New climate data reveals warmer, wetter future for the US

Many Americans could experience 53 days of extreme heat and 3.5 inches of heavy precipitation by 2050

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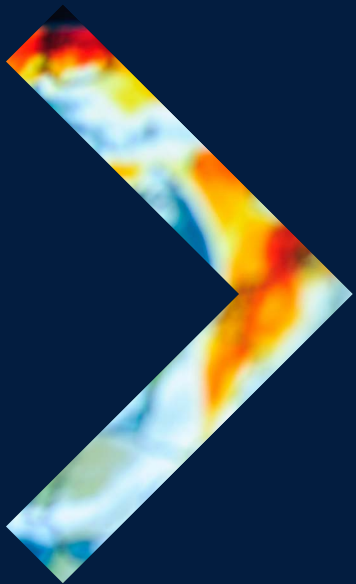


Americans could experience on average up to 53 days with temperatures above 95° F degrees and 3.5 inches during extreme three-day precipitation events by midcentury

Executive summary

Climate change is now affecting every part of the United States. Challenges from climate change touch every sector of the economy—health, energy, financial markets, agriculture, water, and more. As such, every sector has a stake in adapting.

However, only adapting to the climate changes we are already experiencing could leave significant risk on the table. In an era of climate change, the past is no longer an accurate predictor of the future. To understand future climate risks and impacts, and ultimately adapt to them, it's critical to look to the latest climate science that provides projections of future climate hazards. This data allows organizations to understand future risks and plan for them.

New internationally recognized climate projections recently became publicly available. Some federal government agencies and United Nations agencies have begun using the new data, but it's not yet widely used in climate risk and adaptation plans across the U.S. In this report, we use ICF's cutting-edge climate risk analytics platform, ClimateSight,[1] to offer a glimpse into how this new data changes our understanding of future climate risks.

The new data overall projects the potential for warmer and wetter extreme weather in the future across the continental United States. In a worst case scenario, Americans could experience on average up to 53 days with temperatures above 95° F degrees and 3.5 inches during extreme three-day precipitation events by midcentury. The upper end of this range is higher than the projections made with prior versions of the climate data and could change the way federal agencies, state and local governments, utilities, and other stakeholders prepare for future climate risks.

Learn more about climate risk modeling here.

[1] ClimateSight, ICF's proprietary climate risk analytics platform.

As with any massive and complex dataset, it can be unwieldy without a powerful climate risk analytics platform to process the data and a team of climate scientists and resilience specialists to analyze it and provide actionable solutions.

The next generation of climate projections

The Coupled Model Intercomparison Project (CMIP) is the global gold standard in climate data and modeling. For years, CMIP version 5 (CMIP5) was a standard go-to source of climate projections for climate scientists in the research community, federal government, and private sector. But CMIP version 6 (CMIP6) is now the gold standard. CMIP6 was the primary modeling framework in the latest United Nations Intergovernmental Panel on Climate Change assessment report and will be used in the fifth U.S. National Climate Assessment when it's released.

New global climate projections using CMIP6 stand out in a few key ways that help climate scientists project climate risks:

- **Linking human activities to greenhouse gases.** CMIP6 uses new projections of global socioeconomic changes—economic development, demographic shifts, sources of greenhouse gases, policies, and more—to project greenhouse gas emissions scenarios. By incorporating the latest socioeconomic changes into the CMIP6 data, climate scientists can project how much those changes could increase the concentration of greenhouse gases in the atmosphere.
- **Modeling the linkage between greenhouse gases and climate change.** Some CMIP6 models have higher climate sensitivities than CMIP5. This means CMIP6 projections show the earth's temperature could increase significantly in response to future greenhouse gas emissions and, in some cases, more than previously appreciated under CMIP5. These differences between CMIP6 and CMIP5 are amplified under more aggressive future greenhouse gas trajectories. Put simply, CMIP6 data projects the potential for more warming and precipitation than CMIP5 and, in turn, greater future climate risks.

