The Urban Rain Rate Dashboard (URRD)

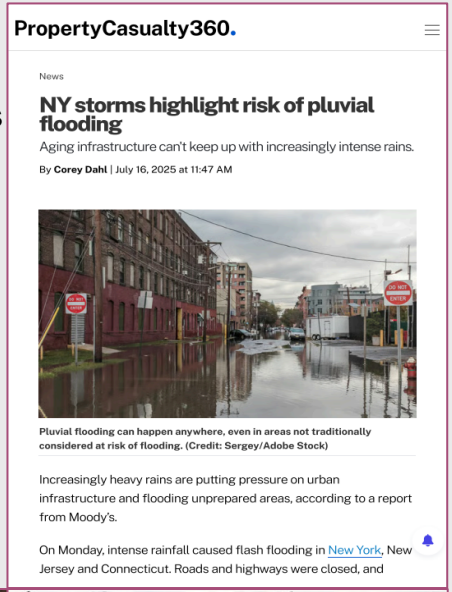
James Nelson[1], David Novak[1]
David Bright[2], Erica Bower[2], Austin King[2],
Rachel A.H. Carr[3], Kathryn Semmens[3], Burrell Montz[3], Keri Maxfield[3], Patrick Painter[3]

[1]*NOAA/Weather Prediction Center (WPC)*
[2]*Cooperative Institute for Research in Environmental Sciences (CIRES)*
[3]*Nurture Nature Center (NNC)*

NWS VLab Forum
August 27, 2025

Motivation for the URRD

- Flooding is the most common, costly, and deadly weather-related disaster in the U.S. (Alliance 2020)
- The number of people affected by urban flooding is increasing annually (National Academies 2019)
- Urban flooding typically occurs when short-term, intense precipitation exceeds its capacity to infiltrate or be removed by the drainage system (Galloway et al. 2018)
- The increase is mainly attributed to population growth, expansion of impervious surfaces, outgrown stormwater infrastructure, local policies, and climate change (National Academies 2019; Galloway et al. 2018)
- Ida Service Assessment (NOAA 2023) Finding 3/Rec. 3: NWS should develop forecast tools…to communicate…the expected hourly rate of rainfall, and a reasonable “worst case scenario”


PropertyCasualty360.

News

NY storms highlight risk of pluvial flooding

Aging infrastructure can't keep up with increasingly intense rains.

By **Corey Dahl** | July 16, 2025 at 11:47 AM

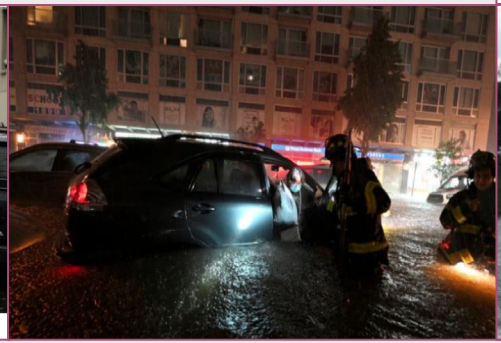
Pluvial flooding can happen anywhere, even in areas not traditionally considered at risk of flooding. (Credit: Sergey/Adobe Stock)

Increasingly heavy rains are putting pressure on urban infrastructure and flooding unprepared areas, according to a report from Moody's.

On Monday, intense rainfall caused flash flooding in New York, New Jersey and Connecticut. Roads and highways were closed, and

Flooding is seen here on Hook Creek Boulevard at 149th Avenue in Queens on Monday. (Theodore Parisienne for New York Daily News)


A person walks down a flooded street in Hoboken, New Jersey. *Gary Hershorn/Reuters*




Credit: Chris “CJ” Johnson/Pixabay

Ensemble QPF to Support Urban DSS

Inform users of the likelihood that your city's critical rainfall threshold will be exceeded using the terms and criteria most meaningful to them

