, the public itself (Herman & Chomsky, 2010).

The first filter is OWNERSHIP: content doesn't interfere with the owners' interests. In the traditional mass media landscape, dominant firms are quite large and expensive businesses, controlled by very wealthy people: not many individuals can afford to build one. As a consequence, they might have interests in common with other major corporations. Furthermore, governments can exert control through the releases of licences and franchises.

The second filter is ADVERTISING: content doesn't interfere with advertisers' interests. Traditional mass media is often partly funded through ads, in order to provide expensive content to the audience without making them pay the full price: it's a trivial matter of price-quality ratio. Since the advertisers basically pay for the programs, they can choose for the ones more in line with their own principles, and in some cases even shape them for their own sake.

The third filter is SOURCES: content depends on the sources that provide it. Traditional mass media need a continuous flow of material, especially for the news. Sources guarantee the raw material, but not every source is worth the same. Government and corporate sources are considered trusted and credible. Also routine sources—which have proved to be reliable over time—have privileged links with media companies. Finally, experts such as scientists have as well a good reputation and are highly valued. All previously mentioned sources maintain a power relation with the media firm which sometimes allows them to push stories of their interest.

The fourth filter is the PUBLIC: content depends on the likeliness that the public will appreciate it. Not only are the traditional mass media companies conditioned by economical and political ties, they also have to be careful not to cause negative reactions in their publics. Even if the mass media system is an effective and powerful ideological institution, a representation of its audience as a passive entity whose thoughts can be shaped at will would in fact be inaccurate and naive.

The power exerted by the public in the mass media system can be explained by the *agenda setting theory*. According to it, the media power resides in selecting the information that gets to the attention of the public, and in influencing the perception of the importance of each piece of content. The influence is exerted through:

- UBIQUITY, as the pervasive presence of the media in a modern society.
- CUMULATION, as the continuing treatment of the topic on various channels and over time.
- CONSONANCE, as the uniformity of details, viewpoints and emphases in the coverage of the same topic on various channels or over time (Shaw, 1979).

The media agenda (what the media say), the public agenda (what the public thinks) and the political agenda (what the policymakers decide) interact with each other in a cyclical system of reciprocal influence and competition (Matsaganis & Payne, 2005).

The media's effects on people perception of an issue depend also, to a certain extent, on the issue's own characteristics and on the relation between the audience and the issue (Matsaganis & Payne, 2005). In the case of climate crisis, the uncertainty dimension previously discussed, together with its spatial and temporal scale, makes it difficult for individuals to have a clear position in its regards. Climate change tends to appear as an ambiguous threat, which needs to be understood to be properly managed. Media promise to provide explanations of the topic, and in that way they can exert some influence on an audience which is generally receptive.

When talking about filters, we cited information sources as a subject to which the traditional mass media complex is tied. Specifically in climate change communications, scientists have a privileged role as authoritative sources: their credibility tends to be even higher than that of journalists (Carrada, 2006). When the perception of a climate emergency started to populate the scientific community, many felt the duty to share what they knew in order to foster a reaction in societies and governments. They tried to take advantage of their power, featuring in newspapers and television programs in order to reach the general public. However, their role has been more passive than active and their contribution often remained subjugated to the system of relationships embedded in the media complex.

Let's make a brief account on the communication of the topic in the US mass media system. Since the 1980s, the climate crisis saw waves of coverage in a *issue-attention cycle* dynamic: long-running stories such as those involving the environment tend to present peaks and troughs in the amount of published content. The public is used to periodically new striking content and incapable of sustaining a high level of anxiety about any topic for a long time. Peaks in the coverage usually matched specific concrete stories and notable events such as international conferences. Moreover, the tendency in the US (and in other western countries as well) has often been to create controversy around the

theme, balancing the views of climate scientists calling for strong government action with climate change deniers even after almost the majority of the scientific community had already agreed on the risks of man-made climate change (Weart, 2023). The representation of the two sides often didn't match the actual proportion of them in the society, both because of the media economic interests in providing controversial content and for the deniers' efforts in getting as much diffusion as they could. As sawn previously, climate scientists were often confronted with fierce opposition, even to the point of receiving personal attacks in order to undermine their credibility and integrity. Not ready to face the media power dynamics and the political polarisation that invested the topic, they lost multiple times control of the issue.

Mechanisms of the new media system

In the last three or four decades, the computer media revolution deeply challenged the domain of traditional mass media's top-down broadcast paradigm. Digital computing started affecting all stages of communication, from production to manipulation, from storage to distribution. It also affected all types of media: texts, still images, moving images, sound, spatial constructions (Manovich, 2001). The translation of all previous media forms into numerical entities accessible by computers produced a radically different system of media, identified with the term *new media*. According to Manovich's definition, new media are identified by two distinct conditions, often confused with one another: they are digital data, accessible through a device such as a computer, and they are numerical data, subject to computation and modifications through discrete operations. The confusion stems from the fact that almost every contemporary digital device is based on a numerical computational logic: however, it's not the device itself that differentiates new media from previous media, but rather the modification it brings on the media essence, which becomes reduced to discrete units. Manovich identified five radically new principles and features brought by computation in the media environment.

1) NUMERICAL REPRESENTATION: since media are discrete and can be described through maths, they can be manipulated through algorithms.
2) MODULARITY: media are made of various layers of units, of which the smallest is the same for all media (numbers).
3) AUTOMATION: part of the process of media creation, manipulation and access can be done without human intentionality (ranging from image editing presets to page rank algorithms, which will be covered later).
4) VARIABILITY: media produces many different versions instead of identical copies, embedding logics of customisation, periodic updates and even open interactivity.
5) TRANSCODING: media follow both human principles and computer principles in their organisation and structure; culture and computer hybridate through new media, and deeply influence each other (Manovich, 2001).

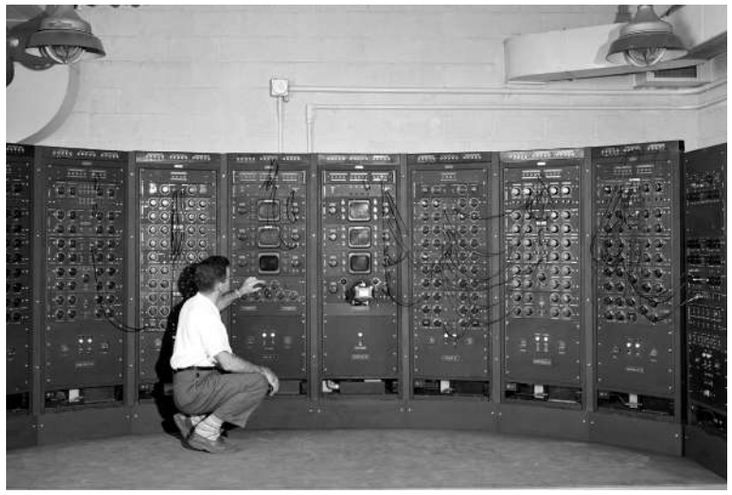


FIG 06. Analog computing machine GPN-2000-000354, based on continuous variations instead of discrete data. 1949.

The multiplication of opportunities for media creation, editing, and diffusion—paired with the reduction of connected costs—pushed the rise of a new model, promising a compelling alternative to vertical information flows driven by economical and political interests. A key moment in this process was the invention of the *World Wide Web* by Tim

Berners-Lee in 1989 (World Wide Web Foundation, n.d.), which revolutionised the dynamics of content distribution. The new media system appears open, decentralised, and participatory, all characteristics which encourage proliferation of different perspectives and make hierarchical control much harder. The bottom-up potential of the internet got a great leap forward in the early 2000s, when Tim O'Really popularised the concept of *Web 2.0*. The expression indicates a shift in dynamics on the web: while at first the net was mostly populated by large top-down companies, and was still widely used as a tool for broadcast, from a certain point on its participatory affordances started to develop and the role of users changed (O'Reilly, 2005). In web 2.0 everybody can produce and share content as well as experience it. It is bidirectional in the sense that everybody can be at the same time part of the public and broadcaster. Through the multiplication of producers, the complex apparatus of filters shaping information in the traditional mass media apparently ceased to exist. The promise of new media was the following: in a communication system so decentralised that ties cannot rule it, truth will prevail.

However, reducing the cost of creating, storing and sharing information had a dramatic side effect: its production increased exponentially, to the point of information overload. The amount of content currently circulating outweighs our capacity of processing it (Carr, 2010). As a consequence, people need radically new ways to organise the information. The tendency to bring order through content has been a constant in human history, but the size of the challenge and, as a result, the methods put in place, changed radically with the web 2.0 development. Control on information hierarchisation and organisation replaced control on information production: the distribution got subjugated to a subtle new system of rules and ties, which evolved driven by market logic. McLuhan described information as the "crucial commodity" in our societies (McLuhan, 2013, p. 182), but the overload of that commodity brought scarcity of another key good: attention, which is consumed by information (Venturini, 2019). Attention is valued by whoever produces content, to the point of competing for it. A new paradigm was established as the dominant one, a paradigm in which the audience's attention is the product and advertisers, as clients, are willing to pay for it: we can call it *attention economy* (Simon, 1971).

Attention economy was not in itself born in the new media system: revenues from advertisers already paid for major costs of newspapers, magazines and televisions. However, both the scale of the competition and the nature of its dynamics changed radically in the web ecosystem.

Google was the first to provide an economic infrastructure for marketing web attention, with the two services *AdSense* and *AdWords*. AdSense allowed website owners to sell advertising space, while AdWords allowed web advertisers to buy that space. The innovative feature of the services was that of matching ads with audiences through the pages that *PageRank* (Google's algorithm for page indexing) associated with specific queries, relevant for the audience (Venturini, 2019): instead of buying pages, the advertisers could buy keywords and let Google select the best pages for them. Not only the targeting system evolved, but also the attribution of economic values: attention, previously estimated through audience measurements, started to be calculated on the number of clicks and impressions. Since the increase of revenues directly depends on the increase of the number of clicks, advertisements with the only purpose of being clicked began to proliferate.

"Clickbaits" received further incentives when *third-party cookies* were introduced: website visitors can now be tracked and the information collected sold to companies that aggregate and resell it to advertisers (Venturini, 2019). The tracking data is subjected to economic transactions for an indefinite time after the interaction that generated them, while the users are often unaware of them.

Social networks also joined the party, bringing to full development an intrinsic dynamic of the new model: content is less and less designed with *stickiness* in mind, meaning the ability to attract users and keep them anchored, but instead with *spreadability*, meaning the ability to encourage the user in sharing (Ford et al., 2013). In a system thriving with diffusion affordances, the most profitable users are the ones that not only click the link, but also share it with all their contacts, fostering new interactions.

Finally, it's important to consider that who holds the most power in the competition for attention are browsers and platforms that connect people to information—companies such as Google, Meta and Netflix. They promised to save people from the jungle of data and communications by organising and distributing the contents in a neat and objective way. And they have been doing that through sophisticated algorithms, devoted to selecting the best content for each user. In fact, algorithms are everything but objective: they often embed the perspectives and biases of the people that created them. Furthermore, they are often configured as black boxes whose founding logic and functioning is obscure (Finn, 2018). Automation in the distribution produced a further distortion in the content production: in order to reach the public, it not only needs to attract and engage but first-of-all it must meet the favour of the algorithmical censor.

The competition for climate change definition has exploded through the contemporary media environment, reaching an unprecedented breadth and scale (Koteyko, 2015). Its methods and evolutions are strongly shaped not only by a network of tied interests but also by the sharing logics peculiar to new media. Deniers have often proved to be skilled in leveraging algorithmic logic and information chaos to push their agenda. Unfortunately, they are not the only opponents of meaningful climate change communications: since the climate crisis became a polarised and urgent theme, climate change started to be used as an empty shape with the only purpose of attracting attention, without providing any information at all. Venturini talks about *junk news*: contents produced with the sole purpose of being consumed and shared, in order to monetise. And they mostly succeed, since they leverage trendiness dynamics which are foundational for many new media (especially social networks) and culturally embedded in fruition practices by users. Junk news often contain fake information, but they differ from fake news because they were not produced to share misinformation in the first place. They are nonetheless extremely dangerous for debate around complex issues—the climate emergency being one of them—since they tend to saturate the media, stealing space to the relevant arguments and forcing the discussion to a shallower level (Venturini, 2019).

Climate activists have tried various strategies to stand out from the mess of empty contents and distorted representations and catch the audience's interest. Fear has often been used in this respect, but the intensification of the levels of anxiety in the narration and the constant competition for visibility had major drawbacks. First of all, as previously mentioned, the focus on panic without providing empowerment tends to generate a feeling of doom which disengages people from the issue. Furthermore, anxiety levels cannot be kept high for a long time, and frequent peaks of fear-inducing communications can push the phenomenon of media attention cycles even faster than before (Moser, 2010). Fear remains a powerful tool, which can bring positive changes through awareness building in the promotion of good causes (Furedi, 1997). But it must be cautiously dosed, and paired with other strategies. An example of a conscious use of fear-based communications is the message of Greta Thunberg at the World Economic Forum in 2019:

"I don't want you to be hopeful. I want you to panic. I want you to feel the fear I feel every day, and then I want you to act. I want you to act as you would in a crisis. I want you to act as if the house was on fire. Because it is."

The discourse, which achieved global resonance, was intended primarily for the world leaders, who have failed to act meaningfully on the climate crisis, and deserved to be called out. In addition to that, "panic" was quickly followed by "act": there is something that can be done about the climate crisis, and it must be done.

In conclusion, while it's important that messages on climate change reach wide audiences, shaping them only according to algorithms and spreadability principles in the new media ecosystem often means trading objectivity and meaningfulness for impact and shock. The problem is complex, and communications about it shouldn't only travel far, but also be understood and push concrete responses.

TIME TO ACKNOWLEDGE THE CLIMATE EMERGENCY

Extremization of weather patterns

In the previous chapters I analysed how the inner characteristics of the climate crisis (global, long term, abstract), as well as the mechanisms of the media environment through which it's communicated, open its representation to a complex social process in which different actors, interests and media logics interact (mainly competing). In the end, people often tend to perceive the climate emergency as something far and abstract. Communication that focuses only on global risks can produce a sense of powerlessness and inadequacy, especially if the information keeps swinging from fatalistic scenarios to denial and uncertainty. Denigration of the individual ability resonates with public mistrust in the existing political system, perceived as useless against the scale of such an issue (Furedi, 1997). Reiteration of dangers in combination with a sense of incapability produces the opposite of awareness: denial from fear. The entity of the risks, the perceived absence of control and the appeal to uncertainty generate scenarios that are blurred and too threatening to be kept constantly in the forefront of our minds (Beck, 1992; Giddens, 1991).

However, climate emergency impacts are much closer and more concrete than people tend to perceive them. Global average temperatures are significantly increasing: "seventeen of the 18 hottest years [ever recorded] have come to pass in the 21st century, and temperatures are rising 10 times faster than during the bounce back from the last ice age" (Randall & Migliozzi, 2018, para. 6). But climate change is not only about temperatures: extreme weather events such as heatwaves, droughts, even storms and floods are going to become more frequent and severe. Further warming will intensify the water cycle, with the patterns of water scarcity and abundance having more extreme peaks (Stern, 2007). Other effects include glaciers melting, sudden shifts in regional weathers, rising sea levels. Eventually, we are starting to experience all of this. We are witnessing record floods, wildfires, heatwaves, droughts and superstorms around the world, every year stronger and more frequent (Mann, 2021). We live in the end of the latency period, and in the extremization of current weather we can recognize fingerprints of the climate emergency (Manzo, 2010): since climate is a scientific abstraction built from weather measurements, we can also state that weather is the concrete expression of climate. Paradoxically, recognizing that dangerous impacts are already here is somehow empowering: we're in danger, but how much additional danger we face depends on our actions (Mann, 2021).

Scientists have begun to study specific weather events in connection with climate change. In 2015 Dr Geert Jan Van Oldenborgh and Dr Friederike Otto founded the *World Weather Attribution* initiative, a collaboration between climate scientists at Imperial College London in the UK, KNMI in the Netherlands, IPSL/LSCE in France, Princeton University and NCAR in the US, ETH Zurich in Switzerland, IIT Delhi in India and climate impact specialists at the Red Cross / Red Crescent Climate Centre (RCCC) around the world with the purpose of providing robust assessments on the role of climate change in the aftermath of weather events (Otto & van Oldenborgh, n.d.) to determine "whether the frequency and/or magnitude of a class of extremes is changing due to anthropogenic climate change" (Philip et al., 2020, p. 178). Extreme weather events analysed by the WWA so far proved in most cases to be correlated to climate change, in either intensity or frequency (or both). The link with geographically and temporally

IMAGES OF EXTREME WEATHER EVENTS CONNECTED TO CLIMATE CHANGE. FROM TOP TO BOTTOM:

FIG 07. Flooding caused by Cyclone Idai in Mozambique, Mar 2019.

FIG 08. Drought-led low water levels at Presa del Parralillo, Parralillo Dam, Gran Canaria, Spain, Dec 2017.

FIG 09. The Pine Bulch Fire in overheated Colorado, Aug 2020.

localised weather, experienced by everybody, might be critical in creating meaningful representations of the climate emergency: representations through which people could face the issue, understand its entity, and feel enough empowered to react. However, even if the WWA produces reports stratified to meet different levels of expertise, its main focus is informing policy-makers and emergency management agencies.

Online weather forecasts' opportunity

Online weather forecasts represent the main account of climate change impacts for the general public. They cover everyday weather phenomena, and they are incredibly pervasive: online forecasts are checked everyday all over the world. According to Similarweb's rankings, most countries include at least a weather website in their top 50 most visited sites (Similarweb, 2023). Some of them are openly dedicated to international audiences, while others are more focused on local contexts. The weather app market is also thriving, with hundreds of millions of downloads each year and a billionaire revenue growing steadily (Statista, 2023).

Popularity and focus on concrete phenomena are the premises from which I argue that weather forecast platforms have a privileged role in influencing the social perception of climate change. They have the opportunity to represent the connection between everyday weather events and wider climate change dynamics, and by doing that bring an issue generally difficult to perceive closer to people's understanding (O'Neill & Hulme, 2009). Through the perception of concreteness and closeness, the climate emergency can be reaffirmed as a meaningful problem which can—and must—be tackled.

It's important to consider, however, that weather forecast platforms are actors in the new media environment, often—even if not always—driven mainly by economic forces and private interests. In any case, they cannot fully escape the relations, ties and dynamics of attention media economy highlighted in the previous chapter. As a consequence, there's no assurance about an actual effort in the weather industry to take advantage of the opportunity it has over climate change communication.

Representations for action

Even when starting from strong premises such as reports of an extreme weather event, it's especially complex to produce representations of the climate crisis that the audience finds engaging and empowering. In the first place, not all audiences are equal: they might differ, for example, in terms of level of concern and scepticism about the issue, views about the organisation of society, political ideology, scientific literacy, beliefs and concerns (Corner et al., 2014; Corner et al., 2015; Center for Research on Environmental Decisions & ecoAmerica, 2014). In the case of weather forecast platforms, addressing the most general public possible, a strategy could be building a solid communicative core and enrich it with different levels of details, in order to provide "something for everyone" (Mijksenaar, 1997, p. 25). Apart from audiences, representation of the climate crisis might stress various aspects of the issue, connect with various visions of the world, and use various framings. I will now point out the most relevant of them, outlining for each one the potential efficacy and implications on the basis of existing literature.

Representations could be VISUAL or TEXTUAL. Texts can provide rational and detailed accounts of the issue, but often require attention and time to be interpreted. On the other hand, it is generally assumed that images communicate at a glance, and appeal more to emotions rather than intellect (Schneider & Nocke, 2014). It is also generally thought that, while texts need to be translated in order to be understood by different publics, images are universally clear. That's however quite imprecise, since often even pictures would benefit from adaptations that make it resonate more with the target audience, both in terms of epistemic (as for understanding) and aesthetic (as for connecting emotionally). Anyway, the emotional layer of images usually makes them both easier to comprehend and more striking than texts: that is true in the case of photographs as well as scientific charts. Because of its power in engaging the public, visual communication is sometimes used as a tool for deception. As a result, images can in some cases be perceived as more ambiguous and less reliable than texts (Schneider & Nocke, 2014). However, it is indisputable that pictures have more potential to push action than text alone. Since the beginning of history, images have been tools that mediate our views of the world and shape our interaction with the environment around us, to the point that sometimes our perception is so influenced by them that they constitute part of reality (Fehlinger, 2020a). That's, in a way, the case with global warming: increase of temperatures became real as soon as we started tracking and mapping them. Nonetheless, both textual and visual communication need to comply with certain principles in order to be perceived as meaningful, especially if their aim is to push action in tackling a complex issue such as the climate crisis (Corner, 2015).

FIG 10. An example of "plastiglomerate," a sand-and-plastic conglomerate which testifies human impacts on the environment.

The role of representations in promoting new relations with the world is even more arduous if we consider that, in order to challenge the standards of modernity which brought us to the climate crisis, they need to challenge the existing imagery which continuously reaffirms an idea of existence based on human domain (Fehlinger, 2020c). Communication of climate change has to deal with the relationship between HUMANITY and NATURE. According to the risk society framework previously discussed, people tend to visualise nature as threatened by human activity and progress (Furedi, 1997; Beck, 1992). However, the culture-nature dichotomy implied in that view is in itself a founding premise of the anthropocene. The artificial separation between those two worlds is a deeply rooted cultural and cognitive concept. In their attempt to control and dominate the hostile world around them, societies and individuals alienated themselves from everything else, producing a counterfeit and hysterical representation of the world based on division and exploitation (Adorno & Horkheimer, 2010). Science and scientific thought are the perfect expressions of the logic of control: they are based on the separation between a studying subject (active) and a studied object (passive). Picturing the world around us merely in terms of resources gave us the right to exploit it. This worldview was the production of the modern era, and doesn't constitute objective reality—as we are often conditioned to think. And now with climate change (and risk society in general) it has reached its breaking point: humans rediscover they are part of nature since they start experiencing on themselves the effects of the fracture they created. They are subjected to a power they produced for control's sake but on which they don't have anymore control. How does all of this translate in climate change representations? Humans can be represented either as part of nature or detached from nature. Communications dealing with nature as something on which we have a power (shown as endangered or to preserve) lean more towards the detachment side of the spectrum. They can produce intention to act through a sense of responsibility, but in doing so they replicate the artificial dichotomy. Communications on the other side of the spectrum can instead be mainly of two kinds. They can foster a feeling of communion with nature which creates positive images and scenarios, with the risk of focusing too much on utopic representations and losing connection with reality. But representations that recognise humans as part of nature might also do so by showing how people are threatened together with the environment of which they are part.

