A physical concept in the press: the case of the Jet Stream

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Abstract. In recent years, science has hardened the discourse on the emergency of global warming, pointing out that the next decades will be decisive to maintain the stability of the climate system, avoiding a cascade effect of events that increase the average temperature above safe limits. The scientific community warns that there are different tipping points that could produce a chain reaction in the global climate. One of them is related to the Jet Stream. But despite the importance of this air current in atmospheric dynamics in the Northern Hemisphere and the changes it is experiencing in the context of global warming, the public is still not familiar with this kind of physical concepts, nor with much simpler others. As concerns about the climate crisis rise, climate literacy remains stagnant. To advance the learning of the science of climate change, in general, and of concepts such as the Jet Stream, in particular, specific scientific communication formats are required that can successfully tackle the difficult task of explaining such complex problems to the general public. These formats should be included in the media because they are the main source for information on climate change and because their characteristics (daily section, scientific dissemination, historic perspective, teleconnections, and specialization) allow taking on the challenge of explaining the complexity of climate science. In this article we present a communication proposal existent in a newspaper published in Spain. We argue that this communication format represents a good model to disseminate climate science, educate readers and even to make physical concepts such as the Jet Stream accessible. We believe that this format conforms to and complies with the enunciation of Article 12 of the Paris Agreement, which calls on the signatory countries to promote education and training on climate change.

1 Introduction

In the last five years, the science discourse on climate change has become more catastrophic. During this time, the scientific community has published several articles highlighting the urgency of the current situation (National Academy of Science, 2020), while pointing out that the progressive increase of greenhouse gases may trigger a domino effect in the global climate system that would make it unstable. The consequence would be a raising of the Earth's average temperature beyond the limits established by the Paris Agreement, which aims to prevent the increase in the average global temperature of the planet from exceeding 2ºC compared with pre-industrial levels (National Academy of Science, 2020, Intergovernmental Panel on Climate Change, 2022). The 'Hothouse Earth' hypothesis, which establishes that if warming continues at the current rate it could produce a cascade of events that could increase the global average temperature above 3 degrees, appears to be a possible future as a result of a feedback process that would give rise to a previously unknown climate situation in human history (Steffen et al., 2018) (Fonseca, 2020c). Since then, concepts such as 'point of no return' and 'tipping point' have been increasingly used. So much so that the Secretary-General of the United Nations, António Guterres, assured during the COP25 held in Madrid in 2019 that 'the point of no return is no longer over the horizon. It is in sight and hurtling toward us' (UN News, 2019). Guterres added in Cop26 in Glasgow 'we are digging our own grave' (UN News, 2021) The supporters of this theory say that climate triggers a domino effect so that, when one of the tiles collapses, it may end up knocking down the others. These individual pieces may refer to unique ecosystems, such as the Amazon and the coral reefs, or to global climate regulation mechanisms, such as the thermohaline circulation (Caesar., et al., 2021) and the Jet Stream, a high speed wind current in the upper troposphere that follows the separation between cold polar air from warm subtropical air in both hemispheres. Knowing these physical concepts is vital to understanding how the global climate system works and the threat that climate change poses.

Despite the climate urgency and the exponential increase of scientific evidence about its origin, behaviour and impact, we can still observe a severe lack of climate education in the general public (Allianz Research, 2021). A possible explanation for this deficit is that the climate change message is not being correctly transmitted by the media, which are the main source of public opinion information. As a result, the recipient –the general public– is unable to embrace it, which is a big problem because knowing the science and the impacts of climate change is the key to understanding how serious it is. (NOAA, 2009)

The problem resides in how this issue has been historically tackled: most of the time from a social, environmental, sociological, political and economic approach, although meagerly focusing on scientific dissemination (Wihbey, 2016). The world seems to have understood that human activity produces global warming gases and that such actions have serious implications on biodiversity and economy. However, this just appears to be a shallow understanding, and, in fact, people remain unaware of how the greenhouse effect works or how each one extra degree impacts the average temperature. In a nutshell, humanity faces a problem yet to be understood by a majority, with the risk and difficulties this entails.

This article begins with a diagnosis of the lack of climate education among the specific public, illustrated with the results of a survey on the knowledge about climate change among university students in Galicia (Spain). This population group is very interesting because they are young, educated people who use several sources of information and who belong to one of the generations that will suffer the most from the consequences of the increase in global temperature.The obtained data supports our main goal for the second part of this article: to design efficient communication tools that allow the public to assimilate a series of ideas and basic concepts about the science of climate change, as it is requested by the Article 12 of the Paris Agreement (United Nations, 2015). We present a dissemination section called *Historias del Tiempo* (Weather Stories) that appears daily on the most widely read Galician newspaper (*La Voz de Galicia*), which has unique key characteristics aimed at improving scientific culture through media. Weather stories are published every day in the newspaper La Voz de Galicia on the page that contains meteorological and maritime information. The format focuses on

informing the public about the weather in Galicia and explaining from a scientific point of view the meteorological events that affect the community, but also topics related to the history of the climate and climate change. The journalist from La Voz de Galicia Xavier Fonseca is the creator and main contributor of this format and works with the Nonlinear Physics Group at the Physics Faculty of the University of Santiago de Compostela, universities and research centers in Galicia, Spain and the rest of the world to produce information every day. This communication format has specific characteristics that make it possible to face the challenge of communicating the science of climate change to a non-specialist audience. These characteristics are daily section, scientific dissemination, historic perspective, teleconnections, and specialization. Our hypothesis is that it can be used as a model to bridge the existing gap between an increasing awareness of climate issues and the apparently stagnant knowledge on these natural phenomena. We illustrate our analysis with a particular example: how this communication format has brought up the dissemination of the *Jet Stream.*

2 The role of climate literacy

The effect that a wider knowledge about climate science may provoke on an individual is widely debated within the academic literature and has both supporters and detractors (Emily L. Howell, 2021). The US National Oceanic and Atmospheric Administration published a manual on climate science knowledge in 2009 (Global Change Research Program, 2009). The document mentions that 'a person who knows how to assess scientifically credible information about climate may communicate their knowledge in a significant way and is able to take informed and responsible decisions regarding actions that may affect climate'. In 2017, the Earth Day theme topic was *Environmental and Climate Literacy* (UN News, 2017). The UN campaign recognized that 'environmental and climate literacy is the engine not only for green growth and advancing environmental and climate laws and policies, but also for accelerating green technologies and jobs'. Both NOAA and the United Nations –two major entities in terms of climate– recognize the transformational role of scientific literacy.

