EFI

THE LOOKOUT STATION

Connecting Journalism and Science

DRIVING SCIENTIFIC RESEARCH INTO JOURNALISTIC REPORTING ON FORESTS, ENVIRONMENT AND CLIMATE CHANGE

HANDBOOK FOR SCIENTISTS

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Foreword

Marc Palahí
Director, European Forest Institute

This century is characterised by accelerated changes and unprecedented global challenges: climate change, water, energy and food security, migration crisis and biodiversity loss among others. These challenges are in one way or another related to the defining issue of our time: how to decouple economic growth from social and environmental degradation.

In a globalised and interconnected world, decision-making increasingly requires a good understanding of diverse aspects in very complex settings. Many of the issues tend to be cross-sectoral, cross-disciplinary, and global. A good example is climate change.

In this rapidly evolving and complex environment the role of science becomes more important than ever. Not only to foster innovation but to ensure the knowledge base for wise and effective policies, business decisions and citizens' participation in the hyper-connected democracies of the 21st century.

In this respect, we are facing a paradox. Never before in human history have there been so many scientists and so much scientific knowledge available. We have the means to understand many of the challenges we are facing, yet we need to admit that post truth politics as well as contradictory media and science messages are also abound.

Therefore, science needs to partner with media to have impact and together put emphasis on the synthesis and contextualisation of information, bringing together scientists and media experts from different disciplines and building appropriate national to international science-policy interfaces. In addition, the right fora, timing, and formats are of crucial importance when communicating scientific information.

In this context, the European Forest Institute (EFI) is continuously developing its operations and structures to be an effective pan-European science-policy-media platform.

We also want to emphasize that the 21st century is also an era of opportunities. Many scientists call it the century of biology. This is because advances in bioscience, biotechnology and bio-infrastructures offer great opportunities in many areas, especially in helping to transform our existing fossil-based economy into a low-carbon one – a knowledge-intensive, sustainable and bio-based bioeconomy.

European forests can help address threats like climate change or biodiversity loss, and provide renewable resources. Such multifunctional role will become increasingly important in the coming decades, in a context of growing competition for land and natural resources resulting from an escalating global population.

Let me finish with a quote by Albert Einstein:

> "We cannot solve our problems with the same thinking we used when we created them"

About the author

Elisabetta Tola
Science communication expert and data journalist

After completing an MSc in Agricultural sciences at the University of Padova and PhD in Microbiology at University College Cork, supported by a Marie Curie grant in Biotechnology, Elisabetta turned to journalism and completed a Master in Science communication at Sissa, the International School for Advanced Studies in Trieste.

In 2005 she founded the Italian science communication agency formicablu, specialized in multimedia and digital production. More recently she launched datajournalism.it, a laboratory for data driven stories and tools.

As a freelance she collaborates with different national and international magazines and is currently a regular contributor for the data journalism section of AGI, Agenzia giornalistica Italia. She developed and co-authored the international crossmedial and investigative projects Seedversity.org and Seedcontrol.eu on global agro-ecology and seed market, supported by the Innovation and Development Reporting grants of the European Journalism Centre and published on an array of international newspapers and magazines, and Hearing voices, a cross-border investigation on forensic speech science supported by Journalismfund.

She is a radio presenter at the Italian national public radio, RAI Radio 3, for the daily program Radio3scienza as well as an author of podcast series for the same channel.

Elisabetta is a media trainer on digital and data journalism as well as verification of user generated contents. She was media trainer for Italy with the Google News Lab between 2015-17 and for the Digital lab of FIEG, the main Italian publishers association, in 2018. She has been lecturing on digital media at different journalism schools for the past 10 years.

She also acts as a consultant and senior communication officer for dissemination and outreach strategies within EU-funded research projects as well as speaker and discussant at national and international public events.

Recently Elisabetta is collaborating as a mentor and a consultant with the European Forest Institute to develop science-media programmes for the Lookout Station.

Purpose of this handbook

We can't do it without you. Scientists are the key to make regulators, policymakers, civil society – people – understand what is at stake when we talk of any complex scientific issue, be it environmental risks, forest management, bioeconomy or climate change. You are the key in helping us understand the challenges and opportunities that lie in front of us as well as which are the steps we have to take, as a society.

Reporting on issues such as those mentioned above puts journalists and storytellers in a very difficult position. For instance, climate change, probably the master environmental and socio-economic topic of our times, entangles so many disciplines and levels of discussion that it is very difficult to convey its complexity and uncertainty in an accessible language without oversimplifying. Yet the stories must be interesting and compelling for a wider audience. We need a wide range of scientific expertise, from chemistry to physics, from agriculture to forestry, to inform people, local communities, entrepreneurs and policymakers on the most likely future scenarios and on the best adaptation and mitigation practices and measures that might support a more sustainable development for our future. But sometimes scientists find it hard to relate to journalists, to explain their data, methods, processes and results. Journalists and media have a tendency to use striking headlines, to reduce complexity to the point of false interpretation, to search for the so-called wow-effect without following up or going deeper into facts.

"As the original knowledge producers, scientists are the best sources to explain how these facts should be read, interpreted and used. "

Combined, these two challenges might ultimately affect the quality of the media coverage.

This handbook will focus on fostering a better communication and media outreach of science issues, highlighting climate change, from the basic science to the innovative solutions and opportunities to act against it. The main focus of this handbook is to discuss the motivations, the possible approaches, the framework and the ingredients needed to find new narratives, to develop a different approach to media, to understand the information needs and expectations of the publics. We will also include practical tools and tips to boost your communication work.

Forestry and forest scientists are on the forefront of the challenge climate change poses on us. Forests are a major carbon storage and they can provide sustainable alternatives to fossil fuels. Thus forest scientists are in the position to play a pivotal role in providing facts, data and stories not merely on the risks and impacts of climate change but also on the strategies and foreseeable solutions to combat them. As the original knowledge producers, scientists are the best sources to explain how these facts should be read, interpreted and used.

Media can be a collaborative counterpart, using the data in an appropriate way to convey the information and promote an open attitude toward change. Media, the traditional as well as the more innovative digital native ones, are a fundamental pillar of our society and represent a key weapon in our hands to nurture democracy.

Media are the main channel of providing information to wider audiences, via the more traditional channels like legacy TV and print media but also via the growing digital presence, through web and social channels which have become the most popular information hubs. For instance, Al Jazeera English has over 4.7 million followers on Twitter, and their videos have millions of viewers on YouTube and almost 2 million subscribers, including a share of their traditional TV audience. The New York Times has over 41 million followers on Twitter and over 1.5 million subscribers on YouTube. In Europe, the BBC has over 4.3 million subscribers and millions of video views on YouTube, 45 million followers on Facebook and over 22 million followers just on their BBC News Twitter account which all complement the already huge number of TV viewers and radio listeners.

Media are thus a landmark in the information landscape for millions of people, as well as for those representing them: politicians, policymakers, entrepreneurs. Media are shaping the agenda and influencing both political and socio-economic development in most countries. They can contribute and enhance the impact of any important information, be it the discussion over a new legislation or a very crucial piece of new data describing or assessing an important complex matter, such as global warming, water crisis or food production. Bolstering popularity and people engagement over a certain topic, media can ultimately trigger public and private support to research.

Journalism has evolved tremendously with the advent of digital technologies. Data journalism and visualisations as well as multimedia storytelling techniques are much closer to scientific reporting than the old formats, based on written texts or interviews. There are developers, professional graphic designers, data scientists and other high tech professionals in the newsrooms nowadays who can deal with complex issues. By experimenting, much like scientists when formulating new hypotheses and designing methods to test them, journalists can today try and use data, images, immersive formats like 360 video, Virtual Reality and Augmented Reality to tell science stories and make the audience understand the efforts and results of research. If scientists and journalists learn to communicate with each other, if they can agree on a common language overpassing the difficulties of technical terms, data can be brought into stories and interactive visualisations of high impact for communities and decision makers alike.

Graphics and visualisations produced by scientists are often aimed to their peers. To become popular on the media, a chart needs to be easy to understand and have the added value of telling a story without the need of an expert background. Data and facts come to life when strong and thoughtful designs are applied to enhance the users' experience and their interaction with data itself.

Today, we have handbooks and guidelines for journalists on how to deal with climate change reporting. What we lack is the active involvement of more scientists in the effort. The best way to enhance the impact and value of the information on climate change is likely to come from an improved communication between scientists and journalists aimed at crafting highly informative and accurate stories based on data as well as real life examples and practices applied worldwide.

This handbook aims at filling a void, trying to bring scientists into the game as co-leading players, giving them reasons and suggestions on how to improve their connection with journalists to bring the much needed data out and together report on the changes we, as humanity, are already facing.

Index of chapters

1 Scientists in the public sphere

Scientific work is hard, tough, complex and requires a lot of focus, attention and dedication – and as little distraction as possible. Scientists have enough on their plate, with high competition for funding, publications, academic recognition and career advancements. In some countries, scientists and young researchers are also affected by the instability of their contracts and career perspectives, by the uncertainty of their future, by the lack of resources and of appropriate funding and so on.

So, there is enough to deal with already without having to embark in public discussion and having to face general audiences and larger publics. Is there?

Charles Darwin published his "On the Origin of Species" in 1859 with the general audience in mind and not restricting his work to scientists.

