

The necessary and inaccessible long-term temperature goal of 1.5° C.

A turning point in the relationship between the science and politics of the climate?

By Hélène Guillemot

Introduction

For many, it was the great surprise of COP 21: whereas the commitment to avoid global warming of more than 2° above pre-industrial levels adopted at COP 15 in Copenhagen had been constantly repeated in the six years since, the Paris COP 21 saw the emergence of an even more ambitious temperature objective of 1.5°. With the support of an increasingly broad coalition, this goal was ultimately adopted in the Paris agreement, whose first article sets out the plan to “[hold] the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre- industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change.” While this mention of a 1.5° target in the agreement was almost unanimously welcomed by state delegations and NGOs, initially it surprised, and even shocked, many climate scientists. According to model-based scenarios, limiting warming to 2° would require immediate and drastic cuts in global greenhouse gas emissions (chiefly CO₂), and even that would not be enough. The socioeconomic scenarios also include the removal of CO₂ from the atmosphere in the second half of the 21st century through “negative emissions technologies” (NETs) – technologies that currently do not exist on the required scale, and that may create negative side effects. Since the official adoption of the 2° target in 2009, greenhouse gas emissions have increased further, making the goal increasingly inaccessible – and yet in Paris an even more stringent target was being proposed.

In this chapter, we use the story of the 1.5° target to talk about science-politics relations at the COP. Climate change has been science-based since its beginnings, but COPs are political negotiating spaces where few scientists are present. They include some scientific side events, a few climate science institutions have a stand, and influential scientists, sometimes members of national delegations, are present for a few days; but generally researchers consider that they have little place at the COPs, seeing them as political, and not scientific events. However, the sciences played a particularly important role at the Paris COP: because of the exceptional scope of the event, but also because relations between climate science and climate politics are undergoing profound changes, linked to shifts in the framing of the climate problem. The 1.5° target is one of the principal questions blending science and politics that emerged strikingly during the conference.

How should we understand the paradoxical success of an arguably unattainable target? The first level of explanation is political: from this perspective, the mention of the 1.5° target in the Paris agreement is unsurprising, since it results from years of obstinate efforts by highly determined actors. But this explanation is partial: while 1.5° is a political target, it is based on scientific research and is criticized by other scientific publications. This was a new situation: the 1.5° target revealed disagreement in a domain where previously, scientific consensus was publicly expressed.

Here we will attempt to analyse the debate on the 1.5° target among scientists, surveying its history (as in fact there was already disagreement on the 2° target) and detailing the arguments and dynamics between the actors involved. The disagreements bear on long-term temperature goals, and in particular on their “safety” and feasibility. These debates are neither scientific controversies nor political disputes, but sit at the boundary between these domains. Long-term temperature goals inherently involve science-politics relations within the climate regime, and disagreements on the 1.5° target can be seen as reflecting a transformation in those relations. The Copenhagen turning point, by upsetting the framing of the problem, changed the sciences' role in the regime. The emergence of the 1.5° target and the resulting disagreements among scientists may be seen as a politicization of this domain that led to a weakening of the sciences' role. However, the heated debate set off by the 1.5° target may not

expand; it could be that instead, following the Paris conference, we are seeing an attempt by the climate science community to retake control over research agendas, and a recomposition of science-politics relations.

To address the questions raised by the 1.5° target, the debates it has stimulated, and the associated transformations in science-politics relations, this chapter combines two approaches. The first, from Science and Technology Studies, attends to the co-production of climate science and politics and to circulation between science and politics in translating and aligning issues (Jasanoff 2004) (Miller 2004) (Latour 1999). The second, based on the sociology of public problems, deals with the specific ways in which groups of actors have framed the climate problem, orienting perceptions and representations of what is at stake as well as proposed solutions.

Analyzing what took place around COP21 is not enough: the 1.5° issue can only be understood by situating it in the history of temperature goals and of relations between climate science and climate politics more generally. To clarify this history, this text is structured in a partly chronological fashion. The first part recalls the dominant framing of the climate problem and science's role in that framing since the outset, and examines the Copenhagen COP, the shift in climate governance and the history of the 2° long-term goal. The second part covers the period from the aftermath of Copenhagen up to the Paris COP, reviewing the debate on the 2° target and the rise of the 1.5° target until its adoption in the agreement. It also documents the resulting turmoil in the scientific community, analysing the positions of different groups. The third part looks at the preparation of the IPCC's upcoming Special Report on the 1.5° target and at the on-going changes in science-politics relations, during and after COP21.¹

I- 1988 – 2009. From the "science first" framing to the Copenhagen turning point

A consensual, hegemonic model of science-politics relations

Science has played a crucial role in defining the climate problem since the beginning of the regime in the late 1980s and early 1990s (with the creation of the IPCC in 1988 and the UNFCCC in 1992). In this domain, science-politics relations have often been presented in terms of the "linear" model, according to which scientists provide knowledge to political actors, who draw on these diagnoses to make decisions, with science and politics functioning independently. In this framing of the climate problem, science is the principal authority that justifies political action, leading some to speak of a "science-driven" or "science-first" problem. The IPCC adopts this model when it describing itself as "policy relevant but not policy prescriptive" and every five to seven years publishes its scientific assessment reports, including its "Summary for Policymakers" for use in UN negotiations (Dahan et Guillemot 2015).²

The linear model has long been shown to be inaccurate: the links between science and politics are more complex, and the boundaries between them more mobile and negotiated. The IPCC does not merely summarize the results of peer-reviewed research, but produces special reports ordered by governments, orchestrates consensus, and more or less directly influences research programs. The IPCC is in fact a hybrid scientific and political institution; indeed, it is precisely to its dual legitimacy, scientific and political, that the IPCC owes its remarkable authority. The place of the sciences in the climate issue thus cannot be reduced to diagnoses and assessments: in defining the problem, they also participate in defining the proposed solutions. It is the climate sciences that provide the indicators and metrics used in negotiations (mean temperature, carbon budget, CO₂ equivalent, estimates of climate change impacts, etc.).

