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Servitizing climate science—Institutional analysis of climate services discourse and its implications

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A B S T R A C T

The complex and severe challenge presented by climate change has led to diverse and intense discussion about the interaction between science, society and policy. One part of this discussion has been the emergence of climate services. Although the concept is still ambiguous, such services can be defined as the production and delivery of climate related information for any kind of decision-making. The servitization concept has been championed especially by the World Meteorological Organization and the European Union.

This paper approaches the emergence of climate services from an institutional perspective, using discourse analysis as the method. Using World Meteorological Organization Bulletin articles, climate services are analyzed as a developing organizational field undergoing a theorization process, where the necessity and characteristics of the field are conceptualized and institutional logics are formed. Within the paper, these logics and their implications are also assessed in the context of climate change adaptation and mitigation, decision-making and service development.

Results show that, within the studied texts, climate services are justified by global challenges, specific needs, technological potential, economic value and shortcomings of existing climate science communication; and that the emerging field is characterized by user orientation, new roles and responsibilities and ambiguous service content. These discourses reveal emerging institutional logics that are based on somewhat narrow assumptions on human and organizational behavior and adaptation dynamics. These indicative results, from this limited study, call for more diverse and critical research approach to climate services.

1. Introduction

> "…a new fertile scientific community breaks down walls between public and private; pure and applied; science and industry. This intellectual and technical fusion offers opportunities as we seek to develop greater resilience to climate change and extreme events." (Sample article #46, WMO Bulletin, Vol. 60, Iss. 1, 2011)

The complex and severe challenge presented by climate change has led to diverse and intense discussion about the interaction between science, society and policy. As the quote above illustrates, new ways of organizing the production, delivery and use of climate information are sought for and suggested. One part of this development has been the emergence of so called 'climate services'.

Climate services can simply be defined as serving climate related information to someone. According to Vaughan and Dessai (2014) they involve the generation, provision, and contextualization of information and knowledge derived from climate research for decision-making at all levels of society. Ideas about delivering such information as a service emerged already in 1970's and 1980's (Changnon et al., 1980; Hecht, 1984; National Academy of Sciences, 2001) but the current momentum and institutional development is unprecedented. This turn indicates a shift in mindset. As Millner (2012) explains, what once was a pure research enterprise is now increasingly a business of service delivery. Especially, the World Meteorological Organization (WMO, 2014) and the European Union (EU, 2015) have promoted the concept of climate services in their agendas.

Climate services can be considered as an emerging organizational field. Organizational fields are aggregates of actors in a recognized area of institutional life (DiMaggio and Powell, 1983) or sets of organizations that share a common meaning system and interact more frequently within the set than outside it (Scott, 1995). Both of these definitions apply to climate services. A key process in field emergence is theorization (Strang and Meyer, 1993; Tolbert and Zucker, 1996) during which the developing practices and structures are conceptualized by developing shared meanings, leading to legitimacy and increased objectification (Greenwood et al., 2002). This process is also tightly connected to agreement on the institutional logics (Thornton

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and Ocasio, 1999) of the new field which in part leads to shared and socially constructed assumptions, values and rules. Climate services can be seen as currently undergoing a theorization process.

The aim of this paper is to explore this emergence of climate services. This is done by analyzing the articles discussing climate services within a selected professional publication: the WMO Bulletin. The bulletin articles are considered to constitute an interesting sample of professional texts that theorize and conceptualize climate services. Such a limited set of texts causes the resulting picture of the emerging field to remain partial, but the importance of WMO as an institution means that the theorization taking place within its publication has the potential to affect the development of the field as a whole.

This paper uses discourse analysis to study the emergence of the field of climate services. There is a long tradition in using discourse analysis in environmental policy research (Hajer and Versteeg, 2005) and also in studying climate policy specifically (O'Brien et al., 2007; Gillard, 2016).

The motivation of this study is clear. It is important to understand the emergence of climate services because of the immense global challenge posed by climate change. If even a partial response to this challenge is the servitization (Vandermerwe and Rada, 1988) of climate science, this transformation from science into services needs to be sound. Critical analysis is currently absent in the academic literature on climate services. The few studies with a broader approach, such as those by Vaughan and Dessai (2014) and Reinecke (2015) explain and conceptualize the issue but lack the analysis of the servitization process itself.

The paper is structured as follows. Section 2 elaborates the paper's connections to relevant theoretical literature. The third section describes the research design. The fourth section is devoted to the results of the discourse analysis, followed by the discussion about these results in the fifth section. The sixth and final section concludes the paper.

2. Theoretical approach

The idea of organizational fields is rooted in institutional theory. Institutional theory can be described as a theoretical approach that emphasizes the processes and impacts related to development and existence of resilient social structures (Scott, 2008). Institutions are these social structures and can exist in many forms, such as organizations, practices, norms or rules. The key role of institutions in climate change adaptation has been pointed out by several authors (Bakker, 1999; Adger, 2000; Næss et al., 2005; Dovers and Hezri, 2010) and institutional theory has proven useful in studies of science policy (Martin, 2012).

Organizational fields were originally defined by DiMaggio and Powell as "sets of organization that, in the aggregate, constitute an area of institutional life; key suppliers, resource and product consumers, regulatory agencies, and other organizations that produce similar services or products." (1983: 148–149). As Phillips et al. (2004) mention, organizational fields consist of shared institutions. A critical phase in the emergence of institutions is *objectification* where general, shared social meanings are developed and attached to behaviors (Tolbert and Zucker, 1996). *Theorization* or theorizing is a central activity enabling objectification (Strang and Meyer, 1993; Tolbert and Zucker, 1996; Greenwood et al., 2002). During theorization the shortcomings of existing institutions are conceptualized and new potential solutions are presented, creating moral and pragmatic legitimacy for the institutional change (Greenwood et al., 2002). Theorization is closely related to the idea of *institutional logics*. Institutional logics are defined by Thornton and Ocasio (1999) as the socially constructed patterns of practices, assumptions, values, beliefs and rules that guide, organize and provide meaning, and therefore they can be viewed as the outcome of the theorization.

Discourse analysis has become an important tool within the development of institutional theory because it offers a way to understand how institutional logics develop, by whom and to what effect. It is also useful in explicating social construction processes such as theorization. (Nelson and Oswick, 2012) This importance of discourse in the emergence of a field has been pointed out by several authors (Phillips et al., 2004; Maguire and Hardy, 2006; Grodal and Granqvist, 2014) as discourses create the meanings that ultimately define the field and its boundaries. Discourse analysis has also been applied extensively in climate change policy research (see e.g. Detraz and Betsill, 2009; Cannon and Müller-Mahn, 2010; Hartmann, 2010).

3. Research design

The empirical component of this paper consists of a document analysis aiming to study the prevailing discourses in the climate services field. Document analysis is an established and popular method in qualitative research that offers an efficient and exact way to achieve high temporal and spatial coverage to track change and development (Bowen, 2009). In general, document analysis involves superficial examination by skimming, more thorough examination by reading and finally interpretation leading to analysis (Bowen, 2009).

The documents selected are WMO Bulletin articles published between 2007 and 2015. This time period was chosen because of its availability and to represent the most recent phase in the emergence of climate services from the scientific-professional point of view. The period also covers both the immediate development of WMO's Global Framework of Climate Services (WMO, 2011, 2014) and its immediate consequences; thus covering perhaps the most substantial formal processes related to the emergence of climate services.

The WMO Bulletin is the official journal of the World Meteorological Organization. It is issued twice a year with the exception of additional special issues, and regards the atmospheric sciences community as its target audience with extended outreach to the broader informed public (WMO, 2016). Because of the global and interdisciplinary nature of the bulletin's audience, highly technical or scientific material is discouraged. Articles are submitted by scientists and professionals in the fields of meteorology, climatology, hydrology, the environment and related fields, and large share of the content is also provided by the editorial board and WMO secretariat.