The history of science shows us that choosing to dwell exclusively within the academic environment is not functional or even strategic in the long run. Science has modelled our contemporary society and has been a key pillar in the development of humanity through the centuries. And scientists have been key players in the process, often explicitly so. Think of Charles Darwin who published his "On the Origin of Species" in 1859 with the general audience in mind and not restricting his work to scientists. The reactions to his work were partly harsh and he was even ridiculed but it did not stop his work. Or think of Michael Faraday who launched and often presented the Christmas lectures for children and Friday evening discourses at the Royal Institution he was leading in the mid-1800s. These events were so crowded that they originated the first traffic jams in London!

Rachel Carson
Marine biologist, author, and conservationist

There are many more recent examples of scientists involved and engaged in the public sphere in. Scientists who have played a very public role often using the media to the advantage of their scientific work, shaping public knowledge, informing policies and eliciting economic advancements. Science has become more and more of a public adventure and a very competitive enterprise. In some cases, scientists have to fight hard get their field recognised, to gain public acceptance, to prove it relevant to get more funding, more opportunities, and more enthusiastic students enrolled in their programmes.

Next, we go from iconic characters of the twentieth century, such as Rachel Carson and Margaret Mead, to more contemporary ones, Stephen Hawking, Guido Tonelli and Fabiola Gianotti.

Rachel Carson and the birth of EPA, the US Environmental Protection Agency

Rachel Carson has been credited for the birth of the American Environmental Protection Agency (EPA). Carson was the first scientist who collected, organised and put together data and case studies which were already known to the scientific community about the effects of pesticides, and particularly of DDT on the entire biosphere. Carson deliberately decided to communicate her scientific findings not only to her peers but also to the general public. She wrote articles on The New Yorker, then collected them in her most famous best seller, selling over 2 million copies. She even agreed to be on a 1-hour long news program, CBS report, that reached over 5 million people. Carson is recognised as one of the main actors behind the mounting public concern about the deterioration and the decline in the human environment that led to the first National Environmental Policy Act in 1970 and ultimately to the establishment of the US Environmental Protection Agency.

At the same time, **Margaret Mead** became known as the 'public voice of anthropology'. Specialised in research on the Asian population, she did extensive field trips to to New Guinea, Bali and elsewhere in Asia. In addition to being very prolific in the scientific field, she was active in the public sphere, becoming a real American icon throughout the 1960s and 1970s. She was actively teaching and lecturing in many scientific organisation as well as providing scientific information to the general population through the media. She spoke often on the radio, appeared on the TV and wrote numerous articles as well as books. Mead is also known for what is considered a methodological breakthrough: in Bali, she documented her research together with her husband Gregory Bateson by taking over 25 000 photos and over 6000 metres of film. These precious materials were not only used in scientific publications but also served the purpose of supporting Mead on her TV appearances, in the Adventure show, where they were be used to showcase to the American audience the life and cultural habits of faraway communities.

Who would be more iconic than the British astrophysicist **Stephen Hawking**? Active at the Centre for Theoretical Cosmology at the University of Cambridge until his death in March 2018, Hawking wrote numerous books discussing his own theories, many of which became best sellers. His "A Brief History of Time" was on the British Sunday Times best seller list for 237 weeks, a record. Hawking was also often interviewed on TV and even decided to appear in various non-scientific shows. He acted as the holographic simulation of himself in Star Trek: The Next Generation in 1993, and later appeared both in The Simpsons and in The Big Bang Theory.

Many of us know **Joe Incandela** and **Fabiola Gianotti**, who led the research groups at CERN during the Higgs Boson quest, and became very popular on main media after appearing on popular radio and TV programmes for months. Or **Kip Thorn**e, the astrophysicist who was awarded the Nobel Prize in 2018 for his scientific contribution, with **Rainer Weiss** and **Barry C. Barish**, on the discovery of gravitational waves. Thorne not only wrote a book for non-specialists on his research topics, but became a consultant for Chris Nolan for the movie Interstellar, writing also a nonfiction book on The science of Interstellar, and appeared on PBS Nova series a few times.

Cédric Villani is a young French mathematician who won the Fields Medal in 2010 and was the director of Sorbonne University's Institut Henri Poincaré. Villani is well known not only amongst his peers for his excellent research but also as a public character who is often present in the media, in radio lectures on RFI and on TV, for example participating in a mini series with Arte. Villani is also known for his eccentric style: he wears flamboyant clothes and a spider-shaped pin, and is often referred to as "the dandy mathematician". He is such a popular personality that he was asked to give his contribution in the politics and was elected as representative in the National Assembly of the French Parliament with the En Marche!, Emmanuel Macron's political party where he acts as president of the office for the evaluation of scientific and technological choices.

Being a star or becoming a public figure is not necessarily the only way to get your work out there. There are many highly committed scientists who make an extra effort to communicate their scientific passion, interest and work to the general public. This

Margaret Mead
Cultural anthropologist

Stephen Hawking's "A Brief History of Time" was on the British Sunday Times best seller list for 237 weeks, a record.

often has a very strong impact on their communities. Or, more simply, an important impact on the people they meet, for instance the students and the families who attend local and regional science festivals and have an occasion to meet and talk to scientists who work in their own community. Researchers who might inspire new generations of students to embrace a scientific career and to continue their work. Or scientists who become involved in their community offering their expertise to deal with their local problems and issues, such as the management of woods, green areas, sustainable mobility, urban pollution and so on.

In any case, we can hardly find a better way to close this short list of examples than with the words of **Stephen Jay Gould**, the evolutionary biologist and paleontologist and yet another scientist to appear in the Simpsons. In 2002, just a few months before his death, Gould ended his 27-year long collaboration with the popular science magazine Natural History with a long editorial (his 300th) titled "I have landed".

There he stated:

"Of all that I shall miss in closing these columns, I shall feel most keenly the loss of fellowship and interaction with readers. Have we not shared 300 episodes of mutual learning?"

2 Why scientists should communicate

Everybody communicates and scientists are more than aware of the various expected communication activities: there is the peer-to-peer communication related to articles, conference presentations, workshops etc. Securing the funding for your research work adds another layer; grant writing and reporting often requires making the work more accessible to the funding bodies, foundations, EU evaluators and other stakeholders. But while communicating their work to different audience every day, one audience is often left out: the general public. But having already made the effort to simplify research work without trivialising it and yet making it understandable to many non-experts, scientists are only one step away to communicating to a much wider audience.

Dissemination and outreach of scientific work is an implicit task, which is strongly considered in the evaluation of any research proposal as well in annual and final reporting.

There is an ethical motivation to do this. Most of the science research is funded through public money, be it national resources of European ones. This means tax payers' money, which is as valuable as the money invested in public services. Therefore, the scientists are expected to give something back: to share their knowledge with the rest of society. This is an enormous contribution to building what has been recently defined as a scientific democracy. The European Commission makes it very clear in Horizon2020 and in general in any funding framework. Dissemination and outreach of scientific work is an implicit task, which is strongly considered in the evaluation of any research proposal as well in annual and final reporting. For an institution it is a way to show to the public how the money was spent, how it was invested, and it is an indicator of governance.

Applied science has definitely a very immediate interesting side to it, as people might benefit from a new therapy, a cleaner environment, a better food quality, a supportive technology and so on. But getting your message across does not need an application. Scientific culture as such, understanding the way of thinking and looking at nature and the way the world works is immensely valuable. There is beauty in science, there is the sense of being part of a collective adventure, part of the immense effort to decipher life and nature, the same fundamental questions that human beings have always lived with. So, it is important to share this, to allow your fellow human beings to be part of such beauty and of this greatly rewarding stream of knowledge. There are so many curious and interested people out there who could or would not pursue a career in science but are hungry for science stories.

Often, scientists are curious and willing to try and reach a wider audience, either directly during science festivals, open days or other public events, or through the media. But they may encounter some constraints and at times also disappointment. Time given for an interview or to explain work and data to journalists is time taken from research activities. And it may be difficult to see the impact of the communication efforts, for instance, when good evidence and new knowledge are brought forward by the scientific community, as in the case of climate change science, and yet political decisions are taken on the basis of other considerations.

After Donald Trump voiced his intention to exit the Paris agreement and put the denialist Scott Pruitt as lead administrator of the Environmental Protection Agency, Jonathan Foley, Director of the California Academy of Science and one of the leading organisers of the March for Science, wrote a very passionate blog post explaining that "The systematic use of so-called "uncertainty" surrounding well-established scientific ideas has proven to be a reliable method for manipulating public perception and stalling political action. And while certain private interests and their political allies may benefit from

these tactics, the damages are something we will all have to face." To change this situation, suggests Foley, "scientists shouldn't shy away from engaging in political conversations. Now more than ever, it is necessary to be participating in them."

Convincing the public of the importance of what researchers are doing might improve the chances to reach e.g. politicians, funders, regulators, evaluators. There is no doubt that having a strong public support might give science a better chance to obtain the needed funding and resources. A great scientific work left to gather dust in the inner pages of a scientific journal reaches very few people and makes no case for its impact, importance or cultural relevance.

Scientists already defend their work in the most difficult arena, that of their peers, where their work gets scrutinised, falsified, analysed, and not always with the best motives. Science is as human as any other enterprise: there is, has always been, harsh competition, strong loyalty to established paradigms, diffidence, sometimes plain envy. Surely, communication amongst peers is different than that with other experts or, even more, with non-experts. But in contemporary science, where it is common to work in multidisciplinary teams, there is already a strong need to communicate with experts in other disciplines, finding common language and theoretical frameworks. And often, beyond the scientific and technical issues, there are also cultural, social and economic aspects which enter into the discourse.

