Greenbuild

Don’t Sweat It

Designing for Extreme Heat and Resilience

Don’t Sweat It: Designing for Extreme Heat and Resilience

Course Description: Extreme heat, wildfires, smoke, drought, and floods are increasingly frequent and severe, posing growing health risks—especially to disadvantaged communities. Schools and multifamily housing are particularly vulnerable to overheating, impacting health, learning, and equity. This session, aligned with LEED v5 and Passive House standards, explores integrated design and enclosure strategies to reduce peak cooling loads, enhance passive survivability, and boost climate resilience. It also covers health risks from wildfire smoke and effective protective measures. Case studies from diverse U.S. climates show how advanced enclosure design and thermal modeling using historical and future weather data can improve comfort and safety during extreme events—even when multiple hazards occur at once.

Learning Objectives / Level

1) Summarize the metrics used to evaluate passive survivability.

2) Describe the difference between future climate projection averages and future peak temperature events.

3) Implement what are the necessary components needed to design a high-performance building enclosure.

4) Explain how meeting LEED v5 BD+C credit Reduce Peak Thermal Loads, option 4 Peak Thermal Load Reductions makes buildings more grid-friendly and improves passive survivability.

Learning Level: Intermediate

Rating System: LEED v5 BD+C

Don’t Sweat It: Designing for Extreme Heat and Resilience

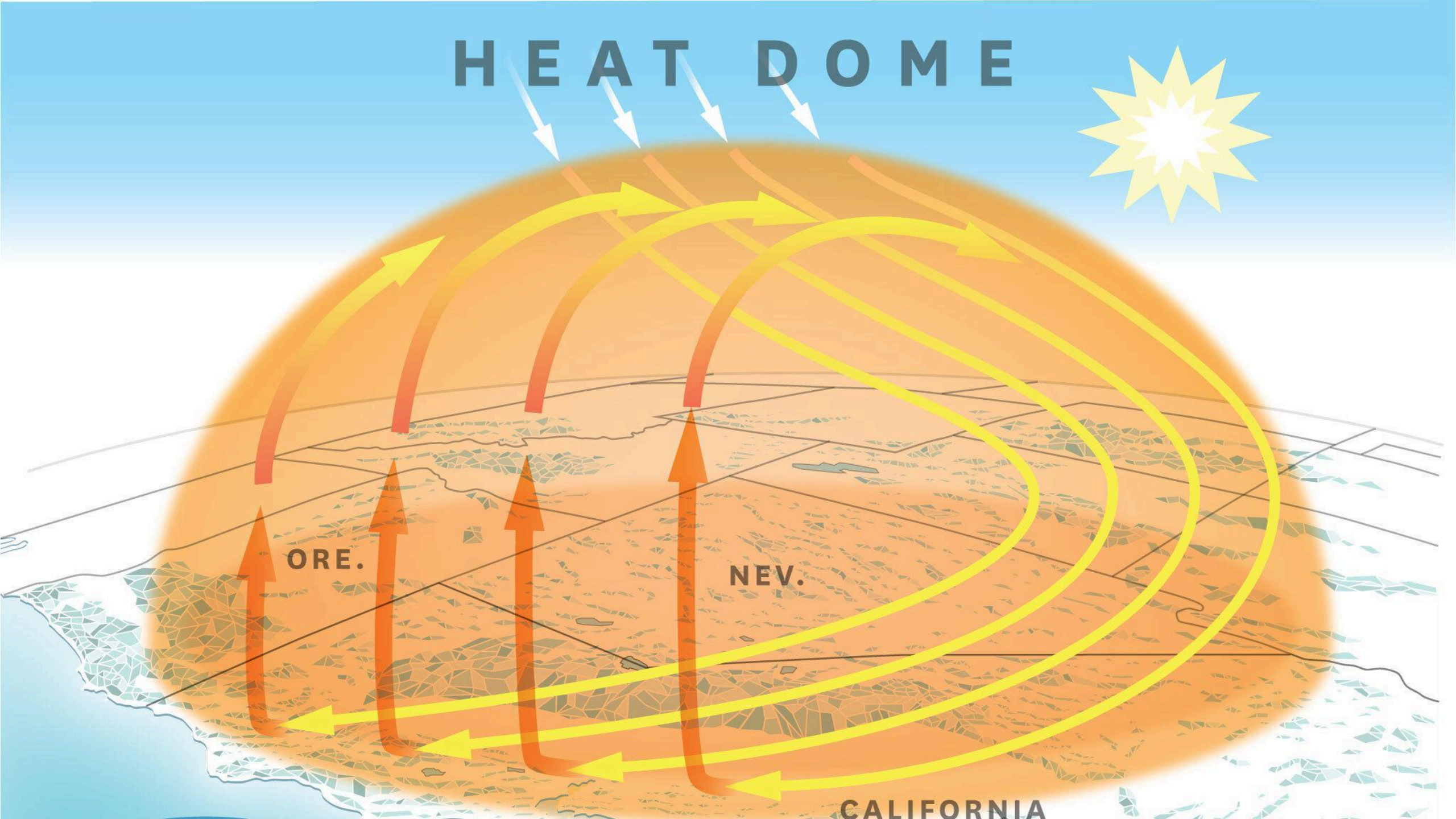
Presenters:

Claire McConnell, BEMP | Mithun

Kerri Mueller, REHS | Missoula Public Health

Mike Fowler, AIA, CPHC, LEED AP | Mithun

Teresa Moroseos, AIA | Integrated Design Lab / Univ. of Washington


HEAT DOME
ORE.
NEV.
CALIFORNIA


U.S. CITIES HIT ALL-TIME HEAT RECORDS MONDAY
SEATTLE
108°F
WA
PORTLAND
116°F
OR
MEDFORD
115°F
OR
QUILLAYUTE
110°F
WA
RECORD HEAT
PACIFIC NORTHWEST BAKES IN "UNPRECEDENTED" HEAT WAVE
LIVE
CNN
NAS ▲ 15.23

Washington State Department of Health (.gov)
https://doh.wa.gov › hot-weather-precautions › heat-wav...

Heat Wave 2021 | Washington State Department of Health

From June 26 to July 2, 2021 the National Weather Service in Seattle reported a long-duration, **unprecedented heat wave** throughout the Pacific Northwest.

E&E News by POLITICO
https://www.eenews.net › Articles

Marine heat wave 'unprecedented but not unexpected'

Oct 7, 2025 — **A wave crashes on Anna Maria Island, Florida**. A 2023 heat wave brought the highest temperature anomalies in the North Sea and Celtic Sea since ...

Earth.Org
https://earth.org › nordic-countries-bake-in-unpreceden...

Nordic Countries Bake in Unprecedented Heatwave

Aug 4, 2025 — **Temperatures surpassed 30C in parts of Finland, Norway and Sweden**, which is significantly higher than average summer temperatures in Nordic ...

AGU Publications
https://agupubs.onlinelibrary.wiley.com › doi › full

The Unprecedented 2023 North China Heatwaves and Their ...

by H Xiao · 2024 · Cited by 35 — In June–July 2023, North China was struck by a series of severe **heatwaves**. Historical temperature records were either reached or surpassed in 22 ...

The Conversation
https://theconversation.com › unprecedented-heat-in-th...

Unprecedented heat in the North Atlantic Ocean kickstarted ...

Jun 4, 2025 — In June 2023, **a record-breaking marine heatwave swept across the North Atlantic Ocean**, smashing previous temperature records.

Relentless Heat in the Southwest

Jul 27, 2023 — An **unprecedented** streak of extreme temperatures scorched the southwestern U.S. in July 2023. Blistering temperatures have lingered in the ...

Yale Climate Connections
https://yaleclimateconnections.org › 2025/06 › unprece...

Unprecedented June heat along the Northeast urban ...

Jun 25, 2025 — On June 24, **temperatures approached or exceeded 100°F** along the urban corridor Washington, DC to Boston.

Nature
https://www.nature.com › ... › articles

Recent European marine heatwaves are unprecedented ...

by JRC Atkins · 2025 — The European North-West shelf seas experienced a **marine heatwave of unprecedented magnitude in June 2023**. Quantifying the likelihood of ...

ScienceDirect.com
https://www.sciencedirect.com › science › article › pii

The Unprecedented Late-Summer 2023 Heatwave in ...

by WM Kim · 2025 · Cited by 1 — The **heatwave** occurred during an ongoing multi-year drought with three continuous years of anomalously low precipitation, which led to an extremely dry summer ...

Nature
https://www.nature.com › articles

Global emergence of unprecedented lifetime exposure to ...

by L Grant · 2025 · Cited by 28 — Under a 1.5 °C pathway, 52% of people born in 2020 will experience **unprecedented** lifetime exposure to **heatwaves**. If global warming reaches 3.5 ° ...

Acropolis closes to protect tourists as Greece faces unprecedented heatwave

First-aid workers drafted in to treat visitors suffering effects of 48C - 118F -temperatures at the country's most visited monument

Helena Smith *in Athens*

Sat 15 Jul 2023 10.10 EDT

Tourists at the Acropolis on Thursday, a day before extreme heat forced officials to close the historic site early. Photograph: Petros Giannakouris/AP

‘Off the charts’: 2023 was hottest year ever recorded globally, US scientists confirm

New analysis confirms ‘unprecedented’ record reported by European Union and United Nations scientists

A child looks at a wildfire in Chasia on the outskirts of Athens, Greece, on 22 August 2023. Photograph: Angelos Tzortzinis/AFP via Getty Images

OUTDOORS

Scientists sound alarm after collecting unprecedented data from world's oceans: 'The broken records ... have become a broken record'

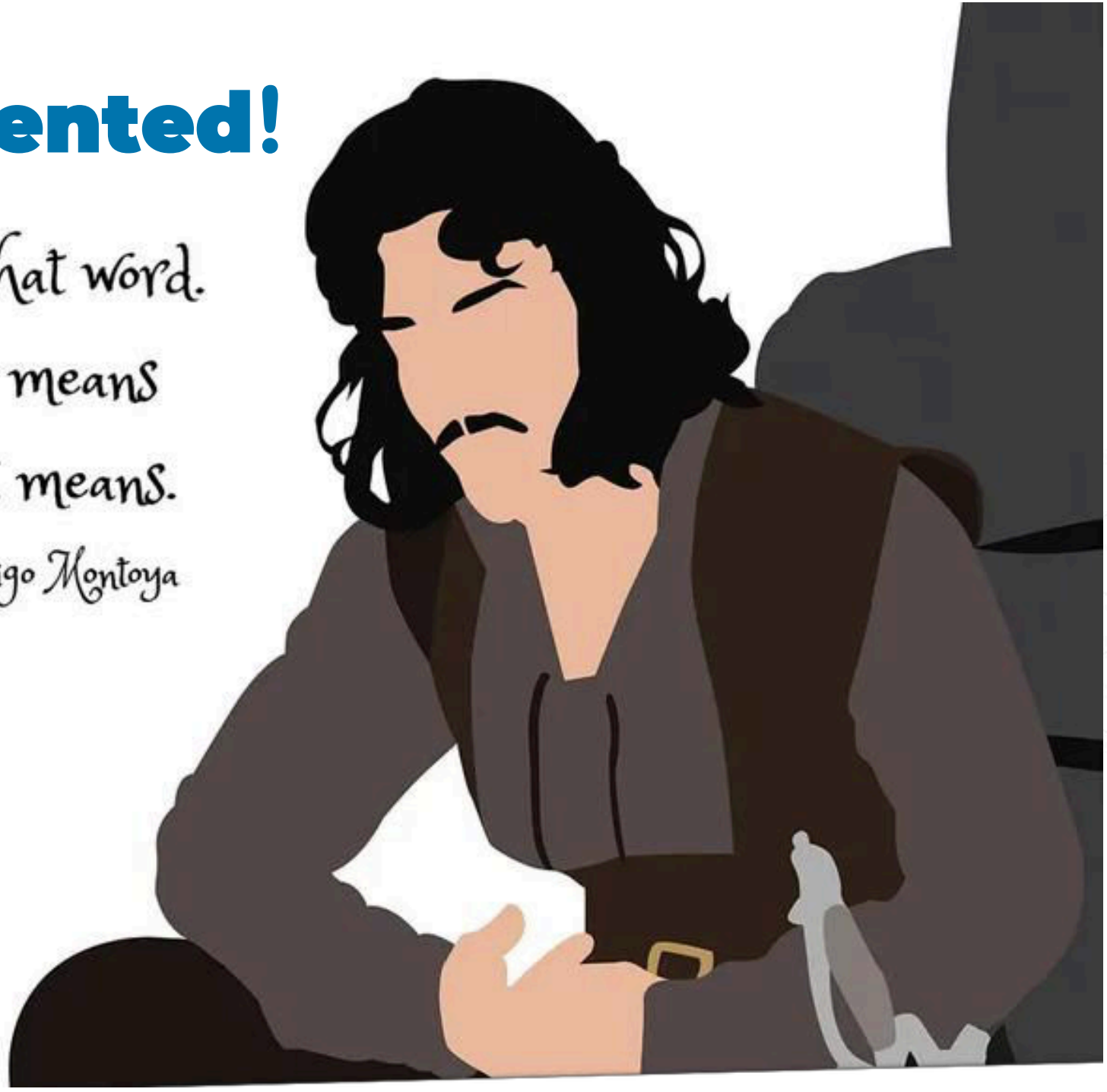
"To know what is happening ... the answer is in the ocean."

