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Original research article

Who is ‘the user’ of climate services? Unpacking the use of national climate scenarios in Switzerland beyond sectors, numeracy and the research–practice binary

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\section*{Abstract}

By whom are national climate scenarios taken up, and which products are used? Despite numerous (national) climate scenarios being published by countries across the globe, studies of their actual uptake and application remain low. Analysing a survey and group interviews on the ways the Swiss climate scenarios CH2011 have been actually used by the Swiss adaptation community, we encoded the emerging differences in a new typology of observers, sailors, and divers. Taking an iceberg as a metaphor for climate scenarios, most respondents were sailors, accessing only key findings above the waterline (i.e., summary brochures). However, the vast majority of climate scenario data remains below the surface (i.e., downscaled climate model data), accessible only to the quarter of respondents labelled divers. Lastly, another quarter are observers, interested in the iceberg from afar, but without applying the climate information directly to their work. By describing three ways of using climate scenarios, we aim to clarify the often vague notion of ‘user’ circulating prominently in discussions around climate services and knowledge co-production. In addition, our results question the adequacy of simplifying climate scenario use by a user’s easily observable characteristics – such as being a researcher or practitioner, by sector or by numeracy. Our typology thus highlights the diversity of use(r)s within sectors or academia, but is also able to characterise various similarities of use(r)s between sectors, researchers and practitioners. Our findings assist in more nuanced and informed discussions of how ‘users’ are imagined and characterised in future developments of usable climate services.

\section*{Practical Implications}

- Climate services and climate information products are increasingly produced across the world. While national climate scenarios are frequently evaluated by academics in order to have them critically peer-reviewed for their climate-scientific adequacy, the actual use of such climate scenarios (rather than needs) has been largely neglected in the peer-reviewed literature. However, such evaluations are necessary for two reasons. One, to understand in what ways the often expensive climate scenarios have been used. Two, to discern how future sets of climate scenarios and other climate services can be improved for users. Our study characterising the actual use of the Swiss national climate scenarios achieves both these two goals. 
- National climate scenarios form the basis for many climate change risk assessments and national adaptation strategies, characterising plausible future meteorological changes in temperature, precipitation, as well as other climatic indices such as rising snowlines or numbers of tropical nights. Climate scenarios are produced with physics-based calculations with different amounts of greenhouse gas (GHG) emissions, the main driver of anthropogenic climate change. The different GHG emissions pathways are used to highlight the implications of different global carbon mitigation policies. As such, national climate scenarios are produced for decision-makers working in civil administration, associations, industry, consultancies and non-governmental organizations (NGOs) of a particular country, as well as politicians, journalists and the interested ‘general public’. In addition, climate scenarios serve researchers as a basis for climate impact studies which highlight the effects of atmospheric changes on land surfaces, such as rockslides or floods.
1. Introduction: who uses what climate information?

«I hate the term ‘user’.»

These two quotes illustrate that the term ‘user’ is contested yet convenient to discuss the application of climate information. The two conflicting opinions are symbolic of a larger discomfort with the concept of ‘the user’. While the term ‘user’ is clear in terms of definition (people who use information are ‘information users’), the term is both ambiguous and vague. ‘Users’ can refer to climate impact modellers, risk managers, administrative officials, or interested publics equally. Further, ‘users’ may have different ways of using climate information. The vagueness thus complicates efforts of producing ‘usable’ climate information, as important nuances often remain implicit. In this study, the term ‘user’ refers to all people, regardless of their sectoral, academic, or professional affiliation, who have interacted with climate scenarios, by minimally having skimmed one of the various brochures, often also applying data into their work.

To support climate adaptation and carbon mitigation initiatives, various countries have published a set of climate scenarios tailored specifically to their country (cf. Skelton et al., 2017). This includes the Netherlands (KNMI, 2015), the US (Mellilo et al., 2014), South Africa (DEA, 2013), Ireland (Gleeson et al., 2013), Germany (DWD, 2012), Switzerland (CH2011, 2011), and Australia (CSIRO and Bureau of Meteorology, 2007). In addition, there is guidance to include climate scenarios in the reporting of Parties to the United Nations Framework Convention on Climate Change (UNFCCC) (Skelton et al., 2019). Despite these numerous national efforts, the actual use of (national) climate scenarios remains blurred. One notable exception is the UK Climate Projections 2009 (UKCP09, Jenkins et al., 2009; cf. Heapby, 2015; Hulme and Dessai, 2008). For instance, Tang and Dessai (2012) analysed how a diverse set of British actors, obliged to report on adaptation, perceived and made use of UKCP09. A longitudinal study by Porter et al. (2015) found that the availability of climate information has risen in British Local Authorities between 2003 and 2013, but that budget cuts and lack of political support restricted adaptation action.

