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This article assesses how science-policy interactions are conceptualised in the social sciences with special reference to climate change and the IPCC. In terms of the dimension of distance (or proximity) between science and policy we discern two ideal-type cases: a 'two-worlds' and a 'one-world' perspective. The first understands science and policy as independent spheres separated by a clear gap, while the second perceives science and policy as tightly coupled. These two perspectives, presented here in detail and in various sub-variants in order to show their complexity appear dominant also in the discussions on how to improve, not only describe, the interaction between science and policy. We argue that this situation of opposing perspectives is not beneficial, nor properly recognised by scholars in the field. In response to this we present a typology that may serve as a modest and judicious way for thinking about and making more nuanced choices in designing science-policy relations.

Key words: science and policy, use of scientific knowledge, climate policy, IPCC

Introduction: science and policy in the climate field

Since being established in 1988, the Intergovernmental Panel on Climate Change (IPCC) has produced five general assessment reports. For many this endeavour is a great success, which means that the IPCC has managed to create a global scientific understanding of climate change, and consequently has become a role model for global scientific assessments, alongside others such as the Millennium Ecosystem

Assessment (MEA) and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) (Vadrot, 2014). Moreover, the Panel has helped to establish climate change as a key issue on the political agenda, recognised as in need of multilateral agreements and concerted political action (Bolin, 2007; Edwards 2010; IAC 2010; Weart, 2008). This means that the IPCC has been a significant indirect contributor towards policy responses, including the Kyoto Protocol in 1997 and the Paris Agreement in 2015, given its mandate as an intergovernmental organisation to provide scientific input to the UN Framework Convention on Climate Change (UNFCCC). In short, and according to its own objective, the IPCC is considered to have succeeded to be a policy-relevant organisation (Yamin and Depledge, 2004, ch.15).

However, international achievements on the policy arena have not been impressive; greenhouse gas concentrations and emissions globally have heavily increased since the late 1980s (IPCC, 2014: 7). Transforming research findings into practical policies has proven to be much more complicated than was foreseen when the IPCC was established. This lack of results has led to discussions about the effectiveness of the IPCC, and many have attempted to explain why the IPCC's work has failed to stimulate needed action (Beck, 2012a; Hulme, et al., 2010; Tol, 2011; van der Sluijs, et al., 2010). In this article we will not explicitly focus on successes or failures, but on the nature of the *interactions* between science and policy, which are connected to the performance of the IPCC as an organisation for summarising science in a policy-relevant way.

How the relationship between science and policy is performed and described seems

also to be an issue of contention, not least among social scientists specialised in studying interactions between climate science and policy. In this article the literature is reviewed, by presenting how social science scholars *describe* science-policy interactions in the climate change field, the *problems* they perceive, and the *solutions* they propose to improve the interplay. We argue that this field of research hosts opposing views, each comprising both critical assessments of the existing situation and recommendations on how the situation could be improved.

Our objective is to follow up on the well-known formulation that policy-relevant scientists want to be close to policy, but not too close (Gieryn, 1995; Jasanoff, 1990). Put differently, to execute policy-relevant research means to perform a balancing act between *separation* and *integration* (Sundqvist et al., 2015). We aim to analyse how scholars in the now quite extensively populated field studying science-policy interactions in the climate area understand and conceptualise the proximity between science and policy. Our analysis starts from a typology based on the dimension of *distance* between science and policy where the two endpoints on this dimension are called the *two-worlds* and *one-world* positions.[1] These endpoint positions – or positions close to them – are extreme but, as soon will be presented, appear to be richly populated.

The aim of this article is to provide a survey of literature, not an analysis of actual policy making. The survey is exploratory and searches for differences in the scholarly

[1] By 'world' we mean a territory or zone of cultural authority. If science and policy are characterized as two distinctive worlds their authorities are of different kinds and not mixed. In this article we understand the distance between science and policy as varying between cases. There can be loose or tight coupling between separated territories but also the development of mixed, not separated, territories (Gieryn, 1995).

understanding of science-policy interactions in the field of climate change, including the recommendations on how interactions could be improved. By use of a proposed typology the objective is to improve the situation by making possible more nuanced descriptions and prescriptions, showing a range of possible positions from which science-policy interactions could be understood and designed. Our intention is to provide a vocabulary for the discussion, not essay a precise mapping of the whole body of literature or an empirically based explanation of the spectrum of different positions that exist in the scientific literature and in science-policy practice. Such work remains for the future.

In the next section we elaborate on our research questions, and present the method as well as our typology. In the subsequent two sections, and with the help of scholarly work on science-policy interactions in the climate field including on the IPCC, the two opposing perspectives (the two-worlds and the one-world) are presented as constituting the two endpoints on the distance dimension.

In the concluding section we suggest that assessing relationships between science and policy requires acceptance of an *aporetic* situation, one that is constantly in doubt and never finally resolved. This framing of science-policy interactions calls for avoiding any notion of a universal ideal. The paper discusses the problematic dominance of the two endpoint positions, along with their clear-cut, but opposing, normative statements on how to achieve a better interaction between science and policy in the field of climate change.

Aims, research questions, methods and a typology

Background, aims and research questions

Our aim is to contribute to elaboration of the conceptualisation and understanding of science-policy interactions. This question has long been of concern for philosophers and social scientists, and is a main task today for scholars in science policy studies and science and technology studies (STS) (Jasanoff, 2012, 2017). One key aspect in this discussion concerns the distance (or proximity) between science and policy. Sheila Jasanoff concludes that science advisers agree on this as a balancing act, where "those on both sides have reason to keep the two territories close but not too close" (Gieryn, 1995, p.435, referring to Jasanoff 1990). Jasanoff identifies a paradox in science advice, in that separation is what gains legitimacy – science advice should be generated clearly separated from policy process – but in practice the successful examples create meeting points "where scientific as well as political conflicts can be simultaneously negotiated" (Jasanoff, 1990, p.237). According to Jasanoff, science advisers use separation as a front-stage performance, while in backstage activities (actual practice) they try to establish close interactions (see also Hilgartner, 2000).