By Leslie Sattler / February 22, 2025

Unprecedented!

You keep using that word.
I do not think it means
what you think it means.

–Inigo Montoya



The Guardian
https://www.theguardian.com › world › aug › france-la...

'Unprecedented' wildfire burns area size of Paris in ...

Aug 6, 2025 — **Advancing blaze scorches 16000 hectares near Spanish border**, destroying homes and forcing people to flee.

UNDRR
https://www.undrr.org › news › europe-confronts-unprec...

Europe confronts an unprecedented wildfire season

Aug 15, 2025 — Europe is experiencing what may become one of its most devastating **wildfire** seasons on record. How can we step up long-term prevention ...

University of Reading
https://www.reading.ac.uk › news › Expert-Comment

'Unprecedented wildfires show no sign of stopping' - expert

Jan 23, 2025 — Dr Olivia Haas, wildfire expert at the University of Reading, explains **what has made the wildfires so devastating**, what needs to happen for the wildfires to ...

BBC
https://www.bbc.com › news › articles

France wildfire is 'catastrophe on an unprecedented scale ...

Aug 6, 2025 — At least 25 homes have been destroyed and **more than 2,500 households are without electricity**. Dozens of vehicles have also been burnt out, ...

DW
https://www.dw.com › deadly-unprecedented-wildfire-r...

Deadly 'unprecedented' wildfire rages in southwestern ...

Aug 7, 2025 — The **intense wildfire near France's border to Spain** has already scorched 16000 hectares, killing one and injuring 13.

OEHHA (.gov)
https://oehha.ca.gov › epic-2022 › impacts-human-health

Wildfire Smoke - OEHHA - CA.gov

3 days ago — A record-high 4.2 million acres burned in 2020, and several large **wildfires** l leading to **unprecedented** air quality impacts.

UK Centre for Ecology & Hydrology
https://www.ceh.ac.uk › News And Media › News

Climate change caused unprecedented wildfires

Aug 14, 2024 — **Unprecedented wildfires** in Canada last year were three times more likely due to climate change and contributed to high levels of CO2 emissions from burning ...

SpringerOpen
https://fireecology.springeropen.com › articles

How an unprecedented wildfire shaped tree hollow ...

by B Wagner · 2024 · Cited by 7 — These large severe fires can impact the entire geographic distributions of many forest-dwelling fauna, as evidenced by the 2019/2020 “Black ...

US Forest Service Research and Development (.gov)
https://research.fs.usda.gov › treesearch

Carbon loss from an unprecedented Arctic tundra wildfire

by MC Mack · 2011 · Cited by 536 — Here we report that tundra ecosystems lost 2,016 ± 435 g Cm^{-2} in the fire, an amount two orders of magnitude larger than annual net C exchange in undisturbed ...

World Economic Magazine
https://worldecomag.com › how-unprecedented-wildfir...

How Unprecedented Wildfire Season Engulfs North ...

North America is experiencing a catastrophic wildfire season, with **fast-moving blazes spreading smoke and ash across vast** regions from Reno to Toronto and New ...

Climate Change A Factor In Unprecedented LA Fires

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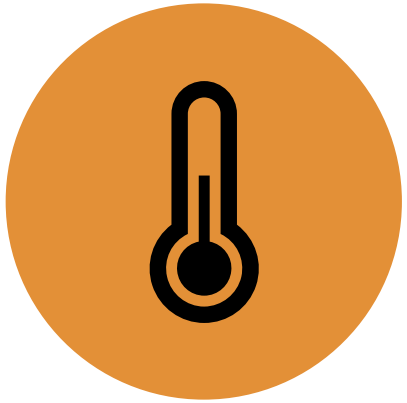
Climate Change and Health Risks

Increased frequency and intensity of wildfires.



More extreme heat events from hotter, drier summers.

Compounding health impacts from wildfire smoke and heat.

Health Impacts of Climate Change

Wildfire Smoke Exposure

- Coughing
- Wheezing
- Itchy, watery eyes
- Itchy, sore throat
- Headaches
- Irritated respiratory tract
- Reduced lung function
- COPD aggravation
- Asthma attacks
- Heart & lung disease complications
- Reduced immune responses
- Pneumonia complications
- Increased + ER hospital visits
- Stroke
- Heart attack
- Cognitive decline
- Mental health decline

Extreme Heat

- Decreased cognitive function
- Sleep disturbance
- Cardiovascular and respiratory issues
- Stroke
- Death

Press Room

"No safe level of air pollution exists. The World Health Organization's new Global Air Quality Guidelines emphasize how improving air quality can achieve substantial health benefits for people everywhere."

Statement from Sumi Mehta, Senior Epidemiologist, Vital Strategies, on the release of WHO's Global Air Quality Guidelines:

https://www.epa.gov/wildfire-smoke-course/why-wildfire-smoke-health-concern
https://www.epa.gov/wildfire-smoke-course/health-effects-attributed-wildfire-smoke

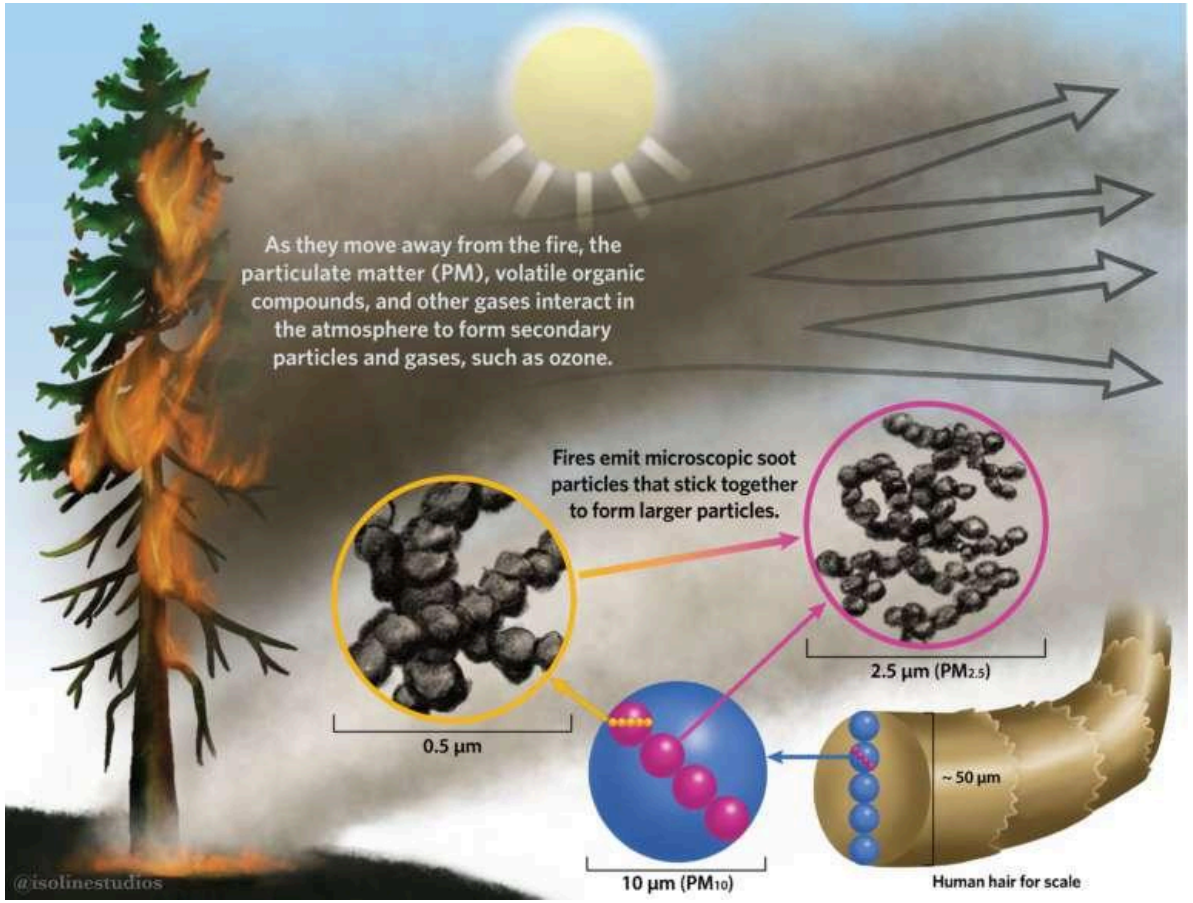
At-Risk Populations of Wildfire Smoke Exposure & Extreme Heat

Sensitive Groups

- Babies and children (<18 yrs old)
- Older adults (>65 yrs old)
- People with chronic health problems
  - Heart or lung disease
  - Diabetes
- Pregnant people
- Outdoor workers
- People living outside
- All of us really, even pets!

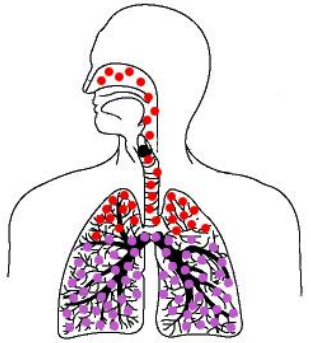
https://www.epa.gov/wildfire-smoke-course/why-wildfire-smoke-health-concern
https://www.epa.gov/wildfire-smoke-course/health-effects-attributed-wildfire-smoke

Why is Wildfire Smoke Harmful?