Further, comparing local government’s use of national climate scenarios in Germany and the UK, Lorenz et al. (2017) found that only few people considered climate information in adaptation. With national climate scenarios recently updated (CH2018, 2018; Lowe et al., 2018) and a European roadmap for climate projections proposed (Hewitt and Lowe, 2018; Met Office and CNRS, 2018), it becomes increasingly important to also understand the utility of different products climate scenarios provide, such as summary brochures or large climate model datasets.

Knowing better how climate scenarios are actually used (or resisted) can also help climate research projects to incorporate the requirement of ‘user-orientation’ better. As such, climate scientists are urged to collaborate with stakeholders on equal terms, a concept also known under the term co-production (cf. Bremer and Meisch, 2017). This change of producing knowledge is most evident in the rise of climate services (Lorenço et al., 2016; Vaughan and Dessai, 2014; Hewitt et al., 2012). However, as the importance of co-produced climate knowledge increases, vague and ambiguous notions of ‘the user’ become problematic. Scientists can too easily pick their preferred characterisation of ‘the user’, failing thus to include users with other needs. For instance, Archer (2003) showed that certain user groups (often socio-economically worse off) were underserved. Calls for engagement ‘beyond lip service’ (Klenk et al., 2015) have been made. This is important, because when public money is spent on the development of usable climate information (Lemos et al., 2012), then the questions of ‘who is included in the knowledge production process’, ‘to whom is the climate information tailored to’ and ‘who uses climate information’ become of considerable importance (Klenk et al., 2015).

Who uses national climate scenarios in what ways? This paper
provides an empirically grounded characterization of national climate scenario uses. Section 2 details our case study, the Swiss climate change scenarios CH2011, before introducing how the data was collected and analysed (Section 3). Section 4 introduces our typology of climate scenario users: observers, sailors, and divers. In Section 5 we discuss the implications of our findings, comparing our typology with common characterisations of users from the literature. We close with a brief conclusion in Section 6.

2. Case study: the Swiss national climate scenarios CH2011

In this study, we analyse the actual use of the Swiss national climate scenarios CH2011 (2011) by the Swiss adaptation community. These scenarios were jointly produced by climate scientists working in several academic and public institutions over three years, in order to speak with ‘one voice’ (Skelton et al., 2017: 2332; see also Brönnimann et al., 2014). Climate scenarios are a distinct form of climate knowledge, potentially encompassing multiple climate models, outputs, and emissions pathways to describe multiple yet coherent climate futures. This includes, for instance, aggregating climate information from multiple climate models and/or climate model runs for one emissions pathway (Skelton et al., 2019: 18).

The CH2011 climate scenarios contain meteorological changes of temperature and precipitation. These were provided with three uncertainty estimates (upper, mean, lower) based on a probabilistic approach (Fischer et al., 2011) characterising model uncertainty and internal variability. Climatic changes conditional on three emissions pathways (reflecting different levels of global mitigation strategies) were explored for three future time periods covering the 21st century. Likely future temperatures and precipitation are communicated against the baseline climate of 1980–2009 for three regions of Switzerland, and as localized daily temperature series for several Swiss weather stations.

CH2011 contained various products: a summary brochure (available in English, German, French, and Italian); a technical report (in English only); as well as raw data downscaled to stations or as a gridded dataset for precipitation and temperature.

The Swiss climate scenarios CH2011 (2011) inform the Swiss national adaptation strategy. Praised as a pre-requisite for climate-sensitive planning, climate scenarios are seen as the basis for explicit, often quantitative risk assessments (Willows and Connell, 2003; e.g. CH2014-Impacts, 2014) and have found qualitative application in national adaptation strategies (Widmer, 2018; Lorenz et al., 2015; Biesbroek et al., 2010). In addition, they informed a large number of adaptation projects from different sectors (Rösler et al., 2019; BAFU, 2017). In autumn 2018, the successor Swiss climate scenarios CH2018 (2018) were published (www.climate-scenarios.ch).

3. Material and methods

To analyse the uptake of, as well as resistances towards, climate information within the Swiss adaptation community, we make use of data gathered in 2015 as part of an assessment of the Swiss climate scenarios CH2011 (MeteoSwiss, 2016). This assessment was mandated by the Swiss Federal Office of Meteorology and Climatology MeteoSwiss to an environmental consultancy. Its aim was to better understand the ways both present and future weather and climate data were used, and how CH2011’s usability could be improved further. A description of this multi-stage assessment process can be found as Supplementary Materials.

