D4.1 Evaluation of language, visual presentation, uncertainty information: A criteria catalogue for climate communication resources

- Report on the results of WP4 of the project “Use.AT”

Contributors: Benedikt Becsi[1], Laura Mainetti[2], Matthias Schwarz[2]

1: BOKU University

2: GeoSphere Austria

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Introduction

Use.AT is a research project funded by the Austrian Climate and Energy Fund as part of the ACRP funding program. It aims at systematically harvest learnings from Austria's current national climate scenarios, ÖKS15, and comparable international approaches. Thus, it contributes as an accompanying research project to the development of new Austrian climate scenarios as part of the Klimaszenarien.AT initiative (see www.klimaszenarien.at).

This report summarizes the results of the activities in WP4 of Use.AT. The aim was to identify best practice criteria for visual and textual representation in climate communication resources (CCRs) from the scientific literature. Based on these criteria, a gap analysis of previous materials based on ÖKS15 was envisioned, along with recommendations of how to improve the communicative aspects of these resources.

After a first presentation of the work package proposal to the stakeholder advisory board of Klimaszenarien.AT, where they also prioritised aspects of communication that the WP should focus on, it became apparent that we had to take another route. The scientific literature on climate change communication presented itself as a diverse field of various disciplines like psychology, cognitive science, information visualisation, climate science, computer graphics, etc. Each field has its own focus and epistemological development, so deriving a best practice even for a limited number of aspects was not viable. Essentially, the two challenges are that what is known and thought about effective climate communication changes and shifts with the expanding scientific knowledge, and what constitutes good communication is always dependent on its goals, framings and target groups.

One of the key points identified in the literature is that there are many different aspects for the effectiveness of climate communication, but for any scientific attempts to measure it, the communication needs to be evaluated. And to even be able to evaluate it, a framework for describing and characterising CCRs would be helpful, so that evaluation efforts could be comparable. A standard to describe and group CCRs after some common framework has been called for in the literature (e.g. Hoffmann et al., 2020; Hewitt and Stone, 2021; Hewitt et al., 2021; Guentchev et al., 2023). The tricky thing is that there are many different forms and formats of climate communication, so the framework needs to be able to capture a wide range of aspects.

Therefore, we focussed on compiling a criteria catalogue to comprehensively describe and evaluate CCRs. Nearly 200 papers from various fields of climate communication and climate services were screened. The resulting catalogue consists of 70 criteria and nearly 1300 references to the literature. The criteria were further grouped into eight categories, representing the most salient aspects of communication identified in the research. With this extensive coverage, the criteria catalogue can characterise communication facets for a wide range of resources.

For evaluation, we went one step further. Following recent paradigms in the literature on co-creation, we hypothesise that evaluation should also consider stakeholder groups, be it target groups or co-designers of the communication. Purely science-led evaluation can fail to capture the priorities of such groups. So instead of aiming for objective evaluation criteria, we surveyed priorities of user groups in terms of the identified communication aspects. In combination with the characterisation of resources based on our criteria catalogue, this approach answers the question 'what aspects of communication that are relevant for user group xy are well represented in resource xy'. This forms the basis of our recommendations to Klimaszenarien.AT.

In this report, we highlight the methods, outcomes and important insights from WP4. Though our original thinking was challenged, the literature research led to robust and scientifically relevant results that

bridge existing knowledge gaps and have the potential to advance the field of climate change communication.

Objectives of WP4

In WP4, we aimed to develop a set of criteria to characterise and evaluate CCRs. The criteria should be based on current scientific literature and encapsulate a wide range of communication aspects like visualisation, framing, and accessibility. We further aimed to assess user preferences regarding those communication aspects and to recommend strategies for focussing communication efforts to specific user groups to Klimaszenarien.AT.

Based on these objectives, the operationalised sub-objectives of WP4 were

a) to collect the scientific literature for several aspects of communication,
b) to devise search criteria for identifying and screening relevant papers,
c) to develop an initial criteria catalogue within the project team that was referenced and expanded during the literature review,
d) to structure, describe and exemplify the resulting criteria catalogue for easy external use,
e) to characterise ÖKS15-based CCRs with the criteria catalogue,
f) to survey user groups of climate scenarios for their preferences regarding climate communication,
g) to harmonise CCR characteristics and user preferences in a fit-for-user-group evaluation,
h) to recommend strategies to Klimaszenarien.AT concerning the focus of communication efforts for specific user groups.

Sub-objectives a) – d) are covered in the Methods section, while sub-objectives e) – g) are covered in the Results section. Following those sections, the recommendations and key learnings from WP4 (h) are summarised in the sections Synthesis and Summary of key learnings respectively.

The following research questions were addressed in WP4:

- Which aspects should be considered for characterising and evaluating CCRs?
- Which criteria covering those aspects can be found in the literature and how can they be operationalised?
- How can user group-specific priorities be included in the evaluation of CCRs?
- Which recommendations can be formulated based on fit-for-user group evaluation of existing CCRs for the next Austrian climate scenarios?

Methods

Here we describe the methodology of how we developed the criteria catalogue for characterising and evaluating CCRs. The approach was a stepwise collection, filtering, and screening of the literature on different aspects of climate change communication. The literature review was aimed to underpin and expand the catalogue of criteria. The first subsection focusses on the literature search, the second on the methods of selecting and screening relevant papers, and the third on finalising the criteria catalogue.

Literature search

Literature search was conducted with the tool 'research rabbit' (https://researchrabbitapp.com/). This AI-powered tool starts with a single paper or a list of publications and looks for relevant matches based on content (title, abstract), authors, and references. It can search its database for older and more recent publications than the ones initially provided. Since AI-based tools like that rather focus on content relations than just keyword or author match, they are much more efficient than conventional literature search methods when authors are not well known or the scientific field is as wide and diverse as climate communication. The search was conducted between August and November 2024.

Because the initial search results of the literature tool were not accurate enough, we defined subtopics of climate communication to focus the search process. Those sub-groups were only used for the literature search and are not considered further in our analyses.

Sub-topics used in literature search:

- Climate services
- Information visualisation
- Framing in climate communication
- Communication and visualisation of uncertainties
- Co-creation processes
- Good practice criteria for processing climate model data

For each subtopic, we started with an initial sample of relevant publications in that field. We screened the tools' search results by title and abstract. Our initial relevance criteria were aimed at exclusion, meaning that only publications that clearly diverged from the topic of interest were excluded, and everything else was added to the collection. We repeated the search process with the new list of publications and appended the collection again with relevant entries. This recursive approach was continued until the search results either expanded well outside the field, or no new publications were found.

The resulting literature database totals 275 publications over all sub-topics, spanning 30 years between 1995 and 2024. The final collection of relevant publications was exported to a shared Zotero library, so the project team could work collaboratively on the literature review.

Literature review

The initial idea for the literature review involved screening the publications for best practice examples and consolidating them for a gap analysis of real-world CCRs. However, the literature search yielded a large collection of papers for a broad topic, and early on it became clear that 'best practice' is a very stretchable and context-specific term. We therefore decided that rather than evaluate, our criteria should comprehensively characterise the CCRs of interest. For us, evaluation represents a separate step that needs to consider the use case and target group of the CCR.

To operationalise our literature review, we first defined the characteristics of our criteria. They should be clear and specific rather than broad. To avoid ambiguity or force evaluators to apply a finely graded scale, criteria should ideally be posed as a yes/no question. The initial draft of the criteria catalogue was developed by the project team based on the discussions and stated priorities of the stakeholder advisory board of Klimaszenarien.AT. It comprised of 33 criteria and provided the basis for further

selecting and screening relevant papers from our literature database. A hierarchical decision tree shown in Figure 1 helped us decide whether a paper should be selected for review or skipped.

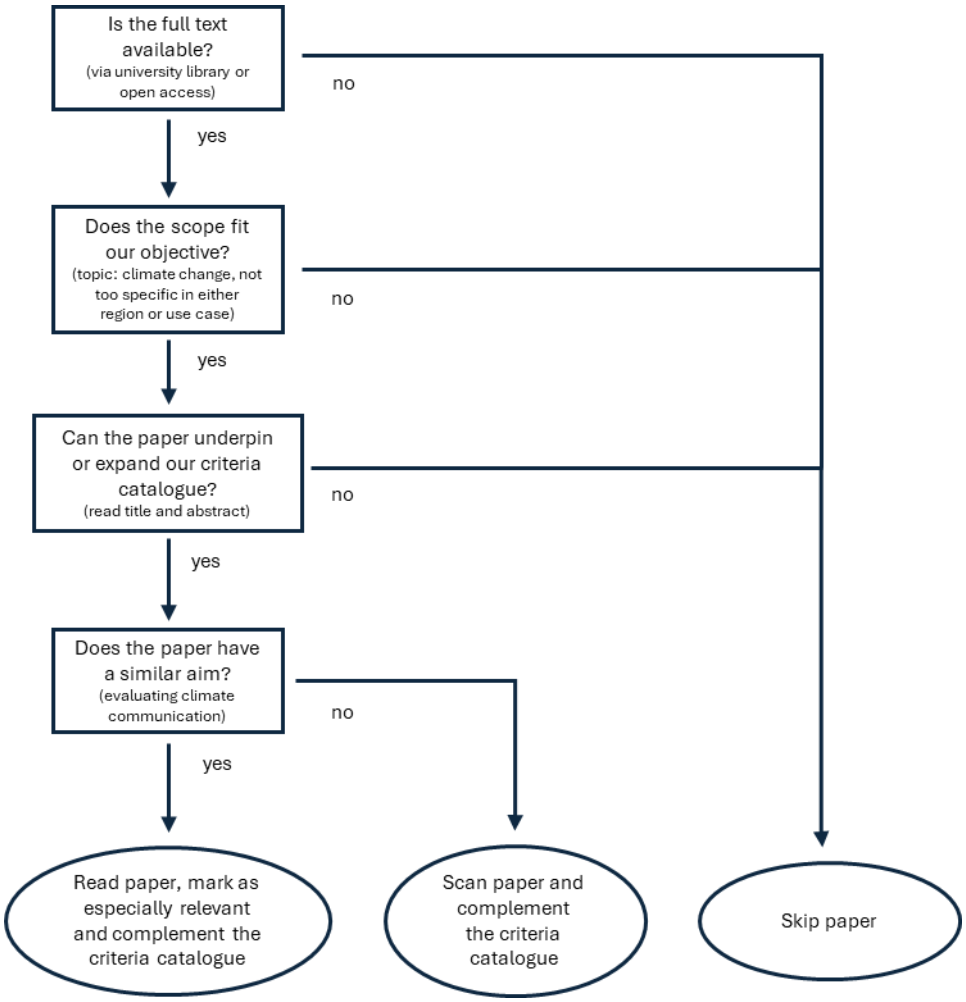

Figure 1: Decision tree used in WP4 to select relevant papers from the literature database.

The filtering process resulted in 169 papers (61.5% of all publications in the database) that were selected for review. Figure 2 shows the total number of papers per year found in the literature search, and the annual number of relevant papers identified via the decision tree. Those were subsequently screened (either scanned or read in detail, depending on their relevance) with the aim to either underpin, contradict or expand the initial criteria catalogue. Each match of a selected publication with a criterion in our catalogue was noted, and for each new aspect introduced by a

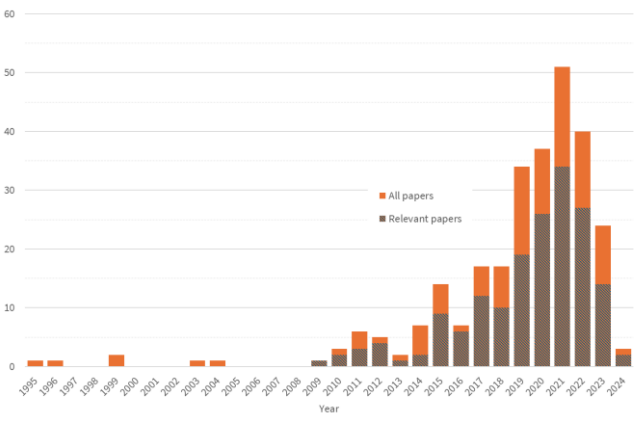

Figure 2: Number of total and relevant papers per year identified in the literature research of WP4.

paper a new criterion was formulated. This work was distributed between the project team and discussed in concurrent meetings to calibrate our understanding of what constitutes a match or extension of the criteria list.