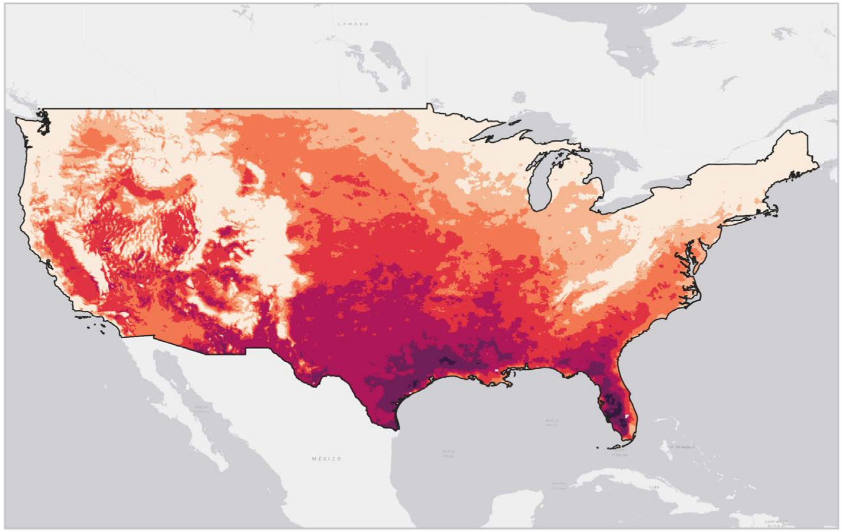
For all its benefits, CMIP6 has one major drawback worth noting. CMIP6 is not a plug-and-play dataset. As with any massive and complex dataset, it can be unwieldy without a powerful climate risk analytics platform to process the data and a team of climate scientists and resilience specialists to analyze it and provide actionable solutions. Climate risk analytics enables us to apply the best available climate science and data to measure and assess the risks posed by climate change. For example, the modeling we perform in this report with ICF's climate risk analytics platform, ClimateSight, analyzed billions of data points from present day through the mid-21st century to understand how temperature and precipitation extremes are projected to change in the future. Many of the projects we're now doing for governments and the private sector with CMIP6 data are even more complex.

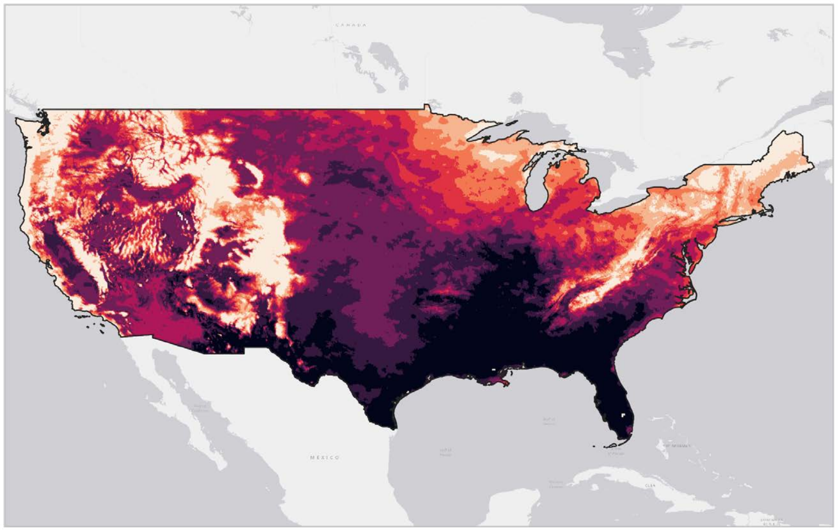
Heat waves in the heartland, deluges in the East: A look at a possible US climate future

Localized Constructed Analogs version 2 (LOCA2)[2] projections are the latest version of high-resolution, downscaled CMIP6 climate model data available for use across the United States. Figure 1 shows LOCA2 CMIP6 projections for both moderate and high greenhouse gas (GHG) emissions scenarios against the historical average. We mainly focus on high GHG emissions scenarios in this analysis because it's important for planners to understand the potential for high-end risks so they can plan for the most extreme possible outcomes. These high emissions scenarios are also one area where climate sensitivity and the differences between CMIP6 and CMIP5 projections are largest.

Americans could experience an average of 17 to 35 additional days each year with temperatures above 95°F degrees by midcentury compared to the historical average.[3] Projections are generally lower under the moderate emissions scenario. The Southeast U.S., Texas, and California's Central Valley are among the locations that could see the largest absolute increase in days over 95° F, compared to historical records (see Figure 1). Days with temperatures above 95° F degrees are significant because these acute extreme heat events are particularly dangerous for lives and livelihoods, impacting health and reliable access to power.

Figure 1: Change in days over 95° F in 2050 compared to historical average[4]





Source: ICF ClimateSight

[2] Pierce, D. W., Cayan, D. R., Feldman, D. R., & Risser, M. D. 2023: Future Increases in North American Extreme Precipitation in CMIP6 downscaled with LOCA. Journal of Hydrometeorology. https://doi.org/10.1175/JHM-D-22-0194.1.

