

# Climate and public health: building resilience capacity and climate adaptation in the US Caribbean



**PR-CLIMAH**  
THIS IS PUBLIC HEALTH

March 7, 2023

Southeastern Coastal Center

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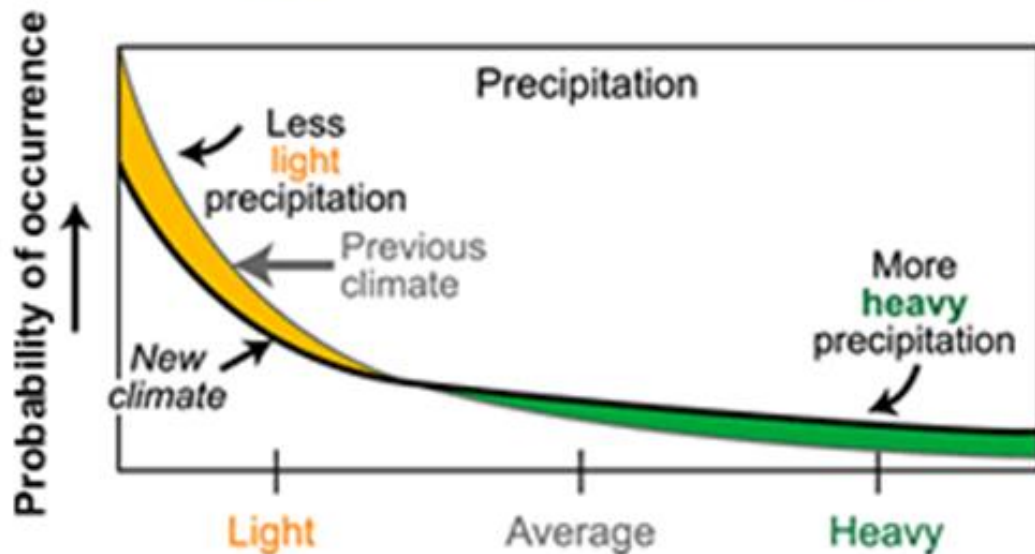
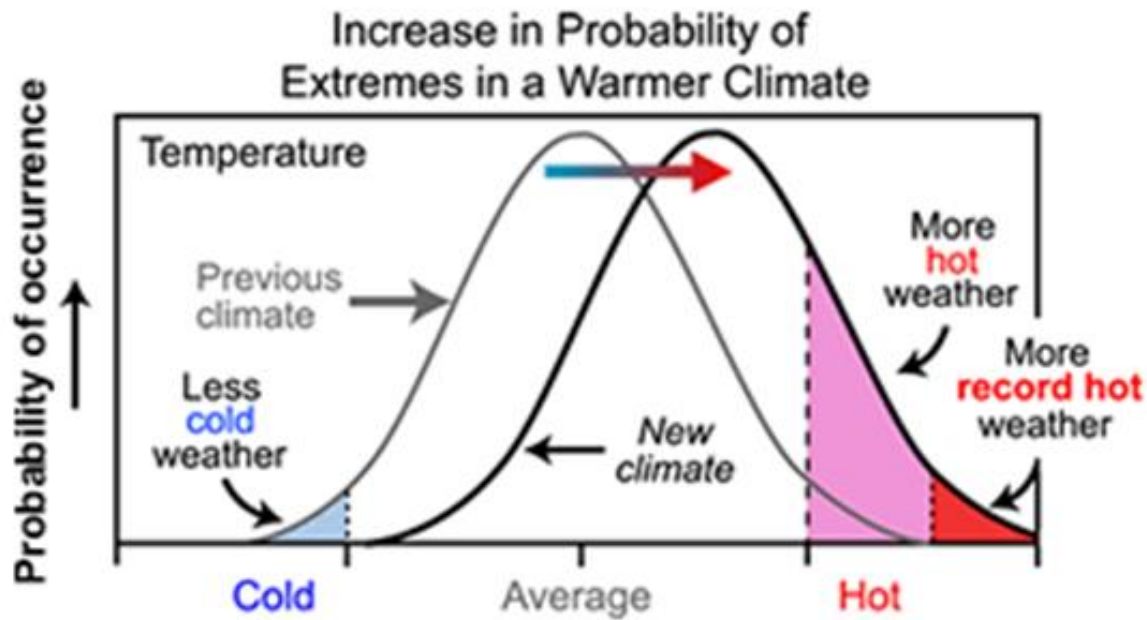


Lead Principal Investigator [NOAA CAP/RISA Caribbean Climate Adaptation Network \(CCAN\)](#)

Lead Principal Investigator [Aerosol Monitoring Tool/Early Warning System](#) (PR-CLIMAH/NASA/UPR/CARICOOS)

# Who are we...

- Long histories of colonization and systemic inequality shape the ability of the US Caribbean peoples to maintain health, quality of life, and overall individual and social well-being.
- Both PR and the USVI suggests risks from climate impacts to multiple elements of human health, including:
  - Vector-Borne Diseases
  - Excess mortality
  - Mental Health
  - Human Zoonotic Diseases
  - Excessive Heat
  - Natural Sources of Air Pollution and Human Health
  - Co-existing & concurrent Crises

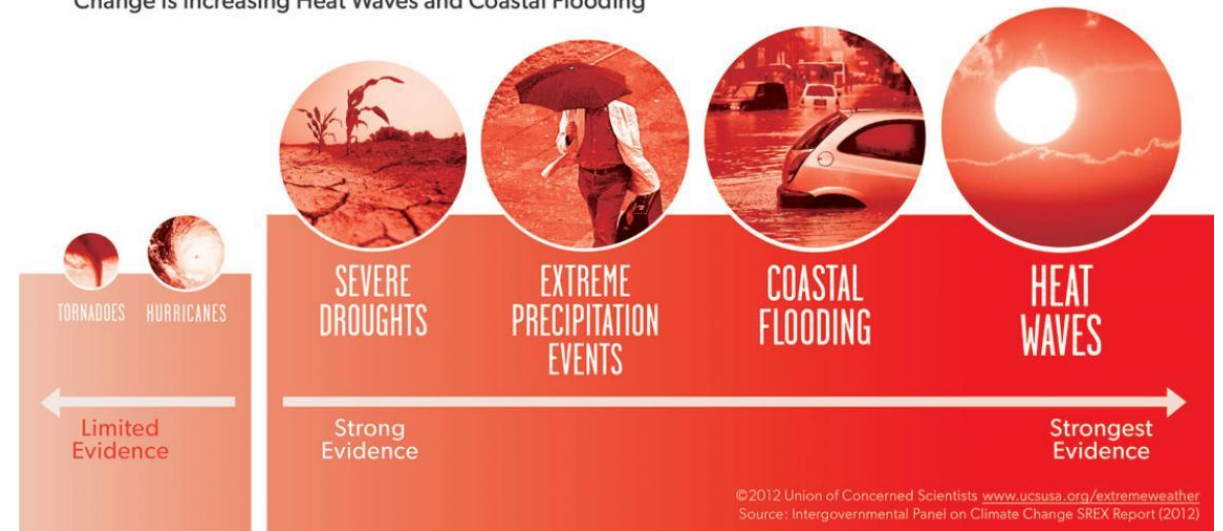


NOAA

Intensity-Duration-Frequency

## SCIENCE CONNECTIONS → EXTREME WEATHER & CLIMATE CHANGE

→ Strongest Scientific Evidence Shows Human-Caused Climate Change Is Increasing Heat Waves and Coastal Flooding



## AGU PUBLICATIONS

### Earth's Future

#### RESEARCH ARTICLE

10.1002/2017EF000686

#### Defining Extreme Events: A Cross-Disciplinary Review

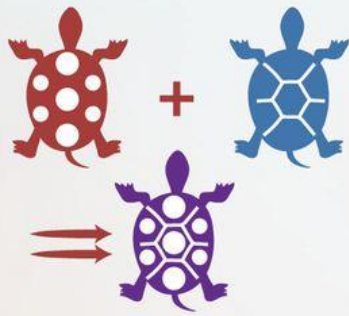
Lauren E. McPhillips<sup>1</sup>, Heejun Chang<sup>2</sup>, Mikhail V. Chester<sup>3</sup>, Yaella Depietri<sup>4</sup>, Erin Friedman<sup>5</sup>, Nancy B. Grimm<sup>6</sup>, John S. Kominoski<sup>7</sup>, Timon McPhearson<sup>4,8</sup>, Pablo Méndez-Lázaro<sup>9</sup>, Emma J. Rosi<sup>8</sup>, and Javad Shafei Shiva<sup>10</sup>

#### Key Points:

- What constitutes an extreme event varies by study and discipline; thus we must be explicit in how we define extreme events
- Extreme events are often conflated with their impacts, but this will inhibit future recognition of resilience
- Bridging across disciplinary differences in communication and definitions is critical for holistic management of extreme events

<sup>1</sup>Global Institute of Sustainability, Arizona State University, Tempe, AZ, USA, <sup>2</sup>Department of Geography, Portland State University, Portland, OR, USA, <sup>3</sup>School of Sustainable Engineering and the Built Environment, Arizona State University, Tempe, AZ, USA, <sup>4</sup>Urban Systems Lab, The New School, New York, NY, USA, <sup>5</sup>Earth and Environmental Sciences, The Graduate Center, City University of New York, New York, NY, USA, <sup>6</sup>School of Life Sciences and Global Institute of Sustainability, Arizona State University, Tempe, AZ, USA, <sup>7</sup>Department of Biological Sciences, Florida International University, Miami, FL, USA, <sup>8</sup>Cary Institute of Ecosystem Studies, Millbrook, NY, USA, <sup>9</sup>Environmental Health Department, Graduate School of Public Health, University of Puerto Rico—Medical Sciences Campus, San Juan, PR, USA, <sup>10</sup>Department of Civil and Environmental Engineering, Syracuse University, Syracuse, NY, USA