We believe that, following the provisions backed by NOAA and the United Nations, the scientific literacy process is vital for boosting ambitious policies that guarantee the climate system's stability and,

therefore, for preventing a cascade effect of events that make the average temperature rise above the safety limits (NOAA, 2009). However, there are also doubts and skepticism by a part of the academic community about the learning process being a game changer. In this sense, we believe that scientific literacy has been more thoroughly analyzed within the educational sphere from a formal point of view and not within an 'informal' education context, such as that provided by the media. In this sense, some conclusions are that the audience's awareness increases after watching one of those audiovisual pieces, such as The Day after Tomorrow (2005), An Inconvenient Truth (2006) or The Age of Stupid (2009); however, the effect vanishes soon (Sakellari, 2014). Education through reading a daily section of a newspaper as we propose here, resembles more the conventional method of study in scholar environments and may have a different impact, with a longer lasting imprint.

Current discussions on the effect of scientific literacy highlight the need to design an educational strategy supported by 'a social experience' (Gaudiano and Meira, 2009) (Cooper, Caren, 2011) (Tomáš Miléř,Petr Sládek, 2011). Building on this idea, we argue that the scientific communication format presented in this article is actually inspired in an 'educational experience' created after a constant process of knowledge acquisition in which the reader learns about meteorology and can put the learning into practice and compare the information with reality, such as for example by checking against the weather forecast. In this sense, the characteristics of the dissemination format described and analyzed in this article can be considered rather unique and different from any other example taken from Spanish or international media. It would be a model designed to educate, rather than to raise awareness.

3 A new language for a different climate: the role of the media

The signing of the Paris Agreement in December 2015 was a milestone in the fight against climate change. The document includes measures tackling the problem from every angle, such as mitigation and adaptation. It states that the 'Parties shall cooperate in taking measures, as appropriate, to enhance climate change education, training, public awareness, public participation and public access to information, recognizing the importance of these steps with respect to enhancing actions under this Agreement' (CMNUCC, 2015).

Since the endorsement of the Agreement, governments, universities and scientific institutions from all over the world –also the United Nations– have increasingly used the terms 'crisis' or 'climate emergency' to refer to global warming (Ripple et al., 2020). This terminology supports the idea that humanity is facing a crucial period and that the document signed in Paris is the roadmap to be followed in order to keep the planet's average temperature increase below two degrees. The IPCC's Special Report Global Warming of 1.5 °C summary released in 2018 mentions that the years to come are probably the 'most important years in history' (IPCC, 2018.)

The use of this terminology has also expanded due to the 'Greta Thunberg Effect'. In her interventions, the Swedish activist uses terms such as 'crisis' and 'emergency' (Ballew et al. 2021). In her speech at COP24 in Katowice, she warned that 'we cannot solve a crisis without treating it as a crisis'. During the Davos Forum, Thunberg also said that the IPCC's estimations 'do not include most feedback loops or non-linear tipping points' that might urge for the need to take more pressing measures (World Economic Forum, 2020).

This change of terminology seems to be aimed at raising the general public's awareness about the causes and effects of the problem; however, it does not entail an increase in climate literacy. Most of the population lacks a sufficient scientific culture to understand the experts when they use expressions such as 'tipping point', which strictly refers to a physical process (T. M. Lenton et al., 2019). Besides, they are not familiar with another basic idea having an impact on global warming: the greenhouse effect (Cassia et al., 2018). A recent investigation states that even climate pundits are unable to understand the urgency and severity imposed by the environmental crisis threat (Bradshaw et al., 2021).

There is a notorious history of media adaptation to the new ways of disseminating this environmental problem. Some newspapers, such as The Guardian, have reacted to the warning issued by the scientific community and have decided to modify their style guide regarding the news about the effects of the average temperature rise (Damian Carrington, 2019). The terms 'climate change' and 'global warming' have been replaced by new terms such as 'climate crisis'.

Mass media also have a double leading role within the current climate emergency context (Maxwell T. Boykoff and J. Timmons Roberts, 2007), as main information and education source. For these different

reasons, we contend that, in order to study the general impact of the climate literacy process, it is vital to take into account the role of the media, which has not been always considered (Rosales López, 2009). Indeed, in order to send a message of urgency, the press is the most efficient medium. This fact has been ascertained during the Covid-19 pandemic. Mass media were considered one of the essential activities, since information is deemed to have the power to save lives. However, journalism faces today a confidence-wise crises (Rodrigo-Alsina, M. & Cerqueira, L., 2019). Credibility is being threatened in post-truth times, a concept understood as the circumstances in which 'objective facts have less influence on opinions and decisions than personal emotions and beliefs' (Wihbey and Ward 2016). A study conducted in Spain on the dissemination of information during the Covid-19 pandemic revealed that most of the fake news were spread through social media and WhatsApp (89.1 %), whereas that figure was of 4 % in press media (Salaverría et al., 2020).

4 Methodology

In order to assess the scarce scientific information available to the public on climate change as well as the importance of mass media, we will use the data gathered in a survey on climate change knowledge carried out in Galicia, a region located in the northwest of the Iberian Peninsula. The average annual temperature there increased by 0.20 degrees per decade between 1961 and 2015. Between 1951 and 2017 there were nine episodes of drought. The absence of rain has a very important impact on this Spanish region because its economy and way of life depend on rainfall, which is usually very reliable. It is also the region of the entire Iberian Peninsula with the most kilometers of coastline and this makes it especially vulnerable to rising sea levels (Xunta de Galicia, 2015).

The quantitative study was conducted during the 2018-2019 academic year in the three universities based in Galicia: University of Vigo (UVigo), University of Santiago de Compostela (USC) and University of A Coruña (UDC). The participants in the survey were 600 students from different years and from both science and humanities fields: Journalism, Sociology, Biology, Political Science, Mathematics, Industrial Engineering, Aeronautical Engineering, Economics and Law. For the statistical analysis, we used the Wilcoxon test and the Kruskal-Wallis test, to identify the factors that have a significant influence on their knowledge on climate change.

We then analyse the content of a model to improve society's scientific culture through media. This is a scientific communication format called *Historias del Tiempo* (a pun in Spanish, mixing the terms Time and Weather as well as Stories and Histories) published in *La Voz de Galicia*, the third most read newspaper in Spain (data from the Media Dissemination Office) since September 2018, both in press and web formats. The project started in 2011 as a daily audiovisual content broadcast on *V Televisión* (*La Voz de Galicia*'s TV channel), which ended its broadcasting in 2018, when such content was transferred to the newspaper. This format has been going on for a decade and has had the purpose of disseminating weather, climate and climate change issues from a scientific point of view. Today, this section is integrated into the daily section about weather and maritime information.