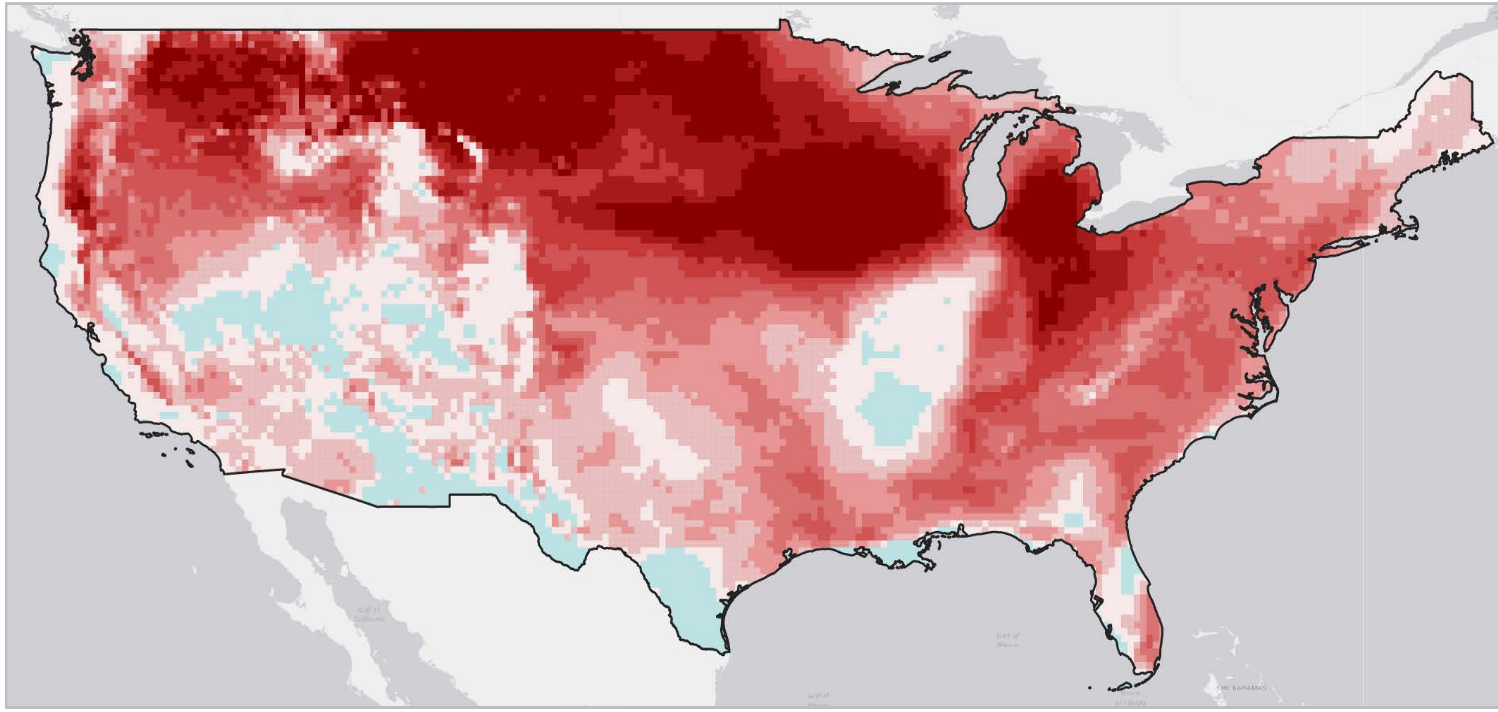
[3] On average across the United States using LOCA2 CMIP6 SSP2-4.5 and SSP5-8.5 50th Percentile projections.

[4] LOCA2 CMIP6 SSP2-4.5 and SSP5-8.5 50th Percentile projections.

NASA Global Daily Downscaled Projections (NEX-GDDP),[5] a downscaled CMIP6 global climate model dataset, has also been released to the public recently. Figure 2 shows the difference between extreme heat projections made with CMIP6 data and CMIP5 data. Overall, CMIP6 projects more warming than CMIP5,[6] however the increase in extreme heat is not distributed evenly across the U.S. CMIP6 reveals the northern Great Plains, the northwestern U.S., and portions of the Midwest could experience more extreme heat than previously projected based on CMIP5. Smaller pockets of the Southwest and Midwest could experience less extreme heat.