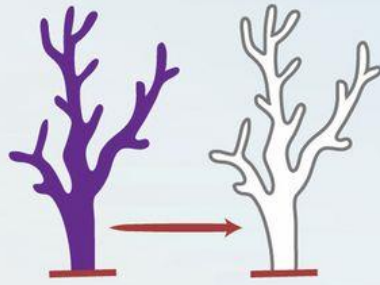


### GENETICS:

Adaptive evolution to heat stress in small organisms with short generations

Limited evidence for adaptive evolution in higher level vertebrates and trees

Increased hybridization



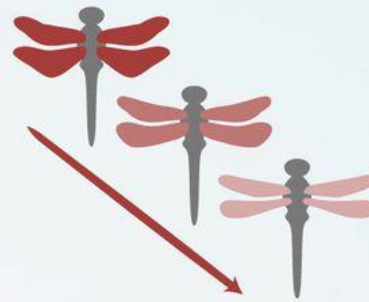
### PHYSIOLOGY:

Increases in coral disease

Extensive dissolution of carbonate-shelled organisms and corals

Direct mortality from heat stress

Changes in life history traits and migration timing



### MORPHOLOGY:

Decreases in body size and changes in shape

Changes in color and brightness



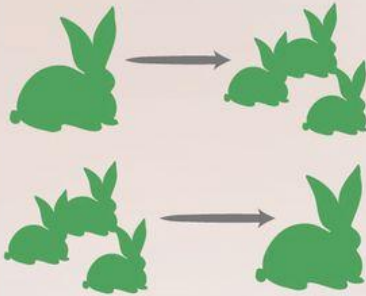
### PHENOLOGY:

Changes in spawning times of marine and freshwater fish

Earlier budding and flowering in plants and earlier growing season

Early and later migration in birds

Increased asynchrony



### DYNAMICS:

Changes in recruitment and age structure

Changes in abundance of reef-building corals, plants, mammals, and birds

Changes in sex ratio

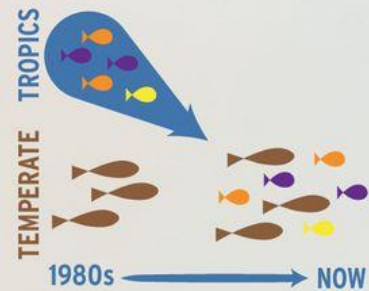


### DISTRIBUTION:

Latitude and altitude range shifts

Range expansion and contraction

Loss of habitat



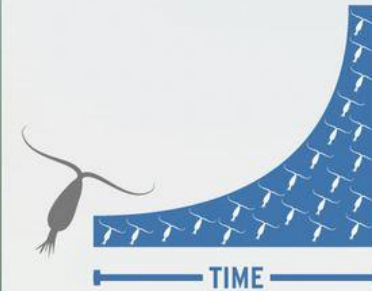
### INTERSPECIFIC RELATIONSHIPS:

Tropicalization of temperate ecosystems

Borealization of Arctic ecosystems

New competitive interactions among species

Desynchronization among dependent species



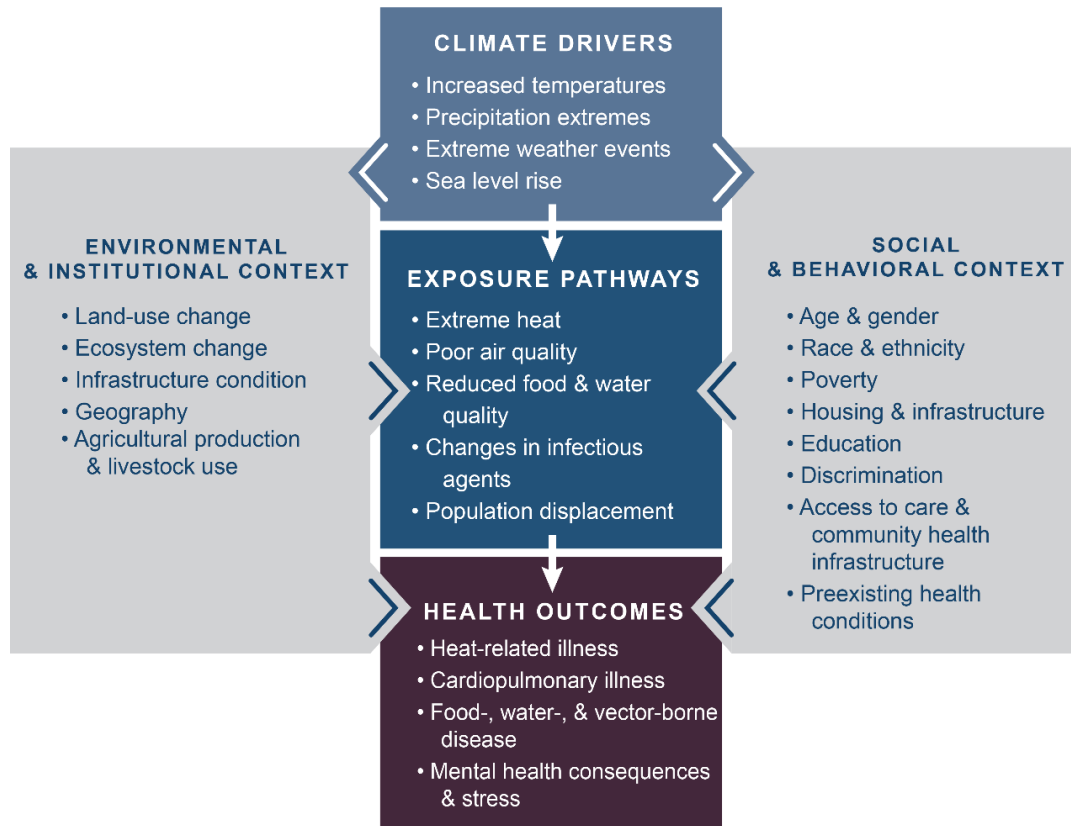
### PRODUCTIVITY:

Changes in net primary productivity on land

Changes in phytoplankton biomass in marine and freshwater ecosystems

<https://nca2018.globalchange.gov/chapter/14/>

## Climate Change and Health



### Ecosystems

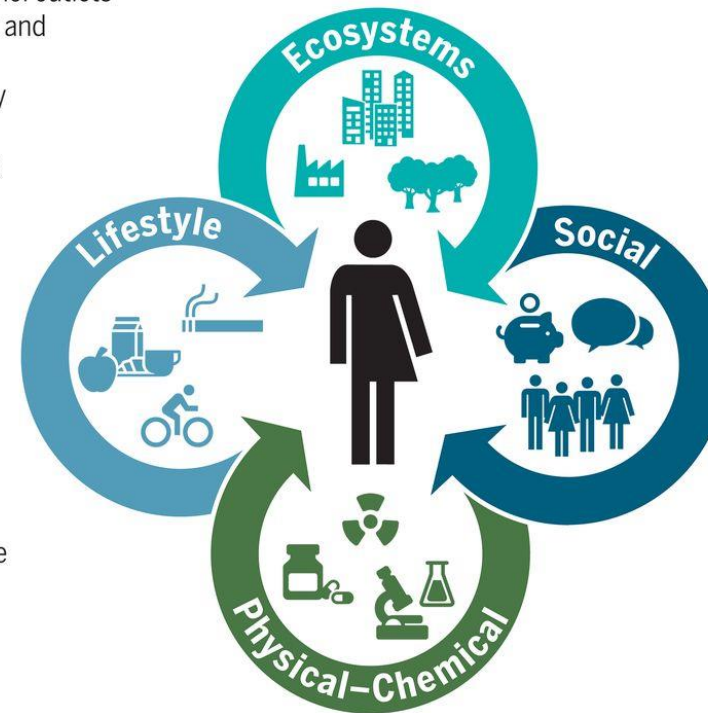
Food outlets, alcohol outlets  
Built environment and urban land uses  
Population density  
Walkability  
Green/blue space

### Lifestyle

Physical activity  
Sleep behavior  
Diet  
Drug use  
Smoking  
Alcohol use

### Social

Household income  
Inequality  
Social capital  
Social networks  
Cultural norms  
Cultural capital  
Psychological and mental stress



### Physical-Chemical

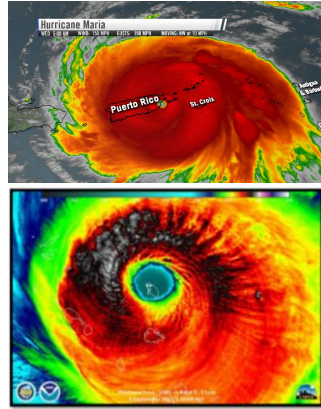
Temperature/humidity  
Electromagnetic fields  
Ambient light  
Odor and noise  
Point, line sources, e.g., factories, ports  
Outdoor and indoor air pollution  
Agricultural activities, livestock  
Pollen/mold/fungus  
Pesticides  
Fragrance products  
Flame retardants (PBDEs)  
Persistent organic pollutants  
Plastic and plasticizers  
Food contaminants  
Soil contaminants  
Drinking water contamination  
Groundwater contamination  
Surface water contamination  
Occupational exposures