More generally, as STS scholars have shown, climate change exemplifies the co-production of a global knowledge order and a (nascent) global political order (Miller 2004). Certain social scientists have criticized the framing of the climate regime and the claim of a policy founded on scientific authority. This model, they write, leads less to a "scientificized" politics than to a politicized science. It serves to disguise political disagreements as scientific ones (Pielke 2002), and to polarize debates

around science rather than around political responses (Sarewitz 2004), (Hulme 2011). This strong polarization around the scientific reality of climate change long made it difficult to express any critique of the climate regime (Guillemot 2014). Furthermore, this hegemonic, consensual framing was backed by a broad coalition of actors – scientists, media, NGOs, UN agencies, etc. (Aykut, Comby et Guillemot 2012).

The Copenhagen shift and the adoption of a long-term temperature goal

The Copenhagen COP deeply challenged this framing. As negotiations failed, it became clear that scientific consensus is not enough to trigger political action.³ While the scientific evidence on climate change was by then widely accepted,⁴ this very success signaled the failure of the framing, since this universal recognition did not produce political effects of the required scope. This inability to reach an agreement on the reduction of greenhouse gas emissions reflected an underestimation of geopolitical and economic factors. Far from leading antagonisms to disappear into a "common future," climate change instead revealed these contradictory interests (Aykut and Dahan 2015). After the patent failure of 20 years of "top-down" strategy, with burden sharing and legally binding reduction targets, in Copenhagen a "bottom-up" approach was adopted: the "pledge and review" system, wherein countries set their own emissions reductions commitments. But the Copenhagen COP also delivered another major "top-down" innovation: the goal of limiting global temperature increase to 2°.

The 2° global limit has a long and complex history (Randalls 2010) (Aykut and Dahan 2011) (Cointe, Ravon and Guérin 2011). Since the 1970s, the 2° figure has appeared in climate change talks in various contexts: as the mean estimate of climate sensitivity,⁵ the reference value for the first cost-benefit studies, and the proposed threshold for dangerous climate change in first international conferences. In 1990, Article 2 of the Climate Convention specified an "ultimate objective": "to achieve (...) stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system " – without specifying the level in question. However, until the late 1990s, the issue of the long term goal remained at the margins of climate debate, despite the adoption of 2° as a long-term objective by the European Union. It was in the 2000s that the long-term goal – first formulated in terms of concentrations of greenhouse gases – took on its central role in the IPCC reports and in climate negotiations. In 2005, Europe launched the proposal of a 2° target for a global agreement, at first unsuccessfully. But in 2007, the Bali COP proposed the adoption of a "shared vision" including a long-term goal. The 2° target crystallized through the continuous interaction between scientific experts and policymakers, initially associated to an atmospheric concentration of 450 parts per-million (ppm) of CO₂. The 2° target came to dominate in the months leading up to Copenhagen due to its ability to connect emissions and impacts and the ease with which it can be communicated, but also because this figure is sufficiently vague to allow several interpretations and is "less accurate and less clearly measurable than concentrations, which affords it an ambiguity that is very useful in the negotiation process" (Cointe, Ravon and Guérin 2011).

The result of a political and scientific co-construction, the 2° threshold benefited from a clear legitimacy. And yet the consensus around it was more fragile than it seemed. While politicians repeated that the 2° target was determined by "the science," scientists recalled that it was a subjective, political choice, and were divided on the subject, as we will see. Moreover, even before the Copenhagen conference certain groups were pushing for a more "ambitious" target: the Alliance of Small Island States (AOSIS) argued that 2° of warming would mean that their islands would be wiped off the map by rising sea levels. Along with the group of Least Developed Countries (LDC) and the Africa group, and with the support of leaders such as Bangladeshi Saleemul Huq, an IPCC specialist on adaptation to climate change, these countries supported the targets of 350 ppm CO₂ and 1.5° of warming. When the 2° target was adopted, these countries, grouped together in the Climate Vulnerable Forum, succeeded in pushing for the Copenhagen Declaration to call additionally for "strengthening the global long-term goal during a review by 2015, including in relation to a proposed 1.5°C target." Thus, the debate on the 2° and 1.5° targets was already in the making at the Copenhagen conference.

II- 2009 – 2015. From a hushed debate on 2° to the public emergence of disagreement on 1.5°

Between the COPs in Copenhagen in 2009 and in Paris in 2015, the 2° target was constantly reaffirmed in climate arenas, but a much wider range of views on long-term goals was expressed in scientific journals. Some articles emphasized the extreme difficulty of attaining the 2° target; others were more optimistic on its feasibility; still others affirmed the need for a 1.5° target due to the gravity of the impacts of 2° of warming; only very few, however, claimed that it is also possible to limit warming to 1.5°. These disagreements, initially confined to a narrow scientific milieu, emerged publicly at the time of the Paris COP.

Warning on the feasibility of the 2° target

In 2009, a survey by the British newspaper *The Guardian* showed that 85% of climate scientists did not believe it would be possible to limit warming to 2°. ⁶ This level of warming by 2100, considered likely in 1995, seemed extremely difficult to attain 15 years later, due both to growth in greenhouse gas emissions over this period (+30% between 1995 and 2010) and to progress in the climate sciences.