Figure 2: 2050 days with maximum temperatures over 95˚F

Difference between CMIP5 and CMIP6[7]



2050 days with maximum temperatures over 95F in 2050:
Differences between CMIP6 and CMIP5

- <= 0
- > 0 – 4
- > 4 – 8
- > 8 – 12
- > 12 – 16
- > 16 – 20
- > 20 – 24
- > 24 – 28
- > 28

Source: ICF ClimateSight

[5] Thrasher, B., W. Wang, A. Michaelis, F. Melton, T. Lee, R. Nemani, 2022: NASA Global Daily Downscaled Projections, CMIP6. Scientific Data, 9 (1), 1-6. https://doi.org/10.7917/OFSG3345

[6] On average across the United States, NEX-GDDP CMIP6 SSP5-8.5 projects 41.9 (50th percentile, or median of models) and 61.2 days per year above 95˚F (90^{th} percentile), while NEX-GDDP CMIP5 RCP 8.5 projects 36.4 (50^{th} percentile) to 47.3 days per year above 95˚F (90^{th} percentile) by mid-century.

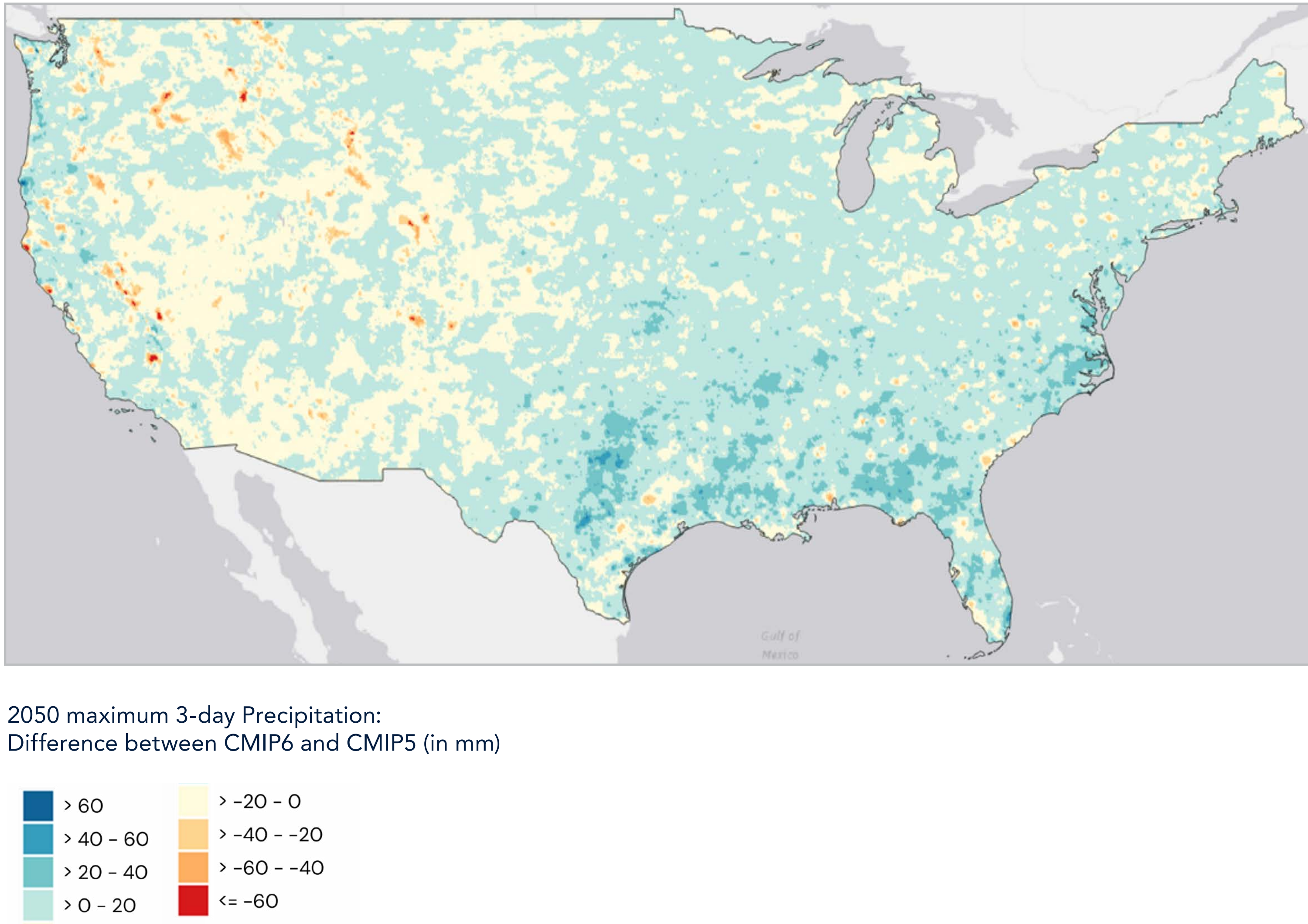
[7] NEX-GDDP CMIP6 SSP5-8.5 90^{th} Percentile – CMIP5 RCP 8.5 90^{th} Percentile