Adaptive Capacity, Sensitivity, Exposure, Capacity to Cope



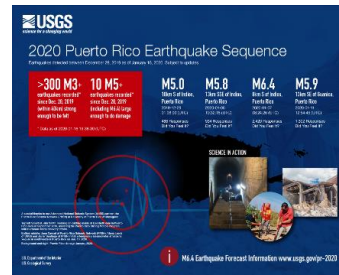
# Disaster Declaration Date: **Co-existing & concurrent Crises** September 20, 2017

Fall 2022  
Hurricane Fiona Cat 1.  
+ Excessive Heat

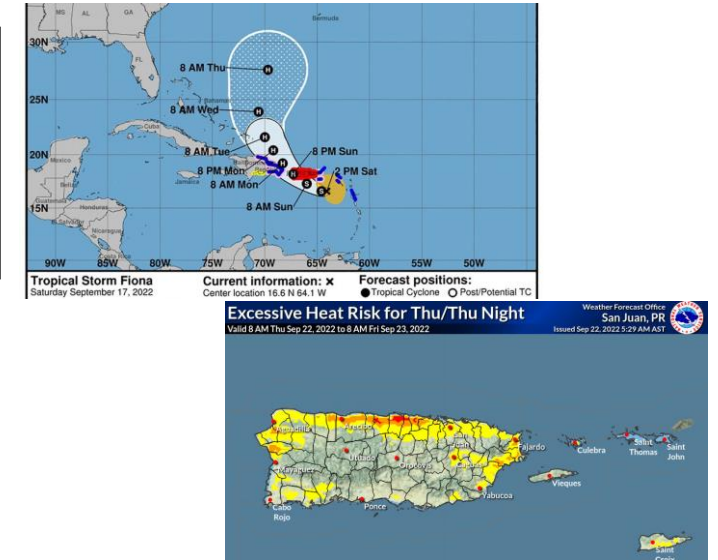
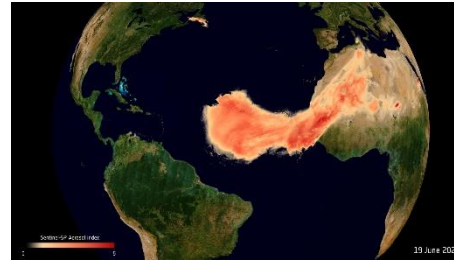


Fall 2017  
Hurricanes  
Irma + Maria

Disaster Declaration  
Date:  
January 16, 2020  
Winter 2020  
Southwest  
Earthquakes



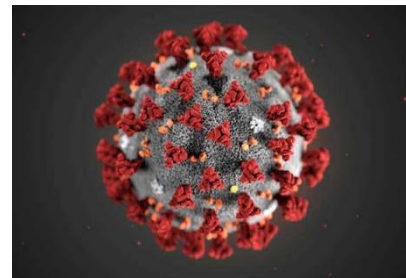
Summer 2020  
Godzilla African Dust Events  
2-3 days with hazardous AQ  
conditions



\$\$  
Financial Crisis  
Spring 2017  
Puerto Rico Declares  
Bankruptcy



Summer 2019  
Political Crisis



Winter-Spring 2020  
COVID-19 Pandemic  
Lockdowns

Drought 2020

COVID-19 2020



Massive blackout.  
100% power outages

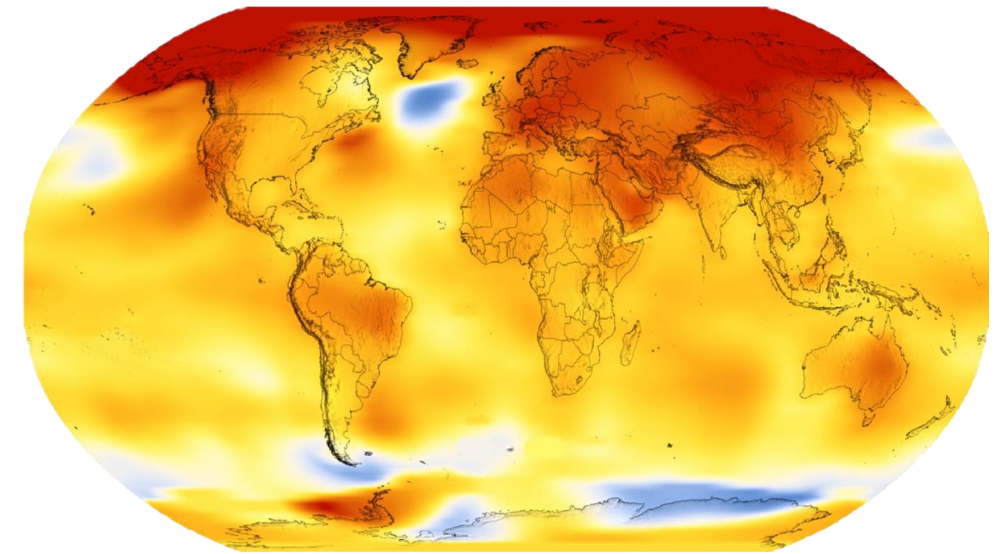


UNITED STATES DISTRICT COURT  
for the District of Puerto Rico  
**PROMESA**  
Puerto Rico Oversight Management and Economic Stability Act

How Climate is Changing in the  
US Caribbean Territories (mainly  
in Puerto Rico?

# Concerning Increasing temperatures + humidity in Tropical areas

## Temperature Change in the Last 50 Years



2014-2018 average vs. 1951-1980 baseline

SCIENCE ADVANCES | RESEARCH ARTICLE

### CLIMATOLOGY

## The emergence of heat and humidity too severe for human tolerance

Colin Raymond<sup>1,2\*</sup>, Tom Matthews<sup>3</sup>, Radley M. Horton<sup>2,4</sup>

Humans' ability to efficiently shed heat has enabled us to range over every continent, but a wet-bulb temperature (TW) of 35°C marks our upper physiological limit, and much lower values have serious health and productivity impacts. Climate models project the first 35°C TW occurrences by the mid-21st century. However, a comprehensive evaluation of weather station data shows that some coastal subtropical locations have already reported a TW of 35°C and that extreme humid heat overall has more than doubled in frequency since 1979. Recent exceedances of 35°C in global maximum sea surface temperature provide further support for the validity of these dangerously high TW values. We find the most extreme humid heat is highly localized in both space and time and is correspondingly substantially underestimated in reanalysis products. Our findings thus underscore the serious challenge posed by humid heat that is more intense than previously reported and increasingly severe.

### INTRODUCTION

Humans' bipedal locomotion, naked skin, and sweat glands are constituents of a sophisticated cooling system (1). Despite these thermoregulatory adaptations, extreme heat remains one of the most dangerous natural hazards (2), with tens of thousands of fatalities in

exceed 35°C in parts of South Asia and the Middle East by the third quarter of the 21st century (14–16).

Here, we use quality-assured station observations from HadISD (17, 18) and high-resolution reanalysis data from ERA-Interim (19, 20), verified against radiosondes and marine observations (see

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*"In these tropical ocean regions, the heat just can't escape. And if nothing escapes, that part of the world just gets hotter and hotter."*