There are various reasons justifying this selection of documents. First, as Phillips et al. (2004) propose, texts produced by actors that are considered legitimate or formal authorities, central within a field, are more likely to become embedded in the action shaping discourse. The WMO Bulletin articles certainly fall into this category. Second, Greenwood et al. (2002) showed that professional associations have a pivotal role in the theorization phase of institutional change. Although the WMO is not by strict definition a professional association, it is a similar community of professionals, within which many of the most notable discussions of the relevant professions take place. It is also worth noting that while WMO membership is country-based, the countries are typically represented by their national meteorological and hydrological services (NMHS) (i.e. scientists and professionals of atmospheric sciences).

The material for in-depth document analysis was selected by identifying all the WMO bulletin articles published between 2007 and 2015 and selecting those ones which explicitly mentioned "climate services", "climate information services", "climate change services" or "climate adaptation services" in the topic or the body of the text. This framing resulted in a cohort of 109 articles. The selection criteria is likely to exclude some articles that discuss the issue but do not use the exact terms and it included multiple articles that discussed climate services only briefly. It can, however, be considered to sufficiently represent the climate services debate within WMO's circle during the time period. The list of sample articles is presented in Appendix A.

After initial scoping and selection the material was processed in three phases. First, the documents were skimmed through to form a general idea on the climate services discussion. During this skimming

phase, one article was excluded from the detailed analysis as it was only a list of events (Sample article #4, WMO Bulletin, Vol. 56, Iss. 1, 2007).

In the second phase the documents were examined in detail. The aim was twofold: 1) to analyze the authorship of the articles, and 2) to identify the texts relevant for the theorization process. In practice this meant that the content and authorship of each document was briefly described. The documents were searched for explicit statements and implied views, especially those regarding the motivation for developing climate services, structure of climate services market, essential elements of climate services, identified challenges and expected or suggested measures to promote climate services.

In this reading, authorship was categorized by two factors: the nature of the affiliated organization and the country of the organization. Regarding the theorization discourse within the texts, 27 themes were identified, where a specific text could be labeled under multiple themes. The theme categories were formed by collecting individual statements from the texts and sorting them under descriptive labels that were generated as the work progressed. Representative excerpts were collected and coded under each theme.

The third phase had an interpretative emphasis and included re-reading the documents and coded excerpts, with the objective to identify the central discourses within the texts. These discourses are described in detail in the Section 4. The work was guided by the model of theorization process presented by Greenwood et al. (2002) with the idea of identifying discourses that either specify current organizational failings or describe and justify the new field. In the process the original 27 themes were further developed and merged, resulting in eight distinct types of discourses. These eight types were seen to fall under two sets of discourses: those justifying the emergence of climate services and those characterizing this new field. The eight discourses were considered to be prevalent enough to describe and cover most of the theorizing taking place in the texts.

The discourse analysis was followed by the identification of institutional logics. This was done by assessing the explicit propositions and implicit assumptions of each discourse. For example, if climate services were being presented as a critical factor in combatting climate change, what kinds of assumptions on the role of information in climate action does such a view build on? After constructing these interpretations of institutional logics, they were assessed in the context of climate science, decision-making, service development and science policy to identify potential risks and shortcomings in the ways climate services are now theorized within the WMO community.

4. Results

Looking at the discussions on climate services in the WMO Bulletins, discourses specifying current organizational failings and justifying the need for change are much more prevalent than discourses describing the new paradigm. That is, *why climate services are necessary and needed* is discussed much more than *what climate services are* or *how they should be organized, developed and delivered*.

In analyzing discourse, what is not said or written can be just as revealing as that what is. Interestingly, the climate service discourse is almost completely lacks any direct critique, elaboration of the concept or discussion of the implementation challenges. Ambiguity of the emerging field can perhaps explain some of the lack of critical discourses, as can the chosen media. Since WMO is one of the institutional champions of climate services, its bulletin can be expected to reflect positive attitudes towards the field.

The articles represent a time period of nine years. In the analysis the discourse did not transform much during this time. There were no drastic changes in the annual amount of articles discussing climate services; at lowest there were nine articles in 2009 and at highest 21 articles in 2013 (when there was a special issue focusing on climate services). The development of Global Framework for Climate Services (GFCS) is naturally reflected in the articles but there is no significant change on *how* climate services are discussed.

4.1. Authorship analysis

The authorship of the articles was analyzed through the affiliation of the authors. For each article, the organization represented by the author was categorized by its type and home country. The results are shown in Appendix A. At times a particular author was affiliated with several organizations, and altogether 172 author affiliations were identified.

64 of the 109 documents had one or several authors directly affiliated with the WMO, 31 were affiliated with national or international meteorological or hydrological services and 50 were affiliated with other research institutes, universities or scientific societies. Other, less typical affiliations included private enterprises, NGOs, other UN agencies and governmental offices. Thus, the voice represented in the texts is mostly that of the scientific community, although largely distilled through the scientific-political organization WMO.

The country affiliations were categorized by the country of the organization. Here the analysis shows a clear bias. 131 of the 164 country affiliations are from OECD countries. Naturally the Swiss based WMO explains a lot of this, but it is still clear that in general the texts reflect the point of view of the global north. This is particularly interesting since WMO is a global U.N. agency and therefore a more inclusive perspective could be expected from it.

4.2. Justifying discourses

The authors of the bulletin articles present myriad arguments justifying the necessity of climate services and specifying the shortcomings of existing ways of organizing. Based on the analysis, arguments were grouped into four dominant discourses: 1) *Global challenge* 2) *Specific industry needs* 3) *Socio-economic value* and 4) *Technological potential*. These discourses are tightly linked and partly overlapping. They are connected to a more general discourse specifying the overall problems of current organizing of climate science within society, the discourse of 5) *Deficient supply and demand*.

The five justifying discourses are summarized and described in Table 1 below. In the articles, the global challenge discourse appears most frequently. Specific industry needs and socio-economic value discourses are frequent as well. While technological potential and system deficiency discourses are repeated less, they are still apparent throughout the studied period.

4.2.1. Global challenge

The discourse of Global challenge focuses on the big picture. The climate is changing, and the changing climate possesses an immense threat to societies across the world. Climate change is also often connected to other threats, such as population growth and poverty. This concern about global development is combined with the acknowledgement of the possibilities and perceived responsibility of scientists to act, as reflected in the following text:

> "*Climate change is one of the greatest challenges facing humankind. We have the means today to bring life-saving information to those who need it most, and a responsibility to make this a reality.*" (Sample article #40, WMO Bulletin, Vol. 60, Iss. 1., 2011)

This discourse is frequently present in texts in an introductory manner. It is used to set the context of the whole issue; it presents the global challenge of climate change as the prime reason for advancing climate science in general.

4.2.2. Specific industry needs

Another justifying discourse is related to the specific needs of certain industries or sectors of the economy. These are often connected to the global challenge of climate change, but the approach is more

Table 1
The five justifying discourses.

Discourse	General logic	Example quote[a]
Global challenge	Climate services are important in addressing climate change.	"*Climate services are essential for adaptation to climate variability and change.*" (#74)
Specific industry needs	Sectors across society need climate services to improve their efficiency or resilience.	*"This tailored information assists farmers in making management decisions to reduce the risks and benefit from the opportunities of our variable and changing climate."* (#77)
Socio-economic value	The value of climate information is determined by its use.	"*Investments in weather, climate and water information and services produce an economic return many times greater than the original amount invested, and represent an investment in well-being and prosperity for all.* (#86)
Technological potential	Technological development enables new, advanced services.	*"Innovation – the advent of satellites, high-speed telecommunications, supercomputers and new scientific insights – has given the ability to provide such climate services. We can now peer further into the future than ever before." (#63)*
Deficient supply and demand	Both supply and demand of climate information are flawed without servitization.	*"In most cases, however, there is a gap between what is currently available and what they need."* (#106)

[a] The quotes are referred by the index numbers in Appendix A.

instrumental; some specific activity is thought to rely on climate services. Typical examples are energy, agriculture and health sectors, but also industries with a more indirect connection to climate are discussed, such as financial services. The following text exemplifies these ideas:

> "*Thus, by properly taking into account weather and climate information, energy systems can considerably improve their resilience to weather extremes, climate variability and change. Climate services can also support increased development and use of renewable energy sources.*" (Sample article #104, WMO Bulletin, Vol. 64, Iss. 2, 2015)

The arguments in this discourse refer to experienced or expected needs that climate services could address. This discussion is, in some occasions, broadened so that it is a general sign of times that more climate information is needed across the society; not just to respond to climate change but because society and business today are inherently more vulnerable to all kinds of changes. This argument is illustrated by the following comment:

> "*Fast-growing urbanisation, environmental deterioration and climate change are making individuals, organisations and businesses more vulnerable to meteorological and environmental hazards.*" (Sample article #99, WMO Bulletin, Vol. 64, Iss. 1, 2015)

The discourse of specific industry needs differs from the global challenge in the sense that it justifies climate services as a response to existing or expected demand, whereas the global challenge discourse acknowledges a threat to be addressed, whether or not any outside group is explicitly demanding climate information.