CMIP6 LOCA2 features improvements from the previous CMIP5 downscaled data resulting in higher daily precipitation extremes. In Figure 3, CMIP6 LOCA2 projections for annual maximum three-day extreme precipitation events indicate the potential for even wetter precipitation extremes in the future than CMIP5 projections.

In a worst-case scenario for increasing precipitation, CMIP6 projects three-day maximum precipitation totals of 3.5 inches on average, compared to CMIP5 projections of 3.4 inches by midcentury.[8] Clearly, the difference between 3.5 inches and 3.4 inches is not dramatic. However, these are U.S.-wide averages and a small increase could signify significant increases at the regional and local scale. For example, more precipitation could occur across the eastern U.S. than previously expected. The difference is most pronounced in the Southeast, where severe storms and hurricanes driven by moisture from the Gulf of Mexico are frequent and impactful. In the west, other than the coastal Pacific Northwest, three-day precipitation events could be less extreme under CMIP6 than CMIP5 based on the high emissions scenarios.

High-resolution CMIP6 LOCA2 projections reveal local variability in precipitation projections and the complexities of characterizing local-scale precipitation across the U.S. Small wetter (blue) areas in the mostly dryer (red) West dot the map. Small dryer areas similarly appear in the wetter East. Small pockets of land in the East may see lower precipitation totals than previously expected even though the region as a whole may experience wetter storms and more precipitation.

Figure 3: 2050 maximum 3-day precipitation difference between CMIP6 and CMIP5 (in mm)[9]



Source: ICF ClimateSight

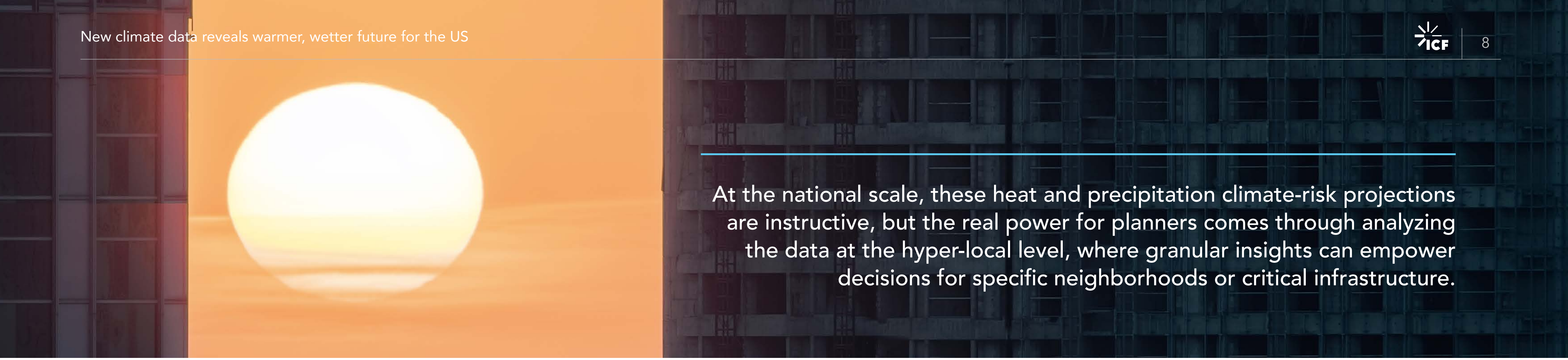
[8] Based on RCP 8.5 and SSP5-8.5 90^{th} percentile projections. On average across the CONUS, LOCA2 CMIP6 SSP5-8.5 projects 3.2 inches (50^{th} percentile, or median of models) to 3.5 inches (90^{th} percentile) for maximum 3-day precipitation totals, while CMIP5 RCP 8.5 projects 77.3 mm (3.0 inches) (50^{th} percentile) to 86.9 mm (3.4 inches) (90^{th} percentile) by mid-century.

[9] LOCA CMIP6 SSP5-8.5 90^{th} Percentile – CMIP5 RCP 8.5 90^{th} Percentile

Climate model data in action at the local level

At the national scale, these heat and precipitation climate-risk projections are instructive, but the real power for planners comes through analyzing the data at the hyper-local level, where granular insights can empower decisions for specific neighborhoods or critical infrastructure. The finer resolution of downscaled projections, such as the CMIP6 LOCA2 data, is particularly important for these downscaled, hyperlocal projections.