Smoke Contains

- Particulate Matter
  - PM10 & **PM2.5**
- Ozone
- Nitrogen Oxides: NOX
- Sulfur Dioxide: SO_2
- VOCs
- Carbon Dioxide: CO_2
- And more…



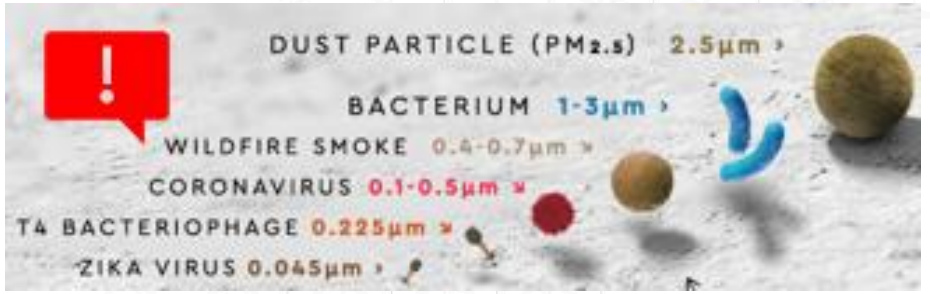


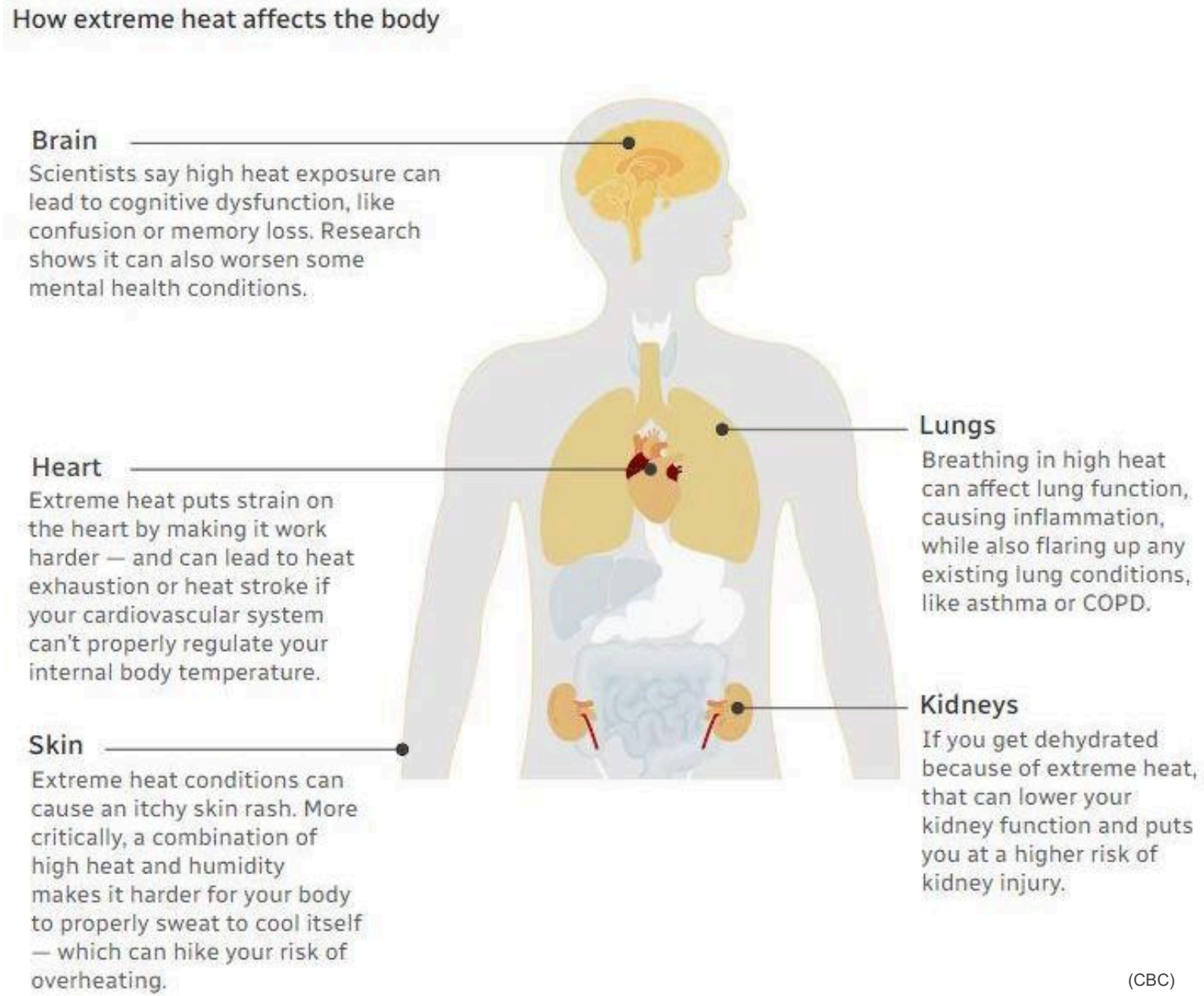
Image sources: https://healthybuildings.hsph.harvard.edu/protecting-your-health-from-wildfire-smoke-spotlight-on-filters/
https://www.visualcapitalist.com/visualizing-relative-size-of-particles/

What is the Air Quality Index or AQI?

- Tool to communicate levels of air pollution related to health concerns.
- Translates PM2.5 levels into a more understandable measurement.

Air Quality Levels of Concern (values of index)	Recommended Actions
Good (0-50)	**Everyone:** Don't see or smell smoke? It's a good time to open windows or go outdoors.
Moderate (51-100)	**Everyone:** Don't see or smell smoke? It's OK to open windows or go outdoors. **Unusually Sensitive People:** Consider making outdoor activities light and short. Go inside to cleaner air if you have symptoms.
Unhealthy for Sensitive Groups (101-150)	**Everyone:** Consider lighter and shorter outdoor activities. **Sensitive Groups:** Go inside to cleaner air if you have symptoms.
Unhealthy (151-200)	**Everyone:** Keep outdoor activities light and short. Go inside to cleaner air if you have symptoms. **Sensitive Groups:** Consider moving all activities inside. Go inside to cleaner air if you have symptoms.
Very Unhealthy (201-300)	**Everyone:** Limit outdoor physical activity. Go inside to cleaner air if you have symptoms. **Sensitive Groups:** Avoid all outdoor physical activity.
Hazardous (301-500)	**Everyone:** Avoid all outdoor physical activity. **Sensitive Groups:** Stay indoors and keep activity levels light. Stay indoors and consider creating a cleaner air room.

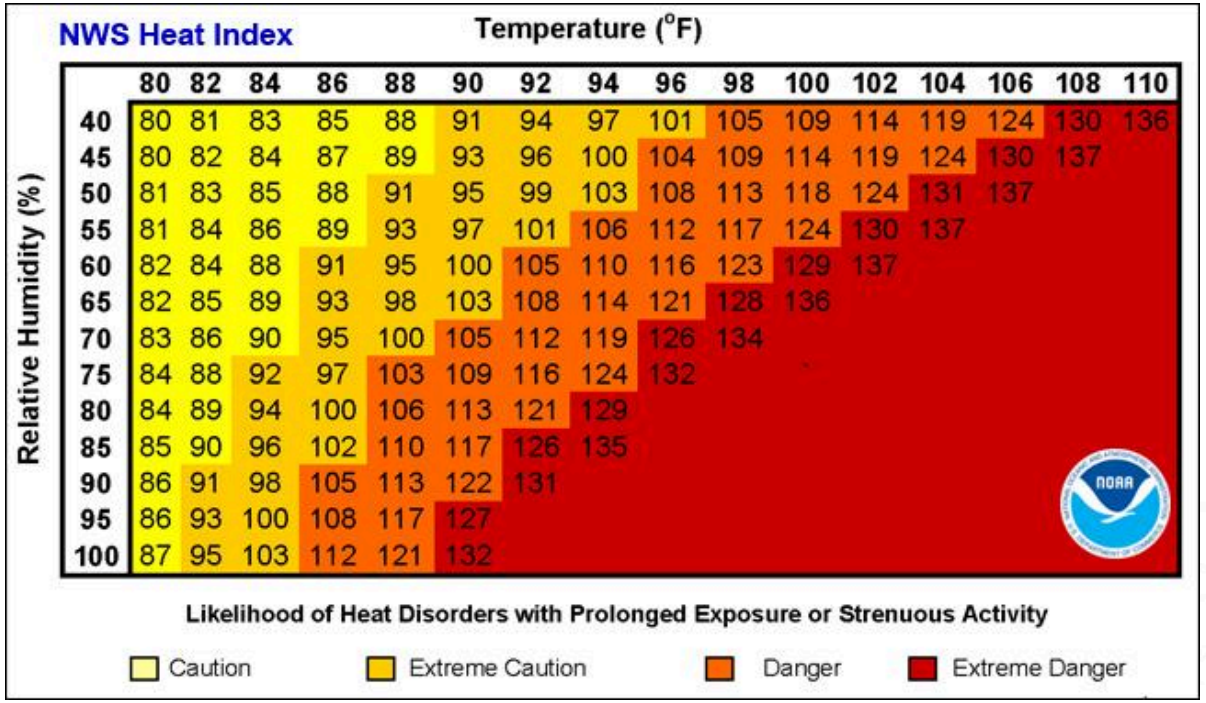
Why is Extreme Heat Harmful?



(CBC)

What is the Heat Index?

- Translates temperatures into a more understandable measurement.
- Tool to communicate air temperature levels and relative humidity.



Classification	Heat Index	Effect on the body
Caution	80°F - 90°F	Fatigue possible with prolonged exposure and/or physical activity
Extreme Caution	90°F - 103°F	Heat stroke, heat cramps, or heat exhaustion possible with prolonged exposure and/or physical activity
Danger	103°F - 124°F	Heat cramps or heat exhaustion likely, and heat stroke possible with prolonged exposure and/or physical activity
Extreme Danger	125°F or higher	Heat stroke highly likely

Preventing Negative Health Effects of Wildfire Smoke & Extreme Heat

- Cleaning indoor air
- Air conditioning
- Building with climate resiliency in mind