4.2.3. Socio-economic value

The third discourse is focused on socio-economic benefits. The difference compared to the two previously described discourses is the abstract nature of the argument and the twofold logic: climate information has value to society and this value is determined solely by the society that uses this information. The argumentation then continues so that currently this value is not as high as it should be and that moving from current ways of organizing into climate services would increase it. As this editorial describes:

> "*The intrinsic value of weather, climate and water services is derived from the use of this information in decision-making, which improves societal and economic outcomes.*" (Sample article #1, WMO Bulletin, Vol. 56, Iss. 1, 2007)

Some of the authors go even further arguing that climate services are necessary to create demand for climate information, thus connecting the value discussion to that of specific industry needs. It should be noted that economic valuation of the socio-economic benefits of weather and climate information has long tradition within the professional community in atmospheric sciences (see e.g. Katz and Murphy, 1997).

4.2.4. Technological potential

> "*Looking to the future, we find ourselves at the beginning of a new era of predicting Earth System behaviour with tremendous potential to serve global society's need for climate and environmental information from days to seasons, years to decades and longer.*" (Sample article #22, WMO Bulletin, Vol. 58, Iss. 3, 2009)

The discourse of Technological potential differs from the others since it is based less on a perceived problem. Instead, it is about opportunities created by the advancement of technology related to climate science and technological advancement in general. In this discourse, the argument is based on a view that the technology to deliver better, more tailored climate information exists and this enables the establishment of new climate services. To put it simply, it should be done because it can be done.

Several technological advancements are incorporated within the technological potential discourse. Some authors discuss the general development and increased predictive skill, or temporal and spatial accuracy, while others specify the nature of new possibilities, such as predictions at seasonal or decadal time scales.

4.2.5. Deficient supply and demand

The four discourses, described above, justify the transition towards servitization of climate science. Still, while they do reason why climate services should be developed, less emphasis is on why these issues could not be managed without climate services. Some authors go further and discuss explicitly how and why climate related decision making is currently not working optimally. This discourse of general system deficiency builds upon two lines of argumentation, as problems are described both in terms of supply and demand.

In many texts, demand, or the user side, is described as underutilizing available climate information. This is notably connected to the idea of the socio-economic value of using climate information that is described above. The fundamental problems on the user side are considered to be lacking knowledge, interest or skills to utilize the available information. The following extract illustrates this stance:

> "*Decision-makers in many climate–sensitive sectors—water, agriculture, fisheries, health, forestry, transport, tourism, energy, disaster risk management—are increasingly concerned by the growing adverse impacts of climate risks, but are ill-equipped to make use of the available climate information.*" (Sample article #21, WMO Bulletin, Vol. 58, Iss. 3, 2009)

In addition to the demand problem a supply problem is identified. These authors argue that the climate science community has failed in its information provision, either in terms of communication or content, or both. Communication failure refers to an inability to reach sufficient accessibility or awareness of the available information, and content failure to an inability to produce the relevant information either

because of not understanding the demand or because of lacking technological capability. As one author puts it:

> "*Much of the currently available climate information is raw scientific data, which is not user-friendly. It needs to be translated into lay terminology and delivered in a way that end users can understand and apply.*" (Sample article#106, WMO Bulletin, Vol. 64, Iss. 2, 2015)

The problems in supply and demand are not considered to be separate. In many of the Bulletin articles the demand and supply side problems are combined and discussed as a single problem of underutilization.

4.3. Descriptive discourses

Besides justifying the need for a new organizational field and institutional logics, part of the theorizing process is defining and describing the foundations of the new field. Not surprisingly, such descriptive discourses can be identified within the examined WMO Bulletin articles. Few authors explicitly discuss the definition of climate services or their composition in a very concrete way, but many implicitly discuss the characteristics they relate to climate services.

Specifically three descriptive discourses can be identified: 1) *User orientation* 2) *New roles and responsibilities* and 3) *Service portfolio*. Together these three discourses paint a somewhat coherent yet ambiguous picture of what climate services are and how they should be organized. The descriptive discourses are summarized in Table 2. In the bulletin articles, descriptive discourses falling under *User orientation* or *New roles and responsibilities* are significantly more common than the discourse describing the emerging service portfolio.

4.3.1. User orientation

User orientation is a pervasive theme throughout all climate service discourse. This is only natural since services are by definition interactions involving both the provider and user or consumer. The discourse within the bulletin articles not only champions identifying user needs and improving service delivery, but also typically argues that the user orientation should be very inclusive and collaborative. The authors advocate for integrating users of climate information tightly to the production, as the following excerpt illustrates:

> "*Success […] will depend crucially on the active involvement of the climate and applications communities, and co-development with stakeholders.*" (Sample article #67, WMO Bulletin, Vol. 61, Iss. 2, 2012)

There seems to be no upper limit for this collaboration or co-development. In some of the bulleting texts users are even invited to influence not only what information should be provided but also how it is produced and by whom:

> *"Climate science should practice this inclusiveness in all its activities, from the bench to the social sciences; and in all stages of its activities, from the initial scoping and research design, to results dissemination and capacity-building."* (Sample article #83, WMO Bulletin, Vol. 62, Special issue, 2013)

This type of collaboration can be thought to go beyond clear producer-user roles. Some authors seem to recognize this, and instead of user needs and engagement they talk about partnerships and stakeholders. The prevailing logic is still the same; climate services should be developed and delivered in close collaboration with actors outside the direct field of science and research.

The question then is who are the users or stakeholders. In the user orientation discourse this issue is often not discussed; instead general remarks of users and their needs are made. Sometimes different groups within the value chain, such as end-users and intermediary users are identified. Still some authors recognize national policy makers and organizations and individuals in sectors, such as agriculture, health, finance or energy, as users or stakeholders. Some authors also directly represent these user sectors. The general perception is that in this discourse the label of user is open and inclusive: climate services can be useful to anyone, although some key sectors are identified.

User orientation is also the discourse that includes majority of the critical and challenging views about the development of climate services. Complex and probabilistic nature of climate information is one issue that is brought up as well as its longer time horizons, which make creating useful services more difficult. As a text in a collaborative article puts it:

> "*Politicians and the public want quick solutions. The perceived slow and cautious approach of science to problem solving and the uncertainty conveyed in the results is at odds with the need to make rapid, unequivocal decision. It is often difficult, therefore, for decision-makers to benefit fully from scientific information and know-how and for the science to satisfy the needs of the user."* (Sample article #3, WMO Bulletin, Vol. 56, Iss. 1, 2007)

While such challenges are pointed out in some of the texts, none seem to consider them insurmountable. Rather they endorse the characteristics of the envisioned climate services as the solution, such as more active communication and improvement of climate literacy to overcome the problems concerning the nature of climate information compared to user needs.

4.3.2. New roles and responsibilities

The definition of users and stakeholders is connected to the conceptions of roles of different actors within the climate services discourse. Climate services are to be built on close collaboration with information providers and different levels of users, but this itself does not specify the exact boundaries and division of roles and power. These are discussed in many of the articles, and three themes seem to emerge: 1) increased actor diversity, 2) NMHS centricity, and 3) protecting the position of NMHSs.