Since 2010, global mean temperature has been often associated to a new dominant metric, the "carbon budget" (Allen, et al. 2009). Due to the long life of CO₂ in the atmosphere, global mean surface warming by 2100 will be determined by cumulative CO₂ emissions. Thus, a carbon budget is associated to each temperature target, with a probability distribution reflecting the associated uncertainties. A two-thirds chance of remaining under 2° of warming translates into a carbon budget of 1,000 GtC (gigatons of carbon). Since we have consumed around 520 GtC since the start of the Industrial Revolution, this leaves another 480 GtC. If we content ourselves with a 50% chance of remaining under 2°, the total budget is 1,300 GtC, and the remaining budget is 820 GtC. If the aim is a 66% chance of limiting warming to 1.5°, the remaining carbon budget decreases to 400 GtC (Rogelj, Hare, William, et al. 2011). ⁷ At the emissions rate of recent years we will have used up the budget for the 2° target (at 66% probability) in two decades – three to 10 years for the 1.5°C target.

Between 2010 and 2015, various scientific articles and reports warned of the challenge of reversing the trend of emissions for attaining the 2° target (Peters, et al. 2013) ; (Friedlingstein, et al. 2014). The review of the 2° target launched by the Climate Convention to respond to the demand in the Copenhagen agreement spurred a debate on the long-term temperature target. To give but one example, in a *Nature* article entitled "Ditch the 2° warming goal," the political scientist David Victor and the physicist Charles Kennel criticized not only the 2° target, but the very principle of a long-term mean temperature target, which they argued is both politically counter-productive and of little scientific relevance, and called for it to be replaced with "an array of planetary vital signs" (Victor et Kennel 2014). The article spurred dozens of responses from scientists and environmentalists defending mean temperature as the best scientific indicator (because of its direct link to both emissions and impacts) and the 2° figure as accessible and politically effective.

Optimistic scenarios and negative emissions

Alongside articles criticizing the 2° goal or highlighting the difficulties of meeting it, other scientific publications concluded, to the contrary, that it was attainable. Paradoxically, between 2010 and 2015, as greenhouse gas emissions continued to grow, a series of increasingly optimistic decarbonization scenarios were published (Rogelj, Luderer, et al. 2015), (van Vuuren, et al. 2011). This paradox is easily explained: the 2° scenarios rely overwhelmingly on "negative emissions technologies" (NETs) that remove carbon from the atmosphere on a large scale. These scenarios are produced by integrated assessment models, ⁸ which set out pathways for socioeconomic evolution according to a given global temperature target and time horizon. On the basis of a portfolio of technologies with associated costs, these models choose the most cost-effective technology for the assigned target. Remaining below 2° of warming in this century (or not exceeding the carbon budget of 1,000 GtC)

requires a very rapid drop in CO₂ emissions around the world, to "zero emissions" within a few decades. Given that this seems to be unachievable, the other alternative is a temporary overshoot of atmospheric CO₂ concentrations, followed by "sucking" carbon out of the atmosphere in the second half of the 20th century through NETs.

Among these technologies, the most widely invoked in 2° scenarios is "bioenergy with carbon capture and storage" (BECCS). It consists in growing plants for bioenergy, burning them, capturing the carbon dioxide released in the process, liquefying it under pressure, and storing it underground. The (theoretical) net result is that atmospheric CO₂ is absorbed through photosynthesis and then stocked under the surface of the Earth while producing energy. These technologies have only been tested experimentally, and they pose various problems: they may be very costly, they require safe geological storage on a large scale, leakage rates could be high, and above all, they would require an enormous proportion of the Earth's total arable land (on the order of the surface area of India, by some estimates). In the fifth IPCC report (published in 2013), out of the 400 scenarios with a 50% probability of warming below 2° in 2100, 344 assumed large-scale use of BECCS (the others assumed that emissions would peak in 2010, and are thus already obsolete).

NETs' central place in the IPCC scenarios is due to the adoption of the 2°C target, which pushed scientists to develop simulations capable of meeting it (Guivarch et Hallegatte 2013). "A few years ago, these exotic Dr. Strangelove options were discussed only as last-ditch contingencies. Now they are Plan A," writes Kevin Anderson, deputy director of the Tyndall Centre for Climate Science Research (Anderson, Talks in the City of Light generate more heat 2015). The incentives to provide 2° scenarios are not only political, but moral (abandoning the 2° target is defeatist) and even financial (funding agencies reward technological optimism). The political imperative can also bias the scientific diagnosis, as "when a stringent target is revealed as infeasible with a given model, it simply does not appear in the literature" (Guivarch et Hallegatte 2013).

The rise of the 1.5°C target

During the same period, between the Copenhagen and Paris conferences, the 1.5° target progressively gained momentum, both politically and scientifically. Following the demand to "[strengthen] the global long-term goal" in Copenhagen, the Climate Convention tasked the SBSTA⁹ with creating a "Structured Expert Dialogue" that brings together scientists and state representatives between 2013 and 2015. In May 2015, this body submitted a 200-page report arguing that the 2° target, although beneficial, would fail to save some countries, populations, and ecosystems, and that "limiting global warming to below 2°C is still feasible and will bring about many co-benefits, but poses substantial technological, economic and institutional challenges."¹⁰ The same diagnosis was offered in 2010 in a report from the Grantham Institute on Climate Change and the Environment,¹¹ and in 2014 by a report for the World Bank by the think tank Climate Analytics.¹²

In the months before the Paris COP, the Climate Vulnerable Forum effectively lobbied politicians, civil society, and the media, promoting the 1.5° target with the help of scientific advisors from the powerful European Climate Foundation, a major philanthropic initiative (see chapter xxx). They recalled that a global increase of 2° would have severe impacts, that would affect ecosystems, sea levels, and extreme events, and that the impacts would be greatest in vulnerable countries. They affirmed, on the other hand, that the 1.5° objective was accessible, citing the low-emission scenarios in the last IPCC report. The 2° target was set by Europe and the developed countries, they argued, but for poor countries the danger threshold is 1.5°: not accepting this target is tantamount to telling vulnerable countries that we do not care to protect them. Shortly before the Paris conference, the government of the Marshall Islands (assisted by a non-profit advisory group) launched a "High Ambition Coalition," which demanded a reference to the 1.5° threshold as a prerequisite to any agreement. Rallying the support of NGOs as well as more than 100 countries before and during the COP, the coalition succeeded in its goal, almost unanimously hailed as a victory.

