# Gathering and applying climate information for decision-making

Climate Change Impacts on Coastal Transport Infrastructure in the Caribbean: Enhancing the Adaptive Capacity of SIDS

**6 December, 2017**

United Nations Conference on Trade and Development

Regional Workshop - Barbados

**Cassandra Bhat**
**ICF**

# Objectives

- Learn the fundamentals about climate scenarios, models, and data
- Understand sources of climate data for the Caribbean


Source: ICF

# Key Message

- Lots of data and resources available!

Source: ICF

# Topic 1

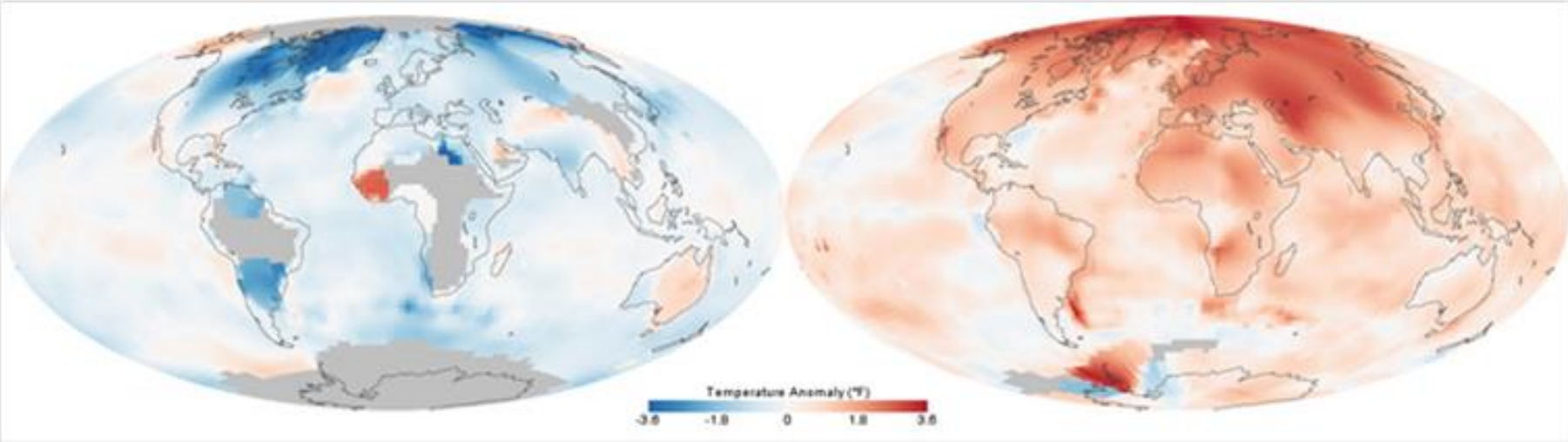
Overview of Climate Scenarios, Models, and Information

# Key Concepts Help us Understand Climate Change Risks and Impacts

Connecting climate information with decisions requires a special vocabulary

# Climate

The average of weather over at least a 30-year period. Note that the climate taken over different periods of time (30 years, 1000 years) may be different.




***Climate is what we expect and weather is what we get.[1]***

Definition: NOAA National Weather Service Climate Glossary | Figure: NASA

# Extreme Events

*Weather or climate conditions near the upper or lower ends of the range of observed values*

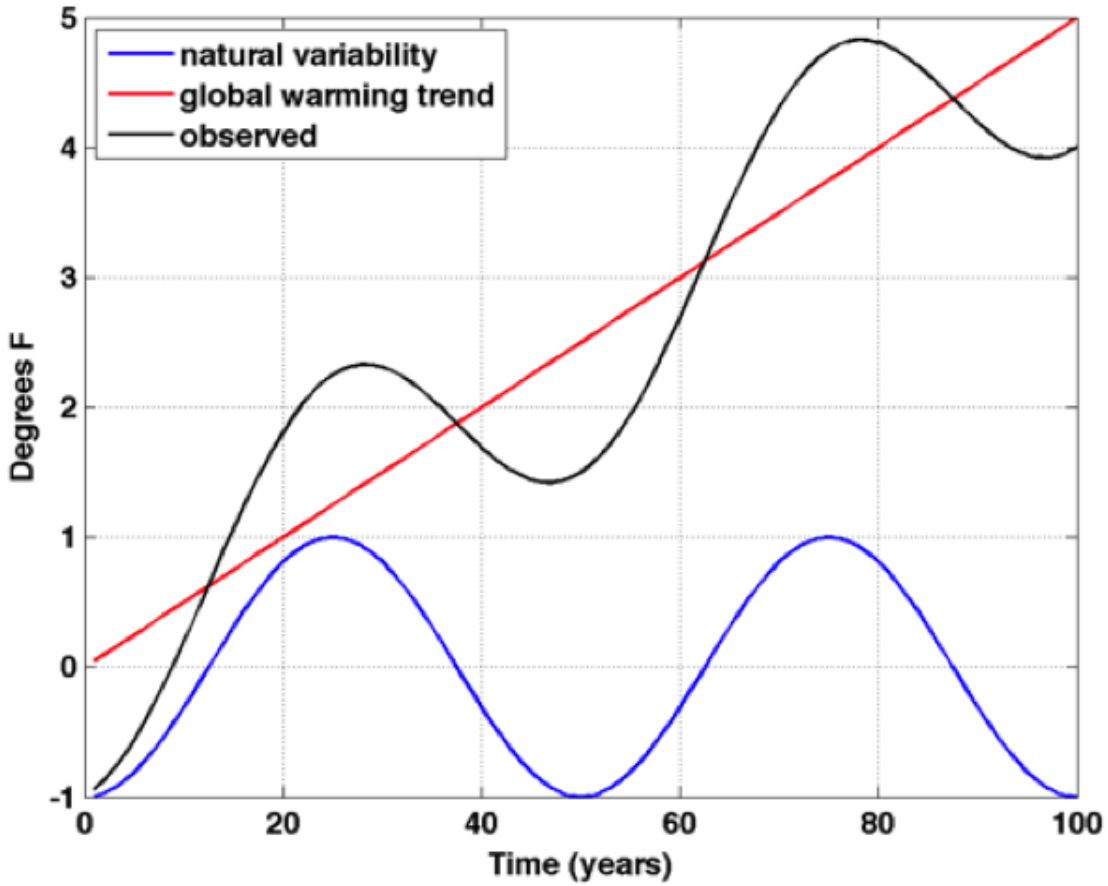
- Sometimes impacts on society and ecosystems become severe when climate conditions pass certain levels, called thresholds.

**Extreme Temperatures**

**Extreme Rainfall and Flooding**

# Climate Change

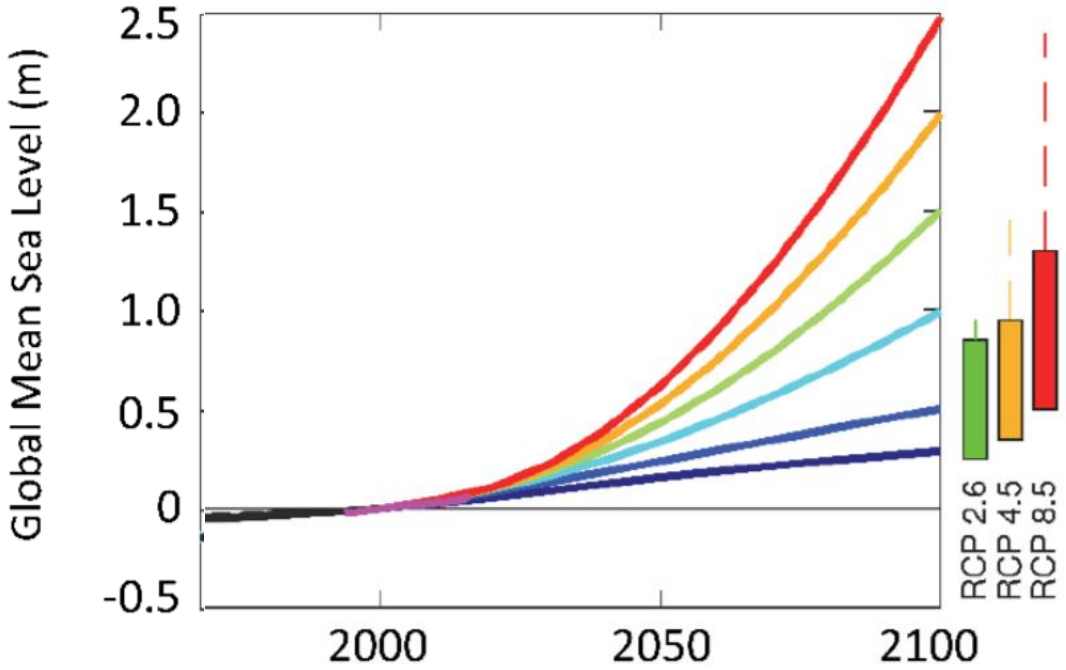
A non-random change in climate that is measured over several decades or longer.