The first theme expresses the overall view that the actor landscape becomes more heterogeneous, with the private sector taking a more active role in the provision and refinement of information. In addition, different public and academic actors should be incorporated to a greater extent in each other's climate related work. This diversification

Table 2
The three descriptive discourses.

Discourse	General logic	Example quote[a]
User orientation	It is necessary and beneficial to engage users in climate service development.	"*Climate services need to be provided to users in a seamless manner and, most of all, need to respond to user requirements.*" (#76)
New roles and responsibilities	The actor field diversifies, but NMHS remain the central actors in the new field and need to expand their activities.	"*The delivery of high-quality climate services will require better-coordinated and more comprehensive observing components that can be supplied only by NMHSs working together with their national and international partners.*" (#86)
Service portfolio	Climate services bring improved accuracy, tailoring, operationalization and integration of climate data with other environmental and societal data.	"*Climate information should include the relevant spatial and temporal resolution detail to support the needs of users at local, sub-national, national, regional and global levels.*" (#51)

[a] The quotes are referred by the index numbers in Appendix A.

of the field is seen as beneficial, and especially as private companies are considered to bring complementary competences to the field, such as developing digital applications or user interfaces. The following excerpt reflects these ideas:

> *"[…] the private sector has unique capabilities and can offer innovative approaches for climate data management and for creating interactive user-friendly technology platforms that are better leveraged to ensure climate information services reach a broader audience and are effectively applied to decision-making."* (Sample article #106, WMO Bulletin, Vol. 64, Iss. 2, 2015)

The second theme acts as a side note to the first. In this discourse, the special nature and importance of NMHSs is emphasized frequently. Private firms and other external actors are welcome, but NMHSs are the key actors, the central nodes, who are responsible for "connecting the dots" between supply and demand. The main argument is that these organizations are naturally suited to be the central actors because of their expertise, institutional position and infrastructure, as illustrated by the following text:

> *"Given the long and proud record of meteorological science and services in the emergence of the climate issue and the traditional role of most National Meteorological Services (NMSs) as their countries' national climate authorities, NMSs should be superbly placed to meet the now almost insatiable community need for climate information."* (Sample article #24, WMO Bulletin, Vol.58, Iss. 3, 2009)

However, according to the third theme this special position is considered to require safeguarding. While developments, such as commercialization, competition and open data are welcomed they should not endanger the role of NMHSs. Thus these organizations are considered to be strong and vulnerable at the same time. The following excerpts describe this cautious stance towards competition:

> *"Competition between meteorological service providers in the public and private sector may ultimately improve the efficiency of services, but the transition from a collaborative intergovernmental environment to a market-driven service will need to be carefully managed to avoid undermining the broader societal and economic benefit of the public goods and services associated with NMHSs."* (Sample article #3, WMO Bulletin, Vol 56, Iss. 1, 2007)

This underscoring of the centrality of NMHSs is quite expectable considering how the WMO is organized. Parallel to NMHS emphasis, the descriptive discourse also strongly favors increased public investments in public provision of climate services. Governments are expected to provide the support and resources to ensure climate services provision, and in connection to the NMHS emphasis above, one endorsed form of such support is the funding of these organizations. The following excerpt reflects this theme:

> *"There has, from time to time, been some criticism of WMO and of the NMSs of its Members for being too inwardly focused or too slow in gearing up to meet the burgeoning requirements for climate services; criticism made, I believe, without sufficient recognition that it has been the policies of governments, including several of those offering such criticism, that have starved the WMO and NMS communities of resources and tied their hands."* (Sample article #24, WMO Bulletin, Vol. 58, Iss. 3, 2009)

The discussion on the roles of the public and private nature of meteorological information has a long tradition in the professional community. The official position of the WMO is that climate information is primarily an international public good; such information covers "*meteorological, hydrological and climatological data and products developed or acquired under WMO auspices and required to support the implementation of the Global Framework for Climate Services*" (WMO, 2015). The boundaries of these definitions within the bulletin articles are somewhat ambiguous. While the general discourse favors both the strong role of NMHSs and intense collaboration with private businesses there are only few explicit descriptions on where the boundaries between the responsibilities and rights of different actors lie.

Discourse on the new roles and responsibilities also includes some elements of concern. More complex networks of information production and delivery are expected to bring new risks, for example, as opportunities for intentional or unintentional harmful behavior. In these commentaries, the vulnerability and institutional deficiencies of developing countries are typically emphasized as well. The following excerpt reflects such concerns related to these interest and power conflicts:

> *"As demand for climate services diversifies, many institutions have become involved, fragmenting service delivery and rendering it more susceptible to vested interests."* (Sample article #56, WMO Bulletin, Vol. 60, Iss. 2, 2011)

4.3.3. Service portfolio

Besides these described general service structure characteristics—user orientation, roles and responsibilities and improved communication—there are some descriptions of envisioned or existing content of climate services in the texts. These are often not very concrete, and the ones described do not form an unambiguous picture of a service portfolio. The typical properties associated with climate services are improved spatial and temporal accuracy and reach, the tailored nature of information, operationalization in for example the form of indices and multidisciplinarity. Especially, multidisciplinary integration of information outside natural sciences is often brought up as an important and necessary feature of climate services, such as in the following:

> *"Effective climate services will depend on maximizing the potential of existing knowledge, new research developments and strong support from and strengthened collaboration between all relevant research communities."* (Sample article #52, WMO Bulletin, Vol 60, Iss. 2, 2011)

This idea of multidisciplinary services is especially interesting in combination with how the roles and responsibilities are discussed. While climate services are considered to consist of inputs across different fields of science, the "ownership" of the field is still considered to lie within the meteorological or climate science community.

4.4. Emerging institutional logics

The discourses identified in the bulletin articles imply several direct and implicit assumptions. These assumptions reveal the institutional logics of climate services as a field as it's being discussed in the WMO Bulletin.

Four direct key assumptions emerge from the discourses. First, climate services are assumed to be necessary to combat climate change but also to bring other benefits to society. Second, technology to produce more useful climate information is assumed to exist. Third, integrating users into the production and specification of climate information is considered the most important way to create climate services. Fourth, the experts in the field of atmospheric sciences are assumed as the principal actors in the emerging climate services field, especially as represented by NMHSs. Strong public funding is required and justified to maintain this position. Private sector, politicians and other fields of research have important but peripheral roles.

When climate services are justified by the global challenge discourse it postulates that lack of information hinders climate action. The discourse also holds the assumption that more actionable and useful information can be produced by climate science and that there is no fundamental economic or technical reason to doubt that increasing temporal and spatial accuracy or coverage of observations is feasible and improves the usability of the information.

The notion of lacking information is directly connected to another

underlying assumption; that of the rationality of actors. Not only are decision-makers assumed to act according to information rationally, they are assumed to be aware of their information needs and able to articulate them. Rationality is assumed to be instrumental in the sense that decision-makers are considered to be able to identify their problems, optimal solutions and paths to achieving those solutions.

From rationality also stems the assumption of the primary mode of adaptation. Adaptation to climate change is assumed to occur proactively by strategic choice in contrast to it happening reactively and guided by environmental determinism. Combined with the idea of user orientation it also assumes that the agents and main actors of adaptation are known or can be identified so that the right information can be (co)produced and delivered.

Finally, the proposed key role of NMHSs and enabling public funding is based on certain assumptions on the effective roles of public and private sector in information provision and research and development. First, market mechanisms are considered insufficient to allocate the necessary resources required. In addition, private sector is seen unable or unfit to be responsible for the innovation effort required by climate change. The necessary role of public innovation is assumed to extend beyond remedying market failures.

5. Discussion: the implications of the emerging institutional logics

The institutional logics described above raise several questions. First, whether the logics derived from the WMO Bulleting discourse are representative of the broader climate services field. Second, whether these logics are sound in terms of climate science, organizational studies and other relevant research.