5 Results

Growing concerns but little climate literacy

Public concern about climate change is gathering momentum, not only in Spain but elsewhere too. In the United States, it has tripled between 2014 and 2019 (Goldberg 2020 et al). In Europe, the 2019 Eurobarometer shows that 93 % of the European population think it is a severe issue and 79 % think it is critical (European Union, 2019). This trend also applies to the analysed population of Galician university students. When asked **'How worried are you regarding the rise in global temperature?'** more than 70 % assure that 'quite a lot' or 'a lot'. Nevertheless, the growing concern does not correspond at all with the general knowledge about the issue. Another of the proposed questions was **'What degree of knowledge do you think you have about the origin and the effects of the current rise in global temperature described by the scientific community?'** 43 % answered 'little' and 38 % replied 'a lot'.

It seems obvious that something is not working properly. At this point, it is necessary to resort to mass media, since they are the main channel to access climate-related contents. The survey suggests this too. Regarding the question **'What source do you mainly use to be informed about the planet's rise in global temperature?'**, almost 54 % answered written and digital press and 26 % said television. In the same vein, when students were asked **'From which of the following people did you obtain information about the rise of Earth's temperature for the last time?'** the majority of the surveyed

population (42 %) answered from a journalist, almost double than from a lecturer and triple than from a scientist.

Both pieces of information indicate that mass media are the first option for the surveyed population (students in the Galician University System, SUG) to find information about climate change, thus coinciding with results from similar studies in other contexts. At the same time, the analysed population shows a worrying lack of knowledge about certain basic concepts. For example, more than 40 % of the surveyed individuals believe that the greenhouse effect is a consequence of human activity and not a natural mechanism that allows for life on Earth to exist.

6 How to build a climate change dissemination social experience: the Weather Stories model

After having introduced a plain case of climate illiteracy, we now delve into communication formats that raise social awareness about climate change science. The starting point is that climate literacy is very limited. We note from the results of our survey that there exists a lack of knowledge about the meaning of basic concepts such as the 'greenhouse effect', which suggests that modern emerging concepts such as 'tipping point' are also widely unfamiliar to the general public.

Our hypothesis is that if a model gathers certain characteristics (daily section, scientific dissemination, historic perspective and specialization), it is possible to tackle the dissemination of a highly complex issue such as climate and build an 'experience' based on a permanent scientific learning by the user. This strategy may have a positive impact, not only in compliance with the Paris Agreement, but also for empowering the general public in the post-truth era. The following model complies with the recommendations of a dissemination manual on climate change (Corner et al., 2018).

6.1 Daily content

Daily content is fundamental for creating a communicative social experience, since it allows opportunities to always have an open space for readers to learn about aspects related to weather, climate and climate change, regardless of the newspaper's informational demands at any particular time. Besides, daily dissemination helps examine, analyse and follow up a weather event or a scientific study. In this sense, the reader is acquainted with a certain ability to contextualise climate news, articles,

reports and interviews. This constant learning is more a training than an information process when creating an 'experience' in which the reader is the main figure. The format also provides the added value derived from applying the scientific knowledge to the everyday weather reality. Thus, by learning and contrasting day after day, this format helps establish a trust relationship between the medium and the reader. Finally, the daily provision of information additionally constitutes reliability, important to build public trust.

6.2 Scientific dissemination

Weather stories has an obvious scientific dissemination purpose, especially in terms of atmospheric physics. Our goal is that readers incorporate new concepts to their weather culture and, therefore, improve their scientific literacy. Mass media usually disseminate weather information focusing on their public service role, thus reporting about weather forecast and warning about extreme events. Only when weather becomes a hot topic, due to the impact of an adverse event or the release of an academic article, media coverage intensifies.

Given the characteristics of the scientific communication format hereby mentioned, the coverage of a certain event, such as a heat wave or an intense storm, begins long before its actual impact and continues for days after it has passed, providing context and a broader knowledge. A good example is the coverage of the storm Filomena that affected Spain in January 2021 (Fonseca, 2021a). The coverage started one week before most of Spain collapsed blanketed in snow and continued days after with the explanation of the origin of this extreme cold event, introducing physical concepts such as the 'Jet Stream' to explain it, while framing it within climate change (Fonseca, 2021b).

Furthermore, given that the population has a limited level of general scientific literacy and a low level of specific climate literacy, the content is presented with a simple language supported by some graphic material that facilitates the understanding of physical concepts.

6. 3 Historic perspective

The historic approach is the format's hallmark. This helps readers to understand the relevance that climate has had in the evolution of life on Earth, and Earth itself, as well as to understand that this

influence can sometimes be unexpected. Also, the historic perspective additionally frames broader concepts in a locally relevant context for the public. Environmental psychologist Robert Gifford alleges that there exist up to seven psychological barriers that prevent the population from responding to climate change. He mentions 29 specific mental blocks, to which he refers as 'dragons of inaction'. In one of them, he explains that our brains have evolved to respond to immediate dangers, not to face a slow distant threat (Gifford, 2011). For our 'sapiens' brain to assimilate climate change, providing a historic perspective may be of great help. Climate change is not only about hurricanes in the East Coast of the United States, heat waves in Europe and droughts in Africa, it can also be linked to a war like Syria's due to the drought that occurred between 2010 and 2017 causing a mass migration of farming families to urban centers (Kelley et al., 2015) (Müller et al., 2016). In this respect, dozens of articles on the influence of climate throughout history have been published in *Weather stories*. Two examples are the consequences that the "Little Ice Age" brought to Galicia's society and economy (Fonseca, 2018) or the decisive role played by the Bhola cyclone in the creation of the State of Bangladesh (World Meteorological Organization, 2020). Looking over the past may also be a powerful ally to fight climate denial. One of the most recurring arguments of those who deny the anthropogenic origin of global warming point to the natural cycles of climate (Hobson, Simon, 2013). In this sense, history can be very useful to show how climate disruptions affected ancient societies, generated epidemics and wars and, in some cases, caused the decline of civilizations.