We typically see issues when rainfall exceeds 1" in an hour

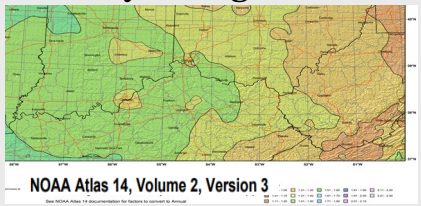
Meteorologists

We typically see issues when rainfall exceeds the 10 year storm

Stormwater, Utility, & EM Officials

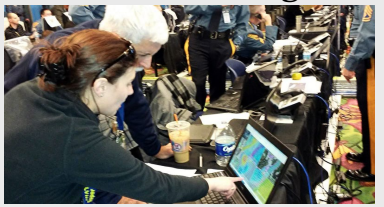
We can translate between rainfall and its statistical average recurrence interval (ARI)

Hydrologists



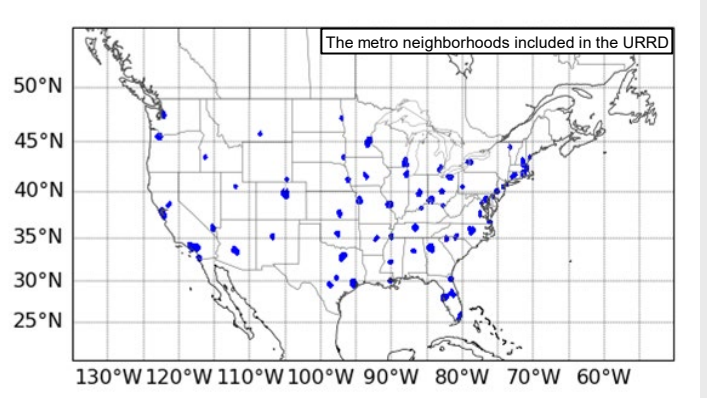
We can provide real-time hourly probabilities of rainfall *or* ARI exceedance

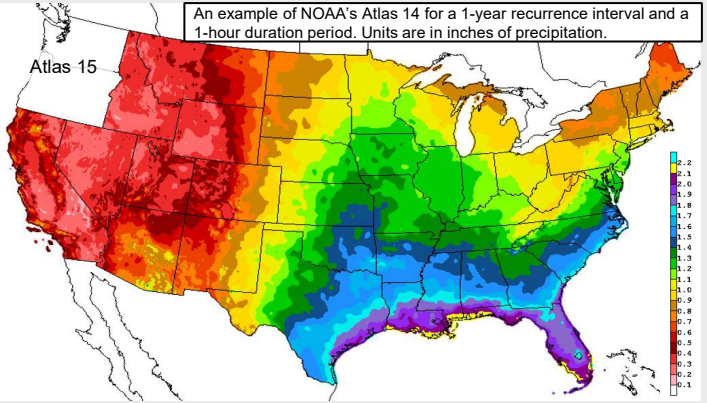
IDSS Meteorologists



Components of the URRD

- Current ensemble systems in the developmental/experimental URRD: HREF, REFS, GEFS
- The REFS will be the only storm-scale ensemble system when operational and the HREF is retired (planned for early 2026)
- A Neighborhood Maximum Ensemble Probability (NMEP) is used to define precipitation probabilities around each city
    - The neighborhood is uniquely defined by the metro's population density
- The QPF from each member of the ensemble is compared to NOAA Atlas 14 Average Recurrence Intervals (ARIs). The URRD shows the probability of exceeding a 1 to 12 hour ARI or the probability of exceeding 1 to 12 hour accumulated precipitation
    - All probabilities are uncalibrated in this version of the URRD
    - Meteorologists preferred precipitation amounts while stormwater managers preferred ARIs
- Eagerly awaiting the Atlas 15 updates for consistent, full coverage
    - Until Atlas 15 in early 2026, Portland and Seattle ARIs derived from 30-years of airport precipitation data