Finalising the criteria catalogue

After the literature review, the criteria catalogue contained 72 criteria and roughly 1300 'hits', i.e. mentions of a criterion in the literature. A hit was counted when a criterion was mentioned or discussed in the paper, no matter how comprehensively. For each criterion a specific paper is only counted once, but it could count as hit for multiple different criteria. As a secondary benefit, these references can be used to create topical literature lists for each combination of criteria in our catalogue.

The criteria were reviewed after the literature research to ensure applicability and consistency of the entire framework. The goal was to harmonise the level of detail each criterion addresses and avoid overlapping or doubling of subjects. Two criteria were dropped, and several were re-defined to fit these requirements. Finally, each criterion received a name, code, short description and some practical examples of how it would look like in a real-world application, as exemplified in Table 1. Additionally, we developed a grouping for the criteria shown in Table 2 to simplify and enhance clarity for application and analysis.

Table 1: Final definition of the criterion 'hierarchical design' in the category 'visualisation'.

UID	Category	Code	Criteria name	Short name	Description	Example
51	VI	VI_DESIGNHIRARCHY	Hierarchical design	DESIGNHIRARCHY	The visualisations follow principles of hierarchical design to better guide viewers to the most important elements.	e.g. visually or textually highlighting important parts

Table 2: Criteria categories in the final catalogue.

Category name	No of criteria	Description
Transparent data and methods	11	Means the scientific quality of the data. Procedures and methods are transparent and documented, data sources are specified, uncertainties and its sources are disclosed.
Fit-for-purpose data	6	Means the quality of fit of the data. Data fits the specific goals and scope of the resource.
User orientation	10	Means that the needs of specific user groups were considered during development of the resource. The user groups could be directly involved in the development of the resource or indirectly surveyed.
Communication goals	8	Means the communicative goal of the resource
Visualisation	13	Means the quality and quantity of visualisations used in the resource.
Interactivity	3	Means the way the user(s) can interact with the resource.

Accessibility	15	Means the way the user(s) can locate, access and navigate the resource to find the required information.
Trustworthiness	4	Means the subjective feeling of trust associated with the resource, mainly concerning the developing and/or publishing organisation

The last step of making the criteria catalogue operational involved developing a quantitative score for analysis and visualisation. For that, we defined single-choice answers for each criterion and assigned a number between 0 and 1 to each answer. Since most criteria are posed as yes/no questions, their score was binary (0 for no, 1 for yes). For some criteria with graded response options (like 'fast – medium – slow), the score could assume values between 0 and 1.

Next, the criteria were grouped by the eight categories described in Table 2. The maximum possible sum of individual criteria scores per category is set to 1, with equal weighting (1/n for each criterion) by default. The criteria's weightings were then tweaked to account for differences in their impact for the overall category. For example, the criterion 'sector orientation' is weighted higher than the criterion 'data quantity' in the category 'fit-for-purpose data'.

An Excel-sheet with all criteria names, definitions and examples was prepared that provides single-choice answers in form of a drop-down list and automatically calculates the weighted scores per criterion and per category. The full criteria catalogue is provided in Annex 1. In the next phase, this evaluation sheet was tested by the project team and applied to several selected CCRs.

Results and Discussion

The chapter is sectioned along the main objectives of WP4. It first presents results of applying the criteria catalogue to characterise several CCRs in a structured framework. The second section presents results of a user group survey that tested preferences regarding characteristics of CCRs. The third section harmonises the characteristics and user group preferences into a fit-for-user group evaluation of CCRs.

Characterising CCRs: Four use cases

Here we present the results of applying the criteria catalogue to the four CCRs listed in Table 3. The selection represents a diverse variety of CCRs to test whether the framework can differentiate between their features. We selected two KLAR! Factsheets with different designs, which are assumed to vary in each category's individual score but not in the overall shape of the spider diagram. ClimaMap is a CCR with less textual explanations, a focus on map visualisations and a different overall scope. The RESY Dashboard is an interactive tool with a focus on spatial planning but also contains climate change indicators.

Table 3: Selected CCRs evaluated in WP4 with the criteria catalogue

Name	Description	Source
KLAR Factsheet Pinzgau	Factsheet for the KLAR-region Pinzgau in Salzburg, new format of KLAR Factsheets	https://klar-anpassungsregionen.at/fileadmin/user_upload/FACTSHEETS/80_KLAR__Pinzgau_Klimainfoblatt_BF.pdf

KLAR Factsheet Pongau	Factsheet for the KLAR-region Pongau in Salzburg, old format of KLAR Factsheets	https://klar-anpassungsregionen.at/fileadmin/user_upload/FACTSHEETS/21_KLAR_Pongau_Klimainfoblatt.pdf
ClimaMap	Maps of climate change impacts indicators for the Austrian federal states	https://data.hub.geosphere.at/group/climamap
RESY Dashboard	Interactive webtool for regional comparison of indicators relevant for spatial planning	https://www.resy-dashboard.at/

For each CCR, the resulting total and individual score per category is shown in Figure 3. The spider diagrams present a summary of the overall performance of the CCRs in each category. For example, the shapes of the KLAR! Factsheets and ClimaMap resemble each other, while the individual category scores vary. The results show that the design update between the earlier and more recent versions improve the overall score significantly. ClimaMap is less easily accessible than the KLAR! Factsheets, and seems to have more clearly defined communication goals.

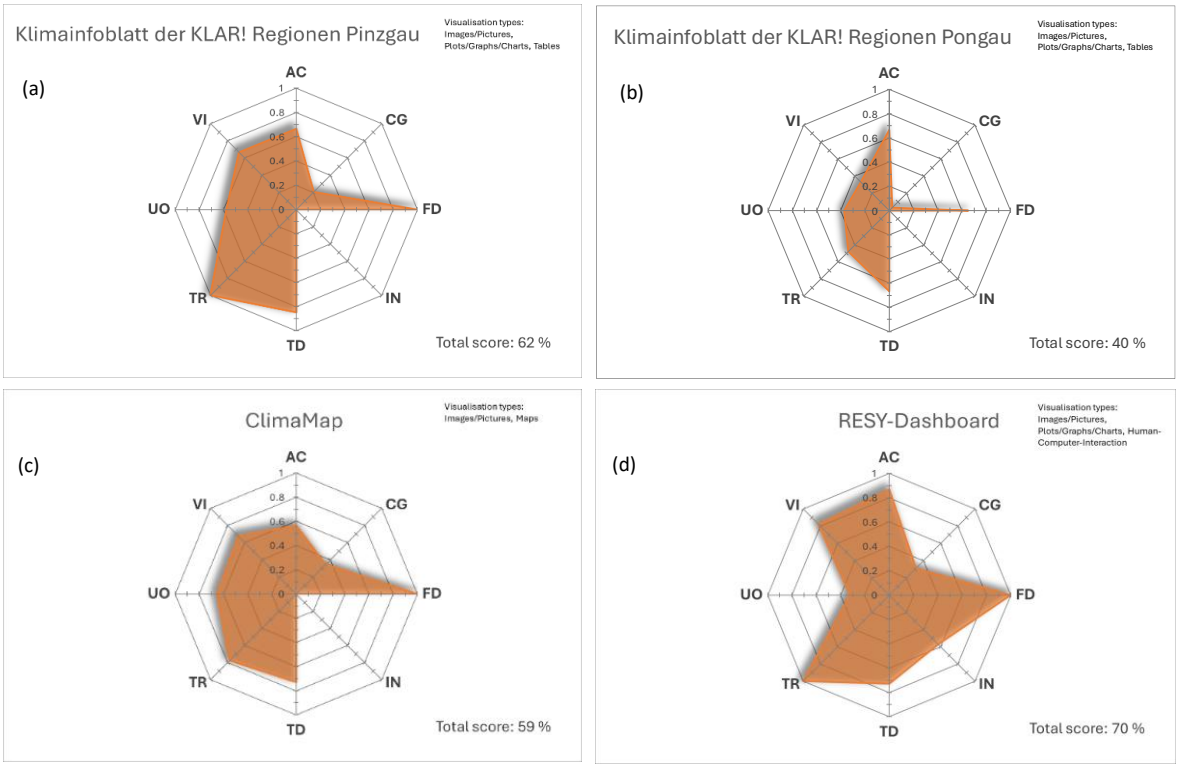

Figure 3: Evaluation results for the four CCRs: KLAR! Factsheet Pinzgau (a), KLAR! Factsheet Pongau (b), ClimaMap (c), and RESY-Dashboard (d). Spider diagrams show the score that the CCRs reached in each category on the radial axis. The total score shown in the left bottom is the average over all category scores, not single criteria scores. On the top left of each panel the types of visualisations used in the respective CCR are listed. This information is not included in the quantitative score.

The RESY dashboard is, in contrast to the other three, an interactive tool with a completely different design philosophy, which is captured by the overall shape of the category scores. While the other three

CCRs are static, the RESY dashboard allows user interaction with the data. On the other hand, the tool lacks well defined communication goals and user orientation.

The criteria catalogue provides developers and designers of CCRs with a framework to characterise and compare different resources with a standard set of criteria, which are robust since they are backed by a large and broad literature base. It seems useful to aggregate to the category level rather than look at single criteria, because there are too many and the uncertainties due to evaluator bias or weighting choices are too high for direct comparisons. At category level, the criteria framework can differentiate well between small and overall design choices of the CCRs.

With this tool at hand, a broad range of CCRs can be examined and compared. For the aims of the Use.AT project, this rather objective approach was the first step towards fit-for-user group evaluation. Now that we can capture the CCRs features, the next step are the preferences of potential user groups.

User group survey

The user group survey was not initially envisioned in the project proposal. The original intention was to evaluate CCRs according to benchmark criteria derived from the literature. It became clear later that the literature does not define what 'optimal' CCRs could look like, but that user group orientation and user-centred design play a pivotal role in how they are conceived and used. That means, rather that evaluating what an overall 'optimal' CCR is, it is important to identify which criteria are especially relevant for which user group. Therefore, we developed a short online survey based on the criteria categories in our evaluation framework.

In the first part of the survey, a user group and use profile was identified. Participants were asked to assign themselves to one of 13 occupational groups. The same groups were used throughout Use.AT:

- Public institutions
  - Federal administration
  - Regional administration
  - Consultants
  - Operations
- Private sector
  - Consulting
  - Insurance
  - Building and real estate industry
  - Infrastructure providers
- NGOs
  - Consultants
  - Activists
- Science
  - Climate data providers
  - Climate data users

Then they should specify the use intensity and prior experience with climate information in their professional work. In the second part, the survey asked participants to prioritise the criteria categories by distributing a total of 100 points between them. Finally, they were asked for their subjective preference of visualisation types and communication goals by choosing up to three from a list. The full user group survey is available in Annex 2.

30 participants started the survey, 19 finished all questions. Due to this relatively small sample, a robust statistical analysis is not possible for the 13 occupational groups we defined. Therefore, the results are grouped after prior experience with climate information. The group with high and very high experience levels contains eleven participants, the group with moderate or little experience eight participants. The sample size is still not high for robust quantitative evaluation. However, the survey was designed as a demonstrator of how fit-for-user group evaluation could be operationalised. The results for both experience levels are shown in Figure 4.

Trust in the data provider plays a major role for the less experienced user group, while the more experienced group emphasises transparency in data and methods. This pattern suggests that users with more experience either already know the quality of the underlying data and methods, or they want to read about it in the documentation themselves. Less experiences users are less likely to read long background manuals and rely on the institutions that publish the data to be trustworthy. The profiles also suggest that less experienced users are not interested as much in interacting with the data, but want materials with clear communication goals and framing, which is even more important than the type of visuals. User orientation, in the sense that users are involved in the design and development process, is more interesting to experienced users.