It seems that policy-relevant scientists act from normative ideas about what position to aim for in this balancing act. According to Thomas Gieryn (1999) scientists do *boundary work* due to their professional interests in maintaining both scientific integrity and relevance, including in order to enhance their authority. However, from Jasanoff we can conclude that science advisers are attracted to both separation and integration, and further that there are mismatches involved between how activities are publicly presented and how they are actually performed (see also Sundqvist et al., 2015).

Acknowledging the need for both separation and integration, Peter M. Haas developed a temporal model of how these could be combined in two different phases. The only way for science to speak truth to power, he argues, is to be detached from policy in the process of establishing truth, i.e. to not connect to policy before scientific consensus has been agreed by scientists (Haas, 2007; Haas and Stevens, 2011; see also Lidskog and Sundqvist, 2015). Connecting science and policy emerges as a central topic, since the gap between them is both something good (in the phase of scientific consensus-making) and bad (in the phase of connecting science to policy).

The IPCC's self-representation contains a quite clear and sophisticated picture on how to deal with distance between science and policy in order to achieve its aim of summarising science for policy. The production process of the IPCC Assessment Reports follows several consecutive phases.[2] Government representatives together with some scientists first decide the scope of the assessments, after which scientists independently prepare first and second draft reports. The second draft is then reviewed by both scientists and government representatives before scientists prepare a final draft. Finally, through line-by-line approval, government representatives approve the summaries for policymakers (SPMs) of all three Working Groups as well as of the Synthesis Report. This process means that the organisation's assessment process oscillates between high and low degrees of separation between science and policy during its different phases. Compared to Jasanoff's picture of separation as a front stage performance and integration as actual practice, we find that IPCC's work is

[2] See figure on the IPCC assessment process at http://www.ipcc.ch/organization/organization_procedures.shtml#.T6pY6MWIga8

organised in consecutive phases in order to contain both integration and separation. Haas, however, proposes consecutive phases, starting in 'separated' science and moving to integration between science and policy.

The same kind of problems of concern to science advisers also occupy social scientists studying the science-policy interface. Scholars who specialise in studies of science-policy interactions do not only describe and explain different positions, ambitions, motivations or existing organisations dealing with science-policy interactions. As we will soon see, most of them, like the scientists and organisations they study, take clear positions on how to improve interaction. For good reasons many of those scholars, and increasingly so, have analysed the situation in the climate field (for overviews see Hulme and Mahony, 2010; Sarewitz, 2011, Sundqvist et al. 2015; van der Sluijs et al., 2010).

Following in the footsteps of Jasanoff we want to advance the discussion on interactions of science and policy, focusing on the dimension of distance between the two. Distance we understand as being more about intellectual closeness than about organizational imbrication, about influences and dependencies and not only spatial locations and boundaries. Moreover, we take an agnostic attitude to the different positions, which gives us possibilities to transcend the conflictual situation of choosing between separation and integration. Our ambition is to deepen the understanding of science-policy interactions in the climate field, for we consider the current state of the literature confusing. While individual scholars and practically engaged actors, the IPCC as a prime example, typically adopt clear views on how to analyse and assess the balancing acts between science and policy, these various clear

views sharply diverge. We will propose a typology of stances, which we use as a starting point for deepening the analyses and increasing reflection.

A typology

In this and the following section of the article we illustrate the opposing positions by a manifold of examples from social science studies concerning science-policy interactions in the climate field. We understand these debates as influenced by two opposed ideal types. Although they are easy to detect in the literature the two are surprisingly little discussed as predominant opposites. We refer to them as two perspectives: *the two-worlds* and *the one-world*. The first understands the science-policy relationship as an interaction between two worlds with different functions, logics and motivations. These worlds are viewed as close to autonomous, separated by a clear boundary, with a considerable distance between them, understood as being about independence. The second has the opposite view. From this perspective, the distance between climate science and policy is close. These two ways of *describing* science and policy interactions conduce to (without enforcing) different predominant ways of identifying and interpreting *problems* and thereby of proposing contrasting *solutions* for improved science-policy interactions.

We use terms as follows. There are two descriptive 'perspectives', which respectively see and/or emphasise the distance between science and policy or their closeness. Since distance or closeness can be approved or disapproved of, there are then four available 'diagnoses'. Two of these appear to predominate: (1) seeing two separated worlds and attributing problems to that separation, and (2) seeing a closely integrated world and attributing problems to that closeness. Since these two dominant diagnoses

are widely used they have acquired richer content, as will be presented in later sections.

The more common of the two-worlds diagnoses not only *describes* gaps between science and policy but refers to 'barriers', 'obstacles', 'hindrance', 'constraints', 'hurdles' and 'tensions' (e.g. Eisenack, 2014), pointing to *problems* or frictions in the cooperation between the two worlds. The gap is the reality, while 'bridging', 'linking', 'shared understanding', 'dialogue', 'interaction', 'co-production' and 'hybrid institutions' are the proposed *solutions* (Dilling and Lemos, 2011; Mastrandrea, et al., 2010).