MERV 13 AIR FILTERS

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Future Climate Projections

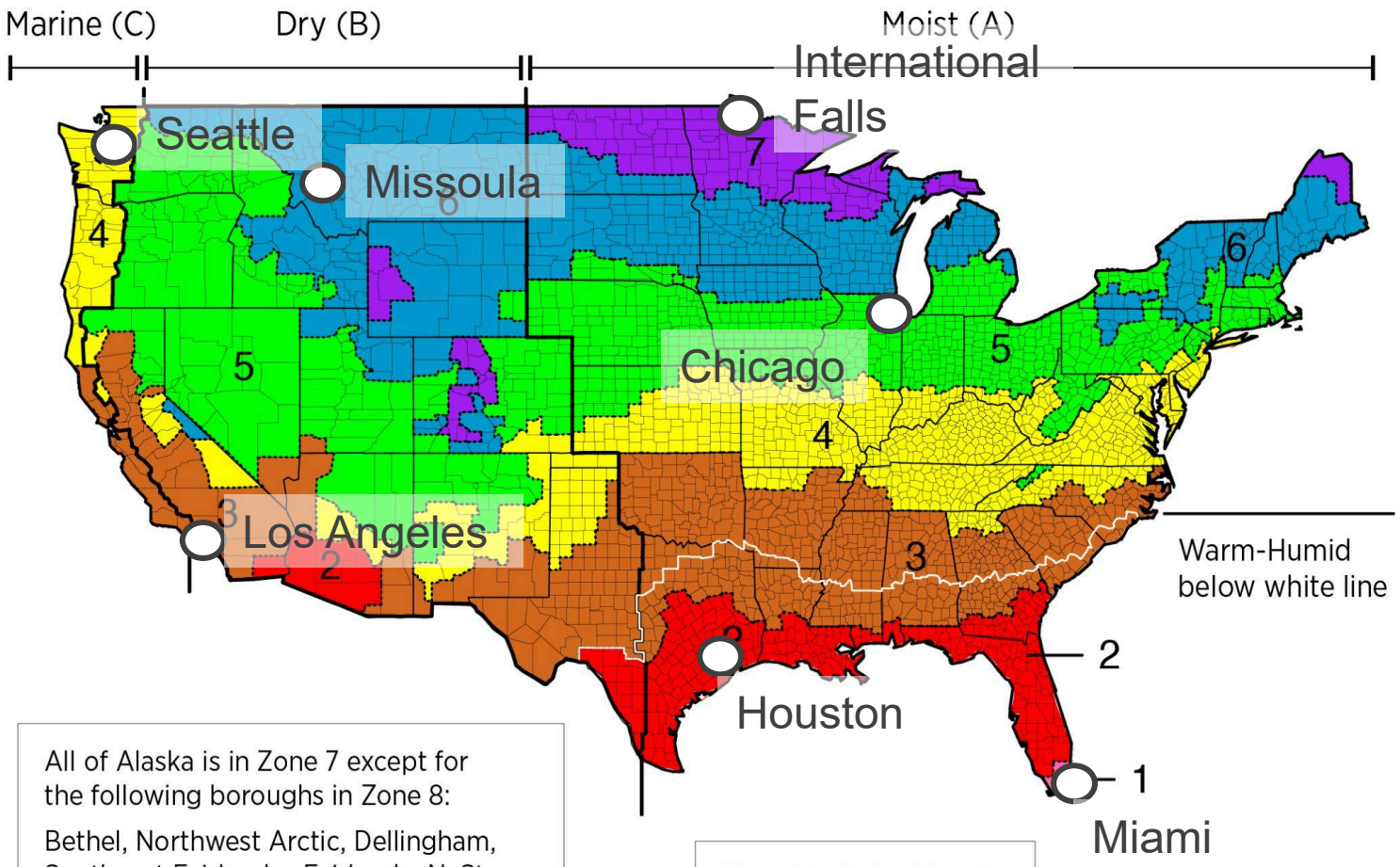
Future Typical Meteorological Year (fTMY) Weather Files[1]

developed by Oak Ridge National Laboratory

- DOE Funded, last update March 12, 2024
- Typifies hourly weather conditions for every US county (dry bulb temp, dew point, wind velocity, solar radiation, etc) for 10-year periods from 1980 to 2099
- Future weather data generated from six IPCC Global Climate Models, projected using IPCC climate scenario SSP 5-8.5 (Shared Socioeconomic Pathway (SSP) 5 and Representative Concentration Pathway (RCP) 8.5)

1. FTMY files for West & MidWest: https://zenodo.org/records/10815135
   FTMY files for East & South: https://zenodo.org/records/10815041

Seven Representative US Locations



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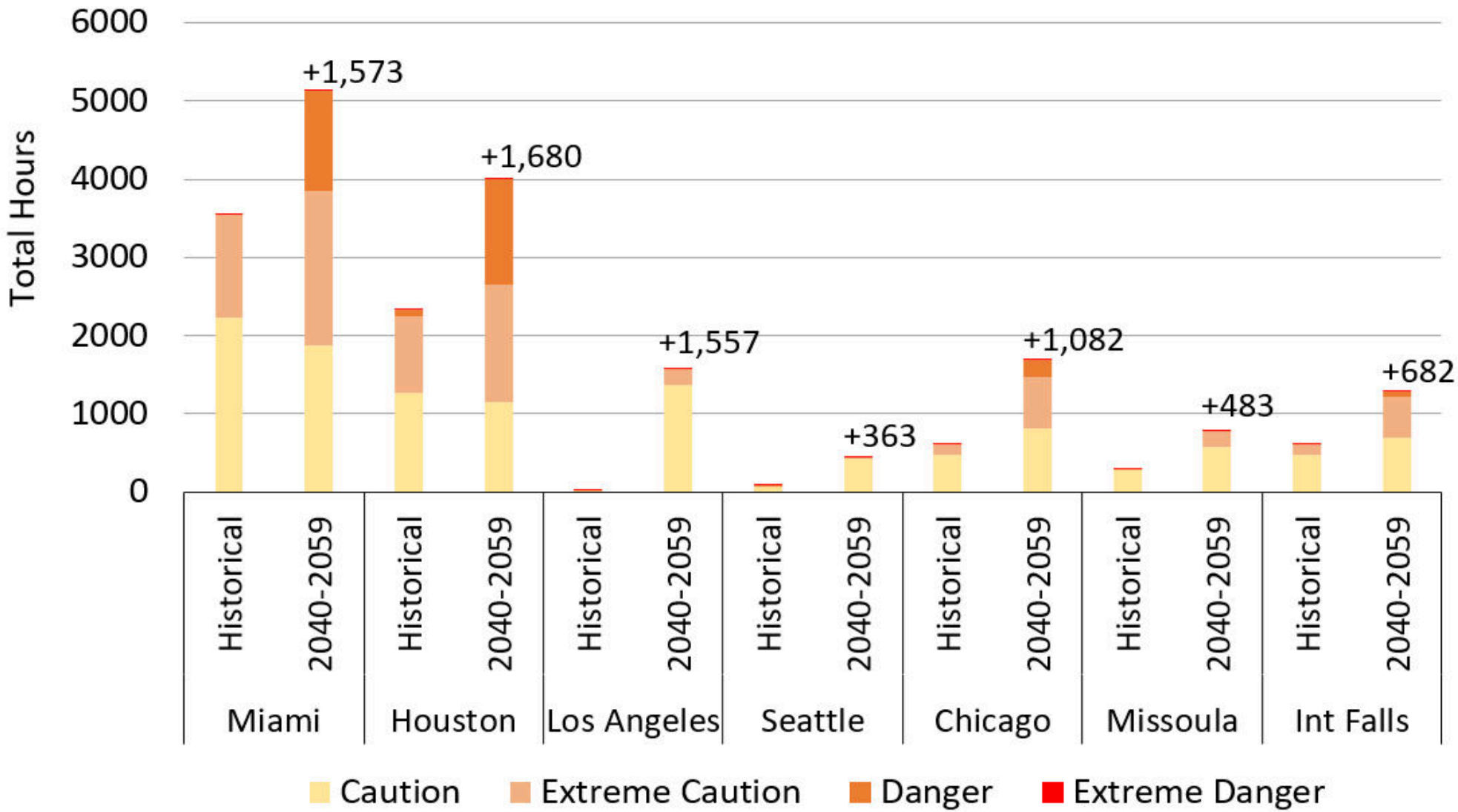
Hours Throughout Year that Outdoor Heat Index is in Caution Through Extreme Danger Zone Across Seven US Locations



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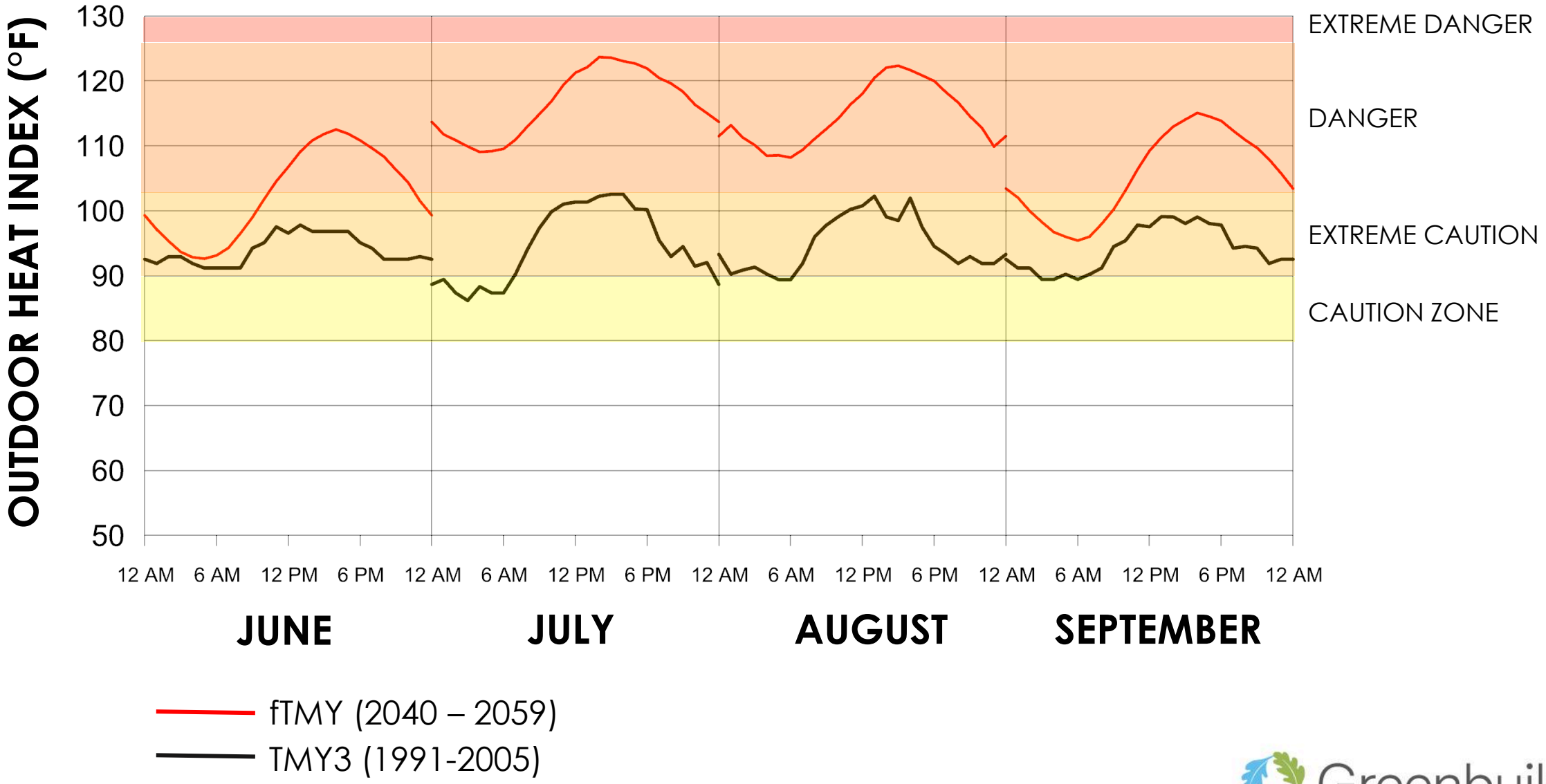
Projected Max Hourly Outdoor Heat Index – Miami (1A)