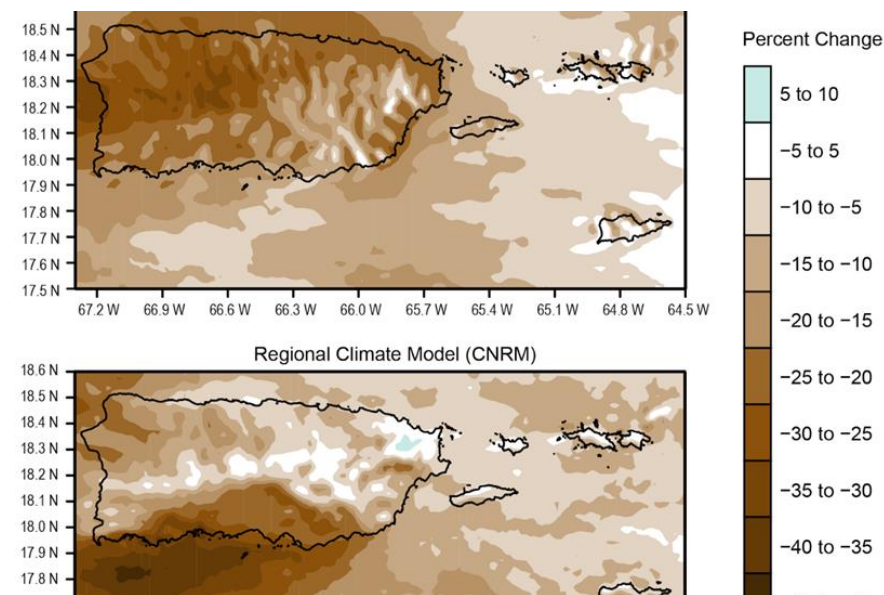
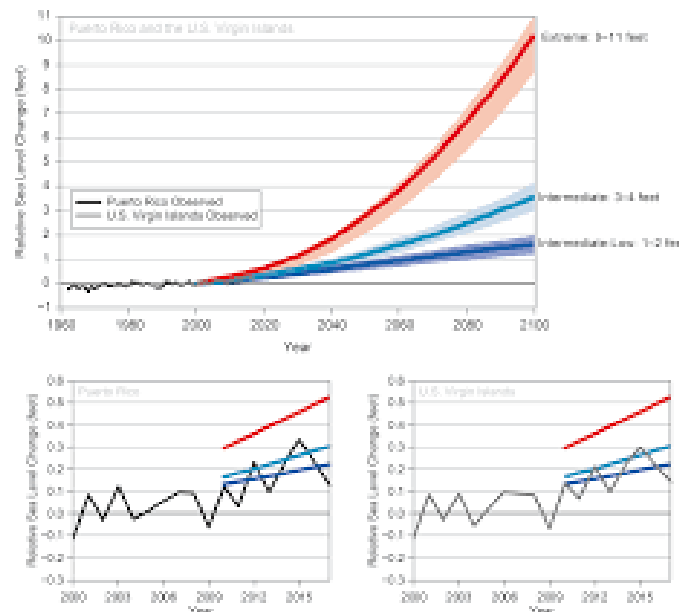
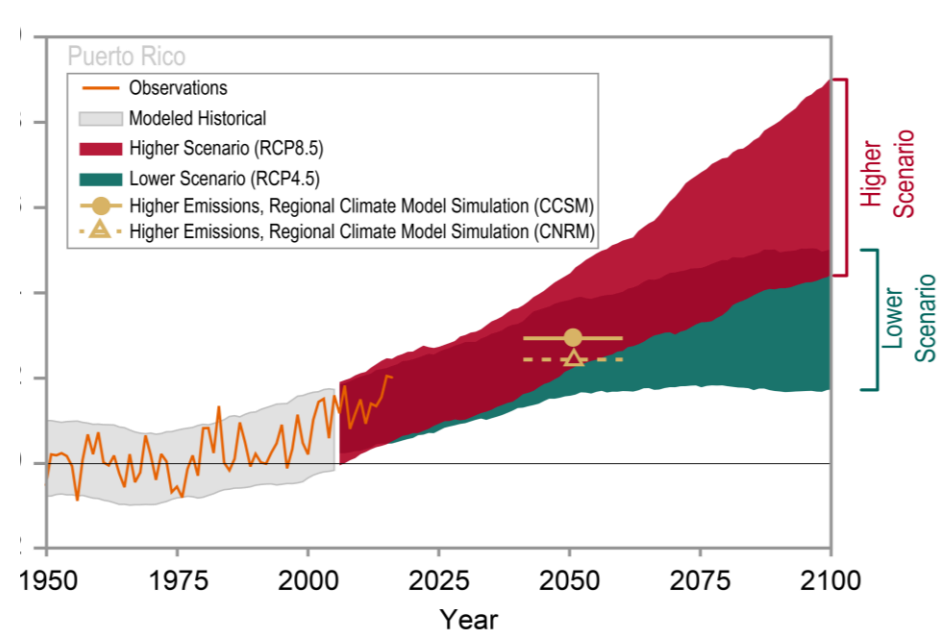
- Graeme Stephens, director of the Center for Climate Sciences at NASA's Jet Propulsion Laboratory (JPL)

## Scientists assess potential for super greenhouse effect in Earth's tropics

NEWS | March 22, 2018

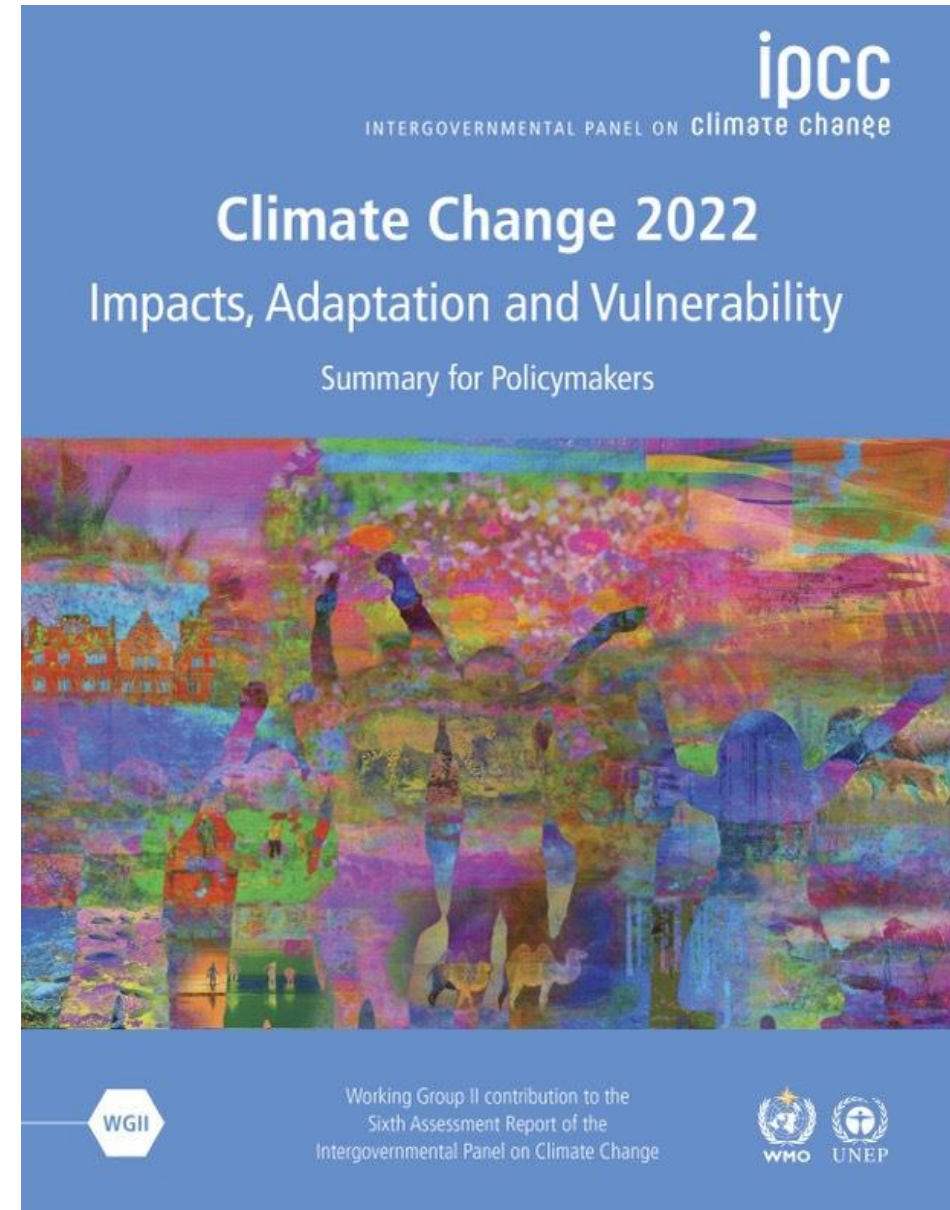
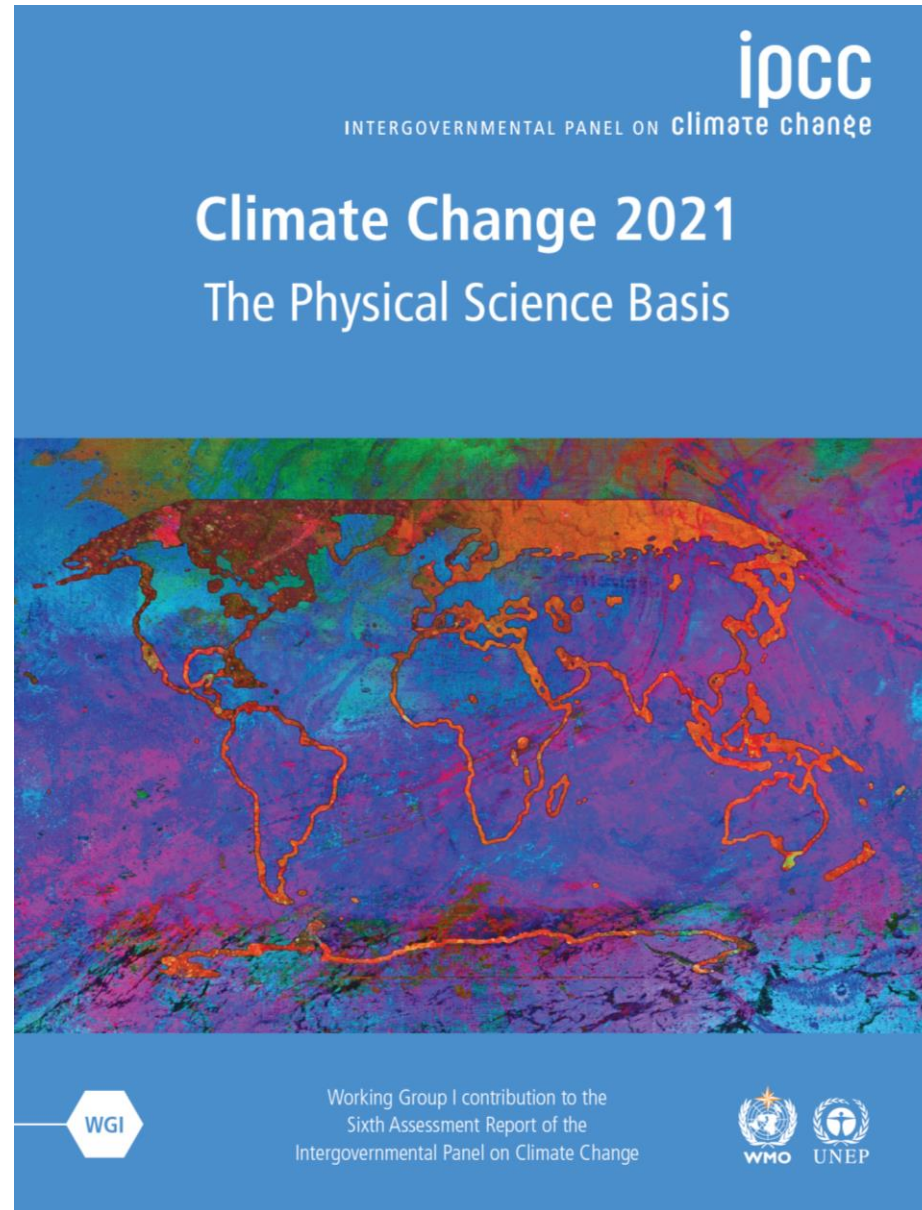






**Key Message 1:** Freshwater is critical to life throughout the Caribbean. Increasing global carbon emissions are projected to reduce average rainfall in this region by the end of the century, constraining freshwater availability, while extreme rainfall events, which can increase freshwater flooding impacts, are expected to increase in intensity. Saltwater intrusion associated with sea level rise will reduce the quantity and quality of freshwater in coastal aquifers. Increasing variability in rainfall events and increasing temperatures will likely alter the distribution of ecological life zones and exacerbate existing problems in water management, planning, and infrastructure capacity.