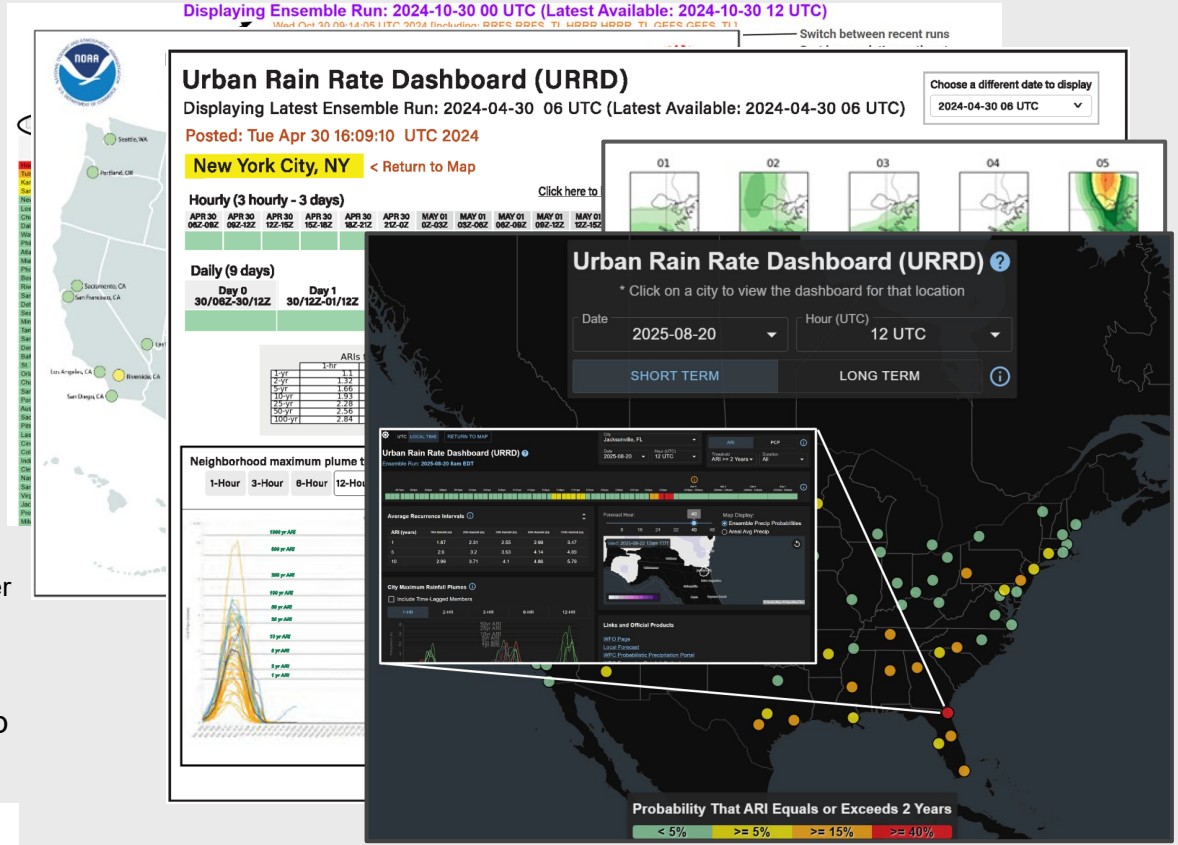
Social Science and User Engagement

- Specialized community engagement led by social scientists from the Nurture Nature Center (NNC)
- Six focus groups in 2024 (included seven WFOs: Atlanta, NYC, New Orleans, LA/San Diego, Denver, and Houston)
    - Initial prototype, several mock-ups, and supplemental data presented to emergency managers, city managers, engineers, stormwater managers, meteorologists from partner WFOs
    - Follow-up survey distributed in early 2025
- URRD development shaped by the focus group feedback

On Fri, Sep 27, 2024 at 3:46 PM (DHSES) <_____ @dhses.ny.gov> wrote:
Thanks so much for inviting us to the focus group. Your team did really great. It was a very valuable session and we appreciate you listening to our feedback. We are excited for the new tool!

Have a wonderful weekend.