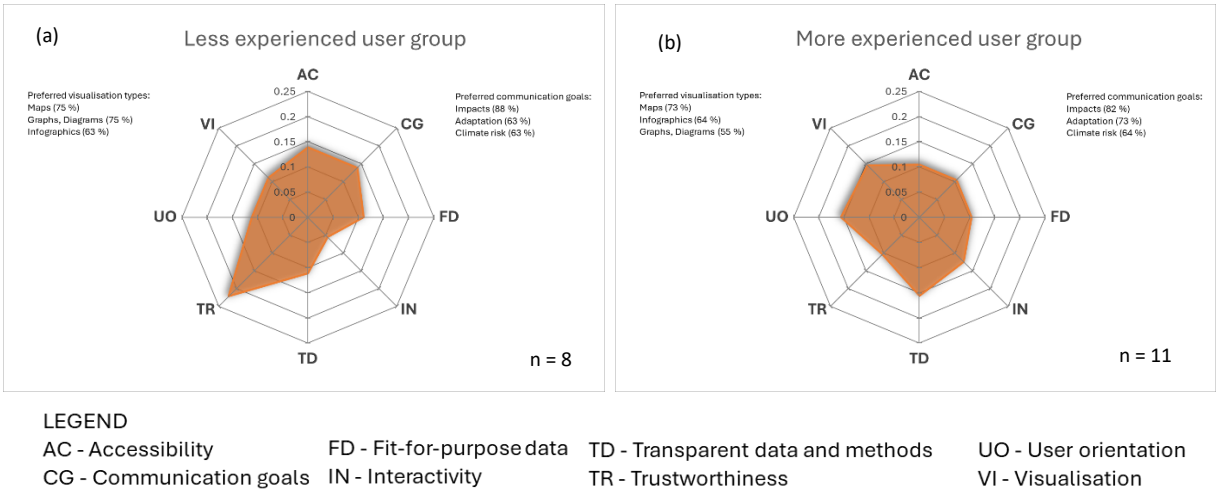

Figure 4: Preferences of climate communication categories stated in the online survey. The results are grouped after prior experience with climate information: users with moderate or little experience (a) and users with high or very high experience (b). Each user distributed 100 points over all categories according to preference for their professional work. The values in each category are medians of the participants' responses normalised by the size of the user group. In the top left and top right of each panel, the three most frequently named visualisation types and communication goals are ranked.

The most preferred visualisation types and communication goals are an exact match over both user groups, with a slightly different ranking of visualisation types. Note that the less experienced group were in more agreement about their visual preferences, while responses of the other group were more scattered across the different visualisation types. In terms of communication goals, an emphasis on

climate change impacts, adaptation and climate risks seems effective, while causes of climate change, mitigation, and sustainability play a subordinate role in the surveyed groups.

Although carrying out a full quantitative survey like in WP3 was not in the scope of WP4, we wanted to demonstrate how it could support the decisions of CCR developers like Klimaszenarien.AT to make their materials useful and usable. The survey provides user-group specific preferences for relevant facets of climate communication, thereby supporting the planning of communication strategies in the light of available resources. In the final step, we harmonise the findings of the CCR characterisation based on the criteria catalogue and the user group survey in a fit-for-user group evaluation which can inform the communication strategies of CCR developers like Klimaszenarien.AT.

Fit-for-user group evaluation of CCRs

The information from the CCR characterisation and user group survey are combined to show which of the selected CCRs best fit the preferences of each user group. Figure 5 shows index scores that were obtained by multiplying category scores of the CCRs with user group preferences from the survey. Like the user preference values in Figure 4, category scores from the CCRs were normalised before the index calculation. The final index score is obtained by summing up all individual category scores per user group.

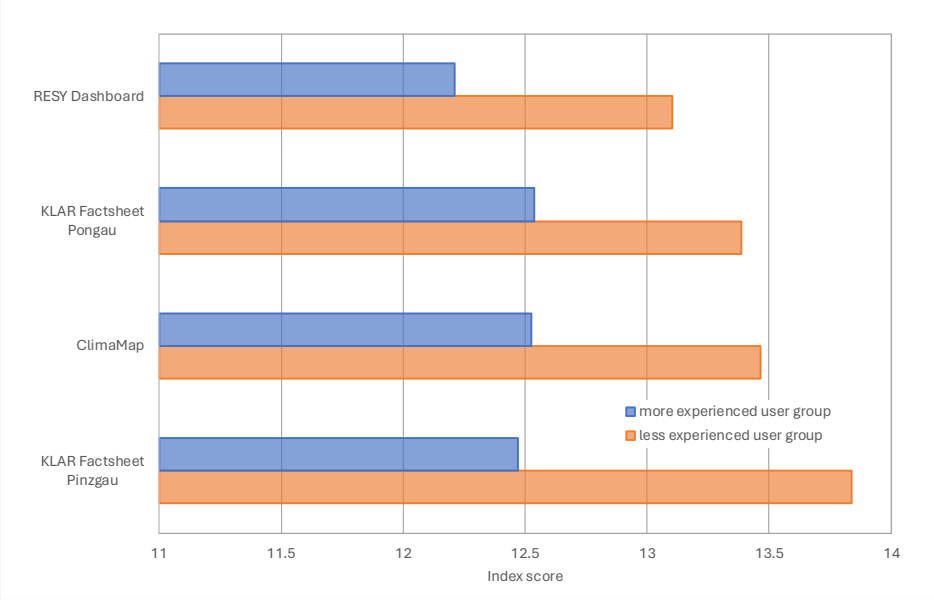

Figure 5: Fit-for-user group evaluation of the four selected CCRs. The index score combines both CCR characteristics and user group preferences over all eight criteria categories. The CCRs are ranked after the evaluation scores of the less experienced user group. Higher index scores mean higher agreement between the CCR characteristics and the user group preferences.

The index scores reflect how well the preferences of the user groups match the characteristics of the CCRs received from applying the criteria catalogue. To interpret them correctly, it should be noted that absolute scores (shown in Figure 3) are discounted, meaning that the ranking is not distorted by differences in the scores from the criteria evaluation. Therefore, the score assumes equally sized shapes of CCR characteristics and user preferences and shows their relative overlaps. Better scores only reflect a better fit in communication facets, not whether they are understood correctly or used at all in the participant's work.

The most noticeable feature of the fit-for-user group evaluation are the higher index scores for the less experienced user group. The differences between user groups are significantly larger than the differences between CCRs, and the ranking of CCRs varies for the two user groups. This shows that the overall score is more sensitive to the level of pre-existing experience with climate information than the distinct characteristics of the CCRs. For example, the ranking of the two KLAR! Factsheets is reversed in the two groups. Scores are more varied in the less experienced user group, suggesting that communication characteristics are less likely to influence the overall preference of the more experienced group than for the less experienced one.

While the results should be interpreted with caution due to the low number of survey participants and the methodology for calculating the fit-for-user group score, they allow some conclusions for the materials and user groups examined in WP4. First, the communicative characteristics of the CCRs seem to be optimised for less experienced users. Users with higher experience may prefer other types of resources for their professional needs, e.g. less focus on framing and visualisation and more flexibility to work with raw data themselves. Second, the low sensitivity of the overall score to CCR characteristics in the more experienced user group suggests that optimising those aspects is not as effective for them than for the other group. Third, the shapes and total scores of the CCR characterisation capture their respective features well, implying that the criteria catalogue and groups are suited for the task as a standardised framework. Finally, knowing your user group and their preferences of these aspects is key to designing effective CCRs. In this study, we took pre-existing experience as differentiating factor for user groups due to the limited number of finalised surveys, but the occupational group or other factors could work as well or better. Further research is needed to identify the best way to stratify user groups for CCR evaluation, but this study confirms that experience with climate information might be a good starting point. Targeted user groups and their preferences should be identified quite early in the CCR development process, because they affect key design decisions.

The results of this WP suggest that CCRs always have their strengths and weaknesses. There is no way of making it work for everyone, and no objective effectiveness of CCRs. Given limited resources for CCR development, they can be improved in certain aspects but might degrade in others at the same time. Therefore, it is essential to think and know about the targeted user groups. Basing the communication strategy on a fit-for-user group evaluation framework like the one presented could enhance the usability and usefulness of CCRs for the selected groups.

Fit-for-user group evaluation can be an important puzzle piece in CCR development and communication strategies. The ready-to-use criteria catalogue backed by extensive literature developed in this project helps standardise the characterisation and evaluation of CCRs, thereby addressing a research gap often mentioned in the wider climate communication literature.

Synthesis

The synthesis provides a summary of the methods, results and key conclusions of WP4. The work in WP4 was guided by four main research questions that were addressed through the literature review, criteria development, survey and fit-for-user group evaluation.

The literature review confirmed that climate communication cannot be reduced to universal "best practices." Instead, effectiveness depends on context, framing, and target audiences. From nearly 200 publications, a wide set of communicative aspects were identified, spanning transparency of data and methods, user orientation, accessibility, visualisation, and interactivity, among others. From that, we developed a catalogue spanning 70 criteria as a standardised framework that covers the diversity of features relevant to CCRs. A scoring scheme enables CCRs to be compared consistently.

Applying this catalogue to four case study CCRs showed that it can differentiate clearly between formats. The more recent KLAR! factsheet scored higher than the older version, demonstrating improvements in design and accessibility. ClimaMap performed well on communication goals but less on accessibility, while the RESY dashboard stood out as interactive but lacked in user orientation and communication goals. These findings highlight that CCRs have distinctive communicative features and that no single resource can meet all user needs equally.

The next step was testing a way of how user group preferences can be included in the evaluation of CCRs. A demonstrator survey was conducted to capture user group preferences related to the categories of the criteria catalogue. Results showed that less experienced users emphasise accessibility, communicative clarity, and trust in providers, while more experienced users prioritise transparency in methods and data, visualisation, and user orientation. Both groups highlighted climate impacts, adaptation, and risks as the most relevant communication goals. These findings suggest that prior experience with climate information is a relevant factor for designing user-group oriented CCRs.

By combining CCR characteristics with user group priorities, the fit-for-user group evaluation demonstrated that the case study CCRs are better aligned with less experienced users, while more experienced audiences may prefer raw data and transparent documentation. The analysis also highlighted that CCRs inherently involve trade-offs: no single format can satisfy all needs equally. Therefore, early identification of priority user groups and user group-specific design decisions and are essential for CCR development and effective communication strategies. The criteria catalogue provides an easy-to-use, robust, literature-based framework for planning those design choices.

In summary, WP4 contributes three major results: (i) a comprehensive criteria catalogue to characterise CCRs systematically, (ii) a practical demonstration of its use across different communication formats, and (iii) an approach to integrate user group preferences into evaluation. Together, these results offer a scientifically robust basis for improving usability and usefulness of CCRs in Klimaszenarien.AT.

Summary of key learnings

What learnings can we "harvest" for the development of CCRs in general and for the next generation of Austrian Climate Scenarios in particular? This section summarises our suggestions for the most relevant learning effects of WP4.

- **Key learning 1: No Universal Best Practice in Climate Communication**

  The effectiveness of CCRs depends on many facets of communication like goals, framing, visualisation, accessibility, or transparency, each of which are of different importance for different user groups. Instead of seeking one-size-fits-all solutions, communication strategies must be aware of user needs and contexts.

- **Key learning 2: There is the need for a standardised framework for CCR characterisation**

  The developed catalogue of 70 criteria, grouped into eight categories, provides a systematic way to describe and characterise CCRs. It offers a common scoring framework for a diverse range of communication formats.

- **Key learning 3: CCRs Involve Trade-offs**

  Different resources highlight different strengths—some excel in accessibility, others in interactivity or goal definition. No CCR can meet all requirements equally; design choices inevitably prioritise some aspects over others.

- **Key Learning 4: Fit-for-User Group Evaluation is a Valuable Approach**

  By combining CCR characteristics with user group preferences, the evaluation framework shows how well resources align for certain audiences. Given limited resources, CCRs cannot be optimised for everyone. Identifying target groups early and aligning design choices with their preferences can improve both usability and usefulness of climate communication efforts.

Bibliography

This bibliography lists all papers that were rated 'relevant' in the literature review and thereby provide the basis for the criteria catalogue developed in WP4.