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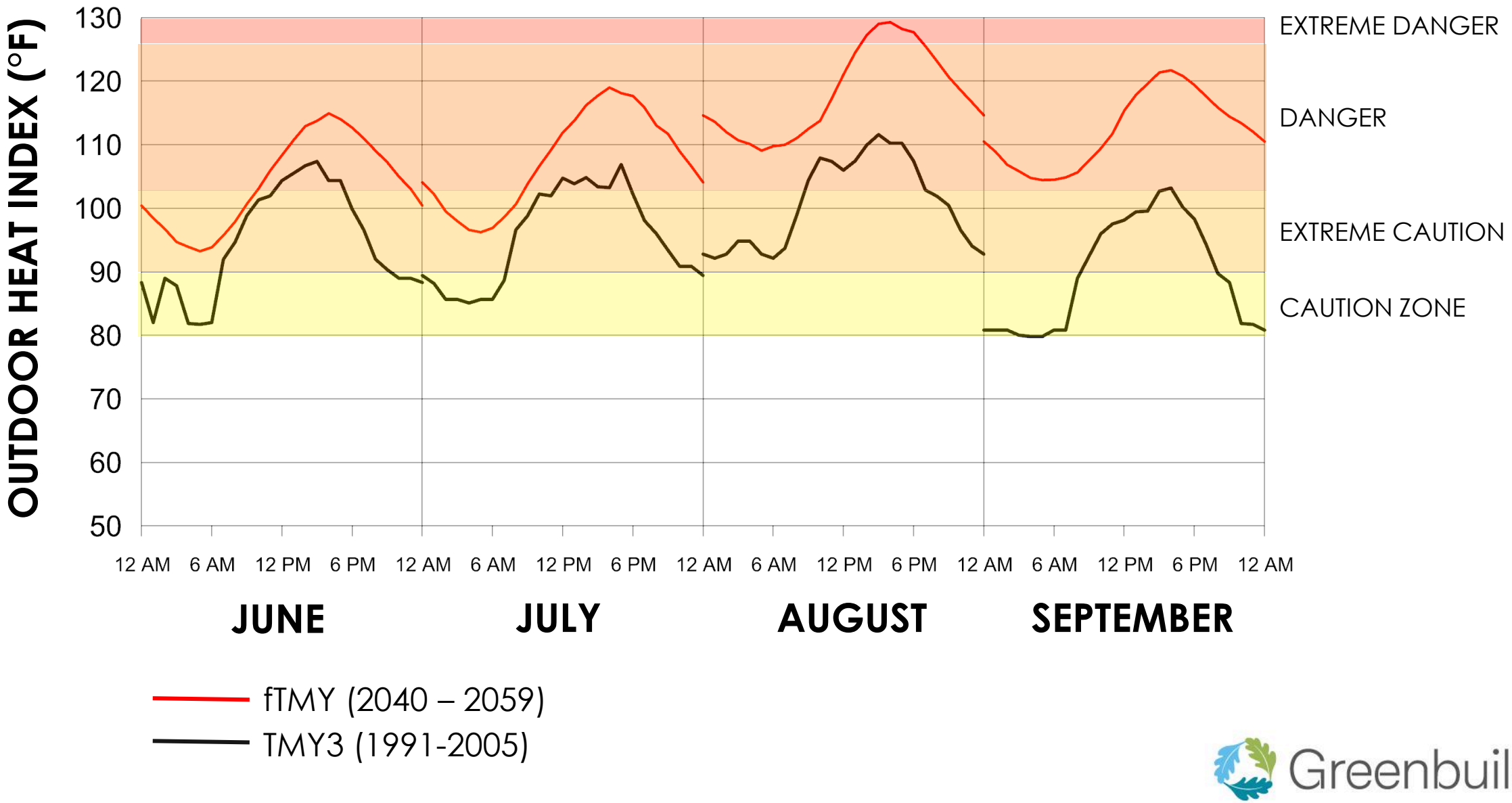
Projected Max Hourly Outdoor Heat Index – Houston (2A)



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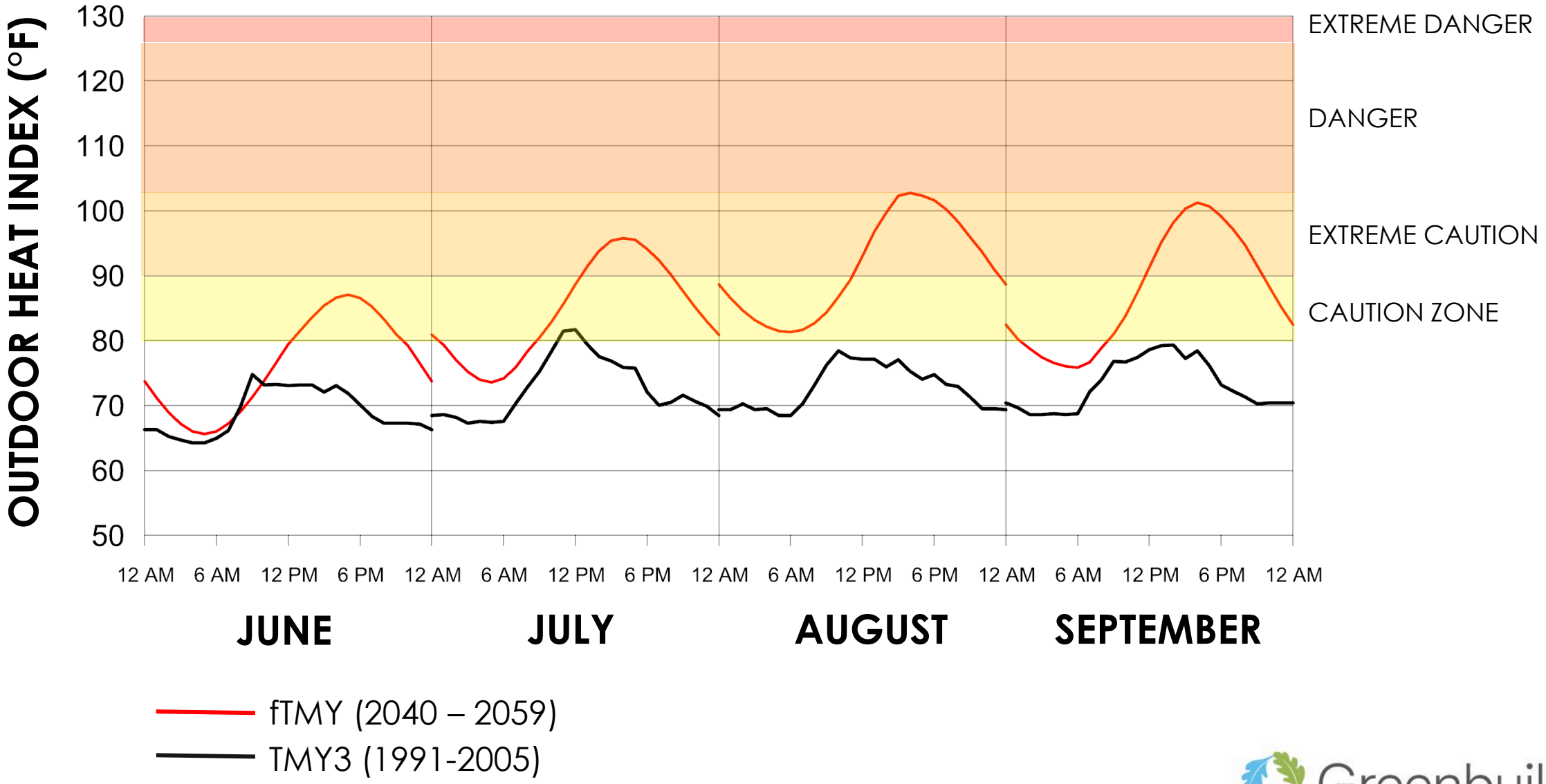
Projected Max Hourly Outdoor Heat Index – Los Angeles (3B)



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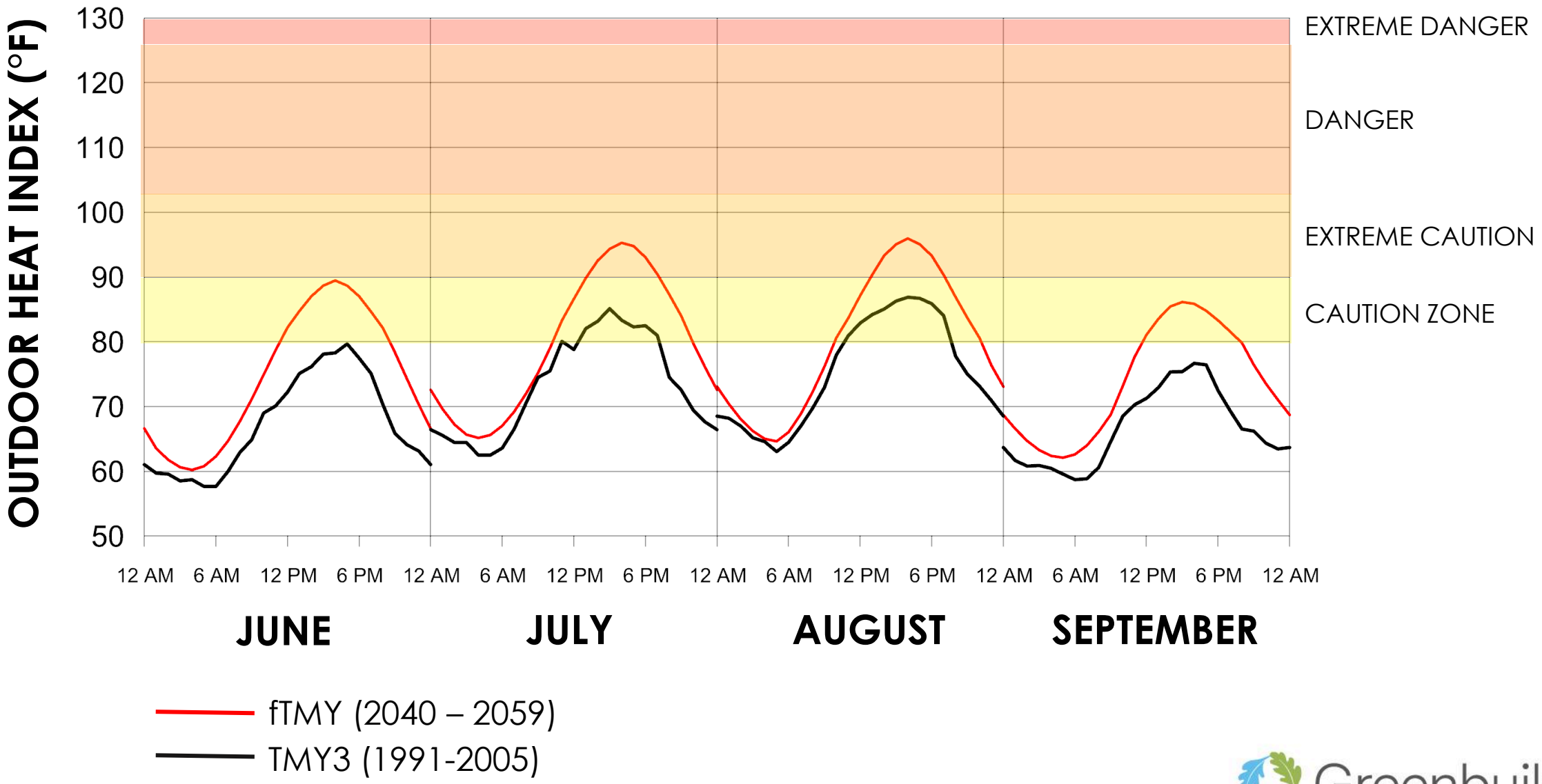
Projected Max Hourly Outdoor Heat Index – Seattle (4C)