Here, we put the CMIP6 data to the test through exploration of risks across three hazards and localities.



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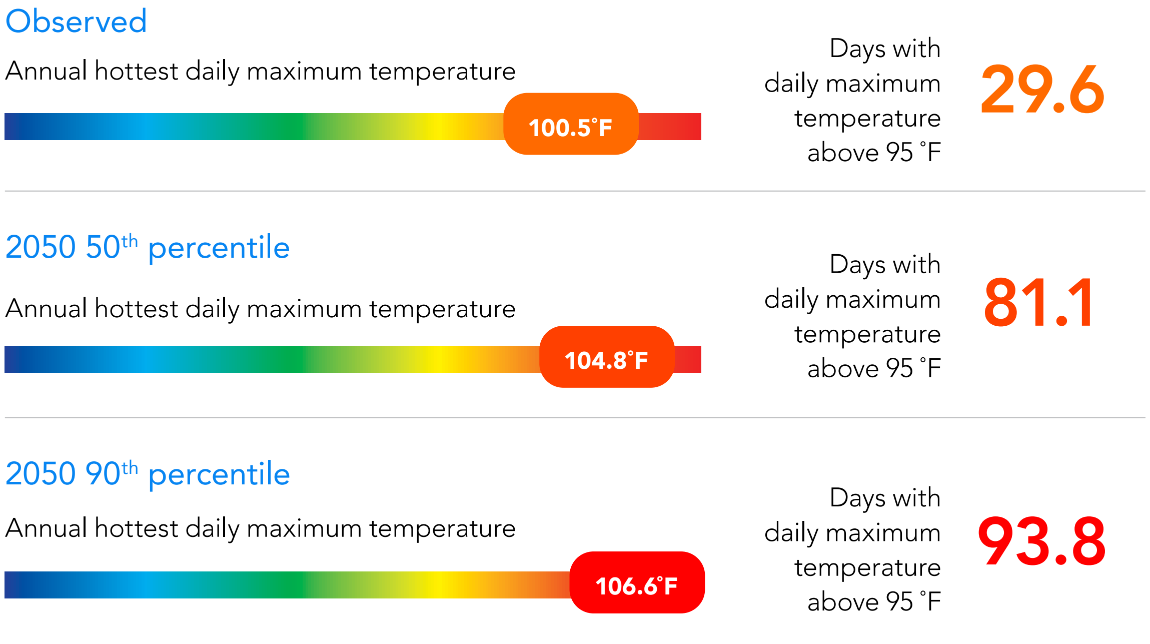
Human health in hot and humid Houston

An extreme heat wave over Texas in 2011 contributed to the warmest summer in Houston since 1889. All but one day exceeded 100 ˚F during August. Then in 2022, Houston experienced its hottest July on record, setting a July daily maximum temperature record of 105 ˚F. CMIP6 median and extreme models for the high emissions pathway indicate that these red-hot summers could be the norm by 2050.

Figure 4 illustrates how much warmer and more frequent heat waves could be under high-end warming scenarios by 2050. Houston could experience two to three times more days over 95 ˚F and hit the July 2022 maximum temperature record of 105 ˚F annually.

These increased heat extremes are likely to have major impacts on human health in the Houston area. It's well documented[10] that extreme heat results in increased deaths and hospitalizations, particularly among vulnerable populations such as the elderly and lower income families who may not have adequate access to air conditioning. But the impacts don't stop there. In a recent study[11] funded by the U.S. Environmental Protection Agency, ICF found that for every degree temperatures warm in the future, the number of suicides could rise. Warming temperatures from climate change could result in an increase of up to 1,660 additional suicide cases annually later this century in the U.S.