Building a good narrative and a good case to bring science to a broader audience, without any expert knowledge to mediate, is not quick nor easy. But it can prove very satisfactory, since the effort will likely match with the strong and passionate interest of many people who are out there, who do not work in science but are mad about it, and are definitely trusting the scientists to tell them how the world works, how nature regulates itself, what is happening regarding a certain phenomenon.

Think of CERN and the Higgs boson quest, for instance. Something so far from common practice, from most people's experience and needs, that it seems impossible to communicate and to meet enthusiasm, interest, support. And yet, during the announcement of the data and experiments made by Fabiola Gianotti and Joe Incandela confirming the existence of a particle consistent with the long sought-after Higgs boson, on July 4th 2012, hundreds of thousands of people connected to the CERN website and its partner institutions' sites around the globe. There were thousands of people following the streaming and most global media gave the main headlines and broad coverage on what had just been announced. CERN communication team worked really well together with the scientists to make sure that the announcement was not only relevant for the scientific community but that it turned into a global event.

So, another good reason to embrace public communication is to build allies for the scientists' work. To make other people, who might not be technical experts or pure scientists, understand the meaning of the research, its potential impacts, its role and effects and the benefit for all of us, from a local to a global level.

There are also many who do not understand science and will remain sceptical forever. Actually, there are even those who are completely unwilling to grab the basis of the scientific method, worst even, who rebuke scientists and science. This is not new, this is part of the human culture and experience. There have been, in any historical phase, people, organisations, even institutions which were against a scientific, rational view of the world. Let them be, and think of the others and think of people like Galileo, who had to defend himself from the inquisition, but did not give up on his work. There are also many people who are simply undecided, insecure, unable to make up their mind. And if the only voices they hear are those of anti-scientific organisations will definitely find it difficult to embrace a rational view. Think of the creationist, of the anti-vaccines, of the climate negationist movement. Culture is the only real resource we have to inspire rational decisions, to judge a complex situation and try and find a reasonable solution or adjustment. Scientists produce culture, every day, and it is their duty to share it with the rest of us.

A great scientific work left to gather dust in the inner pages of a scientific journal reaches very few people and makes no case for its impact, importance, cultural relevance.

Communication might also have a potential direct impact on scientific careers. Many studies, such as the one by David Phillips in the New England Journal of Medicine in 1991 which shows that scientific papers and works covered by general and very popular media, such as The New York Times for instance, end up having a much higher citation index in the following year, by up to 73%, per Phillips). This effect lasts for years. The mechanism has been quite well studied, giving evidence that scientists themselves tend to learn about new scientific breakthroughs outside their specific field more through general media than through specialised publications. Since the impact factor of a journal is measured also through the number of citations, a journal that manages to spread its papers in the press tends to improve its impact factor. The higher the impact factor, the more attractive the journal becomes for the best scientists, triggering a virtuous cycle in favour of those journals. This would be the main reason why very important scientific journals such as Nature and Science invest heavily on their press offices and media communication teams. Nature, for instance, has seen its impact factor increasing dramatically from 28.8 in 1998 to 32.12 in 2004 and up to over 40 in 2016.

And finally, communicating is gratifying, as is the opportunity to receive help and important clues for one's work. Scientists who have embraced the experience of connecting with different societal groups all have a very similar experience to share. The fact that talking to people means not only feeling more rewarded and supported in what they do. It also means being exposed to curious questions, sometimes questions they had not thought about before. It means to collect the needs and requests from people even on the work they are doing and this might help them adjust their research sometimes.

And if a scientist like Stephen Jay Gould, while saying goodbye to his readers on a popular science magazine acknowledged that it was a "mutual learning" experience, why should we not give it at least a try?

3 Visualisation and multimedia that make the difference

Science produces masses of data and usually this data is packed into graphics that are readable basically only by the scientists who produced them and their peers. Very often an important research is illustrated by graphics and images, which remain confined within a circle of experts and peers who share them.

There are visuals which become iconic, which explain an entire phenomenon and are not readable just by the few experts who have all the keys to decipher them. These graphs might go farther and have an impact also on those people who are not necessarily intended as their original targets, as they become a sort of universal representation of a certain phenomenon. Scientists who produce these might be known and associated with them for their entire life. Naturally this is not necessarily the main goal of an entire scientific career. But these graphs can make the difference and generate change, which might well be the main goal of an entire career.

Media have gone deeply visual recently. The use of graphs and interactive data visualisations has taken much space and effort both on traditional and more innovative media. However, as said in Chapter 1, the visualisation needs to be immediately understandable for a wide audience in order to be published and circulated through the media. Sometimes this is the result of a great intuition and visualisation ability on the side of scientists themselves. Sometimes it requires much more collaboration, interaction, negotiation to get to a point where a data visualisation or another piece of visual content can actually be spread through the media and get to a very broad public.

Let's see some examples. The first four examples have nothing to do with environment or climate science, but are included because of their relevance in the history of data communication. Examples 5–10 are from the field of climate, forestry and environmental sciences.

Flo Nightingale and the first medical statistics

Florence Nightingale is known worldwide as the "lady with the lamp", founder of nursing organisations such as the Red Cross. Few know that she had a particularly good statistical mind and that she had envisaged that compiling data was the best way to improve health conditions in hospitals.

She enrolled as a volunteer at the Scutari hospital to take care of the British Army fighting the Crimean War in 1854–55. As soon as she arrived she saw that soldiers were dying more because of diseases such as dysentery, cholera, infected wounds and typhoid fever than on the battlefront. There was short supply of medicines and the sanitary conditions were awful.

To prove that the deaths were more associated with preventable diseases, she started collecting statistics. She worked hard to compile more than 800 pages of data in a book to that prove that between the ages of 25 to 35 the mortality rate in military hospitals was double that in the civilian life.

In the book we find also a polar area diagram, one of the first ever used in literature, that Nightingale used to highlight the causes of mortality during the war in Crimea, month by month, comparing the situation at the battle front with that in the hospitals.

Nightingale's polar area graph shows an array of coloured wedges representing the different causes of death, with the outer ones measuring the deaths from contagious diseases, such as cholera and typhus. It is immediately clear that the most frequent cause of death was due to contagious diseases, often associated with the poor hospital conditions.

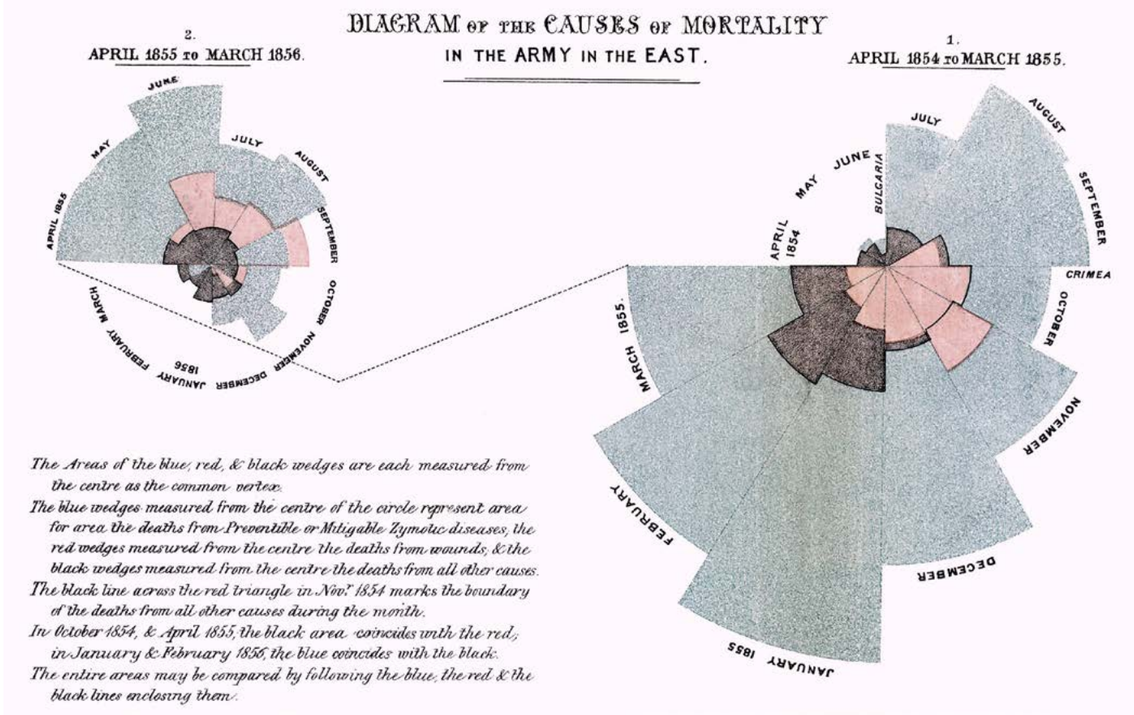
There is no need to be familiar with the data, nor to know statistics to immediately perceive that there is a huge gap in the causes of mortality. The graph is easy to read basically for anybody and it proved very effective in persuading the government officials and those enrolled in the medical profession that sanitation reforms might have reduced mortality dramatically.