5.1. Institutional logics in broader climate services literature

If the WMO Bulletin articles form a somewhat representative setting for the climate services discourse of experts in the emerging field, the institutional logics identified should resemble the way climate services are framed within research papers and editorials in scientific journals in general. Proving this would naturally require another broad systematic review, but there are examples of similar logics in published papers, indicating perhaps a broader applicability. The importance and potential benefits of climate services have been emphasized in papers by several authors (Asrar et al., 2012; Buontempo et al., 2014; Lourenço et al., 2016). The user centric view has also been frequently promoted as the necessary direction for future development (Lemos et al., 2012; Kirchhoff et al., 2013; McNie, 2013; Buontempo et al., 2014).

There are also developments in the climate service research that are not widely reflected in the WMO discourse or the derived logics. Keohane et al. (2014) brought up the issue of ethics and the challenging trade-offs regarding honesty, precision, relevance, transparency and specifying uncertainty in communicating climate information. The ethics of climate services in particular were discussed in a white paper published in 2015 (Adams et al., 2015). This white paper was outlined in one WMO Bulletin article (Sample #100) but otherwise the ethical dimension remains mainly implicit in the articles.

5.2. Potential risks and shortcomings

While challenges related to the development of climate services are occasionally raised, questioning the institutional logics of the emerging field seems to be absent in the studied texts. These logics however contain several problems and risks present that should be acknowledged and addressed as the field develops.

As described, the central assumption within the identified logics is that climate services are somehow necessary to respond to climate change. This would imply that a lack of information is a major barrier to action and this lacking information can be produced and delivered. The user orientation emphasized in the logics assumes that users are interested to participate and that they can identify and articulate their information needs. Adding to this is the assumption that catering these needs evokes an effective response and leads to societal benefits. Embedded in these assumptions is also the idea that actors are rational and adapt strategically. Each of these assumptions are however somewhat problematic.

The lack of information is a complex issue. There is high level of scientific agreement on the main mechanisms related to climate change and the nature and scale of the mitigation and adaptation needs (IPCC, 2014a,b). In mitigation and adaptation, many barriers are psychological, institutional, socio-economic or infrastructure related (Gifford, 2011; IPCC, 2014b) and not necessarily dependent on new information. It should also be noted that in decision-making processes more information does not always lead to better decisions. Seeking for more information can lead to paralysis by analysis (Ansoff, 1965) where actions keep being delayed as more information is gathered or expected. Pielke Jr et al. (2000) discussed this as a limit to the use of predictive scientific information in the face of climate change.

The limits of existing information also come up frequently as one of the challenges when the use of climate information is studied (see e.g. Bolson et al., 2013; Kirchhoff, 2013; Pilli-Sihvola et al., 2015; Soares and Dessai, 2016). The question is whether the required information can actually be produced. Climate information is inherently uncertain and part of this uncertainty can most likely never be removed. This causes severe limitations to decision-making relying on predictive information produced by climate science (Dessai et al., 2009). In conditions of “deep uncertainty” the role of information in decision-making is different, and methods, such as Robust Decision Making (RDM) (Lempert, 2014) have been developed in order to specifically avoid reliance on accurate predictive information. RDM is an iterative decision analytic framework where multiple future states are evaluated in terms of set robustness criteria.

The prerequisites for user oriented service development can also be problematic. In general the typical methods for interacting with end users are interviews, workshops and surveys (Abras et al., 2004). These come with an opportunity cost for the participant. The result may be that the user representation is biased towards organizations that have the resources and interests to participate. Fields such as software development and industrial design have a long history of user-oriented development, and might teach valuable lessons for climate services. In general, user participation is thought to be mostly beneficial, but not easy, as identifying and contacting users takes time, skill and careful planning (Kujala, 2003). User oriented development also faces many kinds of challenges stemming from the societal and cultural contexts of both the producers and users (Gill, 2009) and if not conducted well it may lead to more harm than benefit (Gulliksen et al., 2003).

Even correctly identifying and catering user needs might not bring overall societal benefit. If economic or regulative incentives promote narrow or short term gains, improving individual user or sector capabilities to cope with climate change can increase the overall climate risks. An example is the Arctic where improved climate services might enable increased hydrocarbon extraction. Such activity is not compatible with the emission reductions required to mitigate global warming under 2 °C (McGlade and Ekins, 2015) and would increase the risk of catastrophic climate change. On a more conceptual level improving efficiency of user sectors with climate services may come with a trade-off concerning resilience; theories of complex adaptive systems imply that adaptive capacity builds on diversity, not efficiency (Rammel et al., 2007).

Overall, the institutional logics described maintain the idea that actors are rational and adapt strategically. Empirical and conceptual studies suggests otherwise. Path-dependency (Pierson, 2000) limits organizational choices based on an organization’s history, causing inertia and inflexibility. Such inertia has been perceived in the context of climate change adaptation as well (Harries and Penning-Rowsell, 2011). Availability of information itself might not be enough to trigger

required action; it may require an actual event, as Miao and Popp (2014) describe in their study regarding natural disasters. Proactive adaptation by strategic choices concerning an organization's environment is also only one conceptual model among others (Hrebeniak and Joyce, 1985).

These remarks imply that the institutional logics within the WMO Bulletin might be somewhat problematic. The servitization of climate information can support adaptation and mitigation and bring societal benefits, but the discourse and logics presented seem to undermine some challenges and risks that the emerging field faces.

5.3. Limitations and directions for future research

The methods and material chosen for this study result in many limitations. The choice of discourse analysis as a method can be debated due to its sensitivity for choosing the data and reliance on interpretation. Considering the empirical data used, written documents are only a reflection of all the discussions and debate of the professionals networked within WMO. And as described, certain regions and actors are overrepresented in the WMO view.

The analysis presented here leaves many opportunities for further organizational research on the development of climate services. Recently, the European Union has followed the WMO in becoming an important organizational promoter of climate services through its policies and funding (EU, 2015, 2016). Whether and how the theorization process and logics have transformed as the discourse has expanded from a scientific-professional domain into policy-making is an interesting and important question. Also, field emergence does not happen in a vacuum. Existing macro-cultural discourse determines the context of the emerging field (Lawrence and Phillips, 2004) and it seems possible that macro-level service and market discourses have influenced the shape climate services are taking.

Another important aspect is the perspective. The authorship analysis reveals that the WMO Bulletin discourses are mainly generated by representatives of organizations of the global north. An analysis of climate service discourse within the developing world might reveal different logics and is worth further investigation.

Document based discourse analysis is also only one limited tool for exploring the emerging field. Expanding the empirical data by conducting interviews could broaden the analysis of the institutional logics and may be a way reveal the critical views that are now so strikingly absent in the written documents.

Applying different theoretical approaches might yield new, fruitful insights into climate services as well. Studying institutional work (Lawrence and Suddaby, 2006) instead of institutional logics would shift the focus on agency: Which actors are driving the emerging field, how and why? In addition to these qualitative approaches there are opportunities for interesting and revealing quantitative studies looking at for example the potential size of the envisioned service market or the realities of the socio-economic benefits of climate services.

6. Conclusions

The aim of this paper has been to explore the institutional logics within the emerging field of climate services by analyzing the discourse in the WMO Bulletin articles. Within the texts, five justifying discourses and three descriptive discourses were identified. The discourses that aim to justify the climate services are based on the global challenge of climate change, specific industry needs, socio-economic value, technological potential and deficient supply and demand. The descriptive discourses portray user orientation, new roles and responsibilities and an improved service portfolio as the characteristics of the emerging climate services.

An analysis of the implicit and explicit assumptions embedded within the discourses reveals the emerging institutional logics of climate services. This analysis draws a picture of institutional logics rooted in somewhat straightforward assumptions about information production and use, rationality and adaptive processes.

These critical notions are not meant to delegitimize the concept of climate services or oppose the emergence of the field. As discussed, many authors claim that addressing climate change needs new ways of organizing the relationship between science and society, and the inclusive and solution oriented nature of climate services may contain many of the right elements to do this. Still, in addition to the results described above, the main conclusion is that the field of climate services calls for more diverse and critical research.