PEOPLE are not even always part of the picture in representations of the climate crisis. That's in most cases self-defeating, since evidence has been produced that communications are more powerful and engaging when they include people, especially if individuals or small groups with identifiable emotions: the public is driven to empathise and perceive the climate crisis as a social reality rather than a scientific reality (Chapman et al., 2016; Corner et al., 2015a; Wang et al., 2018). In the case of images, direct eye-contact with the subject has proved to be particularly effective in attracting people's attention and making the picture meaningful to the audience (Corner et al., 2015a). The identification of the public is strongest when the subjects of the representations are victims of climate change impacts or people on the forefront of solutions, especially if they are themselves the authors: first-hand experience is a solid base for trust and affinity (Dupar, 2019), and the perception of authenticity generates interest and persuasion (Chapman et al., 2016). There are some specific categories of people, however, that when cited can generate distance, distrust and undermine the communication effectiveness: this is true for both politicians, who are seen as not credible, and protesters, who often attract cynicism and aversion (Corner et al., 2015a).

Representations can be centred on either climate change CAUSES, IMPACTS or SOLUTIONS (Chapman et al., 2016; Corner et al., 2015; Wang et al., 2018; Moser, 2010). Each of those areas has specific features and communicative effects, depending also on the way the subject is depicted.

The long-term shifts in temperatures and weather patterns we are starting to experience are caused by the emission of greenhouse gases in the atmosphere due to manmade activity (Stern, 2007). As straightforward as that is, it can be translated in many different representations, mainly depending on the scale used: an image of a landscape full of smokestacks and one of a person eating a steak can be both conceived as depictions of climate crisis CAUSES. The size can range from individual behaviours to global trends. Small scale representations have the potential to push people to engage in changes in their daily life habits, but when too centred on the individual they risk to prevent people from recognising "problematic" behaviours as such, or to provoke defensive reactions (Corner et al., 2015a). On the other hand, large scale representations deal with systemic change but when too far from concrete actions and demands they risk making people feel powerless and paralysed. In synthesis, communication on climate change causes, in order to engage, empower and activate the public, needs to be calibrated so that the links with the climate crisis are clear but at the same time people feel they can do something about it.

I previously mentioned that the IMPACTS of climate change are extremely varied, and that they are already striking. The end of the latency period brings us face to face with the concrete effects of the crisis: impact communication is not limited anymore to abstract figures or future scenarios but includes more and more reports on present weather conditions. Representations provide proofs that the climate is changing, and their undeniable concreteness combined with their dramatic and emotional nature can successfully prompt a desire to respond in the public (Corner et al., 2015a). Especially if the

events are framed as specific footprints of a wider issue which, if not tackled, is gonna get worse: in order to react, people need to both experience the impacts and believe in its connection with climate change (Morris & Sayler, 2014). However, the strong negative feelings (alarm, anger, fear, upset or frustration) aroused by extreme weather reports and images can in some cases undermine the ability of the people to react (Chapman et al., 2016). Impacts' depictions attract people's attention and enhance the feeling of urgency and importance around the climate crisis, but repeated exposure to emotionally draining messages not coupled with opportunities for reactions can overwhelm the audience and produce a sense of doom (Center for Research on Environmental Decisions & ecoAmerica, 2014; Chapman et al., 2016; Corner et al., 2015a). Urgency and agency, threat and opportunity should walk together (Mann, 2021). Finally, another attribute to consider is the localisation of the impacts: the closer they are to the public, the more engaging the representation is. On the contrary, showing events hitting places and communities that are far away from the audience generally contributes to distancing the threat (Smith & Joffe, 2013). However, when local impacts are not serious enough in the overview of extreme weather events worldwide, focusing on them may be perceived as a way to trivialise the wider issue (Chapman et al., 2016). This is especially true when comparing extreme weather effects in resilient countries with impacts in underdeveloped countries—the latests generally facing worse weather conditions, being less ready to tackle them and, at the same time, less responsible for causing the crisis (Wendler, 2022).

SOLUTIONS can be represented in terms of sets of actions, tools and demands. They usually generate feelings of empowerment in the public, by implying action, opportunity, and a goal (Center for Research on Environmental Decisions & ecoAmerica, 2014). However, solutions need to be pictured as targeted and concrete to be trusted: stereotyped representations disengage. Coverage of solutions should also be balanced: an excessive focus on them can reduce the perceived importance and urgency of the issue, inhibiting actual efforts (Chapman et al., 2016). Solutions can be of two kinds: adaptation, as ways of dealing with the impacts underway, and mitigation, as ways of preventing further impacts. As true as it is that we need to manage the effects that we are already facing, it's important not to stop working on mitigation in order to keep the threats to an acceptable level. In addition to that, the scale of the representation needs to be considered once again: prioritising large technology-related solutions could decrease motivation for individual action and responsibility through a false belief of "technosalvation" thanks to geoengineering (Center for Research on Environmental Decisions & ecoAmerica, 2014), while failing in connecting the single person level with wider impacts generates powerlessness (Wang et al., 2018). When the scale is balanced, solution depictions can harness the attention and engagement produced through images and messages centred on impacts and (to a minor extent) causes.

Climate change representations can be more or less STEREOTYPED based on the subject and modes through which they address the issue. The theme got public attention from the 1980s (Moser, 2010), and in four decades the communications structured around dominant clichès: smokestacks, polar bears, melting ice and glaciers are amongst them (Manzo, 2010; Corner et al., 2015a; Wang et al., 2018), but also droughts and floods or charts such as the Hockey Stick graph (Schneider & Nocke, 2014). While being familiar, recognisable and easily understandable, those subjects tend to prompt cynicism and fatigue in the audience: they "close down the climate story instead of opening it up to new and diverse interpretations" (Corner et al., 2015a, p.23). The current perception of the issue was already influenced by them, and they are now taken for granted. Some of them have been so overused over the years, that they are now perceived as inauthentic. In order to attract people's attention and produce engagement, new subjects and narrations are necessary: less familiar but more striking and thought-provoking images which connect to concrete aspects of climate change (Chapman et al., 2016).

Communications of the climate crisis can be framed on a spatial scale which goes from GLOBAL to LOCAL. I introduced the importance of localisation when talking about impacts. Generally speaking, linking the global climate crisis to its local expressions, effects and opportunities to tackle is an effective strategy for generating representations that are meaningful to the public: it brings the impersonal issue in everyday life and experience, to a level with

which people feel they can engage (Nerlich et al., 2010; O'neill & Hulme, 2009). However, small scale representations which fail in connecting to the wider picture don't motivate people to react (O'neill & Hulme, 2009; Corner et al., 2015a): localities don't exist disconnected from one another, and it's their links that make up globality (Fehlinger, 2020b). In order for the representations to feel relevant and personal, the spacial scale should highlight impacts and solutions specific for the communities that make up the audience: stories set far away from the public might produce a sense of distance instead of relevance (Center for Research on Environmental Decisions & ecoAmerica, 2014; Van der Linden et al., 2015). However, the abuse of "close-by" representations (especially in depictions of impacts with a low perceived seriousness) can undermine concern, while citing "far away" events or stories when particularly serious helps to generate attention around the issue and create meaningful connections with the global level (Chapman et al., 2016).

Climate change representations can be framed on a temporal scale which goes from PRESENT to LONG-TERM FUTURE. Focusing on distant futures for either impacts' and solutions' communications tends to undermine the will to act (van der Linden et al., 2015; Corner et al., 2015b). When focusing on effects, the temporal interval adds up to the uncertainty component and pushes the people to discount or ignore the risks (Corner et al., 2015b), no matter how serious they are. Since, as I already discussed, we are exiting the latency period, there is the opportunity to set the depictions in the present through fingerprints and harbingers of the climate crisis (Manzo, 2010). After setting the start of impacts in the time being, the long-term frame can be successful in expressing the seriousness and importance of the issue through the persistency of its impacts. However, the public engagement also depends on narrations that leave space for some degree of action, while scenarios that are too apocalyptical often bring with them a sense of inevitability because of their scale and can therefore give birth to strategies of avoidance (Center for Research on Environmental Decisions & ecoAmerica, 2014). When focusing on solutions, in conclusion, a long-term approach can produce blind trust in future technologies, resources and tools which prevents people from engaging with the issue in the present (Center for Research on Environmental Decisions & ecoAmerica, 2014).

Climate change representations have to deal with UNCERTAINTY, and can do it in various ways. As highlighted in the previous chapter, our knowledge of the climate crisis is constantly improving and refining because of the scientific nature of the issue. When not properly communicated, uncertainty can become a significant barrier to engagement (Corner et al., 2015b): people become reluctant to take action when they perceive negative outcomes as potential and not sure (van der Linden et al., 2015). The first way to efficiently address this obstacle is to start representations with what is certain (Corner et al., 2015b; Corner et al., 2018; Center for Research on Environmental Decisions & ecoAmerica, 2014): while being dishonest about the doubts that actually exist might produce significant drawbacks, highlighting only obscure elements isn't a good strategy either. At this point, scientific consensus around all major characteristics of the phenomenon is wide enough to motivate audiences, if communicated clearly. Also, uncertainty tends to be perceived better when framed as probability and part of the scientific discourse rather than ignorance (Corner et al., 2018).

Representations of the climate crisis might be focused more on the downsides of non acting (LOSS-FRAMED messages) or on the upsides of acting (GAIN-FRAMED messages). The latter try to leverage advantages to generate engagement, while the former use fear of consequences for the same purpose (Bertolotti & Catellani, 2014; Center for Research on Environmental Decisions & ecoAmerica, 2014). Studies found loss-framed messages to be more effective in generating concrete reactions, but perception of uncertainty and long-term framing (previously addressed) can undermine their efficacy much more than with gain-framed messages (Bertolotti & Catellani, 2014). The focus on threats needs anyway to be paired with communications producing a sense of hope, agency and efficacy in order to avoid the production of cataclysmic and fatalistic views (Mayer & Smith, 2019; Beehler, 2019). Threats to material well-being can be particularly ineffective in fostering engagement, since they might produce in the audience a sense of scarcity of those exact resources (e.g. health, time, money, ...) that they need in order to make a concrete effort (Levine & Kline, 2017). In conclusion, gain-framed messages are more effective when they don't consider only short-term material and extrinsic incentives (e.g. saving money) but also intrinsically val-

ued long-term goals. However, when dealing with the climate crisis it appears hard to define goals based not on loss negation (prevent the worst) but instead on gain affirmation.

Climate change depictions can be more DATA-BASED (scientific framing) or more story-based (social framing). The founding representations of the issue have been produced in the scientific realm. They convey a sense of precision and accuracy and are mostly perceived as trustworthy. Precisely because of that, they are vulnerable to distortion and manipulation through various strategies which can be hard to recognise for lay-people (Schneider et al., 2014). They can be misleading because of poor design, wrong data, inappropriate amount of data, or even because they pander the audience's prejudices (Cairo, 2019). Anyway, accuracy in itself is not enough to make things understandable (Wurman, 2001), and scientific representations as a whole proved to be limited when it comes to communicating the issue to a non expert audience (Schneider & Nocke, 2014): numbers, charts, trends might be perceived as abstract and technical—especially if dealing with the global and long-term levels. They bring with them all complexities and drawbacks of the scientific discourse: understanding those kinds of representations requires effort and knowledge, and relating them with day-to-day experiences and actual consequences can be even harder (Center for Research on Environmental Decisions & ecoAmerica, 2014; Corner et al., 2018). Some findings regarding the ongoing changes are so vast and huge that rationality-based depictions are not sufficient to imagine them (Schneider & Nocke, 2014). There are exceptions in the landscape of scientific representations, especially in the realm of visual charts: some of them connect to culturally rooted iconographies and imaginaries, and can produce emotional reactions (Schneider, 2016). But anyway, generally speaking there is the need to translate climate findings into languages different from science (Schneider & Nocke, 2014). The climate crisis is a social issue just as much as a scientific issue, and as such should be treated: the physical processes should always be connected with their meaning for communities and individuals (Mahony & Hulme, 2014). The general public usually understands the world through stories and anecdotes, and bases choices more on intuitive and experiential processes rather than rational analysis (van der Linden et al., 2015; Center for Research on Environmental Decisions & ecoAmerica, 2014). Still, when carefully designed, scientific communications can work together with storytelling-based depictions: the latter foster engagement and identification, while the former provide connections with the wider picture and sustain evidence with accurate facts. In order for this cooperation to be effective, its scientific component must be clearly linked to the concrete experience: for example, the metrics

FIG 11. The climate communication specialist Leane de Laigue speaking at Oxford University.

and scales used need to be familiar to the public and easy to grasp (Center for Research on Environmental Decisions & ecoAmerica, 2014).

Assessing of the state of the art

There is a desperate need for meaningful, engaging and empowering communications of the climate crisis that could activate responses in the general public. In a moment in which fossil fuel industries keep carrying out strategies to delay action and governments are failing to provide relevant policies, the citizens should activate to influence the political agenda with all means available. In order to effectively demand and promote the needed systemic change, they all must share a deep understanding of the issue and how it could and should be managed. The conception and consequent push to act come through representations of climate change that take into account all previously mentioned principles and considerations. Weather forecast platforms have a significant opportunity in these regards, but whether they are taking advantage of it is yet to be determined. The purpose of my research is exactly that: to map the state of the art of climate change representations in the online weather forecasts landscape across different contexts and situations. The analysis will provide insights on the identified recurring techniques, trends and patterns while at the same time trying to assess their efficacy in building meaningful knowledge and providing empowering narrations.

Methodology →

CASE STUDIES

Protocols

The landscape of weather forecast platforms will be explored taking into account different case studies, following three research protocols. Each protocol will analyse a specific communicative practice as interpreted by different platforms.

PROTOCOL 1 analyses the online representations of climate change from weather forecast companies when explicitly requested by an external entity. More specifically, it focuses on the series of imaginary *future weather reports* commissioned to different agencies all over the world by the *World Meteorological Organisation* (WMO).

PROTOCOL 2 analyses how climate change discussion is embodied in the structure, visual interface and everyday practice of weather forecast platforms. More specifically, it focuses on the 50 most visited weather websites in the world according to Similarweb's ranking.

PROTOCOL 3 analyses the representations of climate change in online articles on specific extreme weather events which external studies proved to be correlated to the climate crisis. More specifically, it focuses on the communication of 15 events studied by the *World Weather Attribution* initiative (WWA) made by a selection of 5 websites from protocol 2.

Protocol structure

The goal of the work on the case studies is detecting and highlighting patterns and trends inside each protocol as well as between the three of them, in order to provide a detailed mapping of how online weather forecasts shape and visualise the social understanding of climate change. In fact, the three protocols will have a similar structure in order to allow cross-protocol comparisons. Each of them will open with a DATA COLLECTION phase, concluding with the building of a major protocol dataset and followed by the analysis of the gathered data. The data considered can be reconducted to three major types: TEXTS, IMAGES and URLS. Data of the same type over the three protocols will be treated with consistent methods, tools and logics in their collection and, especially, in their analysis. At the same time, protocol-specific data qualities and features will be considered and highlighted: consistency is not obtained by simply reconducting all pieces of information to an a-priori framework, but with the design of a framework that keeps into consideration the data qualities and is flexible enough to adapt to data variation. Texts and images are object of study of all three protocols, while urls are only taken into account in protocol 2. The *protocol-data type* units are non-consequential, which means that the research could be alternatively explored from one protocol to the other or from one data type to another.

Evaluation criteria

The analysis of representations from the case studies (visual, textual and interface-wise) will provide the basis for their evaluation in terms of engagement and empowerment. The process of assessment will be based on the parameters and principles of effective climate communication defined in accordance with existing literature.

NATURE ↓

Which kind of relationship between humanity and nature is implied in the representations? Are humans more detached or in communion with nature? Is humanity represented in control of nature? Or is nature instead represented as out of control? Is nature represented as exploited by humanity? Is nature represented as endangered by human activities? Is humanity represented as part of endangered nature? Are there representations of utopias based on community with nature?

PEOPLE ↓

Are humans included in the representations? How many of them? Can they be identified as individuals? Where do they come from? How are they represented? Which roles do they have (politicians, citizens, officers, protesters, ...)? Are they depicted more as victims, persecutors or saviours?

CAUSES, IMPACTS, SOLUTIONS ↓

Which is predominant in the representations: causes, impacts or solutions? Are there representations highlighting connections between the three of them? Are causes, impacts and solutions represented relevant? Which various kind of causes, impacts and solutions are represented? Which are the most recurring between them? Which are their temporal and spatial scales? Are they more abstract or concrete? Do the representations of solutions focus more on adaptation or mitigation strategies?

STEREOTYPE ↓

How varied are the representations? Are the representations original? Are they recognisable? Are they striking? Are they relevant? Do the representations add something new to the climate change discourse?

SPACE ↓

What is the spatial scale of the representations? Are they global or localised? Are the subjects in the representations close by or far away from the audience? How serious or relevant are they? Are there connections between localities in the representations? Are there connections between different scales?

TIME ↓

What is the temporal scale of the representations? Are they based in the present or in the future? Are they more short-term or long-term? Are there connections between different temporal moments and scales in the representations? Do the representations leave space for variation?

UNCERTAINTY ↓

Is uncertainty addressed in the representations? Is it framed more as ignorance or as part of the scientific discourse? How much space is given to the representations to uncertainty, compared to certainty?

LOSS AND GAIN ↓

Do the representations try to engage more through hope of advantages or fear in consequences? Do they stress more gain affirmation or loss negation? Which kind of loss are represented? And which kind of gains? How much stress is given to action in the representations? Are actions in the representations more individual or collective?

SCIENTIFIC AND SOCIAL ↓

Are representations more based on data or on stories? Which kind of data is the most recurring? And which kind of stories? Do the representations provide more scientific or social framings? Do representations require more rational or emotional responses and interpretations? Are representations easy to understand? Are they more abstract or concrete? Are scientific representations more trustworthy or deceiving? Are connections between physical processes and personal stories addressed in the representations?

All these parameters and questions will be kept into consideration when structuring the data collection, data analysis, and—especially—insight evaluation processes. The expected audience of each representation is assumed to be a varied group of citizens often identified by a geographical or national area on the basis of the individual case study considered. As a consequence, its weight as a criteria of evaluation across this research will be limited.

METHODS

Digital Methods

FIG 12. Richard Rogers.

The research and analysis will be conducted with a *Digital Methods* approach. The premise for digital methods as defined by Rogers is that the web evolved into a space where not only online culture or the virtual society, but cultural and societal conditions at large can be studied (Rogers, 2019). In a context in which every aspect of life, from work to consumption, from communication to travel and leisure is mediated by online platforms and services, contemporary societies are increasingly represented and mirrored in the web space (Kitchin, 2014). The connection between offline and online happens through data: when a digitally mediated experience takes place, the analog world is interpreted by the platform by means of its reduction to discrete data, which is processed and stored. It's evident that the amount of digital data mirroring our cultures and behaviours is currently enormous. It's important to consider, however, that this data is not only the product of individuals and societies, but it's also determined in its features and characteristics by the tools and processes that generated it. This is at the basis of the key concept of digital methods: they "make use not only of born-digital data but also the methods that are native to the medium" (Rogers, 2019, p. 45). If the medium-based processes that produced the data already contributed to its qualities, it makes sense to analyse it through other techniques born in the context of the medium. In synthesis, digital methods constitute a research practice that repurpose online methods and devices in order to study specific aspects of contemporary cultures and societies.

The space analysed in this research is inherently digital and web-based, so a digital methods approach seemed the natural choice. The protocols will focus on various online data from different platforms, such as *Google* and *YouTube*—in addition to individual weather forecast websites. Data will be collected, aggregated, visualised and explored through tools and techniques that are natively digital, with the intention to map and analyse climate change representation and perception in specific contexts. The methods used include web scraping, frame sampling, image processing, speech recognition, text analysis and site mapping.

Data visualisation

After being collected, the data will be analysed through online information visualisation techniques. Information visualisation (infovis) can be defined as a "mapping of data to a visual representation" with the purpose of showing its hidden structure (Manovich, 2011). The advantage of this process in the digital environment is significant, since it allows the handling of extremely large datasets to the point of extracting meaning. By ordering, connecting and translating the data in new visualisations, opportunities to explore and assess the datasets will be created. The visualisations will serve more for data investigation rather than findings' communication: by mapping the complexity, the aim is to extract valuable information on tendencies, paths and trends.

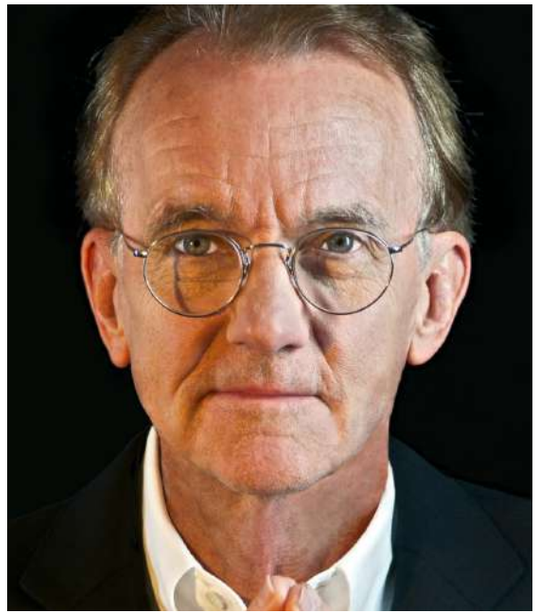


FIG 13. Edward Tufte.

The design of the visualisations produced is deeply dependent on their explorative purpose, and follows key principles identified and defined by Edward Tufte (Tufte, 1997; Tufte, 1998; Tute, 2007): as he pointed out, exploratory displays should be highly dense and characterised by structured visual consistency. The full organised matrix of data should be visible at a glance, and comparisons should be encouraged by setting up recurring designs (Tufte, 1998). The viewers should be anyway allowed control over the information: they should be able to freely select, focus on and recast data for their own uses. In order to facilitate readability inside the complexity, different layers of detail from overview to fine structure should be involved, as well as multiple viewing angles. Summary graphics, if needed, can emerge from the high-information displays. Finally, data containers should be transparent, so that all the attention could converge on the data.

There is another key principle on which many visualisations will be based, strictly connected with the idea of showing the full data matrix: It is the concept of *visualisation without reduction* by Lev Manovich (Manovich, 2011). Traditionally, most infovis relied on the reduction of entities to graphical primitives (points, lines, geometric shapes) with a process of abstraction and on the mapping of data to spatial variables first (position, size, shape, movement) and only after to other visual variables (such as colour). The resulting visualisations have mostly been successful to highlight the structures in the datasets, but the price they paid was extreme schematisation. Visualisations without reduction (also called "direct visualisations"), instead, preserve the original form of the data, or at least part of it. They use actual parts of the analysed media objects as components of the display, instead of graphical primitives: their advantage is remaining closer to the appearance of the considered data. This kind of infovis owes its genesis to the computer graphics development of recent years: thanks to software—and to the numerical reduction of data implied by new media—a designer can now decide whether to map the data to graphical primitives, to the original shape of the data exactly as it is, or to any form in between. In the following analysis, the design of each visualisation will try to find the right balance in its abstraction, so that it clearly reveals patterns and facilitates data exploration while keeping a connection to the original appearance.