For this paper, we analysed two data sources from the original CH2011 assessment (MeteoSwiss, 2016): (i) a written survey, and (ii) group interviews. First, the written survey elicited a good overall response rate of 45% (n = 115/256 approached participants), having been sent to three groups: participants of the 7th Swiss Symposium on Climate Adaptation (n = 70/187, 37%), project managers who received funding through the Swiss Pilot Programme on Climate Adaptation (BAFU, 2017) (n = 10/29, 34%), as well as the sectoral group interviewees (n = 35/40, 88%). Survey questions include how data of today’s climate was used; which CH2011 climate scenario products were used in what way; and what the requirements for the next generation of national climate scenarios were. The survey (in English) is provided as Supplementary Materials. Second, n = 9 group interviews, arranged by those sectors identified as relevant in Switzerland’s national adaptation strategy (FOEN, 2012), were made with n = 33 well-known experts with significant academic and/or professional experience on adaptation working in administration, academia, or in industry. Structured around the survey – which the interviewees answered in writing as a preparation – the discussion explored and clarified past uses and future requirements of the sector representatives. Minutes of the group interviews were taken manually during the interviews. The transcripts thus reflect the interview in condensed form.

We established a user classification emerging from the survey data, rather than categorise users according to previous characterisations in the literature. To cross-validate the emerging classification, and to deepen the understanding how climate scenarios have been used, we manually coded the group interview transcripts with MAXQDA, a qualitative text analysis software.

4. How do observers, sailors, and divers make use of climate scenarios?

4.1. Who uses climate scenarios? Introducing a typology emerging from the data

We grouped survey participants based on what information from the climate scenarios CH2011 they used. (a) respondents using at least one of the four raw datasets provided (e.g., change in mean seasonal cycle per station); (b) respondents making use of key findings presented in at least one of the three summary brochures, including graphs and tables (e.g., climate scenarios report for regions); (c) respondents who skimmed – but did not directly apply – at least one of the three summary brochures, including graphs and tables; and (d) a group labelled ‘other’ who did not fit one of the three previous groups, comprising mostly respondents not answering these particular survey questions. To label the three different types of users (a), (b), and (c), we draw on a typology of energy scenarios users. With the metaphor of scenarios as an iceberg, Braunreiter and Blumer (2018) distinguish two products: the iceberg’s visible tip above the water’s surface consists of key results provided as summary brochures, while the vast amount of the iceberg (raw data) lies beneath the sea surface accessible only to those with the skills and interests to do so. Braunreiter and Blumer (2018) label the users (a) interested in bulk of ice divers, and those respondents (b) keen to explore the iceberg’s visible tip sailors (Fig. 1).

However, compared to the binary typology by Braunreiter and Blumer (2018), a third way (c) of using climate scenarios emerged in our analysis. Partly due to our more diverse sample going beyond academics, various people in the Swiss adaptation community replied that they did not directly apply any information from the climate scenarios to their work, but skimmed the brochures out of interest. We thus extend the sailor–diver binary to characterise this third group (c) as observers. Sticking to the metaphor of the iceberg, observers are users who have seen the iceberg (climate scenarios) from afar (Fig. 1). Observers are thus potential sailors or divers. Divers and sailors can support observers to apply climate scenarios, thus becoming sailors or
4.2. How do observers, sailors and divers use climate scenarios?

Sailors made up the largest share of users in the Swiss adaptation community (n = 45/115, 39%) (Fig. 2). Interestingly, observers (n = 29/115, 25%) and divers (n = 29/115, 25%) were equally common. The following paragraphs paint a more detailed picture of these three user types.

Observers are interested in future changes of Switzerland’s climate, skimmed the CH2011 brochures – but characteristically did not apply any climate information to their work. The following quote illustrates this interest-without-use:

‘So far, [we have made] no direct use of the [climate] information. Uncertainties are important for communication [purposes], but they are hardly usable in practice because, in the end, dimensioning [of transport infrastructure against particular natural hazards] must be based on specific values, regardless of the uncertainties. We cannot dimension it [infrastructure projects] to maximum values everywhere [to increase resilience], simply because of the [high] costs. However, we differentiate dimensioning regionally. For operationally important routes or infrastructure we dimension more cautiously, that is with a greater safety margin, than for less important ones. For example, we dimension more cautiously for Zurich with the flood risk posed by the river Sihl than for a [nationally] less significant location. [...] I am interested in the development of individual natural hazard processes [under climate change]: floods, surface runoff, mudflows, torrents, but also in drinking water supply of small train stations. (#11, observer, group interview, emphasis added)

Working with uncertainties ‘in practice’ as well as a lack of required information on climate impacts are thus reasons for the interest-without-use characteristic for observers. The quote echoes a Norwegian study of the transportation sector, where ‘climate science is often focused on uncertainties, while climate adaptation strives to hold on to the little certainties that exist’ (Ryghaug and Solli, 2012: 434). That the category of ‘observer’ is a meaningful characterisation of climate scenario use is further supported by 86% (n = 25/29) unable to recall which emissions pathway(s) they considered (Fig. 2a).