Thank you,



Example of NNC pre-decision content for focus group discussion

The Iterative Development Process

Engagement

City, Emergency, & Stormwater Managers
NWS WFOs
Language of urban flooding (ARI vs QPF)
Data visualization and interpretation
Decision making and decision support
Specifications
Community feedback

Verification

Determine optimal metric(s)
Limited archive for verification
Recent verification (real-time)
Long-term verification (skill)

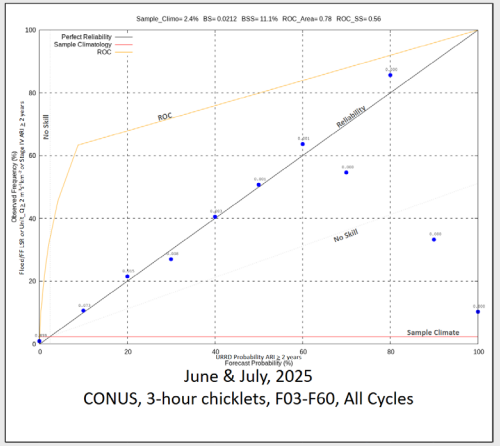
Development

Defining urban areas
Ensemble system(s)
Post-processing QPF and ARI
Defining the threat
Probabilistic modeling/calibration
Prototyping

Performance Verification

Will use multiple verification methods to assess accuracy, discrimination, and skill of the probabilistic forecast. Initial metrics include:

- Attributes Diagram
  - Reliability: Agreement between forecast probability and occurrence frequency
  - Sharpness: Deviation from climatology
  - Resolution: Distinguish different occurrence frequencies
- Relative Operating Characteristic (ROC) Curve and Area Under Curve (AOC)
  - ROC: Hit Rate vs. False Alarm Rate across the probabilistic spectrum
  - AUC: Single score summarizing separation ability (1 = Perfect; 0 = No Skill)
- Brier Score and Brier Skill Score
  - Brier Score: Mean squared error of forecast probabilities vs observations (0 = Perfect)
  - Brier Skill Score: Improvement relative to a climatological forecast
  - Sample climatology provides the event frequency for comparison
- Verification can be used to guide further development and forecast calibration
- A verification database and archive is now established
  - Truth is a flood/flash flood LSR *or* MRMS CREST Unit-Q $\geq$ 2 $m^3s^{-1}km^{-2}$ (Gourley et al. 2017; Gerard et al. 2021) *or* Stage IV ARI $\geq$ 2 years (Lincoln and Thomason 2018; Herman and Schumacher 2018)
  - To keep it manageable, initial verification is based on probabilistic forecasts of ARI $\geq$ 2 years
  - We are assessing the preliminary results while building a longer-term verification archive
  - Expect the performance to change in the coming months as REFS replaces the HREF



Example of initial verification for all the URRD cities

Important URRD Caveats

- Only as good as the accuracy of weather model inputs and Atlas-14 recurrence intervals
  - At its core, the first version of the dashboard is a detector of short-term, high-intensity rainfall events evaluated in rainfall or ARI exceedances
  - Models may be biased, or the ensembles may not capture the PDF correctly
  - ARI applications assume a stationary climate, representative historical record, etc.

- Application depends on accurately linking impacts to the proper rain rate or recurrence interval
  - Most cities have unique infrastructure, unique problem areas, and local issues that may complicate urban flooding prediction and impacts

- Entirely automated model guidance with limited human oversight

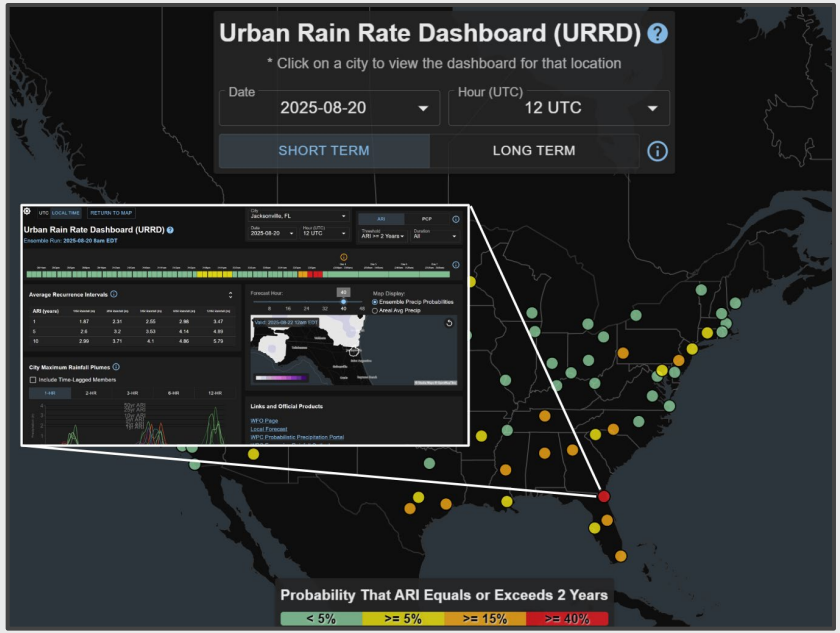
- **The URRD is a Situational Awareness Tool - Does not replace official NWS watches, warnings, advisories, DSS**