FIG 14. Lev Manovich.

PROJECT

A printed map

The mapping of the state of the art of climate change representations in online weather forecasts—which is the objective of this research and the main product of the following analysis—will take the shape of a printed report. The choice of a printed artefact expresses the idea of freezing a deeply ephemeral context—that of online communication—into a static depiction of its current state through a physical support. The decision to use paper and ink also connects with the consolidated imagery of printed maps as a metaphor: the purpose of the report is to foster exploration of the data, as the purpose of printed maps was to facilitate exploration of the physical world. This metaphor could be said to be quite provocative, if we consider that the same control-centred worldview that produced maps and thrived on them brought us to anthropocene and the climate crisis. Anyway, the report is meant to foster individual investigation of the pictured landscape so that viewers can make their own sense of the data, autonomously detecting recurring patterns and structures and drawing their own conclusions. In order to do that, the artefact will include visualisations of all data analysed, investigating texts, images and interfaces aspects through the three protocols. Each visualisation will be contextualised according to the protocol it belongs to, the type of data it analyses, and the process through which it was built.

Design choices

The usage of a printed support for the final report as well as its general principles have been established priorly to engaging in the data analysis and in the construction of the visualisations. However, the declination of the principles into specific design choices has been influenced by the actual data, its features and its affordances—in compliance with the digital methods framework. While the visualisations were designed keeping in mind the designated support, it is also true that the support was partly shaped on the basis of the visualisations which it included. The foundational principles on which the report is founded are:

CLEARNESS OF STRUCTURE: the organisation in protocols and data types should be directly understandable.

EASINESS IN CONSULTATION: the report should be easily handled and browsed.

ENCOURAGEMENT OF COMPARISON: intra-protocol and cross-protocol juxtapositions should be supported by design.

DENSITY AND STRATIFICATION: different reading layers, from at-a-glance overviews to the fine structures, should be provided.

LAYOUT FLEXIBILITY: the format should be easy to adapt to data specificities.

CONNECTION WITH THE MEDIA: the abstraction in the visualisations shouldn't imply a complete loss of visual references to the original analysed object.

The design choices resulting from the mentioned principles are the following:

In order to provide structure and allow comparisons, the report is organised through 3 DISTINCT BOOKLETS, one for each protocol. Booklets are divided into sections according to data processes (collection and analysis) and data types (texts, images and urls).

The size of the booklet is quite small and markedly VERTICAL (11,5x25cm a single page), making it easy to leaf through it. At the same time, the single page gets can be used as a module multiplied in FOLDABLE EXTENSIONS, so to adjust the available space according to each visualisation.

The chosen TYPEFACES have features consistent with the page ratio, and are thought for DENSE DISPLAYS. I chose a serif together with a monospace, the former being used for longer texts and the latter for charts and notes. The monospace is also a variable typeface, and both its weight and width can be adjusted to the needs of the visualisation.

Most visualisations comply with the principles of VISUALISATION WITHOUT REDUCTION, being built with actual parts of the analysed media.

In addition to that, the whole PALETTE OF GRAPHICAL TOOLS, variables and primitives (colour, texture, type styling, weight, scale, position, grouping) are used to provide multiple layers and perspectives for each data matrix.

The data, its visualisation, its assessment

While the report will focus only on the display of the data and the overall process that produced it, the last section of this paper will be centred on data evaluation. The mapping will be interpreted according to the criteria previously defined, in order not only to expose trends and tendencies in the analysed communications but also assess their efficacy in promoting a shared understanding of the topic and supporting action through empowerment. But before discussing the findings, all the processes of data collection and analysis will be explained step by step, with detailed accounts of all procedures and tools used. Protocols will be discussed one after another, for each of them starting with the data collection phase and then covering data analysis of texts, images and—for protocol 2 only—urls. Recurring procedures in different protocols will be addressed as such, and connections between them will be highlighted, in order to provide also non-linear readings based on the cross-protocol consistency of processes and tools.

PROTOCOL 1

How do weather forecast agencies represent climate change when they are explicitly asked to?

Data collection

SOURCES

Between 2014 and 2018 The WMO (*World Meteorological Organization*) asked well-known media companies all over the world to produce imaginary weather reports from the future, with the purpose to sensitise people about the various local impacts of climate change. A total of 63 reports were produced, 62 of which are organised in 5 series, while one is an extra.

The first 4 series are connected to important conferences and summits regarding climate policies (such as the *Lima Conference of Parties* in 2015), and the videos were meant to promote the related event. They are structured as imaginary – but realistic—2050 weather reports from well-known television presenters, designed to sensitise people about the local impacts of climate change.

Series 5 is the result of a collaboration between the WMO and the ngo *Climate Central*, and reports "explore how climate change may affect summer heat in major cities by the end of the 21st century" (World Meteorological Organization, 2017, para. 2). While reports were still produced by weather forecast companies all over the world, Climate Central came up with the general concept and posted an interactive map which shows the reports' conclusions.

The extra report was the last one to be released, produced by the Hungarian national meteorological service and designed with the 2050 weather format.

All videos were published on YouTube in various languages by the WMO official channel, and gathered in a playlist titled "Weather Reports for the future / Climate Change".

SELECTION

A single version of each report was selected (English-spoken one if it exists, otherwise the one with English subtitles), and included in a YouTube playlist, then all 63 videos were categorised in a spreadsheet with the following information:

- REPORT ID in the form *ISO country code_series identifier* (e.g. TH_COP21). If a country produced more than one report in a single series, they were distinguished with a lowercase letter at the end (e.g. US_CS14a and US_CS14b).
- LANGUAGE(S) spoken in the report in the form of Google language codes (e.g. es-PE).
- URL of the YouTube video.
- DATE OF PUBLISHING on YouTube.
- When the future report is SET.
- REPORT DURATION (excluding the WMO personnel's speech section at the end).
- TOTAL DURATION (including the WMO personnel's speech section at the end).

- SERIES to which the report belongs (numbered 1 to 5 plus "extra" for the hungarian video).
- COUNTRY where the report was produced (and consequently set).
- Name of the AGENCY that produced the report.
- Name of the main METEOROLOGIST(S) presenting the report (if specified).
- NOTES: indications on a specific focus of the report (e.g. Mont Blanc).

This spreadsheet constituted the starting point for Protocol 1 analysis, and it will be referred to as **Dataset P1_reports** from now on. The analysis focused on the imagery (images) as well as the speeches (texts) in the reports: both visual representation of climate change and its depiction through words were investigated.

DOWNLOAD

Prior to starting the analysis, the 63 videos were downloaded using the *youtube-dl* playlist download feature using the following settings:

- QUALITY → 720p.
- FORMAT → mp4.

All the videos which couldn't be loaded by youtube-dl were individually downloaded with *y2mate.dog*. Finally, all files were renamed with the corresponding *report ID*.

Text analysis

TRANSCRIPTION

A custom Python scipt based on SpeechRecognition was compiled in order to convert video speech into written text. All downloaded videos were organised into folders named according to the language spoken (e.g. es-PE). Some videos contained spoken portions in more than one language: they were placed in different folders at the same time accordingly. The Python was run on parent folder: the code automatically detected the language of each group of videos and transcribed them. Transcripts were saved in csv files (one for each language of each report) with the following structure:

- 1 row for each MINUTE of speech.

- 1 column dedicated to the TIME in the video.
- 1 column dedicated to the TRANSCRIPTION.
- 1 column dedicated to the LANGUAGE CODE.

For all videos with more than one language, the respective csv files were merged keeping speeches from different languages in different rows. Almost all future weather reports conclude with a final speech stating the intentions of the series. Out of five versions of the speech (one for each series with none for the Hungarian report), four were kept by UN and WMO representatives and one (series 5) by the mayor of Mexico City. The final speeches' transcripts were separated from the actual reports' transcripts: to differentiate them a fourth column labelled "WMO" was added to the database, returning true if the transcript belonged to the final speech, false if it didn't.

In some cases transcripts presented some issues (e.g. missing parts). The steps followed were:

1) Trying to run the code again, changing the duration of processed audio chunks from 60 seconds to 30 seconds.
2) If it didn't work, Adobe Premiere Pro transcription feature was used to get the text, which was then manually placed in the csv.
3) In one case (MW_COP21) the language of the report wasn't available in either SpeechTranscript or Adobe Premiere, so the english subtitles of the video were manually transcribed and placed in the respective csv.

All sheets were merged into a single spreadsheet with *Google Sheets*. From now on it will be referred to as **Dataset P1_transcripts**.

TRANSLATION

Next thing to do in order to analyse the reports' speech was uniforming all transcriptions by translating them into a single language (English). A Python script based on *googletrans* was wrote for that purpose: the code was designed to run through multiple rows of multiple csv files and translate specific cells, then save the selected information in a new series of csv files. It was run on all *Dataset*

P1_transcripts sheets, passing the following information to the output csv files:

- VIDEO ID.
- Corresponding TIME in the video.
- WMO (as in *Dataset P1_transcripts*).
- TRANSCRIPT (original text).
- TRANSLATION (processed with *googletrans*).

Finally, all report-specific output sheets were merged into a single sheet. From now on it will be referred to as **Dataset P1_translations**.

WORD COUNT

A Python-based tool made by Alessandro Quets was used to process a word count on the translated transcripts: the software is designed to select the most frequently recurring words in an input text and order them into a csv file which also reports their frequency. The user can select the input language and the number of words to save. Furthermore, the tool is set with default stop words (excluded by the count) for different languages and the user can also add custom ones. The word count was run on the translated transcript of each video with the following conditions:

- FINAL SPEECHES excluded (the focus is on individual reports produced by weather agencies).
- LANGUAGE set to English.
- Number of SAVED WORDS set to 500, then selection of words with a frequency above 1 (the length of the transcripts changed significantly from one video to another, so the threshold was based on the basis of frequency rather than number of words).
- "Climate" and "change" as custom STOPWORDS (they express the main theme of all reports and it's not relevant to assess their frequency).

All individual csv files were merged into a spreadsheet using Google Sheets. From now on it will be referred to as **Dataset P1_wordCount_individual**. Its purpose is mostly to give a horizontal mapping of the keywords used in the various reports, but the data it contains is very wide and cannot be easily managed to provide some deep analysis insights. For that purpose, the word count tool was run on the overall text from all reports, twice:

1) The first time only on the transcript of the reports (FINAL SPEECHES EXCLUDED).
2) The second time only on the text from the final speeches (FINAL SPEECHES ONLY).

With the following conditions:

- LANGUAGE set to English.
- Number of SAVED WORDS set to 500 in the first case (*final speeches excluded*) and 100 in the second (*final speeches only*, since the text is shorter and analysed as a term of comparison).
- "Climate" and "change" as custom STOPWORDS (as in individual world counts).

The two csv output files were merged into a spreadsheet using Google Sheets. it will be referred to as **Dataset P1_wordCount_total**.

TAG CLOUDS

The tag cloud generator from *Digital Methods Initiative* was used to create visualisations out of the word counts, both for single report's word counts (*Dataset P1_wordCount_individual)* and total word counts (*Dataset P1_wordCount_total*). The generator produces svg files with absolute text sizes associated to number ranges: the equivalence between absolute frequency and text size remains constant from one tag cloud to the other, allowing cross-comparison.

P1 → TEXTS → TAG CLOUDS → **VIZ 01**

Tag clouds of individual reports were gathered in a visualisation which also included indication of:

- The COUNTRY where the report was produced.
- The SERIES from which the report was taken.
- Its DURATION (final speech excluded).

P1 → TEXTS → TAG CLOUDS → **VIZ 02**

Tag clouds from merged texts were also displayed in another visualisation. In order to make the comparison between them more immediate even if they had a different amount of words (500 versus 100), the longest one (*final speeches excluded*) was broken into two pieces: words 1-100 and 101-500.

TAG CLOUDS - CATEGORISATION

All words in the two merged tag clouds (*viz 02*) were classified into one (exclusive) category of 15, elaborate in accordance with the evaluation criteria priorly set as well as keeping into consideration the specificity of the dataset considered. Each category is constituted by one, two or three sub-categories giving sharper definitions of which terms to include. Categories and subcategories are:

1) WEATHER
   - *Forecasts* → words referring to weather and weather forecasting (e.g. forecast);
   - *Phenomena* → Words referring to weather phenomena and events (e.g. rain);

2) CAUSES
   - *General* → words generally related to causation (e.g. due);
   - *Climate change* → words referring to causes of climate change (e.g. greenhouse);

3) SOLUTIONS
   - *Action* → words conveying the general idea of action/reaction (e.g. fight);
   - *Institutions* → words related to institutions, governments and organisations, supposed to act against climate change (e.g. intergovernmental);
   - *Climate change* → words related to specific behaviours connected with climate change savviness (e.g. sustainability);

4) IMPACTS
   - *Extreme* → words conveying a sense of out of the ordinary (e.g. extreme);
   - *Effects* → words generally related to effects (e.g. impacts);
   - *Threats* → words related to clearly negative effects (e.g. disasters);

5) TIME
   - *Time* → words expressing general time periods and intervals (e.g. winter);

6) PAST AND PRESENT
   - *Past* → words expressing specific moments in the past, specifically before the moment when I collected the data (e.g. 2019); "2023" is assumed to be in the past.
   - *Present* → words generally addressing the present moment (e.g. now);

7) FUTURE
   - *General* → words generally related to future (e.g. projections);
   - *Specific moment* → words expressing specific moments in future time (e.g. 2050);

8) ANTICIPATION
   - *Uncertainty* → words expressing uncertainty or doubt (e.g. might);
   - *Certainty* → words expressing certainty or confident expectancy (e.g. sure);

9) LOCATIONS
   - *General* → geographical terms (e.g. south);
   - *Global* → words related to planet earth as a whole (e.g. global);
   - *Local* → words referring to specific locations (e.g. greenland);

10) TEMPERATURE
   - *Temperature* → words related to temperature (e.g. heat);

11) NATURAL ENVIRONMENT
   - *Natural environment* → words related to natural environments, ecosystems and/or their elements (e.g. mountain);

12) SCIENCE
   - *Institutions* → words related to scientists and scientific institutions (e.g. ipcc);
   - *Studies* → words related to scientific studies and measurements (e.g. data);
   - *Information* → words related to scientific communication (e.g. report);

13) MEDIA
   - *Media* → words generally related to formats and channels (e.g. photo);

14) PEOPLE
   - *People* → words connected with humanity as a group (e.g. human);

15) OTHERS
   - *Others* → everything else;

P1 → TEXTS → TAG CLOUDS → **VIZ 03**

A new visualisation was produced to highlight the first layer of categorisation in both *final-speech-excluding* and *final-speech-only* tag clouds. It was designed with the following features:

- Based on TAG CLOUDS → position and size of the visual elements remain related to corresponding word frequency.
- COLOUR-differentiated → words belonging to a specific category are highlighted with the corresponsing colour.
- READABLE → words are listed according to each category next to the tag cloud, keeping the original order inside the category.

In order to make the comparison between the two tag clouds more immediate even if they have a different amount of words, the same strategy used in *viz 02* (division of longest tag cloud in two pieces) was employed. What this mapping visualised was:

- How many words from the tag clouds were included in each category.
- How frequent those words were in the reports.
- How the intentions of the WMO initiative (*final-speech-only* tag cloud) were implemented into the company-produced videos (*final-speech-excluded* tag cloud).

P1 → TEXTS → TAG CLOUDS → **VIZ 04**

Finally, another visualisation was designed to highlight the second layer of categorisation (sub-categories) for the report transcriptions' tag cloud (*final-speech-excluded*). It was designed with the following features:

- Based on TAG CLOUDS → ordering and size of the visual elements remain related to corresponding word frequency.
- COLOUR-differentiated → words belonging to a specific category are highlighted with the corresponsing colour.
- POSITION-organised → Words belonging to the same category but different subcategories are distinguished with position.

What this mapping visualised was:

- How many words from the tag clouds are included in each subcategory.
- How frequent those words were in the reports.

Image analysis

SAMPLING - INDIVIDUAL IMAGES

In order to analyse the images used through the 63 reports, frames were sampled from each video. Two different frame sampling processes were carried out, one with the purpose of selecting individual images and the other aimed at the creation of uniformed video mappings in a grid structure.

VLC's scene filter was used on each of the 63 reports, set to extract a frame every 12 in jpg format. Not all videos have the same frame rate (they vary from 24 to 30 fps), so the sampling time is not consistent through the different videos. However, that's not relevant because the next phase consisted in manually scrolling through all the extracted frames and deleting repeated images, keeping only one copy for each individual image forming the video. This is the logic used to define an individual image:

- Each shot ("single sequence of a motion picture or a television program shot by one camera without interruption", Merriam-Webster) corresponds to at least one unique image.
- Inside the same shot there can be more than one unique image only if there is a significant change in the meaning or content of the frame.
- e.g 1 → When a map turns from showing temperatures to showing wind directions, it's two unique images.
- e.g. 2 → When the same visualisation type is used for the weather forecast of today and for the forecast of tomorrow, it's just one unique image (the meaning doesn't change).
- e.g. 3 → When the same visualisation type is used for the weather forecast of today and for the forecast of 2050, it's two unique images.

The frame sampling resulted in more than 47,000 images. After the manual selection phase, 2,413 individual images remained.

NETWORK

Yale DHLab's *PixPlot* was used to arrange the individual images into a network based on visual similarity, in order to define clusters of images according to their content. Prior to running the tool, a metadata csv file was filled with a row for every image and three columns:

1) FILENAME → name of the image file (including its extension).
2) CATEGORY → ID of the report from which the image was taken.
3) TAGS (separated by |) → video ID (as above), country, continent, series.

Then A Python environment was generated through *Anaconda* and PixPlot was run on the individual images' folder and with the metadata csv linked. A local server was started in order to see the resulting network and work on it. Before clustering the images, the filters (tags) were organised into three different scroll menus in order to be able to cross-use them. To do that, filters.json (in the PixPlot's output folder) was edited with a text editor separating the values into three distinct dictionaries:

1) Video IDs.
2) Countries and continents.
3) Series.

PixPlot's lasso tool was used to group images and create hotspots (clusters) according to their subjects. When the clustering had been finished, the hotspots.json file was downloaded and put in replacement of the default one in the output folder. Finally, the result was uploaded online with *GitHub*.

P1 → IMAGES → NETWORK → **VIZ 00**

In order to create a static visualisation of the clusters in the network, a screenshot of the network arrangement in PixPlot was taken, adjusted (by bringing closer the small detached groups) tagged with *Figma* according to the categorisation previously done. Many clusters were spread around the network, and were not considered in the tagging.

P1 → IMAGES → NETWORK → **VIZ 01**

After mapping the general network, the focus shifted on the clusters previously defined. A new visualisation was produced, with the purpose to highlight:

1) The SIZE of the clusters (number of images compared to total).
2) The RELATIONS between clusters (parents, childs, siblings).

It was designed with the following features:

- Based on the GRID ARRANGEMENT of the images provided by PixPlot.
- Using COLOUR to distinguish sibling clusters.
- Using BAR CHARTS and percentages to show proportions between sibling clusters.
- Using LINES and position to show hierarchies (parent-child clusters).

P1 → IMAGES → NETWORK → **VIZ 02**

Finally, another pixplot-based visualisation was produced, with the purpose to highlight the visual quality of the images in the cluster. It was designed with the following features:

- Based on the NETWORK MAP (*viz 00*).
- Focusing on LAST-LEVEL clusters (no child).
- Zooming on a selection of IMAGES for every considered cluster.
- Showing the actual IMAGE COUNT for every considered cluster.
- Connected to the previous visualisation (*viz 01*) by colour and hierarchy map.

P1 → IMAGES → IMAGE PLOT → **VIZ 01**

The last visualisation centred on individual images was based on mapping colour in the frames through *ImagePlot* for *ImageJ*. First-of-all, *imageMeasure* was run on the 2,413 images. The output txt file was edited adding two rows:

1) One with *hue_median = 0* and *brightness_stdev = 0* (minimum values possible).
2) The other with *hue_median = 255* and *brightness_stdev = 122.5* (maximum values possible).

The purpose of this operation was setting the visualisation scale to make it comparable with corresponding ones in other protocols. Then ImagePlot was run to create a non-polar plot with:

- X AXIS → *hue_median* (median value of the hue for each image).
- Y AXIS → *brightness_stdev* (standard deviation of the brightness values for each image).

Standard deviation of brightness was chosen instead of median because using the latter would have meant having a lot of images stacked one on top of another in the top-left corner (mostly charts, having white background). Standard deviation allowed instead to see them on different Y levels. Finally, the plot was imported into figma and vertically divided in 4 areas (red to green, green to light blue, light blue to purple, purple to red). Recurring images for specific hues were also noted.

SAMPLING - UNIFORMED FRAMES

Concluded the analysis of individual images, the focus shifted to the persistence of image types in the reports timewise. All videos were uniformed using Adobe Premiere Pro:

- RATIO → 16:9.
- IMAGE → fill ratio.
- SQUASHING and STRETCHING → allowed.
- QUALITY → 480p (854x480).
- FRAMERATE → 30fps.

VLC's scene filter was used on each of the uniformed reports, set to extract a frame every 15 (one every half a second) in jpg format. The frame sampling resulted in 42,077 images, named and ordered according to the report from which they were taken and their sequence in the timeline. *Dataset P1_reports* was also updated adding the number of sampled uniformed frames for each report.

P1 → TEXTS → FRAME GRIDS → **VIZ 00**

The sampled frames were used to build image grids (one for each report) in which every row is a reduction of 10 seconds of the original video. Photoshop's *contact sheet* feature was used, but ImageJ's *Magic Montage* would have worked as well (and would have probably been faster). The grid had the following characteristics:

- Each FRAME is 216x120px in the montage
- There's a 1px horizontal and vertical GUTTER between two images.
- The WIDTH of all grids is the same (20 frames, equivalent to 10 seconds).
- The HEIGHT depends on the report's duration (every 6 rows correspond to 1 minute).
- FRAMES in a grid are chronologically ordered.

The grids were mapped onto a table organising them according to each report's series and continent of production (and, as a secondary criteria, according to their duration).