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on the use of future time periods is highest, compared with that of divers and sailors (Fig. 2b). As such, observers have seen the iceberg (i.e. climate scenarios), but either had a different approach to managing uncertainties, lacked quantitative or qualitative information in CH2011 required to achieve the project’s goals, or had no specific project they could apply CH2011 data to.

Sailors worked with at least one of the three written summary brochures of CH2011, qualitatively using the information written in the text or portrayed in the graphs, maps and tables. Fig. 2 highlights that sailors are often interested in the direction of climatic changes, with almost half of sailors (n = 20/45, 44%) unable to recall which emissions pathways they used. Similarly, a quarter of sailors (n = 12/45, 27%) could not answer which of the three future time periods they worked with (Fig. 2). This indicates a certain (passive) disinterest or (active) disregard in how climate scientists communicate climate change, as the following quote by a senior adaptation officer shows:

‘In climate risk analyses and climate strategies [undertaken by local government] there is presently hardly any need for specific (quantitative climate scenario) data, rather [a need] for the direction of change. Cantonal [provincial] experts cannot differentiate between the effects of 2 °C or 4 °C [warming]’. (#31, sailor, group interview)

While the survey data highlights a majority of sailors using more than one future time period (n = 26/45, 58%), the group interviews revealed a tendency for planning horizons being more near-term than the provided 2035s. ‘Organisation Y uses a planning horizon of 15 years. Forecasts extending beyond this period are presently of no need’ (#68, diver, group interview). Similarly, ‘the time horizon considered [in my sector] is rather short-term, for government agencies it is five to ten years, for research slightly longer’ (#62, sailor group interview). These two quotes illustrate that climate scenarios lack relevance when planning in near-term only (cf. Vincent et al., 2017). To sum up, sailors are interested in the key findings found in the summary brochures, such as the trends of climatic changes. However, the bulk of the iceberg below the sea surface (the raw data of climate scenarios) remains hidden to sailors.

Divers distinguish themselves according to their use of at least one of the four gridded or station-data raw datasets provided by CH2011. These divers often run climate impact models (#27, #64, #68, #76, #94, divers, group interviews).

‘[To simulate climate impacts] most variables require [temperature and precipitation] data at least [in a] daily [resolution]. Also, it [the data] needs to be consistent between variables [temperature and precipitation], for instance [to allow] weather simulations over 20 years. In addition, we need [the variables] global radiation and moisture. [Lastly,] we need [the data] transiently [i.e. data not truncated into distinct time periods]’ (#68, diver, group interview).

Despite the CH2011 being truncated into three future time periods, and the co-variation of temperature and precipitation being unavailable, divers were still able to work with these datasets. This is indicative of the skill and knowledge divers have in working with potentially suboptimal climate model output. This skill translated into divers generally working with multiple timeframes as well as numerous emissions pathways (Fig. 2). For instance, the share of divers (48%, n = 14/29) working with the full range of plausible global mitigation scenarios (i.e., using all three emissions pathways provided) was more than double that of sailors (20%, n = 9/45). In addition, divers (69%, n = 20/29) were more likely to explore the near-term, the mid-term as well as the long-term changes than sailors (58%, n = 26/45). As such, divers are numerate and climate-literate users, able to navigate the complexities of post-processed and downscaled climate model outputs.

Overall, the data-based classification of the survey participants into observers, sailors and divers reveals three distinct ways of putting climate scenarios to use. The chi square tests of independence in Table 1 confirms that there is a statistically significant difference how observers, sailors and divers used the emissions pathways (X^2(6, n = 103) = 41.49, p < .0001) and time periods (X^2(6, n = 103) = 30.65, p < .0001) provided in CH2011. Both the group interviews as well as the survey results thus indicate that our typology has empirical merit.