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Appendix A. WMO Bulletin articles

Abbreviations used in the table:
CMA China Meteorological Administration
ECMWF European Centre for Medium-Range Weather Forecasts
FAO Food and Agriculture Organization of the United Nations
NASA National Aeronautics and Space Administration,U.S.
NCAR National Center for Atmospheric Research, U.S.
NOAA National Oceanic and Atmospheric Administration, U.S.
UN United Nations
UNEP United Nations Environment Programme
WMO World Meteorological Organization

Sample article #	Year	Issue	Title	Author	Affiliation	Affiliation category	Country
1	2007	Vol 56(1)	*Editorial*	Editor	WMO	WMO	Switzerland
2	2007	Vol	*Editorial*	Editor	WMO	WMO	Switzerland

		56(1)					
3	2007	Vol 56(1)	*"Deriving societal and economic benefits from meteorological and hydrological services"*	Rogers, D.P. (edit.)	UK Met Office	NMHS	U.K.
4	2007	Vol 56(1)	*"Social and economic benefits of meteorological and hydrological services – a regional overview"*	Editor	WMO	WMO	Switzerland
5	2007	Vol 56(1)	*"Climate data and services: preserving our cultural heritage"*	Editor	WMO	WMO	Switzerland
6	2007	Vol. 56 (1)	*"The socio-economic benefits of climatological services to the renewable energy sector"*	Gil, S.R	Comisión Nacional del Agua (CNA), Mexico	NMHS	Mexico
7	2007	Vol 56(2)	*"Improved development cooperation and regional services to Members"*	Editor	WMO	WMO	Switzerland
8	2007	Vol 56(3)	*"Towards secure and sustainable living: outcomes of the WMO international conference"*	Editor	WMO	WMO	Switzerland
9	2007	Vol 56(3)	*Editorial*	Editor	WMO	WMO	Switzerland
10	2008	Vol 57(1)	*"The World Weather Watch today"*	J. Hayes	WMO	WMO	Switzerland
11	2008	Vol 57(1)	*"Observational needs for climate prediction and adaptation"*	Michel Jarraud	WMO	WMO	Switzerland
12	2008	Vol 57(1)	*"Space-based Earth observations for societal benefit"*	Habib, S. [1] Plessis-Fraissard [2] Ambrose, S.D. [1]	[1] NASA [2] Independent consultant	Other scientific institute, Private enterprise	U.S.
13	2008	Vol 57(1)	*"Observing the climate – challenges for the 21st century"*	Wright, W.	Australian National Climate Centre/WMO	NMHS, WMO	Australia
14	2008	Vol 57(2)	*"Adapting to climate variability and change: the Climate Outlook Forum process"*	Ogallo, L.[1] Bessemoulin, P. [2], Ceron, J-P. [2], Mason, S. [3], Connor, S.J. [3]	[1] Intergovernmental Authority on Development Climate Prediction and Applications Centre, Nairobi, Kenya [2] Météo-France [3] International Research Institute for Climate and Society, USA	IHMS, NMHS, Other research institute	Kenya, France, U.S.
15	2008	Vol 57(3)	*"Short- and medium-term climate information for water management"*	Pearson, C.	WMO	WMO	Switzerland
16	2008	Vol 57(4)	*"Economic valuation and application of services"*	Lazo, J.K. [1] Bushek, N.F. [1], Laidlaw, E.K. [1], Raucher, R.S. [2] Teisberg,T.J. [3], Wagner, C.J. [2] Weiher, R.F. [4]	[1] NCAR [2] Stratus Consulting, USA [3]Teisberg Associates, USA [4] NOAA	Other research institute, Private enterprise, Private enterprise, Other research institute	U.S.
17	2008	Vol 57(4)	*"Taking action through pilot projects: "learning through doing""*	Wong, M.C., Lam, H.	Hong Kong Observatory	Other research institute	Hong Kong
18	2008	Vol 57(4)	*"Public health and weather services–climate information for the health sector"*	Ghebreyesus, T.A. [1], Tadese1, Z. [2] Jima1, D. [2], Bekele, E. [2] Mihretie, A. [3]. Yihdego, Y.Y [4] Dinku, T. [5], Connor, S.J. [5] and Rogers, D.P.[6]	[1] Ministry of Health, Ethiopia; [2] National Meteorological Agency, Ethiopia [3] Anti Malaria Association, Ethiopia; [4] Centre for National	Governmental organization, NMHS, NGO, NGO, University, NGO	Ethiopia, Ethiopia, Ethiopia, Ethiopia, U.S., U.S.

					Health Development in Ethiopia [5] Columbia University [6] Health and Climate Foundation, USA		
19	2009	Vol 58(1)	*"WMO research and development activities in air quality, weather and climate to benefit Africa"*	Foamouhoue, A.M [1], Baldasano, J.M. [2], Agulló, E.C. [3] Diongue-Niang, A. [4], García-Pando, C.P. [2] Poolman, E. [5] Thompson, M. [6]	[1] African Centre for Meteorological Applications to Development [2] Centro Nacional de Supercomputación, Spain [3] Centro de Investigación Atmosférica de Izaña, Agencia Estatal de Meteorologia [4] Direction de la Météorologie nationale, Sénégal [5] South African Weather Service, [6] International Research Institute for Climate and Society (IRI)	IHMS, Other research institute, NMHS, NMHS, NMHS, Other research institute	Niger, Spain, Spain, Senegal, South Africa, U.S.
20	2009	Vol 58(3)	*Editorial*	Editor	WMO	WMO	Switzerland
21	2009	Vol 58(3)	*"World Climate Conference-3: towards a Global Framework for Climate Services"*	Editor	WMO		
22	2009	Vol 58(3)	*"World Climate Research Programme: achievements, activities and challenges"*	Busalacchi, A.J. [1], Asrar, G.R. [2]	[1] University of Maryland [2] WMO	University, WMO	U.S., Switzerland
23	2009	Vol 58(3)	*"Addressing climate information needs at the regional level: the CORDEX framework"*	Giorgi, F. [1], Jones, C. [2] Asrar, G.R. [3]	[1] Abdus Salam International Centre for Theoretical Physics [2] Swedish Meteorological and Hydrological Institute [3] WMO	Other research institute, NMHS, WMO	Italy, Sweden, Switzerland
24	2009	Vol 58(3)	*"Adaptation to a variable and changing climate: challenges and opportunities for National Meteorological and Hydrological Services"*	Zillman, J.W.	WMO	WMO	Switzerland
25	2009	Vol 58(3)	*"A history of climate activities"*	Zillman, J.W.	WMO	WMO	Switzerland
26	2009	Vol 58(3)	*"Climate information in decision-making in the Greater Horn of Africa: lessons and experiences"*	Ogallo, L., Oludhe, C.	IGAD Climate and Applications Centre, Kenya	Other research institute	Kenya
27	2009	Vol 58(3)	*"Climate risk management in western South America: implementing a successful information system"*	Güingla, R.M, Mascarenhas, A.	CIIFEN – International Research Centre on El Niño	Other research institute	Ecuador
28	2010	Vol 59(1)	*Editorial*	Editor	WMO	WMO	Switzerland
29	2010	Vol 59(1)	*"Building a legacy through World Climate Conference-3"*	Editor	WMO	WMO	Switzerland
30	2010	Vol 59(1)	*"WCC-3 High-level Segment: in their own words"*	Editor	WMO	WMO	Switzerland
31	2010	Vol 59(1)	*"Building capacity around the world"*	Editor	WMO	WMO	Switzerland
32	2010	Vol	*"Public weather services for*	Lee, B.Y. and Lam, H.	Hong Kong Observatory	Other research	Hong Kong