**Key Message 4:** Natural and social systems adapt to the temperatures under which they evolve and operate. Changes to average and extreme temperatures have direct and indirect effects on organisms and strong interactions with hydrological cycles, resulting in a variety of impacts. Continued increases in average temperatures will likely lead to decreases in agricultural productivity, changes in habitats and wildlife distributions, and risks to human health, especially in vulnerable populations. As maximum and minimum temperatures increase, there are likely to be fewer cool nights and more frequent hot days, which will affect the quality of life in the U.S. Caribbean.



Climate change is happening, and is **widespread, rapid, and intensifying** – IPCC Many of the changes observed in the climate are **unprecedented** in thousands, if not hundreds of thousands of years, and some are **irreversible** over hundreds to thousands of years.



On September 2017 Puerto Rico experienced one of the most catastrophic hurricane seasons in recent history.



- Puerto Rico experienced major disruptions in essential services (e.g. potable water and electric power, telecommunications, transportation –roads and bridges) and environmental health issues (e.g. water sanitation, contaminant exposure, vector borne diseases, food hygiene, carbon monoxide poisoning and exposure to mold).

**Ticking Bomb!**




SPECIAL ARTICLE

## Mortality in Puerto Rico after Hurricane Maria

Nishant Kishore, M.P.H., Domingo Marqués, Psy.D., Ayesha Mahmud, Ph.D., Mathew V. Kiang, M.P.H., Irmay Rodriguez, B.A., Arlan Fuller, J.D., M.A., Peggy Ebner, B.A., Cecilia Sorensen, M.D., Fabio Racy, M.D., Jay Lemery, M.D., Leslie Maas, M.H.S., Jennifer Leaning, M.D., S.M.H., Rafael A. Irizarry, Ph.D., Satchit Balsari, M.D., M.P.H., and Caroline O. Buckee, D.Phil.

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## GW Researchers: 2,975 Excess Deaths Linked to Hurricane Maria

*The risk of dying in the six months following the devastating storm was highest for Puerto Ricans living in the poorest municipalities.*

Open access

Original research

## BMJ Open Mortality of Puerto Ricans in the USA post Hurricane Maria: an interrupted time series analysis

Mario Marazzi,<sup>1</sup> Boriana Miloucheva ,<sup>2</sup> Gustavo J Bobonis<sup>2</sup>



**CNN**

**US**

[Crime + Justice](#)

[Energy + Environment](#)

[Extreme Weather](#)

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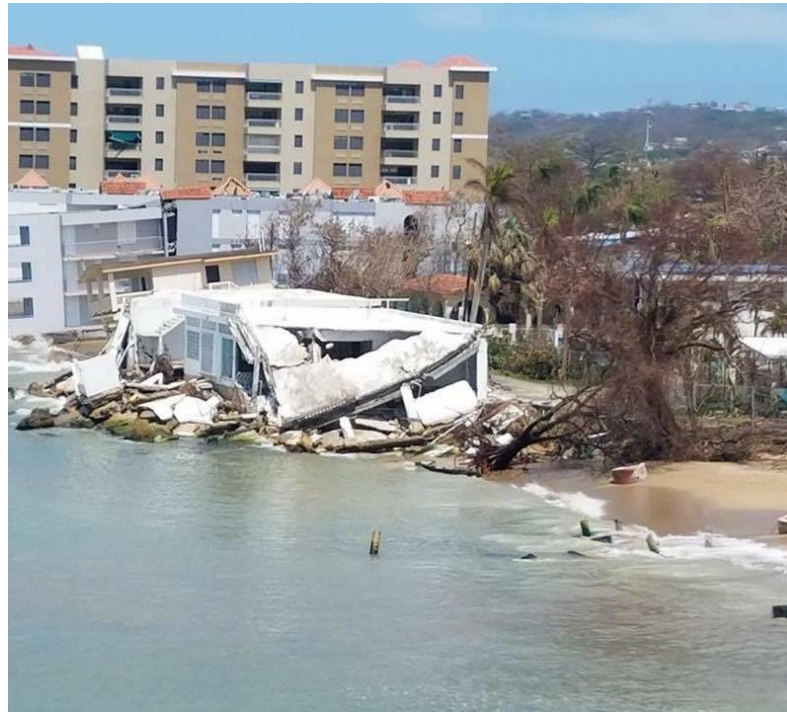
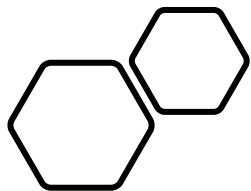
## Hurricane Maria killed 2,975 people in Puerto Rico. It's the second deadliest US storm in over a century.



By [Nicole Chavez](#), CNN

Updated 7:10 AM EDT, Wed August 29, 2018













Meghan Johnson<sup>a</sup>  , Humberto Parada Jr.<sup>a, b</sup>, Karen Ferran<sup>a</sup>, Ramona Perez<sup>c</sup>, William Calo<sup>d</sup>, Istoni da Luz Sant'Ana<sup>e</sup>, Liz Martínez Ocasio<sup>e</sup>, Pablo A. Mendez-Lazaro<sup>e</sup>, Sandra I. Garcia<sup>e</sup>, Guillermo Tortolero-Luna<sup>f</sup>, Sharee A. Umpierre<sup>e, g</sup>, Ana Patricia Ortiz<sup>e, f</sup>

## Article

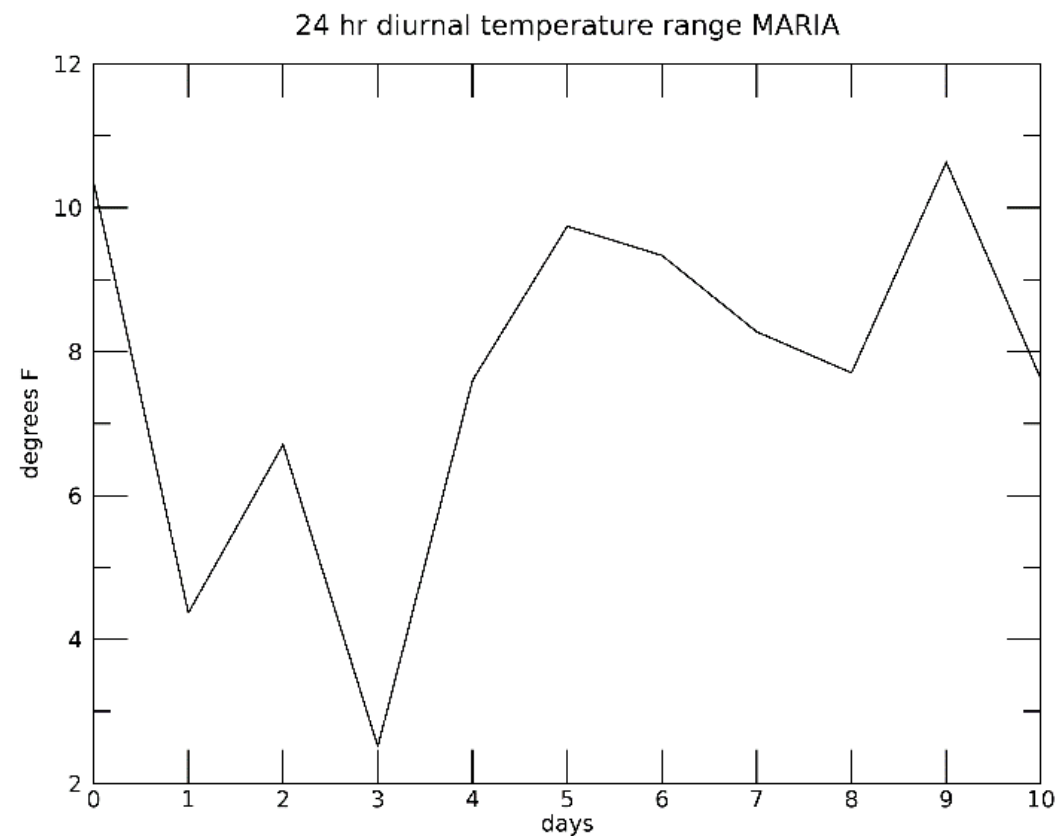
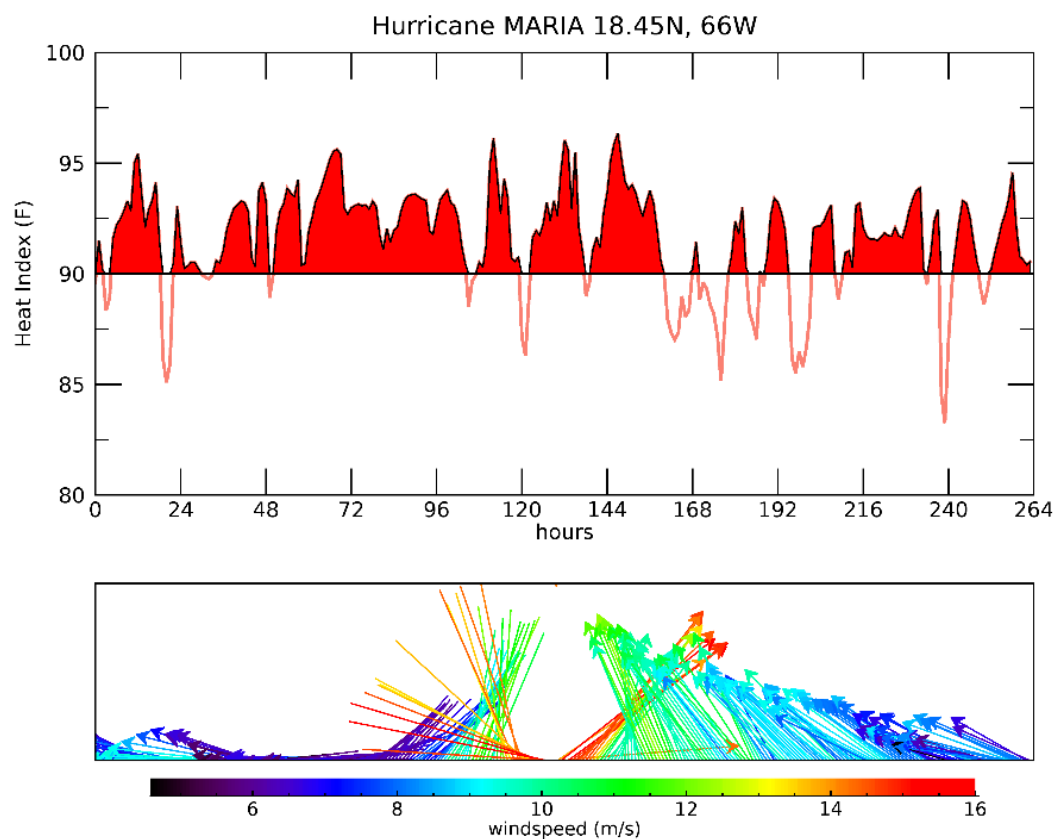
# Environmental Stressors Suffered by Women with Gynecological Cancers in the Aftermath of Hurricanes Irma and María in Puerto Rico