Definition: NOAA National Weather Service Climate Glossary | Figure: Climate Impacts Group - https://cig.uw.edu/learn/climate-variability/

# Climate Change Effects

- Changes in the timing, amount, or intensity of precipitation
- Changes in heat waves, periods of freezing, maximum daily temperature




**NOAA Global Mean Sea Level Scenarios for 2100**

Source: NOAA (2017). Global and Regional Sea Level Rise Scenarios for the United States. National Oceanic and Atmospheric Administration, National Ocean Service. Available at: https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

# Characteristics of Climate Information

**Stressor/Hazard:**

- Temperature
- Precipitation
- Sea level rise
- Storm surge
- Drought
- Etc.

**Variable:**

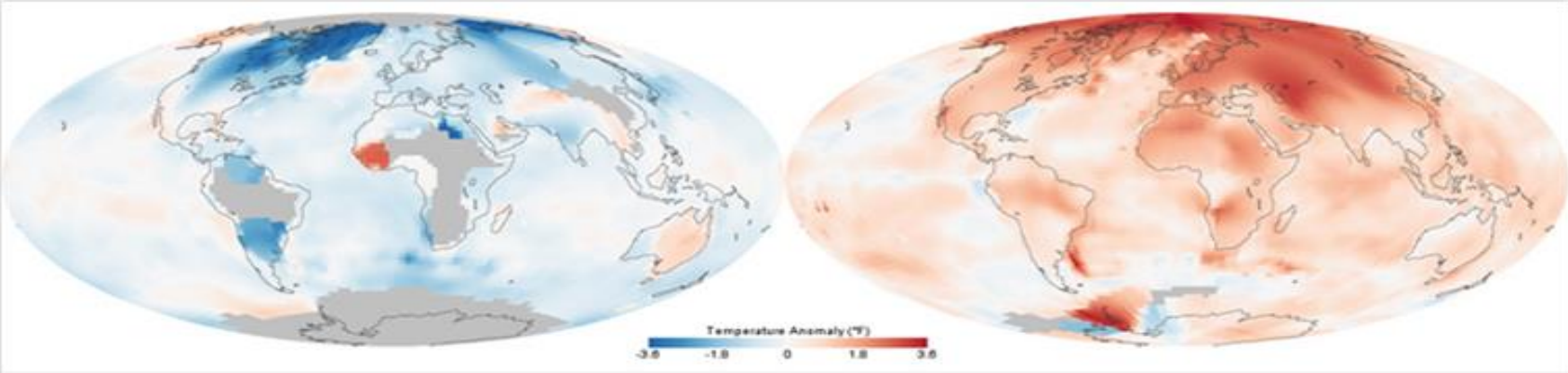
- Tmax
- Tmin
- Tavg
- 24-hour rainfall
- Wind speed
- Humidity
- Etc.

**Time period:**

- Historical
- Forecast
- Projected

**Temporal resolution:**

- Daily
- Monthly
- Seasonal
- Annual
- Decadal




Source: NASA

# Dimensions of Climate Projections

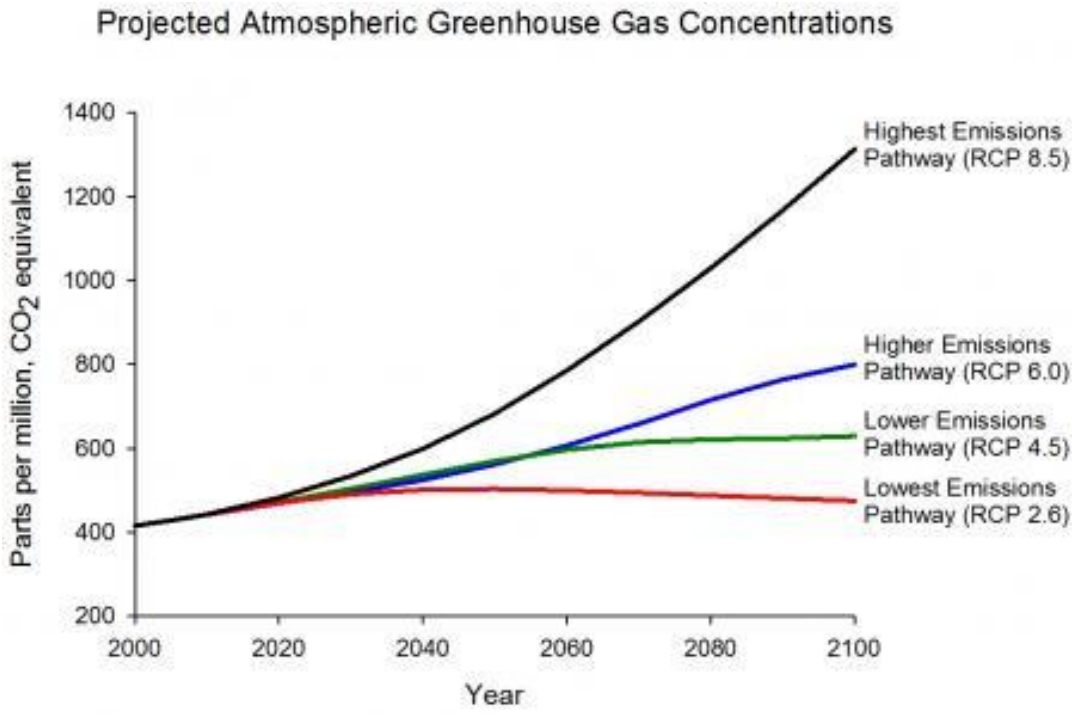
- Emission scenarios
- Climate models
- Spatial resolution

# Emission Scenarios

Scenario = a possible future

Numerous alternatives of how the future can unfold

- Ranges from **high emission** to **low emission**




GHG concentrations → average temperature increase → SLR → other effects

Source: U.S. EPA

# Representative Concentration Pathways (RCPs)

| Scenario Name | Description | Concentrations (ppm $CO_2$ equiv.) by 2100 | Change in $CO_2$ equiv emissions compared to 2010 | | Global Surface Temp. Change by 2100* |
|---|---|---|---|---|---|
| | | | 2050 | 2100 | |
| **RCP 2.6** | Emissions reduced substantially from current pathway. | 430-480 | -72 to -41% | -118 to -78% | 0.5–3.0 °F (0.3–1.7 °C) |
| **RCP 4.5** | Emissions reduced sufficiently so that total radiative forcing is stabilized by 2100. | 580-720 | -38 to 24% | -134 to -21% | 2.0–4.7 °F (1.1–2.6 °C) |
| **RCP 6.0** | Emissions reduced sufficiently so that total radiative forcing is stabilized by 2100. | 720-1,000 | 18 to 54% | -7% to 72% | 2.5–5.6 °F (1.4–3.1 °C) |
| **RCP 8.5** | High emissions continue through 2100. Most representative RCP of current emissions track. | >1,000 | 52 to 95% | 74 to 178% | 4.7–8.6 °F (2.6–4.8 °C) |

# Emission Scenarios

## IPCC Fourth Assessment Report

| Scenario Name | Description | Global Surface Temp. Change by 2100 | Global Mean Sea Level Rise by 2100 |
|---|---|---|---|
| **B1** | Low emissions. | 0.54-1.62 °F (0.3-0.9 °C) | 0.59-1.25 ft (0.18-0.38 m) |
| **A1B** | Medium-High emissions. | 3.06-7.92 °F (1.7-4.4 °C) | 0.69-1.57 ft (0.21-0.48 m) |
| **A2** | Medium-High emissions. | 3.6-9.72 °F (2.0-5.4 °C) | 0.75-1.67 ft (0.23-0.51 m) |

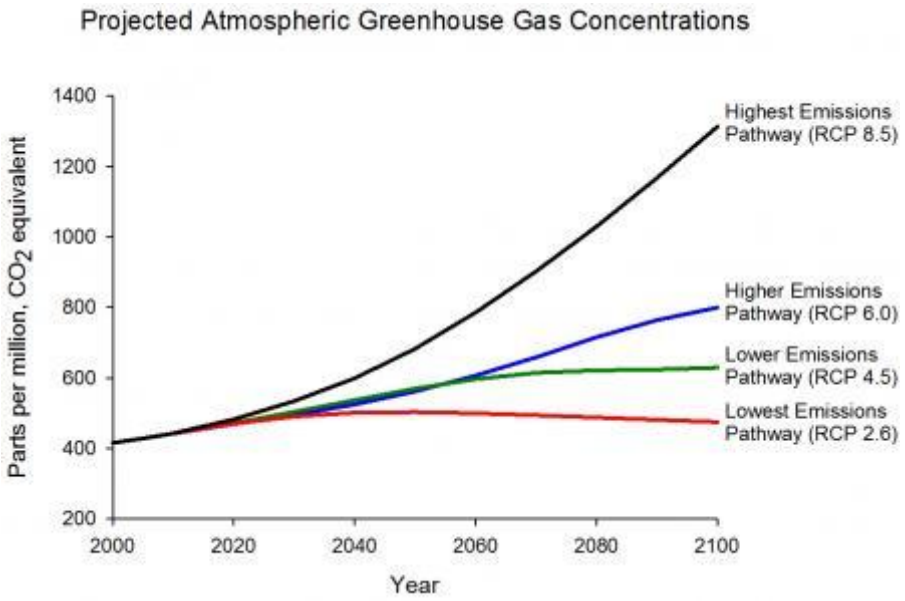
UN IPCC Working Group I: The Scientific Basis (http://www.ipcc.ch/ipccreports/tar/wg1/029.htm)