Politically, this target pleased nearly everyone. For vulnerable countries, it represents a bargaining chip for later negotiations: if it is officially recognized that more than 1.5° of warming is dangerous, they can subsequently seek reparations for resulting losses and damages. For developed countries,

backing the 1.5° limit meant obtaining the signatures of these states without explicitly committing to financial compensation. And institutions and think tanks backing the 1.5° target were all concerned with avoiding a repetition of the failure in Copenhagen, creating favorable "momentum," and obtaining an "ambitious" agreement. The success of the 1.5°C target thus resulted from long-term political aspirations— although it also played out in the final days and hours of the Conference.

Surprise at the COP

Many climate scientists first expressed surprise – and in some cases, even indignation – at the inclusion of the 1.5°C target in the agreement,¹³ before resigning themselves to it, viewing it above all as a political compromise.¹⁴ One event that reflected these questionings was an improvised press conference organized in the Bourget convention centre on Friday, December 11th – the eve of the adoption of the agreement – by the communications officers of the International Council for Science (ICSU) and several major research centers present at the COP. Although it was assembled at the last minute, the press conference brought together 200 journalists and other observers to hear the comments of five prominent scientists on the draft agreement, in particular the long-term goals and the 1.5° target.¹⁵ In principle, these scientists represented divergent positions, with leaders from institutions producing both 2° and 1.5° scenarios among them, as well as a famous critic of these scenarios, the Tyndall Centre's Kevin Anderson. But the message they delivered was coherent, constructive and relatively critical. They welcomed the inclusion of the 1.5°C target in the draft, affirming that it was consistent with the science, but criticized the rest of the text as insufficiently ambitious to achieve this goal. The panelists emphasized that to limit warming to 1.5°, emissions would need to begin decreasing by 2020, reaching zero by 2050, Anderson also pointed out the text's failure to mention emissions from shipping and aviation.

Until the Paris conference, debate on the 2° long-term goal had been confined to the relevant scientific circles, and its implications had not been publicly discussed (although the 2° scenarios and NETs were mentioned in the Summary for Policymakers of the latest IPCC report). Since 2015 and the COP 21, however, this debate has exploded in scientific journals (particularly from the Nature Publishing Group), as well as the press and the Internet. It is not the goal in itself that stirred these various actors to speak out, as both goals require massive transformations of the economy and a very high degree of political will (although the 1.5° target imposes more stringent requirements).¹⁶ The difference between the 2° and 1.5° goals doubtless lies less in their implications than in how they were adopted. As mentioned above, the 2° threshold was co-constructed in a long process that took place between science and politics. It was considered legitimate and there was an official consensus around it, although internal debate existed. The 1.5° target, in contrast, obviously responded to a political demand. The tensions and difficulties surrounding a long-term goal that will be very difficult to meet, which remained latent at 2°, came to be expressed openly both within and beyond the scientific community. The 1.5° target shattered the previous consensus.

The blurry region of long-term goals

While the success of the 1.5° target is political, it is based on scientific reports and articles. The disagreement on the 1.5°C target does not oppose scientists and politicians; nor is it a scientific controversy. The debate is on long-term temperature objectives, and more particularly on their "safety" (or dangerousness) and "feasibility," notions that simultaneously involve scientific elements and value judgments. Neither purely scientific nor exclusively political, the debate on the 1.5° target, and on long-term goals more generally, takes place in a blurry region between these two domains, and brings their relations into play.

In reality, safety (or dangerousness) is no longer at stake in the debate: first, because recent research has demonstrated the severity of the impacts associated to 2° of global warming; but also because scientists are reluctant to identify a danger threshold, seeing this as "a compromise between what is deemed possible and desirable, rather than a 'planetary boundary' that clearly separates a 'safe' from a

'dangerous' world" (Knutti, et al. 2016). The debate around the Paris COP has focused instead on the "feasibility" of the 1.5° (or 2°) target.

The researchers involved in these debates on long-term goals belong to a number of communities, including climatologists working on long-term projections of climate change (authors from IPCC Working Group I), specialists on the impacts of global warming on different ecosystems and societies (Working Group II), and economists from Working Group III on mitigation. The debate also includes social scientists and experts working on climate policies, and representatives of think tanks and institutes defending the 1.5° target. But the central actors here are scientists developing and using integrated assessment models to produce scenarios known as "deep decarbonization pathways". A handful of research centres in the world develop integrated models, including three particularly influential European institutes: the International Institute for Applied Systems Analysis (IIASA), based in Vienna and founded in 1972, played a major role in global pollution assessment in the 1980s; the PBL (Netherlands Environmental Assessment Agency), which has been developing integrated models since the late 1980s; and the Potsdam Institute for Climate Impact Research (PIK) in Germany, which has had a central role in this field in recent years. There are other centres producing such models in the United States, Japan, and France. Among these centres, some are academic institutions, while others are more oriented toward a political advisory role.