Figure 4: Extreme heat projections for Houston, Texas by midcentury[12]



Source: ICF ClimateSight

[10] Future heat waves and heat-related deaths projected to increase in the Pacific Northwest

[11] Understanding the impact of climate change on mental health

[12] LOCA2 CMIP6 SSP5-8.5 Scenarios

Energy demand from extreme heat in the Pacific Northwest

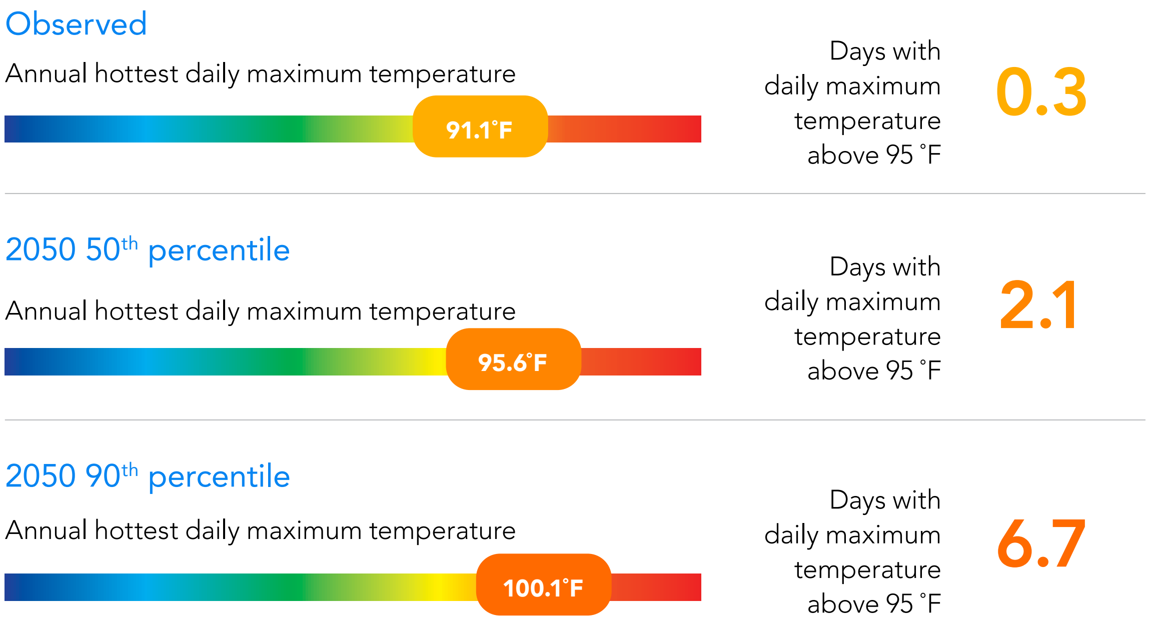
The Pacific Northwest has experienced record-breaking heat waves in recent years. In June 2021, Seattle experienced its warmest day on record (108 ˚F) and exceeded 100 ˚F three times. During a July 2022 heat wave, Seattle set a record of three consecutive days above 95 ˚F.

Figure 5 shows that heat waves could be much warmer and more frequent under high-end warming scenarios by 2050.

While a low percentage of households have air conditioning in the Seattle metro area today, the increased frequency and intensity of heat waves could impact summertime energy demand by midcentury. This increased demand is significant, because fossil-fuel fired peaking plants may come online to meet extra demand during heat waves. Future heatwaves may thus produce a feedback loop that results in higher greenhouse gas emissions, which contribute to more warming.

Some utilities have had to install extra cooling systems to keep their own equipment from overheating. As extreme heat events continue in the future, there will be other strains on electricity infrastructure; above-ground power lines will suffer reduced transmission capacity and thermal power generation plants will suffer reduced efficiency.

Figure 5: Extreme heat projections for Seattle, Washington by midcentury[13]



Source: ICF ClimateSight

[13] LOCA2 CMIP6 SSP5-8.5 Scenario

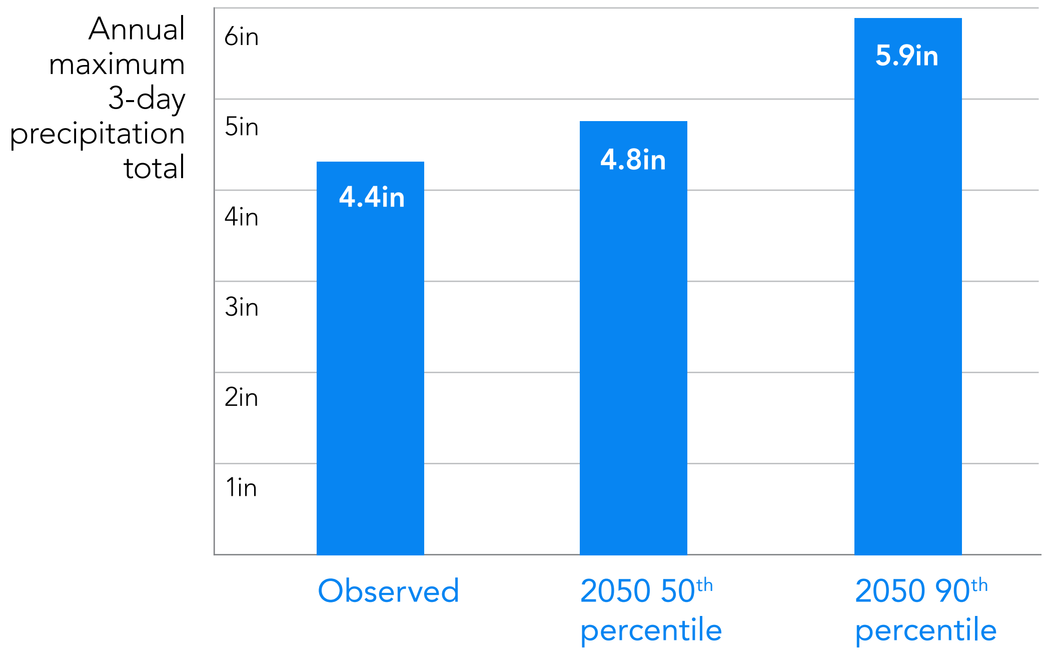
Flooded infrastructure from extreme precipitation in New York