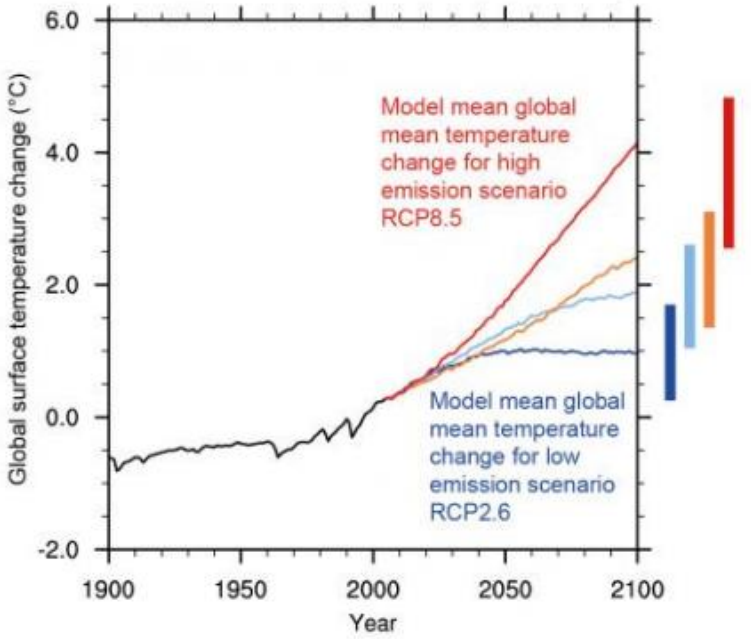
## IPCC Fifth Assessment Report

| Scenario Name | Description | $CO_2$ equiv. ppm by 2100 | Global Surface Temp. Change by 2100 | Global Mean Sea Level Rise by 2100 |
|---|---|---|---|---|
| **RCP2.6** | Substantial and sustained emissions reductions | 475 | 0.5-3.0 °F (0.3-1.7 °C) | 0.85-1.8 ft (0.26-0.55m) |
| **RCP4.5** | Stabilization | 630 | 2.0-4.7 °F (1.1-2.6 °C) | 1.0-2.1 ft (0.32-0.63m) |
| **RCP6.0** | Stabilization | 800 | 2.5-5.6 °F (1.4-3.1 °C) | 1.1-2.1 ft (0.33-0.63m) |
| **RCP8.5** | High emissions continue | 1313 | 4.7-8.6 °F (2.6-4.8 °C) | 1.5-2.7 ft (0.45-0.82m) |

Source: UN IPCC, Climate Change 2013: The Physical Science Basis (https://www.ipcc.ch/report/ar5/wg1/)

# RCPs


Projected Atmospheric Greenhouse Gas Concentrations
Parts per million, $CO_2$ equivalent
1400
1200
1000
800
600
400
200
2000
2020
2040
2060
2080
2100
Year
Highest Emissions Pathway (RCP 8.5)
Higher Emissions Pathway (RCP 6.0)
Lower Emissions Pathway (RCP 4.5)
Lowest Emissions Pathway (RCP 2.6)


Global surface temperature change (°C)
6.0
4.0
2.0
0.0
-2.0
1900
1950
2000
2050
2100
Year
Model mean global mean temperature change for high emission scenario RCP8.5
Model mean global mean temperature change for low emission scenario RCP2.6

# Uncertainties in Emission Scenarios

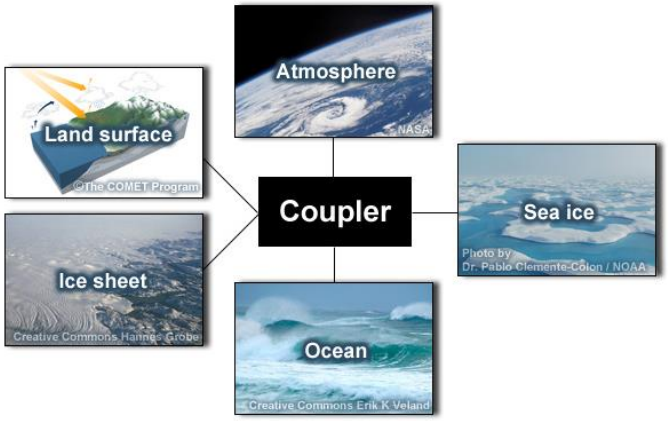
**Uncertainties about the future**

- Socio-economic development
- Technology
- Energy use
- Policies for GHG mitigation

**These uncertainties increase as they are projected further out in the future**

# Climate Models

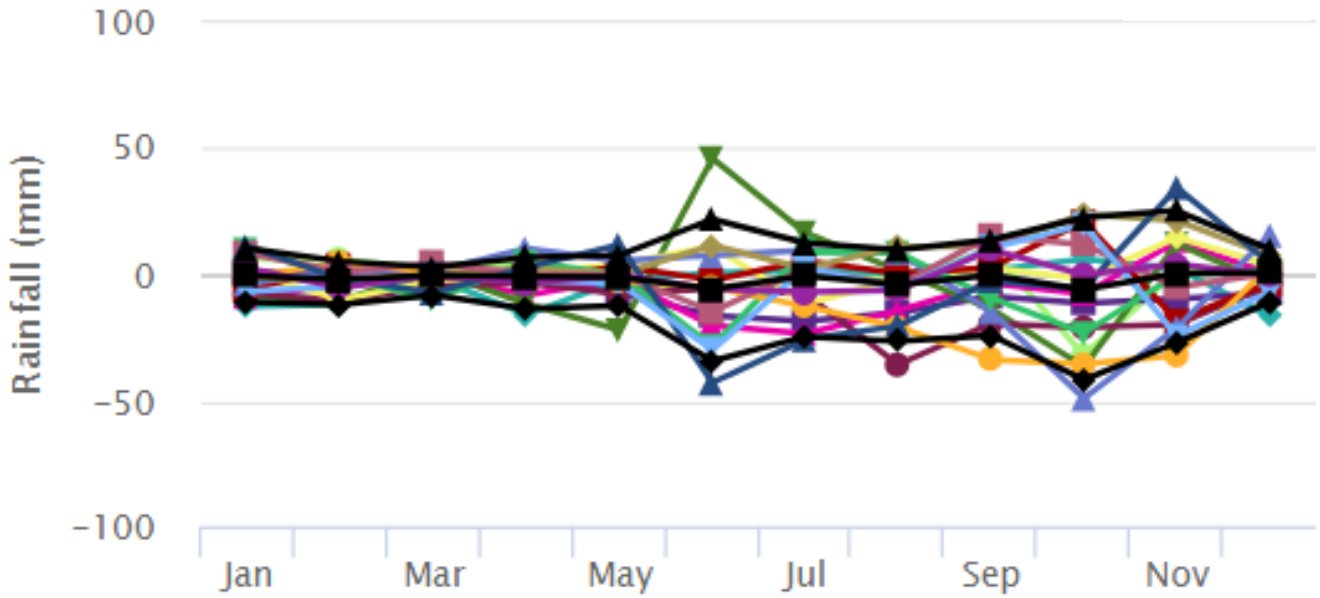
- Mathematical representations of climate system and interacting processes
- Can reproduce key features found in the climate of the past century
- Run emission scenarios and produce projections
- Can be done on different timescales and different geographic areas
- Global climate models referred to as “GCMs”




Model components (UCAR)

# Climate Models

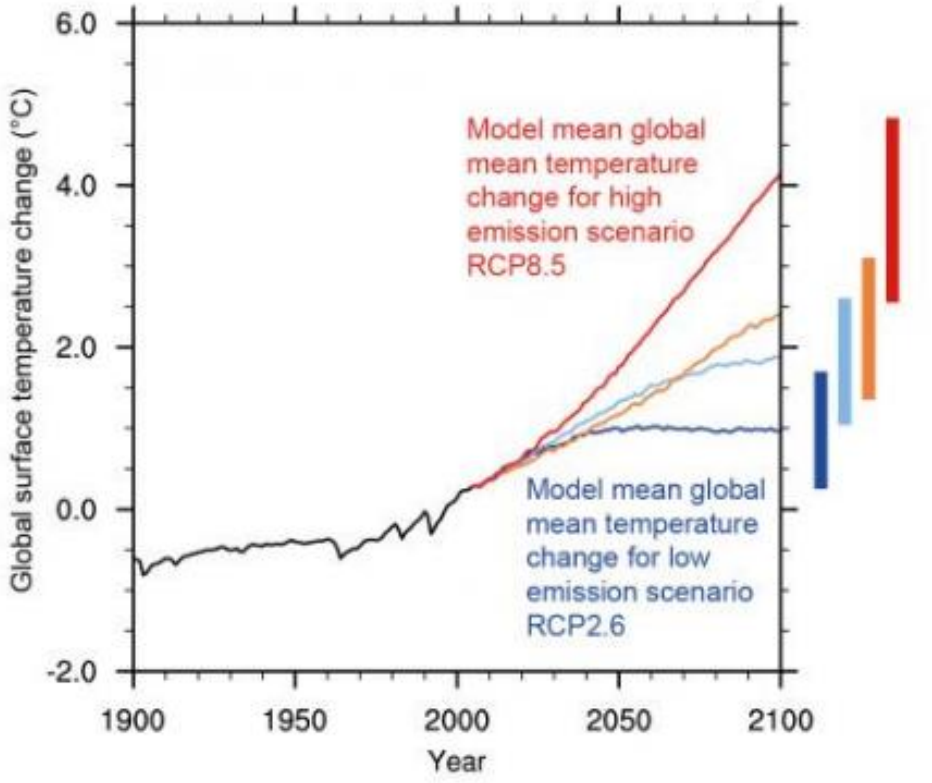
- Many models exist
- Different models produce different results
- Model agreement is not necessarily an indication of likelihood




