Decision Support Research Recommendations to Improve Forecast Understandability and Service Equity

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NOAA CPASW March 2024

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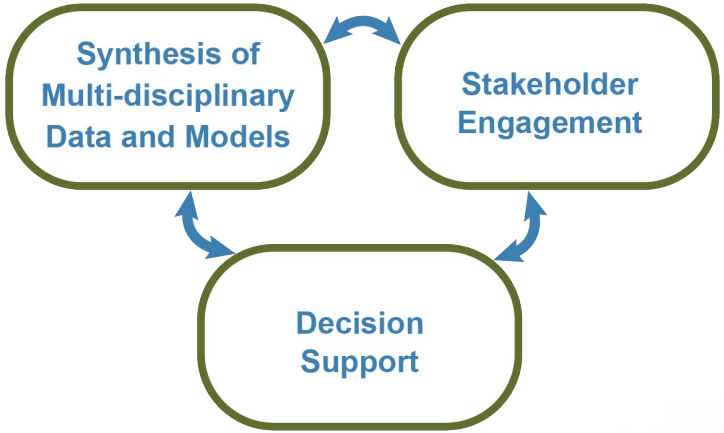
UNIVERSITY OF MINNESOTA
Driven to Discover℠

Environmental Decision Support Science Team

conducts multidisciplinary social science research to increase the use of evidence in climate adaptation and mitigation, environmental management, community resilience, and interdependent infrastructure decisions.

Our goal is to understand and improve the processes and tools that aid these decisions, both in the public and private sectors.



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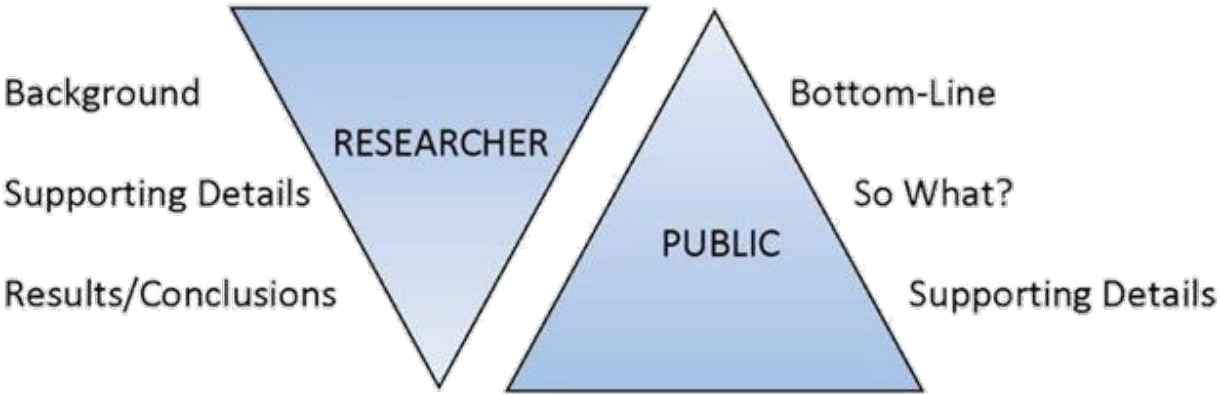
Different Styles of Communication



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From AAAS Center for Public Engagement with Science and Technology https://www.aaas.org/pes

“...intuitions about good design practices may not always match best practice informed by cognitive principles, and viewer preferences may not always be predictive of ease of comprehension.”

-Harold et al., 2016

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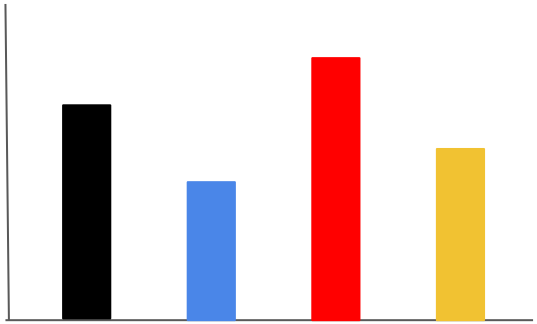
Harold, J., Lorenzoni, I., Shipley, T. F., & Coventry, K. R. (2016). Cognitive and psychological science insights to improve climate change data visualization. Nature Climate Change, 6(12), 1080.

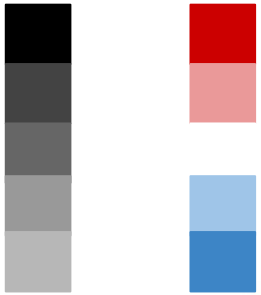
Examples of Best Practice Informed by Cognitive Principles

Easier to distinguish color than shape

Visual variables should match number of dimensions of data



Changes in hue imply more difference than changes in value or intensity



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Dasgupta, Aritra, et al. "Bridging theory with practice: An exploratory study of visualization use and design for climate model comparison." *IEEE transactions on visualization and computer graphics* 21.9 (2015): 996-1014.

5 Lessons Learned...

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Global Change Indicators

Tested two USGCRP indicators and one NCA indicator

Each original was tested against three modifications

Climatic Change (2021) 166: 33
https://doi.org/10.1007/s10584-021-03109-w

Improving the usability of climate indicator visualizations through diagnostic design principles

Michael D. Gerst [1] · Melissa A. Kenney [1,2] · Irina Feygina [3]

Received: 16 October 2020 / Accepted: 20 April 2021 / Published online: 4 June 2021

Abstract

Visual climate indicators have become a popular way to communicate trends in important climate phenomena. Producing accessible visualizations for a general audience is challenging, especially when many are based on graphics designed for scientists, present complex and abstract concepts, and utilize suboptimal design choices. This study tests whether diagnostic visualization guidelines can be used to identify communication shortcomings for climate indicators and to specify effective design modifications. Design guidelines were used to diagnose problems in three hard-to-understand indicators, and to create three improved modifications per indicator. Using online surveys, the efficacy of the modifications was tested in a control versus treatment setup that measured the degree to which respondents understood, found accessible, liked, and trusted the graphics. Furthermore, we

