Working Paper

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Bridging Data and Decisions

Lessons Learned from Co-Producing Climate Tools for the Mid-Atlantic

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About This Working Paper

The growing demand for climate data tools to support planning, design, and policy decisions has led to a proliferation of platforms, dashboards, and datasets. However, not all tools are equally effective in bridging the gap between climate science and actionable policy. This paper synthesizes insights from eight years of collaboration with decisionmakers across government agencies, water utilities, and other practitioners to develop over 30 climate and environmental data tools. These tools, created as part of the Mid-Atlantic Climate Adaptation Partnership (MARISA), address diverse challenges such as drought preparedness, air quality management, stormwater infrastructure design, extreme heat management, and environmental modeling. Drawing from user feedback, surveys, and interviews, as well as lessons learned during tool development and maintenance, we outline six best practices for creating user-centered climate data tools. These practices emphasize addressing user-defined data gaps, designing for real-world integration, matching tool complexity to user capacity, prioritizing iterative development, enabling continuous improvement, and supporting users with complementary resources. By distilling key lessons and emerging best practices, this paper aims to guide researchers and developers working at the science–policy interface, supporting a growing community of practice focused on translating climate data into meaningful policy action.

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Bridging Data and Decisions

The climate data landscape has evolved significantly in recent years, with data tools becoming both more numerous and more sophisticated. This growth reflects the increasing importance of climate data for research, policy, and business decisions, as well as advancements in climate science capabilities. The evolution of global climate models (GCMs) and the emergence of downscaled datasets has been particularly transformative. The most recent phase of global climate modeling efforts—Coupled Model Intercomparison Project Phase 6 (CMIP6) models—for example, show meaningful improvements in resolution, process representation, and ensemble size compared to previous generations (Eyring et al., 2016; Forster et al., 2020). Further improvements in spatial and temporal resolution through downscaling techniques have enabled the use of GCM output for locally relevant predictions (Maraun at al., 2010; Keller et al., 2022). This enhanced granularity—moving from resolutions of 100-250 km to high-resolution projections capable of resolving features at 1-10 km scales (Eyring et al., 2019; Gutowski et al., 2020)—has enabled the development of increasingly specialized analytical tools. Many of these climate data tools leverage data that can represent climate phenomena at watershed, urban, and even neighborhood scales—resolutions previously unattainable but critical for practical adaptation planning.

At the same time, practitioners across sectors from agriculture to urban planning have demonstrated heightened demand for data-driven approaches to climate adaptation, seeking evidence-based methods and resources to incorporate future conditions into current decision frameworks (Hughes et al., 2020). This demand has catalyzed novel methodological frameworks that bridge the persistent gap between climate science and practical implementation, as well as the need for interactive data visualization tools (Swart et al., 2014). The resultant "climate services ecosystem" has expanded, with specialized data providers emerging to translate complex climate projections into sector-specific applications (Hewitt et al., 2022). These services enable diverse stakeholders to incorporate climate considerations into operations, planning and management decisions (Vincent et al., 2018).

As a result, a growing array of climate data tools has emerged to support climate risk assessment, adaptation planning, and policy development by making climate projections accessible and actionable. These tools vary in geographic scope, resolution, and user interface, but share a common goal of translating complex climate model outputs into usable formats for decisionmaking. For example, Cal-Adapt provides downscaled climate projections tailored for California and is widely used by local planners and state agencies (Thomas et al., 2018). The Climate Explorer within the U.S. Climate Resilience Toolkit provides interactive access to historical and projected climate data to support local and regional resilience planning (U.S. Federal Government, 2025). In addition to general-purpose platforms, specialized tools such as

the Flood Factor dataset from the First Street Foundation illustrate how climate projections can be transformed into property-level risk assessments (Wing et al., 2021).

As the universe of tools and its complexity increases, so does the expertise required for proper implementation and interpretation, potentially widening the gap between climate data producers and end-users (Vincent et al., 2018; Nissan et al., 2019). The sheer volume of tools and datasets—often with overlapping functions, inconsistent assumptions, or unclear methodological distinctions—can contribute to user confusion and decision paralysis, particularly among non-specialists (Dilling & Lemos, 2011; McNie, 2013). This tension between sophistication and accessibility underscores the need for continued investment in capacity building and user-centered design principles to ensure climate information remains actionable across diverse decision contexts (Bremer & Meisch, 2017).

It is within this evolving landscape that the present paper is situated. Over the past eight years, we have collaborated with decisionmakers across multiple levels of government, water utilities, and other practitioners to develop a suite of climate and environmental data tools designed to inform real-world decisions. These efforts have spanned a wide range of topics—from drought preparedness or air quality management to water and environmental modeling and stormwater infrastructure design—resulting in a range of tools aimed at translating climate and environmental science into actionable insights. Drawing from this extensive experience, our objective in this paper is to distill key lessons and share emerging best practices that can support other researchers and developers working at the science–policy interface. By synthesizing what we have learned about effective tool design, co-production processes and tool maintenance and updates, we aim to contribute to a growing community of practice focused on bridging the gap between data tools and meaningful policy action.