Source: CCKP, http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_future_climate&ThisRegion=Latin%20America&ThisCcode=JAM

# Climate Projections

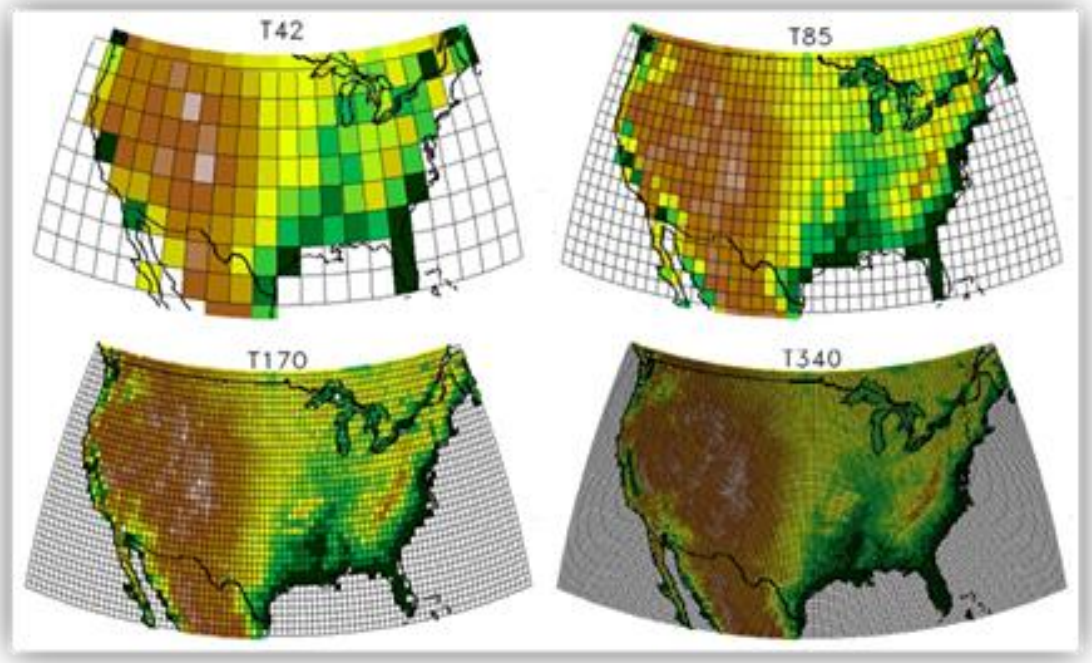
- Simulation of possible climate future in terms of temperature, precipitation, and other climate variables
- Each projection = combination of model, scenario, and initial condition




Source: IPCC, 2013

# Downscaling

- Global climate models (GCM) spatial resolution ranges from about 50 to 300 km
- Resolution may be too coarse for regional decision-making
- Downscaling = take information known at large scales to make predictions at local scales




Source: https://www.pacificclimatefutures.net/en/help/climate-projections/introduction-climate-change-projections/

# Types of Downscaling

- **Statistical –** applies the statistical relationship between local weather variables (e.g., surface rainfall) and larger-scale climate variables (e.g., atmospheric pressure ) to adjust GCM outputs to the local scale
- **Dynamical –** uses GCM outputs to feed a higher-resolution regional climate model (RCM)

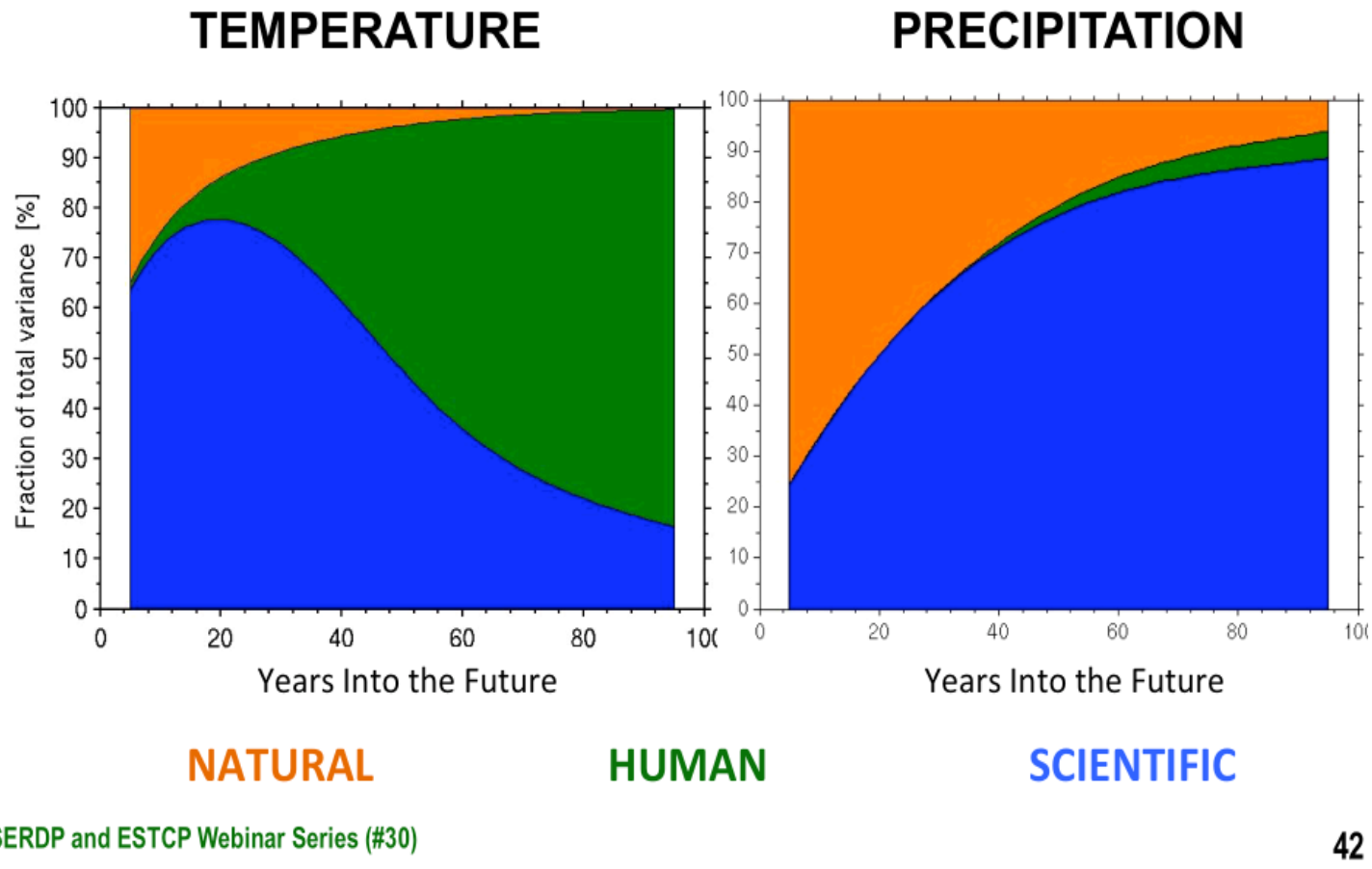
Dynamically downscaled data available for the Caribbean at 25 km and 50 km resolution

# Uncertainties in Models

*"All models are wrong, but some are useful."*

- **Sources of uncertainty:**
  - **Natural** uncertainty – climate variability resulting from natural processes in the climate system
  - **Human** uncertainty – Future emissions of greenhouse gases resulting from human activity (this becomes a larger component of uncertainty on time scales of 50 years or more)
  - **Scientific** uncertainty - an incomplete understanding of and ability for computer systems to model Earth's complex processes (clouds, particles, ice, natural variability, etc.)