6. 4 The importance of *Teleconnections*

Weather stories also emphasises and tries to convey the idea that the atmosphere is the gas layer that wraps the planet and knows no boundaries; thus, the global climate system can connect different areas on Earth. An example is the El Niño phenomenon in the equatorial Pacific, which can affect many other distant regions (Barnston, 2014). It is essential to inform the public about concepts such as atmospheric teleconnection so that they develop a global climate vision, something that science deems appropriate to understand the nature of the problem of climate change (UNESCO, 2020). One common feature of these daily publications is a review of atmospheric phenomena that occur thousands of kilometres away and an effort to connect them to a specific region like Galicia (Fonseca, 2019a).

6. 5 Specialisation

Different regional, national and international institutions, specialising in meteorology, climatology and climate change, collaborate in this daily section. In fact, the person responsible for this communication project carries out his doctoral studies at the Department of Nonlinear Physics in the University of Santiago de Compostela. This innovative collaboration between physicists and scientific journalists working together in the same research group makes it possible for the section's content to have all warranties of a thorough information and to respond to a demand by the scientific community, which requires more specialised communicators and a higher prominence in public areas to debate about the environmental issue (Besley and Nisbet 2013, Belenguer, 2003). Besides, it is also a good example of multidisciplinary science, since his PhD is co-directed at the Department of Sociology of the University of A Coruña in order to ensure that such communication 'experience' has a 'social' dimension.

7 A dissemination case study: the Jet Stream concept

We now illustrate the abovementioned ideas with a specific example that illustrates how this communication format addresses the scientific dissemination of a physical concept: the *Jet Stream*. The inclination of 23.5 degrees in Earth's rotation axis makes solar radiation to be intense in the equator and weak in the poles. To compensate for this energy imbalance, the planet has ocean and air currents that redistribute heat. As part of these redistributing large-scale wind circulations, cold air descending from polar regions and warm flows coming up from subtropical areas converge in mid latitudes. The *Jet Stream* circulates just where these air masses of different temperature meet, forming a high-speed air current in the upper troposphere, blowing from west to east, that encircles the entire hemisphere. There are jets in both the Northern and Southern Hemispheres. The jet stream can present large meanders, like those in rivers, or may move in a more zonal manner. In the latter case, when it follows the parallels, it usually reaches a higher speed. In the North Atlantic this zonal configuration drives a succession of extratropical cyclones towards Europe (Wallace and Hobbs, 2006).

During these years of publications, the daily format of *Weather stories* has released hundreds of articles about the Jet Stream, helping to reveal and popularise the use of this physical concept, therefore highlighting the relevance of this atmospheric current in the meteorology of the entire northern hemisphere in general and Galicia in particular. The permanent scientific dissemination about the jet stream includes a historical approach, its influence on air navigation and the changes experienced in the current global warming context. In essence, the coverage about a complex physical concept is addressed from different points of view, the model's hallmark. Below we break down some of the aspects mentioned about the Jet Stream in *Weather stories*, which can be used as an example of the dissemination strategy that was used, described in the previous section.

7.1 A current with plenty of history

The communication model that we present is aimed for the readers' scientific culture improvement and for their familiarisation with complex physical concepts, such as the Jet Stream. A good way of attaining this objective is by addressing its origin and functioning from a historical point of view. By explaining the jet stream history, we make sure that readers do not assimilate such physical concept as something abstract and unknown, but rather as a natural mechanism with its own history, which has even played a major role in certain historical events.

For example, its discovery is related to an important climatic event of the past. One of the natural mechanisms that intervenes in climate dynamics (Alan Buis, 2020) (Alan Buis, 2020) is intense volcanic eruptions, which inject sulphuric gases in the stratosphere and create an aerosol cloud that blocks sunlight, lowering temperatures and triggering a chain of events in global climate, some of them with catastrophic consequences (Jason Wolfe, 2000). Some of the most famous cataclysms in climate history are caused by a volcano. In 1883, one of the most intense examples was registered. The Krakatoa volcano erupted in Indonesia and the explosion wiped out a large area of the island. The powerful 1883 eruption, which released energy equivalent to a million atomic bombs, raised particles to the upper atmosphere and, in less than two months, a volcanic cloud had covered the whole planet. This kind of climatic events shows the tight interrelations within the global climate system and the role of teleconnections. London's Royal Society received numerous testimonies from people all over the world

describing the effects of this phenomenon at distant locations from the eruption site (Fonseca, 2018). This English scientific institution started one of the first public cooperation networks. Based on the data coming from all around the globe thanks to the telegraph, scientists suspected that something was moving the Krakatoa cloud across the planet. The depiction of the movement of that volcanic cloud produced the first map of the jet streams that circulate the Earth (Kravets, 2010). Besides, this air current played a crucial role in one of the most important historical events of the 20th century. The jet stream is a high-speed airflow situated around 8,000 metres of altitude, just below the tropopause, the boundary between the troposphere and the stratosphere. Winds go from west to east moving about the whole hemisphere at an average speed ranging between 150 and 400 kilometres per hour. The Jet Stream played a crucial role during World War II. In the 1930s, Japan was a great scientific power that kept the jet stream existence as a state secret (Rebecca Maksel, 2018). After the attack to the American naval fleet in Pearl Harbor, Japan thought it was the right moment to use the weapon of which nobody else knew. Hence, they decided to use the stream to attack the United States with balloons loaded with bombs. The goal was to start fires in the west part of the country (Xavier Fonseca, 2020a). (See figure 1)

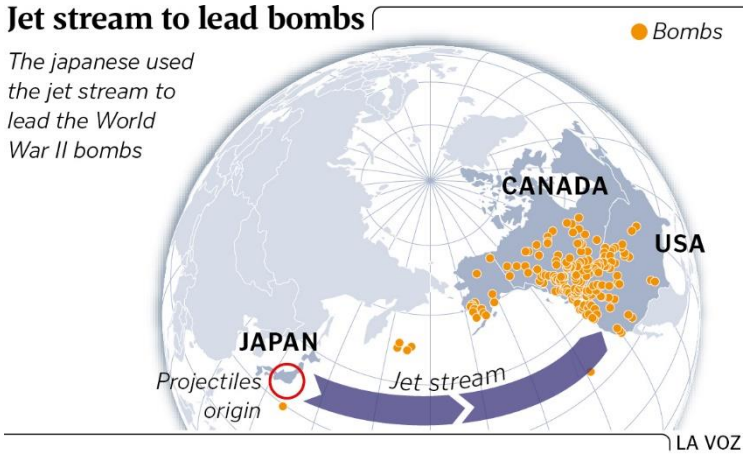

Figure 1: The graphic illustrates how Japanese planes used the jet stream to drop bombs against the United States in the context of World War II