Divergences at the boundary between science and politics

There are in reality very few scenarios based on the 1.5° target (Rogelj, Luderer, et al. 2015), although those that have been produced are widely cited by think tanks and NGOs promoting this target. The scientists who produced these scenarios all belong to one of the influential institutes mentioned above: IIASA, PBL, or PIK. They do not speak out in favor of this goal and do not hide the extremely stringent conditions that it would impose. At first glance, different scientists seem to hold very similar views on the 1.5° target (as we saw with regard to the press conference): all consider that 1.5° of warming would be preferable, recognize the extreme difficulty of achieving this target, and criticize the inadequacy of mitigation goals. Nonetheless, these scientists express diverse perspectives on feasibility, which they themselves sometimes label as "optimistic" and "pessimistic." The "optimists," most associated to the institutes producing 2° and 1.5° scenarios, mainly emphasize the severity of the impacts of 2° of warming, rather than the impacts of NETs. They do not consider the social or political feasibility of the goal: Ottmar Edenhofer, director of PIK and ex-co-chair of IPCC Working Group 3, says that his work is to set down a "cartography of pathways," which it is up to politicians to navigate (Edenhofer and Kowarsch 2015). These scientists focus above all on the "signal" that this ambitious target represents for politicians and industrialists, its potential to leverage action, more than on its means of attainment.

"Pessimistic" scientists – that is, those who are critical of the 2° and 1.5° targets – give greater weight to the implications of these long-term goals. According to some political scientists, a goal that is very difficult to attain, rather than leveraging action, acts as a "substitute for appropriate action" (Geden 2015), and its lack of credibility can undermine the negotiation process. Critical scientists view the long-term target as involving physical, economic, political, and social constraints; they often criticize the simplistic character of the integrated models and their implicit hypotheses, which neglect uncertainties and inertia – the constraints of geology and agriculture as well as of labour markets and finance. Kevin Anderson (2015), cited above, presents a political critique of the 2° scenarios: this target, he argues, supposes "a virtual elimination of CO₂ from the energy system by 2050" and demands profound and immediate changes to the consumption and production of energy... but paradoxically, he adds, experts continue to claim that these drastic transformations will have little effect on economic growth. Moreover, to critical authors, the 1.5° (or 2°) scenarios involving massive recourse to NETs suggest a future more dystopian than utopian, a "brave new world" requiring the management and exploitation of land on a planetary scale. An official from the Natural Environment Research Council (UK) for instance claims that large-scale CO₂-removal could "cause a loss of terrestrial species at the end of the century perhaps worse than the losses resulting from a temperature increase of about 2.8 °C above pre-industrial levels" (Williamson 2016). According to a number of

accounts, pessimistic scientists were pressed not to openly cast doubt on the 1.5° goal during the Paris negotiations.

These groups of scientists are not distinguished by their discipline or their political orientations, but by their divergent conceptions of the political role of the target and the prerogatives of scientists. Critical scientists see these scenarios as akin to "magical thinking" or "science fiction"; others argue that they can have a political effect, spurring change. These different conceptions seem to be linked to the institution that these scientists belong to and to its links with politics and expertise. This connection has already been studied in the case of climate modeling: there are a number of distinct ways to practice modeling, which are tied to the culture of particular research centres and their relationship to politics (Shackley 2001). Depending on what institution they work within, scientists are more or less inclined to "adjust to policy expectations" (Shackley, Risbey, James, et al. 1999). We may hypothesize (noting that further evidence is needed) that the same is true for scientists studying decarbonization pathways, which are more directly linked to politics. These scientists maintain connections to policymakers and NGOs, are involved in the IPCC or in the definition of research programs, and have responsibilities at several levels (national, European, international). The coproduction of global kinds of knowledge and politics that shape the role of decarbonization scenarios takes place concretely and locally through these various connections (Hulme 2010).

III- A new role for the sciences

From the narrative of consensus to the narrative of the gap

The debate on the 1.5° target may be interpreted to reflect a change in the relationship between the science and politics of the climate. One manifestation of this change is the emergence of a central theme in the climate change narrative: the topos of the gap. The gap has become a major subject of scientific climate expertise since the adoption of a long-term temperature goal: the coexistence of "bottom-up" commitments and a distant goal calls for the measurement of the gap between them, which is done notably in the "Emissions Gap Report" published annually by UNEP since 2010, as well as other research comparing the INDCs and the 2° target. But beyond these scientific measurements, the theme of the gap has also become ubiquitous in how the climate problem is represented, via various wordings: inconsistency, schism (Aykut and Dahan 2015)... What is novel here is not the reality of a gap between what "the science" recommends and what politicians accomplish, but the place of the gap in the climate change narrative. Before the Copenhagen COP, what was important was to jointly support a scientific diagnosis expected to lead to a global agreement (without specifying the means). Since Copenhagen, the climate regime has no longer been characterized by continuity between science and politics, but by the gap between them. The consensus on the science having proven to be both solid and unable to spur political action, it is now seen as less essential; critics – of climate governance, the UN, and the framing of the climate problem – now express themselves more freely. Copenhagen confirmed that the scientific diagnosis is not automatically translated into public policy. Politics must choose between conflicting priorities, and is generally not coherent with scientific knowledge: inconsistency is inherent to policymaking (Geden 2015).

If we admit that there is a gap between science and politics, does this mean that the authority of the sciences in the climate regime is weakening? The problem of the 1.5° target may seem to suggest so. An IPCC researcher involved in the 2013-2015 Structured Expert Dialogue on the long-term goal admitted that the 1.5°/2° target "is about our respective willingness to understand and buffer against risk and to pay for abatement and compensation, not merely about reaching or not reaching a single-index number goal" (Tschakert 2015). This politicization of the climate problem may seem like a natural evolution: after a phase of alarm grounded in a consensual scientific diagnosis, the phase of economic and technological choices is necessarily more conflict-laden and political. Have we moved, then, from a "science-first" to a "policy-first" framing? From a scientific consensus that was supposed to unify politics to political division that has propagated into science ?