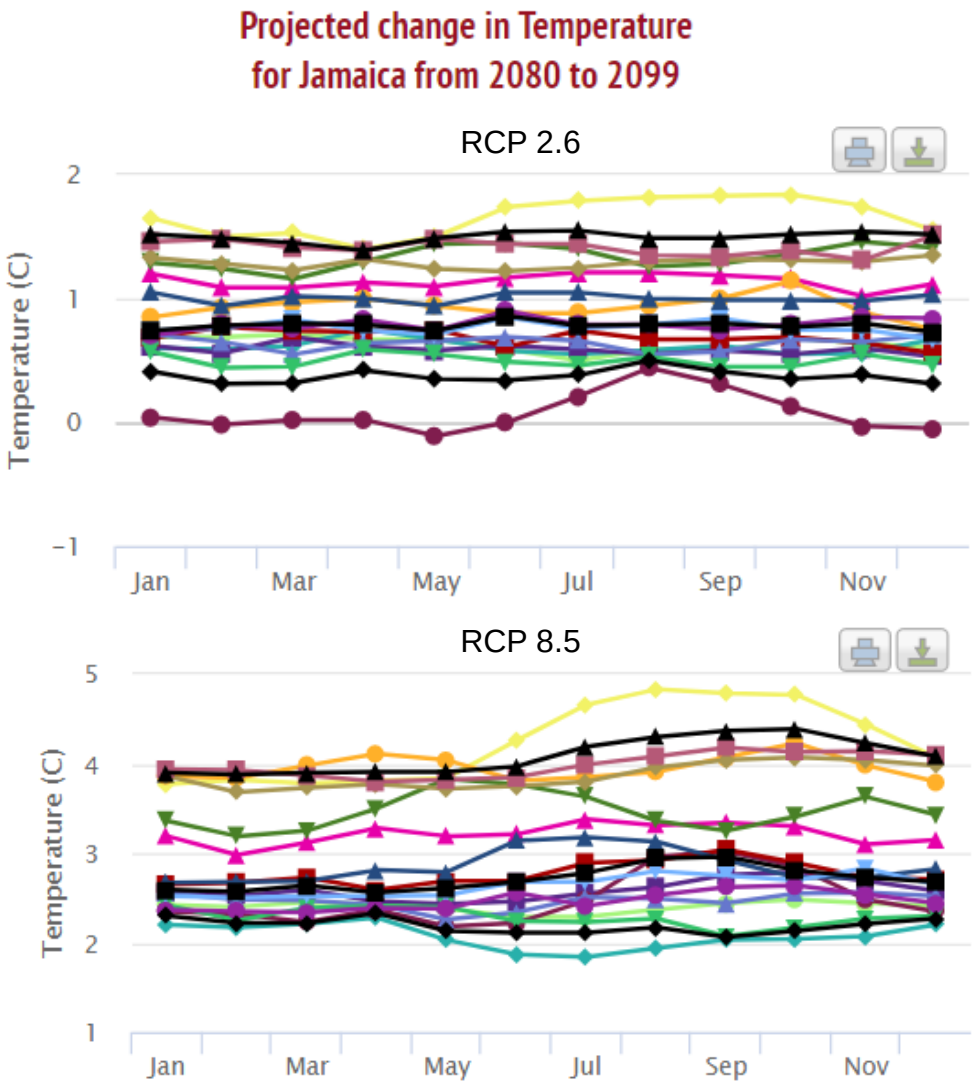
# Uncertainty Varies over Time and by Stressor




Source: https://www.serdp-estcp.org/Tools-and-Training/Webinar-Series/04-07-2016

# Working with Uncertainty

- Despite uncertainties, model information can be useful to decision making
- Use an ensemble of model simulations produced from a range of climate models driven by different future scenarios and timescales
- Consider the spread of the models within an ensemble (10th percentile, median, 90th percentile)

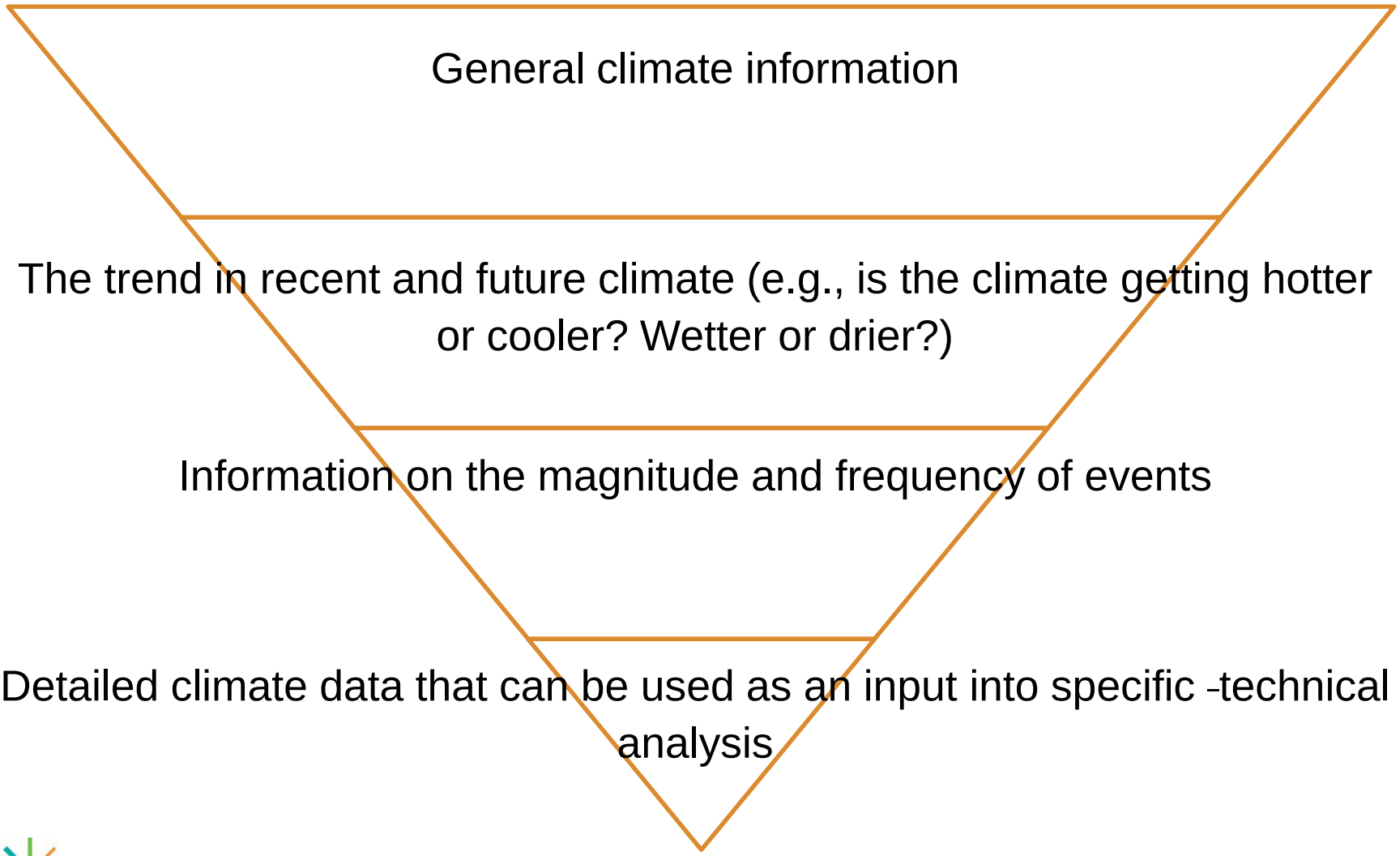



Source: CCKP

# Topic 2

Caribbean climate data sources

# Levels of Climate Information



# Types of Climate Information and Sources

**Time Period**

**Past** | **Present** | **Future**

## Sources of Information

*Weather station*

*Tide gauge*

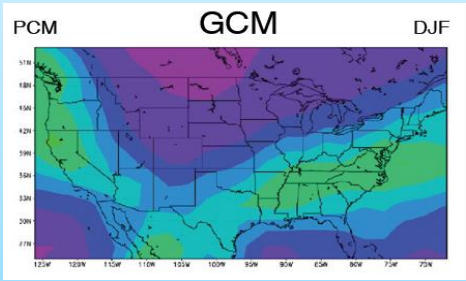
*Anecdotal info*

*River gauge*

*Satellite*

***Precip = f(obs, GCM)***

Statistical Model




Global Climate Model

# Caribbean Climate Data Sources – Historical Data

- **Temperature, precipitation, and wind**
  - Met Service
  - UNDP Climate Change Country Profiles

