




Climate change in Puerto Rico: current conditions, projections, and socioecological challenges

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Science Coordinator

Puerto Rico Climate Change Council

2022

PUERTO RICO

Overview

- Climate Change fundamentals
- The State of the Puerto Rico Climate 2022 *…What we know!*
- Coastal communities, critical infrastructure and natural assets at risk.
- Trends and projections *…What we need to know!*
- Blueprint for resilient coasts and biodiversity
- Translating Science into Policy and Effective Implementation
- Procrastination or Paradigm Shift ? *…An urgent need for consensus!*

Puerto Rico Climate Change Council

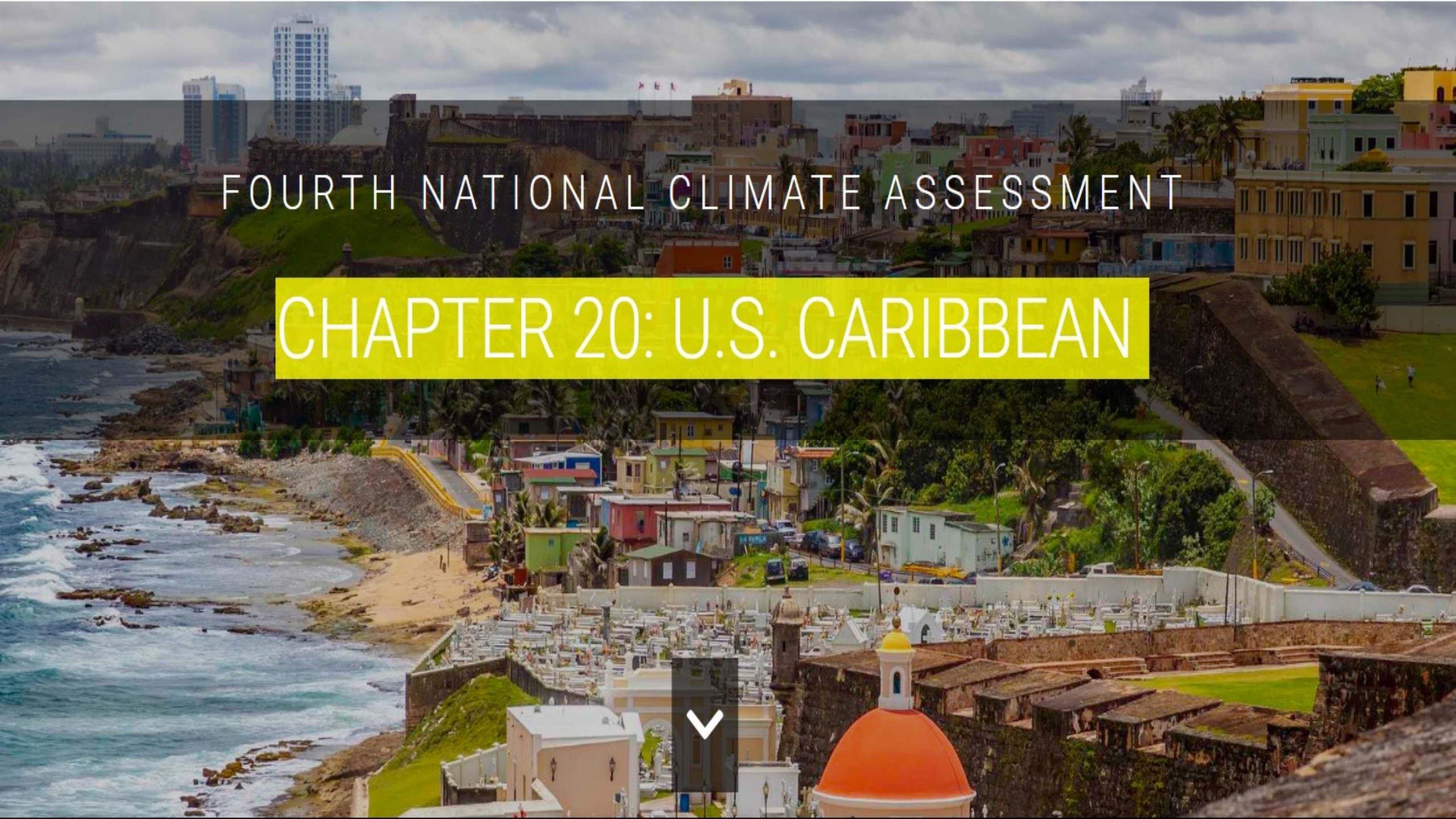
Mission

…assess the state of Puerto Rico's climate, using the best science and knowledge available, understand Puerto Rico's social-ecological vulnerabilities and develop adaptation strategies to build a resilient society.

Membership: 150+


Geophysical
and Chemical
Scientific Knowledge
Ecology and
Biodiversity
Society and Economy
Communicating
Climate Change and
Coastal Hazards
Sea Grant
University of Puerto Rico
NOAA
CARICOOS
USGS
science for a changing world
INTERNATIONAL
INSTITUTE OF TROPICAL FORESTRY
Estuario
de la Bahía de San Juan
COMPAÑÍA DE
TURISMO
PUERTO RICO
Center for Applied Tropical
Ecology and Conservation
CCRI
DRNA
The Nature
Conservancy
Protecting nature. Preserving life.
UNIVERSIDAD
INTERAMERICANA
DE PUERTO RICO
Estudios
Técnicos
Inc.
Investigación | Estrategias | Soluciones
SOCIEDAD
PUERTORRIQUEÑA
DE PLANIFICACIÓN
PUERTO RICO
HOTEL & TOURISM
ASSOCIATION
CAMBIO
AEROPUERTO
INTERNACIONAL
LUIS MUÑOZ MARÍN
PUERTO RICO
CSA Group


V REUNION CUMBRE



FOURTH NATIONAL CLIMATE ASSESSMENT

CHAPTER 20: U.S. CARIBBEAN

Global Climate Change

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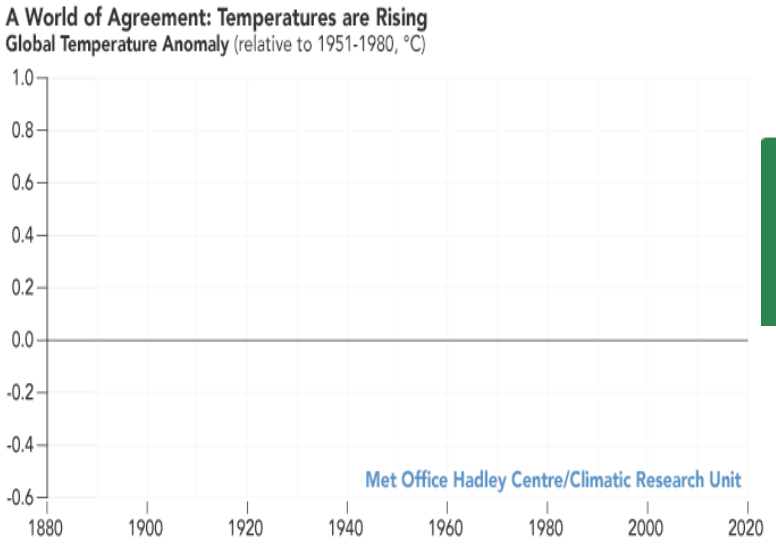
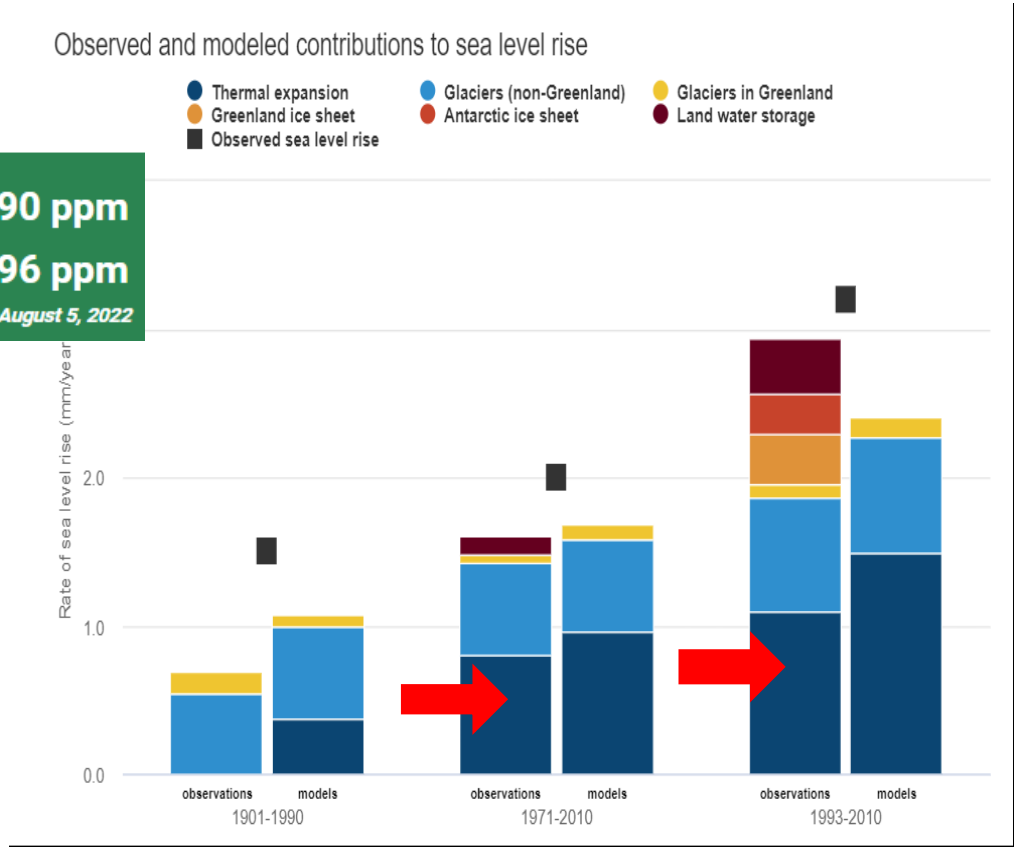
…a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. (UNFCCC 1992)



July 2022: 418.90 ppm
July 2021: 416.96 ppm
Last updated: August 5, 2022

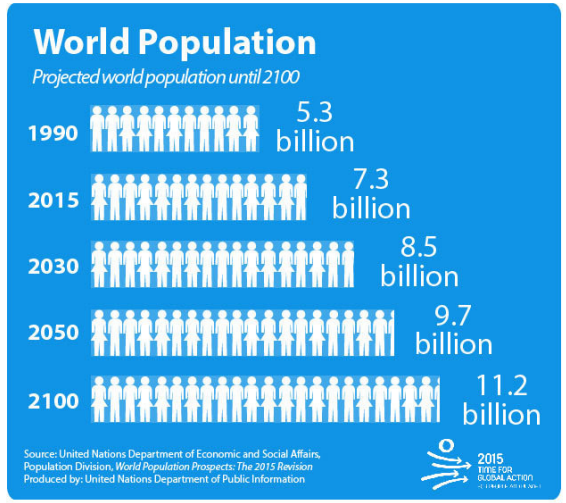


40%
WORLD POPULATION
COASTS

68%
WORLD POPULATION
CITIES (2050)

70%
ENERGY
DEMAND

75%
GHG
EMISSIONS



NCA4 (2018)
World Bank Group (2019)

Puerto Rico's coastal uses and assets

ECONOMICS

GDP: $105 billion/year (PRPB)
Tourism $2B/year
Built up Areas/Coastline 18%
Industrial Parks (81)
Commercial/Recreational Fisheries

HOUSING

Public Housing (15)
Individual Housing ( )

PUBLIC BUILDINGS

Public Buildings not under other sectors ( )

TRANSPORTATION

Airports (11)
Ports (12)
Bridges, Culverts, Piers
Miles of Primary Roads (17,387mi/27,982km)

NATURAL AND CULTURAL RESOURCES

Protected Areas (Land) DRNA 8.7% (2015) – PA-CAT 16% (2016)
Protected Areas (Marine) 27.2%
Shallow coral reefs and associated communities designated for protection 49%
Historical Properties (22+)

Coastal population: 2.3 million (61%) at 44 coastal municipalities

Territorial waters: 9 nm (A=5,078.9mi^2)

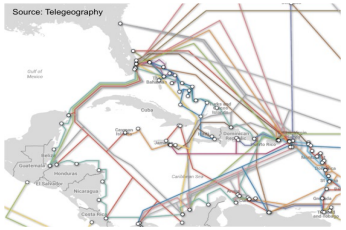
Coastline: 799 mi -1,225 beaches (60% moderate to severe erosion)

Puerto Rico's coastal uses and assets

PUERTO RICO

HEALTH AND SOCIAL SERVICES

Hospitals (3)
Treatment Centers (xx)



COMMUNICATIONS

Fiber Optic Cables (15)
Internet Infrastructure
Public community systems

ENERGY

Power plant systems (5 public, 2 private)
Substations
Distribution and transmission lines

WA

PRASA infrastructure at coastal zone: 200km potable water
260km sanitary infrastructure
6 water systems
Pump stations
Wastewater Treatment Plants (28 coastal)

EDUCATION

Schools (36)

Coastal population: 2.3 million (61%) at 44 coastal municipalities

Territorial waters: 9 nm (A=5,078.9 mi^2)

Coastline: 799 mi -1,225 beaches (60% moderate to severe erosion)

PUERTO RICO

Coastal Risks: Inundation and Erosion

Coastal inundation is the increase in sea levels that affect low-lying lands. Floods are caused by tides, storm surges, waves (episodic) or sea level rise (permanent).