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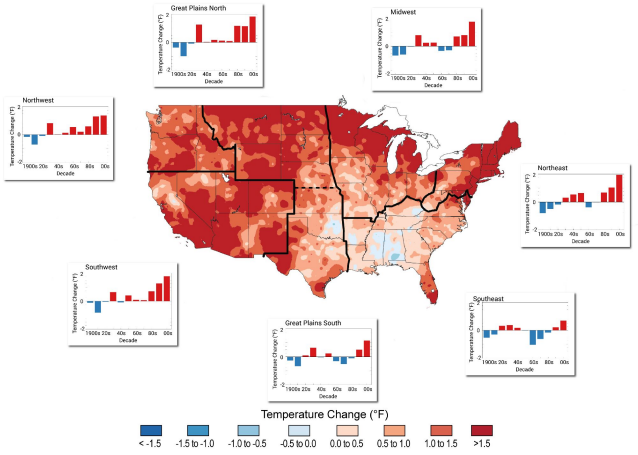
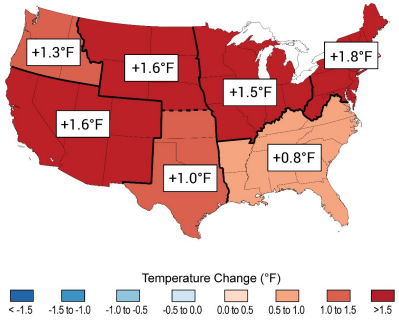
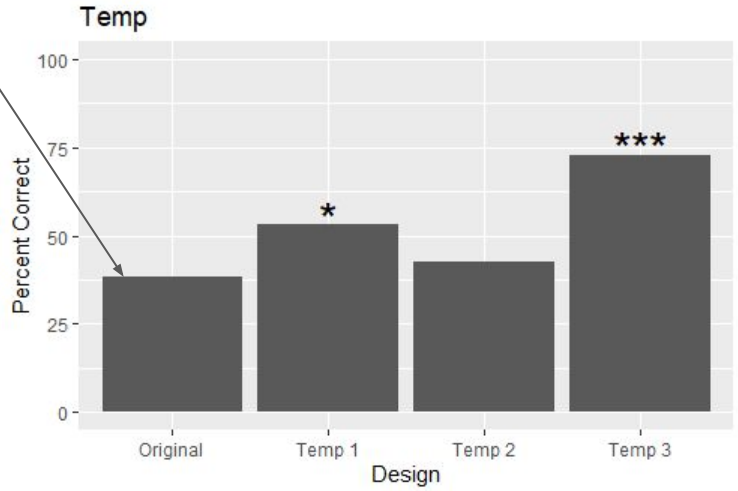
https://link.springer.com/article/10.1007/s10584-021-03109-w

Observed U.S. Temperature Change



Observed U.S. Temperature Change





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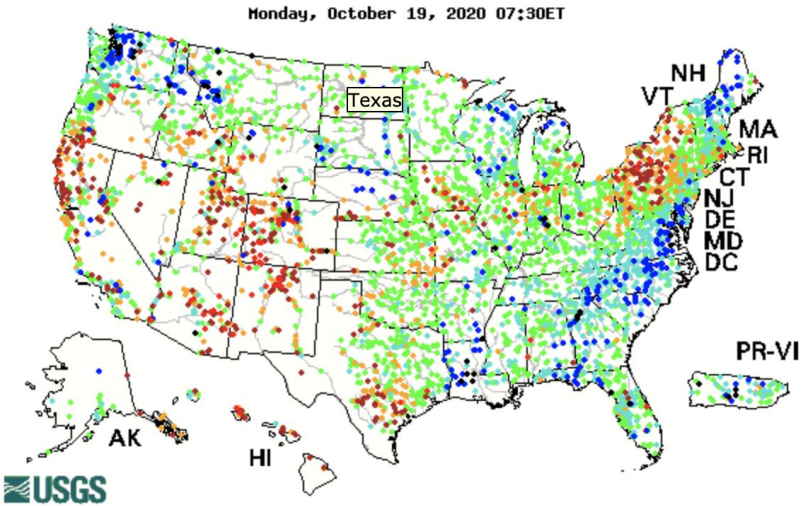
Lesson Learned #1

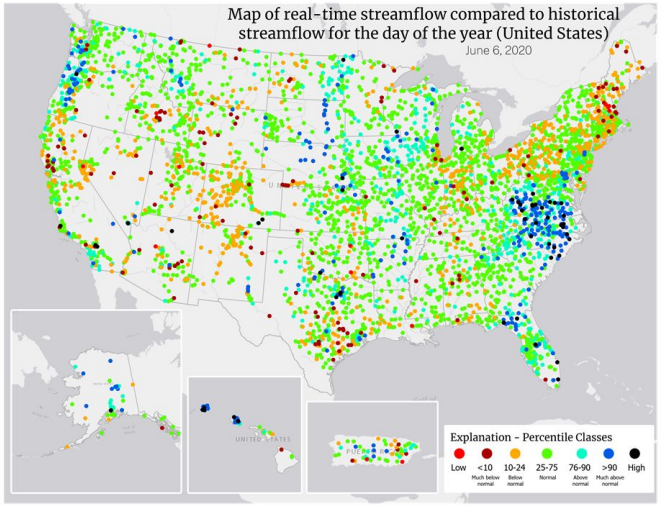
Visualize the main story, nothing more

USGS Water Watches Decision Support Products

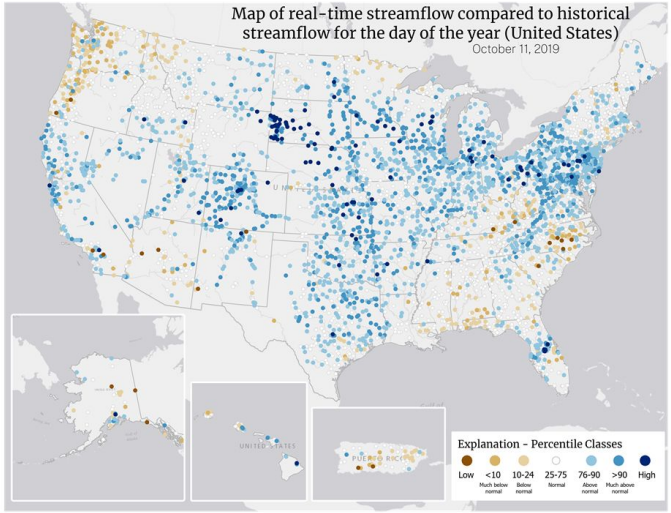


Tested effect of changing colormap and showing a legend

The survey focuses on how color is used in maps that show the amount of water in rivers (e.g., streamflow).



