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(Anti)-boundary work in global environmental change research and assessment

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ABSTRACT

In the 1990s, a discourse emerged within global environmental change research underlining the need to go beyond previously held boundaries between science and society. While not entirely new, this discourse has however reached the highest levels of scientific cooperation embodied among others in the Future Earth (FE) platform and the Intergovernmental Panel on Climate Change (IPCC). Using the concept of (anti)-boundary work developed in Science and Technology Studies (STS), we trace shifts in discourses about the boundaries between social and natural disciplines; between scientists and societal actors; and finally, between the definition of problems and the provision of solutions. We do so analyzing the emergence of global sustainability and solution-oriented science in the discourses of scientific and political actors involved in FE and the IPCC. We conclude with a discussion of challenges connected to the implementation of solution-oriented research and assessment. This article is part of a special issue on solution-oriented GEAs.

1. Introduction

In the last few decades, scientists and experts have assumed an increasingly prominent role in global environmental politics. From the 1980s, the growing concern for environmental problems has led to a multiplicity of international conventions that heavily rely on technical and scientific inputs (Miller, 2001; Mitchell et al., 2006). In order to provide such inputs, there has been a proliferation of scientific programs, organizations and Global Environmental Assessments[1](GEAs) through which scientific knowledge is coordinated and reappropriated by policy-makers (Mitchell et al., 2006; Riousset et al., 2017). The climate change regime[2] is one of the best examples of this trend, with the establishment of scientific programs like the *World Climate Program* (WCP) or the *International Geosphere Biosphere Program* (IGBP) in the 1980s and of the *Intergovernmental Panel on Climate Change* (IPCC) in 1988 (Demeritt, 2001; Edwards, 2010). The new international platform, Future Earth (FE), created in 2012, is seeking to bridge existing cooperation around the notion of 'global sustainability' science.

Most environmental – and particularly the climate – regimes have been conceived according to a rather simplistic model in which an independent and consensual expertise is expected to lead to rational policy-making (Pielke, 2007; Beck, 2011, 2012). According to such prominent but contested understanding (Morin et al., 2013), the more science is isolated from politics, the more influentially it will "speak truth to power" (Haas, 2004; p. 583). Knowledge production should be untainted by political interference and evaluated through objective peer review. Only after consensus is reached among scientists, can knowledge be transmitted to policy-makers and serve as the basis for international negotiations. A similar separation is often established between the different scientific disciplines – with the social sciences often considered secondary compared to the natural sciences (Mooney et al., 2013).

In the last decade, however, this traditional model has been increasingly questioned, particularly with reference to the climate change regime, which, it is argued, should no longer be framed as a

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[1] A broad definition of GEAs is given by Biermann (2002, p. 195): "the immense networks of scientists, experts, national governments, private bodies, and international organizations engaged in these major global environmental assessments can be understood as distinct international institutions within the larger endeavor of global environmental governance, consisting of internationally accepted general principles for producing, synthesizing, and legitimizing expert knowledge; international norms and rules regulating this synthesis and the evaluation of knowledge in specific cases; and pertinent decisionmaking procedures".

[2] We refer to the widely used definition by Krasner (1982, p. 186) of regimes as "sets of implicit or explicit principles, norms, rules, and decision-making procedures around which actors' expectations converge in a given area of international relations". Regimes can include both scientific and political institutions.

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problem of global pollution with marginal social and political dimensions (Hulme, 2009; Goeminne, 2012; Dahan, 2014). Under the hallmarks of 'global sustainability' and 'solution-oriented' science, a new discourse has emerged arguing against these strict separations of scientific disciplines. Such ideas are not completely new, but, in the 2010s, their uptake at the international level has benefited from the favorable political context. Since 2011, the Ad Hoc Working Group on the Durban Platform for Enhanced Action and, since 2012, the Open Working Group of the General Assembly have been important processes leading to the adoption of the Paris Agreement and the Sustainable Development Goals in 2015.

To explore such 'paradigm shift' (Kuhn, 1962), we build upon the concept of 'boundary-work' introduced by Thomas Gieryn to describe the "ideological style found in scientists' attempts to create a public image for science by contrasting it favorably to non-scientific intellectual or technical activities" (Gieryn, 1983; p. 781). The emerging 'solution-oriented' discourse is, we believe, an interesting form of *anti*-boundary work, which challenges the existence of frontiers, especially between disciplines, and the roles of science and politics. We illustrated this shift analyzing the circulation of its discourse in FE and in the IPCC.