Coastal erosion is the loss of land, or the long-term removal of sediment along the coastline due to the action of waves, currents, tides, the impacts of storms, winter swells or wave energy deficits.

Key drivers: Ocean forcing, extreme events, poor planning and design

Resilience

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. . . is the capacity for a social-ecological system to:

1. absorb stress and maintain function in the face of external stresses, and
2. adapt, reorganize, and evolve into more desirable configurations that improve the sustainability of the system, leaving it better prepared for future impacts.

A Louisiana Tribe Is Now Officially A Community Of Climate Refugees

Since the 1950s, the Native American tribe has lost 98 percent of the
calls home.

02/12/2016 08:19 am ET | Updated Feb 15, 2016

La OMM reporta un ritmo alarmante de ca

Will Tuvalu Disappear Beneath the Sea?

Global

atens to

a small island

Sea Rise Th
Oakland's

Submitted by MCAnderson on

Share 0 Email 0 Tweet 0 Like 0 Google + 0

By Barbara Grady, Oakland Local/New America Medi

ROTTERDAM: THE WATER CIT
FUTURE

living below sea level, the Netherlands has developed
with changing weather patte

EYE ON THE STORM

NASA: June 2022 tied as Earth's warmest June on record

elnuevodia.c

Noticias
03 octubre 2014
07:41 p.m.

Expertos discuten sobre los cambios climáticos en Puerto Rico

Resaltan los incrementos en las temperaturas tanto en el día como la noche

Más de 150 expertos de difere
este viernes en la VI Cumbre d
Climáticos 2014 (CCCPR) para p
proyecciones y los nuevos mapa
huracanes y a cambios en el nive
Puerto Rico, Culebra y Vieques.

Científicos, planificadores, arquitec
sociólogos y expertos en diferentes
de los cambios climáticos, así
bierno se dieron cita
en Miran

Crisis en Cataño por falta de operadores de bombas de drenaje

Por Ivelisse Rivera Quiñones

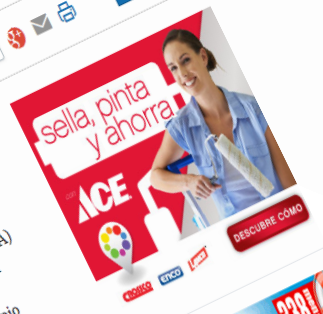
martes, 8 de septiembre de 2015 - 7:36 PM

Calles del casco urbano y parte de Guaynabo quedaron bajo agua

Una supuesta avería eléctrica y la falta de personal en el cuarto de bombas de drenaje del Departamento de Recursos Naturales y Ambientales (DRNA) ubicadas en Cataño y que son utilizadas para evitar inundaciones en el municipio costero y partes de Guaynabo, evitó que la maquinaria cumpliera con su propósito principal.

urbano de Cataño

Guardar



PRESS RELEASE

Warming Climate to Hit Bangladesh Hard w
Sea Level Rise, More Floods and Cyclones, W
Bank Report Says

June 19, 2013

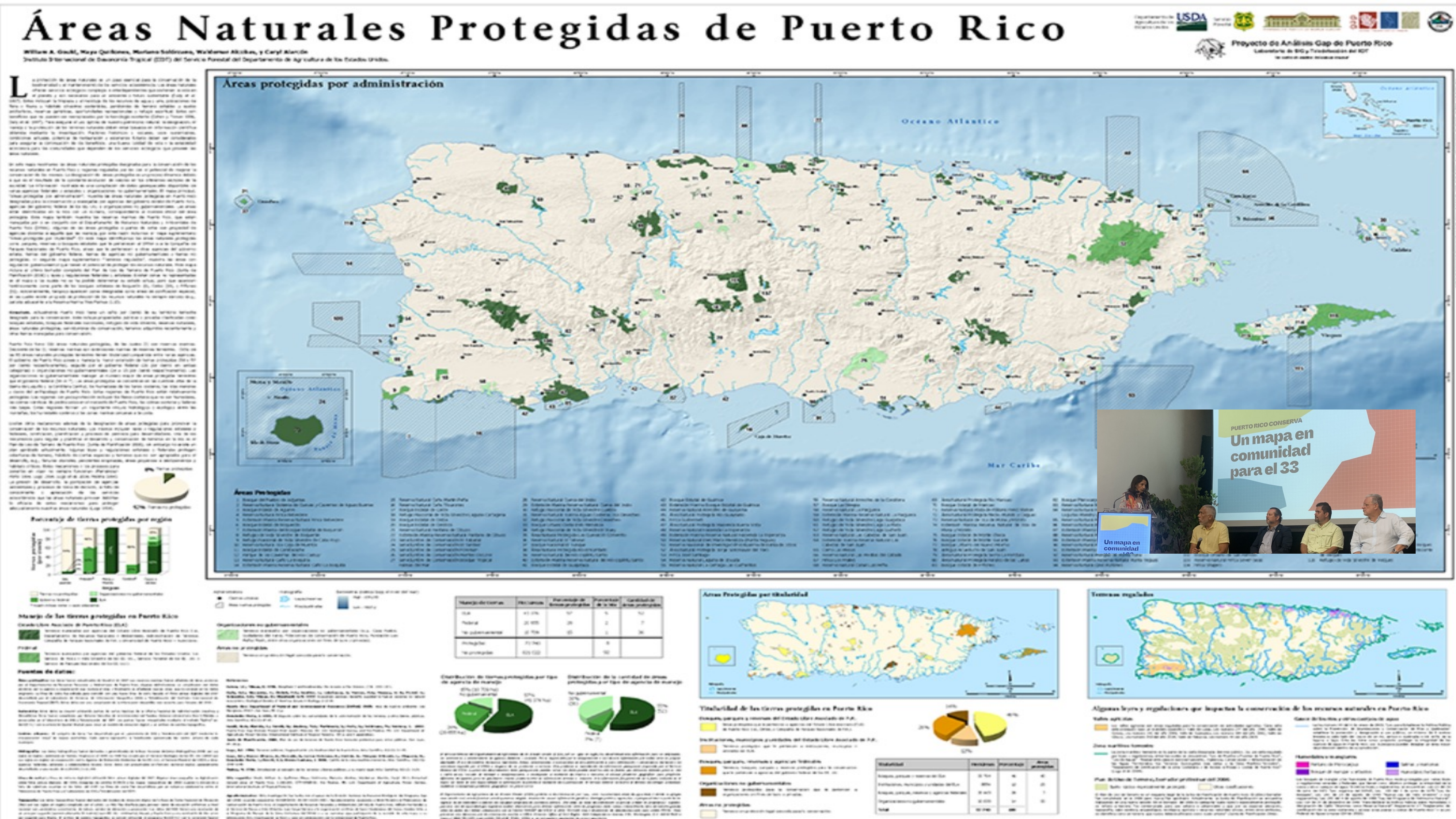
Acuerdo de colaboración en el Caribe sobre cambio climático

Puerto Rico, Islas Vírgenes Norteamericanas y EPA

LOCALES

Acumulación récord de lluvias en San Juan

Según Meteorología, una onda tropical bien activa con muchos aguaceros y tronadas afecta a todo Puerto



Áreas Naturales Protegidas de Puerto Rico
Proyecto de Análisis Gap de Puerto Rico
Áreas protegidas por administración
Océano Atlántico
Mar Caribe
Áreas Protegidas
Porcentaje de tierras protegidas por región
Manejo de las tierras protegidas en Puerto Rico
Fuentes de datos
Áreas Protegidas por titularidad
Titularidad de las tierras protegidas en Puerto Rico
PUERTO RICO CONSERVA
Un mapa en comunidad para el 33

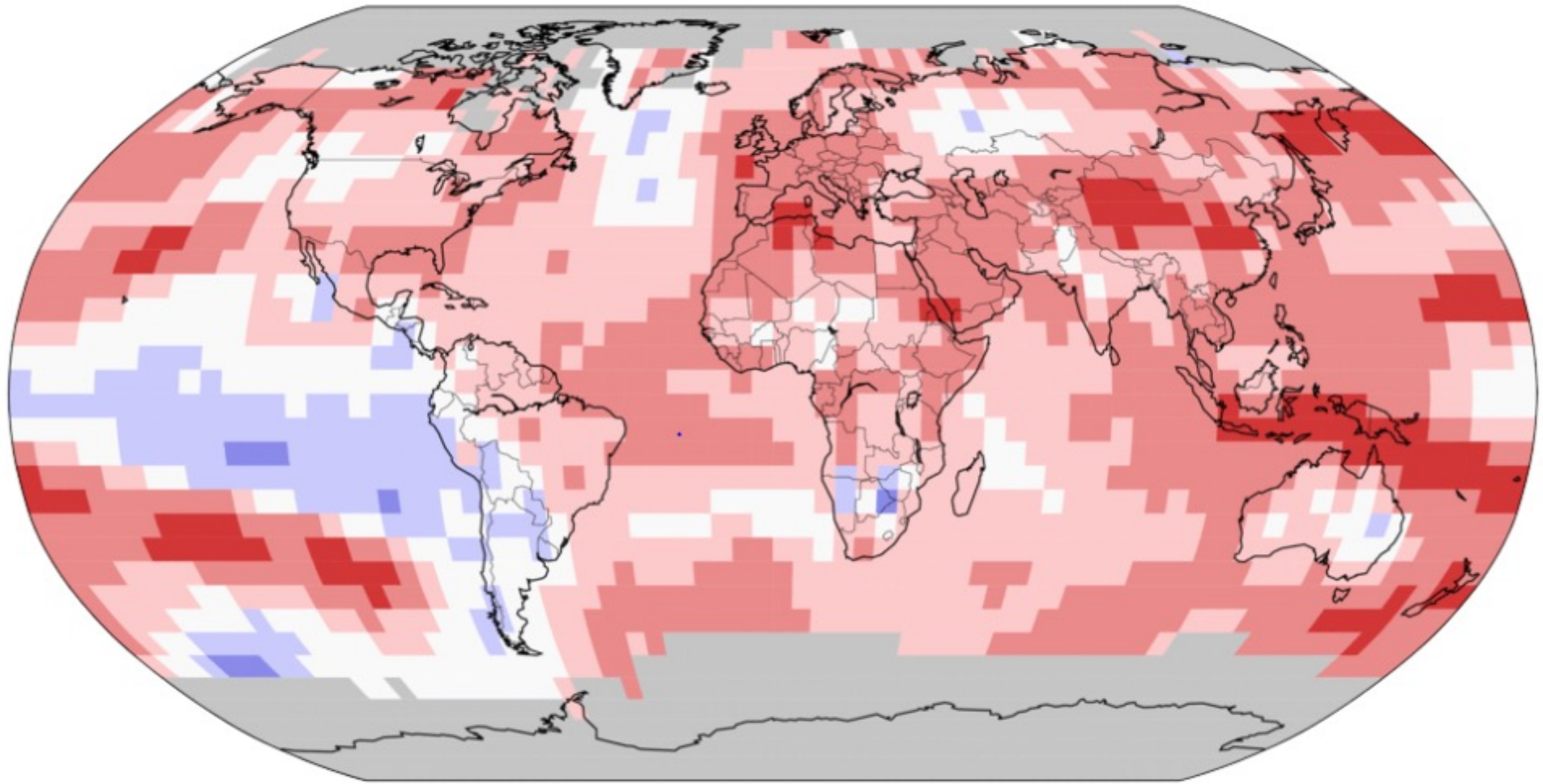
The State of Puerto Rico's Climate 2021-2022