GRID - CATEGORISATION

Starting from the clustering of individual images (and always keeping in mind the evaluation criteria priorly set), 8 exclusive categories were elaborated on the basis of the frame main subject:

1) MAPS → synthesised images of earth from above (including satellite views).
2) CHARTS → charts, including bar charts, line charts, bullet points, tables, 3d scenarios.
3) EXTREME WEATHER → images of environments or people experiencing extreme weather (wildfires, droughts, floods, storms, heatwaves, ...).
4) TECHNOLOGY → images representing some piece of technology as the main subject.
5) NATURAL LANDSCAPE → images of natural environments that don't show clear modifications due to human activity (such as buildings, infrastructures, crops). Pictures of extreme weather are excluded.
6) ARTIFICIAL LANDSCAPE → frames of title sequences (recurring as openings and endings in most videos).
7) TITLE SEQUENCES → frames of title sequences, present as openings/endings in most videos.
8) SPEECH → pictures centered on people talking (giving a speech, interviewing, ...) where the context is not visible or not relevant.

Another 5 categories, this time non exclusive, were elaborated on the basis of the people in the images:

1) NO PEOPLE → nobody is visible in the frame: (only exclusive category of the five).
2) PRESENTERS → weather presenters, meteorologists and scientists or internal personnel of the media company.
3) WMO PERSONNEL → as in most final speeches.
4) POLITICIANS → on all levels, local to national.
5) CITIZENS → basically anyone else.

P1 → TEXTS → FRAME GRIDS → **VIZ 01**

Each frame of each grid was mapped to a combination of content and people categories:

- COLOUR → subject category.
- TEXTURE → people categories (one or more).

P1 → TEXTS → FRAME GRIDS → **VIZ 02**

Once all the frame grids had been mapped, Figma selectors were used to count frames for each combination of *subject-people* categories. A spreadsheet with all counts was created and fed to *RAWGraphs* to create a bar chart with the following features:

- A BAR for each combination of content-people categories (e.g. maps & weather presenter).
- The LENGTH of bars based on frame counts.

Finally, the chart was exported in svg format and imported in Figma to be adjusted:

- The bars were grouped both according to content and people categories.
- A visualisation for the total length of each bars' group was added (e.g. total number of frames including weather presentes).
- The x-axis values were changed from number of frames to corresponding screen time.

PROTOCOL 2

How do weather forecast platforms represent climate change in their everyday practice?

Data collection

SOURCES

Similarweb is a software and data company specialising in web analytics, web traffic and performance. They gather traffic data from public sources, partnerships, analytics services and contributors and use them to provide websites' rankings. The rankings include a list of the *most visited weather websites worldwide* from 1 to 50.

SELECTION - WEATHER WEBSITES

The ranking was accessed on Feb 11, 2023 and used to manually compile a spreadsheet with the following information for each of the top 50 websites:

- RANK (1 to 50).
- WEBSITE (e.g. bom.gov.au).
- COUNTRY where the website is based (information obtained from the domain, from the website itself or from wikipedia.org).
- CONTINENT in which the country is located.

This list is preliminary to data collection for Protocol 2, and it will be referred to as **Dataset P2_websites**.

WEB SCRAPING - WEBSITES

The research intended to explore the 50 websites in order to detect any piece of content (image, text, article, section) explicitly related to climate change. In order to do that, the platforms were scraped using *Google Chrome*'s advanced queries through an anutomated process built on Python and *Selenium*.

First-of-all, a query structure meant to return results referencing climate change from a single website was designed → SITE:WEBSITENAME.DOMAIN "CLIMATE CHANGE (OR TRANSLATION)" (e.g. *site:weather.com "climate change"*). When used into Google Chrome, it will retrieve all content in the specified website which contains the text between commas. this structure was translated into 50 individual queries, one for each website. If the website was based in english, the text in brackets was climate change, otherwise it was the corresponding term in the language of the website (e.g. *site:gismeteo.by "змяненне клімату"*). The queries were grouped by country, in order to optimise the scraping process.

Two different Python scripts using the Selenium package were written, one to scrape *Google search* (with a variation for the US-based queries, because of the structural peculiarity of the United States' result page) and the other for *Google Images*. The same queries were used for both of them and the results of the scraping were saved in CSV files.

The Google Images scraping code was the first to be run (Feb 24, 2023), collecting results' data until reaching either the end of the results or the message "The rest of the results might not be what you're looking for. See more anyway". After a few days, The Google Search scraping code was run (Mar 1, 2023 to Mar 3, 2023), collecting results' data until reaching either the end of the results or the message "In order to show you the most relevant results, we have omitted some entries very similar to the ones already displayed."

Both scripts were run once for every country-based group of queries. Before each scraping, every available tool to simulate navigating from the considered country was used:

- Device tracking was disabled through Google Chrome settings.
- A VPN (*Express VPN*) was set to a server located in the corresponding country.
- The Google Chrome language setting was changed accordingly.
- The Windows "display language" and "country or region" settings were changed accordingly.
- The roght queries were set in the code.

A few times Google detected the usage of automation on the browser, especially for countries with a high number of queries (e.g. the United States) for which the code ran long sessions. In those cases, the VPN server was changed mid-scraping to another inside the considered country (e.g. in the case of the US switching from Washington DC to New York).

Both codes (*Google-Search-scraping* and *Google-Images-scraping*) saved a csv file for each query. Google Images' scraping returned:

- The source SITE RANK according to similarweb.
- The source SITE DOMAIN.
- COUNTRY name.
- Country ALPHA-2-CODE.
- The QUERY used.
- The RANK of the image (result position).
- The image URL.
- The image ALT-TEXT.
- The WEB PAGE where the image is used.
- The DOMAIN of the site containing the image.
- True/false based on whether the END OF RESULTS was reached.

Google Search' scraping returned instead:

- The source SITE RANK according to similarweb.
- The source SITE DOMAIN.
- COUNTRY name.
- Country ALPHA-2-CODE.
- The QUERY used.
- The number of TOTAL AVAILABLE RESULTS (according to Google).
- The TITLE of the result.
- The META DESCRIPTION of the result.
- The RANK of the result (based on its position).
- The SLUG of the result.
- The WEB PAGE linked to the result.
- The DOMAIN of the linked web page.
- TRUE/FALSE based on whether the result had a video preview.

After the scraping had finished, the 50 resulting csv files from Google Images were imported in a Google Sheets' spreadsheet (identified from now on as **Dataset P2_GoogleImg**). The same was done with the csv files from Google Search (the resulting spreadsheet will be identified from now on as **Dataset P2_GoogleSrc**). Those two datasets are the starting point for protocol 2 analysis.

Dataset P2_GoogleImg had to be checked for missing image urls. When one was spot, the conditions of its corresponding scraping were manually recreated, then inspect and ctrl+F were used in the browser to find the web page associated with the missing url and, consequently, detect the problematic url. Most of the missing urls were in base64 format (which is the main reason why they couldn't be scraped), so they had to be converted to jpg through *base64.guru*. ImgBB was then used to upload them and get corresponding urls to manually place in the spreadsheet. If with the method described above the problematic image couldn't be detected through the results, the query was changed to SITE:WEBSITENAME.DOMAIN "IMAGE ALT-TEXT" "CLIMATE CHANGE (OR TRANSLATION)". Inspect and ctrl+f would then be used as before. If no matching result was given once again, the entry was deleted from the dataset (it happened three times in total).

Finally, *Dataset P2_websites* was updated with the addition for each website of:

- Query used for scraping.

- VPN server location.
- Windows set country.
- Windows set language.
- Chrome set language.
- number of saved results from Google Images.
- number of saved results from Google Search.
- number of total results from Google Search (as stated by Google).

DOWNLOAD - IMAGES

All images in *Dataset P2_GoogleImg* were downloaded using Tab Save and ordered in different folders according to the source website.

P2 → DATA COLLECTION → CIRCLE PACKING → **VIZ 01**

The amount of scraped results from each website was mapped: the more they are, the more the supposed effort of the website in communicating climate change. The data regarding the number of saved results from both Google Images and Google Search (*Dataset P2_websites*) was adjusted to fit the circle packing chart in RAWGraphs. it included:

- Scraped WEBSITE.
- COUNTRY where the website is based.
- CONTINENT where the country is located.
- SOURCE: “Google Images” or “Google Search”.
- Number of SAVED RESULTS.

The variables mapped in RAWGraphs were:

- SIZE → number of results.
- COLOUR → source.
- HIERARCHY → continent, country, website.

Text analysis

TRANSLATION - TEXTS

The first thing to do in order to analyse the texts was uniforming all text entries in text entries in *Dataset P2_GoogleImg* (alt texts) and *Dataset P2_GoogleSrc* (titles and meta descriptions) by translating them into a single language (English). The Python script based on *googletrans* used in **protocol 1** was adapted for the purpose, in order to run through multiple rows of multiple csv files and translate specific cells. The output after running it consisted of two csv files:

1) One for GOOGLE SEARCH, with a row for each result and columns listing:
   - Website.
   - Result rank (as in *Dataset P2_GoogleSrc*).
   - Original title.
   - Translated title.
   - Original meta description.
   - Translated meta description.
2) The second for GOOGLE IMAGES, with a row for each result and columns listing:
   - Website.
   - Result rank (as in *Dataset P2_GoogleImg*).
   - Original alt text.
   - Translated alt text.

Finally, The two sheets were merged into a single spreadsheet. From now on it will be identified as **Dataset P2_translations**.

WORD COUNT

The same Python-based word count used in **protocol 1** was run on the translated textual results for each website (alt texts, titles and meta descriptions) with the following conditions:

- LANGUAGE set to English.
- Number of SAVED WORDS set to 100.
- “Climate”, “change” and the website’s name as custom STOPWORDS (they are part of the queries used for the scraping and their frequency is not relevant).

All individual csv files were merged into a spreadsheet using Google Sheets. From now on it will be referred to as **Dataset P2_wordCount_individual**. Its purpose is mostly to give a horizontal mapping of the keywords used in the various websites, but the data it contains is very wide and cannot be easily managed to provide some deep analysis insights. For that purpose, the word count tool was run on the overall text from all websites, three times:

1) The first time only on the texts from GOOGLE IMAGES scraping (alt texts).
2) The second time only on the texts from GOOGLE SEARCH scraping (titles, meta descriptions).
3) The third time on ALL TEXTS (alt texts, titles, meta descriptions altogether).

With the following conditions:

- LANGUAGE set to English.
- Number of SAVED WORDS set to 500.
- “Climate”, “change” and all the websites’ names as custom STOPWORDS.

The three csv output files were merged into a spreadsheet using Google Sheets. it will be referred to as **Dataset P2_wordCount_total**.

TAG CLOUDS

As in **protocol 1**, The tag cloud generator from *Digital Methods Initiative* was used to create visualisations out of the word counts, both for single website’s word counts (*Dataset P2_wordCount_individual)* and total word counts (*Dataset P2_wordCount_total*).

P2 → TEXTS → TAG CLOUDS → **VIZ 01**

Tag clouds of individual websites were gathered in a visualisation which also included indication of:

- The COUNTRY where the website is based.
- The CONTINENT where the country is located.
- Number of GOOGLE IMAGES scraped results.
- Number of GOOGLE SEARCH scraped results.

P2 → TEXTS → TAG CLOUDS → **VIZ 02**

As in **protocol 1**, tag clouds from merged texts were also displayed one after each other in another visualisation. From a qualitative evaluation, no relevant differences from Google Images and Google Search texts emerged, so the focus shifted to the merged Google Search and Google Images tag cloud.

TAG CLOUDS - CATEGORISATION

All words in the merged tag cloud (Google Search + Google Images) were classified into one (exclusive) category and subcategory of 15, exactly as in **protocol 1**. Categories and subcategories are also the ones defined in the previous protocol.

P2 → TEXTS → TAG CLOUDS → **VIZ 03**

A new visualisation was produced to highlight the first layer of categorisation in the tag cloud, designed with the same features as in **protocol 1**. What this mapping visualised was:

- How many words from the tag clouds were included in each category.
- How frequent those words were in the reports.

P2 → TEXTS → TAG CLOUDS → **VIZ 04**

Finally, another visualisation was designed to highlight the second layer of categorisation (sub-categories) for the merged tag cloud. It was designed with the same features as in **protocol 1**. What this mapping visualised was:

- How many words from the tag clouds are included in each subcategory.
- How frequent those words were in the results.

Image analysis

SELECTION

All 8,043 pictures from *Dataset P2_GoogleImg* were taken into consideration in protocol 2’s analysis.

NETWORK

Consistently with **protocol 1**, PixPlot was used to arrange the images into a network based on visual similarity, in order to define clusters of images according to their content. First all images had to be converted to jpg format (with *runningwombat* and *11zon*) and renamed according to the source website.

Prior to running the tool, a metadata csv file was filled with a row for every image and three columns:

1) FILENAME → name of the image file (including its extension).
2) CATEGORY → domain of website from which the image was taken.
3) TAGS (separated by |) → website domain (as above), country, continent.

Then the same procedure of **protocol 1** was followed: creating a Python environment in Anaconda, running PixPlot and starting a local server. Before clustering the images, the filters (tags) were organised into two different scroll menus in order to be able to cross-use them, editing filters.json as in protocol 1. The dictionaries corresponded to:

- Website domains.
- Countries and continents.

Again same procedure of **protocol 1**: creation of clusters and upload on GitHub. The clusters and their logic were mostly the same as in protocol 1 in order to keep the analysis consistent and allow cross-protocol comparison. Anyway, some image types peculiar to protocol 2 were considered relevant enough to be highlighted through new clusters.

P2 → IMAGES → NETWORK → **VIZ 00**

As in **protocol 1**, a screenshot of the network arrangement in PixPlot was taken and tagged with Figma. The clusters were this time more localised in the network, so the static map appears more detailed than that of the previous protocol.

P2 → IMAGES → NETWORK → **VIZ 01**

The visualisation centred on size and hierarchy of clusters was designed exactly as in **protocol 1**, with the same logic and features.

P2 → IMAGES → NETWORK → **VIZ 02**

The last network visualisation, focused on positioning and visual quality, was also designed in complete accordance with **protocol 1**.

P2 → IMAGES → IMAGE PLOT → **VIZ 01**

Images were then mapped according to hue and brightness as in **protocol 1**, using ImageMeasure and ImagePlot to create a non-polar plot with:

- X AXIS → *hue_median*.
- Y AXIS → *brightness_stdev*.

Finally, the plot was imported into Figma, divided in hue areas and tagged.

PLOT - CATEGORISATION

The analysis shifted to subsets of images representing specific aspects of the climate crisis. In order to build them, 6 categories from the 15 of the text analysis were selected (the ones more relevant according to the evaluation criteria). They were:

1) CAUSES → *general, climate change*.
2) SOLUTIONS → *actions, institutions, climate change*.
3) IMPACTS → *extreme, effects, threats*.
4) FUTURE → *general, specific moment*.
5) PEOPLE → *people*.
6) TEMPERATURE → *temperature*.

All the words included in each subcategory in the text analysis of this protocol (*P2 → Texts → tag clouds → viz 04)* were used as filters in the translated alt-text entries of the Google Images scraping (*Dataset P2_GoogleImg*). Images corresponding to the extracted alt-texts were downloaded, organised according to the corresponding subcategory and converted to jpg with *runningwombat*.

P2 → IMAGES → IMAGE PLOT → **VIZ 02**

Finally, the same process used for the creation of the previous visualisation (*P2 → Images → image plot → viz 01*) was applied to each subcategory-based group of images. As before:

- X AXIS → *hue_median*.
- Y AXIS → *brightness_stdev*.

Url analysis

SELECTION - CLIMATE CHANGE PAGES

The weather forecast websites' sections and pages explicitly designed and produced to address climate change were the final subject of analysis in protocol 2. In order to detect them, saved web pages in *Dataset P2_GoogleSrc* and *Dataset P2_GoogleImg* were explored through parsing and opening the urls. The focus was not on single articles connected to climate change particular expressions (e.g. a specific weather event) but portions of the site dedicated to climate change in general. Nine types of climate change pages were identified and defined:

1) SECTION → ramified portion of the website fully centred on climate change, often covering various and perspectives.
2) NEWS TAG → collection of news tagged climate change or similar.
3) BLOG TAG → collection of blog articles tagged climate change or similar.
4) GLOSSARY → information in the form of terminology explanations.
5) EDUCATIONAL → section with lectures, presentations, tests and similar content (mainly intended for schools).
6) RESEARCH → portal that leads to technical studies on climate change aspects.
7) DATA → dashboard showing updated data on aspects of climate change.
8) FEATURE → collaboration of the website with some other orgnisation/entity in order to make climate-change-focused communication.
9) BUSINESS → page which promotes services connected to climate change.

In total 77 climate change pages were identified, each of them classified into an exclusive category from the nine above. The extracted pages were listed in a new sheet including:

- Source WEBSITE.
- COUNTRY where the website is based.
- CONTINENT where the country is placed.
- URL of the climate change page.
- CATEGORY of the web page (from the 9 above).
- Individual ID for each web page, in the form website_category_number.

Fireshot was then used to take a full length screenshot of each page, providing the last information added to the sheet:

- PAGE HEIGHT (in pixels).

The sheet will be identified as **Dataset P2_urls**.

P2 → URLS → MATRIX PLOT → **VIZ 01**

The structure of *Dataset P2_urls* was adjusted in order to fit the matrix plot chart in RAWGraphs. The data was mapped as follows:

- X AXIS → Website.
- Y AXIS → Page categorisation.
- SIZE → Height of the page.

The chart was exported in svg and imported into Figma to be refined. In particular:

1) Websites were ordered according to continents and countries (as done in previous visualisations of this protocol).
2) Single web pages sharing the same category and website were grouped.

PATHS - DETECTION

Once the climate change pages for each website had been identified and mapped, the focuse shifted to their visibility and ease of access in the website's architecture and interface. The shortest path to each climate change page from the corresponding website's home was manually identified with the following procedure:

1) Opening the home page.
2) Trying the following:
   - inspect mode and find box to look for the climate change page's url (or at least a portion of it).
   - English translation of the page and search box to look for keywords connected to the climate change page's title or content.
   - English transaltion of the menu to look for a rationale path in the direction of the climate change page.

3) Two possible cases:
   - If one of the procedures in point 2 led to a promising new page (supposedly closer to the considered climate change page), applying the point 2 in the new page.
   - If none of the procedures in point 2 worked, moving back to previous page and trying other paths.
4) Repeat until reaching the climate change page or until all reasonable paths from the home page proved to be dead ends. In the latter case, the analysis proved that no clear direct path connecting the homepage with the climate change page existed.

Out of 77 climate change pages, 38 didn't have any clear direct path from the website's homepage.

P2 → URLS → PATHS → **VIZ 01**

The paths were grouped on the basis of respective page categories and mapped. The visualisation of the paths had the following characteristics:

- An iconic representation of a computer window to indicate each web page in the path.
- Heights of the page representations proportional to scrolled heights of the actual pages.
- Different colours for home page, climate change page and pages in-between (if any).
- Red dots to indicate interactions (clicks or hovers), positioned in the page icons according to the interaction position in the actual page.
- Red solid lines to indicate the flow of interactions within a single page.
- Red dashed lines to indicate the transition from one page to another.
- A red gradient to indicate that no connection from homepage to target page was detected.

The category-based visualisation had the purpose to study patterns and tendencies for specific climate change-pages' types. Inside each category group, paths are ordered from the shortest to the longest, calculated in terms of:

1) Number of pages in-between.
2) If same, total scrolled pixel.
3) If same, number of total interactions.

P2 → URLS → PATHS → **VIZ 02**

Paths were finally paired with the respective climate change pages and grouped according to the single source websites. The website-based visualisation had the purpose to study patterns and tendencies for specific websites. It had the following characteristics:

- Climate change pages were visualised with a full-length screenshot.
- Climate change pages were grouped according to their category.
- Paths representation was synthesised, showing only pages and scrolled heights.

PROTOCOL 3

How do weather forecast platforms represent climate change in connection to extreme weather events?

Data collection

SOURCES

The *World Weather Attribution* (WWA) is a team of researchers from several institutions worldwide born to study actual extreme weather phenomena and assess their correlation to climate change in terms of frequency and/or intensity.

SELECTION - EXTREME WEATHER EVENTS

Out of 59 total reports they published (archive accessed Feb 11, 2023), 15 extreme weather events were selected with the following characteristics:

- The correlation of the event with climate change was positively proven (either in terms of intensity, frequency or both).
- The event occurred from 2017 afterwards (in order to make it easier to retrieve news about it).

Also, the selection kept into consideration the variety in terms of type (cold spells, drought, extreme rainfall, heatwave, storm, ...) and location (with at least an event affecting every continent, Antarctica excluded). Since WWA already "prioritises events that have a large impact on society, or that provoked a strong discussion in society", no selection based on the resonance of the event was applied. The following information about each event was manually collected from the WWA reports and organised in a spreadsheet:

- Event UNIQUE ID in the form "*YYeventtypeCC*" where "*YY*" are the two last digits of the event's starting year, "*eventtype*" is the type of the event and "*CC*" is the event's continent's Alpha-2-code (e.g. 17heatwaveEU)
- TYPE of extreme weather event.
- YEAR(S) when the event happened.
- PERIOD in terms of days and/or month(s) when the event took place.
- CONTINENT where the event happened.
- COUNTRIES which were hit by the event.
- Entity of the influence of climate change over the event's FREQUENCY.
- Entity of the influence of climate change over the event's INTENSITY.
- LINK to WWA study about the event.

This list is preliminary to data collection for Protocol 3, and will be referred to as **Dataset P3_events**.

SELECTION - WEBSITES

The focus of protocol 3 is on whether the communication of the selected events by weather forecast platforms referred to climate change, and in what terms. Out of the top 50 most visited weather websites worldwide according to similarweb (analysed in protocol 2) 5 were selected. They had the following characteristics:

- They significantly address climate change in their everyday communications (according to analysis in protocol 2).
- They have an archive of weather news going back to at least January 2017 (evaluated with qualitative exploration of the websites).

The selected websites are:

1) ELTIEMPO.ES
2) ILMETEO.IT
3) METOFFICE.GOV.UK
4) TIEMPO.COM
5) WEATHER.COM

WEB SCRAPING - PREVIEWS

The 5 weather news archives were scraped in order to retrieve articles related to the 15 extreme weather events. A custom Python code (using Selenium) was written for each website, scraping the news previews and collecting publishing dates, all textual information and thumbnails if present. Working with the previews kept the scraping fast and having textual results allowed to filter in order to detect articles connected with the chosen weather events. In order to speed up the scraping process, a timeframe was set for each event, starting 15 days prior to the beginning of the event and ending a month after its conclusion. Earliest timeframe starts May 10, 2017 and last ends January 15, 2023. The scraping codes were run on May 19, 2023, after:

1) Disabling the device tracking in Google Chrome.
2) Locating a VPN (*Express VPN*) to a server located in the website's base country.
3) Limiting the scraped news archive on the basis of the set timeframes.