We asked ourselves what previous events and debates underpinned the emergence and circulation of the anti-boundary discourse. Secondly, we investigated what representations of the relation between science and politics it supports. And, thirdly, we explored how it was reappropriated by the IPCC. Doing so, we explored the specific circumstances that facilitated the rise of this discourse, tracing its development in several large transnational scientific initiatives. Such initiatives include a heterogeneous mix of conferences, ad-hoc organizations, individuals and institutional alliances, which go under the name of the "Science and Technology Alliance for Global Sustainability" (or the Alliance). We subsequently described how such discourse was articulated by FE and reappropriated by the IPCC, a potential ally and user of this approach. We concluded discussing several tensions raised in the implementation of this vision.

2. Boundary work and global environmental research and assessment: a discourse analysis

2.1. Boundary work as a form of scientific authority

The difficulty of tracing clear-cut separations among scientific disciplines and between science and other social spheres is a classic theme of Science and Technology Studies (STS). Inquiries in the daily practices of scientific laboratories and advisory committees have demonstrated that science and society are always to some extent 'co-produced' or 'hybridized' (see e.g. Latour and Woolgar, 1979; Jasanoff, 1990, 2004; Knorr-Cetina, 1995; Hilgartner, 2000; Callon et al., 2009) and that 'boundary organizations' exist specifically to facilitate these interactions (Guston, 2001). Hardly present in practice, the separation of science is, however, regularly exposed in the discourses of scientists. Thomas Gieryn calls this rhetorical strategy 'boundary work', pointing to the fact that "'science' is no single thing: its boundaries are drawn and redrawn in flexible, historically changing and sometimes ambiguous ways" (Gieryn, 1983; p. 781). Precisely because there is no such thing as a transcendent, distinct and unique character of science, scientists spend significant amounts of energy defending the specificities of their domains and opposing them to 'non-scientific' activities. Following Latour (2001), in this paper we use the term 'research' to refer to situated and ongoing practices of scientific inquiries, which are always plural, in-progress and, to some extent, uncertain. The term 'science' is used more generally to refer to the results produced by scientists, the ideals that animate them and the institutions that support their work.

The motivations behind such efforts are numerous and context-dependent: scientists may engage in boundary work to secure funding, to establish their authority over key issues or defend their autonomy. According to Gieryn, 'boundaries' can be drawn to prevent external control over the scientific work and to protect its autonomy. They can be elevated between competing disciplines (e.g. fundamental and applied research), different knowledge systems (e.g. scientific and local knowledge) or social worlds (e.g. science, religion or politics). For instance, with regard to the science-policy interface, "any engagement with policy-makers or other potential users of knowledge is considered to be problematic because it signifies a lack of independence and objectivity and threatens the authority of science" (Turnhout et al., 2013; p. 355). Boundary work offers a powerful tool for scientists to present authoritative and unchallenged knowledge (Jasanoff, 2004). When an area of intellectual activity is labelled as 'science', people who are not scientists are discouraged from intervening. Vice versa, "to label something 'not science' is to denude it of cognitive authority" (Jasanoff, 1990; p. 14). In the science-policy interface in particular, boundary work is essential for the legitimacy of expertise and its acceptability by policy-makers.

The practical co-production and rhetorical separation of science and society should thus be seen as two sides of the same effort to maintain scientific influence: "if negotiation is the engine that drives the construction of […] science, boundary work is the casing that gives the result legitimacy" (Jasanoff, 1990; p. 236). On the whole, this double strategy has been rather successful in establishing scientific authority over other forms of knowledge. The twentieth century has witnessed the spread of scientific expertise to many different aspects of society, from military to health and environmental issues. In environmental politics, "[…] the pervasive tendency […], has been to draw the line to favor science: to define problems so that they require scientific solutions, thereby converting political controversies into technical puzzles" (Bocking, 2004; p. 21). Today, scientists are omnipresent in the organizations that enact norms and standards at the national but also at the international level.

2.2. Anti-boundary work as an alternative form of scientific authority

While the practical co-production and rhetorical separation of science and society constitute the main strategies sustaining scientific authority, opposite approaches exist. In this article, we focused on the discursive approaches that support hybridization and blurring of boundaries, describing in particular how these approaches have acquired a growing relevance in the environmental and climate debates. As they go in a direction opposite to the one described by Gieryn, we called these approaches 'anti-boundary' work (Table 1). While boundary and anti-boundary work is used to describe discourses about the relevance of frontiers between academic disciplines and social worlds, proceduralization and co-production can serve the purpose of strengthening or blurring boundaries in practice.

The advent of the solution-oriented research has brought about an interesting novelty: the traditional separation between science and politics is not only overcome in practice, but also challenged in rhetoric. Though boundary discourse remains important in global environmental research and assessment, which still abide by ideas of scientific independence, it is increasingly accompanied by a discourse explicitly promoting interactions across multiple boundaries. Anti-boundary

Table 1
Anti-boundary-work in the larger – non-exhaustive – debate about discourses and practices of scientific production, inspired by the distinction between purification and hybridization introduced by Latour (1993).