Puerto Rico Climate Change Council

Land & Ocean Temperature Percentiles Jun 2022

NOAA's National Centers for Environmental Information

Data Source: NOAAGlobalTemp v5.0.0–20220708



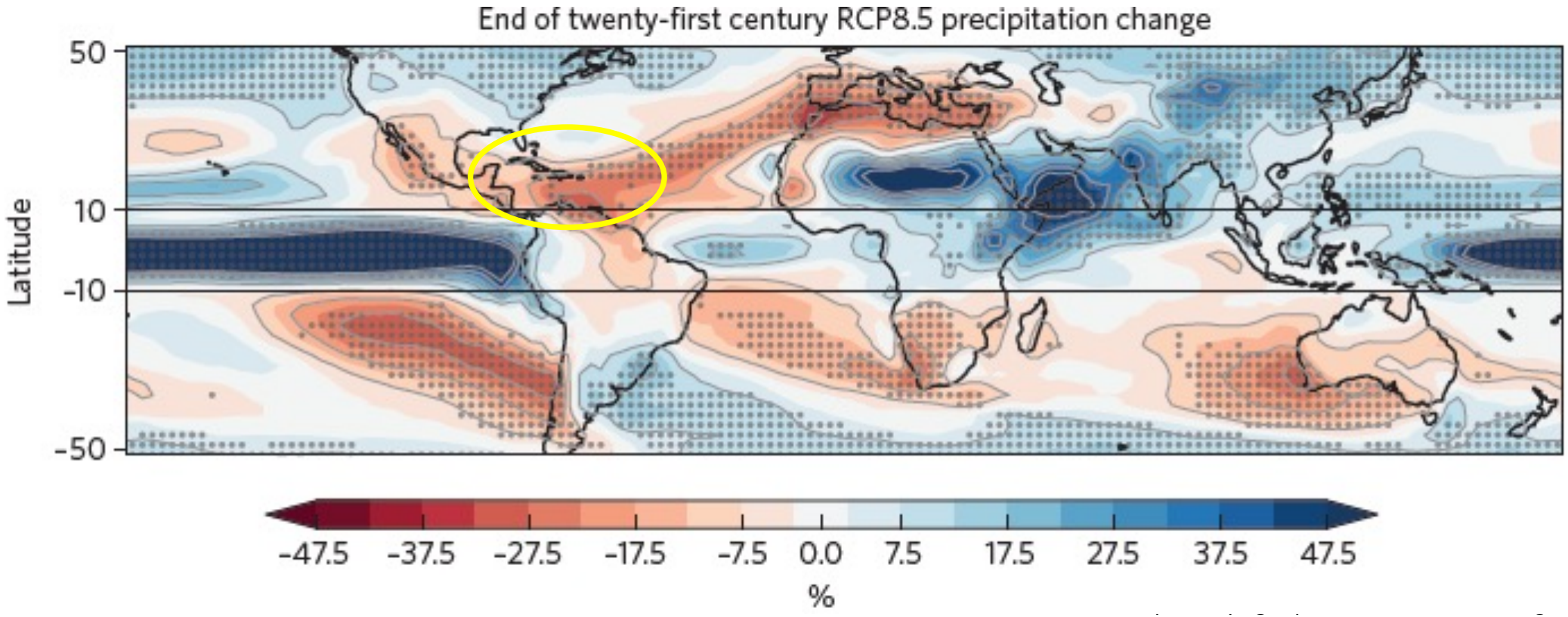
Record Coldest | Much Cooler than Average | Cooler than Average | Near Average | Warmer than Average | Much Warmer than Average | Record Warmest

PRCCC Working Group 1: Geophysical and Chemical Scientific Knowledge (2022)

Section	Authors	Technical Reviewers
Section 1: Our warming planet	Adam Terando[3,4] William Gould[5]	
Section 2: Puerto Rico's contribution to Global Climate Change	Adam Terando[3,4] William Gould[5] Mark Jury[6]	
Section 3: El Niño and Other Forms of Natural Climate Variability	Jared Bowden[4]	
Section 4: Observed and Projected Temperature Changes in Puerto Rico	Adam Terando[3,4] Jared Bowden[4]	
Section 5: Observed and Projected Precipitation Changes in Puerto Rico	Adam Terando[3,4] Jared Bowden[4]	
Section 6: Observed and Projected Sea Level Rise in Puerto Rico	Ernesto L. Díaz[2] (*Coordinator)* Patricia Chardon[6,7]	Aurelio Mercado, William Sweet, Juan González, Mark Osler, Robert Kopp
Section 7: Ocean Acidification	Melissa Meléndez[8] Julio Morell[6,7]	Dwight Gledhill, NOAA Ocean Acidification Program
Section 8: Tropical Cyclones	Adam Terando[3,4] Jared Bowden[4]	

Citation: **Díaz, E., Terando, A., Gould, W., Bowden, J., Chardon, P., Meléndez, M., and Morell, J. (2021). Working Group 1: Geophysical and Chemical Scientific Knowledge. State of the Climate Report. Puerto Rico Climate Change Council. Díaz, E. and Terando, A. [Eds.]**

GCMs provide foundational knowledge for climate risk characterization



Expect higher temperatures and sub-tropical drying in Caribbean region!

PUERTO RICO

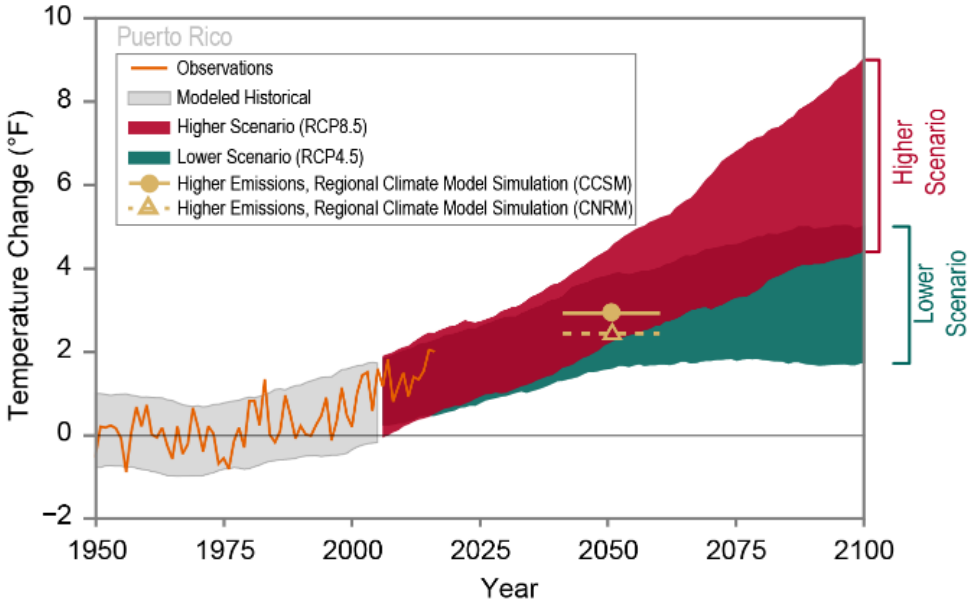
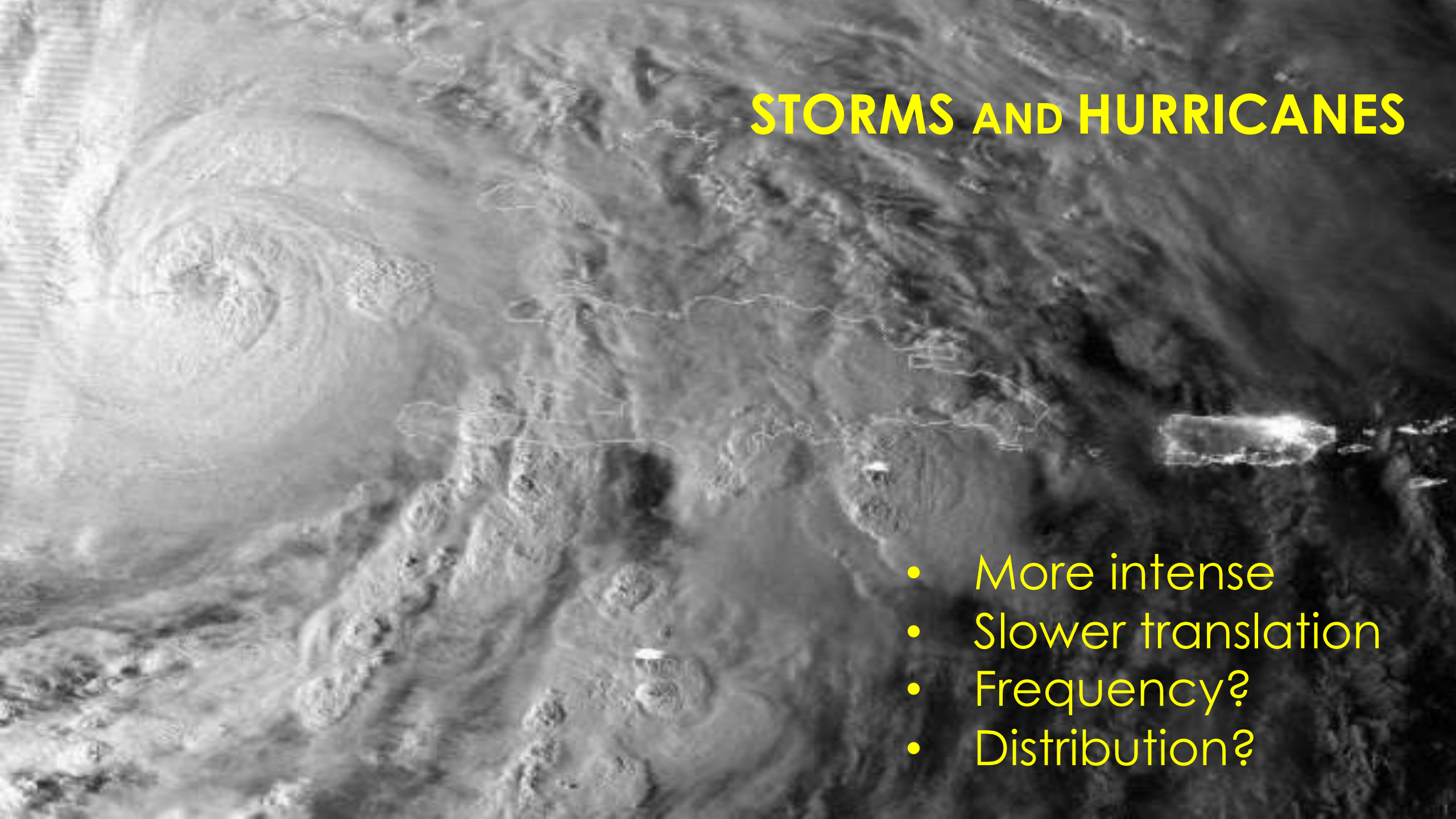