Pablo A. Méndez-Lázaro <sup>1,\*</sup>, Yanina M. Bernhardt <sup>2</sup>, William A. Calo <sup>3</sup>, Andrea M. Pacheco Díaz <sup>2</sup>, Sandra I. García-Camacho <sup>2</sup>, Mirza Rivera-Lugo <sup>4</sup>, Edna Acosta-Pérez <sup>4,5</sup>, Naydi Pérez <sup>5</sup> and Ana P. Ortiz-Martínez <sup>2,6</sup>



# Impact of Hurricane-Related Stressors and Responses on Oncology Care and Health Outcomes of Women with Gynecologic Cancers from Puerto Rico and US Virgin Islands

# NOAA: Building Knowledge about the Intersections of Public Health Issues, Hurricanes, and Heat



Collaboration: Teddy Allen Ph.D. Caribbean Institute of Meteorology and Hydrology

RESEARCH ARTICLE

International Journal  
of Climatology



# Heat stress in the Caribbean: Climatology, drivers, and trends of human biometeorology indices

Claudia Di Napoli<sup>1,2,3</sup> | Theodore Allen<sup>4</sup> | Pablo A. Méndez-Lázaro<sup>5</sup> | Florian Pappenberger<sup>3</sup>



## Geophysical Research Letters<sup>®</sup>

### RESEARCH LETTER

10.1029/2022GL099740

#### Key Points:

- Areas around tropical cyclones have heat index (HI) values significantly warmer than average, a result insensitive to storm strength
- Positive HI anomalies occur after the cyclones passage in all storms;

### Hurricanes and Anomalous Heat in the Caribbean

Zack Guido<sup>1,2</sup> , Teddy Allen<sup>3</sup> , Simon Mason<sup>4</sup> , and Pablo Méndez-Lázaro<sup>5</sup>

<sup>1</sup>Arizona Institutes for Resilient Environments and Societies, University of Arizona, Tucson, AZ, USA, <sup>2</sup>School of Natural Resources and Environment, University of Arizona, Tucson, AZ, USA, <sup>3</sup>Caribbean Institute for Meteorology and Hydrology, St. James, Barbados, <sup>4</sup>International Research Institute for Climate and Society, Earth Institute, Columbia University, Palisades, NY, USA, <sup>5</sup>Environmental Health Department, Graduate School of Public Health, University of Puerto Rico-Medical Campus, San Juan, Puerto Rico



# HEAT & HOSPITALIZATIONS

REGIONAL HEAT INDEX RANGE FOR PEAK HOSPITALIZATIONS



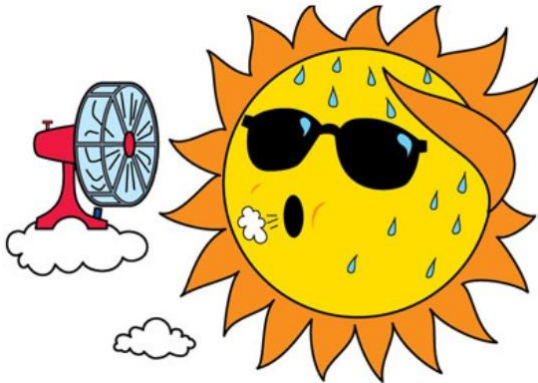
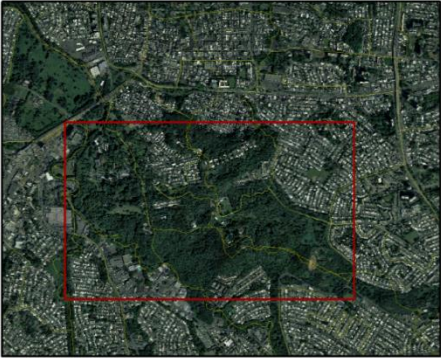
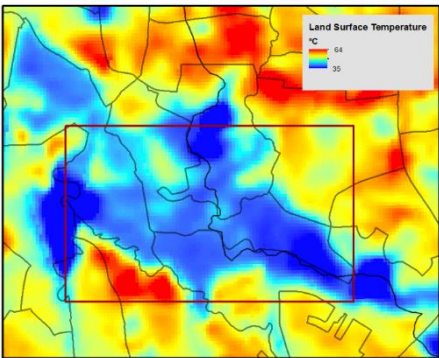
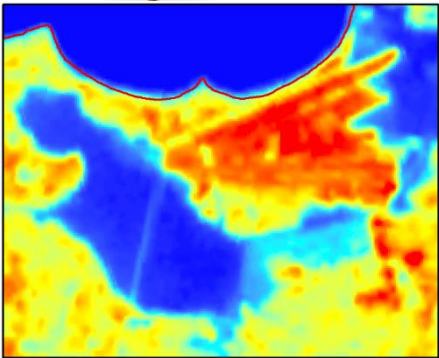
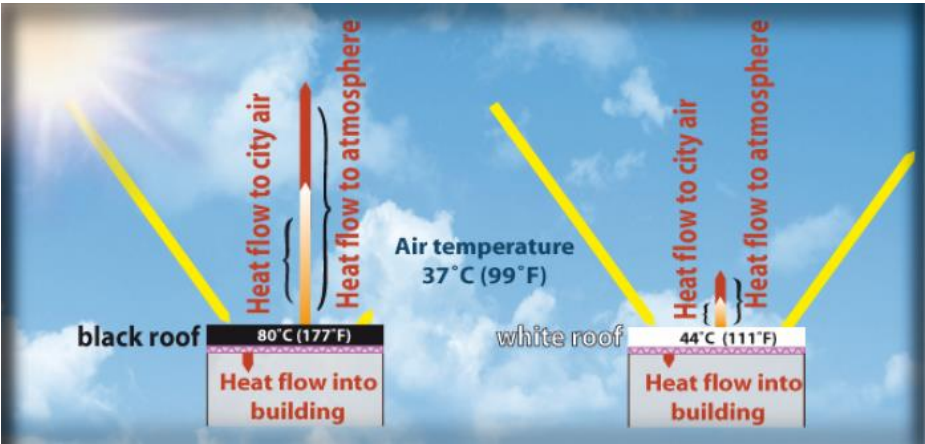
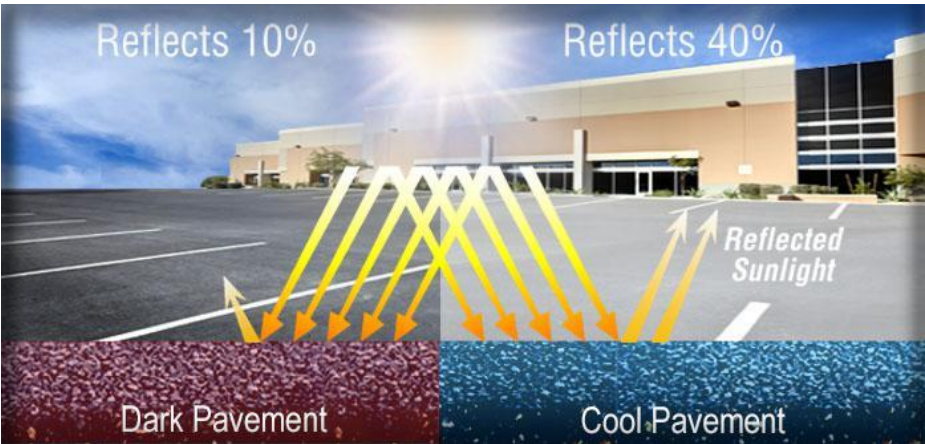
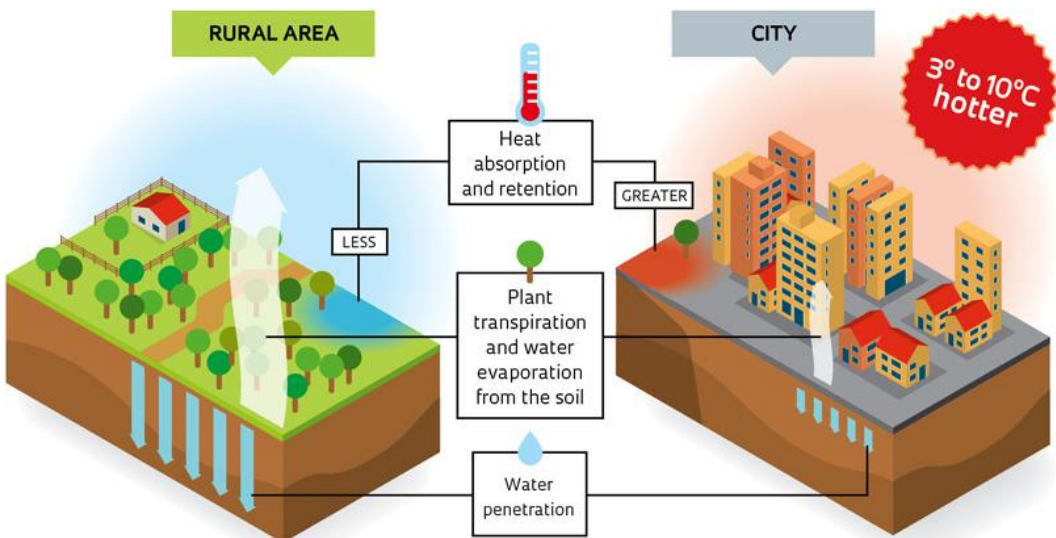
Source: Vaidyanathan, et. al (2019) DOI: 10.1073/pnas.1806393116