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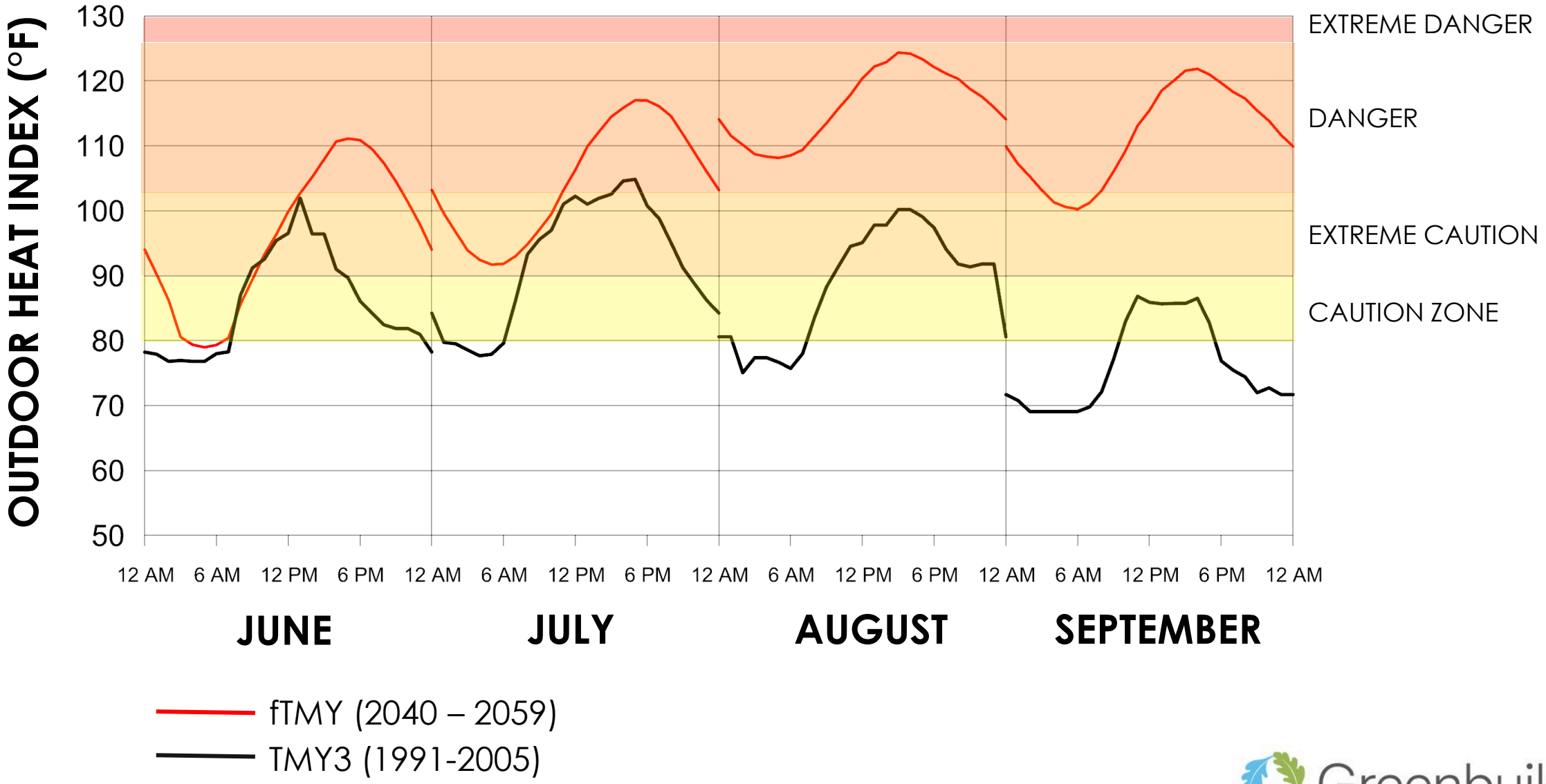
Projected Max Hourly Outdoor Heat Index – Chicago (5A)



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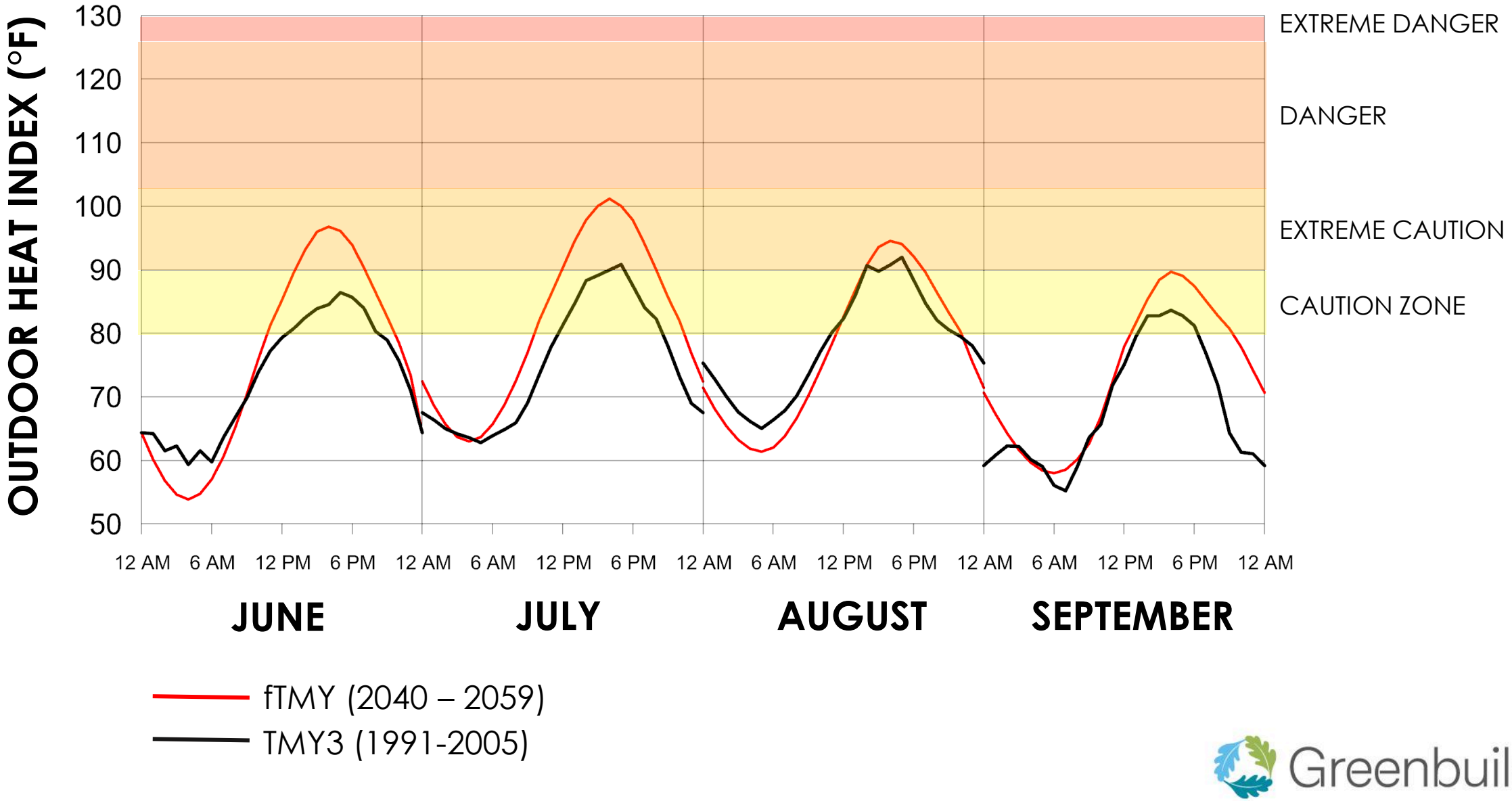
Projected Max Hourly Outdoor Heat Index – Missoula (6B)



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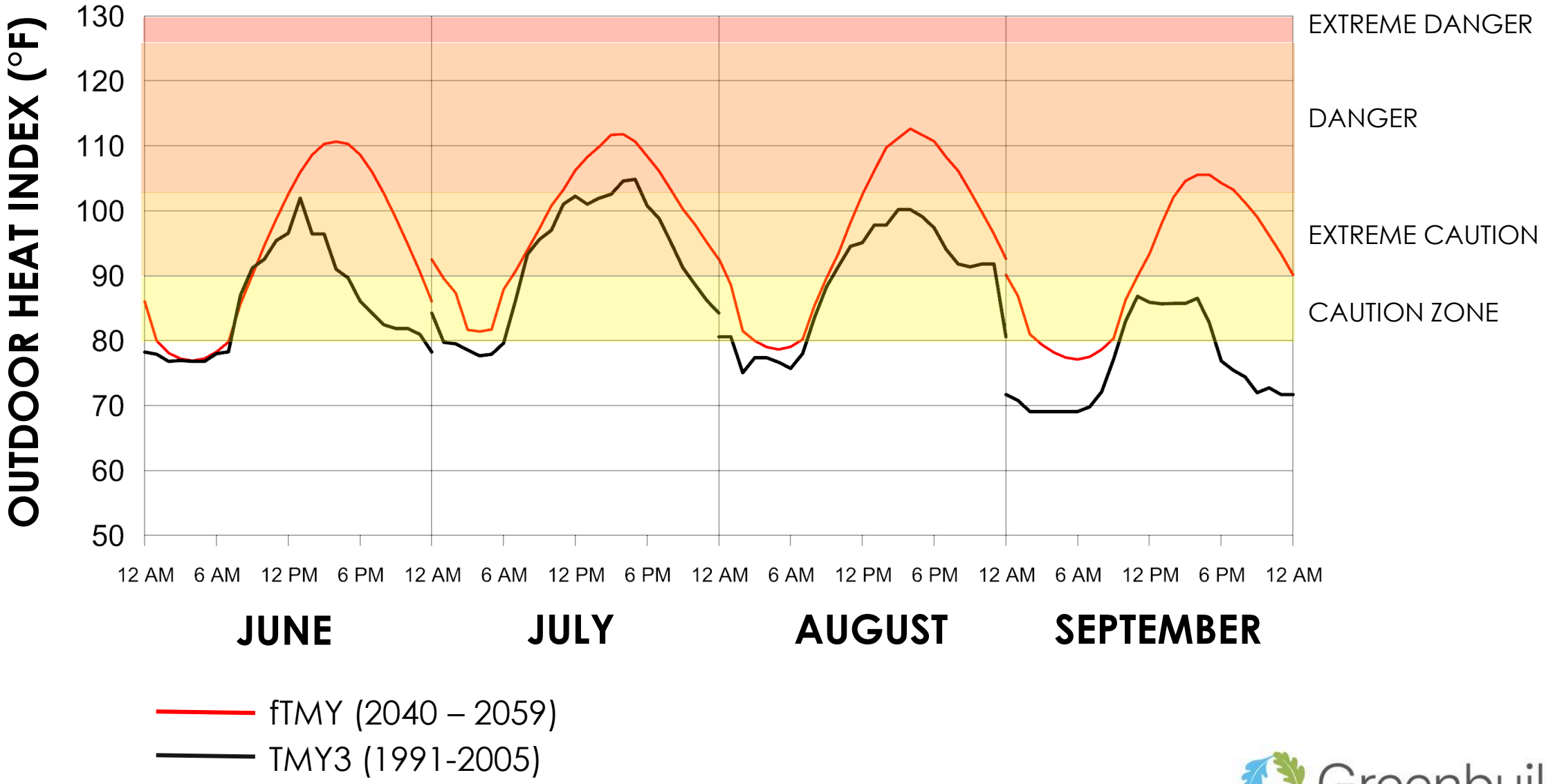
Projected Max Hourly Outdoor Heat Index – International Falls (7)



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Efficacy of External Shading Devices and Natural Ventilation during Extreme Heat for a Seattle Multi-family Apartment Unit

Teresa Moroseos[1], Heather Burpee[1], Christopher Meek[1]

[1]Integrated Design Lab, University of Washington, Seattle, WA

ABSTRACT

Seattle is especially vulnerable to excessive heat events due its historically mild summers. Since the mid-1970s, there have been on average three to four heat-related fatalities every summer in Seattle. In 2021, an exceptionally hot summer, over 60 deaths occurred. Excessive heat events are expected to rise in the near future, increasing the risk of mortality and morbidity related to overheating. Groups most at risk are the elderly, infants, the homeless, and the poor who are socially isolated. While the percentage of homes with air conditioning is increasing, there is a risk that excessive heat could overload the energy grid system if air conditioning becomes widespread.