	Purification	Hybridization
Discourse	Boundary work (Gieryn, 1983)	Anti-boundary work
Practice	Proceduralization (Joly, 2015; Porter, 1996)	Co-production (Jasanoff, 2004; Miller, 2001)

work aims at reaffirming the social influence of science, designing a new role for global environmental research and expanding the number of its legitimate contributors (Forsyth, 2003).

Many STS researchers have studied the hybridization of science and politics in practice (e.g. Gusfield, 1976). Little attention, however, has been dedicated to the discursive strategies that acknowledge the interaction between science and politics. We thus aim to draw attention to how the new discourse has emerged and what it means for the science-policy interface on global environmental change. To investigate this emerging discourse, we started by analyzing the official statements issued by the main institutions involved in this shift. In a similar way to Gieryn (1983), we examined both the style and the content of the anti-boundary discourse.

2.3. Methodology: following discourses across multiple contexts

We analyzed data following a qualitative method of discourse analysis with the objective of understanding the circumstances that supported such discourse, as well as the particular representations of science that it conveys (Neumann, 2008). Discourse can be understood as "an ensemble of ideas, concepts, and categories through which meaning is given to a phenomenon, and which is produced and reproduced through an identifiable set of practices" (Hajer and Versteeg, 2005; p. 175). It does not determine actions, but it may produce preconditions for them: "it constrains how the stuff that the world consists of is ordered, and so how people categorize and think about the world. It constrains what is thought of at all, what is thought of as possible, and what is thought of as the 'natural thing' to do in a given situation" (Neumann, 2008; p. 62). The 'solution turn' is not necessarily the sign that a scientific community is moving from whistleblower to problem-solver, but it is a sign that the social utility perceived by the community changes.

By analyzing the official discourses of the IPCC and Future Earth in different contexts, we identified three narratives in the discourse of these actors in favor of:

1. a better integration of scientific disciplines, as opposed to a strict separation between them, and in particular between natural and social sciences;
2. greater policy-relevance by integrating a wider range of societal actors in the definition and production of scientific research, as opposed to an emphasis on autonomy;
3. a need for science to play a greater role in the process of articulating solutions, as opposed to the more traditional role in the identification of problems.

In order to identify these generalizable – though emerging – trends, this article triangulated multiple data sources (Denzin, 1978). We analyzed the statements by these organizations in the form of reports, editorials, newsletters and interviews with members. The activity of these organizations on social networks, blogs and websites has also proved extremely useful to investigate their discursive strategies. Furthermore, we relied on statements collected during our ethnographic work at conferences and meetings, which act as relevant sites in the circulation of representations and ideas (Neumann, 2008).

With regard to Future Earth, we investigated a corpus of strategic statements produced during the creation and implementation of its co-production design. We also traced documents produced individually and jointly by the actors of the Science and Technology Alliance for Global Sustainability. We compared the written sources with participant observation of the conference Our Common Planet and the Future Earth Days (both organized in Paris in 2015 and 2016). The progressive launch of Future Earth has been a fruitful period to observe the discourses of its scientists and staff.

With regard to the IPCC, we investigated several sources covering the election of the new IPCC Bureau, such as interviews conducted by Carbon Brief in the run-up of the election, the IPCC Press Conference of the 42nd Session as well as official discourses by the new IPCC Chair. Our analysis was further informed by participant observation during the election of the new Bureau at the IPCC 42nd Plenary session in October 2015 in Dubrovnik. The debate among the candidates represented an occasion to investigate the discussions about the future role of the IPCC in the context of solution-oriented science.

By putting these recent developments in their historical context and analyzing a large spectrum of documents produced in the context of the establishment of Future Earth and the election of the new IPCC Bureau, we privileged breadth over depth. In this early phase, we looked at the circulation of the most visible anti-boundary rhetoric in multiple institutional sites. For the moment at least, the objective of the anti-boundary discourse put forward by the Alliance and Future Earth is less to impose specific actions than to create – or renew – international scientific cooperation on complex environmental problems.

By comparing the discourses of an organization engaged in coordinating the production of scientific knowledge (Future Earth) and of another assessing such knowledge (the IPCC), we also challenged the commonly held belief that these two stages of scientific work can be clearly separated.[3] Investigating the *official* discourses in Future Earth and the IPCC, however, we paid less attention to alternative and contesting discourses existing within these initiatives (see e.g. Uhrqvist and Lövbrand, 2014; Lahsen, 2016 for such perspectives).