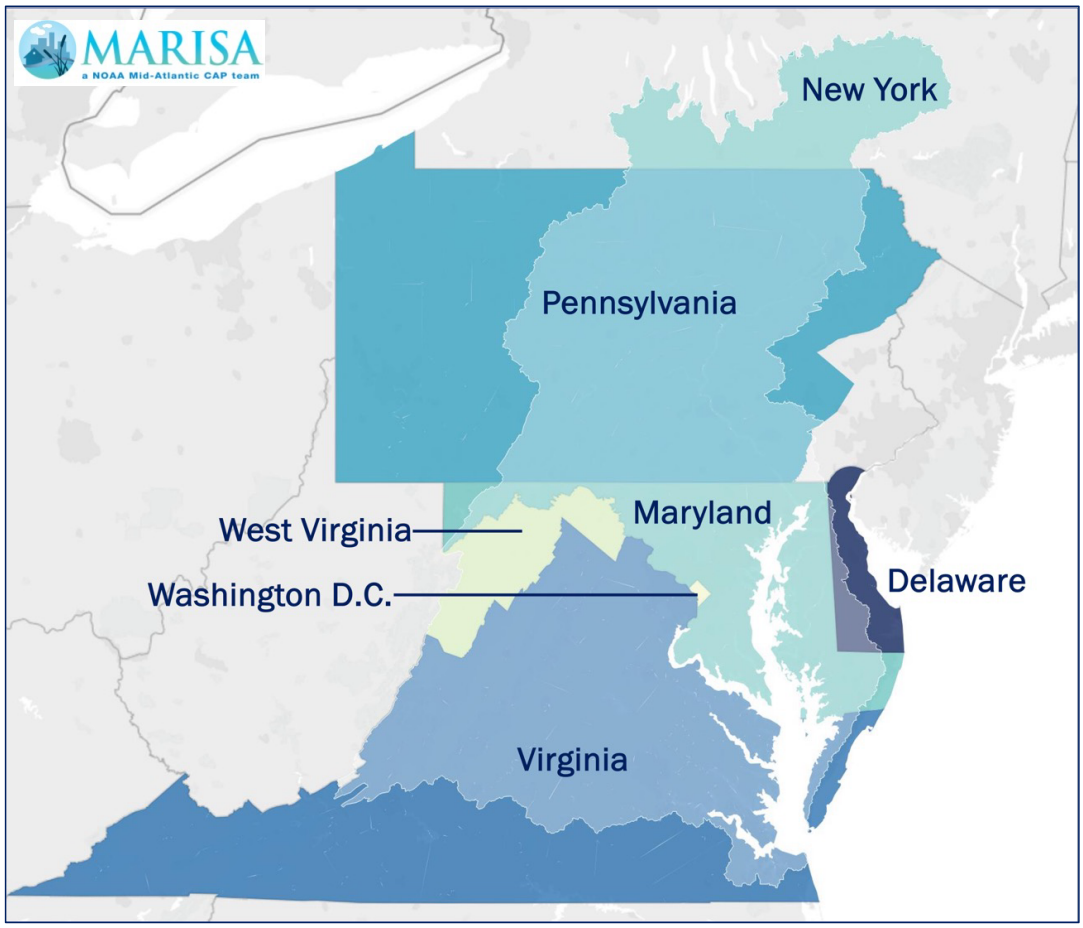
This paper begins by providing an overview of the Mid-Atlantic Climate Adaptation Partnership (MARISA) and the suite of tools we developed as a part of it. We then provide lessons learned from tool users, collected from a survey as well as through feedback we have received from related engagements and interviews over the past several years. We also synthesize our insights as tool developers on what we have learned related to tool production, communication and maintenance. We close with recommended best practices for other tool developers seeking to enhance the usability, utility and impact of their tools.

The Mid-Atlantic Climate Adaptation Partnership

The Mid-Atlantic Climate Adaptation Partnership (MARISA) was established in September 2016 through a five-year grant from the National Oceanic and Atmospheric Administration (NOAA) Climate Program Office (CPO) and received a second five-year grant in September 2021. It is one of over a dozen regional consortia that are funded by NOAA's CPO to serve as boundary organizations and climate service providers to their respective regions. MARISA is the CAP team that covers the Mid-Atlantic region as defined by the map shown in Figure 1.

MARISA is led by RAND, a national non-profit with major offices in Virginia and Pennsylvania, in partnership with researchers at the Pennsylvania State University, Johns Hopkins University, Cornell University, the Virginia Institute of Marine Science, Carnegie Mellon University, and Morgan State University. The team's overarching mission is to collaborate with and support communities in the Mid-Atlantic to improve their resilience and build their capacity to respond to a changing climate through improved data, place-based decision support, and public engagement. Additional information about the MARISA team can be found on our website (https://www.midatlanticrisa.org).

Figure 1. MARISA Service Area



MARISA's Approach to Climate Services

The Fifth National Climate Assessment (NCA5) defines climate services as "scientifically based usable information and products that assist in decision-making and actions relevant to climate change risks, impacts, and responses" (Grade et al., 2023). Over the past several years, the MARISA team has developed our own approach to providing decision-relevant information and tools to our stakeholders, the steps in this approach are summarized in Table 1. The initial

step in this process is, invariably, listening. For example, in the first year of our first grant (2016-2017), MARISA team members went on a listening tour and spoke with stakeholders from federal, state, and local governments, academia, non-governmental organizations, and the private sector to understand what aspects of climate posed the greatest challenges to their work (Berg et al., 2017, Shi, Hobbs, & Jiang, 2019). This input informed MARISA's initial research agenda and major areas of focus, which included building regionally-focused climate data tools. While it was particularly critical to start our work in the region by listening, this is a key aspect of our work at every stage.

Table 1. Summary of the MARISA Team's Approach to Providing Climate Services

MARISA's Approach to Climate Services	Key Activities
Listening	Year 1 started with a listening tour of stakeholders throughout the Mid-Atlantic region. We also engaged in a series of listening sessions before we wrote our proposal for our second 5-year grant.
Shaping an Agenda and Building Partnerships	Input from stakeholders and decisionmakers in the region informed our major focus areas including stormwater management, extreme heat, and building regionally-focused climate data tools.
Co-Developing Tools	Each climate data tool we've created has stemmed from requests from potential users, and we incorporate feedback throughout the development process.
Dissemination and Support	Team members give presentations and trainings on tools and other MARISA products.

Over the past nine years, the MARISA team has created a range of climate and hazard-related data tools (https://www.midatlanticrisa.org/data-tools.html), each of them stem from requests from potential users. Each kind of tool, though not each individual data visualization, was developed using principals of co-production. The particular methods used for each tool-type are discussed in the following section. Generally, this process involved ensuring that the MARISA team members' mental models matched those of the intended users and that the information contained in each tool was useful and easily usable for their needs and decisionmaking processes. This process is also iterative, though the exact form the iterations took varied depending on the tool-type. For example, for some tools, we spent a year or multiple years meeting with people and improving on versions of the tool prior to publication, while with others, we improved the way information was presented as we created similar tools over time based on comments from peer-reviewers and users.

Finally, once our team makes a resource publicly available, we spend time giving presentations and talking to potential users and stakeholders throughout the region (and beyond) about who we are, what we can do to help, and provide trainings and information on our data tools and other resources. This process of dissemination and discussion not only helps to raise awareness of our tools but also informs our understanding of their use and how we can improve.

MARISA's Suite of Co-Produced Climate Data Tools

Over the past nine years, the MARISA team has developed data tools aimed at translating climate and environmental science into actionable insights for decisionmakers. These tools represent a concerted effort to address the unique challenges and opportunities faced by communities in the Mid-Atlantic region, which has historically been divided across boundaries in national datasets and reports, such as those from the National Climate Assessment and NOAA data products. By focusing on regionally specific needs and priorities, MARISA's tool suite seeks to provide tailored resources that enhance climate resilience and inform decisionmaking at multiple levels. This section provides an overview of these tools, including a description of the tool development process, the intended users and use and how we obtained feedback and updated the tools.

Seasonal Climate Impacts Summary and Outlook Series

As of May 9, 2025, the MARISA team has published 26 seasonal climate summaries and over 30 climate data tools as part of this series. The topics covered by these interactive visualizations are included in Table 2. These summaries are written in partnership with the Northeast Regional Climate Center, hosted at Cornell University.