NOAA

CIRES

THE NURTURE NATURE CENTER

URRD Real-time Demonstration



https://www.wpc.ncep.noaa.gov/urrd/demo/

URRD Next Steps and Future Work

- Verification - Continue collecting data for robust statistical analysis of the URRD
  - URRD and its verification will also provide insights into model performance for model developers
- Work with WFOs on unique city criteria
- Gather feedback from meteorological, stormwater, and EM community during experimental period (NOAA Experimental Milestone - Q4 2025)
- Expand to additional cities (have had multiple requests to do so already)
- Continue website refinements and efficiency improvements
- Incorporate Atlas 15 data once available (expected 2026)
- Transition to entirely REFS when operational and HREF is retired (expected 2026)

References

- Alliance, U. W. (2020). Water rising: equitable approaches to urban flooding. US Water Alliance. *Available online at: https://cityparksalliance.org/wp-content/uploads/2020/09/Final_USWA_Water-Rising_0.pdf*
- Galloway, G.E., A. Reilly, S. Ryoo, A. Riley, M. Haslam, S. Brody, …, S. Parker (2018). University of Maryland, Center for Disaster Resilience, and Texas A&M University, Galveston Campus, Center for Texas Beaches and Shores, The Growing Threat of Urban Flooding: A National Challenge (College Park, MD: University of Maryland, 2018). *Available online at: https://cdr.umd.edu/sites/cdr.umd.edu/files/urban-flooding-report-online-revised.pdf.*
- Gerard, A., S. M. Martinaitis, J. J. Gourley, K. W. Howard, and J. Zhang, 2021: An Overview of the Performance and Operational Applications of the MRMS and FLASH Systems in Recent Significant Urban Flash Flood Events. Bull. Amer. Meteor. Soc., 102, E2165–E2176, https://doi.org/10.1175/BAMS-D-19-0273.1.
- Gourley, J. J., and Coauthors, 2017: The FLASH Project: Improving the Tools for Flash Flood Monitoring and Prediction across the United States. Bull. Amer. Meteor. Soc., 98, 361–372, https://doi.org/10.1175/BAMS-D-15-00247.1.
- Herman, G. R., and R. S. Schumacher, 2018: Flash Flood Verification: Pondering Precipitation Proxies. J. Hydrometeor., 19, 1753–1776, https://doi.org/10.1175/JHM-D-18-0092.1.
- Lincoln, W. S., R. F. L. Thomason, 2018: A preliminary look at using rainfall average recurrence interval to characterize flash flood events for real-time warning forecasting. J. Operational Meteor., 6 (2), 13-22, doi: https://doi.org/10.15191/nwajom.2018.0602
- National Academies of Sciences, Division on Earth, Life Studies, Water Science, Technology Board, Policy, ... & Committee on Urban Flooding in the United States (2019). Framing the challenge of urban flooding in the United States. National Academies Press. *Available online at: https://nap.nationalacademies.org/download/25381*
- NOAA Service Assessment: August-September 2021 Hurricane Ida (2023). *Available online at: https://www.weather.gov/media/publications/assessments/Hurricane_Ida_Service_Assessment.pdf*

NOAA

CIRES

THE NURTURE NATURE CENTER