Alexander, M., and Dessai, S. (2019). What can climate services learn from the broader services literature? *Climatic Change* 157, 133–149. doi: 10.1007/s10584-019-02388-8

André, K., Gerger Swartling, Å., Englund, M., Petutschnig, L., Attoh, E. M. N. A. N., Milde, K., et al. (2023). Improving stakeholder engagement in climate change risk assessments: insights from six co-production initiatives in Europe. *Front. Clim.* 5, 1120421. doi: 10.3389/fclim.2023.1120421

André, K., Järnberg, L., Gerger Swartling, Å., Berg, P., Segersson, D., Amorim, J. H., et al. (2021). Assessing the Quality of Knowledge for Adaptation–Experiences From Co-designing Climate Services in Sweden. *Front. Clim.* 3, 636069. doi: 10.3389/fclim.2021.636069

Arts, K., Macleod, C. J. A., Ioris, A. A. R., Han, X., Sripada, S., Braga, J. F., et al. (2019). Towards more effective online environmental information provision through tailored Natural Language Generation: Profiles of Scottish river user groups and an evaluative online experiment. *Science of The Total Environment* 673, 643–655. doi: 10.1016/j.scitotenv.2019.03.440

Attoh, E. M. N. A. N., Goosen, H., Van Selm, M., Boon, E., and Ludwig, F. (2022). Climate services for the railway sector: A synthesis of adaptation information needs in Europe. *Front. Clim.* 4, 968298. doi: 10.3389/fclim.2022.968298

Auer, C., Kriegler, E., Carlsen, H., Kok, K., Pedde, S., Krey, V., et al. (2021). Climate change scenario services: From science to facilitating action. *One Earth* 4, 1074–1082. doi: 10.1016/j.oneear.2021.07.015

Ballantyne, A. G. (2018). *Visualiseringens roller i klimatkommunikation – ett mottagarperspektiv*. Linköping: Linköping University Electronic Press. doi: 10.3384/diss.diva-147726

Bamzai-Dodson, A., Cravens, A. E., Wade, A., and McPherson, R. A. (2021). Engaging with stakeholders to produce actionable science: a framework and guidance. *Weather, Climate, and Society*. doi: 10.1175/WCAS-D-21-0046.1

Bamzai-Dodson, A., and McPherson, R. (2022). When Do Climate Services Achieve Societal Impact? Evaluations of Actionable Climate Adaptation Science. *Sustainability* 14, 14026. doi: 10.3390/su142114026

Bannister, H. J., Blackwell, P. G., Hyder, K., and Webb, T. J. (2021). Improving the visual communication of environmental model projections. *Sci Rep* 11, 19157. doi: 10.1038/s41598-021-98290-4

Becsi, B., Hohenwallner-Ries, D., Grothmann, T., Prutsch, A., Huber, T., and Formayer, H. (2020). Towards better informed adaptation strategies: co-designing climate change impact maps for Austrian regions. *Climatic Change* 158, 393–411. doi: 10.1007/s10584-019-02602-7

Beier, P., Hansen, L. J., Helbrecht, L., and Behar, D. (2017). A How-to Guide for Coproduction of Actionable Science. *CONSERVATION LETTERS* 10, 288–296. doi: 10.1111/conl.12300

Bloomfield, E. F., and Manktelow, C. (2021). Climate communication and storytelling. *Climatic Change* 167, 34. doi: 10.1007/s10584-021-03199-6

Bohman, A., Neset, T.-S., Opach, T., and Rød, J. K. (2015). Decision support for adaptive action – assessing the potential of geographic visualization. *Journal of Environmental Planning and Management* 58, 2193–2211. doi: 10.1080/09640568.2014.973937

Bojovic, D., St. Clair, A. L., Christel, I., Terrado, M., Stanzel, P., Gonzalez, P., et al. (2021). Engagement, involvement and empowerment: Three realms of a coproduction framework for climate services. *Global Environmental Change* 68, 102271. doi: 10.1016/j.gloenvcha.2021.102271

Boon, E., Goosen, H., Van Veldhoven, F., and Swart, R. (2021). Does Transformational Adaptation Require a Transformation of Climate Services? *Front. Clim.* 3, 615291. doi: 10.3389/fclim.2021.615291

Boon, E., Wright, S. J., Biesbroek, R., Goosen, H., and Ludwig, F. (2022). Successful climate services for adaptation: What we know, don't know and need to know. *Climate Services* 27, 100314. doi: 10.1016/j.cliser.2022.100314

Bowyer, P., Brasseur, G. P., and Jacob, D. (2015). "The Role of Climate Services in Adaptating to Climate Variability and Change," in *Handbook of Climate Change Adaptation*, ed. W. Leal Filho (Berlin, Heidelberg: Springer Berlin Heidelberg), 533–550. doi: 10.1007/978-3-642-38670-1_29

Brasseur, G. P., and Gallardo, L. (2016). Climate services: Lessons learned and future prospects. *Earth's Future* 4, 79–89. doi: 10.1002/2015EF000338

Bremer, S., Wardekker, A., Dessai, S., Sobolowski, S., Slaattelid, R., and Van Der Sluijs, J. (2019). Toward a multi-faceted conception of co-production of climate services. *Climate Services* 13, 42–50. doi: 10.1016/j.cliser.2019.01.003

Bremer, S., Wardekker, A., Jensen, E. S., and Van Der Sluijs, J. P. (2021). Quality Assessment in Co-developing Climate Services in Norway and the Netherlands. *Front. Clim.* 3, 627665. doi: 10.3389/fclim.2021.627665

Briley, L., Brown, D., and Kalafatis, S. E. (2015). Overcoming barriers during the co-production of climate information for decision-making. *Climate Risk Management* 9, 41–49. doi: 10.1016/j.crm.2015.04.004

Bruno Soares, M., and Buontempo, C. (2019). Challenges to the sustainability of climate services in Europe. *WIREs Climate Change* 10, e587. doi: 10.1002/wcc.587

Bruno Soares, M., and Dessai, S. (2015). Exploring the use of seasonal climate forecasts in Europe through expert elicitation. *Climate Risk Management* 10, 8–16. doi: 10.1016/j.crm.2015.07.001

Calvo, L., Christel, I., Terrado, M., Cucchietti, F., and Pérez-Montoro, M. (2022). Users' Cognitive Load: A Key Aspect to Successfully Communicate Visual Climate Information. *Bulletin of the American Meteorological Society* 103, E1–E16. doi: 10.1175/BAMS-D-20-0166.1

Cavelier, R., Borel, C., Charreyron, V., Chaussade, M., Le Cozannet, G., Morin, D., et al. (2017). Conditions for a market uptake of climate services for adaptation in France. *Climate Services* 6, 34–40. doi: 10.1016/j.cliser.2017.06.010

Celliers, L., Costa, M. M., Williams, D. S., and Rosendo, S. (2021). The 'last mile' for climate data supporting local adaptation. *Glob. Sustain.* 4, e14. doi: 10.1017/sus.2021.12

Cervenec, J., Fox, J., Peggau, K., Wilson, A. B., Li, B., Hu, D., et al. (2022). Interactive data visualizations of Earth's atmosphere: Effects on student engagement and perceived learning. *Journal of Geoscience Education* 70, 517–529. doi: 10.1080/10899995.2022.2038963

Ceyhan, G. D., and Saribas, D. (2022). Research trends on climate communication in the post-truth era. *Educational and Developmental Psychologist* 39, 5–16. doi: 10.1080/20590776.2021.2001295

Christel, I., Hemment, D., Bojovic, D., Cucchietti, F., Calvo, L., Stefaner, M., et al. (2018). Introducing design in the development of effective climate services. *Climate Services* 9, 111–121. doi: 10.1016/j.cliser.2017.06.002

Clifford, K. R., Travis, W. R., and Nordgren, L. T. (2020). A climate knowledges approach to climate services. *Climate Services* 18, 100155. doi: 10.1016/j.cliser.2020.100155

Collard, M., Stattner, E., Segretier, W., Eugenie, R., and Jadoul, N. (2020). DKP: A Geographic Data and Knowledge Platform for Supporting Climate Service Design. *IJGI* 9, 337. doi: 10.3390/ijgi9050337

Cortes Arevalo, V. J., Verbrugge, L. N. H., Sools, A., Brugnach, M., Wolterink, R., Van Denderen, R. P., et al. (2020). Storylines for practice: a visual storytelling approach to strengthen the science-practice interface. *Sustain Sci* 15, 1013–1032. doi: 10.1007/s11625-020-00793-y

Cradock-Henry, N. A., Diprose, G., and Frame, B. (2021). Towards local-parallel scenarios for climate change impacts, adaptation and vulnerability. *Climate Risk Management* 34, 100372. doi: 10.1016/j.crm.2021.100372

Cremades, R., Mitter, H., Tudose, N. C., Sanchez-Plaza, A., Graves, A., Broekman, A., et al. (2019). Ten principles to integrate the water-energy-land nexus with climate services for co-producing local and regional integrated assessments. *Science of The Total Environment* 693, 133662. doi: 10.1016/j.scitotenv.2019.133662

Crespi, A., Renner, K., Zebisch, M., Schauser, I., Leps, N., and Walter, A. (2023). Analysing spatial patterns of climate change: Climate clusters, hotspots and analogues to support climate risk assessment and communication in Germany. *Climate Services* 30, 100373. doi: 10.1016/j.cliser.2023.100373

Cross, M. S., Oakes, L. E., Kretser, H. E., Bredehoft, R., Dey, P., Mahoney, A., et al. (2022). Tackling the Science Usability Gap in a Warming World: Co-Producing Useable Climate Information for Natural Resource Management. *Environmental Management* 70, 881–895. doi: 10.1007/s00267-022-01718-4

Daly, M. (2021). Unfulfilled promise of better decisions. *Nat. Clim. Chang.* 11, 721–722. doi: 10.1038/s41558-021-01136-0

Daniels, E., Bharwani, S., Gerger Swartling, Å., Vulturius, G., and Brandon, K. (2020). Refocusing the climate services lens: Introducing a framework for co-designing "transdisciplinary knowledge integration processes" to build climate resilience. *Climate Services* 19, 100181. doi: 10.1016/j.cliser.2020.100181

Daron, J., Bruno Soares, M., Janes, T., Colledge, F., Srinivasan, G., Agarwal, A., et al. (2022). Advancing climate services in South Asia. *Climate Services* 26, 100295. doi: 10.1016/j.cliser.2022.100295

Daron, J. D., Lorenz, S., Wolski, P., Blamey, R. C., and Jack, C. (2015). Interpreting climate data visualisations to inform adaptation decisions. *Climate Risk Management* 10, 17–26. doi: 10.1016/j.crm.2015.06.007

Daron, J., Lorenz, S., Taylor, A., and Dessai, S. (2021). Communicating future climate projections of precipitation change. *Climatic Change* 166, 23. doi: 10.1007/s10584-021-03118-9

De Sherbinin, A., Bukvic, A., Rohat, G., Gall, M., McCusker, B., Preston, B., et al. (2019). Climate vulnerability mapping: A systematic review and future prospects. *WIREs Climate Change* 10, e600. doi: 10.1002/wcc.600

Del Pozo, M., Gulikers, J., Van Der Bolt, B., Paparrizos, S., Smolenaars, W., Den Brok, P., et al. (2024). A learning framework for designing climate services for capacity building. *Climate Services* 34, 100499. doi: 10.1016/j.cliser.2024.100499

Dilling, L., and Lemos, M. C. (2011). Creating usable science: Opportunities and constraints for climate knowledge use and their implications for science policy. *Global Environmental Change* 21, 680–689. doi: 10.1016/j.gloenvcha.2010.11.006

Djenontin, I. N. S., and Meadow, A. M. (2018). The art of co-production of knowledge in environmental sciences and management: lessons from international practice. *Environmental Management* 61, 885–903. doi: 10.1007/s00267-018-1028-3

Downs, J. S. (2014). Prescriptive scientific narratives for communicating usable science. *Proc. Natl. Acad. Sci. U.S.A.* 111, 13627–13633. doi: 10.1073/pnas.1317502111

Englund, M., André, K., Gerger Swartling, Å., and Iao-Jörgensen, J. (2022). Four Methodological Guidelines to Evaluate the Research Impact of Co-produced Climate Services. *Front. Clim.* 4, 909422. doi: 10.3389/fclim.2022.909422