Table 2. Topics Covered by Climate Summary Data Tools

Precipitation	Temperature	Other Weather Events
• Comparison of updated climate projections for extreme precipitation • Extreme precipitation projections using updated climate model data from LOCA2 • Longest annual stretch of dry days • Projected changes in total monthly precipitation • Differences from "normal" total annual precipitation • Future precipitation impacts on stormwater management in Pittsburgh, PA • Annual total snowfall across the Mid-Atlantic • Changes in seasonal total precipitation from 1976 to present – bar chart • Changes in future seasonal total precipitation – bar chart • Changes in seasonal total precipitation from 1976 to present – map • Changes in future seasonal total precipitation – map	• Comparison of updated climate projections for extreme temperature • Extreme temperature projections using updated climate model data from LOCA2 • Historical changes in the heat index • Timing of first hot day • Average annual cold low temperature days • Longest stretch of high heat days • Future differences from "normal" temperature • Historical average annual number of days with warm low temperatures • Future projected average annual number of days with warm low temperatures • Historical change in date of last freeze and first warm day • Future projected changes in date of last freeze and first warm day	• Air quality in the Mid-Atlantic • Mid-Atlantic hurricane tracks • Frequency and intensity of recorded Mid-Atlantic tropical storms and hurricanes • Reported crop and property damage from Mid-Atlantic tropical storms and hurricanes

Precipitation	Temperature	Other Weather Events
• Changes in extreme precipitation from 1976 to present • Changes in future extreme precipitation	• Modeled historic and future extreme temperature – daily highs • Changes in future freeze-thaw days • Average annual number of growing degree days from global climate model data • Average annual number of growing degree days from historic observations	

The motivation for producing these summaries was to provide a wide audience of users in the Mid-Atlantic region with a consistent and durable presentation of significant weather events, historical trends, outlooks, and future climate projections focused on the geography of the Chesapeake Bay watershed and larger Mid-Atlantic region. Each seasonal summary discusses the significant weather events that occurred during the season (e.g., drought, thunderstorms, wildfires), a discussion of how seasonal temperature and precipitation compared with historical trends, relevant seasonal outlooks (e.g., Atlantic hurricane season), and an interactive data tool.

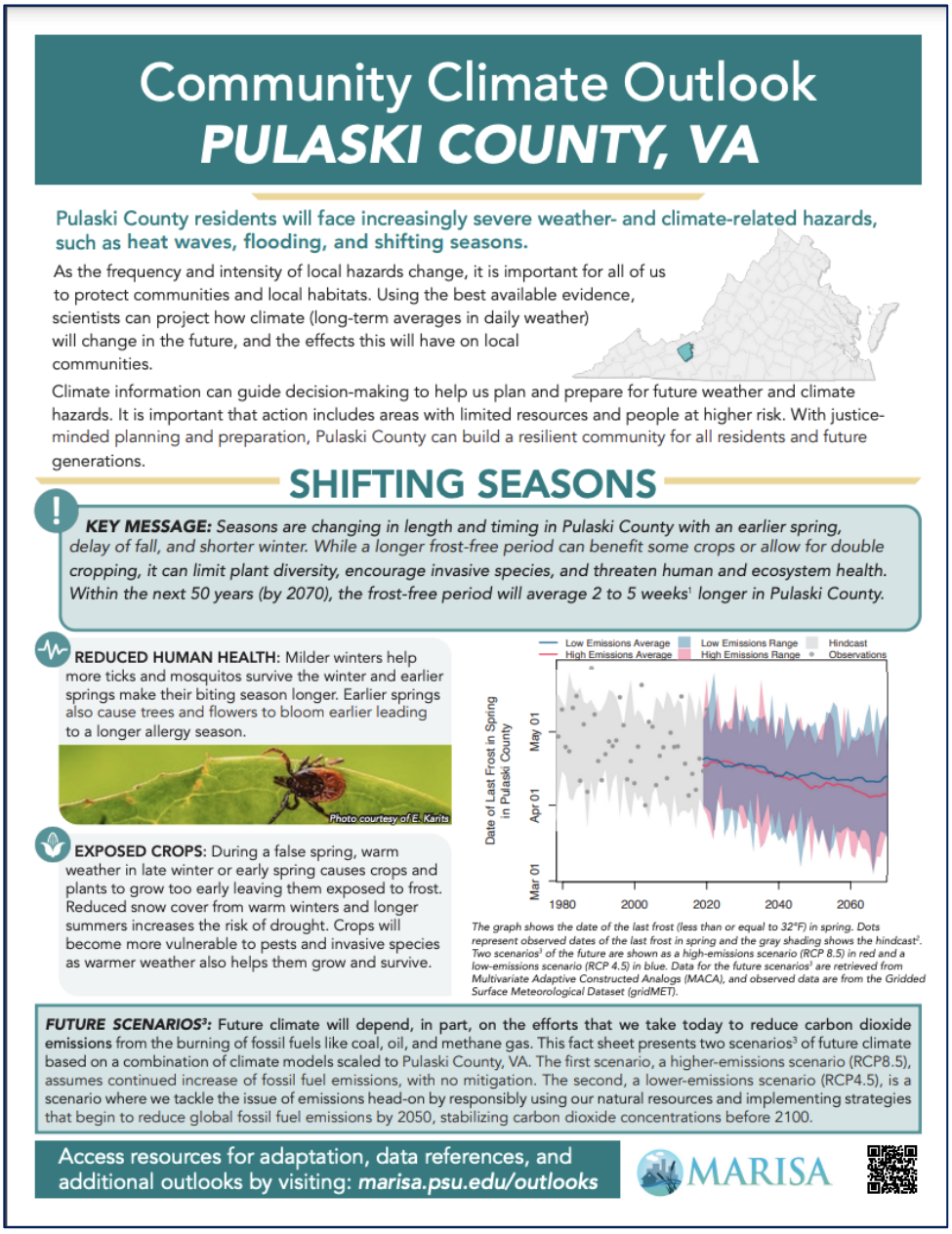
The MARISA team has consistently sought feedback on the information and format of our seasonal climate summaries. In 2018 and 2019, when the series first began, we created a short survey that any reader could complete to share initial thoughts and feedback. Additionally, each climate summary undergoes a rigorous peer-review process. Reviewers have provided countless helpful comments over the past six years that have significantly improved how we structure the summaries and communicate weather and climate information to our stakeholders.

Community Climate Outlooks

The MARISA Community Climate Outlooks are a series of two-pagers that provide information on climate change and its impacts for all counties in Delaware, Maryland, Pennsylvania, Virginia, and Washington, D.C. They provide local, accessible, and relatable summaries of information on climate, highlighting past and potential future changes as well as key impacts on a county-scale. Each outlook contains customized information depending on the location (inland/coastal) and population density (urban/rural) of the county. An example is shown in Figure 2.

The Outlooks underwent a robust feedback process. Initial drafts of outlooks were created and presented informally and via workshops and other venues, revised, and then reviewed again – repeating this process with over 25 reviewers.