7. 2 A highway for planes

One of the most important concepts linked to the jet stream that the reader must learn is its direction. The Jet Stream generally moves from west to east, following the general atmospheric motion in mid latitudes, describing meanders of larger of smaller amplitude. Since the North Atlantic storm track is linked to the jet stream, once readers have knowledge of the general wind direction they can better understand the impact of the Atlantic storm circulation in Galicia, where these systems produce large amounts of rainfall, turning it into one of the most humid regions in Europe. To educate the public about the direction of the jet stream, we often stress its influence on air navigation. It is known that planes use it to save time and fuel. As an example of this, we developed a story about an Emirates Airlines flight from Dallas to Dubai, one of the longest routes on Earth, in December 2019 (Fonseca, 2019c) (See figure 2). While it was going through the Atlantic Ocean, the plane descended in latitude and jumped into the jet stream to gain velocity. The aircraft reached in the Galician sky a subsonic speed of 1,234 km/h, just below the sound barrier, largely exceeding the usual figure of 800 km/h. The estimated duration of this journey is 14 hours and 44 minutes but, thanks to the power and position of the Jet Stream over Galicia, the plane could complete its route in 13 hours and 19 minutes.

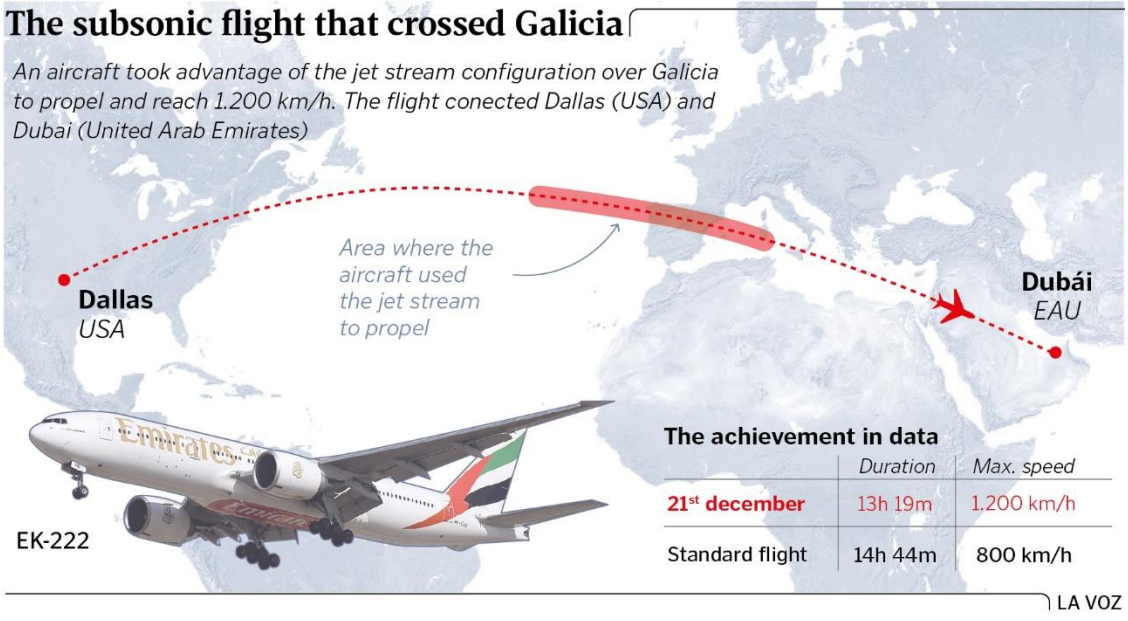

Figure 2: This graphic explains the characteristics of the Emirates company flight that on December 21, 2019 reached a speed of 1,200 kilometers per hour taking advantage of the strong winds from the jet stream.

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7. 3 The role in the northern hemisphere atmospheric dynamics

The jet stream has a decisive role in the northern hemisphere meteorology in general and in the Galician meteorology in particular due to the region's geographic location (in the northwest of the Iberian Peninsula) (Hall, et al., 2014). The different configurations of the Jet Stream can result in high and low
405 temperature situations, long periods of drought, heavy rains and winds and even favour the appearance of a tropical low-pressure system in mid latitudes. In October 2019, the interaction with the Jet Stream induced tropical cyclone Pablo to transform into a category 1 hurricane in the Northeast Atlantic, not far off the Galician coast. Meteorologists defined this event as unprecedented and they assured that it challenged normal atmosphere logic, which establishes that conditions for this type of transitions should
410 not occur as far north as Galicia.

The jet stream has an influence on many unique weather situations, which highlights its major role on meteorology. Hence, by means of these events, we can insist on the learning process, thus favouring that readers are able to become familiar with this physical concept and understand that it can affect their day to day life. For example, the jet stream's configuration may result in a summer that is wetter than
415 usual, making it impossible for people to enjoy the sun and the beach and therefore have a negative impact on the economy in the most important time of the year for the tourist sector. That is what happened in Galicia in the summer of 2019. While the rest of Spain and Europe suffered from an unprecedented heat wave, Galicia did not notice it due to the meanders generated by the Jet Stream (Fonseca, 2019) (See figure 3)