3. The rise of the global sustainability science initiatives

The solution-oriented discourse that has emerged within the research on global environmental change is not entirely new. Numerous scientists (in the social but also in the natural sciences) have supported more democratic and open ways of making science (Funtowicz and Ravetz, 1993; Nowotny et al., 2001; Hulme and Ravetz, 2009). Participatory research (Lengwiller, 2007), civic science (Bäckstrand, 2003), transdisciplinarity (Klein, 2001), all encourage the inclusion of a broader range of stakeholders and publics in the production of scientific knowledge. At the international level, the early work of the IPCC (Price, 1990; Turner et al., 1990), the evolution of research programs like WCRP and IGBP (Uhrqvist and Linnér, 2015) and the discourses about the 'Anthropocene' and 'Sustainability' science also yielded numerous calls for inter- and transdisciplinarity (Kates et al., 2001; Clark et al., 2005; Clark and Dickson, 2003; Leemans et al., 2009). What is new in the 2010s is the international breadth that such discourse has reached and the fact that it has been taken up by scientific and political actors that traditionally supported a stricter separation between science and society.

To briefly – and non-exhaustively – put into context the advent of the anti-boundary discourse, we have straightened out its intricate genealogy in a simplified chronology. The reports, events (marked in italic) and actors (marked in bold) of this chronology represent the most visible part of the complex networks that sustained the rise of the new discourse. We have annotated the relevant data and citations and made their references available in the Supplementary materials.

1994 The turn to solution-oriented research can be traced back to the reflexions of the *Program on Management of Social Transformations (MOST)* by the **United Nations Educational, Scientific and Cultural Organization**

[3] The IPCC claims that "it does not conduct any research nor does it monitor climate related data or parameters" (www.ipcc.ch). However, in practice, it indirectly structures the scientific production by identifying knowledge gaps and organizing research around deadlines to produce scientific inputs that aim "to feed into the IPCC" (http://explore.tandfonline.com/cfp/est/policy-instruments-tcpo). A recent example is a call for a special issue on "Policy instruments for limiting temperature rise to 1.5°C" following IPCC's decision to produce a Special Report on 1.5°.

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(UNESCO) and of the *Integrated Human Dimensions Program (IHDP)* by the **International Council for Science (ICSU)** and the **International Social Science Council (ISSC)**. Both initiatives aimed at bridging science and policy and at fostering a better understanding of the human-nature coupling from a social science perspective.

1999 These reflections led a few years later to the *World Conference on Science* (WCS) convened by the **UNESCO** and **ICSU** as the "first global meeting to cover the complete range of issues concerning contemporary science and its relationship to society" ([14] UNESCO; p.2)

2002 The reports *Science for the Twenty-First Century: A New Commitment* ([14] UNESCO) and *Harnessing for science* ([15] UNESCO) demonstrated the growing commitment of **UNESCO** and **ICSU** to the transformation of the role of science within international politics.

2006 This turn was further specified in 2006 with the *review of the Global Environmental Change Research Programs*[4] by their scientific sponsors. The review constituted an important step in the mutation of these programs in the joint flagship of the **Earth System Science Partnership (ESSP)** initiated in 2001 to study the Earth as an integrated system.

2009 Such reflections were continued when **ICSU**, in cooperation with **ISSC**, organized a wide consultation including both scientific and political actors, under the so-called *Earth system visioning process*. ICSU called for a unified research framework that would encompass most global environmental change research structures. In particular, it advocated for a better integration of the social sciences and extra-scientific knowledge, which would lead to a progressive distancing between 'Earth System Science' and the emerging 'Global Sustainability Science'.

2010 **ICSU** co-produced two monumental reports to mark the paradigm shift to Global Sustainability Science ([4]; [5] ICSU). They "intended to help catalyze and guide an unprecedented decade of solution-oriented, focused and intensive research." ([4] ICSU; p.18). **ICSU** and **ISSC** found further support in the **Belmont Forum** (established in 2009), a group including major national and regional research funders and were joined in 2010 by the **United Nations Environment Programme (UNEP)**, **UNESCO**, the **United Nations University (UNU)** and the **World Meteorological Organization (WMO)** to form the **Science and Technology Alliance for Global Sustainability**.

2012 While **ICSU** encouraged the natural sciences to transition toward an integrated sustainability science, **ISSC** addressed the social sciences in the *Climate and Global Environmental Change Design Project* ([7] ISSC). The ISSC leadership was ensuring that the social sciences would be a cornerstone of the Alliance. This paved the way for the establishment of the overarching program **Future Earth**. Future Earth was launched for ten years in 2012 during two conferences: the *Planet Under Pressure: New Knowledge Towards Solutions* and the *Rio +20 United Nations Conference on Sustainable Development* to reflect its commitment to both scientists and policy-makers (Van der Hel, 2016).