In 2021, the remnants of Hurricane Ida dumped upwards of 9 inches of rainfall in Brooklyn and more than 8 inches in Manhattan (which also recorded an all-time record of 3.15 inches in one hour).

Figure 6 shows maximum three-day rainfall totals in New York City could be much more extreme under high-end warming scenarios by 2050. Events like Hurricane Ida could be more intense as a result of climate change in the future.

With high rainfall totals, the remnants of Ida led to significant flood damage across the greater New York City area. Without substantial climate adaptation efforts, more intense precipitation events will have significant impacts to both residential and transportation infrastructure in New York City, which is highly vulnerable to flooding.

Figure 6: Extreme precipitation and flooding in New York City by midcentury[14]



Source: ICF ClimateSight

[14] LOCA2 CMIP6 SSP5-8.5 Scenario

Conclusion

Most organizations engaged in climate-risk planning today are using CMIP5 data, and it is certainly acceptable to rely on existing studies and risk assessments that use that data. However, the time to start shifting decision-making to CMIP6-based climate risk assessments begins now.

Investments are at stake. The Inflation Reduction Act (IRA) and Infrastructure Investment and Jobs Act (IIJA) created billions in funding for roads, bridges, energy projects, and other critical infrastructure. Federal agencies, state and local governments, utilities, and private sector companies can now use state-of-the-art climate data to identify risk scenarios and actionable insights across all sectors. Ultimately, using the latest climate data can strengthen infrastructure investments to go further and last longer in a changing climate.

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Dr. Daniel Bishop is a climate science and extreme weather expert at ICF who uses complex datasets and tools to assess climate and natural hazard risk and develop resilience and adaptation strategies. Dan brings experience in physical climate science, climate and extreme event modeling, and geospatial analysis to inform climate vulnerability work with an expertise in hydroclimate and drought variability. Dr. Bishop's previous professional experience includes working as an atmospheric scientist in the catastrophe modeling industry, where he developed future climate change scenarios for hurricane, flood, and wildfire models. He has published first-author research in journals such as Journal of Climate, Geophysical Research Letters, and Environmental Research Letters.

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Dr. Mason Fried is a climate scientist who uses climate projections and analytics to assess climate and extreme weather risks and develop resilience solutions for clients in the public and private sectors. Mason offers relevant climate expertise across a range of hazards such as sea level rise, tropical cyclones, and heat waves and has worked with transportation authorities, utilities, and regional governing agencies. He brings experience in physical climate science, climate modeling, remote sensing, and uncertainty calculation to inform climate and extreme weather resilience.

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Matt Townley is an architect and lead developer of a suite of enabling technologies for our Climate Adaptation, Mitigation, and Sustainability practitioners. He deploys cloud resources; architects large databases; applies expert-level R, statistics, and machine learning skills; and leads analysis of multi-terabyte earth-science data in various geospatial formats.

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Matia Whiting is a specialist in ICF's Climate Adaptation and Resilience portfolio. Matia supports a variety of work across the portfolio through GIS and data analysis in R and Excel, graphic creation and mapping, technical writing, and research. She works on the data components of projects within and beyond the energy sector, and her work entails generating custom climate projections, analyzing asset exposure to climate hazards, and creating compelling visuals in the form of maps and graphs to present the data to clients.

Ultimately, Matia seeks to use innovative data-driven techniques to understand climate change impacts and corresponding conservation and resilience options for a variety of users.

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