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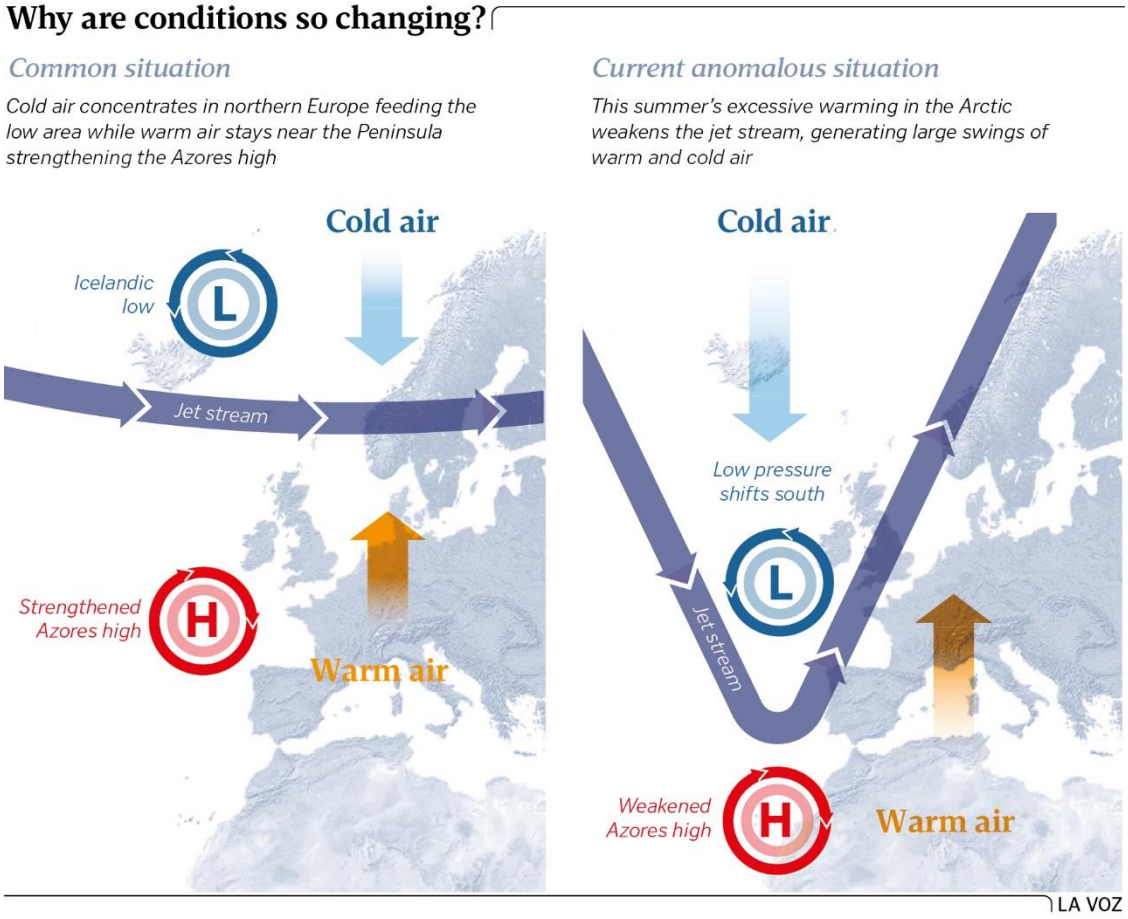

Figure 3: The graph shows the role that the jet stream configuration played during the summer of 2019. The descending region of the jet stream moved cold and maritime air that generated humid conditions in the northwestern of Spain while ascending region in the rest of the country produced high temperatures.

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7. 4 The effect of climate change

The jet stream, as is the case of other atmospheric systems, is reacting to the new climate change of anthropogenic origin. Some investigations suggest that, due to the lower thermal contrast between the equator and the poles, the Jet Stream might become unstable, describing larger amplitude meanders,
430 thus increasing the odds of extreme weather events, such as heat and cold waves (Francis and Cohen, 2017). These jet stream diversions can produce specific atmospheric situations (already mentioned) (See figures 4 and 5), such as a historic snowfall like the one produced by the Storm Filomena in

January 2021, a summer with milder temperatures than usual or the appearance of a hurricane in an unusual latitude. The emphasis of this dissemination proposal is that all of these are events linked to jet stream changes, which serve as an example of the importance that the jet stream has on the planet.

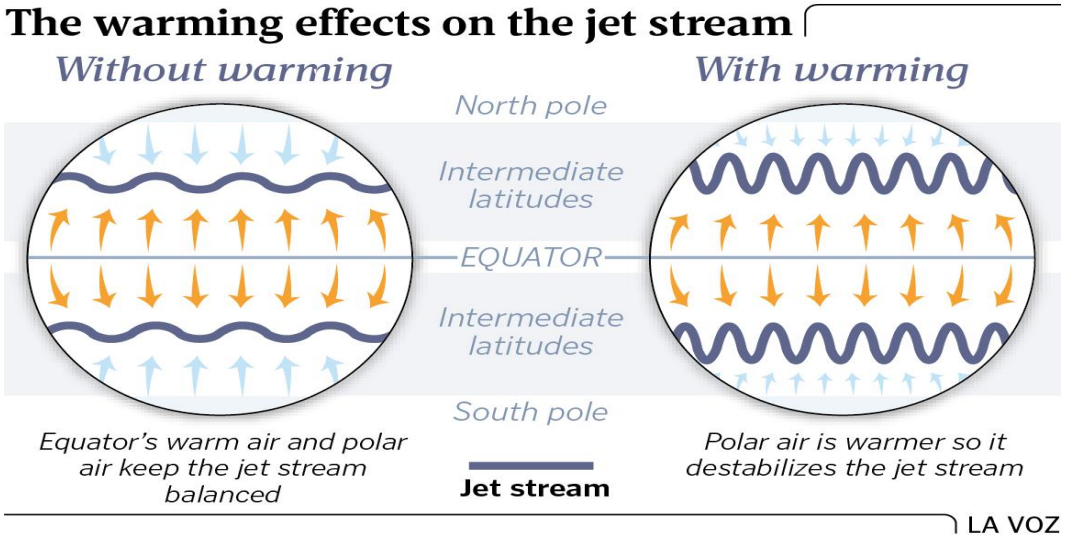

Figure 4: This graph explains how climate change is causing the jet stream to weaken in the northern hemisphere, causing it to travel from north to south and from south to north instead of moving from west to east more and more frequently, often generating situations. of extreme weather such as hot and cold waves in the mid-latitudes.