Figure 2. Example Community Climate Outlook for Pulaski County, Virginia



Climate and Hazard Mitigation Planning (CHaMP) Tool

The Climate and Hazard Mitigation Planning (CHaMP) Tool was the result of several years of collaboration with members of the MARISA team and the Urban Sustainability Director's Network (USDN). The tool was developed to go hand-in-hand with USDN's effort to enable local and regional planners and emergency managers to write hazard mitigation plans and to turn those plans into forward-looking, proactive documents that would include information about climate change (among other topics). The overall goal for the tool was to make it easier for these stakeholders, and anyone else working on climate-related plans to incorporate historic and future

projected climate information. Further, the MARISA team sought to create a longstanding resource for this kind of information that could support planners and others to build capacity in the region over time. The hazard mitigation plan template developed by USDN is available on their website (https://www.usdn.org/projects/all-hazard-mitigation-plans.html). The template mentions when, where and how data from the CHaMP tool can be leveraged. CHaMP contains up-to-date information on both historical and projected future climate and on historical hazard events, as shown in Table 3, as well as interpretive text that is customized for the area of interest that describes for the user any trends in the data and provides definitions, and citations.

Table 3. Hazard Types and Climate Metrics and Projections Available in Version 1 of the CHaMP Tool

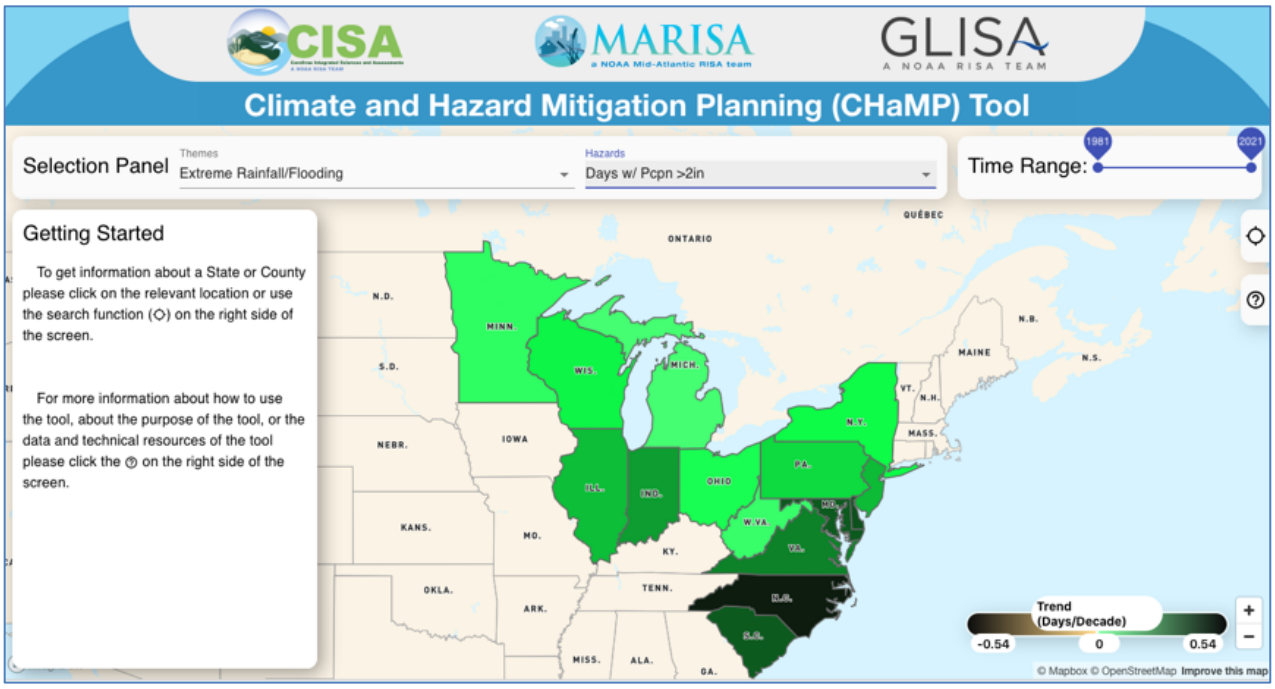
Themes	Hazard Types	Climate Metrics and Projections
Coastal Hazards	• Coastal flood • High surf • Rip current • Storm surge/tide	No climate data or projections available for this theme
Extreme Rainfall/Flooding	• Coastal flood • Flash flood • Flood • Heavy rain • Lakeshore flood	• Days w/ precipitation > 1 in • Days w/ precipitation > 2 in • Total spring precipitation • Total summer precipitation • Total fall precipitation • Total winter precipitation • Total annual precipitation
Fog	• Dense fog	No climate data or projections available for this theme
Great Lakes Hazards	• Lake-effect snow • Lakeshore flood	No climate data or projections available for this theme
Severe Weather	• Flash flood • Hail • Heavy rain • High wind • Strong wind • Thunderstorm wind • Tornado	No climate data or projections available for this theme
Tropical Storms/Hurricanes	• Hurricane (typhoon) • Tropical storm	No climate data or projections available for this theme
Extreme Heat	• Excessive heat • Heat	• Days w/high > 90 degrees F • Days w/high > 95 degrees F • Days w/high > 100 degrees F • Summer maximum temperature
Wildfire	• Wildfire	No climate data or projections available for this theme

Themes	Hazard Types	Climate Metrics and Projections
Winter Weather	• Blizzard • Cold/wind chill • Extreme cold/wind chill • Frost/freeze • Heavy snow • Ice storm • Sleet • Winter storm • Winter weather	• Days w/ low < 0 degrees F • Days w/ low < 20 degrees F • Days w/ low < 32 degrees F • Winter minimum temperature

NOTE: F = Fahrenheit.

Three Climate Adaptation Partnership (CAP) teams engaged in an extensive co-production process prior to its publication. The Great Lakes CAP, the former Carolinas CAP, and MARISA worked with community partners in our regions consistently throughout the design and implementation process to create a resource that was responsive to the needs of local planners and emergency managers. Additional details on the co-production process can be found in the CHaMP technical documentation (Romita Grocholski et al., 2022).

Figure 3. Landing Page of the Climate and Hazard Mitigation Planning (CHaMP) Tool