Control = Rainbow



Treatment = Blue-Brown

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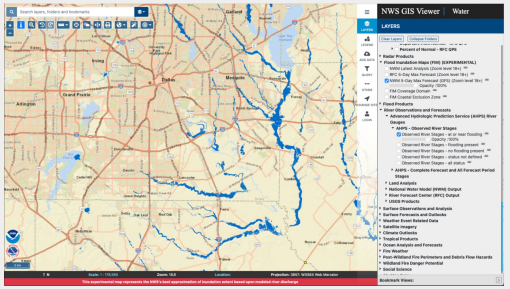
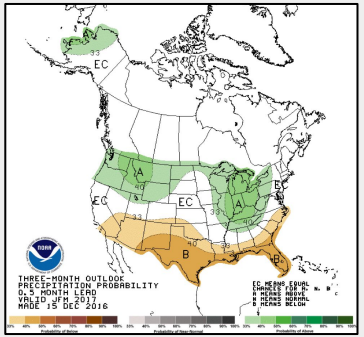
Lesson Learned #2

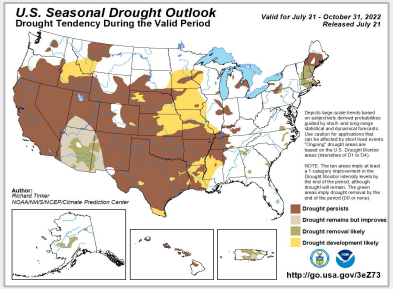
Subjective feedback can be misleading

Diagnosing and testing solutions for NOAA CPC's Temperature, Precipitation, and Seasonal Drought Outlooks and NOAA OWP Flood Inundation Maps

(Apoorva and Sajani)







General Method

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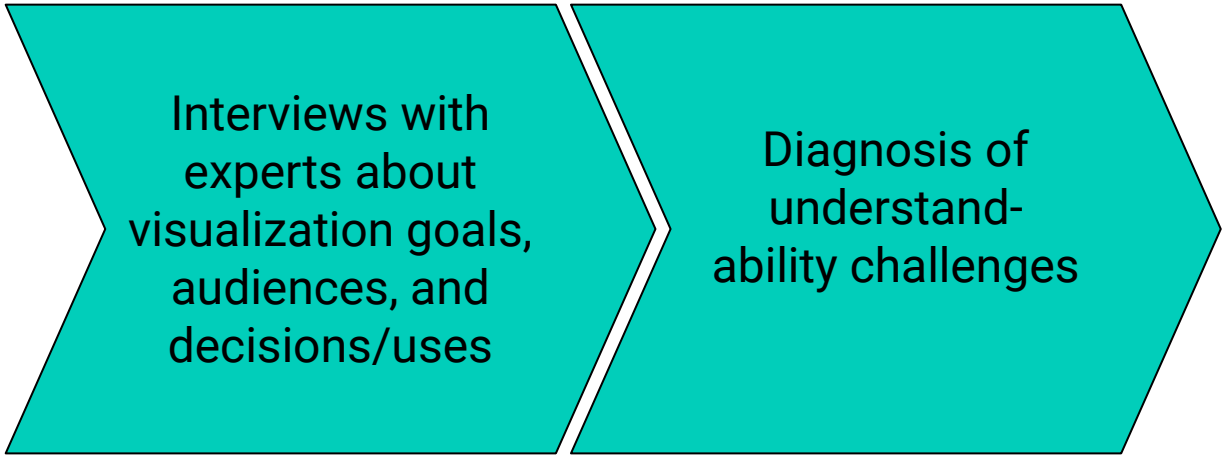
General Method



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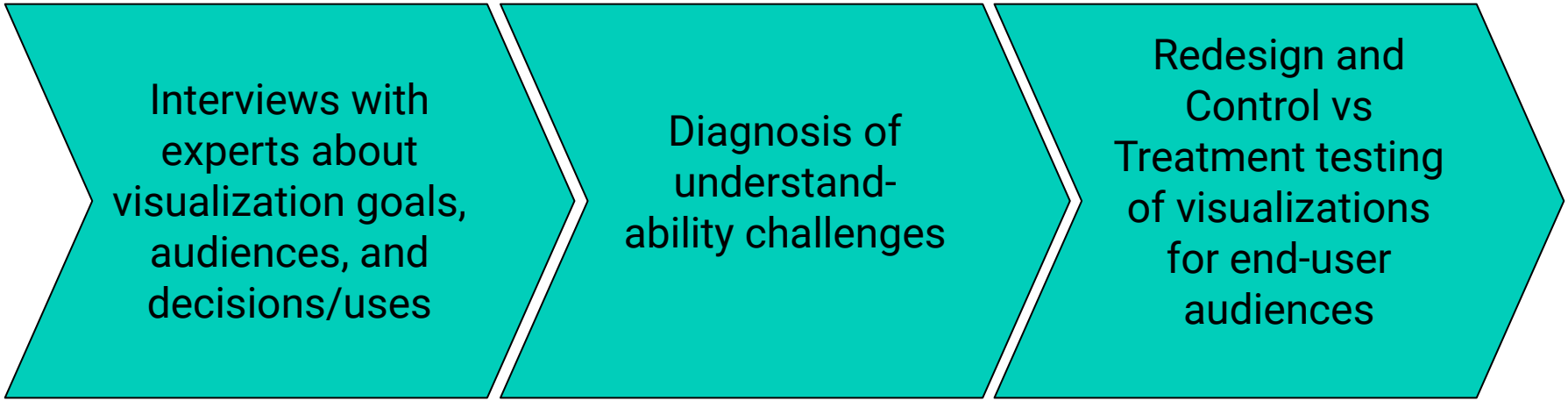
General Method



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General Method

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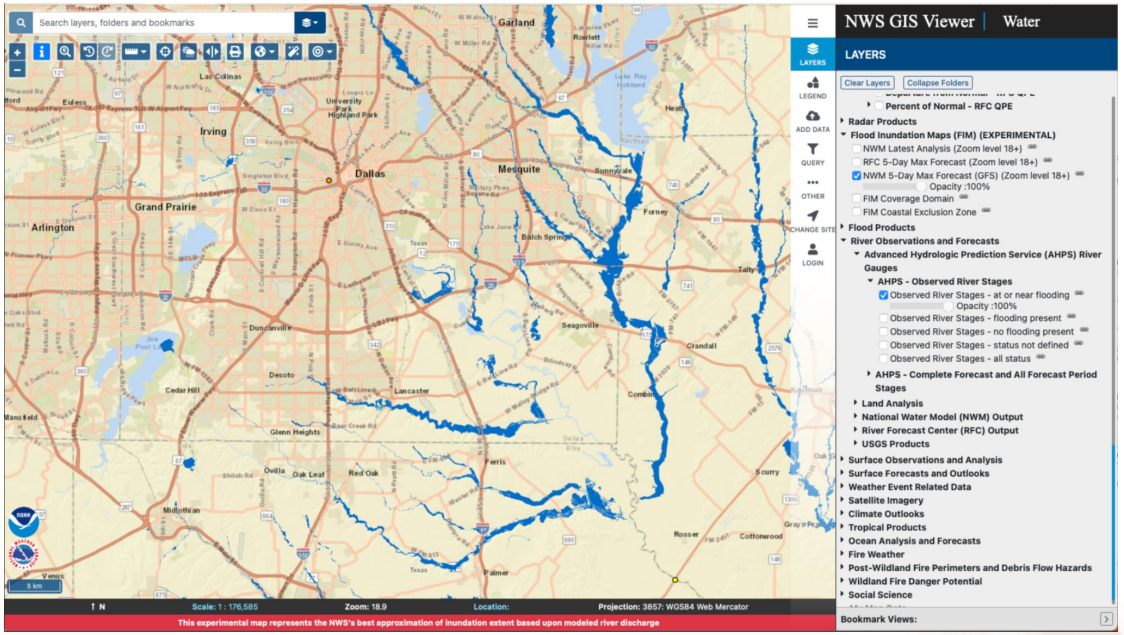
Audience Segmentation to Improve Flood Inundation Mapping:
Engagement and Testing with Technical Users and Impacted Communities

Project Objective:

To develop a novel, empirically based testing procedure to provide operational improvements to **Flood Inundation Mapping (FIM)** forecast graphics' understandability and interpretation among different audiences.