Florence Nightingale
OM, RRC, DStJ was an English social reformer and statistician

Following this pioneer work, medical statistics started being collected both in England and in France. Nightingale was nominated the first woman fellow of the Statistical Society of London (now Royal Statistical Society) in October 1858.

Florence Nightingale
Diagram of the causes of Mortality in the Army in the east

Credit: https://upload.wikimedia.org/wikipedia/commons/1/17/Nightingale-mortality.jpg



John Snow and the cholera map

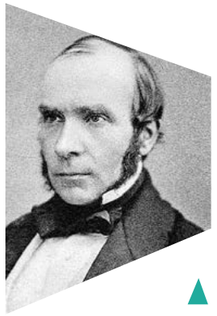
In the first half of the 1800s many diseases were still associated only with environmental conditions and thought to be transmitted by miasma in the air. There was little knowledge about the microbiology of infectious diseases. London had over 2.5 million people living in the biggest metropolitan area of the time. But the organisation of the city in terms of sanitation was still very poor. There were no sewers, and animals like cows and horses were living in the houses with people. The city reeked, and the smell was thought to be the cause for the frequent disease outbreaks. Cholera was one of the worst killers, with cycle of epidemics of 4–5 years and thousands of deaths at each outbreak.

A local Soho doctor, John Snow, had become convinced that cholera was not transmitted by miasma and air but by water contamination and during the next outbreak, in August 1854, he saw an opportunity to prove his theory. Convinced that the outbreak was associated with one unique point of infection, a local water pump, John Snow undertook dozens of interviews to residents in the area to see where the victims were living and whether they had taken water from that pump.

Instead of writing about it, John Snow drew each case, visually, in a map. It became immediately obvious that there was a dramatic concentration of infections around the pump. He numbered each case with a black square and built bars that were proportionate to the number of people dead at each house. Again, there is no need to be able to read the data or to be familiar with statistics to see that the pump is likely to be the cause of infection.

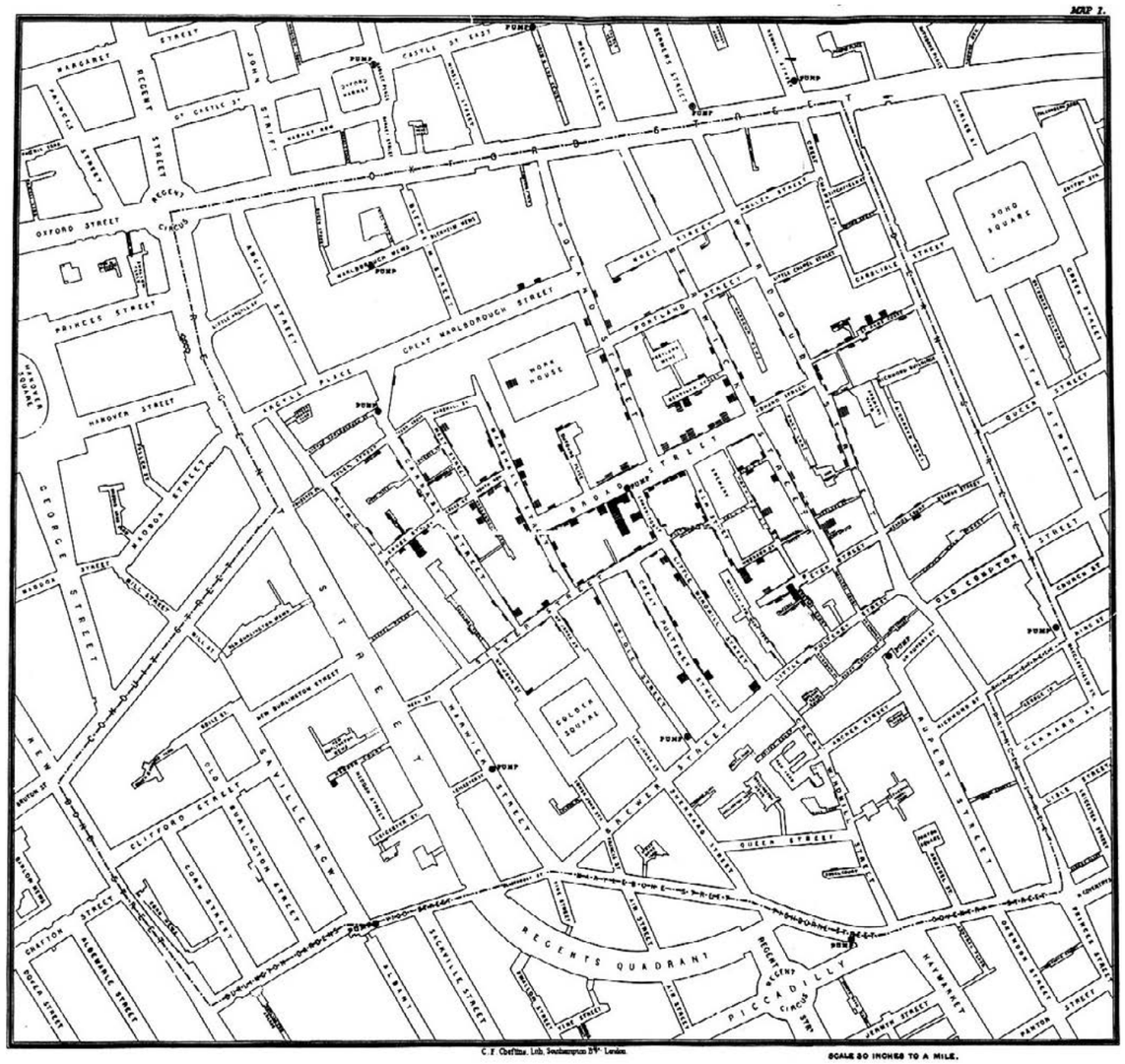
Eventually, by the mid-1860s, when the next cholera epidemics burst in London, the authorities had been convinced by Snow that contaminated water sources were the problem. Sewers were started being constructed and as soon as the disease appeared people were instructed to boil the water. 1866 marked the last cholera outbreak in London.

"That in a way is the ultimate legacy of this map", said Steven Johnson, an American science writer in a TED conference on the subject, "It's a map of deaths that ended up creating a whole new way of life, the life that we're enjoying here today."



John Snow
English physician

John Snow
Cholera map



Credit: https://en.wikipedia.org/wiki/John_Snow#/media/File:Snow-cholera-map-1.jpg

Charles Minard and the Napoleonic war graph

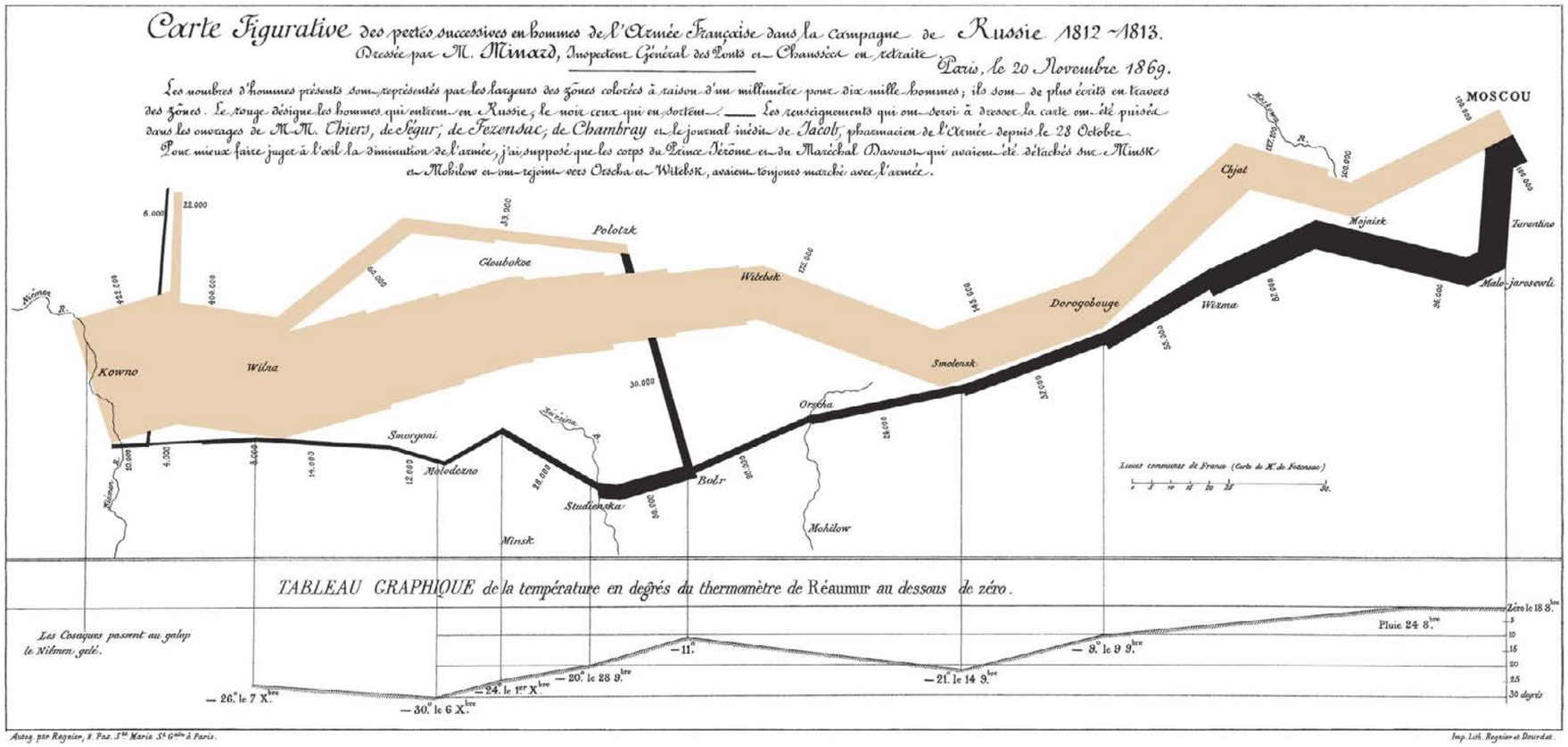
Can data tell the real story of a military campaign? After his retirement, the French civil engineer Charles Joseph Minard, who lived in the mid-1800s, took interest in measuring and finding effective ways to summarise the results of some war campaigns.