### Table 1

| Characteristic | Overall sample | Observer | Sailor | Diver | Chi square tests of independence |
|---------------|----------------|----------|--------|-------|---------------------------------|
| Number of emissions pathways used | X^2(6) = 41.49 | p < .0001 | n = 103 |
| 1 | 12 | 2 | 7 | 3 |
| 2 | 19 | 0 | 9 | 10 |
| 3 | 25 | 2 | 9 | 14 |
| Can’t remember | 47 | 35 | 20 | 2 |
| Number of time periods considered | X^2(6) = 30.65 | p < .0001 | n = 103 |
| 1 | 22 | 6 | 7 | 9 |
| 2 | 28 | 3 | 15 | 10 |
| 3 | 23 | 2 | 11 | 10 |
| Can’t remember | 30 | 18 | 12 | 0 |
| Type of work | X^2(4) = 5.25 | p = 0.26 | n = 103 |
| Public | 9 | 4 | 4 | 1 |
| Researcher | 42 | 13 | 14 | 15 |
| Practitioner | 52 | 12 | 27 | 13 |
| Sectors | X^2(10) = 8.54 | p = 0.58 | n = 82 |
| Trans-sectoral | 19 | 3 | 10 | 6 |
| Energy | 9 | 5 | 2 | 2 |
| Agriculture | 9 | 3 | 3 | 3 |
| Natural hazards | 18 | 4 | 9 | 5 |
| Water | 10 | 2 | 3 | 5 |
| Other | 17 | 4 | 9 | 4 |
| Use of data of today’s climate | X^2(2) = 1.67 | p = 0.43 | n = 82 |
| Sailorpresent | 21 | 3 | 11 | 7 |
| Diverpresent | 61 | 17 | 25 | 19 |

1 For the purpose of these statistical analyses, we disregard the category ‘other’ (n = 12) for being an inconclusive category.
2 Various sectors had low overall numbers of participants. We consider only those sectors with n ≥ 9 participants.
3 We disregard the category ‘otherpresent’ (n = 29) for being an inconclusive category in this statistical analysis.

4.3. In which sectors do observers, sailors and divers work – and as what: researchers or practitioners?

Survey participants indicated being either researchers, practitioners or members of the ‘public’. We find a relatively well-balanced distribution of observers, sailors and divers in research and practice (Fig. 3). Between 45% and 60% of observers, sailors and divers are practitioners. Researchers are most common among data-hungry divers (52%, n = 15/29). Interestingly, there are more researchers grouped as observers (45%, n = 13/29) than sailors (31%, n = 14/45). Members of the ‘public’ were mostly working for the ‘public’, such as consultants or journalists, and were more often observers than divers. Fig. 3 thus clearly indicates that there are multiple ways climate scenarios are used within research and practice.

Sector size varies greatly in the survey sample – and within the Swiss adaptation community. The two largest sectors trans-sectoral...
the considerable amount of data generated by climate models working with models trans-sectoral in general terms. Since the sample size, we refrain from extrapolating and describing these six sectors represented within the adaptation survey sample. Due to the low response rate, only a quarter (Fig. 4). More generally, these sectors are less well represented within the adaptation survey sample. Due to the low sample size, we refrain from extrapolating and describing these six sectors in general terms.

Divers are most common in the sectors water (42%, n = 5/12), trans-sectoral (30%, n = 6/20) and agriculture (30%, n = 3/10). Thus, working with models – one of the few available techniques to process the considerable amount of data generated by climate models – seem to contribute to high shares of divers. For example, hydrologists use weather and climate raw data as an input in their flood risk models (e.g., Rössler et al., 2019). Similarly, the survey sample consisted of various impact modellers, studying a plant’s suitability, agricultural yield and pest epidemiology in a changing climate. Lower-than-average use of raw data is linked to few survey participants, such as mitigation, biodiversity, tourism, forestry, health, and spatial planning.

Sailors are more numerous than average in the sectors trans-sectoral (50%, n = 10/20) and natural hazards (47%, n = 9/19), thus making noteworthy use of climate scenario brochures. The high share of sailors in the cluster ‘trans-sectoral’ is unsurprising, given that the crosscutting nature of adaptation favours generalists. Further, the survey was targeted at pilot adaptation projects receiving governmental funding, often interlinking sectors (BAFU, 2017). Observers made up more than half of the survey respondents in the energy sector (56%, n = 5/9). More exchanges with the energy sector could clarify why the CH2011 brochures were not further integrated into their line of work.

Statistically, Table 1 confirms the described trends visible in Figs. 3 and 4. The chi square tests of independence reveal no significant relationship between our three distinct ways of using climate scenarios with respondents’ type of work as researcher, practitioner of member of the public (X^2(4, n = 103) = 5.25, p = .26) or respondents’ sector (X^2(10, n = 82) = 8.54, p = .58). As such, researchers and practitioners are similar in their mixed ways of using climate scenarios. Similarly, within sectors there is a heterogeneous blend of using climate scenarios as observers, sailors, and divers. Differences between sectors are discernible only for those sectors with few members in the Swiss adaptation community.

### 4.4. Are observers and sailors only able to use qualitative data?

Survey respondents also specified which kind of data of today’s climate they were using. This allows us to analyse if the type of using future climate scenarios corresponds to which present climate data was accessed. For instance, we can check whether sailors also use data for today’s climate qualitatively, or if they change their type and become e.g. more numerate. This section contains three steps. One, to create a typology on the use of present climate data very similar to the typology of future climate scenarios. While we stick to the terminology of sailors and divers for both, we denote in the index whether it is about the use of climate scenarios (‘future’) or today’s climate (‘present’). Two, we contrast how different the same respondents make use of future climate scenarios and of present day climate data. Three, we explore why so many users switch from more quantitative uses of present climate to more qualitative uses of future climates.