The more common one-world diagnosis *describes* a situation of a too tight connection between science and policy, and sees the close distance as a *problem*, since it leads to policy based on a consensus science without alternatives, it is argued, marginalising policy alternatives and public engagement. The *solutions* proposed are about giving 'pluralized strategic advice', 'opening up policy debate' (Hoppe et al., 2013), and giving room for 'alternatives' in both science and policy (Cornell et al., 2013; Sarewitz 2011).

The descriptive perspectives will in the following be treated as ideal-type constructs, meaning that we take them as mental models. They are ways of talking about situations and issues, but are neither fully accurate descriptions nor fully desirable ideals. Within the literature on policy analysis (e.g., Hogwood and Gunn, 1984), a distinction is commonly made between proposed descriptive models of policy processes, proposed prescriptive models, and lastly ideal-type models. This third

variety refers to mental constructs which are presented neither as adequate descriptions nor realistic prescriptions (for example, the model of the perfect bureaucracy, or the unidirectional policy cycle model). They have though an essential intellectual function as mental experiments through which scientific stories can be constructed, and against which real situations can be compared to assess how significant are the divergences.

While we consider the two perspectives on science-policy interactions that we describe as being ideal types, we recognise that many scholars grant them real *descriptive* and/or *prescriptive* status, i.e. for, respectively, *describing* science-policy interactions, and identifying *problems* and *solutions* concerning these interactions. We can then identify four archetypal diagnoses, shown in Table 1 below:

TABLE 1 ONE ABOUT HERE

In Diagnosis 1, existing relations between science and policy are seen to match the one-world perspective and this is approved (desirable one-world situation). In Diagnosis 2, relations are seen to match the one-world perspective, but this is viewed as a problem (undesirable one-world situation). In Diagnosis 3, relations are held to match the two-worlds perspective, but the relationship is disapproved (undesirable two-worlds situation). Whereas in Diagnosis 4, relations are believed to match the two-worlds perspective and this is favourably assessed (desirable two-worlds situation).

In the literature that we examined we have found mainly examples of Diagnoses 2 and 3, where the real situation is negatively assessed and some other arrangement is advocated. In what follows, these two diagnoses of *mismatch* between what is described and what is prescribed are our main interest. They are easy to find in the literature and much more common than the two diagnoses where the existing situation is seen as appropriate. Moreover, they not only contradict each other, but also seem to influence each other in a paradoxical way. Whereas views of an undesirable one-world situation (Diagnosis 2), located descriptively in a one-world perspective, look for solutions in a two-worlds situation, views of an undesirable two-worlds situation (Diagnosis 3), located descriptively in a two-worlds perspective, search for improvements by inspiration from a one-world perspective.

Our point of departure is that both the one-world and two-worlds situations are of great importance and relevance, but should be understood neither as mutually exclusive nor as a choice between right and wrong. On the contrary, in practice they should co-exist and overlap. As shown above, with the examples of the IPCC and Haas, they could be found in different phases of the assessment process. Science and policy interactions are about *separating* as well as *integrating*, and we have to acknowledge that there are good reasons for both those functions (Sundqvist, et al., 2015). One might also describe or prescribe different approaches for different socio-political contexts. Thus, the two perspectives are best seen as intellectual ideal-types; but frequently what is lacking is a more reflexive understanding of the many possibilities and choices available when understanding, performing and designing science-policy interactions.

Methods

In the following sections we will use this typology in order to better sort out the different positions we find in the literature about science-policy interaction in the climate field. What do we mean by 'the literature'? Our study object is the scholarly work, mainly conducted by social scientists, that analyses the relationship between science and climate policy. As additional examples we also discuss 'practical' actors, such as the IPCC, but most often they are the study-objects in the literature that we present and discuss. Our starting point was a literature review exercise, as an element in a research project focusing on how the IPCC Fifth Assessment Reports (AR5) are used in national policy making in five European nations.[3] We collected articles between the publication dates of AR4 and AR5 (2007-2014) from relevant journals such as *Nature Climate Change*, *Global Environmental Change*, *Environmental Science & Policy*, *WIRES Climate Change* and *Climatic Change*. We used key words such as 'science advice', 'science and policy', 'science communication', 'science policy', 'use of climate knowledge', and 'the IPCC' to identify the most relevant articles. Quite soon, we recognized opposing views among the authors, but no articles discussing this interesting but possibly problematic situation of polarized views. When we also noticed that these opposing views are mirror images – the problem in the first approach is the solution in the second and vice versa – we decided to explore this pattern, with special attention to the dimension of distance between science and policy.

[3] 'The IPCC AR5 in Europe' project analyses how key messages from the Fifth Assessment Report of the International Panel on Climate Change (IPCC AR5) are communicated and used by policy makers. The project follows the knowledge from publication to decision making in Norway, UK, Poland, Spain and the Netherlands. The project (2013-2016) was funded by JPI Climate/Norwegian Research Council and led by CICERO Center for International Climate and Environmental Research – Oslo.

Our work started thus from an inductive ambition, but in what follows the two ideal-type perspectives – the one world and the two worlds – and the typology, helping to sort out between descriptive and prescriptive stances, will structure the presentation. This means that examples from the literature are examined in relation to these stances. We present the examples though in a detailed, nuanced way, based in the ambition to be empirically true to the scholarly work; but our main focus is on the concepts, with the ambition to provide more refined tools for future analyses.

Science and policy as two worlds – examples from climate change literatures

In the literature on science-policy interactions in regard to climate change, we find many studies that argue that climate knowledge, the global scientific consensus orchestrated by the IPCC being the prime example, needs to be better communicated to policy makers. Scientific work and policy making are seen as two excessively separated spheres, i.e. a two-worlds problem diagnosis is adopted. In this approach, a lack of usable knowledge is seen as arising out of a *gap* between science and policy. That IPCC knowledge does not automatically lead to action comes then as no surprise.