This chart focuses on the disastrous Napoleonic Russian campaign of 1812. The extent of such a disaster is much more obvious when looking at Minard's representation, which was published in 1869, 50 years after the event. It contains many types of information: the number of soldiers who formed the French army is represented precisely by the width of the two bars (1mm =10 000 men), the light one on the way to Russia and the black one on the way back. But the chart includes also other information: the geography of the entire route in terms of distance and altitudes, the temperatures, the major battles fought, the dates and the directions taken by the army.

The overall picture is dramatic: of the 420 000 soldiers who left, only 10 000 came back. Again, there is no need to understand statistics to appreciate the extent of failure and the reason for all those deaths.

All of Minard's works are "designed to tell a story – to speak to the eyes" says Betsy Mason in an article on Minard's work published on National Geographic magazine in March 2017.

Charles Minard
The Napoleonic war graph



Credit: https://upload.wikimedia.org/wikipedia/commons/2/29/Minard.png

Hans Rosling and 200 Countries, 200 Years, 4 Minutes - The Joy of Stats - BBC Four

Hans Rosling
Swedish physician, academic, statistician, and public speaker

"I teach global health and I know having the data is not enough. I have to show it in a way that people both enjoy and understand."

Hans Rosling was a passionate Swedish physician, an academic and a statistician as well as an amazing public speaker. He was the professor of International Health at Karolinska Institute. He was also convinced of the importance to disseminate statistical knowledge, and that is why he gave life to the Gapminder Foundation, whose payoff was that of "unveiling the beauty of statistics for a fact".

One of the most famous data visualisations produced by Rosling was that done for a BBC Four TV program on the health and wealth of all countries in the world during the last 200 years. The video is now available on YouTube. In his words, Rosling explained at the beginning of the program how he was going to show the data: "Now, I am going to try something I have never done before. Animating the data in real space with a bit of technical assistance from the crew. An axis for health, life expectancy, from 25 years to 75 years, and an axis for wealth, income per person, from 400 to 40 000 $. And then, a timeline from 1810, showing the state of the 200 countries from 1810 to 2010."

While Rosling explains the facts, with almost a theatrical capability to convey the dramatic changes associated with specific historical moments, the animation gives the viewer the possibility to see the visualised data in a very precise and informative way. Again, no much need to understand the statistics behind it to grab the basic information that the graph is displaying.

On the contrary, such an effective visualisation, combined with Rosling's energy and ability to communicate, might lead a viewer to explore more the data, to read more about the subject, to get informed in a more accurate way.

The Blue Marble – the Earth seen from space

At times an image becomes the story, not only its graphic representation. This happened with 1972 picture of the young napalm victim in Vietnam, shot by Associated Press photographer Huynh Cong Ut. It happened with Steve Curry's 1984 photo of the little Afghan girl living in a refugee camp as she became a symbol of her entire country. It happened with some of the images produced by Sebastião Salgado, in his long term project Genesis, that become globally famous for their immense power of representation of the state of the earth and environment.

But there is one picture that was not shot by a famous photographer and yet ended up to hold an immense power: the Blue Marble, shot in December 1972 by the crew of the Apollo 17 at a distance of 29 000 km from our planet. What this image shows is indeed the Earth, our planet, in its entirety and enlightened by the sun that was behind the astronauts at the moment when they captured it. An amazing view which became immediately iconic, in a period where environmentalism was just at the beginning.

NASA credited the image to the entire crew of the Apollo 17, which was on its way to the Moon with three men on board: Eugene Cernan, Ronald Evans and Jack Schmitt. To date, we still do not know which of the three was the actual photographer. But the most important fact is that this was the last Moon mission and all pictures of our planet have been taken by unmanned missions ever since. NASA was so obviously aware of the value of this image it was presented to the public just two weeks after it was shot, on December 23. It made numerous headlines on the media and Christmas covers in magazines becoming famous worldwide.

The image shows our planet as whole, unique, beautiful, frail and vulnerable. It has been said to strike people with feelings of wanting to protect it, to conserve it. It became the symbol of environmental concern and awareness. It has been extensively used in films, TV programmes, articles, conferences and so on. According to NASA, it has been amongst the most widely distributed images in human history. So popular that NASA decided to reproduce new pictures with the same successful title "The Blue Marble", in different series published in 2002, 2005 and 2012. Millions of people have downloaded them from NASA website and Flickr page. But none of these satellite-made pictures will convey the same feeling of surprise and tenderness associated with the original Blue Marble that reminds us how small our planet is.

Jack Schmitt, one of the three astronauts, has been recorded saying to Mission Control after the shot was taken "I'll tell you, if there ever was a fragile-appearing piece of blue in space, it's the Earth right now."

Credit: https://en.wikipedia.org/wiki/The_Blue_Marble

Europe is greener now than 100 years - University of Wageningen and The Washington Post

Rick Noack
Foreign affairs reporter who covers Europe and international security issues from The Washington Post's Berlin burear

In 2014, Rick Noack, at that time a contributor to The Washington Post and currently their Foreign Affairs correspondent from Berlin, published a very nice article showing the extent of reforestation in Europe in the last century, Watch: How Europe is greener now than 100 years ago.

Reforestation is due to a number of causes which are clearly outlined in the article, from the technological improvement which has reduced the amount of cropland needed to produce food to the urbanisation and to the development of a common agricultural policy and many more. The article is complemented by a dynamic map which was produced by Richard Fuchs from the University of Wageningen.

The map works very effectively in an informative context since it allows the reader to see the dramatic changes in forest coverage in different European areas which would be much less appreciated if simply described in words

Mann - and the Hockey stick graph

Michael Mann
American climatologist and geophysicist

In 1999, Michael Mann, a climatologist then at University of Massachusetts published together with his colleagues Raymond Bradley and Malcolm Hughes from the University of Arizona, a scientific paper analysing paleoclimatic data sets from tree rings, ice cores, corals and joining historical data with more recent ones on temperature and CO_2 emissions.

His reconstruction of the Northern Hemisphere temperatures was going back by about 1000 years. The paper was published on the American Geophysical Union magazine. It contained a series of graphs and a conclusion. One of the graphs in particular was striking, showing the dramatic increase in temperatures from the early 20th century on. The graph was renamed by another climatologist, Jerry Mahlman, as the 'hockey stick' and has become the iconic representation of global warming.

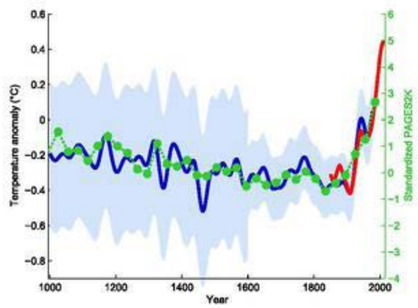
So iconic that the graph itself has been the object of a very highly heated controversy between the supporters of the idea of human induced climate change and the negationists. The hockey stick graph became particularly notorious in 2001, when it was used by the IPCC Third Assessment report in the summary for policymakers. Then the sceptics made an extra effort to undermine Mann's work and conclusions. Mann ended up defending himself in front a congressional committee led by senator James Inhofe of Oklahoma, who was among those calling global warming a hoax. In 2006, the hockey stick was used by Al Gore in his documentary The Inconvenient Truth, which was seen worldwide, in traditional media and at cinemas and has been since one of the most popular films on climate change ever.

Again, why is this graph so powerful? Well, it needs very little further explanation. We are quite a visual species, and this chart is immediately readable and comprehensible and summarises the scientific conclusion in a very defined way.

However, the attacks on Mann convinced him that it is not enough to play in the scientific arena and that more effort is needed to actually explain the global warming data and facts to the general public.

He has founded a blog called realclimate.org where, together with fellow scientists, he explains scientific facts to non-experts. As we will see in Chapter 4, he is not alone in this effort.

More and more climate scientists are striving to use appropriate language and images to talk to different publics.



