“Climate Change Impacts and Adaptation for Coastal Transport Infrastructure in Caribbean SIDS”

Training

Gathering and applying climate information for decision-making

By

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Training

Gathering and applying climate information for decision-making

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

June 1, 2017

United Nations Conference on Trade and Development
National Workshop - Jamaica
Cassandra Bhat
ICF

Objectives

- Learn the fundamentals about climate scenarios, models, and data
- Understand sources of climate data for the Caribbean
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. The old saying is climate is what we expect and weather is what we get.¹

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.

![Graph showing climate change impacts](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

![Graph showing global mean sea level scenarios](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

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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

Representative Concentration Pathways (RCPs)

<table>
<thead>
<tr>
<th>Scenario Name</th>
<th>Description</th>
<th>Concentrations (ppm CO₂ equiv.) by 2100</th>
<th>Change in CO₂ equiv emissions compared to 2010</th>
<th>Global Surface Temp. Change by 2100°</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCP 2.6</td>
<td>Emissions reduced substantially from current pathway.</td>
<td>430-480</td>
<td>-72 to -41%</td>
<td>-118 to -78%</td>
</tr>
<tr>
<td>RCP 4.5</td>
<td>Emissions reduced sufficiently so that total radiative forcing is stabilized by 2100.</td>
<td>580-720</td>
<td>-38 to 24%</td>
<td>-134 to -21%</td>
</tr>
<tr>
<td>RCP 6.0</td>
<td>Emissions reduced sufficiently so that total radiative forcing is stabilized by 2100.</td>
<td>720-1,000</td>
<td>18 to 54%</td>
<td>-7% to 72%</td>
</tr>
<tr>
<td>RCP 8.5</td>
<td>High emissions continue through 2100. Most representative RCP of current emissions track.</td>
<td>&gt;1,000</td>
<td>52 to 95%</td>
<td>74 to 178%</td>
</tr>
</tbody>
</table>
## Emission Scenarios

### IPCC Fourth Assessment Report

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

### IPCC Fifth Assessment Report

<table>
<thead>
<tr>
<th>Scenario Name</th>
<th>Description</th>
<th>CO₂ equiv. ppm by 2100</th>
<th>Global Surface Temp. Change by 2100</th>
<th>Global Mean Sea Level Rise by 2100</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCP2.6</td>
<td>Stabilization</td>
<td>475</td>
<td>0.5-3.0 °F (0.3-1.7 °C)</td>
<td>0.85-1.8 ft (0.26-0.55 m)</td>
</tr>
<tr>
<td>RCP4.5</td>
<td>Substantial and sustained emissions</td>
<td>630</td>
<td>2.0-4.7 °F (1.1-2.6 °C)</td>
<td>1.0-2.1 ft (0.32-0.63 m)</td>
</tr>
<tr>
<td>RCP6.0</td>
<td>Stabilization</td>
<td>800</td>
<td>2.5-5.6 °F (1.4-3.1 °C)</td>
<td>1.1-2.1 ft (0.33-0.63 m)</td>
</tr>
<tr>
<td>RCP8.5</td>
<td>High emissions continue</td>
<td>1313</td>
<td>4.7-8.6 °F (2.6-4.8 °C)</td>
<td>1.5-2.7 ft (0.45-0.82 m)</td>
</tr>
</tbody>
</table>

### RCPs

**Projected Atmospheric Greenhouse Gas Concentrations**

**Global surface temperature change**


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”
Climate Models

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

![Graph showing rainfall variation over time](source)

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

![Graph showing global mean temperature change](source)
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


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

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

General climate information

- The trend in recent and future climate (e.g., is the climate getting hotter or cooler? Wetter or drier?)
- Information on the magnitude and frequency of events
- Detailed climate data that can be used as an input into specific technical analysis

Types of Climate Information and Sources

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Past</th>
<th>Present</th>
<th>Future</th>
</tr>
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</table>

**Sources of Information**
- Weather station
- Tide gauge
- River gauge
- Satellite
- Anecdotal info

**Precip = f(obs, GCM)**
- Statistical Model
- Global Climate Model
Climate Data Sources for Jamaica – Historical Data

- Temperature, precipitation, and wind
  - Met Service
  - State of Jamaican Climate Report
  - Climatic Research Unit