Most of the scholars *describing* in terms of a two-worlds perspective assess the gap in this fashion, as a *problem*. The problem is presented indeed as a whole series of gaps, obstacles and frictions in cooperation. Policy is seen as too independent of science, while science insufficiently influences policy (Eisenack et al., 2014). Therefore, great efforts are put into presenting advice on how to deal with the perceived problem of the gaps between the two worlds. Solutions are described as being about bridging and

linking, and thereby creating shared understanding (Dilling and Lemos, 2011; Mastrandrea, et al., 2010). These solutions aim to improve the communication between the two worlds, which includes acknowledging differences and learning more about the other side. Solutions focusing also on co-production and hybrid institutions often even go as far as adopting Diagnosis 3 in Table 1 above, which sees two worlds in present practice but advocates unifying them.[4]

Social science research on climate change communication, authoritatively reviewed by Moser (2010), characteristically presupposes a gap between knowledge and action, between sender and receiver. The gap separates those who have knowledge from those who have not but are in need of knowledge. The question is how to achieve efficient transfer of knowledge. According to this body of research there are many hindrances and pitfalls to overcome in order to achieve a linkage. In general, lack of interest and mutual understanding creates disconnections between the two worlds. The *solution* is said to lie in mutual understanding, created by increased engagement. The communication challenge is not only related to translating, but also to creating 'bridges' that are perceived as credible, legitimate and salient (Cash, et al., 2003). Corner and Groves (2014, p.743) argue that "climate change communication is trapped between the norms that govern scientific practice and the need to engage the public". According to these authors better communication cannot solve the *gap problem* unless 'appropriate social institutions' are established where these normative

[4] We should note that the use of the idiom of co-production in this climate policy literature often differs from how it is used in STS, even while suggesting that knowledge should be produced jointly by different groups (among them scientists). In the STS literature co-production of science and policy means a historical process, not an end which can be purposefully achieved (Jasanoff, 2004). In this article we are not applying a co-productionist framework, but note that many climate policy scholars adopting a one-world prescription (diagnoses 1 or 2) talk about co-production in an instrumental way. From a Jasanoff-inspired understanding though, the one-world and two-worlds perspectives could both be analysed as different expressions of co-production, understood in the way explained above.

tensions can be accommodated and handled. These institutions – 'hybrid institutions' (Callon, et al., 2009; see also Beck, 2012b) or 'boundary organisations' (Guston, 1999, see also Hoppe, et al., 2013) – should be able to take care of scientific facts together with public concerns at the same time and at the same place (Corner and Groves, 2014, p.744).

Some authors within a two-worlds perspective offer a way to understand the relationship between the two worlds by distinguishing between supply (push) and demand (pull) for scientific knowledge (Sarewitz and Pielke Jr., 2007). The supply and demand dimensions could generate a matrix of four discrete units when answering the following two questions by 'yes' or 'no': 'Is relevant information produced?' (supply side) and 'Can users benefit from research?' (demand side). According to Sarewitz and Pielke Jr. (2007, p.14) we find many examples in which "poor reconciliation between supply and demand reflects the inability of users to take advantage of relevant available information… [and others marked by] a failure to generate relevant and usable scientific information". If both questions in the matrix are answered by a 'no', this indicates an extreme example of a 'gap problem'.

In a similar way Lemos et al. (2012) portray a 'usability gap' and make a distinction between (potentially) useful and useable information. According to these authors, both producers and users are responsible for transforming useful information into something useable, which requires specific measures. Interaction is the key in overcoming the barriers to usability. It is argued that IPCC knowledge in particular has not succeeded to be transformed from useful to useable (Haas and Stevens, 2011).

How then is an effective interaction best organised? Mastrandrea et al. (2010, p.88) recommend co-production, arguing that climate information that can support decision-making is "[i]deally co-produced through sustained stakeholder-scientist interactions to develop information and tools in forms that decision makers are more likely to incorporate into their decision-making processes or use as a basis for modifying those processes…".

Not all scholars who describe a gap in the science-policy relationship support an intimate cooperation between scientists and policy makers. Edenhofer and Minx, for example, are quite content with a two-worlds approach (Diagnosis 4 – the desirable two-worlds situation), supporting a division of labour including "legitimate roles of scientists as mapmakers and policy-makers as navigators"; they argue that "the IPCC can further *inform* international climate policy without prescribing and predetermining future negotiations" (Edenhofer and Minx, 2014, p.38, emphasis added). This quote clearly connects to the IPCC mandate of being "policy-relevant and yet policy-neutral, never policy-prescriptive".[5]

In the remaining part of this section describing a two-worlds perspective, we present two different assessments on how the balancing act between science and policy is actually performed and practiced. First, we meet scholars who focus on the policy side, considered as the problem for effective cooperation, and then those who criticize the scientific side. By this it is shown that the two world-perspective becomes elaborated in practice in multiple different directions.

[5] http://www.ipcc.ch/organization/organization.shtml

Blaming policy makers

A significant number of the scholars who use a two-worlds diagnosis of shortcomings view the 'science side' as less problematic, while problems are considered to be caused by the lack of understanding and engagement on the policy side. In these studies the proposed solutions are about more policy engagement. This idea of questioning the policy side while looking to the science side for answers has by STS scholars been dubbed 'the deficit model', meaning that policy has a deficit compared to science; the deficit could be about knowledge, trust or engagement (Wynne, 1993, p.322; see also Irwin, 2014).