Credit: https://upload.wikimedia.org/wikipedia/commons/thumb/2/2d/T_comp_61-90.pdf/page1-318px-T_comp_61-90.pdf.jpg

An animated GIF on temperature rising going from science to media

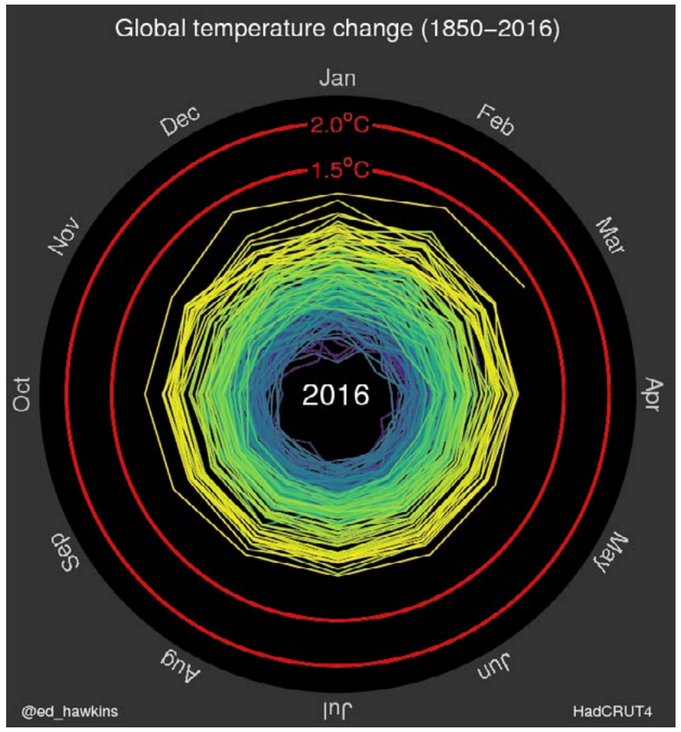
Ed Hawkins
Climate scientist

Ed Hawkins, a climate scientist in the National Centre for Atmospheric Science (NCAS) at the University of Reading and contributing author to the IPCC AR5, created an animated GIF to display the monthly temperature throughout the year from 1850 to 2016.

The animated spiral, says the Climate Lab, a blog kept by Hawkins and his fellow scientists, presents "global temperature change in a visually appealing and straightforward way. The pace of change is immediately obvious, especially over the past few decades. The relationship between current global temperatures and the internationally discussed target limits are also clear without much complex interpretation needed."

Ed Hawkins shared his animation through his Twitter account in May 2016, and got retweeted over 10 000 times while triggering a conversation with over 15 000 people. But his spirals got seen by millions thanks to the fact that such an effective way of representing temperatures and the 1.5 and 2.0 °C scenarios really worked for the general media as well. It went viral, being seen millions of times on Facebook and Twitter but it was also picked and shared by a range of media, from the Washington Post to Vox, from Public Radio International to many more.

And, to the astonishment of its creator, it was used during the opening ceremony of the Rio Olympics, getting covered once more by every media in the world.



https://www.pri.org/stories/2016-05-10/global-warming-gif-shows-how-hot-earth-has-gotten-over-past-165-years

Daniel Crawford - the music of rising temperature

Daniel Crawford
Undergraduate student at the University of Minnesota, Institute on the Environment

Daniel Crawford, an undergraduate student at the University of Minnesota, Institute on the Environment, decided to use his cello to communicate the latest climate science through music.

Instead of using a chart, and visualise the data of the rising temperatures, Crawford invested on data sonification to convert the global temperature records in a series of musical notes. Sonification is the auditory equivalent of data visualisation. It is not a new technique, and in recent years it has been applied to a number of scientific disciplines, from biomedical ones to astronomy, from geoscience to genetics. Crawford's final product is called "A Song of Our Warming Planet".

The reason why it works so well is that it not only gives people something to look at but actually more directly it gives them something they can feel.

A very effective way to connect not only to objective thinking, but to evoke emotional responses.

John Oliver and the science on air on HBO

Host of Last Week Tonight, John Oliver has provided some of the most successful TV coverage to how science and scientists work.

With over 11 millions views only on YouTube, this video entitled "Scientific studies" shows how John Oliver can provide a very strong and yet funny discourse in favour of scientifically based information rather than the casual use of numbers and data that often gets in the media. In another episode of his TV show, Climate Change Debate, John Oliver shows how to host a mathematically representative climate change debate by calling in studio one sceptical against 98 scientists who agree on the man-driven climate change hypothesis. This is the only accurate way to give your audience a fair representation, says John Oliver, of the diversity of positions within the scientific community on this topic.

Again, this video has been seen by over 7 million people only on YouTube, on top of the millions of TV viewers.

Credit: https://youtu.be/0Rnq1NpHdmw

John Oliver
Host of Last Week
Tonight show

4 Scientists who already work on communicating climate change

Far from being an exhaustive list, the following are examples of science initiatives and scientists who have decided to try and communicate their work to a broader audience, either directly or through the media. All selected experiences are related to climate change communication.

Many of these examples are drawn from American experiences. This is mainly due to language issues but also to the fact that the US have elected, in this century, two out of three presidents with strong negationist views on climate change. George W. Bush, who was president until 2009, was hardly committed to fight climate change. And Donald Trump, who just began his mandate as of January 2017, has basically done everything in his power to reduce the US commitment against climate change and in favour of the environment. The decision to exit the Paris agreement, to cut funding and change all executive staff at the EPA speak volumes. But American scientists are determined to fight back. The huge March for Science, which involved rallies and demonstrations in over 600 American cities, saw over 1 million participants on April 22nd 2017. It was called by over 100 scientific organisations and it has been defined an event of unprecedented scale. The March is taking place also in 2018.

In Europe things are more complicated. There is not a unique government policy on the environment, although there are a series of EU policies and directives which go in the direction of having a common strategy to fight climate change and to build a sustainable future for the European people.

But a joint effort by the scientific community towards the building of a stronger European approach to environmental science is at the present less prominent, although there are many regional and national initiatives.

Jonathan Foley

Executive director of the California Academy of Science is a scientist whose highly renowned scientific work has been focusing on understanding worldwide changes in ecosystems, land use and climate, global food security and sustainability. His commitment to environmental communication goes back years, both when he was the director of the Institute on the Environment (IonE) at the University of Minnesota and even before, at the University of Wisconsin, where he founded the Climate, People and Environment Program (CPEP) and the Center for Sustainability and the Global Environment (SAGE). His scientific work is of high impact, with over 130 articles many of which published in Science, Nature, and the Proceedings of the National Academy of Sciences.

But in this context we are more interested in Jonathan Foley's commitment to popular science and science communication for a broader audience. The California Academy not only hosts the 'greenest' museum in the world but also is home to the Institute for Biodiversity Science and Sustainability with more than 100 active scientists. Furthermore, Foley is a very proactive science writer and has published extensively on National Geographic, the New York Times, Scientific American, The Guardian, Ensia, Yale's Environment 360, and bioGraphic.

In addition, he is also very active on social media, using Twitter as @GlobalEcoGuy, with over 41 600 followers. Also, instead of writing only on blogs associated with research institutions, Jon Foley has selected Medium, an immensely popular blog-like platform which reaches millions of people, to write regularly in a very plain and inspiring prose appealing at the same time to citizens and scientists alike.

His interest in science communication is not new and he has written extensively on the best ways to craft science stories and to engage with the audience. He has received many awards both for his science work and for his science communication efforts. Being a very strong advocate for science culture, Jonathan Foley has decided to get even more directly involved and has been one of the organisers of the March for Science, writing extensively on what he calls The war on science as A war on the American future. In his words, "To truly connect with people, I think scientists and their supporters need to paint a positive vision of the future, where science re-affirms its moral authority, articulates how it will help us, and advances a noble cause. In other words: What is the higher purpose of American science? And what will scientists work for, live for, and fight for? I can't answer for other scientists, but here's what I will fight for."

The Union of Concerned Scientists (UCS) - ucsusa.org

"At the Union of Concerned Scientists we put rigorous science to work to build a healthier planet and a safer world. As a founding value, UCS puts together the knowledge and the scientific competence of the scientific community with the interest, passion, support, contribution of citizens, educators, teachers, advocates to "build a healthy planet and a safer world." UCS was not founded on the wave of climate change mounting awareness. It goes back to 1969, when in the middle of the Vietnam War a group of MIT scientists disagreed with the idea of science to be used and associated mainly with war and the development of chemical and technological weapons. The UCS founders called "for scientific research to be directed away from military technologies and toward solving pressing environmental and social problems". UCS does not limit its activities to communication and extends in the political lobbying. With over 20 000 members amongst scientists, engineers, economists and other experts, the network has reached quite a few impactful goals in the years: they contributed to passing acts on clean vehicles, worked with California government to enhance energy production from renewable sources, acted against deforestation and supported REDD+ mechanism. And more and more. UCS is very useful for science communicators as a reliable and very collaborative source of information and experts to work with on environment-related stories.

Euro-Mediterranean Center on Climate Change (CMCC) - Best Climate Solutions

Bestclimatesolutions.eu is a platform, a collaborative project, that collects stories and inputs providing examples of locally-suitable solutions to tackle climate change and help the transition towards a more sustainable development. Building on a previous successful project that ran for over 6 years, this platform is currently led by the CMCC and has slightly shifted the focus from simply looking into local solutions that solve the problem "here and now" to scout for ideas that can be scaled and adapted to face similar problems in other contexts.

Through an open call, Best Climate Solutions selects innovative projects within their contest section and then, in the news section, features these stories. The platform also aims at triggering a conversation to provide local insights and even collaboration opportunities amongst communities.