NWS FIM experimental release page in NWS GIS viewer.

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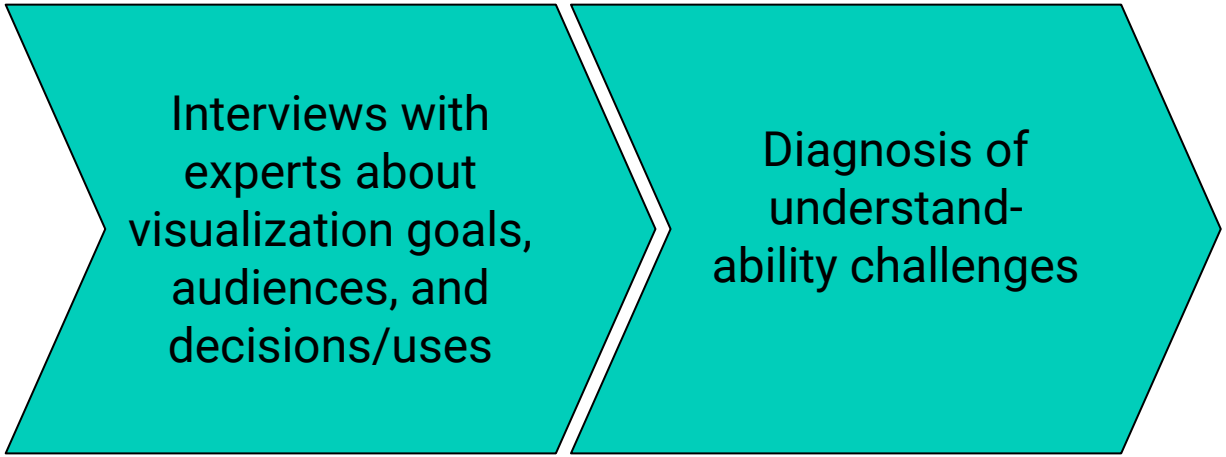
General Method



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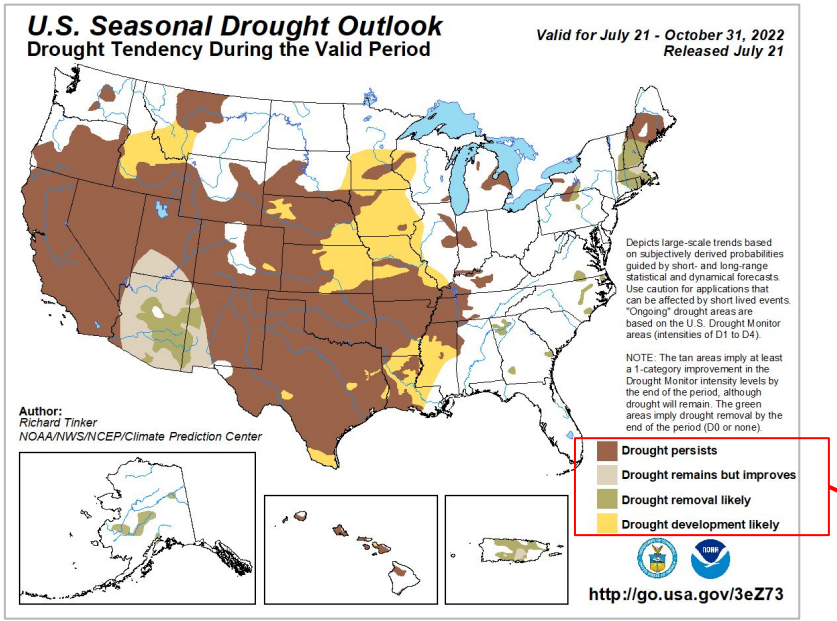
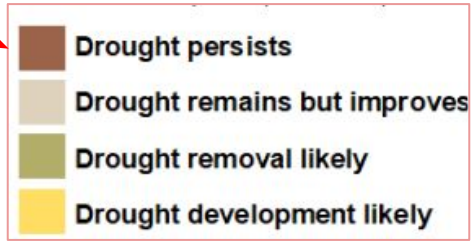
Usability Testing of NOAA CPC Drought Outlooks to Improve Understandability and Decision Making



Usability and understandability challenges emerging from visualization diagnosis:

- Unclear key message
- Confusing legend categories
- Order of categories unintuitive
- Colors not accurately interpreted
- Clutter adds to cognitive load



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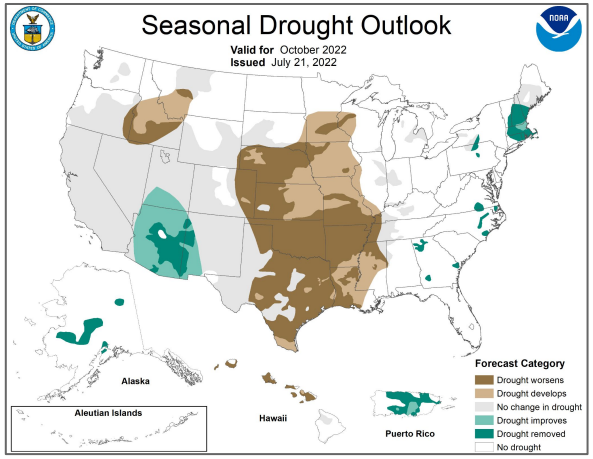
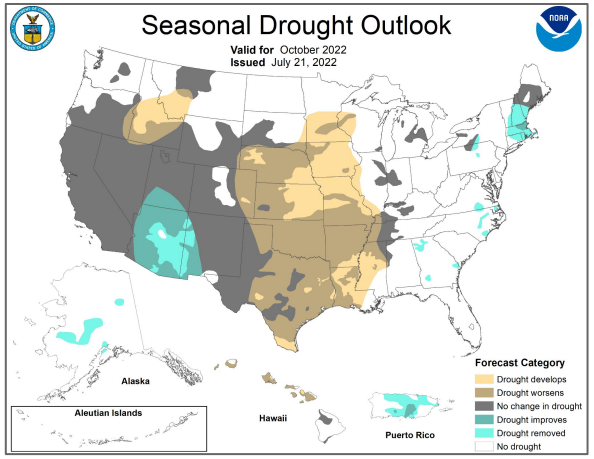
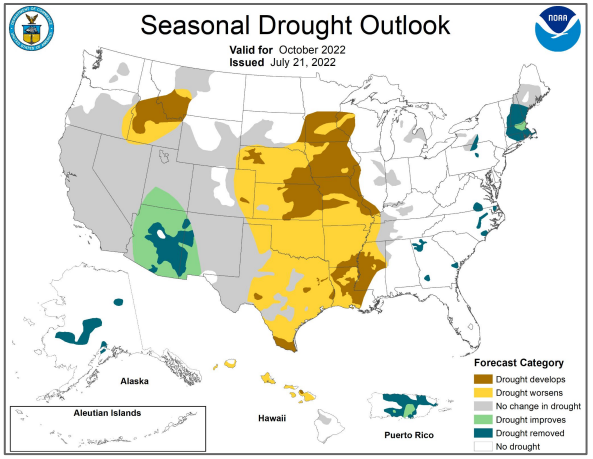
Integrating Evidence from Communication, Visualization, and Behavioral Sciences into Modifying and Testing Drought Outlooks