Intensity-Duration-Frequency (IDF) Curve Tool

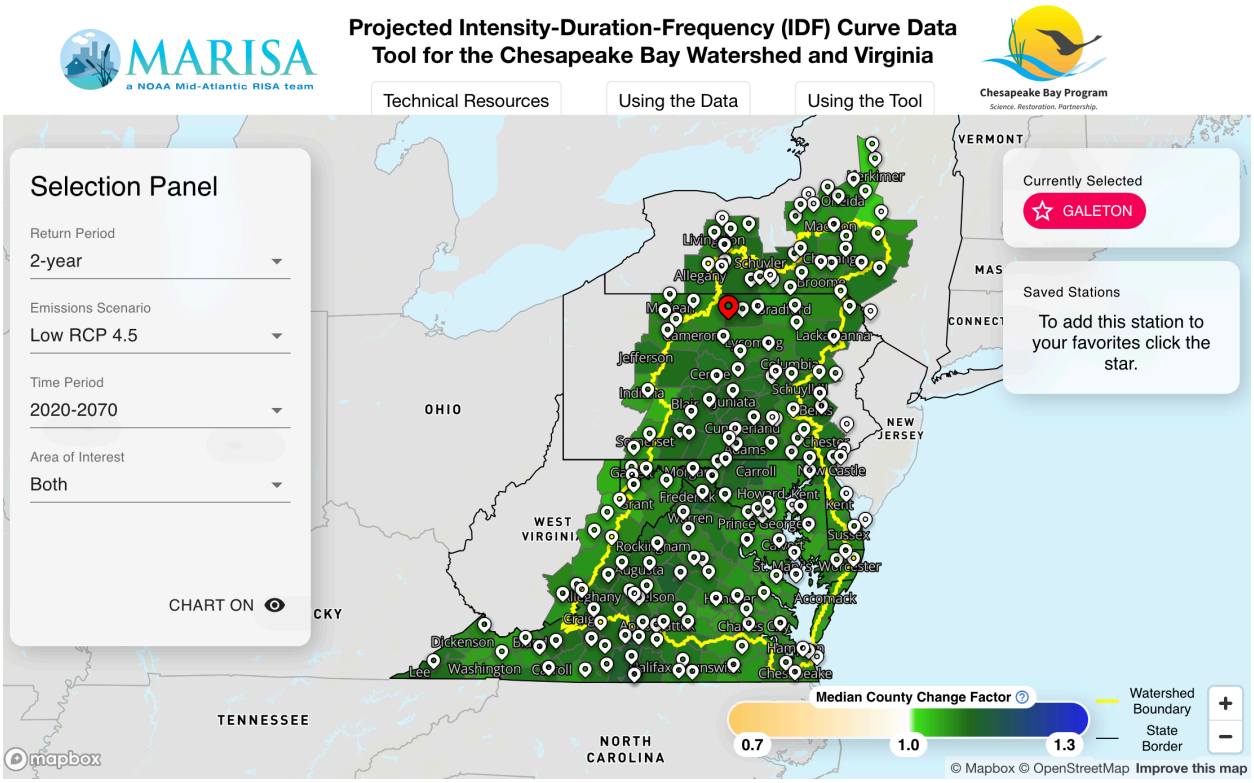
This effort aimed to support planners, engineers, and decision-makers by developing future-looking, climate-informed intensity-duration-frequency (IDF) curves that could be integrated into infrastructure planning and design across the MARISA region, culminating in the

production of the IDF Curve Tool. The development of projected IDF curves for the region was originally conceptualized by the Chesapeake Bay Program's Urban Stormwater Workgroup and primarily funded by the Chesapeake Bay Trust. Due to interest in the work beyond the bounds of the Chesapeake Bay Watershed, additional support from the Virginia Transportation Research Council and the Commonwealth Center for Recurrent Flooding Resiliency enabled the expansion of the work to cover the entire state of Virginia.

Before the production of the tool, the team focused on generating the projected IDF curves. To do so, the research team used the most recent climate model output and adopted an approach that would be applicable to NOAA's Atlas 14 values. With feedback from the Urban Stormwater Workgroup, the team settled on a change factor approach, deriving future percent changes in precipitation for each duration and frequency (e.g., 10-year, 24-hour storm). They also worked with the Urban Stormwater Workgroup as they generated initial values and began conceptualizing how the data would be presented in an online tool.

Throughout the year-long project, the tool development team continued to work closely with members of the Urban Stormwater Workgroup to inform key design decisions related to the tool's usability and content—such as the choice of future time periods and the spatial and temporal resolution of the change factors, as well as the tool interface, guidance material and menu options. Workgroup members gave feedback during and following presentations, via feedback on interim memos and work products, and in smaller group discussions. The landing page of the final tool is shown in Figure 4 below.

Figure 4. IDF Curve Tool



Other (Non-Data) Tools

The MARISA team has also created two tools that provide information about non-MARISA affiliated models and tools. The first is the Chesapeake Bay Model Inventory and Selection Tool (MIST) and the second is the Chesapeake Bay Climate Adaptation Toolbox (CBCAT). These tools are intended to help make it easier for practitioners in the region access useful models, visualizations, and decision-making tools that fit their needs by allowing users to filter through a database of information on various models/tools.

Uses and User Perspectives on MARISA Tools

This section describes insights from users of the suite of MARISA tools. These are derived from a MARISA Tool Survey, interviews focused on stakeholder needs and climate resilience capacity, and web traffic analytics for tools hosted on midatlanticrisa.org. The survey responses offer direct feedback from current and potential users of MARISA's climate data tools, while the interviews—conducted over several years across related projects—provide broader feedback, as well as context on the evolving landscape of climate data needs in the Mid-Atlantic region. A subset of interviews, carried out through a University Corporation for Atmospheric Research (UCAR)-funded effort, specifically explored the use and utility of the IDF Curve Tool, with findings documented in Miro and Romita Grocholski (2023). Together, these sources offer a multifaceted view of how MARISA tools are accessed, interpreted, and applied in decision-making contexts, as well as remaining challenges.

Web Traffic Analysis

MARISA tools have seen significant engagement from users across the Mid-Atlantic region. CHaMP has seen over 5,000 users since its launch in November 2022, with more than 2,000 users in the last year alone. Usage spikes were observed following webinars hosted in collaboration with Resilient Virginia, underscoring the importance of outreach efforts in driving engagement. The IDF Curve Tool has been another widely used resource, attracting over 8,000 users since its publication in May 2021, including more than 3,000 users in the past year. With an average of over 300 visitors per month, the IDF Curve Tool remains a critical resource for infrastructure planning and climate adaptation. The Climate Summaries have also demonstrated impressive reach, with over 13,500 page views across 2023 and 2024 and more than 9,000 views in 2024 alone. Among these, the hurricane tracks tool was the most popular, receiving 1,184 views in 2024 and 2,167 views across the two years. The winter climate summary, featuring a primer on climate projections and future scenarios, emerged as the second-most popular resource in 2024, achieving notable engagement despite being available for less than nine months. These statistics highlight the growing demand for these types of tools and the importance of targeted dissemination strategies to maximize their impact.

Survey Feedback

To better understand the use and impact of its climate data tools, in the spring of 2025 the MARISA team conducted a survey targeting state and local government agencies and resilience professionals, including those focused on stormwater, heat, hazard mitigation, and natural resource management. The survey aimed to assess awareness, usage, and perceived utility of MARISA's tools, identify barriers to use, and gather suggestions for improvement. It also sought to surface unmet climate data needs and inform future tool development, outreach, and engagement strategies. Respondents shared what they gained from these tools—whether it was

improved decisionmaking, enhanced communication, or better infrastructure planning—and offered feedback on aspects like ease of use, supporting documentation, and data quality.