We extend our sailor-diver typology of future climate scenarios to the use of present climate data through the following criteria: We define divers_present as those participants using data on today’s climate in a qualitative way, i.e. with a high temporal resolution (‘10 min’, ‘hourly’ or ‘daily’) as well as using either station observation data or the 2 × 2 km gridded dataset. Surprisingly, a majority of survey respondents (55%, n = 63/115) are divers_present (Fig. 5). Sailors_present are those users giving preference to more qualitative summaries, i.e. using temporal averages for current climatological variables (‘monthly’, ‘annual’), and 4.4. Are observers and sailors only able to use qualitative data?

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‘seasonal’ or ‘annual’). 20% (n = 23/115) of survey respondents classified as sailors\textsubscript{present}. Because the survey questions for today’s climate differed in their answer options to those of the climate scenarios CH2011, we are unable to create the ‘observer\textsubscript{present}’ type. This leads to a larger share of survey respondents being categorised as ‘other\textsubscript{present}’ (n = 29/115, 25%) compared to ‘other\textsubscript{future}’ (n = 12/115, 10%). The omission of one option might also have led to slightly increased numbers of ‘sailors\textsubscript{present}’ and ‘divers\textsubscript{present}’.

Overall, the shares of sailors and divers are very different between present and future climate (Fig. 5). There are twice as many divers\textsubscript{present} (55%, n = 63/115) than divers\textsubscript{future} (25%, n = 29/115). Correspondingly, the share of sailors\textsubscript{present} (20%, n = 23/115) is almost half of sailors\textsubscript{future} (39%, n = 45/115). Fig. 5 illustrates that, overall, users often switch their particular way of using climate data. The statistical tests in Table 1 confirm that the participants’ way of using today’s climate data is independent of the way climate scenarios have been employed (χ2(2, n = 82) = 1.67, p = .43). Overall, an impressive two thirds (!) of survey participants (n = 77/115, 67%) changed their respective type of use. Thus, the particular user type of present climate data is no predictor of using future climate scenarios similarly. But what has caused these n = 25 divers\textsubscript{present} to become sailors\textsubscript{future}, and n = 17 divers\textsubscript{present} to re-group as observers\textsubscript{future} (Fig. 5)? In-depth analysis of the group interviews revealed three explanations: (a) qualitative work with future climate trends is insufficient for the respondents’ work; (b) the climate scenarios CH2011 lacked the climate data needed; and (c) missed windows of opportunity.

a. Some divers\textsubscript{present} indicated that sailing climate scenarios brochures is sufficient for their work. ‘Showing different [emissions] scenarios ... is important, quantitative details [about future climatological variables] are less important’ (#113, divers\textsubscript{present} & sailors\textsubscript{future} group interview). Another user echoes: ‘[organisation K] needs graphics to answer letters to citizens who are sceptic about climate change, or for questions of pupils for their final school project’ (#97, divers\textsubscript{present} & sailors\textsubscript{future} group interview).

b. Some divers\textsubscript{present} were eager for climate scenario raw data, but CH2011 lacked the required information:

‘[I] desire climate data primarily on extreme precipitation [for my assessments of] changes in flood risks, landslides, and slope stability as well as changes in temperature [for my assessments of] permafrost, glacier retreat. Differences in their [precipitation and temperature] distribution over seasons, months and regions are important’. (#51, divers\textsubscript{present} & sailors\textsubscript{future} group interview).

Users required quantitative data on extremes (#3, #51, #62, all divers\textsubscript{present} & sailors\textsubscript{future} group interviews) and information on the co-variation of temperature and precipitation (#21, #48, #110, all divers\textsubscript{present} & sailors\textsubscript{future} group interviews). However, the CH2011 producers felt that the scientific understanding at the time was not mature enough to provide data on extremes (cf. Skelton et al., 2017). And due to the chosen multi-model combination technique (Bayesian methodology), it was not possible to provide information on the co-variation of temperature and precipitation changes (Fischer et al., 2011). However, the new Swiss climate change scenarios CH2018 (2018) contain these required datasets. We thus expect that the user base of CH2018 will be made up by a larger number of divers, while attracting overall more application due to its increased relevance to other sectors such as biodiversity and energy specialists.

c. A third group of divers\textsubscript{present} would have applied the raw data of CH2011, but it was not available at the time. ‘CH2011 was [published] too late for the research programme Forest + Climate Change, which started in 2009’ (#21, #48, #110; all divers\textsubscript{present} & sailors\textsubscript{future} group interview). Such missed windows of opportunity can thus partially explain why some users switched from being divers\textsubscript{present} to sailors\textsubscript{future} of climate scenarios.