Feola, G., Geoghegan, H., and Arnall, A. eds. (2019). "Not for the Faint of Heart: Tasks of Climate Change Communication in the Context of Societal Transformation," in *Climate and Culture*, (Cambridge University Press), 141–167. doi: 10.1017/9781108505284.008

Ferguson, D. B., Meadow, A. M., and Huntington, H. P. (2022). Making a Difference: Planning for Engaged Participation in Environmental Research. *Environmental Management* 69, 227–243. doi: 10.1007/s00267-021-01585-5

Findlater, K., Webber, S., Kandlikar, M., and Donner, S. (2021). Climate services promise better decisions but mainly focus on better data. *Nat. Clim. Chang.* 11, 731–737. doi: 10.1038/s41558-021-01125-3

Fischer, H., Van Den Broek, K. L., Ramisch, K., and Okan, Y. (2020). When IPCC graphs can foster or bias understanding: evidence among decision-makers from governmental and non-governmental institutions. *Environ. Res. Lett.* 15, 114041. doi: 10.1088/1748-9326/abbc3c

Fish, C. S. (2020). Cartographic content analysis of compelling climate change communication. *Cartography and Geographic Information Science* 47, 492–507. doi: 10.1080/15230406.2020.1774421

Fleming, A., Bohensky, E., Dutra, L. X. C., Lin, B. B., Melbourne-Thomas, J., Moore, T., et al. (2023). Perceptions of co-design, co-development and co-delivery (Co-3D) as part of the co-production process – Insights for climate services. *Climate Services* 30, 100364. doi: 10.1016/j.cliser.2023.100364

Font Barnet, A., Boqué Ciurana, A., Olano Pozo, J. X., Russo, A., Coscarelli, R., Antronico, L., et al. (2021). Climate services for tourism: An applied methodology for user engagement and co-creation in European destinations. *Climate Services* 23, 100249. doi: 10.1016/j.cliser.2021.100249

Fraccaroli, C., Marini Govigli, V., Briers, S., Peña Cerezo, N., Paz Jiménez, J., Romero, M., et al. (2021). Climate data for the European forestry sector: From end-user needs to opportunities for climate resilience. *Climate Services* 23, 100247. doi: 10.1016/j.cliser.2021.100247

Franklin, A. L., Grossman, A., Le, J., and Shafer, M. (2019). Creating Broader Research Impacts through Boundary Organizations. *Public Administration Review* 79, 215–224. doi: 10.1111/puar.12985

Gerlak, A. K., Guido, Z., Owen, G., McGoffin, M. S. R., Louder, E., Davies, J., et al. (2023). Stakeholder engagement in the co-production of knowledge for environmental decision-making. *World Development* 170, 106336. doi: 10.1016/j.worlddev.2023.106336

Gerst, M. D., Kenney, M. A., and Feygina, I. (2021). Improving the usability of climate indicator visualizations through diagnostic design principles. *Climatic Change* 166, 33. doi: 10.1007/s10584-021-03109-w

Glaas, E., Ballantyne, A. G., Neset, T.-S., and Linnér, B.-O. (2017). Visualization for supporting individual climate change adaptation planning: Assessment of a web-based tool. *Landscape and Urban Planning* 158, 1–11. doi: 10.1016/j.landurbplan.2016.09.018

Goodess, C. M., Troccoli, A., Acton, C., Añel, J. A., Bett, P. E., Brayshaw, D. J., et al. (2019). Advancing climate services for the European renewable energy sector through capacity building and user engagement. *Climate Services* 16, 100139. doi: 10.1016/j.cliser.2019.100139

Goodess, C. M., Troccoli, A., Vasilakos, N., Dorling, S., Steele, E., Amies, J. D., et al. (2022). The Value-Add of Tailored Seasonal Forecast Information for Industry Decision Making. *Climate* 10, 152. doi: 10.3390/cli10100152

Goudine, A., Newell, R., and Bone, C. (2020). Seeing Climate Change: A Framework for Understanding Visualizations for Climate Adaptation. *IJGI* 9, 644. doi: 10.3390/ijgi9110644

Grainger, S., Mao, F., and Buytaert, W. (2016). Environmental data visualisation for non-scientific contexts: Literature review and design framework. *Environmental Modelling & Software* 85, 299–318. doi: 10.1016/j.envsoft.2016.09.004

Grainger, S., Murphy, C., and Vicente-Serrano, S. M. (2021). Barriers and Opportunities for Actionable Knowledge Production in Drought Risk Management: Embracing the Frontiers of Co-production. *Front. Environ. Sci.* 9, 602128. doi: 10.3389/fenvs.2021.602128

Grainger, S., Ochoa-Tocachi, B. F., Antiporta, J., Dewulf, A., and Buytaert, W. (2020). Tailoring Infographics on Water Resources Through Iterative, User-Centered Design: A Case Study in the Peruvian Andes. *Water Resources Research* 56, e2019WR026694. doi: 10.1029/2019WR026694

Grothmann, T., Leitner, M., Glas, N., and Prutsch, A. (2017). A Five-Steps Methodology to Design Communication Formats That Can Contribute to Behavior Change: The Example of Communication for Health-Protective Behavior Among Elderly During Heat Waves. *SAGE Open* 7, 215824401769201. doi: 10.1177/2158244017692014

Guivarch, C., Le Gallic, T., Bauer, N., Fragkos, P., Huppmann, D., Jaxa-Rozen, M., et al. (2022). Using large ensembles of climate change mitigation scenarios for robust insights. *Nat. Clim. Chang.* 12, 428–435. doi: 10.1038/s41558-022-01349-x

Gustafson, A., and Rice, R. E. (2020). A review of the effects of uncertainty in public science communication. *Public Underst Sci* 29, 614–633. doi: 10.1177/0963662520942122

Harold, J., Lorenzoni, I., Coventry, K., and Minns, A. (2017). *Enhancing the accessibility of climate change data visuals:Recommendations to the IPCC and guidance for researchers*. Available at: https://ueaeprints.uea.ac.uk/id/eprint/73442/ (Accessed August 23, 2024).

Harold, J., Lorenzoni, I., Shipley, T. F., and Coventry, K. R. (2016). Cognitive and psychological science insights to improve climate change data visualization. *Nature Clim Change* 6, 1080–1089. doi: 10.1038/nclimate3162

Harold, J., Lorenzoni, I., Shipley, T. F., and Coventry, K. R. (2020). Communication of IPCC visuals: IPCC authors' views and assessments of visual complexity. *Climatic Change* 158, 255–270. doi: 10.1007/s10584-019-02537-z

Hawkins, H., and Kanngieser, A. (2017). Artful climate change communication: overcoming abstractions, insensibilities, and distances. *WIREs Climate Change* 8, e472. doi: 10.1002/wcc.472

Hermansen, E. A. T., Sillmann, J., Vigo, I., and Whittlesey, S. (2021). The EU needs a demand-driven innovation policy for climate services. *Climate Services* 24, 100270. doi: 10.1016/j.cliser.2021.100270

Hewitt, C. D., Guglielmo, F., Joussaume, S., Bessembinder, J., Christel, I., Doblas-Reyes, F. J., et al. (2021). Recommendations for Future Research Priorities for Climate Modeling and Climate Services. *Bulletin of the American Meteorological Society* 102, E578–E588. doi: 10.1175/BAMS-D-20-0103.1

Hewitt, C. D., and Stone, R. (2021). Climate services for managing societal risks and opportunities. *Climate Services* 23, 100240. doi: 10.1016/j.cliser.2021.100240

Hoffmann, E., Rupp, J., and Sander, K. (2020). "What Do Users Expect from Climate Adaptation Services? Developing an Information Platform Based on User Surveys," in *Handbook of Climate*

Services, eds. W. Leal Filho and D. Jacob (Cham: Springer International Publishing), 105–134. doi: 10.1007/978-3-030-36875-3_7

Howe, L. C., MacInnis, B., Krosnick, J. A., Markowitz, E. M., and Socolow, R. (2019). Acknowledging uncertainty impacts public acceptance of climate scientists' predictions. *Nat. Clim. Chang.* 9, 863–867. doi: 10.1038/s41558-019-0587-5

Jacobs, K. L., and Street, R. B. (2020). The next generation of climate services. *Climate Services* 20, 100199. doi: 10.1016/j.cliser.2020.100199

Jagannathan, K., Arnott, J. C., Wyborn, C., Klenk, N., Mach, K. J., Moss, R. H., et al. (2020). Great expectations? Reconciling the aspiration, outcome, and possibility of co-production. *Current Opinion in Environmental Sustainability* 42, 22–29. doi: 10.1016/j.cosust.2019.11.010

Jagannathan, K., Buddhavarapu, S., Ullrich, P. A., and Jones, A. D. (2023). Typologies of actionable climate information and its use. *Global Environmental Change* 82, 102732. doi: 10.1016/j.gloenvcha.2023.102732

Jahan, M. (2021). A Systematic Evaluation of Climate Services and Decision Support Tools for Climate Change Adaptation. Virginia Tech. Available at: https://vtechworks.lib.vt.edu/items/375fb0e6-5678-4fa6-9786-bfe35cd27c65 (Accessed August 23, 2024).

Jahan, M., Reis, J., and Shortridge, J. (2023). Assessing climate service products with evaluation metrics: an application to decision support tools for climate change adaptation in the USA. *Climatic Change* 176, 113. doi: 10.1007/s10584-023-03595-0

Johannsen, I. M., Fabrikant, S. I., and Evers, M. (2018a). How Do Texture and Color Communicate Uncertainty in Climate Change Map Displays? (Short Paper). *LIPIcs, Volume 114, GIScience 2018* 114, 37:1-37:6. doi: 10.4230/LIPICS.GISCIENCE.2018.37

Johannsen, I. M., Lassonde, K. A., Wilkerson, F., and Schaab, G. (2018b). Communicating Climate Change: Reinforcing Comprehension and Personal Ties to Climate Change Through Maps. *The Cartographic Journal* 55, 85–100. doi: 10.1080/00087041.2017.1386834

Kahan, D. M. (2013). Making Climate-Science Communication Evidence-Based — All the Way Down. *SSRN Journal*. doi: 10.2139/ssrn.2216469

Kalsnes, B., Oen, A., Frauenfelder, R., Heggelund, I., Vasbotten, M., Vollstedt, B., et al. (2023). Stakeholder evaluation of the co-production process of climate services. Experiences from two case studies in Larvik (Norway) and Flensburg (Germany). *Climate Services* 32, 100409. doi: 10.1016/j.cliser.2023.100409

Kause, A., Bruine De Bruin, W., Domingos, S., Mittal, N., Lowe, J., and Fung, F. (2021). Communications about uncertainty in scientific climate-related findings: a qualitative systematic review. *Environ. Res. Lett.* 16, 053005. doi: 10.1088/1748-9326/abb265

Knutti, R., Abramowitz, G., Collins, M., Eyring, V., Gleckler, P., Hewitson, B., et al. (2010). Good Practice Guidance Paper on Assessing and Combining Multi Model Climate Projections., 1–15. Available at: https://www.wcrp-climate.org/wgcm/references/IPCC_EM_MME_GoodPracticeGuidancePaper.pdf

Köberl, J., François, H., Cognard, J., Carmagnola, C., Prettenthaler, F., Damm, A., et al. (2021). The demand side of climate services for real-time snow management in Alpine ski resorts: Some empirical insights and implications for climate services development. *Climate Services* 22, 100238. doi: 10.1016/j.cliser.2021.100238

Körfgen, A., Kuthe, A., Chiari, S., Prutsch, A., Keller, L., and Stötter, J. (2019). "Moving Forward in Climate Change Communication: Recommendations for Rethinking Strategies and Frames," in *Addressing the Challenges in Communicating Climate Change Across Various Audiences*, eds. W. Leal Filho, B. Lackner, and H. McGhie (Cham: Springer International Publishing), 545–564. doi: 10.1007/978-3-319-98294-6_33

Kotamarthi, R., Hayhoe, K., Mearns, L., Wuebbles, D., Jacobs, J., and Jurado, J. (2021). *Downscaling Techniques for High-Resolution Climate Projections: From Global Change to Local Impacts*., 1st Edn. Cambridge University Press. doi: 10.1017/9781108601269