The challenges of the 1.5° Special Report: crisis and reframing

It is not clear that the disagreements around the 1.5° target will continue and lead to durable rifts in the scientific community. The situation has been evolving rapidly since the Paris COP, as time is short for climate scientists: in December 2015, the Conference of the Parties requested that the IPCC "provide a Special Report in 2018 on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways." The IPCC, at a plenary meeting in April 2016, responded positively, explaining that this Special Report will look at global warming of 1.5°C "in the context of strengthening the global response to the threat of climate change, sustainable development and efforts to eradicate poverty." However, this report presents a challenge for the climate sciences community: first, there are few studies on the 1.5° target, and the deadline is very tight to produce more; second, the 1.5° target has major diplomatic implications, so the report will be subjected to scrupulous political examination by all parties; and above all, many researchers find working on the 1.5° target problematic.

Responding to governments' requests is part of the IPCC's functions; the report can be justified insofar as the target is recognized as legitimate and the related domain little explored. But while the request is consistent with the relationship between the IPCC and the political process, it is more controversial in the context of relations between the IPCC and the research world (Hulme 2016). Climate research has indeed long been structured around the problem of climate change, but many researchers are uncomfortable working on a 1.5°C target that they consider "a lost battle." They see this research as a waste of time and resources, which "may distract the community from focusing research efforts on the risks and impacts of warming scenarios between 2°C and 4°C," which are "more likely to happen" – and even as "a form of hypocrisy, sustaining false hope from the public and most vulnerable countries" (Boucher, et al. 2016). Some argue, as an French agricultural economist said bluntly, "the science should not respond to issues of partisan politics." Others feel that they are caught in a double bind, forced to live with the contradiction inherent in a target that is both necessary and inaccessible: "Personally, I'm in a fix," one CIRED researcher said. "If we don't make these scenarios, we're absent; if we say it's not possible [to meet the 1.5°C target] we're the bad guys; if we do it, people will say our scenarios are useless." Moreover, researchers have in mind many other research topics that they see as more interesting, both scientifically and politically.

Scientists working on climate change are thus caught between a rock and a hard place: most of them do not believe in the possibility of attaining the 1.5° target, or even the 2° target, but they want to respond to environmental concerns and the demands of poor countries. Their challenge is thus to reframe the 1.5° report by transforming the obligation to issue the report into an opportunity to perform interesting and novel research. As they prepare the report's outline, the co-chairs of the three working groups are at work on this reframing.¹⁷ Climatologists and economists are making proposals aimed at launching "new directions for climate change research" (Boucher, et al. 2016). By doing so, these researchers are working to align the interests of scientists and policy makers (Latour 1999), reappropriating a political demand to make it of interest to researchers.

The Special Report may change the dynamic around long-term goals, creating convergence of interests rather than deepening rifts. All scientists in the domain, whether or not they are critics of the 1.5° target, recognize that the hypotheses underlying 2° and 1.5° scenarios must be made more explicit (Edenhoffer and Kowarsch 2015). Whereas advocates of the 1.5° target were defending it "at all costs" to save small island countries, since its success at the Paris COP, civil society actors have been taking a greater interest in its implications.¹⁸ Research has begun to specify the conditions and limitations of negative emissions technologies (Smith, et al. 2015). The 1.5° Special Report will be an opportunity to study the impacts, not only of 1.5° of warming, but also of the economic and technological measures suggested to meet this target.

In the climate sciences, the 1.5° Special Report may also provide an opportunity to bridge research gaps. Most articles on the 1.5° target have been published in the "opinion" pages of scientific journals. Opinions must now be grounded in specific research: for example (as suggested by a climatologist from the LSCE), by renewing the study of methane and aerosol emissions, which will play a greater

role if CO₂ emissions are lower. The 1.5° report can offer the community a chance to study the limitations of existing tools, clarify uncertainties, and connect the perspectives of different disciplines. It should also allow climate economists to advance with what has been missing from Working Group III: studies on how to trigger the transition, connecting short-term efforts to long-term objectives and national economic scenarios to global ones (Boucher, et al. 2016). Reformulating the problem of the 1.5° target may also mean, in the words of a CIRED economist, not asking whether the target is attainable but why it is not (conditions of implementation, land use...). In short, this reframing could clarify not only technical but also social sources of inertia.

In search of a new form of coproduction between science and politics

Inevitably, the paradigm shift in climate governance at Copenhagen COP affected the relationship between science and politics that is at the heart of the framing of the climate problem. The case of the 1.5° temperature goal is symptomatic of this change. Although the demands and difficulties created by the 1.5° goal already existed with the 2° goal - and in that sense the shift is not a dramatic break - the success of the stricter target on political grounds, which caught the scientific community off guard, attests to a shift in the balance of power between science and politics. The climate sciences have never been independent of politics, and the model of coproduction continues to account for their interrelations. Nevertheless the 1.5° target reflects a form of coproduction distinct from that which led to the 2° target: this shift could be described as one from “science-driven coproduction” to a “policy-driven coproduction.”

The sciences of climate change are facing the unprecedented situation of having to produce a report on a long-term target that they know to be unattainable in order to satisfy a political demand. The IPCC accepted this request, and many researchers do not want to be left out of the process, cutting themselves off from the political process and from developing countries. They must thus make sense of this target. Although some researchers consider that more work must be done on the issue of feasibility, many want to move beyond this problem and reformulate the demand in scientifically more relevant and interesting terms. The 1.5° Special Report will probably undertake a much broader investigation of the implications of the target, exploring the connections between short and long term, and between climate change and other environmental, social, and economic problems. The aim is also to produce “policy-relevant” knowledge, a requirement for the sciences to maintain their central role, and thus to contribute to “solutions” to the climate problem, another pressing demand facing scientists today.