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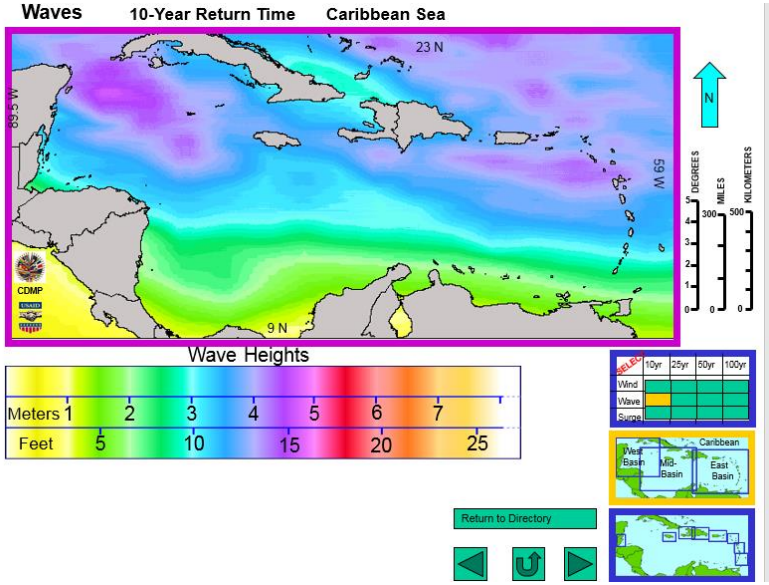

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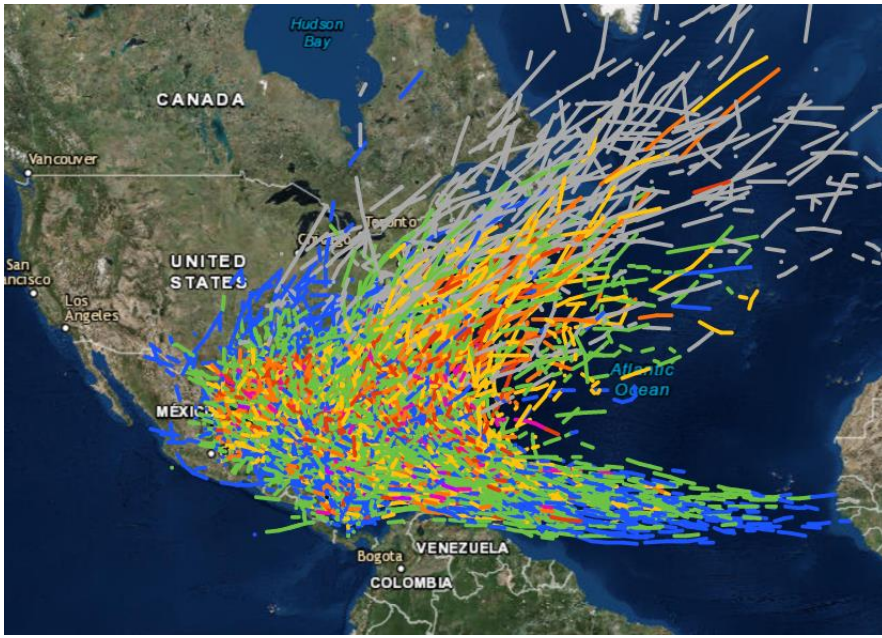


https://coast.noaa.gov/hurricanes/?redirect=301ocm

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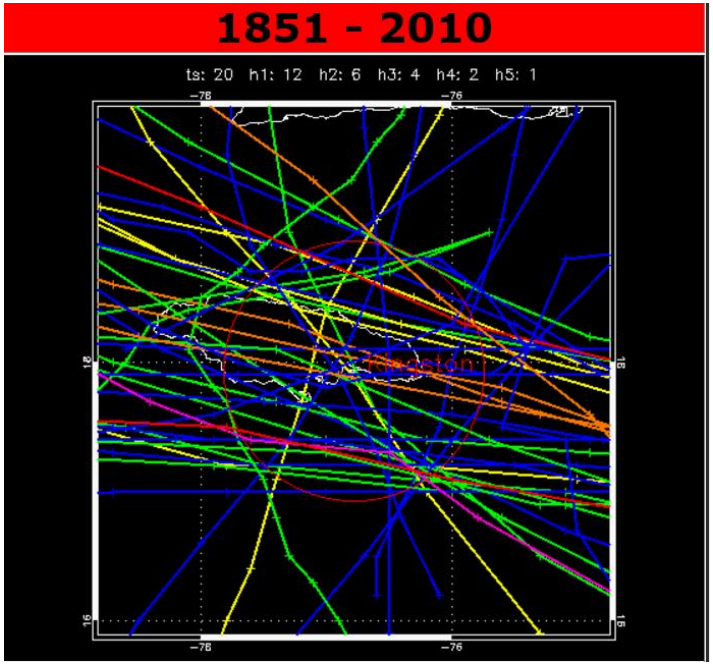
  - Caribbean Hurricane Network

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# Caribbean Climate Data Sources – Projected Data

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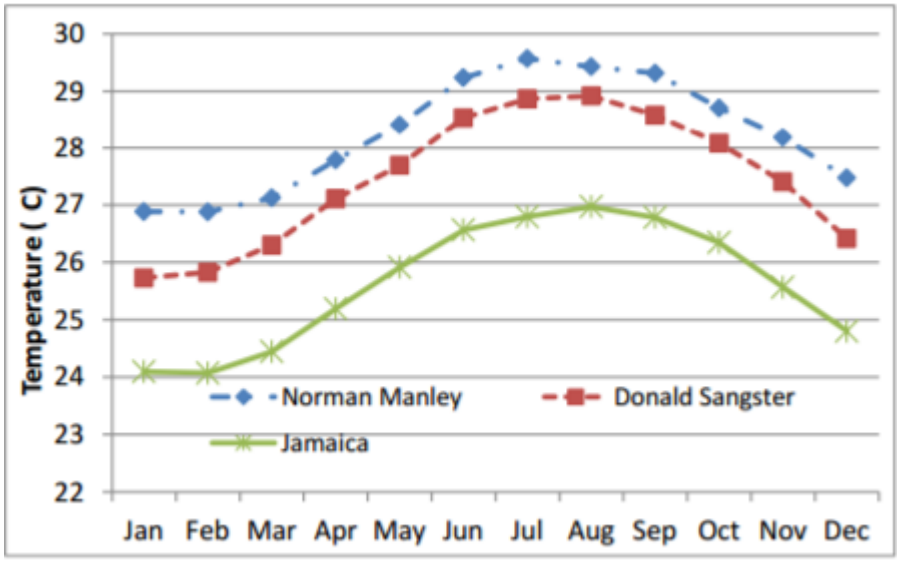

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  - CARIBSAVE Climate Change Risk Atlas

**Table 3.3.1: Observed and GCM Projected Changes in Precipitation for Saint Lucia.**

| Saint Lucia: Country Scale Changes in Precipitation | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Observed Mean 1970-99 | Observed Trend 1960-2006 | | Projected changes by the 2020s | | | Projected changes by the 2050s | | | Projected changes by the 2080s | | |
| | | | | Min | Median | Max | Min | Median | Max | Min | Median | Max |
| | (mm per month) | (change in mm per decade) | | Change in mm per month | | | Change in mm per month | | | Change in mm per month | | |
| | | | A2 | -15 | -2 | 4 | -19 | -4 | 4 | -37 | -16 | 6 |
| Annual | 179.2 | 0.1 | A1B | -10 | -2 | 9 | -18 | -6 | 6 | -29 | -8 | 5 |
| | | | B1 | -11 | -3 | 13 | -18 | -2 | 3 | -21 | -4 | 7 |
| | | | A2 | -3 | 0 | 11 | -8 | -1 | 1 | -10 | -4 | 3 |
| DJF | 125.6 | 1.9 | A1B | -6 | 0 | 4 | -8 | -1 | 6 | -12 | -3 | 3 |
| | | | B1 | -7 | -1 | 14 | -9 | -1 | 7 | -8 | 0 | 6 |
| | | | A2 | -15 | 0 | 8 | -20 | 0 | 17 | -27 | -1 | 9 |
| MAM | 105.3 | -0.9 | A1B | -8 | 1 | 8 | -20 | -1 | 8 | -26 | 0 | 8 |
| | | | B1 | -10 | 0 | 10 | -16 | 0 | 2 | -17 | 0 | 5 |
| | | | A2 | -32 | -7 | 10 | -36 | -18 | 12 | -72 | -27 | 14 |
| JJA | 219.3 | -6.7 | A1B | -25 | -7 | 6 | -34 | -19 | 14 | -45 | -19 | 4 |
| | | | B1 | -26 | -10 | 31 | -36 | -12 | 5 | -40 | -15 | 21 |
| | | | A2 | -29 | -4 | 17 | -40 | -4 | 8 | -57 | -12 | 8 |
| SON | 265.4 | 5.7 | A1B | -30 | -2 | 23 | -35 | -7 | 21 | -59 | -11 | 15 |
| | | | B1 | -24 | -2 | 12 | -39 | -1 | 16 | -45 | -6 | 9 |