Kreienkamp, F., Huebener, H., Linke, C., and Spekat, A. (2012). Good practice for the usage of climate model simulation results - a discussion paper. *Environ Syst Res* 1, 9. doi: 10.1186/2193-2697-1-9

Larsen, M. A. D., Karamitilios, G., Halsnæs, K., She, J., and Madsen, K. S. (2021). Advancing future climate services: Multi-sectorial mapping of the current usage and demand in Denmark. *Climate Risk Management* 33, 100335. doi: 10.1016/j.crm.2021.100335

Laudien, R., Boon, E., Goosen, H., and Van Nieuwaal, K. (2019). The Dutch adaptation web portal: seven lessons learnt from a co-production point of view. *Climatic Change* 153, 509–521. doi: 10.1007/s10584-018-2179-1

Lemos, M. C., Kirchhoff, C. J., and Ramprasad, V. (2012). Narrowing the climate information usability gap. *Nature Clim Change* 2, 789–794. doi: 10.1038/nclimate1614

Lewandowsky, S., Ballard, T., and Pancost, R. D. (2015). Uncertainty as knowledge. *Phil. Trans. R. Soc. A.* 373, 20140462. doi: 10.1098/rsta.2014.0462

Linke, C., Kreienkamp, F., and Zimmer, M. (2017). Leitlinien zur Interpretation regionaler Klimamodelldaten. *Bund-Länder-Fachgespräch-Interpretation regionaler Klimamodelldaten. Essen*. Available at: https://www.klimawandel-rlp.de/nc/fr/aktuelles/einzelansicht/news/detail/News/leitlinien-zur-interpretation-regionaler-klimamodelldaten/

Lorenz, S., Dessai, S., Forster, P. M., and Paavola, J. (2015). Tailoring the visual communication of climate projections for local adaptation practitioners in Germany and the UK. *Phil. Trans. R. Soc. A.* 373, 20140457. doi: 10.1098/rsta.2014.0457

MacPherson-Krutsky, C. C., Brand, B. D., and Lindell, M. K. (2020). Does updating natural hazard maps to reflect best practices increase viewer comprehension of risk? *International Journal of Disaster Risk Reduction* 46, 101487. doi: 10.1016/j.ijdrr.2020.101487

Majooni, A., Masood, M., and Akhavan, A. (2018). An eye-tracking study on the effect of infographic structures on viewer's comprehension and cognitive load. *Information Visualization* 17, 257–266. doi: 10.1177/1473871617701971

Mastrandrea, M. D., Heller, N. E., Root, T. L., and Schneider, S. H. (2010). Bridging the gap: linking climate-impacts research with adaptation planning and management. *Climatic Change* 100, 87–101. doi: 10.1007/s10584-010-9827-4

Matthews, L. (2020). Data-driven climate indices as a climate translation service. Available at: https://uwspace.uwaterloo.ca/handle/10012/15835 (Accessed August 23, 2024).

McKendry, J. E., and Machlis, G. E. (2009). Cartographic design and the quality of climate change maps. *Climatic Change* 95, 219–230. doi: 10.1007/s10584-008-9519-5

McLoughlin, N., Howarth, C., and Shreedhar, G. (2023). Changing behavioral responses to heat risk in a warming world: How can communication approaches be improved? *WIREs Climate Change* 14, e819. doi: 10.1002/wcc.819

McMahon, R., Stauffacher, M., and Knutti, R. (2015). The unseen uncertainties in climate change: reviewing comprehension of an IPCC scenario graph. *Climatic Change* 133, 141–154. doi: 10.1007/s10584-015-1473-4

McNie, E. C. (2012). Delivering Climate Services: Organizational Strategies and Approaches for Producing Useful Climate-Science Information. *Weather, Climate, and Society* 5, 14–26. doi: 10.1175/WCAS-D-11-00034.1

Meadow, A. M., Ferguson, D. B., Guido, Z., Horangic, A., Owen, G., and Wall, T. (2015). Moving toward the Deliberate Coproduction of Climate Science Knowledge. *Weather, Climate, and Society* 7, 179–191. doi: 10.1175/WCAS-D-14-00050.1

Moser, S. C. (2016). Reflections on climate change communication research and practice in the second decade of the 21st century: what more is there to say? *WIREs Climate Change* 7, 345–369. doi: 10.1002/wcc.403

Moser, S. C. (2017). "Climate Change Communication," in *International Encyclopedia of Geography*, eds. D. Richardson, N. Castree, M. F. Goodchild, A. Kobayashi, W. Liu, and R. A. Marston (Wiley), 1–8. doi: 10.1002/9781118786352.wbieg0310

Moss, R. H. (2016). Assessing decision support systems and levels of confidence to narrow the climate information "usability gap." *Climatic Change* 135, 143–155. doi: 10.1007/s10584-015-1549-1

Oliver, K., and Cairney, P. (2019). The dos and don'ts of influencing policy: a systematic review of advice to academics. *Palgrave Commun* 5, 21. doi: 10.1057/s41599-019-0232-y

Pearman, O., and Cravens, A. E. (2022). Institutional barriers to actionable science: Perspectives from decision support tool creators. *Environmental Science & Policy* 128, 317–325. doi: 10.1016/j.envsci.2021.12.004

Photiadou, C., Arheimer, B., Bosshard, T., Capell, R., Elenius, M., Gallo, I., et al. (2021). Designing a Climate Service for Planning Climate Actions in Vulnerable Countries. *Atmosphere* 12, 121. doi: 10.3390/atmos12010121

Pimentel, R., Photiadou, C., Little, L., Huber, A., Lemoine, A., Leidinger, D., et al. (2022). Improving the usability of climate services for the water sector: The AQUACLEW experience. *Climate Services* 28, 100329. doi: 10.1016/j.cliser.2022.100329

Pope, J. O., Logan, M., Kennedy, S., MacDonald, K., Matthews, A., Milne, K., et al. (2023). Musical messages – Creating a bespoke climate story for the Outer Hebrides. *Climate Services* 32, 100407. doi: 10.1016/j.cliser.2023.100407

Porter, J. J., and Clark, C. (2023). Usable, but unused: A critical story of co-producing the UK's Climate Change Risk Assessments. *Environmental Science & Policy* 139, 83–91. doi: 10.1016/j.envsci.2022.10.018

Porter, J. J., and Dessai, S. (2017). Mini-me: Why do climate scientists' misunderstand users and their needs? *Environmental Science & Policy* 77, 9–14. doi: 10.1016/j.envsci.2017.07.004

Preston, B. L., Yuen, E. J., and Westaway, R. M. (2011). Putting vulnerability to climate change on the map: a review of approaches, benefits, and risks. *Sustain Sci* 6, 177–202. doi: 10.1007/s11625-011-0129-1

Prokopy, L. S., Carlton, J. S., Haigh, T., Lemos, M. C., Mase, A. S., and Widhalm, M. (2017). Useful to Usable: Developing usable climate science for agriculture. *Climate Risk Management* 15, 1–7. doi: 10.1016/j.crm.2016.10.004

Rayner, T. (2018). "Feeling the Heat: The Challenge of Communicating 'High-End' Climate Change," in *Handbook of Climate Change Communication: Vol. 1*, eds. W. Leal Filho, E. Manolas, A. M. Azul, U. M. Azeiteiro, and H. McGhie (Cham: Springer International Publishing), 367–383. doi: 10.1007/978-3-319-69838-0_20

Retchless, D., Fish, C., and Thatcher, J. (2022). Climate change communication beyond the digital divide: Exploring cartography's role and privilege in climate action. *Journal of Environmental Media* 3, 101–123. doi: 10.1386/jem_00074_1

Retchless, D. P., and Brewer, C. A. (2016). Guidance for representing uncertainty on global temperature change maps. *Intl Journal of Climatology* 36, 1143–1159. doi: 10.1002/joc.4408

Richardson, E. (n.d.). Exploring the communication of flood risk through online geographic visualisation. University of Nottingham. Available at: http://eprints.nottingham.ac.uk/65485 (Accessed August 23, 2024).

Rigby, J. M., and Preist, C. (2023). Towards User-Centred Climate Services: the Role of Human-Computer Interaction., in *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, (Hamburg Germany: ACM), 1–14. doi: 10.1145/3544548.3580663

Riley, R. E. (2021). An Evaluation of the Utility of a Decision-Maker-Driven Climate Hazard Assessment Tool. *Weather, Climate, and Society* 13, 147–157. doi: 10.1175/WCAS-D-20-0019.1

Rosemartin, A., Crimmins, T. M., Gerst, K. L., Posthumus, E. E., Ramirez, A. R., Wallace, C. S., et al. (2023). Lessons learned in knowledge co-production for climate-smart decision-making. *Environmental Science & Policy* 141, 178–187. doi: 10.1016/j.envsci.2023.01.010

Rowan, K. E., Engblom, A., Hathaway, J., Lloyd, R., Vorster, I., Anderson, E. Z., et al. (2021). "Overcome the Deficit Model by Applying the CAUSE Model to Climate Change Communication," in *The Handbook of Strategic Communication*, ed. C. H. Botan (Wiley), 225–261. doi: 10.1002/9781118857205.ch16

Schneider, B., and Nocke, T. (2018). "The Feeling of Red and Blue—A Constructive Critique of Color Mapping in Visual Climate Change Communication," in *Handbook of Climate Change Communication: Vol. 2*, eds. W. Leal Filho, E. Manolas, A. M. Azul, U. M. Azeiteiro, and H. McGhie (Cham: Springer International Publishing), 289–303. doi: 10.1007/978-3-319-70066-3_19

Simmonds, E. G., Adjei, K. P., Andersen, C. W., Hetle Aspheim, J. C., Battistin, C., Bulso, N., et al. (2022). Insights into the quantification and reporting of model-related uncertainty across different disciplines. *iScience* 25, 105512. doi: 10.1016/j.isci.2022.105512

Singletary, L., Koebele, E., Evans, W., Copp, C. J., Hockaday, S., and Rego, J. J. (2022). Evaluating stakeholder engagement in collaborative research: co-producing knowledge for climate resilience. *Socio Ecol Pract Res* 4, 235–249. doi: 10.1007/s42532-022-00124-8

Singletary, L., and Sterle, K. (2020). Supporting local adaptation through the co-production of climate information: An evaluation of collaborative research processes and outcomes. *Climate Services* 20, 100201. doi: 10.1016/j.cliser.2020.100201

Sippel, M. (2023). Key insights from climate communication – and how they can inspire sustainability in higher education. *IJSHE* 24, 1594–1609. doi: 10.1108/IJSHE-07-2022-0208

Sippel, M., Shaw, C., and Marshall, G. (2022). Ten Key Principles: How to Communicate Climate Change for Effective Public Engagement. *SSRN Journal*. doi: 10.2139/ssrn.4151465

Stahre Wästberg, B., Billger, M., and Adelfio, M. (2020). A User-Based Look at Visualization Tools for Environmental Data and Suggestions for Improvement—An Inventory among City Planners in Gothenburg. *Sustainability* 12, 2882. doi: 10.3390/su12072882

Steuri, B., Bender, S., and Cortekar, J. (2020). Successful user-science interaction to co-develop the new urban climate model PALM-4U. *Urban Climate* 32, 100630. doi: 10.1016/j.uclim.2020.100630

Stoimenova, N. (2011). A Method of Cartographic Visualization for Climate Change Maps. *Kartografija i geoinformacije* 10, 5–15.