The results were stored in 5 csv files (one for each website) then merged in a spreadsheet on Google Sheets. From now on it will be referred to as **Dataset P3_previews**.

SELECTION - ARTICLES

Dataset P3_previews was rearranged in 75 sheets, each of them displaying the data from a single website in a single timeframe (connected to a single extreme weather event). Since timeframes often overlapped, single results could be present in more than one sheet. Google Sheets was then used to filter in each (event-related) individual sheet, using keywords in the corresponding website's language related to either:

- The geographical locations affected by the event considered (continent and countries).
- the type of the event.
- the event's name if it has any.

From the filtered news, the ones that proved to be explicitly related with the considered event were selected. The event had be central to the news article for it to be considered relevant, or at least should have been used as a single case example to talk about a more general theme (e.g. Europe heatwave of 2017 used as an occurrence while talking about temperature increases worldwide). Instead, if for example the event was used only as an introduction to other weather conditions following it (e.g. "Europe heatwave of 2017 is finished, storms are bnow coming") it wasn't considered relevant.

All the relevant news were saved in a new spreadsheet, with a sheet for each website. For every article, in addition to the informations already included in *Dataset P3_previews*, the spreasheet showed:

- Linked event CONTINENT.
- Linked event TYPE.
- Linked event ID.

This spreadsheet is the basis of the further scraping phase, and it will be identified as **Dataset P3_selection** from now on.

Dataset P3_events was also updated, with the addition for each event of:

- The TIMEFRAME considered for scraping.
- The number of RETRIEVED ARTICLES for each of the five websites.

WEB SCRAPING - ARTICLES

Another custom Python code (also based on Selenium) was written for each website: all articles in *Dataset P3_selection* were scraped, collecting texts, pictures, videos and Twitter posts embedded (May 25, 2023). Before running the code, as always:

- Device tracking was disabled in Google Chrome.
- A VPN (*Express VPN*) was set to a server located in the website's base country.

The 5 python codes compiled a csv file each: every website had its own. They were finally merged into a single spreadsheet, which was the starting point for the analysis of Protocol 3. It will be identified from now on as **Dataset P3_articles**.

The dataset was reviewed, manually filling in missing data (caused by errors and exceptions while scraping) and cleaning some text entries containing repeating disclaimers and/or commercial communications, not relevant to our analysis (eg. "Stay connected. Keep up to date with the latest ...").

DOWNLOAD - IMAGES

Prior to starting with the analysis, all images in *Dataset P3_articles* were downloaded and ordered in nested folders according to their source website and role in the page (e.g. thumbnail). The urls had occasionally to be adjusted before downloading (for example removing ",") and in a few cases of profile images from Twitter, the urls didn't work anymore. The reason was that in the meantime the pride month (June) came, and many institutional profiles changed their image adding queer symbols and colours. The new profile pictures were downloaded and put in place of the old ones.

P3 → DATA COLLECTION → MATRIX PLOT → **VIZ 01**

The amount of articles saved for each extreme weather event from each website was mapped: the data was adjusted to fit the matrix plot chart in RAWGraphs. it included:

- Scraped WEBSITE.
- COUNTRY where the event took place.
- CONTINENT where the country is located.
- EVENT ID (as in *dataset P3_events*).
- YEAR when the event started.
- TYPE of the event
- Number of SAVED ARTICLES.

The variables mapped in RAWGraphs were:

- X AXIS → Event ID.
- Y AXIS → Website.
- SIZE → Number of articles

Finally, figma was used to rearrange the chart and add more information. In particular:

- The events were grouped according to the continent where they took place.
- Background colours were used to distinguish events of different types.
- The events inside each continent group were ordered chronologically (past to present).
- The continent groups were ordered according to the number of events (from the one with the most to the one with the least).

Text analysis

SELECTION - CLIMATE CHANGE CITATIONS

The next step was detecting in which articles climate change was part of the account of the extreme weather event. *Dataset P3_articles* was inspected using conditional formatting on all text entries from each website A background colour was automatically applied to the cells which contained the words "climate change" or a synonym (in the language used by the website). In this way, a quick overview of the connections between the weather event and climate change was provided.

P3 → TEXTS → MATRIX PLOT → **VIZ 01**

A more refined visualisation of this information was then produced with RAWGraphs. The dataset was adjusted to fit the matrix plot chart: all text entries' columns were ordered on the basis of importance (how visible the respective text types are on the website). Each text entry was then replaced with with a numeric value based on whether it contained any of the considered climate change synonyms:

- 0 → none of them.
- 1 → the text cell is empty (that article didn't contain any text of that type).
- 2 → climate change (or translation).
- 3 → climate crisis (or translation).
- 4 → climate emergency (or translation).
- 5 → global warming (or translation).
- 6 → climate change & global warming (or respective translations).
- 7 → climate change & climate crisis (or respective translations).

The data frame from each website was pasted into RAWGraphs and stacked on the article url in order to have three columns only:

1) Article url.
2) Text type.
3) Numerical value (as above).

The variables mapped in RAWGraphs were then:

- X AXIS → Article url.
- Y AXIS → Text type.
- COLOUR → Numeric value.

Finally, all 5 matrix plots (one for each website) were imported in Figma and adjusted as follows:

1) The weather event-continent order of previous visualisation (*P3 → data collection → matrix plot → viz 01*) was reproduced.
2) Backgrounds colours based on event type were used as in previous visualisations.
3) Text types for each website were grouped according to their level of importance as defined above (preview, articles, images, embedded).
4) Dots in the matrix plot were recolored to:
   - Differentiate empty text cells from text cells which didn't contain any climate change synonym.
   - Highlight cells which contained climate change synonyms with textures.
   - Differentiate the climate change synonyms one from the others with varied textures.

TRANSLATION - TEXTS

Further text analysis only considered a selection of all scraped texts: texts that are straight visible to the user inside the online article page without any interaction other than scrolling. Entries such as, for example, alt texts or slideshow captions were then excluded. The analysis started with a uniformation process by translating them into a single language (English). The Python script based on *googletrans* used in **protocol 1** was adapted for the purpose, running through multiple rows of multiple csv files and translating specific cells as in **protocol 2**. The output after running the adapted Python code consisted of five csv files, one for each website. Every csv included:

1) Information related to the WEATHER EVENT:
   - Continent.
   - Event type.
   - Event ID.
2) Information to identify the ARTICLE:
   - Article url.
   - Publishing date.
   - Publishing hour (if specified).
   - Translated texts.
   - True or false depending on whether the article cites climate change (*P3 → texts → matrix plot → viz 01*).

Finally, the five sheets were merged into a single spreadsheet. From now on it will be identified as **Dataset P3_translations**.

WORD COUNT

The same Python-based word count used in **protocol 1** and **protocol 2** was run on the translated texts, twice for each website:

1) On texts from all selected articles in the site.
2) On texts from only the selected articles addressing climate change in the site.

With the following conditions:

- LANGUAGE set to English.
- Number of SAVED WORDS set to 100 (words with frequency below 2 manually excluded).
- No custom STOPWORDS.

All individual csv files (two for each website) were merged into a spreadsheet using Google Sheets. From now on it will be referred to as **Dataset P3_wordCount_individual**. Its purpose is mostly to give a horizontal mapping of the keywords used in the various websites (for all articles as well as for climate-change-citing articles only), but the data it contains is very wide and cannot be easily managed to provide some deep analysis insights. For that purpose, the word count tool was run on the overall text from all websites, twice:

1) On texts from all selected articles.
2) On texts from only the selected articles addressing climate change.

In both cases with the following conditions:

- LANGUAGE set to English.
- Number of SAVED WORDS set to 500.
- No custom STOPWORDS.

The two csv output files were merged into a spreadsheet using Google Sheets. it will be referred to as **Dataset P3_wordCount_total**.

TAG CLOUDS

As in **protocol 1** and **protocol 2**, The tag cloud generator from *Digital Methods Initiative* was used to create visualisations out of the word counts, both for single website's word counts (*Dataset P3_wordCount_individual)* and total word counts (*Dataset P3_wordCount_total*).

P3 → TEXTS → TAG CLOUDS → **VIZ 01**

Tag clouds of individual websites were gathered in a visualisation which compared for every website the *all-articles* tag cloud to the *climate-change-citing-articles* one, and included also indication of:

- Total number of selected articles.
- Number of articles citing climate change.

P3 → TEXTS → TAG CLOUDS → **VIZ 02**

As in **protocol 1** and **protocol 2**, tag clouds from merged texts were also displayed one after each other in another visualisation.

TAG CLOUDS - CATEGORISATION

All words in the merged tag clouds (*all-articles* and *climate-change-citing-articles*) were classified into one (exclusive) category and subcategory of 15, exactly as in **protocol 1** and **protocol 2**. Categories and subcategories are also the ones defined in the previous protocols.

P3 → TEXTS → TAG CLOUDS → **VIZ 03**

A new visualisation was produced to highlight the first layer of categorisation in the two tag clouds, designed with the same features as in **protocol 1** and **protocol 2**. Furthermore, the words' opacity in the overall texts' visualisation was manipulated in order to highlight words that appear in both tag clouds.What this mapping visualised was:

- How many words from the tag clouds were included in each category.
- How frequent those words were in the reports.
- Relevant differences (if any) in the discourse between the normal flw of extreme weather reports and reports that cite climate change.

P3 → TEXTS → TAG CLOUDS → **VIZ 04**

Finally, another visualisation was designed to highlight the second layer of categorisation (sub-categories) for the merged tag cloud of *climate-change-citing* articles only. It was designed with the same features as in **protocol 1** and **protocol 2**. What this mapping visualised was:

- How many words from the tag clouds are included in each subcategory.
- How frequent those words were in the articles.

Image analysis

SELECTION

Not all pictures from *Dataset P3_Articles* were taken into consideration in protocol 3's analysis: Twitter images were excluded, since they were considered part of a radically different web element embedded in the website. All other images (article thumbnails, article images, slideshow images, video thumbnails) were instead analysed together: they amounted to 3,538 in total.

P3 → IMAGES → GRIDS → **VIZ 01**

Considered images were organised in nested folders according to respective role (e.g. thumbnail), website and connection with climate change (whether they come from an article citing climate change or not, according to text analysis: *P3 → texts → matrix plot → viz 01*). All images were converted to jpg format (with *runningwombat* and *11zon*), then picarrange was used on each child folder (climate change relation/website/role) to order all included pictures according to visual similarity, 10 images per row. The ordering was manually adjusted in a few cases, in particular bringing identical images next to each other when they were not. The ordered images were then processed with *bulk resize photos* in order for all of them to have the exact same size:

- 900 x 600px.
- Using padding.
- Png format with transparent background.

ImageJ was used to create grid montages with the *Magic Montage Tools* (keeping the images per row to 10). The process was repeated for each child group of resized images: A grid montage of images ordered according to visual similarity was produced for each combination of:

- Climate change relation.
- Website.
- Image role.

Figma was finally used to order all the montages in a tabular structure.

P3 → IMAGES → IMAGE PLOT → **VIZ 01**

Images were mapped according to hue and brightness as in **protocol 1** and **protocol 2**, using ImageMeasure and ImagePlot to create a plot with:

- X AXIS → *hue_median*.
- Y AXIS → *brightness_stdev*.

The plot was then imported into Figma, divided in hue areas and tagged.

P3 → IMAGES → IMAGE PLOT → **VIZ 02**

Finally, the same process used for the creation of the previous visualisation (*P3 → Images → image plot → viz 01*) was applied to each group of images based on role, website, climate change relation (*P3 → images → grids → viz 01*). As before:

- X AXIS → *hue_median*.
- Y AXIS → *brightness_stdev*.

NETWORK

Consistently with **protocol 1** and **protocol 2**., PixPlot was used to arrange the images into a network based on visual similarity, in order to define clusters of images according to their content. Prior to running the tool, a metadata csv file was filled with a row for every image and three columns:

1) FILENAME → name of the image file (including its extension).
2) CATEGORY → climate change relation (whether the article from which the image was scraped was citing climate change or not).
3) TAGS (separated by |) → climate change relation (as above), source website, image role.

Then the same procedure of **protocol 1** and **protocol 2** was followed: creating a Python environment in Anaconda, running PixPlot and starting a local server. Before clustering the images, the filters (tags) were organised into three different scroll menus in order to be able to cross-use them, editing filters.json as in protocol 1 and protocol 2. The dictionaries corresponded to:

- Climate change relation.
- Websites.
- Image roles.

Again same procedure of **protocol 1** and **protocol 2**: creation of clusters and upload on GitHub. The clusters and their logic were mostly the same as in protocol 1 and protocol 2 in order to keep the analysis consistent and allow cross-protocol comparison. Anyway, some image types peculiar to protocol 3 were considered relevant enough to be highlighted through new clusters.

P3 → IMAGES → NETWORK → **VIZ 00**

As in **protocol 1** and **protocol 2**, a screenshot of the network arrangement in PixPlot was taken and tagged with Figma.

P3 → IMAGES → NETWORK → **VIZ 01**

The visualisation centred on size and hierarchy of clusters was designed as in **protocol 1** and **protocol 2**, with the same logic and features. The only difference is that the metadata-based arrangement of images was used in place of the square one: images were divided into two squares based on climate change relation.

P3 → IMAGES → NETWORK → **VIZ 02**

The last network visualisation, focused on positioning and visual quality, was also designed in complete accordance with **protocol 1** and **protocol 2**.

Discussion →

GENERAL

Are weather forecast platforms taking advantage of their opportunity to create concrete and meaningful representations of the climate crisis for audiences across the world? According to my analisis, the answer is “they generally are, but could do better”. A large part of the weather websites and companies in the case studies are addressing the issue not only on specific occasions, but also in their everyday communications. However, their representations are often casual, inconstant, varied and not always rely on the connection with localised impacts. (More or less aestheticised) depictions of extreme weather events are anyway frequent, and while they are usually presented in relation to their specific context, there are also many cases where they are de-contextualised and presented as general iconographies of impact types. Abstraction comes also through technical framings of the topic, both in texts and images. Scientific explanations, charts, maps appear either in connection to the coverage of events in the present, providing a link from the localised threat to the wider image, and as part of rational analysis of future scenarios.

The three research protocols investigated three distinct areas of the weather forecast platforms’ landscape: representation of climate change when requested by external entities, representation of climate change in the normal flow of communications, and representation of climate change in the coverage of extreme weather events. The three directions of analysis, coupled with the attempt to include case studies from all over the world, was critical to provide a comprehensive mapping of the phenomenon. Quite interestingly, there are significant consistencies between the textual and visual spaces of the protocols: keywords and subjects are mostly uniform, even if their weights tend to vary. The visual regularity can be observed through a hue-brightness plot *(images → image plot → vizv 01)*: the pictures are concentrated in two hue areas (red to yellow and light blue to blue). Images in the first area visualise fires, droughts, increase of temperatures, while images in the second area depict the sky, the sea, glaciers and earth as a globe. Plots from subsets of pictures tend to show the same colour tendency. Let’s now contextualise each protocol and give some insights on its peculiarity.

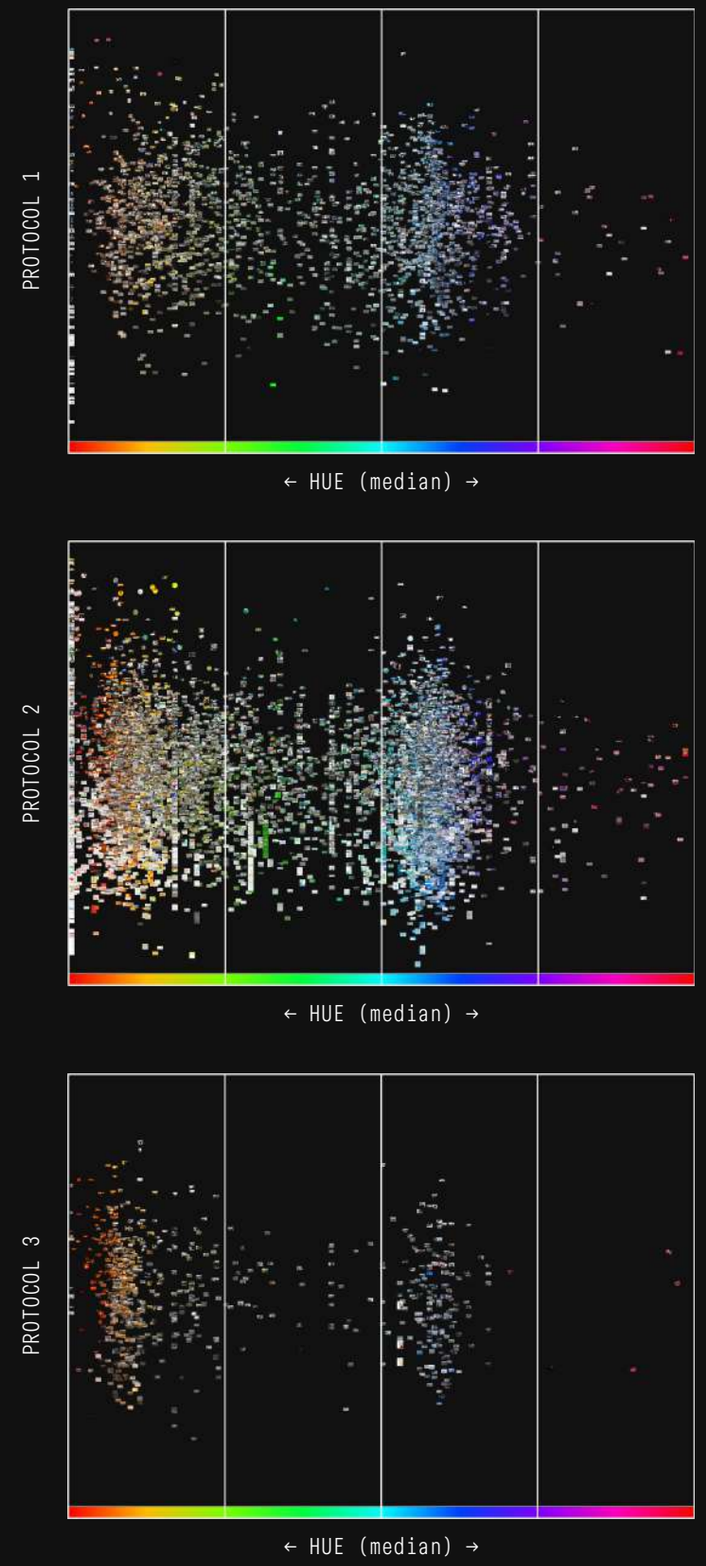
PROTOCOL 1 analyses the imaginary *weather reports from the future* produced by media companies all over the world by request of the WMO (*World Meteorological Organisation*), with the explicit purpose to sensitise people about the local impacts of climate change. The total videos are 63, set in 40 countries in 6 continents. Europe produced the most reports (22), followed by North America and Africa (13 each), Asia (9), South America (5) and Oceania (only 1, set in New Zealand). The WMO provided various versions of a speech which the agencies could use to conclude the reports they realised. My analysis compared them with the reports, in order to assess how the intentions of the UN agency were implemented in the actual videos *(P1 → texts → tag clouds → viz 03)*. Significant differences between the WMO and the media companies’ approaches were identified, and they will be addressed in detail in the following pages. In general, the reports present the tendency to stratify concrete and abstract perspectives in layered representations showing different realities and subjects at the same time. The weather presenters often have the role of a guide directing the narration through a rational and analytical frame.

PROTOCOL 2 analyses interfaces and day-to-day communications of the *top 50 most visited weather websites worldwide* (according to Similarweb), assessing the presence and weight of climate change representations. The websites are based in 28 different countries in 5 continents (even if some of them target for international audiences). Most of them are based in Europe (29), followed by North America (9: 6 in the US and 3 in Canada), Asia (7), Oceania (3) and South America (2). No african-based website was included in the list. Out of 50, 6 websites (*gismeteo.ua, gismeteo.by, sinoptik.ua, ventusky.com, weather.naver.com, windguru.cz*) don’t present any climate-crisis-related content at all, and if another 6 (*havadurumu15gunluk.xyz, meteoam.it, meteociel.fr, rp5.ru, shmu.sk, weather.yahoo.co.jp*) have almost none *(P2 → data collection → circle packing → viz 01)*. Out of the 38 remaining websites, only 27 have at least one *climate change page*, defined as a page explicitly designed and produced to address the climate emergency. A total of 77 climate change pages of different kinds and weights were identified: while about half of the 27 websites include only one climate change page, the other half offers coverage of the topic through multiple of them *(P2 → urls → climate change pages → viz*

01). However, the pages are not always very visible and easy to access in the architecture and interface of the corresponding website. For 38 pages, no access from the home page was detected—even with multiple interactions. Out of 27 websites, only 15 include at least a climate change page which can be accessed from the home page with a single interaction *(P2 → uls → paths → viz 02)*. In synthesis, most of the weather forecast platforms engage in representing climate change but they often do it through unstructured communications and without a strategy. The most relevant exceptions (websites with at least 5 climate change pages) are: *nooa.gov* (10 pages), *metoffice.gov.uk* (9 pages), *wetter.de* (7 pages) *weather.com* (6 pages), *eltiempo.es* (5 pages) and *weather.com.cn* (5 pages). Interestingly, the first two are websites from the public sector rather than private platforms.