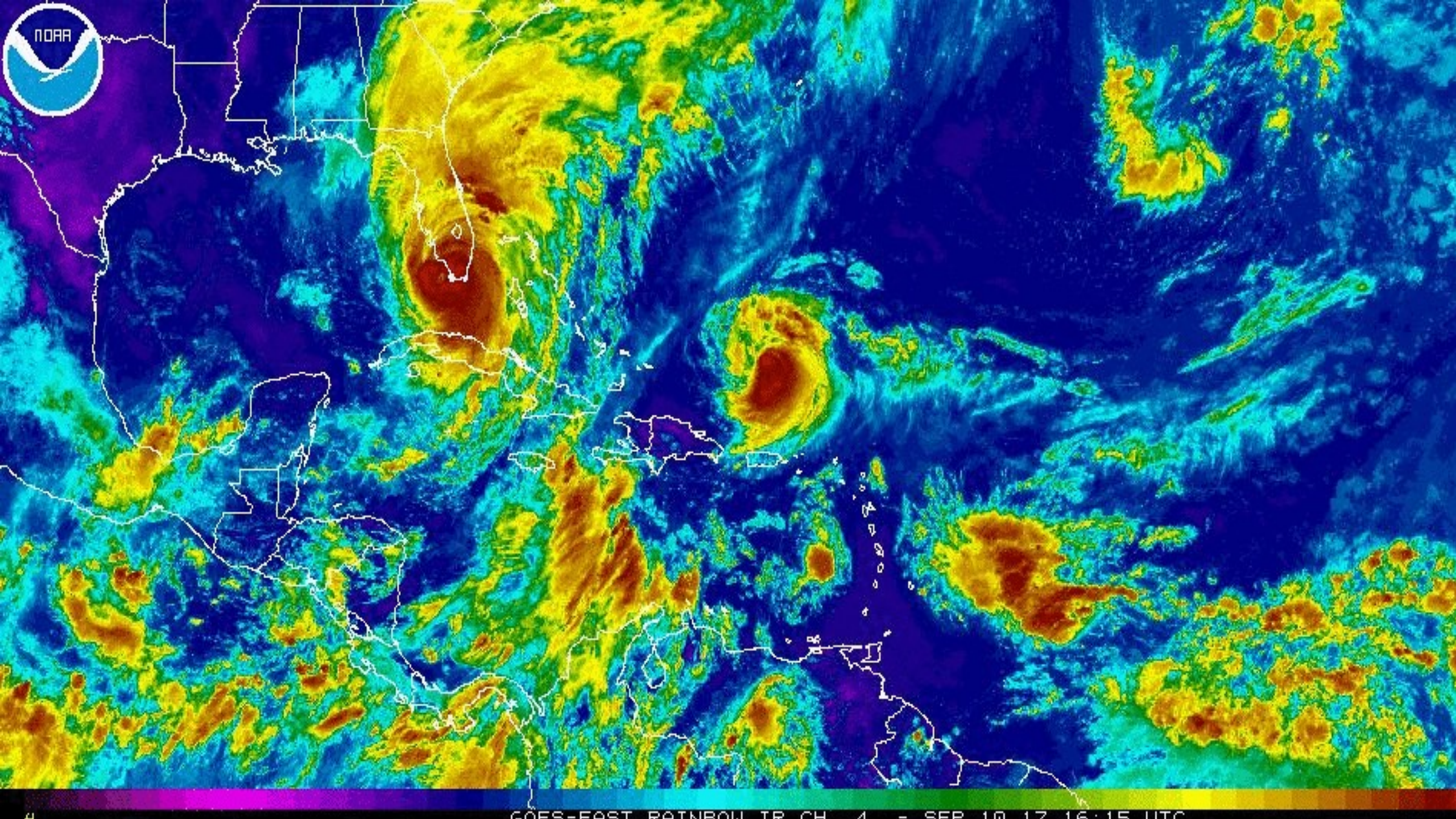
Fig. 20.3: Observed and Projected Temperature Change for Puerto Rico

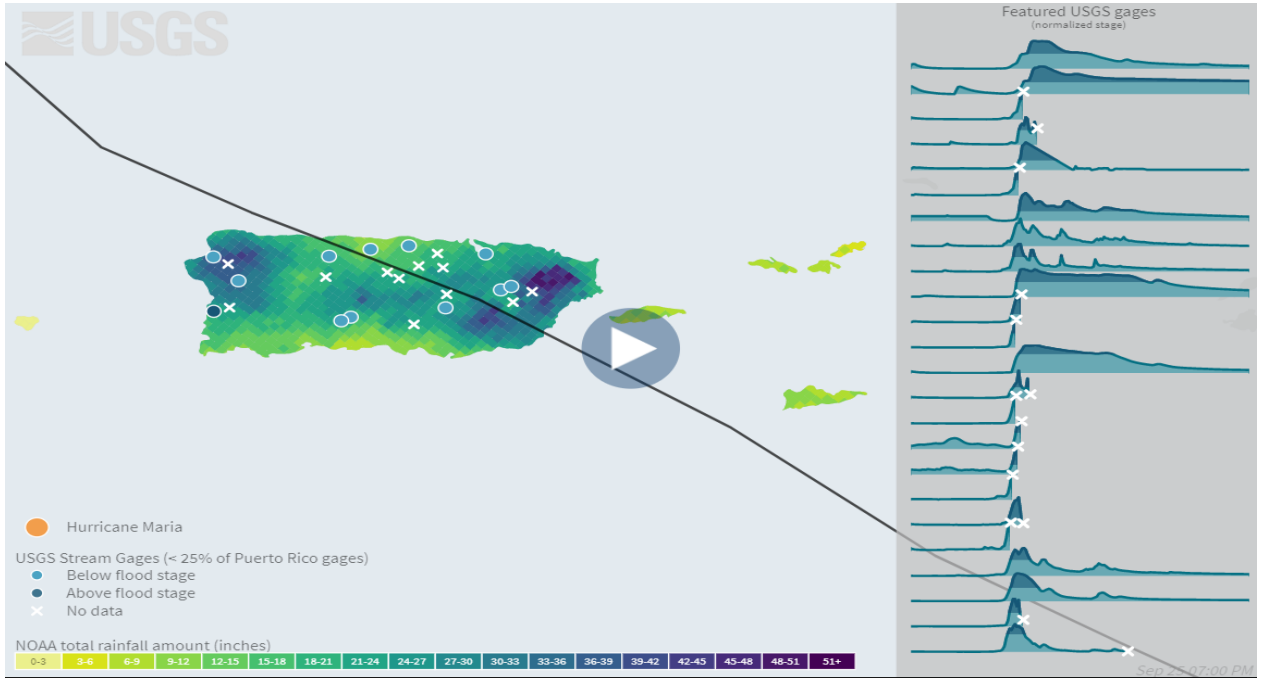
- **Temperatures across Puerto Rico vary strongly with topography.**
- **Temperatures are projected to increase in Puerto Rico and across the Caribbean over the 21st century under scenarios corresponding to both lower and higher levels of GHG emissions.**

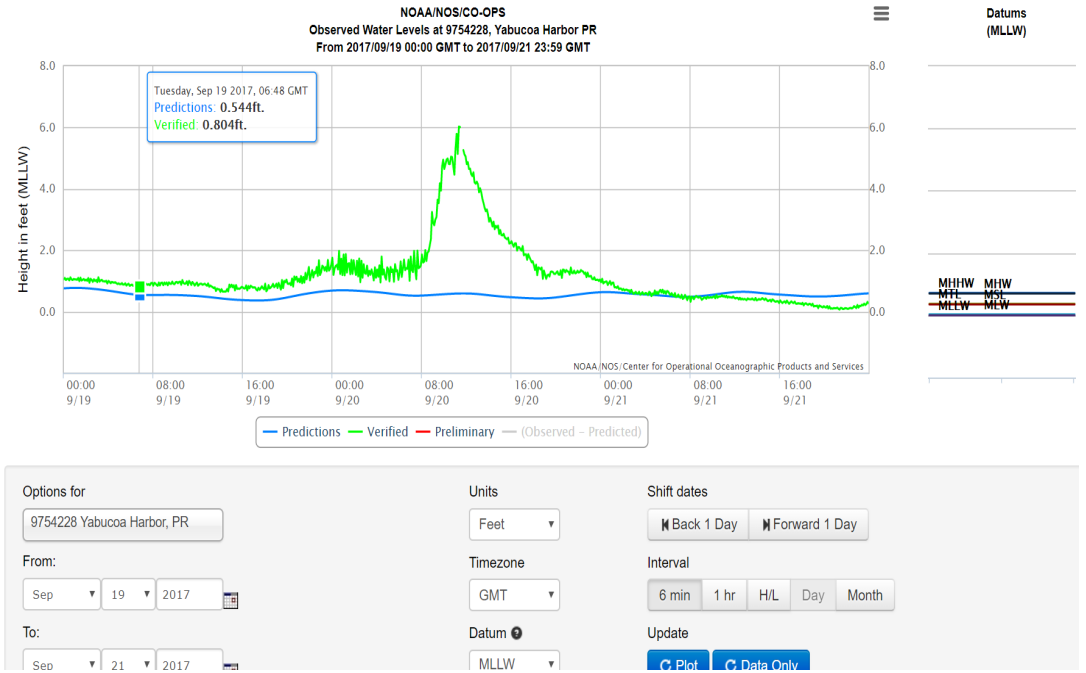


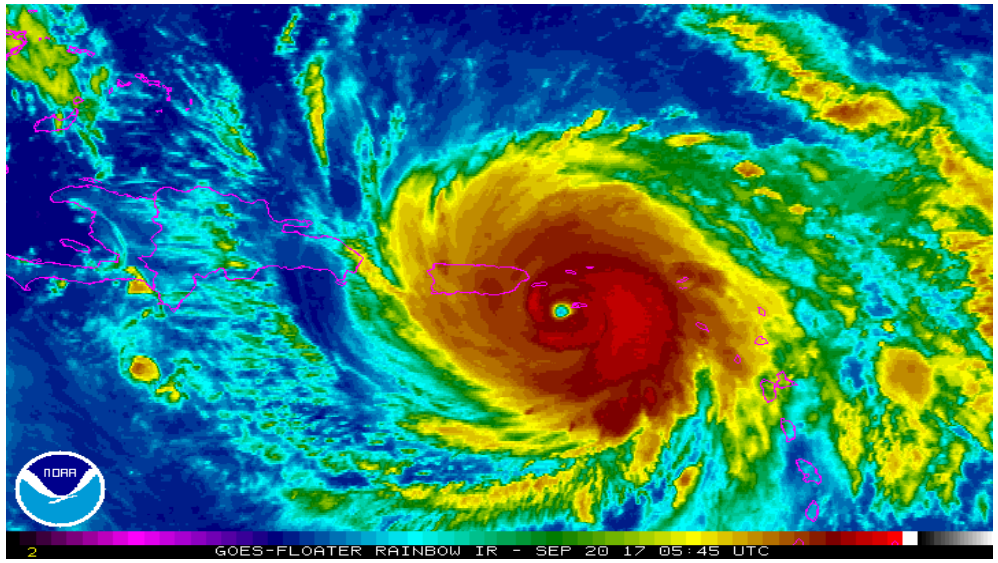
STORMS AND HURRICANES

- More intense
- Slower translation
- Frequency?
- Distribution?