In studies of science communication there is a constant risk of problematising the receiver and leaving the sender unevaluated, since these studies often focus on *impact* and how the message has been *understood* and *used*. The impact is assessed in relation to the intention of the sender, and the assumption is that scientists *do* understand and *are* engaged, and therefore the policy side bears the responsibility for the gap. In the climate field the IPCC is often used as an example of an organisation that possesses knowledge others lack, and that is the provider of the universal yardstick.

Bradshaw and Borchers (2000, p.1) argue that "[o]ne of the most difficult aspects of translating science into policy is scientific uncertainty". Scientists are familiar with uncertainty and complexity, while publics and policy makers often demand certainty and deterministic solutions. Policy actors must learn to understand uncertainty "as information for hypothesis building, experimentation, and decision making" (Bradshaw and Borchers, 2000, p.9; see also van den Hoek, et al., 2014).

Moreover, the pluralist society, containing a variety of values, cultures, life-styles and perceptions, is taken as one of the explanations for the many problems involved in the transfer of scientific descriptions from scientists to the public, politicians and policy makers. The desideratum seems to be "greater convergence in beliefs and willingness to act" (Weber, 2010, p.332), a political consensus that effectively can take advantage of and match a scientific consensus. Plurality and variety, on the policy side, becomes seen as a problem for effective communication.

Blaming scientists

For trying to explain a problematic gap between science and policy, we also find scholars who instead of blaming policy makers focus their attention on the science side. Stehr and Grundmann (2012, p.35) claim that "the IPCC has provided little in terms of practical knowledge". This claim is based on an argument that "the successful 'deployment' of findings in concrete situations is far from trivial. The possibilities for action, i.e. the actors' latitude for action and their chances of shaping events, must be linked together, in order for knowledge to become 'practical knowledge'" (Stehr and Grundmann, 2012, p.34). They conclude that "the IPCC has produced *knowledge for practice,* but not *practical knowledge*" (Stehr and Grundmann, 2012, p.28, emphasis in the original). Some scholars using a two-worlds diagnosis suggest, in line with Stehr and Grundmann, a solution for transforming knowledge into practical knowledge by identifying possible entry points for relevant and needed knowledge to reach and influence policy issues at the right time (Agrawala and van Aalst, 2005; Eriksen and Næss, 2003; Haas and Stevens, 2011).

The aim is to find sites and issues where we can expect science to lead to practical change if only it properly reaches these.

It is also frequently argued that science should be better at 'packaging' the knowledge before it is presented to different policy groups, in order to make it actually usable and not merely potentially useful, e.g. when communicating uncertainties (Budescu, et al., 2009) and emission scenarios (Schenk and Lensink, 2007). Dilling and Lemos (2011) declare that science is currently too dominant and oblivious in this relationship. Science is setting "the information agenda and is not creating usable knowledge" (Dilling and Lemos 2011, p.681). The proposed solution is presented as "a co-production model where the research agenda is shaped in an ongoing, iterative fashion between knowledge producers and users" (Dilling and Lemos 2011, p.682).

A solution to the dominance of science could be to focus on knowledge, which is a broader notion than science, implying 'opening up' the conservative, locked-in situation of science-centred knowledge, to something labelled 'knowledge democracy' (Cornell, et al., 2013, p.61). The problem is again seen as the gap between two worlds, but the burden of required change is located within the world of science; "resistance in the research community" (Cornell, et al., 2013, p.68) is understood as a barrier to effective communication.

To summarise the perspective presented in this section: the *description* is of a two-worlds situation, and typically that is further seen as a *problem*, a gap; within this separation-as-problem stance the blame for the problem is differently distributed to the two sides by different versions. The *solution* proposed in this diagnosis is better

communication based on improved mutual understanding and a more intimate cooperation between science and policy; the two should better adapt to each other, which implies less distance and less independence.

Science and policy as one world – examples from climate change literatures

The one-world perspective *describes* science and policy as tightly coupled. However, this could also further mean the loss of distinct spheres of authority, i.e. the development of a hybrid world. The prime example presented is the close relationship between the IPCC and the policy makers in the UNFCCC. The gap between science and policy described in the two-worlds perspective is within the one-world perspective no longer seen as existing: the gap has deliberately been bridged, in this case by the hybrid organisation IPCC through its close contacts to international policy making (Hoppe, et al., 2013). However, the tight connection between science and policy is usually not presented as a perfect solution. On the contrary, the *problems* associated with a one world-situation are intensively discussed in the literature. The 'gap-bridging-solution' has become a problem, because the connection has become too tight. In many ways the IPCC and UNFCCC are viewed as constituting a self-contained science-policy system, designed to deal with climate change on behalf of humanity, but unable to fulfil its mission (Sarewitz, 2011; see also Beck, 2011; Haas and Stevens, 2011; Rapley and De Meyer, 2014).

Following this line of reasoning, scientific knowledge is anything but independent. According to one-world scholars, the IPCC should not be viewed as a purely scientific community in which scientists summarise research. Rather, scientists are

formulating the research assessment agenda *together* with government representatives, and thus within parameters on focus, relevance, significance and importance that governments co-determine. Government representatives must also approve the final results before publication of the summary (or summaries) for policy makers (SPM) reports, even if during the approval process scientists too retain in principle a final veto regarding scientific content. According to scholars adhering to a one-world perspective, this illustrates how policy relevance is a guideline for the knowledge production process in the IPCC, i.e. on how to summarise science (Haas and Stevens, 2011), including through the inevitable aspects of selection and interpretation.