2014 **Future Earth** defined its *Vision* ([17] Future Earth) and *Strategic Research Agenda* ([18] Future Earth), putting the co-production and co-design of knowledge at its core. The same year, the **IPCC** published its *Fifth Assessment Report (AR5)*, concluding, in a language exempt from all uncertainty qualifiers, that "warming of the climate system is unequivocal" and that "human influence is clear" ([31] IPCC; p. 2).

2015 These conclusions were further emphasised during the conference *Our Common Future under Climate Change Conference* organized in Paris by the same major institutions, only a few months before *the 21st Conference of the Parties (COP21)* of **the United Nations Framework Convention on Climate Change (UNFCCC)**. The outcome statement reaffirmed that "we in the scientific community are thoroughly committed to understanding all dimensions of the challenge, aligning the research agenda with options for solutions, informing the public, and supporting the policy process" ([9] CFCC15; p. 2). In October 2015, the question of solutions became a major stake in the *election of the new IPCC Bureau*.

2016 The *Future Earth-PROVIA-IPCC risks and solutions workshop* further marked the convergence between **Future Earth** and the **IPCC**, seen both as a potential user of scientific knowledge but also as a catalyzer of research and assessment "to inform the solution space" ([22] Future Earth).

4. Anti-boundary work in the alliance and future earth

In this section, we describe the three main anti-boundary strategies as observed in the discourses of the various institutions that have supported the emergence of the new 'global sustainability' science, in particular the Alliance and Future Earth. We have annotated the relevant data and citations and made their references available in the Supplementary materials.

4.1. Integration of natural and social disciplines

All actors involved in global sustainability science agree that, because of the complexity of the problems, environmental change research needs to overcome the traditional disciplinary boundaries between natural and social sciences that run "counter to the need to address interdisciplinary aspects of these grand challenges" ([12] Reid et al.; p. 917). In particular, it is the primacy of natural sciences that is often called into question: "natural sciences should no longer dictate the Earth system research agenda; social sciences will be at least as important in its next phase" ([11] Reid et al.; p. 245). According to its supporters, this interdisciplinarity is meant not only to encourage a more open scientific dialogue, but to structure global sustainability research as a new breed of science encompassing and subsuming all social and environmental concerns:

> "The vision of Future Earth (2025 Vision) is for people to thrive in a sustainable and equitable world. This requires the evolution of a new type of science – Global Sustainability Science – that links disciplines, knowledge systems and societal partners to support a more agile global innovation system" ([21] Future Earth).

4.2. Policy-relevance and integration of a wider range of societal actors

The second strategy of the anti-boundary discourse stresses the need to go beyond the linear model and to gather actors from all policy scales (from the local and national, to the regional and global) to build an "innovative international partnership between researchers, operational agencies, research funders, and users" ([12] Reid et al.; p. 917). This effort of co-design and co-production of knowledge with societal actors has been at the core of Future Earth since its first international event, the 2014 Future Earth Forum, which aimed at connecting "a high-level group of researchers and decision makers from finance, business, reinsurance, foundations, UN bodies and media […] ([19] Future

[4] These programs are the World Climate Research Program (WCRP), the International Geosphere-Biosphere Program (IGPB), International Human Dimensions Program on Global Environmental Change (IHDP) and DIVERSITAS.

Earth)". Global sustainability science supports a profound renewal of the science-policy interface:

> "we must develop a new strategy for creating and rapidly translating knowledge into action, which will form part of a *new contract between science and society,* with commitments from both sides" ([3] Brito and Stafford Smith; p. 4 emphasis added).

This strategy is pursued by FE through the 'Open Network' and the 'Knowledge-Action Networks' (KAN). The Open Network works as an online pool of expertise, whereas KANs gather individuals or groups willing to contribute on a voluntary basis to FE activities. They generate the 'integrated knowledge' sought to benefit to decision-makers from both public and private sectors.

> "Knowledge-Action Networks build on the broad range and diversity of specialist expertise represented in the large community of researchers and practitioners associated with Future Earth, e.g. in Research Projects, Fast-Tack Initiatives and Clusters, and endorsed and associated organizations, projects, and individuals that are part of the Future Earth Open Network" ([24] Future Earth)

4.3. The solutions turn

While calls for interdisciplinarity and transdisciplinarity have long struck a chord in scientific discourse, the third aspect of the anti-boundary work is more original and ambitious. The advent of a solution-oriented science is presented not as a gradual transformation, but as epochal shift:

> "In recent decades the global research community has developed valuable understandings of and predictions about, how humans are changing the world's environment and how these changes are affecting, and will affect, human and societal wellbeing. For the 21st century, societies urgently require innovative solutions to these challenges, based on significant advances in combined natural and social sciences" ([2] Belmont Forum, ICSU, ISSC; p. 1).