NOAA
GOES-EAST RAINBOW IR CH 4 - SEP 10 17 16:15 UTC



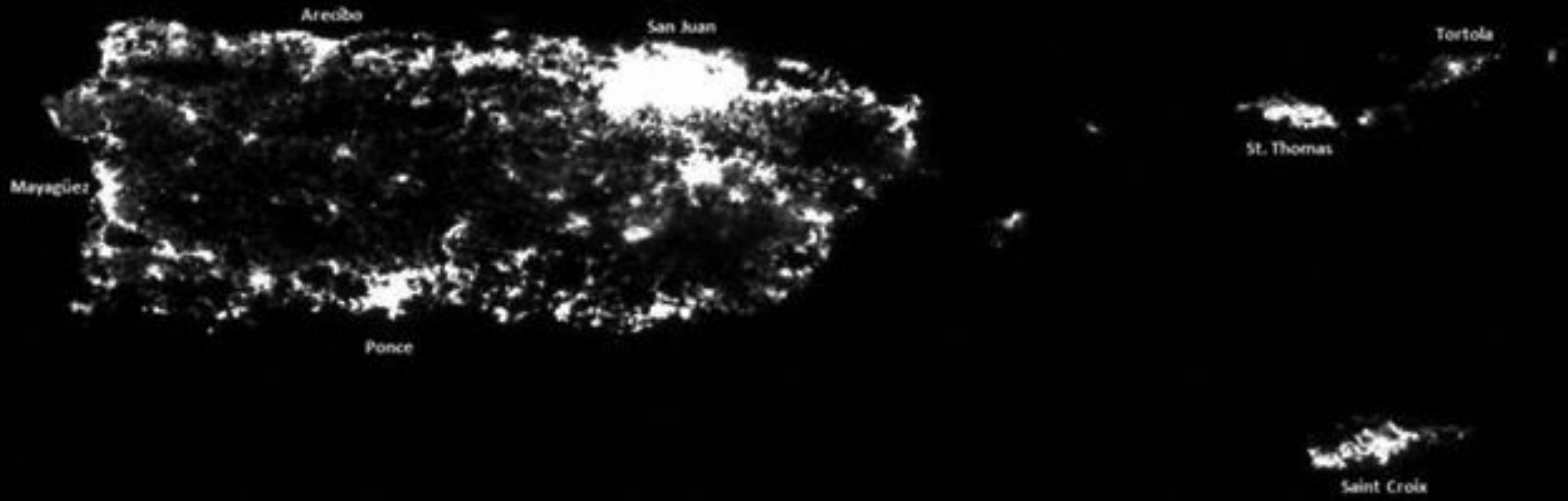




POPULATION A RISK

Floods : 524,469 hab. (15.2%)

Storm Surge: 98,063 hab. (2.7%)


Arecibo
San Juan
Tortola
St. Thomas
Mayagüez
Ponce
Saint Croix







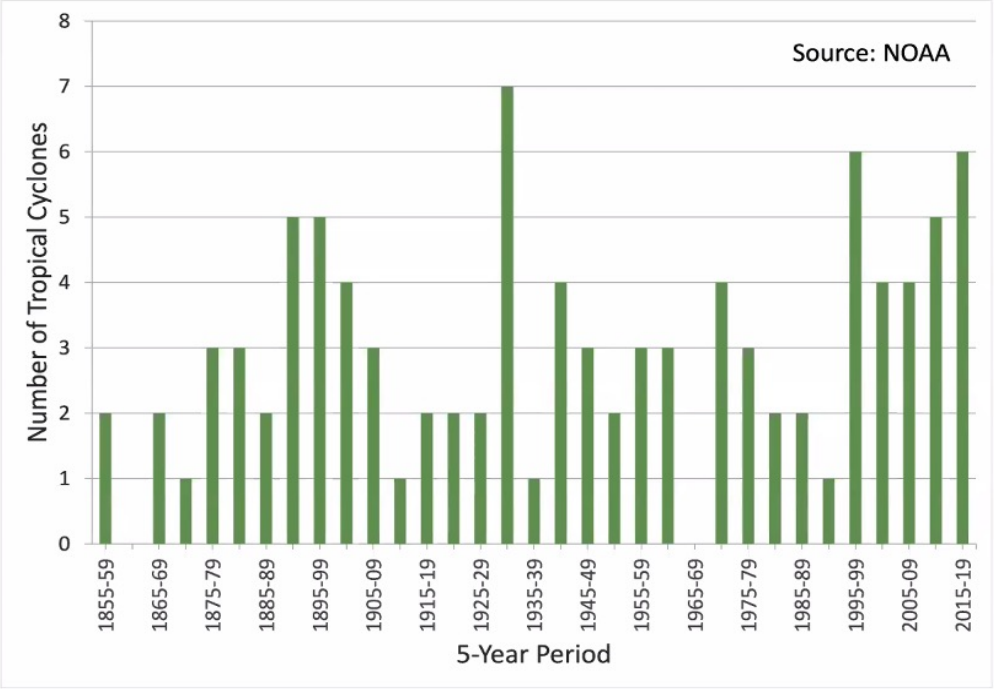





WAPA/September 20
Vieques, Puerto Rico
PUERTO RICO IN CRISIS
STUDY: HURRICANE MARIA DEATH TOLL MAY BE MORE THAN 4,600
CNN
1:51 PM PT
THE LEAD

PUERTO RICO

PRCCC WG1 REPORT (2021)



Tropical Cyclones in US Caribbean – Active Pattern Over Last 25 Years

USGS

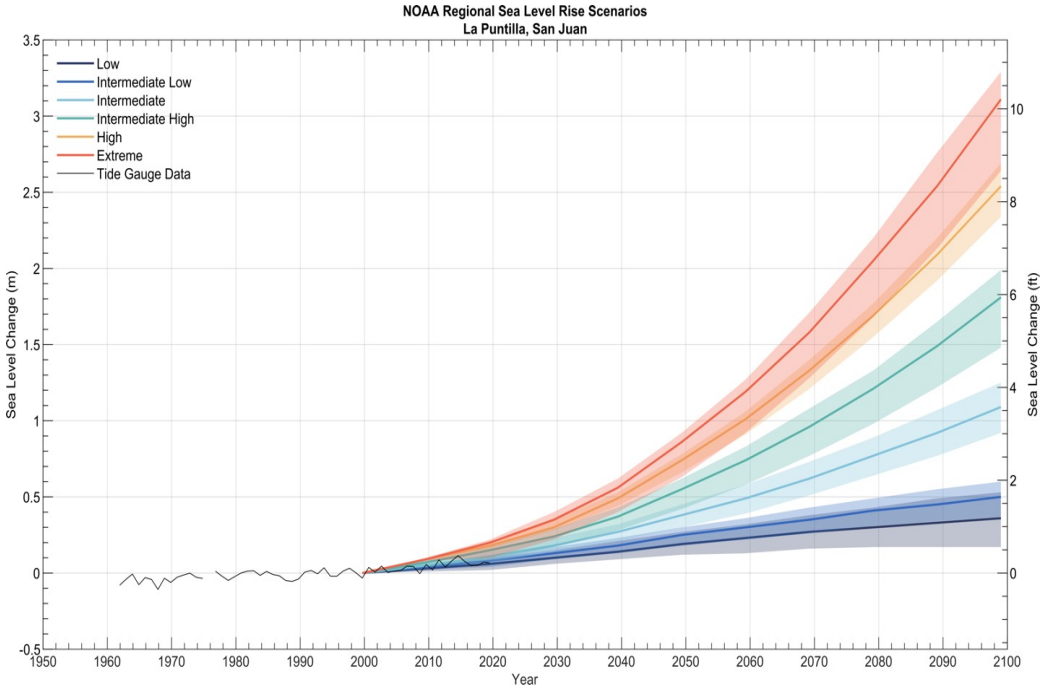
Increased droughts/decreasing rainfall: *The annual average rainfall from the most recent global Climate Model Intercomparison Project (CMIP6) ensemble depicts decreasing rainfall with increasing emissions Statistical and dynamical downscaling indicate a shift to drier conditions within Puerto Rico as greenhouse gas concentrations increase.*

Tropical cyclone intensity is projected to increase. *With a warming of 2°C, projected changes in the total number of storms remains uncertain. This includes increases in the longevity of associated surface winds, and the proportion of tropical cyclones that reach the category 4 and 5 levels with heavier rainfall associated.*

PUERTO RICO

PRCCC WG1 REPORT (2021)

Changing Ocean conditions



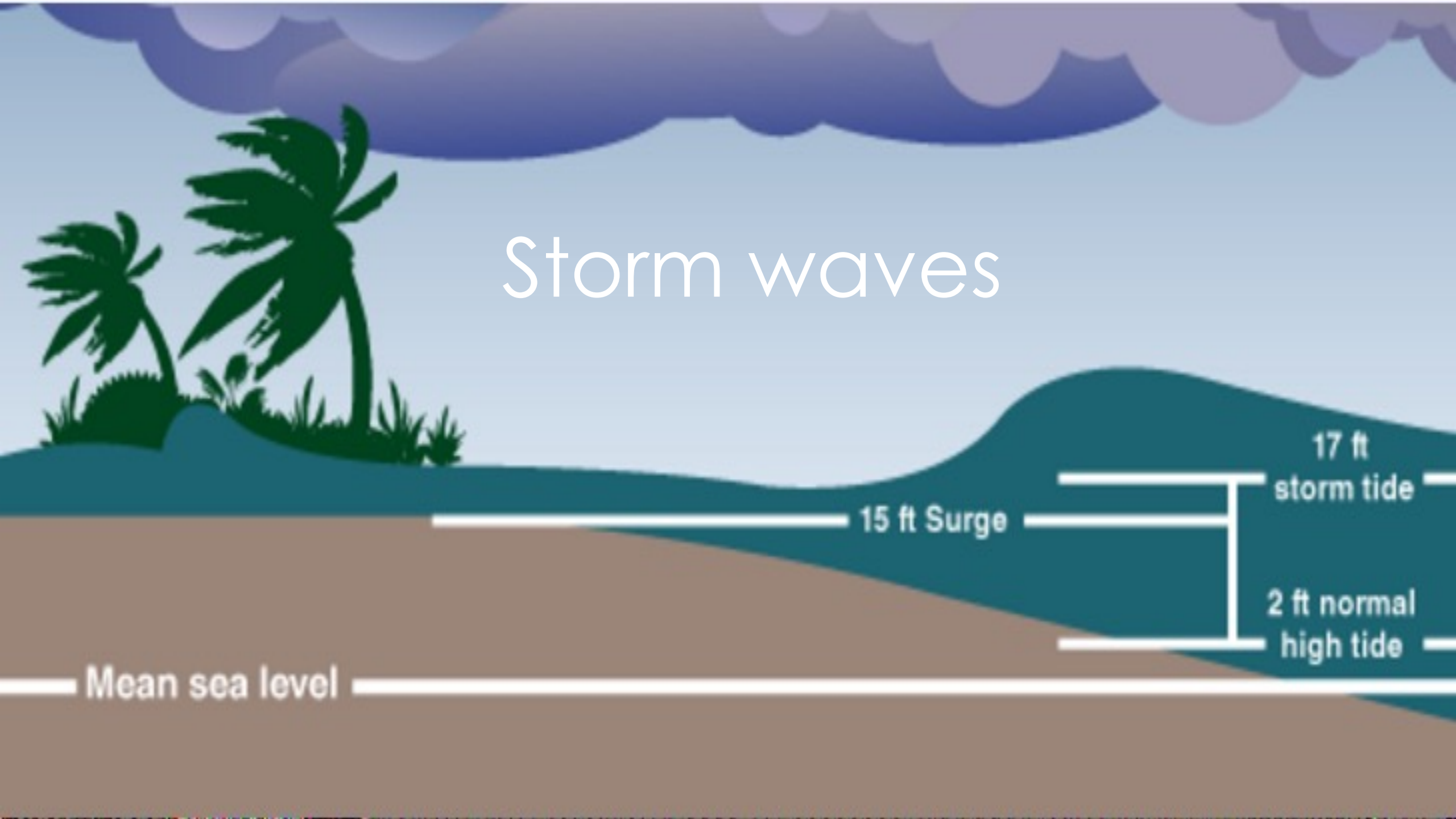
- **Ocean acidification.** Surface ocean is 12% more acidic than in 1988
- **Sea Surface Temperature** is 2.3% higher than in 1992 (double the global ocean rate).
- **Sea level Rise** projections range between 2.75-3.25 m by 2100
- **Combined effects** of increases in tropical cyclone intensity (wind speeds and rainfall rates) with rising sea levels will lead to increases in storm surge and coastal flooding.