- Sea Level/Tides
  - Met Service
  - Permanent Service for Mean Sea Level
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  - Caribbean Hurricane Network
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  - CARIBSAVE Climate Change Risk Atlas
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  - Caribbean Community Climate Centre (CCCCC) Database
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  - Large scale Integrated Sea-level and Coastal Assessment Tool (LISCoAsT) (localized spatial modeling)
  - HadGEM2-ES modeling (localized scenario modeling)
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<tr>
<th>GMESL rise Scenario</th>
<th>RCP4.5</th>
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<th>RCP8.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (0.3 m)</td>
<td>94%</td>
<td>98%</td>
<td>100%</td>
</tr>
<tr>
<td>Intermediate-Low (0.5 m)</td>
<td>49%</td>
<td>73%</td>
<td>96%</td>
</tr>
<tr>
<td>Intermediate (1.0 m)</td>
<td>2%</td>
<td>5%</td>
<td>17%</td>
</tr>
<tr>
<td>Intermediate-High (1.5 m)</td>
<td>0.4%</td>
<td>0.5%</td>
<td>1.3%</td>
</tr>
<tr>
<td>High (2.0 m)</td>
<td>0.1%</td>
<td>0.1%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Extreme (2.5 m)</td>
<td>0.05%</td>
<td>0.05%</td>
<td>0.1%</td>
</tr>
</tbody>
</table>

What if the information you need is unavailable?

Data gaps can be filled by:
- Interpolation of station data
- Reanalysis, satellite data
- Indigenous knowledge
- Non-traditional data sources, such as ship or aircraft data
- Combining data from different sources
- Investing in additional observation stations
- Fostering collaboration between information providers and users
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

<table>
<thead>
<tr>
<th>Name</th>
<th>URL</th>
<th>Variables</th>
<th>Time Period</th>
<th>Temporal Resolution</th>
<th>Models</th>
<th>Scenario(s)</th>
<th>Spatial Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caribbean Community Climate Change Centre (CCCCC) Regional Clearinghouse - RCM</td>
<td>http://clearinghouse.caribbeanclimatecrc.org_ISO/3.5/Report/24944/CM0046624/00275400001</td>
<td>Available soil moisture content in root zone, convective rainfall rate, evaporation rate from canopy, large scale rainfall rate, max temperature, minimum temperature, humidity, etc.</td>
<td>1961-2010</td>
<td>Daily</td>
<td>ECHAM5</td>
<td>A1B</td>
<td>25 km</td>
</tr>
<tr>
<td>CCCCC Regional Clearinghouse - GCM</td>
<td>http://clearinghouse.caribbeanclimatecrc.org_ISO/3.5/Report/24944/CM0046624/00275400001</td>
<td>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)</td>
<td>1990-2010 (ECHAM 5), 2010-2049 (HadGEM3)</td>
<td>Daily</td>
<td>ECHAM5, HadGEM3</td>
<td>A2, B2</td>
<td>50 km</td>
</tr>
<tr>
<td>CARIBSAVE Climate Change Risk Atlas</td>
<td>http://www.caribbeanclimatecrc.org_ISO/3.5/Report/24944/CM0046624/00275400001</td>
<td>Mean temperature, total precipitation, wind speed, relative humidity, sunshine hours, sea surface temperature, frequency of hot days, frequency of hot nights, frequency of cold days, frequency of cold nights, percentage of rainfall falling in heavy events, maximum 1-day rainfall, maximum 5-day rainfall</td>
<td>2025a, 2050a, 2080s (ref to 1970-1999)</td>
<td>Seasonal and Annual</td>
<td>Ensemble of 16 General Circulation Models (GCMs) and PRECIS Regional Climate Model (RCM) driven by ECHAM5 and HadGEM3</td>
<td>GCMs, A2, A1B, B1</td>
<td>RCM: A2</td>
</tr>
</tbody>
</table>

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**Thank you! Questions?**