Drought develops			
Drought worsens			
No change in drought			
Drought improves			
Drought removed			
No drought			

Survey-experiment to ***empirically test*** modified graphics compared to the original Drought Outlooks showing which ***design changes statistically improve usability and intuitiveness*** of the forecast visualizations.

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Using Visualization Science to Improve Expert and Public Understanding of Probabilistic Temperature and Precipitation Outlooks

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Earth System Science Interdisciplinary Center/Cooperative Institute for Satellite Earth System Studies, University of Maryland, College Park, College Park, Maryland, and Institute on the Environment, University of Minnesota, Saint Paul, Minnesota

ALLISON E. BAER, AMANDA SPECIALE, AND J. FELIX WOLFINGER

Earth System Science Interdisciplinary Center/Cooperative Institute for Satellite Earth System Studies, University of Maryland, College Park, College Park, Maryland

JON GOTTSCHALCK, SCOTT HANDEL, MATTHEW ROSENCRANS, AND DAVID DEWITT

National Oceanic and Atmospheric Administration, Climate Prediction Center, College Park, Maryland

(Manuscript received 27 August 2018, in final form 5 November 2019)

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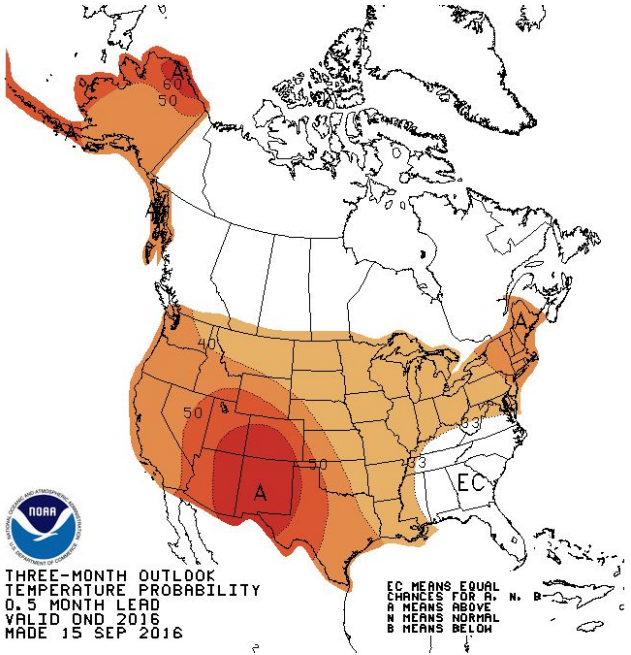
https://journals.ametsoc.org/wcas/article/12/1/117/346128/Using-Visualization-Science-to-Improve-Expert-and

Background



Temperature and precipitation outlooks - used all the time in ecoforecasts!

How to best visualize geospatial uncertainty is an open scientific question

Using decision and visualization science to align user needs and goals with visualization choices

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Results and Recommendations

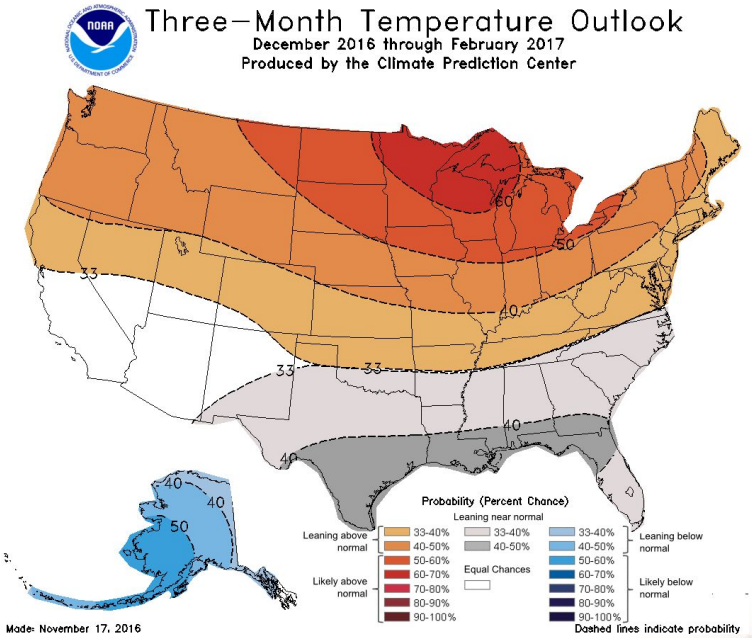
Significant improvements in understanding of near-normal and equal chances categories

Removed clutter

Legend with qualitative and quantitative probability representations

Recommendations:

- Adopt treatment that resulted in the greatest improvement in understanding for decision making
- Create consistency across the entire outlook suite in display and content