		59(1)	*disaster risk reduction"*			institute	
33	2010	Vol 59(1)	*"Pioneering the collection and exchange of meteorological data"*	Branski, F.	NOAA/WMO	Other research institute, WMO	U.S., Switzerland
34	2010	Vol 59(1)	*"60 years of service for your safety and well-being − Message by Michel Jarraud, Secretary-General of WMO on the occasion of World Meteorological Day 2010"*	Jarraud, M.	WMO	WMO	Switzerland
35	2010	Vol 59(2)	*Editorial*	Editor	WMO	WMO	Switzerland
36	2010	Vol 59(2)	*"Predictions will get sharper − Interview with Eugenia Kalnay"*	Editor	WMO	WMO	Switzerland
37	2010	Vol 59(2)	*"Climate services can reverse downward spiral −Case study: Haiti"*	Thow, A.	UN Office for the Coordination of Humanitarian Affairs	Other UN agency	U.S:
38	2010	Vol 59(2)	*"Boosting food security"*	Salinger, J.	WMO	WMO	Switzerland
39	2010	Vol 59(2)	*"The World Meteorological Organization in a changing world"*	Canziani, O.F.	Universidad de Buenos Aires	University	Argentina
40	2011	Vol 60 (1)	*Editorial*	Editor	WMO	WMO	Switzerland
41	2011	Vol 60 (1)	*"Climate services: Reaching the most vulnerable"*	Egeland, J.	WMO	WMO	Switzerland
42	2011	Vol 60 (1)	*"Some Frequently Asked Questions: The Global Framework for Climate Services"*	Editor	WMO	WMO	Switzerland
43	2011	Vol 60 (1)	*"The new communications climate"*	Revkin, A.C.	Pace University Academy for Applied Environmental Studies	University	U.S.
44	2011	Vol 60 (1)	*"Revisiting the East African malaria debate"*	Waweru, S.M. [1], Omumbo, J.A. [2] Lyon, B. [2] Thomson, M.C.[2] Connor, S.J. [2]	[1] Kenya Meteorological Department [2] Columbia University	NMHS, University	Kenya, U.S.
45	2011	Vol 60 (1)	*"Survey of financial firms outlines climate information needs"*	Clements-Hunt, P., Fischer, R.	UNEP	Other UN agency	Kenya
46	2011	Vol 60 (1)	*"Financial markets drive demand for climate models"*	Douglas, R.	Global Analytics	Private enterprise	UK
47	2011	Vol 60 (1)	*"Bring financial and scientific analysts together"*	Waughray, D.	World Economic Forum	INGO	Switzerland
48	2011	Vol 60 (1)	*"Creating a volunteer observing network"*	Doesken, N., Reges, H.	Colorado State University	University	U.S.
49	2011	Vol 60 (2)	*Editorial*	Editor	WMO	WMO	Switzerland
50	2011	Vol 60 (2)	*"Climate change − "a serious challenge to human existence""*	Hasina, S.	Prime Minister, Bangladesh	Government	Bangladesh
51	2011	Vol 60 (2)	*"Understanding user needs for climate services in agriculture"*	Bernardi, M.	FAO	Other UN agency	Italy
52	2011	Vol 60 (2)	*"Meteorology and the energy sector − a WMO perspective"*	Editor	WMO	WMO	Switzerland
53	2011	Vol 60 (2)	*"Improving availability, access and use of climate information"*	Dinkul, T. [1], Asefa, K. [2], Hilemariam, K. [2], Grimes, D. [3], Connor, S. [4]	[1] Columbia University [2] National Meteorology Agency, Ethiopia [3] University of Reading [4]University of Liverpool	University, NMHS, University, University	U.S., Ethiopia, UK, UK
54	2011	Vol 60	*"Laying the foundations for*	Matsuno, T.	Japan Agency for Marine-	Other research	Japan

		(2)	*climate science"*		Earth Science and Technology	institute	
55	2011	Vol 60 (2)	*"From observations to service delivery: Challenges and opportunities"*	Simmons, A.	ECMWF	IHMS	UK
56	2011	Vol 60 (2)	*"Making climate services more effective"*	Bettencourt, S.	The World Bank	Other UN agency	U.S.
57	2012	Vol 61 (1)	*Editorial*	Editor	WMO	WMO	Switzerland
58	2012	Vol 61 (1)	*"The Global Climate Observing System – 20th Anniversary"*	Goodrich, D., Westermeyer, W.	WMO	WMO	Switzerland
59	2012	Vol 61 (1)	*"Reaching the Last Mile with Mobile Weather Alert – The user-interface platform in action"*	Editor	WMO	WMO	Switzerland
60	2012	Vol 61 (1)	*"Powering our Future with Weather, Climate and Water"*	Editor	WMO	WMO	Switzerland
61	2012	Vol 61 (1)	*"Water Sector Industry Perspectives for Climate Services"*	Maitrerobert, X.	AquaFed	NGO	France
62	2012	Vol 61 (2)	*Editorial*	Editor	WMO	WMO	Switzerland
63	2012	Vol 61 (2)	*"The Global Framework for Climate Services – Innovation and Adaptation"*	Editor	WMO	WMO	Switzerland
64	2012	Vol 61 (2)	*"Weathering the risk of climate change"*	Hayashi, C., Kerr, T.	World Economic Forum	Other UN agency	U.S.
65	2012	Vol 61 (2)	*"Partnerships for Success – The WMO Fellowship Programme"*	Editor	WMO	WMO	Switzerland
66	2012	Vol 61 (2)	*"From ship to shore: Bringing real-time weather into the classroom"*	Jacobs, W., Schmitt, P.	DWD- Deutscher Wetterdienst	NMHS	Germany
67	2012	Vol 61 (2)	*"Subseasonal to Seasonal Prediction Project: bridging the gap between weather and climate"*	Vitart, F.[1], Robertson, A.W. [2], Anderson, D. L. T. [1]	[1] ECMWF [2] Columbia University	IHMS, University	UK, U.S.
68	2012	Vol 61 (2)	*"Building Model Evaluation and Decision Support Capacity for CORDEX"*	Whitehall, K.[1,3] Mattmann, C: [1,2,4] Waliser, D.[1,2] Kim, J. [2] Goodale, C. [1] Hart, A. [1] Ramirez, P. [1] Zimdars, P.[1]Crichton, D. [1] Jenkins, G. [3], Jones, C. [5], Asrar, G. [6], Hewitson, B. [7]	[1] California Institute of Technology [2] UCLA [3] Howard University [4] University of Southern California [5] Swedish Meteorological and Hydrological Institute; [6] WMO [7] University of Cape Town	University, University, University, University, NMHS, WMO, University	U.S., U.S., U.S., U.S., Sweden, Switzerland, South Africa
69	2012	Vol 61 (2)	*"Drought and Desertification in Postage Stamps"*	Garry Toth, G. [1], Hillger, D. [2]	[1] Meteorological Service of Canada (retired) [2] NOAA/Colorado State University	NMHS, Other research institute, Unversity	Canada, U.S.
70	2013	Vol 62 (1)	*"The World Weather Watch at 50"*	Editor	WMO	WMO	Switzerland
	2013	Vol 62 (1)	*"The Global Observing System"*	Barrell, S. [1], Riishojgaard, L.P. [2], Dibbern, J. [3]	[1] Bureau of Meteorology, Australia [2] NOAA [3] Deutscher Wetterdienst	NMHS, Other research institute, NMHS	Australia, U.S., Germany
71	2013	Vol 62 (1)	*"The Instruments and Methods of Observation Programme (IMOP)"*	Editor	WMO	WMO	Switzerland