CLIMATE  CENTRAL

Extreme  
Temperatures

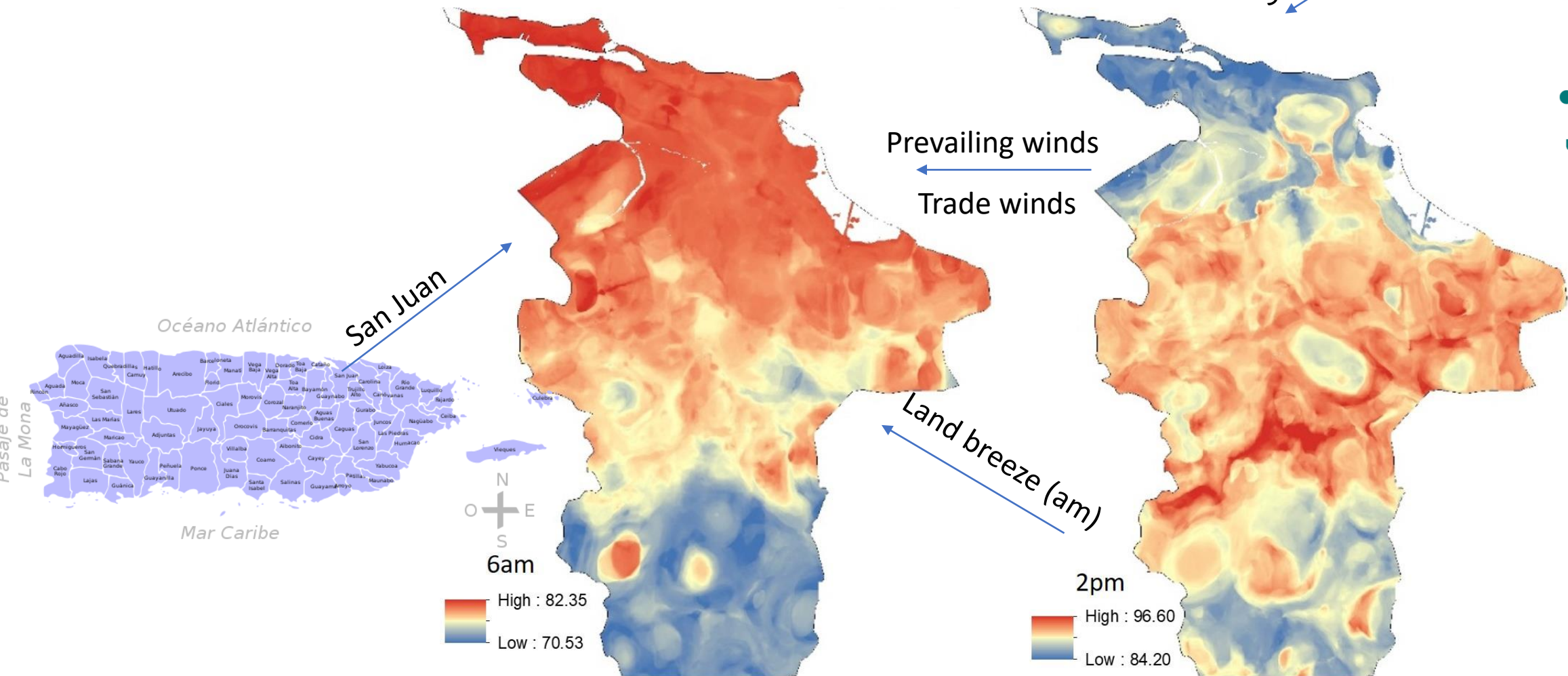


# Why the urban heat island effect occurs





# UHI and Intra-urban heat distribution in San Juan, PR (June 23rd, 2019)





# HAZARDOUS WEATHER OUTLOOK

## HEAT



**THREAT LEVEL: SLIGHT**

Heat Indices between 102 and 107 degrees Fahrenheit are expected between 10:00 AM and 3:00 PM AST today.



DRINK PLENTY OF WATER,  
EVEN IF NOT THIRSTY



AVOID STRENUOUS ACTIVITY  
DURING HOTTEST PART OF DAY



WEAR LIGHTWEIGHT,  
LIGHT-COLORED, LOOSE CLOTHING



AVOID CONSUMPTION OF  
ALCOHOL AND CAFFEINE



WEAR SUNSCREEN



NEVER LEAVE KIDS  
OR PETS UNATTENDED IN  
VEHICLES



Servicio Nacional de Meteorología  
San Juan, Puerto Rico

Friday, October 1st, 2021

## HEAT CALOR



**Maximum Heat Indices | Valid: 6:00 PM AST**

Índices de Calor Máximos | Válido: 6:00 PM AST

Cotton Valley, USVI	113°F
Aguada, PR*	111°F
Fajardo, PR*	109°F
Ponce, PR*	106°F
Arecibo, PR*	106°F
Vega Baja, PR*	106°F
Carolina, PR*	105°F
Guanica, PR	105°F
St Thomas, PR*	104°F
Mayaguez, PR*	104°F

\* These are reports from Public Networks. | Estos son reportes de Redes Públicas.



National Weather Service  
San Juan, Puerto Rico

Tuesday, September 28th, 2021

Air Temperature	Relative Humidity (%)																
	40	45	50	55	60	65	70	75	80	85	90	95	100				
110	136																
108	130	137															
106	124	130	137														
104	119	124	131	137													
102	114	119	124	130	137												
100	109	114	118	124	129	136											
98	105	109	113	117	123	128	134										
96	101	104	108	112	116	121	126	132									
94	97	100	103	106	110	114	119	124	129	135							
92	94	96	99	101	105	108	112	116	121	126	131						
90	91	93	95	97	100	103	106	109	113	117	122	127	132				
88	88	89	91	93	95	98	100	103	106	110	113	117	121				
86	85	87	88	89	91	93	95	97	100	102	105	108	112				
84	83	84	85	86	88	89	90	92	94	96	98	100	103				
82	81	82	83	84	84	85	86	88	89	90	91	93	95				
80	80	80	81	81	82	82	83	84	84	85	86	86	87				

Heat Index  
(Apparent  
Temperature)

With Prolonged Exposure  
and/or Physical Activity

**Extreme Danger**

Heat stroke or sunstroke  
highly likely

**Danger**

Sunstroke, muscle cramps,  
and/or heat exhaustion likely

**Extreme Caution**

Sunstroke, muscle cramps,  
and/or heat exhaustion possible

**Caution**

Fatigue possible

## HEAT CALOR



**Maximum Heat Indices | Valid: 11:00 AM AST**

Índices de Calor Máximos | Válido: 11:00 AM AST

San Juan, PR*	111°F
Cotton Valley, ISX	109°F
Vega Baja, PR*	107°F
Fajardo, PR*	106°F
Arecibo, PR*	105°F
Juncos, PR*	105°F
Humacao, PR*	104°F
Charlotte Amalie, IST*	104°F
Carolina, PR*	104°F
Guanica, PR	102°F

\* Non-official reports from Public Networks. | Reportes no oficiales de Redes Públicas.