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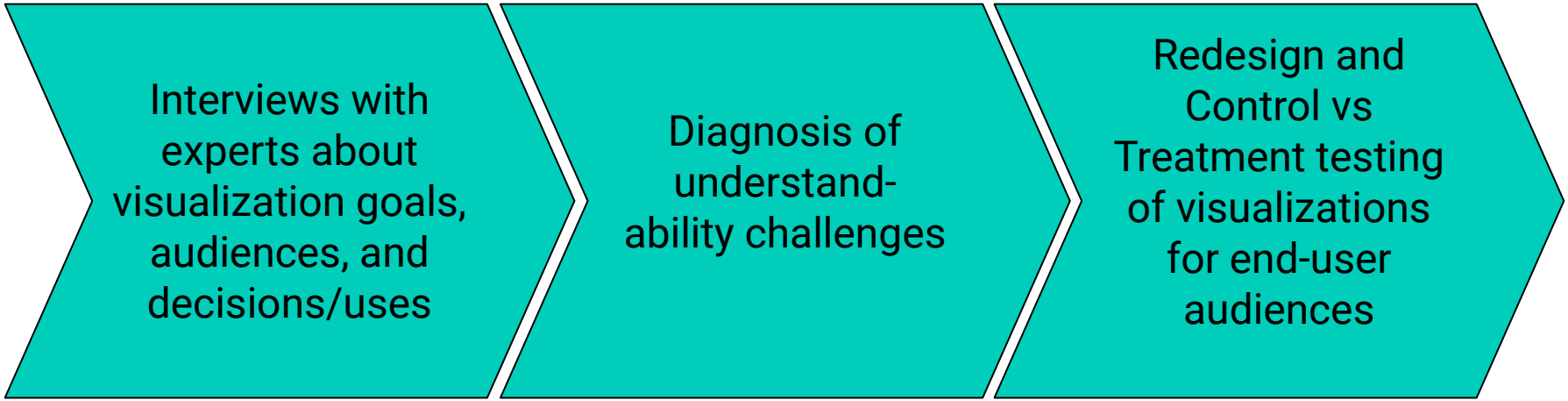
General Method



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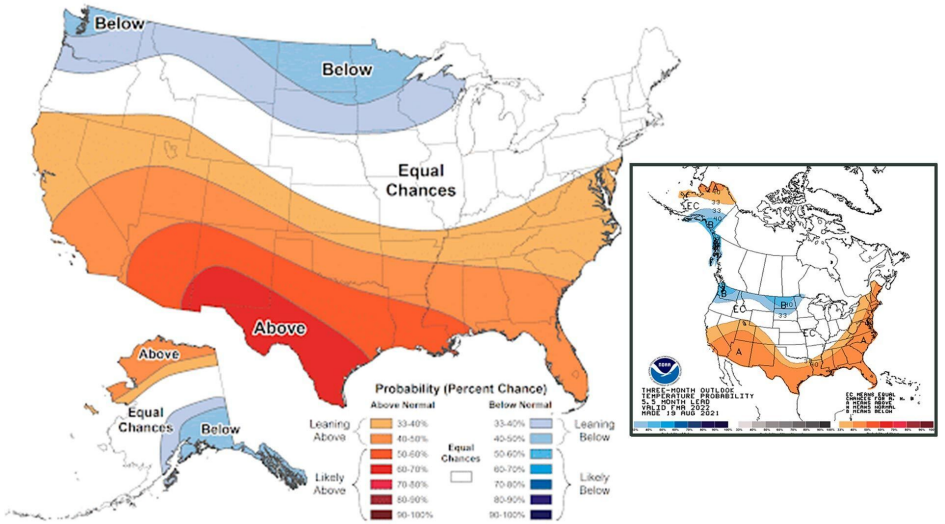
Improving Understandability of High-profile Graphics

Control/Treatment testing to determine whether visual modifications can improve understandability and stated utility of the information for decision-making

Provide evidenced-based, iterative design approach to improve forecast visualizations to support NOAA decision-making→ operationally updated in September 2021!



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Gerst, M.D., M.A. Kenney**, A.E. Baer, D. Dewitt, J. Gottschalck, S. Handel, M. Rosencrans, A. Speciale. (2020) Using Visualization Science to Improve Expert and Public Understanding of Probabilistic Temperature and Precipitation Outlooks. Weather, Climate, and Society. 12:117-133. https://doi.org/10.1175/WCAS-D-18-0094.1
https://www.weather.gov/news/211409-temperature-precipitation-maps

Lesson Learned #3

Empirical testing accelerates solutions that lead to user-centered research-to-operational changes

Improving NOAA Hydrologic Decision Support Products

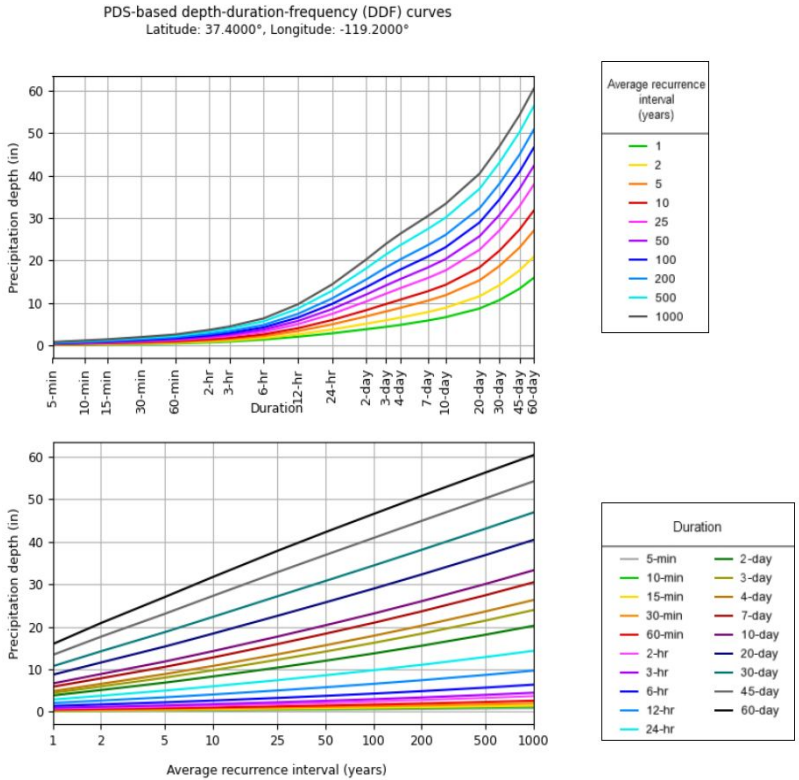
(Suby)

Applied behavioral concepts for intuitive decision-making.

Enhanced the use of colors for clarity.

Improved accessibility (Section 508 compliance).