Results from the survey reveal that MARISA tools are widely valued across the region for their ability to support planning, engineering design and policy development. Respondents emphasized one of the strengths of these tools were their ability to help addressing climate-related challenges, including flood mitigation, infrastructure planning, as well as supporting risk communication. They highlighted the value in having a standardized, trusted and independent set of tools that were tailored to and consistent across the region, supporting state-level policy and cross-regional planning. Users also found the tools intuitive to use and accessible, particularly for engaging stakeholders and communicating climate risk. When questioned about the usefulness about various aspects of the tools, respondents to that question indicated the following:

- Format and style: 88% found the tool format or style to be somewhat or very useful;
- Independence of tool provider: 88% highlighted the importance of the independence of the tool provider.
- Data provided: 75% of respondents to a question on usefulness of the tools said the data within the tools was somewhat or very useful;
- Ease of use: 75% of respondents rated the "ease of use" of the tools as somewhat or very useful,
- Supporting documentation: respondents gave this slightly lower ratings, with 65% of users finding it somewhat or very useful.

Survey respondents also provided narrative feedback on the tools, noting key uses: "we used the IDF tool for precipitation change estimates for . . . a local park in Maryland. It was helpful in understanding future changes in precipitation and in creating engineering designs", and: "we have incorporated the MARISA IDF curve tool in modeling future flood risk…and for updating stormwater design guidelines to account for more extreme weather scenarios," as well as how the tool was integrated into planning efforts: "Much of [a local planning] document pulled from the various MARISA tools and cites them directly," and communication: "we occasionally use MARISA tools to demonstrate risk and changes when discussing issues with stakeholders."

The survey revealed several needs and areas for improvement. Supporting documentation was one of these, with only 65% of respondents rating it as somewhat or very useful. Users requested clearer guidance on how to use the tools, select among climate scenarios and interpret the data and information in the tool. Respondents also highlighted the need for expanded functionality, including additional data types such as intra-storm intensity distributions under climate change and Chesapeake Bay tidal range data, as well as more robust statistics and projections tailored to specific use cases. The survey revealed gaps in outreach and dissemination efforts, as many respondents discovered MARISA tools through internet searches rather than direct engagement. While the tools are primarily used by larger jurisdictions, such as state governments and larger localities, there is limited evidence to suggest they are effectively

reaching smaller or lower-resourced communities. Additionally, usage in Delaware and New York was minimal, indicating opportunities for greater regional outreach and inclusivity. Table 4 presents this feedback by tool.

Table 4. Tools Survey User Feedback

Tool	Number of Users (% of Respondents)	Locations Used	Primary Uses	Feedback and Suggestions	User-Described Benefits
IDF Curve Tool	9 respondents (50%)	Pennsylvania, Maryland, Virginia, Washington, D.C.	Planning, Engineering Design, Vulnerability Analysis	Positive feedback; suggested refinements in documentation, scenario explanations, and additional data types (e.g., intra-storm intensity distribution, Chesapeake Bay tidal range data).	Climate adaptation, infrastructure planning, regional standardization.
CHaMP	4 respondents (18.75%)	Pennsylvania, Maryland, Washington, D.C.	Planning, Vulnerability Analysis, Policy Development, Communication	Suggested improvements in supporting documentation and usability; valued for understanding climate impacts and mitigation strategies.	Policy development and risk communication.
Seasonal Climate Summaries	6 respondents (31.25%)	Pennsylvania, Maryland, Virginia, Washington, D.C.	Planning, Policy Development, Vulnerability Analysis	Positive feedback; suggestions for more detailed projections and scenario-specific insights to	Accessible format and regional focus.

Tool	Number of Users (% of Respondents)	Locations Used	Primary Uses	Feedback and Suggestions	User-Described Benefits
				support long-term planning.	
Community Climate Outlooks	6 respondents (31.25%)	New York, Pennsylvania, Maryland, Virginia, Washington, D.C.	Planning, Vulnerability Analysis, Communication	Suggested clearer documentation and expanded functionality for community-level challenges; valued for fostering collaboration and stakeholder engagement.	Collaboration and alignment with regional goals.
MIST	2 respondents (12.5%)	Washington, D.C., Maryland	Planning, Policy Development, Communication	Suggested expansion of capabilities for robust data comparisons and scenario analyses.	Identifying appropriate models for projects.

NOTE: Percentage of respondents is calculated based on 18 total respondents, as of May 19, 2025

Other Feedback

The development and refinement of MARISA tools have been heavily informed by a co-production process that emphasizes direct engagement with users—this has been the team's main mechanism for obtaining feedback from users. This process has included rounds of user feedback and iteration, survey-based feedback, and informal engagements such as email exchanges and follow-up conversations. While this approach has provided meaningful, targeted insights into the functionality of tools, their communication of data, and strategies for dissemination, the focus has largely been on gathering input during the production phase and disseminating tools after publication. Feedback collection post-publication has been more limited, with occasional user emails—particularly for tools like CHaMP, which has a dedicated email address. However, some issues may only become apparent once users begin applying tools in practice. This means that receiving ongoing feedback is essential to maximize the impact and utility of data tools.

Notably, focused interviews and discussions conducted after the publication of the IDF Curve Tool proved highly effective, offering valuable lessons about user needs and implementation challenges.[1] From these, we identified that the tool is being used by local agencies and practitioners for a number of applications, chief among them to update stormwater regulations, inform infrastructure design, and plan for more resilient stream restoration projects. Users agreed that its simplicity and ease of use made it a practical resource for integrating climate-informed design standards and is particularly relevant in contexts where infrastructure must remain effective for decades under uncertain future conditions. Users appreciated that the tool provides a scientifically grounded basis for adjusting storm sizes and noted the value of having the tool provided by an impartial third-party source. Finally, nearly all users found that compatibility with existing widely used datasets, namely NOAA's Atlas 14, made the tool practical by fitting into existing workflows and processes, as well as justifiable to leadership and community members.

However, users described several challenges, particularly around the interpretation and application of future scenarios and percentile choices. There was uncertainty about whether to base designs on Representative Concentration Pathway (RCP) 4.5 or RCP8.5, and how to weigh median versus higher-end projections in different contexts. Additionally, gaps in the tool—such as the absence of 15-year storm data, in one case, and intensity metrics—limited its broader utility. Users called for more technical guidance, visual aids to support stakeholder engagement, and expanded documentation of use cases, especially in nontraditional applications like stream restoration. These improvements could help users more confidently apply the tool and push for stronger climate resilience in project design and policy.

[1] More information on the focus of these interviews can be found in Miro and Romita Grocholski (2023).

Lessons Learned from the MARISA Team

Over the past eight years, the development of the MARISA tool suite has been a collaborative effort between a core team at RAND—comprising experts in environmental science, science communication, policy analysis, and web development—and MARISA partners at Cornell University, including two climatologists and the director of the Northeast Regional Climate Center (NRCC). Together, we have continuously refined visualizations, streamlined data workflows, and created tools aimed at improving the accessibility and utility of climate data for users across the Mid-Atlantic region. This chapter shares our reflections on that process, distilling key lessons learned through the challenges we encountered, the strategies we adopted in response, and what ultimately proved most effective.