National Weather Service  
San Juan, Puerto Rico

Friday, September 3rd, 2021



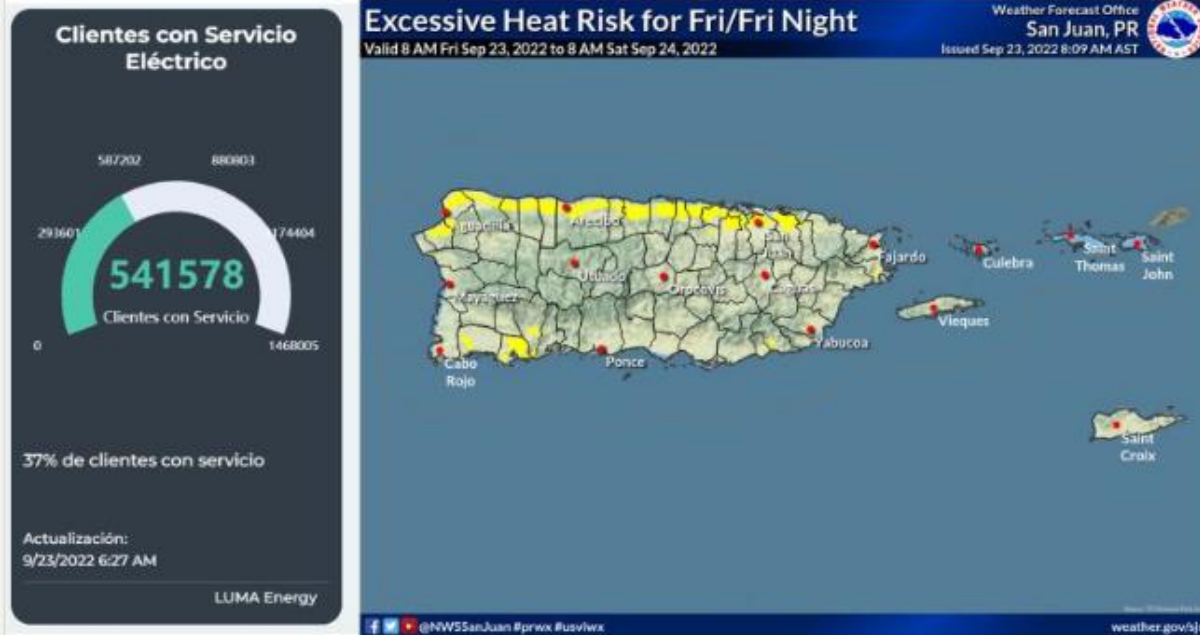
3rd Consecutive day with Excessive Heat Risk in the Aftermath of Hurricane Fiona with less than 50% of the population with Electricity. <https://www.preps.pr.gov/>

The Good news is that the advisory issued by NWS-SJ for Excessive Heat is covering less municipalities than previous days. Probably Heat threat will decrease in the upcoming days.

Without power, many residents and communities are unable to mitigate Extreme Heat.

Kudos to the **National Weather Service**-San Juan Office for keeping puertorricans inform about the existing climate hazards potentially affecting Public Health.

[#publichealth](#) [#electricity](#) [#climatechange](#) [#climatecrisis](#) [#climateaction](#) [#extremeheat](#)



2nd Consecutive day with EXCESSIVE HEAT RISK IN PUERTO RICO!!!

Puertorricans without power and unable to mitigate extreme temperatures.

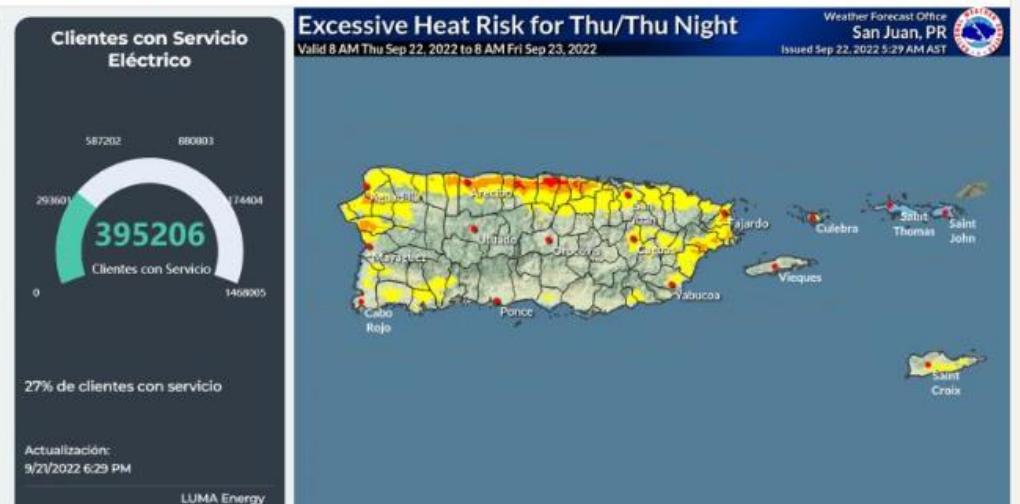
Inefficient actions in the last 5 years in Transforming the Electric System and its Governance in Puerto Rico coupled with extreme weather events and community marginalization are nowadays more evident than ever.

Today, official Government webpage suggests that **ONLY 27%** of the population have power in the Aftermath of Hur. Fiona (Cat1). <https://www.preps.pr.gov/>

Residents in Puerto Rico continue to be prisoners of the lack of equitable actions, energy justice, resilient and sustainable energy.

Vulnerable patients and communities living below poverty level continue to be at risks and are suffering: elderly, children, people with cardiovascular diseases, cancer patients, diabetes, hypertension, obesity, chronic lower respiratory disease, pneumonia, and kidney disease.

[#makeitaboutthepeople](#) [#energy](#) [#climatechangeadaptation](#) [#extremeheat](#) [#cascadingeffects](#) [#climatecrisis](#) [#climateurgency](#)



CCAN-Caribbean Climate Adaptation Network:  
Building equitable adaptive capacities of the  
US Virgin Islands and Puerto Rico.

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Carlos Ramos-Scharrón (Co-PI), K Stephen Hughes (Co-PI)



**Climate Adaptation  
Partnerships**  
*Formerly RISA*





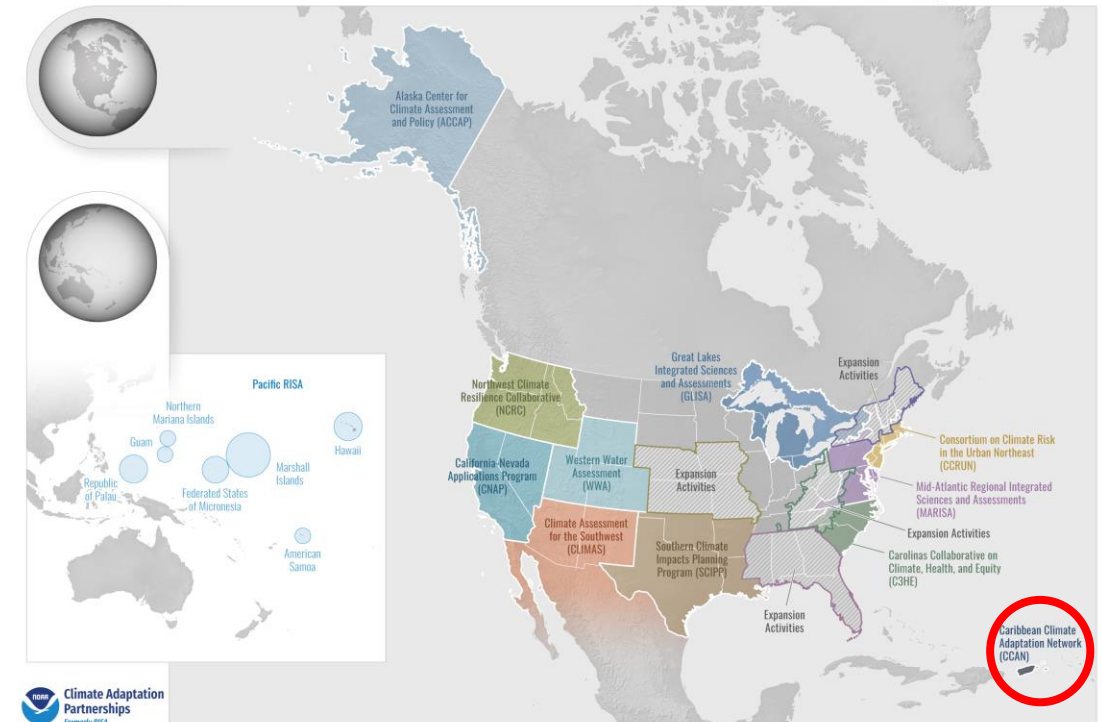
# NOAA CAP/RISA

## Climate Adaptation Partnerships

Advancing equitable adaptation through sustained regional research and community engagement



## Currently Funded CAP/RISA Teams and Expansion Activities











# Questions!

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**Lead Principal Investigator** [Aerosol Monitoring Tool/Early Warning System](#) (PR-CLIMAH/NASA/UPR/CARICOOS)