ATLAS 14



Key variables in the diagnosis:

- Key message
- Color and legend
- Reuse and conflicting use of color
- Understandability
- Intuitiveness

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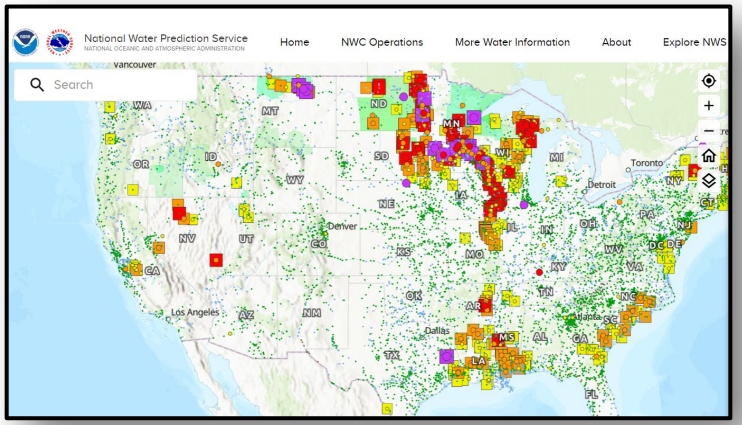
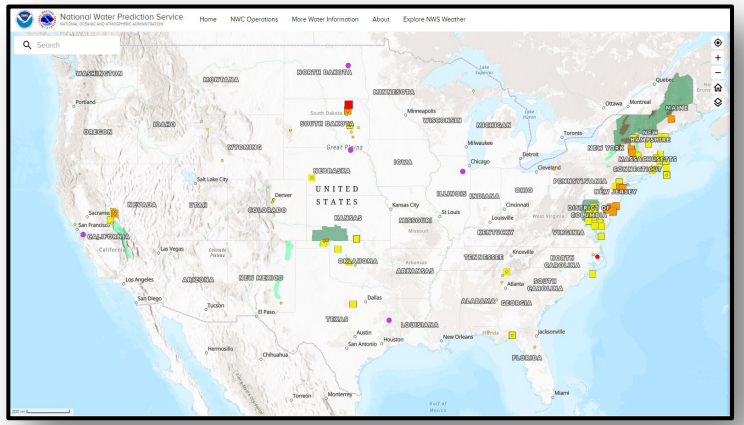
Providing **actionable social-science based recommendations** on the National Water Prediction Service (NWPS) mapping tools based on a synthesis of research on improving the understandability of OWP products for diverse public users.





Landing page of the National Water Prediction Service (NWPS) platform under development (pre-public release).

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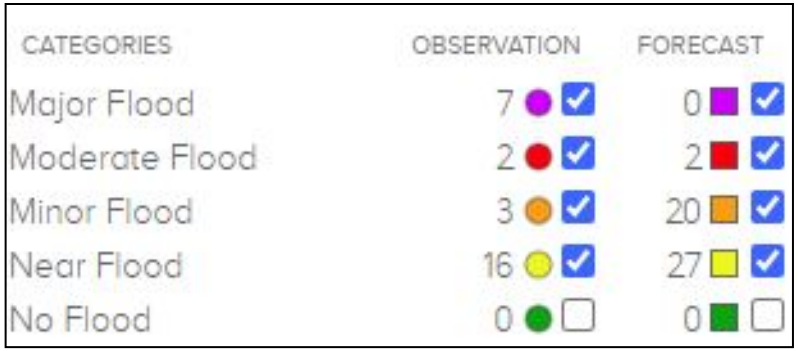

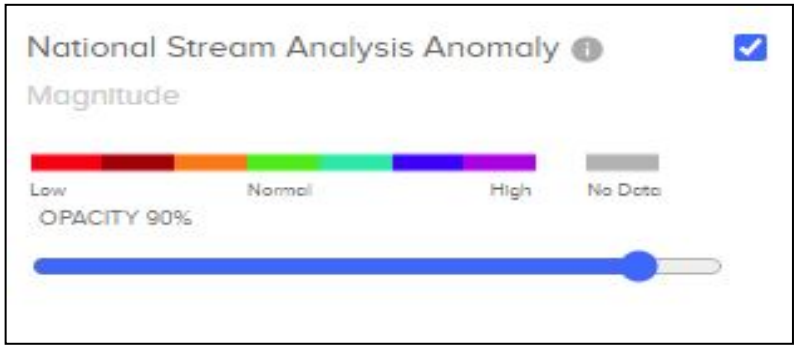

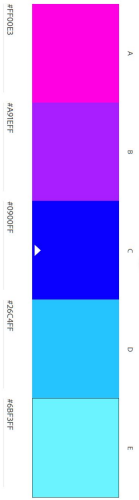

Social science evidence-based actionable recommendations for optimizing NWPS

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Lesson Learned #4

New interactive data products may require revisiting status quo visualization norms

Co-developing NOAA Data Products: Service Equity for Flood and Drought Predictions

(Emily)

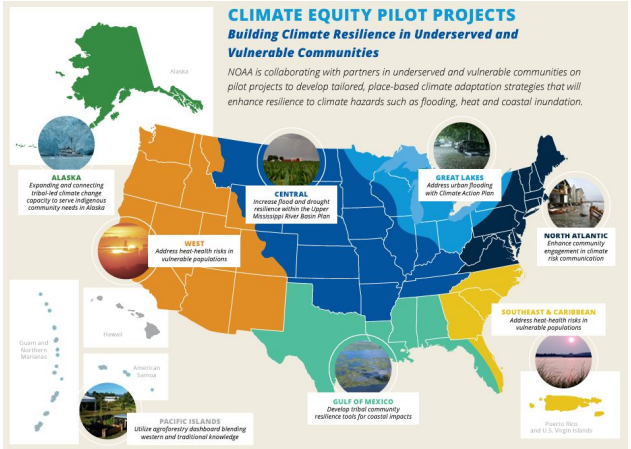
Tested two USGCRP indicators and one NCA indicator

Each original was tested against three modifications

Building Knowledge to Support Equitable Climate Resilience in the Upper Mississippi River Basin

One of seven **NOAA Climate and Equity Pilot Projects** - initiated in 2021

Supporting equitable climate resilience through projects focused on community involvement, equity and environmental justice.



Project Objective:
Estimate hydrologic risk and resilience opportunities for at-risk communities in the Upper Mississippi River Basin

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Building Knowledge to Support Equitable Climate Resilience in the Upper Mississippi River Basin

Two project components:

Climate modeling and integration into hydrologic models with constant communication at formative stages of the analysis: what analysis products/variables/etc. are useful?

Engagement with local communities that have faced disproportionate flood and drought risk to understand the needs and barriers associated with future river planning.

Lessons Learned:

Development of practical workflows: integrates statistically downscaled climate models into NOAA workflows.

Integration of physical science into social priorities in the region: Community engagement priorities ensuring the use of this information by multiple stakeholders throughout the region and support climate equity goals.