NO ESTACIONE


PROHIBIDO
ARROJAR
BASURA


San Juan

Storm waves


17 ft
storm tide
15 ft Surge
2 ft normal
high tide
Mean sea level

San Juan metro coral reef barrier

Map of Puerto Rico highlighting the metropolitan area of San Juan.

Cangrejo Arriba

© 2018 Google

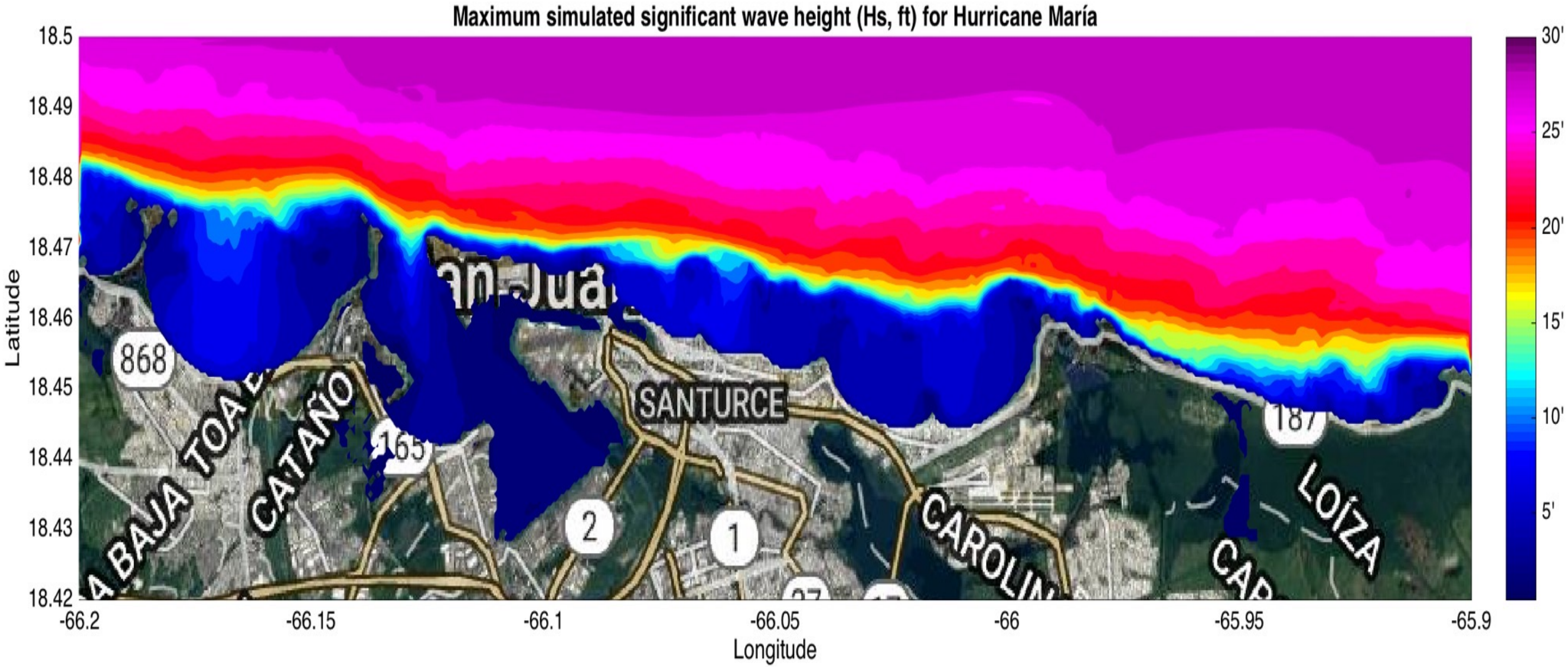
Image © 2018 DigitalGlobe

Google Earth

1994

18°28'03.27" N 66°04'09.90" W elev 0 ft eye alt 30454 ft

MAX WAVE HEIGHT @ SJ / CAROLINA– HURRICAANE MARÍA (SEP 20.2017)



CARICOOS

CAOSE


2018


eloy4k
2019

SCIENCE ADVANCES | RESEARCH ARTICLE

ENVIRONMENTAL STUDIES

Coral reef structural complexity provides important coastal protection from waves under rising sea levels

Daniel L. Harris,[1,2,3]* Alessio Rovere,[1,2,4] Elisa Casella,[2] Hannah Power,[5] Remy Canavesio,[6] Antoine Collin,[7,8] Andrew Pomeroy,[9,10,11] Jody M. Webster,[12] Valeriano Parravicini[6]

Coral reefs are diverse ecosystems that support millions of people worldwide by providing coastal protection from waves. Climate change and human impacts are leading to degraded coral reefs and to rising sea levels, posing concerns for the protection of tropical coastal regions in the near future. We use a wave dissipation model calibrated with empirical wave data to calculate the future increase of back-reef wave height. We show that, in the near future, the structural complexity of coral reefs is more important than sea-level rise in determining the coastal protection provided by coral reefs from average waves. We also show that a significant increase in average wave heights could occur at present sea level if there is sustained degradation of benthic structural complexity. Our results highlight that maintaining the structural complexity of coral reefs is key to ensure coastal protection on tropical coastlines in the future.

Letter | Published: 06 June 2018

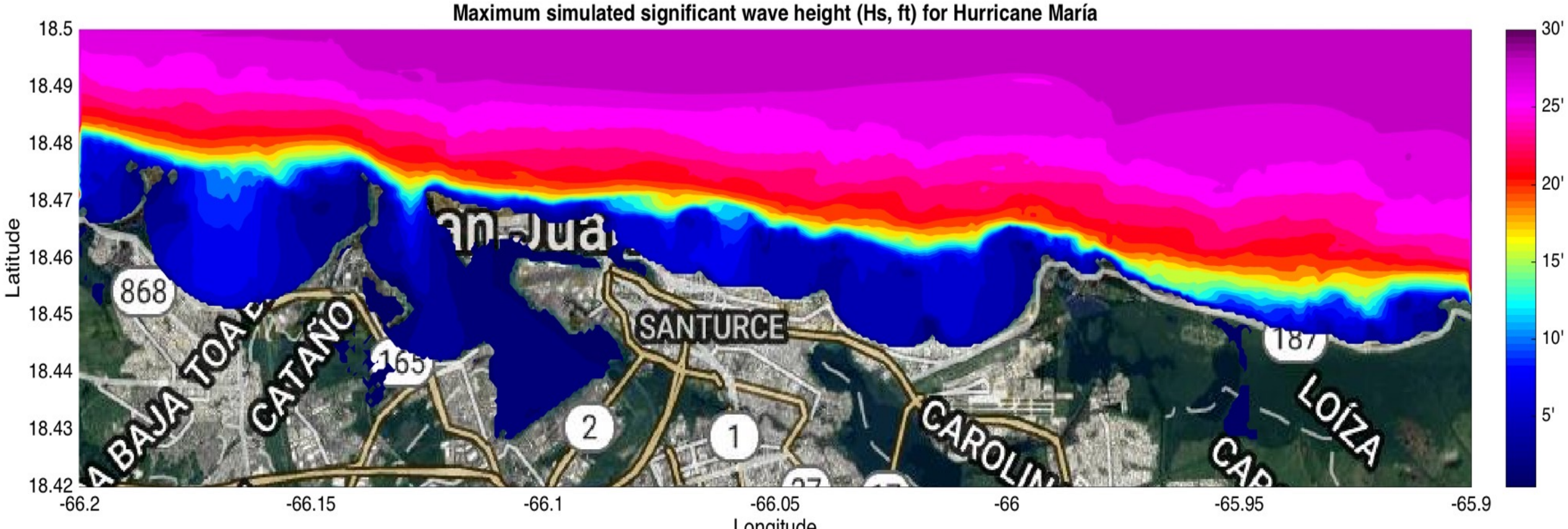
A global slowdown of tropical-cyclone translation speed

James P. Kossin

Nature **558**, 104–107 (2018) | Download Citation

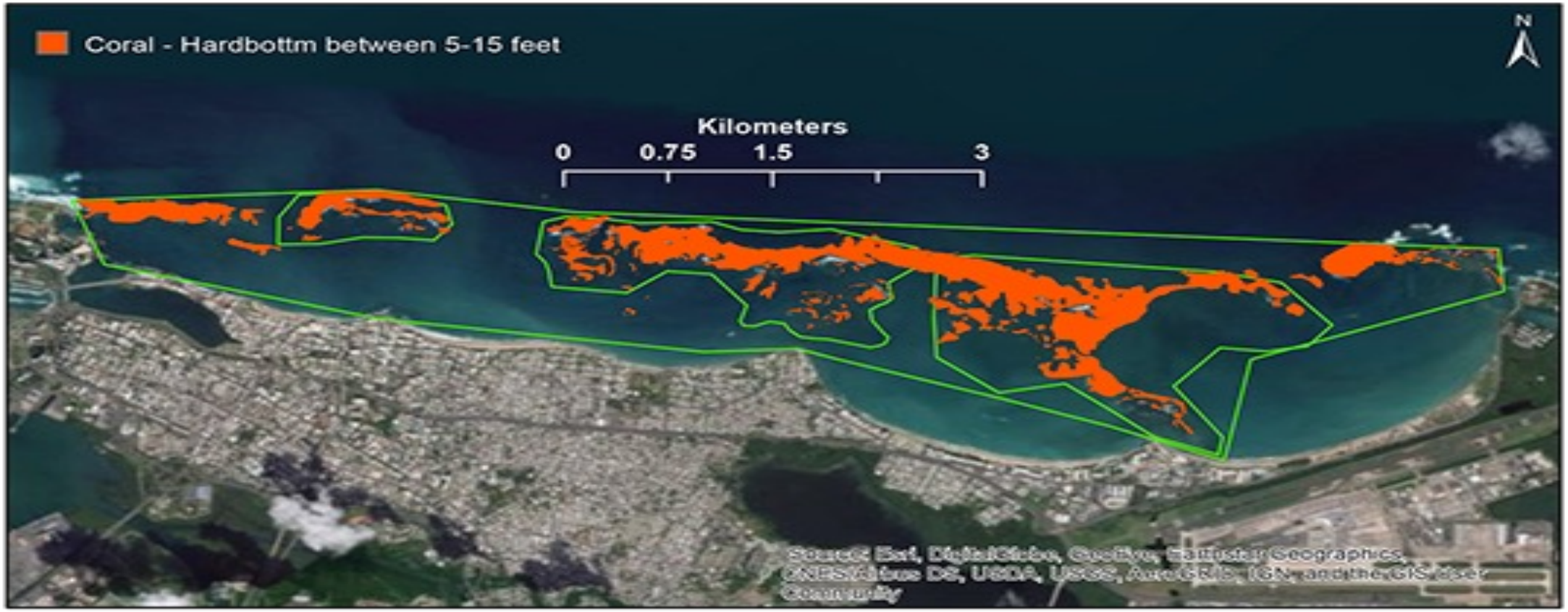
Abstract

As the Earth's atmosphere warms, the atmospheric circulation changes. These changes vary by region and time of year, but there is evidence that anthropogenic warming causes a general weakening of summertime tropical circulation[1,2,3,4,5,6,7,8]. Because tropical cyclones are carried along within their ambient environmental wind, there is a plausible a priori expectation that the translation speed of tropical cyclones has slowed with warming. In addition to circulation changes, anthropogenic warming causes increases in atmospheric water-vapour