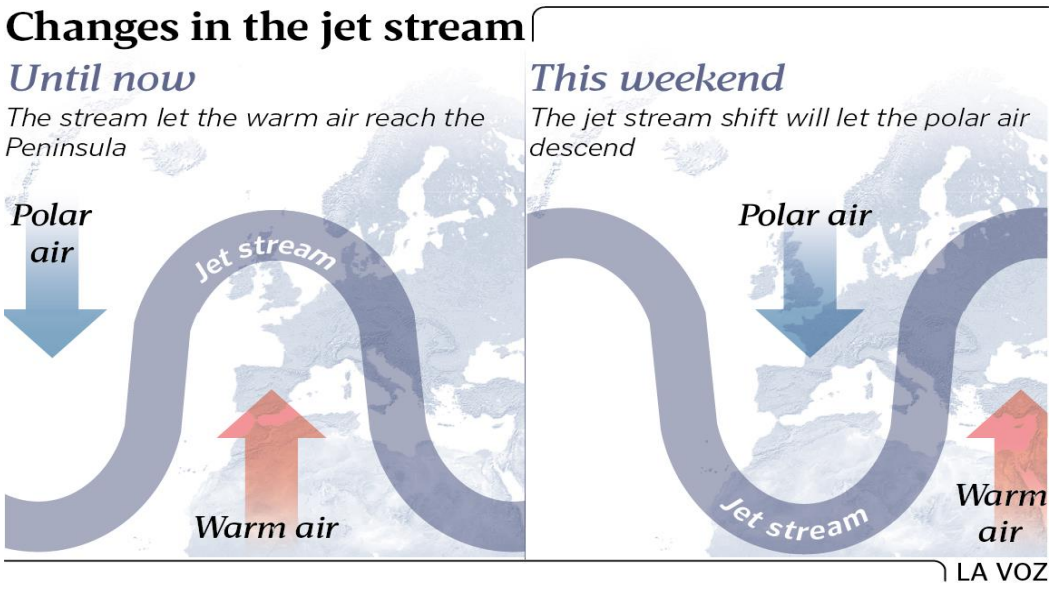

Figure 5: The image shows a practical example of the effects of jet stream weakening on a specific region of the northern hemisphere such as Spain. In addition to generating adverse conditions, the weather can change from one extreme to another in a short time depending on the movements of the jet stream. In this case, as the graph shows, in a few days the positive thermal anomalies, due to the arrival of warm air, became negative due to the irruption of polar air.

Conclusion

Our civilization faces a decisive moment to make sure the global average temperature does not exceed the limits established by the Paris Agreement in 2015, thus preventing an abrupt and irreversible climate change. In the last few years, the degree of concern and climate awareness has increased in society, as shown by different surveys all around the world, from Europe to the United States (Goldberg 2020 et al) (European Union, 2019).. Nonetheless, global warming knowledge remains stalled. The public does not even understand the most basic science concepts about climate change.

The origin of this imbalance between awareness and knowledge is partly due to the manner in which mass media deal with this issue, always reporting but never educating. The climate crisis, given its characteristics: global, slow and often invisible to the untrained eye, represents a challenge for the homo sapiens' brain ability. For that reason, communication cannot simply be based on the typical news

coverage of mass media. New instructional and educational formats are required. We need formats able to contextualise each piece of news, making the invisible become visible, connecting different areas of the world, creating a global mentality and, above all, conveying the transformational power of climate. Weather Stories format, published daily in *La Voz de Galicia* newspaper, may be a reference to achieve the goal of Article 12 of the Paris Agreement, since it generates a 'experience' based on a constant scientific learning process about climate change, by means of a series of characteristics that make it unique: daily frequency, specialisation in scientific dissemination, commitment towards a historic perspective and emphasis on teleconnections. A good example of this approach is the way in which the dissemination of a physical concept such as the Jet Stream has been addressed.

Besides, the prominence of meteorology, climate and climate change in the press does not match the severity of the problem, as reported by the scientific community, or the increasing concern in society. The press coverage depends on the latest news, high impact extreme weather events, climate summits or relevant articles in scientific journals (Quesada et al., 2015). But apart from this aspect, thoroughly investigated in the scientific literature, we must highlight that the content treatment in the press features an excessively informational but non-educational approach. Yet scientific dissemination requires analysis, depth, context and perseverance, so that the public can piece together each part of the complex puzzle that forms the Earth's climate, while understanding the role played by each piece (Belenguer, 2003). Approaching climate change from a dissemination point of view and not from an informational one is a necessary step that mass media must take in order to succeed in making the audience comprehend the nature of such an existential issue as global warming.

We would like the media in Spain and the rest of the world to adopt specific scientific communication formats such as Weather Stories in order to be able to take on the challenge of explaining climate change to a non-specialized public with guarantees. We also believe that it would be wise to try to measure the impact that Weather Stories has on the public through experimentation. Our wish for the future would be that the media would become a valuable resource for the educational system. By combining education and information, it would be possible to successfully face the challenge of understanding climate change.

Bibliography

Sabherwal, A, Ballew, MT, van der Linden, S, et al. The Greta Thunberg Effect: Familiarity with Greta Thunberg predicts intentions to engage in climate activism in the United States. *J Appl Soc Psychol*; 51: 321– 333. https://doi.org/10.1111/jasp.12737, 2021

Buis, A. Milankovitch (Orbital) Cycles and Their Role in Earth's Climate. Retrieved from NASA - Global Climate Change: https://climate.nasa.gov/news/2948/milankovitch-orbital-cyclesand-their-role-in-earths-climate/, 2020

Sabherwal, *et al.* The Greta Thunberg Effect: familiarity with Greta Thunberg predicts intentions to engage in climate activism in the United States J Appl Soc Psychol, https://doi.org/10.1111/jasp.12737, 2021

How ENSO leads to a cascade of global impacts https://www.climate.gov/news-features/blogs/enso/how-enso-leads-cascade-global-impacts, 2014

Hall R, et al., A Drivers of North Atlantic polar front jet stream variability Int. J. Climatol, https://doi.org/10.1002/joc.4121, 2014

Besley JC, Nisbet M, How scientists view the public, the media and the political process. Public Understanding of Science, https://doi.org/10.1177%2F0963662511418743 2013, 2011

Bradshaw CJA, Ehrlich PR, Beattie A, et al. Underestimating the Challenges of Avoiding a Ghastly Future. Frontiers in Conservation Science 1: 9. https://doi.org/10.3389/fcosc.2020.615419, 2021

Delicado, A., et al.,.(2021). Citizen consultations on science communication: A citizen science approach. Metode Science Studies Journal https://dx.doi.org/ 10.7203/metode.12.17510, 2021

McLoughlin, N., Corner, A., Capstick, S., Richardson, H., Bell, A., Muller, C. and Illingworth, S. Climate communication in practice: how are we engaging the UK public on climate change? Oxford: Climate Outreach, https://climateoutreach.org/reports/climate-communication-in-practice-how-are-we-engaging-uk-public/ 2018

A.Corner, C. Shaw, J. Clarke Principles for Effective Communication and Public Engagement on Climate Change: A Handbook for IPCC, Climate Outreach, Oxford, 2018

Cohen, J., Screen, J., Furtado, J. et al. Recent Arctic amplification and extreme mid-latitude weather. Nature Geosci 7, 627–637 https://doi.org/10.1038/ngeo2234, 2014

Gaudiano, Édgar and Meira, Pablo Educación, comunicación y cambio climático. Resistencias para la acción social responsable. Trayectorias 11, no. 29 :6-38.