External shading devices and natural ventilation are well-known passive design strategies that reduce cooling loads and improve thermal comfort. While their benefits are recognized among architects and engineers, there is very little research on their efficacy during excessive heat for residential typologies in mild climates.

We conducted a study to assess the interior ambient conditions for a prototypical, west-facing apartment unit in Seattle for historic and projected 2050 weather data. We also studied whether external shading devices and natural ventilation can effectively improve indoor ambient conditions during hot weather in Seattle. The research was conducted using simulation based energy models, with several simulations cases studied by varying building parameters including exterior shading devices, natural ventilation strategies, infiltration rates, window assembly, and wall assembly. An annual energy analysis was performed for all simulation cases to assess interior ambient conditions.

Our results show that a prototypical, west-facing apartment unit has interior ambient conditions that are detrimental to human health in many of the simulations that we studied, especially for the projected 2050 weather, but even for historic weather conditions. The best mitigation strategy that we assessed was incorporating natural ventilation, followed by incorporating exterior shading.

KEYWORDS: Excessive heat events, heat index, passive cooling, exterior shading devices, natural ventilation

PAPER SESSION TRACK: Public Health and Human-Centered Design *or* Global Sustainability: Mitigation and Adaptation

1.0 INTRODUCTION

1.1 Excessive Heat Events and Human Health

Climate change is increasing the occurrence of excessive heat events throughout the world (Sheridan 2018). Excessive heat events, or periods of unusually high summer temperatures compared to local historical trends, can be completely catastrophic and result in thousands of deaths, such as the 2010 Moscow heat wave that killed more than 11,000 people (Shaposhnikov 2014). In addition to death, several studies have shown a wide range of human health implications associated with overheating ranging from decreased cognitive function (Seppanen 2006), sleep disturbance (Van Loenhout 2016), cardiovascular and respiratory issues (Ueiio 2016), and heat stroke. Those likely to

Research Questions

- How uncomfortable is a typical apartment unit (without a/c) during a Seattle summer under…
  - historical weather conditions?
  - projected climate conditions?

- What intervention to the building envelope can help improve comfort (without a/c) in a typical apartment unit in Seattle during projected climate conditions?

Methodology

+

Ladybug Tools

Annual hourly comfort metrics

- ✓ Interior Temps
- ✓ Interior Humidity

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Typical Apartment Unit

- How uncomfortable is a **typical apartment unit** (without a/c) during a Seattle summer under…
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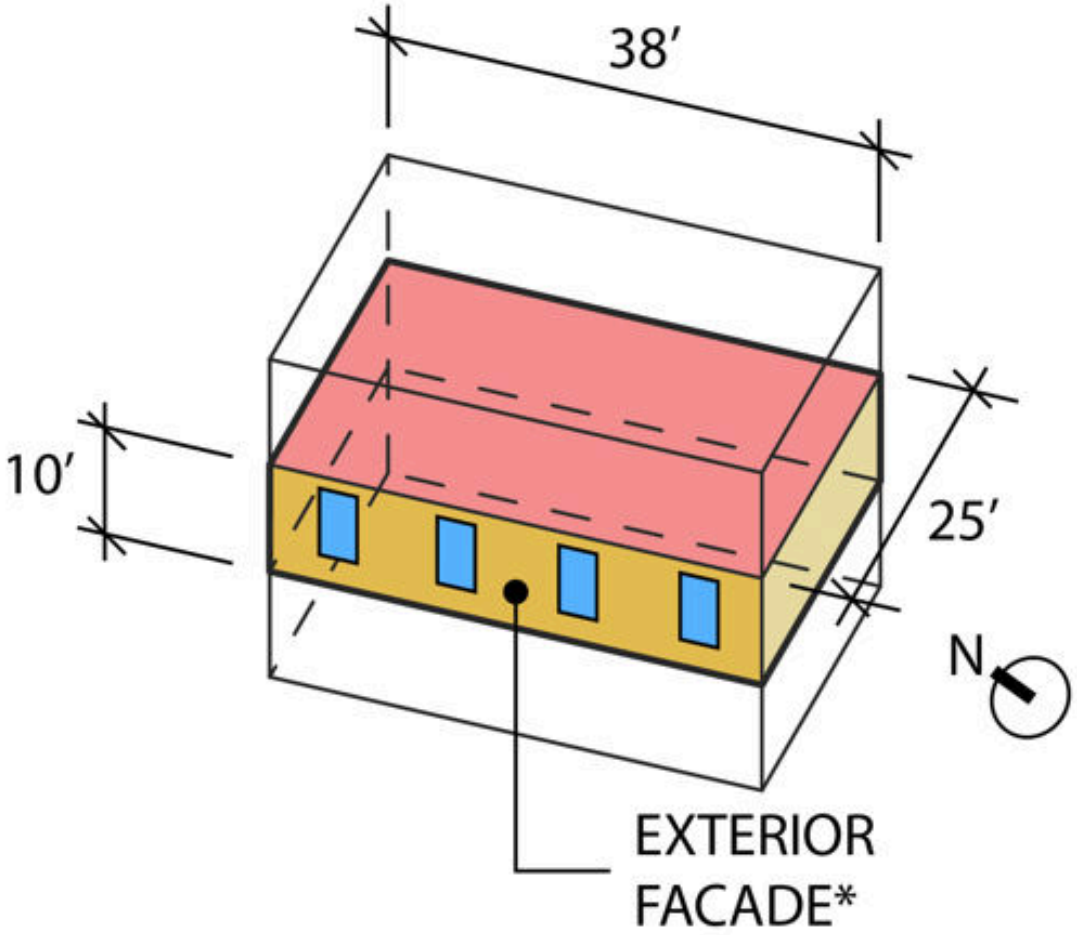
  - projected climate conditions?

- What intervention to the building envelope can help improve comfort (without a/c) in a **typical apartment unit** in Seattle during projected climate conditions?



US Department of Energy reference buildings mid-size multifamily reference model

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Weather Files

- How uncomfortable is a typical apartment unit (without a/c) during a Seattle summer under…
  - **historical weather conditions?**
  - **projected climate conditions?**

- What intervention to the building envelope can help improve comfort (without a/c) in a typical apartment unit in Seattle during projected climate conditions?

Weather files:

- Two Options:

1) Seattle TMY2 – SeaTac Airport

2) Seattle 2050 Projection

A1fb climate change scenario - Generated by Weather Morph: Climate Change Weather File Generator (Jiang et al)

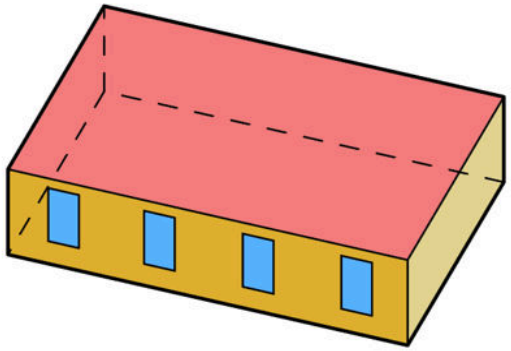
Building Envelope

- How uncomfortable is a typical apartment unit (without a/c) during a Seattle summer under…
  - historical weather conditions?
  - projected climate conditions?

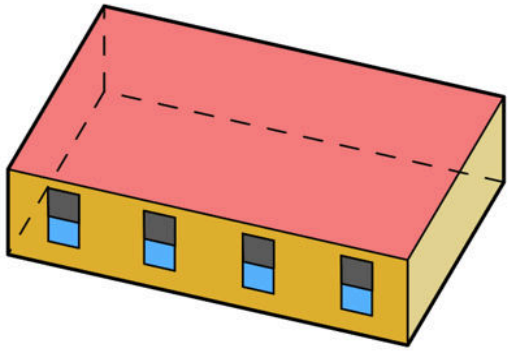
- What intervention to the **building envelope** can help improve comfort (without a/c) in a typical apartment unit in Seattle during projected climate conditions?

Variable Inputs	*Values*
Weather File	Seattle TMY2 Seattle A1FI project year 2050
Exterior Shading Devices	No exterior shading Half exterior shading 3/4 exterior shading
Infiltration	0.35 Air Changes per Hour (ACH) 0.5 ACH
Construction	2004 Construction 2015 Construction
U-Factor Window	0.35 Btu/h·ft^2·F 0.15 Btu/h·ft^2·F
Natural Ventilation	None Windows always open Optimal natural ventilation

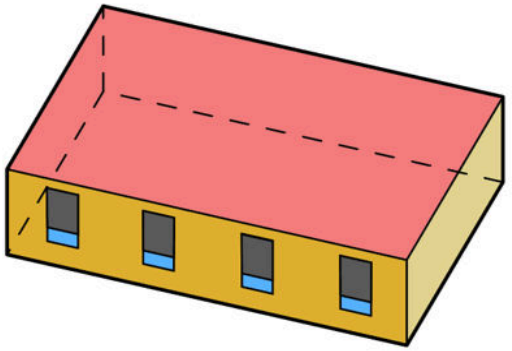
Exterior Shading Devices



1) No Exterior Shading
SHGC = 0.4



2) Half Exterior Shading
SHGC = 0.2



3) ¾ Exterior Shading
SHGC = 0.1

Variable Inputs	*Values*
Weather File	Seattle TMY2 Seattle A1FI project year 2050
Exterior Shading Devices	No exterior shading Half exterior shading 3/4 exterior shading
Infiltration	0.35 Air Changes per Hour (ACH) 0.5 ACH
Construction	2004 Construction 2015 Construction
U-Factor Window	0.35 Btu/h·ft^2·F 0.15 Btu/h·ft^2·F
Natural Ventilation	None Windows always open Optimal natural ventilation

Infiltration

Variable Inputs	*Values*
Weather File	Seattle TMY2 Seattle A1FI project year 2050
Exterior Shading Devices	No exterior shading Half exterior shading 3/4 exterior shading
Infiltration	0.35 Air Changes per Hour (ACH) 0.5 ACH
Construction	2004 Construction 2015 Construction
U-Factor Window	0.35 Btu/h·ft^2·F 0.15 Btu/h·ft^2·F
Natural Ventilation	None Windows always open Optimal natural ventilation

Opaque Assemblies

Assembly	*R-Value Assembly*	*Assembly Materials*
2015 Construction Wall (Basis: IECC 2015)	17.2 h·ft^2·F/Btu	25mm Stucco 5/8 in. Gypsum Board Typical Insulation-R15 5/8 in. Gypsum Board
2004 Construction Wall (Basis: 1980-2004 CBECS)	12.3 h·ft^2·F/Btu	25mm Stucco 5/8 in. Gypsum Board Typical Insulation-R10 5/8 in. Gypsum Board