Scientists and journalists cooperating in reporting - Climate Central

Climate Central is a US based independent organisation whose members are leading scientists in the field of climate science and journalists. They both work and report, together, on the data and facts regarding climate change and its impacts on our world. They provide not only reporters but also local scientists and meteorologists as well as local regulators with great maps and data visualisations. The work undertaken by Climate Central is superb, since it is both scientifically thorough and at the same time organised and developed with the narrative, visual aids and language which are perfectly matchable with top media. Maps, visual graphics and other works developed by Climate Central often end up as part of articles and programmes in media outlets such as The New York Times, MSBCN, CBS and many others.

Michael Mann and Gavin Schmidt - Realclimate.org

We mentioned realclimate.org in Chapter 2, speaking of Michael Mann and his hockey stick chart. After the huge controversies and personal attacks he suffered for defending his work, Mann decided to start this website to communicate not only with his peers but also to non- experts about the science and facts of climate change. One of the most active contributors, as well as the website developer, is Gavin Schmidt, climate modeller at NASA Goddard Institute for Space Studies and Earth Institute at Columbia University in New York. Gavin Schmidt is a super active and enthusiastic scientist who puts a lot of time and passion into communication. Originally educated in the UK, he moved to NOAA for his post doc. He is the author of over 100 peer reviewed papers and has been cited in 2004 by Scientific American as one of the 50 research leaders. At the same time, he has worked a lot on science education and outreach in collaboration with the American Museum of Natural History, the College de France and the New York Academy of Sciences. He won the American Geological Union Climate Communications Prize and has been the EarthSky Science communicator of the year in 2011. Gavin has also been a TED speaker in 2014 and is very active on Twitter, with the handle @ClimateOfGavin and has over 30 000 followers.

A global network of scientists fact-checking climate change news - Climate feedback

Climate feedback has a very effective and yet original mode of operating: a group of scientists, all specialised in climate science and with at least a PhD education, go through the claims and narratives published in media articles and provide a transparent, non partisan, and scientifically accurate feedback to the editors as well as to the general public, the influencers, the decision makers and so on. "Our first mission is to help Internet users – from the general public to influential decision-makers – distinguish inaccurate climate change narratives from scientifically sound and trustworthy information in the media" they state on their website. On the same platform it is indeed possible to see the very broad group of participating scientists as well as the papers, media and articles which have been checked up to now. "We believe it is scientists' civic duty to better inform our fellow citizens in our area of expertise" claim the members, and certainly they have a point. Fact checking is a journalistic/editorial genre that is recently growing in popularity and reach in a media ecosystem that has suffered a loss of trust and credibility. The International Fact Checking network, started in 2015 by Poynter, aggregates over 100 projects globally, including this one. Within this framework, scientific fact checking, which helps fostering good quality science journalism is definitely more than welcome and is a precious resource for journalists to rely on.

Ed Hawkins and open climate science - Climate Lab Book

Climate Lab Book is a blog edited and launched in 2012 by Ed Hawkins, climatologist at the University of Reading, UK, as an experiment in 'open source' climate science. Climate Lab Book is written by climate scientists but it is also open to other contributors who might submit their ideas and pitches to the editor. The underlying idea is to promote an open scientific discussion and thus a collaboration on the science of climate. "Please keep the discussion scientific and on topic – this is not meant to be a typical blog discussion of the consensus view on climate science." says Ed Hawkins, the author of the climate spirals, the GIF animations which became particularly successful in 2016 as a way to convey data on rising temperatures from 1850s to the present (see Chapter 3).

Climate Visuals - climatevisuals.org

"The images that define climate change shape the way it is understood and acted upon. But polar bears, melting ice and arrays of smoke stacks don't convey the urgent human stories at the heart of the issue. Based on international social research, Climate Visuals provides seven principles for a more diverse, relatable and compelling visual language for climate change". Climate visuals is a project by Climate Outreach, a UK based team engaged in climate change communication that develops social research in partnership with the University of Cardiff, Oxford and many other academic teams. The ultimate aim is to support campaigners, editors, communication practitioners, journalists to find the appropriate images to be used when speaking of climate change.

5 Know your travel mates, journalists and communicators

Science is not a one-man show. It has not been such for a long time. Any of the major science enterprises from the mid twentieth century on, be it the Manhattan Project, which led to the construction of the atomic bomb, the Human genome project or the Higgs boson quest have been undertaken by thousands of scientists worldwide and required a huge collaboration, coordination and, obviously, communication effort. The same is true for climate science, where physicists have to work with geologists, statisticians, oceanographers, mathematicians, social scientists and more and more. Complex science requires complex research teams.

Now, think of science reporting. Yes, you still have written articles, simple interviews, short TV programmes with a scientist hosted by an anchor man or woman or brief radio interviews. But journalism is evolving fast and media is now producing data journalism, multimedia and very articulate projects. Data journalism has brought reporters to deal with data, numbers, databases, maps and charts, and to learn how to use them as sources for their stories, complemented by more traditional reporting such as interviewing or going on the field and collecting people impressions. Filming, and more experimental formats such as the VR/360 images or the augmented reality have allowed reporters to produce immersive pieces which bring their audiences right within a story and allow them to have a full view of an environment and not only the angle previously chosen by the video maker. Newsrooms around the world are changing and transforming, and the journalistic product is rarely the result of a one person's work. It is the outcome of a strong and proactive collaboration with graphic designers, developers, science and data analysts, photographers and filmmakers.

So, here we have a great opportunity to foster a better and stronger communication that brings scientists and journalists to work together more and better in the development of a reporting idea, in the production and in the revision and fact check of the final product. This does not means transforming scientists into journalists. Nor, on the other hand, having journalists acting as spokesmen for science.

On the contrary, this dialogue aims at involving journalists in understanding what the work of a scientist is, how it is done, where, when, how to collect and interpret scientific data. And maybe even become able to challenge, ask more complex questions, to go deeper in the implications.

It aims at empowering scientists to find suitable ways to tell their stories, to bring their outcomes to a wider public. It aims at bringing much more completeness and substance to the reporting, ultimately making a better service to the public.

There are already great examples of very successful and constructive processes that yielded high quality communication products. Usually, this kind of work means that the scientists agree to see the journalist more than once, maybe giving them the time not only of a 10- minute interview but actually a day in a lab or bringing them along on a field trial or data collection campaign. It is time consuming and not easy to organise, but the results are really rewarding and the scientists who took part in these adventures usually enjoyed them a lot. Firstly, because it is very interesting to see your work through the eyes of a non-expert and also because, in many cases, these journalistic products turn out to be beautiful, not aggravated by misinterpretation or striking assumptions and are something scientists can be proud to share with other people.

Here there is a showcase of some of these works:

1. From Miami to Shangai: 3 °C of warming will leave world cities below sea level - The Guardian

Data and scientific visualizations produced by the scientists of the Climate Central team (see

Chapter 4) was analysed by Guardian journalists and reorganised to show the dramatic impacts of the 3 °C of global warming scenario on some coast cities in the world (from Shangai to Alexandria, from Miami to Rio to Osaka), affected by irreversible sea-level rises. from would ultimately lock in irreversible sea-level rises of perhaps two metres.

2. Losing ground - Propublica

A high impact data visualisation on Mississippi river delta, where last few years have seen the increase of very serious phenomena of soil erosion, subsidence and land loss. Data and images come from NASA, USGS, Earth Observatory and the final product is the output of an 18-month work undertaken by news app developer and journalist Al Shaw and his two colleagues in collaboration with many different researchers in the field.

Here the very thorough representation of scientific data comes to life and is framed with the stories of the people living on the delta whose life has been deeply affected by these major changes.

3. As Greenland Melts, Where's the Water Going? - New York Times

In 2015, two journalists from the New York Times joined a team of 7 researchers from different universities in Greenland. Here, the scientists were conducting a unique experiment by empirically measuring the melting of water from the top of the ice. The scientists published their work and so did the journalists. The result is a highly visual long form piece of reporting, with striking photographs, some of which come from NASA/USGS Landsat, and even a drone video. This piece gives a very consistent amount of scientific information while bringing to the front the passion, interest and perseverance of scientists, who risk their lives in extreme conditions to collect data. It also helps to frame their work within the complex contemporary political situation that might ultimately affect these campaigns by reducing the funds invested year by year.

4. InfoAmazonia

A multimedia platform providing enormous databases, interactive visualisations and reportages on the Amazon forest organised and updated by a coalition of media from the nine countries of the forest. There are many open datasets available for reuse provided by scientific teams also coming from all the nine countries and a number of special projects and focus on specific issues, such as deforestation, social index and so on.

5. The Lookout Station - European Forest Institute (EFI)

The Lookout Station is a programme and an accelerator developed by EFI which offers programmes for journalists to experiment, test and try new ideas to tell climate change stories, like scientists do in the laboratory. At the same time, to support the work of journalists, it also offers programmes to help scientists find narratives around their research and simplify their scientific language.

As a pilot project, at the end of 2017, EFI and the Global Editors Network launched Lookout360° that focuses on 360 video storytelling on climate change. Twelve journalists and producers, working for 12 media from around the world, were trained on climate change storytelling and on 360° video filming and post-production. They then finalised and published the video on their respective media by the end of April 2018. The videos offer a novel perspective on climate change stories, giving the opportunity to the viewer to enter the different environments and be with the people, the protagonists, while they tell their stories and how they try and fight climate change locally.