To conclude, let us return to the question posed throughout this book: How are science-politics relations changing in an increasingly “climatized” world? What is the “climatization of the world” doing to climate science? After the turning point in Copenhagen, and still more after the Paris COP, the phase of a global, consensual alarm is now behind us. The issue is no longer informing negotiators of the scope of the problem, but to respond to a more diverse and fragmented set of scientific and political questions. While the sciences have largely contributed not only to defining the climate problem but also to extending it into numerous domains (agriculture, economics, etc.), today these climatized domains are presenting the sciences with numerous questions: regionalizing climate change, solutions to climate problems, insights into trade-offs with other problems (environmental or otherwise)... In this extension of the domain of expertise, the climate question is no longer isolated. Scientific research must take into account other factors, including political factors, which constitutes a profound change in the role of the sciences in the climate regime. The 1.5° target, which responds to a demand from small island countries, can also be seen through this prism.

Bibliographie

n.d.

- Allen, Myles, et al. "Warming caused by cumulative carbon emissions toward the trillions tone." *Nature* 458 (2009): 1163-1166.
- Anderson, Kevin. "Duality in climate science." *Nature Geoscience* 8 (2015): 898-900.
- Anderson, Kevin. "Talks in the City of Light generate more heat." 528 (2015): 437.
- Aykut, Stefan, and Amy Dahan. *Gouverner le climat? Vingt ans de négociations internationales*. Paris: Presses de Sciences Po, 2015.
- Aykut, Stefan, and Amy Dahan. "Le régime climatique avant et après Copenhague: sciences, politiques et l'objectif des deux degrés ." *Natures Sciences Sociétés* 19 (2011): 144-157.
- Aykut, Stefan, and Amy Dahan. "Le régime climatique avant et après Copenhague: sciences, politiques et l'objectif des deux degrés." *Nature, Sciences, Sociétés* 19, no. 2 (2011): 144-157.
- Aykut, Stefan, Jean-Baptiste Comby, and Hélène Guillemot. "Climate change controversies in French mass media 1990-2010." *Journalism Studies* 13, no. 2 (2012): 157-174.
- Boucher, Olivier, et al. "In the wake of Paris Agreement, scientists must embrace new directions for climate change research." *PNAS* 113, no. 27 (2016): 7287-7290.
- Cointe, Béatrice, Paul-Alain Ravon, and Emmanuel Guérin. *2°: the history of a policy-science nexus*. working paper, IDDRI, 2011, 28.
- Dahan, Amy, and Hélène Guillemot. "Les relations entre science et politique dans le régime climatique: à la recherche d'un nouveau modèle d'expertise?" *Natures, Sciences, Sociétés* 23 (2015): 6-18.
- Edenhoffer, Otmar, and Martin Kowarsch. "Cartography of pathways: a new model for environmental policy assessment." *Environmental Science and Policy* 51 (2015): 56-64.
- Friedlingstein, Pierre, et al. "Persistent growth of CO2 emissions and implications for reaching climate targets." *Nature Geoscience* 7 (2014): 709-715.
- Geden, Oliver. "The trouble with targetism." *The Guardian*, 15 december 2015.
- Guillemot, Hélène. "Les désaccords sur le changement climatique: au-delà d'un climat bipolaire." *Natures, Sciences, Sociétés* 22 (2014): 340-350.
- Guivarch, Céline, and Stéphane Hallegatte. "2°C or not 2°C? ." *Global Environmental Change* 23 (2013): 179-192.
- Hulme, Mike. "1.5° and climate research after the Paris Agreement." *Nature Climate Change* 6 (2016): 222-224.
- Hulme, Mike. "Problems with making and governing global kind of knowledge." *Global Environmental Change* 20 (2010): 558-564.
- Hulme, Mike. "Reducing the future to climate: A story of climate determinism and reductionism." *Osiris* 26,1 (2011): 245-266.
- Jasanoff, Sheila. *States of Knowledge: The Co-production of Science and Social Order*. London: Routledge, 2004.
- Knutti, Reto, Rogelj, Joeri, Sedlacek, Jan, and Fischer, Erich. "A scientific critique of the two-degree climate change target." *Nature Geoscience* 9 (2016): 13-18.
- Latour, Bruno. *Pandora's Hope. Essays on the Reality of Science Studies*. Cambridge: Harvard University Press, 1999.
- Miller, Clarke. "Climate Science and the Making of a Global Political Order." In *States of Knowledge: The Co-production of Science and Social Order*, by Sheila Jasanoff, 46-66. London: Routledge, 2004.
- Peters, Glen, et al. "The challenge to keep global warming below 2°." *Nature Climate Change* 3 (2013): 4-6.
- Pielke, Jr, Roger. "Policy, politics and perspective." *Nature* 416 (2002): 368.

- Randalls, Samuel. "History of the 2°C climate target." *Wiley Interdiscip Rev Climate Change* 1 (2010): 598-605.
- Rogelj, Joeri, et al. "Emission pathways consistent with a 2° global temperature limit." *Nature Climate Change* 1 (2011): 413-418.
- Rogelj, Joeri, et al. "Energy system transformations for limiting end-of-century warming to below 1.5°." *Nature Climate Change* 5 (2015): 519-527.
- Sarewitz, Daniel. "How science makes environmental controversies worse." *Environmental Science and Policy* 7 (2004): 385-403.
- Shackley, Simon. "Epistemic lifestyles in climate change modeling." In *Changing the atmosphere: Expert knowledge and Environmental Governance*, by Clarke Miller and Paul Edwards. Cambridge: MIT Press, 2001.
- Shackley, Simon, Risbey, James, Stone, Peter, and Wynne, Brian. "Adjusting to Policy Expectation in Climate Change Modeling." *Climatic Change* 43, no. 2 (1999): 413-454.
- Smith, Pete, Davis, Steven, Creutzig, Felix, Fuss, Sabine, Minz, Jan, and Gabrielle, Benoit. "Biophysical and economic limits to negative CO₂ emissions." *Nature Climate Change* 6 (2015): 42-50.
- Tschakert, Petra. "1.5°C or 2°C: a conduit's view from the science-policy interface at COP 20 in Lima, Peru." *Climate Change Responses*, 2015.
- van Vuuren, Detlef, et al. "RCP 2.6: exploring the possibility to keep global mean temperature increase below 2°." *Climatic Change* 109 (2011): 95-116.
- Victor, David, and Charles Kennel. "Climate Policy: Ditch the 2° warming goal." *Nature* 514 (2014): 30-31.
- Williamson, Phil. "Emissions reduction: Scrutinize CO₂ removal methods." *Nature* 530 (2016): 153-155.