Variable Inputs	*Values*
Weather File	Seattle TMY2 Seattle A1FI project year 2050
Exterior Shading Devices	No exterior shading Half exterior shading 3/4 exterior shading
Infiltration	0.35 Air Changes per Hour (ACH) 0.5 ACH
Construction	2004 Construction 2015 Construction
U-Factor Window	0.35 Btu/h·ft^2·F 0.15 Btu/h·ft^2·F
Natural Ventilation	None Windows always open Optimal natural ventilation

Glazing Assemblies

Variable Inputs	*Values*
Weather File	Seattle TMY2 Seattle A1FI project year 2050
Exterior Shading Devices	No exterior shading Half exterior shading 3/4 exterior shading
Infiltration	0.35 Air Changes per Hour (ACH) 0.5 ACH
Construction	2004 Construction 2015 Construction
U-Factor Window	0.35 Btu/h·ft^2·F 0.15 Btu/h·ft^2·F
Natural Ventilation	None Windows always open Optimal natural ventilation

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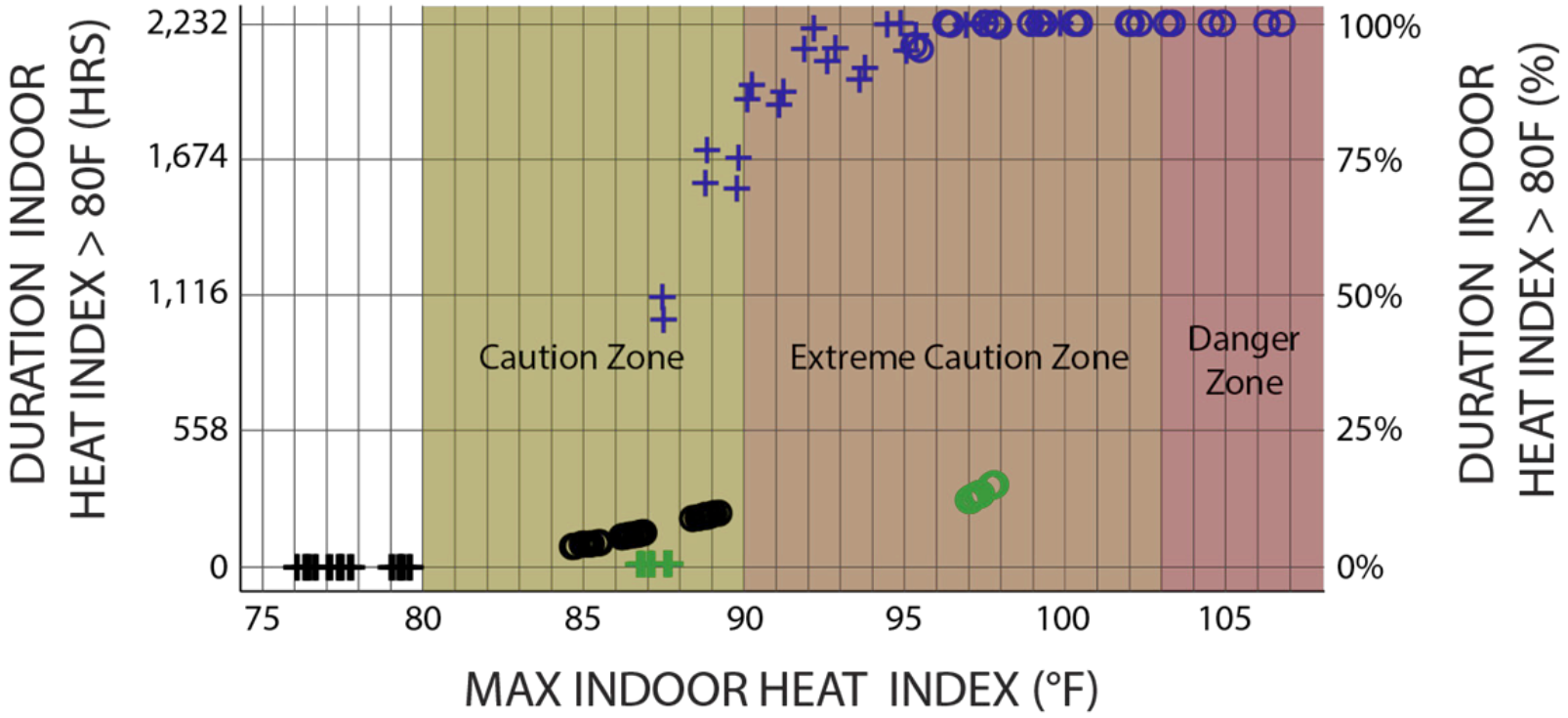
Ventilation Strategy

Variable Inputs	*Values*
Weather File	Seattle TMY2 Seattle A1FI project year 2050
Exterior Shading Devices	No exterior shading Half exterior shading 3/4 exterior shading
Infiltration	0.35 Air Changes per Hour (ACH) 0.5 ACH
Construction	2004 Construction 2015 Construction
U-Factor Window	0.35 Btu/h·ft^2·F 0.15 Btu/h·ft^2·F
Natural Ventilation	None Windows always open Optimal natural ventilation

Impact of Climate & Ventilation



	windows optimally open & close	window always open	window always closed
Historic Seattle Weather File	+	+	+
2050 Seattle Weather File	○	○	○

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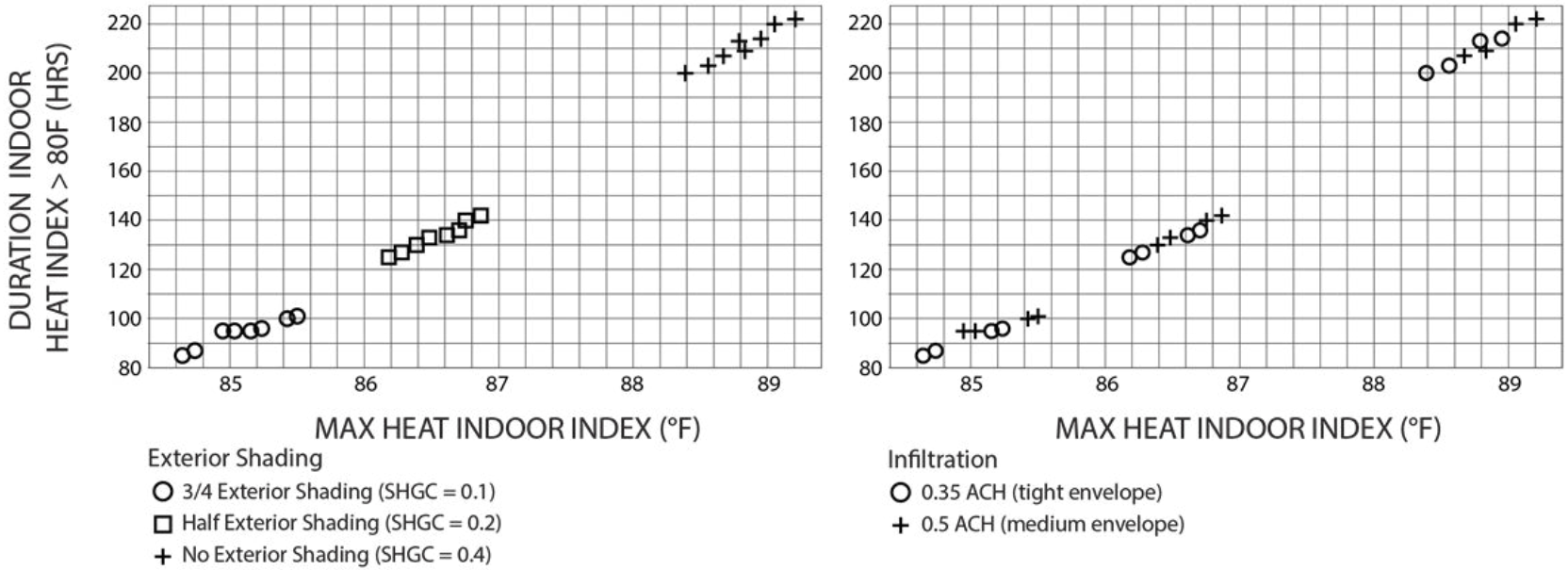
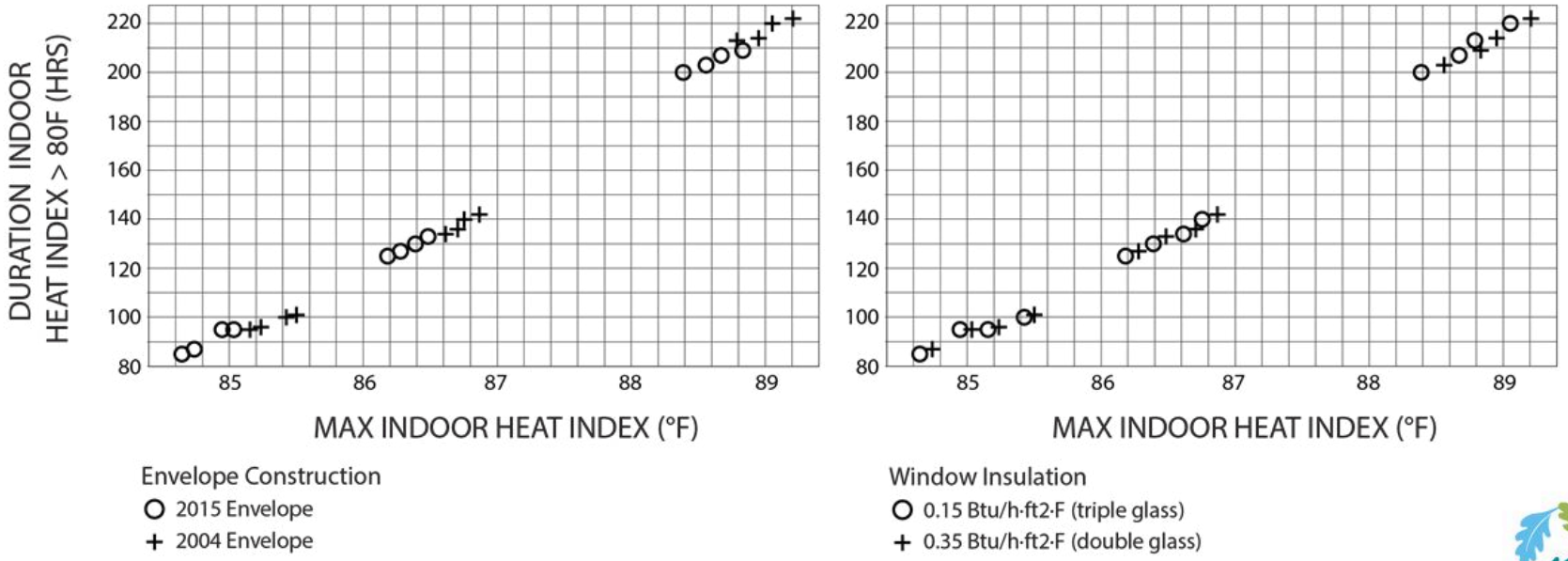
Impact of Envelope





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Study Findings

- very dangerous conditions in 2050!
  - A typical west-facing apartment unit in Seattle will have 80 - 2,232 hours in the extreme caution heat-index zone

- Air-conditioning may be required, but has many disadvantages:
  - Cost of running may be a barrier
  - Relatively low adoption currently, will need to be a retrofit solution

- Natural ventilation the most effective passive cooling strategy
  - Future study: Study how different types of window openings and fan movement improves comfort in Seattle senior housing unit
  - Investigate retrofit, low energy mechanical options for brining outdoor air inside

- Solar shading effective when used with natural ventilation