In summary, the distinct way of using climate scenarios as observers\textsubscript{future}, sailors\textsubscript{future} or divers\textsubscript{future} is in two-thirds of the cases not related to the same use of present climatological data (Fig. 5). The chi square tests of independence in Table 1 confirm that there is no statistically significant relationship between the ways climate scenarios and data on today’s climate have been used. Thus, use of raw station data and gridded datasets of present climatology is more common than the focus on climate scenarios would suggest. This result indicates that a large share of the adaptation community is ‘numerate’ and able to work with large sets of quantitative data.

5. Discussion: who is using climate scenarios in what ways?

We have analysed the use of the Swiss climate scenarios CH2011 within the Swiss adaptation community four years after its publication. Three distinct ways of using climate scenarios emerged from the dataset: observers, sailors, and divers. Using the metaphor of the iceberg as climate scenarios (Braunreiter and Blumer, 2018), sailors access key findings above the surface. The vast majority of data supporting these findings lies below water, accessible only to divers. Observers were interested in the iceberg from a distance – but did not apply the climate scenarios to projects. Sailors made up the majority of users, with tied shares of divers and observers.

So how does our typology compare with other user characterisations offered in the scientific literature, such as (a) the research–practice binary; (b) by sectors; and (c) by users’ numeracy and ability to work with climate model data?

a. Studies on the user needs of climate information have often differentiated between requirements within academia and outside (Rössler et al., 2017; Benestad et al., 2014; Groot et al., 2014). However, as Fig. 3 highlights, the picture of more data-hungry scientists and qualitative practitioners is too simplistic. The particular way climate
scenarios are used is not linked to being a researcher or practitioner (Table 1). Our findings show that it is not only impossible to reliably predict how climate scenarios are used with the research–practice binary, it is also an inadequate way to generalise ‘users’. The research–practice binary might make sense to describe different aims – understanding for scientists, relevance for practitioners (Pohl et al., 2017) – but fails to adequately describe users of climate scenarios.

b. Various authors have characterised users and their requirements by sectors (e.g. Bruno Soares et al., 2018). However, Fig. 4 illustrates that the way climate scenarios are used cannot be reliably predicted by a user’s sector. We find a mix of observers, sailors and divers among all sectors, echoing the conclusion by the original typology developers: ‘[s]ailors and divers are not principally split along the disciplinary backgrounds of interviewees’ (Braunreiter and Blumer, 2018: 123). While these results do not disqualify sector-specific climate services, the focus on sectors clouds the diversity of user(s) within sectors and the similarity of user(s) across sectors. As such, sectoral characterisations of climate scenario use are likely influenced by the sectoral organisation of academic and governmental units, as the sectoral focus of climate risk analyses (e.g. Funk, 2015; CH2014-Impacts, 2014) and national adaptation plans (e.g. Defra, 2018; FOEN, 2012) highlights.

c. The use of different climate scenario products has been explained by users’ numeracy, that is, their ability to work quantitatively with climate raw data. For instance, a Copernicus Climate Change Service survey labelled numerate users as ‘Donna Data’, and those using aggregated packages ‘Pete Product’ (C3S, 2017). In the ‘mini-me’ characterisation, Porter and Dossai (2017) criticise climate scientists imagining users to be similarly numerate and modelling-efficient as themselves. We show that a significantly larger proportion of users is able to process and work with large climate datasets when they concern today’s climate (Fig. 5). A perceived lack of numeracy is in many cases more imagined than justified. Further studies should illuminate why there is no statistically significant relationship between divers/present and divers/feature (Table 1). As such, even when users are similarly numerate as climate scientists, there seem to be underlying reasons why many users prefer to work qualitatively with climate scenarios.

To sum up, our results caution against using ‘external’ (i.e., independent) traits of users – such as the research–practice binary or sectoral affiliation – as explanations and predictors of how climate scenarios are used. We further highlight that a user’s numeracy is in many cases higher than the focus on climate scenarios would suggest. Overall, the different aims of researchers and practitioners (Pohl et al., 2017), the similarity of problems faced within sectors, and the mere possession of particular numerate skills are thus not indicative of how climate information is used.