While the process of tool development has yielded tools that improve the accessibility and utility of climate data, models or related information, the MARISA team has also experienced several challenges inherent to co-producing science-based resources for a diverse group of stakeholders.

One of the initial hurdles we faced was the significant effort to develop the first few MARISA tools, particularly the early precipitation data tools that were a part of the climate summary series. The data processing needed for these tools required advanced computing infrastructure, access to GCM output and related downscaled datasets and a standardized approach to presenting the uncertainty in long-term climate projections. While each of these were surmountable, they required dedicated staff, computing resources and data analysis and review processes that took time. These steps all came before creating dynamic visualizations based on user feedback that made up the final tool. After a few initial tools that took a significant effort to produce, we shifted to a partnership model in which NRCC, a climate data provider, would process and format the climate data and RAND would develop the visualization. This streamlined efforts and allowed us to develop a much larger suite of climate data tools, as well as do so in a way that was responsive to seasonal climate information needs (e.g., heat tools in the summer, precipitation tools in the spring).

We found that even with improved workflows, the process of co-production posed its own set of challenges. While MARISA is committed to co-production and obtaining ongoing feedback from tool users, we have also come to understand that such collaboration is time-consuming and may not be feasible for all projects or contexts. We have also seen that most of our co-production effort has been spent upfront, in conceptualizing the tool to meet user needs and streamlining structure or functionality, but there is a need to return to a tool after it has been released to evaluate its use and utility over time.

Another persistent challenge has been managing the gap between user expectations and the technical or scientific limitations of climate data. Users have requested flood model output or higher-resolution (temporal and spatial) data, for example, that are beyond the scope of what could be produced or are not feasible based on limitations in both GCM output and downscaled

climate projections. In other cases, users frequently requested the ability to download data from the climate summaries, a feature that was not feasible to implement in a way that would work for stakeholders. Similarly, stakeholders expressed a strong desire to integrate MARISA tools with their own GIS layers, but technical limitations have prevented the team from implementing this functionality—a source of frustration for both developers and users. Another common request was for auto-updating data in the climate summaries, which was not possible with the Tableau-based approach used to build these tools. While some of these issues were addressed in the development of subsequent tools, this mismatch between expectations and resources requires careful communication to help users understand the constraints of available data while also making a meaningful effort to deliver tools that remain useful and actionable for the region.

Operationalizing the tools for users has also presented challenges. While developing training materials and guidance can significantly enhance the usability of already well-designed, user-centered tools, creating these resources is time-intensive. As a result, many of the MARISA tools were initially developed without accompanying guidance or training materials. Over time, the team recognized that such resources could be developed or adapted after a tool's release, as real-world use revealed new insights about user needs and applications. This iterative approach has proven valuable but requires additional effort and resources that are not always available.

Finally, tracking the use and impact of the tools has been difficult. The anticipated uses envisioned during the development phase often shifted once the tools were released, making it challenging to identify the right users to survey and the best methods for evaluating impact. Additionally, there is limited funding and support for long-term tool maintenance, evaluation, and iteration. These constraints can limit the ability to fully assess how the tools are being used and to refine them based on evolving user needs.

Despite the challenges, several aspects of our approach were effective over time and contributed to the growing use of our suite of tools. One of the most valuable elements was the strong partnership between NRCC climatologists and RAND policy researchers. This collaboration ensured that the tools were grounded in robust scientific data while remaining attuned to the direct needs of decisionmakers and stakeholders in the region. The team also recognized that creating a tool is only part of the process—operationalizing the information it contains requires additional support, such as training materials and guidance. This insight was particularly evident in tools like the IDF curve tool and CHaMP, where efforts to bridge the gap between technical outputs and practical application enhanced their usability.

The regular, seasonally-timed nature of the climate summary series enabled important efficiencies and improvements. We standardized data formats and developed reusable tool templates, which significantly streamlined both data processing and tool development. These internal efficiencies made production more manageable for our team and improved the user experience by promoting a consistent look, feel, and functionality across tools. Users could quickly become familiar with the format, making it easier to engage with new tools as they were released. Additionally, centralizing access by hosting all tools on a single landing page made

them easier to find and encouraged users to explore related tools with similar designs—for instance, extreme heat tools that function similarly to those for extreme precipitation. The seasonal production schedule also allowed us to align each tool with specific seasonal decision-making needs. For example, we released snow-related tools during the winter and hurricane-related tools at the start of hurricane season. This seasonal relevance helped drive both awareness and use by meeting stakeholders where and when they needed actionable information.

Additionally, the long-term funding provided by NOAA was instrumental in enabling our team to create, update, and refine the tools over time, as well as to maintain them—something not available to all projects. Stable and consistent funding allowed the team to maintain a cohesive group of experts over multiple years, refine processes, and steadily build recognition and trust in MARISA products. As our suite of tools expanded, so did the user base and visibility, creating a positive feedback loop that bolstered the project's impact. The CHaMP tool, for example, was the result of many years of extensive collaboration between the MARISA team and USDN and eventually two additional CAP teams (CISA and GLISA). This meant that the three teams combined outreach efforts throughout the co-development process and were able to be more efficient and learn from a broader set of perspectives of potential users. Additionally, the CAP teams pulled in lessons learned from their previous experiences with tool building. The MARISA team was also able to implement feedback from other tools, specifically the climate summaries.

Finally, the co-production approach, involving engaged partners throughout the process, ensured that the tools were responsive to user needs and priorities, fostering a sense of shared ownership and increasing their relevance and impact. The development of the IDF Curve Tool, in particular, was grounded in a strong, collaborative partnership with end users, particularly the Chesapeake Bay Program's Urban Stormwater Workgroup. The tool was also intended to meet a specific need identified by members of the workgroup that led to the request for proposals that funded our work. The clearly identified need—IDF curves capable of reflecting future climate projections—gave the team a precise understanding of its intended use and user base. As a result, key design and methodological decisions were directly informed by user context and priorities. The highly engaged user community played a critical role throughout the development and early deployment phases—participating in interviews, offering feedback, and maintaining regular communication post-release. It also enabled us to rapidly address issues; early reports of errors and problems with the tool from users led to quick updates and corrections. This close collaboration not only enhanced the relevance and usability of the tool but also supported its wide dissemination across target audiences. We were able to provide tool demos and overviews to a broad range of interest groups—from regional practitioners to national organizations—to raise awareness of the tool and encourage adoption. Similarly for CHaMP, the USDN collaboration was critical. Integrating the tool within the USDN All Hazard Mitigation Plan framework allowed users to have both a planning framework and the data to go into it. Further, the USDN members that engaged with each CAP team were also highly responsive and willing

to have multiple conversations over the year-long piloting process. The commitment of these practitioners was a key component of the tool's broad use.