Street, R., Alterio, I., Hewitt, C., Golding, N., New, S., and Mysiak, J. (2022). Enabling climate action: Messages from ECCA2021 calling for re-imagining the provision and use of knowledge and information. *Climate Risk Management* 36, 100428. doi: 10.1016/j.crm.2022.100428

Suckall, N., and Soares, M. B. (2022). Evaluating the benefits of weather and climate services in South Asia: a systematic review. *Reg Environ Change* 22, 104. doi: 10.1007/s10113-022-01947-7

Suhari, M., Dressel, M., and Schuck-Zöller, S. (2022). Challenges and best-practices of co-creation: A qualitative interview study in the field of climate services. *Climate Services* 25, 100282. doi: 10.1016/j.cliser.2021.100282

Swart, R., Celliers, L., Collard, M., Prats, A. G., Huang-Lachmann, J.-T., Sempere, F. L., et al. (2021). Reframing climate services to support municipal and regional planning. *Climate Services* 22, 100227. doi: 10.1016/j.cliser.2021.100227

Swart, R. J., De Bruin, K., Dhenain, S., Dubois, G., Groot, A., and Von Der Forst, E. (2017). Developing climate information portals with users: Promises and pitfalls. *Climate Services* 6, 12–22. doi: 10.1016/j.cliser.2017.06.008

Tart, S., Groth, M., and Seipold, P. (2020). Market demand for climate services: An assessment of users' needs. *Climate Services* 17, 100109. doi: 10.1016/j.cliser.2019.100109

Terrado, M., Calvo, L., Bojovic, D., and Christel, I. (2022). Current Practice in Climate Service Visualization: Taking the Pulse of the Providers' Community. *Bulletin of the American Meteorological Society* 103, E828–E837. doi: 10.1175/BAMS-D-21-0194.1

Terrado, M., Christel, I., Bojovic, D., Soret, A., and Doblas-Reyes, F. J. (2018). "Climate Change Communication and User Engagement: A Tool to Anticipate Climate Change," in *Handbook of Climate Change Communication: Vol. 3*, eds. W. Leal Filho, E. Manolas, A. M. Azul, U. M. Azeiteiro, and H. McGhie (Cham: Springer International Publishing), 285–302. doi: 10.1007/978-3-319-70479-1_18

Thatcher, A., Laughton, K.-A., Adamson, K., and Vogel, C. (2019). "Communicating Climate Change Data: What Is the Right Format to Change People's Behaviour?," in *Proceedings of the 20th Congress of the International Ergonomics Association (IEA 2018)*, eds. S. Bagnara, R. Tartaglia, S. Albolino, T. Alexander, and Y. Fujita (Cham: Springer International Publishing), 707–716. doi: 10.1007/978-3-319-96068-5_76

Vaughan, C., and Dessai, S. (2014). Climate services for society: origins, institutional arrangements, and design elements for an evaluation framework. *WIREs Climate Change* 5, 587–603. doi: 10.1002/wcc.290

Venhuizen, G. J., Hut, R., Albers, C., Stoof, C. R., and Smeets, I. (2019). Flooded by jargon: how the interpretation of water-related terms differs between hydrology experts and the general audience. *Hydrol. Earth Syst. Sci.* 23, 393–403. doi: 10.5194/hess-23-393-2019

Vincent, K., Archer, E., Henriksson, R., Pardoe, J., and Mittal, N. (2020). Reflections on a key component of co-producing climate services: Defining climate metrics from user needs. *Climate Services* 20, 100204. doi: 10.1016/j.cliser.2020.100204

Vincent, K., Daly, M., Scannell, C., and Leathes, B. (2018). What can climate services learn from theory and practice of co-production? *Climate Services* 12, 48–58. doi: 10.1016/j.cliser.2018.11.001

Vincent, K., Steynor, A., McClure, A., Visman, E., Waagsaether, K. L., Carter, S., et al. (2021). "Co-production: Learning from Contexts," in *Climate Risk in Africa*, eds. D. Conway and K. Vincent (Cham: Springer International Publishing), 37–56. doi: 10.1007/978-3-030-61160-6_3

Visman, E., Vincent, K., Steynor, A., Karani, I., and Mwangi, E. (2022). Defining metrics for monitoring and evaluating the impact of co-production in climate services. *Climate Services* 26, 100297. doi: 10.1016/j.cliser.2022.100297

Vollstedt, B., Koerth, J., Tsakiris, M., Nieskens, N., and Vafeidis, A. T. (2021). Co-production of climate services: A story map for future coastal flooding for the city of Flensburg. *Climate Services* 22, 100225. doi: 10.1016/j.cliser.2021.100225

Wall, T. U., Meadow, A. M., and Horganic, A. (2017). Developing Evaluation Indicators to Improve the Process of Coproducing Usable Climate Science. *Weather, Climate, and Society* 9, 95–107. doi: 10.1175/WCAS-D-16-0008.1

Wang, Y., Song, L., Hewitt, C., Golding, N., and Huang, Z. (2020). Improving China's Resilience to Climate-Related Risks: The China Framework for Climate Services. *Weather, Climate, and Society* 12, 729–744. doi: 10.1175/WCAS-D-19-0121.1

Ward, R., Lackstrom, K., and Davis, C. (2022). Demystifying Drought: Strategies to Enhance the Communication of a Complex Hazard. *Bulletin of the American Meteorological Society* 103, E181–E197. doi: 10.1175/BAMS-D-21-0089.1

Wardekker, A., and Lorenz, S. (2019). The visual framing of climate change impacts and adaptation in the IPCC assessment reports. *Climatic Change* 156, 273–292. doi: 10.1007/s10584-019-02522-6

Warner, D., Moonsammy, S., and Joseph, J. (2022). Factors that influence the use of climate information services for agriculture: A systematic review. *Climate Services* 28, 100336. doi: 10.1016/j.cliser.2022.100336

Weichselgartner, J., and Arheimer, B. (2019). Evolving Climate Services into Knowledge–Action Systems. *Weather, Climate, and Society* 11, 385–399. doi: 10.1175/WCAS-D-18-0087.1

Westra, S., and Zscheischler, J. (2023). Accounting for systemic complexity in the assessment of climate risk. *One Earth* 6, 645–655. doi: 10.1016/j.oneear.2023.05.005

Wibeck, V., and Neset, T. (2020). Focus groups and serious gaming in climate change communication research—A methodological review. *WIREs Climate Change* 11, e664. doi: 10.1002/wcc.664

Wijnen, F., Strick, M., Bos, M., and van Sebille, E. (2024). Evaluating the impact of climate communication activities by scientists: what is known and necessary? *Geoscience Communication* 7, 91–100. doi: 10.5194/gc-7-91-2024

Wilby, R., and Lu, X. (2022). Tailoring climate information and services for adaptation actors with diverse capabilities. *Climatic Change* 174, 33. doi: 10.1007/s10584-022-03452-6

Williams, D. S., Máñez Costa, M., Kovalevsky, D., Van Den Hurk, B., Klein, B., Meißner, D., et al. (2020). A method of assessing user capacities for effective climate services. *Climate Services* 19, 100180. doi: 10.1016/j.cliser.2020.100180

Xexakis, G., and Trutnevyte, E. (2021). Empirical testing of the visualizations of climate change mitigation scenarios with citizens: A comparison among Germany, Poland, and France. *Global Environmental Change* 70, 102324. doi: 10.1016/j.gloenvcha.2021.102324

Zeng, Y., Su, Z., Barmpadimos, I., Perrels, A., Poli, P., Boersma, K. F., et al. (2019). Towards a Traceable Climate Service: Assessment of Quality and Usability of Essential Climate Variables. *Remote Sensing* 11, 1186. doi: 10.3390/rs11101186

Zepner, L., Karrasch, P., Wiemann, F., and Bernard, L. (2021). ClimateCharts.net – an interactive climate analysis web platform. *International Journal of Digital Earth* 14, 338–356. doi: 10.1080/17538947.2020.1829112

Ziaja, S. (2019). Role of Knowledge Networks and Boundary Organizations in Coproduction: A Short History of a Decision-Support Tool and Model for Adapting Multiuse Reservoir and Water-Energy Governance to Climate Change in California. *Weather, Climate, and Society* 11, 823–849. doi: 10.1175/WCAS-D-19-0007.1

Ziegler, R., Hedder, I. R., and Fischer, L. (2021). Evaluation of Science Communication: Current Practices, Challenges, and Future Implications. *Front. Commun.* 6, 669744. doi: 10.3389/fcomm.2021.669744

Annex 1: Criteria catalogue for characterising CCRs

Category	Criteria name	Short name	Description	Example
AC	English language	LNGEN	The resource is available in english.	
AC	Easy language	LNGEASY	The language style is simple and designed to aid understanding.	
AC	Easy navigation	NAVEASY	The resource is designed for easy navigation.	Principles like overview first, details later support easy navigation of the resource (as a whole, not for single graphics)
AC	Screen format	SCREENFORMAT	The resource was designed to fit different screens.	e.g. aspect ratios, resolution
AC	Open access	OPENACCESS	The resource is publicly available and free of cost.	
AC	Long-term availability	LONGTERMAVAIL	The availability of the resource is assured for the forseeable future.	e.g. via funding
AC	Data compatibility	DATACOMPAT	Does the resource use established data formats and can be accessed with common applications?	
AC	Data formats	DATAFORMATS	The resource is available in different data formats.	
AC	Findability	FINDABLE	How is the difficulty to locate the resource online perceived?	
AC	Consulting and training	CAPACITYBUILD	Consulting and training on using the resource is offered.	
AC	Perceived speed of service	SERVICESPEED	How is the speed of service when accessing the resource online perceived?	Website load times and download speeds are subjectively fast.
AC	User profiles	USERPROFILES	The resource allows users to create profiles.	e.g. to save custom search and processing queries
AC	Searching and filtering	SEARCHFILTER	The resource includes a search or filter function to support navigation.	
AC	Promoted via existing networks	NETWORKS	The resource was communicated and promoted via established, pre-existing (thematic) networks.	
AC	Promoted via social media	SOCIALMEDIA	The resource was communicated and promoted via social media.	
CG	Communication goal: Added value for decision support	COMMADDEDVAL	The resource communicates its added value for supporting decisions, considering uncertainties.	
CG	Communication goal: Solution-oriented	COMMSOLUTION	The resource has a solution-oriented goal and framing.	e.g. sustainable solutions, self-efficacy, climate justice
CG	Communication goal: Adaptation to climate change	COMMADAPT	The resource communicates (measures for) adaptation to climate change.	
CG	Communication goal: Climate change mitigation	COMMMITIGATE	The resource communicates (measures for) mitigation of climate change.	
CG	Communication goal: Systemic connections	COMMSYSTEMIC	The resource communicates systemic connections and interactions related to climate change.	
CG	Communication goal: Impacts of climate change	COMMIMPACTS	The resource communicates impacts of climate change.	
CG	Communication goal: Causes of climate change	COMMCAUSE	The resource communicates causes of climate change.	

CG	Communication goal: Vulnerability/sensitivity/adaptive capacity to climate change	COMMVULNERABLE	The resource communicates vulnerability/risk/sensitivity/adaptive capacity to climate change.	e.g. higher-aggregated indices including socio-economic data
FD	Sector orientation	SECTORORIENT	The resource connects climate change with other topics and sectors.	
FD	Adequacy of spatial resolution	FITRESSPACE	The spatial scope/resolution of the resource is adequate for its purpose.	
FD	Adequacy of temporal resolution	FITRESTIME	The temporal scope/resolution of the resource is adequate for its purpose.	
FD	Data quantity	DATAQUANT	The quantity of provided data is adequate for the purpose of the resource.	
FD	Absolute values	VISABSVALUES	Where appropriate, visualisations show states or changes in absolute terms.	
FD	Relative values	VISRELVALUES	Where appropriate, Visualisations show states or changes in relative terms.	
IN	User-defined colour schemes	COLUSERDEF	The resource lets users define colours or class boundaries themselves.	
IN	User-defined fonts	FONTUSERDEF	The resource allows user-defined font styles.	
IN	Interactivity	INTERACTIVE	The resource is interactive and/or allows user-defined visualisation or processing.	
TD	Explanations and manuals	MANUALS	The resource includes explanations and manuals.	Manuals, definitions, guidelines, use scenarios , interactive tooltips
TD	Metadata	METADATA	The resource includes metadata of the source data.	
TD	Documentation of methods	METHODDOC	The resource includes documentations on the methods and calculations used for data processing.	
TD	Uncertainties are specified	UNCRTSPECIFY	The resource provides information on underlying uncertainties.	
TD	Sources of uncertainties are specified	UNCRTSOURCES	The resource breaks down different sources of underlying uncertainties.	
TD	Data sources are specified	DATASOURCES	The resource names data sources.	
TD	Uncertainty language	UNCRTLNG	The uncertainty language of the resource follows established guidelines.	e.g. IPCC
TD	Qualitative uncertainties	UNCRTQUAL	Uncertainties are indicated in qualitative terms.	
TD	Quantitative uncertainties	UNCRTQUANT	Uncertainties are indicated in quantitative terms.	
TD	Methods follow recommendations	METHODRECOMMEND	The methods and calculations used to process the data follows established recommendations or guidelines.	
TD	Relation to historical or observational data	OBSDATA	The resource relates projected changes to historical/observational data.	e.g. bias adjustment, future change vs. current state, natural variability
TR	Perceived trustworthiness and competence of organisations	PERCEIVEDTRUST	The organisation that developed and/or published the resource is perceived as competent and trustworthy in the respective field.	