Inherent to studies assessing users are limitations. For instance, our sample was deliberately targeted towards the Swiss adaptation community. The survey was sent out to selected members, leading to data collected only on ‘the usual climate-primed suspects’. In addition, the number of responses for some sectors was very low (e.g., health, spatial planning); often the sectors currently underrepresented in the Swiss adaptation community. While the survey results are likely to be representative of the Swiss adaptation community, the findings are certainly not representative outside this community or the general public. As such, exploring the use (or neglect) of climate scenarios in regional and local adaptation planning, or by sectoral experts not part of the adaptation community, could complement this study. Two further geographical limitations are a bias towards the German-speaking part of Switzerland, and the socio-political differences among countries. Climate scenario use in Germany and the UK, for instance, is influenced by their different institutional-political settings (Lorenz et al., 2017). While we would be surprised if our typology of observers, sailors, divers could not be transferred to these countries (after all, the products within climate scenarios are similar across countries, cf. Skelton et al., 2017), the respective shares of observers, sailors, and divers may well be different.

The successor Swiss climate scenarios CH2018 (2018) profited from the feedback from the original assessment (MeteoSwiss, 2016). While the original report contained content and communication recommendations, this study adds significant explanatory power by reclassifying the data upon an emerging pattern and describing the similarities with the typology of sailors, divers and observers. This allows, for instance, to highlight how the original recommendations help the different types of user. As such, improved brochures with personified key messages (for reaching a larger audience and increasing the number of sailors); quantitative information on extremes (which will likely make some observers and sailors of CH2011 to become divers); and transient raw datasets (satisfying needs of observers and sailors of CH2011 to become divers) were some of many changes in CH2018 (2018) to provide more user-oriented climate scenarios. Switzerland has not only improved their product climate scenarios, but could institutionalise user dialogues under the roof of the Swiss National Centre for Climate Services (NCCS). This allows to exchange with users beyond the duration of individual projects; a constraint present in e.g. Sweden (Ernst et al., 2019). As such, this assessment and its typology can serve as a baseline for comparing future studies on climate scenario use in other countries too.

How can our findings help to develop ‘usable’ climate scenarios and other climate services (Lemos et al., 2012)? We conclude with four points: One, our typology of sailors, divers and observers offers climate services producers a concept to understand what information products are used how and by whom. It serves as a reminder that the distinct ways of using climate information – quantitatively or qualitatively – are neither predicted by a user’s numeracy nor by a user’s sectoral, academic or professional affiliation. However, our typology also shows that there are cross-cutting similarities in using climate services, helping to produce usable climate services. Two, while our study supports efforts to tailor climate services to sectors or practitioners, producers of climate services should bear in mind that within sectors and among practitioners there are both sailors and divers. Thus, our study strongly recommends that climate information should be distributed both as key findings in brochures as well as through datasets. For example, our findings suggest that sectoral products of Copernicus Climate Change Service (e.g., Thépaut, 2016) benefit from climate information for both sailors and divers. Three, to make observers (skimming brochures without applying them) into either sailors or divers, efforts to incorporate observers’ voices through exchanges ‘beyond lip service’ (Klenk et al., 2015) in climate services projects is encouraged. Four, more intensive exchange – or further studies – could highlight why so many users make quantitative use of data on today’s climate, but only qualitative use of brochures (if at all).

Overall, our analysis paints a heterogeneous picture of the different ways climate scenarios are used. Our typology of observers, sailors, and divers captures essential differences, and extends the potentially misleading user characterisations by sector, the research–practice binary, or users’ numeracy. As such, it helps to see the diversity of use(s) within and among sectors, researchers and practitioners, but also the similarity of use(s) between these groups. Using our typology to discuss which climate information is used how, it can help to tailor climate services by clarifying vague discussions about ‘users’ and by addressing the underlying concerns of the introductory quote ‘I hate the term ‘user’.

6. Conclusion

Our work introduces a typology to better characterise actual use(s) of climate information. The concept of observers, sailors, and divers encapsulates three ways of using climate scenarios. Using the metaphor of the iceberg, most respondents were sailors, accessing only the key findings above the waterline (i.e., summary brochures). The vast majority of data remains below the surface (i.e., raw data), accessible only
to the quarter of respondents labelled divers. Lastly, another quarter are observers, interested in the iceberg (i.e., climate scenarios), but did not (yet) use it directly for any particular project. We find observers, sailors and divers in both research and practice; in all (but two) sectors; and demonstrate that numerical among users is generally much higher than perceived, as many sailors and observers of future climate scenarios are skilled in using quantitative data of today’s climate. As such, our results question the adequacy of describing the ways of actual using climate scenarios primarily by a user’s easily observable characteristics. Our typology offers a first step in better understanding in what distinct ways climate information is used, can extend vague notions and discussions of ‘the user’, and helps to tailor future climate scenarios and other climate services by highlighting the similarities of distinct use(s) not within sectors, but between the three user categories proposed in the literature: sectors, researchers and practitioners. This analysis thus calls for more nuanced discussions of how use(s) are imagined, portrayed and characterised.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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