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Lesson Learned #5

Co-production with diverse users in the early stages improves service equity of data products

Lesson Learned

1. Visualize the main story, nothing more
2. Subjective feedback can be misleading
3. Empirical testing accelerates solutions that lead to user-centered research-to-operational changes
4. New interactive data products may require revisiting status quo visualization norms
5. Co-production with diverse users in the early stages improves service equity of data products

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In a Nutshell…

In a nutshell…

1. Know your audience’s goals and capabilities

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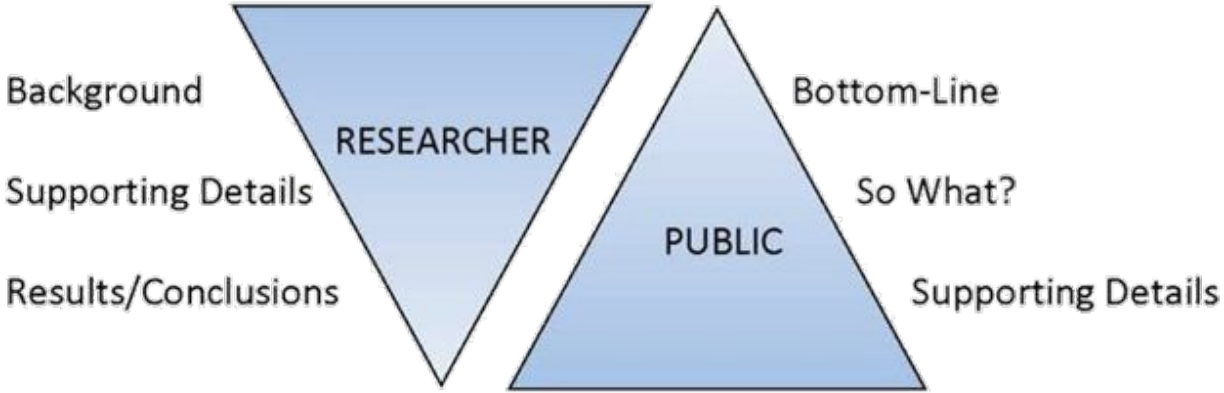
In a nutshell…

2. For general audiences, design to inform not to explore



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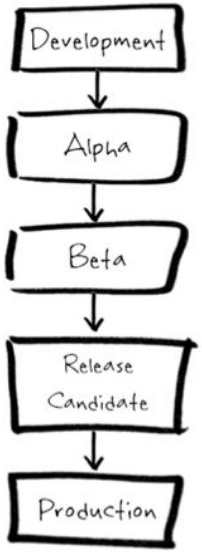
In a nutshell…

3. Co-production and iterative design and testing is key to success



Applying design theory, similar to software development, allows the development of decision support products that are:

- understandable,
- useable, and
- useful for multiple types decisions.

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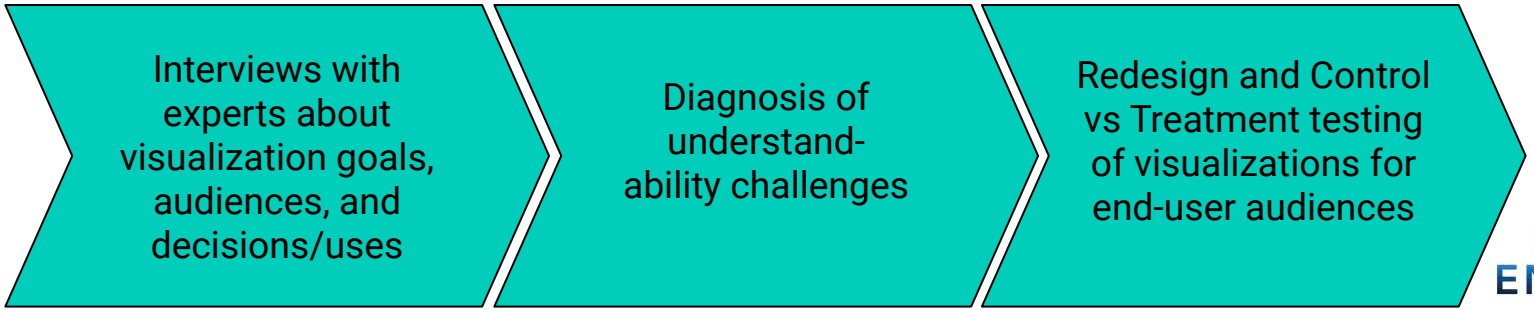
In a nutshell…

4. These findings across three in-depth visualization studies point to diagnostic design guidelines as a useful tool for creating more accessible, engaging climate and environmental graphics for the public.



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Acknowledgements

Funding: **NOAA Climate Program Office** **and** **NOAA Climate Prediction Center** both via grant NA09NES4400006 and NA14NES4320003 (Cooperative Institute for Climate and Satellites -CICS) at the University of Maryland/ESSIC. **Department of Interior, USGS** funded this project via grant G19AC00237 to the University of Minnesota, Water Resources Center. **Cooperative Institute for Research to Operations in Hydrology (CIROH)**, the **Cooperative Institute for Satellite Earth System Studies (CISESS)**, the NOAA Climate Prediction Center, and the **National Integrated Drought Information System** (NIDIS). The research is led by team members at the University of Minnesota Institute on the Environment and University of Maryland.

Collaborators/Acknowledgements: Michael D. Gerst (UMD), Allison Bredder (UMN ESSIC, CISESS), Shubhechchha Sharma (UMN, IonE), Apoorva Joshi (UMN, IonE), Emily Kreiter (UMN, IonE), Sajani Kandel (UMN, IonE), Felix Wolfinger, Kelly Abraham, Dana Williamson Nfamara Dampha (UMN IonE, CIROH), David DeWitt, Jon Gottschalck, Scott Handel, Matt Rosencrans, Brad Pugh, Adam Hartman (NOAA CPC), Bethany Perry, Doug Kluck (NOAA Central Region), Emily Read, Jennifer Bruce, Megan Hines, and Charlotte Snow (USGS), Chip Gobs and Sudhir Shrestha (NOAA OWP- Geo-Intelligence Division), David R. Vallee (NOAA OWP-NOAA OWP Service Innovation Partnership Division), Valerie Were, Olivia Watson (NOAA Affiliate), Zachary McEachran, Brian Connelly (NOAA National Weather Service), Amanda Speciale, Carly Brody, Riley Cassidy, Dean Sproul, Jason Winik, Candela Cerpa, Natalia Jaffee, Samantha Ammons, Ingrid Sund (UMD Students), Tracy Twine, Alejandro Fernandez (UMN Department of Soil, Water, and Climate), Mark Ellis, Brian Stenquist, Kirsten Wallace, Erin Spry (Upper Mississippi River Basin Association), Molly Woloszyn (NOAA NIDIS, CIROH), Sam Grant (Rainbow Research), Huda Ahmed (Transformational Solutions), Michael Fedoroff (UA), Anne Jefferson (UVM), Lakelyn Taylor (UVM), Sarah Noyes (UVM), Kate Abshire (NOAA/NWS/AFSO Water Resources Services Branch).

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