PROTOCOL 3 analyses the coverage of 15 extreme weather events across the world made by 5 weather forecast platforms selected from the 50 of the previous protocol. The chosen weather events were proved to be caused or reinforced by climate change through independent studies of the *World Weather Attribution* (WWA). They include droughts, extreme rainfall, storms and cold spells from different areas in 6 continents: 4 of them are localised in Europe, 4 in Asia, 2 in Africa, 2 in North America, 2 in South America and 1 in Oceania. The selected websites are: *eltiempo.es*, *tiempo.com* (both based in Spain), *ilmeteo.it* (Italy), *metoffice.gov.uk* (United Kingdom) and *weather.com* (the United States). They all address climate change in their everyday communication (according to protocol 2), and include an archive of news which could be analysed. The first thing that was noticed is that none of the websites covered all the weather events *(P3 → data collection → matrix plot → viz 01)*. The selected platforms are all based in the Global North, and they mostly privileged (to different extents) events happening locally or close by, failing to provide a really global perspective. The sense of closeness that influenced reporting one event or another shouldn't be intended as purely geographical but contaminated with cultural aspects: the Australian heatwave of 2019 (and consequent series of bushfires) caught the attention of all the websites, even if none of them is based there. *Weather.com* even dedicated more articles to that event than to the 2021 heatwave interesting the US (where the website is based) and Canada. Instead, none of the websites dedicated any articles to events in South America, and very few news were dedicated to events in Africa. When the focus of the analysis shifts from weather to climate change, further limitations in the accounts of the natural disasters appear: Only 52 out of 275 total articles cite climate change or a synonym *(P3 → texts → matrix plot → viz 01)*. *Eltiempo.es* and *ilmeteo.it* are the worst in addressing the topic, with only 3 articles referencing the climate emergency each. Furthermore, the citations tend to be hardly visible: they appear more often inside the articles rather than in their preview, and in low level text rather than titles. The most striking example in that sense is *weather.com*, whose 19 articles citing climate change do it only in lowest text level (not even in highlighted sentences). On the other hand, *metoffice.gov.uk* and *tiempo.com* include many articles with references to the issue on various text layers. The latter (*tiempo.com*) is also the website with the highest frequency: all events covered present at least an article citing the climate crisis, and half the total articles reference it on different text levels. Comparisons between *climate-change-avoiding* articles and *climate-change-citing* articles were made, and will be addressed in detail in the following pages. When considering the visual space of protocol 3, it appears evident that most images come from a single source: *weather.com*, which news pieces often contain slideshows *(P3 → images → grids → viz 01)*. Slideshow images are more frequent in *climate-change-citing* articles than in *climate-change-avoiding* ones, and most of them are centred on wildfires (especially the ones striking Australia in 2019) and floods, which are then the main constituents of protocol 3's imagery.

Let's now investigate the climate crisis representations collected in the three protocols on the basis of the single principles and criteria listed in the methodology section. The text covering each aspect will be coupled with relevant image examples from the case studies in the protocols.



NATURE

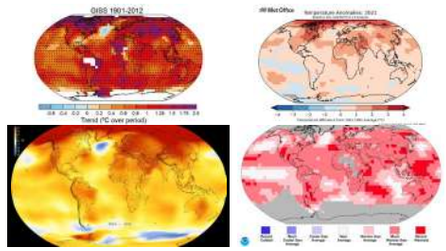
The artificial fracture between culture and nature is reaffirmed in most communications. Humanity and nature are depicted as separate entities with an ambiguous power relation. Sometimes the latter is framed as pure and endangered by human presence: that's the case, for example, with pictures of pristine landscapes or reports on the ice melting. Communications of that kind tend to conceive nature as healthy only if freed from human presence and its impacts. Other times nature is represented as threatening for human survival, such as in some coverage of extreme weather events. The same human activities exerting control and damaging nature are sometimes framed as menaced by the uncontrollable forces of nature. That's the case with communications regarding food security *(P1 → images → network → viz 01 & P2 → images → network → viz 01)*: crops—human activity over nature—are threatened by droughts—nature's power over human agency. Or with pictures of wildfires — nature—burning down cars—agents of pollution *(P3 → images → network → viz 01)*. In a similar fashion, insects can be at the same time pictured as victims of climate change—like bees, whose population is declining because of it—or part of climate change's impacts on humanity (like parasites, who spread new illnesses *(P2 → images → network → viz 01)*.

A framing distinguishing a victim (endangered) and a prosecutor (endangering) leaves space to a third subject: a rescuer. Even if not common, representations of that kind were identified through the case studies considered. For example, in an article covering the Australian 2019 heatwave a photoshoot was dedicated to volunteers saving wild animals from the fires *(P3 → images → network → viz 01)*. It's a representation with the potential to challenge the human-nature separation: we as humans are threatened because we are part of the nature we are threatening, and we need to acknowledge it in order to engage in solutions.

The complex—and partly artificial—dichotomy of endangering-endangered resonates with the hue mapping of images *(images → image plot → viz 01)*: centuries of human experience in combination with social and cultural codes brought us to perceive red hues as more connected to threat, and blue hues as more connected to fragility. They are two sides of the same coin, and by no surprise they are the dominant colours in climate change images. It is evident in protocol 3's pictures of the wildfires *(P1 → images → network → viz 01)*: the representations with dominant red, orange and yellow hues tend to present dangerous environments and situations seen from close by (images of flames and fire), while the blue-dominant ones often imply a distant point of view (aerial pictures with smoke clouds). In the first case the audience identifies and feels endangered, while in the second they observe the fragile nature and landscapes from a detached perspective. It can also be seen in the representations of planet Earth as either blue satellite images where human impacts disappear or red-covered visualisations of the dangerous increases in the temperatures *(images → network → viz 01)*. However, the visualisation of earth as a globe is extremely ambiguous in itself, implying the greatness of nature and its vulnerability at the same time (for more on the topic: Schneider, 2016).

In fact, all analytical or technical representations, all "views from above" are tools for control in the first place, produced by the same worldview that led to the anthropocene (Fehlinger, 2020a). And they populate the case studies. They might assess the threats we are facing and direct policies, but they can't challenge the mentality that produced them. To effectively respond to the climate crisis we need to produce devices for a re-definition of humanity's place in the world: images and texts that foster a comprehensive understanding where prosecutor, victim and rescuer are fictional subjects part of the same unit, which is nature. In the communication landscape analysed, they are still largely missing.

THREATENING HUMANS ↓



THREATENED BY HUMANS ↓

(NATURE-THREATENING) THREATENED BY NATURE ↓

(THREATENED BY HUMANS) SAVED BY HUMANS ↓

PEOPLE

In the context analysed the climate emergency is often represented as a dehumanised issue. People are in many cases excluded from the communications, and when cited they are rarely presented as active subjects: agency is rarely depicted. This is generally true for all three protocols, but there are significant differences.

The intention of the future weather reports analysed in protocol 1, as expressed by WMO officials in the final speech, was strongly connected to the empowerment of individuals and—especially—communities *(P1 → texts → tag clouds → viz 03)*. However, the actual reports contain vast portions representations of the issue deprived of human figures. In terms of screen time, the most shown people are weather presenters, personifications of the "view from above" analytical frame *(P1 → images → frame grids → viz 02)*. They are generally shown in the detached environment of the studio, in front of charts and maps: they use technology to control and analyse the exterior world, explaining events in a scientific perspective, instead of promoting emotional connection and empathy. Right after presenters, the second biggest portion of screen time is dedicated to humans-free frames. Citizens are the least represented, a sign that not much effort was put on providing means of identification. They are usually shown in groups as victims of climate change impacts, such as extreme weather and heat, defined mostly by the threat they face. WMO officials and politicians (the latter quite completely absent) are only depicted while giving speeches, and almost all of their screen time is due to reports' final speech. Quite interestingly, images of causes and solutions generally don't include people at all.

Protocol 2 is the one where people are less represented: only 13% of the images extracted and analysed include humans *(P2 → images → network → viz 01)*. When pictured, they have different roles: citizens make up the most frequent one, shown mainly as victims of extreme weather conditions but also as protesters during strikes. While protesting involves agency, researches demonstrated that strike imagery tends to attracts cynicism and aversion (Corner et al., 2015a). Other roles include politicians (mainly from the United States and China) and, in a small number, weather presenters.

Protocol 3 has a people-including / people-excluding ratio similar to that of protocol 1 when considering images: 45% of them include humans *(P3 → images → network → viz 01)*. They are mainly defined by threats, but there's more space to agency than in previous cases: people can either be victims and endangered subjects or fighters that contrast the extreme weather. Actually, the latter role is the most frequent in the depictions. Anyway, it's a kind of agency which deals more with the single event than with the issue at large: it's more about adaptation rather than mitigation. The consequences for victims are framed both in terms of health—to the point of death—and well-being—to the point of losing all belongings *(P3 → texts → tag clouds → viz 04)*. Other roles (such as weather presenters) are almost absent.

In conclusion, it's also worth pointing out that few representations of victims succeed in stimulating identification and empathy: people represented are often shown in big groups, and in images they tend to be distant or facing away from the camera *(images → network → viz 02)*.

VICTIMS (BACK VIEW) ↓

FIREFIGHTERS ↓

PROTESTERS ↓

POLITICIANS ↓

WEATHER PRESENTERS (VIEW FROM ABOVE) ↓

CAUSES, IMPACTS, SOLUTIONS

As expected, the representations analysed focus more on climate change impacts rather than causes and solutions *(texts → tag clouds → viz 03)*. Generally speaking, it's more common to see the climate crisis pictured as a cause of specific impacts (such as extreme weather events) rather than depictions of actual causes of climate change. The few that are communicated are represented through pieces of technology in dehumanised environments: for example, smokestacks or car traffic *(images → network → viz 01)*. Interestingly, cars are not always presented as causes, and other vehicles such as planes sometimes get included in representations of green sustainable utopias. Solutions (appearing even more rarely than causes) are also mostly connected with technology, and energy production in particular: they include renewable energy devices such as solar panels and wind turbines. Another type of solutions' representation focuses on institutions supposed to deal with the climate emergency—especially the IPCC. Focusing on the impacts, most of the representations in the case studies are split between maps and charts on one side and aestheticised depictions of extreme weather events on the other. Increases in temperatures are also often cited, while other less frequent communications regard epidemics and food security. In general, the effects of climate change often convey the idea of out of the ordinary and emergency *(texts → tag clouds → viz 04)*. The patterns highlighted up to now are true for all cases studies considered. However, each protocol presentes its unique tendencies in the balance between causes, impacts and solutions.

Protocol 1 is once again characterised by a gap between the WMO intentions and their implementation through the reports: while the final speeches explicitly address specific causes of climate change as well as directions of action, the reports are much more focused on impacts, especially extreme weather events *(P1 → texts → tag clouds → viz 03)*. They are represented generally through maps, charts and (to a minor extent) extreme imagery. Most of the weather events pictures either include the presenter or show no people at all *(P1 → images → frame grids → viz 02)*: victims appear quite seldom, and an analytical framework is favoured over an emotional one. Technology-related images, connected with causes and solutions., have the overall lowest screen time amongst all subjects considered: 10 minutes out of a total of over 6 hours. Also, in most of them no human figure is depicted.

Protocol 2 presents very similar patterns to protocol 1: impacts are pictured mainly through maps and then through vivid imagery, causes are dehumanised and together with solutions mostly deal with technology *(P2 → images → network → viz 01)*.

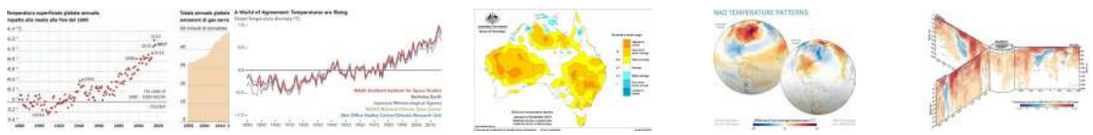
Protocol 3 is even more centred on impacts rather than the previous ones. They are framed as extreme events (especially wildfires) and increases in temperatures *(P3 → texts → tag clouds → viz 03)*. Expressions of emergency recur very often, and tend to present connections to vivid consequences on the personal and social level (death and devastation). Extreme imagery is much more common than maps and charts in this case *(P3 → images → network → viz 01)*. In terms of solutions, the articles usually cite organisations (or individuals) fighting the specific weather event instead of institutions dealing with the climate crisis at large. Representations of causes are almost absent, and even cars are often represented as "victims" of the events: they are shown blocked in flooded roads or burnt down. Only two pictures out of more than 3,500 show smokestacks.

The overall focus on impacts is undoubtedly useful in producing a sense of urgency in the audience. However, both the scarce presence of people in the frames as well as the absence of meaningful representations of solutions risks to affect the production of engagement and sense of agency. Furthermore, representing the causes as humanless and context-less can contribute to hiding the actual responsibilities in the crisis and create confusion on how to act in response to it.

CAUSES: EMISSIONS ↓

IMPACTS: EXTREME WEATHER EVENTS ↓

IMPACTS: TEMPERATURE INCREASE ↓



SOLUTIONS: RENEWABLES ↓

STEREOTYPES

The visual and the textual spaces identified and explored through the research maintain significant consistencies and similarities between them. When connecting with concrete and localised weather events, they generally succeed in providing original and engaging communications. Sometimes, however, the representations of impacts are centred on typologies of weather events in general, through de-localised and de-contextualised depictions which can be perceived as inauthentic or not relevant *(images → network → viz 01)*. That's the case with images of dry soil, for example. Icebergs and melting glaciers are other clichè subjects which can be found across the analysis—the first iconic ice-focused picture dates back to 1997, when Greenpeace documented the splitting of the Larsen B ice shelf in Antarctica—and protocol 2 even includes some pictures of polar bears *(P2 → images → network → viz 01)*. Stereotypes are much more common across depictions of causes (smokestacks and traffic) or solutions (solar panels and wind turbines). While such representations generally imply more ease of understanding, they often provoke fatigue and disengagement in the public by promoting already digested perspectives on climate change. Finally, even specific charts can become clichès—that's the case with the "hockey stick" graph, or with the "burning worlds" maps representing the global increase of temperatures: while the former is almost absent through the analysis, the latter proved to be quite popular across protocol 2 *(P2 → images → network → viz 01)*.

CAUSES

SMOKESTACK ↓

IMPACTS

DRY SOIL ↓

GLACIERS ↓

POLAR BEARS ↓

SOLUTIONS

SOLAR PANELS ↓

WIND TURBINES ↓

SPACE

In the matter of spatial scales, representations in protocols 1 and 2 are quite different from those in protocol 3. The first two tend to provide local contextualization of the global issue: while they focus on local impacts, they mostly present them as concrete instances of climate change, often stressing the links with the wider picture. This is one of the few points which the reports in protocol 1 interpreted in close accordance with the intentions expressed by the WMO. Depictions of localities are generally based on vivid imagery, while the global scale is presented through technical representations, mostly maps and diagrams *(P1 → images → network → viz 01 & P2 → images → network → viz 01)*. Decontextualized images of impacts—such as close ups of dry soil—also try to give a general representation of the impacts by translating a specific occurrence into a view that could be anywhere in the world. However, this strategy undermines the sense not only of localisation but also of authenticity of the image: if it could represent anywhere, it feels like it represents nowhere. Local representations are mostly—even if not always—connected to impacts close to the audience, generally in the respective state-nation *(P1 → texts → tag clouds → viz 04 & P2 → texts → tag clouds → viz 04)*. The application of country-limited narratives sometimes implies distortions of reality, since the weather is not affected by borders. Anyway, when centred on relevant and close-by impacts the communications tend to be perceived as meaningful by the public. Finally, while impacts are frequently localised, causes and solutions are always presented from a global and abstract perspective.

Protocol 3 is much more centred on the local level: not many connections with the wider issue are provided, even if considering only climate-change-citing articles *(P3→ texts → tag clouds → viz 04)*. Interestingly, some representations link the depicted event to other local events instead. The impacts pictured are sometimes far-away for the audience: events from "somewhere else" have probably been selected and covered on the basis of their perceived gravity as well as according to a perception of closeness in terms more cultural than geographical *(P3→ data collection → matrix plot → viz 01)*. Somehow, the coverage of the extreme weather embeds power relations: the five websites analysed, based in the Global North, did very few reports on impacts in the Global South. While "Global North" and "Global South" may be confused as purely geographical terms, the division is much more complex and based on socio-economic and political characteristics. In conclusion, depictions of causes are almost absent and abstract while solutions tend to be localised—even if they are framed more in terms of adaptation rather than mitigation.

GLOBAL DYNAMICS ↓

DECONTEXTUALISED IMPACTS ↓

LOCALISED IMPACTS ↓

TIME

Generally speaking, vivid representations of concrete impacts deal with the present time: they regard something that just happened. The reports analysed in protocol 1 overturn this rule: being supposedly set in the future, they use vivid and concrete imagery from the present to depict events that—always supposedly—will happen in 2050 or 2100 *(P1 → images → network → viz 02)*. Impacts set in the future are presented as current events (in the frame of future weather reports), until the illusion is broken and they are reframed as scenarios connected to our ability to tackle the issue—in perfect accordance with the WMO intentions. Technical representations and 3d scenarios are the main tools for contextualising the imagery in the future time *(P1 → images → network → viz 01)*. They build the bridge from present to future on the basis of trends and rational analysis. Pairing charts with pictures of extreme weather generates communications in which the risks can be both understood and felt. However, reframing present impacts as happening in the future can imply an undervaluation of the actual dangers of business-as-usual policies on emissions.

The case studies of protocol 2 rely much more on technical and scientific representations in portraying the future *(P2 → images → network → viz 01)*. While this kind of framing takes advantage of the authoritative perception of science, it often produces abstract and vague scenarios that feel far for the audience. Extreme weather is instead usually communicated in connection with the present time. While causes can only be pictured in the present, solutions are often framed in the future through the depiction of sustainable utopias and scenarios. This strategy can become dangerous if the audience is given the idea that future times will bring unforeseen technological solutions and we shouldn't deal with the issue now.

Articles in protocol 3 focus almost entirely on present (or even past) impacts, with only a couple references to the future in vague terms *(P3 → texts → tag clouds → viz 03)*. Charts and maps are extremely rare while most of the imagery is made of pictures of extreme weather *(P3 → images → network → viz 01)*.

PROTOCOL 1: FUTURE MEETS PRESENT ↓

3D FUTURE SCENARIOS ↓

UNCERTAINTY

Uncertainty is part of the climate change representations identified in the case studies—in protocols 1 and 2 more than in protocol 3 *(texts → tag clouds → viz 04)*. However, it is mostly addressed as part of the scientific discourse instead of ignorance. Uncertainty is also often connected to future scenarios in terms of agency: partially, the impacts which humanity will face depend on its ability to tackle the issue. There is an image type that emerges in protocol 2 which can be identified as the perfect expression of this concept *(P2 → images → network → viz 01)*: *half and half images*. While rare in the case studies considered, other researches found them to be quite relevant in Google Images' representation of the climate crisis (Pearce et al., 2022). Half and half images are characterised by a layout which breaks the single picture in a left part and a right part: one half is characterised as a dystopian scenario based on destruction and devastations, while the other is shown as a utopian scenario based on flourishing and greenery. Their exact implications are yet to be determined: while the left part might be connected with the present and the right with the future, the fact that the images are often mirrored *(P2 → images → network → viz 02)* seems to suggest that both scenarios represented are possible futures which depend on our actions. However, agency is invisible in the images themselves, since human figures are never represented.

HALF AND HALF IMAGES ↓

LOSS AND GAIN

Representations across the three protocols favour loss framing over gain framing: by centering on present impacts and future risks, they leverage interest through fear of undesirable consequences. In general, it is much harder to define goals as advantages to reach than consequences to avoid when dealing with the climate crisis. Threats are pictured both in relation to material well-being (properties endangered and food security) and to health (even if extreme consequences such as death are more implied than explicitly represented). One of the most striking threat-centred representation types is that of *cataclysmic images*—generally quite rare through the analysed case studies, and found mainly in protocol 2 *(P2 → images → network → viz 01)*. They are characterised by very iconic monuments or pieces of architecture isolated in an environment unrecognisable because of the climate impacts it faced: for example, the coliseum surrounded by sand dunes or the statue of liberty emerging from the ocean. Humanity is usually absent in those pictures, presumably gone extinct *(P2 → images → network → viz 02)*. One of the first images of this kind to be produced represented the Cologne Cathedral in the city flooded by the river Rhine, and was featured on *Der Spiegel*'s cover in August 1986. By recurring to well-known icons, the symbolic meaning is obvious: climate change can cause the fall of the nations, and subsequently, the civilization and culture each one represents (Grittmann, 2014). Finally, gain-framing only happens through rare depictions of green utopias, which also appear often dehumanised and are perceived as quite far from the audience *(images → network → viz 01)*. While loss framing is usually more effective than gain framing in producing concrete responses, cataclysmic imaginaries tend to undermine the role of individual and communal agency and generate a sense of fate and powerlessness which discourages engagement.

HOPE ↓

CATACLYSMIC IMAGES ↓

SCIENTIFIC AND SOCIAL

The climate crisis is an issue born and defined in the scientific realm. Consequently, across the case studies analysed it is mostly pictured with data-based representations. References to metrics, values, scientific studies and institutions *(texts → tag clouds → viz 03)* are paired with diagrams, especially maps *(images → network → viz 01)*: the territory is translated as a surface on which different phenomena and measures can be superimposed. Often maps are used to show impacts on wide areas, to the point of covering the whole world. Depictions of Earth as a globe are quite frequent: they relate to the idea of the planet as a finite entity, which deals with feelings of detachment, fragility and greatness at the same time (Schneider, 2016). Scientific representations convey accuracy and are mostly perceived as authoritative and trustworthy, to the point that they can be perceived as direct expressions of reality even if they are the product of complex processes and deliberate choices. This shift also happens because charts and maps often hide their own construction processes: that's the case, for example, with satellite imagery (for more on the topic: Fehlinger, 2020b). However, when not linked to social-framed narrations linked to the concrete experience, the technical depictions risk to feel abstract. The connection and balance between the two framings was handled in different ways across the case studies analysed.

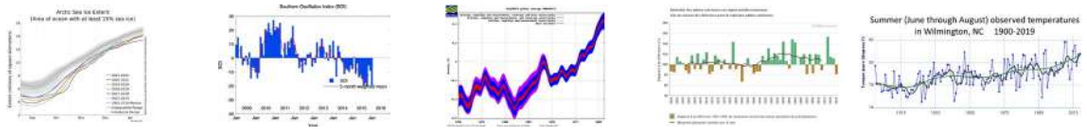
In protocol 1, the data-based representations dominate—even if links with concrete narrations are sometimes provided. Charts and (especially) maps rule screentime-wise *(P1 → images → frame grids → viz 02)*, and the analytical framing is also strengthened by the constant presence of a presenter explaining and describing what is shown (providing an unambiguous perspective for interpretation). Interestingly, maps are also sometimes used as backgrounds, without any functional purpose other than reaffirming the scientific framing based on control through technical aesthetics *(P1 → images → network → viz 02)*.

Protocol 2 is equally characterised by the prevalence of scientific representations, at times in connection with concrete depictions. Diagrams make up almost half of the total images *(P2 → images → network → viz 01)*. Maps are the most frequent pictures in the groups, and almost half of them appear in the shape of globes. There are many other types of diagrams: tables, slides and pages from pdf files, as well as different charts. Some specific visualisations appear in various almost identical copies: they are iconic charts such as the "burning worlds" map (a planisphere visualising increase in temperature through red hues) and the "climate stripes" (long-term temperature trends visualised through blue to red vertical stripes). The former, especially, produces emotional reactions despite its technicality: it connects to culturally and socially rooted iconographies, in particular in regards to the usage of the red colour (Schneider, 2016). The dichotomy data-stories is also reflected in the types of the climate change pages identified *(P2 → urls → climate change pages → viz 01)*: some are more prone to frame the issue from a social perspective (news tag, features) while others tend to frame it more from a scientific perspective, either for an expert public (research, data, blog tag) or for a wider audience (glossary, educational). The latter are more in variety but less populated than the former, but put all together the number of individual pages in the two main areas (scientific and social) is actually pretty close. There are also climate change pages that tend to bring together both framings in a structure where they can reinforce each other: section pages. They are present in 11 websites and are generally extremely easy to access: most of them can be opened straight from the homepage through the navbar with one or two interactions *(P2 → urls → paths → viz 01)*.