Talking to non-experts

How can we practically improve the connection and communication from scientists to journalists and improve the production of high quality reporting on climate change?

The first step is understand how the audience can react and which are the mechanisms activated by information related to risk, fear and uncertainty on people, and particularly on people's ability to receive that information, to frame and classify it and to respond to it.

In his very informative and fascinating book "How risky is it, really?" American author David Ropeik goes through over 30 years of research on the mechanisms underlying our risk perception and the mental shortcuts we developed to handle decision making in situation of uncertainty and risk. "The research outcomes in fields like neuroscience, psychology, sociology, anthropology and economics help to explain the underlying roots of the way we respond to risk, and why most of us at one time or another are more afraid of relatively smaller threats or less afraid of relatively big ones." writes Ropeik. This information proves very useful when dealing with risk communication and thus with anything related to global change. "We share a well-identified set of psychological factors – called Risk Perception Factors – that are strongly associated with whether we are more or less afraid. Think of it this way; risks have personality traits that help us instinctively judge their character, even while we consciously consider the facts."

The fact that even experts and people who think of themselves as very rational rarely judge uncertain situations exclusively on the base of data and rational facts and knowledge has been demonstrated by many researchers. Daniel Kahneman, an American-Israeli cognitive psychologist, won the Nobel Prize in Economic Sciences in 2002, together with his colleague Amos Tversky, for challenging the assumption that humans act based on rationality when faced with decisions under uncertainty.

It is then really strategic to approach communication without thinking that the acquisition of knowledge, information and facts are the primary and only needed ingredient to foster a rational judgement and response by a community towards a complex subject. The so-called deficit model, based on the effort to close the knowledge gap between experts and non-experts to gain support for rational thinking, has proven quite ineffective. A more modern approach takes into consideration the engagement of the public and thus the ability of the communicator to establish a real dialogue and to respond to information needs that come from different audiences.

"A burgeoning evidence base on the social science of climate change communication now provides many explanations for why engaging on climate change can be challenging.", writes Roz Pidcock on the recently released "Principles for effective communication and public engagement on climate science", a handbook for IPCC authors. Pidcock adds that "Climate change is filled with uncertainties, a notorious stumbling block for communicating with non-scientists. For some, the topic can seem abstract and intangible. For others, the abstract statistics that define the climate discourse can feel distant from their day-to-day experiences."

And yet, continues Pidcock, social science insights now help scientists to communicate more effectively and make the message more relevant to people's lives and experiences.

In situations of risk and uncertainty, we tend to react with a fear-first mechanism which gives way to rational thinking only in a second moment, depending on a number of factors, be them cultural, social, economic or even affective. The way a risk is presented, and therefore the framing of a situation, as well as our desire to be in control of the situation both play a crucial role in making us decide one way or another.

Also, we hardly react to numbers, or few of us do. Most people are not particularly proficient in numeracy, and this has little to do with education. It has more to do with the way our brain reads the environment and the reality around us. When data like the global temperature or the atmospheric concentrations of greenhouse gases are needed to discuss climate change facts and impacts, but if the communication focuses too much on the numbers there might be a widespread perception that the subject is a very abstract technical issue. This in turn might result in people distancing themselves from the problem, either because it is not thought to be related to our life or because we do not see means to deal with it. This is why it is very important to work on the framing and to find ways to talk about science with a language that is relatable to the public. By using appropriate images and analogies it is possible to describe the problem in a more familiar and accessible way. Framing means also to try and understand which are the core values shared between the scientists and their audience. This is easier in local situations, where the scientists are part of a community they know well. But in any case, also at the global level, finding a common ground to discuss with audiences is a milestone to be effective in communication. Media, for instance, work hard to get to know their audiences, to understand their readers and viewers' preferences, values, interests. Therefore, when talking to the media it is useful to discuss these expectations with the journalists.

Trust is another variable. And in this context, scientists have an advantage as, according to many social studies, they are amongst the most trusted players in contemporary society. Building on this trust can prove very effective. For instance, by sharing with people the human aspects, story and adventure behind the scientific work. Scientists are always the protagonists of a story, be it a local or a global one. Being able to tell a part of this story to the people listening or reading creates a bond. And this bond is very precious when there is more to tell, beside the human side, and there is the need to make people understand that their environments might be in peril, that their lives might need to change course and so on.

We like stories. Oral as well as written narratives have been the best companions human beings have ever had. Stories have shaped our beliefs, our civilizations, our ability to react to the unknown. Building a communication on a narrative format is much more effective than doing it on numbers, facts and demonstrations. Yet, we need those facts, but the challenge is to link them to our everyday life and to our ability to look into the future.

In the handbook for IPCC authors there is a very nice suggestion on how to work on. It is a template developed by the marine biologist Randy Olson in his book "We have a narrative. Why science needs story" (2015) which goes by the acronym of ABT:

> Use "And" in the exposition of the story, while you are listing the facts and setting the scene; you then move to "But", which is the moment where you describe the conflict, the problem, the challenge; finally you move to "Therefore", the resolution, the final decision of acting to solve the problem.

So, working on a narrative, it is possible to craft an effective way to reach diverse audiences and establish a connection with them.

Communicating through and with the media

Dealing with journalists is not too different from dealing with a non-expert public, in terms of the specific scientific knowledge that usually is not part of the journalist background. However, journalists are experts in crafting a story, in finding an angle and using a direct language, in framing a situation and linking a fact or a piece of information to a wider context. Putting together the diverse expertise is a key asset to enhance and improve the quality of science communication through the media.

A few tips can help in developing a healthy relationship with the media and the journalist, without wasting scientists' time and effort to a disappointing result, such as striking headlines or very reductive accounts. Let's go through some of them.

Know the diverse type of media

Know the diverse type of media you are dealing with: media are all different, and today more so than ever. Being interviewed for a TV show is very different that having to share your data with a reporter and take her to the extent of understanding how you collected the data and how it can be read. So, ask the reporter what kind of product do they have in mind, and how you can help. You can have a more precise idea of what is needed, what kind of product they are aiming at, and what can be your role. And don't be afraid to say you'd prefer to contribute in a different manner. Maybe a video interview is not really appealing to you but you might be happy to sit for an afternoon and guide them through your papers. They might enjoy that even better. Or you might prefer to be interviewed on the radio or to be protagonist of a podcast. Again, oral communication is a fantastic way to establish a connection and to develop a narrative, to explain something in depth. In any case, make sure that you prepare some stories on who you are, why you work in your field of research, why are you keen to share your knowledge. These insights might prove very effective not only with the audiences but also with the journalist talking to you.

Know the deadline and respect it

There is a very clear line between media who need an expert for an on air experience and those which are working on a longer term project. Make sure you understand the deadlines correctly. Often journalists work on a very strict deadline, and if it is a radio or a TV show the deadline may be "now". So, make sure that if you say you are going to be available to be on video or on the phone for a radio show at a certain time, then you will be able to comply. There is nothing worst to a journalist than be left on air at the last minute with no guest to interview.

Understand exactly what they are asking

Is this a science popular magazine or a very general media? If you are unsure, talk to them and have them tell you the type of audience, the type of stories they usually portray, and so on. Audiences are very different, they use and expect different languages, values, frames. Make a choice, do not accept to be on a media you do not trust and give a chance to the people who work for media and outlets with a good reputation.

Make sure to understand the time constraints

If you are going to be a guest on a video or radio show make sure you know how long you can speak. This will save you from getting to the point you really want to make only when there is no time left. In general, it is good to chat with journalists for a while before going on air, so you get to understand their ways of posing questions, their requests, but you can also suggest a more interesting fact, data, story to be told to their audience than the one they were thinking of. Very often you might come up with a very interesting anecdote or an observation that

they might use as a lead to the conversation. The best interviews are not the ones made on the spot but those that have been carefully prepared.

See what you can contribute to a more complex and articulate project

The new formats in media allow a lot of experimentation, where your data, your skills, and your knowledge are really precious and unique. You might discuss a project with a journalist and see if the proposed story can be improved, made more interesting, maybe have fresher and stronger data. You can suggest locations and help shaping the narrative. Respect the journalist, since their work is different from yours, and you should not consider them as your press officer. But be ready to discuss and challenge their point of view and to help them focus more and better and to articulate the contents of the piece they are working on. Ultimately, this might not be a peer-to-peer collaboration but it can prove to be a very effective and even satisfactory relationship that will give you a chance to discuss publicly your work and to the journalists a much stronger foundation for the story they are crafting.

Endnote

This handbook was produced to inspire forest scientists and other natural scientists from various disciplines to think about the potential of their role in connecting their research significance to society for better public engagement around environment and climate change. Forests are not only important in our society, but also offer many undiscovered and unknown stories that could be told in more visual ways to help the public understand the natural ecosystem and environment better. We hope to encourage and inspire scientists to become agents of change and impact in today's journalistic efforts to report environment and climate change.

Handbooks and reports

- Climatetracker.org. Beginner's guide to writing about climate change.
- Climate outreach. 2018. Principles for effective communication and public engagement on climate change. A Handbook for IPCC authors.
- EU framework programme for research and innovation. Horizon 2020. 2014. Communicating EU research and innovation guidance for project participants
- Unesco. Series on Journalism Education. 2013. Climate change in Africa. A guidebook for journalists.

Further readings
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