TR	Funding disclosure	FUNDINGDISCLOSE	The institution that developed the resource is disclosing the funding sources and/or business model for the resource.	
TR	Timely publication	TIMELY	The publication of the resource occured at the right time for its purpose.	
TR	Updates	UPDATES	The resource is perceived to be up-to-date. Updades are communicated to user group(s) e.g. via website or newsletter.	
UO	Local language	LNGLOCAL	The resource is available in the local language.	
UO	User integration point	USERINTPOINT	At which stage of resource development were users included in the process?	Users/stakeholders can be included at various points in the co-creation process.
UO	Communication format tailored to user group(s)	TAILOREDFORMAT	The resource is available in different formats tailored to specific user group(s).	
UO	Level of difficulty tailored to user group(s)	TAILOREDLEVEL	The resource is available for different levels of expertise tailored to specific user group(s).	
UO	Co-creation	COCREATION	The resource was co-developed with stakeholders or (potential) user groups, no matter at which development stage they were included.	
UO	Evaluation of resource	EVALUATION	The effectiveness of the resource regarding ist stated goal(s) was evaluated using defined criteria of success.	Means ex-post and ex-ante evaluation
UO	Framing and narrative tailored to user group(s)	TAILOREDNARRAT	The resource applies a framing and/or narrative that is tailored to specific user group(s) and/or communication goals.	
UO	Visualisations and design tailored to user group(s)	TAILOREDDESIGN	The resource applies designs for visualisations that are tailored to specific user group(s) and/or communication goals.	
UO	Colour schemes tailored to user group(s)	TAILOREDCOLS	The colour schemes were selected with specific user group(s) and/or cultural aspects in mind.	e.g. the cultural annotation of different colours
UO	Language tailored to user group(s)	TAILOREDLNG	The resource uses language tailored to different levels of expertise of user group(s).	e.g. scientists, practitioners, laypersons
VI	Legibility	LEGIBLE	The font styles used in the resource are well legible.	e.g. size, contrast, font type
VI	Balance of text and graphics	BALANCE	The resource is designed to balance out textual descriptons and graphical elements.	
VI	Colour schemes follow recommendations	COLRECOMMEND	The colour schemes used in the resource follow established recommendations.	e.g. IPCC guidelines, ColorBrewer, empirical studies
VI	Colour schemes for visually impaired persons	COLVISIMPAIRED	The colour schemes used in the resource are designed for readers with various visual impairments.	e.g. types of colour blindness
VI	Visualisation of uncertainties	UNCRTVISUAL	The visualisations of uncertainties follow established design principles, empirical studies or guidelines.	
VI	Clear design	CLEARDESIGN	The visualisations use desing principles that emphasize clearness and comprehensability.	e.g. reduced complexity, legibility, easy navigation, overview before details pertaining to visualisations
VI	Hierarchical design	DESIGNHIRARCHY	The visualisations follow principles of hierarchical design to better guide viewers to the most important elements.	e.g. visually or textually highlighting important parts

VI	Interconnected visualisations	VISINTERCON	The resource interconnects different visualisation types to link and/or highlight different aspects of the data.	Data is not only presented with a single visualisation type, but different visualsiation types are used to show different aspects of the data, e.g. brushing and linking
VI	Varying design elements	VARYINGDESIGN	Quantitative data is visualised with varying design elements.	e.g. symbols, size, position, storylines
VI	Visualisation type	VISTYPE	What type(s) of visualisations are used in the resource?	
VI	Labels and Text in Visualisations	VISLABELS	The visualisations are labelled well to guide attention and support comprehension.	
VI	Map design follows recommendations	MAPVISRECOMMEND	Map visualisations used in the resource follow established recommendations for or empirical studies on map comprehension.	
VI	Map projection follows recommendations	MAPPROJRECOMMEND	Map visualisations used in the resouce follow established recomendations on map projections.	e.g. equivalent projections for large-scale maps

Annex 2: User group survey

Klimaszenarien.AT: Nutzer:innengruppen und deren Bedürfnisse

Herzlichen Dank für die Teilnahme an unserer Befragung zur Nutzbarkeit von Klimaszenarien. Der Fragebogen umfasst zwei Teile:

1. **Zuordnung zu einer Nutzer:innengruppe**
Welche Nutzer:innengruppe entspricht am ehesten Ihrer (zukünftigen) beruflichen Arbeit mit Klimainformationen?

2. **Bewertung von Facetten der Klimakommunikation**
Wie wichtig sind Ihnen verschiedene Aspekte der Klimakommunikation?

Die Beantwortung des Fragebogens dauert ca. 5-6 Minuten.
Mit Ihrer Teilnahme tragen Sie zur Entwicklung nutzbarer Klimainformationen bei. Bei Fragen wenden Sie sich bitte an den Umfragenautor. In dieser Umfrage sind 11 Fragen enthalten.

Zuordnung zu einer Nutzer:innengruppe

Bitte wählen Sie eine passende Nutzer:innengruppe aus. *

Welcher der folgenden Gruppen fühlen Sie sich in Ihrer beruflichen Tätigkeit am ehesten zugehörig? *

Bitte wählen Sie nur eine der folgenden Antworten aus:

- Öffentliche Institution:

  Bundesverwaltung
  Landesverwaltung
  Berater (z.B. AGES, FFG, Umweltbundesamt)
  Umsetzer (z.B. WLV, Einsatzbehörde)

- Privatwirtschaft:

  Consulting
  Versicherung
  Bau- und Immobilienwirtschaft
  Infrastrukturanbieter (z.B. Energieversorgung, Netzbetreiber, ÖBB)

- NGO:

Berater (z.B. Klimabündnis, Energieagentur)
Umsetzer (z.B. klimaaktiv, Global2000)

- Wissenschaft:

  Klimadaten-Provider
  Klimadaten-User

- Medien

'Ich fühle mich keiner dieser Gruppen zugehörig: Bitte nennen Sie die Nutzer:innen-gruppe, der Sie sich am ehesten zugehörig fühlen.'

Wie schätzen Sie Ihre eigene Erfahrung bei der Nutzung von Klimainformationen ein? *

Bitte wählen Sie eine der folgenden Antworten:
Bitte wählen Sie nur eine der folgenden Antworten aus:

- Sehr viel Erfahrung
- Viel Erfahrung
- Mäßig viel Erfahrung
- Geringe Erfahrung
- Sonstiges

Wie schätzen Sie die Häufigkeit ein, mit der Sie Klimainformationen im beruflichen Umfeld verwenden? *

Bitte wählen Sie eine der folgenden Antworten:
Bitte wählen Sie nur eine der folgenden Antworten aus:

- Sehr häufig
- Regelmäßig
- Selten
- Fast nie

Bewertung von Facetten der Klimakommunikation

Im zweiten Schritt geht es um die Relevanz verschiedener Facetten von Klimakommunikation für Ihre berufliche Tätigkeit. Diese Facetten werden zunächst anhand von Beispielen ausführlicher beleuchtet.

Bitte machen Sie sich mit den Themen etwas vertraut, damit Sie diese im nächsten Schritt bewerten können.

Transparenz bei Daten und Methoden

Verfügbarkeit von Guidelines und Handbüchern | Daten und Methoden orientieren sich am Stand der Wissenschaft | Dokumentation der zugrundeliegenden Daten, Unsicherheiten und Methoden | Verfügbarkeit von Metadaten (-standards)

Eignung der Daten für die Fragestellung

Daten sind in ihrer räumlichen, zeitlichen und sachlichen Detailebene für die jeweiligen Fragestellungen geeignet | Daten liegen in ausreichender Menge für die jeweiligen Fragestellungen vor

Visualisierung

Grafische Darstellungen orientieren sich am Stand der Wissenschaft bzw. an Empfehlungen | Balance von Text und Grafik | Lesbarkeit | Verknüpfung unterschiedlicher Visualisierungstypen zum besseren Verständnis der Daten

Nutzer:innenorientierung

Einbindung von Nutzer:innen in die Entwicklung | Nutzer:innengerechtes Narrativ | Nutzer:innengerechtes Format | Nutzer:innengerechtes Design

| Nutzer:innengerechte Sprache | Evaluierung der Nutzbarkeit/Effektivität der Klimakommunikation

Ziele und Framing der Kommunikation

Klimakommunikation verfolgt ein bewusstes Ziel | Klimakommunikation nutzt bewusstes Framing

Einfache und barrierefreie Zugänglichkeit

Open Access | Auffindbarkeit | Durchsuchbarkeit | Geschwindigkeit von Webseiten und Downloads | Langfristige Verfügbarkeit | Barrierefreie Sprache und Navigation | Verfügbarkeit von Beratung

Interaktivität

Interaktives Erforschen der Daten | Eigene Prozessierung | Eigene Wahl von Designs, Farben, Schriftarten

Vertrauenswürdigkeit von Daten und Organisationen

Entwickelt und veröffentlicht von kompetenten Organiationen | Offenlegung von Finanzierung und Geschäftsmodellen | Zeitgerechte Publikation und Updates

Bitte bewerten Sie nun die Relevanz der verschiedenen Facetten von Klimakommunikation. Denken Sie dabei an die Prioritäten in Ihrem Arbeitsfeld.

Vergeben Sie insgesamt 100 Punkte nach Belieben auf die verschiedenen Kategorien.

Für Kategorien mit keiner Relevanz tragen Sie bitte 0 ein, da sonst ein Abschluss der Frage nicht möglich ist.

*

Die Summe muss gleich 100 sein.
Jede Antwort muss zwischen 0 und 100 sein
Nur ganzzahlige Werte können in diese Felder eingegeben werden. Bitte geben Sie Ihre Antwort(en) hier ein:

Transparenz bei Daten und Methoden	000
Eignung der Daten für die Fragestellung	000
Visualisierung	000
Nutzerorientierung	000
Ziele und Framing der Kommunikation	000
Einfache und barrierefreie Zugänglichkeit	000
Interaktivität	000
Vertrauenswürdigkeit	000

Welche Art der Visualisierung bevorzugen Sie für die Darstellung von Klimainformationen?

Denken Sie dabei an typische Anwendungsfälle in Ihrem beruflichen Tätigkeitsfeld.

Bitte wählen Sie bis zu 3 Arten von Visualisierungen.

* Wählen Sie alle zutreffenden Optionen
Bitte wählen Sie zwischen 1 und 3 Antworten aus. Bitte wählen Sie alle zutreffenden Antworten aus:

- Bilder, Fotos
- Karten
- Abbildungen, Diagramme
- Tabellen
- Videos
- Storymaps
- Virtual Reality Erfahrungen
- Interaktive Plattformen
- Infografiken
- Sonstiges:

Welches kommunikative Ziel von Klimainformationen ist in Ihrer beruflichen Tätigkeit besonders wichtig?

Bitte wählen Sie bis zu 3 Kommunikationsziele. *

Wählen Sie alle zutreffenden Optionen
Bitte wählen Sie zwischen 1 und 3 Antworten aus. Bitte wählen Sie alle zutreffenden Antworten aus:

- Anpassung an den Klimawandel
- Auswirkungen des Klimawandels
- Ursachen des Klimawandels
- Nachhaltige Entwicklung, Klimaschutz
- Systemische Zusammenhänge zwischen Ursachen, Folgen und Lösungsansätzen
- Klimarisiko, Vulnerabilität (kombiniert mit sozioökonomischen Daten)
- Sonstiges:

Vielen Dank für Ihre Teilnahme und den wertvollen Input für die Initiative Klimaszenarien.AT!