¹ This text is based on field work conducted at and around the Paris COP, on the analysis of numerous scientific publications in various journals and websites, and on interviews with scientists I want to thank for their help and availability: Olivier Boucher (Laboratoire de Météorologie Dynamique, LMD), Philippe Ciais (Laboratoire des Sciences du Climat et de l'Environnement, LSCE), Pierre Friedlingstein (University of Exeter), Céline Guivarch (Centre International de Recherche sur l'Environnement et le Développement, CIRED), Franck Lecoq (CIRED), Corinne Le Quéré (Tyndall Centre), Valérie Masson Delmotte (LSCE, co-chair IPCC Working Group 1) and Denise Young (International Council of Scientific Unions, ICSU). Most interviews were conducted in collaboration with Amy Dahan, whom I thank for stimulating exchanges.

² The climate problem involves many areas in the natural sciences as well as the social sciences and economics, which have different relationships to politics. However, in public discourse, the use of the term "sciences" is usually reserved for the natural sciences.

³ The "consensus" in question is that on the scientific reality of global warming and its anthropic origins. Beyond this consensus, there are scientific debates in all domains: on the intensity of climate change; its effects, its manifestations in different regions, its impacts, the risks associated to a given level of warming, the corresponding costs, etc.

⁴ Although climate skepticism persists in certain political circles, notably in the United States and Australia.

⁵ "Climate sensitivity" is the change in mean temperature at the Earth's surface that results from a doubling of the atmospheric concentration of CO₂

⁶ For the poll, the Guardian contacted all registered participants in the scientific conference organized in Copenhagen in March 2009, in the leadup to the December COP. Out of 1756 participants, 261 responded, including 200 climate scientists. <https://www.theguardian.com/environment/2009/apr/14/global-warming-target-2c>

⁷ These figures are subject to large uncertainties, and vary depending on whether emissions linked to land use, non-CO₂ greenhouse gases and aerosol emissions are taken into account.

⁸ Integrated assessment models (IAMs) differ from global climate models (GCMs). GCMs are physical models (very similar to those used for weather forecasting), whose algorithms are drawn from physical laws and that

describe atmospheric movements and their evolution with increasing greenhouse gas concentrations. IAMs are socio-economic models consisting of several modules (climate, land use, energy use, etc.) that describe how different parameters change over time under different constraints (such as a temperature target).

⁹ The SBSTA (Subsidiary Body for Scientific and Technical Advice) is a body of scientific experts whose role is to advise the Climate Convention on matters of science, technology and methodology. It is open to the participation of all parties, and has a key role in science-politics relations in the climate regime.

¹⁰ Report on the structured expert dialogue on the 2013–2015 review, UNFCCC, Message 6
<http://unfccc.int/resource/docs/2015/sb/eng/inf01.pdf>

¹¹ <http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2014/02/PB-global-warming-mitigating.pdf>

¹² One of the authors of the World Bank report, Bill Hare, is also one of the most influential experts promoting the 1.5°C target. A regular at COPs for more than two decades, Hare, previously the climate policy director for Greenpeace International, is founder and CEO of Climate Analytics, a German think tank whose mission is "to help provide scientific and technical advice about climate change to the poorest and most vulnerable developing countries." See also the chapter by Edouard Morena in the present volume.

¹³ "To me 1.5° is delusional," a French climatologist said; "It's the stupidest thing they could do," a World Bank economist exclaimed; "When I hear 1.5° I want to cry," admitted a Tyndall Centre researcher.

¹⁴ "It's a diplomatic compromise that has little basis in the sciences. But you can understand vulnerable countries playing this card," declared a climatologist from the LMD. "Poor countries and small islands have been focused on this target for ten years, their delegates can't go home without getting it," according to one expert on the negotiations. "I wasn't surprised: it's how they got poor countries into the agreement," said a climate economist from the CIRED, "There's been a lot of research, the vision on the impacts has changed, it's getting more and more alarmist."

¹⁵ The panel of scientists at the December 11th press conference consisted of Hans Joachim Schellnhuber, Director of the PIK; Johan Rockstrom, Director of the Stockholm Resilience Centre; Steffen Kallbekken, Research Director at CICERO; Kevin Anderson, Deputy Director of the Tyndall Centre; and Joeri Rogelj, IIASA.

¹⁶ "The technologies required for the 1.5°C scenarios are the same as for the 2°C pathway, but need to be deployed faster, and energy demand needs to be reduced earlier, implying a higher cost than in the 2°C scenarios." Report on the Structured Expert Dialogue on the 2013–2015 review, UNFCCC

¹⁷ As of this writing, in May and June 2016, the content of the 1.5° Special Report is unknown.

¹⁸ The first session of the Climate Convention after the Paris Agreement, held in Bonn in May 2016, saw a heated debate on BECCS technologies. Several African networks issued a joint statement entitled "Sacrificing the global South in the name of the global South: Why the 1.5°C goal must not be met with land grabs."