What we here identify as a one-world perspective refers to a tight relationship in terms of ideas, and not necessarily (though possibly) also a close organisational relationship. In other words, *distance* is understood as being about *independence*. A tight intellectual relationship can exist in various organisational set-ups: first, where science is completely answerable to a policy authority, for example within a totalitarian state or totalitarian private organisation; but also, second, where science and policy are organisationally separate but procedurally interwoven, as in the IPCC set-up; and third, where the two organisational worlds are fully separate but where one of them intellectually dominates the other in crucial respects. In a one-world situation science and policy are not independent from each other. We will examine cases where authors see a domination of science by the world of policy and politics, and also cases where the reverse is perceived.

A typical claim in a critical one-world approach (Diagnosis 2) is that the relation between the IPCC and policy makers is dominated by (natural) science, and is consequently characterised by a form of reductionism. The reason for this is said to be historical. Natural scientists managed to draw attention to the climate change problem and convince many policy makers and politicians about the need for comprehensive assessment, which led to the establishment of the IPCC. In other words, climate change has been a science-driven issue from the beginning (Weart, 2008; Edwards, 2010), and the science-dominated relationship between science and policy is based on 'the linear model' (Beck, 2011) where science is expected to 'speak truth to power' (Rapley and De Meyer, 2014). However, there is also a contrasting view that the relation between science and policy is dominated by policymakers, that science is hampered or trapped by policy (e.g., Brysse, et al., 2013; Wynne, 2010). Those contrasting descriptions share though the idea that science and policy are tightly connected, and in key respects are one world.

In what follows we further describe the elements of a critical one-world approach by focussing on two aspects given importance in such analyses: a striving for *consensus* (in both science and policy) and, as a consequence, *marginalisation* of other opinions.

The strong focus on consensus

Scholars based in the critical one-world approach attribute to the IPCC a desire to speak with one single voice, through a strong focus on identifying a consensus (Hulme and Mahony, 2010), and also to achieve strong policy impact by creating a clear and unified message emerging from scientific consensus that then has to be followed and implemented in a single-policy-path. Consensus could of course also be

of importance in a two-worlds situation, but what we find here is the idea that scientific consensus is considered to have a direct strong influence on policy, which leads to a tight connection, i.e. a one-world. Many climate scientists support the consensus-focused way of working, because it leads towards a definite policy message (Tol, 2011). However, an exaggerated emphasis on consensus, it is argued, has led to a restricted way to understand what type of problem climate change is and its possible solutions. Too often, climate change is reduced to very largely a CO_2-emission problem, presented in terms of statistics and emission targets, rather than say being framed as a development issue, associated to specific forms of progress and development. Some leading scholars who adopt a one-world problem diagnosis describe this as *scientific reductionism*: "the fusion of climate science with a single policy path… climate science thus came to mean Kyoto science, cap-and-trade science, Al Gore's science – and nothing else" (Sarewitz, 2011, p.479). The strong focus on consensus has been called the strength *and* weakness of the IPCC, i.e. the search for scientific consensus across disciplines *and* the preoccupation with "securing formal agreement between the academy and governments through line-by-line approval of [each] summary for policymakers" (Hulme and Mahony, 2010, pp.710-711). This reductionism crowds out other ways of understanding climate change than those from mainstream earth sciences (Hulme, 2009).

An alternative one-world diagnosis considers that policy dominates science. Brysse et al. (2013) argue that climate scientists as a consequence of being faced with fierce climate scepticism are increasingly "erring on the side of least drama", i.e. being overly conservative in their estimates and judgements, including by omitting certain issues. The IPCC "has consistently understated the rate and intensity of climate

change and the danger those impacts represent, say a growing number of studies… A comparison of past IPCC predictions against 22 years of weather data and the latest climate science find that the IPCC has consistently underplayed the intensity of global warming in each of its four major reports released since 1990" (Scherer, 2012). In this diagnosis we see that scientists adapt to what they consider is politically possible for policy makers to digest.

Stage-by-stage conservatism throughout the process of projecting futures and estimating impacts is argued by some authors to be widespread in mainstream policy-oriented climate change analyses (e.g. Hansen et al., 2016). In IPCC work, not only can conclusions gravitate towards the lowest common denominator amongst participating climate scientists, pressure from the watching governments and corporate interests can exert further conservative influence. The 2014 IPCC Assessment Report gave low attention to 'outlier' events, extremes of weather whose frequency is too difficult to predict but that happen increasingly. It also marginalized possible low-probability-but-very-high-damage climate system shifts, such as through melting of the permafrost or destabilization of the West Antarctica ice-cap. The associated concept of *tipping-point* was almost totally absent from the 2014 Assessment (Fløttum, et al., 2016). Scientists present what they think policy makers can understand, accept and will consider relevant and politically usable, and gradual changes are presumed to be easier to deal with compared to radical ruptures. This is an example of an overly close relationship in which scientists and policy makers adapt to each other in a way that is not made transparent to outsiders (Wynne, 2010; Shackley and Wynne, 1997), creating a closed and hybrid one-world.

The IPCC seems to be aware of the risk of scientific reductionism and of emphasising a lowest common denominator, that has emerged from the focus on establishing a scientific consensus as the basis of climate change policy. In recent years, we see some increased tendency to focus on the solution space. Working Group II, studying impacts, vulnerability and adaptation, and Working Group III, studying options for mitigation, have increased in prominence, acknowledging that not only the 'physical science basis' – the topic for Working Group I, traditionally treated as the core group of the IPCC – is essential for understanding and dealing with climate change. However, the style of the increased attention to adaptation and mitigation has also been criticised by some, as using the same logics from the natural sciences and now seeking a global science-based consensus voice on every aspect of the climate change issue (van der Sluijs, et al., 2010).