Protocol 3 presents the opposite trend: the social perspective is the favoured one, and only rarely it is connected to the wider picture with scientific representations. The images contain very few diagrams, mostly in the form of maps *(P3 → images → network → viz 01)*. Interestingly, each website has a quite distinctive graphic style for maps and charts. Most images are documentary photographic pictures. They not only have the potential to foster identification and engagement, but also imply a "truth claim": they represent reality. Through images of that kind, impacts themselves can't be denied anymore. What can be denied and challenged in absence of scientific representations, however, is the link of concrete experiences with the global phenomenon (the climate crisis) and its causes.

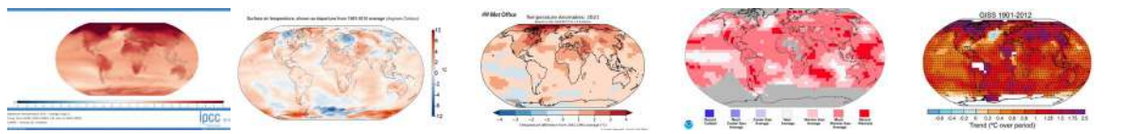
CHARTS AS BACKGROUNDS ↓

LINE AND BAR CHARTS ↓

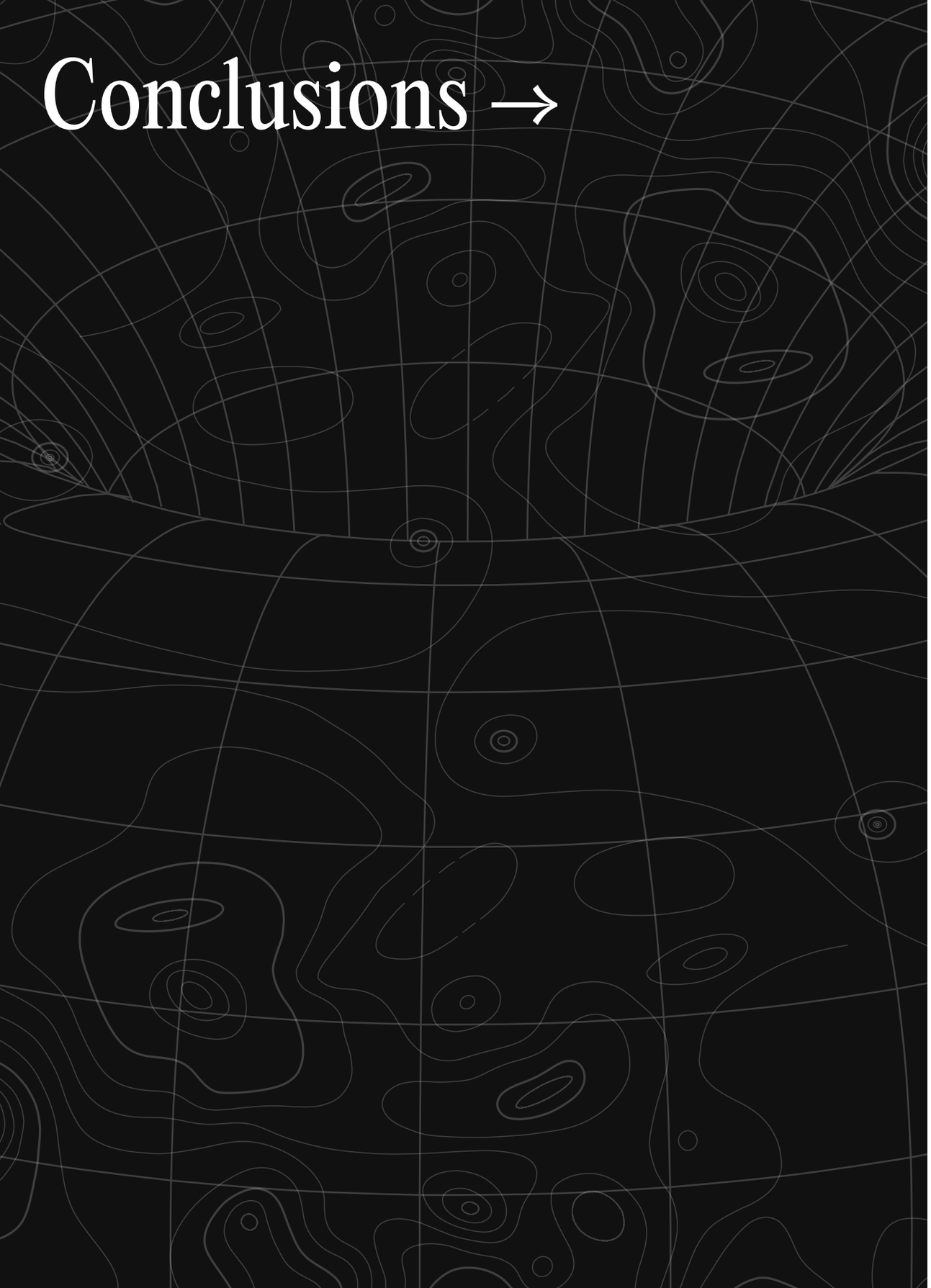


CLIMATE STRIPES ↓

BURNING WORLDS ↓



BLUE MARBLE ↓



Conclusions →

The analysis of the climate change representations in the online weather forecasts' landscape highlighted significant communicative trends and patterns, either general (cross-protocol) or specific to a contextual environment (protocol-specific). The first relevant finding is that most weather platforms do talk about climate change. However, not all of them are providing coverage of the issue on a constant basis, and even fewer appear to have a strategic thinking when producing and sharing its representations. Inconstancy and abscence of structure are often paired with superficiality and imbalance.

In general, the communications analysed had rarely the potential to empower the audience and foster action. Many platforms succeeded in framing extreme weather events as links between the climate crisis and localised concrete experiences. At the same time, they often failed in highlighting responsibilities and directions for reaction. Climate change is mostly represented as an impersonal issue, tangible in its impacts but dehumanised and out of scale in regards to its causes and its handling. Very few representations challenged the deep roots of the anthropocene worldview, and the perception of urgency was in general not paired with that of agency. Without that component, their potential to push individuals and communities into being part and engine of a proper climate emergency management is strongly limited.

REFERENCES

Adorno, T. W., & Horkheimer, M. (2010). *Dialettica dell'illuminismo*. Einaudi.

Altheide, D. L. (2019). Media Culture and the Politics of Fear. *Cultural Studies ↔ Critical Methodologies, 19*(1), 3-4. https://doi.org/10.1177/1532708616655749

Anderson, A. (2011). Sources, media, and modes of climate change communication: the role of celebrities. *WIREs Climate Change, 2*, 535-546. https://doi.org/10.1002/wcc.119

Baer, K., & Vacarra, J. (2008). *Information Design Workbook: Graphic Approaches, Solutions, and Inspiration + 30 Case Studies*. Rockport.

Bauman, Z. (2007). *Liquid times: living in an age of uncertainty*. Wiley.

Beck, U. (1992). *Risk society: Towards a new modernity*. Sage Publications.

Beehler, B. (2019, August 16). *Opinion | Why doom and gloom won't help us fight climate change*. The Washington Post. Retrieved July 8, 2023, from https://www.washingtonpost.com/opinions/why-doom-and-gloom-wont-help-us-fight-climate-change/2019/08/16/0d-0bf0fa-b880-11e9-a091-6a96e-67d9cce_story.html

Bernays, E. L. (1928). *Propaganda*. Horace Liveright.

Bertolotti, M., & Catellani, P. (2014). Effects of message framing in policy communication on climate change. E*uropean Journal of Social Psychology, 44*(5), 474-486. https://doi.org/10.1002/ejsp.2033

Borie, M., Mahony, M., Obermeister, N., & Hulme, M. (2021). Knowing like a global expert organization: Comparative insights from the IPCC and IPBES. *Global Environmental Change, 68*(102261). https://doi.org/10.1016/j.gloenvcha.2021.102261

Boyd, D. (2012, March 10). *The Power of Fear in Networked Publics*. SXSW. https://www.danah.org/papers/talks/2012/SXSW2012.html

Boyd, D., & McBride, K. (2013). The Destabilizing Force of Fear. In T. Rosenstiel & K. McBride (Eds.), *The New Ethics of Journalism: Principles for the 21st Century* (pp. 177-188). SAGE Publications.

Brossard, D., Shanahan, J., & McComas, K. (2004). Are Issue-Cycles Culturally Constructed? A Comparison of French and American Coverage of Global Climate Change. *Mass Communication and Society, 7*(3), 359-377. https://doi.org/10.1207/s15327825mcs0703_6

Cairo, A. (2019). *How Charts Lie: Getting Smarter about Visual Information*. WW Norton.

Carr, N. (2010). *The Shallows: What The Internet Is Doing To Our Brains*. WW Norton.

Carrada, G. (2006). *Communicating Science: "a Scientist's Survival Kit*. Office for Official Publications of the European Communities.

Castald, M., Venturini, T., Frasca, P., & Gargiulo, F. (2021). Junk news bubbles modelling the rise and fall of attention in online arenas. *new media & society, 24*(9), 2027-2045. https://doi.org/10.1177/1461444820978 64

Cattaneo, A., Macrini, L., Zheng, C., Puca, L., Moreschi, N., Sghirinzetti, S., & Hu, Y. (2022). *Artificial Climate Images - Questioning Stable Diffusion's interpretations of climate change*. Density Design. https://densitydesign.github.io/teaching-dd18/reports/report_group06.pdf

Center for Research on Environmental Decisions & ecoAmerica. (2014). *Connecting on Climate: A Guide to Effective Climate Change Communication*. https://ecoamerica.org/wp-content/uploads/2014/12/ecoAmerica-CRED-2014-Connecting-on-Climate.pdf

Chapman, D. A., Corner, A., Webster, R., & Markowitz, E. M. (2016). Climate visuals: A mixed methods investigation of public perceptions of climate images in three countries. *Global Environmental Change, 41*, 172-182. https://doi.org/10.1016/j.gloenvcha.2016.10.003

Christ, K., Colombo, G., De Gaetano, C., Hanteng, Heinicker, P., Jing, Z., Kienbaum, J., Kollányi, B., Li, M., Lussana, M., Ojala, M., Omena, J. J., Ozgen-Tuncer, A., Pearce, W., Pilipets, E., Rani, N., Rohden, F., Schneider, B., Theoulakis, E., … Zhao, Z. (2019, August 29). *Climate image spaces and the new climate movements*. Digital Methods Initiative. Retrieved July 2, 2023, from https://wiki.digitalmethods.net/Dmi/ClimateImageSpaces

Clark, W. C., Mitchell, R. B., & Cash, D. W. (2006). Evaluating the Influence of Global Environmental Assessments. *Global Environmental Assessments: Information and Influence*, 307-338.

Climate Central. (2017, July 4). *Global Shifting Cities*. Climate Central. Retrieved July 8, 2023, from https://www.climatecentral.org/climate-matters/global-shifting-cities

Cohen, S. (2011). *Folk Devils and Moral Panics*. Taylor & Francis.

Corner, A. (2015, July 6). *12 tools for communicating climate change more effectively | Guardian sustainable business*. The Guardian. Retrieved July 6, 2023, from https://www.theguardian.com/sustainable-business/2015/jul/06/12-tools-for-communicating-climate-change-more-effectively

Corner, A. (2016). *Climate Visuals. Towards a new visual language for climate change: An evidence-based Briefing for COP22 and beyond*. Climate Outreach. https://climateoutreach.org/reports/climate-visuals-briefing-for-cop22/

Corner, A., & Groves, C. (2014). Breaking the climate change communication deadlock. *Nature Climate Change, 4*, 743-745. https://doi.org/10.1038/nclimate2348

Corner, A., Lewandowsky, S., Phillips, M., & Roberts, O. (2015). *The Uncertainty Handbook*. University of Bristol. https://climateoutreach.org/reports/uncertainty-handbook/

Corner, A., Shaw, C., & Clarke, J. (2018). *Principles for effective communication and public engagement on climate change: A Handbook for IPCC authors*. Climate Outreach. https://climateoutreach.org/reports/ipcc-communications-handbook/

Corner, A., Webster, R., & Teriete, C. (2015). *Climate Visuals: Seven principles for visual climate change communication (based on international social research)*. Oxford: Climate Outreach. https://climateoutreach.org/reports/climate-visuals-seven-principles-for-visual-climate-change-communication/

Critcher, C. (2011). For a political economy of moral panics. *Crime Media Culture, 7*(3), 259-275. https://doi.org/10.1177/1741659011417605

Damasio, A. R. (1998). *Descartes' error : emotion, reason, and the human brain*. HarperCollins.

Dittrich, K., Parnow, J., Thomet, F., Müller, B., Herseni, J., Zeissing, N., & Morini, F. (2020, June 3). *SENSES - Visualization and Communication of Climate Change Scenarios*. Urban Complexity Lab. Retrieved July 3, 2023, from https://uclab.fh-potsdam.de/projects/senses/

Doric, A., Moreschi, J., Valentini, L., Repetto, M., Paggi, M., Altamura, S., & Li, W. (2022). *Sustainability communication in the days of fast food chains' websites*. Density Design. https://densitydesign.github.io/teaching-dd18/reports/report_group02.pdf

Doyle, J. (2014). Picturing the Clima(c)tic: Greenpeace and the Representational Politics of Climate Change Communication. In B. Schneider & T. Nocke (Eds.), *Image Politics of Climate Change: Visualizations, Imaginations, Documentations* (pp. 225-247). Transcript. https://doi.org/10.1080/09505430701368938

Dupar, M. K. (2019). *Communicating Climate Change: A Practitioner's Guide*. Climate and Development Knowledge Network.

European Commission, Directorate-General for Research and Innovation & Carrada, G. (2006). *Communicating science : a scientist's survival kit*. Publications Office.

Fehlinger, S. (2020a). Material and Visual Revolutions. Post-production Tools for Change. *Diseña, 16*, 124-147. https://doi.org/10.7764/disena.16.124-147

Fehlinger, S. (2020b). *Teasing New Weather TV: Post-producing Global Views*. Cité du design. Retrieved July 1, 2023, from https://www.citedudesign.com/en/a/teasing-new-weather-tv-post-producing-global-views-2039

Fehlinger, S. (2020c). *De la fiction météo à une réalité trans-corporelle des climats*. Medium. Retrieved July 1, 2023, from https://medium.com/anthropocene2050/de-la-fiction-m%C3%A9t%C3%A9o-%C3%A0-une-r%C3%A9alit%C3%A9-trans-corporelle-des-climats-cc8e2fee8ff2

Finn, E. (2018). *Che cosa vogliono gli algoritmi?* (D. A. Gewurz, Trans.). EINAUDI.

Fleming, J. R. (2014). Picturing Climate Control: Visualizing the Unimaginable. In B. Schneider & T. Nocke (Eds.), I*mage Politics of Climate Change: Visualizations, Imaginations, Documentations* (pp. 345-361). Transcript. https://doi.org/10.1515/transcript.9783839426104.345

Ford, S., Jenkins, H., & Green, J. (2013). *Spreadable media: I media tra condivisione, circolazione, partecipazione*. Maggioli.

Furedi, F. (1997). *Culture of fear: risk-taking and the morality of low expectation*. Cassell.

Gao, Y., Li, Y., Lin, R., Li, M., Sun, L., Gestri Spapperi, L., & Zhong, Y. (2022). *How do climate images circulate online*. Density Design. https://densitydesign.github.io/teaching-dd18/reports/report_group01.pdf

Giddens, A. (1991). *The Consequences of Modernity*. Polity Press.

Glassner, B. (2018). *The Culture of Fear: Why Americans Are Afraid of the Wrong Things*. Basic Books.

Goffman, E. (1986). *Frame Analysis: An Essay on the Organization of Experience*. Northeastern University Press.

Grevsmühl, S. V. (2014). The Creation of Global Imaginaries: The Antarctic Ozone Hole and the Isoline Tradition in the Atmospheric Sciences. In B. Schneider & T. Nocke (Eds.), I*mage Politics of Climate Change: Visualizations, Imaginations, Documentations* (pp. 29-53). Transcript. https://doi.org/10.1515/transcript.9783839426104.29

Grittmann, E. (2014). Between Risk, Beauty and the Sublime: The Visualization of Climate Change in Media Coverage during COP 15 in Copenhagen 2009. In B. Schneider & T. Nocke (Eds.), *Image Politics of Climate Change: Visualizations, Imaginations, Documentations* (pp. 127-151). Transcript. https://doi.org/10.1515/transcript.9783839426104.127

Harold, J., Lorenzoni, I., Coventry, K. R., & Minns, A. (2017). *Enhancing the accessibility of climate change data visuals: Recommendations to the IPCC and guidance for researchers*. Tyndall Centre for Climate Change Research. https://tyndall.ac.uk/wp-content/uploads/2021/09/Data_Visuals_Guidance_Full_Report_0.pdf

Hartmann, J., Eschenbacher, A., Morini, F., & Dörk, M. (2022, December 2). *Klimakarten - UCLAB – FH Potsdam*. Urban Complexity Lab. Retrieved July 3, 2023, from https://uclab.fh-potsdam.de/projects/klimakarten/

Heijmans, A. (2001). *'Vulnerability': A Matter of Perception*. Benfield Greig Hazard Research Centre - University College of London. https://www.ucl.ac.uk/hazard-centre/sites/hazard_centre/files/wp4.pdf

Heine, U. (2014). How Photography Matters: On Producing Meaning in Photobooks on Climate Change. In B. Schneider & T. Nocke (Eds.), *Image Politics of Climate Change: Visualizations, Imaginations, Documentations* (pp. 273-298). Transcript. https://doi.org/10.1515/transcript.9783839426104.273

Herman, E. S., & Chomsky, N. (2010). *Manufacturing Consent: The Political Economy of the Mass Media*. Random House.

Higgs, R. (2006). The Foundation of Every Government's Power. *The Independent Review, 10*(3), 447-466. https://www.jstor.org/stable/24562342

Kahan, D. (2012). Why we are poles apart on climate change. *Nature, 488*, 255. https://doi.org/10.1038/488255a

Kalmus, P. (2021, November 4). *Climate depression is real. And it is spreading fast among our youth | Peter Kalmus*. The Guardian. Retrieved July 5, 2023, from https://www.theguardian.com/commentisfree/2021/nov/04/climate-depression-youth-crisis-world-leaders

Kitchin, R. (2014). *The Data Revolution: Big Data, Open Data, Data Infrastructures and Their Consequences*. SAGE Publications.

Koteyko, N., Nerlich, B., & Hellsten, L. (2015). Climate Change Communication and the Internet: Challenges and Opportunities for Research. *Environmental Communication, 9*(2), 149-152. https://doi.org/10.1080/17524032.2015.1029297

Leahy, S. (2019, November 5). *Most countries aren't hitting Paris climate goals, and everyone will pay the price*. National Geographic. Retrieved July 6, 2023, from https://www.nationalgeographic.com/science/article/nations-miss-paris-targets-climate-driven-weather-events-cost-billions

Levine, A. S., & Kline, R. (2017). A new approach for evaluating climate change communication. *Climatic Change, 142*, 301-309. https://doi.org/10.1007/s10584-017-1952-x

Mahony, M., & Hulme, M. (2014). The Color of Risk: Expert Judgment and Diagrammatic Reasoning in the IPCC's 'Burning Embers'. In B. Schneider & T. Nocke (Eds.), *Image Politics of Climate Change: Visualizations, Imaginations, Documentations* (pp. 105-124). Transcript. https://doi.org/10.1515/transcript.9783839426104.105

Mann, M. E. (2021). *The New Climate War: The Fight to Take Back Our Planet*. PublicAffairs.

Manovich, L. (2001). *The Language of New Media*. MIT Press.

Manovich, L. (2011). What is visualisation? *Visual studies, 26*(1), 36-49. https://doi.org/10.1080/1472586x.2011.548488

Manovich, L. (2013). *Software Takes Command*. Bloomsbury Publishing.

Manzo, K. (2010, June 17). Beyond polar bears? Re-envisioning climate change. *Meteorological Applications, 17*(2), 196-208. https://doi.org/10.1002/met.193

Masco, J. (2010, February). Bad Weather: On Planetary Crisis. *Social Studies of Science, 40*(1), 7-40. https://doi.org/10.1177/0306312709341598

Matsaganis, M. D., & Payne, J. G. (2005). Agenda Setting in a Culture of Fear: The Lasting Effects of September 11 on American Politics and Journalism. *American Behavioral Scientist, 49*(3), 379-392. https://doi.org/10.1177/0002764205282049

Mayer, A., & Smith, E. K. (2019). Unstoppable climate change? The influence of fatalistic beliefs about climate change on behavioural change and willingness to pay cross-nationally. *Climate Policy, 19*(4), 511-523. https://doi.org/10.1080/14693062.2018.1532872

McCarthy, A. (2023, January 12). *Exxon scientists predicted global warming with 'shocking skill and accuracy,' Harvard researchers say*. Harvard Gazette. Retrieved July 4, 2023, from https://news.harvard.edu/gazette/story/2023/01/harvard-led-analysis-finds-exxonmobil-internal-research-accurately-predicted-climate-change/

McLuhan, M. (2013). *Understanding Media: The Extensions of Man*. Gingko Press, Incorporated.

McQuail, D. (2010). *McQuail's Mass Communication Theory*. SAGE Publications.

Mijksenaar, P. (1997). *Visual Function: An Introduction to Information Design*. 010 Publishers.