The development of the MARISA tool suite demonstrates the role of collaboration, long-term funding, and iterative refinement in producing tools that address regional climate decision-making needs. The challenges encountered, including resource constraints, gaps between user expectations and technical limitations, and the time demands of co-production, reflect common issues in developing science-based tools for diverse stakeholders. By establishing partnerships, standardizing workflows, and incorporating user feedback, the team worked to improve the accessibility and utility of climate data. This process provides insights into the practical considerations and strategies involved in creating tools that support decision-making in climate-related contexts.

Co-Production Best Practices

The growing demand for climate data tools to support planning, design, and policy decisions has led to a proliferation of platforms, dashboards, and datasets. Yet not all tools are equally useful or impactful. Drawing on our lessons learned, we outline six best practices for the development of climate data tools that meet the needs and capacities and intended users, shown in Table 5. These best practices highlight that tool development should be user-centered, not only to ensure that tools fill genuine data gaps but also integrate effectively into decision-making contexts, match user capacity, and remain adaptable over time.

Table 5. Climate Data Tool Best Practices

Best Practice	Description	Relevant Stage in Tool Development Process
Address User-Defined Data Gaps	Establishing a clear understanding of user needs is a foundational best practice in climate data tool development. Tools should be designed in direct response to specific data gaps or decision-making challenges faced by the intended user community. This alignment not only increases the likelihood of tool adoption but also guides critical choices in data analysis, formatting, and communication strategies. Absent a well-defined need, developers risk producing tools that fail to deliver actionable value—solutions in search of a problem.	Problem Identification & Scoping
Design for Real-World Integration	Once user needs are clearly defined, tool developers should collaborate closely with intended users to understand how the tool will integrate into existing workflows, such as planning, design, regulatory compliance, or operational decision-making. This insight should inform both the type and format of the data provided—whether it be change factors that adjust existing datasets, station-based time series, or other context-relevant outputs—as well as the structure and functionality of the tool itself. Designing with the end-use in mind increases usability and relevance, whether that means generating a single-page PDF for inclusion in a hazard mitigation plan or supporting more complex analytical tasks.	Design & Development
Match Complexity to Capacity	In parallel with understanding intended use, tool developers must	Design & Development

Best Practice	Description	Relevant Stage in Tool Development Process
	learn from and work with user groups to get a sense of their capacity to engage with the tool. This includes evaluating the time, technical expertise, and institutional resources users can reasonably devote to interpreting and applying climate data. Some users may be looking for customizable and complex future climate projections, while others may prefer simple, ready-to-use outputs—such as downloadable graphics or text for direct inclusion in reports or plans.	
Prioritize Iteration During Development	Tool development should be approached as an iterative process, with multiple opportunities for obtaining user feedback and refining based on these inputs. Engaging users during a beta testing phase is one approach to making sure the tool meets the needs and capacity of the intended user community. Beta testing could involve a set of pilot testers that work directly with the tool development team, or broader live feedback during a beta tool demonstration.	Testing & Refinement
Build in Mechanisms for Continuous Improvement	Iteration should not end once a tool is published. Even after they are released, climate data tools benefit from ongoing evaluation and adaptation based on real-world use. Developers should establish mechanisms—such as user surveys, usage analytics, version control, or dedicated feedback channels (e.g., email)—to continuously collect input and guide future updates.	Post-Release Maintenance
Support Use and Understanding with Complementary Resources	Effective climate data tools go beyond data visualization to support users in operationalizing the information for decision-making. Many users require additional resources—such as user guides, step-by-step instructions, recorded tool demos, case studies, or templates—to fully understand and apply the data in their specific context.	User Engagement & Support

The MARISA team's experiences and the above best practices reaffirm conclusions in prior academic work. The literature on climate services best practices generally emphasizes user-centered design, practical integration, and iteration with users. Numerous studies underscore the

importance of addressing user-defined data gaps, with Lemos et al. (2012) arguing that climate information is more likely to be used when it is co-produced with stakeholders and explicitly tailored to their decision-making contexts. Similarly, Moss et al. (2019) highlight that tools designed without a clear understanding of user workflows and institutional capacities often fail to achieve meaningful uptake, reinforcing the value of designing for real-world integration and matching tool complexity to user capacity. Iterative development and continuous improvement are also widely endorsed; for example, Meadow et al. (2015) emphasize that ongoing stakeholder engagement is critical for ensuring tool usability and relevance over time. Finally, complementary resources such as training materials and user support are identified as essential for bridging the gap between data availability and practical application (Wall et al., 2017).

Conclusion

The climate data landscape is evolving, with tools becoming increasingly sophisticated and specialized to meet the growing demand for actionable climate information across diverse sectors. While the availability of this information has enabled advancements in climate risk management, it has also underscored the challenges of ensuring tools remain accessible, impactful, and responsive to user needs. The MARISA team's experience developing tools for the Mid-Atlantic region highlights both the successes and persistent gaps in bridging the science-policy interface. Moving forward, addressing these gaps will require greater attention to post-publication feedback, expanded outreach to communities with more limited access to resources, and sustained funding for tool refinement and maintenance.

User feedback revealed several areas for improvement, including enhancing supporting documentation, expanding functionality to include additional data types, and providing clearer guidance on climate scenario selection and data interpretation. The MARISA tools are currently used primarily by larger jurisdictions, such as state governments and well-resourced localities, suggesting a need to better reach smaller and lower-resourced communities. Minimal usage in some MARISA states further highlights opportunities for targeted regional outreach. As the landscape of climate tools continues to shift—particularly with changes in federal government data availability—it is essential to equip tool developers with the resources and capacity to adapt to evolving user needs and technical constraints.

To ensure climate data tools remain effective amidst these changes, developers must prioritize iterative feedback processes, both during initial development and post-publication, to capture insights that emerge as users engage with tools in real-world contexts. Additionally, the growing complexity of tools demands greater investment in user-centered design principles, training materials, and complementary resources to bridge the gap between technical sophistication and practical application. As we have found, collaboration, sustained funding, and iterative refinement are essential to creating tools that not only provide high-quality climate data but also empower stakeholders to make informed, impactful decisions in the face of a changing climate.

Abbreviations

CAP	Climate Adaptation Partnership
CBCAT	Chesapeake Bay Climate Adaptation Toolbox
CHaMP	Climate and Hazard Mitigation Planning Tool
CMIP6	Coupled Model Intercomparison Project Phase 6
CPO	Climate Program Office
GCM	Global climate model
IDF	Intensity-Duration-Frequency
LOCA2	Localized Constructed Analogs, Version 2
MARISA	Mid-Atlantic Climate Adaptation Partnership
MIST	Model Inventory and Selection Tool
NCA5	Fifth National Climate Assessment
NOAA	National Oceanic and Atmospheric Administration
NRCC	Northeast Regional Climate Center
RCM	Regional climate model
RCP	Representative Concentration Pathway
UCAR	University Corporation for Atmospheric Research

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