The marginalisation of alternatives

Consensus-driven science, according to critics of a one-world set-up, implies a focus on certainty and truth which brings a trap. Sarewitz (2011, p.477) argues that 'climate scientism' encourages its counterpart, 'climate scepticism'. The IPCC quest for near-certainty and its orientation to a one-single-policy pathway of CO_2 emission reductions becomes an easy target for climate sceptics. Political discussions about trust or distrust in science occur when knowledge comes in one single package without alternatives, creating dichotomies between believers and non-believers. Discussions about climate change actions become a controversy over scientific evidence, and consequently ever more evidence is called for. Oreskes (2004, p.369) describes the interaction between sceptics, policy makers and scientists in the following way: "In recent years, it has become common for opponents of

environmental action to argue that the scientific basis for purported harms is uncertain, unreliable, and fundamentally unproven. In response, many scientists believe that their job is to provide the 'proof' that society needs. Both the complaint and the response are misguided".

When policy debates about climate change are purely based on scientific evidence, the science which provides the evidence becomes politicised, and policy making becomes de-politicised (Beck, 2012a). Scientific controversies over evidence of climate change become a proxy for political battles over climate change action (Beck, 2011; see also Pielke Jr., 2007). The strong focus on global scientific consensus can "erase cultural differentiation and heterogeneity… [and] fail to do justice to the plurality of human living and may have considerably less purchase in problem-solving and policy-making than a multiplicity of local and diverse tools and indicators" (Hulme, 2010, p.563). Interestingly, whereas in a critical two-worlds diagnosis the pluralist society is often seen as generating problems in effective communication of scientific findings, here in a critical one-world diagnosis *lack* of plurality brings a problem.

When discussing *solutions*, some critical one-world analysts correspondingly focus on the underconsidered dimensions – the 'human dimensions' of climate change – that are assessed as having great importance in order to mobilise action and appeal to multiple audiences outside scientific laboratories and mathematical models. Reducing climate change knowledge to earth science can lead to neglecting attention to the importance of public engagement (Jasanoff, 2010; Hackmann, et al., 2014; Yearley, 2009). Sarewitz (2011, p.481) argues that "[p]rogress waits not on better science, nor on better communication of science… but on new approaches that focus first on the

articulation of an inclusive and compelling politics built on a rich array of possibilities for the future". The solution is therefore often seen as to *open up* the natural science-centred-regime to make space for more voices, more alternatives, not least policy alternatives and local and public engagement, but also for alternatives in science.

The recommendation to the IPCC is to renounce its 'epistemological hegemony' (Mayer and Arndt, 2009) and 'quasi-monopoly' of providing policy advice in the climate field (Tol, 2011). It should instead aim at giving 'pluralized strategic advice' and 'opening up policy debate' (Hoppe, et al., 2013, p.296) to broader audiences within the UN, the scientific community, NGOs, and the wider public, and to show more transparency (Beck, 2012b).

These authors are close to Diagnosis 2 in Table 1 above, which asserts that present practice is one-world and that two-worlds would be a superior arrangement. The Paris Agreement could be viewed as an answer that acknowledges this critique. The top-down UNFCCC Kyoto Protocol, specifying IPCC-supported emission cuts for all countries, is now replaced by a bottom-up approach in which countries individually specify their contributions, the so-called Nationally Determined Contributions (NDCs). The Paris Agreement represents an important shift in climate governance (St.Clair and Aalbu, 2016), which could be interpreted as a response to an undesirable one-world situation.

To summarise the approach presented in this section: the *description* is of a one-world situation, including a tight coupling between science and policy on the international level. The *problem* most of the authors see is the dominance of science (including an

epistemic dominance of the biophysical sciences), the consensus ambition, and the specification of one-single-policy-path coming out of the UNFCCC: a climate – or carbon – reductionism, that marginalises many actors and also alternative framings and policy options, not least on national and local levels (Hulme, 2009). The *solution* proposed supports policy alternatives that are less science-dominated and more connected to everyday concerns among 'local' people: too many actors become marginalised as an effect of the too tight relationship between the IPCC and the UNFCCC, which means that the policy-regime itself eventually becomes marginalised. Scholars who argue instead that policy dominates over science, so that scientific assessments adapt to what policy wants to hear, agree on the distorting impact of the emphasis on consensus and on a too tight policy-science linkage. Not surprisingly, given the different diagnoses, scholars disagree on how to deal with the problems of a one-world situation and the perspective is in practice developed in various ways.

Reflections and conclusions

We have described two different approaches regarding science-policy interactions that we found predominant among scholars studying these interactions in the climate field, corresponding to what we called Diagnosis 2 (undesirable one-world situation) and Diagnosis 3 (undesirable two-worlds situation). They both argue that a mismatch exists between the kind of science-policy interaction that exists and what is desirable. The predominant two-worlds approach, Diagnosis 3, expresses a critique of the gap between science and policy, and its proposed solution is to bridge this gap. The predominant one-world approach, Diagnosis 2, implies a dissatisfaction over a too

tight connection between science and policy, which could be solved by opening up the closed one-world to bring more plurality in both science and policy. The problem in the first approach is the solution in the other, and vice versa. This is an interesting finding, and even more so since there has been insufficient recognition and discussion among scholars in the field about this opposition.