According to Reid et al. ([11]; p. 245), "the most pressing research questions are now quite different from those that shaped these [environmental] programs". The orientation toward solutions is often presented in opposition to the previous focus on the identification of problems. In the words of Hervé Le Treut ([8]), the traditional outcomes of climate expertise "are a factual documentation of the effect of climate change on the whole climate system, so what we need now is better understanding of *what this implies* and therefore *what we want to do about it and how*" (emphasis added). As argued by Corinne Le Quéré ([23]), "we can [now] move toward this fabulous word that has invaded our language, which is solution". The shift from a problem-oriented science to solution-oriented science is thus inscribed in a narrative of progress, which justifies the opportunity of such a shift with the successes obtained in the past. Such opportunity is further reiterated by reference to the fact that the planet is in a state of urgency. Paul Shrivastava ([25]), Executive Director of Future Earth, recently pointed out that "we need the science solutions now, we don't have another twenty years to wait".

5. Anti-boundary work in the IPCC

In this section, we discussed how the discursive strategies introduced above have progressively penetrated the IPCC, and particularly its Bureau. To some extent, this rhetorical transfer is not surprising. Several IPCC authors are also members of Future Earth, e.g. Dahe Qin (AR4 and AR5 WGI Co-Chair) and Youba Sokona (current IPCC Vice-Chair) are both members of the Future Earth Science Committee. Debra Roberts, the newly elected Co-Chair of WG II, is a member of the Future Earth Engagement Committee (stakeholders). Furthermore, the IPCC's parent organizations, UNEP and WMO, are among the initiators of the global sustainability movement.

5.1. Integration of all natural and social disciplines

The call for a better integration among disciplines (and to some extent the emergence of a new kind of science) could be found in the discourse of all candidates for the Panel chairmanship.[5] Chris Field, for instance, affirmed that "big opportunities are in better integration of all of the different components. Better integration of the climate science components, with the human dimensions components, with the technology and economic components. *I think that we really need a kind of new generation of science and a new generation of scientists*" ([29] Field emphasis added). The experience working with other disciplines, and across WGs was also consistently presented as an asset.

> "My background is in Working Group 1 but I have been Vice Chair between 2002 and 2008 of Working Group 2, so I know that community as well. And I have published in the three working group areas, I have had papers in AR3 – the Third Assessment Report – quoted in the three working group volumes. […] 'This [the Chair position] is very much *a cross-working group, a cross-boundary, and also cross-disciplinary boundary job*' ([43] Van Ypersele, emphasis added).

Candidates did not put into question the current structure and mandate of the three WGs, but encouraged discussions about cross-cutting themes. The Synthesis Report (the report integrating the conclusions of the three WGs) and the Special Reports (shorter and more focused reports) were presented as the keystones of interdisciplinary integration ([38] Nakicenovic; [34] Lee).

5.2. Transdisciplinarity

The IPCC being an *intergovernmental* panel, the science-policy interface was a major concern for the candidates, but also a slippery road on which candidates drove carefully. The need to be more policy-relevant was stressed in the sense of providing more contextualized information "at the scale where they [climate issues] impact people" ([29] Field) and "for the decisions they [policy-makers] are making in their daily lives" ([34] Lee). The need to involve other stakeholders was emphasised by most candidates. Jean-Pascal Van Ypersele ([44]) in his official statement declared his intention to

> "stimulate real collaboration and knowledge sharing across as many interfaces as possible: science-policy; IPCC-government Members of IPCC, IPCC-other institutions (in particular WMO, UNEP, and UNFCCC); IPCC-stakeholders, discipline-discipline; people–people […]. Let's assess the science of climate change together, in the most balanced, policy-relevant way, in the interest of all!".

Lee ([35]) also explicitly affirmed the need to incorporate inputs from business, industries and finance, as "governments cannot solve the problem of climate change alone". According to Lee ([42]), "they [the business, industry and finance sectors] have the resources, they have the information, they have the knowledge, and we will benefit greatly by capitalizing on their intellectual basis. We will increase the interactions with business and financial sectors through our outreach activities".[6]

[5] The five candidates were: Jean-Pascal van Ypersele (Belgium), Hoesung Lee (South Korea), Chris Field (United-States), Thomas Stocker (Switzerland) and Nebojsa Nakicenovic (Austria and Montenegro).