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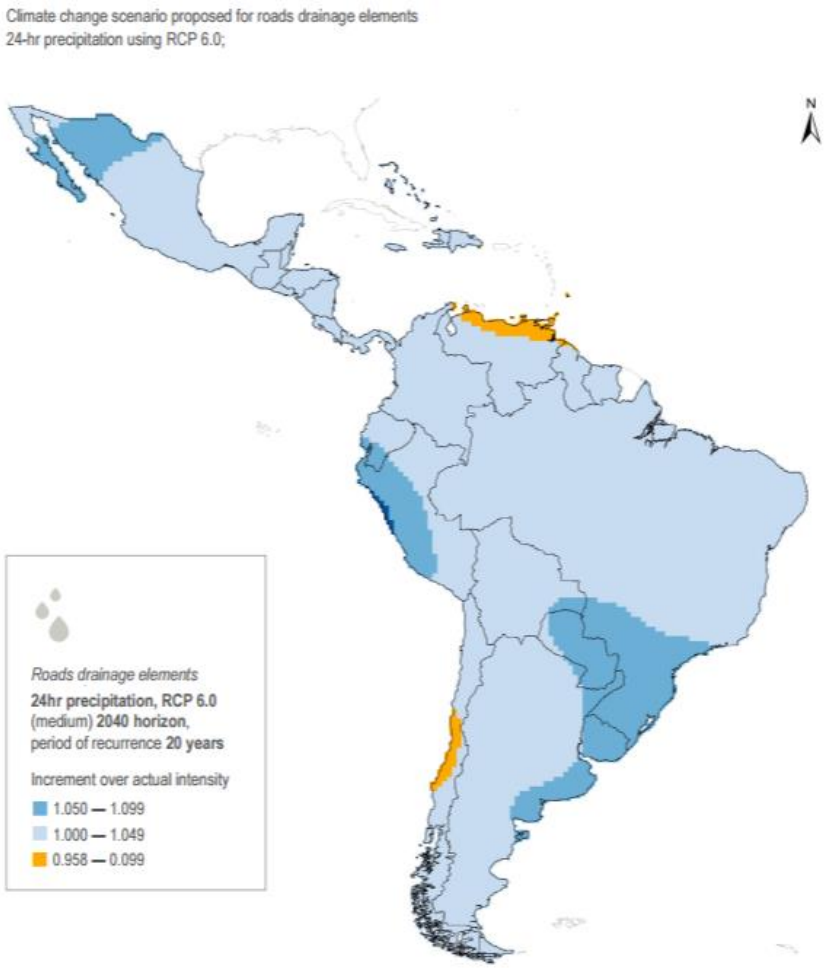

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synthesis reports

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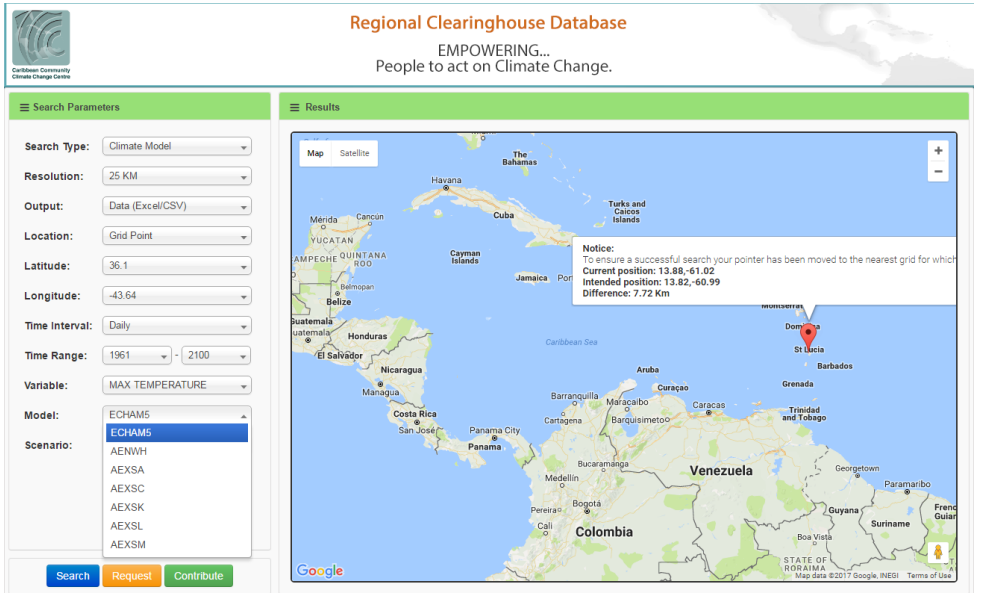
model data

- Caribbean Community Climate Centre (CCCCC) Database



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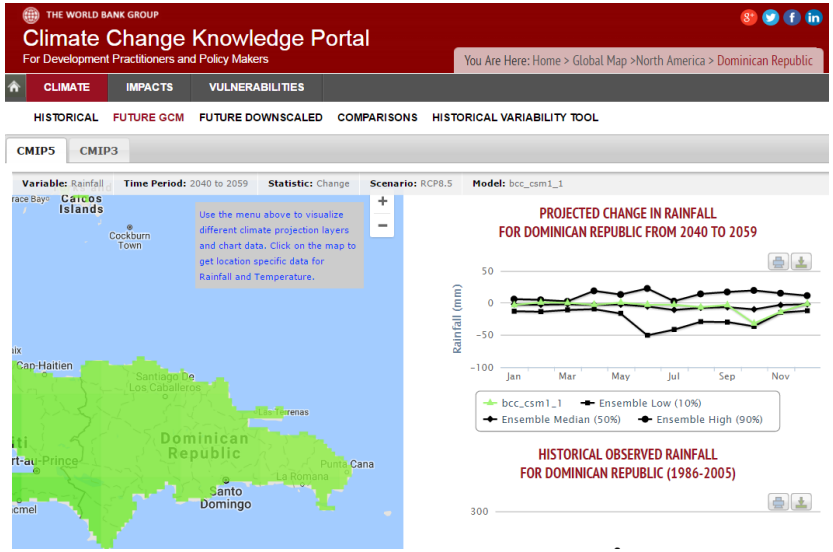
- World Bank Climate Change Knowledge Portal (CCKP)



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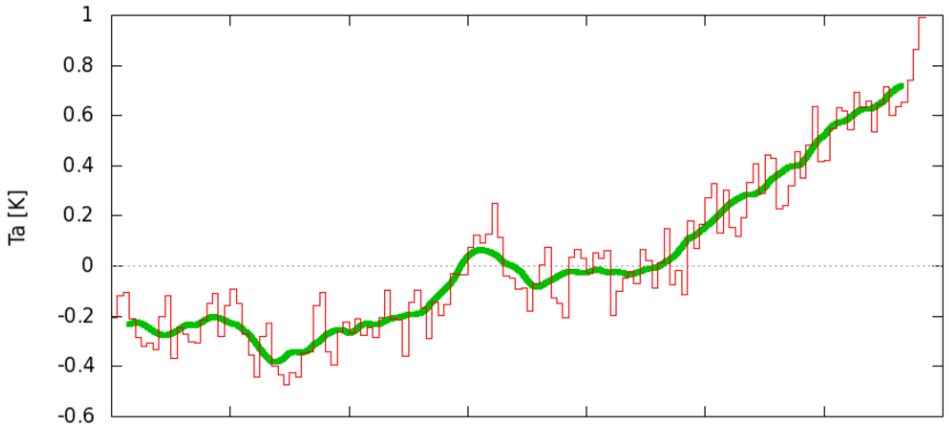
- KNMI Climate Explorer



# Caribbean Climate Data Sources – Projected Data

- **Sea Level/Tides**
  - NOAA 2017, Technical Report on Global and Regional Sea Level Rise Scenarios for the United States (scenarios)

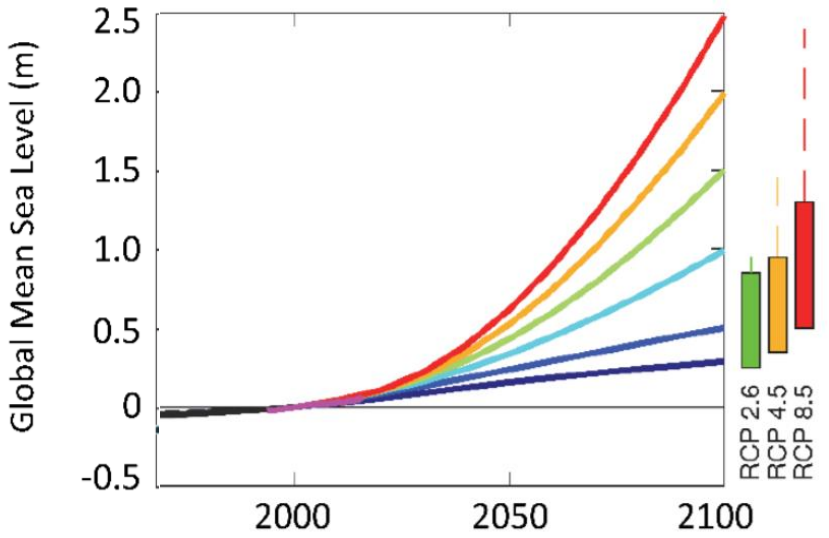
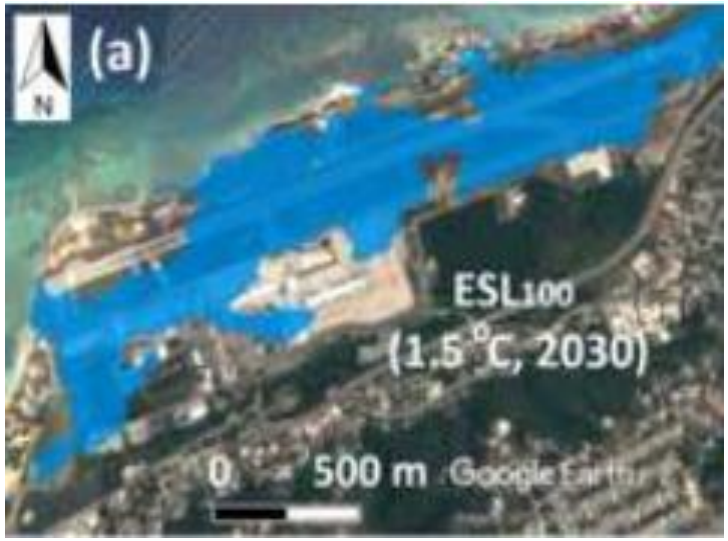