72	2013	Vol 62 (1)	*"Valuing Investments In Data Processing and Forecasting Systems"*	Lee, W-J.	Korea Meteorological Administration	NMHS	South Korea
73	2013	Vol 62 Special issue	*Editorial*	Editor	WMO	WMO	Switzerland
74	2013	Vol 62 Special issue	*"Funding the Global Framework for Climate Services: Challenges and Opportunities"*	Editor	WMO	WMO	Switzerland
75	2013	Vol 62 Special issue	*"Norwegian support for the Global Framework for Climate Services"*	Editor	WMO	WMO	Switzerland
76	2013	Vol 62 Special issue	*"What do we mean by Climate Services? — Climate is what you expect and weather is what you get"*	Tall, A.	CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)	University	Denmark
77	2013	Vol 62 Special issue	*"Localizing Climate Information Services for Agriculture"*	Selvaraju, R. [1], Khanh, N.D. [2], Dalida Jr, L.U. [3], Alvina, P. [4], Chung, P. [5], Tejada, E. [1], Luzcúber, M. [1], Mori, R. [1], Madima, T. [1], Gautam, B.R. [1]	[1] FAO [2] National Hydrometeorological Services, Vietnam [3] Southern Luzon PAGASA Regional Services Division, Legaspi, Philippines [4] Department of Agriculture, Region V (Bicol), Naga City, The Philippines [5] Rural Agricultural Development Authority, Jamaica	Other UN agency, NMHS, NMHS, Government, Government	Italy, Vietnam, Philippines, Philippines, Jamaica
78	2013	Vol 62 Special issue	*"Weather and Climate Resilience Effective preparedness through National Meteorological and Hydrological Services"*	Rogers, D., Tsirkunov, V.	The World Bank	Other UN agency	U.S.
79	2013	Vol 62 Special issue	*"Reducing and managing risks of disasters in a changing climate"*	Editor	WMO	WMO	Switzerland
80	2013	Vol 62 Special issue	*"The application of climate science to benefit society"*	Hewitt, C., Dale, K., Stanford, J.	UK Met Office	NMHS	U.K.
81	2013	Vol 62 Special issue	*"Clim-Health Africa"*	Editor	WMO	WMO	Switzerland
82	2013	Vol 62 Special issue	*"From global to regional to national: building operational climate services"*	Editor	WMO	WMO	Switzerland
83	2013	Vol 62 Special issue	*"Reconciling post-positivist and post-modern worldviews in climate research and services"*	de Leon, I.P., Gotangco, C.K.	Ateneo de Manila University	University	Philippines
84	2013	Vol 62 Special issue	*"Addressing the potential climate effects of China's Three Gorges Project"*	Meiyan, J. [1], Lianchun, S. [1], Jun, W. [2] Yiming, K. [1], Cunjie, Z. [1], Tianjun, Z. [4], Ying, X. [1], Tong, J [1], Changhan, Z. [1], Xianyan, C [1], Xuejie, G [1], Shihao, T [1], Peiqun, Z [1]	[1] CMA [2] Ministry of Water Resources, China [3] The Chinese Academy of Sciences (CAS).	NMHS, Government, Other research institute	China
85	2013	Vol 62 (2)	*Editorial*	Editor	WMO	WMO	Switzerland

86	2013	Vol 62 (2)	*"WMO Integrated Global Observing System (WIGOS)"*	Barrell, S.	WMO/Bureau of Meteorology, Australia	WMO, NMHS	Switzerland, Australia
87	2013	Vol 62 (2)	*"A Strategy for an Architecture for Climate Monitoring from Space"*	Mohr, T. [1], Dowell, M. [2]	[1] WMO [2] Institute for Environment and Sustainability, European Commission	WMO, Other research institute	Switzerland, Italy
88	2013	Vol 62 (2)	*"Public Weather Services Programme – What's the Future?"*	Kootval, H.	WMO	WMO	Switzerland
89	2013	Vol 62 (2)	*"The-Hong-Kong Observatory – Through Science We Serve"*	Shun, CM	Hong Kong Observatory	Other research institute	Hong Kong
90	2014	Vol 63 (1)	*Editorial*	Editor	WMO	WMO	Switzerland
91	2014	Vol 63 (1)	*"Towards Integrated Urban Weather, Environment and Climate Services"*	Grimmond, S. [1], Xu, T. [2], Baklanov, A. [2]	[1] University of Reading/WMO [2] WMO	Univeristy, WMO	UK, Switzerland
92	2014	Vol 63 (1)	*"Junior Professional Officers"*	WMO Secretariat	WMO	WMO	Switzerland
93	2014	Vol 63 (1)	*"Who Wants to be a Weather Forecaster? Engaging students in meteorology"*	Grasso, V.	CNR IBIMET – Consorzio LaMMA, Italy	Other research institute	Italy
94	2014	Vol 63 (2)	*"Weather & Climate – Understanding Risks and Preparing for Variability and Extremes"*	Editor	WMO	WMO	Switzerland
95	2014	Vol 63 (2)	*"Third UN Conference on Small Island Developing States"*	Editor	WMO	WMO	Switzerland
96	2014	Vol 63 (2)	*"GFCS Climate Services Adaptation Programme in Africa Supports Maasai Community Members in Tanzania"*	Editor	WMO	WMO	Switzerland
97	2015	Vol 64 (1)	*Editorial*	Editor	WMO	WMO	Switzerland
98	2015	Vol 64 (1)	*"The Future of the Weather Enterprise"*	Hayes, J. [1], Ahluwalia, H. [2], Abraham, J. [3]	[1] Harris Corporation [2] Canadian Meteorological and Oceanographic Society (CMOS) [3] Environment Canada (Retired)	Private enterprise, Scientific society, Other research institute	Canada
99	2015	Vol 64 (1)	*"Megacities – Refining Models to Client Environment"*	Zilitinkevich, S.[1], Kulmala, M. [1], Esau, I. [3], Baklanov, A. [4]	[1] University of Helsinki/Finnish Meteorological Institute/ University of Nizhny Novgorod/Moscow State University/Institute of Geography of Russian Academy of Sciences; [2] University of Helsinki [3] Nansen Environmental and Remote Sensing Centre/ Bjerknes Centre for Climate Research [4] WMO	University, NMHS, University, University, Other research institute, University Other research institute, WMO	Finland, Russia, Finland, Norway, Switzerland
100	2015	Vol 64 (1)	*"Call for an Ethical Framework for Climate Services"*	Adams, P. [1], Hewitson, B. [2], Vaughan, C. [3], Wilby, R. [4], Zebiak, S. [3], Eitland, E. [5], Shumake, J. [6]	[1] Acclimatise [2] University of Cape Town [3] International Research Institute for	Private enterprise, University, University, University, WMO	UK, South Africa, U.S., UK, U.S., Switzerland

					Climate Change and Society [4] Loughborough University [5] Harvard University [6] WMO		
101	2015	Vol 64 (2)	*"WMO Prioritizes Gender Equality"*	Alexieva, A.	WMO	WMO	Switzerland
102	2015	Vol 64 (2)	*"A Pathway to Climate Services for SIDS"*	Avellan, T.	WMO	WMO	Switzerland
103	2015	Vol 64 (2)	*"The Polar Challenge: Pushing the Boundaries of Observations for Climate Research and Services"*	Rixen, M., Carlson, D., Sparrow, M., Lee, B., Tuma, M.	WMO	WMO	Switzerland
104	2015	Vol 64 (2)	*"Climate Services for the Energy Sector: A New Priority Area for the GFCS"*	Troccoli, A. [1], Boscolo, R. [2]	[1] World Energy & Meteorology Council [2] WMO	NGO, WMO	UK, Switzerland
105	2015	Vol 64 (2)	*"Towards Substantially Reduced Disaster Risk in 2030"*	Luther, J.	WMO	WMO	Switzerland
106	2015	Vol 64 (2)	*"Why Does Access to Good Climate Data Matter?"*	Bell-Pasht, K., Krechowicz, D.	Environmental Commissioner of Ontario, Canada	Government	Canada
107	2015	Vol 64 (2)	*"Managing Risk with Climate Prediction Products and Services"*	Hewitt, C. [1], Silva, V.B.S. [2], Gao, R. [3], Coelho, C.A.S. [4], Duell, R. [4], Pollock, J. [5], Onogi, K. [6], Tamara, F.L.C. [7], Gong, Z. [7]	[1] UK Met Office [2] NOAA [3] China Meteorological Administration [4] National Institute for Space Research, Brazil [5] The Australian Bureau of Meteorology [6] Japan Meteorological Agency [7] WMO	NMHS, Other research institute, NMHS, Other research institute, NMHS, NMHS, WMO	UK, U.S., China, Brazil, Australia, Japan, Switzerland
108	2015	Vol 64 (2)	*"Interview: Vladimir Ryabinin, Executive Secretary of the Intergovernmental Oceanographic Commission (IOC) of UNESCO"*	Castonguay, S., Belfiore, S.	WMO	WMO	Switzerland
109	2015	Vol 64 (2)	*"Meteo Data Use Could Help Raise Level of Preparedness for Postal Services"*	–	Universal Postal Union and United States Postal Service	Other UN agency, Government	Switzerland

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