[6] While the election of the Indian R. K. Pachauri in 2002 had created much turmoil, following allegations that his candidacy was supported by the oil-industry lobbies (Giles, 2002), the perspective seems to have shifted in 2015. The fact that Lee has collaborated with Exxon and Hyundai Corporation is presented as an asset and an invitation for the industry and business sector to contribute to the IPCC (both in his campaign and CV available on the IPCC website).

5.3. The solution turn

The need to move from problems to solutions was particularly explicit in the discourse of Hoesung Lee. In the wake of his election, he declared that he "would like to be remembered as the chairman that shifted the IPCC's focus to solutions" ([42]). After the Paris agreement, Lee further stressed that "[…] perhaps the most important reason the IPCC needs to produce another round of assessments is that we are moving into the implementation of the Paris Agreement, and the IPCC *now* needs to focus attention on the solutions to climate change" ([37] Lee emphasis added).

During the press conference held at the end of the 42nd IPCC session, the new IPCC Bureau confirmed that the "questions that are being asked of us [scientists] have changed. […] We are shifting along the spectrum from cause and impacts into solutions, but that it does not mean that the IPCC mandate would change" ([32] Roberts). This implies providing policy-makers with information on the effectiveness of actions: "I think one of the big challenges […] for IPCC in the next cycle would be to highlight the concrete measures and steps that countries will need to take rather than high level statements about percentage changes in emissions" ([32] Skea).

6. Discussion

Although terms such as 'objective', 'neutral' and 'non-prescriptive' have not vanished from the vocabulary of scientists, we have shown that another discourse is emerging in support of a more inclusive, co-produced and solution-oriented science. Since Gieryn's has called 'boundary work' the rhetoric of separation in the discourse of scientists, we called 'anti-boundary work' this alternative discourse that highlights the importance of co-production and blurring of boundaries in solving complex environmental problems. The research on environmental issues has long been dominated by a traditional approach according to which scientists identify and quantify the problems, but hand to policy-makers the responsibility of solutions. While the emerging paradigm we described is not entirely new, its current institutionalization and penetration at the international level is unprecedented. Uncertainties about anthropogenic climate change and its impacts have not vanished, but the recent developments in the international arena toward the COP21 and the SDGs seem to have offered a window of opportunity for advocating a new relationship between science and society. The publication by Future Earth of its strategic vision in 2014 and the reappropriation of the solution discourse by the IPCC Bureau suggest that such discourse is maturing and seeking to transform the relation between science and politics on global environmental problems.

Multiple reasons are underpinning the call for a new social contract for science. On the one hand, we can mention the willingness of a part of the scientific community to reaffirm its authority and secure funding, in a context in which questions asked by policy-makers are changing. It is a reminder that research and assessment are also interested activities (Hughes, 2015). On the other hand, we can point at the 'reflexive' turn encouraged by the advent of risk society and the Anthropocene – the era in which techno-scientific progress elevates humans as the major driver of geological and ecological changes and the main producer of social and natural risks (Beck, 1996; Lövbrand et al., 2009). It stresses the epistemological rupture of science making in the Anthropocene (Hamilton, 2016). Finally, it also echoes recommendations voiced by many STS scholars who have argued that "science could progress if it became more accessible for debate and deliberation by a wider group of stakeholders, resulting perhaps in improved and more credible policies" (Lidskog and Sundqvist, 2004; p. 207).

Whether this strategy will succeed and how it will be implemented remains to be seen. In this section, we discuss several challenges that such a discourse might have to face, drawing on the literature already available as well as our own observations.

6.1. Challenges with bridging disciplines

The Global Sustainability science promoted by Future Earth can be interpreted as a 'softer' version of the Earth System Science, a new 'science of integration' based on a new interpretation of the relationship between nature and society (Lövband et al., 2009). However, putting interdisciplinary approaches into practice is not easy. Whereas the IPCC does not consider, at least for the moment, substantive changes between the three Working Groups, Future Earth is working on ways to implement its vision. Criticisms, however, have been raised by Lahsen (2016) regarding the prominence of natural sciences in framing the research agenda of FE and by Leemans (2016) on the numerous internal tensions present in such an all-encompassing organization. In our view, the debate within FE as to whether the organization is a 'platform' supporting the dialogue between multiple stakeholders or just an cooperation among existing research programs has churned in the first years of the organization and still continues to influence its relations to the scientific community, the policy-makers and the stakeholders. What is at stake is the meaning of the 'intersubjectivity' for Future Earth, which reflects decades of discussions on inter- and transdisciplinarity.

The anti-boundary discourse is implemented in the three research themes proposed by Future Earth: 'Dynamic Planet', 'Global Sustainable Development' and 'Transformations towards Sustainability' (Future Earth, 2014). However, such implementation could meet resistance from traditional scientific institutions and earlier transdisciplinary initiatives, for instance in the case of the Knowledge-Action Networks. Future Earth does not operate in an institutional vacuum and existing academic organizations and think tanks may have different views on inter- and transdisciplinary approaches.