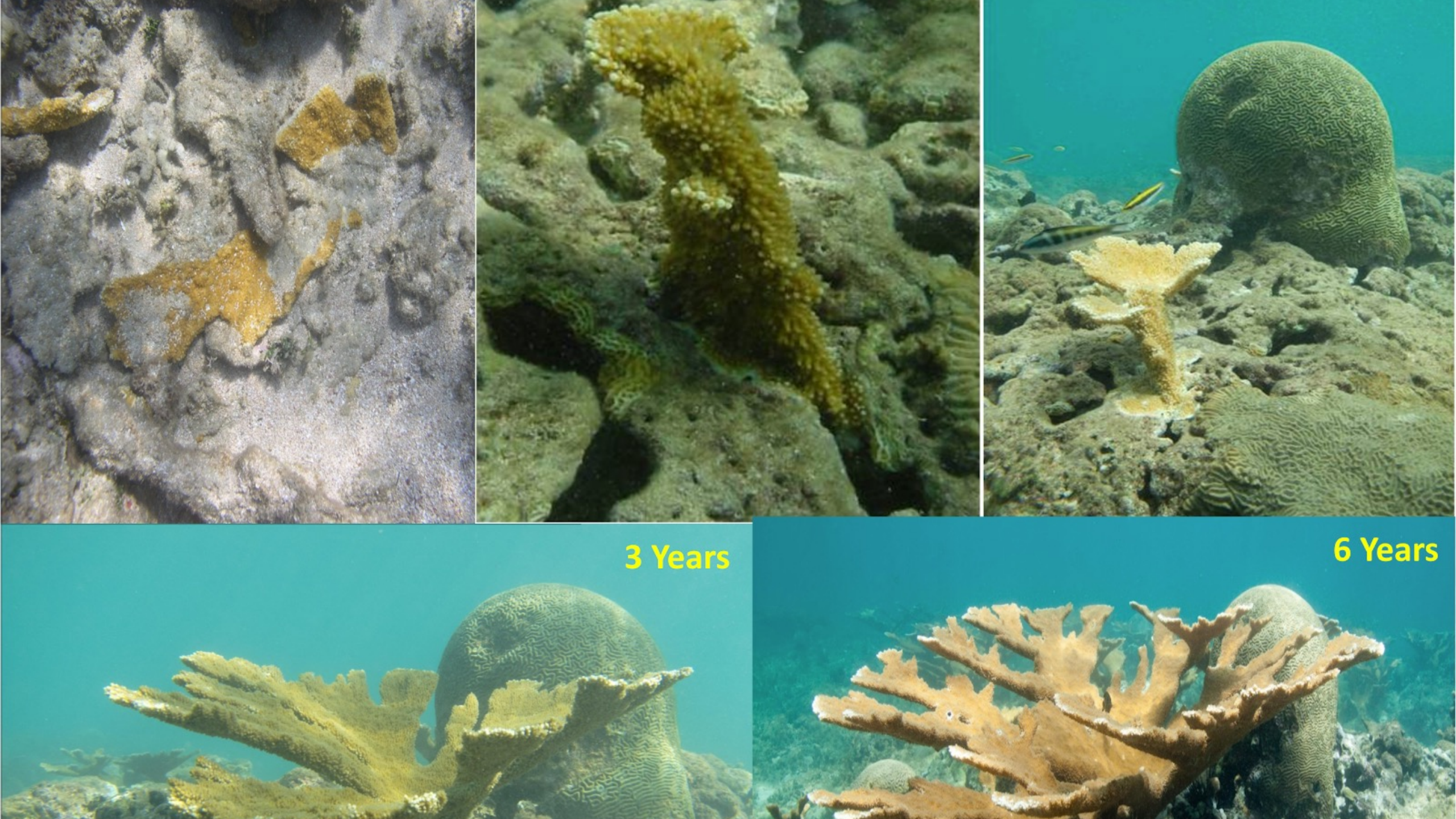
Reef and Beach Intervention to enhance coastal protection in Puerto Rico - Pilot projects at San Juan metro and Rincón

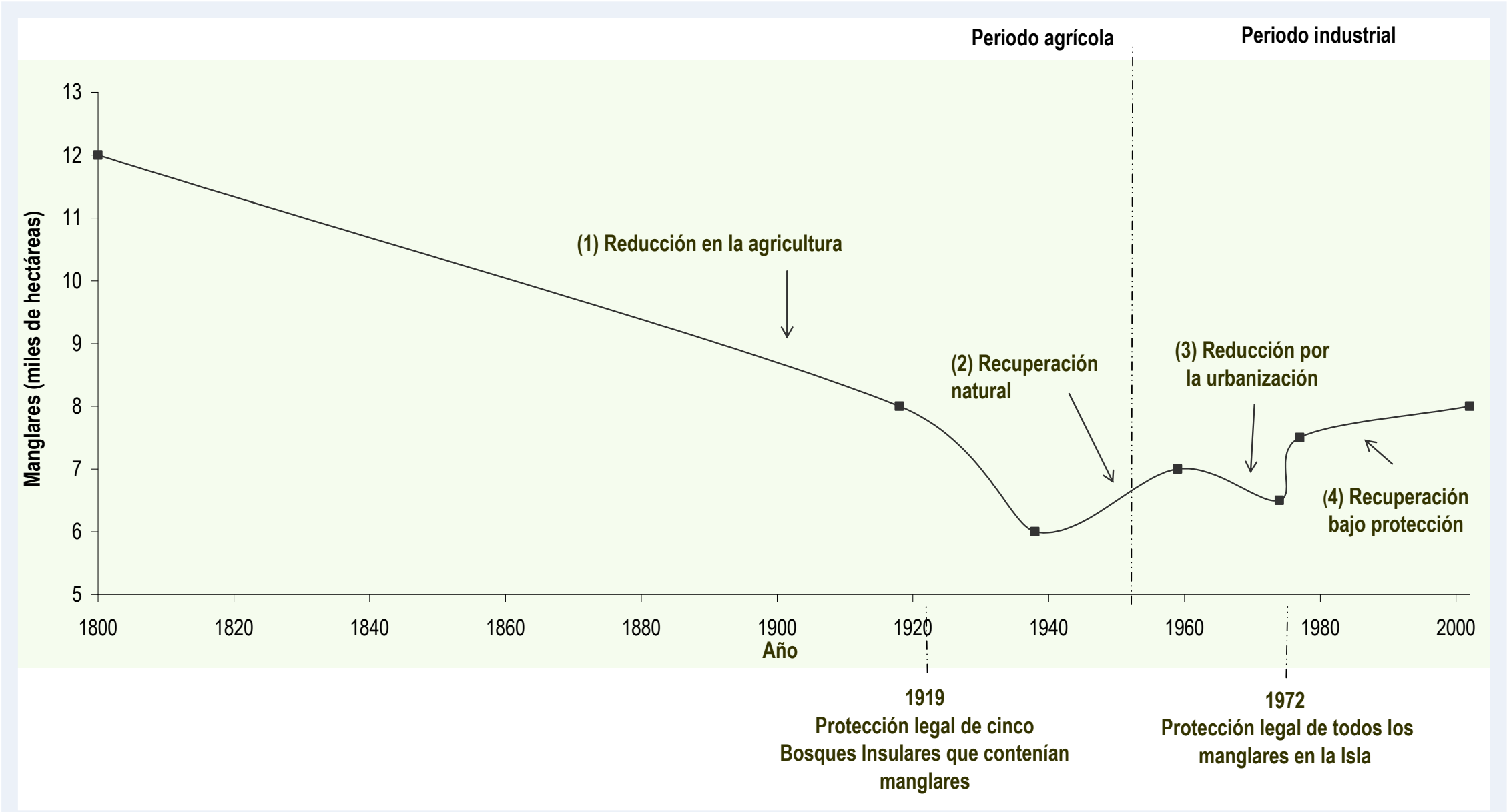
SITE: San Juan



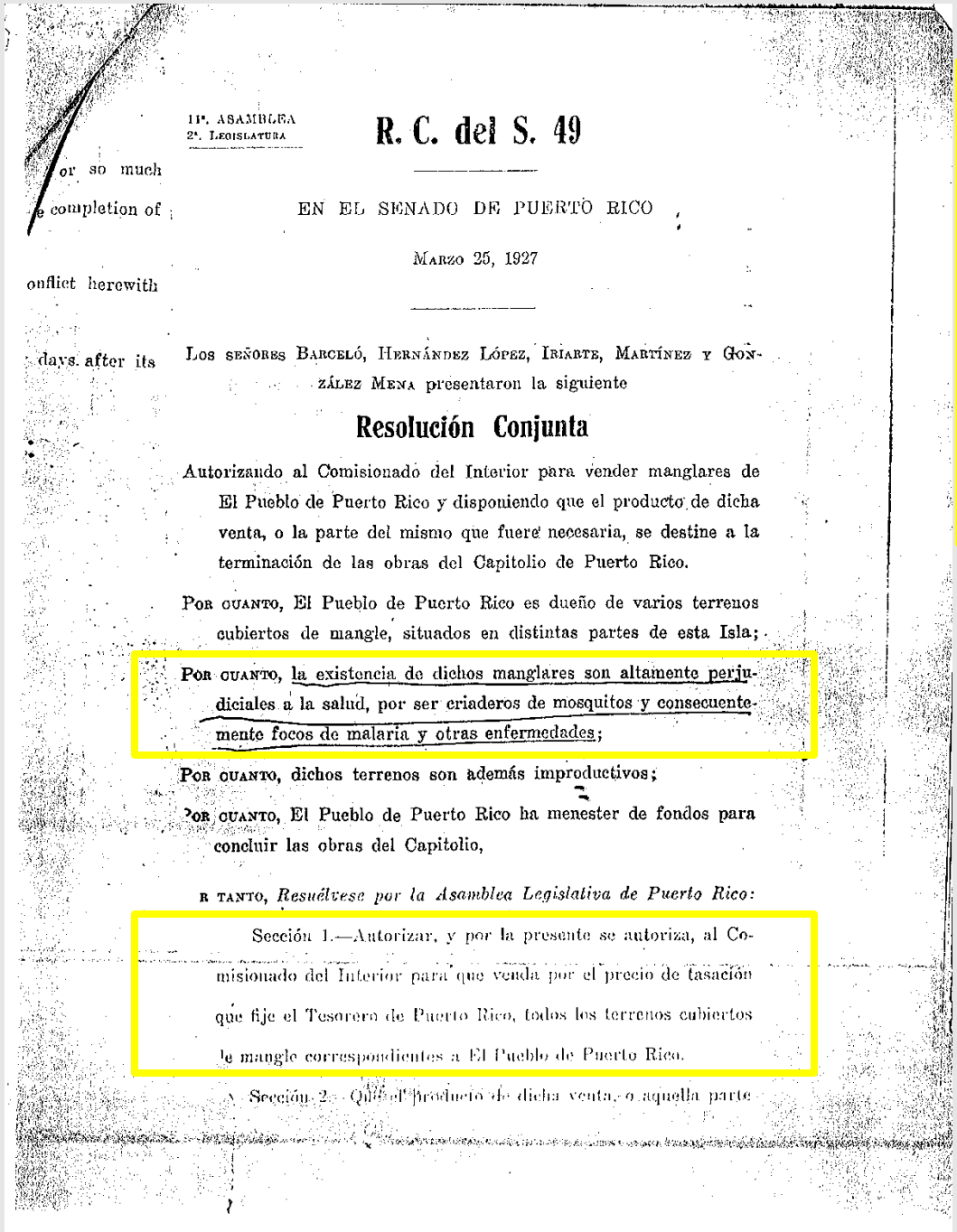
Total Site Area: 3,015 acres

Estimated area of reef between 5-15 feet: 520 acres


3 Years
6 Years



Fuente: *Martunizzi, S., William.A. Gould, Ariel.E. Lugo, Ernesto Medina. (2009). Conversion and recovery of Puerto Rico mangroves: 200 years of change. International Institute of Tropical Forestry*



11ª. ASAMBLEA
2ª. LEGISLATURA

R. C. del S. 49

EN EL SENADO DE PUERTO RICO

MARZO 25, 1927

LOS SEÑORES BARCELÓ, HERNÁNDEZ LÓPEZ, IRIARTE, MARTÍNEZ Y GONZÁLEZ MENA presentaron la siguiente

Resolución Conjunta

Autorizando al Comisionado del Interior para vender manglares de El Pueblo de Puerto Rico y disponiendo que el producto de dicha venta, o la parte del mismo que fuere necesaria, se destine a la terminación de las obras del Capitolio de Puerto Rico.