As already shown the two approaches are both visible though in the organisation of the IPCC assessment cycle. Trying to utilise both approaches, for organising the interplay between science and policy, is not surprising. As argued above, both separation (a two-worlds situation) and integration (a one-world situation) are highly valued by most relevant actors in the climate field. Both are canonical views of science-policy interactions (Nowotny et al., 2003; Sundqvist, et al., 2015). Some scholars have tried to connect them by distinguishing between different phases in a process that involves both separating and integrating science and policy (Haas, 2007; Haas and Stevens, 2011).

Viewed together, the two approaches could also be seen as a historical progression, an important societal trend, going from separation to integration, which could also be identified in the development of climate science and the set-up of the IPCC as a prime example, i.e. moving from exclusively academic science to summarising and interpreting science for policy. A view of the two approaches as complementary is supported by the argument that separation (two worlds) and integration (one world) of science and policy fit different levels in analysis. At the international level we find very close cooperation given the links between the IPCC and the UNFCCC, almost as one package of mutual dependency, while on national and local levels there is more

distance between IPCC science and climate policy. The tight coupling between science and policy, perceived in the one-world approach, is a 'small-group-interaction' from which most policy makers and publics remain on the outside, distant from the dominant elites in the IPCC and the UNFCCC. The integration of science and policy involves the international elite, while for others a two-worlds situation is what remains.

The most important and recent example from the international climate science-policy scene illustrates the two approaches at work simultaneously. A major feature of the Paris Agreement is the 'pledge and review system' where the so-called Nationally Determined Contributions (NDCs) constitute the building blocks of the new Agreement. In other words, the top-down 'one-world' Kyoto-model is replaced by a bottom-up system based on each country's individual pledges, in line with a Diagnosis 4 position (desirable two-worlds situation). However, the NDCs will also be reviewed and assessed every five years in an arrangement called 'global stocktake', aiming to increase climate policy ambitions over time. Consequently, in order to be policy-relevant to the global stocktaking process, the IPCC main reports will after the Paris Agreement be released every fifth year, as opposed to every 6-7 years previously. The decision to synchronise the IPCC and the UNFCCC cycles in this manner is arguably in line with a Diagnosis 1 position (desirable one-world situation), as it implies a tighter integration between the IPCC and the UNFCCC. In other words, the Paris Agreement has led to measures that are in line with descriptions and prescriptions from both approaches, i.e. the two important mechanisms constituting the Paris Agreement illustrate the two different predominant diagnoses in Table 1.

From what is said above the one-world and two-worlds approaches are thus not pure rivals, rather complementary. Science-policy interactions are neither linear nor single-directional, but contain an irresolvable tension that has no single best solution. This means that we should understand the different science-policy configurations in the climate field as contingent, changing and strategically used. The approaches and the specific science-policy interactions that constitute them are not static. We suggest that awareness of dealing with an *aporia* (a situation of undecidability) should increase among social scientists analysing the interactions between climate science and policy and that this will spur a more fruitful analysis on ways to improve the policy uptake of climate change science. However, what we found in the literature was a frequent ambition to arrive at simple generalised solutions, seen in the scholarly attraction to the opposing endpoints on the dimension of distance between science and policy, largely prescribing either separation or integration as ideal solution.

In our view, there is no best solution. The best we can search for is experimentation and learning, which implies that analyses and proposals for improvements should be assessed from the perspective of what actors want to achieve, often related to the stage or types of science involved and the stage in policy processes. A necessary starting point is to acknowledge (i) the important influence the opposing ideal-type approaches have in much scholarly work; (ii) that the dominant diagnoses are mirror images – what in one diagnosis is a problem becomes a solution for the other; (iii) that organisations sometimes want to adhere to both without realising the tension, and (iv) that there is insufficient communication and cross-fertilisation between proponents of the various diagnoses. More interaction between them would help both

understanding and practice in the science-policy interface on an appropriate case by case basis.

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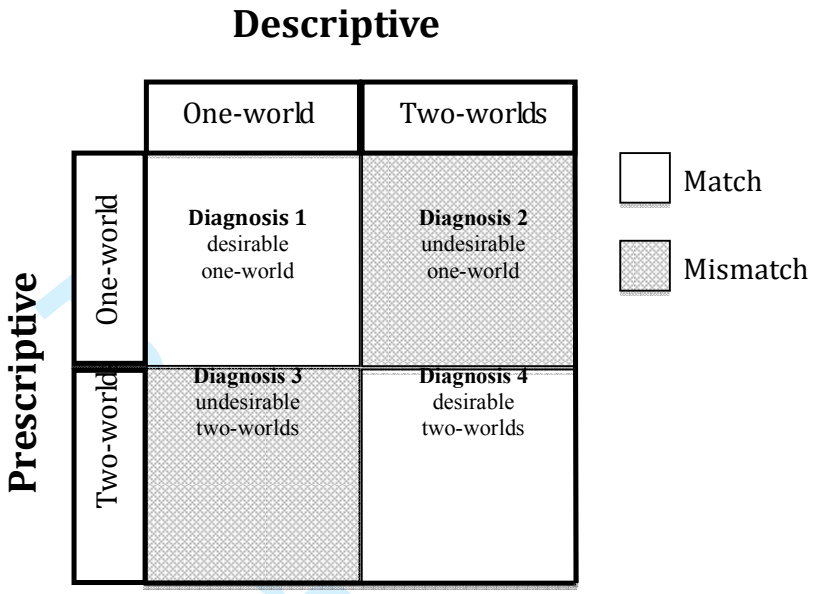

Table 1: Four diagnoses on relationships between science and policy emerging from the two ideal types of one-world and two-worlds perspectives. The figure illustrates match or mismatch between what is described, and what is prescribed.