6.2. Challenges from engaging with new actors

Several tensions behind the co-production discourse of Future Earth and its actual implementation can also be highlighted with regards to the engagement of new stakeholders. Van der Hel (2016) noticed how the engagement of extra-scientific stakeholders could lead to tensions regarding their differentiated role and weight in the process, e.g. between the funding agencies, the actors that represent non-academic knowledge or journalists. She remarked that the concrete role of these new stakeholders in the governance of the program is not always clear and can vary "from a primarily advisory role toward active engagement in processes of knowledge production" (Van der Hel, 2016; p. 172). Finally, her study also raised questions about the capacity of the program to move beyond the linear model of science and the risk of remaining "accommodative of ideas and values of scientific independence and autonomy, thus resonating with 'traditional' perceptions of science and its role in society" (Van der Hel, 2016, p. 173).

Similar concerns can be raised regarding the evolution the IPCC toward solution-oriented assessments. While underlying the need to be more inclusive, the new IPCC Bureau remains unclear about how to concretely engage with new stakeholders. The organization is already open to a range of actors (UN organizations, intergovernmental organizations and NGOs – including both representatives of environmental groups and other interest groups) who can intervene as experts in the review process or as observers in the IPCC plenary but do not have a direct influence on the scoping, acceptance and approbation of the reports. Discussions in the IPCC, however, do not seem to consider a substantive change of the its mandate and procedures (IPCC, 2015). In our view, the proposal to include new actors does not consider substantially opening-up the decision-making process of the IPCC to a broader diversity of stakeholders and leave unchanged the dominant role of governments in structuring and supervising the work of the Panel, which remains an 'intergovernmental' institution.

As of today, the interaction with other stakeholders has mainly remained confined to outreach activities. The IPCC, which has already carried out an intensive communication strategy during AR5, is looking

to strengthen and broaden its efforts in the next assessment (IPCC, 2016). Following the Chair election and the IPCC Expert Meeting on Communication organized in February 2016, the IPCC expressed its willingness to communicate with stakeholders and the public from the very beginning of the assessment cycle (the scoping meeting). Though this is certainly valuable, we believe that the risk exists for the IPCC to remain bound to an information deficit model (closely linked to the linear model mentioned earlier), in which better communication, clearer language and diversified tools (e.g. social media, improved uncertainty qualifiers, headline statements, inputs from communication experts) will defeat skepticism and indifference toward climate change (Beck, 2012).

6.3. Challenges with moving toward solution-oriented GEAs

The IPCC Summaries for Policy Makers (especially the one of the Synthesis Report) have been indicated as the privileged communication tool to approach solutions and reach the stakeholders and the public (Lee, 2015). While commendable in theory, tensions could arise between the desire to make the Summaries "highly accessible" to a wide range of actors (IPCC, 2016; p. 47) and the fact that they also constitute the knowledge base for the UNFCCC negotiations (Riousset et al., 2017). This means that issues that have contentious political implications for multilateral negotiations (increasingly questions raised in WGIII) can find, in participants' own words, "limited coverage" in SPMs (Field and Barros, 2015; p. 36). Examples of such limited coverage include the critical evaluation of international cooperation and climate policies, e.g. the performance of the Kyoto Protocol (Victor and al., 2014; Edenhofer and Minx, 2014; Dubash et al., 2014; Stavin, 2014). As researchers working on the biodiversity assessment process of the IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services) have argued, it is crucial to inform both policy-makers and the public about "indirect drivers" or "underlying causes" that hamper the effective implementation of environmental policies (Rankovic et al., 2016). This means scrutinizing policy performances and the underlying social, economic and political causes of their success or failure.

7. Conclusion

In this paper we have discussed the anti-boundary work as observed in the discourses of a variety of political and scientific initiatives on global environmental problems. We have seen how this discourse is presented in direct opposition to the traditional narratives of scientific purification and is implemented through three main strategies: the call for interdisciplinarity, for transdisciplinarity and for a solution-oriented science. We described how this discourse has emerged in the global environmental research community and how it is increasingly permeating the IPCC. This investigation, however, is only at its inception. The agenda of 'global sustainability science' is still emerging, and its development is marked by a plurality of boundary and anti-boundary works lingering within and beyond the initiatives we analyzed. Organizations such as the IPCC and Future Earth are not monoliths that speak with one voice or act in unison. More inquiry is still necessary to analyze both the discourses and the practices of global environmental research and assessment in ways that acknowledge their value but also their internal tensions.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.envsci.2017.03.012.

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