Montgomery, D. (2021, April 12). *Climate news is relentlessly, objectively grim. Should we ever allow ourselves to feel optimism?* The Washington Post. Retrieved July 3, 2023, from https://www.washingtonpost.com/magazine/2021/04/12/climate-news-is-relentlessly-objectively-grim-should-we-ever-allow-ourselves-feel-optimism/

Morris, E., & Sayler, S. (2014). The Pensive Photograph as Agent: What Can Non-Illustrative Images Do to Galvanize Public Support for Climate Change Action? In B. Schneider & T. Nocke (Eds.), *Image Politics of Climate Change: Visualizations, Imaginations, Documentations* (pp. 299-322). Transcript. https://doi.org/10.14361/transcript.9783839426104.299

Moser, S. C. (2010). Communicating climate change: history, challenges, process and future directions. *WIREs Climate Change, 1*(1), 31-53. https://doi.org/10.1002/wcc.11

Nerlich, B., Koteyko, N., & Brown, B. (2010). Theory and language of climate change communication. *WIREs Climate Change, 1*, 97-100. https://doi.org/10.1002/wcc.2

Nisbet, M. C. (2009). Communicating Climate Change: Why Frames Matter for Public Engagement. *Environment: Science and Policy for Sustainable Development, 51*(2), 12-23. https://doi.org/10.3200/ENVT.51.2.12-23

Nocke, T. (2014). Images for Data Analysis: The Role of Visualization in Climate Research. In B. Schneider & T. Nocke (Eds.), *Image Politics of Climate Change: Visualizations, Imaginations, Documentations* (pp. 55-77). Transcript. https://doi.org/10.1515/transcript.9783839426104.55

O'Neill, S. J., & Hulme, M. (2009). An iconic approach for representing climate change. *Global Environmental Change, 19*(4), 402-410. https://doi.org/10.1016/j.gloenvcha.2009.07.004

1,001 *Blistering Future Summers*. (n.d.). Climate Central. Retrieved July 6, 2023, from https://legacy.climatecentral.org/wgts/CityFutureTemps/index.html

O'Reilly, T. (2005, September 30). *What Is Web 2.0*. O'Reilly. Retrieved July 8, 2023, from https://www.oreilly.com/pub/a/web2/archive/what-is-web-20.html

Otto, F., & van Oldenborgh, G. J. (n.d.). *World Weather Attribution initiative*. World Weather Attribution. Retrieved July 5, 2023, from https://www.worldweatherattribution.org/about/

Packard, V. (2007). *The Hidden Persuaders*. Ig Publishing.

Parak, G. (2014). Picturing the State of the Nation's Environment: Early Aerial Photography in the United States from the 1930s to the late 1960s. In B. Schneider & T. Nocke (Eds.), *Image Politics of Climate Change: Visualizations, Imaginations, Documentations* (pp. 325-344). Transcript. https://doi.org/10.1515/transcript.9783839426104.325

Pearce, W., & De Gaetano, C. (2021). Google Images, Climate Change, and the Disappearance of Humans. *Diseña, 19*.

Pearce, W., Pilipets, E., Borie, M., Bruschi, L., Chen, A., Dell'Orto, D., Hanchard, M., Quets, A., & Xu, Z. (2022, August 1). *According to Google Images: Visual epistemologies of climate change and biodiversity loss*. Digital Methods Initiative. Retrieved July 2, 2023, from https://wiki.digitalmethods.net/Dmi/AccordingToGoogleImages

Pelletier, P. (2021). *Clima, capitalismo verde e catastrofismo* (C. Milani, Trans.). Elèuthera.

Peters, G.-J. Y., Ruiter, R. A. C., & Kok, G. (2013). Threatening communication: a critical re-analysis and a revised meta-analytic test of fear appeal theory. *Health Psychology Review, 7*(1), S8-S31. https://doi.org/10.1080/17437199.2012.703527

Peters, H. P. (2012). *Science journalism as a governance mechanism in medialized societies: a conceptual model of society-level effects of PCST*. Pcsr International Conference. https://www.semanticscholar.org/paper/38.-Science-journalism-as-a-governance-mechanism-in-Peters/d780302b91346f39dacdf9c0716bacf976bbd4d8

Peters, H. P. (2013, August 12). Gap between science and media revisited: Scientists as public communicators. *PNAS, 110*(Supplement 3), 14102-14109. https://doi.org/10.1073/pnas.1212745110

Philip, S., Kew, S., van Oldenborgh, G. J., Otto, F., Vautard, R., van der Wiel, K., King, A., Lott, F., Arrighi, J., Singh, R., & van Aalst, M. (2020). A protocol for probabilistic extreme event attribution analyses. *Adv. Stat. Clim. Meteorol. Oceanogr., 6*, 177-203. https://doi.org/10.5194/ascmo-6-177-2020

Pousman, Z., Stasko, J. T., & Mateas, M. (2007, November 5). Casual Information Visualization: Depictions of Data in Everyday Life. *IEEE Transactions on Visualization and Computer Graphics, 13*(6), 1145 - 1152. https://doi.org/10.1109/TVCG.2007.70541

Purvis, K. (2015, May 5). *15 ways to powerfully communicate climate change solutions | Working in development*. The Guardian. Retrieved July 7, 2023, from https://www.theguardian.com/global-development-professionals-network/2015/may/05/15-ways-to-powerfully-communicate-climate-change-solutions

Randall, T., & Migliozzi, B. (2018, January 18). *Earth's Relentless Warming Sets a Brutal New Record in 2017*. Bloomberg. Retrieved July 5, 2023, from https://www.bloomberg.com/graphics/hottest-year-on-record/

Reports — IPCC. (n.d.). IPCC. Retrieved July 1, 2023, from https://www.ipcc.ch/reports/

Rogers, R. (2009). *The End of the Virtual: Digital Methods*. Amsterdam University Press.

Rogers, R. (2019). *Doing Digital Methods*. SAGE Publications.

Sander, L., Hartmann, J., Eschenbacher, A., Morini, F., Strothmann, L., Jean, B., Malkowski, J., Dörk, M., & Hamm, R. (2022, December 2). *taz-Datenprojekt zum Klimaschutz: Heiße Grüße aus Deutschland*. Taz. Retrieved July 4, 2023, from https://taz.de/taz-Datenprojekt-zum-Klimaschutz/!5898240/

Schäfer, M. S. (2012). Online communication on climate change and climate politics: a literature review. *WIREs Climate Change, 3*, 527-543. https://doi.org/10.1002/wcc.191

Schneider, B. (2016). Burning worlds of cartography: a critical approach to climate cosmograms of the Anthropocene. *Geo: Geography and Environment, 3*(2). https://doi.org/10.1002/geo2.27

Schneider, B., Heidmann, F., Nocke, T., Kienbaum, J., & Heinicker, P. (2019). *Klimabilder - ANCI viewer*. ANCI viewer. Retrieved July 6, 2023, from https://vikusviewer.fh-potsdam.de/anci/klimabilder/

Schneider, B., & Nocke, T. (Eds.). (2014). *Image Politics of Climate Change: Visualizations, Imaginations, Documentations*. transcript Verlag.

Schneider, B., Nocke, T., & Feulner, G. (2014). Twist and Shout: Images and Graphs in Skeptical Climate Media. In B. Schneider & T. Nocke (Eds.), *Image Politics of Climate Change: Visualizations, Imaginations, Documentations* (pp. 153-186). Transcript. https://doi.org/10.1515/transcript.9783839426104.153

Schrickel, I. (2014). Images of Feasibility: On the Viscourse of Climate Engineering. In B. Schneider & T. Nocke (Eds.), *Image Politics of Climate Change: Visualizations, Imaginations, Documentations* (pp. 363-382). Transcript. https://doi.org/10.1515/transcript.9783839426104.363

Serani, D. (2008, January). If It Bleeds, It Leads: The Clinical Implications of Fear-Based Programming in News Media. *Psychoanalysis and Psychotherapy, 24*(4), 240-250. http://dx.doi.org/10.3200/PSYC.24.4.240-250

Shaw, C., Corner, A., & Clarke, J. (2017). *Climate Visuals. Towards a new visual language for COP22 and beyond. Supplementary report: A comparison of images from COP21 and COP22*. Climate Outreach. https://climateoutreach.org/reports/climate-visuals-briefing-for-cop22/

Shaw, E. F. (1979). Agenda-Setting and Mass Communication Theory. *International Communication Gazette, 25*(2), 96-105. https://doi.org/10.1177/001654927902500203

Similarweb. (n.d.). *Top Websites Ranking - Most Visited Websites in February 2023*. Similarweb. Retrieved February 11, 2023, from https://www.similarweb.com/top-websites/

Simmons, H. A., Deutsch, K. W., Shubik, M., & Daddario, E. Q. (1971). Designing organizations for an information rich world. In M. Greenberger (Ed.), *Computers, Communications, and the Public Interest* (pp. 37-72). Johns Hopkins Press.

Smith, N., & Joffe, H. (2013). How the public engages with global warming: A social representations approach. *Public Understanding of Science, 22*(1), 16-32. https://doi.org/10.1177/0963662512440913

Smith, T. (2020, October 7). *Getty Images partners with Climate Visuals to launch guidelines helping brands and businesses use visuals which incite change - Climate Outreach*. Climate Visuals. Retrieved July 2, 2023, from https://climatevisuals.org/getty-images-partners-with-climate-visuals-to-launch-guidelines-helping-brands-and-businesses-use-visuals-which-incite-change/

Statista. (n.d.). *Weather - Worldwide*. Statista. Retrieved July 8, 2023, from https://www.statista.com/outlook/dmo/app/weather/worldwide#revenue

Steffen, A. (2021, May 18). *We're not yet ready for what's already happened*. The Snap Forward. Retrieved July 4, 2023, from https://alexsteffen.substack.com/p/were-not-yet-ready-for-whats-already

Stern, N., & Great Britain Treasury. (2006). *The Economics of Climate Change: The Stern Review*. Cambridge University Press.

Tollmann, V. (2014). The Uncanny Polar Bear: Activists Visually Attack an Overly Emotionalized Image Clone. In B. Schneider & T. Nocke (Eds.), *Image Politics of Climate Change: Visualizations, Imaginations, Documentations* (pp. 249-272). Transcript. https://doi.org/10.1515/transcript.9783839426104.249

Tudor, A. (2003). A (macro) sociology of fear? *The Sociological Review, 51*(2), 238–256. https://doi.org/10.1111/1467-954X.00417

Tufte, E. R. (1995). *Envisioning information*. Graphics Press.

Tufte, E. R. (1997). *Visual Explanations: Images and Quantities, Evidence and Narrative*. Graphics Press.

Tufte, E. R. (2001). *The visual display of quantitative information* (2nd ed.). Graphics Press.

United Nations Department of Global Communications. (n.d.). *Communicating on Climate Change | United Nations*. the United Nations. Retrieved July 6, 2023, from https://www.un.org/en/climatechange/communicating-climate-change

Vaish, A., Grossmann, T., & Woodward, A. (2008). Not All Emotions Are Created Equal: The Negativity Bias in Social–Emotional Development. *Psychological Bulletin, 134*(3), 383-403. https://doi.org/10.1037/0033-2909.134.3.383

van der Linden, S., Mailbach, E., & Leiserowitz, A. (2015). Improving Public Engagement With Climate Change: Five "Best Practice" Insights From Psychological Science. *Perspectives on Psychological Science, 10*(6), 758-763. https://doi.org/10.1177/1745691615598516

van Oldenborgh, G. J., van der Wiel, K., Kew, S., Philip, S., Otto, F., Vautard, R., King, A., Lott, F., Arrighi, J., Singh, R., & van Aalst, M. (2021). Pathways and pitfalls in extreme event attribution. *Climatic Change, 166*, 13. https://doi.org/10.1007/s10584-021-03071-7

Venturini, T. (2019). From Fake to Junk News, the Data Politics of Online Virality. In E. F. Isin, E. Ruppert, & D. Bigo (Eds.), *Data Politics: Worlds, Subjects, Rights*. Routledge.

Volkholz, J., & Thomet, F. (2020, December 9). *Extreme Events*. Senses Toolkit. Retrieved July 1, 2023, from https://climatescenarios.org/extreme-events/

Walsh, L. (2014). "Tricks," Hockey Sticks, and the Myth of Natural lnscription: How the Visual Rhetoric of Climategate Conflated Climate with Character. In B. Schneider & T. Nocke (Eds.), *Image Politics of Climate Change: Visualizations, Imaginations, Documentations* (pp. 81-104). Transcript. https://api.semanticscholar.org/CorpusID:193312527

Wang, S., Corner, A., Chapman, D. A., & Markowitz, E. M. (2018). Public engagement with climate imagery in a changing digital landscape. *WIREs Climate Change, 9*. https://doi.org/10.1002/wcc.509

Wardekker, A., & Lorenz, S. (2019). The visual framing of climate change impacts and adaptation in the IPCC assessment reports. *Climatic Change, 156*, 273-292. https://doi.org/10.1007/s10584-019-02522-6

Weart, S. (2023, May). *The Discovery of Global Warming - A History*. The Discovery of Global Warming - A History. Retrieved July 6, 2023, from https://history.aip.org/climate/index.htm

Wendler, D. (2022, September 22). *In the climate crisis, vulnerable countries bear the least responsibility*. Datawrapper Blog. Retrieved July 8, 2023, from https://blog.datawrapper.de/climate-risk-readiness-responsibility/

World Meteorological Organization. (2014, September 5). *Weather Reports for the Future | World Meteorological Organization*. World Meteorological Organization |. Retrieved July 5, 2023, from https://public.wmo.int/en/media/news/weather-reports-future

World Meteorological Organization. (2017, July 11). *Weather reports about climate change | World Meteorological Organization*. World Meteorological Organization |. Retrieved July 8, 2023, from https://public.wmo.int/en/resources/weather-reports-from-future

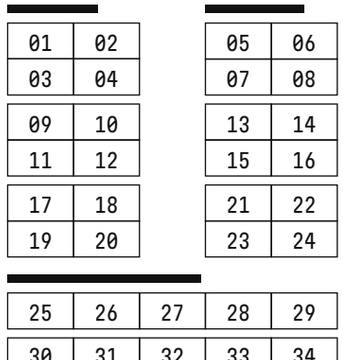
World Wide Web Foundation. (n.d.). *History of the Web*. World Wide Web Foundation. Retrieved July 7, 2023, from https://webfoundation.org/about/vision/history-of-the-web/

Wrobel, M., & Reusser, D. (2014). Towards an Interactive Visual Understanding of Climate Change Findings on the Net: Promises and Challenges. In B. Schneider & T. Nocke (Eds.), *Image Politics of Climate Change: Visualizations, Imaginations, Documentations* (pp. 187-210). Transcript. https://doi.org/10.1515/transcript.9783839426104.187

LIST OF FIGURES

IMAGES FROM CASE STUDIES

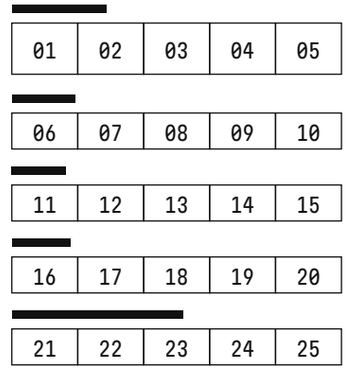
NATURE — Page 67



Protocols and sources

01	P2 - *weather.com*
02	P2 - *ilmeteo.it*
03	P2 - *eltiempo.es*
04	P2 - *theweathernetwork.com*
05	P2 - *gismeteo.ru*
06	P2 - *gismeteo.ru*
07	P2 - *ilmeteo.it*
08	P2 - *tiempo.com*
09–16	P3 - *weather.com*
17	P2 - *meteored.com.ar*
18	P2 - *metoffice.gov.uk*
19	P2 - *weather.com*
20	P2 - *wunderground.com*
21	P2 - *bom.gov.au*
22	P2 - *meteored.cl*
23	P2 - *meteored.com.ar*
24	P2 - *eltiempo.es*
25	P2 - *meteored.cl*
26	P2 - *metoffice.gov.uk*
27	P2 - *theweathernetwork.com*
28	P2 - *wetter.de*
29	P2 - *wetter.de*
30–39	P3 - *weather.com*

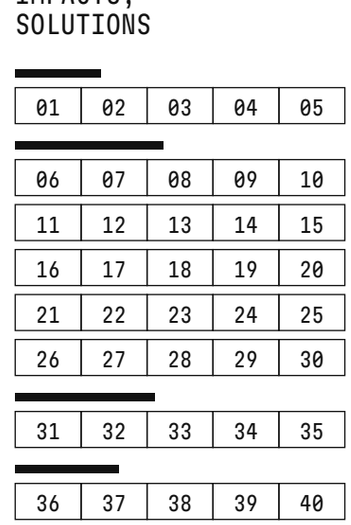
PEOPLE — Page 69



Protocols and sources

01	P2 - *eltiempo.es*
02	P2 - *theweathernetwork.com*
03	P2 - *tiempo.com*
04	P2 - *meteored.com.ar*
05	P2 - *weather.com.cn*
06–10	P3 - *weather.com*
11	P2 - *eltiempo.es*
12	P2 - *eltiempo.es*
13	P2 - *eltiempo.es*
14	P2 - *weather.com*
15	P2 - *wetter.de*
16	P2 - *wunderground.com*
17	P2 - *weather.com*
18	P2 - accuweather.com
19	P2 - *weather.com*
20	P2 - *wetter.de*
21	P1 - *CA_COP20*
22	P1 - *FR_COP20*
23	P1 - *IE_COP21*
24	P1 - *RU_COP21*
25	P1 - *MG_UNWC*

CAUSES, IMPACTS, SOLUTIONS — Page 71



Protocols and sources

01	P1 - *BG_CS14*
02	P2 - *buienradar.nl*
03	P2 - *eltiempo.es*
04	P2 - *eltiempo.es*
05	P2 - *wetter.de*
06–10	P3 - *weather.com*
11	P3 - *eltiempo.es*
12	P3 - *tiempo.com*
13	P3 - *weather.com*
14	P2 - *wetter.com*
15	P2 - *wetter.com*
16	P2 - *eltiempo.es*
17	P2 - *meteored.com.ar*
18	P2 - *theweathernetwork.com*
19	P2 - *meteored.cl*
20	P2 - *noaa.gov*
21	P2 - *meteored.com.ar*
22	P2 - *tiempo.com*
23	P2 - *weather.com*
24	P2 - *wetter.com*
25	P2 - *wetter.de*
26	P2 - *accuweather.com*

→

27 P2 - *eltiempo.es*
28 P2 - *eltiempo.es*
29 P2 - *tiempo.com*
30 P2 - *wetteronline.de*
31 P2 - *3bmeteo.com*
32 P2 - *accuweather.com*
33 P2 - *bom.gov.au*
34 P2 - *eltiempo.es*
35 P2 - *eltiempo.es*
36 P2 - *eltiempo.es*
37 P2 - *meteored.com.ar*
38 P2 - *metoffice.gov.uk*
39 P2 - *meteored.cl*
40 P2 - *meteored.com.ar*

STEREOTYPES Page 73

01	02	03	04	05
06	07	08	09	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30

Protocols and sources

01 P2 - *accuweather.com*
02 P1 - *BG_CS14*
03 P2 - *gismeteo.ru*
04 P2 - *theweathernetwork.com*
05 P2 - *weather.com*
06 P2 - *meteored.cl*
07 P2 - *wetteronline.de*
08 P2 - *tiempo.com*
09 P3 - *tiempo.com*
10 P2 - *meteored.cl*
11 P2 - *meteored.com.ar*
12 P2 - *theweathernetwork.com*
13 P2 - *tiempo.com*
14 P2 - *tiempo.com*
15 P2 - *weeronline.nl*
16 P2 - *foreca.fi*
17 P2 - *meteored.com.ar*
18 P2 - *noaa.gov*
19 P2 - *wetter.de*
20 P2 - *theweathernetwork.com*
21 P2 - *meteored.cl*
22 P2 - *gismeteo.ru*
23 P1 - *AR_COP21*
24 P2 - *eltiempo.es*
25 P2 - *meteored.cl*
26 P2 - *eltiempo.es*
27 P2 - *tiempo.com*
28 P2 - *tiempo.com*
29 P2 - *accuweather.com*
30 P2 - *wetter.de*

SPACE Page 74

01	02
03	04

05	06
07	08

09	10
11	12

Protocols and sources

01 P2 - *accuweather.com*
02 P2 - *buienradar.nl*
03 P2 - *eltiempo.es*
04 P2 - *eltiempo.es*
05 P2 - *eltiempo.es*
06 P2 - *tiempo.com*
07 P2 - *wetter.de*
08 P2 - *wetter.de*
09 P3 - *weather.com*
10 P3 - *weather.com*
11 P3 - *weather.com*
12 P3 - *weather.com*

TIME Page 75

01

02	03
04	05
06	07

Protocols and sources

01 P1 - *IS_CS14*
02 P1 - *BE_CS14*
03 P1 - *FR_17100*
04 P1 - *JP_COP21a*
05 P1 - *JP_CS14*
06 P1 - *US_COP20*
07 P1 - *US_CS14a*

UNCERTAINTY Page 76

01	02	03	04
05	06	07	08

Protocols and sources

01 P2 - *wetter.com*
02 P2 - *ilmeteo.it*
03 P2 - *gismeteo.ru*
04 P2 - *meteored.com.ar*
05 P2 - *tiempo.com*
06 P2 - *ilmeteo.it*
07 P2 - *tiempo.com*
08 P2 - *meteored.cl*

LOSS AND GAIN Page 77

01	02
03	04
05	06

07	08
09	10
11	12

Protocols and sources

01 P2 - *meteored.com.ar*
02 P2 - *meteored.cl*
03 P2 - *meteored.com.ar*
04 P2 - *meteored.cl*
05 P2 - *meteored.cl*
06 P2 - *eltiempo.es*
07 P2 - *meteored.com.ar*
08 P2 - *eltiempo.es*
09 P2 - *tiempo.com*
10 P2 - *meteored.cl*
11 P2 - *meteogiornale.it*
12 P2 - *meteored.cl*

UNCERTAINTY Page 79

Protocols and sources

01 P1 - *AE_COP21*
02 P1 - *DE_17100b*
03 P1 - *JP_COP21b*
04 P1 - *RU_COP21*
05 P1 - *US_COP21a*
06 P2 - *3bmeteo.com*
07 P2 - *bom.gov.au*
08 P2 - *metoffice.gov.uk*
09 P2 - *tiempo.com*
10 P2 - *weather.com*
11 P2 - *meteored.cl*
12 P2 - *theweathernetwork.com*
13 P2 - *theweathernetwork.com*
14 P2 - *wetter.de*
15 P2 - *wunderground.com*
16 P2 - *eltiempo.es*
17 P2 - *weather.com*
18 P2 - *metoffice.gov.uk*
19 P2 - *wunderground.com*
20 P2 - *meteored.com.ar*
21 P2 - *accuweather.com*
22 P2 - *bom.gov.au*
23 P2 - *meteored.com.ar*
24 P2 - *sinoptik.bg*
25 P2 - *noaa.gov*

MASTER THESIS

Politecnico di Milano - School of Design
Master of Science in Communication Design
a.y. 2022 / 2023

SUPERVISOR

Matteo Ciastellardi

CO-SUPERVISOR

Richard Rogers

STUDENT

Daniele Dell'Orto