**Table 4.** Probability of exceeding GMSL (median value) scenarios in 2100 based upon Kopp et al. (2014).

| GMSL rise Scenario | RCP2.6 | RCP4.5 | RCP8.5 |
|---|---|---|---|
| Low (0.3 m) | 94% | 98% | 100% |
| Intermediate-Low (0.5 m) | 49% | 73% | 96% |
| Intermediate (1.0 m) | 2% | 3% | 17% |
| Intermediate-High (1.5 m) | 0.4% | 0.5% | 1.3% |
| High (2.0 m) | 0.1% | 0.1% | 0.3% |
| Extreme (2.5 m) | 0.05% | 0.05% | 0.1% |

# Caribbean Climate Data Sources – Projected Data

- **Sea Level/Tides**
  - NOAA 2017, Technical Report on Global and Regional Sea Level  Rise Scenarios for the United States (scenarios)
  - Large scale Integrated Sea-level and Coastal Assessment Tool (LISCoAsT) (localized spatial modeling)

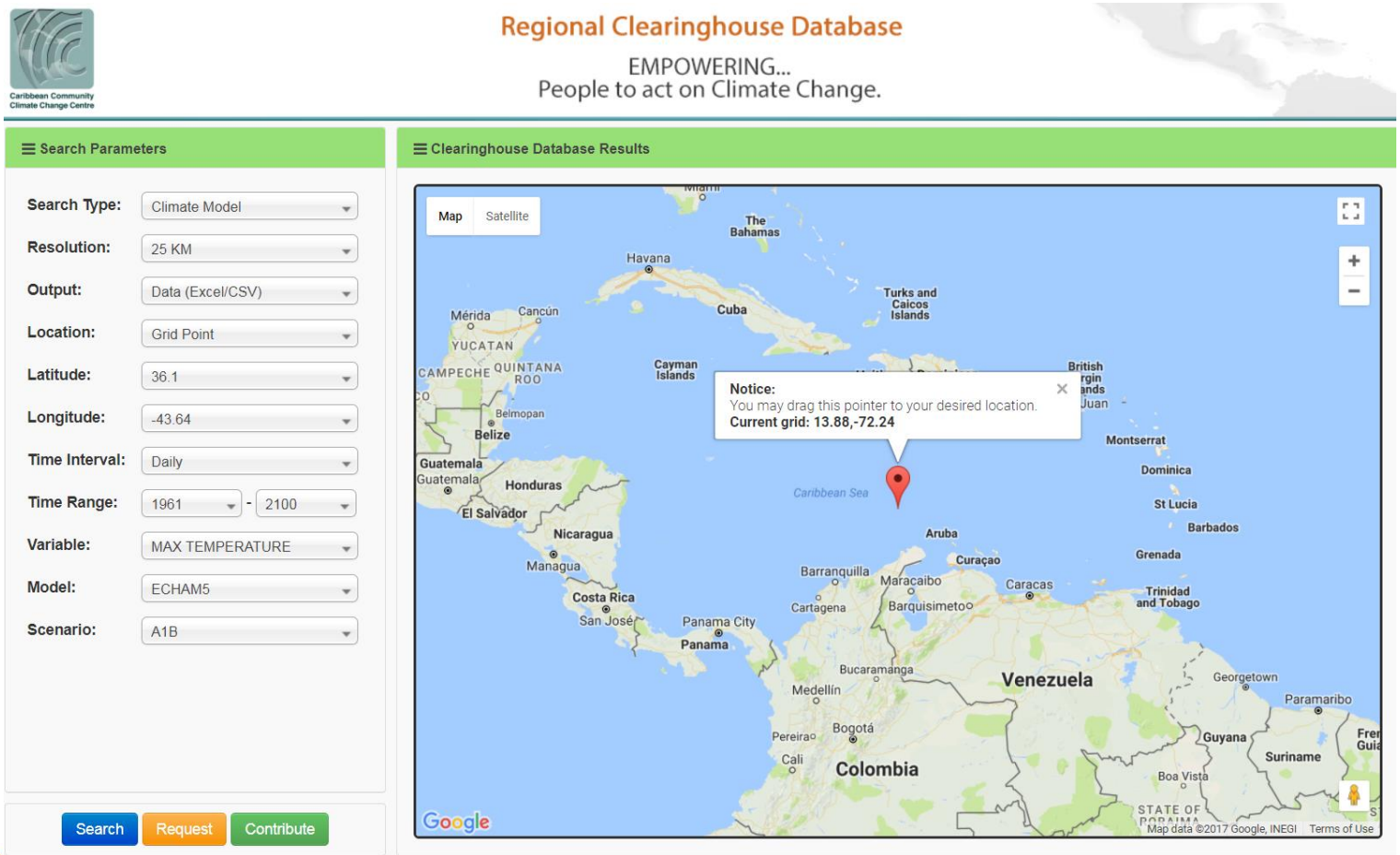


# Caribbean Climate Data Sources – Projected Data

- **Sea Level/Tides**
  - NOAA 2017, Technical Report on Global and Regional Sea Level  Rise Scenarios for the United States (scenarios)
  - Large scale Integrated Sea-level and Coastal Assessment Tool (LISCoAsT) (localized spatial modeling)
  - SMASH (from 5Cs)

# 5Cs Regonal Climate Clearinghouse

- http://clearinghouse.caribbeanclimate.bz/



# Build relationships and trust with information providers

- Build relationships with partner(s) who are well-equipped to collect and analyze climate data
  - Universities, 5Cs, Met Office, consulting firms
- Work together to identify and overcome data gaps, refine data needs
- As you become familiar with the climate information it becomes more useful, and your needs more apparent. This may involve some capacity building and active partnerships.

# Summary: Best practices in identifying information

- Consider how climate has impacted the system in the past, recognizing that it is not a direct parallel
- Account for climate variability, both natural and human-caused, and potential climate extremes.
- Recognize uncertainty in future outcomes and consider a full range of climate scenarios.
- Ask for help from partners and experts if you cannot find or understand the information you need.

# More Details in Report

| Name | URL | Variables | Time Period | Temporal Resolution | Models | Scenario(s) | Spatial Resolution |
|---|---|---|---|---|---|---|---|
| Caribbean Community Climate Change Centre (CCCCC) Regional Clearinghouse – RCM | http://clearinghouse.caribbeanclimate.bz/?db_type=Climate%20Model&country=&collection=V501&s=&sector=&topic= | Available soil moisture content in root zone, convective rainfall rate, evaporation rate from canopy, large scale rainfall rate, max temperature, minimum temperature, humidity, etc. | 1961-2100 | Daily | ECHAM5 | A1B | 25 km |
| CCCCC Regional Clearinghouse – GCM | http://clearinghouse.caribbeanclimate.bz/?db_type=Climate%20Model&country=&collection=V501&s=&sector=&topic= | Change in annual mean temperature, Change in total precipitation rate (mm/day), Change in mean surface temperature, Change in relative humidity, Change in wind speed at 10 m (m/s) | 1990-2100 (ECHAM), 2010-2069 (Had) | Daily | ECHAM4, HadAM3P | A2, B2 | 50 km |
| CARIBSAVE Climate Change Risk Atlas | http://www.caribbeanclimate.bz/closed-projects/2009-2011-the-caribsave-climate-change-risk-atlas-cccra.html | Mean temperature, total precipitation, wind speed, relative humidity, sunshine hours, sea surface temperatures, frequency of hot days, frequency of hot nights, frequency of cold days, frequency of cold nights, per centage of rainfall falling in heavy events, maximum 1-day rainfall, maximum 5-day rainfall | 2020s, 2050s, 2080s (rel. to 1970-1999) | Seasonal and Annual | Ensemble of 15 General Circulation Models (GCMs) and PRECIS Regional Climate Model (RCM) driven by ECHAM4 and HadCM3 | GCMs: A2, A1B, B1<br><br>RCM: A2 | GCMs: 2.5 degrees<br><br>RCM: unknown |

# Thank you! Questions?