POR CUANTO, El Pueblo de Puerto Rico es dueño de varios terrenos cubiertos de mangle, situados en distintas partes de esta Isla;

POR CUANTO, la existencia de dichos manglares son altamente perjudiciales a la salud, por ser criaderos de mosquitos y consecuentemente focos de malaria y otras enfermedades;

POR CUANTO, dichos terrenos son además improductivos;

POR CUANTO, El Pueblo de Puerto Rico ha menester de fondos para concluir las obras del Capitolio,

POR TANTO, *Resuélvese por la Asamblea Legislativa de Puerto Rico:*

Sección 1.—Autorizar, y por la presente se autoriza, al Comisionado del Interior para que venda por el precio de tasación que fije el Tesorero de Puerto Rico, todos los terrenos cubiertos de mangle correspondientes a El Pueblo de Puerto Rico.

Sección 2.—Que el producto de dicha venta, o aquella parte

R.C del S. 49 (1927):

Por cuanto la existencia de dichos manglares son altamente perjudiciales a la salud, por ser criaderos de mosquitos y consecuentemente focos de malaria y otras enfermedades

*…se autoriza al Comisionado del Interior para que venda por el precio de tasacion que fije el Tesorero de Puerto Rico, **todos** los terrenos cubiertos de mangle correspondientes a El Pueblo de Puerto Rico.*

PLANO DE LA PLAZA DE SAN JUAN DE PUERTO-RICO

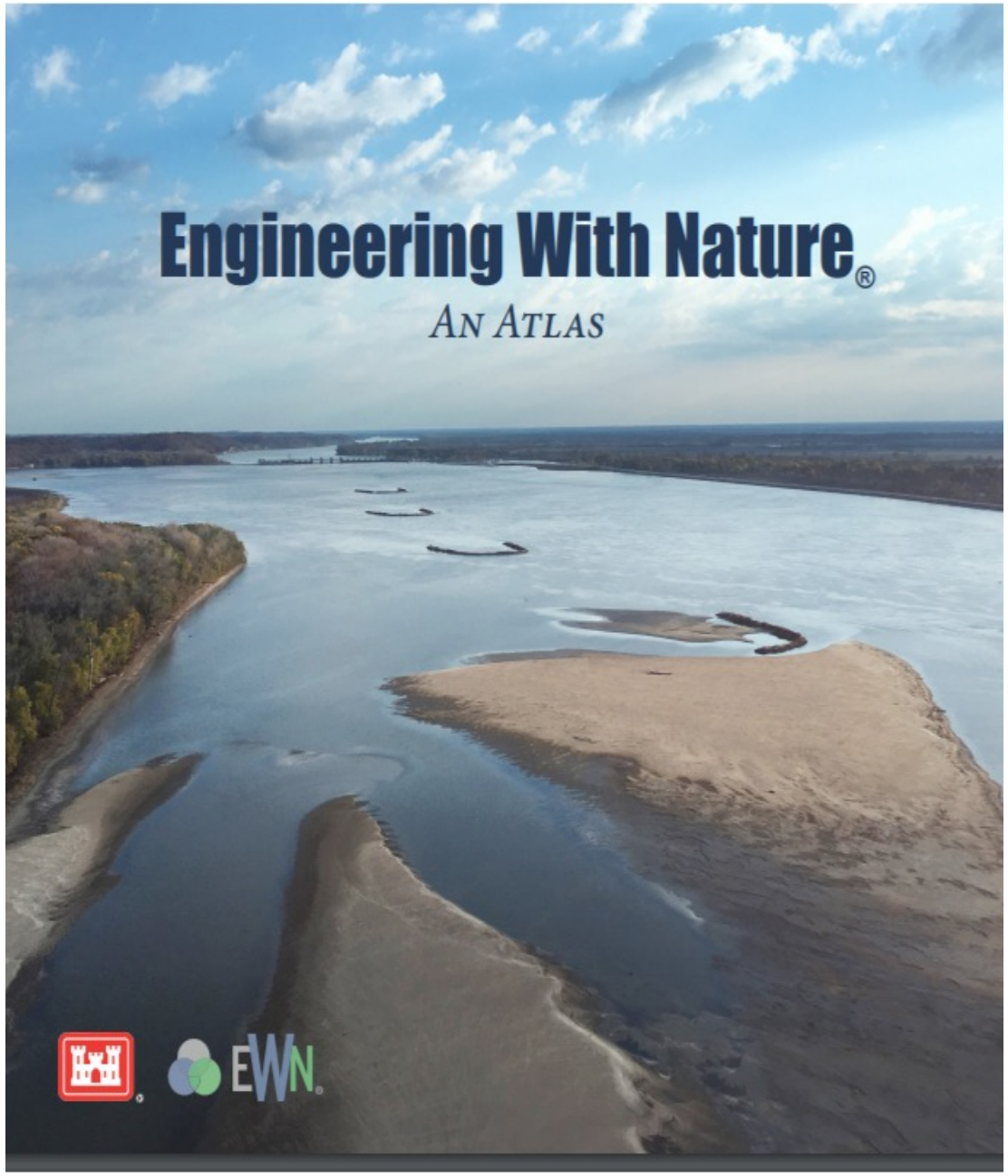
y sus alrededores

LEVANTADO POR EL CUERPO DE INGENIEROS MILITARES

para el estudio de las nuevas defensas de la misma.

Escala de 1/20000.

Equidistancia de las curvas 4 metros.



TETRA TECH

Nature-based Solutions for Coastal Systems

Coastal Engineering Handbook Part II

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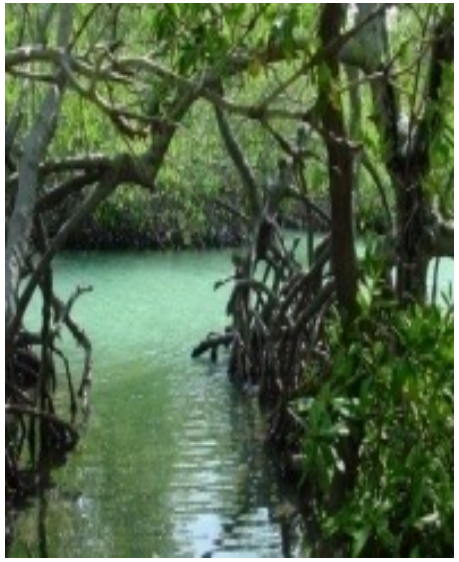
Submitted to: Department of Natural and Environmental Resources
Coastal Zone Management Program

July 2022

Conservation is essential to build Resilience



- Healthy reefs
- Wider beaches
- Taller dunes
- Healthy Wetlands
- Watersheds
- Nature-based Solutions

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Key challenges for biodiversity conservation in the Anthropocene

…to counteract the accelerating rate of species extinctions resulting from habitat loss and fragmentation, climate change, and invasive species.

Ensuring connectivity between protected areas is an important element to foster biodiversity conservation, climate change adaptation and ecological resilience.

KEY OBJECTIVES OF BIODIVERSITY CONSERVATION

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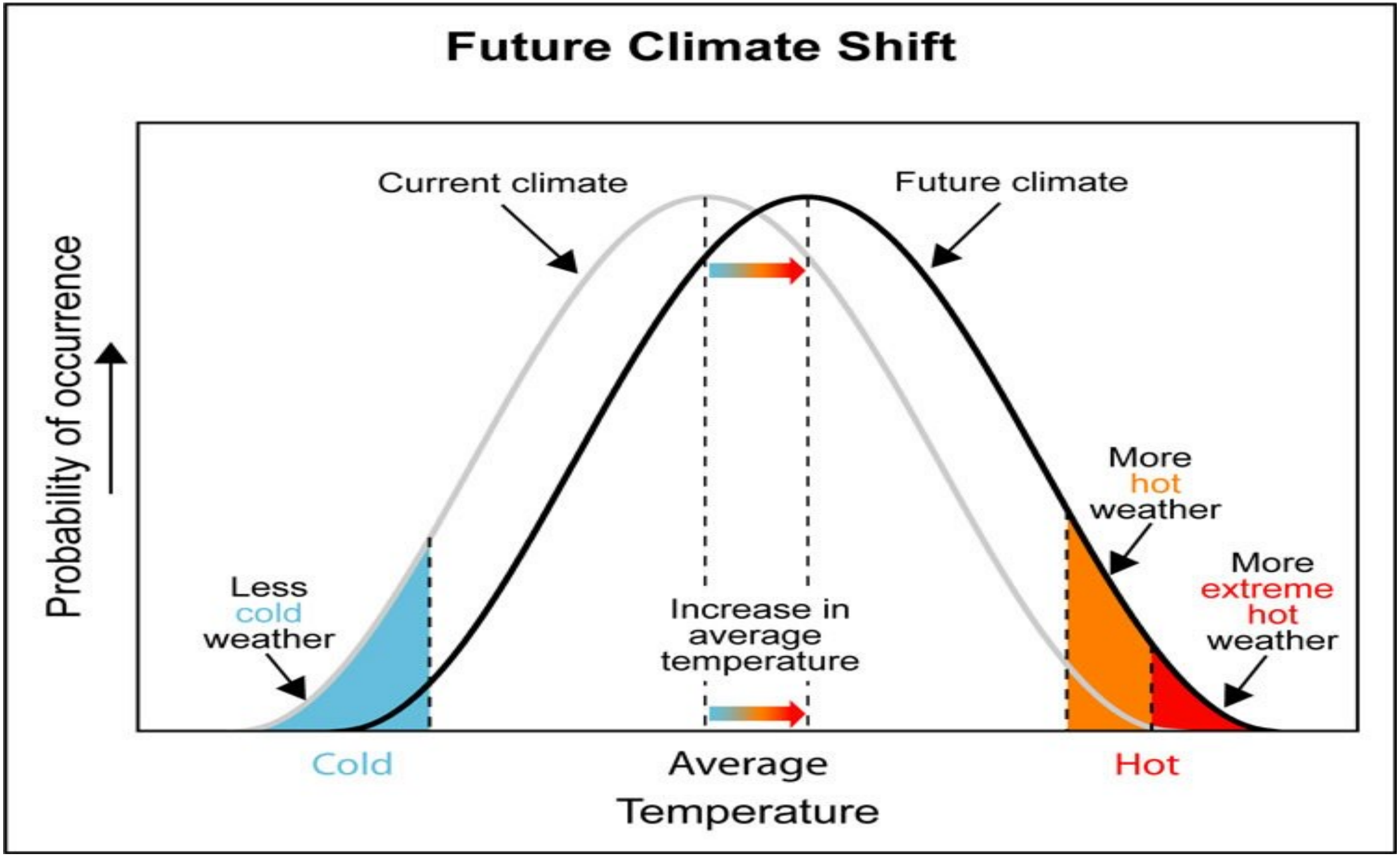
Representativeness is a measure of how well terrestrial protected areas represent the ecological diversity of a country.

Redundancy measures if sufficient examples of species and ecosystems in a protected area network to capture genetic variation and protect against unexpected losses.

Ecological Connectivity is the unimpeded movement of species and the flow of natural processes that sustain life on Earth.

Ecosystem Services are the many and varied benefits to humans provided by the natural environment and from healthy ecosystems.


Future Climate Shift
Current climate
Future climate
Probability of occurrence
More
hot
weather
More
extreme
hot
weather
Less
cold
weather
Increase in
average
temperature
Cold
Average
Temperature
Hot

Take away messages

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- Translating science into policy takes time and can be frustrating
- Planning and designing based on historic trends increase vulnerability
- Adaptation strategies for built-up/developed areas differ from strategies for undeveloped areas
- Policy implementation requires political will, education and sustainable financing
- Biodiversity conservation is essential to build social-ecological resilience






Climate change in Puerto Rico: current conditions, projections, and socioecological challenges

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2022