Redalyc, https://www.redalyc.org/articulo.oa?id=60712749003, 2009

Hobson K, Niemeyer S. What sceptics believe: The effects of information and deliberation on climate change scepticism. Public Understanding of Science. 22(4):396-412. doi:10.1177/0963662511430459, 2013

Kelley CP, Mohtadi S, Cane MA, et al. Climate change in the Fertile Crescent and implications of the recent Syrian drought. Proceedings of the National Academy of Sciences 112(11): 3241. doi:10.1073/pnas.1421533112, 2015

Belenguer, M., Información y divulgación científica: dos conceptos paralelos y complementarios en el periodismo científico, Estudios sobre el mensaje periodístico, 9, pp. 43-53, 2003

Boykoff MT Roberts JT,Media coverage of climate change: current trends, strengths, weaknesses, UN Development Programme, New York, 2008

François Mü, Jim Yoon, et al., Impacts of the Syrian conflict on water resources, Proceedings of the National Academy of Sciences, 113 (52) 14932-14937; doi:10.1073/pnas.1614342113, 2016

Quesada M, Blanco, E, Teruel, Laura El cambio climático en la prensa europea discurso editorial en El País, Le Monde, The Guardian y Frankfurter Allgemeine Zeitung, 523-539, https://doi.org/10.5209/rev_ESMP.2015.v21.n1.49109, 2015

Ripple WJ, Wolf C, Newsome TM, et al. World Scientists' Warning of a Climate Emergency. *BioScience* 70(1): 8–12. DOI: 10.1093/biosci/biz088, 2020

Rodrigo-Alsina,M and Cerqueira,L. Journalism, ethics and post-truth. *Cuadernos.info*, (44), 225-239. https://dx.doi.org/10.7764/cdi.44.1418, 2019

Rosales C Aprendizaje formal e informal con medios. Pixel-Bit. Revista de Medios y Educación, 35, 21 – 32,

Sakellari M. Cinematic climate change, a promising perspective on climate change communication. Public Understanding of Science. 2015;24(7):827-841. doi:10.1177/0963662514537028, 2009

Salaverría, R; Buslón, et al., Desinformación en tiempos de pandemia: tipología de los bulos sobre la Covid-19. El profesional de la información, v. 29, n. 3, e290315. https://doi.org/10.3145/epi.2020.may.15, 2020

Steffen W, Rockström J, Richardson K, et al., Trajectories of the Earth System in the Anthropocene. Proceedings of the National Academy of Sciences 115(33): 8252. DOI: 10.1073/pnas.1810141115, 2018

Mother Earth Day: Environmental and climate literacy vital for a cleaner, https://news.un.org/en/story/2017/04/555812-mother-earth-day-environmental-and-climate-literacy-vital-cleaner-greener, 2017

Integrating action for climate empowerment into nationally determined contributions: a short guide for countries¸ https://unesdoc.unesco.org/ark:/48223/pf0000373762.locale=en, 2020

Paris Agreeement, file:///C:/Users/User/Downloads/english_paris_agreement.pdf, 2015

Wihbey,J and Ward,B Communicating About Climate Change with Journalists and Media Producers. Oxford University Press. https://doi.org/10.1093/acrefore/9780190228620.013.407, 2016

Greta Thunberg: Our house is still on fire and you're fuelling the flames. https://www.weforum.org/agenda/2020/01/greta-speech-our-house-is-still-on-fire-davos-2020/, 2020

Tomáš Miléř, Petr Sládek, The climate literacy challenge, Procedia - Social and Behavioral Sciences, https://doi.org/10.1016/j.sbspro.2011.02.021, 2011

Howell, E. L., & Brossard, D. (Mis) informed about what? What it means to be a science-literate citizen in a digital world. Proceedings of the National Academy of Sciences, 2021

Allianz Research, Climate Literacy Survey: Time to leave climate Neverland, https://www.allianz.com/content/dam/onemarketing/azcom/Allianz_com/economic-research/publications/specials/en/2021/october/2021_10_27_Climate-literacy.pdf, 2021

What is Climate Science Literacy?, NOAA, https://www.climate.gov/teaching/what-is-climate-science-literacy#:~:text=People%20who%20are%20climate%20science,caused%20factors%20that%20affect%20it, 2009

Atmospheric science: an introductory survey. Wallace JM and Hobbs PV. Academic Press, Elsevier. 2006

Fonseca, X Krakatoa: el volcán que descubrió el «Jet stream». https://www.lavozdegalicia.es/noticia/biodiversa/2018/12/26/volcan-descubrio-jet-stream/0003_201812H26P55991.htm, 2018

Fonseca, X La Edad de Hielo revolucionó Galicia. https://www.lavozdegalicia.es/noticia/galicia/2018/02/19/edad-hielo-revoluciono-galicia/0003_201802H19P39991.htm, 2018b

Fonseca, X Galicia, víctima de las teleconexiones atmosféricas https://www.lavozdegalicia.es/noticia/sociedad/2019/09/14/gilbert-walker-hombre-conecto-atmosfera/00031568471459766994463.htm, 2019a

Fonseca, X ¿Por qué el verano está siendo tan inestable en Galicia? https://www.lavozdegalicia.es/noticia/sociedad/2019/07/23/verano-siendo-inestable-galicia/00031563897366601137275.htm, 2019b

Fonseca, X Un vuelo subsónico sobre el cielo de Galicia. https://www.lavozdegalicia.es/noticia/sociedad/2019/12/23/vuelo-subsonico-sobre-cielo-galicia/00031577129876537209212.htm, 2019c

Fonseca, X Cuando el «jet stream» bombardeó a Estados Unidos. https://www.lavozdegalicia.es/noticia/sociedad/2020/04/11/jet-stream-lanzaba-bombas/00031586614170827304320.htm, 2020a

Fonseca, X Los meteorólogos gallegos: «Si el cambio climático continúa puede llegar un gran huracán». https://www.lavozdegalicia.es/noticia/sociedad/2019/10/29/meteorologos-gallegos-cambio-climatico-continuapuede-llegar-gran-huracan/00031572372389656830702.htm, 2020b

Fonseca, X «Si hacemos oídos sordos también con el cambio climático no descartamos un colapso del sistema socioeconómico global». https://www.lavozdegalicia.es/noticia/sociedad/2020/04/20/tierra-dirige-escenario-desconocido-homo-sapiens/00031587383178445884633.htm, 2020c

Fonseca, X ¿Cómo afectará a Galicia «la gran nevada»? https://www.lavozdegalicia.es/noticia/sociedad/2021/01/04/afectara-galicia-gran-nevada/00031609760401301940503.htm 2021a

Fonseca, X ¿Por qué Filomena ha sido capaz de colapsar España? https://www.lavozdegalicia.es/noticia/espana/2021/01/11/filomena-capaz-colapsar-espana/00031610368939180554603.htm, 2021b